Title: Simulated sea surface temperatures around New Zealand from 1982-2015 compared to three ground truth datasets

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Abstract

In this brief note, I show the extent of global warming, as exemplified by sea surface temperature – SST – around New Zealand from 1982-2015. We use 16 members of the UKESM historical simulations from the sixth Assessment Report of the Intergovernmental Panel On Climate Change. These model data are compared to ground truth data from three observational datasets. All data is plotted with respect to the values at the beginning of 1982 for each dataset considered, the date from which all three observational products are available. All data used in this work is freely and publicly available. The three datasets show noticeably different results in the magnitude of their respective warming signals and this has important ramifications for how model-data comparisons are assessed for island nations with a predominantly maritime climate.

In this study I examine the transient climate response to greenhouse gas (GHG) forcing in the UK Earth System Model, version 1.0, UKESM1.0 in a region surrounding New Zealand. This region is used due to its relevance to recent climate modelling studies[1] and I use the 16 member historical ensemble,[2] which runs from 1850-2015. All model data shown here is available freely at the Earth Sytem Grid Federation, https://esgf.llnl.gov/. The experiment identifiers[3] are as follows:

1. `r1i1p1f2`
2. `r2i1p1f2`
3. `r3i1p1f2`
4. `r4i1p1f2`
5. `r5i1p1f3`
6. `r6i1p1f3`
7. `r7i1p1f3`
8. `r8i1p1f2`
9. `r9i1p1f2`
10. `r10i1p1f2`
11. `r11i1p1f2`
12. `r12i1p1f2`
13. `r16i1p1f2`
14. `r17i1p1f2`
15. `r18i1p1f2`
16. `r19i1p1f2`

Note that ensemble members `r13i1p1f2`, `r14i1p1f2`, and `r15i1p1f2` were not used since they were run on a different high-performance computer and I wanted to remove any possible – albeit unlikely – effect of this on the conclusions drawn.

[1] Erik Behrens et al. "Local Grid Refinement in New Zealand's Earth System Model: Tasman Sea Ocean Circulation Improvements and Super-Gyre Circulation Implications". In: *J. Adv. in Modeling Earth Sys.* 12.7 (2020). DOI: https://doi.org/10.1029/2019MS001996.

[2] Yongming Tang et al. *MOHC UKESM1.0-LL model output prepared for CMIP6 CMIP historical.* 2019. DOI: 10.22033/ESGF/CMIP6.6113. URL: https://doi.org/10.22033/ESGF/CMIP6.6113.

[3] C. Pascoe et al. "Documenting numerical experiments in support of the Coupled Model Intercomparison Project Phase 6 (CMIP6)". In: *Geosci. Model Dev.* 13.5 (2020), pp. 2149–2167. DOI: 10.5194/gmd-13-2149-2020.

The model results are compared to three different ground truth datasets and I use sea surface temperature – SST – data as the validation metric. The observational products used are HadISST,[4] EN4 version 4.2.0 (bias correction version 'g10')[5] and NOAA Optimum Interpolation - OI - SST.[6]

Figure 1 shows the time evolution of SST in the region shown for all the simulations – the full model range – and for the three observational datasets described above. The model data used is daily means, this is also the case for the NOAA-OI data. The HadISST and EN4 datasets are monthly. All data is filtered to produced an annual, running mean.

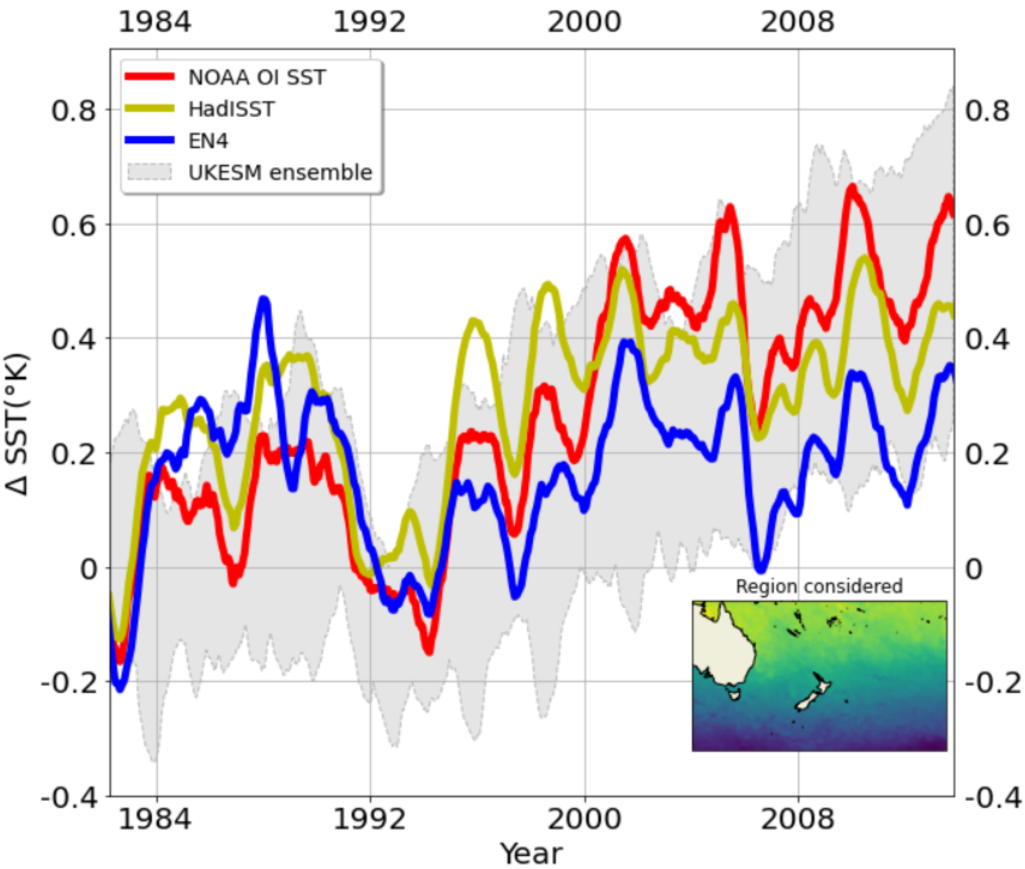

Figure 1: SST data with respect to the start of 1982. UKESM ensemble data (shaded region), NOAA OI SST (red line), HadISST (yellow line) and EN4 (blue line). The full range of the model ensemble is shown, rather than ± 1 standard deviation, for example. The inset shows the region considered.

Figure 1 shows that, broadly speaking, the simulations span the range of the results from the three observational products. In addition, it is clear that – although agreeing in their general upward trend – the increase in temperature shown by the three products is far from uniform. Indeed by 2015 (the end of the period in the simulations) the NOAA dataset has warmed by ≈ 0.3°K compared to EN4. Additionally, around 2006-7, the peak of the NOAA data and the trough of EN4 differ by ≈ 0.6°K, comparible with the warming signal observed over the whole

[4] N. A. Rayner et al. "Global analyses of sea surface temperature, sea ice, and night marine air temperature since the late nineteenth century". In: *J. Geophys. Res.* 108.D14 (2003). DOI: 10.1029/2002jd002670.

[5] Simon A. Good et al. "EN4: Quality controlled ocean temperature and salinity profiles and monthly objective analyses with uncertainty estimates". In: *J. Geophys. Res.: Oceans* 118.12 (2013), pp. 6704–6716. DOI: 10.1002/2013jc009067.

[6] Boyin Huang et al. "Improvements of the Daily Optimum Interpolation Sea Surface Temperature (DOISST) Version 2.1". In: *J. Clim.* 34.8 (2021), pp. 2923 –2939. DOI: 10.1175/JCLI-D-20-0166.1.

period.

There are multiple reasons for why this might be. For example observational coverage, processing algorithms in the data published, the annual mean smoothing applied in this work, and so forth. This result is of course only valid for the relatively small region considered. However it does have subtle but important ramifications for how we assess the fidelity of models to reproduce observed trends in climate change, especially for island nations governed by a predominantly maritime climate.