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Ocean Science Discussions

Interactive comment on "DINEOF reconstruction of clouded images including error maps. Application to the Sea-Surface Temperature around Corsican Island" *by* J.-M. Beckers et al.

J.-M. Beckers et al.

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We thank the reviewer for his carefull reading and commenting of our paper. Since some of the remarks concour with those of other reviewers we will keep some answers short.

GENERAL COMMENTS The mathematics included in sections 2 to 5, although crucial to this work, are not easy to digest by common oceanographers. I myself had problems following them, especially in section 5! I concur with the other reviewers of the OSD that some of them must be moved to an appendix in order to make the overall paper more readable. Please keep the essential maths in the main text, eventually with better explanations to help readers with less mathematical background. **Response:** We will relegate the square root calculation (35) to (37) into the appendix as well the asymptotic expansions (39) to (49) (for large and small S/N ratio), only referring to it as showing the importance of the factor $mu^2N/(m_p\sigma^2)$ in the error fields. Also a little bit more basic explanations on OI and EOF will be provided, or at least standard EOF properties will be identified as such by proper references. Your request is somehow at incompatible with the demand of reviewer II to use data assimilation notation. The latter generally assumes the reader is familiar with OI and EOFs. Preferring clarity, we will keep our original notations and add further explanations on the method.

Please add somewhere in the text that DINEOF and extended DINEOF are not able to reconstruct entirely cloudy images whereas OI can if both spatial and temporal decorrelation scales are known. Maybe the missing images can be obtained by interpolation of the EOF amplitudes in time, but this involves the choice of a temporal decorrelation scale. **Response:** Absolutely right. We will add a comment in this sense. Concerning time interpolation via interpolation of EOF amplitudes, this is of course the way to do it. The choice of decorrelation time-scale for the interpolation can then be taken similar to the one that would be used in OI.

By comparing Figs. 3a and 3b, it appears that, in addition to the reconstruction of the missing values, some kind of spatial smoothing has been applied to the image since the data structure (e.g., near 43N and 7.5E has disappeared. If this is true, this should be explained and motivated in the text. **Response:** Right. But OI also would filter out some of the signal. Here the signals that are filtered are those that the method is not able to reconstruct should a cloud of similar shape and size as other clouds be present (this is how cross validation has truncated, or filtered, the representation). Note that if you trust those features (note however how close they are to cloud edges), you could interpolate data only in the missing data points and keep the original data at unclouded pixels, though this would lead to inconsistent statistics of the picture's pixels.

To show the strength of the extended DINEOF method I would also show the results on the inter-annual SST variability (Figs 9 to 11) as calculated from the original (non

OSD

3, S354–S358, 2006

interpolated) images, and I would discuss the differences quantitatively using the error estimates obtained with the reconstructed images. **Response:** Graphically, the time series is not very different , specially of low-pass filter is used. This is why we chosed not to show them. The error estimates are however very different and in reality the brute force approach leads to a field that is outside the error bar of DINEOF analysis. This is what we explained in the last paragraph. Stated differently: The brute force approach with its error bar for the mean around the signal has no intersection with the dineof version and its error bars (independently how we estimate this error: from the standard variation of the data or the typical error of sensors 0.3 divided by the square root of number of data. Even applying an inflation factor to this, which amounts to use the number of independant data only in the estimation of the error on the mean, the same conclusion holds). Hence we must admit that both time series are significantly different. We will expland the paragraph. an possibly add some images.

Page 737 Line 11. "not too large gaps": relative to what? **Response:** This is the phrasing used in the paper we cite. In their problem (CFD at high Reynolds numbers), 50 % gappyness starts to be "large".

Page 741. Lines 23 and 24. Eqn. 13 and math expressions before are not clear and must be derived in more details. **Response:** EOFs are orthogonormal, so the norm of the original matrix (ie its total variabily, the sum of all data squares) equals the sum of the squared singular values. When using only a few EOFs, the sum of the squared singular values divided by the total variability is the fraction of the variance explained by the first EOFs. This is a well known property of EOFs (REFERENCE). If we define σ^2 as the variance of the signal and consider N EOFs responsible for the signal, the (13) is obvious. Probably moving the information we assumed that the first N EOFs contain signals and the remaining EOFS some noise earlier into text will make things more readily understood. *Page 742. Lines 2 and 3. "because the reconstructions is only valid E? , but (13) remains valid". This is not obvious to me, please clarify.* **Response:** For the higher EOFs, the property is not valid, because the EOFs themself

OSD

3, S354–S358, 2006

Interactive Comment

are not correct. For the signal part, event if the higher EOFs are incorrect, they are still orthogonal to the first N, so that the first N EOFs still account for the fraction of the variance as explained.

Page 743. Lines 6 and 7. "we assumed that the first N EOFs contain signals and the remaining EOFS some noise". This important information should have been clearly stated before! **Response** Ok, see above

Page 752. Line 12. Change to the " the SST seasonal cycle in the Ligurian". **Response** OK

Page 752. Line 14. The modified AW is generally colder that the Med waters. Are you sure that we have modified AW north of the front? I would put the cooler AW south of the front? Also, please add references to support this statement. **Response** Modified Atlantic Water (MAW) is the name given to the surface water mass of the Mediterranean, that originally enters the Gibraltar Strait at the surface. This water mass travels anticlockwise through the Mediterranean, so when it reaches the Ligurian Sea through the Corsican Strait its initial characteristics have changed substantially. The reviewer may refer to the same water mass when it refers to it as "Mediterranean Waters". Some authors (e.g Astraldi et al 1999) refer to this water mass as MAW. The current CIESM classification refers to it as AW (Atlantic Water). In any case, on average, the waters in the central Ligurian Sea are colder than those at nearer the coast (see Medar climatology for example). The text will be adapted.

Page 752. Line 18. Which main characteristics? The WCC, ECC and NC? Clarify. **Response** We meant "patterns", or "currents contributing to the circulation in the Ligurian Sea". Will be corrected

Page 756. Lines 4-5. Why can we expect that the SST scale is larger (same magnitude) than the SST error length scale? Please explain in text. **Response** We thought it reasonable, because this is what we are used to for in situ data. But you are right that for satellite images this is not necessarely true. But then the problem becomes more

OSD

3, S354–S358, 2006

Interactive Comment

and more difficult when the errors have similar structures or scales than the data. To separate the two is then almost a mission impossible, unless you have a very clear idea on the error structure. We will add a comment in the text.

Page 756. Lines 13-14. Explain how an internal Rossby number of 4-7 km can give a wavelength of 25-44 km. **Response** Same response as for Damia Gomis: For a baroclinic instability and the standard definition of the deformation radius, the most unstable wavelength is found around 6 times the deformation radius. Different factors arise for different base currents and/or different definitions of the deformation radius, but the order of magnitude "several times" the deformation radius remains. I think we will just add a reference to Cushman-Roisins GFD book.

Page 761. Line 4. Add that the highest error appears in winter because it is during this season that we have the minimum number of images (I presume!). **Response**: the comment is already in the original text: "The seasonality of the error estimation is due to the cloud coverage. The unfiltered error estimation correlates to 0.85 with the fraction of missing data. The correlation between the filtered error estimation and the filtered fraction of missing data is 0.92". It is rather the fact that for each image, there are more clouds in winter than in summer that explains the higher errors in winter. We will add a concluding phrase in this sense to the paragraph. *Page 766. Figure 1. Please indicate by a rectangle the location of the study area in the whole Med inset. Add the following names to help with geography: Tyrrhenian and Ligurian Seas, Sardinia, Corsica, France. Please show the typical location of the Liguro-Provencal Front.* **Response** Will be done.

OSD

3, S354–S358, 2006