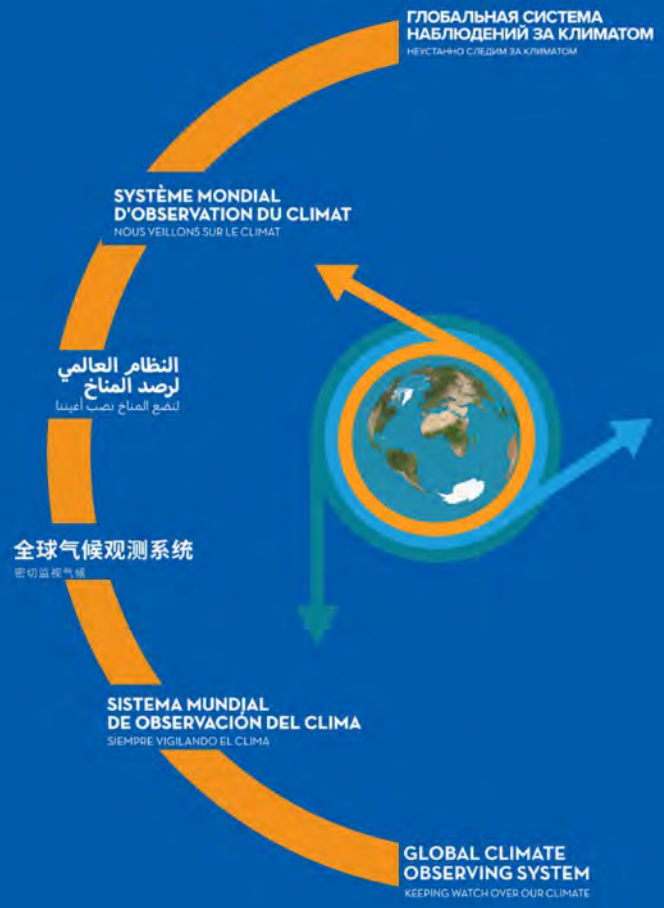


2.1 GCOS Origin
2.2 The history of GCOS

31st Session of the GCOS Steering Committee

Geneva, 2-5/07/2024

Thelma Krug and Peter Thorne

GLOBAL CLIMATE OBSERVING SYSTEM
KEEPING WATCH OVER OUR CLIMATE

WMO

unesco
Intergovernmental Oceanographic Commission

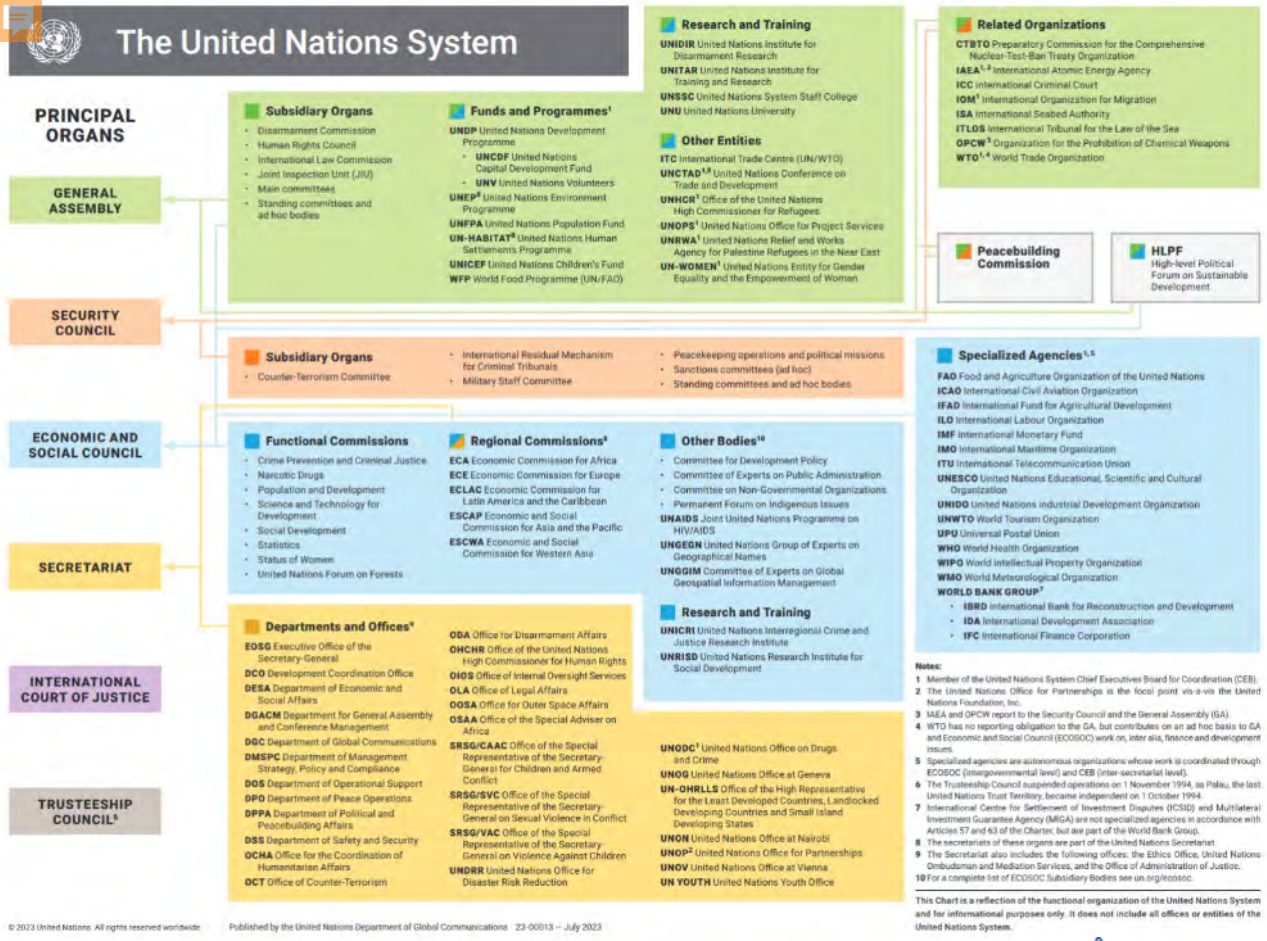
International Science Council

UN environment programme

Supported by the European Union

opernicus
Europe's eyes on Earth

Who takes care of climate?



Specialized Agencies[1,5]

- **FAO** Food and Agriculture Organization of the United Nations
- **ICAO** International Civil Aviation Organization
- **IFAD** International Fund for Agricultural Development
- **ILO** International Labour Organization
- **IMF** International Monetary Fund
- **IMO** International Maritime Organization
- **ITU** International Telecommunication Union
- **UNESCO** United Nations Educational, Scientific and Cultural Organization
- **UNIDO** United Nations Industrial Development Organization
- **UNWTO** World Tourism Organization
- **UPU** Universal Postal Union
- **WHO** World Health Organization
- **WIPO** World Intellectual Property Organization
- **WMO** World Meteorological Organization
- **WORLD BANK GROUP**[7]
  - **IBRD** International Bank for Reconstruction and Development
  - **IDA** International Development Association
  - **IFC** International Finance Corporation

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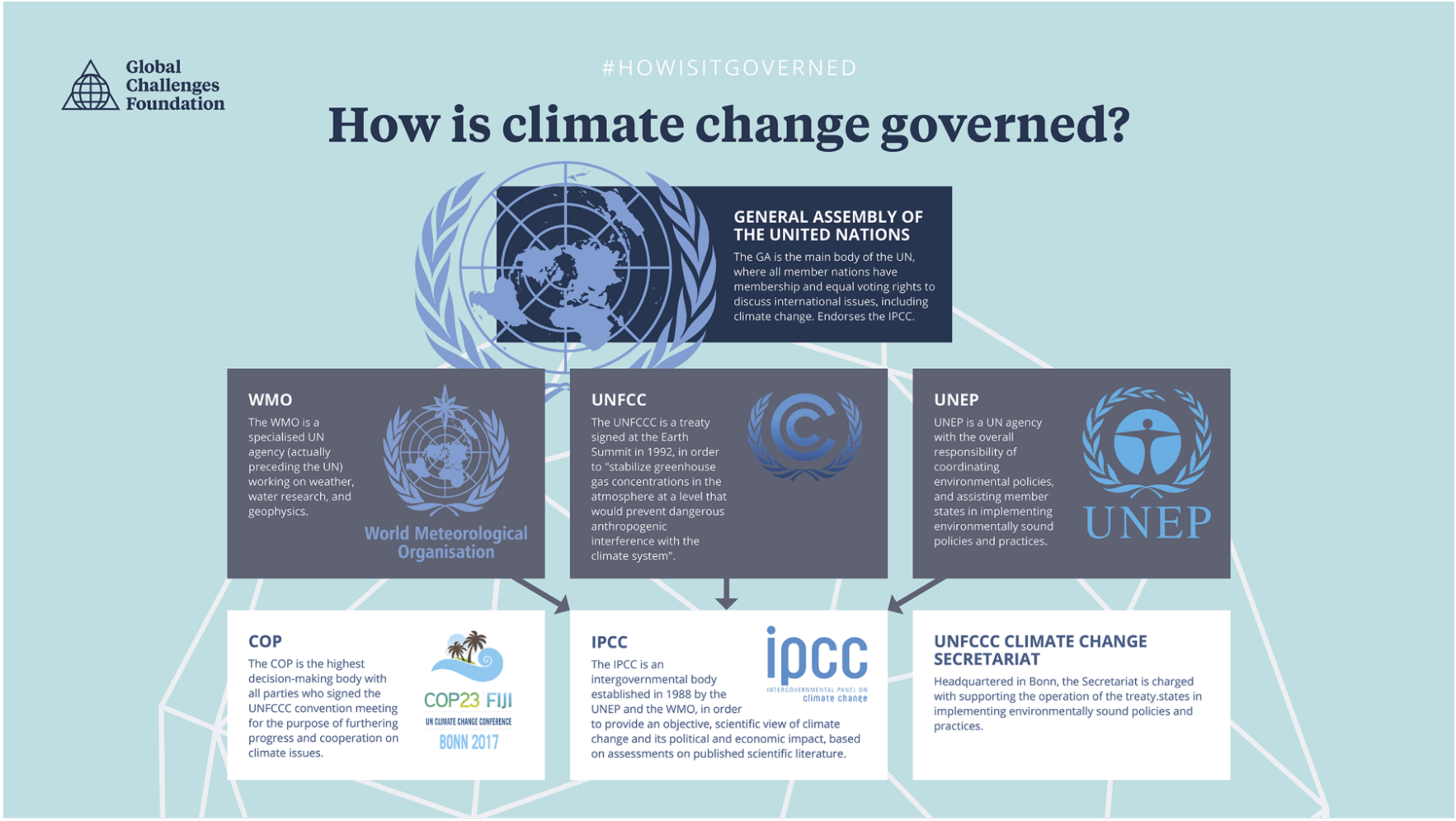
WMO

Who takes care of climate CHANGE?



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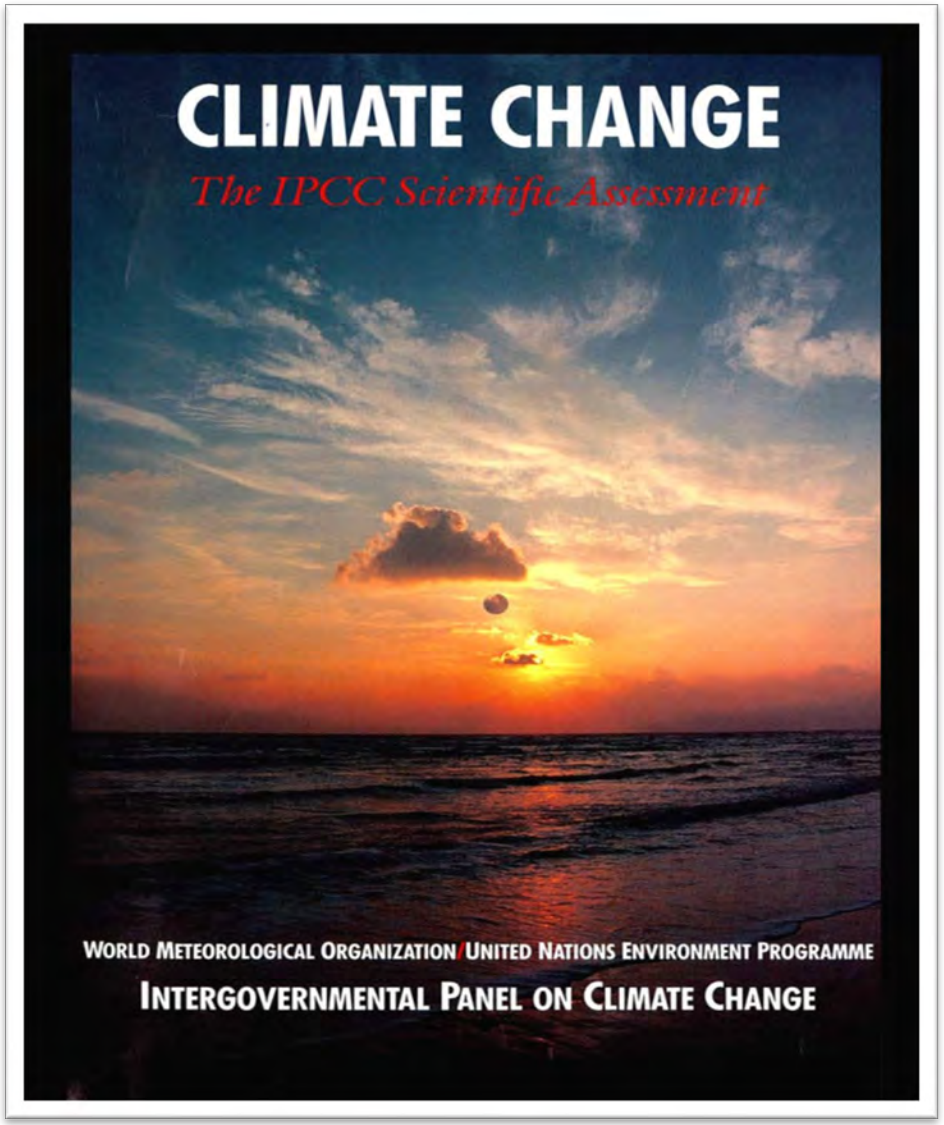
Who takes care of climate CHANGE?

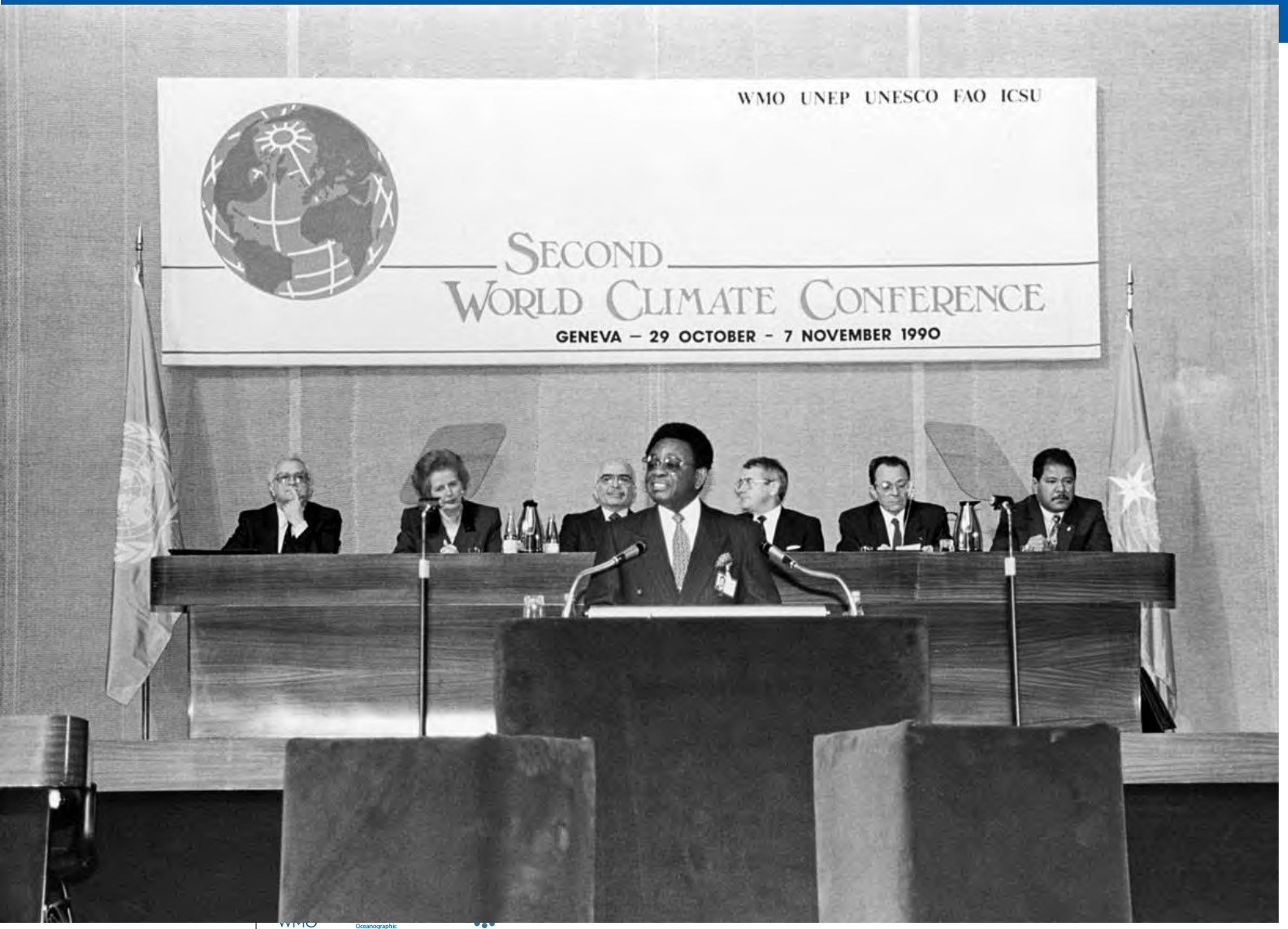
Importance of observations for Climate

IPCC First Assessment Report (1990)

IPCC concluded „that improved predictability of (human induced) climate change would require improved systematic observation of climate related variables on a global basis“

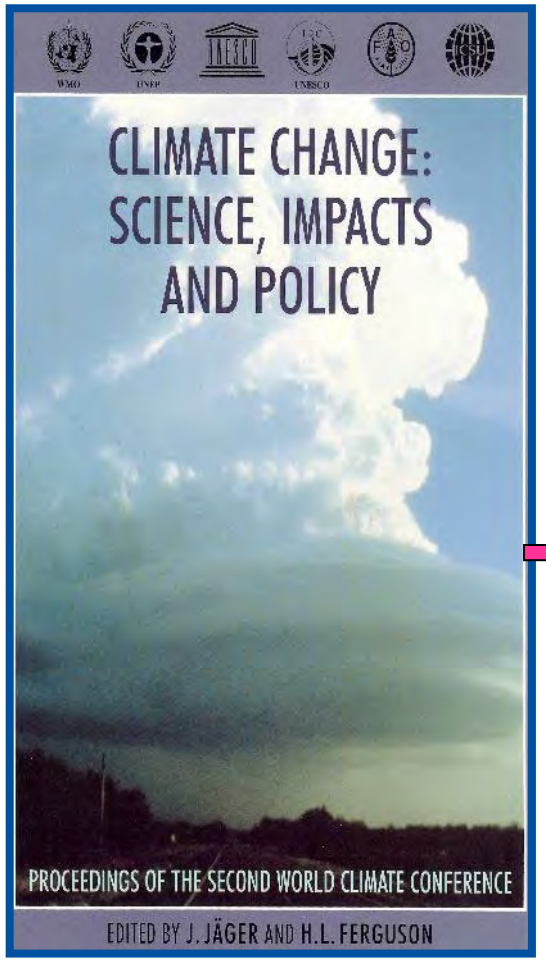


Second World Climate Conference (WCC-2) Ministerial Session

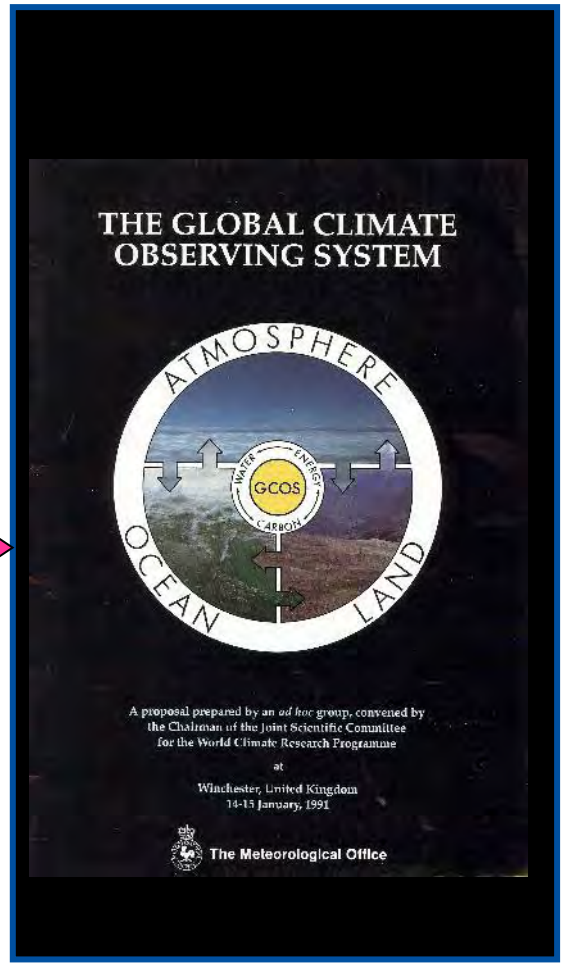


Establishment of GCOS

WCC-2
Ministerial Declaration
7 November 1990



Winchester Proposal
January 1991



GCOS MOU
April 1992

WMO, IOC of UNESCO, UNEP, ICSU

WMO, IOC, UNEP and ICSU

- Noting 1-6
- Recognizing…..
- Considering…
- Agree 1-5
- Agree further….
- Approve:
  - Annex A
  - Annex B
  - Annex C
- Agree….
- Agree….
- Agree….

Annex A Concept of the Global Climate Observing System

Annex B Terms of Reference, Structure and Functions of the JSTC and JPO

Annex C Financial Arrangements

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The Concept of GCOS

Goal	To provide comprehensive information on the total climate system, involving a multi-disciplinary range of physical, chemical and biological properties and atmospheric, oceanic, hydrologic, cryospheric and terrestrial processes.
Objectives	**To support all aspects of the World Climate Programme and relevant aspects of other climate-related global programmes…….**
Needs to be met	Climate system monitoring. Climate change detection and attribution. Operational climate prediction. Research towards improved understanding, modelling and prediction. Applications and services. Requirements of IPCC and UNFCCC.
Design philosophy	Build on existing operational and scientific observing, data management and information distribution systems (especially GOS, GAW, GOOS, GTOS, IGBP) and further enhancements of these systems

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UN Framework Convention on Climate Change (UNFCCC)
(May 1992)

Article 4 Commitments

All Parties shall:

1(g) Promote and cooperate in scientific, technological, technical, socio-economic and other research, systematic observation and development of data archives related to the climate system…….

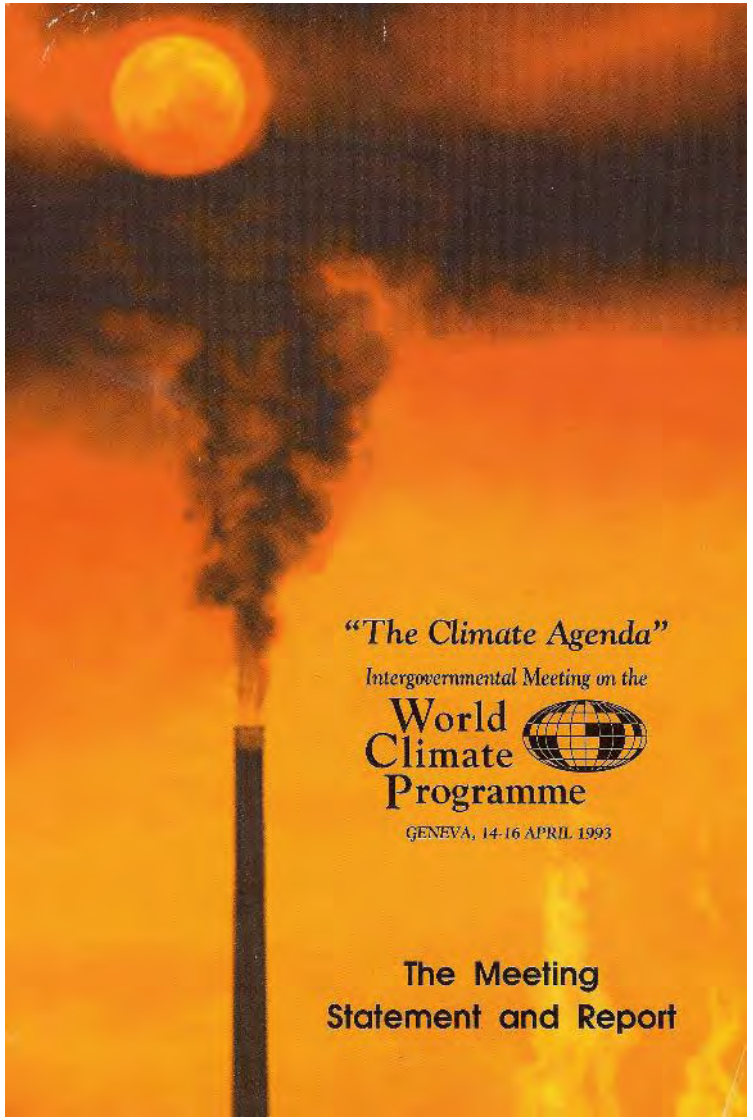
Article 5 Research and Systematic Observation

In carrying out their commitments under Article 4, paragraph 1(g), the Parties shall:

(a) Support and further develop…programs and networks or organizations aimed at defining, conducting, assessing and financing research, data collection and systematic observation, taking into account the need to minimize duplication of effort;

(b) Support international and intergovernmental efforts to strengthen systematic observation….particularly in developing countries, and to promote access to, and the exchange of, data and analyses thereof……

Intergovernmental Meeting (1993) and the Climate Agenda



Statement on the Climate Agenda (16 April 1993)

The Meeting ……endorsed the proposed four main thrusts of the World Climate Programme (WCP) and its associated activities:

- **Climate services for sustainable development;**
- **New frontiers in climate science and prediction**
- **Dedicated observations of the climate system**
- **Studies of climate impact assessments and response strategies to reduce vulnerability.**

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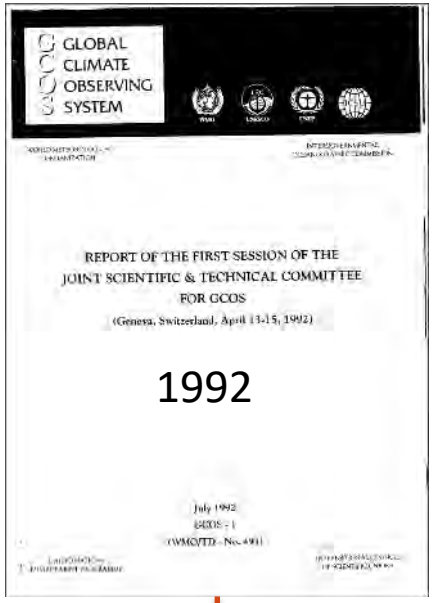
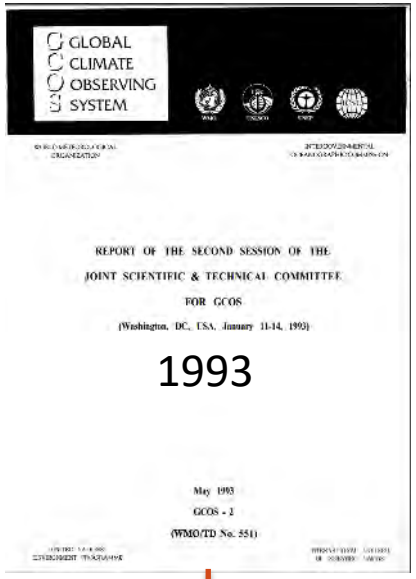
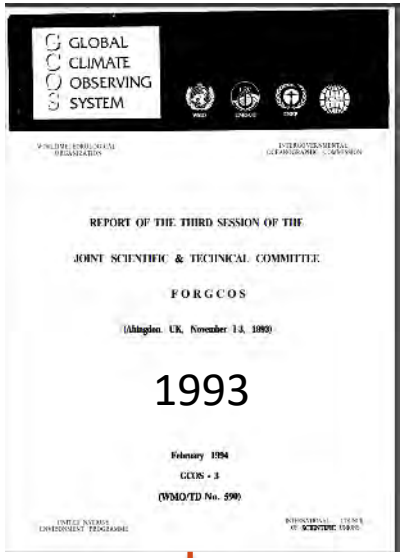


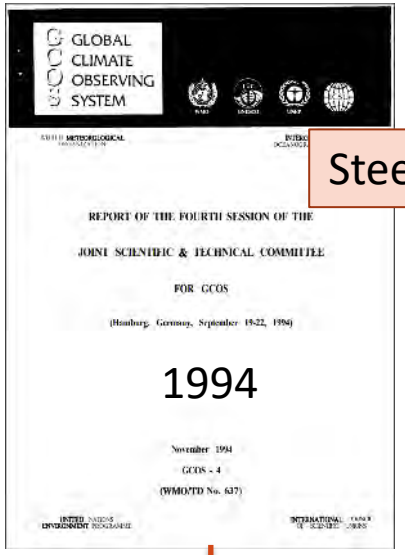
- Plans for a GCOS Implementation Plan
- Establishment of Task Groups
- Publishing of a brochure
- Funds



- Presentation of national Plans for GCOS: Germany, UK, Japan, Australia, Venezuela, Nigeria, China
- Establishment of groups to address the atmosphere, ocean, land surface processes and the data system



- Establishment of the 3 panels for atmosphere, terrestrial and oceanic observations
- Task groups on data management and space-based observations
- Reports of national activities



Steering Committee

- Report of the GCOS Data System Task Group
- Report of the GCOS Atmospheric Observation Panel: first session
- Report of the GCOS Space-based Observation Task Group
- Report of the GCOS/GTOS Terrestrial Observation Panel: first session
- Report of the GCOS Working Group on Socio-economic Benefits, first session

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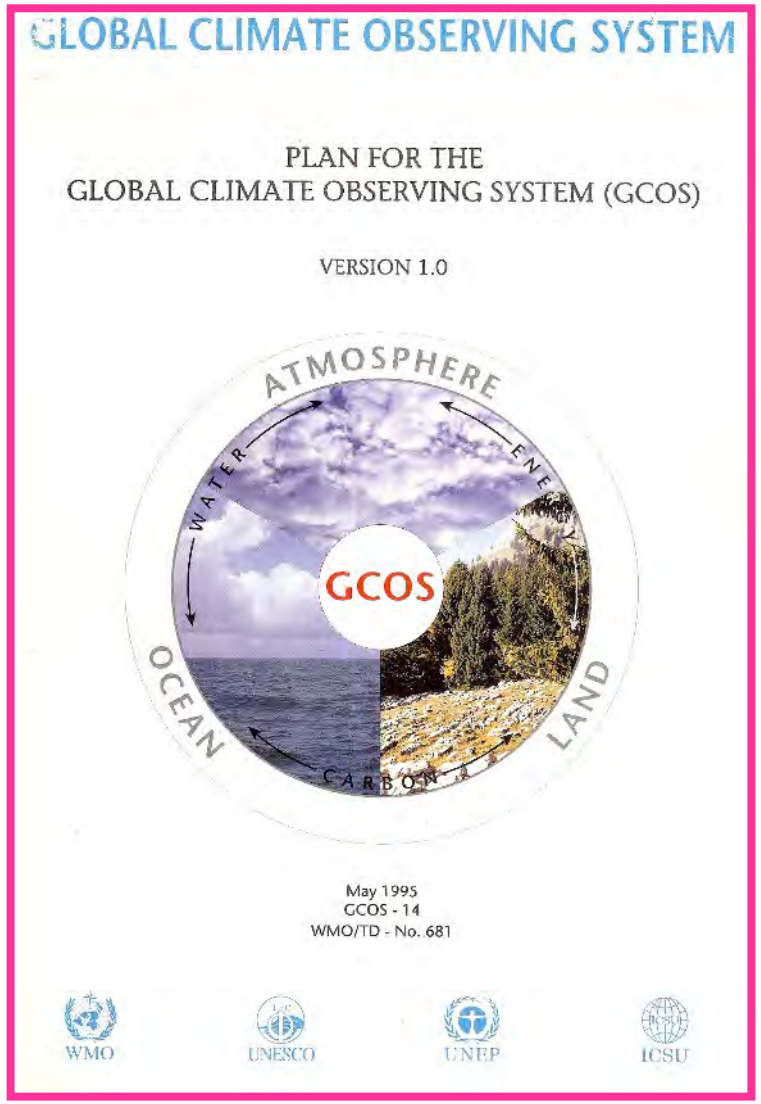
The GCOS Plan 1995


GLOBAL CLIMATE OBSERVING SYSTEM

PLAN FOR THE
GLOBAL CLIMATE OBSERVING SYSTEM (GCOS)

VERSION 1.0

ATMOSPHERE
WATER
ENERGY
GCOS
OCEAN
CARBON
LAND

May 1995
GCOS - 14
WMO/TD - No. 681

WMO UNESCO UNEP ICSU

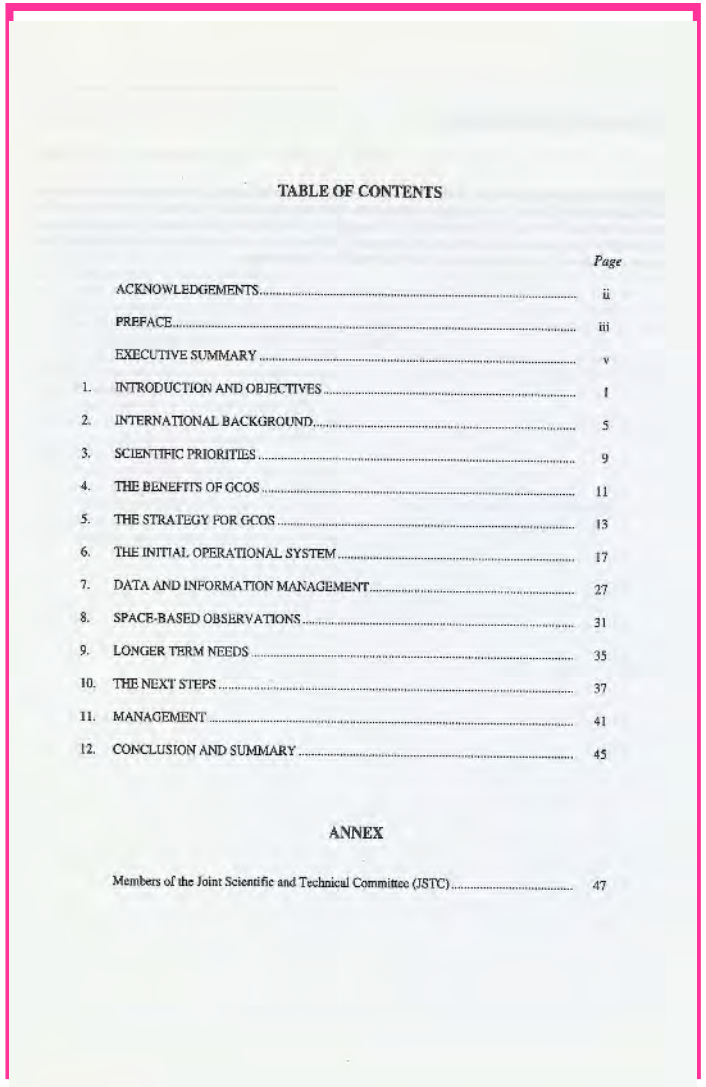
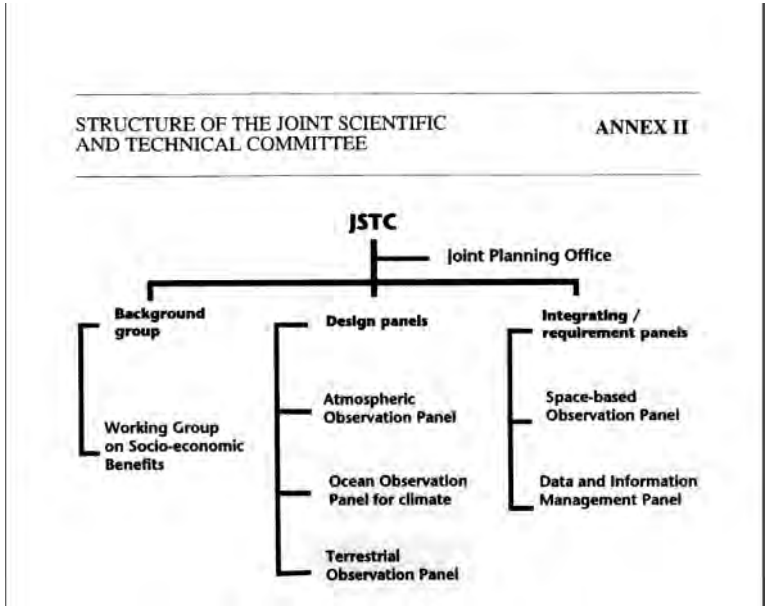


TABLE OF CONTENTS

The plan was the basis for the evolving activities of GCOS and presented the detailed plans for GCOS, including overall concepts, strategy, relevant scientific issues, recommendations and toles for participating organizations.


STRUCTURE OF THE JOINT SCIENTIFIC AND TECHNICAL COMMITTEE — ANNEX II

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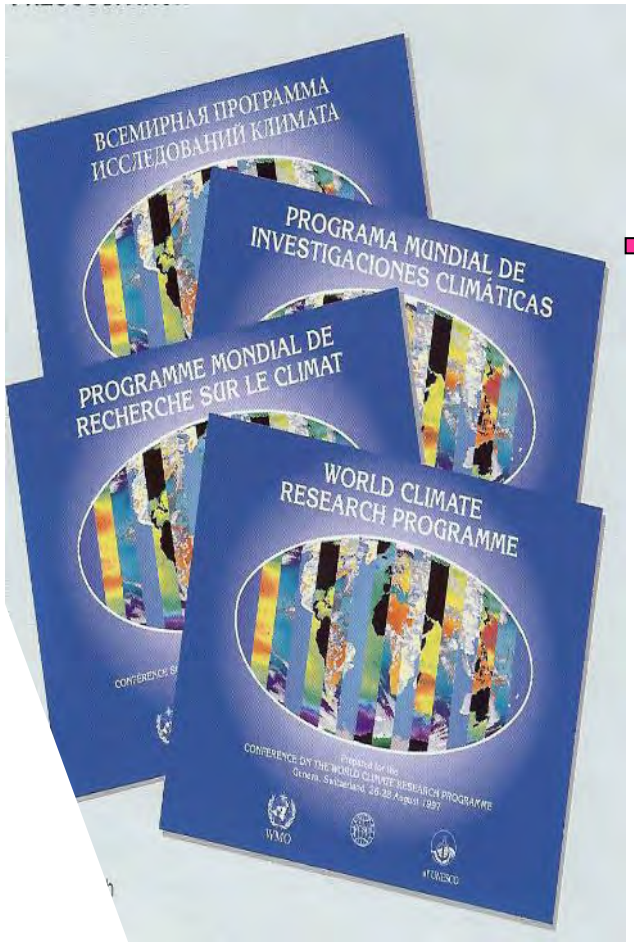
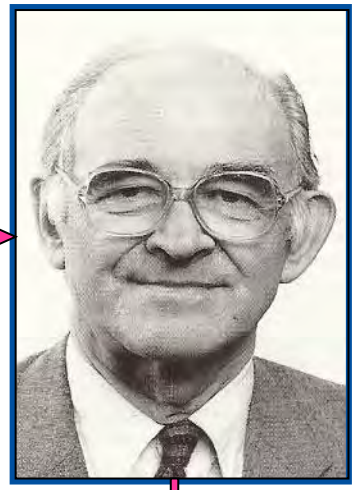
WCRP Conference, Kyoto, First Adequacy Report, Regional Workshops and Action Plans

WCRP Conference August 1997



Prof Bert Bolin



UNFCCC COP-3 Kyoto Dec 97

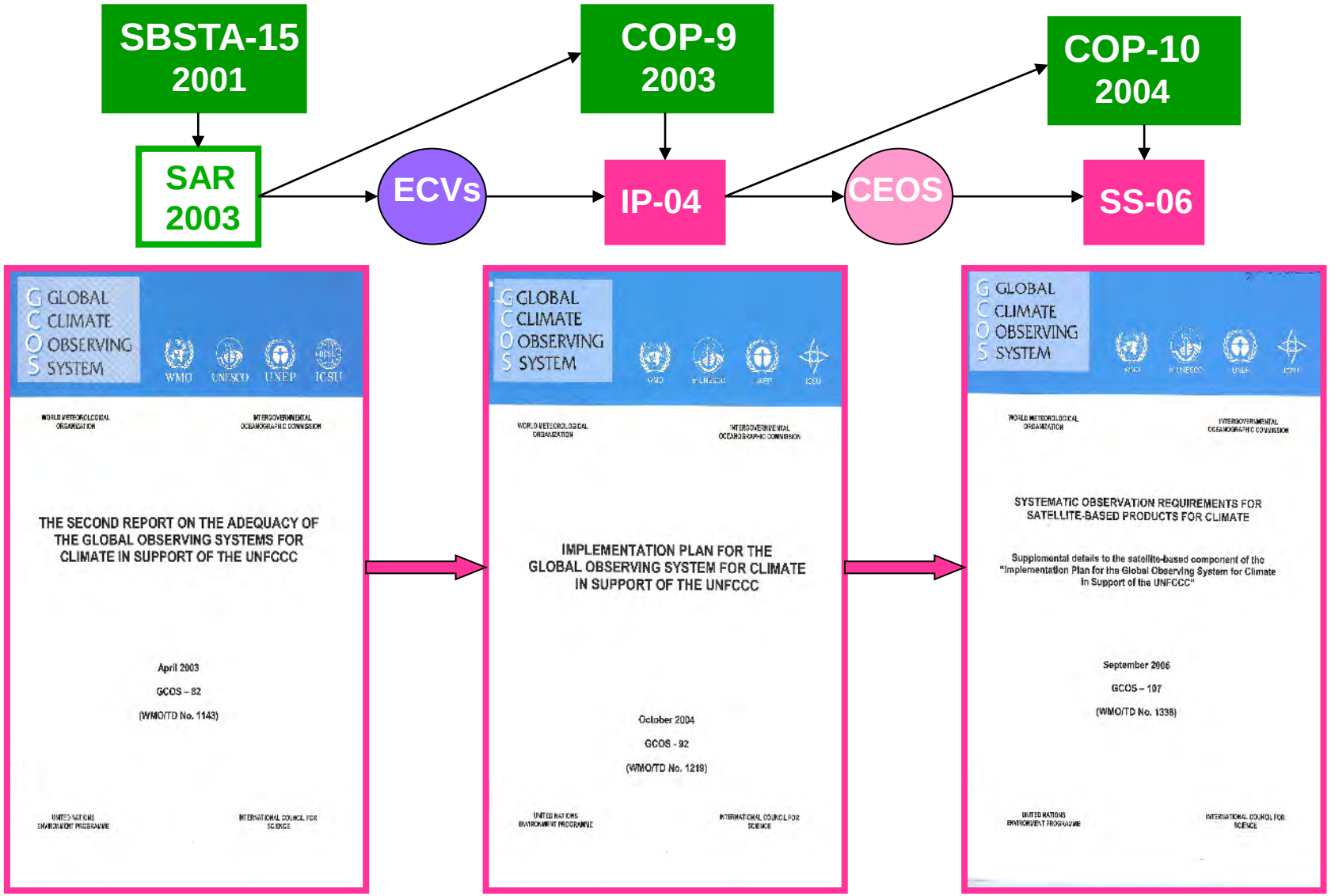
First Adequacy Report (FAR) (1998)

Regional Workshops (2000-06) (UNDP, GEF)

Regional Action Plans

- Pacific Islands
- Eastern and Southern Africa
- Western and Central Africa
- Central America and the Caribbean
- East and Southeast Asia
- Central Asia
- South and Southwest Asia
- South America
- Eastern and Central Europe
- Mediterranean Basin

Second Adequacy Report (2003), Implementation Plan (2004) and Satellite Supplement (2006)



The Essential Climate Variables

Conclusion 1: Achieving global coverage and climate-quality observations for the variables in table 1 is essential to ensure that the needs of the UNFCCC and the IPCCC for systematic climate information are addressed (2004)

Table 1. Essential Climate Variables that are both currently feasible for global implementation and have a high impact on UNFCCC requirements.

Domain	Essential Climate Variables	
Atmospheric (over land, sea and ice)	**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[5], Aerosol properties.
Oceanic	**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	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.	

GCOS Status Report - the assessment cycle

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:

–welcomed the 2010 Plan and urged Parties to work towards implementation

–invited a subsequent progress report and encouraged a review of adequacy

–welcomed the timetable proposed by GCOS for

- a Status Report in 2015
- a further Implementation Plan in 2016

Latest Documents

- Status Report 2021
- Implementation Plan 2022

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GCOS the first 15 years

Sponsors: WMO, IOC, UNEP, ISC

3 panels (Atmosphere, ocean, terrestrial); 2 cross-panel: data and information management (dissolved in 2000) and space/satellite observations (dissolved in 2000)

GCOS Secretariat: full director and administrative support, 3-4 scientific officers

Reporting to UNFCCC with status reports and implementation plans; GCOS monitoring principles 1999)

ECV concept: Implementation Plan in 2004 uses the ECV concept for 44 variables

National GCOS:

- Informal meetings with national Coordinators were held in 2000
- Brief summaries of GCOS-related activities in their respective countries, including Australia, China, Germany, Japan, Norway, Russian Federation and the United States were presented to GCOS SC (ex of 2000)
- Regional workshops to identify the priority capacity-building needs of developing countries related to participation in systematic observation were initiated (first regional workshop in 2000)
- National Communications on systematic observations for climate which are to be submitted to the UNFCCC/COP initiated

GCOS Cooperation Mechanism: established in 2004

Networks: GUAN and GSN established (1993), GTN-G, GTN-P established; no reference networks

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GCOS Reviews

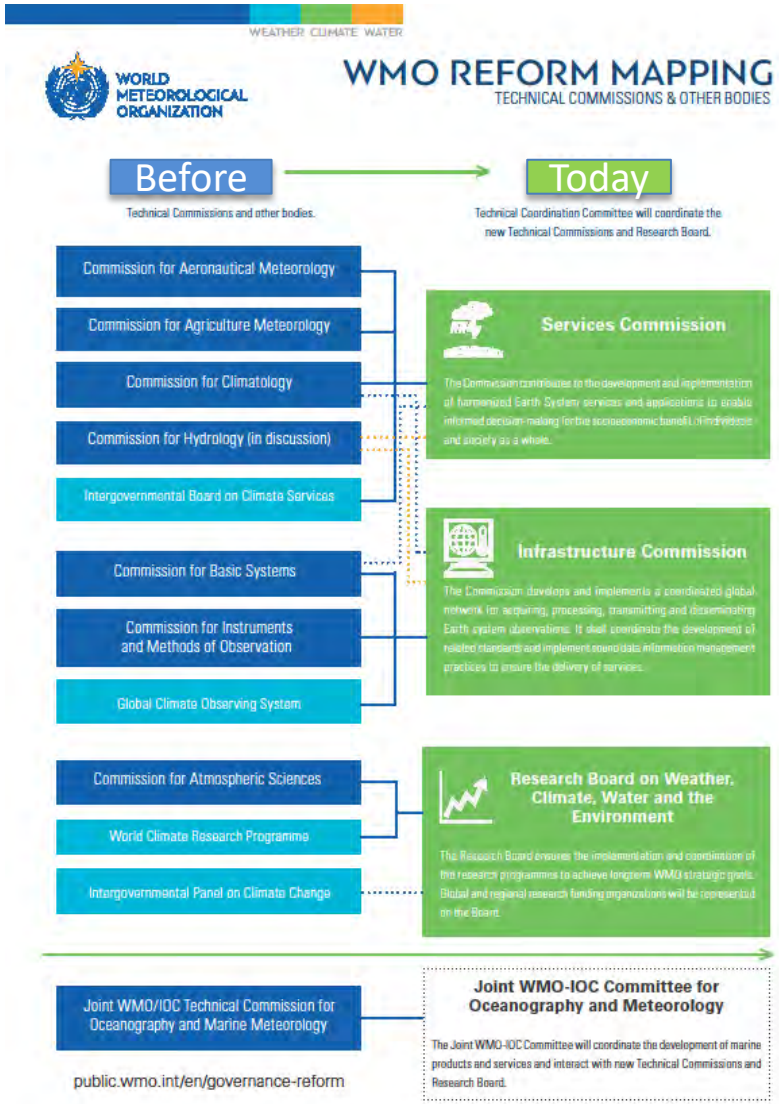
GCOS Review – 2012-2014

- The climate community needs GCOS
- Revision of the MoU: commitments from sponsors, optimized structure for the GCOS Secretariat, the Steering Committee and the Panels
- Support by a more stable financial foundation
- Increase visibility
- Improve terrestrial observations
- Better approach to capacity building
- Strengthen its ties to national governments by promoting the role of national and regional coordinators
- Develop a communication strategy to communicate the unique value of GCOS
- elaborate the ECV concept to specify its key deliverable and outputs

Joint Study Group on GCOS - 2020-2022:

- GCOS is recognized as a powerful and authoritative mechanism for the international coordination, planning, developing and review of Climate Observing Systems and networks.
- Revision of the MoU
- GCOS should improve its engagement with stakeholders and partners
- continue to address new challenges (energy, water and carbon climate cycles, support climate adaptation and mitigation measures and policies, and address the biosphere, biodiversity and biogeochemistry)
- Build close linkages with INFCOM and SERCOM

WMO REFORM



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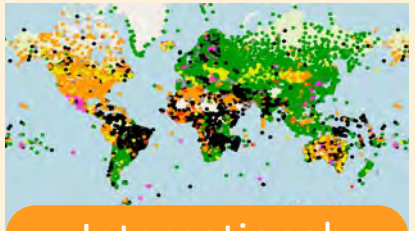
GCOS – Today

Climate-related infrastructure – must be designed and managed globally

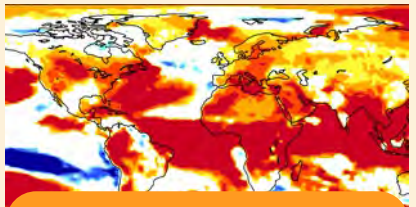
GCOS addresses observations and data exchange but is informed by the needs of the whole value chain

Observations from the entire globe



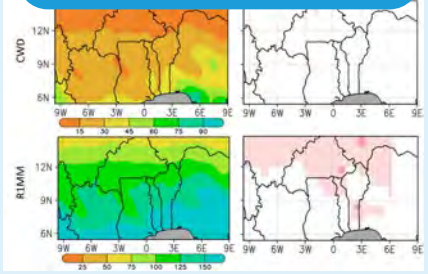
International exchange of observations

GLOBAL ACTIVITIES



Global climate modelling

Local Data Processing, forecast, warning and advisory products



Delivery of climate services

Effective decision making and action

Last-mile activities undertaken at regional, national and local level

GCOS role and impact

Climate Monitoring:
GCOS:
- works across systems and across domains ensuring the monitoring of all components of the climate system.
- provides priorities in terms of observations and reanalysis
- provides guidance on the design of future satellite missions and of in-situ networks (including reference networks)

Climate Services:
- GCOS supports the delivery of climate data, underpinning services.
- GCOS work on historical data exchange and data archive supports the Copernicus Climate Data Store and the provision of in-situ data required for reanalysis.
- C3S/Copernicus contractual agreements with services providers are determined by the list of ECV/ECV quantities defined by GCOS (and now being reviewed)

Climate policies:
- GCOS responds to the UNFCCC, periodically delivering the GCOS Status Report, the Implementation Plan and participating in the Earth Information Day
- Through its work in stewardship ECVs, GCOS provides information that is used in reports and assessments useful for decision making

Climate research:
- GCOS has ensured the continuity of global climate observations, resulting in reliable climate data records that are fundamental for climate research and for IPCC.
- The prioritization provided by the ECV framework helps streamlining funding to support research projects.
- Many of the long-standing GCOS-supported initiatives are done in collaboration with research partners such as the World Climate Research programme.

GCOS – Global Climate Observing System

GLOBAL CLIMATE OBSERVING SYSTEM

KEEPING WATCH OVER OUR CLIMATE

GCOS is a joint programme of:

- WMO
- IOC/UNESCO
- UNEP
- ISC

Major contributors:

- US State Dept.
- NOAA
- EU Commission

Established in 1992 to address the UNFCCC systematic observation agenda

a Chair — GCOS Steering Committee

Part time director and administrative support; 3 scientific officer and a network manager

Governed by a Steering Committee and supported by a Secretariat — GCOS Secretariat

WCRP World Climate Research Programme

- Atmospheric Observation Panel for Climate (AOPC)
- Ocean Observations Physics and Climate Panel (OOPC)
- Terrestrial Observation Panel for Climate (TOPC)

Guided by 3 panels of experts: AOPC, OOPC, TOPC

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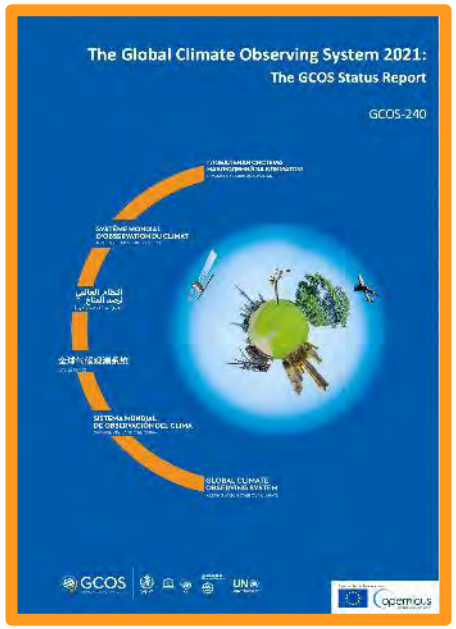
Reporting to UNFCCC

GCOS Status Report



Assess if the status of the observing system for climate meets those requirements

≃ 5 years cycle

Identify what we need to measure

GCOS ECVs Requirements and Implementation Plan

Propose actions to address gaps and improve the observing system for climate

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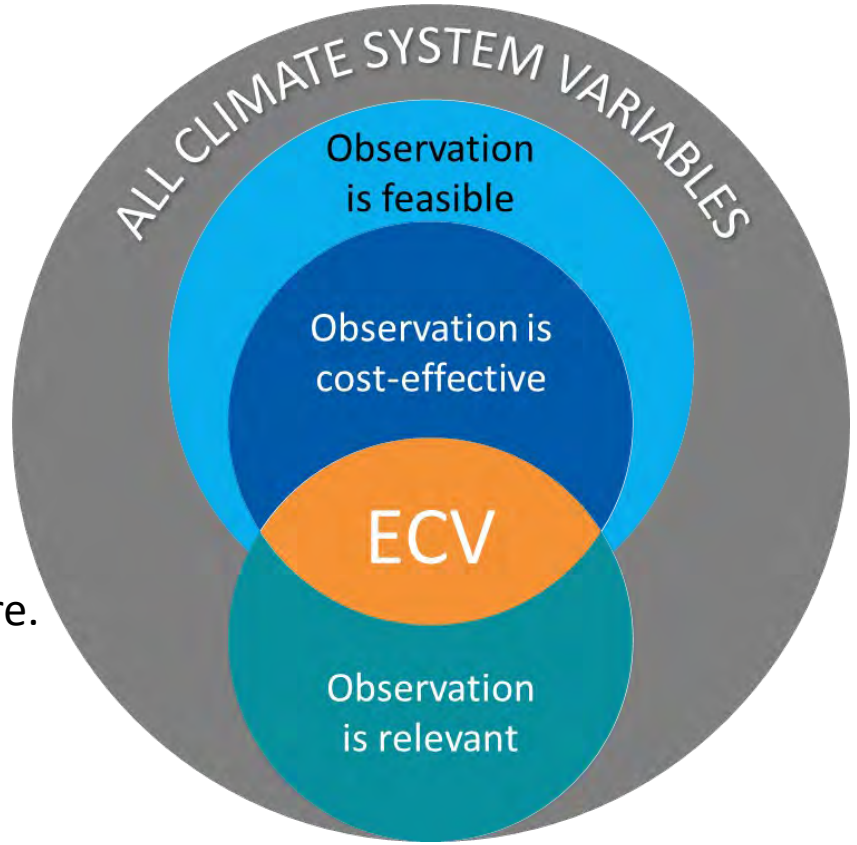
ECVs - Essential Climate Variables

GCOS developed and implemented the concept of Essential Climate Variables (ECVs) which are widely endorsed by the community and scientific programs.



Essential Climate Variables (ECVs)

- are physical, chemical or biological variables that critically contribute to the characterization of Earth's climate.
- are not stand-alone variables; they are part of a wider concept.
- are founded on climate science and observational capability and infrastructure.

ECV datasets provide the empirical evidence

- to understand and predict the evolution of climate,
- to guide mitigation and adaptation measures,
- to assess risks,
- to enable attribution of climatic events to underlying causes,
- to underpin climate services.

SOURCE: Bojinski et al. 2014

GCOS is acknowledged as the leading independent reference in defining requirements for climate observations

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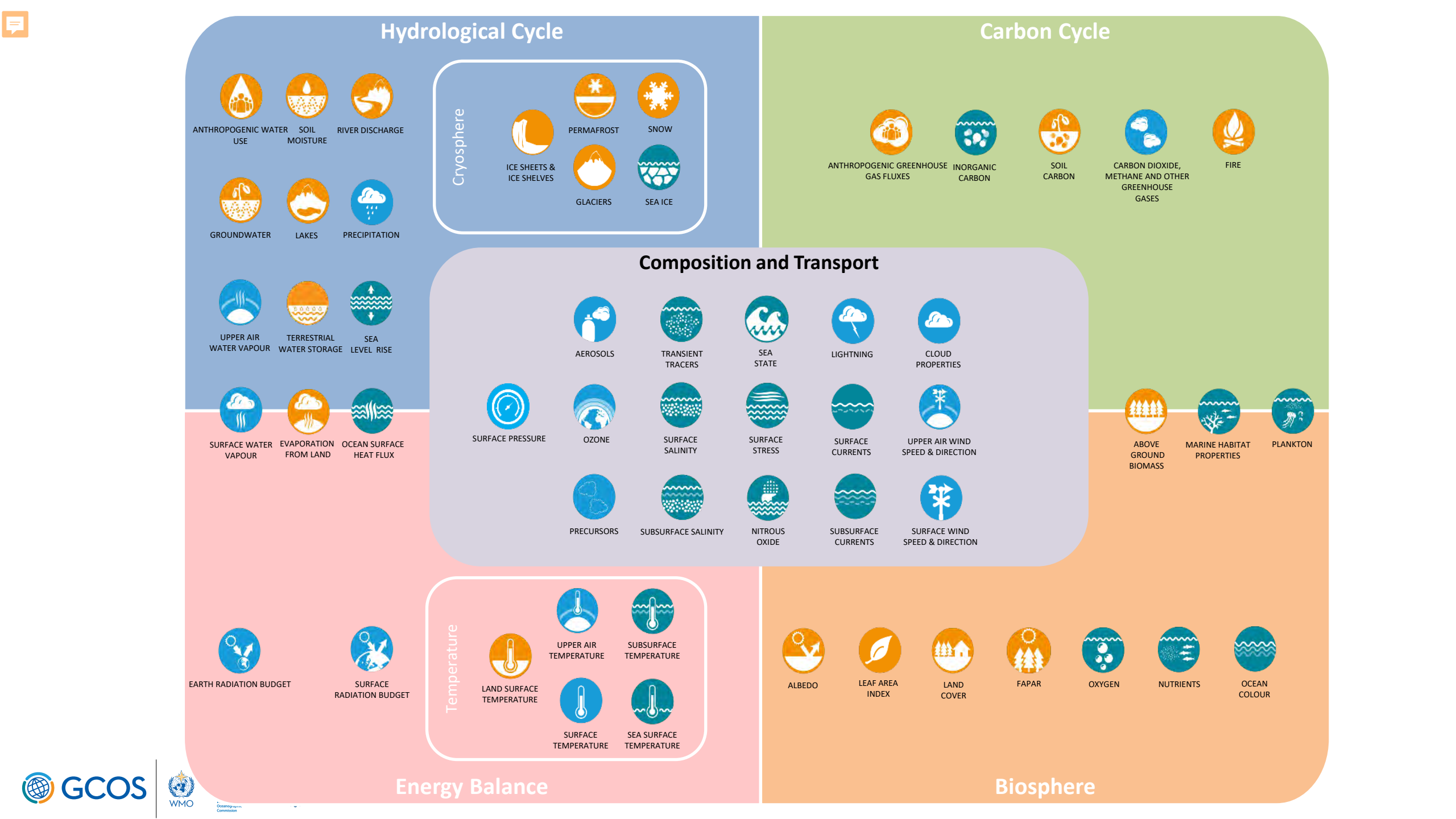

Hydrological Cycle
ANTHROPOGENIC WATER USE
SOIL MOISTURE
RIVER DISCHARGE
GROUNDWATER
LAKES
PRECIPITATION
UPPER AIR WATER VAPOUR
TERRESTRIAL WATER STORAGE
SEA LEVEL RISE
SURFACE WATER VAPOUR
EVAPORATION FROM LAND
OCEAN SURFACE HEAT FLUX
Cryosphere
ICE SHEETS & ICE SHELVES
PERMAFROST
SNOW
GLACIERS
SEA ICE
Carbon Cycle
ANTHROPOGENIC GREENHOUSE GAS FLUXES
INORGANIC CARBON
SOIL CARBON
CARBON DIOXIDE, METHANE AND OTHER GREENHOUSE GASES
FIRE
Composition and Transport
AEROSOLS
TRANSIENT TRACERS
SEA STATE
LIGHTNING
CLOUD PROPERTIES
SURFACE PRESSURE
OZONE
SURFACE SALINITY
SURFACE STRESS
SURFACE CURRENTS
UPPER AIR WIND SPEED & DIRECTION
PRECURSORS
SUBSURFACE SALINITY
NITROUS OXIDE
SUBSURFACE CURRENTS
SURFACE WIND SPEED & DIRECTION
ABOVE GROUND BIOMASS
MARINE HABITAT PROPERTIES
PLANKTON
EARTH RADIATION BUDGET
SURFACE RADIATION BUDGET
Temperature
UPPER AIR TEMPERATURE
SUBSURFACE TEMPERATURE
LAND SURFACE TEMPERATURE
SURFACE TEMPERATURE
SEA SURFACE TEMPERATURE
ALBEDO
LEAF AREA INDEX
LAND COVER
FAPAR
OXYGEN
NUTRIENTS
OCEAN COLOUR
Energy Balance
Biosphere

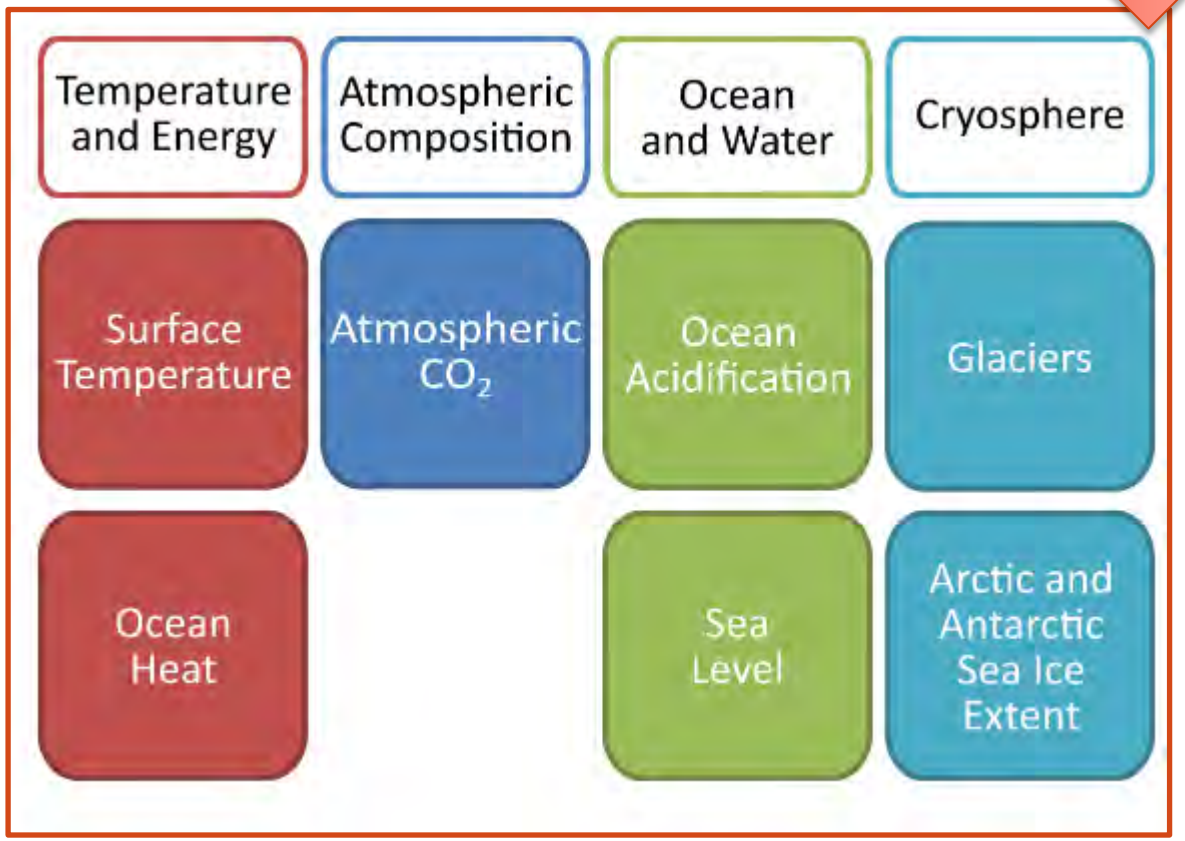
GCOS WMO

INDICATORS

Workshop in 2017:
Identify a set of climate change indicators to be used as a basis for reporting climate change to the public.

Overview of some of the existing work on climate/adaptation indicators (in 2017)

- Joint CCl/WCRP(Clivar)/JCOMM Expert Team On Climate Change Detection And Indices (ETCCDI)
- WCRP
- WMO
- C3S
- NASA, NOAA (mostly US focused
- UNEP/GEO
- IPCC/AR5
- ……..



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National GCOS and Regional Workshops

Some National GCOS still operate, but connection to GCOS Secretariat very limited.

Activities with national GCOS only recently resumed due to a lack of resources. Renewed TOR for GCOS National Coordinators and started contacts with National Coordinators of Switzerland, Germany, Ireland.
(more in item 7.4)

No regional workshops organized due to lack of resources

Pacific Islands - 2000
Eastern and Southern Africa – 2001
Central America and the Caribbean– 2002
East and Southeast Asia - 2002
Western and Central Africa - 2003
South America - 2003
South and Southwest Asia – 2004
Central Asia - 2004
Mediterranean Basin – 2005
Eastern and Central Europe -2005
Sout America - 2012
Pacific SIDS – 2017
East Africa – 2018
Caribbean - 2019

GCOS Cooperation Mechanism

- The GCM is the system improvement and resource mobilization activity of the GCOS programme. It has been established following a decision by the UNFCCC SBSTA in 2004 (UNFCCC Decision 5/CP.5) in order "to enable developing countries to collect, exchange, and utilize data on a continuing basis in pursuance of the UNFCCC".

- Since then, approximately 4 million USD was raised to accomplish projects dedicated to improving climate observation systems.

Training – Instrument Maintenance

Testing – Radiosonde System

Contributions to the GCM (Examples)
2007/08 : 780kchf (Netherlands, Germany, Switzerland, UK, Spain, Australia & Canada)

20014/15 : 230kchf (Germany, Japan & UK)

2021/22 : 30kchf (Germany)

Training – Communication

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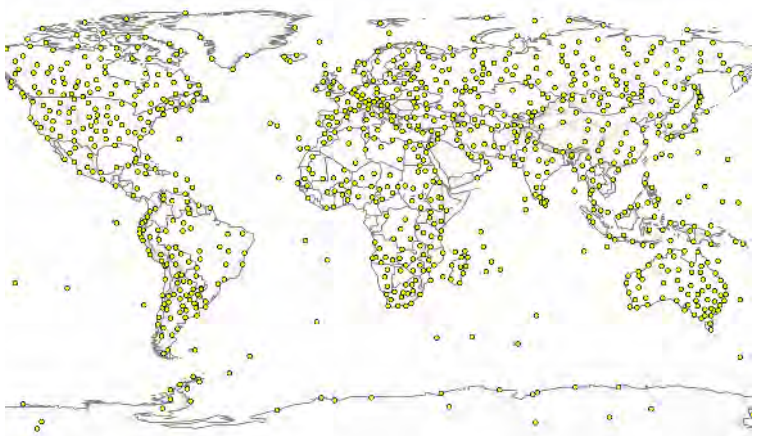
GUAN and GSN



GCOS Surface Network (GSN) 2023

RA-I	154 Stations (0)	No Changes
RA-II	258 Stations (0)	No Changes
RA-III	101 Stations (0)	No Changes
RA-IV	178 Stations (0)	No Changes
RA-V	153 Stations (0)	No Changes
RA-VI	139 Stations (0)	No Changes
ANTON	42 Stations (0)	No Changes
TOTAL	**1025 Stations (0)**	

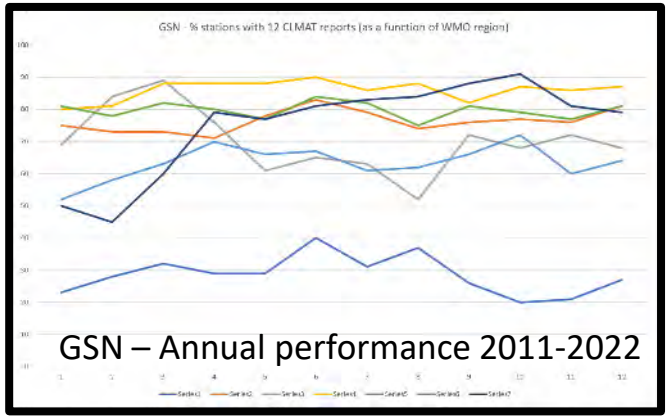
GCOS Upper Air Network (GUAN) 2023

RA-I	23 Stations (0)	No Changes
RA-II	38 Stations (0)	No Changes
RA-III	18 Stations (0)	No Changes
RA-IV	24 Stations (0)	No Changes
RA-V	39 Stations (0)	No Changes
RA-VI	24 Stations (0)	No Changes
ANTON	12 Stations (0)	No Changes
TOTAL	**178 Stations (0)**	

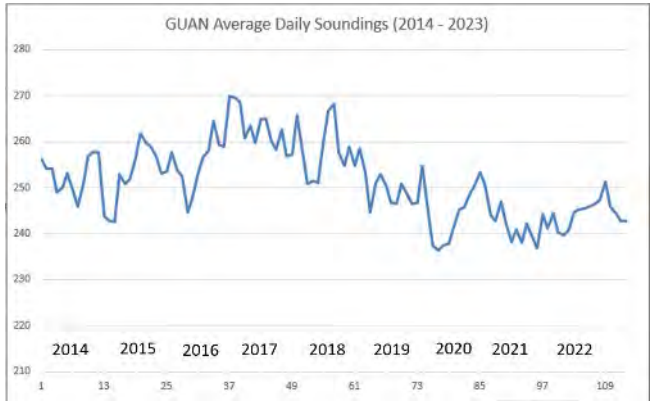
Networks implemented in 1994.

2001 : 987 GSN and 150 GUAN

2023: 1025 GSN and 178 GUAN



GSN – Annual performance 2011-2022



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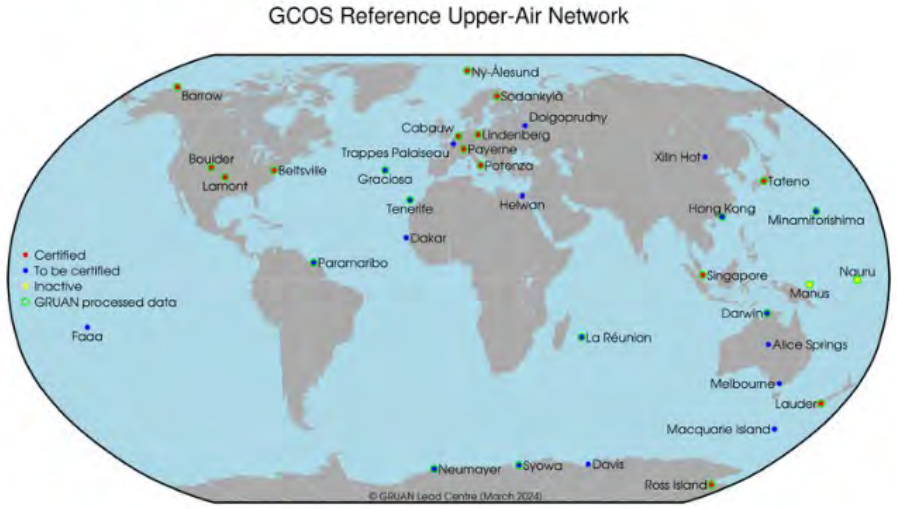
GCOS Reference Upper-Air Network

Established in 2008

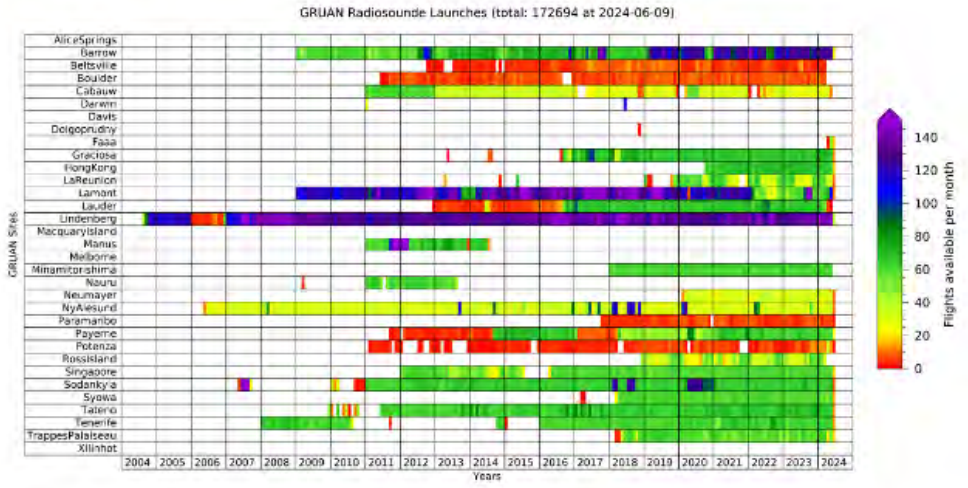
First 6 stations: Cabauw, Netherlands; Lindenberg, Germany; Potenza, Italy; Payerne, Switzerland; Sodankylä, Finland; Xilin Hot, China (2009)

Status of GRUAN sites



GRUAN is envisaged as a global network of eventually 30-40 measurement sites. To the extent possible, it builds on existing observational networks and capabilities. As at March 2024, GRUAN comprises of 33 sites, 14 of which have been GRUAN certified.

Status of data flow



A comprehensive volume of measurement data has been collected by GRUAN since 2008. The archive includes raw data and related meta-data. For the Vaisala RS41 & RS92 and the Meisei iMS-100 & RS-11G radiosondes, GRUAN Data Products (GDP) have been fully implemented and certified. Further GDPs are in certification process or under development.

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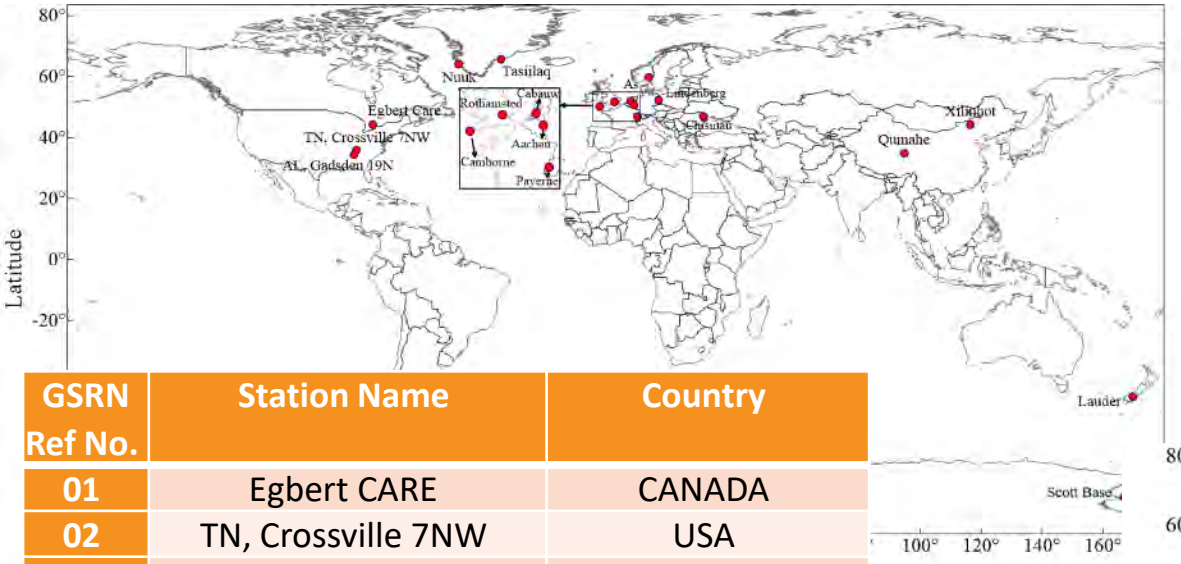
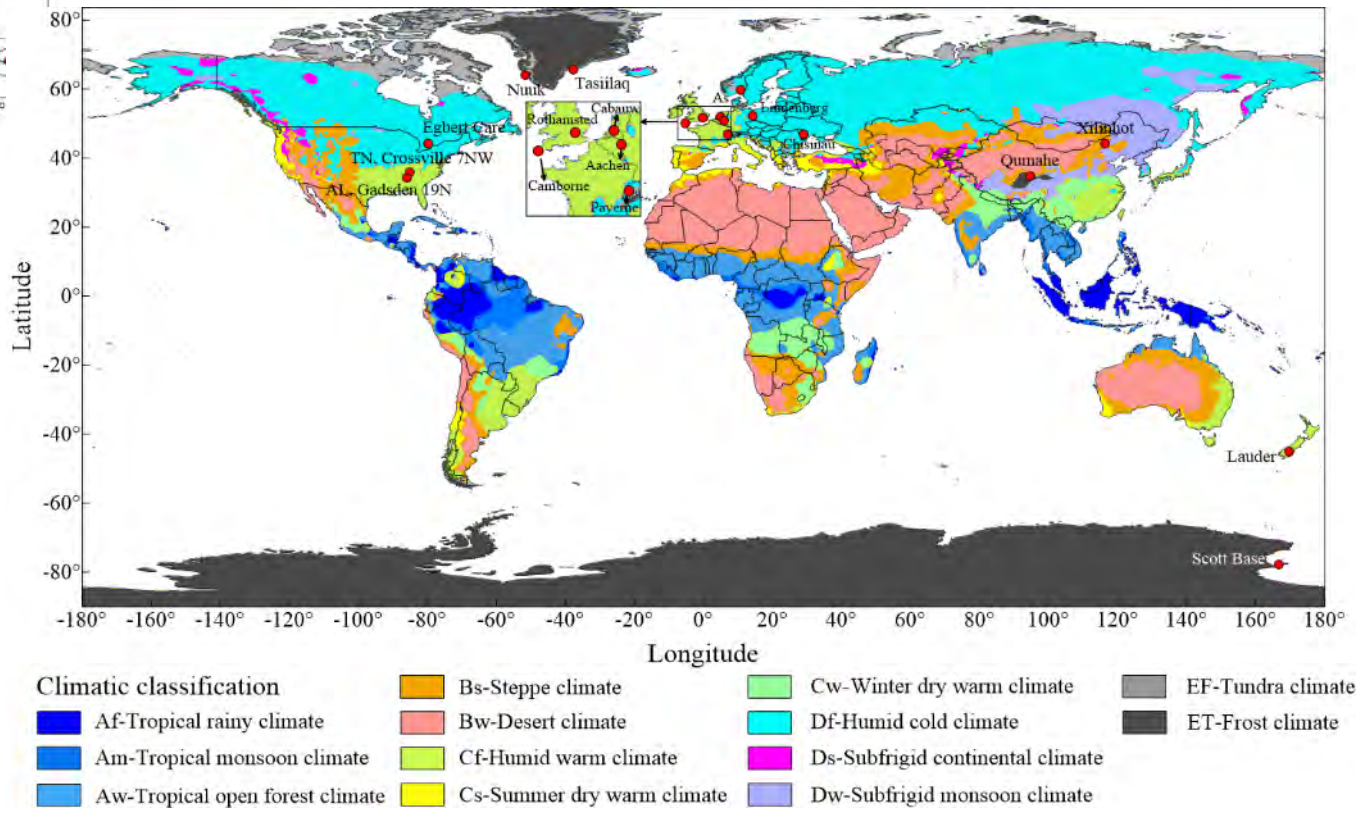
GSRN

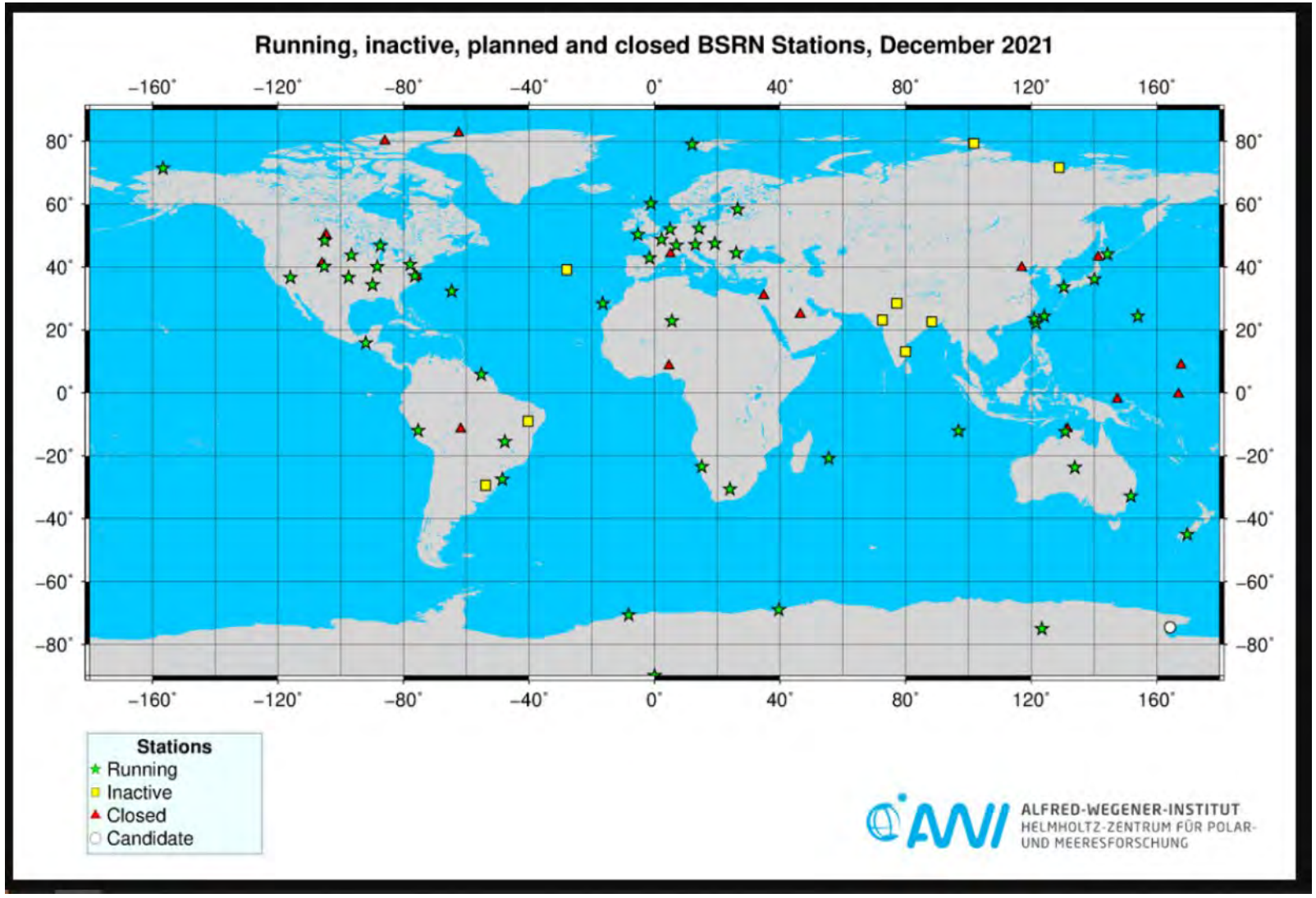


GSRN Ref No.	Station Name	Country
01	Egbert CARE	CANADA
02	TN, Crossville 7NW	USA
03	AL, Gadsden 19N	USA
04	Cabauw	THE NETHERLANDS
05	Chisinau	Republic of Moldova
06	As	NORWAY
07	Aachen	Germany
08	Lindenberg	Germany
09	Camborne	UK
10	Rothamsted	UK
11	Qumahe	China
12	Xilinhot	China
13	Payerne	Switzerland
14	Scott Base	New Zealand
15	Lauder	New Zealand
16	Nuuk	Denmark
17	Tasiilag	Denmark

Task Team for the implementation of the GSRN established in 2021
Lead Centre (CMA) established in 2022
Pilot Phase of GSRN started in 2023
1st Kick-off meeting 5th February 2024



BSRN



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GTN-R – Global Terrestrial Networks for Rivers (part of the GRDC – Global Runoff Data Centre)

October 2004:

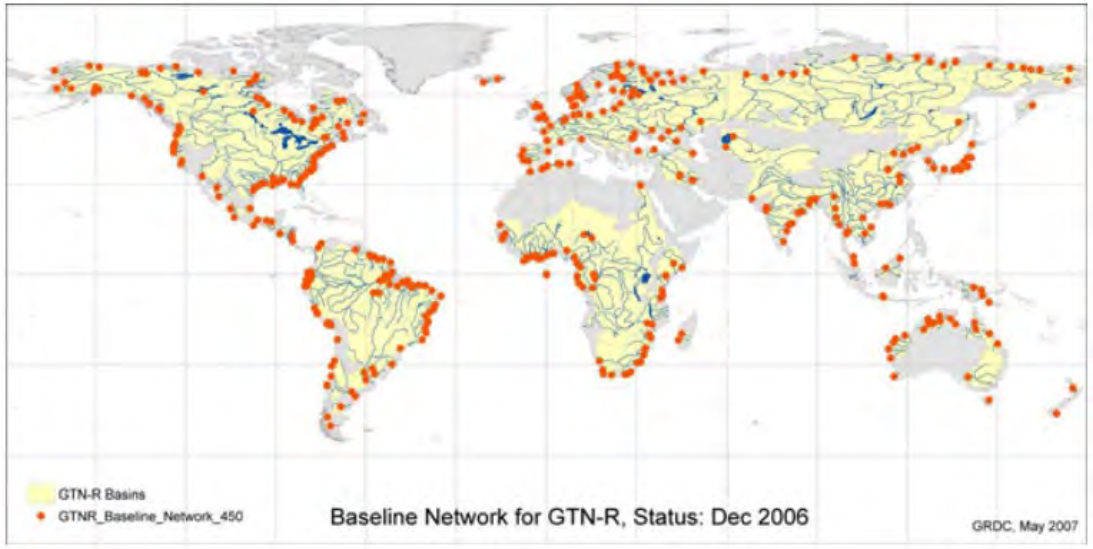
- **GCOS-IP*** Proposed as a GCOS Baseline River Discharge starting with ≃ 380 reference stations near the downstream end of the largest rivers of the world, capturing ≃ 70% of the global freshwater flux to the oceans.
- Subset of GRDC stations to provide climate-relevant data for global assessments and models.

April 2005: GCOS secretariat sent out a data request and support letter

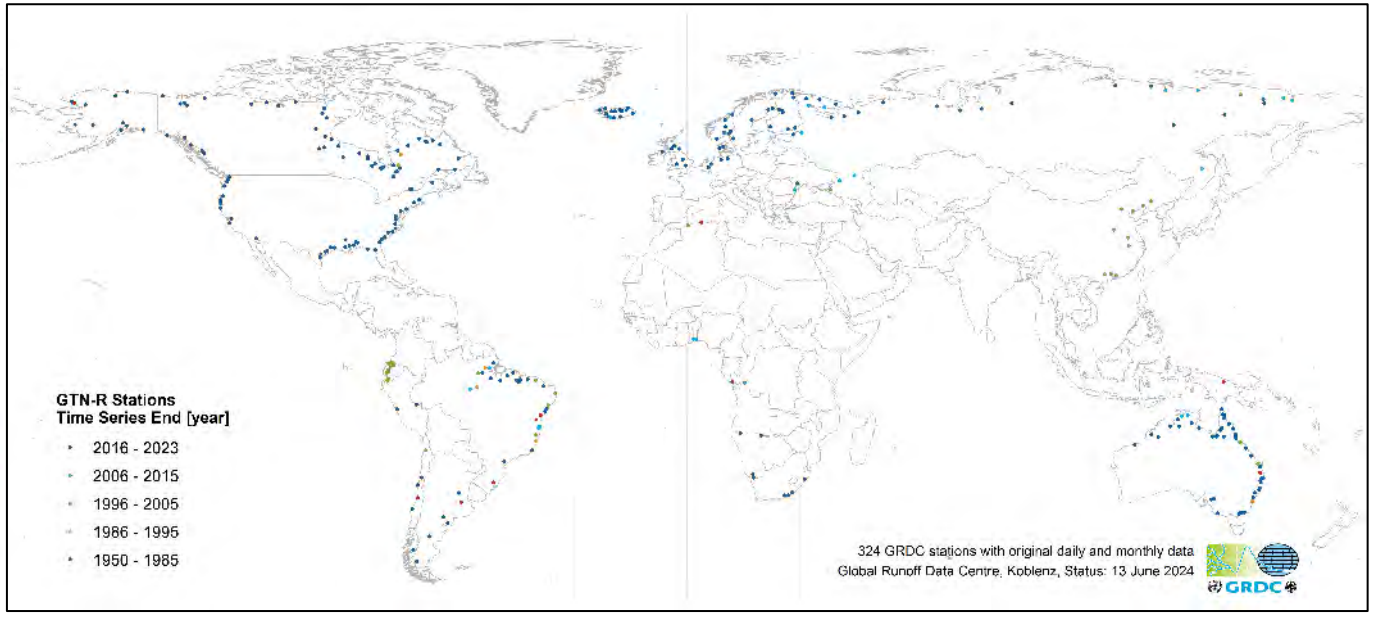
July 2007: 21 countries replied positively / 75% no reply

July 2024: 324 stations (instead of the planned > 400)

Planned baseline network: 450 stations



June 2024: 324 stations



* Implementation Plan for the Global Observing System for Climate in Support of the UNFCCC, October 2004, GCOS-92 (WMO/TD No. 1219)

Ocean Observations

1990

- Ocean observing system remained relatively sparse and regionally-focused until the 1990s
- Several reviews that culminated in the Global Ocean Data Assimilarion Experiment.
- Consensus to undertake an internationally coordinated sustained global ocean observing effort.
- Altimeter constellation measures sea level globally

2000

- The use of autonomous *in situ* platforms revolutionizes the ocean observing system: ARGO floats
- Increased used of data standards, ocean data in the GTS
- More global networks established: Ocean SITES (moorings) –ocean data meeting climate standards

2010

- Biogeochemistry and biology become part of the global ocean observing system and start to be measured systematically – GO-SHIP network.
- Remote sensing to measure salinity, currents, waves
- Advances in technology make the description of the state of the large-scale ocean circulation becomes possible
- Data sharing starts also for biogeochemical and biological variables

2020

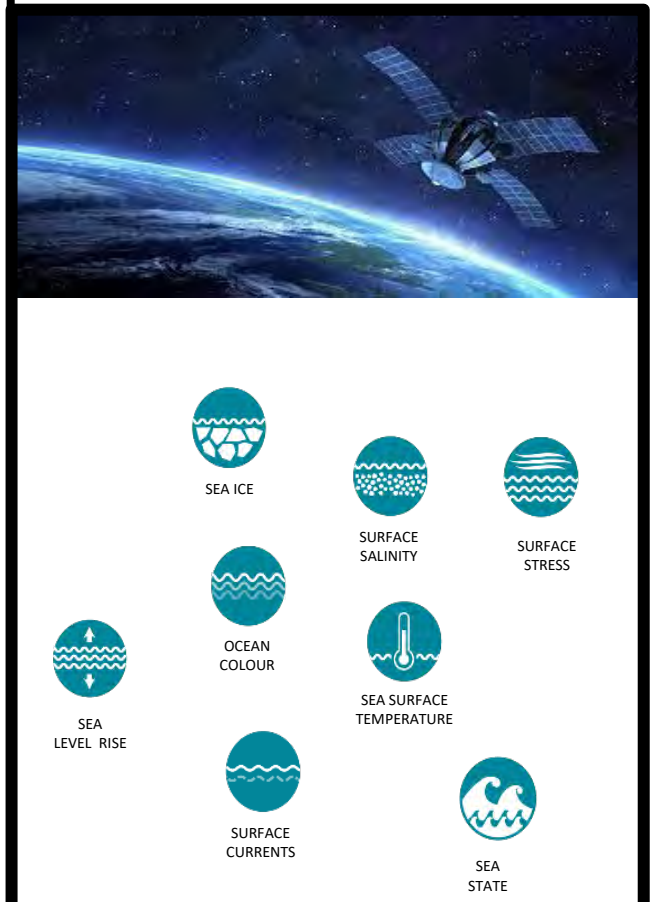
- More technological developments and change of paradigm: multiplatform approach.
- Autonomous vehicles that allow to reach deeper and farther.
- Satellites provide high-resolution data in coastal areas

1990

No global in situ network, most of what we know about the oceans come from research cruises. Data not shared.

Satellites only measure **Sea ice extent** and **Sea Surface Temperature**

Satellite 2023 In situ



GOOS *in situ* networks [1]	Implementation	Data & metadata			Best practices [6]
	Status [2]	Real time [3]	Archived high quality [4]	Metadata [5]	
Ship based meteorological - SOT	★★☆	★★☆	★★☆	★★½	★★☆
Ship based oceanographic – SOT	★★½	★★½	★★★	★★☆	★★★
Repeated transects - GO-SHIP	★★★	Not applicable	★★★	★½☆	★★★
Sea level gauges - GLOSS	★★½	★★☆	★★★	½☆☆	★★☆
Time series sites - OceanSITES	★★☆	Not applicable	★★½	★☆☆	★★☆
Coastal Moored buoys – DBCP	★★★	★★★	★★★	★☆☆	★★½
Tsunami buoys - DBCP	★★½	★★★	★★★	★★☆	★★★
Tropical moored buoys - DBCP	★★½	★★★	★★★	★★★	★★☆
HF radars	★½☆	★½☆	½☆☆	½☆☆	★★★
Drifting buoys - DBCP	★★★	★★½	★★½	★★½	★★★
Profiling floats - Argo	★★★	★★★	★★★	★★★	★★½
Deep & biogeochemistry floats - Argo	★½☆	★★½	★★½	★★★	★★☆
OceanGliders	★½☆	★★☆	★☆☆	★★☆	★★☆
Animal borne sensors - AniBOS	½☆☆	★☆☆	★★☆	½☆☆	★★☆

Earth Energy, Carbon and Water Cycles

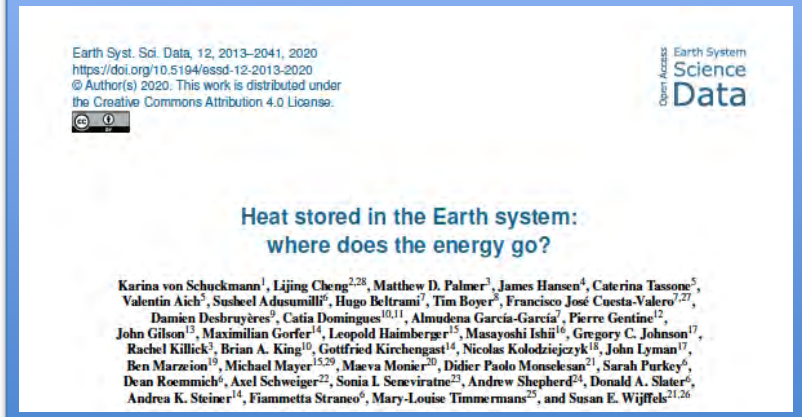
3 papers published: 2020-22


BAMS Article

Closing the Water Cycle from Observations across Scales

Where Do We Stand?

Wouter Dorigo, Stephan Dietrich, Filipe Aires, Luca Brocca, Sarah Carter, Jean-François Cretaux, David Dunkerley, Hiroyuki Enomoto, René Forsberg, Andreas Güntner, Michaela I. Hegglin, Rainer Hollmann, Dale F. Hurst, Johnny A. Johannessen, Christian Kummerow, Tong Lee, Kari Luojus, Ulrich Looser, Diego G. Miralles, Victor Pellet, Thomas Recknagel, Claudia Ruz Vargas, Udo Schneider, Philippe Schoeneich, Marc Schröder, Nigel Tapper, Valery Vuglinsky, Wolfgang Wagner, Lisan Yu, Luca Zappa, Michael Zemp, and Valentin Aich


Earth Syst. Sci. Data, 12, 2013–2041, 2020
https://doi.org/10.5194/essd-12-2013-2020
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Earth System Science Data

Heat stored in the Earth system: where does the energy go?

Karina von Schuckmann[1], Lijing Cheng[2,28], Matthew D. Palmer[3], James Hansen[4], Caterina Tassone[5], Valentin Aich[5], Susheel Adusumilli[6], Hugo Beltrami[7], Tim Boyer[8], Francisco José Cuesta-Valero[9,27], Damien Desbruyères[9], Catia Domingues[10,11], Almudena García-García[7], Pierre Gentine[12], John Gilson[13], Maximilian Gorfer[14], Leopold Haimberger[15], Masayoshi Ishii[16], Gregory C. Johnson[17], Rachel Killick[3], Brian A. King[10], Gottfried Kirchengast[14], Nicolas Kolodziejczyk[18], John Lyman[17], Ben Marzeion[19], Michael Mayer[15,29], Maeva Monier[20], Didier Paolo Monselesan[21], Sarah Purkey[6], Dean Roemmich[6], Axel Schweiger[22], Sonia I. Seneviratne[23], Andrew Shepherd[24], Donald A. Slater[6], Andrea K. Steiner[14], Fiammetta Straneo[6], Mary-Louise Timmermans[25], and Susan E. Wijffels[21,26]


Reviews of Geophysics

REVIEW ARTICLE

How Well Do We Understand the Land-Ocean-Atmosphere Carbon Cycle?

David Crisp[1], Han Dolman[2,3], Toste Tanhua[4], Galen A. McKinley[5], Judith Hauck[4], Ana Bastos[7], Stephen Sitch[8], Simon Eggleston[9], and Valentin Aich[9]

Action B10: Identify gaps in the climate observing system to monitor the global energy, water and carbon cycles

1. Continue to periodically review observations of the Earth's energy, water, carbon cycles to identify gaps and areas of high uncertainty.
2. Review consistency of the underlying observations.
3. Develop plans to address the gaps identified in (1), if feasible.

GCOS/WCRP WORKSHOP
June 2023

- identify challenges for research, modelling and observing system capabilities;
- identify key indicators for measuring, monitoring and modelling the cycles and indicate how they can be used in global assessment frameworks;
- identify key processes that need to be better understood & improve the monitoring of the cycles

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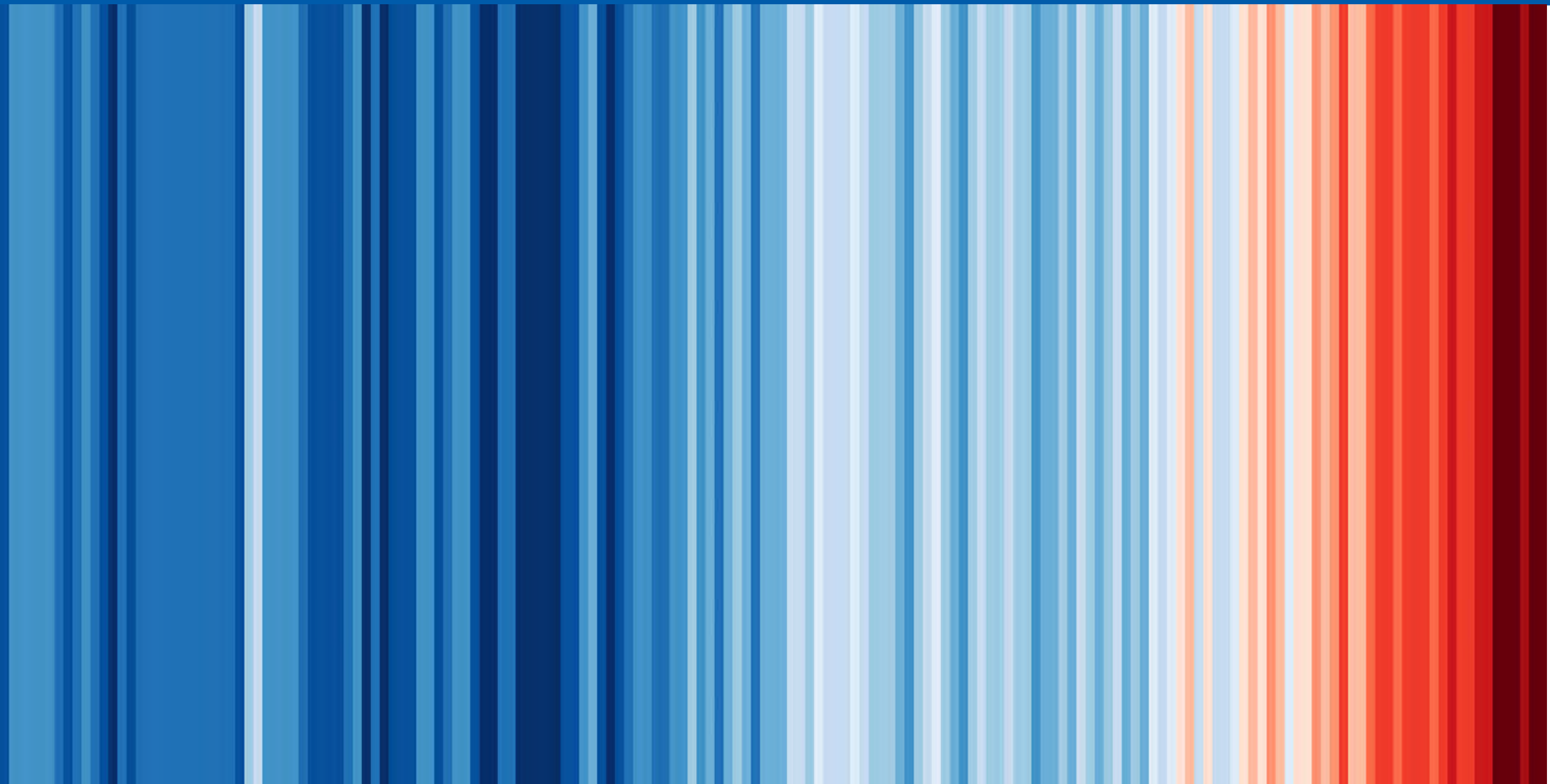
The landscape of institutions around GCOS




JPI Climate
CSIC
CONSEJO SUPERIOR DE INVESTIGACIONES CIENTÍFICAS
OECD
ETTER POLICIES FOR BETTER LIVES
UNEP
United Nations Environment Programme
GCOS
futurearth
GEO
GROUP ON
EARTH OBSERVATIONS
European
Green Deal
bc3
BASQUE CENTRE
FOR CLIMATE CHANGE
Klima Aldaketa Ikergai
PARIS2015
UN CLIMATE CHANGE CONFERENCE
COP21·CMP11
Life
IP Climaz
ForestNavigator
JRC
COMMISSION
THE FRAMEWORK PROGRAMME FOR RESEARCH AND INNOVATION
HORIZON
HORIZON EUROPE (2021-2027)
NOAA
NATIONAL CENTERS FOR
ENVIRONMENTAL INFORMATION
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
IGES GHG
Emissions Database
UNFCCC
REGULATIONS
REGULATION (EU) 2021/1119 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL
of 30 June 2021
establishing the framework for achieving climate neutrality and amending Regulations (EC) No 401/2009 and (EU) 2018/1999 ('European Climate Law')
WCRP
CLIMATE
EIONET
CEN
INTEGRATED CLIMATE DATA CENTER
ICDC
CEOS
ipcc
INTERGOVERNMENTAL PANEL ON
climate change
WMO
UNEP
ICOS
Integrated
Carbon
Observation
System
European
Environment
Agency
opernicus
Europe's eyes on Earth
Climate
Change Service
SUSTAINABLE
DEVELOPMENT
GOALS
esa
GOBIERNO
DE ESPAÑA
MINISTERIO
PARA LA TRANSICIÓN ECOLÓGICA
Y EL RETO DEMOGRÁFICO
WORLD
METEOROLOGICAL
ORGANIZATION
AEMet
Agencia Estatal de Meteorología
ENV

Strategies

SUSTAINABLE DEVELOPMENT GOALS

European Green Deal

Projects programmes

futureearth

ICOS Integrated Carbon Observation System

GREEN FEEDBACK

WCRP

GCOS

Financing instruments

GREEN CLIMATE FUND

gef

Data

Copernicus Europe's eyes on Earth

Climate Change Service

CEN INTEGRATED CLIMATE DATA CENTER ICDC

IGES GHG Emissions Database

EIONET

UN Institutions

UNEP United Nations Environment Programme

ipcc INTERGOVERNMENTAL PANEL ON climate change

WORLD METEOROLOGICAL ORGANIZATION

Legal instruments


REGULATIONS

REGULATION (EU) 2021/1119 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 30 June 2021 establishing the framework for achieving climate neutrality and amending Regulations (EC) No 401/2009 and (EU) 2018/1999 ('European Climate Law')

PARIS2015 UN CLIMATE CHANGE CONFERENCE COP21·CMP11

UNFCCC

Other International Institutions

GEO GROUP ON EARTH OBSERVATIONS

OECD BETTER POLICIES FOR BETTER LIVES

CEOS

UN environment programme

esa

National Institutions

bc3 BASQUE CENTRE FOR CLIMATE CHANGE Klima Aldaketa Ikergai

NOAA NATIONAL CENTERS FOR ENVIRONMENTAL INFORMATION NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

AEMet Agencia Estatal de Meteorología

WPI TOHOKU UNIVERSITY & JAMSTEC AIMEC

CHINA METEOROLOGICAL ADMINISTRATION

How do we get to climate observations?

NACIONES UNIDAS

INSTITUTIONS WITH CAPACITY TO ISSUE LAWS: UN EU, STATES…

Strategies

Financing instruments

Legal instruments

PROJECTS, PROGRAMMES

GCOS

Climate observations

GCOS | WMO | unesco Intergovernmental Oceanographic Commission | environment programme

GCOS and the landscape in 1990

NACIONES UNIDAS

UNEP

WORLD METEOROLOGICAL ORGANIZATION

ipcc
INTERGOVERNMENTAL PANEL ON climate change

GCOS

SCATTERED

Climate change starts to be discussed, it is recognized as a global issue that needs to be tackled at the UN level, only one International Convention (UNFCCC), two UN agencies, mainly three programmes (GCOS, WCRP supporting IPCC), no specific financial instruments, data landscape very scattered and research based, remote sensing in its infancy….

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GCOS and the landscape in 2023

SOCIETAL CHALLENGE…
SOCIETAL URGENCY !!

GCOS
KEEPING WATCH OVER OUR CLIMATE

WMO UNESCO IOC International Science Council UN environment