INTERANNUAL CHANGES IN NORTH ATLANTIC SEA LEVEL AND SURFACE CIRCULATION AS MEASURED BY SATELLITE ALTIMETRY

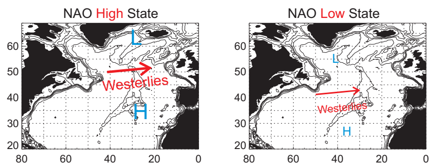
Saskia ESSELBORN
Universität Hamburg, Institut für Meereskunde (esselborn@ifm.uni-hamburg.de)

Laury MILLER, Bob CHENEY
NOAA, Laboratory for Satellite Altimetry

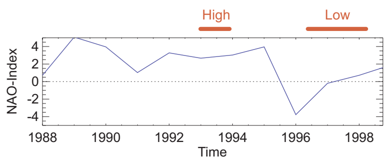
INTRODUCTION

The interannual variability of sea level (SL) and of geostrophic surface circulation in the North Atlantic is investigated using altimeter data from Topex/Poseidon, ERS-1, and ERS-2 [AVISO, 1997] between October 1992 and September 1998. Considerable oceanic changes can be observed after winter 1995/96 when the atmospheric forcing changed abruptly.

HIGH AND LOW: TWO STATES OF NAO

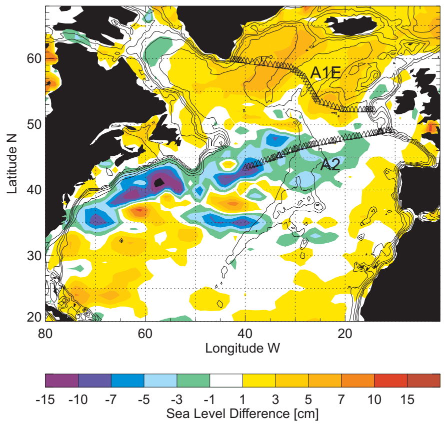


The dominant mode of atmospheric variability in the investigated area on interannual to decadal time scales is the North Atlantic Oscillation (NAO). A NAO High (Low) state is characterized by strong (weak) Icelandic Low and Azores High resulting in strong (weak) Westerlies.



The state of the NAO can be described by the NAO index [Hurrel, 1995] where a positive index represents a NAO High state. After several NAO High years the index turned abruptly negative in winter 1995/96. In order to investigate the accompanying oceanic changes we have constructed two data sets (High and Low) for each SL, geostrophic surface currents, sea surface heat fluxes, and wind stress curl.

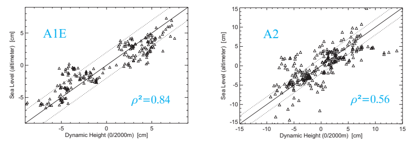
CHANGES IN SEA LEVEL: 'LOW-HIGH'



The difference of the mean SL between the Low (12/92-11/93) and the High (3/96-2/98) period is shown to the left. The SL of the subpolar gyre rose from the High to the Low period by ~5cm. At the same time the SL along the mean paths of Gulf Stream, Azores Current, and North Atlantic Current fell by up to 15cm.

Dynamic heights and SL deviations at section A1E (right) agree very well, which suggests that SL changes are mainly baroclinically induced. At section A2 the correlation is less pronounced - an indication that barotropic SL changes might be important in the northeastern subtropical gyre.

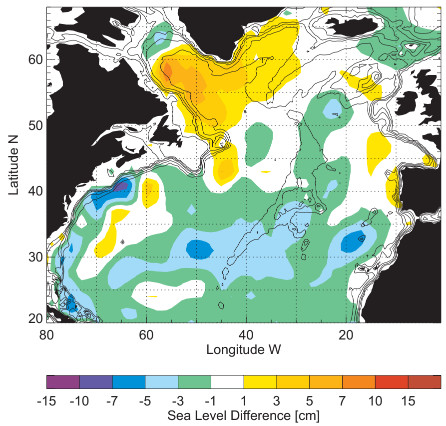
BAROCLINIC AND BAROTROPIC CHANGES



Dynamic height anomalies at A1E (4 repeat sections, courtesy of M. Bersch) and at A2 (5 repeat sections, courtesy of K. Lorbacher) are plotted against the corresponding SL deviations from altimetry (above). The slope of the solid line is 1, and the dashed lines mark error levels of ±2cm.

CHANGES IN ATMOSPHERIC FORCING: 'LOW-HIGH'

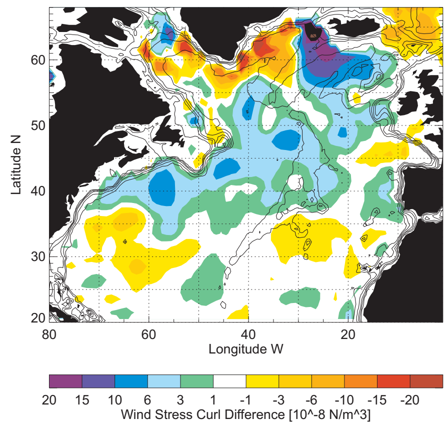
CHANGES DUE TO HEAT FLUXES



The difference of the mean SL between the Low and the High period calculated from NCEP-Reanalysis sea surface heat fluxes is shown to the left. The SL difference derived from the heat fluxes has only in the western subpolar gyre and in the northern subtropical gyre the right sign to explain the SL difference measured by altimetry.

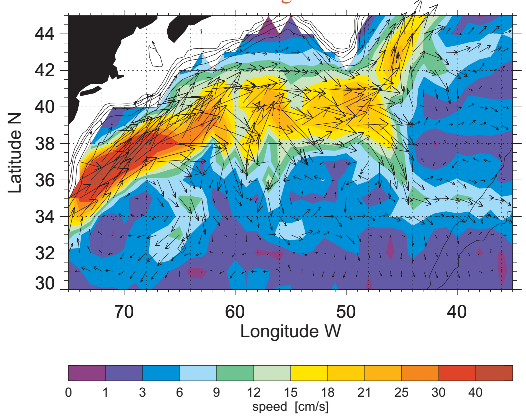
The changes in wind stress curl (Low-High) derived from ERS scatterometers [IFREMER, 1998] are shown to the right - note the reversed color axis. The changes in the Sargasso Sea, at the western subpolar gyre, and along the mean paths of Gulf Stream and North Atlantic Current can explain the observed SL differences qualitatively.

CHANGES IN WIND STRESS CURL

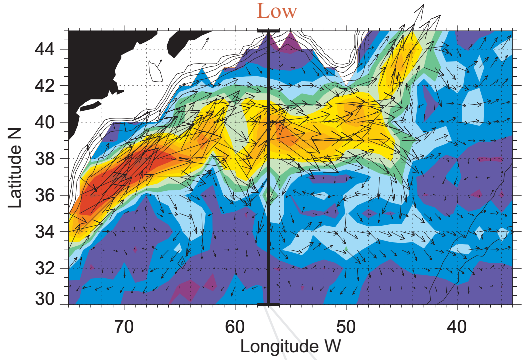


COMBINED CURRENTS: GULF STREAM

High



Low



COMBINED CURRENTS

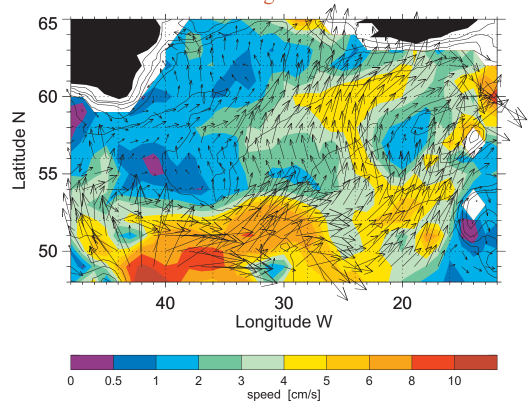
We have constructed mean geostrophic surface current for the High and Low periods. In order to show the surface circulation for the two periods we combine the velocity deviations from altimetry with long-term mean geostrophic surface currents. The mean currents at the sea surface referenced to 2 m have been calculated on the base of the hydrographic climatology of the WOCE Special Analysis Center [Gouretski and ancke, 1998]. The same method has been used for the calculation of monthly averaged surface currents at 57 W and 54 N.

CONCLUSIONS

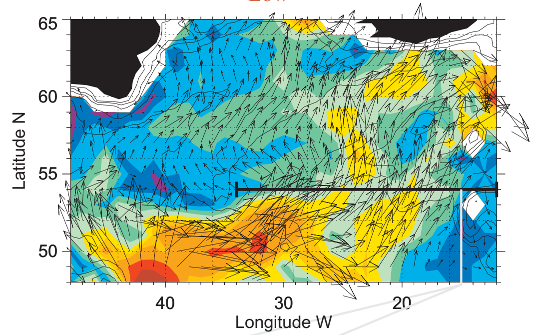
After 1995 the sea level in the subpolar gyre rose by ~5cm while the sea level in the northwestern subtropical gyre fell by up to 15cm. These changes were mainly caused by changes in wind and heat flux related to the strong negative pulse in the North Atlantic Oscillation. The role of advection needs to be further investigated. In the Gulf Stream area we have found increased surface velocities and a slight southward shift of stream core after 1995. The northward branches of the North Atlantic Current south of the Rockall Plateau seem to be slowed down and shifted to the west.

COMBINED CURRENTS: SUBPOLAR REGION

High

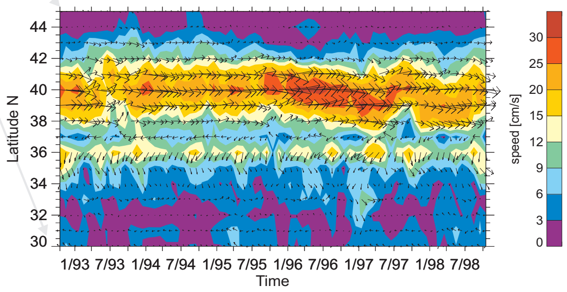


Low

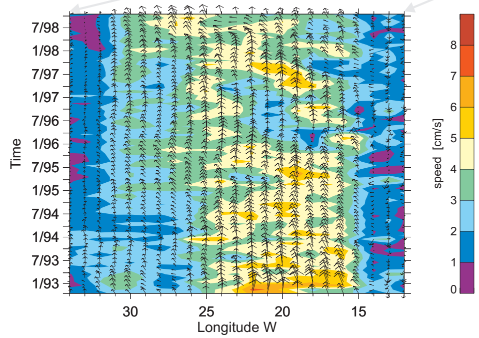


Downstream of 6 W the Gulf Stream seems to be accelerated and shifted to the south for the Low relative to the High period (above). The temporal development of position and speed of the Gulf Stream can be observed in more detail at the latitude-time plot at 57 W to the right. The arrows indicate the direction of the currents.

COMBINED CURRENTS AT 57 W



COMBINED CURRENTS AT 54 N



The northern branches of the North Atlantic Current seem to be decelerated and shifted to the west for the Low relative to the High period (above). The temporal development of position and speed of the Current branches can be observed in more detail at the longitude-time plot at 54 N to the left. The arrows indicate the direction of the currents.

REFERENCES:

AVISO, AVISO User handbook for sea level anomalies (SLAs), 1997.

Gouretski, V., and K. ancke, A new World Ocean Climatology: Ob ective Analysis on Neutral Surface, WOCE report No. 256/17, Hamburg, 1998.

Hurrel, .W., Decadal trends in the North Atlantic Oscillation: regional temperatures and precipation, Science 269,676-679, 1995.

IFREMER, Mean Surface Wind Fields - ERS-AMI and ADEOS-NSCAT Microwave Scatterometers, published for the WOCE Conference, Halifax, 1998.