Modeling of Aerosol-Cloud-Drizzle Interactions in the Southeast Pacific

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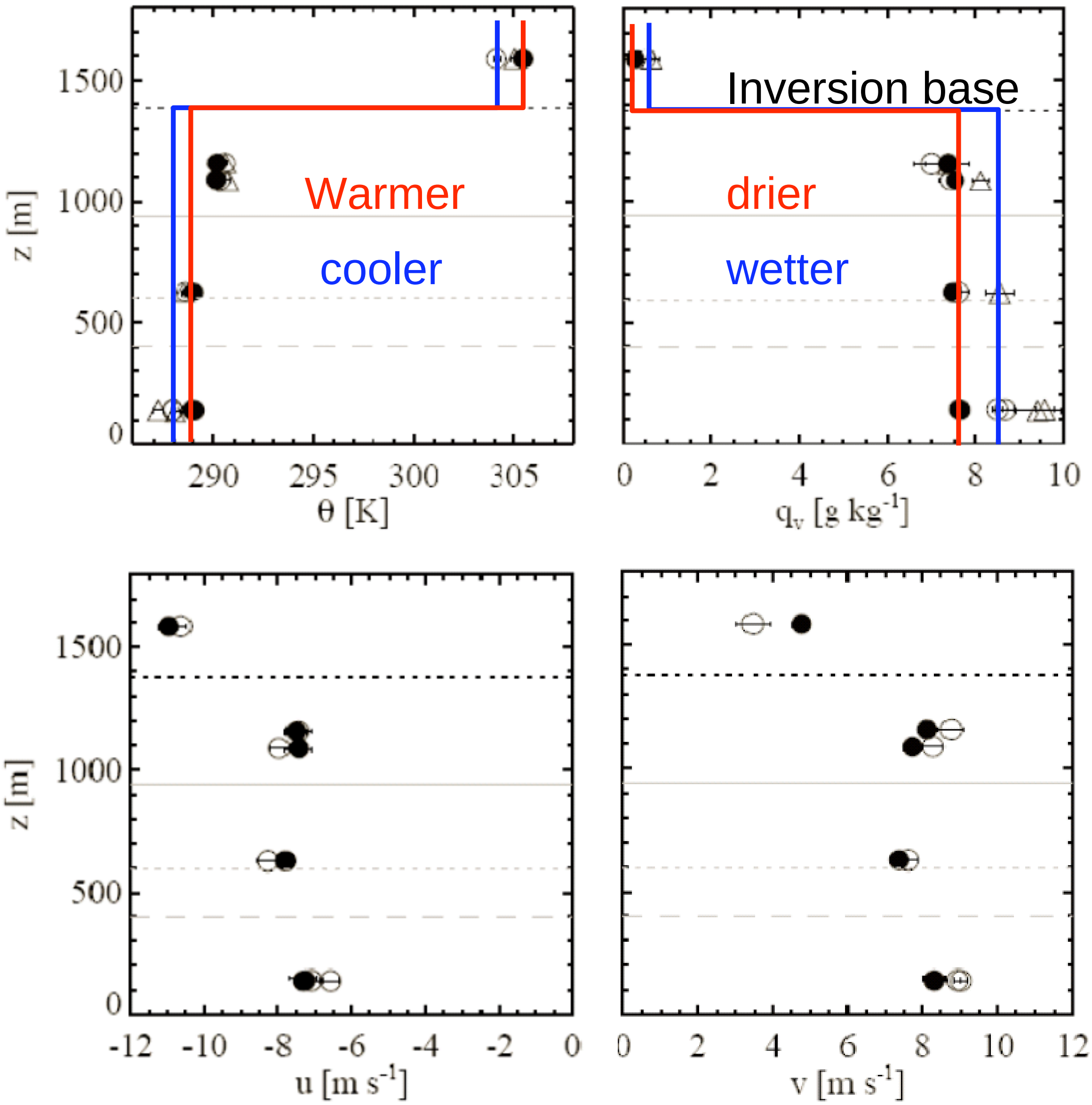
Leg-mean profiles in POC and overcast region



C-130 RF06, 10/28

- ● overcast
- o POC
- △ boundary

Surface forcing:

LHF: 122/148 Wm^{-2}

SHF: 15/3 Wm^{-2}

u_*: 0.2 m s^{-1}

Large-scale divergence:

1.67×10^{-6} s^{-1}

(0.2 cm s^{-1} subsidence near inversion)

Model and experiments

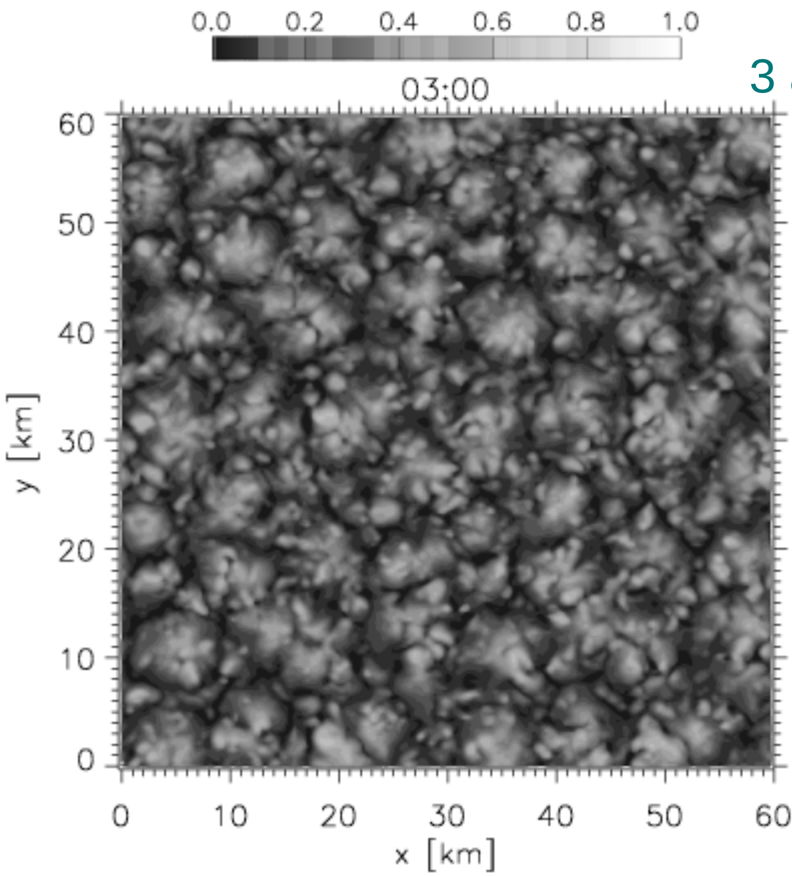
- The Weather Research and Forecasting (WRF) model:
  - Two-moment (bulk) cloud microphysics (Feingold et al. 1998)
  - Aerosol budget (w/ or w/o chemistry)
  - Monotonic advection (Wang et al. 2009)
  - Cyclic boundary conditions in both x and y
- Experiments:
  - 60 × 60 × 2 km^3 domain ($\Delta x=\Delta y=300$ m; $\Delta z \sim 30$ m; $\Delta t=3$ s)
  - CCN: 30 cm^{-3} (clean) and 150 cm^{-3} (polluted)
  - Local midnight to sunset of the next day
  - Four experiments with different combinations of CCN and initial soundings (D30, W30, D150, W150)

Results: clouds in the drier boundary layer

Cloud albedo

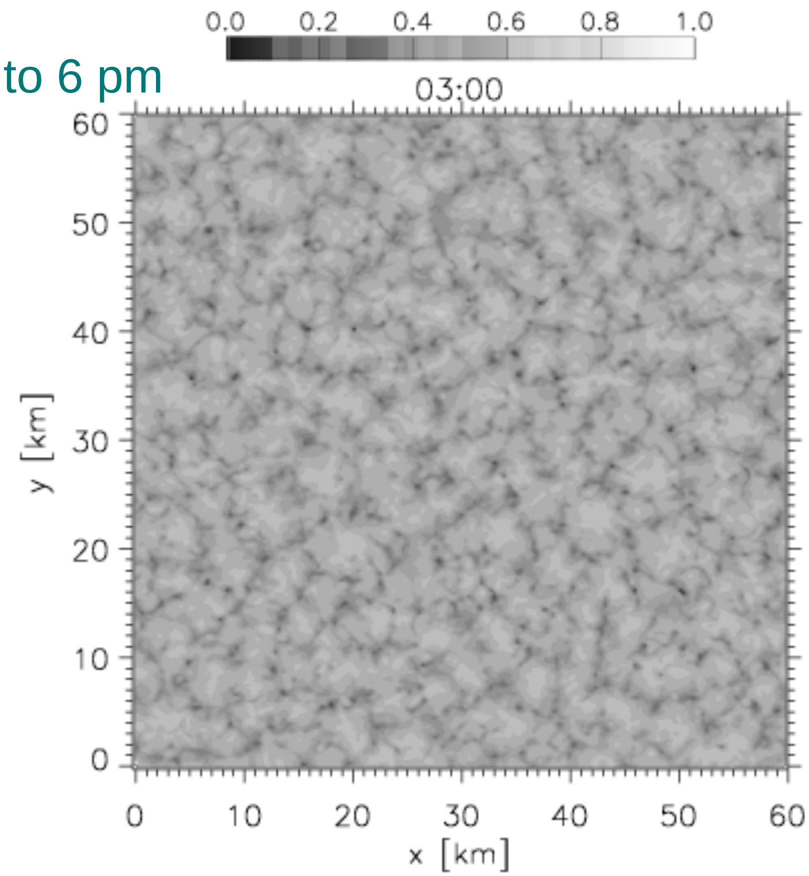
3 am to 6 pm

D30



Open cells; solar heating breaks up wall clouds

D150



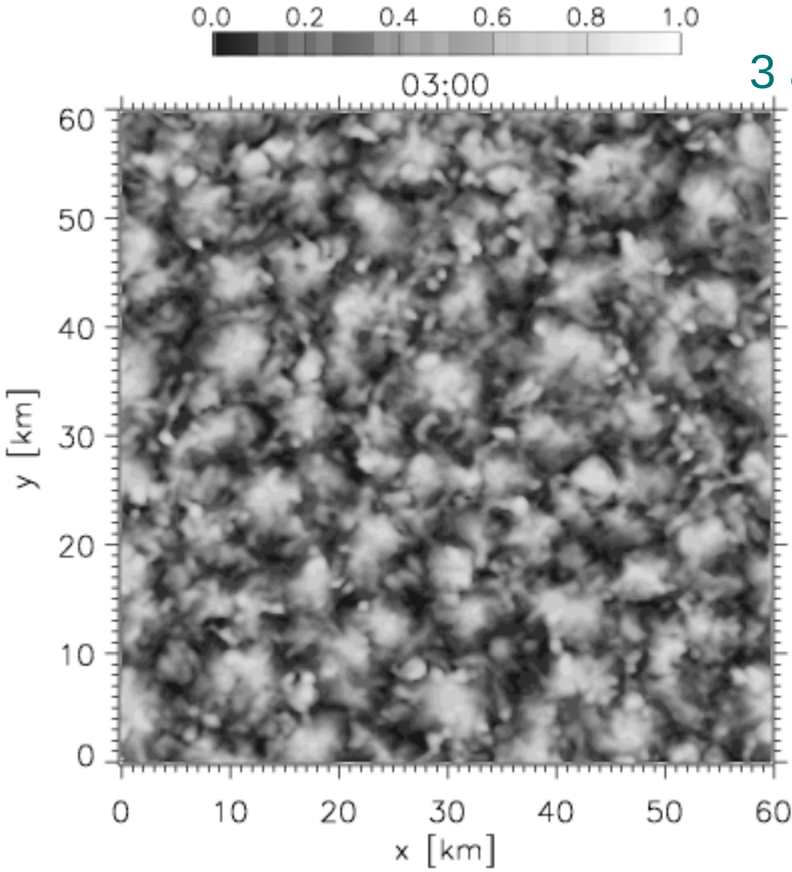
Closed cells; almost completely dissipated by solar heating

Results: clouds in the wetter boundary layer

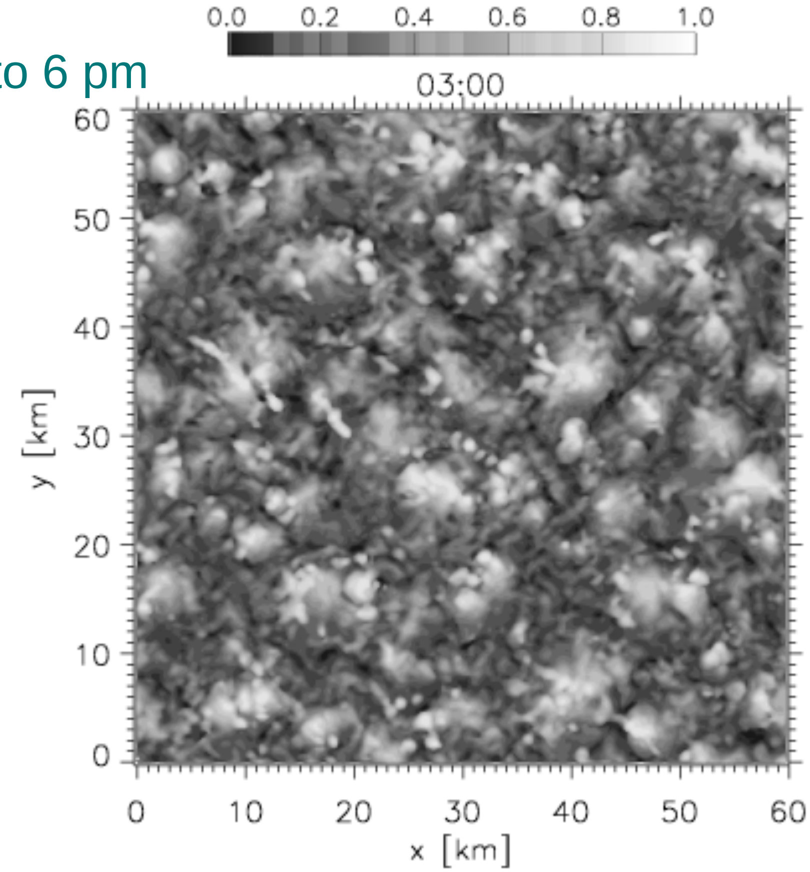
Cloud albedo

3 am to 6 pm

W30

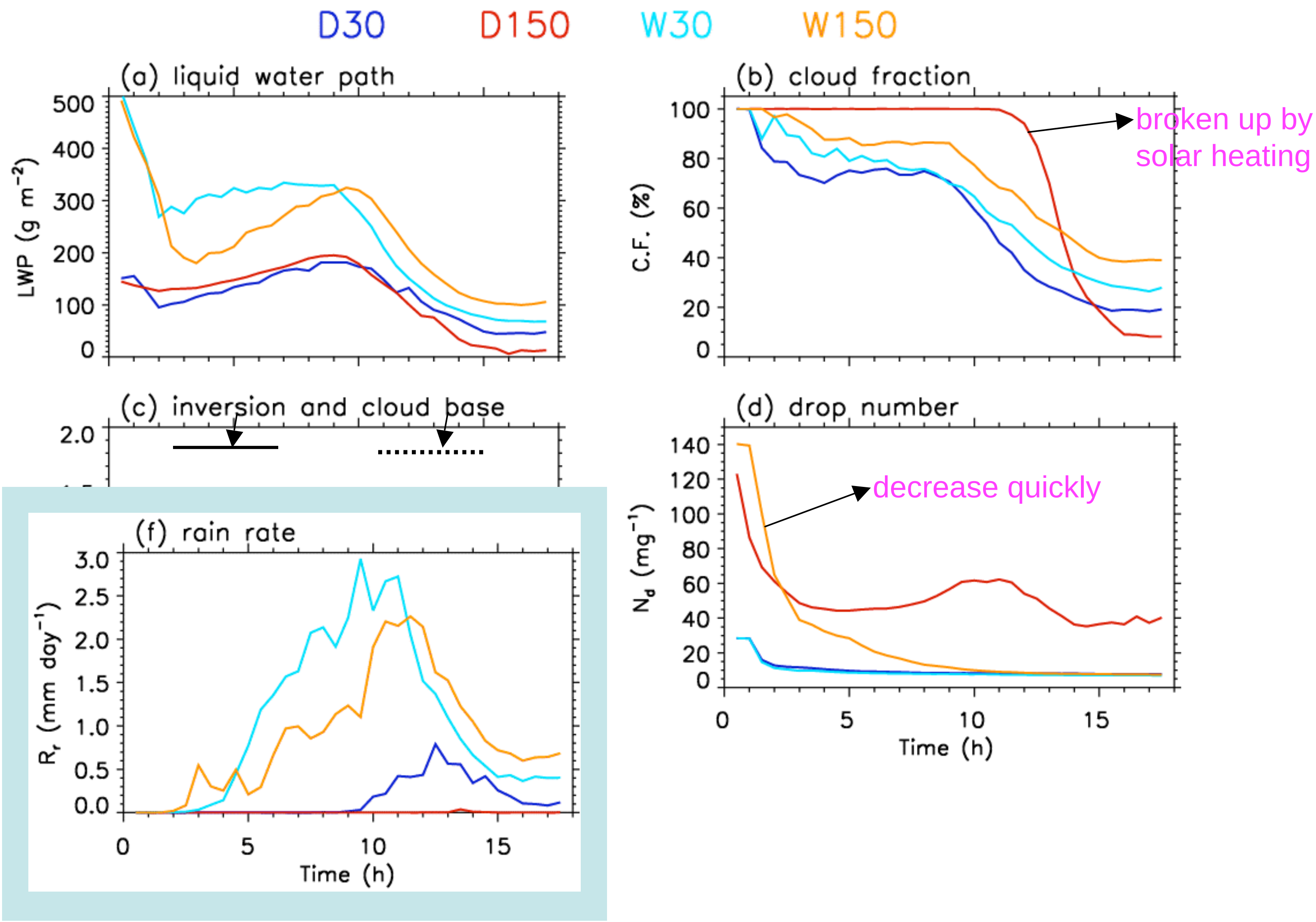


W150

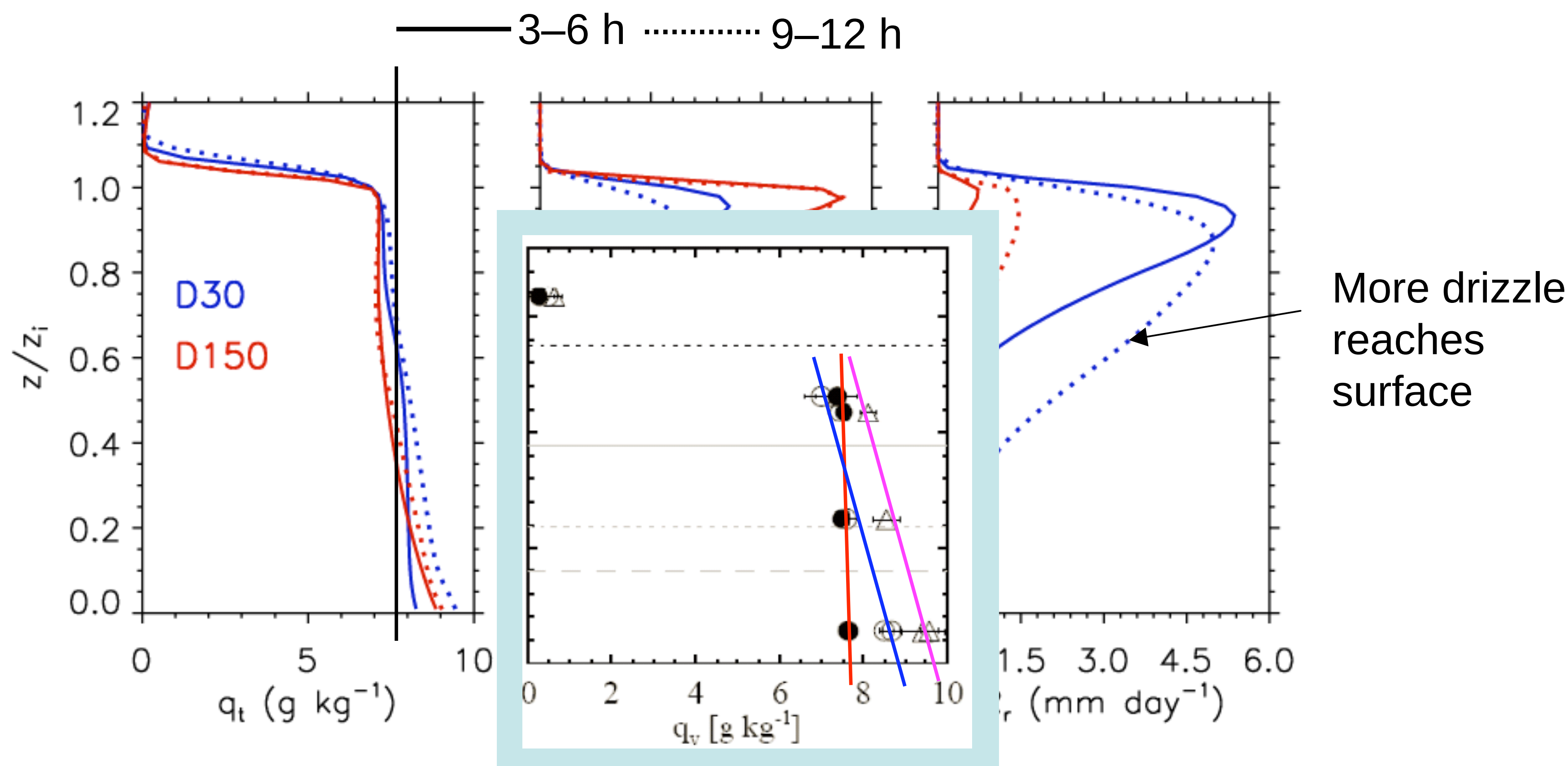


Open cells for both clean and polluted cases

Results: time series



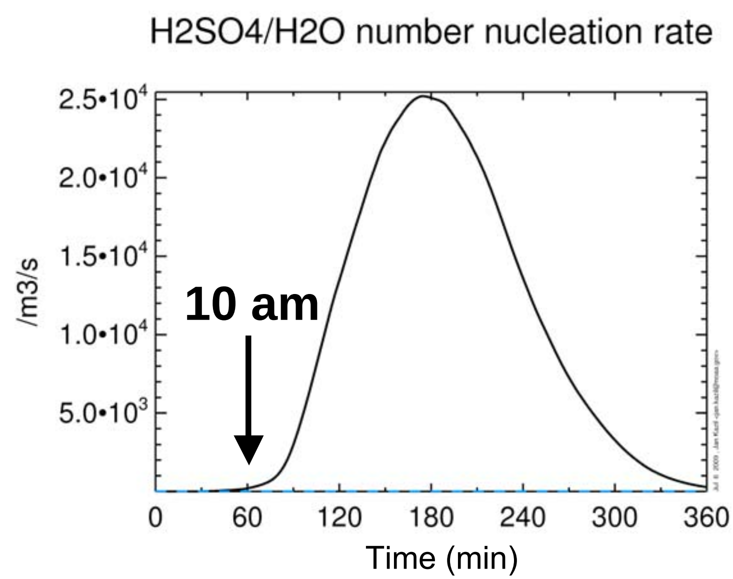
Results: impact of drizzle on water profile



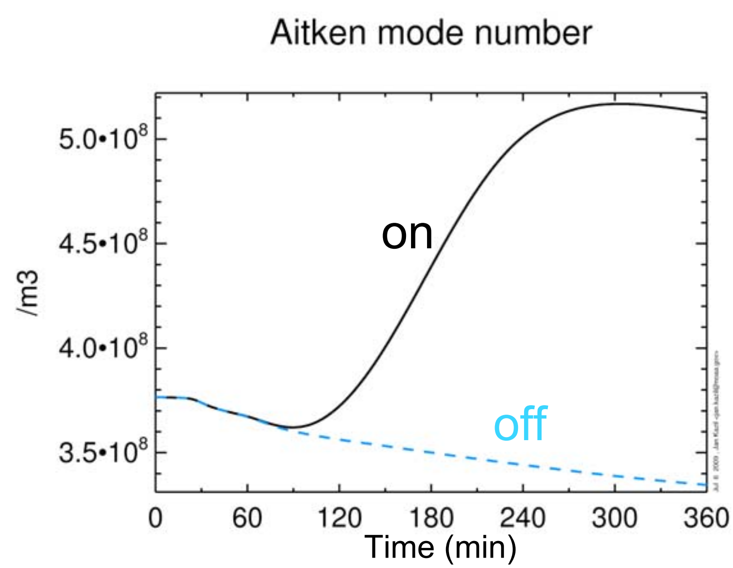
Drizzle makes the boundary layer more conducive to the development of open cells, supporting the idea of self-organization

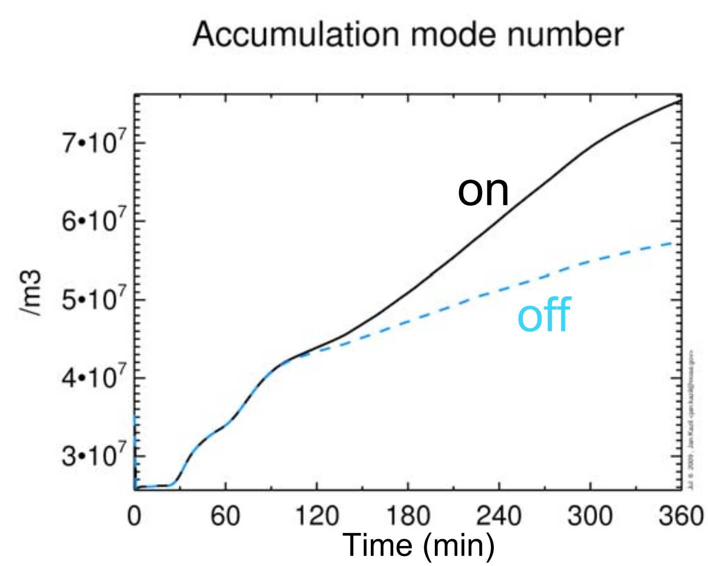
- Moistening/cooling (dynamical feedback)
- Cleansing aerosol (new particles?)

Simulations with a new aerosol nucleation scheme



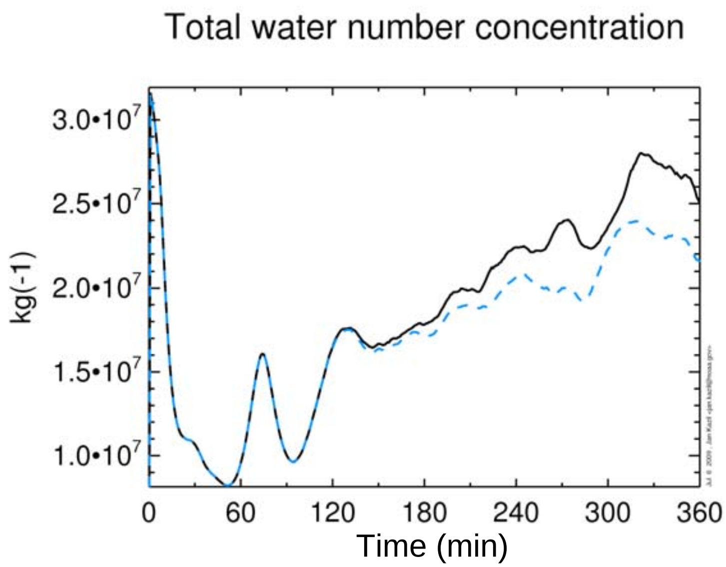
- The WRF/Chem model:
  - Gas-phase and aqueous chemistry
  - New aerosol nucleation scheme (Jan Kazil)
  - aerosol microphysics coupled with the cloud microphysics
- clean marine boundary layer
  - SO_2 (75 ppt), O_3 (35 ppb), CO (40 ppb), H_2O_2 (200 ppt), SO_4^{2-} (0.5 µg/kg)
- Experiments with aerosol nucleation on/off

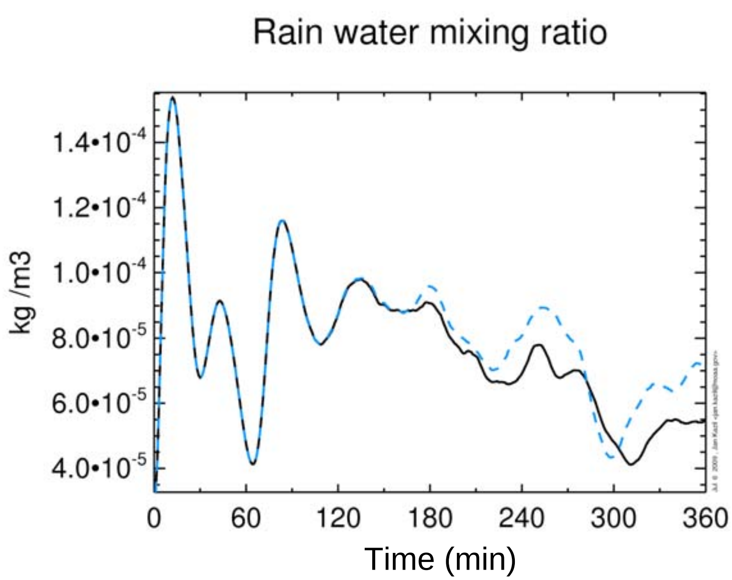




Nucleation significantly increases aerosol # concentration

Results: aerosol nucleation affects drizzle





Aerosol nucleation:
on — off - - - - - - -

- Aerosol nucleation increases cloud+rain drop # concentration
- Reduces drizzle formation

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Summary

- Drizzle is more sensitive to meteorological conditions than to aerosol concentration
- Drizzle makes the boundary layer more conducive to the formation of open cells
- Solar radiation has an important impact on the evolution of cloud cellular structures
- Aerosol nucleation affects drizzle in marine boundary layer
- Ongoing and future work
  - Diurnal evolution of cellular structures
  - Including aerosol nucleation in POC simulations
  - Evaluating simulations with VOCALS observations