Development of Regional Atmospheric Nudging in ACCESS for Regional Climate Modelling

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1. Introduction

- Regional climate modelling downscales global climate model (GCM) simulations to finer resolutions.
- A regional climate model (RCM) is driven by time varying meteorological lateral boundary conditions (LBCs) derived from the global model simulations and prescribed sea surface temperatures (SST).
- In large domains, as the boundary influence is not sufficiently strong, the RCM can develop its own large-scale structures. While this is desired in the interior domain, this can lead to mismatch of LBCs, leading to noise and wave reflection and affecting the solution in the interior domain.
- This study demonstrates and tunes the use of dynamical nudging to minimise this for BARPA, an ACCESS-based RCM.

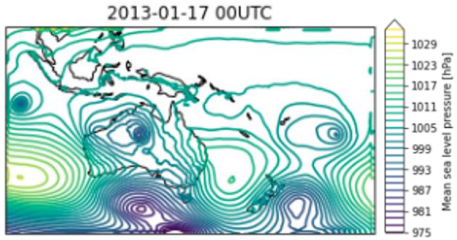

Fig. 1: Contours of mean sea level pressure (hPa) simulated in un-nudged BARPA-R nested in ERA-Interim, showing a strong cyclone at the western boundary of the domain.

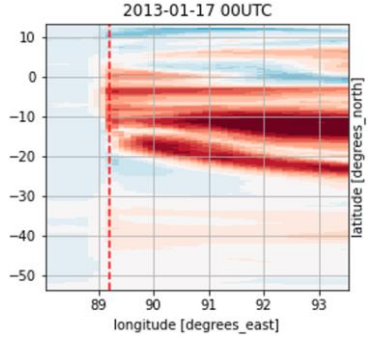

Fig. 2: Difference in wind speed at 200 hPa between the GCM and the RCM close to the western boundary.

2. Methods

- Unified Model: 0.11º x 0.11º grid spacing over 63 vertical levels up to 40 km above surface, CORDEX-Australasia domain (**Fig. 1**).
- One-way nesting setup, using 6-hourly timeseries of surface pressure, wind, temperature, and specific humidity from ERA-Interim reanalysis.
- Lateral forcing is applied across a 10-grid cell relaxation zone.
- Nudging is applied by adding a non-physical relaxation term to the tendency equations of air temperature, horizontal u- and v-wind. The model is relaxed towards its driving model ERA-Interim.
- Three sensitivity experiments: mid-tropospheric nudging (6 km and above), upper-tropospheric nudging (11 km and above) and un-nudged free simulation.

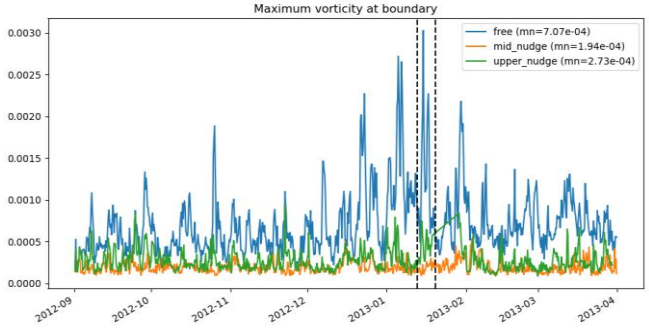

Fig. 3: Maximum vorticity at the lateral boundary over time for the free, mid-tropospheric and upper-tropospheric nudged simulation.

3. Key Results

- In the free (un-nudged) simulations a cyclone forms in the RCM (**Fig. 1**) that doesn't exist in the driving model. When the cyclone moves close to the boundary it create discontinuities in wind speed (**Fig. 2**), large artificial vorticity (**Fig. 3**).
- All nudged simulations are found to stay closer to the driving model (**Fig. 4**) and sufficiently supress boundary artefacts (**Fig. 3**).
- The upper-troposphere nudging is found to perform better in its representation of near-surface wind extremes (**Fig. 5**).

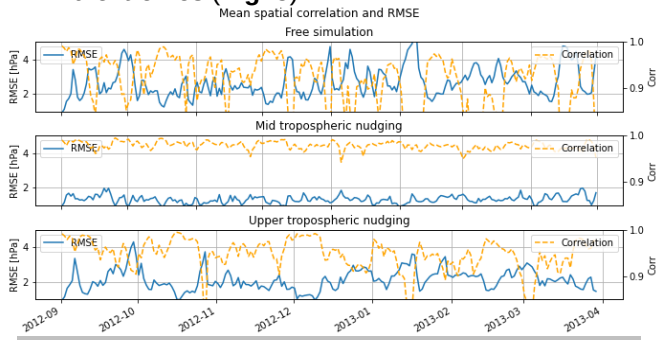

Fig. 4: RMSD and spatial correlation of mean sea level pressure between the driving model (ERA-Interim) and BARPA-R for the three sensitivity experiments.

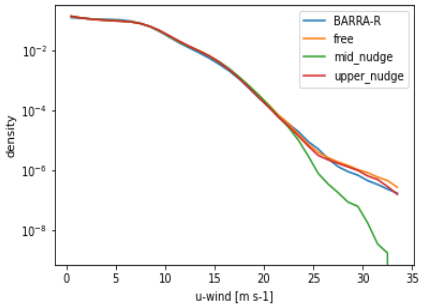

Fig. 5: Histogram of 6 hourly 10 m u-wind speed for BARRA-R reanalysis, the mid-tropospheric nudged, the upper-tropospheric nudged and the free simulation.