Professor Maria Shahgedanova
on behalf of the MRI network

Essential Mountain Climate Variables

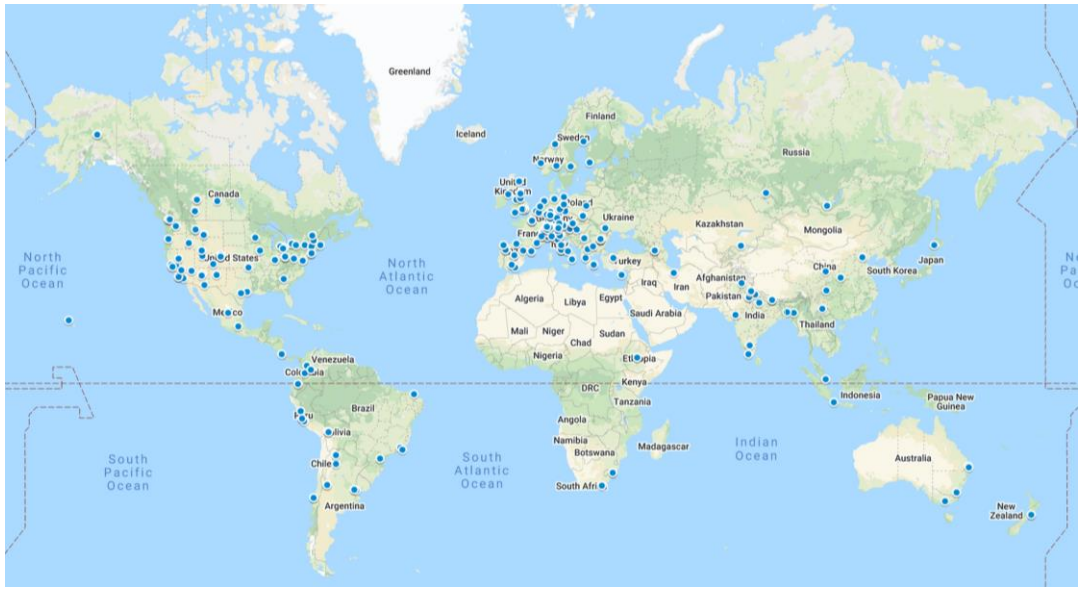
The Mountain Research Initiative

THE MRI NETWORK

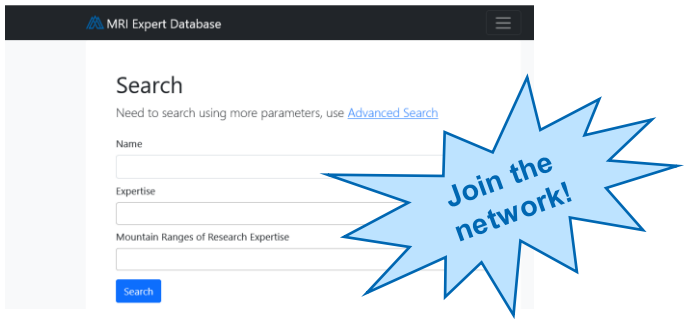
The MRI and its Coordination Office was proposed in 2000 by the then International Geosphere Biosphere Programme (**IGBP**) of the International Council for Science (ICSU), together with the International Human Dimensions Programme (**IHDP**) of the International Social Science Council and the FAO/UNEP/UNESCO/WMO/ICSU-sponsored Global Terrestrial Observation System (**GTOS**), in response to a need to …

*"…achieve an **integrated approach** for observing, modelling and investigating global change phenomena and processes **in mountain regions**, including the impacts of these changes and of human activities on mountain ecosystems".*

The MRI is hosted by the **Centre for Development and Environment** (CDE) at the University of Bern and funded by the **Swiss Academy of Sciences (SCNAT).**



Search the MRI Expert Database

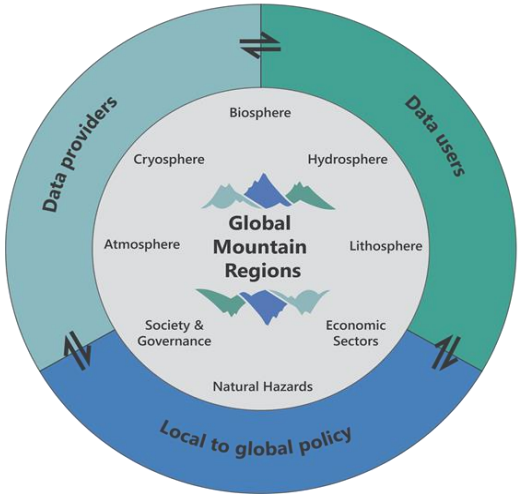


https://www.mountainresearchinitiative.org/find-an-expert

Dr. Carolina Adler
Executive Director
Mountain Research Initiative

Executive Director

FLAGSHIP ACTIVITIES



GEO MOUNTAINS
Observing Mountain Environments

www.geomountains.org

Global Network for Observations and Information in Mountain Environments, GEO Mountains.

COMMUNITY-LED ACTIVITIES

MRI Working Groups:

- **Elevation Dependent Climate Change**
- **Mountain Governance**
- **Mountain Resilience**
- **Mountain Observatories**
- **Mountain Social Ecological Futures**

https://www.mountainresearchinitiative.org/activities/community-led-activities

Priority regions:
Central Asia, Hindu Kush – Himalayas, Caucasus, East Africa, tropical and subtropical Andes

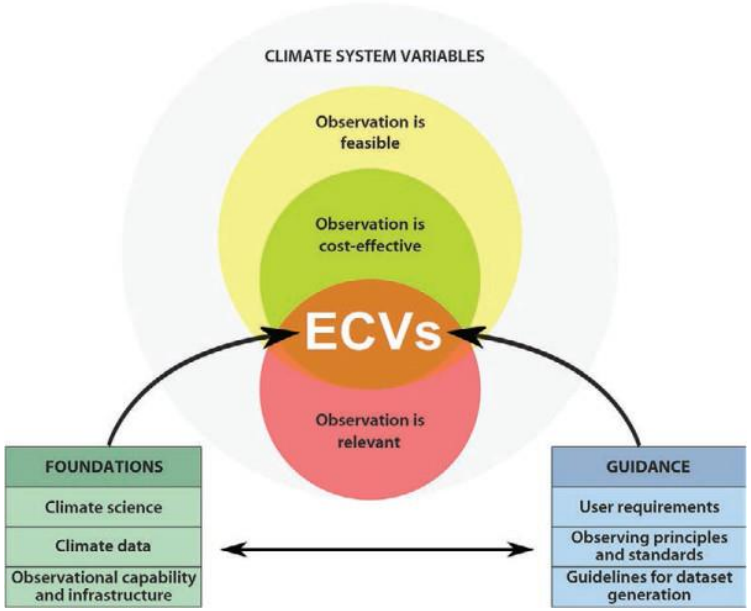
- Regional workshops: identification of network-level research issues, gaps in knowledge, and fostering multi-disciplinary observational programmes
- Development of metrics and indicators to be monitored by mountain observatories
  - **Essential Mountain Climate Variables (Thornton et al., 2021)**
  - Essential Biodiversity Variables
  - Essential socio-economic variables

Collaboration with WMO via GCW and PHORS

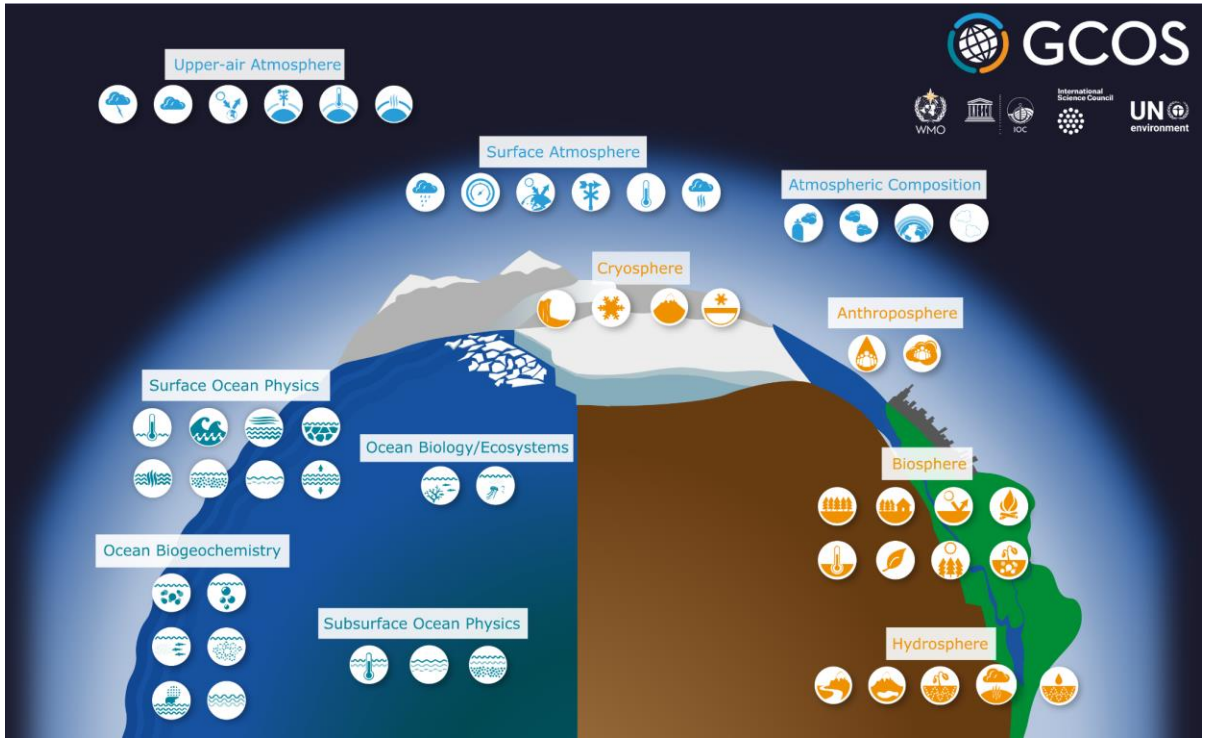
Acknowledgement of MRI contribution to the public consultation process on ECVs by GCOS, 2022

Essential Climate Variables (ECV)

"Physical, chemical or biological variable or a group of linked variables that critically contributes to the characterization of Earth' s climate" (Bojinksi et al., 2014).



Bojinski et al., 2014; 10.1175/BAMS-D-13-00047.1



A definitive set of ECV is curated by the Global Climate Observing System (GCOS) https://gcos.wmo.int/

Currently 55 ECVs and a larger number of ECV products (GCOS 245, 2022).

Strong emphasis on remote sensing

Criteria: Relevance, feasibility, cost effectiveness

Essential Mountain Climate Variables (EMCVs)

“Essential climate variables for observations in mountains” organized by the MRI under the auspices of GEO Mountains, June 2019.

Focus on atmosphere, cryosphere, biosphere, and hydrosphere, and interactions between these domains.

One Earth

Gold Standard for the Global Goals | 1 ton of CO_2 offset

CellPress OPEN ACCESS

Perspective

Toward a definition of Essential Mountain Climate Variables

James M. Thornton,[1,2,*] Elisa Palazzi,[3] Nicolas C. Pepin,[4] Paolo Cristofanelli,[3] Richard Essery,[5] Sven Kotlarski,[6] Gregory Giuliani,[7,8] Yaniss Guigoz,[7,8] Aino Kulonen,[1] David Pritchard,[9] Xiaofeng Li,[10] Hayley J. Fowler,[9] Christophe F. Randin,[11] Maria Shahgedanova,[12] Martin Steinbacher,[13] Marc Zebisch,[14] and Carolina Adler[1]

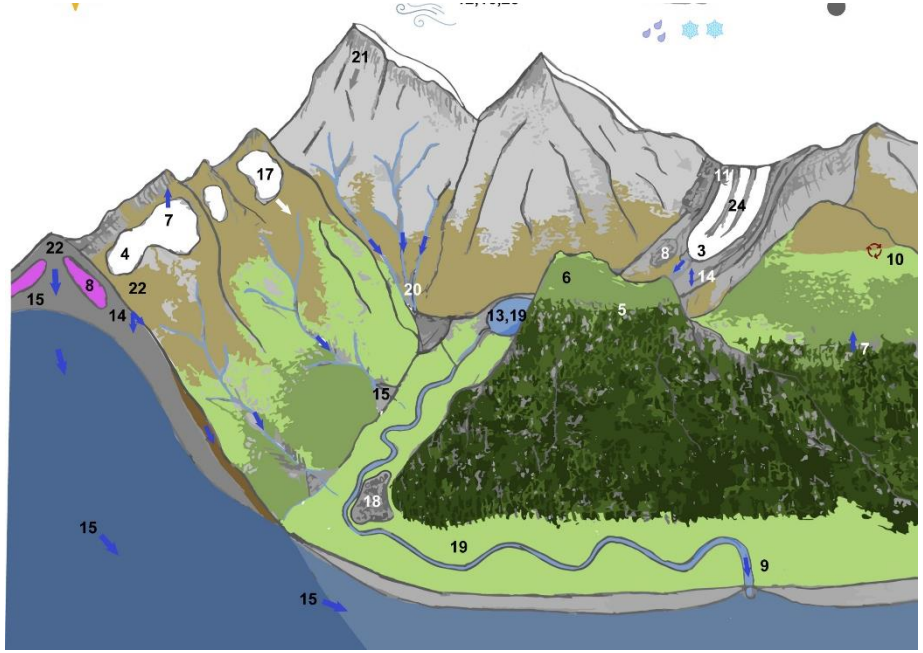
[1]Mountain Research Initiative, c/o University of Bern, Bern, Switzerland

https://doi.org/10.1016/j.oneear.2021.05.005

“Physical, chemical or biological variables that either currently do, or potentially could, significantly contribute to the **characterization of Earth's mountainous environmental systems**, especially under climatic change” (Thornton et al., 2021).

ECV and NEW MOUNTAIN-UNIQUE VARIABLES

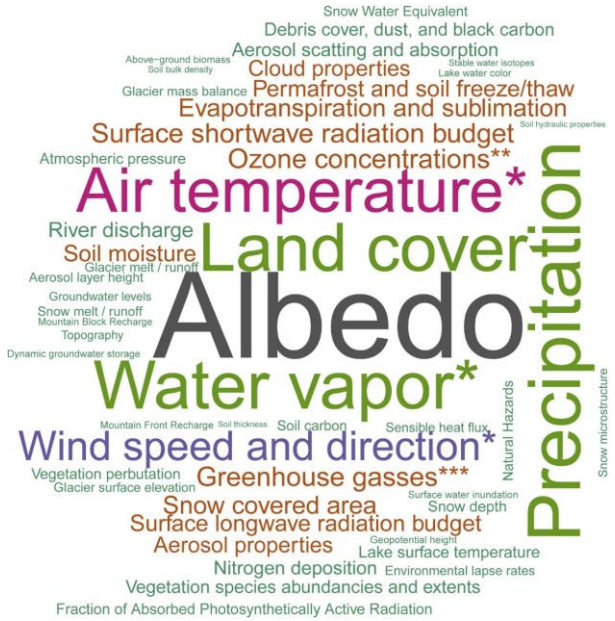
- Maintain GCOS's broad definition of "climate"
- Specific to mountains and processes shaping mountain environments
- More inclusive**:** in situ, modelling and remote sensing data
- Measurement feasibility: "What do we need?" as opposing to "What can we get?"
- Global relevance with potential for some EMCV to become ECV in the future (e.g. aerosol deposition)



1. Increasing atmospheric greenhouse gas concentrations
2. Shifts in the radiative forcing, air temperature, and precipitation
3. Increasingly negative glacier mass balance or glacial retreat
4. Changing snow properties and dynamics
5. Rising tree lines
6. Increased species richness or biomass on mountain summits
7. Changing evapotranspiration and sublimation dynamics
8. Permafrost and rock glacier thaw
9. Changing streamflow dynamics
10. Accelerated nutrient cycling
11. Changes in glacier debris cover
12. Changes in the atmospheric transport and deposition
13. Changing lake water temperatures and ecology
14. changing hydrological partitioning at the land surface
15. Changing groundwater recharge, storage, flow,
16. Changing redistribution of snow by wind
17. etc….

ECV and NEW MOUNTAIN-UNIQUE VARIABLES / PRODUCTS

Principal sphere(s)	EMCVs
Biosphere and hydrosphere	evapotranspiration
Atmosphere	nitrogen deposition
Biosphere	vegetation species abundances and extents
Atmosphere	*in situ* ozone concentration
Biosphere	geomorphological or avalanche perturbation of vegetation (spatial extents)
Cryosphere	glacier debris cover (extent and thickness) and dust deposition on snow and ice
Atmosphere	*in situ* aerosol absorption
Atmosphere	*in situ* aerosol scattering
Atmosphere	near-surface air-temperature lapse rates and orographic precipitation gradients
Biosphere	forest extent
Cryosphere	snow microstructure
Atmosphere and cryosphere	black carbon deposition
Atmosphere	geopotential height
All	upward longwave radiation flux
All	upward shortwave radiation flux
All	natural hazard maps
All	spatially distributed topographic data
Hydrosphere	mountain front recharge
Hydrosphere	mountain block recharge
Hydrosphere	glacier melt (also known as runoff)
Hydrosphere	snow melt (also known as runoff)
Hydrosphere	stable isotopic composition of water (snow, rain, glacier ice, surface, and groundwaters)
All	past natural hazard event extents and intensities
Hydrosphere	dynamic groundwater storage
Hydrosphere	soil hydraulic properties
Hydrosphere and biosphere	soil thickness



Contributed to the key decision adopted at COP27 which emphasizes the need to address systematic observation gaps, including in mountain regions and concerning the cryosphere (https://mountainresearchinitiative.org/news/cop27-summary-report-significant-step-for-mountains/)

- **More specific** (e.g. glacier debris cover, vegetation disturbance extents, dynamic groundwater storage)
- Some **derived measures**, e.g. environmental lapse rates
- The importance of ***in situ*** measurements
- Importance of **topographic/terrain characterisation**
- Emphasis on **extreme events / natural hazards**
- Some may have **broader global relevance** > potential to become ECVs in future (e.g. aerosol deposition on cryosphere)

EMCVs for the THIRD POLE REGION

Currently in the TPRCC outlook and seasonal climate bulletins:

- Air temperature
- Precipitation
- Extent of snow cover
- Extreme and hazardous events

EMCV products can contribute to obtaining standardized and interoperable data in TPRCC region

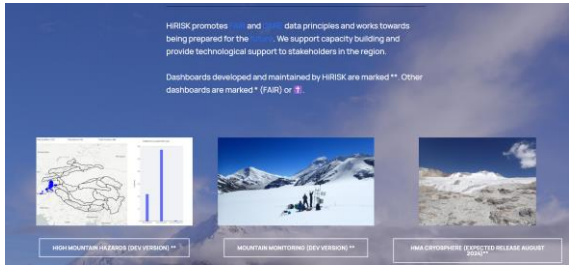
Potential to monitor both ECV and EMCV using WMO and research in situ infrastructure combining these data with remote sensing and modelling

- NHMS meteorological stations and gauging sites

➢ Mountain Observatories – MRI WG

➢ Thematic networks (e.g. WGMS, water stable isotopes networks in China and Central Asia)

➢ Monitoring sites related to regional research institutions



MRI HiRISK project at HUC (https://hirisk.org/#Dashboards)

Mountain Research and Development (MRD)
An international, peer-reviewed open access journal published by the International Mountain Society (IMS)
www.mrdjournal.org

MountainAgenda
Target knowledge

Mountain Observatories: Status and Prospects for Enhancing and Connecting a Global Community

Maria Shahgedanova[1], Carolina Adler[2], Aster Gebrekirstos[3], H. Ricardo Grau[4], Christian Huggel[5], Robert Marchant[6], Nicholas Pepin[7], Veerle Vanacker[8], Daniel Viviroli[5], and Mathias Vuille[9]*

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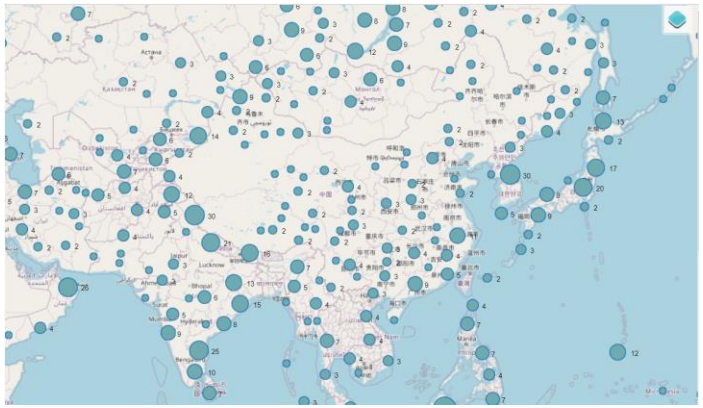
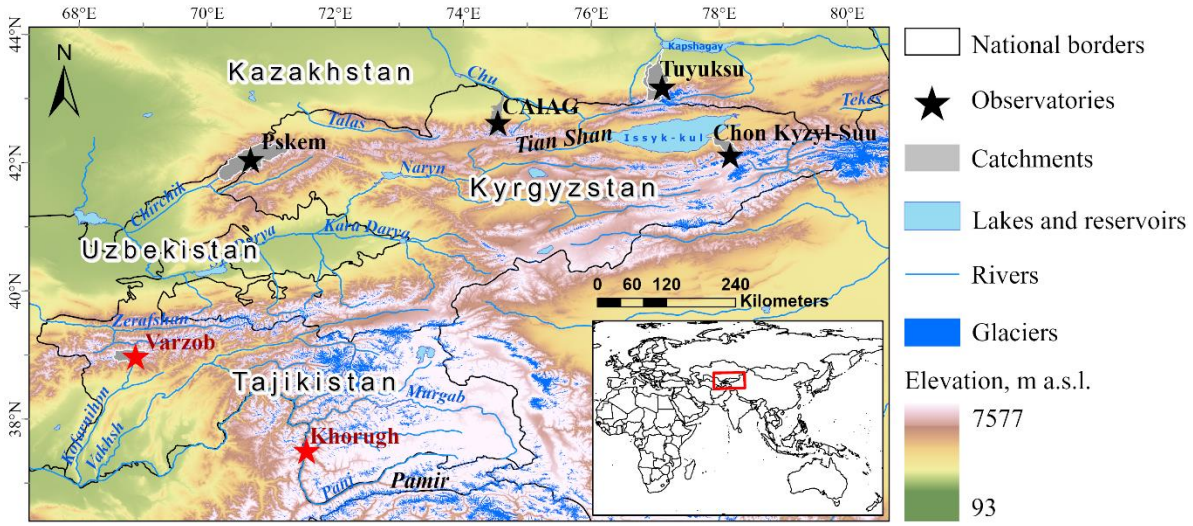
https://doi.org/10.1659/MRD-JOURNAL-D-20-00054.1

GEO Mountains Inventory of In Situ Observational Infrastructure



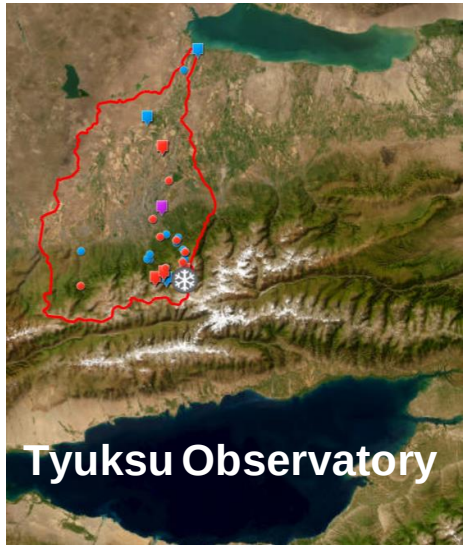
https://www.geomountains.org/resources/resources-surveys/inventory-of-in-situ-observational-infrastructure

Example: Central Asia Mountain Observatories Network (CAMON)



- Specialises in cryosphere, climate, hydrology, hydrochemistry, and hazards monitoring.
- Delivers EMCV products using in situ and remote sensing monitoring and combines it with numerical models to assess impacts of climate variability and change.

https://research.reading.ac.uk/central-asia-mountain-observatory/



CONCLUSIONS

- A **range of EMCV and their cross-disciplinary ranking** have been developed, but further and wider discussion is required, especially around associated **minimum observational requirements in TPRCC region**

- EMCVs serve as a **framework that could contribute** to more **standardized and interoperable** climate-related data in TPRCC region as illustrated by examples of the existing monitoring networks

- The **intelligent combination of numerical models** and a broad range of **observational data – both *in situ* and obtained via remote sensing –** offers many possibilities to meet societal needs for information on mountain climate change impacts

- MRI has substantial experience in the assessment of monitoring requirements and implementing these requirements in collaboration with stakeholders, including the WMO

Thank you

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