#### Representation of blocking in a multi-model ensemble of high-resolution coupled global climate models

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## Introduction

- Blocking (or its absence) is associated with a range of surface impacts, and models traditionally underestimate blocking occurrence.
- Several studies have show that resolution increase benefits the representation of blocking in GCMs.
- For example, in an AMIP ensemble, where horizontal atmosphere resolution in four GCMs was increased from about 100 to 25 km (Schiemann et al. 2017).
- Despite such improvements, this study also found that considerable biases remain (underestimation of Euro/Atlantic blocking) in winter and summer.

Here, opportunity to revisit this, and assess the role of resolution and coupling in the PRIMAVERA multimodel ensemble.



FIG. 11. Blocking frequency root-mean-square error and spatial correlation with respect to the reanalysis blocking frequency field shown in Fig. 1 for the Atlantic–European sector (45°–75°N, 280°–80°E). (a)–(d) The four different models; small symbols correspond to ensemble members and large/thickened symbols to the ensemble mean (see Table 2): results are shown for coarse resolution (upside down triangles), medium resolution (circles), and high resolution (triangles); and DJF (blue), MAM (green), JJA (red), and SON (orange).

Schiemann et al. 2017



Experiment (coupling)	Centre/Model	Resolution atmosphere	Resolution ocean	Notional resolution	Ensemble members
highresSST-present (forced)	MOHC HadGEM3-GC31	N96	(0.25° daily HadISST2)	L	5
		N216		М	3
		N512		н	3
	ECMWF IFS	Тсо199		L	6
		Тсо399		н	4
	EC-Earth-Cons. EC-Earth3	TL255		М	1
		TL511		н	1
	СМСС СМСС-СМ2	1°		L	1
		½°		н	1
	MPI-M MPI-ESM1-2	T127		L	1
		T255		М	1
hist-1950 (coupled)	HadGEM3-GC31	N96	1° (1/3° tropics)	u	1
		N216	¼°	ММ	1
		N512	¼°	нм	1
		N512	1/12°	нн	1
	ECMWF-IFS	Tco199	1°	u	6
		Тсо399	¼°	нм	4
	EC-Earth-Cons. EC-Earth3P	TL255	1°	ML	2
		TL511	¼°	нм	1
	CMCC CMCC-CM2	1°	¼°	LM	1
		1/4°	٧4°	нм	1
	MPI-M MPI-ESM1-2	T127	TP04	LM	1
		T255	TP04	мм	1

# Reanalysis blocking climatology

- 2D "AGP" index (Scherrer et al. 2006)
- generalisation to 2D of Tibaldi and Molteni 1990
- 1) reversal of equator-pole Z<sub>500hPa</sub> gradient
- 2) westerlies to the north
- 3) persistence of at least five days



FIG. 1. Climatological-mean reanalysis blocking frequency (fraction of blocked days) based on concatenating ERA-40 (1962–78) and ERA-Interim (1979–2011) for (a) December–February, (b) March–May, (c) June–August, and (d) September–November. The light blue lines show five regions: ATL (47°–63°N, 16°W–7.5°E), BAL (53°–67°N, 7.5°–40°E), PAC (64°–75°N, 145°–225°E), GL (63°–75°N, 295°E–0°), and NEU, which is the joint area of ATL and BAL.

Schiemann et al. 2017

### Metrics...

• use of instantaneous vs. dailymean Z500 matters somewhat



## Example: ECMWF IFS

forced

coupled





improvement,
especially in pattern,
for HM





# Blocking climatology (systematic evaluation)



- underestimation, similar to CMIP5
- no robust improvement with resolution across all models



- small improvement at higher resolution in 3 of 5 forced models
- improvement in ~all 5 coupled models
- some improvement over CMIP5

# Variability



- models relatively too variable
- too many years with very little or no blocking
- no significant trends in the historical period (but interesting recent winters 2013/14 and 15/16)

### Persistence



- relatively too many short events
- > (and too few long events)

persistence might be improved a little at higher resolution

# Summary

Northern European *mean blocking frequency* remains underestimated:

- DJF: some models now within 20% observed blocking frequency
- JJA: large underestimation by up to 50%
- transition seasons comparatively well represented (not shown)
- little sensitivity to model resolution

#### Euro-Atlantic *Geographical pattern* of blocking occurrence improved

- 'sizeable' when compared to total model biases
- high-resolution PRIMAVERA models improve upon CMIP5 MMM
- benefits of high resolution more clearly seen in coupled models

#### Variability in the historical period is 'relatively too large':

- too many years with very little simulated blocking
- as much as observed in some years
- any long-term trend in the historical (PRIMAVERA) period is small

#### Persistence underestimated:

- broad distribution in reanalysis with some events lasting several weeks
- relatively too few long-lived events in models
- possibly small improvement at higher resolution

Resolution increase benefits representation of blocking, but will, in isolation, not eliminate model bias. Our results may be conservative as high-resolution models are not tuned.