Inside the Asian Summer Monsoon: in situ observations from within deep convective clouds

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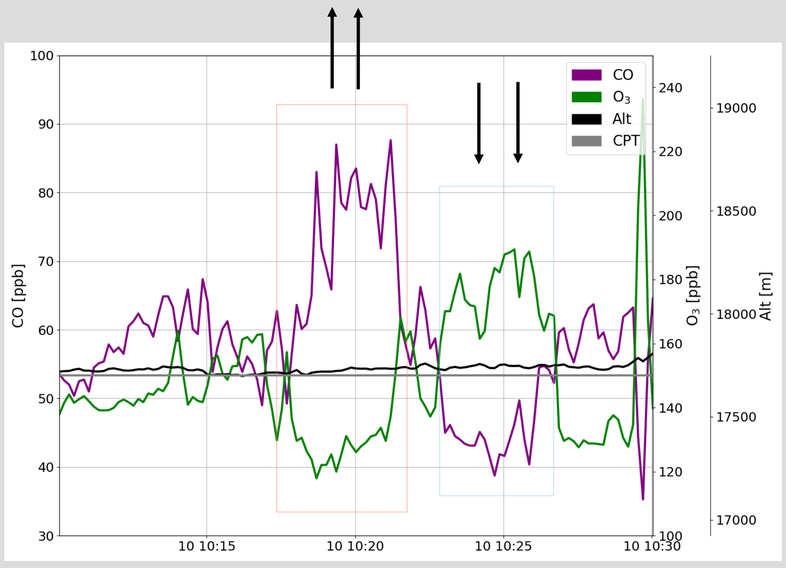
Background

The StratoClim campaign (over Nepal) during the Asian Summer Monsoon (ASM) in 2017 employed the high altitude aircraft Geophysica (max. ceiling 21km). The aircraft was probing (high altitude) clouds in deep convective systems, including convective overshoots that reached the stratosphere.

Instrumentation

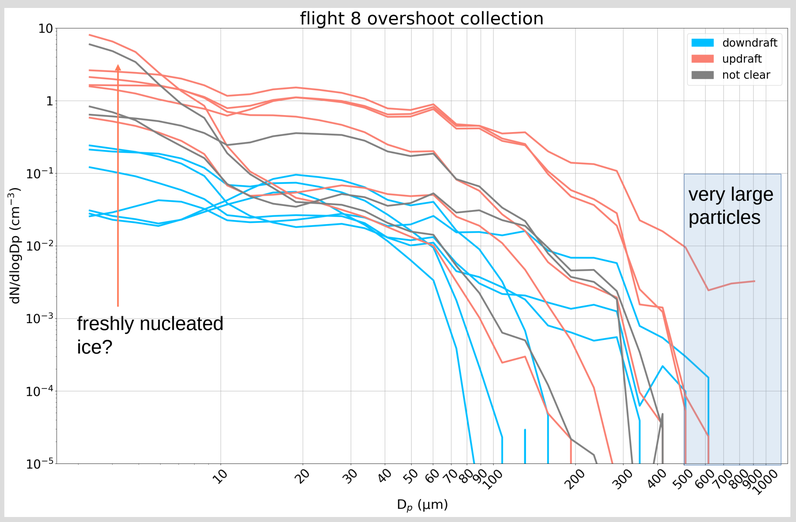
parameter	instrument
T, p, alt, position	UCSE
cloud particle size, number	NIXE
cloud miniature lidar	MAL
cloud backscatter	MAS
O3, CO	FOZAN, COLD
H_2O (total/gas)	FISH/FLASH

Updrafts and downdrafts

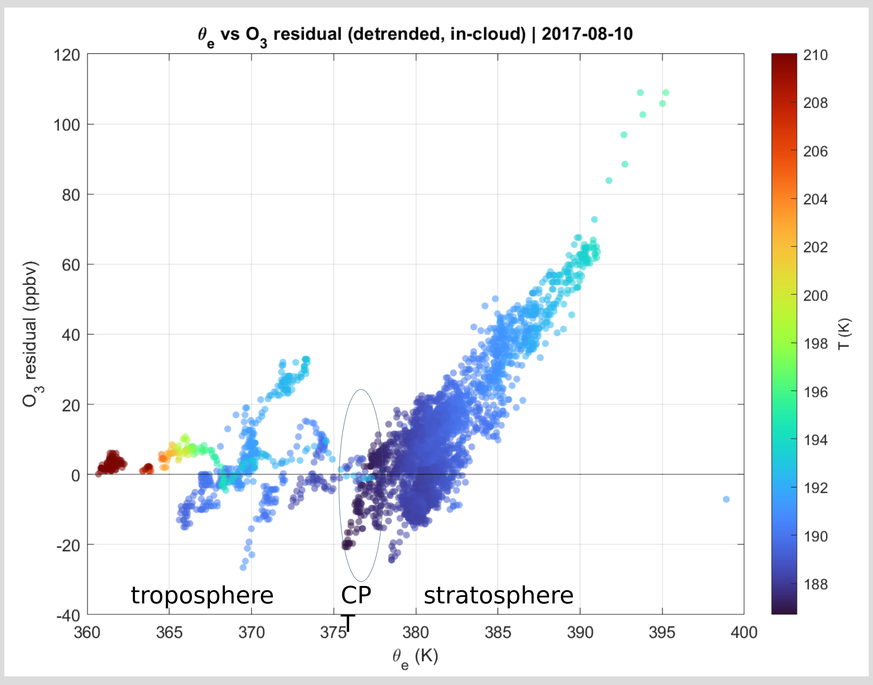


- using trace gases for identification:
  - O_3 concentrations: low in tropopshere, high in stratosphere
  - CO concentrations: high in tropopshere, low in stratosphere

Example of updraft/downdraft identification by trace gas signatures (above). Size distributions from within convective overshooting during flight 8, colour coded by updraft/downdraft (red/blue, or grey if identification not showing a clear signal; below).



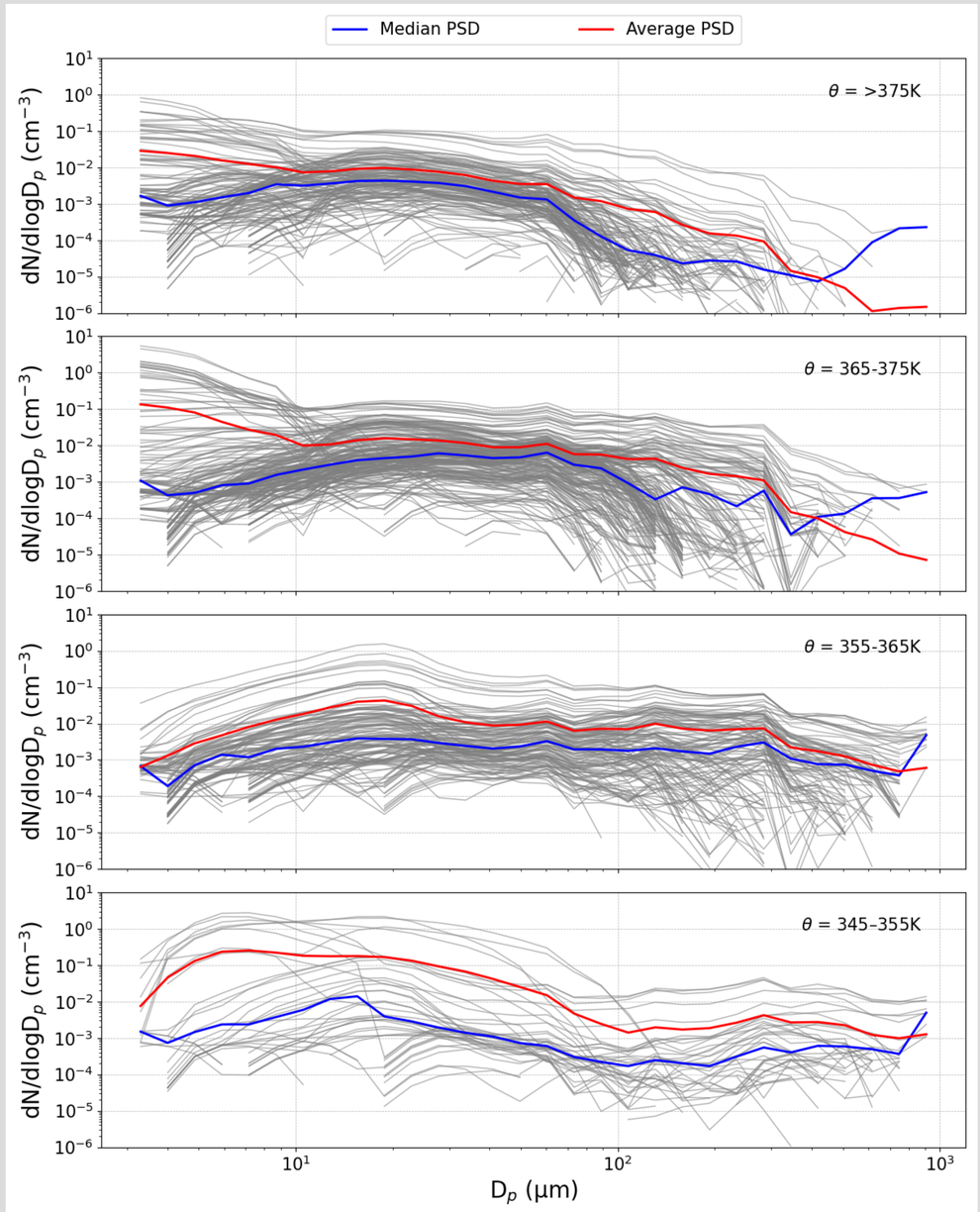
- ice particles in StratoClim convective overshoots larger than observed during other campaigns
- signs for recent homogeneous nucleation: high numbers of small sized particles



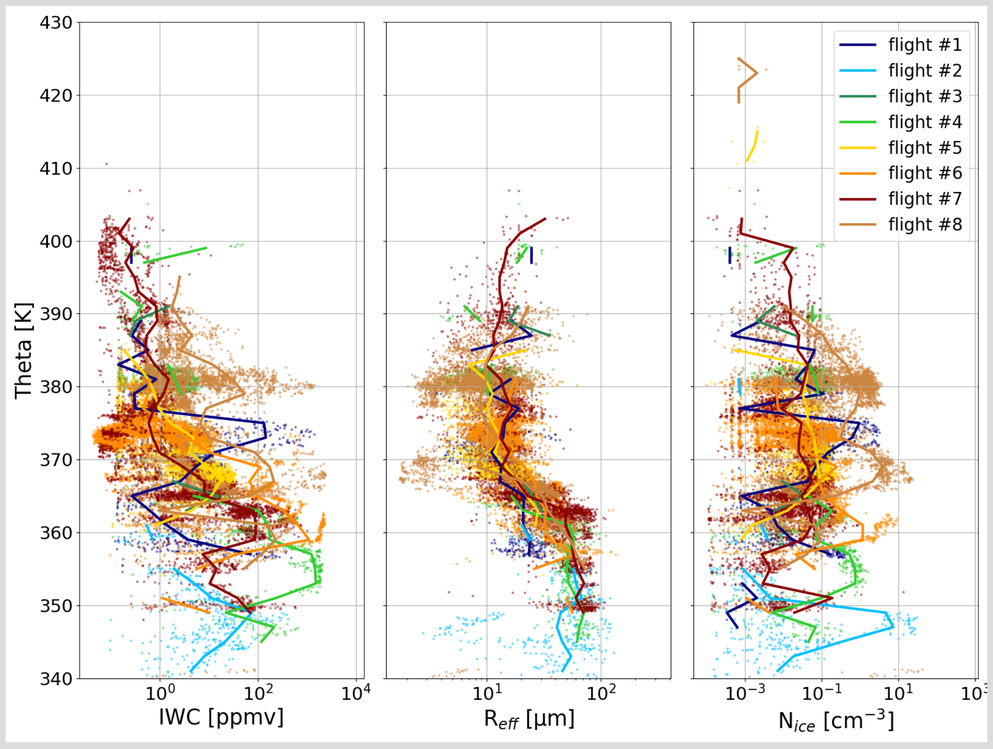
- further alternative to trace gases for identification of vertical motion (updraft/downdraft): equivalent potential temperature
- strong correlation of the ozone residual to θ_e in the stratosphere on the "golden overshoot day"

Correlation of θ_e and ozone residual (difference of ozone concentration measurement to mean ozone profile at respective level)

Vertical cloud structure



Average size distributions sorted by altitude, including average and median distributions for each altitude bin.



Vertical profiles of Ice Water Content (left), effective radius (middle), and cloud particle number concentrations (right) for all flights.

Conclusions

- unique measurements at high altittude in ASM deep convective systems:
  - high number of cloud observations within tropical tropopause layer
  - presence of very large ice crystals (up to 750µm) in stratosphere
  - up- and downdrafts identified in overshoots
- amazing testbed for modelling studies for convection, microphysics, and transport in clouds

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