Cloud and Cloud-Aerosol Interactions and Feedbacks

Breakout Group Summary

Co-chairs: Stephen Klein, Jiwen Fan, Brian Medeiros, Hui Su

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Talks

Cloud Feedbacks and Climate Sensitivity

- Spencer: Inferring cloud feedbacks from observations
- Zelinka: Assessing feedbacks in CMIP models
- Qin: Dependence of model feedbacks on ocean coupling
- Klein: Expert assessments of cloud feedbacks

Coupling of Cloud Radiative Effects with the Hydrologic Cycle and Circulation

- Pendergrass: Sensitivities of global mean precipitation
- Medeiros: Regional precipitation distributions and extreme events
- Lau: ITCZ narrowing with climate warming

Relationships of Clouds and Aerosols to Regional Changes

- Myers: Dependence of cloud feedback on SST patterns
- Morrison: Role of clouds in Southern Ocean Heat Uptake
- Wang: Roles of aerosol/clouds/other feedbacks in Arctic change

Aerosol-Cloud Interactions

- Pokharel: Cloud seeding conditions changes in a warmer climate
- Zhang: Aerosol impacts on deep convective clouds over Houston
- Wang: Relative impacts of aerosols and climate warming on tropical cyclones

Biomass Burning / Fire and Climate

- Fasullo: Role of specified emissions on observed temperature changes
- Zou: Incorporated fire models into ESMs

Research Gaps and Opportunities (1)

Approaches to Reducing Uncertainties in Cloud Feedbacks and Aerosol-Cloud Interactions

- Focus on cloud types where the greatest uncertainty is currently thought to be: Deep convection, cirrus and low-clouds beyond subtropical marine low clouds
- What is the relationship between the temperature sensitivity (cloud feedbacks) and aerosol sensitivities of clouds?

Better utilize observations to narrow uncertainties in models

- Apply model-data fusion techniques such as Emergent Constraints applied to model ensembles to identify the specific processes and aerosol-cloud interactions most critical to reducing uncertainties in model projections
- Develop critical observational test cases (impact of volcanic aerosols on downstream clouds)
- Develop understanding of the factors driving observed long-term changes in aerosols and clouds

Research Gaps and Opportunities (2)

Relationship to Other Phenomena in the Climate System

The Hydrologic Cycle and Circulation

- How do cloud-radiative effects and aerosol-cloud interactions contribute to the aspects of the precipitation distribution including the global mean, its spatial distributions (ITCZs) and the amplitude of extreme precipitation events (e.g. TCs)?
- What is the role of cloud-radiative effects and aerosol cloud interactions in changes in atmospheric circulation both observed and expected in the future?

The Ocean

- How do clouds and aerosols modulate variability in the ocean including heat uptake and the amplitude of coupled-ocean modes of variability?
- How do cloud changes depend on the distribution of SST changes?

The Biosphere

- How do clouds and aerosols influence the biosphere and vice versa (e.g. fire, impact of CO2 changes on stomatal for impacts on clouds)?

Research Gaps and Opportunities (3)

Maximize the opportunities resulting from high-resolution modeling

- What scientific insights for cloud feedbacks and aerosol-cloud interactions can be derived from resolving mesoscale and convective circulations?
- Apply the panoply of diagnostic techniques to help reduce the remaining deficiencies in these models

Machine Learning / Artificial Intelligence

- We recognize the potential of ML/AI to improve cloud and aerosol parameterizations in ESMs, among other applications
- We're interested in finding ways to use ML/AI to improve understanding of cloud and aerosol processes (i.e. avoid using it as a black box)