

1 MOTIVATION

The 2025 spring season (March-May; MAM) was characterised by pronounced positive precipitation anomalies over the Iberian Peninsula (Fig. 1a). The spatially-averaged total precipitation in Iberia over this period represents 151% of the climatological mean (reference period 1991-2020), making it the third wettest since 1961¹. In terms of surface air temperatures, spring 2025 ended with a slightly positive anomaly of +0.3 °C (Fig. 1b). These surface impacts were driven by a dipole anomaly in the North Atlantic circulation, with persistent anticyclonic blocking at higher latitudes

(around the British Isles) and low-pressure anomalies east of the Azores archipelago (Fig. 2).

The aim of this work is to identify the forcings that may have driven this seasonal circulation pattern over the North Atlantic, as well as to evaluate the ability of the SEAS5 dynamical seasonal forecasts from the European Centre for Medium-Range Weather Forecasts (ECMWF) to capture the observed pattern.

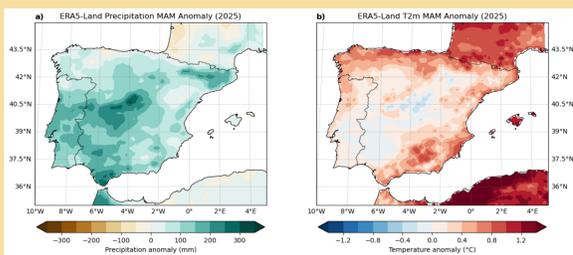


Fig. 1: Total precipitation (mm, a) and surface temperature (°C, b) anomalies for 2025 Spring (MAM) over the Iberian Peninsula in the ERA5-Land reanalysis.

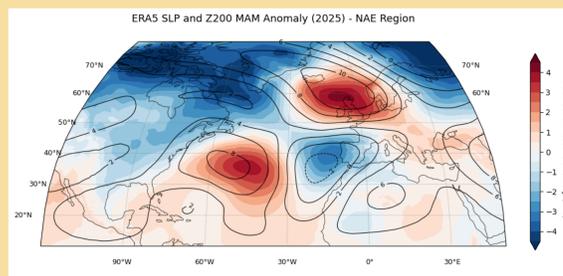


Fig. 2: Sea level pressure (hPa) and Z_{200hPa} (dam) anomalies for MAM 2025 over the North Atlantic-European region in the ERA5 reanalysis.

2 DATA

Variable	Datasets	Region
Precipitation (Tp)	ERA5-Land / SEAS5	Iberian Peninsula
Surface Temperature (T2m)	ERA5-Land / SEAS5	Iberian Peninsula
Sea Level Pressure (SLP)	ERA5 / SEAS5	North Atlantic - Europe
Sea Surface Temperature (SST)	ERA5 / SEAS5	Global
Zonal wind at 10hPa (U_{10hPa})	ERA5 / SEAS5	North Atlantic - Europe
Geopotential at pressure levels (Z)	ERA5 / SEAS5	North Atlantic - Europe

Tab. 1: Description of the variables, datasets and regions used in this study. Climatologies are computed against the period 1991-2020 for all the datasets. ERA5-Land² and ERA5³ have been downloaded from the Copernicus Climate Data Store, while SEAS5⁴ February initialisation hindcasts from the ECMWF meteorological archive.

3 Results: Forcings and Dynamical Forecast

Observations

Relevant sea surface temperature (SST) anomalies were present over the extratropics (Fig. 3a). In the tropics, significant warm SST anomalies were found over the eastern equatorial Pacific. These SST anomalies may have contributed to the anomalous atmospheric circulation in the North Atlantic in spring.

A stratospheric final warming (SFW⁵) event took place in March 2025, with zonal-mean zonal wind at 10hPa 60°N dropping to -20 m/s (Fig. 3b). The SFW event may have driven atmospheric circulation changes in the North Atlantic through April and possibly May, as seen by the northern annular mode (NAM) index (Fig. 3c).

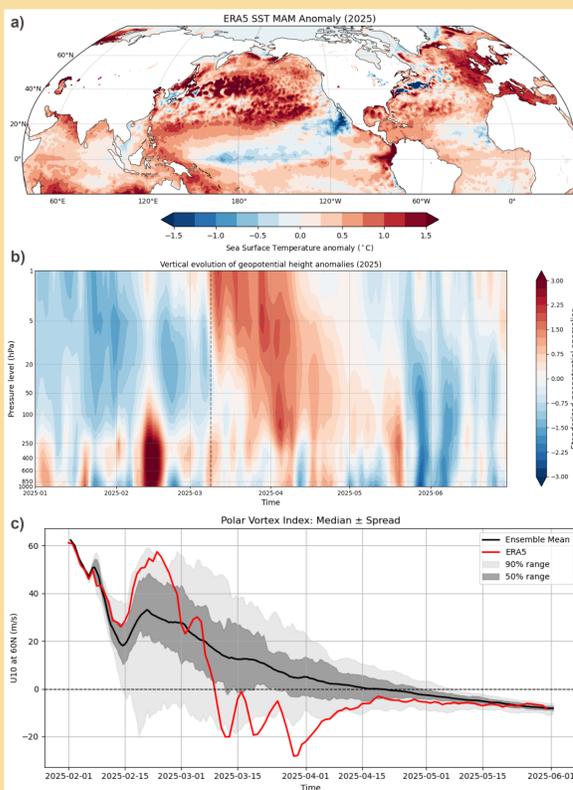


Fig. 3: Sea surface temperatures (°C, a), NAM index (b) anomalies for MAM 2025 in the ERA5 reanalysis. Zonal-mean zonal wind at 60°N and 10hPa for FMAM 2025 in the ERA5 reanalysis (red line) and SEAS5 forecasts from February initialisation (ensemble mean in solid black line and spread in gray shading). The grey vertical line in (b) indicate the date of reversal of the polar vortex zonal wind.

Seasonal Forecasts

SEAS5 ensemble-mean forecasts initialized in February predicted cold SST anomalies over the eastern equatorial Pacific, which contrasts with observations (Fig. 4a). In the Atlantic, the model predicted colder-than-observed anomalies, except in the equatorial region.

Regarding the polar vortex, the model showed a significant spread in representing its weakening (Fig. 3c), which translates into a weak downward signal across the stratosphere and troposphere (Fig. 4b). The SLP pattern predicted by the model partially resembles the observed pattern but with very weak signals (Fig. 4c).

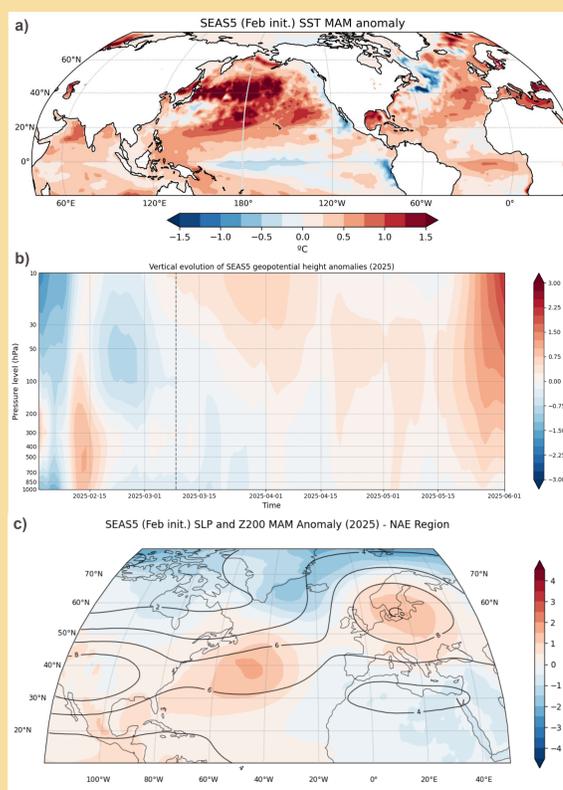


Fig. 4: Same as Fig.3 (a,b) but for the SEAS5 ensemble-mean forecast initialisation. Sea level pressure (hPa) and Z_{200hPa} (dam) anomalies for MAM 2025 over the North Atlantic-European region in the SEAS5 ensemble-mean forecast initialisation (c). The grey vertical line in (b) indicate the date of reversal of the polar vortex zonal wind.

4 DISCUSSION

Spring 2025 was one of the wettest on record in the Iberian Peninsula. An anomalous high-pressure system centred close to the British Isles favoured a southward tilt of the storm track, with low-pressure systems continuously affecting the Iberian Peninsula.

The anomalous atmospheric circulation over the North Atlantic may have been driven by different agents. A SFW event may have contributed to high-latitude blocking through April and perhaps May, contributing to the persistence of the anticyclonic anomaly close to the British Isles and Scandinavia. Significant SST anomalies may have provided additional forcing for this pattern.

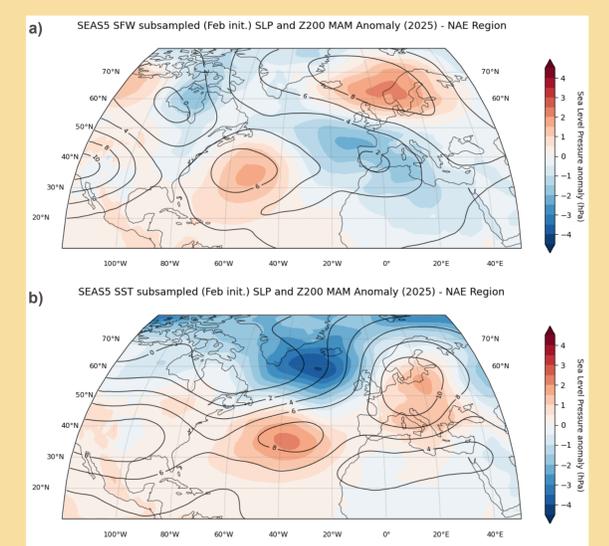


Fig. 5: Sea level pressure (hPa) and Z_{200hPa} (dam) anomalies for MAM 2025 over the North Atlantic-European region in the SEAS5 members with an early SFW event (a) with better eastern Pacific SSTs representation (b).

SEAS5 forecasts initialised in February did not accurately capture the atmospheric circulation anomaly over the North Atlantic region, perhaps due to the limited ensemble support for the early SFW event and some discrepancies with the observed SST anomalies. Ensemble member subsampling of SEAS5 forecasts suggest that the stratospheric warming event may have played an important role in shaping up the anomalous North Atlantic circulation (Fig. 5a), and a rather limited influence of SST anomalies, but sensitivity analyses are needed to confirm this (Fig. 5b).

Despite the hypothetical role of these two drivers (SFW and SST), more analyses are needed in order to identify additional drivers, such as arctic sea-ice cover anomalies, snow cover extent or atmospheric internal variability.

Acknowledgements

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