Analysis of CAM clouds with COSP (a lot has happened in the last year!)

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CFMIP
Cloud Feedback Model Intercomparison Project

NCAR
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NSF

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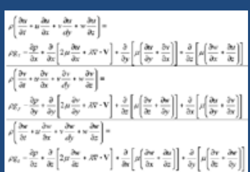
Why are satellite simulators (COSP) useful?

When satellite simulators accurately mimic the observational retrieval process, they enable “apple-to-apple” comparisons between models and observations.

Climate Model



Satellite simulator

Trusted comparison

Satellite retrieval

Observed radiances

Is it easy to evaluate CAM clouds with COSP?

Yes!

../models/atm/cam/src/physics/cosp
../models/atm/cam/src/physics/cam/cospsimulator_intr.F90

COSP v1.3 (with local modifications) validated for use with CAM4 and CAM5. Code on CAM trunk and in CESM1 releases. For details, see http://www.cgd.ucar.edu/staff/jenkay/cosp/cosp.htm.

Using COSP requires only three simple steps:

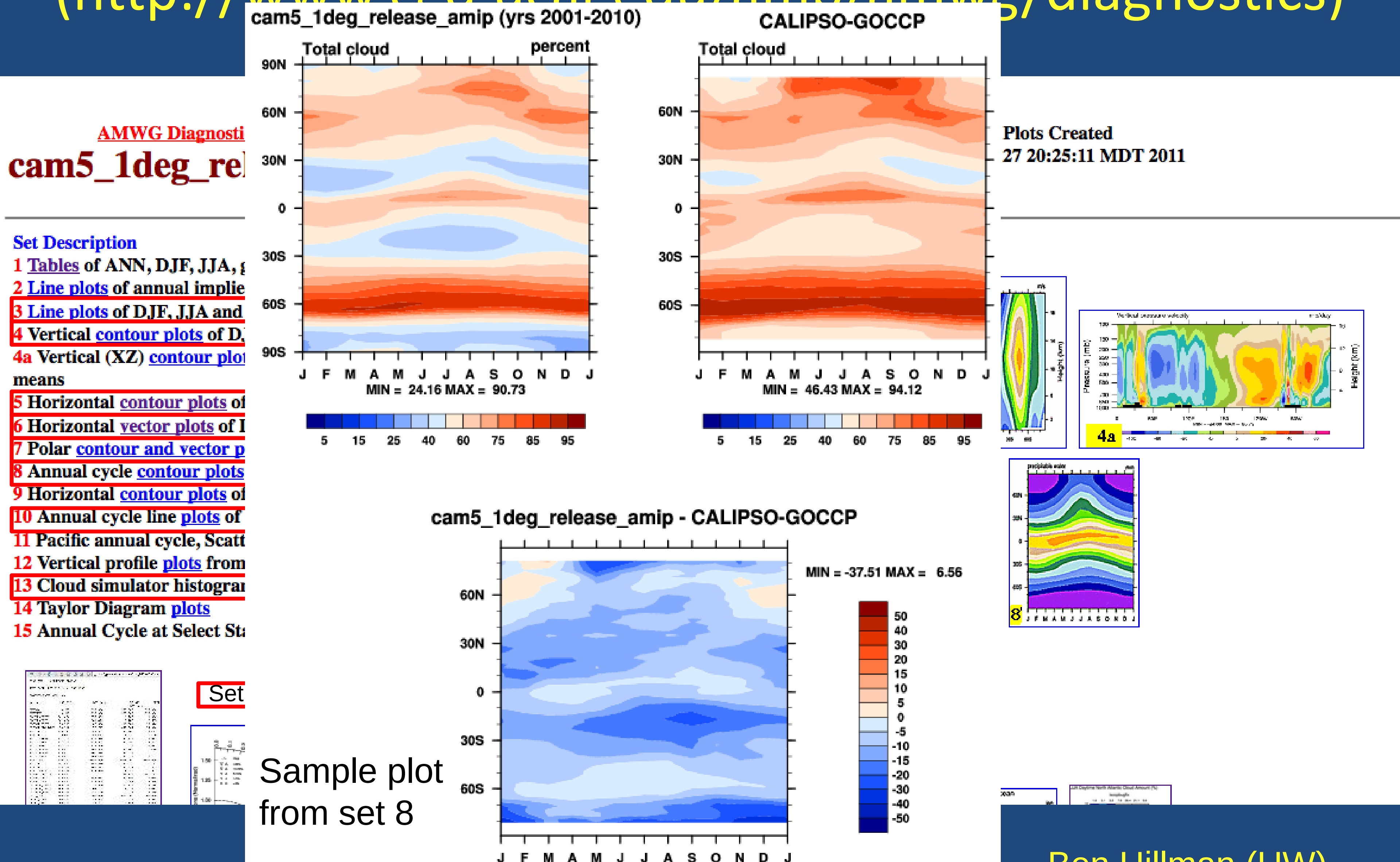
1) Configure with cosp. (configure –cosp ….)

2) Set cosp_amwg=.true. in the CAM namelist.

3) Run CAM at least one year, and then use the AMWG diagnostics package to look at COSP outputs.

(Note: Setting cosp_amwg=.true. approximately doubles the CAM run time.)

COSP in the AMWG Diagnostics Package
(http://www.cgd.ucar.edu/amp/amwg/diagnostics)



Sample plot from set 8

Ben Hillman (UW)

Cloud Feedbacks Model Intercomparison Project
NCAR run progress (years complete/years planned)

Simulation	CAM4	CAM4(ext)	CAM5	CAM5(ext)
AMIP	30/30	4/4	20/30	0/4
AMIP(4XCO2)	30/30	4/4	21/30	0/4
AMIP(+4K)	30/30	4/4	18/30	0/4
AMIP(patt)	30/30	4/4	20/30	0/4
Control SST	30/30	-	0/30	-
Control SST (4XCO2)	30/30	-	0/30	-
Control (coupled)	120/120	-	0/30	-
CO2ramp (coupled)	105/105	-	0/30	-

Courtesy: Ben Sanderson (NCAR)

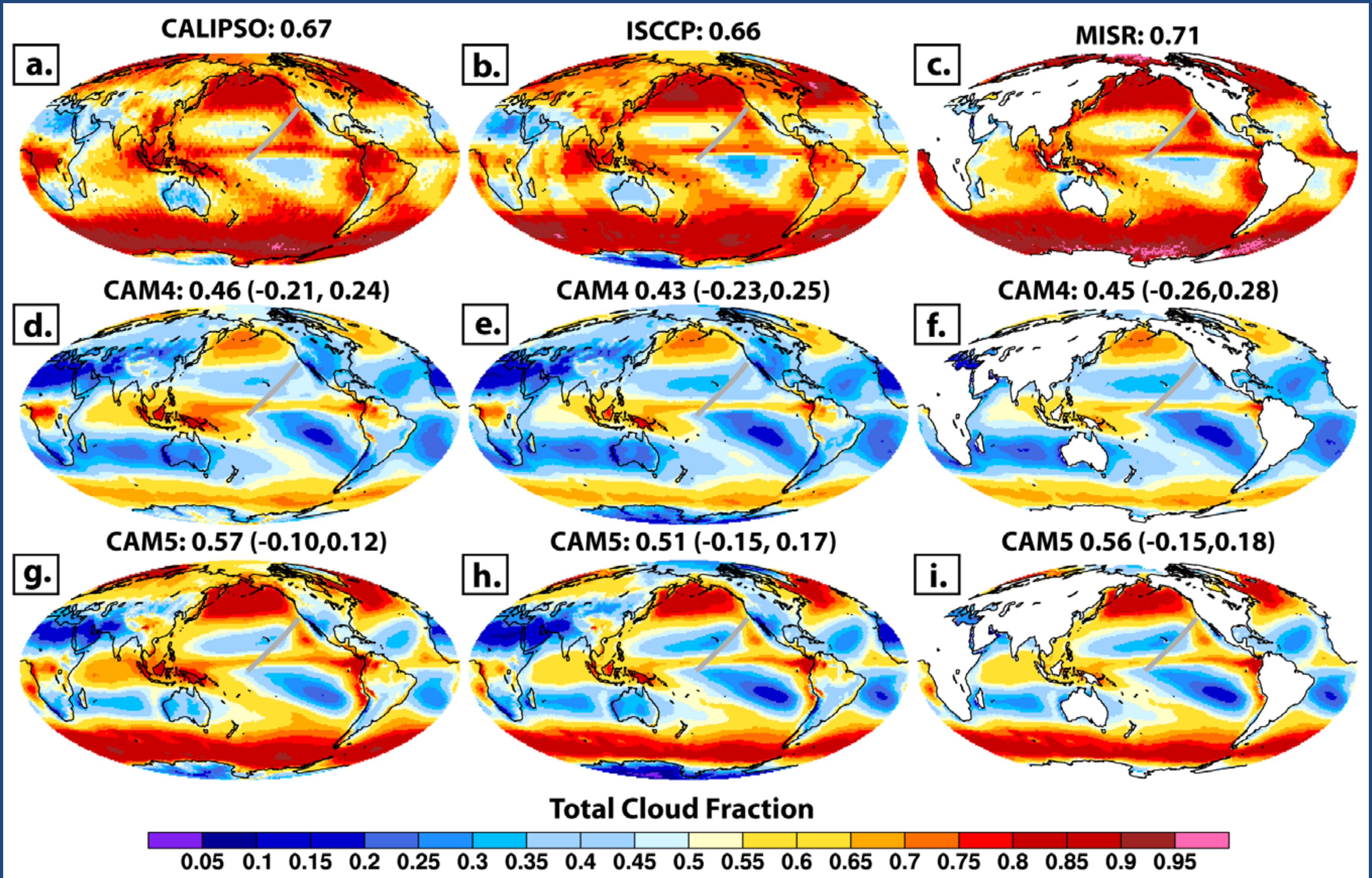
Paper on COSP-enabled evaluation of CAM clouds for CESM Special Issue

ABSTRACT

Satellite observations and their corresponding instrument simulators are used to document global cloud biases in the Community Atmosphere Model (CAM) versions 4 and 5. The model-observation comparisons show that despite having nearly identical cloud radiative forcing, CAM5 has a much more realistic representation of cloud properties than CAM4. In particular, CAM5 exhibits substantial improvement in three long-standing climate model cloud biases: 1) the underestimation of total cloud, 2) the overestimation of optically thick cloud, and 3) the underestimation of mid-level cloud. While the increased total cloud and decreased optically thick cloud in CAM5 result from improved physical process representation, the increased mid-level cloud in CAM5 results from the addition of radiatively active snow. Despite these improvements, both CAM versions have cloud deficiencies. Of particular concern, both models exhibit large but differing biases in the subtropical marine boundary layer cloud regimes that are known to explain inter-model differences in cloud feedbacks and climate sensitivity. More generally, this study demonstrates that simulator-facilitated evaluation of cloud properties, such as amount by vertical level and optical depth, can robustly expose large and at times radiatively compensating climate model cloud biases.

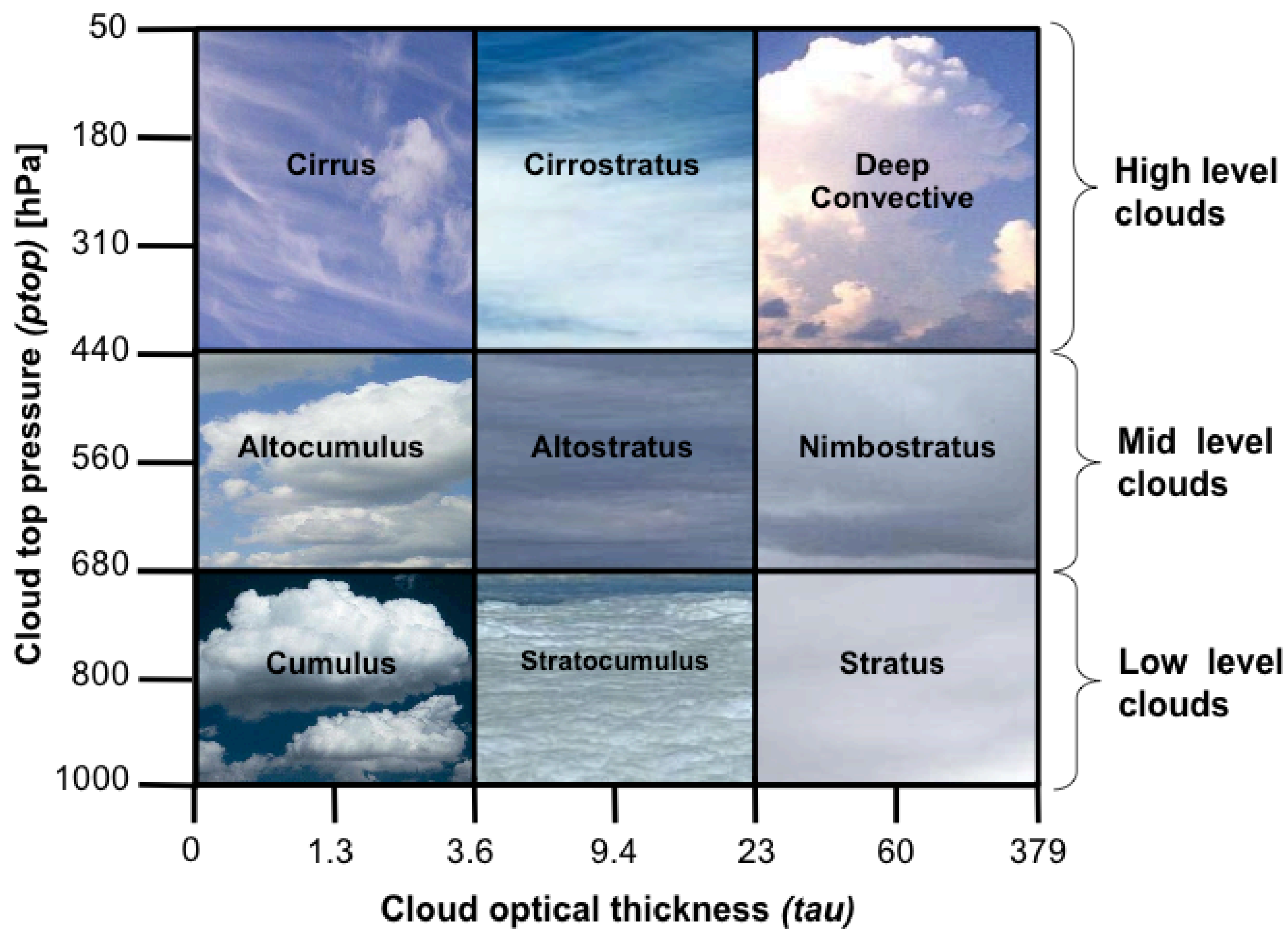
Kay, J. E., Hillman, B., Klein, S., Zhang, Y., Medeiros, B., Gettelman, G., Pincus, R., Eaton, B., Boyle, J., Marchand, R. and T. Ackerman (2012): **Exposing global cloud biases in the Community Atmosphere Model (CAM) using satellite observations and their corresponding instrument simulators**, J. Climate, in press
(available at: http://www.cgd.ucar.edu/staff/jenkay/)

COSP-enabled total cloud fraction comparisons



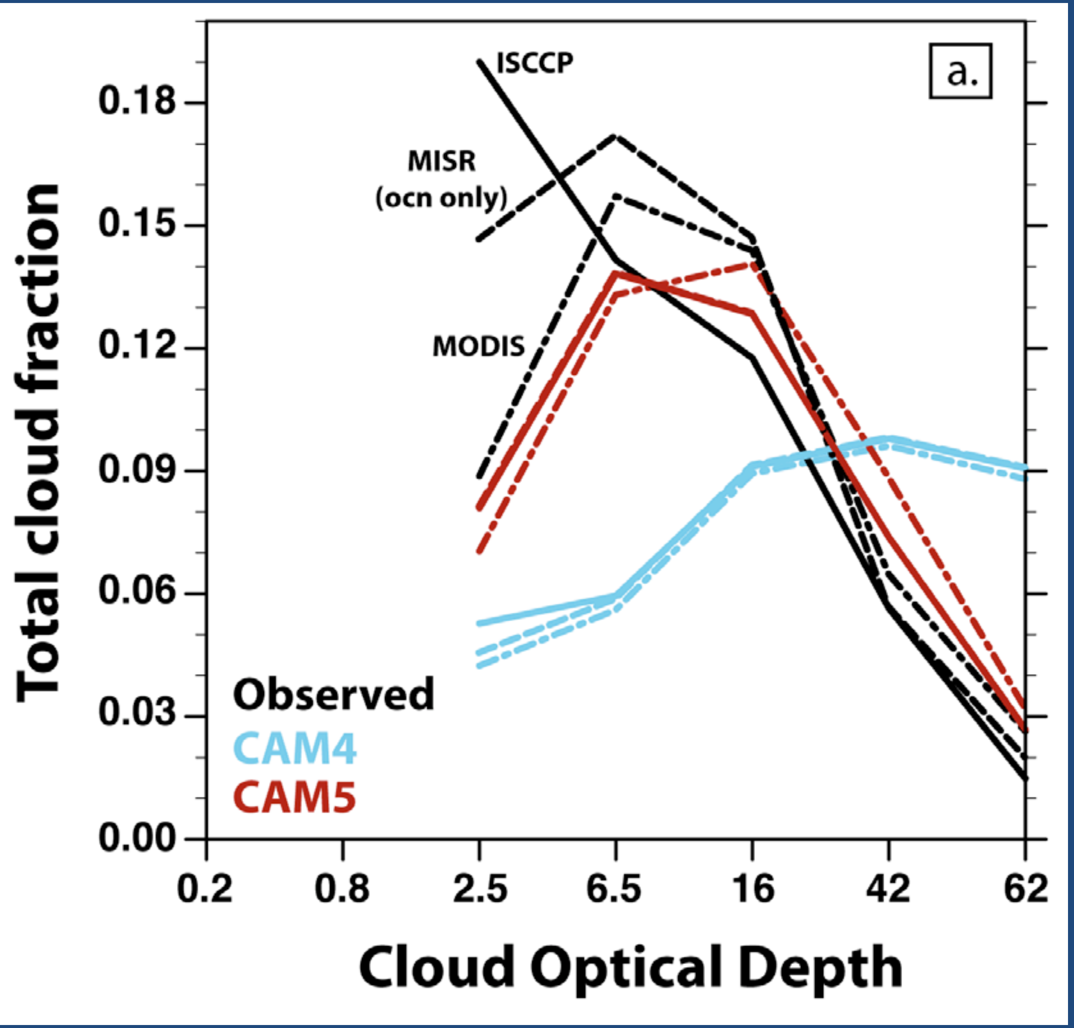
Observational Uncertainty < Model Bias: CAM4 bias > CAM5 bias, Kay et al. (2012)

COSP enables evaluation of cloud amount by height and optical depth



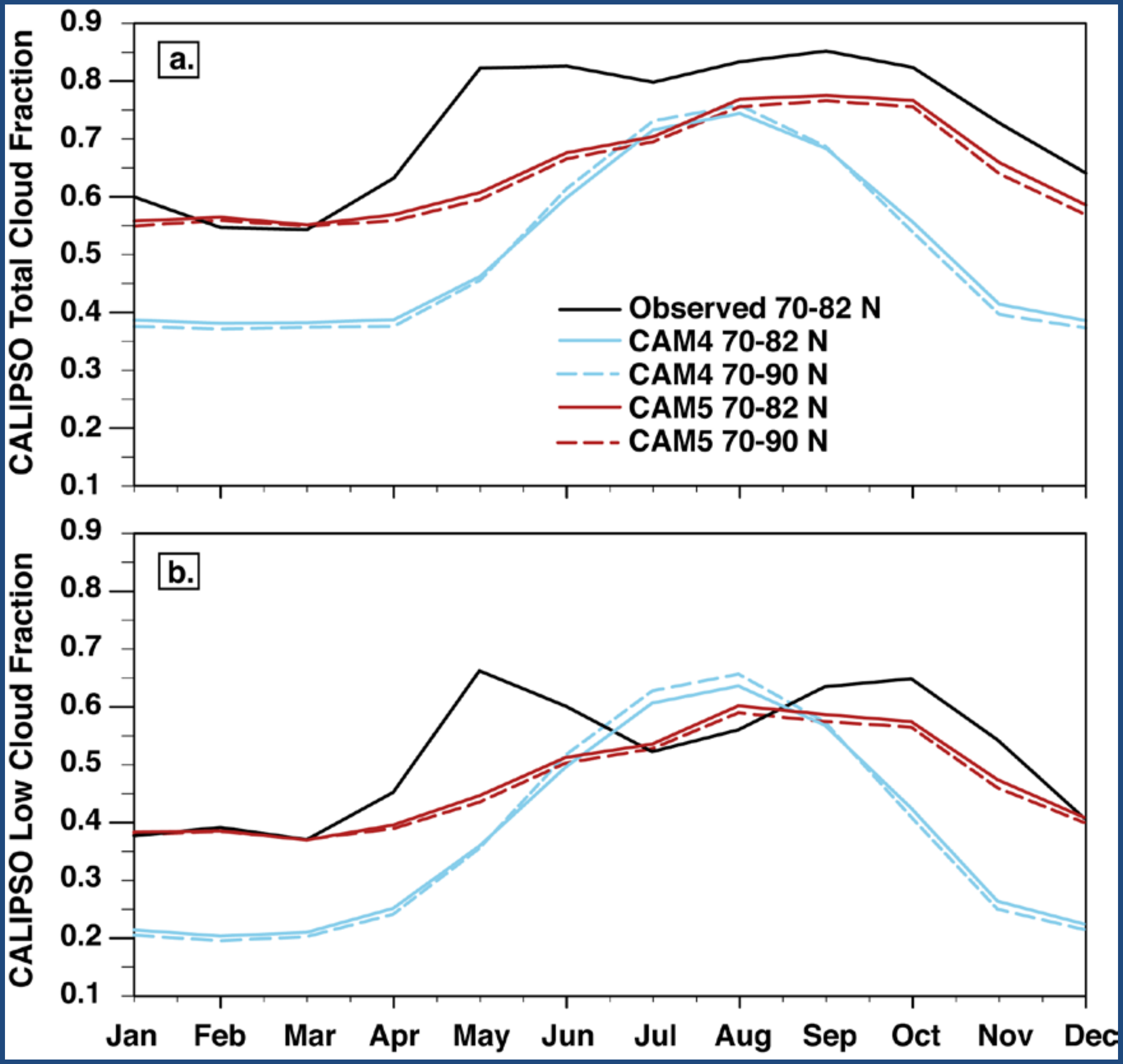
credit Swati Gehlot (DWD)

COSP-enabled comparisons robustly show that the CAM5 physics has reduced long-standing climate model cloud biases (too many optically thick clouds, too few clouds in CAM4 and many other models, see Zhang et al. 2005).



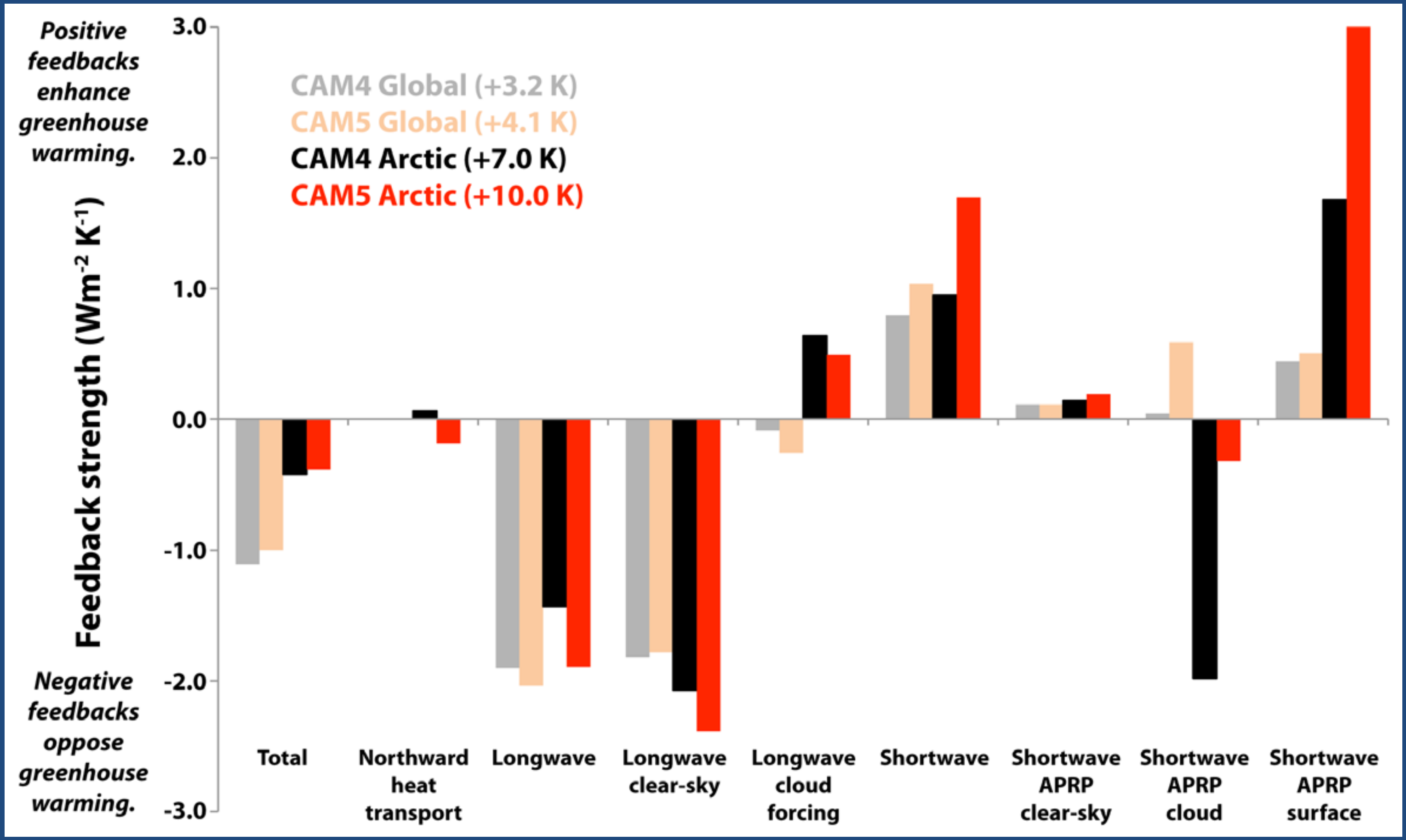
Kay et al. (2012)

Improved Arctic cloud seasonal cycle in CAM5 (despite known low aerosol issues…)



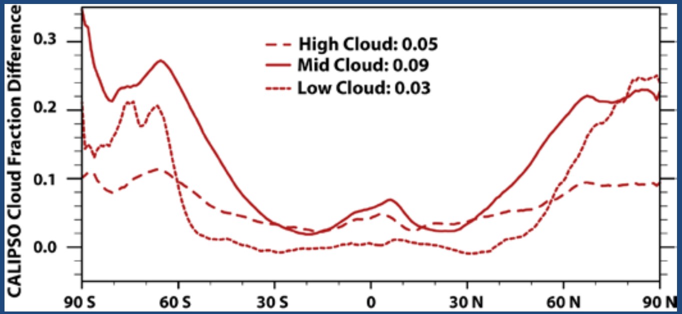
Kay et al. (2012)

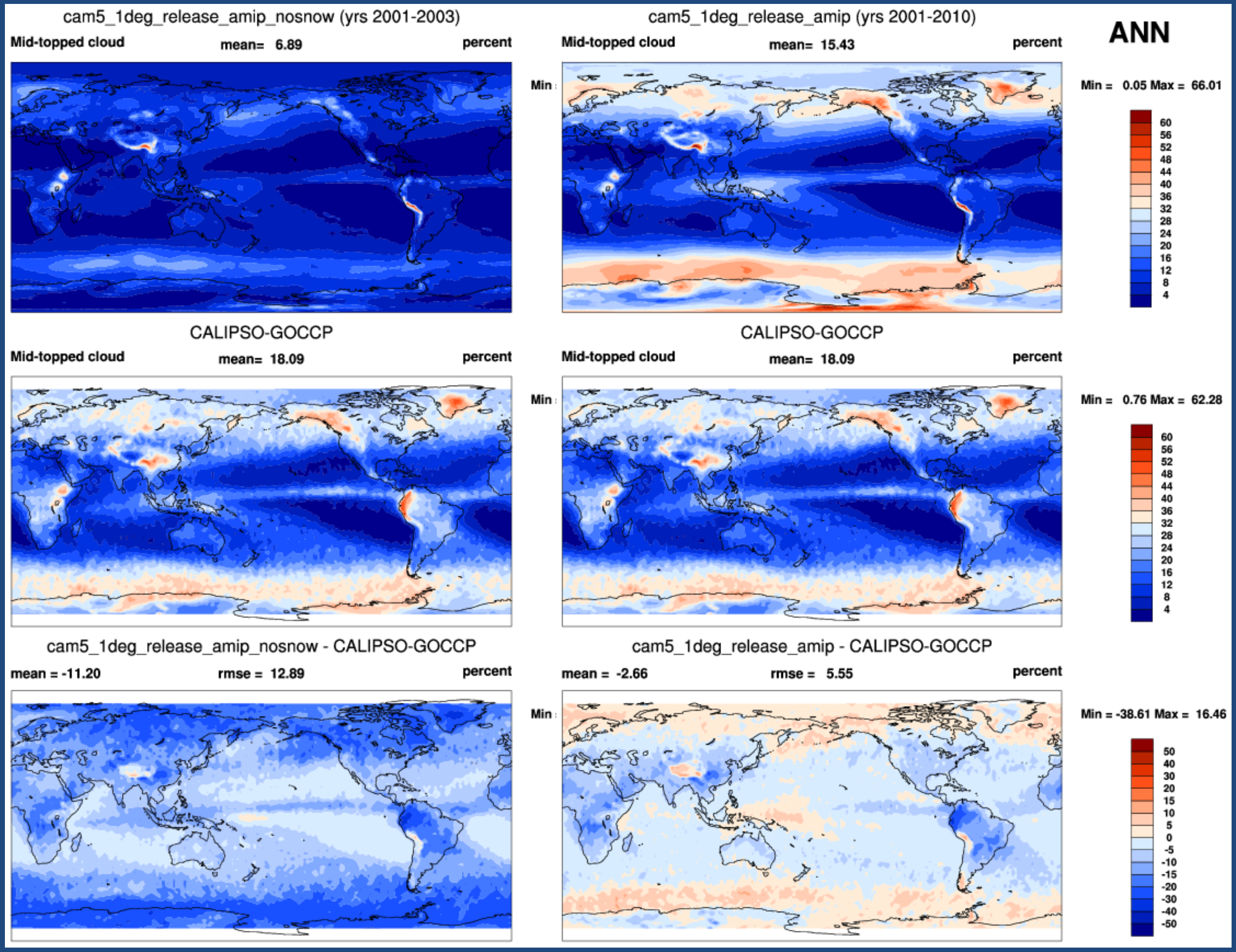
CAM5 has improved clouds and increased sensitivity to $2xCO_2$ forcing… both globally and in the Arctic



Kay et al. (2012): The influence of local feedbacks and northward heat transport on the equilibrium Arctic climate response to increased greenhouse gas forcing in coupled climate models, *J. Climate*

Snow has a large impact on CAM5 COSP diagnostics





Important biases remain in both CAM versions (e.g., low cloud deficit in transition from stratocumulus to deep convection)

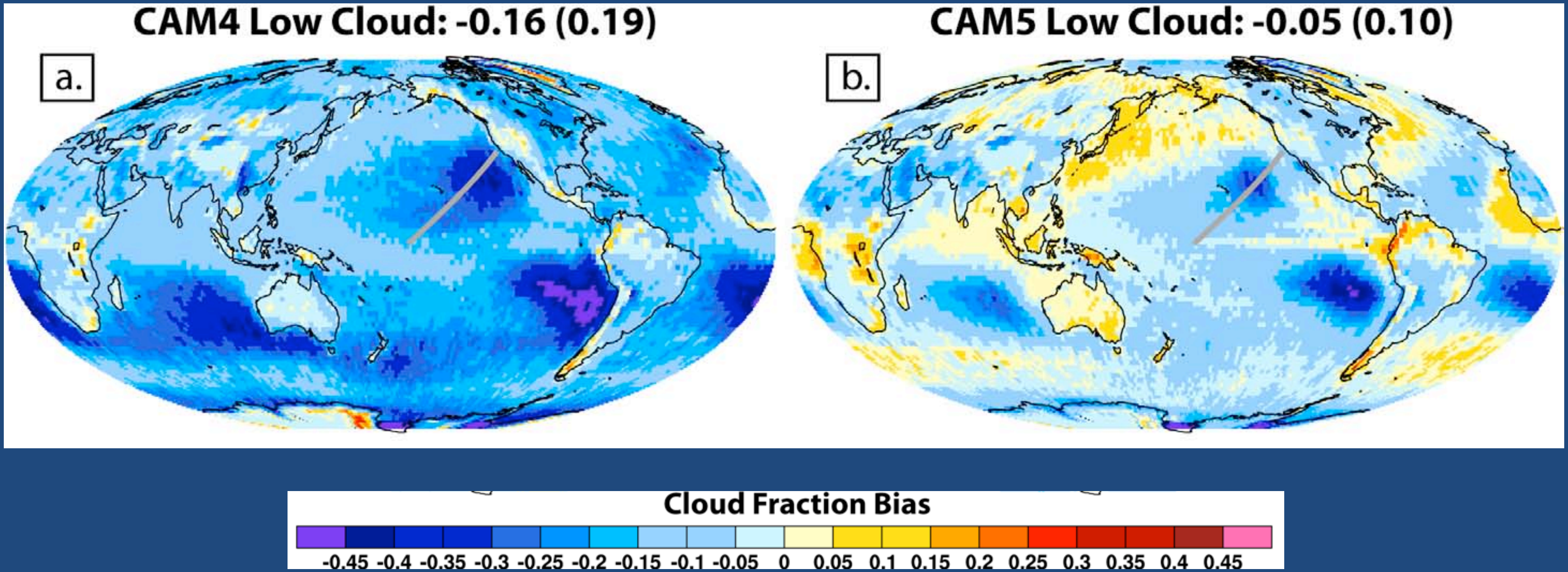


Figure 5, Kay et al. (2012)

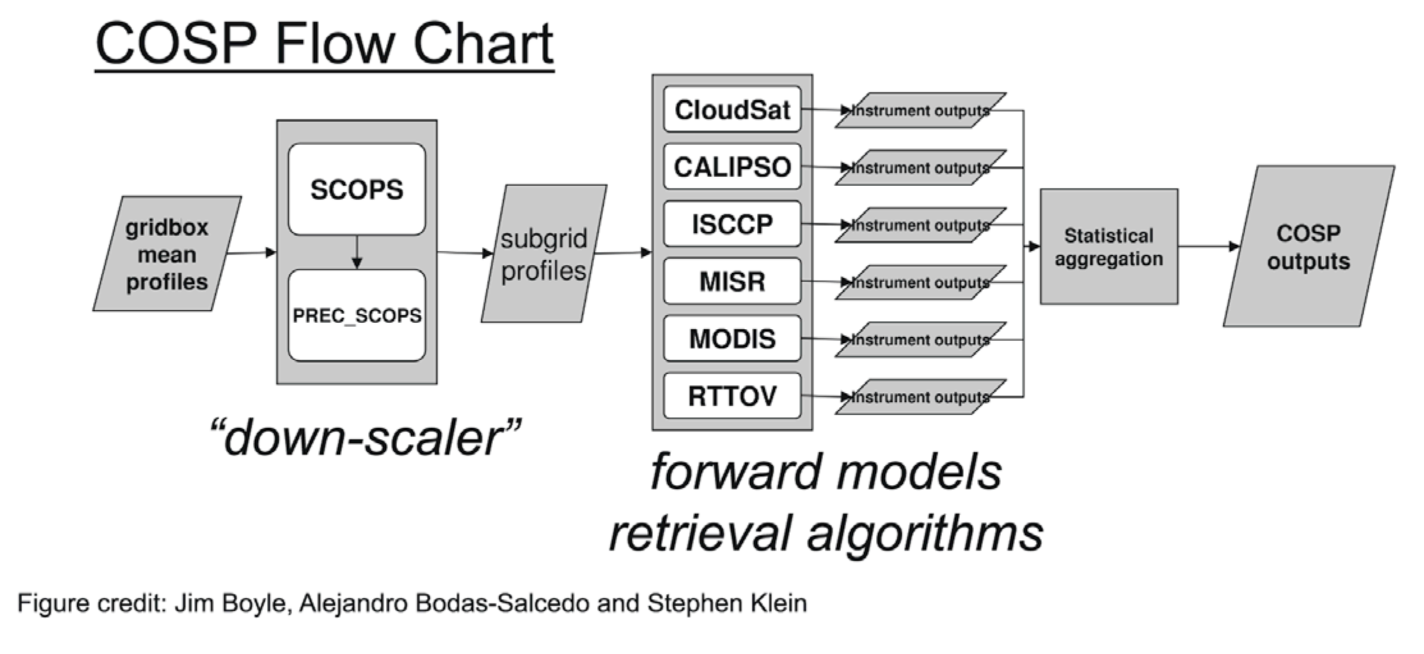
Summary:

1) COSP and CFMIP-requested diagnostics are validated and ready to use within CESM.

2) Analysis using COSP is beginning (and documenting large improvements in clouds from CAM4 to CAM5). COSP/CFMIP help address key climate questions for the AMWG and the larger climate community, such as…

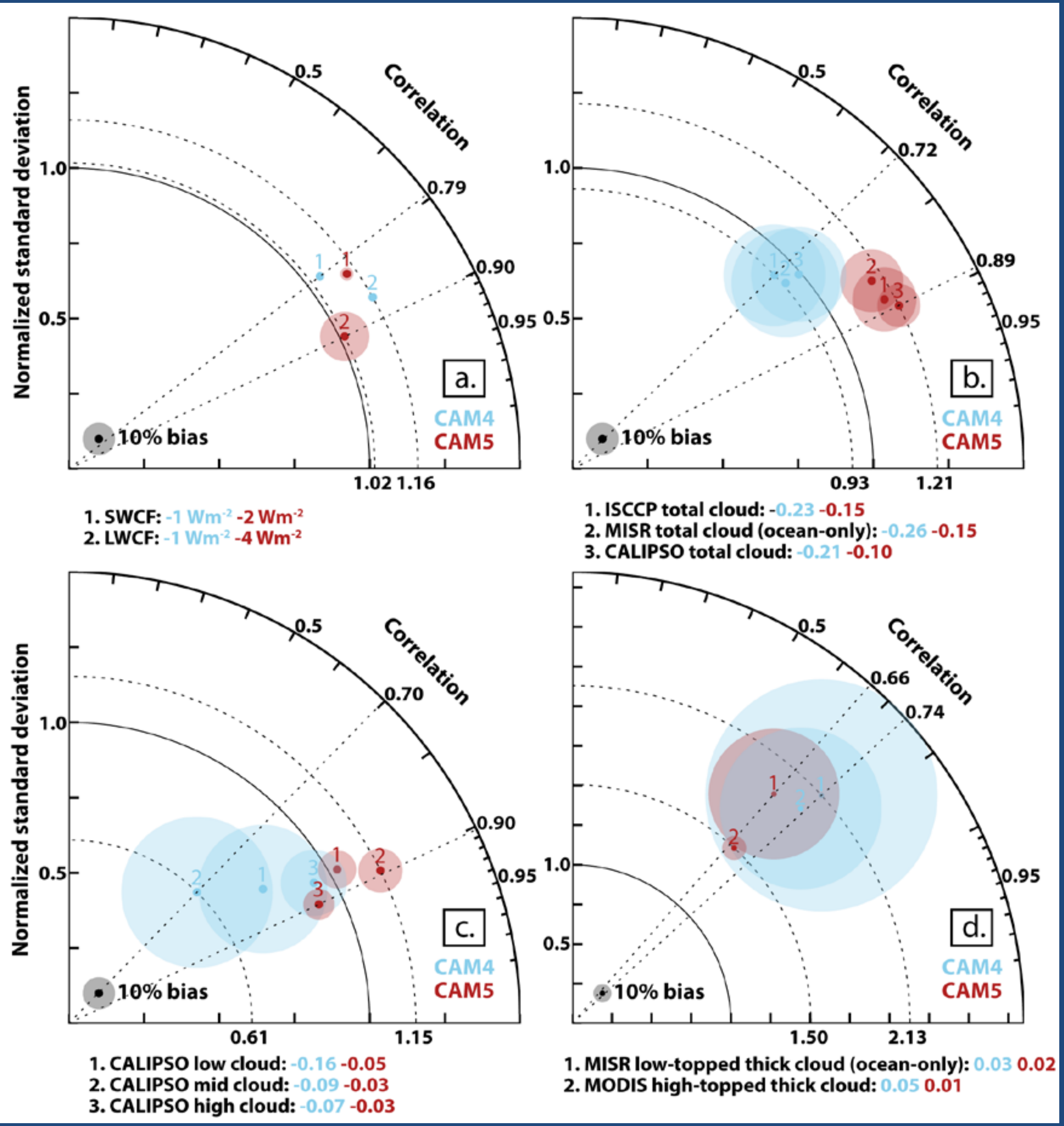
How do we know if we have the clouds "right"?

How does COSP work?



COSP contains satellite simulators for both passive (MODIS, MISR, ISCCP) and active (CloudSat radar and CALIPSO lidar) observations.

For COSP metrics, CAM5 > CAM4.



Kay et al. (2012)