Tropical Atlantic Rainfall Drives Bias in Extratropical Seasonal Forecasts

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1) Key Points

- We investigate seasonal forecast biases in the North Atlantic - European region.
- Internal variability between members is used to infer the impact of mean bias by selecting model members which resemble the tropical rainfall bias in the model.
- Tropical Atlantic rainfall bias generates a clear Rossby wave train bias in the North Atlantic geopotential height.
- We conclude that tropical rainfall bias drives a large component of the extratropical mean bias.

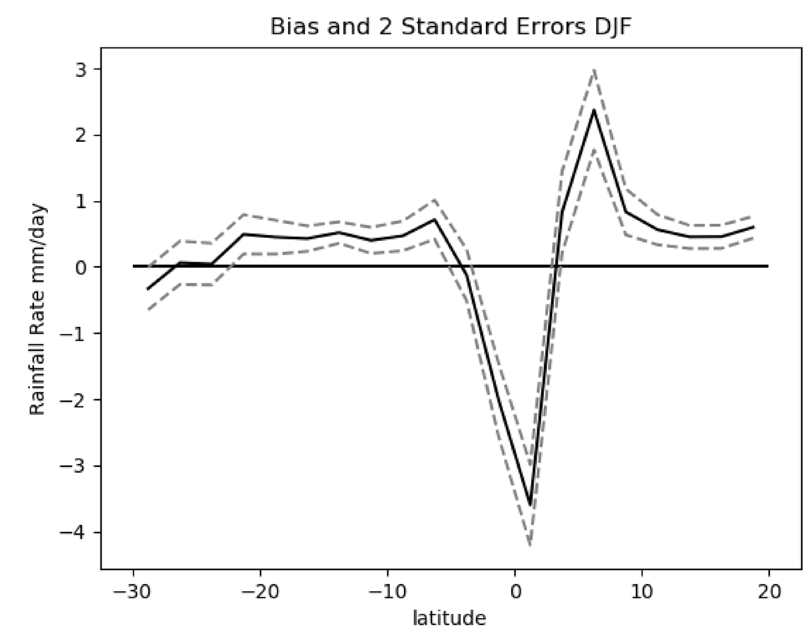

Figure 1:Forecast rainfall bias in the tropical Atlantic. The zonal average of the rainfall rate bias is plotted for winter (DJF) GloSea5 hindcasts compared to GPCP rainfall data for the tropical Atlantic region: 15W to 45W. The bias is calculated over 1993-2016.

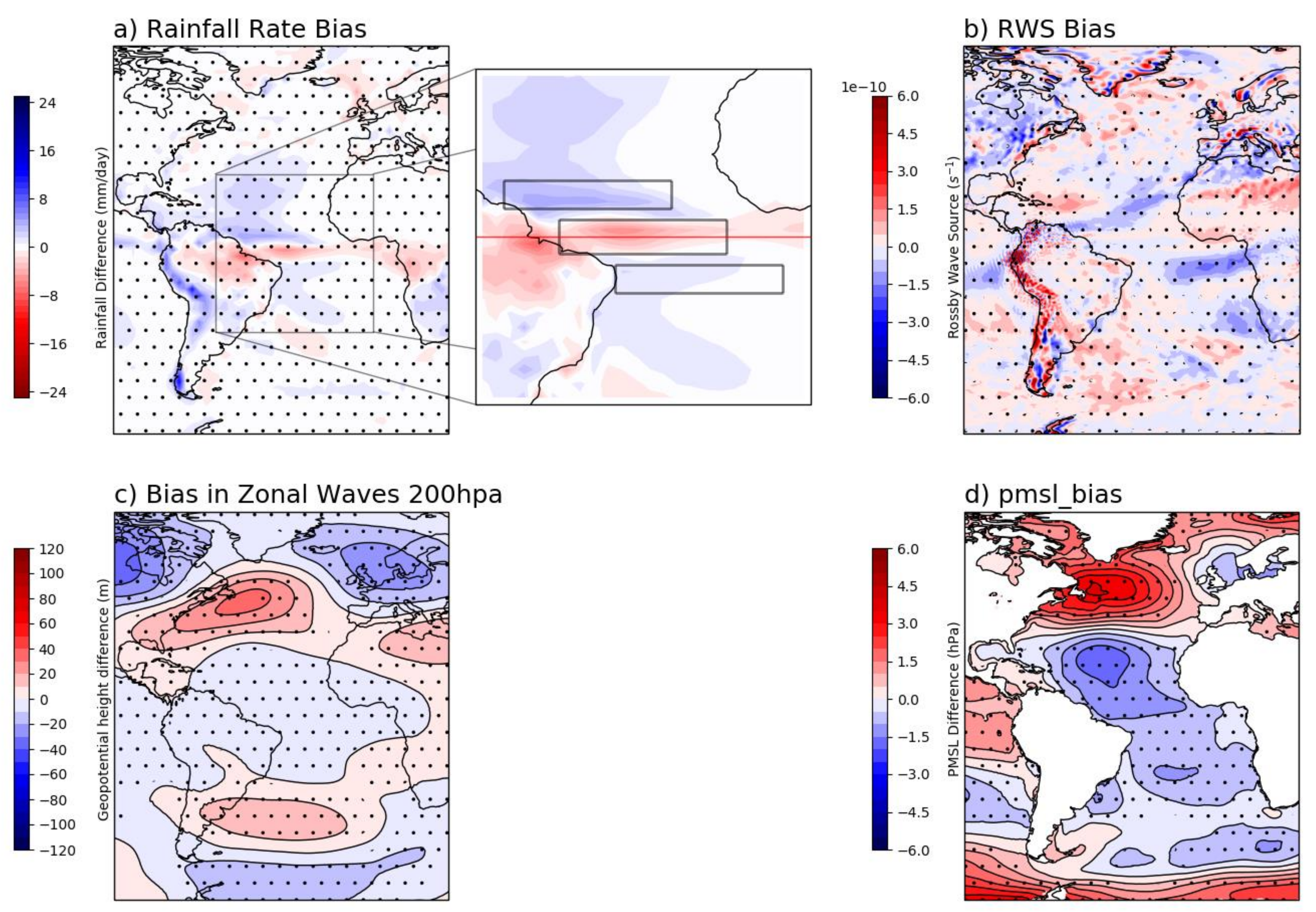

Figure 2: Biases in seasonal hindcasts. a) Rainfall Rate (mmd^{-1}), b) Rossby wave source (S^{-1}), c) Geopotential height (m) and d) Pressure at mean sea level (hPa). Each plot is stippled where the bias is significant.

2) Data

- GloSea hindcasts initialised on 25th October, 1st November and 9th November with 7 realisations per initialisation date over 1993-2017.
- Observed rainfall is from GPCP version 2.3 and ERA Interim is used for all other variables.

3) Seasonal Forecast Biases

- Biases in GloSea5 hindcasts are shown in figures 1 and 2.
- GloSea5 hindcasts have a dry slot in the rainfall field over the equator and two areas of increased precipitation to the north and south (Figure 1, Figure 2a), consistent with a double ITCZ pattern.
- Negative Rossby wave source biases occur just off the North East coast of South America and positive Rossby Wave source biases occur in the Caribbean (Figure 2b) .
- There is a Rossby Wave pattern in the geopotential height (Fig. 2c) in both the northern and southern hemispheres and a strong imprint on North Atlantic sea level pressure (Fig. 2d)

4) Internal Variability as a Proxy for the Bias

- We use a novel method to infer the impact of the bias.
- After regressing out the impact of ENSO, we created an index to differentiate ensemble members with high and low equatorial rainfall. The index is based on the average of the northerly and southerly box subtracted from the average of the central box in Fig. 2a.
- Ensemble members with positive index values look similar to the observations and those with negative values look similar to the model bias. We take the difference between the top 10% of each to infer the impact of the bias.

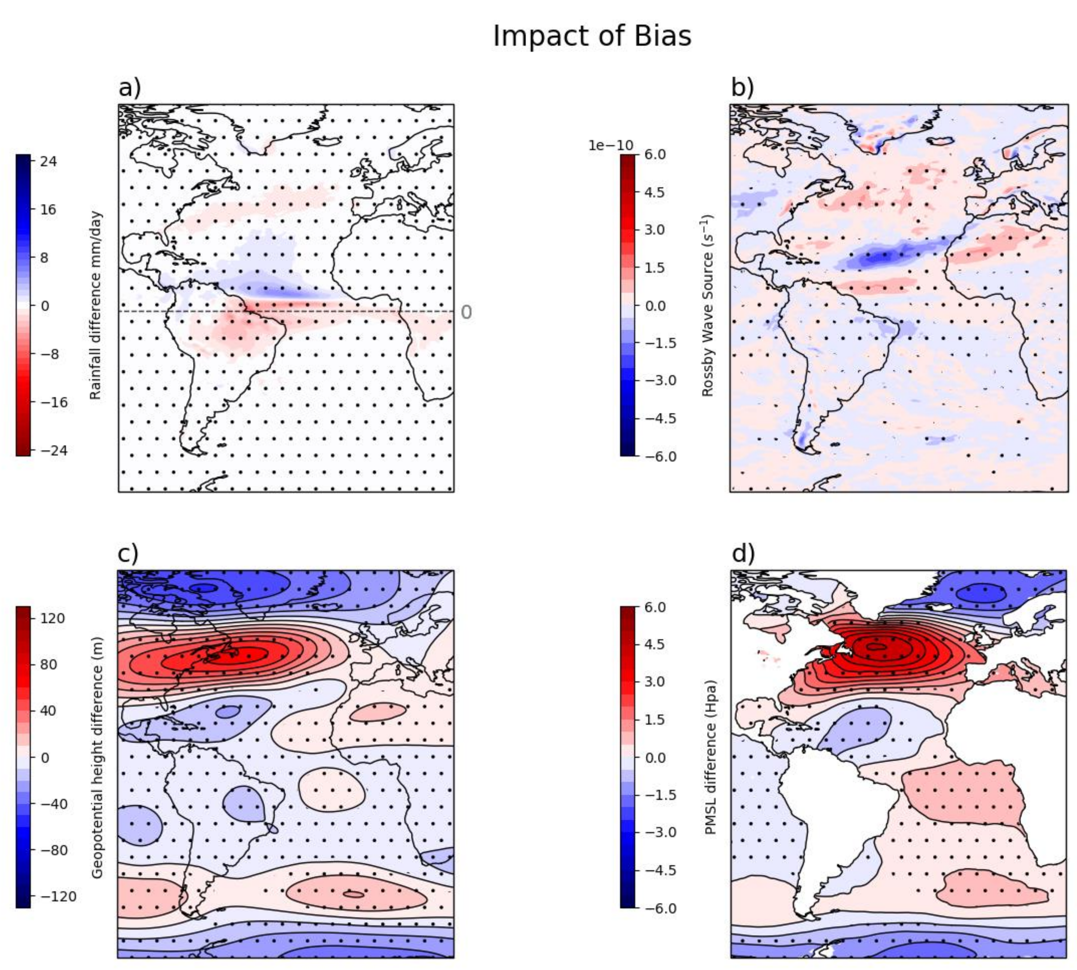

Figure 3:Impact of tropical rainfall bias. a) rainfall rate, b) Rossby Wave Source, c) geopotential height and d) pressure at mean sea level. Differences between the highest and lowest 10% of ensemble member tropical rainfall cases are shown and a scaling of 0.8 is applied so that tropical rainfall matches the mean bias in Fig.2.

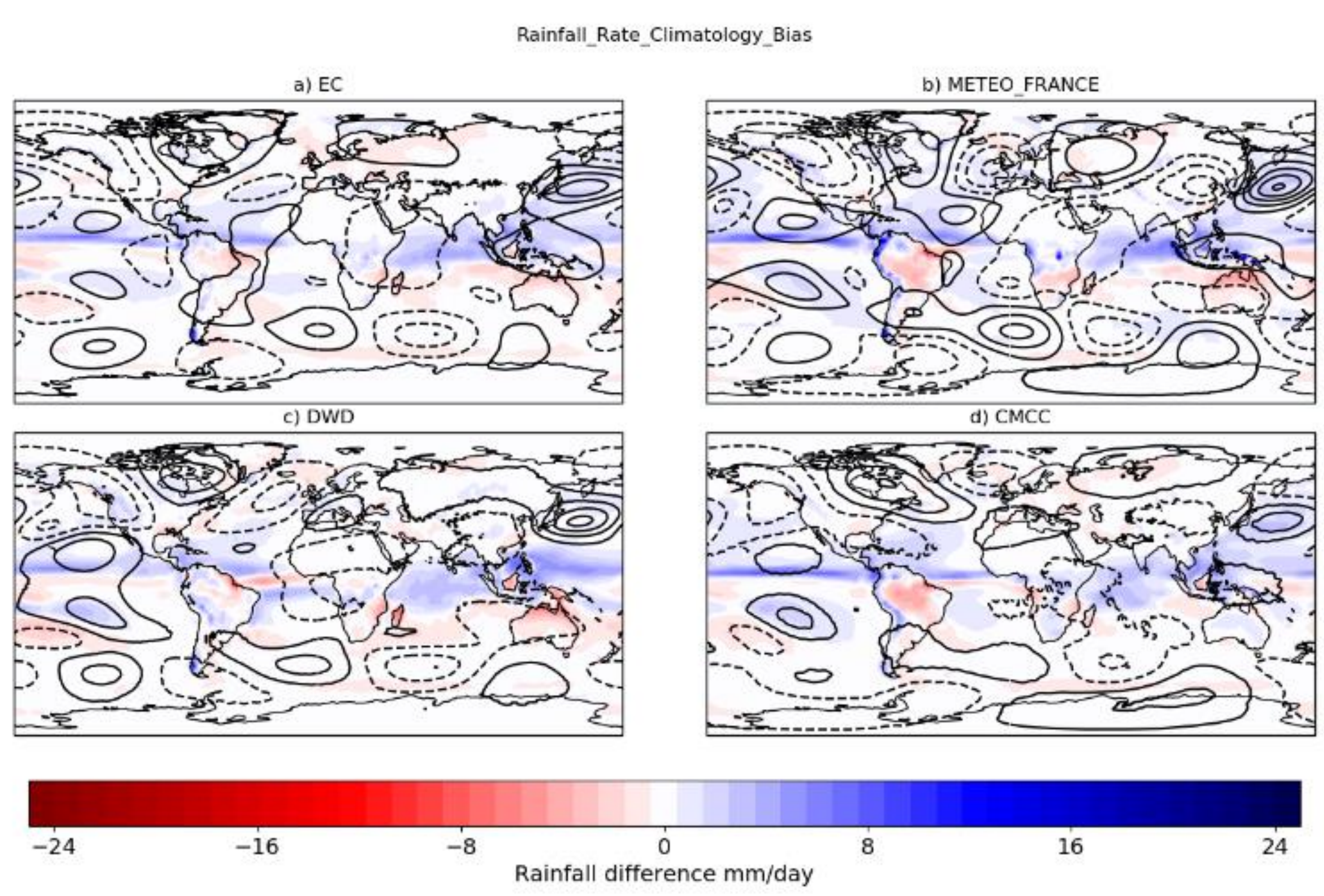

Figure 4:Rainfall and geopotential height bias from other seasonal forecast systems. a) ECMWF, b) Meteo France, c) DWD and d) CMCC. The zonal mean has been removed. Note the similar tropical Atlantic rainfall bias in all cases.

5) Extratropical Impacts

- As shown in figure 3a, the index is able to pick up the dry slot on the equator and the wet bias to the north of the equator in ensemble member (internal) variability.
- The same ensemble member differences show corresponding differences in Rossby Wave Source (Fig. 3b), geopotential height (Fig.3c) and pressure at mean sea level (Fig.3d).
- There is a strong area of negative Rossby Wave source in the northerly part of the equatorial Atlantic and a positive area just to the south which can account for a large amount of the bias in Rossby Wave source in Fig.2.
- The geopotential height shows similarities between Figure 3c and the bias in Figure 2c. A Rossby wave of low number emanates into the northern hemisphere.
- The PMSL signature in Figure 3d is also very similar to the mean the bias in Figure 2.
- Similar errors are present in other Copernicus Seasonal forecast systems (shown in figure 4).

Conclusions

- Tropical Atlantic rainfall biases are responsible for a large component of mean bias in the extratropical Atlantic-European Region.
- Rainfall biases give rise to bias in Rossby wave sources and an erroneous extratropical stationary wave
- Internal variability between ensemble members can be used as a proxy to infer these effects.

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