Previsioni stagionali dei cicloni tropicali atlantici: il ruolo della sottosuperficie oceanica

Remote subsurface ocean temperature as a predictor of hurricane activity

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Summary

The **prediction of North Atlantic hurricane activity months in advance** is of great potential societal significance. We aim to investigate the relationship between the temperature of the Atlantic Ocean and the Tropical Cyclone (TC) activity in terms of **Accumulated Cyclone Energy (ACE)**. **Strong correlations** (Figure 1) **between September ACE** and Sea Surface Temperature (**SST**) are found, resembling the correlation between SST and the main modes of variability of the North Atlantic (Atlantic Meridional Mode - **AMM** and Atlantic Multidecadal Oscillation - **AMO**). A **negative correlation** (blue pattern in Figure 2 central panel) is found between ACE and 10m wind, **coherently with the trade winds weakening over the Main Development Region (MDR) corresponding to wind shear reduction under really active TC years** (Figure 2 lower panel). The applied lag analysis reveals that together with the local (over the MDR) Sea Surface Temperature (SST) modulation of the TC activity, a **remote effect induced by the Eastern Atlantic ocean temperature** (Figure 3) , through the **induced reduction of the wind-shear** over the MDR, appears. In fact, **a higher correlation between Atlantic TC activity and Ocean temperature emerges, when considering also the eastern part of the Atlantic basin** (non only the MDR, Figures 3-5)**. In addition , a reinforcement of the aforementioned relationship is found when considering the subsurface (down to 40m) averaged temperature,** instead of the usage of SST only, **at certain time lags (figure 5)**. The described remote effect is evident since two months in advance, suggesting the **importance to consider the first 0-40m layer averaged, to predict/project September Atlantic hurricane activity**.

Data and Methods

One of the parameters used to quantify the Tropical Cyclone (**TC**) intensity in a period (typically a season) is the **Accumulated Cyclone Energy - ACE**, an integrated view convolving storm duration, intensity, and number: **ACE** combines the numbers of systems, how long they existed and how intense they became. It is calculated here by squaring the maximum sustained surface wind in the system every six hours and summing it up for September from 1980 to 2015 based on IBTRACS (https://www.ncdc.noaa.gov/ibtracs/) observational data. **ERA-Interim Reanalysis** are used to investigate spatial distribution of **10m wind**, **wind shear** (300mb wrt 850mb) together with **AMO** and **AMM** indexes provided by the National Oceanic & Atmospheric Administration (**NOAA**, https://www.esrl.noaa.gov/psd/data/timeseries/). Finally, to represent the ocean state, we use **CMCC Ocean Reanalysis C-GLORSv5** (http://c-glors.cmcc.it/index/index.html) based on NEMO model at **¼ of horizontal resolution**.

September SST correlation with ACE, AMO and AMM

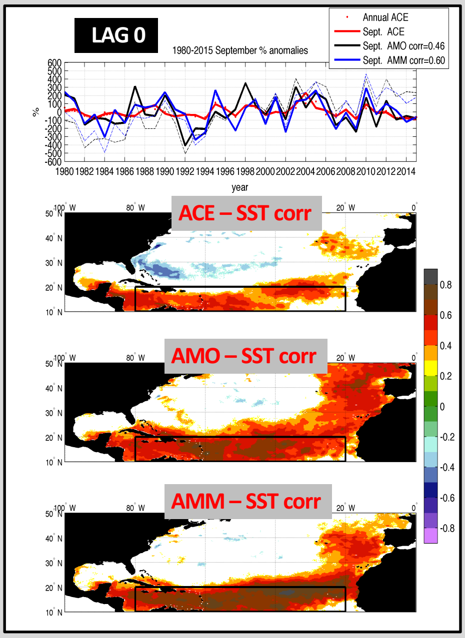
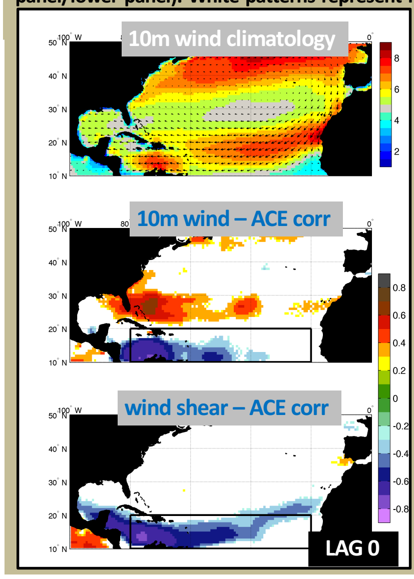


Fig.1 September Correlation of SST with ACE, AMO and AMM. ACE, AMO and AMM time series are shown in the upper panel in terms of % anomalies wrt the 1980-2015 period. Dashed (not detrended) and solid (detrended) lines refer to September only. The lower three panels represent the september SST correlation with ACE, AMO and AMM respectively..

Fig.2 Correlation between ACE and wind / wind shear. 10 meter wind (U10) climatology is shown in the upper panel. The two lower panels show the correlation between ACE and the 10 meter wind/wind shear (central panel/lower panel). White patterns represent regions where the correlation is not statistically significant.



lag correlations between September ACE and ocean temperature

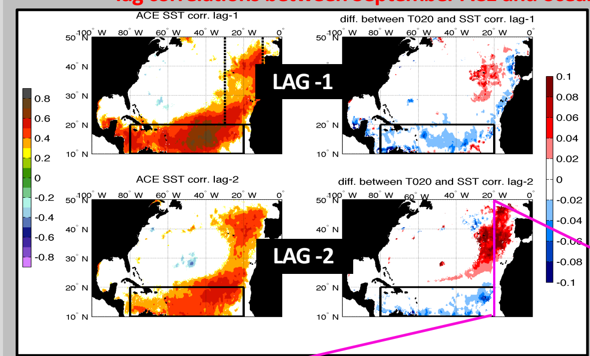
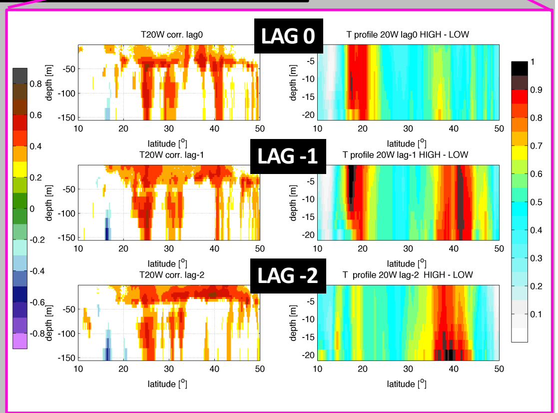


Fig.3 Lag correlation between September ACE and ocean temperature. One month (upper panels) and two months (lower panels) lag correlations between ACE and SST (left panels), and differences between ACE correlation computed based on T020 averages and SST (right panels. Magenta line corresponds to the section shown in Fig. 4.

Fig.4 Vertical sections at 20W. Correlation between ACE and Temperature (left panels) and Temperature difference (right panels, units are [°C]) between high-ACE years and low-ACE years (defined based on the median of the ACE time series). Top panels represent September correlation (lag0) while central/lower panels represent September ACE relationship with August/July (lag-1/lag-2) Temperature.



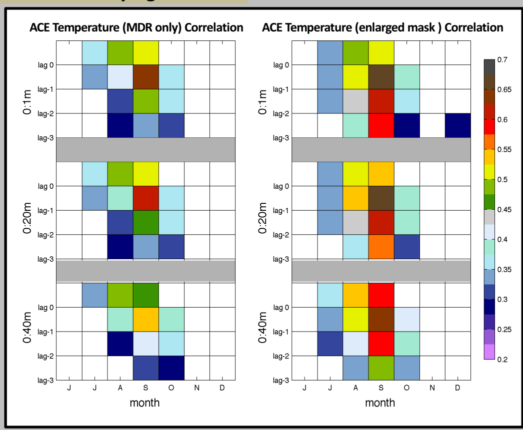


Fig.5 correlation between ACE and ocean temperature. The correlation coefficients between ACE and averaged temperature of different layers (y axis) is shown. (lag-0 represent the correlation coefficient computed based on ACE and averaged temperature of the same month. Lag-3 refers to the correlation coefficients computed based on the ACE month and the ocean temperature of three months before. White color indicates no statistically significant correlation found. Temperature is averaged over the MDR for the left panels and over the extended remote domain (considering the north-eastern part of the domain as defined by the mask in figure 3 upper left panel).

Reference:
Scoccimarro et al., 2018: Remote sub-surface ocean temperature as a predictor of Atlantic hurricane activity. PNAS doi:10.1073/pnas.1810755115

CONCLUSIONS:

- The September Accumulated Cyclone Energy (ACE) correlation with Sea Surface Temperature (SST) resembles the AMM and AMO patterns.
- The eastern extra-tropical section of the Atlantic Ocean (first 40m averaged temperature) is identified as a new source of TC predictability at the seasonal scale.