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with Contributions from

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To use A-Train satellite observations to evaluate CMIP5 simulations of clouds and water vapor and thus contribute to IPCC AR5:

- Cloud feedback remains the largest uncertainty for climate projections.
- Accurate simulations of current climate is a necessary condition for credible future projections.
What New Capabilities Enabled by A-Train?

1. Vertical profiles of water vapor and clouds
2. Simultaneous multiple measurements enable physics-driven process understanding
3. Knowledge of observational uncertainties enables quantitative assessment

For IWC and LWC, a logarithm of the ratio of modeled value to the observed is used due to large spread among the models.

- In the denominator represents the uncertainty range of the observation.
- The scaling factor $n_g = 3$ ($=4$ for LWC at 900 hPa)

A zero $G$ score means: 1) for H$_2$O, the model-observation difference is > 3 times the observational uncertainty; 2) for IWC and LWC, the model value is either $> 2^3 = 8$ times (16 times for 900hPa) or $< 1/8$ (1/16 for 900hPa) of the corresponding observation.

References: Douglass et al. [1999], Waugh and Eyring [2008], and Gettelman et al. [2010]

See Jiang et al. (2011, to be submitted)
Performance of current climate simulations for water vapor and clouds

Processes that govern the simulations

Simulations of water vapor and clouds in future climate

Impact on current climate radiation and precipitation

Impact on future climate energy and water cycles
Step 1

Performance of current climate simulations for water vapor and clouds
Evaluation of Multi-year Climatology

Jiang et al. (2011, to be submitted)
Comparing Spatial Mean, Variance and Correlation

Jiang et al. (2011, to be submitted)
Model Performance

Jiang et al. (2011, to be submitted)
## Overall Score and Rank

<table>
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<th>AR5 Model</th>
<th>Overall Score</th>
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Jiang al. (2011, to be submitted)
Performance of current climate simulations for water vapor and clouds

processes that govern the simulations
Conditional Sampling
Conditional Sampling
Step 3

Performance of current climate simulations for water vapor and clouds

Impact on current climate radiation and precipitation
Model Spread in Cloud Forcing Sensitivity

Spatial correlation between net cloud forcing and clouds over tropical ocean

100hPa
- Correlation
- obs, 0.234
- model

215hPa
- Correlation
- obs, 0.242
- model

600hPa
- Correlation
- obs, 0.0969
- model

900hPa
- Correlation
- obs, -0.718
- model
Model Spread in Cloud Forcing Sensitivity
Spatial correlation between precipitation and clouds over tropical ocean

100hPa
- obs, 0.683
- model

215hPa
- obs, 0.856
- model

600hPa
- obs, 0.822
- model

900hPa
- obs, -0.359
- model
Correlation with Precipitation

600 hPa
Summary

- Significant improvements are found from CMIP3 to CMIP5 in simulated IWP and LWP.
- Water vapor is generally better simulated than clouds.
- Model spreads in the upper troposphere are much larger than those in the lower and middle troposphere.
- The simulated relationships of clouds with large-scale dynamic and thermodynamic regimes are drastically different -> large errors in model physics
- Boundary layer clouds constitute the largest spread for the net cloud forcing sensitivity
- Mid-tropospheric clouds constitute the largest spread for the precipitation sensitivity
More work is needed ......
Back-up Slides
Relevance to TOA Cloud Forcing

200 hPa
Model Spread in Cloud Forcing Sensitivity

Spatial correlation between long wave cloud forcing and clouds over tropical ocean

100hPa
- Observed: 0.741
- Model: Various

215hPa
- Observed: 0.896
- Model: Various

600hPa
- Observed: 0.79
- Model: Various

900hPa
- Observed: -0.372
- Model: Various
Model Spread in Cloud Forcing Sensitivity

Spatial correlation between short wave cloud forcing and clouds over tropical ocean

- **100hPa**
  - obs, -0.446
  - model

- **215hPa**
  - obs, -0.57
  - model

- **600hPa**
  - obs, -0.59
  - model

- **900hPa**
  - obs, -0.227
  - model

Variations in model spread for cloud forcing sensitivity across different atmospheric pressures.
Correlation with Precipitation

100 hPa
Correlation with Precipitation

215 hPa
Correlation with Precipitation

900 hPa