MJO simulation biases in the kilometre-scale UM and the contribution of moisture

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Moisture coupling to physics is a primary reason for biased MJO simulation, but cannot clearly be observed. Higher-resolution models offer a chance to learn the coupling and improve the simulation.

An MJO event & Related Precipitation

- Study period: DYAMOND period [20th Jan – 28th Feb 2020]
- MJO identification: apply 2D-FFT to precipitation fields
- Related precipitation events identification: high anomalies area/ near peak in the MJO-filtered precipitation field

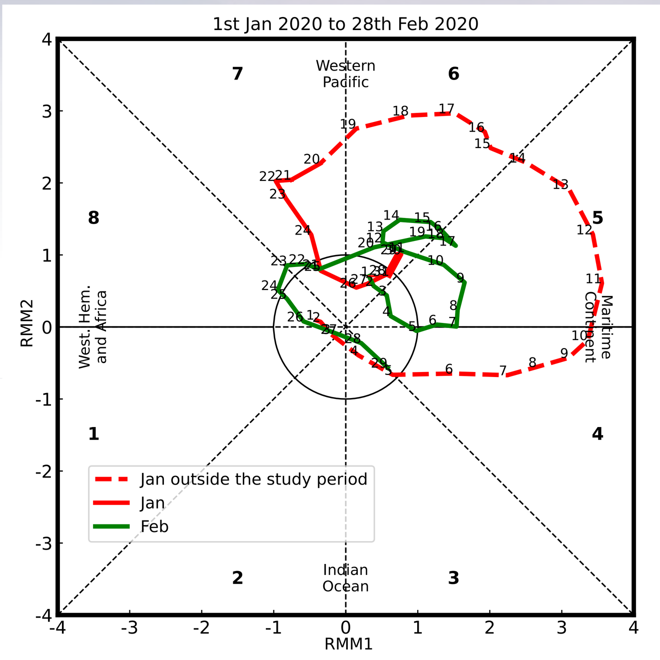


Figure 1. MJO RMM Index during DYAMOND Period

1 Biases of MJO Simulation

Precipitation events appear earlier when encountering the Maritime Continent (MC) in k-scale UM than E MERGE.

The k-scale explicit convection UM (UK Unified Model) simulates good MJO propagation with 5.5 km when boundary conditions using convective parameterisation (Fig 2 (d)).

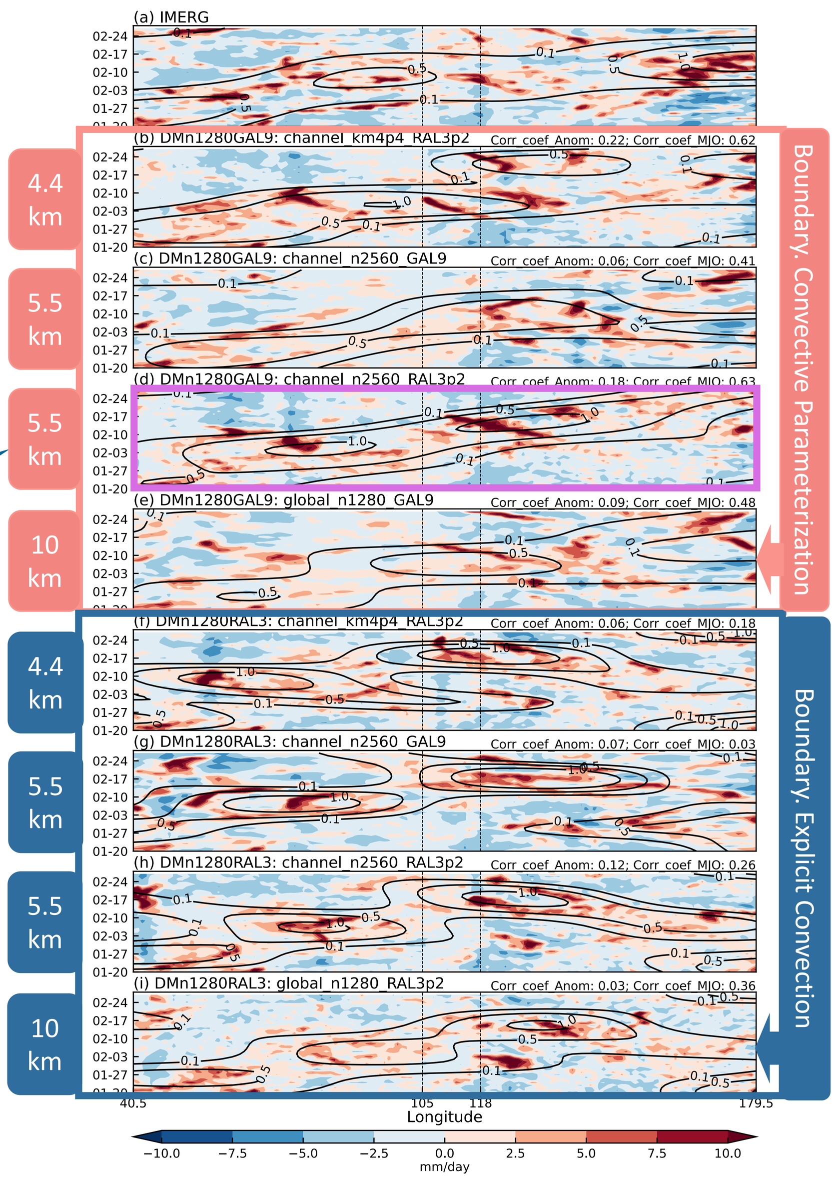


Figure 2. Hovmoller Diagram of Precipitation Field from IMERG (a) and two sets of UM simulations (b-d) (f-h). The boundary conditions of the two sets of simulation experiments are derived from the UM global simulation using convective parameterisation (e in pink box) and explicit convection (i in blue box), respectively.

2 Mean Moisture

Dry bias in the lower troposphere is significant in the MC but more extended in the k-scale UM than in global UM.

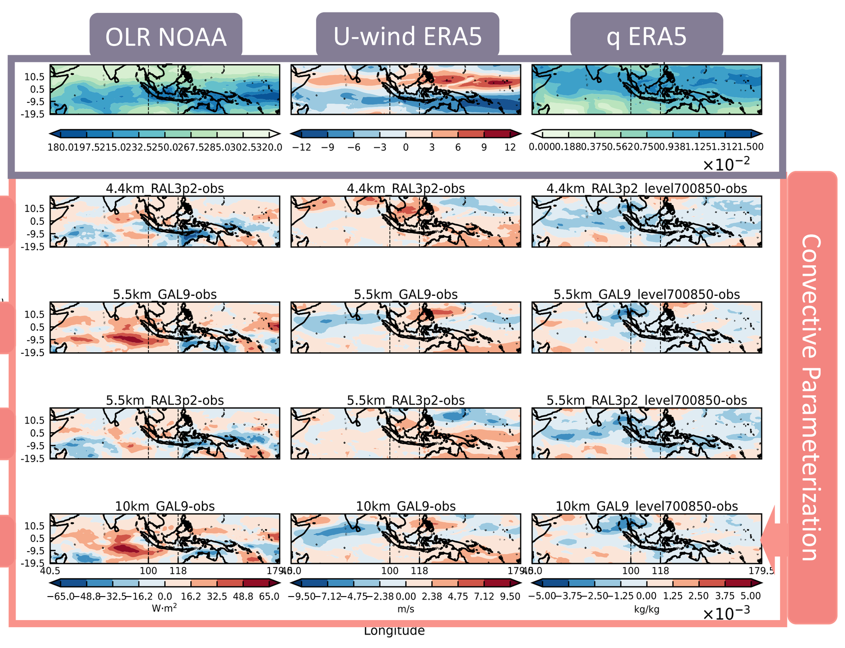


Figure 3. Observed mean state (first row) and the anomalies of mean state of the OLR (first column), u-wind (second column), and specific humidity (last column)

3 Moisture Biases in a Related Precipitation Event on 2nd Feb 2020

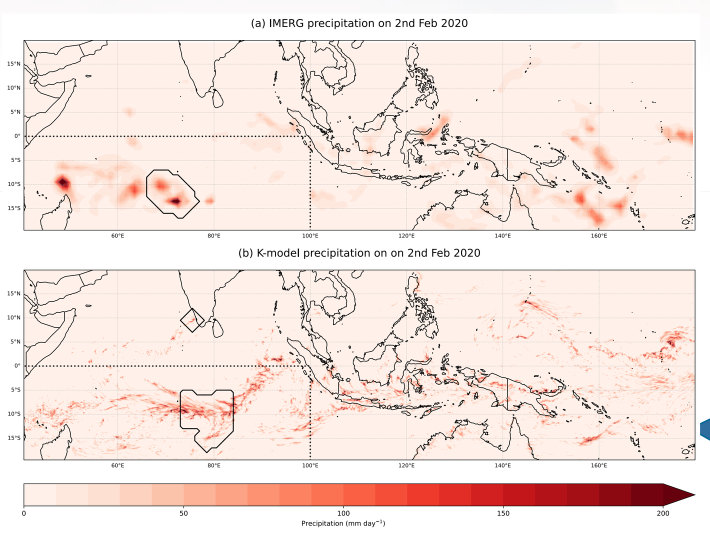


Figure 4. Precipitation case of IMERG (a) and the best k-scale UM (b) on 2nd Feb 2020. Dashed boxes show the area selected to check moisture biases, and solid lines show areas where precipitation anomalies are above the 95th percentile at that time. The shade represents precipitation amplitude, unit is mm/day.

The spatial range of precipitation distribution in the k-scale UM is wider with weaker intensity.

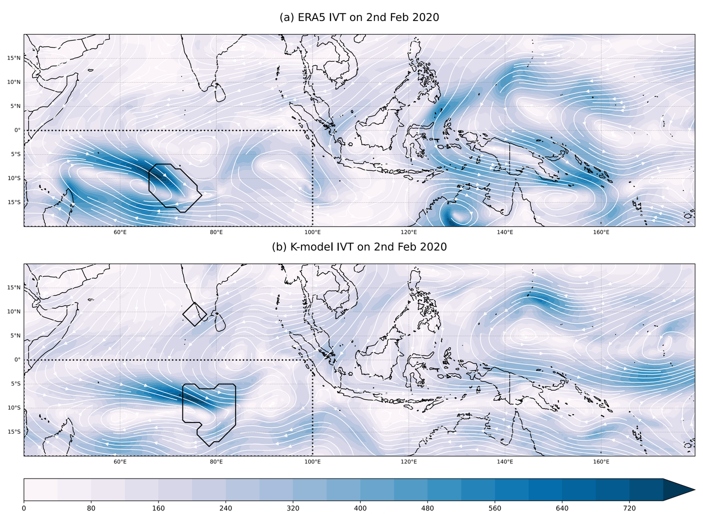


Figure 5. Integrated water vapour transport (IVT) of ERA5 (a) and k-scale UM (b). The meanings of dashed and solid lines are the same as in Figure 3.

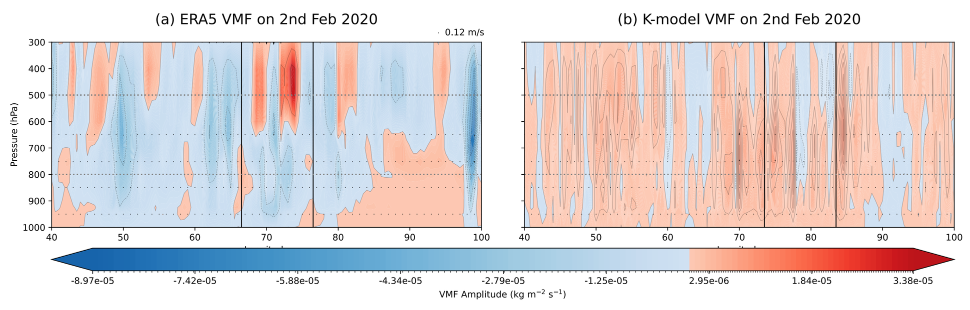
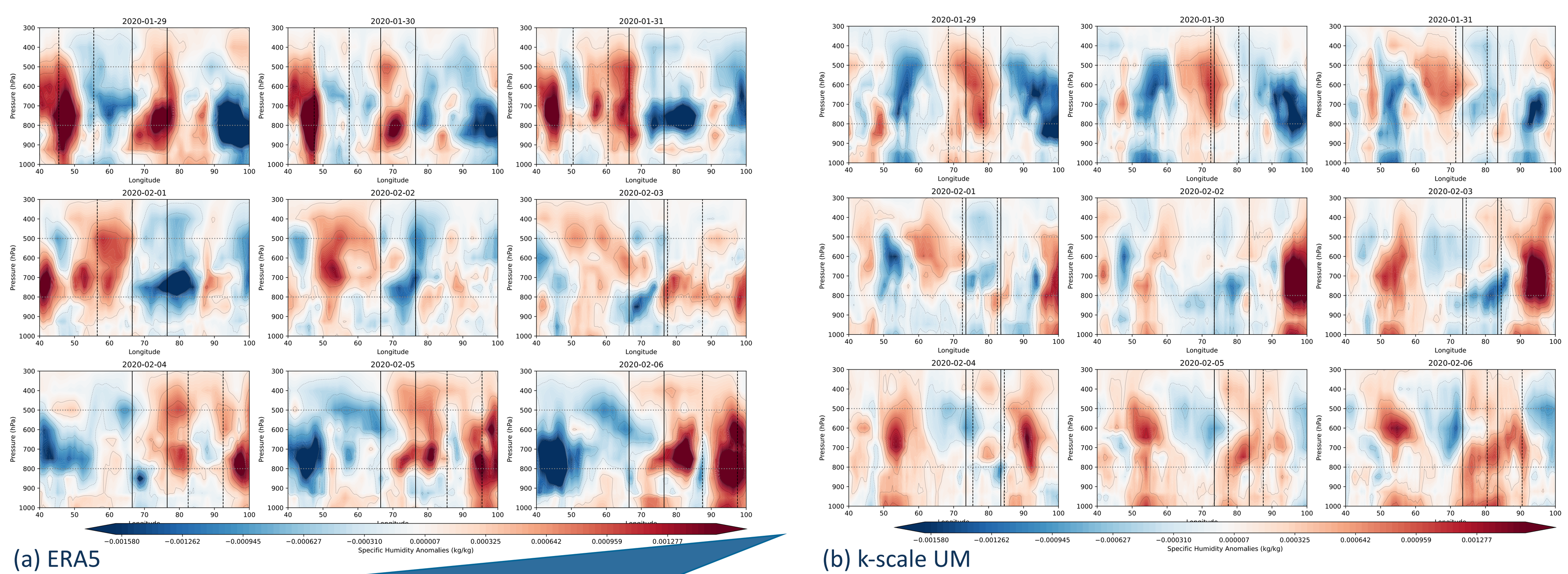


Figure 6. Vertical moisture flux (VMF) of ERA5 (a) and k-scale UM (b) in the dashed-line area. The meaning of the solid line is the same as in Figure 3.

In k-scale UM, the moisture primarily comes from low latitude. The upward VMF is too strong.

Figure 7. Latitude-averaged specific humidity anomalies. The meaning of the solid line is the same as in Figure 3.



The moisture in the lower troposphere does not show an obvious moisture accumulation pattern to the east of the precipitation centre before propagation in the k-scale UM.

The k-scale UM has significant moisture biases. During precipitation, water vapour from high latitudes in the summer hemisphere is weaker than in ERA5. The MJO propagation seems good despite the weak moisture variation in the lower troposphere.

Highlights & Next Step

- Highlights:
  - Under proper zonal wavenumber and period setting, 2D-FFT can identify the MJO in short-term data (in this study, zonal wavenumbers are set as 1 to 4, and the frequency between 1/96 to 1/20).
  - The k-scale UM reproduces MJO propagation if and only if the boundary condition is from a global model with convective parameterisation.
  - The humidity variations in k-scale UM are much weaker than in ERA5.

- Next Step:
  - Clarify the correlation between precipitation and moisture
  - Analyse the cause of moisture biases by checking the apparent convective heat source (Q1) and the apparent moisture sink (Q2).
  - Identify the contribution of moisture biases to MJO simulation.
  - Understand MJO-related convective events whose thermodynamics are primarily controlled by variability in moisture.

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