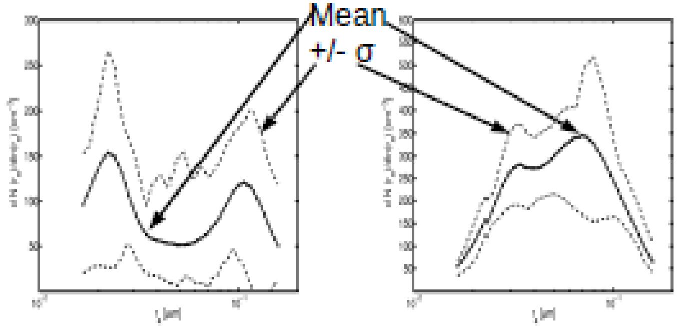
Numerical Modelling of the cloud–aerosol interactions for VOCALS

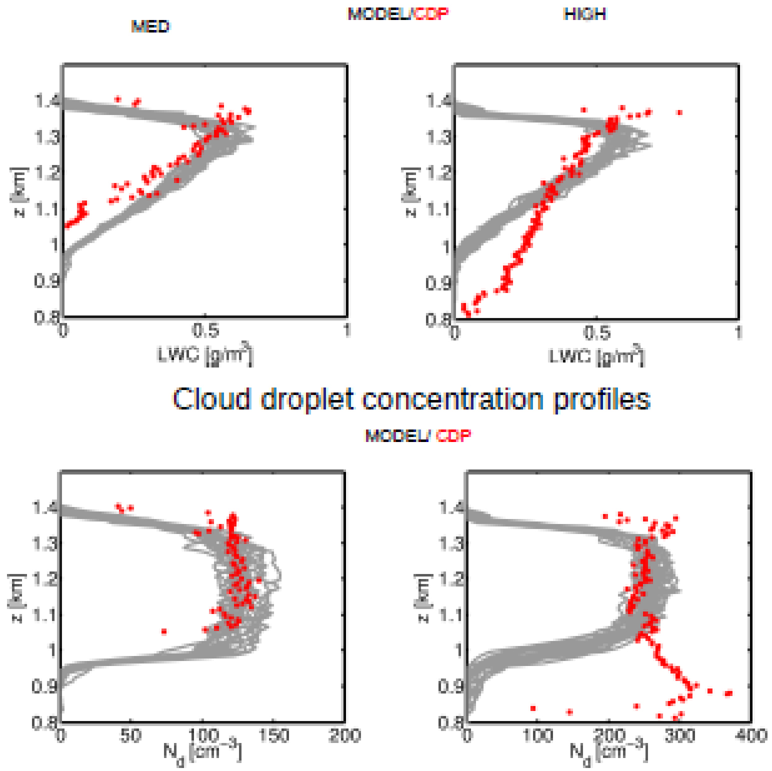
Mirek Andrejczuk, Alan Gadian & Alan Blyth

Initial Conditions based on the flight B420 of BAe-146. Two profiles from this flight were chosen. One with MEDium cloud droplet concentration (120 cm^{-3}) and one with HIGH cloud droplet concentration (250 cm^{-3})
Aerosol distribution from below the cloud observations were used to initialize the model. Two modal, log-normal distribution was fitted to observations.



Forcing long wave radiative cooling at the cloud top and surface fluxes of potential temperature and water vapour mixing ratio.
Setup 2D runs 80x200 grid points with dx=40 and dz=10.
Solution 7 hour runs with data saved every 10 minutes

Model Validation
LWC profiles



Also see plots on the poster for

- solution sensitivity to aerosol distribution and
- solution sensitivity to number of bins in radius and aerosol space (Na)

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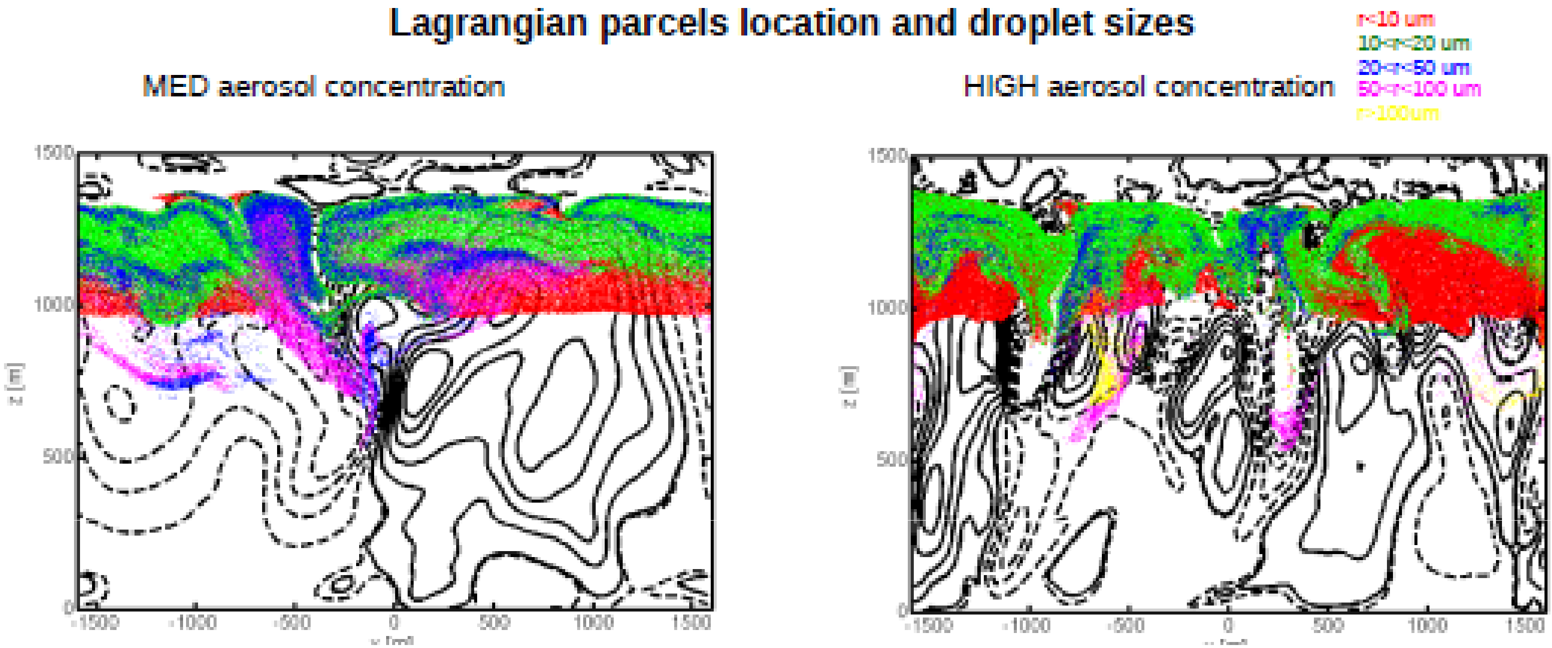


Conclusions (some of) :

- **Lagrangian representation of the microphysics can predict the observed LWC and cloud droplet concentration.**
- **CDN and Qc are more sensitive to the uncertainty in the initial conditions (aerosol distribution) than to the number of bins in the Eulerian collision grid.**
- **Cloud droplet spectrum depends on the number of bins used in the collision grid.**

See: Andrejczuk et al (2008) JGR 2007JH009445 : Andrejczuk et al (2010) JGR 2010JD014248 : plus 2 in preparation

Numerical modelling of stratocumulus over the South-East Pacific with WRF

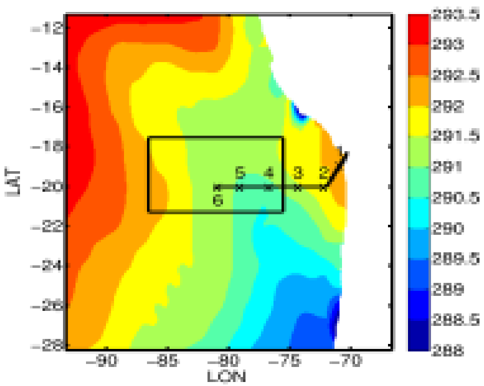
Mirek Andrejczuk, Alan Gadian & Ralph Burton

WRF was used, initialised with GFS analyses, 00:00Z 12 Nov., and compare with B420, Nov. 13 2008. Sensitivity studies with:

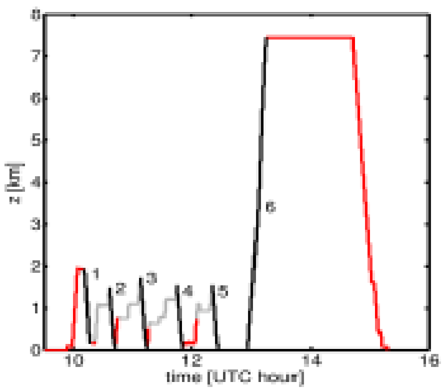
(a) 36,81,121 levels: (b) Resolution of 9km, outer and 3km inner: (c) Microphysics (Kessler, Thompson, Morrison) .

(d) Land surface and boundary layer: (R) Plein-Xiu/Noah/ACM2: (SF1) Monin-Obukov / thermal diffusion / YSU: (SF2) Monin-Obukov (ETA) / thermal diffusion / MYJ TKE.

Model domain/subdomain, SST temperature and B420 flightpath



Height/time for the B420 flight



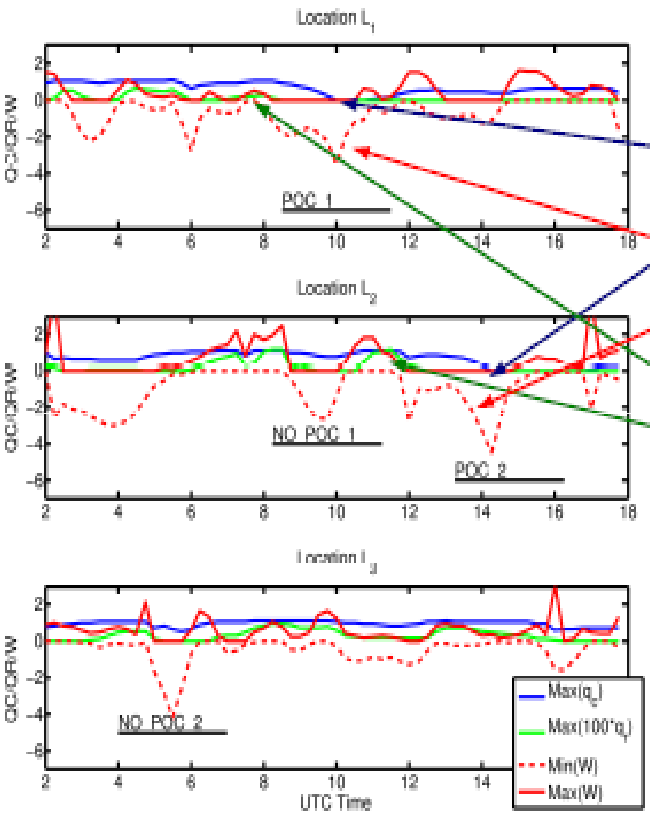
Model Validations Conclusions:

- Observations show big variability in space
- There is a problem with prediction of the potential temperature and/or water vapour mixing ratio in the boundary layer, and the height of the boundary layer
- Boundary layer height is sensitive to:
  - land surface and boundary layer parametrizations,
  - when changing number of levels from 36 to 81,
  - to the change of the horizontal resolution from 9 km to 3 km for 36 vertical levels run.
- Boundary layer height shows little sensitivity to:
  - different microphysics parametrizations,
  - when changing number of vertical levels from 81 to 121,
  - change in horizontal resolution for 81 and 121 vertical levels.

Look at the poster to see model profiles compared with observations.

Numerical modelling of stratocumulus over the South-East Pacific with WRF

Evolution in time of the maximum of cloud water mixing ratio (qc), rain water mixing ratio (qr), vertical velocity (w) and minimum velocity within the boundary layer (z < 1200 m) for the 3 chosen locations in space (L1, L2, L3)



Cloud free region formation

Subsidence

Precipitation. Is necessary?

NO_POC_1 and NO_POC_2 have precipitation and subsidence, but do no lead to a cloud free region. Subsidence is not strong enough or does not act for long enough!

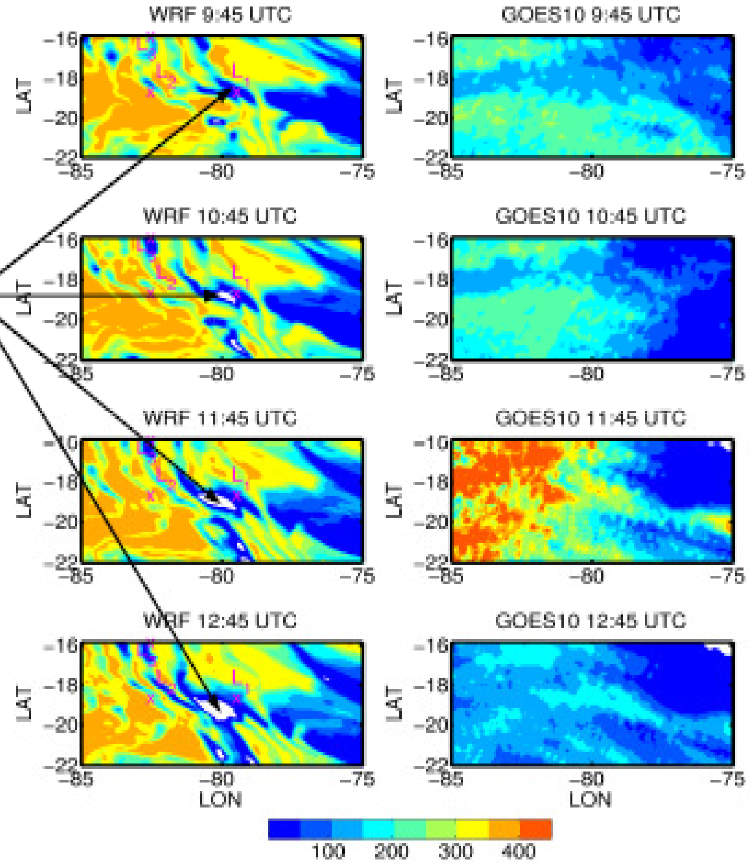
Model LWP structure and evolution different than from GOES!

LWP: Numerical model

LWP: Observations GOES10

Hole formation In the model

Is this structure POC?



Also vertical velocity plots shown in the poster

Numerical modelling of stratocumulus over the South-East Pacific with WRF

Holes Formation Conclusions:

- Holes in clouds are created as a result of mixing of the dry and warm, free atmospheric air with the cloud, with the mixing forced by subsidence.

- Precipitation limits the amount of water (Liquid Water Path) in the profile, but ends ~ 2 hours before the cloud free region develops.

- Subsidence must be strong enough (more than 3 cm/s for 9km resolution) and last long enough to lead to a cloud free profile.

- Holes are created for the combination of the land surface / boundary layer parametrizations as in R only. For the SF1 (YSU) and SF2 (MYJ TKE), the cloud free region does not form, but there is a drop in LWP near 19W, 80S.

There are underlying LWP structure differences between observations and model results, and there are ni cumulus like circulations inside the cloud free region.