Ocean Science Discussions, 2, S151–S155, 2005
www.ocean-science.net/osd/2/S151/
European Geosciences Union

Ocean Science Discussions

Interactive comment on "El Niño in a changing climate: a multi-model study" *by* G. J. van Oldenborgh et al.

G. J. van Oldenborgh et al.

Received and published: 30 August 2005

1. We have added references to papers discussing the properties of the simulated ENSO to the models in Sections 3. Their contents match our findings.

   There was a typo giving rise to a sign error in the sentence describing the CSIRO model, the manuscript reads 'lower frequency' when we meant 'shorter period' or 'higher frequency'. We thank the reviewer for pointing this out. The amplitude is indeed slightly higher, so we moved CSIRO to the group that has most of these properties, but not all.

2. The reviewer suggests that we change the normalization of the EOF plots to emphasize the different widths of the patterns of ENSO variability. However, to estimate a measure of the width, say FWHH, is easiest when the EOFs are normalized to have the same peak amplitude, which is exactly what has been done. We do not see how a change of normalization would make this clearer, as any

change would make the width turn up at a different colour. Note also that the EOFs where, whenever possible, computed on the ocean grid to retain the higher meridional resolution.

3. *Why not compare the mean thermocline depth, the slope (east-west) and the sharpness (tightness) of the thermocline.* This is an interesting subject, but we felt it would make the paper (which focuses on variability) too long to include it here. Differences in the mean thermocline depth should be compared with the coupling parameter α in Section 6, and the slope with its longitudinal dependence. The sharpness of and temperature difference across of the thermocline are also very relevant to the nature of the thermocline waves. All these will be studied in follow-up articles.

4. Indeed, the three models with large thermocline variability also have a too weak thermocline response. We suspect that the temperature contrast across the thermocline is too low here, so that a given wind input generates larger amplitude waves. The sentence has been reformulated to explicitly mention the possibility of other effects: 'The weak response in most models explains why thermocline variability is in general lower than observed, although the exceptions (CNRM-CM3, FGOALS-g1.0, and INMCM3.0) show that there are other factors as well.'

5. *My experience is that higher resolution sometime makes it worse.* This is also our experience (note HadGEM1). However, we tried to say that, whereas a high resolution does not necessarily increase the fidelity of the response, a low resolution almost always gives too narrow a response. Added 'although not necessarily improved at higher resolutions'

   A pattern correlation or regression method would have to be weighted by the relevance of the regions to the ENSO signal, which depends on latitude and the longitude of the ENSO pattern in that specific model. In our opinion this complicates the analysis too much to make it very useful. We also attempted to fit

OSD

2, S151–S155, 2005

the responses to a Gill atmosphere response in order to be able to present the quality in a few numbers. However, as can be seen from the plots, for too many models the reponse is so strongly unlike a Gill model that the fit fails completely. Examples of problems we encountered are in HadCM3 and HadGEM1 the positive rather than negative responses at 10N, and the lack of negative response on the equator to the east of the SST anomaly in many models.

6. Thank you.

7. There are indeed several ways in which a shift towards El Niño or La Niña-like states could be detected. Considering SST, in an earlier study (Zelle et al, 2005) we found that in the CCSM 1.4 ensemble, computing Niño3 minus the rest of the world (as used in Cai and Whetton 2000) does not work, as the rest of the world warms at a significantly higher rate than the tropical Pacific: the remaining signal is not La Niña-like, but concentrated at high latitudes. A better measure was found to be Niño3 minus SST(15S–15N), but the shift towards La Niña or El Niño was found to depend critically on the rather arbitrary boundaries.

   Another method is to project the observed warming onto the ENSO pattern defined as the EOFs of Section 2, as done for instance by Merryfield (2005). The problem here is that the first EOF is a monopole, so that it always has a positive projection onto uniformly rising SST. Visual inspection of the SST increases shows that in most models the cold tongue warms more than the rest of the equatorial Pacific Ocean, it depends on the model whether the ENSO pattern coincides with the cold tongue.

   Finally, the reviewer suggested we could just make EOFs of the whole SST fields following Cai and Whetton (2001). However, this suffers from the problem that the principal components have to be orthogonal to each other. As the first EOF describes the global trend in SST, the PC of the second (or higher) EOF that most resembles the ENSO pattern has to have trend zero by construction: the trend of ENSO is included in the first EOF. Extracting the ENSO component from the first EOF gives the same problems as extracting the ENSO signal from the trend maps.

We chose to use SLP as this is the measure that corresponds most closely to the teleconnection patterns, which are the main reason to study the shift in the first place. We checked whether the pattern of SLP changes did in fact mirror the ENSO pattern, or was some other pattern which just happened to project onto the rather large ENSO pattern. The latter was the case in some models we did not consider reliable, with large changes in the western Indian Ocean being interpreted as ENSO changes. However, in the six models we consider more reliable the patterns did coincide in the two models which show a shift to El Niño-like conditions, ECHAM5/MPI-OM and MIROC3.2(medres).

This has been added to the text. In the La-Niña-like models: 'In most of these models this shift is due to a large change in the Indian Ocean or off-equatorial Pacific Ocean projecting onto the ENSO pattern. The only model in which the time change in surface pressure resembles the Southern Oscillation is INM-CM3.0.' In El-Niño-like: 'Again, only in ECHAM5/MPI-OM and MRI-CGCM2.3.2 the shift resembles the Southern Oscillation pattern.'

The trends in sea-level pressure are not necessarily consistent with the trends in SST, as investigated by others, e.g., E. Guilyardi's manuscript 'El Niño — mean state — seasonal cycle interactions in a multi-model ensemble' (submitted to Clim. Dyn.) and W. J. Merryfield's manuscript 'Changes to ENSO under CO_2 doubling in the IPCC AR4 coupled climate models' (submitted to J. Climate). Quite few models show warming in the cold tongue, but no change in psl, or even a shift to La Niña (CGCM3.1(T47), IPSL-CM4). This could be understood as a change ΔT in the cold tongue having less affect on air pressure than the same change in the warm pool. As the main reason for this study is the effect of ENSO on the weather, we consider the pressure trends to be the more important ones.

OSD

2, S151–S155, 2005

Interactive Comment

Interactive comment on Ocean Science Discussions, 2, 267, 2005.