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Ocean Obs needs

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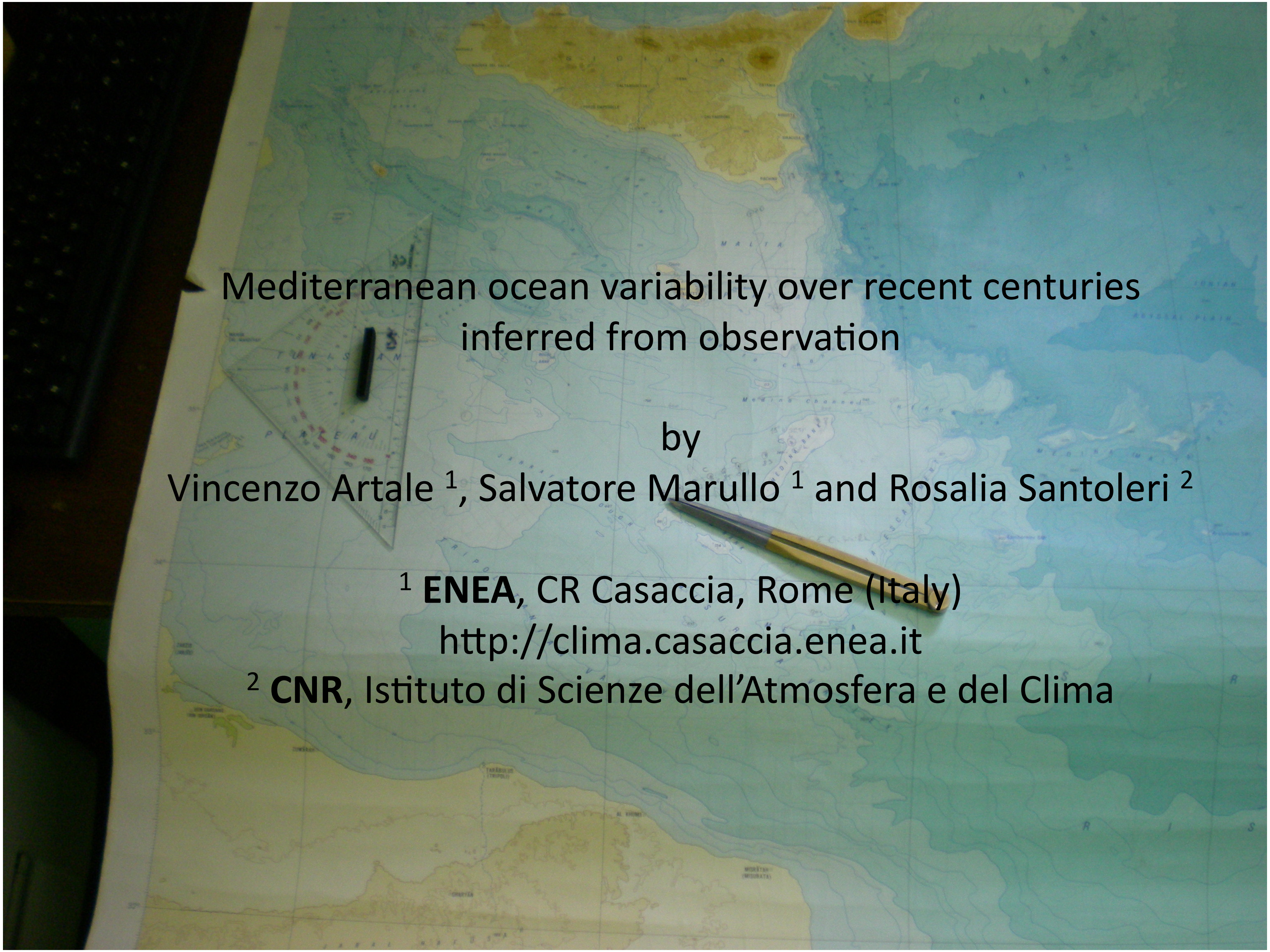

Mediterranean ocean variability over recent centuries inferred from observation

by

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Mediterranean SST studies for

- To evaluate long term variations of the Sea Surface Temperature (as climatic index) in the North Atlantic Ocean and Mediterranean Sea
- To understand relations between Atlantic and Mediterranean variations
- To measure the contribution of harmonic components to long terms variations (multidecadal variability)
- To understand how much the observed multi-decadal variability is internal versus forced climate change

Available Data

The Sea Surface Temperature is the longest instrumental information available for the global world ocean.

- Interpolated: Reconstructed SST produced by NCDC (ERSST.v3 1854-present) and Hadley Centre (HadISST 1870-present) including pre-1942 adjustment.
- Non interpolated: ICOADS (International Comprehensive Ocean-Atmosphere Data Set) SST (gridded, non interpolated 1x1 , 2x2) up to may 2007.

Barnett (1984) gave strong evidence that historical marine data are heterogeneous. He found a sudden jump around 1941 in the difference between SST and all-hours air temperatures reported largely by the same ships. Folland *et al. (1984) explained this as* being mainly a result of a sudden but undocumented change in the methods used to collect sea water to make measurements of SST. The methods were thought to have changed from the predominant use of canvas and other uninsulated buckets to the use of engine intakes (From Folland and Parker 1995).

ERSST.v3 pre-1942 SST corrections are based on Smith and Reynolds (2002) while HadISST corrections are based on Folland and Parker (1995)

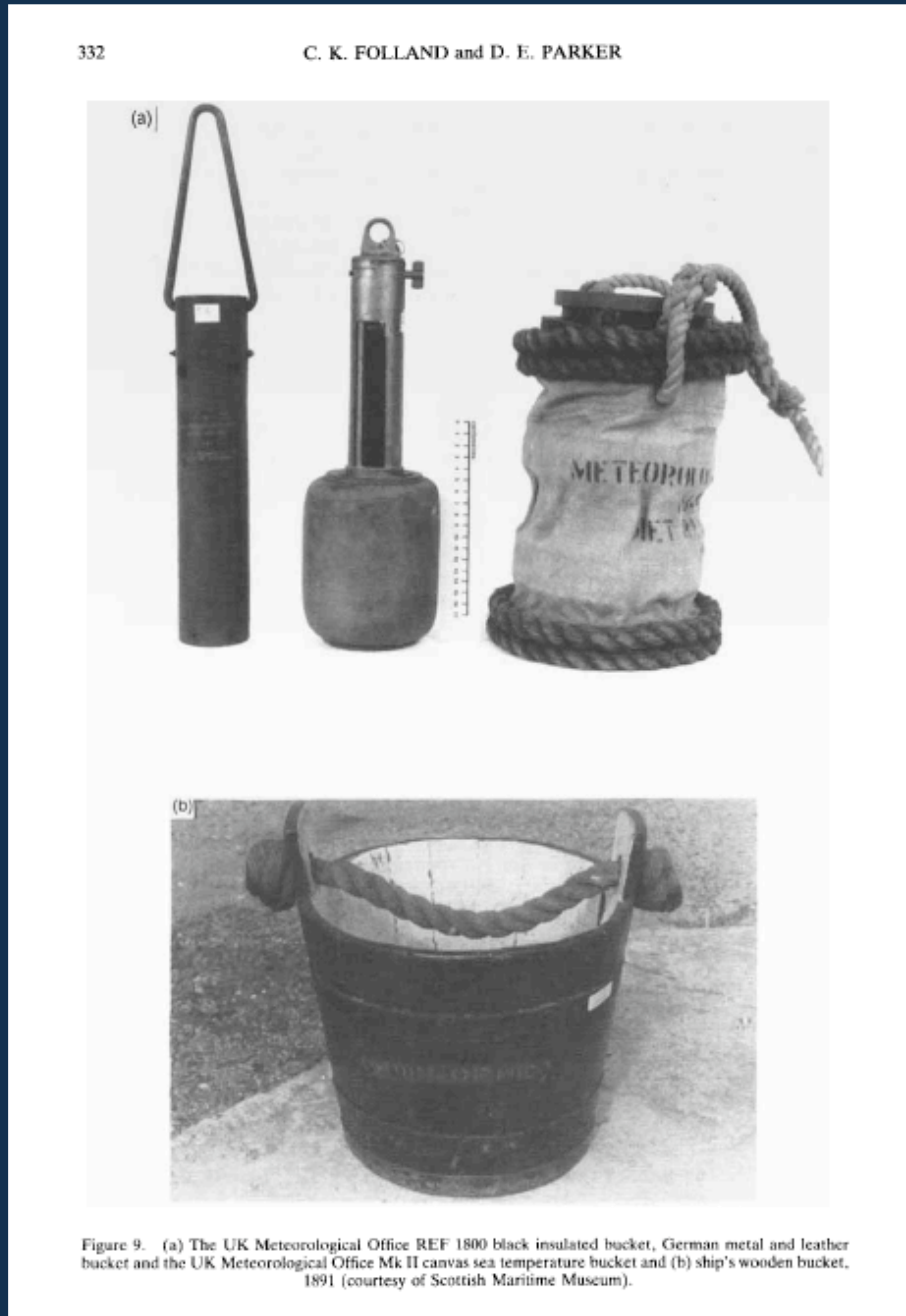
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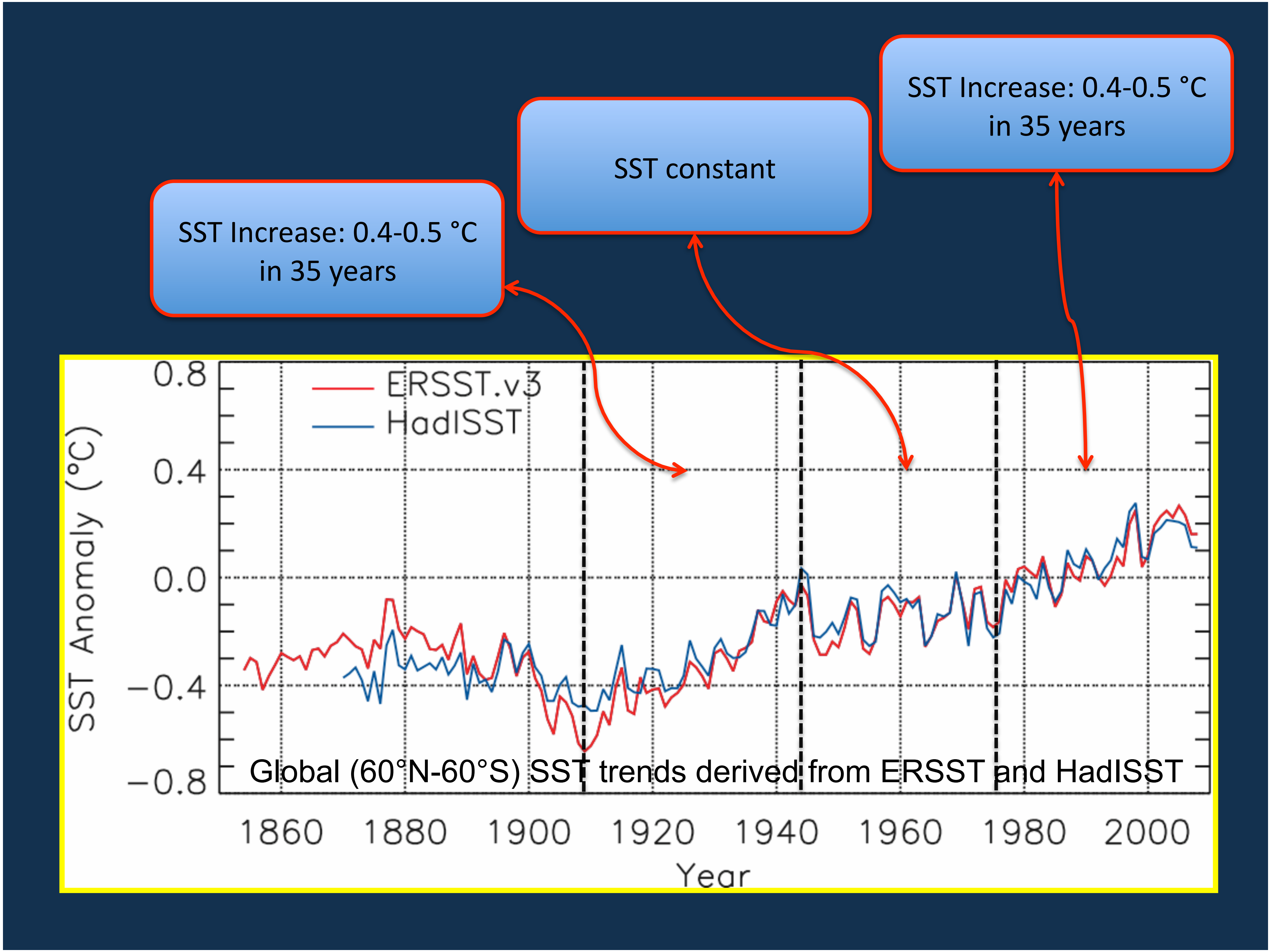
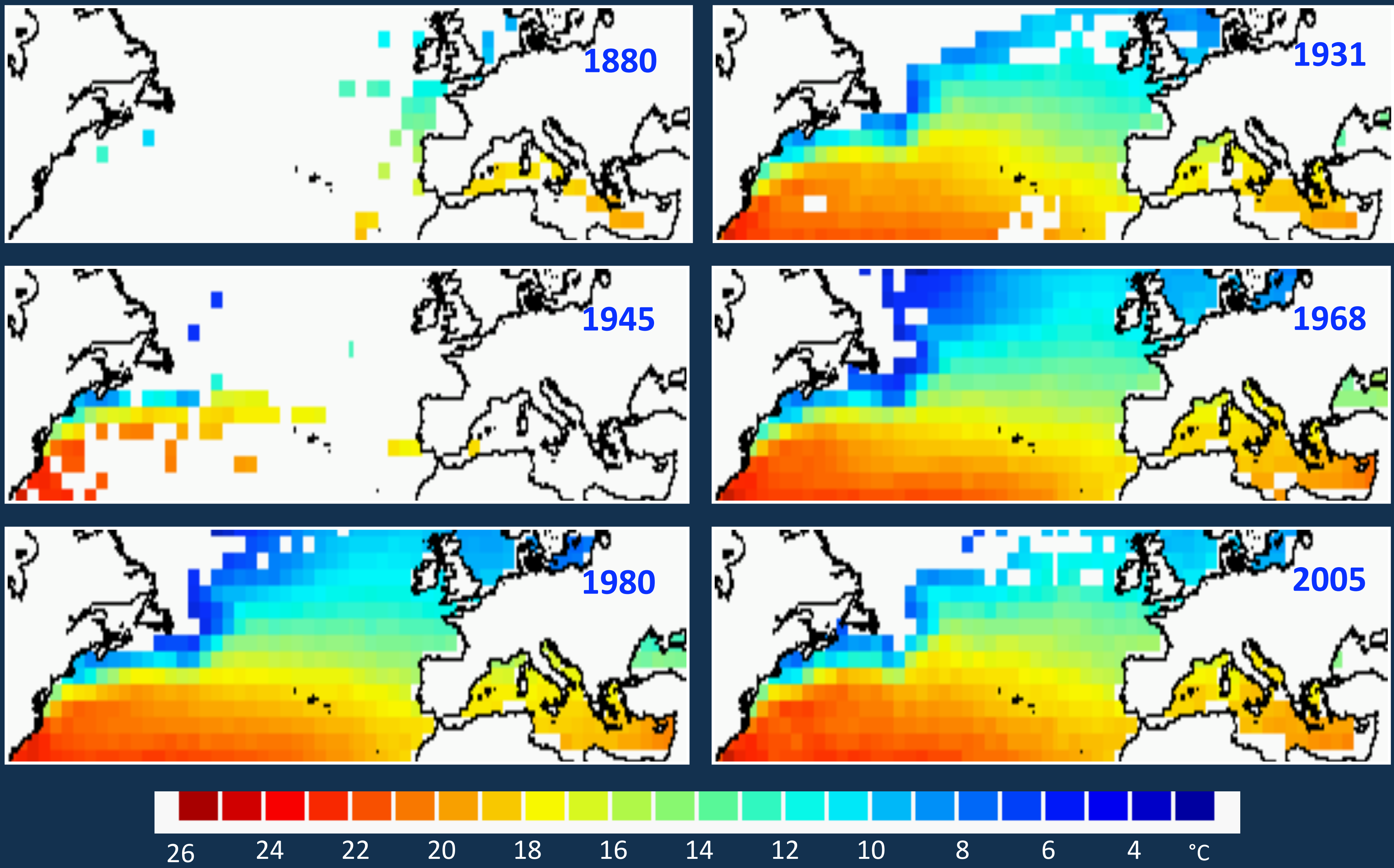
Figure 9. (a) The UK Meteorological Office REF 1800 black insulated bucket, German metal and leather bucket and the UK Meteorological Office Mk II canvas sea temperature bucket and (b) ship's wooden bucket, 1891 (courtesy of Scottish Maritime Museum).


SST Increase: 0.4-0.5 °C in 35 years
SST constant
SST Increase: 0.4-0.5 °C in 35 years
ERSST.v3
HadISST
SST Anomaly (°C)
0.8
0.4
0.0
−0.4
−0.8
1860
1880
1900
1920
1940
1960
1980
2000
Year
Global (60°N-60°S) SST trends derived from ERSST and HadISST

1. which dataset would be better to use?
2. Are gridded interpolated datasets suitable for climate trend studies?

It is evident that globally complete, i.e. interpolated, datasets must be used with care (Rayner et al. 2003) particularly in specific regions or periods of time where data are too sparse and the reconstruction procedure can introduce or distort climatic trends and spatial variations.

Spatial distribution of available yearly ICOADS SST average for some selected year at the Mediterranean latitude



Having no independent sea truth data to validate the reconstructed SST products for most of the analysis period (1854 - today), a strategy could be either to investigate the consistency between the two time series evaluating differences in long term trends or oscillations and seasonal components or to produce a third SST time series over some region where more original ICOADS data are available using a simple but robust space average that consider the number of valid ICOADS SST for each month in the whole region.

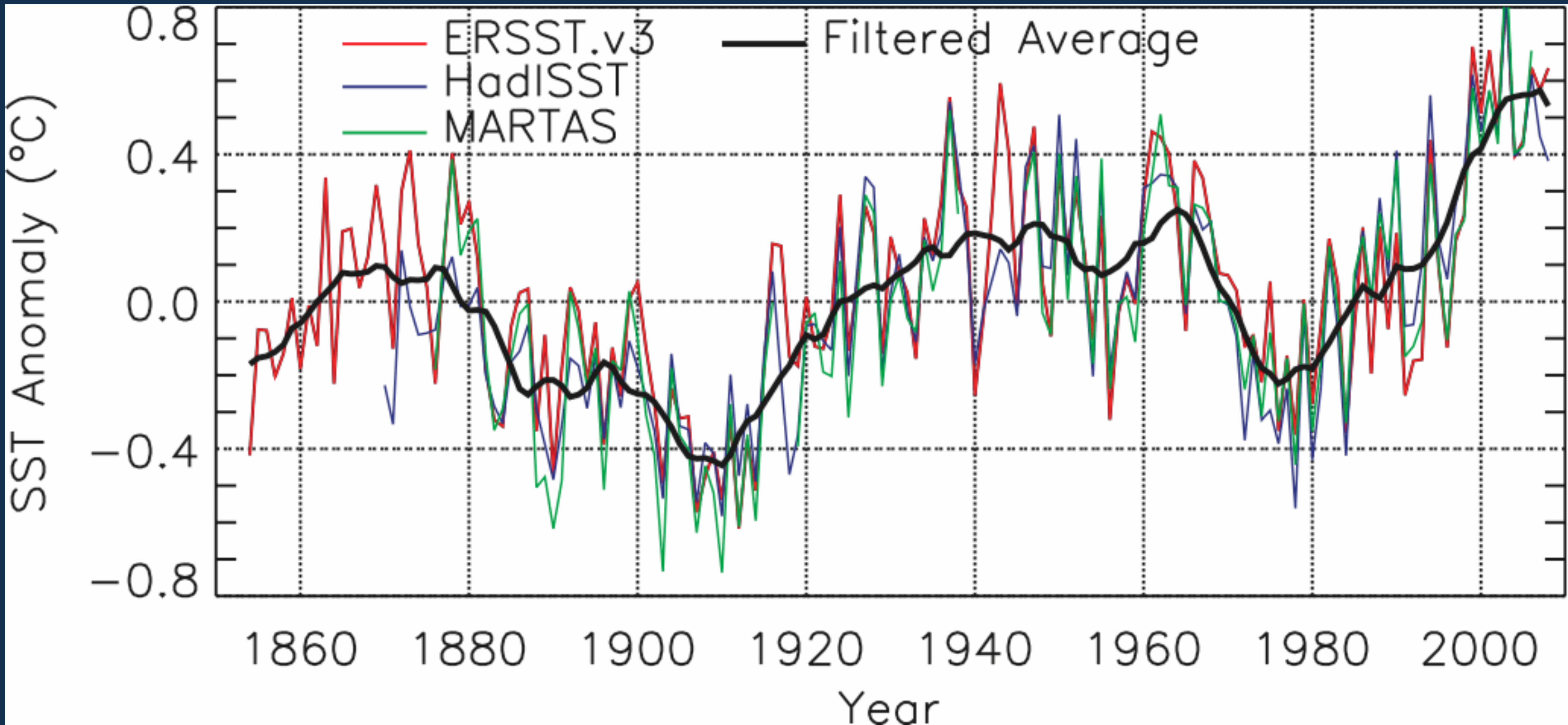
The Mediterranean Sea is one of these data rich region.

A correction factor *F* has been calculated for each year as ratio between the spatial average of a mean SST map obtained averaging all the yearly maps (reference map) and the spatial average of the same map computed excluding those grid points that in a particular year under investigation were not available.

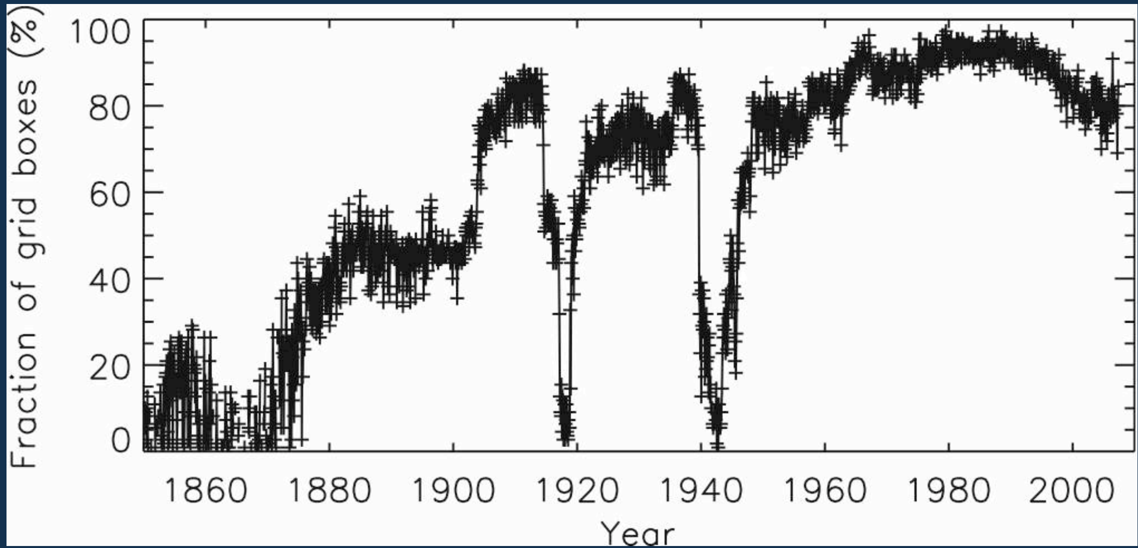
$$F(i) = \frac{< Map(i) >}{Rave}$$

Rave = spatial mean of the reference map

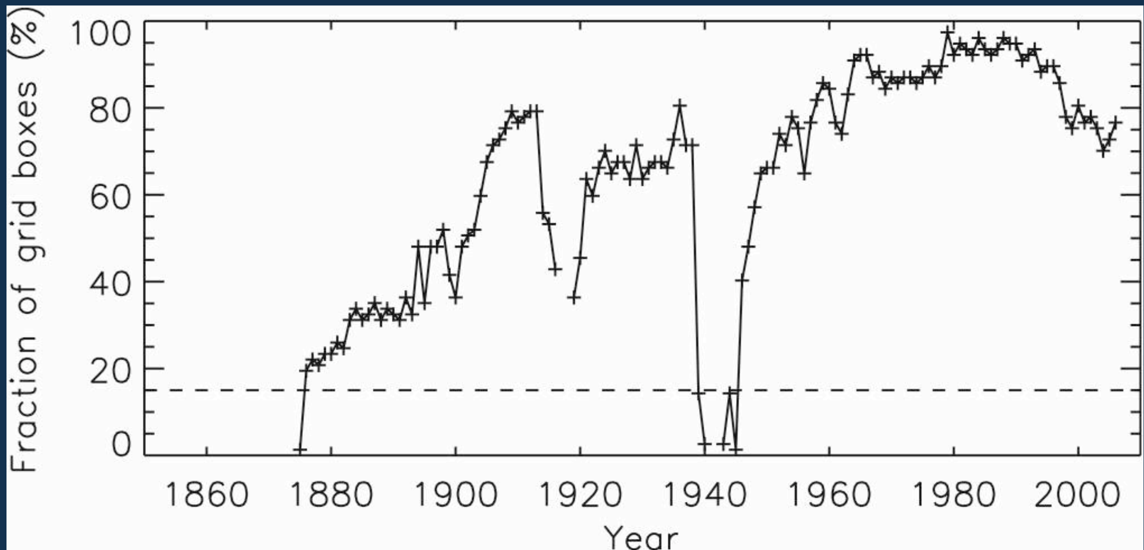
<*Map(i)*> = mean of all the valid data present in the yearly map of the i_{th} year



Mediterranean annual SST anomaly (respect to the 1971-2000 average) from 1854 to 2008. Red line ERSST.v3, blue line HadISST, green line MArtaS (Marullo-Artale-Santoleri). The black solid line represent the filtered average of the three datasets. Martas pre-1942 has been corrected using SR02.

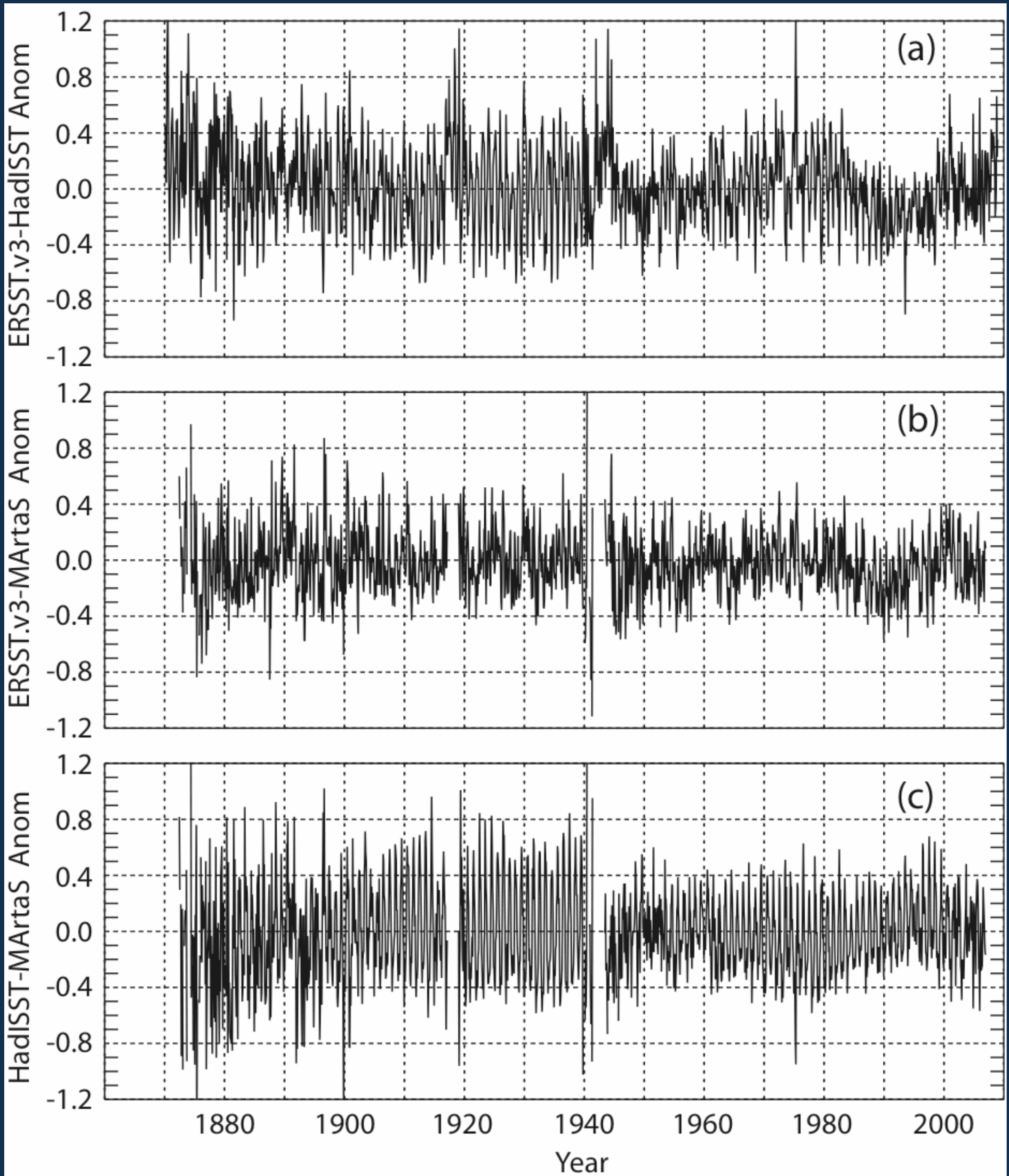


Percentage of grid boxes with monthly ICOADS SST data in the Mediterranean Sea.



Percentage of Mediterranean grid boxes where yearly SST averages were computed (12 monthly SST available). In years falling below the horizontal dotted line (15%), spatial averages of the Mediterranean Sea surface temperature were not computed.

Monthly Differences



When we switch to monthly mean, differences between the two interpolated data sets became larger,. These differences exhibit a marked annual cycle that suggests a sort of compensation between seasons corresponding to the better agreement found for yearly averages.

This difference in the amplitude of the annual cycle can, possibly, be ascribed to the different bias adjustment used for the three datasets; Folland and Parker (1995) for HadISST and Smith and Reynolds (2002) for ERSST.v3 and MArtaS. Figure 5b, that is based upon difference between datasets that have applied the same bias correction, supports this conjecture showing no differences between period before and after 1942.

WARMING OF THE MEDITERRANEAN SURFACE LAYER: SST ARE INCREASING SINCE 1860 BY 0.4°C

(Marullo et al., 2009)

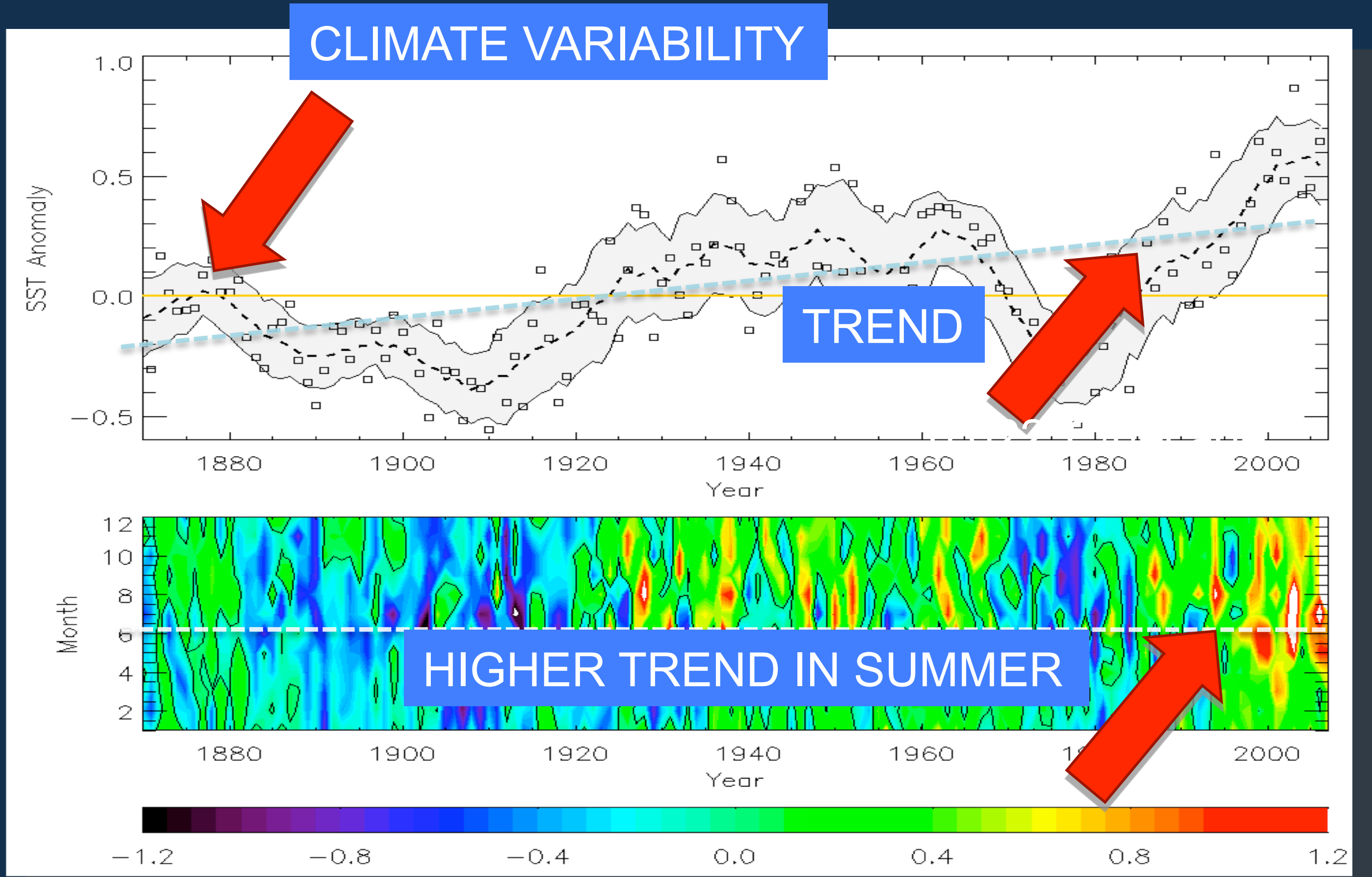


Figure 1. Upper panel SST yearly anomaly. Lower panel SST Monthly anomalies. The black contour line is the zero level

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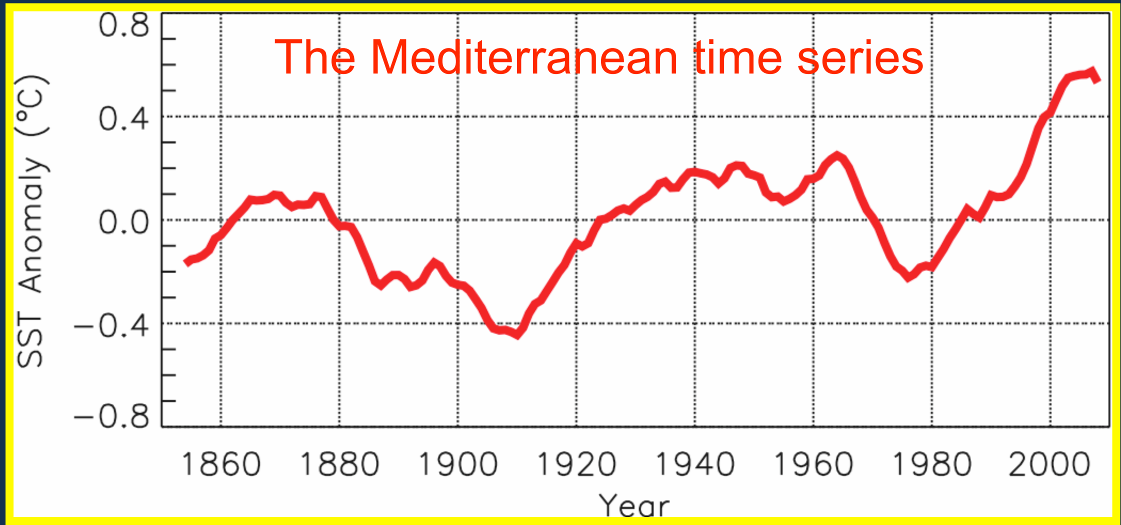
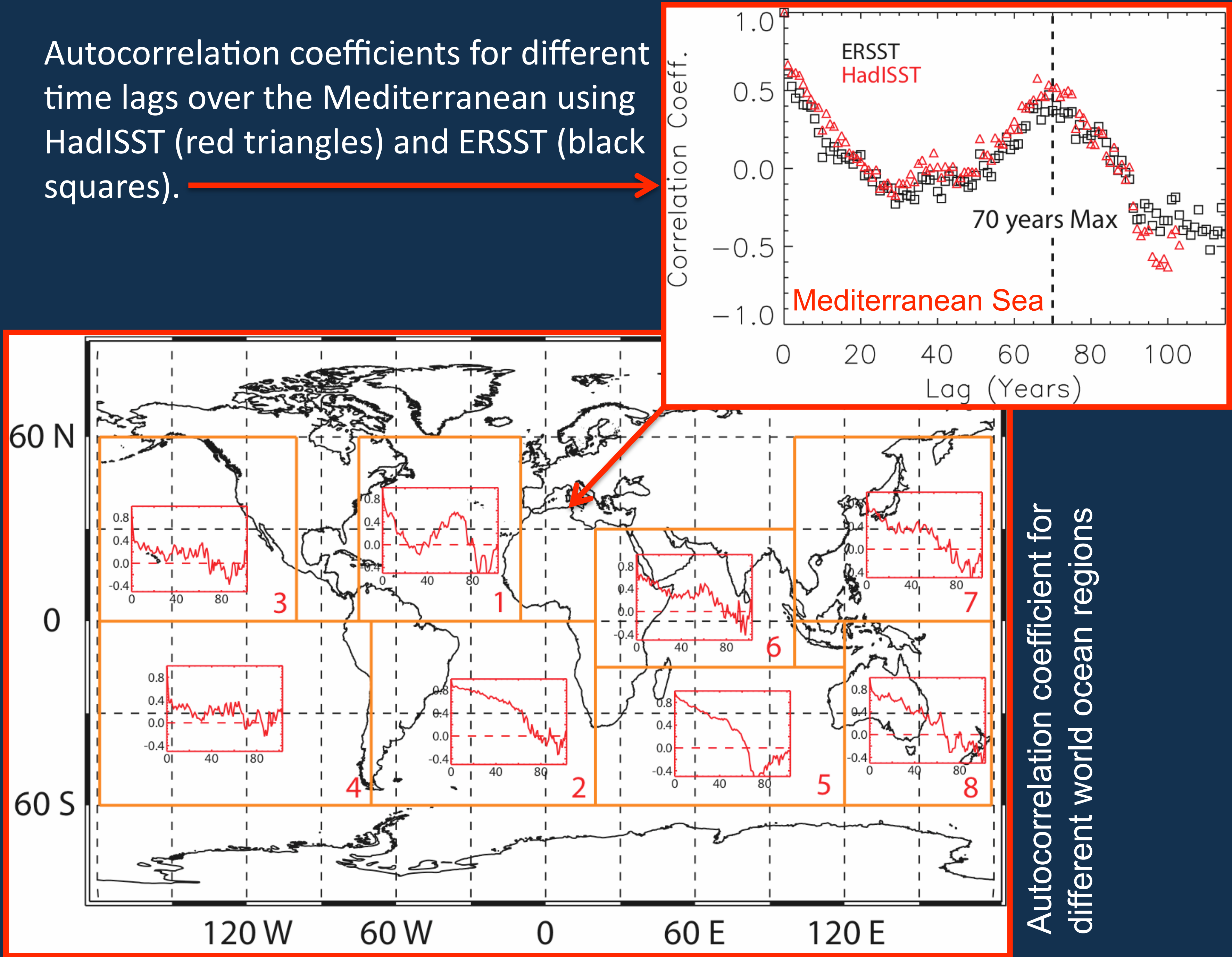
Analysis of the Med-Atlantic SST Time Series



The visual inspection of the Mediterranean SST Time Series suggests the occurrence of a multidecadal (close to 70 years) signal.

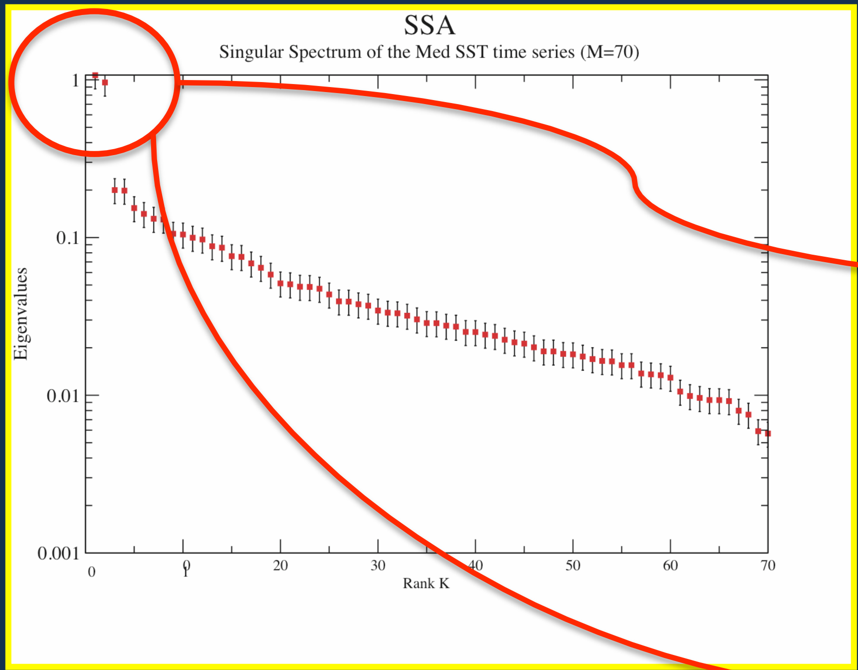
Is this frequency observed in other areas of the world oceans?

Autocorrelation coefficients for different time lags over the Mediterranean using HadISST (red triangles) and ERSST (black squares).

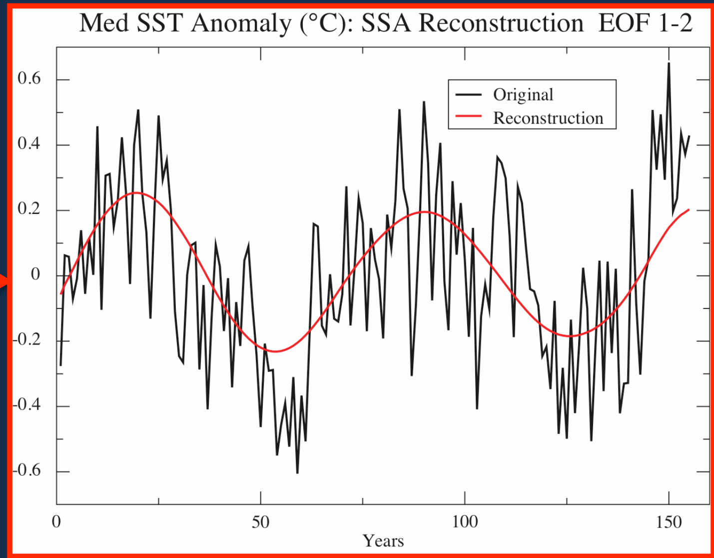


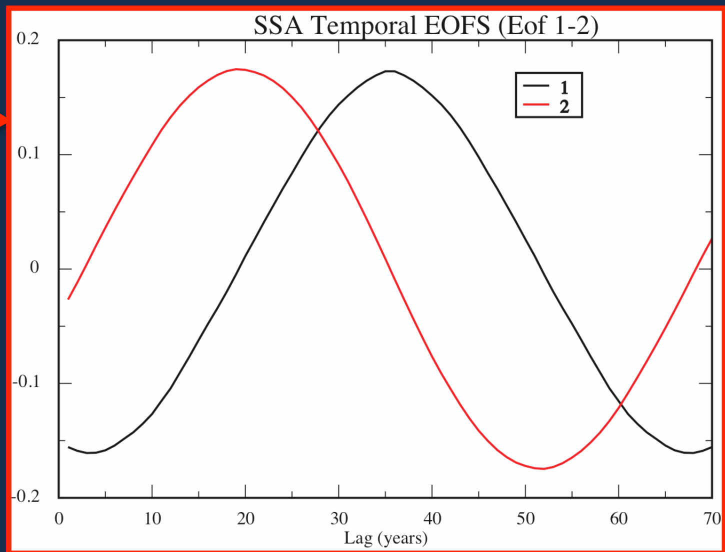
Autocorrelation coefficient for different world ocean regions

Mediterranean Multi-decadal SST Variability (SSA - Singular Spectral Analysis)



40% of the Total variance4



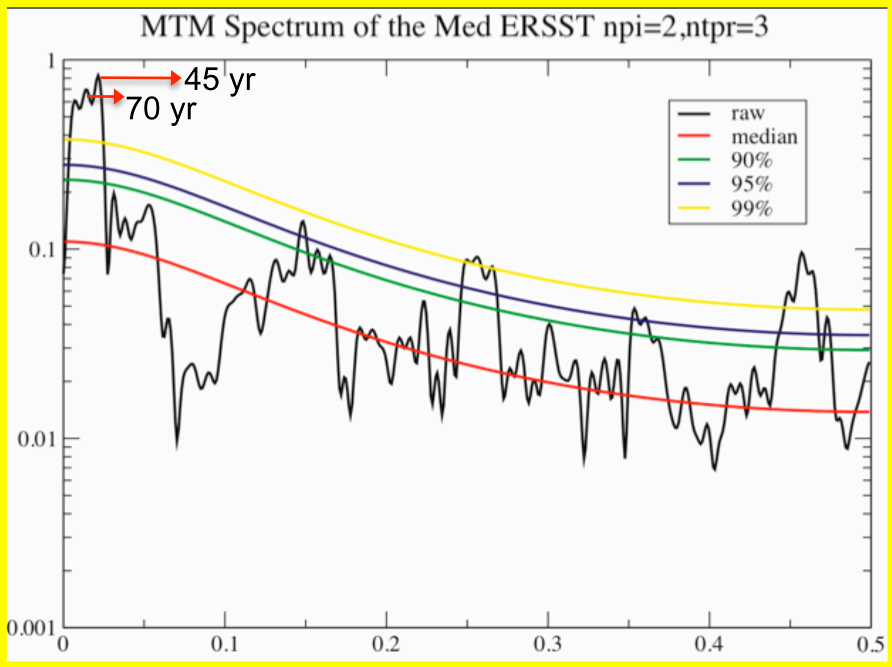


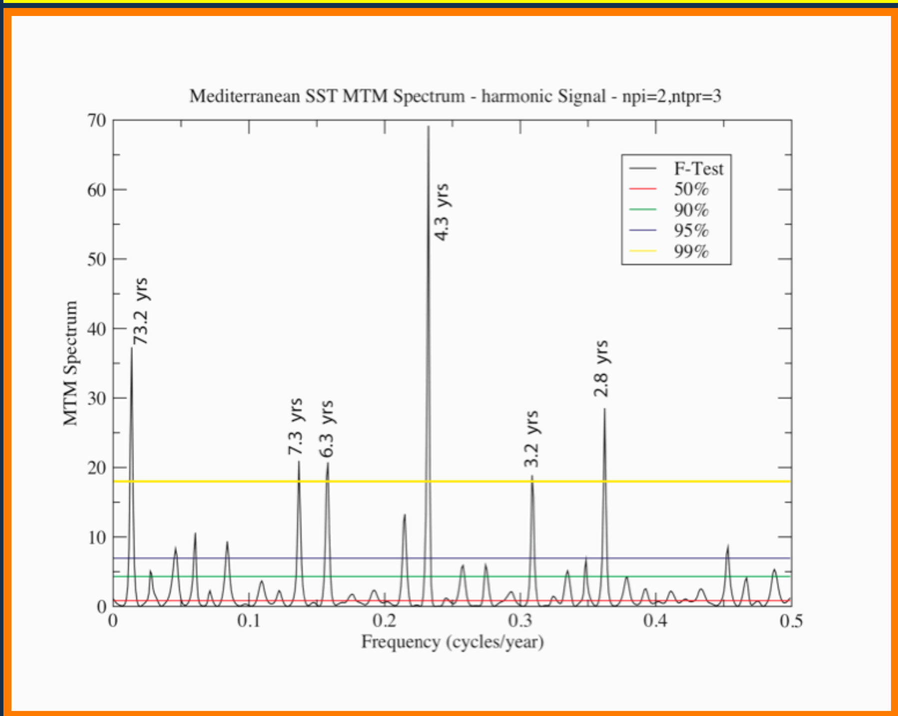
The first two leading EOFs have approximately the same amplitude and are in quadrature. They capture the main low frequency variability of the SST time series (about 70 years). This fact could be interpreted as the occurrence of a ghost limit cycle related to a physical oscillation of the dynamical system that has generated the SST time series (Ghill et al., 2001)

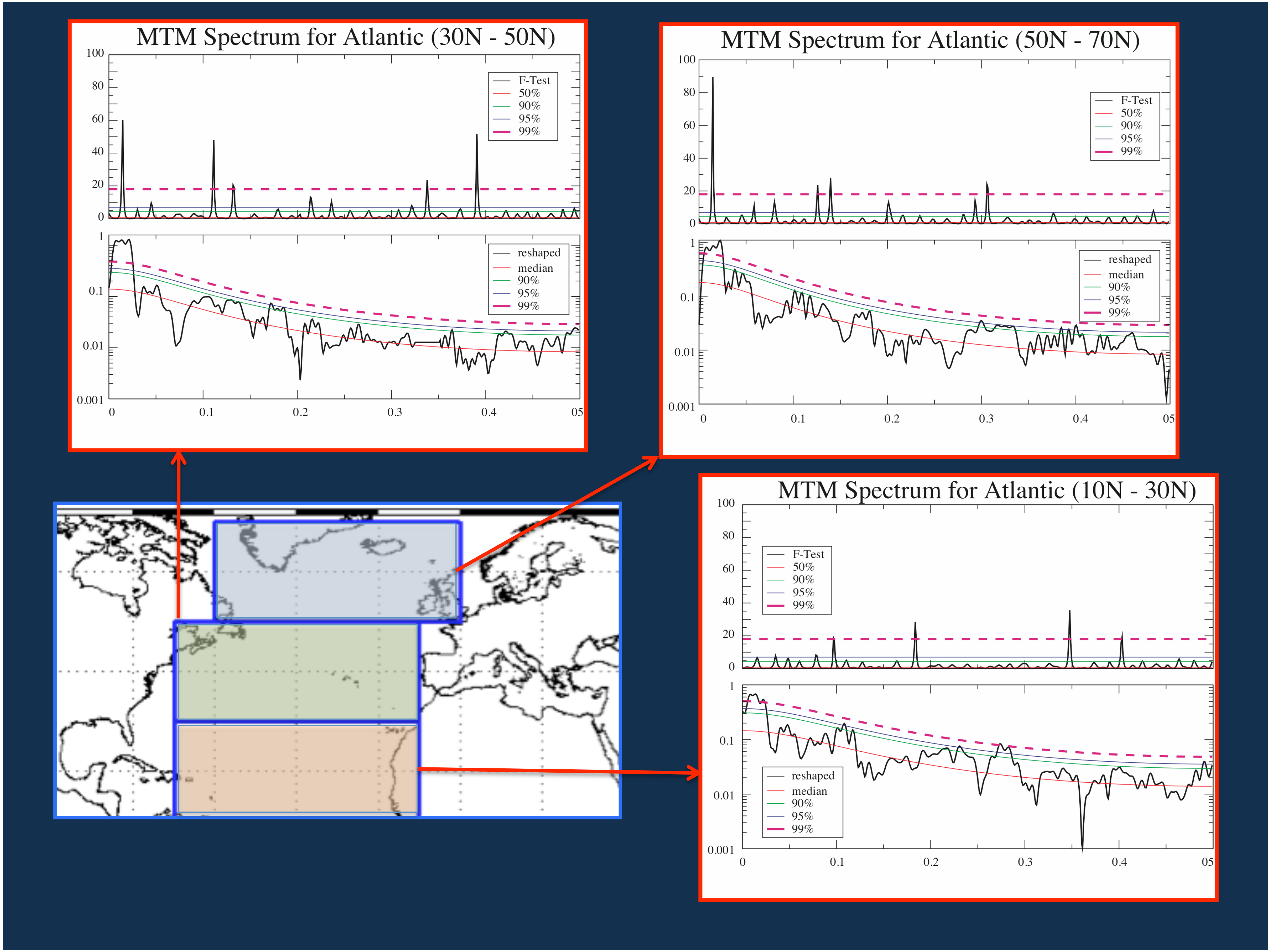
The low frequency variability of the Mediterranean was evaluated applying the Multitaper method (MTM) method to the detrended SST. The Multitaper method is a technique developed by D.J. Thomson (1982) to estimate the power spectrum of a stationary ergodic finite-variance random process.

a)MTM spectrum of the Med ERSST time series, the estimated red noise background and associated 90%, 95%, 99% significance levels are shown by the four smooth curves.

b) Six harmonic signals, significant at 99% level, with interannual (between 2.8 and 7.3 years) and multidecadal (73.2 years) frequencies.

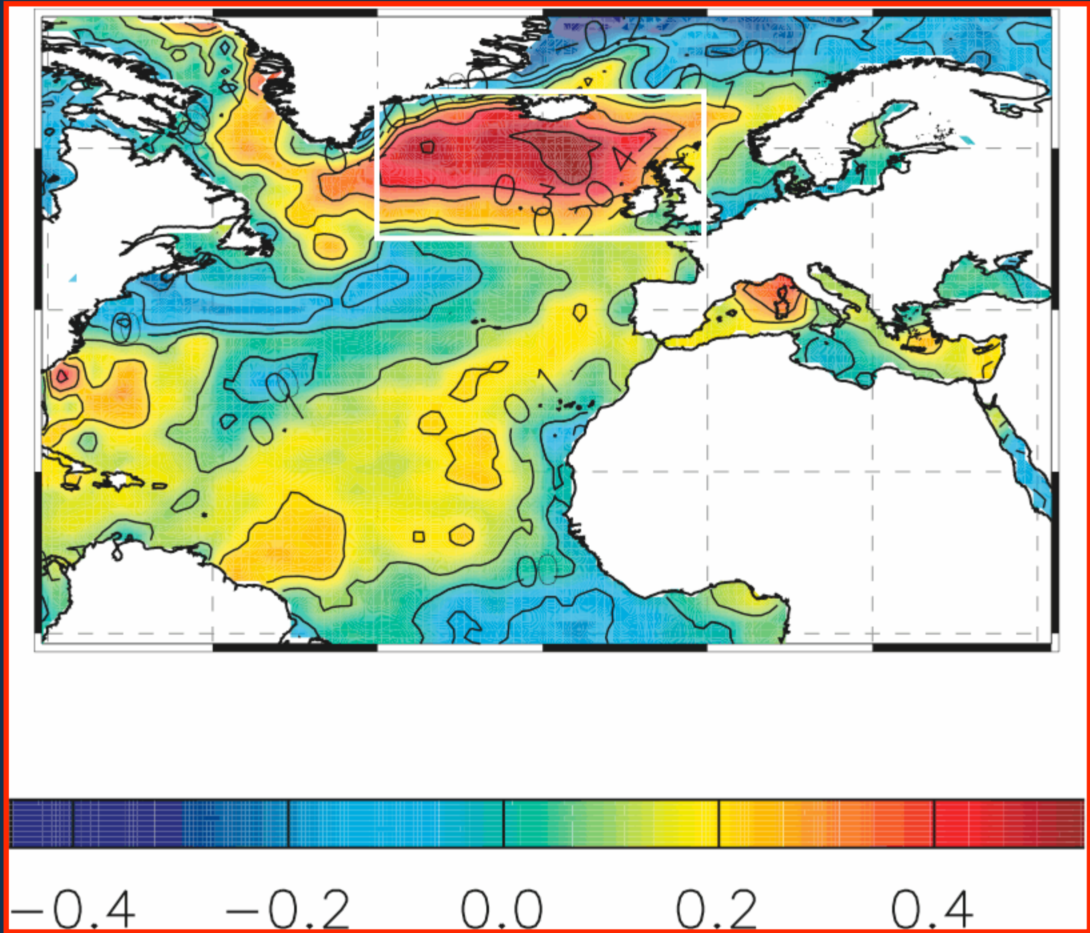


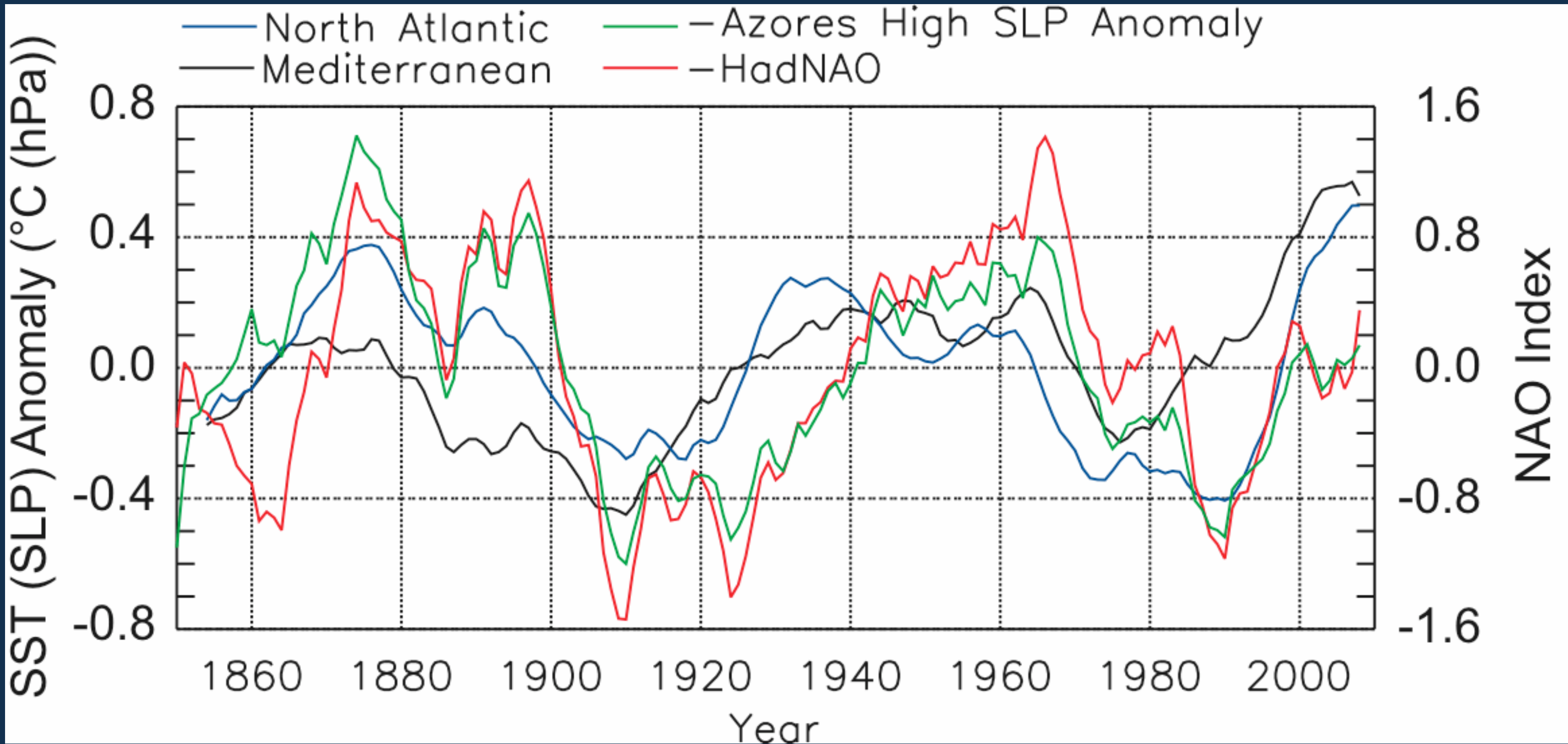




MTM Spectrum for Atlantic (30N - 50N)
F-Test
50%
90%
95%
99%
reshaped
median
90%
95%
99%
100
80
60
40
20
0
1
0.1
0.01
0.001
0
0.1
0.2
0.3
0.4
05
MTM Spectrum for Atlantic (50N - 70N)
F-Test
50%
90%
95%
99%
reshaped
median
90%
95%
99%
MTM Spectrum for Atlantic (10N - 30N)
F-Test
50%
90%
95%
99%
reshaped
median
90%
95%
99%

Correlation map between Azores High Sea Level Pressure Anomaly (sign changed) and Sea Surface Temperature Anomaly (Period 1870-2007). Areas with high correlation values indicate situations where periods of higher SLP at about 30-35 N in the Atlantic Ocean correspond to period of colder SST (and vice versa)




North Atlantic
Mediterranean
−Azores High SLP Anomaly
−HadNAO
SST (SLP) Anomaly (°C (hPa))
NAO Index
0.8
0.4
0.0
-0.4
-0.8
1.6
0.8
0.0
-0.8
-1.6
1860
1880
1900
1920
1940
1960
1980
2000
Year

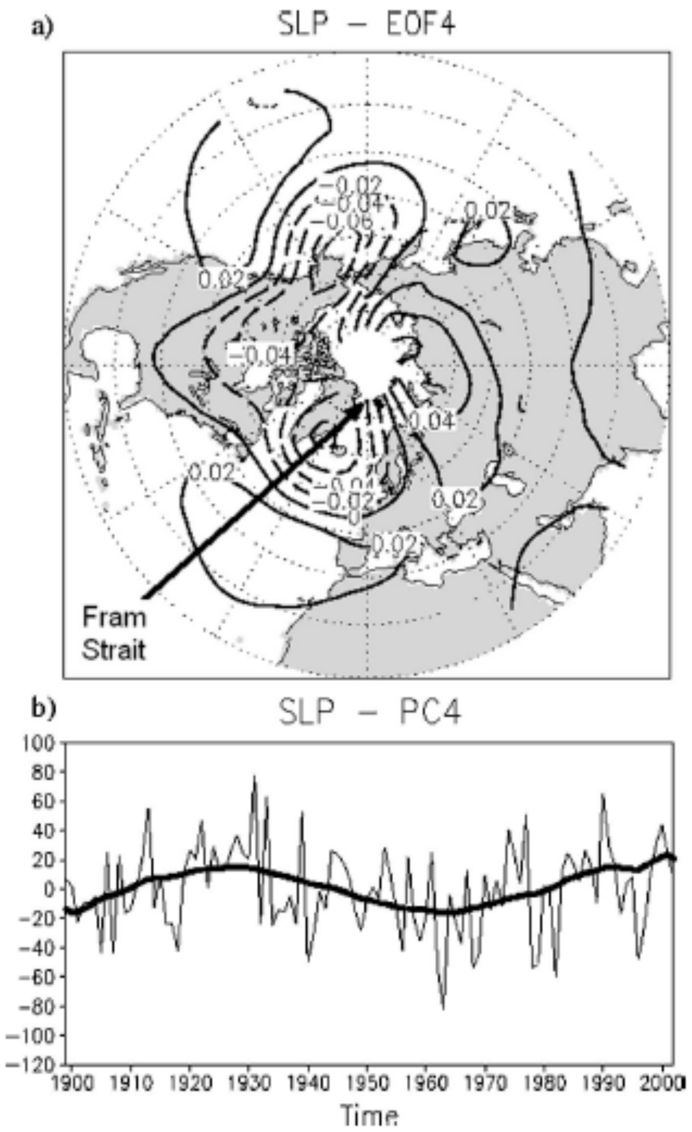


FIG. 2. (a) The fourth EOF of winter SLP anomalies from Trenberth and Paolino (1980) over the 1899–2002 period and (b) the associated time component (thin line) and its dominating component (thick line) identified through SSA.

From Dima and Lohmann , J. of Climate, 2007

eastern North Atlantic. The fourth EOF (8%) is of specific importance in our study (Fig. 2). It includes two connected centers of negative anomalies over the North Pacific and Greenland and two other centers of positive anomalies over the North Atlantic and Siberia. A similar pattern was presented by Cavalieri (2002) in association with the Fram Strait sea ice export. The hemispheric wavenumber-1-like (hereafter HWN1) structure of this pattern is consistent with a zonally asymmetric oceanic forcing on the atmosphere. As will be shown below, the same structure is also obtained as a composite map. The associated time series (Fig. 2b) is dominated by a multidecadal time component (12%), which is identified through SSA using a 40-yr window.

Mechanisms of the observed multidecadal variability (AMO)

The AMO is thought to be driven by multidecadal variability of the Atlantic thermohaline circulation (THC). Enhanced THC strength enhances the poleward transport of heat in the North Atlantic, driving the large-scale positive SST anomalies.

(Bjerknes 1964; Folland 1984; Delworth et al., 1993; Delworth and Mann 2000; Latif et al 2004)

But why the Mediterranean Sea should follow the same oscillation?

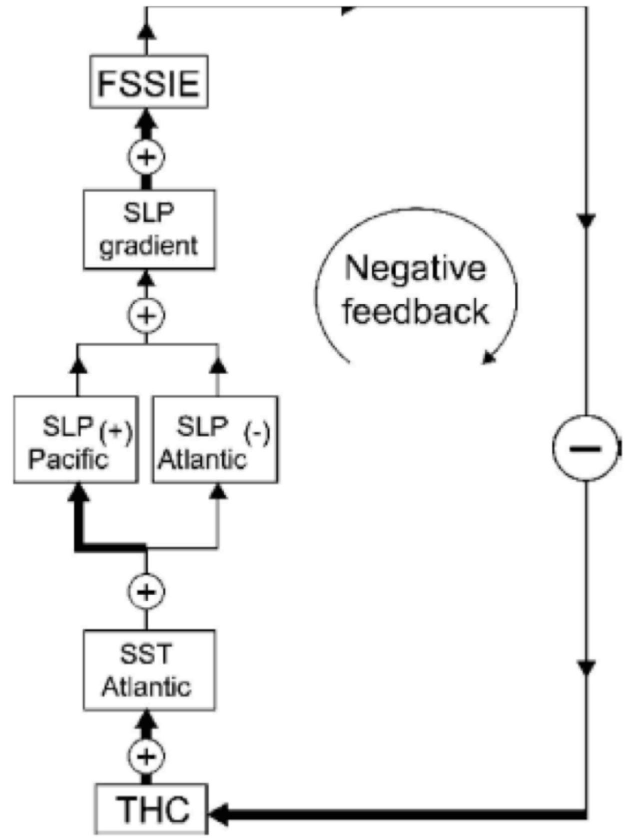
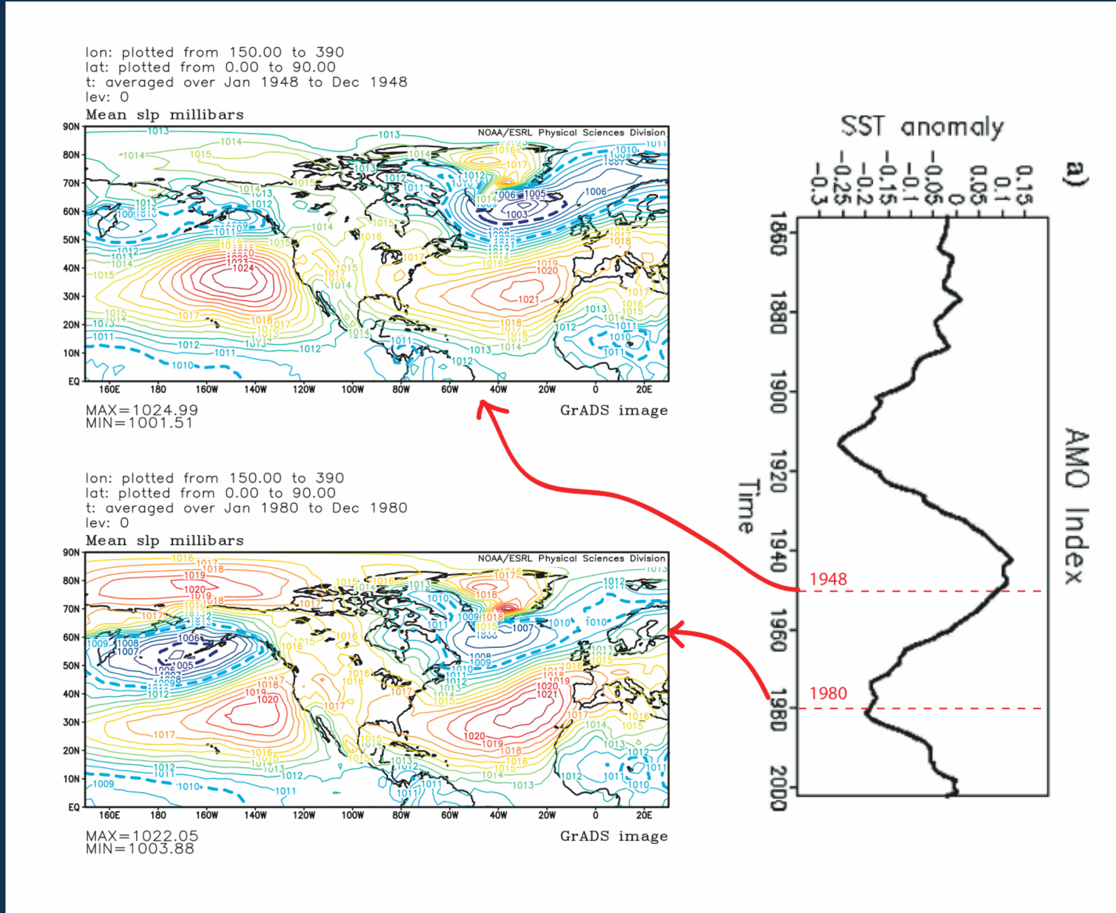


FIG. 8. Schematic representation of the AMO mechanism. Th
ick arrows represent links that are associated with memory
HC adjustment to freshwater fluxes (horizontal line), Atlanti
ST response to meridional overturning, oceanic adjustment i
e North Pacific, and sea ice response to wind stress.




Thank you for your attention !!