Are North Atlantic SST anomalies significant for the Nordic Seas SSTs?

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Background

The topic of possible connections between SSTs in the North Atlantic Ocean and the Nordic Seas will here be addressed by examination of *in situ* observations. This report is related to a publication by Sutton and Allen [1997], who found evidence of propagation of SST anomalies along the pathway of the Gulf Stream, Gulf Stream extension and the North Atlantic Current towards, and possibly into the Nordic Seas across the Scotland-Iceland ridge. Sutton and Allen based their analysis on the SST data that are provided as a part of the "Atlas of Surface Marine Data 1994" [da Silva et al., 1994], hereafter referred to as the daSilva SST data. This data set is based on the COADS data [Woodruff et al., 1987, 1998], which in addition to the directly observed quantities such as SST, include derived quantities such as moisture and pseudo oceanic fluxes, in which transfer coefficients have been ignored. The daSilva SST data are corrected for stability dependent heat and momentum fluxes, as well as evaporation, precipitation and radiational fluxes which were absent from the COADS summaries. Also, a new scientific Beaufort equivalent scale was developed which reduces wind speed bias and artificial wind speed trends in the post World War II period.

Using the remote sensing data by Reynolds and Smith [1994] (a data set constructed from remote sensing data and *in situ* data), Furevik [2000] described how SST anomalies propagate within the Nordic Seas. However, from the remote sensing data, Furevik found no evidence for a North Atlantic origin of the Nordic Seas SST anomalies, but he speculates that the Nordic Seas SST data may be related to subsurface anomalies in the North Atlantic.

In this report, the daSilva SST data will be used to re-examine whether or not there is a relationship between anomalies in the North Atlantic and Nordic Seas SSTs.

Methods

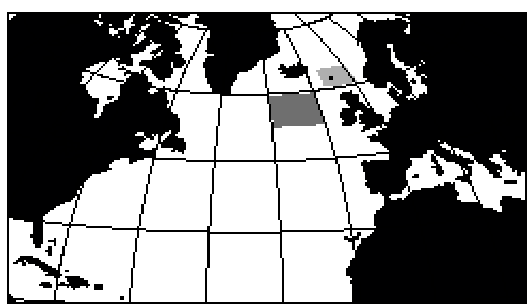

Figure 1. *Reference domains: In dark gray, northeastern North Atlantic; in light gray, southern Norwegian Sea.*

In order to examine details on relations between SSTs in the North Atlantic and Nordic Seas, we define two reference domains in the vicinity of the Scotland-Iceland ridge, where most of the inflow of warm, salty waters to the Nordic Seas takes place. The first region, defined as the area between 30°W and15°W, and between 52°N and 60°N, lies in the northeastern corner of the North Atlantic Ocean. Hereafter, this area will be referred to as NA-NE, and is depicted as a dark gray box in Figure 1. The second region, defined as the area between 11°W and 1°E, and between 60°N and 65°N, lies in the southern Norwegian Sea, with the Faeroe Islands in the southwestern corner. Hereafter, this area will be referred to as NS-S, and is depicted as a light gray box in Figure 1.

The analysis will be performed using leading and lagged correlations, and determination of the statistical significance of the results. In addition, Hovmøller plots of SST along selected pathways will be inspected visually. The resolution of the data that will be used here is 1°-by-1° in space, and one month in time. The winter season is defined as November through April. For each cell and each winter, the mean winter SST is determined, and the average values for the reference domains are computed, and de-trended. Then, a five-winter low pass boxcar filter (LPB filter) is applied, and correlations are computed with offsets ranging from leading the reference time series by three winters to lagging the time series by four winters. (A three-winter LPB filter was used for the Hovmøller diagrams.)

The statistical significance of the results is described by reshuffling all the winters randomly, thereafter applying the five-winter filter. A total number of 10,000 sets of reshuffles is considered, and the confidence level is set by placing the correlation value from the analysis of the original time series in the low-to-high sequence of 10,000 correlation values from the analysis of the reshuffled winter data.

Discussion

The analysis of the daSilva data is performed very similarly to the approach of Sutton and Allen [1997]. The differences are the time period (here: 1945-1993, Sutton and Allen: 1945-1989), and that here, the data have been de-trended prior to all post-processing such as computation of correlation values. Moreover, Sutton and Allen based their analysis on the time series from a reference domain in the southwestern North Atlantic Ocean (between 80°W and 60°W, and between 31°N and 39°N), examining propagation of SST anomalies within the North Atlantic Ocean.

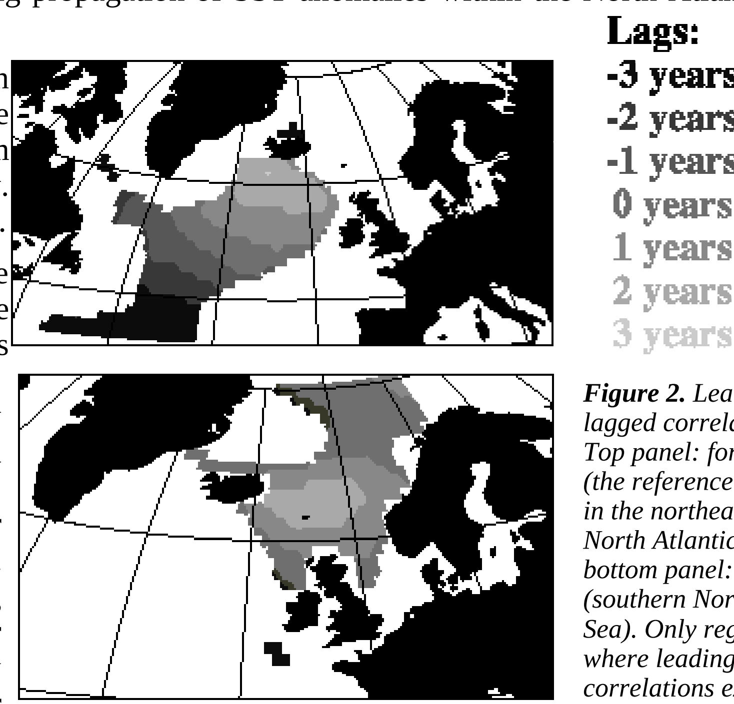

Figure 2. *Leading and lagged correlations. Top panel: forNA-NE (the reference domain in the northeastern North Atlantic); bottom panel: for NS-S (southern Norwegian Sea). Only regions where leading/lagged correlations exceed 0.7 have been shaded. See the text for details.*

The results for reference domain NA-NE and domain NS-S are depicted in the top and bottom panels of Figure 2, respectively. Later lags are overlaid on other lags.

From the top panel, we note that the North Atlantic current is one possible pathway for SST anomalies that propagate into NA-NE. There are also indications of a secondary pathway from the Labrador Sea along the Atlantic Subpolar Gyre. However, we find no evidence for signal propagation into the Nordic Seas, but there are hints suggesting propagation towards the Irminger Sea west-southwest of Iceland. By inspecting Hovmøller diagrams for alternative pathways (not shown), we find that the reason for the stronger signal towards the Irminger Sea, rather than into the Norwegian Sea, can be attributed ta a warm anomaly in the southern Norwegian Sea that can’t be traced back to the North Atlantic Ocean.

The results in the bottom panel also correspond to a lack of SST traces from the North Atlantic. A possible source region in the northern Norwegian Sea is found, but the data quality for these remote latitudes may not be the best. When it comes to propagation away from the NS-S (positive lags), we don't find evidence for this at all.

We supplement the lagged correlations analysis by examining the statistical significance of the results. The confidence levels for SSTs leading the NS-S SST data by three years are depicted in Figure 3. We note that there are indications of a connection to a region to the east of the pathway of the North Atlantic Current. The region where the confidence is above the 99% level corresponds roughly to the region where the lagged correlations exceed 0.6. Moreover, this is also a region that has a local minimum in the mean winter surface heat flux (the sum of the latent and sensible heat fluxes), and the bulb-shape of the 99% confidence level contour to the southwest of Ireland corresponds to a local minimum in the wind curl. Hence, the conditions of the coupled ocean and atmosphere system in this region may be more favorable for conservation of a surface property such as SST than other locations in the vicinity of the Scotland-Iceland ridge.

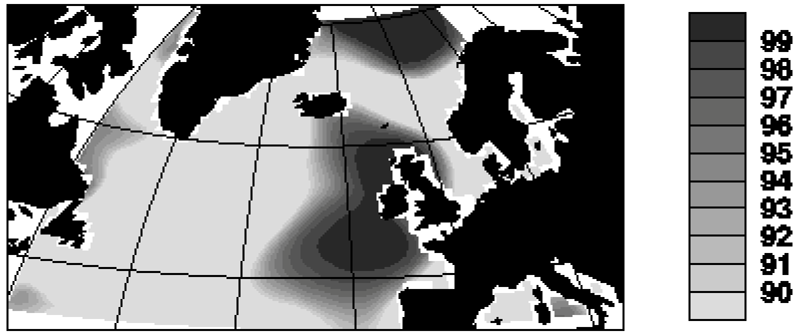

Figure 3. *Confidence levels for the SST results that lead the NS-S SSTs by three years. The numbers on the label are levels of confidence, in %.*

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