Observational and Model Estimates of Cloud Amount Feedback over the Indian and Pacific Oceans

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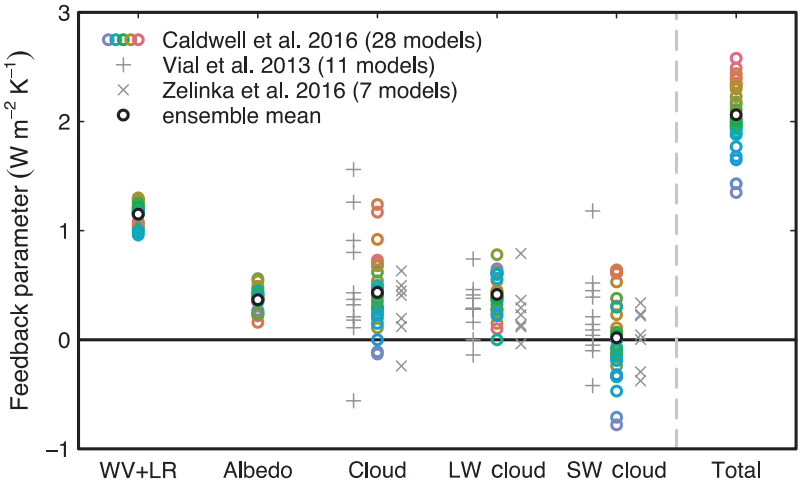
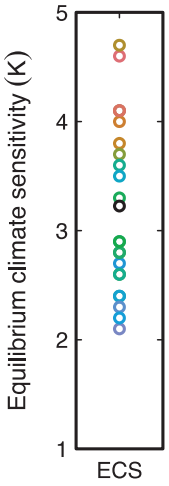
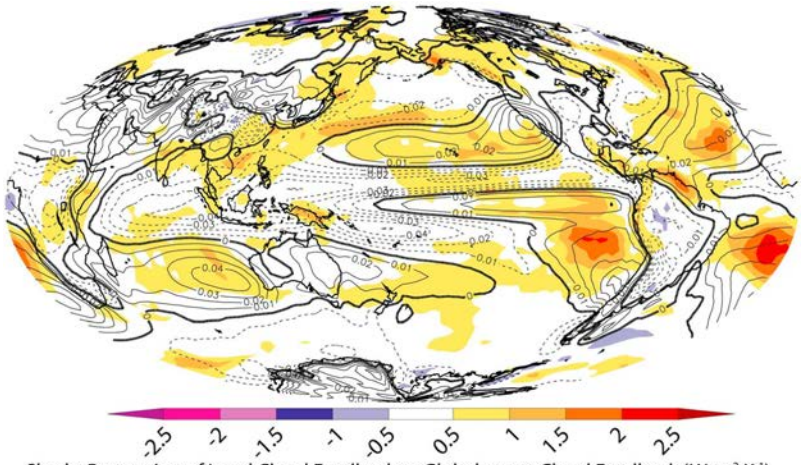
Background

- Cloud Feedback is the largest uncertainty in estimates of climate sensitivity





Ceppi et al. 2017



Soden and Vecchi 2011

- The uncertainty is largest for low-level clouds and for SW cloud feedback (cloud amount)

- Lack of **long-term** observational constraints on the sign and magnitude of cloud feedback

Cloud Observations

Ship observations

EECRA, derived from ICOADS*
1954-2008

*Hahn and Warren 2009, Eastman et al. 2011

Pros: Long-term (55 years), better at observing low/total cloud cover

Cons: Sparse, subjective, only cloud amount and cloud type

Satellites

ISCCP and PATMOS-X (AVHRR)*
1984-2009

*corrected, Norris and Evan 2015

Pros: Objective, known biases, information on vertical properties

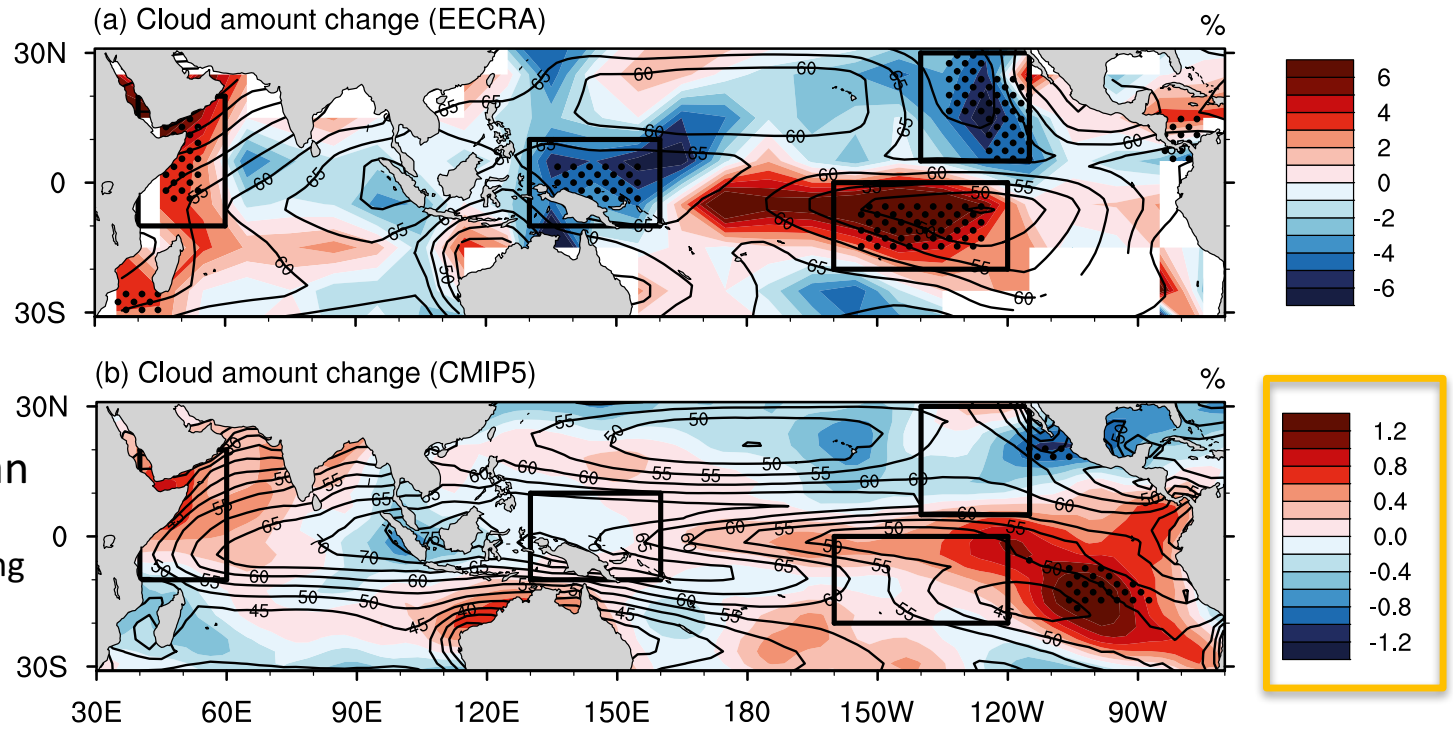
Cons: Short-term (30 years), problems at identifying low clouds

Total Cloud Amount change 1954-2005

Computed as linear trend multiplied by # of years (52 years)

EECRA (ship) observations

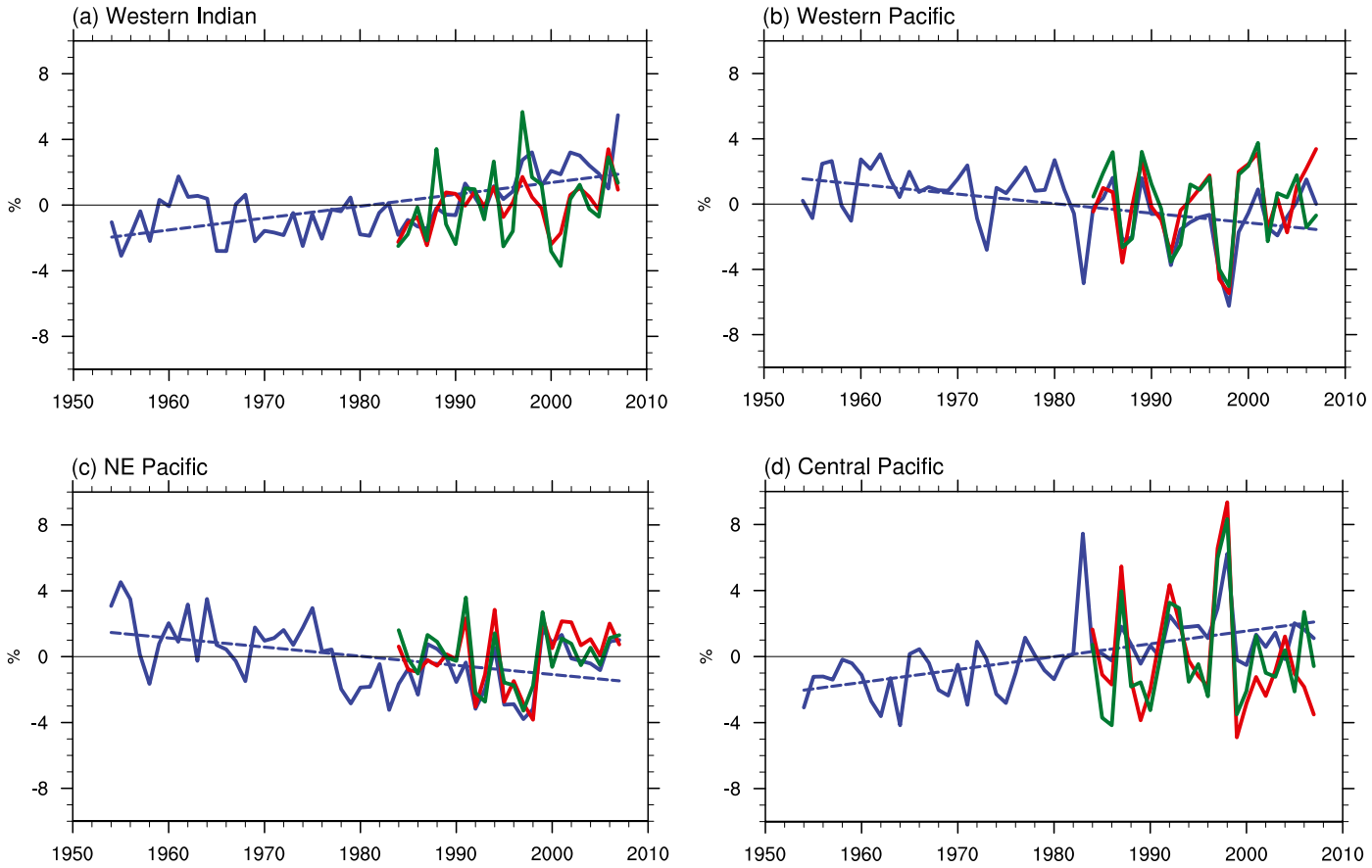
CMIP5 historical multi-model mean
(42 models run with prescribed time varying historical forcings)



- 4 regions where the obs trend is statistically significant
- Overall pattern similar to the multi-model (forced) mean

Comparing with Satellite Obs

Blue: EECRA (ships)
Red: ISCCP
Green: Patmos-X (AVHRR)



Correlation coefficient	EECRA-ISCCP	EECRA-PATMOSX	ISCCP-PATMOSX
Western Indian	0.24	0.20	**0.64**
Western Pacific	**0.81**	**0.78**	**0.79**
Northeast Pacific	**0.83**	**0.77**	**0.82**
Central Pacific	**0.75**	**0.78**	**0.86**

Estimate of
Cloud Amount Feedback

$$\mathrm{CAF} = \frac{k\Delta c}{\Delta T_s}.$$

Where:

c = Total Cloud Amount

T_s= Surface Temperature

k = Cloud Amount Radiative Kernel

$$k = \frac{\overline{\mathrm{CRE}}}{\overline{\overline{c}}},$$

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- Only the cloud amount part of the total cloud feedback
- Does not include the effect of changes in vertical and optical properties of the clouds

Cloud Amount Radiative Kernel

$$k = \frac{\overline{\mathrm{CRE}}}{\overline{\overline{c}}},$$

Cloud Radiative Effect = net SW+LW all-clear sky at TOA

Negative = cooling
Positive = warming

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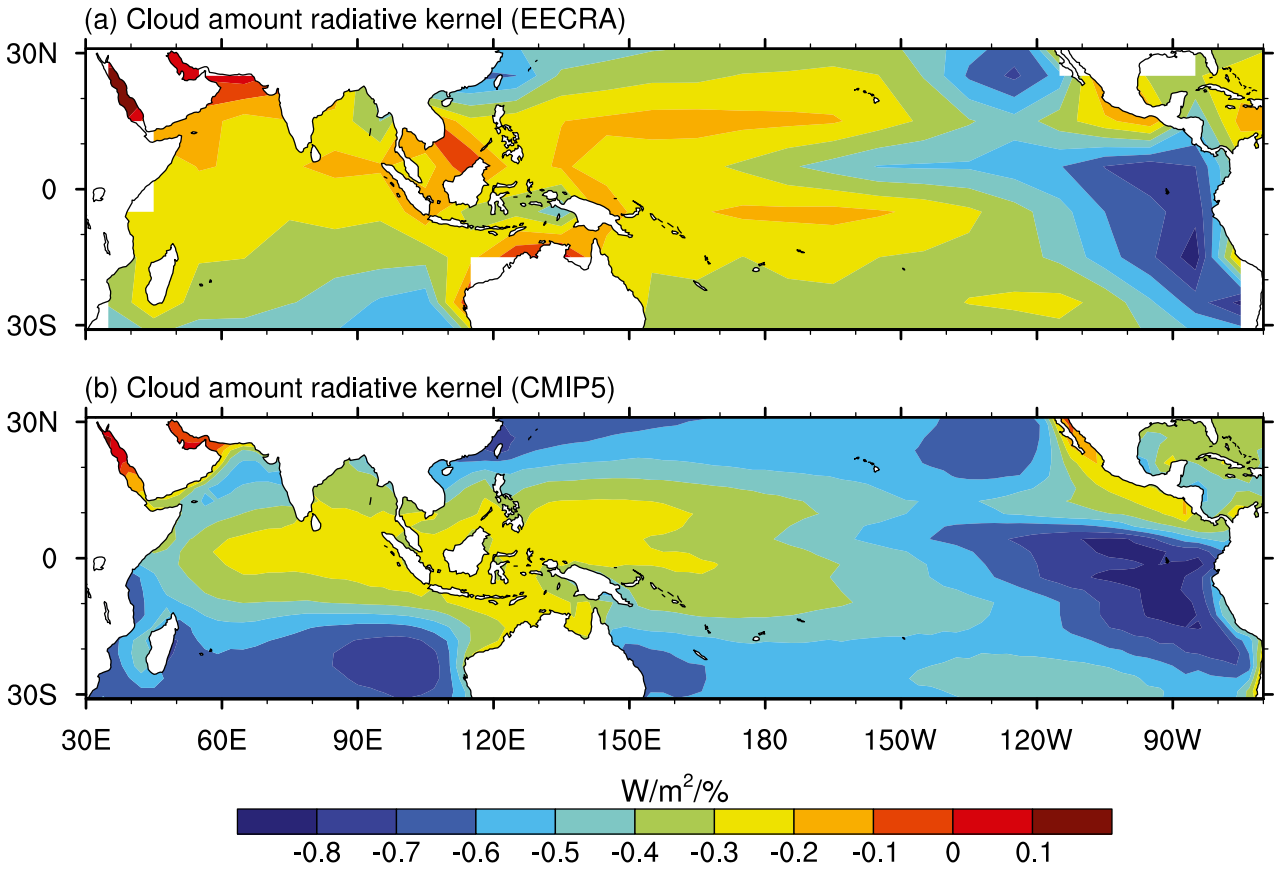

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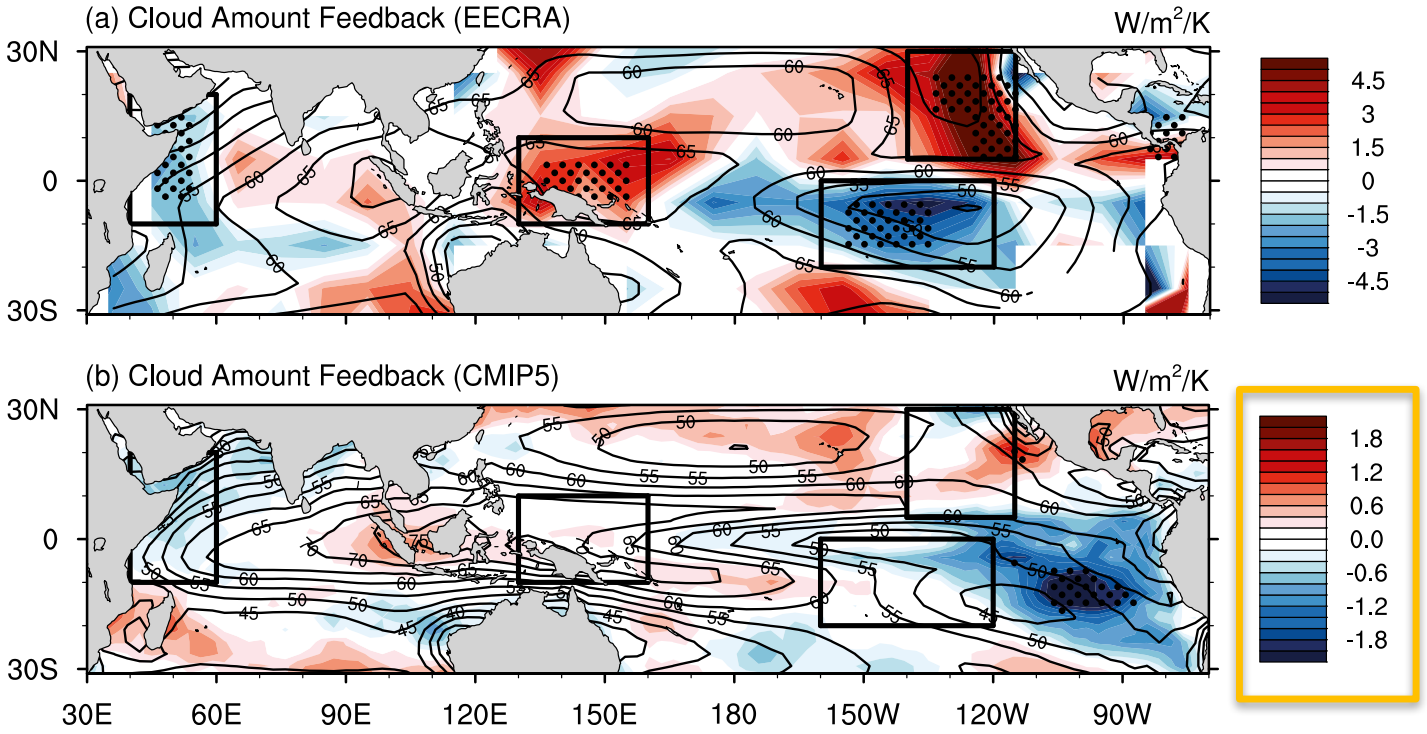


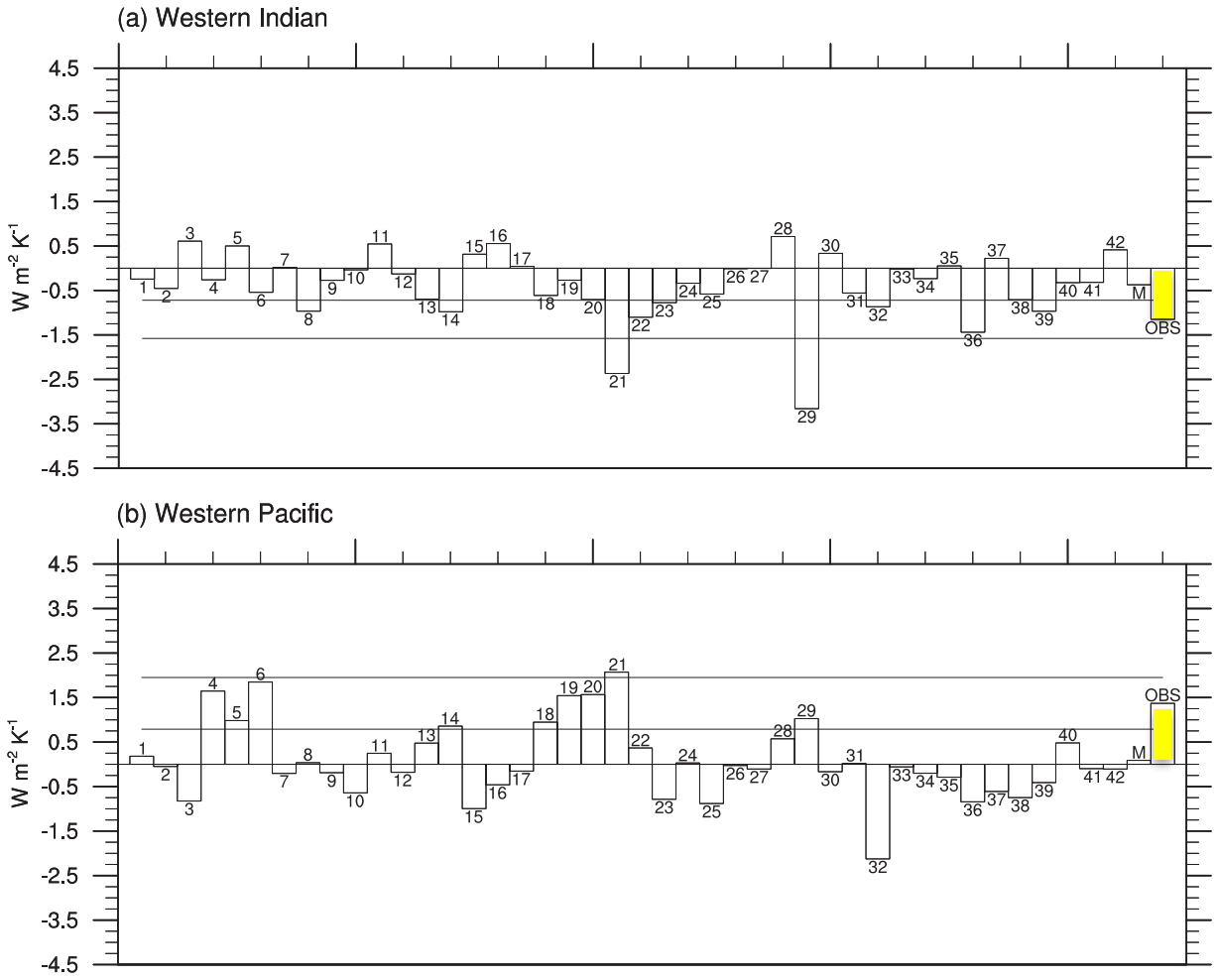
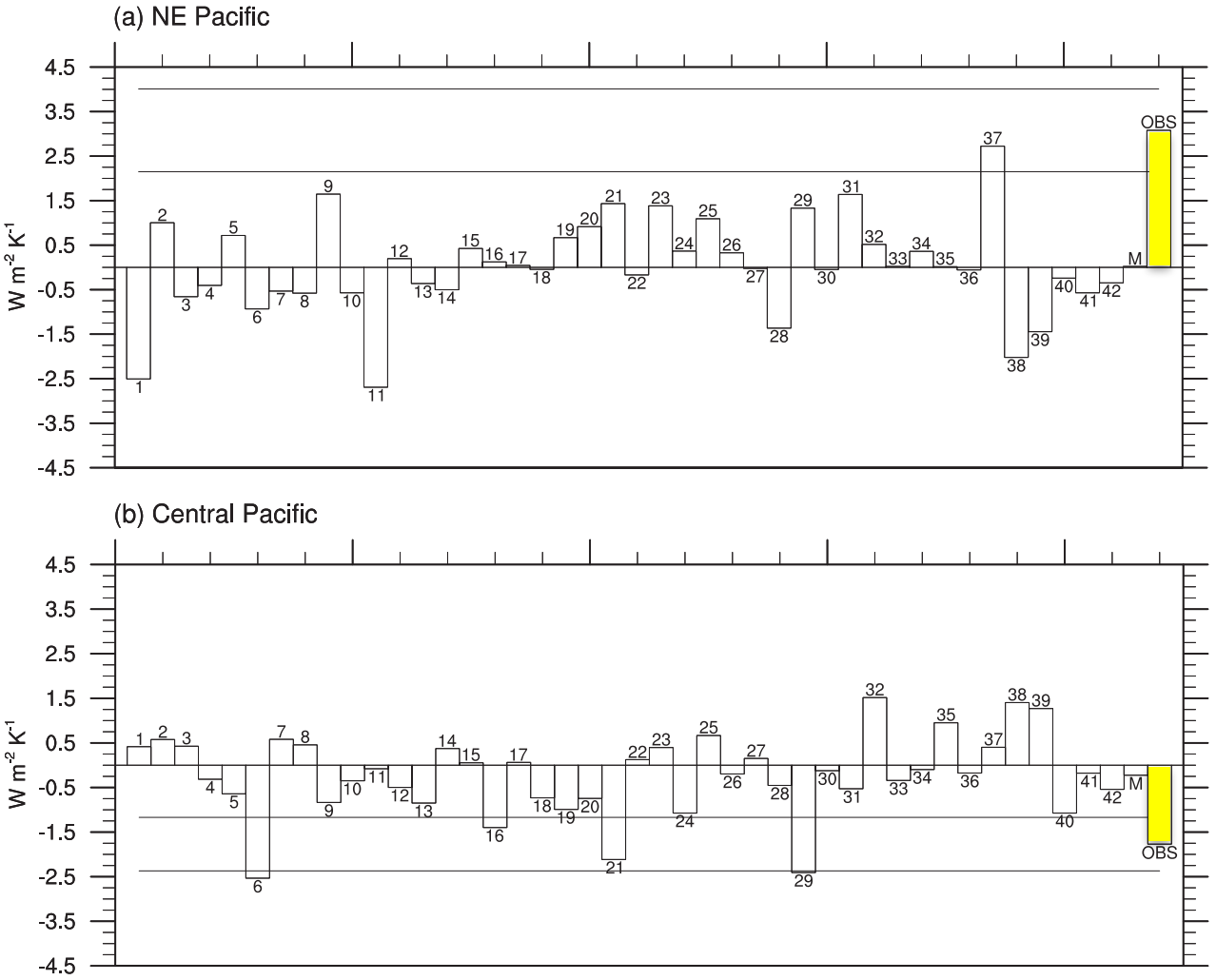


TABLE 4. Legend of model numbers for Figs. 5 and 6.

1. ACCESS1–0	15. GFDL-CM3	29. MIROC-ESM-CHEM
2. ACCESS1–3	16. GFDL-ESM2G	30. MIROC-ESM
3. BNU-ESM	17. GFDL-ESM2M	31. MIROC4h
4. CCSM4	18. GISS-E2-H-CC	32. MIROC5
5. CESM1-BGC	19. GISS-E2-H	33. MPI-ESM-LR
6. CESM1-CAM5	20. GISS-E2-R-CC	34. MPI-ESM-MR
7. CESM1-FASTCHEM	21. GISS-E2-R	35. MPI-ESM-P
8. CESM1-WACCM	22. HadCM3	36. MRI-CGCM3
9. CNRM-CM5–2	23. HadGEM2-AO	37. MRI-ESM1
10. CNRM-CM5	24. HadGEM2-CC	38. NorESM1-ME
11. CSIRO-Mk3–6-0	25. HadGEM2-ES	39. NorESM1-M
12. CanESM2	26. IPSL-CM5A-LR	40. BCC-CSM1-1-M
13. FGOALS-g2	27. IPSL-CM5A-MR	41. BCC-CSM1-1
14. FIO-ESM	28. IPSL-CM5B-LR	42. INM-CM4



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Summary

- The biggest uncertainty in estimates of climate sensitivity is due to the sign and magnitude of cloud feedback, especially in regions of low-level clouds
- Constraining the sign and magnitude of cloud feedback is difficult because observations are limited and affected by biases
- Here we examined ship-based observations, which are longer, covering about 55 years
- Observed trends in cloud cover are significant over 4 regions: NE Pacific, Central Pacific, Western Pacific, Western Indian
- We estimated cloud amount feedback from observations and compared with historical simulations. Some models get the sign and magnitude right, but there is not any one model that gets it right over all 4 regions

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Bellomo, K., A. C. Clement, J. R. Norris, and B. J. Soden, 2014: Observational and Model Estimates of Cloud Amount Feedback over the Indian and Pacific Oceans. *J. Climate*, 27, 925–940.