The Global Observing System for Climate

IMPLEMENTATION NEEDS

Vision and Challenges

GCOS Secretariat, WMO

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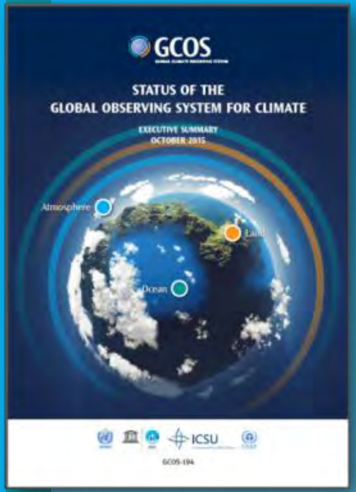
WMO UNESCO IOC UN environment International Science Council

GCOS Progress: Improving global climate observations

United nations conference on climate change
COP21/CMP11



2015

COP-22, Marrakech,
Decision 19/CP.22
SBSTA Conclusions

2016

Support Adaptation & Mitigation

Water, Energy and Carbon cycles

Additional Essential Climate Variables

More help for networks in developing countries

Climate Indicators

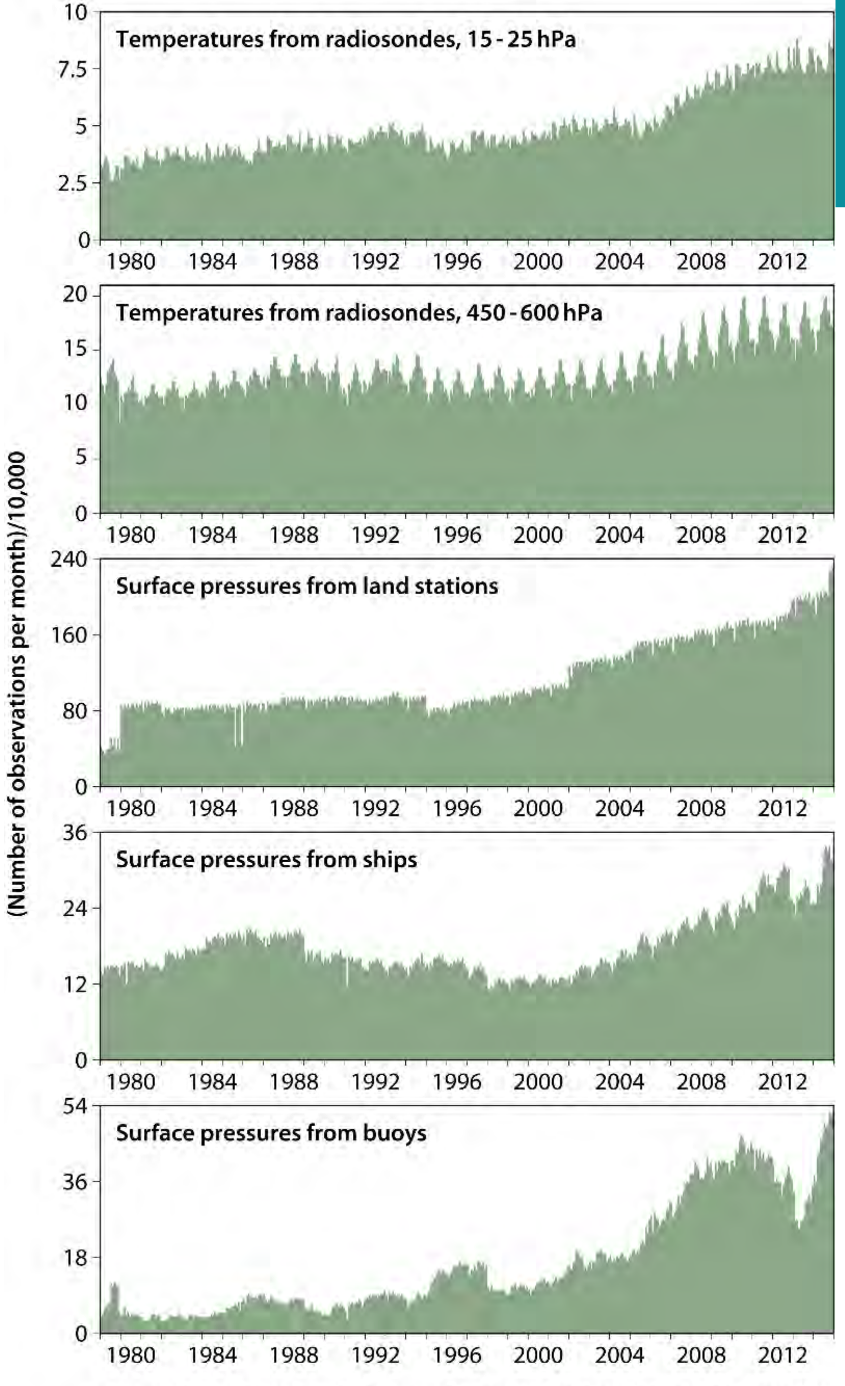
2017

- 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

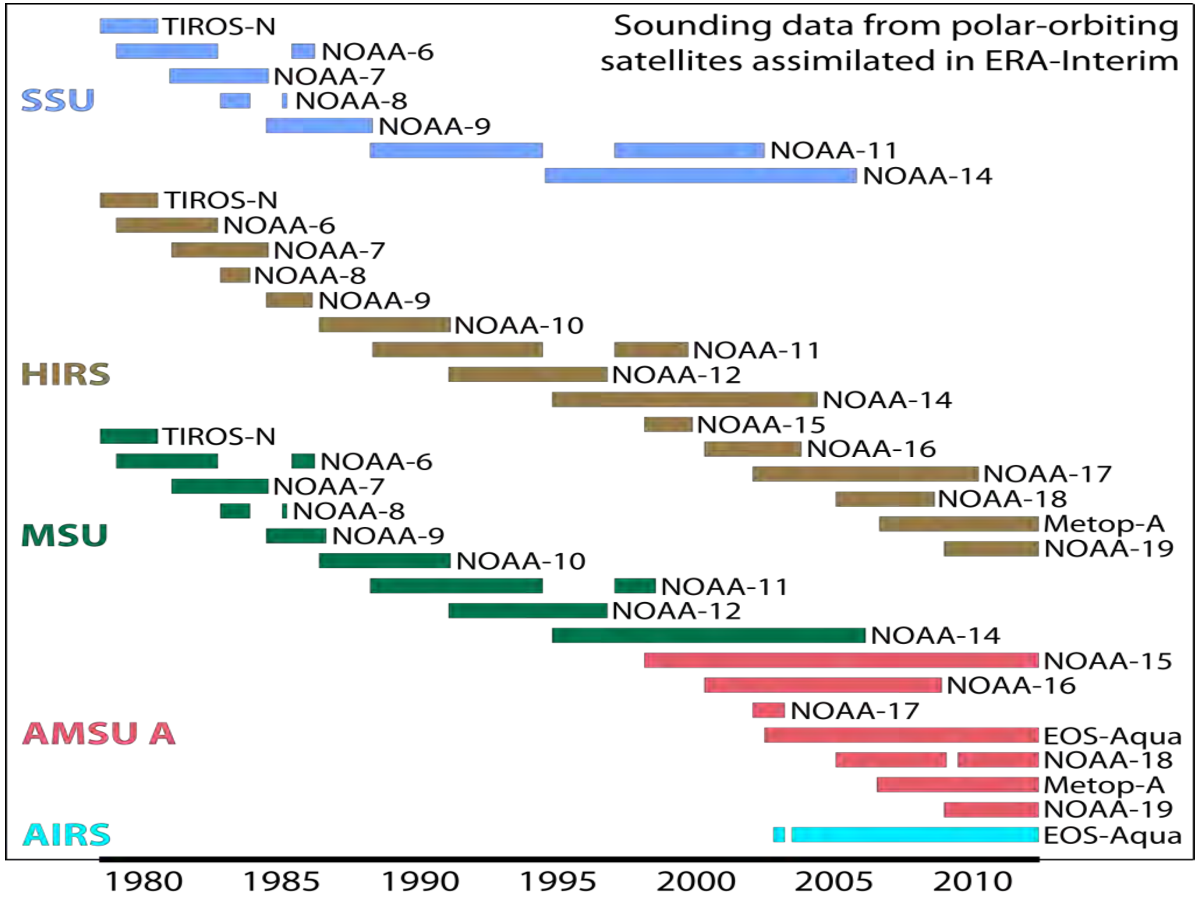
WGClimate CEOS CGMS

ECV Inventory: The Architecture for Climate Monitoring from Space in Action

Evolution of the observing system – Assessment in 2015



Examples of *in situ* data numbers assimilated by ERA-Interim

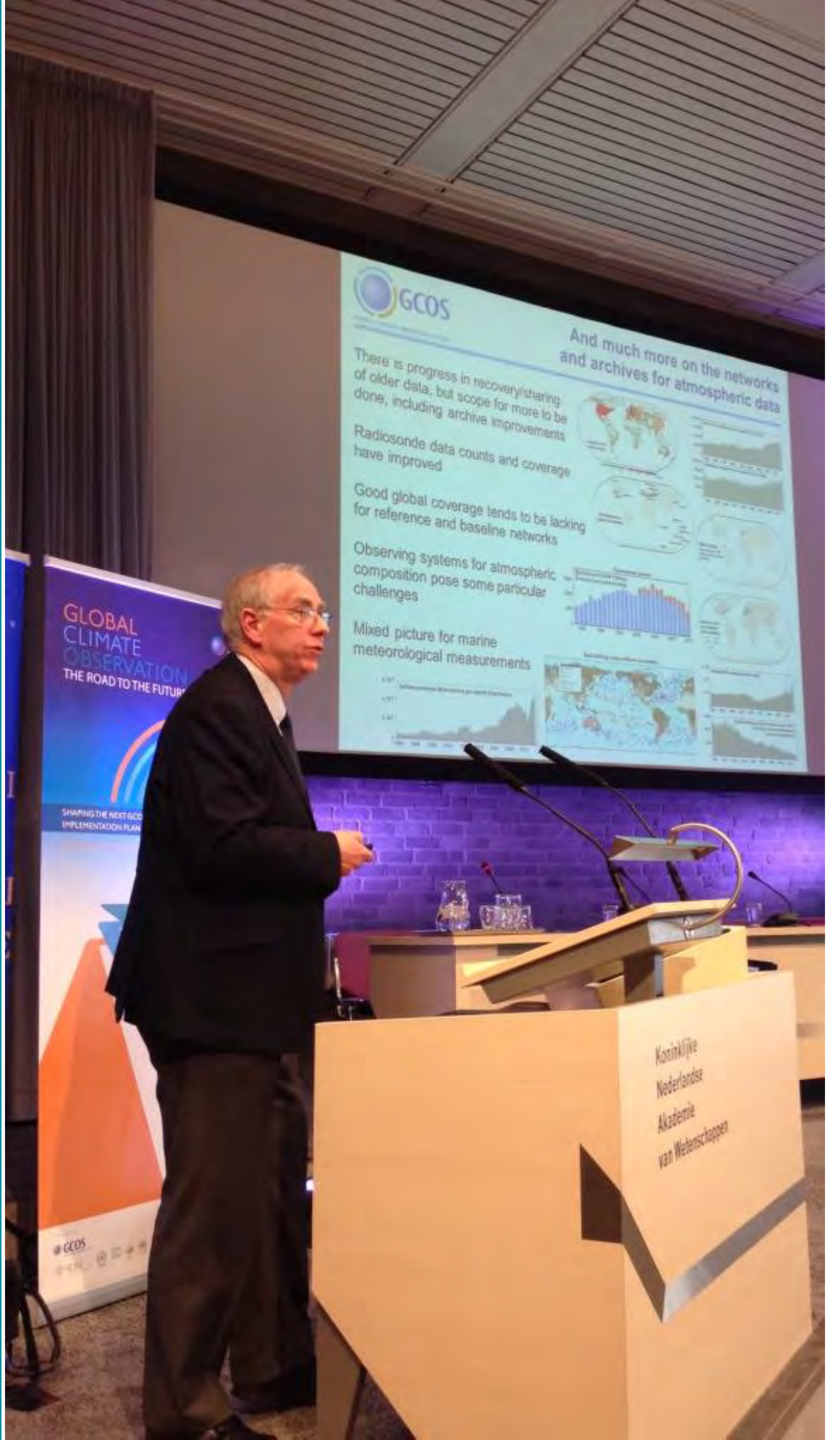


Data from IASI and NPP could not be used in 2006 version of assimilation system frozen for ERA-Interim. Use of data from Metop-B was not activated in 2012

Data from FY-3 are a candidate for use in future reanalyses

Coverage is for SSU-1, HIRS-2, MSU-4, AMSU-A10, AIRS-40

Source: A. Simmons



Some continuing concerns, including

- deterioration of some *in situ* networks; lack of progress in filling gaps in others
- limited provision for limb sounding and reference measurement from space

but many improvements (that need sustaining) including

- quantity and quality of data from several *in situ* sources, including radiosondes
- quantity, quality and variety of data from satellites
- recovery and reprocessing of past data, both *in situ* and remotely sensed
- reanalysis, with coupling of atmosphere to ocean and land, and inclusion of chemistry
- conventional analysis of instrumental records
- converging temperature information from various observational and model datasets

and evolving requirements

- e.g. for global, ground-based, soil-moisture data to complement remote sensing and reanalysis

Source:Status Report 2015, A. Simmons

Strategy

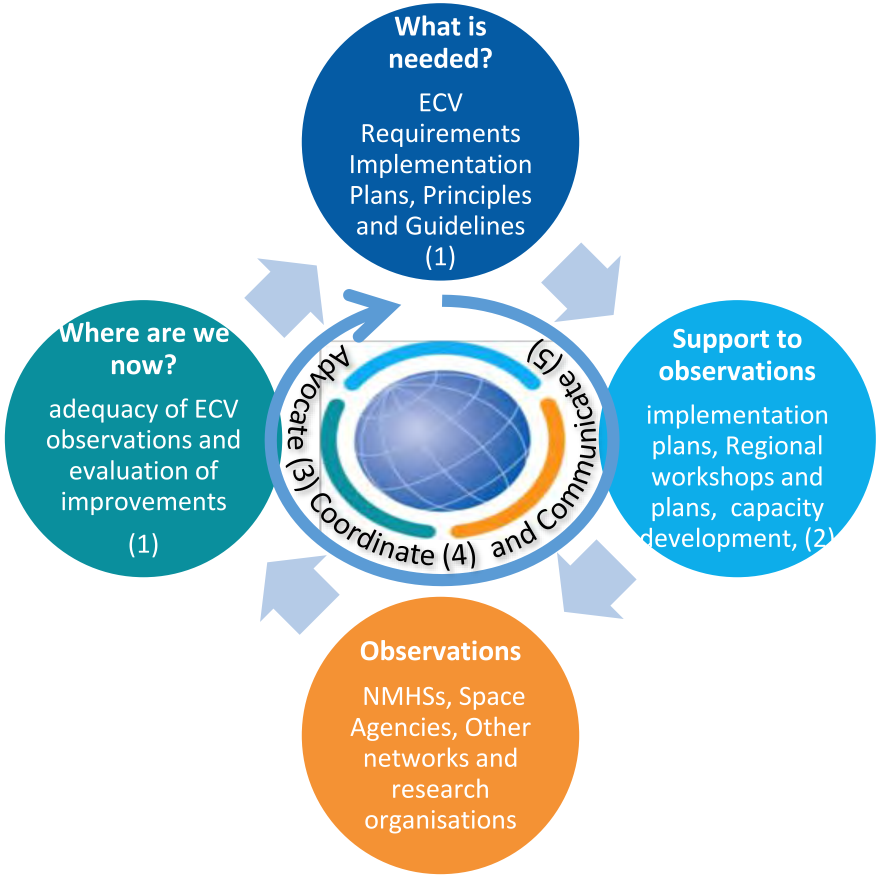
The new GCOS Strategy is being considered by the partners before its final adoption.

Strategy: Advocate - Coordinate - Communicate

Vision	***a world where users have free access to the climate-related information they need***
Aim	***to ensure the availability and quality of observations necessary to monitor, understand and predict the global climate system so that communities and nations can live successfully with climate variability and change***

Networks contributing to global climate observations should be:

- Free and Open
- Transparent
- Accurate
- Useful
- Timely
- Use best available science

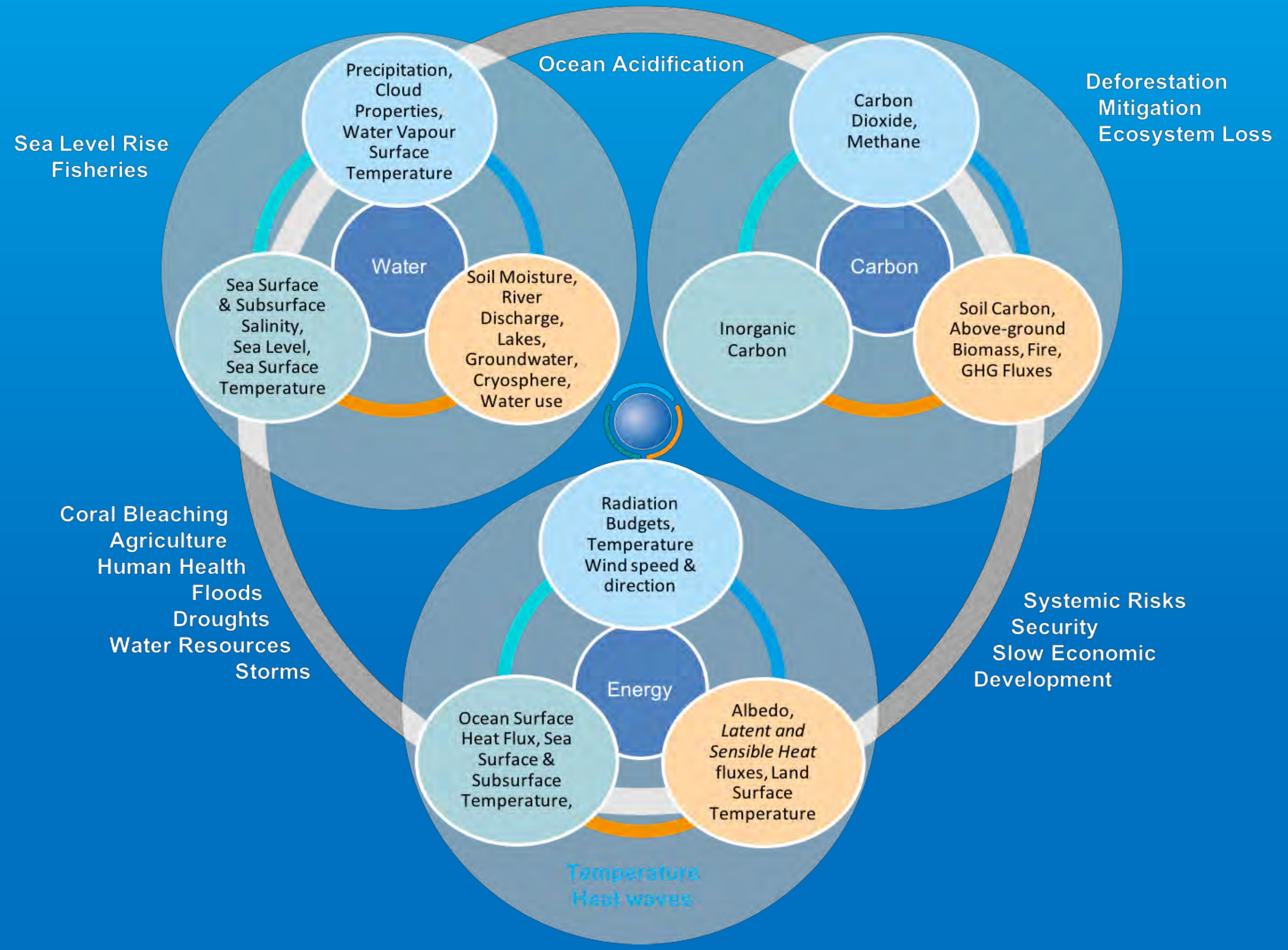


GCOS Sponsors:

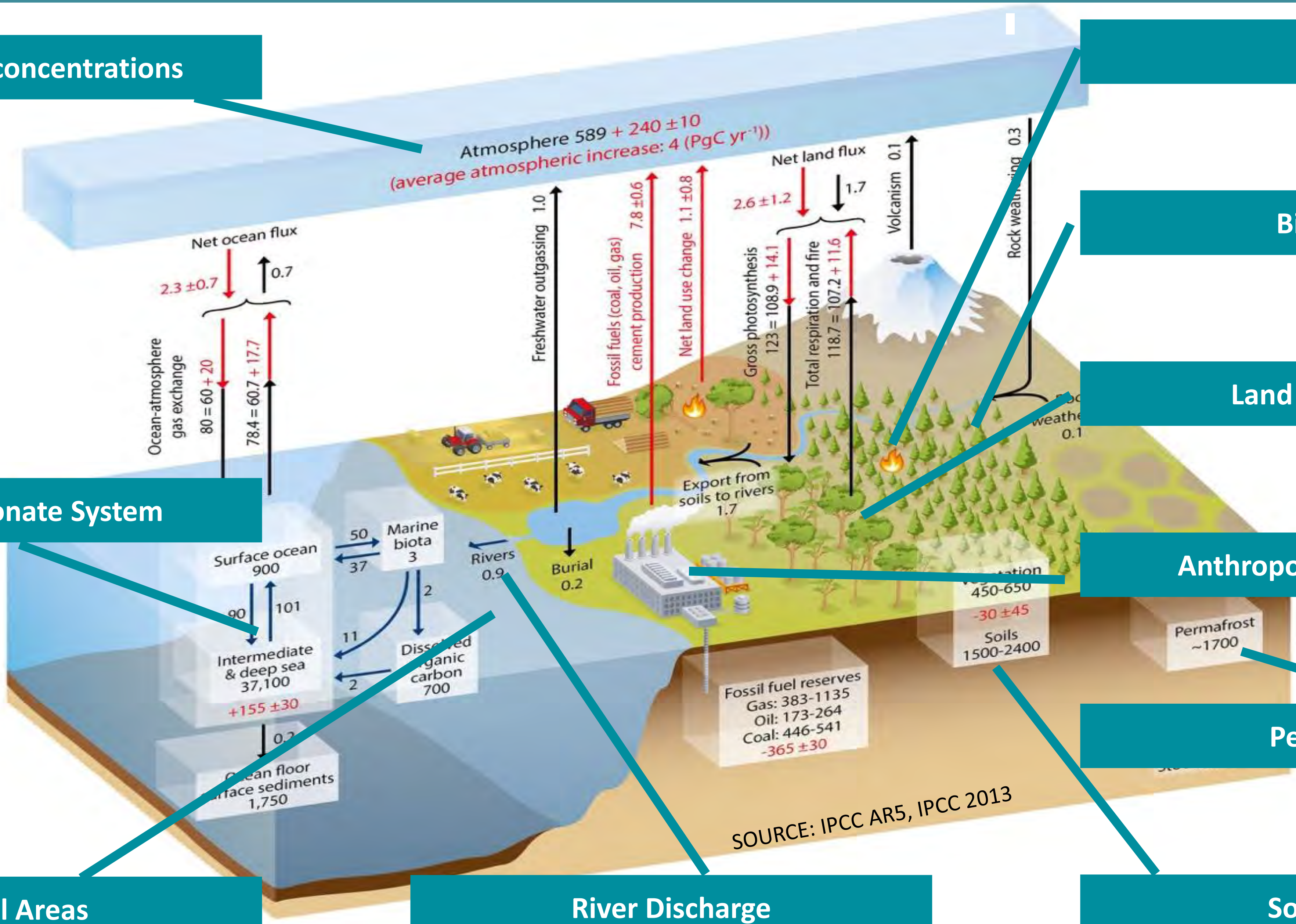
- The GCOS implementation plan has an aim to improve the monitoring of the 3 climate cycles
- For carbon the target is to quantify
  - fluxes of Carbon related gases to ± 10%
  - Changes in stocks of carbon to ± 10% on decadal scales on land and in the oceans
  - Changes in atmospheric annually carbon stocks to ± 2.5%

GCOS has many ECV related to the carbon cycle, the main ones are:

- Ocean Inorganic Carbon
- Atmospheric composition of CO_2 and CH_4
- Greenhouse Gas Fluxes
- Soil Carbon, Aboveground biomass, Permafrost



Improving observations of the Global Carbon Cycle



- Atmospheric concentrations
- Fire
- Biosphere
- Land Use Change
- Ocean Carbonate System
- Anthropogenic Emissions
- Permafrost
- Coastal Areas
- River Discharge
- Soil Carbon

new GCOS Implementation Plan aims to improve monitoring of Global Climate Cycles

- **Carbon Budget**
  - Quantify fluxes of carbon-related greenhouse gases to +/- 10% on annual timescales
  - Quantify changes in carbon stocks to +/- 10% on decadal timescales in the ocean and on land, and to +/- 2.5 % in the atmosphere on annual timescales
- **Global Water Cycle**
  - Close water cycle globally within 5% on annual timescales
- **Global Energy Balance**
  - Balance energy budget to within 0.1 Wm^{-2} on annual timescales
- **Explain changing conditions of the biosphere**
  - Measured ECVs that are accurate enough to explain changes of the biosphere (for example, species composition, biodiversity, etc.)

Indicators

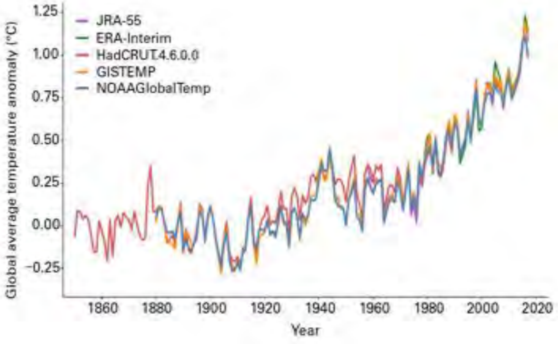
Part of the Communication Strategy.

For describing the rate and range of climate changes, and also becoming an input into the UNFCCC

Climate Indicators

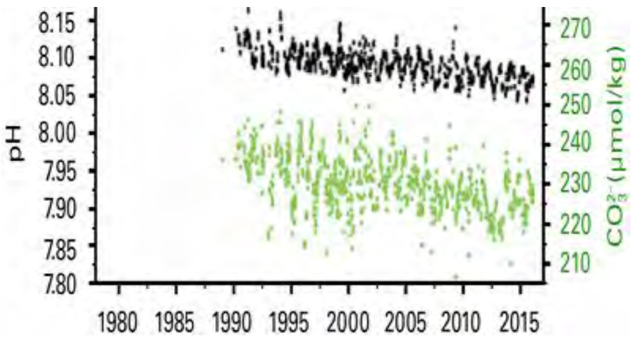
	Temperature and Energy	Atmospheric Composition	Ocean / Water	Cryosphere	Biosphere
Global Indicators	Surface Temperature Ocean Heat	Atmospheric CO_2	Ocean Acidification Sea Level	Glacier Mass Balance Arctic and Antarctic Sea Ice	
Indicators under development	Heat Waves		Heavy Precipitation Droughts		Ecosystem change
Supplementary Indicators	Top of atmosphere energy balance	Methane N_2O Halocarbon GHG		Snow extent	

Mean Temperature



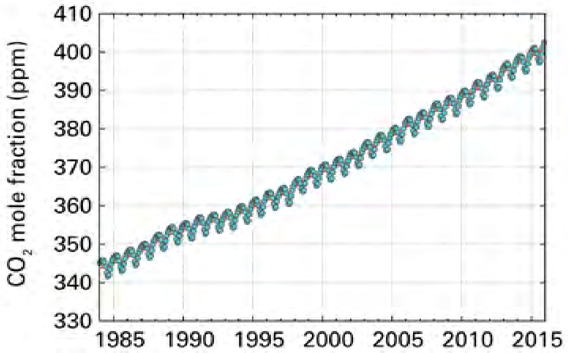
Global mean temperature anomalies, with respect to the 1850–1900 baseline, for the five global datasets (Source: UK Met Office Hadley Centre)

Ocean Acidity



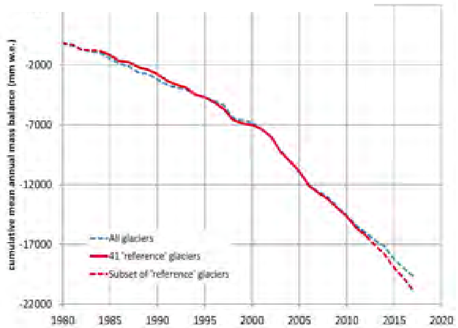
Trends in surface (< 50 m) ocean carbonate chemistry calculated from observations obtained at the Hawaii Ocean Timeseries (HOT) Program in the North Pacific over 1988–2015. Seawater pH (black points, primary y-axis) and carbonate ion concentration (green points, secondary y-axis). Ocean chemistry data were obtained from the Hawaii Ocean Timeseries Data Organization & Graphical System (HOT-DOGS). (Source: US National Oceanic and Atmospheric Administration (NOAA), Jewett and Romanou, 2017)

Atmospheric CO_2



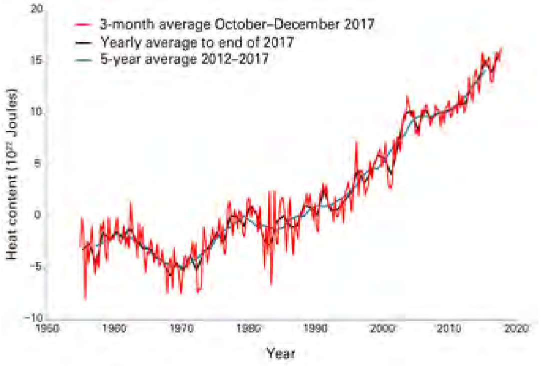
Globally averaged mole fraction (measure of concentration), from1984 to 2016, of CO2 in
parts per million (left), CH4 in parts per billion (middle) and N2O in parts per billion (right). The red line is the monthly mean mole fraction with the seasonal variations removed; the blue dots and line depict the monthly averages. (Source: WMO Global Atmosphere Watch)

Glacier Mass Balance



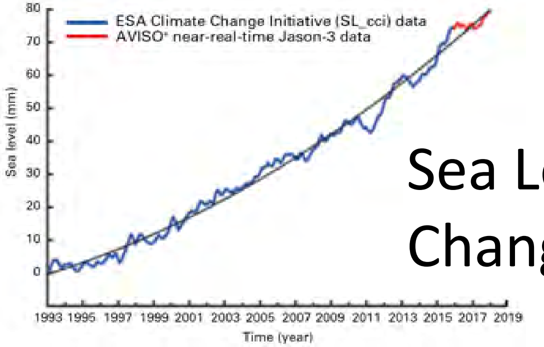
Mean cumulative mass balance of all reported glaciers (blue line) and the reference glaciers (red line). SOURCE: **world glacier monitoring service** http://wgms.ch/

Ocean Heat Content



Global ocean heat content change (x 1022 J) for the 0–700 metre layer: three-monthly means (red), and annual (black) and 5-year (blue) running means, from the US National Oceanic and Atmospheric Administration (NOAA) dataset. (Source: prepared by WMO using data from NOAA National Centers for Environmental Information)

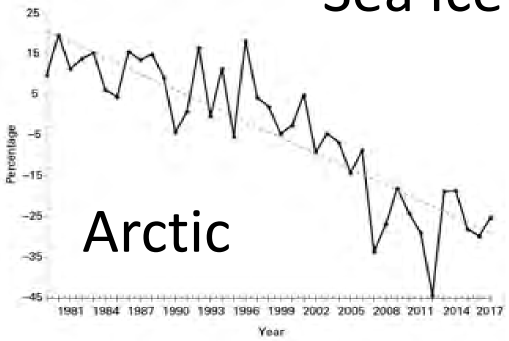
Sea Level Change



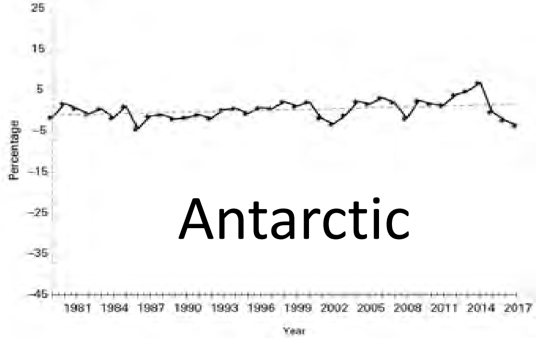
Global mean sea-level time series (with seasonal cycle removed), January 1993–January 2018, from satellite altimetry multi-missions. Data from AVISO
(Source: Collecte- Localisation-Satellite (CLS) – Laboratoire d'Etudes en Géophysique et Océanographie Spatiales (LEGOS))

Sea Ice Extent

Arctic



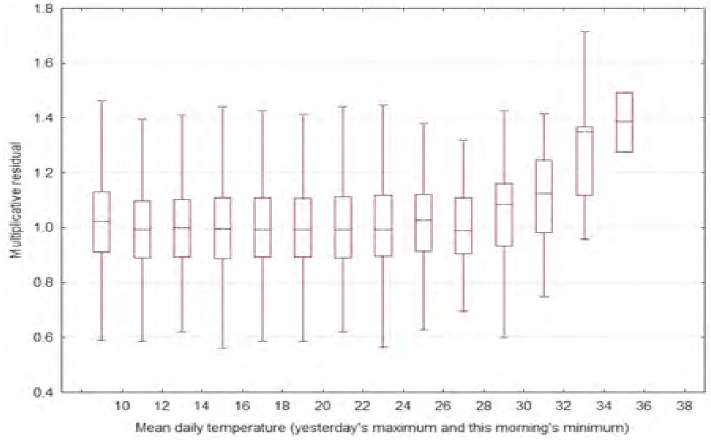
Antarctic



September sea-ice extent for the Arctic, and (right) September sea-ice extent for the Antarctic. Percentage of long-term average of the reference period 1981–2010 (Source: prepared by WMO using data from the US National Snow and Ice Data Center)

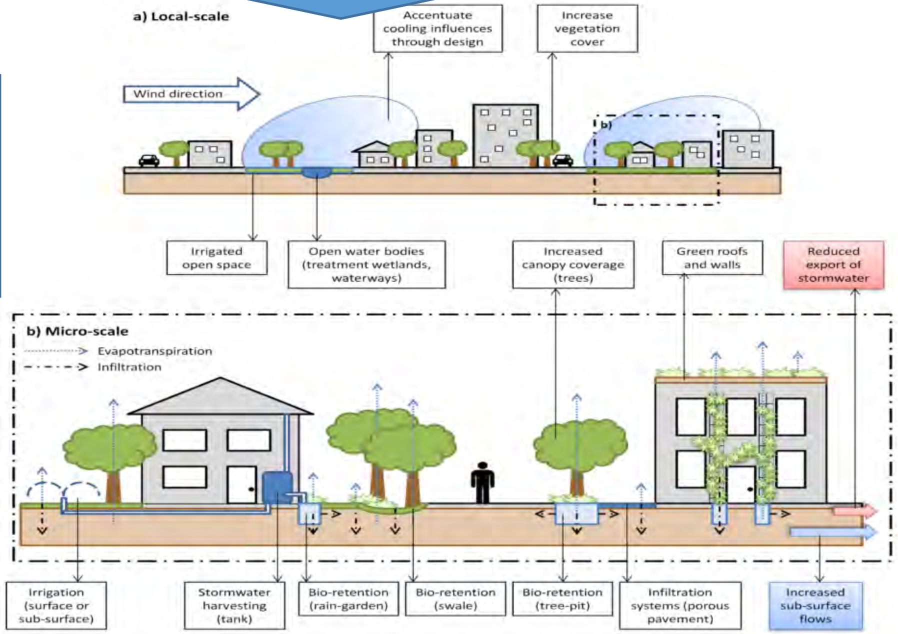
Example of potential remote sensing of implementation of adaption actions

Adelaide. SOURCE: modified Copernicus Sentinel data (2017), processed by ESA, CC BY-SA 3.0 IGO



Expected Mortality leads to Actions to cool Cities

Overall impact of these actions can be monitored remotely



GCOS Task Team on Adaptation, Terrestrial Observation Panel for Climate, Nigel Tapper, 2018.


EVEN THE SMALLEST PIXEL IS TOO LARGE
NEED FOR HIGHER SPATIAL AND TEMPORAL RESOLUTION

Adapting to a changing climate – what observations are needed ?

“Virtually all observations support adaptation.”

“We must model what we cannot measure (or predict with global systems).”

Adrian Simmons, Workshop on Observations for Adaptation, DWD, Offenbach, Feb 2013

Presentation: “The Global Climate Observing System: Observations and products from global to local”

- Benefit for climate observing systems, particularly in Africa but also in remote locations (Galapagos, Cook Islands, Maldives).
- Limitations due to resources available, and direct funding to the GCM trust fund has decreased significantly in recent years.

GCOS Cooperation Mechanism

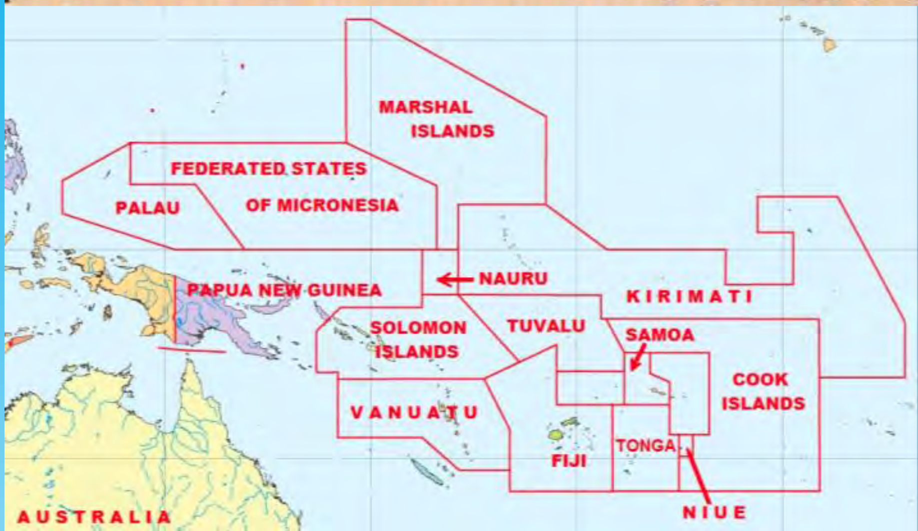
- Africa remains by a long way the worse performing WMO Region according to the monitoring of the GCOS surface and upper-air networks (GSN & GUAN). Current requests for support from many National Services, totaling more than 1 million US$.
- Sustainable solutions are always the focus of GCM projects but this is reliant on the ongoing commitment from the National Service as continual funding is not possible. But technical support is.

MORE REAL ACTIONS:

First Regional workshop - Pacific Island States

- Held jointly with the WMO Integrated Global Observing System (WIGOS) and hosted by the Fiji Meteorological Office and supported by The Secretariat of the Pacific Region Environment Programme (SPREP)

- **Systematic upper air observations, lead to global benefits**, underpinning forecasting and climate reanalyses which form the basis of much of our understanding of climate and climate change;
- These observations in the Pacific region have the **highest impact, of all ground-based measurements**, on the global quality of weather and climate analysis and prediction.
- Both the spatial density and observing frequency currently fall short of GCOS and WMO requirements and a beyond the resources of SIDS.
- **These observations are a global good and therefore the upper air network over the South Pacific needs sustained international support.**
- National precipitation observations and often insufficient and unrepresentative
- Communications are a major regional issue
- The workshop developed an outline for a ***Pacific region observing network plan*** which will be presented to COP 24



Review ocean observation system

Tracking heat and freshwater content changes in the ocean essential for closing global energy and water budgets.

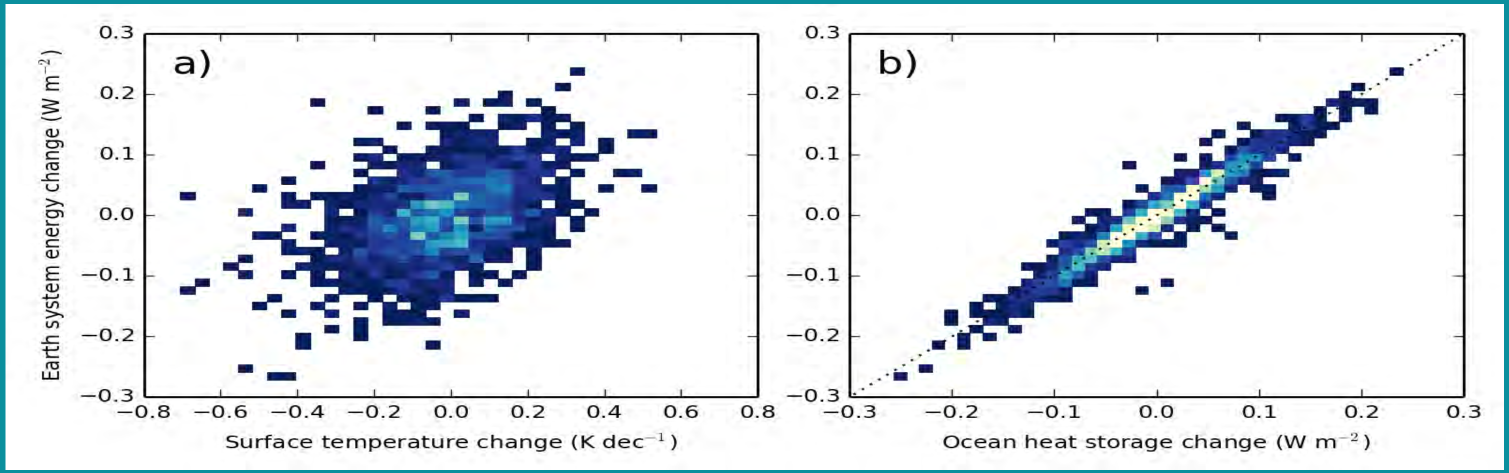
A review is currently being planned by OOPC to evaluate whether the observing system can meet requirements.

Ocean Heat Content:

- Aim: Resolve annual cycle in heat content, at basin scale (level of uncertainty?)

Freshwater content

- Aim: Annual estimates. Challenges particularly in high latitudes re. Ice changes, River discharge.

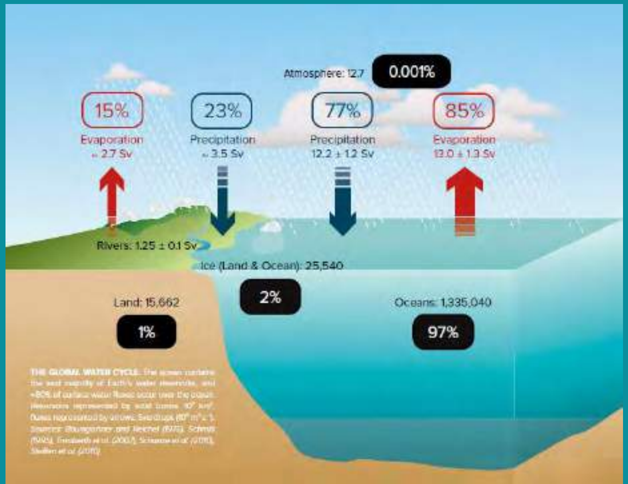


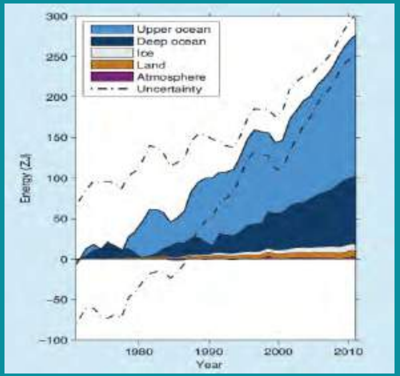
Surface temperature is a weak indicator of Earth's energy imbalance on decadal timescales

Ocean heat content change is a reliable on Earth's energy imbalance on decadal timescales

Palmer and McNeall [2014]

von Schuckmann et al [2016]





IPCC WGI Ch 3 &13

Oceans absorbed >90% of the energy storage trapped in the atmosphere due to green house gas emissions.

Wide scale monitoring of lightning is possible and a proxy for severe weather: GCOS is laying the foundations for NEW global climate observations

Interest for climate applications:

- Indicator for trends of storminess under Climate Change
- Lightning produces NO_x and is therefore impacting the climate


GOES-R satellite , Lockheed Martin

Handheld lightning detector from Boltek

Establishing global weather radar climate records

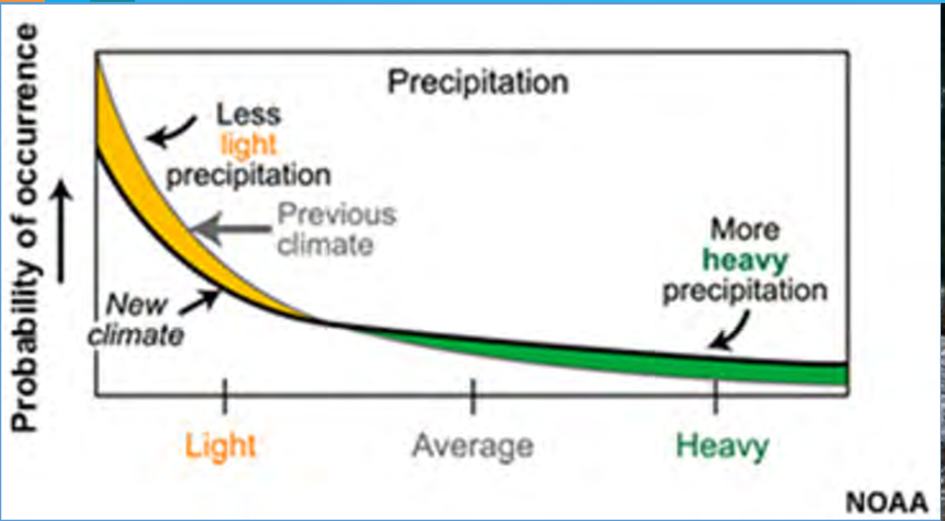
Changing extremes of precipitation are a major concern in a changing climate – e.g. floods

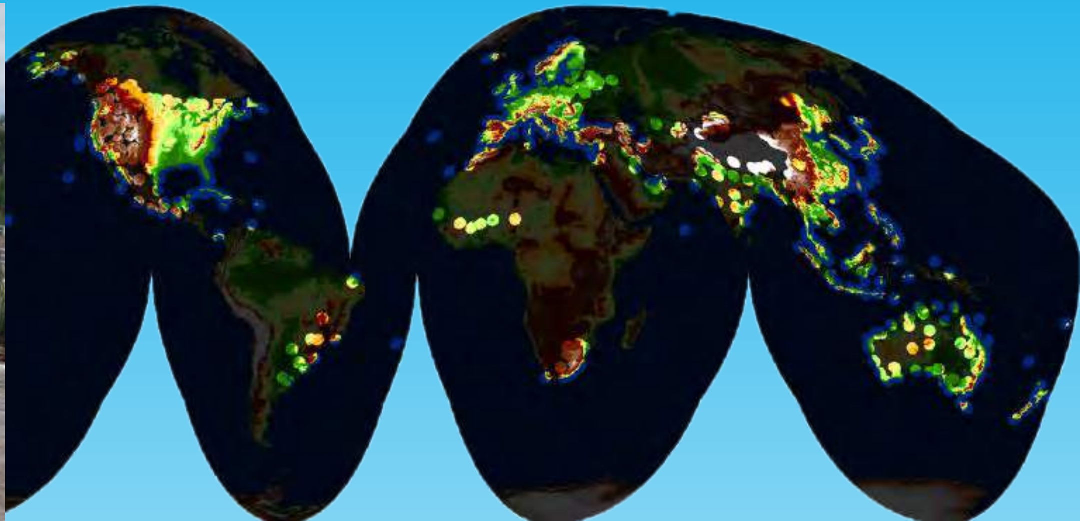
Observations need to have high spatial and temporal resolution;

Radar can provide this BUT while OK for weather uses they do not provide consistent long-term information;

NO global coverage, uniform method, data standards, continuity of observations, archive globally, or data exchange;

The GCOS Task Team on Climate Radar will develop a proposal for the framework for climate radar observations and data archiving.





A GCOS Surface Reference Network

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

- Aims
  - To achieve simultaneous high-quality observations of many ECVs
  - Provide reference data to constrain and calibrate more spatially comprehensive observing systems.
- A 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 sites from WMO GCW

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