



WMO



of UNESCO

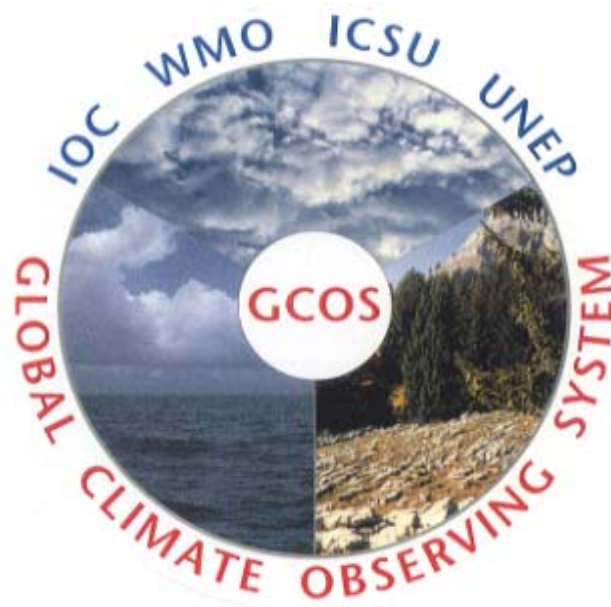


UNEP



ICSU

Implementation Plan for the Global Observing System for Climate in Support of the UNFCCC



Professor Paul Mason

Chairman GCOS steering committee

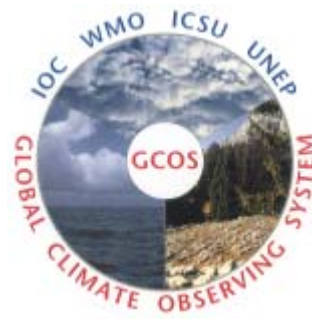


Global Climate Observing System

Mission: To ensure that the data required to meet the needs of users for climate information are obtained and made available for:

- ◆ Climate system monitoring, climate change detection and attribution;
- ◆ Research, modelling and prediction of the climate system;
- ◆ Assessing impacts, vulnerability & adaptation;
- ◆ Application to sustainable economic development.

Global, long-term, high-quality, sustainable, reliable, ...

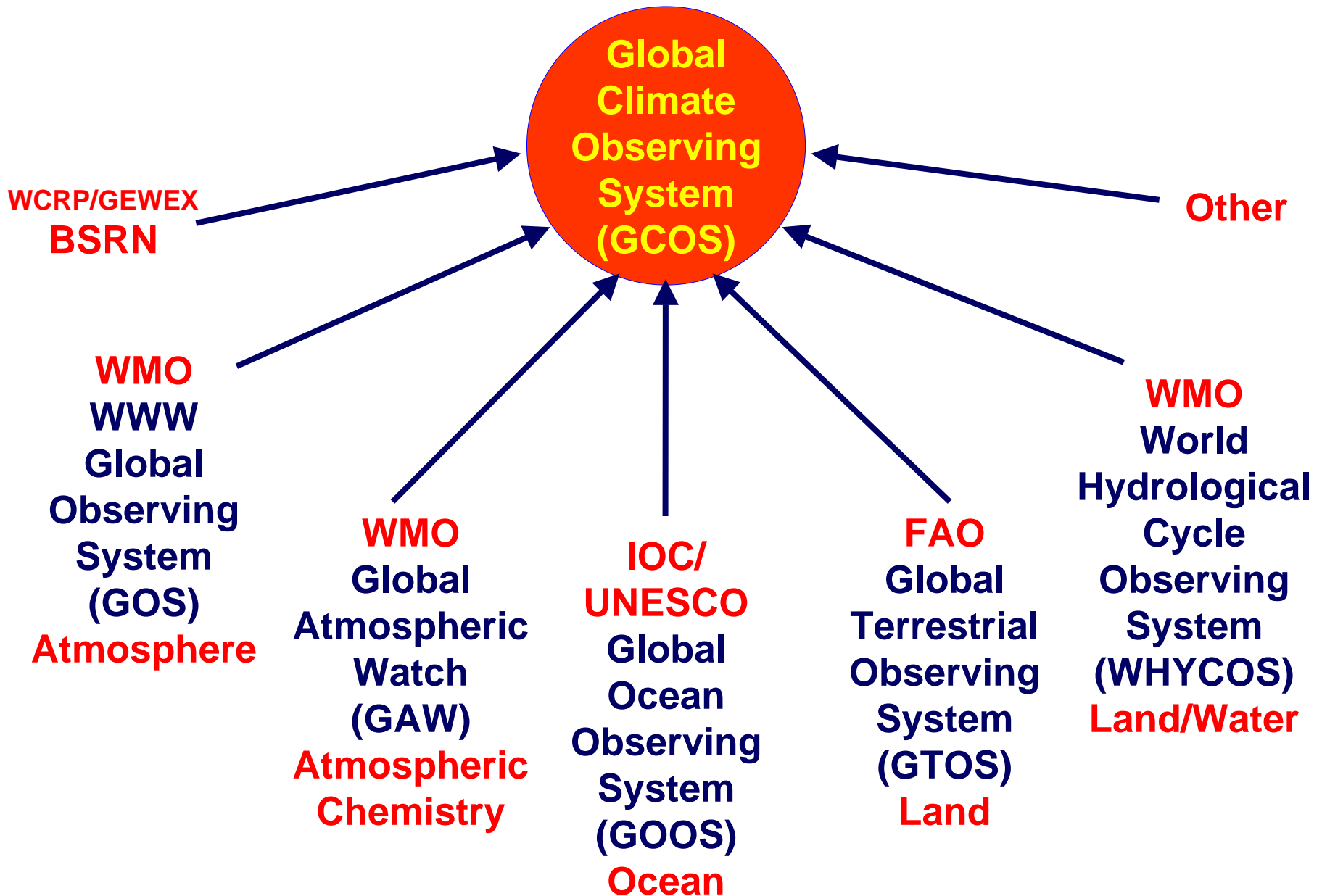


GCOS Strategy

- ◆ **Identify observational requirements for climate applications**
 - ◆ Science panels, sponsors, partners
- ◆ **Build on existing systems to the extent possible**
 - ◆ Operational (institutional), research, baseline, comprehensive
 - ◆ Work with partners to implement systems to GCOS standards – sponsors, CEOS, IGOS, other observing systems
- ◆ **Engage intergovernmental, regional and national bodies**
 - ◆ UNFCCC/COP on systematic observation issues
 - ◆ National and regional entities to address deficiencies
 - ◆ Capacity building
- ◆ **Resource mobilization**
 - ◆ Multi-governmental funding, national support



GCOS is comprised of climate components of various global observing systems including both satellite and *in situ* observations



GCOS Networks Strategy

◆ Baseline Systems

- ◆ Globally distributed, limited number of key variables
- ◆ High-quality, long-term, consistent, reliable, homogeneous
- ◆ Satellite and *in situ*
- ◆ *In situ* provide calibration/validation for satellite observations

◆ Comprehensive Systems

- ◆ All observations that can be used for producing synthesized data sets (assimilation, interpolation, reanalysis)

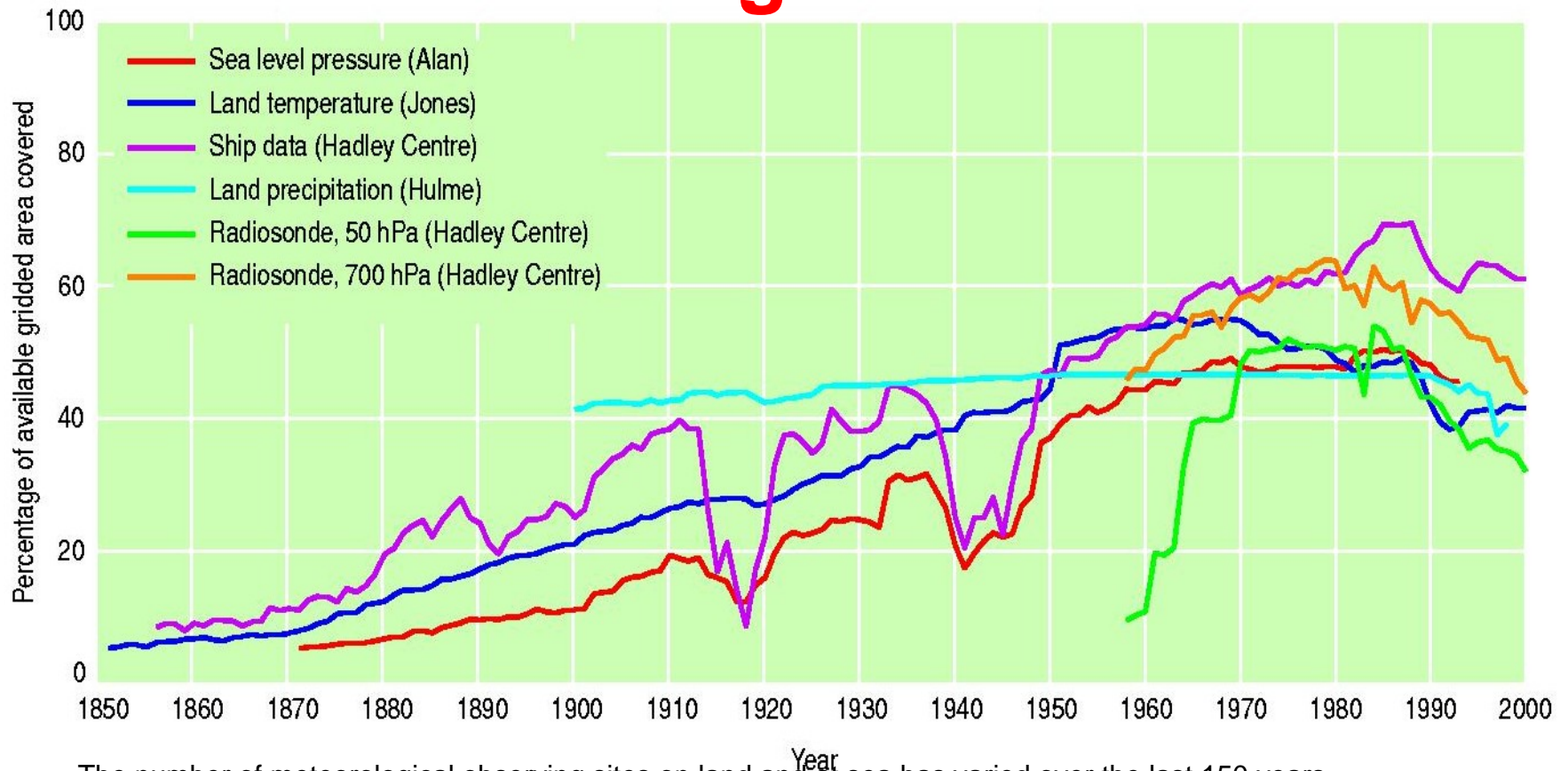
◆ Reference Networks / Ecosystem Networks

- ◆ Highly-detailed, accurate observations at a few locations

◆ Research Networks

- ◆ Detailed data sets for process studies & model evaluation

IPCC TAR raised concerns over declining networks



The number of meteorological observing sites on land and at sea has varied over the last 150 years for a wide variety of reasons, including economic factors and times of war and peace. For many key elements (below), the percentage of available gridded area covered by observations has decreased since the 1980s. Government commitment is essential to ensure that the necessary data are available for planning and early warning against weather and climate extremes, and for research and better management within a varying climate. (Courtesy WMO (2003): "Climate into the 21st Century" p. 160 and Chris Folland, MetOffice, UK)

UNFCCC requested GCOS 2ND Adequacy Report

- ◆ **Rationale for observational needs of UNFCCC**
- ◆ **Progress since first adequacy report**
- ◆ **Adequacy of current observing system and identification of needed improvements**

The Essential Climate Variables

◆ Atmospheric (16)

- **Surface** – Air temperature, Precipitation, Air pressure, Surface radiation budget, Wind speed and direction, Water vapour
- **Upper Air** – Earth radiation budget (including solar irradiance), Upper-air temperature (including MSU radiances), Wind speed and direction, Water vapour, Cloud properties
- **Composition** – Carbon dioxide, Methane, Ozone, Other long-lived greenhouse gases, Aerosol properties.

◆ Oceanic (15)

- **Surface** – Sea-surface temperature, Sea-surface salinity, Sea level, Sea state, Sea ice, Current, Ocean colour (for biological activity), Carbon dioxide partial pressure
- **Sub-surface:** Temperature, Salinity, Current, Nutrients, Carbon, Ocean tracers, Phytoplankton

◆ Terrestrial (14)

- River discharge, Water use, Ground water, Lake levels, Snow cover, Glaciers and ice caps, Permafrost and seasonally-frozen ground, Albedo, Land cover (including vegetation type), Fraction of absorbed photosynthetically active radiation (FAPAR), Leaf area index (LAI), [Biomass], Fire disturbance, [soil moisture]

GCOS Implementation Plan

- ◆ Responds to the request in UNFCCC decision 11/CP.9 to develop a 5- to 10-year implementation plan that
 - Requirements in the ‘Second Adequacy Report’;
 - Essential Climate Variables (ECVs)
 - Integrated global analysis products
 - Views of Parties with respect to that report;
 - Existing global, regional and national plans, e.g., GEO;
 - Open review by broad range of scientists and data users;
 - Indicators for measuring its implementation;
 - Implementation priorities and resource requirements.

“Implementation” Strategy

- ◆ Implementation depends primarily on **national** efforts, but
- ◆ Recognises role of **international** bodies for planning, coordination & standards.
- ◆ The observing strategy includes:
 - **Global coverage** from satellite and *in situ* systems
 - **Sustained generation** of integrated global climate (analysis) products
 - **Strengthened institutional infrastructure** for
 - Monitoring performance of observing systems and products – **stable** data to allow reliable detection of climate change – GCOS climate monitoring principles
 - Ensuring access to the data (e.g., data centres)
 - Evaluating quality (eg., errors) of climate data and products.
 - Using **all available data** – cost-effective – important for reanalyses
 - Comprehensive networks of all relevant observations
 - Global baseline networks, reference networks

Characteristics of the Plan

- ◆ **Identified as the Climate component of the GEOSS of the Group on Earth Observations (GEO).**

Observational Strategy

- Achieving an optimal balance of **satellite and in-situ data**
- Ensuring data are **stable** enough to allow reliable detection of climate change – GCOS climate monitoring principles
- Utilising (Making full use of) **all available** data to achieve a **cost-effective** global observing system for climate (and meeting needs at lowest cost)
 - Comprehensive networks of all relevant observations
 - Global Baseline networks
 - Reference networks

Characteristics of the Plan

- ◆ **A major satellite component**, operated in a manner that ensures the long-term accuracy and homogeneity of the data. **[Satellites ~41% of costs]**
- ◆ **Some ECVs will remain critically dependent on *in situ* observations** for their full measurement, or for calibration and validation of satellite records. **[In situ networks ~38% of costs]**
- ◆ **Global participation** is essential for global coverage of key in-situ networks. **[Capacity building ~5% of costs]**
- ◆ **Sustained product generation and improved data management.** **[Infrastructure ~10% of costs]**
- ◆ **International oversight and coordination – linkage to GEO.** **[Oversight of implementation ~4% of costs]**

Data for Climate Applications

“Adherence by nations to the agreed policy of **free and unrestricted exchange** is urgently required for both *in situ* and satellite climate observations”

- ◆ **Key Action 8:** Need to ensure that **International Data Centres** are established and/or strengthened for **all ECVs**

“Ensure that observations and associated metadata for the ECVs, including historical observations, are available at international data centers”

- ◆ **Key Action 9:** The relevant intergovernmental organizations including WMO, FAO, UNEP, and ICSU need to create a mechanism for establishing **standards, regulatory material and guidelines for terrestrial observing systems.**
- ◆ **Key Action 10:** Parties need to ensure that their climate-observing activities adhere to the GCOS **Climate Monitoring Principles**
- ◆ **Key Action 11:** International **standards for meta-data** for all ECVs need to be established and adopted by the Parties in the creation and archiving of climate data records

Key Actions - Atmosphere

◆ Key Action 12:

- (a) Ensure the implementation and full operation of the baseline networks and systems noted below and to ensure the exchange of these data with the international community, and to recover and exchange historical records;
 - GCOS Surface Network (**GSN**).
 - Atmospheric component of the **composite surface ocean observation** system including sea-level pressure (see Key Oceanic Actions),
 - GCOS Upper-Air Network (**GUAN**),
 - Global Atmosphere Watch (GAW) **global CO₂** network,
 - **MSU**-like radiance satellite observations,
 - Total solar irradiance and **Earth radiation budget** satellite observations
- (b) Establish a high-quality **reference network** of about 30 precision radiosonde stations and other collocated observations
- (c) Exploit emerging new technology including the use of **radio-occultation** techniques and ground-based Global Positioning System (GPS) sensing of the total water column.

Key Actions - Atmosphere

◆ Key Action 13:

- (a) establish a **reference network of precipitation** stations on key **islands and moored buoys** around the globe and at high latitudes;
- (b) submit national precipitation data (preferably hourly data) to the International Data Centres;
- (c) support the further **refinement of satellite precipitation measurement techniques**.

◆ Key Action 14:

- (a) Support research to extend and improve current capabilities for **monitoring clouds** as a high priority.

◆ Key Action 15:

- (a) fully establish a **baseline network for key greenhouse gases**;
- (b) improve selected **satellite observations of atmospheric constituents**; and
- (c) extend existing networks to establish a **global baseline network for atmospheric optical depth**.

Key Actions - Ocean

◆ **Key Action 17:** Ensure climate quality and continuity for essential ocean satellite observations.

- (a) Sustained support for **vector-wind (scatterometer), sea- ice, sea-surface temperature (microwave and infra-red) and ocean-colour** measurements,
- (b) Continuous coverage from **altimeters** to provide high-precision and high-resolution sea-level measurements (1 high-precision and 2 lower-precision altimeters).

Key Actions - Ocean

- ◆ **Key Action 18:** Global coverage of the surface network by implementing and sustaining:
 - (a) GCOS **baseline network of tide gauges**;
 - (b) Enhanced **drifting buoy array**;
 - (c) Enhanced **Tropical Moored Buoy** network;
 - (d) Enhanced Voluntary Observing Ships Climatology (**VOSCLim**) network; and
 - (e) Globally-distributed **reference mooring network**.

- ◆ **Key Action 19:** Global coverage of the sub-surface network by implementing and sustaining:
 - (a) **Argo** profiling float array;
 - (b) Systematic sampling of the **global ocean full-depth water column**;
 - (c) Ship-of-Opportunity Expendable Bathythermograph (**XBT**) **trans-oceanic sections**; and
 - (d) **Tropical Moored Buoy and reference mooring networks** referred to in Key Action 18 above.

Key Actions - Terrestrial

- ◆ **Key Action 20:** Support the operational continuation of the priority satellite-based products given below.
 - Daily global **albedo** from geostationary and polar orbiting satellites,
 - **LAI** and **fAPAR** products to be made available as gridded products,
 - Gridded **fire and burnt area** products through a single International Data Centre,
 - **Snow** cover of both hemispheres,
 - Digital elevation maps of the **ice sheet surfaces and full glacier** inventory from current spaceborne cryosphere missions.
 - Specification and production of **land-cover** characterization data sets.
- ◆ **Key Action 21:** A global network of at least **30 reference sites** (collocated with atmospheric sites if possible) to monitor key biomes and to provide the observations required in the calibration and validation of satellite data.
- ◆ **Key Action 22:** Fill the identified gaps in the global networks for **permafrost, glaciers, rivers and lakes**

Key Actions - Climate Products

The routine generation and ready availability of global climate products is a high and urgent priority.

- **Key Action 23:** An internationally-coordinated approach to the development of **integrated global climate products and making them accessible to all “Parties”**.
- **Key Action 24:** Establishing a **sustained capacity for global climate reanalysis**, to develop improved methods for such reanalysis, and to ensure coordination and collaboration among centres conducting reanalyses.

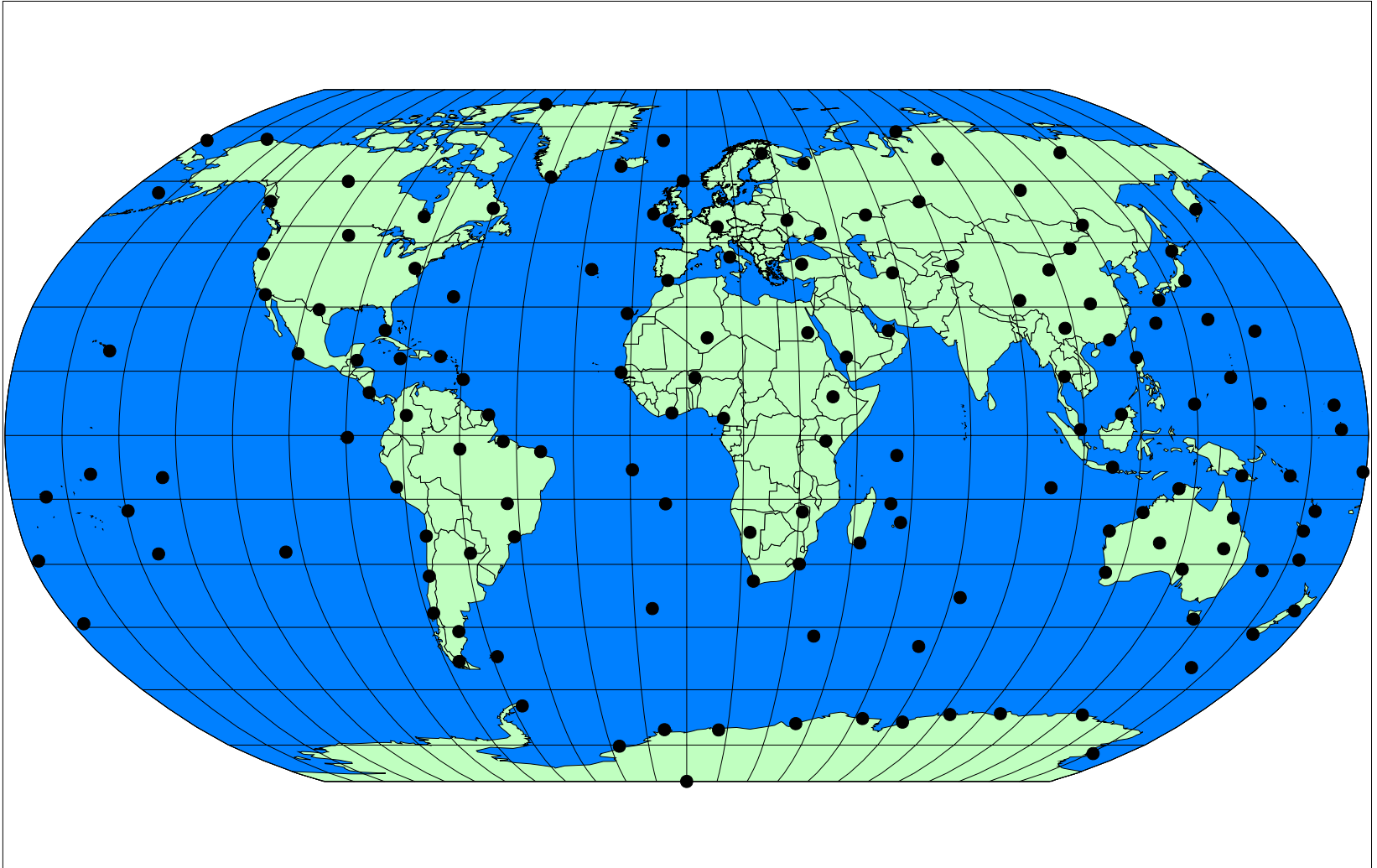
COP-10 decision and SBSTA conclusions

- ◆ **Encourages Parties to strengthen their efforts to address the priorities identified in the implementation plan,**
 - **incorporate actions in their national plans and**
 - **invited to report on their activities.**
- ◆ **Invited Parties supporting Earth observation satellites to provide a coordinated response.**
- ◆ **Welcomed the emphasis on enhancing the participation of developing countries and encouraged Parties to implement “regional action plans”**
- ◆ **Appreciated the collaboration between GCOS and GEO.**
 - **Welcomed progress on 10-year GEOSS implementation plan**
 - **Incorporate actions in GCOS IP into the GEOSS IP.**
- ◆ **Encourages Parties to enhance their work and collaboration on observing ECVs and on developing climate products, including through participation in the GCOS cooperation mechanism**
- ◆ **Invited the GCOS to report on progress at subsequent sessions.**

Annually Recurring Costs of actions

Cost Category*	Number of Common Actions	Number of Atmospheric Actions	Number of Oceanic Actions	Number of Terrestrial Actions	Total
I – <100K	4	8	7	11	30
II – 100K-1M	8	4	11	13	34
III – 1M-10M	2	11	17	11	42
IV – 10M-30M	1	8	6	2	17
V – 30M-100M	0	1	0	0	1
Common actions with costs covered in domains	6	-	-	-	6
Total Number	21	32	41	37	131
Estimated total cost profile	34.4M	282.8M	211.2M	102.6M	631.0M

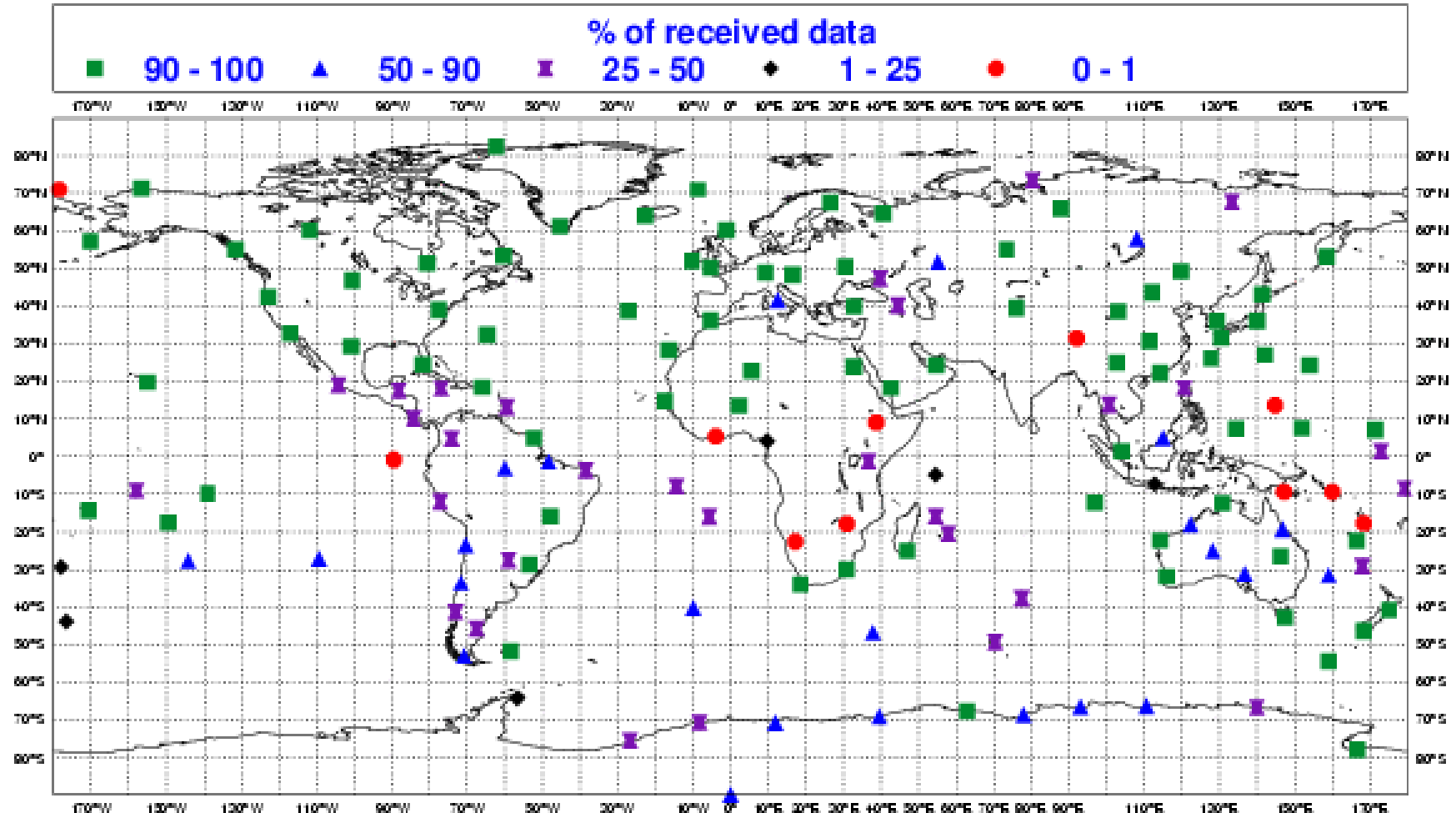
Global Upper Air Network (GUAN)



GUAN STATIONS NOV 2004

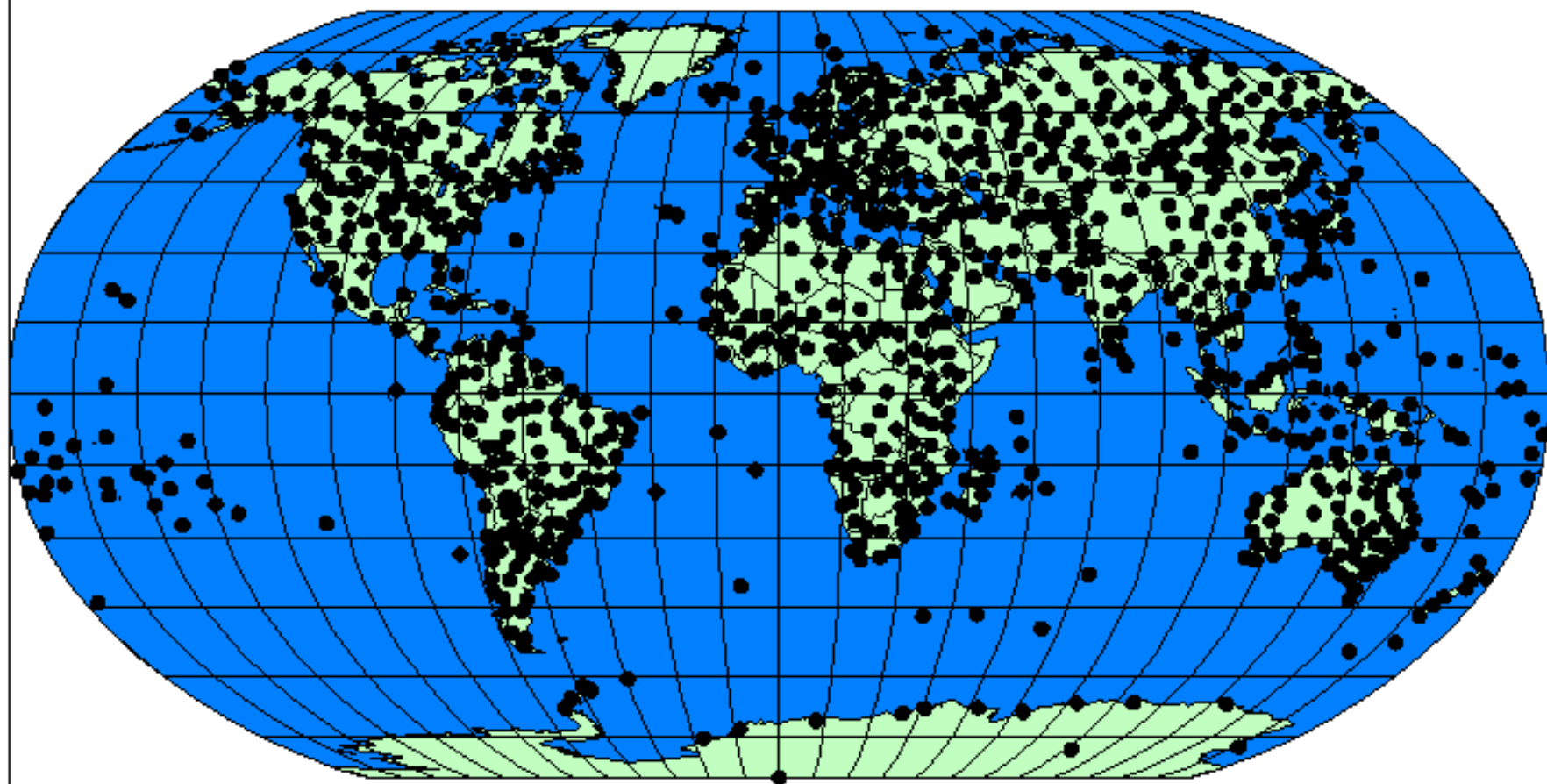
Frequency of RECEPTION data at ECMWF

Level: 700 hPa Temperature SUMMARY 00/12 UTC



GCOS Surface Network (GSN)

981 Stations

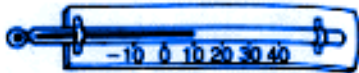


GCOS Secretariat: 1 January 2003

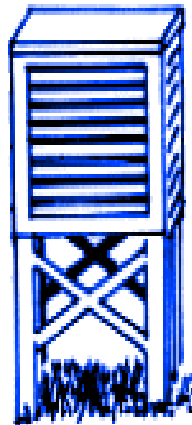
Weather Stations

- Stevenson Screen
- Temperature
- Precipitation

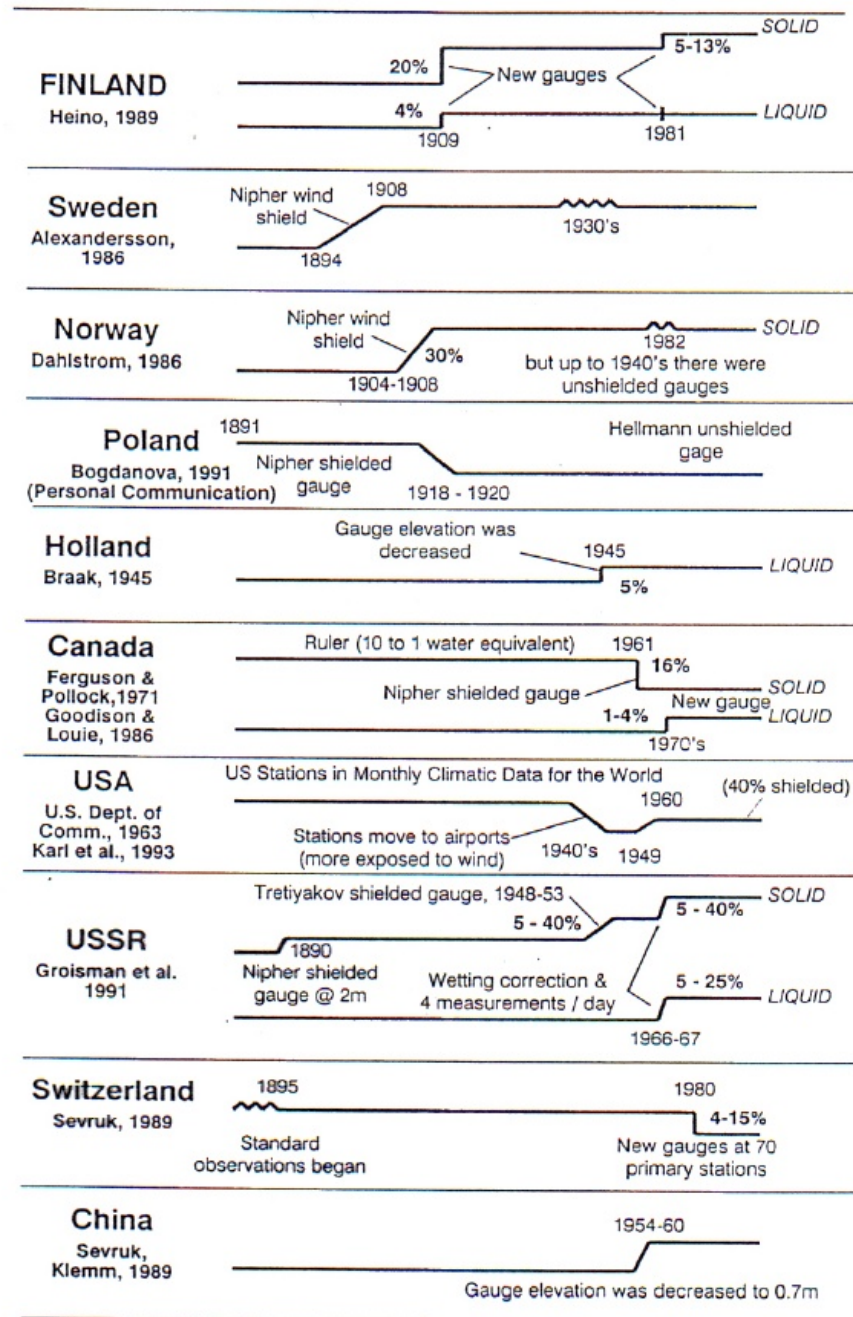
Maximum thermometer



Minimum thermometer

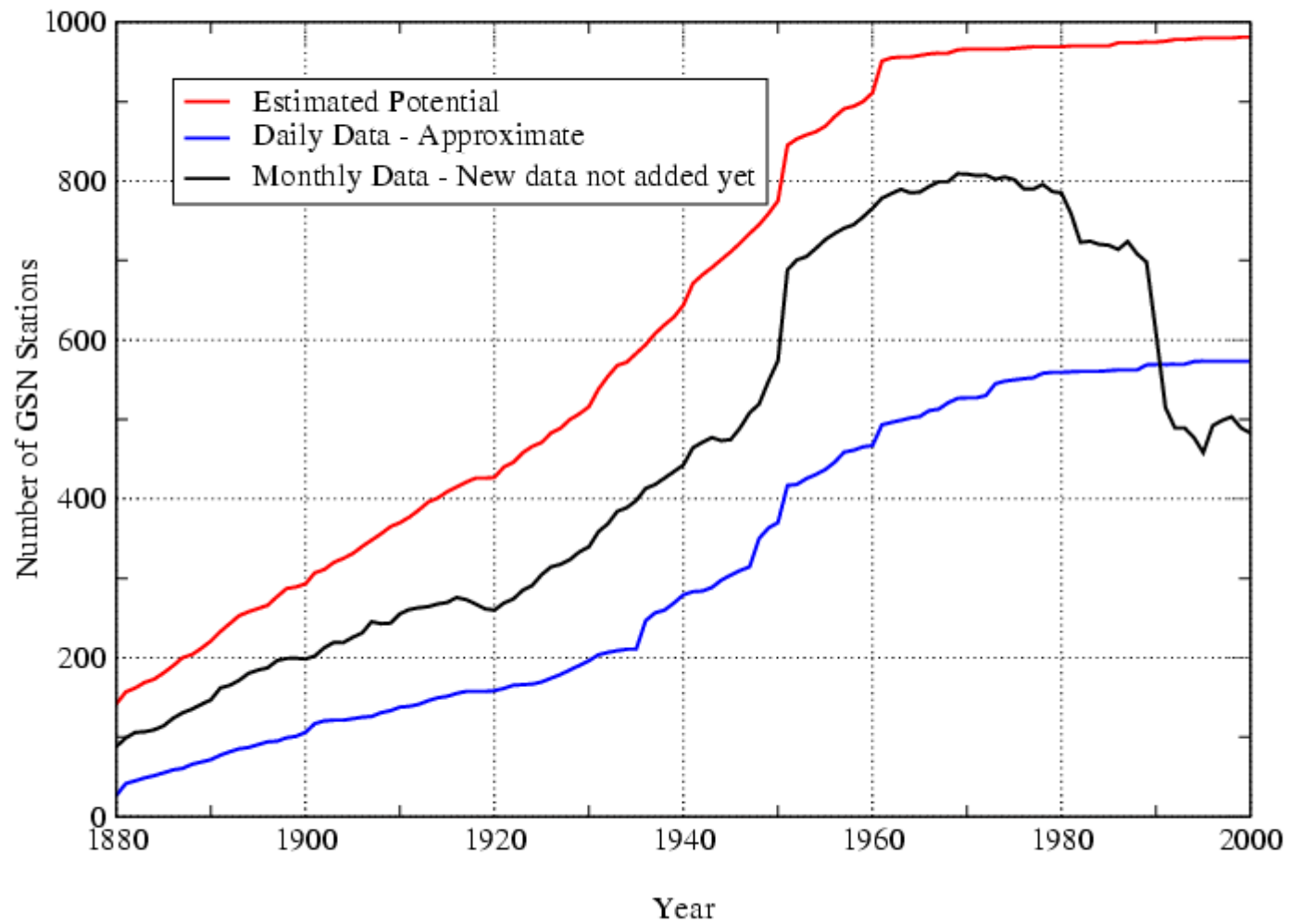


Precipitation discontinuities

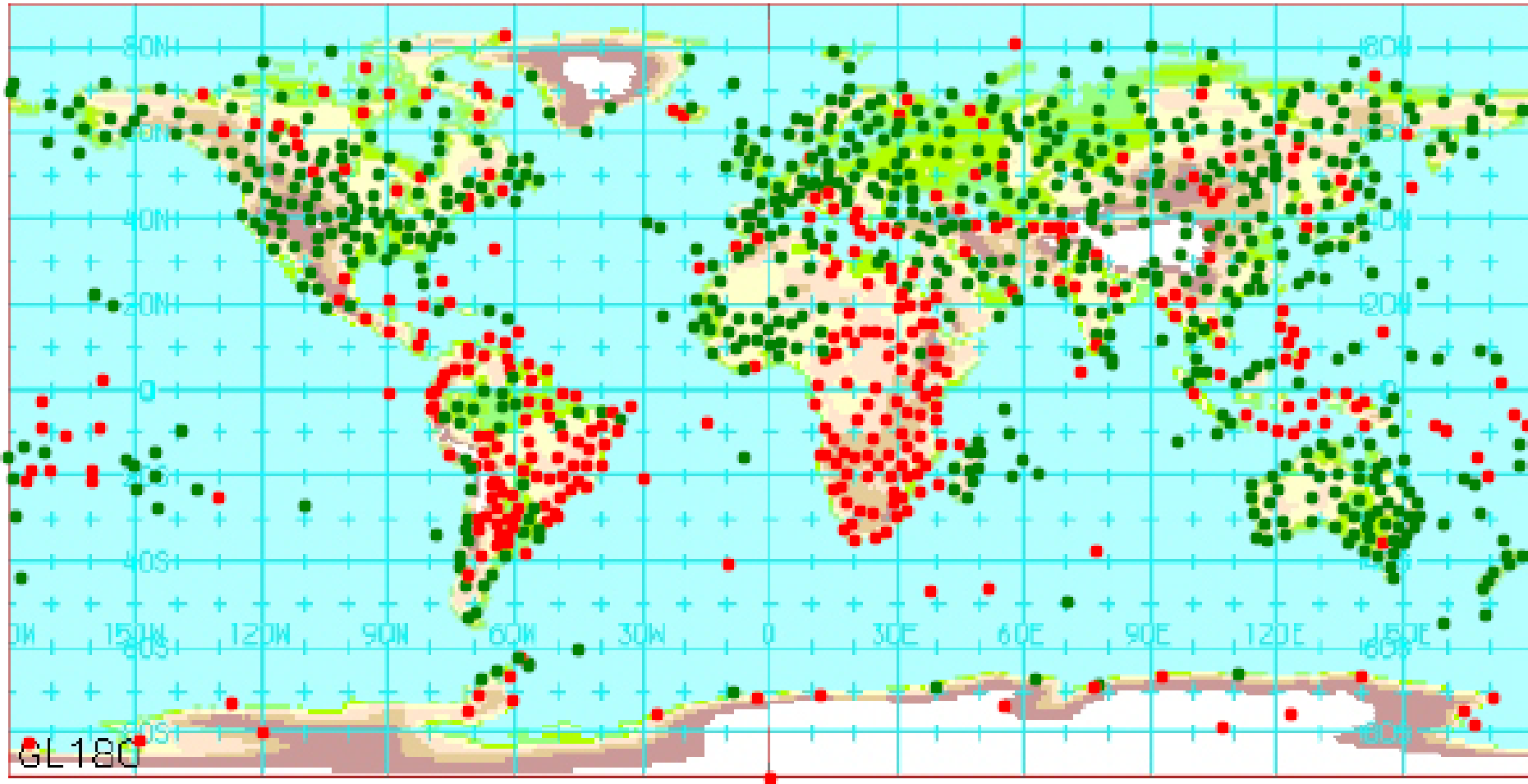


Courtesy P. Groisman

GSN Stations



Percentage of received CLIMAT-Reports Selection: GSN-stations from August 2004



● 100% rec. (646 St.)

● 76 - 99% rec. (0 St.)

● 51 - 75% rec. (0 St.)

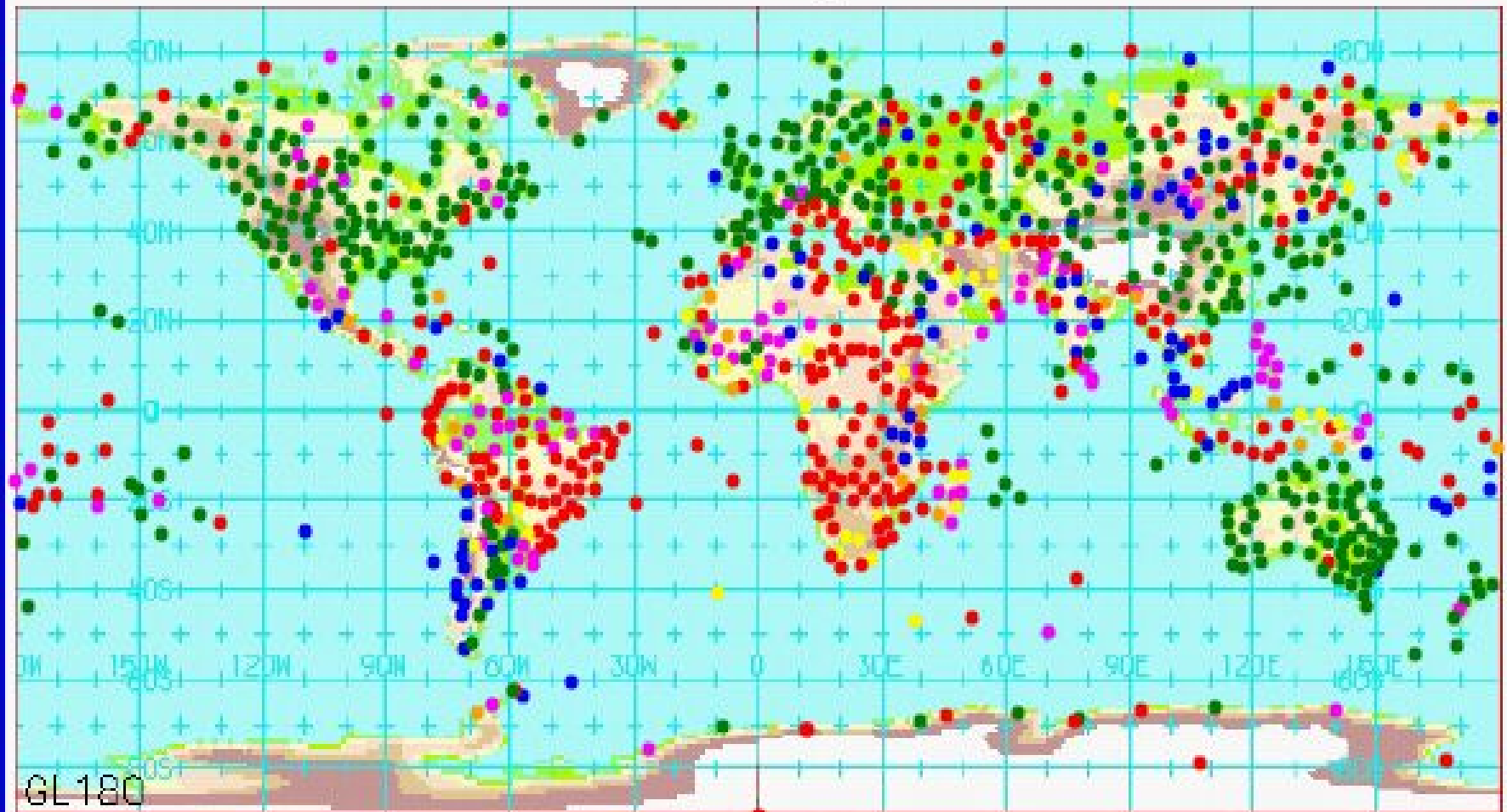
● 26 - 50% rec. (0 St.)

● 1 - 25% rec. (0 St.)

● not rec. (346 St.)

rec.: received until 20th day of a month following the month to be monitored

Percentage of received CLIMAT-Reports
Selection: GSN-stations from January 2002 to December 2002

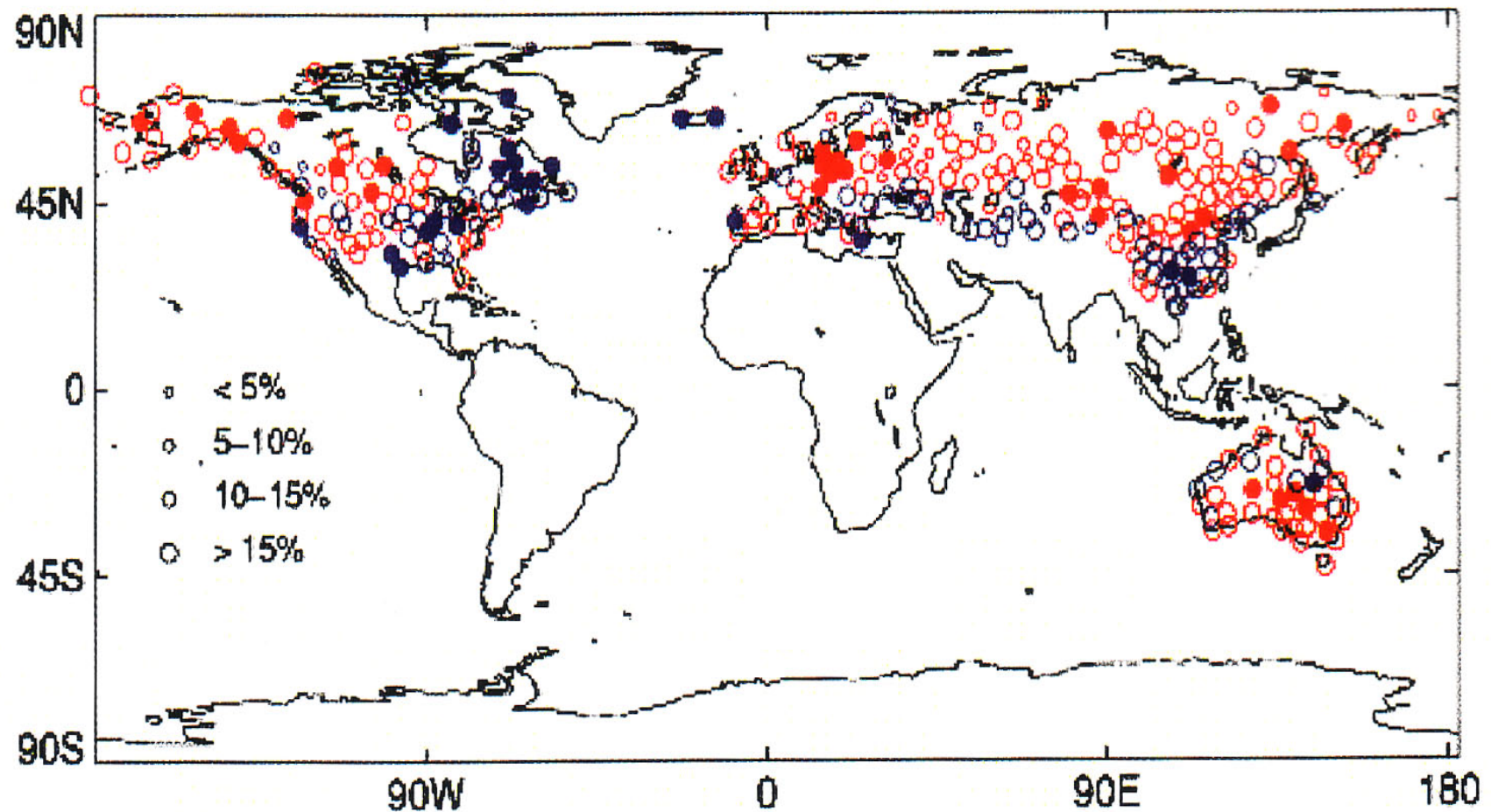


- | | | |
|--------------------------|--------------------------|--------------------------|
| ● 100% rec. (424 St.) | ● 76 - 99% rec. (94 St.) | ● 51 - 75% rec. (93 St.) |
| ● 26 - 50% rec. (22 St.) | ● 1 - 25% rec. (37 St.) | ● not rec. (299 St.) |

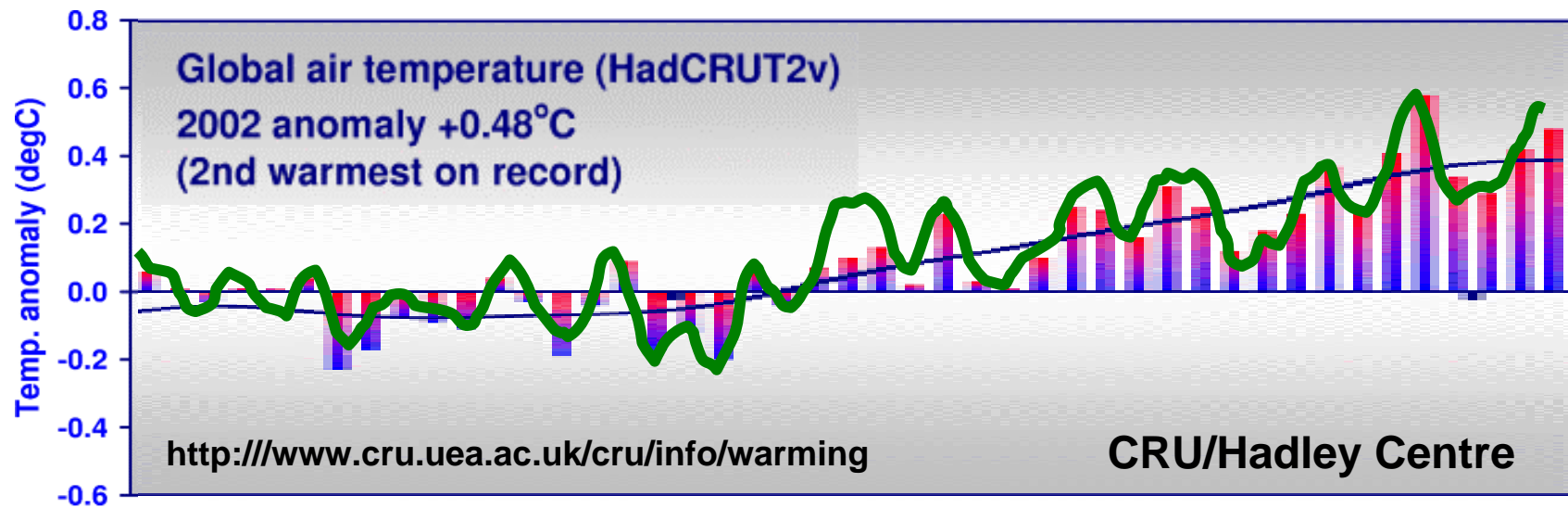
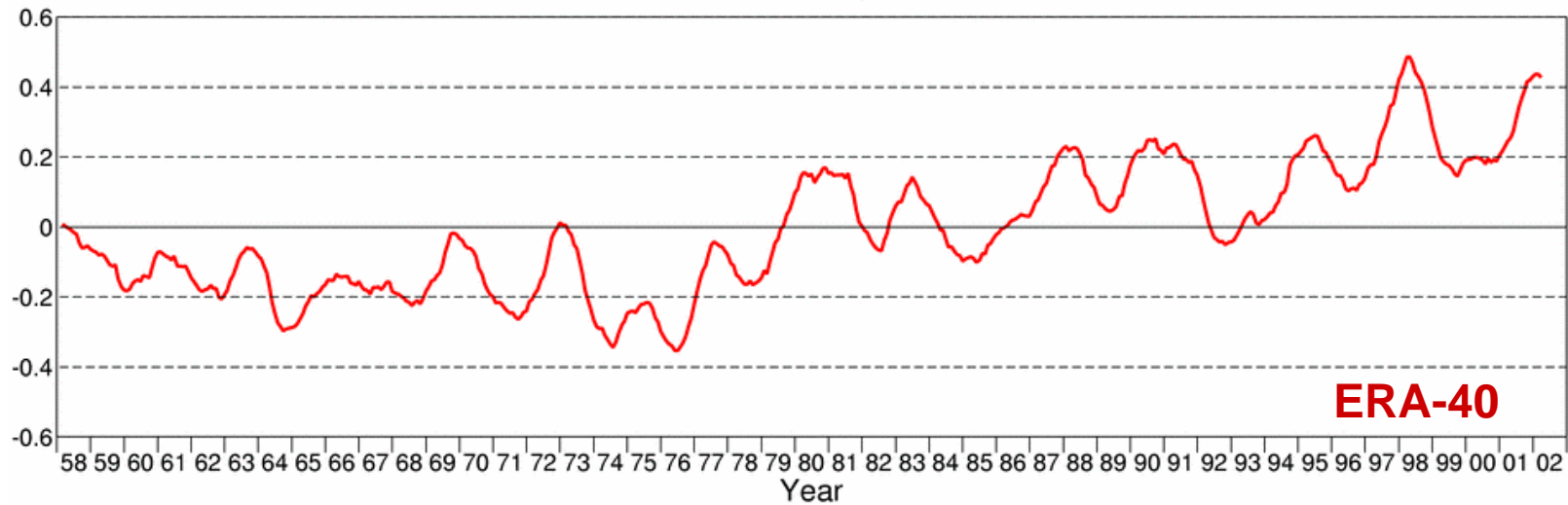
rec.: received until 20th day of a month following the month to be monitored

Heat Wave Duration Index (144 HWDI)

Change (%) between two multi-decadal averages during 2nd half of 20th Century

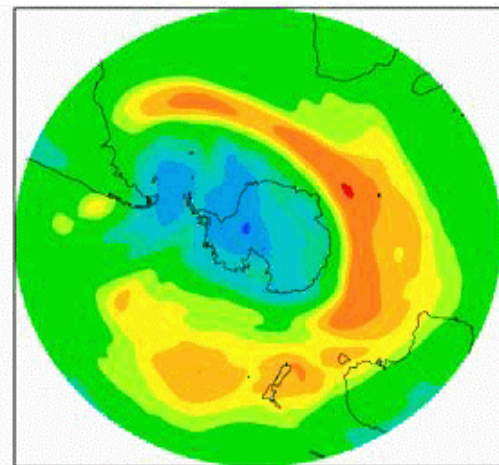
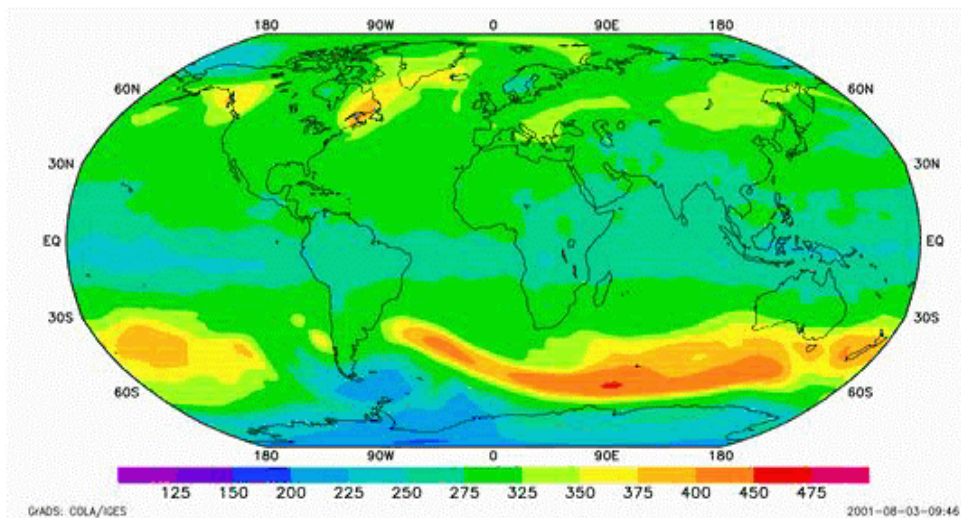


Global-mean two-metre temperature anomaly (Deg C)
Annual running mean

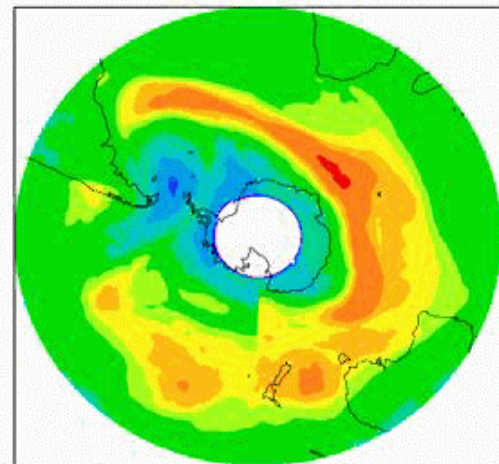
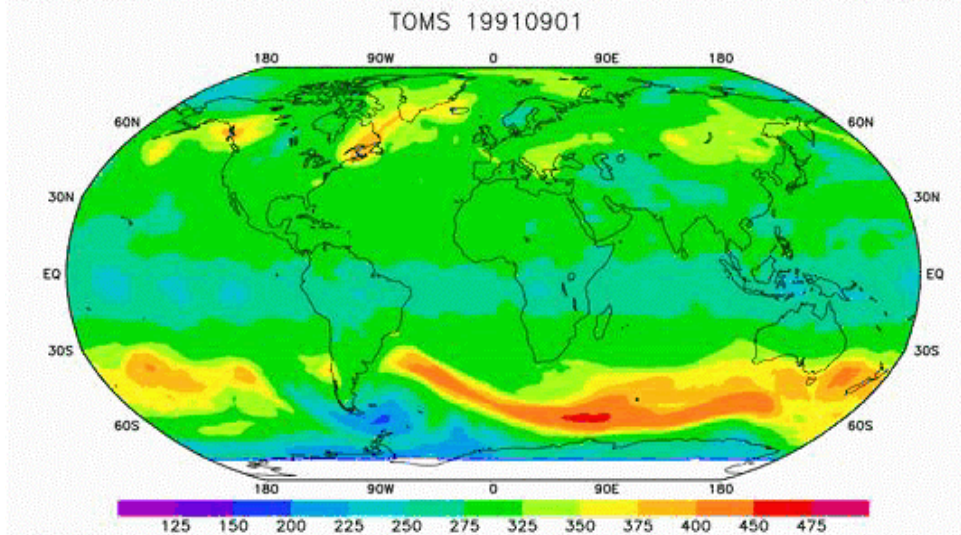


Total Ozone, 1 September 1991

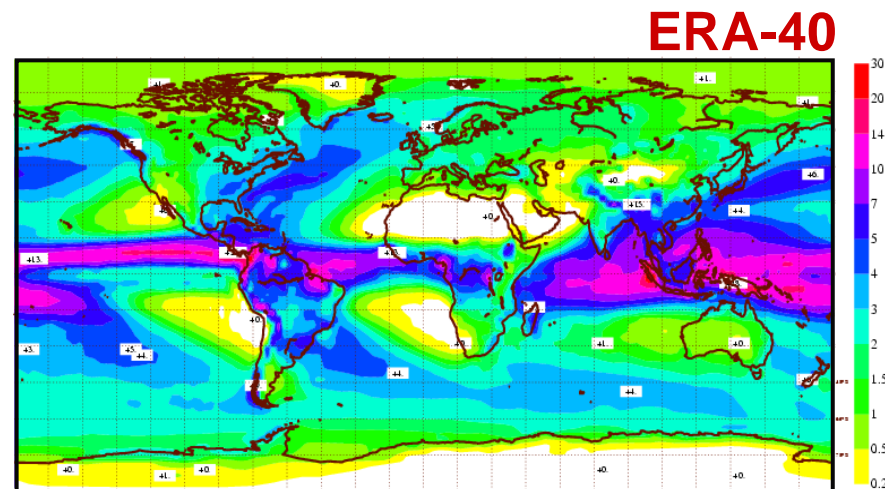
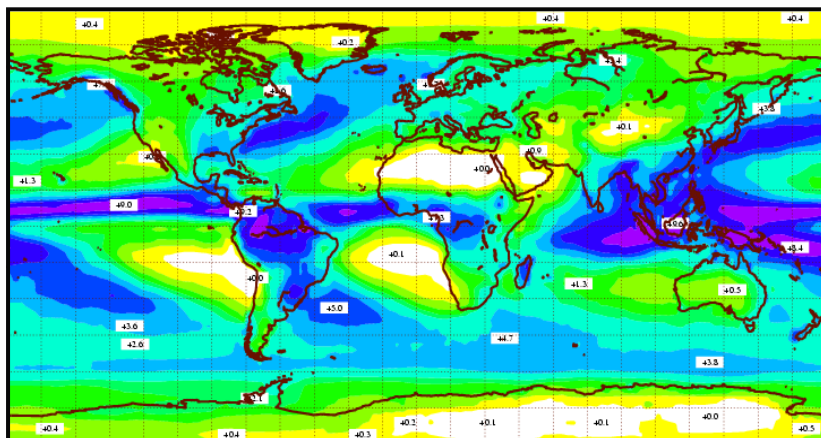
ERA-40



TOMS



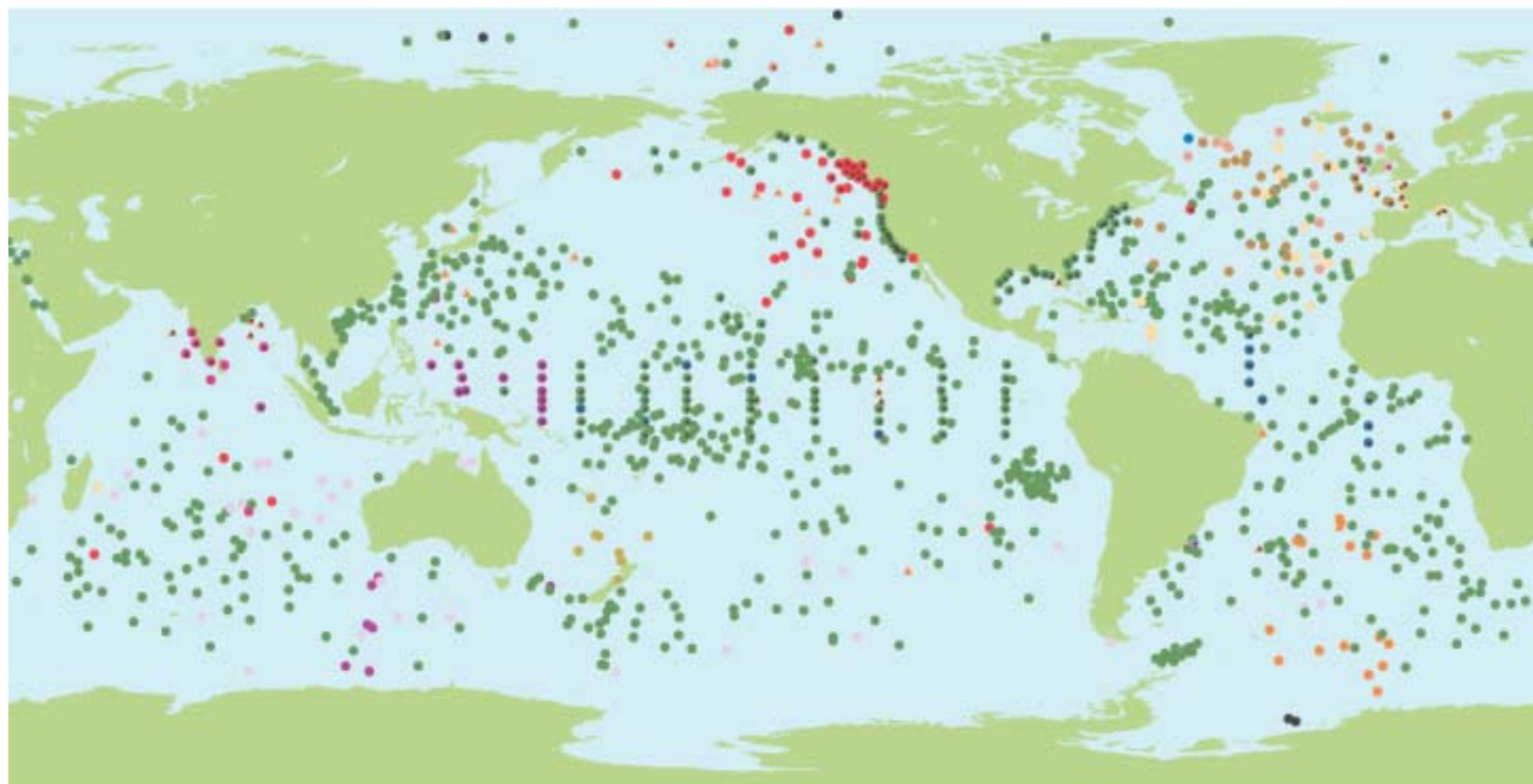
Excessive precipitation over tropical oceans



- HIRS (or VTPR) data moisten where cloud-free, SSM/I where rain-free
- Analysis spreads increment and saturates already moist areas
- Moisture fuels too-strong circulations
- Too-strong circulations imply too-dry descent regions
- HIRS and SSM/I data moisten descent regions
- Neither HIRS nor SSM/I data are used in precipitating ascent regions
- Problem exacerbated by volcanic aerosol effects on HIRS radiances and subsequent bias-correction problems

The GAW Global Observatories





DBCP status by country, February 2004 (data buoys reporting on GTS)

Drifting buoys: 902

Moored buoys: 177

● AUSTRALIA (31)	● BRAZIL (1)	● BRAZIL/FRANCE/USA (13)
● CANADA (26, 16)	● FRANCE (19, 8)	● GERMANY (5)
● INDIA (3, 6)	● IRELAND (2)	● JAPAN (5, 16)
● NETHERLANDS (1)	● NEW ZEALAND (8)	● NORWAY (13)
● SOUTH AFRICA (16)	● UNITED KINGDOM (29, 7)	● UNITED STATES (745, 109)
⊙ MOORINGS	▲ UNKNOWN	

National Contributions to Argo Array



Argo Network, as of January 2004

(1043 Floats)

● AUSTRALIA (19)
● CANADA (73)
● CHINA (10)
● DENMARK (0)
● EUROPEAN UNION (55)

● FRANCE (38)
● GERMANY (48)
● INDIA (21)
● IRELAND (2)
● JAPAN (181)
● KOREA (Rep. of) (46)

● MAURITIUS (1)
● NEW ZEALAND (3)
● NORWAY (9)
● RUSSIAN FEDERATION (3)
● SPAIN (7)
● UNITED KINGDOM (60)
● UNITED STATES (467)

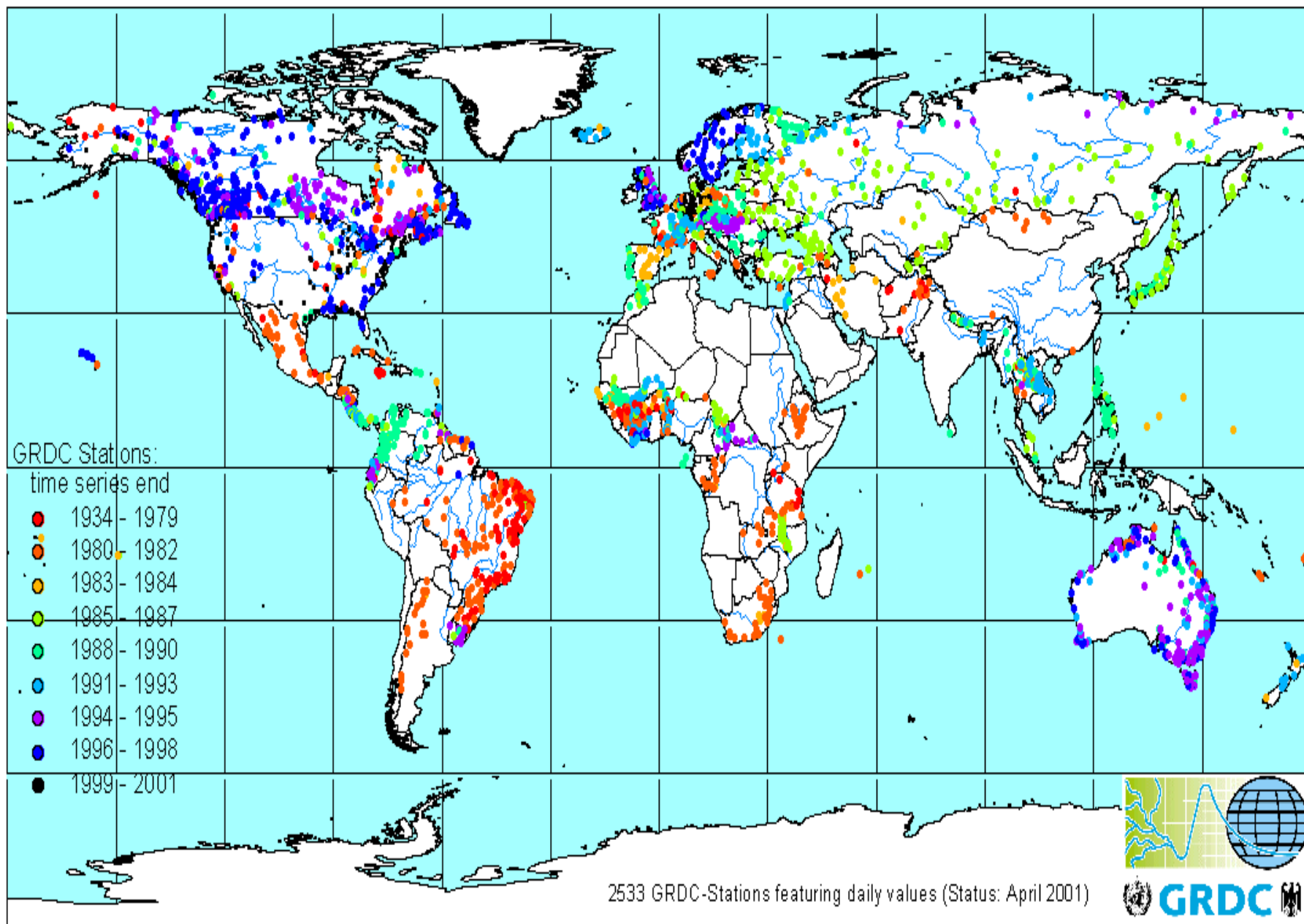
Array increased from ~20% to ~33% desired density in 2003

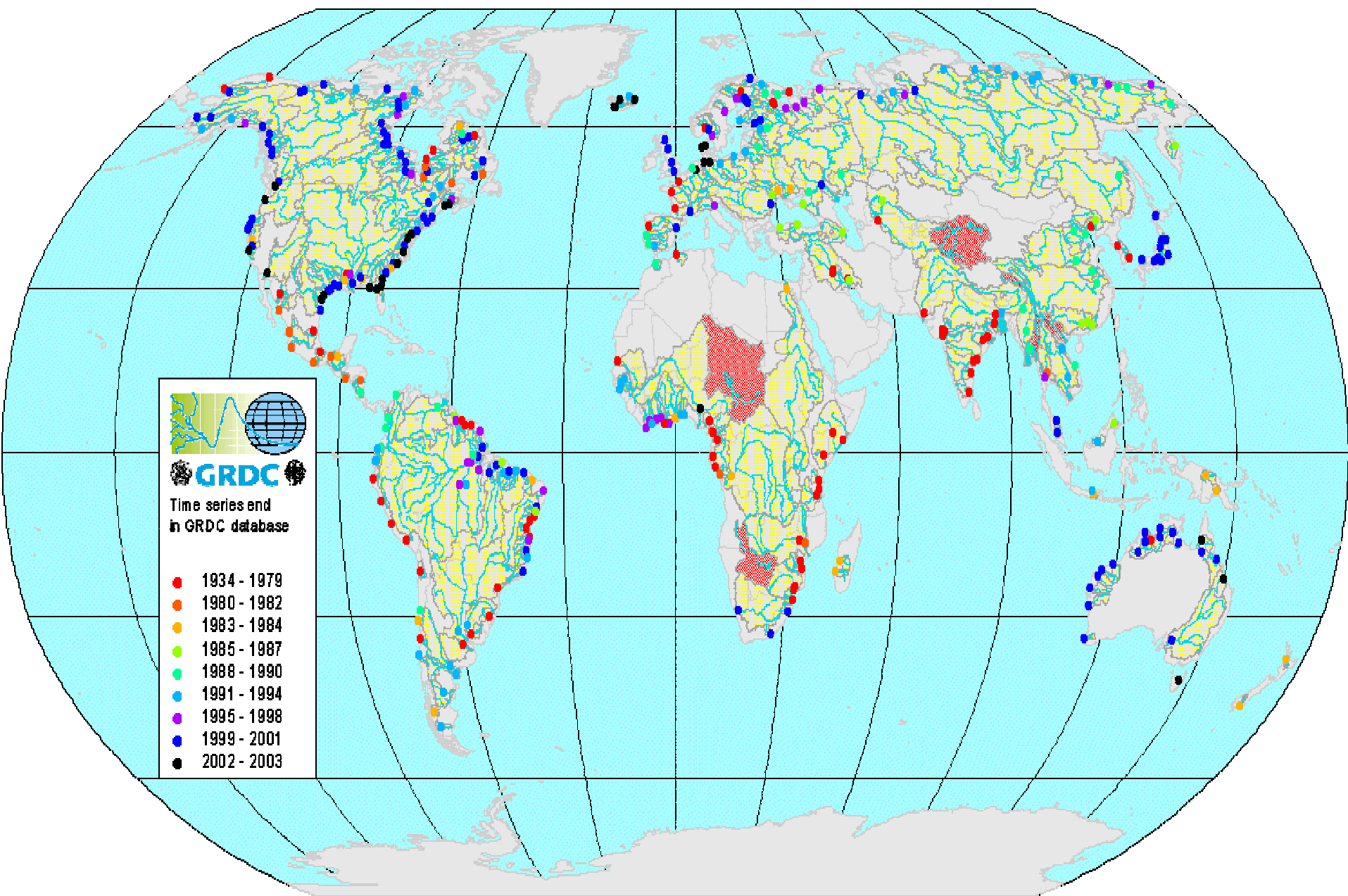
Observation networks and systems contributing to the Terrestrial ECVs

ECV	Contributing Network(s)	Status of network	Contributing Satellite Data	Status of satellite systems
River Discharge	Proposed GCOS Baseline River Discharge Netw'k - GRDC priority list.	Stations selected, but GTN-R not formally established. EO based network only research.	Research on Laser / radar altimetry For river levels and flow rates	Operational laser altimeters not scheduled.
Lake variables	Proposed GCOS Baseline Lake Level-Area Netw'k -TOPC priority list. Also freeze up / break up	Stations selected, but GTN-L not formally established. EO based network only research.	Proposed altimetry, high-res. Optical & radar; reprocess of archived data.	Opn'l laser altimeters not scheduled. Uncertainty on continuity of high-res. systems
Ground water levels and use	None, but many national archives of ground water level do exist.			
Area of Irrigated land	No network, but a single geo-referenced database exists.		Any high / medium-res. optical / radar systems.	Lack of high-resolution optical continuity.

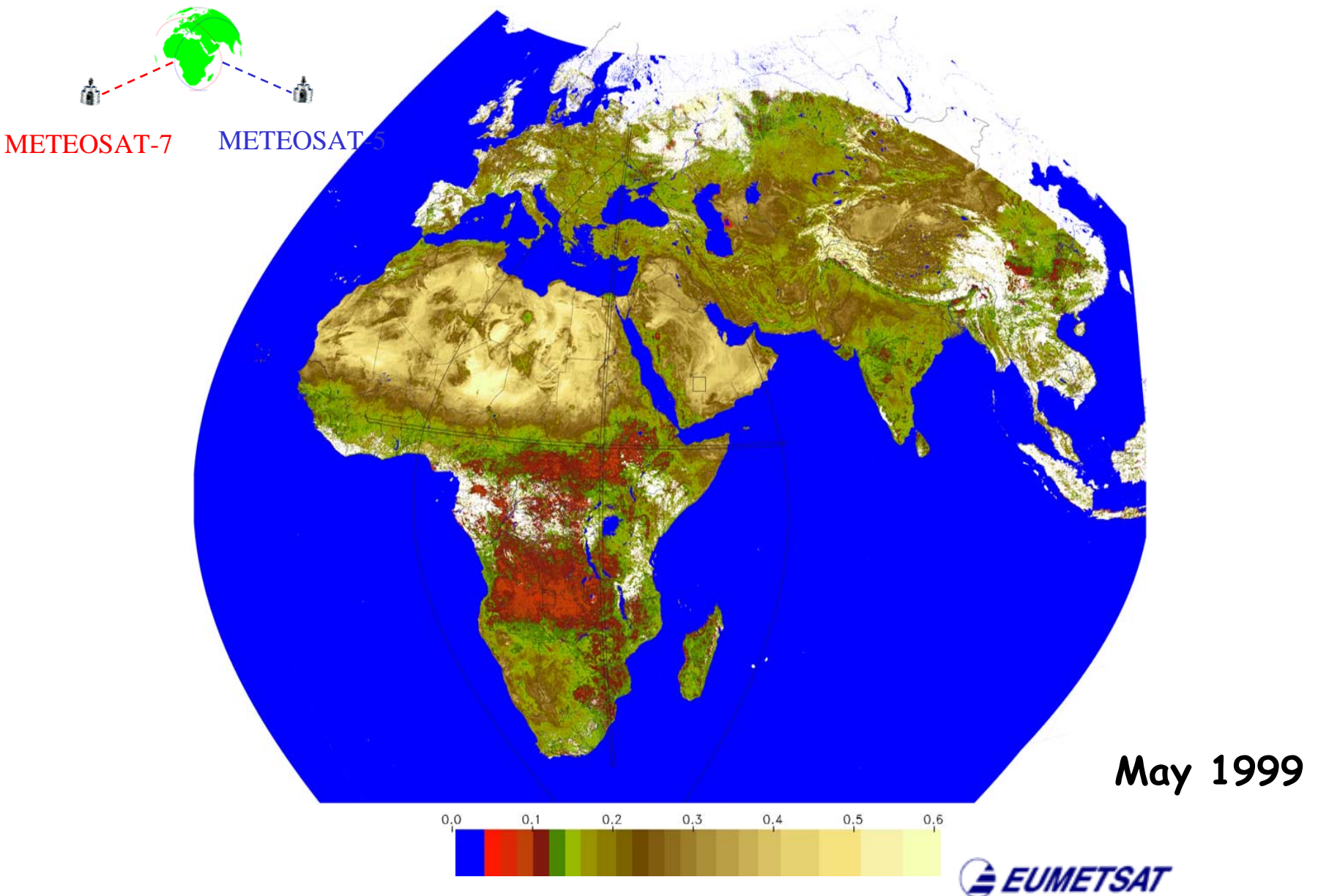
Networks and systems contributing to the Terrestrial ECVs

ECV	Contributing Network(s)	Status of network	Contributing Satellite Data	Status of satellite systems
Snow Cover	WWW/GOS Synoptic Network (depth). Nat'l Networks (depth and snow water equivalent).	Synoptic & nat'l networks signif. gaps and are ALL contracting. / SH not monitored operationally for extent & duration.	Moderate-res optical for extent/duration Passive MW for snow water equivalent.	Moderate resolution optical system follow on is programmed.
Glacier and Ice Caps	GTN-G co-ordinates national monitoring networks	Major geographic gaps need closing esp., for glacier mass balance measurements - inadequate.	Visible and IR high-res. Along track stereo optical imagery SAR. Sat. altimetry	Continuity of high-res optical sat. is lacking. Sat. altimetry res. missions will help.
Greenland & Antarctic Ice Sheets	Radarsat Antarctic MapProj Prog Arctic Reg Clim Assessmnt Inter Trans-Antarctic Scientific Exp	One off research projects	Satellite laser altimetry	Lack of laser altimetry mission continuity.
Permafrost	GTN-P co-ordinates National Monitoring Networks.	Major geographical gaps.	Sat. derived variables are essential (e.g. veg. type, snow cover, water) plus skin temp. measurements	

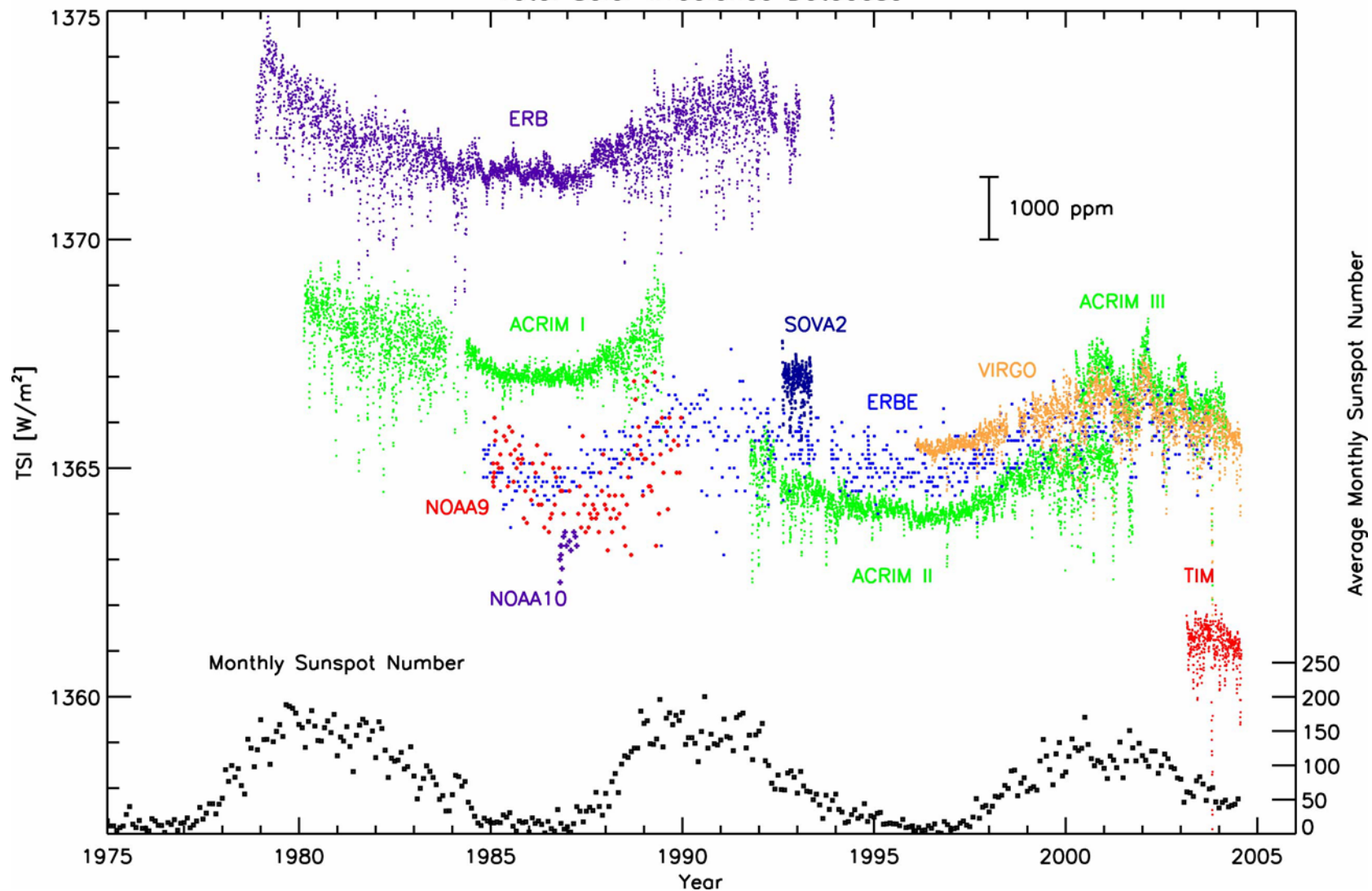




BENCHMARKING of SURFACE ALBEDOS



Total Solar Irradiance Database



GCOS thanks the many contributors
to the Implementation Plan

END