Tracking Tropical Cloud Systems – Comparison of Observations with Simulations by the Weather Research and Forecasting (WRF) Model

Andrew Vogelmann[1], Wuyin Lin[2], Edward Luke[1], Alice Cialella[1], Michael Jensen[1], Minghua Zhang[2]

[1] Brookhaven National Laboratory, [2] State University of New York at Stony Brook

SUMMARY

To aid in improving model parameterizations of clouds and convection, we examine the capability of models, using explicit and parameterized convection, to simulate the life cycle of tropical cloud systems in the vicinity of the ARM Climate Research Facility (ACRF) Tropical Western Pacific sites.

- Model statistics are simulated using the Weather Research and Forecasting (WRF) Model.
- Simulations are compared to the observed cloud life cycle, determined using a satellite cloud tracking algorithm. Simulations are run at a resolution comparable to observations.

Later investigations will examine how well the simulated cloud systems compare with ACRF observations in terms of properties such as cloud overlap within the vertical column as a function of cloud life cycle stage.

2. TRACKING

Satellite cloud identification and tracking performed using Boer and Ramanathan (1997)

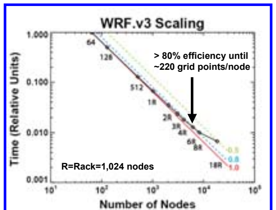
- Observed tracking uses GOES-9 11 μm (channel 4) brightness temperature (BT)
- WRF-equivalent BTs for this pilot study are obtained by converting:
  - Top-of-model outgoing longwave radiation (OLR) to a 11-μm narrowband BT
  - Translate the 11-μm narrowband BT from the 50-mb model top to 0 mb

  Future studies can avoid the 1st conversion by storing the output for WRF's RRTM band #6 (820-980 cm^{-1}).

We focus on mesoscale convective systems (MCS), defined as (Laing and Fritsch, 1993):

- Core area > 50,000 km^2 with BT < 219 K, surrounded by an anvil with BT < 240 K
- Core plus anvil area > 100,000 km^2

1. SIMULATIONS



Scaling tests performed using the WRF 2.5 km CONUS bench, which has 1.8M grid points. 18R represents all NY Blue nodes. Efficiency suffers when there are fewer than ~220 grid points per node.

Simulations run on NY Blue

- Blue Gene/L Supercomputer
- 18,432 nodes each w/ 2 processors and 1 GB
- Jointly operated by BNL and SBU
- 40% dedicated to BNL & SBU

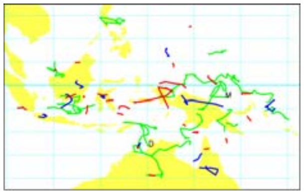
Baseline Simulation Parameters

- One-week simulations: 25 to 31 December, 2003
- Domains:
  - Inner: 4-km resolution, 22S-17N, 100E-162E
  - Outer: 20-km resolution, 27S-27N, 89E-170E
- Radiation: LW=RRTM, SW=Dudhia
- Cloud microphysics: WRF Single-Moment 3-class

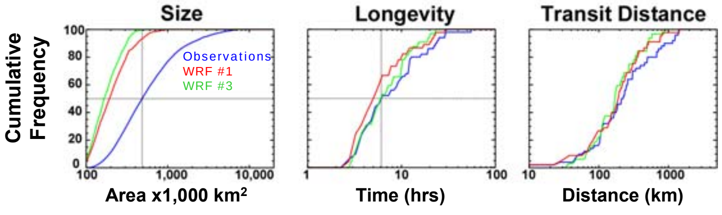
Four Sensitivity Tests to Convective Treatment

- Outer domain: Kain Fritsch (new eta) each 6 mins
  Inner domain:
- #1: Explicit convection (no parameterization)
  Cumulus scheme = Kain Fritsch (new eta)
- #2: Called every 6 mins
- #3: Called every 30 mins (inner and outer)
- #4: Called each step (18s)

3. PILOT RESULTS



Fifty observed MCS paths determined by the cloud tracking algorithm for a 6-day period 26-31 December. Colors indicate their duration: t ≤ 6 hrs, 6 < t ≤ 12 hrs, t > 12 hrs. ARM sites indicated: D = Darwin, M = Manus.



Observed MCS statistics (blue) compared to WRF runs #1 (red) and #3 (green); the number of tracks, respectively, are 50, 45 and 32. Simulations #2 and #4 produced substantially fewer MCSs. Compared to observations, the WRF-simulated MCSs had smaller areas, shorter duration, and transited shorter distances. Further work will refine the simulations and assess the causes for these differences.

References

Boer, E, and V Ramanathan, 1997: Lagrangian approach for deriving cloud characteristics from satellite observations and its implications to cloud parameterization. *J. Geophys. Res.*, 102, 21,383–21,399.

Laing, A.G., and J.M. Fritsch, 1993: Mesoscale Convective Complexes over the Indian Monsoon Region. *J. Climate*, 6, 911–919.

Contact Information

NY Blue Climate Science Wiki
https://wiki.bnl.gov/bg_climate_science/index.php/Main_Page

Andy Vogelmann
vogelmann@bnl.gov, 631-344-4421