Negative wind anomalies generated a diminution of productivity in the North Atlantic in 2010

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1. The message

The weakening of the wind intensity in winter 2010, related to a low NAO index, generated **unseen temperature anomalies** and a significant **decrease of biological activity** in the Canary Current upwelling system.

2. Method

The background of this work is mainly **observational**, and is based on:

1. **Publicly available** data sets (in situ, remote sensing, *etc*).
2. **Simple methods** to derive the anomalies.

For the calculation of the anomalies for a given variable, we first compute **monthly climatological** fields using all the available years until 2009. Then we compute the differences between the monthly fields corresponding to 2010 and the climatological fields to obtain the **anomalies**.
For the time-series, the fields are averaged over the domain 0-40°N, 0-80°W.

3. Data

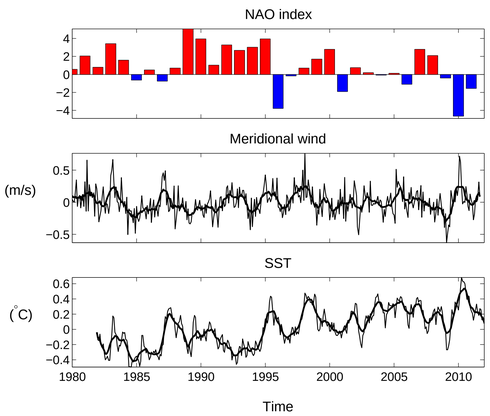
The data we employed are summarized below. All are observational data, except the wind, which comes from ECMWF interim re-analysis.

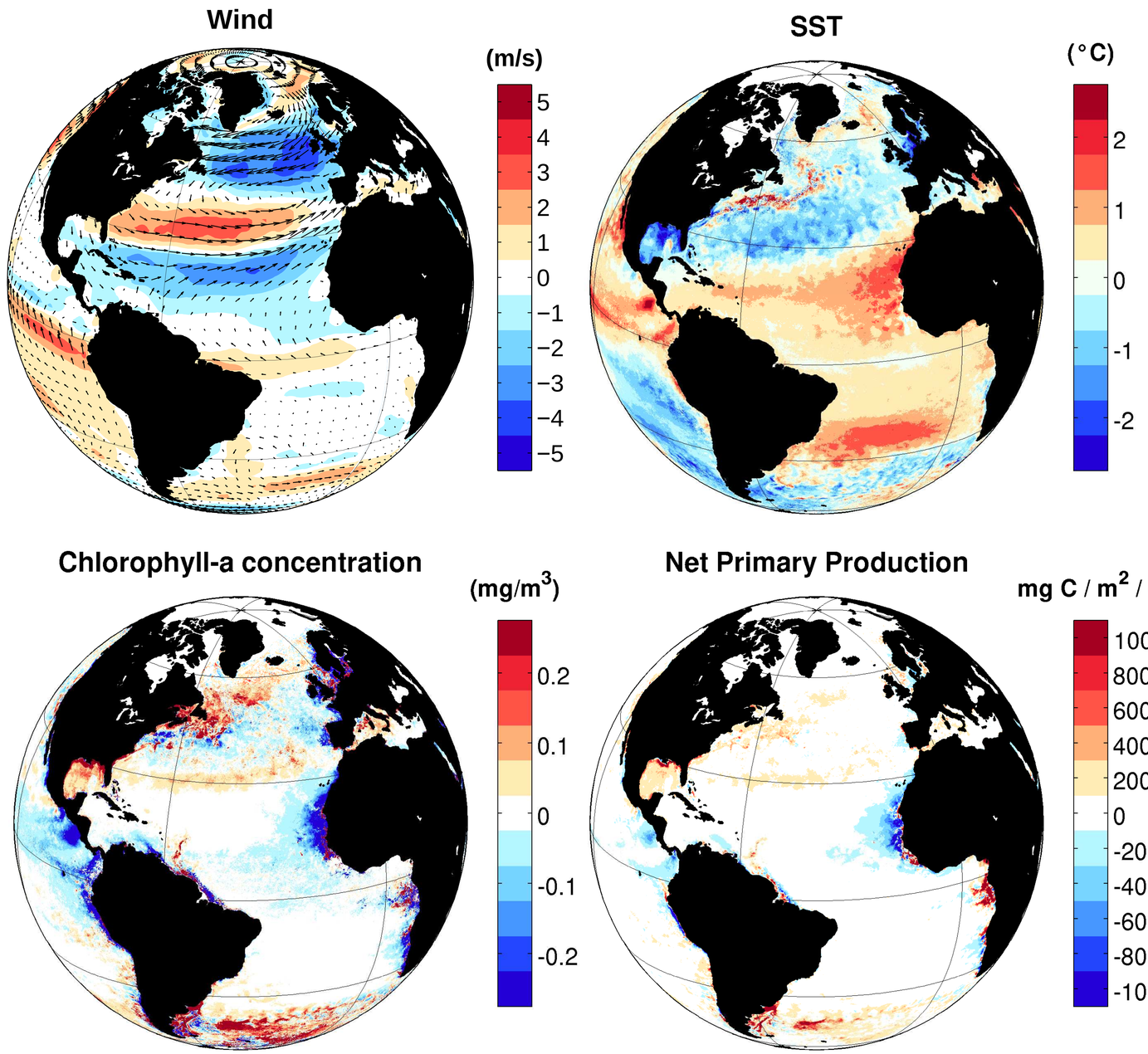
Data type	Product	Provider
Remote sensing	MODIS-Aqua & Terra L3	NASA Ocean Color
SST climatology	OI SST	NOAA
In situ profiles	WOD09	US NODC
Profilers	ARGO	US GODAE
Hydrographic climatology	WOA09 (T and S)	US NODC
Wind velocity	Interim Re-analysis	ECMWF
NAO index	Seasonal station-based index	NCAR CDG's Climate Analysis Section

4. Results

The next figure shows the time series of NAO, north-south component of the wind and SST, averaged over the studied region.

- The 2010 **NAO index** reaches its lowest value of the last 30 years.
- The **meridional** component of the **wind** is strengthened northward.
- The **SST** anomalies reach their maximum of the last 30 years.





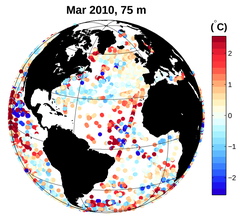
4.1. Wind

The wind anomalies for winter 2010 shows:

- a clear structure with positive anomalies north of an imaginary line joining Florida to south Spain,
- negative anomalies south of this line;
- the zonal component (see arrows) of the wind is stronger;
- close to the coast of Northwest Africa, the wind anomaly has also a stronger northward component (anomalies around **2-3 m/s**).

4.2. Sea temperature

The SST in the coastal area exhibits strong anomalies ($>$ **2°C** with respect to the climatology), because of the weakening of the wind-driven upwelling.
The positive anomalies cover a large part of the tropical and subtropical Atlantic Ocean.
The animation shows a westward propagation of the anomalies (**Rossby waves**).
Comparison of in situ measurements with respect to the World Ocean Atlas global climatology shows that the anomalies extends until a depth of **75 m**.



4.3. Chlorophyll-a concentration and net primary production (NPP)

The chlorophyll-a concentration anomalies are negative in the Canary upwelling system.
In the open ocean, the anomalies are almost zero. The NPP anomalies also exhibits negative values along Northwest Africa coast, null in the open ocean.

5. Consequences

The negative values of the NAO in winter 2010 has numerous effects:

1. A weakening of the coastal upwelling off NW Africa, hence higher SST and lower chlorophyll-a concentrations.
2. A decrease of the ocean productivity.
3. A possible increase of the number of storms in the North Atlantic.

Future work will be focused on comparison with numerical model outputs, in order to confirm the mechanism for the development of these anomalies.