DEPENDENCE OF CIRCUMSOLAR RADIATION ON ICE CLOUD PROPERTIES

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MOTIVATION

- In the presence of an ice cloud, the scattered solar radiation is strongly concentrated into the forward direction.
- Radiation scattered into the solar and circumsolar region can bias the measurement of direct radiation.
- Sensitivity of shortwave circumsolar radiance to ice crystal shape and surface roughness is not well known.

METHOD

Radiative transfer simulations and measurements of downwelling monochromatic radiances were compared in the angular range of 0-8° from the Sun.

The simulations were based on in-situ derived size distributions of ice crystals. To quantify the sensitivity of the radiances to crystal shapes, simulations were carried out with different single-habit shape distributions in addition to the in-situ derived shape distributions.

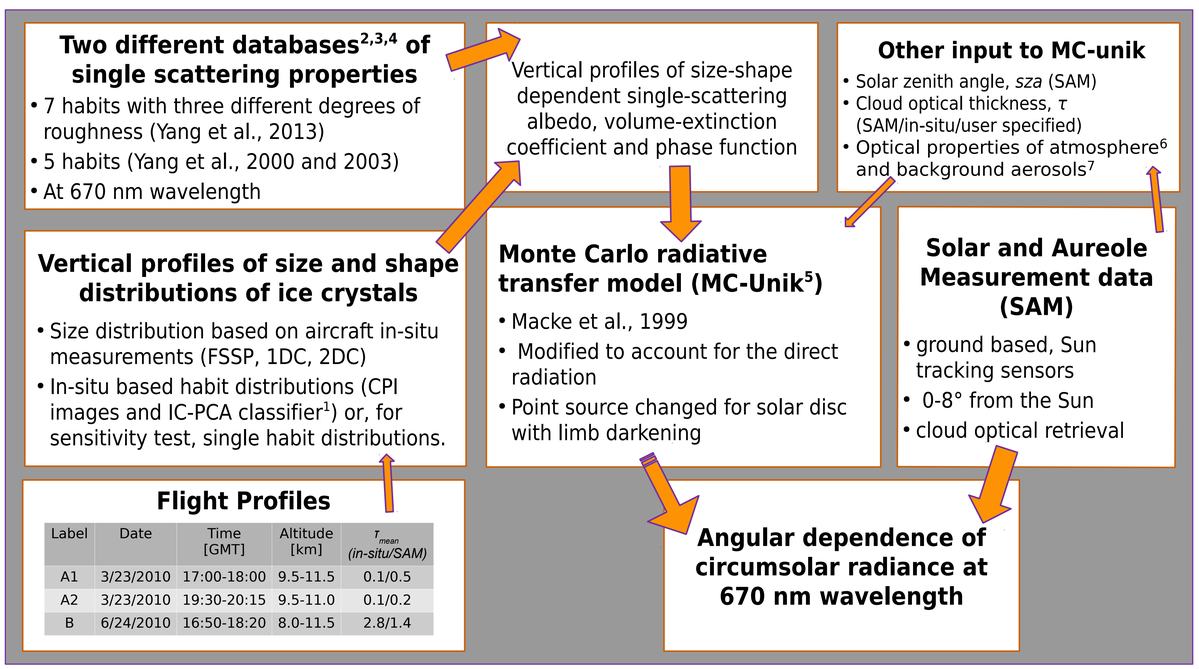
MEASUREMENTS

Measurements were conduced during ARM's SPARTICUS 2010 field campaign at the SGP site. Size and shape distributions of ice crystals were measured using in-situ probes installed on the SPEC Inc. Learjet. Ground based solar disk and circumsolar radiances were measured using Visidyne's Solar and Aureole Measurements (SAM) sensors.

HABITS

Shape distributions of large ice crystals were obtained using the IC-PCA classifier[1] which classifies the CPI images of individual ice crystals into six habits: **column, plate, bullet rosette, irregular and plate and column aggregates.** Small crystals (<100 μm) were assumed to be droxtals. Single scattering properties for the habits were obtained from existing databases.

- **Database_2000[2,3]: column, plate, bullet rosette, and smooth and rough aggregate, droxtal**.
- **Datebase_2013[4]: solid column, plate, solid bullet rosette, plate aggregate with 5 and 10 branches, column aggregate, and droxtal.** All habits with three roughness options (smooth, moderately rough, severely rough).



Label	Date	Time [GMT]	Altitude [km]	τ_{mean} (in-situ/SAM)
A1	3/23/2010	17:00-18:00	9.5-11.5	0.1/0.5
A2	3/23/2010	19:30-20:15	9.5-11.0	0.1/0.2
B	6/24/2010	16:50-18:20	8.0-11.5	2.8/1.4

PRELIMINARY RESULTS

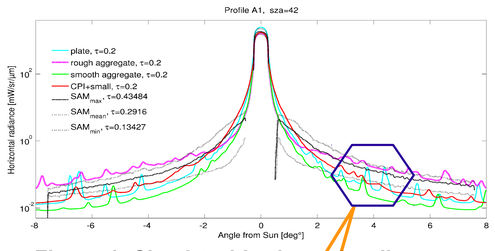


Figure 1. Simulated horizontal radiance as a function of angle from the center of the Sun. Simulations based on three different shape distributions (plate, aggregates and CPI based) of profile A1 are shown together with SAM measurements (sza 41.5°-42.5°). Aggregates with two different roughnesses were used (Database_2010[2,3]).

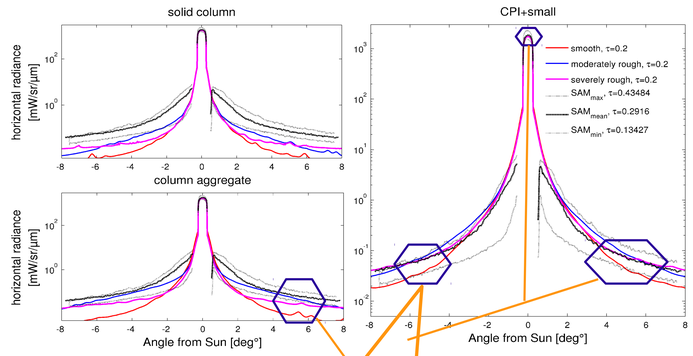


Figure 2. Same as Figure 1, but simulations conducted using column, column aggregate and CPI based habit distributions with three different degrees of roughness (Database_2013[4]).

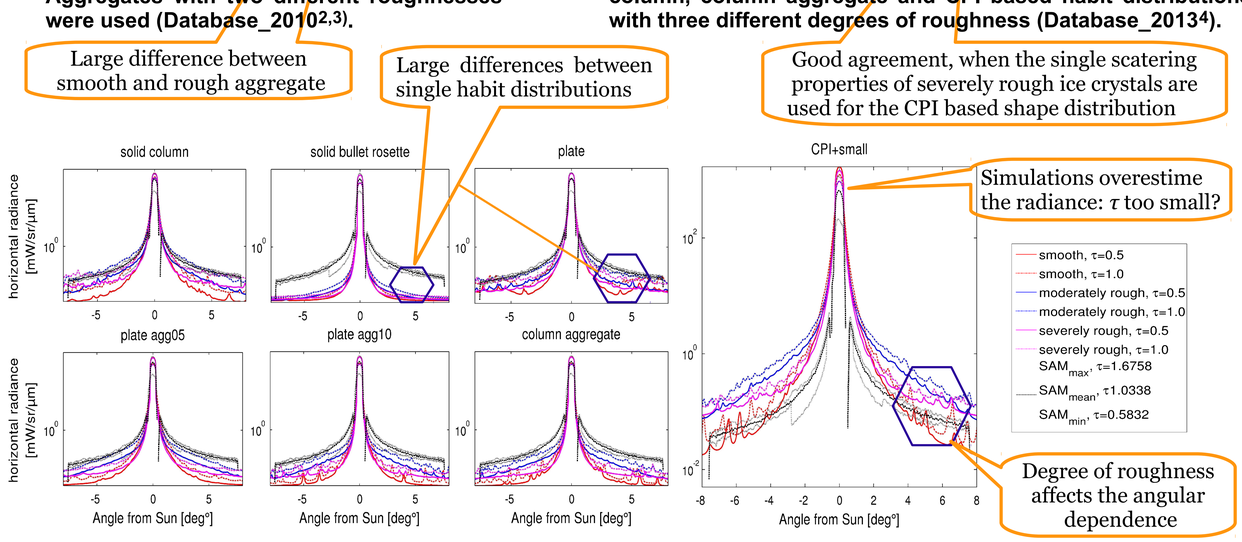


Figure 3. Angular dependence of simulated and measured horizontal radiances. Simulations are conducted using three different roughness options (Database_2013[4]) for the seven different shape distributions of profile B (sza=50°).

CONCLUSIONS

Based on the preliminary results it was found that

- the angular dependence of circumsolar radiance is clearly sensitive to size, shape and surface roughness of ice crystals
- simulation results depend also on the single-scattering database used
- best agreements with measurements are typically obtained using severely rough ice crystals
- SAM data might be useful for quantifying ice crystal roughness

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