Improving model simulations of radiation fog – a case study (IOP1)

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What is the problem?

- Simulating radiation fog is difficult, as the small-scale processes that form the life cycle interact non-linearly. We want to understand the role of aerosol-fog interactions.[1 2]
- IOP1 was a stable fog case in Cardington, UK, where it was optically thin throughout the night.
- We simulate this case using the default settings of the:
  - Met Office NERC (MONC) model; a LES model run at a high resolution.
  - CASIM; a 2-moment bulk microphysics scheme with the Abdul Razzak and Ghan (ARG) aerosol activation component.[3]
  - SOCRATES; radiative transfer scheme.
- The model was initialised based on the observational data available, with the objective to analyse the initial formation stages.

What are the model challenges?

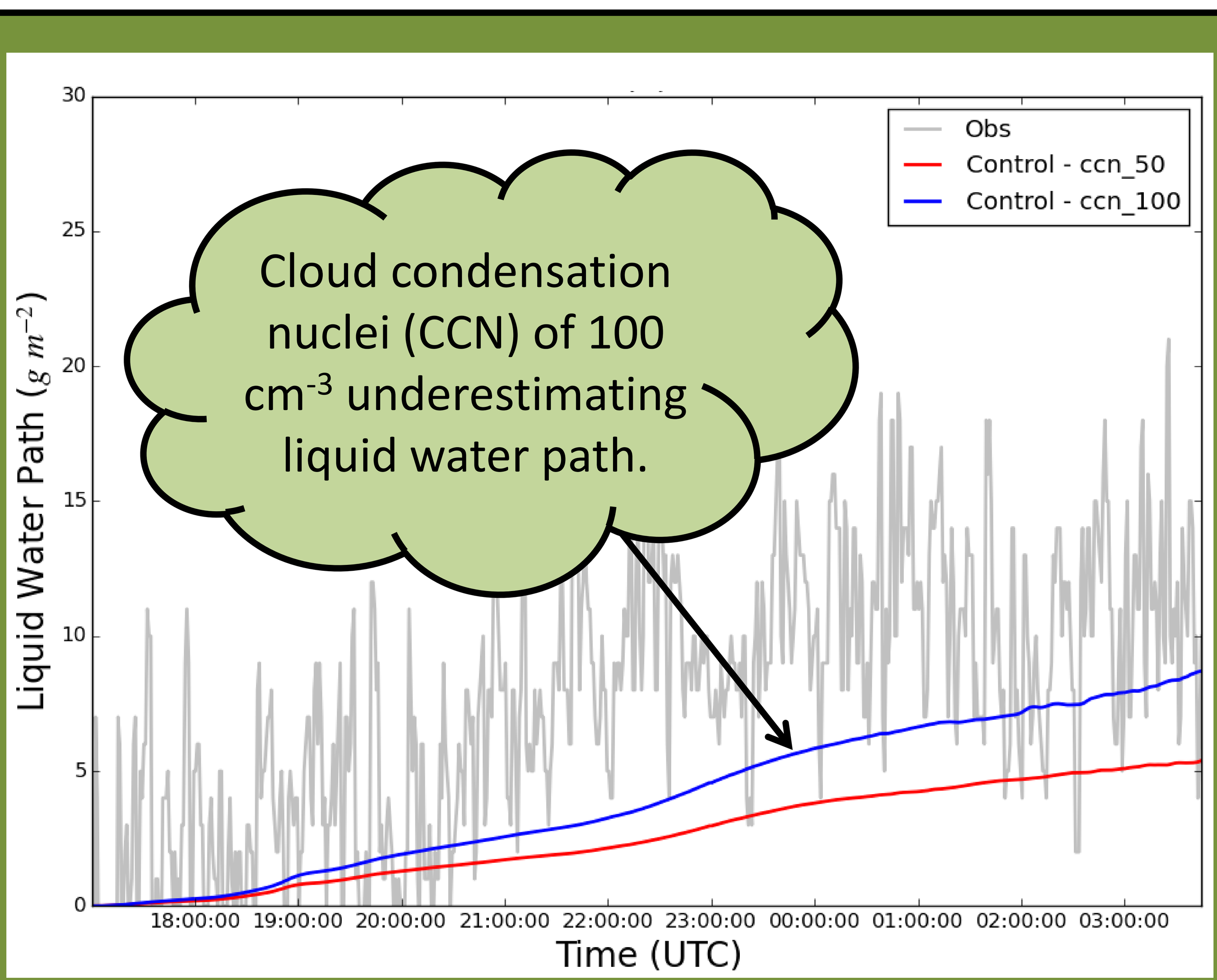

Fig 1: *Comparison of simulated liquid water path to observed liquid water path for different aerosol concentrations.*

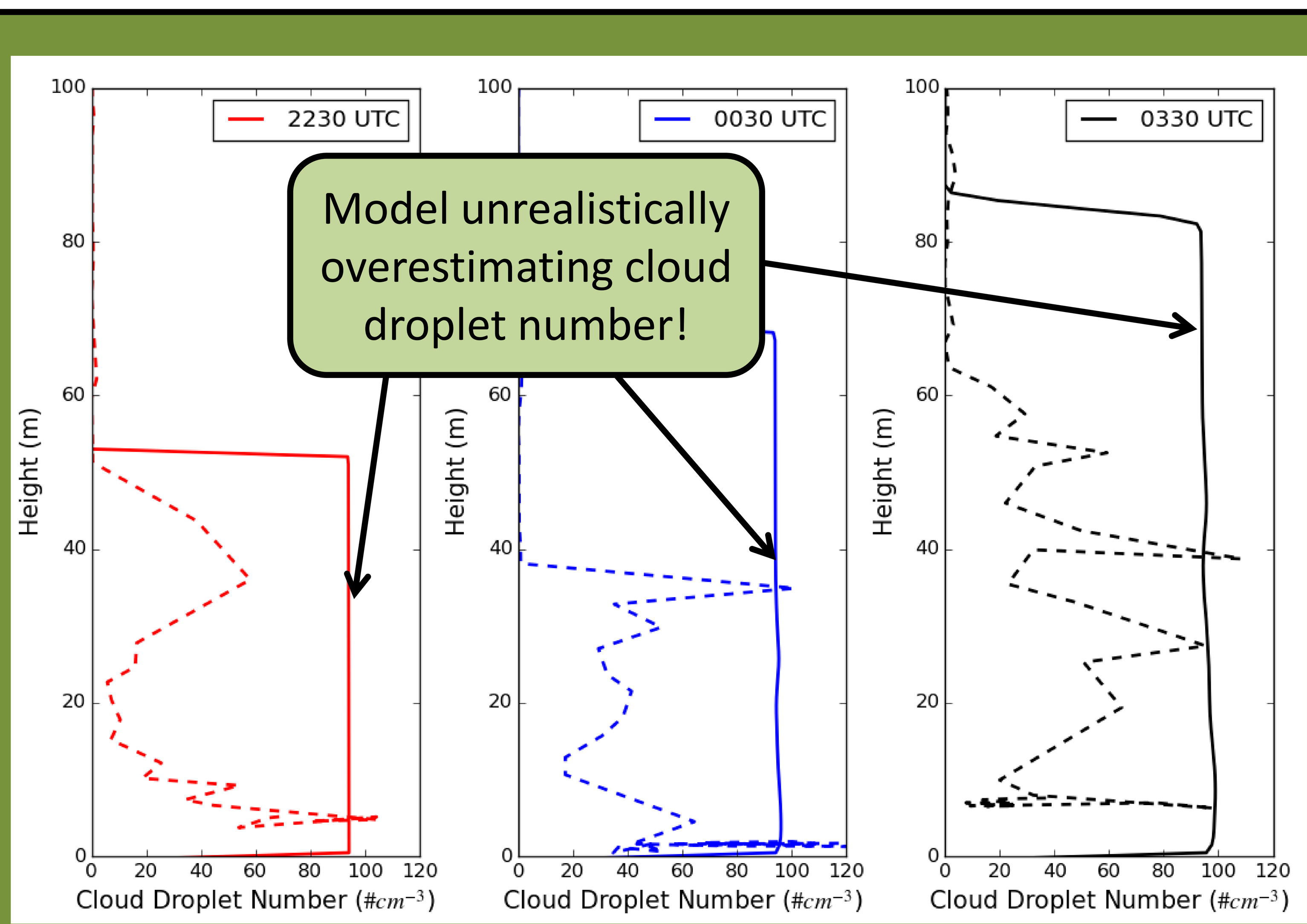

Fig 2: *Comparison of simulated (solid "-" line) and observed (dashed "--" line) cloud droplet number for a CCN = 100 # cm^{-3} at different times of the fog life cycle.*

How do we go forward?

- Results suggest that radiative cooling is poorly represented in the simulation. The calculation for the rate of cooling is strongly dependent on both the liquid mass and number, which are both under and overestimated, respectively.
- A preliminary result not shown is how the sedimentation rate is dependent on the shape parameter of the cloud droplet distribution, therefore determining the total liquid water content. Further analysis will be conducted to choose a more suitable parameter suitable for fog.
- Overestimation of the cloud droplet number (CDN) is due to all CCN being activated due to the representation of cooling in ARG. The solution is to have the cooling represented as a cooling rate rather than an artificial updraft speed. This would then result in a CDN found in radiation fog.

1. Price, J. (2011). Radiation fog. Part I: observations of stability and drop size distributions. *Boundary-layer meteorology*, *139*(2), 167-191.
2. Boutle, I., Price, J., Kudzotsa, I., Kokkola, H., & Romakkaniemi, S. (2018). Aerosol–fog interaction and the transition to well-mixed radiation fog. Atmospheric Chemistry and Physics, 18(11), 7827-7840.
3. Abdul-Razzak, H., & Ghan, S. J. (2000). A parameterization of aerosol activation: 2. Multiple aerosol types. *Journal of Geophysical Research: Atmospheres*, *105*(D5), 6837-6844.

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