Influence and estimation of 2-D solar radiative processes in clouds

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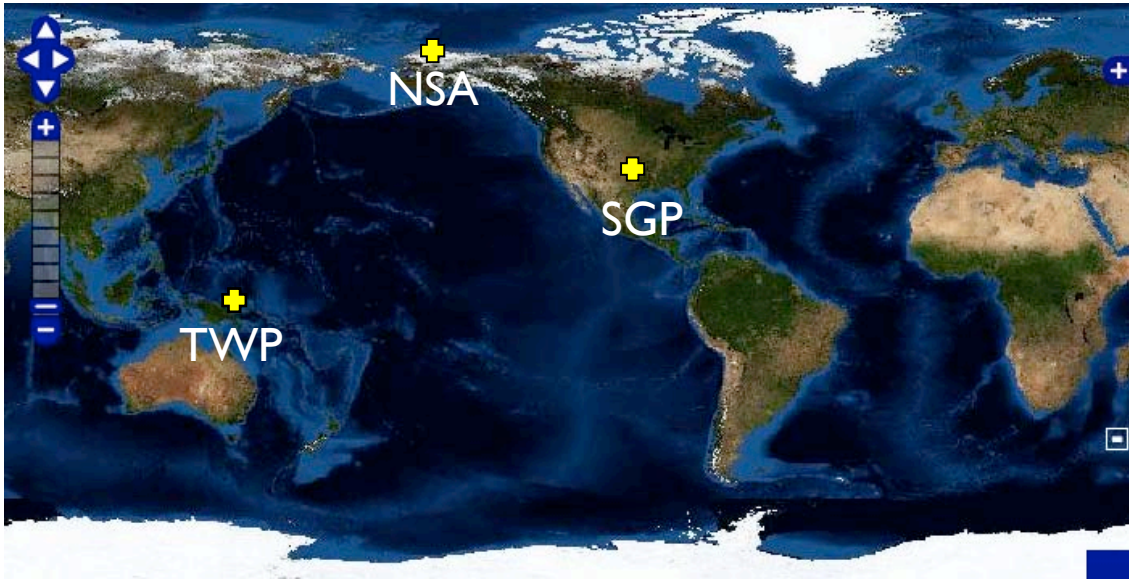
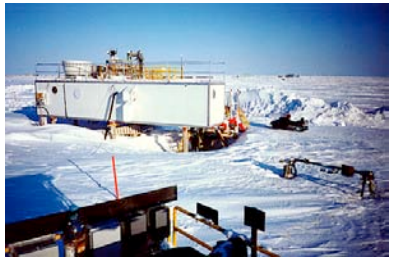
ARM sites

- Oklahoma: 1999-2001
- Alaska: 2005-2007
- Papua New Guinea: 2003-2004



ARM
Atmospheric Radiation Measurement



ARM cloud observations

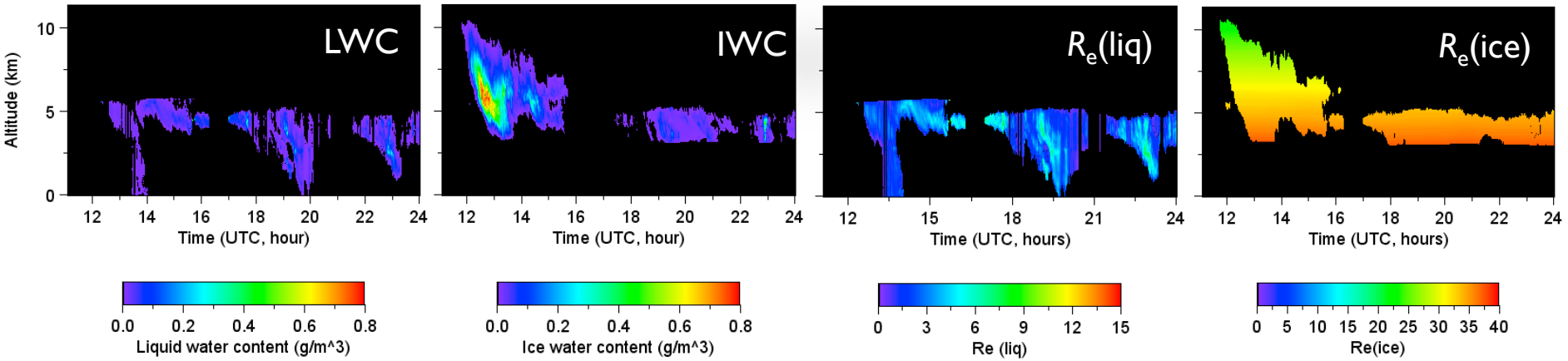
Cloud radar

Lidar

Microwave radiometer

Radiosonde

Radar wind profiler

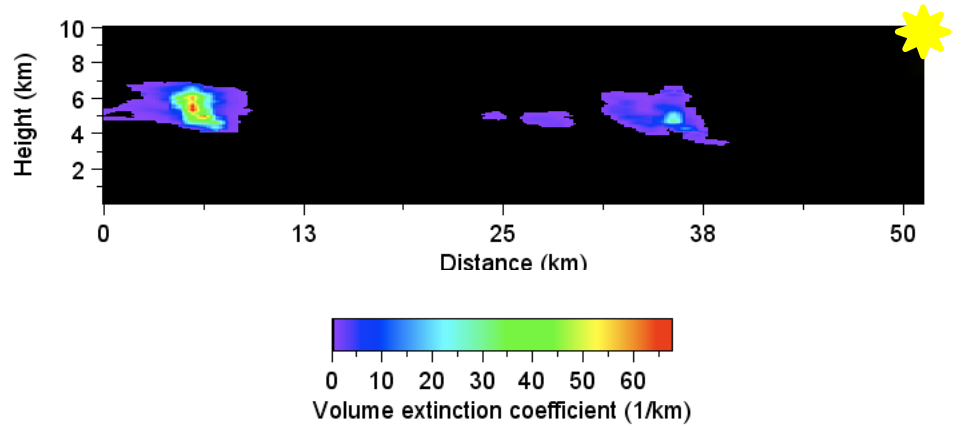


SGP 2004-10-04

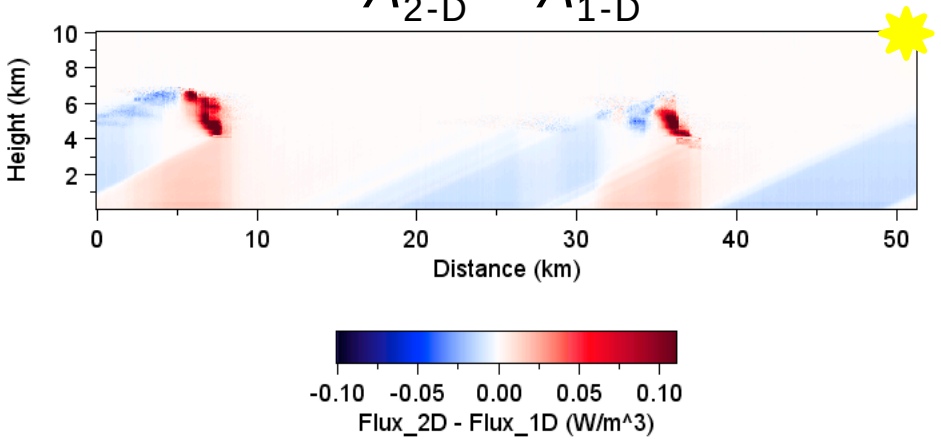
Radiative transfer simulations

SGP, 2001-03-10, ~4:30 PM

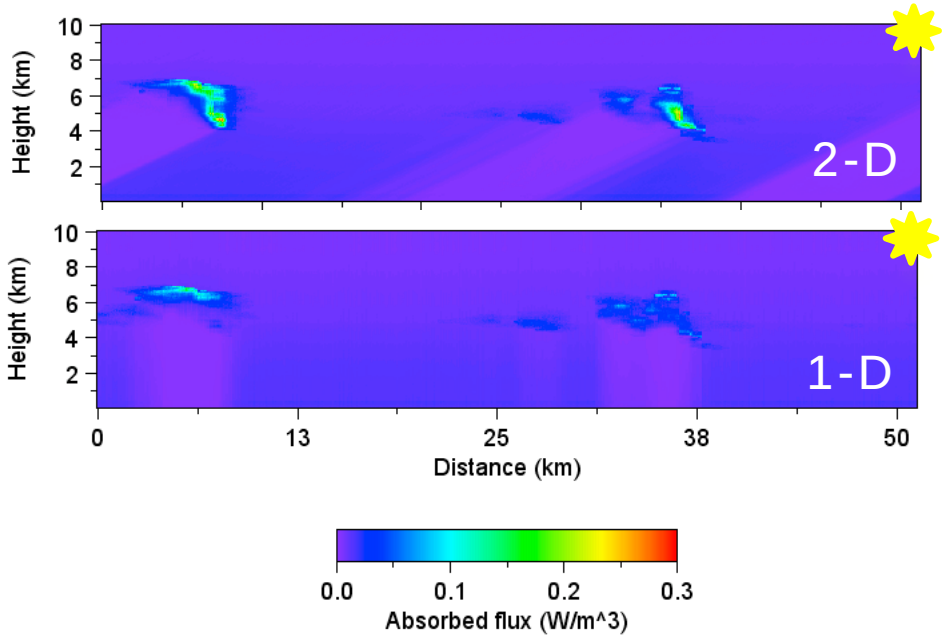
Vol. ext. coeff.



$A_{2\text{-}D} - A_{1\text{-}D}$



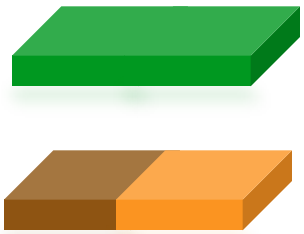
Absorption (A)

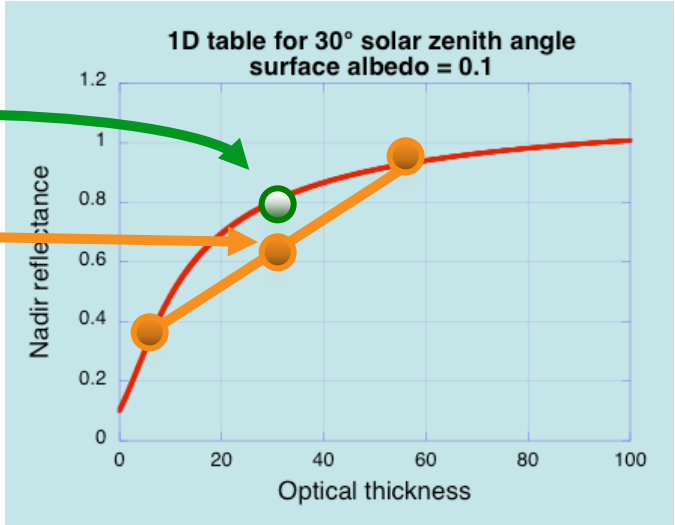


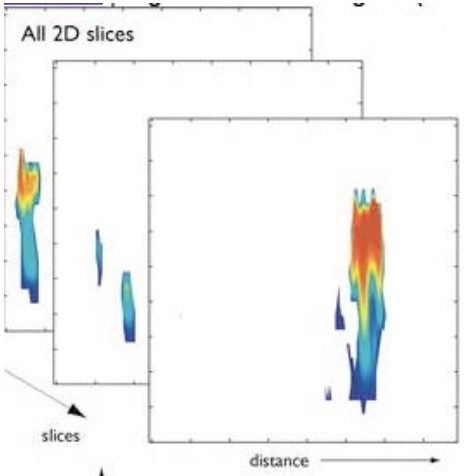
Limitations

- Uncertainties in input cloud structures
- Not 3-D
- 1-D biases of coarse resolution models not included

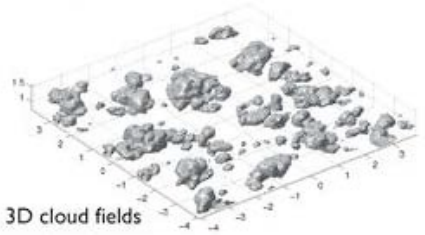
  (Median resolution: NSA: 86 m, SGP: 141 m, TWP: 74 m)





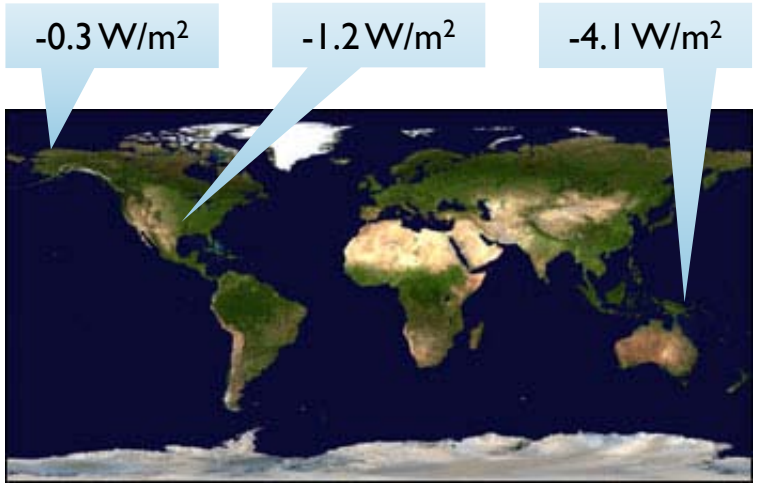


dimensionality
$E_{2D\text{-}all} - E_{3D}$



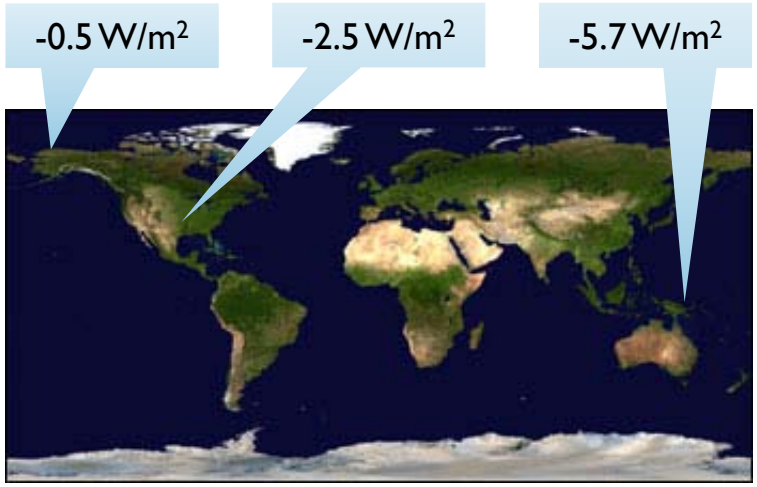
Overall average results

Multiyear full-day (24 hour) average difference between
2-D and 1-D calculations of reflected sunlight

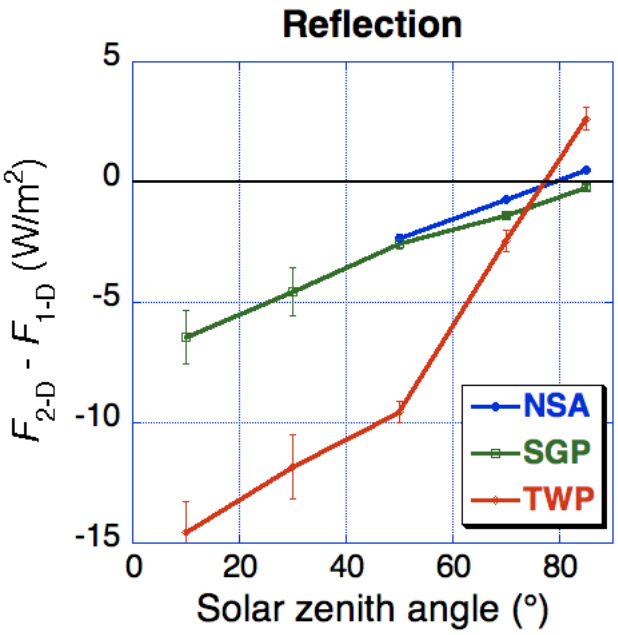


Mean effect for clouds

Influence of 2-D effects on the average reflection of 1 m^2 cloud

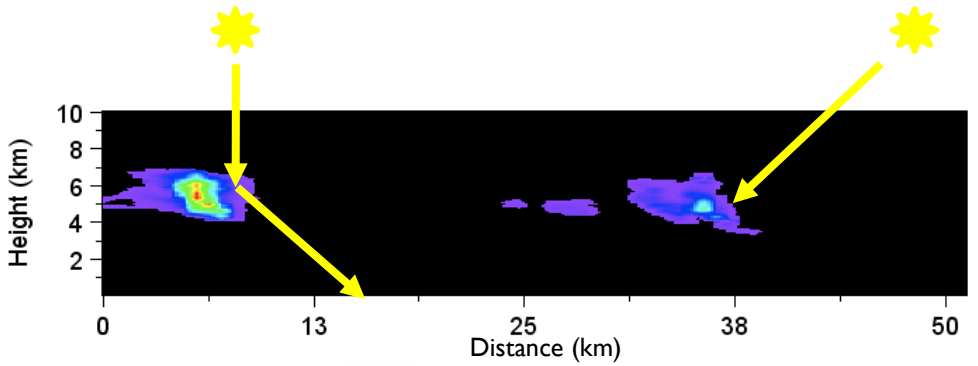


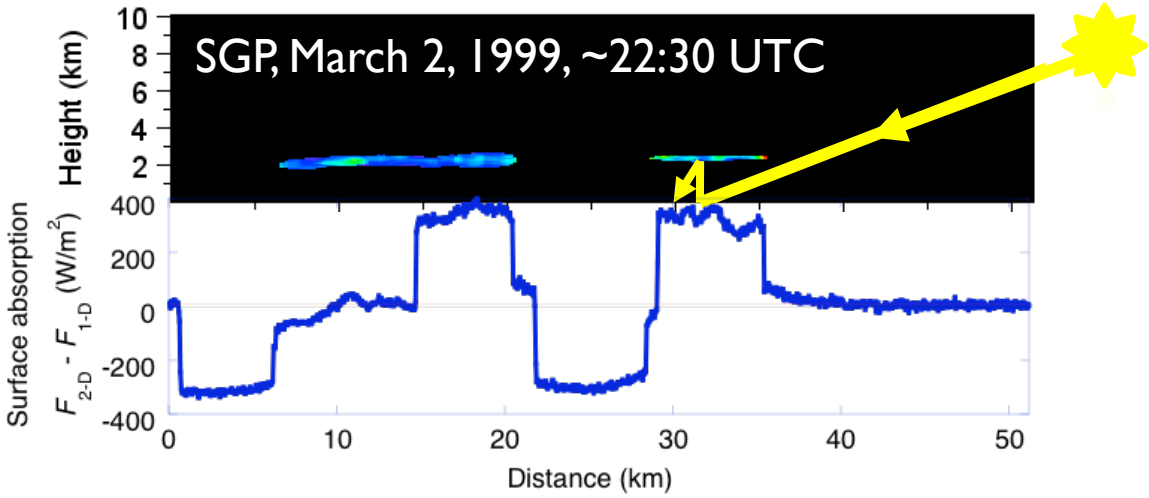
Influence of solar elevation



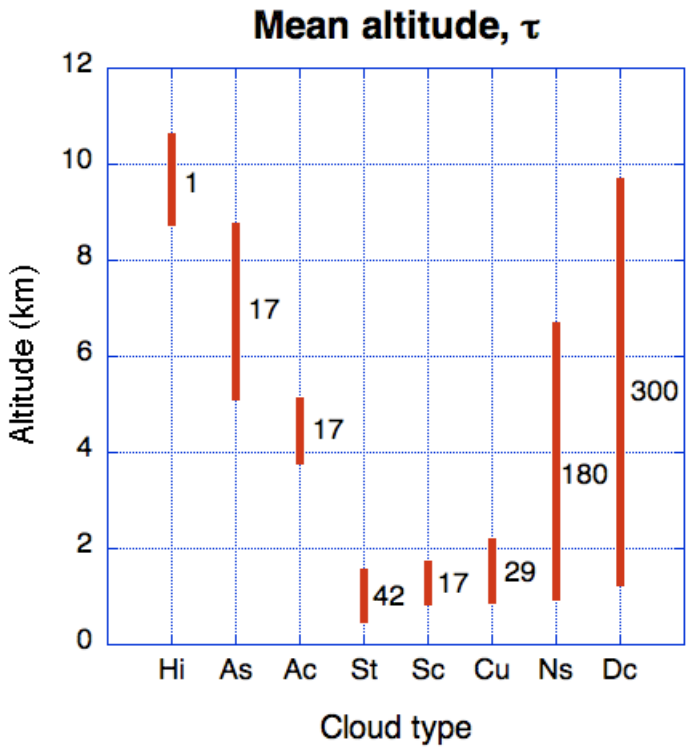
High sun
diffusion to thin areas

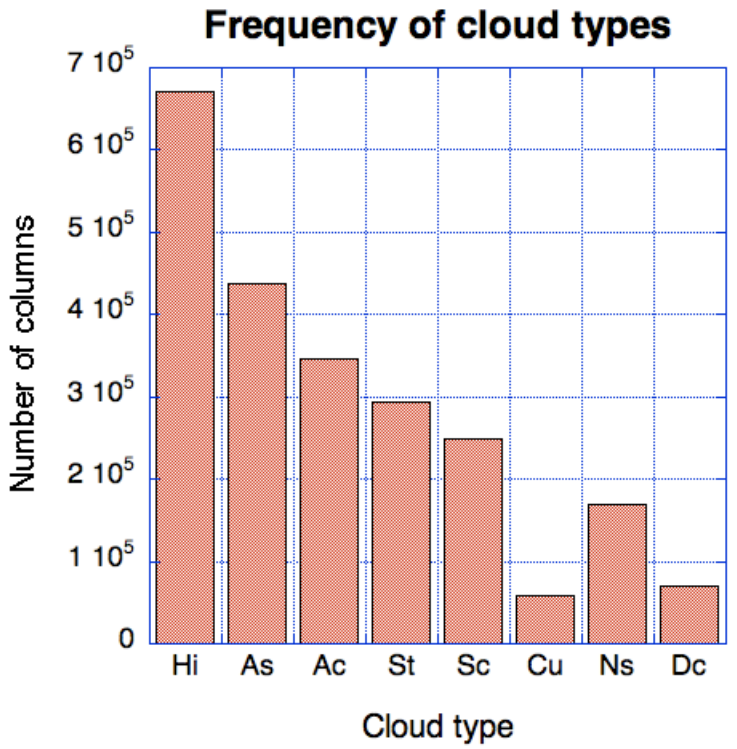
Low sun
cloud side illumination



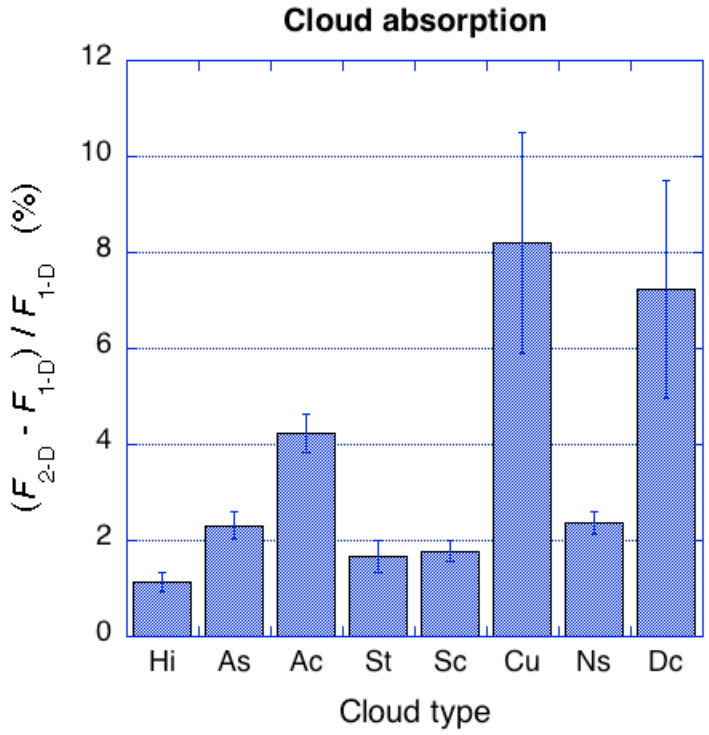


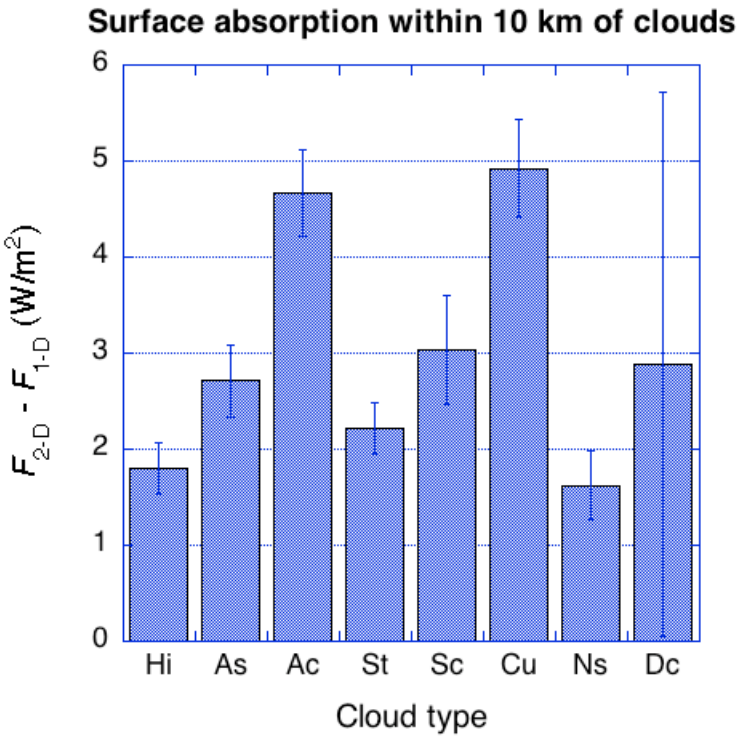
Cloud types at SGP site



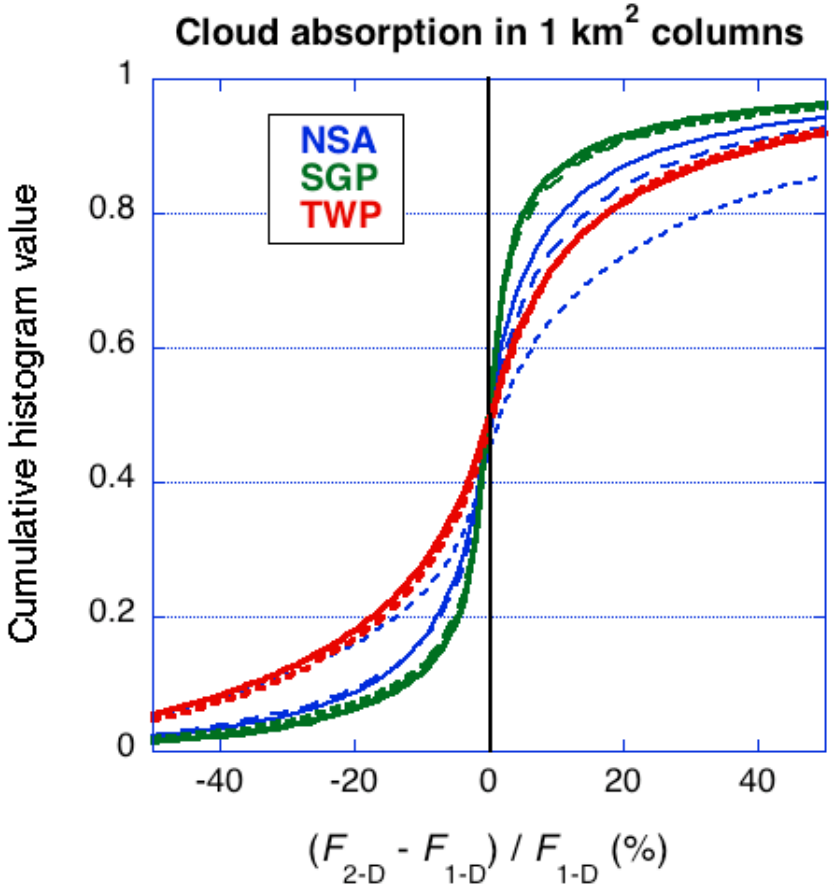


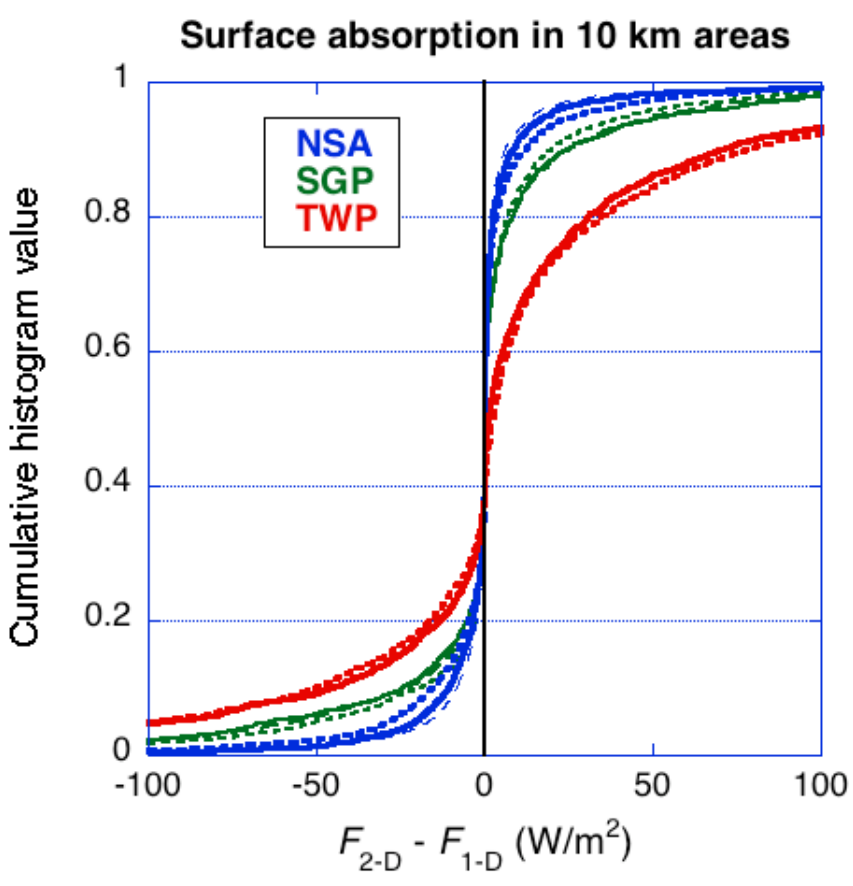
2-D effects and cloud type





Histogram of 2-D effects

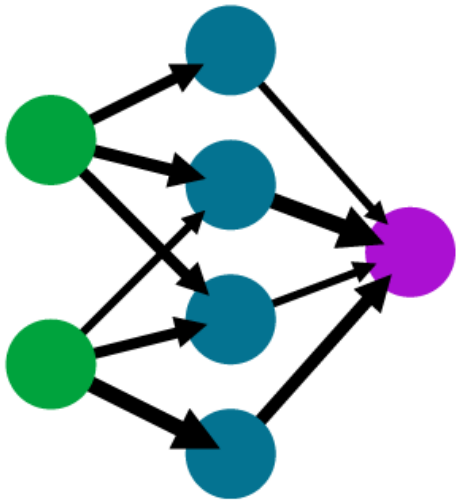




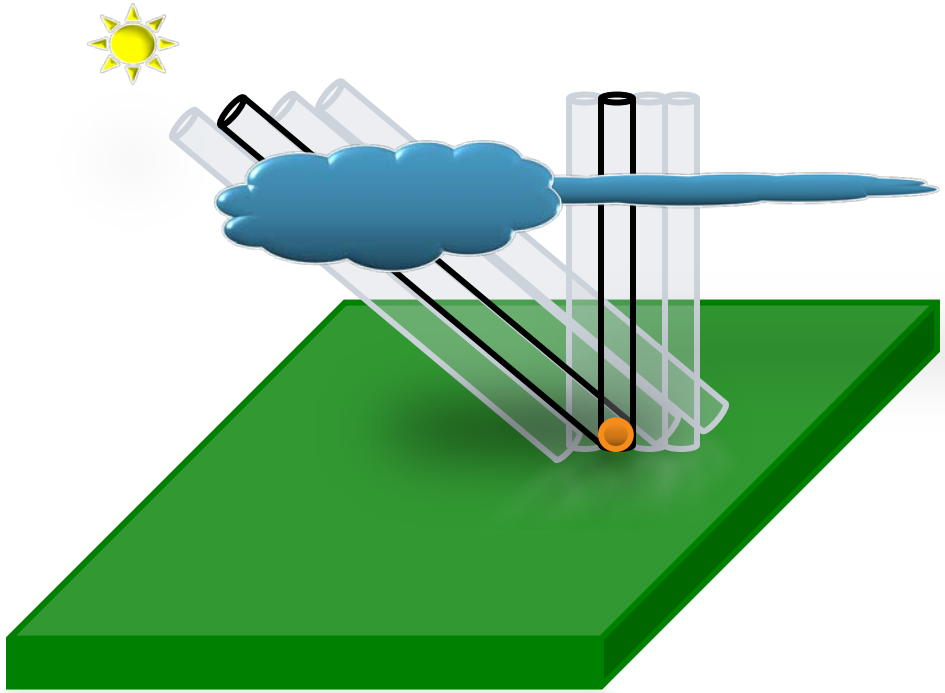
Concept for adjusting 1-D fluxes

A simple neural network

input layer hidden layer output layer



Cloud variability parameters → Difference between 2-D & 1-D fluxes

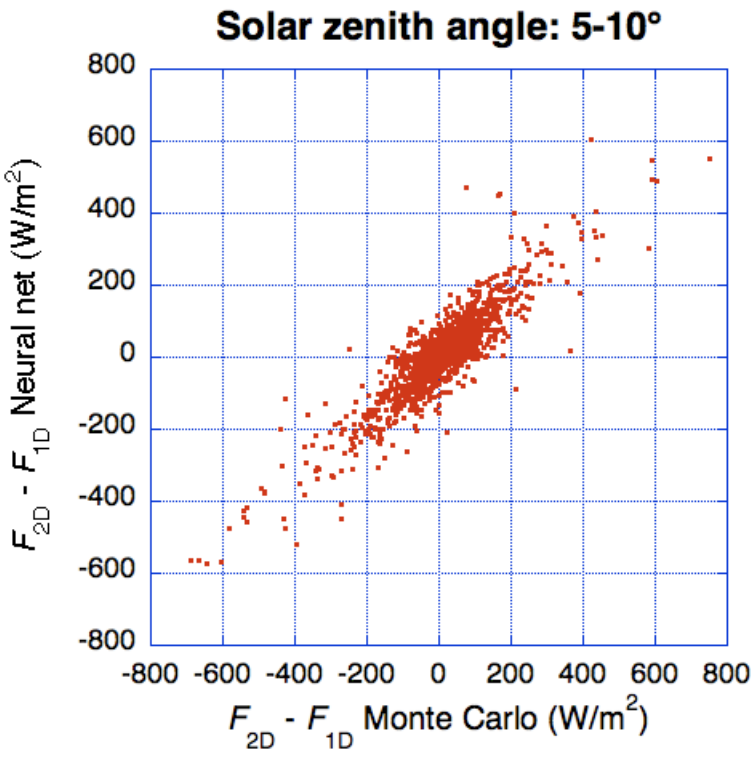


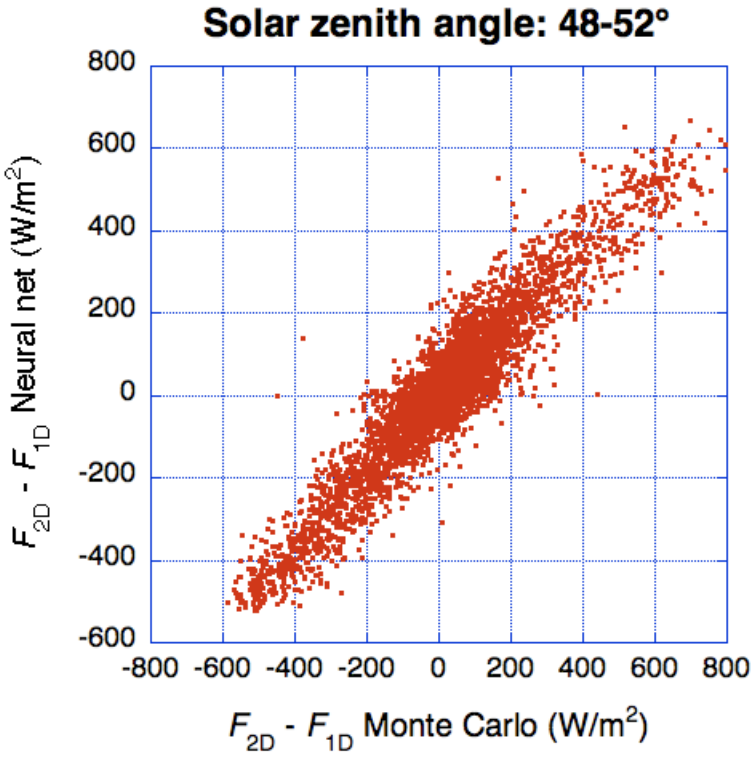
Variability parameters:

Gradients (up to 10 km) in τ, F_{1D}, Z F_{TICA} - F_{ICA}

Initial results

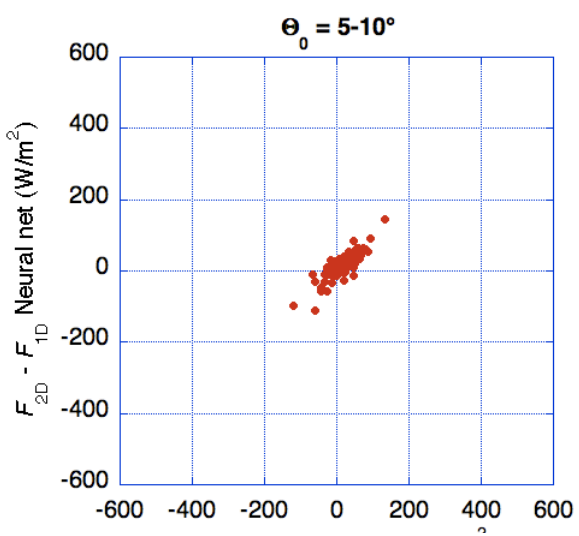
Surface absorption at 1 km resolution, at TWP site

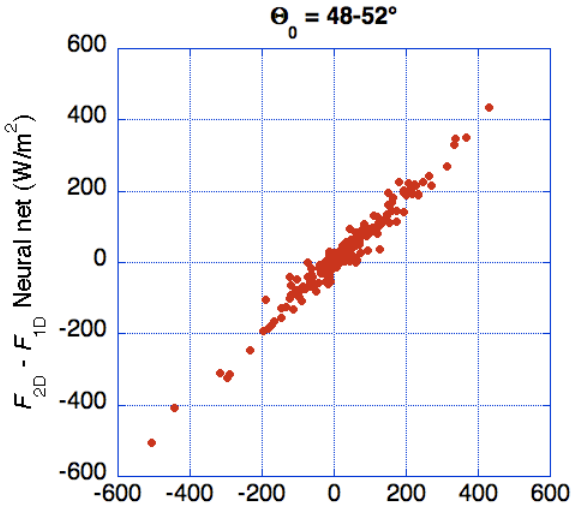




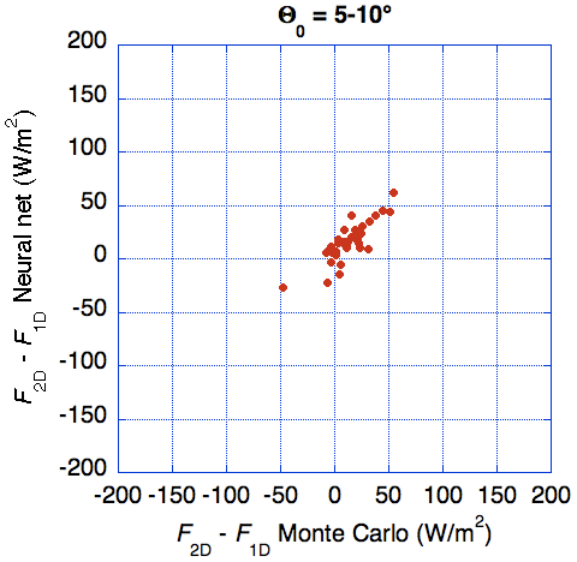
Large-scale effects at TWP

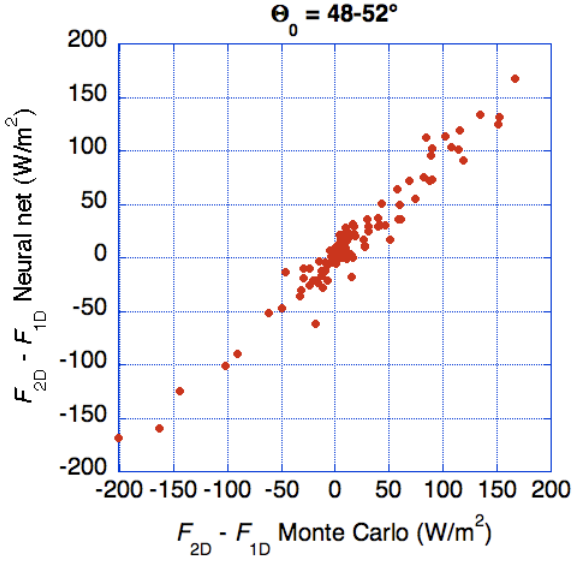
10 km regions





35 km regions

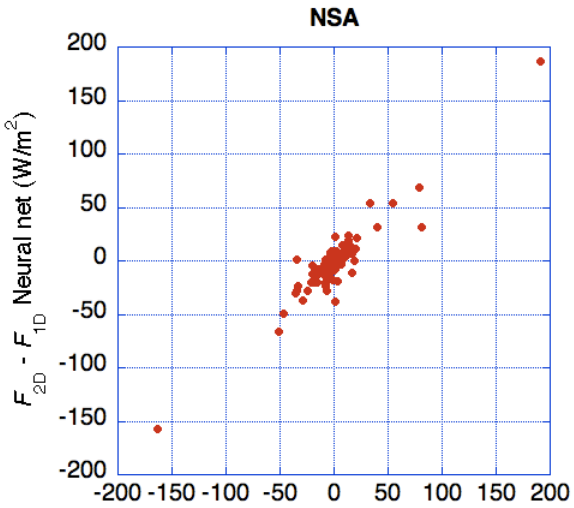


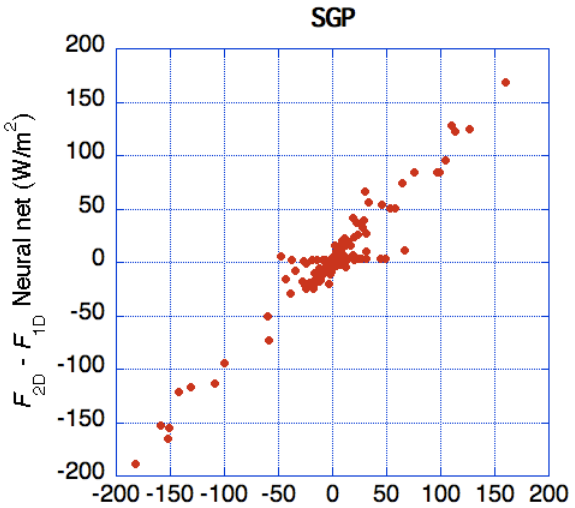


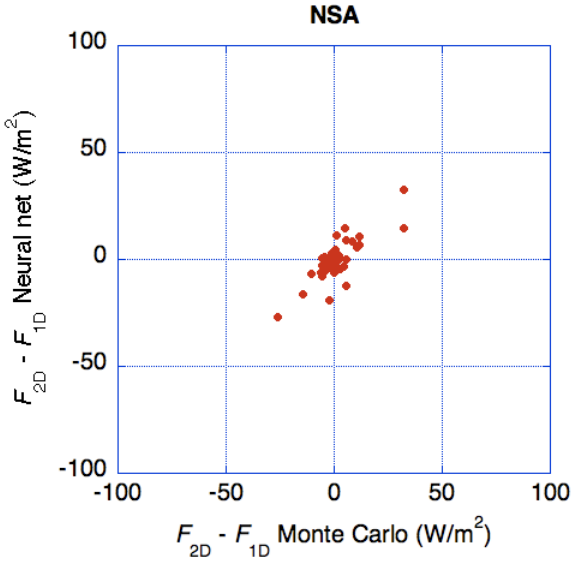
Effects at NSA and SGP sites

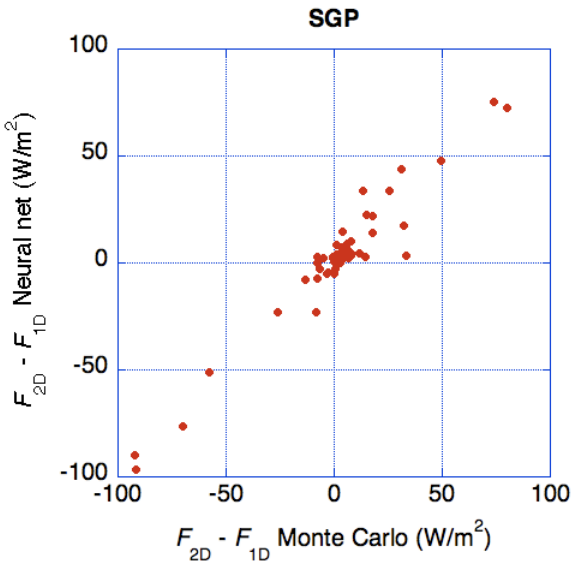
10 km regions

35 km regions









Summary

• Simulations show 2-D radiative effects increasing multiyear average total (cloudy and clear, day and night, surface and atmospheric) solar absorption by 4.1, 1.2, 0.5 W/m^2 at the three ARM sites, respectively.

  •These are rather conservative estimates of 1-D errors: no cloud variability in cross-wind direction and no plane-parallel bias for coarse-resolution models.

• 2-D effects are locally often much larger than these average values, especially for high sun and for convective clouds.

• Neural-net based parameterizations show promise in improving the 1-D solar flux calculations of dynamical simulations by adjusting them for 2-D radiative effects.

• ARM scanning radars will offer new opportunities for examining full 3-D effects, which in earlier case studies were about 30% stronger than 2-D effects.

Considered Ci cases