Cascade multi-resolution simulations of a YOTC MJO case

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1. Introduction

The Madden-Julian Oscillation (MJO) includes variability at many scales which are difficult to model simultaneously. As part of Cascade, a NERC-funded UK consortium project, we use the Met Office Unified Model (UM) at three grid spacings (40km, 12 km and 4 km, ultimately at 1.5 km) over a large limited area domain (the tropical Indian and western Pacific oceans) to simulate several case studies, including this one starting April 6, 2009, and running 10 days. So far, the MJO has not been well simulated even at 4 km grid size, possibly because of insufficient moisture transport at lower levels. Smagorinsky diffusion in the vertical (3D) leads to some improvement.

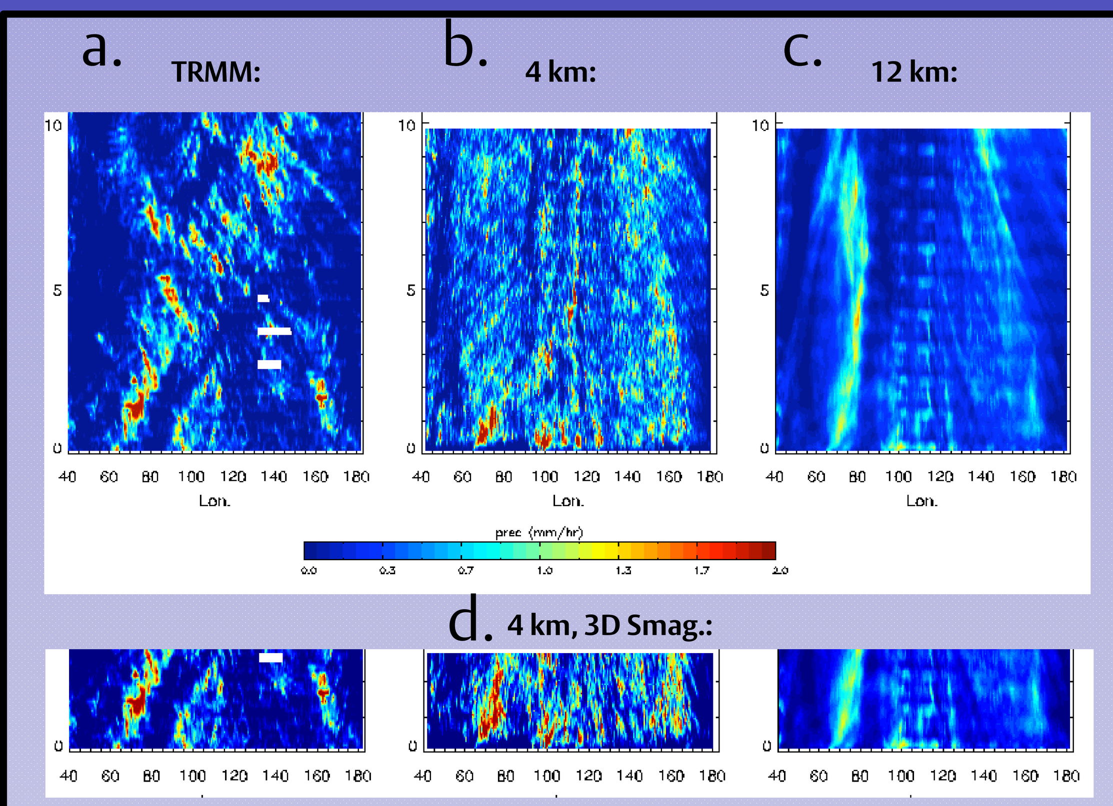

Figure 1 Precip. regrided onto 25km, 3-hr, averaged 7.5S-7.5N for: (a) TRMM satellite data, (b) 4 km grid, (c) 12 km grid, and (d) first 3 days of 4 km with 3D Smagorinsky mixing.

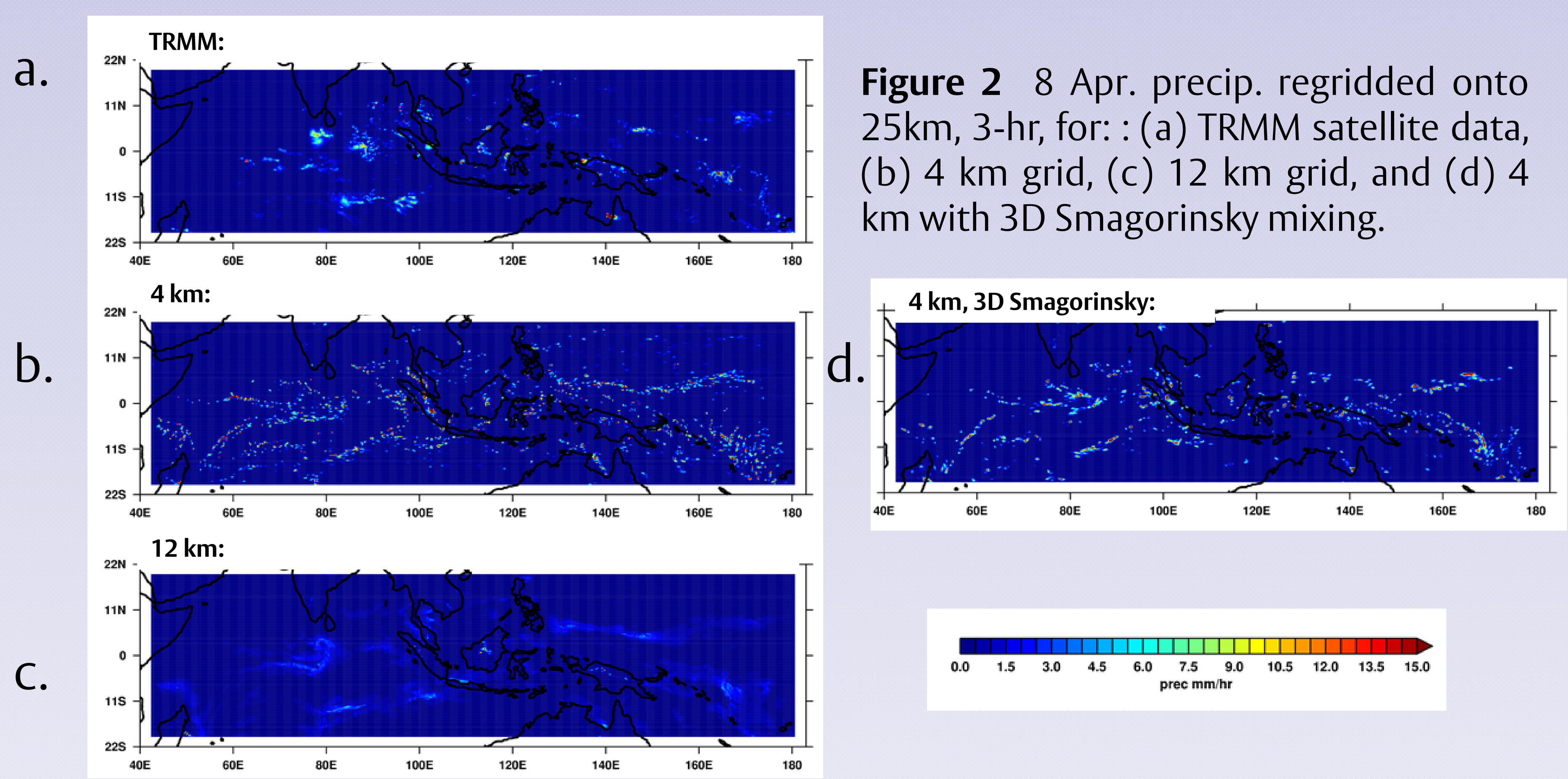

Figure 2 8 Apr. precip. regridded onto 25km, 3-hr, for: : (a) TRMM satellite data, (b) 4 km grid, (c) 12 km grid, and (d) 4 km with 3D Smagorinsky mixing.

2. Comparisons with observations

The 4 km run shows more realistic mesoscale organization but little large-scale propagation compared with TRMM precipitation (Figs. 1,2). The 12 km run has too little equatorial precipitation which is too stationary and diurnally forced. The 3D Smagorinsky run has somewhat better suppressed areas.

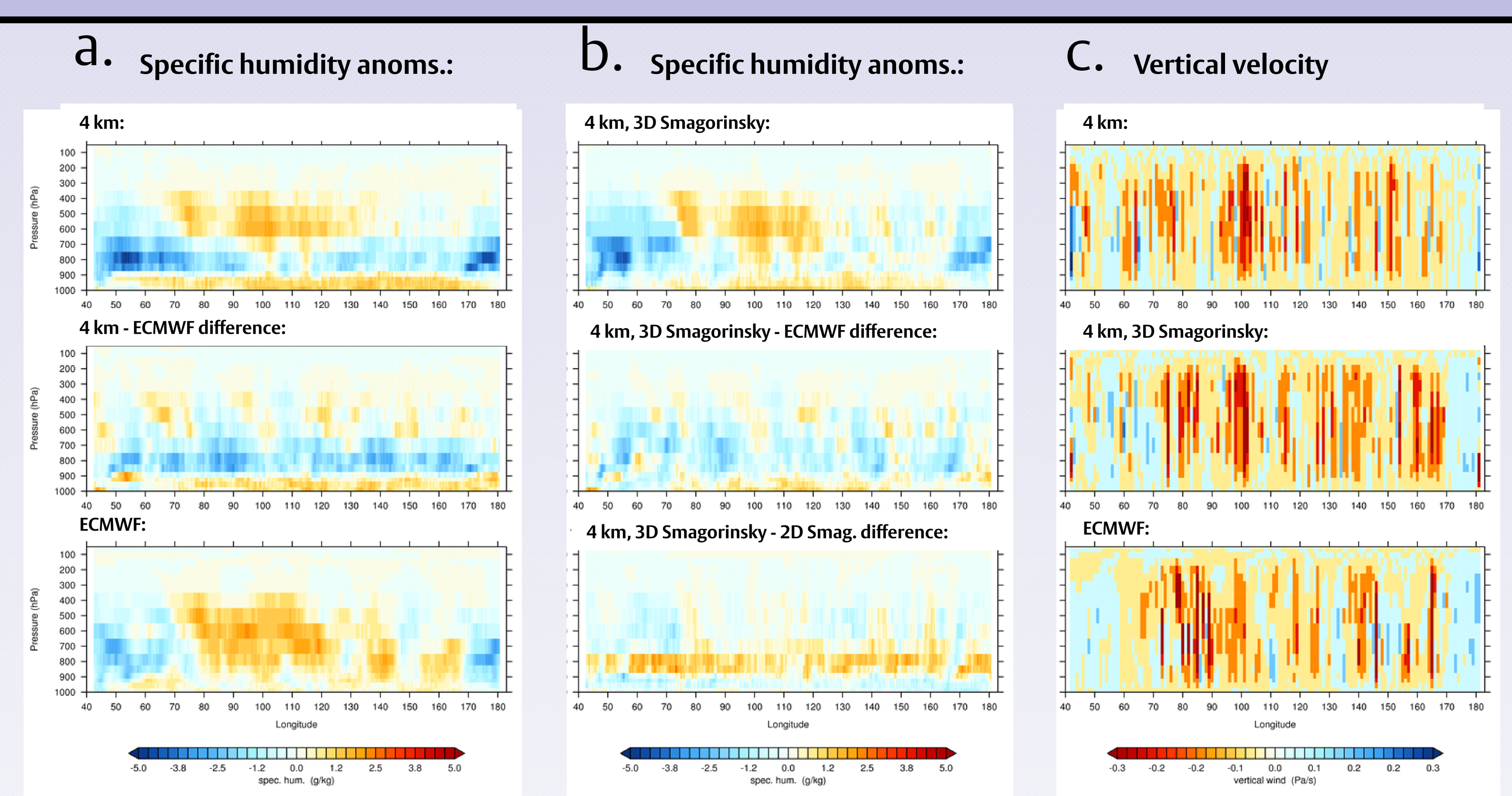

Figure 4 8 April specific humidity anomalies from zonal mean at initialization for (a) 4 km run and ECMWF analysis, (b) 4 km run with 3D Smagorinsky mixing. (c) similar anomalies for vertical velocity for each 4 km version and ECMWF analysis.

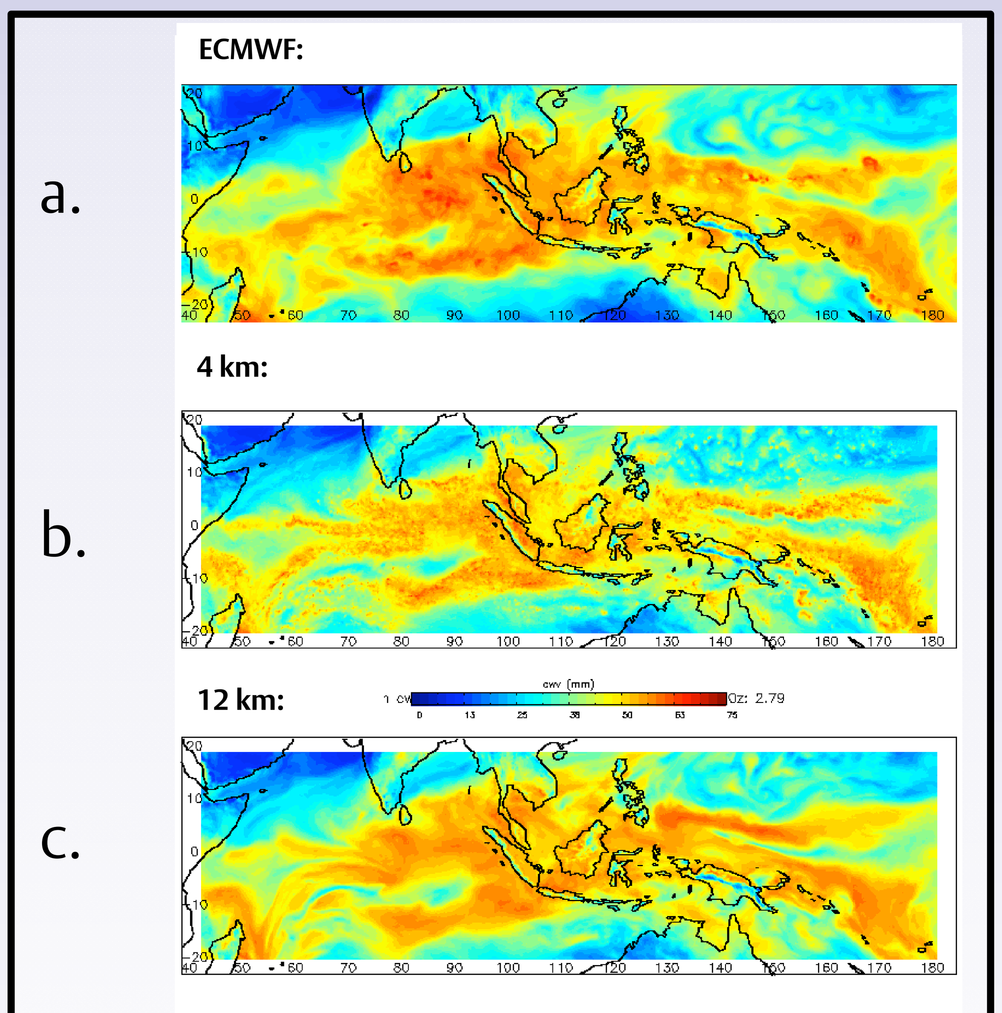

Figure 3 8 Apr. column water vapour, regridded onto 25 km, for: (a) ECMWF analysis, (b) 4 km grid, and (c) 12 km grid.

3. Moisture analysis

Column water vapour is too low in the model, especially at 4 km, and there is not enough variation with longitude (Fig. 3b). This seems to be due to insufficient lower-level insufficient lower-level water vapour transport, and is improved by 3D Smagorinsky mixing (Figs. 4a,b). The vertical velocity distribution with longitude also improves with 3D Smagorinsky mixing after about three days, with larger scale areas of ascent and descent (Fig. 4c). Interestingly, even the original 4 km run produces a much better precipitation distribution than the 12 km run (Fig. 5), suggesting that organization at larger scales is not necessary to reproduce realistic fractional distributions.

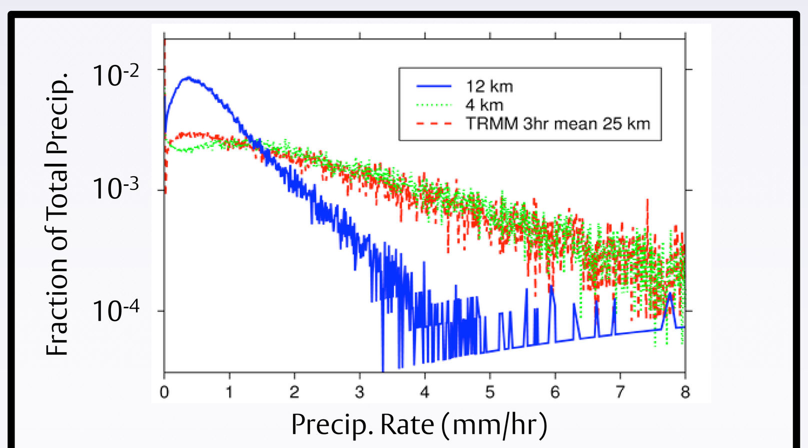

Figure 5 Fraction of total precipitation falling at a given intensity for 12 km grid, 4 km grid, and TRMM, regridded onto 1-deg., 3-hr mean.

4. Summary

An MJO case study is simulated using limited-area UM runs at 12 km and 4 km grid size. The 4 km run shows more realistic precipitation distributions and mesoscale clusters but does not maintain large-scale organization. This may be due to insufficient lower-level vertical moisture transport, which is improved with 3D Smagorinsky mixing.

5. Future work

- Continue testing sensitivity to physics
- Analyse energy and moisture budgets
- Complete and analyse 1.5 km runs