**Relationships Between Ice Cloud Properties and Radiative Effects from A-Train Observations and Global Climate Models**

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**Motivation**
- Large differences exist between modeled cloud ice and observations (Li et al., 2012)
- Yet models show consensus for a positive high cloud feedback (Vecchi and Soden, 2011)
- Examine cloud radiative effects as a function of ice water path
- Which type of cirrus contribute most to heating the upper troposphere?
- Use A-Train satellite data to evaluate ice clouds in a global climate model

**Cloud Characteristics**
- Focus on Southeast Asia during monsoon season (Aug. & Sep. 2007-2008)
- High clouds dominate vertical distribution
- Db2 thresholds reveal more small ice at higher heights
- Large fraction of middle level clouds are precipitating
- CloudSat misses clouds below ~1km due to multiple scattering effects

**Ice Water Path (IWP) Statistics**
- Ice microphysical properties from the CloudSat/CALIPSO 2C-ICE dataset (Deng et al., 2010)
- Precipitating/Convective profiles identified with 2B-CLDCLASS-LIDAR dataset (Waliser et al., 2009)
- Mean IWP=440 g m^-2, Median IWP=24 g m^-2
- Due to skewed distribution, mean IWP is a poor diagnostic of radiative impact for cirrus clouds

**Cloud Radiative Effect (CRE)**

\[
CRE = \langle F_{\downarrow} - F_{\uparrow} \rangle_{\text{All}} - \langle F_{\downarrow} - F_{\uparrow} \rangle_{\text{Clear}}
\]

**Methodology**
- Multiplatform algorithm suite (CloudSat, CALIPSO, MODIS optical depth) to derive the cloud microphysical and radiative properties (Mace, 2010)
- A two-stream radiative transfer model is used to obtain the radiative fluxes (Toon et al., 1989)
- Use cloud radiative kernels (Zelinka et al., 2012a) to investigate radiative impact of ice clouds: \( R = K \times C \).
- \( R \) is contribution of each cloud type to top of atmosphere (TOA) radiation

**Cloud Radiative Kernel (K):** gives the sensitivity of TOA fluxes to perturbations in cloud fraction as a function of cloud top pressure (CTP) and IWP

C is the cloud fraction histogram

**Future Work**
- Do climate models show a similar distribution of cloud ice and radiative effect?
- Perform cloud radiative kernel analysis with Community Atmosphere Model version 5 (CAM5)
- How do modeled ice clouds differ from observed clouds?
- Use output from CAM5, run in weather forecast mode (Xie et al., 2012), to see how quickly ice cloud biases develop