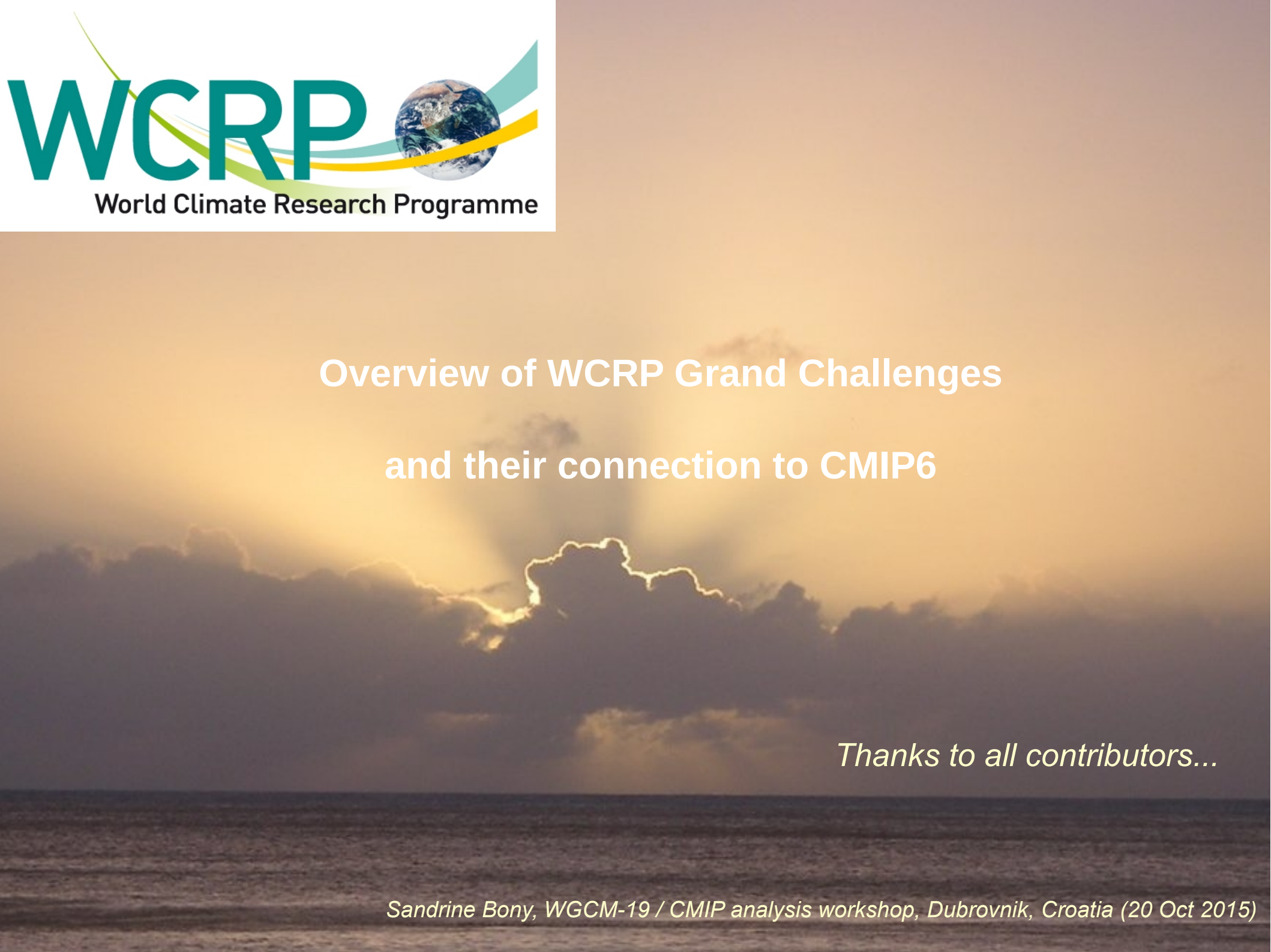


Overview of WCRP Grand Challenges

and their connection to CMIP6

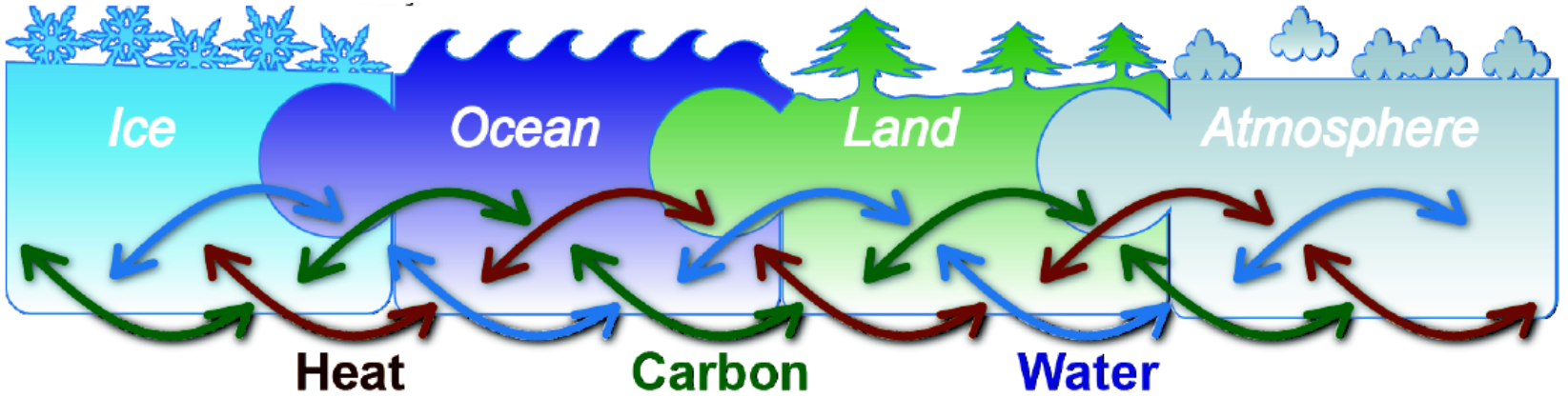
Thanks to all contributors...

Sandrine Bony, WGCM-19 / CMIP analysis workshop, Dubrovnik, Croatia (20 Oct 2015)

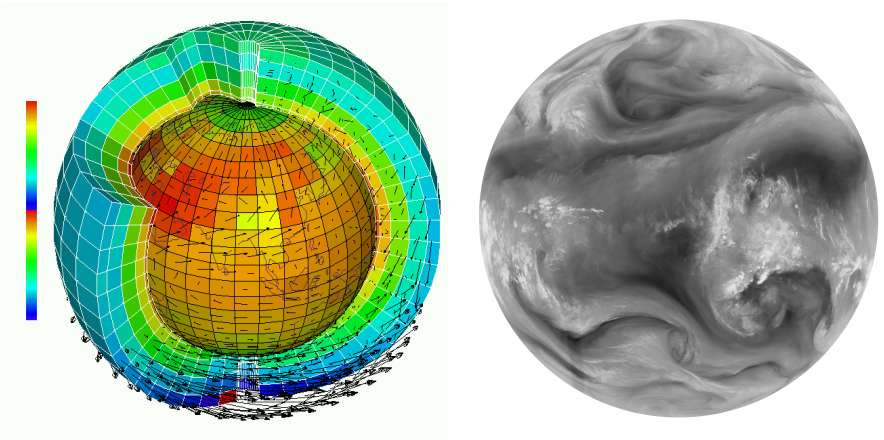
WCRP
World Climate Research Programme

in a nutshell...

Four core projects (CLIC, CLIVAR, GEWEX, SPARC)



Working Groups, Panels & Advisory Councils in modelling & observation



- A structure and organization that has a rationale.
- But most pressing questions of climate science are cross-cutting issues

WCRP Grand Science Challenges

Goals :

- **Promote research on critical gaps of knowledge in climate science**

- **Focus efforts and integrate communities** (observation, modeling, paleo-climates, process studies) **around a few key questions where new opportunities** (observations, technologies, maturation of understanding, etc) **raise the possibilities of significant progress on the timescale of 5-10 years.**

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5 Grand Challenges (GCs) identified

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5 Grand Challenges (GCs) identified + 2 under consideration :

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5 Grand Challenges (GCs) identified + 2 under consideration :

→ Brainstorming about gaps and opportunities; Workshops; New initiatives
Ideas/recommendations to fill observational or modelling gaps

WCRP Grand Science Challenges

1. Clouds, Circulation and Climate Sensitivity
2. Climate extremes
3. Water availability
4. Melting Ice
5. Sea level rise

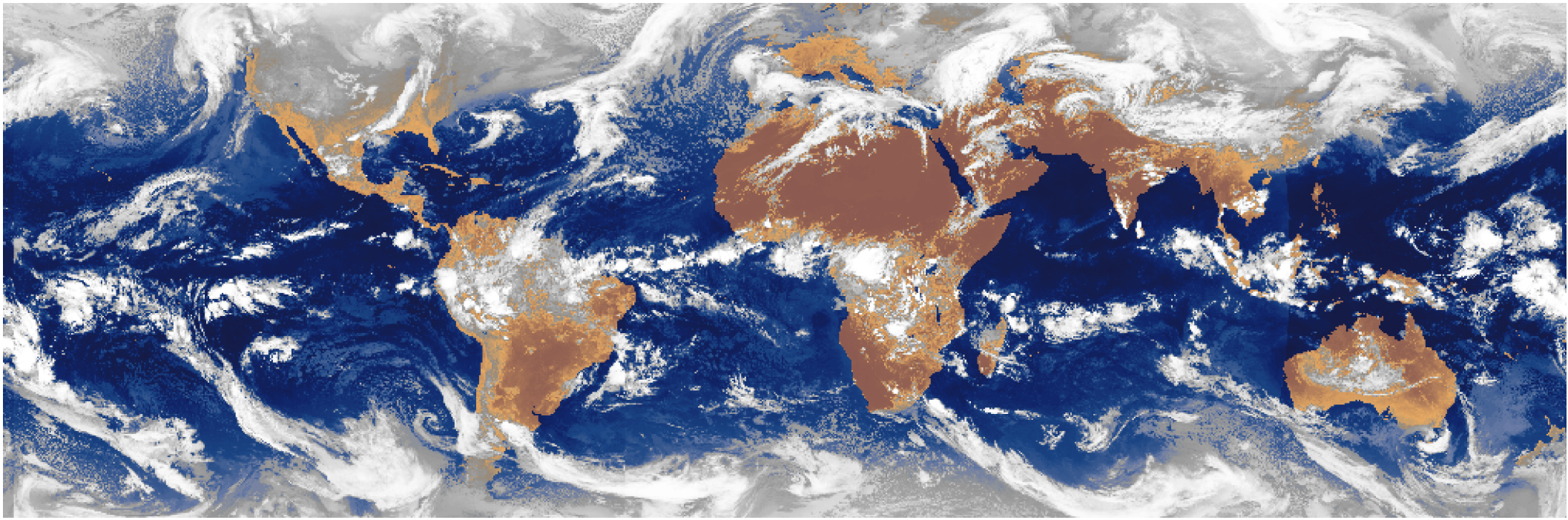
+ ?

6. Decadal prediction
7. Biogeochemical feedbacks

→Main science questions ? Link to CMIP6 ?

WCRP Grand Challenge on

Clouds, Circulation and Climate Sensitivity



Coordinators : S Bony, B Stevens, D Frierson, C Jakob, M Kageyama, R Pincus, T Shepherd, S Sherwood, P Siebesma, A Sobel, M Watanabe, M Webb

What role do clouds play in atmospheric circulation and climate feedbacks? Implications for climate patterns and climate sensitivity?

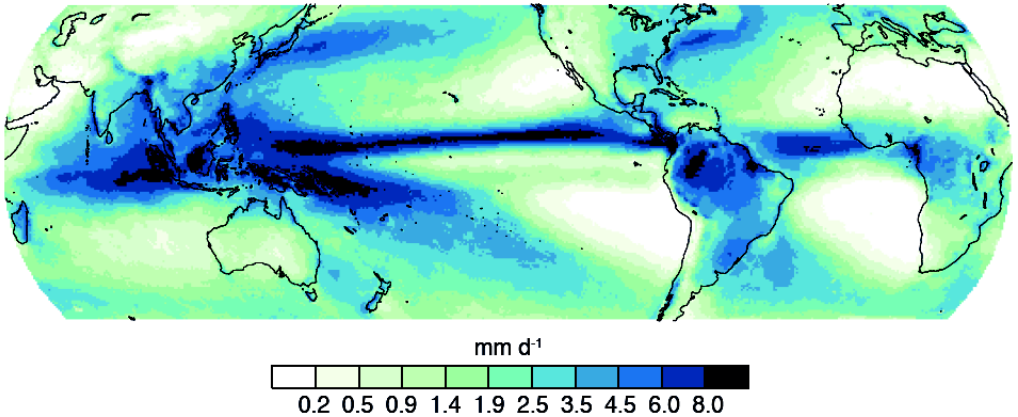
http://www.wcrp-climate.org/index.php/gc-clouds

An old and still burning issue... but ripe for progress

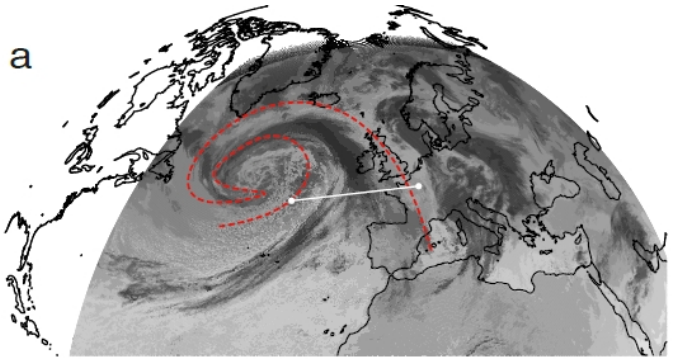
April 2015

Four questions

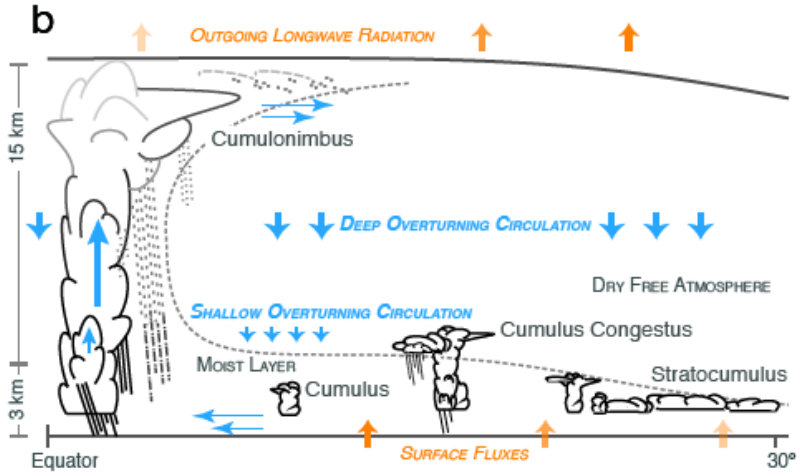
1. What controls the position, strength and variability of tropical rain belts ?



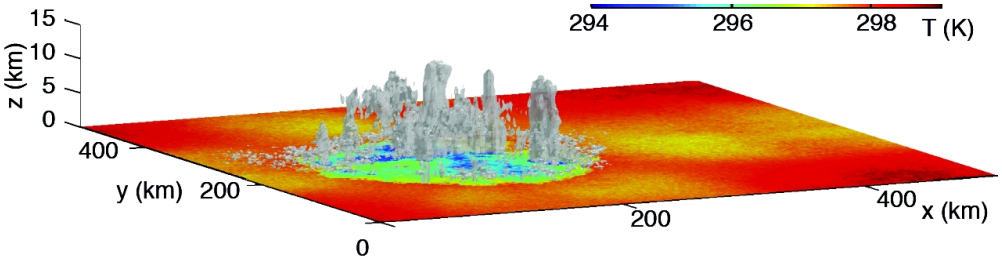
2. What controls the position, strength and variability of storm tracks ?



3. What role does convection play in cloud feedbacks ?



4. What role does convective aggregation play in climate ?



Bony et al., Nature Geoscience, 2015

Link to the modelling

Focus :

- Idealized experiments
- Hierarchy of models (ESM, OAGCMs, AGCM, aquaplanet, SCM, CRMs, LES)
- Synergies modelling / observation / processes / paleo

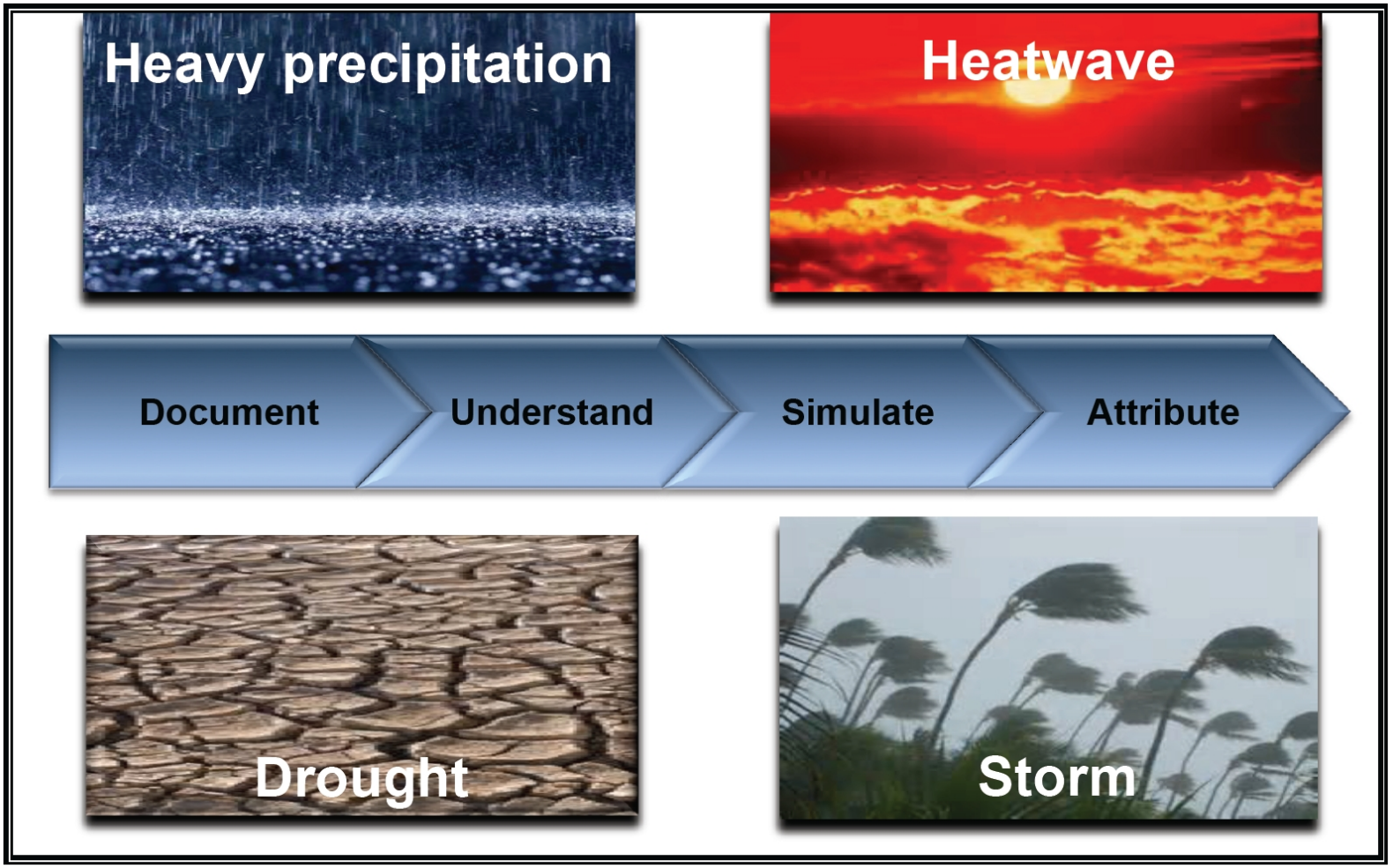
Connection to CMIP6:

- **DECK** (including satellite simulator outputs and process diagnostics)
- **CFMIP, RFMIP, PMIP**
- also GeoMIP, DynVar, GMMIP, VolMIP, HighResMIP

Additional coordinated experiments :

- Easy aerosols (robust impacts of aerosol forcing on circulation)
- TRAC-MIP (tropical rain-belts with an annual cycle and continent intercomparison)

WCRP Grand Challenge on Climate Extremes



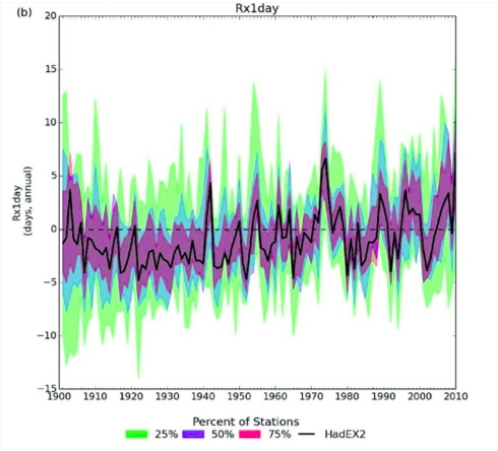
Coordinators : L. Alexander, A. Behrangi, S. Seneviratne, O. Martius, R. Vautard, G. Hegerl, E. Fischer, J. Silimann, X. Zhang and F. Otto

Four overarching themes: Document, Understand, Attribute and Simulate

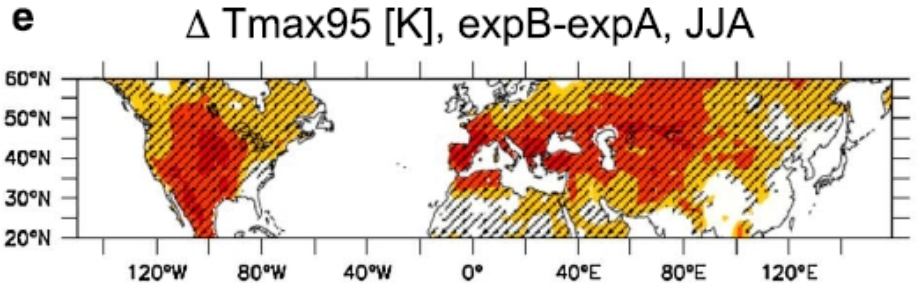
http://www.wcrp-climate.org/index.php/gc-extreme-events

Four areas of activities

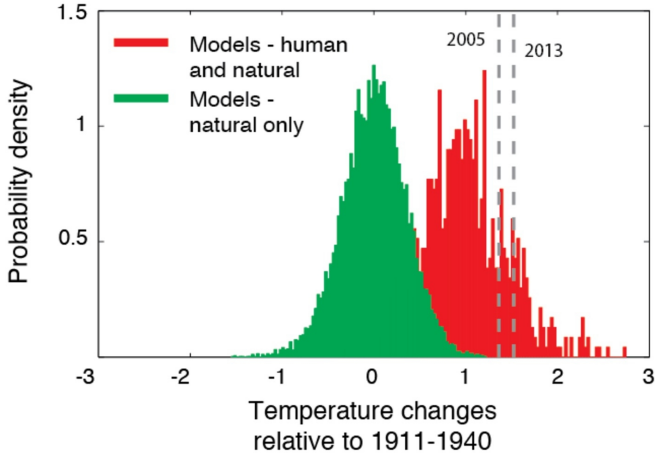
[Document] Are existing observations sufficient to underpin the assessment of extremes ?



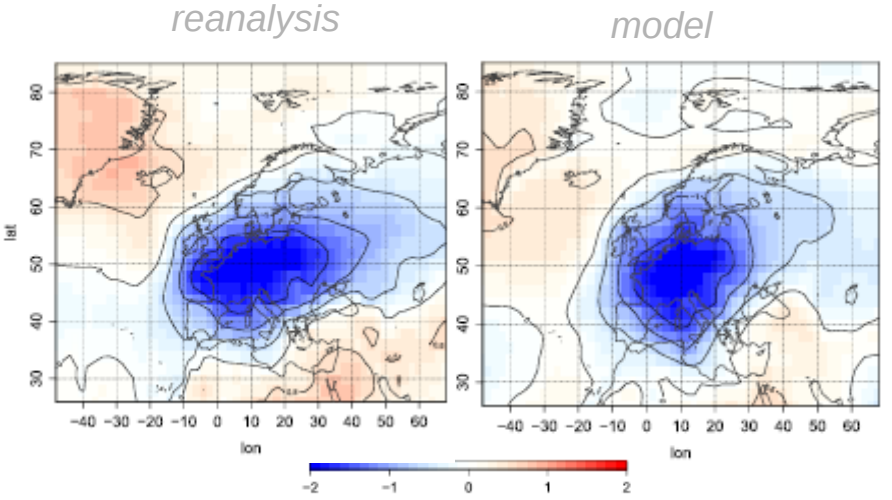
[Understand] How do large-scale and regional-scale processes control extremes ?



[Attribute] How can we determine the contributors to individual observed extreme events and to observed changes in the frequency/intensity of extremes ?



[Simulate] Are models able to reliably simulate extremes and their changes, and how can this be evaluated and improved ?



Links to the modelling

Connection to CMIP6 & MIPs :

- DECK
- LS3MIP, LUMIP, ScenarioMIP, DAMIP, CORDEX

Additional coordinated experiments :

- C20C+
- weather@home
- ExtreMEx

WCRP Grand Challenge on

Water Availability

Coordinators/Input : G. Stephens, P. van Oevelen, Sonia Seneviratne

http://www.wcrp-climate.org/index.php/gc-water-availability

Four main themes

- **Precipitation on land**
- **Land surface processes and hydrology (evapotranspiration)**
- **New observations**
- **Predictability**

White paper + post-AR5 workshop

Links to CMIP6

Primary connection to CMIP6:

LS3MIP, ScenarioMIP

Also:

HighresMIP, LUMIP

Relevant:

CFMIP, DAMIP, DCPP

WCRP Grand Challenge on

Melting Ice and Global Consequences

Coordinators/Input: G. Flato, V. Kattsov, G. Krinner

How will melting ice respond to, and feedback on, the climate response to increasing greenhouse gases, and what will the impacts be?

Three main questions

How will the thawing permafrost affect the global carbon cycle ?

How will the shrinking of mountain glaciers and large ice sheets affect sea level rise and water resources ?

How will the declining coverage of sea ice and snow affect marine and ground transportation across the Arctic, ecosystems and climate?

Links to the modelling

A focused effort on model development:

- improving the representation of permafrost and high-latitude land surface, including wetlands, in climate models, with specific emphasis on their role in the global carbon cycle.

- developing ice sheet and global glacier models, with specific emphasis on their role in sea-level rise (directly connected to sea-level GC).

Polar climate predictability initiative (PCPI):

Focus on seasonal, interannual and longer-term predictions and projections of polar climate and the role of the cryosphere in climate predictability. + **DCPP**

Analysis of CMIP6-endorsed MIPs results aimed specifically at the cryosphere:

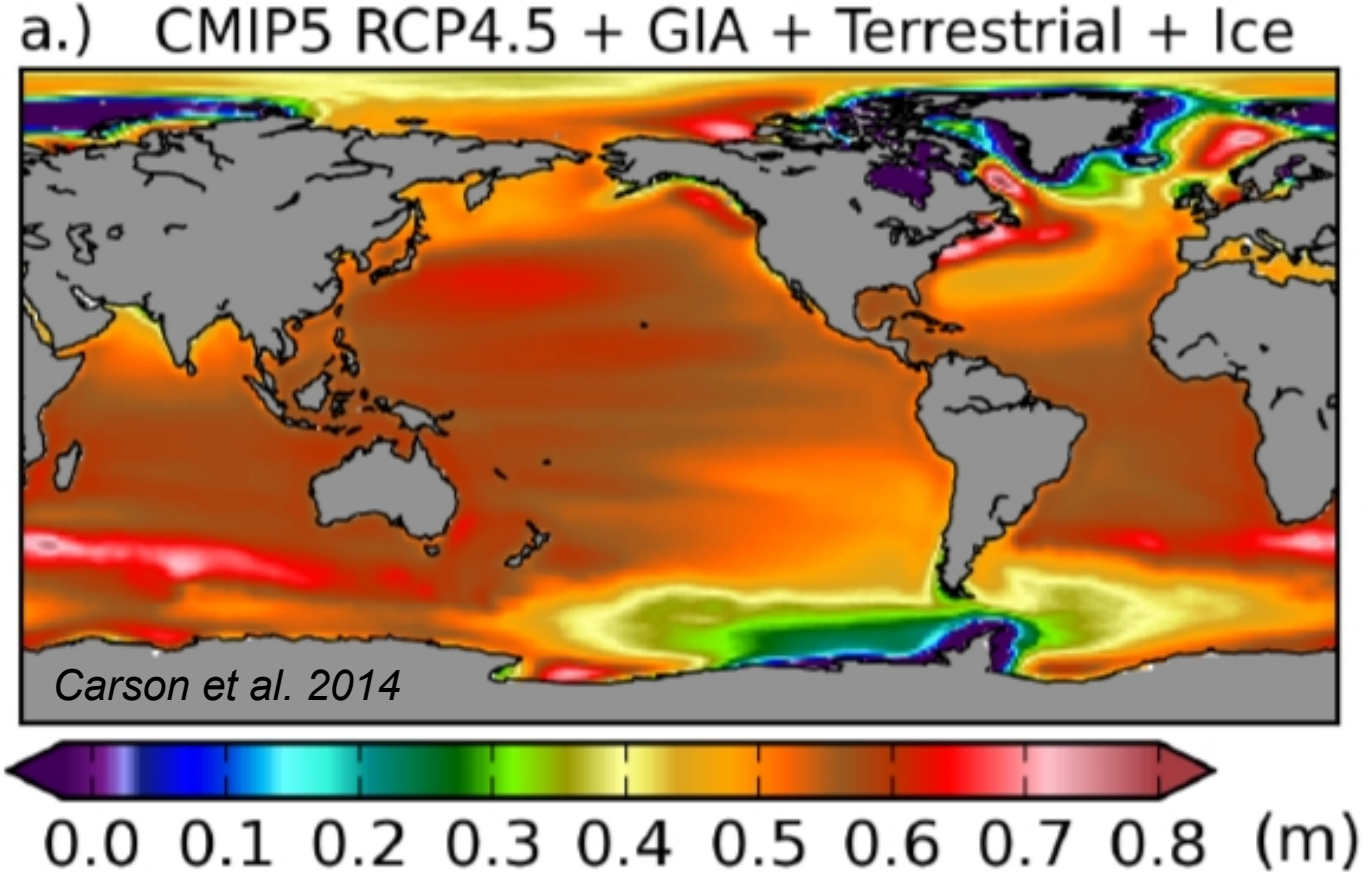
SIMIP – focused on evaluating sea-ice component

ESM-SnowMIP – snow component of **LS3MIP**

ISMIP6 – ice sheet model intercomparison

WCRP Grand Challenge on

Regional Sea Level Rise and Coastal Impacts



Coordinators: Rob Nicholls, Detlef Stammer and Roderik van de Wal

http://www.wcrp-climate.org/index.php/gc-sealevel

Five science foci

- An integrated approach to historic sea level (paleo time scale)
- Process understanding of fast ice sheet dynamics (contemporary)
- Causes for contemporary regional sea level variability and change
- Predictability of regional sea level
- Sea level science for coastal zone management

Links to CMIP6

The dynamic response of the ocean to changes in surface fluxes dominates the geographical variation of sea level change in many parts of the world, but has a pattern and amplitude which are strongly model-dependent.

Connection to CMIP6 :

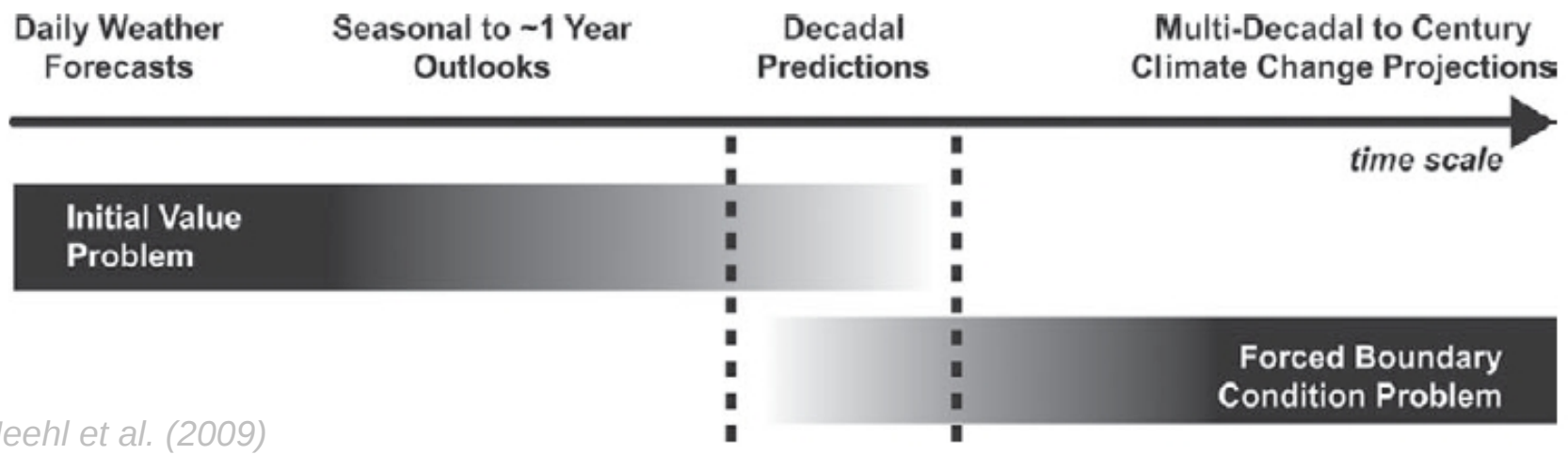
FAFMIP will address model uncertainty in the projection of regional and global sea level change due to change in ocean density and circulation.

FAFMIP diagnostics will also be valuable in analysis of the contribution of unforced variability to sea level change, and of the effect of atmospheric forcing on changes in ocean temperature near to ice-shelves. These are also subjects of interest to the Grand Challenge.

Other important MIPs :

- ISMIP6
- OMIP
- DCPP

(A future?) WCRP Grand Challenge on Near-Term Climate Prediction



Meehl et al. (2009)

Concept Team: Adam Scaife and Yochanan Kushnir (co-leads): Joan Alexander, George Boer, David Carlson, Francisco Doblas-Reyes, Ed Hawkins, Katja Matthes, Masahide Kimoto, Arun Kumar, Scott Power, Doug Smith, Michael Sparrow, and Matthias Tuma.

Develop activities that will lead to improved near-term prediction skill and improved availability of near-term predictions

Main research themes and connection to CMIP6

- Predictability and prediction of forced and free variability
- How to determine and present / communicate uncertainty
- Communication and delivery of Near Term Climate Predictions

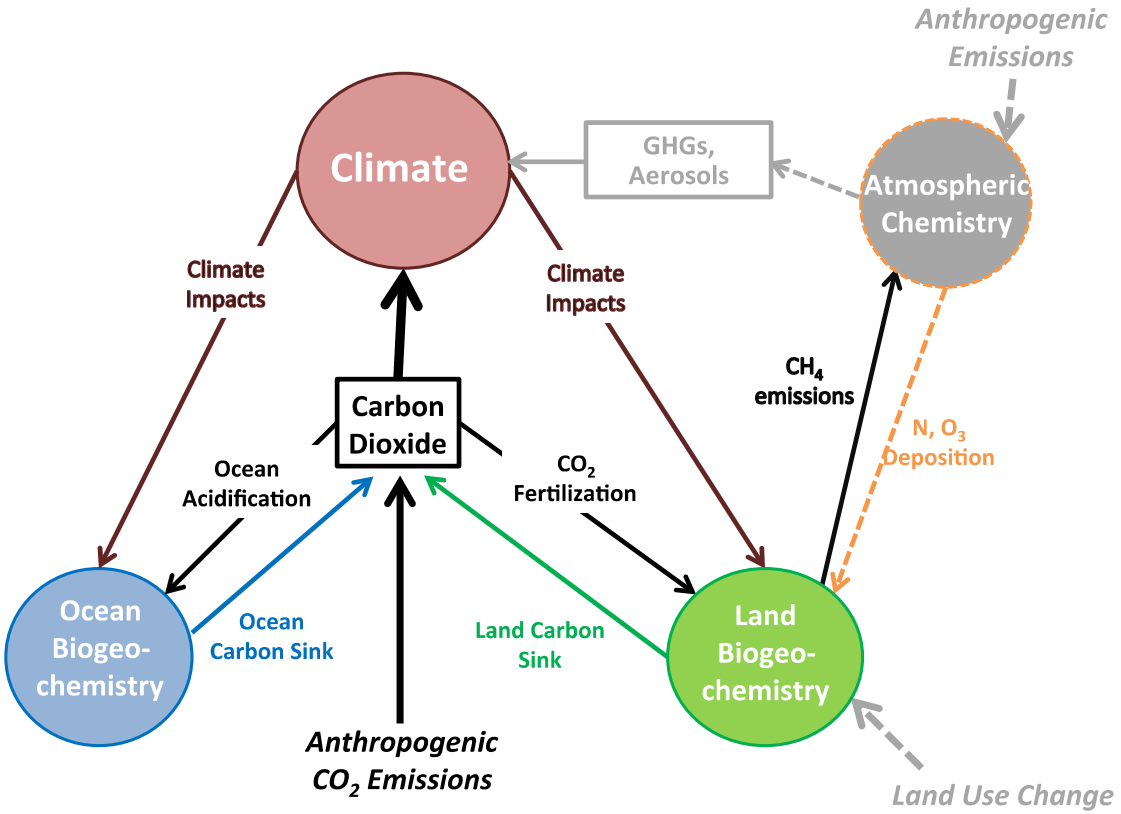
Scientific goals:

- *Predict the end to the current hiatus & future ones? (DCPP, CLIVAR DCVP, WGCM)*
- *Model resolution, physics, drifts and biases and their impact on forecast skill (S2S and WGSIP)*
- *Arctic Sea Ice decline, predictability and global impacts (CLIC, PCPI, PPP)*
- *The role of land surface interactions in decadal predictability/prediction (GEWEX)*
- *Forced change: volcanoes, solar, GHGs, anthropogenic aerosols, ozone (SPARC, DCPP)*
- *The role of the ocean in the planetary heat balance (CLIVAR DCVP)*
- *Realizing the decadal prediction of hydroclimate over land (GEWEX / CLIVAR / DCPP)*
- *The use of ongoing hindcast performance to improve predictions and explore scenarios (DCPP / WGSIP)*
- *External forcing role in invoking a response in the natural "modes"? (CLIVAR DCVP, DCPP, WGCM)*
- *Observational needs for initialization and verification/validation (CLIVAR / GCOS)*

Most relevant MIPs:

DCPP; VolMIP; AerChemMIP; FAFMIP; GMMIP; HighResMIP; LS3MIP; OMIP; RFMIP; DynVar.

(A future?) WCRP Grand Challenge on biogeochemical cycles and climate change



Input from Pierre Friedlingstein and Tatiana Ilyina

How do biogeochemical cycles and feedbacks control greenhouse gas concentrations and climate change?

Main questions and connection to CMIP6

- What is the potential for amplification of climate change over the 21st century via biogeochemical processes and feedbacks?

- How is land and ocean uptake of anthropogenic carbon affected by changes in climate, CO_2, and nutrient availability?

- How do GHG fluxes from highly vulnerable carbon pools (e.g. permafrost, tropical forest) respond to changing climate including climate extremes and abrupt changes?

- What is the role of atmospheric chemistry in mediating the global carbon-climate interactions?

Most relevant CMIP6 & MIPs :

DECK + C4MIP, ScenarioMIP, OMIP, LS3MIP, DCPP

-> feedback analysis, projections, process understanding and evaluation

Conclusion

- Grand Challenges : an opportunity to focus and accelerate research on some key questions using the full spectrum of expertise and infrastructure across WCRP.

- CMIP6 is using the WCRP Grand Challenges as its scientific backdrop with many MIPs very closely aligned with specific Grand Challenge questions

- The link between the MIPs and the grand challenges provides an opportunity to showcase the important role of modelling and model development for advancing climate science

- The success of the grand challenges depends on :
  - active participation of the modelling centers in the MIPs, also in the analysis
  - the contributions and creativity of indvidual scientists
  - ability of our community to work collectively on a few important but tractable questions


Thank You