

Global Measurements of the Essential Climate Variables

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with major contributions from

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- cover a wide range of atmospheric, oceanic and terrestrial variables
- are made *in situ* and remotely sensed, to varying degrees and levels of maturity
- need to be complemented by socio-economic and ecosystem data
- may serve several purposes and be used repeatedly over many years
- may be used most effectively only after many years, in originally unforeseen ways
- are prone to biases and changes in instrument and coverage
- may be processed and re-processed, and integrated in various types of product
- are subject to a diverse set of institutional arrangements

In 1990, a GCOS function was strongly requested by

- the IPCC through its first assessment report (AR1)
- the participants of the 2nd World Climate Conference (WCC-2)

Basic GCOS requirements defined in 1992 and refined in 2003

GCOS shall be capable of:

1. Characterizing the state of the global climate and its variability
2. Monitoring the forcing of the climate system, including both natural and anthropogenic contributions
3. Supporting the attribution of the causes of climate change
4. Supporting the prediction of global climate change
5. Projecting global climate change information down to regional and national scales
6. Characterising extreme events for the assessment of impacts, risk and vulnerability

GCOS encompasses the climate components of:

- the WMO observing systems (WIGOS: GOS, GAW, WHYCOS, ...)
- the IOC-led co-sponsored Global Ocean Observing System (GOOS)
- the FAO-led co-sponsored Global Terrestrial Observing System (GTOS)
- observational elements of research programmes (WCRP, IGBP, ...)
- other systems contributing climate observations, data management or products

which together form our overall global observing system for climate, and the climate-observing component of the Group on Earth Observations System of Systems (GEOSS)

The GCOS programme:

- assesses and communicates overall requirements
- advises on implementation and reporting
- reviews and promotes progress

covering the observations, transmission and management of data, establishment of fundamental climate data records and the formation of products from them

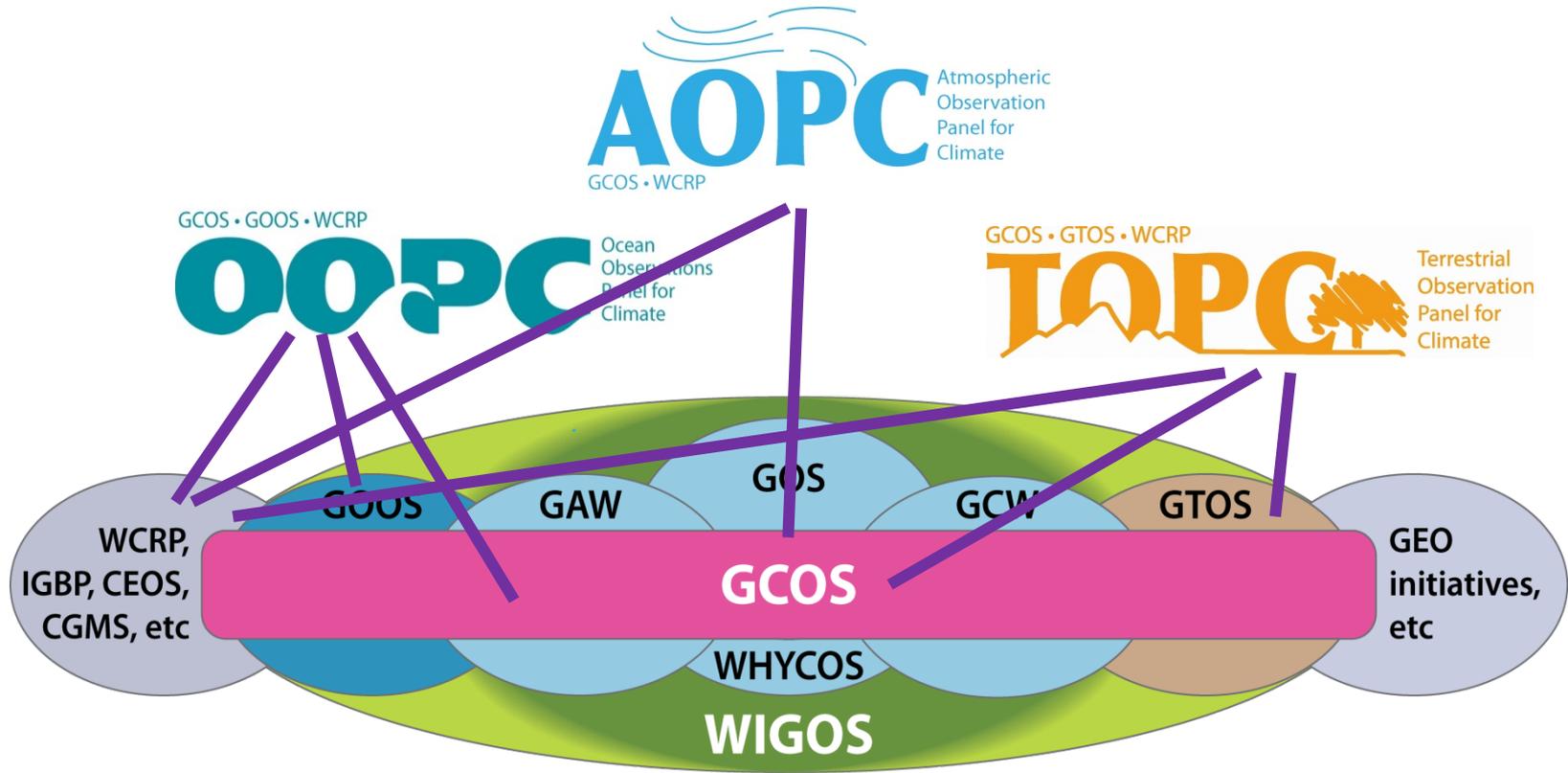
National weather services and other national and regional agencies

- operating observing systems, including baseline and reference atmospheric networks designated by GCOS, following GCOS principles and guidelines
- providing monitoring centres (such as GPCC@DWD or WDC-GG@JMA), an analysis/archive centre (such as NCDC@NOAA), lead centres (such as CBS Lead Centres for GCOS (BAS, BoM, DMC, DMN, DWD, INM, IRIMO, JMA, NCDC)), ...
- supporting the GCOS Cooperation Mechanism and regional activities
- coordinating specific national GCOS activities

Secretariats of contributing observing systems, related Technical Commissions, space-agency coordinating bodies, expert groups, ...

GCOS bodies:

- the Programme Director and staff at WMO
- the Steering Committee
- co-sponsored Panels for Atmosphere, Ocean and Land, and their working groups
- representation on the Data Advisory Panel of the World Climate Research Programme



GCOS cyclically assesses progress, adequacy and requirements

- work is starting on a new cycle, with publications scheduled for 2015 and 2016
- has been primarily in support of UN Framework Convention on Climate Change (UNFCCC)
- needs to address further the requirements for climate services and for adaptation to change

Requirements are for observations, data records and products

- have been set out in two editions of an “Implementation Plan” and “Satellite Supplement”
- are indicative, to be refined for specific measurement or product-generation initiatives
- have long-term stability of data (uniformity of “systematic error” over time) as a specific need
- are set out using terminology that is GUM-aware, though GUM is not fully applicable

Process

- prepared by editors and Steering-Committee/Panel chairs based on input from workshops
- with drafts subject to open review
- presented to UNFCCC for consensus response of parties to the convention
- largely transparent and traceable, though this could be improved

Notions of “Principal Observations” and “Key Variables” emerged in the 1990s
– in a US National Research Council report, and in GCOS plans

GCOS published its First Adequacy Report in 1998

- addressed to the Parties to the UNFCCC
- following a request by the UNFCCC COP 3 in 1997 addressed to SBSTA, for a report produced in consultation with the IPCC

GCOS published its Second Adequacy Report in 2003

- under the endorsement by SBSTA of its preparation
- addressed to the Parties to the UNFCCC
- introducing the “Essential Climate Variables” (ECVs)

Adopted by COP5 to the UNFCCC in November 1999 (decision 5/CP.5)

Effective monitoring systems for climate should adhere to the following principles:

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 should be required.
3. The results of calibration, validation and data homogeneity assessments, and assessments of algorithm changes, should be treated with the same care as data.
4. A capacity to routinely assess the quality and homogeneity of data on extreme events, including high-resolution data and related descriptive information, should be ensured.
5. Consideration of environmental climate-monitoring products and assessments, such as IPCC assessments, should be integrated into national, regional and global observing priorities.
6. Uninterrupted station operations and observing systems should be maintained.
7. A high priority should be given to additional observations in data-poor regions and regions sensitive to change.
8. Long-term requirements should be specified to network designers, operators and instrument engineers at the outset of new system design and implementation.
9. The carefully-planned conversion of research observing systems to long-term operations should be promoted.
10. Data management systems that facilitate access, use and interpretation should be included as essential elements of climate monitoring systems.

Furthermore, satellite systems for monitoring climate need to:

- a) Take steps to make radiance calibration, calibration-monitoring and satellite-to-satellite cross-calibration of the full operational constellation a part of the operational satellite system; and*
- b) Take steps to sample the Earth system in such a way that climate-relevant (diurnal, seasonal, and long-term interannual) changes can be resolved.*

The complete set of principles (including 11-20 for satellite systems) was adopted Cg-XIV in May 2013 through Res. 9; agreed by CEOS-17 in November 2003; and adopted by COP9 in Dec 2013 through decision 11/CP.9

Complete List adopted by Cg-XIV in May 2013 through Res. 9; agreed by CEOS-17 in Nov 2003; and adopted by COP9 in Dec 2013 with 11/CP.9

Thus satellite systems for climate monitoring should adhere to the following specific principles:

11. Constant sampling within the diurnal cycle (minimizing the effects of orbital decay and orbit drift) should be maintained.
12. A suitable period of overlap for new and old satellite systems should be ensured for a period adequate to determine inter-satellite biases and maintain the homogeneity and consistency of time-series observations.
13. Continuity of satellite measurements (i.e., elimination of gaps in the long-term record) through appropriate launch and orbital strategies should be ensured.
14. Rigorous pre-launch instrument characterization and calibration, including radiance confirmation against an international radiance scale provided by a national metrology institute, should be ensured.
15. On-board calibration adequate for climate system observations should be ensured and associated instrument characteristics monitored.
16. Operational production of priority climate products should be sustained and peer-reviewed new products should be introduced as appropriate.
17. Data systems needed to facilitate user access to climate products, metadata and raw data, including key data for delayed-mode analysis, should be established and maintained.
18. Use of functioning baseline instruments that meet the calibration and stability requirements stated above should be maintained for as long as possible, even when these exist on de-commissioned satellites.
19. Complementary in situ baseline observations for satellite measurements should be maintained through appropriate activities and cooperation.
20. Random errors and time-dependent biases in satellite observations and derived products should be identified.

An ECV is a physical, chemical, or biological variable or a group of closely-related variables that critically contributes to the characterization of the Earth's climate. They are identified based on the following criteria:

- **Relevance:** The variable is *critical* for characterizing the climate system and its changes
- **Feasibility:** Observing or deriving the variable on a global scale is technically feasible using *proven* scientifically understood *methods*
- **Cost effectiveness:** Generating and archiving data on the variable is affordable, mainly relying on coordinated observing systems using proven technology, taking advantage where possible of historical datasets

ECVs are either specific variables or groups of closely-related variables:

<p>Atmospheric</p> <p>AOPC</p>	<p>Surface: Air temperature, wind speed and direction, water vapour, pressure, precipitation, surface radiation budget</p> <p>Upper-air: Temperature, wind speed and direction, water vapour, cloud properties, earth radiation budget (including solar irradiance)</p> <p>Composition: Carbon dioxide, methane, and other long-lived greenhouse gases, ozone and aerosol, supported by their precursors</p>
<p>Oceanic</p> <p>OOPC</p>	<p>Surface: Sea-surface temperature, sea-surface salinity, sea level, sea state, sea ice, surface current, ocean colour, carbon dioxide partial pressure, ocean acidity, phytoplankton</p> <p>Sub-surface: Temperature, salinity, current, nutrients, carbon dioxide partial pressure, ocean acidity, oxygen, tracers</p>
<p>Terrestrial</p> <p>TOPC</p>	<p>River discharge, water use, groundwater, lakes, snow cover, glaciers and ice caps, ice sheets, permafrost, albedo, land cover (including vegetation type), fraction of absorbed photosynthetically active radiation, leaf area index, above-ground biomass, soil carbon, fire disturbance, soil moisture</p>

For details see GCOS, 2010: Implementation plan for the global observing system for climate in support of the UNFCCC (2010 update) GCOS Rep. 138, 186 pp.

A. Becker for GCOS-AOPC:
Global Measurements of ECVs

BIPM Carbon 2015 WS, Paris, 30 June 2015

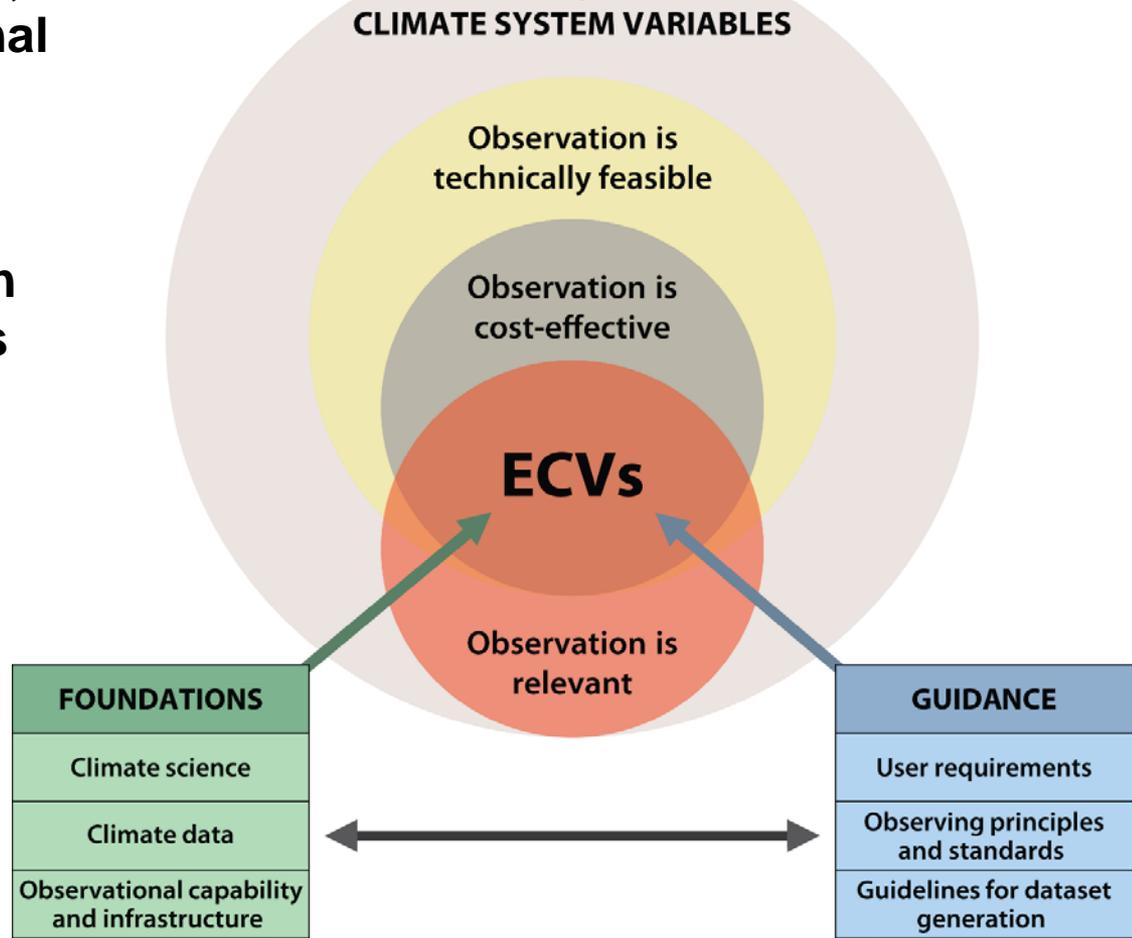
They build on existing science, data holdings and observational infrastructure

Guidance is provided on their observation, and the formation of products from observations

They provide one basis for an organised assessment of capabilities and needs

Organisation could be by observing network, physical/chemical cycle or societal benefit area

Fig.2 in Bojinski et al., 2014: The concept of Essential Climate Variables in Support of Climate Research, Applications, and Policy, *BAMS*, DOI:10.1175/BAMS-D-13-00047.1



Following the Second Adequacy Report in 2003, GCOS produced:

- an Implementation Plan in 2004
- a Supplement to the Plan in 2006 on requirements for satellite-based data products
- a Progress Report in 2009
- an updated Implementation Plan in 2010
- an updated Satellite Supplement in 2011

UNFCCC/SBSTA, in welcoming the 2010 Implementation Plan:

- urged Parties to work towards full implementation
- invited a subsequent progress report and encouraged a review of adequacy, on a timetable to be proposed by GCOS

UNFCCC/SBSTA welcomed the timetable proposed by GCOS in 2012

- for a Status Report in 2015 (draft completed) and a new Implementation Plan in 2016

The ECV list was first published in 2003 in the Second Adequacy Report

The list was updated a little in the 2010 Implementation Plan

- revising some wording, naming ocean acidity and ice sheets explicitly
- adding ocean oxygen content, soil moisture and precursors for O₃ and aerosols
- not adding land-surface temperature
- and including supplementary notes stating that:
 - “ecosystems are characterised, *inter alia*, by a range of biodiversity and habitat properties that are at present too complex to define as an ECV, mainly due to the large variability of scales, the absence of universally-accepted indicators and non-systematic data collection.”
 - “because of the importance of ecosystem changes to the goals of the UNFCCC, such long-term and collocated measurements are recognised in this Plan as ‘Essential Ecosystem Records’.”

The list may be updated again in the 2016 Implementation Plan

IPCC 5th Assessment Report, and this workshop

National reporting to UNFCCC on systematic observation

GCOS workshops on observations for adaptation and mitigation

WCRP Open Science Conference and Workshops

Eumetsat/WCRP Climate Symposium

COSPAR roadmap report on observations and integrated Earth-system science

WMO (GFCS, WIGOS), IOC (GOOS) and post-2015 GEO planning

Ongoing CEOS/CGMS/WMO initiatives (Architecture, Inventory of datasets)

Other assessments of requirements (GEO, ESA Climate Change Initiative)

Assessments by GCOS panels and dedicated workshops

Open reviews

Copernicus Workshop on Climate Observation Requirements

- just started yesterday (29-June to 2 July 2015) at ECMWF
- with focus on the observational content of the Copernicus “Climate Data Store”
- and likely to consider:
 - climate data records from satellites
 - collections of *in situ* climate observations
 - gridded ECV products derived from observations
 - input observations for (and feedback from) model-assisted reanalyses

GCOS Conference on “Global Climate Observations, the Road to the Future”

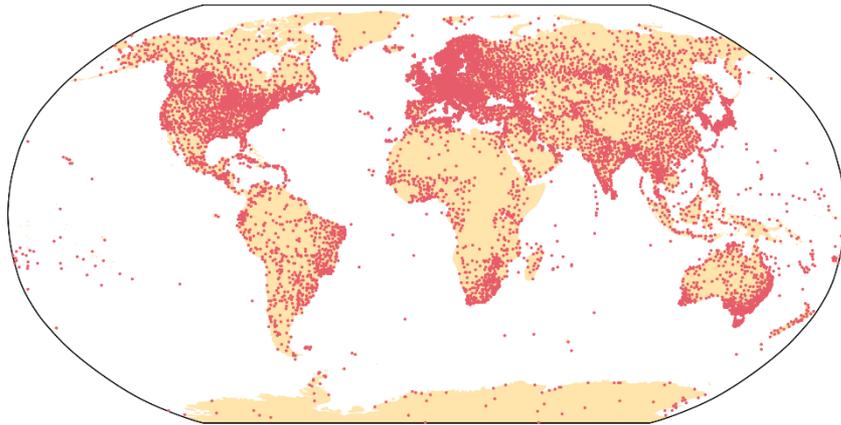
- expected to be held in Royal Acad. of Arts, Amsterdam, from 2 to 4 March 2016
- in part to consider a draft of the new Implementation Plan
- with preparations led by Han Dolman ; Org. Com. : GCOS-SC@eumetsat.int

By evaluating responses to actions from 2010 Implementation Plan

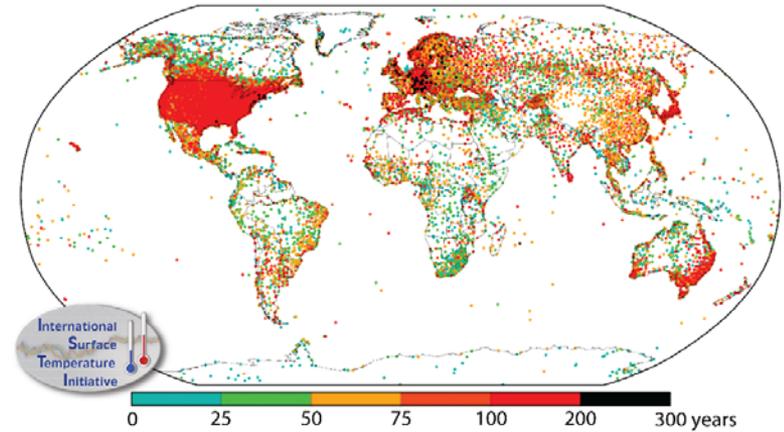
- Action A2: Obtain further progress in the systematic international exchange of ... hourly SYNOP reports and monthly CLIMAT reports ...
- Action A3: Ensure sustained operation of surface meteorological stations addressing national and sub-national needs ... implement additional stations where necessary ...
- Action C13: Collect, digitize and analyse ... historical ... data records ... and submit to International Data Centres

By evaluating network performance and data-centre holdings

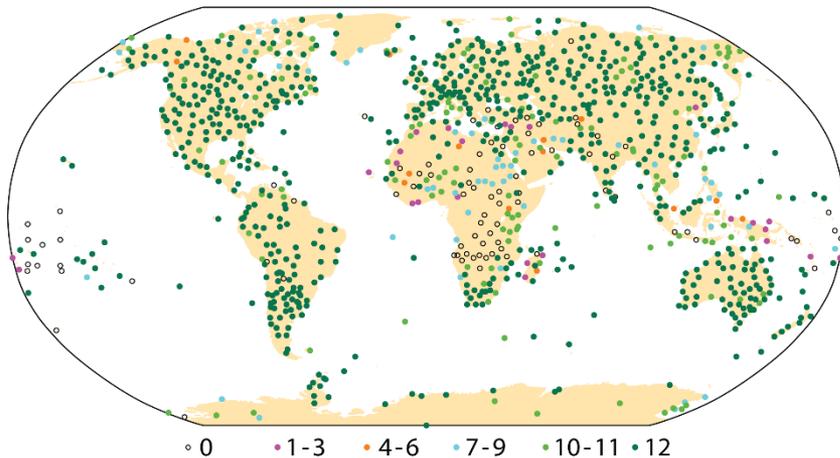
Stations providing surface data at least once per day as received operationally by ECMWF in October 2014



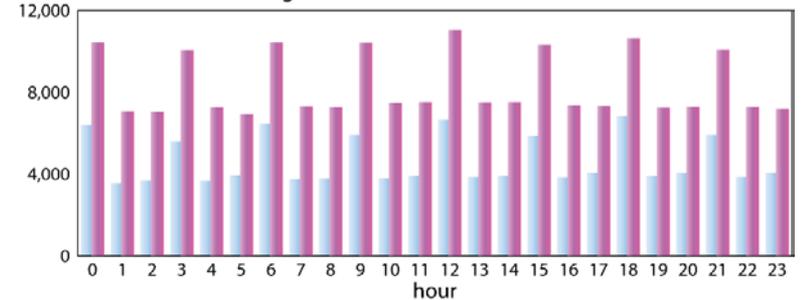
Lengths of monthly surface air temperature records for >32000 stations



Number of monthly CLIMAT reports from GCOS Surface Network held by NOAA/NCDC for 2013



Mean daily counts of surface air temperature obs in NOAA/NCDC's Integrated Surface Database

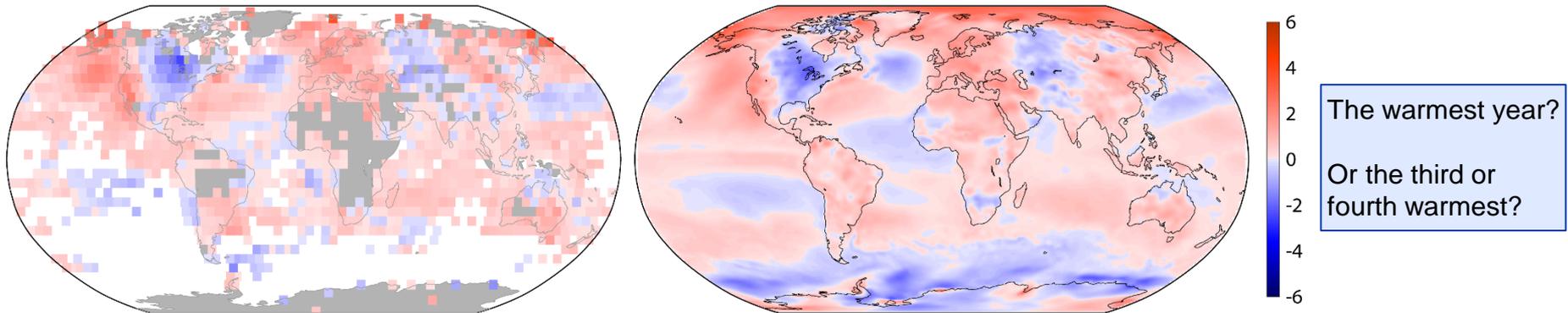


An improving situation, but gaps and lack of local resolution remain

AR5 WGII 13.2.1 notes need for sub-monthly rather than monthly/seasonal/yearly data

Gap-filling and local resolution are required

HadCRUT4 Two-metre temperature (K) for 2014 relative to 1981-2010 ERA-Interim



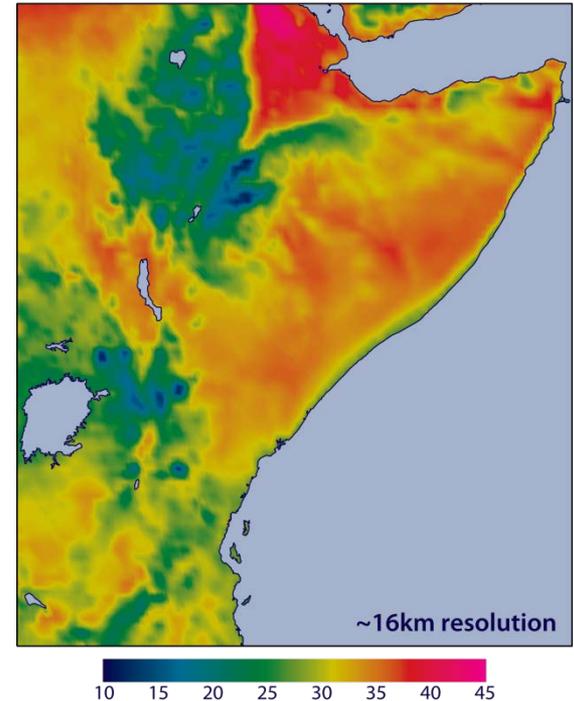
Model-assisted products are gap-free and may be constrained by many types of satellite and *in situ* data

Products with 10km or finer resolution are feasible from global weather prediction analyses and from regional or downscaled global reanalysis

There is need for complementary enhancement of *in situ* observation where gaps are large, or where fine resolution is especially important for decisions on adaptation

AR5 WGII 21.6 notes the “research need” for gridded products

ECMWF 2m temperature (K) 12UTC 24 Sept 2014



By evaluating responses to actions from 2010 Implementation Plan

By evaluating network performance and data-centre holdings

By relating to key uncertainties identified in IPCC AR5

WG I: “Confidence in global precipitation change over land is low prior to 1951 and medium afterwards because of data incompleteness.”

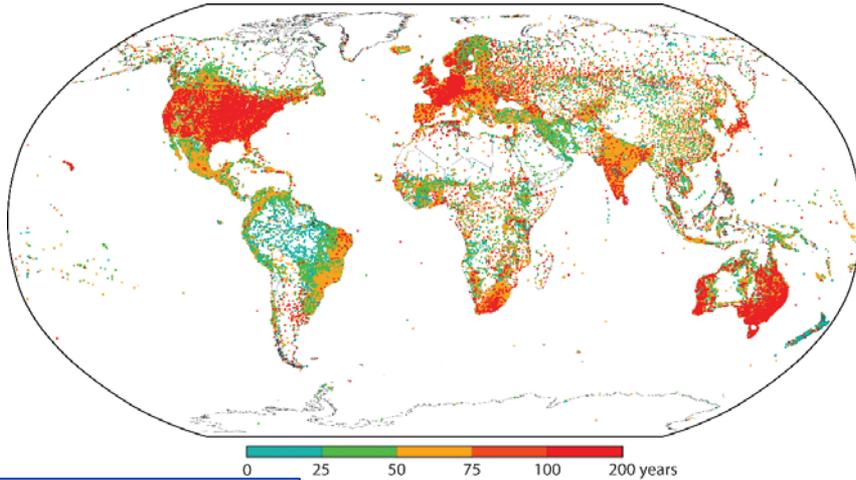
WG II: Notes observational records do not allow determination of century-scale precipitation trends for most areas of Africa and Asia

By relating to issues raised by the World Climate Research Programme

“Over the last few decades, *in situ* observations of land surface hydrological variables, such as streamflow, rainfall and snow, have generally been in decline.”

From discussion of the WCRP Grand Challenge on Water Availability

Locations of 75631 stations and lengths of their precipitation records held in the monthly database of the Global Precipitation Climatology Centre at DWD.

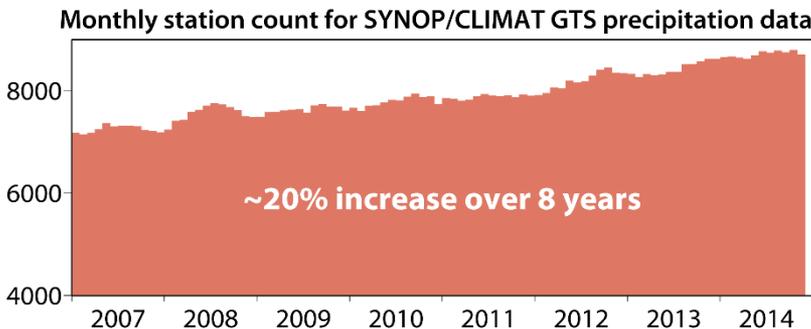


Reflection of the inter-active data acquisition process by the long-term GPCC head Bruno Rudolf.

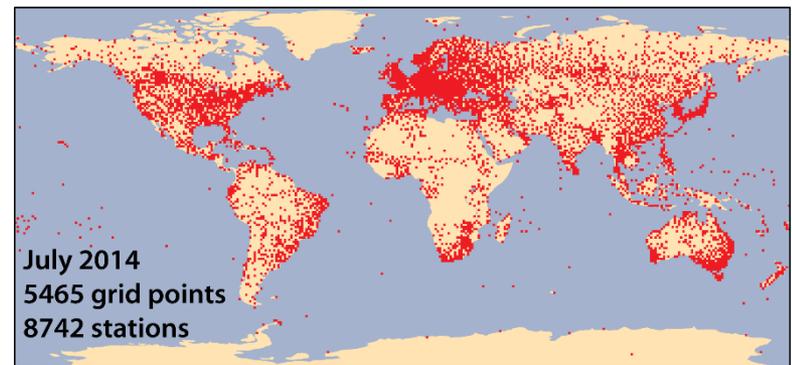
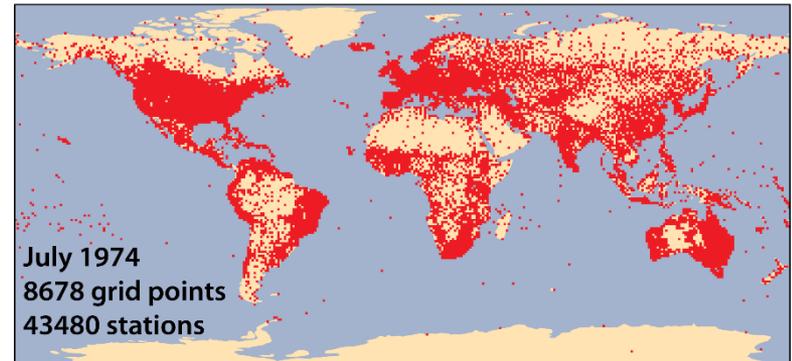
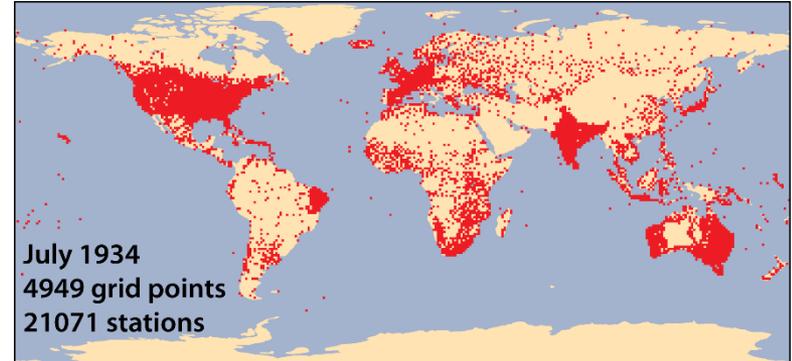
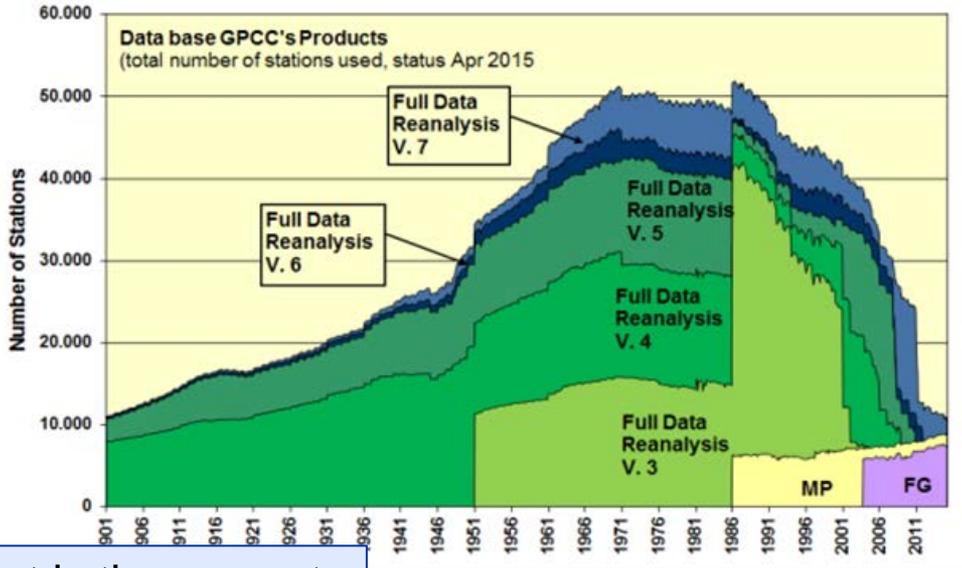
Indeed, the success of any data collection and production centre (DCPC) such as GPCC heavily dwells on the readiness of WMO member countries to share their data!!!



What is the scope to recover more data from before 1951?

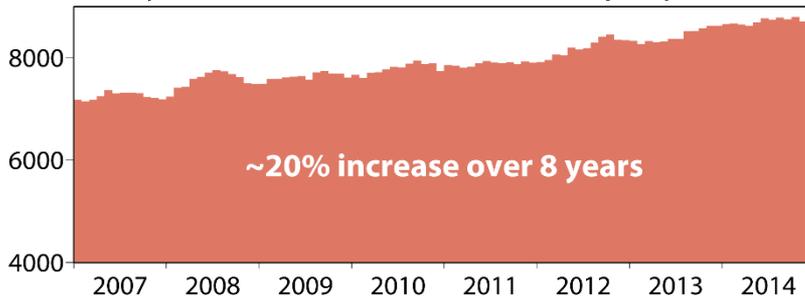


<- Data Centre Head



What is the scope to recover more data from before 1951?

Monthly station count for SYNOP/CLIMAT GTS precipitation data



1⁰x1⁰ grid boxes with one or more stations used in a monthly GPCC product

GTS-Data (SYNOP reports):

- check of precipitation amounts against the weather information
- consistency check of reports overlapping in time
- (fill gaps without precipitation, if weather group indicates no precipitation)

Delivered data

- Check of station location (if within country and over land, and against station meta information in GPCC data base)
- Coding of missing values (sometimes “0” is used)
- Data from station already existing in data base or new one (check of meta data and data)
- Precip. data checked against background statistics for the station or, if not available, for the 2.5° grid (since 2009); data flagged as questionable (below the 1% or above the 99% percentile) are checked manually

QC: Errors typically detected

- Stations are sometimes located in the ocean (no island or atoll!) or outside of the boundaries of the country
- Unusual annual cycle or extreme outliers of monthly precipitation
- Temporal shifts in the data
- Factor*10 errors
- Typing or coding errors
- Errors in the conversion of inch, mm etc. (mostly with historical data)
- Incorrect flagging of missing precipitation observations (might be misinterpreted as „0“)

GPCC examined the Core-Climax Maturity Index for CDR's for its Full Data Reanalysis Product V6



Software readiness	Metadata	User documentation	Uncertainty Characterisation	Public Access, Feedback and Update	Usage
Are the codes compliant with standards, stable, portable and reproducible?	Do the metadata meet international standards, and allow provenance tracking?	Are the formal documents and peer-reviewed papers up-to-date and public?	Are the uncertainties assessed systematically in a standard manner?	Are the data, source code, and documents publicly available and regularly updated?	Are the data widely used in the scientific, and decision and policy making communities?

GPCC examined the Core-Climax Maturity Index for CDR's for its Full Data Reanalysis Product V6

GPCC Full Data Reanalysis Version 6
Climate Data Record (CDR) Maturity Matrix

Maturity level as of 20.09.2015 (2015/09/20)

Maturity	SOFTWARE READINESS	METADATA	USER DOCUMENTATION	UNCERTAINTY CHARACTERISATION	PUBLIC ACCESS, FEEDBACK, UPDATE	UTILITY
1	Conceptual development	Incomplete, no standards considered	Draft scientific description of the methodology	None or incomplete	Restricted availability from PI	None
2	Research grade code	Research grade	Scientific description of the methodology. Peer reviewed paper on methodology published, draft validation report and user guide	Standards defined, limited information on uncertainty and quality, preliminary validation	Data available from PI, feedback through scientific exchange, irregular updates by PI	Application demonstrated for research and emerging for decision support systems
3	Research code following producers standards with some portability, reproducibility	Research grade. Meets international standards for metadata, file naming conventions and file format for the dataset	Public scientific description of the methodology. Peer reviewed paper on methodology published. Peer reviewed paper on the product in preparation, reviewed validation report and user guide	Standards partially applied, information on uncertainty and quality identified, validation for selected locations	Data and source code publicly available, feedback through scientific exchange, irregular updates by PI	Product is used in research activities. Potential benefits for climate services identified
4	Code with systematically applied standards, portability and reproducibility tested	Exists at file and collection level. Stable. Allows provenance tracking and reproducibility of dataset. Meets international standards for the dataset	Public scientific description of the methodology. Draft description on the operational concept of the methodology. Peer reviewed papers on methodology and product published, public validation report and user guide	Standards systematically applied, information on uncertainty and quality quantified and documented, validation for widely distributed locations and time, representativity and redundancy of information characterised	Data and source code archived and under version control and publicly available. Known issues are public. Data provider establishes feedback mechanisms, regular updates by PI	Used with growing acceptance by research community. Started to be used in climate service. Social and economic benefits discussed
5	Operational code following standards with known quality, documented, portable and reproducible	Complete at file and collection level. Stable. Allows provenance tracking and reproducibility of dataset. Meets international standards for dataset	All formal documents public and maintained by data provider. Peer reviewed journal papers on methodology and product validation published.	Standards systematically applied, errors quantified, participation in an international assessment, representativity and redundancy of information characterised	Data and source code archived and under version control and publicly available. Known issues are public. Feedback mechanisms and international data quality assessment are considered in periodic data record update	Widely used and accepted by research community. Social and economic benefits are demonstrated.
6	Operational code fully compliant with standards, stable and reproducible, portable and operationally efficient	Updated and complete at file and collection level. Stable. Allows provenance tracking and reproducibility of dataset. Meets current international standards for dataset	As Level 5	Standards systematically applied, errors minimized, participation in multiple international assessments, representativity and redundancy of information characterised	As Level 5, capability for fast improvements in continuous data provision established	Widely used by multiple research communities. Influencing decision and policy making.

1 & 2 Research Capability (RC)
3 & 4 Initial Operations Capability (IOC)
5 & 6 Full Operations Capability (FOC)

CORE-CLIMAX V6 | TUM/USC/DOC/13/701166, 09/07/2013

- **Features of gridded precipitation data as required by the users:**
- **Timeliness** (for drought monitoring)
 - **High resolution** (for regional structures in global maps)
 - **High accuracy** (for verification of model results)
 - **Homogeneity** (for climate change and variability analysis)

All of these requirements cannot be met by one single gridded data set

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A portfolio of different **DOI referenced** analysis products has been designed and optimized with respect to the **application purposes**



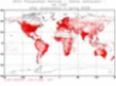
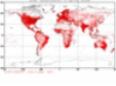
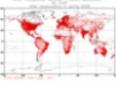
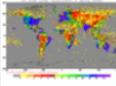
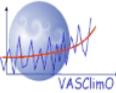
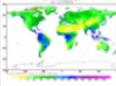
Federal Ministry
of Transport and
Digital Infrastructure



Deutscher Wetterdienst
Wetter und Klima aus einer Hand



Visualize and Download GPCC Products

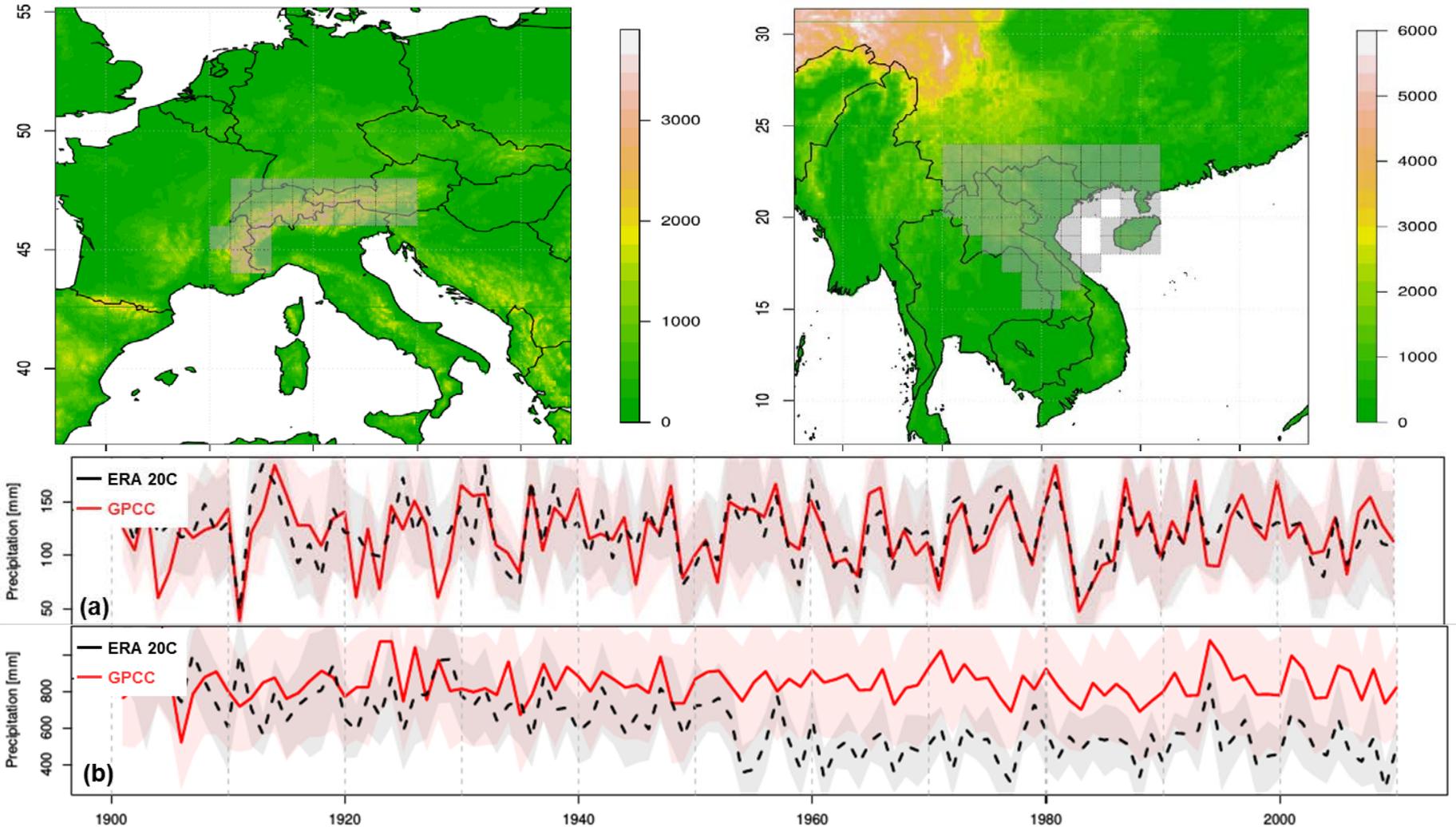
<i>First Guess Daily</i>		<i>First Guess (monthly)</i>	
	GPCC First Guess Daily Product with gridded precipitation data sets for Day/Month/Year at 1.0 ° [more]		GPCC First Guess Product with gridded precipitation data sets for Month/Year at 1.0 ° [more]
<i>Monitoring Product</i>		<i>Full Data Reanalysis Version 7 (Spring 2015)</i>	
	GPCC Monitoring Product with gridded precipitation data sets for Month/Year at 1.0 ° resp. 2.5 ° [more]		GPCC Full Data Reanalysis (V.7 1901-2013) with gridded precipitation data sets at 0.5 °, 1.0 ° and 2.5 ° [more]
<i>GPCC Drought Index Product</i>			
	GPCC Drought Index Product (GPCC_DI) at 1.0° Globally Gridded Drought Index with averaging periods 1,3,6,9,12,24,48 months [more]		
<i>Precipitation Climatology</i>		<i>VASClimo Dataset</i>	
	GPCC precipitation normals (Version 2015) with gridded precipitation data sets for calendar months and the annual total at 0.25 °, 0.5 °, 1.0 ° and 2.5 ° [more]		VASClimo 50-year Precipitation Data Set (Version 1.1 1951-2000) with gridded precipitation data sets for Month/Year at 0.5 °, 1.0 °, 2.5 ° [more]
<i>Visualizer</i>		<i>GPCC at DWD</i>	
	Access to the GPCC Visualizer, with which you can create maps in your own coordinates and parameters [more]		Detailed information about GPCC (in high performance cases temporarily not available) [more]

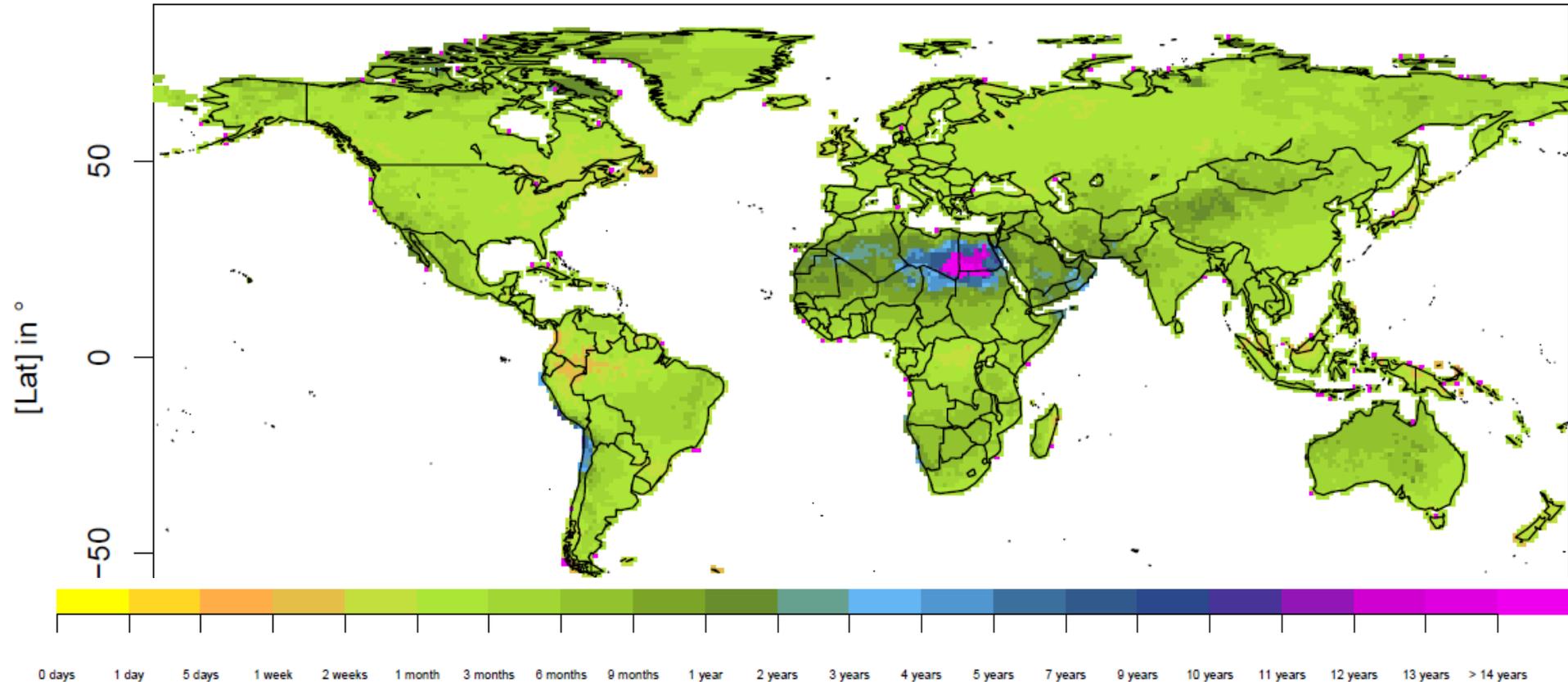
<http://gpcc.dwd.de>

ftp://ftp-anon.dwd.de/pub/data/gpcc/html/download_gate.html

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Utilization of monthly Full Data Reanalysis for ERA_CLIM2 Project





Diagnosis of precipitation related indices of the ETCCDI package (Klein Tank et al., 2009) based on new GPCP daily data set (Raykova et al., EMS2015-532). Here the global distribution of the maximum number of consecutive dry days, CDD in 21 yrs (1998-2008) is shown.

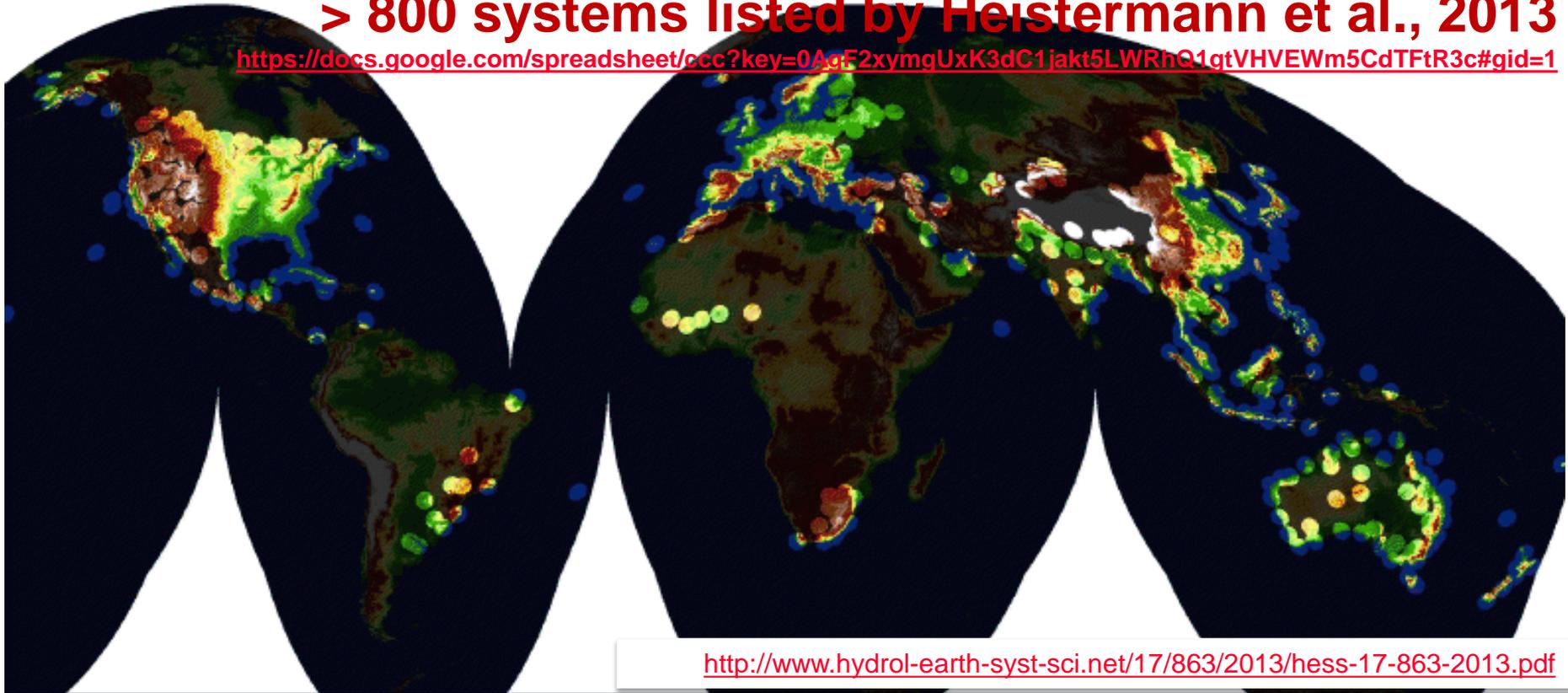
- **Satellite based records and data products** have entered into climate time scales reaching the **30yrs limit**
- **GTS based holdings and products improving**
- **Automation of networks** tremendously increases the volume of observations in many networks
- **Holdings of historic data continuously growing** but access and rescue to historic records remains a challenge. Still substantial delays until data arrives with GPCP and/or information becomes accessible.
- Certain areas remain in particular challenging when it comes to data sharing.
- Main **reasons** are either **administrative** or **technical** issues whereby the latter ones often stem from **encoding problems** with regard to the WMO data formats (BUFR/GRIB). **XML based formats** being OGC compliant might bear the potential to alleviate technical obstacles.

- **GEWEX launched new initiative** to tackle remaining uncertainties in quantification of the global water cycle -> Related BAMS paper discussed yesterday
- **Arctic precipitation** remains a particular challenge
- For the studying of **extremes, sub-daily and hourly information** is crucial. Here the higher **automation** and in the long run **radar networks** will enhance the observational regime substantially.
- For radar data first initiatives to **harmonize** reflectivity formats have taken place (Workshop in Exeter)
- **Combined rain-gauge products** developed in many countries (Australia, Netherlands, France, Germany). In Germany it runs in operational mode to consult federal flood warning agencies, and decadal-reanalysis of a harmonized re-processing are about to be accessed for climatological studies.
- **Improved Integration of 4 (!) obs regimes** (in-situ, satellite, radar and micro-links) still requires research and development and scientific exchange

Weather Radar Data, the untapped source for the ECV (extreme) precipitation!

**World wide weather radar coverage
> 800 systems listed by Heistermann et al., 2013**

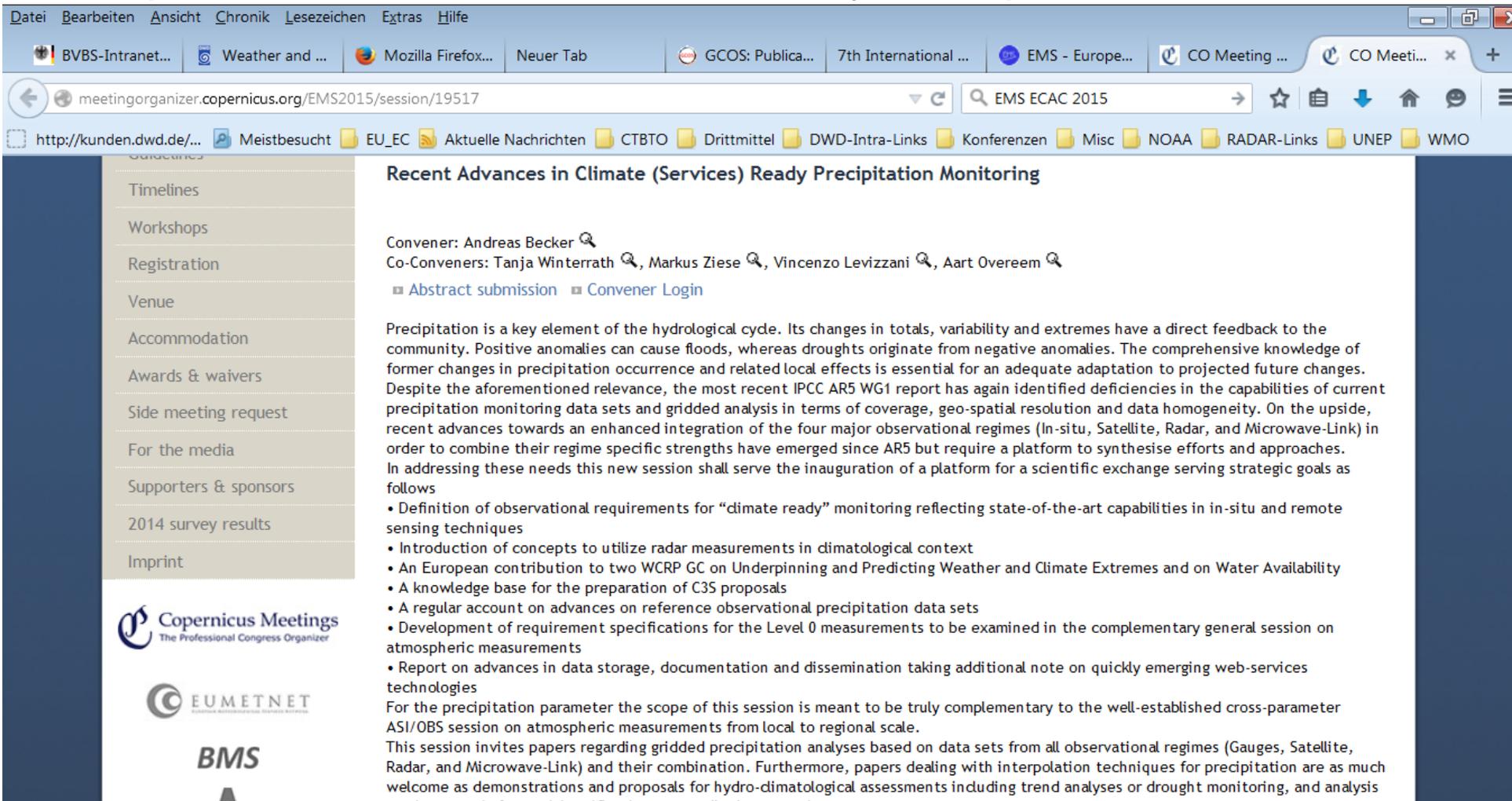
<https://docs.google.com/spreadsheet/ccc?key=0AqF2xymgUxK3dC1jakt5LWRhQ1qtVHVEWm5CdTFtR3c#gid=1>



<http://www.hydrol-earth-syst-sci.net/17/863/2013/hess-17-863-2013.pdf>

Switching from stations (GPCP) to radar will certainly not improve the global coverage, but certain areas (East Asia, Indonesia, West-Africa) show coverage's in climate regimes extremely relevant to study variability's, trends and extremes

Prepare for Climate Services Ready Precipitation Information



The screenshot shows a web browser window with the URL `meetingorganizer.copernicus.org/EMS2015/session/19517`. The page title is "Recent Advances in Climate (Services) Ready Precipitation Monitoring".

Recent Advances in Climate (Services) Ready Precipitation Monitoring

Convener: Andreas Becker
Co-Conveners: Tanja Winterrath, Markus Ziese, Vincenzo Levizzani, Aart Overeem

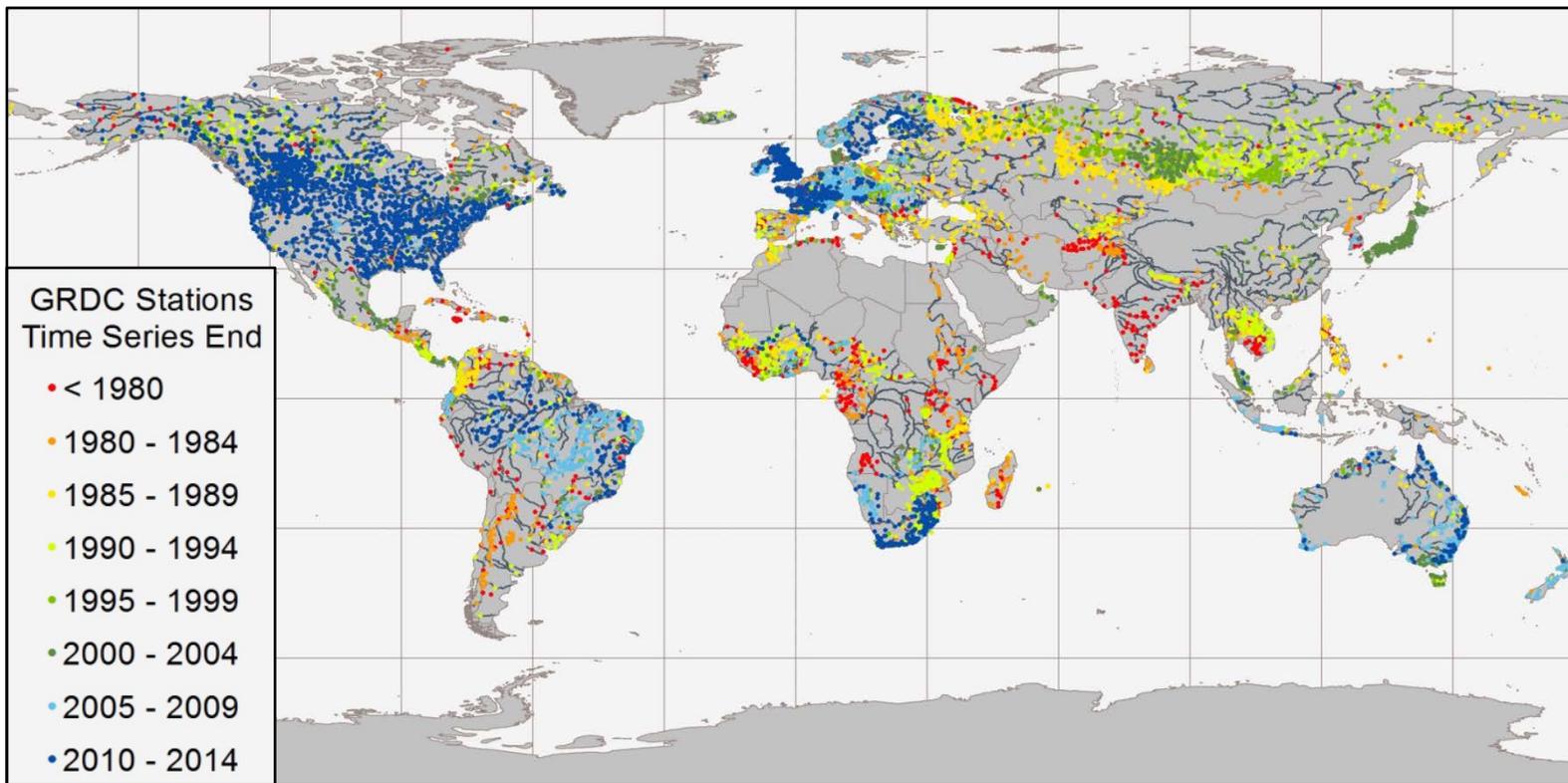
▣ Abstract submission ▣ Convener Login

Precipitation is a key element of the hydrological cycle. Its changes in totals, variability and extremes have a direct feedback to the community. Positive anomalies can cause floods, whereas droughts originate from negative anomalies. The comprehensive knowledge of former changes in precipitation occurrence and related local effects is essential for an adequate adaptation to projected future changes. Despite the aforementioned relevance, the most recent IPCC AR5 WG1 report has again identified deficiencies in the capabilities of current precipitation monitoring data sets and gridded analysis in terms of coverage, geo-spatial resolution and data homogeneity. On the upside, recent advances towards an enhanced integration of the four major observational regimes (In-situ, Satellite, Radar, and Microwave-Link) in order to combine their regime specific strengths have emerged since AR5 but require a platform to synthesise efforts and approaches. In addressing these needs this new session shall serve the inauguration of a platform for a scientific exchange serving strategic goals as follows

- Definition of observational requirements for "climate ready" monitoring reflecting state-of-the-art capabilities in in-situ and remote sensing techniques
- Introduction of concepts to utilize radar measurements in climatological context
- An European contribution to two WCRP GC on Underpinning and Predicting Weather and Climate Extremes and on Water Availability
- A knowledge base for the preparation of C35 proposals
- A regular account on advances on reference observational precipitation data sets
- Development of requirement specifications for the Level 0 measurements to be examined in the complementary general session on atmospheric measurements
- Report on advances in data storage, documentation and dissemination taking additional note on quickly emerging web-services technologies

For the precipitation parameter the scope of this session is meant to be truly complementary to the well-established cross-parameter ASI/OBS session on atmospheric measurements from local to regional scale. This session invites papers regarding gridded precipitation analyses based on data sets from all observational regimes (Gauges, Satellite, Radar, and Microwave-Link) and their combination. Furthermore, papers dealing with interpolation techniques for precipitation are as much welcome as demonstrations and proposals for hydro-climatological assessments including trend analyses or drought monitoring, and analysis

River discharge: locations and latest years in Global Runoff Data Centre holdings



9009 GRDC stations with monthly data, incl. data derived from daily data (Status: 24 June 2014)
Koblenz: Global Runoff Data Centre, 2014.



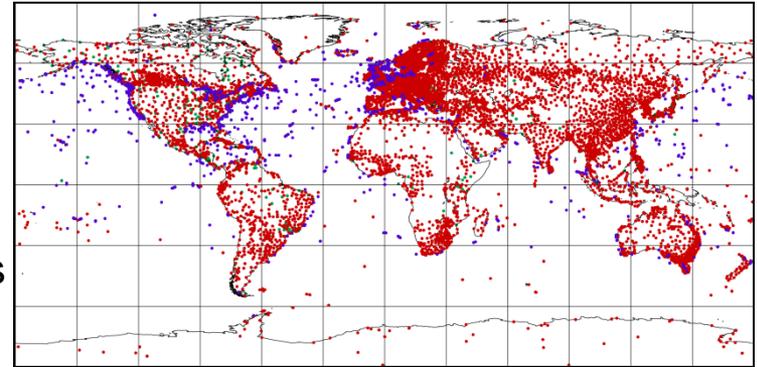
WMO Congress in 2015 adopted Cg-17-d04-1(5) resolutions
4 covering exchange of streamflow and other climate data

Coverage and transmission of surface weather data are mainly good

- but with some gaps in network coverage
- and some deficiencies in quality and transmission, especially of the monthly means from climate stations

Ensuring observation continues at “baseline” locations is a priority

- and the focus of the GCOS Cooperation Mechanism



Locations of 36064 SYNOP/METAR/SHIP observations received by ECMWF 0900-1500UTC 12 June 2012

Continuing observation needs to be supplemented by:

- converting past data into modern digital formats and databases
- increasing international exchange of these data
- using data assimilation and downscaling to fill remaining gaps

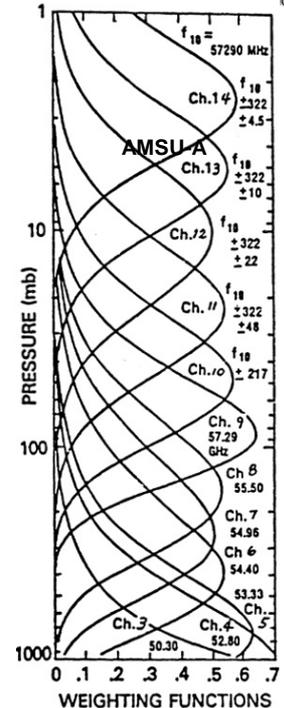
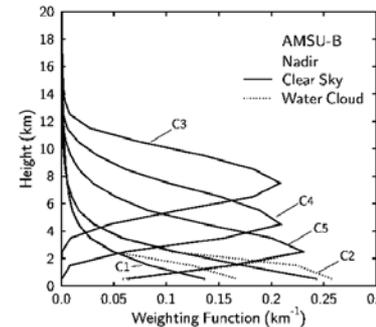
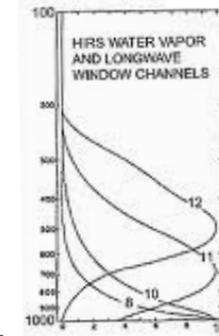
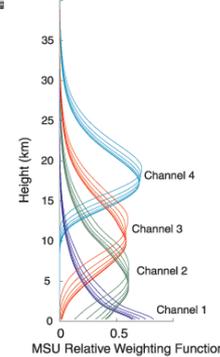
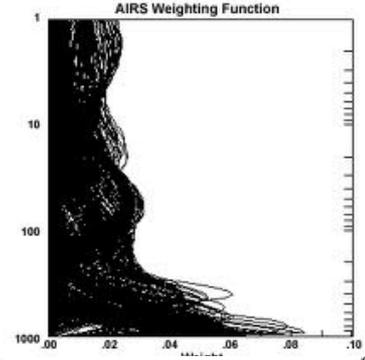
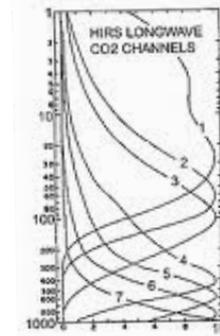
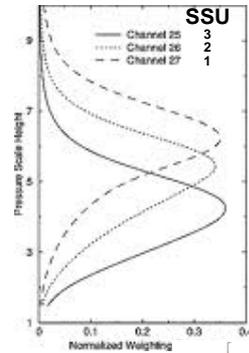
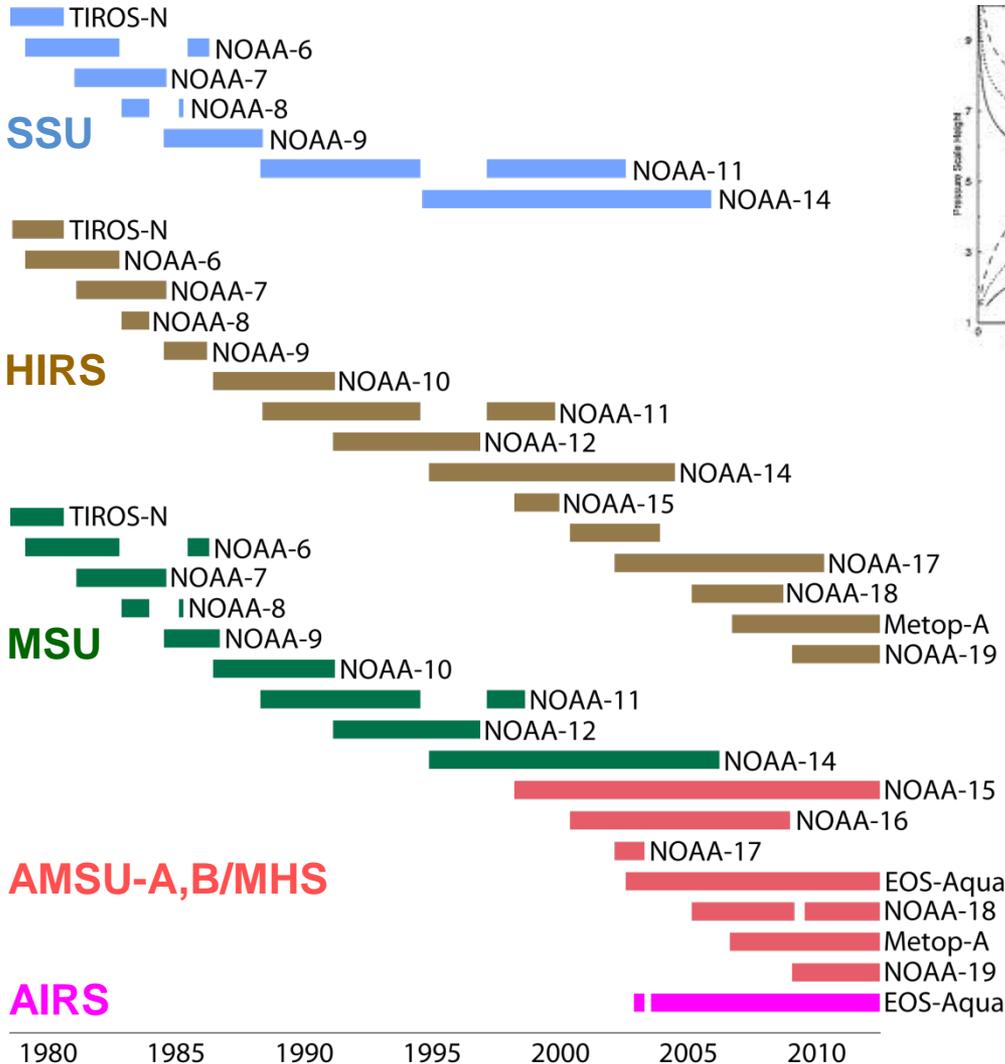
Some gaps exist in all countries

- e.g. observations at up to ~180m height for siting wind turbines

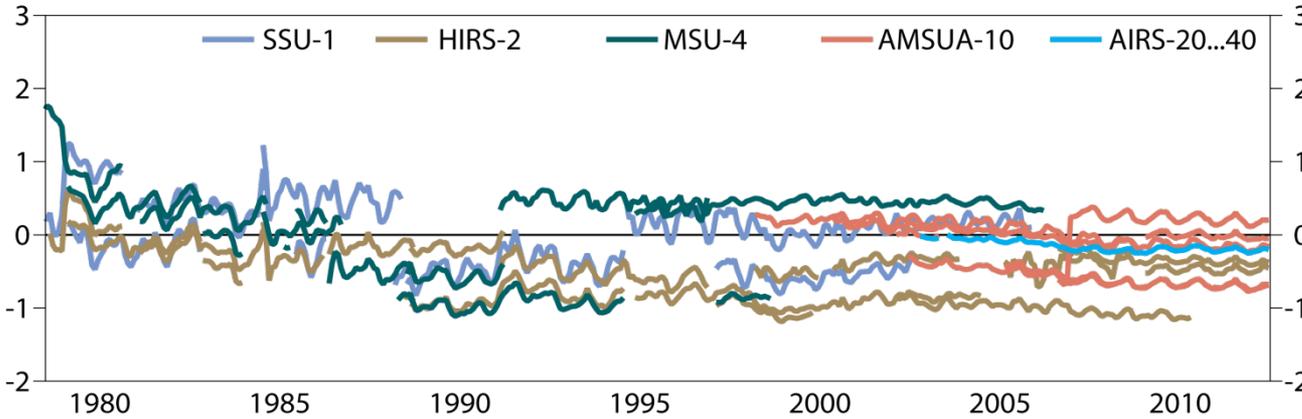
as does scope for data rescue



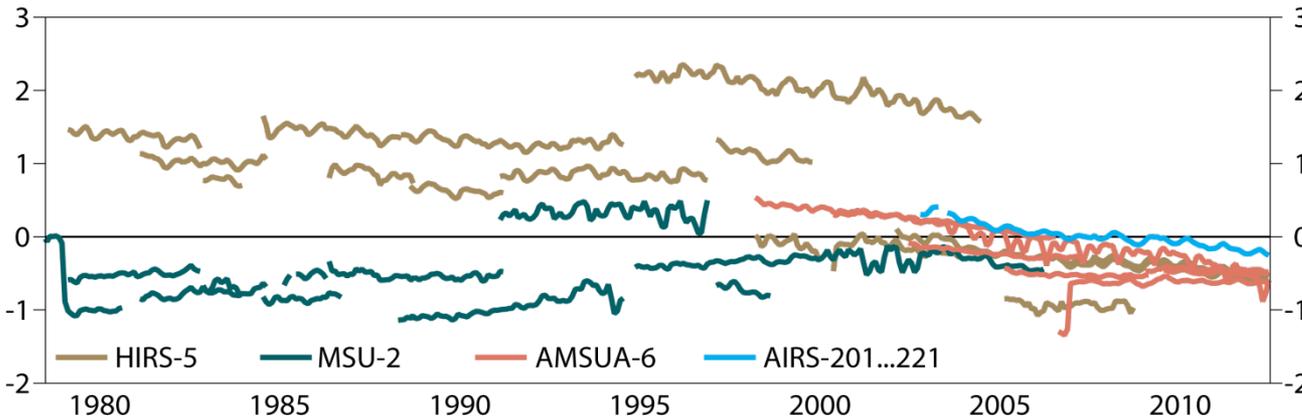
Atmospheric sounding data from NOAA, NASA and EUMETSAT polar-orbiting satellites



Atmospheric sounding data from NOAA, NASA and EUMETSAT polar-orbiting satellites



Brightness temperature(K) adjustments for measurements of lower-stratospheric layer



Brightness temperature(K) adjustments for measurements of upper-tropospheric layer

Bias adjustments shown above are estimated variationally in a comprehensive data assimilation system. Adjustments account for differences in bias between instruments, and drifts in instrumental measurements and orbits, in other assimilated data, in background-model bias and in the radiative transfer calculations that link model variables to measured radiances.

Operational meteorological satellite programmes and related missions are in generally good shape

- with new contributors such as China and India
- compensating for vulnerability to failure of platforms or key instruments

Copernicus programme places many other types of environmental observation on an operational basis

- first satellite of six multi-satellite Sentinel missions was launched in 2014
- includes supporting monitoring and forecasting services, and has open data policy

Various issues related to continuity of other types of observation

- continuity for quite well-established types of measurement?
- continuity or intermittent enhanced missions for specific R&D purposes?
- what next for measurements that are emerging or may emerge as important?
- how serious is the absence of a reference mission?

Requirements are for observations, data records and products

For generation of data records and products, GCOS has guidelines

- and is working with partners to develop and implement data inventories
- and supports partner efforts on assessment and comparison of product quality

For observation, GCOS has the concept of a network hierarchy

- involving comprehensive, baseline and reference networks

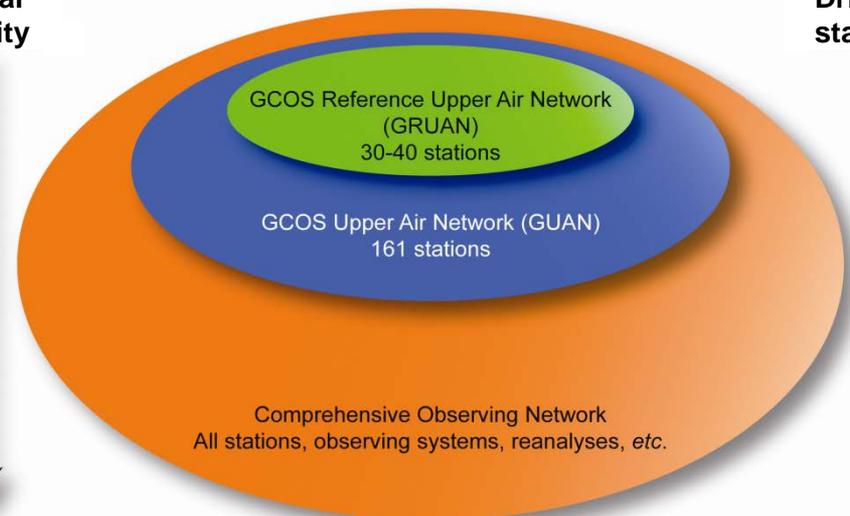
For upper-air observation, this entails

- all networks and satellite systems
- a baseline subset of the radiosonde network (GUAN)
- a set of reference sites providing high-quality radiosonde operation and supplementary measurement of vertical profiles (GRUAN)
- ideally a satellite reference mission

Spatial density



Driven by standards



WMO GAW network is the designated baseline network for CO₂ and CH₄

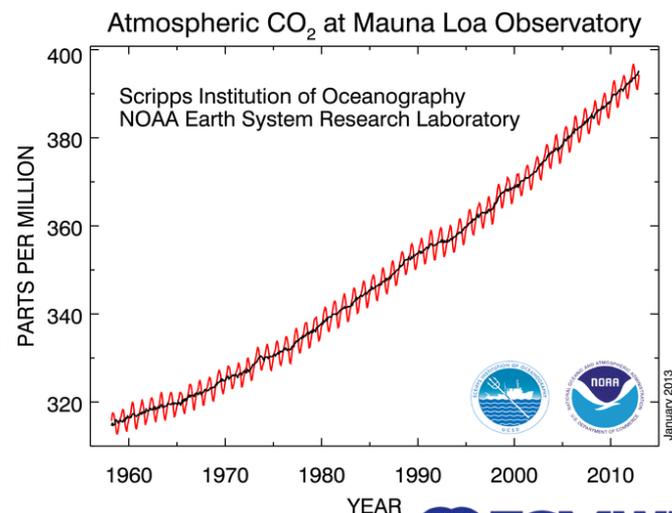
- NOAA/ESRL and JMA are the World Calibration Centres for CO₂ and CH₄ respectively
- NOAA/ESRL is the Central Calibration Laboratory for CO₂ and CH₄ (and other trace gases)

Tasks of the Central Calibration Laboratory include:

- maintaining the WMO Mole Fraction Scale for the respective species
- carrying out comparisons with independent primary scales
- establishing traceability to Primary Reference Materials or Fundamental Constants through the NMIs and the BIPM
- ensuring transparency: providing complete and prompt disclosure, including uncertainties

Comprehensive networks comprise:

- surface-based *in situ* measurement and remote sensing
- aircraft-based *in situ* measurement
- satellite-based remote sensing



Drifting buoys

- their surface pressure data have tripled in number over the last decade
- their SST data have contributed increasingly to estimates of global temperature

Moored buoys

- a significant component in the Tropics

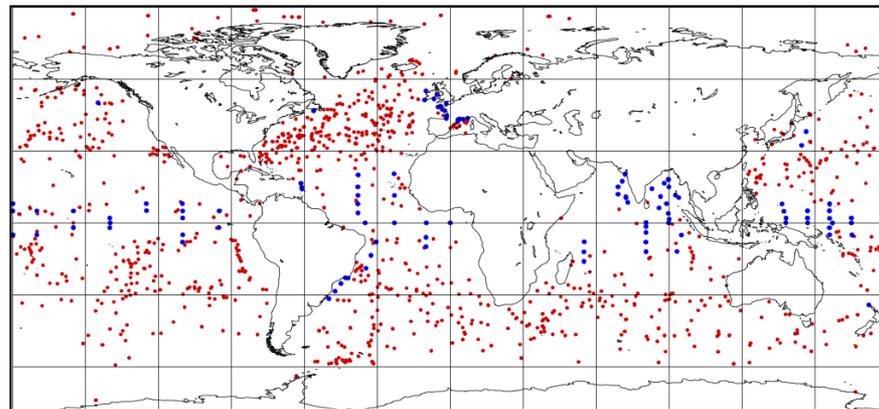
Argo floats

- reached 3000 in number in 2007; some 800 need replacing each year

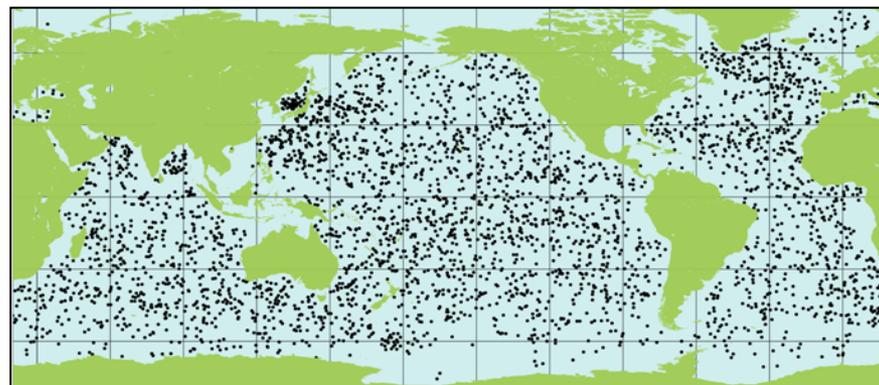
Concerns include:

- continuity of satellite-based altimetry, maintenance of moorings, reliance on research funding

Developing and implementing a deep ocean observing strategy is a priority



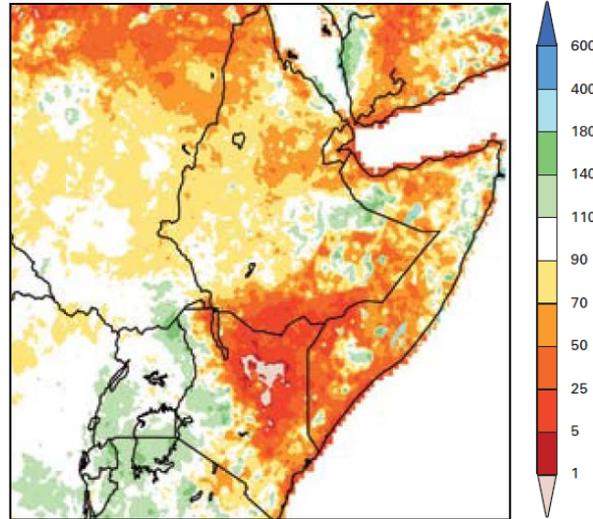
Locations of 7303 observations from drifting and moored buoys received by ECMWF 0900-1500UTC 12 June 2012



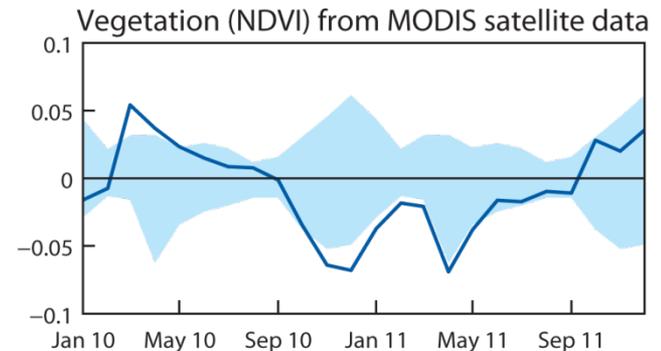
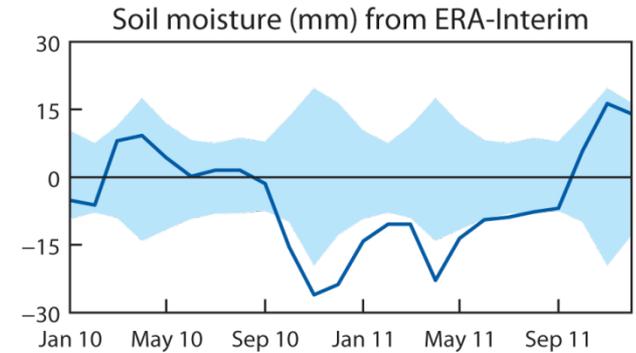
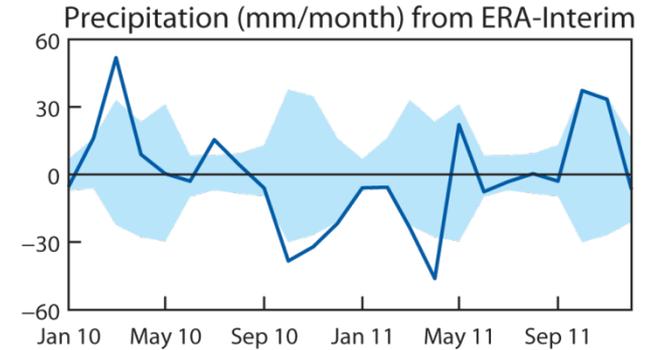
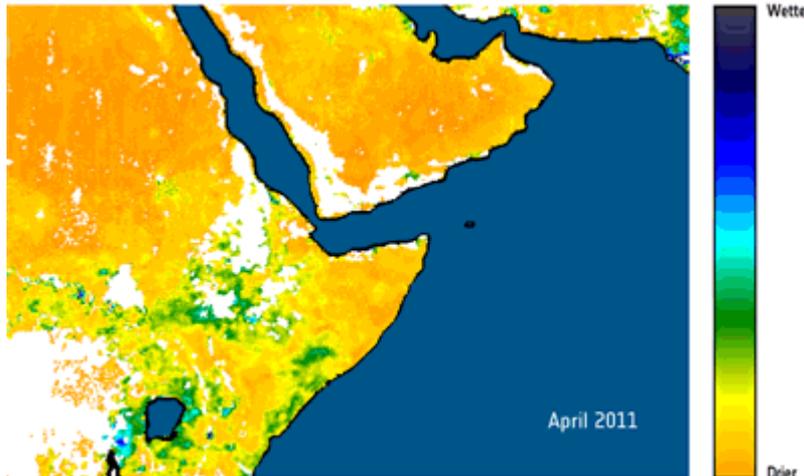
Locations of 3497 Argo floats profiling upper 2000m of ocean, on 12 June 2012 from <http://www.argo.ucsd.edu/>

Multiple observation-based indicators of drought in East Africa

Rainfall for Feb – Sep 2011 as a percentage of the 1983–2009 average estimated using blended station and satellite data (NOAA CPC, reproduced from WMO statement on the status of the global climate in 2011)



Soil moisture derived from SMOS satellite data from April to mid-July 2011 (CESBIO/ESA)

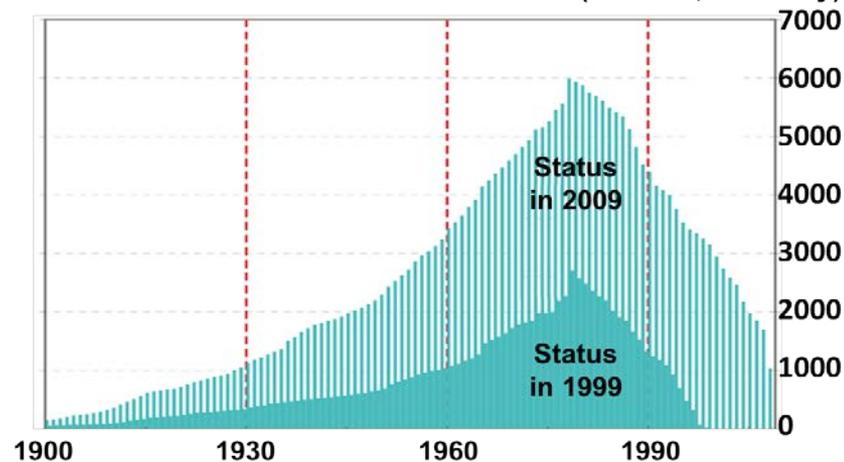


10th – 90th percentile 2011 anomaly

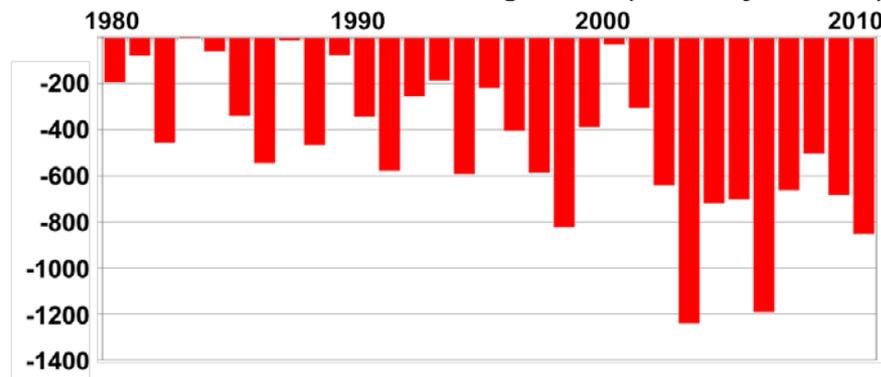
There is progress, but still a need to enhance observation and/or data exchange, for variables such as:

- precipitation, soil moisture, river flow, lake levels, snow depth, glacial retreat, ...
- dust (for health, solar power generation, ...)
- wild fires (for emissions, public safety)
- forest conditions (including soil carbon)
- marine conditions in coastal zones (including ecosystems)
- urban conditions (temperature, humidity, air quality, ...)
- trace species (other greenhouse gases, other aerosol types, precursor species)

Number of stations providing monthly river discharge data to archive of Global Runoff Data Centre (Koblenz, Germany)



Mean annual glacier mass balance (mm w.e.) from the World Glacier Monitoring Service (University of Zürich)



Does the concept of the ECVs and the working of the assessment process remain appropriate, fit-for-purpose, relevant, useful, ...?

- How can they be improved, or have you a radically different approach to propose?
- Should impact-related ECVs be included?

Has there been progress on “Essential Ecosystem Records (EERs)”?

- Do such actions and the “EER” concept need to be restated in the 2016 plan?
- Are there specific proposals for impact-related ECVs?

What are your perceptions of the current state of climate observation and related products and services?

- Where, from your perspective, is progress being made?
- Where, from your perspective, is progress not being made?
- What do you see as the priorities for improvement?