Extension of ACSPO VIIRS SST domain using pattern recognition analyses

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Motivation

- Customarily, clear-sky masks for ocean are independent of downstream ocean dynamics applications, such as detection of ocean thermal fronts, currents, eddies and cold upwellings
- Ocean dynamics in satellite SST imagery and its monitoring in time are analyzed over clear sky pixels only
- The result may be strongly affected by the quality of clear-sky scene detection

Quality of Clear-Sky Mask

Majority of current masking algorithms use thresholds. Liberal thresholds result in “cloud leakages”, whereas conservative settings lead to “false alarms”

Conservative SST mask is usually considered preferable, to minimize cloud leakages, at the expense of losing a (presumably small) fraction of clear pixels, globally

Standard Criteria:

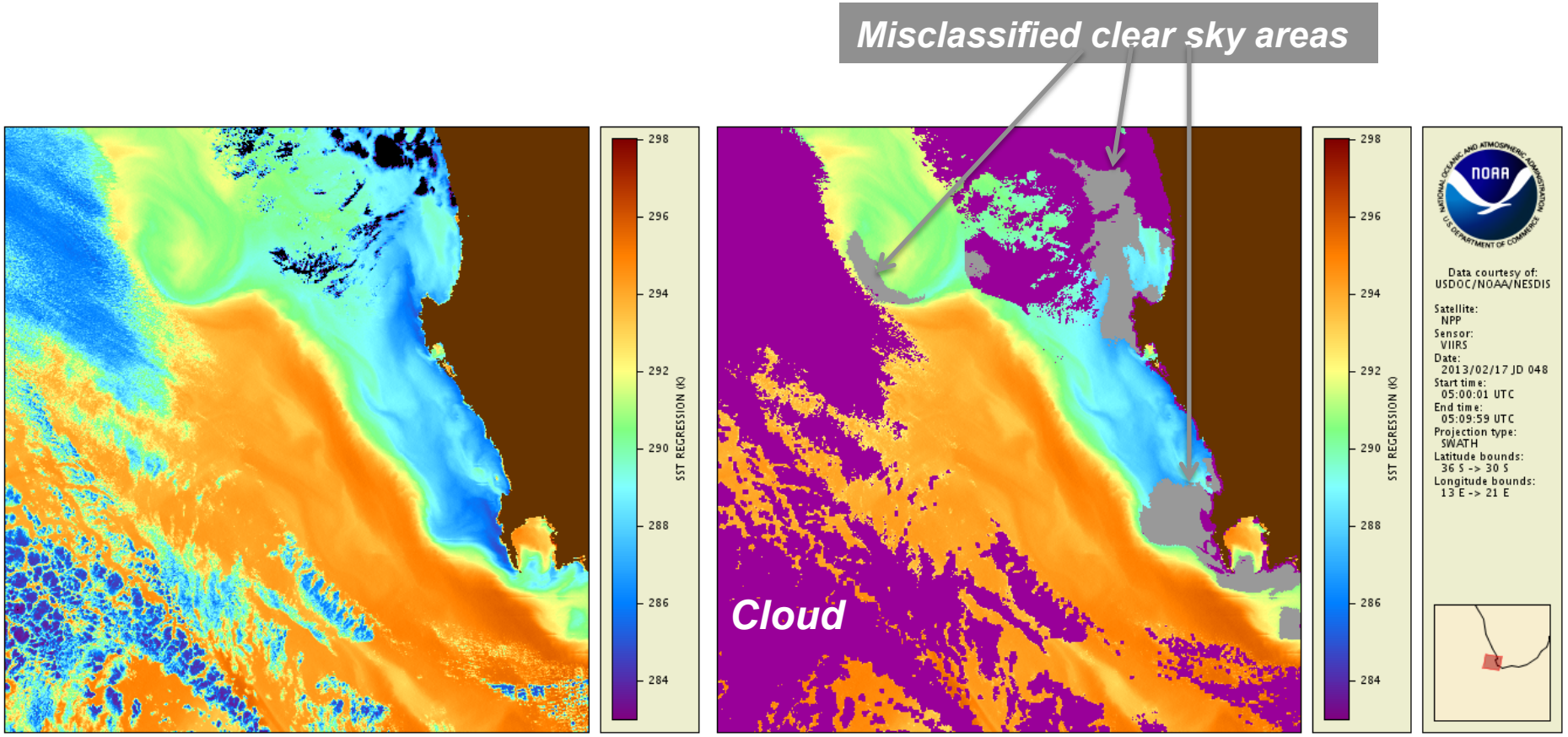
- Minimal cloud leakages; and
- Large geographical coverage

What is the price?

- The geographic distribution of “false alarms” is highly non-uniform
- “False alarms” are often persistent from pass to pass
- Misclassification mostly occurs in those ocean areas where SST is variable and/or significantly colder than surrounding waters and/or first guess field

Typical Misclassifications

South Africa (SNPP day pass)



VIIRS ACSPO SST (no cloud mask)

SST with ACSPO cloud mask overlaid

What is the price?

It is those dynamical and coastal waters that are of most interest to SST users, including

- accurate reproduction of ocean dynamics in L4 products
- modeling of ocean dynamics
- coastal management
- fishing
- ship navigation
- generating unbiased climatologies
- marine biology studies

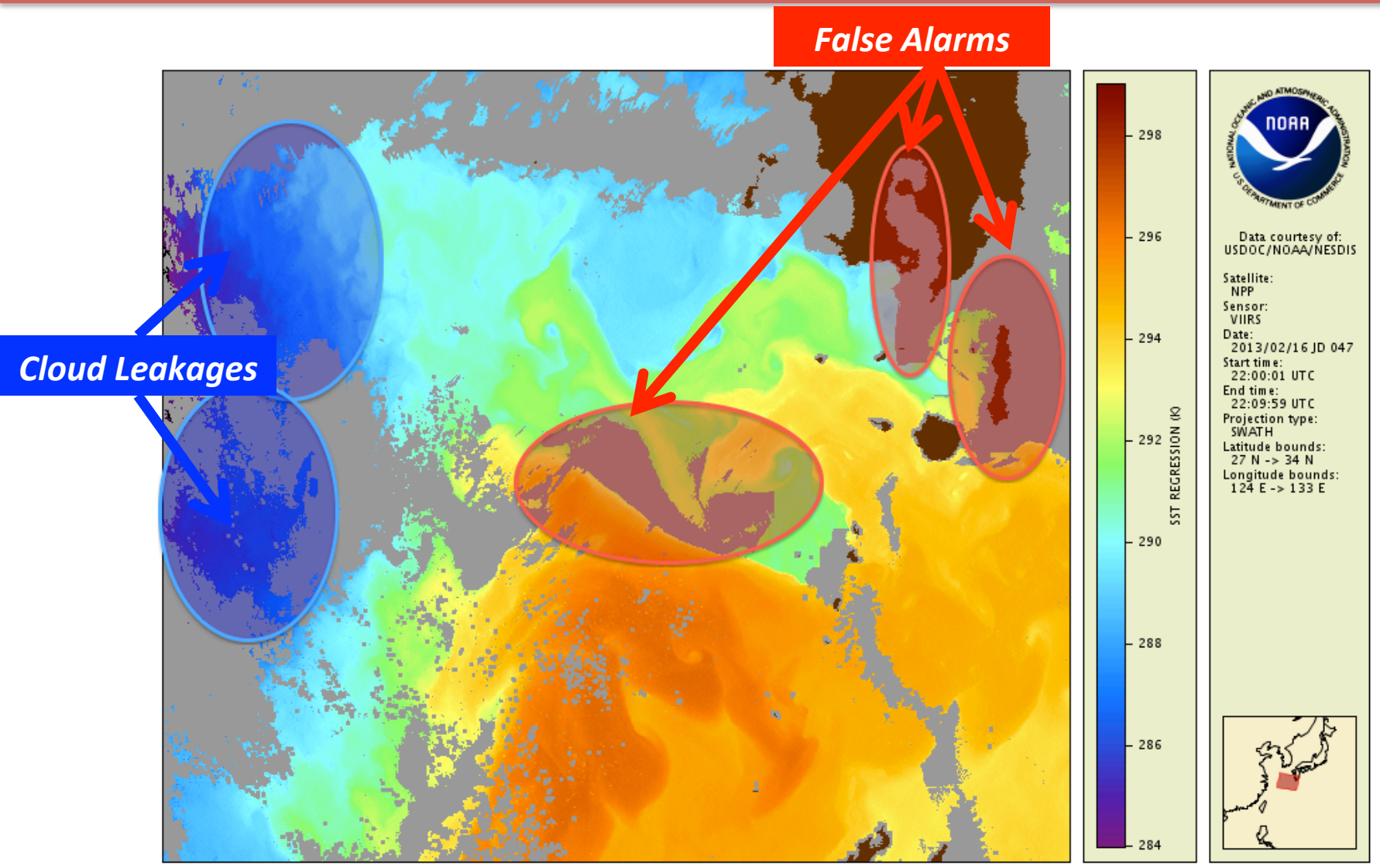
  and more

Objective of this Study

Open up interesting areas of the ocean in ACSPO SST product by incorporating elements of ocean dynamics analysis in ACSPO Clear-Sky Mask

- Our initial objective is to reclassify (at least, some) "false alarms" back into ACSPO clear-sky domain for SST users
- We do not address "cloud leakages", at this stage of analysis
- Eventually, the method will be extended to MODIS 1km, and AVHRR (1km FRAC, and 4km GAC) data

ACSPO Clear Sky Mask



Typical False Alarms

Typically, clear sky ocean regions misclassified by ACSM

- Contiguous
- Have well-defined boundaries
- Located in the vicinity of ocean thermal fronts

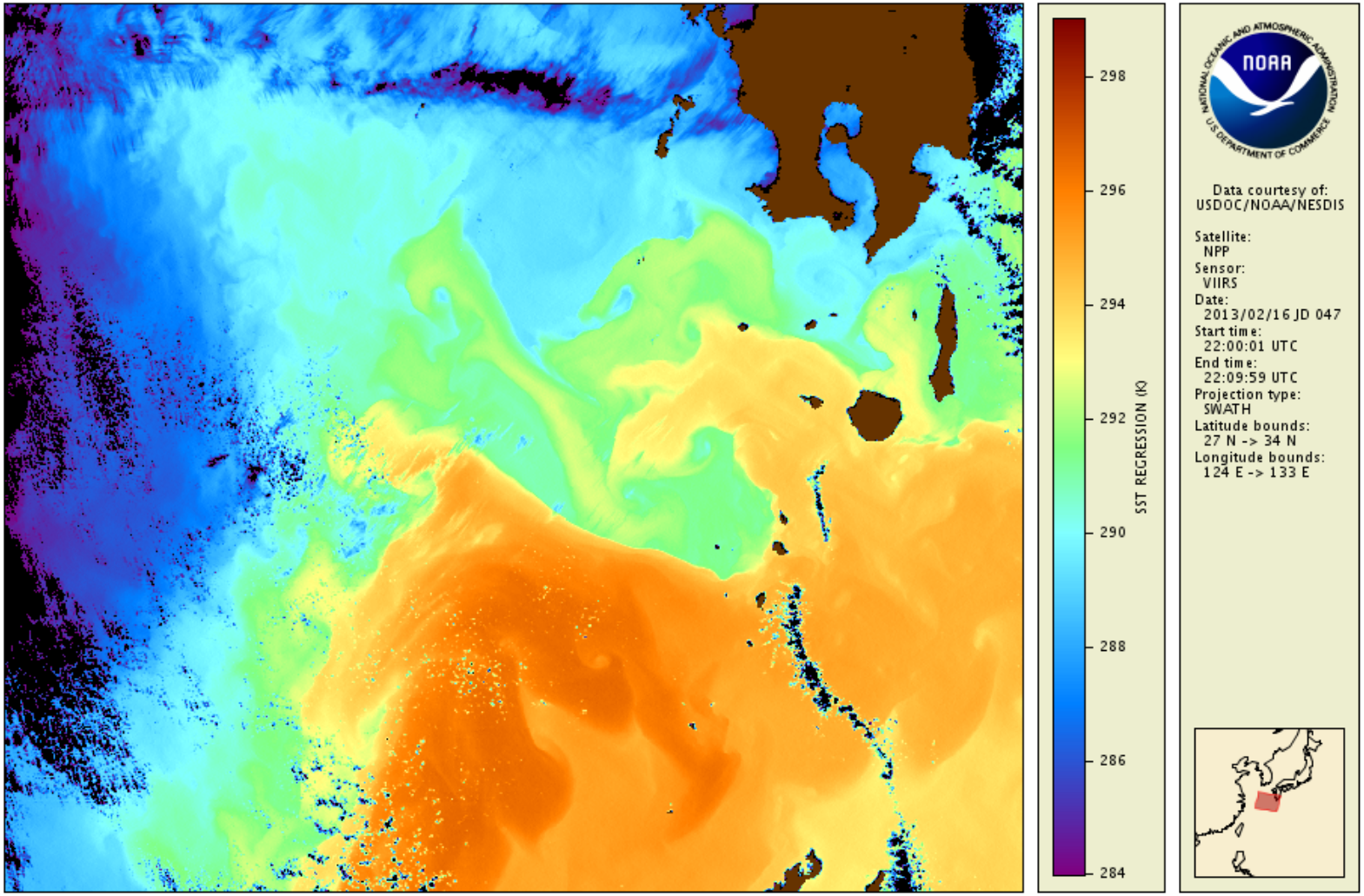
Existing image processing techniques

- Clustering, Segmentation, Connected Components
- Morphological Procedures: erosion, dilation
- Thermal Front, Edge and Ridge detection algorithms

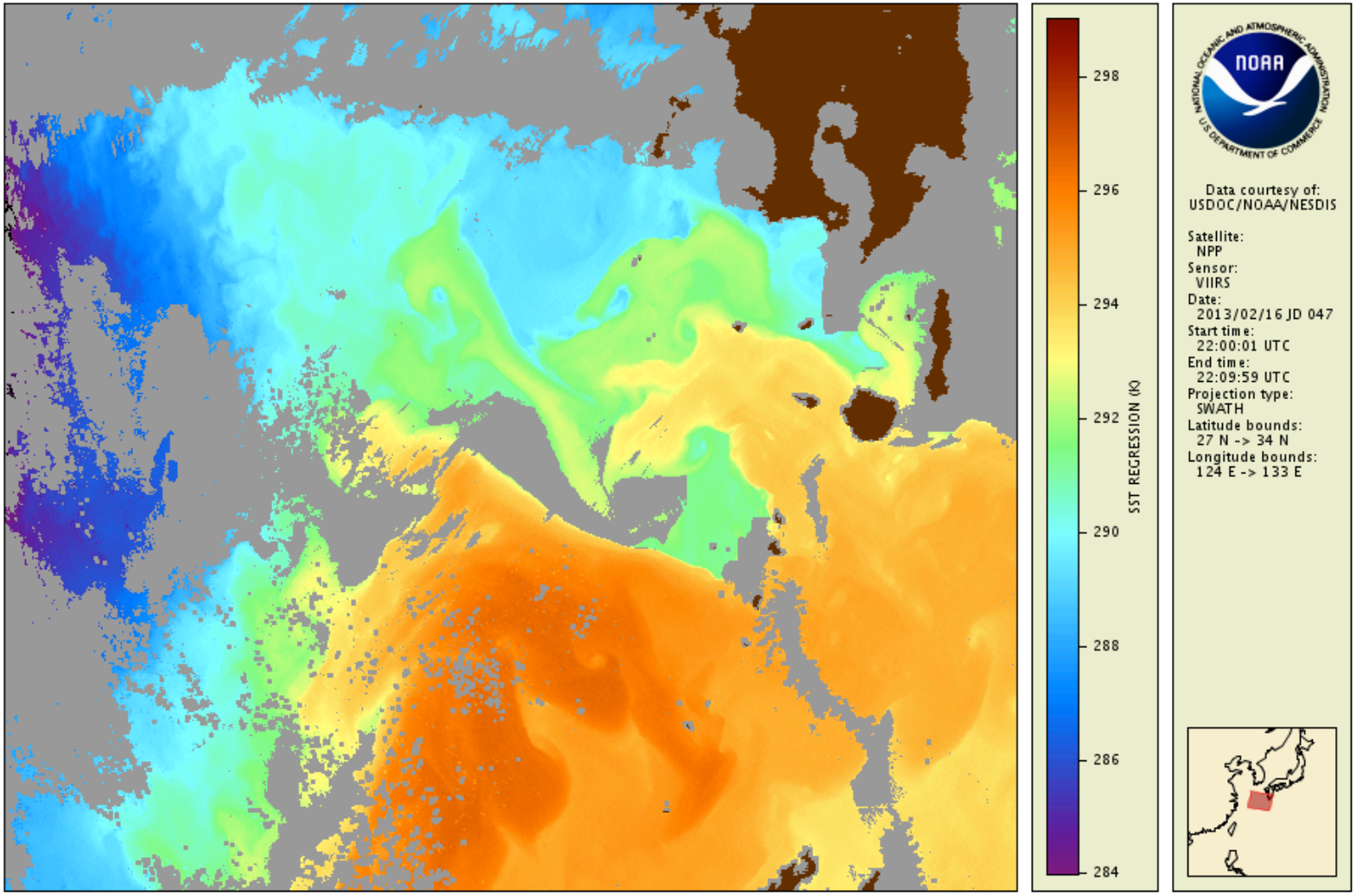
Human Perception

- Human eye does not perceive absolute values of the image (i.e., SST)
- Instead, it relies on local contrasts and ratios, which more directly correlate with gradients in an image
- Difference between ocean and cloud patterns is more pronounced in the SST gradient magnitude domain
- Most clouds can be visually detected from SST derivatives and their variations

Retrieved SST

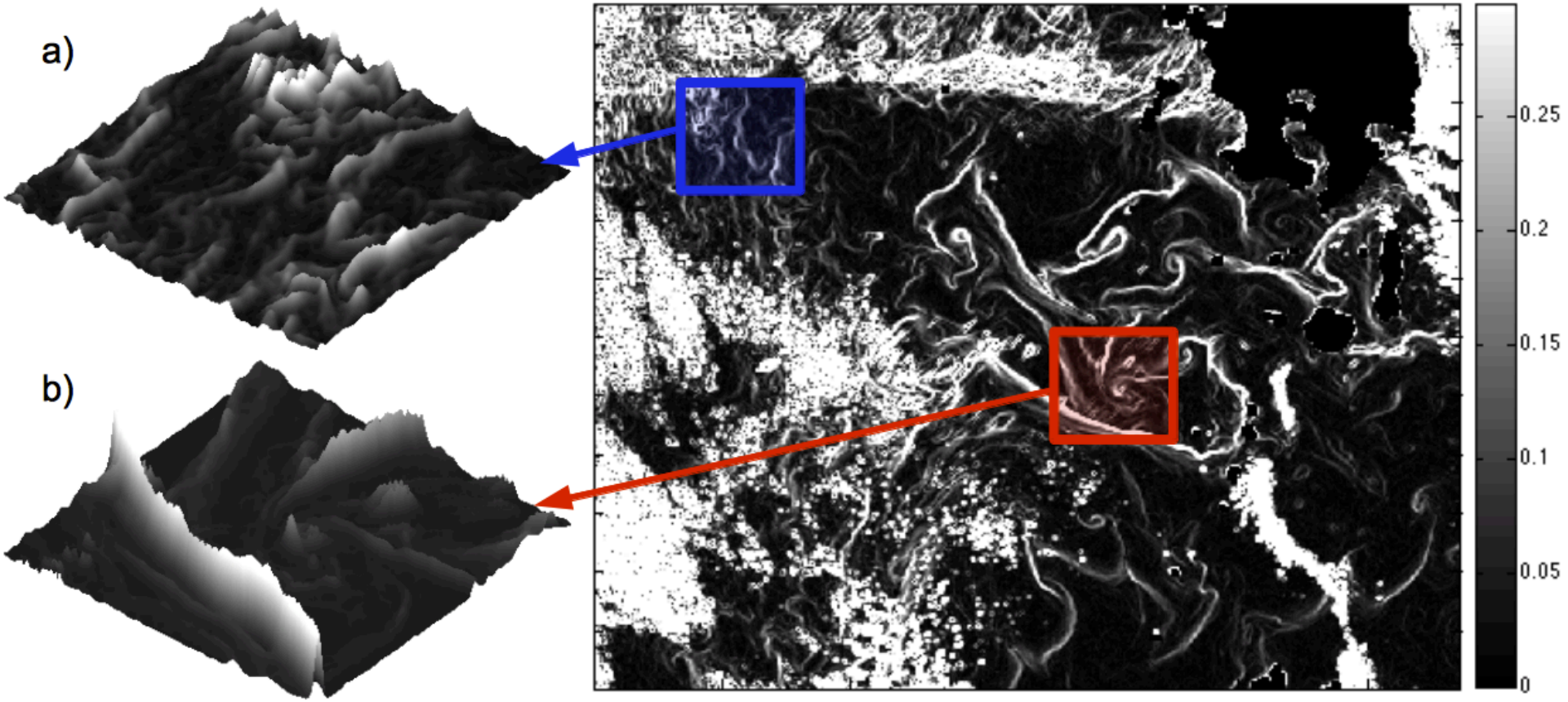


With cloud mask overlaid



Gradient Magnitude

Gradient magnitude viewed as a terrain look like sharp ridges towering over flat valleys.



The Algorithm

Step 1: Identify Search Domain (Liberal thresholds)

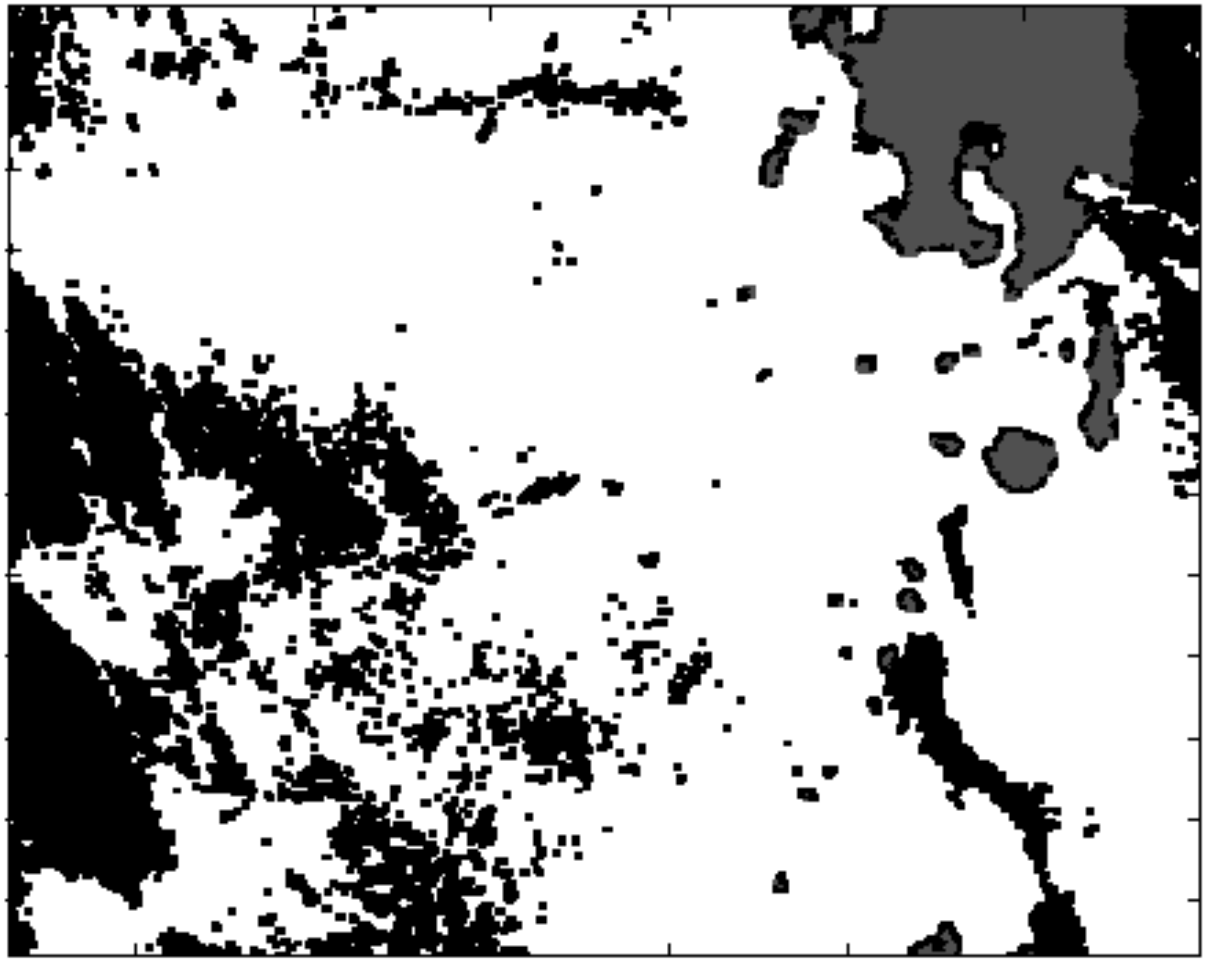
Step 2: Determine spatially connected cold SST regions

Step 3: Determine SST gradient ridges

Step 4: Discard SST segments found in Step 2 that do not border the ridges found in Step 3

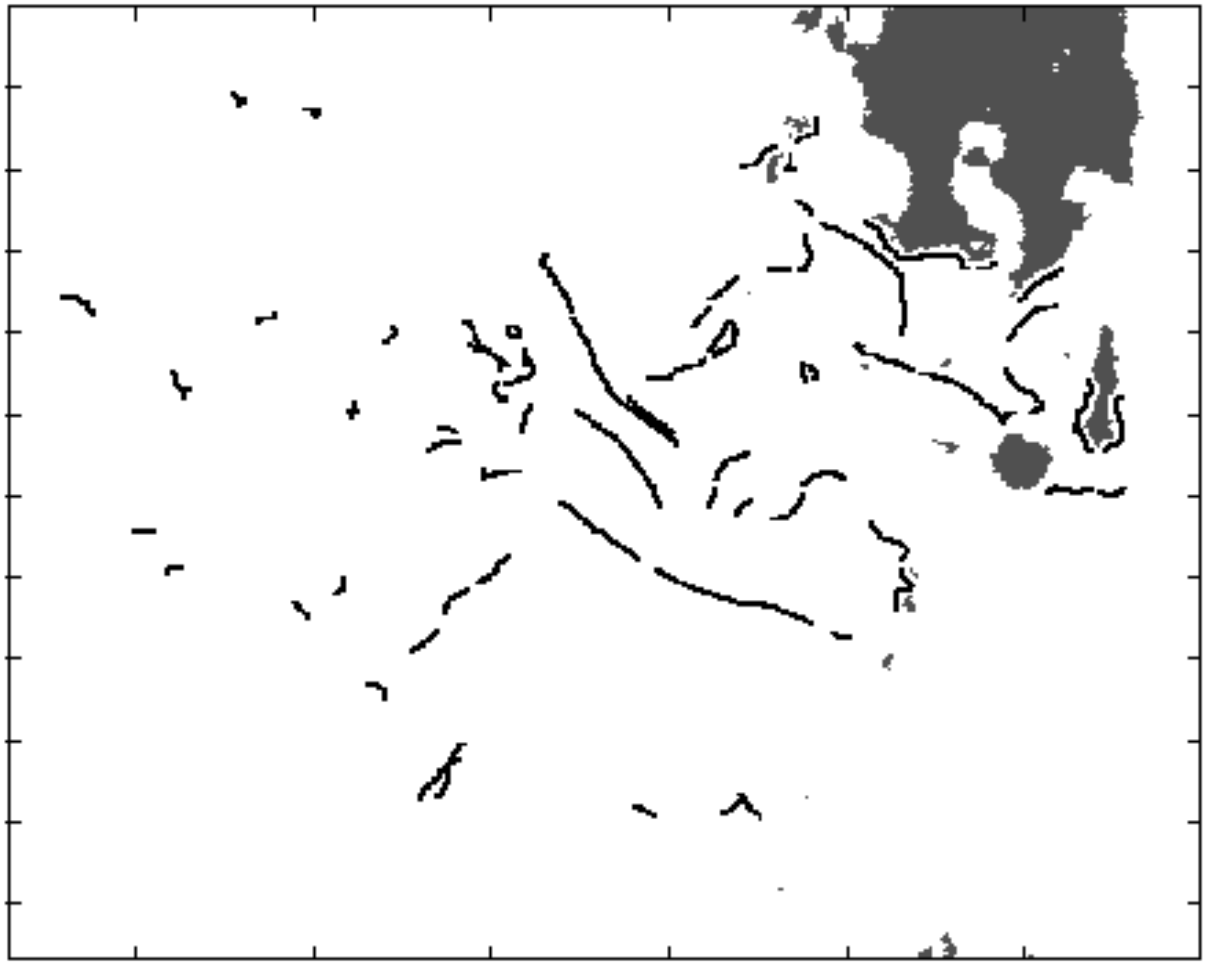
Step 5: Statistical Test

Step1: Search Space



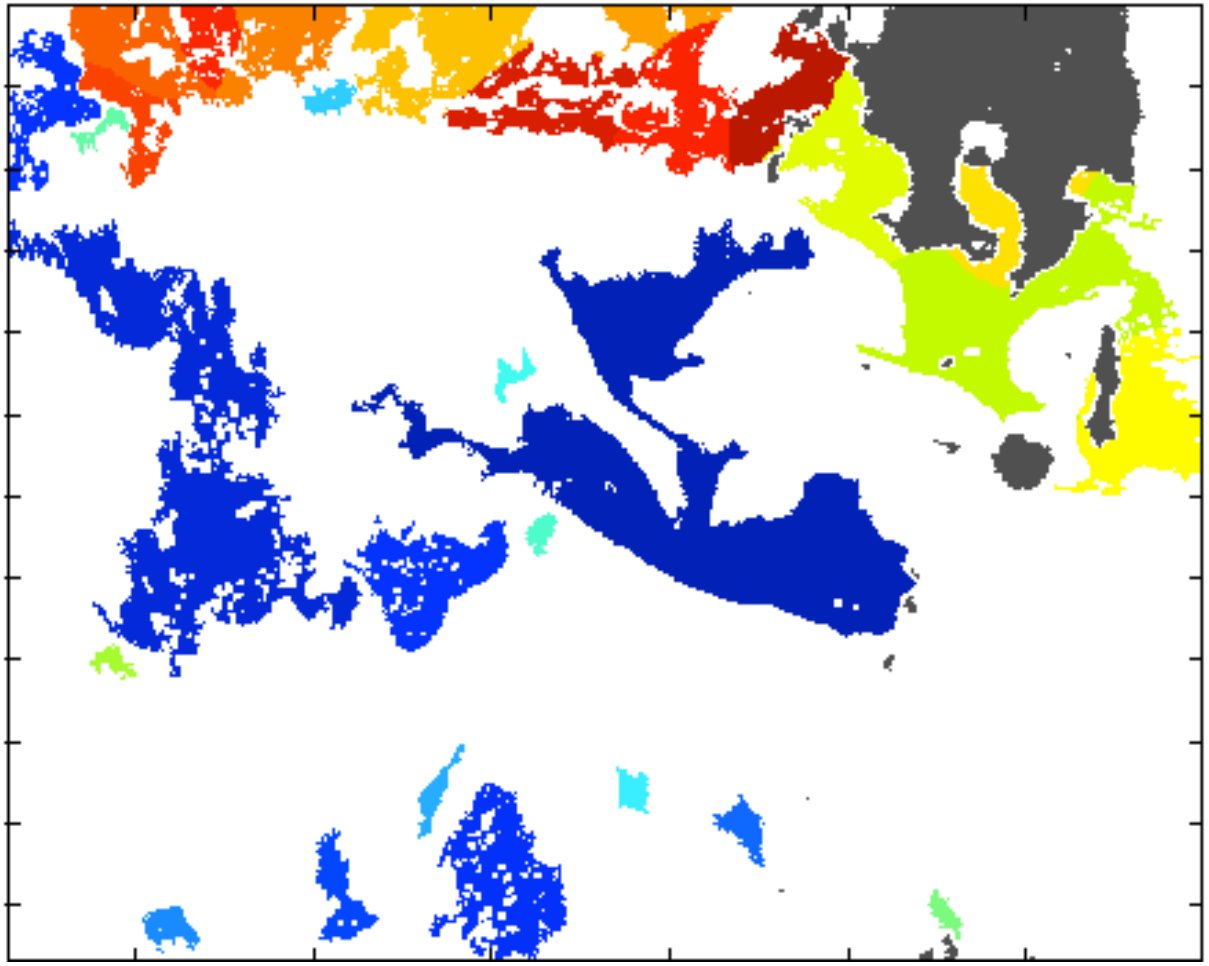
Narrow down search space, in the interest of processing time

Step 2: Gradient Ridges



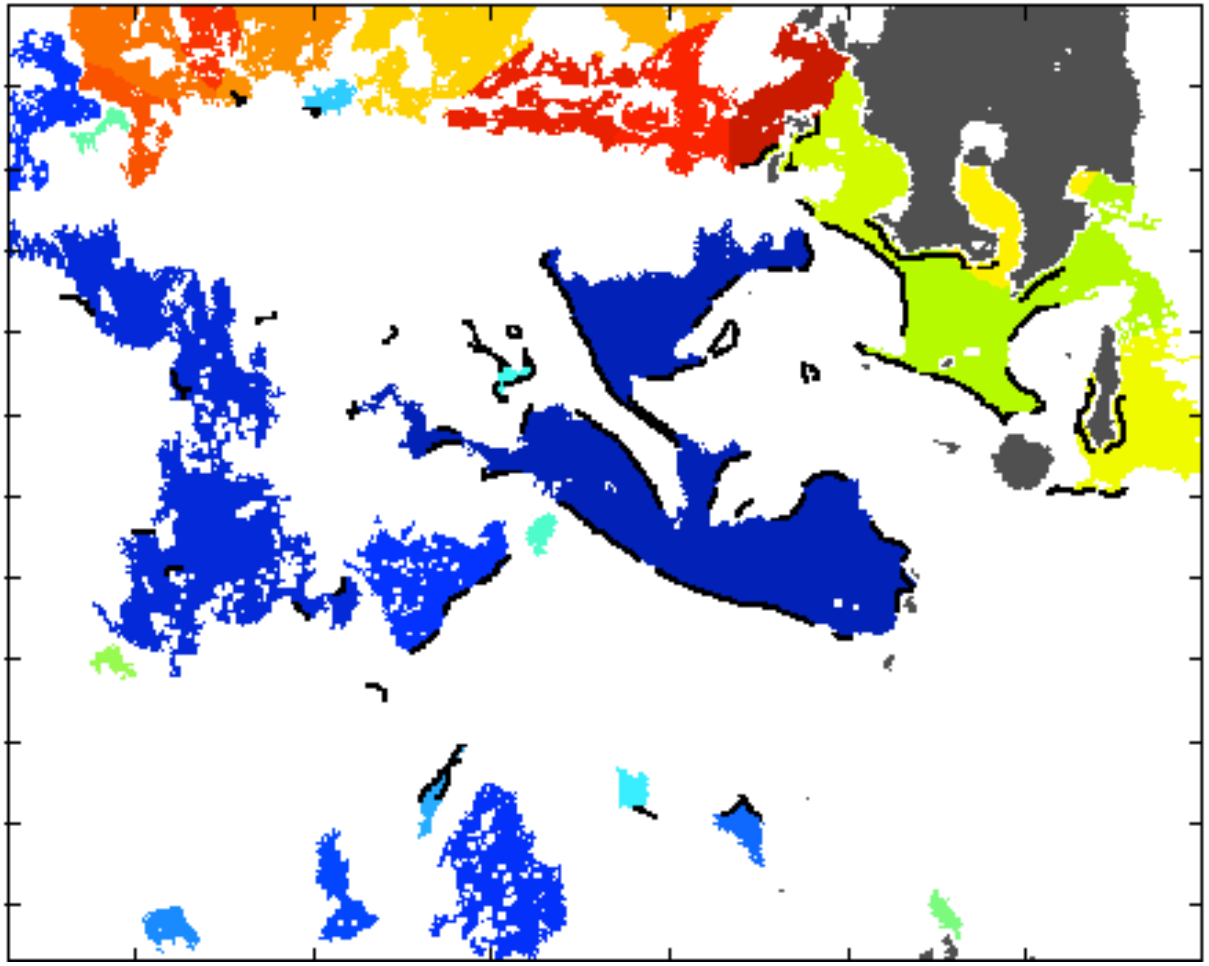
Determine contiguous portions of thermal fronts

Step 3: Segmentation



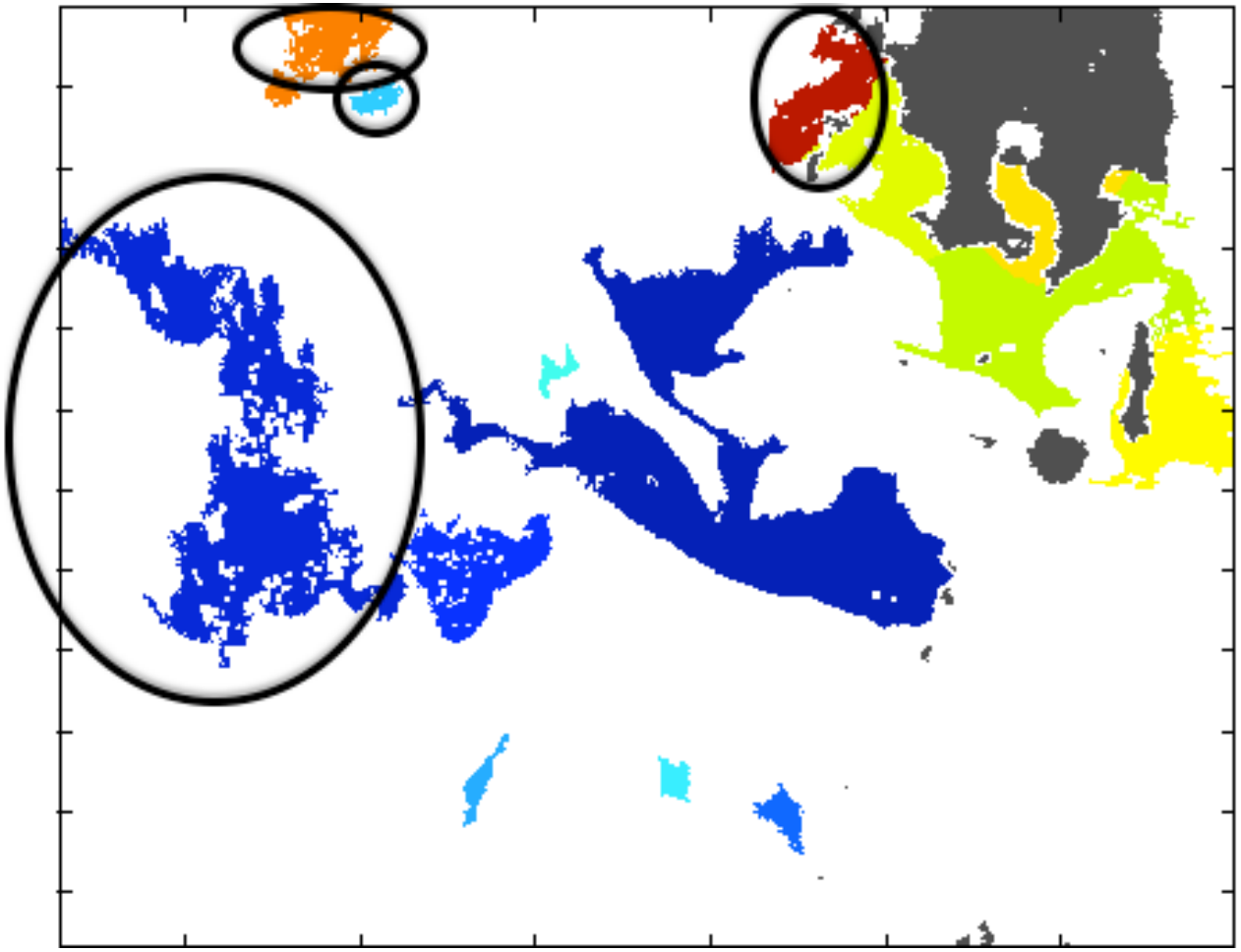
Find spatially connected regions with negative ΔSST

Step 4: Adjacency



Keep Segments that have adjecent Ridges

Step 5: Statistical Test



Keep segments which more statistically similar to ocean then cloud

Potential and Limitations

2 VIIRS data sets have been analyzed:

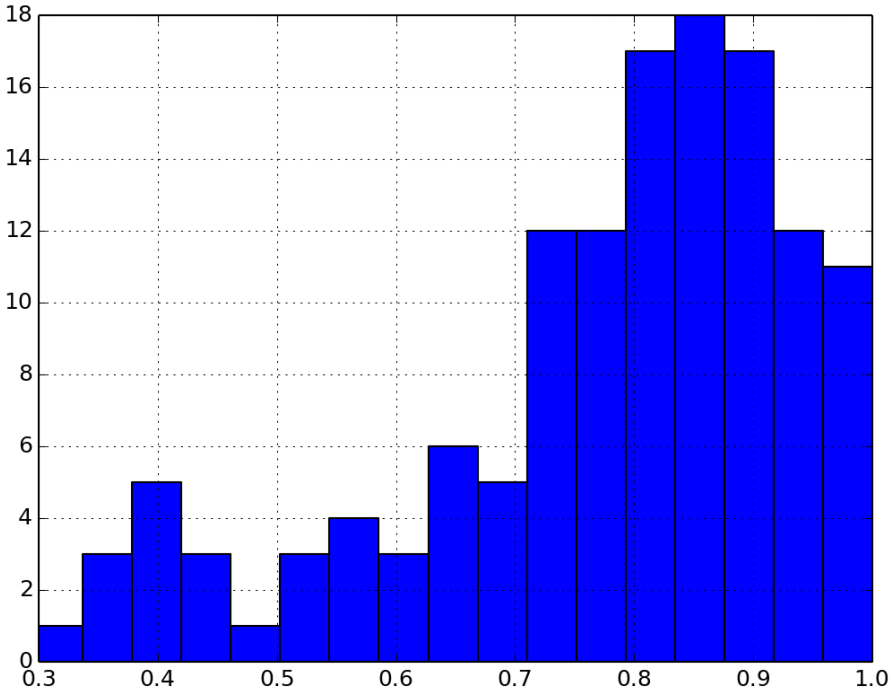
- 48 hand picked and cropped regions with typical ACSPO clear sky misclassification
- 288 granules representing 2 days of global observations

Results have been visually inspected:

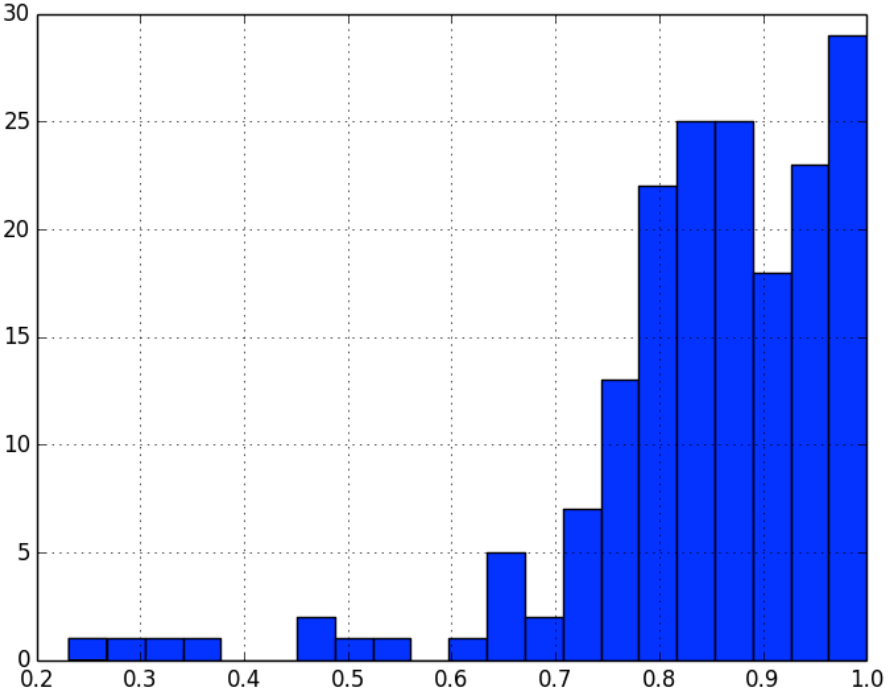
- Day granules compared to reflectances in visible bands
- Consecutive passes analyzed

Conservative vs. Liberal

Histograms below show the number of granules in a day of global observations binned according to the overlap fraction between liberal and conservative masks



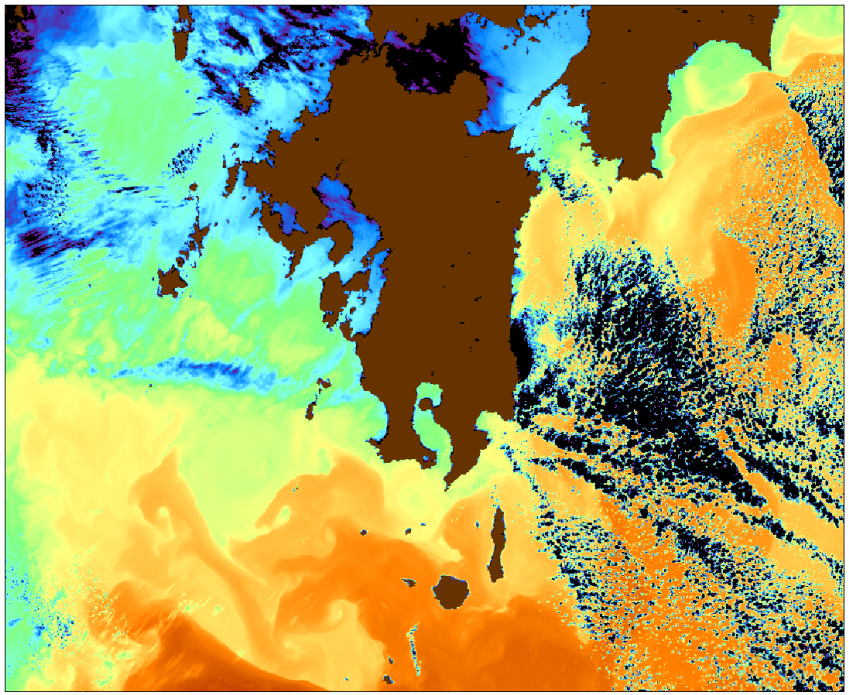
April 27, 2014

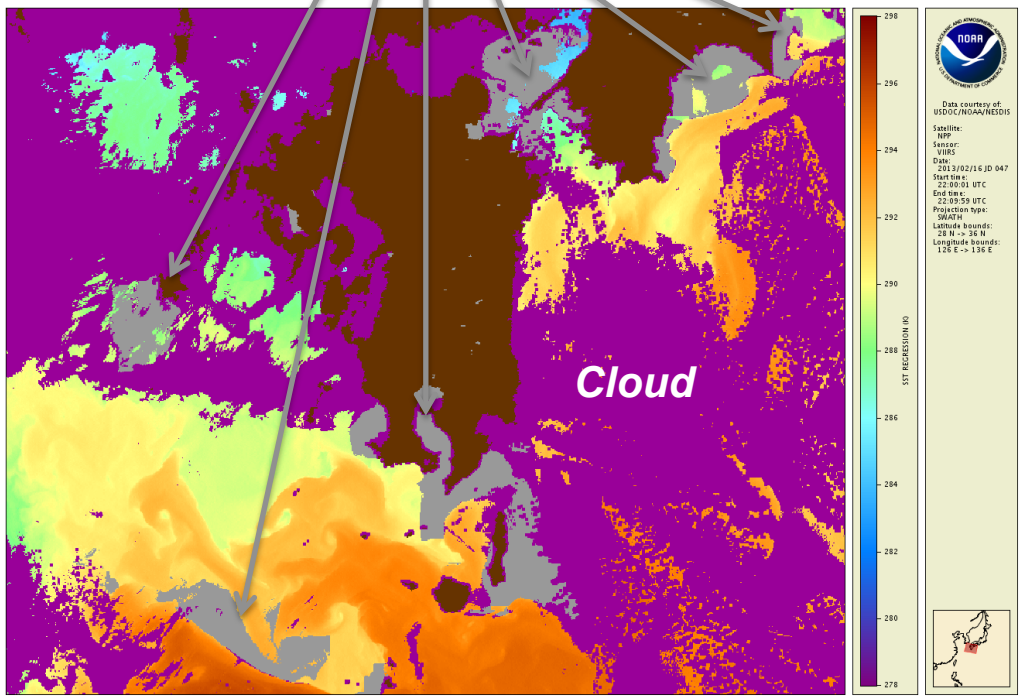


May 10, 2013

Roughly 85% of clouds are detected by a simple set of liberal thresholds.

North Pacific near Japan (Feb. 02, 2013)

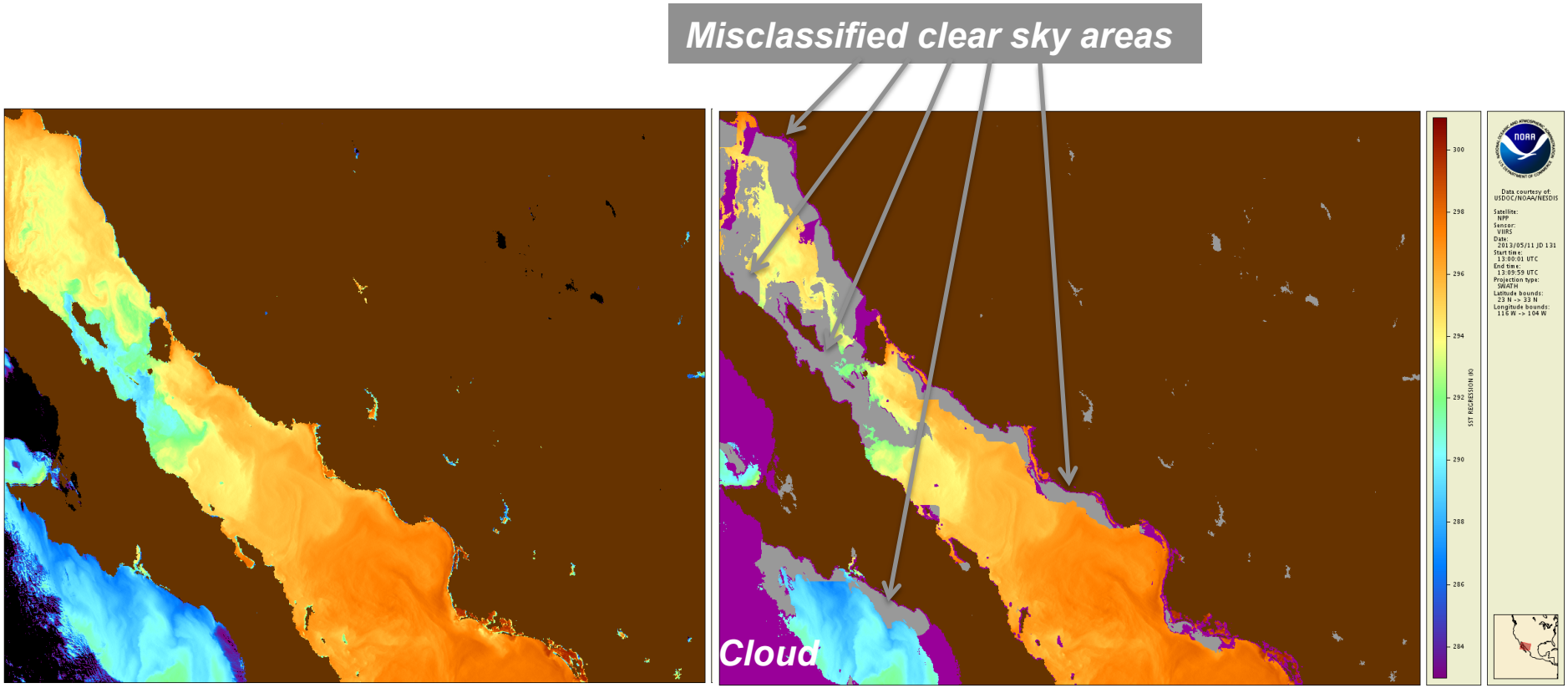




VIIRS ACSPO SST (no cloud mask)

SST with ACSPO cloud mask overlaid

Bay of California (May 11, 2013)



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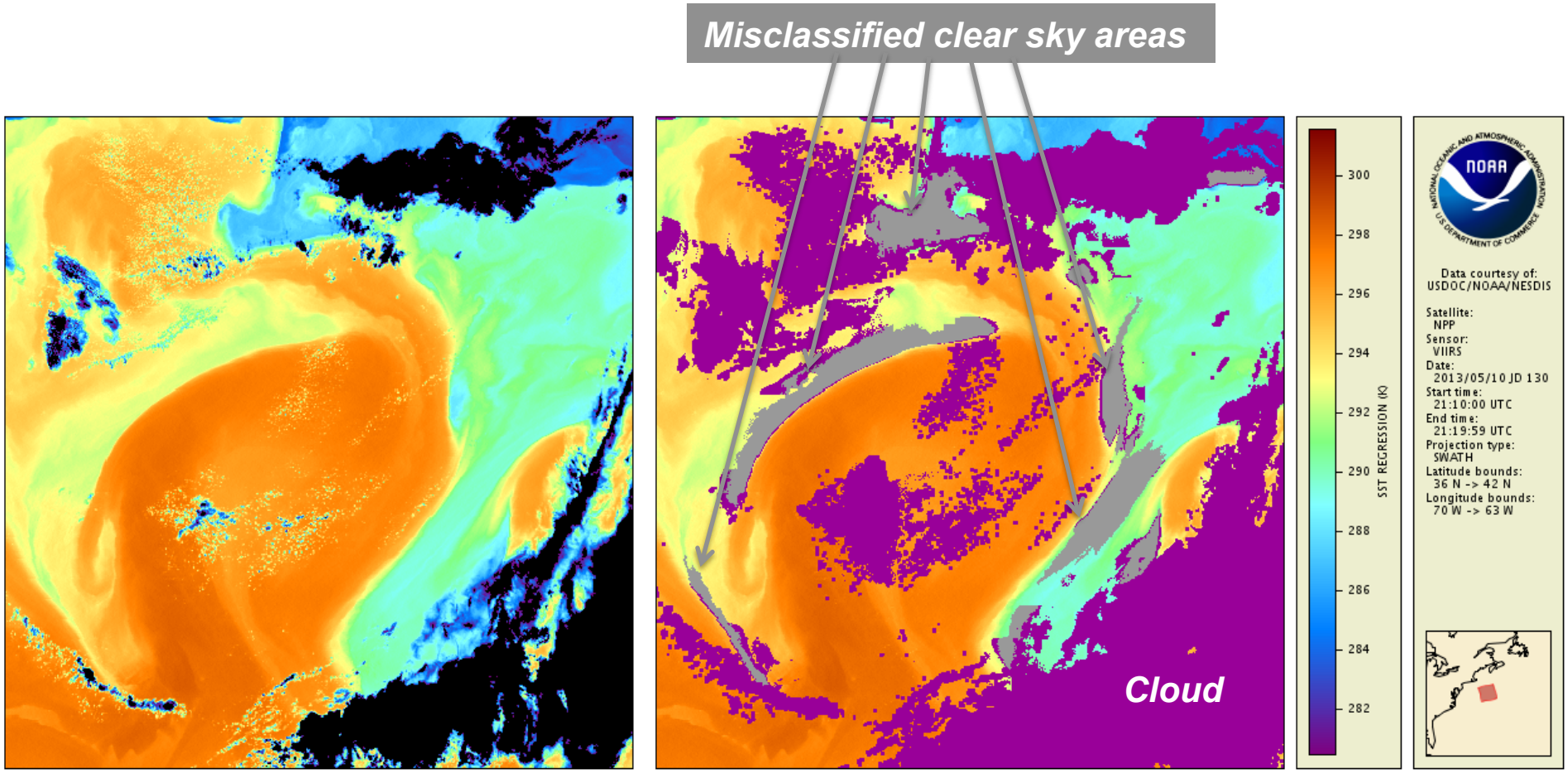
Gulf Stream (May 10, 2013)



VIIRS ACSPO SST (no cloud mask)

SST with ACSPO cloud mask overlaid

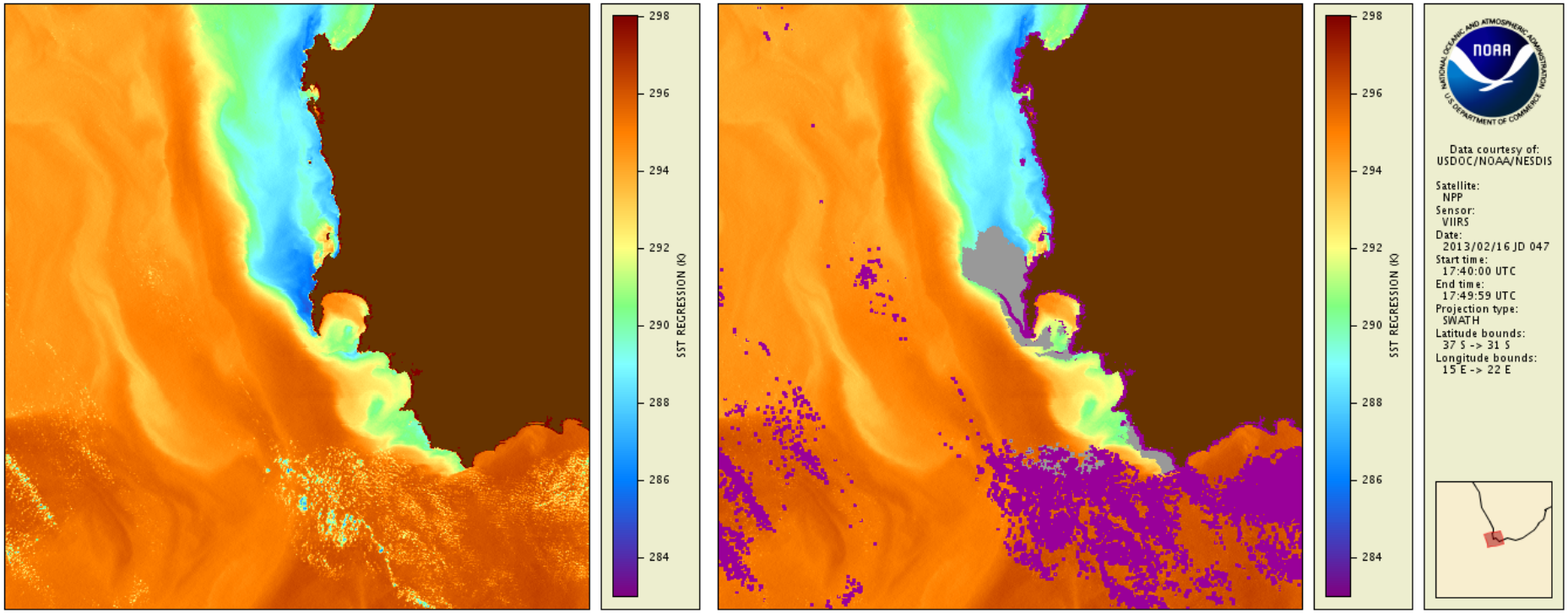
Future Work

- The algorithm was initially designed as a supplementary step to the existing ACSPO Clear-Sky Mask
- We will consider redesigning the current ACSM, based on the new pattern recognition approach
- It will be first implemented and extensively tested with the VIIRS SSTs, and later extended to AVHRR and MODIS data
- We will also consider generating an ocean front product at the stage of cloud masking, and outputting in the ACSPO SST files, as an additional layer

Backup Slides

Persistent Misclassifications

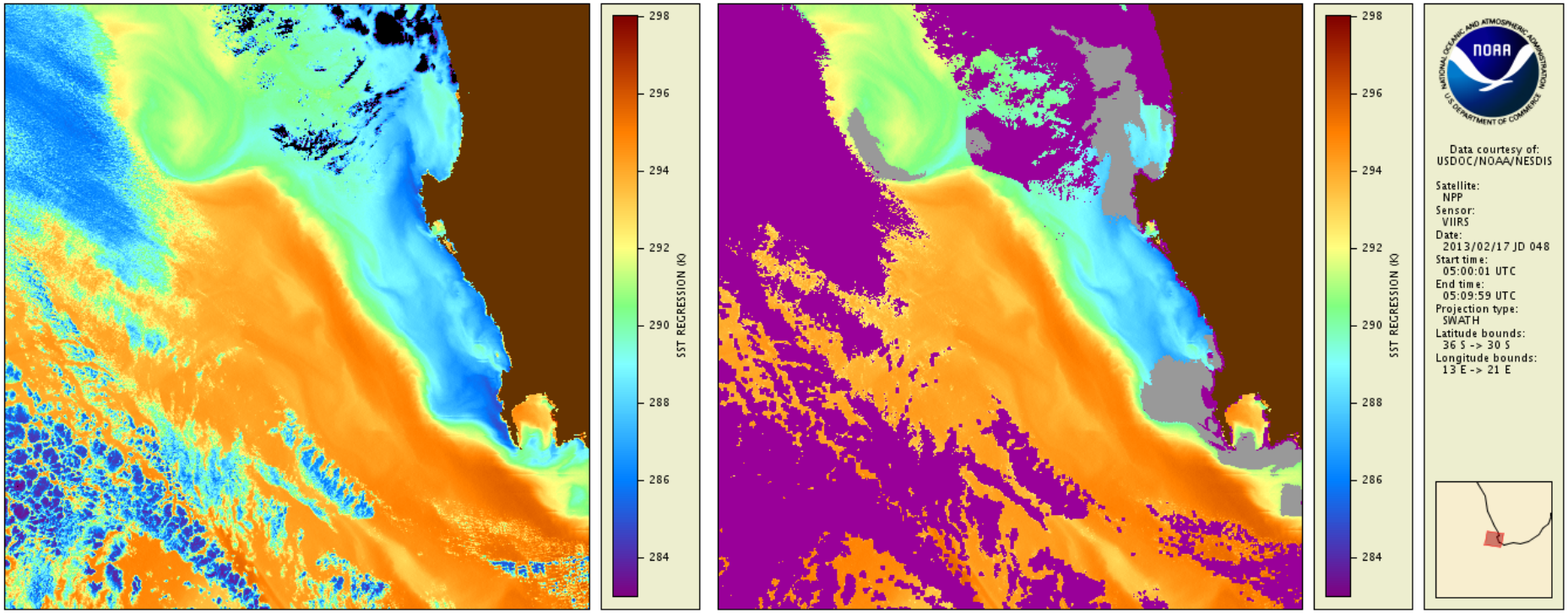
South Africa, 02/16/2013 (day pass)



Cold upwelling (gray) is misclassified by ACSPO as cloud

Persistent Misclassifications

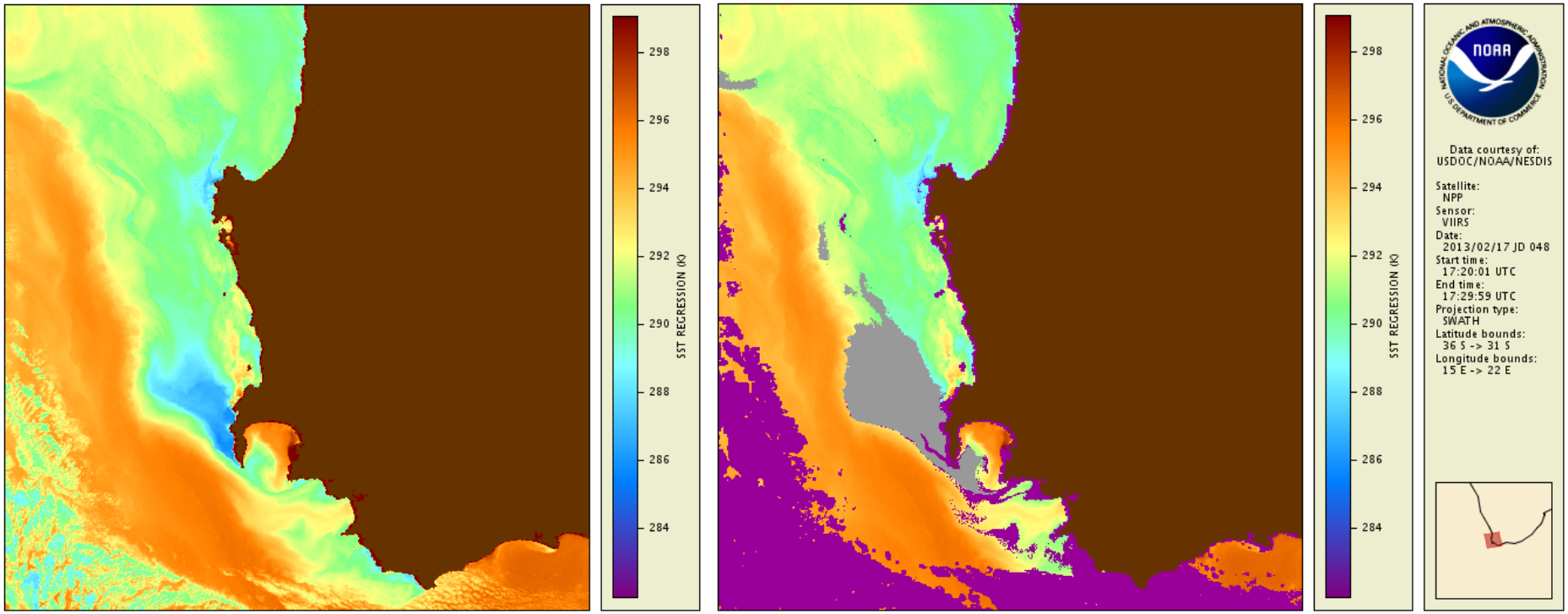
South Africa, 02/17/2013 (day pass)



Misclassified by ACSPO as cloud on the next day as well

Persistent Misclassifications

South Africa, 02/17/2013 (night pass)



Same cold upwelling misclassified at the night pass