SEVIRI and VISSR SST Front and Gradient Datasets

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GHRSST XIV
20 June 2013

The Manhattan Club

Outline

Objective of this Presentation

- To describe an atlas for SST fronts and gradients.
- To highlight the difference between two classes of edge detection algorithms.
- To indicate how one might acquire these data.

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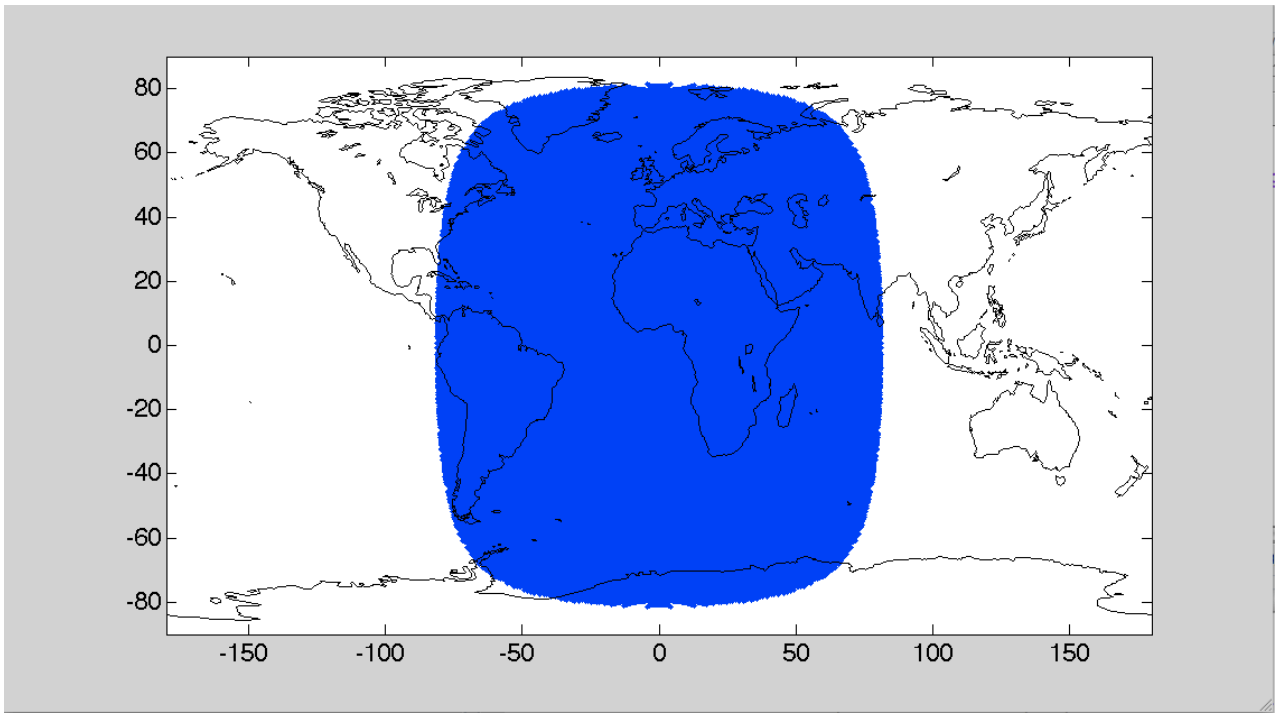
Lannion is Beautiful

Although They Could Improve on Their Plumbing

And they have in fact improved their plumbing, although . . .

The Data - Two series of geostationary satellites

- SEVIRI on Meteosat 8 and 9
  - 12 June 2003 through 28 February 2011
  - Hourly data
  - ≈66,000 3712×3712 pixel images
- GOES) 8 and 12 Imagers
  - 20 February 2001 through 28 February 2011
  - Partial scans hourly
  - ≈73,000 1980×2400 pixel images



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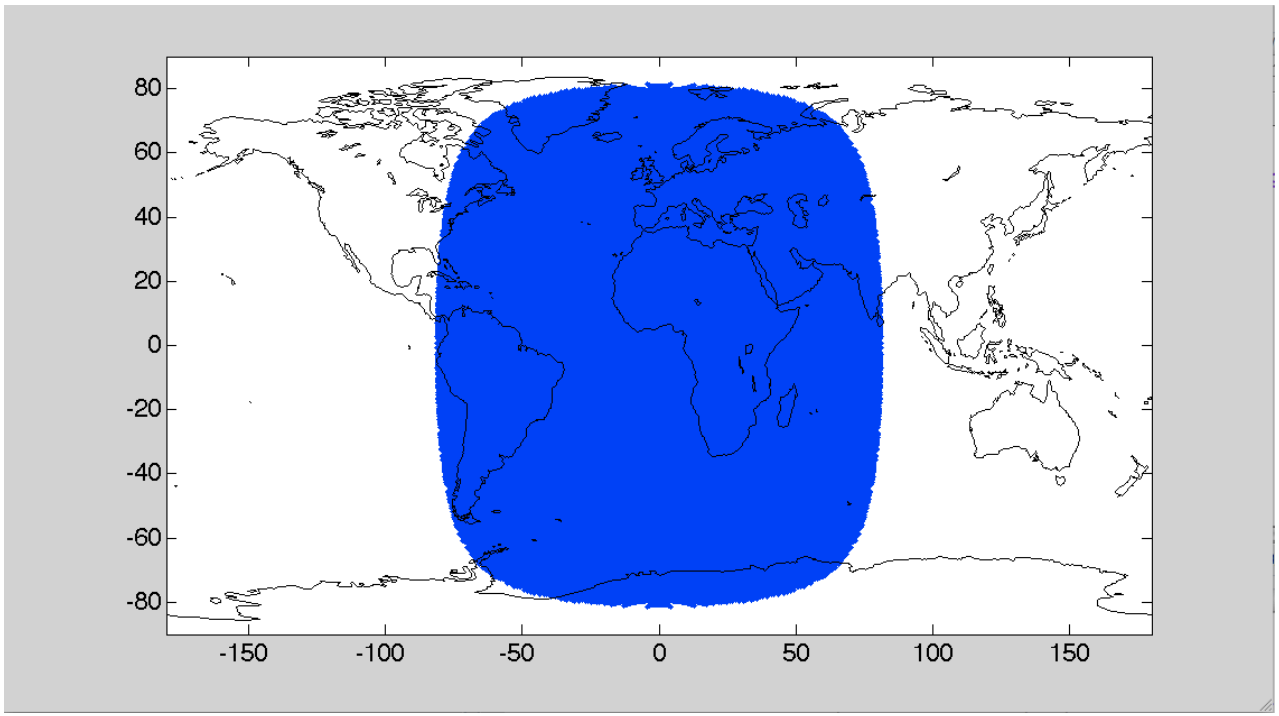

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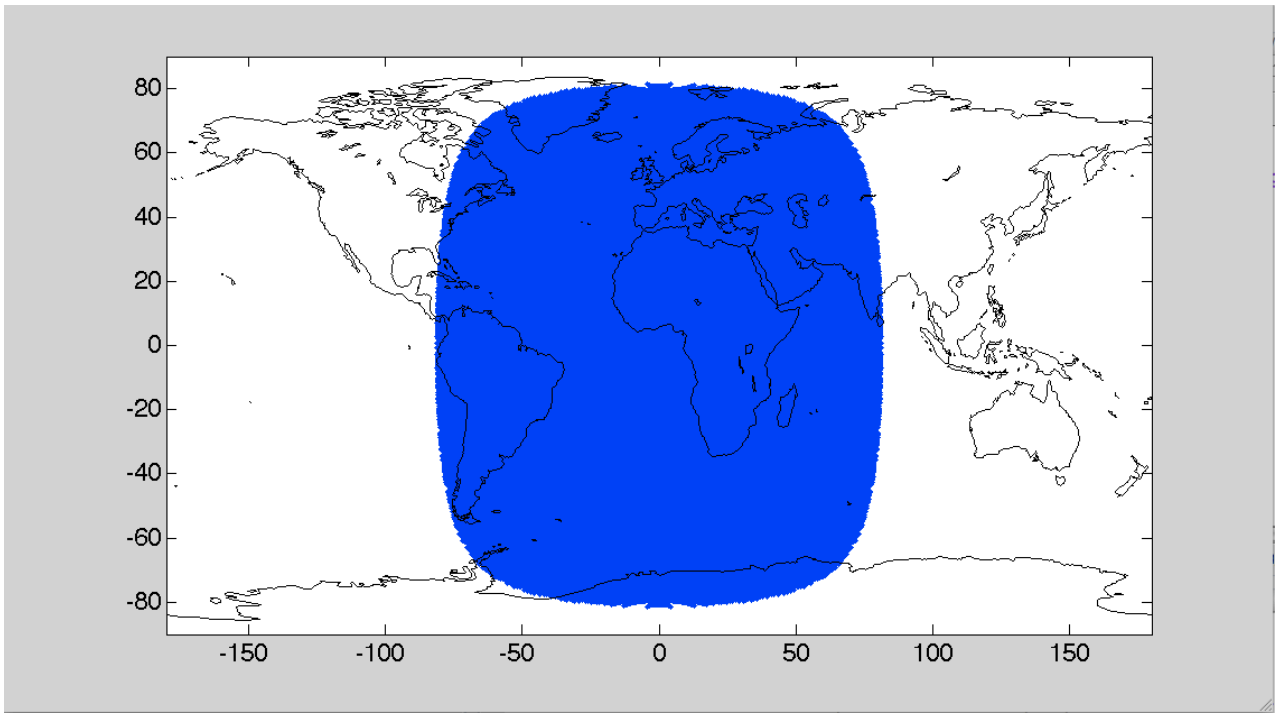

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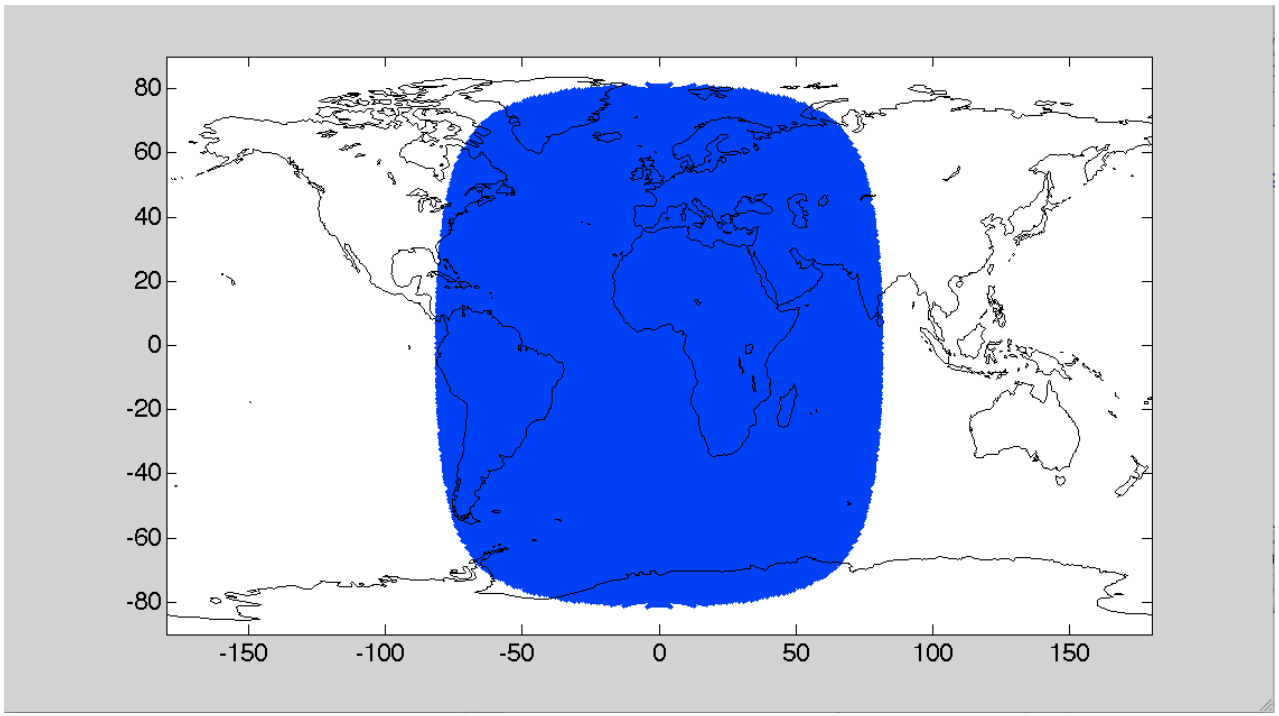

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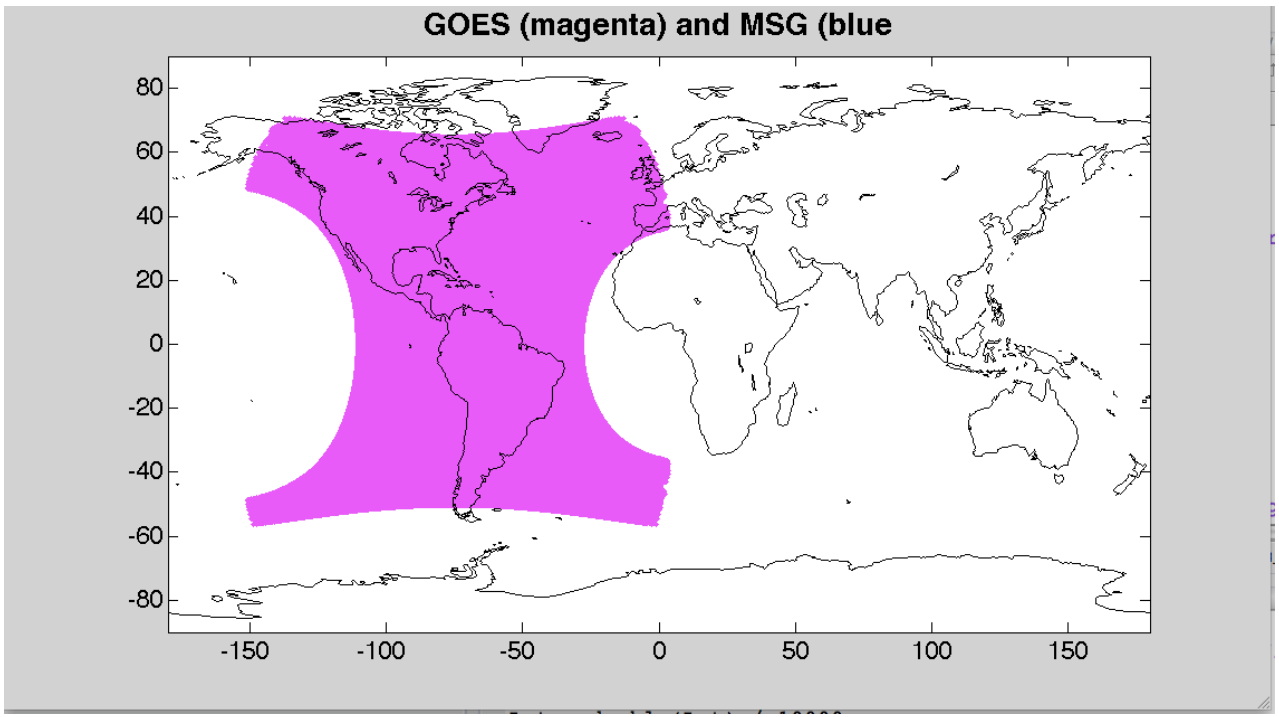

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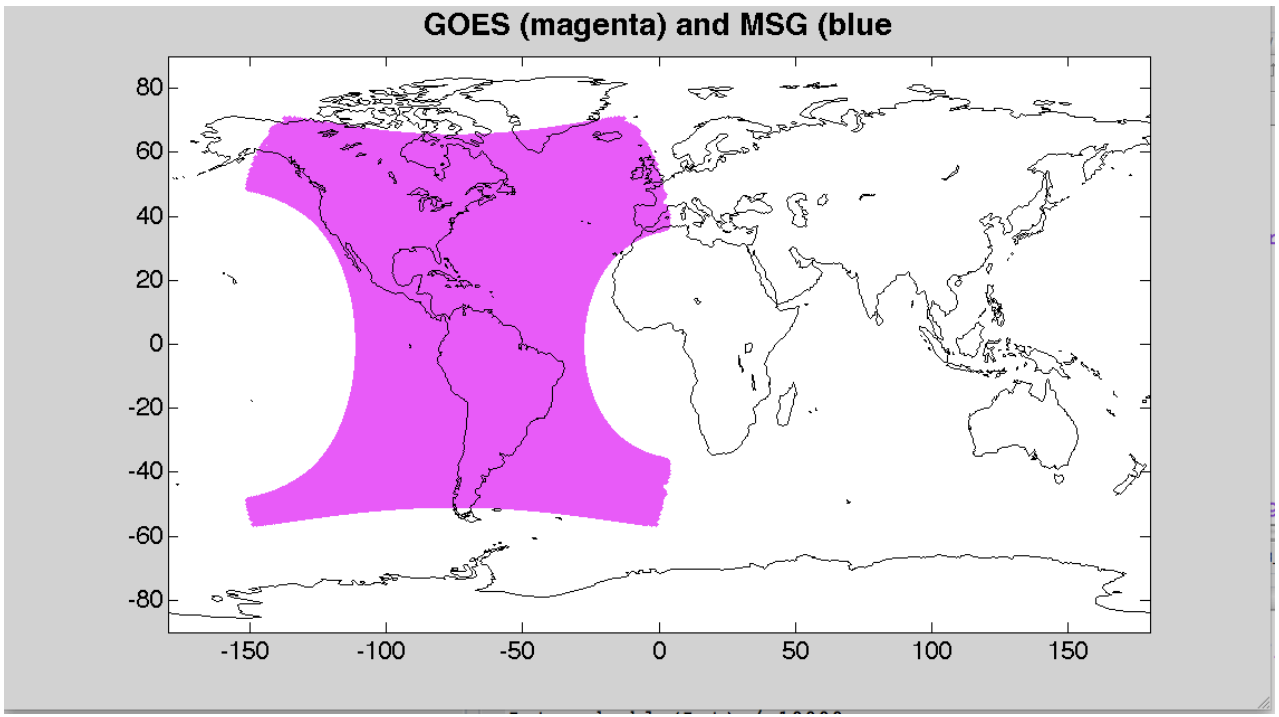

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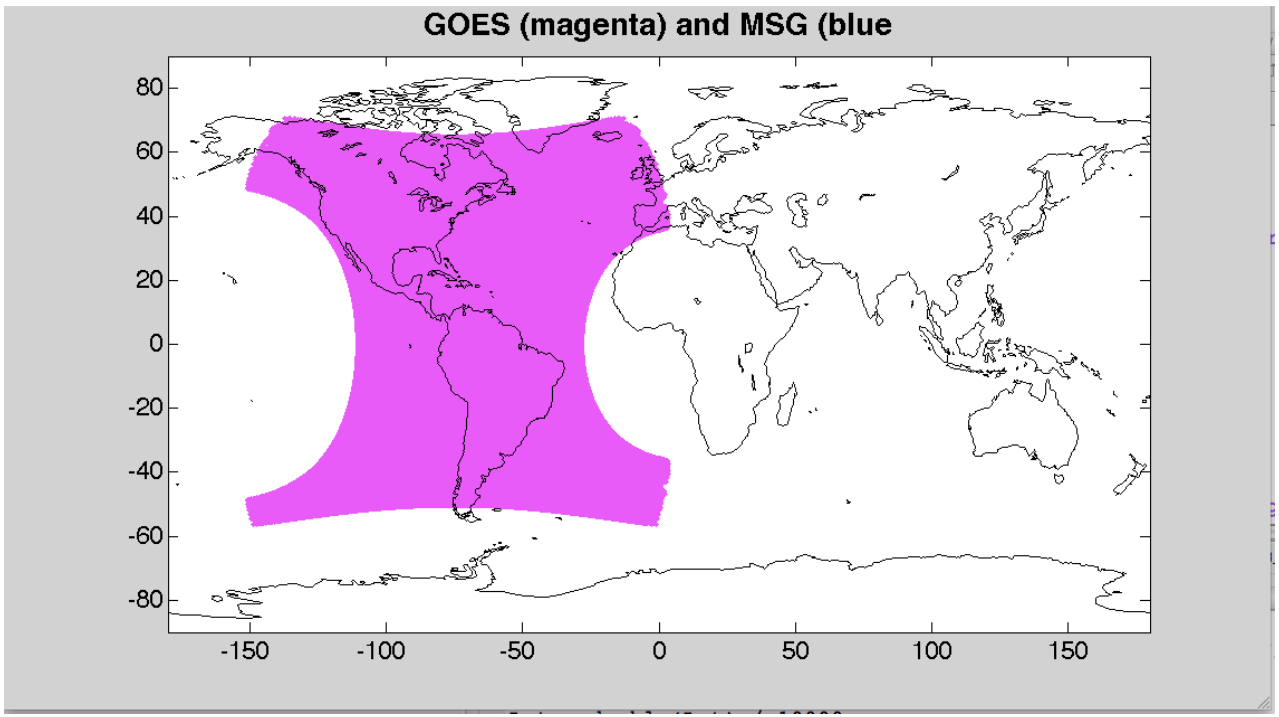

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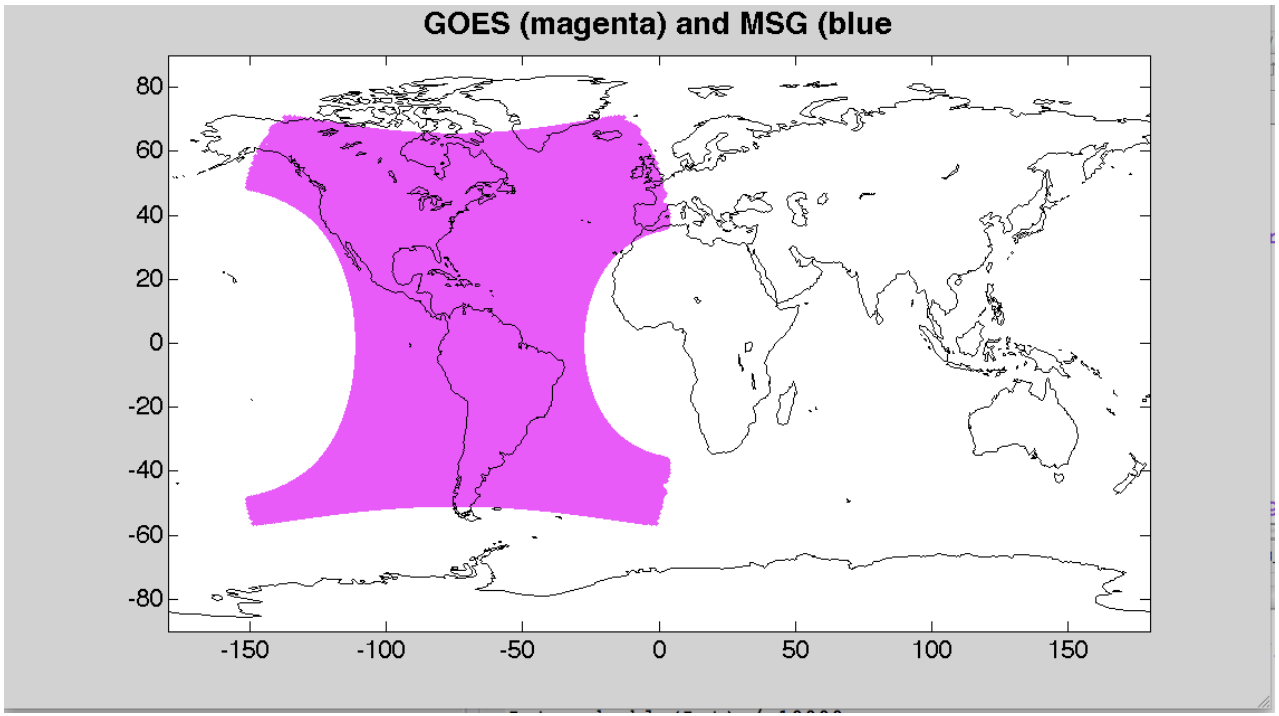

Processing to SST

- Performed at the Centre de Météorologie Spatiale
- Based on EUMETSAT's Ocean and Sea Ice Satellite Application Facility (OSI-SAF) basic processing chain.
- GOES-8 daytime and all Meteosat retrievals based on split window.
- GOES-8 nighttime retrievals based on triple window.
- GOES-12 nighttime retrievals based on $T_{3.7}$ and T_{11}.
- No GOES-12 daytime SSTs - no T_{12}.
- Quality flag from 0-no data to 5-good.
- Data processed to SST every hour.
- Data available in two projections: Platte-Carre and Space View.
  - Earth as seen by the satellite
  - Along the prime meridian, the Meteosat spatial resolution is:
    - 3 km at nadir,
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  - GOES resolution is a little coarser
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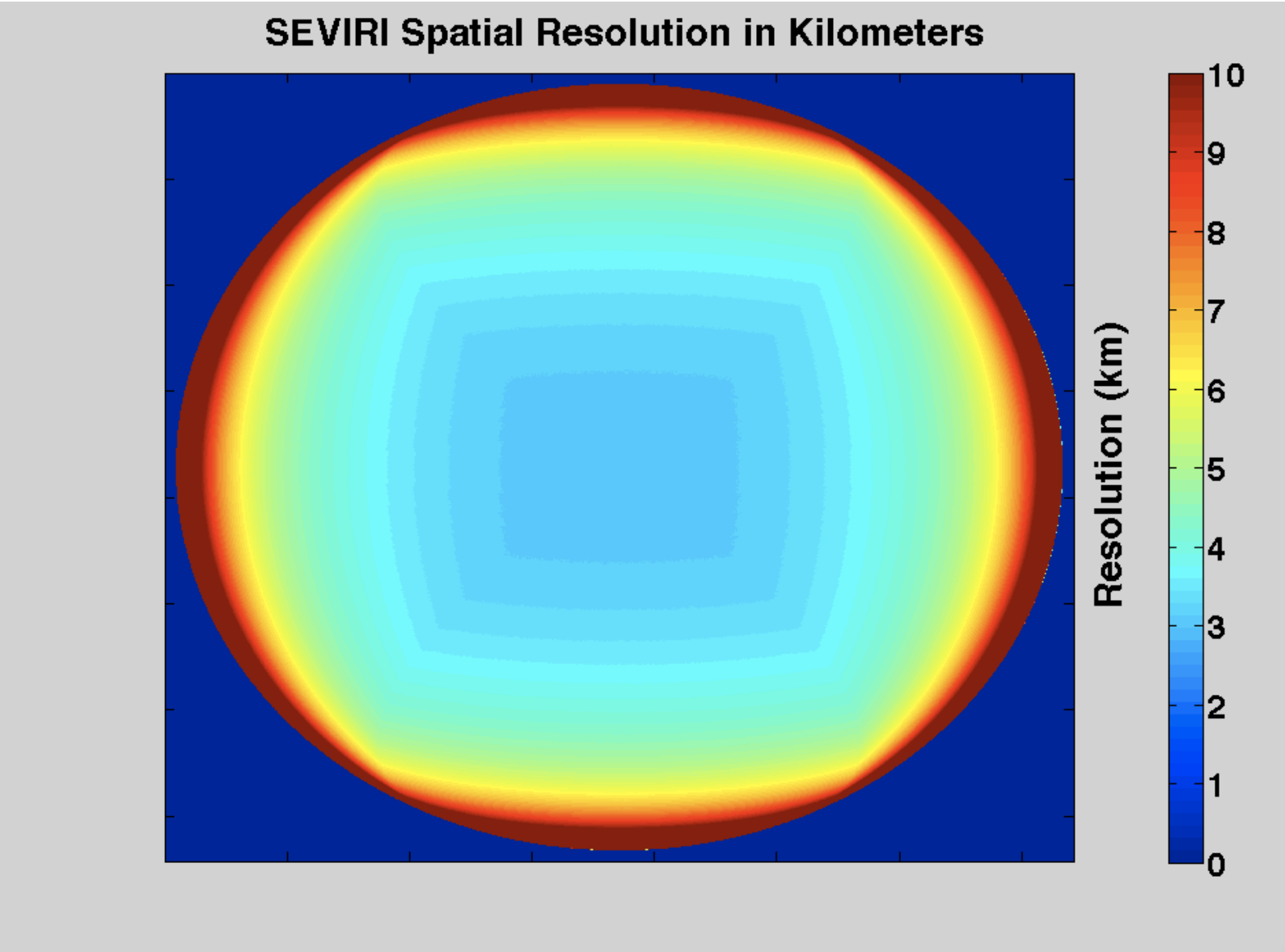
Spatial Resolution



Outline

Two Approaches to Locating Fronts

- Two types of SST front algorithms
  - Gradient based
    - Fronts are defined by 'high gradient' pixels.
    - We used the Sobel gradient operator.

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

  - Population based
    - Fronts are defined as pixels separating different populations.
    - We used the Cayula-Cornillon algorithm
      – a.k.a. single image edge detection (SIED) algorithm.
    - Based on histograms of 32×32 pixel squares.
  - These approaches are complimentary
  - Both approaches require the definition of thresholds, but the thresholds are on different physical parameters hence the complementarity of the approaches.

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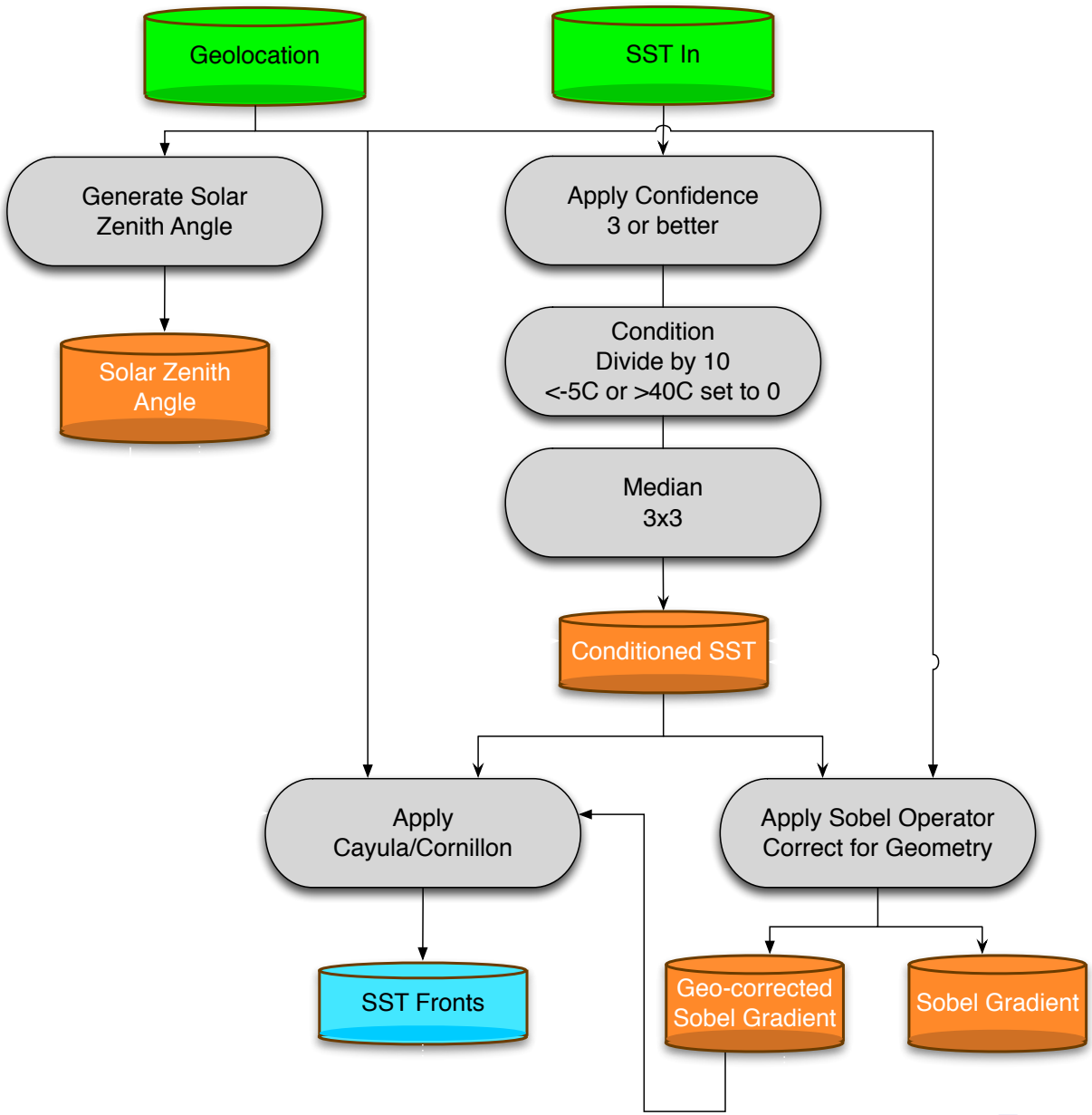

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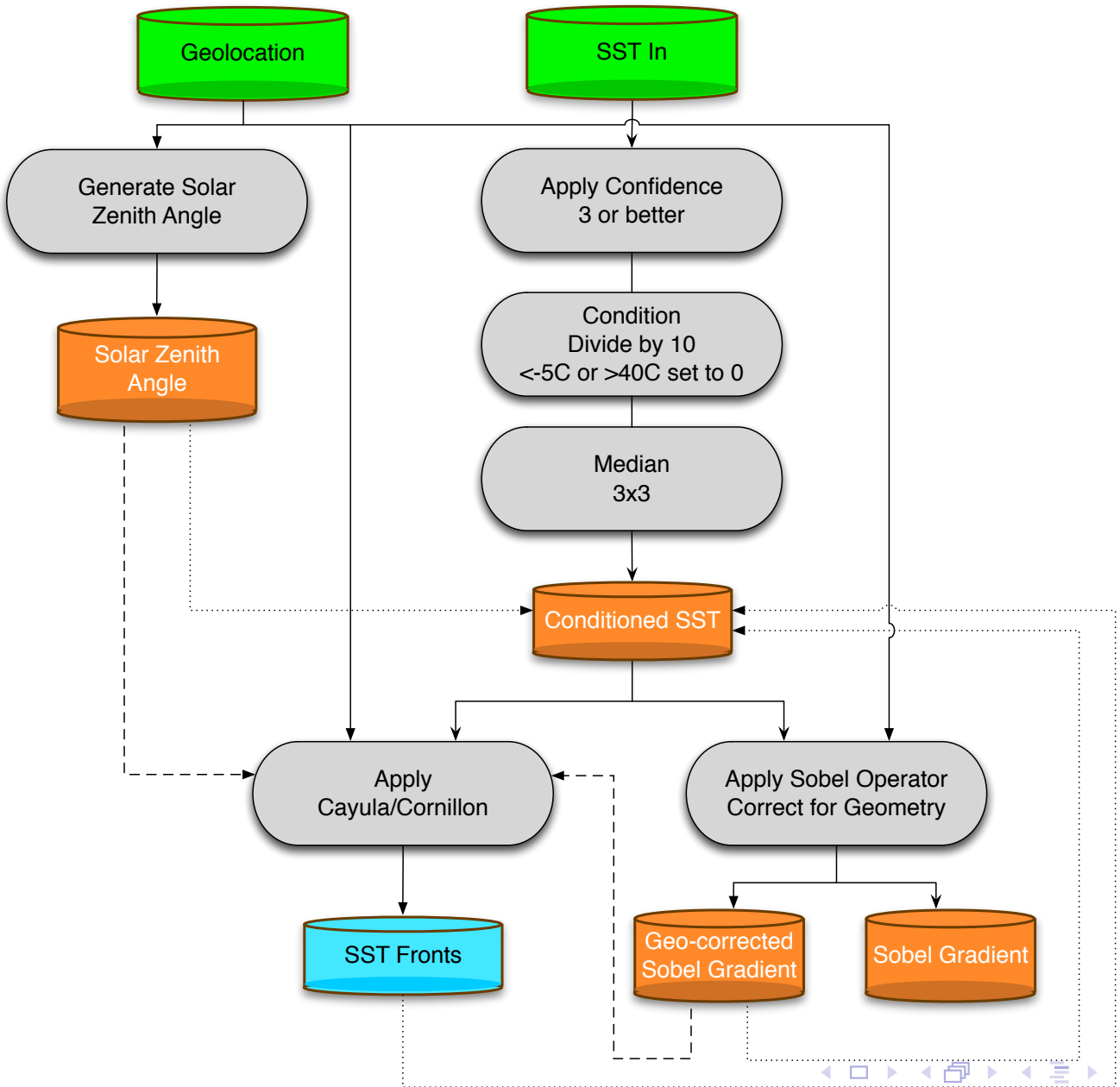

Outline

Where to Find the Data

All data output by the URI Fronts/Gradients workflow are available via OPeNDAP at:

http://sstfronts.org/opendap

Outline

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The output of the URI Fronts/Gradients workflow for each archive is divided into the following directories:

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The Directory Structure: Statistical Directories

In addition, the following statistical fields are created for each archive:

- Nighttime Sobel gradient magnitudes: **SobelSums**
  - Daily Sobel sums: **NighttimeSobelSums**
  - Monthly Sobel sums: **MonthlySobelSums**
  - Daily climatology Sobel sums: **DailyClimatologicalSobelSums**
  - Monthly climatology Sobel sums: **MonthlyClimatologicalSobelSums**
  - Dataset Sobel Sums: sst_msg_DatasetSumSobelMag
- Histograms of Sobel gradients: **SobelHistograms**
  - Nighttime Sobel histograms: **NighttimeSobelHists**
- And, as an added bonus local sun time SST: **LST**

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An Example Directory Structure: MSG

OPeNDAP

Contents of /

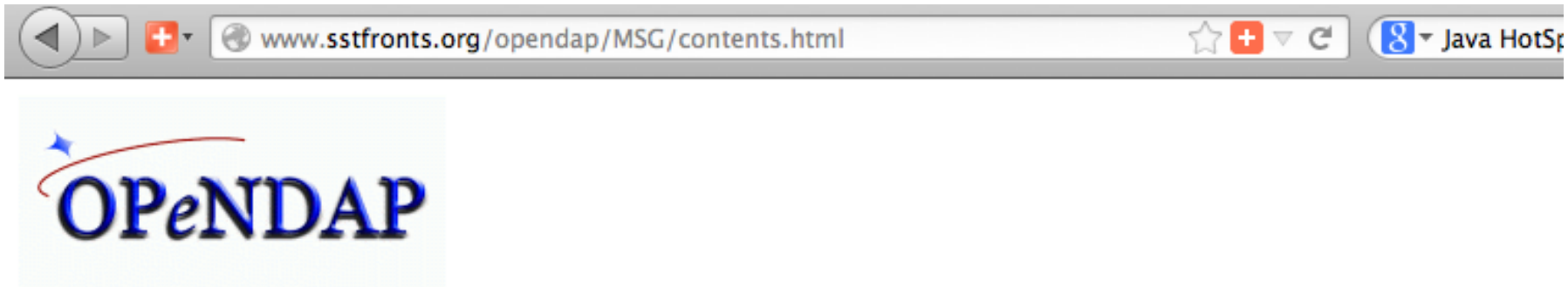
Name	Last Modified
AVHRR/	2013-02-06T17:05:24
GOES/	2013-02-06T19:03:33
MSG/	2013-02-04T18:41:38
Pathfinder/	2010-11-09T21:44:58

THREDDS Catalog XML

OPeNDAP Hyrax (1.8.8) ServerUUID=e93c3d09-a5d9-49a0-a912-a0ca16430b91-contents

Documentation

An Example Directory Structure: MSG



An Example Directory Structure: MSG

OPeNDAP

Contents of /MSG/Fronts_2nd_Pass/2005/04

Name

Parent Directory/

sst_meteosat08_20050401_0000_fronts_2nd_pass.nc

sst_meteosat08_20050401_0100_fronts_2nd_pass.nc

sst_meteosat08_20050401_0200_fronts_2nd_pass.nc

sst_meteosat08_20050401_0300_fronts_2nd_pass.nc

sst_meteosat08_20050401_0400_fronts_2nd_pass.nc

sst_meteosat08_20050401_0500_fronts_2nd_pass.nc

sst_meteosat08_20050401_0600_fronts_2nd_pass.nc

sst_meteosat08_20050401_0700_fronts_2nd_pass.nc

sst_meteosat08_20050401_0800_fronts_2nd_pass.nc

Outline

Sobel Gradients: Basic Dataset

For each SST field we determine:

- Sobel eastward gradient.
- Sobel northward gradient.
- Sobel gradient magnitude.

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Sobel Gradients: Statistics - SobelSums

Nighttime ONLY - solar zenith angle $> 90°$ at each pixel.

- At each pixel location for each night **NighttimeSobelSums**:
  - Count the # of times the pixel was clear.
  - Sum Sobel gradient magnitude.
  - Sum Sobel gradient magnitude squared.
  - Determine the maximum Sobel gradient magnitude for that night.
  - Get the time of the maximum gradient magnitude.
  - Calculated the mean Sobel gradient magnitude.
- Accumulate the above by:
  - Climatological day: **DailyClimatologicalSobelSums**
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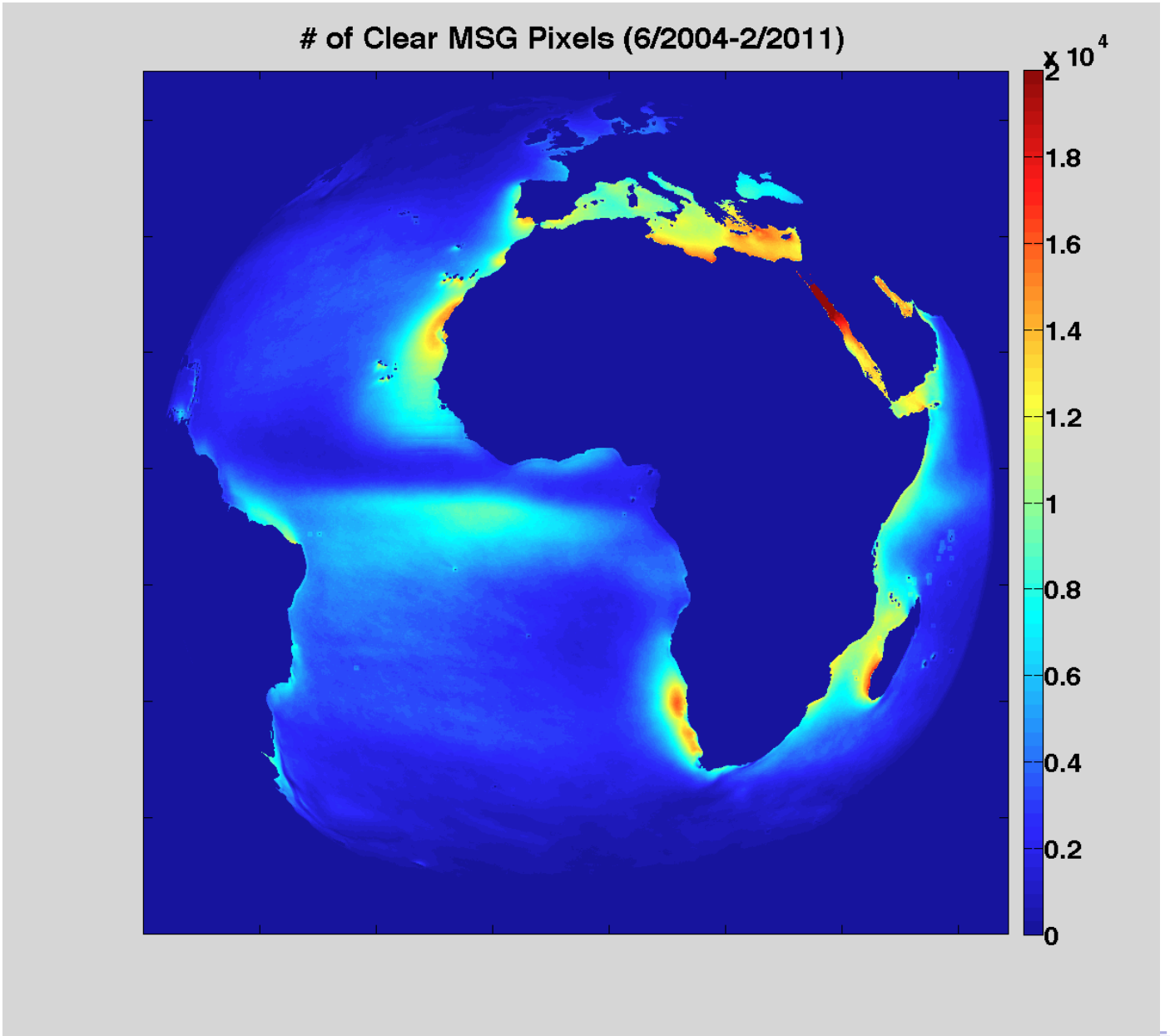
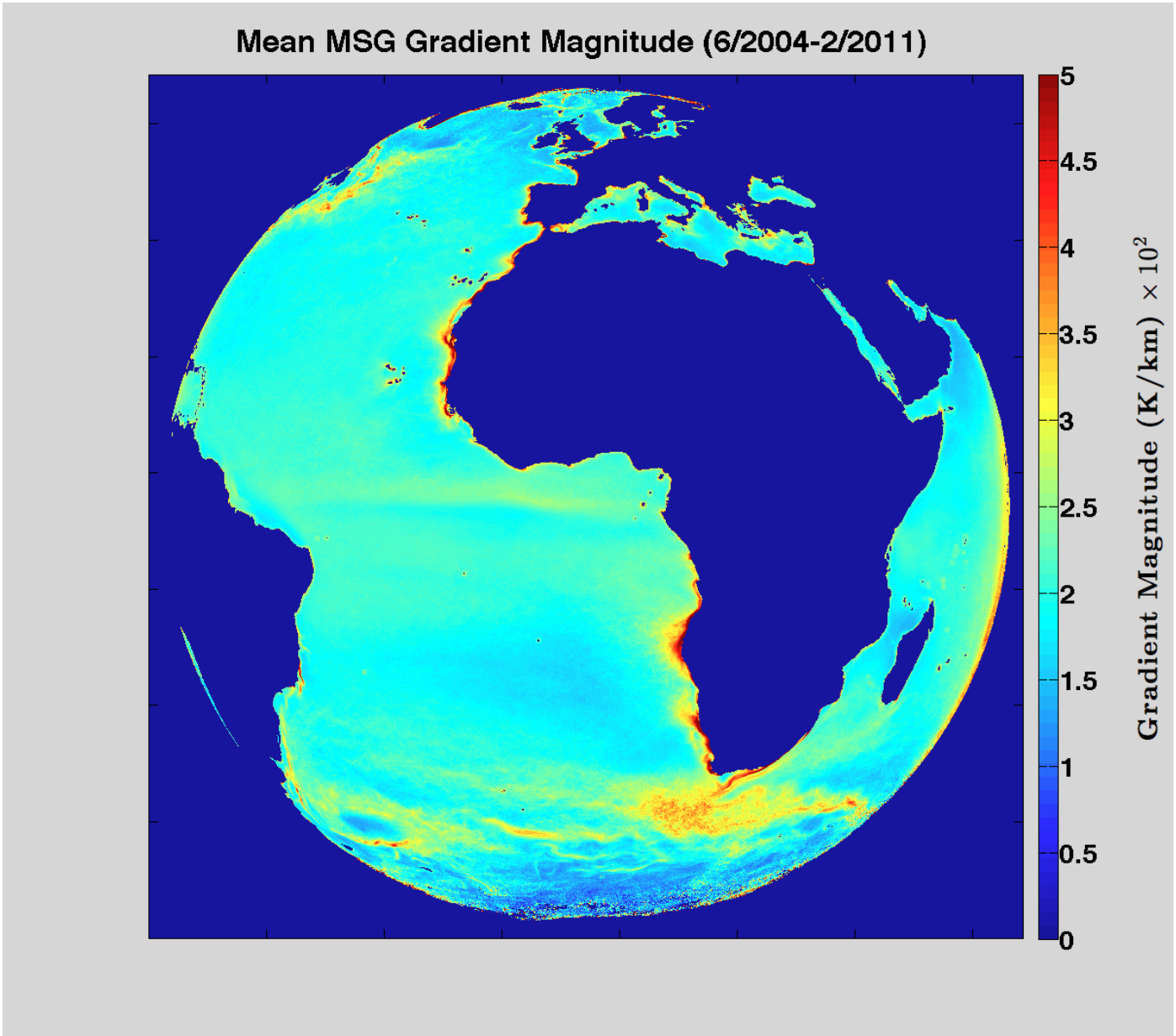
    $\Rightarrow$ All the information required to calculate the mean *and* the variance for any aggregation is available.

Outline

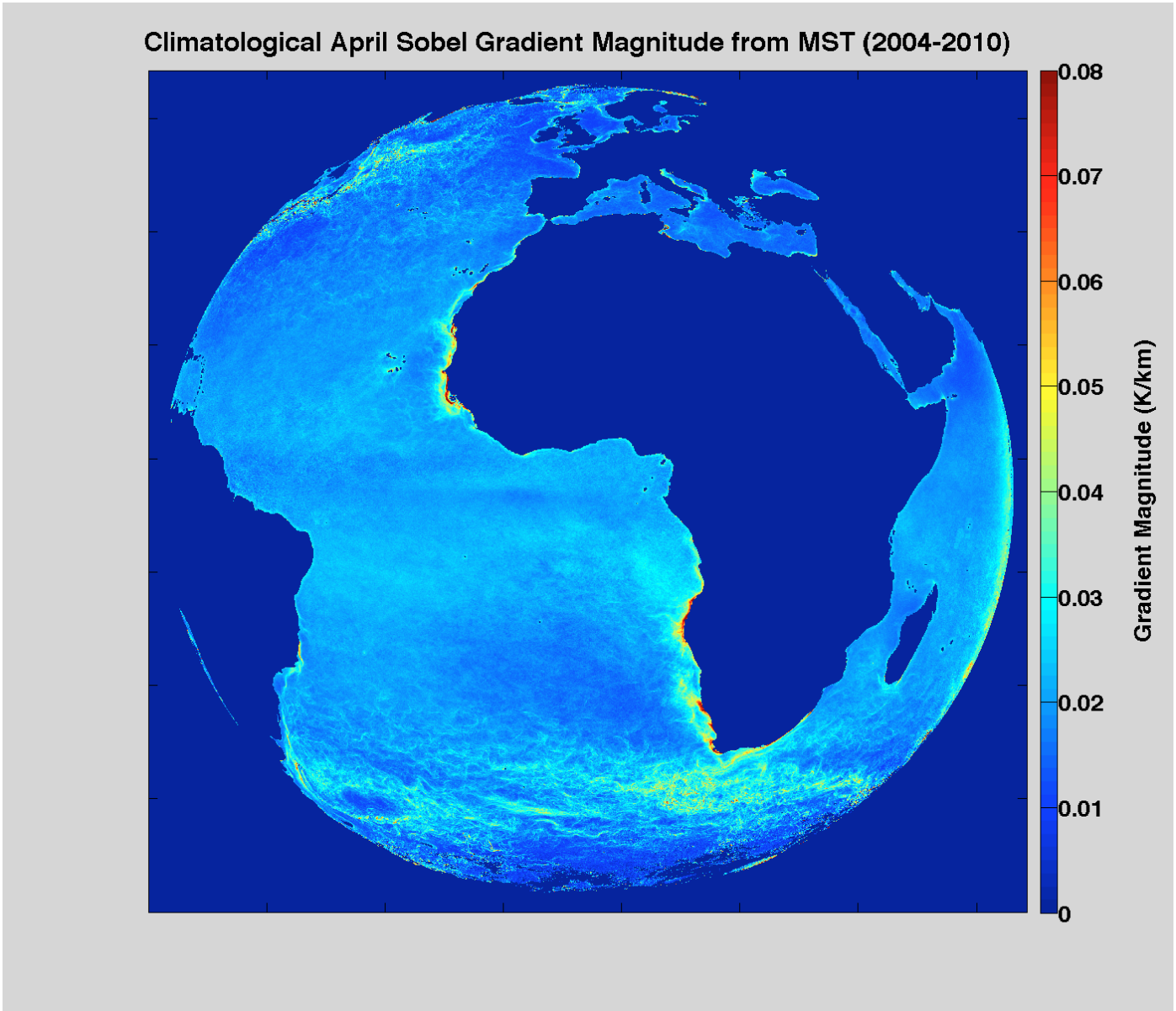
Number Clear Nighttime Pixels June 2003 through February 2011



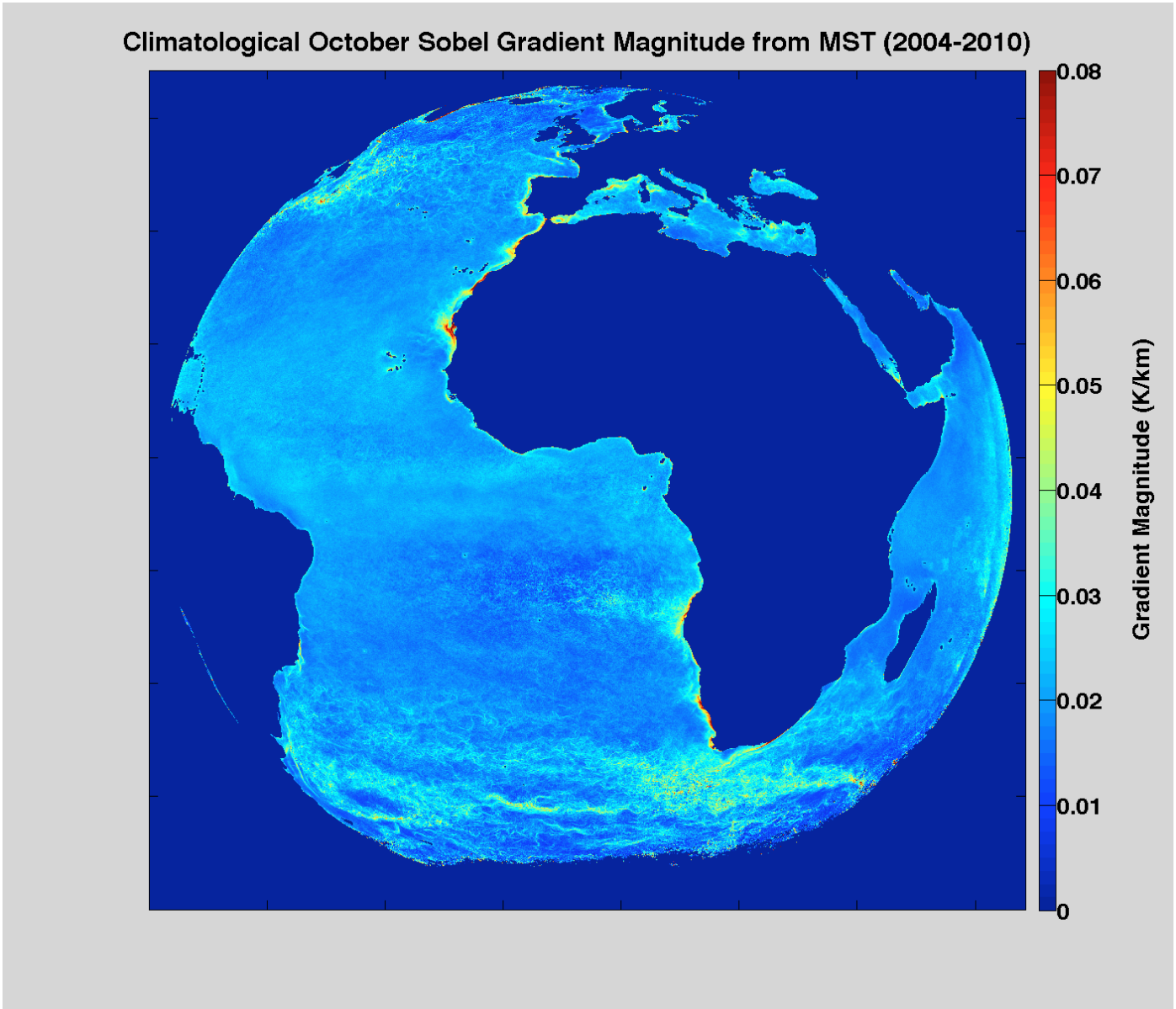
Mean Sobel Gradient Magnitude for June 2003 through February 2011



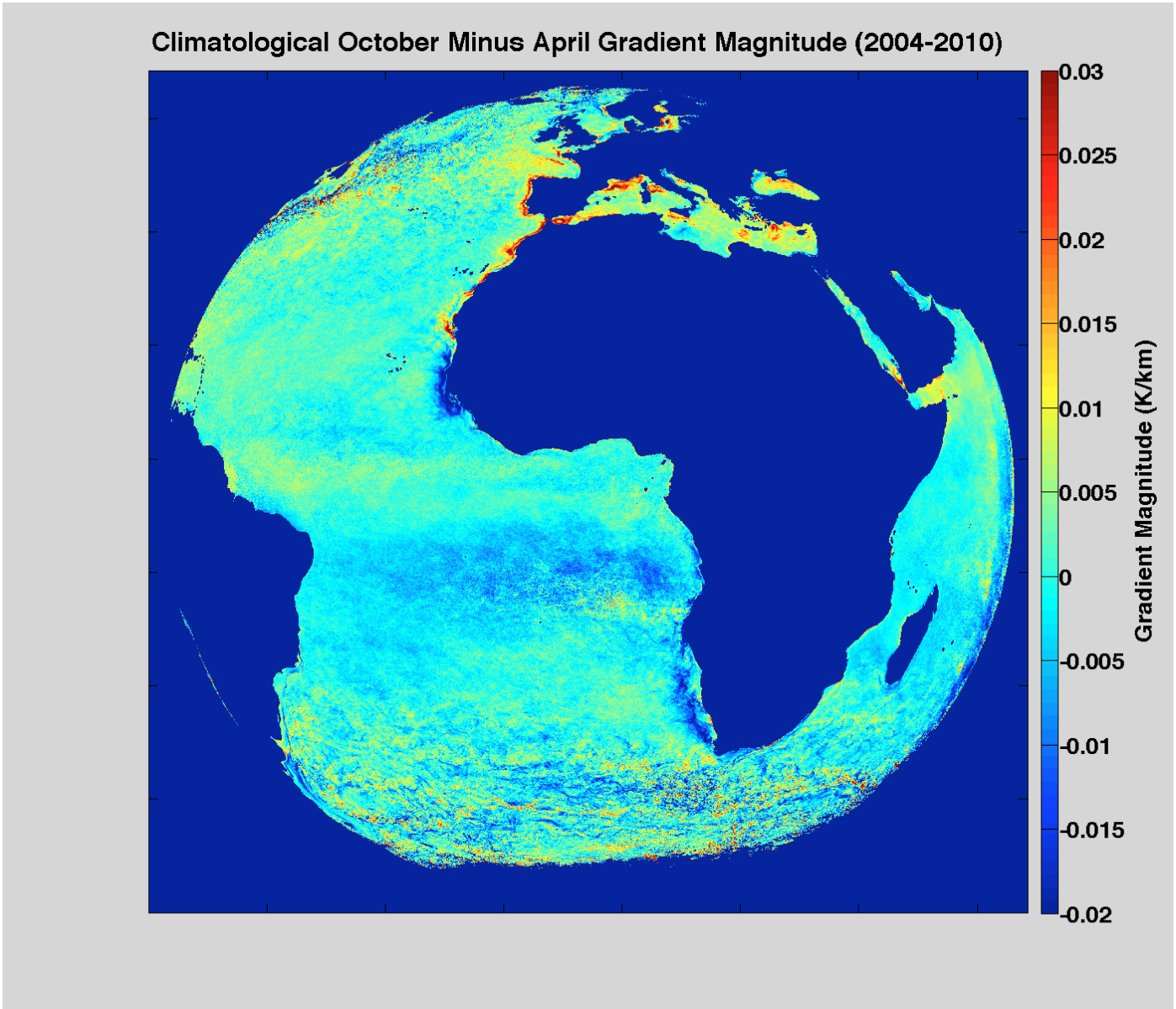
Climatological Sobel Gradient Magnitudes April



Climatological Sobel Gradient Magnitudes October



Climatological Sobel Gradient Magnitudes October minus April



Outline

Front Segments

For each image the SIED is passed over the data twice yielding fronts for both passes:

- The primary fields are:
  - A list of SST front pixels, and
  - A list of SST front segments - one pixel wide lines of contiguous frontal pixels.
    - The stating location of the segment in the front pixel list, and
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    - The stating location of the segment in the front pixel list, and
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Front Segments

For each image the SIED is passed over the data twice yielding fronts for both passes:

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The Cross-Front Array

For each front pixel there is a lot of information, much of which is based on an $n \times 17$ pixel array associated with each frontal segment.

- At each pixel location a cross-frontal line is defined:
  - 17 pixels long,
  - Normal to the segment - based on 5 pixels centered on the pixel of interest
  - Centered on the pixel of interest.
- For each 17 pixel line following is determined:
- The cross-front SST step:

$$\frac{\Sigma_{i=1}^{8} SST_i}{8} - \frac{\Sigma_{j=10}^{17} SST_j}{8}$$

- In-front SST gradient:

$$\frac{\Sigma_{i=8}^{10} \nabla_{E,N} SST_i}{3}$$ where E is eastward and N is northward

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Problems

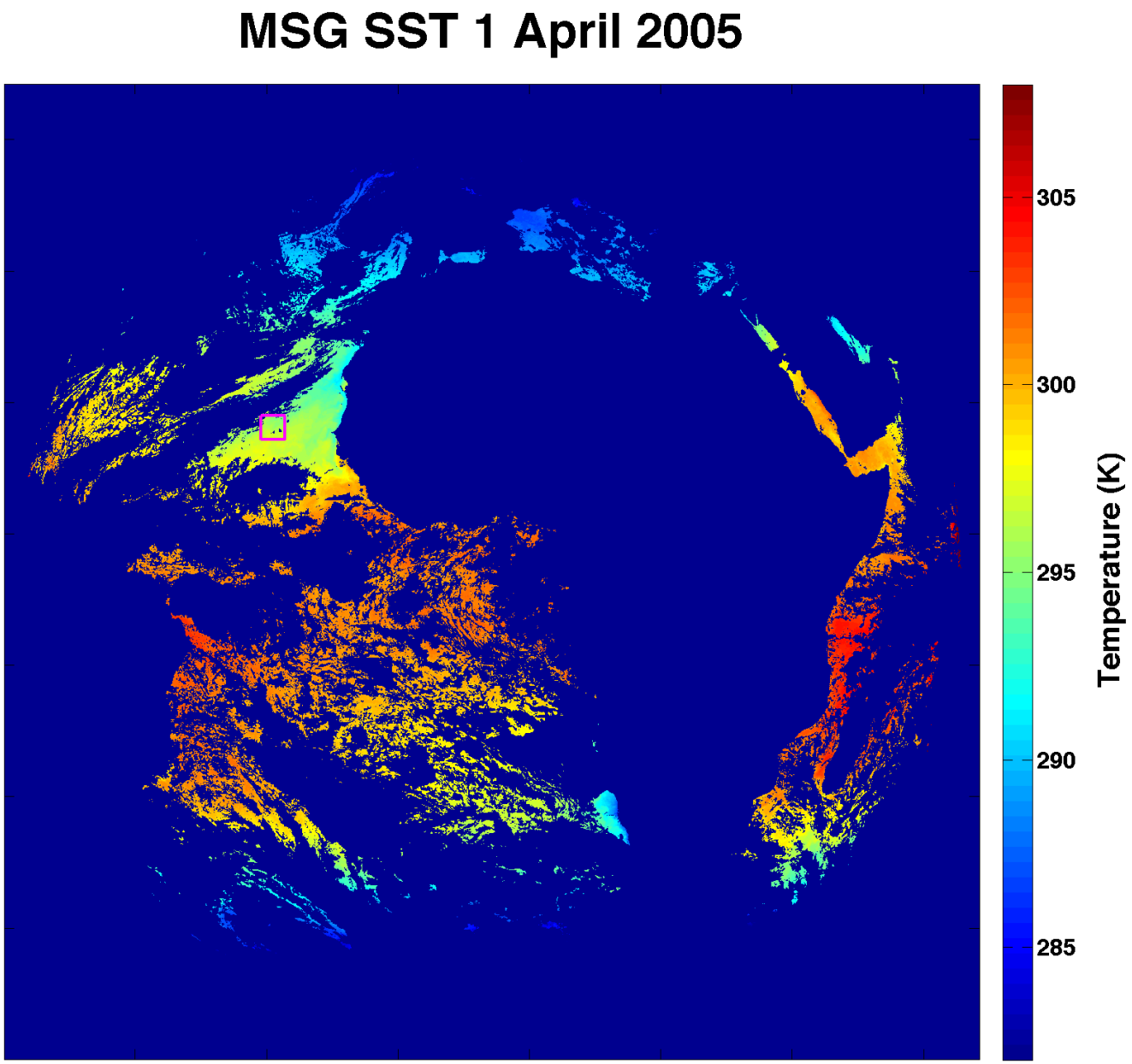
Things were looking' bad; Matlab was Broken.

Problems

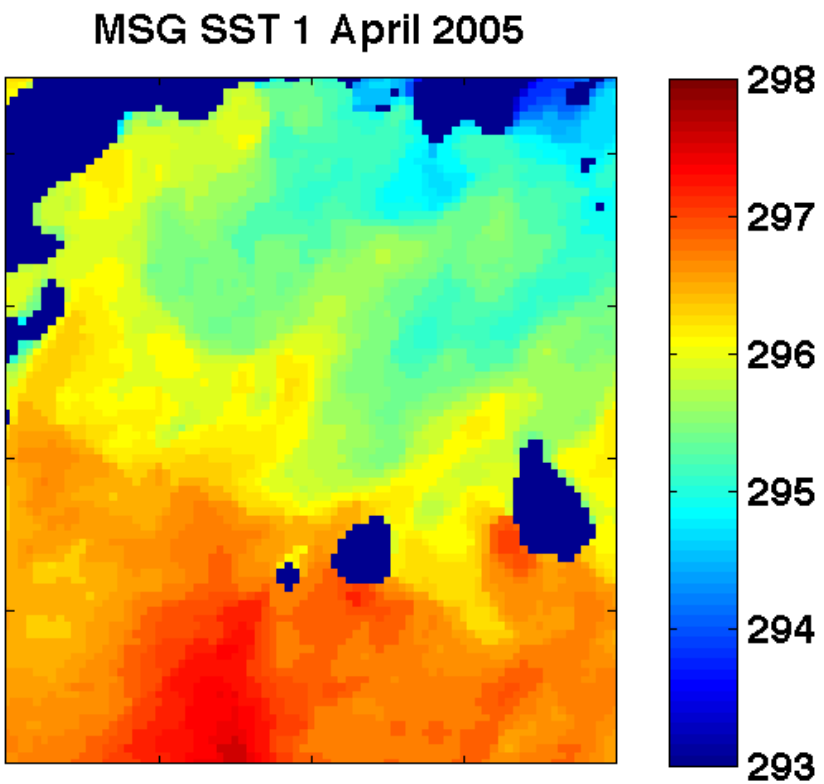
And then along came John.

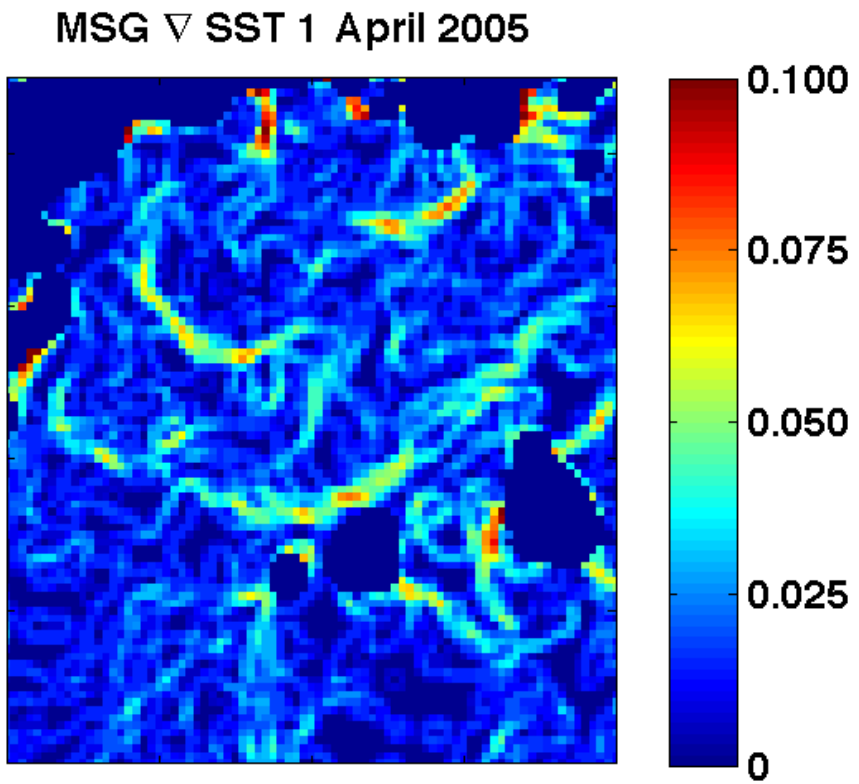
Problems

A Front: 1 April 2005 0000 GMT

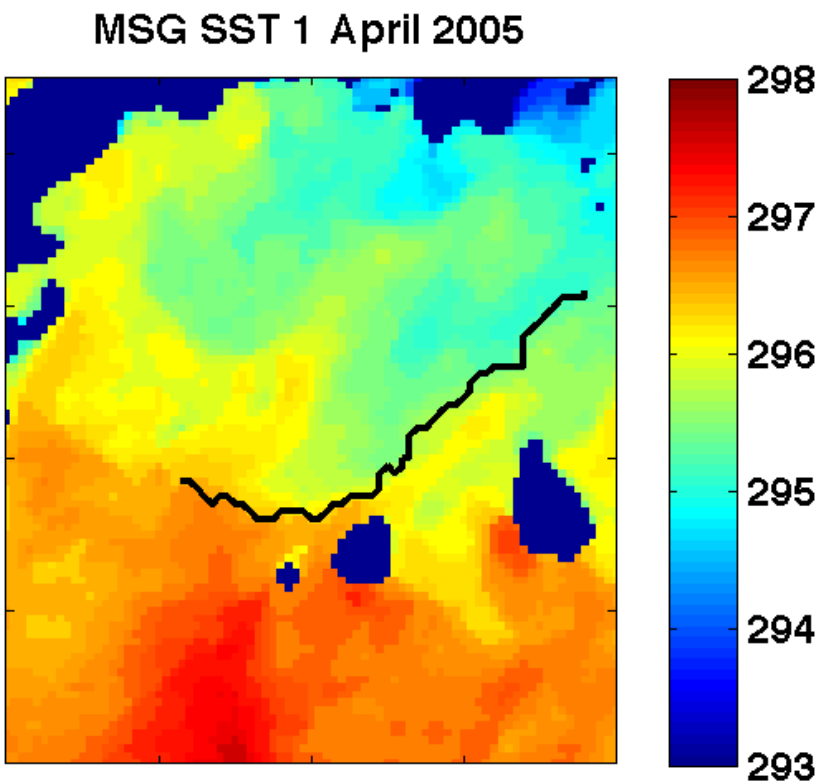


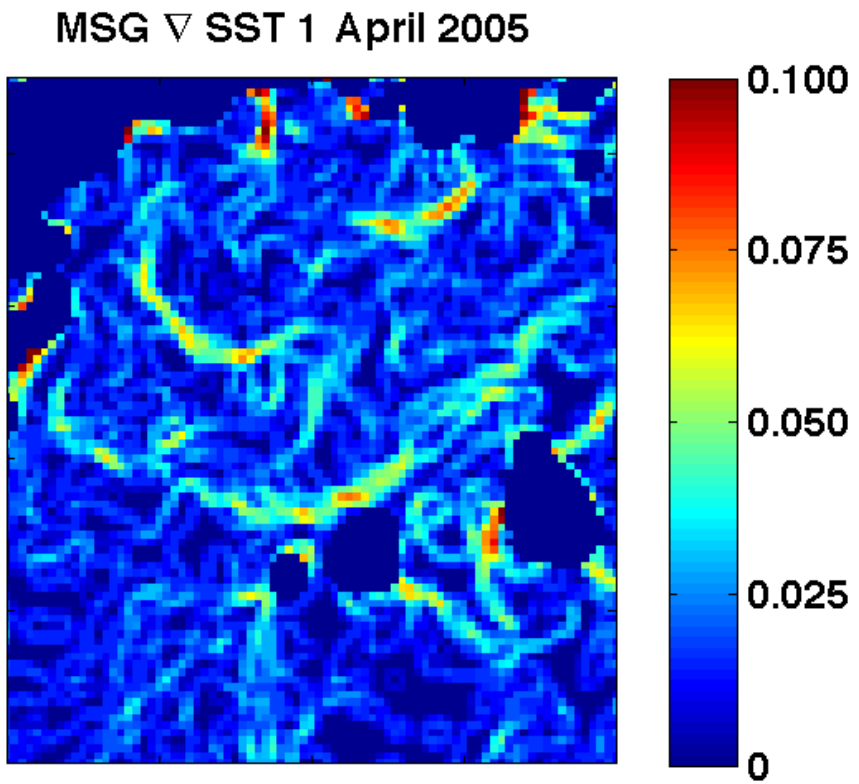
A Front: SST and ∇ SST



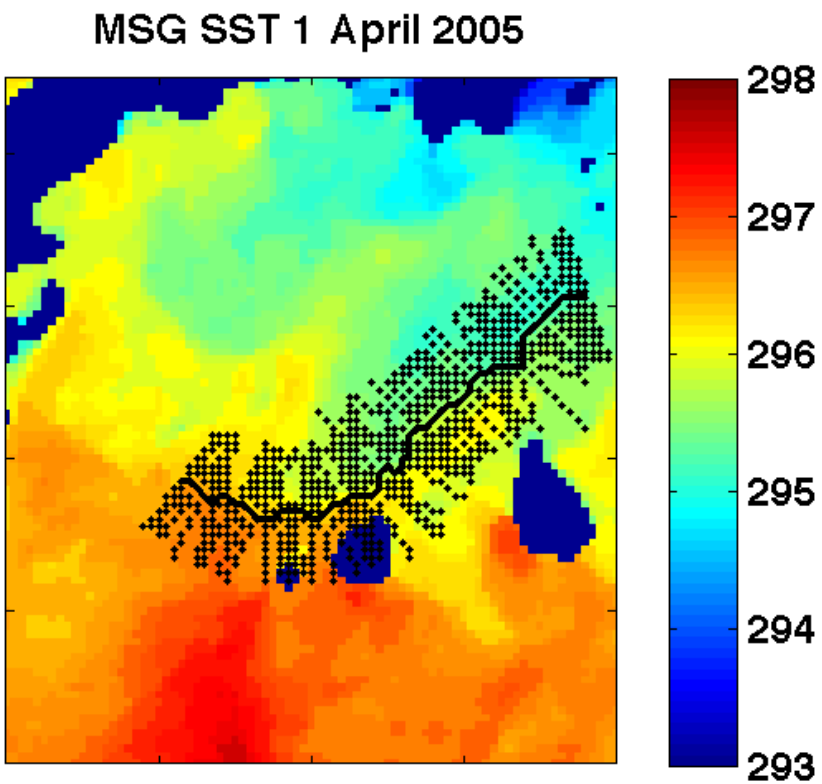


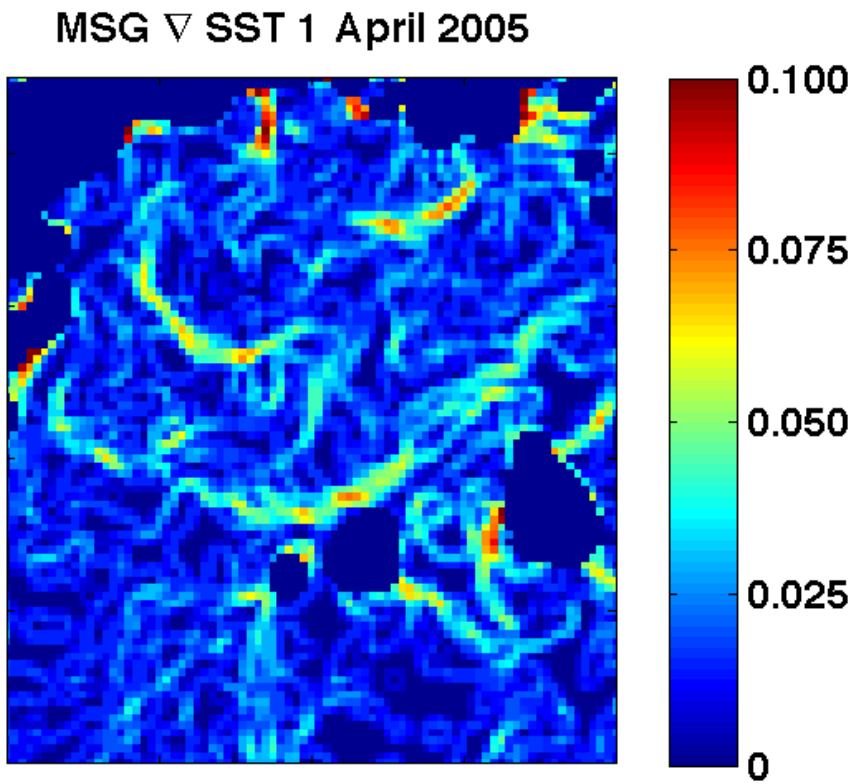
A Front: Front Pixel Locations



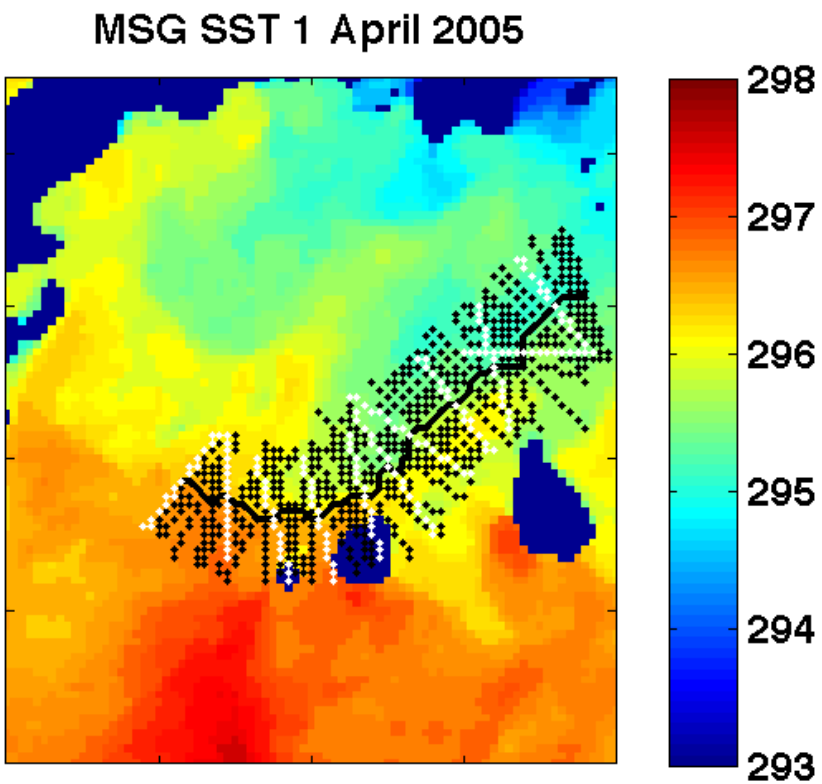


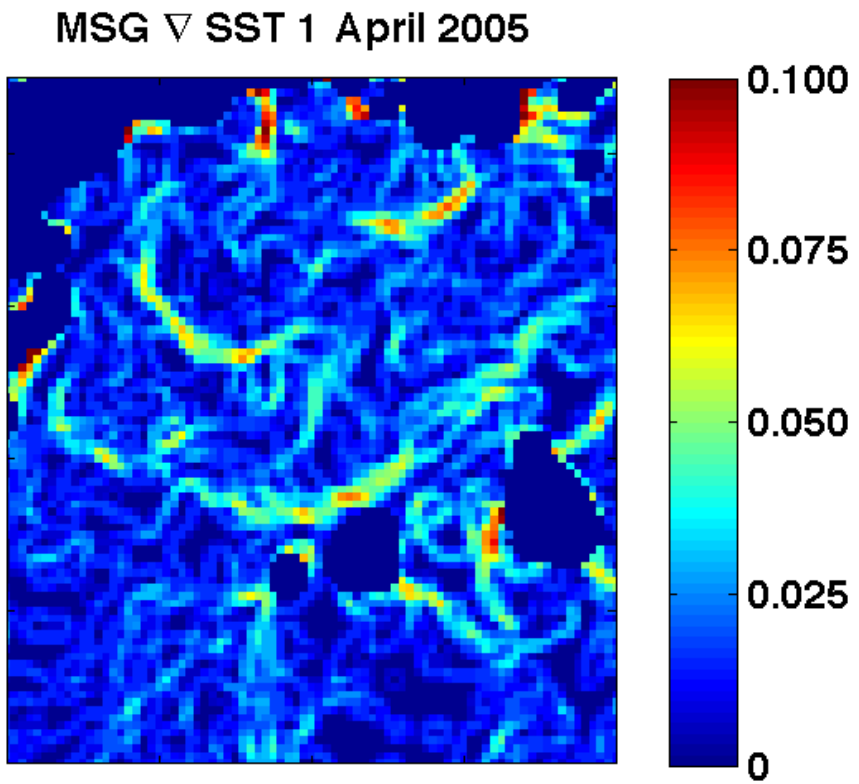
A Front: The n $\times$ 17 Locations



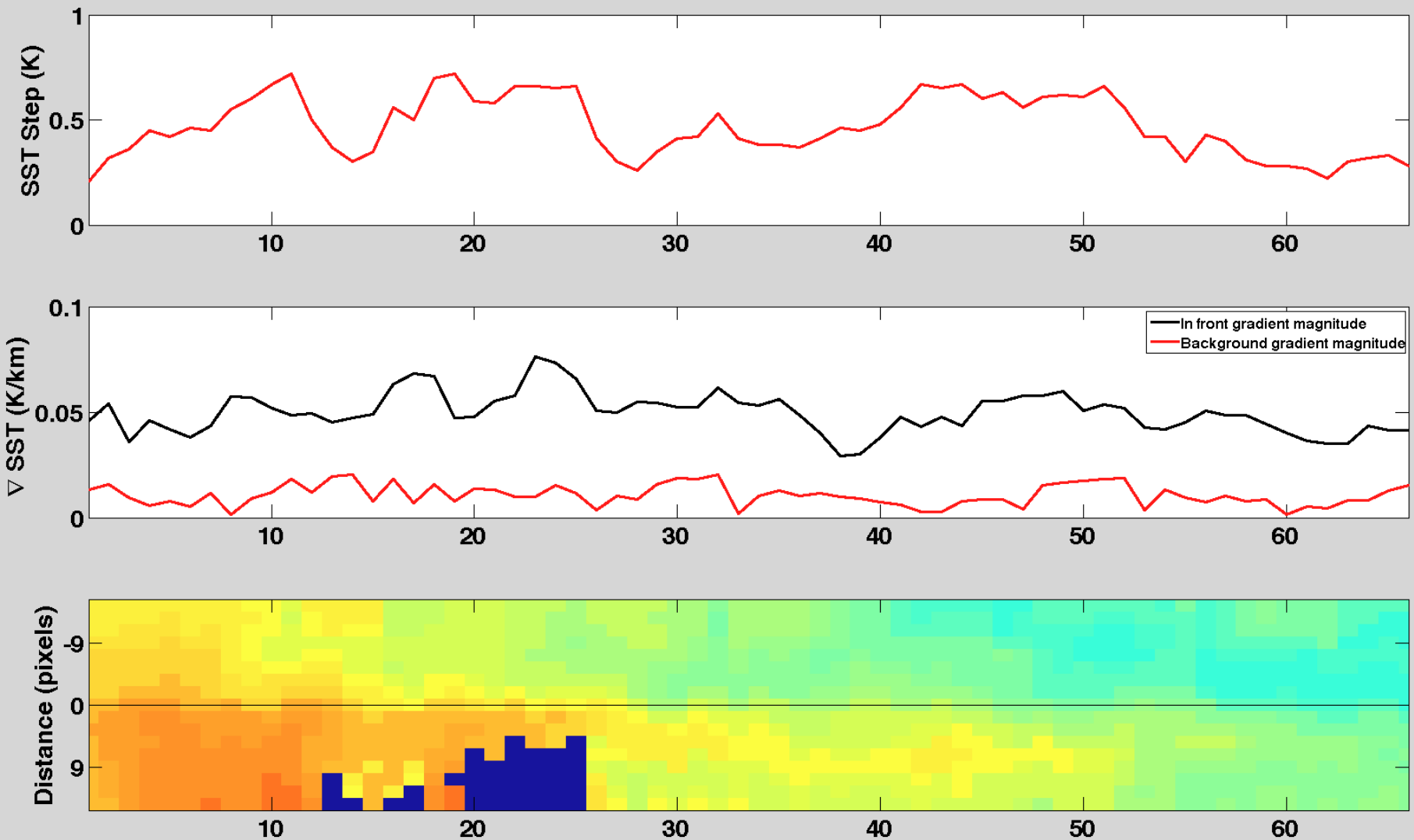


A Front: Representative Cross-Front Lines



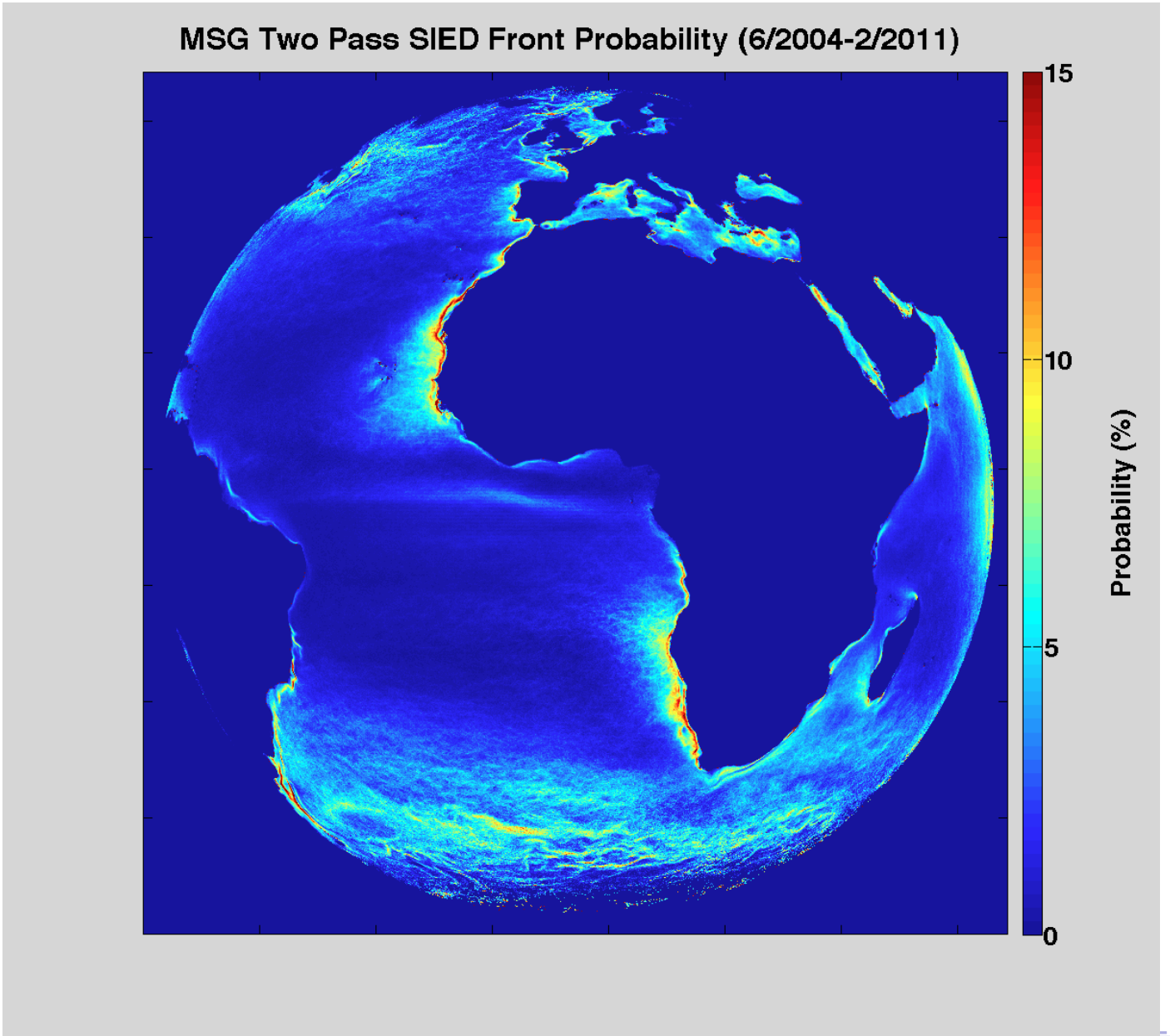


A Front: Cross-Front Properties

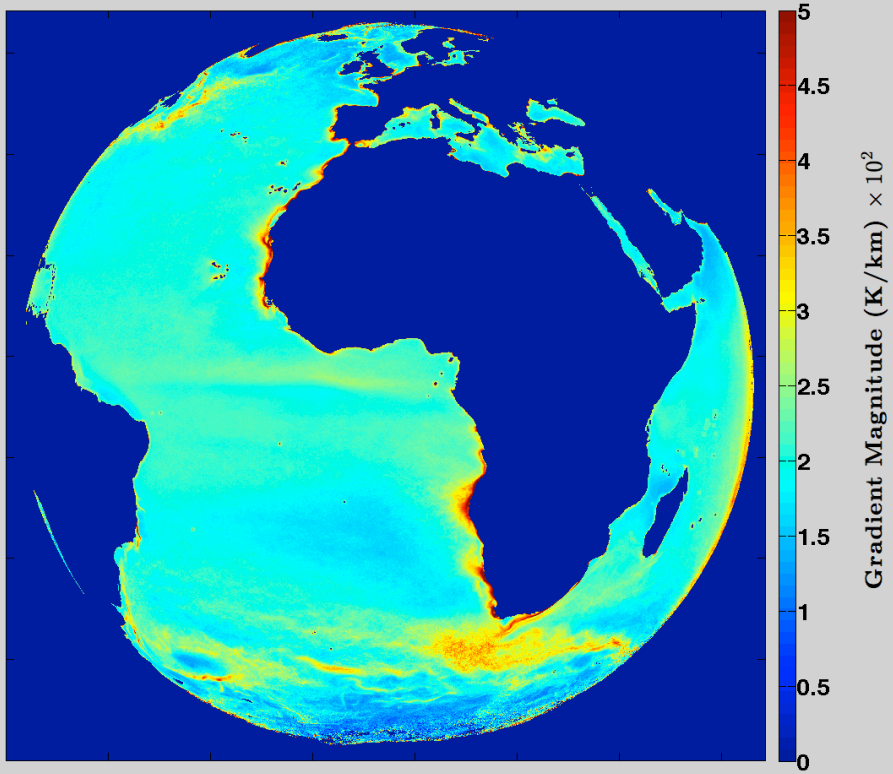


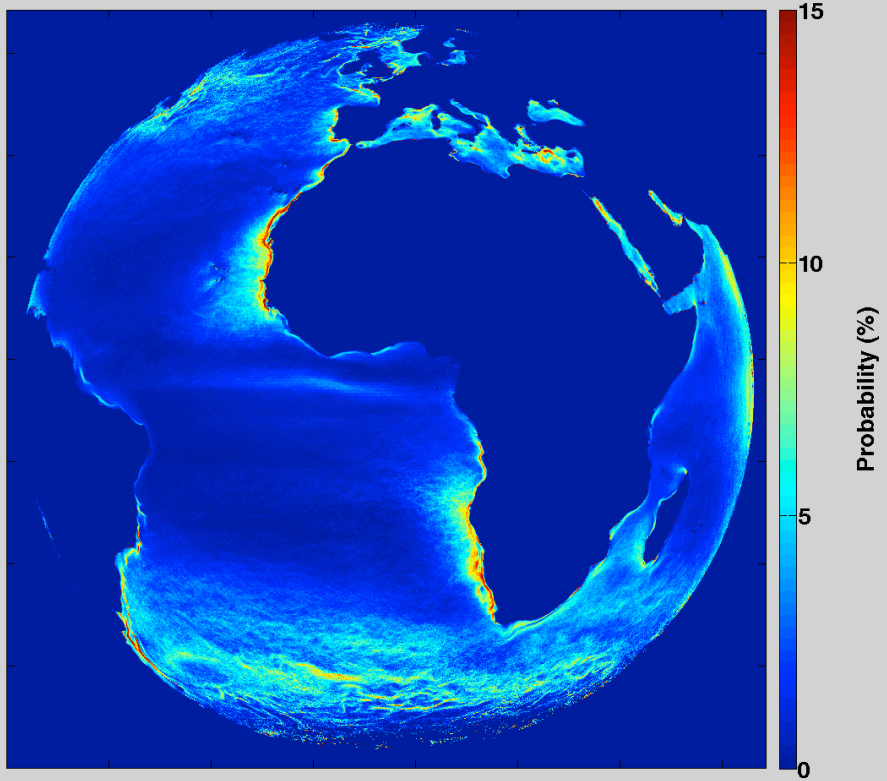
Outline

Nighttime Front Probability for June 2003 through February 2011



Nighttime Front Probability vs Mean Gradient Magnitude (2003– 2011)





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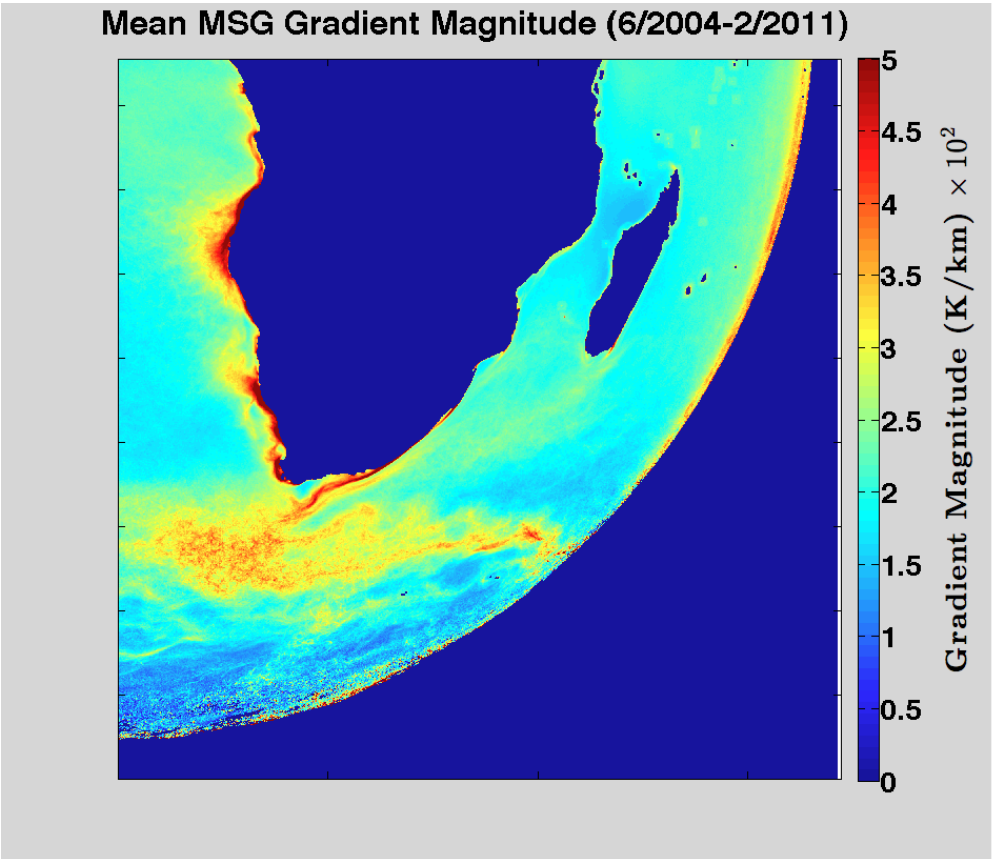
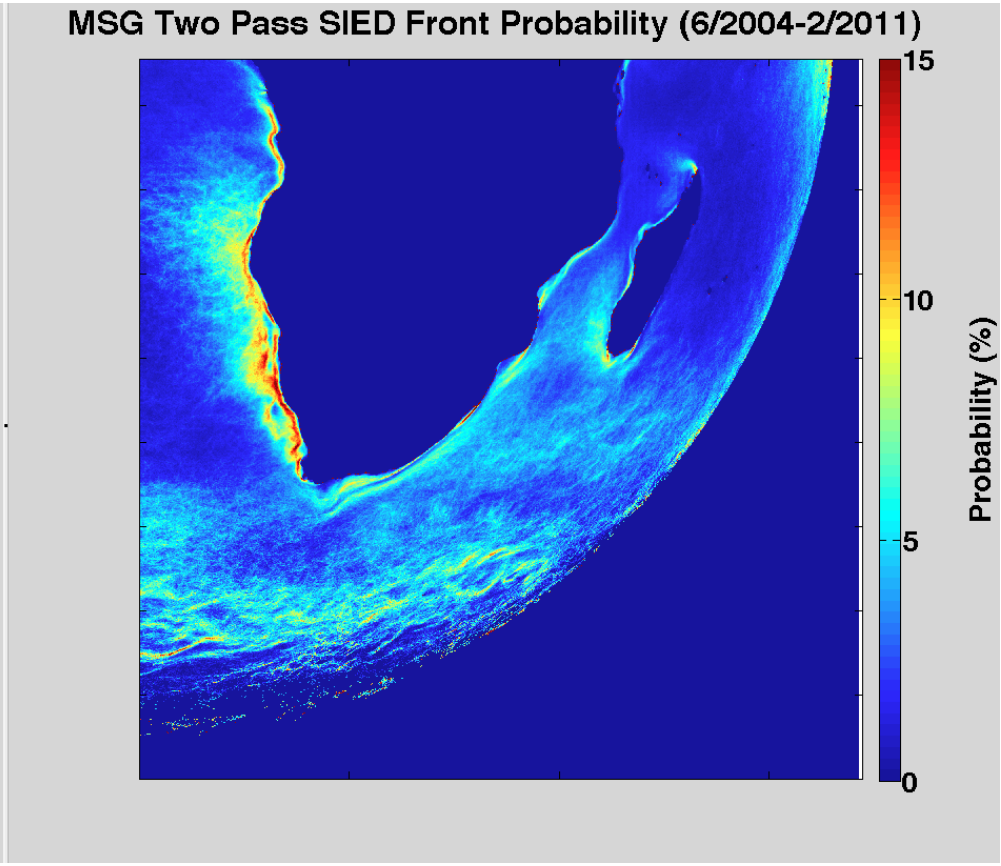




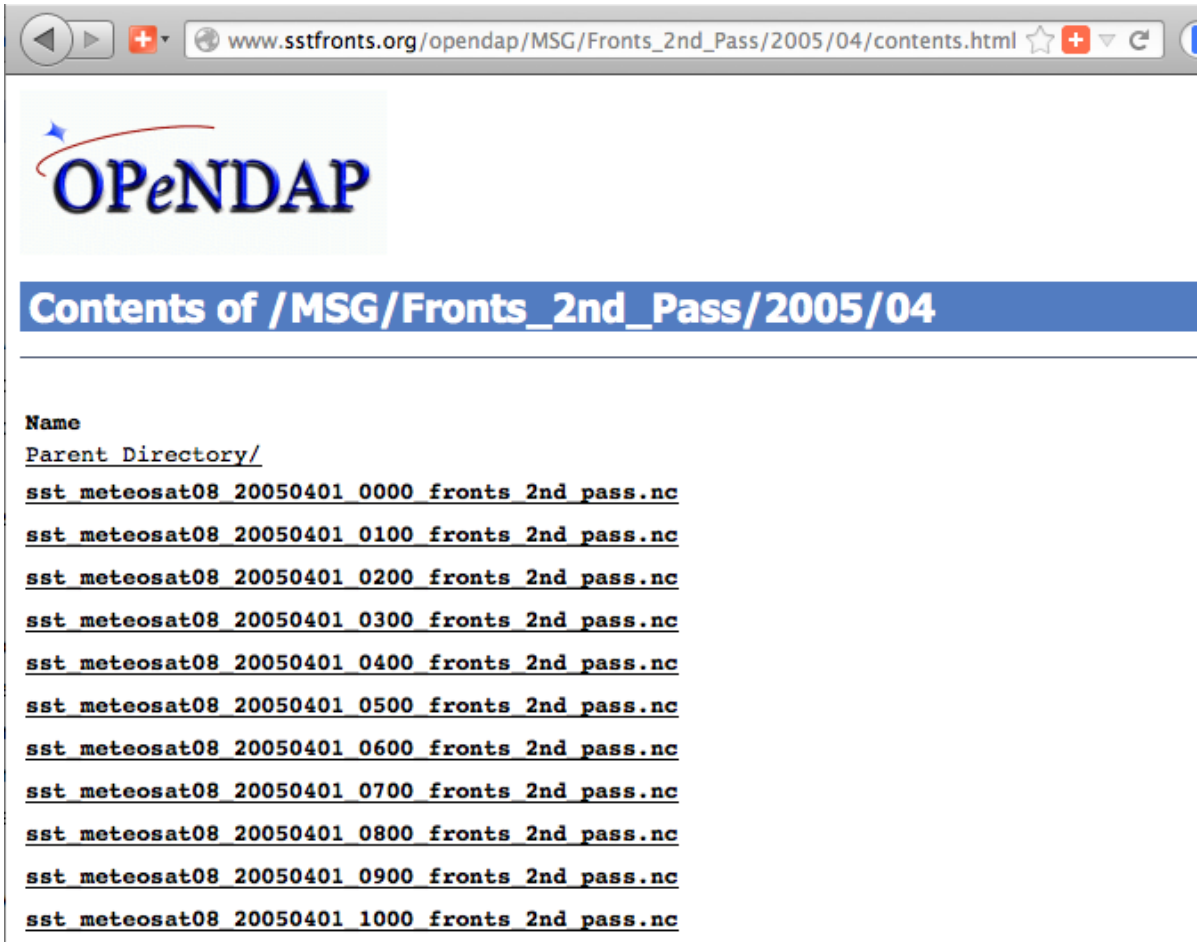
Outline

Accessing the Data via a Browser

The data are easy to access via a browser at: http://sstfronts.org/opendap

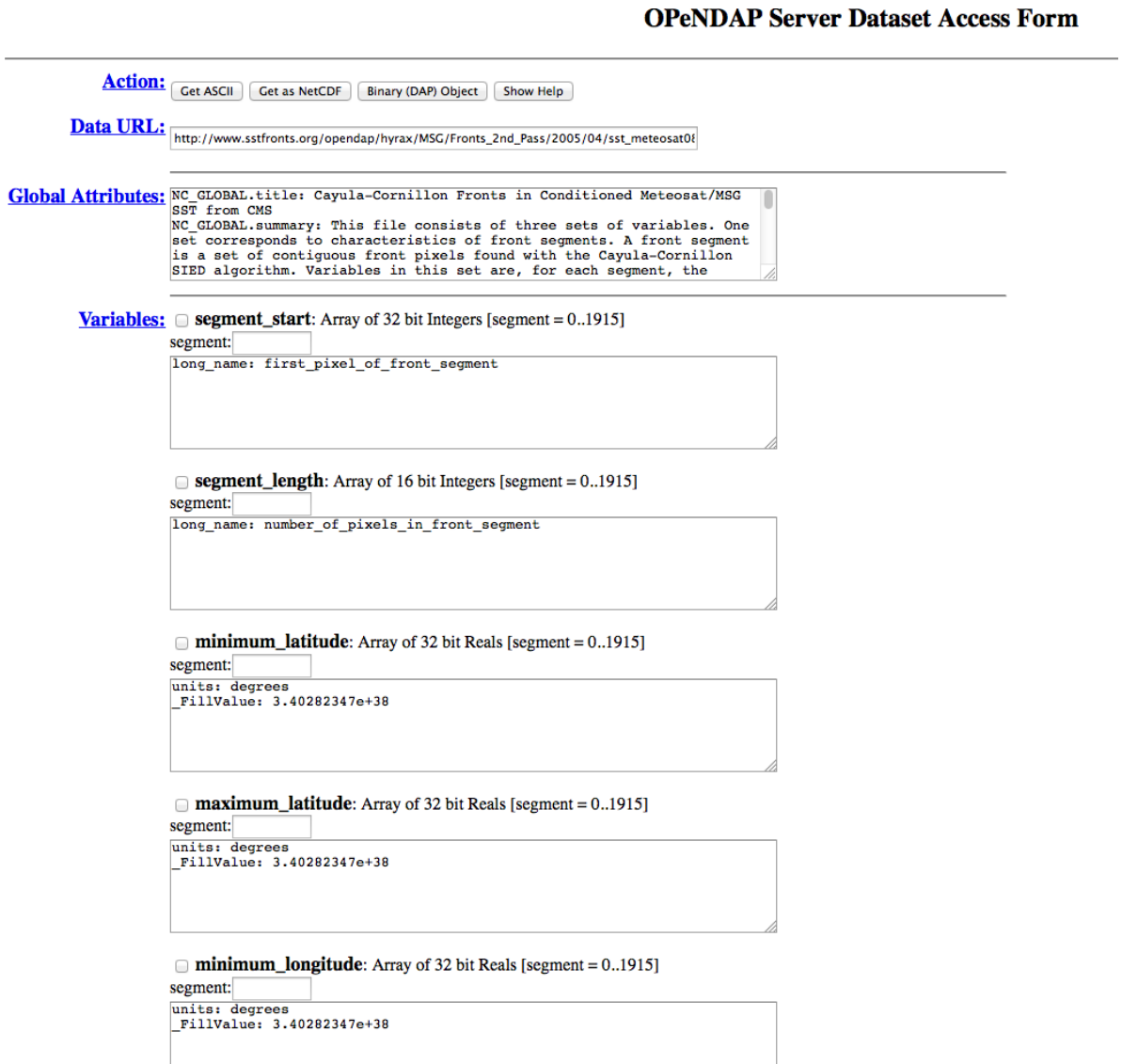
Accessing the Data via a Browser

Tree down to the file of interest



Accessing the Data via a Browser

Click on the filename



OPeNDAP Server Dataset Access Form

Action: Get ASCII | Get as NetCDF | Binary (DAP) Object | Show Help

Data URL: http://www.sstfronts.org/opendap/hyrax/MSG/Fronts_2nd_Pass/2005/04/sst_meteosat0

Global Attributes:

```
NC_GLOBAL.title: Cayula-Cornillon Fronts in Conditioned Meteosat/MSG
SST from CMS
NC_GLOBAL.summary: This file consists of three sets of variables. One
set corresponds to characteristics of front segments. A front segment
is a set of contiguous front pixels found with the Cayula-Cornillon
SIED algorithm. Variables in this set are, for each segment, the
```

Variables:

segment_start: Array of 32 bit Integers [segment = 0..1915]

segment:

```
long_name: first_pixel_of_front_segment
```

segment_length: Array of 16 bit Integers [segment = 0..1915]

segment:

```
long_name: number_of_pixels_in_front_segment
```

minimum_latitude: Array of 32 bit Reals [segment = 0..1915]

segment:

```
units: degrees
_FillValue: 3.40282347e+38
```

maximum_latitude: Array of 32 bit Reals [segment = 0..1915]

segment:

```
units: degrees
_FillValue: 3.40282347e+38
```

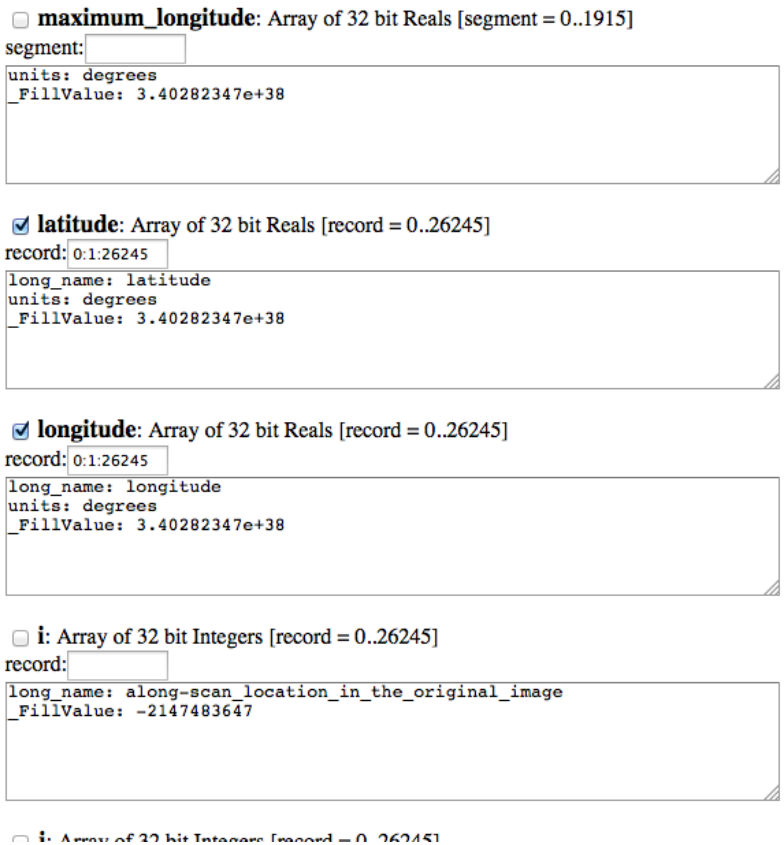
minimum_longitude: Array of 32 bit Reals [segment = 0..1915]

segment:

```
units: degrees
_FillValue: 3.40282347e+38
```

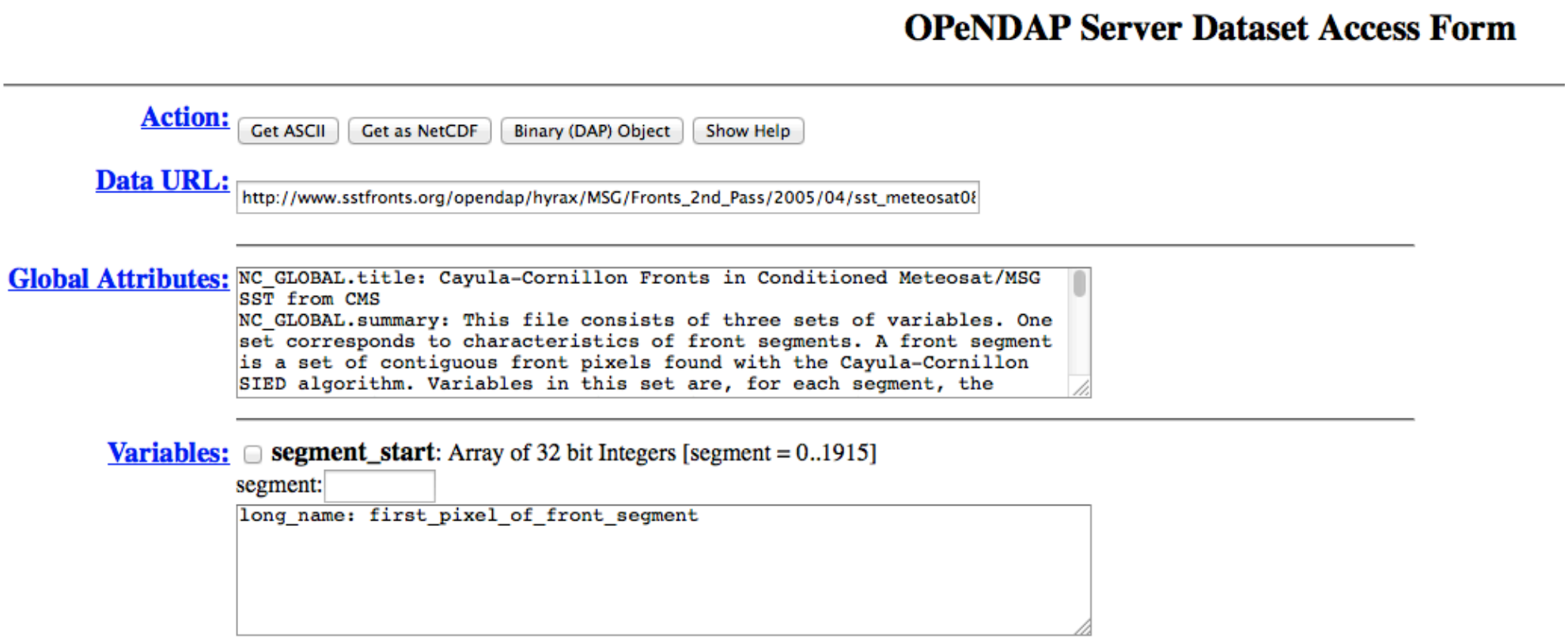
Accessing the Data via a Browser

Select the elements (and range if desired) of variables from the list.



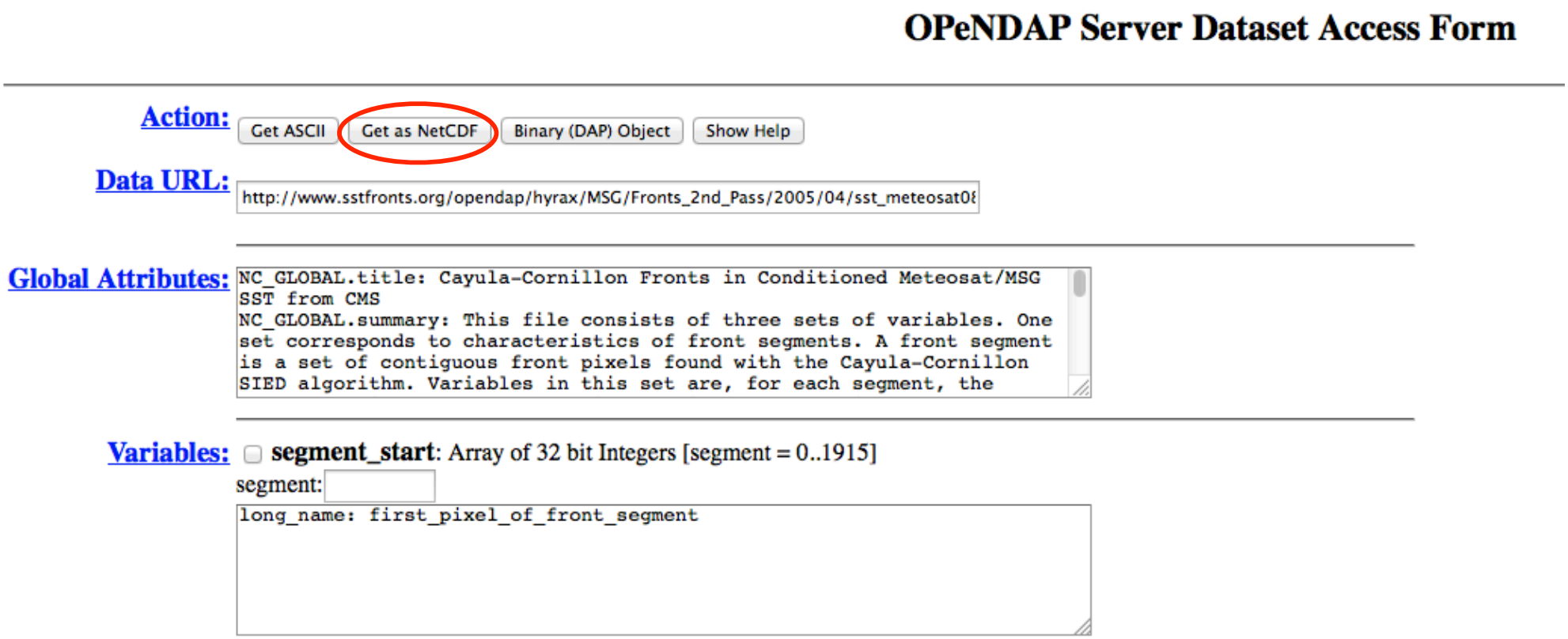
Accessing the Data via a Browser

Click “Get as NetCDF":



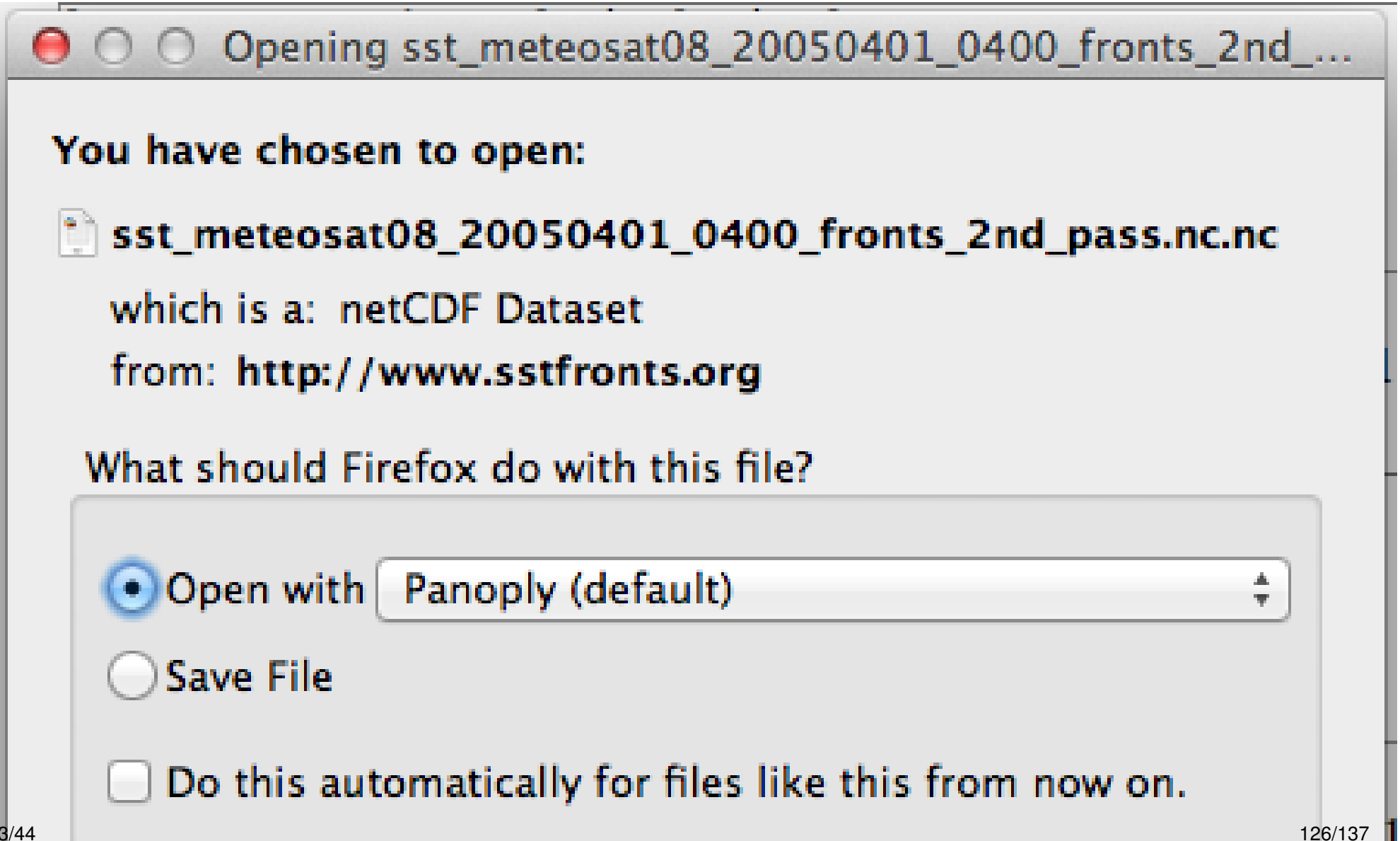
Accessing the Data via a Browser

Click “Get as NetCDF":



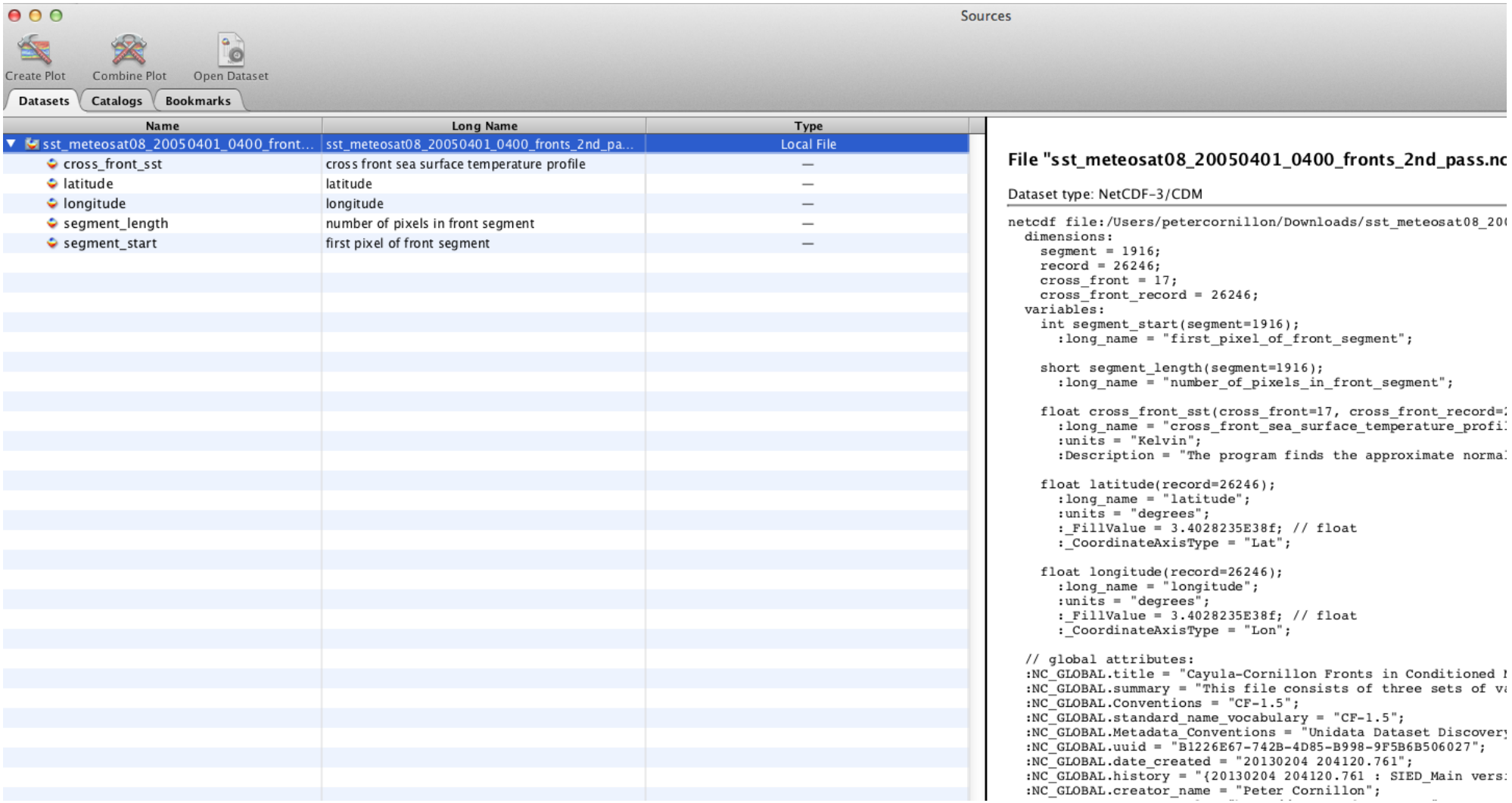
Accessing the Data via a Browser

Select action on your system:



Accessing the Data via a Browser

And voila:



Accessing the Data via wget

- The data are also readily accessible/subsettable via wget:

  ≫ wget http://www.sstfronts.org/opendap/hyrax/MSG/Fronts_2nd_Pass/2005/04/sst_meteosat08_20050401_0400_fronts_2nd_pass.nc.nc?segment_start,segment_length,latitude,longitude,cross_front_sst

  Note the second .nc at the end of the filename. (.nc4 in a few weeks will get a chunked/compressed response.)

- Or you could access the data directly from Matlab substituting the filename (without the extra .nc) in the Matlab netCDF commands.

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  - MSG-SEVIRI
  - GOES-east-VISSR
- Available within a week:
  - AVHRR
    - 4 km Global V5.2
    - 1 km Western North Atlantic - Wallops Island regional station
  - MODIS 4 km Global
    - Aqua, Terra
      - NSST
      - SSTA
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