Quantifying the Dust Impacts on the Ice Generation in Supercooled Stratiform Clouds

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1. Motivation and goal

Dust particles are known as one main source of ice nuclei (**IN**). However, there are large uncertainties in the effectiveness of dust particles as IN. In this study, we combine ground-based and satellite active remote sensing to evaluate dust impacts on ice generation in Supercooled Stratiform Clouds (**SSC**). Multi-year Barrow site observations show that dust has potential to lower liquid mass partitions in mixed-phase SSC when Cloud Top Temperature (**CTT**) colder than -15 °C . This is consistent with satellite observations. Approaches are developed to quantitatively estimate dust impact with CloudSat and CALIPSO measurements of Middle level SSC (**MSSC**). By comparing ice generation in the dusty and non-dusty MSSCs, it was found that dust can enhance ice number concentrations in MSSCs by a factor 2 to 6 depending on CTT. The dust ice enhancement is also a function of dust concentration and mineralogical composition.

2. Spring time dust impacts in SSC observed at Barrow

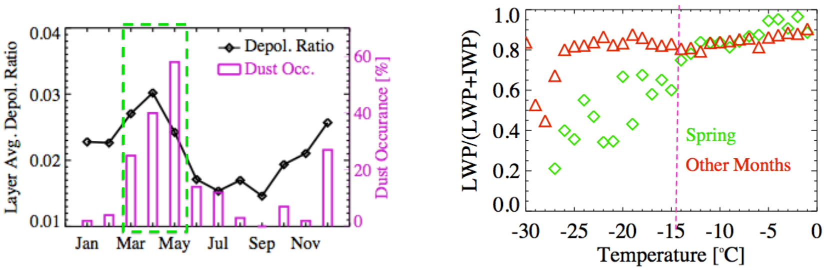
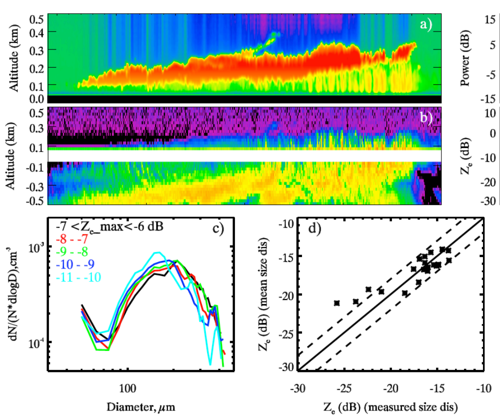


Fig. 1. At the Barrow site, spring time dust could be responsible for significantly lower liquid-ice mass partition in arctic mixed-phase clouds when CTT colder than -15 °C .

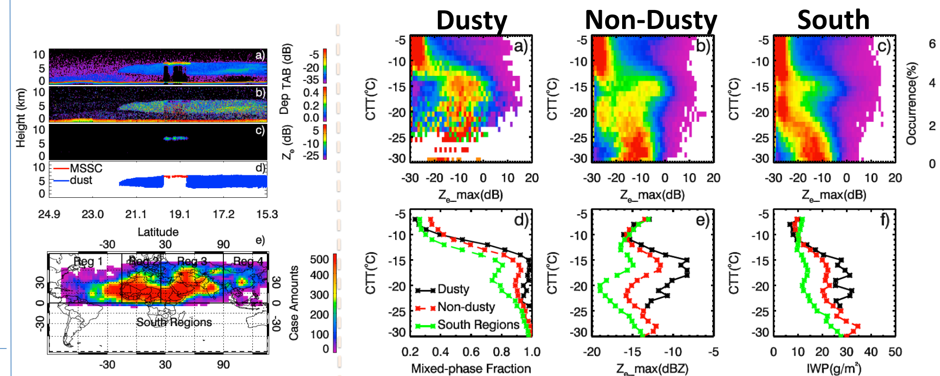
3. Ice growth in SSC

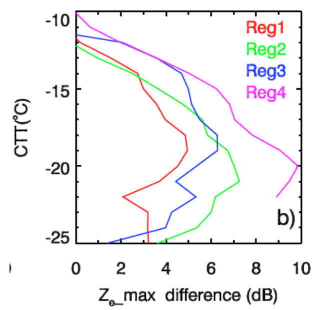
For similar SSCs in terms of CTT and LWP, ice particle growth and falling trajectory in them are same statistically. Therefore, observed Z_e differences among similar SSCs reflect ice number concentration difference.

Fig. 2. A MSSC observed by airborne lidar (a), radar (b), and 2D-C probe (c) during the ICE-T project. Among different Z_e values, normalized ice particle size distributions (by total concentration) are similar (c and d).



4. Dust impacts in MSSC observed by satellite active measurements





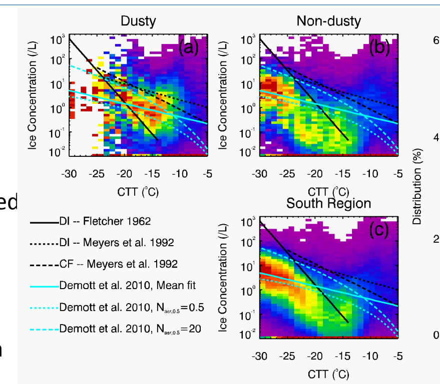
Upper left: An example of MSSC embedded in a dust layer observed by CloudSat and CALIPSO satellites. Multi-year satellite data offer a large sample to study dust impact.

Upper right: (a-c) MSSC occurrence as a function of CTT and Z_e_max (CloudSat maximum Z_e within 500 m of cloud top). Dust impacts are illustrated with mixed-phase fraction, mean Z_e_max and IWP. A 8 dBZ higher Z_e_max indicates a factor 6 higher ice concentration in dusty MSSC.

Lower left: Regional different dust impacts illustrated by Z_e_max difference (Dusty - South Regions).

5. Dust impacts in the context of ice concentration parameterization

- Ice concentration in MSSC can be estimated from Z_e (see poster by Zhang et al).
- Dusty MSSC contain much higher ice concentration.
- Large variations of observed and parameterized ice concentration at a given temperature.
- Old and widely used ice concentration parameterizations over estimate ice concentrations in non-dusty conditions.
- We are working to link ice concentration with aerosol properties and other processes.



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