Topographic Control of Ocean Dynamics in the Subtropics

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University of Rhode Island

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Outline

Study Objectives

Primary Objective: To achieve a better understanding of the processes responsible for the topographic control of banded structures observed in satellite-derived parameters of the mid-latitude ocean.

In order to achieve this we will:

1. Generate global SST front datasets from AMSR-E, 4 km MODIS, 4 km AVHRR and $\frac{1}{6}^{\circ}$ ECCO2 fields.
2. Generate a global ocean color front dataset from 4 km MODIS fields.
3. Undertake a statistical description of the interannual variability of quasi-zonal bands in the vicinity of bathymetric features observed in these data sets.
4. Perform an analysis of the performance of the URI single image edge detection (SIED) algorithm as a function of the resolution of the SST fields on which the detector is being applied.

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Ocean Fronts

- Ocean fronts are regions of large spatial gradients of ocean properties
- Properties can be:
  - Temperature
  - Density
  - Ocean Color
  - etc.
- Our focus is on temperature and ocean color fronts.
- Ocean fronts may occur at any depth.
- Our focus is on sea surface fronts.
- Surface fronts, especially SST fronts, are significant because they:
  - Often mark dynamically active regions in the ocean
  - Effect air-sea interactions.
  - Separate water masses.
  - They are also often biologically active regions, hence the interest in ocean color fronts.
- Satellite-derived data are ideally suited for frontal studies.

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How does one detect fronts in ocean surface fields?

- Two extremes for front detection algorithms:
  - Gradient based
    - Fronts are defined by 'high gradient' pixels.
    - The Sobel gradient operator is often used for front detection:

$$\begin{matrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{matrix} \qquad \begin{matrix} 1 & 2 & 1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{matrix}$$

    - Detected fronts are sensitive to a threshold applied on the gradient.
  - Population based
    - Fronts are defined as pixels separating different populations.
    - We used the Cayula-Cornillon algorithm.
    - Based on histograms of 32×32 pixel squares.
    - Probability of finding a front is a weak function of the gradient separating populations.
    - But, the 32×32 kernel used is substantially larger than the 3×3 Sobel kernel.
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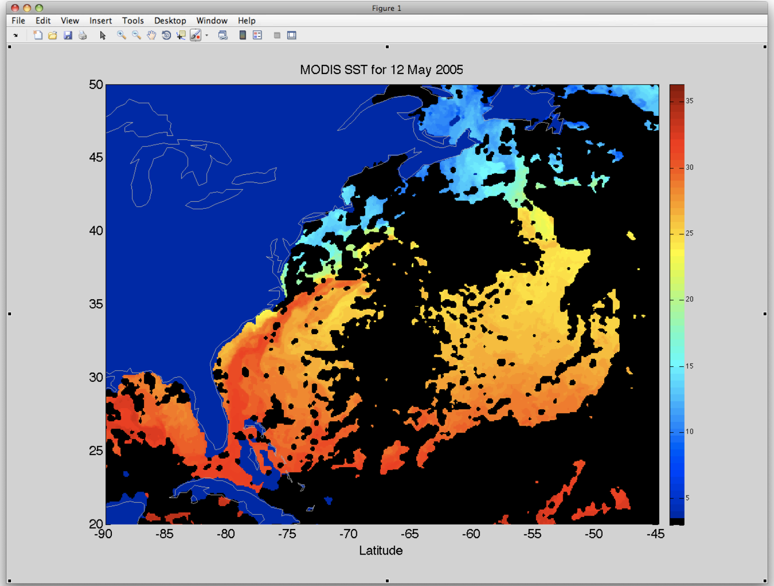
Example

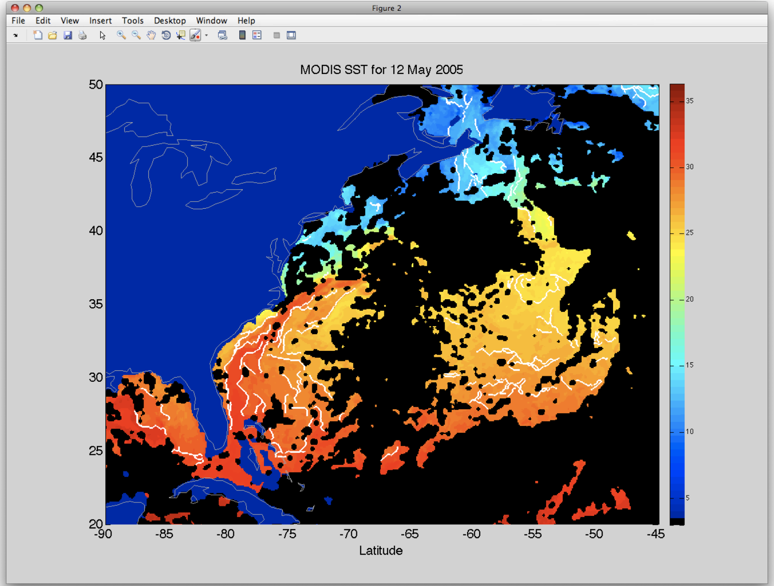
Let's look at an example:

MODIS SST data for 12 May 2005

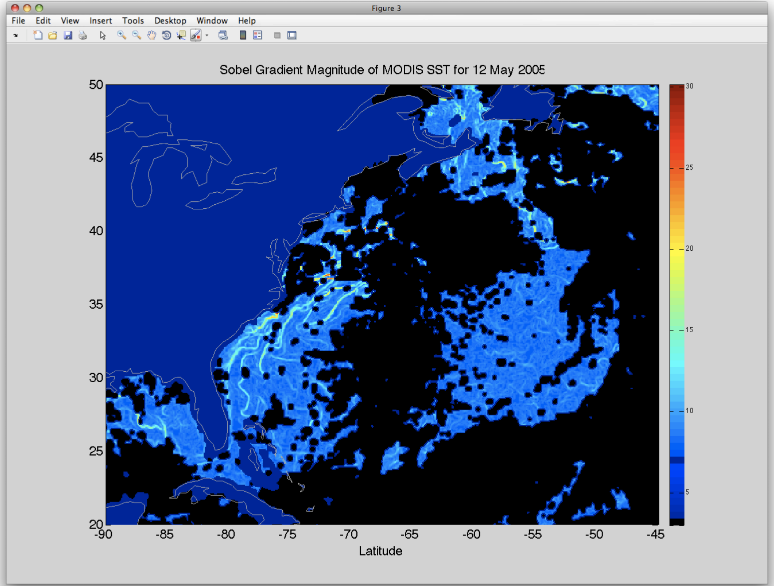
Example: Median SST only



Example: Median SST with Fronts



Example: Sobel Gradient Magnitude of Median SST



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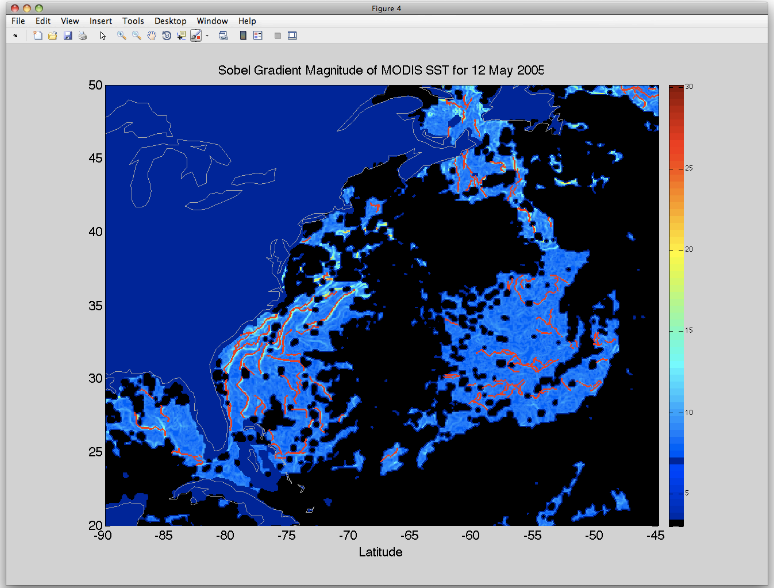

The Frontal Probability

- The population-based algorithm finds frontal pixels - lines separating different water masses
- These fronts are:
  - Noisy - spurious fronts
  - Gappy - clouds, rain, . . .
- So we look for persistence in the frontal field - by finding the frontal probability.

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$$\text{Probability of a front} = \frac{\sum_{i=1}^{N} \text{Front}_i}{\sum_{i=1}^{N} \text{Clear}_i}$$

i is over all pixels in a spatial and temporal region,
Front_i is 1 if the pixel is a front pixel, 0 otherwise and
Clear_i is 1 if the pixel is clear, 0 otherwise.

Work to Date

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- We used data in satellite coordinates (14 orbits per day) from July 2002 - May 2009
- AMSR-E is a microwave sensor.
  - Can 'see' through clouds.
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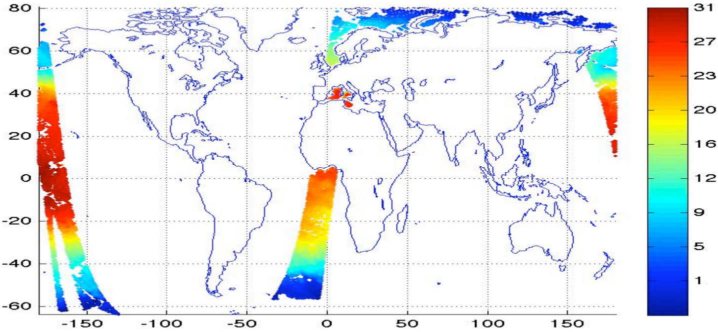
Processing steps

- Each orbit was passed through the URI edge detector.
- This was done for all 14*30 (520) orbits/month.
- Monthly frontal probability fields were then generated.
- These fields suggest zonal bands with a characteristic meridional length scale.



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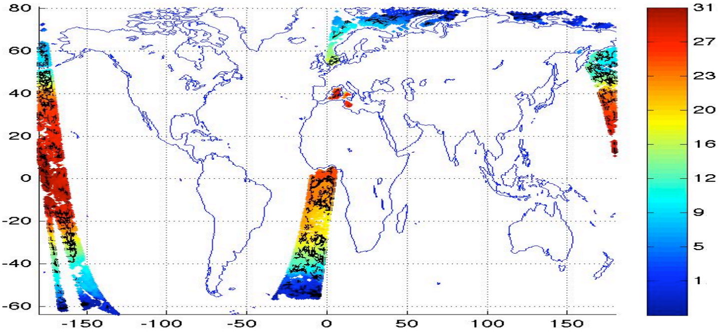

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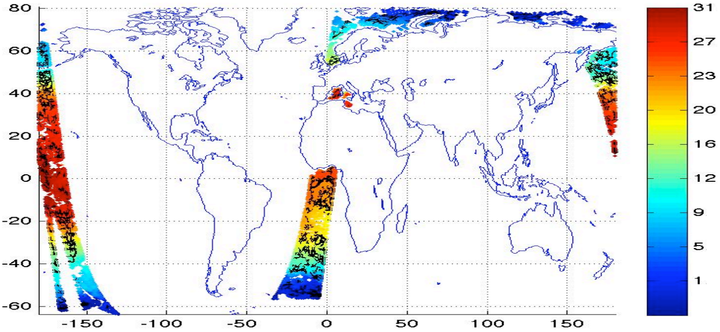

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Introduction
Data Processing
Frontal Bands
Bathymetry
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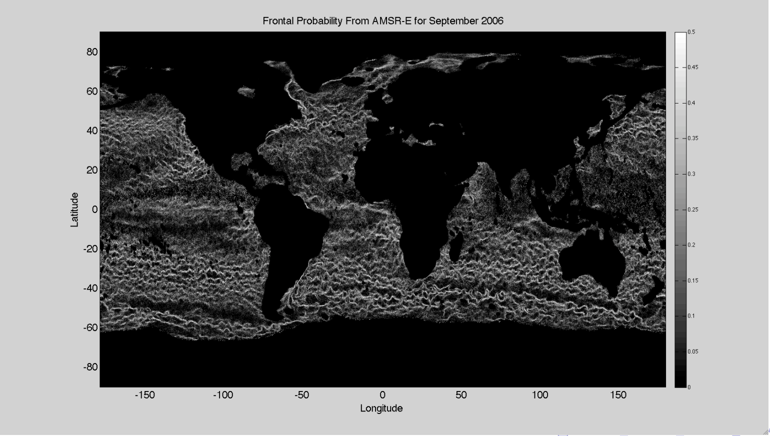

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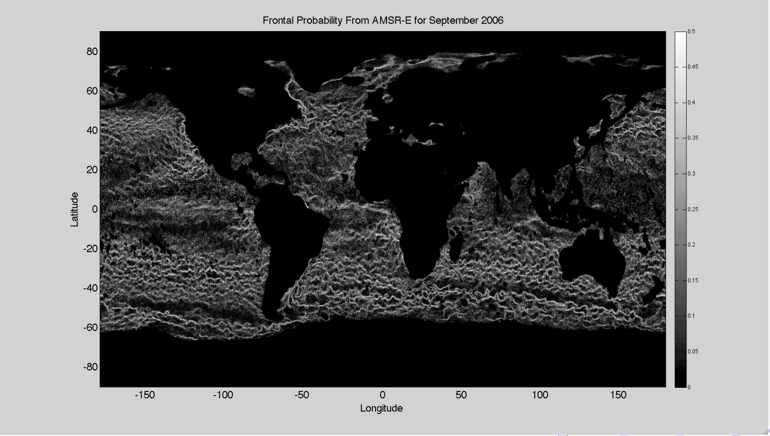

Persistent Bands of Front Probability

And this is true even for long term averages

Normalized front probability for June 2002 - June 2009.

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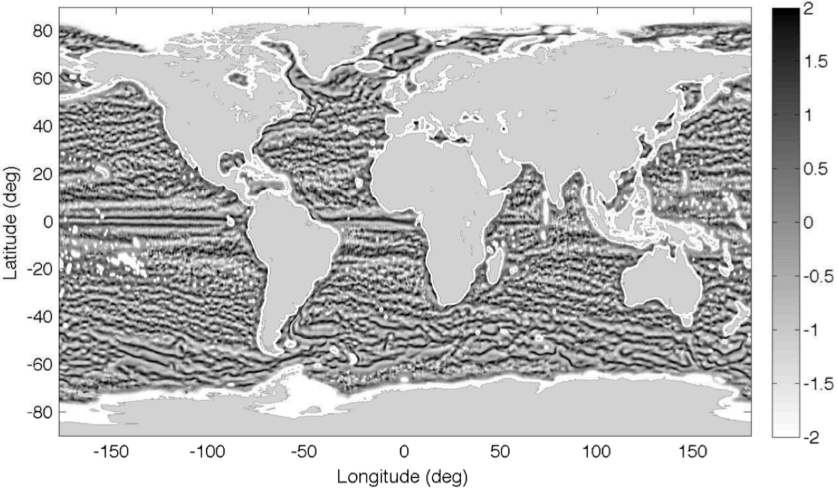

Persistent Bands of Front Probability - continued

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Mean zonal surface geostrophic velocity from Maximenko et al. 1993 - 2002.
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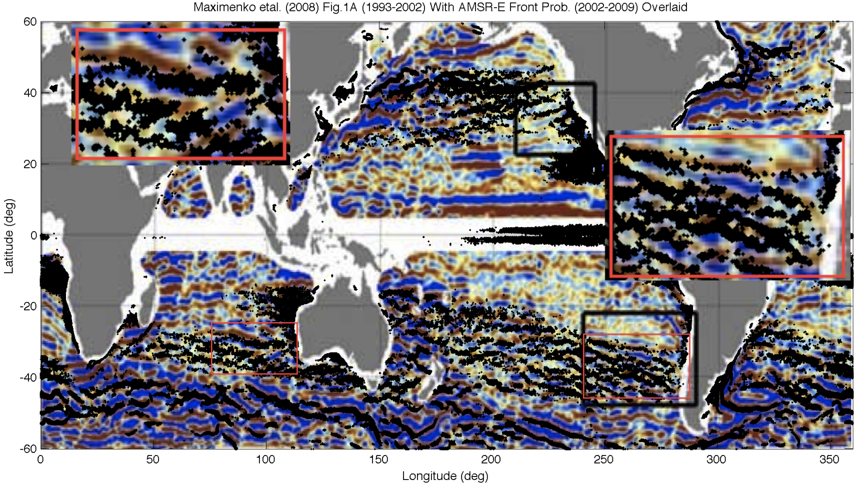

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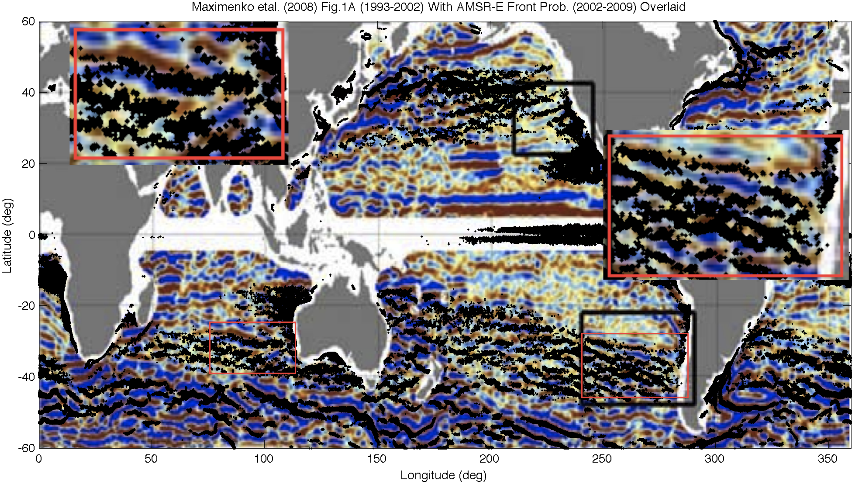
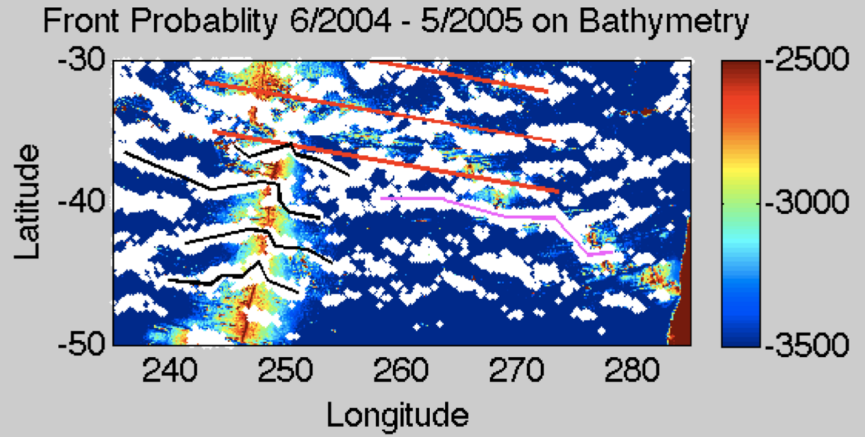


Bathymetry Plays a Role in the Location of Frontal Bands



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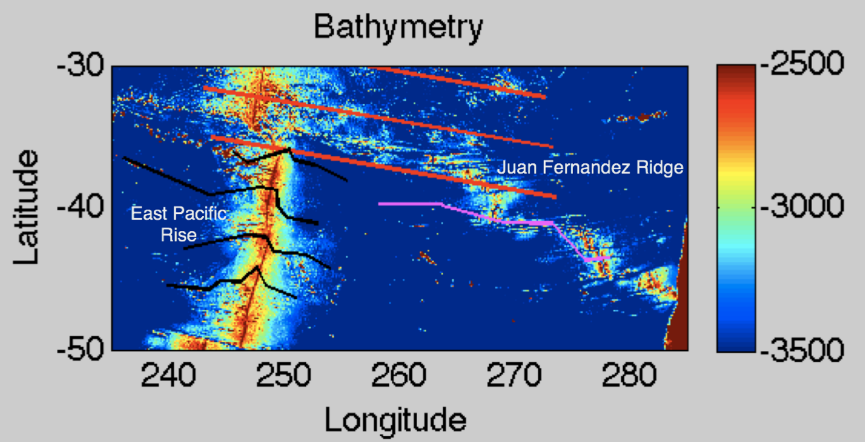

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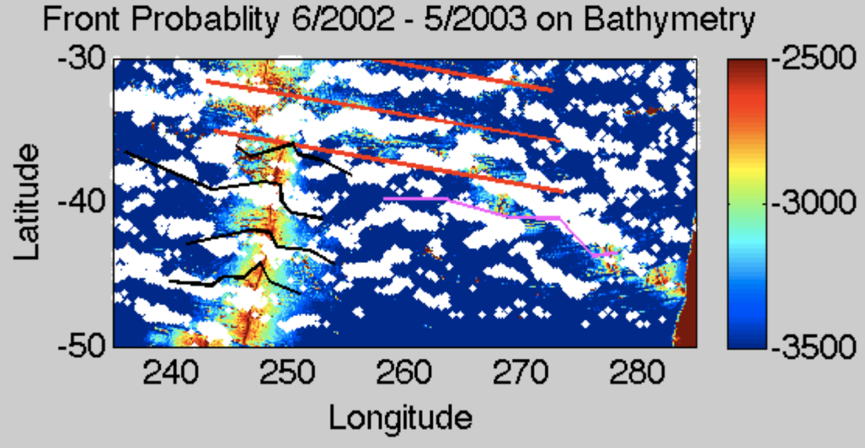

Study Objectives

Primary Objective: To achieve a better understanding of the processes responsible for the topographic control of banded structures observed in satellite-derived parameters of the mid-latitude ocean.

In order to achieve this we will:

1. Generate global SST front datasets from AMSR-E, 4 km MODIS, 4 km AVHRR and $\frac{1}{6}^{\circ}$ ECCO2 fields.
2. Generate a global ocean color front dataset from 4 km MODIS fields.
3. Undertake a statistical description of the interannual variability of quasi-zonal bands in the vicinity of bathymetric features observed in these data sets.
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The Data

Satellite/ Sensor	Spatial Resolution (km)	Temporal Resolution	Time series (years)	Coverage
AMSR-E	50	12 hrs	8	Global
MODIS (SST)	4	12 hrs	11	Global
AVHRR	4	12 hrs	30	Global
AVHRR	1	12 hrs	10-30	Regional
GMS	4-8	15 minutes	8	Hemisphere
GOES	4-8	20 minutes	10	Hemisphere
ECCO-2	16	24 hours	Many	Global
MODIS (Color)	4	12 hrs	11	Global

All Done

The End