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Geoscientific Model Development Discussions

Interactive comment on "The HadGEM2 family of Met Office Unified Model Climate configurations" *by* The HadGEM2 Development Team: G. M. Martin et al.

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1. On figures comparing models and observations, statistical summaries (bias, RMS difference, correlation) of the differences should be included, similar to those in the description papers for the GFDL CM3 (Donner et al., 2011, J. Climate; Griffies et al., 2011, J. Climate) and the NCAR CCSM4 (Gent et al., 2011, J. Climate). Statistical summaries would be especially useful for Figs. 4, 6, 7, 11, surface fields of Fig. 12, and 19.

A: The statistics suggested by the reviewer have now been included in either the figures or their captions.

2. For the family members other than HadGEM2-ES, which includes tropospheric chemistry, summarize how emissions are related to sulfate concentrations. Is a simplified representation of the relevant chemistry used to relate DMS and sulfur dioxide emissions to concentrations of sulfate aerosol?

A: Aerosol representations are the same in all models of the HadGEM2 family. What changes is the source of some emission fluxes and oxidant mass-mixing ratios in the sulphur cycle. The sulphur cycle receives ocean DMS emissions from the interactive biogeochemistry model if that model is available, or from prescribed climatologies (e.g. Kettle et al. [1999]) otherwise. Similarly, the sulphur cycle receives oxidant mass-mixing ratios from the interactive tropospheric chemistry model if that model is available, or from prescribed climatologies (derived from a chemistry-transport model or from simulations by another HadGEM2 family member) otherwise. Section 4.2.3 has been modified to clarify this point.

3. Summarize how cloud properties (e.g., drop sizes) depend on aerosols, if they do, i.e., how do the family members treat aerosol indirect effects?

A: Section 4.2.3 now summarises Jones et al. [2001], with description of the parameterisation of the dependence of cloud droplet number concentration on aerosol number concentration, which underlies the modelling of aerosol indirect effects in HadGEM2 family models.

4. On p. 773, briefly indicate the vertical co-ordinate system used. Fig. 2 could be clarified. The panel on the right presumably shows nominal thicknesses for locations without orography.

A: The vertical coordinate system is height-based and terrain-following near the bottom boundary. The reviewer is correct that the right panel shows a location with zero orography. This information has been added to the caption for Fig. 2.

5. Regarding the precipitation diagnostics (p. 775), is the CMAP analysis the latest ver-

sion (v. 2)? CMAP v. 2 differs substantially from v. 1. Yin et al. (2004, J. Hyrdometeor.) discuss the relative merits of GPCP and CMAP.

A: We think the reviewer is referring to the GPCP v2 dataset, which is what we are using in comparison with CMAP. The latter is the observation-only version covering the period 1979-1998. We have included the reference to Yin et al in the revised version.

6. Although this paper focuses on the HadGEM2 family, it is interesting to note (p. 777) that HadGEM2-A is capable of producing a correlation of 0.76 between observed and modeled tropical cyclone variability in the North Atlantic, similar to the correlation obtained by Zhao et al. (2009, J. Climate) using a model with a much finer (50 km) horizontal resolution.

A: In the Atlantic, tropical cyclone variability is strongly cross-correlated with Atlantic interannual SST variability, wind shear and other factors such as the Atlantic Multi-decadal Oscillation (see, for example, Smith, D. M., R. Eade, N. J. Dunstone, D. Fereday, J. M. Murphy, H. Pohlmann, and A. A. Scaife, 2010, Skilful multi-year predictions of Atlantic hurricane frequency, Nature Geoscience, DOI: 10.1038/NGEO1004), factors which don't require high resolution. Using observed SST forcing, and a large ensemble, are both likely to increase the correlation by improving the forced signal to internal variability noise. This has been added to the text.

7. In Section 4.2.3, the aerosol optical depths on Fig. 7 should be compared with AERONET observations.

A: Figure 7 now presents the climatology of aerosol optical depth observed by AERONET, overlaid on to simulated aerosol optical depth fields. Section 4.2.3 has been modified to discuss the modified figure: Total present-day AOD was low in HadGEM1 compared to AERONET observations, with only a few regions associated with large optical depths. Distributions for the HadGEM2 family members, shown in the same figure, compare much better with observations, with smaller root-mean square errors. The revised figure is attached.

8. Regarding the discussion of ENSO metrics (p. 782), note that ENSO amplitudes and periods can vary appreciably over multiple decades (Wittenberg, 2009, Geophys. Res. Lett.). The robustness of the quoted spectrum analysis may depend on the length of the model integrations for which it has been calculated.

A: The values quoted from Martin et al. (2010) were taken from over 150 years each of pre-industrial control runs of HadGEM1 (200 years) HadGEM2-AO (155 years). A note on the robustness of this analysis has been added to section 4.2.5.

9. The discussion of the terrestrial carbon cycle (pp. 785-786) states that the carbon cycle is included in HadGEM2-CC and HadGEM2-ES. Table 1 indicates that HadGEM2-CCS also includes terrestrial carbon.

A: That is correct, since HadGEM2-CCS is the same as HadGEM2-CC except for the stratospheric extension. This has been clarified in the text.

10. In Section 4.2.9, the first paragraph states that the tropospheric chemistry scheme has improved the ozone distribution, while the second paragraph describes the interactive distribution as comparable to the prescribed distribution. In fact, Fig. 22 shows some large differences between the prescribed and interactive distributions.

A: There is additional discussion of the ozone simulation in the paper by Collins et al. (2011), and we now have made further reference to this in section 4.2.9 in order to remove these apparent contradictions. Figure 22 does indicate that the interactive ozone points are rather closer to the observations than the prescribed values at several levels. The ozone concentrations near the tropical tropopause are higher in the prescribed distribution due to a lower ozone tropopause in HadGEM2-ES (diagnosed from the 150 ppb contour). From 3km above the tropopause, the interactive ozone values are relaxed to the CMIP5 climatology.

Technical corrections:

p. 776, l. 26: "stratospheric" -> "stratosphere"

p. 783, l. 14: "Table 3" -> "Table 2"

p. 786, l. 26: Text refers to Panel 19c, but Fig. 19 does not have a,b,c,d labels.

p. 790, l. 11: "famiiy" -> "family"

Fig. 14: "contour interval" -> "shading interval"

A: All corrected.

Interactive comment on Geosci. Model Dev. Discuss., 4, 765, 2011.

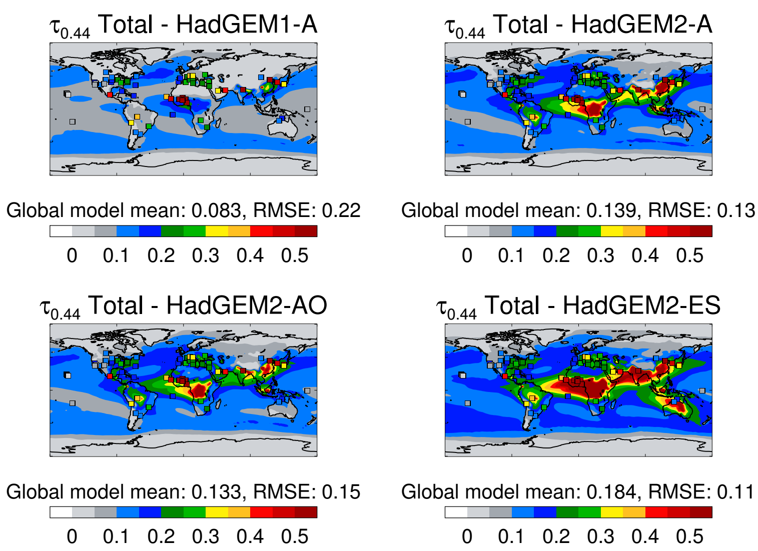

Fig. 1. Revised Figure 7