FRONT: Front-Resolving Observational Network with Telemetry

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LONG-TERM GOALS

The goal of this National Ocean Partnership Program is to develop an autonomous network of ocean sensors that telemeter their physical and biological data to shore in real-time with cutting edge communication technologies. With additional remotely sensed data (satellite measurements of temperature and color and shore-based high-frequency radar (CODAR) measurements of surface currents), these data streams will be assimilated into physical and biological models to predict the 4-dimensional properties of a limited coastal region. The accuracy of the assimilated products will be tested with data from a series of high-resolution ship surveys. Additional measurements of turbulence and other small-scale properties will be used to aid the eddy diffusivity parameterizations used in the data assimilation model.

OBJECTIVES

The objectives of the URI component of the FRONT project is to produce maps of SeaWiFS-derived phytoplankton chlorophyll distributions, sea-surface temperature (SST) and surface currents for the data assimilation model. The URI group will also undertake regional surveys of the hydrographic fields at several times during the project.

In addition to these data products, we will examine the variability of SeaWiFS-derived phytoplankton chlorophyll distributions and its coupling to physical processes in the FRONT region. We will compare pigment fronts with thermal fronts and other collected in situ data sets to examine the biophysical

coupling. We will attempt to understand the mechanism(s) of formation and the dynamical significance of mid-shelf SST fronts. The turbulence (microstructure) measurements will be used to examine the best way to parameterize the mixing processes for the modelling work. Also, we will develop improved methods of obtaining surface currents from the CODAR radar backscatter measurements.

APPROACH

Using SeaWiFS ocean color images, maps of phytoplankton pigment (chlorophyll) in and near our study site will be produced. These images have been processed using NASA's software processing package, SeaDAS. Thermal images covering the same time-period and the same study area are available from the URI Satellite Archive. The annual cycles of chlorophyll and sea-surface temperature patterns and their distributions will be used to study the variability and co-variability between chlorophyll, sea surface temperature and other collected data sets as part of this project.

CODAR stations will be established to measure surface currents in a region where SST fronts occur. We will analyze concurrent AVHRR SST images for the occurrence of fronts within the range of CODAR. The CODAR-derived velocities will be combined with SST to estimate the rate of change of horizontal SST gradients (frontogenic tendency) due to the action of the horizontal deformation field.

Measurements of conductivity microstructure obtained on a towed body will be compared to turbulence measurements from an AUV operated by Dr. Edward Levine (NUWC). Estimates of mixing rates will be investigated in context of the larger hydrographic fields, especially in the vicinity of the fronts.

Improvements to the determination of surface currents using the CODAR data will be investigated by the use of global smoothness constraints to remove the present ambiguity inherent in the currently used CODAR algorithm.

WORK COMPLETED

In early June, 2000 we completed the installation of CODAR HF surface current mapping radars at three sites (Block Island, RI; Misquamicut Beach, RI and Montauk Point, NY) covering the NOPP FRONT region of interest. Measurement of the receive antenna patterns has been carried out with the resulting patterns found to be close to ideal, suggesting that the site locations are adequate. The region with greater than 90% coverage extends from Block Island Sound to about 30 km south of the line between Block Island and Montauk Point.

Real time transfer of radial velocity files from the three remote sites to the central site at URI is being achieved via cellular data modems. We have experienced some difficulty with file transfers from one of the sites (Block Island) and are currently attempting to identify and correct the problem.

Preliminary analysis of the CODAR velocity data was carried out by an undergraduate student supported by the Summer Undergraduate Research Fellow in Oceanography program at URI. Harmonic analysis was performed on a 1.5 month segment of data and the resulting tidal ellipses are presently being compared with model results generated by Philip Bogden and Chris Edwards at the University of Connecticut (UCONN). Comparison of CODAR velocities with in situ ADCP data has been performed in collaboration with Dan Codiga (UCONN).

In collaboration with UCONN workers, we are posting real-time CODAR maps on the web (available off the main FRONT web site at http://nopp.uconn.edu). Work is presently underway to make these data available through the Distributed Oceanographic Data System (DODS).

During the past year we have set up the processing path for real-time SST images provided by the University of Miami satellite group. These images are manually navigated and are then passed through the URI declouding algorithm. The images are posted on the web at the main FRONT web site.

Earlier this year, the annual reprocessing of all SeaWiFS data to date was scheduled to be released by the SeaWiFS Project Office at NASA. Annual reprocessings are deemed necessary as improvements are made to instrument calibration issues (e.g. time-dependent corrections, temperature corrections/ calibrations etc), band offsets are adjusted, product retrieval algorithms are updated, and other sensor problems are addressed and evaluated. The aim of these reprocessings is to improve the quality of the retrievals including the chlorophyll retrieval. Initially this reprocessing was scheduled for 1999 but was delayed and did not happen until mid-2000. Due to this reprocessing, a new time-series of reprocessed SeaWiFS images for this study is being assembled. At this time, quality-controlling of each image to check for any problems or artifacts in the chlorophyll maps is underway. The first few months of images are completed.

A towed body, the Acrobat, was obtained along with the necessary ancillary equipment. During a test cruise, the tow cable parted at the termination and the towed body and CTD were lost. Since the cable parted well below its breaking load, Sea Sciences has agreed to replace the towed body and redo the cable termination (the cable manufacturer did the previous termination). We hope to receive the new equipment shortly.

RESULTS

The comparison between CODAR and ADCP velocities has shown RMS differences of 10-15 cm/s, which is in line with similar comparisons done at other CODAR sites. This leads us to believe that CODAR is providing us with a reasonable picture of the surface circulation in the NOPP FRONT study area.

Preliminary analysis of CODAR velocity data has shown strong correlation between the non-tidal flow and wind, particularly in the along-shelf direction (east-west). The spatial structure of the non-tidal flow has also been found to correlate extremely well with the persistent SST frontal structure that has been observed in retrospective SST analysis (Fig. 1). The current jet seen flowing southwest past Block Island is coincident with the SST front separating warm offshore water from cooler inshore water. Evidence of mean outflow from Long Island Sound is also observed. These observations suggest that the jet is associated with the outflow of cool (and presumably fresh) water from the Sound.

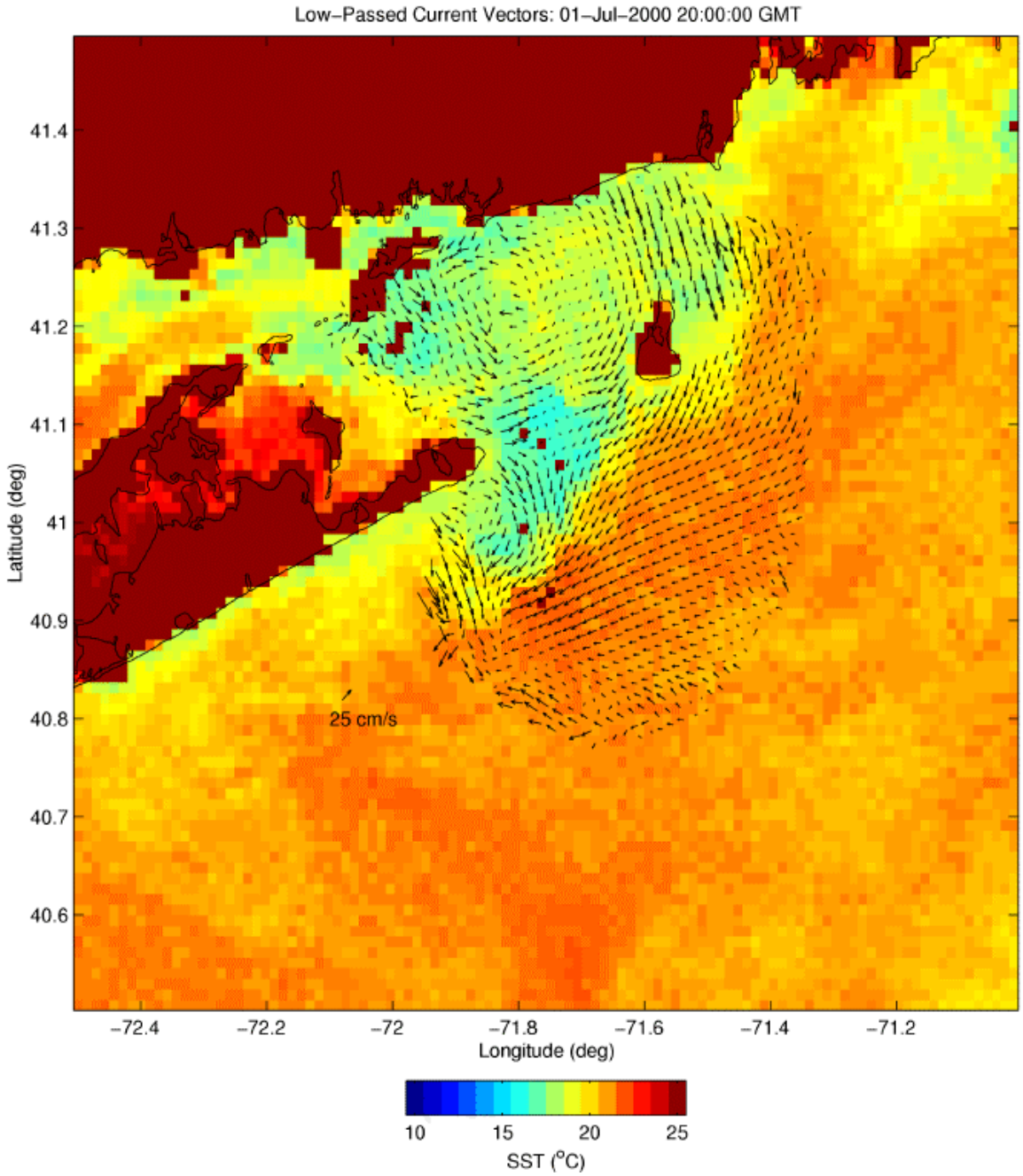

Figure 1. AVHRR Sea Surface Temperature (SST) from 20:12 GMT on July 1, 2000 with low-pass filtered CODAR current vectors overplotted.

Quality-controlling of the reprocessed SeaWiFS images is ongoing. Progress have also been made in the coding for the frontal edge-detection routines. The frontal edge-detection algorithm has been tested on a few selected images during the period when CODAR data is available. These are the first attempts to compare CODAR results with SST and chlorophyll maps. For example, on July 1, 2000, there is an increased chlorophyll concentration adjacent to the south coast of Long Island and surrounding Block Island (Fig. 2). The chlorophyll front shows correspondence to cooler waters as seen in the SST figure (Fig. 1).

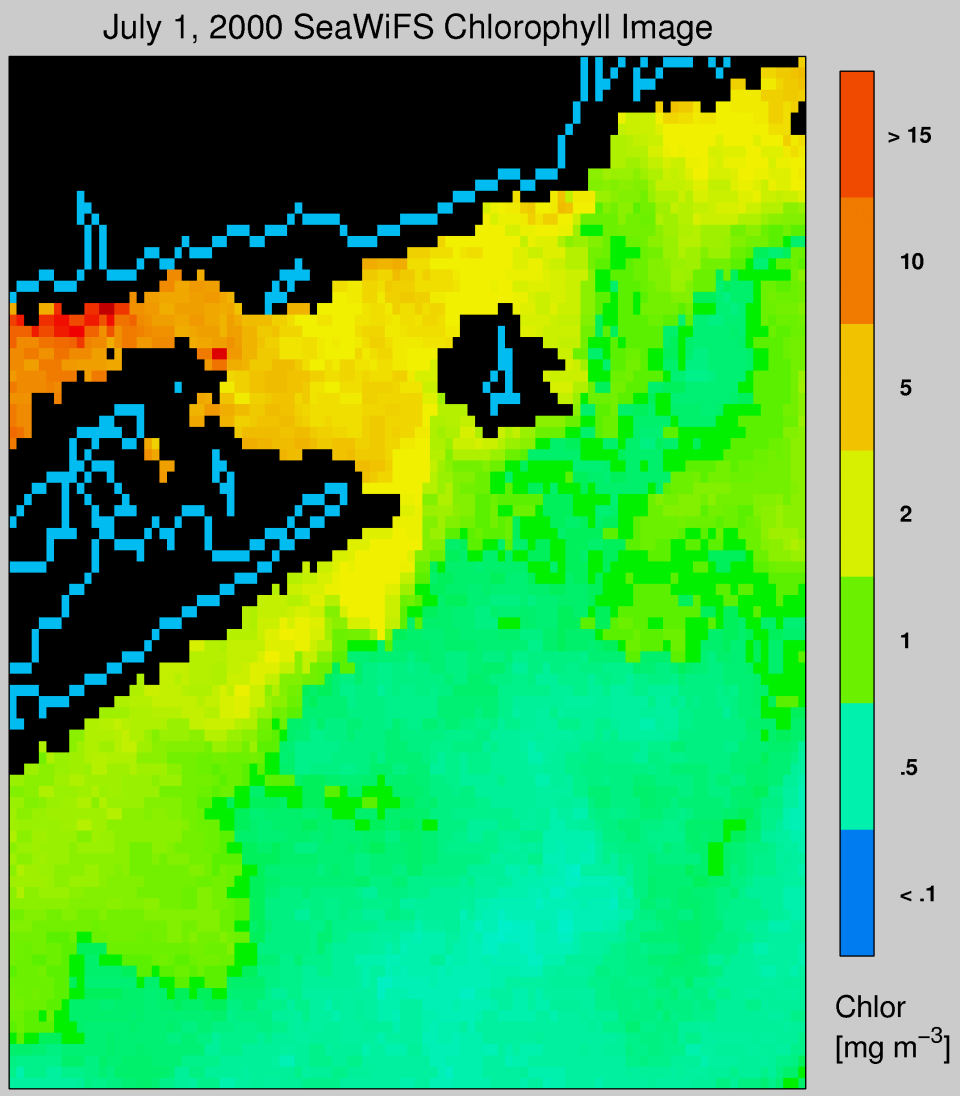

Figure 2. Chlorophyll concentration for the same period as the SST and CODAR shown in Figure 1.

IMPACT/APPLICATIONS

A full year of contemporaneous pigment and thermal data will provide details on the annual cycle of each as well as their variability and co-variability. The same also holds true for the pigment and thermal front activity over the same time period. Furthermore, information on the concurrent pigment and thermal patterns may be important for partners involved in the model initialization aspect, planning for the survey cruises, or deployment of moorings, arrays etc.

The eddy parameterizations based on the coastal microstructure measurements will be available for testing in dynamical models of the coastal ocean.

RELATED PROJECTS

This is a cooperative project with many other institutions. Additional reports by Bodgen (UCONN), Levine (NUWC) and Rice (SSC-SD) with the same title describe our other partners' work.

PUBLICATIONS

Ullman, D.S. and P.C. Cornillon, Continental Shelf Surface Thermal Fronts in Winter off the Northeast U.S. Coast, Continental Shelf Research, (in press), 2000.