“Remote sensing” ice generation

Quantify dust impact on heterogeneous ice generation remotely

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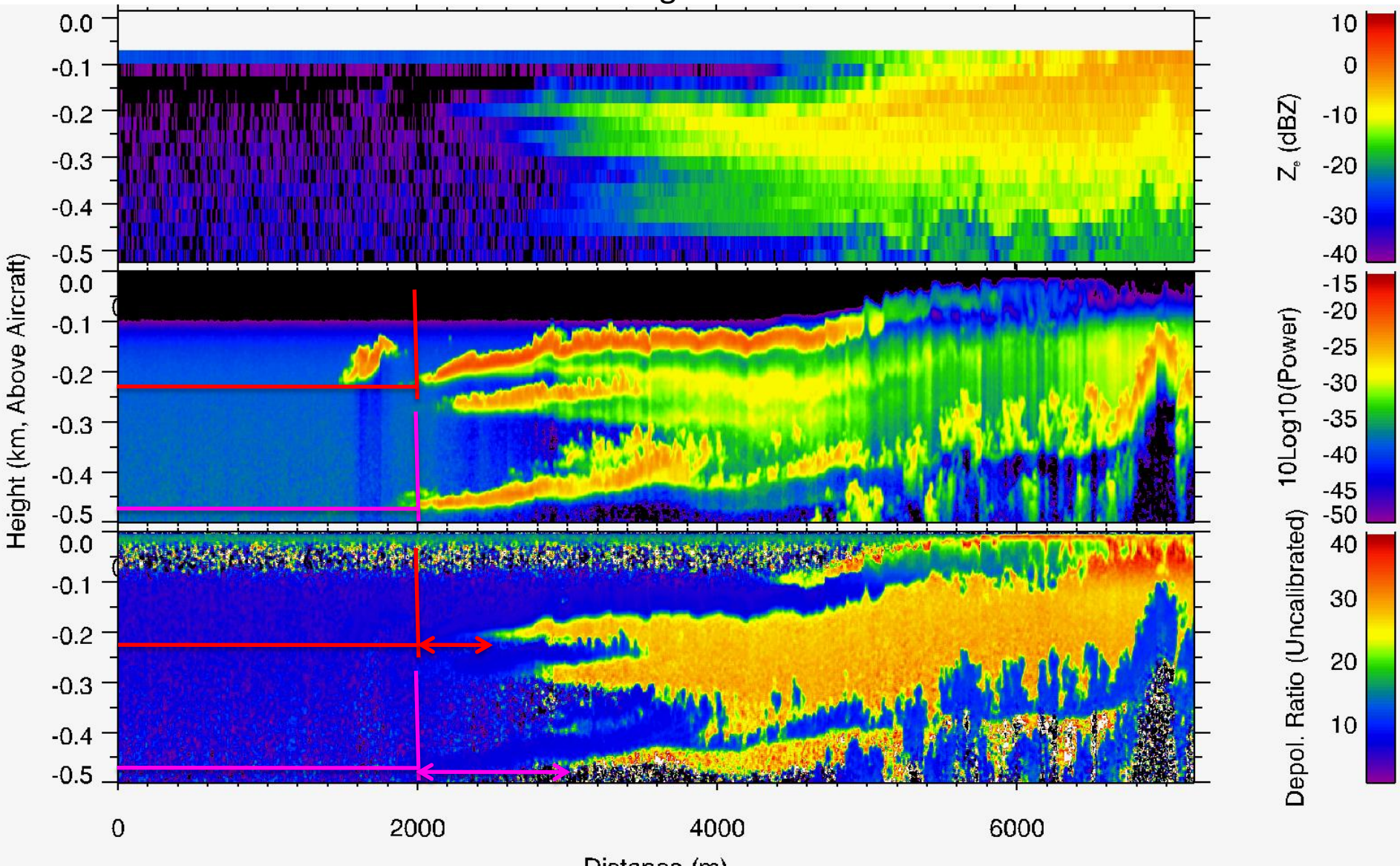
WCL and WCR observations of ice generation in a multi-layer wave clouds.

-31°C at the flight level



Why are there rooms for remote sensing?

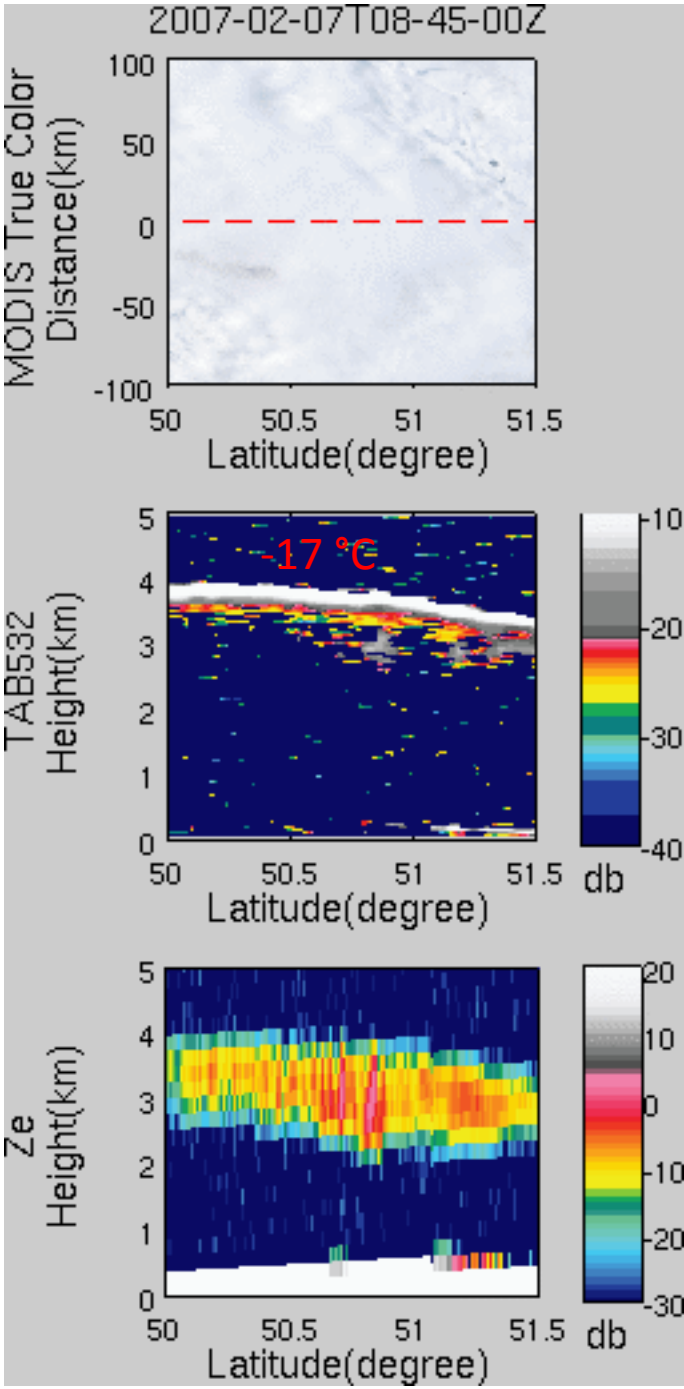
- Big uncertainty exist in our knowledge on ice generation – we can make some progresses remote sensing even with **BIG** uncertainties.

- The global picture from remote sensing

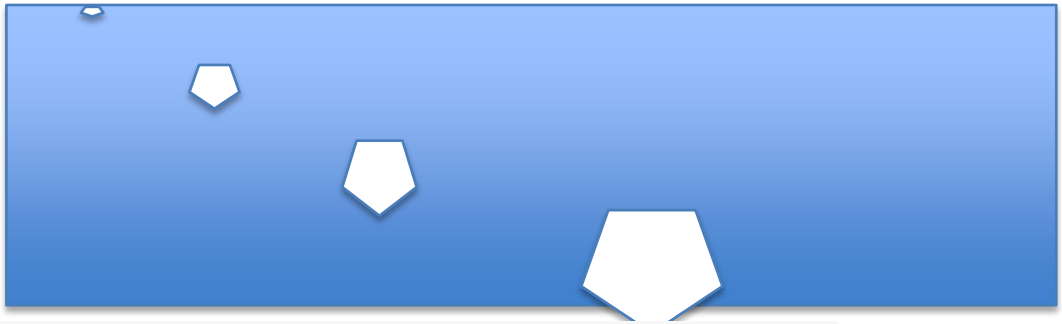
- **But**, we have to relay on **in situ** measurements to develop new potentials.

The approach

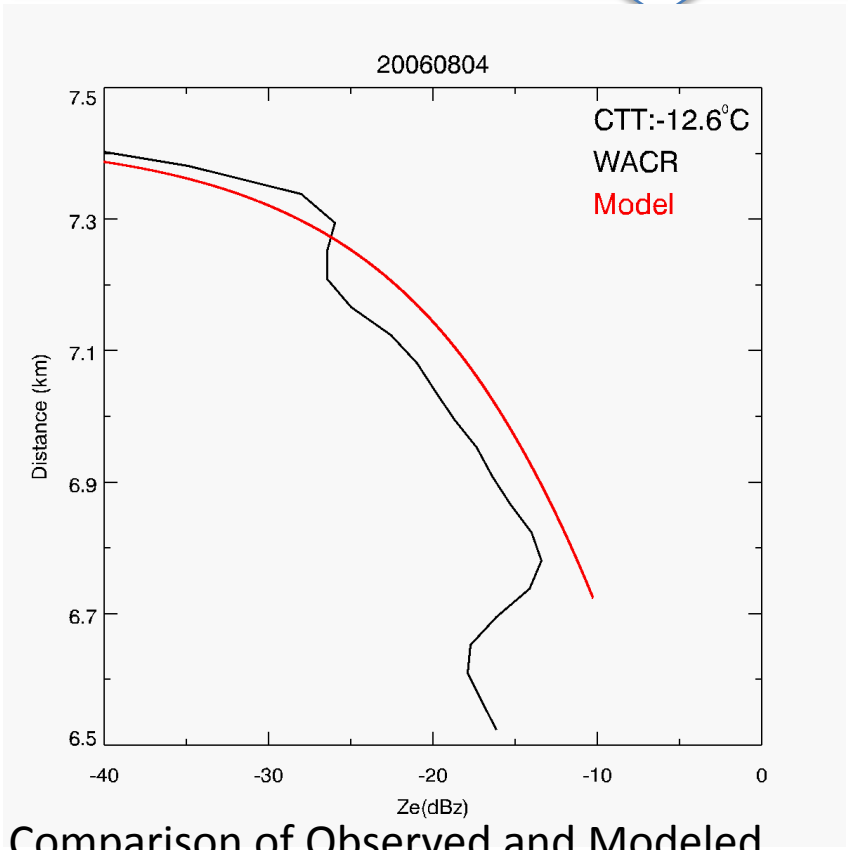
1. Select right clouds – mixed-phase Ac → heterogeneous ice generation
2. Understand the growth of ice in them
3. Evaluate with in situ observations
4. Extend in situ measurements to the global view of ice generation with the remote sensing.



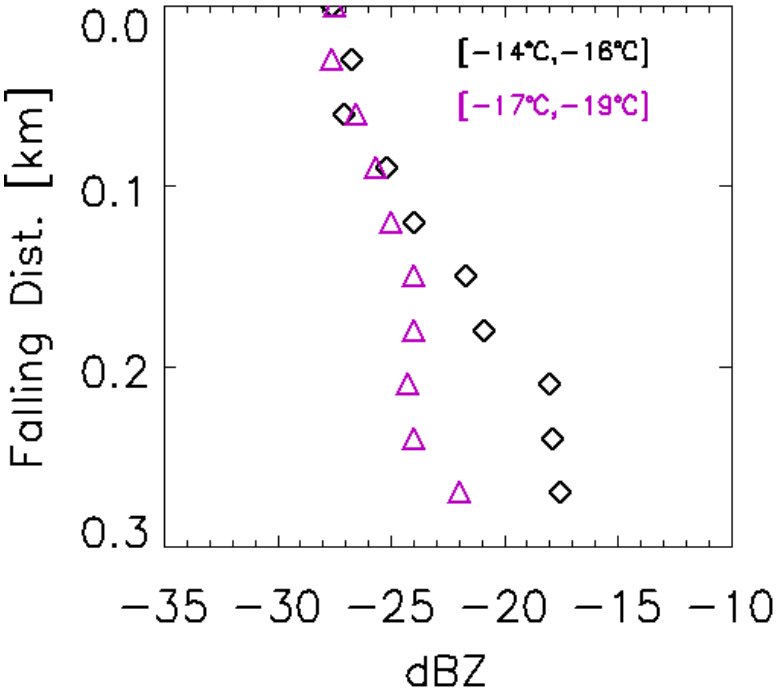
The growth model



1. Given cloud top temperature and LWP.
2. Ice crystal start near top, and grow and fall.

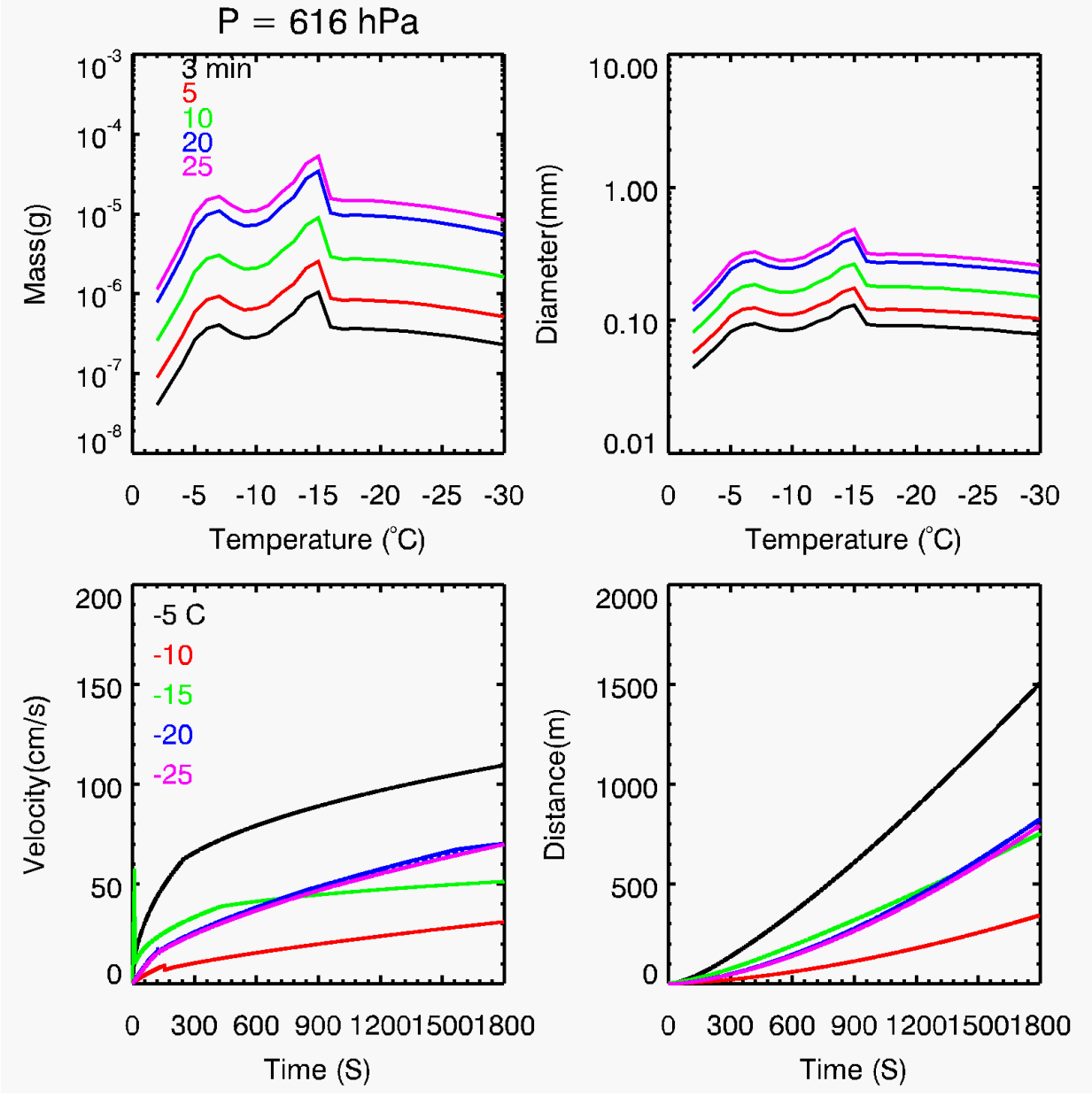


A Comparison of Observed and Modeled



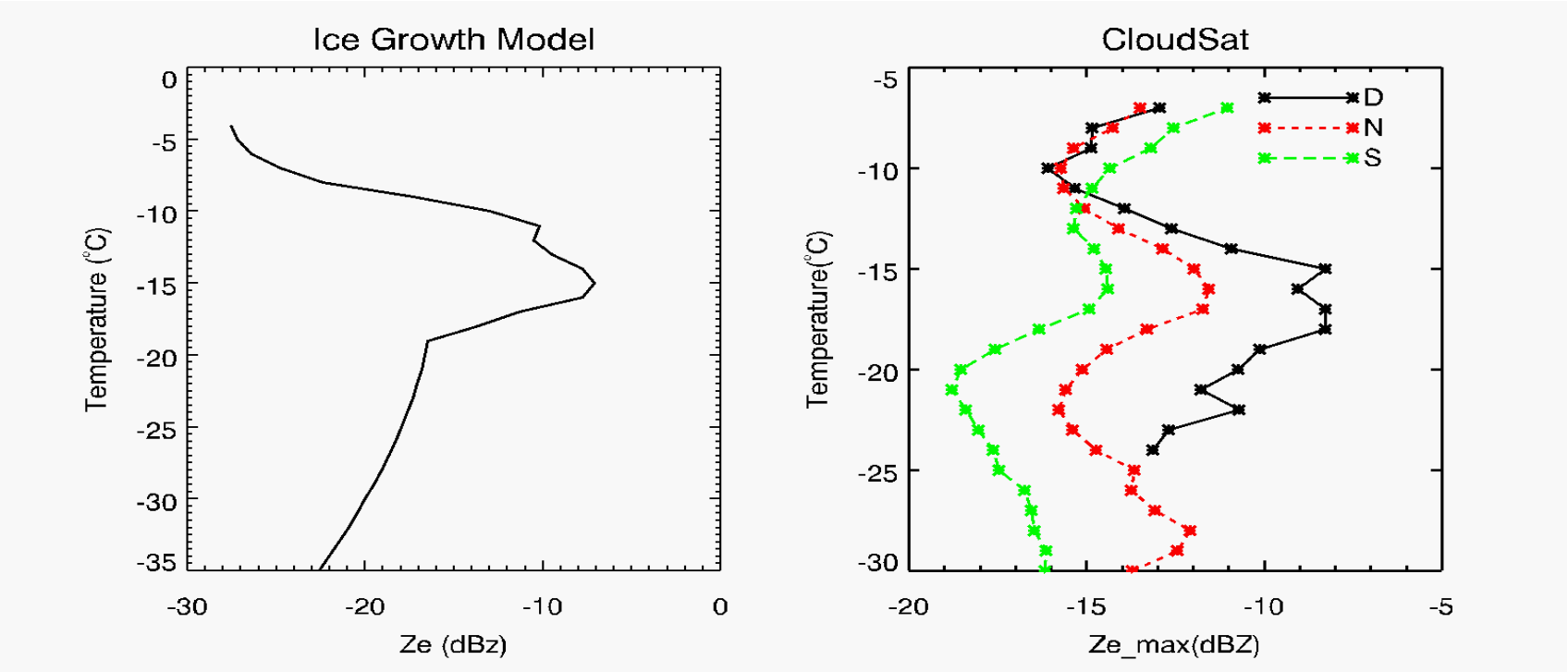
Further refinement with data at different temperatures.

Temperature Dependent Growth



Temperature Dependent Ze

Within 500m of cloud top



Modeled Ze for 1 per liter ice concentration

Observed Ze

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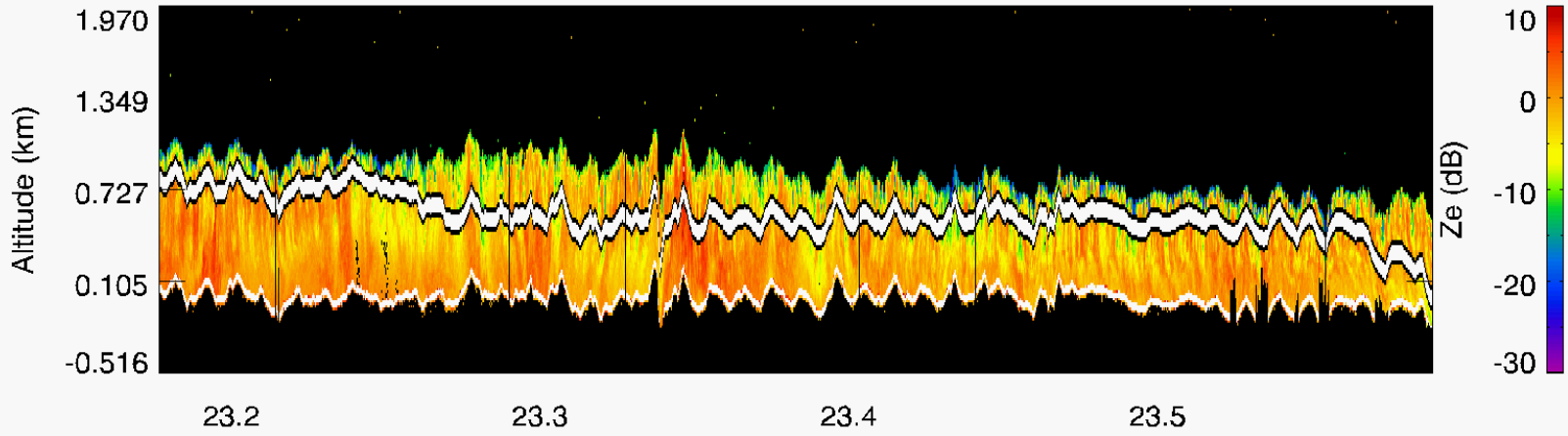
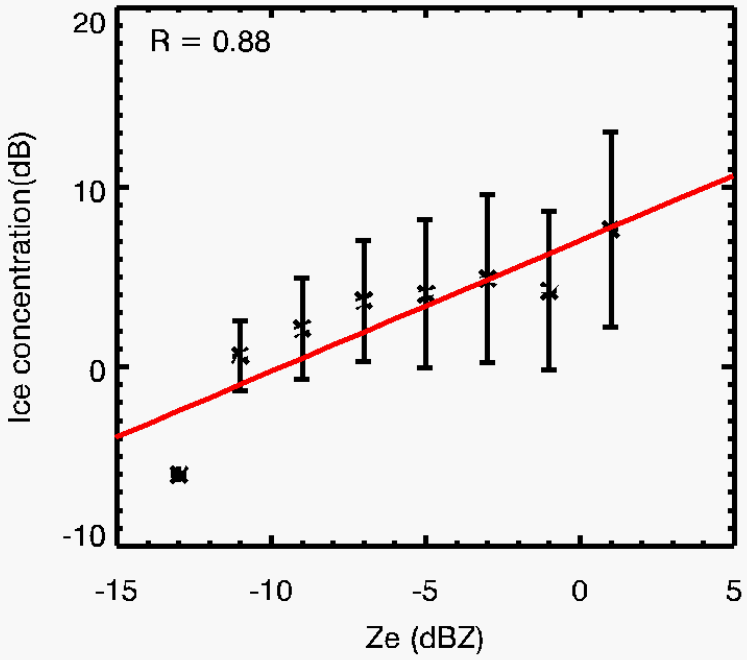
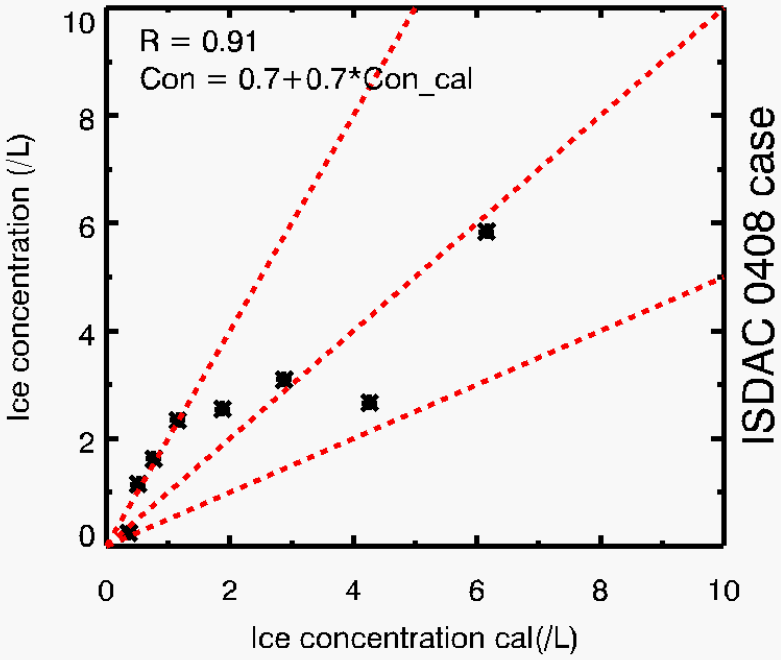
Observed global ice generation within -6 and -38 degree.

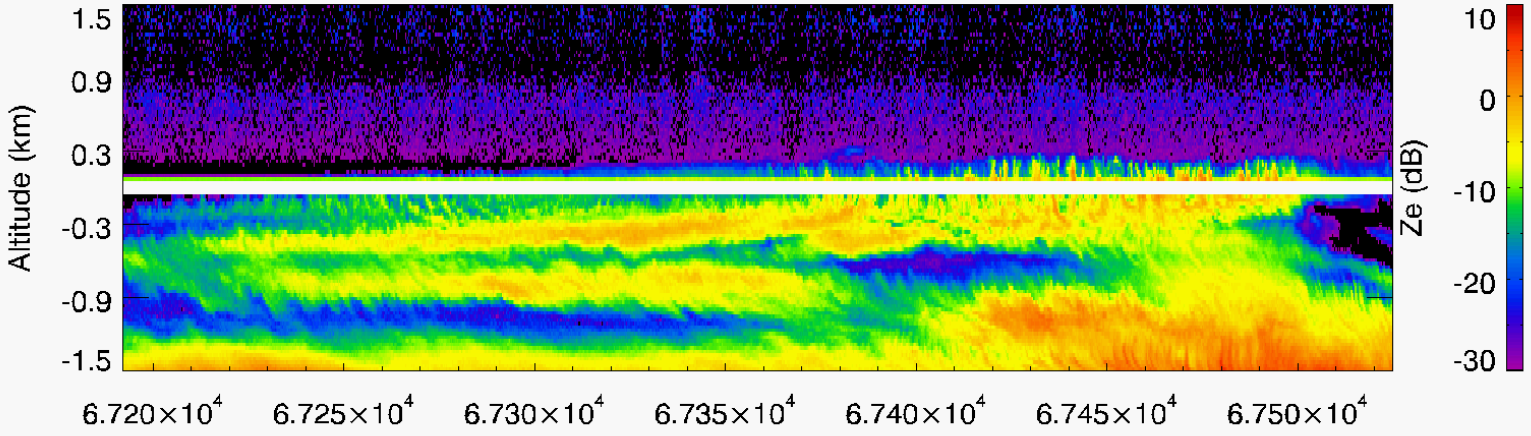
In situ case 1: -15 °C

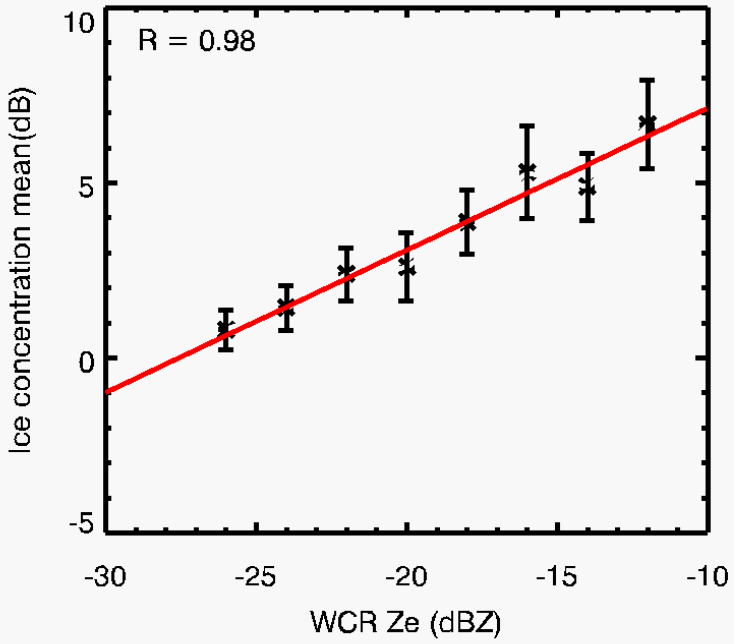


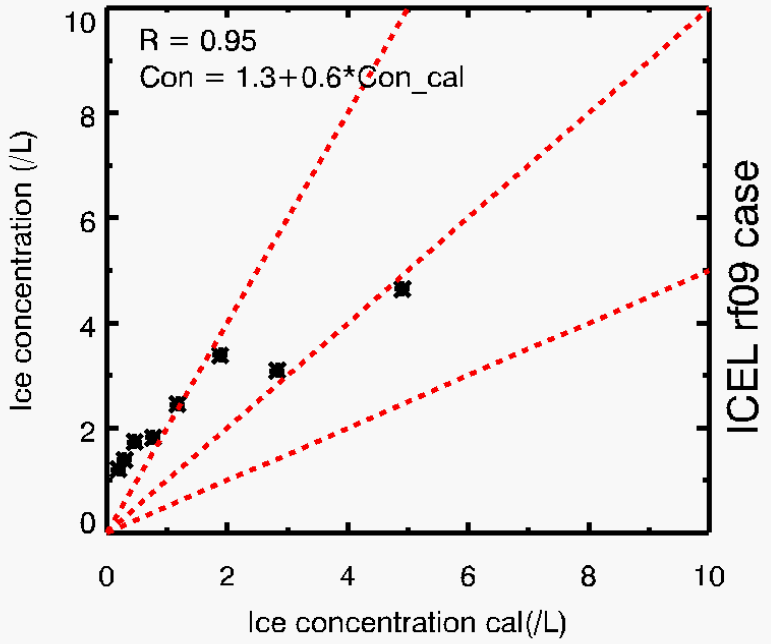




In situ case 1: -23 °C



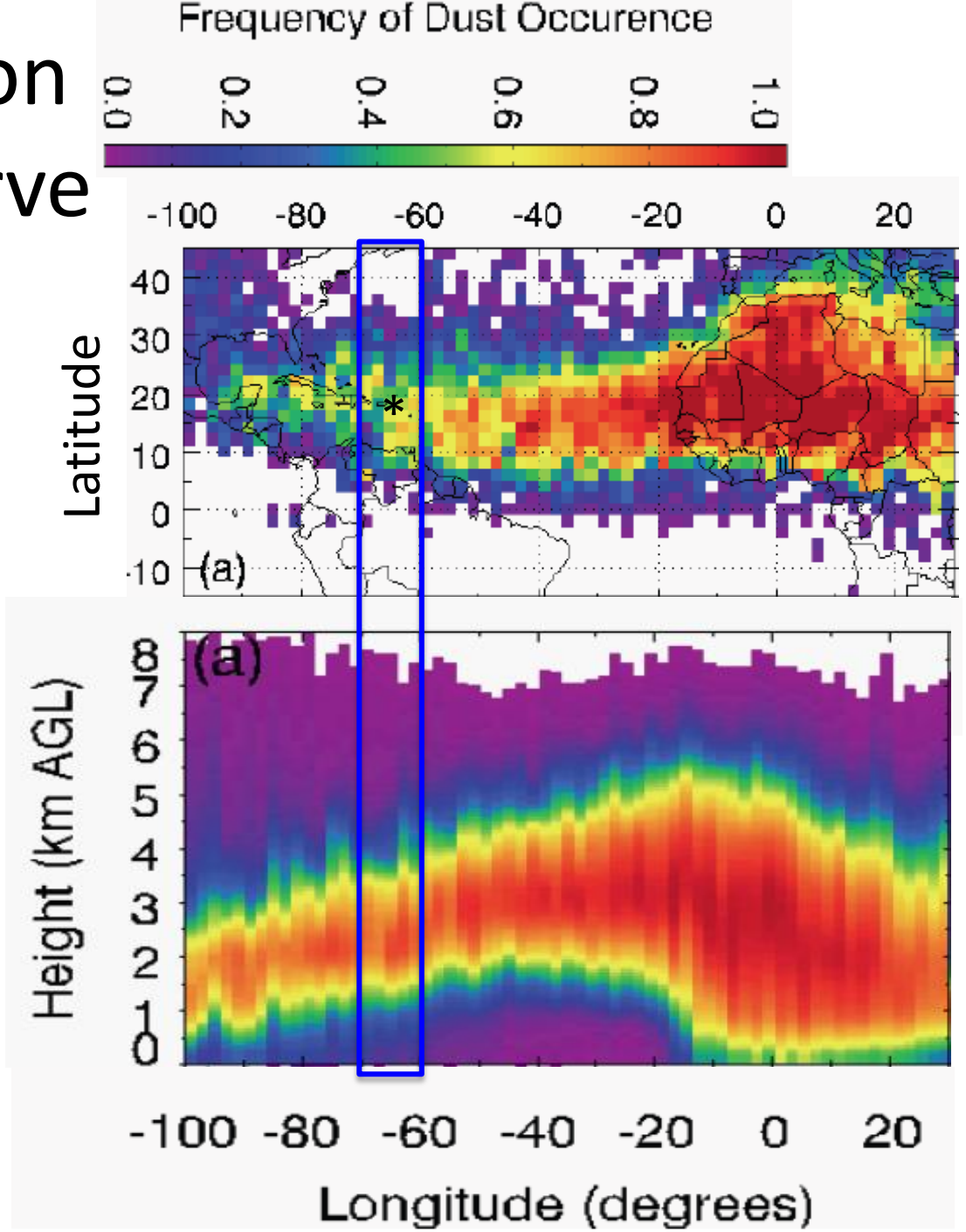




ICE-T: nice location and time to observe dust impact.

The JJA mean dust occurrence

The vertical location of dust when they occur.

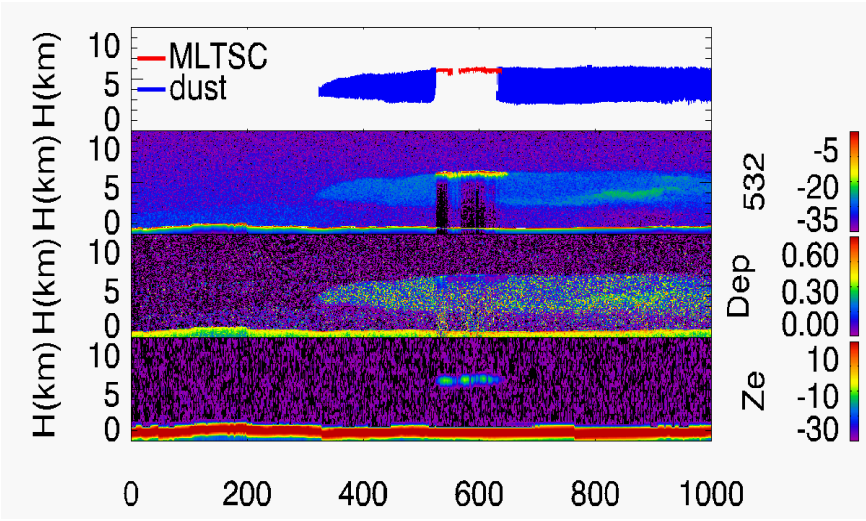


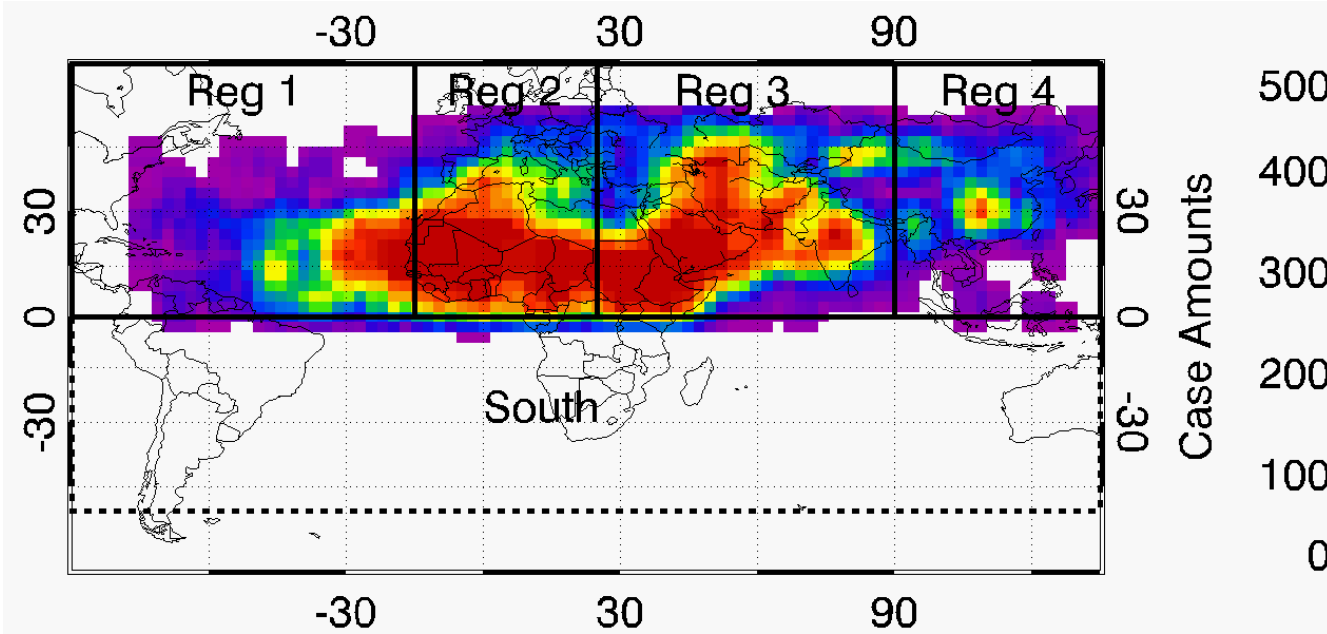
Dusty Conditions

1.Clouds with dense dust plume – ***dusty***

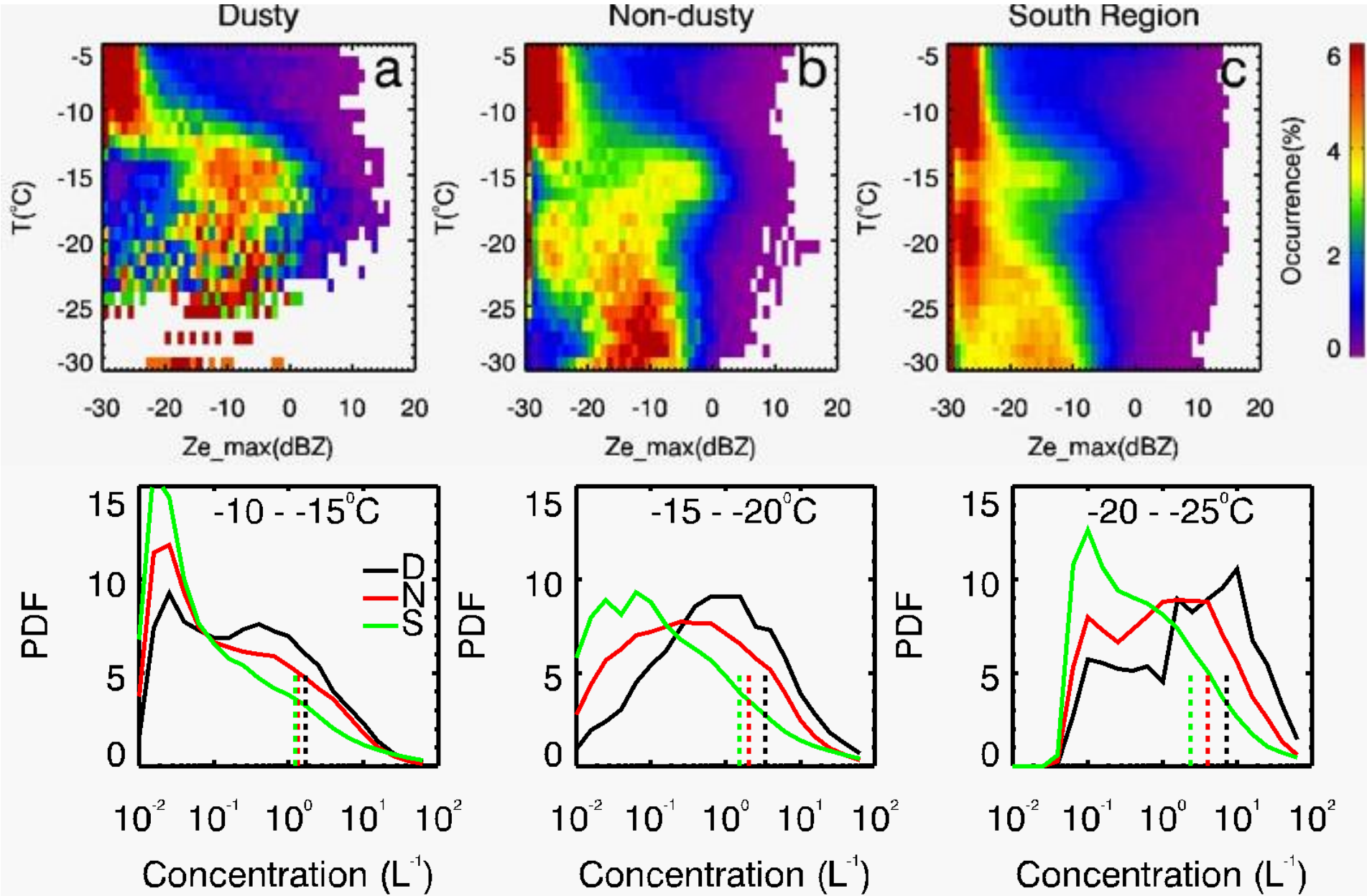
2. Clouds over dust belt without clear dust layer – ***non-dusty***

3. The same lat and lon zone in the southern hemisphere – ***south***





Dust impacts on heterogeneous ice generation



Summary

1. Remote sensing (lidar and radar) is capable to estimate ice crystal number concentration in mixed-phase altocumulus clouds with uncertainties about a factor of 2 (statistically).
2. Dust can enhance ice number concentration in mixed-phase altocumulus clouds by a factor 2 to 5.