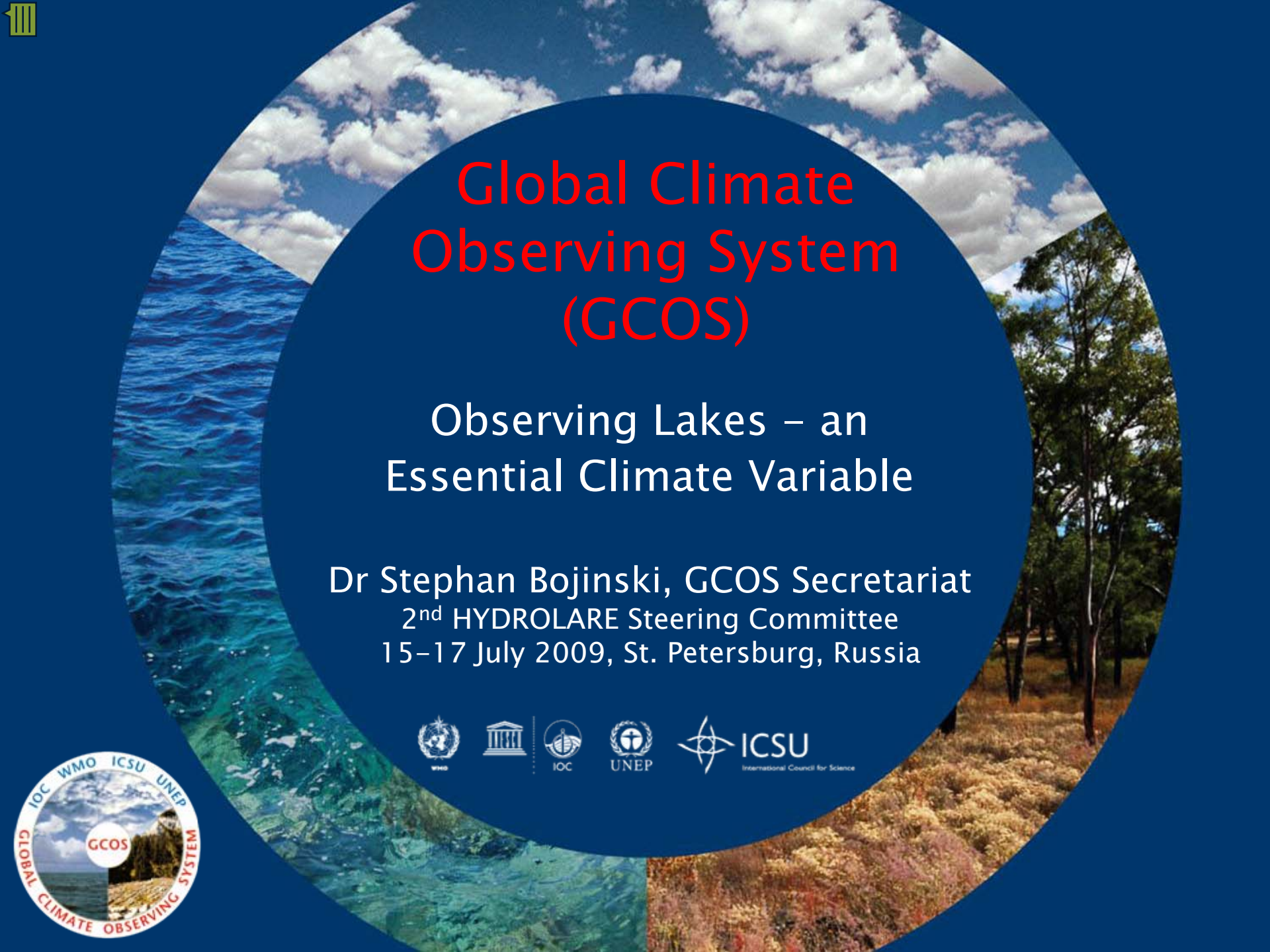


Global Climate Observing System (GCOS)

Observing Lakes – an Essential Climate Variable

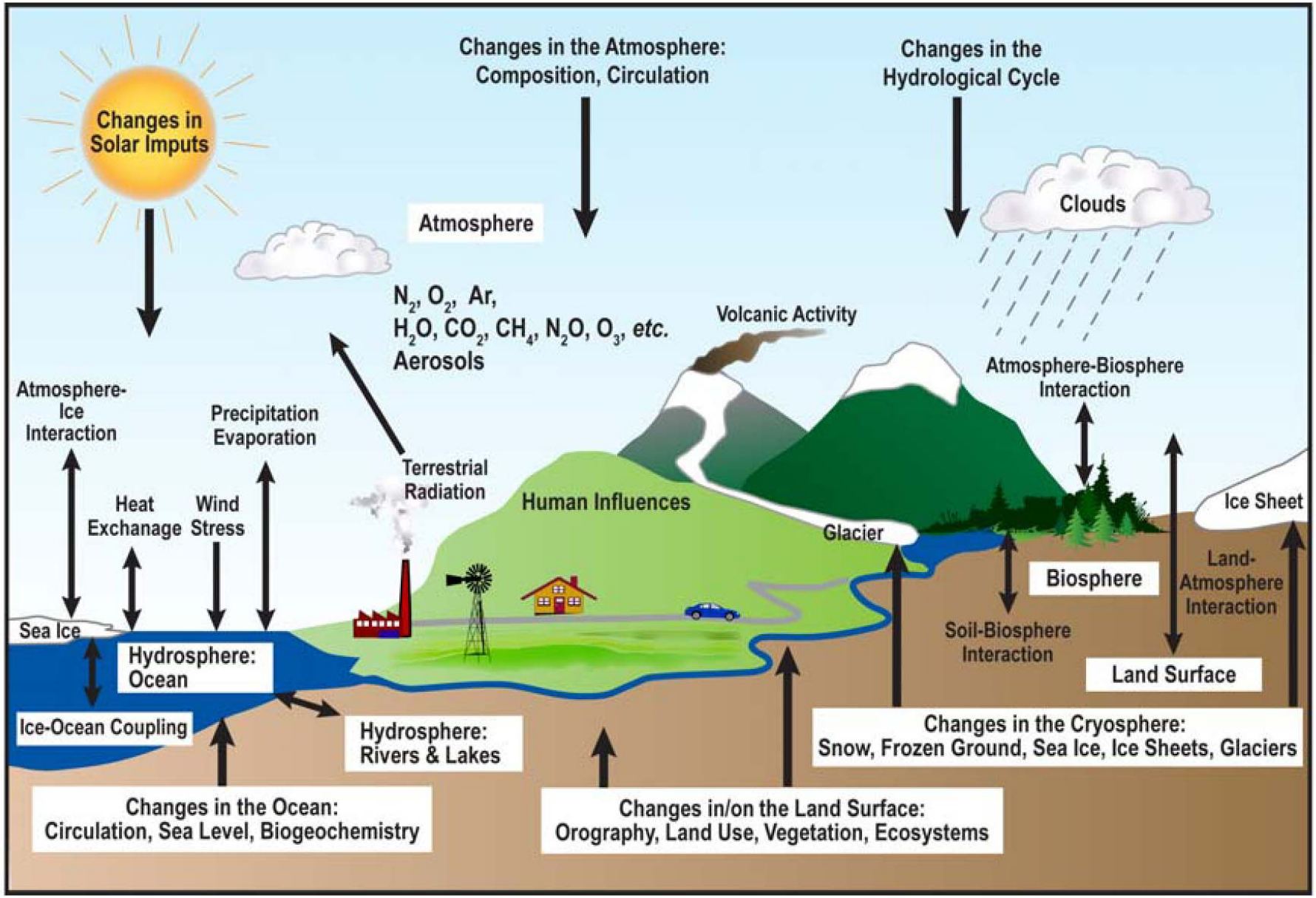
Dr Stephan Bojinski, GCOS Secretariat

2nd HYDROLARE Steering Committee
15-17 July 2009, St. Petersburg, Russia

WMO IOC UNEP ICSU International Council for Science

IOC WMO ICSU UNEP GCOS GLOBAL CLIMATE OBSERVING SYSTEM

The Climate System



GCOS Observational Strategy

- Achieving an optimal balance of satellite and *in-situ* data
- Ensuring data are stable and accurate to allow detection of climate change
- 20 GCOS climate monitoring principles (10 basic + 10 specific for space-based observations)
- Making full use of all available data to achieve a cost-effective global observing system for climate

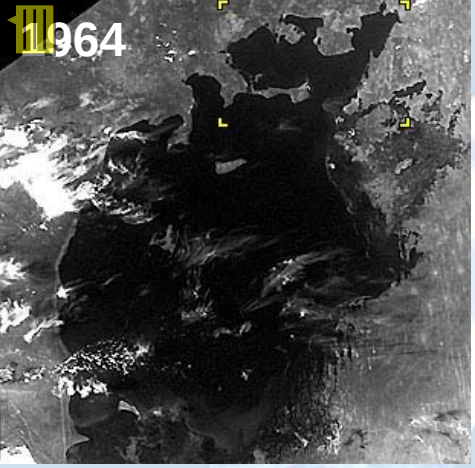
GCOS Essential Climate Variables (ECVs; 44)

- **Priority list of variables to be observed systematically**
- **Criteria:**
  - Global observations feasible (practical, cost-effective)
  - High impact on needs of UNFCCC, climate change assessments (IPCC)
- **Review in 2009**

- **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, 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 (13)**
  - 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]

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.



Example: Lake Area and Level

(Satellite Supplement, GCOS-107, 2006)

***Benefits*:**

- Assessment of changes in regional climate, better knowledge of regional water balance
- Lake area, combined with lake level, gives indication of the volume of the lake-water body, which is an integrator variable, reflecting both atmospheric (precipitation, evaporation-energy) and hydrological (surface-water recharge, discharge and ground-water tables) conditions

Resolution, Accuracy, Stability:

Level:

- Accuracy: 10 cm with respect to reference geoid; Resolution: <4km horizontal resolution, monthly coverage;
- Stability: 10 cm with respect to reference geoid

Area:

- Accuracy and Stability: 5% (maximum error of omission and commission in lake area maps); location accuracy better than 1/3 of instantaneous field-of-view (IFOV) with 250 m target IFOV
- Resolution: 250 m horizontal resolution, monthly observing cycle, global all-weather coverage

Instruments and datasets:

Fundamental Climate Data Record of appropriate VIS/NIR imagery and radar imagery, for example through:

- Moderate-resolution optical instruments (MERIS/MODIS-class)
- ALOS L-band in ScanSAR mode

Cal/val, archiving needs:

- Calibration will be required against in situ measurements
- Validation by high-resolution imagery (10-30 m) from sample sites and in situ measurements
- No current capability for global data archiving is established; data documentation, availability and distribution by such a centre needs to be established with high priority

Coordination by:

- WMO CHy, GCOS TOPC, GTN-H, WCRP GEWEX

Recommendations in GCOS Implementation Plan

Action T5: Create a ***lake information data centre***.

Who: TOPC in consultation with WMO CHy and National Hydrological Services.

Time-Frame: Operational by 2006.

Performance Indicator: Commitment by host country.

DONE

Action T6: Submit weekly/monthly lake level/area data for the 156 GTN-L lakes to the ***International Data Centre***; submission of weekly/monthly altimeter-derived lake levels by Space Agencies to the International Data Centre.

Who: National Hydrological Services, through WMO CHy; Space Agencies; the new global lake information data centre.

Time-Frame: Continuous.

Performance Indicator: Completeness of database: National Communications to UNFCCC

IN PROGRESS; MILESTONES 3,10

Recommendations in GCOS Implementation Plan

Action T7: Submit weekly/monthly lake level and area data measured during the19th and 20th centuries for the 156 GTN-L lakes to International Data Centre.

Who: National Hydrological Services, in cooperation with WMO CHy and the new global lake information data centre.

Time-Frame: Completion of archive by 2009.

Performance Indicator: Completeness of database, National Communications to UNFCCC.

IN PROGRESS; MILESTONES 5,8,11

Action T8: Submit weekly surface and sub-surface water temperature, date of freeze-up and date of break-up of 156 priority lakes in GTN-L.

Who: National Hydrological Services; Space Agencies in response to request from TOPC through the WMO.

Time-frame: Continuous.

Performance Indicator: Completeness of database, reporting to UNFCCC.

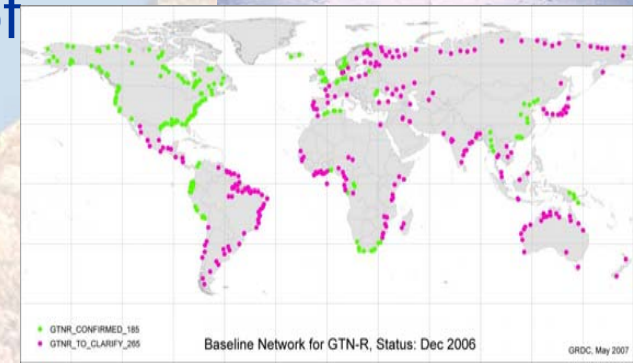
IN PROGRESS

GCOS Progress Report 2004-2008

- Based on **2004 GCOS Implementation Plan**:
  - Submitted to COP 10 -> decision 5/CP.10
  - In support of UNFCCC, IPCC
  - 131 recommended Actions in Atmosphere, Ocean, Terrestrial domains
  - To ensure the availability of observations of Essential Climate Variables in support of, *inter alia*:
    - Prediction of global climate change, and attribution of its causes
    - Projection of global climate change information down to regional and local scales;
    - Characterization of extreme events important in impact assessment and adaptation, and to the assessment of risk and vulnerability
    - Mitigation assessment
- Actions on Parties, int'l organizations and other institutions, with: Timelines, Performance Indicators, Costs
- Assessment of progress 5 years later, following invitation by UNFCCC at SBSTA 23 (2005); national reports; …

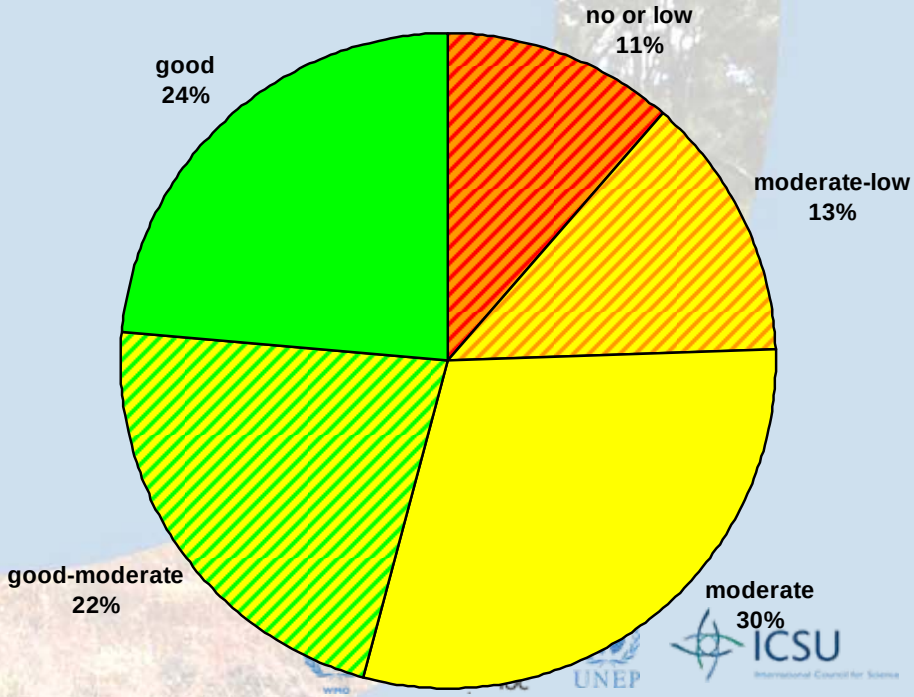
GCOS Progress Report 2004-2008 – Terrestrial

- Increasing **significance and recognition** of terrestrial data for climate change adaptation and impact studies
- Good progress in **defining standards** for observation of terrestrial variables
- Slow take-up of **institutional support** for terrestrial climate observations has limited some in-situ progress
- Networks dealt with by **research** community show some good progress
- Progress towards establishment of **Global Terrestrial Networks** (GTN) for many of the ECV's
- Good engagement of **satellite needs** including product development, reprocessing and continuity



GCOS Progress Report 2004-2008 – Summary

- Increasing profile of climate change has reinforced awareness of the importance of a Global Climate Observing System
- Developed Countries have improved their climate observation capabilities, but limited progress in resolving financial issues related to long-term continuity
- Developing Countries have only made limited (in-situ) progress, with decline in some regions, and capacity building support remains small in relation to needs
- Operational and Research Networks show increasing regard to climate needs; long-term continuity a challenge
- Satellite agencies have improved both mission continuity and capability and are increasingly meeting climate needs
- GCOS has progressed, but still falls short of meeting all UNFCCC needs



Спасибо!

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

Thank you

For more information about the GCOS programme
please visit our website

http://gcos.wmo.int

Contact Information
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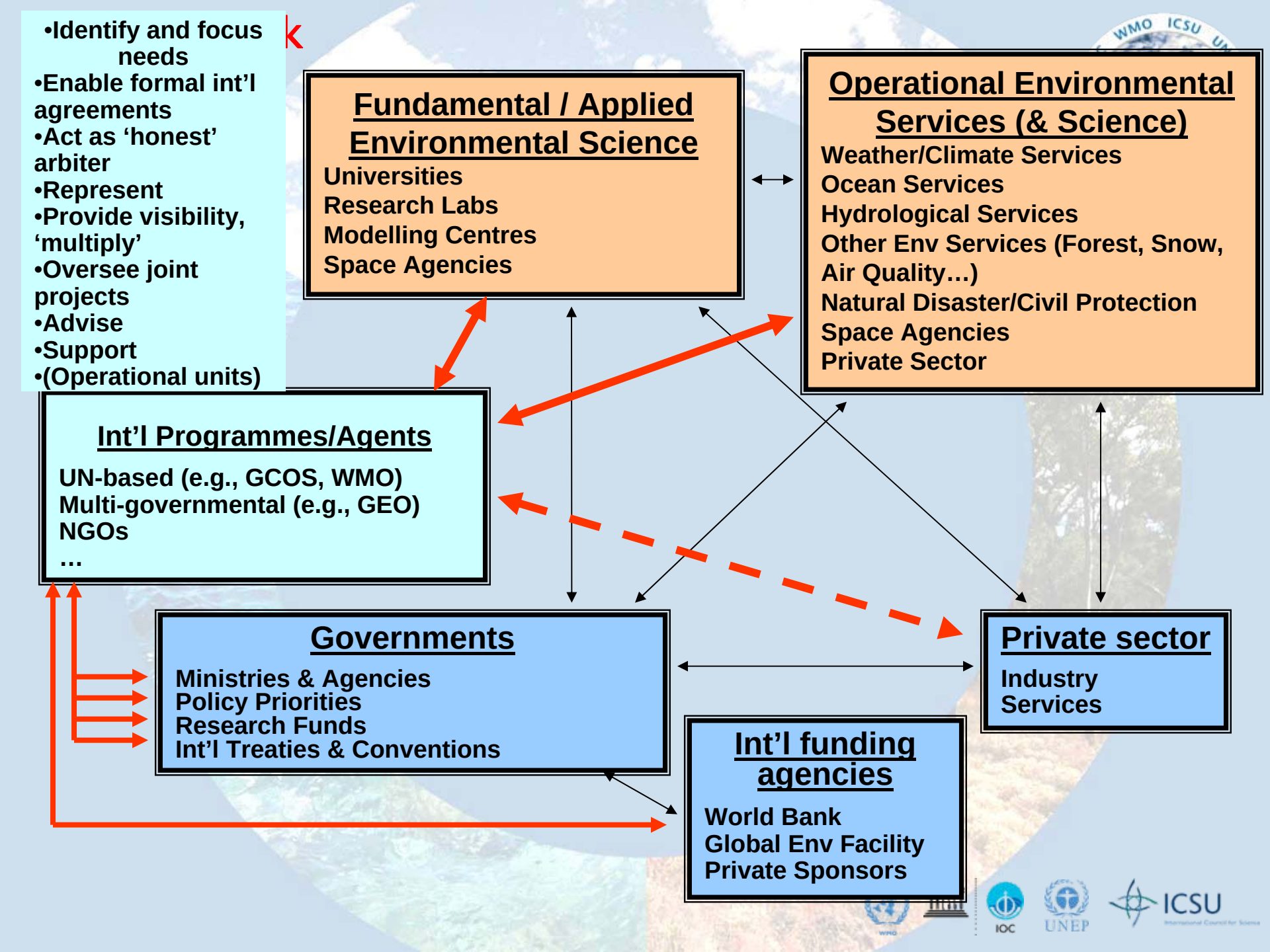
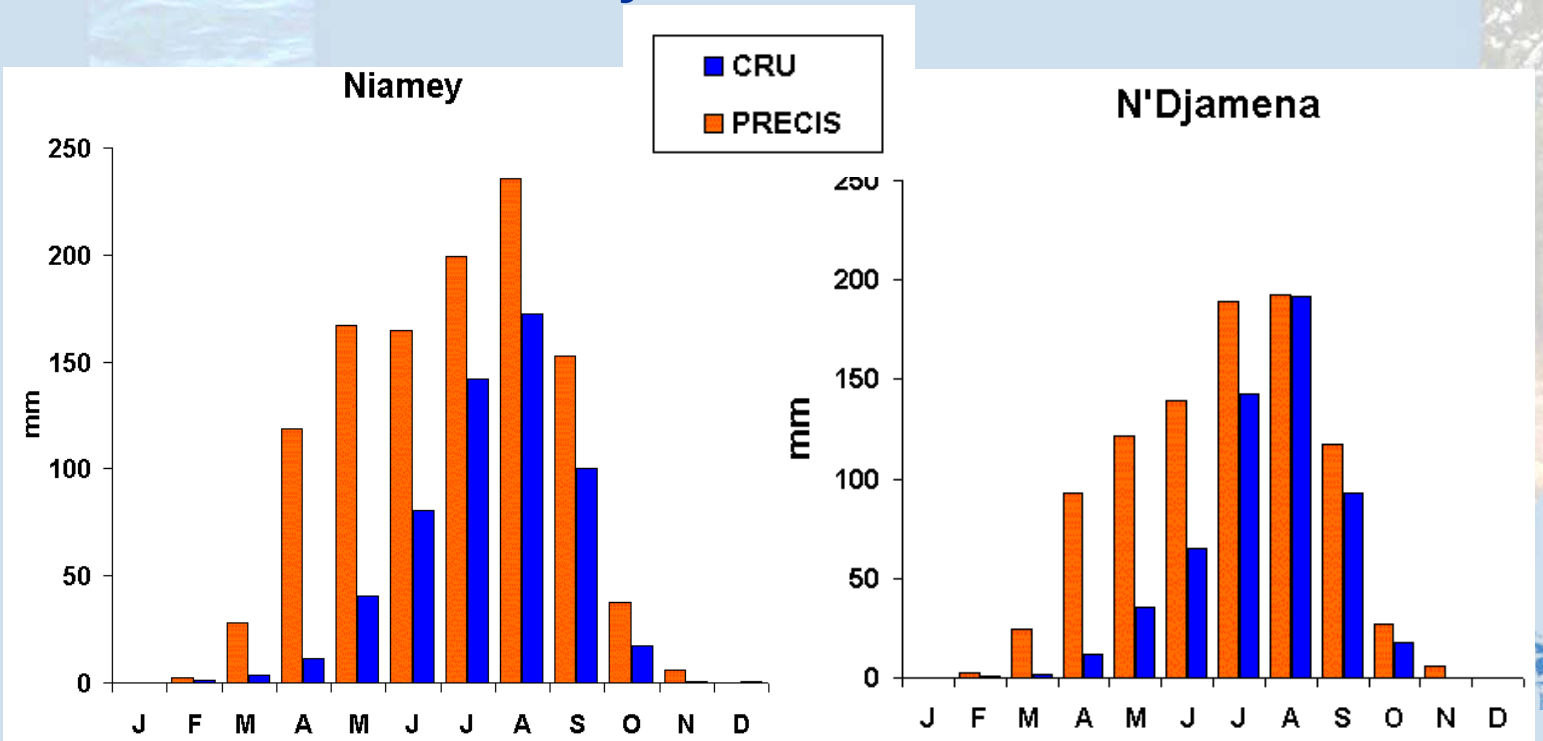

•Identify and focus needs
•Enable formal int'l agreements
•Act as 'honest' arbiter
•Represent
•Provide visibility, 'multiply'
•Oversee joint projects
•Advise
•Support
•(Operational units)
Fundamental / Applied Environmental Science
Universities
Research Labs
Modelling Centres
Space Agencies
Operational Environmental Services (& Science)
Weather/Climate Services
Ocean Services
Hydrological Services
Other Env Services (Forest, Snow, Air Quality…)
Natural Disaster/Civil Protection
Space Agencies
Private Sector
Int'l Programmes/Agents
UN-based (e.g., GCOS, WMO)
Multi-governmental (e.g., GEO)
NGOs
…
Governments
Ministries & Agencies
Policy Priorities
Research Funds
Int'l Treaties & Conventions
Private sector
Industry
Services
Int'l funding agencies
World Bank
Global Env Facility
Private Sponsors

GCOS Progress Report 2004-2008: Remarks

- Climate observations are essential for improving the skill of climate prediction models

- Such models are at the basis of impact, adaptation and vulnerability assessments.



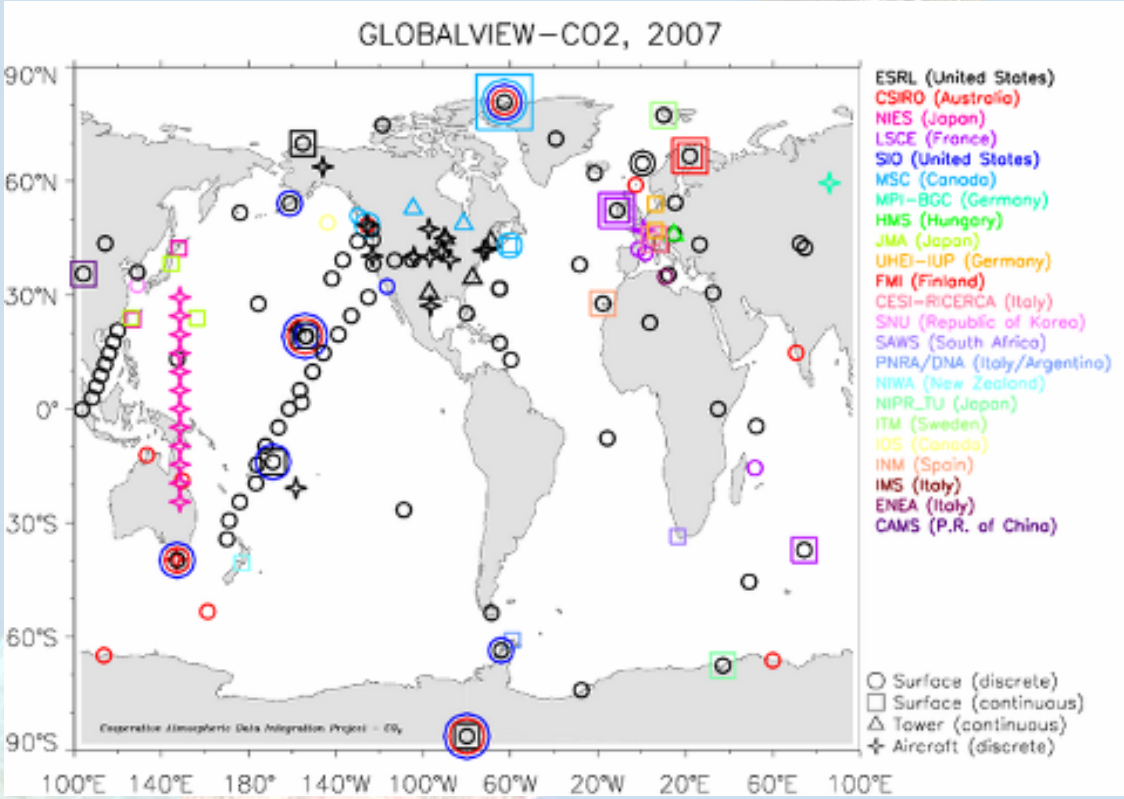
A. Kamga, April 2009

GCOS Progress Report 2004-2008: Atmosphere

- Mitigation assessment needs to be based, *inter alia*, upon reliable determination of sources and sinks of greenhouse gases; hence, observations of the changing distribution of these gases are needed.

Global network for in-situ observation of CO2

Good-Moderate Progress



GCOS Progress Report 2004-2008 – Atmosphere

- Good progress with availability, quality and exploitation of data from **satellites** for climate purposes across the range of ECVs, from basic meteorological variables to radiation and atmospheric composition
- Good progress in general with **in-situ meteorological networks**, and support through the system improvement programme has helped maintaining a baseline; however, overall progress in developing countries has been limited
- Some **specific issues** persist (e.g., measurement of precipitation, clouds, snow depth; precipitation data exchange; sunshine obs; metadata)
- Good progress in advancing **climate reference networks**
- Improved planning and progress with implementation of **atmospheric composition networks** meeting climate needs

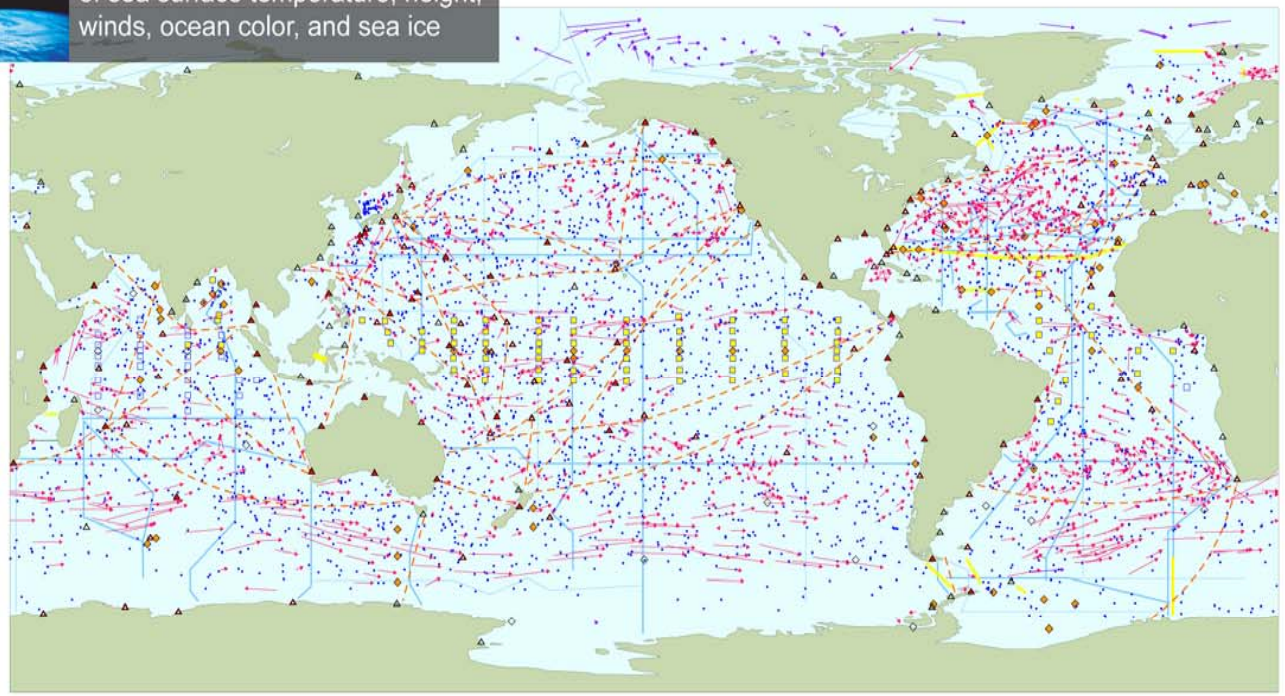
GCOS Progress Report 2004-2008 – Oceans

- **Useful progress in almost every action called for in the Plan, but many actions remain incomplete.**
- **The ice-free upper 1500 m of the ocean are being observed systematically for temperature and salinity for the first time in history.**
- **Most in-situ networks have made progress (e.g., tide gauges, moored reference sites, tropical moored arrays, full ocean depth observations)**
- **Most in-situ observing activities continue to be carried out under research agency support and on research programme time limits.**
- **Important progress in provision of critical ocean satellite data of sea surface ECVs has been made, but not for all variables, and data access remains to be ensured.**
- **Important progress in development of historical ocean reanalysis and in high resolution ocean forecasting capabilities.**
- **Promising developments in improved methods and standards will allow wider measurement of biological and chemical ECVs and consideration of new ECVs in the years ahead.**
- **Data sharing remains incomplete, particularly for tide gauges and biogeochemical ECVs. Data archeology needs to continue.**

GCOS Progress Report 2004–2008 – Oceans

continuous satellite measurements of sea surface temperature, height, winds, ocean color, and sea ice

Total *in situ networks* **60%** December 2008



87% **Surface measurements** from volunteer ships (VOS)

250 ships in VOSclim pilot project

100% Global **drifting surface buoy** array

ice buoys

5° resolution array: 1250 floats

66% **Tide gauge** network (GCOS subset of GLOSS core network)

fast data · slow/no data · GPS

170 real-time reporting gauges

81% **XBT** sub-surface temperature section network

51 lines occupied

100% Argo **profiling float** network

3° resolution array: 3000 floats

Transport monitoring 24%

29 sites

54% Global **time series** network

58 moorings planned

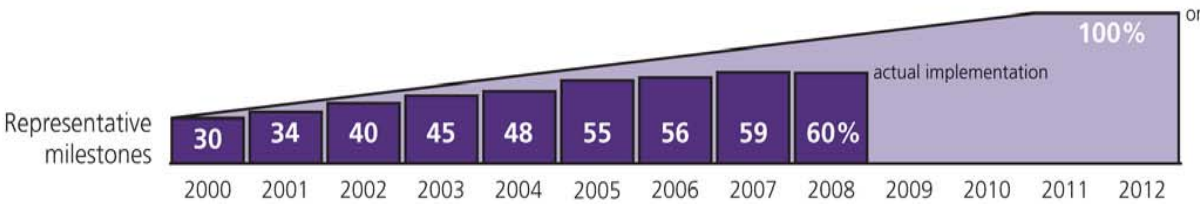
79% Global tropical **moored buoy** network

119 moorings planned

59% Repeat **hydrography** and **carbon inventory**

(planned)

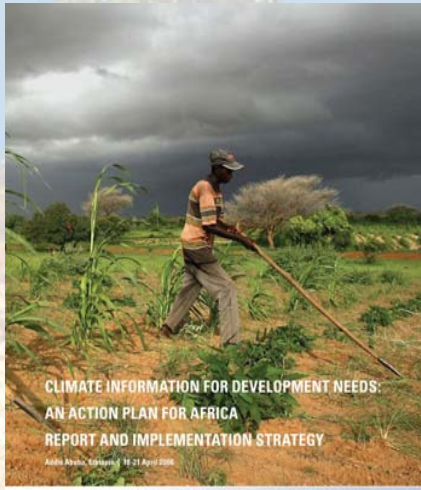
Full ocean survey in 10 years



System % of initial goals

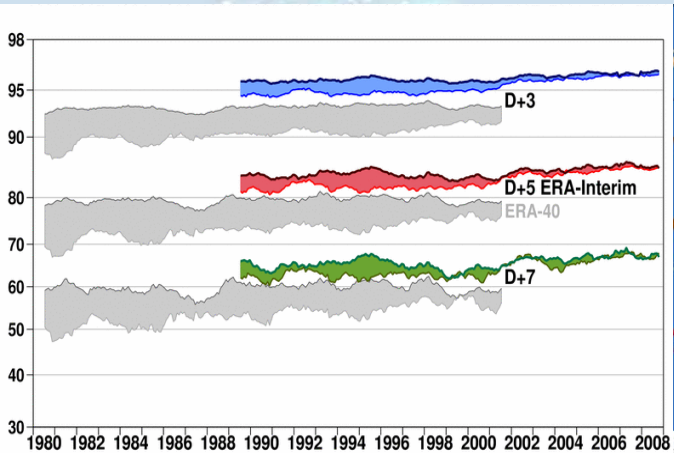
GCOS Progress Report 2004-2008 – Cross-cutting

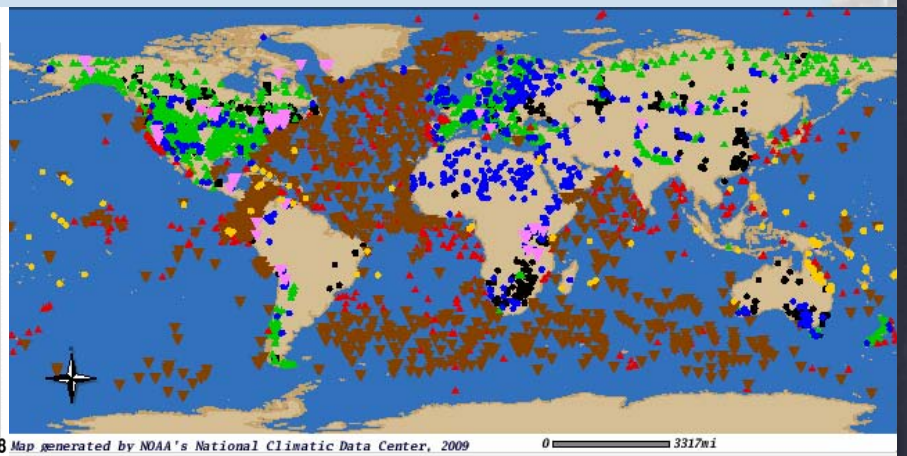
- Good engagement of GCOS IP by GCOS Sponsors and Partners
- Implementation is partial in many/most cases
- Increasing national attention to climate change observation needs, despite remaining gaps in national coordination
- Capacity building activities may have seen some improvement, but overall support to developing countries has fallen well short of needs
- Research networks and systems have been maintained, long-term continuity remains a challenge

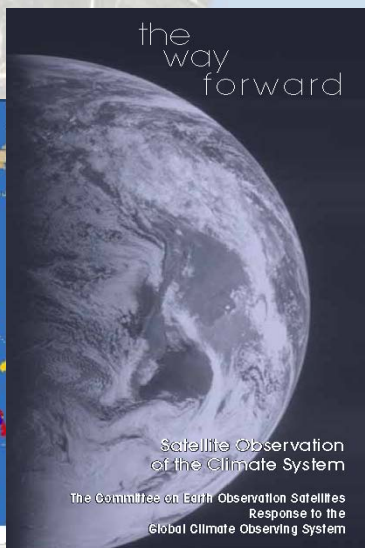


GCOS Progress Report 2004-2008 – Cross-cutting

- Good commitment to GCOS climate monitoring principles, and some improvements in data exchange
- Good engagement by satellite agencies
- Reprocessing, Analyses and Reanalysis progressing
- Moderate to good progress in the assembly of historical data records and in acquiring and archiving palaeoclimatic records
- National reports show financial difficulties and limits in most countries







GCOS Progress Report 2004-2008: Outlook to next 5 years

The preparation of the 2004-2008 Progress Report has helped to identify a number of important priorities for GCOS for the future, including:

- The urgent need for funding support for implementation of the GCOS Regional Action Plans developed over the period 2001-2006;
- Immediate attention to the design and implementation of the national and local-scale networks needed for impact assessment and adaptation to climate change;
- The appointment of GCOS National Coordinators in many more than the present 14 countries which have well established national coordination arrangements for climate observations;
- Much stronger and higher-level commitment of Parties to the GCOS Cooperation Mechanism for supporting GCOS implementation in developing countries;

GCOS Progress Report 2004–2008: Outlook to next 5 years

- Finding new mechanisms for ensuring sustained long-term operation of essential *in situ* networks, especially for the oceanic and terrestrial domains, that are presently supported from project-timescale research funding;
- Strong support for the further development and promulgation of observational standards for the full range of terrestrial climate variables;
- Continued encouragement for the coordinated implementation and long-term continuity of the cross-cutting space-based component of GCOS;
- Strong support for the observational and research-based "Global Framework for Climate Services" proposed for endorsement by World Climate Conference-3;
- Reaffirmation of the value of the UNFCCC National Reports on observations as a mechanism for fostering, focussing and guiding GCOS implementation at the national level.

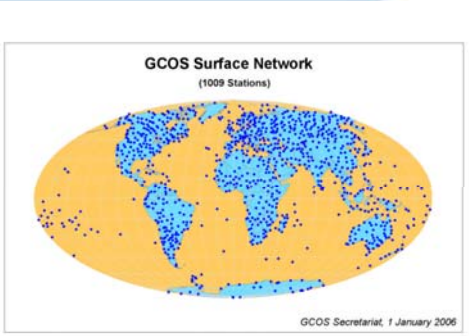
GCOS Strategy

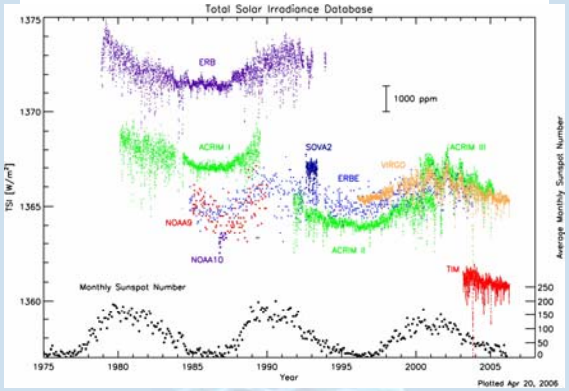
- **Identify observational requirements for climate applications**
- **Identify networks/systems needed to meet requirements**
- **Build on existing systems to the extent possible**
  - **Work with partners (Operational Services, Research Institutions, Archive Centres, Space Agencies, Academia, …)**
- **Engage intergovernmental, regional and national bodies**
  - **Sponsors (WMO, IOC)**
  - **UNFCCC/Conference of the Parties on 'systematic observation' requirements**
  - **National and regional entities**
  - **Group on Earth Observation (GEO)**
  - **Other organizations, coordination programmes and mechanisms (FAO, G8, 'Acronym soup')**
  - **Regional Workshops**
  - **Capacity building; System improvement**
- **Resource mobilization**
  - **Seek multi-governmental funding, national support: USA, UK, NZ, AUS, E, CH, D**
  - **Trust Fund (GCOS Cooperation Mechanism)**

Global Climate Observing System (GCOS)

- Since 1992 (after 2nd World Climate Conference)
- 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… data
- Sponsored by WMO, IOC/UNESCO, UNEP, ICSU
- Science panels (Atmosphere, Oceans, Terrestrial), Secretariat, Steering Committee, Experts
- National GCOS coordinators and focal points, National support (e.g., Swiss GCOS Office)

GCOS Milestones



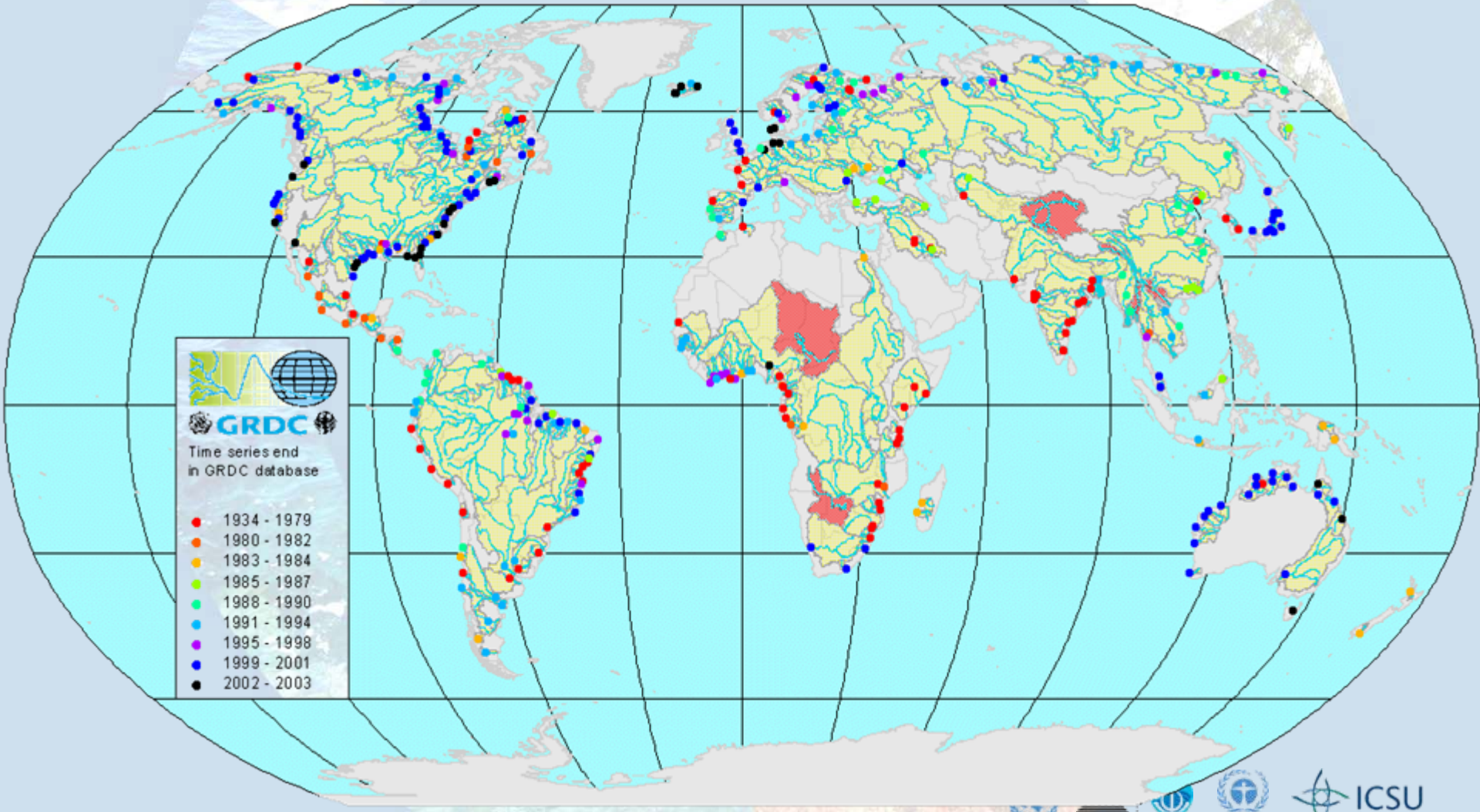


- **GCOS 2nd Adequacy Report (2003): identified gaps and deficiencies in observing systems**
- **GCOS Implementation Plan (2004): the roadmap for the global climate observing system in the next 5-10 years (in situ, space-based, models, institutions, agents…)**
- **September 2006: Publication of GCOS-107 "Systematic Observation Requirements for Satellite-based Products for Climate" ('Satellite Supplement' to GCOS IP)**
- **November 2006:**

  Climate Information for Development Needs: An Action Plan for Africa (Report and Implementation Strategy)

Global Terrestrial Network Rivers (GTN-R)

(380 river gauge stations)



IOC UNEP ICSU

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	