Towards multi-thousand member atmospheric simulations at 60km resolution in climate*prediction*.net

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1. Introduction and summary

Many of the most important impacts of global warming will be due to changing frequencies of extreme weather. Estimates from numerical climate model simulations of how climate change is affecting extremes are an important source of data for studying this. Ideally, this would be done using large ensembles of high-resolution model runs. However, due computational resource constraints, such studies have previously either used limited ensemble sizes or coarse-resolution models, which cannot reliably simulate important weather phenomena like storms and blocking anticyclones.

To address this, **we have developed 60km and 90km resolution atmospheric models that can be run in the climate*prediction*.net distributed computing project**, based on the Met Office's HadAM4 (box 2). This will **allow multi-thousand member atmospheric simulations to be performed at state-of-the-art climate model resolution** for the first time. The model will also **allow many events to be studied without requiring regional downscaling**.

Below, we show that **the model achieves state-of-the-art performance at simulating weather in the northern extratropics in the December-February season**. We also show biases in the June-August season and progress being made to improve these using parameter tuning.

2. The model: HadAM4

HadAM4 is a global model of the atmosphere and land surface (Williams et al., 2003). We have increased its resolution to 60km and 90km horizontally. Compared to the current model used in climate*prediction*.net, it has twice the number of vertical levels (38) and updates to cloud, microphysics and boundary layer parameterisations. Sea surface temperatures, sea ice and the atmospheric composition are given as boundary conditions.

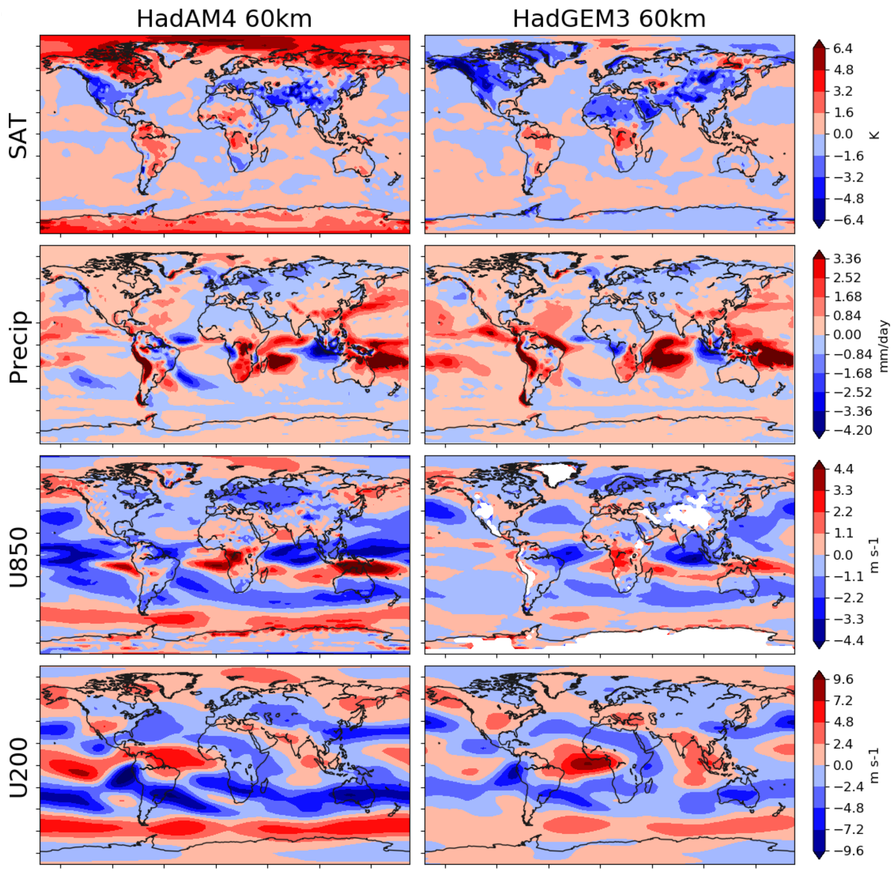
3. DJF mean biases

Biases in HadAM4 at 60km resolution (left) are compared with those of HadGEM3-A at the same resolution – a state-of-the-art Met Office model (right; Ciavarella et al., 2018). Box 4 compares biases in dynamical phenomena. Biases are relative to GPCP for precip and ERA-Interim otherwise. Biases in HadAM4 at 90km resolution are similar to those at 60km resolution. Overall, HadAM4 has a comparable performance to the state-of-the-art model in DJF in the extratropics.

Surface air temperature – biases are similar in size in both.

Precip – biases are similar in both size and pattern.

Zonal winds – biases are similar in size in the northern extratropics, but HadAM4 has larger biases in the tropics and southern extratropics, though they are not unreasonably big.

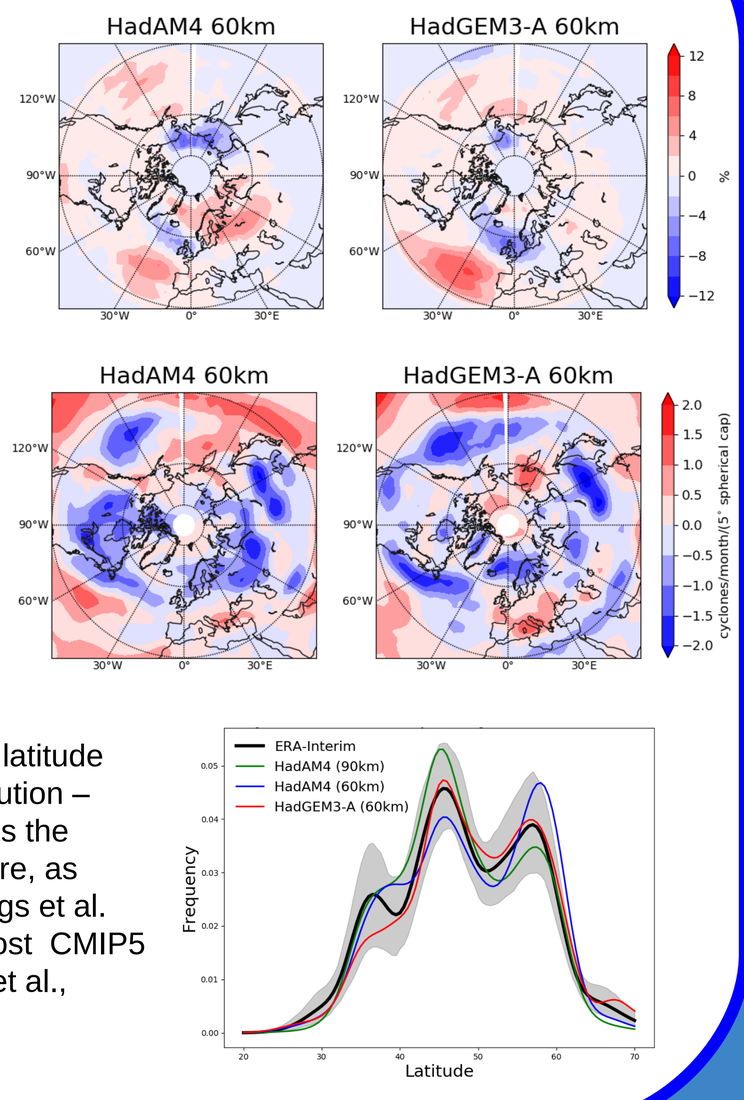


4. DJF dynamical biases

Blocking frequency – both models have similarly sized biases, better than the CMIP5 model average (Mitchell et al., 2016).

Storm track density – similar biases in both models.

North Atlantic jet latitude frequency distribution – HadAM4 captures the 3-peaked structure, as found by Woollings et al. (2010), unlike most CMIP5 models (Anstey et al., 2013).

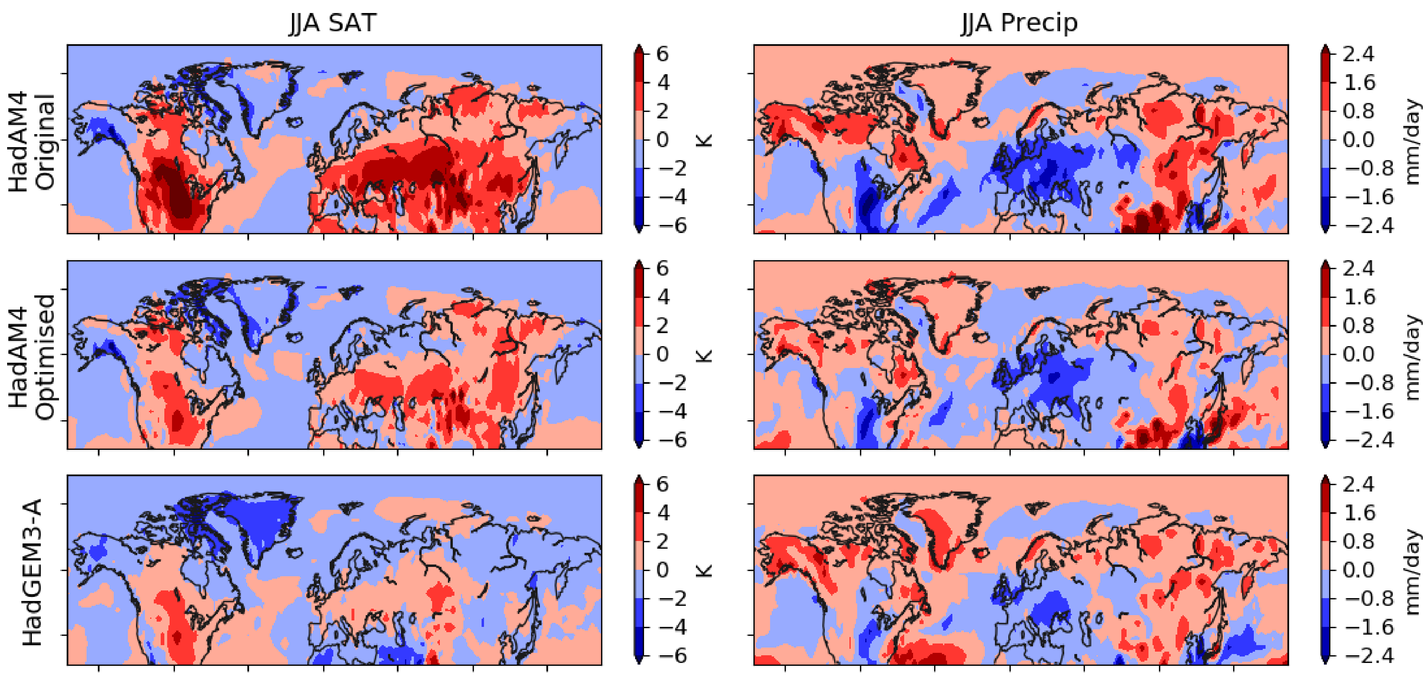


5. JJA biases

The model has mean Northern Hemisphere land temperatures that are too warm (top left), which seems related to having too little cloud cover, and too little precip in the eastern USA and Europe (top right).

We are tuning the model's physics parameters, using a method based on Neelin et al. (2010). Preliminary results for the 90km resolution model are very promising (middle row), with biases reduced to be much closer to those in HadGEM3-A (bottom row), associated mainly with increasing cloud cover. Other variables are not very affected (not shown).

The tuning needs to be finalised and tested in the 60km resolution mode as well.



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This work was supported by funding from the Natural Environment Research Council.