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STRATEGY FOR THE VIRTUAL LABORATORY FOR EDUCATION AND TRAINING IN SATELLITE METEOROLOGY 2027-2030

Mission of VLab

To support protection of life and property and economic development through improved weather, climate, water, and related environmental services by enabling WMO Members to utilize satellite data in services and science, through coordinating and delivering education, training, and knowledge exchange across a global network of VLab Centres of Excellence and Satellite Operators.

Scope and Definition

The WMO-CGMS Virtual Laboratory for Education and Training in Satellite Meteorology (VLab) is an activity of the WMO Space Programme, based on a global network of specialized training centres, named Centres of Excellence (CoEs), that are supported by one or more Coordination Groups for Meteorological Satellites (CGMS) Satellite Operators (SatOps)
(see http://vlab.wmo.int).

The CoEs are established in the various WMO Regions to address user needs for increased skills and knowledge in using satellite data within their region. Many CoEs are co-located with WMO Regional Training Centres (RTCs), complementing their mandates by providing satellite specialized expertise and linking regional user needs with satellite operator's capabilities

VLab activities are implemented by CoEs in cooperation with CGMS SatOps. Through this partnership model, VLab coordinates, develops, and delivers satellite focus training, facilities knowledge exchange and promotes the effective uptake and products in services and research.

Upholding WMO Core Values and Key Drivers

(1) Accountability for results and transparency;

(2) Collaboration and partnership;

(3) Inclusiveness and diversity.

Long-term Goals of VLab

1. To continuously strengthen and advance the effective operational and scientific utilization of data from the space-based component of the WMO Integrated Global Observing System (WIGOS) for weather, climate, water, and related environmental services that are increasingly reliant on satellite data, through coordinated training, knowledge exchange, and user engagement;

2. To strengthen and sustain global capacity by building knowledge and sharing expertise, methods, tools, and best practices related to access to and use of satellite data, with a particular focus on training and user engagement in support of WMO Members with limited resources.

Strategic Objectives that VLab Seeks to Support

The VLab Strategy seeks to encourage members and partners to plan and deliver training that enhances the ability to:

- *Objective 1*. Improve the availability of Earth observation data to support operational service delivery in line with the expected growth of the space-based observing system component as outlined in the *Vision for the WMO Integrated Global Observing System in 2050* (WMO-No. 1243).

- *Objective 2*. Provide support to achieve readiness for the evolutions and next generations of satellites, instruments, data and product dissemination systems, and processing hardware and software.

- *Objective 3*. Transfer the improved scientific understanding, technological advances, and emerging capabilities, including the use of Artificial Intelligence (AI) and Machine Learning (ML), to enhance National Meteorological and Hydrological Services (NMHSs) capabilities and support the evolution of the services they provide.

- *Objective 4*. Promote the uptake of satellite data in research institutions.

- *Objective 5*. Respond to new and emerging service demands for weather, climate, water, and other related environmental applications. These include impact-based decision support services and the application of climate services in support of marine and land applications.

- *Objective 6*. Increase the diversity and quality of services offered by WMO Members in line with the WMO Earth System approach and efforts to enhance the quality of these services.

- *Objective 7*. Achieve the competence, quality control requirements, and professionalism within WMO Services, particularly taking into account the operational challenges faced by NMHSs, including constraints in staffing and resources.

- *Objective 8*. Strengthen collaboration with education and training partners to enhance the sharing, reuse, and discoverability of satellite training resources.

Challenges and areas of improvement

During the past years, members report shortages of both trainers and operational staff due to retirement, leaving for other employment, or lack of funding. VLab Trainer interaction with the regional WMO Satellite Data Requirements Groups and User Conferences further revealed limited available resources for organizing and participating in capacity development activities, lack of expertise in various satellite focus areas, and language barriers. Many members expressed increased training needs for discovery, utilization and visualization of various satellite data sets for local applications.

Translation of communications, documents, and real-time translation during meetings and events continues to be an issue for VLab progress. New technologies, including artificial intelligence translation, will continue to be explored and evaluated to improve in this area.

Following the pandemic, which accelerated the adoption of virtual modes of work and training, virtual and hybrid approaches continue to be widely used today due to their flexibility and extended reach. Although this transition has enabled continuity and broader participation, many members reported ongoing challenges. In particular, operational staff often face difficulties participating in online training and meetings due to operational duties and shift work. Additional challenges include low Internet bandwidth for both instructors and trainees, limited access to learning management systems for sharing training materials and tracking

participants, and challenges with trainers learning and adapting to online teaching methodologies and tools.

Where the training was offered successfully, participation was often very high that required additional facilitators to effectively manage sessions and interactions. Furthermore, many organizations require certificates for staff who attend virtual training activities. In some cases, limitations in participant tracking mechanisms made it challenging to accurately record participation and, consequently, to issue certificates in a timely and consistent manner.

Improving the usage and adoption of learning management systems (LMS) like Moodle in our community would greatly mitigate many of these operational challenges. A more consistent and enhanced utilization of LMS platforms (including those supported by WMO ETRP) enables automated real-time tracking of attendance and progress, efficient delivery and sharing of training materials (even in low-bandwidth scenarios via on-demand access), streamlined facilitation for large groups, and automated/on-demand issuance of digital certificates.

Many VLab CoE and SatOp members are willing to share the lessons learned from the challenges and successes and collaborate on training. Two main areas identified include:

(1) *Training material*: Continue to identify and connect resources in formats that can be easily accessible, reusable and adaptable by others to facilitate translations, as well as modifications, contextualization and regular updates of training resources. The VLab Strategy seeks to enable Members to continue to collaborate with WMO ETRP and actively contribute to the Global Campus initiative through leveraging their training resources library, learning management system, software advice, and techniques, shared tools and methodologies. Through this collaboration, VLab aims to enhance discoverability, interoperability and reuse of satellite training resources across regions;

(2) *Training personnel*: Encourage interaction among the operational trainer and technical communities to participate actively in training events of their CoEs or SatOps. Promote members to invite speakers, lecturers and subject matter experts from other CoEs and SatOps for specialized subjects. In addition, VLab will promote the continuous professional development of trainers through Training-of-Trainers initiatives, peer learning, and sharing the pedagogical practices, including digital delivery methods, learning assessment and impact evaluation.

Members commit to identifying, advocating and reporting on the challenges and barriers in the regions they represent through the regional Satellite Data Requirements Groups. This includes issues related to capability and capacity to utilize satellite data. CoEs are expected to maintain an up-to-date understanding of the challenges, barriers and successes in their respective region. This should also be reported though the relevant Regional Associations (RAs) and to Satellite Operator management, as appropriate.

VLab will continue to strengthen its collaboration with the WMO ETRP, recognizing the value of this partnership. This will support alignment with established good practices and promote a more coherent and effective approach across WMO training activities, leveraging shared expertise and resources in support of capacity development.

VLab strategic approaches

The VLab Strategy describes the priorities for the WMO-CGMS VLab. It takes into account the drivers articulated in:

(1) WMO Strategic Plan;

(2) Capacity Development Strategy;

(3) The Recommendations of the Symposia on Education and Training (SYMET);

(4) Coordination Group for Meteorological Satellites (CGMS) High Level Priority Plan.

VLab also recognizes the growing importance of community-based approaches to training and capability development, particularly communities of practice that share experiences, lessons learned, and innovations across regions. Such approaches are essential to fulfilling the WMO vision by strengthening collaboration, fostering peer learning, and accelerating the uptake of satellite data and products globally.

VLab will advance its objectives through the following strategic approaches:

- Identifying regional training needs and prioritizing the organization of VLab training interventions.
- Developing, sharing, reusing, coordinating, and implementing training that links the enabling satellite skills to the competencies and qualification frameworks where they exist.
- Encouraging evaluation of the impact of the training on the use of satellite data and products to demonstrate the long-term benefits of training.
- Facilitating the availability of training materials in the official UN languages and other languages, including the use of AI-based translation.
- Facilitating the exchange of information and enhanced communication between researchers, trainers, and operational users in developing new products from current and planned satellite missions that can lead to improved weather, climate, water, and related environmental services.
- Promoting the benefits of using current and new satellite-based products and providing technical, operational and training support, where possible, to make them available to users.
- Engaging directly with and reporting to its co-sponsors, which currently include the WMO Expert Team on Space Systems and Utilization (ET-SSU) and the Coordination Group for Meteorological Satellites (CGMS), and partner organizations.
- Engaging students, young professionals, and early-career researchers to build skills in the use of satellite data for applied research and operational applications.
- Increasing efforts to engage interdisciplinary early career professionals by creating opportunities for them to participate in and contribute to WMO activities.
- Promoting mentoring and peer-to-peer learning opportunities for both students and instructors.

VLab will implement these strategies through the following activities:

- Developing and delivering training on user identified needs for access, display, and applications in the form of virtual, blended, and face-to-face events, Regional Focus Group discussions, and self-study resources.

- Supporting regional and cross-regional satellite user conferences and associated training workshops, with dedicated opportunities for student and early-career participation.

- Contributing to the regional satellite data requirement dialogues, and providing briefings on the regional data access to NMHSs to ensure they have the appropriate staff to support access, processing, visualization and application of satellite data.

- Providing feedback to satellite operators on the use of the available data, products, systems and services as well as the challenges associated with their full exploitation.

- Raising awareness on the available in-person/online training and distance-learning resources provided by WMO-CGMS VLab CoEs, Satellite Operators and other WMO Members in various regions.

- Advertising training events in the VLab Calendar of Training Events and WMO Global Campus Events Calendar.

- Encouraging VLab Members to add linkages to their training resources to the WMO Global Campus Collection of Learning Resources.

- Providing support via the VLab Trust Fund to promising and early career personnel to participate in training events, satellite user conferences, visiting scholar programmes, and conduct scientific activities that contribute towards satellite product development, evaluation, and implementation.

In the period 2027 to 2030, VLab will pay particular attention to:

- *Emerging technologies for satellite data exploitation*: strengthen the use of modern technologies—including AI/ML, big data and cloud platforms, and immersive tools such as VR/AR—to enhance satellite data analysis, visualization, and training. This includes promoting responsible AI/ML practices, supporting scalable online processing and data sharing, and exploring immersive environments to enrich learning and provide innovative training experiences.

- *Impact-based forecasting and impact-based decision support services*: encourage NMHS personnel to continuously work with and support core partners, such as emergency personnel, public safety officials, disaster preparedness agencies and social scientists, on the production and dissemination of accurate and consistent forecast information for weather, climate, water, and other related environmental areas of application that have a high impact.

- *Advancing EW4All capacity through tailored training:* develop integrated training modules focused on the "Monitoring and Forecasting" pillar of EW4All, with specific adaptations to meet the needs and operational contexts of WMO Members with limited resources.

- *Technical capacity developmen*t: supporting the technical staff involved in satellite data reception and processing, through training, provision of up-to-date information, and potentially a skills framework.

- *Earth systems approach*: Establishing interdisciplinary connections to ensure data interoperability and knowledge sharing for satellite-based application areas linking meteorology, climatology, hydrology, agrometeorology, oceanography, atmospheric composition, and many other fields.

- *Space weather*: noting the growth in interest for space weather services around the world, VLab will engage and cooperate with relevant partners, including the Committee on Space Research (COSPAR), the International Space Environment Service (ISES), and the WMO Expert Team on Space Weather (ET-SWx), seeking to enhance the implementation of space weather services.

The delivery of training will rely on:

- Use and advances in digital technology where appropriate, recognizing that in certain situations, the solutions may rely on simple technology and human expertise.

- In-person and distance-learning delivery of training that uses a combination of formal, semi-formal, and informal learning methods where appropriate.

It is essential that VLab partners maintain a sustained commitment to their continued development, including the ability to deliver training using innovative approaches, to enhance the accessibility of training opportunities, to strengthen outreach to academia—which plays a key role in educating the next generation of professionals—and to adopt emerging methodologies, particularly those related to AI/ML, as well as the use of data platforms and notebooks in training activities.

Quality Control and Evaluation

To ensure the quality and effectiveness of services provided by VLab, a more standardized approach to quality control and evaluation will be promoted across all CoEs. This will include the development of common evaluation indicators, moving beyond quantitative metrics (e.g. number of training sessions delivered) towards a more comprehensive assessment of training impact, relevance, and outcomes.

Internal evaluations will focus on measuring how training contributes to improved capabilities and use of satellite data, as well as alignment with VLab priorities. Procedures will be established to ensure consistency in reporting and to support continuous improvement across CoEs.

Annual reviews of achievements will be carried out to ensure that efforts remain focused on priority areas identified in the VLab Strategy and that VLab activities deliver tangible value to Members.

Collaboration

Enhance regional and global coordination and collaboration between CoEs, SatOps, WMO RTCs, and other partners to maximize the efficiency of effort, enhance synergies and ensure responsiveness to regional needs.

Maximize the discoverability and usability of resources. Foster the co-development of learning events and materials utilizing existing and emerging platforms, including social.

Promote good practice in the VLab training community (including the co-development of learning events and training materials) and encourage collaboration with the WMO Global Campus network to enhance the discoverability and usability of resources. Grow cross

disciplinary relationships with other Earth observation training communities to explore opportunities to collaborate and to share tools and knowledge for the delivery of the VLab objectives. Encourage the other communities to use the WMO competency frameworks.

The development and delivery of training, with particular emphasis on national and regional specific demands and requirements, relies on the strong collaboration between VLab CoEs and SatOps. It is the VLab belief that these collaborative activities have and will continue to contribute to the social and economic benefits of the large investments in the space-based observing system.

The continuation of VLab collaboration with other training and education programmes is essential for further success. VLab will continue to explore partnerships with the WMO Education and Training Programme, the Community for the Advancement of Learning in Meteorology and related disciplines (CALMET), the Earth Observation Training, Education, and Capacity Development Network (EOTEC DevNet) and with other programmes in areas of common or complementary interest, to foster cross-disciplinary learning and promote the use of WMO Competency Frameworks.

Resources

VLab is an entity sustained by contributing CoEs and SatOps. The technical support function is critical for VLab coordination. Currently, VLab provides a broad support to CoEs activities with its central website (http://vlab.wmo.int) serving as a platform for collaboration and networking. The work of a dedicated Technical Support Officer (TSO) is mission-critical in this regard. VLab seeks to expand its reach by providing support via the VLab Trust Fund to promising and early career personnel to attend training events and conferences, or conduct scientific activities. Both of these activities require a long-term collaborative funding effort from CGMS Satellite Operators via the designated WMO VLab Trust Fund.

ANNEX

VLab Logic Map – Impact Pathway

Long Term Impacts

The VLab ultimately contributes to three high-level societal impacts:

1. *Protection of life and property* through the provision of warnings and information across all meteorological timescales.
2. *Economic resilience* enabled by the availability of actionable environmental risk information.
3. *Improved understanding of the Earth system and its evolution*, supporting advances in weather, climate, water, and risk services.

These impacts are realized at national and regional levels and lie beyond the direct scope of the VLab. However, they represent the overarching objectives that VLab activities are designed to support.

Outcomes

Through its activities, the VLab aims to enable the following outcomes:

1. *Enhanced use of satellite data in warning production*, including:
    - Nowcasting and very short-range forecasting
    - Medium-range forecasting
    - Seasonal and longer-term outlooks
2. *Enhanced use of satellite data in environmental risk information assessment*, including:
    - Monitoring of anomalies
    - Development and application of indices
3. *Strengthened Earth system science*, including:
    - Contributions to reanalysis activities
    - Contributions to scientific research studies

Role of the VLab

All warning, risk information, and Earth system services are delivered primarily at the national and regional level, involving a wide range of operational and scientific stakeholders.

The specific role of the VLab is to support these actors by:

- Providing education, training, and learning opportunities
- Promoting best practices in the use of satellite data

- Enabling the selection and effective application of the right satellite tools for the right tasks