Master Thesis

Impact of Model Initialization on Predictability of Weather Regimes over the Euro-Atlantic Region on Inter-annual to Decadal Timescales

Carlos Delgado Torres

Supervisors:
Markus Donat (BSC)
Deborah Verfaillie (BSC)
Elsa Mohino Harris (UCM)

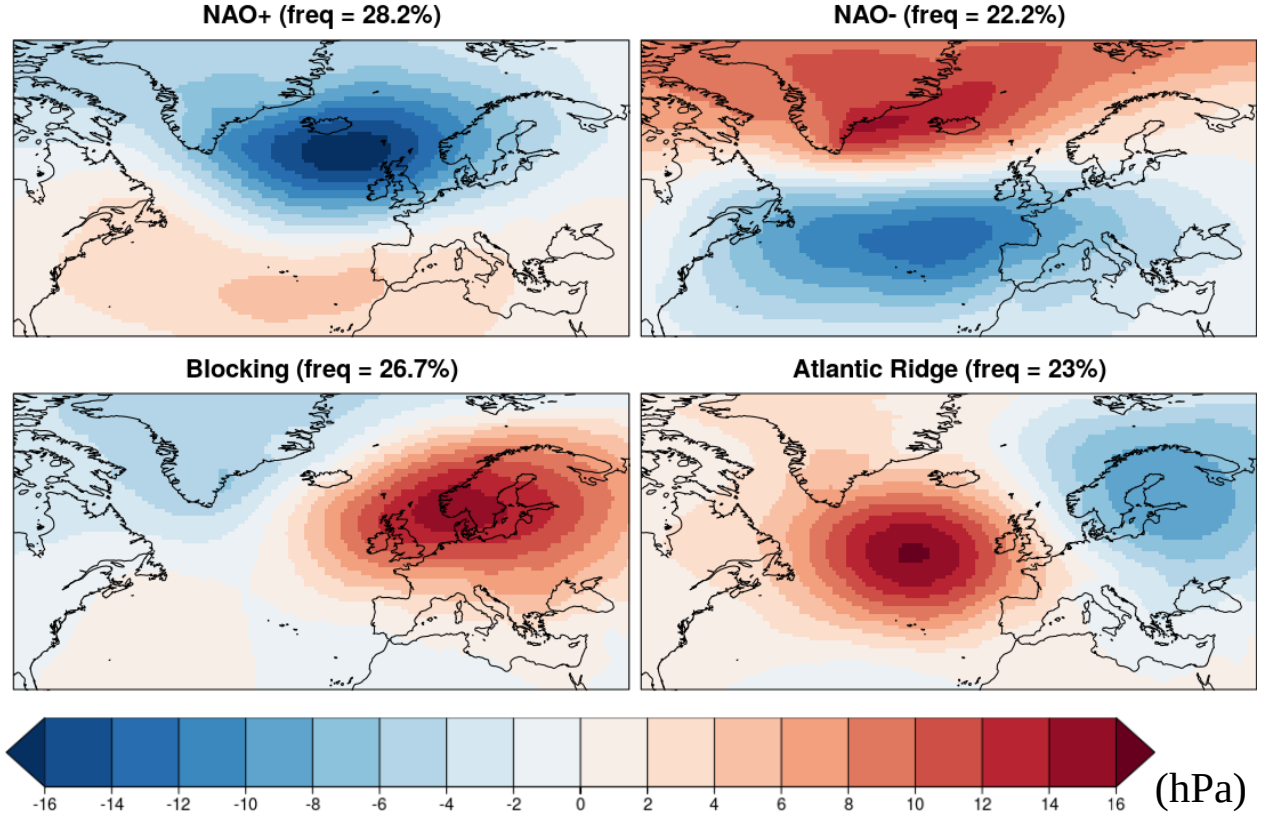
Máster en Meteorología y Geofísica
Departamento de Física de la Tierra y Astrofísica
Facultad de Ciencias Físicas
Universidad Complutense de Madrid

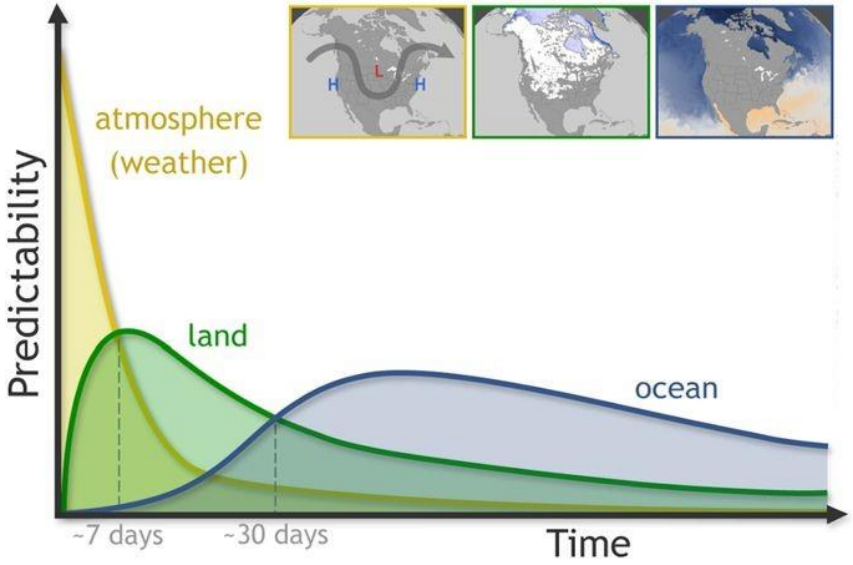
Climate Prediction Group
Earth Sciences Department
Barcelona Supercomputing Center

Contents

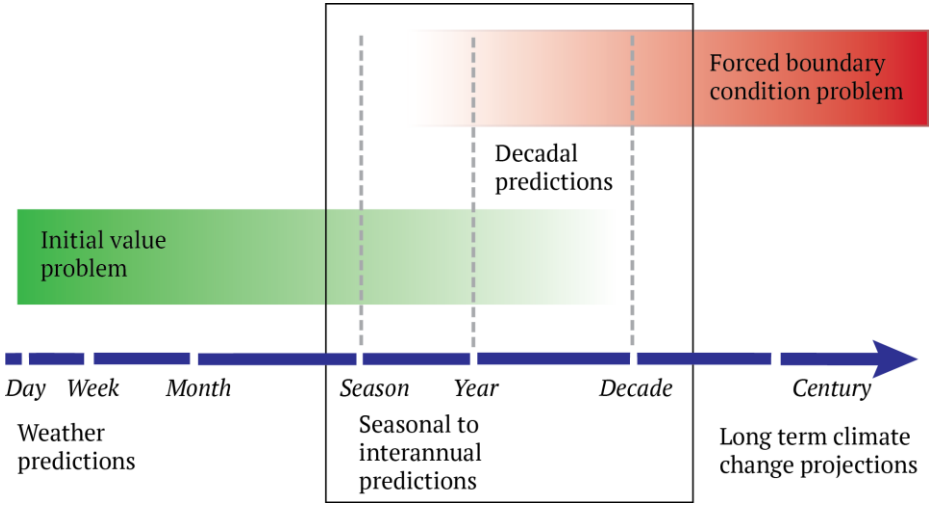
1. Introduction

- Decadal climate prediction
- Internal variability and external forcings
- Hincasting and model initialization
- European weather regimes [Cortesi et al., 2019]





[Mariotti et al., 2018]



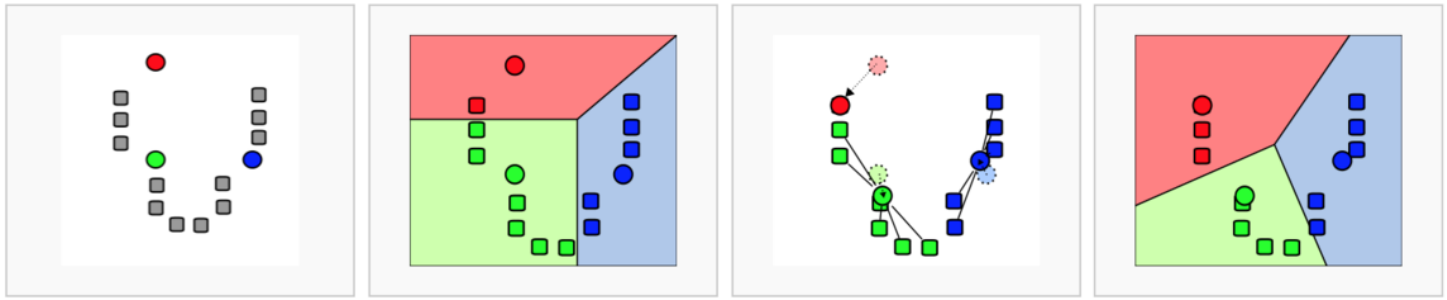
[Kirtman et al., 2013]

2. Data

- Region: 27ºN – 81ºN; 85.5W – 45ºE
- Seasons: DJF, JJA, NDJFMA, MJJASO
- Period: 1960 – 2010
- EC-Earth model v3.2 (Earth System Model) [Doblas-Reyes et al., 2018]
  - Atmospheric component: Integrated Forecast System (IFS) – European Centre for Medium-Range Weather Forecast (ECMWF)
  - Land and vegetation component: Hydrology Tiled ECMWF Scheme of Surface Exchanges over Land (HTESSEL)
  - Ocean component: Nucleus for European Modelling of the Ocean (NEMO) – Atmospheric forcing from the IFS
  - Sea ice component: Louvain-la-Neuve Sea Ice Model (LIM)
  - Atmospheric chemistry component: Tracer Model (TM) (Not activated for these simulations)
  - Coupler model: Ocean Atmosphere Sea Ice Soil (OASIS)
- Hindcast experiments (CMIP6) [Taylor et al., 2012]
  - Historical simulations (No initialized) – 10 members
  - Decadal predictions (Initialized) – 5 members
- JRA-55 reanalysis [Kobayashi et al., 2015] and ERSST.v4 dataset [Huang et al., 2015]

3. Methodology

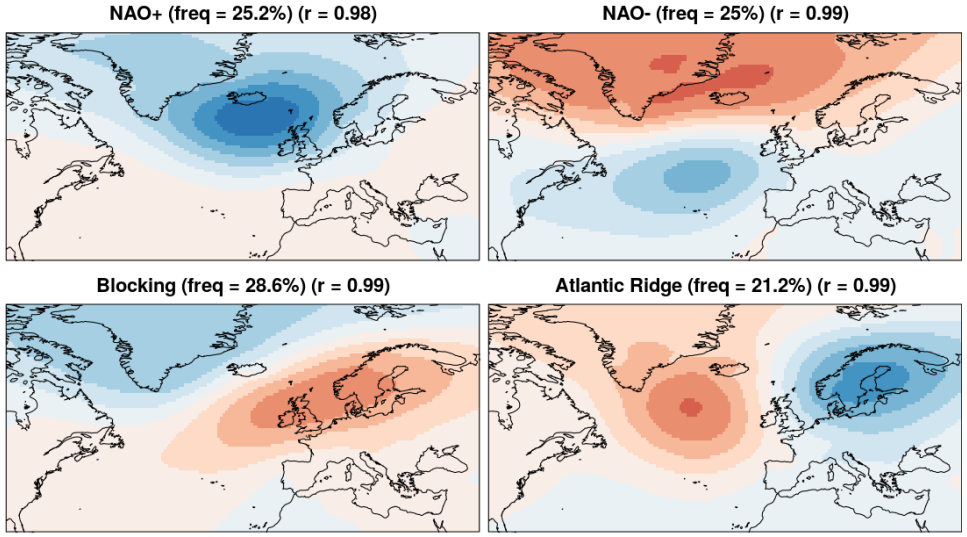
- Climatologies and anomalies
  - Monthly climatologies, smoothed by applying a LOESS filter
  - Daily standardized anomalies, weighted by the cosine of the latitude
- K-means clustering algorithm
  - Initial cluster partition ($k = 4$)
  - Assignment phase
  - Update phase

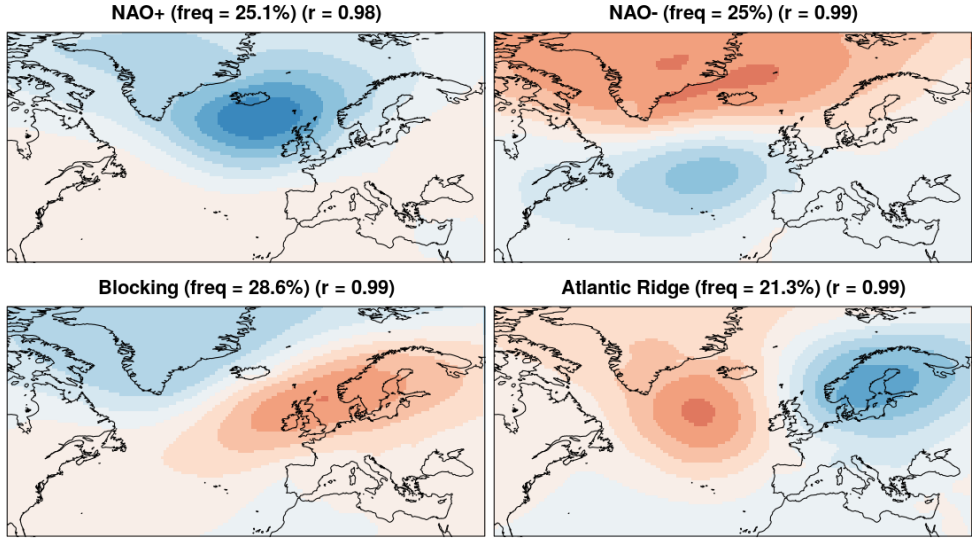


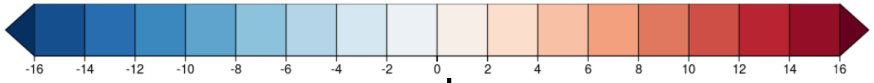
  - Method 1: Observed WR are calculated, and simulated WR are projected on the observed ones
    It is analysed how often the model simulates situations that fit into the observed patterns
  - Method 2: Both observed and simulated WR are calculated independently
    It shows how the model defines its own WR
- Metrics
  - Spatial correlation: Anomaly Correlation Coefficient (ACC)
  - Time series correlation: Pearson correlation coefficient (r)
  - To analyse the significance of the correlations: t-test
  - To compare the correlation coefficients: Confidence intervals

4. Results and discussion

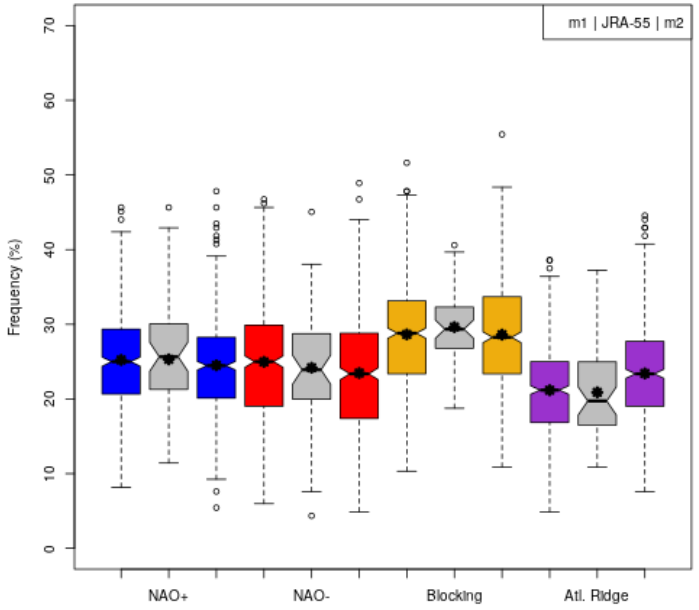
Historical simulations (No-Init) [MJJASO-Method 1] Decadal predictions (Init) – y2

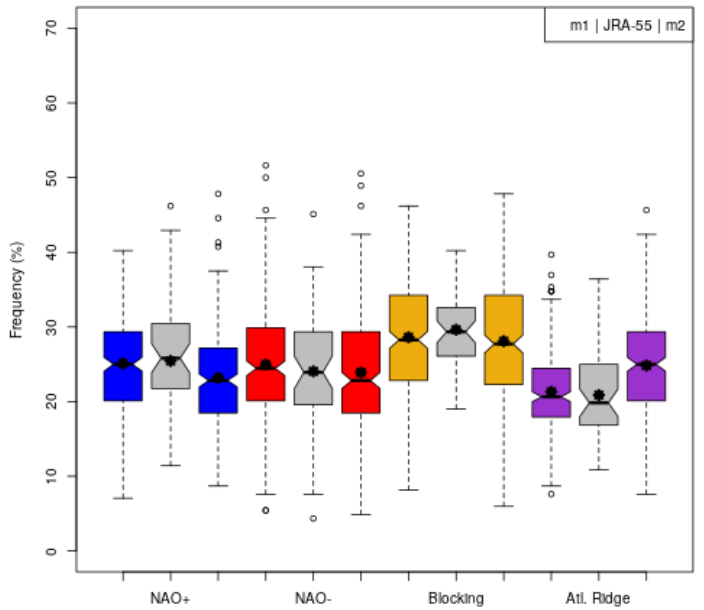






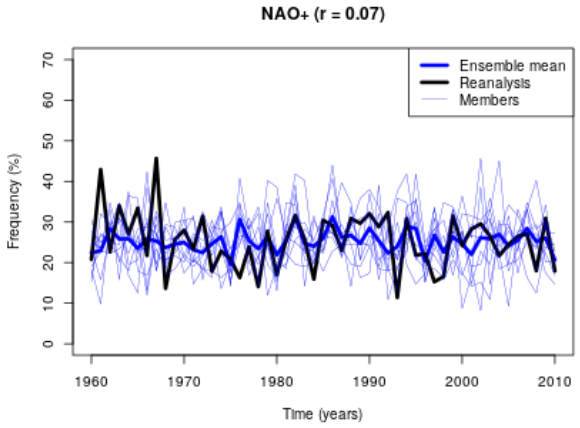
(hPa)

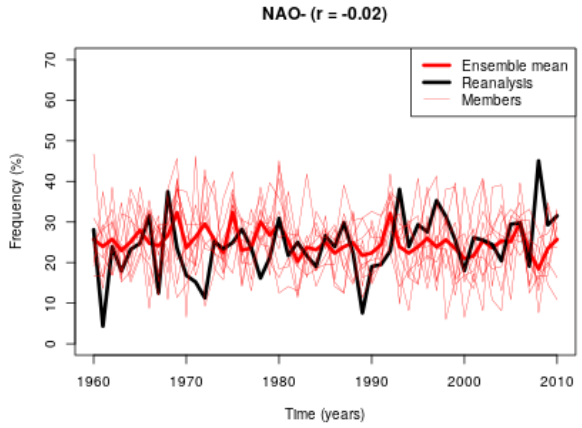


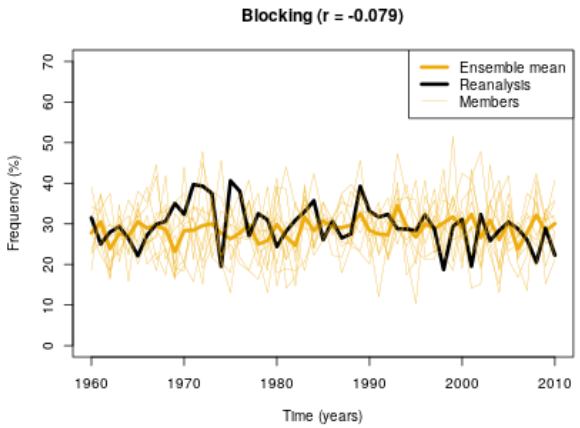


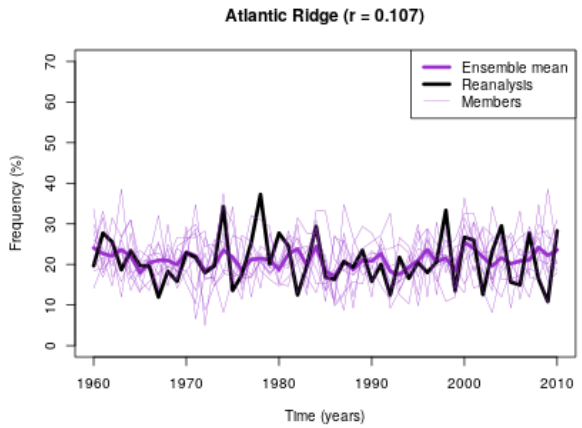
4. Results and discussion

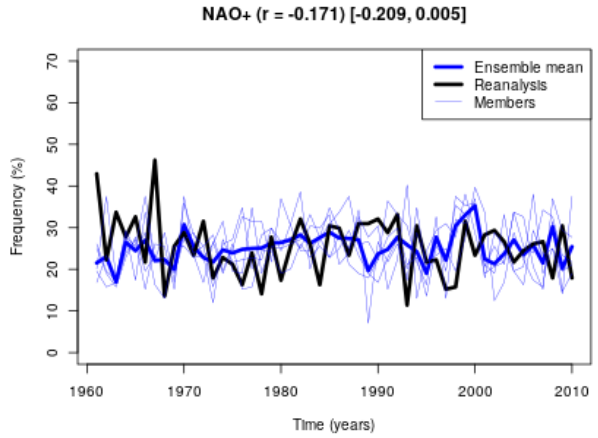
Historical simulations (No-Init) [MJJASO-Method 1] Decadal predictions (Init) – y2

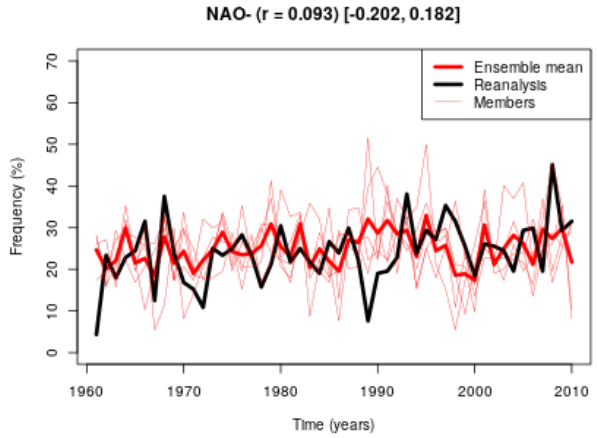


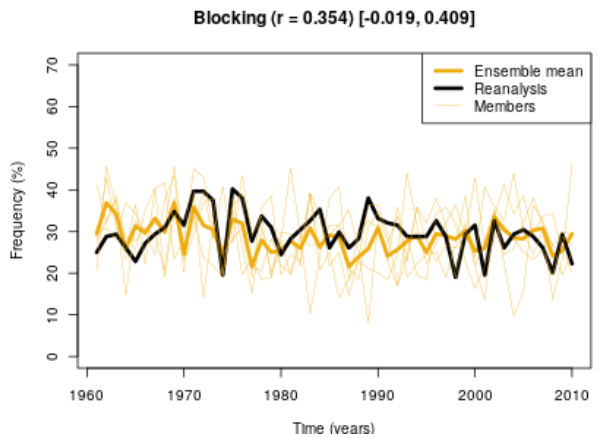


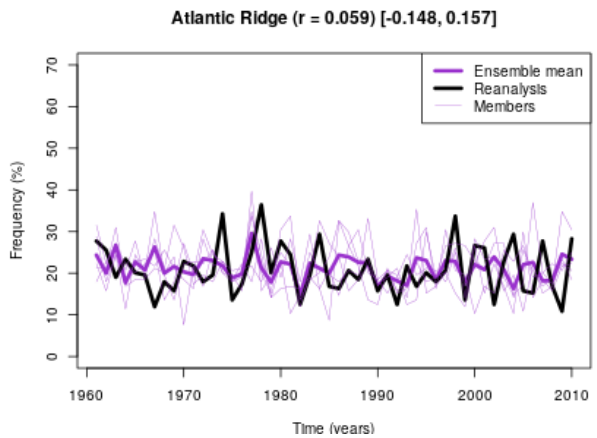






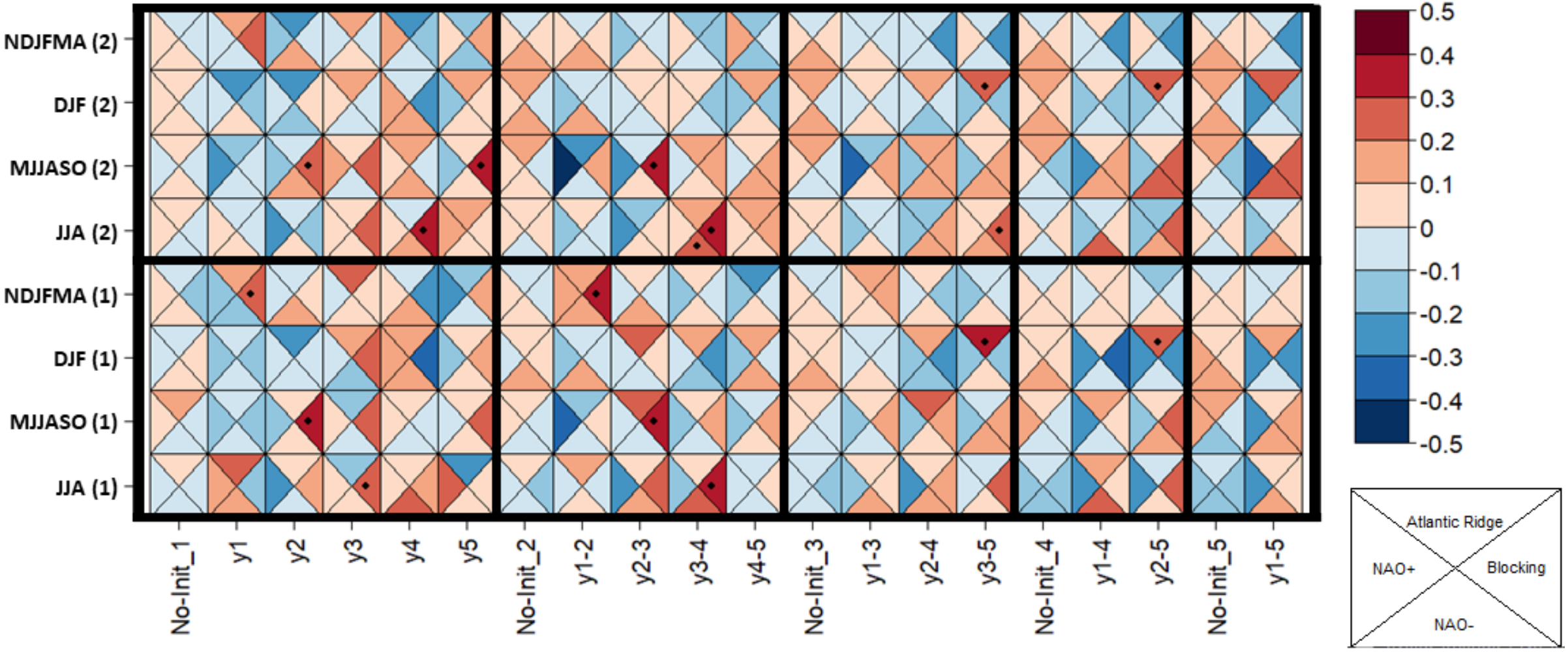






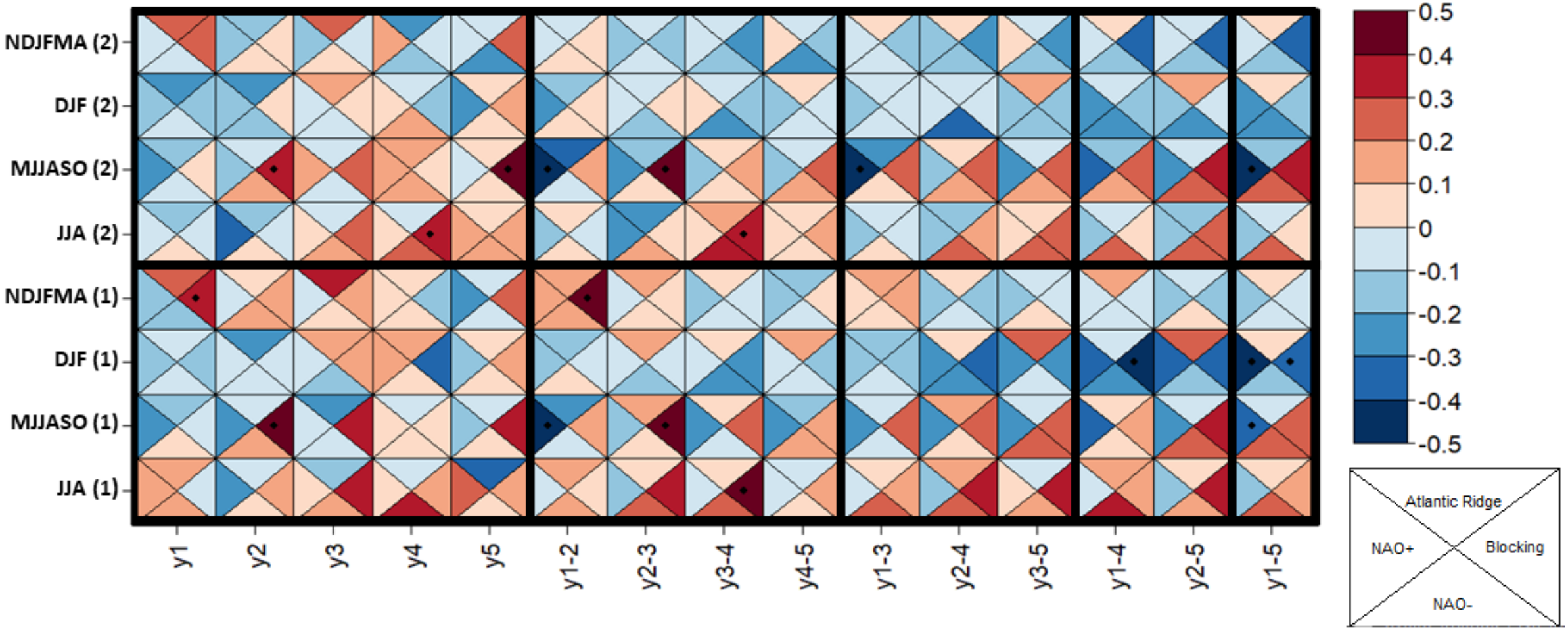
4. Results and discussion

Time series correlation between simulations and reanalysis



4. Results and discussion

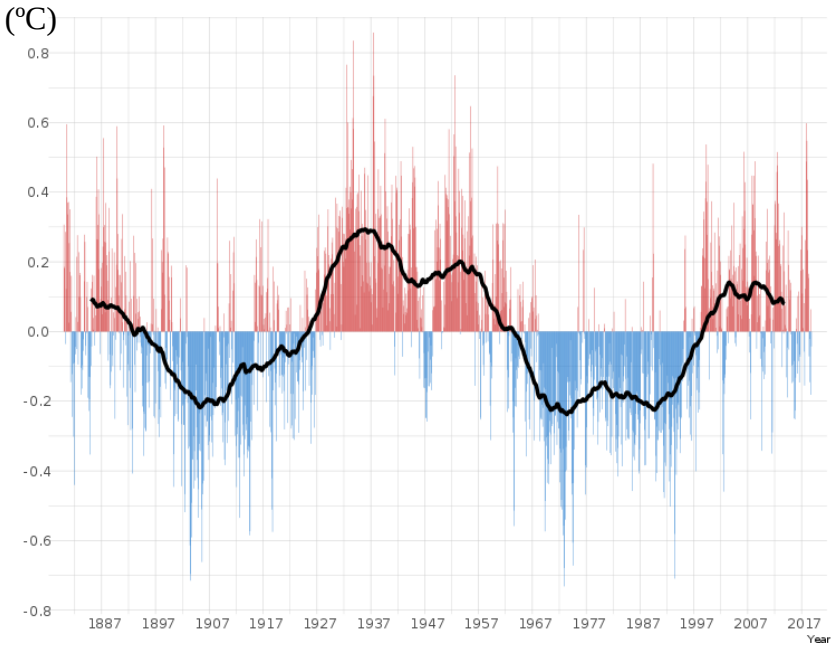
Time series correlation difference between historical simulations and decadal predictions



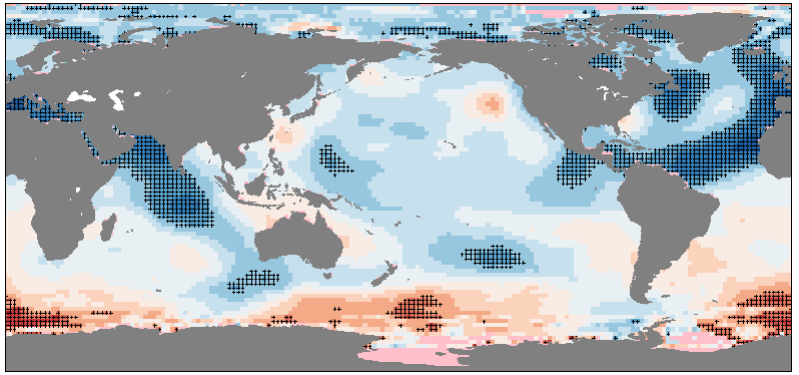
4. Results and discussion

AMV (Atlantic Multidecadal Variability)

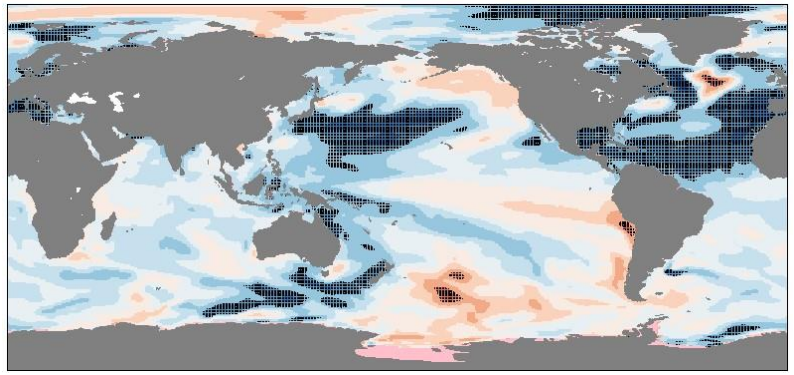
- Sea Surface Temperature throughout the North Atlantic Ocean
- Quasi-periodicity of about 70 years



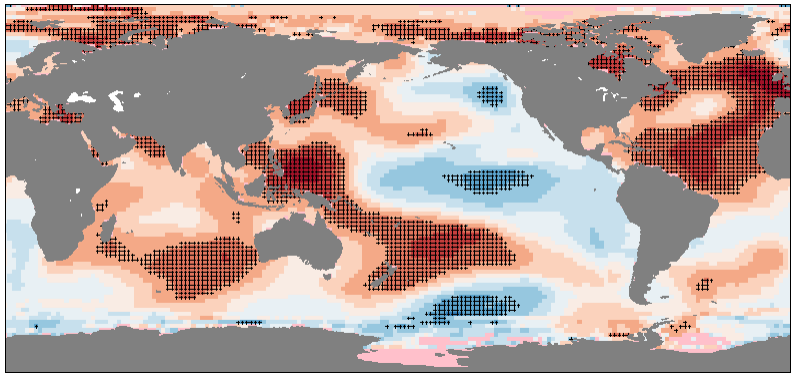
Time series correlation



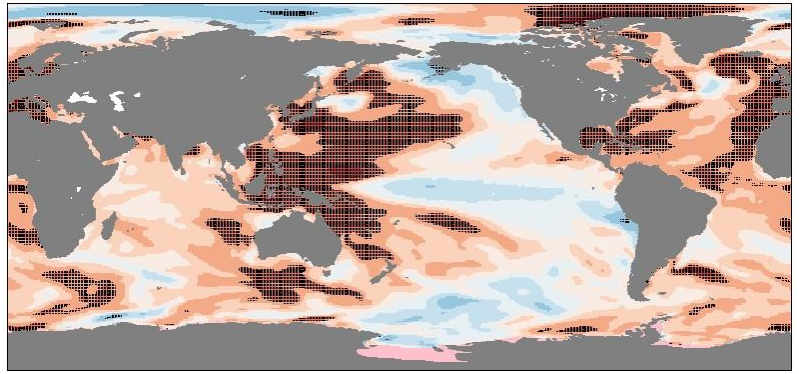
(a) Observed SST vs Blocking frequency



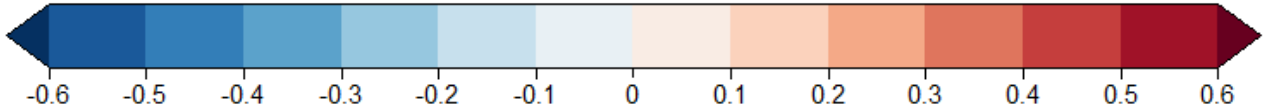
(b) Predicted SST vs Blocking frequency



(c) Observed SST vs NAO- frequency



(d) Predicted SST vs NAO- frequency



5. Conclusions

- The model simulates well the spatial distrobution of the NAO+, NAO- and Blocking
- Most frequent regime during summer is Blocking and the least frequent is NAO-
- Most frequent regimes during winter are NAO+ and Blocking
- Ensemble mean variability in historical runs is cancelled out due to the different phasing between members
- External forcings do not play an important role in the WR frequencies (they do not show any trend)
- The model generally simulates well the mean frequencies of the four WR
- WR frequencies show a narrower spread during the summer season
- In most cases, initialization does not provide significant improvements in the predictions of the WR
  - Blocking: most improved WR and related to AMV
  - NAO-: improved and related to AMV
  - Atlantic Ridge: slightly improved
  - NAO+: worsened WR

Master Thesis

Impact of Model Initialization on Predictability of Weather Regimes over the Euro-Atlantic Region on Inter-annual to Decadal Timescales

Carlos Delgado Torres

Supervisors:
Markus Donat (BSC)
Deborah Verfaillie (BSC)
Elsa Mohino Harris (UCM)

Máster en Meteorología y Geofísica
Departamento de Física de la Tierra y Astrofísica
Facultad de Ciencias Físicas
Universidad Complutense de Madrid

Climate Prediction Group
Earth Sciences Department
Barcelona Supercomputing Center