

DINEOF univariate reconstruction of missing satellite data from the North Sea Belcolour-1 database.



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1. Abstract

Space-time filling of the gaps in satellite data archives caused by clouds or other retrieval problems is necessary for various ecosystem studies. This study demonstrates use of the Data Interpolation with Empirical Orthogonal Functions (DINEOF) method for reconstruction of complete space-time information for a 4-year archive of surface chlorophyll a (CHL) and total suspended matter (TSM) images of the Southern North Sea and English Channel derived from MERIS sensor. These data are part of the Belcolour-1 archive of ocean colour satellite imagery (<http://www.mumm.ac.be/BELCOLOUR/>). For the CHL, The complete reconstruction of this data archive is achieved from 7 dominant modes for CHL and from 19 dominant modes for TSM. Each of these modes are described by a spatial EOF (2D map) and a corresponding temporal EOF (1D time series, also called the EOF amplitudes). By reconstruction, weekly averaged fields are illustrated for typical situations, together with time series at two reference stations (the turbidity maximum in the Scheelde river plume, Belgian coast and the CEFAS buoy 'West G' off the south-east English coast).

2. DINEOF analysis of 4 years of MERIS CHL and TSM

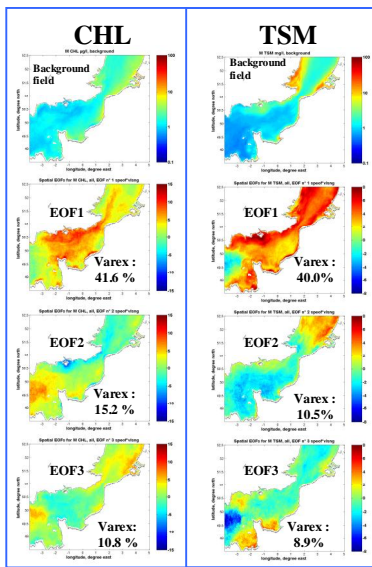


Fig.1 Background fields (top) and first three spatial modes

DINEOF is an efficient methodology allowing to calculate missing data in geophysical datasets without requiring a priori knowledge about statistics of the full data set (Beckers and Rixen, 2003). Well suited to the processing of remote sensing archives, It was successfully applied to SST reconstructions (Alvera Azcárate et al, 2005). Here, DINEOF is applied to the colour remote sensing products MERIS TSM and CHL. The log10 of these parameters was used prior to treatment. Data were further processed as anomalies around the background field (fig.1- top), before being submitted to DINEOF analysis.

Optimal reconstructions were obtained when synthesising the original signals into 7 modes for the CHL and into 19 modes for the TSM. The variability of the original signal explained by the EOF synthesis reached 93 % for CHL and 97 % for TSM. The 3 dominant spatial EOFs are illustrated in figure 1 for CHL and TSM, with mention of the variability of the original signal explained by each EOF (parameter 'varex'). For these 3 dominant modes, the corresponding temporal EOFs are given in figure 2 for TSM and in figure 3 for CHL.

The first TSM mode shows a clear seasonal signal, indicating general increase of TSM for most part of the area in winter due to stronger resuspension, and a general decrease in summer, relatively to the background field. The contribution of the second TSM mode represent a relative enrichment in the Southern North Sea and depletion in the central English Channel, occurring mostly during fall and winter, while an opposite phase occurs mostly during early summer.

The first CHL mode shows a general concentration increase over the domain, more important off southern England and in the central English Channel. The temporal evolution of this mode is rather complex to be identified as a repeated blooming event. The contribution of the second CHL mode represent mainly an enrichment in the western part of the English Channel and a depletion in the south-eastern coast of England. Positive pics of the second temporal mode occur more frequently in april and end summer.

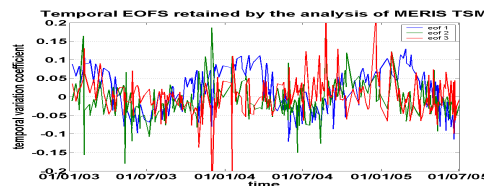


Fig.2 3 first temporal modes for TSM

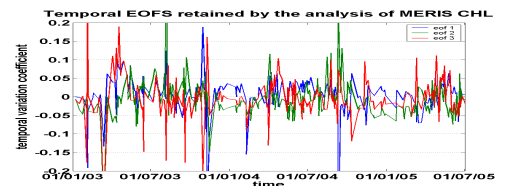


Fig.3 3 first temporal modes for CHL

3. Original and filled images, weekly mean fields and time series at reference stations

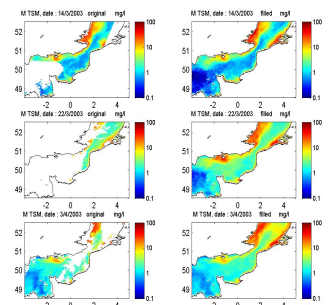


Fig.4 Original (left) versus filled (right) TSM images

At the time of each original image, a corresponding filled image can be reproduced (ie. Fig.4) as the sum of :

- the background field (2D field)
- the global mean anomaly around the background field (scalar deduced from the anomaly dataset prior to DINEOF analysis)
- the sum over all EOFs, of the products : spatial EOF (2D field of coefficients) * singular value the EOF (scalar weight) * value of the temporal EOF coefficient at the moment of the original image

Similarly, full fields can be produced at any time by introducing a linear interpolation between temporal EOF coefficients obtained at recorded image dates. Such daily reconstructions were used to produce weekly averaged fields of TSM and CHL, as illustrated in figure 5 for typical situations: (a) the high level of winter TSM concentrations is correlated with bathymetry, (b) lower level of summer TSM concentration except at estuaries, (c) generally low winter CHL content with slight increasing gradients towards the coasts and from the western english channel towards the southern North Sea, (d) high concentrations of a spring bloom event

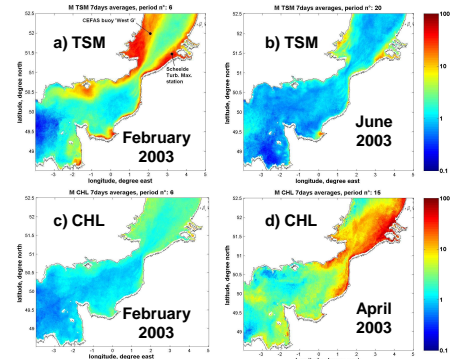


Fig.5 Typical weekly averaged reconstructed fields for TSM and CHL

From these weekly averaged reconstructed fields, continuous time series can be extracted at any reference station as illustrated in figure 6 for the Scheelde plume turbidity maximum station and for the CEFAS buoy 'WestG' (positions on fig.5a).

These time series show :

- higher TSM and CHL concentration of the Scheelde plume station regarding to the 'WestG' station,
- the onset of the spring blooms following shortly the spring reduction of TSM,
- the unusually intense 2003 spring bloom in the Scheelde plume. This event can be linked to the unusual levels of PAR light and Phosphorus concentrations described by Borges et al. (2008).

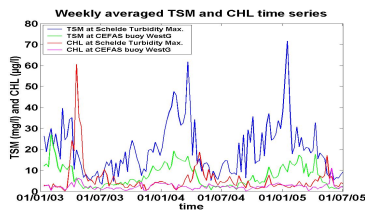


Fig.6 Weekly averaged reconstructions at reference stations

More Information on DINEOF at : <http://groups.google.com/group/dineof>

Acknowledgments

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References

- J.M. Beckers and M. Rixen. 2003. EOF Calculations and Data Filling from Incomplete Oceanographic Datasets. Journal of Atmospheric and Oceanic Technology, 20:1839-1856.
- A. Alvera Azcárate, A. Barth, M. Rixen, and J. M. Beckers. 2005. Reconstruction of incomplete oceanographic data sets using Empirical Orthogonal Functions. Application to the Adriatic Sea surface temperature. Ocean Modelling, 9:325-346.
- Borges A.V., K. Ruddick, L.-S. Schiettecatte & B. Delille (2008) Net ecosystem production and carbon dioxide fluxes in the Scheldt estuarine plume, BMC Ecology, pending acceptance