Transition to Automated Ground-based Measurements

RA-V Workshop Day 2
Network Planning

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WEATHER CLIMATE WATER
TEMPS CLIMAT EAU

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World Meteorological Organization
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Topics

- Where to get help?
- Links to Competency Framework
- WIGOS Implementation Plan, GBON, SOFF
- Network Design Principles
- GCOS Climate Monitoring Principles
- Tiered networks
- Measurement standards and calibration
- User requirements, multiple applications
- Current situation
- Network Resolution and Accuracy
- Redundancy (of measurement)
- Data collection and management

Costs	Benefits	Risks
• Equipment purchase • Installation costs • Support and maintenance • Staff induction and training • Testing • Integration in existing infrastructure • Required tools/facilities for calibration, maintenance and monitoring	• Facilitate greater density of networks • 24/7 access • Improved reliability of measurement (digital techniques) • Homogeneity of networks by standardizing measuring techniques • Able to meet new observational needs and requirements • Reduce human errors • High frequency or continuous measurement • Eliminating mercury • Modern data archive	• Spares • Cost / Scope overruns • Lifecycle overhead • People change • Complexity • Technical constraints • Site visit/maintenance • Discontinuities in measurement series • Non-homogenous due changing techniques e.g., mean temperature (0.5 *(max + min)) • Predefined solution – not what is needed • Integration / compatibility • Non-conformance

Some reference documents

- A Compendium of Topics to Support Management Development in National Meteorological Services (ETR-24)
- **Guide to Instruments and Methods of Observation** (**WMO-No. 8, Vol I, II, III and V**)*
- Guide to Climatological Practices (WMO-No. 100)
- Guidance on Automatic Weather Systems and Their Implementation (WMO-No. 862)
- **Manual on the WMO Integrated Global Observing System** (**WMO-No. 1160**)*
- **Guide to the WMO Integrated Global Observing System** (**WMO-No. 1165**)*
- Guidelines on the Role, Operation and Management of National Meteorological and Hydrological Services (WMO-No. 1195)
- Challenges in the Transition from Conventional to Automatic Meteorological Observing Networks for Long-term Climate Records (WMO-No. 1202)
- Compendium of WMO Competency Frameworks (WMO-No. 1209)
- Guidelines on Homogenization (WMO-No. 1245)
- Guidelines for Managing Changes in Climate Observation Programmes (WMO-TD No. 1378)

* Regularly updated – every two years

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WMO-No. 8, Volume I, Measurement of Meteorological Variables

Chapter 1. General

- Annex 1.A. Operational measurement uncertainty requirements and instrument performance requirements
- Annex 1.B. Strategy for traceability assurance
- Annex 1.C. Regional Instrument Centres
- Annex 1.D. Siting classifications for surface observing stations on land
- Annex 1.E. Operating equipment in extreme environments
- Annex 1.F. Station exposure description

WMO-No. 8, Volume III, Observing Systems

- Chapter 1. Measurements at Automatic Weather Stations

Some places to look

Data Collection Network Modernisation – What you need to know
Links to: extended abstract, presentation, recording of presentation

WMO Knowledge Sharing Portal
https://community.wmo.int/activity-areas/imop/knowledge-sharing-portal

WMO Library
https://library.wmo.int/

Generic AWS Tender Specification
https://community.wmo.int/activity-areas/imop/aws-tender-specifications

GCOS Essential Climate Variables
https://gcos.wmo.int/en/essential-climate-variables/

Neighboring countries/NMHSs

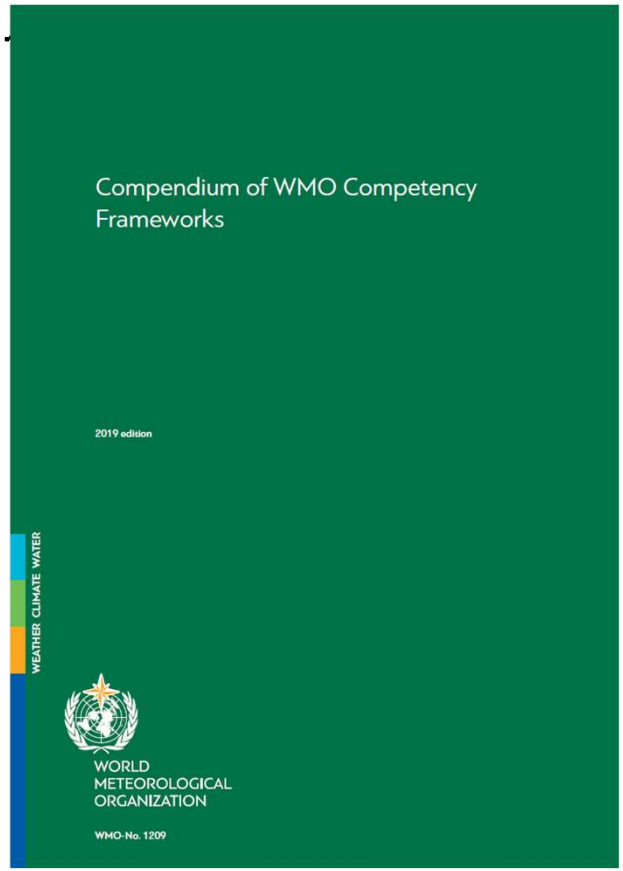
Competency Framework

WMO-No. 49, Vol. I, Part V

WMO-No. 1209, Chapter 2.7.4, and

WMO-No. 8, Vol V, Chapter 5, Annex 5.D - programmes and networks.

1. *Plan the observing programme*
2. Procure equipment
3. Select and acquire sites
4. Install network components
5. Manage the network operation
6. Manage the observing programme



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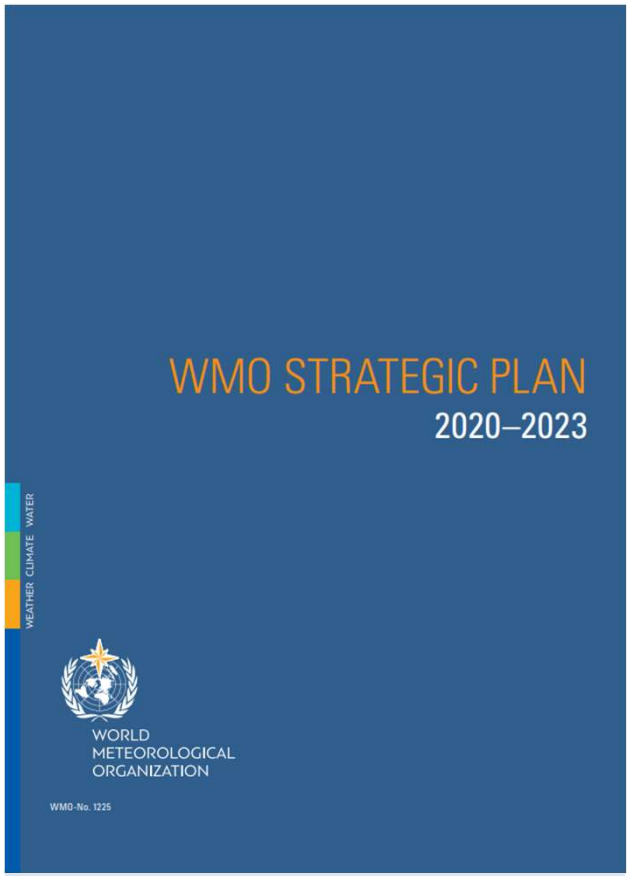
WIGOS, GBON and SOFF

WMO-No. 1225, WMO Strategic Plan 2020-2023

1. WIGOS Initial Operational Phase 2020-2023
   https://community.wmo.int/activity-areas/wigos
2. Global Basic Observing Network (GBON)
   https://community.wmo.int/gbon
3. Systematic Observation Finance Facility (SOFF)
   https://public.wmo.int/en/our-mandate/how-we-do-it/development-partnerships/Innovating-finance
4. WMO Unified Data policy
   https://public.wmo.int/en/our-mandate/what-we-do/observations/Unified-WMO-Data-Policy-Resolution



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Network Design Principles

WMO-No. 1160, section 2, App. 2.1 & 2.2

WMO-No. 1165, Chapter 5 Observing network design

1. Serving many application areas
2. Responding to user requirements
3. Meeting national, regional and global requirements
4. Designing appropriately spaced networks
5. Designing cost-effective networks
6. Achieving homogeneity in observational data

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Network Design Principles (Pt2)

WMO-No. 1165, Chapter 5 Observing network design

7. Designing through a tiered approach
8. Designing reliable and stable networks
9. Making observational data available
10. Providing information so that the observations can be interpreted
11. Achieving sustainable networks
12. Managing change

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GCOS Climate Monitoring Principles

https://gcos.wmo.int/en/essential-climate-variables/about/gcos-monitoring-principles (see also WMO-No. 1160, sec.2, App.2.2)

1. The impact of new systems or changes to existing systems should be assessed prior to implementation.
2. A suitable period of overlap for new and old observing systems is required.
3. The details and history of local conditions, instruments, operating procedures, data processing algorithms and other factors pertinent to interpreting data (i.e., metadata) should be documented and treated with the same care as the data themselves.
4. The quality and homogeneity of data should be regularly assessed as a part of routine operations.
5. Consideration of the needs for environmental and climate-monitoring products and assessments, such as IPCC assessments, should be integrated into national, regional and global observing priorities.

GCOS Climate Monitoring Principles

https://gcos.wmo.int/en/essential-climate-variables/about/gcos-monitoring-principles

6. Operation of historically-uninterrupted stations and observing systems should be maintained.
7. High priority for additional observations should be focused on data-poor regions, poorly observed parameters, regions sensitive to change, and key measurements with inadequate temporal resolution.
8. Long-term requirements, including appropriate sampling frequencies, should be specified to network designers, operators and instrument engineers at the outset of system design and implementation.
9. The conversion of research observing systems to long-term operations in a carefully-planned manner should be promoted.
10. Data management systems that facilitate access, use and interpretation of data and products should be included as essential elements of climate monitoring systems.

Tiered Networks

GCOS – 226 https://library.wmo.int/doc_num.php?explnum_id=6261

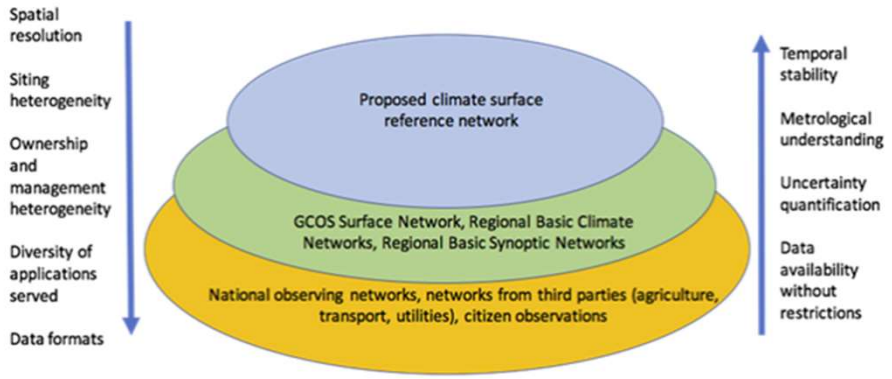

Figure 1. Conceptual outline of how surface observational capabilities for climate map onto the tiered system of systems approach of Thorne et al.(2017). The tiers from top to bottom are reference, baseline, and comprehensive. Arrows and associated text denote important facets of the measurements that increase as you move down tiers (left-hand side) or up tiers (right-hand side). The network types given for each tier are solely exemplars.

Reference Networks

- Highest quality measurements
- "Goal" requirements in OSCAR
- Fully traceable to international standards
- Complete metadata

Baseline Networks

- Globally representative
- "Threshold" requirements in OSCAR as a minimum
- Data exchanged globally
- Cover all climatic and environment situations

Comprehensive Networks

- Remaining observing platforms.
- Additional regional, national and local details.
- Might not meet established requirements, but still provide useful information.
- Provides application specific information

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Applications – Network Requirements

- High temporal/spatial resolution
  - Weather forecasting
  - Early Warning
  - Aeronautical
- Medium temporal/spatial resolution
  - Water resource management
  - Agriculture operations (e.g., irrigation)
- Low temporal/spatial resolution
  - Climate monitoring
  - Seasonal prediction

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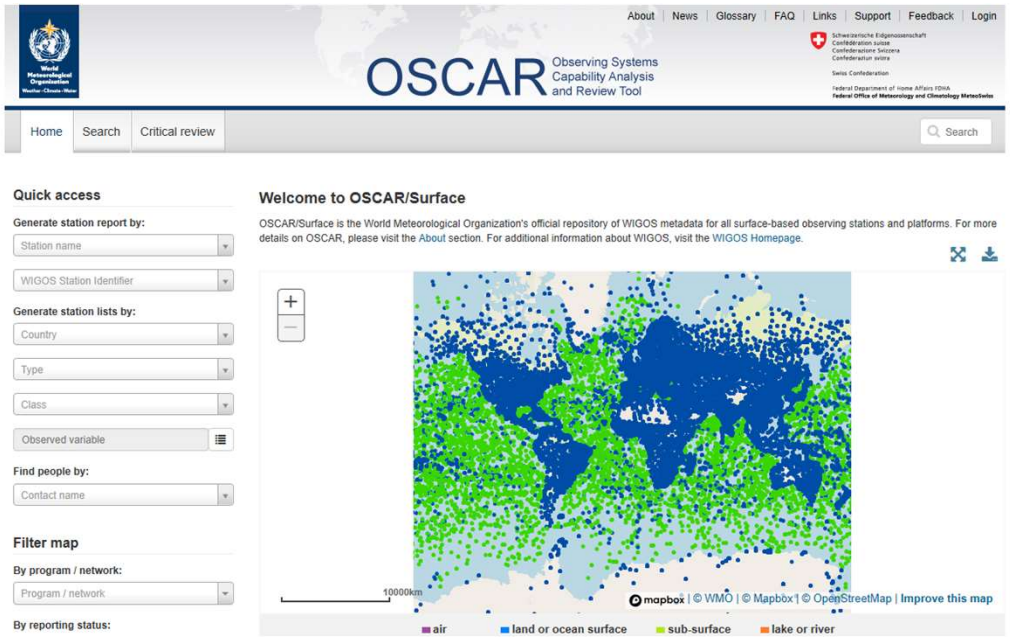
Current Situation

- What is the current situation?
- Does this meet user requirements? (OSCAR, RRR, Critical Review?)
- Is there a need to relocate/continue?
- What infrasctructure exists and can be reused?
- Rationalization?
- Fill gaps?
- What do the capital and operational budgets allow?
- Integration into existing systems



https://oscar.wmo.int/surface/index.html#/

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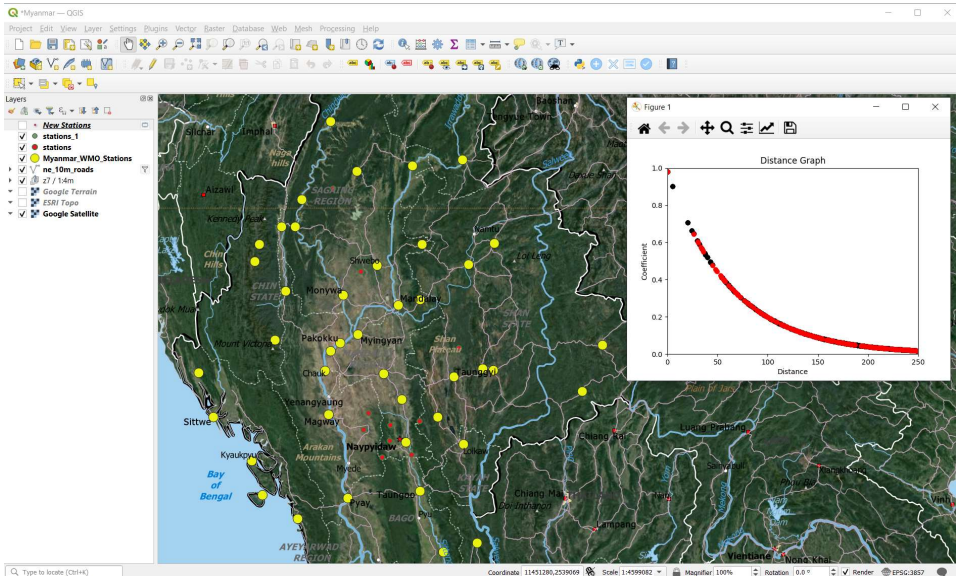
Network Resolution and Accuracy

- The application will drive the requirements for resolution and accuracy (aeronautical to climate monitoring).
- Temporal resolution depends on scale of phenomena: meteorological to seasonal temporal scales
- Spatial resolution depends on scale monitoring requirements:
  - Local (daily variability)
  - Regional (wet/dry seasons)
  - Climatological conditions (tropical, mid-latitude)
  - Topographic (mountains, plains)



Innovative Observation Platforms

Benefits:

- Uses inexpensive, innovative technology, and locally sourced materials
- Uses low-cost, reliable micro-sensors
- Systems are designed to be assembled and maintained locally
- Spare components are readily available to support long-term sustainability
- More affordable to increase network density (gap filling)

Limitations:

- Observation data quality may be lower than climate reference stations
- Sensors and station infrastructure not as "hardened" as reference stations
- Challenge network data integration (different data formats, transmission protocols, etc.)

Example: 3D-Printed Automatic Weather Station (3D-PAWS)

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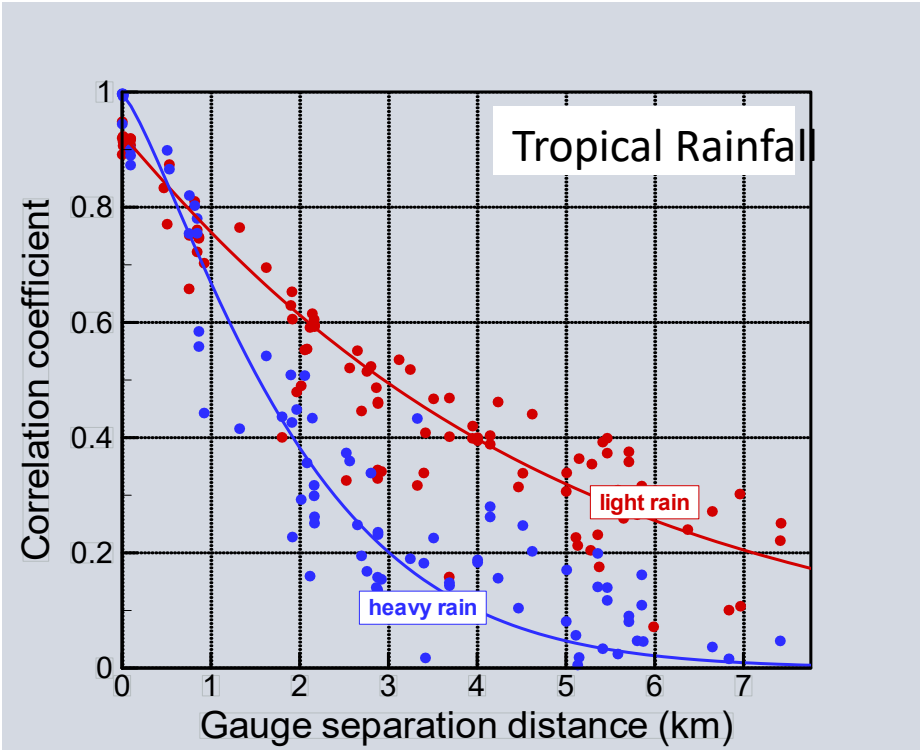
Redundancy

- Multiple sensors provide information for backup and consistency checks
- Depends on application, land surface/land use, topography, requirements
- Budget limitations:
  - Training
  - Spare Parts
  - Maintenance



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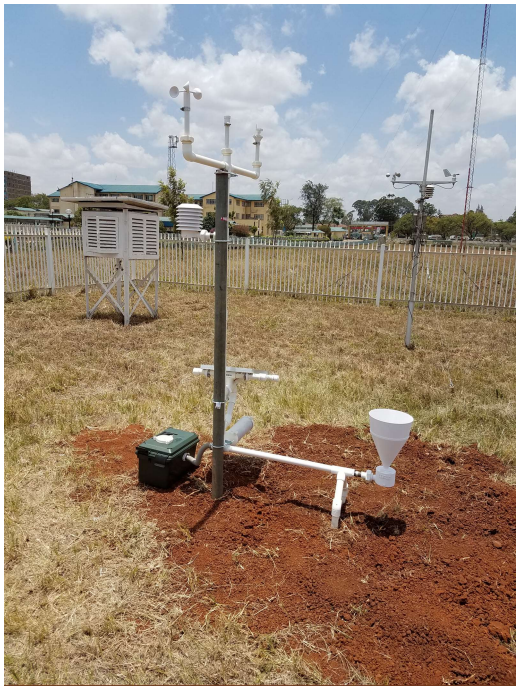
Data Collection and Management

- How will data be collected, managed, and shared?
- Manual collection, direct connection, landline, cellular, satellite, radio?
- Cost of communications?
- What software and algorithms are needed for these tasks?
- Integration into existing systems and operations
- IT Security



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Resourcing

- How is this being financed?
- How will ongoing operational funding impact on the operation of the network and people?
  - Operational costs (communications, data management, QA/QC, etc.)
  - Life cycle (maintenance, calibration, spares, etc.)
  - Training, people change, etc.

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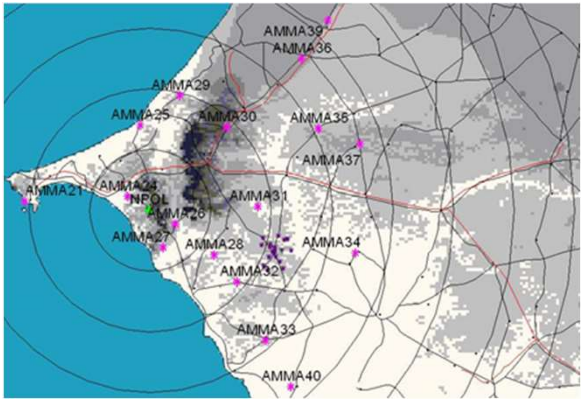
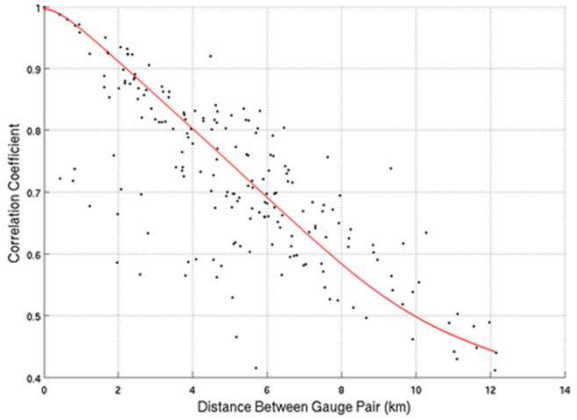
Share our experiences...

Paul's example.

- Experience in deploying surface observation networks for 30 years from the tropics to high latitude climates
- Observation network design is important: what is the application (urban flood monitoring – long-term climate variability)?
- Proper siting is critical for representative measurements
- Routine monitoring, maintenance, and calibration is important
- Budget for spare and replacement sensors and equipment
- Capacity development is critical: conduct periodic training of the team to work on all aspects of network operations (deployment to analysis) to support long-term sustainability of the network





Share our experiences...

Andrew's example.

- Historically ad-hoc development – now more planning.
- Managing change – highly variable.
- Technology has enabled new design criteria – altitude. Now have much better vertical spatial coverage.
- Site security – changing land-use, long-term leases, homogeneity.
- Operational and funding challenges - climate vs weather vs project based.
- Prioritizing Essential Climate Variables (ECVs).
- Quality vs quantity - "buy cheap, buy twice!“, maintenance still priority.
- Site selection - use of siting classification tool is crucial.
- Transition to tiered networks.
- Metadata.

Can you share an experience?

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Thank you
Merci

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