Cloud-Resolving Simulations Using the WRF Model Driven by Large-Scale Forcings

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Introduction

The FASTER project plans to use the WRF model as a cloud resolving model (CRM) to provide dataset for the evaluation and development of parameterizations in climate models.

Default function of WRF-LES (em_les)

- Horizontally uniform initial condition
- Periodic boundary conditions
- Only constant sensible heat flux
- No radiation, no Coriolis, ….

Not enough

We extend the capability of WRF-LES for the CRM simulations and evaluate it against other models' results.

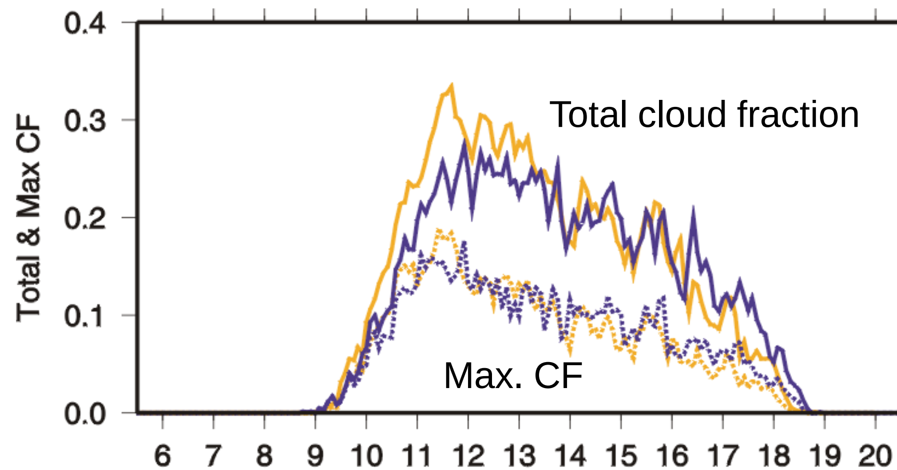
The modified WRF (WRF-FASTER)

- Prescription of horizontally uniform time-varying large-scale forcings
- Prescription of surface sensible heat flux, latent heat flux, albedo and skin temperature
- And more.

Continental Shallow Cumulus (ARM SGP)

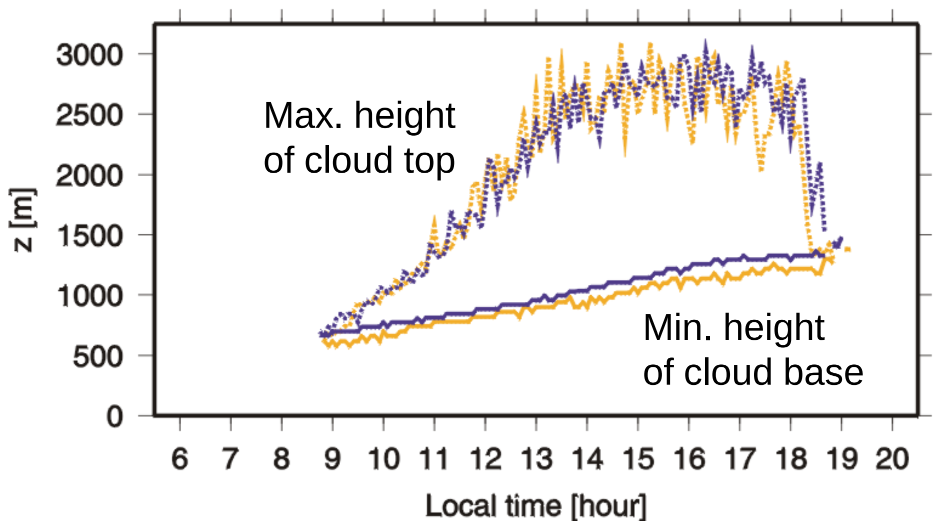
● Idealized simulation of cumulus topped convective boundary layer on 21 June 1997 at ARM SGP site (one of the GCSS inter-comparison cases; Brown et al. 2002)

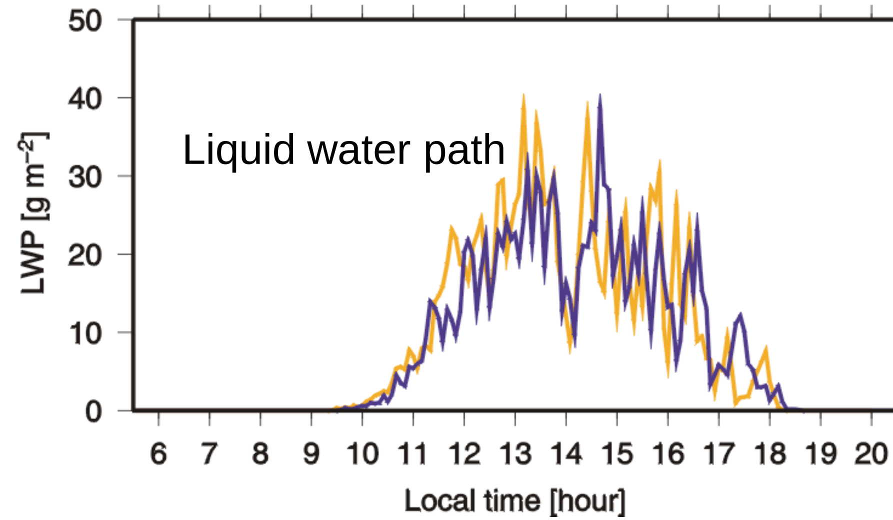
● WRF-FASTER produced similar diurnal variation of clouds to KNMI-LES.



WRF-FASTER

KNMI-LES



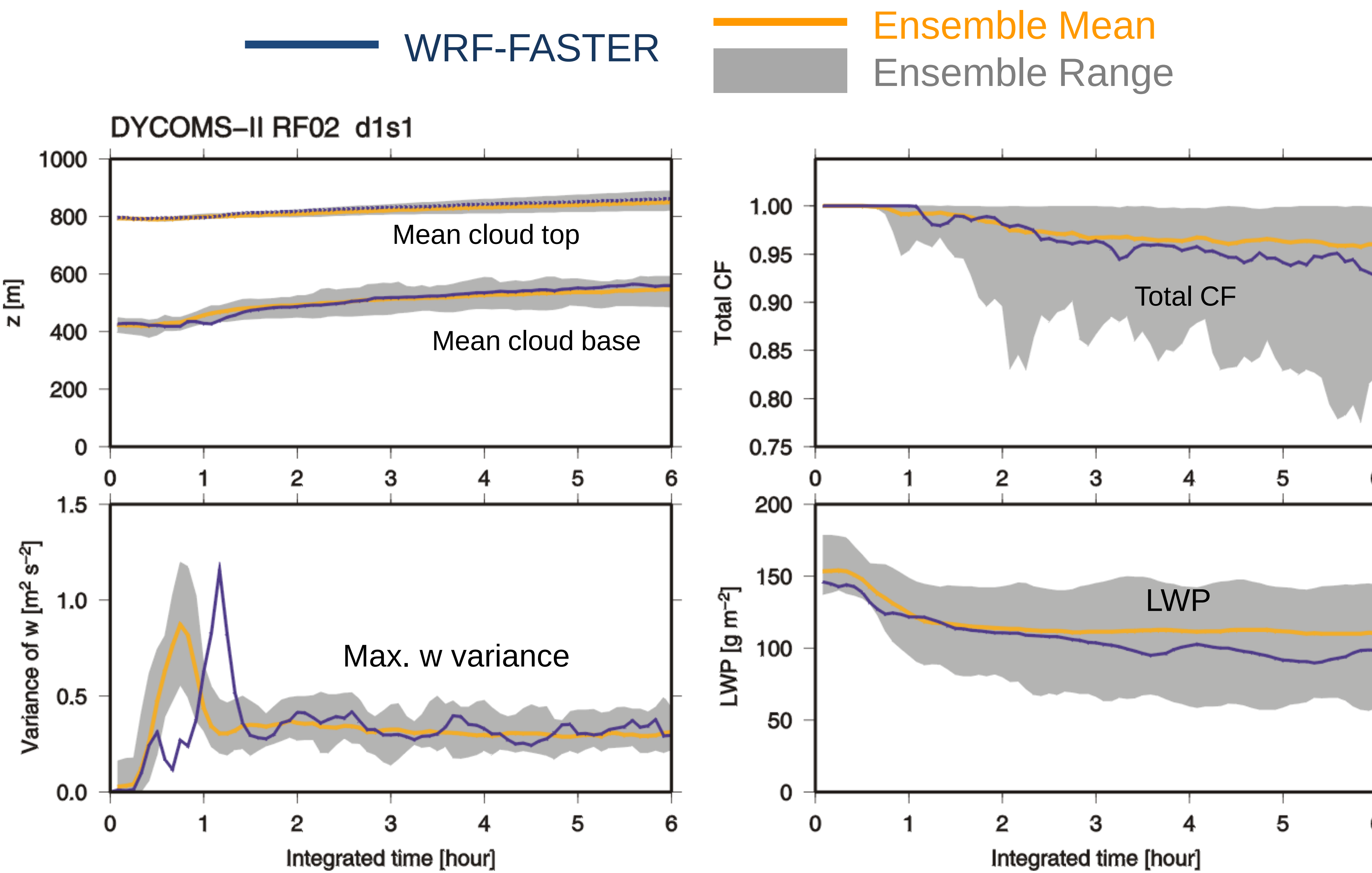


Maritime Stratocumulus (DYCOMS-II RF02)

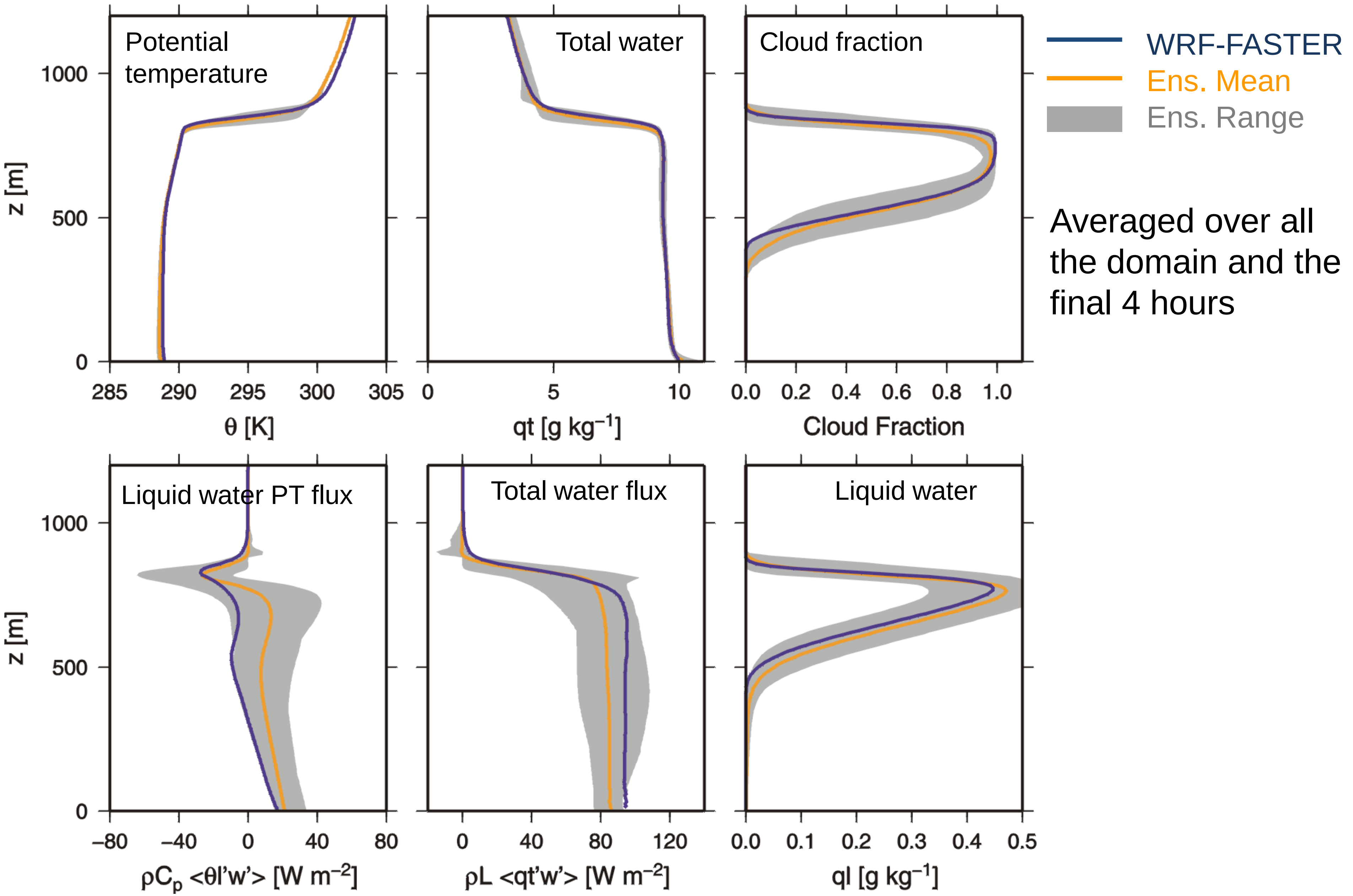
- Idealized simulation of stratocumulus based on the 2nd research flight (RF02) of DYCOMS-II project.
- Another GCSS inter-comparison case (Ackerman et al., 2009)
- Configuration follows the specification except for vertical resolution.

Period	6 hours with nighttime setting
Resolution (Domain)	50 m x 50 m x 7.5 m (average) (6400 m x 6400 m x 1500 m)
Microphysics	Lin et al. scheme with cloud water sedimentation and Nc = 55 cm^{-3}
Turbulence	TKE scheme
Radiation	SW: None LW: Stevens et al. (2005)
Surface	Constant friction velocity (0.25 ms^{-1}), SHF (16 Wm^{-2}) and LHF (93 Wm^{-2}).
Forcing	Surface forcing above. Subsidence (div = 3.75×10^{-6} s^{-1}) and consequential heating, drying.

Time evolution



Profile



Averaged over all the domain and the final 4 hours

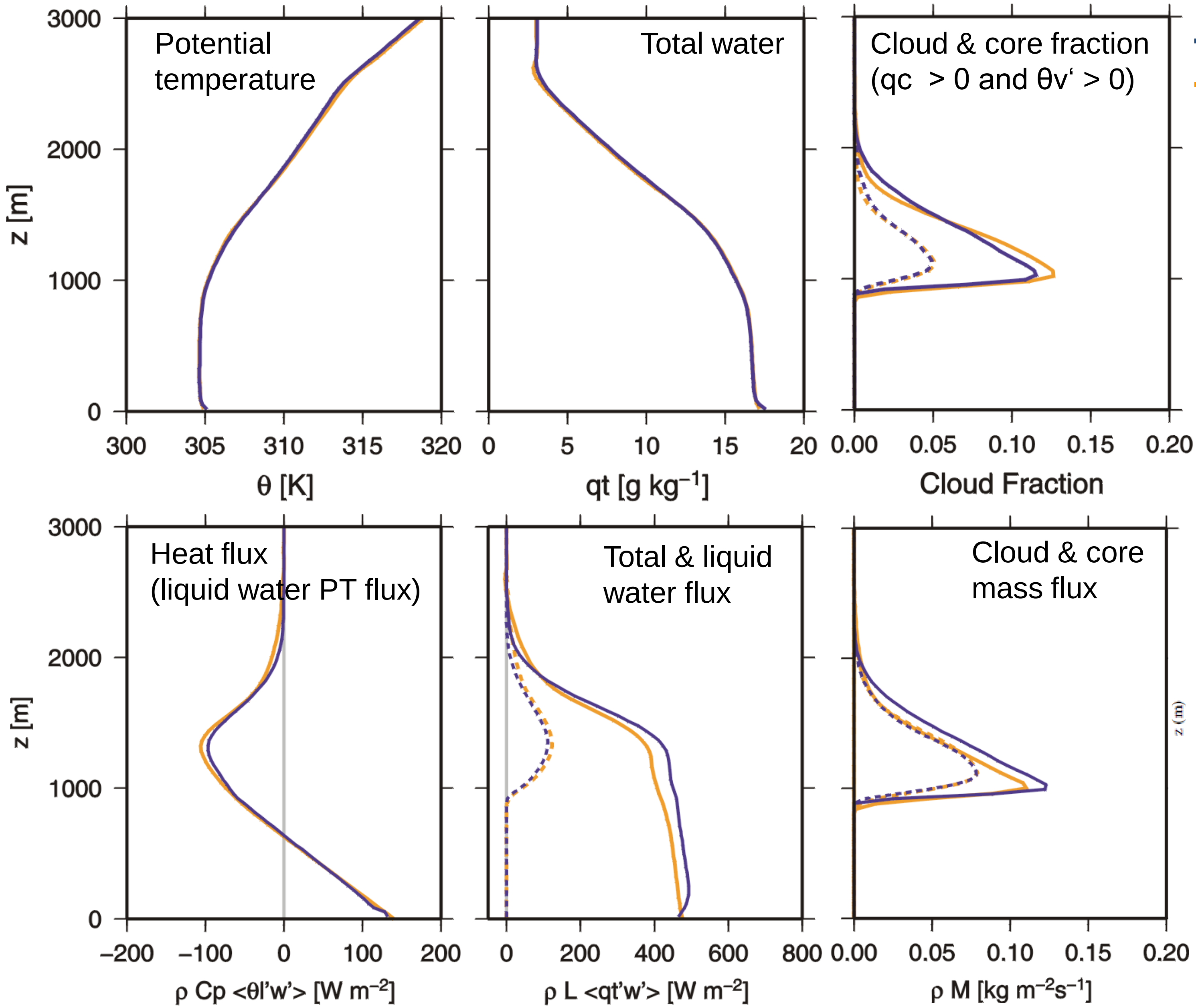
Summary

● Additional functions were implemented into WRF, including prescription of time-varying large-scale and surface forcings.

● The properties of simulated continental shallow cumulus clouds agreed well with that of KNMI-LES, and those of simulated maritime stratocumulus clouds dropped in the range of spreading among other models.

● Though not shown here (shown in POSTER), frontal clouds in March 2000 IOP at SGP were also simulated using continuous forcings. The results were comparable to those of other models.

The ARM SGP case: Vertical profile



WRF-FASTER
KNMI-LES

Averaged over all the domain and time period of 12-13 LT