6.1 - PARTITIONING BETWEEN DEEP AND SHALLOW CONVECTION IN MPAS

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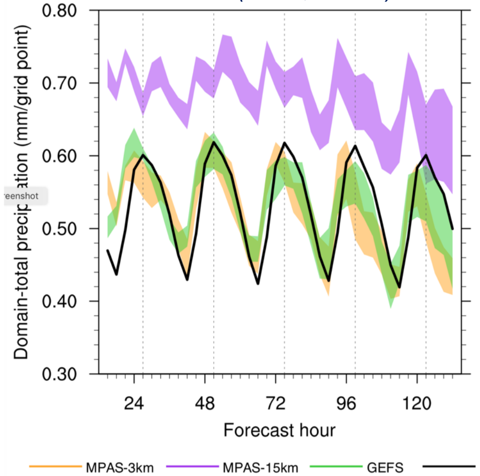
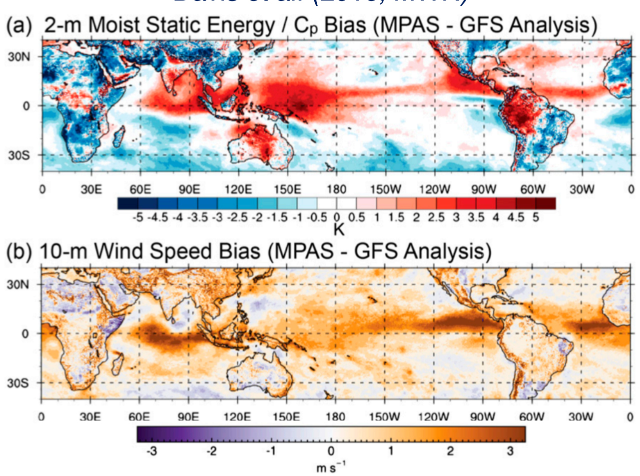
Schwartz (2019, MWR)



Average 3-h accumulated precipitation (see Fig. 5)

Davis et al. (2016, MWR)



15 km uniform mesh (see Fig. 7)

MOTIVATIONS

In the middle-latitudes over land:

- To date, most of our research with a variable-resolution mesh and a convection-permitting physics in MPAS has focused on medium-range forecasts over CONUS (*Wong and Skamarock 2016; Schwartz 2019*).
- Emphasis on forecast errors in precipitation.

In the tropics over oceans:

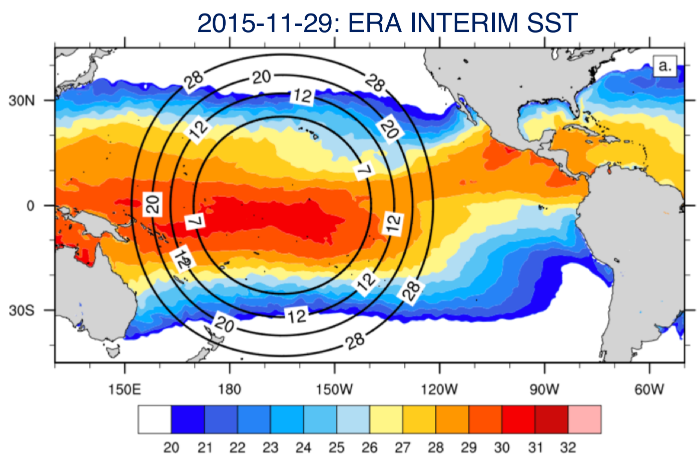
- The convection-permitting physics at nonhydrostatic scales has not been evaluated in the tropics over oceans.
- At hydrostatic scales, using the mesoscale reference suite, large biases are seen over the Tropical Pacific Ocean, over the Eastern Pacific and Western Pacific warm pool (*Davis et al. 2016; Huang et al. 2017*).

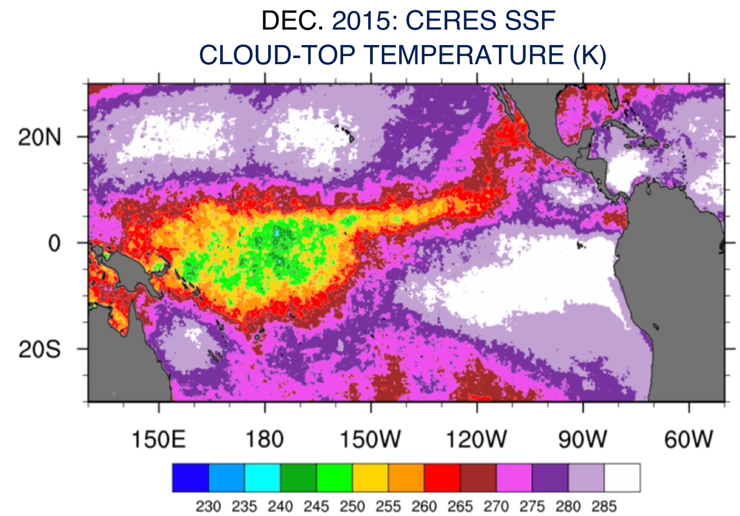
QUESTIONS

As we plan to extend our medium-range forecasts to seasonal forecasts, and implement the convection-permitting suite within an Earth System framework:

1. *How does the convection-permitting suite behaves in the tropics?*
2. *Does it help reduce biases seen with the mesoscale reference suite when using a variable-resolution mesh?*

30 km UNIFORM-MESH AND 30-6 km VARIABLE-MESH NUMERICAL EXPERIMENTS





4 30-day experiments for December 2015 with the scale-aware Grell-Freitas (GF) and Multi-Scale Kain Fritsch (MSKF) convection schemes

GFu: 30 km uniform mesh with GF
GFv: 30-6 km variable mesh with GF

KFu: 30 km uniform mesh with MSKF
KFv: 30-6 km variable mesh with MSKF

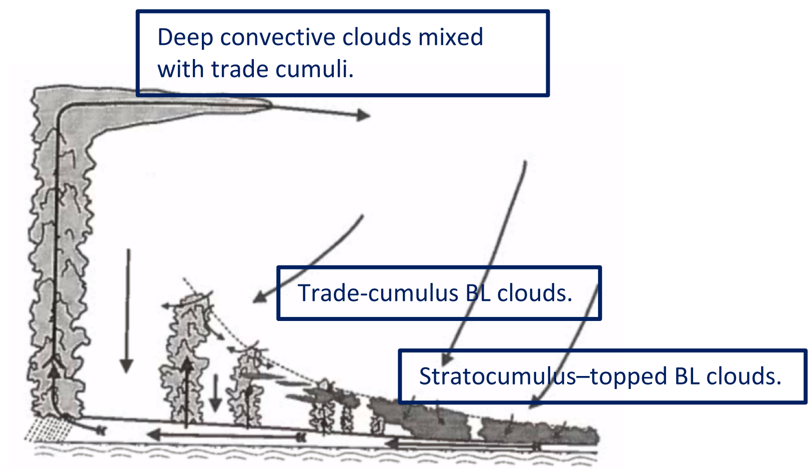


Fig. 14.7 Structure of the tropical atmosphere, showing the various regimes, approximately as a function of sea surface temperature.

From Atmospheric Convection, K. Emmanuel, 1994

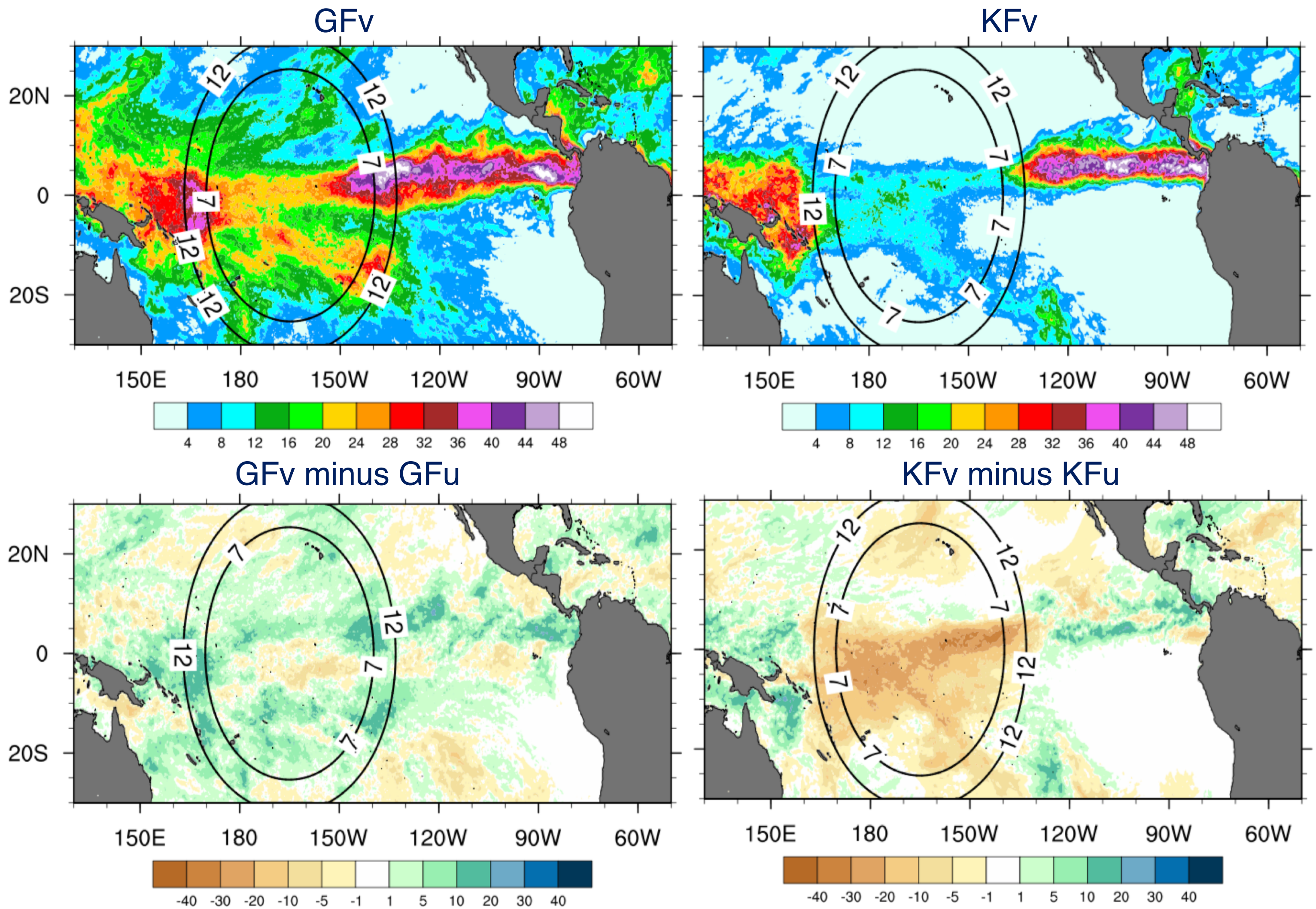
Grell-Freitas (GF) versus Multi-Scale Kain Fritsch (MSKF)

- Both GF and MSKF are scale-aware for deep convection, but:
  - Different scaling with horizontal resolutions.
  - Different triggering mechanisms.
  - Different partitioning as function of temperature between detrained cloud liquid water and ice water as sources to grid-scale microphysics.
- GF and MSKF treat shallow convection differently. In GF and MSKF, shallow convection does not precipitate.
  - In GF, shallow convection is a separate parameterization, but structured as deep convection. Deep and shallow convection can occur simultaneously in the same grid cell.
  - In MSKF, shallow convection is a subset of deep convection: a convective updraft is defined as shallow as a function of the cloud height. Allows for detrainment of rain and snow as sources to grid-scale cloud microphysics.

Other physics in Convection-Permitting Suite

- Microphysics: Thompson (WRF 3.9.1).
- 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).

DECEMBER 2015: INCIDENCE OF DEEP CONVECTION (%)

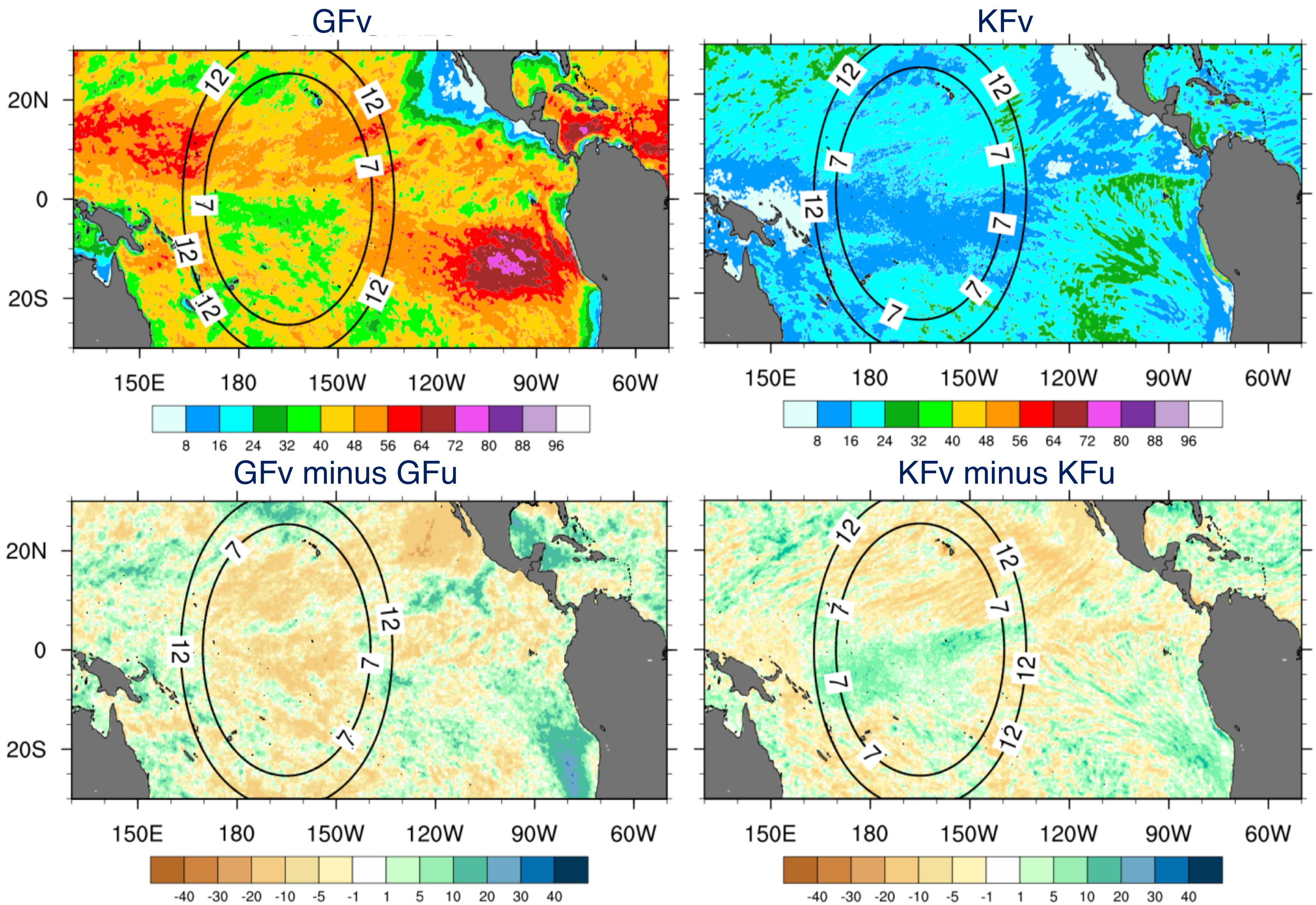


GFu: 30 km uniform mesh with GF
GFv: 30-6 km variable mesh with GF

KFu: 30 km uniform mesh with MSKF
KFv: 30-6 km variable mesh with MSKF

Incidence of deep convection is set to 1 if convective precipitation rate is greater than 0.

DECEMBER 2015: INCIDENCE OF SHALLOW CONVECTION (%)

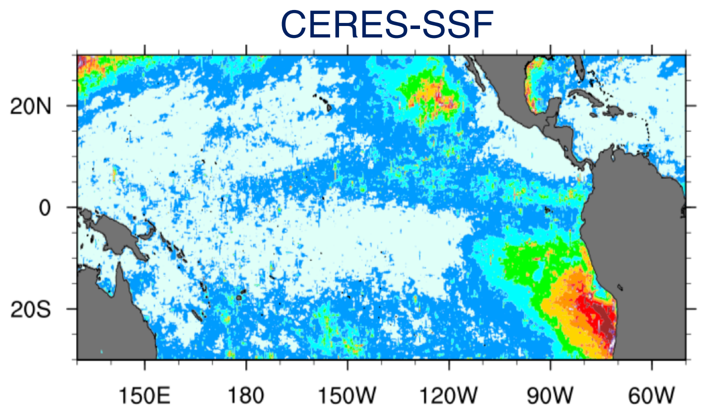


Incidence of shallow convection is set to 1 if shallow cloud-top is detected.

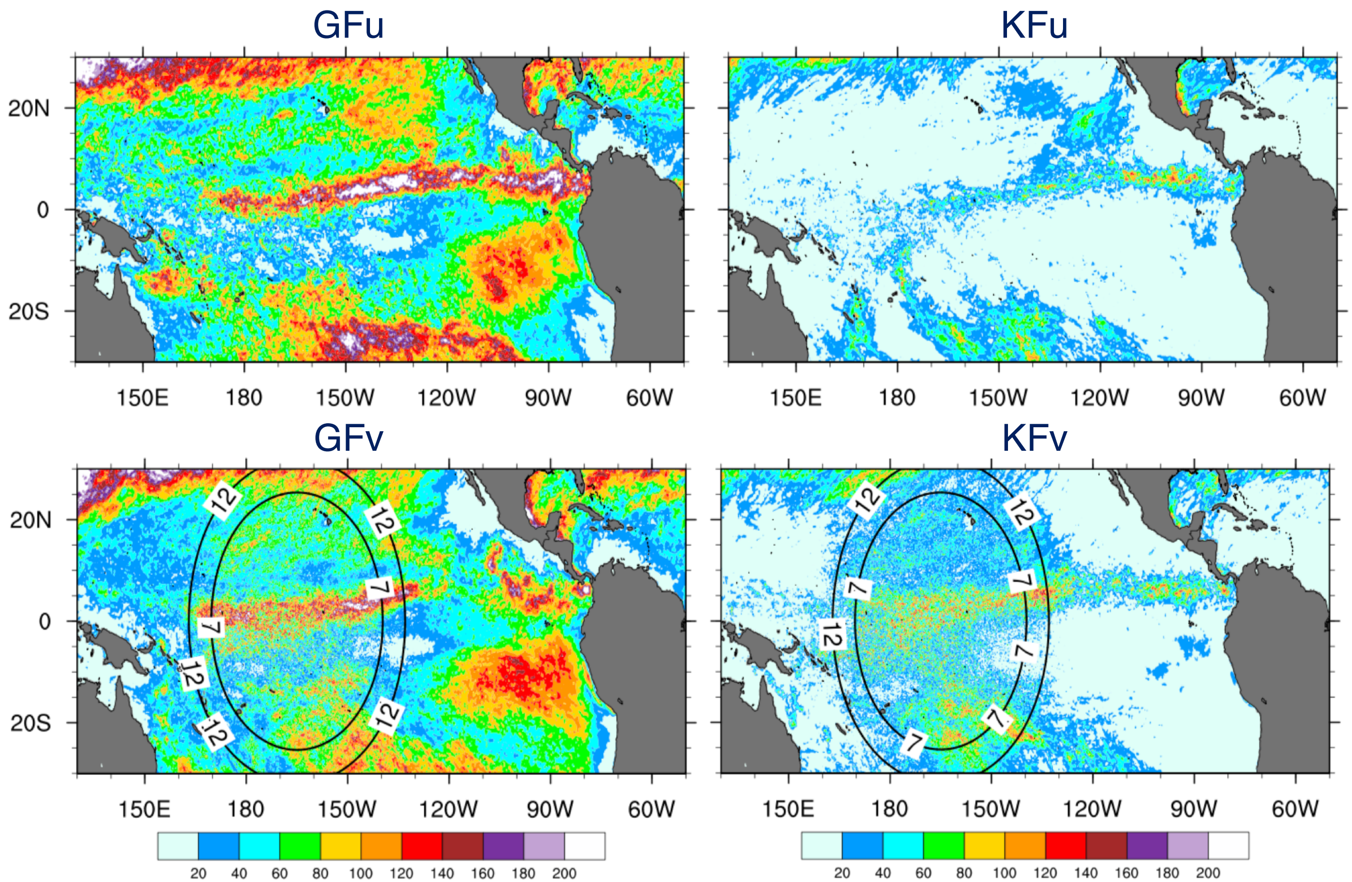
GFu: 30 km uniform mesh with GF
GFv: 30-6 km variable mesh with GF

KFu: 30 km uniform mesh with MSKF
KFv: 30-6 km variable mesh with MSKF

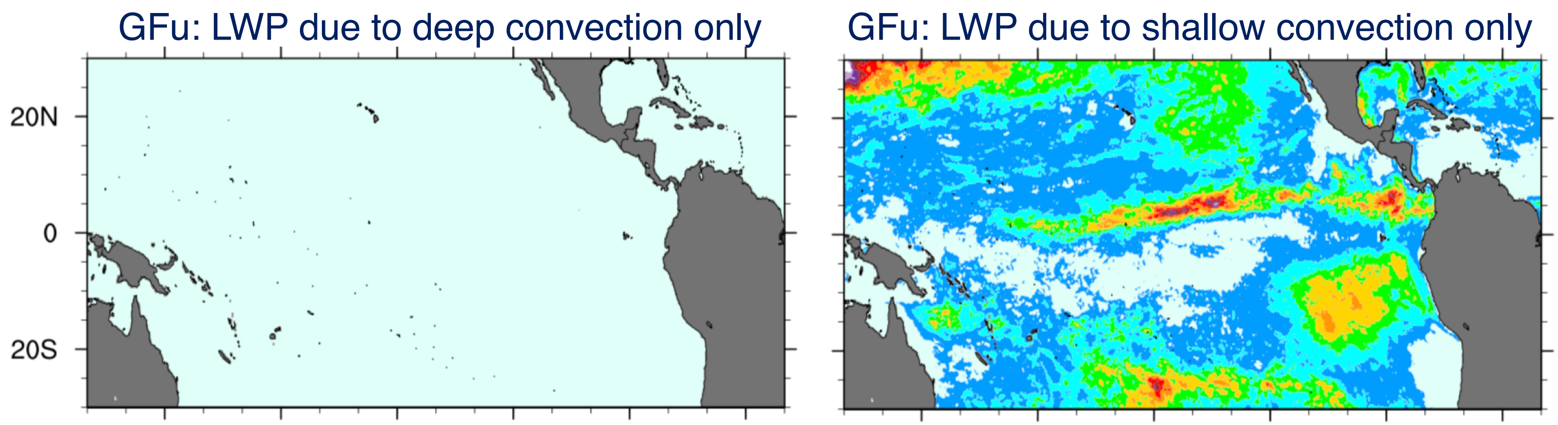
DECEMBER 2015: CLOUD LIQUID WATER PATH (g m²)

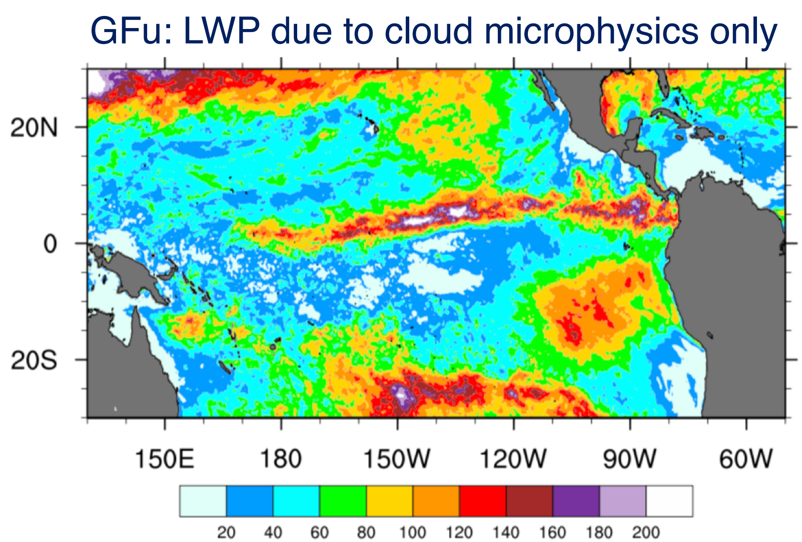


- GFu and GFv strongly overestimate the LWP compared to the SSF LWP.
- KFu and KFv are in better agreement than GFu and GFv compared to the SSF LWP.
- Over the refined area, the LWP increases in GFv and KFv relative to GFu and KFu, in response to increased vertical mass flux of moisture.



DECEMBER 2015: CLOUD LIQUID WATER PATH (g m²)



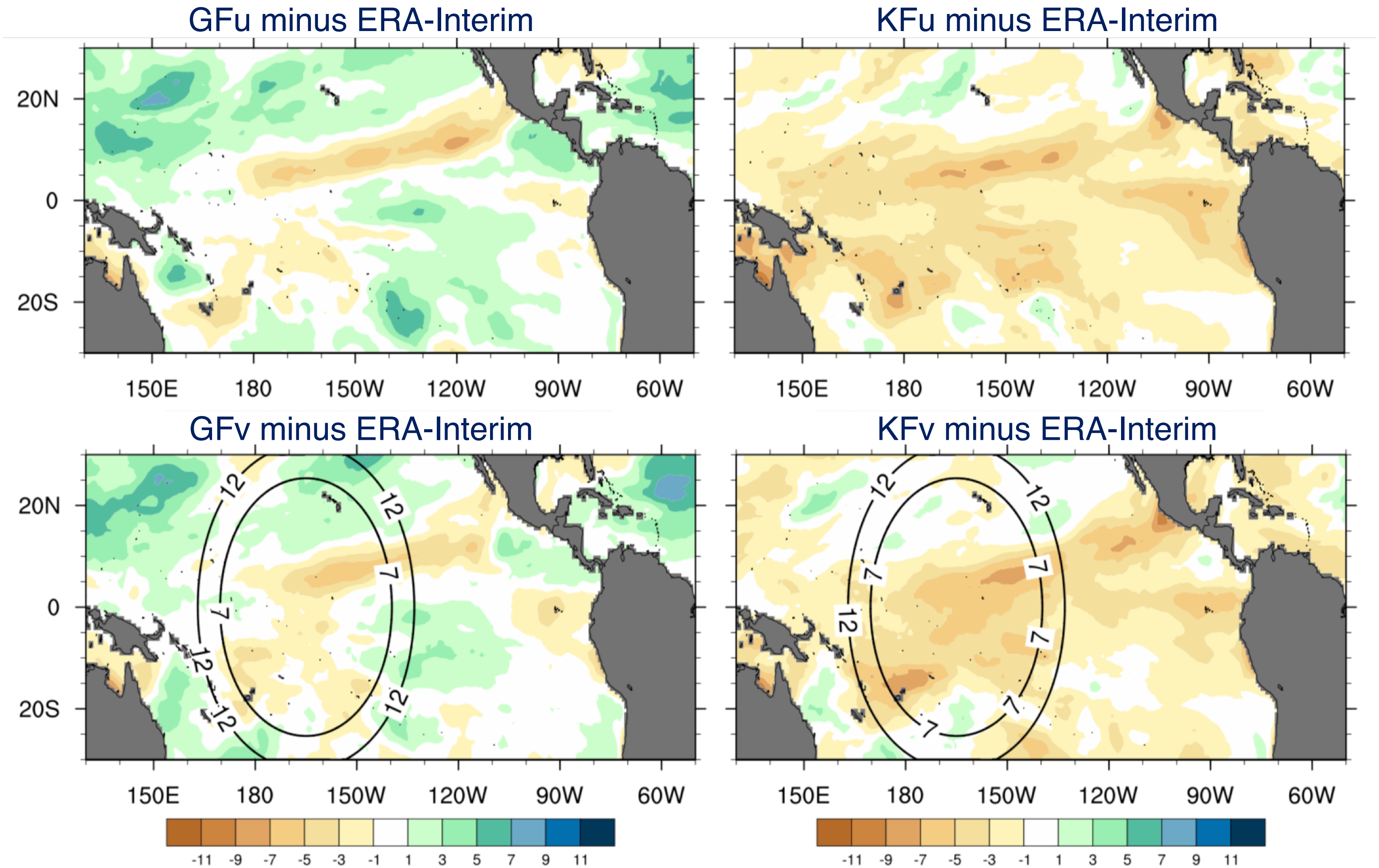


Partitioning of the LWP is based on the hourly incidence of deep and shallow convection over 30 days.

GFu: 30 km uniform mesh with GF
GFv: 30-6 km variable mesh with GF

KFu: 30 km uniform mesh with MSKF
KFv: 30-6 km variable mesh with MSKF

DECEMBER 2015: WATER VAPOR BELOW 700 hPa (kg m^{-2})



- In GF: Outside areas dominated by deep convection, shallow convection leads the lower troposphere to be too moist relative to ERA-Interim.
- In MSKF: the lower troposphere is too dry relative to ERA-Interim.

SUMMARY

- Shallow convection plays a major in the moisture budget of the tropical and subtropical Pacific Ocean, but:
  - ➢ GF overestimates shallow convection, leading the lower troposphere to be too wet and too cloudy.
  - ➢ MSKF underestimates shallow convection, leading the lower troposphere to be too dry compared to ERA-Interim data.
- Condensation increases over most of the refined area of the mesh, in response to increased vertical moisture flux in the lower troposphere.
- The convection-permitting suite needs to be better understood and analyzed at tropical latitudes.