A 60km-resolution GCM for Large-Ensemble Climate Simulations in climate*prediction*.net

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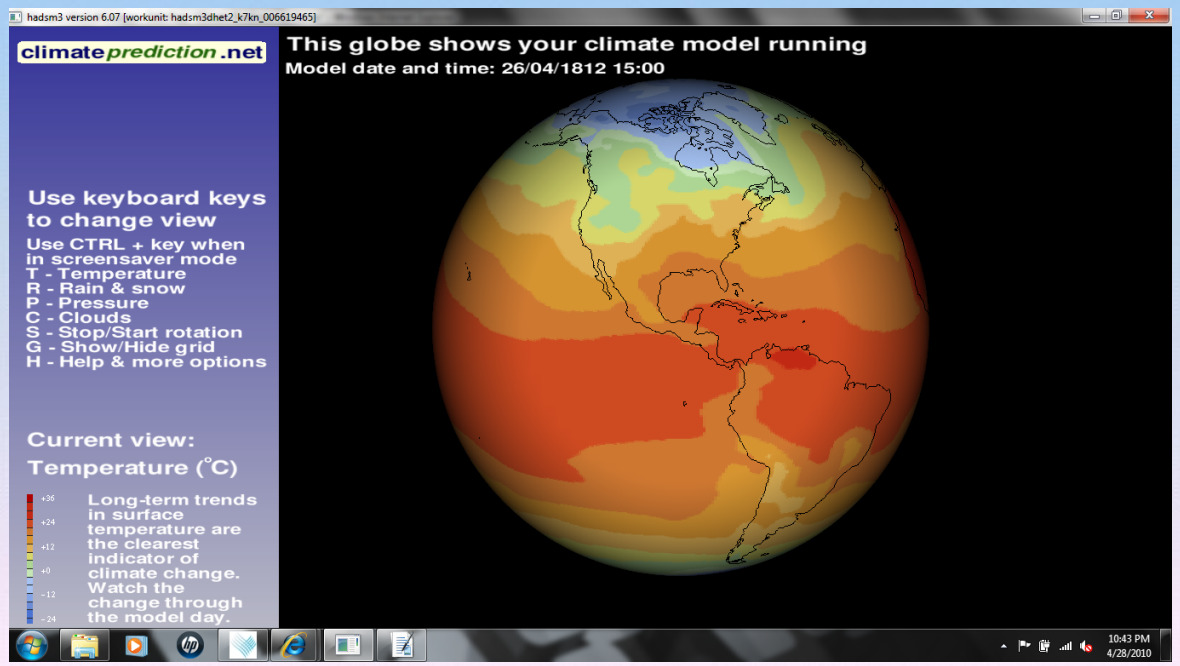
The climate*prediction*.net infrastructure

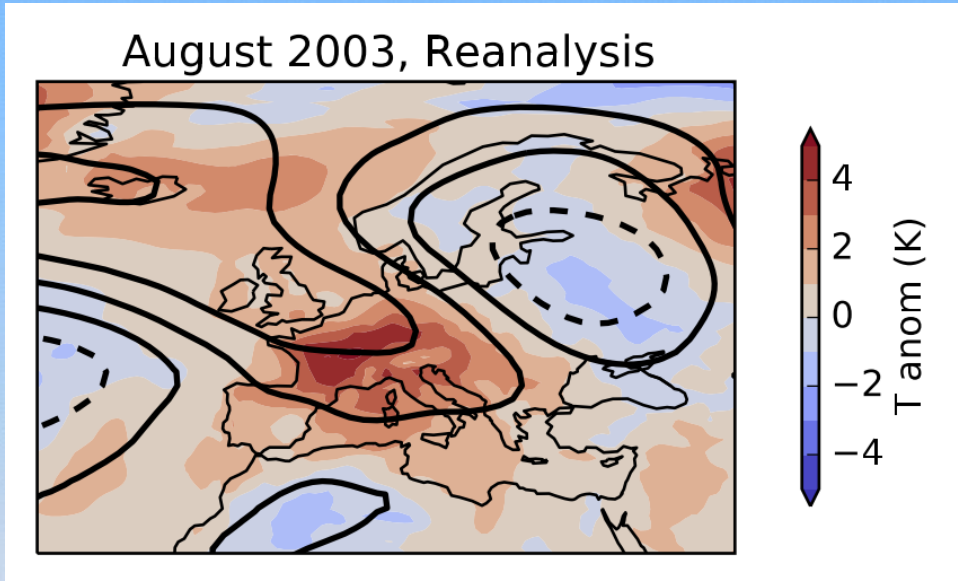
- At present, the Met Office models HadXM3(P) are run on thousands of volunteers' computers using distributed computing to study extreme weather events.
- Used because they are highly memory-efficient.
- The global model has ~150km L19 resolution and regional models have 25km or 50km resolutions.



The need for higher global resolution

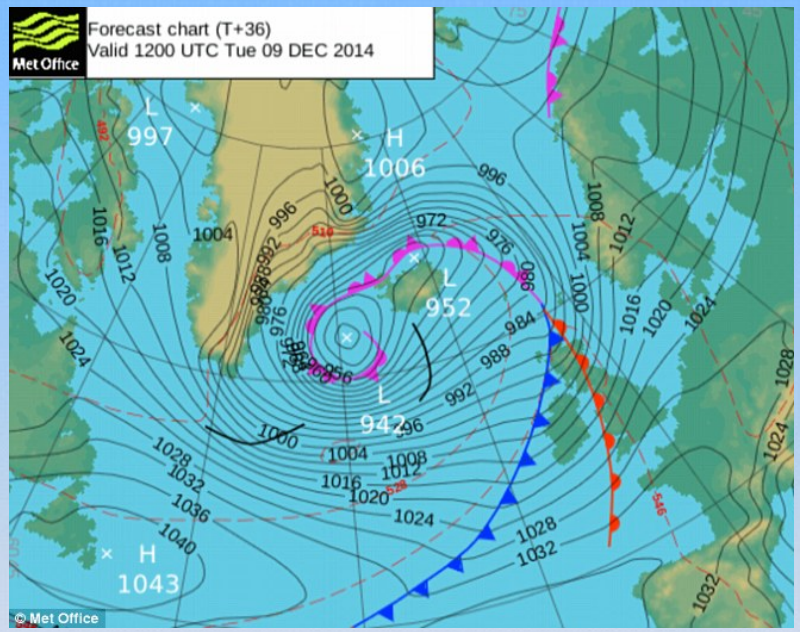
- Many extreme weather events involve large-scale dynamical extremes e.g. blocks, storms.

High blocking occurrence in Europe in 2003 summer:



Mitchell et al. (2016)

High number of storms in 2013/14 winter:



- Simulation of these events improves considerably going from ~100km to ~20-40km global resolution (e.g. Jung et al., 2012; Davini et al., 2017)

DOCILE project

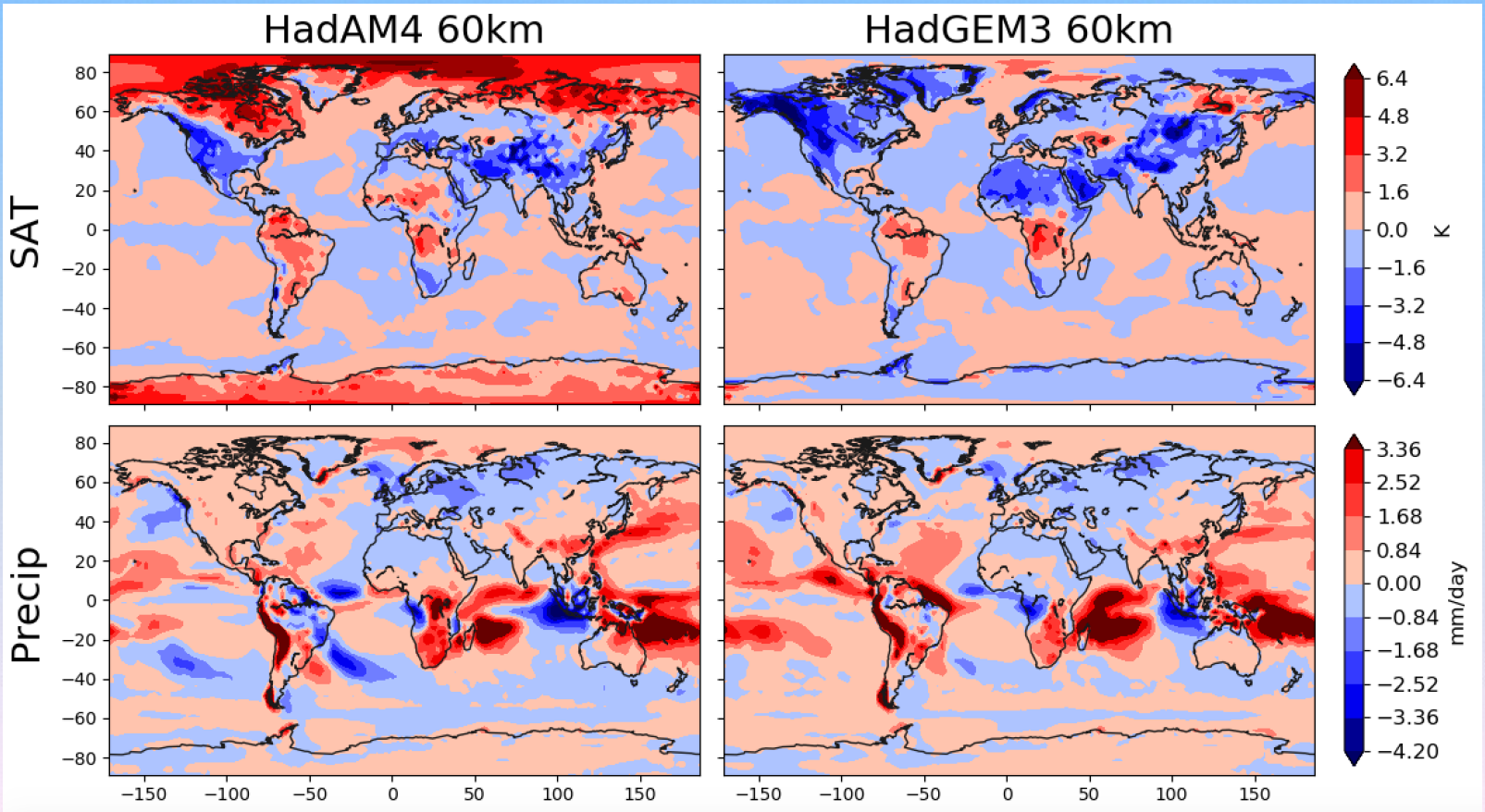
- Aim is to develop ~60km (N216) and ~90km (N144) 38-level global atmospheric models to run in climate*prediction*.net.
- Will be open to use by the academic community.
- Based on Met Office's HadAM4 (Williams et al., 2003).
- HadAM4 also includes updates to parameterisation schemes (microphysics, clouds and boundary layer).

Role for statistics

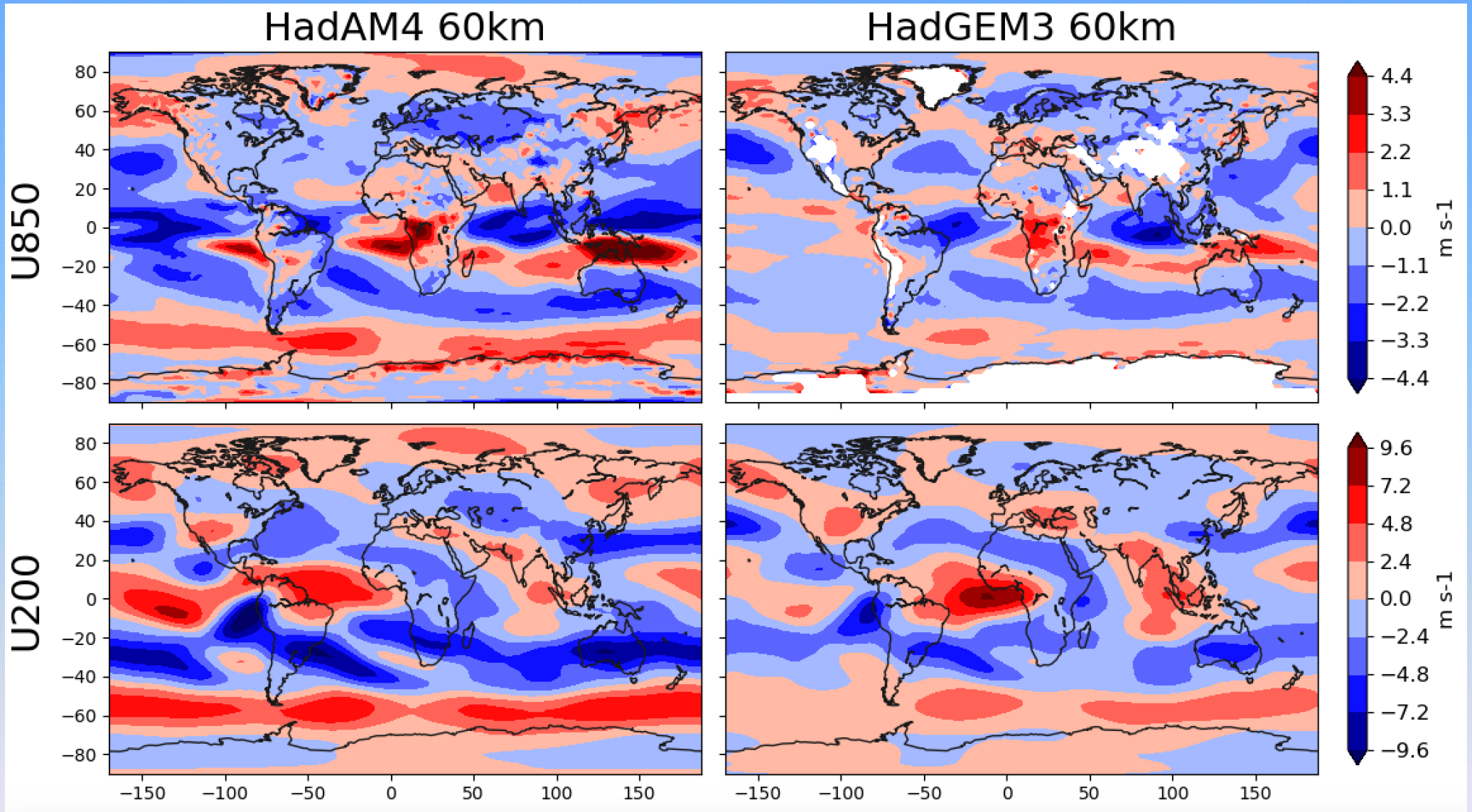
- Model evaluation
- Finding optimal parameters
- Getting information from the multi-thousand member ensembles.

DJF SAT and Precip biases

- Comparing atmosphere-only HadAM4 60km (3 members) and state-of-the-art HadGEM3 GA6 60km (15 members; Ciavarella et al. [2018]) biases over 1986-2012.
- Using GPCP precip, CERES for radiation and ERA-Interim for other variables.

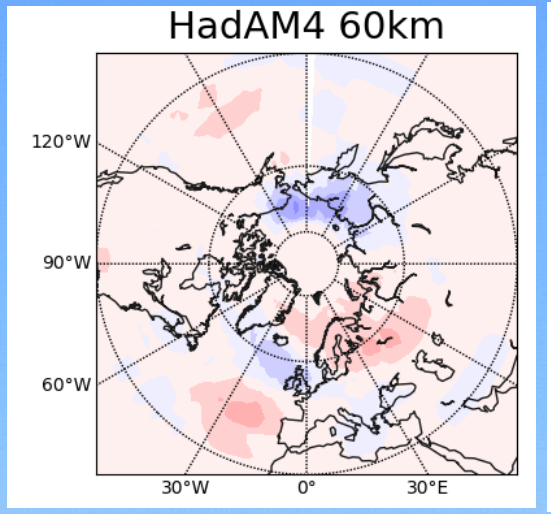


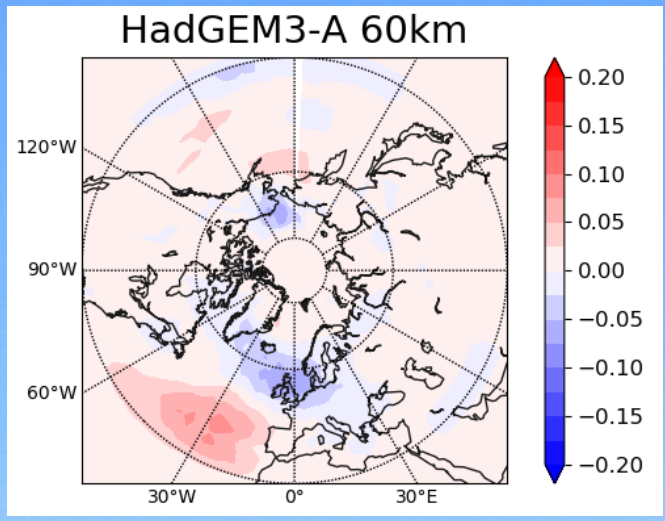
DJF U850 and U200 biases



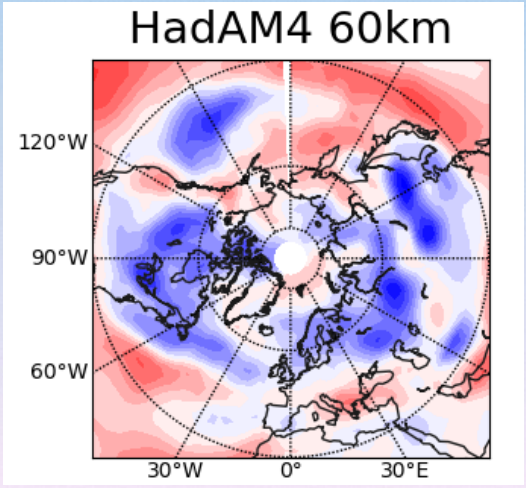
DJF dynamical variability

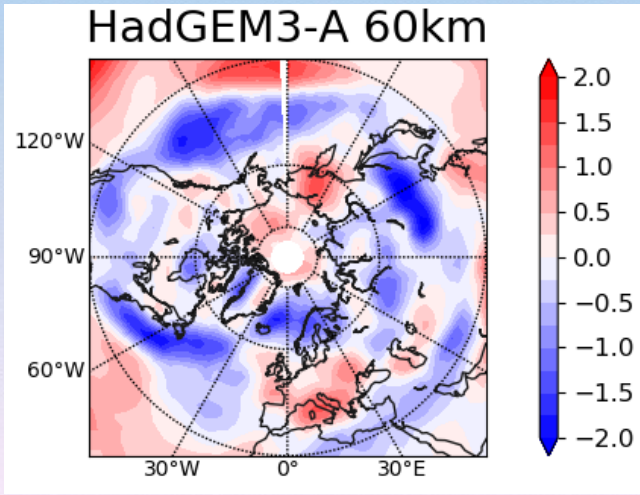
- Blocking bias
  - HadAM4 shows the common negative bias over Europe, but it is comparable with HadGEM3's
  - Smaller than in the CMIP5 multi-model mean (Mitchell et al., 2016).





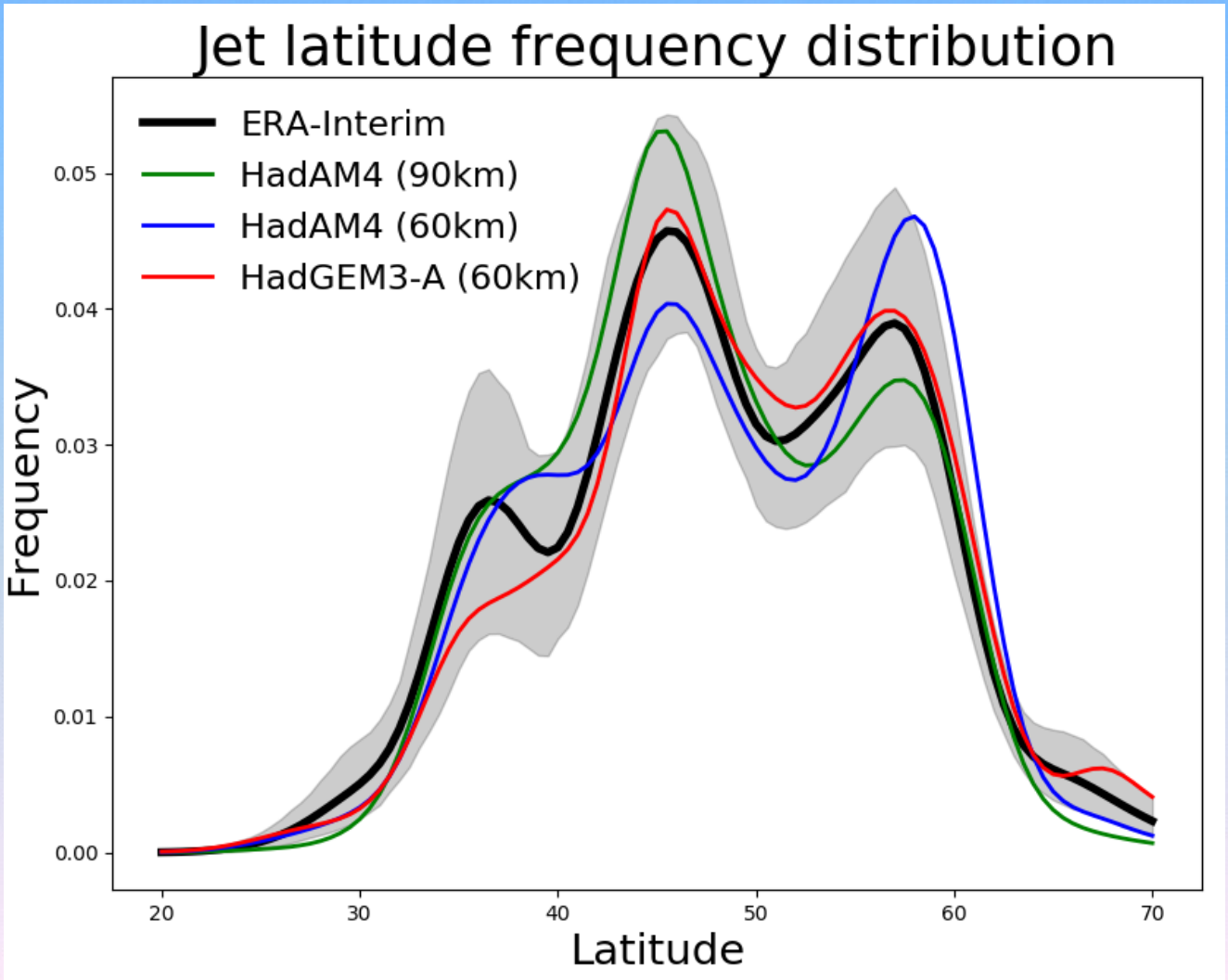
- Storm track density
  - HadAM4 captures main features well.
  - Biases have similar size to those in HadGEM3 except in continental North America.





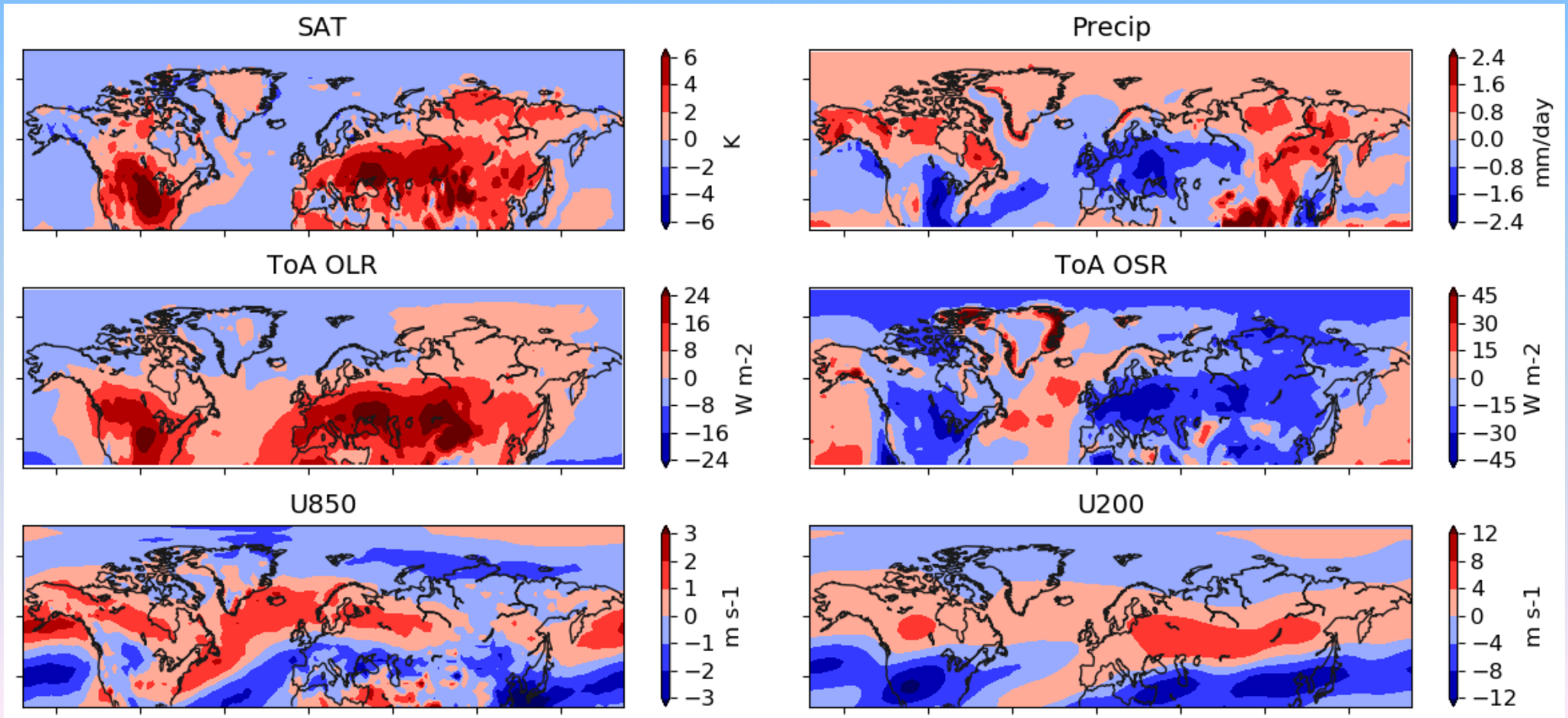
DJF N. Atlantic jet latitude distribution

- The trimodality of the frequency distribution of the latitude of the North Atlantic eddy-driven jet is captured in HadAM4 (unlike in most CMIP5 models).



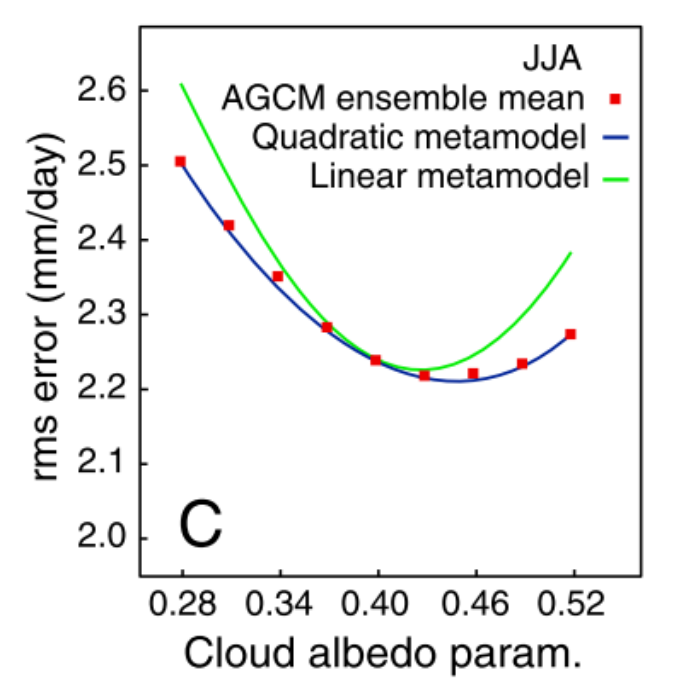
JJA biases

- Large biases in NH land JJA SAT, precip and radiation with initial parameter settings.
- Seems associated with having too little cloud.

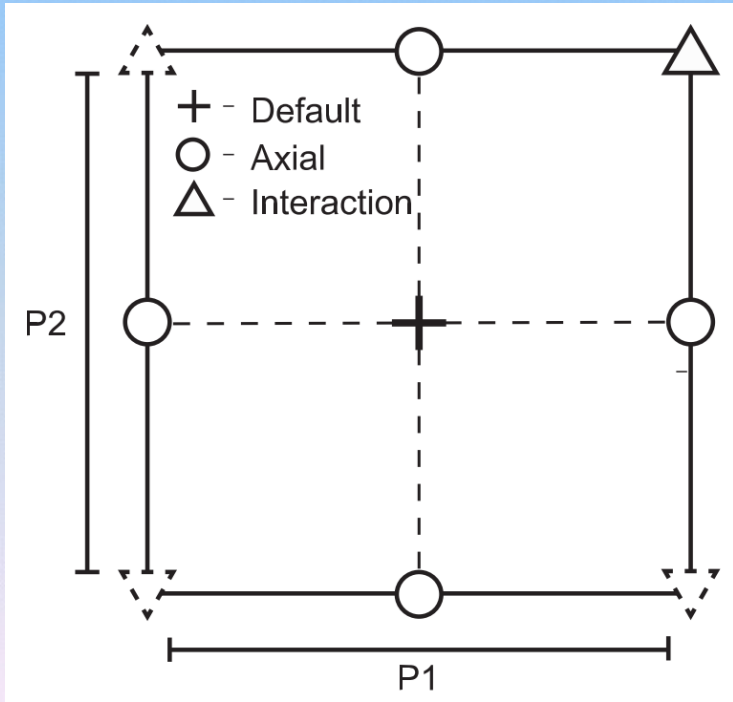


Tuning the mean state

- Using “algorithmically-assisted” method (Neelin et al., 2010).
- Based on optimising a cost function that depends on RMSE of mean climate.
- 26 parameters perturbed – only the 8 most important were optimised.



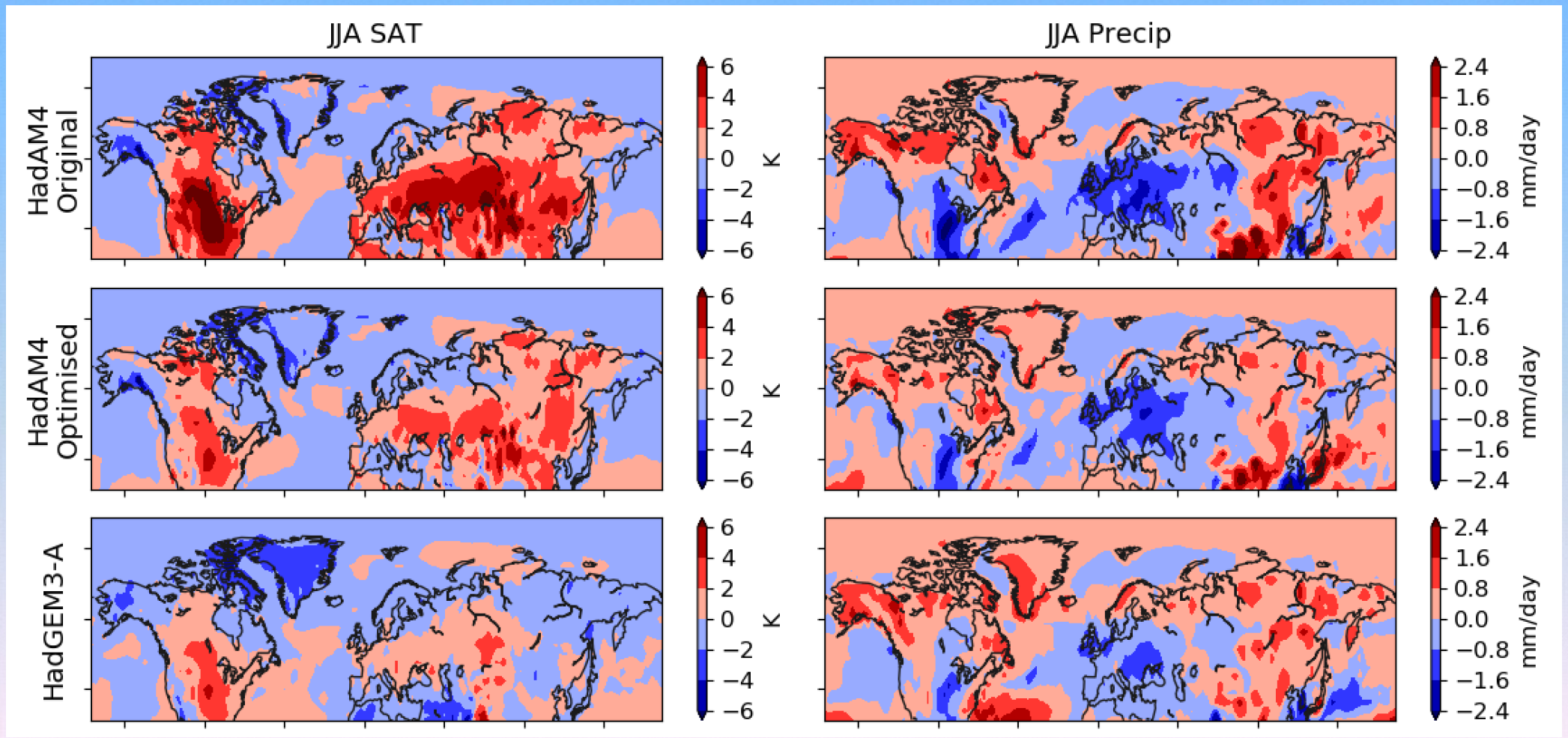
Neelin et al. (2010)



Bellprat et al. (2016)

Preliminary tuning results

- Optimising 30-90N SAT, precip, U200 and U850 in JJA and DJF gives good results (90km resolution).



Thoughts on tuning methods

- Perturbing individual parameters alone helpful for debugging – useful to include as well as multi-parameter perturbations.
- Cost function that matches our best judgement is complex and uncertain (Hourdin et al., 2016) – counts in favour of using emulator (e.g. Rougier et al., 2009; Neelin et al., 2010) rather than iterative updating (e.g. Tett et al., 2013).
- Methods that take into account whole distributions would be useful.

Summary

- 60km and 90km L38 configurations of HadAM4 have been newly developed for the climate*prediction*.net distributed computing project.
- This will allow large-ensembles to be produced to study extreme events with a much better representation of extratropical dynamics.
- HadAM4 can simulate NH extratropical DJF weather about as well as a state-of-the-art Met Office model.
- Experiments to study NH winter extremes are in progress.
- Parameter tuning to reduce JJA model biases further is being finalised.