The Global Observing System for Climate

Towards a global land surface climate fiducial reference measurements network

CIMO-TECO-2018

Amsterdam, The Netherlands

GCOS Secretariat, WMO

Tim Oakley, GCOS Network Manager
GCOS established April 1992

The vision of GCOS is that all users have access to the climate observations, data records and information which they require to address pressing climate-related concerns. GCOS users include individuals, national and international organizations, institutions and agencies.

The role of GCOS is to work with partners to ensure the sustained provision of reliable physical, chemical and biological observations and data records for the total climate system – across the atmospheric, oceanic and terrestrial domains, including hydrological and carbon cycles and the cryosphere.
GCOS Progress: Improving global climate observations

Support Adaptation & Mitigation
Water, Energy and Carbon cycles
Additional Essential Climate Variables
More help for networks in developing countries
Climate Indicators

- First Regional workshop held in Fiji for Pacific Island States
- Working group in Lightning starts work
- Working group on GCOS Reference Surface Network meets for first time
- Weather radar data for climate
- Review of ocean observing systems

2015
2016
2017
A GCOS Surface Reference Network

- Is traceable to an internationally accepted standard and has a comprehensive uncertainty analysis and is validated;
- Is documented in accessible literature and includes complete metadata description
- Will measure temperature and precipitation and a range of other surface ECVs
- May be based on existing networks such as the US Climate Reference Network and the Cryonet

Improved long-term accuracy, stability and comparability of observations.

To achieve simultaneous high-quality observations of many ECVs
Provide reference data to constrain and calibrate more spatially comprehensive observing systems.
GCOS Surface Reference Network (GSRN) Task Team Report
to the AOPC-23 Meeting
6-March-2018; Darmstadt, Germany

GSRN TT Initial Meeting from 1-3 Nov 2017;
Maynooth University; Dublin, Ireland

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USCRN Station in Denali National Park Alaska
GSRN Task Team Membership

- Co-Chair – Howard Diamond – USA
- Co-Chair and TOPC Rep – Nigel Tapper – Australia
- AOPC Representative – Phil Jones – UK
- GRUAN Representative – Peter Thorne – Ireland
- GSN Representative – Tim Oakley – UK
- CBS/WIGOS/CIMO Representative – Andrew Harper – New Zealand
- NMHS Representative – Jiankai WANG – China
- BIPM Representative – Andrea Merlone – Italy
- Climate Scientist Representative – Victor Venema – Germany
- Satellite – (Bojan Bojkov – Germany)
- Region I Representative – Rachid Sebbari – Maroc
- GCOS Secretariat – Caterina Tassone
- WMO Secretariat – Peer Hechler
Scientific charge from the AOPC

1. Create a scientifically robust basis for a proposed network spatial composition, taking into account fairness in national contributions and the need for globally representative measurements.

2. Accounting for stakeholder needs including inter-alia climate monitoring, process understanding and understanding remaining measurements (including space-borne measurement systems), define a robust siting rationale.

3. Propose a phased implementation that ‘starts small, but starts’ and builds over time to a holistic set of measurements of all relevant ECVs at each site to the extent practicable.

4. Alight on a potential governance structure in collaboration with key stakeholders.

5. Propose one or more management options that undertake day-to-day operational oversight and ensures a globally traceable, comparable network of measurements, recruiting possible host institutions.

6. Provide indicative costings on the proposed solutions sufficient to inform a decision as to whether to move forwards.

7. Address additional needs identified by the Task Team and agreed with AOPC as they arise.
Spatial resolution
Siting heterogeneity
Ownership and management heterogeneity
Diversity of applications served
Data formats

Proposed climate surface reference network

GCOS Surface Network, Regional Basic Climate Networks, Regional Basic Synoptic Networks

National observing networks, networks from third parties (agriculture, transport, utilities), citizen observations

Temporal stability
Metrological understanding
Uncertainty quantification
Data availability without restrictions
Sustain a national climate observing network that in the future, with the highest degree of confidence, can answer the following question:

How has the climate of the U.S. changed over the past 50-100 years?
CONUS – Done 2008

Station Coverage

On-Going USCRN Work in AK

- 21 stations installed in AK as of Aug 2017 (blue dots)
- 1 new station for FY18 (green dot)
- 7 more stations to be installed from FY19-22 (yellow dots)

Standard USCRN Station Configuration

- 3-wire weighing precipitation gauge with backup gauge inside a large wind fence with single altar
- Solar Radiation (Pyranometer)
- Surface Temp Temperature
- Three High-Precision Platinum Resistance Thermometers in individual ventilated radiation housing
- Wetness Sensor
- Relative Humidity
- Power

Typical soil sensor installation
The GCOS Reference Upper-Air Network

GRUAN Leadcentre and the GRUAN Working Group

[Image: Diagram of the GRUAN network and data products]

**GRUAN Goals**
- Provide long-term high-quality upper-air climate records
- Constrain and calibrate data from more spatially comprehensive global observing systems
- Fully characterize the properties of the atmospheric column and their changes (Fig. 2)
- Measure correlated state variables with deliberate measurement redundancy
- Focus efforts on characterizing observational biases, including complete estimates of measurement uncertainty (Fig. 3)
- Ensure traceability of measurements by extended metadata collection and comprehensive documentation of observational methods (Fig. 4)
- Tie measurements to SI units or internationally accepted standards
- Ensure long-term stability by managing instrumental drifts and introducing traceable SI units or accepted standards

**GRUAN Data Products**
- GRUAN data based on RS92 Temperature, Humidity and wind measurements available on

**Key scientific questions**
- Characterization of changes in temperature, humidity, and wind
- Understanding the climatology and variability of water vapour, particularly in the upper troposphere/lower stratosphere region, which is of crucial importance for understanding climate sensitivity
- Understanding changes in the hydrological cycle
- Understanding and monitoring troposphere characteristics
- Understanding the vertical profile of temperatures bringing closure to the Earth's radiation budget and balance
- Understanding climate processes and improving climate models

**GRUAN Structure**
- Working Group (WG-GRUAN)
- GRUAN Lead Centre at the Lindenberg Meteorological Observatory (O&DW)
- Current GRUAN task teams:
  - GNSS: Precipitation Water
  - Radiosondes
  - GNSS Precipitation Water
- Measurement schedules and associated site requirements

**References**
- [Article Title], [Year], Journal Name, Volume, Issue, Pages
- [Article Title], [Year], Report Name, Number, Pages
- [Article Title], [Year], Report Name, Number, Pages
- [Article Title], [Year], Report Name, Number, Pages
- [Article Title], [Year], Report Name, Number, Pages
Benefits of a GSRN

1. Relevance of “reference”-type measurements
   a. Having each single measurement traceable to an absolute standard allows moving from relative to absolute accuracy in measurements
   b. Defined and agreed measurement standards

2. Underpinning existing networks
   a. Validation of the GSN and broader surface networks and CDRs derived therefrom
   b. Long term homogeneous record will ensure better use of the data and serve to improve the quality of data from other networks

3. Capacity Building
   a. Exchange of knowledge and skills between institutes globally

4. Scientific value of answering questions about long-term nature of climate change
   a. Increased accuracy and confidence in observed changes will allow us to answer new questions and open still unknown new fields of research
   b. Better understanding of the Global Cycles (e.g. Water, Carbon and Energy)

5. Societal Benefits
   a. An initial focus on temperature and precipitation would support plans to adapt to climate change to heat waves, flooding and drought

6. Looking to the Future
   a. Supersites can contribute in research on the evaluation of emerging technologies, improved measurement procedures and measurement principles.
But then...... Day 2!
GSRN Design Principles

Define the measurement requirements of the station, including uncertainty and traceability
Define the calibration and maintenance requirements
Define the infrastructure requirements of the station
Define the data requirements of the station
Define the local management requirements and skill requirements

No predefined set of stations but a vision of global coverage, maximum number of stations, representation of different climatic zones. Need to articulate the stakeholder needs and the priority questions that need to be addressed

Need to identify a Lead Centre(s)

Define the centralised management, infrastructure, data processing, data policy, station/data monitoring, outreach

Funded and managed cooperation mechanism to support ‘least developed countries’ in the implementation of stations (new or upgrade) and ongoing operations. Trust fund, twining.

Invite Member countries to nominate candidate stations to the GSRN and have a robust selection criteria

ABOVE can be based on the GRUAN document GCOS-112 but will need extensive revision
Preliminary List of ECVs to be Monitored (not every GSRN site would need to necessarily observe each ECV)

- Atmospheric
  - Air temperature
  - Precipitation
  - Pressure
  - Wind speed and direction (10 m)
  - Relative humidity
  - Surface radiation (down and up)

- Terrestrial
  - Land Surface Temperature
  - Soil moisture (standard WMO depths)*
  - Soil temperature (standard WMO depths)*
  - Snow/Ice*
  - Albedo*
  - River discharge
  - Ground water

* In conjunction with satellite derived data to a certain degree
• First Task Team Meeting was a successful meeting of the minds with some basic agreements to requirements, design principles, diversity of areas observed, and ECVs.
• Builds on an initial whitepaper, now Thorne et al. (2018) accepted for publication that gives us a firm underlying scientific foundation.
• Use existing reference observing systems (GRUAN and USCRN) as a model to begin from.
• Draft a “GCOS-112-like” document to give the GSRN a firm technical foundation – this was successful for the GRUAN and we believe will serve a possible GSRN very well. May also help to consider regular in-person meetings on an annual basis once we have that in hand.
• A number of related near-term activities over the next year, to be reported out at APOC-24, will be undertaken.
• This is not a small effort, nor is there any thought that this will be easy to do. There are many obstacles in the way.
• The job of this Task Team is to provide the documentation and work necessary to WMO members to decide if this is indeed something that the global climate community wants to take on.
• The Task Team will do its best to deliver on the charter for the Task Team as laid out by the AOPC with a final deliverable by AOPC-25 in 2020.
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Thank you

gcos.wmo.int