The VARYSIAN Guide

2025

A reference guide for capacity building and industry solutions in hydrometeorology

Contents

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Foreword

From the Editor

Until recently, conversations around global hydromet investment were largely driven by the Global North, with decision-making power and narratives often centred there. But thankfully, this is beginning to change.

From WIS 2.0 and SOFF to the growing visibility of regional voices, we are beginning to see momentum shift. Solutions are increasingly being designed not for NMHSs, but with them—taking into account local context, language and infrastructure. This edition of the Varysian Guide highlights that evolution and the growing impact of collaborative, open and sustainable approaches to strengthening weather and climate services.

We take a close look at the progress of Early Warnings for All, as well as WMO-backed training programmes that are equipping NMHSs across Africa, Latin America and the Pacific with the skills needed to operationalise WIS 2.0 (page 006). There are stories of innovation—from Zimbabwe's 3D-printed AWS components (page 028) through to regional collaboration on data sharing and open-source tools (page 018).

It's also clear that the future of hydromet isn't just about infrastructure — it's about people. We explore how locally rooted initiatives are helping bridge the gap between science and society, such as Sudan's use of traditional knowledge in early warning systems (page 034), and a fascinating look at how local weather phenomenon can shape community resilience (pages 036 and 044).

As always, this issue brings together insights from the public, private and academic sectors. From AI to lightning detection, policy to procurement, we hope it sparks new thinking and conversations about what's possible when we truly invest in systems that work—for everyone.

If there's something you'd like to see in a future issue, or if you'd like to connect with the Varysian team, our details are on page 003.

Thank you for reading, we put our all into this magazine and we hope you enjoy reading it.

Keri Allan
Head of Content, Varysian

Initiatives 01

+ community.wmo.int/en/activity-areas/wis/WIS2-overview + Initiatives

Building digital capabilities

WIS 2.0 open-source software and training

The World Meteorological Organization (WMO) Information System 2.0 (WIS 2.0) marks a fundamental shift in global weather data sharing. Built on modern web technologies and open standards, it makes data exchange more accessible and affordable for all WMO Members, while ensuring reliability and security. The system represents a crucial transition from the traditional global telecommunication system (GTS) to a cloud-ready, internet-based solution for the 21st century.

This evolution addresses long-standing challenges faced by many national meteorological and hydrological services (NMHSs) in accessing and sharing weather data, particularly those in developing regions.

The power of open-source software: WIS2 in a box

WIS2 in a box (wis2box) stands at the core of the WIS 2.0 implementation as an open-source reference implementation of a WIS 2.0 node. Specifically designed for developing countries, least developed countries (LDCs) and small island developing states (SIDS), wis2box provides a cost-effective and low-barrier entry point for data exchange on WIS 2.0, while implementing best practices in modern web technologies. It also serves as a learning platform to introduce how free and open-source software can enable community-driven development in support of sustainable software and products for users.

Released under the Apache 2.0 license, wis2box creates opportunities for both NMHSs and industry to freely use, modify and build upon. The software includes comprehensive documentation, configuration examples and monitoring tools that help users operate their WIS 2.0 nodes effectively, as well as data conversion tools to transform data into a WMO compliant format before publication.

All images are from last September's Latin America WIS2 training workshop hosted by the Instituto Nacional de Meteorologia (NMET)

The license ensures that the software remains freely available, while allowing commercial companies to create value-added services and support packages, fostering a sustainable ecosystem around WIS 2.0 implementation.

The development of wis2box reflects a deep understanding of the challenges faced by meteorological services in resource-constrained environments. Its design prioritises ease of deployment and maintenance, and minimal infrastructure requirements. These characteristics make it particularly suitable for organisations that may have limited IT resources or technical expertise.

The software uses containerisation technology to simplify deployment and maintenance, allowing NMHSs to run their WIS 2.0 node either on local servers or in cloud environments. This flexibility is particularly important for organisations transitioning from traditional on-premises infrastructure to modern cloud-based solutions.

Wis2box incorporates standard open-source components that are widely used in the technology industry as well as the geospatial domain, giving NMHSs experience with tools and practices that can benefit their broader IT operations.

Wis2box's open-source nature enables a collaborative approach to improvement and problem-solving. Users can share their experiences, contribute improvements and help identify and fix issues. This community-driven development model has already led to several enhancements based on real-world implementation experiences in different regions.

The software serves not only as a technical solution but also as a practical example of how open-source development can help international organisations achieve their goals more effectively.

Building digital skills through hands-on training

The WIS 2.0 training program empowers NMHS staff with vital digital skills through a carefully structured approach. Via intensive five-day workshops, participants gain hands-on experience with cloud computing, Internet of Things (IoT) protocols, web application programming interfaces (APIs) and real-time data exchange. Participants learn how to setup a WIS2 node, configure datasets, publish data notifications and download data published by other nodes in the network.

The training covers essential operational tasks such as monitoring the frequency and quality of the data being published, troubleshooting issues with data conversion and how to secure the operational environment.

During training sessions, each participant accesses a virtual machine to setup their own WIS2 node within the local training network. This provides a safe and isolated learning environment in which to gain practical experience working with MQTT and the WIS2 standards. Participants practice installing and configuring their WIS 2 node using wis2box, gaining practical experience with the technologies that will be used in their operational systems.

This hands-on approach has proven remarkably effective, with 80% of participating members successfully implementing WIS 2.0 nodes after training. The practical experience builds confidence and competence, preparing staff to independently manage their WIS 2.0 infrastructure in their home institution.

To ensure sustainable implementation, the training program uses a 'portable cloud' system that can be deployed in locations with minimal IT infrastructure requirements. This innovative approach allows each participant to work in a complete yet safe environment, experimenting with the full range of WIS 2.0 technologies without risk to operational systems.

Global impact and community building

The training program has achieved remarkable scale and impact in just two years. Starting in March 2023 with a workshop in Windhoek, Namibia that served 11 Southern African countries, the program quickly expanded.

A session in Port of Spain brought together 15 Caribbean nations, while a Jakarta workshop reached 13 Asian and Pacific countries. The momentum continued through 2024 with sessions in Brasilia delivering training in Spanish to 15 Latin American countries, Fiji reaching 16 Pacific Region nations, and Casablanca providing French-language instruction to 22 Western African countries.

In total, over 90 countries have participated in WIS 2.0 training workshops. The program particularly emphasises supporting LDC and SIDS, ensuring comprehensive global participation in weather data exchange. Many participating countries have already implemented operational WIS 2.0 nodes, demonstrating the practical impact of the training program.

Delivering training in participants' native languages has proven crucial for the program's success. With workshops already established in English, Spanish and French, the program is expanding to include training in Portuguese and Russian. This language-focused approach ensures that technical concepts are clearly understood and that participants can fully engage in hands-on exercises.

Complete documentation is available at docs.wis2box.wis.wmo.int, while training materials and resources can be accessed at training.wis2box.wis.wmo.int.

For more information about WIS 2.0 training opportunities and open-source software, please contact wis@wmo.int.

The shared language creates lasting regional communities where professionals can collaborate and support each other effectively, leading to more efficient knowledge sharing and problem-solving. The regional alignment has sparked innovative solutions, including shared WIS 2.0 nodes where multiple countries collaborate on infrastructure and operations.

Driving digital transformation

Beyond implementing WIS 2.0, the training program drives broader technological advancement within NMHSs. Participants learn to work with cloud-ready services, manage containerised applications, and implement automated data exchange systems. These skills extend beyond WIS 2.0, enabling modernisation of other meteorological operations. Many participants report applying their new knowledge to improve other aspects of their services, from data management to system administration.

The training program's impact extends beyond technical skills. It helps create a culture of innovation and continuous learning within meteorological services.

Participants gain confidence in working with modern technologies and become advocates for digital transformation within their organisations. This cultural shift is particularly significant in organisations that have traditionally relied on manual processes and legacy systems.

The program demonstrates how targeted training combined with open-source tools can accelerate digital transformation. Many participating NMHSs have moved from manual data handling to automated, cloud-based solutions, significantly improving their operational capabilities.

The success of the training program continues to drive WIS 2.0 adoption across WMO members, building momentum for the global transition from GTS to WIS 2.0.

Planning is already underway for additional training workshops in 2025, with a focus on reaching more countries and providing advanced training for existing WIS 2.0 operators. The program will continue to evolve based on participant feedback and emerging technological needs. Future workshops will maintain the emphasis on hands-on learning while incorporating new tools and best practices as they emerge.

By combining practical training, open-source software and community development, the WIS 2.0 training program isn't just implementing a new data sharing system – it's building the digital future and driving digital transformation of meteorological services worldwide.

Authors: Tom Kralidis from the Meteorological Service Canada and Enrico Fucile, Maaike Limper and David Berry from the WMO

Building momentum towards Early Warnings for All

Updates from the Climate Risks and Early Warning Systems (CREWS) initiative

The Climate Risks and Early Warning Systems (CREWS) initiative is gaining momentum by harnessing the growing commitment of national governments and regional agencies while actively pursuing new opportunities to promote people-centered multi-hazard early warning systems (MHEWS). This momentum is driving a steady expansion in the scope and scale of CREWS' efforts.

As of November 2024, the initiative has consolidated a portfolio of 26 projects including four newly launched projects: Caribbean phase 2, Djibouti, Niger phase 2 and Early Warning for All (EW4A) multi-country. Six additional projects are currently under full proposal development, namely Papua New Guinea + (Drought Regional Programme), Pacific phase 3, South Asia, Benin, West Africa phase 3 and Dominican Republic.

This growth is also reflected in increased funding contributions, made possible by the renewed support of members: Australia, Austria, Canada, Finland, France, Germany, Luxembourg, Monaco, Netherlands, Norway, Switzerland and the UK. This is in addition to the engagement of new members: Austria, Monaco and Norway.

Measuring impact

CREWS consistently advocates for and implements a people-centered and gender-responsive approach to early warning systems (EWS). Its monitoring, evaluation, accountability and learning (MEAL) framework was developed to collect data on project implementation and measure the impact at both project and portfolio level. It also monitors progress towards the initiative's objective of reducing deaths and economic losses caused by climate hazards, while contributing to global agreements such as the Sendai Framework, the Paris Agreement and Sustainable Development Goals (SDGs).

Reaching the most fragile communities

According to the World Bank, almost a third (24) of the 81 countries where CREWS is currently implementing projects are countries affected by social and institutional fragility and conflicts. Despite the extra risks associated with these contexts, CREWS projects have continued to be implemented. In Haiti, for example, where security concerns prevent project managers leaving their homes, the CREWS project is delivering its expected outcomes thanks to flexible funding arrangements and a strategic partnership with UNDP to support community engagement.

In Sudan, planned activities were interrupted to prioritise the development of a rescue plan in collaboration with the Sudan Meteorological Agency (SMA).

Schoolgirls wade through flooded dirt roads on their way to school in the Sahel region due to climate change.

This restored and augmented weather and climate services and simultaneously contributed to humanitarian action. These examples highlight CREWS' commitment to sustaining and strengthening its operations and results across its portfolio. In line with this, CREWS is currently developing operational procedures for fragile, conflict-affected countries to better mitigate risks, anticipate future crises and streamline its efforts in these challenging contexts.

A peek into the future

During the initial discussions on the direction of CREWS post-2025 at the 19th Steering Committee Meeting, contributing members expressed a desire to be more ambitious, and help countries establish and enhance people-centered, risk-informed MHEWS.

The outcome of this discussion was to initialise the next phase of CREWS strategy, which will cover up to 2030. This is currently under development, and will address six key building blocks: scope, operational modalities, policy alignment, strategic partnership, scale of ambition and sustainability.

Authors: Programme Officer Maria Lourdes Kathleen Macasil and Assistant Project Officer Chiara Ditonno, from the CREWS secretariat, WMO

SOFF in action

A systematic observation partnership to close the basic weather and climate data gap

The Systematic Observations Financing Facility (SOFF) is a specialised United Nations climate fund, which supports developing countries to accelerate the sustained collection and international exchange of the most essential surface-based weather and climate observations. This is in compliance with the internationally agreed Global Observing Basic Network (GBON), which became mandatory as of January 2023.

SOFF is putting an initial focus on small island developing states (SIDS) and least developed countries (LDCs), as only eight percent of their mandatory surface land stations, and 13 percent of upper air stations, are compliant with GBON.

For example, the 39 fragile and conflict-affected states (FCS) have only seven surface stations in total that report accordingly. In fact, Germany has more reporting surface stations than the whole African continent.

A new partnership with developing countries

Investments in systematic observation are needed most in regions where they matter the most – developing countries. Collecting basic weather and climate data in these regions generates substantial socio-economic benefits for the entire globe, including for the most advanced economies, and therefore has to be valued as a global public good.

This calls for a new systematic observation partnership with developing countries, built on equal footing and recognising the crucially important contributions of these countries to the global observing system.

SOFF operates at speed and scale

As of March 2025, 61 countries have had readiness funding approved. Of those, 15 countries are receiving investment funding approved for a total budget of US$ 91 million to close the GBON gap. This support includes 184 surface stations and 36 upper air stations in the 15 countries. The SOFF Action Report 2024 summarises successes to date.

SOFF fosters a community for effective long-term support

According to partners, in addition to the financial support, one of the greatest achievements of SOFF implementation to date is the communities of practice SOFF managed to create.

SOFF countries, peer advisors and implementing entities have created a great momentum and enthusiasm to achieve the joint goal. In 2024, the SOFF Secretariat organised regional workshops and partner meetings bringing together partners to share experiences and discuss common challenges and solutions.

This community now offers a great resource to countries as well as the World Meteorological Organization (WMO) to provide both technical and operational knowledge on achieving GBON compliance.

To further cultivate this community of practice, the SOFF Secretariat has developed the SOFF Learning Portal for peer advisors. Additionally, several webinars have been conducted in collaboration with WMO, about the WMO Information System (WIS) 2.0 (see page eight) as well as maintenance and calibration of meteorological instruments.

These sessions featured experts from the WMO Commission for Observation, Infrastructure and Information Systems (INFCOM), who shared their knowledge and experiences for peer advisors and implementing entities.

At the 29th UN Climate Change Conference (COP29), the WMO Secretary-General Celeste Saulo signed an agreement on collaboration on behalf of SOFF with the Weather Ready Pacific Programme (WRPP) to bolster this partnership aiming to strengthen the entire meteorological value chain.

Further information is available on the SOFF website or by emailing the SOFF Secretariat.

Authors: Ana Heureux, Programme Management Officer, Pauline Trepczyk, Advocacy and Communications, and Zulkarnain Zulkarnain, Scientific Programme Officer at the SOFF Secretariat

James Kinyangi of the AfDB, and Ana Heureux and Serena Odianose from the SOFF Secretariat, speaking at a regional workshop in Abidjan, Cote d'Ivoire.

The role of the private sector in SOFF implementation
The private sector plays a critical role in achieving the SOFF objectives and supporting countries in becoming GBON compliant.

SOFF implementation provides an opportunity to explore various options of public-private partnerships and identify the best solution for the country.

To adjust to varying needs of countries, SOFF is collaborating with the Association of the Hydro-Meteorological Industry (HMEI) to jointly support the promotion of optimal technological solutions for the implementation of GBON in SOFF countries. NMHSs in developing countries currently face several challenges, including limited financial incentives, issues with data ownership and accessibility, and a lack of awareness about successful support models like data as a service by the private sector which has been implemented in other countries already successfully.

The table on the right provides an overview of planned investments financed by SOFF.

Country	Planned new Upper air station	Planned new Surface station	IE	Peer advisor	Amount Approved (USD)
Belize	0	0	IDB	United Kingdom	864,543
Bhutan	1	0	UNEP	Finland	4,624,024
Cabo Verde	0	1	UNEP	Netherlands	3,879,118
Chad	3	6	WFP	Austria	6,980,084
Ethiopia	3	13	UNDP	Norway	9,956,803
Kiribati	2	0	UNEP	Australia	11,155,102
Madagascar	1	2	UNDP	Germany	4,914,296
Maldives	0	1	UNEP	Finland	4,907,326
Mozambique	4	6	WFP	South Africa	7,892,560
Rwanda	1	0	UNDP	Finland	3,535,377
Solomon Islands	3	0	UNDP	Australia	8,488,524
South Sudan	3	11	tbc	Austria	2,480,496
Timor-Leste	1	0	UNEP	Finland	5,756,742
Uganda	1	0	IsDB	Netherlands	6,316,536
United Republic of Tanzania	4	9	UNDP	Denmark	9,067,504

L-R: Sefanaia Nawadra, Director General of the Secretariat of the Pacific Regional Environmental Programme (SPREP), Celeste Saulo, WMO Secretary-General World Meteorological Organisation and Co-Chair of the SOFF Steering Committee, and Misaeli Funaki, Director of the Fiji Meteorological Service and Chair of the WRPP Steering Committee sign a Memorandum of Understanding.

WMO launches study group on environmental sustainability

WMO moves to take action on environmental sustainability of weather and climate observations

In 2000, Nobel Prize recipient and atmospheric chemist Paul J. Crutzen coined the term 'Anthropocene' to refer to a time when human activities are capable of modifying the environment on all scales and even outcompeting natural processes.

In today's modern world we see evidence of this new period in the Earth's history characterised by increasing greenhouse gas emissions, demand on natural resources and a changing climate.

As scientists and government officials, we have an obligation to minimise the impacts of our work on the environment and to advance sustainable practices in all aspects of our work that enhance the resilience and the well-being of our rapidly changing planet.

At the same time, we must recognise that earth system observations, and the systems by which they are collected, are critical to our understanding of the natural world.

Until recently, the environmental impacts of our observing systems have not been a significant consideration in our plans and operations; yet, as we strive to meet today's needs, we must not prevent future generations from meeting theirs.

It is with increasing awareness of this stewardship responsibility that the World Meteorological Organization (WMO) has committed to an environmentally sustainable approach to weather and climate observing systems and has included it as a key objective in the 2024-2027 WMO Strategic Plan.

Study group on environmental sustainability

To carry out this ambitious commitment, a decision was endorsed by the WMO Commission for Observations, Infrastructure and Information Systems (INFCOM) to establish a Study Group on Environmental Sustainability (SG-EnvS) in April 2024.

This new group will build upon earlier work led by the WMO International Focal Point (FP) on environmental sustainability of observing systems and methods. The FP role was established in 2021 when WMO first officially recognised the importance of environmental sustainability.

The SG-EnvS has been established to develop proposals and recommendations to minimise the impacts of observing system operations by WMO Members without risking the services they provide and to facilitate a coordinated approach throughout INFCOM.

The group is tasked with delivering:

- A roadmap to address WMO environmental sustainability
- Communication of best practices
- Dissemination of best practices to members to reduce the environmental impact of INFCOM operations

Why now?

To make a lasting change and safeguard the responsible use of the natural environment, the WMO must lead by example. Not only is it the right thing to do and our responsibility to minimise our impact, but the public demands it.

Environmental stewardship is everywhere in the news, and major organisations across the globe are being asked about our actions and our impacts by funding agencies, program offices, regulatory offices and stakeholders.

In the US, the National Science Foundation requires the environmental impacts associated with proposed activities be considered prior to making an award. The European Research Council requires an ethics self-assessment that includes adverse impacts to the environment. The UK Research & Innovation Responsible Business Statements lists environmental responsibility as one of the four priority areas.

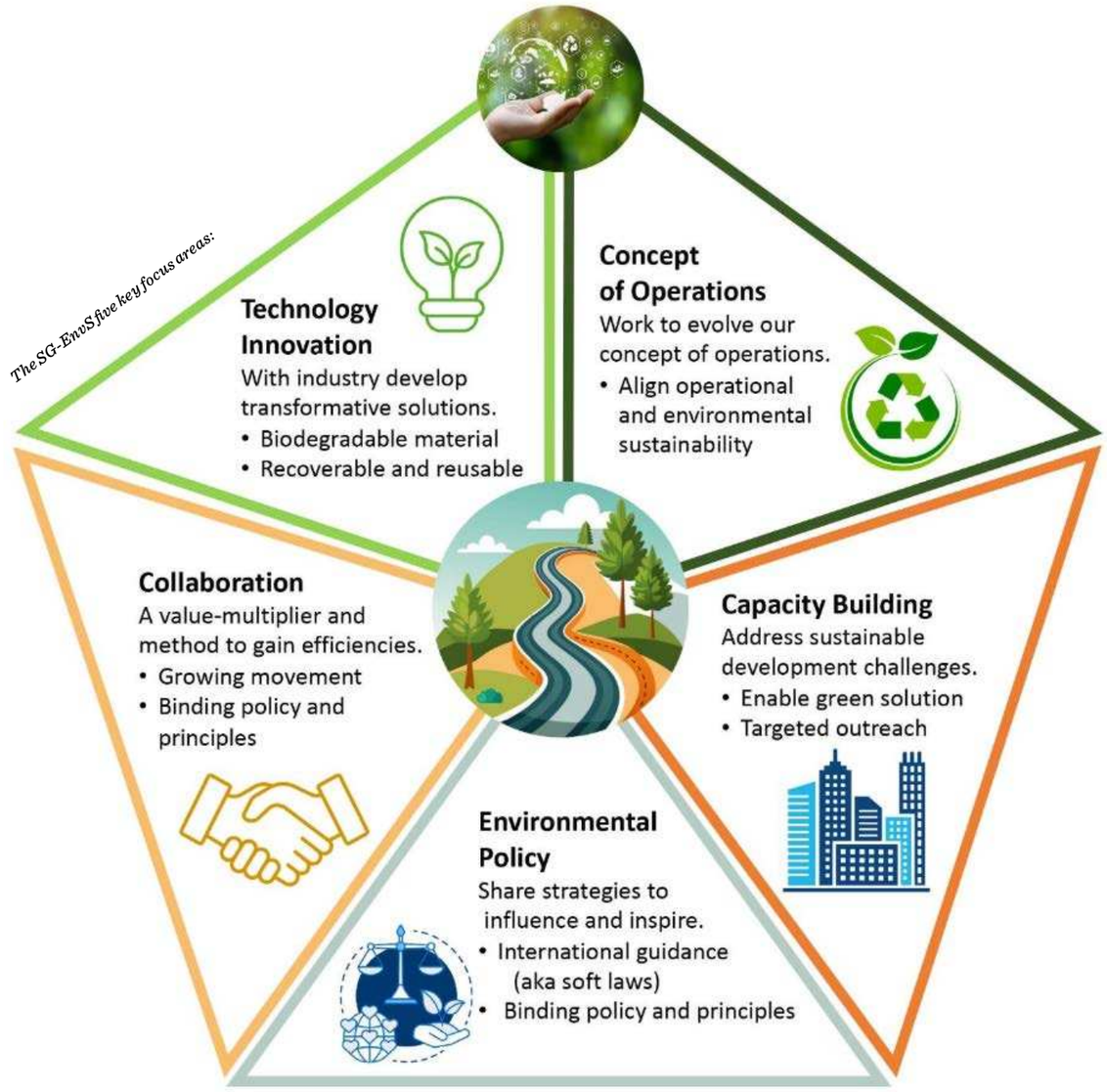
To meet these demands and reduce our impact we must adopt a comprehensive approach. The WMO/INFCOM are committed to developing and adopting cost-effective and environmentally sustainable technologies and promoting awareness within the international weather and climate observing community.

This has included workshops highlighting technical advancements at the Technical Conference (TECO) in 2022, the Meteorological Technology World Expo (MTWE) in 2023, and a major international survey in 2022 and workshop (virtual) in 2023.

The new SG-EnvS mandate encompasses all aspects of Earth observations from program management and procurement, to technology, concept of operations and data management, to funding incentives and policy.

Looking ahead

The current mandate of the WMO and past experience are illuminating the path forward for SG-EnvS. Looking to the future, the roadmap for environmental sustainability of weather and climate observations and technologies includes five key focus areas: innovation, operations, policy, collaboration and capacity building.



Over the next two years, the SG-EnvS will emphasise best practices within each of these five focus areas through promotion and participation in workshops and conferences. It will oversee a coordinated approach across all INFCOM subsidiary bodies by enabling WMO Members to act and implement sustainable best practices for Earth observations in all Earth system domains.

The group will serve as a focal point for environmentally sustainable observations and liaise with other international organisations, such as the Intergovernmental Oceanographic Commission (IOC), Global Ocean Observing System (GOOS), United Nations Environment Programme (UNEP) and the Global Partnership on Plastic Pollution and Marine Litter (GPML) to mainstream environmental sustainability.

This collaborative path will inform Members about best practices and empower them to make choices based on lessons learned that can be tailored to their local needs.

Authors: Karen R. Grissom, National Oceanaic and Atmospheric Administration (NOAA) , Michael Earle, and Shannon Kaya, from Environment and Climate Change Canada (ECCC)

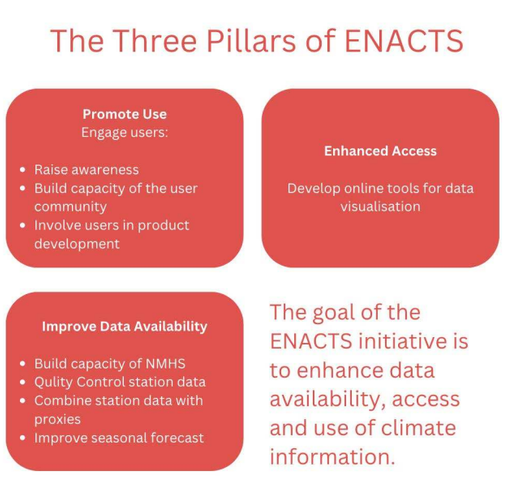
Tools for enhancing national climate services

Introducing the ENACTS initiative

Africa faces significant challenges in adapting to climate variability and change, partly due to limited access to reliable and actionable climate information. The Enhancing National Climate Services (ENACTS) initiative, led by the International Research Institute for Climate and Society (IRI) at Columbia Climate School, USA, addresses these gaps by improving the availability, accessibility and use of high-quality climate data.

Launched in Ethiopia in 2012, ENACTS has since been implemented in over 15 countries in Africa and five countries in Asia and South America.

ENACTS is an innovative approach that equips national meteorological and hydrological services (NMHSs) with powerful tools to enhance their capabilities. Key tools include the Climate Data Tool (CDT) and the Automatic Weather Station Data Tool (ADT).



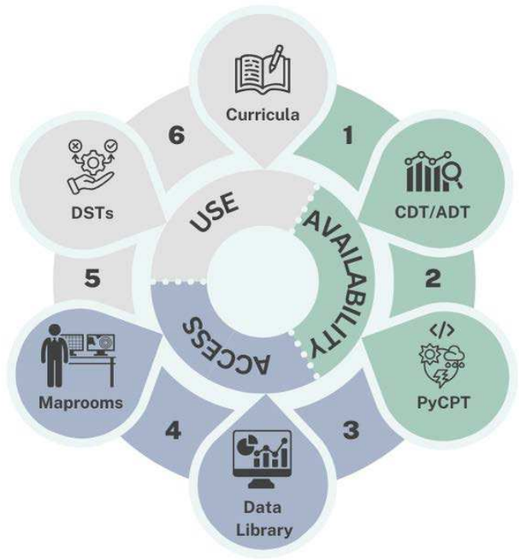
What is ENACTS?

ENACTS aims to transform climate services by addressing critical data and service gaps through a multi-faceted approach:

1 Improved climate data availability: ENACTS combines quality-controlled local weather station data with global datasets, such as satellite rainfall estimates and reanalysis temperature products. This integration fills spatial and temporal gaps, creating high-resolution (4km) datasets with coverage spanning decades (1981 to present). These datasets provide a solid foundation for developing decision-relevant climate information products.

2 User-friendly data access: The initiative develops online climate information portals, known as Maprooms. These platforms enable users to visualise, analyse and download climate data tailored to specific needs. Maprooms include products for past climate analysis, seasonal monitoring and flexible forecast formats, addressing sectoral requirements in agriculture, water, health and disaster risk management.

3 Capacity building and engagement: ENACTS invests in training NMHS staff to generate, interpret and disseminate climate products. A co-production approach ensures that products are developed collaboratively with end-users to address specific decision-making needs.



ENACTS tools used for the different components (pillars)

ENACTS tools

Many NHMSs do not have access to easy-to-use and freely available tools for performing the different ENACTS-related tasks. To bridge these gaps, ENACTS provides NMHSs with several powerful tools for the different activities.

These include the Climate Data Tool (CDT) for organisation, quality control, analysis and visualisation, the Automatic Weather Station (AWS) Data Tool (ADT) for organising data from different AWS systems, the PyCPT for seasonal and sub-seasonal forecasting, and IRI Data Library for developing online climate information products (maprooms).

The Climate Data Tool

The CDT is a free, open-source package created specifically for NHMS in Africa, which generally doesn't have access to data organisation and analytical tools for climate data. It has been evolving for over five years and has become a powerful and easy to use tool.

The main functionalities include:

- Organising station and proxy data
- Assessing data availability and quality
- Combining station observations with proxies (like satellite rainfall and reanalysis) to fill temporal and spatial gaps
- Evaluating gridded products, such as satellite and reanalysis datasets
- Extracting data from gridded products for specific locations, administrative boundaries, or regions
- Analysing and visualising station and gridded datasets

Beyond NMHSs, the CDT's versatility has drawn interest from regional institutions and universities, which are incorporating CDT training to equip students with robust data analysis skills for climate-sensitive sectors.

The Automatic Weather Station Data Tool

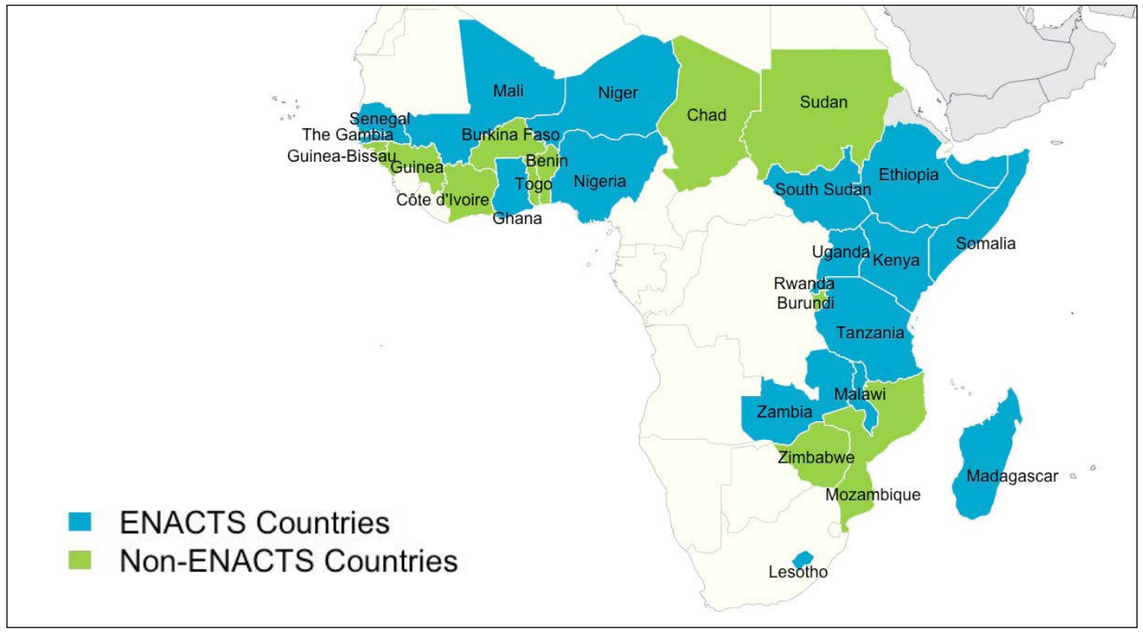
Automatic weather stations represent a critical advancement in meteorological monitoring, providing real-time data at fine temporal resolutions (every 15 minutes, for example). However, the lack of coordination among initiatives and donors has resulted in fragmentation of some AWS networks.

Different vendors, such as Vaisala, Adcon, Thamo, and Campbell, use varying data formats, creating challenges for NMHS in harmonising and analysing these datasets. The ADT was developed to address this issue.

It is a free, web-based application with an intuitive graphical user interface that enables NMHSs to:

- Access and process data from different AWS networks
- Perform quality control and visualization of AWS data in one platform
- Monitor real-time station activity to identify and address data transmission issues promptly
- Simplify AWS data management, helping NMHSs overcome fragmentation and better utilise AWS data for decision-making.

Author: Dr Tufa Dinku, Senior Research Scientist at the International Research Institute for Climate and Society's (IRI) Columbia Climate School



Implementation of CDT in Africa

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Regional events
2025/26

May 2025	July 2025	September 2025
Hydromet LAC	Hydromet AFRICA	Hydromet PACIFIC



December 2025	March 2026
Hydromet MENA	Hydromet ASIA

Join us at one of our regional events across 2025/26 and connect with national decision-makers and innovators in the meteorological industry in unique settings curated by Varysian

Find out more

Varysian Network

www.varysian.com

Capacity Building 02

Open-source innovation

Transforming early warning systems in Africa

In the face of escalating climate challenges, Africa is embracing digital transformation to strengthen early warning systems (EWS) and climate services. Through a pioneering collaboration between the World Meteorological Organisation (WMO) and NORCAP, a suite of open-source solutions is redefining how meteorological and hydrological institutions deliver critical information to communities at risk.

A collaborative digital transformation

Recognising the urgent need for digital public infrastructure, this initiative adopted a bottom-up approach, working directly with national meteorological and hydrological services (NMHSs) across Africa. Over the past two and a half years, 20 countries have deployed new digital tools designed to enhance climate services, streamline workflows and improve data accessibility.

By engaging technical teams weekly, the agile and fully remote development process ensured that the software met the unique needs of African institutions. The result? Open-source solutions that are now available for adoption worldwide, empowering countries to build climate resilience.

Game-changing open-source tools

The initiative developed three core tools that are already making an impact:

ClimWeb: A comprehensive platform for managing and communicating climate services, ensuring that key weather and climate information reaches decision-makers and the public efficiently.

Alertwise: A user-friendly CAP Composer tool that enables NMHSs to issue and disseminate warnings in the common alerting protocol (CAP) format, standardising emergency alerts and boosting early warning effectiveness.

WIS2Box Automated Data Loader: A system that streamlines the integration of automatic weather station data into global forecasting networks, improving data sharing and analysis.

Part of the work to improve data transmission in Chad involved using an open-source tool, Automated Data Loader, to collect data from various automatic weather station models.

Strengthening Africa's climate resilience

The impact of these tools has been profound. The adoption of ClimWeb has improved service delivery for climate information, while CAP Composer has contributed to a staggering increase in CAP alert publishing and dissemination. A number of countries, including Chad, published their first CAP formatted warning and started sharing data internationally for the first time.

Moreover, the registration of over 1,000 new observing stations on the Observing Systems Capability Analysis and Review (OSCAR) Surface platform and the addition of 960 stations to the Global Basic Observing Network (GBON) have significantly enhanced Africa's contribution to global forecasting systems.

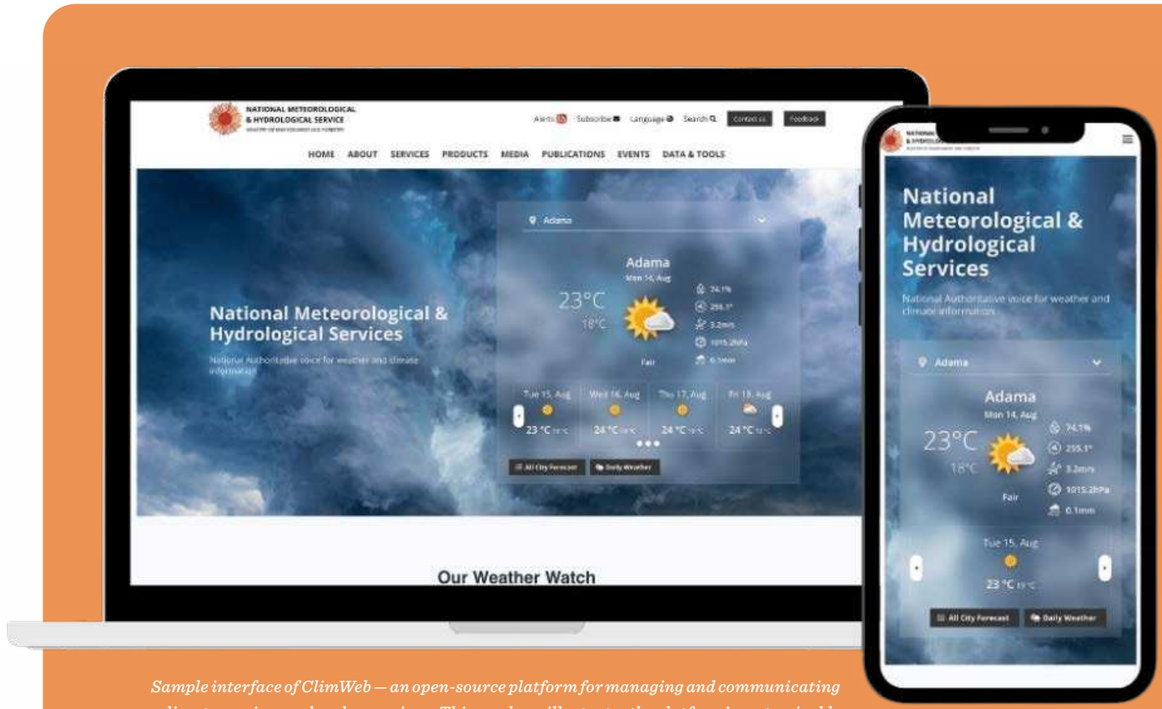
Beyond technology, capacity building has been at the heart of this initiative. Nearly 500 experts across Africa have received training and mentoring, equipping them with the skills to leverage these digital tools effectively.

A model for global adoption

These solutions are poised to be recognised as digital public goods (DPGs), reinforcing their value in the global push for climate resilience. By enabling countries to adopt and customise these open-source tools, the initiative supports the UN's Early Warnings for All initiative, the Paris Agreement and the Sustainable Development Goal (SDGs).

As Africa continues to lead in climate innovation, this collaboration demonstrates the power of open-source technology, multilateralism and collective action in building a safer, more resilient future. The success of these tools in Africa sets a precedent for other regions looking to enhance their climate services through digital transformation.

Authors: Marta Baraibar, Seconded Expert from NORCAP, working in Innovation and Climate Services at the WMO's Regional Office for Africa and Abubakr Salih Babiker, Technical Coordinator for Infrastructure at the WMO Regional Office for Africa



Sample interface of ClimWeb — an open-source platform for managing and communicating climate services and early warnings. This mock-up illustrates the platform's customizable dashboard used by National Meteorological and Hydrological Services (NMHSs).

Early warning systems save lives

Baron Weather's tools support meteorological agencies in planning, detecting and communicating actionable information

Extreme weather in various forms continues to make headlines and negatively impact many countries' fragile economies.

The good news is that the World Meteorological Organization (WMO) reports decreasing deaths from these events due to the growing implementation of early warning systems (EWS). The challenge is that many developing countries still haven't fully implemented these life-saving solutions.

"The most vulnerable communities unfortunately bear the brunt of weather, climate and water-related hazards," said the former WMO Secretary-General, Professor Petteri Taalas.

Floods are the most common natural disaster worldwide, affecting millions annually and resulting in substantial economic and societal impacts. According to the WMO, the frequency and intensity of flooding events are increasing due to climate change and human activities such as poor drainage design and urban development.

Other notable severe weather conditions include extreme temperatures, storms producing hail, wind damage and wildfires. With annual economic costs reaching billions, the need for innovative solutions to predict and manage flooding and other extreme events has never been greater.

With a 36-year history in radar development and weather detection technology, Baron Weather has emerged as a global leader in providing comprehensive tools to predict, detect, analyse and communicate extreme weather events.

These tools provide the foundation for an EWS that builds community resilience and sustainability, empowering people to make timely and informed decisions and respond appropriately to dangerous weather events.

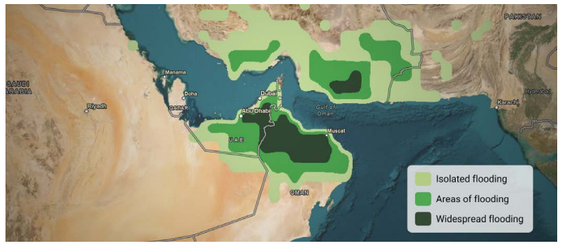
Early detection with the Baron Extreme Weather Index

A recent example of Baron's innovation is the Baron Extreme Weather Index, which delivers unparalleled precision in detecting rare or extreme flood events up to seven days in advance.

Unlike traditional models, the Extreme Weather Index offers straightforward insights that identify large-scale risks a week in advance. By assessing the atypical nature of weather threats compared to historical norms on an easy-to-understand impact scale, the index enables actionable planning for extreme temperatures, flooding, wind and other weather parameters.

For instance, it provided a week's notice of a rare heavy rain event in 2024 which brought unprecedented flooding to Dubai.

Flooding in Dubai



The Baron Extreme Weather Index consistently predicted a level 3 heavy rain event five days before the historic Dubai flood in April 2024.

This event, which saw double the city's annual rainfall in just 24 hours, affected 3.6 million people and highlighted the value of early detection.

"The Extreme Weather Index considers how extreme a situation is compared to historical data for the same location," explains Matt Havin, Baron's Data Services Manager. "It produces a real-life impact scale that is easy to understand, helping forecast the severity and human impacts of weather events."

Precision forecasting for informed decision-making

Baron's custom high-resolution modelling refines predictions as the event approaches. These models provide detailed insights into the precise location and severity of weather impacts within 60 hours of onset, integrating numerical weather prediction (NWP), hydrological, tropical, air quality, land surface and road weather models.

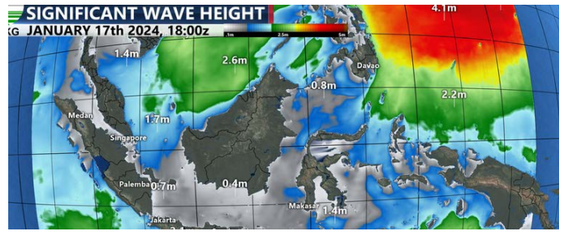
Local models can be efficiently and cost-effectively run and tailored to specific regions, allowing local meteorological organisations to control meteorological forecasting resources. The most effective models must be scalable, customisable and precise for the area. Advanced high-resolution models generate precision forecasts based on the weather dynamics of a country's operational area.

Baron's 3km atmospheric model, based on the weather research and forecasting (WRF) framework, excels in tropical and convective weather environments. Recent successes include accurate rainfall forecasts during Cyclone Dana in Bangladesh and Typhoon Trami in Vietnam, where rainfall patterns diverged significantly from the storm's centres.

The flexibility of Baron's modelling allows organisations to tailor outputs to specific needs, improving decision-making in diverse weather scenarios. Local meteorological agencies benefit from this customisation, gaining ownership and control over model performance adjustments.

A prime example is the world's first coupled atmospheric water and ocean (CAWO) modelling system, developed for the Indonesian Agency for Meteorological, Climatological and Geophysics (BMKG). The agency faced the challenge of providing accurate forecasts, alerts and warnings across the nation's vast and complex archipelago, home to over 17,000 islands reliant on maritime activities.

BMKG partnered with CLS and Baron Weather to address this and develop a tailored NWP and hydrological forecast system. Baron's advanced met ocean model, now operational as part of BMKG's Maritime Meteorological System (MMS) program, integrates atmospheric, oceanic and wave data, significantly enhancing forecast accuracy, timeliness and reliability.



An operational example of the CAWO model showing the impact of the tropical storm on oceanic waves.

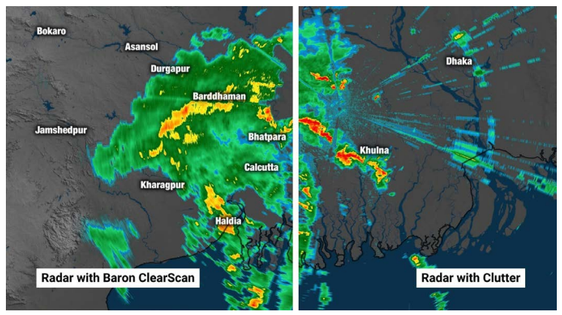
This innovative solution provides critical early warnings for dangerous weather, protects lives and property in coastal and island communities, supports sustainable maritime operations and showcases how tailored technology can transform environmental forecasting. CAWO is an example of Baron leading the way in modelling technology designed to meet the increasing need for more reliable forecasting.

Cutting-edge radar technology for ground truth

Ground truth is essential in detecting and managing the impacts of heavy rain and other extreme weather. Baron's radar systems, recognised globally for their performance, provide real-time insights and enhance the accuracy of weather models. With advanced clutter suppression technologies like ClearScan and CLEAN-AP, Baron's radars deliver high-quality data essential for practical EWS. Baron's radar solutions include:

- S-band radars: ideal for long-range weather surveillance in tropical environments where heavy precipitation is expected
- C-band radars: known for their balance of power, range and affordability
- X-band radars: effective for detecting smaller-scale weather events and winter precipitation

The Baron ClearScan is a unique machine-learning technology supported by human intervention that learns and removes extraneous returns or 'noise' from radar returns and provides the user with precipitation data with unmatched clarity. Baron ClearScan learns to recognise data from actual weather targets versus radio frequency interference (RF) or anomalous propagation (AP).



An example of a custom Baron Radar solution with ClearScan technology (left) that reduces clutter and noise most radars produce in a highly populated or karst topographic environment (right).

Additionally, Baron addresses common calibration challenges using advanced, patented algorithms. Its auto-calibration technology removes human error, enabling reliable adjustments across networks. The Multi-Radial ZDR Calibration further improves radar reliability by eliminating the need for solar or hardware measurements, which minimises equipment requirements, reduces the likelihood of mistakes and improves rainfall estimates. Integration with forecasting models further enhances their utility, enabling timely and accurate community warnings.

A sustainable Baron radar is an excellent tool for enhancing an EWS. This system provides life-saving information through timely warnings and can improve locally run weather models.

Clear communication for at-risk populations

Meteorological agencies, particularly in vulnerable regions, struggle to connect with communities. Research shows that the damage caused by a disaster can be reduced by 30% if an early warning is issued within 24 hours. Reaching people where they are requires a multi-pronged approach. The heart of an agency's communication strategy should focus on turning weather data into engaging information so that a non-meteorological audience can understand the message and take action. Workstation software like Baron Weather's Lynx assists agencies in rapidly and effectively disseminating severe weather information. The platform combines data from various sources for precise forecasts and visualisations.

It serves as both an analytical and communication tool for meteorologists who need to convey updates about severe weather events swiftly and comprehensively.

Baron Lynx enhances the communication of weather risks with dynamic graphics and clear risk areas.

By integrating data from various sources, Lynx provides precise forecasts, visualisations and engaging content tailored for non-meteorological audiences. Baron Lynx can be utilised to engage with the public and other agencies throughout a weather event's life cycle.

Lynx easily facilitates communication through social media, websites and even apps with relevant daily and critical weather information.

Baron Lynx simplifies posting informative and visually appealing weather information to social channels.

Using Lynx's on-camera features or weather animation capabilities ensures that materials are engaging and capture attention longer, making it easier to communicate complex weather information in easily sharable ways. Lynx facilitates:

- Real-time weather updates through social media, websites and apps
- High-resolution radar imagery and forecast animations
- Informative and engaging video content for public communication

This platform helps forecasters craft clear, actionable messages, enhancing community preparedness and response to severe weather threats.

A comprehensive approach to resilience

Thirty percent of the world's population is not covered by an EWS. Baron Weather's integrated solution — comprising high-resolution modelling, radar systems, advanced products like the Extreme Weather Index, and Lynx software — offers a holistic approach to managing weather events.

These tools support meteorological agencies in planning, detecting and communicating actionable information, ultimately enhancing community resilience.

An effective EWS fosters preparedness, empowers communities and saves lives. By leveraging advanced weather solutions, organisations can mitigate risks, safeguard infrastructure and help communities recover swiftly from natural disasters.

Baron's technology is vital in building a safer, more resilient future in an era of increasing climate uncertainty.

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

Damage to Floridian homes after Hurricane Ian

Lessons learnt from extreme weather in Chile

An extreme weather event in Chile highlights the need for stronger forecasting, infrastructure resilience and climate adaptation

Between 21-26 June 2023, extreme hydrometeorological conditions led to a state of catastrophe in Chile's Valparaíso to Biobío regions. The rivers Aconcagua, Maipo, Rapel, Mataquito, Maule and Itata experienced extreme runoff and flow increases, posing severe risk to local populations. The Mataquito River in particular caused significant flooding in Licantén, damaging both public and private property.

Unseasonably high temperatures were recorded in Chile by the General Directorate of Waters' (Dirección General de Aguas – DGA) network. These temperatures caused the isotherm and snow line to rise above normal levels for June. This triggered increased runoff at elevations above 2,000 metres, compounding the impact of high-intensity rainfall in mountainous areas. Accumulated precipitation exceeded 200mm in several locations.

Despite the DGA's dense station network providing real-time monitoring and timely alerts to SENAPRED (National Emergency Bureau), many hydrometeorological stations suffered infrastructure damage due to rising river levels. The Chilean Meteorological Directorate (DMC) issued forecasts on June 21 predicting heavy rainfall, but underestimated the actual amount, especially in mountain regions where freezing levels exceeded 2,500 metres above sea level.

Event development

Temperature anomalies were a key factor, as seen at DGA snow measurement stations like Laguna Negra, Lo Aguirre and Alto Mallines. During peak rainfall (21-24 June) temperatures stayed above 0°C, expanding the contributing area for runoff and accelerating snowpack ablation.

Snowmelt significantly increased river flows. The estimated meltwater contribution for elevations below 3,380 metres above sea level was:

- Río Aconcagua: 0.17 million m³
- Río Maipo: 1.35 million m³
- Río Rapel: 48.68 million m³
- Río Mataquito: 32.07 million m³
- Río Maule: 54.28 million m³

High-intensity rainfall in the Metropolitan, O'Higgins, Maule and Biobío regions further exacerbated the situation, with some stations recording over 600mm of accumulated precipitation.

Impact on river flows and infrastructure

The extreme conditions triggered significant flooding in multiple basins. The Mataquito and Maule rivers experienced major flow surges, overwhelming river infrastructure. Transmission was lost at the Mataquito River station in Licantén when flow peaked at 5,383 m³/s, and at the Teno River fluviometric station after reaching 1,106 m³/s on June 23.

Several fluviometric stations recorded historically high flows, exceeding return periods of 100 years in some cases, and reservoir levels also rose sharply. The Colbún Reservoir saw a sudden influx of 800 million m³ due to incoming floodwaters.

Infrastructure damage and monitoring challenges

A total of 217 stations monitor flow rates across the Valparaíso to Biobío regions, with 40 prioritised for extreme events. This event damaged 48 DGA hydrometric stations, disrupting data collection in critical locations.

The Vergara Pass is the drainage area of the Teno River

Despite infrastructure losses, the remaining stations enabled real-time monitoring of river levels and flow rates, ensuring authorities could track ongoing risks and issue alerts where possible.

Takeaways

This event highlighted the growing vulnerability of Chile's hydrological systems to extreme weather, emphasising the need for improved forecasting, infrastructure resilience and emergency response. Key lessons include:

- **Enhancing forecast accuracy**

Rainfall and freezing-level projections underestimated the event's severity. Advanced predictive modelling, real-time data assimilation and cross-agency collaboration must be strengthened to improve forecast reliability.

- **Infrastructure resilience**

The destruction of 48 DGA hydrometric stations hampered real-time monitoring. Future efforts should focus on reinforcing station structures, diversifying data transmission systems and deploying backup sensors in high-risk locations.

- **Emergency response optimisation**

While early warnings were issued, the rapid flood development required faster and more localised emergency coordination.

Strengthening local response capabilities, increasing community preparedness and improving evacuation protocols are critical.

- **Integrated water management**

The sharp increase in reservoir levels poses secondary flood risks. Improved reservoir operation strategies, incorporating climate adaptation measures, will help mitigate future events.

- **Climate adaptation measures**

Given the increasing frequency of extreme events, investments in watershed conservation, reforestation and sustainable land-use planning are essential for long-term resilience.

Future preparedness should prioritise data-driven decision-making, resilient infrastructure investments and enhanced cross-sector collaboration to better anticipate and mitigate the effects of extreme hydrometeorological events.

Author: Felipe Pérez Peredo, Field Hydrologist at Chile's Dirección General de Aguas (DGA)

Colbun resevoir, Maule, Chile

Individual lightning preparedness solutions

Nowcast can provide tailored-made, customised solutions for any country, customer, geographical situation, use case, quality requirements and commercial conditions

When lightning strikes, lives as well as investments are in acute danger. Even though the exact position of a lightning strike cannot be predicted, a thunderstorm can be detected with precision, tracked and short-term forecasted in terms of position and severity. This allows for confident and solid decision making, public warning and best possible damage containment.

Real-time as well as historical lightning data is vital for a vast number of industries including aviation, energy providers, infrastructure operators, mining, military and insurance.

The high precision delivered by nowcast's LINET technology is key to the value of its lightning data, which is accurate enough for the most demanding use cases.

However, not every use case requires the same approach. Nowcast is known for its individual approaches to craft the best specific solution for every customer.

In order to create the optimum lightning detection system, nowcast offers different procurement models and technologies.

TECHNICAL APPROACHES

1.1 High-precision lightning detection networks

Nowcast's LINET system is known for its excellent precision and reliability alongside vital features such as cell-tracking and 60-minute nowcasting of thunderstorm cells in terms of position and arrival time.

1.2 Global lightning data

This precision technology is based on a local set of LINET sensors distributed within the zone that required coverage at sensor-baselines of approximately 300 km.

The complete process from lightning strike to final data is delivered in real-time and therefore optimises decision-making for a variety of lightning-affected users.

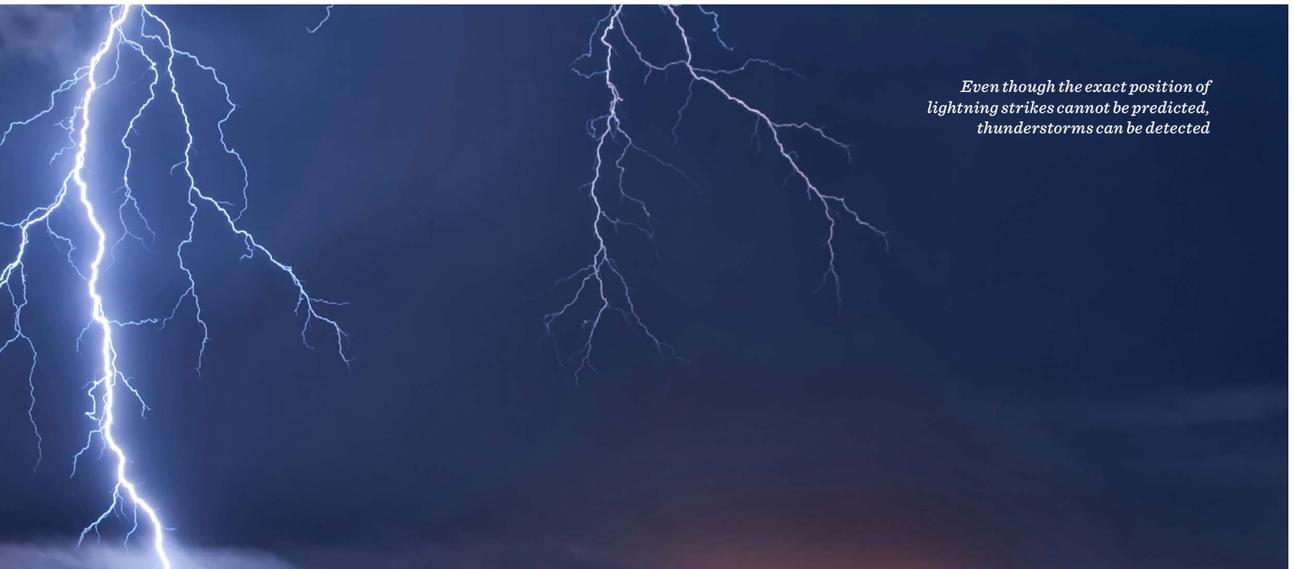
With a LINET high-precision lightning detection network, customers can get best-in-class data, including:

- Average location accuracy (mean value): 75m
- Detection efficiency: down to 2kA strokes
- Measured stroke types: intra-cloud/cloud-to-ground discrimination
- IC-emission height: delivered in km
- Operation mode: near real-time (<30 seconds on average)

Lightning data is derived from a global set of nowcast sensors distributed at vast distances across the globe, which provides lightning information for every place on the planet.

This data is a vital starting point if no high precision local lightning detection network is in place for a required region, or if it is not feasible to install sensors – for example over the ocean, in deserted areas or in very remote regions.

The beauty of this global lightning network is the fact that customers can receive the lightning data immediately without the need for their own hardware.



Even though the exact position of lightning strikes cannot be predicted, thunderstorms can be detected

Understandably, this technology delivers lower precision and fewer detail-stroke-parameters as a local high precision network, but the accuracy and efficiency of this nowcast technology can still be considered high quality, with an average location accuracy < 1km.

It's the perfect data source for a wide range of customers and use-cases, including:

- As an intermediate solution, before a high-precision network is deployed locally
- As an additional data source to enhance a local precision lightning detection network cross-border, over open waters or into remote parts of a country
- For small countries or islands that cannot comply with the baselines required to deploy a high-precision lightning detection network
- For applications or customer groups requiring global coverage

1.3 Hybrid technology model

A hybrid model allows users to combine the advantages of the single approaches into a both powerful as well as financially attractive overall solution – particularly for countries with densely populated areas but also very large deserts, forest or water areas, or to cover the wider surrounding of the country including ocean areas.

A locally deployed high-precision network can be installed with a particular focus on the populated areas. The density of the sensors will follow the quality needs and additional data from Nowcast's global lightning detection network, which can enhance the capabilities to detect thunderstorm systems approaching from the ocean or neighbouring countries.

PROCUREMENT MODELS

2.1 Network procurement with full ownership

The classic way would be a procurement process with complete ownership of the hardware as well as the produced data. This approach is associated with a one-off investment (CAPEX) and lower ongoing servicing costs (OPEX).

Nowcast is known for its customer focus and excellent long-term total cost of ownership due to highly reliable equipment. Long-term component support is also a given, customers are never put into a position where they need to buy new hardware because their older model is 'no longer supported'. Any version of nowcast's lightning detection sensors (the first ones were deployed more than 20 years ago) are still supported by the latest software.

This is how nowcast builds trust and customer satisfaction, resulting in excellent value for money for all customers demanding the full ownership and maximum independency.

2.2. Partnership (public-private)

A private public partnership (PPP) approach can also form the basis for a new lightning detection system for a country. This way, both the public organisation, such as the national weather service, nowcast, and in some cases further local companies, act as partners and jointly operate the technology. Even though this model is quite different from classic supplier-customer relationship, it provides a win-win scenario for all involved.

2.3. Service-based solution

A third possible approach is a pure data service procurement, which uses data from either an existing nowcast local high-precision network (existing for Europe, Africa, US and several other areas of the world) or from our global network.

Nowcast can also set up the required technology together with a local business partner and is therefore able to offer lightning data and solutions as a service. This option normally frees the customer from any investment (CAPEX) and the need to take care of hardware installations and servicing as it is purely based on a monthly fee.

A solution specific to your needs

Lightning detection is a fundamental cornerstone for sophisticated weather analysis, for any early warning system and for improved operation of many industry sectors all over the world. Key to an advanced system is precision, reliability and stability, which enable it to work in locations with weaker infrastructure and extreme conditions. However, there's no one-size-fits-all solution.

At nowcast, we can offer our extensive experience across different climate zones, topologies and infrastructure situations. Find out more at www.nowcast.de

Author: Richard Fellner, CEO of nowcast

SHONE: Zimbabwe's sustainable weather network

Zimbabwe is making its sustainable hydrometeorological observing network by every player (SHONE) a reality, leveraging cutting-edge technology, government collaboration and 3D-printed weather stations

The significance of weather observations in Zimbabwe cannot be over emphasised. It's deeply rooted in a rich history of meteorological monitoring that spans over a century. The earliest records of meteorological values date back to 1878 when rainfall measurements were first recorded at Hope Fountain Mission near Bulawayo. This marked the inception of a legacy that has endured for 145 years, providing invaluable insights into the country's climate trends.

Over the years, Zimbabwe has significantly expanded its weather observation network, with daily synoptic observations commencing in 1922 and regular weather forecasts beginning in 1924. More than 120 manned weather stations were established to gather crucial data on atmospheric conditions and weather patterns. Despite challenges during the liberation war era from 1974 to 1980, which led to a temporary reduction in the number of stations due to personnel displacement, the commitment to weather monitoring remained steadfast.

Enhancing capacity

The country's meteorological capabilities took a significant leap forward with the establishment of the first weather radars. Between 1951 and 1954, three storm weather radars were installed in key locations such as Harare (Salisbury), Bulawayo and Zambia (Ndola), marking a pivotal moment in advancing weather monitoring and forecasting capabilities. This development laid the foundation for enhanced detection and tracking of weather phenomena, contributing to improved preparedness and response to extreme weather events.

The installation of the first automatic weather station (AWS) over a decade ago marked another milestone in modernising Zimbabwe's weather observation infrastructure. This technological advancement enabled real-time data collection and enhanced accuracy in weather monitoring, supporting more precise forecasting and decision-making processes.

As Zimbabwe celebrates over a century of weather forecasting since 1924, the continuous evolution and expansion of its observation network underscores the critical role of meteorological data in understanding climate dynamics, predicting weather patterns and safeguarding lives and livelihoods in the face of changing environmental conditions.

The whole of government approach

Meteorology, often perceived as a complex and intricate field, presents challenges not only in pronunciation but also in comprehension. Understanding the depth of this scientific discipline underscores the critical necessity of adequately equipping organisations involved in meteorology, particularly the meteorological services. Fully grasping this need can indeed be a monumental task, requiring a concerted effort from various stakeholders.

In Zimbabwe, much like numerous African countries, the meteorological services function as a vital arm of the government. Consequently, major infrastructural decisions within this domain necessitate broad support and recognition of its importance across the government.

The adoption of a comprehensive 'whole of government approach' in Zimbabwe highlights a unified commitment to leveraging meteorological insights for national progress and resilience.

The urgency for this collaborative approach has become increasingly apparent in the face of mounting climatic risks. Events such as tropical cyclones Idai, Ana and Freddy, as well as recent droughts, have vividly demonstrated the critical need for robust early warning systems to mitigate the impact of such extreme weather phenomena.

Sectors fundamental to the nation's wellbeing, such as agriculture and food security, disaster risk reduction (DRR) and health, have borne the brunt of these climatic challenges. Consequently, ministers overseeing these crucial sectors united in advocating for the empowerment and enhancement of the meteorological services.

Their collective efforts reflect a shared commitment to fortifying the nation's resilience, safeguarding communities and vital sectors against the unpredictable forces of nature, underscoring the unity of purpose in addressing climate-related risks.

The government did not act alone. Players from various national and international organisations, which had been making fragmentary efforts, came together in a more organised and collaborative approach empower communities to be resilient to climate shocks, while at the same time equipping the met services, and engaging in capacity building initiatives and community activities.

Improved meteorological observational network

In 2021, seventy years after the first weather radar in Zimbabwe, the government was able to acquire five state-of-the-art Doppler weather radars covering the entire country. These have enabled accurate precipitation detection and tracking in systems such as thunderstorms, rain belts and tropical cyclones.

They measure wind speed and direction, predicting storm development and intensity as well as hailstorms, easing the issuing of timely warnings.

Aviation weather support is also provided, ensuring safe flight operations, disaster preparedness through accurate wind, precipitation and flood forecasts, enhancing weather forecasting and warning systems.

This technology has revolutionised weather monitoring and prediction, and plays a critical role in protecting life and property.

Digital weather stations were also added at all meteorological stations to phase out the mercury-based equipment in line with the Minamata Convention.

Added to this, in 2022 Zimbabwe was able to establish a network of over 100 AWS, with almost 50% funded through the Government.

These have enabled real-time remote data monitoring, enhancing accuracy and continuous operation while also improving spatial coverage, forecasting capabilities, and ultimately supporting informed decision-making in various fields.

The sustainability issue: 3D-printed AWS

As part of its sustainability plan, the Meteorological Service Department Zimbabwe acquired 3D printers, and has so far produced automatic weather station (AWS) components to cover almost half its network.

This ongoing exercise should see all stations having these innovative, cost saving 3D-printed systems (3DPAWS) by the end of 2025.

Notably, 3DPAWS are being field tested and measured against other AWS, digital and manual meteorological equipment.

Therefore, Zimbabwe is now in a phase where a sustainable hydrometeorological observing network, built with the assistance of every player (SHONE), is not only a dream but a reality.

Author: James Ngoma, Head of Public Weather Services, Meteorological Service Department Zimbabwe

Enhancing Varysian's Hydromet Network

Varysian's plans for 2025

Since 2021, Varysian has developed its virtual campus – The Hydromet Network – a platform for all stakeholders within the weather, climate and environmental community to connect, share knowledge and find resources to build capacity.

Developed as a temporary solution to the global pandemic, it grew into a permanent knowledge base and networking tool for its members. Providing virtual access to Varysian's in-person events like never before, allowing stakeholders outside of the event region to learn about the gaps, challenges and solutions others are experiencing.

Now with over 2,500 members from across academia, private sector technology providers, NGO's, funding agencies, national hydrological and meteorological services and other government bodies, Varyian plans to further advance the Hydromet Network in 2025.

Big plans for 2025

Varysian plans to increase the number and scope of its existing virtual webinars, engaging with high-level stakeholders from across the globe to present their case studies, research and groundbreaking projects.

The variety of resources will be expanded to include courses from well-reowned technology providers and academic institutes, podcasts and industry news.

By investing in modern software, Varysian is putting more resources than ever into its network, while continuing to provide free resources to its members – supporting capacity building efforts in the regions that need it most.

Varysian events

The network will continue to act as a growing hub for all Varysian events. Whether attending virtually or in-person, members can benefit from exclusive in-the-room access to Varysian's regional symposia year-round.

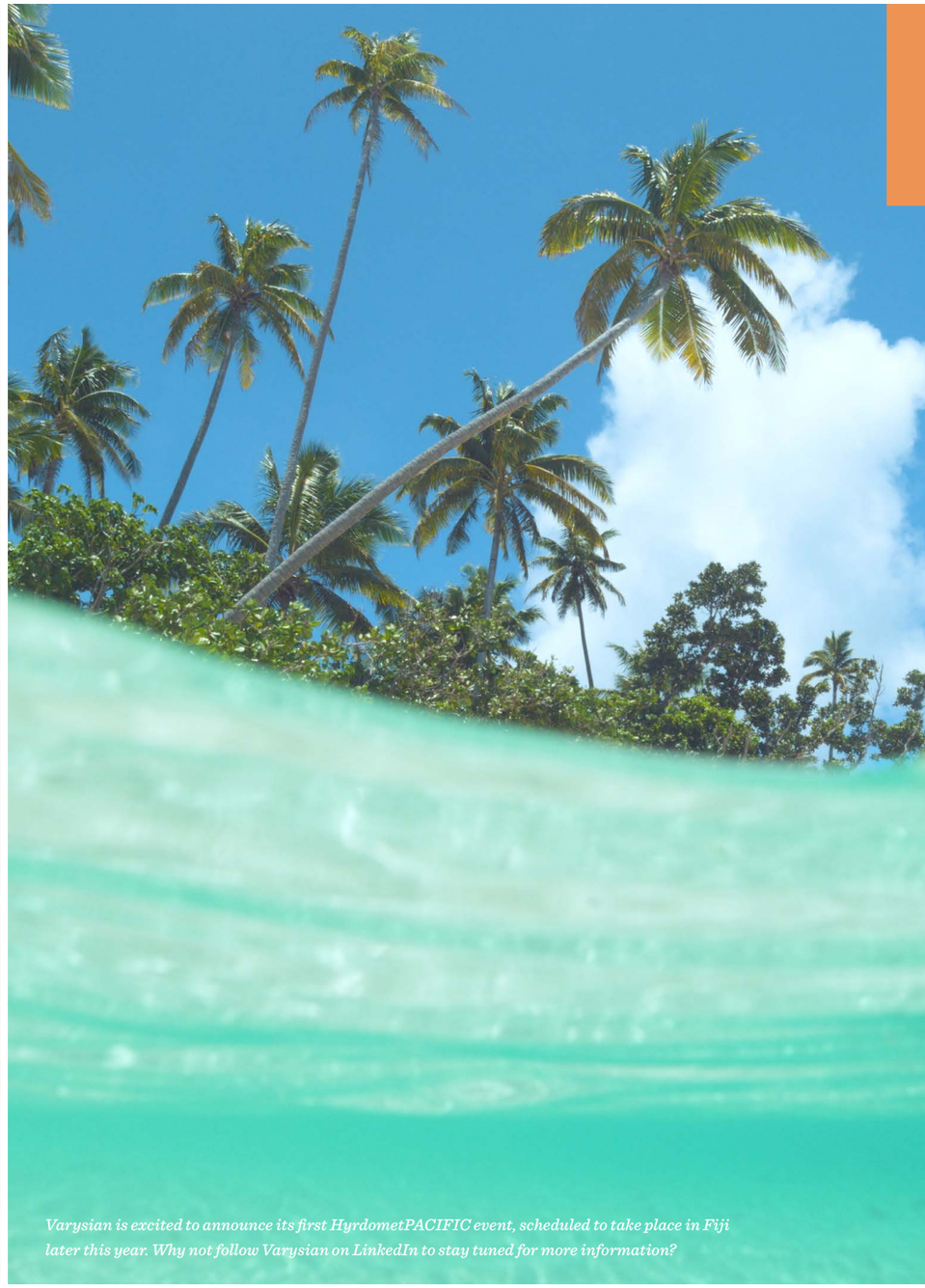
Varysian also plans to expand its events into new regions, bringing a unique intimate take on the existing conference or tradeshow model and engaging more varied stakeholders in each region. Be sure to visit our website or follow us on LinkedIn to keep up to date with our latest news.

If you have any case studies, research or knowledge to share with our Hydromet Network members, please email us at *events@varysian.com.*

Author: Katie Barkans, Operations Manager, Varysian

Pretoria will once again host Varysian's HydrometAFRICA event this July.

Varysian's upcoming inaugural HydrometLAC event will take place in Miami this May.



Varysian is excited to announce its first HyrdometPACIFIC event, scheduled to take place in Fiji later this year. Why not follow Varysian on LinkedIn to stay tuned for more information?

Early Warning Systems 03

Harnessing local knowledge to enhance early warning systems

Insights from Sudan's dust storm phenomena

As extreme weather events grow more frequent, there is an increasing need to reevaluate our understanding of certain phenomena and uncover new connections to explain their dynamics. Community observations, often overlooked, can provide critical insights that complement scientific research, enabling more accurate and context-specific forecasting.

Dust storms, a significant weather phenomenon in arid and semi-arid regions like Sudan, serve as a powerful example of this interplay between local knowledge and scientific inquiry. While traditionally viewed in isolation due to their specific components, such as pressure differences between air systems, these storms often reveal broader implications—both meteorological and societal.

The four dust storms of Sudan

In Sudan, dust storms occur in several distinct forms, each with its own triggers and characteristics. Over time, local communities have developed a nuanced understanding of these storms, often linking their intensity and timing to seasonal patterns and agricultural outcomes.

- **Downdraft dust storms**

Associated with strong downdrafts from rainy cumulonimbus clouds, these storms mark the onset of the rainy season (June to September). Communities believe that the storm's intensity—measured by wind strength, dust density and duration—offers clues about the upcoming season's rainfall patterns. This traditional knowledge helps guide agricultural decisions, complementing expert forecasts.

- **Inter-tropical convergence zone (ITCZ) dust storms**

These storms are caused by fluctuations in the ITCZ, primarily in eastern Sudan during July and August. While their heavy rainfall can lead to destruction of homes and infrastructure, they also impact camel-grazing areas, highlighting their broader significance beyond agriculture

- **Sudan thermal low dust storms**

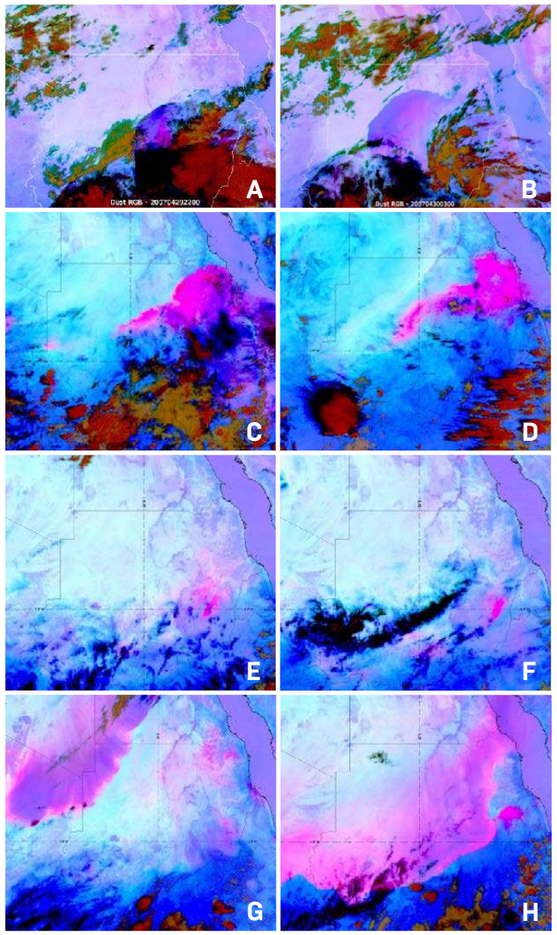
Occurring in April, these storms result from stagnant thermal lows over the eastern region, with temperatures often exceeding 45°C. Winds from the Red Sea flow towards the Sudan thermal low, generating prolonged dust storms. Locals use these storms as rainy season indicators.

- **Frontal system dust storms**

The most extensive and widespread, these storms are driven by interactions between Mediterranean and African desert air masses during March. This phenomenon isn't currently associated with the rainy season, but as with other storm types, further research could reveal connections.

Bridging community knowledge and scientific research

The value of community input lies not just in recognising observations but in integrating them into systematic scientific research. By doing so, local insights become a vital source of weather information, revealing patterns that conventional methods might overlook.



The four types of dust storms in Sudan, depicted with a three-hour time step (12:00–15:00 GMT). Panels A and B illustrate dust storms caused by strong downdrafts, C and D represent storms driven by ITCZ fluctuations, E and F highlight those resulting from Sudan thermal low stagnation, and G and H depict dust storms associated with frontal systems. Sourced from eumetrain.

The Sudan Meteorological Authority (SMA) has embraced this approach through its innovative early warning unit. The unit disseminates daily weather bulletins nationwide via official and public channels. Leveraging a network of traditional and automated weather stations, advanced forecasting technologies, satellite imagery and robust data archives, the SMA has created a system that protects lives and property from extreme weather events.

The Sudan Meteorological Authority's Early Warning Unit issues warning documents as part of its daily responsibilities, aligned with the unit's core mission. These are the warning templates in Arabic.

By incorporating community knowledge into this framework, the SMA ensures its forecasts are not only scientifically robust, but also relevant to local contexts, ultimately enhancing the nation's resilience and development.

Dust storms in Sudan exemplify how local knowledge can uncover meaningful connections between weather phenomena and societal impacts.

By integrating these insights into scientific research, meteorological agencies can develop more effective early warning systems that protect communities and foster sustainable development.

Author: Mohammed Ali Mohammed Hamed, Nanjing University of Information Sciences and Technology, Atmospheric Science, and a past member of the Sudan Meteorological Authority's Early Warning Unit

Developing an extreme wave early warning system

University of The Bahamas is leading work to provide early warnings for extreme waves at the Glass Window Bridge in Eleuthera

Despite its immense beauty and capacity to sustain life, the ocean also possesses incredible dynamical forces that have the demonstrated potential to cause incredible damage to natural and human environments.

Outside of seasonal hurricane activity, The Bahamas is not typically associated with extreme weather and as such, when the ocean brings extreme weather to its idyllic shorelines, residents and visitors alike are often caught unawares.

Rages – extreme wave events

This phenomenon is most readily apparent at the Glass Window Bridge which connects the northern head of the island of Eleuthera with its southern body. There, extreme wave events, known as 'rages' by locals, are sufficiently energetic to leap eastward from the wider Atlantic Ocean across what is called the narrowest place on Earth, to strongly affect foot and vehicular traffic, before settling into Exuma Sound on the western side of Eleuthera.

For this reason, the Bahamas Department of Meteorology (BDM) regularly issue warnings to minimise the unfortunate intersection of people with this otherwise beautiful wave activity, however there will always be room for improvement.

Developing a suitable early warning system

To this end, it has been proposed to design an early warning system (EWS) that integrates in situ and remote sensing observational platforms, alongside numerical model and artificial intelligence-based forecasting capabilities.

The system is envisioned as a multi-tiered, overlapping platform designed to turn oceanographic and meteorological data into information, information into knowledge, and knowledge into rapid action.

The in-situ and remote-sensing platforms are perhaps the most crucial components and the base of the system. These will take the form of oceanographic buoys and high-frequency coastal radar respectively, and are used to provide near real-time observations of wind, wave and current properties, but with specific attention placed on the bulk and spectral wave parameters. In particular, the buoys will be geared towards identifying significant wave heights below three metres, while the coastal radar will provide insights on waves over three metres.

A multi-tiered solution

Buoys are widely used throughout the global ocean but are expensive and cannot be placed at every point of interest, necessitating the usage of high-frequency coastal radar to expand the spatial range of the early warning system. Specifically, radar of operation frequencies ranging from 3-10 MHz will allow for the monitoring of waves with periods from 5-20 seconds and wavelengths from 50-300 metres.

Lower frequencies enable observations over a longer range, but distinguishing low significant wave heights from background noise becomes challenging. This approach allows for continuous monitoring of both average and extreme wave conditions, ensuring they can be cross-validated.

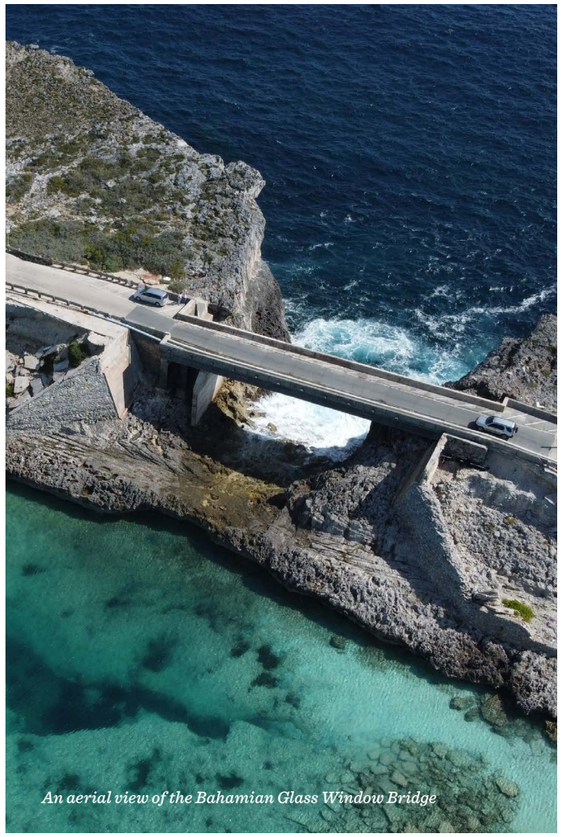
The stark contrast of the Atlantic Ocean and the Bight of Eleuthera

At the next level, a high-resolution numerical wave model captures the small islands across the entire archipelago. This is supported by the most detailed bathymetric dataset available, ensuring fine-scale ocean features accurately reflect real-world conditions.

The model will then be adjudicated, validated and tuned by the use of both the buoy and coastal radar, and will then provide a capability that is not available from either observational platform: forecasting.

Seven-day forecasting

Seven-day lead forecasting will ensure that the potential development of extreme wave activity as may be caused by extratropical cyclones doesn't catch either the relevant authorities at the BDM and the Disaster Risk Management (DRM) Authority or the coastal population they serve by surprise.



An aerial view of the Bahamian Glass Window Bridge

It is often the element of surprise that causes the vast majority of loss of life and damage to infrastructure or vehicles in the area, and this may be eliminated entirely if bridge closures can be planned far ahead of extreme events.

These numerical model-based forecasting capabilities will naturally incur a high computational cost with large requirements for data storage, but this can be mitigated with the final layer of coverage.

In the recent decade, the usage of artificial intelligence (AI) and deep learning (DL) methods have been demonstrated to allow for rapid and precise forecasting of a wide range of variables, inclusive of wave properties.

Important for our purposes, these methods allow for similar if not better forecast results but at dramatically lower computational and data storage costs.

While it may be easy to train personnel to use and interpret AI and DL techniques, both require large datasets to be trained on. However, the previous two layers provide both observational and numerical model output data will be in great abundance for AI/DL model training. Therefore, computationally inexpensive and rapid forecasts can potentially be made on a daily basis.

A quantum leap in integrated coastal zone management

While it is designed for extreme wave forecasting at the Glass Window Bridge, this system can be easily expanded to derive its data from other sources (e.g satellites, automatic weather stations etc.). However, despite their interlinking networks of data transfers, each layer would remain relatively siloed.

To overcome this, specialised algorithms to communicate between the layers will be required to determine minimum thresholds for automatically identifying and validating extreme wave events, shunting results to human experts for a further round of validation, before finally connecting the relevant authorities at the BDM and DRM Authority for warning dissemination.

For The Bahamas, the development and deployment of this extreme wave early warning system would be a quantum leap in integrated coastal zone management as its data can be used in a variety of vital economic activities beyond purely coastal defense purposes.

Author: Dr Brandon Bethel, Small Islands Sustainability Assistant Professor of Marine Science at University of The Bahamas

Africa steps up to roll out Early Warnings for All initiative

Update from the WMO Regional Office for Africa

Africa has a vast majority of its land vulnerable to the adverse impacts of climate change, most exposed to natural hazards such as riverine and flush flooding, droughts, tropical cyclones and marine-related hazards such as high waves and storm surges. The latest 2023 State of Climate Report in Africa highlights these extremes.

The continent has low capacities to better manage extreme weather events to protect the vulnerable and exposed communities. Multi-hazard early warning systems (MHEWS) linked to early actions are key to the continent's efforts to manage risks, enhance adaptation and build community resilience.

The World Meteorological Organisation's (WMO) Global Status of Multi-Hazard Early Warning Systems 2023 report indicated that close to 60 percent of Africa's population lack MHEWS. Gaps are largest in small islands developing states (SIDS) and least developed countries (LDCs).

In 2022, on World Meteorological Day, the UN Secretary General called for everyone in the planet to be protected by early warning services by the end of 2027.

"There is need for a collective understanding"

This call gave way to the Early Warnings for All (EW4All) initiative, which was launched at the 28th Conference of the Parties, in Sharm el-Sheikh, Egypt.

EW4All aims to enhance the capacity of countries to provide timely and effective early warning information to their populations, particularly the most vulnerable. As each country has its unique challenges and opportunities, there is much flexibility for individual communities to set their own implementation pathway.

At the global level as well as the Africa continent level, the WMO and United Nations Office for Disaster Risk Reduction (UNDRR) co-lead the EW4All initiative, with support from the International Telecommunications Union (ITU) and International Federation of the Red Cross/ Red Crescent (IFRC) and Member States as the key implementing entities.

The four key elements of EW4All

Effective early warning systems are be people-centred and integrate four key elements:

- Disaster risk knowledge

Risk assessment provides essential information to set priorities for mitigation and prevention strategies and designing early warning systems.

- Detection, observations, monitoring and forecasting

Systems with monitoring and predicting capabilities to provide timely forecast of the potential risks faced by communities, economies and the environment.

- Dissemination and communication of key information

Alerting of local and regional governmental agencies and those at risk. The alerts need to be in a reliable manner, systematic and simple to be understood.

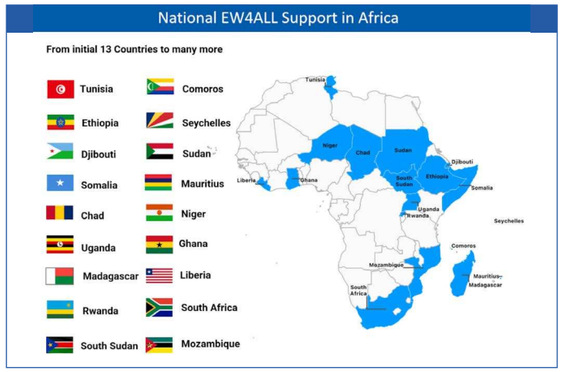
- Preparedness to respond

Early action coordination, good governance and appropriate early actions to mitigate the negative impacts of the forecasted event. This should be supported by a strong commitment to allocate adequate and earmarked finance for the implementation early actions.

Likewise, public awareness and education are critical aspects of disaster mitigation measures.

Implementing EW4All at national level

A guide developed by the WMO, UNDRR and a cohort of organisations and partners proposes a step-by-step process for implementing the initiative at national level.



This image shows the number of countries that have undertaken EW4A rollout. Credit Grace Amondi.

This includes stakeholder mapping, a national consultative workshop, gap analysis, developing of national plans, implementation, monitoring and reporting.

Based on this implementation plan, 20 African countries: Ethiopia, Uganda, South Sudan, Burundi, Chad, Comoros, Seychelles, Madagascar, Mauritius, Mozambique, Liberia, South Africa, Ghana, Sudan, Tunisia, Somalia, Djibouti, Rwanda, Niger and Sao Tome and Principe have undertaken roll-out of EW4All.

In addition, Ethiopia, Mozambique, Madagascar, Tunisia, Liberia, Ghana, Sudan and Somalia have development EW4ALL national roadmaps.

Action in Africa

In September 2022, the WMO partnered with organisations including the African Union Commission (AUC) and the Government of the Republic of Mozambique to convene a Ministerial Conference on Early Warning and Early Action for the Southern Africa Development Community. This took place in Maputo, Mozambique.

Africa has built on the outcome of this conference, undertaking further activities to support the EW4ALL initiative. Significantly, another critical milestone in the implementation of EW4ALL on the continent is the development of the Africa Action Plan on Early Warning, which was launched in the Nairobi Africa Summit on Climate Change in September 2023.

This plan outlines where Africa would like to be, what constitutes success, and the actions required to achieve these goals.

Last October, the Ninth Session of the Africa Regional Platform for Disaster Risk Reduction (AfRP-9) and the Eighth High-Level Meeting on Disaster Risk Reduction 24 was held in Windhoek, Namibia under the theme 'Act Now for the Resilient Africa We Want'.

It was here Africa held its first EW4All multi-stakeholder forum. This brought together diverse stakeholders to enhance Africa's disaster preparedness, and focused on improving early warning systems across the continent. Key themes included inclusivity, innovation, governance and financing.

SOFF and CREWS

Many initiatives are now in place on the continent to support various facets in the value chain of providing early warning services. In Kenya, for example, with support from the Systematic Observations Financing Facility (Read about SOFF on page 10), they are actively working to support establishment of infrastructure to support data collection that contributes to improved weather forecasts, EWS and climate information services.

Climate Risk and Early Warning Systems (CREWS), in collaboration with other partners, is present in many African countries, supporting timely, accurate forecasting and ensuring early warnings reach every person for necessary actions.

There is tremendous support from many other organisations in technical assistance, institutional strengthening, capacity development and infrastructure enhancement to support EW4All on the continent. The WMO has taken the lead, with many programs such as the Severe Weather Forecasting Programme (SWFP) that supports impact-based warnings.

Challenges ahead

One of the main challenges in attaining EW4ALL is the fragmented approach of many African governmental bodies that often results in duplicated efforts, inconsistent and poorly informed policymaking, and inefficient use of limited resources. There is need for a collective understanding and benefit of comprehensive and harmonised systemic risk assessment, and policy coherence. Effective risk assessment and management, particularly in the context of climate change, requires a comprehensive, harmonised and systemic approach.

Author: Zablon W. Shilenje, WMO Technical Coordinator for Services for Africa at the WMO Regional Office

Restoring climate services in conflict-ridden Sudan

Generating early warning amidst insecurity

Sudan's ongoing conflict has crippled its meteorological infrastructure and services, jeopardising the nation's ability to anticipate and respond effectively to extreme weather events. This article details the Sudan Meteorological Authority's (SMA) pre-conflict capabilities, the innovative Sudan Climate and Weather Rescue Plan, its remarkable achievements despite continuing challenges, and the crucial need for sustained international support.

The SMA's resilience underscores the critical importance of investing in climate services within fragile and conflict-prone regions.

Situation pre-conflict

Before the conflict, the SMA was a proactive agency engaged in crucial projects to enhance data collection and forecasting. Key collaborations included the International Centre for Environmental Monitoring (CIMA) for early warning systems (EWS), Finnish Meteorological Institute (FMI), UN Environment Programme (UNEP), Food and Agriculture Organisation (FAO) and the Desert Research and Sustainable Development Association (DRESSA).

Two NORCAP experts provided critical support in climate services and weather research and forecasting (WRF) modelling. The SMA's observational network comprised 24 traditional weather stations, 64 automated weather stations (AWS) and sophisticated operational forecasting models. Recent initiatives like CREWS (see page 9) and Water at the Heart of Climate Action further highlighted the need for improved climate services.

Sudanese experts were seconded at ICPAC with the ICPAC director, Dr Abdi Fidar, and the UN Special Envoy for the Horn of Africa, Hanna Tetteh. This collaboration highlights the regional support and expertise sharing essential for enhancing early warning systems in Sudan.

A response to crisis

Faced with the urgent need to maintain essential weather and climate services during the conflict, the SMA implemented a comprehensive rescue plan cantered on:

- Establishing an operational emergency office
- Implementing crucial data rescue initiatives
- Strengthening technical capacities through training and expertise sharing
- Forging partnerships with key organisations including CIMA, NORCAP and the IGAD
- Intergovernmental Authority on Development – Climate Prediction and Applications Centre (ICPAC)
- Integrating the rescue plan with ongoing projects to maximise impact and align operations with the Early Warning for All (EW4A) initiative

Resilience in the face of adversity

Despite the ongoing conflict, the rescue plan has delivered significant successes. An emergency office was established in Port Sudan, and collaborations with the Egyptian Meteorological Authority (EMA) and ICPAC ensured partial service continuity.

The SMA successfully maintained some data collection using phone calls and recovered 50% of historical data from 29 stations. Active international engagement included participation in key events such as Climate Africa Week, COP28, and the Greater Horn of Africa Climate Outlook Forums (GHACOFs).

In particular, SMA experts participated in the first East Africa Dialogue on Anticipatory Actions held in Mombasa, supported by Save the Children and ICPAC. This engagement highlights the SMA's commitment to enhancing early warning capabilities through regional cooperation and shared learning.

Securing the future of climate services

The SMA faces significant challenges stemming from its reliance on CIMA for model outputs, which has been critical for operating the WRF model.

The support provided for running the WRF model through the high-performance computing (HPC) resources at CINECA, the Italian supercomputing centre, is anticipated to continue until December 2025. However, the broader technical and institutional support from CIMA is expected to conclude in the first quarter of 2025, marking the end of the current three-year investment.Currently though, negotiations are underway on a new agreement.

Key priorities moving forward include:

- Securing continued support: Sustaining forecasting capabilities, operational infrastructure and ongoing training efforts will be critical to ensure the benefits of previous investments are maintained.
- Service sustainability: It is essential to develop strategies to secure financial and operational stability beyond the current project funding cycle.
- Rehabilitation of observation stations: Repairing and upgrading damaged observation stations is crucial for accurate data collection and monitoring, which underpin forecasting and warning systems.

These efforts are necessary to preserve and enhance the resilience of early warning services and ensure long-term operational effectiveness.

Participation in COP Events

At COP28, SMA Director General Dr Hanan Rabbah highlighted the SMA's operational challenges during the war, including infrastructure losses, staff displacement and data loss, while emphasising the agency's ability to maintain some operations.

At COP29, supported by the DARAJA project managed by the consultancy firm Resurgence, Dr Rabbah showcased the progress of the rescue plan and outlined potential challenges for future rehabilitation needs.

The SMA's efforts exemplify remarkable resilience and a commitment to restoring climate services in Sudan. Continued international collaboration, sustained funding and capacity building are crucial for overcoming future challenges, and particularly sustaining the SMA transition to self-sufficient forecasting capabilities while approaching the conclusion of the three years of technical assistance from the APIS project funded by the Italian Agency for Development Cooperation AICS.

The SMA's collaboration in high-level dialogues, such as those in Mombasa, emphasises the importance of shared knowledge and strategies tailored to the unique challenges of conflict-affected regions.

Effective EWS, as advocated by the WMO – UNDRR Centre of Excellence for Climate and Disaster Resilience, must be seen as essential services to protect vulnerable populations in conflict zones.

Dr Hanan Magzoub Rabbah with Dr Mark Harvey, CEO at Resurgence.

The SMA's success highlights the vital role of partnerships and advocates for ongoing support to ensure the delivery of life-saving climate information to the Sudanese people.

As we move forward, stakeholders must recognise the interconnection between climate resilience, disaster risk reduction and peacebuilding in fragile contexts like Sudan. The experiences of the SMA and its partnerships serve as a model for addressing climate-related challenges in conflict-affected environments worldwide.

With ongoing support, investment and collaboration, we can ensure that Sudan—and similar regions—develop the robust early warning systems necessary to protect their communities against the escalating threats posed by climate change and natural disasters.

Special acknowledgements

The efforts of the SMA would not have been possible without the invaluable support from the World Meteorological Organisation (WMO), UN Office for Disaster Risk Reduction (UNDRR), ICPAC, CIMA, EMA, NORCAP, Save the Children, International Federation of Red Cross and Red Crescent Societies (IFRC), and other significant contributors who have provided guidance, expertise and resources throughout this challenging period.

Additionally, special thanks to the Varysian Network for providing the platform to present the Sudan Climate and Weather Rescue Plan. Their support has been instrumental in maintaining and enhancing the capabilities of the Sudan.

Final thoughts

Restoring and enhancing climate services in conflict-affected regions like Sudan is not only a matter of technical capability but also of social responsibility. By investing in EWS and fostering cooperation among local and international stakeholders, we can build a foundation for a more resilient future for the people of Sudan, ensuring that they are equipped with the knowledge and tools needed to navigate the complexities of climate change amidst ongoing insecurity.

Dr Abuelgasim I. I. Musa's webinar on the Sudan Climate and Weather Rescue Plan is available to view on *the Varysian Network*.

Author: Dr Abuelgasim I. I. Musa, Head of Early Warning Unit, Sudan Meteorological Authority

World of Data 04

The Pholourie Effect

Trinidad's own afternoon pop-up 'Soca' storms

Meteorology in Trinidad and Tobago has long focused on observing, forecasting and analysing local, regional and synoptic weather patterns.

In Trinidad, two distinctive facts stand out. First is that the local delicacy, pholourie, is a beloved snack. Secondly, strong thunderstorms will often develop rapidly along the western coastal regions and the east-west corridor.

These storms, which are characterised by intense rainfall and flash flooding, occur even when upper and mid-level atmospheric conditions do not favour deep convection. They are driven by the interplay of weak synoptic winds and sea breezes caused by the temperature gradient between the land and Gulf of Paria.

The introduction of Doppler radar and modern satellite technologies has enabled detailed observations of these phenomena. Cumulonimbus clouds often form within 15 to 25 minutes, producing heavy rainfall, strong downdrafts and occasional funnel clouds, before dissipating just as quickly.

This phenomenon is referred to as 'the pholourie effect' due to the resemblance between the squeezing of pholourie dough into hot oil and the rapid development of thunderstorms depicted on radar imagery.

The radar's colour scheme for maximum reflectivity (MAX) mirrors the golden-brown hue of fried pholourie, highlighting a unique connection between Trinidad's food culture and its dynamic weather patterns.

The pholourie effect refers to the convergence of surface airflows from opposing directions across Trinidad, forcing air to rise and trigger rapid free convection. This process can overcome unfavourable mid-to-upper-level atmospheric conditions, resulting in the formation of cumulonimbi and intense, localised thunderstorm activity.

These events are typically confined to areas ranging from 5 km to 50 km (high microscale to low mesoscale). Doppler radar imagery shows these thunderstorms as brown dots that start small, but rapidly intensify and expand.

The phenomenon usually occurs during late mornings or afternoons when four key conditions are met:

- Trade wind speeds drop to 10 knots or below
- Land temperatures reach 30°C or higher
- Trade winds flow from between the east to the south
- A westerly sea breeze develops, matching the strength of the prevailing trade winds

An example of this occurred on March 14, 2014, when thunderstorms formed despite a 3°C trade wind inversion at 9,000 ft. These observations challenge traditional meteorological assumptions that upper-level convergence or downward air transport suppress deep convection.

Instead, strong surface forcing can overcome such suppression in localised areas, as supported by Riehl's 1954 work on trade wind inversions, which suggested that overcoming such conditions, though rare, is not impossible.

Pholourie balls
Image credit: silofoods.ca

Conditions for the pholourie effect

Drier days with clear skies play a crucial role, allowing land temperatures to rise steeply between 10am and 2pm. This creates a significant temperature gradient between the warmer land and the cooler waters of the Gulf of Paria, generating a westerly sea breeze that counteracts the slow easterly or south-easterly trade winds. The strength of the sea breeze correlates with the steepness of this temperature gradient.

Urbanised areas along Trinidad's west coast, with dense clusters of concrete buildings and paved streets, experience the steepest temperature gradients. The two primary zones are Port-of-Spain, including the expansive East-West Corridor, and San Fernando. Port-of-Spain's built-up area is notably larger—three to four times the size of San Fernando—making it the primary region for these localised effects.

Figures 1, 2 and 3 illustrate three general wind regime scenarios. These diagrams show areas where cumulonimbi are most likely to develop (green cloud borders), locations of the strongest thunderstorms (red cloud borders), and general surface wind flow patterns (blue arrows).

They are based on years of observations, including low-cloud movements, cumulonimbi development patterns, satellite imagery, anemograph recordings at Piarco, weather prediction models and Doppler radar renditions of MAX and surface rainfall intensity (SRI) products.

It is this combination of climatic and urban factors that sets the stage for the rapid convective activity which defines the pholourie effect.

When is the pholourie effect most likely to occur?

The pholourie effect is most frequently observed between May and December, when the four key criteria for its development align. However, during Trinidad's rainy season's more active months (July to September), it may go unnoticed amidst larger synoptic-scale weather events.

Strong trade winds, common during the dry season (January to May), often prevent the westerly sea breeze from developing. Conversely, between the transition times from the dry to the rainy season and vice versa, the North Atlantic High is situated further north, weakening the trade winds and allowing conditions for the phenomenon to arise.

During this period, disturbances like tropical waves, cyclones, troughs and the Intertropical Convergence Zone (ITCZ) interrupt the steady trade wind flow, enabling the localised conditions necessary for the pholourie effect.

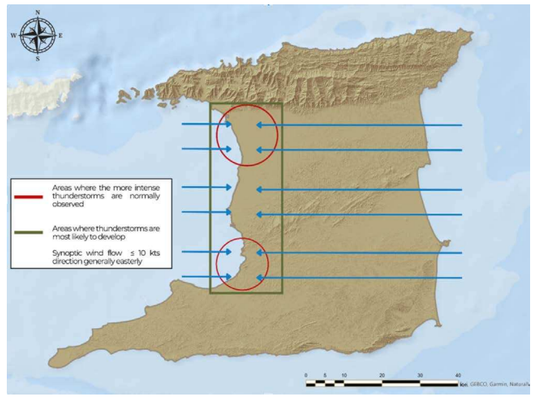


Figure 1: Wind generally from the East

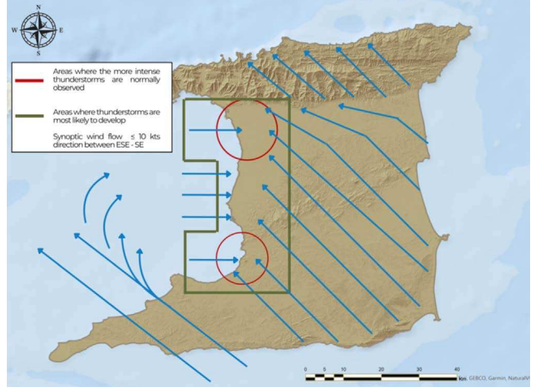


Figure 2: Wind generally from between ESE to SE

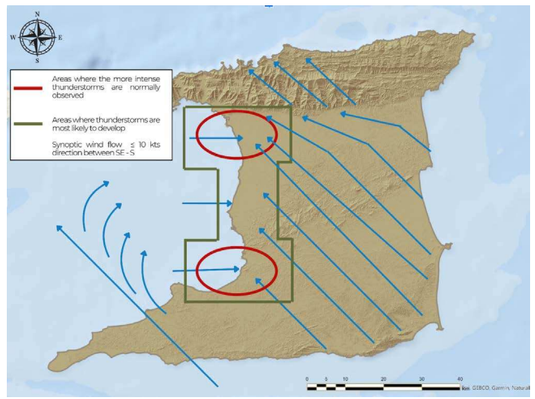


Figure 3: Wind generally from between SE to S

Although most common from late spring to late autumn, the phenomenon can occur at any time of year if the right conditions are met. For example, on 14 March 2014, and 28 January 2020, intense rainfall caused street and flash flooding in Port-of-Spain, even during the dry season. In the latter case, while thunderstorms were absent, towering cumulus clouds (Cumulus Congestus) were observed.

Predictability - signs to look for

The pholourie effect is most likely to occur when surface synoptic wind speeds across Trinidad drop below 10 knots, with winds coming from between the east and south. These conditions must combine with overland air temperatures reaching 30°C or higher by late morning and the development of a sea breeze flow from the Gulf of Paria.

Weather forecasters at Piarco routinely monitor for these conditions, particularly in anticipation of afternoon thunderstorms over western Trinidad. When the first three conditions are met, there is an estimated 75% probability of thunderstorm development.

The likelihood increases when moisture is present in either the westerly sea breeze from the Gulf of Paria or the easterly trade wind flow.

The intensity of the event appears to correlate with higher overland temperatures, leading to more severe thunderstorms. While forecasting the general possibility of western thunderstorms is feasible, pinpointing the exact location and timing falls under nowcasting.

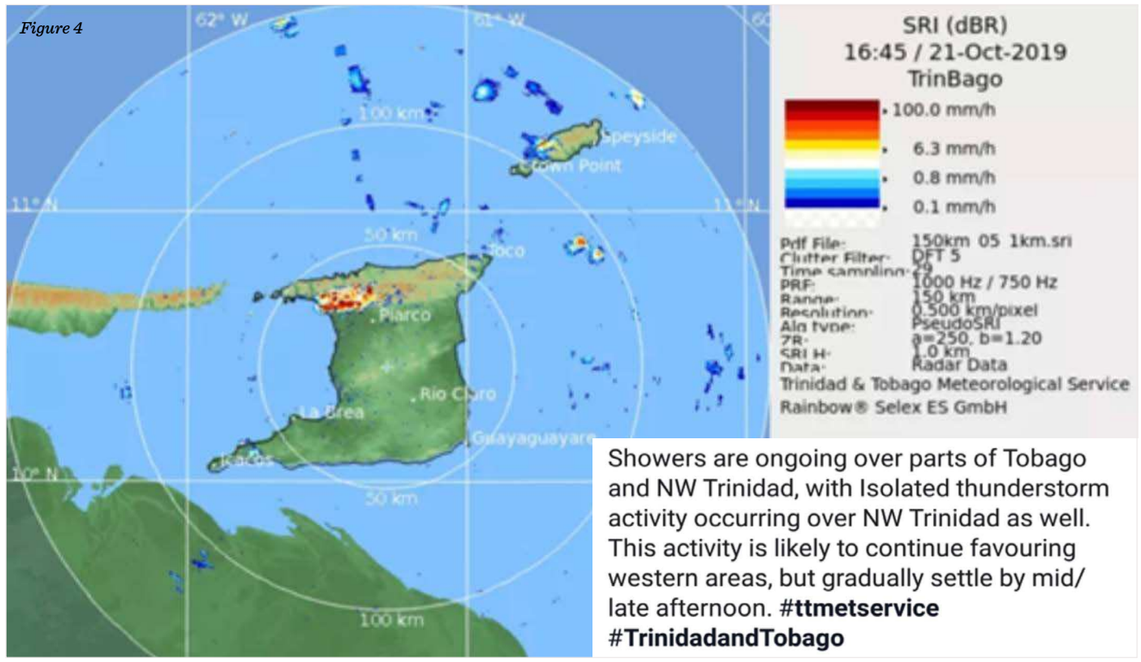
Continuous monitoring of Doppler radar is essential for identifying the onset of such events, allowing forecasters to refine predictions and provide timely updates.

Examples of the pholourie effect

Example 1 – March 14, 2014. Wind speeds at Piarco Airport were below 10 knots, with temperatures reaching 33.0°C by noon. Doppler radar captured the development of thunderstorms over Port-of-Spain and San Fernando, despite a 3°C trade wind inversion at 9,000 feet. Radar imagery highlighted concentrated storm activity over these areas.

Example 2 – October 21, 2019. Thunderstorms were observed over the western foothills of the Northern Range, with flash flooding reported in Port-of-Spain. Temperatures reached 32.3°C, and Doppler radar recorded significant reflectivity in the affected areas. Satellite images showed developing cells over the western regions (Figure 4).

Figure 4



Showers are ongoing over parts of Tobago and NW Trinidad, with Isolated thunderstorm activity occurring over NW Trinidad as well. This activity is likely to continue favouring western areas, but gradually settle by mid/ late afternoon. #**ttmetservice** #**TrinidadandTobago**

Example 3 – November 14, 2019. Thunderstorms developed east of San Fernando, producing heavy rainfall and localised flooding. Radar imagery highlighted concentrated activity over the affected region. Satellite views corroborated the intensity of localised convective activity (Figure 5).

Example 4 – June 8, 2020. A visible spectrum satellite image captured convective activity over central Trinidad, aligned with westerly sea breeze convergence. Thunderstorms caused flash flooding along the convergence line. Satellite imagery showed rapid cloud buildup along the inland areas of convergence.

Example 5 – July 15, 2020. Thunderstorms developed over the southwestern coast, producing gusty winds and localised flooding. Satellite imagery and meteorological reports confirmed the event. Images depicted concentrated cloud development over Claxton Bay and its surroundings.

Documented impacts of the pholourie effect

While strong thunderstorms are common in Trinidad during the rainy season, driven by synoptic features like tropical waves, the ITCZ and troughs, the pholourie effect presents a unique risk due to its sudden onset.

Unlike larger synoptic events that can be forecast advance, the pholourie effect can develop with little warning, catching people off guard.

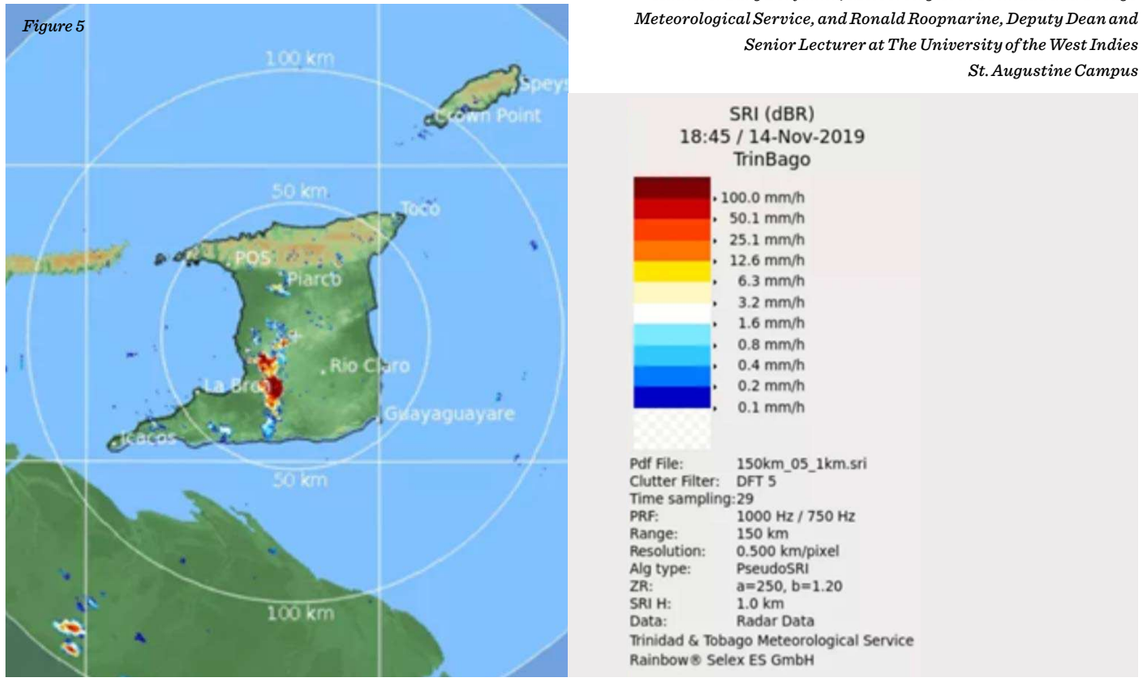
The rapid development of thunderstorms leads to intense rainfall over localised areas, causing street and flash flooding that poses significant threats. These sudden storms disrupt public and private transportation, leaving people stranded. The storms also bring lightning, powerful downdraughts and in some cases, downed trees and power outages.

Roofs have been torn off buildings, and funnel clouds and waterspouts have been observed during these events. Based on eyewitness accounts, the conditions also suggest the possibility of short-lived tornadoes.

In addition to physical damage, there are economic and emotional impacts. Businesses, farmers and homeowners have suffered losses in stock, crops, livestock and personal property. Many families have lost furniture, appliances and pets. The emotional and mental toll on those affected by these events is immeasurable, with the trauma lingering long after the storm has passed.

Authors: Gary Benjamin, Meteorologist at Trinidad and Tobago Meteorological Service, and Ronald Roopnarine, Deputy Dean and Senior Lecturer at The University of the West Indies St. Augustine Campus

Figure 5



Advancing resilience through geospatial technology

A unified approach to extreme weather challenges

Extreme weather events are no longer distant threats — they are here, unfolding with greater frequency and intensity, reshaping lives, landscapes and livelihoods.

Communities, infrastructure and ecosystems face mounting challenges, demanding a new era of preparedness, response and resilience. In this rapidly changing world, geographic information systems (GIS) and artificial intelligence (AI) are revolutionising the way we anticipate, manage and mitigate the impact of severe weather.

By integrating real-time data with advanced analytics, these innovative technologies empower decision-makers to predict risks, streamline emergency responses and fortify communities against future disasters.

From tracking hurricanes to managing wildfires, GIS provides a dynamic, data-driven approach that enhances situational awareness and drives informed action. The fusion of geospatial intelligence with environmental and social data is transforming disaster management — offering not just immediate solutions but long-term strategies for adaptation and sustainability.

Across the globe, agencies and organisations are harnessing GIS to foster collaboration and innovation, ensuring that responses to extreme weather are faster, smarter and more effective.

Whether through the rapid mobilisation of resources during Hurricane Helene or the forward-thinking climate strategies of the Cork County Council in Ireland, real-world examples highlight the importance of technology.

As we navigate an era of intensifying meteorological extremes, the ability to harness GIS and AI for informed decision-making has never been more vital. These tools are not just shaping how we respond to disasters — they are paving the way for a future where we are better prepared, more adaptable, and more resilient.

Inspiring resilience through innovation: A case study from Hurricane Helene

During Hurricane Helene, the South Carolina Emergency Management Division (SCEMD) exemplified the power of GIS technology in driving cross-agency collaboration and utilising remote sensing to enhance recovery efforts.

Their strategic approach not only illustrated the critical role of technology in disaster management but also demonstrated the strength of partnerships in overcoming challenges.

The South Carolina Emergency Management Division's utilisation of GIS and remote sensing technology during Hurricane Helene serves as a compelling example of how innovative approaches can enhance recovery efforts. Their strategic use of remote sensing not only displayed the critical role of technology in managing extreme weather but also highlighted the importance of cross-agency collaboration.

By incorporating tools such as ArcGIS Enterprise, ArcGIS Dashboards and synthetic aperture radar (SAR) data from ICEYE, SCEMD enhances situational awareness, decision-making and recovery efforts.

Their proactive approach includes scaling GIS operations across all departments, utilising imagery to assess flood risks and collaborating with external agencies like the South Carolina State National Guard to aggregate data for more informed responses.

This strategic use of GIS for mitigation, response and recovery allows SCEMD to better understand and address the impact of natural disasters, facilitating more efficient recovery and fostering long-term resilience for the state. Discover how their methods are paving the way for improved resilience against future storms on *our website*.

Empowering communities with data-driven resilience: the Cork County Council's innovative approach

As Ireland faces an increasing barrage of severe storms and weather-related challenges, the Cork County Council is leading the charge in emergency preparedness. Leveraging Esri's ArcGIS technology, the council is turning complex data into actionable insights, ensuring both immediate response and long-term resilience.

This forward-thinking initiative is more than just a reaction to extreme weather — it's a proactive strategy that strengthens public safety, equips emergency responders with critical information and fosters a culture of preparedness.

Through strategic partnerships and advanced GIS capabilities, the Cork County Council is setting a new standard for disaster management, demonstrating how technology can build a framework for resilience in the face of an unpredictable climate.

Their efforts highlight the power of geospatial intelligence in navigating nature's challenges — proving that with the right tools and collaboration, communities can not only withstand extreme weather but emerge stronger and more prepared for the future.

Harnessing GIS: the essential tool for wildfire and storm response

As wildfires and severe storms grow more destructive, state and local agencies are turning to powerful GIS technology to stay ahead of the disaster. With tools like Esri's Scene Viewer, responders can visualise essential data, such as fire perimeters and evacuation zones, giving them the clarity needed to make fast, informed decisions. This unified view not only strengthens situational awareness but also streamlines communication, ensuring that first responders are always on the same page, working together to protect lives and property.

Real-time data transforms how agencies adapt to rapidly changing conditions, allowing them to integrate critical information from terrain features to storm paths. This ability to adjust strategies on the fly is essential for maintaining coordination, even in remote locations where connectivity is limited. By equipping responders with this vital insight, agencies can act swiftly, minimising damage and ensuring the safety of those in harm's way.

Nonetheless, the impact does not stop with the immediate response. Advanced GIS and AI predictive tools are helping agencies plan for the future, anticipating risks and allocating resources to where they are needed most. In an era of growing natural disasters and urban sprawl, this technology is a beacon of hope, enabling agencies to proactively safeguard communities and strengthen resilience against the challenges of tomorrow.

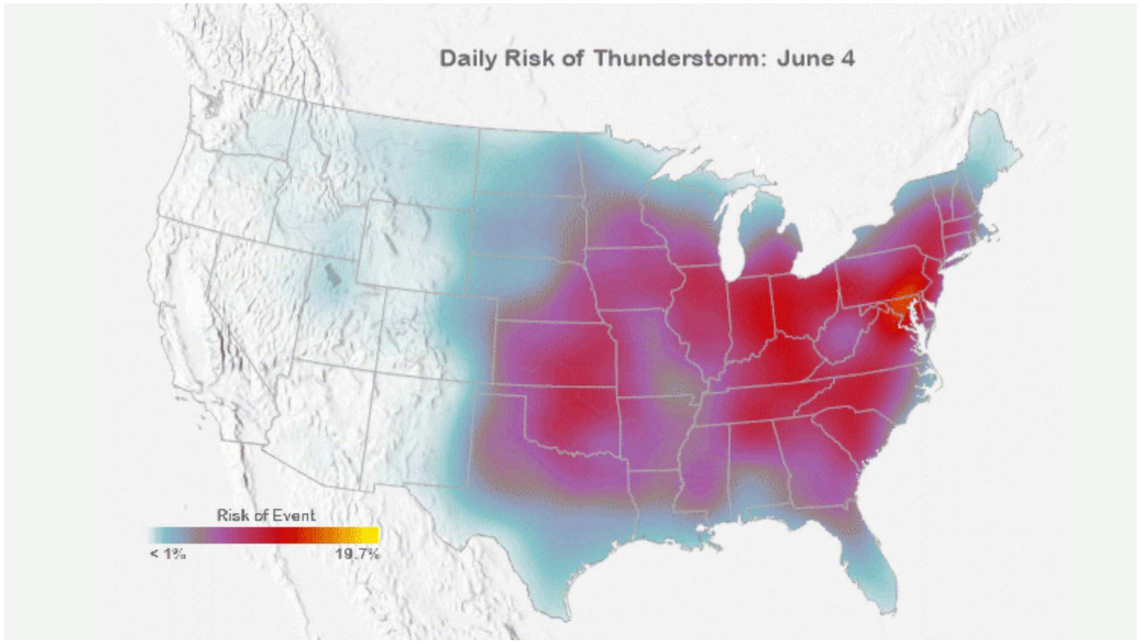
Navigating nature's fury with GIS

In the heart of the Midwest, a small town nestled between vast stretches of farmland had long been at the mercy of unpredictable severe weather. Each spring, residents braced themselves for storms that could bring anything from torrential downpours to tornadoes carving destructive paths through their community. Emergency responders worked tirelessly, but the ability to predict the timing and intensity of these events remained a challenge — until GIS transformed their approach. By leveraging the Space Time Kernel Density tool within ArcGIS Pro's Spatial Analyst extension, local meteorologists and planners began to analyse years of storm data, uncovering hidden patterns in how, when and where severe weather struck.

What had once been a reactive process turned into a proactive strategy. By mapping historical storm activity and layering it with real-time atmospheric conditions, emergency management teams could identify high-risk zones and anticipate where the next storm could cause the most damage. City planners used this intelligence to fortify vulnerable infrastructure, ensuring that schools and emergency shelters were placed in safer locations and built to withstand extreme winds. Farmers adapted their planting schedules, minimising crop losses by preparing for weather shifts before they happened.

In this way, GIS did not just provide data — it illuminated a path forward, equipping the town with the insights needed to protect lives and property.

Heavy rain floods a road in Cork, Ireland. An incident like this would be mapped by the Cork County Council using ArcGIS Online.



This GIS-generated visualisation highlights the daily risk of thunderstorms across the United States on June 4. The fusion of historical data and real-time insights empowers emergency responders and decision-makers to navigate nature's challenges with confidence.

The power of GIS extends beyond a single town. Across the country, state and federal agencies integrated geospatial technology into disaster preparedness frameworks, strengthening resilience on a national scale.

By combining meteorological data with demographics, decision-makers ensure that vulnerable populations receive early warnings and prioritised resources. This approach, which visualises storms in both space and time, pushes weather preparedness far beyond the traditional forecasting methods.

As extreme weather intensifies, GIS remains a vital tool for safeguarding communities. By combining historical trends, real-time analytics and spatial intelligence, responders and citizens alike can transform uncertainty into preparedness—building a future where resilience leads the way.

Unlocking the future of disaster response with GeoAI

A breakthrough in disaster management has come through the use of ArcGIS pre-trained geospatial artificial intelligence (GeoAI) models, which allow emergency responders and analysts to process critical data in real time.

These models automate tasks such as damage detection and threat identification, streamlining the response process and enabling teams to act with greater speed and accuracy during times of crisis.

One of the most significant advantages of GeoAI is its ability to assess damage almost immediately after an event occurs. For example, it can detect collapsed buildings after an earthquake or pinpoint flooded areas following a storm. This rapid analysis allows first responders to prioritise their efforts, ensuring that resources are directed where they are needed most. By detecting emerging threats like wildfires or flooding, GeoAI helps responders make quicker, more informed decisions, increasing the overall effectiveness of disaster response.

Beyond speeding up damage assessment, these tools also reduce the need for manual data analysis, freeing up emergency management teams to focus on critical coordination efforts.

Automation helps minimise human error and enhances the accuracy of the data being used to guide recovery efforts.

With these technologies, communities are better equipped to handle the challenges posed by unpredictable natural disasters, laying the foundation for more resilient, adaptive disaster management systems.

Shaping a resilient future together

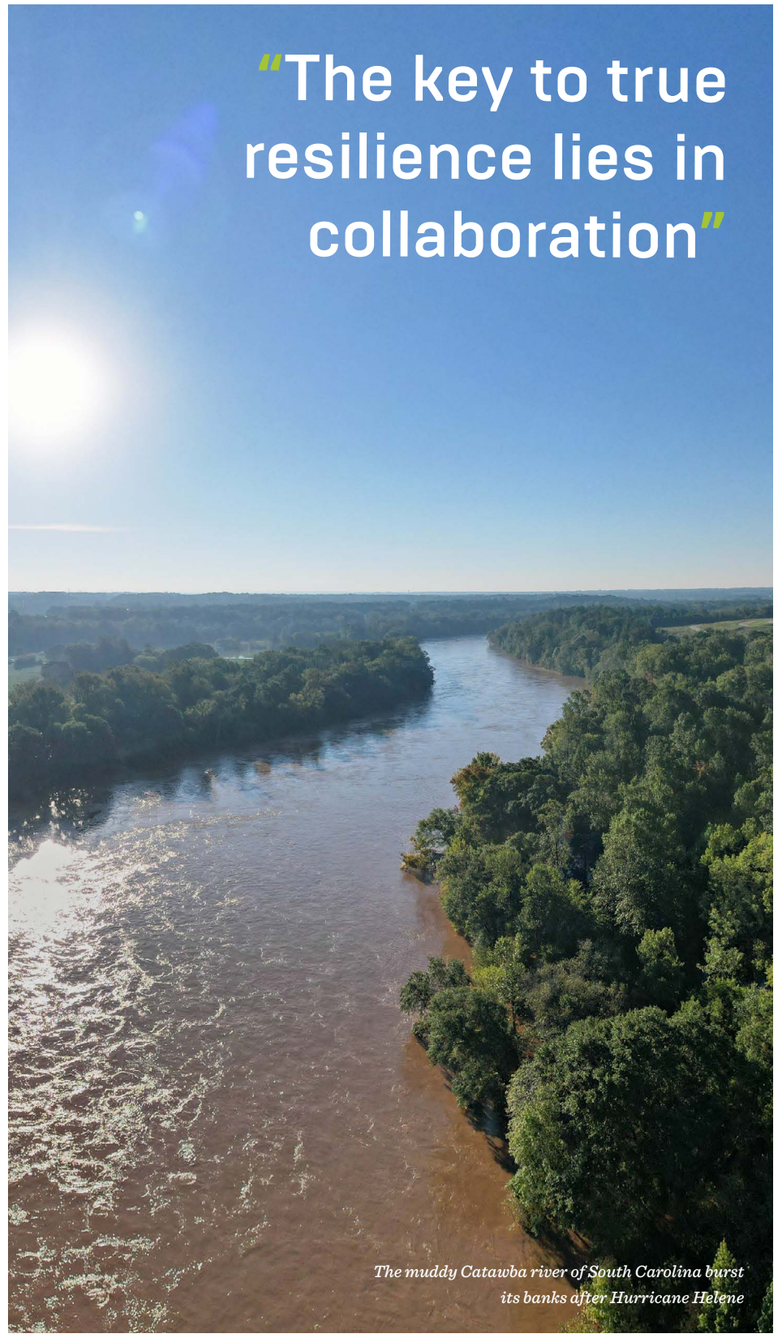
Through real-world applications, GIS and AI are not only enhancing our ability to manage severe weather but also redefining how we prepare for the future. By transforming data into decisive action, these technologies empower communities, strengthen resilience and ensure that we are ready to face the challenges of an increasingly unpredictable climate.

As we navigate this new era of extreme weather, integrating GIS and AI into disaster preparedness and response is no longer optional — it's essential. By harnessing real-time data and interdisciplinary insights, we can develop innovative strategies that protect lives, infrastructure and ecosystems. But technology alone is not enough.

The key to true resilience lies in collaboration — between government agencies, private sector innovators, researchers and the communities most affected by severe weather events.

Now is the time to act. Let's leverage the power of geospatial technology to turn information into impact, insight into action, and risk into resilience. Together, we can build a world where data-driven decisions save lives, proactive planning reduces disaster impact, and innovation paves the way for a safer, more prepared future.

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



The muddy Catawba river of South Carolina burst its banks after Hurricane Helene

AI tool generates realistic satellite images of future flooding

Method could help communities prepare for approaching storms, writes Jennifer Chu, MIT News

MIT scientists have developed a method that generates realistic satellite imagery depicting how a region would look after a flooding event. Combining a generative artificial intelligence (AI) model with a physics-based flood model, this method produces images of a region showing where flooding is likely to occur given the strength of an oncoming storm.

Typically, policymakers can get an idea of where flooding might occur based on colour-coded maps. The process begins with a hurricane track model, which then feeds into a wind model. This is combined with a flood or storm surge model, and then a hydraulic model maps out where flooding will occur based on the local flood infrastructure. It is from this that a colour-coded map can be generated.

The researchers looked at whether visualisations of satellite imagery could add another level to this, in order to create something more tangible and emotionally engaging.

As a test case, the team applied the method to Houston and generated satellite images depicting what certain locations around the city would look like after a storm comparable to 2017's Hurricane Harvey.

They used a conditional generative adversarial network (GAN); a machine learning (ML) method that can generate realistic images using two competing, or adversarial, neural networks.

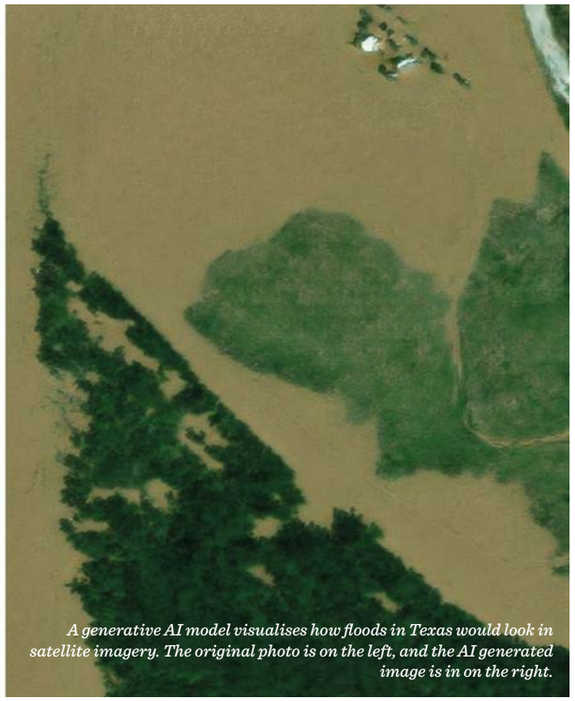
The first 'generator' network is trained on pairs of real data, such as satellite images before and after a hurricane. The second 'discriminator' network is then trained to distinguish between the real satellite imagery and the one synthesised by the first network.

Each network automatically improves its performance based on feedback from the other. The idea is that this adversarial push and pull should ultimately produce synthetic images that are indistinguishable from the real thing. Nevertheless, GANs can still produce hallucinations - factually incorrect features.

Flood hallucinations

In response, the researchers considered a risk-sensitive scenario in which generative AI created satellite images of future flooding that could be trustworthy enough to inform storm preparation decisions.

Both pre-flood images are from Maxar Open Data Program via Gupta et al., CVPR Workshop Proceedings. Both generated images are from Lütjen et al., IEEE TGRS. MIT



A generative AI model visualises how floods in Texas would look in satellite imagery. The original photo is on the left, and the AI generated image is in on the right.

They first tested how generative AI alone would produce satellite images of future flooding. They trained a GAN on images taken by satellites as they passed over Houston before and after Hurricane Harvey.

When they tasked the generator with producing new flood images of the same region, they found that the images resembled typical satellite imagery. However, a closer look revealed hallucinations in some images, in the form of floods where they should not be possible – such as locations at higher elevation.

To reduce hallucinations and increase trustworthiness, the team paired the GAN with a physics-based flood model that incorporates real, physical parameters and phenomena such as an approaching hurricane's trajectory, storm surges, and flood patterns. With this reinforced method, the team generated satellite images around Houston that depict the same flood extent, pixel by pixel, as forecasted by the model.

This proof-of-concept demonstrates that generative AI models can create realistic, trustworthy content when paired with a physics-based model.

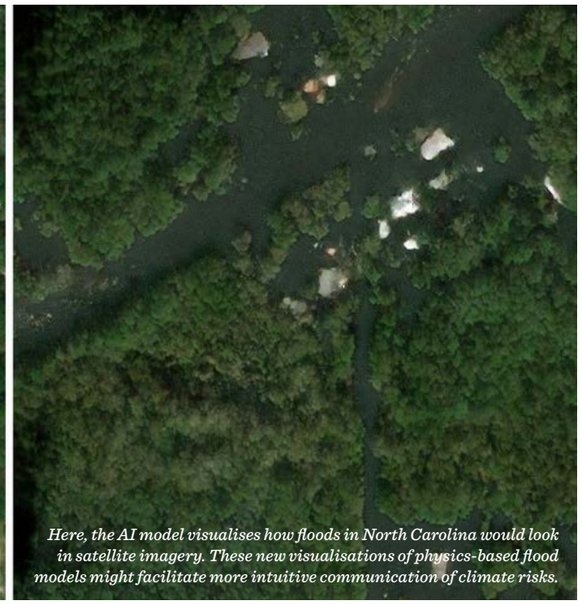
"One day, we could use this before a hurricane, where it provides an additional visualisation layer for the public," says Björn Lütjens, a postdoctorate associate in MIT's Department of Earth, Atmospheric and Planetary Sciences, who led the research while at MIT's Department of Aeronautics and Astronautics (AeroAstro).

"One of the biggest challenges is encouraging people to evacuate when they are at risk. Maybe this could be another visualisation to help increase that readiness," says Professor Dava Newman, the study's senior author and Director of the MIT Media Lab. "People relate to their own zip code, their local environment where their family and friends live. Providing local climate simulations becomes intuitive, personal and relatable."

In order to apply the method, which the researchers have dubbed the 'Earth Intelligence Engine,' to other regions, it will need to be trained on many more satellite images to learn how flooding would look in these areas. To support this, the team has made it available as an online resource for others to try.

"We can't wait to get our generative AI tools into the hands of decision-makers at the local community level, which could make a significant difference and perhaps save lives," Newman concludes.

Author: Jennifer Chu, MIT News



Here, the AI model visualises how floods in North Carolina would look in satellite imagery. These new visualisations of physics-based flood models might facilitate more intuitive communication of climate risks.

THE LIGHTNING DATA PROCESSING SOFTWARE

CATS

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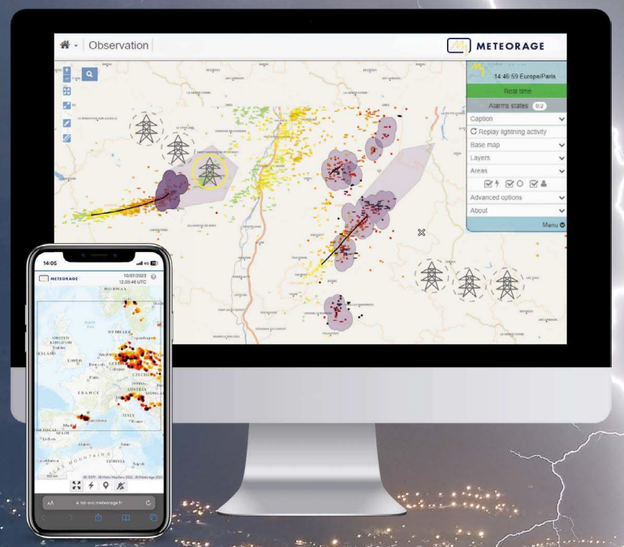

CATS is a modular production tool provided worldwide:

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- **User focused services** tailored to every need,
- **Compatible** with all types of lightning data streams,
- With an **autonomous user accounts management**.

Integrated system designed to produce and manage **5 ranges of solutions** using lightning data:

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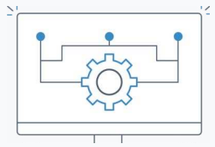
live thunderstorms and lightning.

BE ALERTED
when a thunderstorm is approaching and leaving.

CHECK
any damage on installations after a thunderstorm.

EVALUATE
the lightning risk exposure.



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METEORAGE

Public Private Partnerships 05

Strengthening resilience in the Pacific

A report from the Pacific Meteorological Council meeting PMC-7

The most recent Pacific Meteorological Council meeting, PMC-7, was held in Vanuatu last September and continued to be a driving force in addressing the unique and complex meteorological challenges faced by Pacific Islands Countries and Territories (PICTs).

One project at the forefront of these efforts is Weather Ready Pacific (WRP), an ambitious 10-year initiative aimed at enhancing early warning systems and fostering regional resilience against extreme weather, climate variability and disasters. Ultimately, this will not only reduce the human and economic cost of natural disasters, but also support the livelihoods of local people who rely on industries most affected by climate change.

Weather Ready Pacific: a cornerstone for resilience

At PMC-7, updates and ongoing progress for the Weather Ready Pacific project were shared, continuing to align with global initiatives such as the World Meteorological Organisation's (WMO) Early Warnings for All (EW4All) initiative and the Systematic Observations Financing Facility (SOFF). These global frameworks provide valuable support to enhance regional capacities in data collection, forecasting and preparedness.

WRP is a pivotal step forward in creating sustainable, coordinated systems to provide early warnings and mitigate the impact of disasters on vulnerable Pacific communities. The project's success hinges on integrating traditional knowledge with cutting-edge technology and will address gaps in communication and infrastructure. WRP sets a foundation for more adaptive responses to climate and disaster risks.

Public-private partnerships: unlocking potential

One of the recurring themes on the PMC-7 agenda was the emphasis on partnerships, and in particular, the role of the private sector. The side event hosted by Varysian on private-sector engagement discussed how approaching partnerships in a region-specific way can help Pacific nations and territories bridge gaps in sustainable maintenance, technology and expertise.

Aerial view of Port Vila, Vanuatu

One issue raised was the need for more sustainable parts and maintenance procedures in meteorological and hydrological equipment. Several solutions were suggested by members of the private sector panel, who were very interested in discussing the issue further with local representatives. This is an example of why in-person meetings focused on addressing Pacific-related challenges are so important.

Public-private collaborations have proven instrumental in delivering transformative solutions globally and in areas with region-specific challenges. Varysian will continue to provide a space for discussions to not only enhance the technical aspects of meteorological services, but also create economic opportunities and strengthen stakeholder relationships.

Regional collaboration and integrated solutions

The PMC-7 meeting highlighted the importance of regional efforts, open discussion and organisational collaboration to share expertise and align priorities. Initiatives like the Pacific Climate Services Roadmap (2024-2033) and the Framework for Resilient Development in the Pacific (FRDP) support the WRP by providing strategic direction for addressing long-term climate resilience in the Pacific.

Moreover, the Pacific Island Communication and Infrastructure (PICI) panel focuses on guiding principles for improving observation and communication systems.

Public-private partnerships can significantly bolster these efforts by leveraging private investment to develop infrastructure, including reliable internet connectivity and advanced weather monitoring equipment.

The way forward: building resilience together

As Pacific Island nations stand at the frontline of climate action, their ability to withstand and recover from disasters depends on unified efforts with the Weather Ready Pacific project. Supported by strong public-private partnerships, it exemplifies the potential of cross-sector collaboration.

By aligning regional priorities with global frameworks, fostering innovation through private sector engagement, and basing solutions in local priorities, the Pacific region can lead by example in building a resilient and sustainable future for vulnerable regions.

Introducing HydrometPAC

To continue to support these initiatives, Varysian is developing a regional Pacific conference (HydrometPAC) to act as an interim between PMC meetings, the next of which is due to be hosted in 2026.

The volcanic hills on the island of Ovalau, Fiji

HydrometPAC will be hosted in Fiji later this year and will focus on bringing stakeholders together to continue conversations on public-private partnerships, equipment maintenance and sustainability and delivering solutions to the region's specific challenges and needs.

More information on this upcoming event can be found at www.varysian.com.

Author: Katie Barkans, Operations Manager, Varysian

Lightning services

South African Weather Service (SAWS) partners with METEORAGE to better protect citizens

Every day, all over the world, lightning associated with thunderstorms causes severe injuries and death. South Africa is one of the countries most impacted by this meteorological phenomenon, with more than 260 lightning deaths every year. To limit the accidents related to lightning strikes and other storm-related risks, in 2016 the South African Weather Service (SAWS) deployed its own lightning detection network across the country, and has been improving on this ever since.

Today the South African Lightning Detection Network (SALDN) consists of 26 lightning detection sensors spread across the country, allowing full coverage and guaranteeing high quality data nationwide. Over the last 18 years, SAWS has used its data to develop various services aimed at educating on -and therefore reducing- lightning risks.

Since 2001, SAWS has had a dual mandate which allows it to provide 'public good' services and tailored commercial services, supported by a team of client liaison officers located at head office, as well as the five main regional weather offices around the country. This proved to be a fruitful organisational choice, generating important complementary revenue sources and helping the organisation to better fulfil its mandate. It also underlined the importance of producing and delivering not just data, but customer-focused meteorological services.

METEORAGE, a global expert company in lightning detection and services

To strengthen safety for all in the country, and to further develop the use of its lightning data, SAWS has set up a partnership with METEORAGE, a French private company subsidiary of Météo France and Vaisala.

METEORAGE installed its own lightning detection network in France in 1987, progressively extending it over most of Europe. This network now includes more than 100 sensors, based on the same technology used by the SALDN.

METEORAGE also developed its own dedicated production software, CATS. This provides specialised lightning risk mitigation services answering a large array of needs, from the safety of people and equipment and the optimisation of maintenance and operational processes, through to incident correlation and verification of insurance claims.

Leveraging its extensive knowledge and experience of the entire lightning information chain, today METEORAGE provides services to thousands of end-users worldwide. It has provided complete lightning information chains on a turnkey basis, including sensors, service production capabilities and knowledge transfer for using lightning data, with customers including Meteoswiss in Switzerland, AEMET in Spain and BMKG in Indonesia.

SAWS and METEORAGE partnership

This new public private partnership (PPP) is based on the integration of lightning data issued from the SALDN into METEORAGE's CATS data processing software, which has been installed at the SAWS headquarters. The uses of the CATS lightning services in South Africa are then jointly developed by SAWS and METEORAGE teams on an equal footing and in a spirit of knowledge cross-sharing.

SAWS, however, will always remain the front end and key contact point for users, as it's important that national meteorological services maintain their authoritaty on meteorological information in their country.

The right solution for each lightning-related issue

The CATS software is designed to work as a lightning toolbox, with many customisable modules offering adaptable services that can control what each user can access.

The CATS solutions can be divided into five large families:

Evaluate: tools to produce various statistics and better understand your exposure to the lightning risk;

Alert: automated early warnings;

Follow: real-time monitoring interfaces to track thunderstorms;

Check: lightning activity reports;

Integrate: data/image feeds and APIs to feed various lightning-related information into third-party systems.

These solutions are adapted to various issues of multiple sectors and activities, including but not limited to utilities, schools, disaster management, mines, industries, transport, defence, renewables, insurers and sports.

A collaboration contributing to the MHEWS Initiative

In March 2022, the UN Secretary-General announced that everyone on Earth should be protected by early warning systems within five years, and as a regional leader, SAWS is committed to be at the forefront of this worldwide effort.

Providing CATS solutions helps SAWS in the fulfillment of its state missions, by better protecting citizens and industries in the country.

It participates in the Early Warnings for All (EW4All) initiative by delivering alert tools to help anticipate thunderstorms and mitigate the associated risks.

For a safer future

By joining forces, SAWS and METEORAGE are committed to ensuring all South African actors receive qualitative information to better understand and mitigate lightning-associated risks.

"Most economic and human activities are 'storm sensitive', and our mission is to bring decision-making tools to mitigate the risks to lives and properties," says Dominique Lapeyre de Chavardès, President of Meteorage.

"I am very proud of this public private partnership with SAWS, illustrating our shared commitment to make it happen."

Public and private actors can do more to benefit local communities when they combine their expertise in a mutually beneficial relationship, Ishaam Abader, SAWS CEO, highlights.

"As the South African Weather Service, we are pleased to join hands with METEORAGE, a global authority where matters of lightning detection are concerned.

"This collaboration will go a long way to enhance our safety efforts against lightning strikes for our citizens, as well as for industries that are critical to our economy," he concludes.

Authors: Michelle Hartslief, SAWS' Senior Manager: Commercial and Solal Bordenave, Head of Marketing & International Sales at METEORAGE

Eyes on the storm

How Vanuatu's radar, apps and partnerships are rewriting climate fate

Vanuatu's designation as the most at-risk country for natural disasters and extreme weather events by the World Risk Report is no exaggeration. This aligns with the ongoing concerns of our Pacific leaders, who continue to stress that climate change poses the greatest existential threat to the wellbeing and livelihoods of our people and communities.

In Vanuatu we've witnessed how the impacts of climate change have sadly become our new normal. As you're reading this, our nation is still reeling from the impact of a 7.3 magnitude earthquake that struck just before Christmas 2024. While the rest of the world celebrated what is normally the happiest season of the year, ours was one of desperation, digging through the rubbles for survivors and trying to pick up the pieces of our broken lives.

The feeling of deja-vu is not uncommon for us, along with that of despair, sadness and anxiety. In 2023, two cyclones, Judy and Kevin, made landfall within 48 hours of each other. Storm surges, flooding and destructive hurricane-force winds wreaked havoc across our nation. Vanuatu is no stranger to cyclones, but experiencing two in just as many days was a stark reminder that as the climate crisis intensifies, we're increasingly vulnerable — left like sitting ducks at the mercy of this harsh reality.

Our families, people and communities can no longer feel safe. But our will to survive and thrive is strong and as Pacific people, we're resilient. If anything, Vanuatu's climate vulnerabilities highlight the necessity to strengthen climate resilience and hydromet advancements to mitigate risks and protect communities.

Partnerships for climate resilience

A key part of strengthening climate resilience for Vanuatu is the life-saving work of the Vanuatu Klaemet Infomesen blong Redy, Adapt mo Protekt (Van-KIRAP) project. Van-KIRAP is funded by the Green Climate Fund (GCF) and implemented by the Secretariat of the Pacific Regional Environment Programme (SPREP) in partnership with the Vanuatu Meteorology and Geohazards Department (VMGD), Commonwealth Scientific and Industrial Research Organisation (CSIRO), Australian Bureau of Meteorology (BOM) and APEC Climate Center (APCC).

A testament to the value of durable partnerships and collaboration, Van-KIRAP has showcased effective multi-stakeholder governance in building local technical capacity in harnessing and managing climate data, developing and fostering the use of climate information services (CIS) tools and disseminating tailored climate information.

Since its inception in 2018, the five-year USD22 million project has been the cornerstone for the expanded the use of CIS in five targeted sectors: agriculture, fisheries, infrastructure, tourism and water.

Innovation and tools

Innovation is a big part of Van-KIRAP's work. For example, the Vanuatu Climate Futures Portal is a gateway to climate information services and tools, providing users with the science, mapping, data, videos and other resources to plan their adaptation actions.

In another development, large volumes of hydromet data records have been digitally converted using a Bookeye 3 digital scanner, and are now available for assessing climate trends in Vanuatu. The expansion of the Vanuatu Climate Observations Network across 16 new locations has strengthened both Hydromet and ocean observations.

The VMGD Weather App, a digital platform designed to strengthen climate resilience and disaster preparedness nationwide launched recently, and will go a long way towards saving lives and safeguarding livelihoods. This offers real-time weather forecasts, geo-hazard alerts and offline functionality, ensuring inclusivity for remote communities. The use of cutting-edge technology such as automated weather stations and climate modelling tools has improved data collection and dissemination of critical information.

In the infrastructure sector, a review and update of the Vanuatu Rural Road Design Guide was conducted to identify climate resilience issues. The updated version takes into account climate change projections and rainfall/temperature intensities to ensure climate proofing.

The development of the Sarakata Flood Management Plan and installation of its early warning system (EWS) is another key step towards climate resilience. The plan and standard operating procedures for assessing and mitigating the risks associated with Sarakata River's unpredictable flooding events also minimises the impacts of flooding, reducing property damage, safeguarding public health, and ensuring the continued functioning of critical infrastructure.

One of the most significant milestones for the Van-KIRAP Project was the groundbreaking Vanuatu Weather Radar System, which will greatly boost the capacity of the country's weather monitoring and EWS. The radar system will ensure that high quality data for planning and responding to severe weather events is available on a timely manner and accessible for decision makers and end-users.

Community impact

By placing vital weather and hazard information directly into the hands of farmers, fishers, businesses and families, we enable proactive decision-making that save lives and safeguards livelihoods.

The partnership between VanKIRAP, SPREP and VMGD highlights the critical role of international climate financing in disaster resilience. As Vanuatu faces escalating hydromet hazards, such collaborations ensure the nation can protect its citizens. We might not be able to change the course of the climate crisis but we are certainly going to fight for our survival.

National, regional and global

We're deeply grateful for SPREP's leadership and vision in guiding this work. As a key facilitator of regional cooperation, it provides technical expertise, capacity building and knowledge-sharing across Pacific nations. It serves as an invaluable conduit for Vanuatu in effectively implementing global multilateral environmental agreements (MEAs) and regional environmental frameworks.

At the national level, Van-KIRAP's mandate aligns with Vanuatu's National Adaptation Plan and National Sustainable Development Plan. Through SPREP's ongoing work, lessons from Van-KIRAP are being incorporated into broader Pacific initiatives such as the Weather Ready Pacific (WRP), Pacific Resilience Partnership and Framework for Resilient Development in the Pacific. Interlinking with other SPREP-led initiatives has also highlighted the work of Van-KIRAP by the Pacific Meteorological Council (PMC) to amplify regional impact.

Reliable data is the backbone of effective warning systems. Van-KIRAP's work in Vanuatu to strengthen climate and disaster resilience through tailored information services and infrastructure support is at the heart of the goals of the Paris Agreement. It links with the Green Climate Fund's mandate to support climate-vulnerable nations as well as the aspirations of the UN's Early Warnings for All initiative (EW4all). It's especially important to advance climate justice, ensuring equitable access to critical climate information to the last mile.

The Van-KIRAP project has been a great example of a partnership-executed project. The shared climate databases, cross-border alert systems and lessons learned can shape many future initiatives for climate resilient development, in the Pacific and around the world – and that's something we can get excited about!

Authors: Sunny Kamuta Seuseu, Van-KIRAP Project Maqnager, Sosikeni Lesa, Media and Public Relations Officer at SPREP and Levu Antfalo, Director-Vanuatu Meteorology and Geo-hazards Department

Mr. Sefanaia Nawadra, Director General, Secretariat of the Pacific Regional Environment Programme (SPREP) and Senior Management Team at the official groundbreaking ceremony of the Vanuatu Weather Radar System, Port Vila Vanuatu

HydrometAFRICA 2024

Building resilience through collaboration and innovation

HydrometAFRICA 2024 brought together a diverse group of meteorological and hydrological experts, decision-makers and stakeholders to discuss strategies for improving early warning systems (EWS) and climate resilience in Africa.

Varysian's flagship event, the three-day symposium served as a platform for knowledge exchange, partnership building and technical innovation, focusing on the urgent need to bridge gaps in Africa's hydrometeorological capabilities.

The event attracted over 120 participants to Pretoria, South Africa last May, including directors of national meteorological and hydrological services (NMHSs), international organisations, academia, NGOs and the private sector.

Featuring a mix of presentations, panel discussions, roundtables and an exhibition, HydrometAFRICA 2024 emphasised the importance of collaboration in achieving the Early Warnings for All initiative (EW4A) championed by the World Meteorological Organization (WMO).

Day one: identifying Africa's current status

The opening day focused on assessing Africa's progress toward implementing EW4A. Dr Agnes Kijazi, Director of the WMO Regional Office, set the tone with her address highlighting the challenges and opportunities in strengthening EWS across the continent. She underscored the importance of integrating hydrological and meteorological data to better predict and mitigate the impacts of extreme weather events.

Panel discussions explored the existing gaps in Africa's EWS infrastructure, including data sharing, capacity building and funding limitations. Roundtable discussions allowed participants to delve deeper into specific challenges like improving data integration and increasing community engagement.

Key takeaways from day one included:

- The need for standardised data collection and sharing protocols across NMHSs
- Leveraging artificial intelligence (AI) and machine learning (ML) for predictive modelling
- Establishing stronger public-private partnerships to mobilise resources for EWS

Speakers such as Owiti Zablone, Thematic Manager, Weather and Climate Services at NORCAP, and Vanetia Phakula, Acting Senior Manager: Disaster Risk Reduction, South African Weather Service (SAWS), all contributed to these critical discussions.

Day two: advancing hydrological observations

The second day shifted focus to hydrological observations, which are critical for water resource management and disaster risk reduction. Sessions covered advancements in hydrological monitoring technologies, including radar systems, remote sensing and IoT-enabled (Internet of Things) devices.

A highlight of the day was a presentation by Dr Modathir Zaroug, Regional Water Resources Modeller at the Nile Basin Initiative Secretariat and Maureen Abla Ahiataku, Senior Meteorologist and External Relations Officer at Ghana Meteorological Agency, who discussed the Hydrological Status and Outlook System (HydroSOS).

Roundtables on day two tackled topics such as:

- Enhancing the accuracy and reliability of hydrological forecasts
- Integrating hydrological data into national climate adaptation plans
- Training NMHS staff to use advanced monitoring systems more effectively

Day three: bridging the gaps

The final day focused on bridging the gaps between policy, technology and community engagement.

Discussions revolved around ensuring that EWS effectively reach vulnerable populations, particularly in remote and underserved areas.

One of the most engaging sessions on financing featured representatives of SOFF, CREWS, International Fund for Agricultural Development (IFAD) and the World Bank.

The final day concluded with actionable recommendations for advancing multi-hazard early warning systems (MHEWS) across Africa.

Outcomes and impact

HydrometAFRICA 2024 was a resounding success, fostering meaningful connections among stakeholders and generating actionable insights for advancing Africa's hydrometeorological capabilities.

The event facilitated collaboration among NMHSs, NGOs, academic institutions and private companies, laying the groundwork for future projects and initiatives, and participants gained valuable insights into the latest technologies, methodologies, and best practices in hydrometeorology.

Looking ahead

HydrometAFRICA 2024 underscored the critical role of partnerships and innovation in building a more resilient Africa.

By leveraging the momentum generated at this event, stakeholders can drive meaningful progress toward ensuring early warnings for all and safeguarding the continent against the impacts of climate change. For interested parties unable to attend, all sessions were recorded and are available to view on *the Varysian Network*.

As part of its commitment to supporting the hydrometeorological community, Varysian will continue to host events and provide resources through its Hydromet Network.

This online platform offers year-round opportunities for professionals to connect, share knowledge and collaborate on projects that enhance climate resilience.

HydrometAFRICA will also be returning in 2025, with the next symposium scheduled for Pretoria this July.

Directory 06

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At Baron Weather Inc., we understand the challenges of effectively integrating and utilising weather data. Your organisation deserves the best tools to make informed decisions, protect assets, and enhance public safety. That's why we're committed to equipping you with industry-leading meteorological solutions.

With a legacy of innovation, Baron Weather provides best-in-class critical weather intelligence to businesses, government agencies, and consumers worldwide. Our advanced tools set the industry standard for radar engineering, hydrological modeling, data integration, storm tracking, and early warning systems—helping organisations stay ahead of severe weather threats.

Our radar systems feature exclusive calibration and clutter suppression technology, while our precision forecast modeling delivers accurate insights into precipitation, wind, winter weather, flooding, and air quality. The Baron Lynx weather analysis and communication system ensures that you share life-saving information when it's needed most—empowering communities to take action before disaster strikes.

From detecting dangerous weather to delivering vital information, Baron Weather technology forms the foundation of a successful early warning system and helps meteorological organisations operate more efficiently and effectively. It ensures that the most accurate and actionable weather data is always at your fingertips.

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METEORAGE is a subsidiary of Météo France and Vaisala. Since 1987, METEORAGE has been dedicated to lightning and thunderstorms.

Thanks to this unique specialisation, the company developed an in-depth know-how across the entire lightning information chain: design and management of lightning detection networks, collection and exploitation of lightning data and the development of packaged lightning services to meet the specific needs of various lightning-sensitive end-users.

The expertise of METEORAGE is based on the deployment and operation of its own lightning detection network in Europe, the management of lightning detection network installation projects delivered on a turnkey basis to national meteorological services, and the sales of end-user services using lightning data.

Using its own dedicated production software called CATS, METEORAGE provides lightning risk mitigation services to thousands of end-users worldwide. These services are fed by data from the METEORAGE network in Europe and Vaisala's GLD360 network everywhere else in the world.

Data from other existing local networks can also be used to feed the CATS software platform.

METEORAGE meets the needs of lightning information in many fields: national meteorological services, civil security, air traffic control, electrical networks, gas networks, wind and solar power plants, telecommunications, industrial sites, and insurance.

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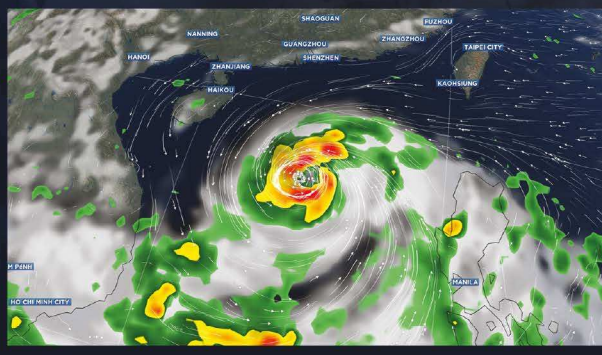
nowcast is a German-based organisation fully focused on lightning research, detection, warning technologies and associated risk profiles.

The exceptional quality of nowcast's commercial data and solutions, which enable ultra-precise detection of lightning strokes, is regularly confirmed both by scientific research and customer's satisfaction.

Those high precision lightning data help national weather services and as well as many different industry sectors to protect lives and assets and are a perfect enabler for increasing operational efficiency and financial performance.

Predict. Detect. Protect.

Elevate your Early Warning System today for safer communities and faster decision making with superior and sustainable tools. Baron's meteorological tools supersede the industry standard.



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Relying on insufficient, inferior, or outdated weather detection and forecasting technology can have dire consequences. Baron helps you remove the guesswork in a smart, sustainable way.

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