EUCLIPSE

EU Cloud Intercomparison, Process Study and Evaluation Project

FP7 collaborative project

Feb 2010-Feb 2014

5 million Euro

42 man year

www.euclipse.eu

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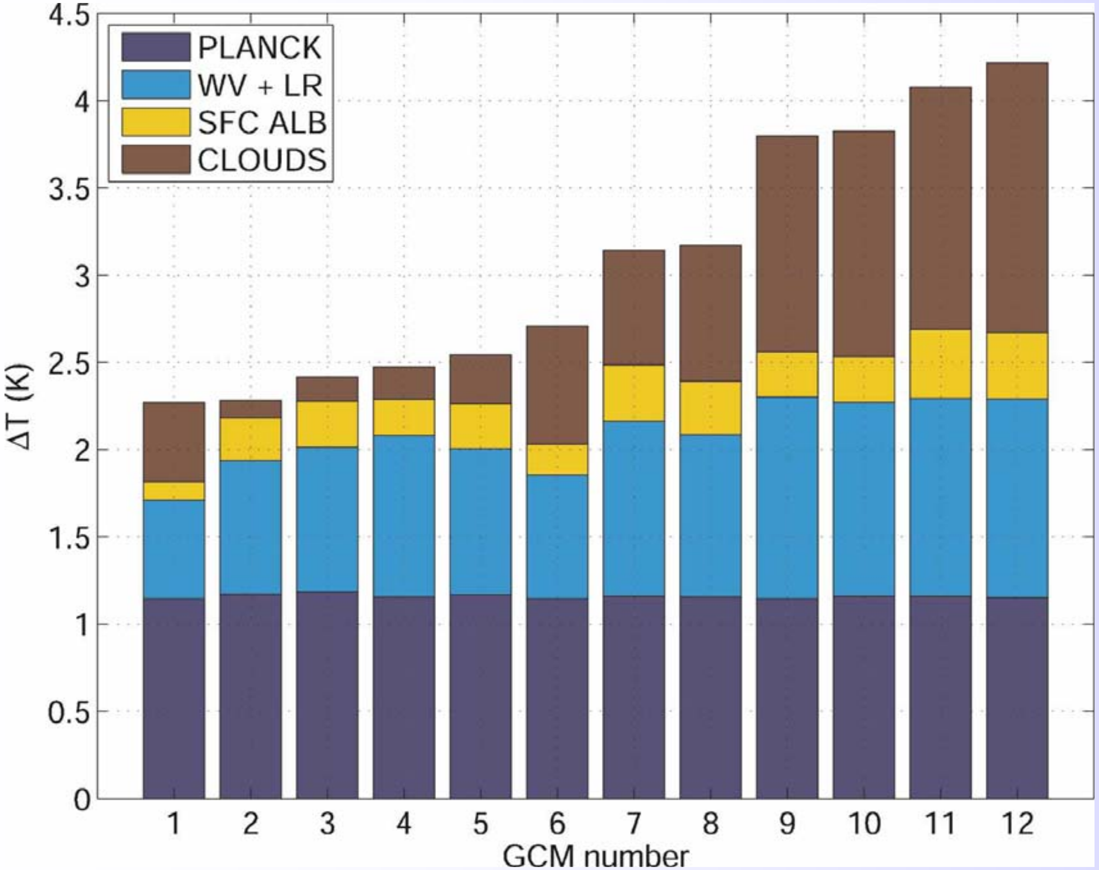
EUCLIPSE CHALLENGE: to determine, understand and reduce the uncertainty due to cloud-climate feedback.

$2XCO_2$ Scenario for 12 Climate Models



Cloud feedback

Surface albedo feedback

Water vapor feedback

Radiative effects only

Dufresne & Bony, Journal of Climate 2008

EUCLIPSE OBJECTIVES

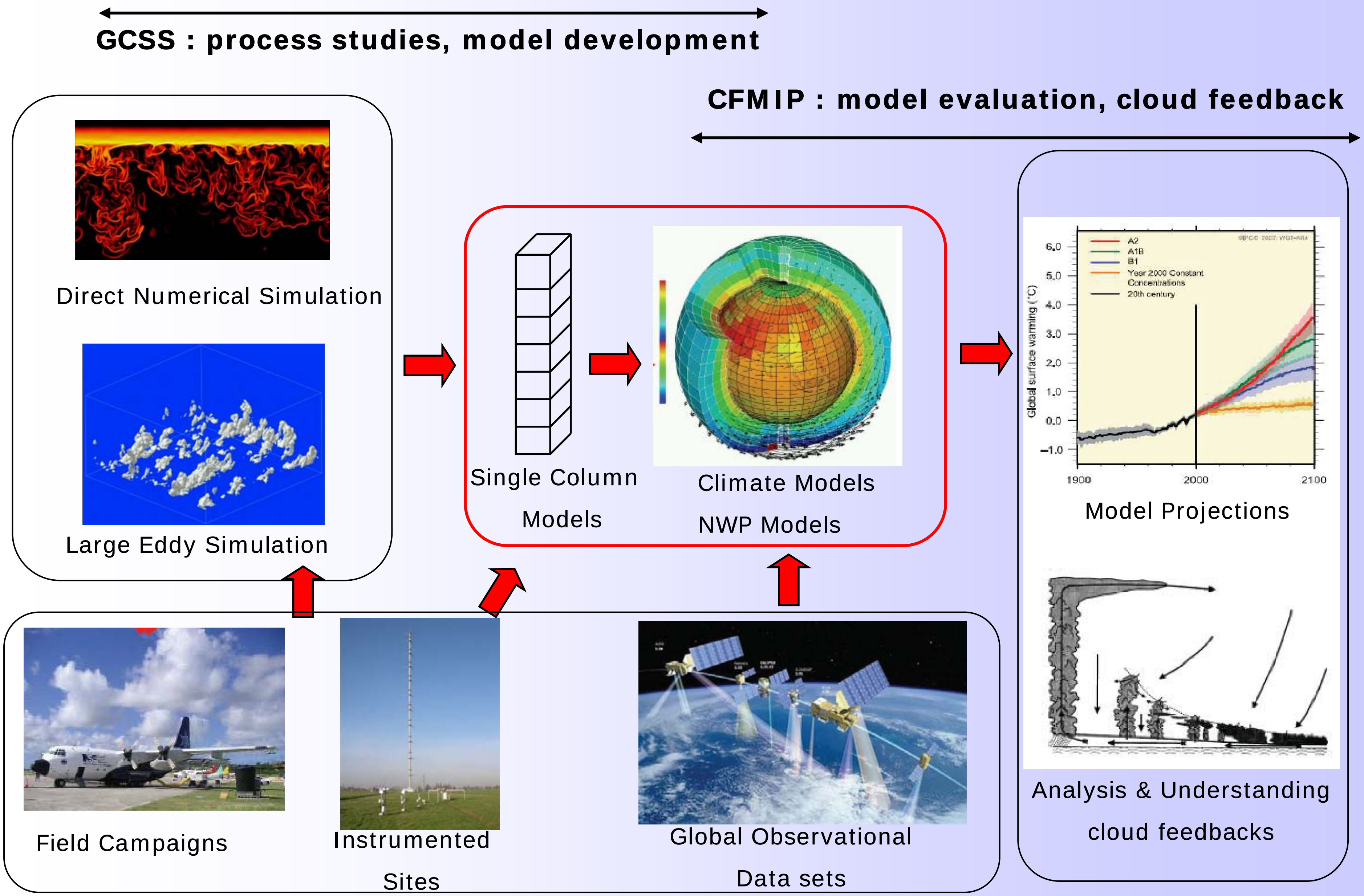
- Evaluation of cloud processes in Earth System Models.

- Development of metrics to measure the relative credibility of the cloud feedbacks by different Earth System Models.

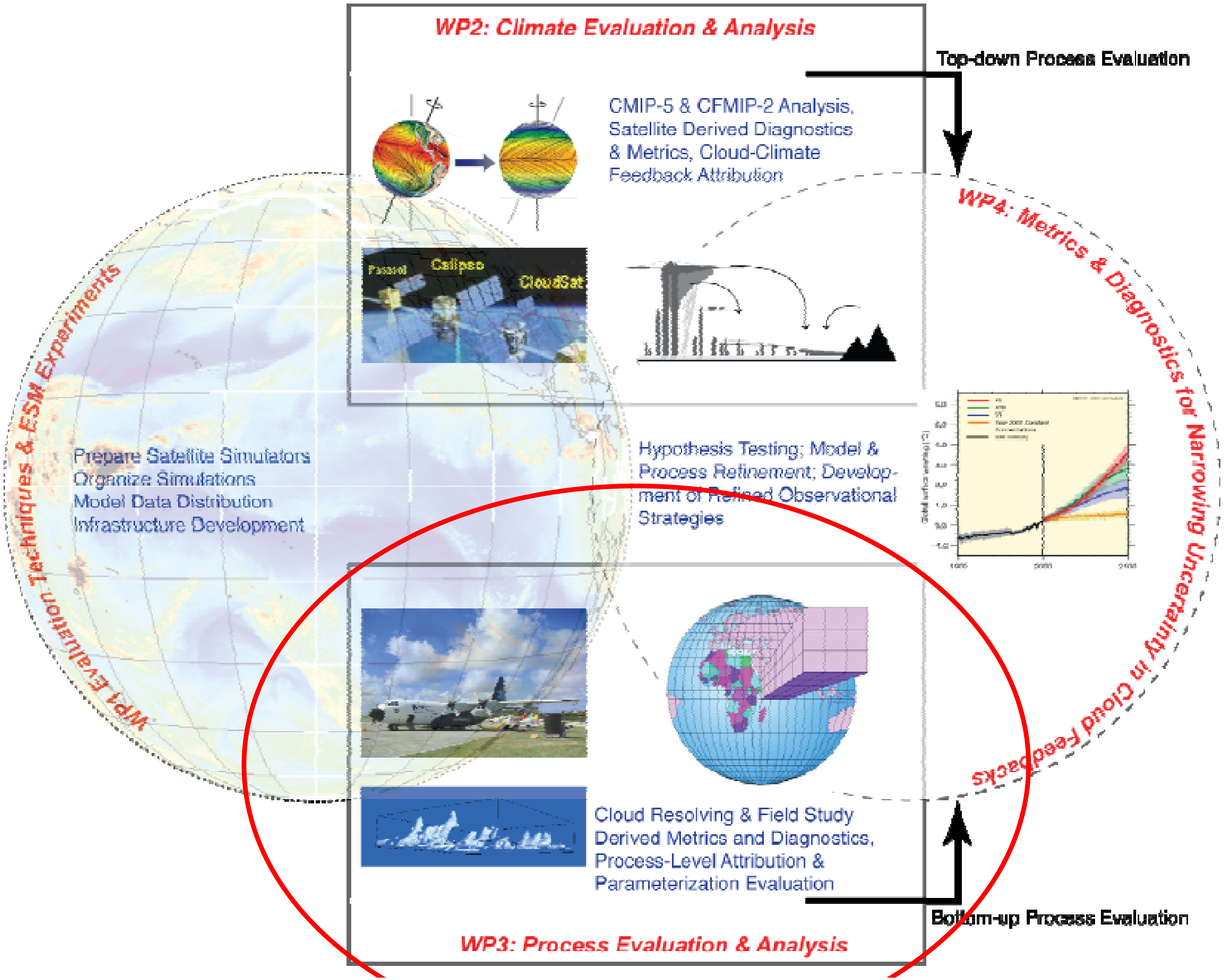
- Development of physical understanding of how cloud processes respond and feedback to climate change.

- Improvement the parameterization of cloud related processes in current Earth System Models

EUCLIPSE Methodology



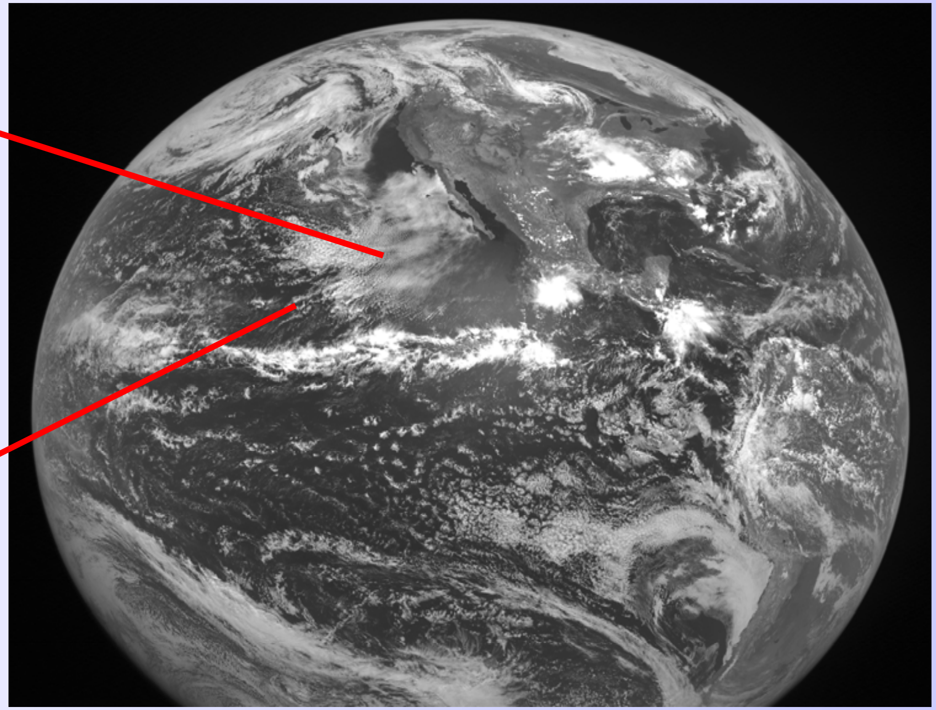
Break up of the Work



Primarily due to marine low clouds

Stratocumulus

Shallow cumulus

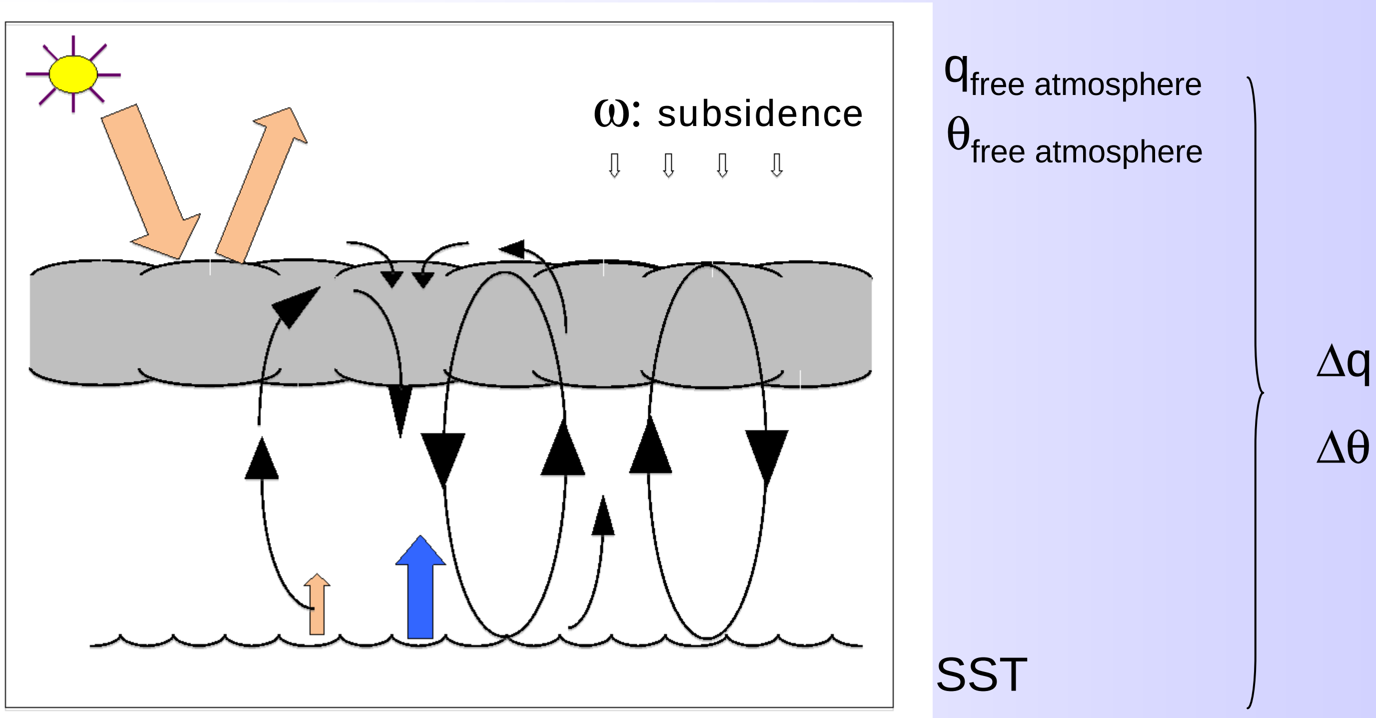


“Marine boundary layer clouds are at the heart of tropical cloud feedback uncertainties in climate models”

(Bony Dufresne GRL)

Challenge: Find the cloudy state c as a function of the slow varying large scale conditions:

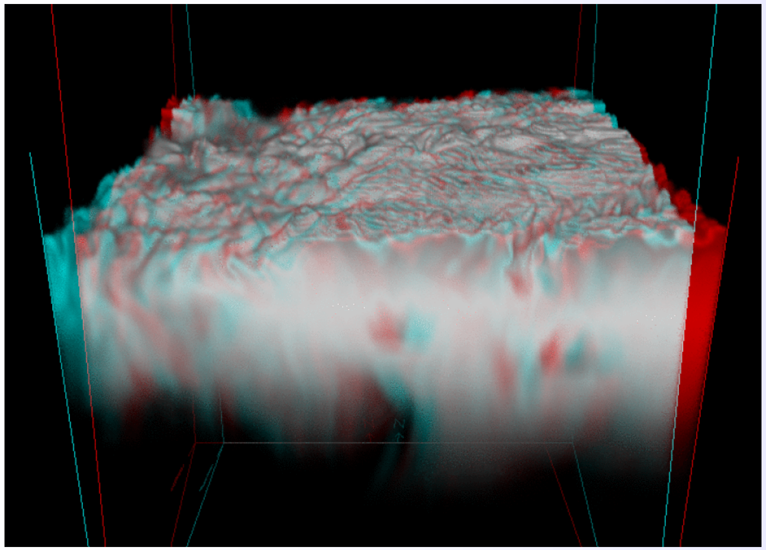
$$c(SST, \Delta q, \Delta\theta, \omega, \ldots\ldots)$$



For boundary layer clouds:

Large scale forcings ⇔ response cloudy BL

Master-Slave principle:



LES

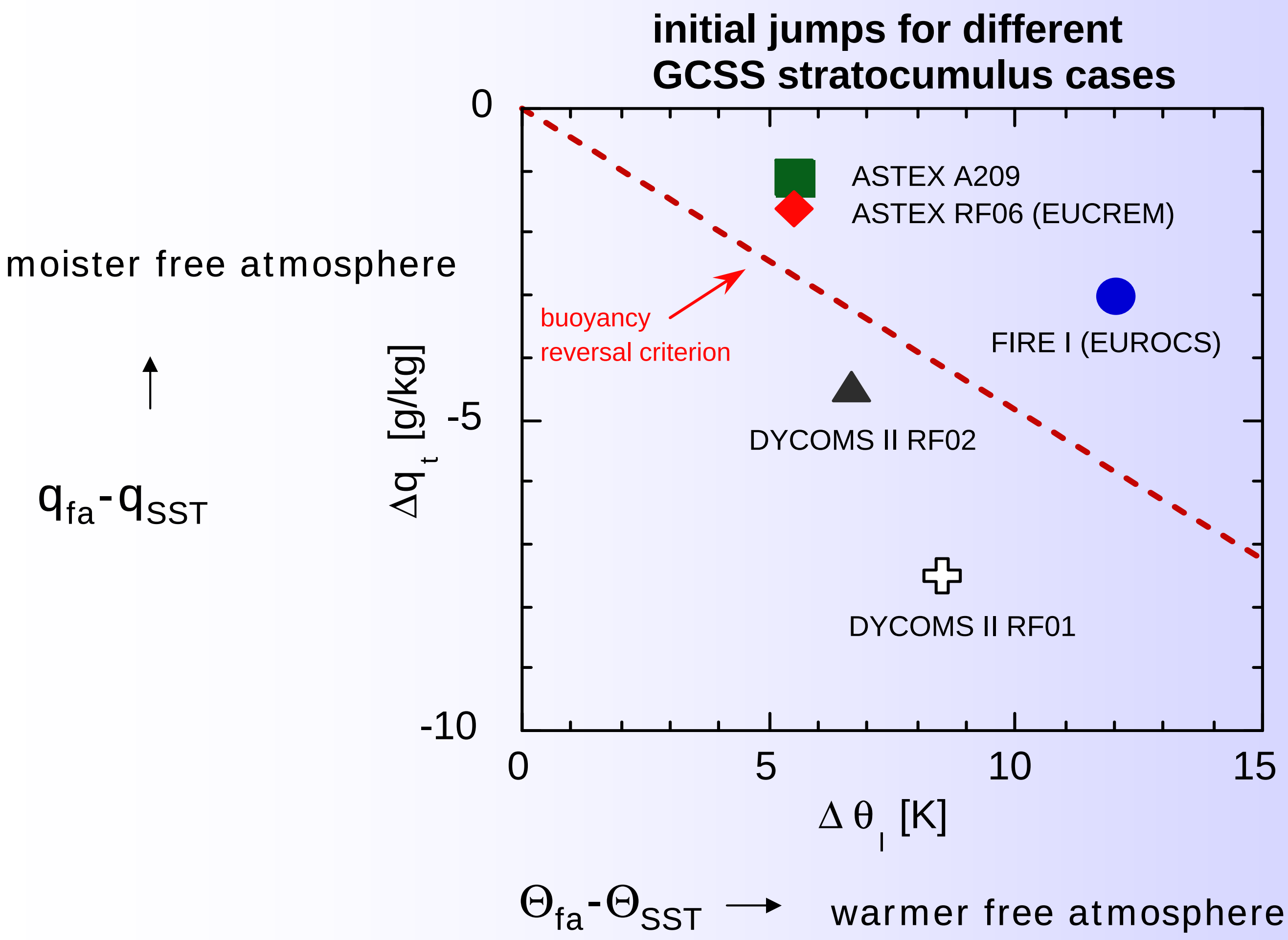
Steady state Solutions for c :

$$\lim_{t \to \infty} \frac{\partial c}{\partial t} = \left(\frac{\partial c}{\partial t}\right)_{Large\ scale} + \left(\frac{\partial c}{\partial t}\right)_{small\ scale} \approx 0$$

$\downarrow$ Prescribed by observations

$\downarrow$ Response simulated by LES, parameterizations

So far GCSS has only explored a small part of the phase space for Scu based on field experiments:

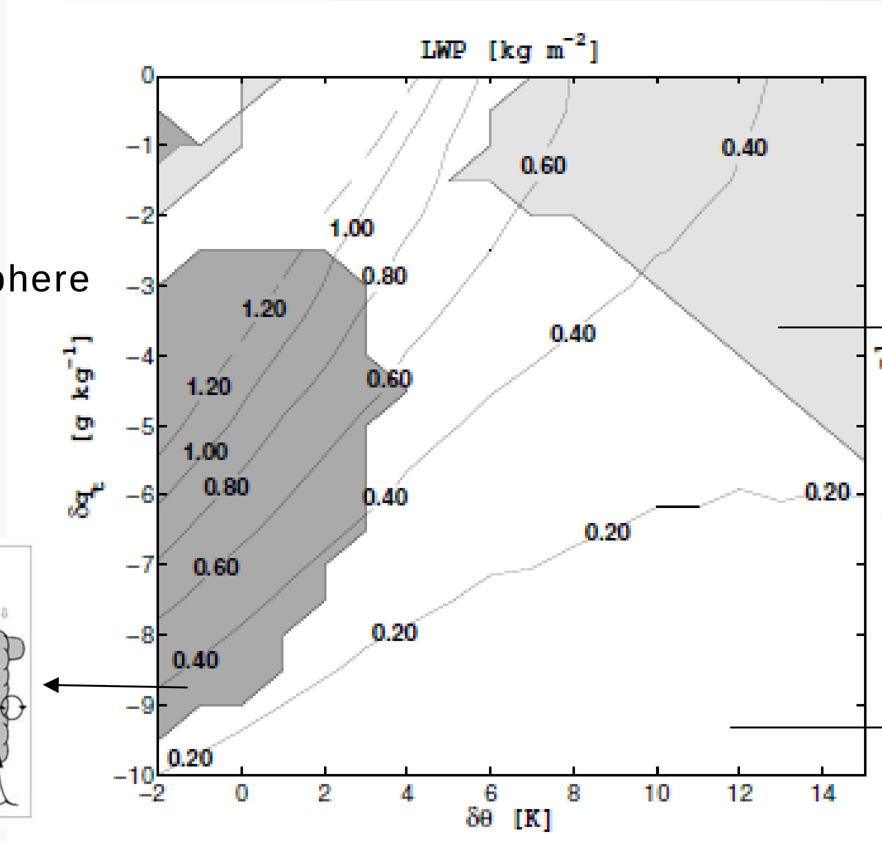


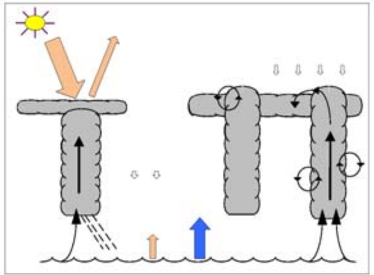
But we can systematically explore the whole phase space by LES or, in this case, by a mixed layer model and obtaining steady state solutions:

moister free atmosphere

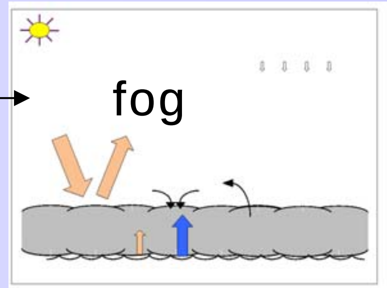
↑

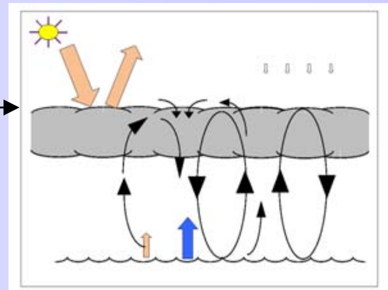
q_{fa}-q_{SST}





Decoupling!!





Θ_{fa}-Θ_{SST} ⟶ warmer free atmosphere

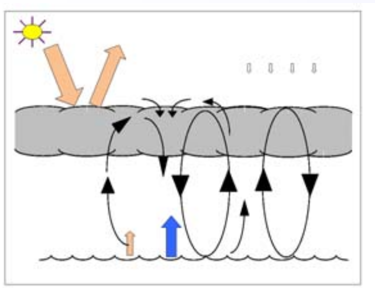
provides critical tests for parameterizations…..!

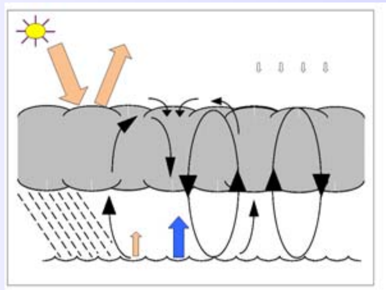
CGILS: Perturbing equilibrium states with future climate scenario's:

$$\delta c\,(SST, \Delta q, \Delta\theta, \omega, \ldots\ldots) = \left(\frac{\partial c}{\partial SST}\right) dSST + \left(\frac{\partial c}{\partial \omega}\right) d\omega$$

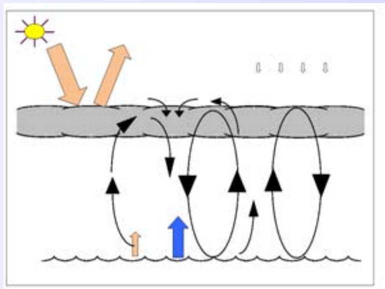
Present

Perturbed Future $SST \uparrow \quad \omega \downarrow$

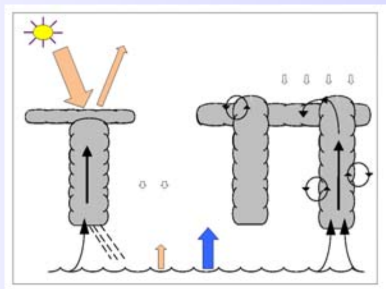




Neg. Feedback



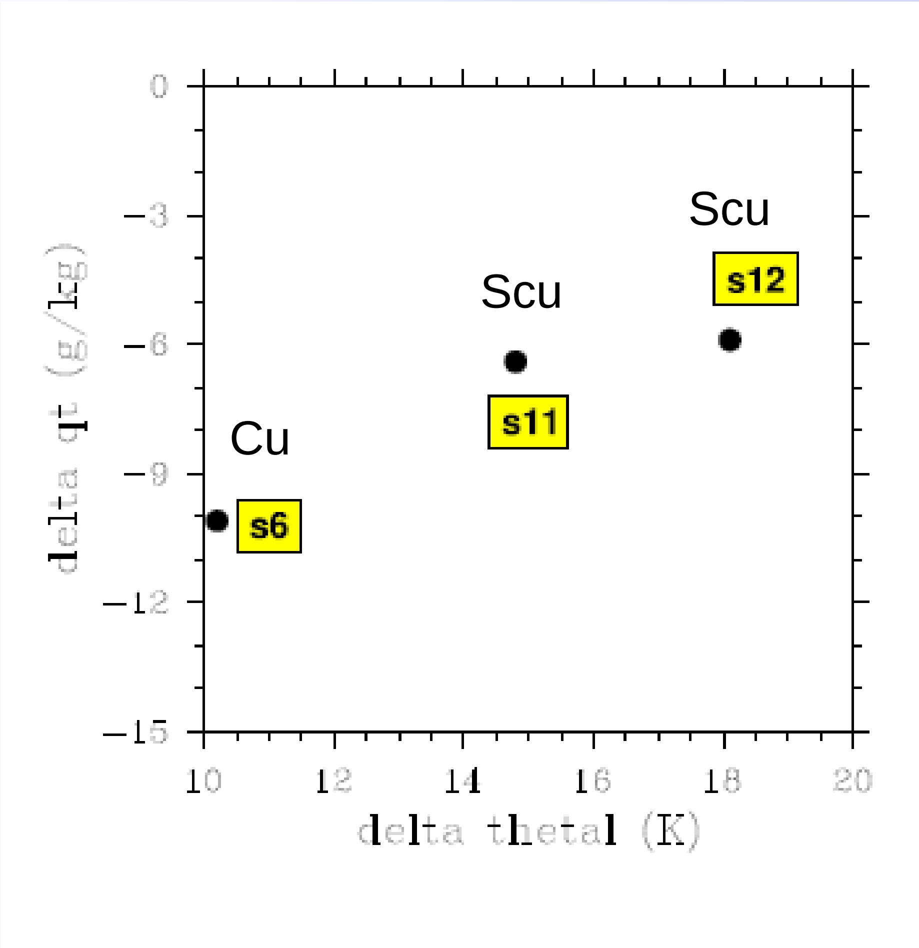
Pos. Feedback



Strong Pos. Feedback

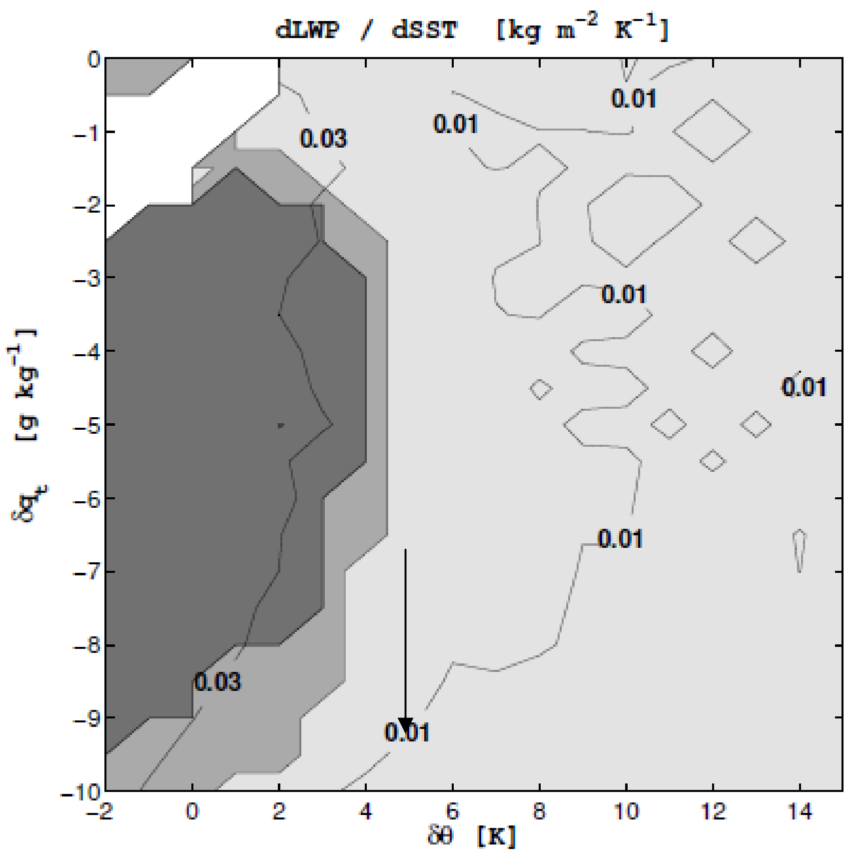
Next Thursday

CGILS concentrates on 3 points in the phase space



But again… could be generalized by exploring the full phase space (at least for simple mixed layer models)

ΔLWP/ΔSST



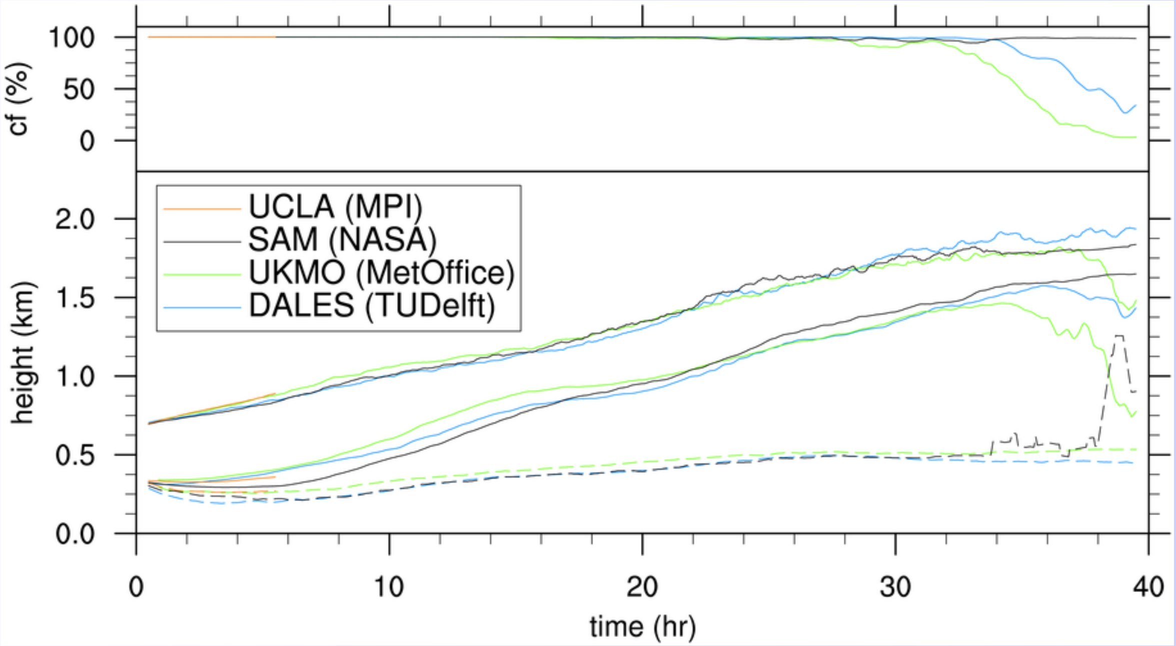
Small increase of LWP

(small negative feedback)

Transition from Scu to Cu (strong positive feedback)

Subsequently how do parameterizations of ESM's compare??

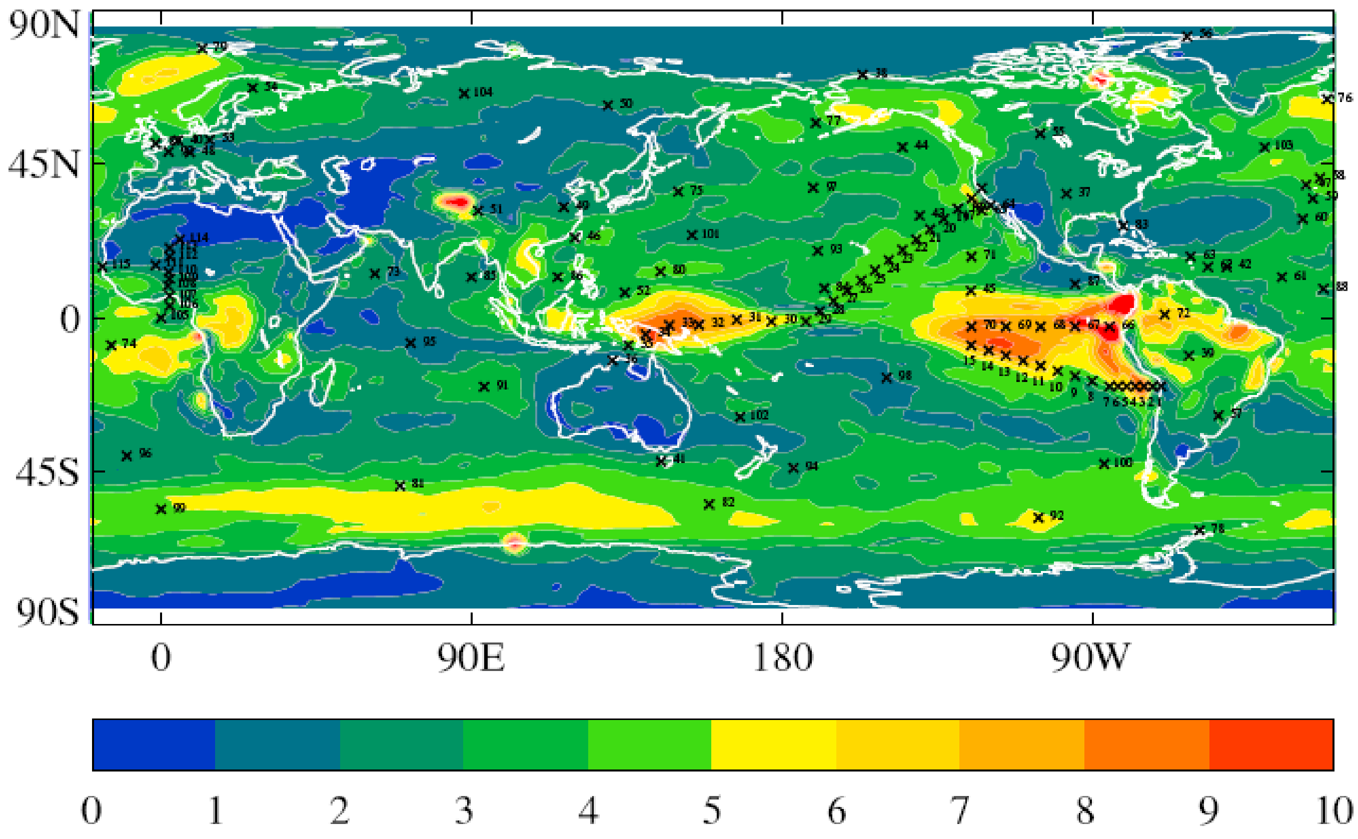
EUCLIPSE/GCSS Transition cases:



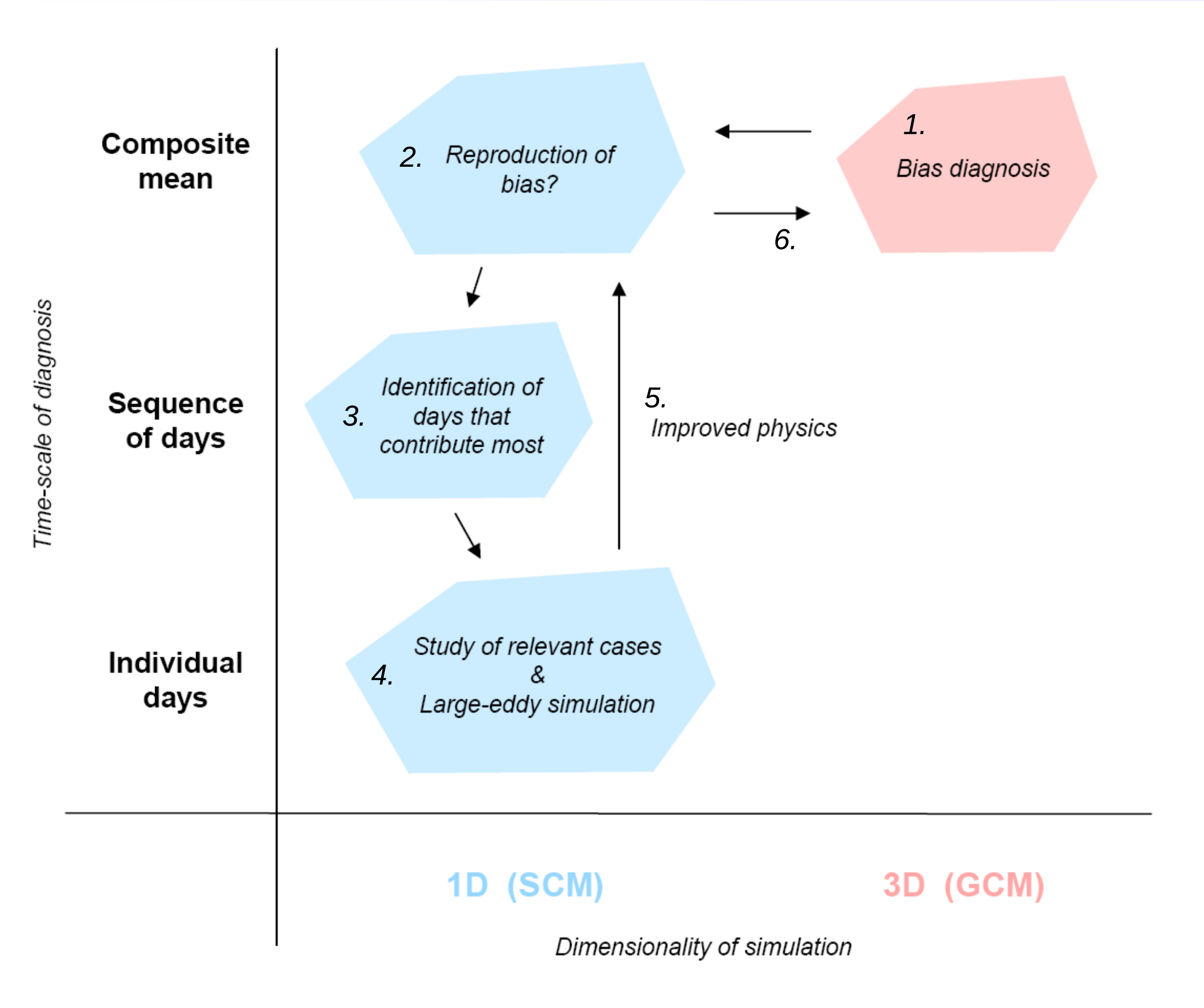
For details see www.euclipse.eu

Next Wednesday !!!

Analysis at selected gridpoints

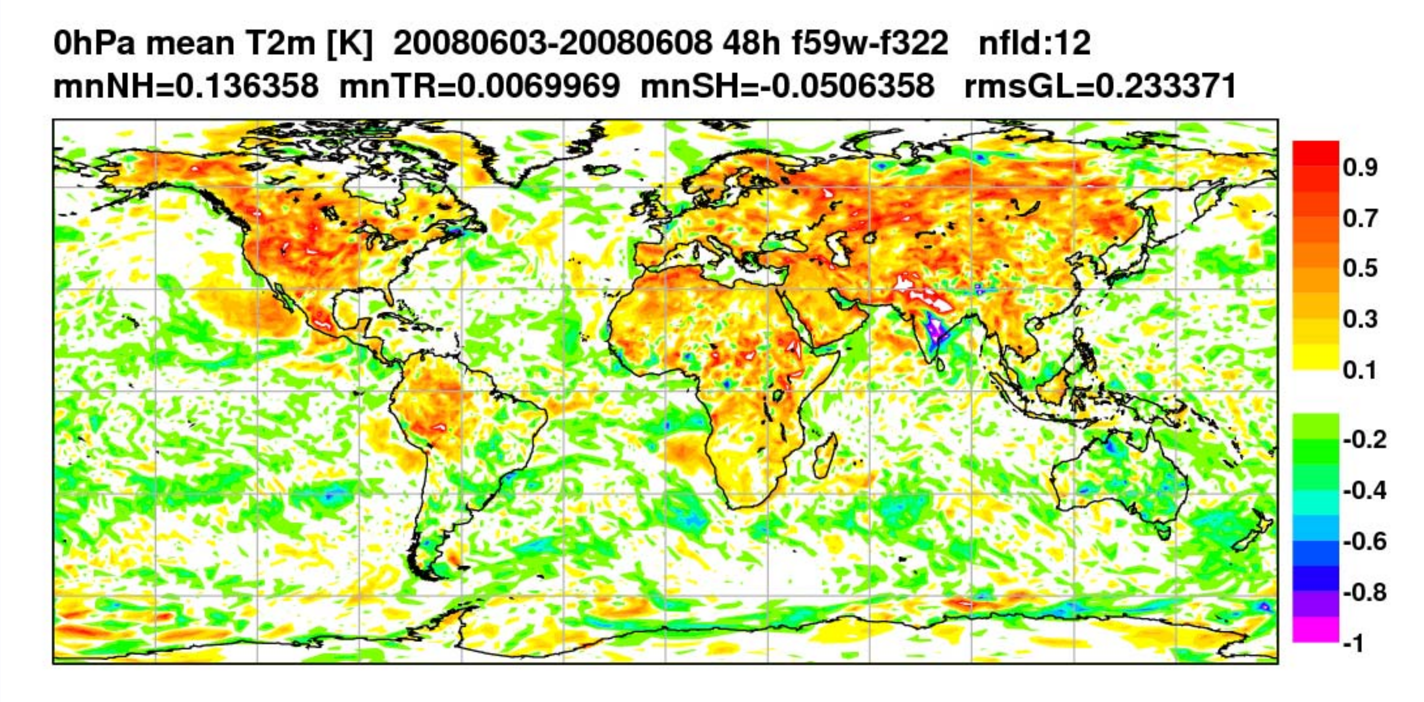


Strategy of Analysis



ESM with a bias of T2m during local noon.........

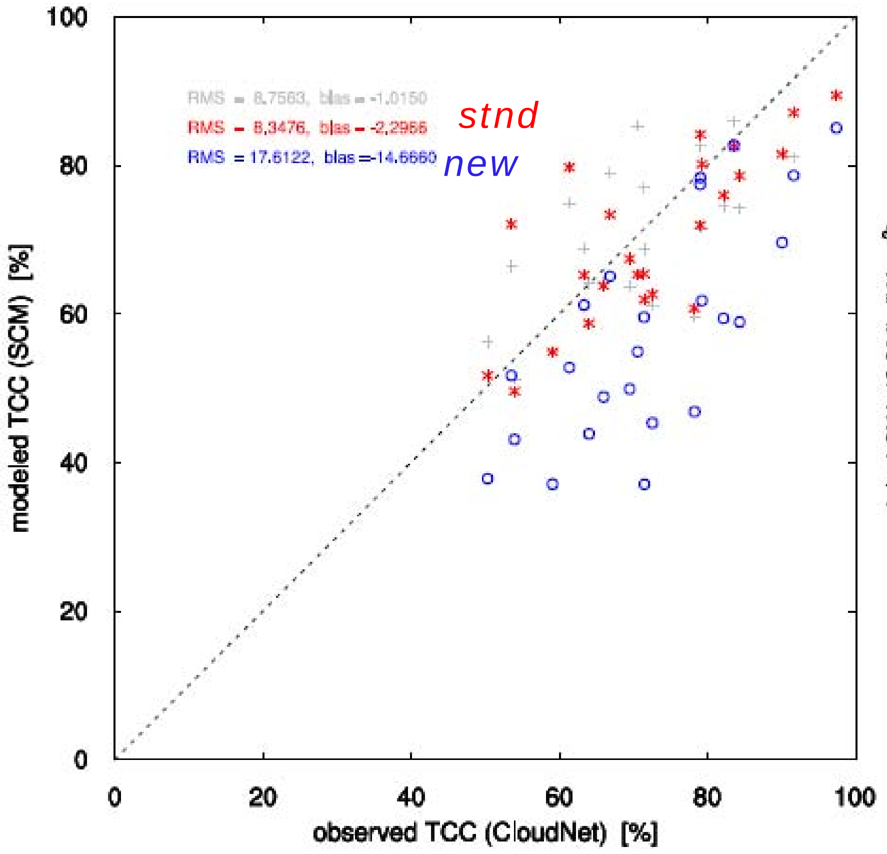
free climate run, June-July 2008

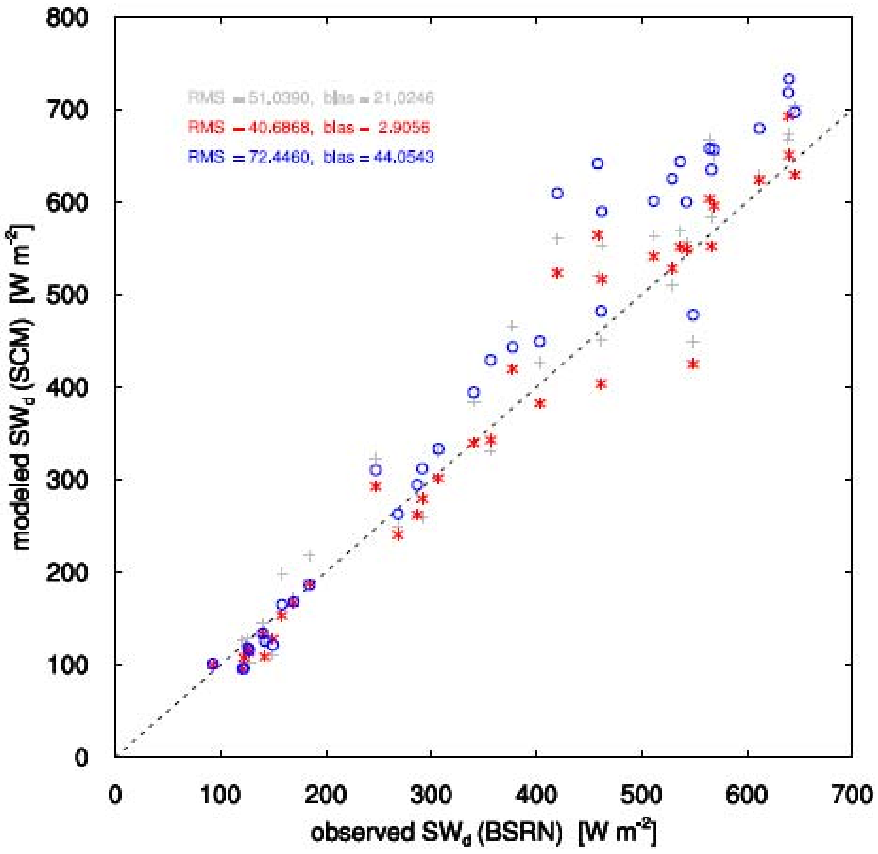


Reproduced in SCM on single grid point and related to: too low cloud cover and too much SW radiation...

Cloud cover

SW-down





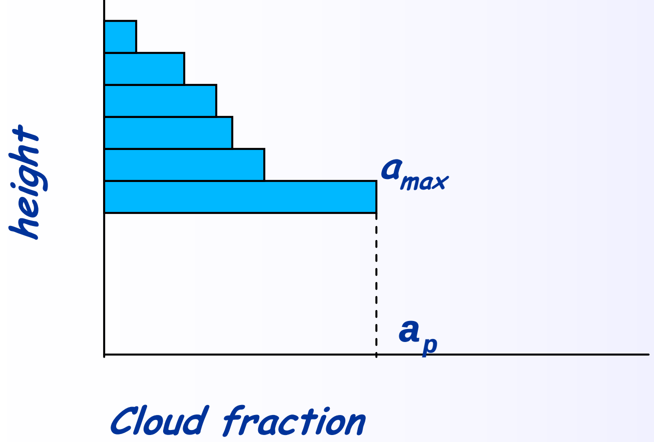
Run LES for those days with the strongest bias

Jerome Schalkwijk TU Delft

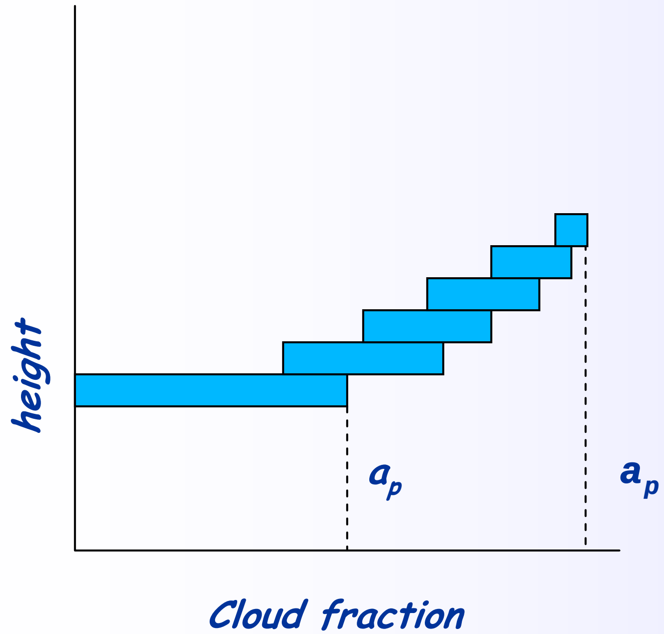
Cabauw June 18 2008, executed on a Graphical Processor Unit (GPU)

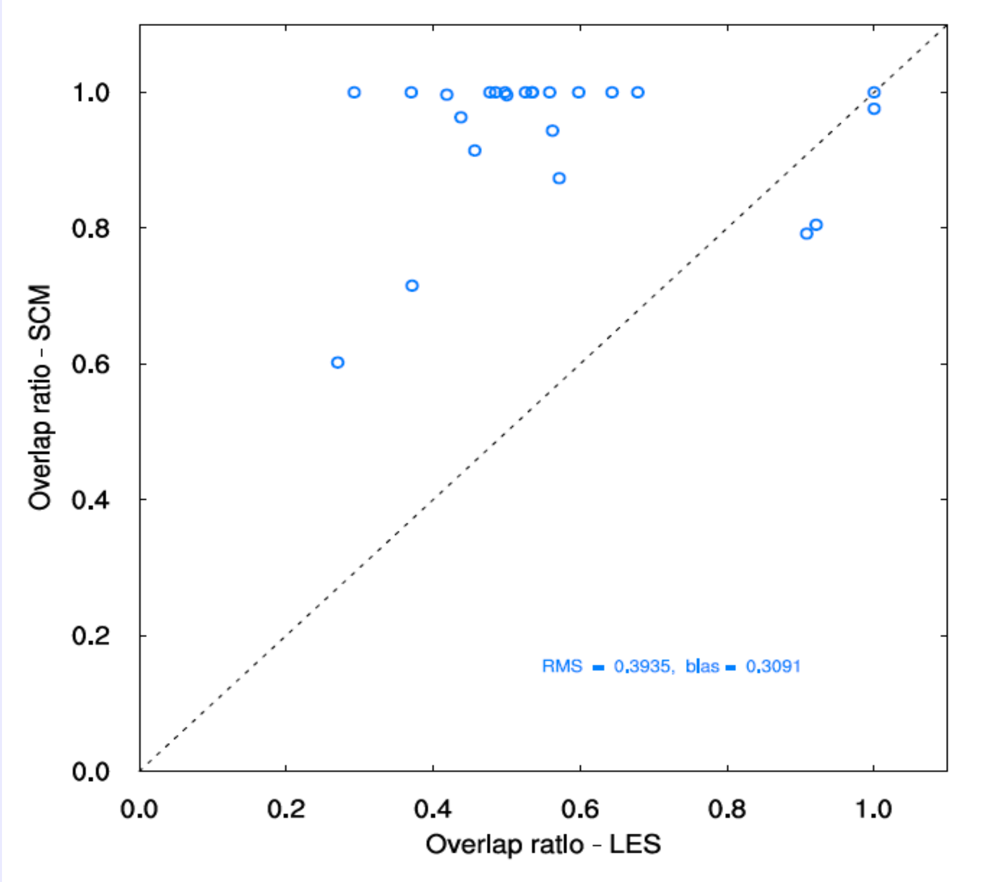
Cloud Overlap functions:

at present maximum overlap for all GCMs!)



Implies : total cloud fraction $cf_{tot} = cf_{max}$





$$\boxed{r = \frac{a_{\max}}{a_p}}$$

maximum cloud fraction

TCC

Neggers et al 2011

Understanding Cloud Feedback of Low Clouds

- Use observational well constrained cases to explore equilibrium states.
- Generalise to explore the phase space
- Perturb equilibrium states to future climate large scale conditions
- Utilize the increased amount of observational data and computional tools

Thank you.