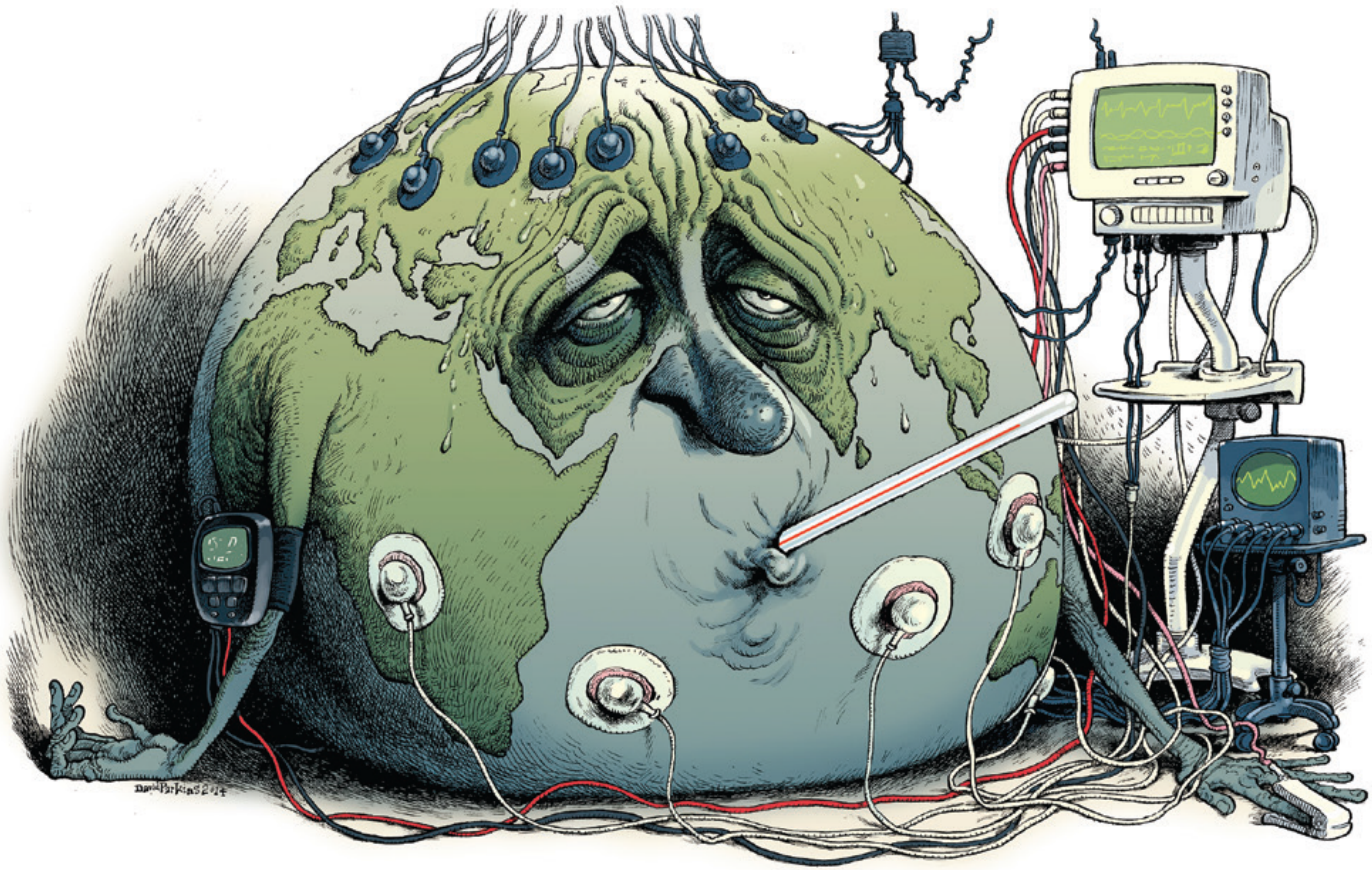
GCOS and the Carbon and Water Cycle ECV's

Han Dolman
VU University Amsterdam

The importance of observations

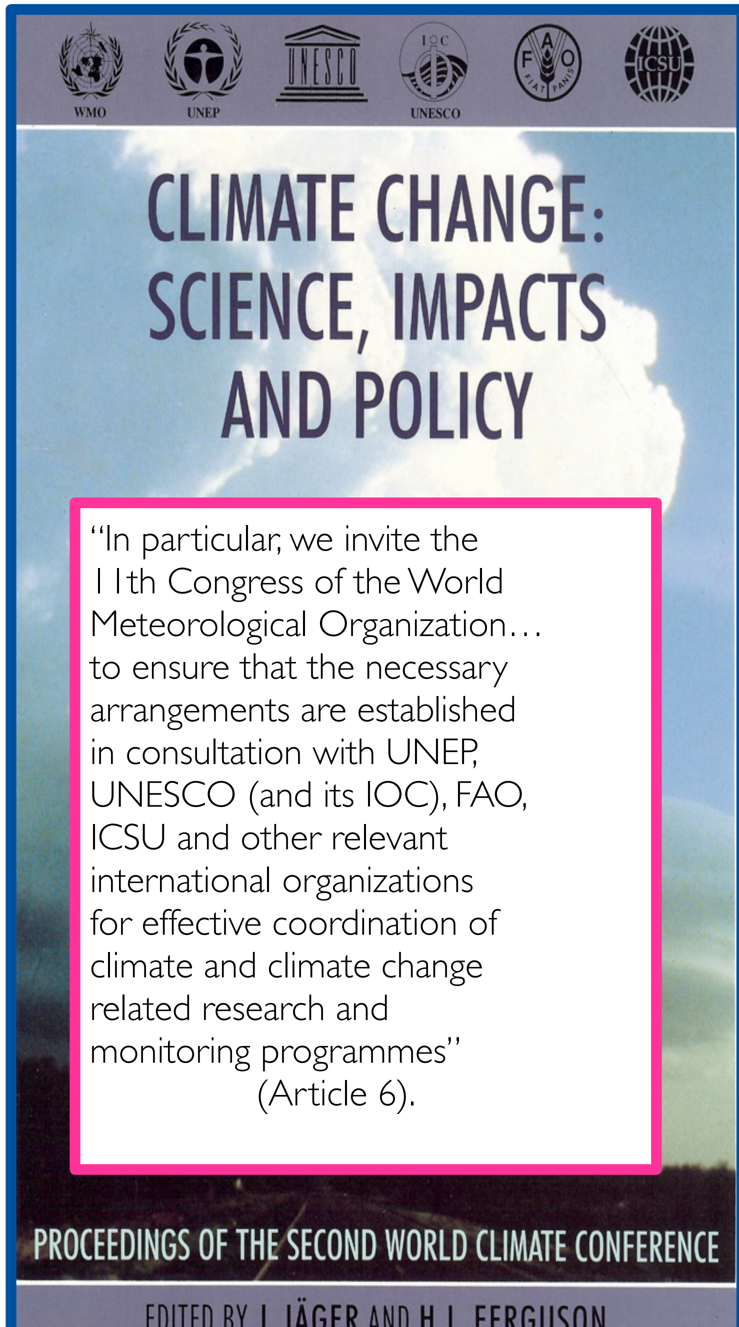


Credit: Victor & Kennel, Nature Climate Change, 2014.

Establishing GCOS

WCC-2 Ministerial Declaration

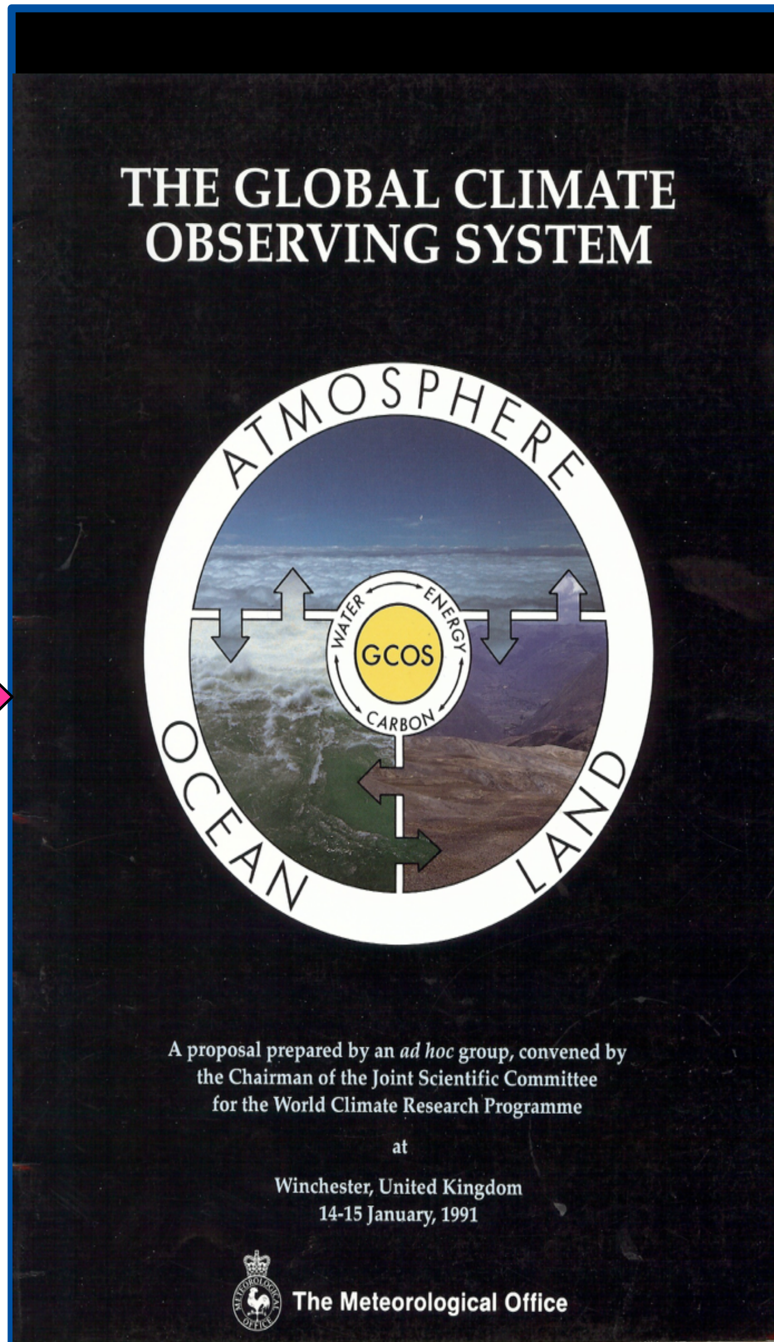
7 November 1990



"In particular, we invite the 11th Congress of the World Meteorological Organization… to ensure that the necessary arrangements are established in consultation with UNEP, UNESCO (and its IOC), FAO, ICSU and other relevant international organizations for effective coordination of climate and climate change related research and monitoring programmes" (Article 6).

Winchester Proposal

January 1991



GCOS MOU

April 1992 (revised 98)

WMO | of UNESCO | UNEP | ICSU

WMO, IOC, UNEP and ICSU

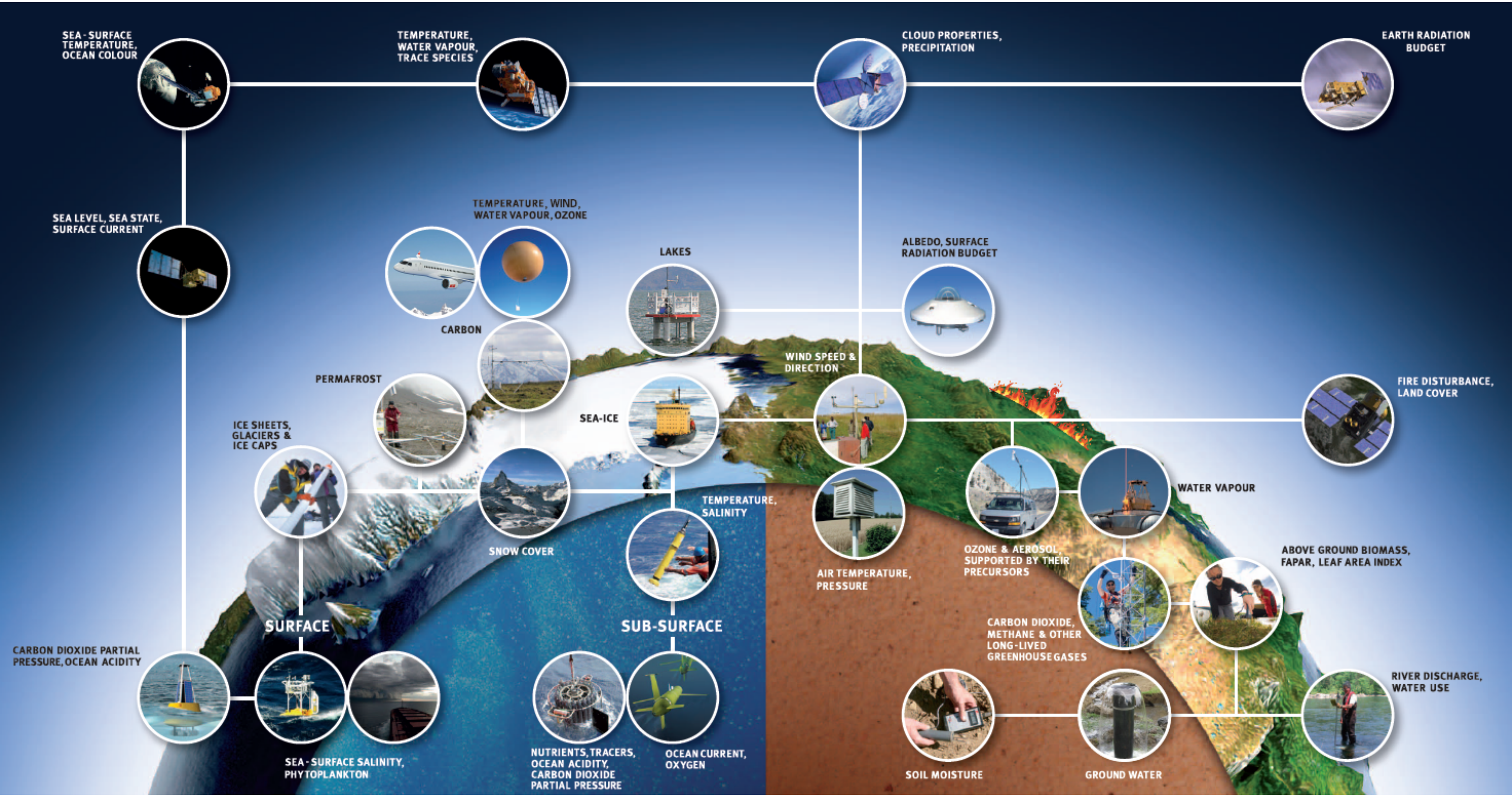
- Noting 1-6
- Recognizing…..
- Considering…
- Agree 1-5
- Agree further….
- Approve:
  - Annex A
  - Annex B
  - Annex C
- Agree….
- Agree….
- Agree….

Annex A Concept of the Global Climate Observing System

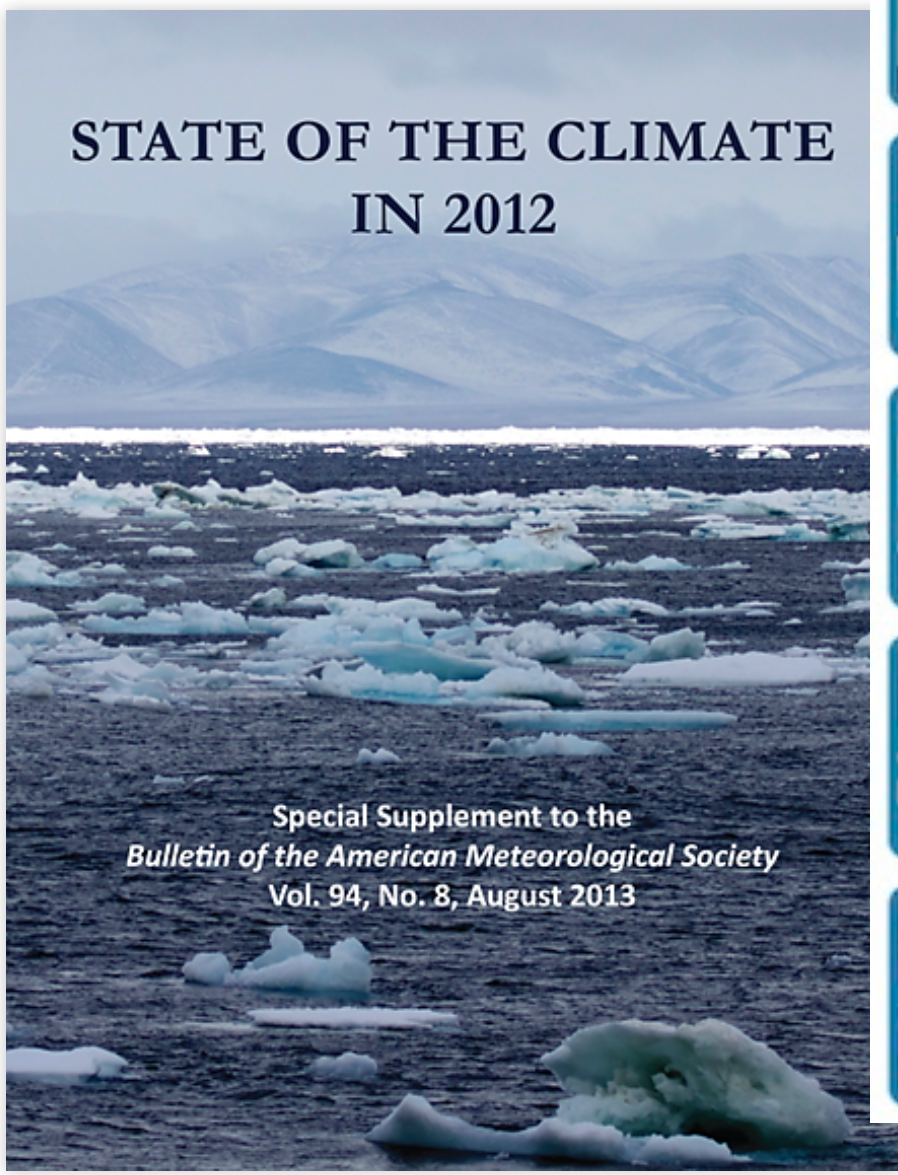
Annex B Terms of Reference, Structure and Functions of the JSTC and JPO

Annex C Financial Arrangements

GCOS Essential Climate Variables



GCOS reception in community



GCOS Releases Updated Implementation Plan for the Global Observing System for Climate

GCOS

31 August 2010: The updated version of the Implementation Plan for the Global Observing System for Climate in Support of the UNFCCC, including the revised list of Global Climate Observing System (GCOS) Essential Climate Variables (ECVs), has been published.

The Plan contains 138 recommended actions that include agents for implementation, timelines, performance indicators and estimated costs. If fully implemented, these actions will substantially improve the availability of the observational information needed by all governments to understand, predict, and manage their response to climate and climate change.

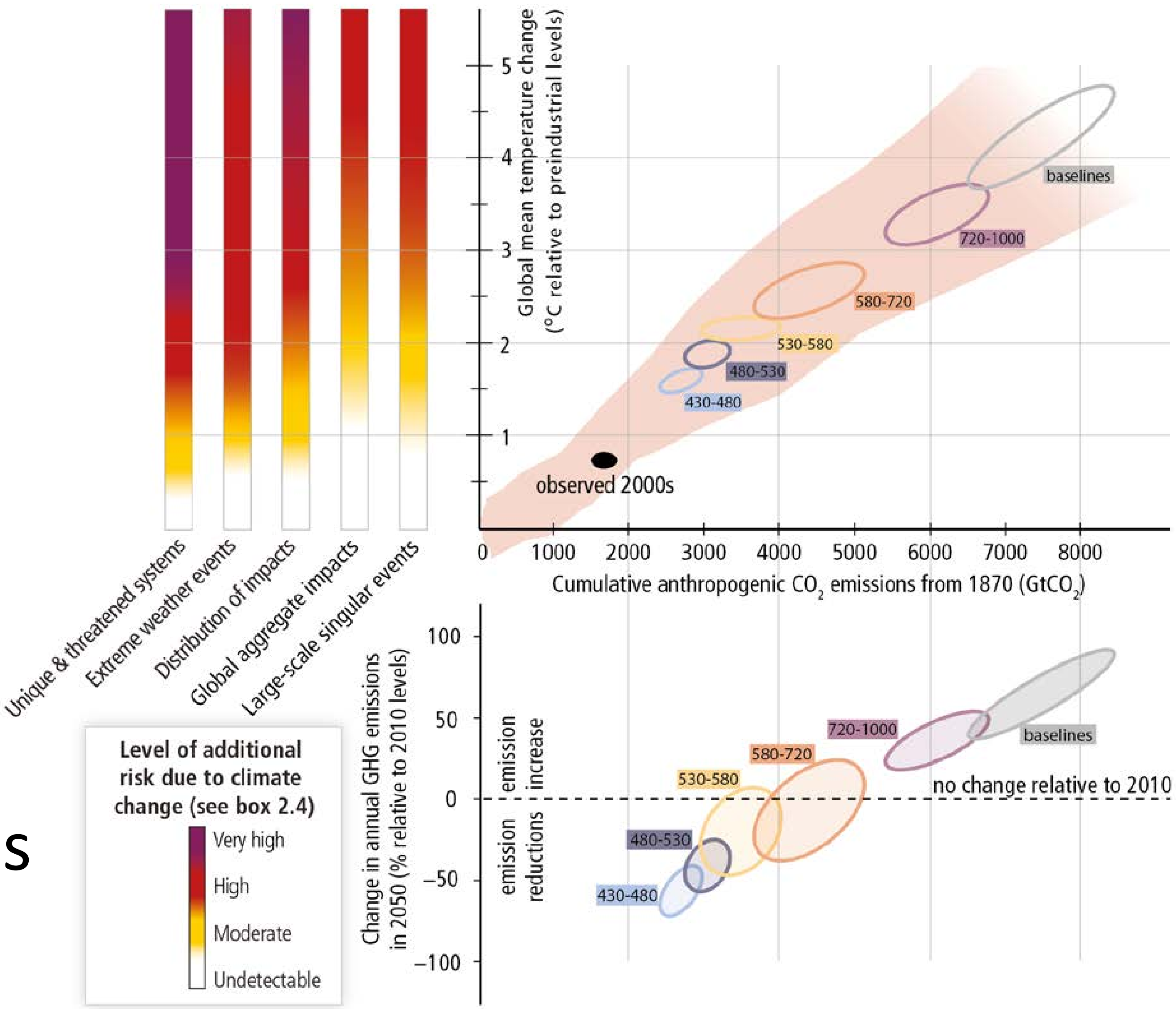
The 2010 Implementation Plan updates the original version from 2004 and considers recent progress in science and technology, an increased focus on adaptation, efforts to optimize mitigation and the need for improved projections. The additional costs of implementing the plan are estimated at US$2.5 billion. The Plan was submitted to the UNFCCC Secretariat for consideration by parties at the 33 rd session of the UNFCCC Subsidiary Body for Scientific and Technological Advice (SBSTA), which will be held in conjunction with the 16th session of the Conference of the Parties (COP 16) in Cancún, Mexico, from 29 November-10 December 2010

read more: http://climate-l.iisd.org/news/gcos-releases-updated-implementation-plan-for-the-global-observing-system-for-climate/#more-41116

The impact and reception of GCOs and its ECVs has a much wider impact than originally thought (UNFCCC): it is now the key organization stressing the importance of observations in climate science

The climate challenge

Adaptation agenda
GFCS
UNFCC
Space/in situ organizations
Attractiveness science
Completeness e.g. radiation,
Ts, i.e. budget closing
Better links to WCRP/IPCC
Relevance to grand challenges



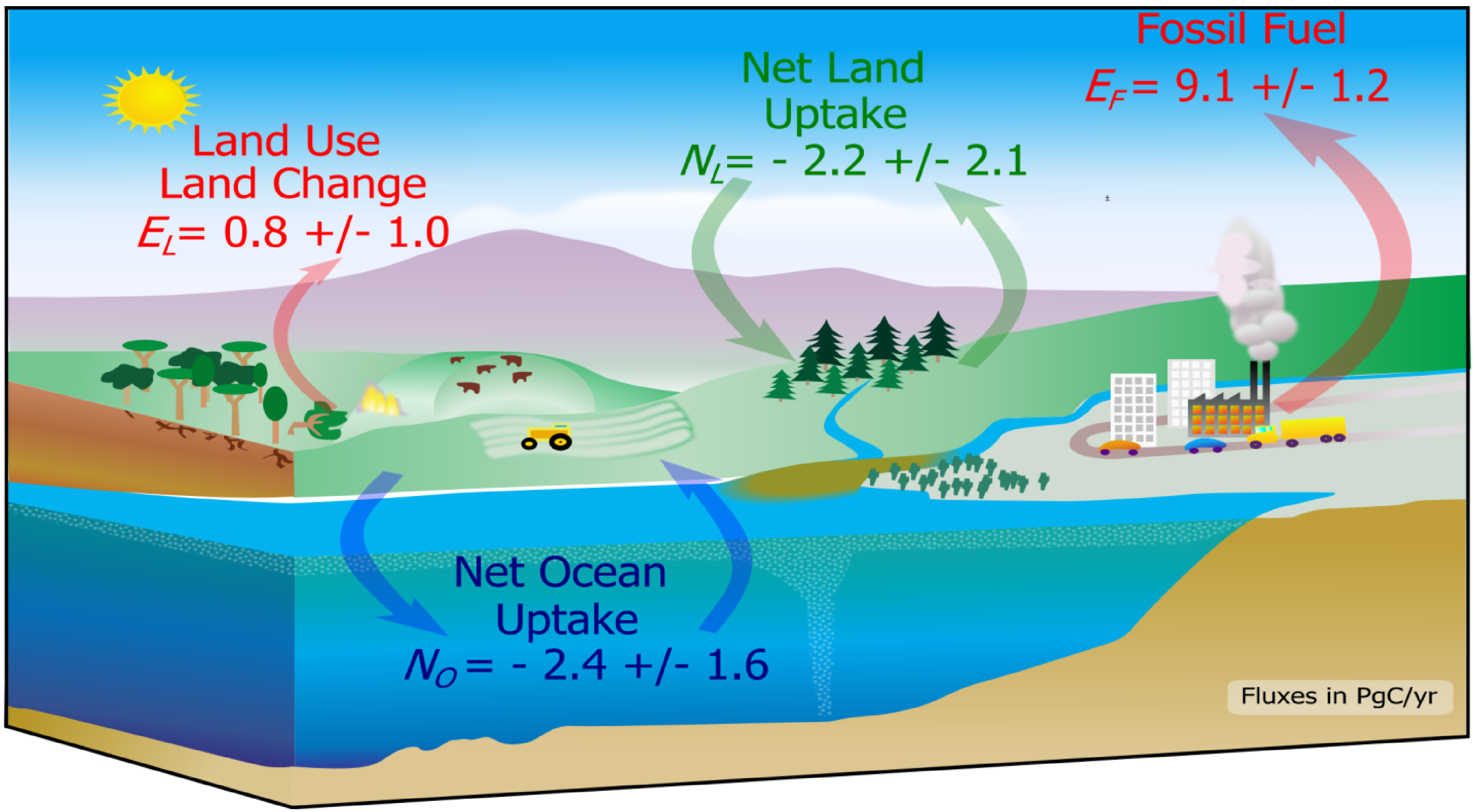
(C) …which in turn depend on annual GHG emissions over the next decades

Four Water, GEWEX questions

- How can we better understand and predict precipitation variability and changes
- How do changes in the land surface and hydrology influence past and future changes in water availability and security
- How does a warming climate contribute to extremes such as drought, floods and heatwaves, and what is the role of the land surface in enhancing feedbacks?
- How can we improve the understanding of the balances and budgets of energy and water?

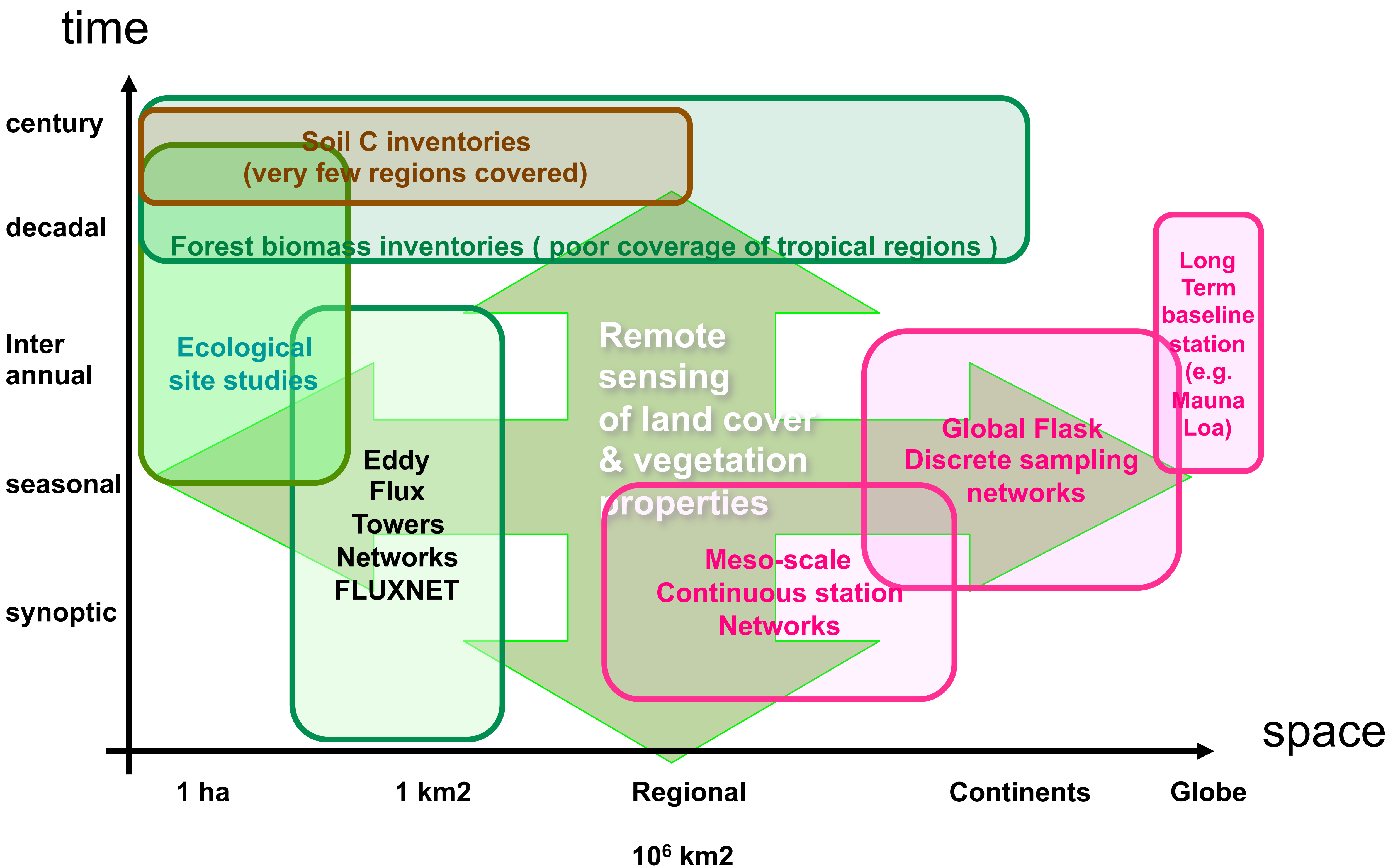
Courtesy Graeme Stephens and Sonia Seneviratne

The global carbon budget

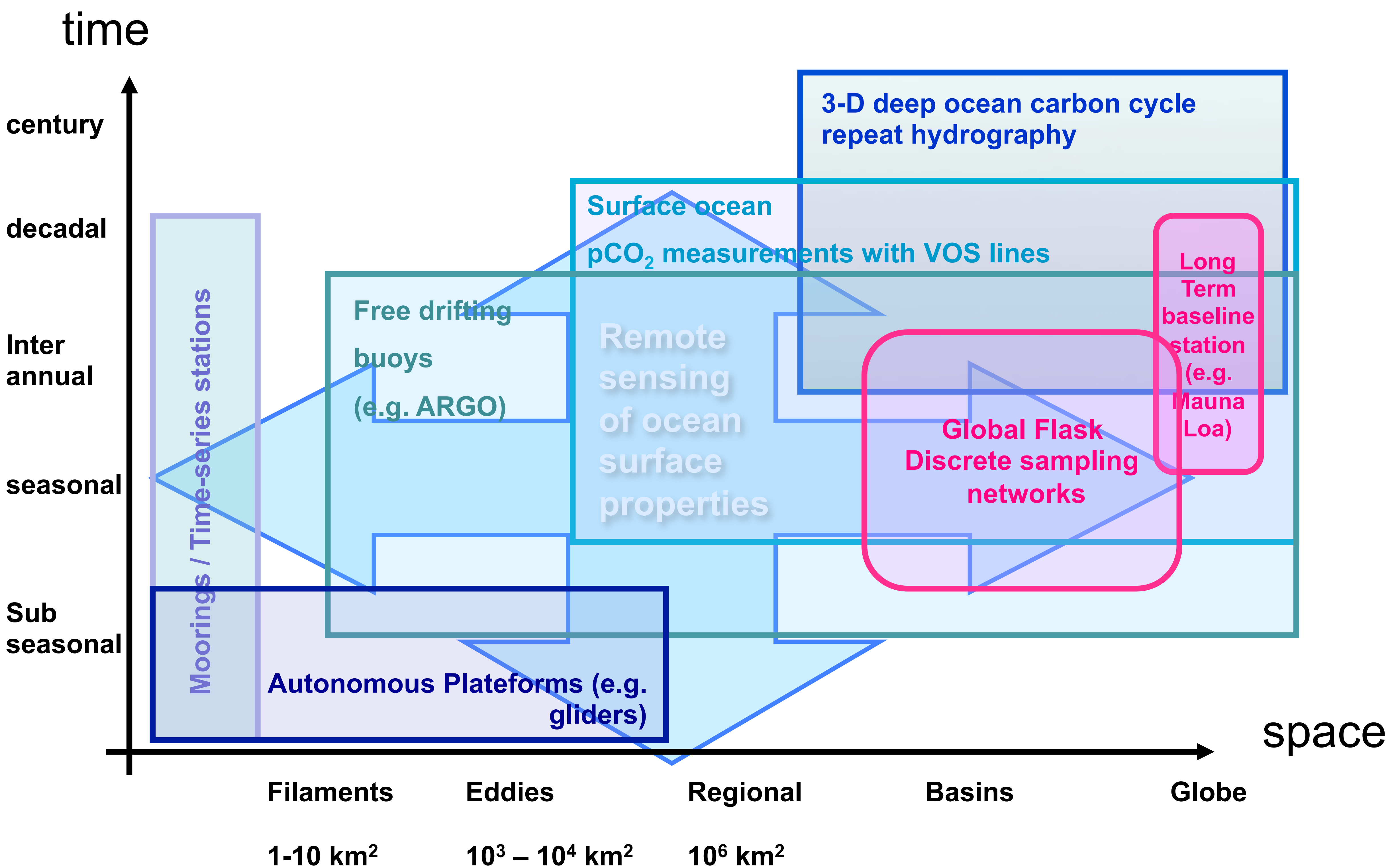


Ballantyne et al., 2015

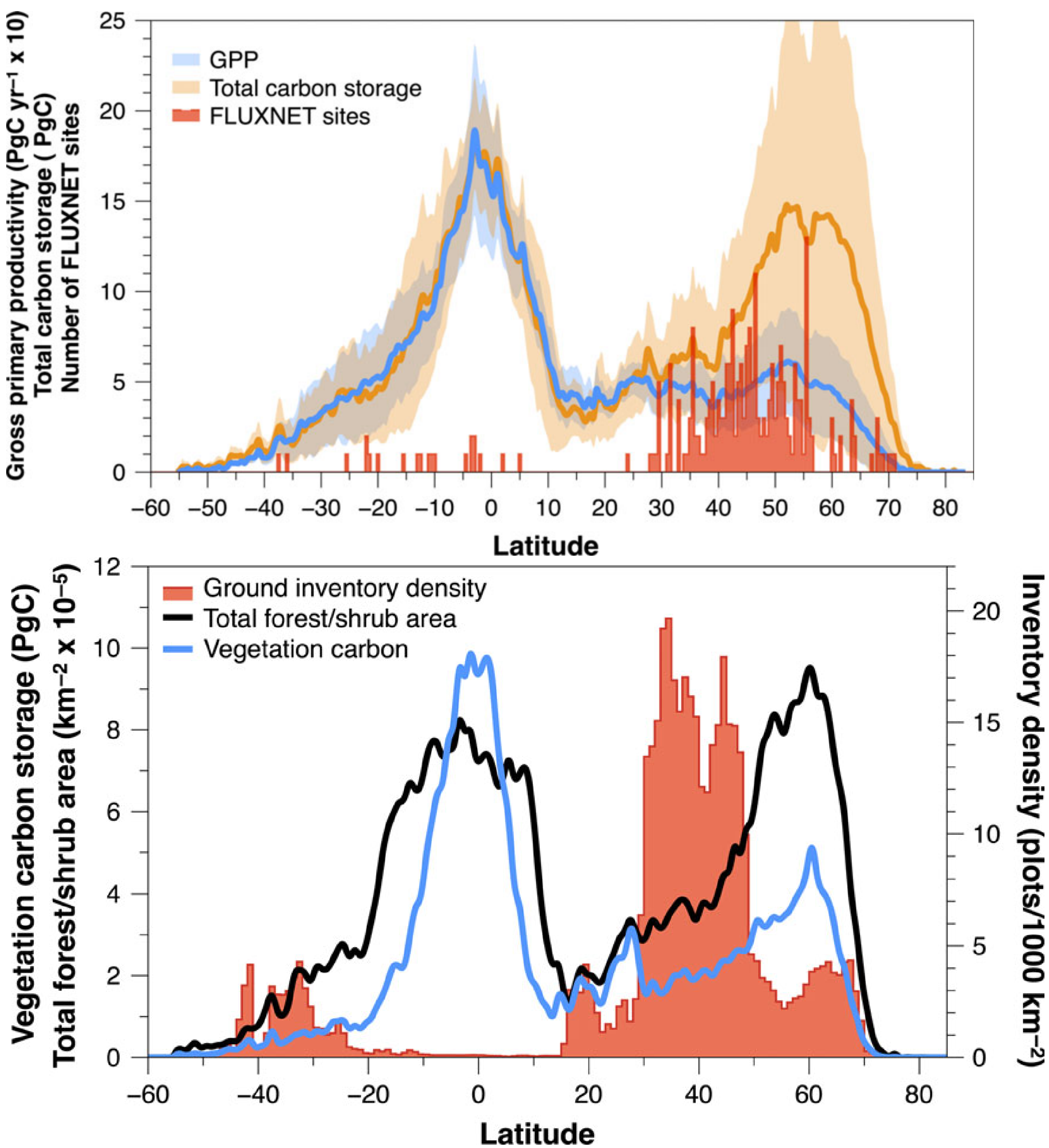
Terrestrial observations need to be integrated across time and space scales



Observations need to be integrated across time and space



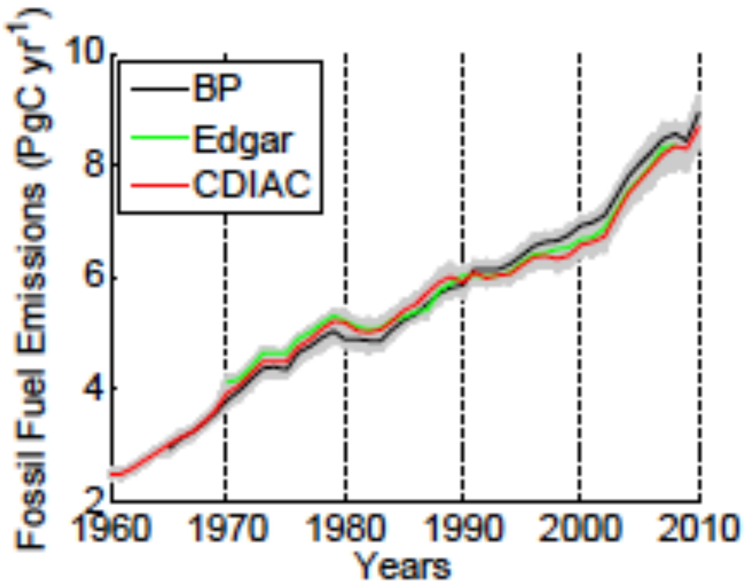
The "observational gap"

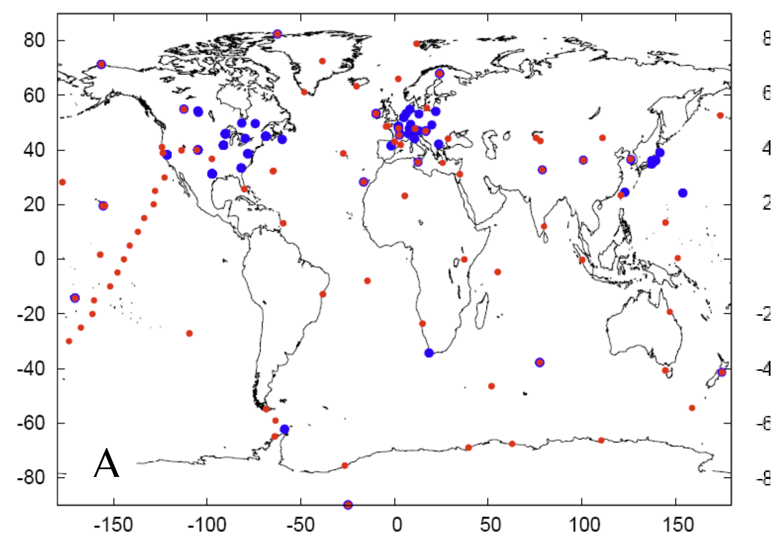


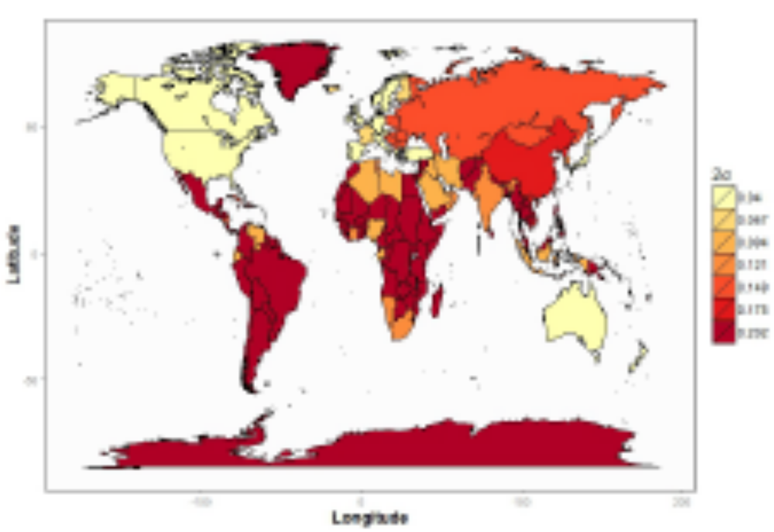
Flux sites are located at temperate latitudes: GPP is largest in the tropics

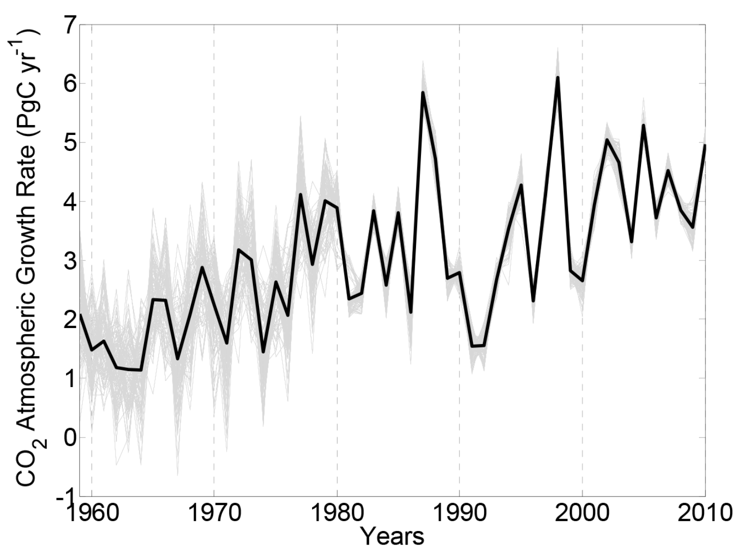
Inventory sites are located at temperate latitudes: storage is largest in the tropics

Uncertainties in the global budget





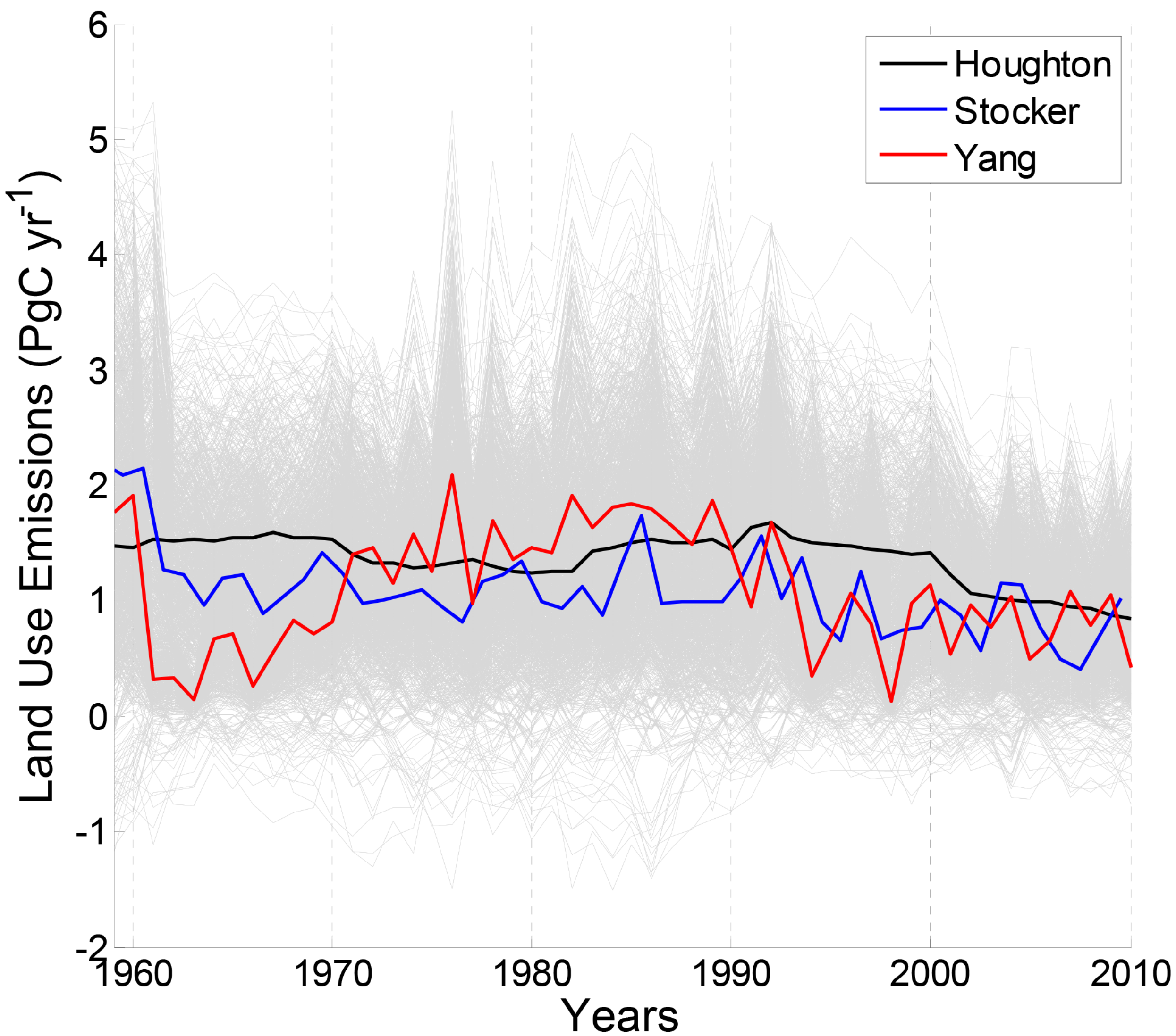




- **The 2σ uncertainties of the atmospheric growth rate have decreased** from 1.2 Pg C yr^{-1} in the 1960s to 0.3 Pg C yr^{-1} in the 2000s due to an expansion of the atmospheric observation network.
- **The 2σ uncertainties in fossil fuel emissions have increased from** 0.3 Pg C yr^{-1} in the 1960s to almost 1.0 Pg C yr^{-1} during the 2000s due to differences in national reporting errors and differences in energy inventories.

Ballantyne et al., 2015

Uncertainties in land use

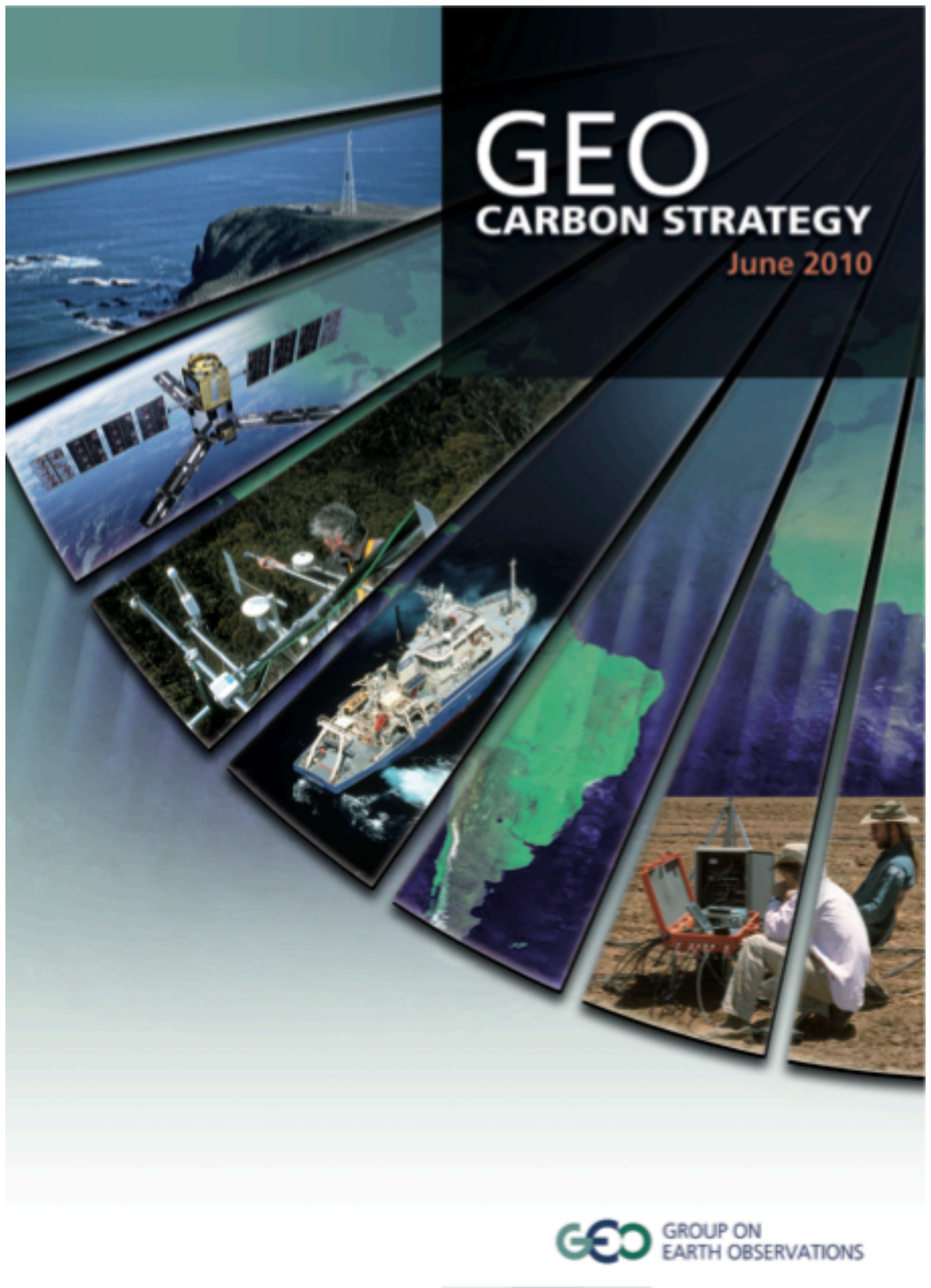


While uncertainties in growth rate have gone done, those in land use have remained the same

Variable	Decadal mean values and standard deviations 1960s	1970s	1980s	1990s	2000s
Atmospheric CO_2 ($PgC\,yr^{-1}$; $\partial C/\partial t$)	1.75	2.72	3.42	3.18	4.14
Mean of standard deviations	(0.60)	(0.61)	(0.22)	(0.18)	(0.16)
Standard deviation of the means	(0.61)	(0.91)	(1.21)	(1.40)	(0.82)
Land use emissions ($PgC\,yr^{-1}$; E_L)	1.16	1.28	1.42	1.15	0.89
Mean of standard deviations	(0.76)	(0.64)	(0.65)	(0.67)	(0.63)
Standard deviation of the means	(0.25)	(0.11)	(0.13)	(0.23)	(0.12)
Fossil fuel emissions ($PgC\,yr^{-1}$; E_F)	3.09	4.76	5.53	6.45	7.89
Mean of standard deviations	(0.15)	(0.24)	(0.30)	(0.35)	(0.47)
Standard deviation of the means	(0.44)	(0.41)	(0.33)	(0.24)	(0.69)

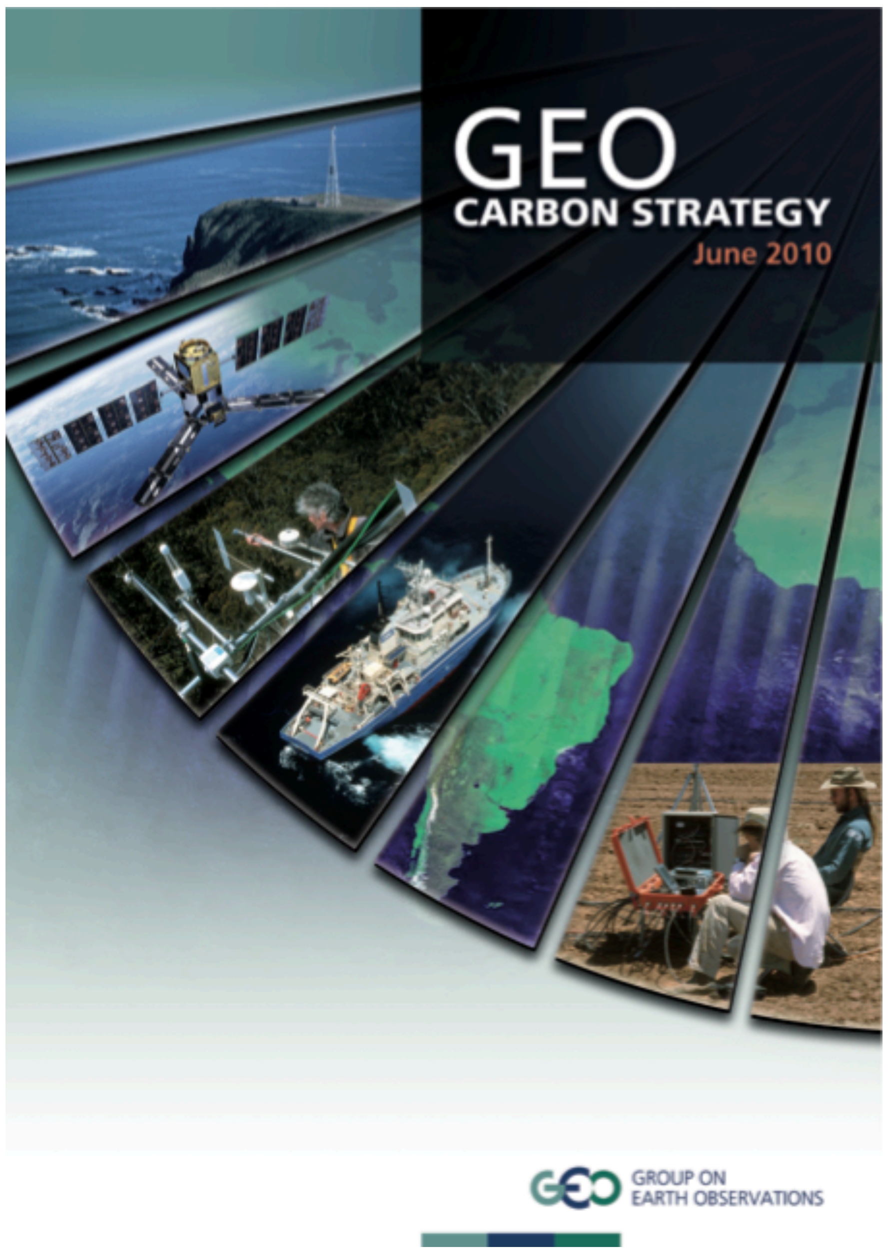
Ballantyne et al., 2015

The GEO Carbon Strategy



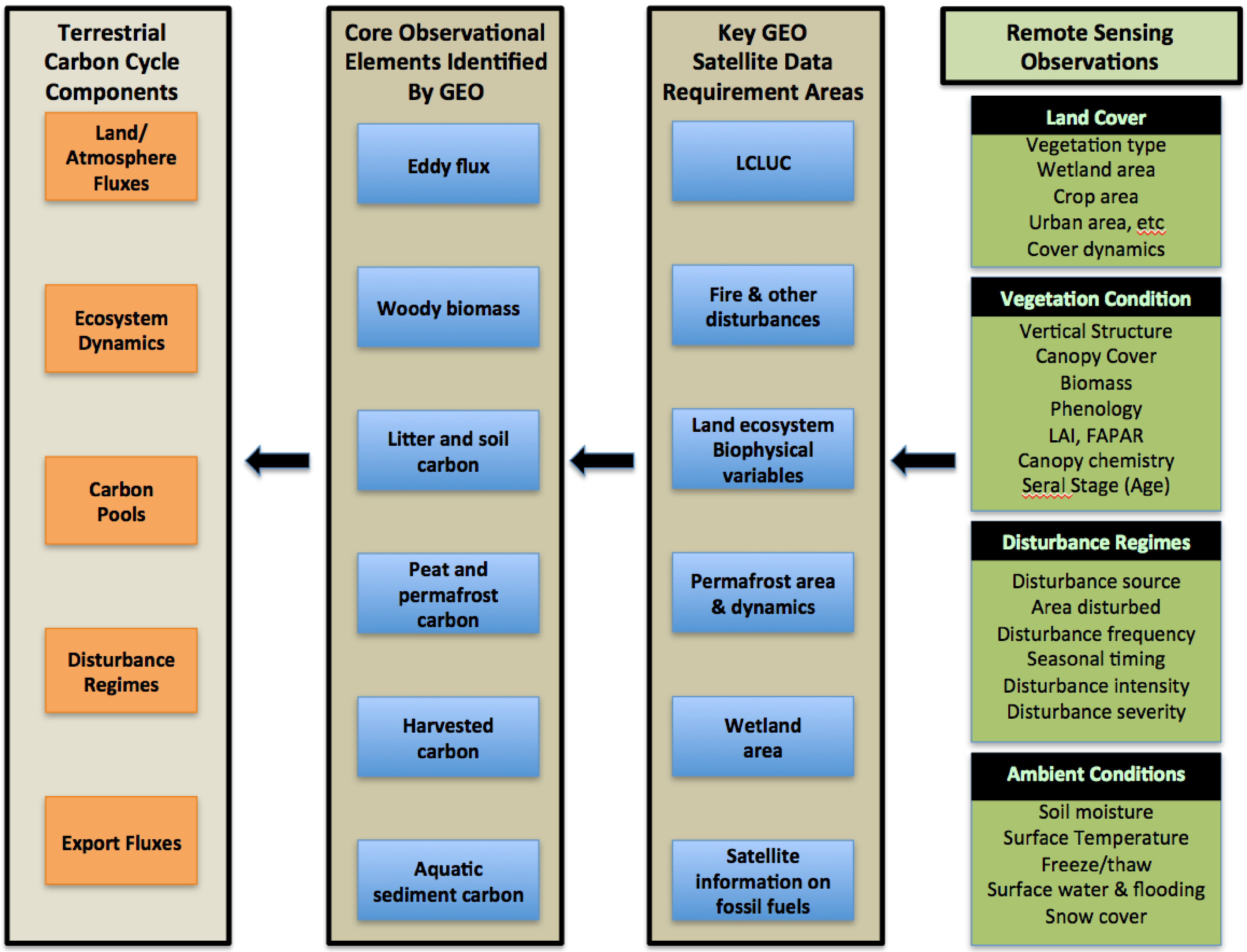
- increase the density of in situ networks, in particular for stations and aircraft atmospheric observations, ocean pCO2 observing systems using Voluntary Observing Ships, and eddy covariance terrestrial ecosystem flux measurement networks.
- develop space measurements of global CO_2 and CH_4 distributions, to fill the gap after GOSAT and SCIAMACHY;
- develop spatial scaling techniques for pCO_2 and land flux observations for application to wider regions, using satellite information;
- undertake a decadal full basin survey of ocean carbon state, together with regular inventories of forest biomass and soil carbon pools;

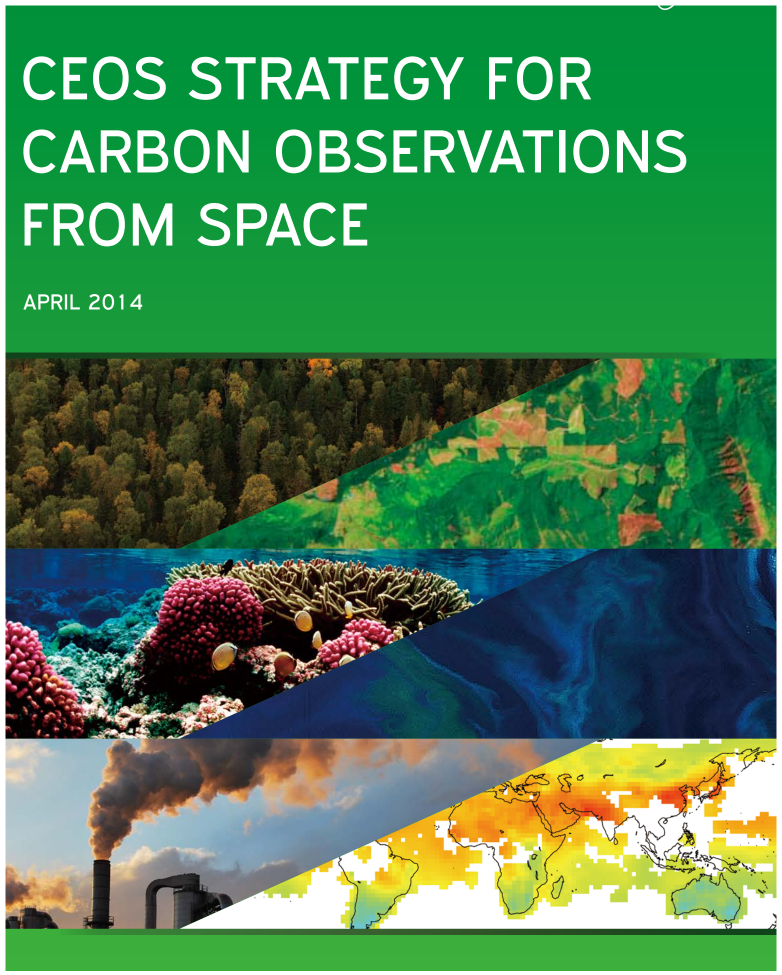
The GEO Carbon Strategy



- improve access to a continuous supply of mid-resolution Earth observing (satellite) data, to monitor areas of forest;
- improve access to geospatial and temporal fossil fuel emission information, including spatial-data infrastructure;
- assemble geospatial information about use of wood and food products, and continuously monitored dissolved and particulate carbon, if possible with age information, for relevant rivers;
- implement a data architecture that facilitates the combination of different data-streams;
- establish an International Carbon Office to operate a program to produce annually updated regional and global carbon budgets.

From the GEO Carbon Strategy to the CEOS response





Satellite missions for CH_4 and CO_2

Updated from CEOS response to GEO

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

Atmospheric (over land, sea and ice)
Composition: Carbon dioxide, Methane, and other long-lived greenhouse gases.

Oceanic
Surface: Ocean colour (for biological activity), Carbon dioxide partial pressure, Ocean acidity,
Sub-surface: Nutrients, Carbon dioxide partial pressure, Ocean acidity, Oxygen, Phytoplankton; Marine biodiversity and habitat properties

Terrestrial
Land cover (including vegetation type), Fraction of absorbed photosynthetically active radiation (fAPAR), Leaf area index (LAI), Above-ground biomass, Soil carbon, Fire disturbance, Terrestrial biodiversity and habitat properties

The new IP

- Better explanation in terms of science and convention relevance, can we close the C-budget, verification purposes?
- Do we need to include fluxes (GPP,…GBP)?
- Evaluate ECV's to relevance for carbon cycle: new ECV fossil fuel emissions?

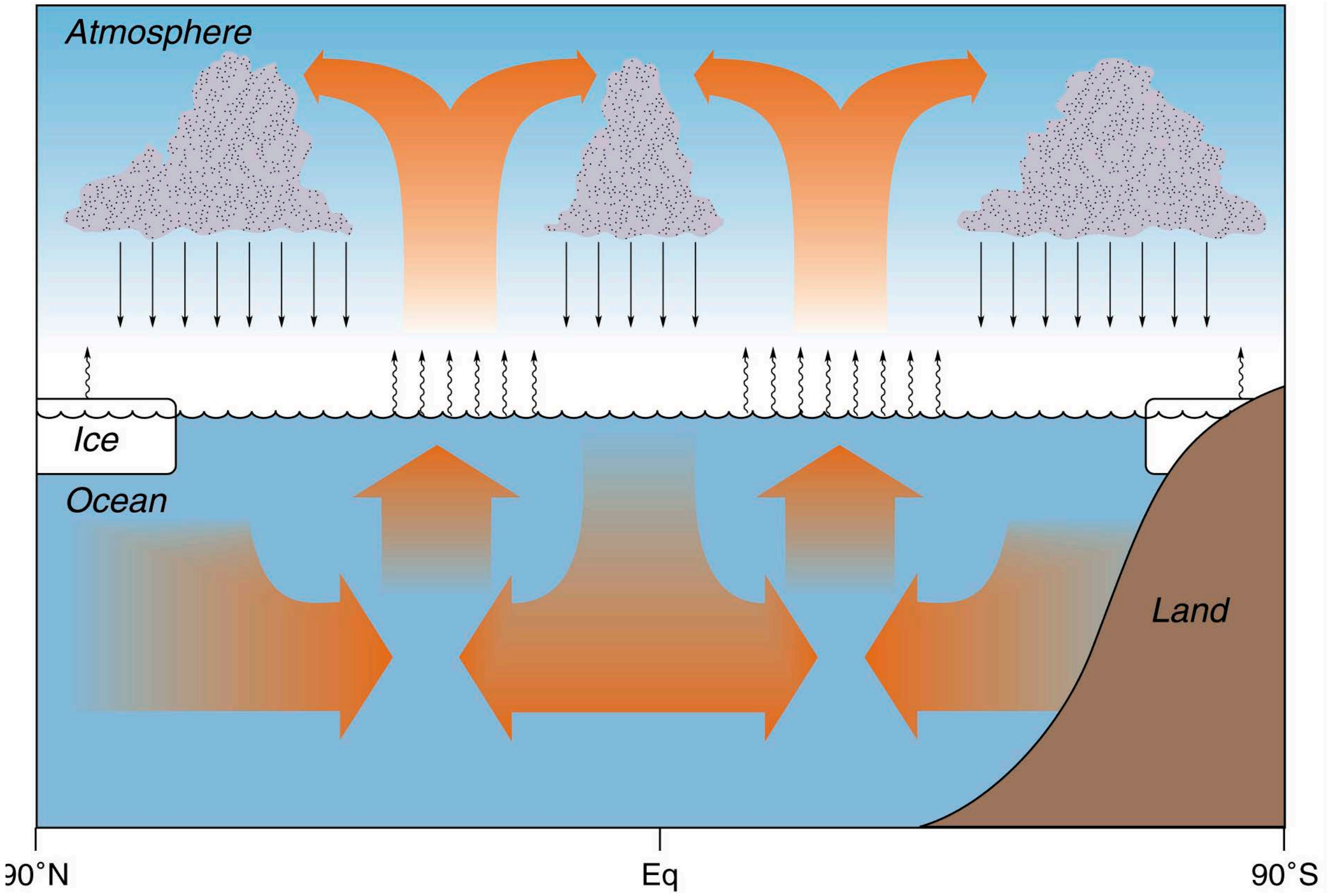
Hydrological ECVs

- The GCOS ECV framework helps to address the energy and water cycle and related science questions;
- Global energy and water cycles can be balanced within uncertainty of component fluxes;
- It is suggested to extended the GCOS ECV framework to essential variables describing E&W cycles;

Thanks to Jorg Schulz, EUMESAT

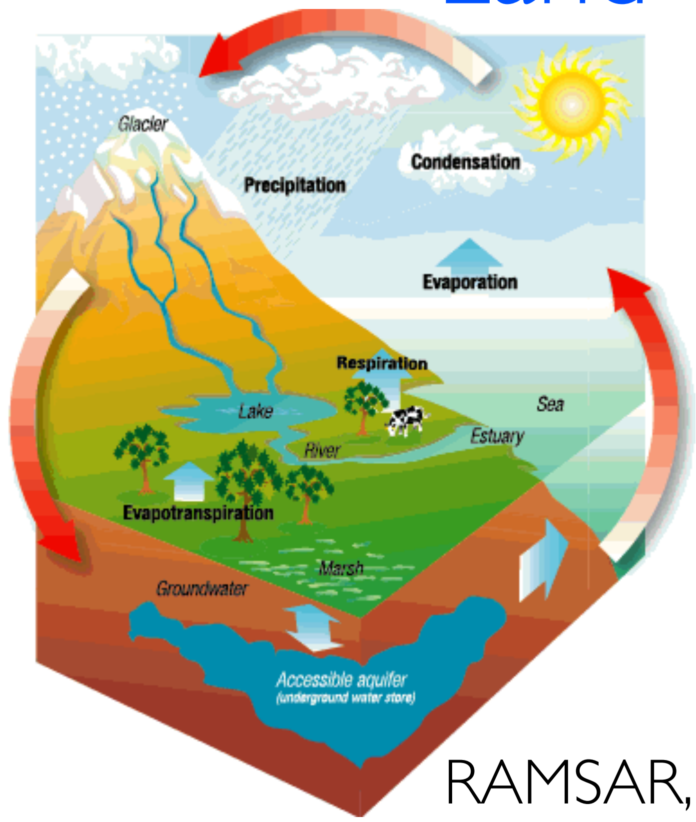
Different perceptions of the global water cycle

Ocean



Clayson, 2014

Land

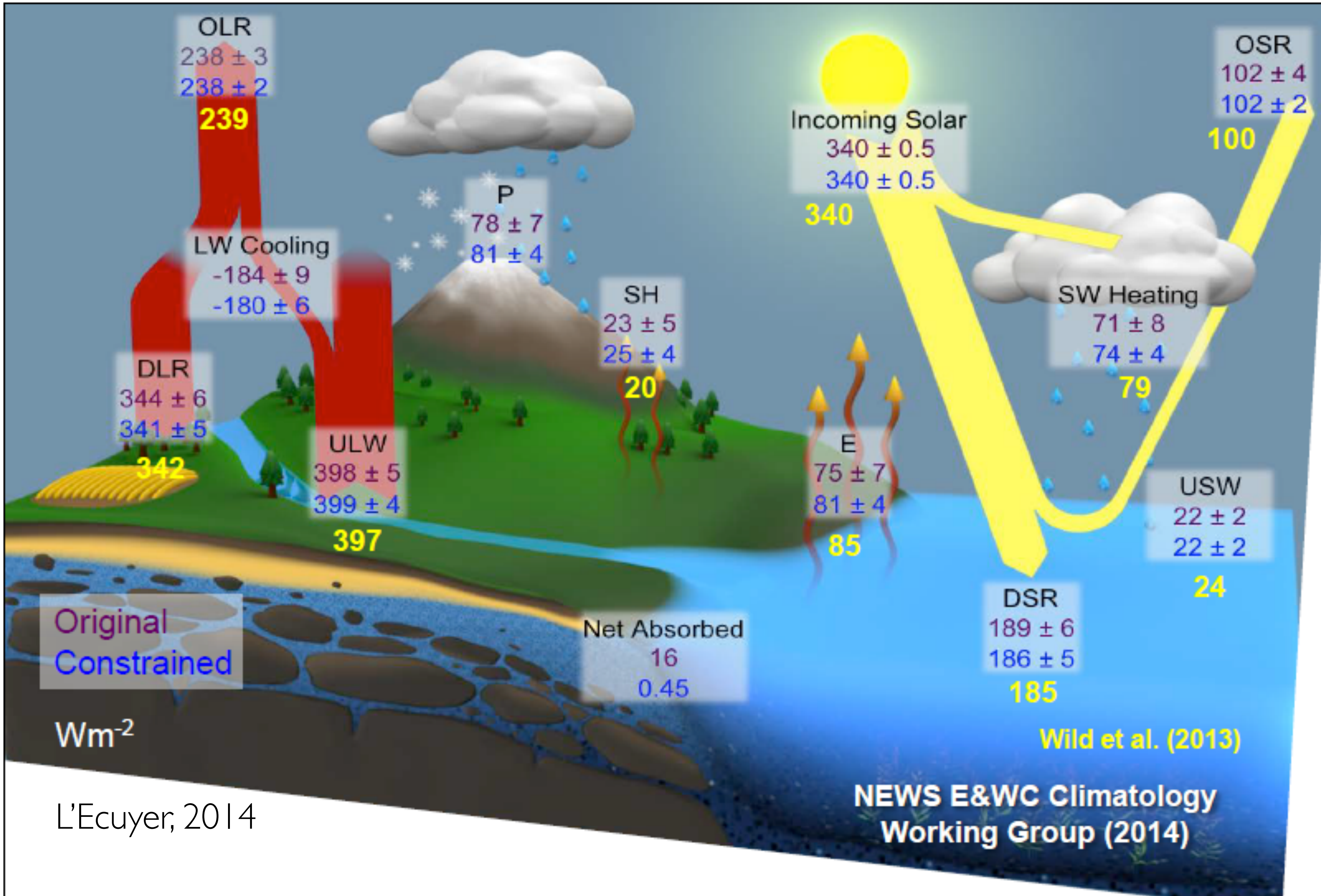


RAMSAR, GTOS

Energy Cycle

Satellite inputs include:

- Microwave radiance data,
- lidar, radar data
- Vis/IR imaging radiance data
- GRACE gravity and Altimetry
- Assessment of uncertainties



L'Ecuyer, 2014

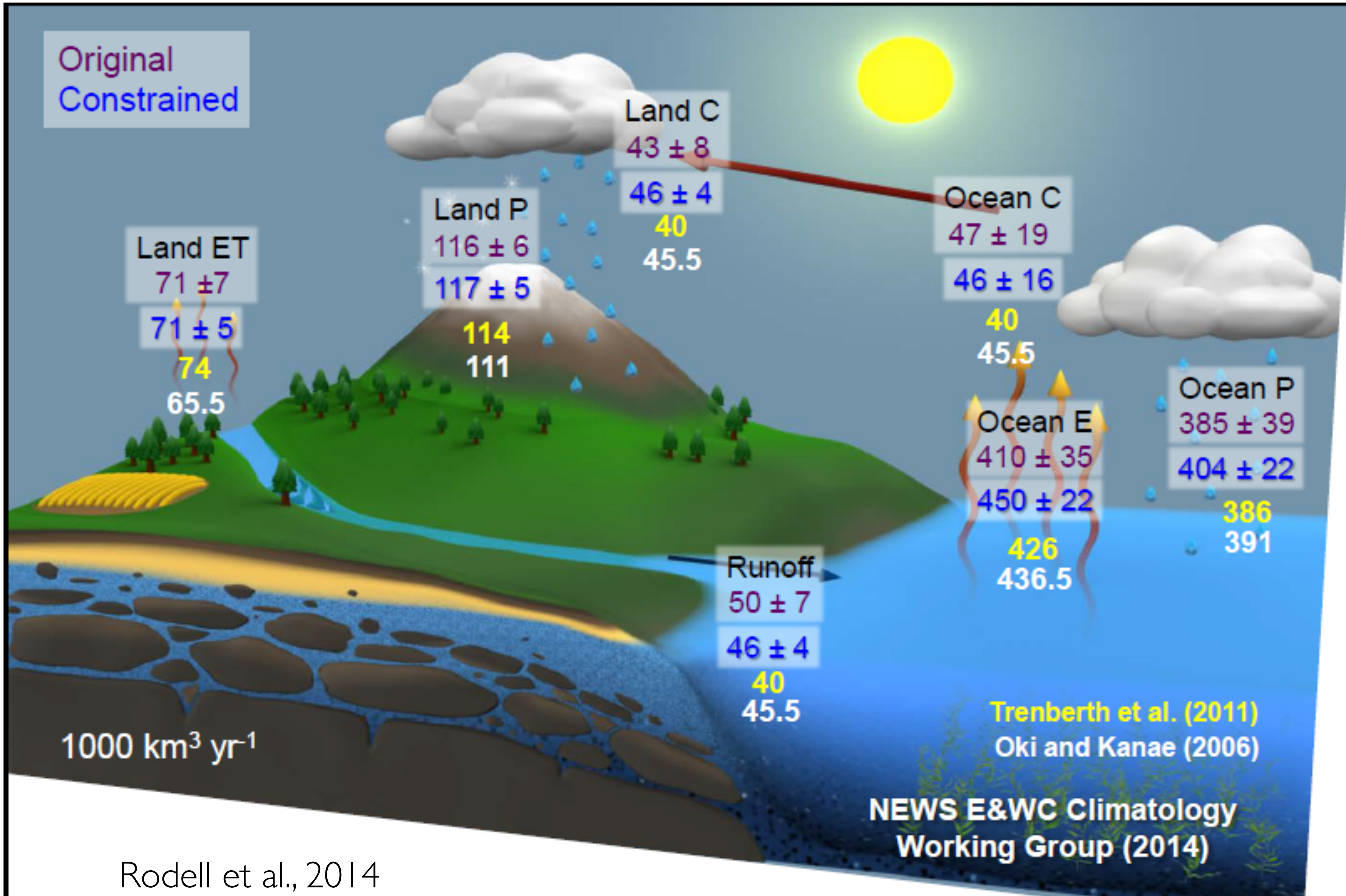
Earth's energy budget with balance constraints imposed.

NASA ENERGY AND WATER CYCLE STUDY NEWS

Water Cycle

Energy cycle link:

E ⟷ LH



Rodell et al., 2014

Earth's water cycle with balance constraints imposed.

Constrained Estimates Realistic?

Flux	Raw	Optimized	Change	Error
OLR	238	239	1	2
OSR	100	102	2	5
DLR	344	341	3	7
DSR	190	186	4	6
E	75	81	6	7
P	77	81	4	7
SH	21	25	4	5

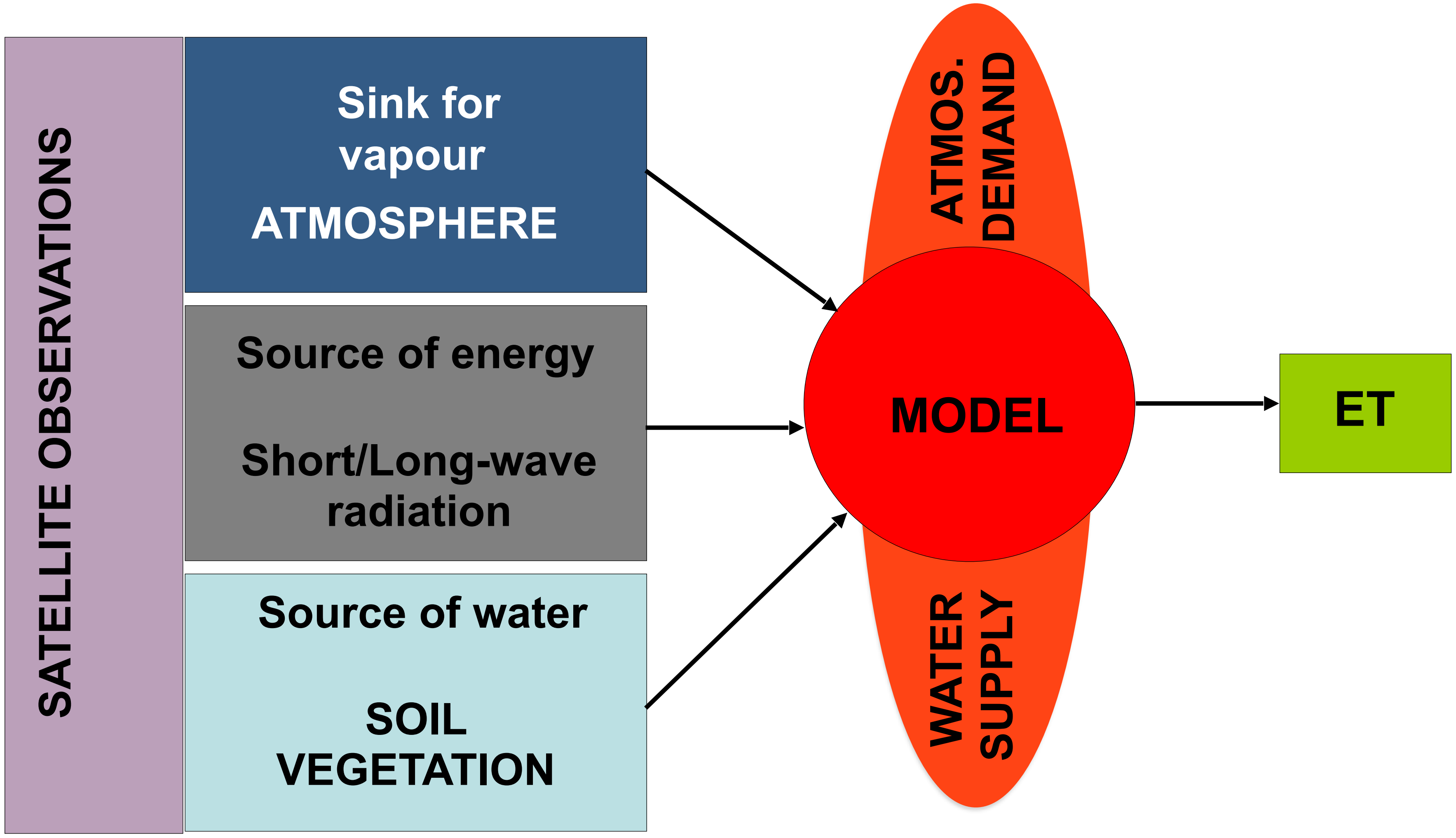
All in Wm^{-2}

L'Ecuyer, 2014

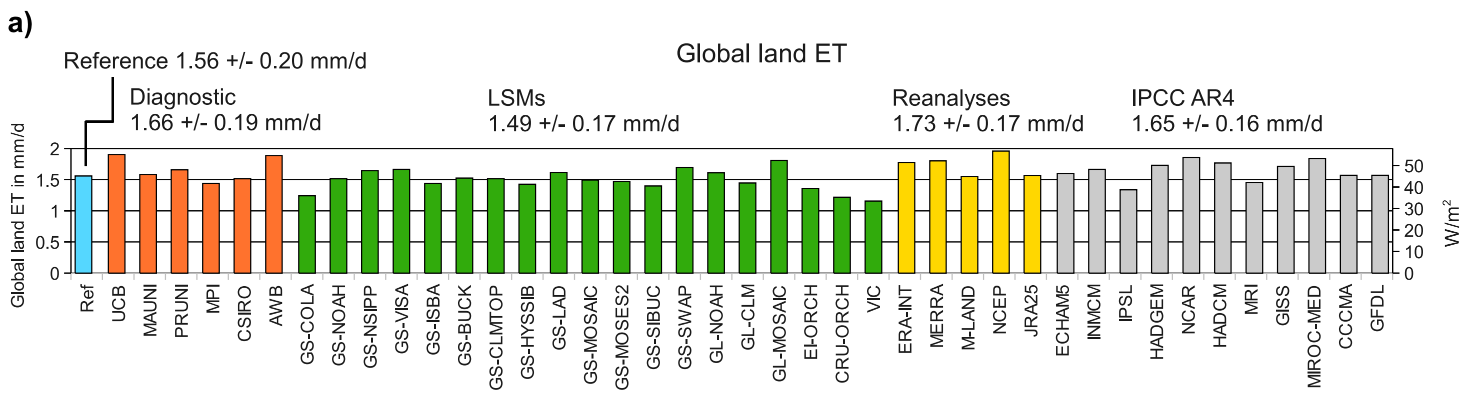
GEWEX Landflux

GEWEX Data and Assessments Panel (GDAP):

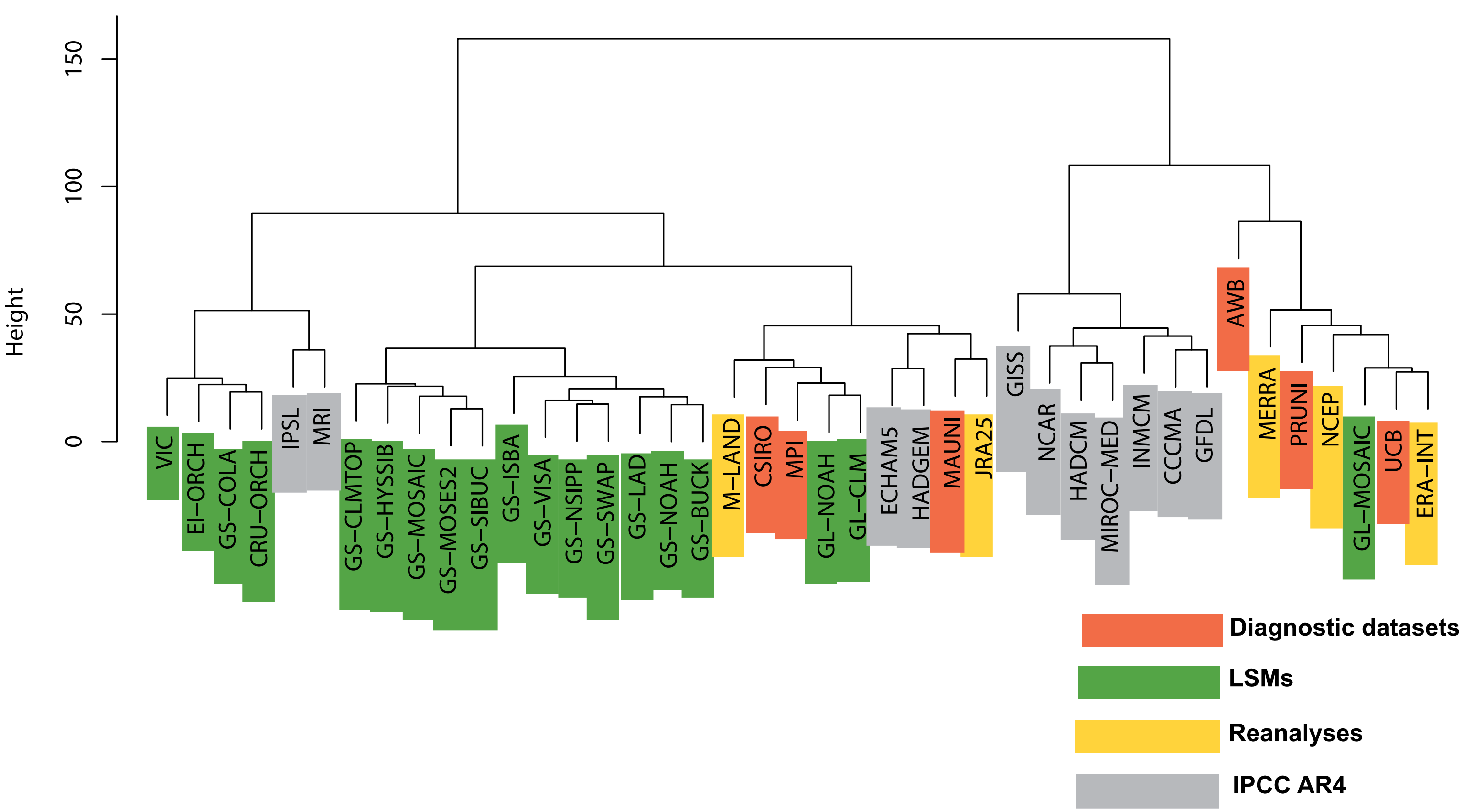
Goal: Develop global observationally based products to allow independent water and energy cycle assessment (1984-2007).



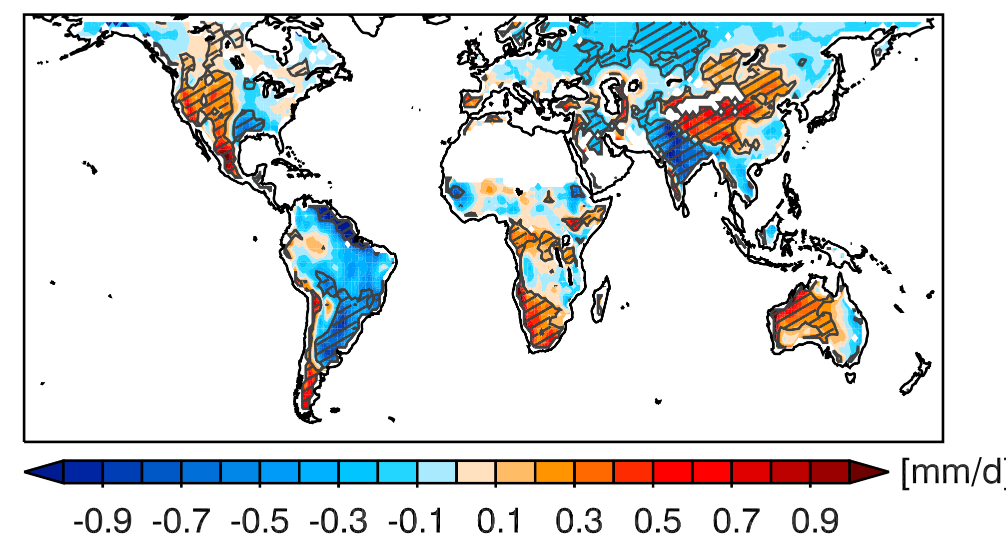
Results Landflux



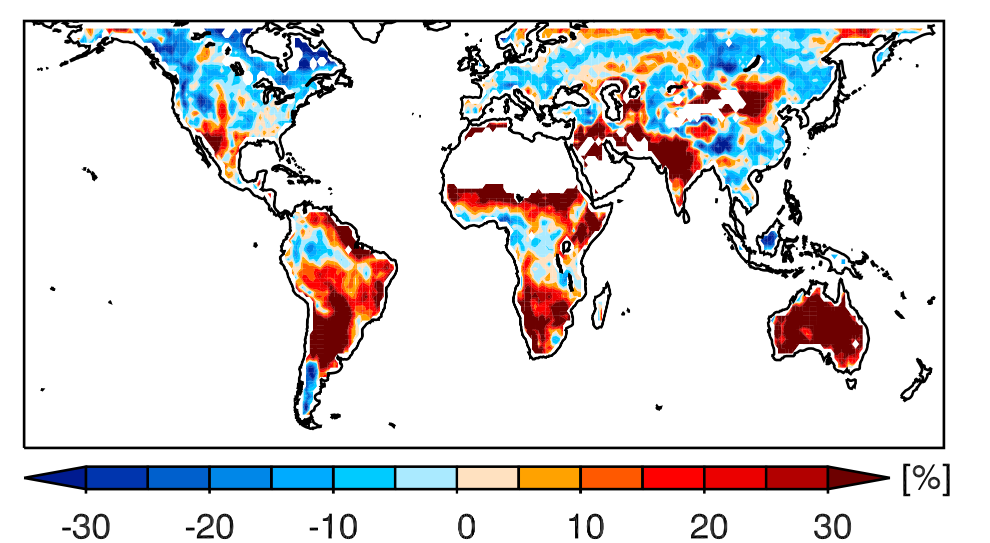
Cluster analysis of multi-year mean ET 1989-1995 (global)



Difference of mean ET: IPCC - Ref.

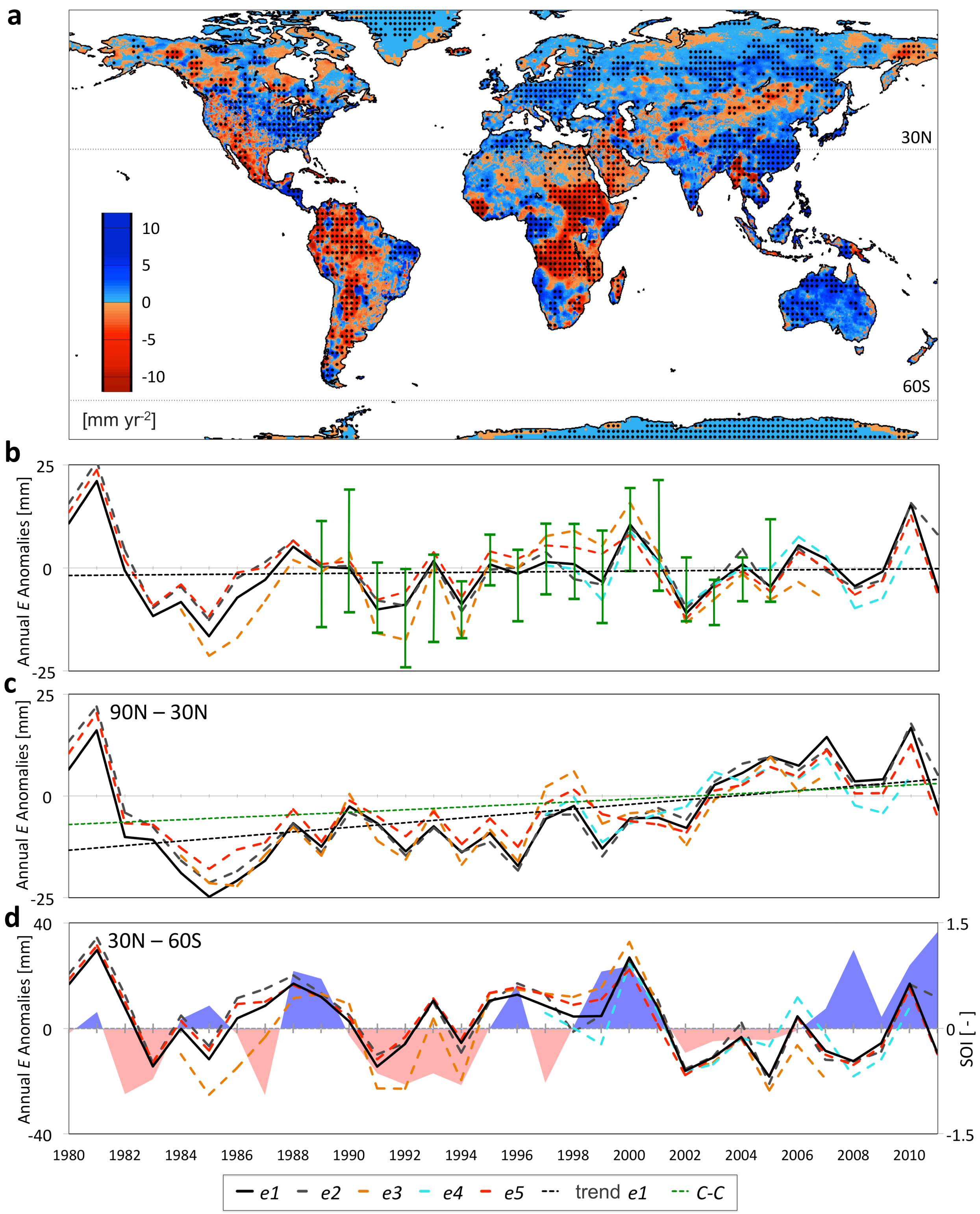


Difference of relative IQR of ET: IPCC - Ref.



Mueller et al., 2011. GRL. VOL. 38, L06402, doi:10.1029/2010GL046230, 2011

Can we explain the interannual variability?



Increase in Northern latitudes and "stable" in Southern

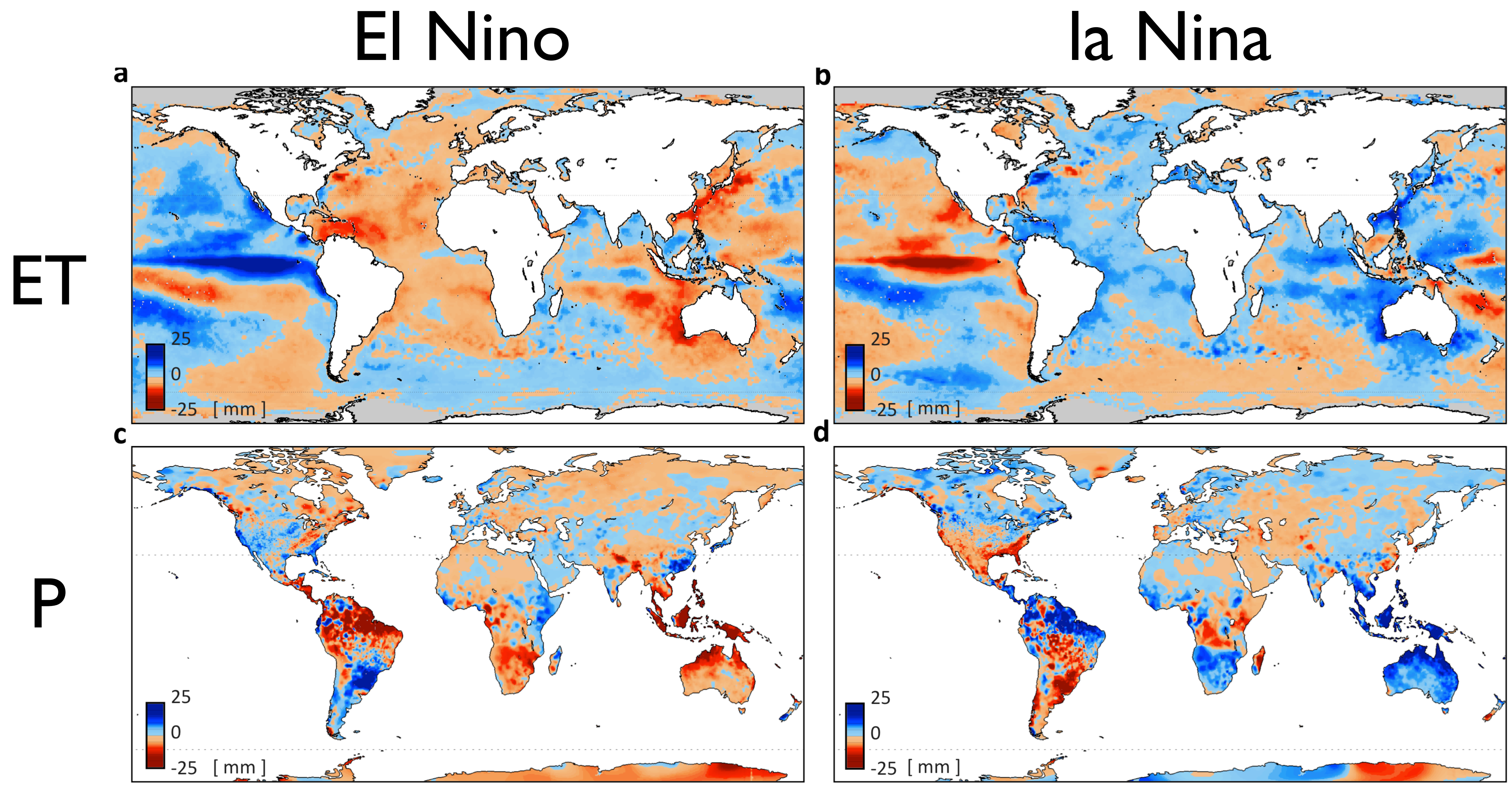
Global

Northern

Southern

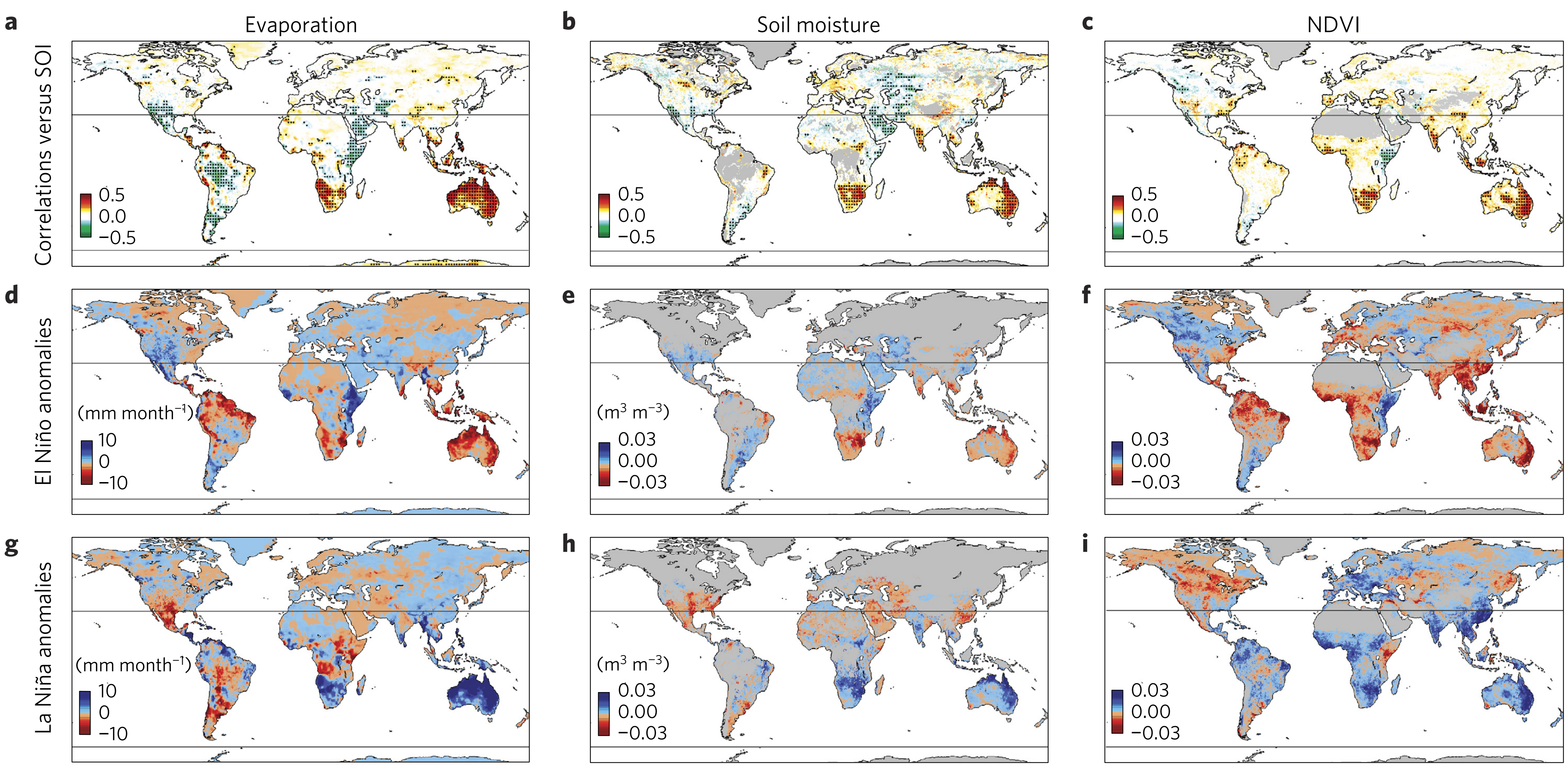
Miralles, et al., 2013

Coupling ocean land



Ocean evaporation

The importance of interconnections

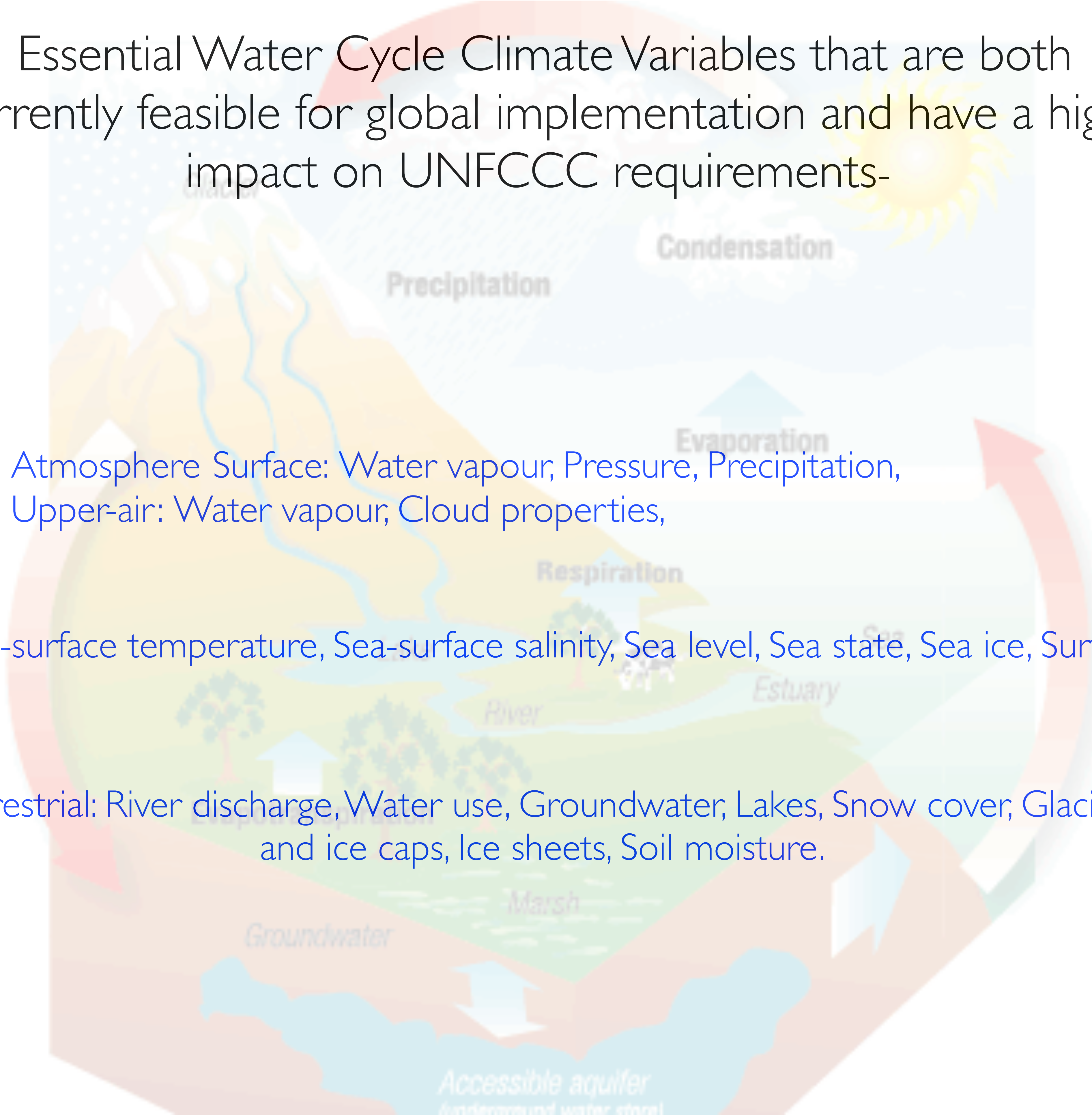


Essential Water Cycle Climate Variables that are both currently feasible for global implementation and have a high impact on UNFCCC requirements-

Atmosphere Surface: Water vapour, Pressure, Precipitation,
Upper-air: Water vapour, Cloud properties,

Ocean Sea-surface temperature, Sea-surface salinity, Sea level, Sea state, Sea ice, Surface current,

Terrestrial: River discharge, Water use, Groundwater, Lakes, Snow cover, Glaciers and ice caps, Ice sheets, Soil moisture.



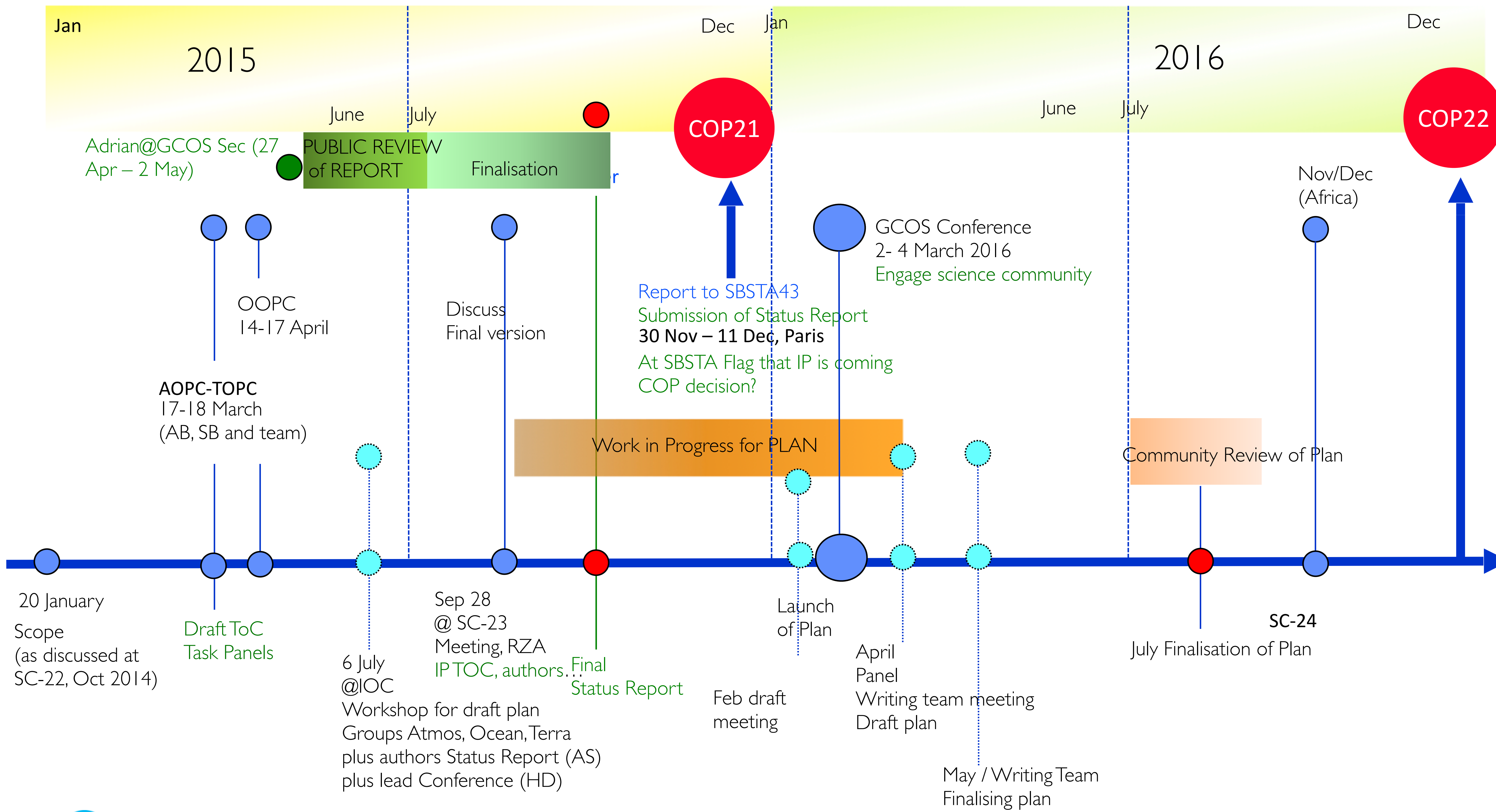
Potential Improvements to Water ECVs

- To better represent E&W cycles GCOS ECV set could be enhancement with:
  - Land Surface temperature (radiative skin temperature);
  - Turbulent heat fluxes (ocean and land);
  - Precipitation/hydrometeor profile (latent heat release).
- Requirements for component fluxes need to be carefully engineered to be consistent with state variables;
- Provide requirements for ECVs with application in mind – process, budget and climate trend studies have different requirements but we need measurements to cover all applications.

Conclusions

- ECV need to be (re) evaluated against their use
- GCOS monitoring principles support investigation of complex relations

Road Map for the new Plan (2015 – 2016)

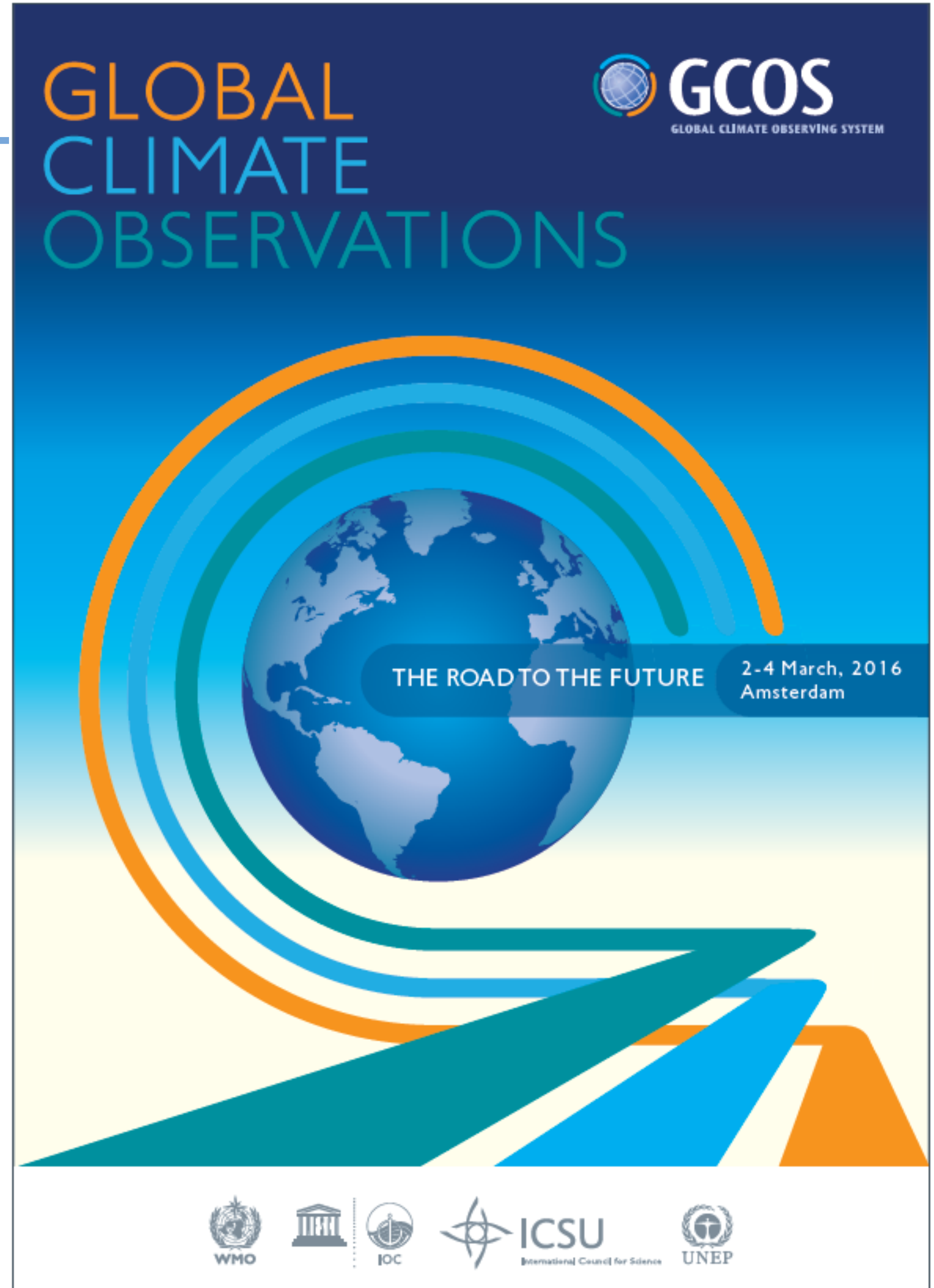


updated@17 March 2015

GCOS International Science Conference

2 – 4 March 2016

Royal Academy of Arts and Sciences, Amsterdam, The Netherlands



GCOS
GLOBAL CLIMATE OBSERVING SYSTEM