SPECIAL PROJECT PROGRESS REPORT

All the following mandatory information needs to be provided. The length should *reflect the complexity and duration* of the project.

Reporting year	2019
Project Title:	WeatHer rEgimes' REpresentation (WHERE)
Computer Project Account:	spitmavi
Principal Investigator(s):	Alessia Balanzino
Affiliation:	Istituto di Scienza dell'Atmosfera e del Clima, Consiglio Nazionale delle Ricerche (CNR-ISAC)
Name of ECMWF scientist(s) collaborating to the project (if applicable)	……………………………………………………………… ………………………………………………………………
Start date of the project:	01/01/2018
Expected end date:	31/12/2019

Computer resources allocated/used for the current year and the previous one

(if applicable)
Please answer for all project resources

		Previous year		Current year	
		Allocated	Used	Allocated	Used
High Performance Computing Facility	(units)	8 millions	5.9 millions	8 millions	0.27 millions
Data storage capacity	(Gbytes)	32,000	20,000	64,000	20,000

Summary of project objectives (10 lines max)

In this special project we plan to carry out a set of atmosphere-only (AMIP) ensemble historical (1950-2014) and future scenario (2015-2050) simulations with the EC-Earth global climate model in order to study the ability of the model to represent the Euro-Atlantic and Pacific North American atmospheric weather regimes (e.g. Cassou 2010, Straus et al. 2007) and the related prevailing teleconnection patterns. Several ensemble members are necessary to assess the relative contribution of the forced and the unforced variability to the frequency of weather regimes. Since all the ensemble members will be run using the same Sea Surface Temperatures (SSTs), the inter- ensemble variability provides an estimate of the internal variability, whereas the forced variability is represented by the variability of the ensemble mean. The activation of a stochastic physics parameterization scheme Palmer et al. 2009 to represent subgrid-scale processes will be investigated by comparing with the baseline simulations.

Summary of problems encountered (10 lines max)

We decided to deviate from our original plans of performing a 10-member ensemble of atmospheric only (AMIP) historical (1950-2014) experiments, performing instead two atmospheric only (AMIP) historical simulations at different horizontal resolutions, namely TL255 and TL511. The control integration has been performed with the EC-Earth Model version 3.2.2 (i.e. EC-Earth-3P) at TL255, while the high-resolution (i.e. EC-Earth-3P-HR) was run at TL511. Our decision was motivated by the opportunity to compare our results with those from other models in conformity with the protocols of the High Resolution Model Intercomparison Project (HighResMip) and Phase 6 of the Coupled Model Intercomparison Project (CMIP6). This report refers therefore to so-called "HighresSST-present" experiment, an atmosphere-only integration forced with observed SSTs, observed sea-ice concentrations, and external radiative forcings over the period 1950-2014. By carrying out these two simulations we have used about 5.9 millions of SBUs.

Summary of plans for the continuation of the project (10 lines max)

In the next months we plan to carry out a couple of simulations identical to the ones performed so far but applying the stochastic physics perturbation (SPPT and SKEB schemes). These will cover the same time window and will respect an identical protocol (HighresSST-present experiment from the HighResMip protocol), covering the 1950-2014 period at both high resolution (TL511) and low resolution (TL255)

With the remaining computing time we plan to extend the available number of ensemble members at low resolution, running up to three members with stochastic physics and three members in the standard configuration.

List of publications/reports from the project with complete references

None – The simulations are still running.

Summary of results

Over the last two decades, evidence has begun to accumulate that suggests large scale circulation at mid-latitudes exhibits interesting local structure which manifests itself in the form of quasi-persistent weather regimes (e.g. Straus et al. 2007, Woollings et al. 2010, Franzke et al. 2011, Hannachi et al. 2017). In particular, such regimes have been identified in the winter season in the Euro-Atlantic region, and there is a growing recognition of their importance in modulating European weather (Ferranti et al. 2015, Matsueda et al. 2018, Frame et al. 2013) and, possibly, the regional response to anthropogenic forcing (Palmer 1999, Corti et al. 1999). Representing these regimes correctly is therefore an important goal for any general circulation model (GCM). Previous studies (Dawson et al. 2012) had suggested that high horizontal resolution may be an important factor in achieving this.

Regimes are identified by applying a k-means clustering algorithm to the daily 500hPa geopotential height anomalies, following the methodology of Dawson et al. 2012. ERA-Interim re-analysis shows evidence for the existence of four regimes in the period 1979-2015 covered by this product (NAO+, NAO-, Blocking and Atlantic Ridge), shown in figure 1.

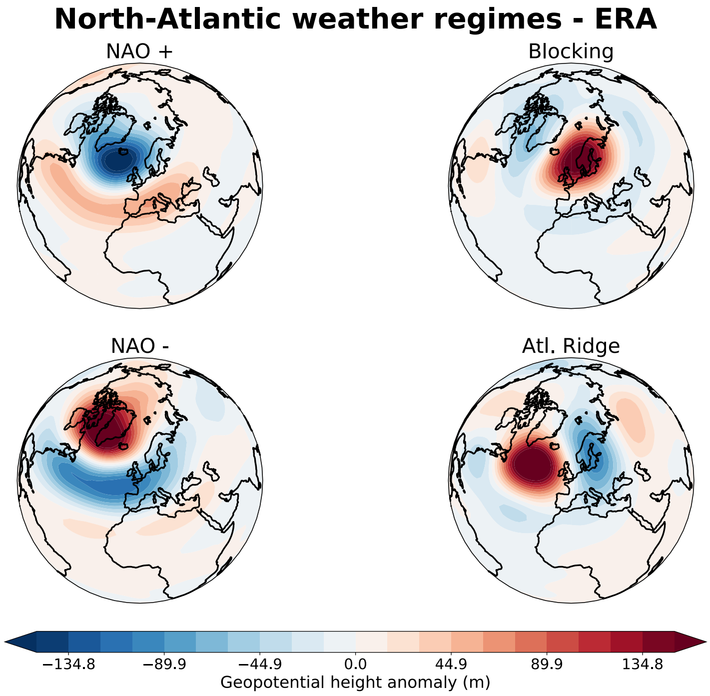

Figure 1: The four Euro-Atlantic regimes, as computed in the re-analysis product ERA-Interim.

We thus applied regime detection to the two simulations run at TL255 and TL511 focusing on the period where data are shared with ERA-INTERIM (1979-2014).

In order to diagnose the model ability to represent these regimes well, we considered two aspects of the data. Firstly, how tightly clustered is the model data compared to re-analysis (i.e. how robust is the regime structure). Secondly, how similar the regime patterns of the model data are compared to those in re-analysis.

The "significance metric" gives a measure of how tightly clustered the dataset is relative to what is expected from random sampling variability (see Dawson et al. 2012 for details), and so measures the robustness of the model regimes. We found that in EC-Earth-3P significance increases with resolution (going from 70% at TL255 to 82% at TL511), however this value is still lower then tat found for ERA-Interim (i.e. 98%).

When it comes to the similarity of regime patterns of the model data compared to those of the reanalysis we found that for the NAO- regimes there is an improvement with increased resolution, while for the other regimes resolution does not improve the simulation of regime patterns. More in general we found that, while for some models and regimes, resolution improves the similarity with re-analysis, in many cases it is degraded. On average across all models analyzed the impact of increased resolution is a small degradation of the pattern. Figure 2 shows a Taylor diagram summarizing the impact on the spatial patterns of the regimes found in model data.

In conclusion increased resolution appears to improve the geometric robustness of North Atlantic regimes, but no other aspects of the regimes are systematically improved.

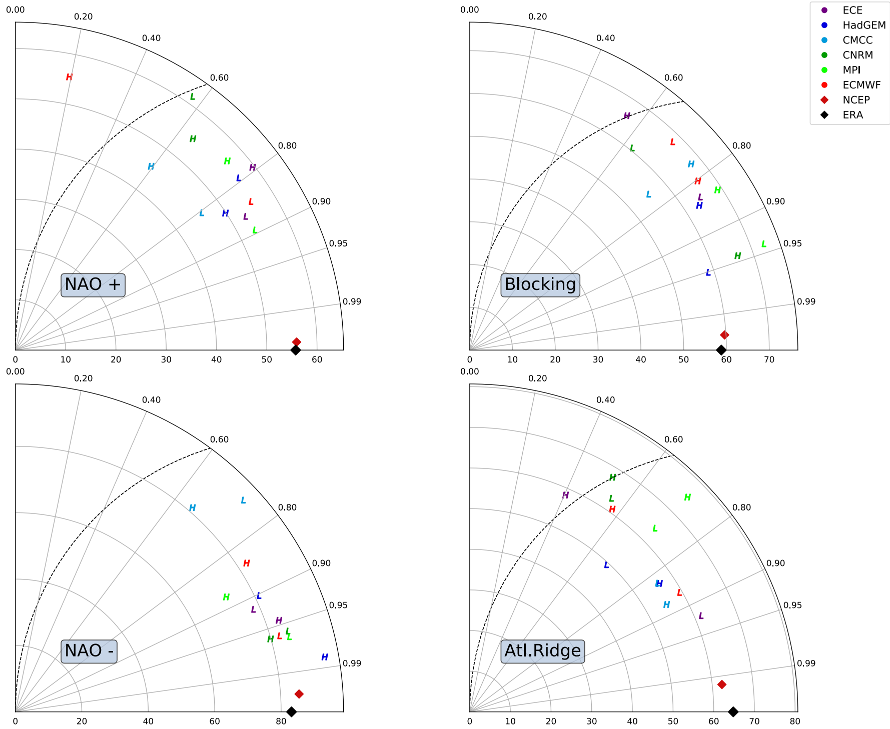

Figure 2: Taylor plot representation of the visual similarity between the model clusters (low resolution simulations shown with an L, high-resolution with an H) and those in re-analysis (ERA-Interim). Pattern correlation with ERA-Interim (black diamond) is denoted by the outer arc, the axes represent the standard deviation of the patterns, and the RMS error to ERA-Interim is denoted by the distance from ERA to the model point.

References

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