Introducing the Multi-Scale Kain-Fritsch scheme to the Model for Prediction Across Scales

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Background

- Clouds are critical players in the earth's climate system
  - Impact radiation balance, surface temperatures, and precipitation generation
  - Influence creation of stratospheric ozone
- Motivation:
  - Most mesoscale models neglect interaction between convective parameterization (CP) and radiation scheme
  - CP schemes have not been adapted for new variable-resolution model grids
- **Project Goal:** Test the performance of the scale-aware Multi-scale Kain-Fritsch (MSKF) CP scheme in the Model for Prediction Across Scales (MPAS)

Methods

- Multi-scale Kain-Fritsch (MSKF) CP scheme includes:
  - Dynamic adjustment timescale
  - Scale dependent entrainment effects
  - Sub-grid scale interactions between clouds and radiation, among other features
- Model for Prediction Across Scales (MPAS) v. 4.0
  - 15-60 km variable resolution mesh (Fig. 1)
  - Mesoscale reference physics suite:
    - WSM6 microphysics scheme
    - YSU planetary boundary layer scheme
    - RRTMG radiation schemes
    - Noah land-surface model
  - CP scheme: MSKF and KF
- NCEP Climate Forecast System Reanalysis (CFSR)
  - 0.5° x 0.5° horizontal grid spacing
  - Used for initial conditions and surface update fields
- Simulation spanned 15 May 2006 – 14 August 2006
  - Conducted on DOE supercomputer *Titan*

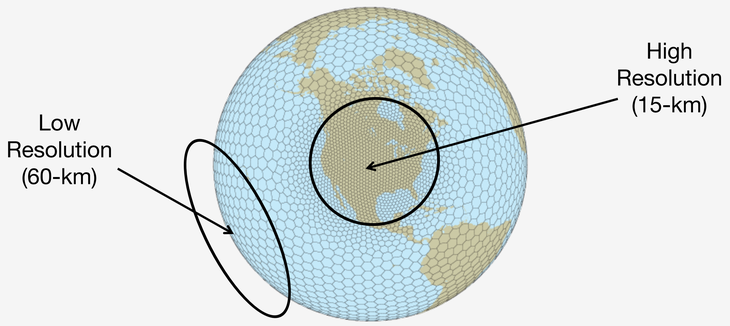

Figure 1. Image from http://mpas-dev.github.io/ showing the high-resolution (15-km) mesh over the U.S. expanding to the low-resolution mesh (60-km) elsewhere.

Precipitation

- Increases in precipitation with MSKF:
  - Along ITCZ
  - Over portions of SE Asia
  - Off west coast of India
- Differences in precipitation correlated with differences in cloud cover

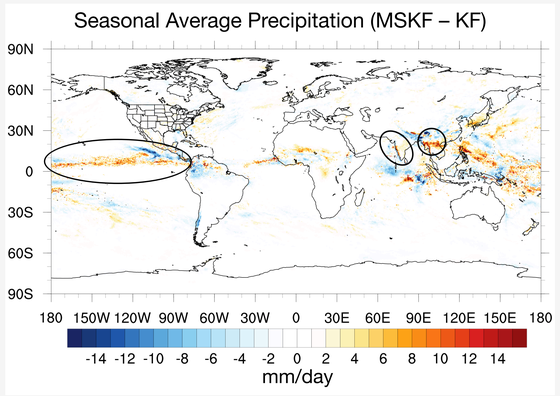

Figure 2. Global seasonal average precipitation for MSKF – KF in mm/day. Blue (red) colors indicate less (more) precipitation in the MSKF simulation.

- MSKF precipitation patterns more closely resemble observations

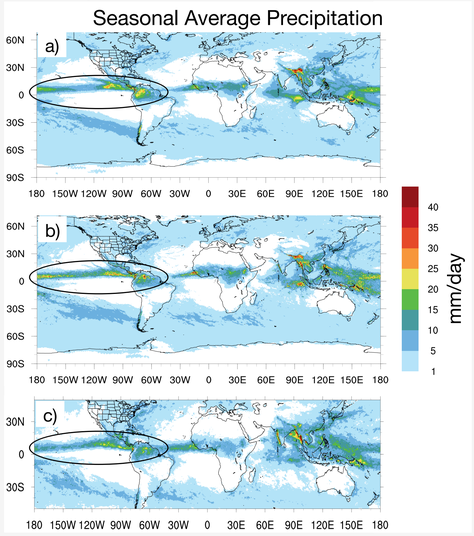

Figure 3. Global seasonal average precipitation for (a) KF simulation, (b) MSKF simulation and (c) TRMM

- Large differences in monthly mean precipitation

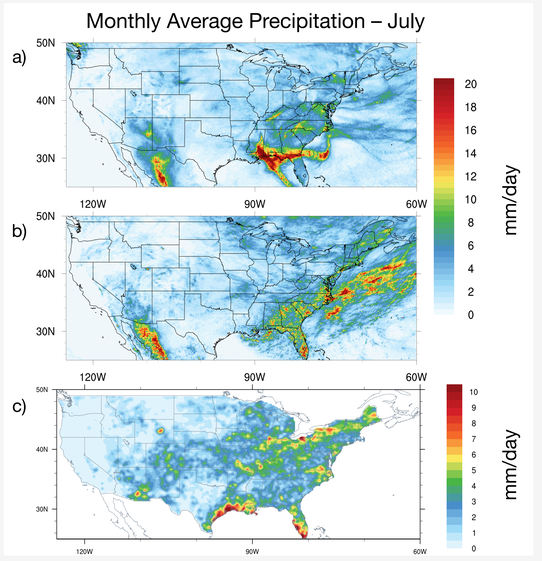

Figure 4. Monthly average precipitation for July 2006 in mm/day for (a) KF, (b) MSKF, and (c) CPC Unified Gauge-Based Analysis

Cloud Cover and Near-Surface Temperature

- Notable increases in cloud cover and using MSKF:
  - Along ITCZ
  - Over parts of southeast Asia
  - Along western coast of India

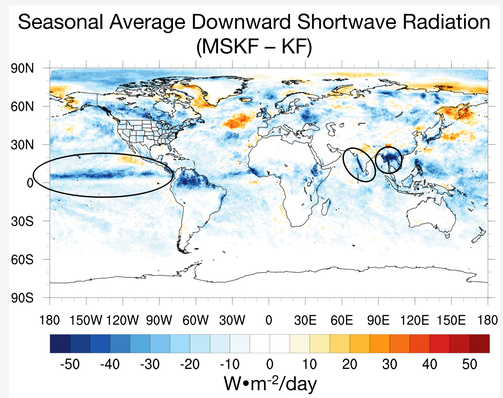

Figure 5. Global seasonal average downward shortwave radiation for MSKF – KF in Wm^{-2}/day. Blue (red) colors indicate more (less) cloud cover in the MSKF simulation.

- General increase in cloud cover over CONUS with MSKF – especially in the NE
- Slight reductions in cloud over over Gulf of Mexico and off northern CA coast
- Differences in near surface temperature consistent with differences in cloud cover

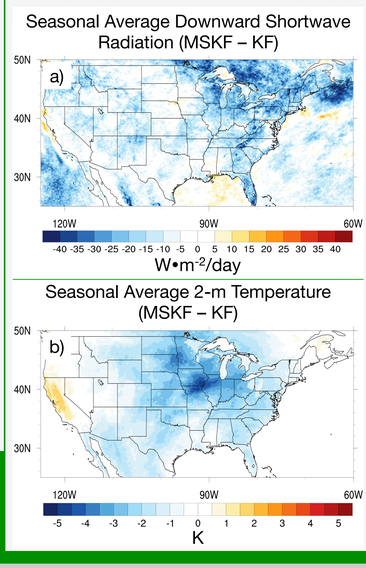

Figure 6.
(a) Seasonal average downward shortwave radiation for MSKF – KF in Wm^{-2}/day over the CONUS. Blue (red) colors indicate more (less) cloud cover in the MSKF simulation.

(b) Seasonal average 2-m temperature for MSKF – KF in K over the CONUS. Blue (red) colors indicate lower (higher) temperatures in the MSKF simulation.

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Conclusions

- MSKF produces *increased cloud cover* and *precipitation* along ITCZ, south of China, and off west coast of India
- Structure of precipitation in MSKF more closely *matches observations*
- Over CONUS, MSKF results in *more cloud cover* and *reduced 2-m temperature*
- Discrepancy in *precipitation patterns* between KF and MSKF simulations needs to be *investigated further*

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