Statistics of simulated 2-D solar radiative effects over three ARM sites

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Summary

1. We analyze a yearlong dataset of observed cloud structures and corresponding radiation fields simulated using 1-D and 2-D radiative transfer models.
2. 2-D effects have modest influence on overall average fluxes, but are often strongly influence scene average values for individual 50 km-size scenes.
3. 2-D effects reduce average nadir reflectances most of the time, especially at TWP and for cumulus clouds.

Project overview

Goals

- Develop a parameterization of shortwave 3-D radiative processes (e.g., shadowing and cloud side illumination) for cloud-resolving models
- Examine the influence of 3-D radiative processes on cloud development

Steps

- Create dataset of observed cloud structures, simulate radiative fluxes (F_{1-D}, F_{3-D}) for them

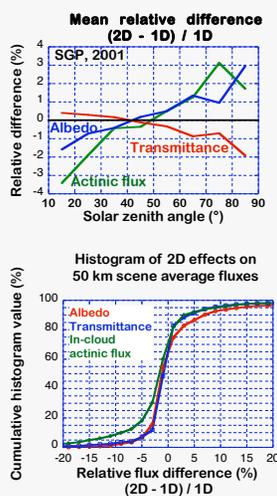 Current step

  $$C = F_{1-D} / F_{3-D}$$

- Use dataset to develop parameterization:
  Neural net:
  estimate C-values using local cloud variability
  Cloud resolving model:
  $F_{3-D} = C \times F_{1-D}$ (F_{1-D} from 1-D code)

- Examine influence of 3-D radiation on cloud development, by using parameterization in RAMS model simulations at Penn State.
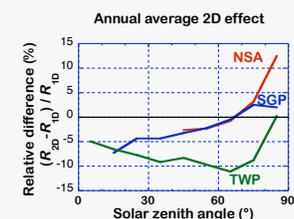
Dataset and flux results

Current dataset

- 1 year at NSA, SGP, TWP
- Microbase: cloud profiles (LWC, IWC, r_e^{liq}, r_e^{ice})
- Mergesonde: wind aloft (time diff. ➡ distance)
- Cloud classification at SGP
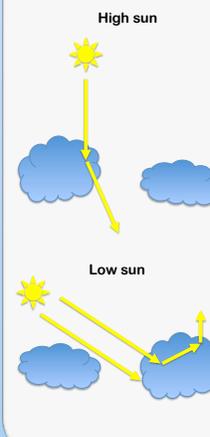- Simulated 1-D & 2-D fluxes and nadir reflectances at 0.86 µm

Flux results

Mean relative difference (2D - 1D) / 1D

Histogram of 2D effects on 50 km scene average fluxes

Nadir reflectance results
(relevant to satellite remote sensing)

Overall tendencies

Annual average 2D effect

Mechanisms

High sun

Low sun

Cloud type

Average magnitude of 2D effects for various cloud types (Averaged over all solar zenith angles)

Strength of dependence on solar zenith angle (Θ_0)