SATELLITE CLIMATOLOGY OF CHLOROPHYLL AND SEA SURFACE TEMPERATURE FRONTS IN THE NORTHEAST U.S. LARGE MARINE ECOSYSTEM

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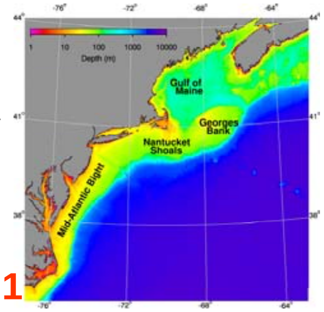
STUDY AREA

The Northeast U.S. Large Marine Ecosystem (**Figure 1**) is ideal for testing and refining satellite-based front models. It features a variety of fronts, from large quasi-stationary fronts (Gulf Stream and Shelf Slope Front) to small-scale transient fronts.



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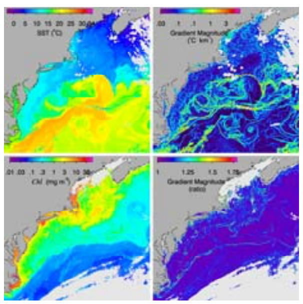

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Figure 4 Synoptic examples of SST (3 May 2001) and chlorophyll (14 October 2000) gradient magnitude.

ABSTRACT

Satellite data from several thermal and ocean color sensors (AVHRR, SeaWiFS, MODIS-Aqua and MODIS-Terra) were processed with a newly developed algorithm to generate a climatology of chlorophyll and sea surface temperature (SST) fronts in the Northeast U.S. Large Marine Ecosystem. The main novelty is image pre-processing with context shape-preserving selective median filter iterated until convergence. When applied to chlorophyll data, the context median filter emphasizes spatial patterns peculiar to this field, namely chlorophyll enhancement associated with thermohaline fronts, and small- and meso-scale chlorophyll blooms. These patterns are modeled as ridges and peaks that are preserved and treated differently from other fronts modeled as steps or ramps. The resulting climatology of fronts is based on 10 years of chlorophyll data and 8 years of SST data. This presentation describes the main spatial patterns and temporal features, relationships between SST and chlorophyll fronts, and long-term trends of this climatology.

METHODS

Front Model

- A new shape-preserving algorithm with a scale-sensitive median filter is used to detect oceanic fronts in chlorophyll and SST imagery. Most fronts are modeled as steps and ramps (**Figure 2**), whereas chlorophyll blooms and frontal enhancements are modeled as peaks and ridges respectively (**Figure 3**). Synoptic examples of the frontal analysis for SST and chlorophyll are shown in **Figure 4**. (See the **Belkin & O'Reilly Poster** for more details on the front model methods).

SeaWiFS Chlorophyll *a*

- 9,331 full-resolution scenes (Jan. 1998–Dec. 2006) from NASA DAAC were processed using SEADAS (Fu et al. 1998). Monthly mean SeaWiFS chlorophyll *a* concentrations are shown in **Figure 5**. Chlorophyll data were log transformed prior to analysis.

MODIS Sea Surface Temperature (SST)

- Full-resolution MODIS-Terra (Jan. 2001–Dec. 2006) and MODIS-Aqua (Jan. 2003–Dec. 2006) 4 μm nighttime SST (°C) data were merged to create 2164 daily SST scenes. Monthly mean SST are shown in **Figure 6**.

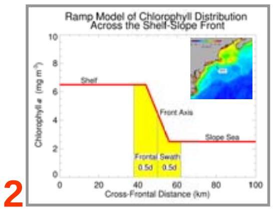

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Figure 2 Ramp model of a generic Shelf-Slope Front and example of stepwise distribution of chlorophyll across the Shelf-Slope Front (SSF) from September, 2002 (inset).

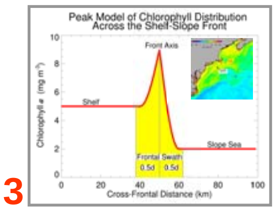

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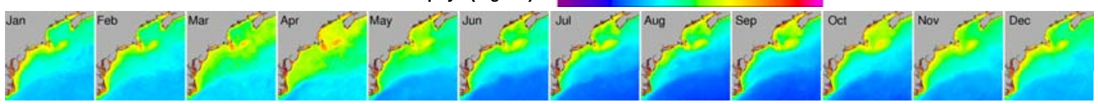
Figure 3 Peak model of chlorophyll distribution across a generic Shelf-Slope Front and example of chlorophyll enhancement at the Shelf-Slope Front (SSF) from April, 2001 (inset).

Chlorophyll (mg m-3)



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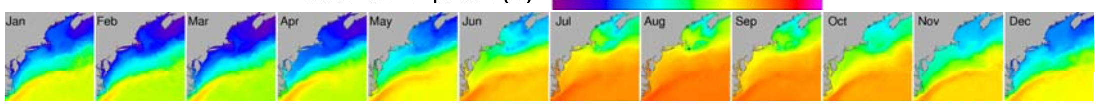
Sea Surface Temperature (°C)



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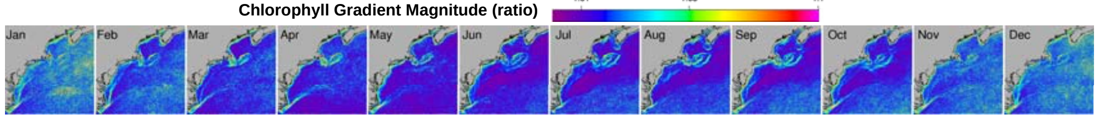
Chlorophyll Gradient Magnitude (ratio)



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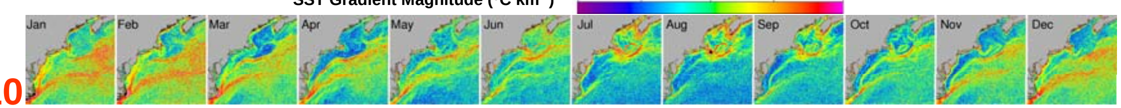
SST Gradient Magnitude (°C km-1)



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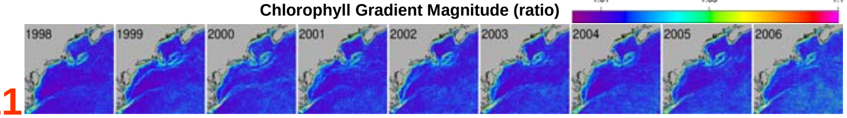
Chlorophyll Gradient Magnitude (ratio)



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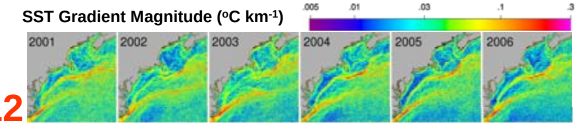
SST Gradient Magnitude (°C km-1)



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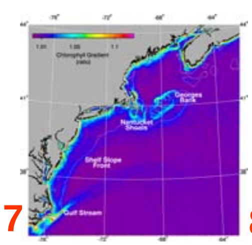
RESULTS

- The **Gulf Stream, Shelf-Slope Front,** and fronts on **Georges Bank** are easily identifiable in both the 9-year chlorophyll (**Figure 7**) and 6-year SST (**Figure 8**) means.
- There are some persistent chlorophyll fronts in locations where SST fronts are absent (i.e. between **Martha's Vineyard** and **Nantucket**).
- Most chlorophyll fronts (**Figure 9**) are discernable throughout the year while some SST fronts (**Figure 10**) are seasonal.
  - Tidal mixing fronts around **Georges Bank** emerge in spring, peak in August and dissipate in January.
  - The **Shelf-Slope Front** is weakest in summer.
  - **Gulf of Maine** SST frontal patterns change substantially on a monthly scale, with most fronts peaking in August.
- There is noticeable interannual variability in both chlorophyll (**Figure 11**) and SST (**Figure 12**) front patterns.



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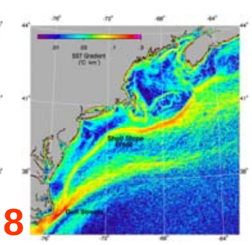

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CONCLUSIONS

- A new front detection algorithm based on a contextual median filter that removes impulse noise (spikes) in satellite imagery was able to preserve important oceanographic features in the chlorophyll and SST fields.
- The frontal climatology documents spatial, seasonal and interannual variability of large-scale fronts associated with western boundary currents; water mass fronts such as the Shelf-Slope Front; and tidal mixing fronts around Georges Bank and in the Gulf of Maine.
- In addition, this new algorithm has created an unprecedented opportunity to quantitatively study the spatial and temporal relationships between chlorophyll features and SST fronts.

REFERENCES

Belkin, I. M. and J. E. O'Reilly (2008). An algorithm for front detection in chlorophyll and sea surface temperature satellite imagery. *Journal of Marine Systems.*

Belkin, I.M., O'Reilly, J.E. and Hyde, K.J.W. (2008). Satellite climatology of chlorophyll and sea surface temperature fronts in the Northeast U.S. Large Marine Ecosystem. *In preparation.*

ACKNOWLEDGEMENTS

We are grateful to NOAA for funding this project under the Research to Operations program and through a contract to the University of Rhode Island. We also thank Teresa Ducas for her assistance with data processing and maintaining the satellite data base.

NASA Carbon Cycle and Ecosystems
April 28-May 2, 2008