**Ocean Science
Discussions**

Interactive
Comment

Interactive comment on "Temporal and spatial characteristics of sea surface heightvariability in the North Atlantic Ocean" *by* D. Cromwell

Anonymous Referee #2

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Results from a statistical investigation of North Atlantic SSH variability are presented. Complex EOF analysis is used to identify dominant cyclic or propagating patterns. Some of these patterns are described, and their time dependence is further investigated using a wavelet decomposition. Although the subject is interesting and important and most of the statistical analyses seem to be appropriate and well done, I find the discussion of the results somewhat disappointing. The paper contains interesting material, but more can and should be done in the area of interpretation and explanation.

My three main problems with this paper are:

1. There is very little physical discussion of the statistical outcomes.

2. I have my doubts on the added value given by the wavelet analysis.

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3. Statistical significance is claimed for very low correlations.

Ad 1)

a) No attempt is made to connect the patterns and time series found to physical mechanisms that might be behind the variability. The analysis is mostly confined to 'maxima here and minima there and then'. This is an interesting starting point for further investigation, as mentioned by the author in the last paragraph. The correlation analysis does not provide many answers, and although negative results can also be valuable, the statistical results by themselves are not enough to increase our understanding of North Atlantic variability.

b) Some of the patterns shown (such as the modes three and four of the first two CEOF analyses) are barely mentioned in the text. As the added value of this paper over the analysis of Fu (2004) is said to be in the investigation of these higher modes (page 615, first paragraph), I would expect more treatment, although some of the patterns seem to be so disorganized that they might not mean much physically.

c) As a connection between SSH variability and the East Atlantic Pattern is mentioned several times, I would suggest explaining a bit more on this pattern and how it might drive ocean variability. Can this mode of variability somehow be connected to some of the patterns, through displaced wind stress maxima or other atmospheric phenomena?

Ad 2)

a) The 'jumps' in phase, which are of course no real jumps as 360 equals 0 degrees, seem to strongly determine the results. An example is the analysis of figure 6, where in 2002 a slight change in phase angle causes a jump through 360 to just above 0 and back to 360. I am wondering if the wavelet analysis brings insights that cannot be gained from visual inspection of the phase lines themselves. The time between two phase-jumps seems to set the main frequency found. From figure 5A or 6A, one can see that the full cycles take 3, 2 and 3-4 years, which is more or less confirmed by the

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wavelet analysis.

b) A 'cone of influence' is drawn and its meaning is explained, but it is further neglected. In many cases the time series is too short to really resolve by the wavelet analysis the frequencies found to be dominant. In table 2, the dominant timescales are found to be between 2 and 5 years. For the 2-year timescale, only the period between 1995 and 2001 is not affected by edge effects, and for the 5-year timescale no part of the period is on the safe side of the cone of influence. In my opinion, this need not disqual-ify the results, but should warn one against interpreting some of the notable features mentioned in tables 1 and 2. Statements on amplitude peaks and more or less phase propagation should be made with proper care, preferably aided by other observations or a mechanistic explanation that could explain the variability.

c) Why are the amplitude time series of the PC's (the green lines in figs 2 and 5) not used in this analysis? These time series might provide good indicators of the relative strength of a particular mode in a particular period. They might be less affected by edge effects than the wavelet analyses, although the maxima are often the beginning and end of the period. Is this caused by the low-pass filtering working over a shorter period, thus being less of a low-pass filter? How are the beginning and end of the time series treated?

In some cases, the results seem to contradict each other:

- Table 1, mode 2: 'amplitude low in 1997', but normal in the PC amplitude. Also, in the lower panel of fig.3, the 2-4 year frequencies show a strong peak in 1997.

- Table 2, mode 2: a peak in 2001 is mentioned, whereas the amplitude time series peaks between 1996 and 2000.

Ad 3)

I have some doubts on the statistical significance testing, which finds 0.17 to be a

significant correlation. For this, one would need over a hundred degrees of freedom, which is very unrealistic given the strongly smoothed data. I would not consider more than, say, 25 samples to be statistically somewhat independent when smoothing a 12-year time series with a filter retaining frequencies over 18 months. For 25 samples, a correlation 0f 0.4 would be needed to be significant at the 95

Minor comments:

a) Page 615, lines 24-26, "However (...) the same" The pattern is very different from the first CEOF pattern shown by Fu (2004) in a rather similar analysis. How come? If the patterns are not the same, and there only "appears to be a degree of similarity", I would suggest to remove this sentence.

b) Page 615/616, "energy running northwards" Most of the arrows seem to point somewhere between 'north' and 'northwest'. I do not see the propagation, as off Spain arrows are pointing 'northwest' already. More analysis (such as a time-distance plot along a trajectory following the coast with the smoothed SSH fields) is needed to show such a subtropical-subpolar connection.

c) Page 617, par.2, "the NAO-related pattern found in Sect. 3.1" In section 3.1, the NAO is not mentioned and the patterns are found to be unlike that associated with the NAO.

d) Same paragraph Figure 4a looks very similar to the corresponding region in fig.1a, which also explains a similar fraction of the variability). Phases seem to differ however. Do the phase differences in EOF and PC compensate each other?

e) Section 3.2.2

- The 'trajectory' of Rossby waves is based on a statistical mode that describes 3

- Maybe the mode describes a higher fraction of the variance locally than it does over the total domain?

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- How is this trajectory, or path of higher variability, in other modes of comparable strength? (e.g. mode 4).

- Could we see the (baroclinically unstable?) Azores front/current here? (Such as is mentioned in [Cromwell, 2001, GRL].)

- Maybe this front slightly moves in time? Mode 3 seems to describe some variability present during 1996-1999. Is mode 4 concentrated over another period? Could such variability be associated with the EAP or other larger scale variability?

f) Please remove or more seriously deal with possible connections between the MOC and its variability and the present investigation. Now the MOC is mentioned to be important in the first and last sentences of the paper, and nowhere else a connection is made. Not everything has to be put into this framework, but if this is, please make a convincing point why.

g) Figure 1 is very small which makes it hard to really see what is shown.

Specific questions

1) Does the paper address relevant scientific questions within the scope of OS? YES

2) Does the paper present novel concepts, ideas, tools, or data? NO, BUT INTERESTING DATA ANALYSIS IS PERFORMED THAT MIGHT LEAD TO NOVEL IDEAS.

3) Are substantial conclusions reached? NO

4) Are the scientific methods and assumptions valid and clearly outlined? YES (EXCEPT FOR SIGNIFICANCE TESTING OF THE CORRELATIONS IN 3.3)

5) Are the results sufficient to support the interpretations and conclusions? THE PAPER WOULD BENEFIT FROM MORE INTERPRETATIONS AND CONCLUSIONS.

6) Is the description of experiments and calculations sufficiently complete and precise to allow their reproduction by fellow scientists (traceability of results)? YES

7) Do the authors give proper credit to related work and clearly indicate their own new/original contribution? YES

8) Does the title clearly reflect the contents of the paper? YES

9) Does the abstract provide a concise and complete summary? YES

10) Is the overall presentation well structured and clear? YES

11) Is the language fluent and precise? YES

12) Are mathematical formulae, symbols, abbreviations, and units correctly defined and used? N.A.

13) Should any parts of the paper (text, formulae, figures, tables) be clarified, reduced, combined, or eliminated? NO

14) Are the number and quality of references appropriate? YES

Interactive comment on Ocean Sci. Discuss., 3, 609, 2006.

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