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## Spring regional sea surface temperature precursors of European summer heat waves

**Goratz Beobide-Arsuaga**<sup>1,2</sup>, André Düsterhus<sup>3</sup>, Wolfgang A. Müller<sup>4</sup>, Elizabeth A. Barnes<sup>5</sup>, and Johanna Baehr<sup>1</sup>

<sup>1</sup>Universität Hamburg, Germany

<sup>2</sup>International Max Planck Research School on Earth System Modelling, Germany

<sup>3</sup>Maynooth University, Ireland

<sup>4</sup>Max Planck Institute for Meteorology, Germany

<sup>5</sup>Colorado State University, United States

Past case studies have proposed many different spring and early summer sea surface temperature anomalies (SSTA) over the North Atlantic as precursors of European summer heat waves. Negative SSTAs in the Subpolar Gyre and western tropical Atlantic, and positive SSTAs in North Sea and Mediterranean Sea are few of the examples suggested to precede different European summer heat waves. Any robust description of North Atlantic spring SSTA precursors is further complicated by the large spatial heterogeneity of European summer heat waves and the limited number of observed events. Here, we combine the MPI-Grand Ensemble dataset with its 100 historical simulations (1850-2006) with a Neural-Network-based Explainable Artificial Intelligence method. In this unique data set, we systematically investigate the relevance of the North Atlantic spring SSTAs in preceding different types of European summer heat waves. We find that spring European regional seas provide useful information to differentiate and anticipate different types of European summer heat waves. While positive SSTAs in western Iberian Peninsula precede western European summer heat waves, positive SSTAs in the North Sea or Mediterranean Sea precede eastern European summer heat waves. The regional spring SSTAs relate to distinct soil moisture anomaly patterns in June, which resemble the location of the heat waves. These results could potentially improve seasonal prediction of European summer heat waves.