Met Office
Hadley Centre

Integration of metrics for cloud feedback

Yoko Tsushima

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“metric” (plural metrics) What is metric?

(from "Wiktionary")

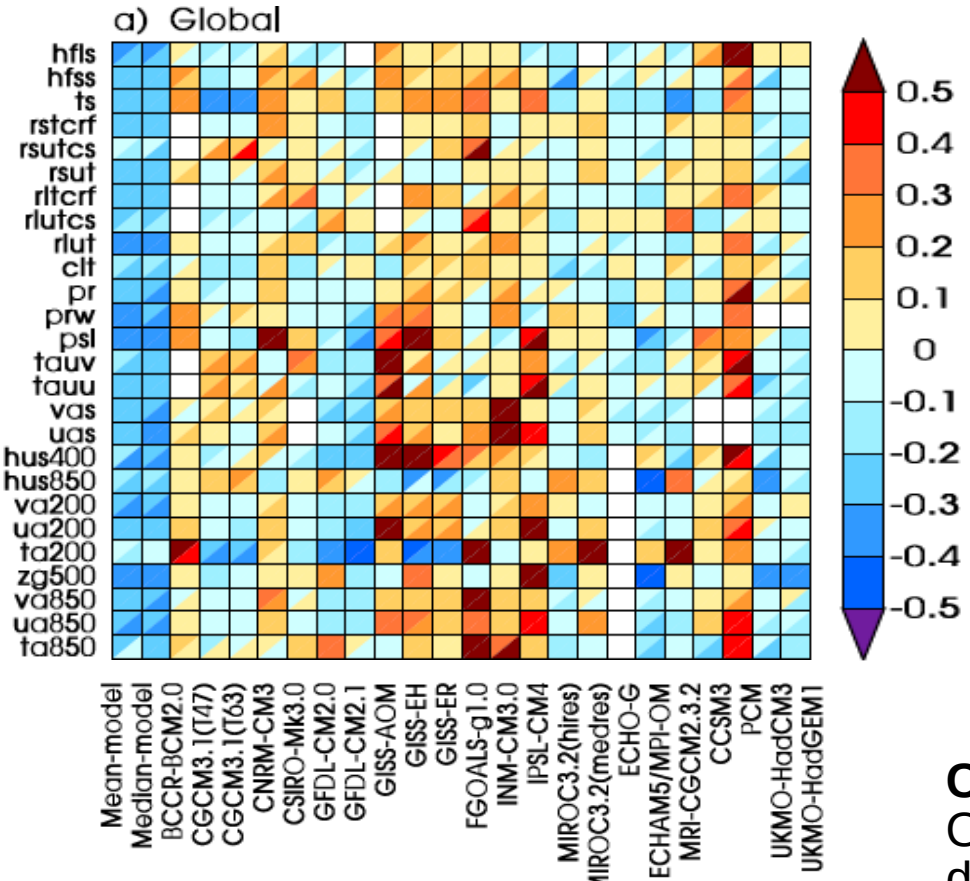
- A measure for something; a means of deriving a quantitative measurement or approximation for otherwise qualitative phenomena (especially used in Software Engineering)
- (mathematics) A measurement of the "distance" between two points in some metric space...

Metrics for standard CMIP3 output

(Gleckler et al., 2008)

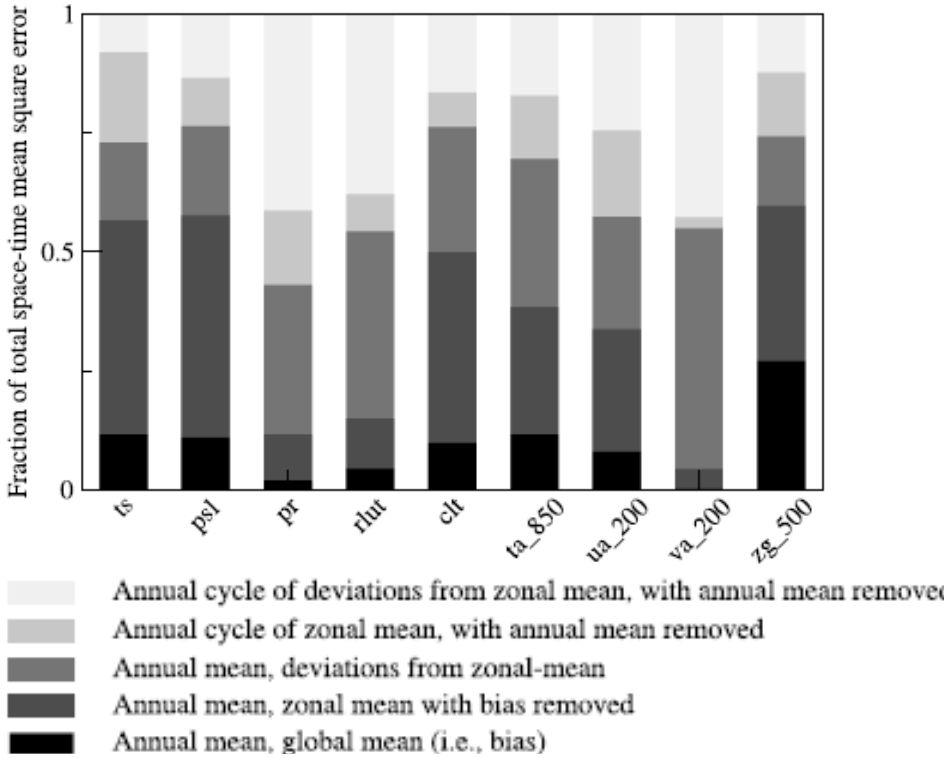
A)RMS error, relative error of models

The bluer is better.



B) Decomposition of relative error

Ex. Annual cycle vs. annual mean



C) Model ranking changes in different aspect. Order of ranking of model in mean climate does not hold in the other case (annual cycle, interannual variation).

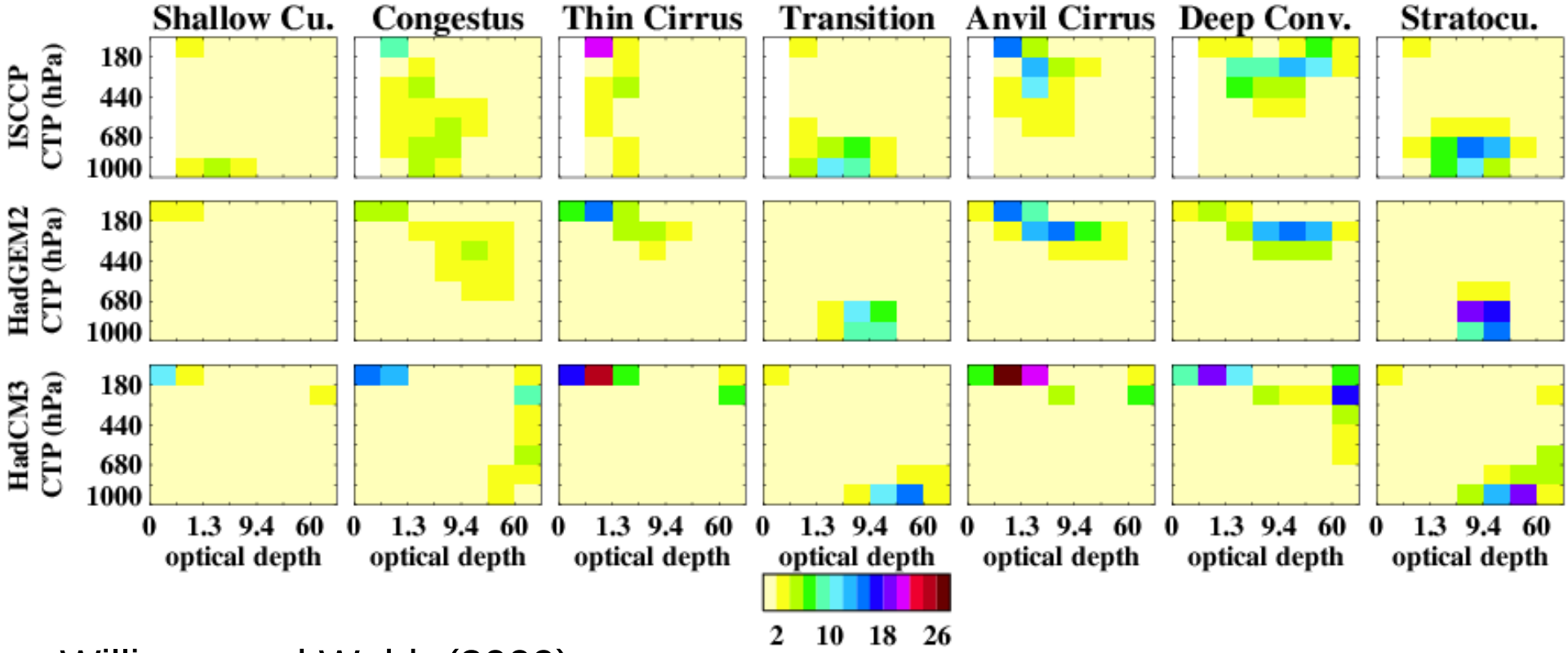
Metrics for cloud & cloud feedback Why we need them?

- Oobservational data did not exist for CMIP3 data!
- We need a clue for finding out of source of the problem in cloud/cloud feedback.
- We need metrics which are more physically based than just evaluation of bulk quantity for cloud radiative field.
- We expect such metrics also help our understanding of cloud feedback in climate change simulations.

Metrics for clouds
cloud regime error metric (CREM)

Williams and Webb (2009)

Cloud regimes from clustered daily ISCCP data/ISCCP simulator(COSP)



Williams and Webb (2009) **after Jacob and Tselioudis (2003), Rossow et al (2005)**

Patterns of groups of clouds when they appear. -> Physically based regimes

Evaluation of regime properties

Regime histogram

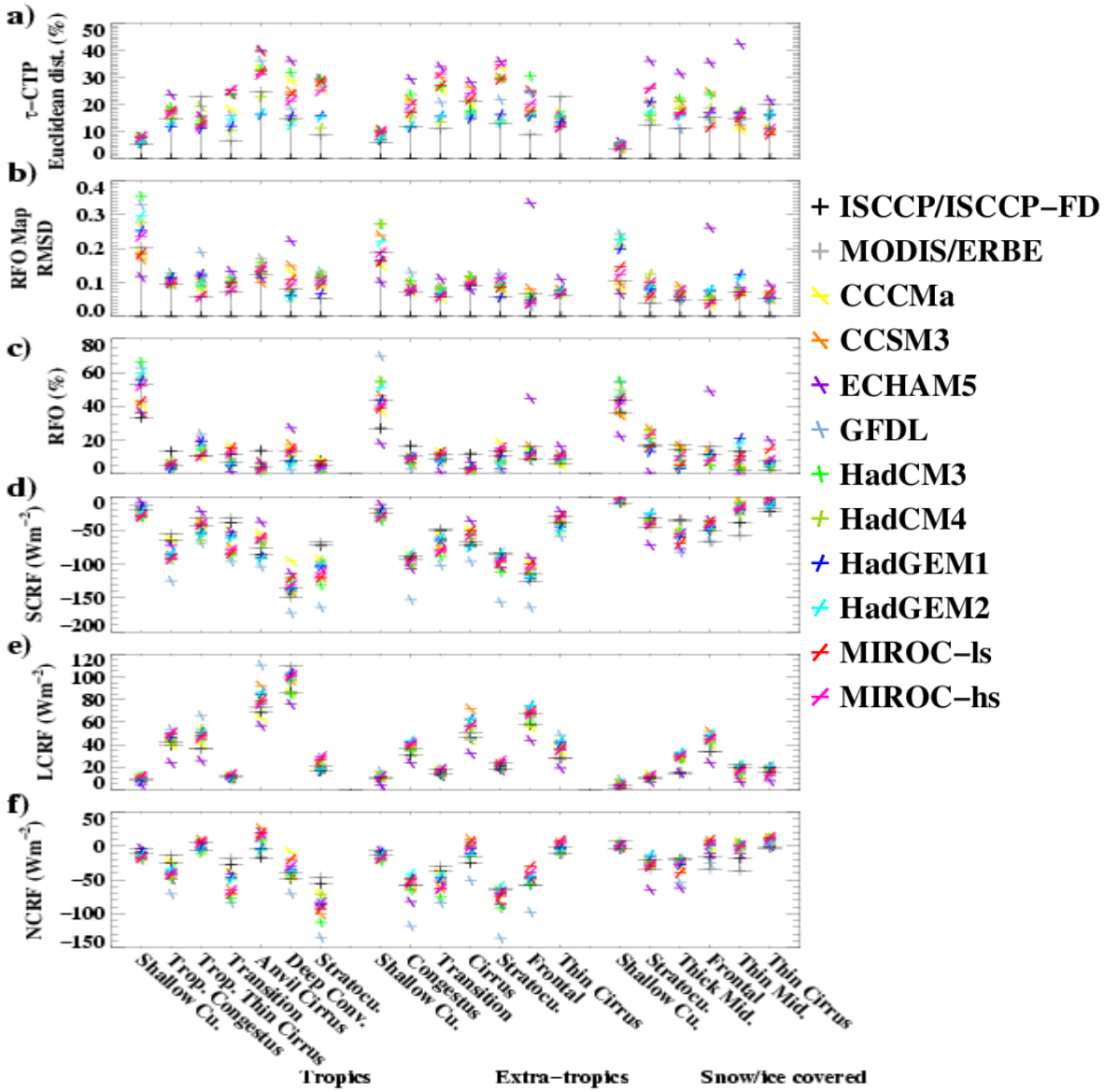
Geographical location

Relative frequency of occurrence (RFO)

Shortwave cloud radiative forcing (SCRF)

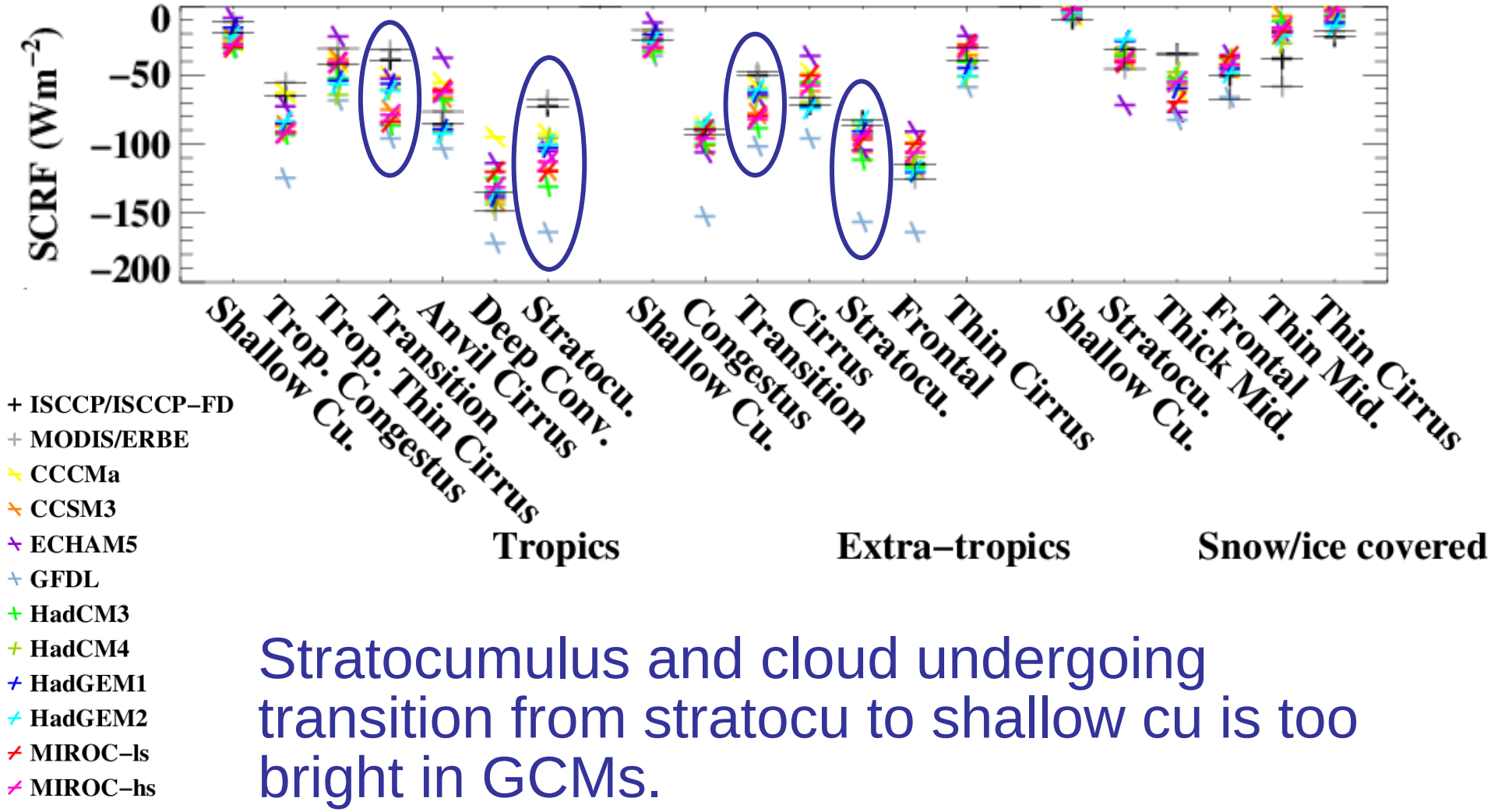
Longwave cloud radiative forcing (LCRF)

Net cloud radiative forcing (NCRF)



Williams and Webb (2009, Clim Dyn)

Evaluation of regime properties
(shortwave cloud radiative forcing)



Stratocumulus and cloud undergoing transition from stratocu to shallow cu is too bright in GCMs.

A present day Cloud Regime Metric
Williams and Webb (2009)

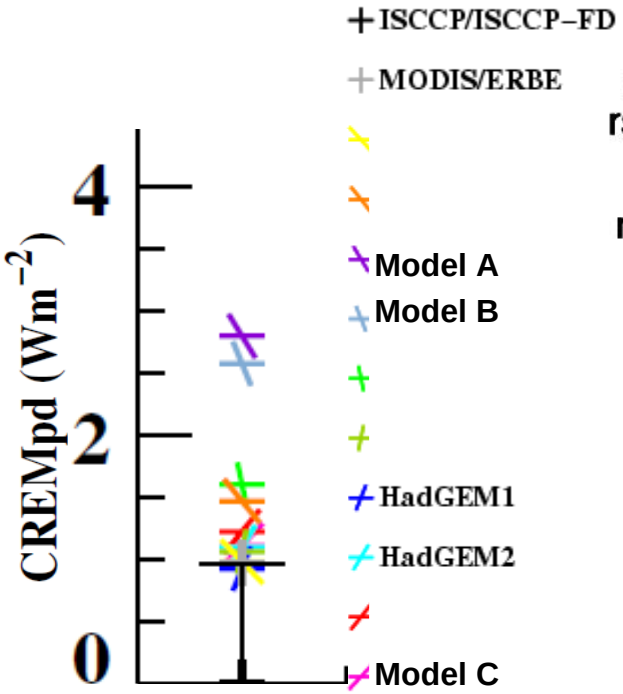
$$\mathrm{CREMpd}_r = \mathrm{aw}\sqrt{\left(\mathrm{NCRF}'_r \mathrm{RFO}_{\mathrm{obs}r}\right)^2 + \left(\mathrm{RFO}'_r \mathrm{NCRF}_{\mathrm{obs}r}\right)^2}$$

$$\mathrm{CREMpd} = \sqrt{\frac{\sum_{r=1}^{\mathrm{nregimes}} \mathrm{CREMpd}_r^2}{\mathrm{nregimes}}}$$

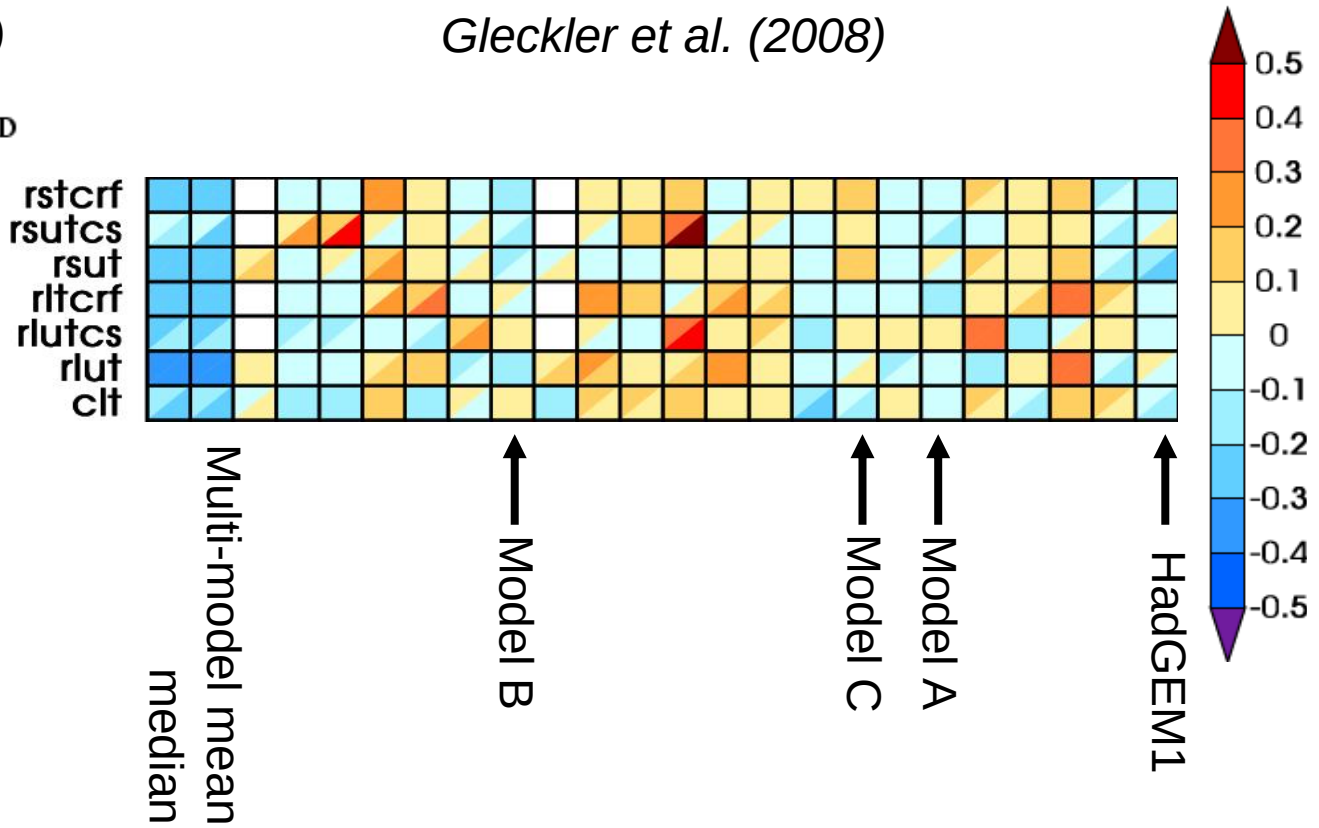
NCRF' is the NCRF bias within the cluster
RFO' is the RFO bias for the cluster
aw is an area weighting term

Comparing cloud regime error metric with traditional cloud metrics

Williams and Webb (2009)



Gleckler et al. (2008)



Satellite simulators can help model developers to identify compensating errors in cloud simulations not apparent from evaluation of radiative fluxes alone.

Metrics for cloud feedback example

Metrics for radiative feedback in the annual variation

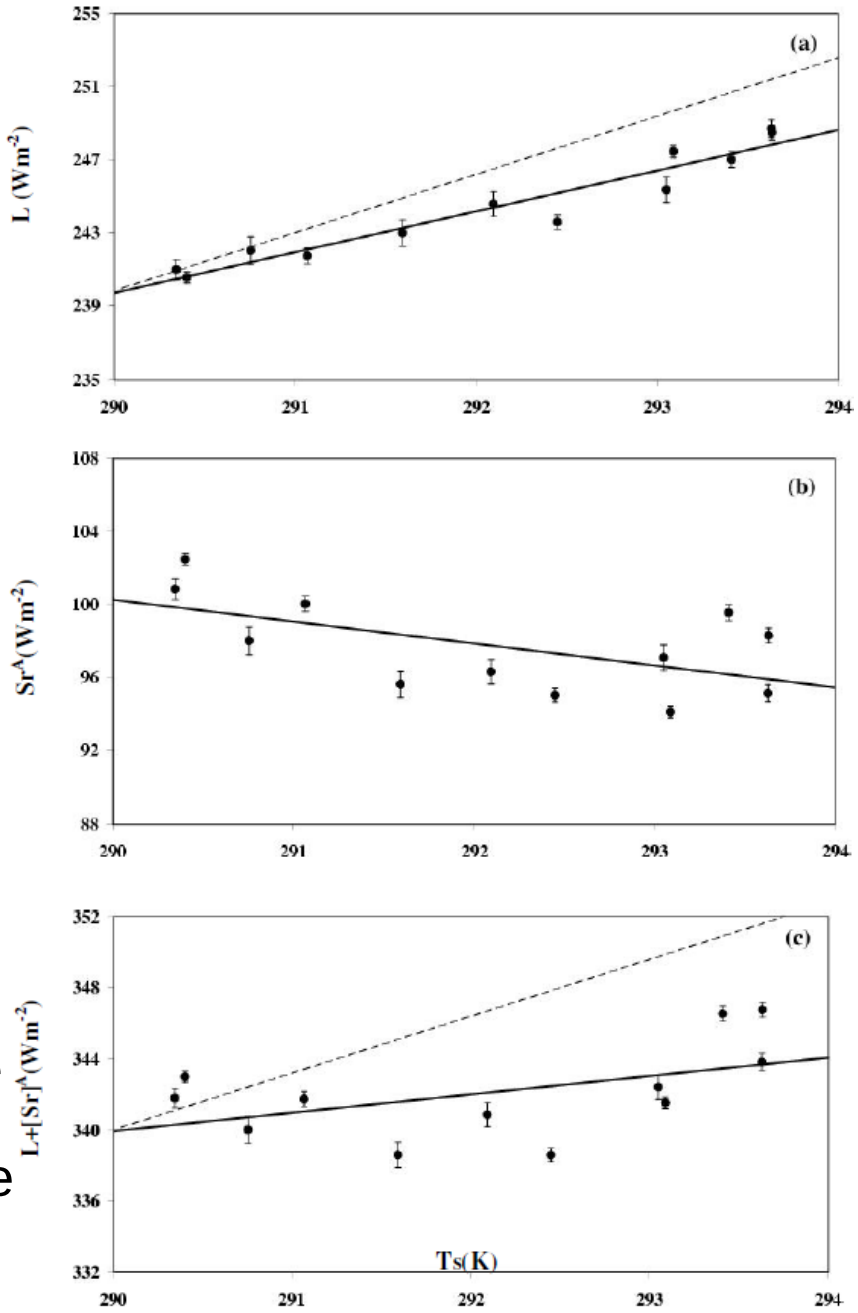
Tsushima and Manabe, 2010

- Seasonal cycle: Largest climate change with satellite observation
- Simple indicator of radiative feedback

$$\lambda = \frac{dR}{dT_s},$$

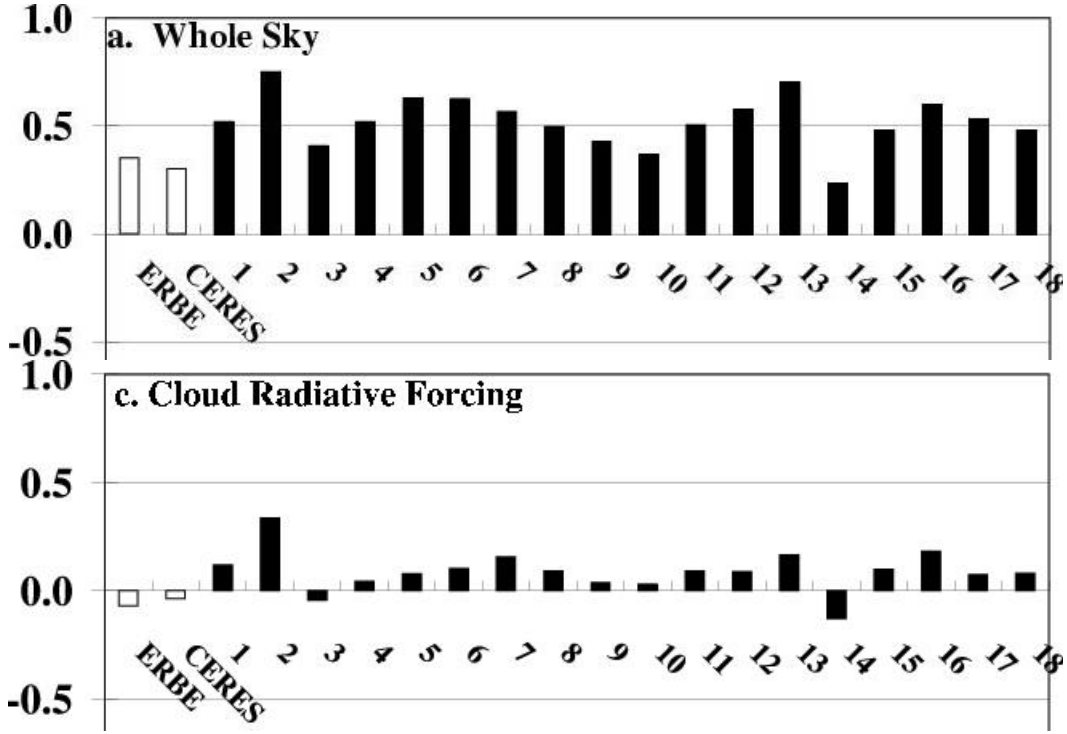
$$R = L + S_r$$

dR: perturbation of radiative flux by the earth-atmosphere
dT: perturbation of surface temperature
Both are global mean.



Errors in cloud feedbacks

Longwave gain factor (Tsushima and Manabe, 2010)



$$\lambda = \lambda_0 (1\text{-}f)$$

Longwave Gain Factor	ERBE	CERES	CMIP3
cloud radiative forcing	-0.07	-0.04	0.09 (0.10)
clear sky	0.42	0.34	0.44 (0.06)
whole sky	0.35	0.30	0.52 (0.12)

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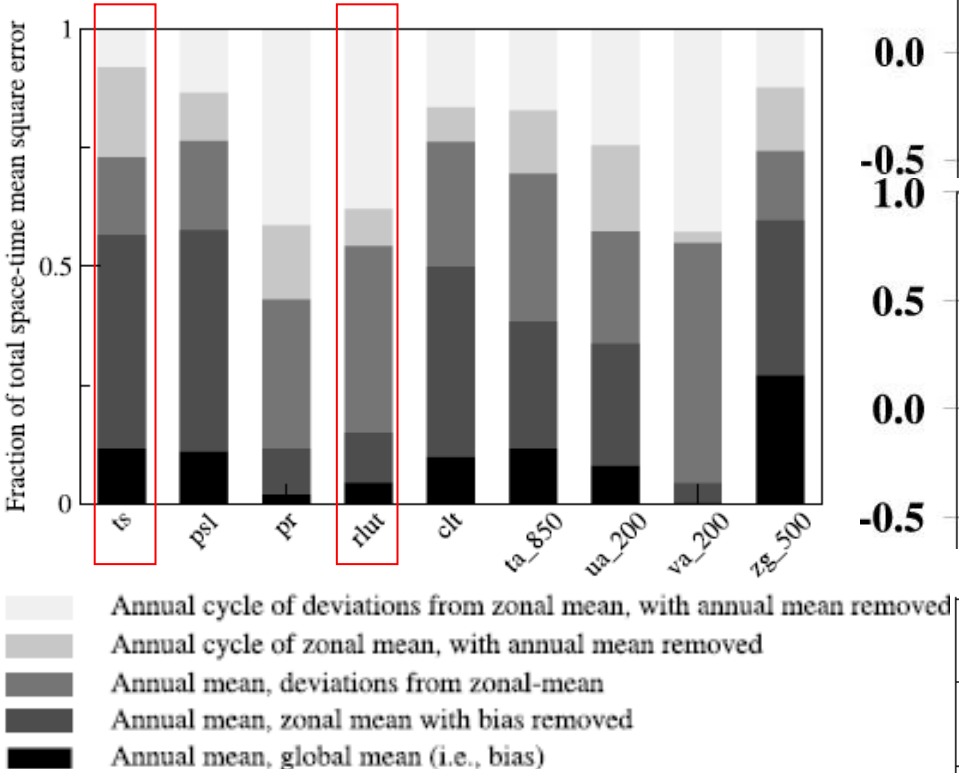

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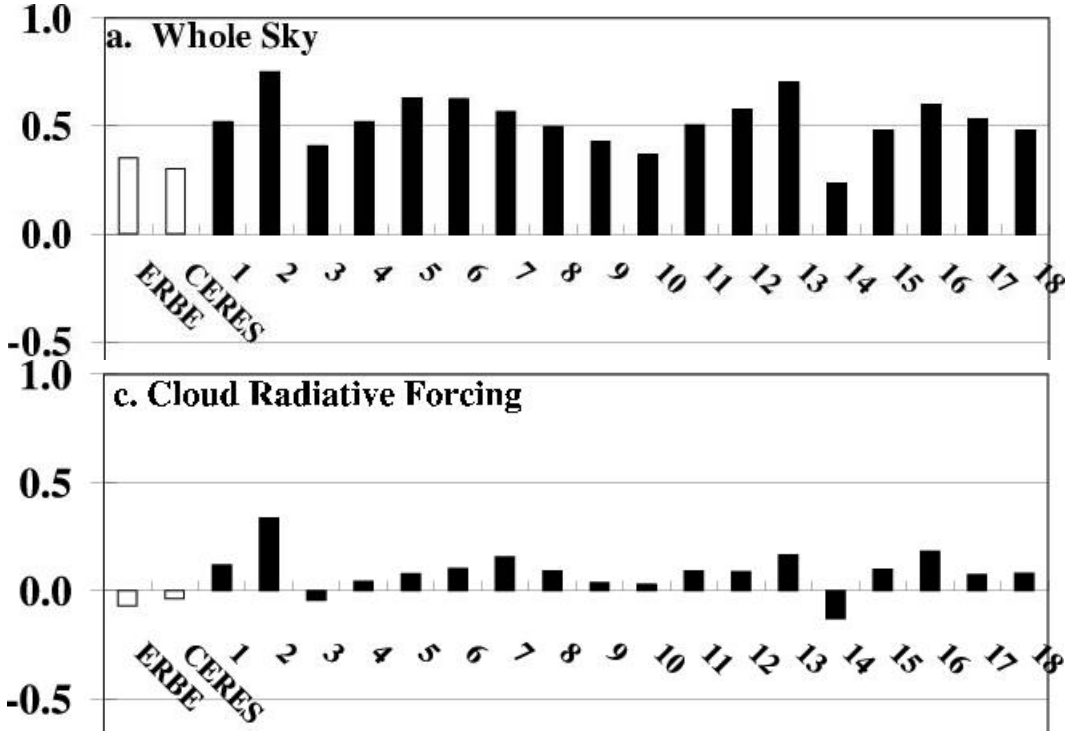

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Cloud metrics: toward better understanding of climate and climate change

- Identification of the key processes in climate and climate change
- Links to precipitation, hydrological cycle (ex. George's talk)
- What cloud metrics tell us in a context of "robust change"?
  - ex. Mass flux decrease (*Held and Soden, 2006*)
  - ex. Positive longwave feedback (*Zelinka and Hartmann, 2010*)
- Combination of metrics
  - ex. CREM and gain factor

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