Objectives of Boulder HIWC-2022 Workshop

Presented by Walter Strapp

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Part 1

Workshop Objective

- Given that insufficient high-altitude in-situ measurements in high aerosol were collected in HIWC-2022 to form conclusions, we want to summarize other supporting measurements, analysis, and literature
  - Review Nayoya U. and TASS modeling results
  - Review in-situ TCu measurements
  - Limited relevant literature review

  - Collect above material to write a section for future NASA Technical Memorandum, summarizing HIWC-2022 effort

Workshop format

- Very informal talks
  - Suggest that questions be welcome during talks
  - Presenters please talk clearly
- Priority (no particular order):
  - Nagoya University Model results
  - TASS model results
  - Literature reviews and TCu studies
- If necessary, the above talks may need more time than agenda allocates
  - If so, Thursday afternoon general HIWC-2022 talks may be postponed to post-workshop telecoms

Part 2

Current situation and Workshop Objective

- HIWC-2022 only provided one case of high CCN concentration; insufficient to make any conclusions on first-order hypothesis
- Given the limited results, we should see what further could be done with cloud models, the TCu data, and literature review (due diligence)
  - Nagoya U. model simulations of HIWC-2022 cases and aerosol sensitivity studies
  - TASS model simulations of HIWC-2022 cases and aerosol sensitivity studies
  - Literature review of warm rain and high aerosol, and TCu study of warm rain (Strapp)
  - Literature review of ice initiation and effect of aerosol (Bansemer)
- Objective is to summarize the above in NASA Technical Memorandum.

How TCu measurements fit into this.

- Many flight hours were spent looking at towering cumuli surrounding MCSs, initially to support Nagoya U. study
- There was no formal plan for a complete analysis of these data.
  - Based on real-time observations, Strapp thought that useful conclusions regarding the first-order hypothesis might be reached from the TCu data.
  - FAA provided additional funding to Strapp and Bansemer to do a limited study of the TCu data (Strapp warm rain, Bansemer ice)

How TCu measurements fit into this?
Warm Rain

- First order hypothesis assumes:
  - Low aerosol → production of drizzle and rain below the freezing level (warm rain) → reduces TWC aloft
  - high aerosol → suppresses drizzle and warm rain → **higher TWC aloft**
  - Based on: high aerosol → higher drop concentration, smaller droplets, more difficult for condensation-coalescence (warm rain) process to get started
  - This suppression of warm rain has been supported by several observations and model studies in the literature (to be shown)

  - Does our HIWC-2022 TCu data exhibit warm rain? Is it significant enough to lower LWC?

How TCu measurements fit into this? Ice

Can other microphysical processes counteract or support warm rain hypothesis?

1. Does high aerosol alter the initiation of ice through higher IN?
   - Does high aerosol also increase the number of ice nuclei, thereby starting ice precipitation earlier?
   - Could this reduce TWC aloft if ice formation is earlier?
2. Does high aerosol alter the initiation of ice through suppressing ice multiplication?
   - Does high aerosol suppress drizzle drops that may be important to ice multiplication? (Hallet-Mossop process, or drop freezing spicules, or other)
   - Could this increase TWC aloft if ice formation is later?

How TCu measurements fit into this? Ice

3. Could high aerosol alter the particle sizes in cloud via graupel?
    - Large high-density graupel particles are accounted for in the Appendix D size characterization
    - More graupel could be important for aviation (e.g. pitots)
    - If ice formation is delayed, implies more LWC, more graupel, more lightning

- Ice interactions are arguably more complex that warm rain, and conclusions may be difficult.
- There may be other important factors for regulatory interests not identified in this summary

End of presentation