Regional and Cloud-Scale Modeling of Tropical West Pacific Clouds Using WRF

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Introduction

The Tropical West Pacific is now a well-observed region of tropical convection, and ARM data is being used as verification for model parameterization studies. Cloud-scale modeling in this region will serve as a guide for parameterization of convection that is needed in climate models.

In this poster we focus on three improvements being made in WRF physics for applications in regional climate and cloud-scale modeling, (1) model-top clear-sky downward longwave radiation, (2) microphysics-radiation assumptions, (3) convective parameterization sensitivity

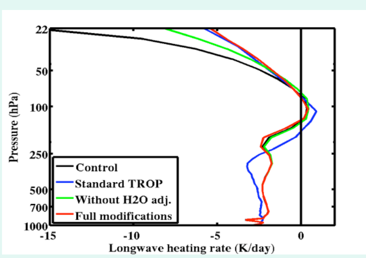
1. Model-top Radiation Improvement

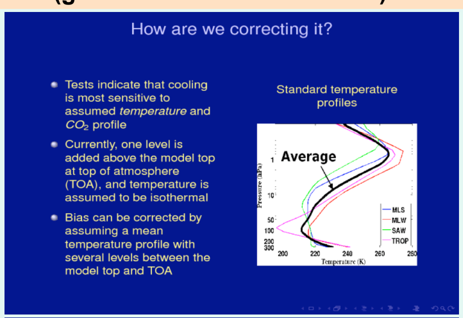
Mesoscale model tops are usually at 10-50 hPa. A noticeable erroneous cooling occurs near the model top level as seen in 1D tests using the RRTM longwave scheme (below left).

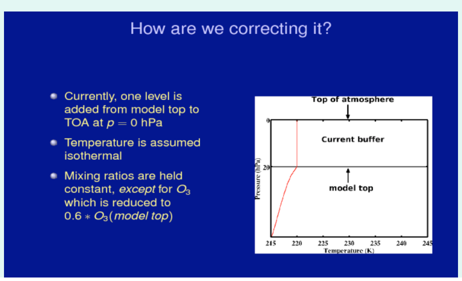
This has been traced to the usual isothermal assumption for downward longwave radiation above the model top.

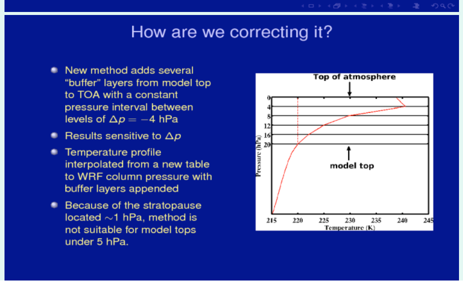
Here we improve on this assumption to remove the bias using a method of adding a more realistic lapse rate at high levels, that is applied in the RRTM longwave scheme (black and green curves below).

An added improvement comes from reducing the relative-humidity assumption for levels with missing data (green and red curves below).









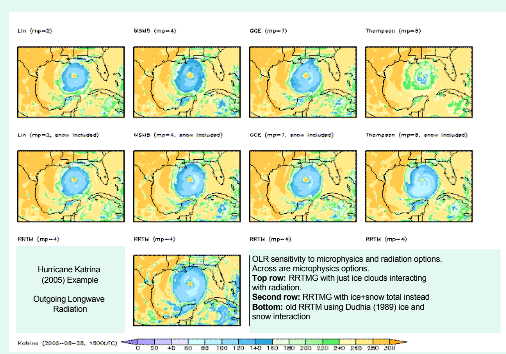
2. Microphysics-Radiation Interaction

The interaction between microphysics and radiation parameterizations is sensitive to the particle assumptions.

In the below examples, we see that for some microphysics options, ice clouds are not suitable for OLR calculations.

A fix for this is to consider ice+snow for radiation purposes, but ideally the particle assumptions should be consistent between microphysics and radiation.

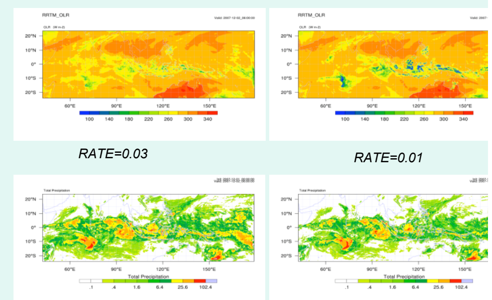
More work is ongoing in this area and this project has a microphysical observation component (Heymsfield and Mace) that will be helpful in guiding this development.



OLR sensitivity to microphysics and radiation options. Across are microphysics options. **Top row:** RRTMG with just ice clouds interacting with radiation. **Second row:** RRTMG with ice+snow total instead **Bottom:** old RRTM using Dudhia (1989) ice and snow interaction

3. Cumulus Parameterization

The Kain-Fritsch convective scheme is a popular scheme in regional climate simulations. One parameter in this schem is *RATE* which represents the cloud to precipitation conversion rate in parameterized updrafts. We find sensitivi to this parameter that affects the partitioning of condensate into upper clouds and precipitation. The default valu of 0.03 is modified to 0.01 to give better OLR and precipitation for tropical convection.



The above figures show that the OLR is significantly reduced and precipitation is slightly reduced when *RATE = 0.01* consistent with more cloud, less precipitation.

Synergistic Activities: TWP-ICE LAM Intercomparison study. Domains 9/3/1 km shown below with Case 1 and Case 2 sample results. Se also Varble et al., Zhu et al., Hagos.