WRF Model Simulations of tropical Cloud Systems observed during TWP-ICE

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1. Introduction

The Tropical Warm Pool-International Cloud Experiment (TWP-ICE) took place in Darwin, Australia during January and February 2006. It provides an outstanding data set describing tropical cloud systems, their evolution and interaction with the larger-scale environment. During the experiment four different convective regimes were sampled. The measurements of these different regimes during TWP-ICE provide a valuable resource for the validation of numerical simulations under different tropical meteorological situations.

The Weather Research and Forecasting (WRF) model has been used to simulate tropical cloud systems observed during TWP-ICE. Simulations for two different periods have been performed. The overall model performance during the two convective regimes is evaluated. In particular, this study focusses on WRF's ability to reproduce the observed cloud structures as well as the model's performance in terms of precipitation.

2. Tropical Warm Pool – International Cloud Experiment (TWP-ICE)

instruments:

- ground-based observational systems:

  polarimetric weather radar, cloud radar, wind profilers, radiation measurements, lightning network, balloon-borne sounding network
- five research aircraft

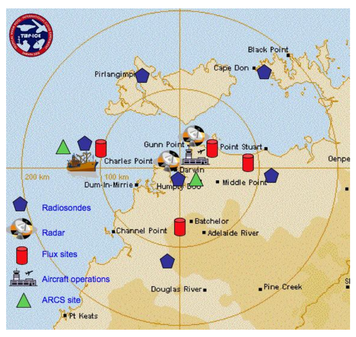

Fig. 1: TWP-ICE domain.

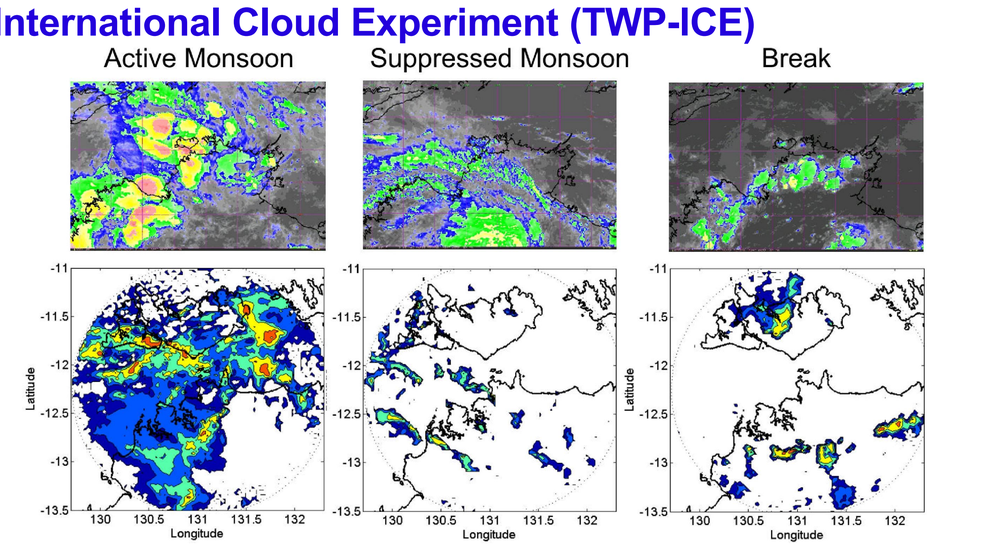

Fig. 2: Sample IR satellite images from MTSAT1-R (top) and radar PPI maps (bottom). These panels are not necessarily at the same dates and times, but were chosen as representative of typical structure and organisation observed in the different periods. Colours in the IR images are grey for T>250K, blue for 250-230K, green for 230-210K and yellow for 210-190K. Radar contours are drawn every 10 dBZ from 10 dBZ.

3. WRF simulations

- Weather Research and Forecasting model (WRF); Advanced Research WRF (ARW, Skamarock, 2005)
- multi-nested runs with 4 domains;
- 64 levels
- resolution of inner-most nest: 1.259km
- initialisation: 6-hourly NCEP 1.0°×1.0°
- physics options: explicit Lin microphysics; YSU or Mellor-Yamada-Janjic (MYJ) boundary layer scheme; thermal diffusion surface scheme; RRTM/Dudhia radiation scheme

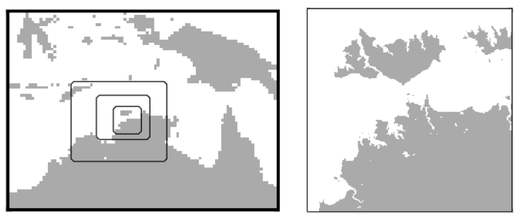

Fig. 3: Simulation domain including the nests (left); inner-most nest (right)).

simulation periods:

- 20/01-24/01/2006 (active monsoon)
- 05/02-09/02/2006 (break period)

4. WRF results: overall model validation

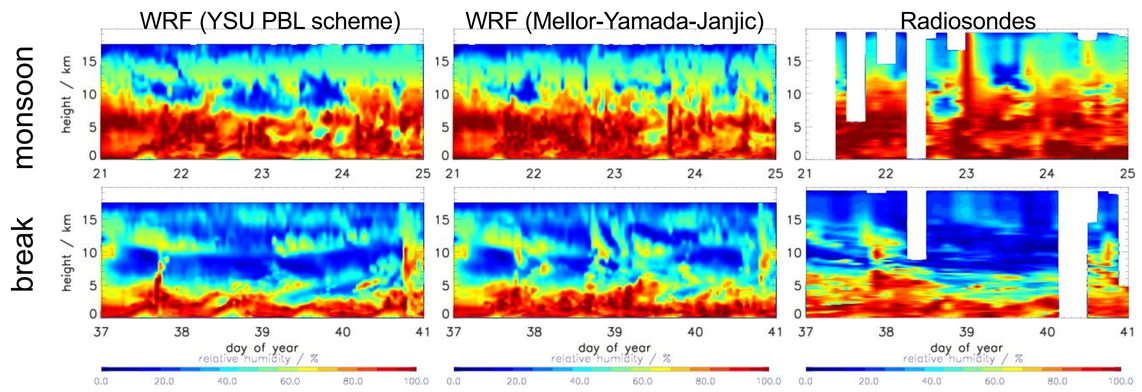

Fig. 4: Time height cross-section of relative humidity (with respect to water) from WRF (YSU PBL scheme (left) and Mellor-Yamada-Janjic PBL scheme (middle)) and measured by radiosondes at Point Stuart (right)).

5. WRF results: clouds and precipitation

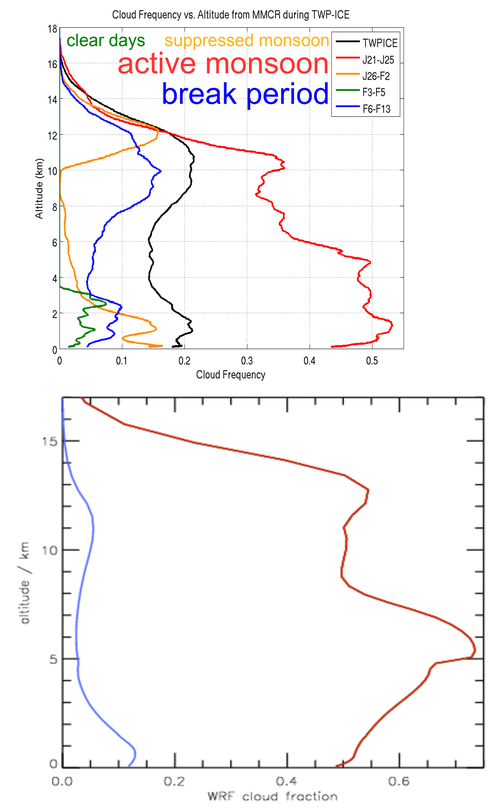

Fig. 5: Measured mean cloud frequency profiles for the four regimes (top) and WRF cloud fractions (bottom).

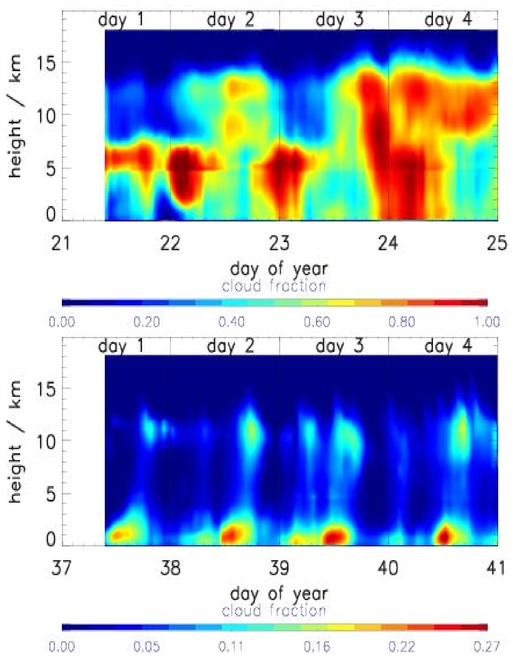

Fig. 6: Time height cross-section of cloud fractions from WRF for the active monsoon (top) and the break period (bottom).

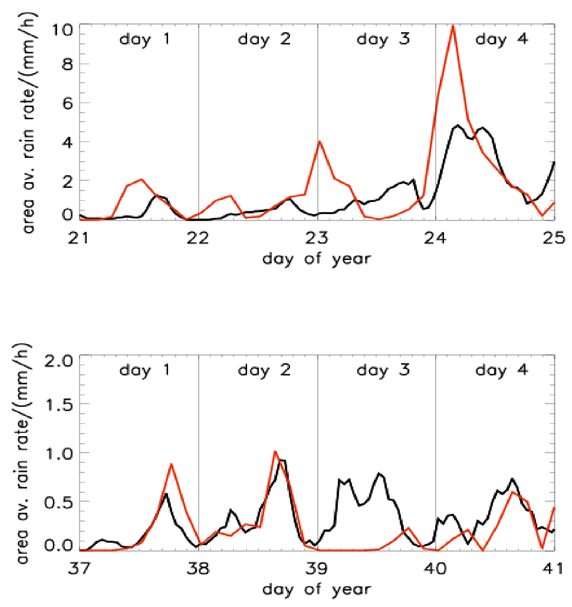

Fig. 7: Area averaged rain rates of the polarimetric radar (red) and WRF simulations (black).

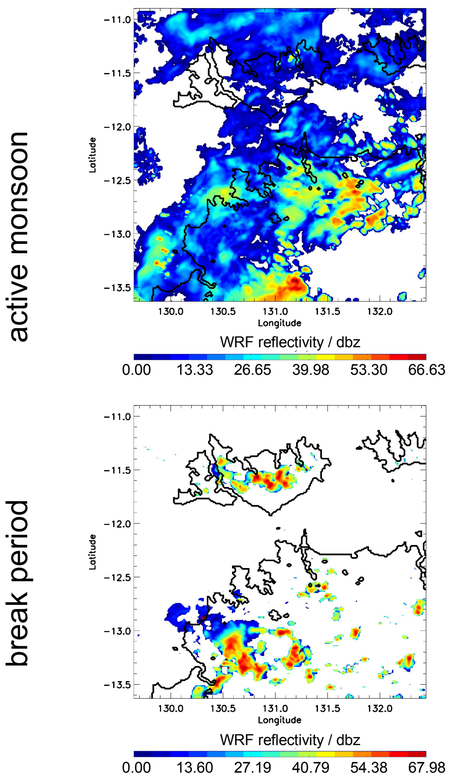

Fig. 8: Example of WRF reflectivities for monsoon (top) and break period (bottom).

6. Summary and future work

- observed cloud structures for different regimes well reproduced by model simulations
- WRF overestimates the diurnal circle of the relative humidity over land near the surface for both regimes with YSU PBL scheme; improvement with Mellor-Yamada-Janjic boundary layer scheme
- WRF performance in terms of precipitation:
  - good agreement between observed and simulated local rain rates (not shown) as well as area averaged accumulated precipitation
  - simulation of occurrence of precipitation is regime dependent: much better for break period, where the convection is more strongly forced by the diurnal circle
  - WRF precipitation excellent for day 1, 2 and 4 of the break period simulation, but not for day 3 (subject to continuing investigation)

References

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Acknowledgements

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