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fronts
Recognition and analysis of time series derived from satellite data

Detection and Analysis of Fronts in the North Sea

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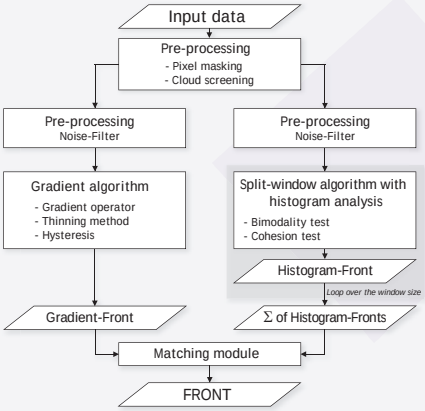
Project Overview

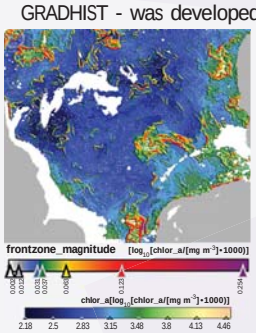
The project **FRONTS** is focussing on evaluating long time series of satellite observations to establish a front climatology of the North Sea, and to study derived statistical quantities with respect to potential climate change impact. It is conducted in the framework of the German national KLIWAS project, which has been initiated by the Federal Ministry of Transport, Building and Urban Development in order to assess the impact of climate change on river, coastal and ocean water ways.

KLIWAS
Klima · Wasser · Schifffahrt

GRADHIST: Method, Validation & Test



Oceanic fronts are regions where certain properties of sea water such as SST, total suspended matter (TSM) or chlorophyll concentration change significantly over a relatively short horizontal distance of some hundred meters to a few kilometres. These property changes are the key feature used by the algorithms for the detection of fronts and their spatial structures. In the FRONTS project, a new approach - GRADHIST - was developed which combines and modifies the gradient algorithm of Canny (1986) and the histogram algorithm of Cayula and Cornillon (1992) in order to improve the front detection ability. The flowchart above outlines the processing chain of GRADHIST which includes three steps: pre-processing including pixel identification and noise filtering, application of the modified gradient and histogram algorithms, matching module.



Chlorophyll field and chlorophyll fronts in the northern part of the North Sea: fronts identified by GRADHIST (MODIS AQUA, 2012.05.23, 12:30)

Validation is performed to assess the accuracy, effectiveness and quality of the different algorithms. Synthetic data have been used for an absolute assessment of front detection. Furthermore, only real satellite images with their own complexity and variability of quality on different temporal and spatial scales allow for a testing of the applicability of GRADHIST and a comparison with other front detection algorithms.

Acknowledgement
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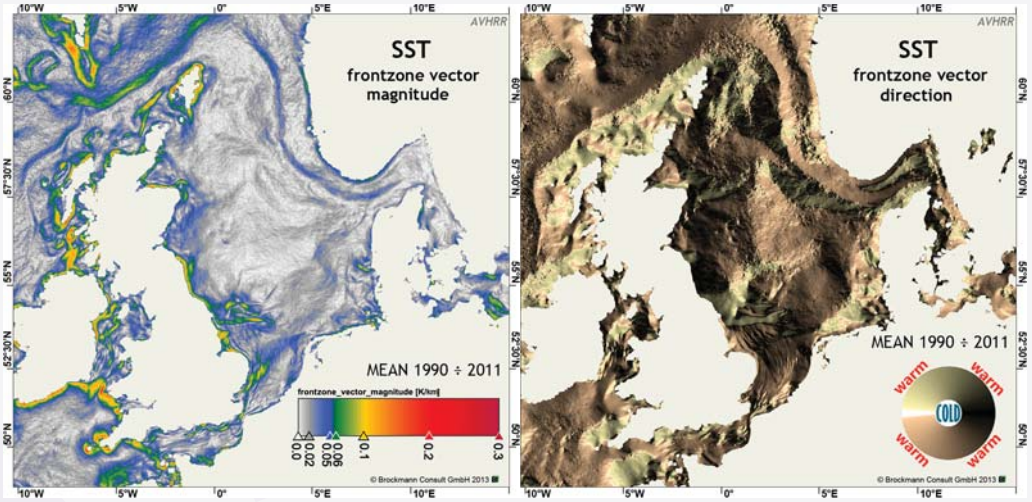


Statistics for SST front gradient vector magnitude and direction (AVHRR, 1999-2011)

Temporal Statistic

After computation of the gradient magnitude and gradient direction for each image, a set of statistical measures was computed for SST and OC front products.

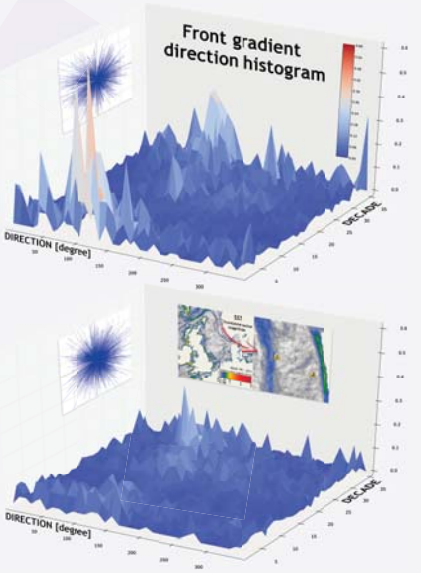
Monthly statistics for SST front gradient vector magnitude (AVHRR, 1999-2011)

One measure is the magnitude of mean SST parameter gradient vector for the front over a time interval per pixel:

$$|\overline{\nabla SST}| = \left| \frac{\sum_t^{N_{front\_obs}} \nabla SST_t}{N_{front\_obs}} \right|$$

The direction of mean SST parameter gradient vector for the front over a time interval per pixel is defined as:

$$Dir.\,\overline{\nabla SST} = \frac{\sum_t^{N_{front\_obs}} \nabla SST_t}{N_{front\_obs}}$$

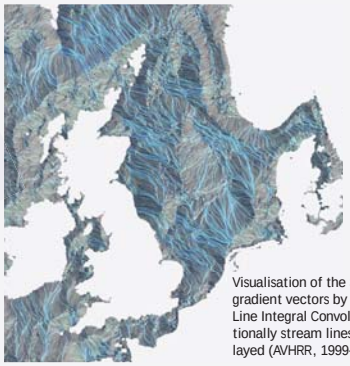


Distribution of the SST front gradient vectors and 2D histogram of the direction of the SST front gradient vectors and decades for two selected locations (p1: 60.40543°N, 3.301203°E; p2: 60.31009°N, 4.313275°E) and retrieved from the AVHRR data 1990 – 2011)

Conclusion

Three areas in the North Sea have been identified where inflow and penetration mechanisms of different water masses occur: The inflow of the Baltic Sea water, the exchange with the North Atlantic water and the river plume of the Elbe River. Horizontal scales of structures of interest have been investigated w.r.t. sensor characteristics available as well as location, type of front and wind field. Questions can be answered concerning the characteristic temporal scales of the occurrence and the location of fronts. Here, the changed wind regime and the global warming have to be taken into account.


Visualisation of SST front gradient vector in the southwest of Cornwall.


Visualisation of the SST front gradient vectors by using the Line Integral Convolution, additionally stream lines are overlayed (AVHRR, 1999-2011).

References
Canny, J.F. (1986). A computational approach to edge detection. IEEE Transactions on Pattern Analysis and Machine Intelligence 8(6), 679–698.
Cayula J.-F. and Cornillon P. (1992). Edge detection algorithm for SST images. Journal of Atmospheric and Oceanic Technology 9(1), 67–80.
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