Towards cross-ECV activities in the new GCOS Implementation plan- what are the questions?

Han Dolman and the GCOS/WMO secretariat

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1. GCOS – The way we work
2. GCOS ECV and Climate cycles
3. Adaptation
4. What role can you play?

ECV and the GCOS Mandate

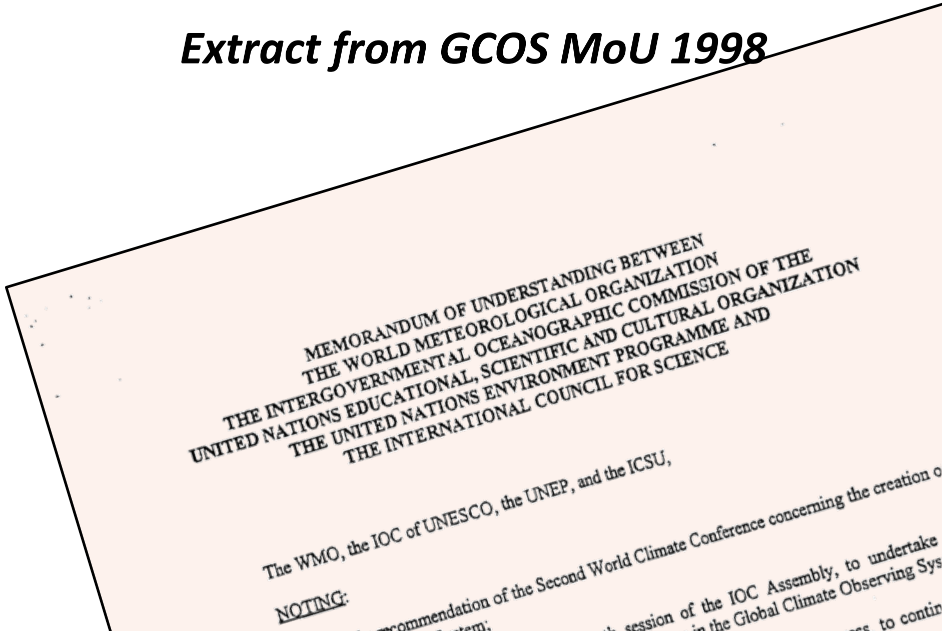
The goal of the GCOS is to provide comprehensive information on the total climate system involving the multi-disciplinary range of physical, chemical and biological properties and atmospheric, oceanic, hydrologic, cryospheric and terrestrial processes.

The GCOS is intended to meet the needs of:

> *Climate system monitoring, climate change detection and monitoring the impacts of and response to climate change, especially in terrestrial ecosystems and mean sea-level;*
>
> *Data for application to national economic development;*
>
> *Research toward improved understanding, modelling and prediction of the climate system*

Extract from GCOS MoU 1998

- The first step is for GCOS to identify what needs to be observed and to define requirements of these observations
- This lead to the **Essential Climate Variables: ECV**
- GCOS reviews the performance of observations of ECV and reports to WMO, UNFCCC and others
- GCOS provides advice and support


MEMORANDUM OF UNDERSTANDING BETWEEN
THE WORLD METEOROLOGICAL ORGANIZATION
THE INTERGOVERNMENTAL OCEANOGRAPHIC COMMISSION OF THE
UNITED NATIONS EDUCATIONAL, SCIENTIFIC AND CULTURAL ORGANIZATION
THE UNITED NATIONS ENVIRONMENT PROGRAMME AND
THE INTERNATIONAL COUNCIL FOR SCIENCE

The WMO, the IOC of UNESCO, the UNEP, and the ICSU,

NOTING:

GCOS Activities

- **Supporting and promoting climate observations**
  - **Atmospheric Observations**, WMO:
    - ECV requirements feed into WMO requirements (OSCAR), System monitoring (WDQMS), network development/ improvement (GBON), Data Exchange
    - GCOS Networks: GSN GUAN and GRUAN
  - **Ocean Observations**, (IOC and WMO): works with GOOS on ECV requirements feeding into observational networks and WMO (OSCAR)
  - **Terrestrial Observations:** working with a wide range of bodies covering
    - Global Terrestrial Networks (Hydrology, Glaciers, Permafrost…);
    - Land Use and fires GOFC-GOLD
    - GHG fluxes and anthropogenic water use
- **Reporting**
  - UNFCCC (Status Report, Implementation Plan, regular reporting to UNFCCC on climate observations
  - WMO and IOC on user needs
  - GCOS Sponsors
- **Regional Plans/Information** (Regional workshops)
- **GCOS Cooperation Mechanism:** Direct support to countries (NMHS) e.g. on radiosondes, communications

GCOS Supports ECV through:
User Requirements
Observing principles and standards
Guidelines for dataset preparation
Systematic reviews of ECV observations
Improvement plans for the whole system
Community Involvement/consultation
Widespread public reviews

1. STATUS OF THE GCOS ESSENTIAL CLIMATE VARIABLES (Adequacy of the Observing System and Data Stewardship)
2. STATUS OF THE OBSERVING NETWORKS
   - 2.1 Satellite Observations
   - 2.2 GCOS Networks
   - 2.3 Ocean Networks
   - 2.4 Terrestrial Networks
3. STATUS OF THE IMPLEMENTATION OF ACTIONS FROM THE 2016 IMPLEMENTATION PLAN
4. OBSERVATIONS OF AND FOR ADAPTATION, AND EXTREMES
5. OBSERVATIONS OF THE EARTH SYSTEM CLIMATE CYCLES
6. CONCLUSIONS

Status Report

Adequacy of the Observational System	**Availability and Stewardship**
(5) Very Good: Meets requirements.	(5) Very Good: Data available worldwide, with high standards of data stewardship
(4) Good: Generally, meets requirements, provides reliable global trends.	(4) Good: Data available but not meeting the highest standards of data stewardship
(3) Medium: Does not meet requirements: while observations are useful and reliable from a user's perspective, they have significant issues at a regional level.	(3) Medium: Most regions have available data but there may be stewardship issues, however the data are useful and reliable from a user's perspective
(2) Low: Can only produce datasets with limited reliability from a user's perspective at global and regional levels.	(2) Low: Some data is available but of limited utility
(1) Poor: Do not meet requirements and does not provide reliable trends.	(1) Poor: Useful data is not available at a global or regional level.

ECV		Adequacy **of the Observational System Assessment**		**Availability and Stewardship Assessment**
River Discharge	3➔	In-situ observations with gaps and highly variable Satellite data: measure water elevations, no direct measurement of discharge. Global monitoring but weak temporal resolution depending on the satellite orbit cycle (several days). The use of constellations (with 10 satellites or more) could improve the temporal resolution.	3➔	In-situ data quality and availability dependents on national hydrological service Satellite data: all freely available, long-term monitoring foreseen with the Copernicus program, QA/QC but dependant on in-situ data, and adequate metadata. Water elevation accuracy less precise than in situ (few decimetres accuracy).
Soil Moisture	3➚	Meeting requirements in semi-arid regions and crop lands, issues still in dense vegetation, organic soils, and regions of strong topography	5➚	**Most datasets are open access, including doi and validation reports and many are produced operationally**
Glaciers	3➔	Very limited glaciers have in-situ observations. Satellite data is globally covered but has too low spatial resolution to extract useful data with sufficient time resolution.	5➚	**In-situ data and remote sensing data is collected and published by prevailing networks with high quality and efficacy. Users can access and use most data easily.**
Ice Sheet and Ice Shelves	4➚	Great achievements cover vast and ca. inaccessible area.	4➚	Data product efforts were done, and information was compiled, and dissimilation have been progressing.

ECV and the Earth's Climate cycles

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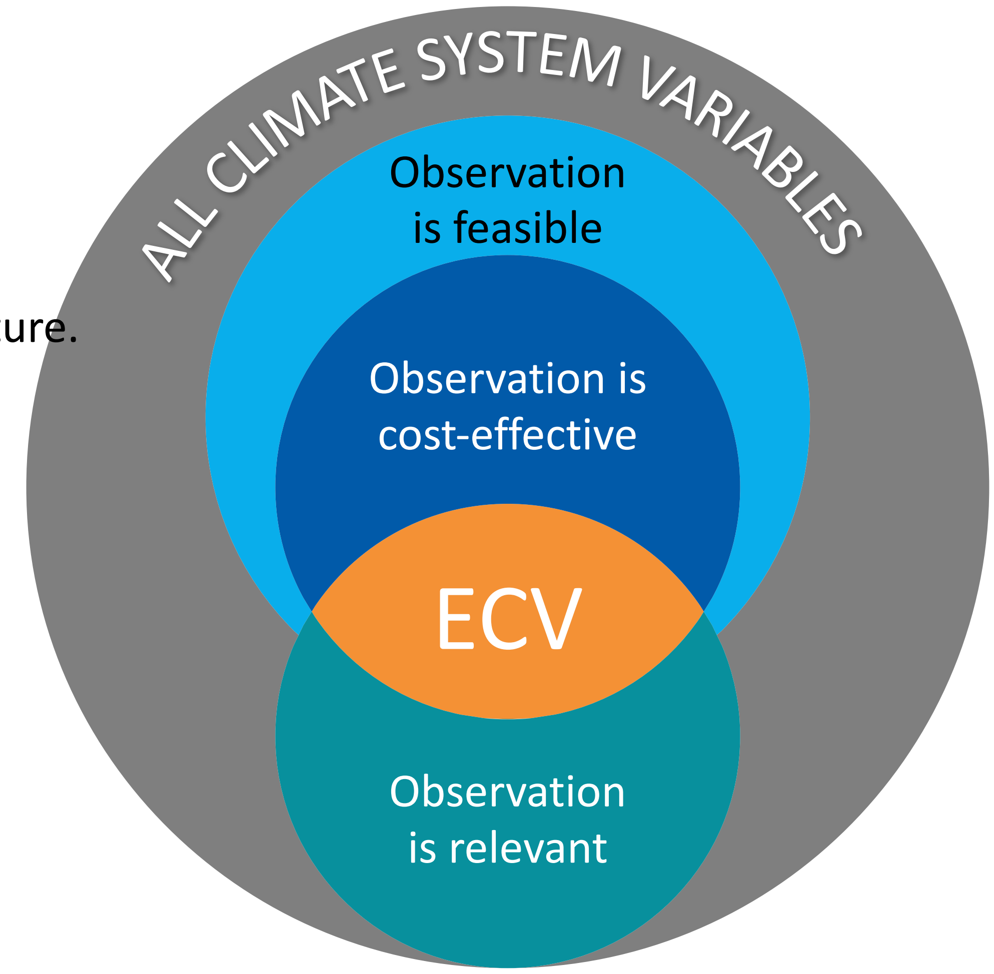
Essential Climate Variables (ECV)

- are physical, chemical or biological variables that critically contribute to the characterization of Earth's climate.
- are not of 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, S. et al., 2014

ECVs should meet these principles

- **Free and Open**, data is openly available to all users
- **Transparent**, the methods and assumptions are clear, with standardised metadata, where possible
- **Accurate**, climate data needs high accuracy to distinguish small trends from larger annual variability
- **Useful**, there should be a clear demand from users
- **Timely**, there should be a minimum delay before publication to monitor recent trends
- Based on best **available science**

2016 Essential Climate Variables (ECVs)

Atmospheric

Surface

Precipitation, Surface pressure, Surface radiation budget, Surface wind speed and direction, Surface temperature, Surface water vapour

Upper-air

Earth radiation budget, Lightning, Upper-air temperature, Upper air water vapor, Upper-air wind speed and direction

Composition

Aerosols properties, Carbon dioxide, Methane and other greenhouse gases, Cloud properties, Ozone, Aerosol and ozone precursors

Oceanic

Physical

Ocean surface heat flux, Sea ice, Sea level, Sea state, Sea surface Salinity, Sea surface temperature Subsurface currents, Subsurface salinity, Subsurface temperature

Biogeochemical

Inorganic carbon, Nitrous oxide, Nutrients, Ocean colour, Oxygen, Transient tracers

Biological/ecosystems

Marine habitat properties, Plankton

Terrestrial

Hydrology

Groundwater, Lakes, River discharge, Soil moisture

Cryosphere

Glaciers, Ice sheets and ice shelves, Permafrost, Snow

Biosphere:

Above-ground biomass, Albedo, Fire, Fraction of absorbed photosynthetically active radiation, Land cover, Land surface temperature, Latent and sensible heat fluxes, Leaf area index, Soil carbon

Human use of natural resources:

Anthropogenic greenhouse gas fluxes, Anthropogenic water use

SOURCE: GCOS Implementation Plan 2016

2016

Item	Notes
ECV	Name of ECV
Products	Sub-variables needed (e.g. lake area, temperature and colour)
Frequency	e.g. hourly, annual, etc.
Resolution	Horizontal and vertical
Required measurement uncertainty	Follow international definitions
Stability	Vital for climate change
Standards/ References	Where they exist

Changes to definitions of ECV Requirements

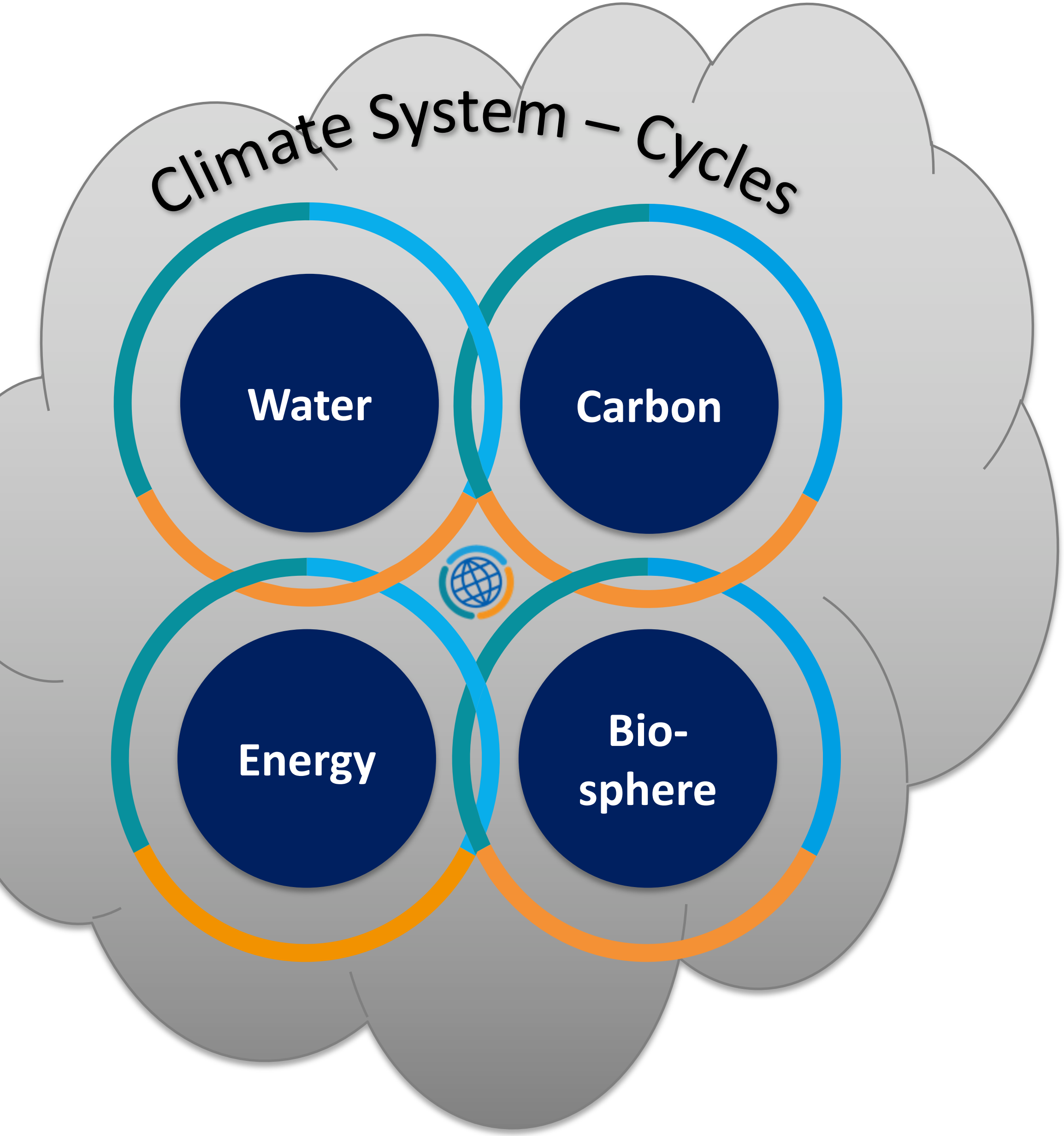
2022

Name					
Definition					
Unit					
Note					
Requirements					
Item needed	SI Unit	Metric		Value	Derivation and References and Standards
Horizontal Resolution			G		
			B		
			T		
Vertical Resolution			G		
			B		
			T		
Temporal Resolution			G		
			B		
			T		
Timeliness			G		
			B		
			T		
Required Measurement Uncertainty			G		
			B		
			T		
Stability			G		
			B		
			T		
Standards and References					

Background information/explanation for each value mandatory
In order to make the process transparent and allow for discussions

Have 3 values: “threshold”, “breakthrough” and “goal”

Climate ‘cycles’



- GCOS aims for these important parts of the climate system to be completely measured
- GCOS has set long-term targets for monitoring all 4
- One ECV can belong to several cycles
- ECV must be consistent within a cycle and between cycles
- ECV are also measured for other purposes – avoid duplication
- Papers on each cycle under preparation, results will feed into the Status Report
- e.g for the carbon cycle, not just fluxes but ocean and terrestrial carbon measurements should be consistent – operating across these domains GCOS can provide guidance

The Earth’s climate cycles

- Assess the status of consistently assessing the variability of the carbon, hydrological and energy cycles at various spatial and temporal scales,
- Assess the relevant land, atmosphere, and ocean storages and the fluxes between them, including anthropogenic fluxes and stores,
- Identify gaps in existing observation systems and in consistency and attribute their origin,
- Conclude with formulating guidelines for future Earth cycle observation strategies.

The Earth Cycle budget closure in the IP

Box 4: Closing the carbon budget

Targets	Quantify fluxes of carbon-related greenhouse gases to +/- 10% on annual timescales Quantify changes in carbon stocks to +/- 10% on decadal timescales in the ocean and on land, and to +/- 2.5 % in the atmosphere on annual timescales
Who	Operators of GCOS-related systems, including data centres
Time frame	
Performance indicator	

Box 5: Closing the global water cycle

Targets	Close water cycle globally within 5% on annual timescales
Who	Operators of GCOS-related systems, including data centres
Time frame	
Performance indicator	

Box 6: Closing the global energy balance

Targets	Balance energy budget to within 0.1 Wm^{-2} on annual timescales
Who	Operators of GCOS-related systems, including data centres
Time frame	
Performance indicator	

Box 7: Explain changing conditions of the biosphere

Targets	Measured ECVs that are accurate enough to explain changes of the biosphere (for example, species composition, biodiversity, etc.)
Who	Operators of GCOS-related systems, including data centres
Time frame	Ongoing
Performance indicator	Regular assessment of the uncertainty of estimates of changing conditions as listed above

The energy cycle (EEI)

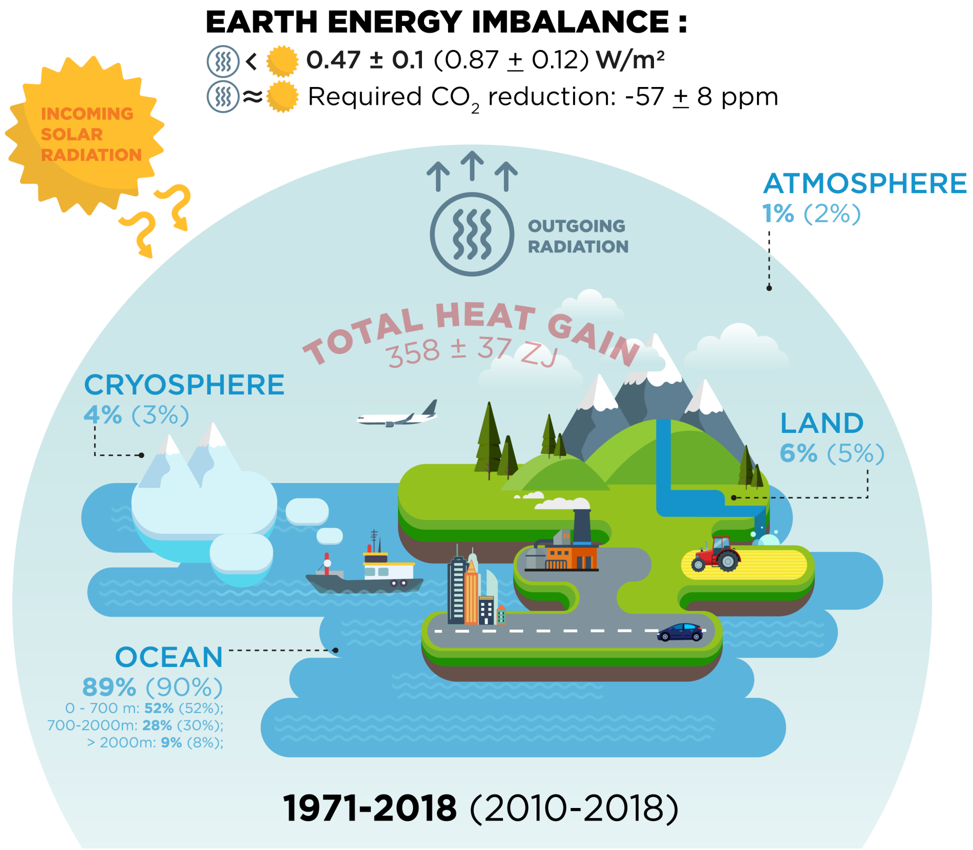
Open Access Earth System Science Data

Earth Syst. Sci. Data, 12, 1–29, 2020
https://doi.org/10.5194/essd-12-1-2020

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[7,27], 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]

Just published on Monday7/9/20



The Carbon cycle

Earth Syst. Sci. Data, 11, 1783–1838, 2019
https://doi.org/10.5194/essd-11-1783-2019
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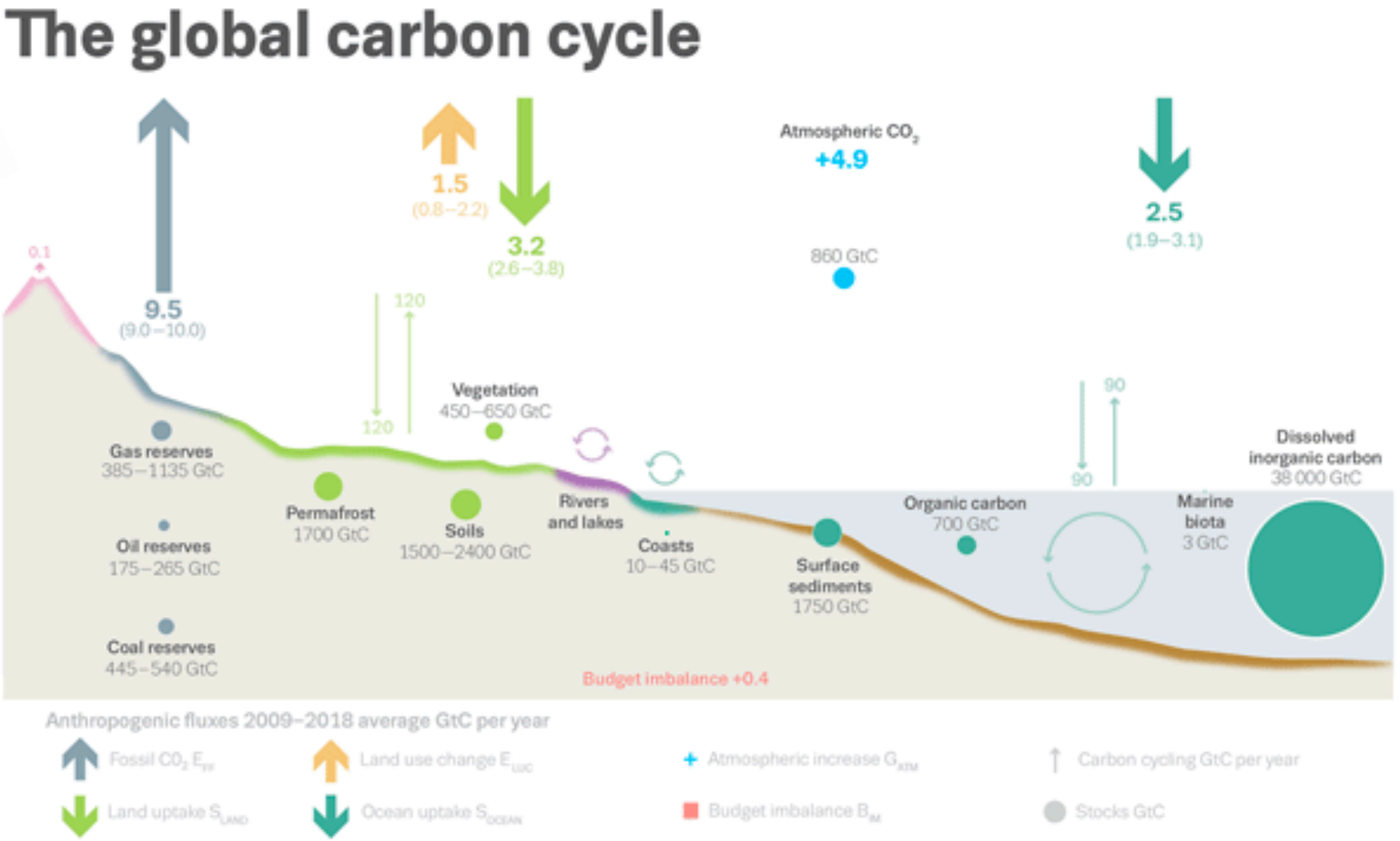
Open Access Earth System Science Data

Global Carbon Budget 2019

Pierre Friedlingstein[1,2], Matthew W. Jones[3], Michael O'Sullivan[1], Robbie M. Andrew[4], Judith Hauck[5], Glen P. Peters[4], Wouter Peters[6,7], Julia Pongratz[8,9], Stephen Sitch[10], Corinne Le Quéré[3], Dorothee C. E. Bakker[3], Josep G. Canadell[11], Philippe Ciais[12], Robert B. Jackson[13], Peter Anthoni[14], Leticia Barbero[15,16], Ana Bastos[8], Vladislav Bastrikov[12], Meike Becker[17,18], Laurent Bopp[2], Erik Buitenhuis[3], Naveen Chandra[19], Frédéric Chevallier[12], Louise P. Chini[20], Kim I. Currie[21], Richard A. Feely[22], Marion Gehlen[12], Dennis Gilfillan[23], Thanos Gkritzalis[24], Daniel S. Goll[25], Nicolas Gruber[26], Sören Gutekunst[27], Ian Harris[28], Vanessa Haverd[11], Richard A. Houghton[29], George Hurtt[20], Tatiana Ilyina[9], Atul K. Jain[30], Emilie Joetzjer[31], Jed O. Kaplan[32], Etsushi Kato[33], Kees Klein Goldewijk[34,35], Jan Ivar Korsbakken[4], Peter Landschützer[9], Siv K. Lauvset[36,18], Nathalie Lefèvre[37], Andrew Lenton[38,39], Sebastian Lienert[40], Danica Lombardozzi[41], Gregg Marland[23], Patrick C. McGuire[42], Joe R. Melton[43], Nicolas Metzl[37], David R. Munro[44], Julia E. M. S. Nabel[9], Shin-Ichiro Nakaoka[45], Craig Neill[38], Abdirahman M. Omar[38,18], Tsuneo Ono[46], Anna Peregon[12,47], Denis Pierrot[15,16], Benjamin Poulter[48], Gregor Rehder[49], Laure Resplandy[50], Eddy Robertson[51], Christian Rödenbeck[52], Roland Séférian[53], Jörg Schwinger[34,18], Naomi Smith[6,54], Pieter P. Tans[55], Hanqin Tian[56], Bronte Tilbrook[38,57], Francesco N. Tubiello[58], Guido R. van der Werf[59], Andrew J. Wiltshire[51], and Sönke Zaehle[52]



This is not a GCOS paper per sé.

Another paper Crisp, Tanhua, Dolman et al is in preparation

Earth System cycles and budgets

- There are fundamentally two way to compile budgets and determine imbalances:
  - Look at the (time difference of) stocks
  - Look at the fluxes
- These two ideally should match (e.g. the Earth's Energy Imbalance)
- GCOS works with WCRP to make these two approaches match by improving the data quality and identifying gaps, and specifying ECV requirements.

The challenge of providing adaptation climate data

- “GCOS should establish a specific activity to understand the needs of adaptation and how to develop their observational requirements. This will require the direct involvement of adaptation experts rather than rely solely on the observation experts traditionally associated with the GCOS Science panels, including those with financial, implementation and policy responsibilities for successful adaptation to climate change. “

- “The ability to understand and estimate risks, both current and how they change in the future, will be vital to support adaptation planning and increase the resilience of societies to climate changes. GCOS should consider the world-wide and regional observations that support or monitor adaptation, but not the detailed local observational needs, in line with its remit as a global observing system.”

GCOS Adaptation note, 2018

ECV's and adaptation

- Most ECVs are conceived for long term climate monitoring purposes
- For adaptation, we need generally high spatial and temporal resolution
- The science panels are reviewing the current requirements with this view in mind: i.e. are they useful for adaptation purposes?

ECVs and Adaptation

For each ECV we are checking the relevance for **extremes and adaptation**

In the new IP this my have consequences for the requirements

ECV	Extremes	Adaptation
Wind Speed and direction (surface)	Essential	Essential
Temperature (surface)	Essential. Land Surface Air Temperatures are used to infer many of the ETCCDI extreme indices. Extremes of heat and cold have large-scale implications for human health, thermal comfort, agriculture, ecosystem services etc. Emerging SST requirement for monitoring of marine heat waves	Essential. Knowledge of present temperature variations is key to effective adaptation decision making.
Pressure (surface)	Sea-level pressure datasets are widely used for the study of tropical and extra-tropical storms. SLP measurements are also used for assessments of long-term changes in storminess and wind speeds since the 19th century.	Essential, particularly for circulation indices and the numbers of tropical and mid-latitude storms.
Water vapour (surface)	Essential as contribution to heat stress index. Used in some drought indicators.	Essential as a key contributor to heat stress indices
Precipitation	Extreme events can be captured regionally on a local to global scale by combining observing systems like radar adjusted to in situ measurements. In situ measurements provide direct estimates at many locations.	Precipitation is a key variable in adaptation decision making. Lack of or too much precipitation leads to some of the most widespread and costly impacts to which we must adapt. Longer term precipitation records are key to understand natural variability and the range of possible future conditions. Data rescue and long-term analysis are key.
Surface Radiation Budget	Extremes in surface radiation can be captured, with better capture at continuously monitored in-situ sites.	Limited applicability
Upper-air temperature	Limited applicability	Limited applicability

ECV and the CCIs

What can you do?

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Implementation Plan

Update of the GCOS IP: input from status report and climate observations conference

Timeline: ***Published by October 2022***

- A shorter document than earlier Implementation Plans
- Integrative actions
  - Consider benefits of synthesis and consideration of activities across ECVs
- Actionable actions
  - Things that are actionable by GCOS / GCOS sponsors
- Important actions
  - Select what is critical
- ***Update of requirements***

Process for Updating Requirements

- Two public reviews
- Greater involvement of stakeholders
- More detailed information and definitions required
- More specific consideration of different users (e.g. adaptation and extremes)

Thank you

Sponsored by EUMETSAT
2nd Climate Observation Conference
12–14 October 2021, Darmstadt, Germany

This conference follows on from the first climate observations conference, Global Climate Observation: The Road to The Future held on 2–4 March 2016 in Amsterdam.

AIM: assess how well the current global climate observing system supports current and near-term user needs for climate information. In particular the meeting will examine how well observations of the global Earth cycles (the global energy balance, global water and carbon cycles, and explaining changing conditions of the biosphere) support users' needs for climate data.

The outputs will provide inputs into the **next GCOS implementation plan** which will make recommendations to meteorological networks, major observing systems and satellite agencies and will be presented to the UNFCCC in 2022 as a contribution towards the UNFCCC's Global Stocktake.

Opportunity for experts dealing with climate observations and other key stakeholders to review and give input to and feedback on the production of the Implementation Plan.

Invitation for papers and posters in the autumn 2020.

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GCOS - WGClimate

- Review of ECV requirements: March 2020
- Input to GCOS Status Report: August 2020
    - Satellite observations
    - Status of the implementation of satellite related actions from the GCOS IP 2016
- Review of GCOS Status Report: January-March 2021
- Input in Climate Observations Conference: October 2021
- Review of GCOS Implementation Plan: January-March 2022
  (includes 2nd review of ECV requirements)