Reducing and quantifying uncertainties in climatically relevant cloud microphysical parameters derived from optical array probes

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1. Motivation

- In situ measurements of ice crystal number distribution \(N(D)\), ice water content \(IWC\), median diameter \(D_{\text{mm}}\), effective radius \(r_e\), and extinction \(\beta\) from 2D Cloud Probes (2DCs) potentially affected by shattered artifacts
- Data from National Research Council of Canada Convair-580 collected during Indirect and Semi-Direct Aerosol Campaign (ISDAC) and from National Science Foundation (NSF)/NCAR C-130 during Instrumentation Development in Airborne Science 4 (IDEAS-4) campaign used to assess impact of shattered artifacts on \(N(D)\), \(\beta\), \(D_{\text{mm}}\), \(r_e\), and \(IWC\) in varying cloud conditions

2. Shattering removal techniques

- Use of modified tips reduces \(\beta\), \(IWC\) from 2DCs by ~20% no systematic bias in \(r_e\)
- Bias in \(D_{\text{mm}}\) up to a factor of 4, with 67% difference on average.

3. Field projects

- Parameters derived from ISDAC (30 Apr. 2008) and IDEAS-4 data (25 Oct. and 1 Nov. 2011):
  - \(N_N(0.25 < D < 1.6\,\text{mm}), IWC_{\text{st}}, \beta_{\text{st}}, r_{\text{st}}, \) and \(D_{\text{mm-st}}\) from standard tips 2DC
  - \(N_N(0.25 < D < 1.6\,\text{mm}), IWC_{\text{mo}}, \beta_{\text{mo}}, r_{\text{mo}}, \) and \(D_{\text{mm-mo}}\) from modified tips 2DC
  - High-resolution particle images from a (3V) Cloud Particle Imager.

Method: Compare \(N(D)\), \(IWC\), \(D_{\text{mm}}\), \(r_e\), and \(\beta\) for 2DCs processed with/without shattering removal algorithms.

4. Analysis of \(N(D)\)

- \(N_N\) (no algorithms used)/\(N_e\) (algorithms used) for IDEAS-4 for standard (red) & modified (blue) probes. Shattered artifacts present with modified tips \(\rightarrow\) need algorithms. \(N_N/N_e < N_N/N_{\text{mo}}\) \(\rightarrow\) tips more effective than algorithms at removing shattered particles.

5. Bulk properties

- \(IWC_{\text{mo}}\) vs. \(IWC_{\text{st}}\) for IDEAS+ISDAC showing ~20% difference. No algorithms used.
- \(\beta_{\text{mo}}\) vs. \(\beta_{\text{st}}\) for IDEAS+ISDAC showing ~20% difference. No algorithms used.

6. Conclusions

- Using shatter reducing tips reduces \(N(D) < .5\,\text{mm}\) by factor of > 2 for \(D_{\text{mm}} > 1\,\text{mm}\)
- Larger \(D_{\text{mm}}\) and presence of graupel are predictors of amount of shattering
- Using modified tips & artifact removal algorithms removes more shattered particles than artifact removal algorithms alone for 2DC
- Shattered artifacts still impact \(N(D)\) derived from probes with modified tips
- Use of modified tips reduces \(\beta\), \(IWC\) from 2DCs by ~20% no systematic bias in \(r_e\)
- Bias in \(D_{\text{mm}}\) up to a factor of 4, with 67% difference on average.

7. References


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