NCAR Microphysical parameterization work

(FAA Model Development and Enhancement PDT supported)

- **Goals:**
  - Improve forecasts of water phase at surface and aloft to support aircraft icing forecasts.
  - Incorporate recent microphysical observations from field projects (WISP, AIRS, SLDRP, ICE-L, etc.).
  - Transition to operations (RUC and WRF-Rapid Refresh).

- **Sponsor**: FAA's Aviation Wx Research Program

- **Participants**:
  - **NCAR:** Greg Thompson, Roy Rasmussen, Trude Eidhammer
  - **Collaborators:** Istvan Geresdi (U. of Pecs, Hungary), Ulrich Blahak (Germany), Hugh Morrison (NCAR), John Brown (NOAA/ESRL)

NCAR Microphysical parameterization work

(FAA Model Development and Enhancement PDT supported)

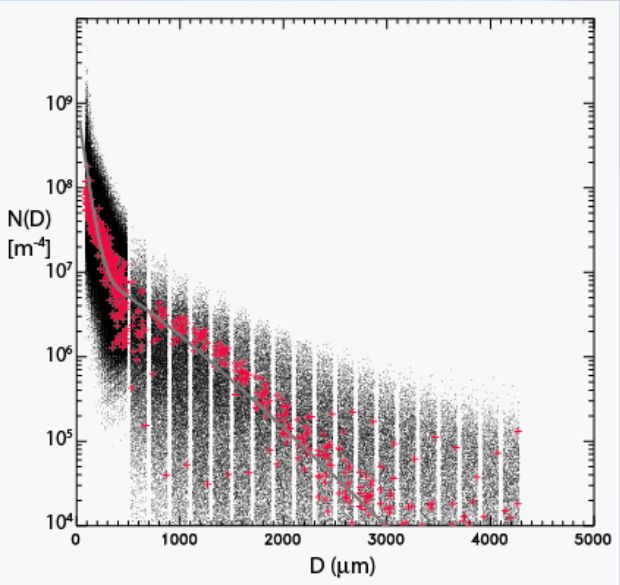
- **Accomplishments**
  - Developed Reisner et al. (1998) microphysics scheme
    - Transferred Reisner et al. 1998 scheme to the NOAA RUC modeling group for implementation into RUC2 .
  - Developed Thompson et al. (2004) scheme
    - Transferred to NOAA RUC modeling group for implementation into RUC20 and 13.
  - Developed Thompson et al. (2008) scheme.
    - Transferred to NOAA RR modeling group for implementation into Rapid Refresh 13 km and HRRR 3 km.

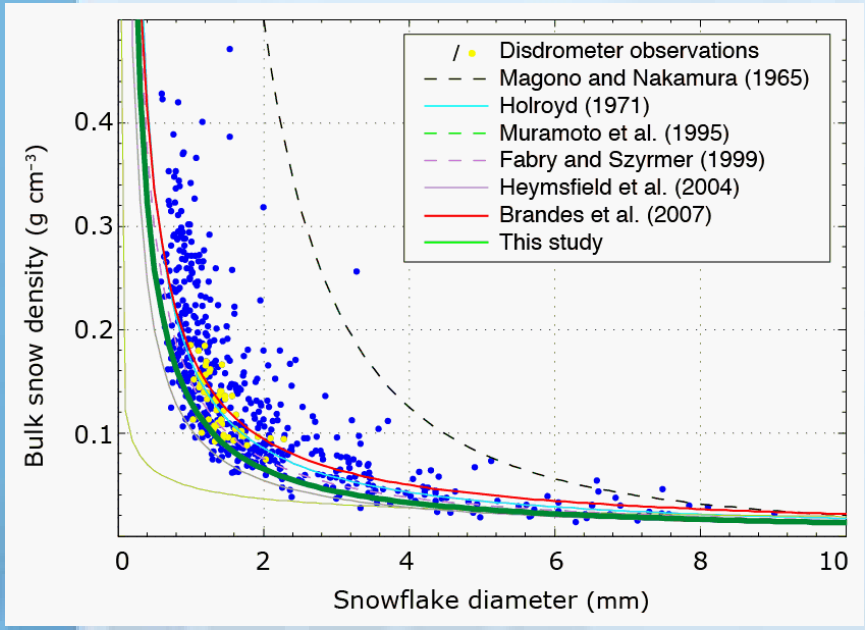
Model/ System	Horizontal Resolution	Number levels	Assimilation Frequency	Implemented at NCEP	Microphysics
RUC1	60 km	25	3 hr	Sept. 1994	
RUC2	40 km	40	1 hr	April 1998	Reisner 1998
RUC20	20 km	50	1 hr	April 2002	Thompson 2004
RUC13	13 km		1 hr	2005	Thompson 2004
RR	13 km		1 hr	mid- 2010	Thompson 2008
HRR	3 km				Thompson 2008

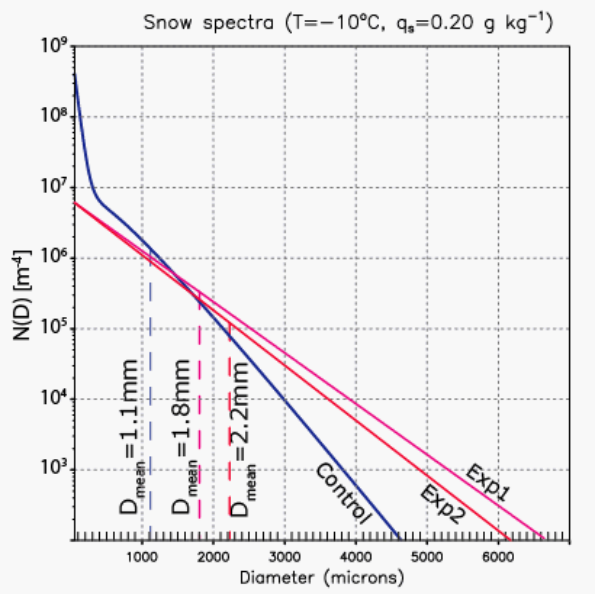
Thompson et al. 2008 MWR

- **Non-dimensional snow size distribution added with more realistic snow particle shapes**
  - More realistic diffusional growth (less than before), resulting in more SLW.
  - Improved conversion of snow to graupel (less graupel)

(Thompson et al., 2008, MWR)

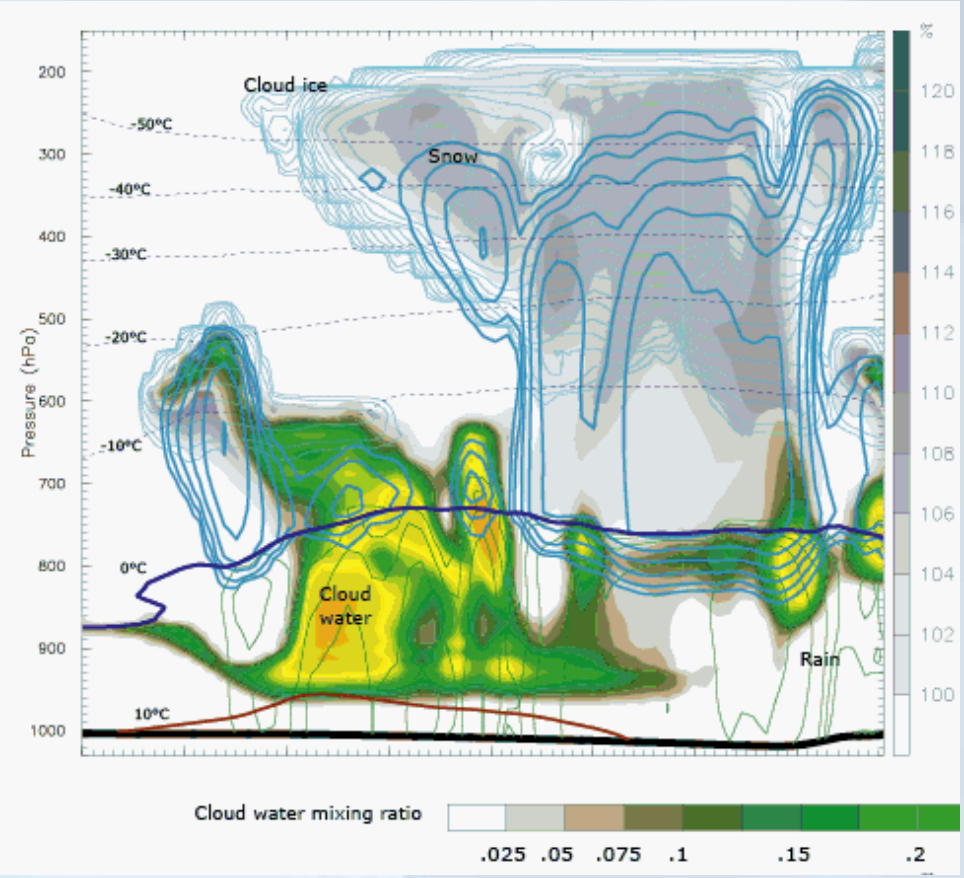






Case studies

- **Ongoing testing for large number of cases in all seasons and weather regimes:**
  - weakly-forced mesoscale events
  - orographic clouds, upslope and wave clouds
  - large & deep synoptic storms
  - convective events including squall lines and supercells
  - all cases taken from intensive field projects with specialized data resources for verification

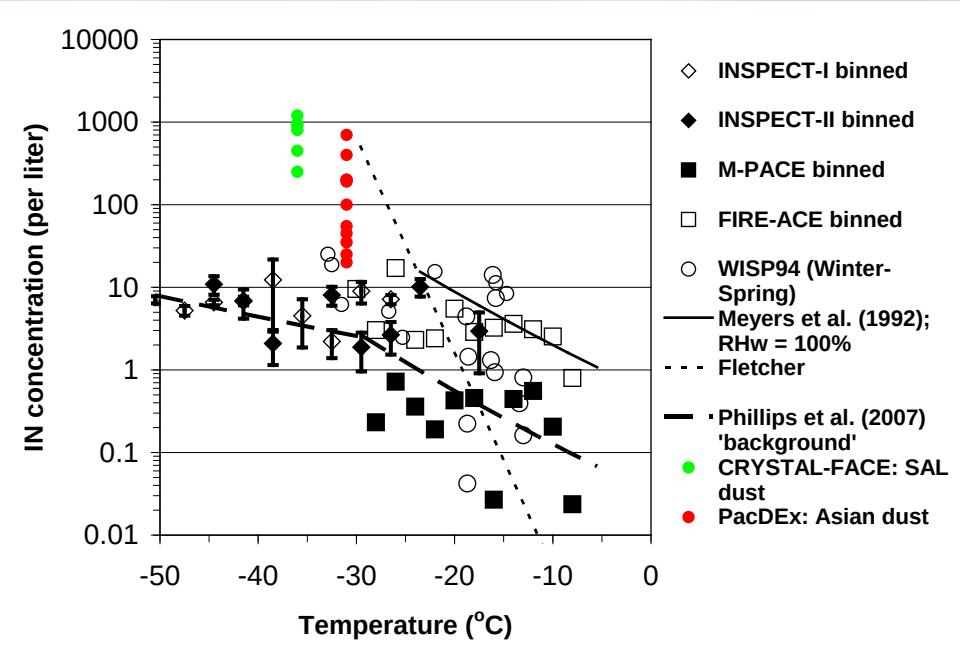


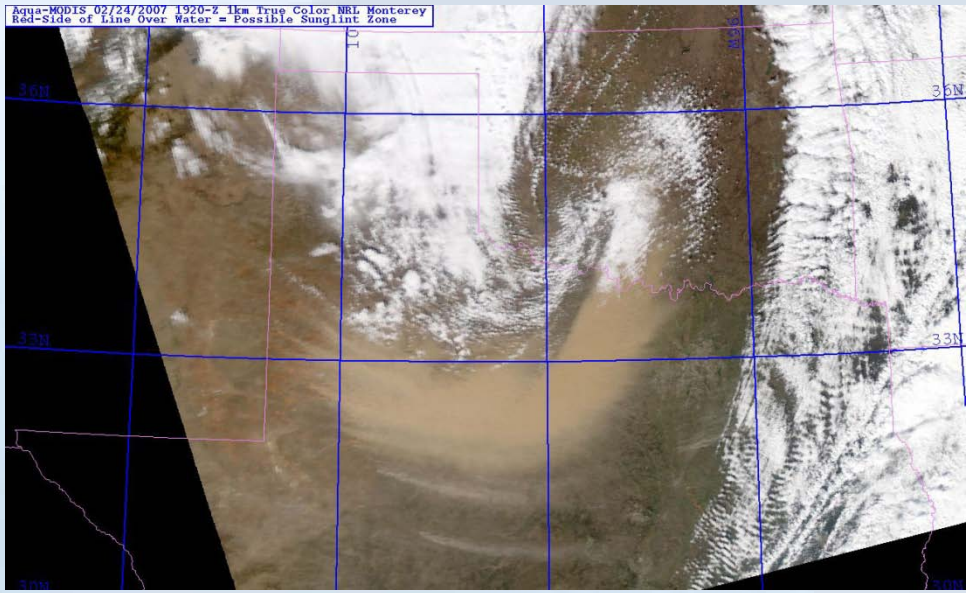
Initial success

- overall more liquid water should verify better against icing pilot reports
- deep/cold glaciated storms contain less liquid
- shallow & relatively warm clouds contain more liquid

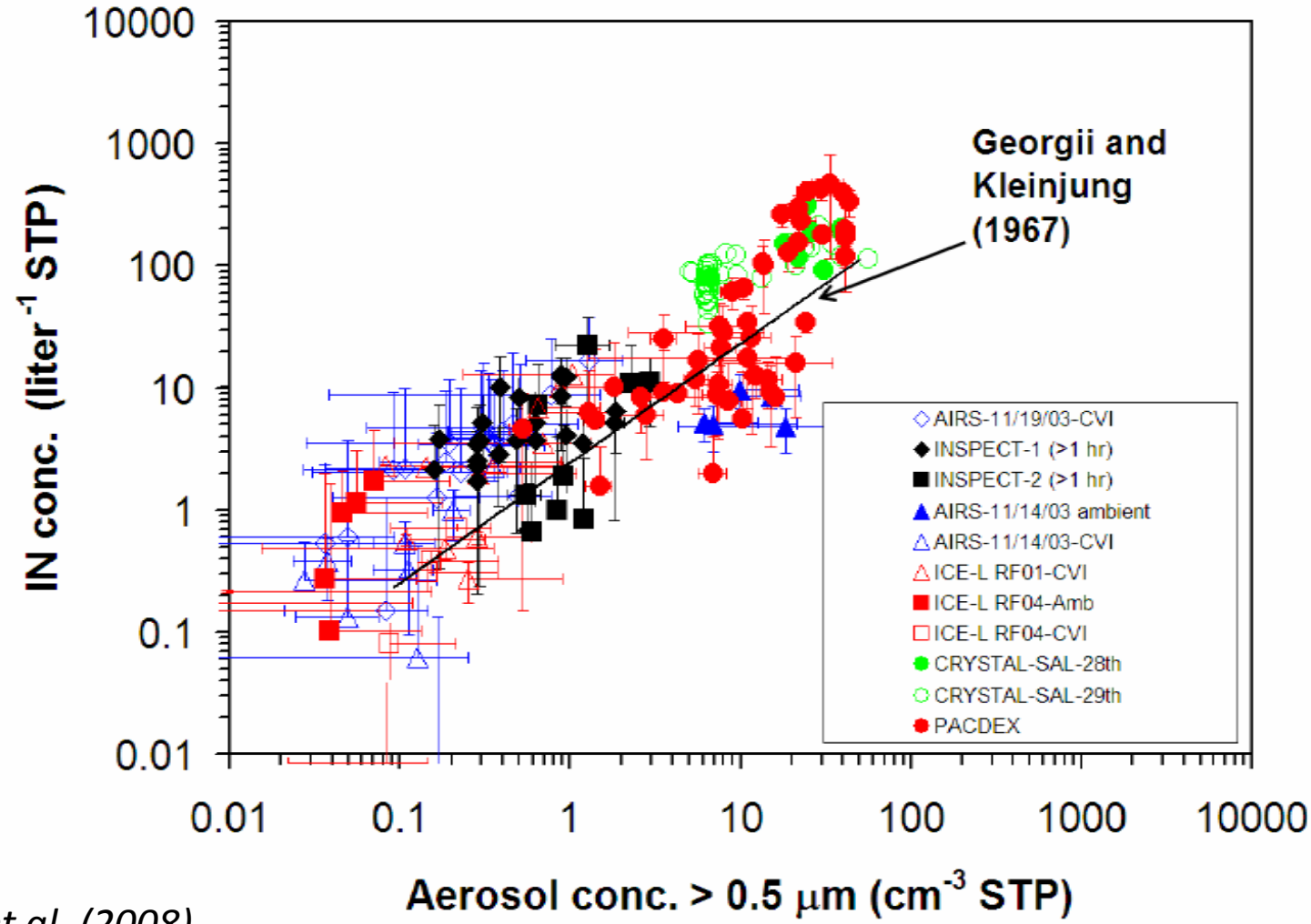
Current work

- **Adding aerosols into the microphysics scheme: dust/ice nuclei**
  - incorporate dust/mineral category and influence ice nucleation
  - ICE_L case studies
  - Hired aerosol expert Trude Eidhammer to take the lead on this effort



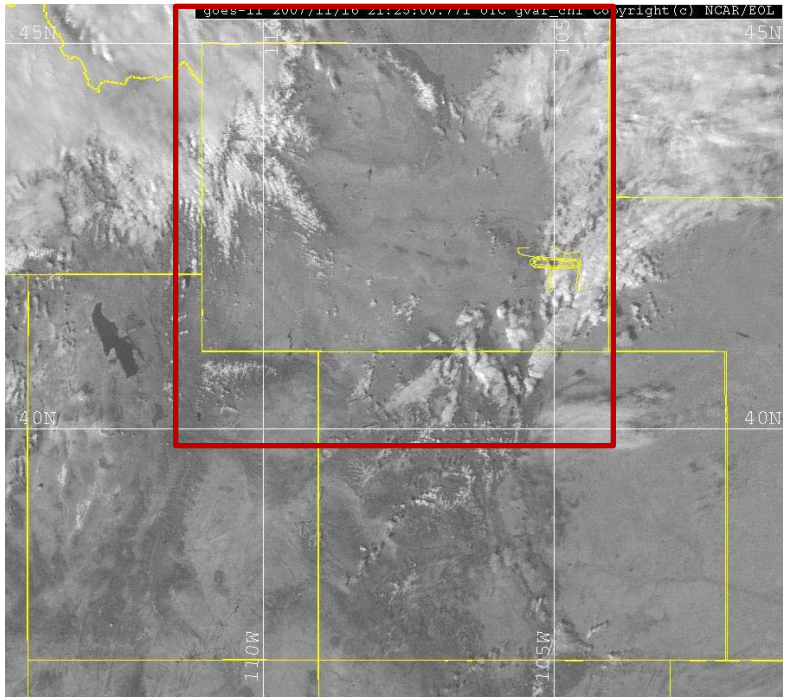


Relationship between aerosol concentration and ice nuclei (IN) concentration



DeMott et al. (2008)

Ice in Clouds Experiment – Layer clouds (ICE-L)

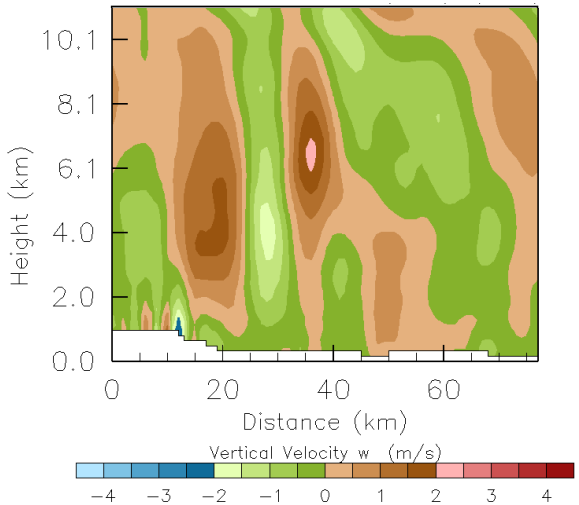


- In situ measurements of wave clouds in Wyoming and Colorado, November/December 2007.
- Focus on primary heterogeneous nucleation, in clouds where this type of nucleation can be distinguished from other types of ice nucleation.
- Mixed phased clouds

Original Thompson version (Cooper curve)

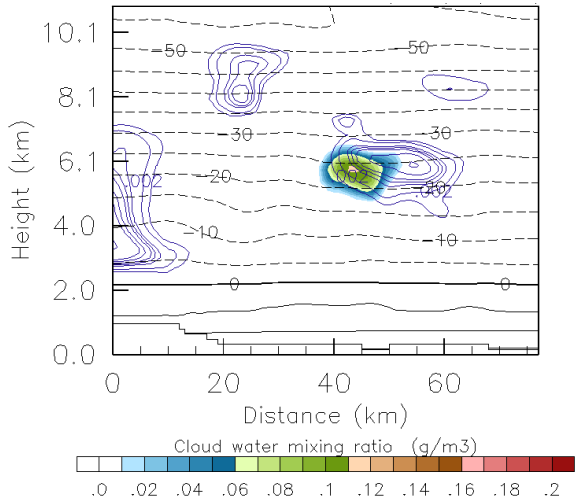
New version Dust dependent

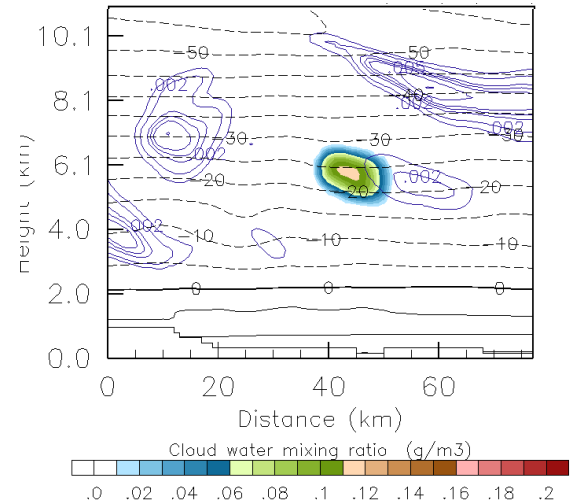
Vertical velocity



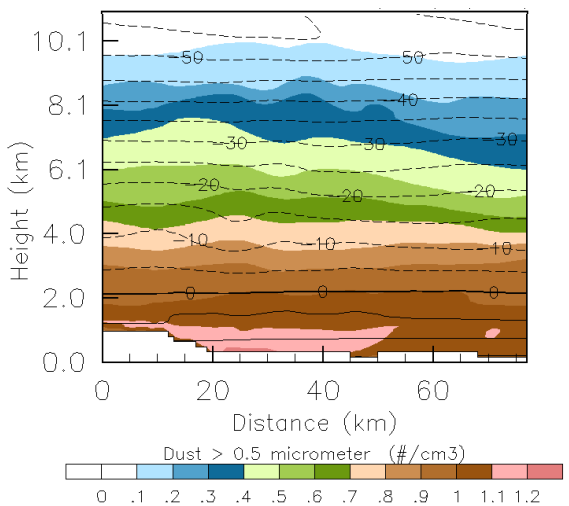
Water content

Ice and snow water content (g/m³)

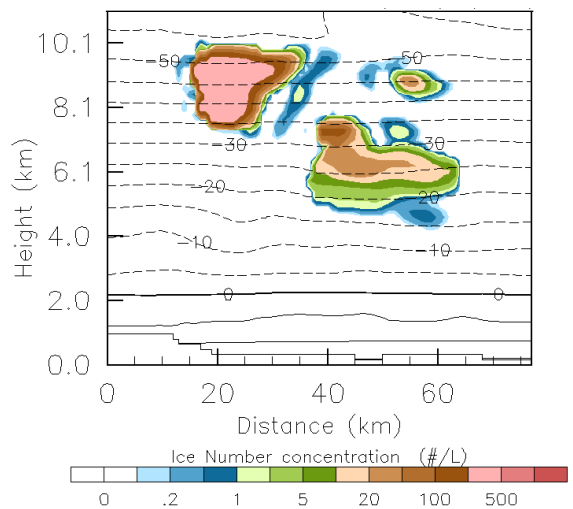


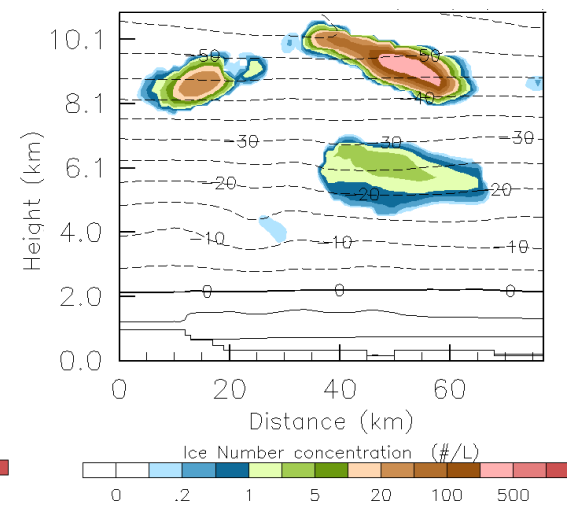


Dust concentration for sizes > 0.5 µm

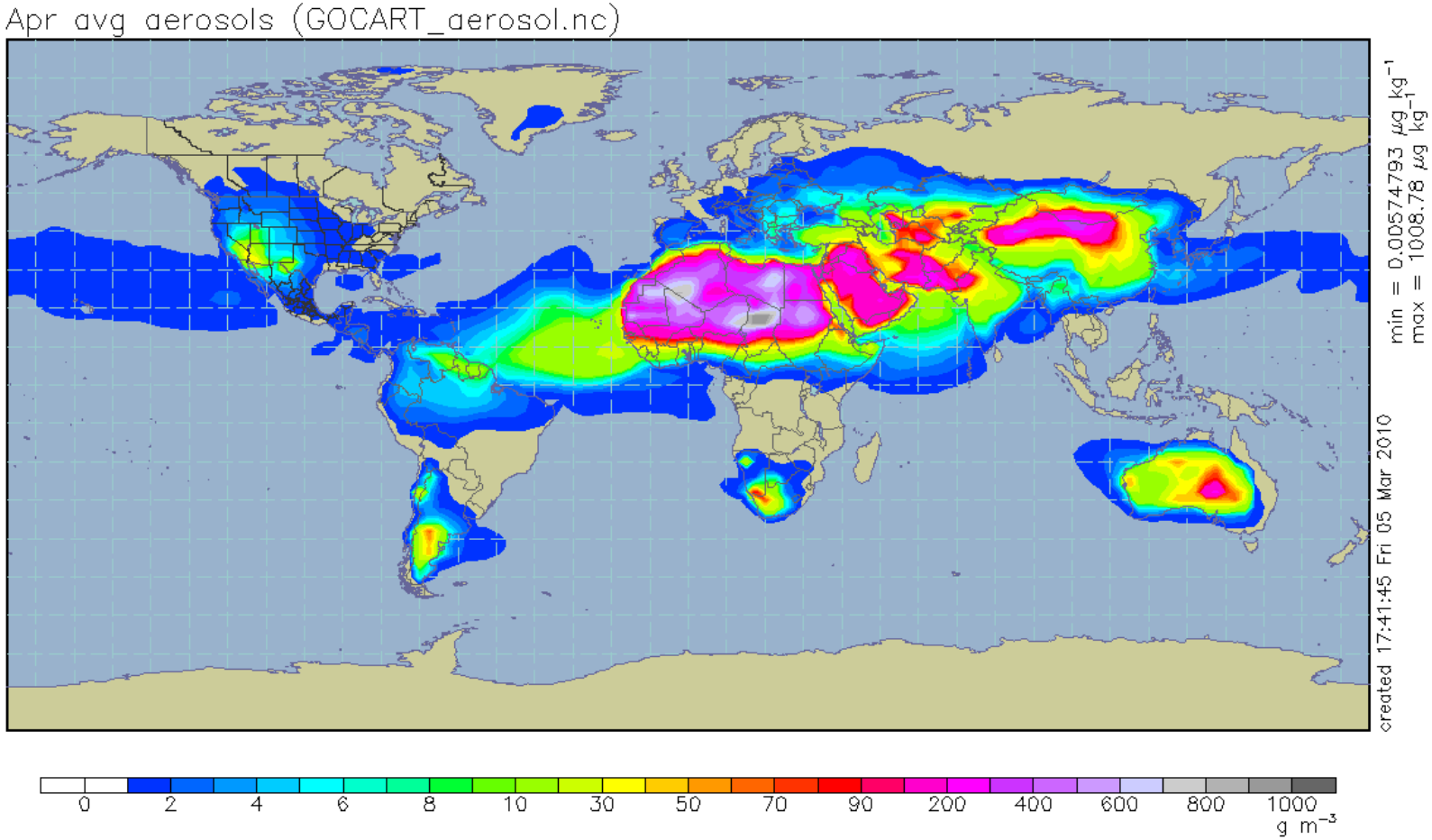


Ice crystal concentration



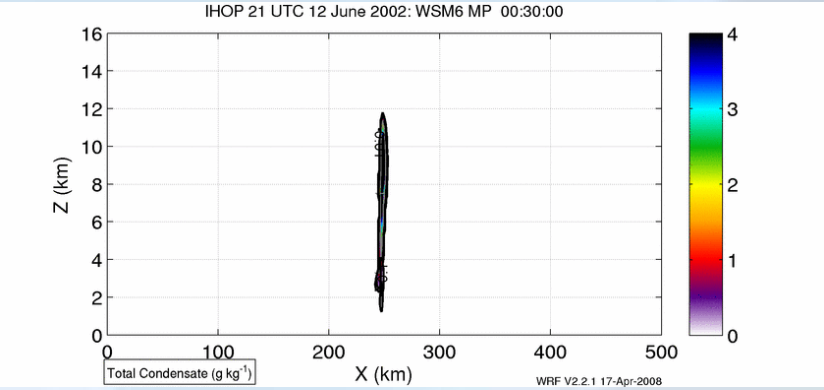


Relating Ice Nucleation to Dust in Thompson Microphysics Scheme in WRF

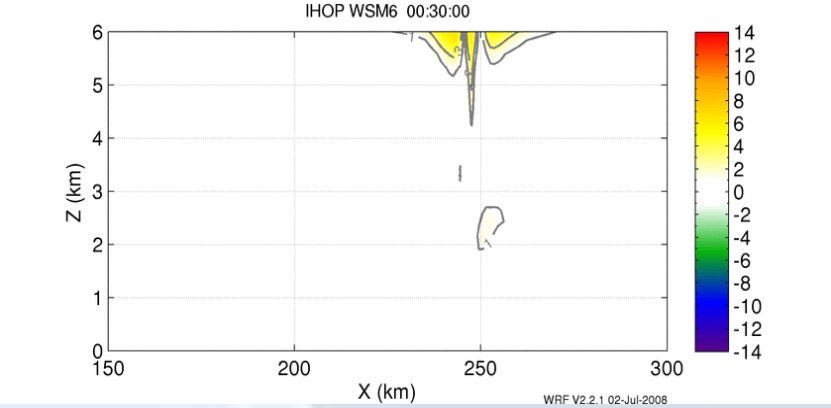


Microphysical Modeling

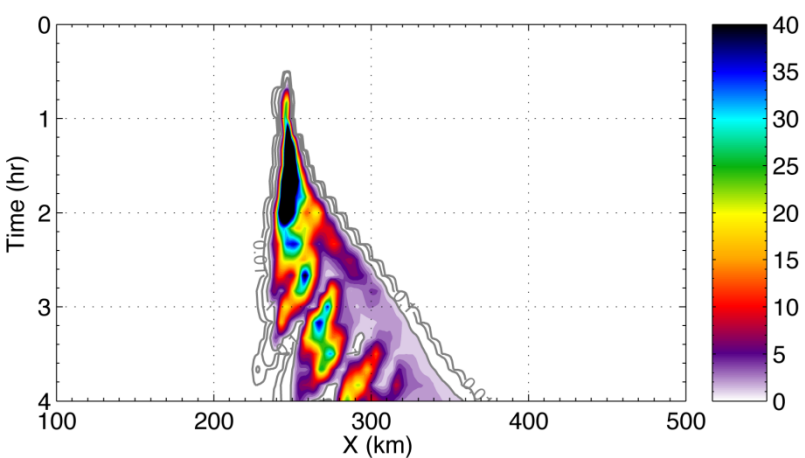
- *Understanding the role of microphysics in cold pool formation in thunderstorms (STEP)*



- *Cold Pool formation*

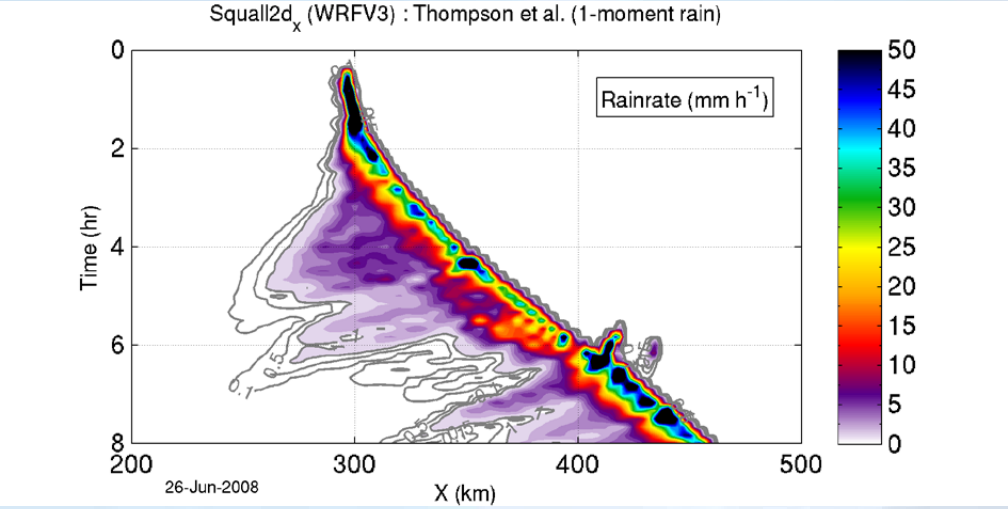


- *Hovmuller diagram of modeled reflectivity for a 4 hour period*

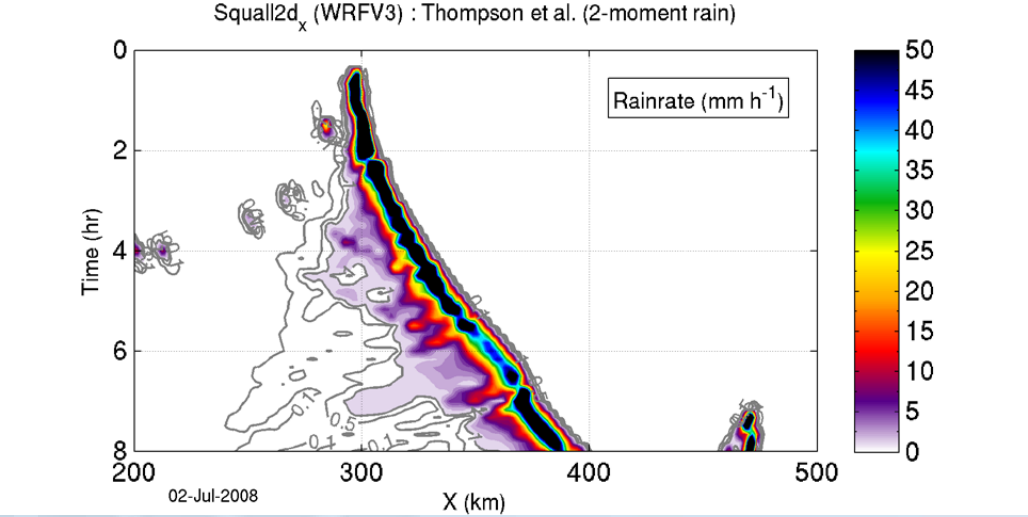


Microphysics

IHOP Squall Line simulation with 1-moment and 2-moment rain using Thompson et al. microphysics



1-moment rain



2-moment rain

Priorities and Plans for FY10-11

- **Priorities:**
  - Continue case study analysis and transition to operations.
  - Use explicit supercooled water predictions to improve FAA icing algorithms (FIP).
  - Incorporate more aerosol chemical species and interactions plus explicit droplet nucleation and ice nuclation.
  - Continue to improve bulk schemes using guidance from bin/detailed scheme(s).