Novel Evaluation of Cloud Model Microphysical Fields using Polarimetric Radar Observations

S. A. Rutledge[1], B. Dolan[1], T. Matsui[2,3], T. Iguchi[2,3], W.-K.Tao[3], J. Barnum[1], and S. Lang[3,4]

[1]Department of Atmospheric Science, Colorado State University, Fort Collins, CO
[2]University of Maryland College Park
[3]Goddard Space Flight Center
[4]SSAI, Inc.

Introduction

A number of cases from two past DOE field projects have been analyzed using polarimetric radar observations as well as simulations using the NASA-Unified WRF model (NU-WRF) with the goal of carefully evaluating and improving cloud microphysical parametrizations. A new framework for direct comparisons between polarimetric radar observations and model simulations has been developed, Polarimetric Radar Retrieval and Instrument Simulator (POLARRIS). POLARRIS is a comprehensive package that calculates the full range of polarimetric variables (at S-, C- and X-band), using the model-derived microphysical fields as input (the forward model). Output from the POLARRIS forward model is then directly linked to observational radar analysis tools such as Hydrometeor Identification (HID), allowing for direct comparisons of model-derived polarimetric variables and hydrometeor retrievals with observational data.

Herein we analyze two cases from two DoE field projects with polarimetric and Doppler observations, allowing for retrievals of the 3-D wind field and hydrometeor categories. The Tropical Warm Pool – International Cloud Experiment (TWP-ICE) took place near Darwin, Australia in January – March 2006. The Mid-latitude Continental Convective Clouds Experiment (MC3E), took place in the spring of 2011 at the Southern Great Plains Central Facility. From MC3E, a deep convection (23-24 May) case was analyzed. From TWP-ICE, a monsoon case was chosen for examination (23 January). These two cases, representing very different meteorological regimes, are compared to evaluate the ability of NU-WRF with the 4ICE microphysics scheme to capture the different microphysics and dynamics.

POLARRIS: POLArimetric Radar Retrieval and Instrument Simulator

POLARRIS Forward Model

Generate statistical plots.
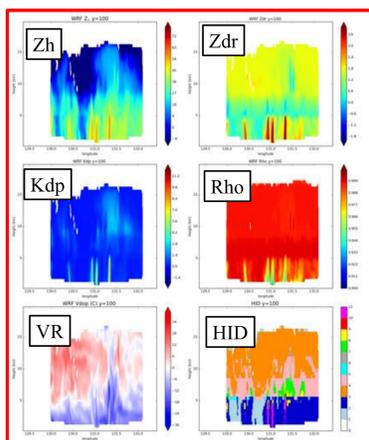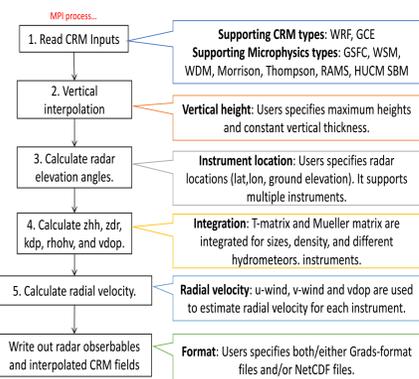
POLARRIS- Inverse: Radar Retrievals
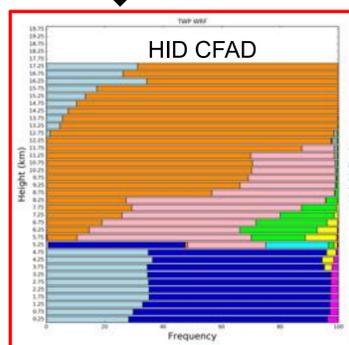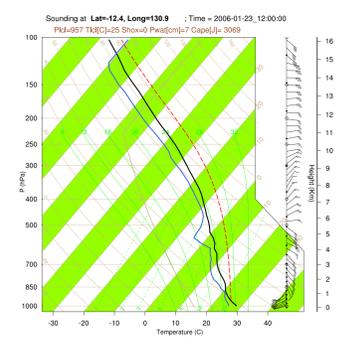
TWP-ICE: 23 January Monsoon

Pre-Storm Environment

Conditional Rain Rates

- Larger stratiform contribution later in the model compared to observations
- An earlier peak in convective/total rainfall (04-11 UTC) in observations but overall missed by the model
- About a 2 hour offset in peak rainfall

CPOL 1820

WRF 1910
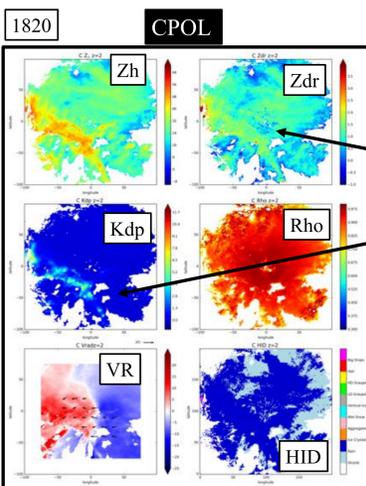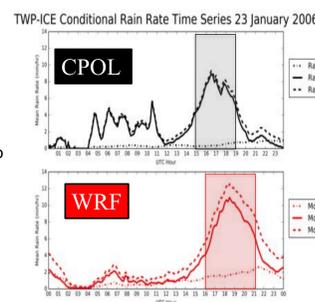
- Texture of fields is similar
- Larger Z_{dr} and K_{dp} values from model
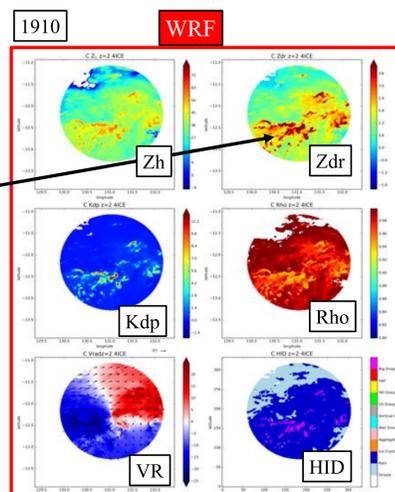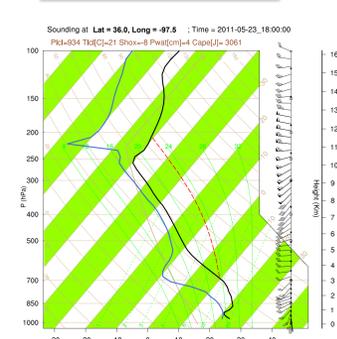
MC3E: 23 May Supercells

Pre-Storm Environment

Conditional Rain Rates

- Later peaks in observed rainfall are missed by model (06 - 11 UTC)
- Model shuts down convection in domain earlier than observations
- Overall magnitudes in the model are low compared to observations.

CSAPR 2230

WRF 0000
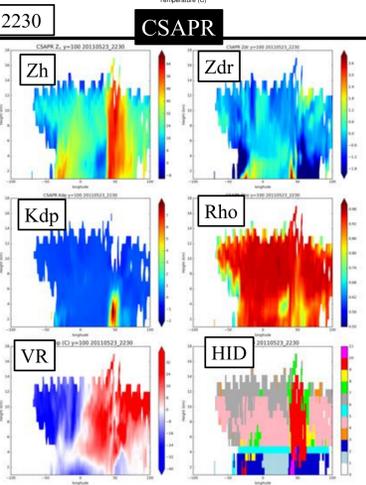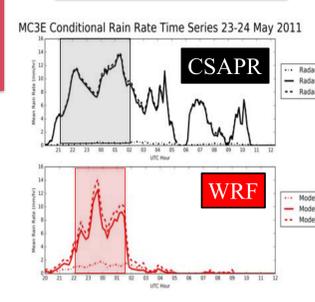
- Larger Z_{dr} aloft in anvil
- Z_{dr} similar magnitude in rain
- K_{dp} enhanced aloft in simulation
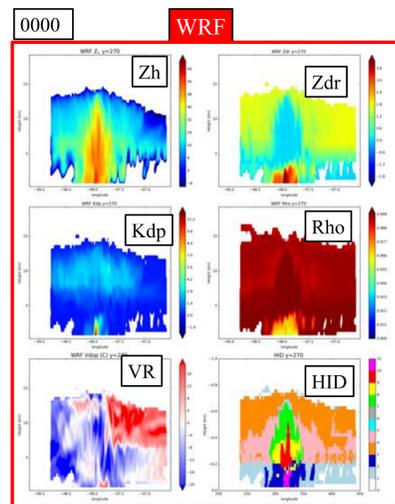
Intercomparisons

Integration times:
TWP: 15-19 Z
MC3E:21-02 Z

Integration times:
TWP: 16-21 Z
MC3E:21-02 Z

Reflectivity CFAD

CPOL / CSAPR

WRF-POLARRIS
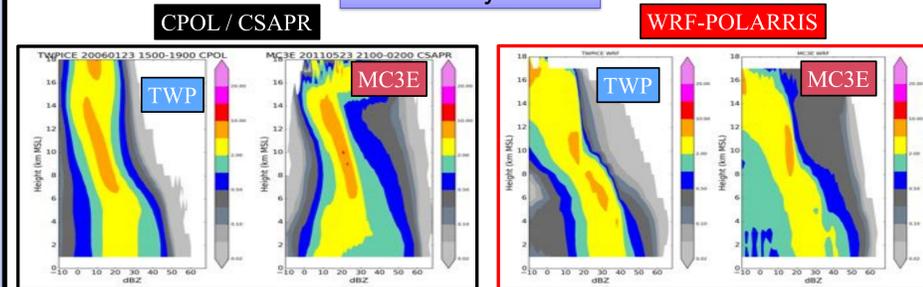
- Model captures stronger upper levels in MC3E compared to TWPICE
- General structures are similar between model and obs

ZDR CFAD

CPOL / CSAPR

WRF-POLARRIS
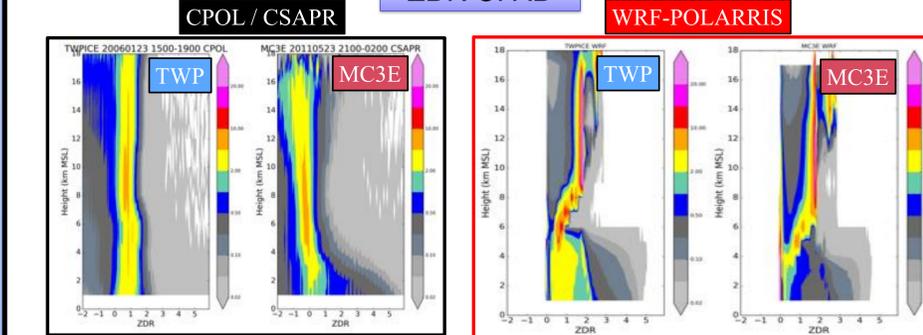
- Different trends in upper levels, lower levels compare better between model and obs
- Model has too large of values in the upper levels compared to obs

HID Frequency

CPOL / CSAPR

WRF-POLARRIS
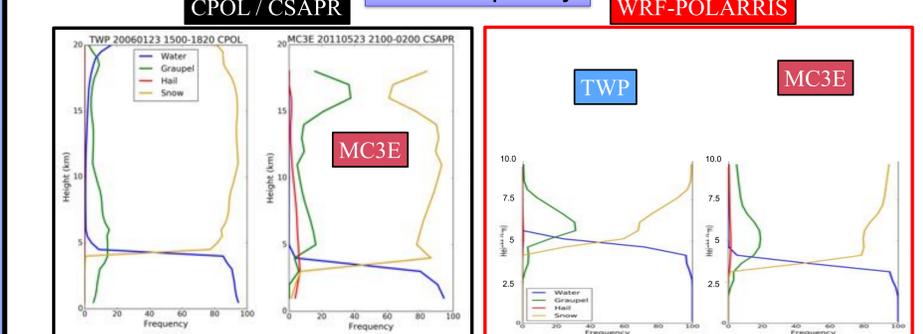
- Model has more graupel in mid levels compared to observations in TWPICE
- Both observations and model have hail in MC3E compared to TWP-ICE

Updraft Width

CPOL / CSAPR

WRF-POLARRIS
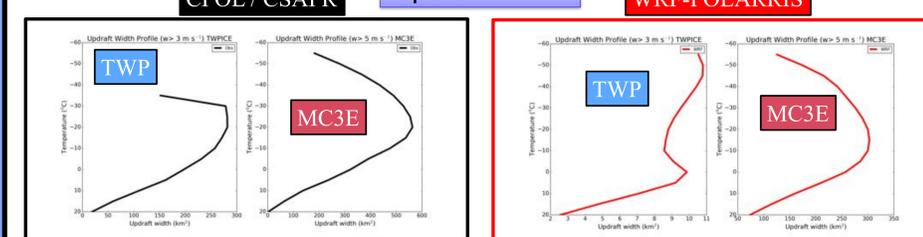
- Updraft width similar for MC3E in model and obs, but widths peak higher in observations
- TWPICE widths are significantly smaller compared to obs and peak at wrong levels

Acknowledgements

Forthcoming Papers

Dolan, B. et. al., 2017: Primary modes of global rain drop-size distribution variability
Matsui, T. et al., 2017: Polarimetric Radar Characteristics of Simulated and Observed Convective Cores Between Continental and Maritime Environment