UNIVERSITY OF MIAMI
ROSENSTIEL
SCHOOL of MARINE &
ATMOSPHERIC SCIENCE

An observational constraint on cloud feedback?

Katinka Bellomo[1], Amy Clement[1], Joel Norris[2],
Brian Soden[1], Robert Burgman[3], Paquita Zuidema[1]

[1]Rosenstiel School of Marine and Atmospheric Science, University of Miami
[2]Scripps Institution of Oceanography, UCSD
[3]Florida International University

Inter-model spread in climate sensitivity estimates is primarily caused by **uncertainty in cloud feedback** over subtropical stratus regions (Soden and Vecchi, 2011).

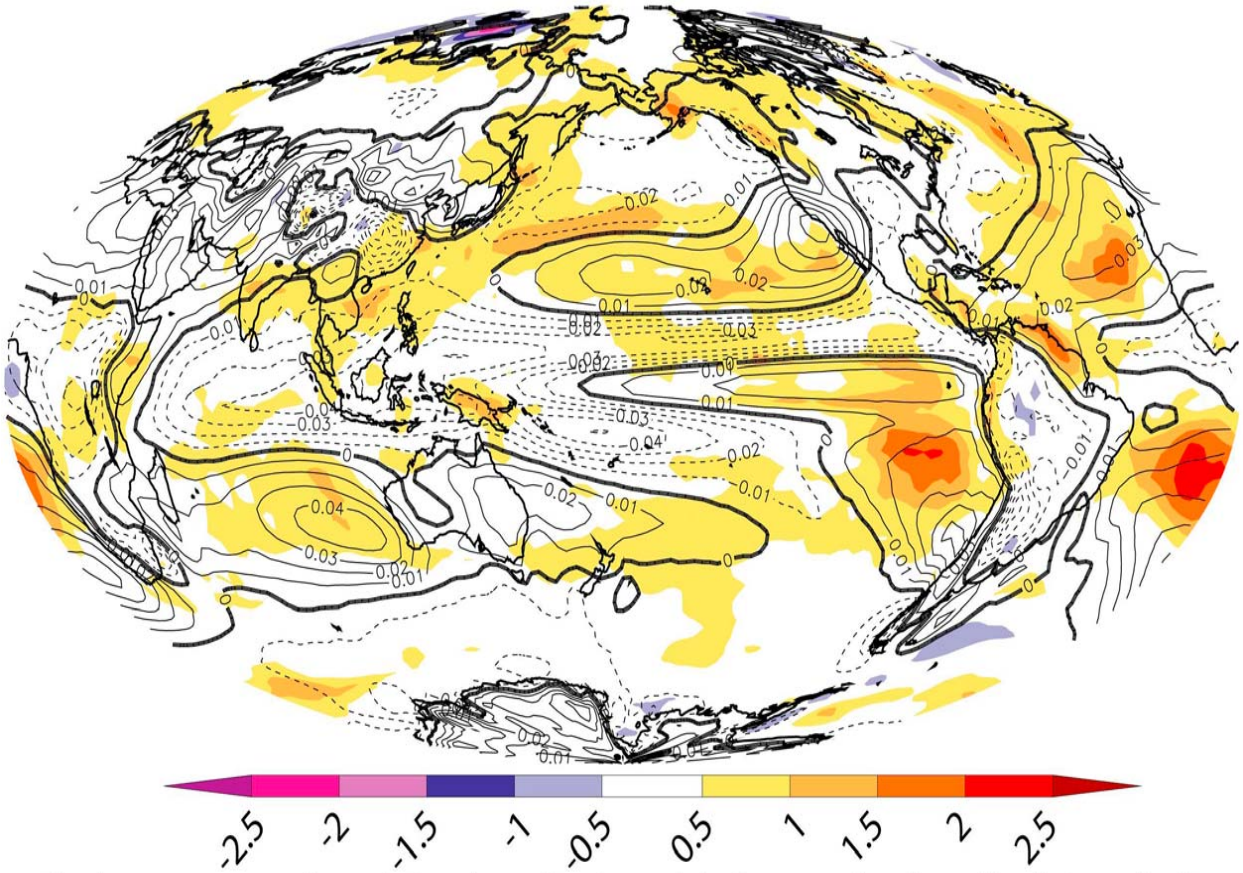


*Fig. 4 from Soden and Vecchi, GRL11

The cloud feedback is the major source of uncertainty in the modeling of climate change:

Can cloud **observations** be used to constrain cloud feedback in subtropical stratus regions?

Do CMIP5 historical simulations agree with observations? What are physical mechanisms controlling long-term cloud changes?

A **longer-term perspective** from cloud observations:

Ship-based observations:
EECRA (from ICOADS)

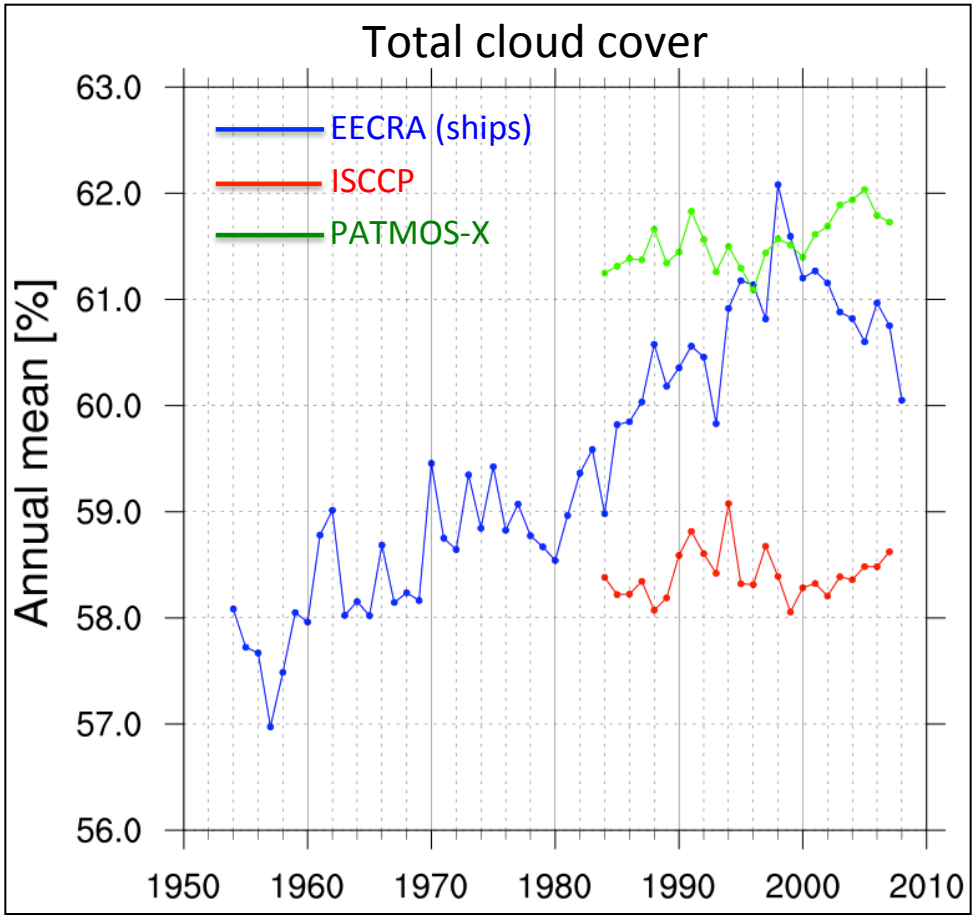
- **Long-term: 1954-2008**, obs. over the global oceans, 5x10 grids
- Affected by an unidentified artifact that introduces a spurious increase in tropical mean cloud cover

Satellite observations:
ISCCP and PATMOS-X

- Shorter-term: 1984-2007, 2.5x2.5 grids
- Better quality (after corrections for artificial low-frequency variability by J. Norris and A. Evan)

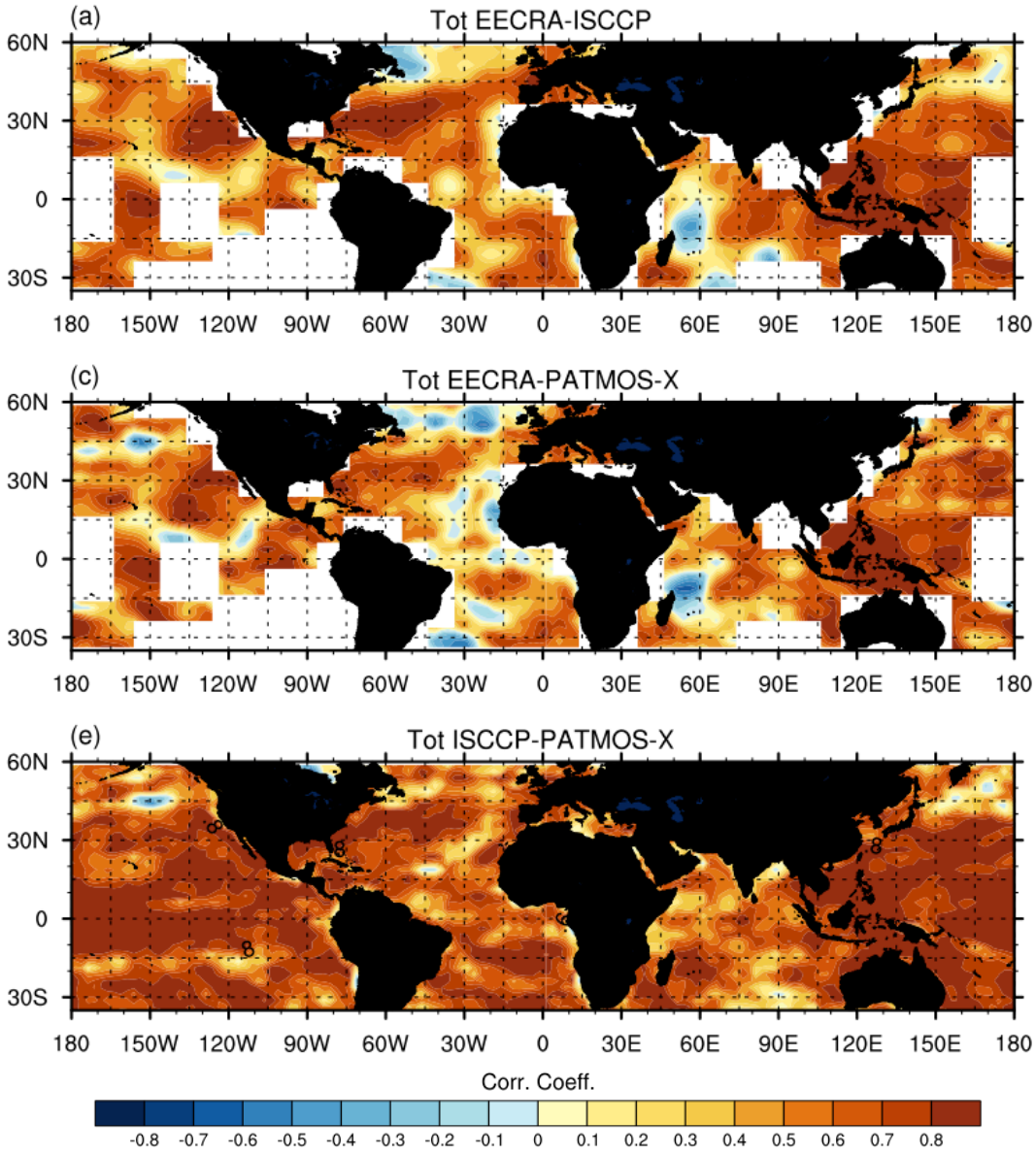
Spurious increase in tropical mean total cloud cover:

- Unidentified artifact (Norris 2005)
- **Corrections applied to EECRA:** remove tropically averaged annual means (30S:30N) to each grid box (following Deser et al. 2004, 2010)



Inter-comparison of cloud datasets:

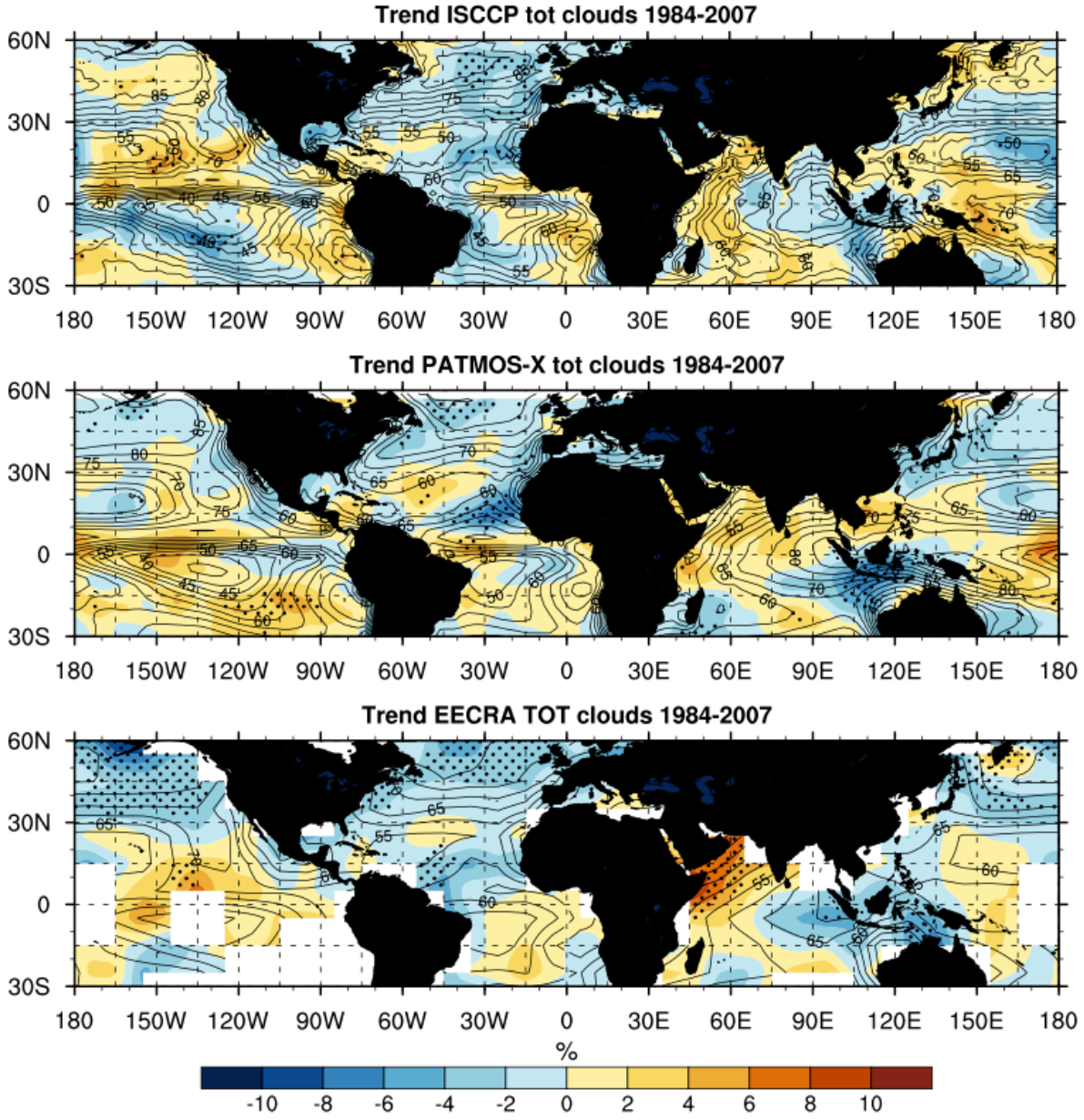
Correlation of inter-annual cloud anomalies among corrected datasets:



Good agreement in short-term (1984-2007) cloud trends:

Satellites

Ships →



Estimates of cloud feedback (1954-2005):

Methodology:

Cloud Feedback parameter:

$$\lambda_{CL} = \frac{\Delta CRF}{\Delta T}$$

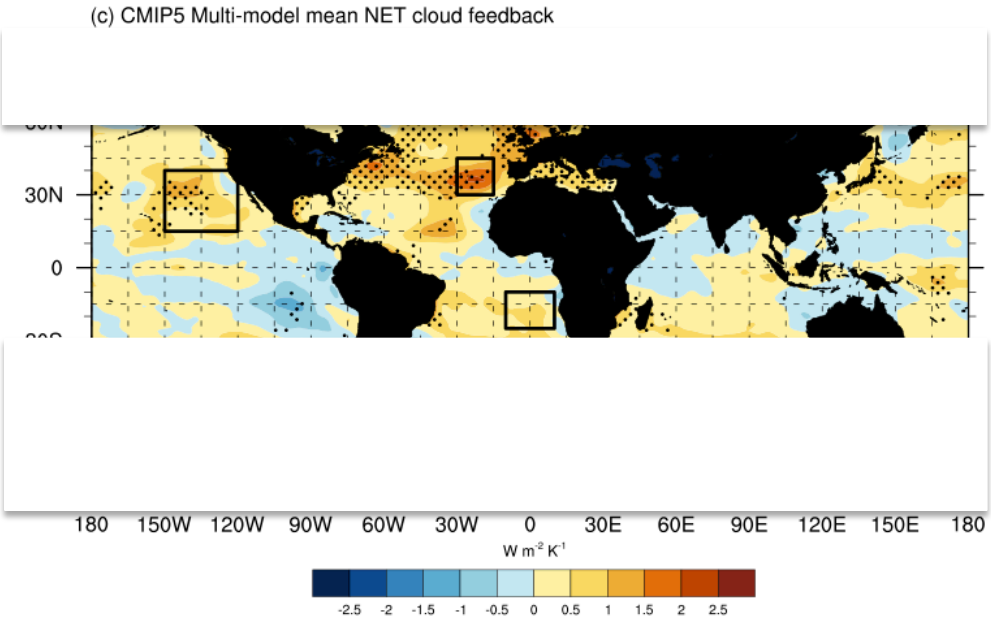
ΔCRF = change in CRF at TOA from 1954 to 2005, obtained regressing satellite retrievals of net radiation fluxes (ISCCP and CERES) on total cloud cover (ISCCP) and multiplying this regression coefficient by the long-term EECRA cloud dataset.

ΔT = change in global mean sea surface temperature (HadISST).

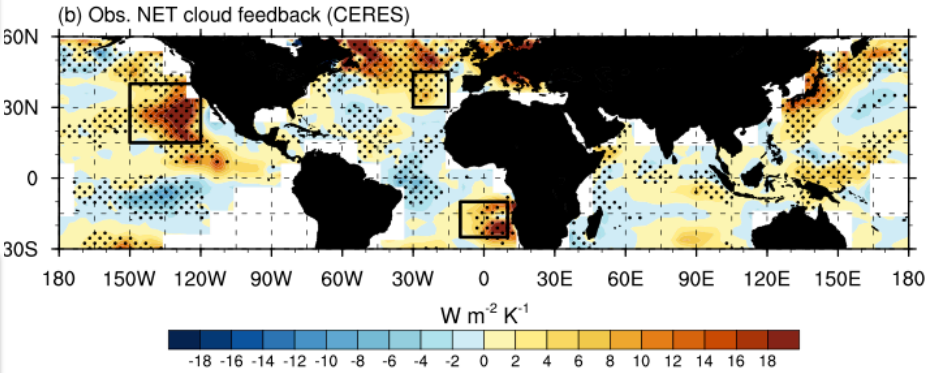
This same definition is used to estimate cloud feedback from CMIP5 models (historical simulations).

Results: estimates of net cloud feedback (1954-2005)

CMIP5 multi-model mean*:



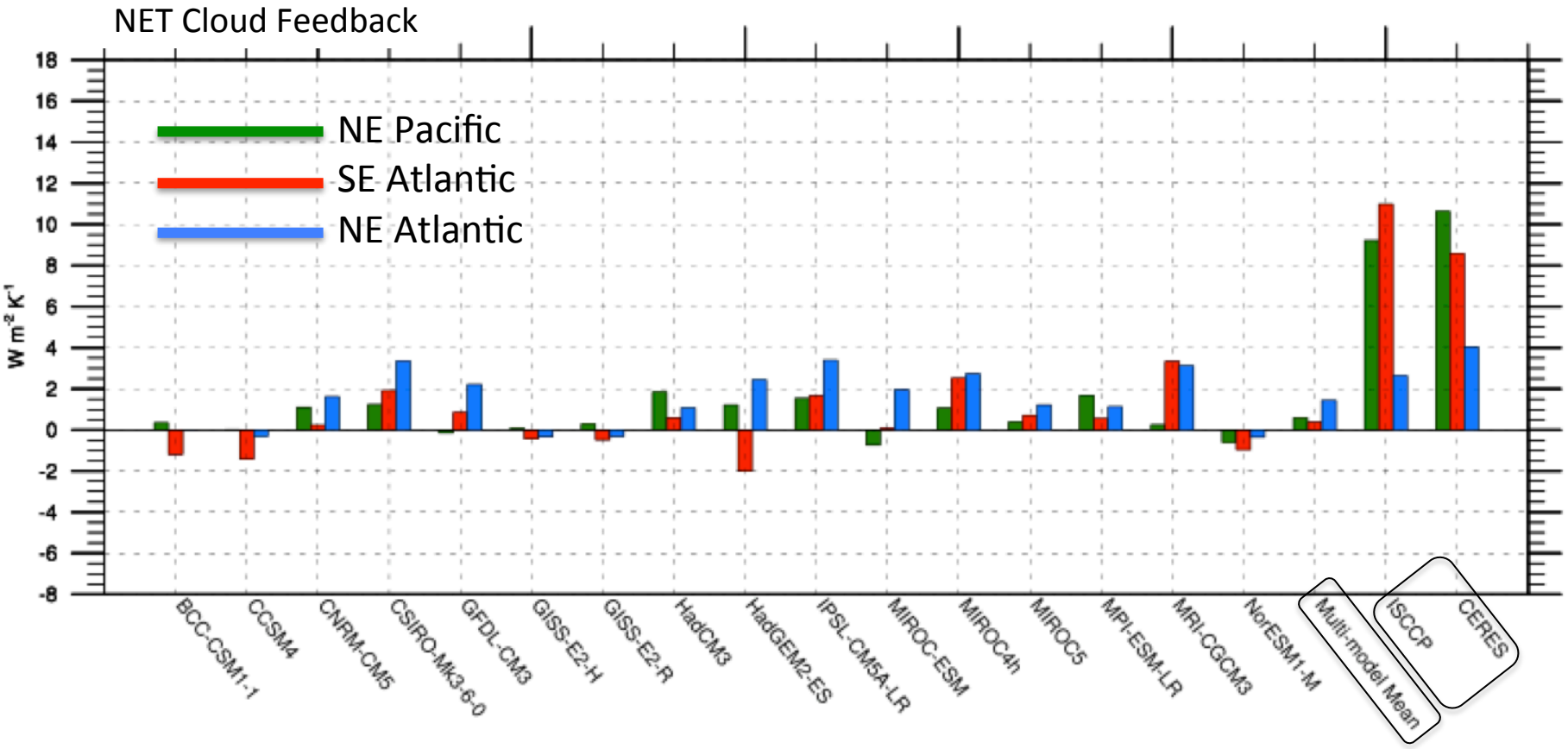
Observations:



The multi-model net cloud feedback mean agrees in sign with observations but is smaller in amplitude (in NE Pacific and SE Atlantic).

*Multi-model cloud feedback mean of 16 model output from historical simulations (3 ensemble members for each model)

The NET cloud feedback is **positive** over 3 subtropical stratus regions: NE Pacific, SE Atlantic and NE Atlantic, over the years 1954-2005.



Decrease in total cloud cover (1954-2005):

- Large decrease in cloud cover in observations and (much smaller) in CMIP5 models over 3 subtropical stratus regions.
- SE Atlantic: cloud change is not captured by models (cloud climatology is not right).
- Estimate of cloud feedback from total cloud cover…

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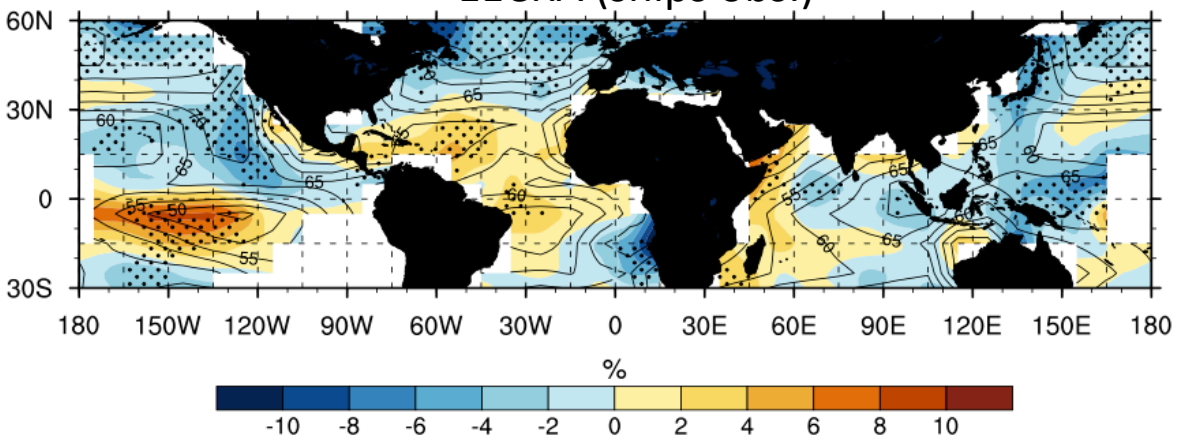
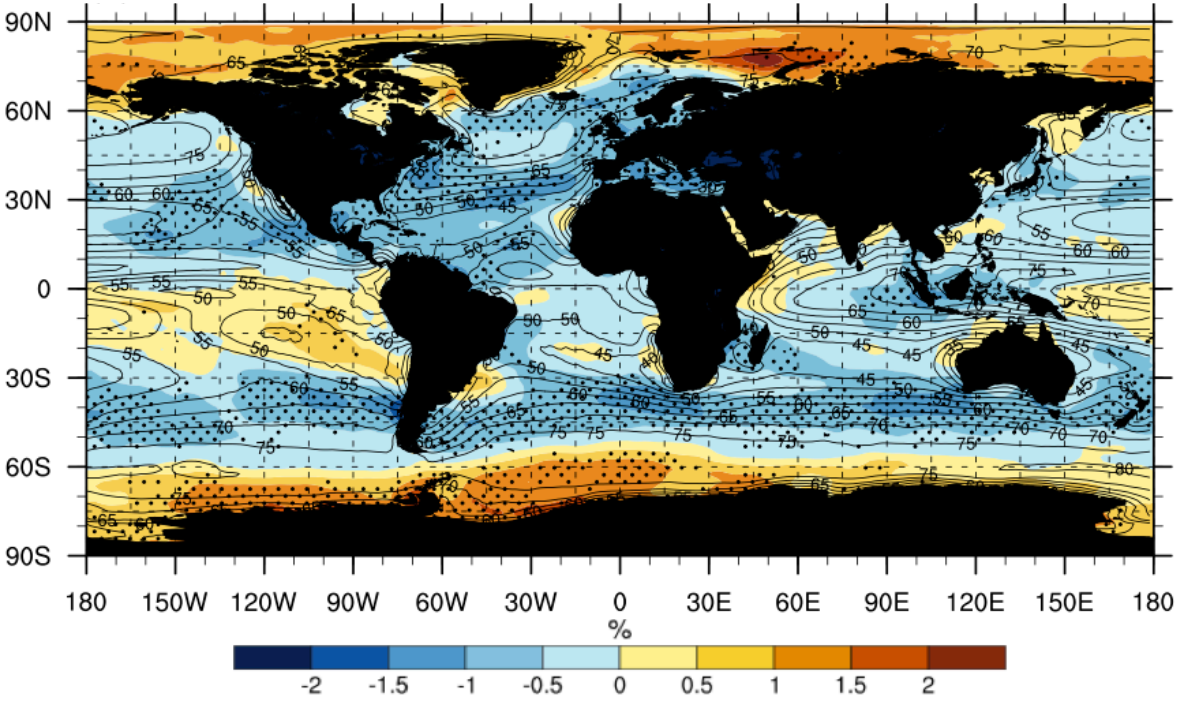
How is the vertical profile of cloud change?

EECRA (ships obs.)

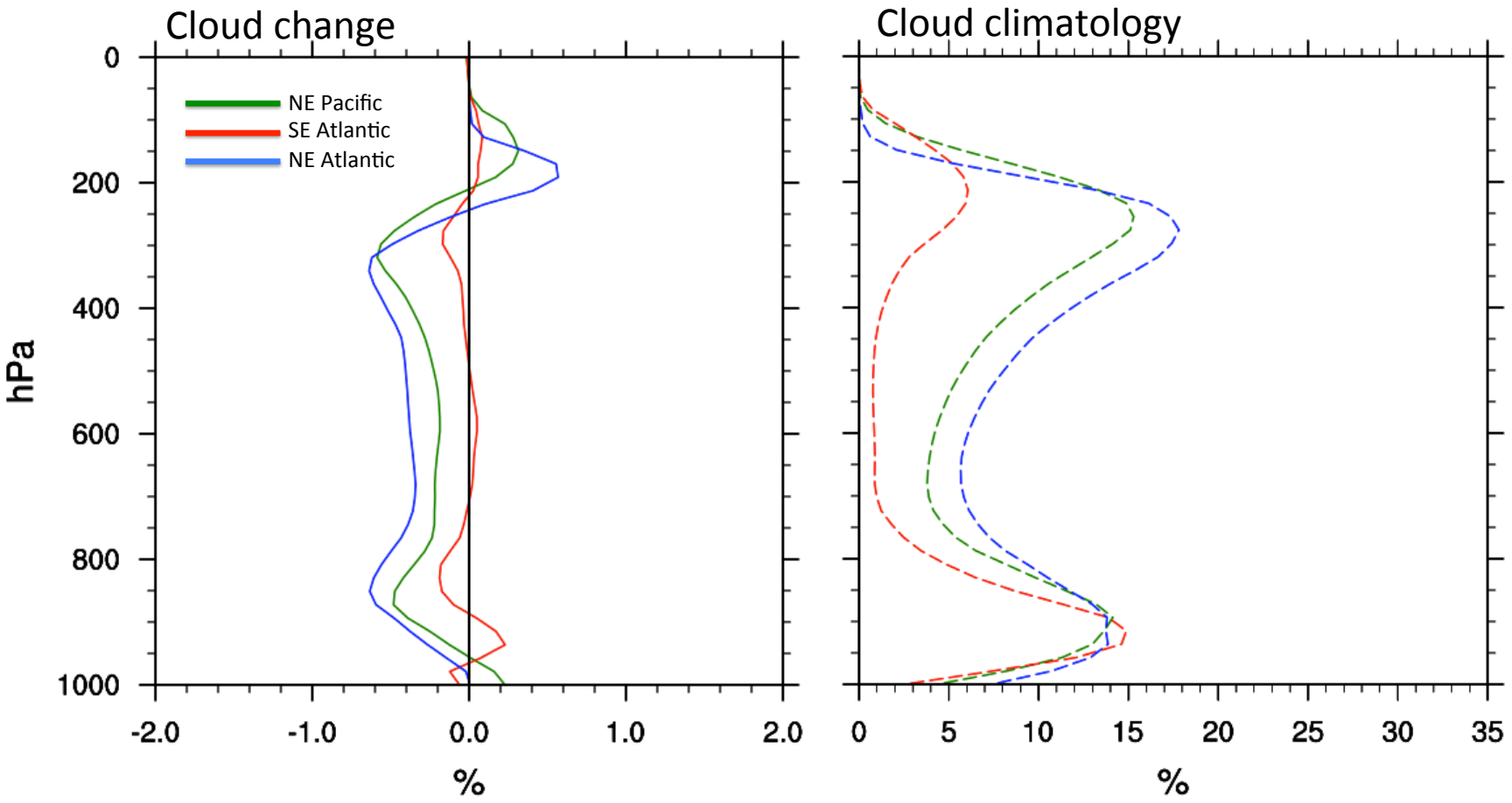


CMIP5 multi-model mean



Vertical profile of cloud change in CMIP5 models:

CMIP5 multi-model mean (10 models):



- Decrease in cloud cover is found **at all levels** from surface to 300-250 hPa in NE Pacific and NE Atlantic, then increase at lower pressure levels.
- Model bias in SE Atlantic? Models overestimate cloud climatology at upper levels?

Summary:

- Observational records indicate that there has been a long-term decrease in total cloud cover over three subtropical stratus regions (NE Pacific, NE Atlantic and SE Atlantic) and positive net cloud feedback.

- The CMIP5 multi-model mean agrees in sign with observational estimates of cloud feedback but is smaller in amplitude over NE Pacific and SE Atlantic (comparable over NE Atlantic).

- In CMIP5 models the decrease in cloud cover occurs at all pressure levels from surface up to 300-250 hPa, then there is an increase.