Deep Convective Microphysics Experiment -- DCMEX

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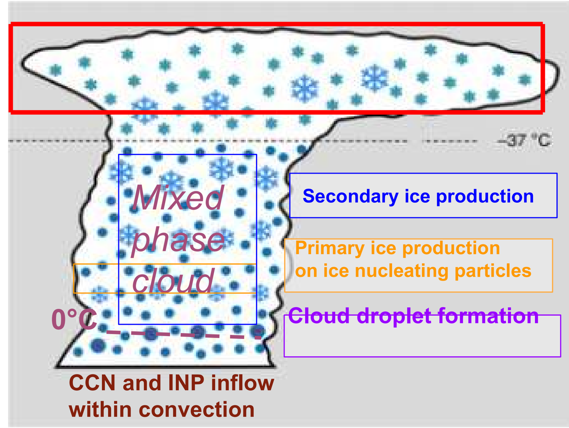
Motivation

Reduce the uncertainty in **equilibrium climate sensitivity** by improving the representation of **microphysics processes** in global climate models

Addresses: **How are Observations Being Used to Improve Models?**

Test and improve the Met Office microphysics module CASIM. Apply improved model to compare radiation against satellite observations using sensitivity studies; see *Finney et al* poster. Apply to tropical convection case (Darwin); see *Sun et al* poster

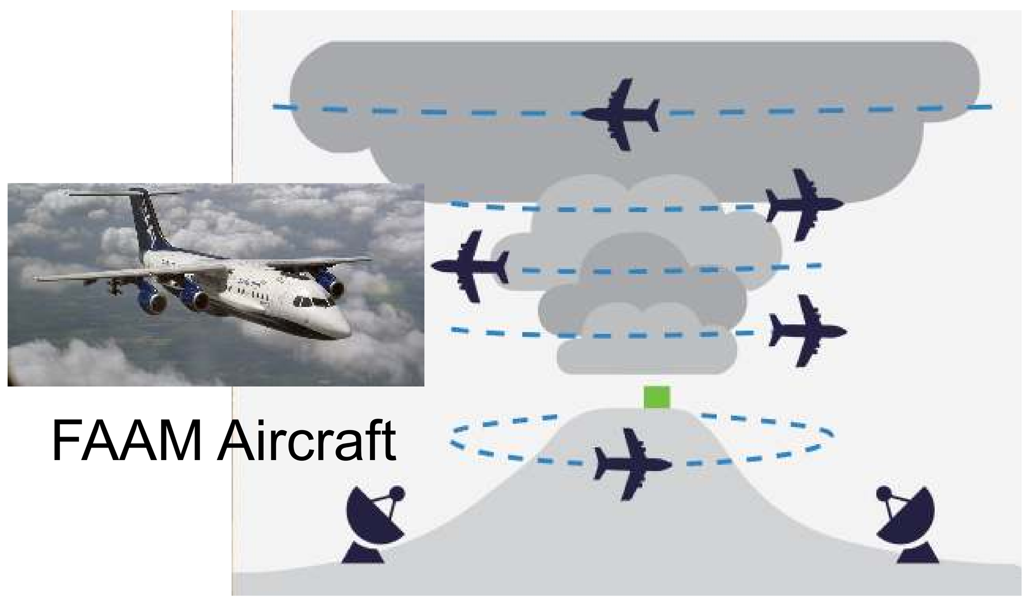
How do microphysics processes in mixed-phase region and in anvil cloud itself affect anvil cloud albedo?



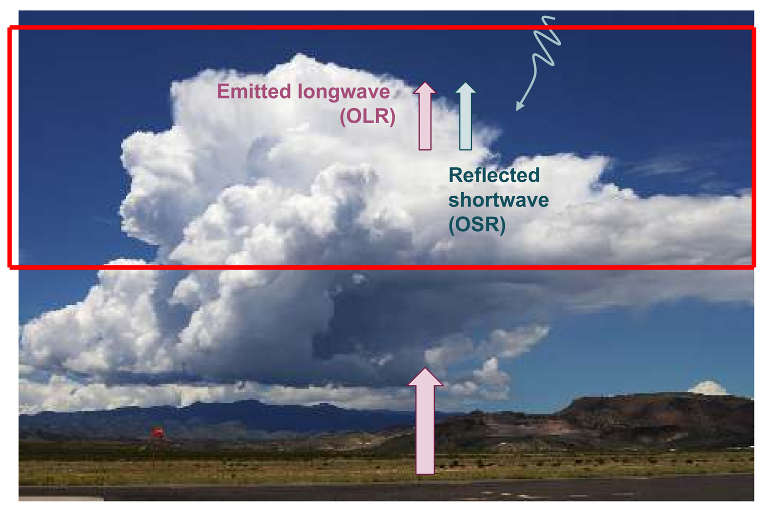
Can We Even Observe Microphysics? Yes, somewhat...

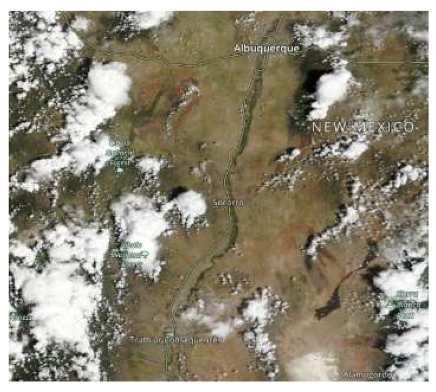
DCMEX project: Study of development of laboratory cloud system.

Clouds over Magdalena mountains, central New Mexico



FAAM Aircraft





Satellites

Radars -- S-band X-band, U of Oklahoma; NEXRAD

Aerosols, including INP at Langmuir Lab

Ground-based time-lapse cameras

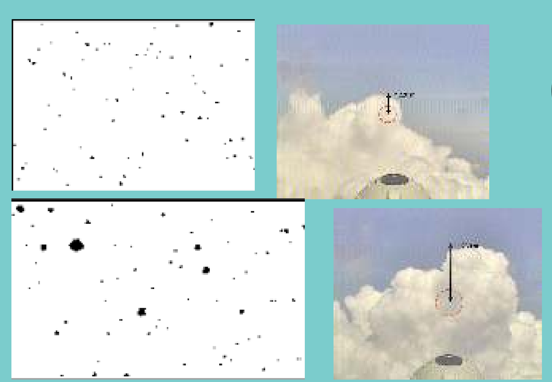
- Clouds anchored to the mountain
- 17 cases with varying environments (See: *Finney et al, 2024, ESSD*[1])
- Good measurements of the formation and growth of liquid and ice particles as clouds developed
- Only a few measurements in anvils
- S-band radar data on several days, but not all; good NEXRAD coverage on all days
- Good INP and aerosol measurements

But...
Missing aircraft measurements:
cloud base, most anvils, developed vigorous clouds with larger graupel

Early results

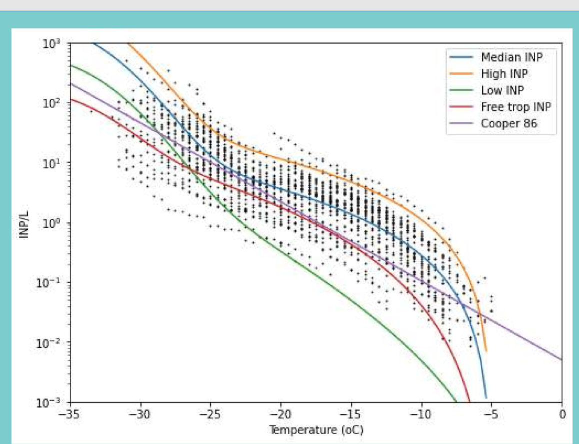
Measurements of INP -- one of few combined measurements of INP and primary ice; new parametrisation in CASIM

Primary ice -- first detected ice observed near tops of clouds at T ~ -10 to -13C during passes as cloud tops ascend



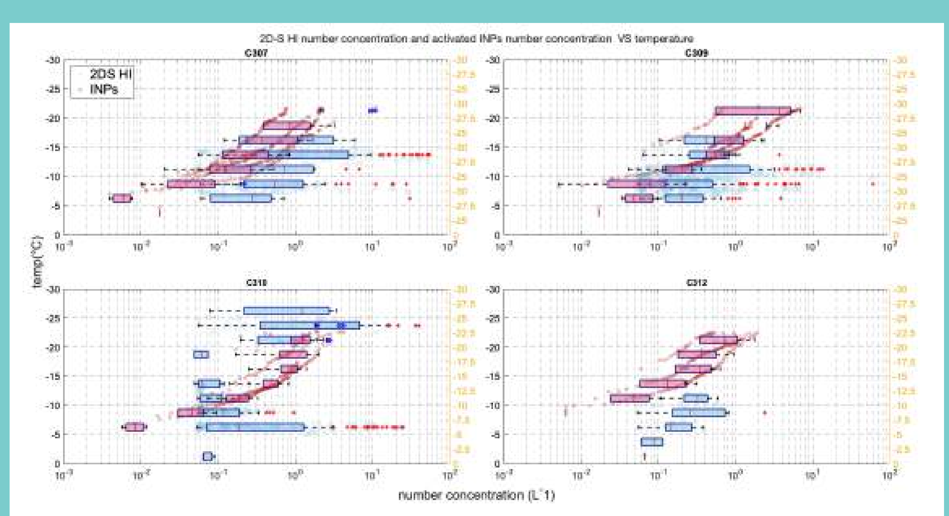
0.05/L; T~-12.5C (out-of-cloud T)

1.0/L; T~-21C



HVPS images from two cloud-top passes on 23 July shown in ffc images. (Right) INP curves for the project. *Gary Lloyd, Ben Murray, Martin Daily*

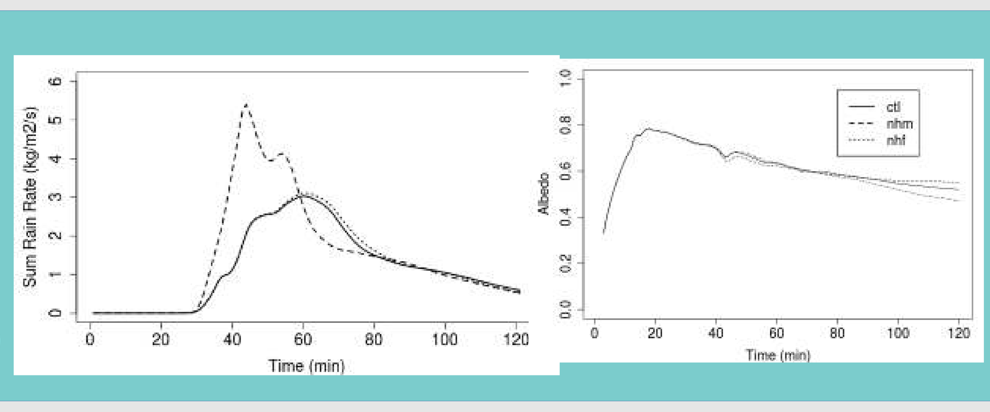
Enhanced conc of ice -- observations of concentrations of ice particles were often greater than those of INP



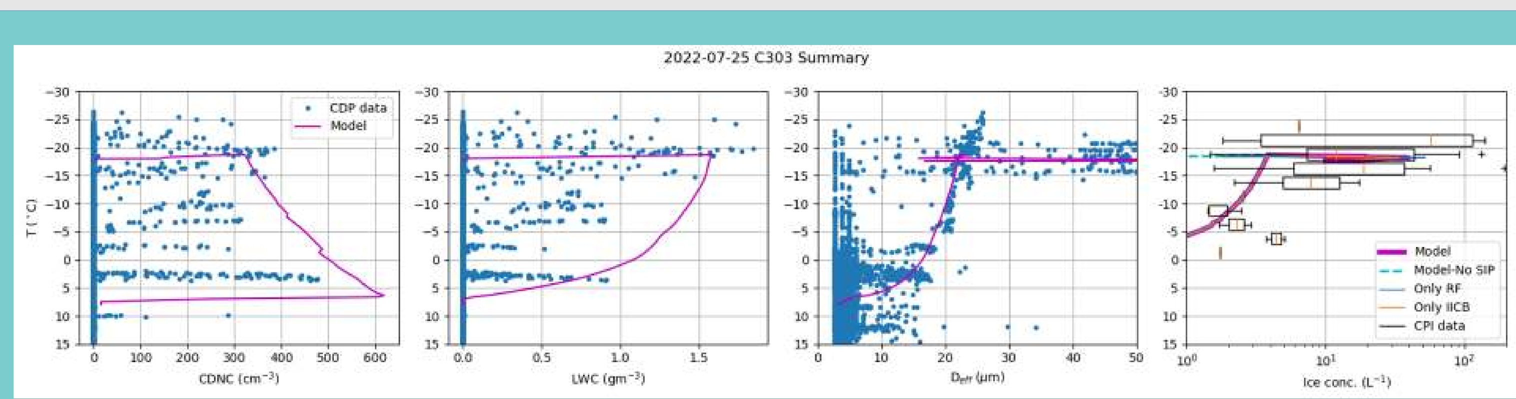
4 cases: 2DS High Irregular conc (blue box circles and red crosses) and activated INPs (pink box and circles) vs temperature. N_ice > N_INP at some T for all 4 cases shown. But not all cases and criteria for HM not always met. *Kezhen Hu*

Cloud Model 1 -- Ice-Spheroids Habit Model with Aspect-Ratio Evolution (ISHMAEL)[2]. The grid spacing is 150 m.

Rain rate (left) and mean cloud albedo (right) ctl (solid), without Hallett-Mossop process (dashed) and no homogeneous freezing (dotted)



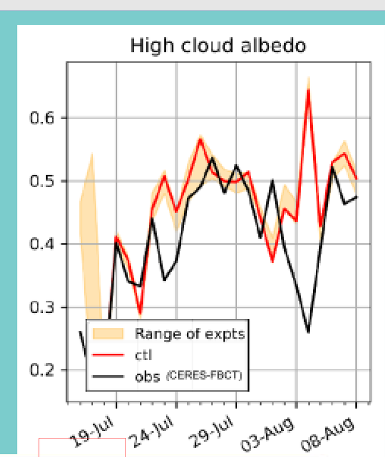
Cloud Parcel Modelling -- Understand secondary ice particle production processes and depletion of cloud drops



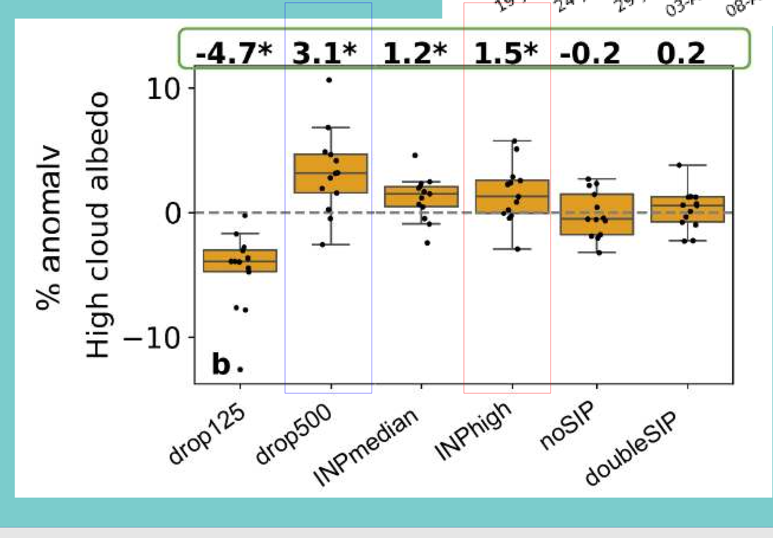
Only RF - only raindrop breakup. Only IICB - only ice-ice collisional breakup *Paul Connolly*

UM/CASIM[3] -- Varying microphysics can modify high cloud ice particle concentration and reflectivities

The UM-CASIM model control simulation used fixed 250e6 droplets/kg up to 6km and an exponential decay above. It used the DCMEX curve for INP and SIP rate of 350e6 splinters/kg (rime). SIP is HM process.



Experiment anomaly compared to control. Subset of 13 cases (black points). Bold numbers are means. Asterisks show significant results (5% level)



Declan Finney: See poster

References

1. Finney et al (2024) ESSD https://doi.org/10.5194/essd-16-2141-2024
2. Jensen et al (2017) https://doi.org/10.1175/JAS-D-16-0350.1
3. Field et al (2023) QJRMS https://doi.org/10.1002/qj.4414