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Frontal climatology based on advanced very high resolution radiometer sea surface temperatures in the eastern North Sea

Anne E. Lucas and W. Paul Budgell

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In an attempt to map the distribution of fronts within the North Sea, a two-pass filtering technique is used to identify temperature gradients on NOAA-AVHRR SST data. Even with 8-day, 9-km resolution, seasonal trends in frontal regimes can be identified.

Keywords: AVHRR, fronts, GIS, SST.

A. E. Lucas: Department of Geography, University of Bergen, Breiviksveien 40, NO-5045 Bergen, Norway [tel: +47 55 959659; fax: +47 55 959393; e-mail: anne.lucas@geog.uib.no]; W. P. Budgell: Institute of Marine Research, PO Box 1870, Nordnes, NO-5817 Bergen, Norway [tel: +47 55 238628; fax: +47 55 238584; e-mail: paul.budgell@imr.no]. Correspondence to A. E. Lucas.

Introduction

The remote sensing component of the EU LIFECO project (available at http://www.lifeco.dk) involves mapping and characterizing frontal conditions in the North Sea and Skagerrak from advanced very high resolution radiometer (AVHRR) sea surface temperature (SST) imagery. The mapped frontal distributions are to be used as a basis for the interpretation of biomass and fisheries recruitment data. This article describes the methodology used to identify areas prone to frontal activity as defined by steep temperature gradients.

Materials

SST data have been obtained from the Physical Oceanography Distributed Active Archive (PODAAC, available at http://podaac.jpl.nasa.gov) and processed through a suite of spatial tools, including Matlab 6.1, ENVI/IDL 3.4, and MFWorks 2.6. The daytime satellite passes are processed as 8-day 9-km composites from the original GAC imagery (with a nominal 4-km spatial resolution) for the period 1990–1999 and subsetted to cover the area shown in Figure 1. For each 8-day period, missing data (or cloud contaminated pixels) are removed from the analysis. Data are scaled to yield SST values from –3°C to 30°C (PODAAC, 1999).

Methods

The present analysis investigates long-term large-scale patterns as captured by the 8-day averages for the 10-year time-series. Interannual variability will be dealt with elsewhere.

Frontal areas are identified using a GIS-based two-pass filter method. In the first stage, a low-pass filter with a 3×3 kernel is used to reduce high frequency noise through spatial averaging. In the second pass, a standard 3×3 Sobel filter based on the gradient discontinuity identifies edges and is sensitive to changes in both the horizontal and vertical directions (Jensen, 1986).

Prior to running the filter procedure, each data set was interpolated landwards using an inverse distance algorithm. This allowed the filter procedure to relax smoothly at the shoreline, effectively eliminating edge detection at the land/water boundary. At the same time, the few remaining cloud-covered pixels were also filled.

Results

The 46 resultant maps were overlain with bathymetric data. A temporal analysis of the data indicates that there are three areas of interest; the area associated with the shelf break around southern Norway, Dogger Bank and the inflow through the English Channel. These are indicated on Figure 1. In each

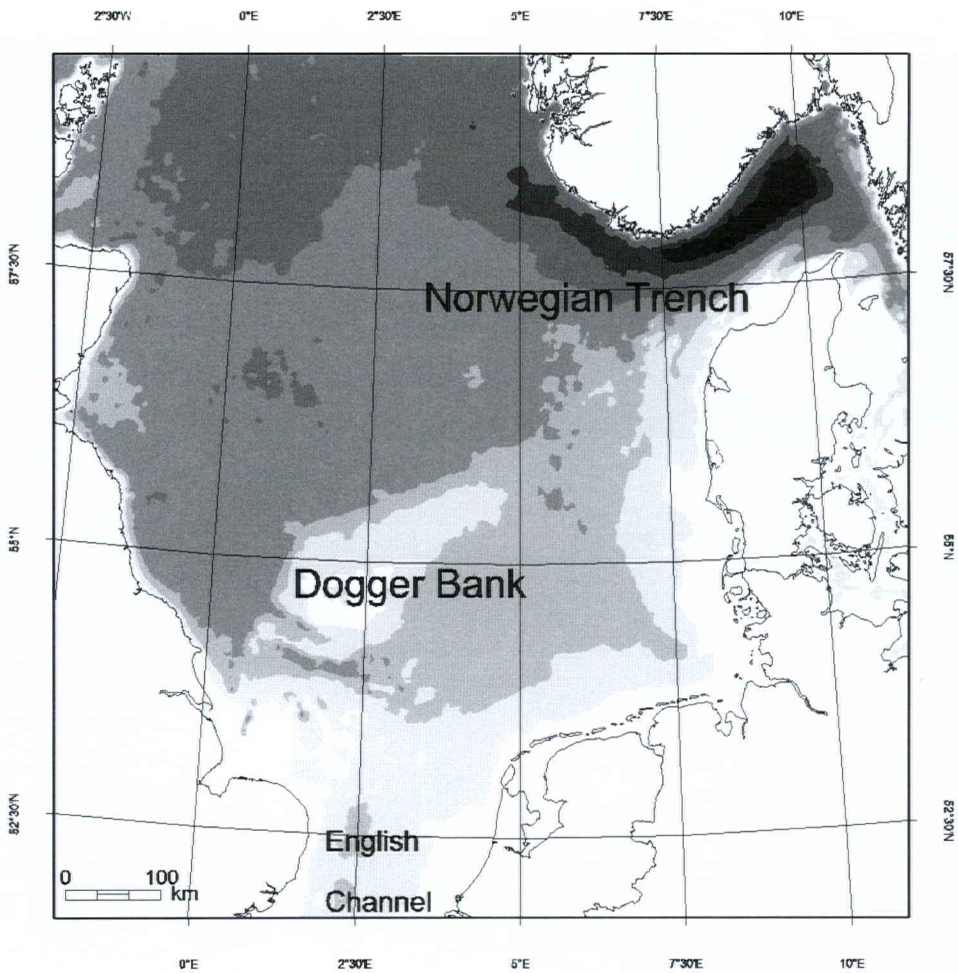

Figure 1. Location map with bathymetry. Deepest (darkest) areas exceed 600 m. Dogger Bank has an average depth of 29 m.

case, the frontal regime exhibited strong temperature gradients and high variability throughout the seasonal cycle.

At the shelf break, temperature gradients are strongest during the winter months (periods 1–16, 43–46), producing a nearly continuous zone of frontal activity. By mid-May the temperature gradients have weakened and the appearance through the summer is a more confused (or complex) state.

The inflow through the English Channel varies from a bifurcated state during the winter to stronger temperature gradients on the north side by period 10. During the spring and summer, the pattern reverses, such that there is a broad zone of intense temperature gradients on the south side of the channel.

The area around Dogger Bank shows the most complex regime. Frontal activity is most intense on the south slope during the winter. By early spring the northeast slope shows most activity, after which there is a period of calm. The fronts return late May on the south and southwest slope. A number of these features are illustrated in the frontal distribution map from period 6, shown in Figure 2.

Discussion

Even at this spatial and temporal scale, patterns emerge. The seasonal development of frontal regimes is repeated consistently over the decadal analysis period. The distribution of fronts through time and space is more complex than had been anticipated, based on the frontal distribution shown in Becker (1981). Future analysis will investigate the interannual variability of the distribution and intensity of frontal activity.

SST values inferred from AVHRR may be representative of only the upper few millimeters of the water column; surface effects can mask the horizontal structure of temperature through the upper layer (Cracknell, 1999). Furthermore, thermal fronts are not necessarily dynamical fronts; density will not

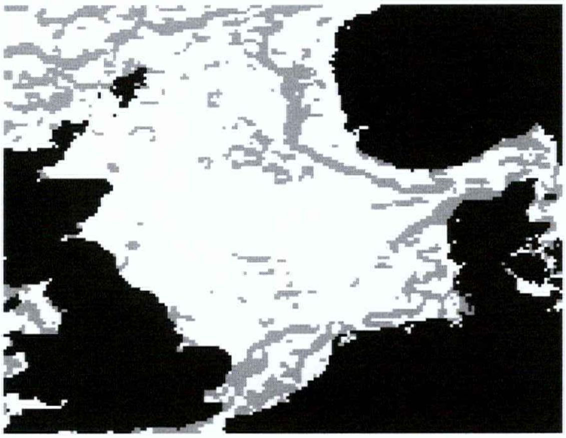

Figure 2. Sample output from period 6. Areas of high frontal activity are shown in grey. Other water areas have been masked out and appear white. Land areas are black.

vary across the front if salinity variations compensate for the temperature gradient. For these reasons, it is wise to supplement the SST analysis with other data sources.

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