

The Cloud Feedback Model Inter-comparison Project



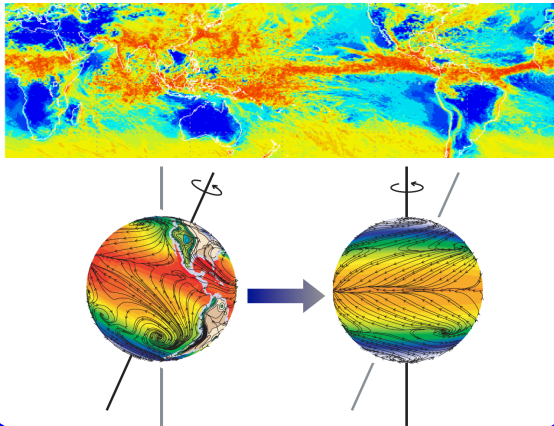
Sandrine Bony & Mark Webb, CFMIP co-chairs

CFMIP Coordination Committee:

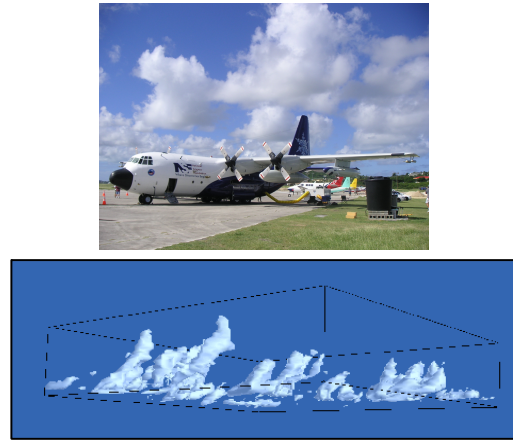
Chris Bretherton, Steve Klein, George Tselioudis, Pier Siebesma & Minghua Zhang

Cloud Feedback Model Inter-comparison Project Phase-2 CFMIP-2 (www.cfmip.net)

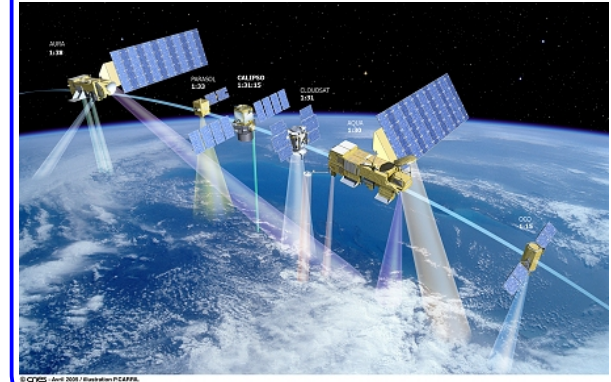
GCM analysis through a hierarchy of models



Process studies (in-situ obs, LES/CRMs)



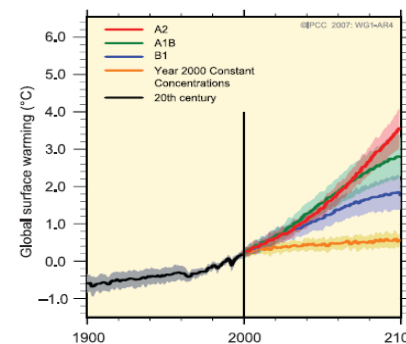
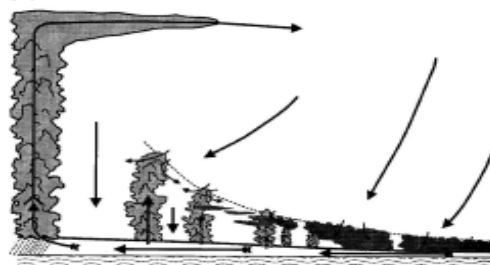
Satellite observations & simulators (COSP)



Understanding

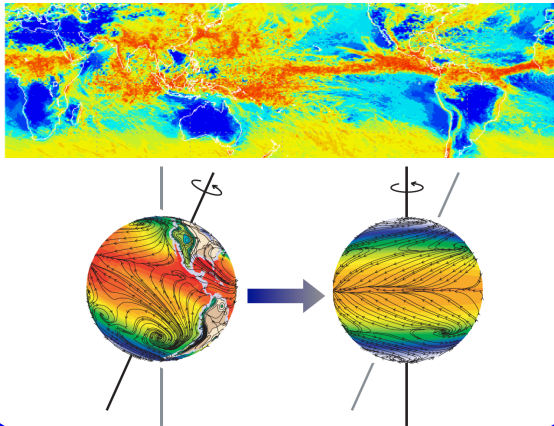
Evaluation

Assessment of cloud-climate feedbacks

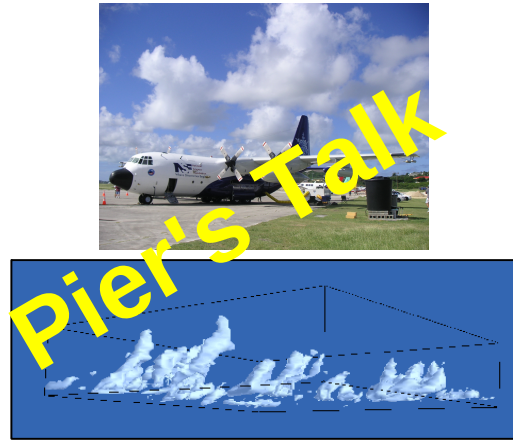


Cloud Feedback Model Inter-comparison Project Phase-2 CFMIP-2 (www.cfmip.net)

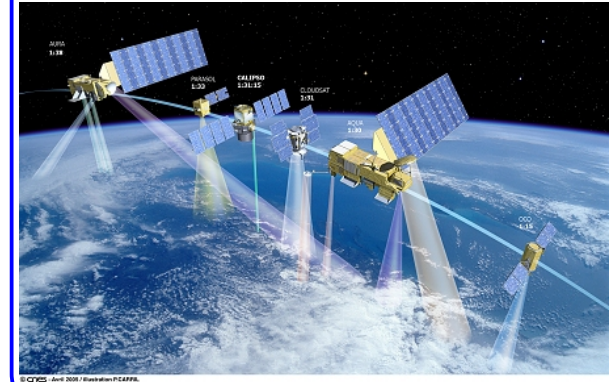
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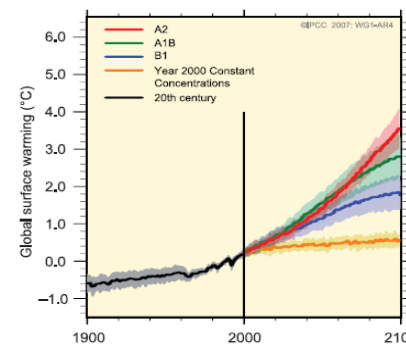
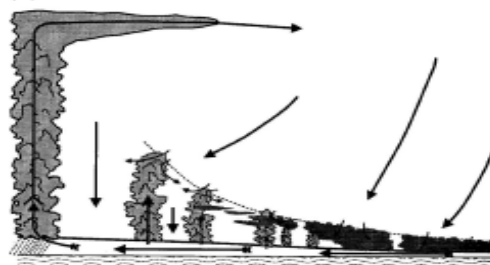
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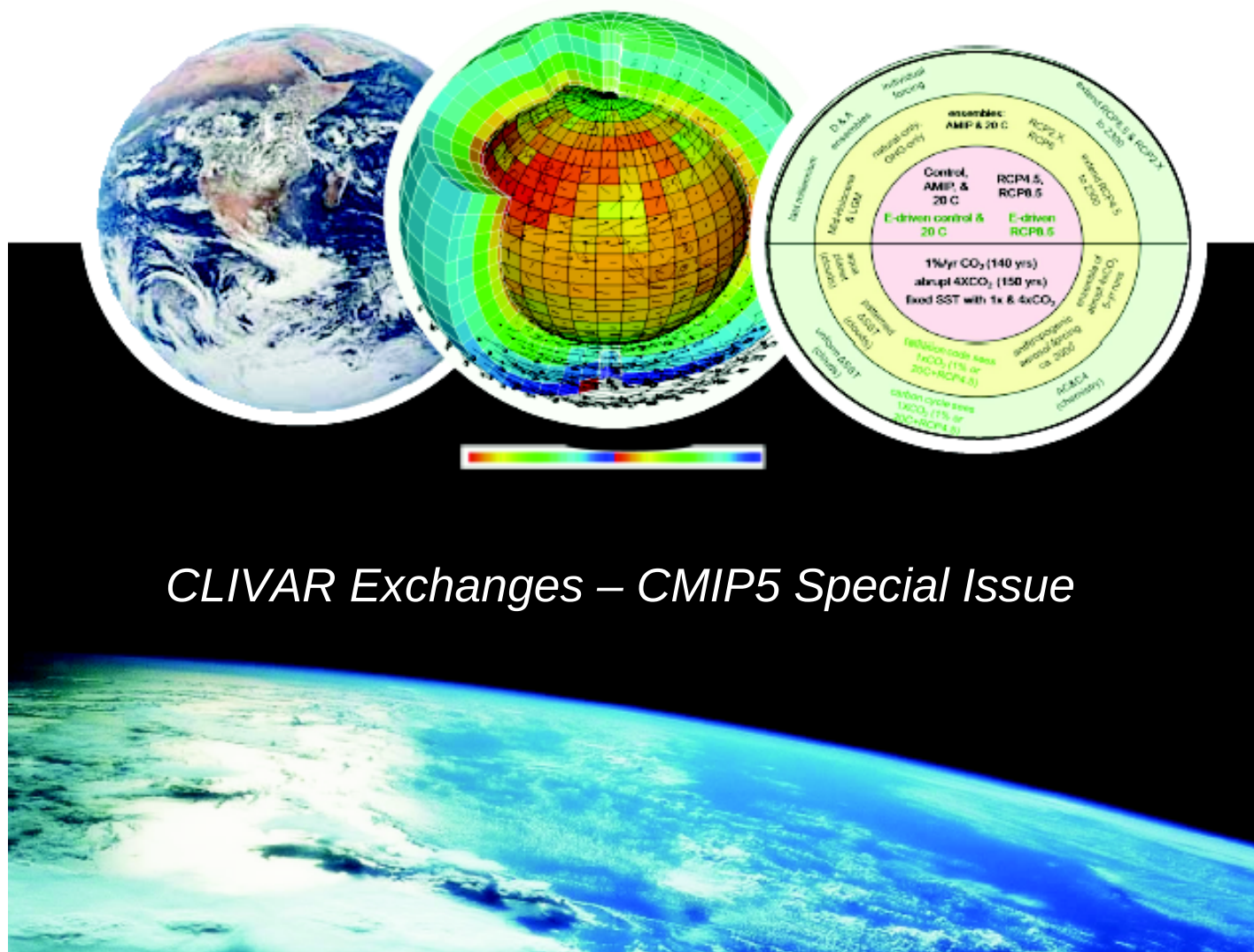
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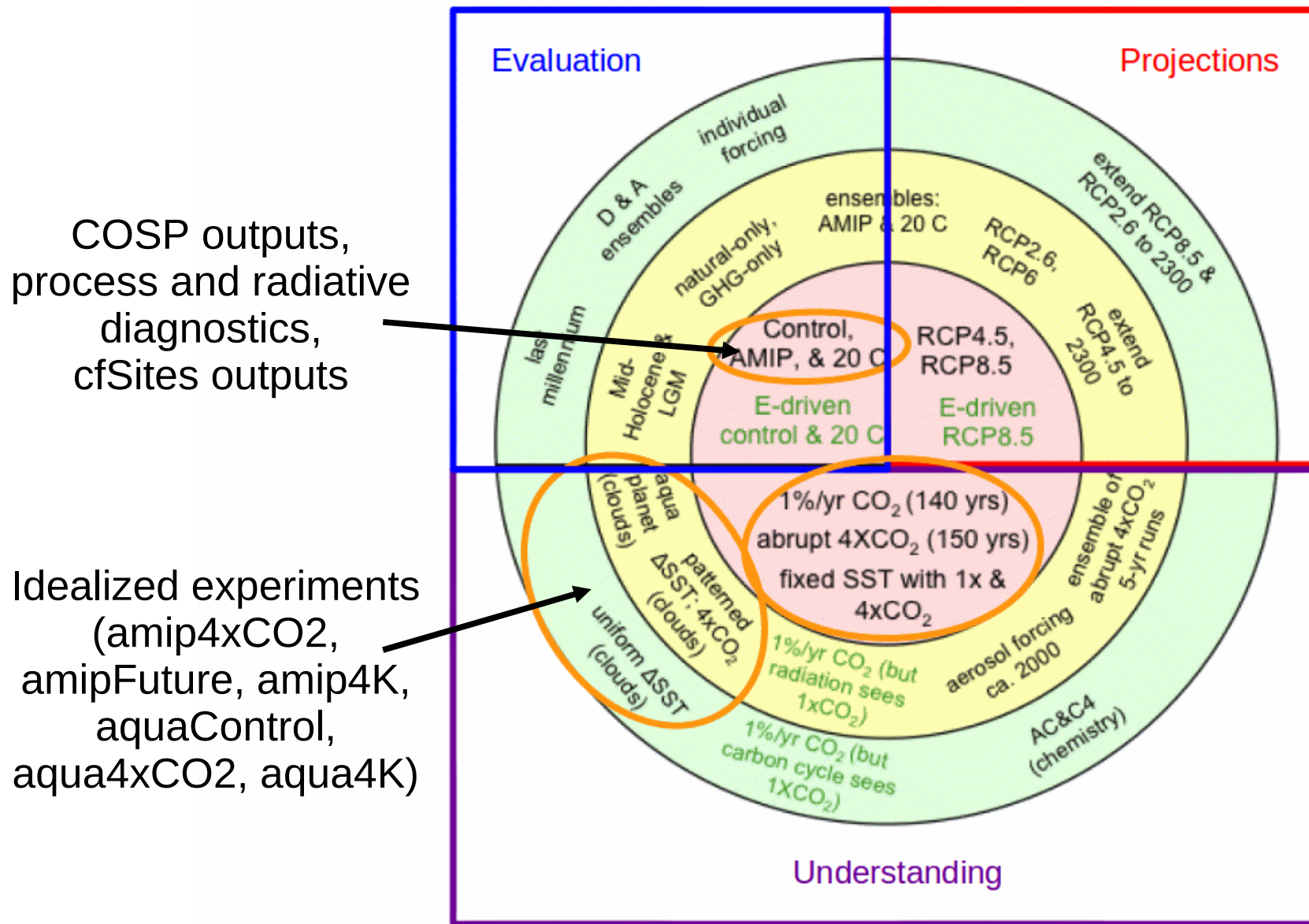
CFMIP activities now closely coupled to CMIP5

WCRP Coupled Model Intercomparison Project - Phase 5 - CMIP5 -



Includes a CFMIP contribution: Towards a better evaluation and understanding of clouds and cloud feedbacks in CMIP5 models

CMIP5 “long-term” set of experiments



CMIP5 Status

At least 21 modelling groups participating

Primary Group	Country	Model	Primary contact
CAWCR	Australia	ACCESS	Tony Hirst
BCC	China	BCC-CSM1.1	Tongwen Wu
GCESS	China	BNU-ESM	Duoying Ji
CCCMA	Canada	CanESM2, CanCM4, CanAM4	Greg Flato
CCSM	USA	CESM1, CCSM4	Jim Hurrell
RSMAS	USA	CCSM4(RSMAS)	Ben Kirtman
CMCC	Italy	CMCC-CESM, CM, & CMS	S. Gualdi, C. Cagnazzo
CNRM/CERFACS	France	CNRM-CM5	D. Salas-Mélia, L.Terray
CSIRO/QCCCE	Australia	CSIRO-Mk3.6	Leon Rotstayn
EC-EARTH	Europe	EC-EARTH	Wilco Hazeleger
MPI-M	Germany	ECHAM6/MPIOM-HR & LR	M. Giorgetta, S. Legutke
?	China	FGOALS-G2.0, S2.0 & gl	Tianjun Zhou
GFDL	USA	GFDL-HIRAM-C360, C180, CM2.1, CM3, ESM2G, ESM2M	R. Stouffer, T. Delworth, B. Wyman, L. Horowitz
MOHC	UK	HadCM3, CM3Q, GEM2-AO, GEM2-ES	Mat Collins, Chris Jones
NMR/KMA	Korea / UK	HadGEM2-AO	Hyo-Shin Lee
INM	Russia	inmcm4	Evgeny Volodin
IPSL	France	IPSL-CM5A-LR, CM5A-MR, CM5B	Jean-Louis Dufresne
MIROC	Japan	MIROC5, 4m, 4h, ESM, ESM-CHEM	M. Watanabe, S. Emori, M. Ishii, M. Kimoto, A. Abe, M. Kawamiya, T. Nozawa
MRI	Japan	MRI-AM20km, AM60-km, CGM3, ESM1	Shoji Kusunoki
NorClim	Norway	NorESM	Trond Iversen / Mats Bentsen
NASA/GISS	USA	GISS-E2-H, GISS-E2-H-CC, GISS-E2-R, GISS-E2CS-H, GISS-E2CS-R	Gavin Schmidt
NASA/GSFC	USA	?	Max Suarez

40+ models

K. Taylor (PCMDI)

“Long-term” experiments: participation summary

** Core simulations*

Experiment(s)	# of models
* Control & historical	27
* AMIP	23
* RCP4.5 & 8.5	25
RCP2.6	15
RCP6	11
RCP's to year 2300	10
* 1% CO2 increase	24
* Fixed SST CO2 forcing diagnosis	15
* Abrupt 4XCO2 diagnostic	20

Experiment(s)	# of models
Fast adjustment diagnostic	8
Aerosol forcing	9
ESM control, historical & RCP8.5	15
Carbon cycle feedback isolation	9 & 9
Mid-Holocene & LGM	10
Millenium	7
CFMIP runs	8
D & A runs	15

Mean Resolution: 2.1 deg (atm) ; 0.9 deg (ocean)
 + a few high-resolution models for atmosphere-only experiments

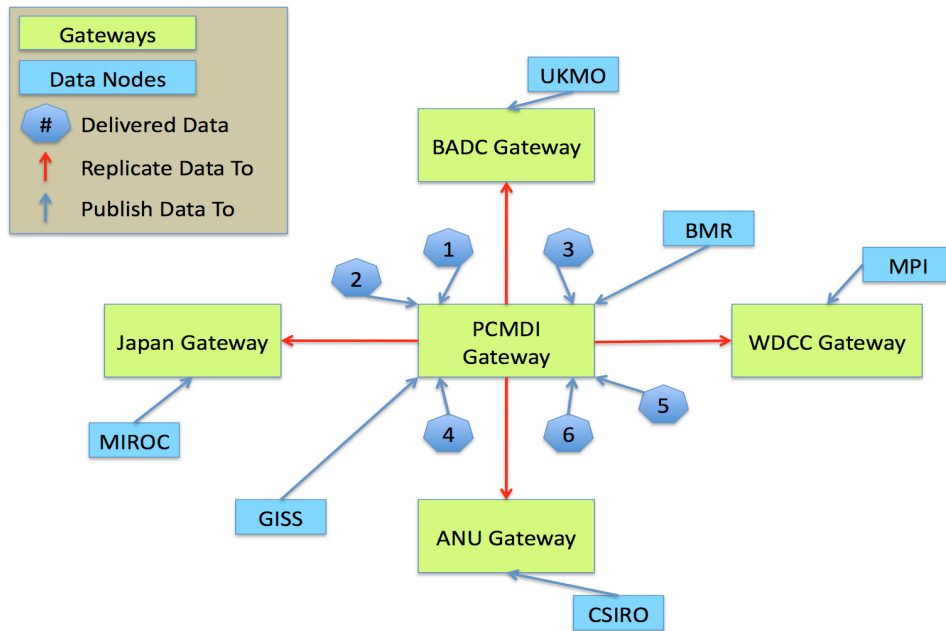
Karl Taylor (PCMDI)

Access to CMIP5 data :

The Earth System Grid (ESG) is up and running

CMIP5 website: <http://cmip-pcmdi.llnl.gov/cmip5>

Model output will be served by federated centers around the world and will appear to be a single archive :



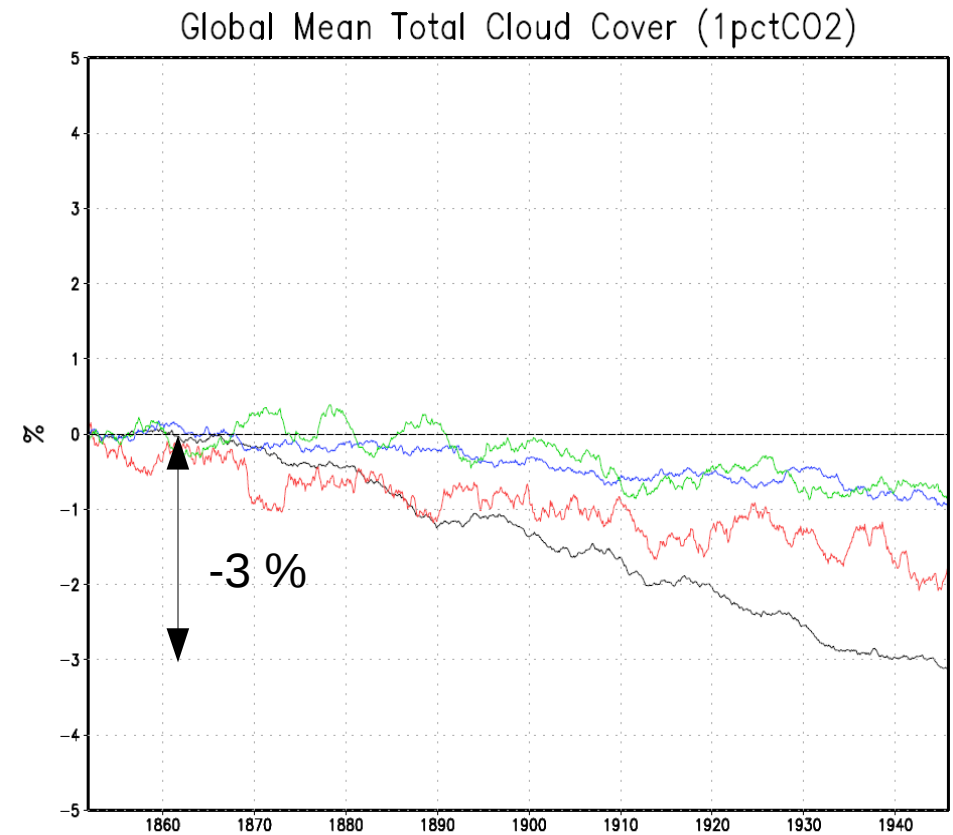
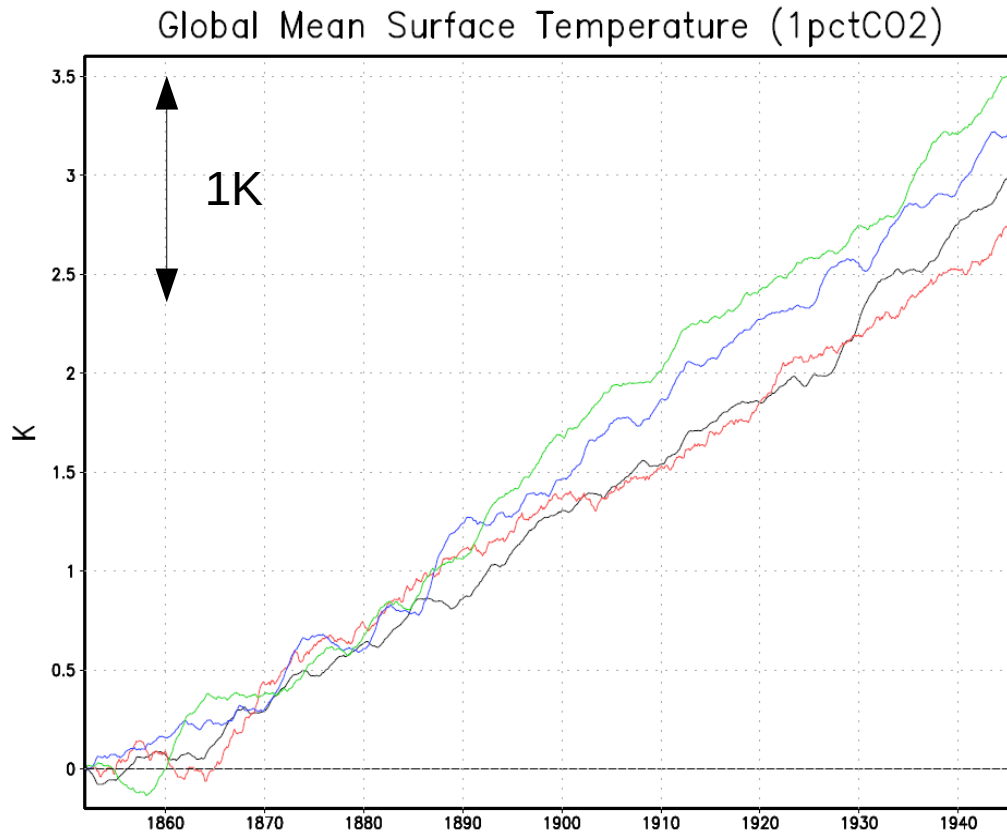
As of June 3rd 2011:

- 11 models have started to publish their CMIP5 outputs on the ESG
- many more models will be available by this summer
- more than 700 users already registered
- CMIP5 analysis is about to start !

The screenshot shows the CMIP5 search interface. At the top, there is a search bar with a dropdown menu set to 'Datasets' and a 'Search' button. Below the search bar, a message states: 'To conduct a search, select a category from the pull down menu and/or enter text into the text box.' On the left, there is a 'Search Categories' sidebar with a tree view showing 'Project' (CMIP5), 'Institute' (listing various institutes like CNRM-CM5, CanCM4, etc.), 'Model', 'Experiment', 'Frequency', 'Product', 'Realm', 'Variable', and 'Ensemble'. The main area displays 'Total Number of Results: 5040' and a list of search results. Each result includes a project name, model name, experiment name, time frequency, modeling realm, ensemble, version, and description. On the right, there is a 'File Download' section with a file name input field and a 'Download Files' button.

CMIP5 OAGCMs

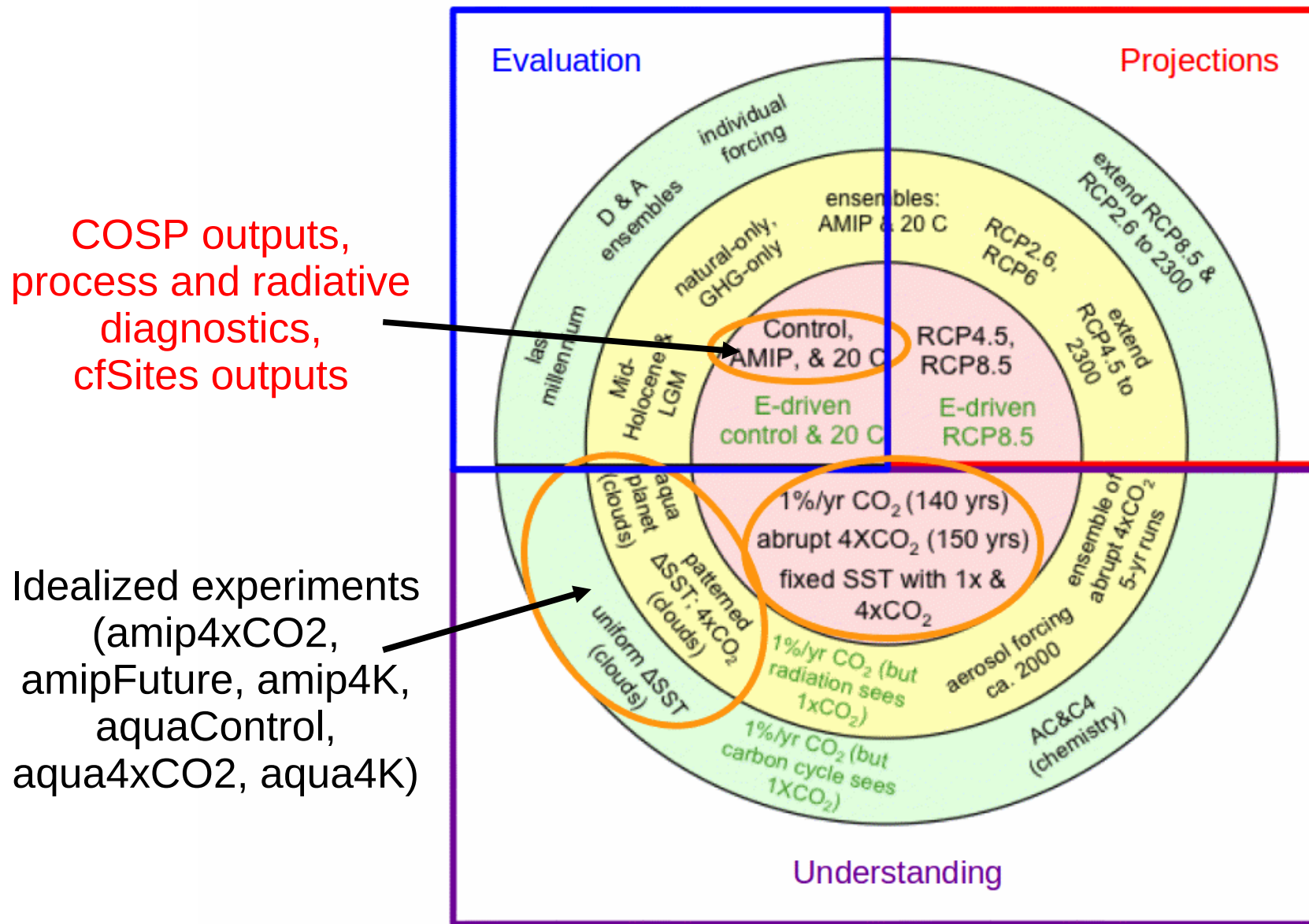
+1% CO₂/year experiment
(HadGEM2-ES, CanESM2, CNRM-CM5, IPSL-CM5A-LR)



Origin of inter-model differences ?

How well do models simulate clouds in the present climate ?

CMIP5 “long-term” set of experiments



COSP

The CFMIP Observations Simulator Package

- Several years of development in several institutions
- Now used in many models : about 2/3 of CMIP5 models (TBC) + several NWP models
- Bodas-Salcedo A, M J Webb, S Bony, H Chepfer, J-L Dufresne, S A Klein, Y Zhang, R Marchand, J M Haynes, R Pincus, and V O John, 2011 :
COSP: Satellite simulation software for model assessment, *BAMS* (in press)
- **Recent changes to COSP governance :**
 - Project Management Committee (PMC), chaired by A. Bodas-Salcedo & Steve Klein
 - First activities undertaken by the COSP PMC:
 - * Code moved to a SVN repository in Google code:
<http://code.google.com/p/cfmip-obs-sim/>
 - * User survey => discussion of future COSP developments:
 - new capabilities (e.g. new modules, new diagnostics)
 - software improvements (e.g. speed, documentation)

CFMIP Observations for Model Evaluation

<http://climserv.ipsl.polytechnique.fr/cfmip-obs.html>



CFMIP Observations for Model evaluation

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CFMIP Observations for Model evaluation

The Cloud Feedback Model Intercomparison Program has designed a protocol to evaluate clouds in climate and weather prediction models based on satellite observations (http://cfmip.metoffice.com/CFMIP2_experiments_March20th2009.pdf)

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- [CERES Sat](#)
- [CLOUDNET Ground](#)
- [CLOUDSAT Sat](#)
- [ISCCP Sat](#)
- [MISR Sat](#)
- [MODIS Sat](#)
- [MULTI-SENSORS Analysis Sat](#)
- [MULTI-SENSORS Sat](#)
- [PARASOL Sat](#)
- [References](#)

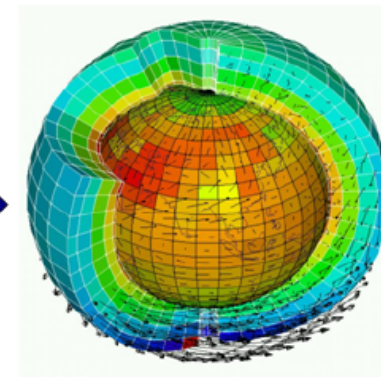
Satellite Observations



Ground-based Observations

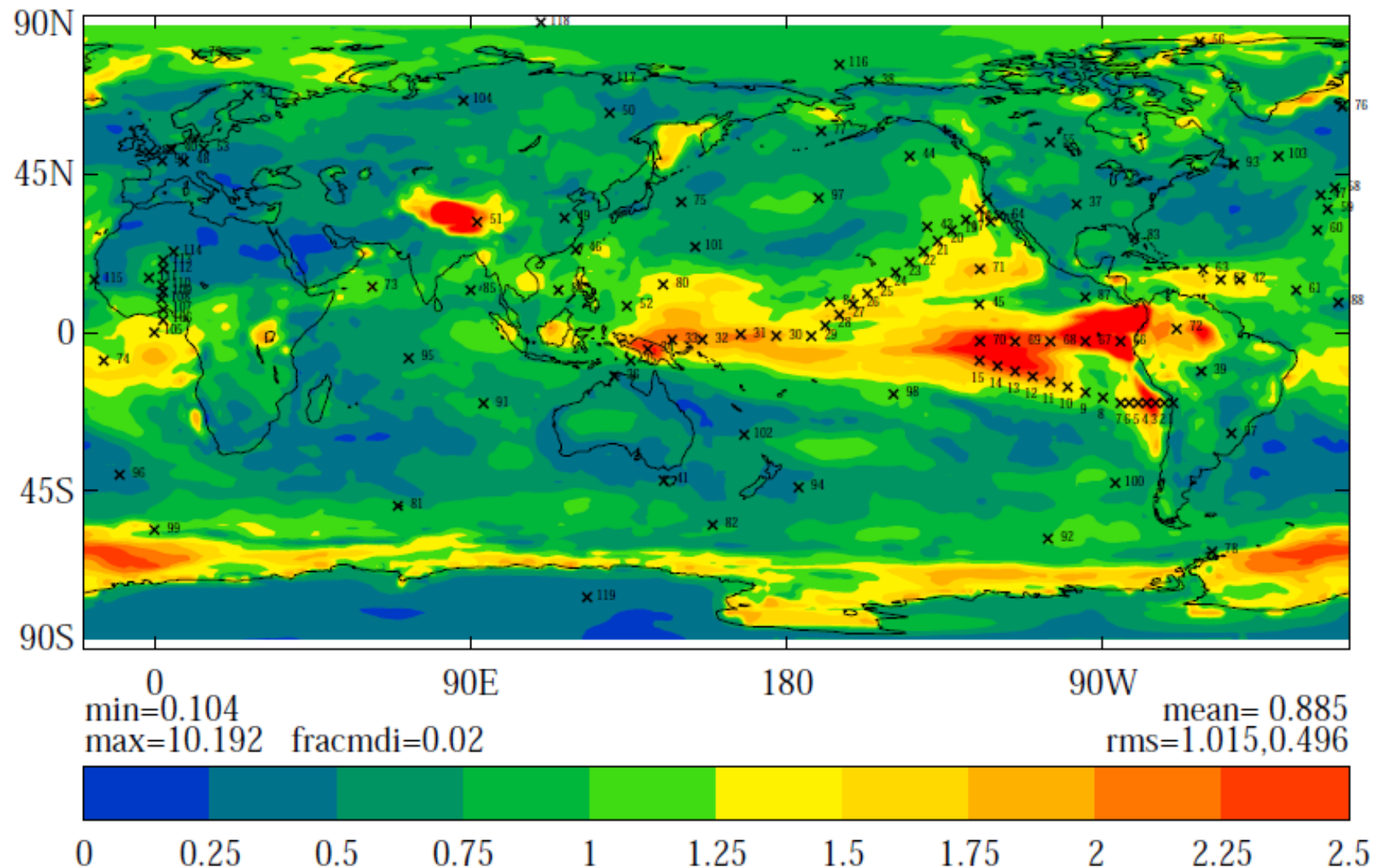


Climate Models



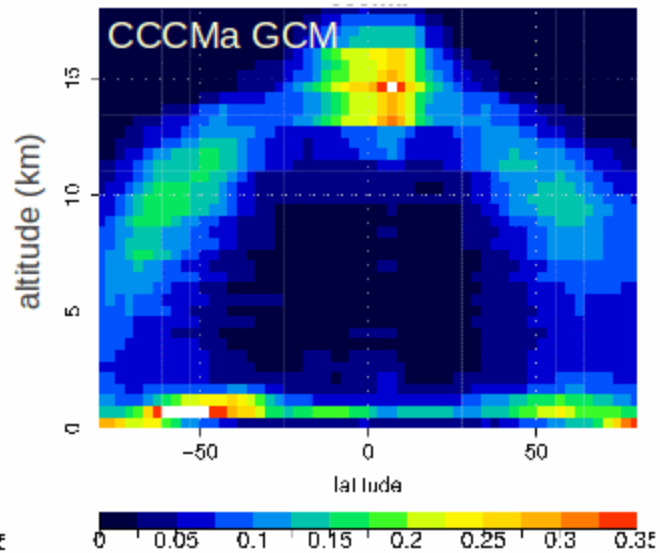
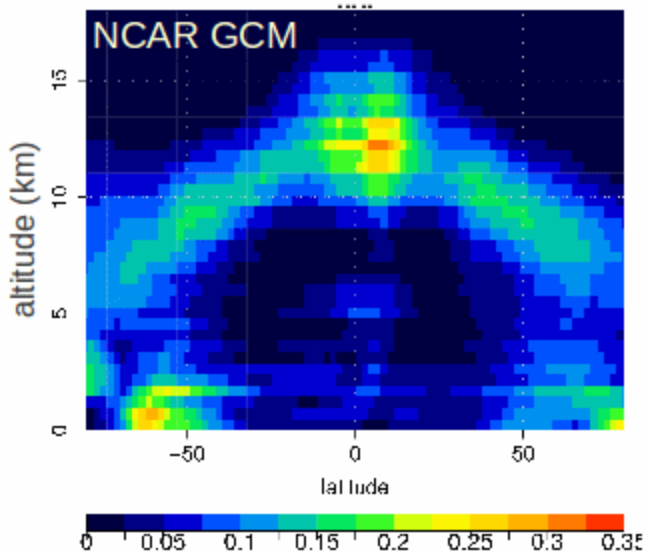
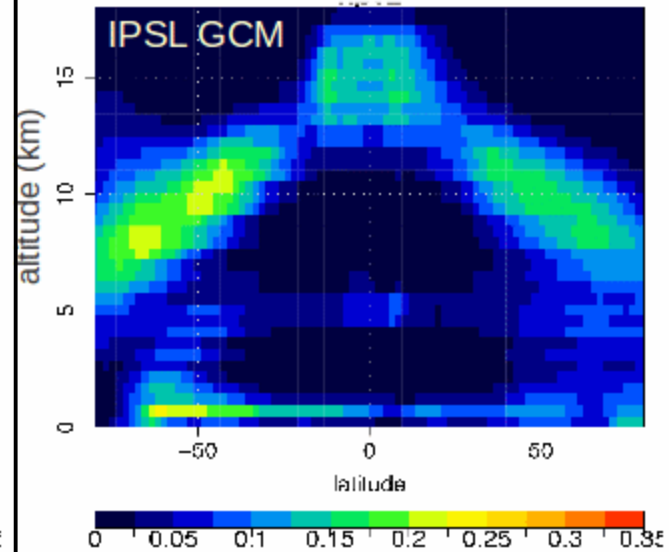
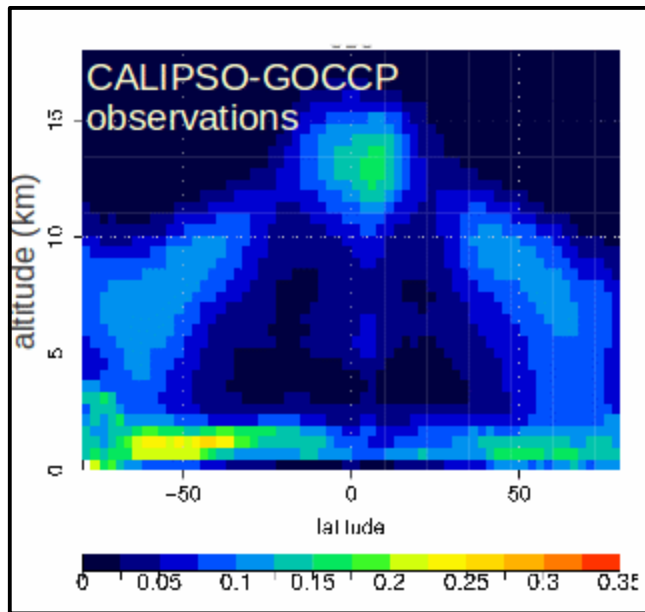
Thanks to all contributors !

CMIP5 model outputs at selected locations (120 locations, high-frequency, detailed cloud diagnostics)

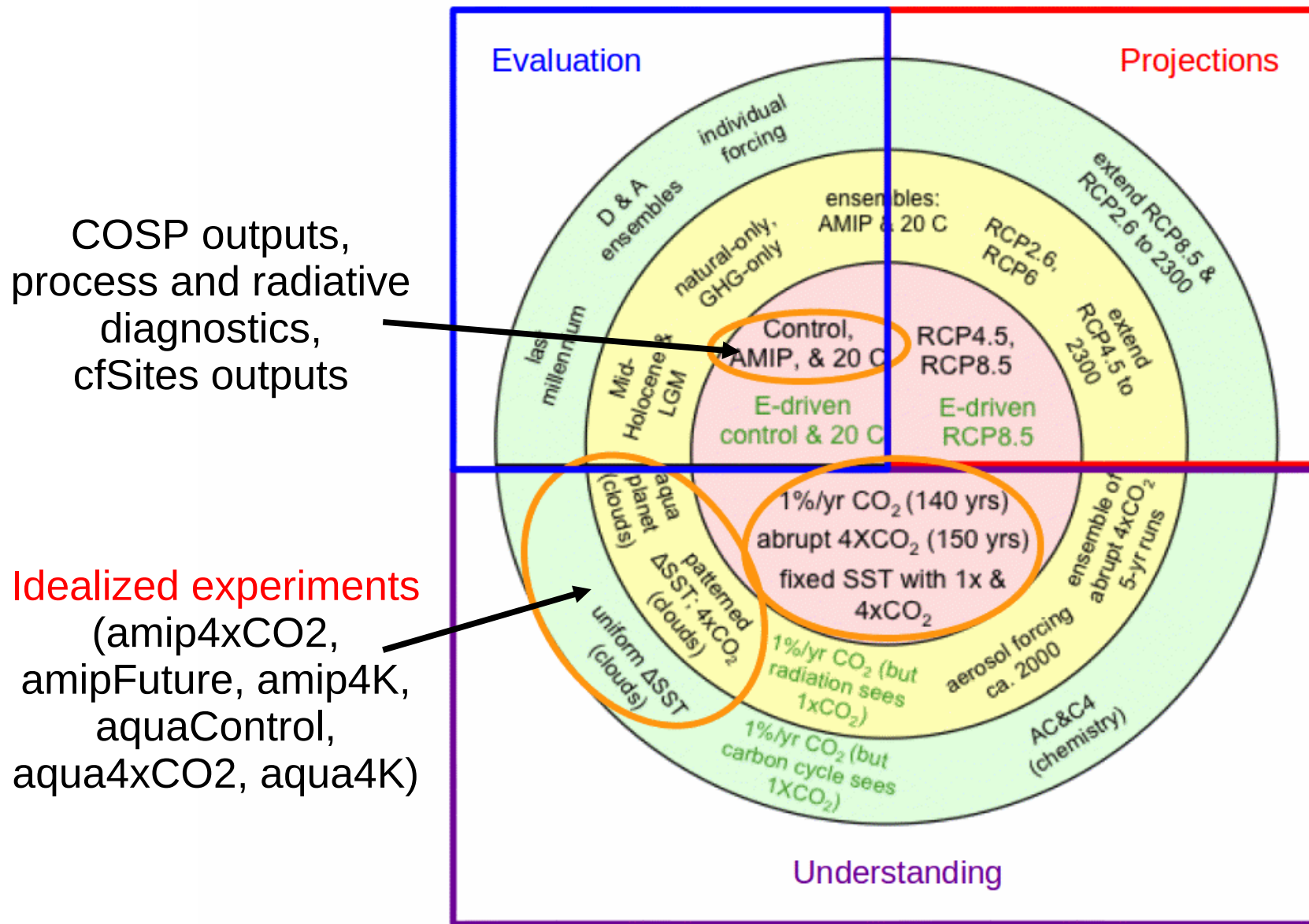


- ARM, CEOP, CloudNet instrumented sites
- GPCI / Tropical West & South East Pacific / AMMA transects
- Field experiments / GCSS case studies
- Locations of large inter-model spread of cloud feedbacks (CMIP3)

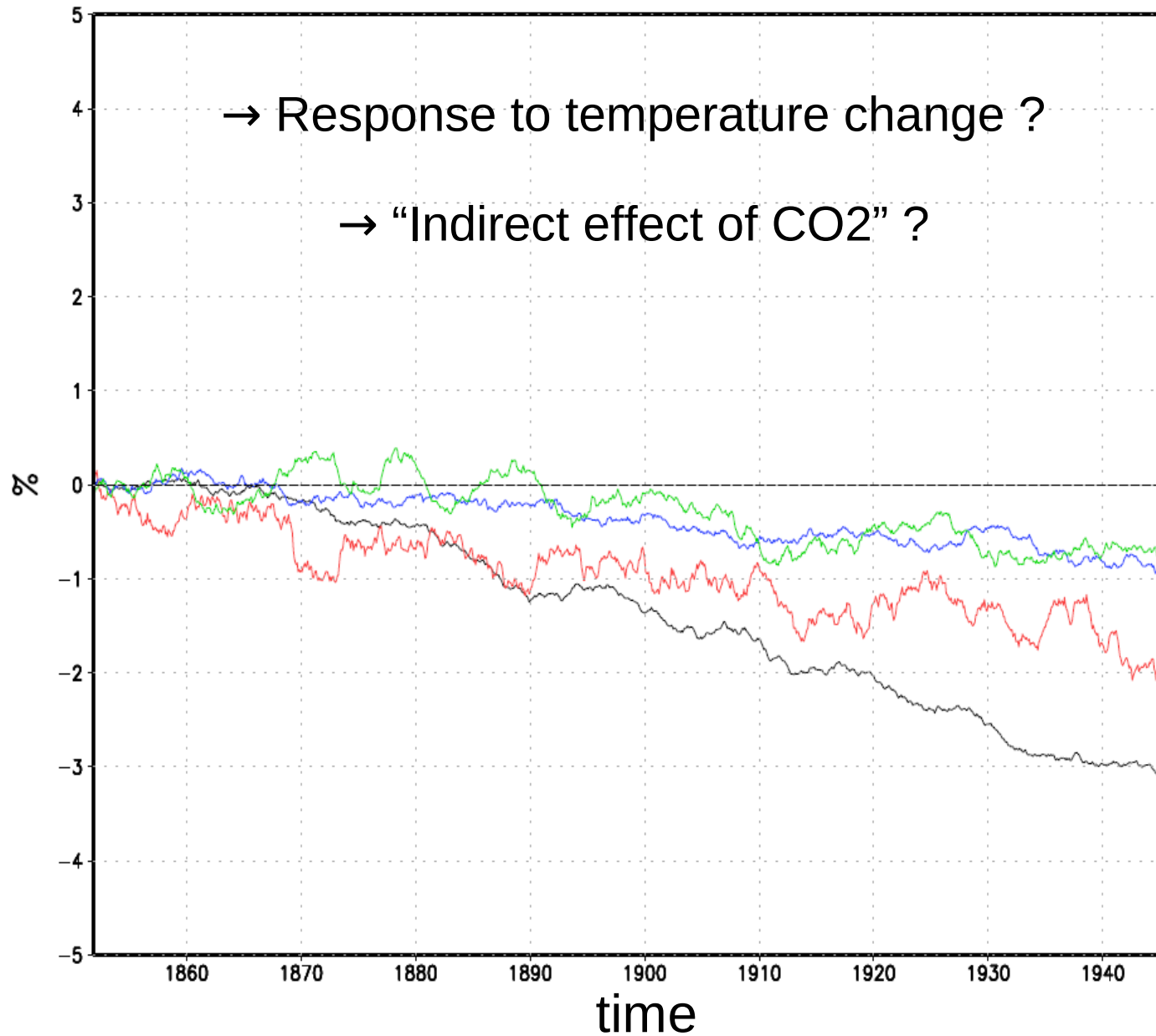
Evaluation of the 3D distribution of clouds simulated by global climate models and observed by CALIPSO



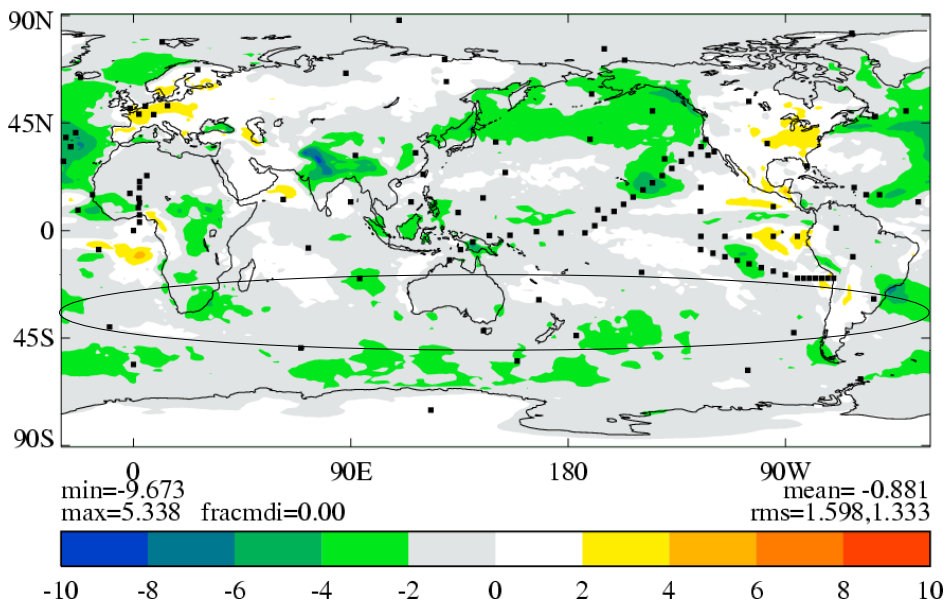
CMIP5 “long-term” set of experiments



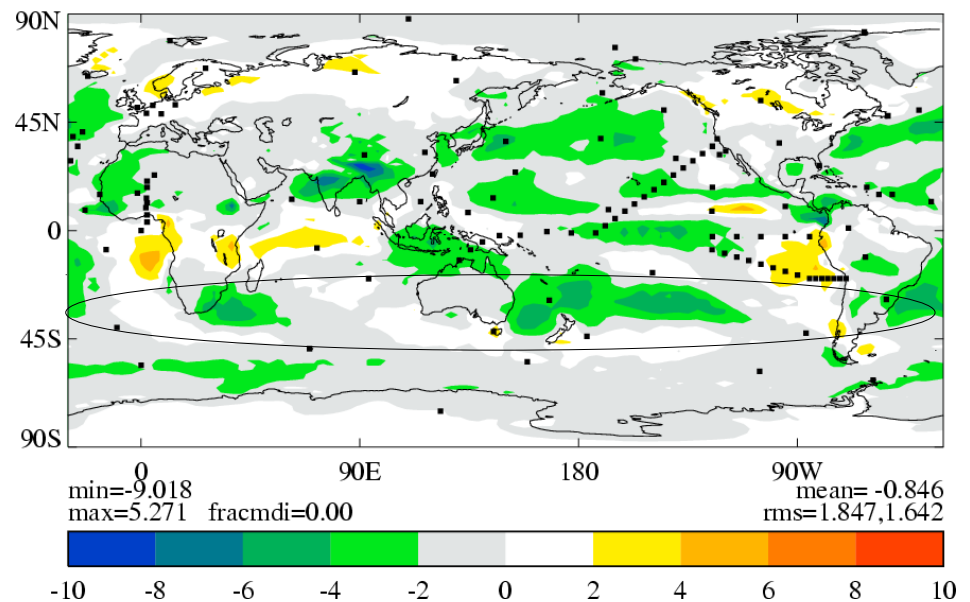
Evolution of the global-mean cloudiness when
CO₂ increases by 1%/year (1pctCO₂)



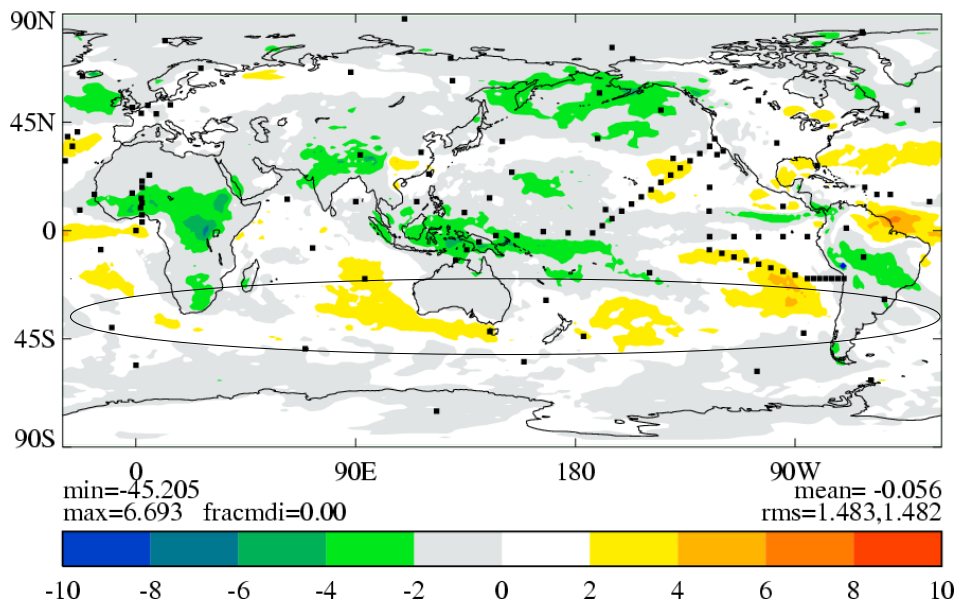
HadGEM2-A 4xCO₂ Fixed SST
Net CRE Response
Global 2xCO₂ Equivalent = -0.44 Wm⁻²



IPSL-CM5A-LR 4xCO₂ Fixed SST
Net CRE Response
Global 2xCO₂ Equivalent = -0.42 Wm⁻²



CNRM-CM5 4xCO₂ Fixed SST
Net CRE Response
Global 2xCO₂ Equivalent = +0.03 Wm⁻²



AMIP 4xCO₂ - AMIP

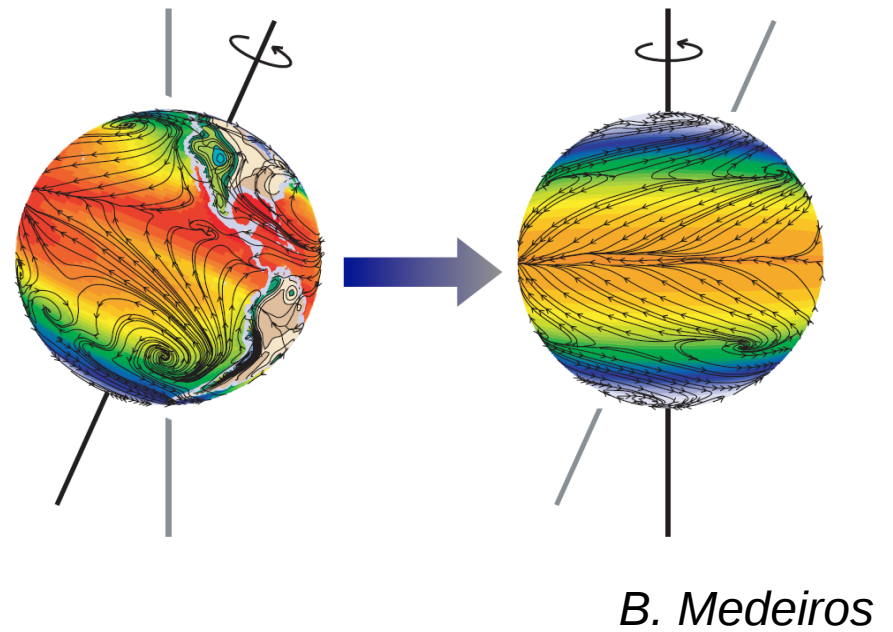
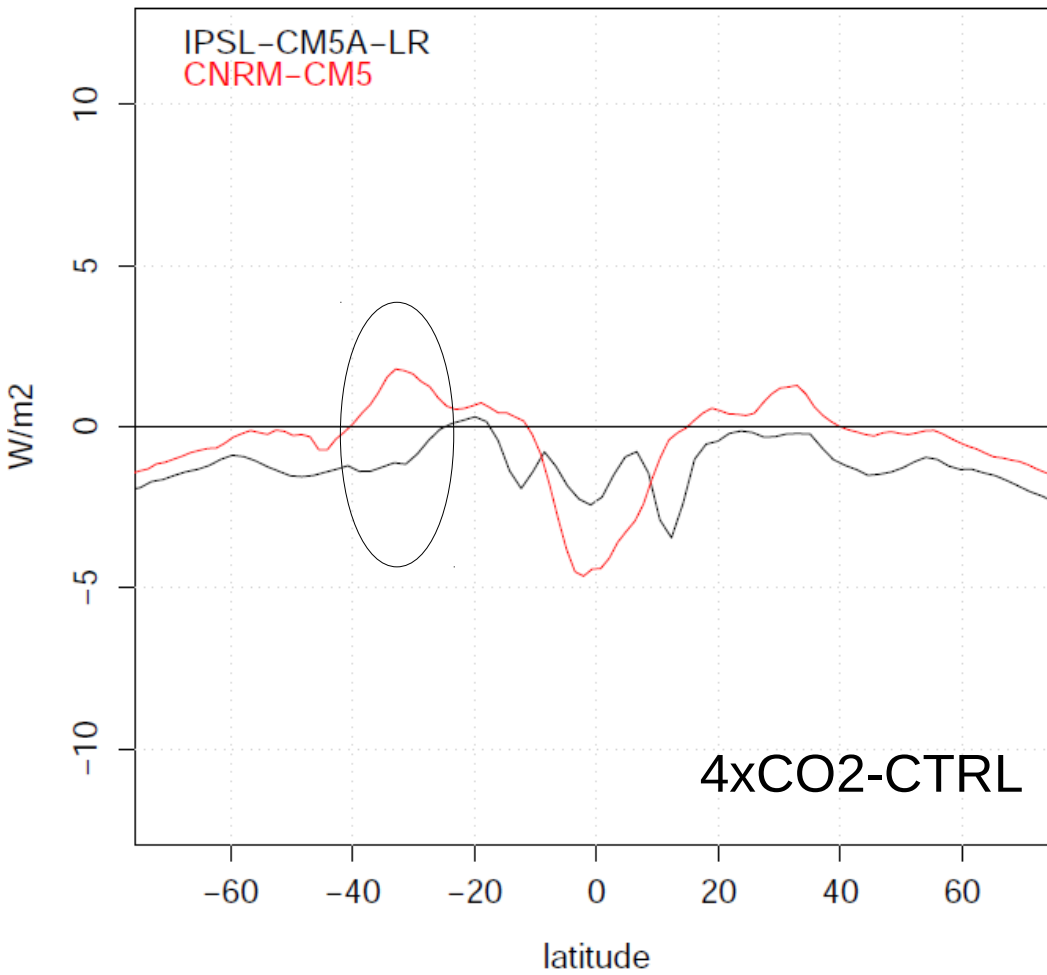
***Global mean Net CRE responses
to CO₂ quadrupling with fixed SSTs***

cf Mark Webb's talk

CMIP5 Aqua-Planet Experiments

NET CRF

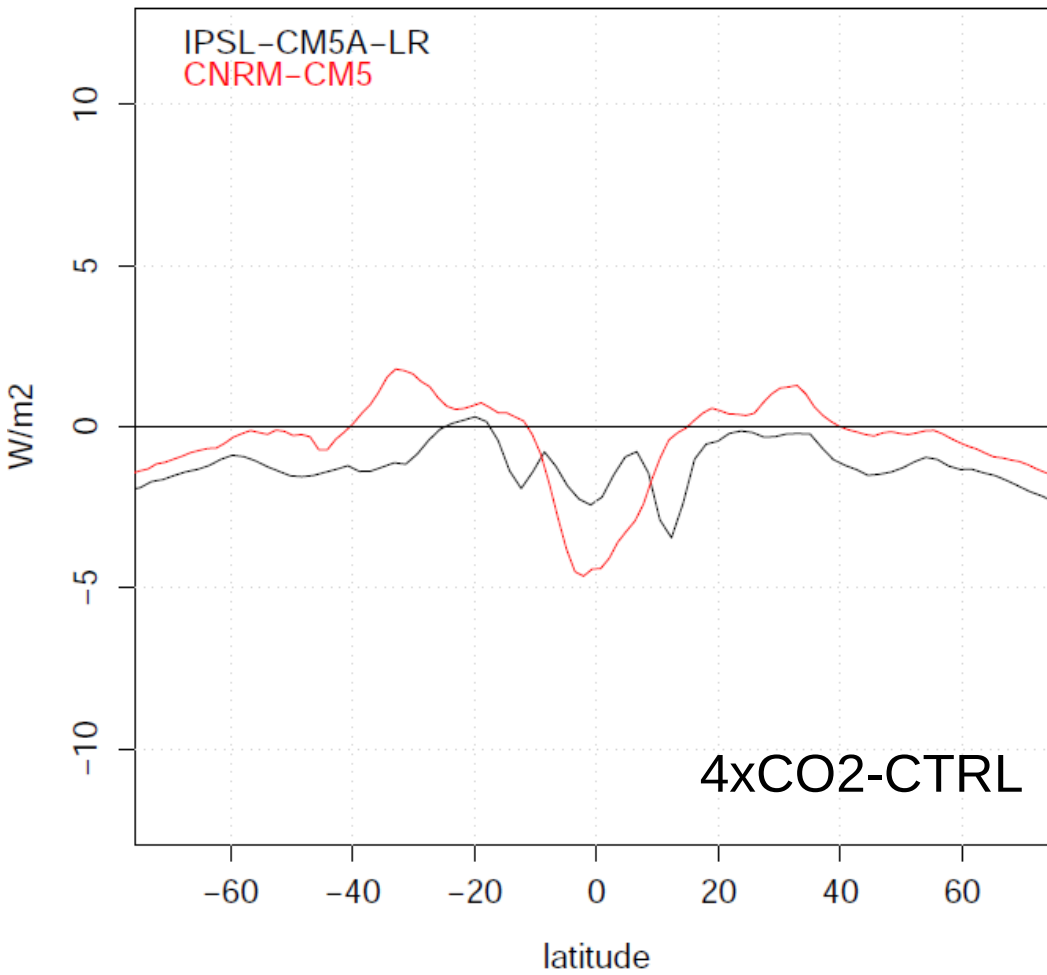
NET CRF Change (aqua4xCO2-aquaControl)



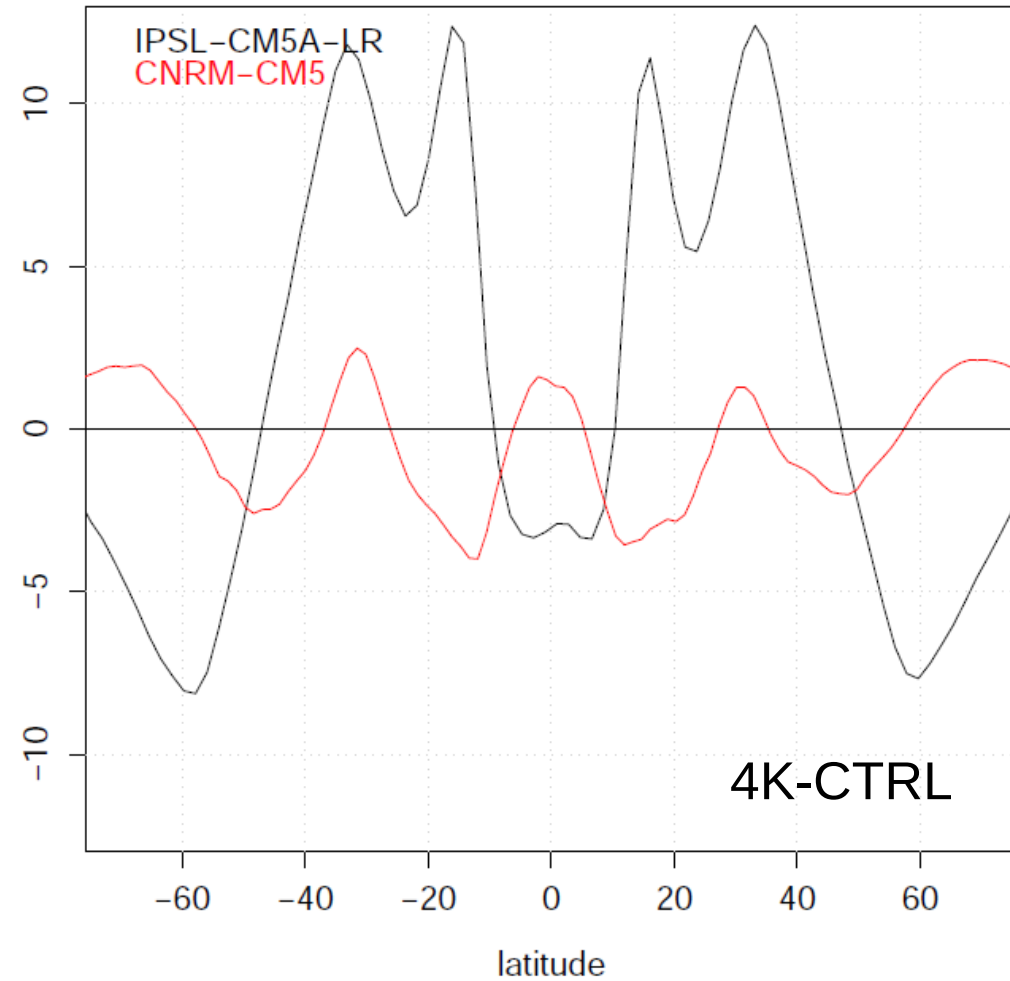
CMIP5 Aqua-Planet Experiments

NET CRF

NET CRF Change (aqua4xCO2-aquaControl)



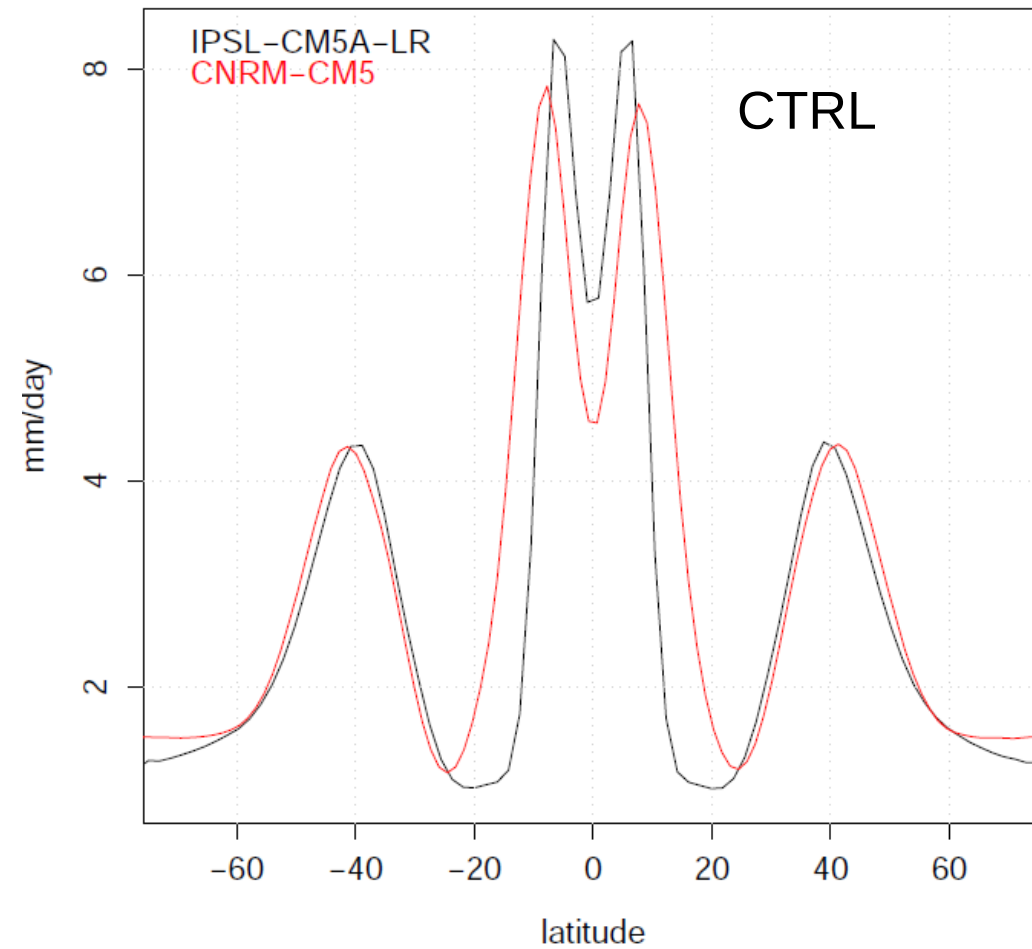
NET CRF Change (aqua4K-aquaControl)



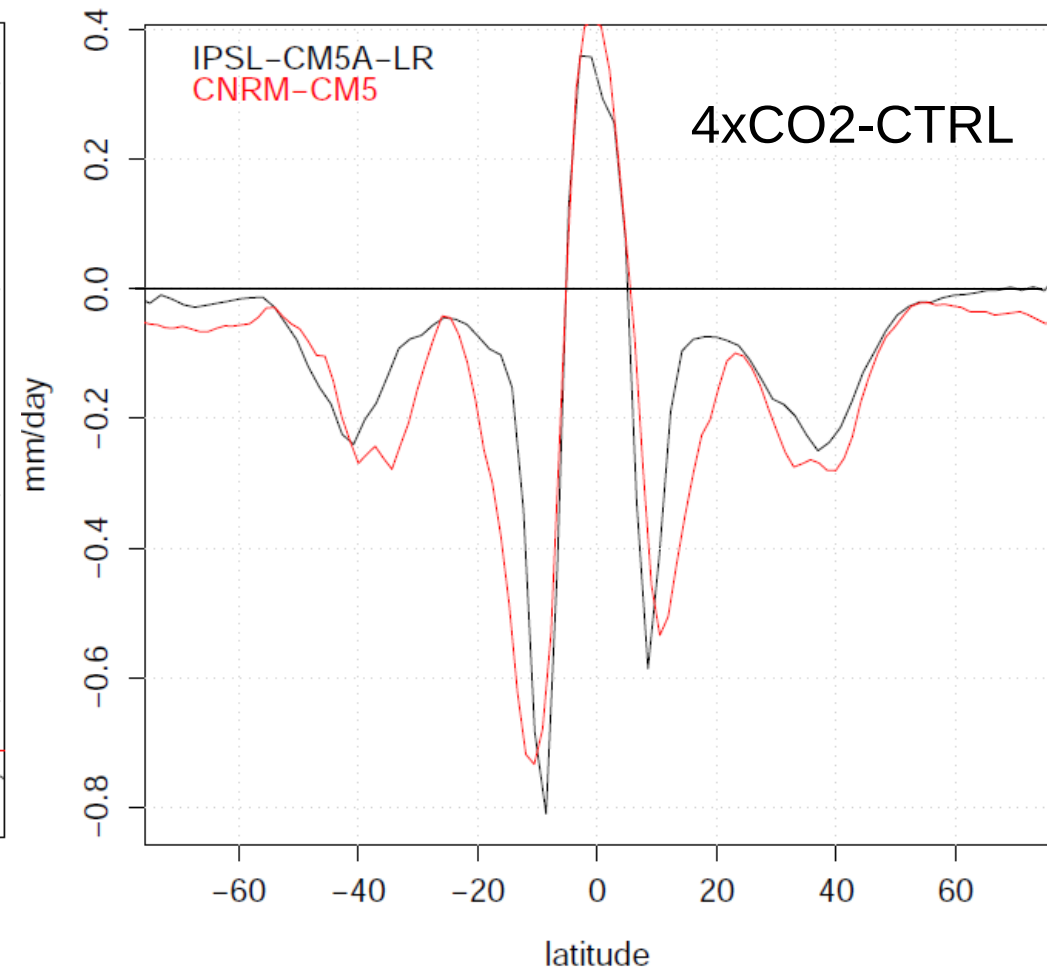
CMIP5 Aqua-Planet Experiments

Precipitation

Precipitation (aquaControl)



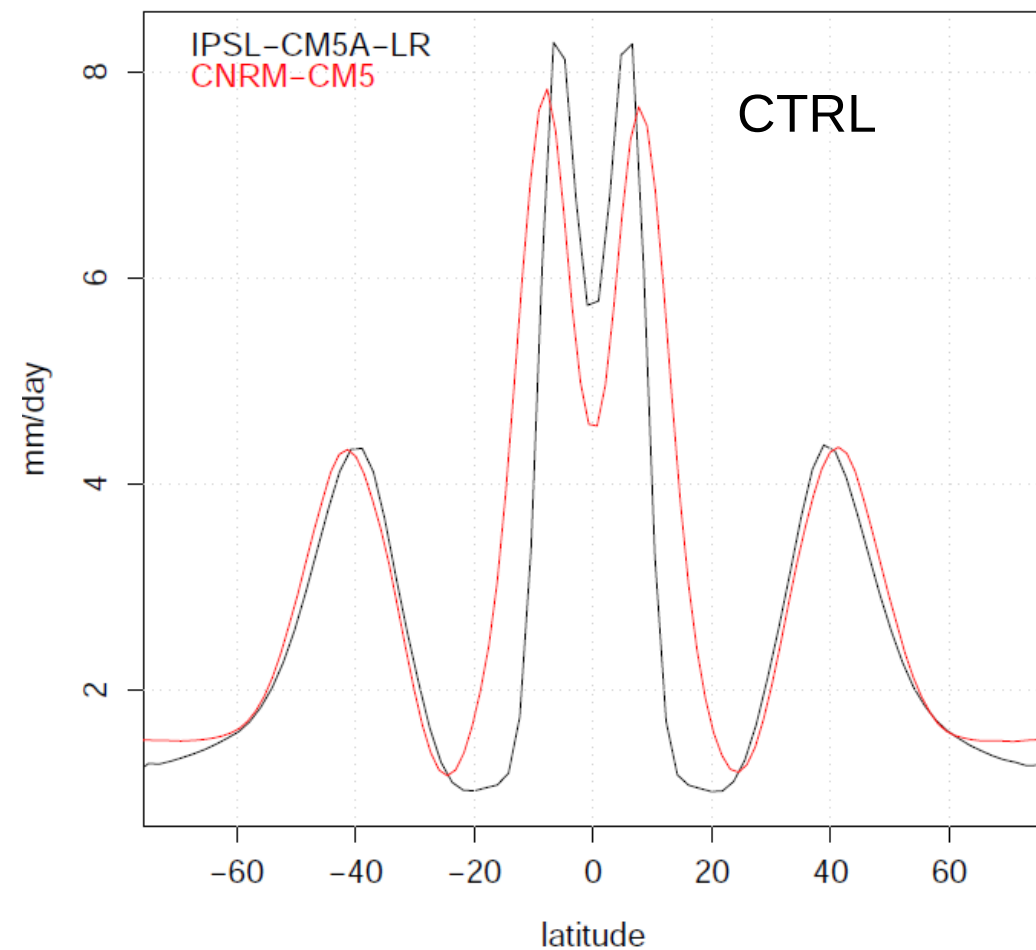
Precipitation Change (aqua4xCO2-aquaControl)



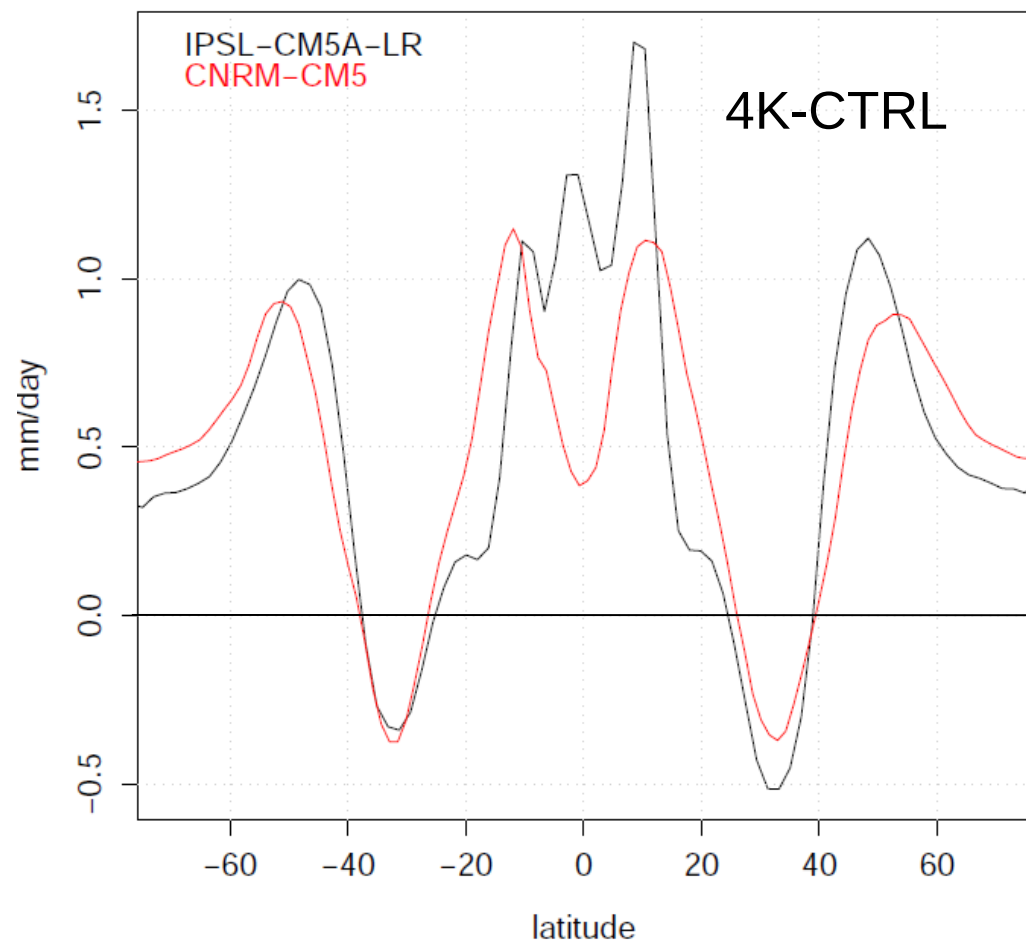
CMIP5 Aqua-Planet Experiments

Precipitation

Precipitation (aquaControl)



Precipitation Change (aqua4K-aquaControl)



A new generation of climate models is emerging

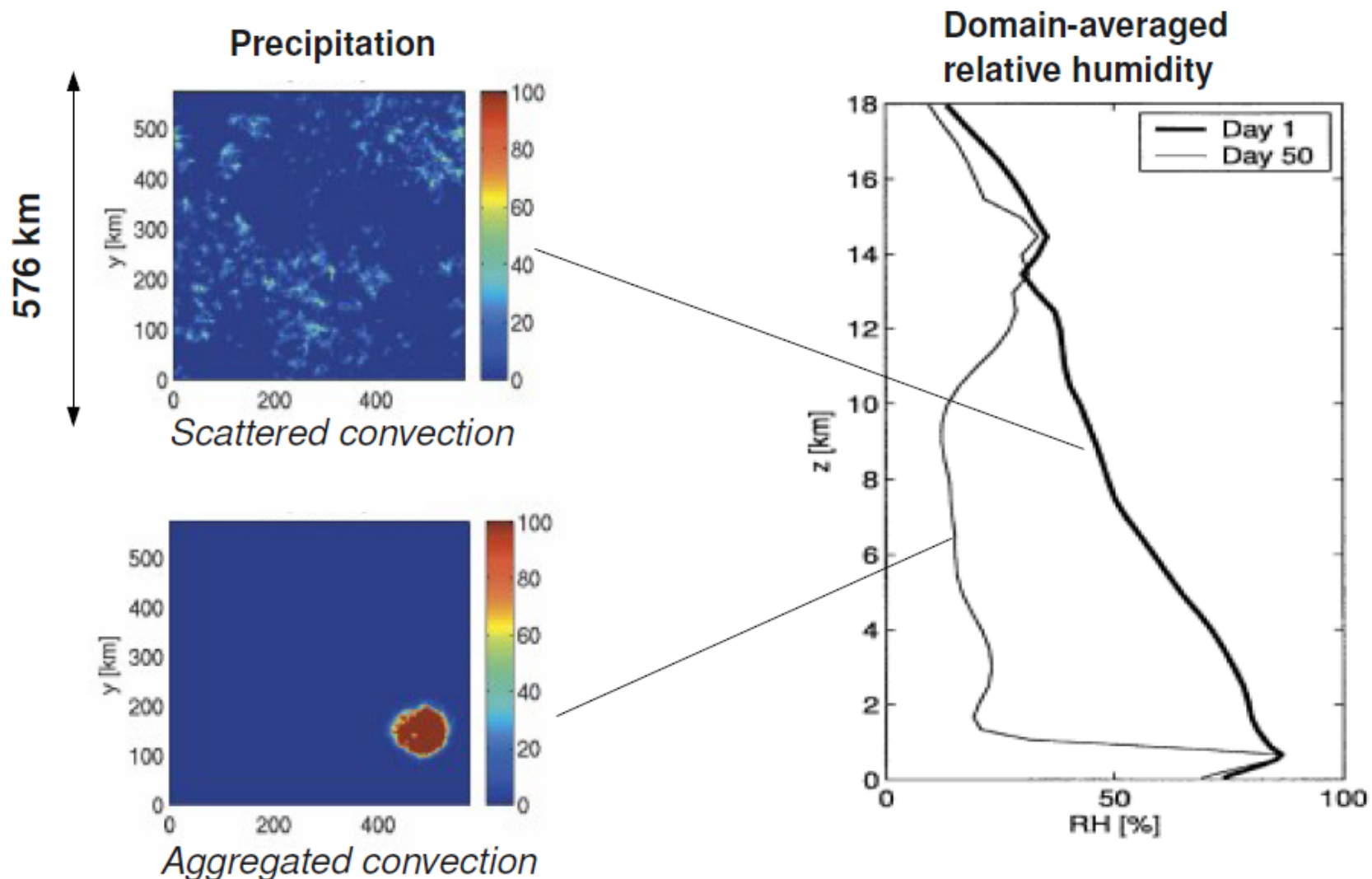
- High resolution climate models ($< 50\text{km}$)
- Super-parameterizations
- Global Cloud Resolving Models
- LES/CRM simulations over large domains ...

→ *Is the climate change response different from that predicted by CMIP5 GCMs ?*

→ *Idealized atmosphere-only experiments (CGILS, aqua-planet, AMIP..)*

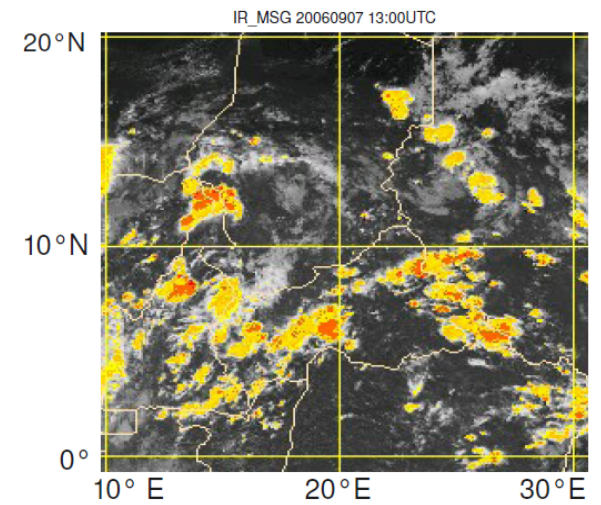
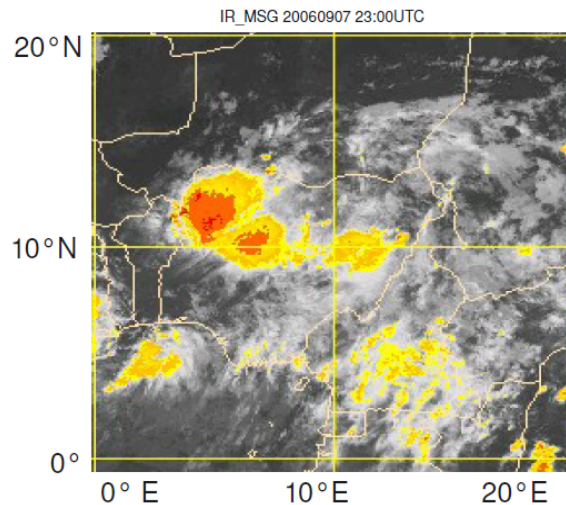
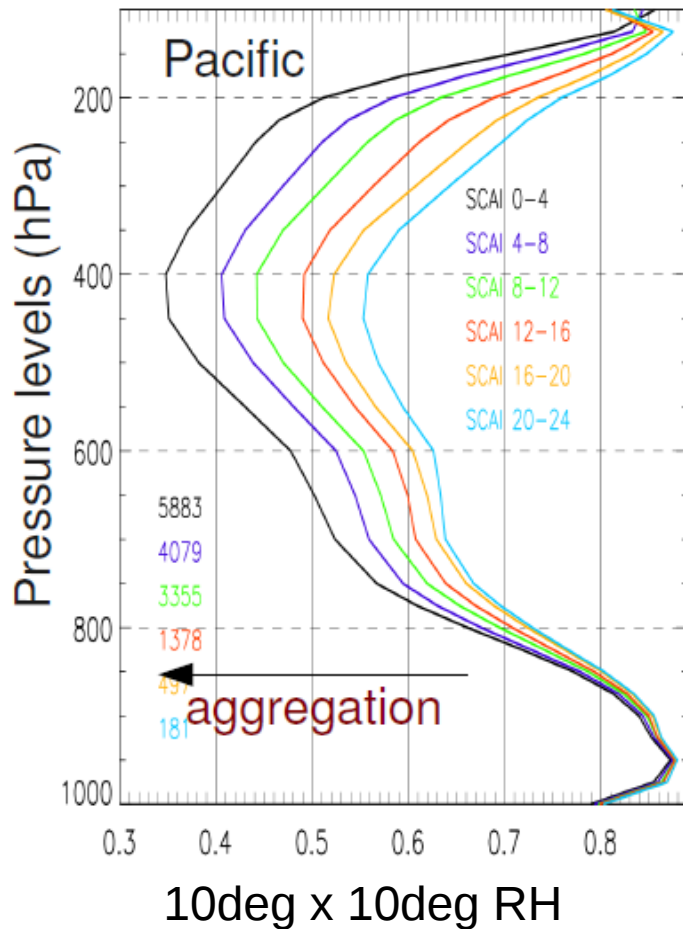
→ *If yes : Why ?*

Studies using Cloud Resolving Models suggest that the large-scale atmospheric state ((RH, surface fluxes, OLR..) may depend on the degree of convective aggregation



(Bretherton, Blossey and Khairoutdinov, 2005)

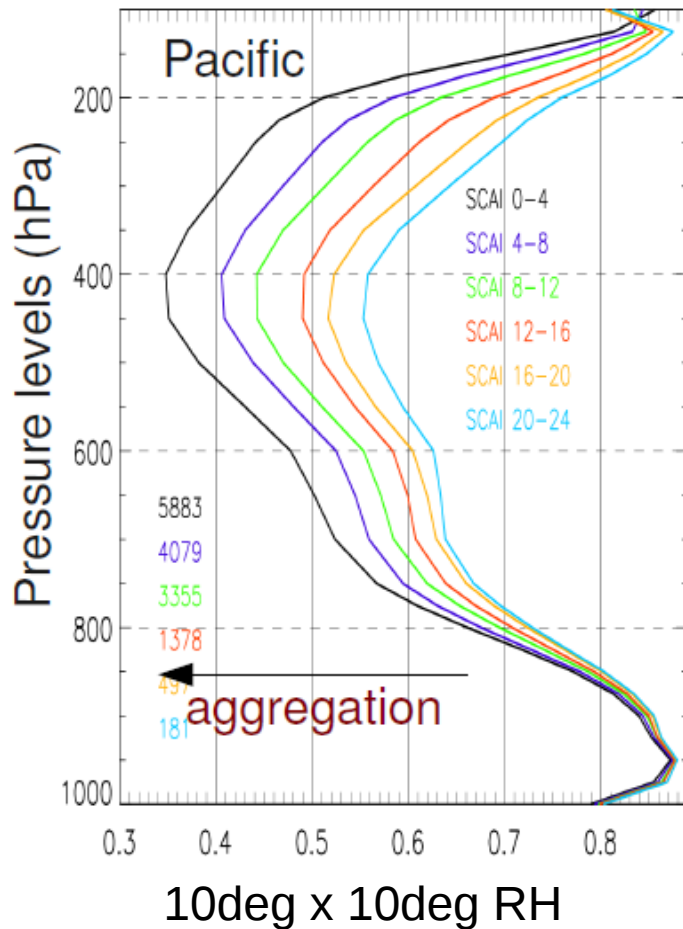
Observations to confirm these findings



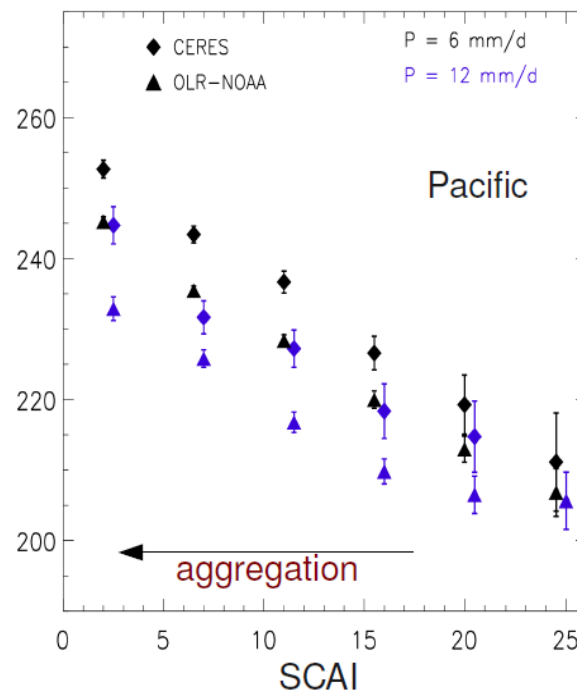
What impact on water vapour and cloud feedbacks ?

(Tobin, Bony and Roca, submitted)

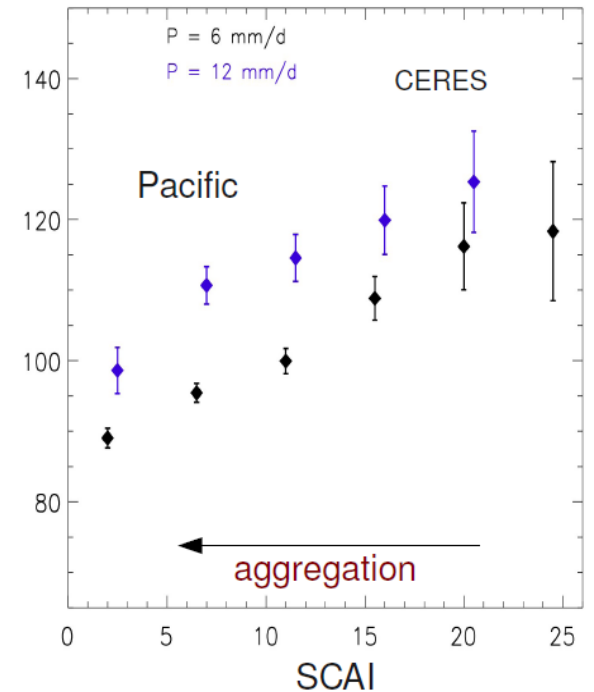
Observations to confirm these findings



Outgoing Longwave Radiation (W.m^{-2})



Reflected Shortwave Radiation (W.m^{-2})



What impact on cloud-climate feedbacks?

(Tobin, Bony and Roca, submitted)

CFMIP experiments and outputs : New Opportunities !

- **Assess clouds through a wide variety of observations, scales, methods :**
 - global space observations + in-situ instrumental data
 - from tropical to polar regions
 - wide range of time scales, from climate to weather (T-AMIP) to half-hourly (sites)
 - possibility to identify model errors and to develop a wide set of metrics and diagnostics for model evaluation & development (-> WGNE/WGCM metrics panel)
 - any observational test discriminating for climate change feedbacks ?
- **In association with other on-going projects (e.g. CGILS, T-AMIP, GCSS..), CFMIP will help to better understand**
 - the impact of model formulation on cloud-climate feedbacks
 - the role of cloud-climate feedbacks on the simulation of future AND current climates.
- **Study different aspects of climate change through :**
 - a suite of complementary experiments, configurations and outputs
 - a hierarchy of models (from LES to ESMs)
 - possibility to better assess the robustness of results (radiative forcing, feedbacks..) and to better understand inter-model differences
- **A growing community !**

Contribution to IPCC AR5

- Three chapters of special interest :

Chapter 7 : Clouds and Aerosols

Chapter 9 : Model Evaluation

Chapter 12 : Model Projections

- Deadline for paper submission : 31 July 2012
- Deadline for paper acceptance : 15 March 2013

Meetings of interest

- **WCRP Open Science Conference, Denver, 24-28 October 2011 :**

Several oral / poster sessions of interest for CFMIP/GCSS/EUCLIPSE :

B6: *Understanding Atmospheric Processes in Climate: Clouds, Aerosols and Dynamics*
(conveners: J. Alexander, S. Sherwood, A. Brown)

B7: *How Reliable are the CMIP5 Climate Models?*
(conveners: V. Eyring, P. Gleckler, B. van den Hurk, Pascale Braconnot)

B12: *Understanding Anthropogenic Climate Change in Terms of Processes and Feedbacks*
(conveners: C. Senior, J. Mitchell, H. Le Treut)

C12: *Clouds, Aerosols and Climate* (conveners: M. Webb, P. Siebesma, G. Feingold)

C28: *Improving Climate Models, Including their Components and Parameterizations*
(conveners: C. Bretherton, S. Legg, E. Manzini)

C33: *Understanding Climate Feedbacks* (conveners: B. Sanderson, D. Randall)

C34: *Global Model Evaluation and Projections: CMIP5 and Other Model Intercomparisons*
(conveners: J. Meehl, D. Waugh, J. Fasullo, K. Williams)

- **Workshop on the Physics of Climate Models, Caltech, 20-23 March 2012**

(J. Teixeira, C. Jakob, P. Siebesma)

- **CMIP5 Workshop**, University of Honolulu, **Hawaii, 5-9 March 2012**, comparable to the CMIP3 Workshop held there in 2005, similar “short presentation/poster” format

Thank You