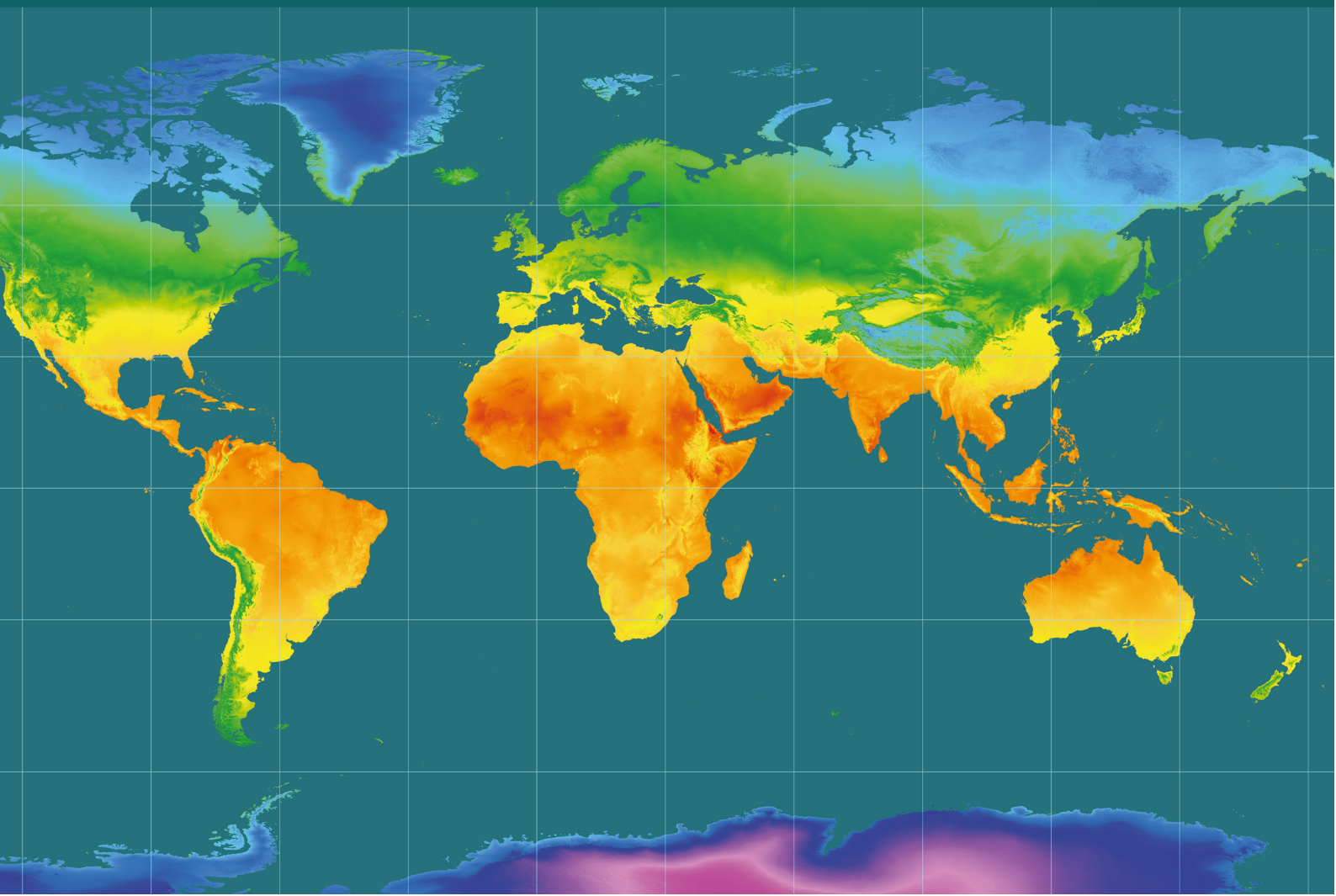
VARYSIAN

The Varysian Guide

2023 | Issue 2

Hydrometeorology

A Reference Guide for Capacity Building & Industry Solutions



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Foreword

CEO, Varysian Ltd

Until the early 2000s NMHSs in the Global South had been predominantly shunned, unable to do their role through a lack of funding, or archaic project design that leads to graveyards of weather data gathering potential, and worse capacity than before, hailed development projects.

Today, after billions of dollars of 'investment' we find dilapidated NMHS across much of the developing world not having enough funding for wages and dealing with broken data sets and a lack of organisational continuity when compared with their Global North contemporaries.

NMHSs in the Global South are often at the behest of loans with project structures that have rarely worked, facing more challenges after projects than before. And yet these are the countries most impacted by the effects of climate change.

While it's positive that lowering carbon footprint is high on the climate agenda, it only does so much to help the situation by offering mid to long term mitigation. The real fight, right here, right now, is to build capacity in the Global South in order to improve resilience to extreme weather events.

Private sector investment needs to come through impact investment and projects also need to be restructured to provide sustainability.

Thankfully this is beginning to happen through initiatives like the WMO's SOFF for example, and I'm excited for the positive change WMO Secretary General Elect, Professor Celeste Saulo, will enact.

I had the pleasure of speaking with her during her campaign, where we discussed her ideas on how to improve the WMO's engagement and communication with NMHSs in the Global South, as well as all key stakeholders from across the public, private and academic sectors.

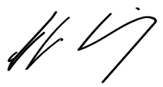
You can read about these, as well as her thoughts on regional offices and potential new secretariats, in our exclusive interview on page 065.

You can also read the latest from SOFF on page 009, part of our Initiatives section that also provides updates on other programmes including the WMO's WIS 2.0 (page 011) and the UN's Early Warnings for All initiative (page 007).

Early warning systems are a key focus for the sector right now, and rightly so, which is why we also have a dedicated section beginning on page 037, which includes examples of EWS projects in the Caribbean and Latin America.

There's this and much more in this issue of the Varysian Guide, so I hope it educates, informs and engages you all. If there's anything you'd like to see in a future issue, or would like to reach out to Varysian to discuss, please feel free to get in touch – our contact details are on page 003.

Yours Sincerely,



Thomas Copping

Initiatives 01

The UN Early Warnings for All initiative

A global commitment to ensure that everyone on Earth is protected from hazardous weather, water, or climate events through life-saving early warning systems by the end of 2027

This past July was declared the hottest month ever recorded. This set the way for the hottest three-month period on record. In addition, the summer was marked by an alarming number of hazardous weather events. These included severe rainfall and flash floods wreaking havoc in Beijing and causing thousands of deaths in Dema, devastating wildfires ravaging regions like Corfu and Arctic Canada, and unprecedented heatwaves scorching Phoenix, Arizona.

With human-induced climate change leading to more extreme weather conditions, the need for early warning systems is more crucial than ever. According to the Global Commission on Adaptation, giving just 24 hours' notice of an impending hazardous event can reduce damage by 30 per cent. Investing just US$800 million in such systems in developing countries would prevent losses of $3 to $16 billion annually.

Despite the urgent need, only half of the countries worldwide report having adequate multi-hazard early warning systems, and even fewer have regulatory frameworks that connect early warnings to emergency and response plans. There also are big gaps in the global observing system required to generate forecasts.

Early warnings for all

In response to this we've seen the launch of the UN Secretary General's Early Warnings for All (EW4All) initiative to ensure everyone on Earth is protected from hazardous weather, water or climate events through life-saving early warning systems by the end of 2027.

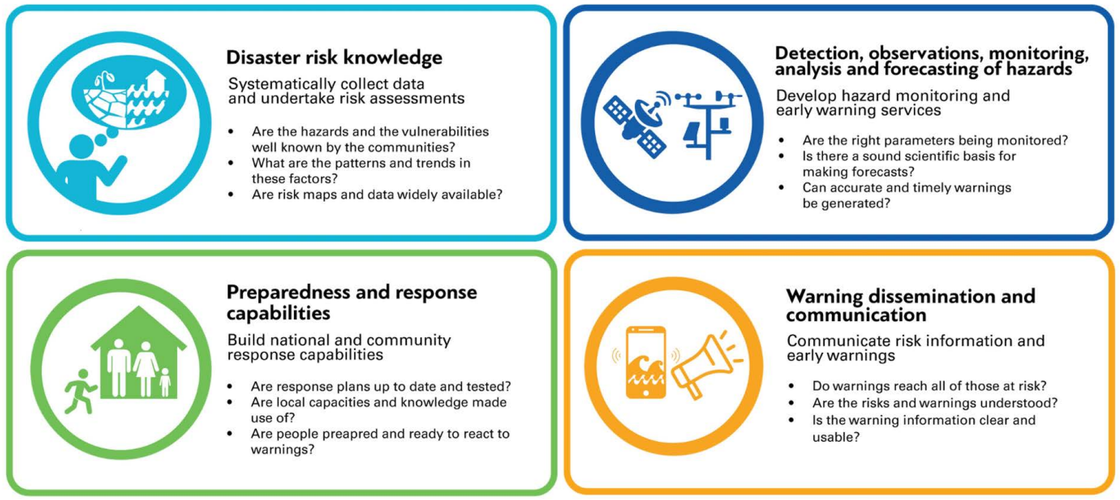
The Early Warnings for All initiative is co-led by the World Meteorological Organisation (WMO) and the United Nations Office for Disaster Risk Reduction (UNDRR), with support from the International Telecommunication Union (ITU), the International Federation of Red Cross and Red Crescent Societies (IFRC) and other partners.

The initiative is also engaging development partners through existing partnerships and coalitions such as the Alliance for Hydromet Development, the Risk-informed Early Action Partnership and other regional partnerships and alliances.

Additional implementing partners include the Food and Agriculture Organisation of the United Nations (FAO), United Nations Office for the Coordination of Humanitarian Affairs (OCHA), United Nations Development Programme (UNDP), United Nations Environment Programme (UNEP), United Nations Educational, Scientific and Cultural Organization (UNESCO), Risk Informed Early Action Partnership (REAP) and the World Food Programme (WFP).

The Early Warnings for All initiative is built on four pillars to deliver effective and inclusive multi-hazard early warning systems: risk knowledge and management, observations and forecasting, dissemination and communication, and preparedness to respond.

Safeguarding individuals demands prioritisation of inclusive early warning systems, especially for vulnerable communities. To ensure a comprehensive approach, our



The EW4All executive action plan's four pillars for implementation. Image credit: WMO

efforts must span multiple sectors: food security, clean energy, water and sanitation, good health, wellbeing, gender balance and economic prosperity. Only through such a holistic approach can we protect those at risk.

In 2023, the focus is on executing at the national level. National rollout has begun across countries as per the five steps detailed here on the right.

Spotlight on The Maldives

National consultations kicked off this July, starting in The Maldives, which held a national workshop as part of its commitment to the EW4All initiative. This brought together participants from government, local councils, civil society, the private sector, the UN Country Team and EW4All pillar leads.

The event reviewed the current state of early warning systems in the Maldives, identified priority areas for action and strengthened multi-stakeholder early warning coordination.

Participants agreed to formulate a common agenda to guide the scale-up of national early warning systems, which will be implemented with the support of the partners of the EW4All initiative. Participants also engaged in the further elaboration of an UNEP-led planning exercise for a GCF early warning proposal.

We've also seen consultations in Tajikistan, Ethiopia, Madagascar, Nepal and Lao. More are planned for the rest of the year. Notably, there's also a new Early Warnings for All Action Plan for Africa, announced at the Africa Climate Summit in September.

The same month, at the UN Secretary General's Climate Ambition Summit, a number of multilateral development banks announced their commitment to the EW4All initiative, including the World Bank, Inter-American Development Bank, Asian Development Bank, Islamic Development Bank, and European Investment Bank. This builds on the GCF announcement to fund EW4All and ensure universal coverage.

Looking ahead

With COP 28 around the corner, now's the time for the global community to unite and dedicate concerted effort to the Early Warnings for All initiative as we stand at a critical juncture in tackling the climate crisis and fortifying adaptation and resilience for future generations.

For more information on the EW4All initiative please visit earlywarningsforall.org.

STEP 1. Stakeholder mapping: to identify and map out all relevant stakeholders in the country, to clearly aid in defining roles, responsibilities and gaps in engagement and coordination. The mapping includes government agencies, non-governmental organisations, academic institutions, private sector entities, communities at risk and donors.

STEP 2. National consultative workshop: to present the initiative, secure institutional buy-in, present ongoing early warning work in the country, identify an appropriate coordination mechanism, discuss gaps and priority technical needs for support. A key outcome is agreement on the most appropriate coordination mechanism for EWS and identification of priority technical areas of support required.

STEP 3. Gap analysis: to identify the strengths and weaknesses of the existing early warning systems and highlight areas for improvement. A Minimum Core Capability Checklist developed by the EW4All Initiative can be made available for the gap analysis at country level.

STEP 4. National plans/roadmaps for technical support: the action plan or roadmap should set out how to bridge the identified gaps and outline the key actions, technical support and capacity required to improve the effectiveness of early warning systems, as well as agreed timelines and budget.

STEP 5. Implementation, monitoring and reporting: to monitor progress in countries, and to strengthen reporting on Target G of the Sendai Framework, which tracks progress on early warning systems.

Authors: Daniela Cuellar Vargas, Roberta Boscolo and Jesse Cruz, World Meteorological Organisation

Supporting countries to close the basic weather and climate data gap

SOFF is already working with 62 countries and rapidly expanding

The Systematic Observations Financing Facility (SOFF) is a specialised UN fund co-created by the WMO, UNDP and UNEP. Its goal is to close the basic weather and climate observations data gap in countries with the most severe shortfalls in observations, prioritising least developed countries (LDCs) and small island developing states (SIDS).

SOFF is a delivery vehicle of the UN Secretary General's Early Warnings for All initiative, aiming to protect everyone on Earth with early warning systems by 2027.

SOFF as a new way of financing

SOFF provides long-term financial and technical assistance to support the acquisition and international sharing of basic weather and climate observations, according to the internationally agreed Global Basic Observing Network (GBON) regulations.

Danmarks Meteorologiske Institut working with Tanzania. Copyright Danish Meteorological Institute

SIDS and LDCs represent areas of high priority for better weather forecasts and climate projections. These will receive technical and financial support to build human capacity, and install or improve the needed infrastructure to collect and share data, as well as sustain operations and maintenance.

Speedily moving to implementation

SOFF support is provided to countries in three phases: readiness, investment and compliance.

Countries eligible for overseas development aid (ODA) qualify for the first SOFF phase, SIDS and LDCs for all three.

SOFF operations are implemented through a close collaboration between those countries, implementing entities – consisting out of multilateral development banks and UN organisations – peer advisors and advanced national meteorological services.

At the time of writing, 62 countries are programmed to start with the readiness phase. A total of 36 have already started implementation and approximately 20 countries saw funding approved in September.

By the end of 2023, we expect to see around 10 countries move to the investment phase. Upon successfully completing all phases, countries are sustainably compliant with Global Basic Observing Network (GBON).

Regionally-coordinated action

SOFF promotes regional and sub-regional approaches to optimise GBON implementation and explore options for effective procurement, operations, maintenance and learning exchange.

Regional workshops are planned for the upcoming months including one in Cabo Verde for Atlantic SIDS in November and one in Fiji for the Pacific countries in January 2024.

These will be followed with workshops for Latin America and the Caribbean, as well as Indian Ocean countries. The details for these will be confirmed in due course.

Further information on the Systematic Observations Financing Facility (SOFF) can be found at: un-soff.org

Author: Pauline Trepczyk, Communications Lead, Systematic Observations Financing Facility (SOFF)

CREWS initiative – annual report findings

Strengthening early warning systems for climate risk reduction

The latest WMO Climate Risk and Early Warning Systems (CREWS) annual report was published in June, and focuses on the work achieved during 2022.

According to the 2022 report, the CREWS initiative made significant progress in establishing effective early warning systems last year. Aligned with the UN Secretary General's Early Warnings for All initiative (AW4ALL, see page 007) CREWS expanded its support to least developed countries (LDCs) and small island developing states (SIDS).

The initiative launched three new national and regional projects in Malawi, Central Africa, East Africa, and the Greater Horn of Africa, bringing the total number of CREWS-funded projects to 18. Moreover, a new project was approved for East Africa, with a US$7 million investment over four years.

While some CREWS projects faced challenges due to COVID-19 restrictions, others continued to progress.

During 2022 CREWS implemented operational guidelines and procedures to ensure that early warning solutions reached those most at risk. These guidelines emphasised the involvement of women, communities and local organisations in the design, implementation and monitoring of early warning systems.

The International Federation of Red Cross Red Crescent Societies facilitated consultation with its national societies, ensuring their contribution and financing for translating early warnings into anticipatory and early actions.

New pathways to access early warning financing

New pathways to access early warning financing were also created. CREWS introduced the Accelerated Support Windows initiative, providing short-term interventions to LDCs and SIDS. Additionally, collaboration with the Green Climate Fund (GCF) allowed for scaling up early warning system financing. Successful implementation of CREWS-funded projects made countries eligible to access up to US$25 million per project through the GCF's Simplified Approval Process (SAP) for further early warning system development.

The GCF-SAP-CREWS Scaling Up Framework for Early Warning was established to pilot the process of accessing early warning finance through the GCF.

Significant strides taken

Overall, in 2022 the CREWS initiative made significant strides in strengthening early warning systems for climate risk reduction. Through expanded projects, new funding mechanisms and people-centred approaches, CREWS aimed to reduce the impact of disasters on lives, livelihoods and infrastructure.

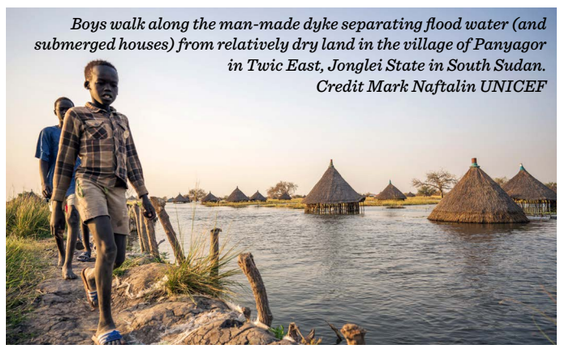
By enabling communities to take early action and save lives and assets, CREWS played a vital role in building resilience and preparedness in vulnerable regions worldwide.

In 2023, the CREWS Steering Committee has initiated US$20 million in financing to develop projects in the Caribbean (next phase), Niger, Djibouti and to support the kick-off countries of the EW4ALL Initiative.

In addition, the initial countries for the GCF-CREWS Scaling Up Framework have started to be discussed. The countries put forward are Belize, Guyana and Trinidad and Tobago.

The next Annual Report covering the progress made in 2023 will be published in June 2024.

Author: CREWS Secretariat, WMO



Boys walk along the man-made dyke separating flood water (and submerged houses) from relatively dry land in the village of Panyagor in Twic East, Jonglei State in South Sudan. Credit Mark Naftalin UNICEF

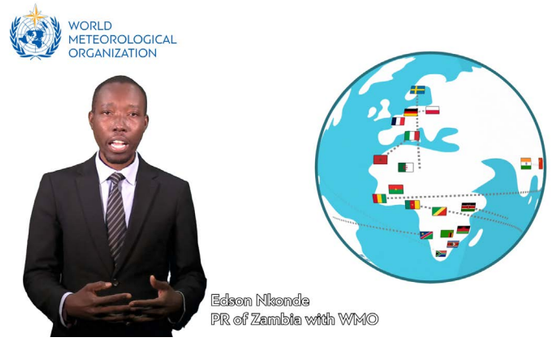
Mozambique Red Cross taking part in an early warning drill in a small community outside of Mopeia. Credit Damien Schumann IFRC

WIS 2.0 update

WIS 2.0 is the WMO data-sharing framework for the 21st century

Since the global telecommunication system (GTS) entered operational life in 1971, it has been a reliable real-time exchange mechanism of essential data for WMO members.

In 2007, the WMO Information System (WIS) was developed to complement this system, providing a searchable catalogue and global cache to enable additional discovery, access and retrieval.



The success of WIS was limited as the system only partially met the requirement of providing simple access to WMO data. Today's technologies developed for the Internet of Things (IoT) opens the possibility of creating a WIS 2.0 able to stand to its expectations of delivering an increasing number and volume of real-time data to WMO NWP centres to improve their forecast skills.

Benefits of WIS 2.0

WIS 2.0 has been designed to meet the shortfalls of the current WIS and GTS, support the WMO's Unified Data Policy and Global Basic Observing Network (GBON), and meet the demand for high data volume, variety, velocity and veracity.

It's simple, effective and able to share high volumes of authoritative data in real-time. Its implementation started at the beginning of this year and already has more than 40 participating countries sharing observations data in real-time through WIS 2.0 nodes or providing global services. Before the end of the year, ECMWF and EUMETSAT will also publish their data on WIS 2.0.

The upgrade has been designed around three foundational pillars: simpler data exchange, cloud-ready solutions and open standards.

Access, discovery, use and sharing of weather, climate and water data will be improved, helping members to develop effective and reliable data processing workflows.

For example, the prioritisation of the internet over private telecoms networks will make access easier, while the use of open standards will avoid the building of bespoke solutions that create niche markets and force NMHSs to procure special equipment.

This is also supported by the use of cloud-ready technologies, as cloud infrastructure enables easier deployment of solutions and allows the implementation of reliable processing systems without the need to build local infrastructure that is difficult to sustain for many countries.

Cloud also enables WIS 2.0 to deploy infrastructure and systems more efficiently, with minimum effort from NMHSs, by shipping ready-made services and implementing consistent data processing and exchange techniques.

Implementation

A collaborative implementation approach has been adopted for WIS 2.0, taking into consideration lessons learnt from the original development and implementation of WIS. This path was chosen in order to lower barriers and increase participation by WMO members and partner organisations.

The implementation of WIS 2.0 began this year with a 12-month pilot phase. Training first took place in Africa in March, where representatives from 13 member countries came together in Namibia.

WIS 2.0 training session in Namibia

In the Caribbean, training took place in Trinidad and Tobago, which was attended by 15 member countries from across the region, and a final training session took place in Jakarta this October, attended by a further 11 member countries.

Training concludes with attendees requested to develop a plan on return to their organisations for implementation of WIS 2.0. The WMO supports the development of the national WIS 2.0 implementation plan, and the countries qualifying for funding by the SOFF (Systematic Observations Funding Facility, see page 009) are supported by another NMHS as a peer advisor in identifying the gaps in their transmission systems and implementing WIS 2.0.

The interest in WIS 2.0 implementation is very high among WMO members and the training sessions facilitate the initial experimental implementation of WIS 2.0 nodes, which are used to share real-time national observation data.

Consequently, in September this year, over 30 WIS 2.0 nodes shared data in real-time through WIS 2.0. The data from the WIS 2.0 nodes are shared by the global services that are already operational and provide the entry point to WIS 2.0 to user communities around the world. At the time of writing, seven countries are providing WIS 2.0 global services.

Entering the operational phase

As the pilot phase closes at the end of 2023, WIS 2.0 will enter the pre-operational phase. This will lead into the operational phase in early 2025, which is when WMO members will be required to migrate from GTS to WIS 2.0.

Once completed, members (and WMO-affiliated organisations) will have the option to switch off their GTS reception and transmission equipment. WMO will operate gateways bridging between GTS and WIS2 ensuring that data remains available to all WMO members throughout the transition period.

This process is expected to be fully completed by 2033, however the WMO aims to have 90% of members migrated to WIS 2.0 by 2030. For more information on WIS 2.0 please visit community.wmo.int/en/activity-areas/wis/wis2-implementation.

Authors: Dr Enrico Fucile, Head of the WMO's WIS Data and Information Management Division, Rémy Giraud of Météo France and Chair WMO Standing Committee on Information Management and Technology, Jeremy Tandy of the Met Office and vice-Chair WMO Standing Committee on Information Management and Technology, Tom Kralidis of Meteorological Service Canada and Chair WMO Expert Team on Metadata Standards, and Varysian's Senior Content Manager Keri Allan

WIS2 training session in Namibia

WIS2 in a box

WIS2 in a box (wis2box) was created to provide a reference implementation to verify WIS 2.0 architecture, but also to provide a low-cost solution for LDCs, small island developing states (SIDS) and developing countries.

wis2box is free, open-source software using open standards and can be readily deployed on-premise or in the cloud. The software is available at docs.wis2box.wis.wmo.int, along with user and reference guides, as well as community documentation.

Capacity Building | Hydromet Value Chain 02

Solid solutions

Leonardo's latest remote sensing solutions for the met community

Companies that create advanced radar and lidar systems for weather prediction face many difficult technical challenges when developing practical solutions that meet their customers' needs.

LEONARDO Germany GmbH's approach to creating effective solutions is built on three main pillars. These are: high-end radar and lidar products, cutting-edge algorithms and meeting customer requirements by tailoring customised solutions.

Weather surveillance systems enable users to monitor and predict atmospheric conditions. This process starts with the remote sensing sensors that gather the information for numerical weather prediction (NWP). Because of this, users need to have confidence in the accuracy of the data.

Remote sensors need to be versatile and capable of meeting a client's bespoke operational, technical and economic requirements. Solutions that meet all these high-performance needs will be complex, and therefore likely require a significant financial investment.

Today the most successful way forward for weather sensor manufacturers is to embrace open technology and follow a solution-oriented approach. World-leading weather solution providers like Leonardo have a presence all over the world, and this puts them in a great position to gather knowledge and understand the needs of various settings.

Leonardo's latest solutions

Leonardo has developed innovative remote sensing solutions that take advantage of artificial intelligence (AI), which led to the creation of its latest sustainable weather radar that uses cutting-edge solid-state technology.

This radar complements Leonardo's existing METEOR C-band product line, and is known as the METEOR 2000C. Alongside this, Leonardo offers the world's only high-performance lidar and has recently introduced new software algorithms to further enhance its solutions.

METEOR 2000C – Solid-state weather radar

The flexibility in design and performance of Leonardo's new solid-state weather radar METEOR 2000C enables the delivery of different transmitter power levels.

The recommended output power for the METEOR 2000C is 8kW (2x4 kW) or 16kW (2x8 kW); however, 4kW (2x2 kW) or 32kW (2x16 kW) can also be chosen. All power levels can be provided without any changes to the radar's basic design.

The existing C-Band METEOR product line enables upgrades to all types of transmitter power levels in the future.

In order to support sustainability while enabling the meteorological community to benefit from Leonardo's latest product developments, previously delivered systems are designed to be easily upgradable to solid state.

METEOR 2000C solid-state weather radar system

SKIRON3D lidar in combination with a Leonardo X-Band weather radar

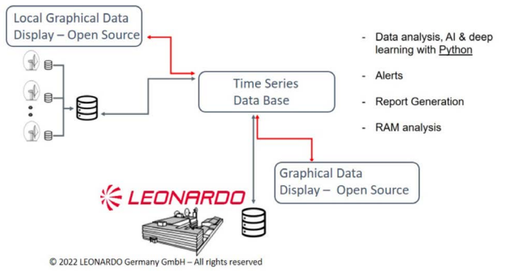


Figure 1: Leonardo International Data Centre

SKIRON3D – High-end lidar system

Complementary to a weather radar is a lidar for clear-air detection (in the absence of any precipitation or even fog) of atmospheric hazards.

To make sure operations are fast and timely, the design aims were simple: do as much as possible more quickly, and up to a high maximum range. The lidar's performance is determined by its figure of merit (FOM). In the case of the SKIRON3D, its FOM is high at 120mJ*sqrt(Hz).

The figure of merit is the most important parameter and the quality of different systems should be measured by this number. The FOM is directly related to the lidar detectability and as such determines the maximum operational range at a certain integration time, i.e. scanning speed.

The maximum operational range of any heterodyne Doppler lidar is dependent on the state of the atmosphere and therefore cannot be part of a rigorous technical specification.

Leonardo chose to use four independent wavelength channels to achieve the SKIRON3D's high FOM, achieving an effective PRF of typically 18kHz, while the unambiguous range corresponds to only 4.5kHz and is therefore 33.3km.

SKIRON3D supports PPI generation in about 30 seconds, so windshear warnings can be provided once a minute as well as a full volume scan every five minutes. This provides a complete picture of the surrounding atmosphere, even with special scans including RHI for explicit monitoring in one direction (e.g. glide paths).

The modular design of the SKIRON3D allows for easy maintenance and a quick exchange of any modules or line replaceable units. The high reliability and uncomplicated maintenance in combination with the offered performance secures SKIRON3D the pole position in the lidar sector.

AI: the new standard for remote sensing data quality

Leonardo uses machine-learning techniques to enhance the monitoring of operational data quality.

The new Leonardo data centre approach strives for the transformation from a sensor system service view to a solution-oriented service view.

This new and unique Leonardo concept brings together the full potential of new technologies and insights from user experiences. It introduces novel approaches to asset performance management (APM) and forms a strong foundation for automation of failure management.

The International Data Center for Quality Assurance at Leonardo aims to create a centralised framework for operational data quality surveillance as a service. To achieve this, it will assess and analyse representative operational parameters from sensors, data processing components or even complete Leonardo solutions.

All of these components generate a substantial amount of hardware and software monitoring data. Currently, this data is used for real-time system monitoring, historical issue checks ranging from a month to a year, sub-systems performance checks, calibration and adjustments, debugging and reporting.

This data assists engineers and customers in assessing system status and deriving further operational statistics.

AI: The new standard for innovative data processing

The placement of 3D scanning remote sensors requires suitable spots with unobstructed views from all angles. But in places like airports, mountains and cities, it's often not feasible, so there are trade-offs to make.

These compromises usually lead to areas where data can't be collected, causing gaps in measurements. This issue becomes more pronounced when two devices, like a radar and lidar combination need to be set up close to each other for an all-weather windshear system. In these scenarios, blockages are unavoidable.

Leonardo's software uses machine learning to address challenges in sensor placement using advanced computational techniques.

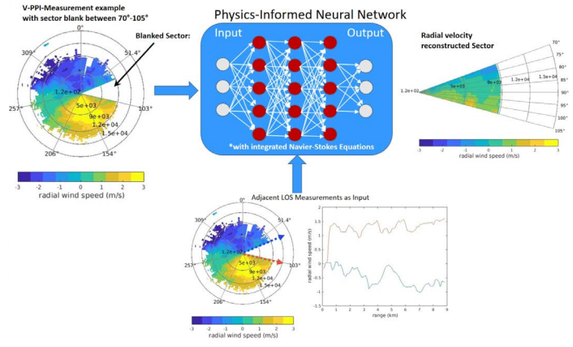


Figure 2: Sector blanking reconstruction of radial velocity using physic-informed neural networks and 3D scanning remote sensing sensor

Physics-informed neural networks (PINN) are used to fill in the missing areas of radial velocity PPIs measured by radar or lidar. The neural network is trained to approximate a solution based on the Navier-Stokes equation, where the measurements from adjacent lines of sight (LOS) act as the boundary conditions.

PINN can also be used to extend the operational range of the Doppler lidar. By measuring only at sparse azimuth angles 'spoke scan', the accumulation time per LOS can be increased while the total PPI measurement time remains the same. PINN is then used to fill in the gaps between these sparse measurements, creating a complete PPI with an extended range.

An example of a PPI with range extension provided here (Figure 3, middle) demonstrates that the range can be extended to 25km while maintaining the total recording time of 30 seconds as for the reference PPI scan (Figure 3, right) featuring only a maximum range of approximately 12km.

Outlook

Leonardo offers a collection of powerful remote sensing sensors that use the latest advanced technology. These sensors work together with software modules that include AI algorithms.

This combination ensures that Leonardo's success story will continue, and customers will receive the solid, customised solutions they require.

Authors: Dr Christina Stanzel and Dr René Grasselt, Sales Managers and Senior Aviation MET Experts at Leonardo

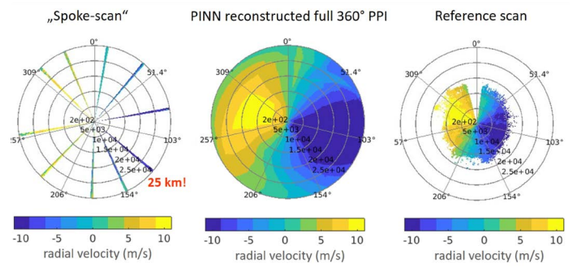
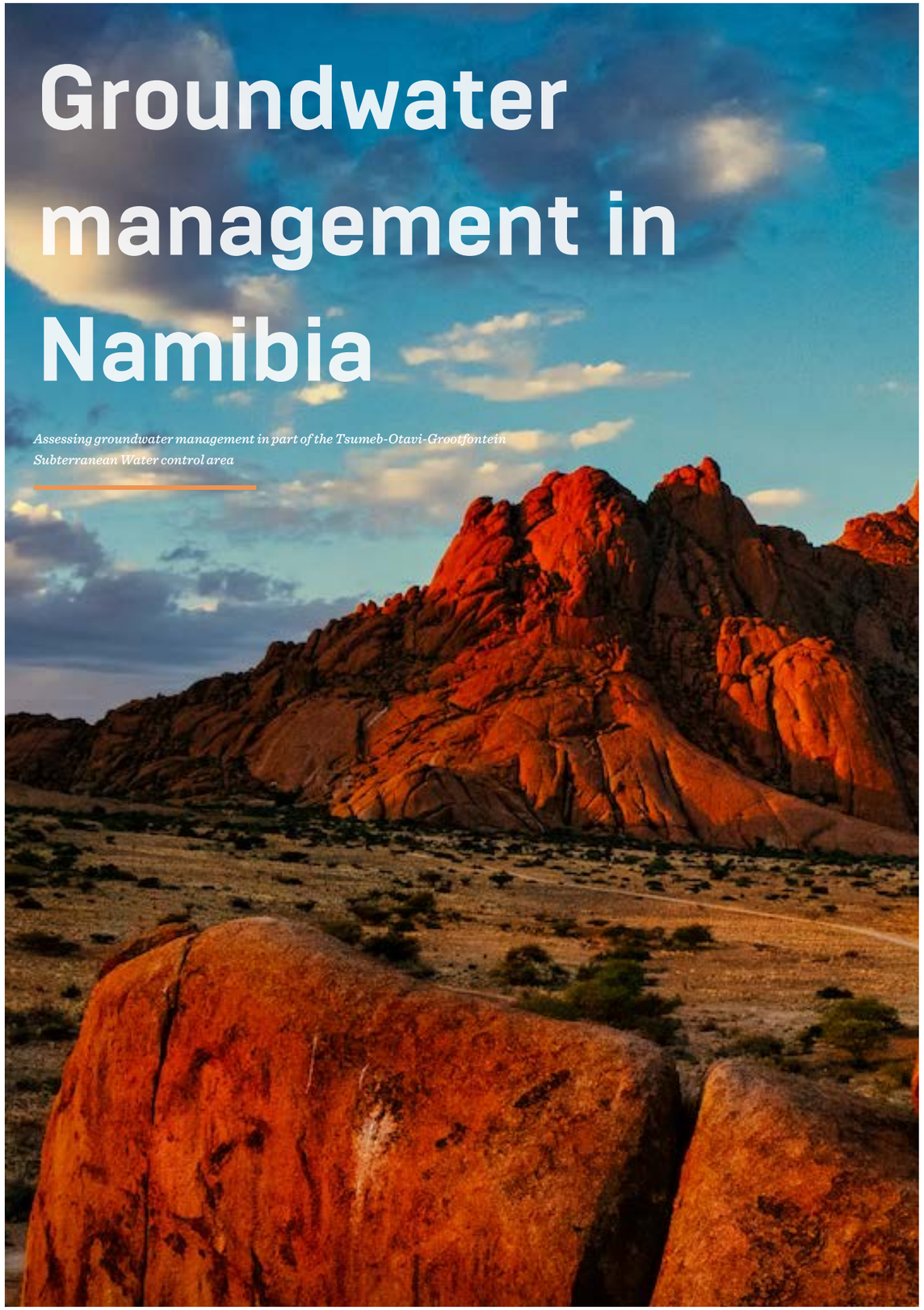


Figure 3: Left: Range extension scan, middle: PINN reconstructed full 360° PPI, right: reference scan



Groundwater management in Namibia

Assessing groundwater management in part of the Tsumeb-Otavi-Grootfontein Subterranean Water control area

Namibia's reliance on groundwater across most parts of the country prompted the government to delineate water control areas and regulate the long-term sustainable abstraction amount. However, regular groundwater balance is lacking.

The B2 water control sub-region was recommended in 2004 to abstract a maximum of 6.2 Mm3/a (million cubic metres per year) for irrigation, and is currently licensed to abstract 10.9 Mm³/a. To assess the groundwater management of the B2 sub-region, this study focused on its recharge amount and groundwater abstraction for irrigation purposes and covers the 2008–2015 period where the Department of Water Affairs (DWA) had sufficient, requisite data.

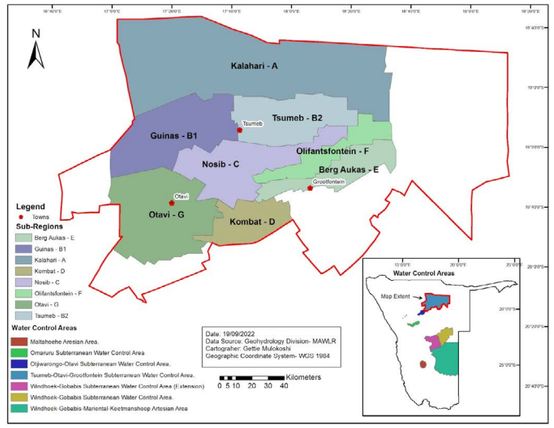


Figure 1: Water control areas and the TOG sub-regions

The water table fluctuation (WTF) method was employed, which requires specific yield (Sy) and water level to estimate the recharge. Groundwater abstraction volumes were obtained from 44 compliant irrigation farmers, while the groundwater level was derived from 22 monitoring boreholes.

The Sy values were obtained from literature, with the Sy for dolomite obtained from literature carried out in the study area. However, the Sy value for calcrete within the study area could not be obtained. Instead, it was taken from similar hydrogeological settings outside the study area.

Hydrogeology

Three aquifer types occur within the study area. The dolomite aquifer consists of fractured rock of low primary porosity and is directly recharged from rainfall in the area. The permeability of the dolomite aquifer is locally enhanced due to intense fracturing and karstification, especially at contact and tectonic shear zones with yields exceeding 100 m3/h.

The calcrete aquifer is unconsolidated, porous and may often be compacted, fractured and locally karstified due to the abundance of calcareous cementing material. It is a moderate potential with yields typically ranging from 5 to 30 m3/h.

The quartzite aquifer is a minor aquifer which is regionally considered as aquitard due to its overall low permeability.

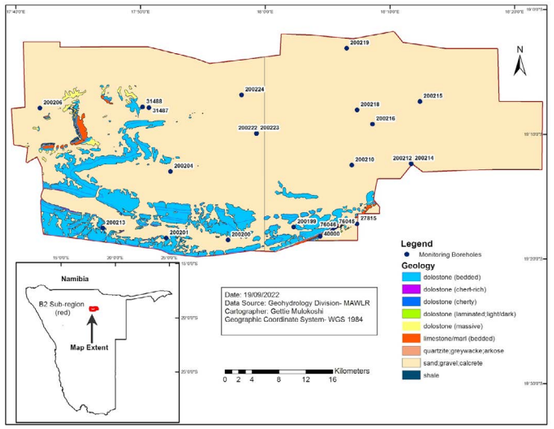


Figure 2: Location of the 22 monitoring boreholes and the geology of the study area

Results

Recharge values of the 22 monitoring boreholes were spatially interpolated for each year using ArcGIS-10.0. The results indicate that the recharge was highest in the calcrete, with an average of 82mm/a and 8.2mm/a using the Sy value of 0.05 and 0.005 respectively, and lowest in the dolomite, with an average recharge of 0.88 mm/a with Sy value of 0.0005.

The highest recharge was recorded in 2012, following the wettest 2011 during the study period. The lowest was in 2013; the second driest year. The overall average recharge from the two recharge maps created was 8.3Mm3 and 81Mm3.

Rainfall, abstraction and recharge

This annual average abstraction is comparable to the recommended amount, but nearly half the licensed abstraction long-term volume. Additional recharge may be from irrigation return flow and groundwater inflow from adjacent sub-aquifers.

High variation in recharge values within the calcrete is attributed to the literature-based Sy values, which points to the need for empirical value to ensure a robust groundwater

monitoring framework for sustainable use in the study area. The average abstraction was 5.3Mm3 for the 2008–2015 period in the study area.

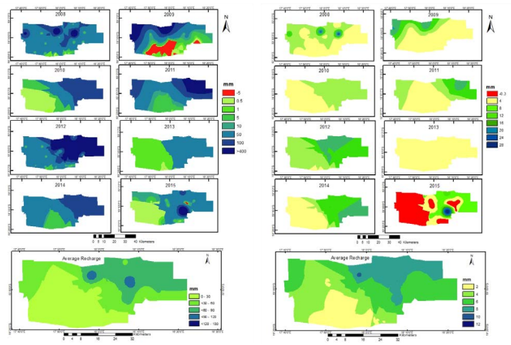


Figure 3 Left: Spatial and temporal distribution of recharge based on the WTF method employing the Sy value of 0.05 for 2008 to 2015 and the average recharge. Right: Spatial and temporal distribution of recharge based on the WTF method employing the Sy value of 0.005 for 2008 to 2015 and the average recharge

The results show that the highest rainfall occurred in 2011, of which the entire B2 sub-region received more than 600mm rainfall (see figure 3 – right).

The average rainfall was between 450 and 550mm during the study period and the years 2009 and 2012 also received above average rainfall.

The lowest rainfall occurred in 2015, ranging between 200 and 300mm.

Conclusion

Although meaningful results were obtained, especially for the dolomite aquifer, the present study is not without limitations, which must be addressed in future research.

First, the Sy value allocated for the calcrete aquifer appears to cause resultant high recharge values and should be used with caution.

Over the study period, the abstraction for irrigation has been increasing yearly and there is no evidence of overexploitation from the recharge.

Results from the water balance show that the difference between recharge and abstraction is 2.9Mm3 and 75.7Mm3, resulting in an overall positive groundwater balance with a considerable difference between recharge and abstraction.

However, for the conservative recharge the recharge is directly caused by rainfall, and in years of low rainfall, abstraction exceeds recharge.

The groundwater abstraction for irrigation is clearly below the recharge of the entire study area. Although the 10.9 Mm3 licensed abstraction for the B2 sub-region may appear to be a conservative figure, more research is required to confidently confirm this hypothesis.

It is observed that during dry years the abstraction for irrigation is high, which is mainly due to the prolonged irrigation period that extends into the dry rainfall months.

Provided that no groundwater abstraction for mining activities is presently taking place, some of the previously abstracted volumes of water for the mines may still be available for irrigation, as the water eventually flows out of the system.

Recommendations

Future studies may employ an improved recharge assessment for the calcrete aquifer, using a different method and new reliable Sy values.

However, it is worth noting that the three aquifers should be treated separately, as the recharge values are highly variable between them. Further research is required, which was beyond the scope of this study.

Efforts to encourage long-term monitoring for irrigation abstraction need to be focused on and improved. Government should introduce a hybrid of remote sensing (estimating irrigated areas) and in situ groundwater abstractions to accurately estimate groundwater abstractions from both registered compliant irrigation farmers and non-registered non-compliant farmers.

Should a negative trend in rainfall be visible, it is indicative that there will be a resultant reduction in recharge, and thus the amount of groundwater abstracted will have to be minimised and no new permits should be issued.

Namibia's DWA should instigate campaigns to share knowledge on the importance of compliance for irrigation farmers.

Authors: Hydrogeologist at the Ministry of Agriculture, Water and Land Reform for Namibia Gettie Mulokoshi, Lecturer at the University of Namibia Martin Hipondoka PhD, and Lecturer at the University of The West of England (UWE) UK Heike Wanke PhD

Tackling today's climate change needs local to national-scale GIS solutions

ArcGIS offers a way to derive powerful intelligence to tackle today's biggest problems

Climate change is one of the most pressing challenges in the 21st century. It's linked to intensifying global temperatures, sea level rise, disruption of ecosystems and extreme weather events like hurricanes, droughts, floods, wildfires and storms. Such events can cause devastating, far-reaching impacts on the environment, the economy and society, and demand urgent action on both global and local scales.

We're increasingly seeing the effects of climate change at the local level these days. I didn't grow up with floods, extreme heat, drought or frequent and intense wildfires. Yet in the three months prior to writing this article, my childhood neighbourhood in Nova Scotia, Canada, witnessed extreme heat and wildfires due to drought, despite being in a mid-temperate zone with constant rain and fog. The community subsequently saw extreme flooding.

According to a risk assessment from the Nova Scotia Department of Environment and Climate Change, the province faces an increased risk of floods, wildfires and crop-killing intense heat because of climate change.

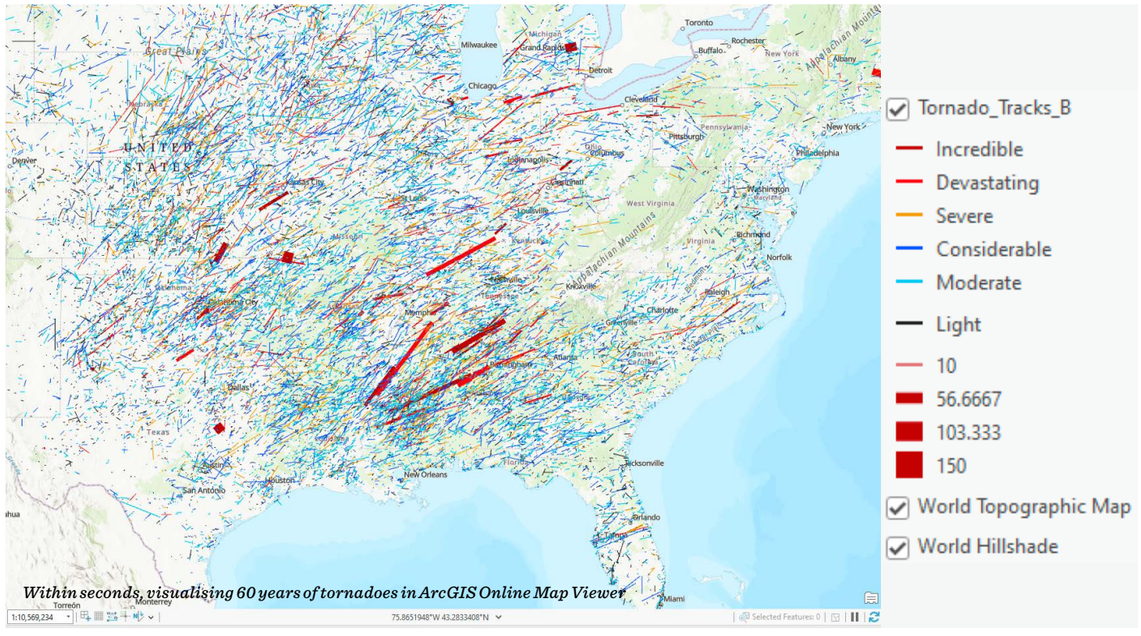
The assessment indicates that warmer temperatures extend the growing season and bring greater potential for drought and floods. Like those in Nova Scotia, many people across the globe can speak about climate change's impacts wreaking havoc in their neighbourhoods, causing significant economic losses. Understanding the world around us is key to addressing climate change.

The ability to understand climate change with GIS

Geographic information system (GIS) powerful spatial analysis tools add geographic context to weather and climate data, making it easier to identify patterns, trends and anomalies that may not be apparent in traditional tabular or textual formats.

When data like temperature change, sea level rise, extreme weather, deforestation and urbanisation information is visualised on maps and in three dimensions, we can better understand climate trends and regions often exposed to extreme hazards.

With ArcGIS from Esri, meteorologists and climate scientists can apply artificial intelligence and machine learning (AI/ML) techniques. These accelerate scientific analysis, climate predictions and environmental change monitoring, while adding real-time dynamic and animated maps and portals increases collaboration, understanding and our ability to identify potential risks.



Within seconds, visualising 60 years of tornadoes in ArcGIS Online Map Viewer

By understanding vulnerability and at-risk regions, we can make better-informed decisions, enhance preparedness and mitigate the adverse effects of extreme weather events. GIS helps expand our understanding by visually communicating ideas to everyone, from to the project manager to the public.

GIS technology for creating a common ground

ArcGIS collaborative features encourage community engagement and collaboration in addressing climate change challenges. ArcGIS software provides a means for communities to contribute geospatial data, observations and local knowledge that enhance the accuracy and relevance of analyses. For instance, tracking water usage, forestry and agriculture trends can lead to sustainable practices that help mitigate climate change.

With the ability to easily create web-based applications and dashboards to disseminate weather and climate information, display real-time data and engage with the community, more transparent, accessible and effective communication is a reality. By providing accessible, user-friendly maps and data, local governments can engage the public in decision-making processes in climate action.

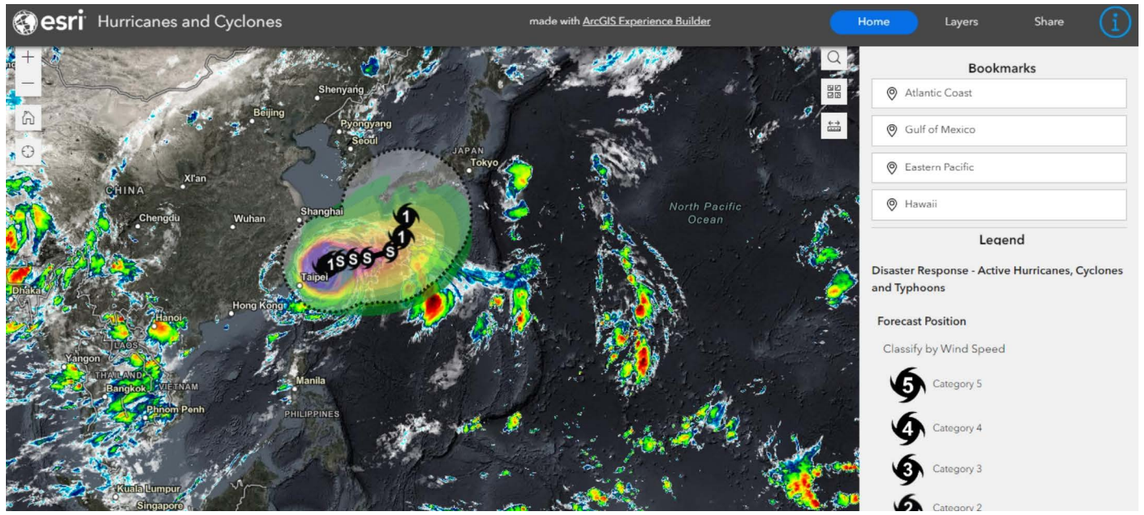
Weather forecasting and warning systems for building resilient communities

GIS is used extensively in weather forecasting and warning systems. Meteorologists can create predictive models for various environmental factors by integrating real-time data with historical weather records. GIS aids in identifying patterns, analysing trends and predicting the trajectory of weather systems – crucial information for issuing timely warnings, preparing emergency response plans and mitigating the impact of severe weather events.

Weather warnings and watches issued by regional and national authorities are the primary means of communicating the risk of severe weather to the public. Operationally, this communication requires cross-agency collaboration and coordination, which are made easier with cloud-based GIS technology such as ArcGIS Online.

GIS technology improves the accuracy of weather hazard warnings and enhances communication between forecasters and the public through an open and extensible built-in collaborative framework. It facilitates the delivery of briefings during dynamic situations with current live streaming capabilities and virtual chat functionality to allow agile, tactical decision-making for enhanced hazard mitigation and resource deployment.

Agencies and organisations are moving toward dynamic, digital versions of their briefings. New tools and workflows and broader data access provide insights into weather patterns, forecasts and predictions faster and of higher quality than ever. Apps like the Daily Operations Weather Briefing Portfolio, built on ArcGIS Online technology, provide a robust way to deliver briefings and reach the public.



GIS helps manage hurricane or cyclone response with live feeds and sensor data through the Esri Disaster Response Program

Emergency response and disaster management

GIS is invaluable in emergency response and disaster management scenarios. When a hazard like a wildfire occurs, GIS can assist in predicting its paths and impacts. Meteorologists can generate risk assessments and develop evacuation plans by integrating real-time weather data with topographic maps, population density data and critical infrastructure locations. GIS helps predict storm paths, identify evacuation routes, locate emergency shelters and assess the potential impact on affected areas.

GIS also aids in post-event analysis by visualising the extent of damage and helping prioritise recovery efforts.

Climate change solutions at all scales

As climate change transcends geographic boundaries, GIS technology enables the creation of effective climate change solutions and strategies everywhere, from entire nations to small communities. GIS solutions empower governments, organisations and communities to address climate change proactively by promoting sustainability and encouraging agency and organisation collaboration at the national scale – and community engagement at the local scale.

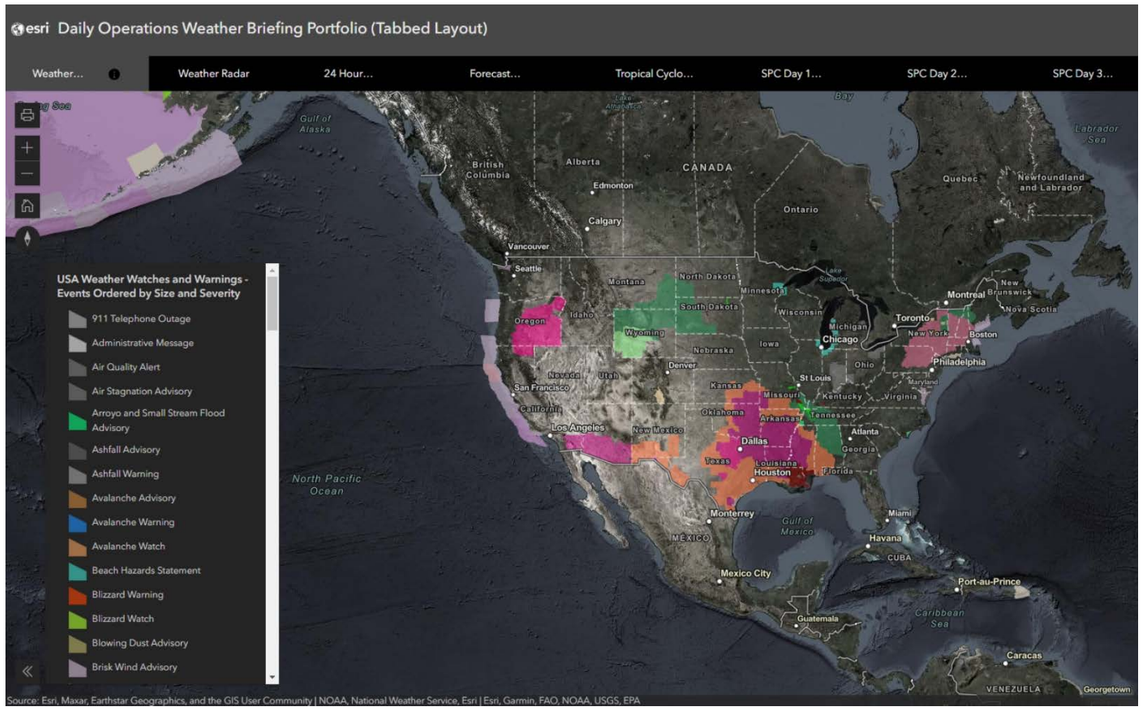
Local-scale GIS solutions

At the local level, GIS plays a crucial role in assessing communities' specific vulnerabilities and risks due to climate change.

Incorporating scientific data helps people better understand what's happening with the changing climate locally. Local communities can use GIS to monitor and manage resources efficiently.

National-scale GIS solutions

Addressing climate change at the national scale is advanced by geospatial data portals incorporating geography and technology. National agencies and organisations are turning to GIS portals to bring together everyone's data, tools and apps to help better understand climate change's complexities and empower residents, scientists, policymakers and program leaders with insight.



The Daily Operations Weather Briefing Portfolio app is part of the ArcGIS Instant Apps collection in ArcGIS Online. The app contains a series of national weather service maps with live information feeds for situational awareness

These portals generate opportunities for knowledge advancement, interdisciplinary cooperation and information sharing. Integrating real-time data on key climate issues – including wildfire, flooding, drought, heat and coastal resilience – with GIS generates one central data location to create visualisations and understanding accessible to all societal tiers.

The CMRA portal

Climate-related hazards are affecting US communities every day. The United States national government embarked on a mission to create the Climate Mapping for Resilience and Adaptation (CMRA) portal.

Built on ArcGIS Hub technology, this integrates authoritative data from multiple agencies and organisations to help local and national governments see their exposure to climate-related hazards.

The CRMA portal allows anyone to view real-time statistics and maps documenting where people, property and infrastructure experience hazards like wildfire, drought, inland and coastal flooding and extreme heat.

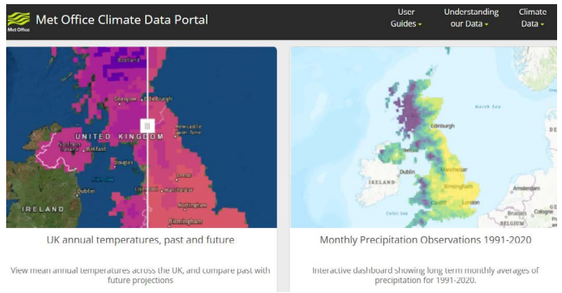
The portal brings together cities, counties, states and tribes to make better decisions. Knowing which hazards could harm the things you care about is the first step in protecting them.

The CMRA portal is one example of how the national government helps its people understand what climate-related hazards they may face, now and in the future.

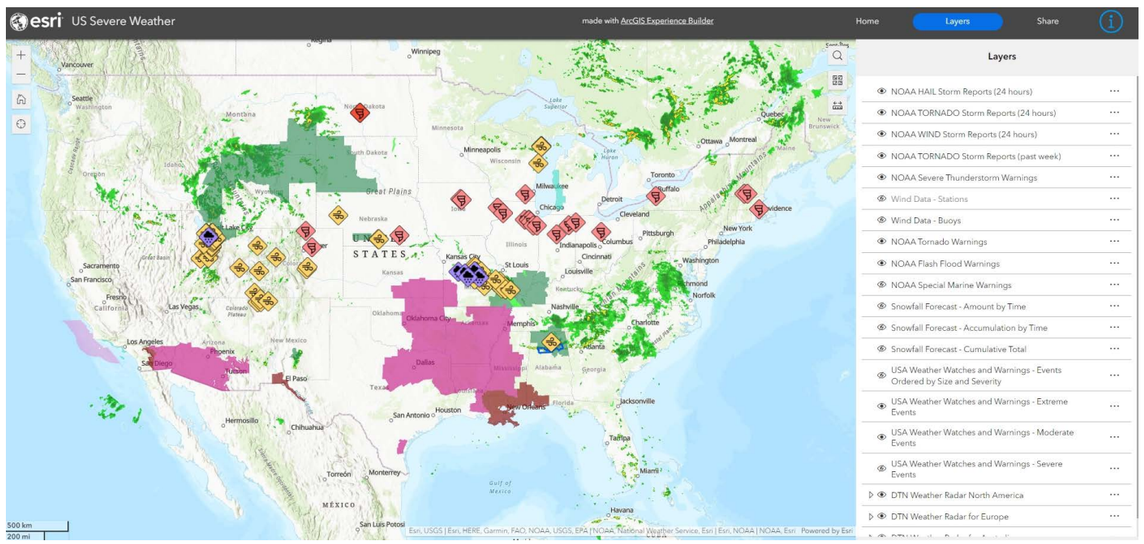
The Met Office national climate data portal

The UK Met Office, the United Kingdom's national weather service, has a significant role in monitoring and understanding climate patterns and changes and providing weather and climate-related information and services.

Like the National Oceanic and Atmospheric Administration (NOAA) in America, the UK Met Office has a climate portal built on GIS technology. It too offers climate-related data, reports and services.



UK Met Office climate data portal, built on ArcGIS technology



The US Severe Weather public information map lets you manage your organisation's severe weather response with live feeds and sensor data for tornados, hailstorms, windstorms, winter storms and severe thunderstorms

The portal lets users explore and download historical and projected precipitation, temperature, sea level observation and socioeconomic data. Users can access apps, examples of climate data in action and various resources like work on climate change completed by ArcGIS users.

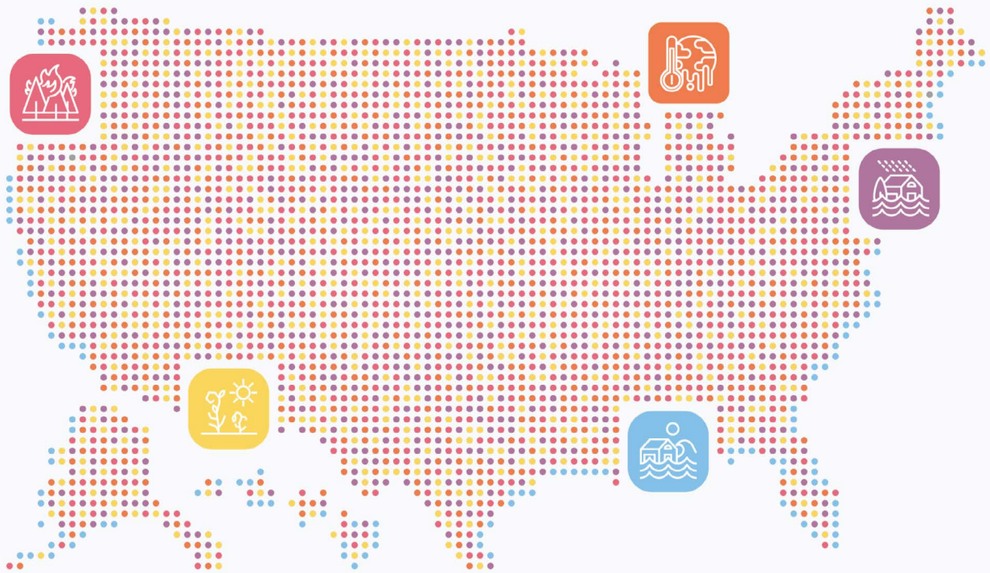
Similarly, the UK Met Office dashboard brings together data from respected institutes and research groups worldwide to provide a complete picture of what's happening regarding climate. The portal and resources allow users to help develop science-based services that enable the most effective approach to managing climate risk.

User-driven solutions—business and technology

ArcGIS solutions align with users' needs to optimise workflows that help make data-driven decisions. The solutions leverage authoritative data to improve operations, provide new insight and enhance services in government, utility, defence, public safety and telecommunications organisations. User-driven ArcGIS solutions' Weather Operational Effects and Flood Impact Analysis configurations are two examples benefiting weather and climate-based applications.

The Weather Operational Effects solution helps defence organisations understand weather conditions within an area of responsibility, analyse its potential effect on operations and share information among staff and leadership. Built on ArcGIS technology, Weather Operational Effects provides maps, a data structure and step-by-step instructions that help expand unit intelligence capabilities. Intelligence staff use an ArcGIS Pro project to compile weather data for an area of responsibility and analyse it for specific operations.

The project applies doctrinal operational thresholds against weather forecast data to determine the favourable, marginal, or unfavourable weather conditions for specific types of operations and equipment. With the resultant tactical decision aids, charts, dashboards and overlays, planners and leaders can see weather effects over space and time, maximising operational effectiveness and reducing operational risk.



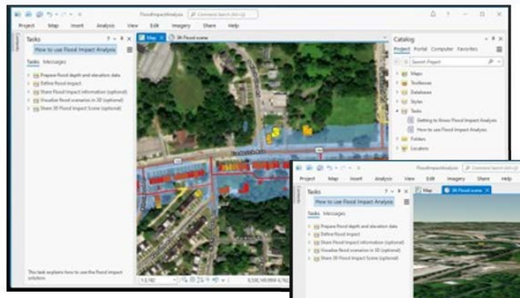
In partnership with the US' National Oceanic and Atmospheric Administration (NOAA), Esri built the Climate Mapping for Resilience and Adaptation (CMRA) portal on ArcGIS Hub technology

Users of the Flood Impact Analysis solution can analyse the impact of flooding on critical infrastructure and share flood impact maps with internal and external stakeholders.

When heavy rains or storm surges descend on a community, rich geospatial data (such as flood depth, ground elevation and public asset information) and spatial analysis help staff understand the impact of flooding and produce a series of flood impact maps.

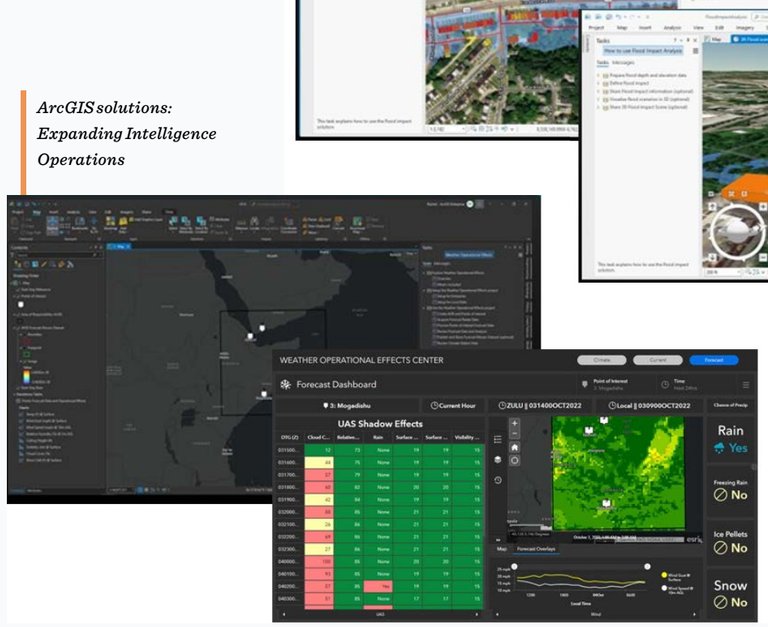
These maps help communicate the extent of flooding events and provide government officials and the public with valuable information about the affected areas and the potential risks and hazards. They also help emergency management agencies develop mitigation strategies, plan road closures and prioritise evacuation areas.

Any delays in producing flood impact maps could affect a community's emergency response plans and reduce its resiliency to flooding events. Geographic information system (GIS) analysts use the Flood Impact Analysis solution to investigate the impact of flooding on critical infrastructure.



GIS technology is advancing climate risk and resiliency understanding as our changing climate continues to deliver a wide range of costly impacts

ArcGIS solutions: Expanding Intelligence Operations



Flood Impact Analysis Visualisation

Author: Dr Lorraine Tighe, Director of Earth Sciences Solutions, Esri

Participatory Integrated Climate Services for Agriculture (PICSA)

Climate services for farmers in Latin America and the Caribbean

Participatory Integrated Climate Services for Agriculture (PICSA) is an agricultural extension and climate services approach that supports farmers in making plans and decisions tailored to each farmer's own 'context' in their production systems.

It is implemented by facilitators (e.g., extension officers, non-governmental organisation field staff, community volunteers and researchers) through a series of meetings with groups of farmers. Rather than focusing on the delivery of information, PICSA integrates information with decision-making tools: resource allocation maps, agroclimatic calendars, crop, livestock and livelihood option matrices and participatory budgets.

The underlying principles

PICSA was developed at the University of Reading and is built around the following two principles:

1. **The farmer decides:** using a set of participatory tools designed to help farmers identify, plan and make their own choices that are most suitable for their specific needs and circumstances.
2. **Options by context:** recognising that each farmer operates within their unique biophysical and socioeconomic context, and as a result, different options will be appropriate for different situations.

Scale and reach of PICSA

PICSA has experienced a surge of interest and demand from governments as well as regional and nongovernmental organisations.

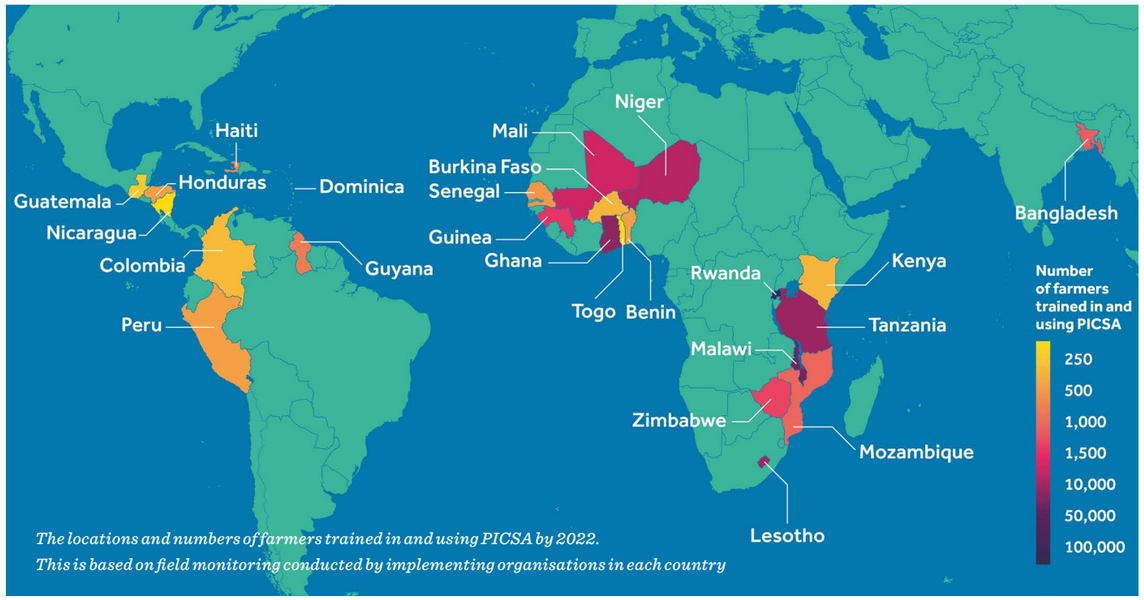
As a result, since 2015 it has been implemented in at least 30 countries worldwide and benefited hundreds of thousands of households.

PICSA in Latin America and the Caribbean (LAC)

PICSA is an innovative approach that challenges the traditional top-down information /technology-transfer methods that currently limit farmers' participation in the region.

In 2017, PICSA was piloted in Colombia, followed by Nicaragua in 2018. This provided the opportunity to test, learn, reflect, contextualise and adjust the range of participatory tools to add innovative adaptations, such as dream maps.

Today, several organisations/projects have been promoting the implementation of PICSA across LAC since their first pilot. The International Center for Tropical Agriculture (CIAT) implemented PICSA through the Climate Change, Agriculture, and Food Security (CCAFS) program and World Food Programme (WFP); (ii) The Caribbean Institute for Meteorology and Hydrology (CIMH) through projects funded by USAID, UNDP and recently under the CLIMSA project by European Union; (iii) University of Florida through USAID; and (iv) the National Meteorology and Hydrology Service of Peru through the ENANDES project.



The locations and numbers of farmers trained in and using PICSA by 2022. This is based on field monitoring conducted by implementing organisations in each country

PICSA plays a crucial role in advancing farmer climate risk management and adaptation in the LAC.

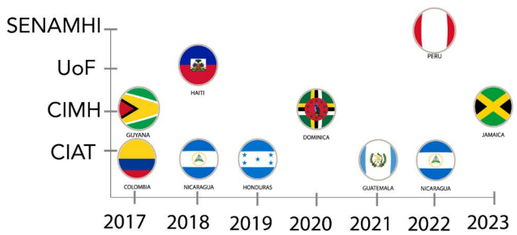


Figure 2: Organisations that have been involved in promoting the implementation of PICSA across the LAC region

Effects of PICSA for farmers

PICSA implementations have had positive effects for farmers, significantly impacting their decision-making and livelihoods. It has been shown that enhanced participation of farmers and institutions makes a substantial difference in the use of climate information, creating effective climate services. For example, 73% of the farmers in Honduras expressed that PICSA was key to the success of their harvest despite the challenging 2019 season.

"Thanks to PICSA, I implemented poultry farming and bought a pig to raise and sell to improve food security and household income. I feed them with homemade concentrate. The income generated by the pig will be for my son's graduation and studies expenses." -Honduras farmer

"I observed an increase in yield in my cabbage crops, which helped in the availability of food and income in my household. My farm produce was also sold locally, throughout my community." -Dominica farmer

"After growing a new variety of maize that matured faster, I earned enough to buy some pepper seeds to grow for home consumption. Also, my wife started selling small commodities through petty trading, and our children had some pocket money to buy food before school" -Haiti farmer

As a result of PICSA engagement, most farmers made changes in their crops and livestock, which had effects on their food security and income. Particularly in LAC, farmers changed the crop they grew, adjusted crop and land management practices, altered planting dates, modified inputs and experimented with different crop varieties.

Effective climate services for farmers

PICSA has demonstrated not only that literacy challenges can be overcome through discussion and training, but also that farmers appreciated the bottom-up, participatory approach. This has enabled them to be at the centre of the decision-making process. The process has successfully brought together meteorological services, government, extension and academia alongside other actors to support farmers in the innovation system.

Scaling up the PICSA approach by adapting it to local knowledge contexts requires time and investment in the capacity development of staff in relevant institutions. However, once integrated, it can fit within the operations of existing structures. Notably, the inclusion of the PICSA approach within the Climate Resilience Plan of the national bean chain in Honduras and the exploration of gender dynamics in the rural sector of Guatemala demonstrate the approaches' potential to be integrated into existing systems/initiatives.

The PICSA approach can be a part of a broader transformation of the institutional, knowledge and innovation networks in the region. Transforming climate services to better account for why and how farmers make relevant decisions could herald a new era in climate action for agriculture, with significant implications for future adaptations in Latin America and the Caribbean. It would also contribute to building capacity and expertise in local communities, empowering them to manage their resources and implement measures for climate adaptation in a systematic and effective manner.

Authors: Research Fellow Diana Giraldo[1] and [2], Senior Research Fellow Graham Clarkson[1] and Professor Peter Dorward[1].

[1] University of Reading, School of Agriculture, Policy and Development, United Kingdom.
[2] International Center for Tropical Agriculture (CIAT), Cali, Colombia.

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Transmitting accurate intelligence

Choosing the right radar

Radar is the most effective tool for assessing meteorological conditions and providing superior intelligence to those affected by weather's impact on a local area. Yet choosing the best radar for an entity's needs is no easy feat. Some key elements must be carefully considered during the decision-making process.

Baron high-precision radars are available in multiple configurations so that every organisation can find the best solution

Choose the right transmitter

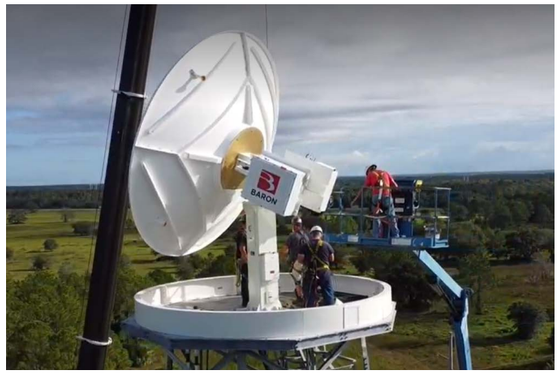
Selecting a transmitter is undoubtedly a critical decision. While three types of transmitters are typically used in weather radar design, Baron highly recommends choosing a magnetron or klystron transmitter. Klystrons and magnetrons are large vacuum tubes that amplify the radio frequency signal for high-performance radar systems to provide unparalleled resolution and efficiency. Both transmitters are well-known for signal stability, which helps remove data contamination like ground clutter, buildings and cellular towers from the display.

Keep calibration in mind

The radar must be calibrated regularly for peak operational capacity and reliability. Baron was the first to develop auto-calibration technology and multi-radial ZDR calibration, setting an even higher standard for radar accuracy. This patented, ground-breaking technology solves several calibration and operational challenges, even in fast-changing meteorological environments.

Baron's auto-calibration checks numerous parameters with every volume scan. The calibration interval can be selected by the user as frequently as desired. Even when operating in adverse environments, the hardware can correct for temperature-related drift – particularly useful for daily (diurnal) temperature fluctuations. This keeps Baron Gen3 radar systems reliable, accurate and easier to operate and maintain.

Baron's multi-radial calibration is automatically calculated with each sweep, more than 300 times per hour, thus eliminating the need for human intervention to keep radar differential reflectivity precise. That means constant accuracy, less downtime and less money spent on upkeep.



Every Baron radar system is built to the highest accuracy, precision and durability standards. Baron radars come standard with exclusive calibration and clutter suppression technology

Deliberate the location

The climate must be considered when choosing suitable radar and equipment. For example, if the area experiences flooding, the de facto standard in flooding conditions is a magnetron or klystron radar. These transmitters, which excel during any type of weather event, can accurately detect features like heavy rain, hail cores, tornadic signatures and wintery precipitation.

Contemplate a financial cushion

Several considerations must be deliberated when budgeting for a weather radar system. When choosing a radar, ensure enough capital is budgeted to purchase the radar and, more importantly, to maintain the equipment.

Best practice is to ensure there's enough funding upfront if considered a capital expense or to have funds allocated for suitable spare parts in the future.

Baron recommends that a customer has a budget to maintain the radar for the first five years. The annual operating costs can be between 5-10% of the radar's purchase during the system's lifetime. Remember to account for infrastructure, maintenance and monitoring needs when making this purchase to avoid the frustration of not being able to reap the full benefits of the radar.

Consider long-term upkeep

When it comes to radar maintenance, Baron recommends that entities plan preventative checks at least once or twice a year. Providing proactive inspections and maintenance can be planned around weather events and minimise the risk of downtime when hazardous weather emerges.

This maintenance can be conducted to check transmitter power and ensure internal power systems as well as pedestal drivetrain are working at peak performance. The tower's infrastructure should also be inspected, and the radome should be examined for possible cracks or punctures.

It's important to consider the maintenance of all the moving parts when purchasing. All radars are generally built with the same functioning parts regardless of transmitter type. Baron has engineered the motors and gears in the pedestal, which rotate and change the elevation of the radar to reduce maintenance. The bearings and gears are integrated into a single sealed unit which does not require annual greasing. There are fewer maintenance consumables, less waste and less manpower.

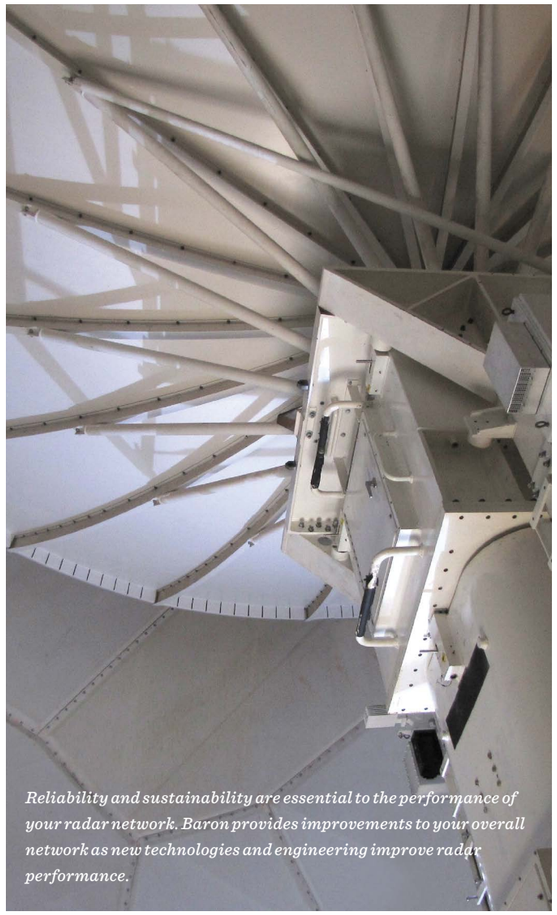
The C-Band magnetron tubes typically last 8-12 years. S-Band magnetron tubes typically last 10-15 years and klystron tubes can last 15-20 years.

Timely evacuation of at-risk communities with a high possibility of flooding is critical to reducing the loss of lives and property. Baron radars can help entities detect areas and people in danger quickly and more effectively

Magnetron tubes can be easily switched by a technician in about 30 minutes. Because magnetron tubes can be easily rebuilt by replacing the cathode structure, the old tube can also be rebuilt if desired to reduce waste and cost.

Baron works with customers to help determine the best path for extending equipment life based on needs and budget. Support is a crucial element in ensuring maximum operational success.

Lastly, purchasers should consider the computer requirements. Baron has reduced the number of computers and transitioned to a high-performance computer with multiple virtual machines to increase performance, reduce computing power consumption and future electronic waste.



Reliability and sustainability are essential to the performance of your radar network. Baron provides improvements to your overall network as new technologies and engineering improve radar performance.

This equipment will wear down or need to be oiled or replaced. No matter the brand, every radar has some electronic and mechanical parts that are subject to wear. And, if spare parts are purchased ahead of time, a repair doesn't take as long as if the entity must order the part as some of these may have long lead times.

Request a warranty

Baron suggests securing a warranty for at least three to five years. This covers the equipment with the highest wear and tear such as motors, and other components that make up the radar. Baron can also offer a configurable warranty based on customer needs.

A magnetron or klystron transmitter, the most expensive radar component, rarely requires repairs, and most last up to 20 years.

Think through tenders

Certain aspects get overlooked repeatedly in tenders (see page 081). For example, a tender might reveal that an entity wants multiple radars and a one-year warranty but won't ask for extra parts or a more extended warranty. Sometimes there's also no consideration for the ongoing cost of maintenance. Remember that a one-year warranty isn't sufficient since that radar will likely be operational for at least 20-25 years.

Baron also recommends consulting with manufacturers to ensure sustainability has been built into the tender—no matter the desired radar. Baron is available for aiding organisations in evaluating and identifying their radar needs.

Don't forget numerical weather prediction

Radar data combined with numerical weather prediction means improved short-term local modelling accuracy when early warning systems are most critical. Baron Weather acts as a client's modelling partner and can provide a three-kilometre model for a specific region or area processed on a local computing device or at Baron.

The assimilation of radar data into high-resolution models delivers improved model performance and more accurate forecast predictions.

Baron's advanced high-resolution models generate precision forecasts tailored to an operational area's unique weather dynamics. Baron also offers several options for managing local atmospheric or hydrological models, thus enabling clients to monitor weather situations or prepare alerts and notifications to mitigate risk.

Insights into rainfall accumulations, temperature, wind patterns, storms and more can ensure an entity stays ahead of weather events to make informed decisions that optimise resource allocation and maximise operational efficiency.

Study sustainability

A Kenyan proverb sums up the idea of sustainability quite nicely. The saying goes, "Treat the Earth well. It was not given to you by your parents. It was loaned to you by your children."

When it comes to tube transmitters, most of the metal parts can be reused or recycled to avoid going into landfills.

Yet, sustainability is more than just environmentalism. The term recognises the roles of social and economic dimensions in delivering long-term prosperity. More and more leaders are integrating sustainability principles into their organisations.

The radar provides sustainability for citizens and societies, alerting us to take action during severe weather. Therefore, the meteorological process itself is sustainable. The whole purpose of the radar is to provide clear-cut forecasts enabling earlier warnings. And careful, complete forecasts are a foundation for a more sustainable world.

Baron Weather has always focused on designing components to last as long as possible. Baron, who has been in the industry for decades, creates products and services to support customers over the long haul. Partnering with Baron means a client has an expert resource and advocate throughout the process.

Author: Jon Tarleton, Vice President – Integrated Weather Systems at Baron Weather.

Baron Weather is the go-to for many countries when in need of a radar. Its best-in-class radar support team is available 24/7/365. Baron also offers guidance during the tender process.

Managing vulnerabilities in Cabo Verde, Africa

Building resilience in the face of climate change

Cabo Verde, also known as Cape Verde, is a small island developing state (SIDS) that sits in the Atlantic Ocean around 550km from the West African coast. It's an archipelago with 10 volcanic islands, nine of which are inhabited, with the tenth an important partial nature reserve.

These islands vary significantly in shape and geology, with some being shallow and others mountainous. The latter have steep terrain, with peaks like Pico de Fogo reaching 2,829 metres and Topo de Coroa at 1,979 metres.

Cabo Verde is located in the Sahel, a zone of arid and semi-arid climates that covers the whole of Africa south of the Sahara and lies in the transition strip between the Sahara Desert and humid tropical regions.

This shapes the archipelago's arid and semi-arid climatic conditions.

Rising temperatures and reduced precipitation

According to the country's latest National Adaptation Plan, published in October 2022, the average air temperature has a low thermal amplitude, with an average annual value of between 8-10°c.

Between 1991-2020, the annual temperature averages were approximately 23.7°c in Sal and 25.5°c in Praia City; slightly higher than the 1981-2010 average. The monthly average varies regularly and reaches its maximum value in September and October and its minimum in January and February.

Where and when rainfall occurs is very varied and the country has a very short rainy season, which is between August and October. The irregularity in precipitation is largely due to the islands' geology and position in relation to the prevalence of the wind. The average annual rainfall is around 244mm.

Impacts of climate change

Given its Sahelian and SIDS status, Cabo Verde is particularly vulnerable to the effects of climate change, which includes extreme weather events like droughts, hurricanes, landslides and floods.

Rapid rural-urban migration, continuous land degradation, persistent poverty and the risk of natural disasters like volcanic eruptions heighten its vulnerability further.

Without continuous water courses, natural forest mineral resources, climate change is expected to further intensify floods and droughts in the country, as well as exacerbate sea-level rise, sandy beach erosion and coral reef bleaching.

The impact of climate change is already being felt across the islands, from disruption to water and energy supplies and infrastructure damage through to coastal erosion.

Agriculture is one of the biggest sectors impacted, in particular due to lower rainfall, with crop losses, salt intrusion and salination of agricultural soil.

The tourism sector is also vulnerable to the effects of climate change, due to coastal erosion and rising sea levels. A quarter of the country's GDP comes from tourism, so this is of big concern.

Other sectors, including biodiversity, health and transport, are also considered vulnerable.

Future projections

Projections made using a climate rationale model indicate a temperature increase in Cabo Verde between 2011-2040 of approximately 10°c. This could rise by up to 3°c by the end of the 21st century.

Precipitation is predicted to reduce by 5%, even when some models show that the country will face more frequent and intense tropical cyclones, which will bring flooding and landslides.

Data analysis also forecasts the shortening of the rainy season, with a concentration of heavy, localised rains in a short period of time, causing high water discharge and run-off, and soil erosion.

Achada Fazenda, Santa Cruz, Santiago Island. Horticulture production zone. Image credit Paulo Barros.

Opportunities

Cabo Verde is very rich in terms of green resources such as wind, solar and sea, and although geothermal is yet to be explored, there are indications of great potential.

Other opportunities include the use of solar energy instead of fossil fuels by introducing electric vehicle fleets. The recent approval of a new plastics law, as well as the process for the approval of the climate law, aims to create new investment and financing opportunities for environmental protection.

Praia Branca, São Nicolau Island. First plot of land to be cultivated within the scope of the Praia Branca hydro-agricultural project. Image credit Paulo Barros.

In the face of climate change, Cabo Verde has seen an increase in tourism thanks to its geographical location in a geostrategic region. This geostrategic position is also relevant for meteorological data collection – surface, altitude and marine.

Capacity and resilience building

The INMG has been making some progress in developing this by working to optimise its network of meteorological stations.

Several automatic weather stations have been installed across the country, in addition to a system named NETSYS, which has helped connect all the islands and therefore improve communication.

The INMG is also developing an app for its early warning system called TEMPO CV, which is at time of writing available for testing on the Google Play store.

This will allow the organisation to disseminate all warnings and alerts, including those related to the maritime and agriculture industries. It's also working to provide warnings in simple language in order to reach the most vulnerable.

The national met institute is also taking its first steps in capacity building its Eta model, plus it aims to install an agrometeorological model (SARAH-O or AquaCrop) that will allow the met service to provide crop yield forecasts that will help to mitigate crop losses.

It is also looking to improve its maritime network and acquire some weather radars to support decision makers with improved real-time information, but this will require further funds to be achieved.

The biggest challenge Cabo Verde currently faces is building resilience in the face of climate change and its National Adaptation Plan breaks down a detailed climate resilience and action strategy.

The aim of this is to ensure that by 2030, Cabo Verde can "minimise the impacts of climate change through planned and concerted actions at all levels and will be a safe small island state, with all the necessary capacities favourable to seize the opportunities provided by climate change to become more sustainable, innovative and resilient".

Author: Denise Semedo de Pina, Executive Administrator at the National Institute of Meteorology and Geophysics of Cabo Verde.

Early Warning Systems 03

Weathering the storm

Assembling early warning systems

Why early warning systems?

According to the World Meteorological Organisation (WMO) early warning systems (EWS) provide four key services:

- Meaningful grassroots engagement
- Public education and risk awareness
- Effective communication
- Promote consistent readiness and timely mitigation

These four services are critical in managing the impacts of natural hazards and particularly so in vulnerable populations and communities, where their perception and understanding of risks associated with natural hazards are indispensable to a successful EWS.

It requires risk assessments that determine the likelihood of occurrence of a hazardous event, characteristics and circumstances of the susceptible population and vital utilities including laws and regulations, havens and potential effects, adaptability and management strategies.

These findings should be iteratively included in the EWS with a goal of clarity, universal comprehension and building public confidence in the information shared.

The information mechanisms must endure hazards and include procedures to confirm receipt of information and to communicate dissipation of a hazard and effects. Training should be conducted among various actors such as community-based organisations, faith leaders and businesses. The efficacy of alert communication and readiness to initiate action should be consistently evaluated.

Stream gauge installed at the Caparo River in central Trinidad

EWS require institutional synergy, consistent observation and identification of hazards, systematic data storage and examination of performance. They should accommodate innovations. Disparities in vulnerability on different scales should be assessed and considered. These may be structural, systematic or personal. A cost-benefit analysis of an EWS could be documented.

Moreover, the window of time required to initiate management mechanisms before an impact should be considered, with attention paid to additional needs such as the elderly and persons with disabilities or illnesses. This will be facilitated by greater accuracy which supports public confidence.

Prediction in tropical climates encompasses challenges owing to the haphazard, intense and variable nature and the spatial and temporal scale of events in these regions. The record of effects of events should be used to extrapolate and advise communities likely to be affected by an imminent event. Threats should be communicated as the status at the moment of dissemination. Comparisons to known experiences can be made to enhance understanding.

Early warning systems in the Caribbean

EWS have been under development in the Caribbean since 2001. Enhanced EWS form a key deliverable of the Regional Strategy on Comprehensive Disaster Management 2014 – 2024 of the Caribbean Disaster Emergency Management Agency (CDEMA).

EWS in the region focus on hydrometeorological hazards such as tropical cyclones and droughts among other types of threats. Two projects between June 2017 and April 2020 facilitated the improvement of EWS in the region.

The first benefited Antigua and Barbuda, Cuba, Dominica, the Dominican Republic, Haiti, Saint Lucia and Saint Vincent and the Grenadines by enabling risk avoidance, management and action among stakeholders.

It was a collaboration among the United Nations Development Program (UNDP), International Federation of the Red Cross and Red Crescent (IFRC) and CDEMA, with financing from the General Directorate of Civil Protection and Humanitarian Aid of the European Union (ECHO).

The second project was amongst Antigua and Barbuda, Cuba, Dominica, the Dominican Republic, Saint Lucia and Saint Vincent and the Grenadines, UNDP, IFRC, ECHO, CDEMA and the United Nations Office for the Coordination of Humanitarian Affairs. This focused on local and regional institutions.

Outcomes included:

- Information dissemination on tropical cyclones and the COVID-19 pandemic
- EWS for flood management
- Apparatus for common alerting protocol (CAP)
- Legislation for a national EWS

Some areas for future work in the project countries included:

- Enhancement of stream network gauging in the Dominican Republic
- Local engagement, data gathering and assessment on streams and skill development to manage apparatus in Saint Vincent and the Grenadines

The Regional Early Warning Systems Consortium, headed by CDEMA, formed in December 2019 under the Climate Risk Early Warning Systems (CREWS - see page 010) Initiative to provide guidance in the improvement of EWS.

It is made up of the following organisations:

- Caribbean Agricultural Research and Development Institute
- Caribbean Community Climate Change Centre
- Caribbean Community Secretariat
- Caribbean Institute for Meteorology and Hydrology
- Caribbean Meteorological Organisation
- Caribbean Public Health Agency
- Caribbean Telecommunications Union
- Faculty of Earth and Environmental Sciences, University of Guyana
- Intergovernmental Oceanographic Commission of the United Nations Educational, Scientific and Cultural Organisation-led Intergovernmental Coordination Group for the Tsunami and Other Coastal Hazards Warning System for the Caribbean and Adjacent Regions
- National Emergency Management Office (Saint Vincent and the Grenadines)
- National Meteorological Service (Jamaica)
- Office of Disaster Preparedness and Emergency Management (Jamaica)
- The University of the West Indies

Observers include the Organisation of Eastern and Caribbean States (OECS), IFRC, CREWS and UNDP (Barbados and OECS).

Healthy coral reefs are indispensable to storm defence and livelihoods, and The Caribbean Climate Change Centre collaborated with the National Oceanic and Atmospheric Administration to develop the Coral Reef EWS.

This monitors air temperature, wind speed and direction, barometric pressure, photosynthetically available radiation and ultraviolet radiation (among other variables) and was undertaken in Antigua and Barbuda, Barbados, Belize, the Dominican Republic, Grenada, Jamaica, Saint Lucia, Saint Vincent and the Grenadines and Trinidad and Tobago.

Strategies

The WMO highlighted the diversity of disaster management systems among territories in the Caribbean. In some instances, a territory is served by its own meteorological and disaster management agencies, while others rely on support partially or fully from other territories.

Moreover, different information sharing strategies exist.

In Antigua and Barbuda, Cuba, Curaçao and Sint Maarten, the meteorological service communicates directly with stakeholders while the meteorological services in Belize, Saint Lucia and Trinidad and Tobago maintain technical communication with the disaster management agency which then shares information with stakeholders and the public.

The meteorological and disaster management agencies of the Bahamas, Jamaica, Suriname, and the French West Indies communicate systematically to different stakeholders.

Robust communication

The WMO recommends that robust connection between meteorological services and disaster management agencies remains indispensable to a multi-hazard EWS.

CAP entails a tripart structure that outlines the nature of the threat, the degree of danger and suitable protective actions that can be taken. Universal understanding can be facilitated using graphics and a colour scheme for the first two components.

EWS should include the flexibility to cater to industrial needs. For example, the capture of the native languages of non-anglophone tourists from port authorities and communication should be coordinated with their accommodation.

Anguilla demonstrated the use of inclusive, multilingual, multi-hazard CAP. The ICT4Fisheries Consortium and the Caribbean Regional Fisheries Mechanisms created the Fisheries Early Warning and Emergency Response System to socially and financially safeguard stakeholders in this industry. It allows technical communication and grassroots exchange of information. Utility companies may require information that allows them to secure a nation's resilience in the face of an imminent threat.

The Trinidad and Tobago Red Cross Society demonstrated a flood early warning system pilot project in two flood-prone areas in collaboration with the Ministry of Rural Development and Local Government, the Water Resources Agency, The Trinidad and Tobago Meteorological Office and the Ministry of Works and Transport Highways and Drainage Divisions.

A high density of instruments has been attributed to Cuba's low vulnerability to hydrometeorological hazards despite high exposure.

Moreover, the EWS for tropical cyclones uses an extensive historical record. However, uncertainty is inherent in an EWS with a large spatial extent. Actions are considered based on characteristics of the system, accessibility of vulnerable communities and time of day.

Strategies are revised according to practitioners' needs and published annually during the dry season. Additionally, experts in monitoring, forecasting and communication engage in continuous training to enhance accuracy.

Weather information is delivered to the public in a recurrent education campaign. Nevertheless, Cuba's deployment of an EWS also demonstrates that effectiveness ultimately depends on citizens' willingness to adhere to recommendations.

Authors: Ronald Roopnarine of The University of the West Indies, St. Augustine Campus, Trinidad and Tobago and Kervelle Baird of Université Côte D'Azur, Nice, France.

Solar powered data logger that transfers information in real-time to the Water Resources Agency (WRA)

Multi-hazard early warning system case study - Advanced Radar Company

Customised and efficient MHEWS for Buenos Aires

Advanced Radar Company's (ARC) observation, surveillance and alert hydro-meteorological system is a multi-hazard early warning system (MHEWS) delivered to the Gobierno de la Ciudad Buenos Aires (GCBA) to address weather nowcasting and forecasting needs specific to the city.

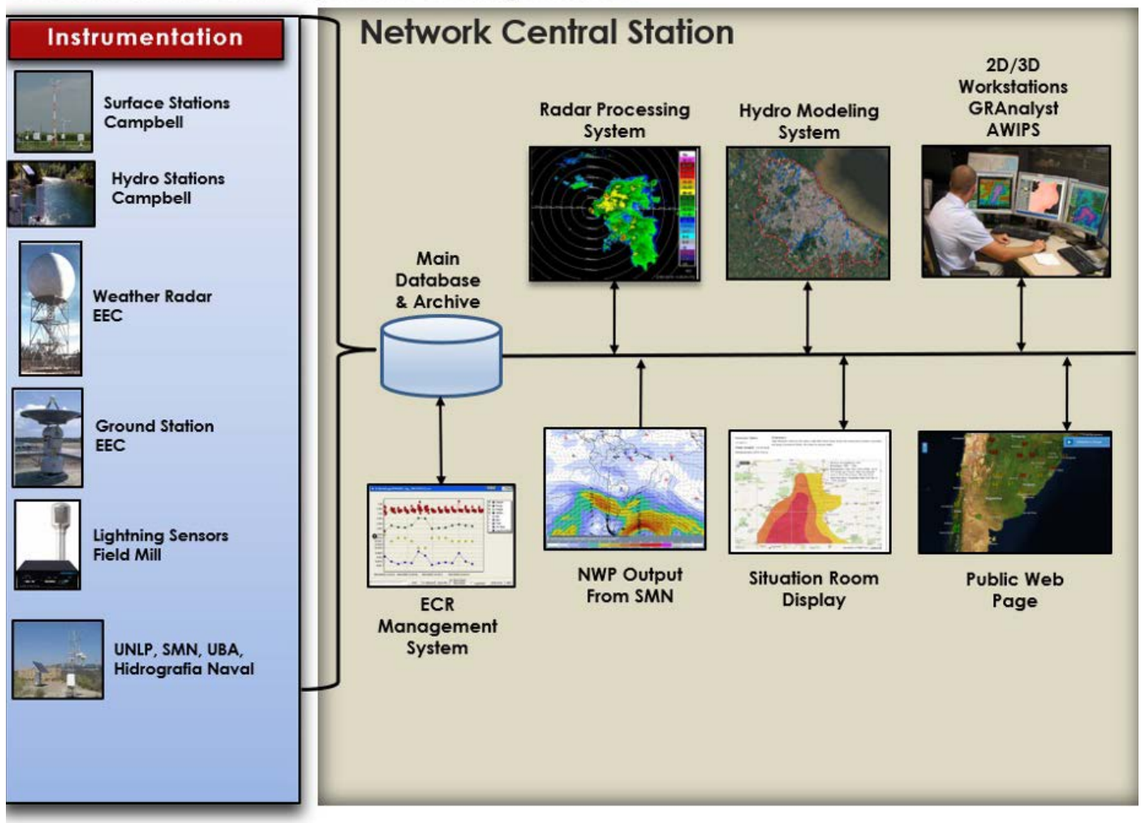
This is a forecaster-oriented system that ingests data from numerous sources such as weather radar, satellite, surface and hydrological observations, numerical weather prediction (NWP) models, radiosonde observation and a lightning network.

The system integrates and processes these data through a series of meteorological algorithms, and displays the data in a logical way for the forecaster to analyse and interpret in the weather decision-making process.

Automated and human-generated hazardous weather alerts are created and sent to emergency managers and the public. The image below illustrates the delivered system.

All meteorological data are centralised and processed using hardware installed at the Buenos Aires Emergency Management Centre, which is also the location of the forecast office. There are several processing components which include:

- Warning Decision Support System – Integrated Information (WDSS-II) – developed at the US National Severe Storms Laboratory for weather radar processing.
- Advanced Weather Interactive Processing System II (AWIPS-II) – meteorological data processing and display system developed by Raytheon for the US National Weather Service.



- Danish Hydrological Institute hydrological model – used to forecast pipe system and stream water levels along with providing inundation mapping of the city.
- GIS-based Alert and Messaging System (GAMS) – integrates system results and an asset database to produce automated alerts based on user-selected thresholds on various weather parameters.
- GRAnalyst – three-dimensional weather radar viewer built by Gibson Ridge software.
- iMAP – web-based user interface to display various datasets, system alerts and messages.

Automatic alerts are generated for a number of parameters including rain gauge quantitative precipitation estimation (QPE), basing average quantitative precipitation forecasts (QPF), thunderstorm intensity, hail and damaging winds potential.

Several meteorological datasets and products are archived and available for playback to examine previous weather events.

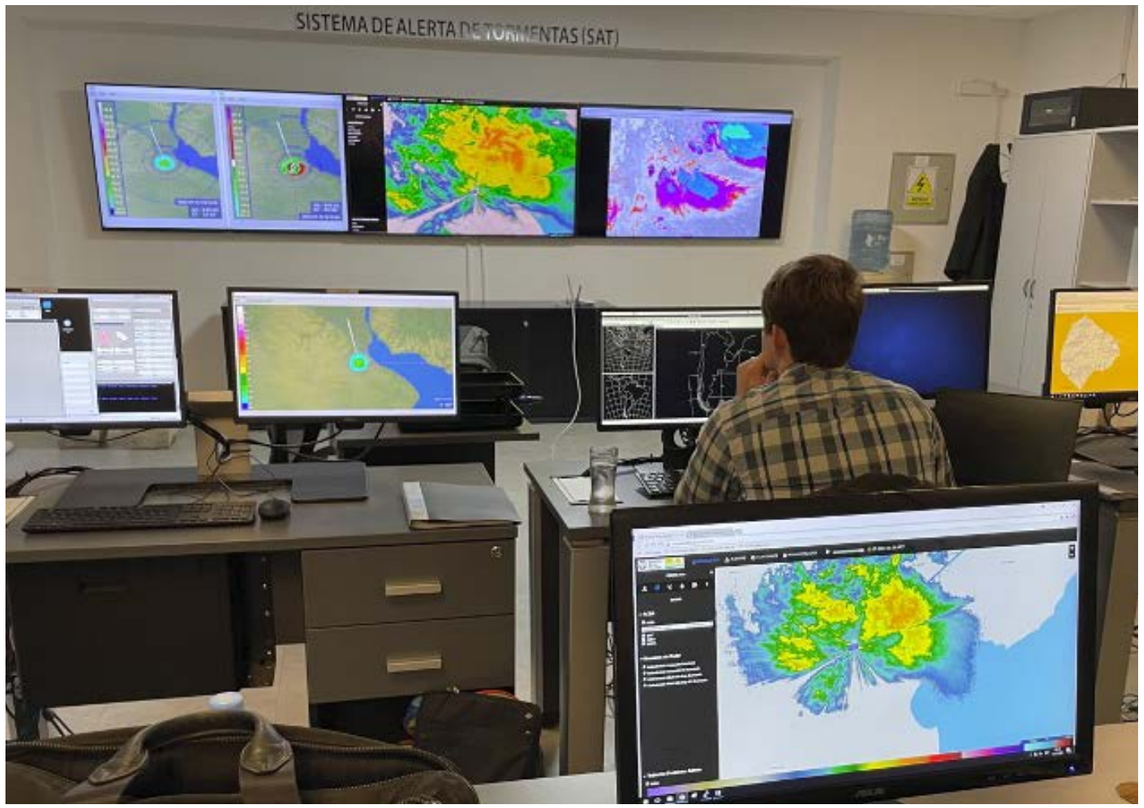
Overall, the ARC MHEWS delivered is a cornerstone forecasting and warning system for Buenos Aires.

ARC staff designed, implemented and maintained this system to incorporate the comprehensive aspects of WMO best practices and globally accepted EWS standards.

Our staff have experience with our own manufactured instrumentation, multiple OEMs and, most significantly, the proven ability to integrate these resources into an efficient and effective multi-hazard early warning system.

Author: Neil Brackin, President, ARC and Radiometrics

Forecast office at Buenos Aires Emergency Management Centre



A human-centred understanding of disaster risk

UNDRR studies human sociocultural factors that present barriers to taking early action in the face of a disaster

While being covered by multi-hazard early warning systems (MHEWS) is critical to mitigating loss of lives and livelihoods in the face of a disaster, to progress towards the goal to 'leave no one behind', it's equally critical to ensure that these systems and the policies that govern them are designed with and for the individuals and communities they are intended to serve.

An effective MHEWS needs to be end-to-end, people-centred (as well as nature-centred) and consider all components of a warning system – systematically, from risk knowledge to the implementation of preventive and preparedness actions to reduce risks and protect exposed populations – whose design considers all the complexities that different groups may have in order to implement protective measures and early action against the potential disastrous impacts of different hazards.

A human-centred risk perception study

The many coastal vulnerable communities across the Caribbean small island developing states (SIDS) are increasingly exposed to extreme climatic events, which are becoming more intense, unpredictable and frequent due to climate change.

To ensure that MHEWS consider the needs of their users and communities and can adequately address them, last year the UNDRR conducted a study in collaboration with the University of the West Indies, International Federation of Red Cross and Red Crescent Societies, national Red Cross Societies and national and local disaster offices. Financial support was provided by the Climate Risk and Early Warning Systems (CREWS) initiative (See page 10).

This study was performed in four Caribbean communities – Tobago in Trinidad and Tobago, Arnos Vale in St. Lucia, Bequia in St. Vincent and the Grenadines, and Portland, Jamaica. Its goal, to better understand the human sociocultural factors, such as trust in institutions, risk perceptions, migrant status and language, that may present barriers to not taking, or not being able to take, early action in the face of a disaster.

The purpose of the study was to increase understanding of the risk and early warning systems perceptions of institutions and communities and facilitate increased engagement of MHEWS stakeholders and practitioners, including private sector entities and groups mobilising women, persons with disabilities and youth.

Photo credit: UNDRR website

The study also aimed to strengthen the effectiveness of MHEWS by identifying the gaps in perceptions between policymakers and community users of MHEWS.

The UNDRR study supports recommendations for risk perception studies based on gap analyses conducted for several Caribbean countries, which found that in many instances "when warnings are issued some people do not take heed for various reasons, such as affinity and invincibility". This study therefore delved deeper to understand the human factors and perceptions that promote or hinder responses to warnings.

Study participants and methodology

A total of 143 people participated in the study, with 58% representing authorities and 42% representing the community. Of the total participants, 43% were male, while 57% were female. These participants, along with a mix of community members and policymakers at the national and local levels, were brought together for in-person workshops facilitated by local and national disaster risk management offices, national Red Cross Societies and the International Federation of Red Cross and Red Crescent Societies.

The study's methodology adapted the Resilience Performance Scorecard by Khazai (2018) and asked participants a series of questions based on five parameters:

- Awareness and advocacy – measuring awareness of hazards and disasters in their community or their country (e.g. through participation in events)
- Social capacity – measuring access to warning information via basic services and social networks and the impact this has on people's capacity to respond to the warnings
- Legal and institutional arrangements – measuring a community's trust and confidence in authorities with respect to forecasting and the impact this has on how people respond and act when warnings are issued
- Early warning systems infrastructure – measuring a community's understanding that the infrastructure for early warnings is sufficient (e.g. via sirens, social media and traditional media)
- Emergency response and preparedness capability – measuring the capability of a community to take prompt and protective action when they have received warnings (e.g., how many people in your community have an emergency preparedness bag)

People-centred early warning systems

Trust is critical to effective risk communication. Where communities feel they're not receiving or able to understand or trust the warnings being disseminated, they are less likely to take action in the face of a hazard.

Spaces for dialogue, such as those created in the development of this study, are critical sites for building trust and connection between policymakers and communities.

The workshops demonstrated that meaningful and sustainable community engagement allows communities to share their voices and experiences. It helped communities better understand the role of policymakers and the processes as well as the limitations of their roles and knowledge, and how they can create partnerships to better engage or transmit information throughout the community.

Traditional and local knowledge that has been developed and tested within a community over generations can be a source of knowledge when it comes to disaster risk management. Part of this knowledge comes from observing changes in nature such as the rapid fall in sea level as the ocean retreats, exposing fish and rocks on the sea bottom.

The workshops also highlighted the experience of some of the more vulnerable parts of the community. For instance, the study highlighted the need for warnings to meet different segments of society, including the need for translations to meet non-native language speakers, such as migrants or tourists.

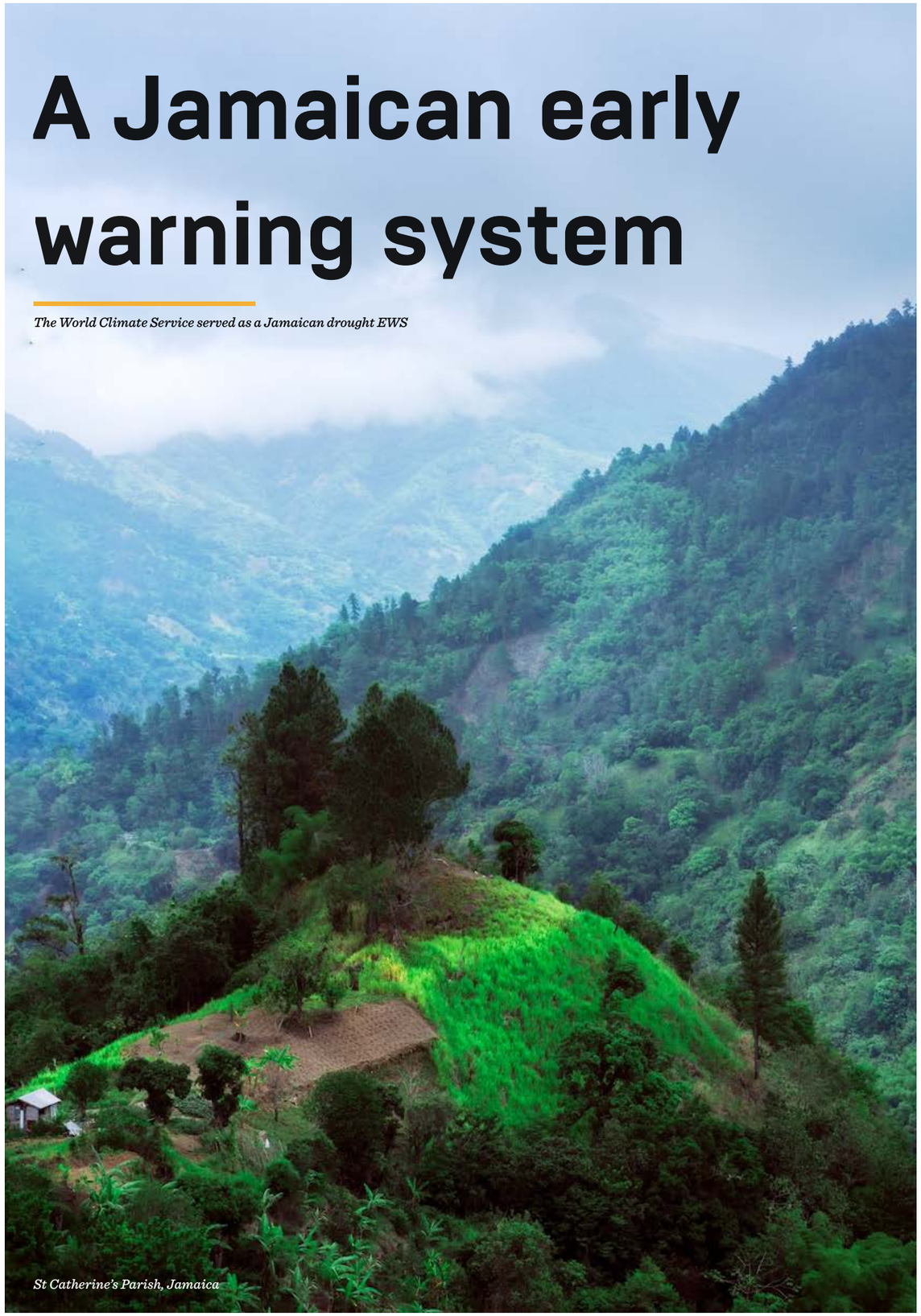
While the full results and report are still being finalised, preliminary recommendations will work towards integrating these human-centred risk insights into policy as well as strengthening disaster risk knowledge, institutional architecture through community, private sector, media and NGO partnerships, community integration mechanisms and addressing underlying socioeconomic factors that limit capacities.

It will also recommend improving infrastructural capacity, the understandability of warnings, promoting impact-based forecasting and enhancing feedback. We must measure and monitor how effective warnings are and strengthen the governance framework for MHEWS.

This article was originally published on the United Nations Office for Disaster Risk Reduction (UNDRR) website

A Jamaican early warning system

The World Climate Service served as a Jamaican drought EWS



St Catherine's Parish, Jamaica

The user: Meteorological Service of Jamaica

Jamaica experienced a drier-than-normal season heading into Spring 2023, motivating Jamaica's Ministry of Economic Growth and Job Creation Portfolio Minister to determine whether he should initiate drought mitigation actions.

The Minister turned to Evan Thompson, Director of the Meteorological Service of Jamaica (MSJ) and Jacqueline Spence-Hemmings, the MSJ Climate Branch Head.

"Given the time of year, this was a critical subseasonal to seasonal (S2S) timescale forecast, and we needed to understand the chances of different outcomes," says Spence-Hemmings. "While there are many sources of S2S forecast information, it's scattered all over the web and not necessarily prepared consistently. I didn't have much time to prepare our briefing, so I wanted to obtain as much valuable information as possible in one application."

The early warning system: The World Climate Service

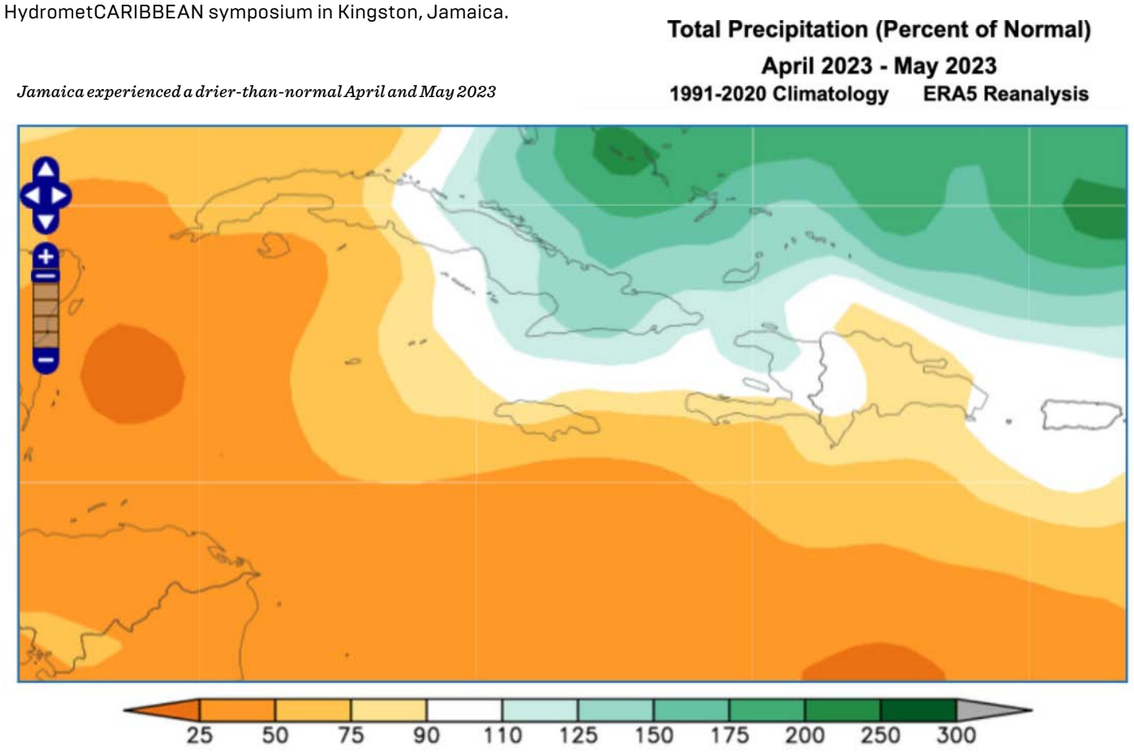
Spence-Hemmings contacted the folks at the World Climate Service, having met them earlier in the year at Varysian's HydrometCARIBBEAN symposium in Kingston, Jamaica.

The information provided by the World Climate Service web portal was the critical information source for preparing their S2S forecast briefings.

The information included:

1. Calibrated, probabilistic subseasonal forecasts from the European Centre for Medium-Range Weather Forecasting (ECMWF), National Oceanic and Atmospheric Administration's (NOAA) Global Ensemble Forecast System and Climate Forecasting System
2. Calibrated probabilistic seasonal forecasts from the ECMWF, NOAA and the wide range of forecasts from data originating from Europe's Copernicus project
3. Analogue analysis and forecasts to complement the dynamical forecast information
4. Forecasts of both seasonal and subseasonal climate indices such as the El Niño/Southern Oscillation and the Atlantic Multi-decadal oscillation
5. Historical climate data in an easy-to-use ECMWF Reanalysis v5 data viewer

Jamaica experienced a drier-than-normal April and May 2023



The World Climate Service served as a Jamaican drought early warning system to help the government understand if it should implement drought mitigation efforts. The S2S forecast information allowed the MSJ to provide the probabilistic forecast context, weighing the likelihood of different outcomes.

"There are various sources of information available to enable long-range forecasts," says Thompson, "and yet, making sense of all that data is enabled with a common framework to post-process both dynamical model and observational data sets.

"The World Climate Service not only improved our understanding of the risks implied by the forecasts, but we also got the benefit of the sub-seasonal timescale that the portal provides in its web-based location."

The future: mitigating climate risk

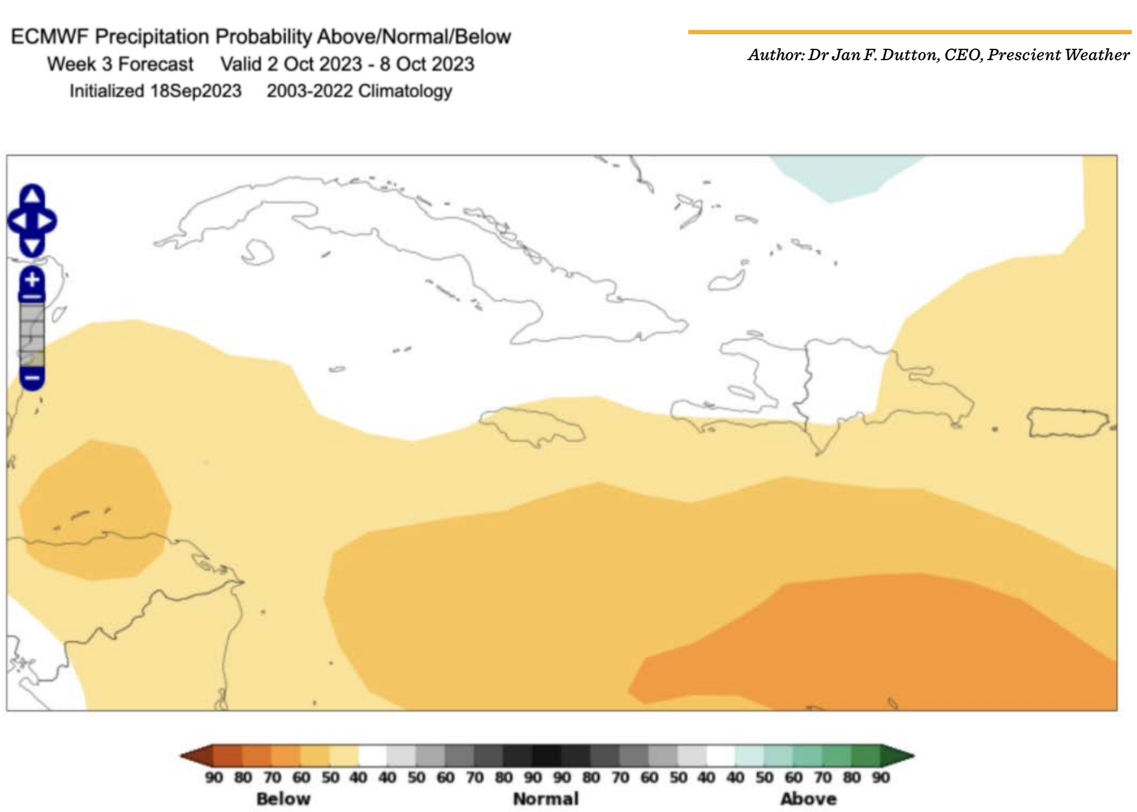
Our changing climate is increasing climate variability, which increases the risks of dangerous and disruptive weather and climate conditions having material and even deadly impacts on businesses, countries and governments.

National meteorological services worldwide seek pre-existing, ready-to-use S2S forecasting systems to improve their early warning system capacity. The MSJ plans to continue to use the World Climate Service for the foreseeable future to ensure its government is prepared for the climate risks that will inevitably impact the island nation.

What to do next?

Contact info@worldclimateservice.com to request more information about the World Climate Service, or visit www.worldclimateservice.com.

Author: Dr Jan F. Dutton, CEO, Prescient Weather



The early warning forecast was supported by World Climate Service calibrated probabilistic subseasonal forecasts indicating elevated probabilities of drier than normal conditions three weeks in advance

World of Data 04

Towards better flood and drought monitoring

How innovative approaches to remote sensing data are improving understanding of floods, droughts and the challenges posed by climate change

When Dr Wolfgang Wagner first saw the extent of open waters as he mapped Pakistan's devastating 2022 floods using radar images from the Copernicus Sentinel-1 satellite, he thought that there must have been something wrong with the data.

But after his team triple-checked the data and algorithms used to detail the evolution of the floods as *part of a new Copernicus service to improve flood monitoring*, Wagner – based at the Vienna University of Technology (TU Wien), Austria – realised that the data were telling the dramatic story of an unprecedented catastrophe.

The post-flood analysis showed that at their peak, the massive floods submerged an area the size of Belgium – some 30,000km2. Large swathes of land continued to be submerged by flood waters even months after the event.

More than 1,700 people were killed, 33 million affected and more than two million homes were damaged or destroyed. It was one of the costliest natural disasters ever recorded.

Getting the bigger picture

As the major component of the water cycle, rainfall is the most critical and direct cause of flood disasters. However, it is not the end of the story. Wagner says that efforts to better monitor and predict floods can benefit from observations of other key variables, such as the water within snow, vegetation and soil.

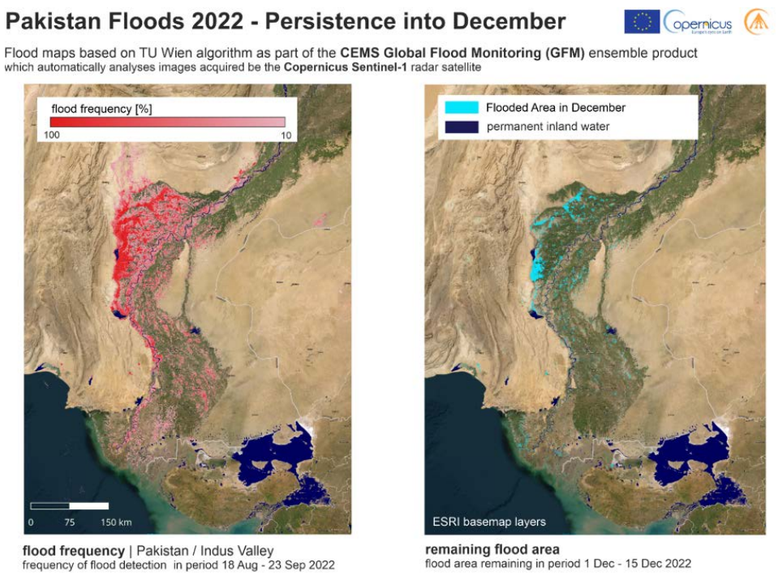
"Soil moisture accounts for just a minor fraction of the world's water resources, yet it has substantial influence on air temperature, humidity, rainfall and other highly dynamic exchanges between the land and lower atmosphere," says Wagner, whose team contributes to *EUMETSAT's Satellite Application Facility on Support to Operational Hydrology and Water Management (H SAF)*.

"Knowing the soil's wetness or dryness can make important contributions to understanding the likelihood of floods or drought in a particular area. With the help of *the Advanced Scatterometer (ASCAT) onboard EUMETSAT's Metop polar-orbiting satellites* we can produce soil moisture maps within around two hours after sensing.

"For example, in our analysis of the Pakistan floods, we saw in our ASCAT soil moisture data that soils were saturated long before the flooding. If we can better understand the correlations and get this information to authorities quicker, then it could help community response."

Developing algorithms

To retrieve soil moisture data from ASCAT, Wagner's team develops algorithms that filter soil moisture data from other features that impact the 'backscatter' from the satellite's microwave signal, such as the roughness of the land surface, vegetation such as crops and forests, and concrete in urban areas.



"ASCAT transmits pulses of microwave energy towards Earth and records the resulting echoes," he says. "From these signals, we can obtain estimates of the moisture in the soil, because the soil dielectric constant – the electrical properties of the soil – depends strongly on its wetness or dryness.

"Satellite scatterometers were preliminarily intended to measure wind speeds over the ocean, but luckily, ASCAT works at a microwave frequency that also guarantees a high sensitivity to soil moisture.

"While in situ observations are invaluable, the power of satellite data is that they provide observations worldwide in near-real-time. This is especially important when looking to predict and respond to extreme weather events such as floods and droughts, which are often preceded by events that happen across large regions, such as continents.

"Another benefit of satellite radar data is their ability to penetrate clouds, rain and darkness – therefore providing regular, reliable inputs that many applications depend on. This includes everything from flood prediction and drought monitoring, to agricultural yield modelling, climate studies and numerical weather predictions.

"'These applications benefit immensely from EUMETSAT H SAF's near-real-time soil moisture data services, which launched in 2009 and provide global soil moisture observations within 130 minutes after sensing."

Future focus

Once soil moisture data have been obtained from the microwave signal, there are still substantial challenges.

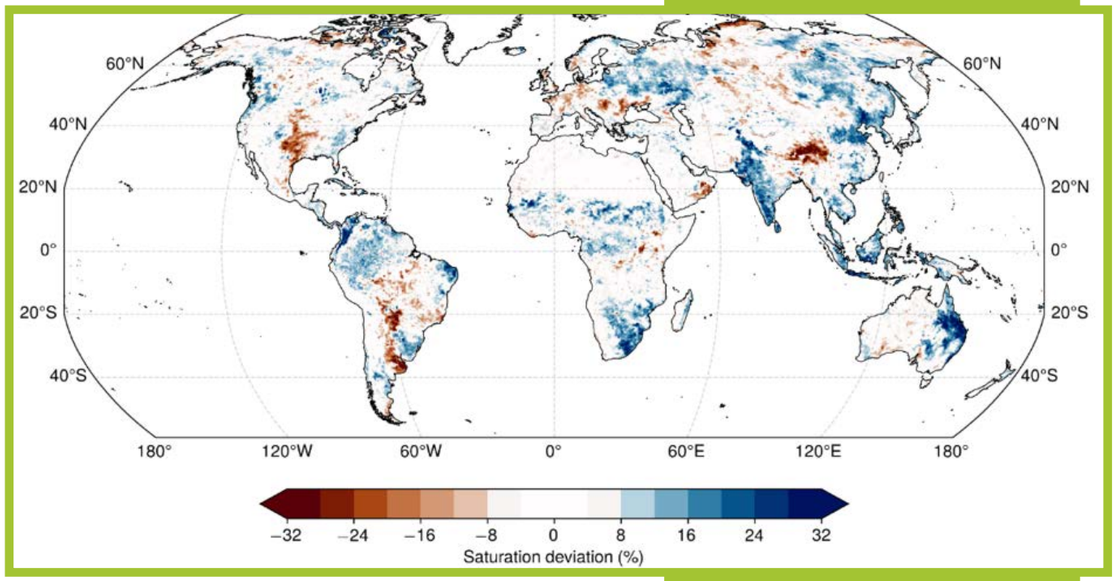
"It's not simply a case of taking data and feeding it into models," Wagner says. "We need to account for limitations such as the resolution of the observations and to provide these data in a way that is accessible and timely for a wide range of users.

Examples of H SAF soil moisture products

H SAF provides ASCAT soil moisture products in near-real-time and in the form of data records spanning from 2007 to the present.

This enables comparisons of present-day soil wetness with historic soil moisture conditions, which can help in the assessment of the risk of hydrometeorological extremes such as floods and droughts.

The map below shows ASCAT soil moisture anomalies in July 2022 compared to the years 2007–2021. One can observe, for example, the very wet conditions in Pakistan, India and Australia, and dry conditions in China and Europe.



"Another issue is that there are still a lot of areas where it is very hard to obtain accurate soil moisture data – for instance in mountainous and heavily forested regions, or in desert regions. While soil moisture does not fluctuate quite as dramatically as rainfall, it's still a highly dynamic variable. Experts are still learning how to relate signals in the data to impacts on the ground.

The ASCAT soil moisture anomaly map for July 2022 was created by Sebastian Hahn from TU Wien based on ASCAT soil moisture data provided by H SAF.

+ eumetsat.int

"For example, deviations from the average may mean one thing for relatively dry countries such as Kenya and another thing entirely for relatively wet countries such as India or Western Europe. And within these different contexts, what do lower or higher than average soil moisture levels mean for vegetation growth in the long term?

How does drought in spring affect the probability of extreme weather events in summer? Can we find clear relationships between soil saturation levels, rainfall and flash floods?"

Answering these questions also presents exciting opportunities, Wagner says.

"We can identify what soil moisture readings in spring might mean for crop harvests in summer, to develop more timely drought and flood warnings, to use the data to infer other measurements such as rainfall, or even imagine entirely new applications," he says.

"The dawn of next-generation satellite programmes such as the *EUMETSAT Polar System – Second Generation (EPS-SG)* will expand our technical capacities, whilst also enriching datasets with more observations.

"ASCAT has provided a flavour of what is possible: the scatterometer on board Metop Second Generation satellites will improve the spatial resolution of soil moisture measurements by a factor of two – it will be a fantastic instrument that will radically increase our ability to observe key aspects of the Earth's water cycle.

"Combining these observations with bounties of data collected by other satellite missions and in situ measurements will enable better observations of global soil moisture fluctuations. Assimilating these datasets with other meteorological observations will enhance applications relating to floods, crop growth, numerical weather forecasts, nowcasts and much more.

"Science rarely follows a defined path. To really integrate the data and come up with answers that are of benefit to society, this interdisciplinary work requires collaboration with experts spanning social scientists, water managers, modelers, machine learning experts, programmers and more.

"There are a range of factors impacting community vulnerabilities to extreme weather events, including demographic changes, human impacts on the landscape and climate change, which studies show likely worsened the Pakistan floods – a reality we are now seeing in many parts of the world.

"It's therefore critical that we do everything we can to make the most of remote sensing data that can help authorities to predict, prepare and respond to these threats."

This article was originally published on EUMETSAT's website

The 2022 Pakistan floods are estimated to be amongst the most costly natural disasters ever. The floodwaters submerged large areas of cities such as Tando Adam in Pakistan's Sindh province.
Image credits: UNDP/ Jamil Akhtar

The future of weather observation

WMO-compliant stations at the forefront

By 2027, an expected US$3.1 billion will be invested globally in early warning systems (EWS).

The United Nations (UN) and World Meteorological Organization (WMO) are working together to ensure every country operates an EWS to help save lives and infrastructure. The Early Warnings for All Initiative (EW4All, see page 07) is an effort jointly funded by the UN and the WMO to focus on early hazard warning and climate adaptation for the world's most vulnerable populations. Their goal is to have every person on Earth protected by an EWS by 2027.

One of the four pillars of EW4All focuses on the detection, observation, monitoring, analysis and forecasting of hazards in order to deliver accurate and timely warnings. Campbell Scientific provides a range of weather and water monitoring solutions designed to help emergency managers make informed, data-driven decisions and take decisive action.

Make informed, data-driven decisions

National and regional weather networks globally depend on Campbell Scientific automatic weather stations (AWS) backed by network management software to deliver 'Measurements to Insights™'.

There are several significant challenges to overcome when building a robust weather network. Successfully operating weather station networks often requires a team of highly-skilled technicians who benefit from a regular training regimen. High personnel turnover driven by budgetary constraints is amplified when system solutions are complex and require specialised skills.

Closed ecosystem solutions also limit the ability for organisations to cultivate in-house, long-term expertise. Inadequate capacity building can lead to eventual network failure.

The Malawi team successfully integrates sensors with Campbell Scientific dataloggers as part of a UNDP-funded project. Credit for both images in this article goes to Gcobane Quvile in Business Development for Campbell Scientific

Challenges to overcome

Many surface weather networks struggle to continually produce high-quality data due to budgetary constraints for operations and maintenance. Although new funding mechanisms, such as the WMO's Systematic Observations Financing Facility (SOFF, see page 009) are beginning to address long-term funding issues, networks need to find long-lasting solutions that have a high return on investment (ROI) over the lifespan of the equipment.

Operations and maintenance challenges are often compounded by difficult environmental conditions out of the weather network operator's control. Equipment needs to be durable to withstand hazardous or extreme weather, interactions with wildlife and insects, security concerns and unreliable remote communications infrastructure.

Together with our world-class support services, Campbell Scientific's WMO-compliant AWS solutions address the challenges weather network operators face. Our systems are robust, high quality, simple and upgradeable, and when properly maintained will give years of dependable service.

Our WMO-compliant, complete AWS offers a comprehensive range of environmental measurements designed as permanent installations for NMHS organisations and mesonets serving a diverse set of stakeholders.

Similarly, our WMO-compliant, basic AWS offers a select range of environmental measurements designed as permanent installations for NMHS organisations to meet minimum standards for conformance to the WMO's Global Basic Observation Network (GBON) requirements.

The GBON initiative

The GBON initiative will facilitate a significant overhaul of the methods for the international exchange of observational data, which underpin all weather, climate and water services and products.

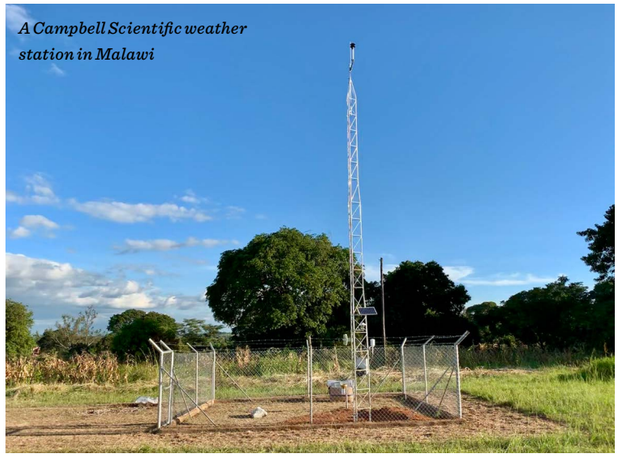
The impetus for the GBON project is that although local weather forecasts depend on access to 24/7 global observations, there are large geographical gaps in data availability. In some parts of the world, weather observations are either not made or not exchanged internationally, and in other parts they are not made or exchanged frequently enough.

Once completed, GBON will improve the availability of the most essential surface-based meteorological data.

This will have a direct positive impact on the quality of local weather forecasts, help scientists gather data to assist in the understanding of climate change and other human-made environmental impacts, and support countless organisations, institutions and national agencies in providing more efficient meteorological and hydrological services to their people.

Durable and long-lasting systems and sensors, such as those earmarked for the GBON initiative, are vetted by weather networks globally and return high-quality data suitable for numerical weather prediction, EWS and climate science.

Campbell Scientific systems represent a tremendous lifetime value proposition as a sensor-agnostic, future-proof and open-platform solution – ideal for both modernising legacy AWS networks and implementing new stations.



A Campbell Scientific weather station in Malawi

Key benefits:

- Equipment is field-tested for durability in extreme environments
- Flexible and innovative solutions incorporate a customised 'fit-for-purpose' design
- Using low-power, modular devices allows for capacity building and simplifies maintenance
- Campbell Scientific's AWS is a complete solution for weather networks seeking SOFF funds
- Required measurements include surface wind, air temperature, relative humidity, precipitation, atmospheric pressure and snow depth where applicable

Author: Garrett Wheeler, Application Engineer II, Campbell Scientific

Flood disaster management in Ghana

The impact of satellite technology

Flood disasters have become a recurrent and devastating issue in Ghana, significantly impacting economic growth and the wellbeing of the population. The country's increasing exposure to flood disasters is due to a combination of factors including its geographical location, the increased frequency of intense rainfall events and rapid urbanisation.

Flooding events predominantly occur in the rainy season, from June to November, with high-risk areas including the northern regions, coastal areas and urban centres like Accra and Kumasi. The country's vulnerability to flooding has been exemplified by several tragic episodes over the last decades, causing loss of life, displacement of people and substantial damage to property and infrastructure.

Historically, flooding events have been recorded in Ghana since the 1930s, but they have grown more frequent and severe over recent decades. A significant episode occurred in 1999 when floods affected approximately 300,000 people across the Northern, Upper East and Upper West regions. Later, the infamous 2007 floods – one of the worst in Ghana's history, resulted in the deaths of over 30 people and affected more than 630,000.

In 2015, a combined flooding and fire explosion in Accra led to approximately 150 casualties. These and numerous other instances reveal a concerning pattern of recurring flood disasters.

In the northern part of the country, the White Volta River Channel; the downstream area of the Bagre Dam located in Burkina Faso, has become highly susceptible to perennial floods. Flooding in this area is predominantly driven by a combination of natural and anthropogenic factors, and usually occurs from July to September.

Primary triggers for floods

Seasonal heavy rainfall is a primary trigger for flooding leading to two effects. First, heavy rains cause maximum saturation of the ground and increase the surface runoff, and secondly the spillage of excess water from the Bagre Dam reservoir.

Other factors include the geographical characteristics, such as low-lying topography and the nature of the White Volta basin, also contribute to the vulnerability of this area to flooding.

Human activities have also significantly exacerbated the flood risks. The spread of rural settlements, agriculture activities and deforestation have disrupted the natural drainage systems, leading to increased surface runoff and waterlogging during rainy seasons.

The impacts of these floods are multi-faceted and severe, usually resulting in significant loss of life, displacement of people and destruction of property and infrastructure, particularly in vulnerable rural communities. Moreover, these floods usually trigger outbreaks of waterborne diseases, impact agricultural productivity and cause long-term socioeconomic disruptions, undermining national efforts towards sustainable development and poverty reduction.

NADMO Operation staff on search and rescue mission in communities that have been cut off

Ghana's current flood disaster management strategies are multi-pronged, involving a range of policies, agencies and activities aimed at reducing the country's vulnerability to floods.

These strategies are mainly coordinated by the National Disaster Management Organisation (NADMO), which is tasked with managing disasters and similar emergencies in the country. The approach encompasses four major phases namely mitigation, preparedness, response and recovery.

Adopting satellite technology for flood disaster management

The adoption of satellite technology for flood disaster management in the country is still in its developing stages but shows promising growth. The Ghanaian government, in collaboration with international space agencies and organisations, has made strides in leveraging satellite technology for various applications, including disaster management.

The country is a part of international initiatives such as the International Charter on Space and Major Disasters, which provides timely satellite data during major disaster events.

At the national level, institutions like the Ghana Space Science and Technology Institute (GSSTI) have been instrumental in promoting the use of space technology. GSSTI, in collaboration with other agencies, has used satellite data for flood forecasting and mapping, particularly in the Volta Basin.

Satellite technology has had a notable impact on managing recent flood events in the area. During the heavy rains and subsequent floods in the northern parts of the country in 2020, satellite data proved invaluable in identifying the extent of the flooding and directing response efforts.

Images from earth observation satellites provided real-time insights into the situation on the ground, aiding NADMO in targeting rescue operations and relief provision. Satellite-derived flood maps were used to understand the progression of the flood and predict future flood-prone areas.

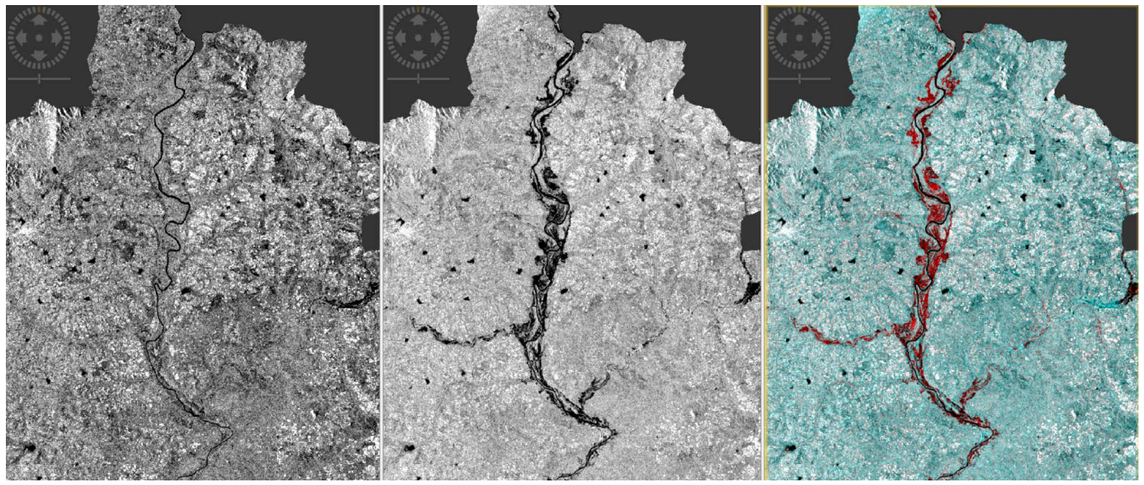
Moreover, in the aftermath of the floods, the use of satellite imagery helped in assessing the damage to homes, infrastructure and agricultural lands, enabling NADMO to prioritize recovery efforts and allocate resources effectively.

Overcoming obstacles to the use of satellite technology

One of the main obstacles to the use of satellite technology is the high costs associated with acquiring, operating and maintaining satellite systems, as well as processing and analysing the data they generate. This is particularly challenging for developing countries with limited resources.

Even the technical expertise required to use and interpret satellite data effectively has been inadequate. Thus, there's a need for capacity building and training to ensure that this technology is used optimally.

Issues of data access and availability can pose yet more difficulties, particularly during emergency situations when timely data is crucial. Satellite imagery is often subject to cloud cover interference, which can limit its usefulness in real-time flood monitoring and assessment.



Flood analysis map 15th August 2021(left)-27th August 2021(middle)-Difference(right)

Additionally, integrating satellite data into existing disaster management frameworks and practices can be complex and requires strong coordination among various stakeholders.

Lastly, legal and policy issues, such as data sharing and privacy regulations, can also present challenges.

Numerous opportunities

Despite the challenges, the use of satellite technology in disaster management presents numerous opportunities and potential solutions.

The cost issue can be addressed through international cooperation and partnerships, with developed countries and international organisations offering support in the form of shared resources, funding and capacity-building initiatives.

This is exemplified by programs such as the International Charter on Space and Major Disasters, which provides free satellite data during major disaster events.

For technical challenges, educational and training programmes can be instituted to enhance local expertise in satellite technology and data analysis.

The advent of cloud-based platforms and open-source software has also democratized access to and processing of satellite data.

Advances in satellite technology, like the development of cloud-penetrating radar satellites, can overcome issues related to cloud cover interference.

Legal and policy frameworks can be developed and refined to facilitate data sharing and ensure privacy and security.

Harnessing these opportunities requires concerted efforts from all stakeholders, including governments, space agencies, research institutions and communities.

A promising future

The future of satellite technology in disaster management in Ghana looks promising. As the technology continues to evolve and become more accessible, its potential applications in flood disaster management will likely expand.

Small satellites, AI, and machine learning, in particular, are areas of growing interest. These advancements can enhance real-time data collection and analysis, leading to more accurate predictions, timely responses and efficient recovery.

With increased investment and capacity building, more local institutions will likely incorporate satellite data into their operations.

There is also an increased push towards international collaborations and data sharing initiatives, which can enhance access to satellite resources.

Finally, it is important to note that efforts are underway to engage local communities in using satellite-based tools and information, further decentralising disaster management.

Author: Timothy Elikem Harvor, Principal Disaster Officer of the Geospatial and Big Data Unit, National Disaster Management Organisation (NADMO), Ghana

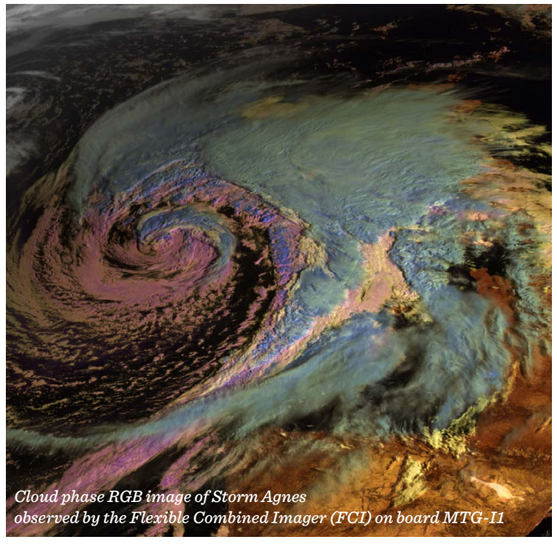
Director General presenting relief items to flood victims

Make the most of next generation satellite data

Next-gen EUMETSAT satellite data training offered to met services across Europe, Africa and the Middle East

To ensure met services are able to make the most of the vastly increased amount of information its next gen satellite systems will produce, EUMETSAT is rolling out dedicated training to users.

This will not only be available to meteorological services in its member states, but also across the Middle East and Africa – the latter thanks to agreements between the EUMETSAT Council and the African Union Commission (AUC).



Cloud phase RGB image of Storm Agnes observed by the Flexible Combined Imager (FCI) on board MTG-I1

The new training framework, developed specifically with its next-gen systems in mind, builds upon EUMETSAT's long-standing training programmes, which reached more than 2,500 users of EUMETSAT data in 2022 alone.

A revolution in satellite meteorology

The next generation systems, Meteosat Third Generation and EUMETSAT Polar System – Second Generation, represent a step up in terms of satellite meteorology.

The first of EUMETSAT's next-generation geostationary meteorological satellite fleet – the Meteosat Third Generation Imager 1 – was launched last December, and uses infrared to record a wide range of wavelengths and frequencies.

"We can look at where there's water vapour in the atmosphere, whether the particles on top of a cloud are big or small, whether they're ice or water etc," says Dr Mark Higgins, EUMETSAT Training Manager. "This will help meteorologists to better forecast thunderstorms for example, and whether there will be hail or heavy rain. There's a lot more information produced that can help us work out how big a storm will be." This first satellite also includes a lightning imager, which detects lightning flashes day and night. This will help met services to know where the most intense parts of a storm are, and see how it's evolving in a particular way.

Data validation underway

The first set of images from the Meteosat Third Generation Imager I were released earlier this year and EUMETSAT experts then began their work to verify and validate that the processing chain was working exactly as they expected.

"Over the summer we've shared the data with a small user group and then made it more public this autumn – although it's not yet labelled as ready for operational use," says Higgins.

He's also been coaching his training team, ready for them to visit met services and show them how they'll be able to use this new data in their operations, such as severe storm forecasting.

Training for African met services

In the case of Africa, the first 'trainer training' session took place in Kenya this October and Higgins also has plans to run several testbeds across Africa. This first training event was an English language course, but EUMETSAT also plans to run the same session in French in early 2024.

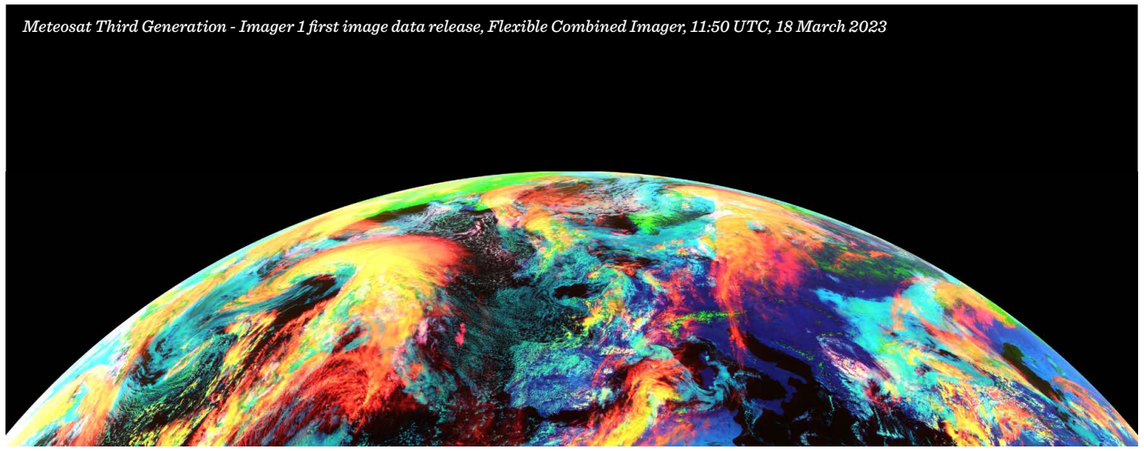
"We work with four training hubs, or centres of excellence, in Africa that are part of the African Satellite Meteorology Education and Training (ASMET) project. These are in Morocco, South Africa, Kenya and Niger, and support the regional met services," says Higgins.

Higgins expects that the new data will start being rolled out to African weather services at the start of next year and that the higher capacity services will start making use of it "pretty fast".

"They're going to get really big benefits from it – as will those with slightly lower capacity, where this new data will be even more valuable because many of these met services don't have access to radar data. With this new system they'll be getting so much more information to base their forecasts on. This is something we're really excited about," he enthuses.

Further Information

To find out more about EUMETSAT training courses, please visit the Eumetsat Training Zone at eumetsat.int.



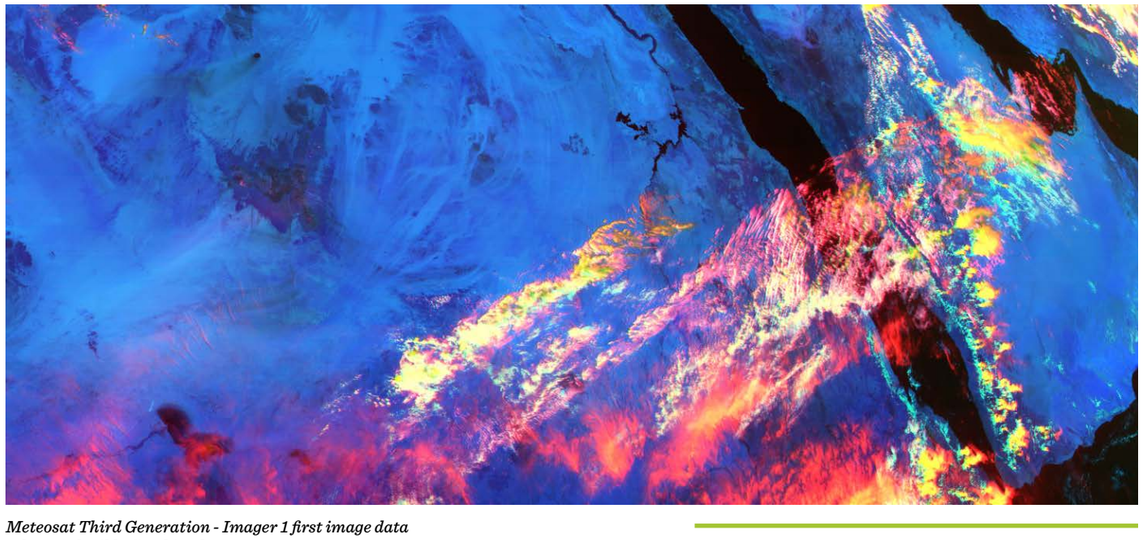
Meteosat Third Generation - Imager 1 first image data release, Flexible Combined Imager, 11:50 UTC, 18 March 2023

EUMETSAT updates data policy

At the end of 2022, the EUMETSAT Council approved changes to the agency's data policy to reflect the vastly increased amount of data that will be produced by its next generation satellite systems.

"We're committed to making our data available as widely as possible," says Phil Evans, EUMETSAT's Director-General. "The WMO's Unified Data Policy resolution will remain the reference for our data policy, which will continue to offer full and non-discriminatory access to as much as possible of our data under documented licensing conditions, while protecting the value of EUMETSAT membership.

"Our data policy is designed to empower data users worldwide and to support initiatives that assist communities in relation to weather-related disasters, such as the United Nations' Early Warnings for All. Our policy ensures the data we disseminate can help to protect communities and boost economies."



Meteosat Third Generation - Imager 1 first image data release, Flexible Combined Imager

Author: Keri Allan, Senior Content Manager, Varysian

Camera-based flow measuring system for stream and river monitoring

DischargeKeeper case study

Real-time stream flow monitoring, particularly during extreme events, has become more and more important in recent years. Reliable river water level, velocity and discharge data are crucial for flood monitoring and for the design of flood protection measures. Conventional measurement methods, however, reach their limits precisely then, as they often rely on a sensor installed inside the flood area.

Image-based flow measurement systems offer a flexible non-intrusive alternative with real time measurement. Unlike conventional measurement methods, the ratio of measurement signal to measurement noise is optimal for extreme events.

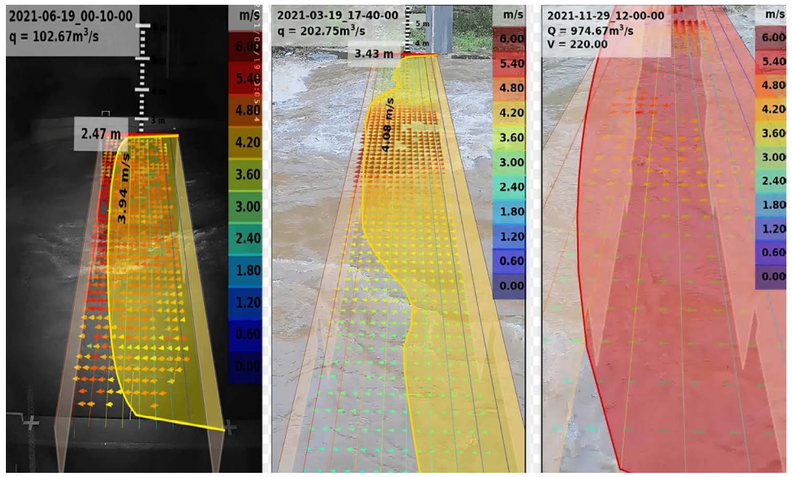


Figure 1. Proof images at different flow and lighting conditions on a DischargeKeeper site in Spain

This article presents a case study of the camera-based discharge system developed by SEBA Hydrometrie and Photrack called DischargeKeeper. The measuring system, which is based on the surface structure image velocimetry (SSIV) method, consists of an IP camera, an infrared illuminator for measuring at night and a central unit with remote data transmission.

The implemented algorithm is running in real-time on the device to provide on-site measurement and evaluation. The measuring process including recording image streams takes less than one minute. This enables very short measuring intervals which is very beneficial for flood monitoring.

In addition to the digitised measured values of the water level, mean flow velocity and discharge, proof images and videos are stored and can be transmitted to an FTP server.

A DischargeKeeper system was permanently installed in northern Spain two years ago. In November 2021 an event with a 500-year return period was recorded there. Most of the conventional measuring systems installed at this station were destroyed during the flood event, but the camera-based system remained intact because it was mounted on the side of the cross-section far enough away from the flood water. The measured discharge at the flood peak was 980 m3/s.

The high flows destroyed much of the intrusive sensors. The water even reached the house where the IP-camera was installed, but not the camera itself. Figure 1 shows three different flow conditions with discharge values from 100 m3/s to 980 m3/s. While the left image shows a sudden water level increase which occurred at night, the image in the middle shows a relatively moderate flood event with about 200 m3/s discharge. The image on the far right shows the maximum condition with about 975 m3/s discharge close to the flood peak.

It was possible to get the river stage using an existing water level sensor which is housed inside the monitoring station and was not affected by the flood. The transmitted proof images were very helpful for the optical verification of the measurement, especially during the flood events and to support the customer's early warning system.

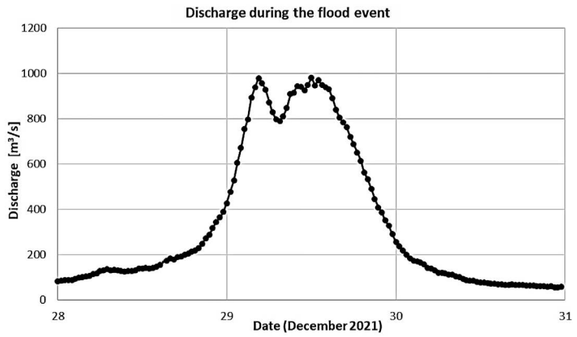


Figure 2: hydrograph of the flood event – including the peak – measured by the DischargeKeeper site in Spain

Author: Dr Issa Hansen, Product Manager, SEBA Hydrometrie

The Future of the WMO 05

A conversation with WMO Secretary General Elect, Professor Celeste Saulo

Varysian CEO, Tom Copping, was given an exclusive opportunity to interview WMO Secretary General Elect, Professor Celeste Saulo

Tom Copping: Professor Celeste Saulo, it's a pleasure to speak with you and I wanted to start by asking where you began in meteorology and how you ended up where you are today?

Celeste Saulo: Well, I come from academia; I'm still a Professor at the University of Buenos Aires in Argentina and a researcher in the field of atmospheric sciences. My expertise lies in numerical weather prediction and data simulation.

For some time, I was Director of the Department of Atmospheric and Ocean Sciences there, and then moved into the role of Director of the Argentinian Met Service around a decade ago. So, it's a great mix of experience across two different worlds that I've really enjoyed.

TC: An illustrious career, and congratulations on being chosen as the latest Secretary General of the WMO. I wanted to ask what made you decide to run?

CS: Well, I saw it as an opportunity to help the developing world raise its voice in the organisation, which is critical. Coming from the Global South, I'm highly motivated to really work for our countries, and help every NMHS achieve their mission.

We're discussing all the time that no 'one solution fits all', but we've not been doing much as an organisation to support each and every member country. That's what motivates me, as I think we can make a big difference.

Ensuring the Global South is heard

TC: I think that the WMO have been criticised in recent years for not allowing those in the Global South to be heard. Do you feel that's been the case and is something you want to work on?

CS: Yes, definitely. That's why the organisation has undergone important reforms in terms of governance, to put more emphasis on support in the regions. But that's far from being in place yet.

I think those in charge hadn't paid strong enough attention to regional necessities. Up to now the organisation's had lots of high-level initiatives that sound very good, but in the end the ones that have to implement these ideas are the NMHSs and that's a challenge for them. I think we have to work much more in connection with each country if we really want to roll out these initiatives successfully.

TC: Are you saying that the WMO has been working 'top down', but that you want to be using the regional offices more to get messages and support out to the met services, as opposed to it all coming from Geneva?

CS: Yes, the only way you can engage all the actors is through a bottom-up approach. Of course, you always need a top-down approach for things like decision-making or political advocacy, but in the end, the only way to really have success with these initiatives is by taking a bottom-up approach.

I'm fully convinced of this as in my experience the processes are always more efficient and the results stronger when this path is taken.

TC: I also wanted to discuss with you some of the findings of Varysian's 2023 global survey. We had responses from 600+ people in the hydromet sector, from 161 countries. This is really important as it's the Global South that are in most need of mitigation, adaptation and resilience to extreme weather.

Improving communication

At Varysian we've felt at times that there hasn't been much reach or consultation on matters with and within these countries. The lack of communication is shocking – half of the met service directors in Africa I speak with weren't even aware of SOFF or the Early Warnings for All initiatives! As Secretary General, how do you plan to ensure members in the Global South will be better engaged with and heard?

CS: Communication is very important if we want to fully engage with all our members. I have to say that from my experience, your example from Africa is repeated across the global south.

In the past the WMO has conducted surveys, but it seems it does little to analyse that information to better understand what's happening with each member.

I think communication needs to be simple and direct if we're going to be able to help address their problems – which are unique to each member – in Argentina we may be going in a completely different direction to a country in Africa for example.

Communication needs to improve within each country too – some projects are being funded within Argentina without the knowledge of the NMHS! That cannot happen, it's ridiculous to repeat efforts.

I'm going to do my best to ensure we reach everyone, and that communication across our industry in general also improves. It's important that the WMO responds when members contact us, and address the issues they raise. If we don't, then they'll give up trying and we'll never get these countries engaged.

TC: Yes, communication and stakeholder engagement are key. I remember during your campaign you said that co-development with the scientific and educational sector and public private cooperation and engagement are pillars to strengthen NMHSs and the integral development of countries.

CS: Engaging with education is so important, we have to move away from this idea of knowledge being assumed. To me, co-development, co-production, are key at every level; be that stakeholder, interagency, academia or the WMO. This will change the results of what we are doing.

Let's smash the silos

TC: At a global level I believe the challenge is the current siloed approach we have, which as you said often leads to doubling up of projects. I think we need more joined-up thinking – if we can truly match NMHS's requirements with the challenges in their countries we're going to have a much better opportunity to succeed.

I know from your work in Argentina there have been a number of projects to create resilience to extreme weather, but during our conversations, it's quite clear you've seen this siloed approach. From that perspective, do you think that the WMO will become instrumental in changing this in the coming years?

CS: I agree there's been a siloed approach, with secretariats working separately and I'd like to look at ways we can overcome this. Internal communication within the organisation should be improved.

I believe we have to build teams inside the WMO at regional levels, and then within them, team members that work closely with each country.

By discussing – and listening to – each region's areas of concern, it's possible to create regional solutions. For example, in South America, in three years we were able to bring together six countries to develop a coordinated system to deal with droughts.

We asked the WMO, US and Mexico for support, as they had projects underway and were experts in this area and together, we built this system. We weren't expecting a drought in the near future, but then Argentina was hit by the most severe drought in our history and thanks to this pilot we were prepared.

I really want to put a lot of emphasis on solutions like this; where you work together on a shared problem potentially following roadmaps from other countries that are a step ahead and can possibly assist you in the development.

Public private partnerships are a necessity

TC: Moving on, our survey also looked at the sectors affected by extreme weather, and results showed that 90% of all industries are impacted. Agriculture is the largest at over 24%, but what does this have to do with NMHSs beyond providing monitoring and forecasting data?

In my opinion, quite a lot! While the WMO's WIGOS and GBON initiatives are a necessity for all national met services and civilians, when we talk about industries, the private sector needs data to mitigate risks related to supplying goods. Whether this is through transportation to get medical supplies to hospitals or the need for weather index-based insurance for farmers these all link together, and that's where this public private engagement needs to happen.

Public private partnerships need to happen because we're all in this together.

NMHSs aren't just important for the public, they're also important for the private sector. Sometimes this sector is seen as the 'dark side', but if not for these companies, we all lose out.

NMHSs should be thinking about selling raw data for monitoring and forecasting, but also developing weather products that can be sold. I understand there's resistance to this, and that the WMO policy is that it should be free to all and I agree free data should be made available to civilians, but there's different kinds of data and services that NMHSs should have the capacity to create revenue from.

Soybean crop damaged by drought in Argentina

When you look at most of the countries in the Global South, there's not much money flowing around. Money isn't a bad thing, although a lot of people think it is.

Because the private sector deals in revenues and bottom lines they will pay for data and services that help optimise their businesses. In these contexts, selling this data isn't bad. How do you think that the WMO should approach this?

CS: I like the way you've posed this issue, as it's definitely something we need to talk about much more because it's not the same for the Global North as the Global South.

I think the WMO needs to assist NMHSs with two things. Firstly, maintaining an up-to-date, robust and reliable network. This is important, because, as you mentioned index assurance calculations, you need something robust in order to make these kinds of decisions.

Making the most of our data

The WMO also needs to help NMHSs to implement systems to gather meteorological data generated by different sources so that they're, in a way, the guardians of this information and can provide added value.

As you said, NMHSs are often seen as just data providers, but we have to move away from that view of our role – we're part of the value cycle. The WMO needs to help met services to add value to raw data, which is critical to building capacity in these countries and also providing the public sector with something that's useful to their decision-making processes.

That means engaging with academia and also explaining the NMHS's needs and their value to their country's policymakers. This would make NMHSs more visible.

As it currently stands, tailoring information for the different private sectors is impossible for many met services. In Argentina, for example, we have more than 1,000 staff but are unable to cover all bases. We need to engage with the private sector and other partners throughout the value chain in order to support a wider range of industries.

TC: Moving on, our survey looked at the key challenges NMHSs face globally. It appears that different regions have different strengths and weaknesses, but that a lot of the same challenges come up.

For example, the Caribbean is very advanced when it comes to knowledge sharing and institutional frameworks, but it struggles with limited funding and capacity building.

WMO Headquarters, Geneva. Image credit: WMO

These two challenges come up time and time again and funding is a big issue that appears to be holding the sector back. What are your thoughts on this?

CS: I believe many NMHSs face this problem, but certainly in Argentina my experience has been that we hear about green funds, opportunities from development agencies etc, but putting together a proposal is very complex.

Sometimes you need to fill in a form you don't really understand because of its complexity, or perhaps the language barrier.

A new department for the WMO?

I believe the WMO needs to help countries to really benefit from this funding. I think the WMO should create a new proposal writing division that helps members not only write proposals, but also follow them along the process of applying for funding until they succeed.

From my own experience, it took Argentina five to six years to get funding from the Japan International Cooperation Agency (JICA). It was very complicated.

We have the funding now, but not as much time to achieve our goals. Think about achieving early warnings for all in five years. Do we have five years to write the proposal? No! So, the WMO needs to set up an office to write these proposals together with each country, or possibly each region if they share very similar problems, as these funding mechanisms aren't reaching us all currently.

TC: Yes, it's about expediting funding proposals and acceptance. I remember when I worked in the private sector, an African NMHS put together a proposal relating to an issue that had taken place that year, but it took five years to get the funding. Imagine the number of changes that can occur during that time – it was a completely different country with different needs by then.

If you're able to set up this new department it will be pioneering because this will expedite funding and get all these projects up and running much quicker.

Maintaining infrastructure

Other areas of concern include building and maintenance of equipment and training. There always seems to be problems around this. I personally think the onus is on the different stakeholders to make these things work, but could something be done, like set aside part of the funding specifically for maintenance?

CS: I think the WMO's SOFF initiative is the first time the organisation has captured the issue of building the capacity and maintaining infrastructure.

System sustainability is part of the problem. I'm really glad to see this is starting to work. It took time, because we needed donors, countries on board.

Another interesting thing is SOFF brings the beneficiary NMHS together with one from the developed world and they work together right from the start. This is really important to building capacity and understanding what's required to maintain the new infrastructure. I think this model should be replicated and enlarged so that in five years' time if the developing world has less funding than expected it doesn't suddenly have to search for alternatives to ensure everything can keep going.

But it's not just about money for capacity building either, we also need people at the local level in order to keep things going. People are a critical component of all these initiatives.

TC: I believe the SOFF initiative was going to have $400 million in funding, but it's got $25 million so far and is already over a year into the programme. Capacity building, maintenance and training is a great focus, but we both know that unless you have the actors on the ground to do all of this then it's not going to work.

And it's not the NMHSs that should do all of that, there will be other actors, like civil works engineers for example, doing installation and training. How is the private sector going to come back into this?

Let's say there's a problem in two or three years and the private sector got its money and already moved onto the next project. Who is going to fund the private sector to come back and do maintenance, or will it be someone on the ground?

CS: That's a very good question and I think that we have to work on the developed world's commitment to funding adaptation and mitigation. There's $100,000 million that the developed world has committed to the developing world because of climate change, and as a community we need to work hard to get that money into efforts like SOFF.

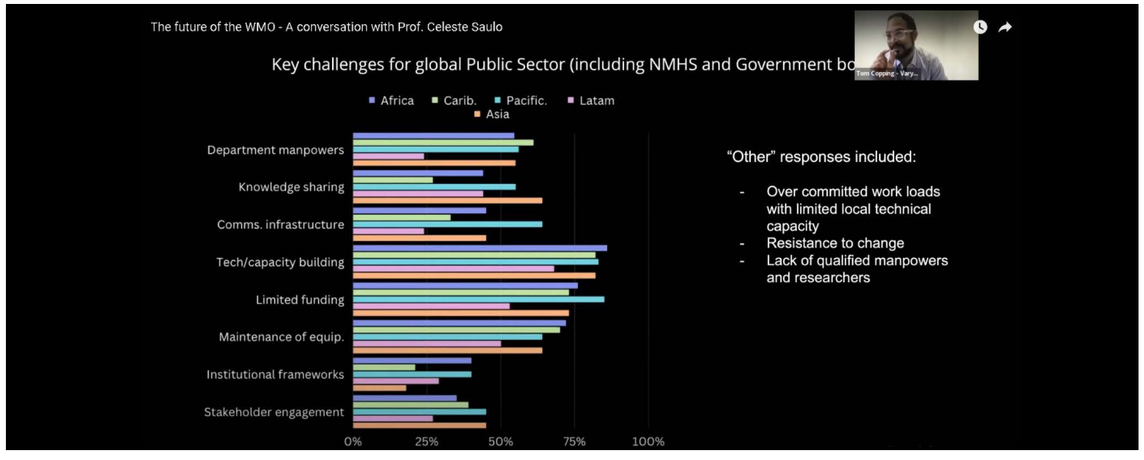
It's not just about communication between the WMO and donor countries though. It needs to be a global effort if we're going to succeed in the Paris Agreement. We need to keep things moving in order to keep capacity building and achieve the long-term goal of having better observation and early warning systems.

Air quality monitoring

TC: Our survey findings highlight that a lot of the projects completed in the last three to four years focused on early warning systems and disaster risk reduction (DRR), so that's a positive thing.

Another focus area was precipitation, which we highlighted earlier is of great concern to many NMHSs, but I also wanted to talk with you about air quality.

As Secretary General how are you going to bring these topics into the conversation? I ask because we're seeing more and more tenders from the private sector with air quality additions to meteorological tenders because air quality and pollution is



a massive problem all around the world. How can you promote the WMO to be more involved in this topic?

CS: Air pollution and air quality is very hard to really measure in a precise way and I would say it's very expensive, but we all know that we need that.

We're speaking with countries that have this component very well developed regardless of whether it is done by a met service of any other agency and some other countries where this isn't a priority.

I think that the WMO needs to engage with other UN agencies to really look at this because met services in many parts of the world really won't be able to handle this too.

But that doesn't mean we should leave NMHSs out of the conversation. We need to stay connected, as does the private sector, because many markets will set requirements in the future around air pollution, but we're not there yet.

So again, the private sector could play an important role here, engaging with NHMSs from the beginning, perhaps around developing new equipment, but also cheaper products that are just as good. This could lead to better revenues for all parties.

Lobbying for policy change

TC: One more thing I wanted to raise was about policy and lobbying. As we discussed earlier, many national met services aren't able to provide data for a cost. I appreciate that policies can be difficult to change, so how do you go about lobbying the ministries to make it easier for NMHS' to make revenue from the services and data they have?

CS: I think that these regional or continental-level organisations like the African Union are terribly important in getting voices heard – they become louder and clearer when everyone collaborates. In terms of policy making, we should be working closer with these groups.

Hydromet network puts questions to Professor Saulo

TC: I also have some questions from members of our Hydromet Network, if you don't mind. Firstly, what are your plans to enhance the participation of Africa in the WMO?

Air quality and pollution is a problem all around the world

CS: Well, I don't know if you are aware, but I've been looking into the geographical breakdown of WMO staff and today around half are from Europe.

The first thing to do is when we have posts open, we need our African colleagues to apply because, if we want to represent the diverse world, we need diversity within the organisation. I would also like to highlight that the WMO needs to understand and address Africa's issues. I would say the largest regional offices we have are in Africa, but they're still not enough. We need to really build engagement.

I'd love to hear people's suggestions of course, but I had one from a South African colleague about having internships in Geneva for people coming from Africa or other developing world countries to help to build bridges.

TC: Next up is how can the WMO leverage its global influence to reach politicians at national level to provide more support to NMHSs – noting that many have limited human resource capacity due to limited funding?

CS: Many met services have limited human resources capacity and funding for staff remuneration, including my own. I think the WMO needs to do more to get politicians understanding that it's their NMHS that's helping them achieve their commitments to the Sendai Framework and Paris Agreement.

To do so, we need to speak in the same language as them. They don't care about the need for more observations, we need to put all our efforts into translating how the work we do will help them achieve the sustainable development goals (SDGs) they committed to.

So, the WMO needs to help met services translate our results into steps towards achieving SDGs and also speak to governments about the importance of a strong NMHS in achieving a variety of SDGs; not just climate action but also zero poverty and hunger.

The key is translating hydromet language into policymaker language.

TC: Another question we have relates to the WMO's view on capacity building.

CS: For me, capacity building is at the centre of everything and the only way to achieve sustainability. Currently the WMO's capacity building system isn't strong enough and we have to change that. Also, there are different aspects of capacity building we need to consider, including training and staff numbers.

Each NMHS is unique in its set up and challenges and we need to develop a programme with flexibility to suit each situation. We also need to build on educational paths too, so we can build expertise on key topics.

TC: Another member of our network asks what are your plans regarding hydrology?

CS: Well, for me hydrology and meteorology are one. The WMO understands that hydrology is crucial; water security is crucial.

I think we need to find a way to more efficiently incorporate hydrology into our agenda though, as it's still very much in a silo. We see the same issue within NMHSs however; in some cases, they're in the same department, in other cases separate.

TC: Finally, noting the range of climate services NMHSs will have to provide in the coming years, how do you see the training and role of the meteorologists and hydrologist changing?

CS: Well, everything is evolving so fast. The first thing that I imagine is that we need much more flexibility at the level of capacity building and training etc, because as you mentioned we'll be providing services for sectors including health, energy, transportation and food security and we couldn't cope with everything.

I think social sciences are critical to help us really translate and work with these sectors to provide better climate services.

75th Session of the Executive Council in Geneva, June 2022. Image credit: WMO

At least it worked in Argentina, where we are a few meteorologists, some with a background in physics, and not all well equipped to cope with questions raised by firemen, for example.

With a small division of social scientists, we made great advances in the way we engaged with sectoral services, because they're able to understand and translate our work, so I would go in this direction.

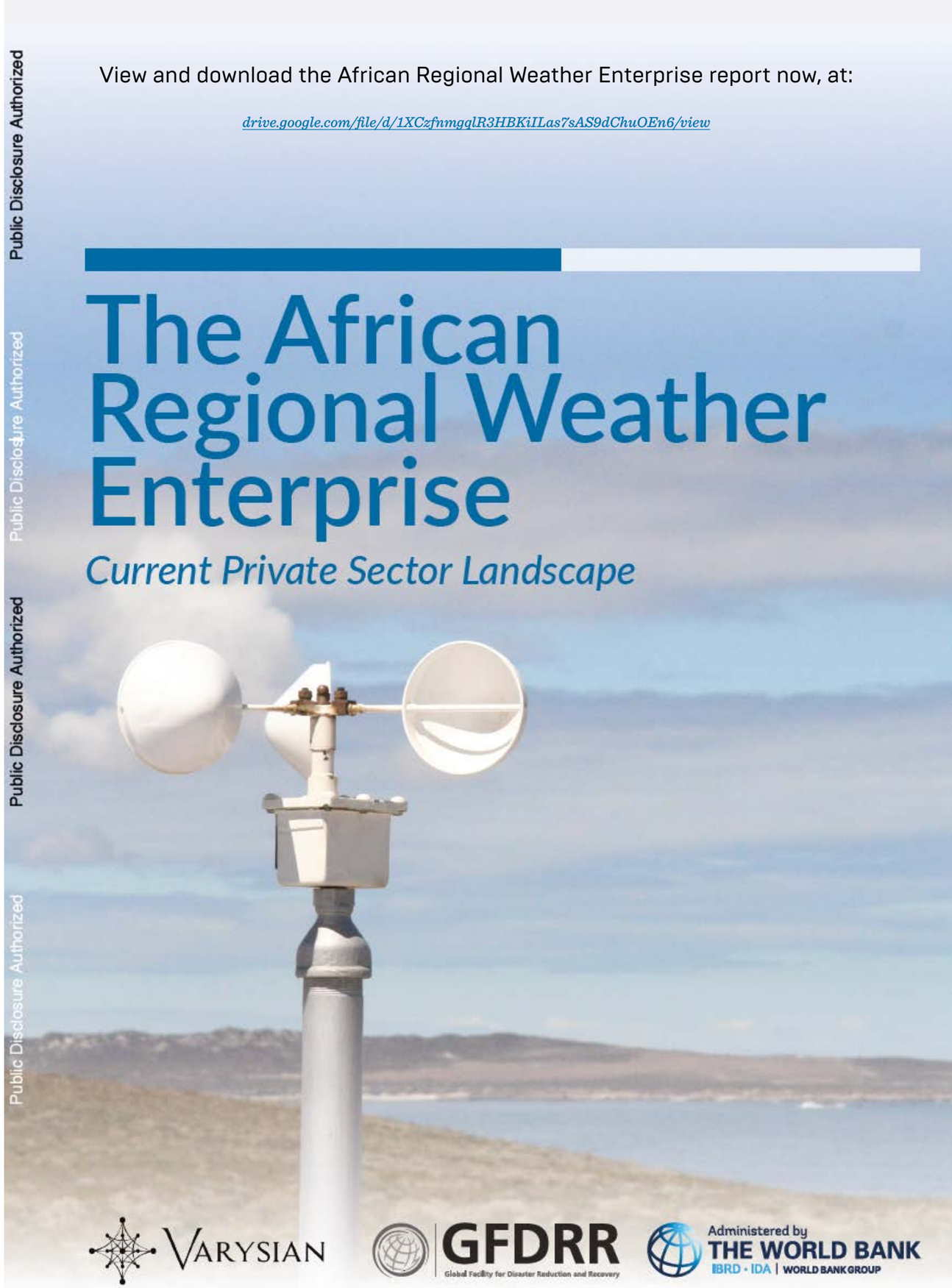
I think we should train meteorologists in social sciences, communication and economics, not just maths and physics. It's all about people, and having a better understanding of our communities."

Author: Varysian

WMO Headquarters, Geneva

View and download the African Regional Weather Enterprise report now, at:

drive.google.com/file/d/1XCzfnmgqlR3HBKiILas7sAS9dChuOEn6/view



Funding 06

Unlocking financial resources

Exploring funding sources

Met services based in countries with developing economies often require financial support to enhance their capacity and/or operations and there are a wide variety of funding sources available – if you know where to look.

Here we share some of the funding sources met services could be taking advantage of.

Government

The majority of met services receive funding directly from their respective governments, but the amount is influenced by political priorities and budgetary constraints.

To advocate for increased budget allocations, met directors could dedicate time to engaging with the relevant government officials and policymakers and present a clear case highlighting the societal benefits of well-funded meteorological services.

Also reach out to fellow government agencies/departments that have links to climate and disaster management. These will understand the importance of accurate weather forecasts, climate projections and early warning systems, and may be willing to allocate some of their own budget to capacity building projects.

Climate finance funds

Funds including the Green Climate Fund (GCF), Special Climate Change Fund (SCCF), Least Developed Countries Fund (LDCF) and Adaptation Fund (AF) are available to help address the challenges posed by a changing climate and can support projects related to early warning systems, data collection, technology upgrades, community engagement and more.

“For example, the Green Climate Fund has dedicated sector guidelines regarding climate information and early warning systems with three pathways,” says Paques Sidonie Kouam-Gwet, Regional Investment Lead at the Global Green Growth Institute (GGGI) in Africa and a speaker on Varysian’s recent Climate Finance webinar series (see page 080).

“These are strengthening climate information services (CIS), promoting impact-based multi-hazard early warning systems (MHEWS) and early action, and improving climate information and early warning systems (CIEWS) for investment and financial decisions.

“The objective of the strengthening capacity pathway is to make robust climate information services widely available for informed decision making through the modernisation of

hydromet services by operationalising the Global Framework for Climate Services (GFCS), sustainable business delivery and quality management models, and policy de-risking to drive uptake and investment in CIS," she continues.

"The promoting impact-based MHEWS and early action pathway focuses on making people-centred, end-to-end and impact-based early warning and action services widely available through the modernisation of disaster management institutions, community-based organisations and related institutions.

"The Improving CIEWS for investment and financial decisions pathway will support CIEWS for strengthening systemic resilience frameworks, asset design and structuring, and innovative financial solutions to reduce climate risks."

It's also worth noting that the GCF can, in certain situations, provide pre-funding towards early-stage consultancy. These take the form of Project Preparation Facility (PPF) grants.

Bilateral and multilateral funding sources

Climate finance can also come through bilateral, regional and other multilateral financial institutions and development agencies.

The World Meteorological Organization (WMO) and United Nations Development Programme (UNDP) are great places to start, as these regularly announce funding opportunities and capacity building initiatives.

The UNDP, for example, has a Small Grants Programme (SGP), which is part of the Global Environment Facility (GEF). This aims to support initiatives that promote environmental conservation, biodiversity conservation and sustainable development. In certain scenarios, fast-track approval procedures can ensure funds are made available quickly in response to urgent situations.

Partnering with international entities not only provides financial backing, but also grants access to a global network of experts, knowledge sharing and best practices.

The list of potential funding donors is vast, but includes the World Bank, African Development Bank, Caribbean Development Bank, Japan International Cooperation Agency (JICA), New Zealand Aid Programme and the United States Agency for International Development (USAID).

Further examples are available on the United Nations Framework Convention on Climate Change Secretariat's website.

Monetise your data

Met services could look to develop weather products to the private sector for a fee.

You must keep in mind the WMO's "commitment to the free and unrestricted exchange of data, which has been the bedrock of WMO since it was established", and so data could of course continue to be freely available to the public, but added value services and specialised data could become revenue sources, critical to building capacity.

For instance, commercial airlines may pay for specific weather forecasts and meteorological data to optimise flight planning and safety, while agricultural industries may purchase climate information and predictions to enhance crop management.

This idea is discussed in more detail in our Q&A with incoming WMO Secretary General, Professor Celeste Saulo, on page 065.

Public private partnerships (PPPs)

Taking this a step further, look to establish partnerships with private entities such as commercial weather service providers, technology companies, energy providers and the insurance industry – to name but a few.

These partnerships may not only involve sharing resources, expertise and data, which can be monetised to generate additional funding, but also private partners directly providing the funds necessary to support specific projects that offer mutual benefits.

Research grants

Met services can seek external funding through research grants provided by governmental agencies, non-profit organisations and international collaborations.

These usually support scientific investigations, technology development and innovation within the meteorological field.

Consider engaging in interdisciplinary collaborations with research institutions, universities and climate research centres, but be sure to formulate research proposals that demonstrate the potential impact of the study on met services and the broader scientific community.

Private foundations

Private foundations are becoming a more common source of financing for climate projects, especially for smaller or more economically disadvantaged countries, as these organisations appear to be particular interested in investing in areas where resources are limited.

There are several well-known private foundations and philanthropic organisations that are actively involved in funding climate-related projects and initiatives. These include the Bill and Melinda Gates, David and Lucile Packard, MacArthur, Rockefeller, Ford, ClimateWorks and Open Society Foundations.

Membership dues and contributions

Some meteorological organisations operate on a membership basis, where participating countries or institutions pay annual dues or contributions. These funds are pooled to support joint initiatives, research programs and capacity-building activities.

Examples include regional meteorological organisations like the European Centre for Medium-Range Weather Forecasts (ECMWF) and the Caribbean Institute for Meteorology and Hydrology (CIMH).

Author: Varysian

Varysian hosts climate finance webinar series

Each year Varysian releases a research survey to 20,000 global weather and climate contacts to better understand what challenges they face and what initiatives are underway. This past year, one main topic that came up time and again was climate finance.

Varyisan worked with its international contacts to pull together experts on this topic and in September ran a series of informative lectures, which are now available to view on demand.

Climate finance resources mobilisation for meteorological services

Presenting this webinar was Paques Sidonie Kouam-Gwet, Regional Investment Lead, Africa for the Global Green Growth Institute (GGGI).

The GGGI is a treaty-based international, inter-governmental organisation focused on supporting developing and emerging countries to achieve inclusive and sustainable economic growth. Included in their work is a 2030 global strategy which encompasses five global operational priorities and 11 pragmatic solutions including green investments, climate-resilient agriculture and waste management. The GGGI green investment services offering includes national financing vehicles, sustainable finance instruments and international climate finance including; upstream support, funding proposals and technical assistance.

Results of green investment services

Between 2015-2022 the GGGI raised over US$8 billion in green investment commitments, enabled 54 green growth policies to be adopted by 15 countries and established 16 climate funds in 11 countries. Additionally, over 2000 officials were trained in over 48 countries.

Climate financing for meteorological services

Kouam-Gwet explored the different types of financial structures available to meteorological services, then moved on to examples of where the GGGI has supported climate services, including in Malawi, the Philippines and Guatemala.

The Malawi-based project, which has a total value of US$16.3 million, aims to enhance capacity of hydromet networks and staff to generate climate-related data and forecast extreme weather and climate change, develop and disseminate tailored climate products and decision support systems, as well as strengthen capacities of communities of early warning systems (EWS) in response to climate-related disasters.

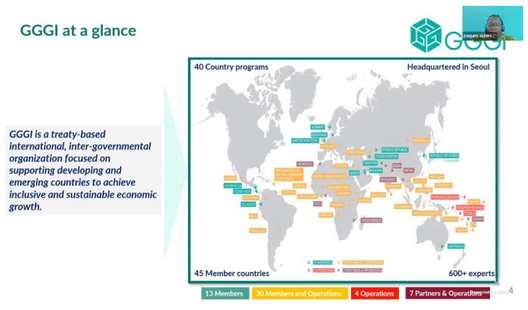
She then went on to discuss with the online audience topics such as the limited access to climate finance information, how national meteorological and hydrological services (NHMSs) can go about securing finance for innovative solutions, and the role of technology transfer in enhancing meteorological servicing via climate finance.

Facilitating private sector investments in climate finance

Presenting this session was Ayaka Fujiwara, a climate investment specialist from the Green Climate Fund (GCF), focused on the private sector facility.

The private sector facility

Fujiwara started off by sharing the four pillars of how the private sector facility works within the GCF; creating a conducive investment environment, accelerating climate innovation, mobilising finance at scale and strengthening domestic financial systems. It's believed that by collaborating with the private sector on these core approaches, sustainable growth can be fostered while making a real impact on climate change.



Climate Finance Resources Mobilization for Meteorological Services with Paques Sidonie Kouam-Gwet

Concessional capital's role in the future of climate change

She explained that the facility believes they can create a powerful financial mechanism by blending capital from investors with different kinds of risk tolerance levels. She went on to explain that in the nascent market of climate finance, private sector participants are interested but also hesitant to jump into deals because of the lack of a proven track record standardised approach, and although it's the reality of the pipelines, the GCF offers a safety net that shields private sector investors from bearing that first loss rates, and that this should encourage greater participation from private sector.

"We're trying to make public investment more affordable and accessible, and we believe that this approach is extremely important. But as we try to fill the financing gap that currently exists and climate finance, in itself needs a lot of capital, there is an almost 90% financing gap that needs to be filled, and there's no way that public sector money like GCF can fill all of that. So that's the reason why in private sector facilities, we try to act as a bridge to fill that gap by de-risking private sector investors."

Fujiwara went on to answer some questions relating to the risk associated with investment in climate finance and how to overcome these risks, which often involves waiting until there is a track record and some liability shown within the project. She also discussed the geographical challenges related to this topic stating that, especially in developing countries, the necessary regulations or disclosure policies and frameworks are not necessarily in place, so investors can be left in the dark about what they are investing in.

Climate finance panel

Two panellists, Srinivasan Ancha, Principal Climate Change Specialist and Climate Change Focal Point for Southeast Asia, from the Asian Development Bank (ADB), and Katherine Cooke, Principal Consultant in Climate Finance and Policy from Oxford Policy Management took part in this discussion.

Needs vs. reality

Current climate investment levels are nowhere near enough to limit global warming to 1.5 degrees – Srinivasan showed that currently we are at 1/10th of the funding required to hit this goal. Specifically for adaptation finance, the financial needs are around US$180 billion, and are currently at around US$46-49 billion. However, the level of adaptation finance available is increasing, which is a positive sign, rising from US$14 billion in 2011 to US$56 billion available in 2020. However, there's still more to be done to hit our target of 1.5 degrees of global warming.

What is ADB doing?

Asian Development Bank President Asakawa announced at COP26 an ambitious goal of "US$100 billion of cumulative climate finance from our own resources by 2030". US$20 billion was added in addition to an original $80billion target to support five main areas:

- New avenues for climate mitigation
- Scale up of transformative adaptation projects
- Increase in climate finance in ADB's private sector operations
- Support for a green, resilient and inclusive recovery from COVID-19
- Support to advance policy reforms in developing member countries

Cooke opened up her presentation with an introduction to Oxford Policy Management's work and projects, including work with India's Green Growth Equity Fund and the Policy and Institutions Facility (PIFS). She then went on to give some details of her experience in Fiji, working as the Commonwealth National Climate Finance Advisor, and covered the challenges that the Pacific region faces in accessing and applying climate finance, as well as the ability to use data for climate rationale.

Utilising geospatial data

Katherine's role in Fiji was specifically working with the *CommonSensing platform*, designed to enable users to visualise, analyse and compare data to produce actionable insights. This, alongside geospatial data in conjunction with the local government, United Nations Institute for Training and Research (UNITAR) and Satellite Applications Catapult (SAC), assessed project pipelines with the objective of using satellite remote sensing technology and earth observation data to feed into climate finance proposals, with the goal of making them more evidence-based and robust.

Katherine went on to describe many more projects going on in the region, including in relation to the Fiji Rural Electrification Fund.

Discussions

Both panellists then responded to questions from the audience, ranging from the sustainability of projects with a focus on relying on the maintenance of technology rather than applications for funding for new technology, to the best ways to inform developing countries regarding the process of applying for funding for EWS.

Author: Katie Barkans, Operations Manager, Varysian

Writing an effective funding tender

Optimise your chance of securing funding

Securing funding through successful tender applications is crucial for met services to maintain and enhance operations.

Writing a funding tender requires a strategic approach that emphasises the importance of your organisation's work and aligns with the interests of the funding source you're targeting.

By following the tips below, you can increase your chances of securing the funding you require to maintain infrastructure and build capacity.

1. Understand the purpose and scope

Before beginning the writing process, ensure you have a clear understanding of the funding purpose and scope.

Define the specific projects or initiatives that require financial assistance and align them with the overall goals and priorities of your organisation.

Identify the key challenges that the funding will address and articulate the potential impact of the proposed projects on stakeholders and the community.

2. Research potential funding sources

Thoroughly research potential funding sources that align with the objectives of your organisation and/or specific project.

Explore government grants, private foundations, international organisations and public-private partnerships that focus on meteorology, climate change, disaster preparedness, or related fields. (see page 77)

Tailor your tender to match the interests and priorities of each funding organisation.

3. Clearly outline the budget

Develop a detailed and transparent budget that demonstrates how the funding will be used.

Divide the budget into specific categories, such as personnel costs, equipment acquisition, research and development, data collection and outreach programs.

Ensure that each expense aligns with the proposed projects and presents a clear rationale for the cost estimates.

4. Emphasise the importance of your service and/or project

Highlight the significance of your met service and/or specific project in supporting public safety, economic planning and environmental sustainability.

Emphasise the value of accurate weather forecasts, early warning systems and climate change analysis in mitigating risks, reducing losses and enhancing decision-making.

Showcase success stories and real-life examples of how you have made a positive impact on various sectors. The more relevant to the funding you're currently requesting, the better.

5. Demonstrate expertise and experience

Establish credibility by showcasing the expertise and experience of your meteorological team.

Highlight the qualifications, achievements and contributions of key personnel involved in the proposed project.

Mention any relevant certifications, accreditations or partnerships that add weight to your organisation's capacity to deliver high quality services.

6. Address sustainability and long-term impact

Funding organisations often seek projects with sustainable outcomes and long-term impact.

Clearly outline the measures you will take to ensure the continuity and expansion of the proposed projects beyond the funding period.

Discuss plans for ongoing research, capacity building and community engagement to make a lasting difference.

7. Present a compelling narrative

Craft a compelling narrative that weaves together the goals, challenges and potential solutions of the proposed project.

Use clear and concise language to communicate complex ideas effectively.

Engage the reader with stories, statistics and visuals that illustrate the importance of this project.

8. Seek expert support

Experts are available that can come in and help you write a funding tender – where possible take advantage of these individuals.

Then, before submitting your funding tender, seek further input and feedback from subject matter experts, colleagues or consultants. This is because an external review can help identify any gaps, inconsistencies or areas that need work.

Author: Varysian

Public Private Partnerships 07

Partnerships with academia in the Caribbean

Key to early warning efforts, planning and monitoring impacts

An installation in St. Thomas that is fitted with a module to enable transmission of weather data in near real time for the Data Acquisition System for the Meteorological Service Jamaica

In the context of competing priorities and resource constraints, partnerships involving academia, the public and private sector, donor agencies and multilaterals are critical for small island developing states (SIDS) like Jamaica.

These partnerships have been important to advancing the Caribbean's agenda to develop early warning systems (EWS) and decision support tools for planning, and safeguarding lives, properties and the environment.

Here we briefly present four examples of how these partnerships are being used in a weather and climate context to assist Jamaica and the region to respond to a changing climate.

Bushfire warning index

From 2016 to 2019, the number of bushfires across Jamaica increased from approximately 3,716 to 5,838. With warmer and drier conditions being experienced on average under a changing climate, a bushfire warning index holds great potential for improving fire management and response.

A Jamaica Bush Fire Warning Index has been implemented by the Meteorological Service, Jamaica (MSJ) which forecasts the risk of fire outbreaks in the country.

The index is a geographic information system (GIS) -driven instrument that combines meteorological data with physics to determine the areas in the country at risk of bush fires. It is premised on the Keetch-Byram Drought Index (KBDI) which early research has shown is a useful indicator of bushfire potential for Jamaica.

The research has also identified other skilful indicators such as water potential that can be included in future versions of the warning system. Several partners have enabled the research and implementation of this index including, but not limited to The University of the West Indies (UWI), the Jamaica Fire Brigade, Forestry Department, National Environment and Planning Agency, Office of Disaster Preparedness and Emergency Management and the Rural Agricultural Development Authority.

Currently, when generated, the Jamaica Bush Fire Warning Index is shared with key stakeholders including the Jamaica Fire Brigade and the Rural Agricultural Development Authority.

Real-time rainfall data capture

Another manifestation of a changing climate is an increased intensity in rainfall extremes. To enable closer monitoring of rainfall amounts across Jamaica, a Data Acquisition System for the Meteorological Service Jamaica has been designed by the UWI.

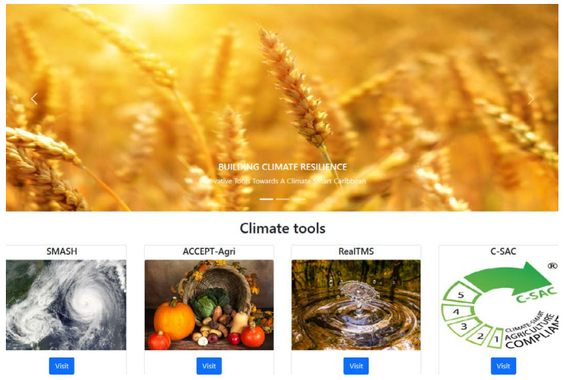
The system enables (near) real-time data capture from select automatic weather stations in Jamaica with data access by the MSJ Staff enabled via an online platform. The system also has a functionality to trigger warnings when rainfall recorded at the stations has exceeded pre-defined thresholds.
The systems are powered by solar energy to improve the sustainability of this effort.

In the first phase, 10 stations have been added to the system with another suite of stations to be added in the next phase.

Other partners have included the Planning Institute of Jamaica and the Inter-American Development Bank through the Pilot Programme for Climate Resilience funded by the Climate Investment Funds.

The Simple Model for Advection of Storms and Hurricanes (SMASH)

Extremes are also experienced via tropical storms and cyclones traversing the region. In an effort to better understand impact the Simple Model for Advection of Storms and Hurricanes (SMASH) has been developed by the UWI.



Landing page of UWI Climate Tools hosting SMASH and RealTMS

SMASH allows users to examine different scenarios of tracks, intensities and forward speeds of select hurricanes that have traversed the Caribbean and to output the associated rainfall rates and windspeeds.

The outputs can then be fed into models to determine impacts of these storms on different sectors. Partners have included Newcastle University and the University of East Anglia in the United Kingdom; Instituto de Meteorología (Cuba), Caribbean Community Climate Change Centre (CCCCC) and CCRIF SPC for updates to the system.

Real Time Monitoring System (RealTMS) for Water Quality

Real Time Monitoring System (RealTMS) for Water Quality is a technological solution that allows environmental regulators, industry practitioners and other stakeholders to monitor the water quality in rivers, drains and other moving bodies of waters.

The system enables monitoring of parameters including biological oxygen demand (BOD), chemical oxygen demand (COD), potential hydrogen (pH), temperature and conductivity.

This was inspired by a private sector need for monitoring water quality and partners have included the CCRIF SPC in advancing the re-commissioning of the system.

Effective partnerships

These tools have been designed for the Caribbean within the Caribbean through effective partnerships and are representative of the capacities to be found in the region to address regional problems.

There is scope to do more within the region and to find innovative solutions fit for the Caribbean. This will require further developing capacities by expanding the pool of professionals available to solve problems in the region.

It requires more regional institutions recognising the merits of collaboration in developing responses to region-specific questions. It requires more attention being placed on data collection and compilation across the physical and social sciences to underpin the development of new tools.

It requires funders recognising that there are competences in the region which can be leveraged. It requires governments being willing to increase financial support to local professionals working on regional problems and even facilitating a pool of funds to support efforts to address priority areas identified by them over pre-determined cycles.

If we are able to work on these approaches, more may be accomplished by the region to support its planning and monitoring activities.

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The return of HydrometCARIBBEAN

Symposium focuses on strengthening early warning systems in the Caribbean

Following the success of the 2019 Caribbean Symposium in Barbados, and with travel opening up post-pandemic, Varysian kicked off 2023 with its second physical conference in the region – HydrometCARIBBEAN.

Held from 31 January-2 February in Kingston, Jamaica, the symposium brought together all 16 Caribbean Meteorological Organisation (CMO) member directors of NMHSs, as well as key professionals from academia, NGOs and the private sector.

Roughly 25 speakers and panellists took to the stage over the three days. These included met service directors from across the region, World Bank Consultant Stefan von Gruigenen, Professor and Deputy Dean of the Faculty of Science and Technology at the University of the West Indies (UWI) Tannecia Stephenson, Network Manager of Caribbean WaterNet and Lecturer of agri-environmental disaster risk resilience Ronald Roopnarine, CEO of the Public Broadcasting Corporation of Jamaica Keith Campbell, and Senior Director of Tourism Policy and Monitoring at Jamaica's Ministry of Tourism, Osbourne Chin.

Addressing regional challenges

The symposium's aim was to create a space to foster new connections and facilitate conversations with policy and programme makers, as well as the NHMS themselves, on how best to tackle these issues.

Varysian worked closely with Dr Arlene Laing, Coordinating Director of the CMO and Evan Thompson, Director of the Jamaican Meteorological Service and WMO RA IV President, to develop an agenda that would address the main challenges faced in the region. It was also an honour to have them co-chair the event.

Theme for 2023 – early warnings for all

The overarching theme of the symposium was the strengthening of early warning systems (EWS), as this is a key focus for the region's NMHSs, and day one focused on identifying where the region is on its journey to ensuring EWS for all.

The event opened with a presentation from Dr Arlene Laing, who discussed the goals of the symposium; to identify gaps

Panel session at HydrometCaribbean 2023

in each pillar where NMHSs should contribute and to take concrete actions to advance or enhance EWS in the Caribbean through partnerships with the private sector, academia, civil societies and development agencies.

Each day consisted of a mix of presentations, panels and round table discussions, and highlights from day one included the panel on best practice in operation, which showcased the variety of EWS currently in place or being developed in the region.

Solutions presented included an EWS for multiple hazards, an EWS with community input, an EWS which used forecasts from a third party and a hydrology-focused EWS.

"The symposium was fantastic – very educational! I've already spoken with my director on a way forward in setting up our met service." - Jacob Adolphus, Emergency Communications Officer at the Government of the Virgin Islands' Department of Disaster Management

The round table topics for the day were closing the gaps, capacity building – in particular developing predictive capabilities, and EWS data management and sharing. Feedback from these sessions included:

- Data sharing and integration are critical to advancing EWS
- It's better to develop skills for use of NWP from global centres for most applications, but stick to local and regional models for convection
- NMHSs should collaborate for financing and resource mobilisation
- AI can be useful for some applications
- NMHSs should consider crowd-sourcing to aid observations and improve engagement with the community, but it's key to closely manage the data quality

The importance of partnerships

Day two focused on the importance of partnerships, and included a panel session on public private partnerships (PPP) and a presentation on partnerships with academia.

The round tables were particular highlights, with participants discussing everything from regional partnerships (A) and the role of the private sector in advancing EWS in the region

A round table session in full flow

(B), through to the development and refinement of standard operating procedures between different departments and organisations (C).

Discussions on table A included what difference cross-border collaboration and regional integration can make towards the goal of EWS for all, examples of successful regional partnerships and what the Caribbean can do to support the growth of these.

Over on table B, private sector participants put a key question to the met directors: what are your biggest challenges around EWS – from the early stages of gathering data through to getting the information out to the public?

From here the discussion moved to whether the technology currently exists to overcome these challenges, and if not, whether manufacturers are able to develop the technology to bridge these gaps and help NMHSs progress on their EWS journey.

On table C, attendees discussed the WMO-CDEMA project focused on standard operating procedures between met services and national disaster offices, as well as the role of different organisations and sectors in the process.

"A fabulous job – all parties appeared to find it super valuable. Forging these partnerships is a particular passion of mine and I think Varysian is playing a unique role in brokering a space for creative deal-making." - Janot-Reine Mendler de Suarez, Climate-Smart Development Consultant, World Bank

The last mile – communication and dissemination of warnings

The third and final day revolved around the last mile of EWS, which is the communication and dissemination of information. A double session was given to this exact topic, which saw a great array of panellists from the telecoms, broadcast and tourism sectors, as well as academics that work closely with local communities.

The discussions between the panellists and audience – as well as on the later round tables – covered improving dissemination of information, the importance of community-level early warning systems and the role of the media and telecommunications in getting early warnings out to everyone.

PPP Panel

Outcomes of HydrometCARIBBEAN 2023

HydrometCARIBBEAN was a great success, strengthening relationships between NMHSs, NGOs, academia, the private sector and other partners and stakeholders supporting EWS in the Caribbean.

The event gave attendees a better understanding of existing EWS and supporting mechanisms on which to advance early warnings in the region and helped to establish and enhance partnerships to support multi-hazard early warning systems (MHEWS).

Attendees were able to work together to start charting a path forward on ensuring early warnings for all and Varysian will continue to support them on their journey.

This comes in the form of the Hydromet Network, which offers a virtual networking hub for the hydromet sector, hybrid events, weekly webinars, technology demonstrations, one-to-ones, training modules, specialist conferences and 20:20 events consultancy.

Varysian would like to thank everyone who made HydrometCARIBBEAN possible; from those involved in the planning sessions through to the speakers, moderators, sponsors and attendees. We truly appreciate your support.

Author: Keri Allan, Varysian Senior Content Manager

Dr Arlene Laing presents

Varysian supports WMO RA IV 45th Hurricane Committee Meeting

Nurturing public private engagement

Varysian had the pleasure of supporting the WMO RA IV 45th Hurricane Committee meeting, held in San José, Costa Rica this March. This was the committee's first face-to-face meeting since 2019.

The committee's function is to coordinate and improve forecasting capacity and issuing of hurricane warnings, therefore reducing loss of life and property in RA IV.

Meeting annually, the event's main goal is to review and update the operational plans for the upcoming hurricane season.

This latest meeting took place over five days, and consisted of high-level talks and presentations between stakeholders including NMHSs and regional NGOs and IGOs.

Key topics

Attended by over 100 delegates from across the public sector, key topics of discussion at the meeting included:

- Annual review of the Operational Plan on Hurricanes and the Tropical Cyclone Program
- Improving facilities and procedures in order to have effective and efficient early warning systems
- Impact-based forecasting
- The need for countries affected by tropical cyclones to continue collaborating and redoubling their efforts to reduce human and material losses
- Accelerated modalities of action for small island developing states (Samoa Pathway)
- Coordinating the operational procedures for forecasting and warning of tropical cyclones
- Promoting cooperation between the WMO and other international organisations regarding preparedness and prevention of disasters by tropical cyclones

The committee made the decision to retire Fiona and Ian from the rotating lists of Atlantic tropical cyclone names because of the death and destruction they caused in Central America, the Caribbean, the United States and Canada. Farrah will be used to replace Fiona in the lists of names, whilst Idris will replace Ian.

The meeting also focused heavily on Early Warnings for All (EW4ALL, see page 007)– the UN's global early warning initiative for the implementation of climate adaptation, which was announced at COP27.

Varysian was invited to organise a private sector exhibition for the event. This showcased advancements in technology to support the development of early warning systems in the region.

Eight key organisations participated in the exhibition, and the private sector delegates were also invited to participate in a number of sessions in order to offer an insight into the technology required to achieve the stakeholders' goals.

This also provided them a great opportunity to gain a better understanding of RA IV's key challenges.

The next RA IV Hurricane Committee meeting will take place in Panama in 2024.

Author: Keri Allan, Varysian Senior Content Manager

HydrometLATAM

Capacity building in South America

Last December, Varysian hosted HydrometLATAM 2022; a three-day technical symposium that brought together approximately 70 key professionals from across the public, private and academic sectors.

Taking place in Buenos Aires, Argentina, the aim of this event was to create an opportunity for WMO RA III NMHS technical managers to discuss the challenges and potential solutions around capacity building in South America, particularly in the areas of operations, technology and science and research.

Main challenges for South American NMHSs

Attendees cited the biggest challenges RA III NMHS's face as:

- Having an adequate vision, mission and developed plan
- Being able to deliver high quality and timely services and products
- Having full knowledge of critical success factors
- Knowing, understanding and satisfying all of their stakeholders' needs

From a technology standpoint, the following were called out as key technological requirements for capacity building:

- Knowledge of the latest technologies available
- Empowering technical managers and providing them with the required resources
- Knowledge and experience sharing between the public and private sectors
- Linking project development with sustainability

The symposium was split into a variety of sessions including presentations, panels, innovation talks and round tables, which created opportunities to share experiences and ideas, as well as nurture potential partnerships both between regional NMHSs and the public and private sector.

This was encouraged through the event's exhibition area, where technical managers were given the opportunity to network with representatives from leading hydrometeorological equipment and services providers.

Varysian CEO Tom Copping welcomes delegates to HydrometLATAM

The future of South American NMHSs

Renowned speakers participated in the event, including the incoming Secretary-General of the WMO, Dr Celeste Saulo, who discussed the short and medium-term future of South American NMHSs.

Conclusions from her session, and the linking round table, included that many climate observations are currently underexploited due to a lack of consistency in their processes, interoperability and useability, and that more training was required on the available observation systems in order to highlight, predict, mitigate and adapt to changes in the climate system.

The need to develop "service-oriented science" was discussed, in order to provide value-added services that will support local economies, as well as the need for NMHSs to have access to state-of-the-art technology in order to develop their impact-based forecasting and comply with the Early Warnings for All initiative (See page 007).

Finally, discussions revolved around enabling capacity building through strategic alliances, which could be inter-institutional, inter-regional, international or inter-sectorial in nature.

Technical advances

Dr Diego Oliveira de Souza, CEMADEN Situation Room Technologist, took to the stage for his presentation entitled 'Hydrometeorological and environmental monitoring systems' technological advances, control systems and data processing, and new technologies'.

He stated that it's important for NMHS staff, and in particular technical managers, to know about the latest technical innovations, especially as these may support NMHS capacity building and help to introduce operational efficiencies.

He also discussed that staff needn't fear for their jobs, as automation will only be there to support, rather than replace, and that when considering the purchase of new equipment, it's imperative that technical managers and their colleagues consider monitoring and maintenance costs.

Quality management systems and their impact on technical managers

Another session, run by Dr Guillermo Navarro and Dr Marco Erize – international experts in the implementation of quality management systems (QMS) – discussed QMS and their impact on technical managers.

The speakers highlighted the benefits of QMS, noting that they can help to keep employees motivated and strengthen relationships between stakeholders, as well as ensure the NMHS is able to fulfil all its customers' needs by optimising efficiencies.

They also directed attendees to look at the WMO's Guide to the Implementation of QMS for NMHS and Other Relevant Service Providers.

Economics

The event also looked at Latin American NMHSs' need for significant investment in order to provide timely, reliable and accurate forecasts of severe weather events.

Ricardo Aguilar (left), Sales director for LATAM and the Caribbean, Campbell Scientific deep in discussion at the HydrometLATAM exhibition

Technical managers from across LATAM

Therefore, it's imperative that they can calculate the economic and social value of their services in order to gain access to more funding.

Furthermore, having a strong understanding of the economics of any given project will help technical managers to optimise their use of resources and ensure cost efficiency.

Conclusions pointed to NMHSs in low and middle-income countries benefiting from incorporating their plans into those of national development, poverty reduction and climate adaptation plans.

The role of technical managers

Technical managers are well placed to help structure development plans, but a key part of their role also lies in ensuring compliance with WMO guidelines, as well optimising the exchange of knowledge, experiences and good practice in the technical field.

This topic was broached in a presentation by Dr Elian Wolfram, Director of Observation Networks of the National Meteorological Service of Argentina, and during a later roundtable session.

These covered a number of topics, including the importance of NMHSs complying with WMO programmes like observation networks criteria, the WMO Integrated Global Observing System (WIGOS), the Global Basic Observing Network (GBON) and the Observing Systems Capability Analysis and Review (OSCAR).

Discussions highlighted that technical managers' role in this was to ensure data traceability and quality – the latter through meta data management, calibration and adequate instrumentation, as well as integrating partners' data networks when necessary.

These challenges could be overcome by the use of multi-disciplined team and systems thinking tools, as well as improving technical managers' ability to deal with environments where the only constant is change.

Varysian would like to thank everyone who made HydrometLATAM possible; from those involved in the planning sessions through to the speakers, moderators, sponsors and attendees. We truly appreciate your support.

Author: Keri Allan, Varysian Senior Content Manager

Strength and solidarity in the Pacific

Progressing resilience to extreme climate and weather events in Fiji at the PMC-6

On 13-15 August, the Secretariat of the Pacific Regional Environment Programme (SPREP), Government of Fiji and the World Meteorological Organisation (WMO) co-hosted the Sixth Meeting of the Pacific Meteorological Council (PMC-6) in Nadi, Fiji.

Bringing together heads of the Pacific national meteorological and hydrological services (NMHSs) to deliberate across three days, the PMC-6 led into the donor round table on 16 August and the Third Pacific Meteorological Ministers Meeting on 17 August.

The Pacific Meteorological Council (PMC) serves as a specialised subsidiary body of the SPREP meeting, responsible for facilitating and coordinating the scientific and technical and activities of the regional hydrological and meteorological services. The sixth PMC meeting encompassed an examination of strategic issues on a national and regional scale, with over 200 delegates present over the five days.

The PMC-6 also brought together the national disaster management office directors from across the Pacific, civil society and development partners. The private sector was also present throughout the week, as Varysian partnered with the co-hosts to organise a technical exhibition and expert panels. This was a vital part of the event in terms of public-private partnerships (PPPs).

On the last day of the meeting, ministers responsible for meteorology also joined, in order to be briefed on the role of NMHSs and their contributions to both national and regional safety and sustainable development through the provision of weather, climate, hydrology, ocean and related services.

PMC-6 goals

The goal of the PMC-6 was to serve as a platform for discussing strategic matters of significance in the region. Key topics of focus included updates on the progress made in implementing the *Nuku'alofa Ministerial Declaration*, which pertains to sustainable weather and climate services

Varysian CEO Tom Copping with Ben Churchill, WMO Regional Office Director for Asia and the South-West Pacific

for a resilient Pacific, as well as the *Honiara Ministerial Statement* on sustainable weather, climate, oceans and water for a resilient Pacific.

Emphasis was placed on utilising the gathering of high-level delegates to discuss developing services to ensure the safety and wellbeing of Pacific communities. Special attention was given to the Weather Ready Pacific Programme of Investment, a ten-year programme to strengthen the Pacific region's ability to anticipate, plan for, and respond to high impact and extreme weather, water, and ocean events.

PMC-6 outcomes

Improved crop resilience for the people of Vanuatu

Ms Moirah Mato, Project Manager for the Vanuatu Klaemet Infomesen blong Redi, Adapt mo Protekt, (VanKIRAP) project introduced a new tailor-made tool which gives the people of Vanuatu the ability to make informed decisions to improve crop resilience based on what is happening in the local climate. Vanuatu is the first country to use the *WMO's Observing Systems Capability Analysis and Review tool (OSCAR)* in the Pacific.

Taking into account technical expertise

On day three of PMC-6, ten private sector organisations showcased their work and products during an exhibition event organised by Varysian in partnership with the event hosts.

This exhibition was an opportunity for the private sector to build relationships and network with members of the PMC, as well as to understand the unique challenges and threats the Pacific region and its people increasingly face.

Representatives from ten companies flew in from around the globe to be at PMC-6, some bringing examples of their technology, visualisations and technical information for attendees to interact with.

The technologies presented ranged from weather radars and automatic weather stations to rain gauges, software and more, it provided the PMC members a tangible idea of how technological challenges and gaps within their meteorological services can be remedied.

Varysian also arranged for a side event which consisted of a panel of private sector representatives.

Panellists discussed successful examples of weather information PPPs from other regions, and how their experiences could be applied to the Pacific Island context as well as benefits of private sector involvement in weather information provision.

Financing models and funding mechanisms

Also discussed were potential financial models and funding mechanisms that can be employed to sustain weather

L-R: Sefanaia Nawadra, Director General of SPREP, Bipen Prakash, Chair of PMC-6, and Petteri Taalas, Secretary General, WMO.

information PPPs in the long term, as well as shared experiences of how met service clients have reached their audience (public, media, ministers, etc.) specifically when discussing early action and preventive measures.

It was an opportunity for attendees of the PMC-6 to ask the panel questions and share experiences, working towards the improvement of public-private partnerships.

Varysian's Managing Director, Luke Pierce, right

Raising awareness of gender, disability and the vulnerable during disasters

Members of the PMC-6 were urged to remember the needs of people with disabilities in their work to protect members of Pacific communities from all hazards.

The message from the Pacific Disability Forum (PDF) was voiced by Ms Litia Naitanui of Fiji, who reminded the Council that in times of disasters, the needs of people with disability are often ignored, resulting in many individuals being left behind, or becoming vulnerable to extreme weather impacts.

The need for a more inclusive and thoughtful approach to early warning alerts and processes was highlighted, for example, taking into account those who are sight or hearing impaired, as well as accommodating wheelchair users in evacuation centres.

One presentation highlighted the leadership value of women during extreme climatic events but also the challenges and expectations they face post-disaster, which was a poignant topic, considering that more women than ever were present at the PMC-6 than any preceding meeting.

This reflected the PMC's mission to improve the gender balance within meteorological services and introduce more women and girls to the world of science and technology.

Weather Ready Pacific

Developed as a result of a call from the PMC, the Weather Ready Pacific Decadal programme of Investment (WRP) was developed as a critical part of the Pacific's response to predictions of more intense tropical cyclones, increased heat stress, extreme rainfalls, storm surges, droughts, sea level rise and marine heatwaves.

WRP has a goal of US$167 million for ten years to implement the work, with the Government of Australia providing initial funding support of AU $30 million.

As NMHSs strive to improve their services, critical gaps remain in areas such as observation networks, governance, computing, communications, forecasting and training. This sustained sequence of investment is designed to provide a collaborative regional approach to address these issues. It also aims to reduce the economic and human cost of extreme climate events, to protect livelihoods and lives.

During the event, a proposed roadmap for the next steps in the programme were *presented and discussed among the members*, with plans for further review and discussion on how to best move forward.

Moving forward

The PMC-6 and related meetings were an opportunity to call for further support from governments, development partners and donors to ensure that NMHSs in the Pacific have the necessary capacity to support sustainable and resilient development.

The event ended on a high note, with the future safety of the Pacific islands relying on programmes such as the WRP programme as well as a sense of solidarity and unity, something encouraged by Mr Sefanaia Nawadra, Director General of SPREP, who had strong messages of togetherness in his closing speech.

The PMC was duly officially closed by Bipen Prakash, Acting Head of the Fiji Meteorological Service with Vanuatu hosting the next meeting (PMC-7) in 2024.

Author: Katie Barkans, Operations Manager, Varysian

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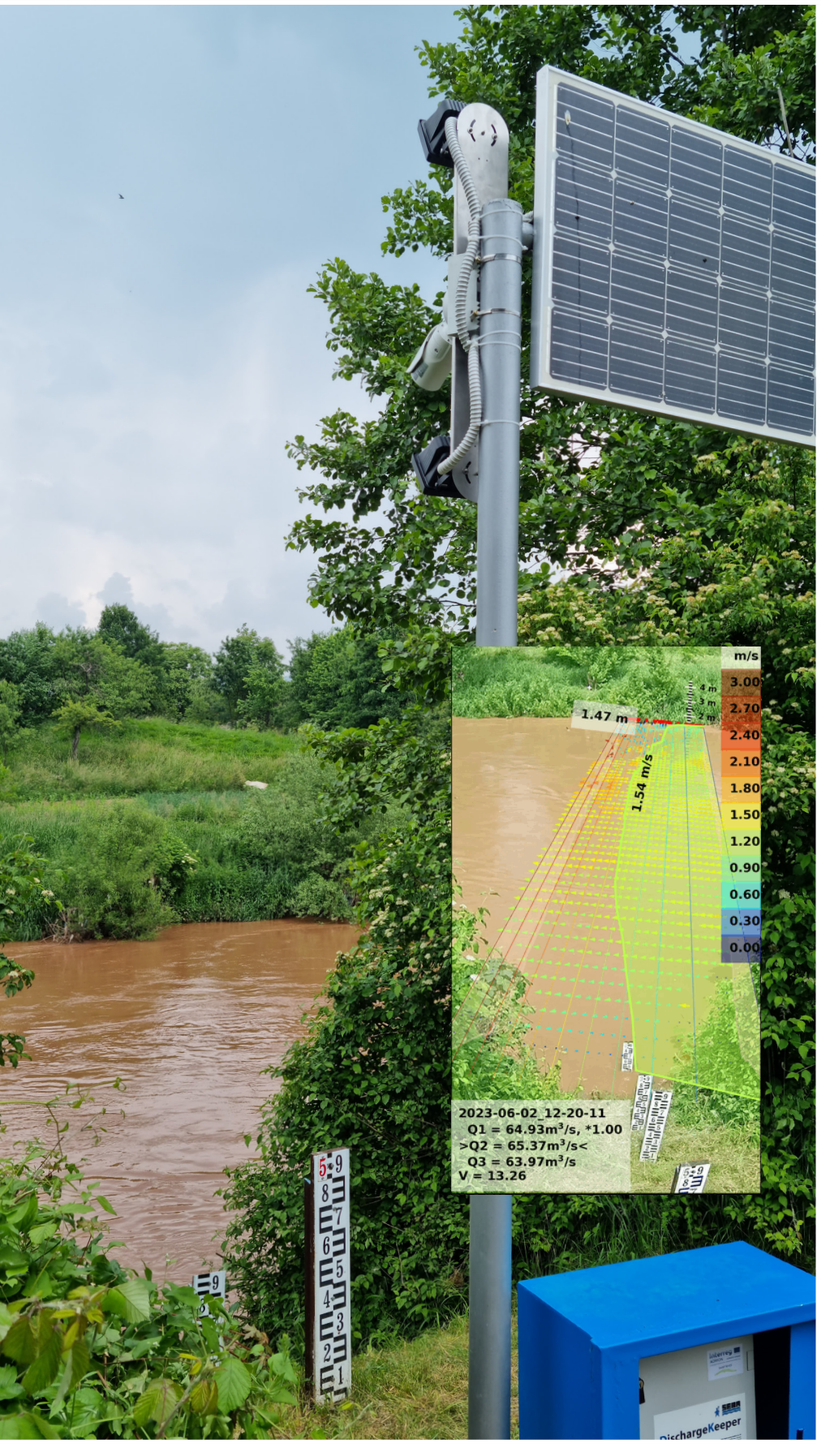

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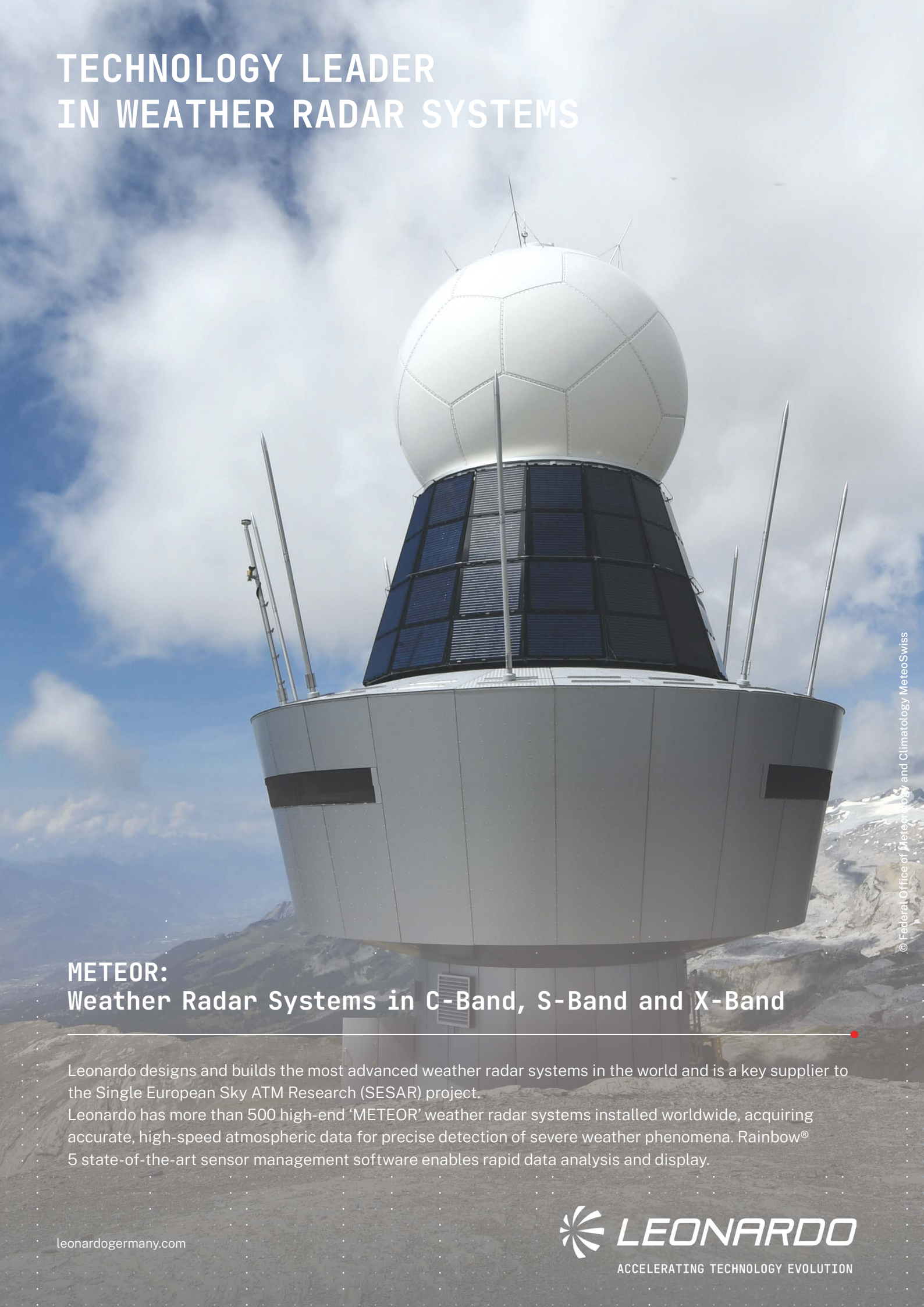

METEOR:
Weather Radar Systems in C-Band, S-Band and X-Band

Leonardo designs and builds the most advanced weather radar systems in the world and is a key supplier to the Single European Sky ATM Research (SESAR) project.
Leonardo has more than 500 high-end 'METEOR' weather radar systems installed worldwide, acquiring accurate, high-speed atmospheric data for precise detection of severe weather phenomena. Rainbow® 5 state-of-the-art sensor management software enables rapid data analysis and display.

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