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Atmospheric response to the North Atlantic Ocean variability on seasonal to decadal time scales

G. Gastineau (1), F. D'Andrea (2), and C. Frankignoul (1)

(1) University Paris 6, LOCEAN/IPSL, IPSL, LOCEAN, Paris Cedex 05, France (gglmd@lmd.jussieu.fr), (2) LMD/IPSL, Ecole Normale Supérieur, Paris, France

The NCEP 20th century reanalysis and a 500-year control simulation with the IPSL-CM5 climate model are used to assess the influence of ocean-atmosphere coupling in the North Atlantic region at seasonal to decadal time scales. At the seasonal scale, the air-sea interaction patterns are similar in the model and observations. In both, a statistically significant summer sea surface temperature (SST) anomaly with a horseshoe shape leads an atmospheric signal that resembles the North Atlantic Oscillation (NAO) during the winter. The air-sea interactions in the model thus seem realistic, although the amplitude of the atmospheric signal is half that observed, and it is detected throughout the cold season, while it is significant only in late fall and early winter in the observations. In both model and observations, the North Atlantic horseshoe SST anomaly pattern is in part generated by the spring and summer internal atmospheric variability. In the model, the influence of the ocean dynamics can be assessed and is found to contribute to the SST anomaly, in particular at the decadal scale. Indeed, the North Atlantic SST anomalies that follow an intensification of the Atlantic meridional overturning circulation (AMOC) by about 9 years, or an intensification of a clockwise intergyre gyre in the Atlantic Ocean by 6 years, resemble the horseshoe pattern, and are also similar to the model Atlantic Multidecadal Oscillation (AMO). As the AMOC is shown to have a significant impact on the winter NAO, most strongly when it leads by 9 years, the decadal interactions in the model are consistent with the seasonal analysis. In the observations, there is also a strong correlation between the AMO and the SST horseshoe pattern that influences the NAO. The analogy with the coupled model suggests that the natural variability of the AMOC and the gyre circulation might influence the climate of the North Atlantic region at the decadal scale.