Observations and data products for climate monitoring:

Assessing the status and requirements

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Scope of this presentation

The function and functioning of the GCOS programme

The cycle of assessing progress, status and requirements

Some general aspects of climate observation and product generation

Some examples of progress and issues

The new assessment cycle being undertaken by GCOS

The GCOS programme

GCOS was established in 1992

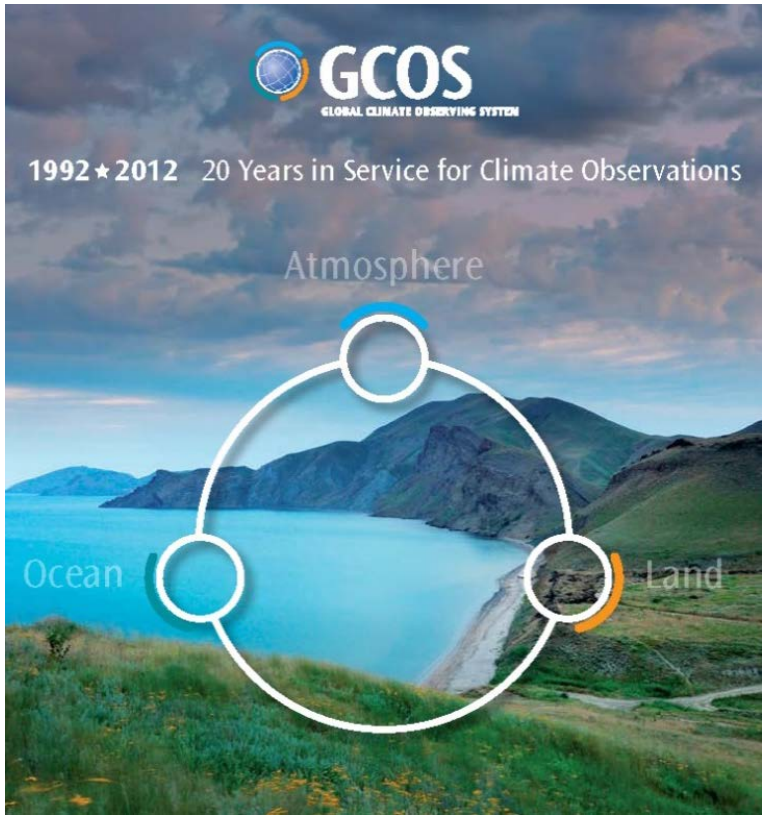
- as a co-sponsored programme of WMO, IOC, UNEP and ICSU
- to help ensure provision of observations and information on the full climate system: its physical, chemical and biological properties, for atmosphere, ocean and land

to meet the needs for

- monitoring, research and services

The programme functions through

- activities undertaken by nations and their international agencies
- a steering committee
- panels for atmosphere, ocean and land, co-sponsored by WCRP and others
- a secretariat



The GCOS programme

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- assesses and communicates overall requirements
- advises on and supports implementation, and reviews progress
- reports principally to its sponsors and by invitation to the parties to the UNFCCC

The GCOS programme and the ECVs

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Developed the concept of the Essential Climate Variables (ECVs)

- providing a long-term organisational basis for GCOS assessments
- providing a basis for national reporting under the UNFCCC
- providing a basis for responses from space agencies, EU programmes, …

Requirements were set out in 2004 Implementation Plan, revised in 2010

- expressed in terms of the actions needed, both cross-cutting and ECV by ECV
- supplemented by detail provided subsequently for products based on satellite data
- supplemented by general monitoring principles and product-generation guidelines

Organisational framework: The Essential Climate Variables (ECVs)

Atmospheric	**Surface:**	**Air temperature, wind speed and direction, water vapour, pressure, precipitation, surface radiation budget**
	Upper-air:	**Temperature, wind speed and direction, water vapour, cloud properties, earth radiation budget (including solar irradiance)**
	Composition:	**Carbon dioxide, methane, other long-lived greenhouse gases, ozone and aerosol, supported by their precursors**
Oceanic	**Surface:**	**Sea-surface temperature, sea-surface salinity, sea level, sea state, sea ice, surface current, ocean colour, carbon dioxide partial pressure, ocean acidity, phytoplankton**
	Sub-surface:	**Temperature, salinity, current, nutrients, carbon dioxide partial pressure, ocean acidity, oxygen, tracers**
Terrestrial		**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**

ECVs for which satellite observations make a significant *direct* contribution

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The cycle of improvement and assessment

Looking back - the 2003 GCOS Adequacy Report called for:

- space agencies to ensure that homogeneous climate data and integrated products are generated
- sustained, coordinated reanalysis activities to meet needs for monitoring climate, for extension to atmospheric composition and for establishment of ocean reanalysis

Looking forward - next steps for the GCOS programme:

- a report on progress and status of climate observation, scheduled for 2015
- a new implementation plan to identify the actions and products needed, scheduled for 2016

Interdependencies

Climate services are built on a range of products

- observational data and metadata
- data products such as provided by the CM-SAF and Climate Change Initiative
- data products from comprehensive reanalyses such as ERA-Interim and JRA-55
- monitoring, interpretation and attribution
- predictions and projections

Products of one type are commonly used in the generation or evaluation of other types of product

- including the evaluation of components such as the models that make projections
- providing itself some evaluation of the product being used

Reanalysis is central in this

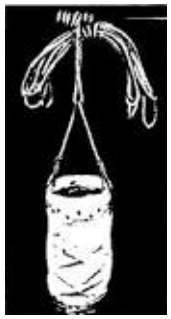
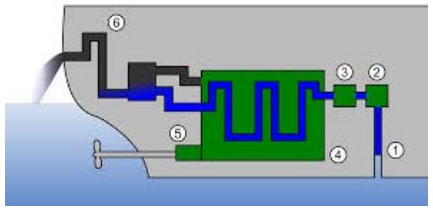
- using observational data and metadata, and data products for variables that have to be specified in its production system
- providing outputs that support the range of product and service lines

Estimating global surface temperature



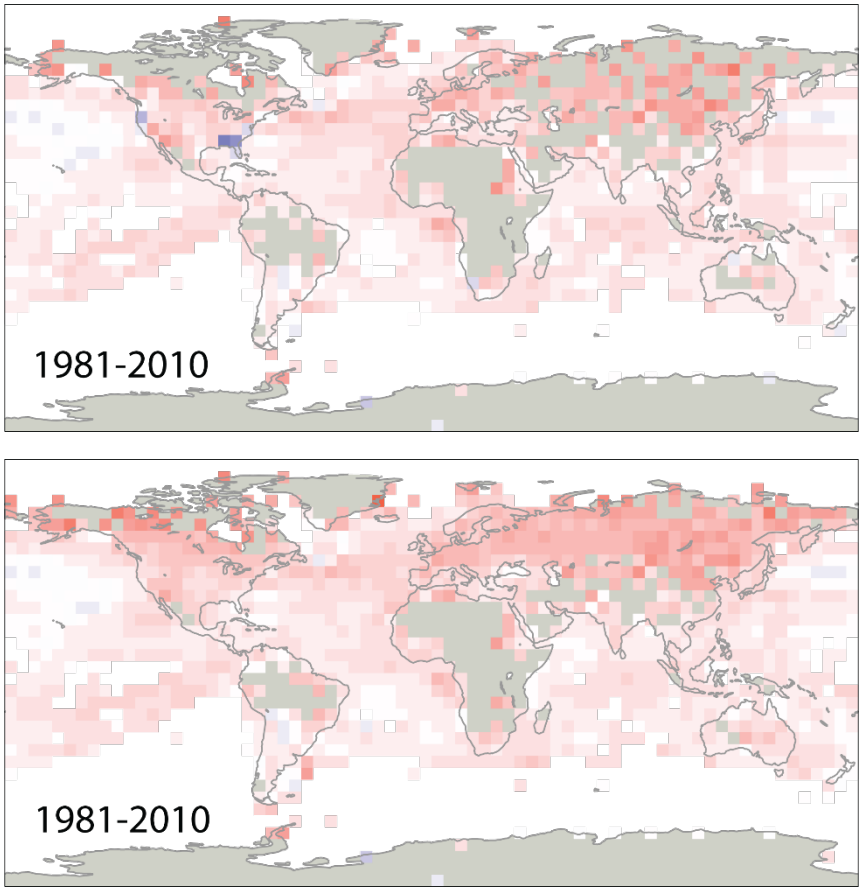




Credits: DWD, Met Office, NOAA, Thigpen, WHOI, Wikipedia

HadCRUT3 (Brohan *et al*., 2006)



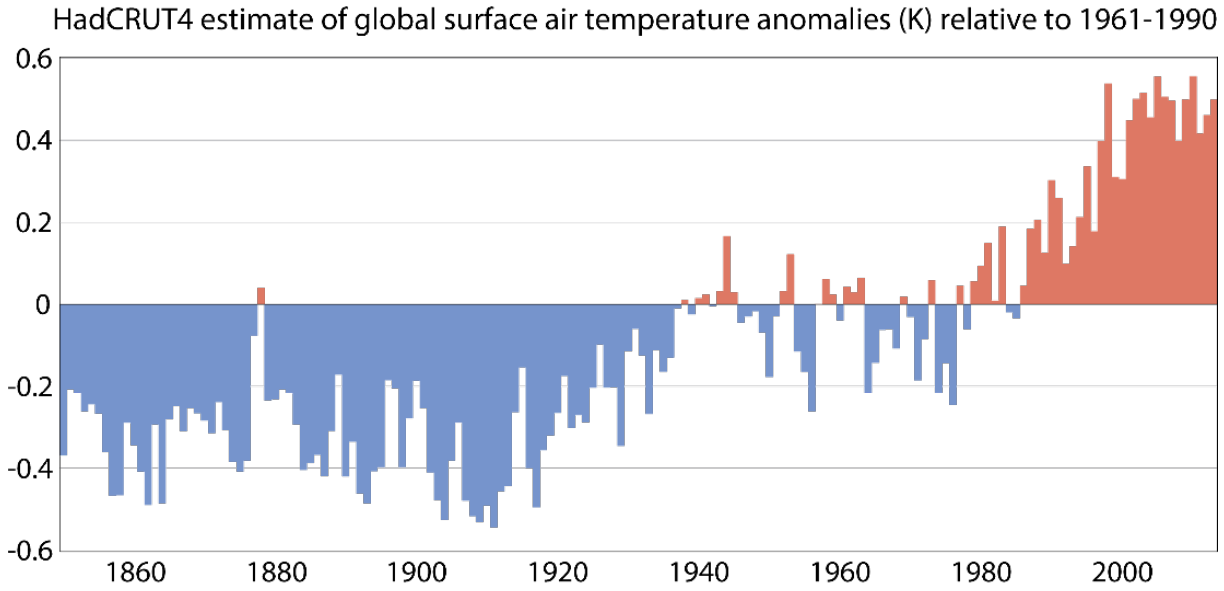
HadCRUT4 (Morice *et al*., 2012)

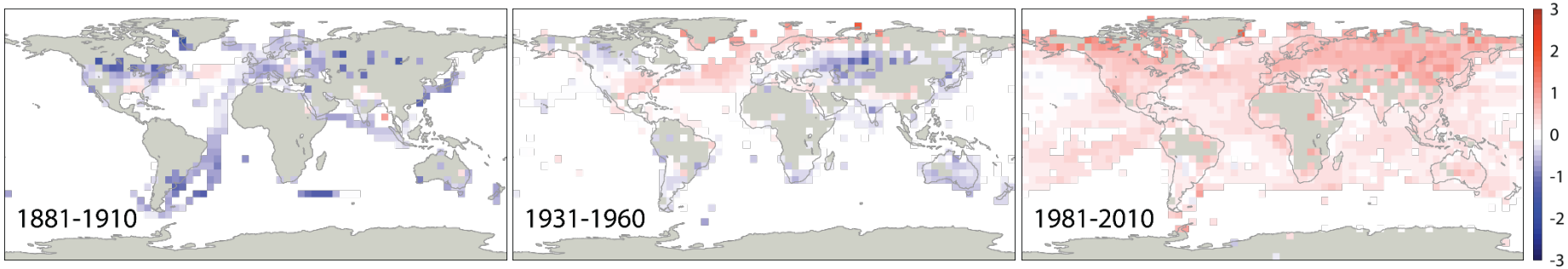
Anomaly relative to 1961 to 1990 is shown for grid boxes with no more than 12 months missing in 30 years

Changes in surface temperature – and in data coverage

HadCRUT4 provides values only for 5^{O} grid squares where there are observations

Global estimates are based on averages over these grid squares

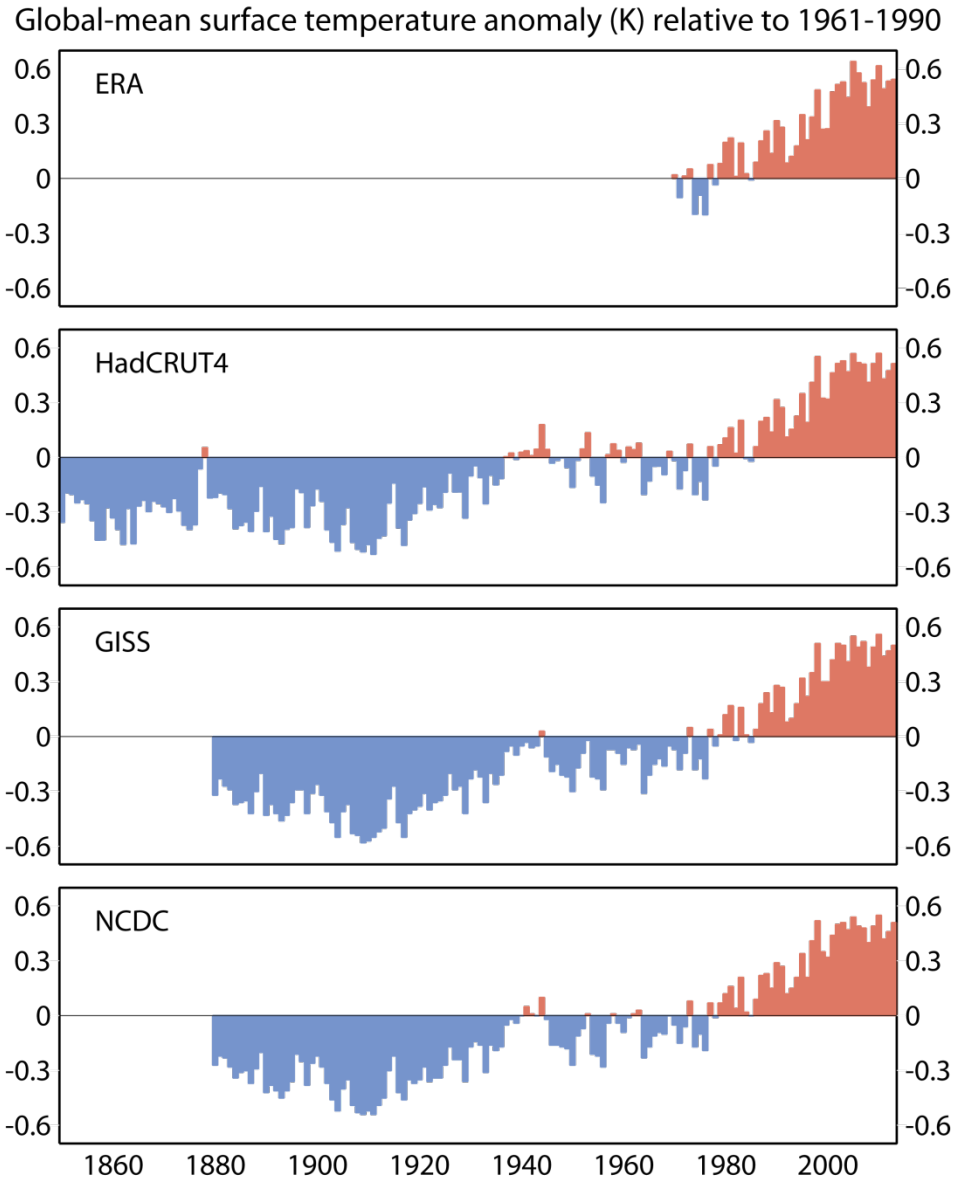




Anomaly relative to 1961-1990 is shown for grid boxes with no more than 12 months missing in 30 years

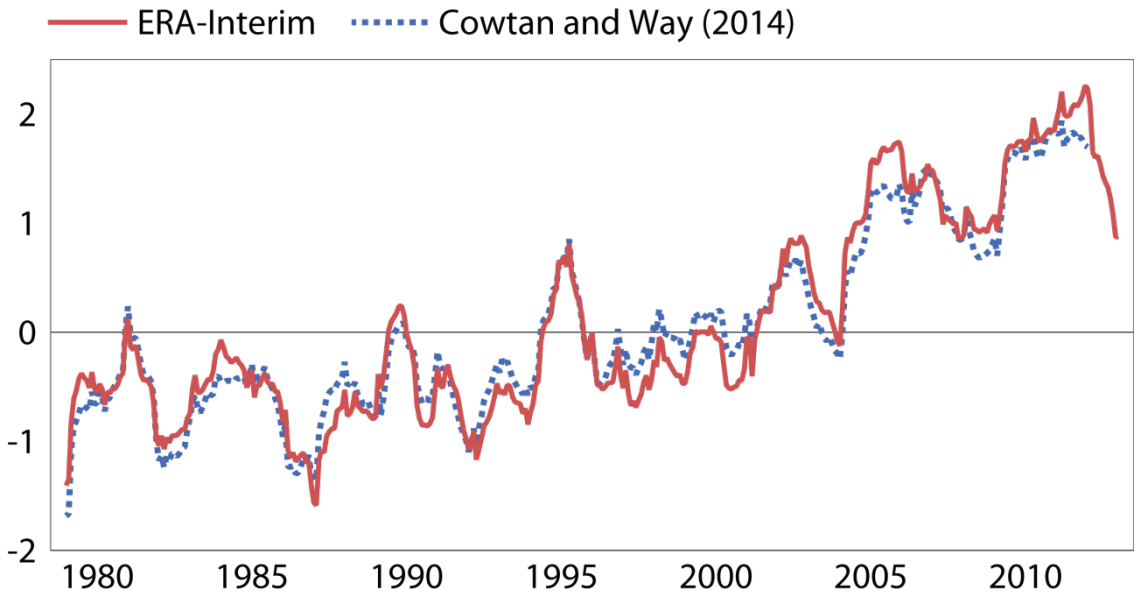
Estimates of change in global-mean surface temperature

- Estimates are based on combining analyses of:
  - surface air temperature over land and (for ERA) sea-ice
  - analyses of sea-surface temperature
- ERA values are from ERA-40 for 1970-1978 and ERA-Interim for 1979-2013
- ERA-Interim SSTs are adjusted by 0.1K from July 2001 for consistency with HadCRUT4 SSTs
- HadCRUT4 provides error estimates: the two-standard-deviation uncertainty is about 0.15K for 1850-1870 and about 0.08K from 1970 onwards



Addressing limited coverage of the high Arctic in the conventional products

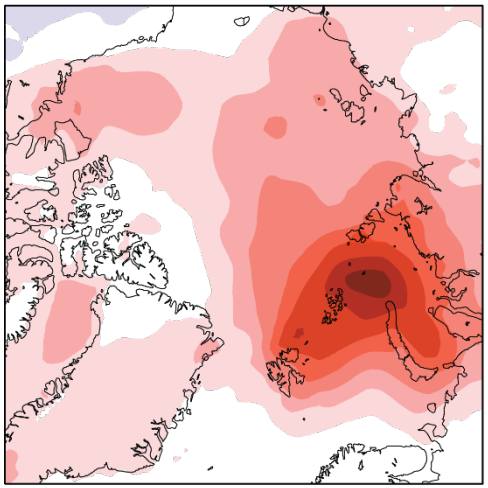
Surface air temperature anomaly (K) averaged from 70°N to 90°N



2012 surface air temperature anomaly

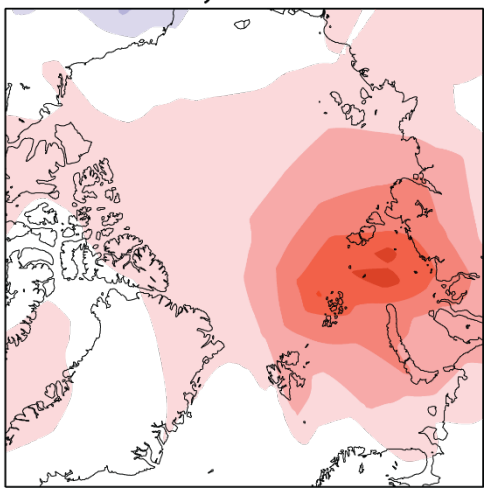
Contour interval: 1K

ERA-Interim



Cowtan and Way (2014) have gap-filled HadCRUT4 using optimal interpolation and the UAH MSU/AMSU lower tropospheric temperature product

Cowtan and Way



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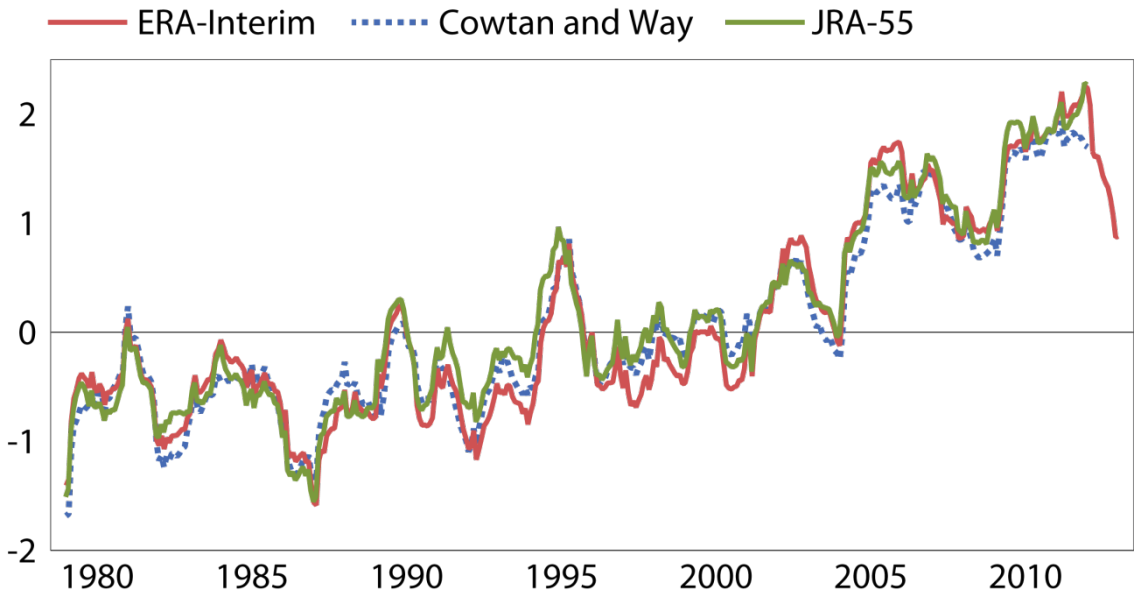

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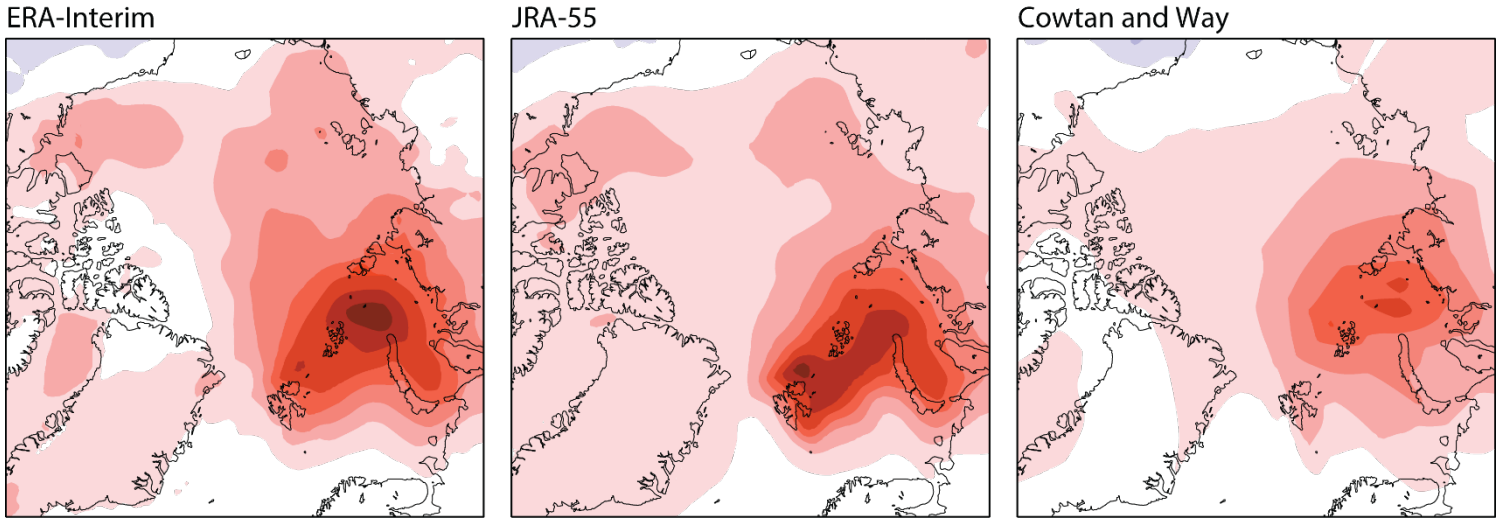
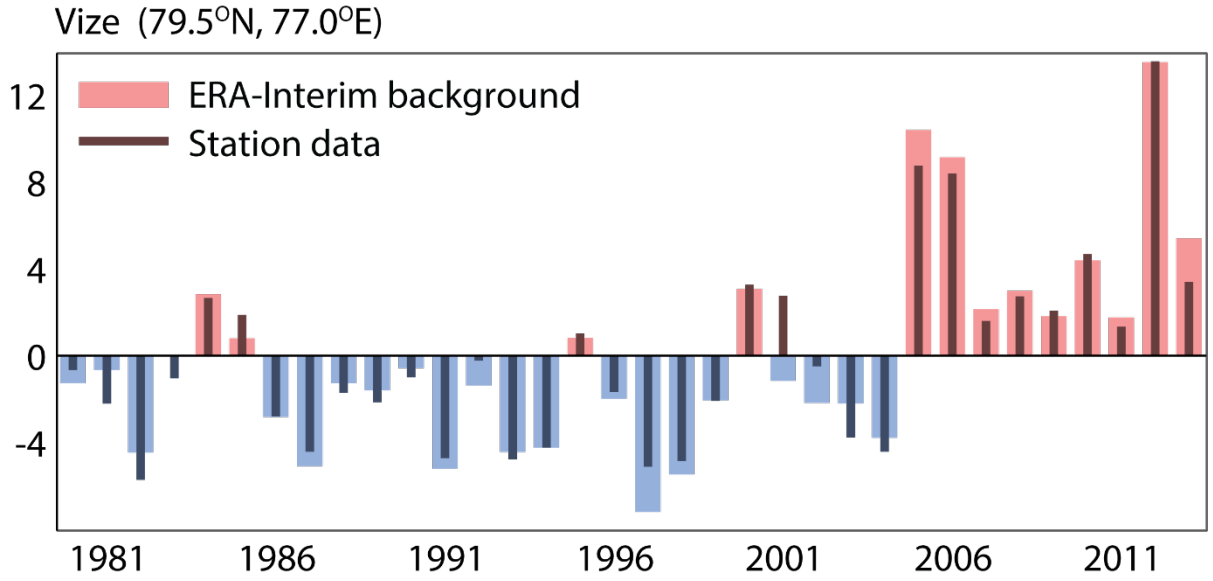


Addressing limited coverage of the high Arctic in the conventional products

Comparison of winter (DJF) anomalies at a high-latitude island station



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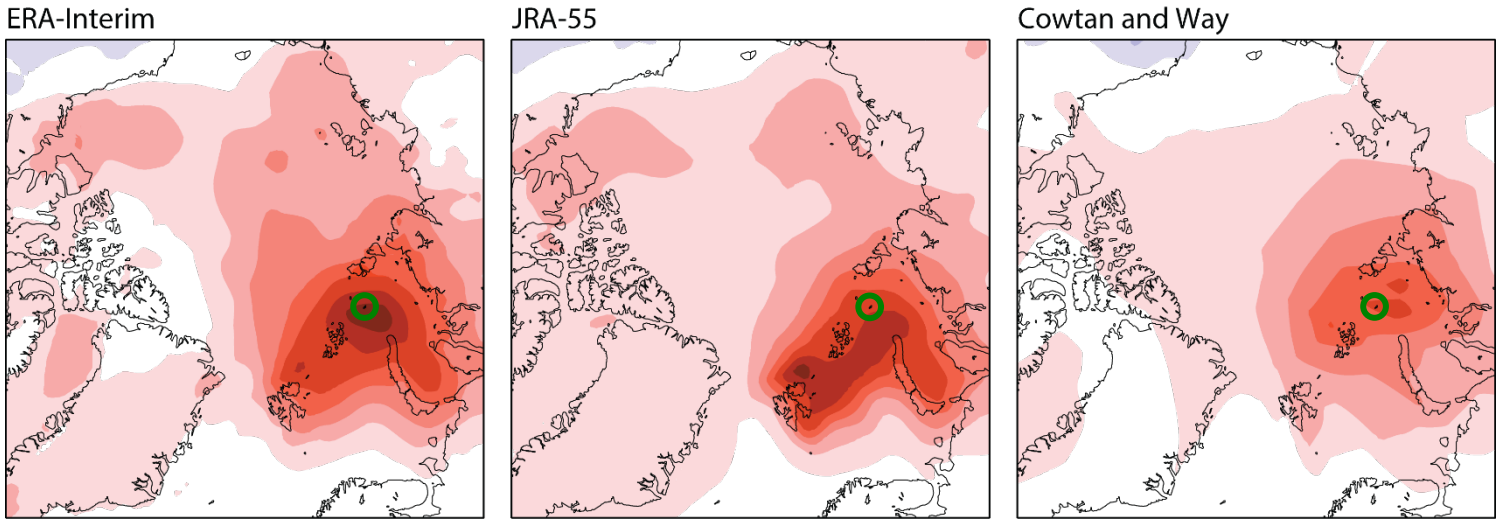
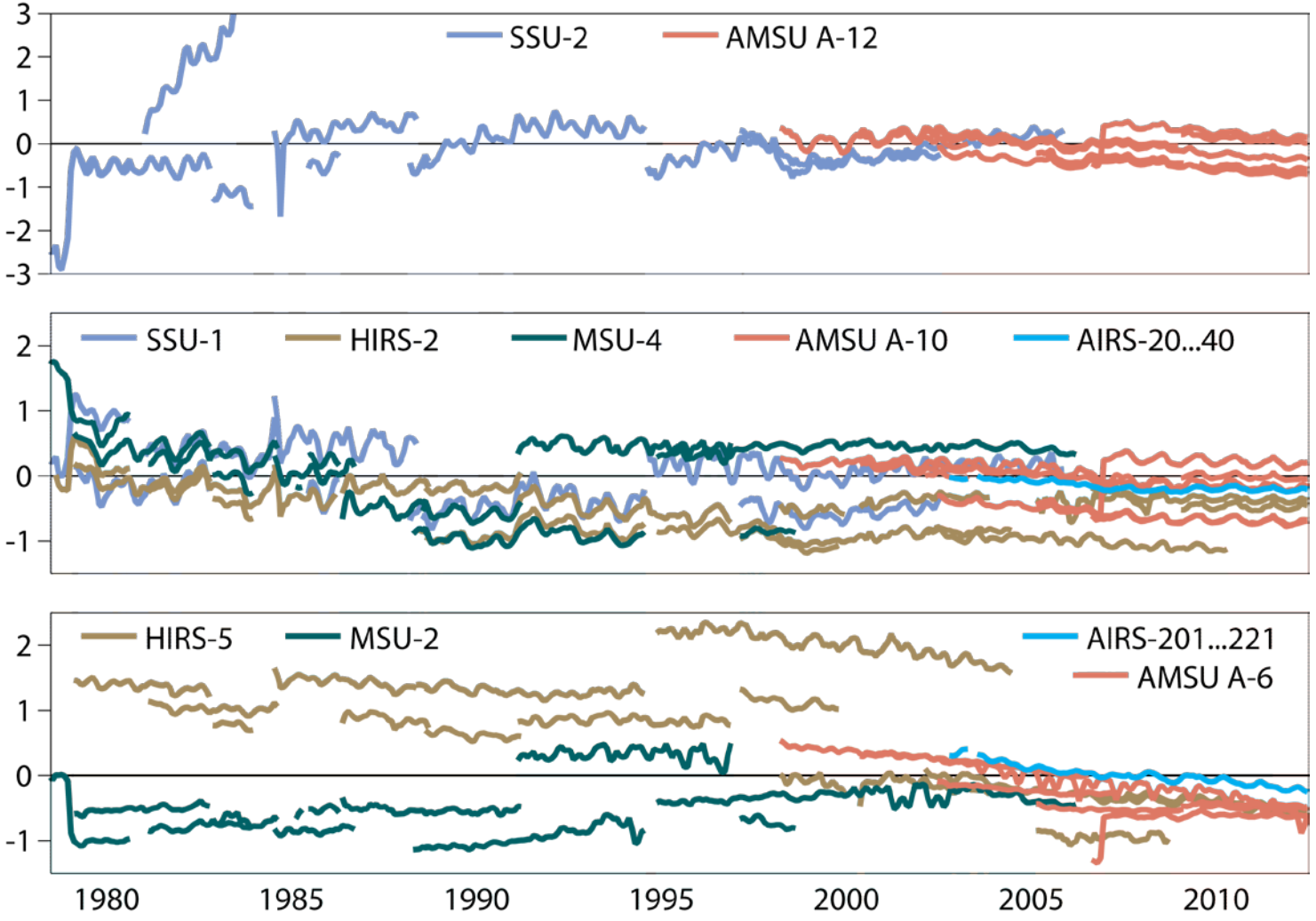


Bias estimates (K) for some sounding channels used in ERA-Interim



Analysis fits bias-adjusted radiances closely

Key for realism of analysed variability and trends is the reliability of the bias adjustments

Estimates of global-mean biases are shown for tropospheric and lower to middle stratospheric channels

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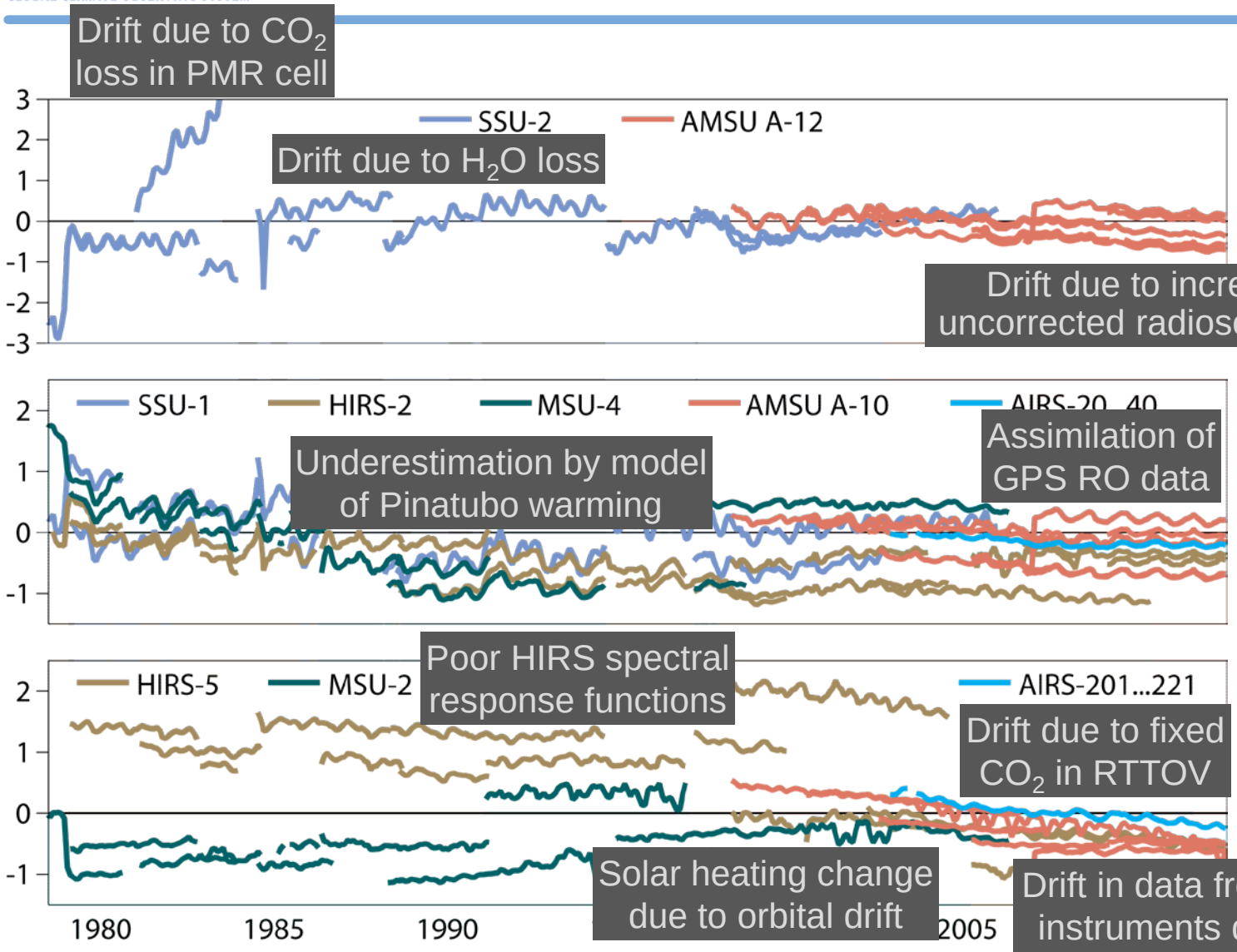

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Estimates of global-mean biases are shown for tropospheric and lower to

Kobayashi *et al*.(2009), Lu and Bell (2014),
Nash and Saunders (2013), Saunders *et al*.(2013), Simmons *et al*.(2014)

What are the “Fundamental Climate Data Records”?

To what extent should inter-satellite calibration be carried out for climate use of radiance records?

A reanalysis centre carrying out radiance assimilation requires:

- uniform calibration (or re-calibration) of records from individual satellites, adjusting for instrumental drifts only if they cannot be modelled
- metadata and modelling of instrument characteristics to enable mapping from assimilation-model values to what is actually measured
- software (RTTOV, …) that maps from model values to what is actually measured
- inter-calibration (through SNO technique) only to the extent that inter-satellite differences cannot be modelled or handled well by variational bias correction

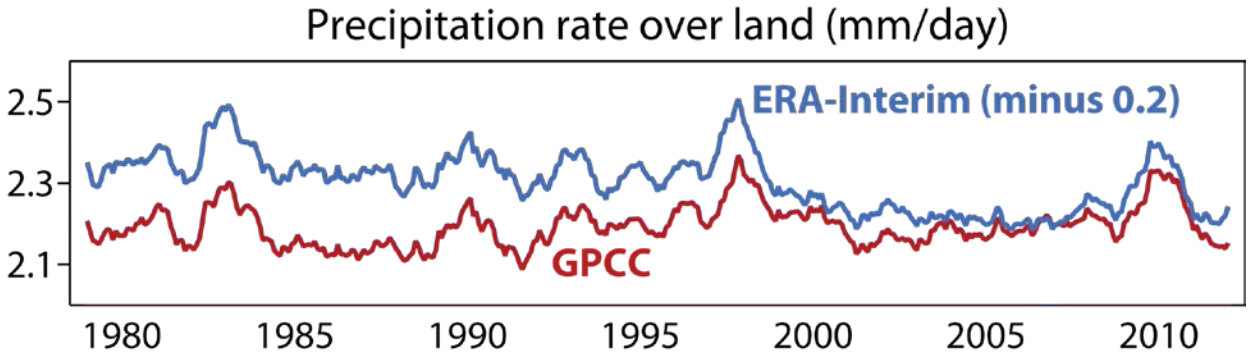
and progress is likely to be iterative

But other users have requirements for inter-calibrated radiances

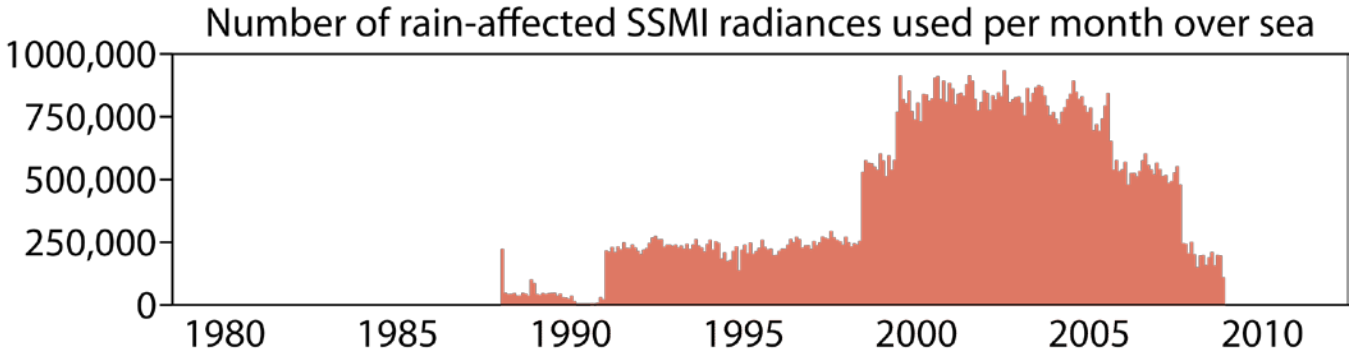
There is scope for comparison and feedback between various providers

Use of GPCC products to evaluate the ERA-Interim reanalysis

Average over all 1^{O} grid boxes for which Global Precipitation Climatology Centre at DWD has access to data from at least one station for all months



A change in source of SST analysis in 2001 also contributes to reducing rainfall by cooling the ocean by about 0.1K

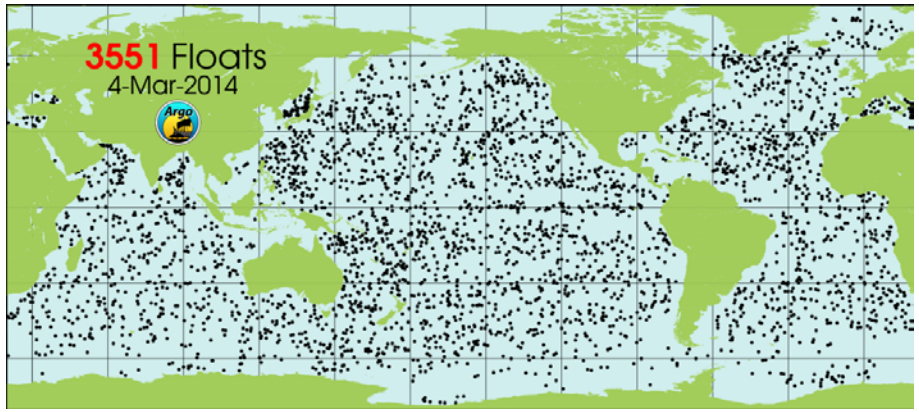


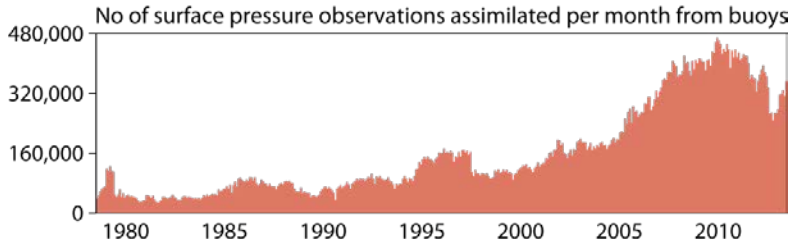
- ERA-Interim still has problems with lower tropospheric humidity and rainfall over sea
- Its replacement will be an improvement, but not the last word
- Handling of tropical upper tropospheric humidity is in better shape

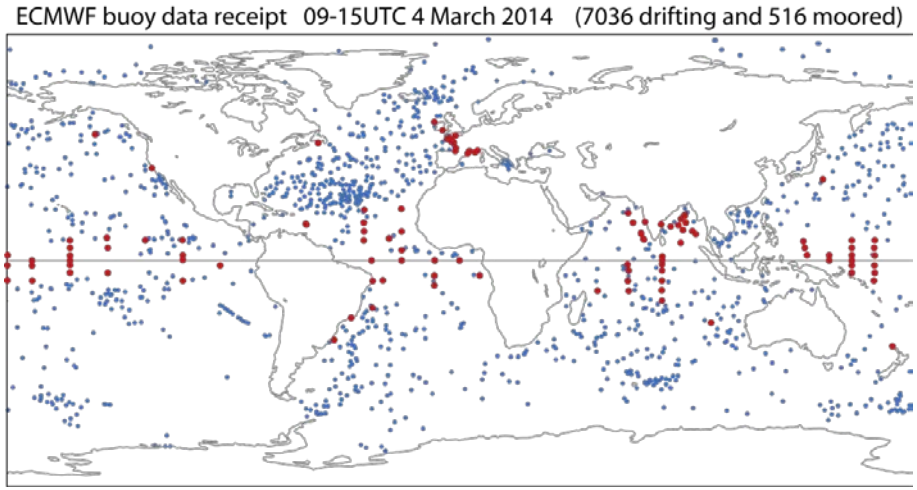
Progress and issues: examples for ocean observation

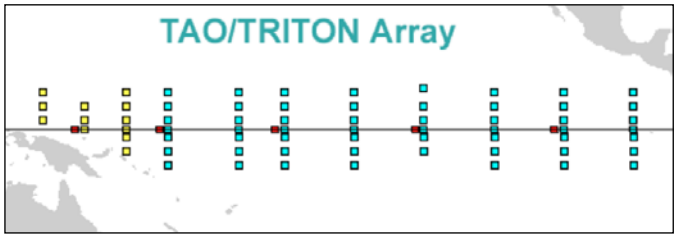
- Argo floats profiling the upper 2000m now number more than 3500
  - exceeding the initial target of about 3000
  - with prospect of coverage to greater depths

- Issues with buoy networks
  - tropical east Pacific moored array is suffering from lack of maintenance
  - this was considered at a recent workshop, which developed a proposal for a TPOS 2020 project
  - there has also been a recent decline in drifter numbers, with lower coverage of the North Pacific, but a sign of recovery

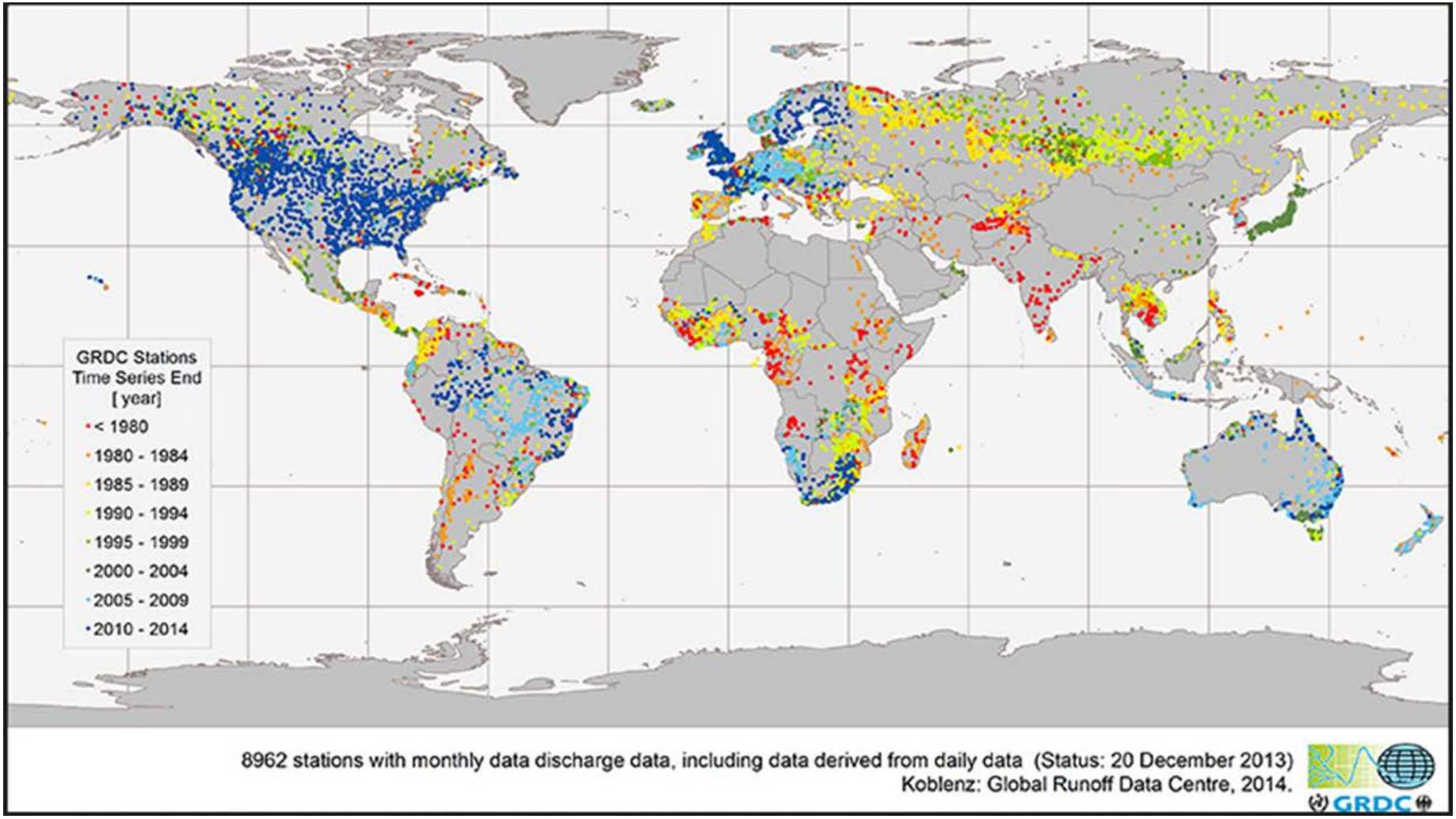








Progress and issues: an example for terrestrial observation



New Assessment Cycle

The GCOS programme has started the process for:

- **a 2015 report on the progress and status of climate observation**
- **a new Implementation Plan in 2016, which should identify:**
  - continuing and new requirements, including a restatement of the rationale for the list of ECVs and possible amendment of the list
  - the adequacy of present arrangements for meeting the requirements
  - the additional actions needed, with indicative costs, performance indicators and potential agents for implementation
- **and include statements of specific requirements for products**
  - from both the space-based component and *in situ* networks
  - and from integration of the data provided by both
  - either embedded in the main Plan or as separate supplement(s)

Inputs to the new assessments

Content will be based on various inputs, including from:

- 2011 WCRP Conference and 2013 SPARC Data Requirements Workshop
- 2013/2014 Fifth Assessment Report of the IPCC
- 2013/2014 national reporting to UNFCCC on systematic observation
- GCOS workshops on observations for adaptation (2013) and mitigation (2014)
- 2014 EUMETSAT/WCRP Climate Symposium
- 2014 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/WCRP panels and dedicated workshops
- an open review

Final remarks

This CM-SAF workshop will provide a further source of input

- to the assessment of progress and status
- to the review of requirements

There will be much positive to report

- on the performance and planning of much of the observing system
- on the development of data products and what has been learnt from them

But concerns also

- over several networks for *in situ* observation
- over some matters concerning space-based observation
- over the international coordination arrangements for terrestrial observation

And questions to be addressed regarding future requirements

- at forthcoming meetings of the three panels in the first instance