Model name	Ensemble member	Historical dates
ACCESS-CM2	r1i1p1f1	1950-2010
AWI-ESM-1-1-LR	r1i1p1f1	1900-2010
BCC-CSM2	r1i1p1f1	1950-2010
BCC-ESM1	r1i1p1f1	1950-2010
CanESM5	r1i1p1f1	1900-2010
CESM2-FV2	r1i1p1f1	1900-2010
CESM2	r1i1p1f1	1900-2010
CESM2-WACCM-FV2	r1i1p1f1	1900-2010
CESM2-WACCM	r1i1p1f1	1900-2010
CNRM-CM6-1	r1i1p1f2	1950-2010
CNRM-CM6-1-HR	r1i1p1f2	1900-2010
CNRM-ESM2	r1i1p1f2	1950-2010
EC-Earth3	r1i1p1f1	1900-2010
FGOALS-f3	r1i1p1f1	1950-2010
FGOALS-g3	r1i1p1f1	1900-2010
GFDL-CM4	r1i1p1f1	1910-2010
GISS-E2-1-G	r1i1p1f1	1910-2010
HadGEM3-GC31-LL	r1i1p1f3	1900-2010
HadGEM3-GC31-MM	r1i1p1f3	1900-2010
INM-CM4-8	r1i1p1f1	1900-2010
INM-CM5-0	r1i1p1f1	1900-2010
IPSL-CM6A-LR	r1i1p1f1	1950-2010
MIROC6	r1i1p1f1	1900-2010
MPI-ESM1-2-HAM	r1i1p1f1	1900-2010
MPI-ESM1-2-HR	r1i1p1f1	1900-2010
MPI-ESM1-2-LR	r1i1p1f1	1910-2010
MRI-ESM2-0	r1i1p1f1	1950-2010
NorESM2-LM	r1i1p1f1	1950-2010
NorESM2-MM	r1i1p1f1	1950-2010
TaiESM1	r1i1p1f1	1900-2010
UKESM1-0-LL	r1i1p1f2	1900-2010

Table S1: CMIP6 models used in this paper, with the range of historical data available.

Model name	Ensemble member	Historical dates
AWI-CM-1-1-LR	r1i1p1f002	1950-2014
AWI-CM-1-1-HR	r1i1p1f002	1950-2014
CMCC-CM2-HR4	r1i1p1f1	1950-2014
CMCC-CM2-VHR4	r1i1p1f2	1950-2014
CNRM-CM6-1	r[1,2]i1p1f2	1950-2014
CNRM-CM6-1-HR	r1i1p1f1	1950-2014
EC-Earth3	r[1,2,3]i1p2f1	1950-2014
EC-Earth3-HR	r[1,2,3]i1p2f1	1950-2014
ECMWF-IFS-LR	r[1,2,3,4,5,6,7,8]i1p1f1	1950-2014
ECMWF-IFS-MR	r[1,2,3]i1p1f1	1950-2014
ECMWF-IFS-HR	r[1,2,3,4,5,6]i1p1f1	1950-2014
HadGEM-GC31-LL	r1i[1,2,3,4,5,6,7]p1f1	1950-2014
HadGEM-GC31-MM	r1i1p1f1	1950-2014
HadGEM-GC31-HM	r1i[1,2,3]p1f1	1950-2014
HadGEM-GC31-HH	r1i1p1f1	1950-2014
MPI-ESM1-2-HR	r1i1p1f1	1950-2014
MPI-ESM1-2-XR	r1i1p1f1	1950-2014

Table S2: PRIMAVERA models used in this paper, with the range of historical data available.

Model name	Ensemble members	Historical dates
ACCESS1-0	r1i1p1	1950-2005
ACCESS1-3	r1i1p1	1950-2005
BCC-CSM1-1	r1i1p1	1950-1998
BCC-CSM1-1-m	r1i1p1	1950-2005
BNU-ESM	r1i1p1	1950-2005
CanESM2	r[1,2,3,4,5]i1p1	1950-2005
CCSM4	r6i1p1	1950-2005
CMCC-CESM	r1i1p1	1950-2005
CMCC-CM	r1i1p1	1950-2005
CMCC-CMS	r1i1p1	1950-2005
CMCC-CM5	r1i1p1	1950-2005
EC-EARTH	r[1,2,7,9,12]i1p1	1950-2005
FGOALS-g2	r[1,3]i1p1	1950-2005
GFDL-CM3	r[1,2,3]i1p1	1950-2005
HadCM3	r[1,2,3,4,5,6,7,8,9,10]i1p1	1960-2005
HadGEM2	r[1,2,3]i1p1	1960-2005
IPSL-CM5A-LR	r[1,2,3,4,5,6]i1p1	1950-2005
IPSL-CM5A-MR	r[1,2,3]i1p1	1950-2005
IPSL-CM5B-LR	r1i1p1	1950-2005
MIROC5	r[1,2,3,4,5]i1p1	1950-2005
MIROC-ESM-CHEM	r1i1p1	1950-2005
MIROC-ESM	r[1,2,3]i1p1	1950-2005
MPI-ESM-LR	r[1,2,3]i1p1	1950-2005
MPI-ESM-MR	r[1,2,3]i1p1	1950-2005
MPI-ESM-P	r[1,2]i1p1	1950-2005
MRI-CGCM3	r1i1p1	1950-2005
MRI-ESM1	r1i1p1	1950-2005
NorESM1-M	r[1,2,3]i1p1	1950-2005

Table S3: CMIP5 models used in this paper, and the corresponding ensemble members and historical date range available.

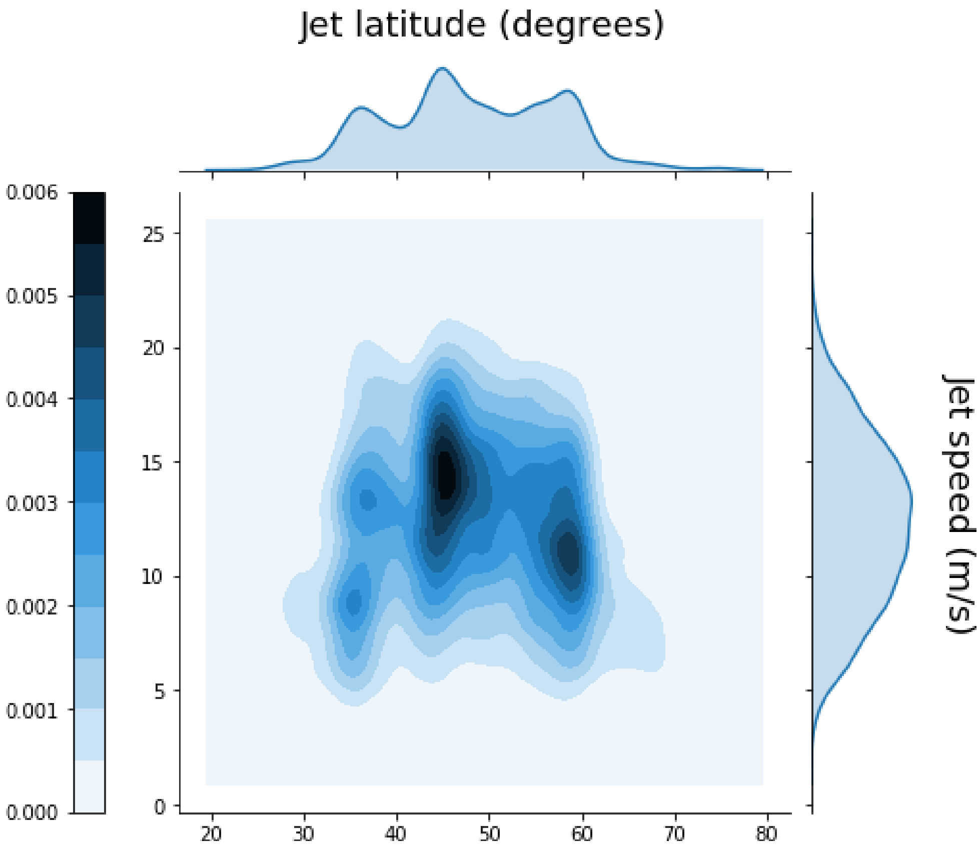

Figure S1: The joint and marginal probability distributions of daily DJF jet speed and jet latitude in the ERA20C reanalysis 1900-2010. The jet latitude shows a clear trimodality, while the jet speed has an essentially Gaussian distribution. The two indices are approximately orthogonal, although the central jet regime is in general associated with higher jet speeds.

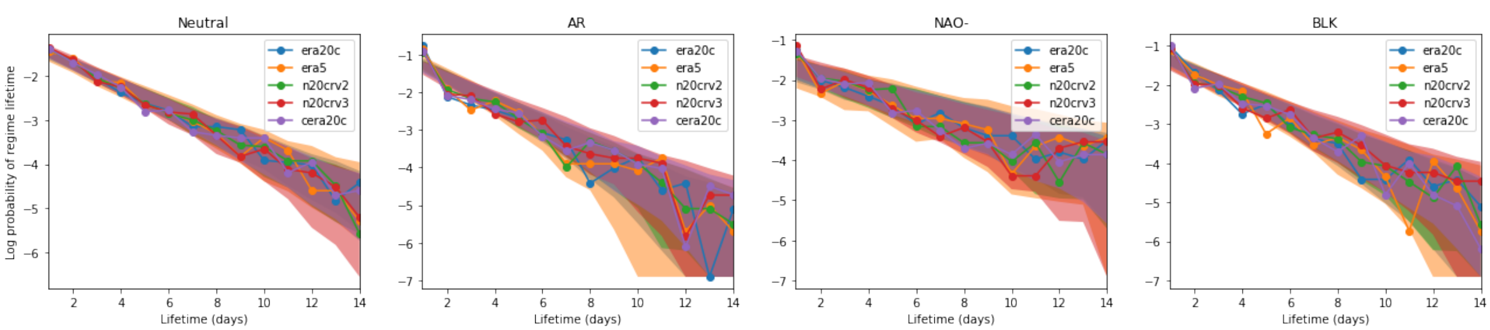

Figure S2: The log probability of regime events lasting for different numbers of days, calculated for the 5 reanalysis products used in the main text. For a purely markovian process, regime lifetime will decay exponentially, and so log probability will decrease linearly. Markovian transition matrices were fitted to the regime sequence for each separate reanalysis product, which were used to generate 1000 synthetic state sequences of equal length to the reanalysis dataset. The shaded regions show the 95th percentile range of that synthetic markovian lifetime distribution. All active regimes show slightly higher day-1 persistence than the Markovian model would suggest, but the effect is small.

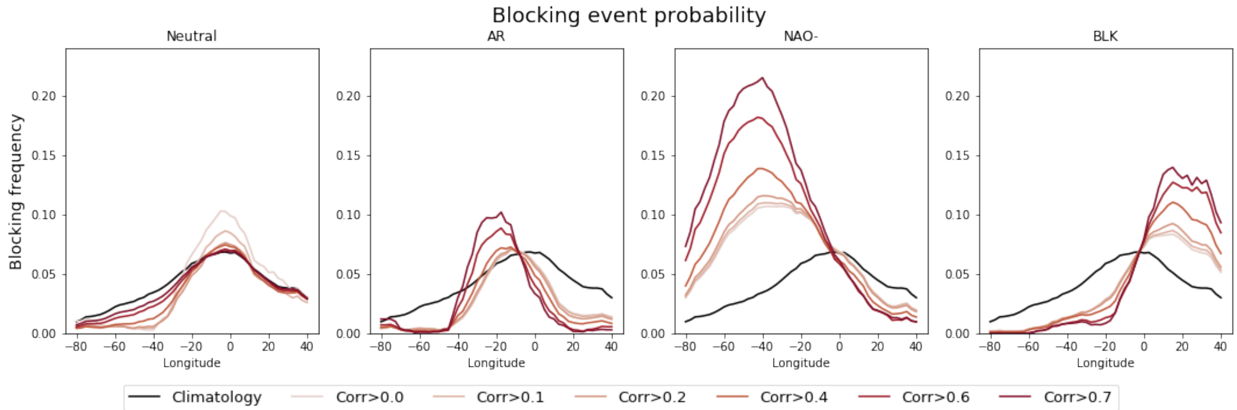

Figure S3: The black line shows the ERA20C climatological latitudinal DJF average frequency of European blocking events, as defined in **?**, averaged meridionally over the domain [30-75N]. Blocking events represent a temporally persistent, spatially extended reversal of the meridional Z500 gradient. Coloured lines show equivalent frequencies, composited by geopotential-jet regime, for a range of different neutral-state thresholds. More stringent thresholds amplify the blocking frequency anomalies in the active regimes. For a threshold of 0.4 the neutral regime features less blocking than in the overall climatology at all longitudes, while all active regimes show more blocking than in climatology, within particular longitude ranges.

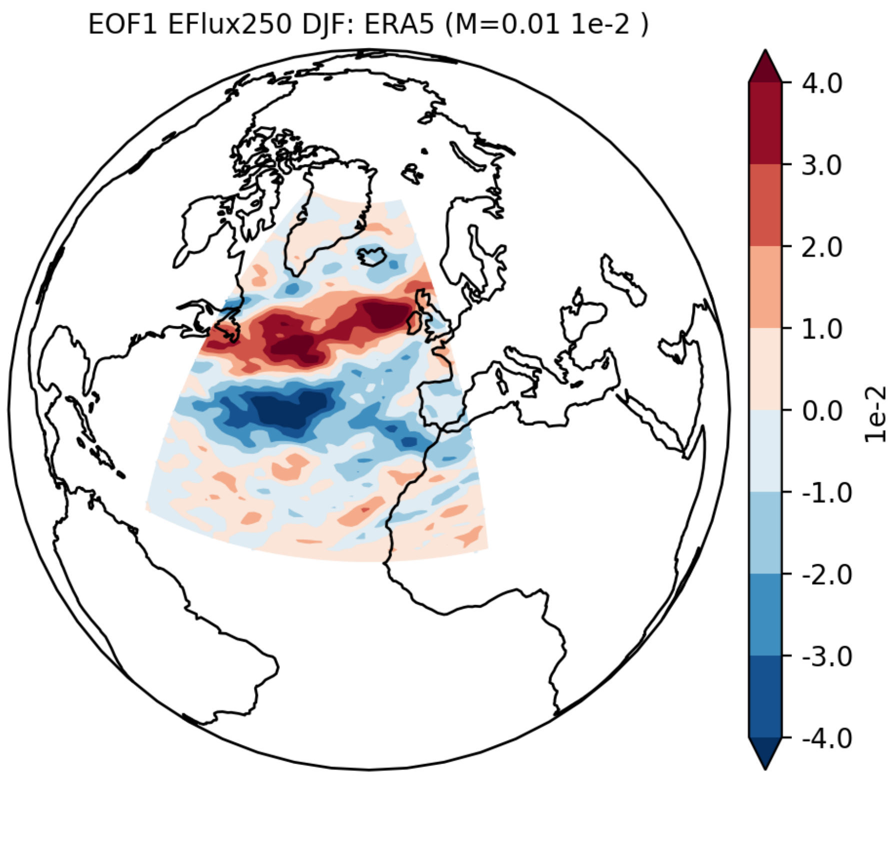

Figure S4: The first EOF of ERA5 DJF mean E_{250}. The first EOFs of E_{250} calculated for model data were found to be similar (not shown).

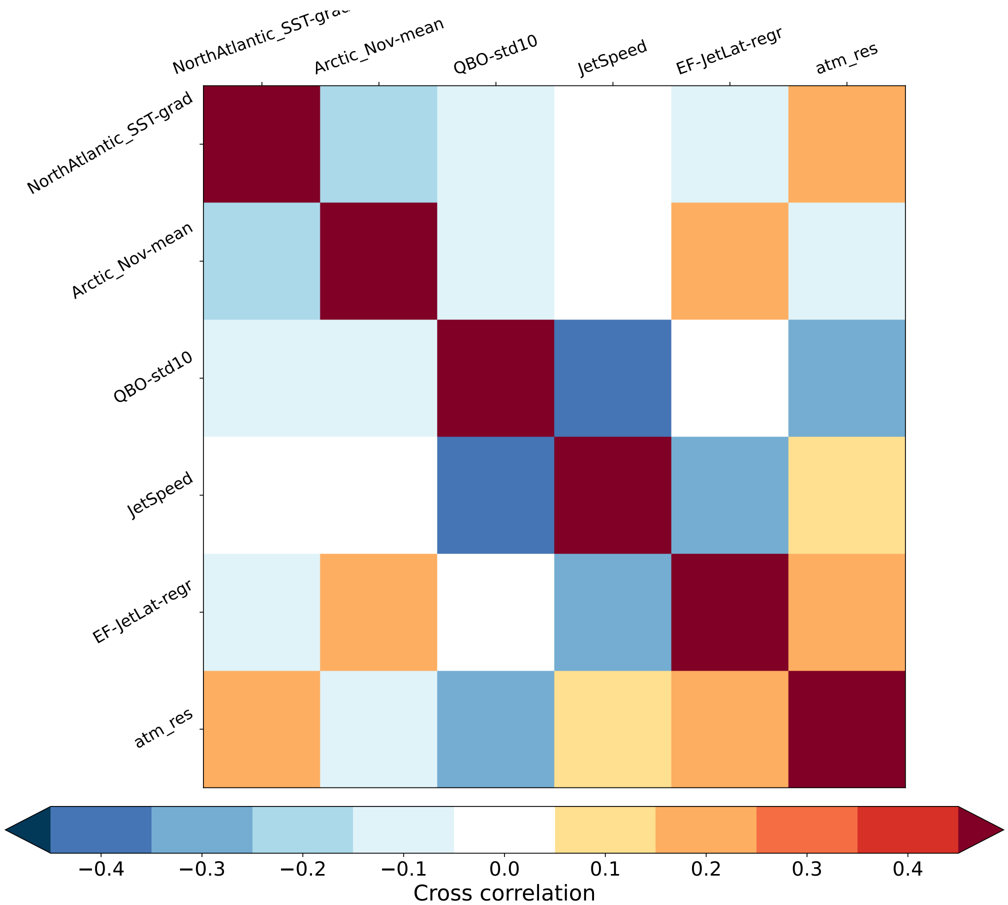

Figure S5: Cross correlations between the 6 predictors used to explain inter-model differences in regime behaviour

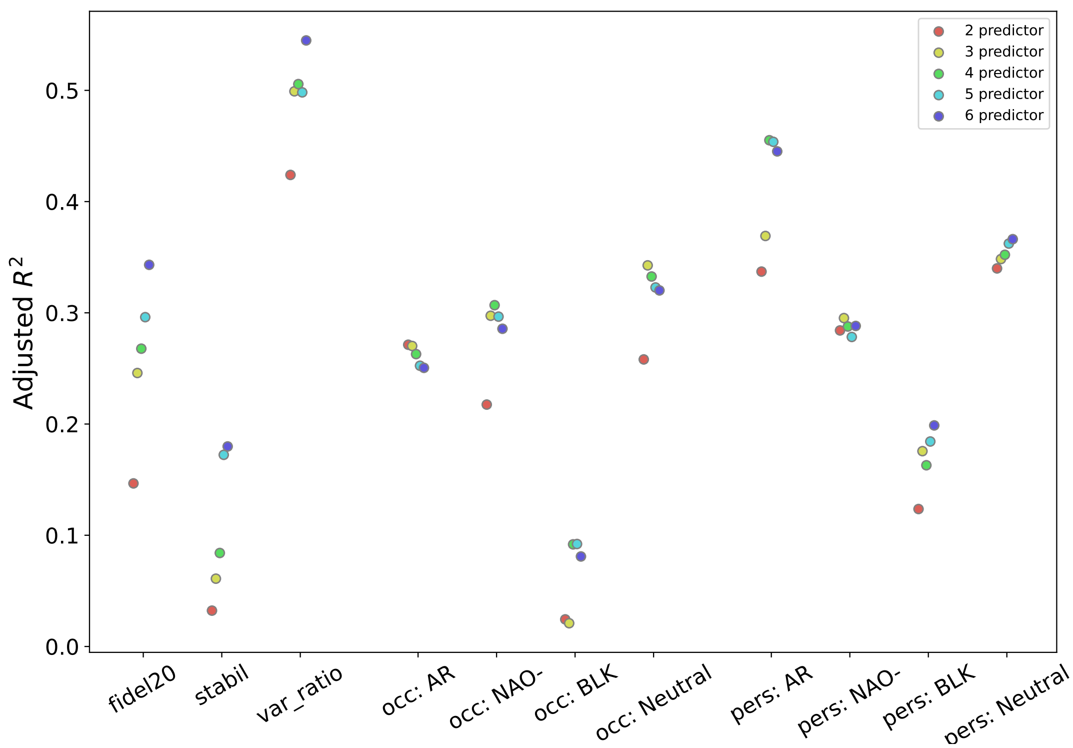

Figure S6: The adjusted R^2 value for the ridge regression model used to explain inter-model differences in regime behaviour, for different numbers of drivers. While R^2 will always increase when adding additional explanatory variables, the adjusted R^2 will not, making it useful for choosing a suitable number of predictors. We use 6 predictors as this maximises the adjusted R^2 for 5 of the 11 regime metrics.

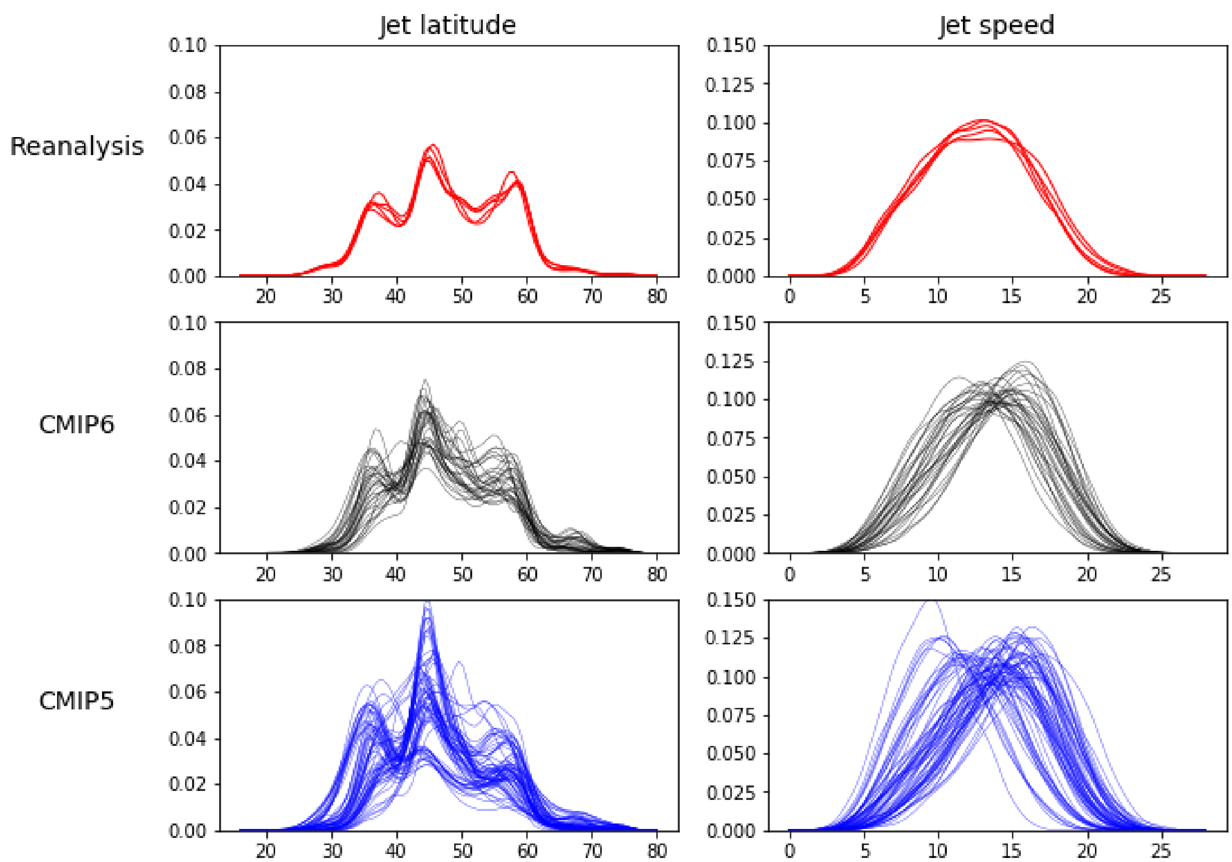

Figure S7: Probability distributions of jet speed and jet latitude, with one line shown for each reanalysis and climate model ensemble member. Distributions have been smoothed with a kernel density estimate. The prevailing bias towards fast jet speeds is visible in both CMIP ensembles, while the CMIP6 jet latitude distribution is far more consistently trimodal than CMIP5.

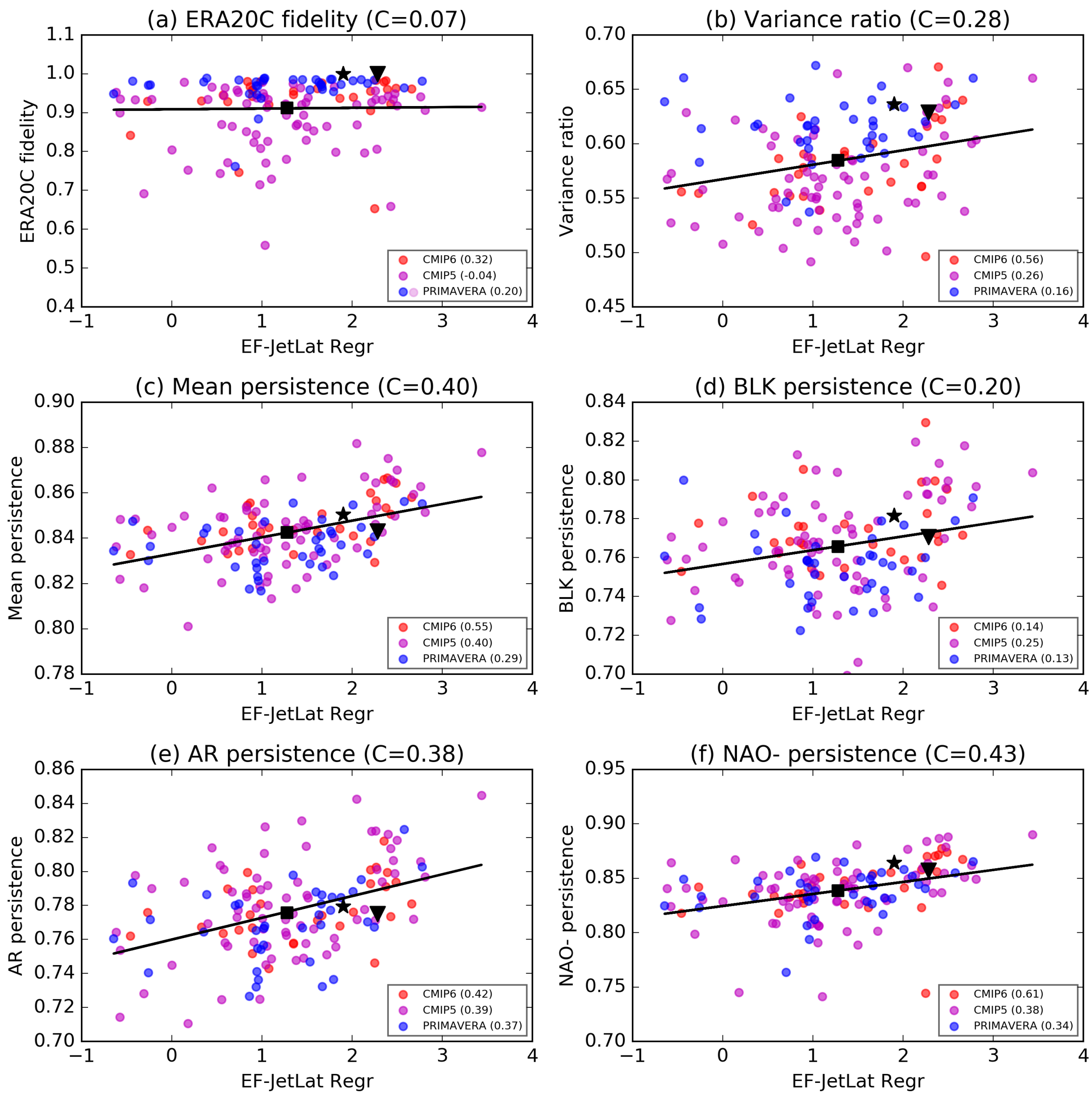

Figure S8: As in figure 15 of the main text, but using all ensemble members rather than the ensemble mean for each model.

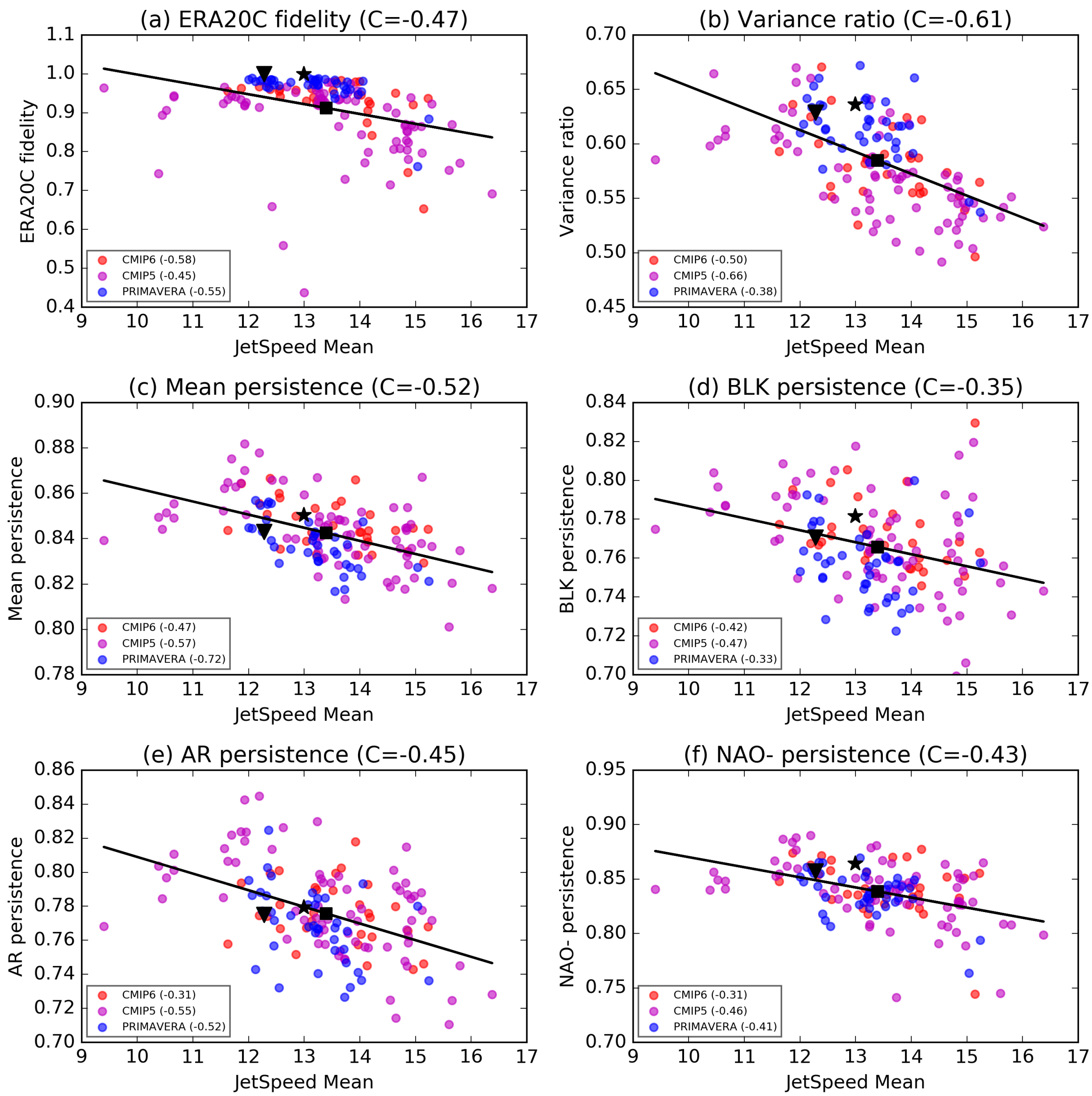

Figure S9: As in figure 16 of the main text, but using all ensemble members rather than the ensemble mean for each model.

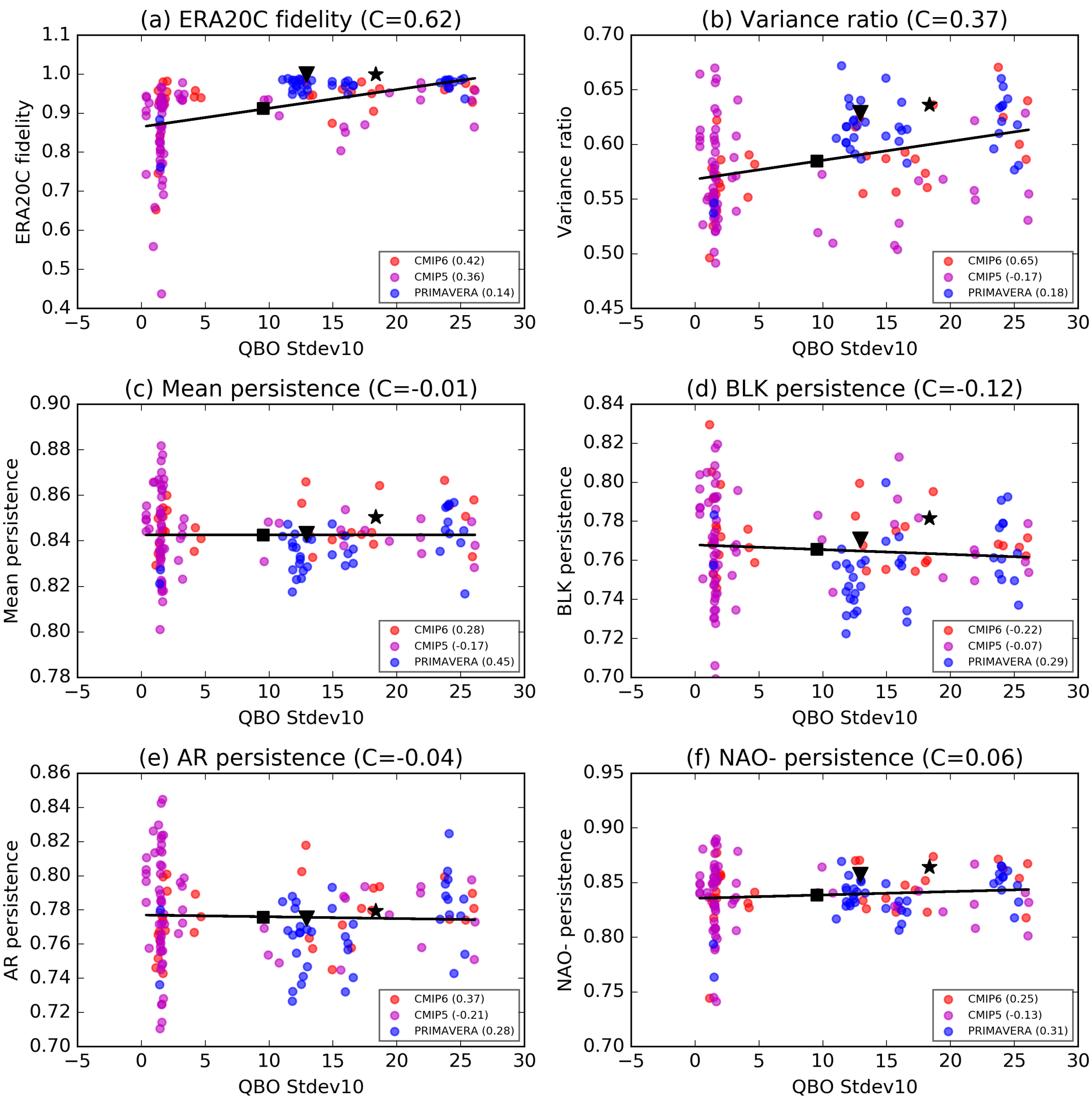

Figure S10: As in figure 17 of the main text, but using all ensemble members rather than the ensemble mean for each model.

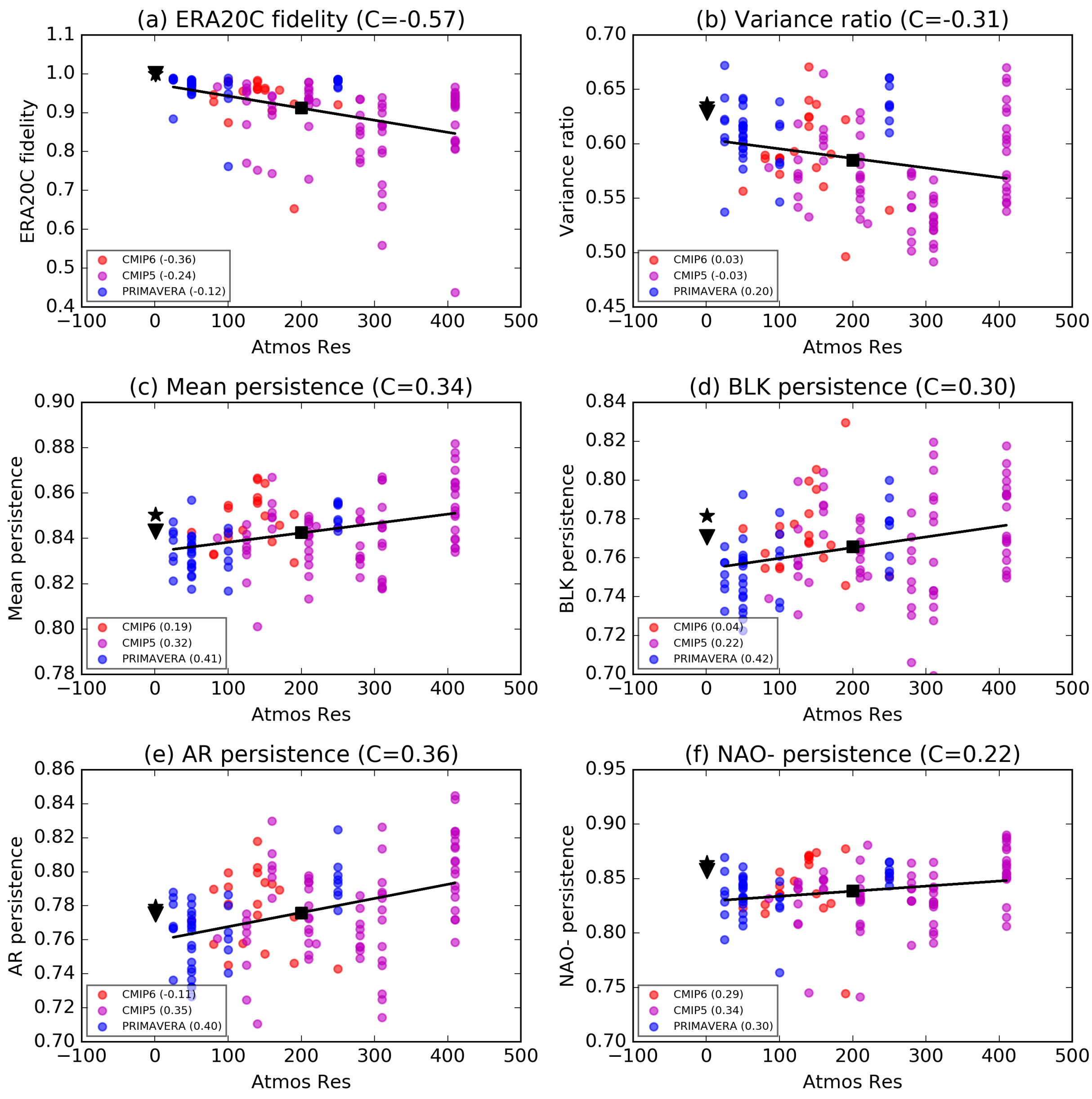

Figure S11: As in figure 18 of the main text, but using all ensemble members rather than the ensemble mean for each model.