ICE-T Science Objectives, Data Analysis & Numerical Modeling

Sonia Lasher-Trapp & Alexandria Johnson (graduate student)

ICE-T Planning workshop

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Science Objectives

- Importance of the warm rain process (WRP) to ice nucleation
  - Freezing of raindrops as a source of the first ice → secondary processes including drop shattering, or rime-splintering thereafter?
  - How does the presence of desert dust affect these mechanisms (soluble coatings to act as CCN, or just as more IN)?

- Enhanced ice nucleation in evaporation zones
  - Can we find evidence of this being true during ICE-T?
  - Maritime cumuli appear to become diluted more quickly than continental cumuli

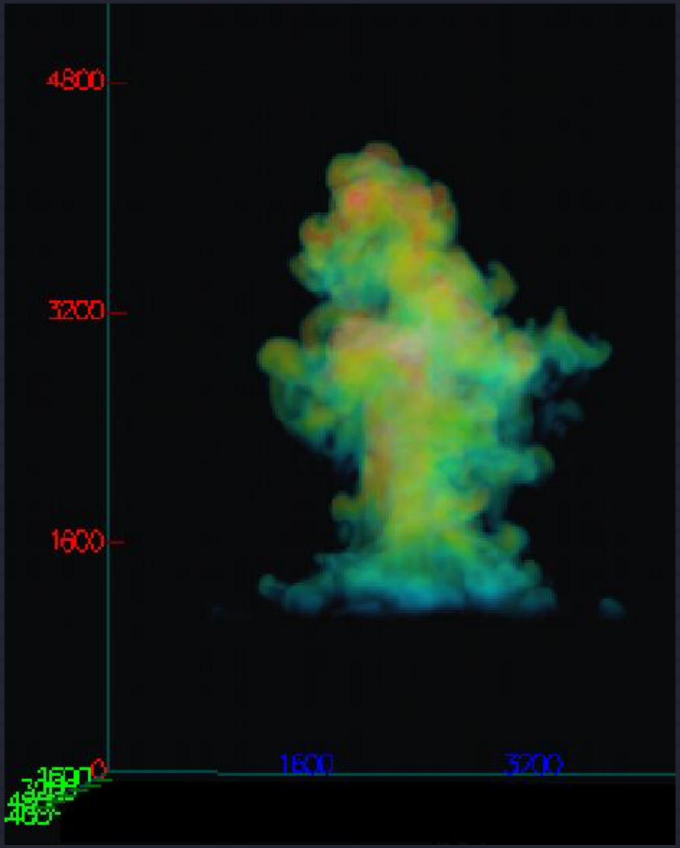
- APIPS
  - Can we rule out the influence of APIPS upon our ICE-T data set? Do we see the same enhancements in ice crystal numbers if we do?

Purdue Cloud Microphysics

Placing the ICE-T Data in a Dynamical Context: 3D Cloud Modeling with Bulk Microphysics

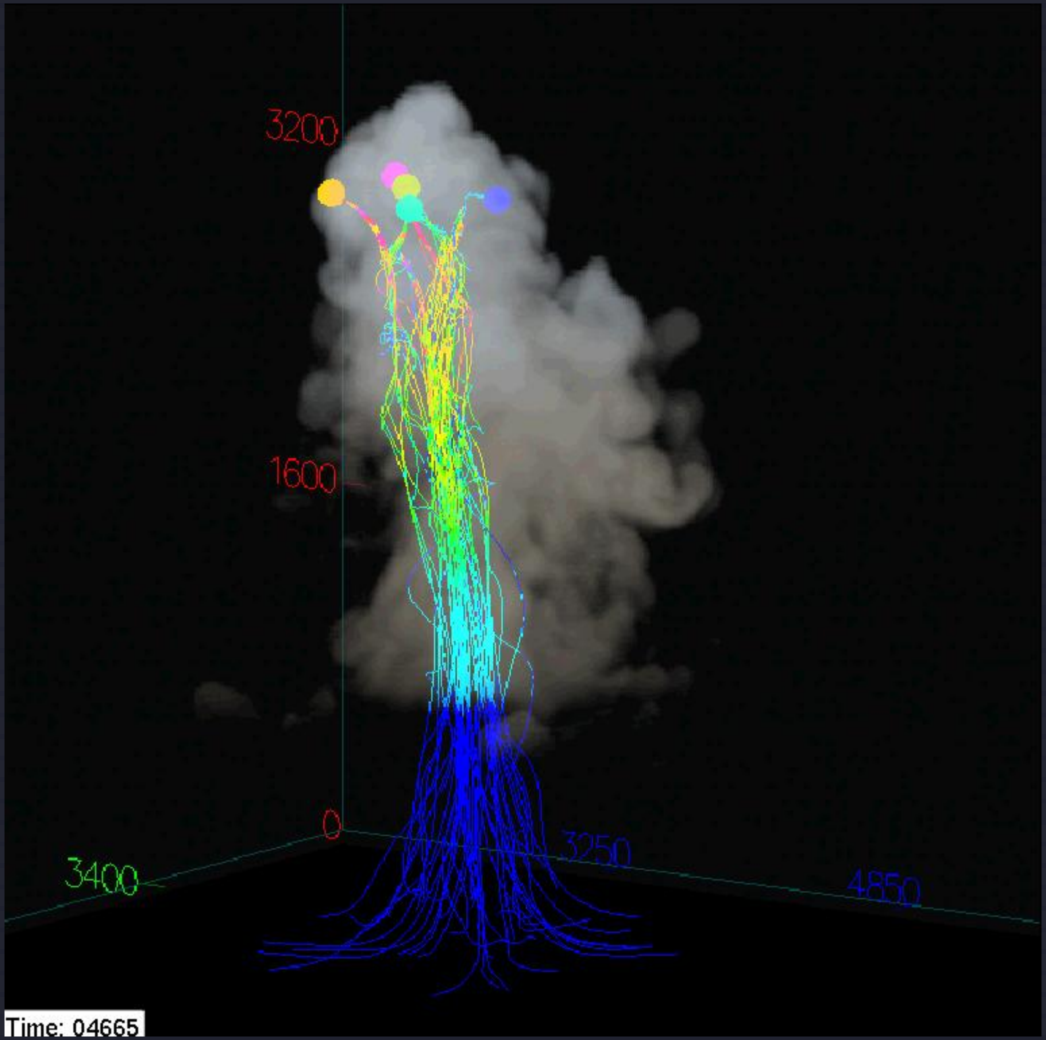
- Straka Atmospheric Model will be used to create a 3D simulation representative of the clouds on each day of interest, constrained by the data collected.
  - Model initialized with atmospheric sounding
  - Documentation of cloud top heights and cloud evolution with WCL and WCR
  - Documentation of DSDs from warm rain process at freezing level
  - Documentation of PSDs from earliest ice processes
  - 10 classes of ice in the model allow for consideration of different fall velocities and reasonable zones of interaction among ice and liquid & to test hypotheses regarding time and space of nucleation of first ice

- Test simulations against cases with and without desert dust
- Is first ice always observed in downdrafts (evaporation zones), or could it be transported there but nucleated in other regions? Comparison with WCR dual-Doppler analysis from U of Wyoming
- If simulate APIP formation, how quickly and where are they transported--where might they be influencing our observations?



PURDUE CLOUD MICROPHYSICS

Placing the ICE-T Data in a "Historical" Thermodynamic Context: Lagrangian Modeling along Particle Trajectories



- Knowledge of the variable conditions (T, S) experienced by different particles can help to sort out variability seen in the observations.
- Different microphysical "parcel" models will be initialized with observed CCN and CSU's IN, run along the trajectories using the modeled conditions to test various scenarios with primary and secondary nucleation processes by comparing with observed PSDs and WCR data.
- Entrainment of desert dust and ice nuclei into the sides of the developing cumuli can also be studied

PURDUE CLOUD MICROPHYSICS

Flight Plan in Support of Numerical Modeling Studies

- Every flight: Clear-air sampling:
  - aircraft sounding once "on station" up to 7.5 km (25 kft or higher?). (time = x hr?)
  - Sample CCN/giant particles/IN beneath cloud base. Also document updraft speeds beneath cloud bases. (time = 1 hr?)
  - Sample CCN/giant particles/IN in clear air up to -15 °C. (time = x hr?)
- Every flight: Sample cloud bases to document conditions there, especially number of cloud droplets.
- Single-cloud studies:
  - Cloud penetration as cloud top ascends thru 0 °C; document products of warm rain process.
  - Penetrations as cloud top ascends thru -5 °C, -10 °C, -12 °C, etc. (likely only time for one of these passes)
- Statistical sampling:
  - Cloud penetrations at 0 °C – clouds at various stages. Use WCR/WCL to document cloud top height for each cloud sampled.
  - Penetrations at -5 °C, -10 °C, -12 °C, etc. – clouds at various stages. Use WCR/WCL to document cloud top height for each cloud sampled.
  - Fly over tops of clouds at 0 °C, -5 °C, -10 °C, -12 °C, etc.; use WCR to discern ice development.
- Every flight: Clear-air sampling:
  - aircraft sounding up to 7.5 km (25 kft or higher?) before departing study area

Flight Plan in Support of APIPs Studies

- (Same) Clear-air sampling:
  - aircraft sounding once "on station" up to 7.5 km (25 kft or higher?). (time = x hr?)
  - Sample CCN/giant particles/IN beneath cloud base. Also document updraft speeds beneath cloud bases. (time = 1 hr?)
  - Sample CCN/giant particles/IN in clear air up to -15 °C. (time = x hr?)
- (Same) Sample cloud bases to document conditions there, especially number of cloud droplets.
- Single-cloud APIP studies:
  - Descending pattern: Fly over CT with WCR looking down to document microphysical stage, then later passes at warmer T within cloud (minimizes APIPs?)
  - No penetration pattern: Fly over CT with WCR looking down to document microphysical stage, then later passes above CT when at lower temperatures with WCR looking down (no APIPs)
  - Single penetration pattern: Penetrate cloud at -5 °C, then later passes over ascending top of cloud to track subsequent evolution with WCR (no APIPs).
- Statistical sampling of APIPs:
  - Seeding pattern: Cloud penetration at -5 °C or -10 °C within line of developing Cu. Use WCR/WCL to document cloud top height for each cloud penetrated. Some cells penetrated; others not. Fly pass above all cloud tops; use WCR to discern ice development diffs.
- (Same) Clear-air sampling:
  - aircraft sounding up to 7.5 km (25 kft or higher?) before departing study area