REMARKS AND MOTIVATIONS


2. If we want to use variable-resolution meshes for regional NWP and climate predictions, it is essential that the parameterization of “deep” convection works at ALL scales, particularly in the coarse area of the mesh where it does most of the work.

3. It is also important to understand the contribution of the parameterization of shallow convection in the refined and coarse areas of the mesh.

4. It may be important to focus on one suite to provide the details of the interactions between the parameterization of convection and the other parameterizations (detrainment of cloud condensates to microphysics, subgrid scale convective cloud feedbacks to radiation, …)

Disclaimer: The views expressed in this presentation are those of the authors and not necessarily represent the views or policies of the US Environmental Protection Agency.
Highly parameterized moist convection

Explicitly resolved moist convection

15-3 km variable-resolution mesh over the Pacific Ocean

1. Variable-resolution meshes spanning from non-hydrostatic to hydrostatic scales as the ones built for the non-hydrostatic Model for Prediction Across Scales (MPAS) are ideal tools for regional climate modeling:
   - Computationally less expensive than global high-resolution meshes.
   - No need for nesting and nudging techniques at the edges of the high-resolution domain.
   - Allow two-way dynamics and physics interactions between the outer lower-resolution and inner higher-resolution meshes.

2. Variable-resolution meshes do require the use of scale insensitive physics parameterizations, particularly parameterized convection.

How do differences in the treatment of moist processes between the refined and coarse areas of the mesh affect precipitation, cloud condensates, cloud fraction, and radiation over the Tropical Pacific Ocean?
Because the suite includes the scale-aware Grell-Freitas (GF) parameterization of deep convection, the suite was originally designed for use with variable-resolution meshes.

15-3 km VARIABLE MESH CENTERED OVER THE TROPICAL PACIFIC OCEAN

Partitioning between the convective and grid-scale precipitation across the transition zone between the refined and coarse areas of the mesh.

CONVECTION AND GRID-SCALE MOIST PROCESSES

- Convection: Grell-Freitas (WRF 3.8.1).
- Microphysics: Thompson (WRF 3.9.1.1) with scale-aware aerosols turned off.

As spatial resolution increases, the Grell-Freitas scheme reduces to a precipitating shallow convection scheme, so that:

- Inside the refined mesh, grid-scale explicit microphysics processes (Thompson) dominate.
- Outside the refined mesh, parameterized convective processes (Grell-Freitas) dominate.

OTHER PARAMETERIZATIONS

- Gravity wave drag over orography: GWDO (WRF 3.6.1).
- Long- and short-wave radiation: RRTMG (WRF 3.9.1), except for climatological aerosols.
- Horizontal cloud fraction: Function of relative humidity (WRF 3.9.1).
- PBL and surface layer: MYNN (WRF 3.9.1).
- Land model: NOAH (WRF 3.9.1).
The variable (top) and uniform (bottom) meshes display similar biases relative to TRMM data:

- Overestimation of precipitation in the Eastern Pacific Ocean.
- Underestimation of precipitation along the ITCZ in the Central Pacific Ocean.
- The location of the ITCZ is located southward of its actual observed location.
Each CERES Single Scanner Footprint (20 km nadir resolution) includes TOA fluxes from CERES and spatially coincident cloud properties from MODIS.

To compute MPAS monthly means, we regridded and masked hourly model outputs to simulate the actual satellite orbits.
There is a sharp contrast in the LWP between the refined- and coarse-resolution of the mesh along the ITCZ:

- Maximum values of the LWP occur through detrainment of cloud liquid water from the GF scheme over the Eastern Pacific Ocean.
- Minimum values of the LWP over the refined mesh through cloud microphysics processes with the Thompson scheme.
As for the LWP, there is a sharp contrast in the IWP between the refined- and coarse-resolution of the mesh along the ITCZ.

- Over the Eastern Pacific, decreased convection would lead to decreased convective precipitation and detrainment of cloud liquid water and ice.

○ 4 km resolution isoline of the 15-3 km variable mesh.
SCALE-AWARE PARAMETERIZATIONS OF CONVECTION:

- **GF**: from WRF 3.8.1, Grell and Freitas (2014), Fowler et al. (2016), scale insensitive, following Arakawa and Wu (2013).

- **MSKF**: from WRF 3.9.1, Alapaty et al. (2014), scale insensitive through 1) adjustment time-scale; 2) "Tokioka" parameter in the formulation of the entrainment.

DIFFERENCES BETWEEN GF AND MSKF:

- Formulation of the entrainment rate.
- Formulation of the convection closure, to determine the cloud base mass flux.
- Formulation of condensation and precipitation processes in the cloud model, particularly handling of the ice phase.
- Formulation of the partitioning between the detrained cloud liquid water and cloud ice to the grid-scale microphysics.
- Treatment of non-precipitating shallow convection and its interactions with the grid-scale microphysics.
DECEMBER 2015 – TOTAL PRECIPITATION RATE (mm day$^{-1}$)

a) TMPA

b) GF TOT

c) MSKF TOT

d) GF-TMPA

e) MSKF-TMPA

30 km UNIFORM MESH

30 km UNIFORM MESH
CLOUD LIQUID WATER PATH (g m⁻²)

DECEMBER 2015

a) SSF LWP (Aqua)

b) SSF LWP (Aqua)

c) GF LWP

d) GF LWP

e) MSKF LWP

f) MSKF LWP

30 km UNIFORM MESH
DECEMBER 2015 – CONVECTIVE PRECIPITATION RATE (mm day⁻¹)

GF: 30-6 km VARIABLE MESH

MSKF: 30-6 km VARIABLE MESH

GF: 30 km UNIFORM MESH

MSKF: 30 km UNIFORM MESH

○ : 7 km resolution isoline of the 30-6 km variable mesh.
December 2015 – Cloud Liquid Water Path (g m⁻²)

GF: 30-6 km Variable Mesh

MSKF: 30 km Uniform Mesh

- 7 km resolution isoline of the 30-6 km variable mesh.
There are significant biases in the distributions of precipitation, and cloud liquid water and ice paths in all four simulations relative to observations:

- A parameterization of convection cannot be simply substituted with another one without important re-tuning of the parameterization and understanding of its interactions with the other physics schemes.
- Results suggest the importance of focusing and improving one physics suite, for studies of tropical convection.

Focus should be given to improve microphysics and precipitation processes in convection schemes.

Focus should be given on improving interactions between the convective and cloud microphysics parameterizations to ensure a seamless distribution of the liquid and ice water paths at all scales.

Using variable-resolution meshes, focus should be given on the impact of the “scale-awareness” of the convection schemes in the transition zones, and its impact in the coarse area of the mesh.

In variable-resolution experiments, impact of the refined area of the mesh on the coarse area of the mesh on monthly-time scales.
DEC. 2015 – CLOUD LIQUID WATER PATH (g m⁻²)

CERES_SST_Aqua-XTRK_Edition4A

DEC. 2015 – CLOUD ICE PATH (g m⁻²)

CERES_SST_Aqua-XTRK_Edition4A

TOTAL

LOWER

UPPER