New Microphysical Insights from Analysis of Holographic Data during ACE-ENA

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Introduction

- HOLODEC – Holographic Detector for Clouds [1] was flown aboard the G1 aircraft during ACE-ENA research flights.
- Each hologram has a measurement volume of 13 cm^3 and droplet diameter measurement range between 5µm – 1mm.

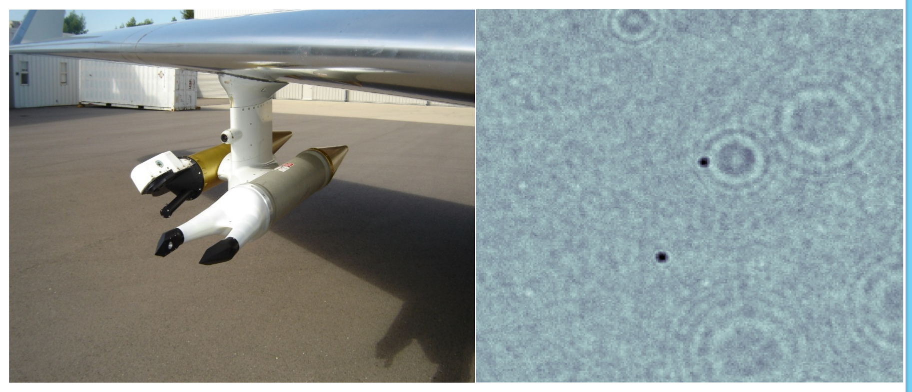

Fig. 1 (left) HOLODEC attached below the aircraft wing (source: NCAR), (right) hologram with detected droplets.

- High resolution local variability in cloud properties such as number concentration, size distribution etc. was measured.

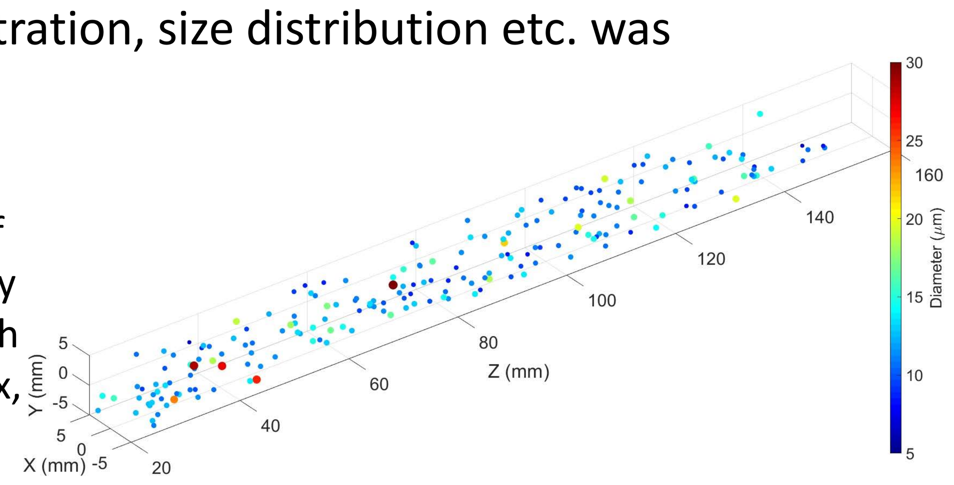

Fig. 2 Scatter plot of droplets detected by HOLODEC along with their diameter and x, y, z position.

Objectives

1. To investigate cloud microphysical variability at centimeter scale resolution.
2. Investigate how microphysical variability affects cloud processes like entrainment mixing, auto-conversion etc.

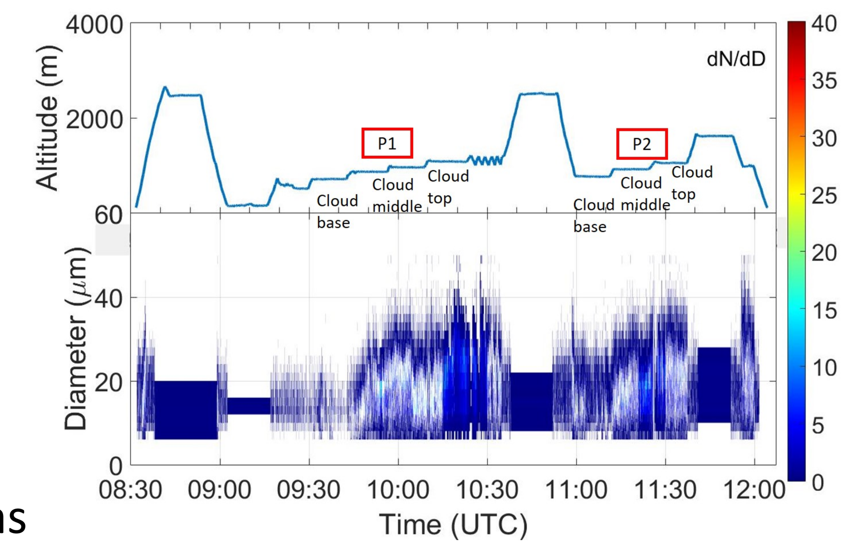

Fig. 3 Altitude, droplet size and number density along flight path for July 18, 2017 research flight

- RF 18 on July 18th was analyzed.

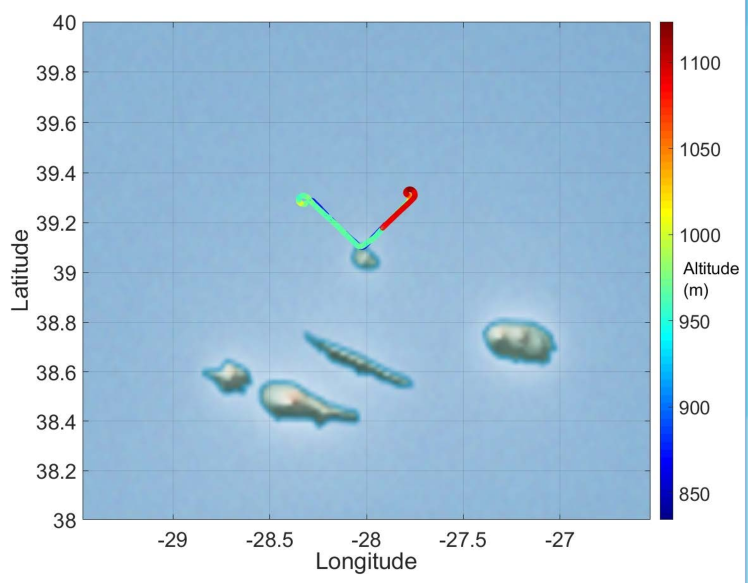

Fig. 4 The flight path consisted of 2 legs at each altitude, one parallel to the wind and another perpendicular. This was followed by a turn to ascend to a higher altitude.

Mixing type vs altitude

- For each flight altitude, mixing diagrams show primarily in-homogeneous mixing occurring.
- This is contrary to prior concept of mixing being in-homogeneous at the top and homogeneous near base [2].
- Large number of holograms with d^3/d_o^3 >> 1, especially at cloud base indicates droplet growth.

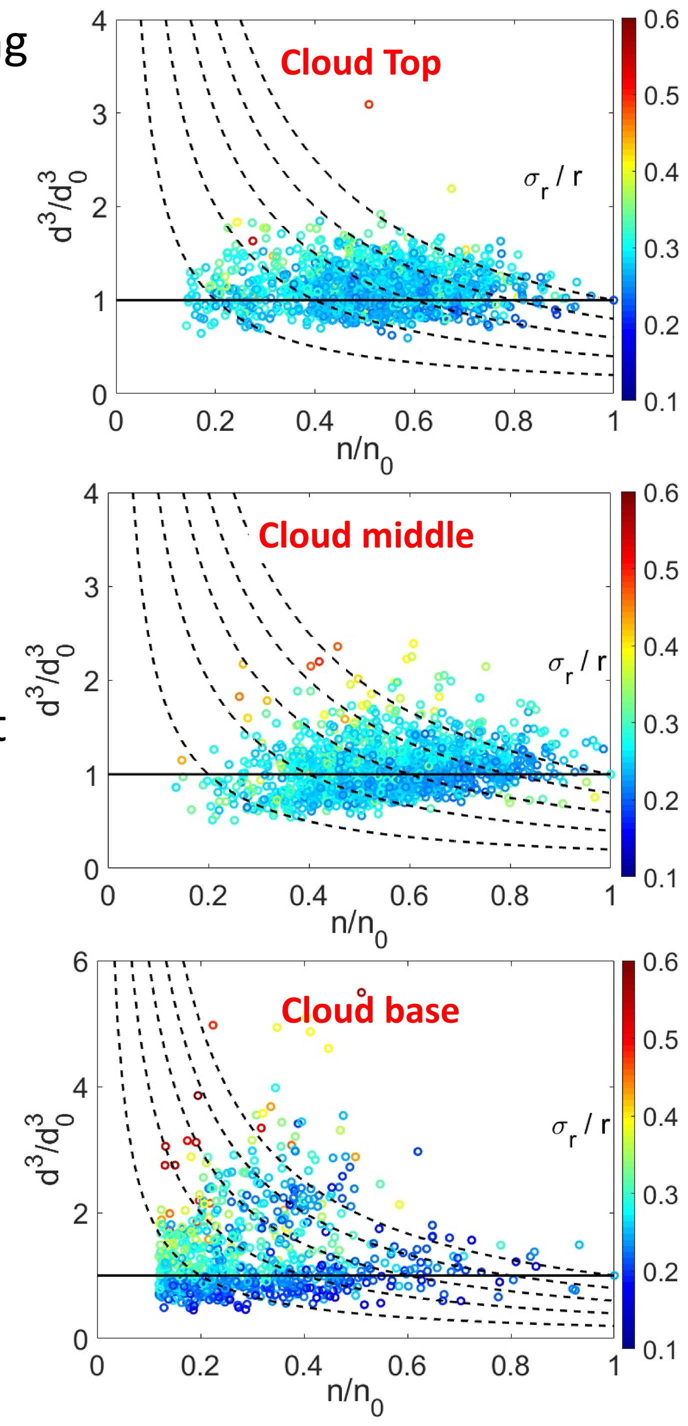

Fig. 5 Mixing diagrams with number concentration on X axis and normalized volume diameter on Y axis, both normalized by adiabatic value. Each hologram averaged point colored by the relative dispersion for P1.

P1 vs P2

- P1 cloud middle also showed the same mixing tendency as cloud base, but cloud top was mostly in-homogeneous.
- P2 did not show the same mixing type variability with altitude or flight direction.
- This suggests that this mixing variability may not be systematic with altitude or wind direction.
- Related to LWC which varied between flight legs.

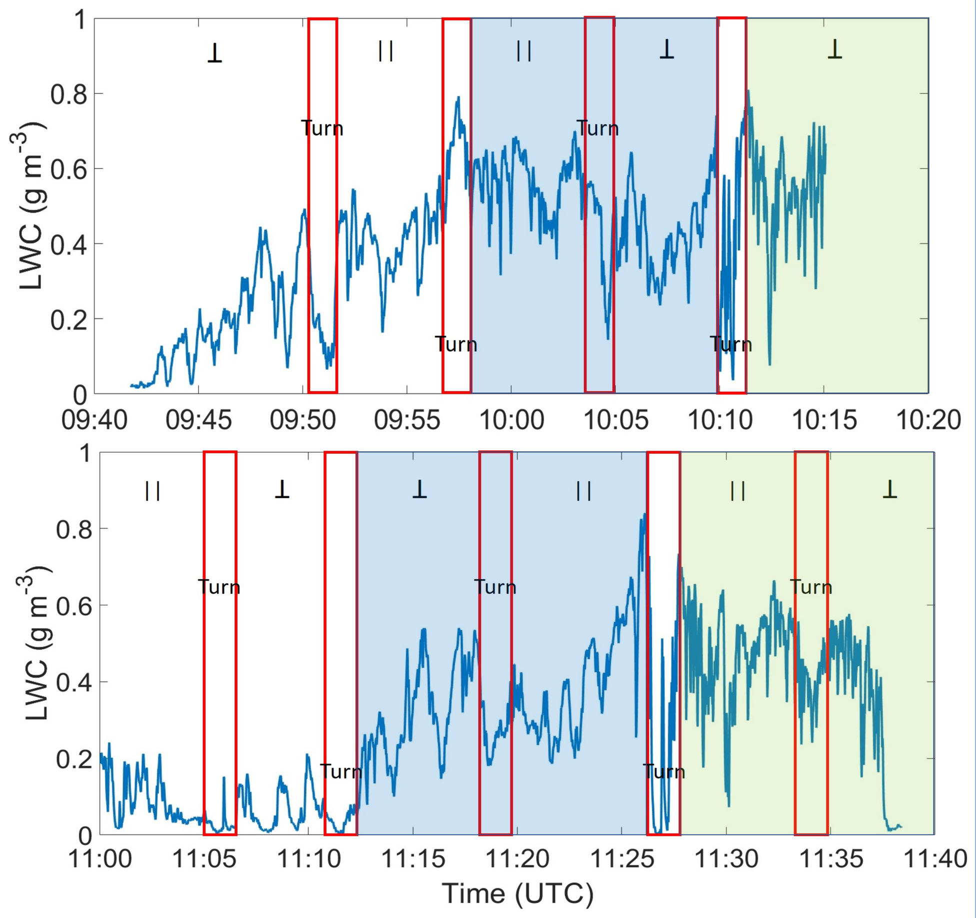

Fig. 7 LWC using the WCM King Probe for (top) P1 and (bottom) P2. Shading:
White: cloud base
Blue : cloud middle
Green: cloud top

Variability at constant altitude

- Separating the P1 cloud base pass into parallel, perpendicular flight legs and the turn.
- The turn and parallel leg show signatures of homogeneous mixing
- Perpendicular leg shows in-homogeneous mixing.
- Averaging cloud properties over a single altitude may not take into consideration spatial variability.

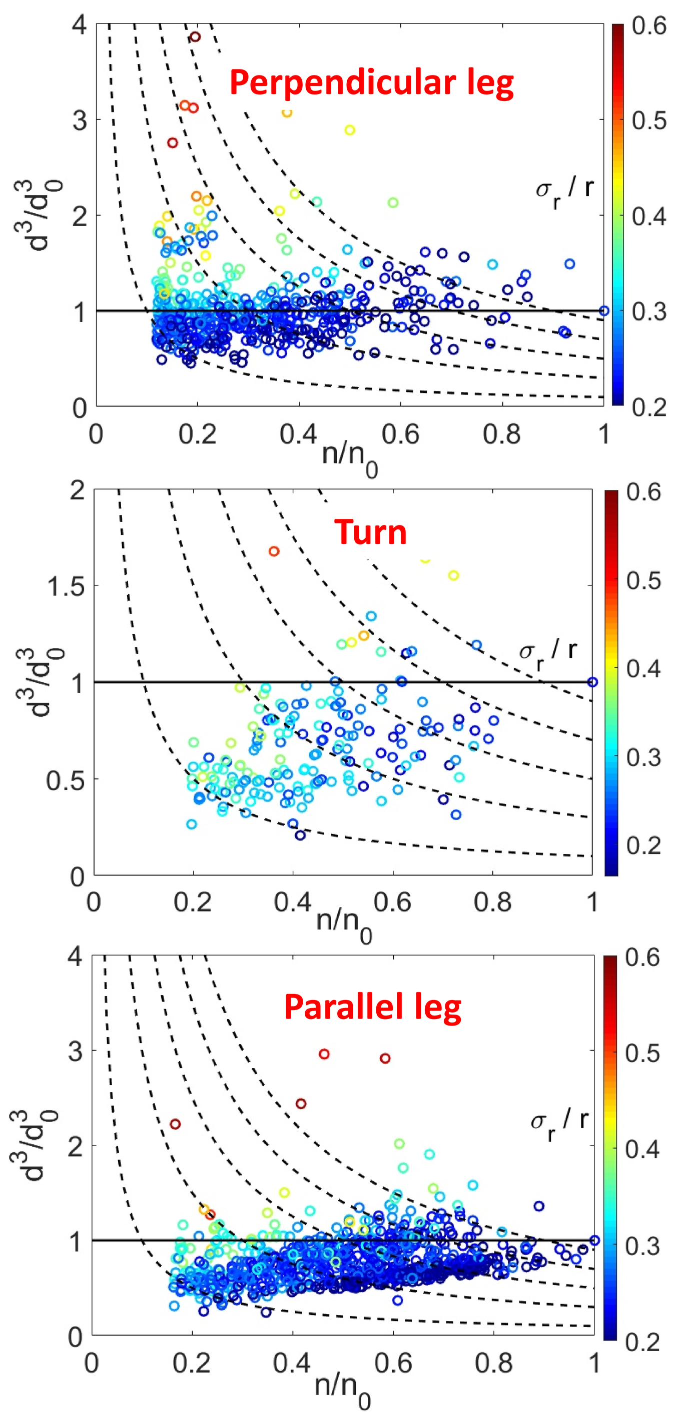

Fig. 6 Mixing diagrams separated between cloud base, middle and cloud top for P1.

Auto-conversion

- Both P1 and P2 cloud decks were drizzling.
- P1 cloud base: 0.17% of all drops > 40µm (drizzle drops)
- 1.5% of individual parcels (holograms) satisfied auto-conversion requirement [3].
- P2 clouds: 0.4% of all drops > 40µm and 6.7% of parcels satisfied auto-conversion requirement.

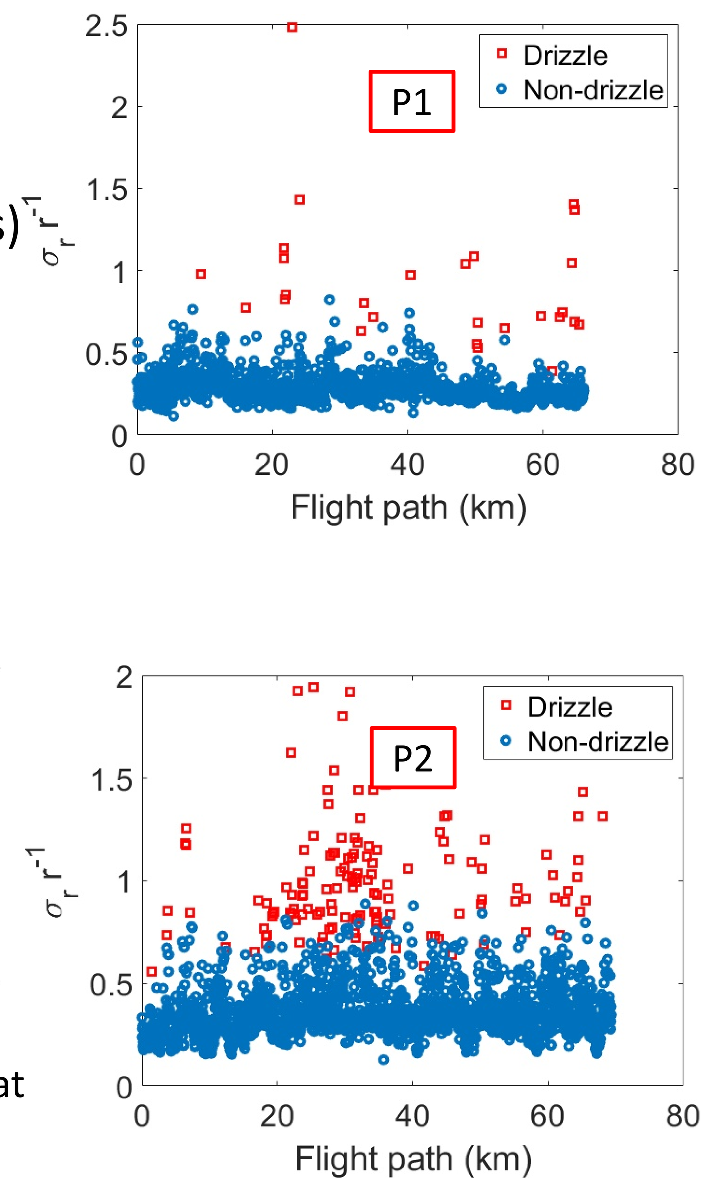

Fig. 8 Relative dispersion for parcels (holograms) at cloud base that passed the auto-conversion threshold are in red and those that didn't pass the threshold are in blue for P1 (top) and P2 (bottom).

References

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Conclusions

- Microphysical variability may lead to variable mixing types at constant altitude.
- Auto-conversion analysis shows interspersed drizzling (lucky) parcels instead of a homogeneous drizzling deck.