UNIVERSIDADE DE SÃO PAULO
Instituto Oceanográfico

Jet Propulsion Laboratory
California Institute of Technology

Laboratório de Oceanografia por Satélites

A comparative study of ocean thermal gradients from GHRSST Level 4 SST products

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GHRSST
GROUP FOR HIGH RESOLUTION
SEA SURFACE TEMPERATURE

FAPESP
SÃO PAULO RESEARCH FOUNDATION

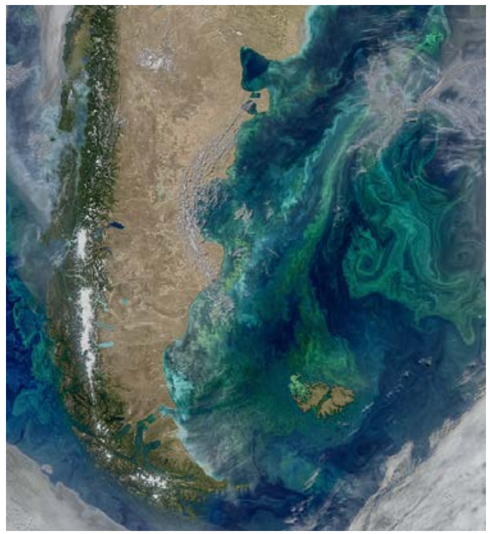
20th GHRSST International Science Team Meeting
ESA/ESRIN, Frascati, Italy, 3-7 June 2019

Outline

- Importance of fronts
- Statistics vs Geometry
- SST gradients from Level 4 products
    - Feature resolution
    - Temporal variability
- Conclusion

Fronts in oceanography

Marine ecosystem boundaries

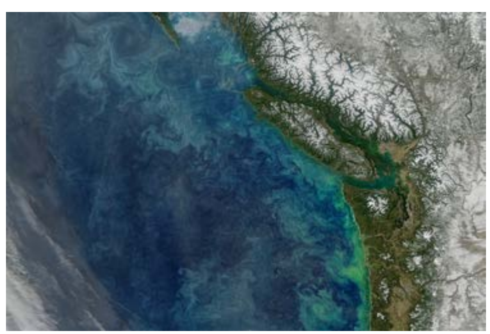


Aqua MODIS, February 4, 2019

Landsat 8, OLI, June 3, 2018

Ocean 2D / 3D dynamics

Fisheries



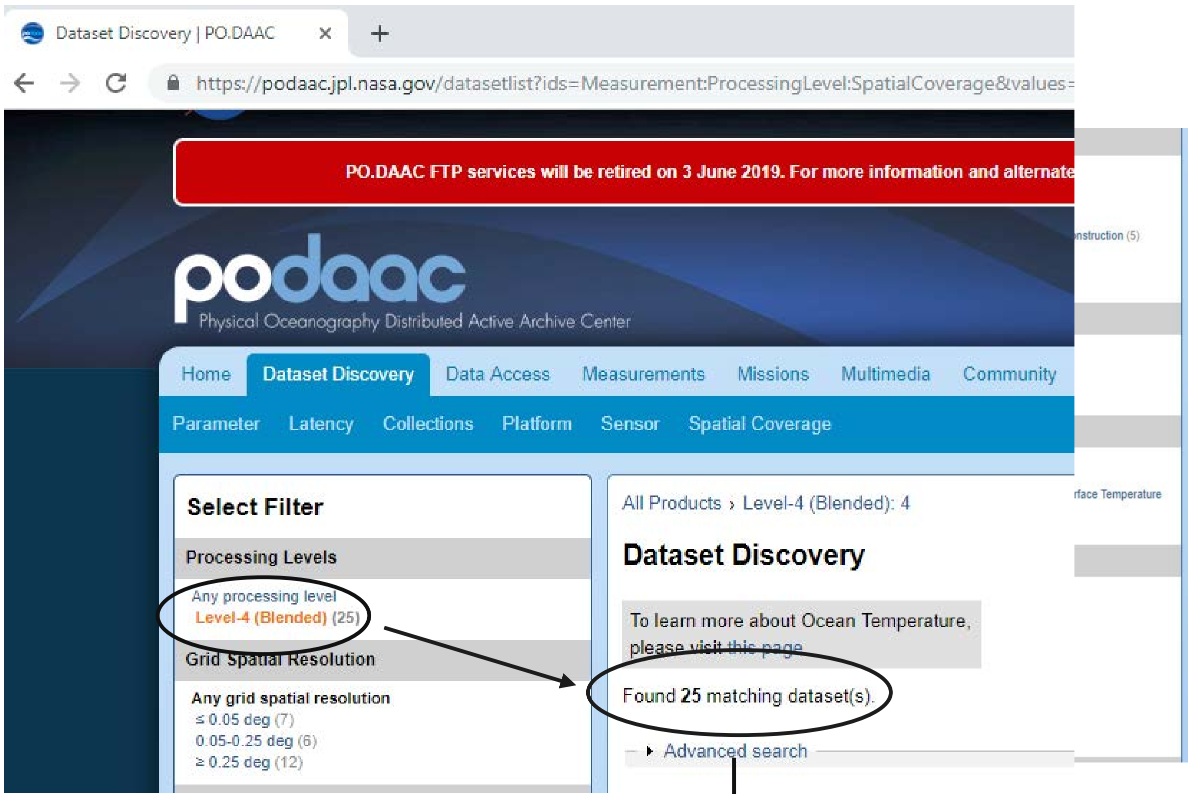
Aqua MODIS, March 18, 2019

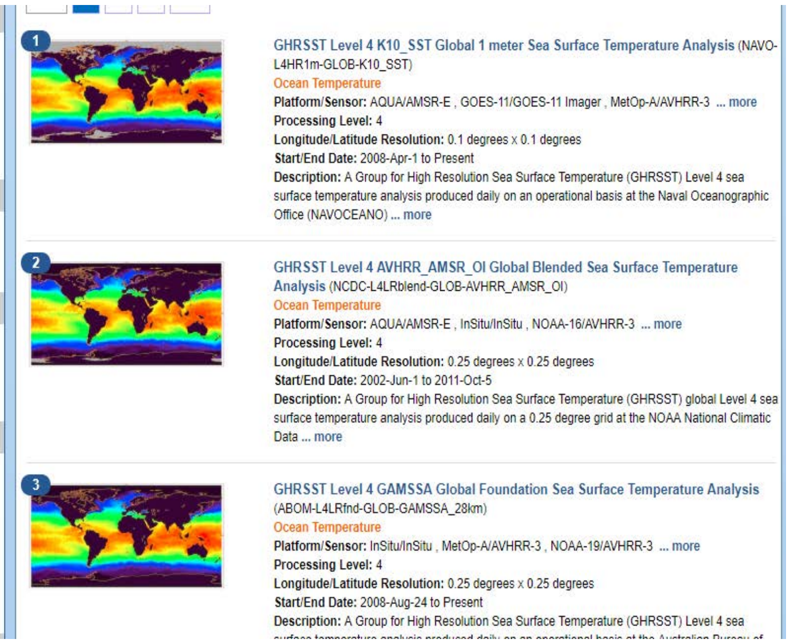
Aqua MODIS, July 5, 2018

Ocean-Atmosphere interaction

https://oceancolor.gsfc.nasa.gov/gallery/

Product selection for SST gradients





“What's the *“best”* Level 4 product for SST gradients?”

Daily

Temporal Coverage

>10 Years

Fronts in synoptic maps

Fishing spots

Submarine acoustic communication

Seasonal variability

Coastal Upwelling

Ocean models

Long term change

Impact of climate on ocean frontal activity

“What's the <u>*“best”*</u> Level 4 product for SST gradients?”

Daily

Fronts in synoptic maps

Fishing spots

Submarine acoustic communication

Can we use <u>*in situ*</u> measurements to evaluate the quality of a dataset with respect to SST gradients?

Long term change

Impact of climate on ocean frontal activity

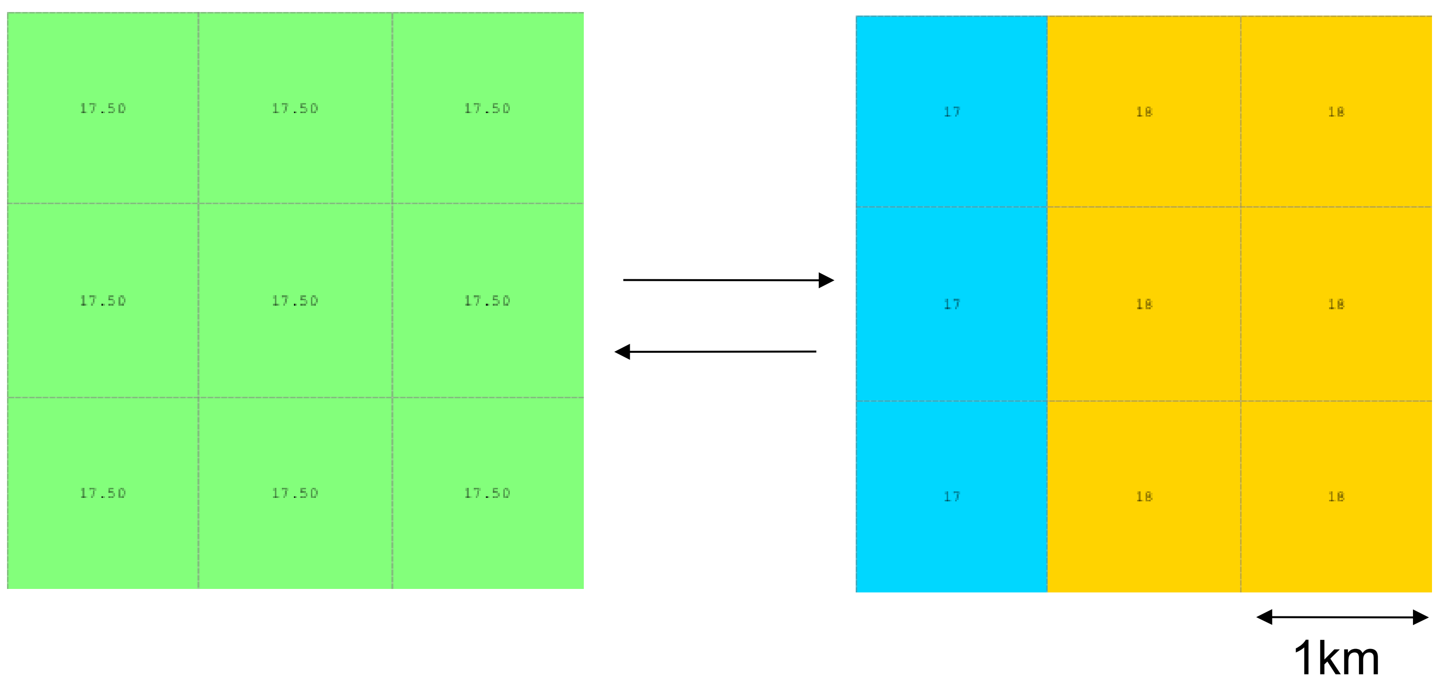
>10 Years

Statistics vs Geometry

Matchup

In situ

Satellite

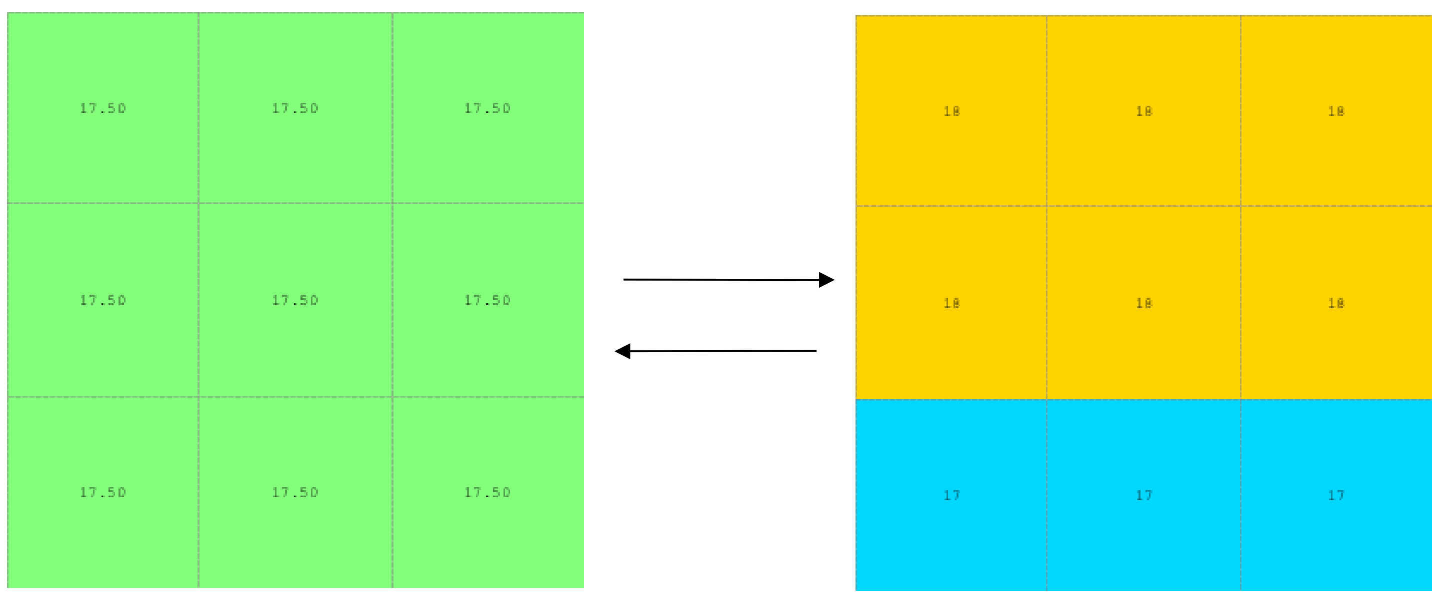


Bias = 0.16˚C
Stdev = 0.5˚C

Statistics vs Geometry

Matchup

In situ Satellite



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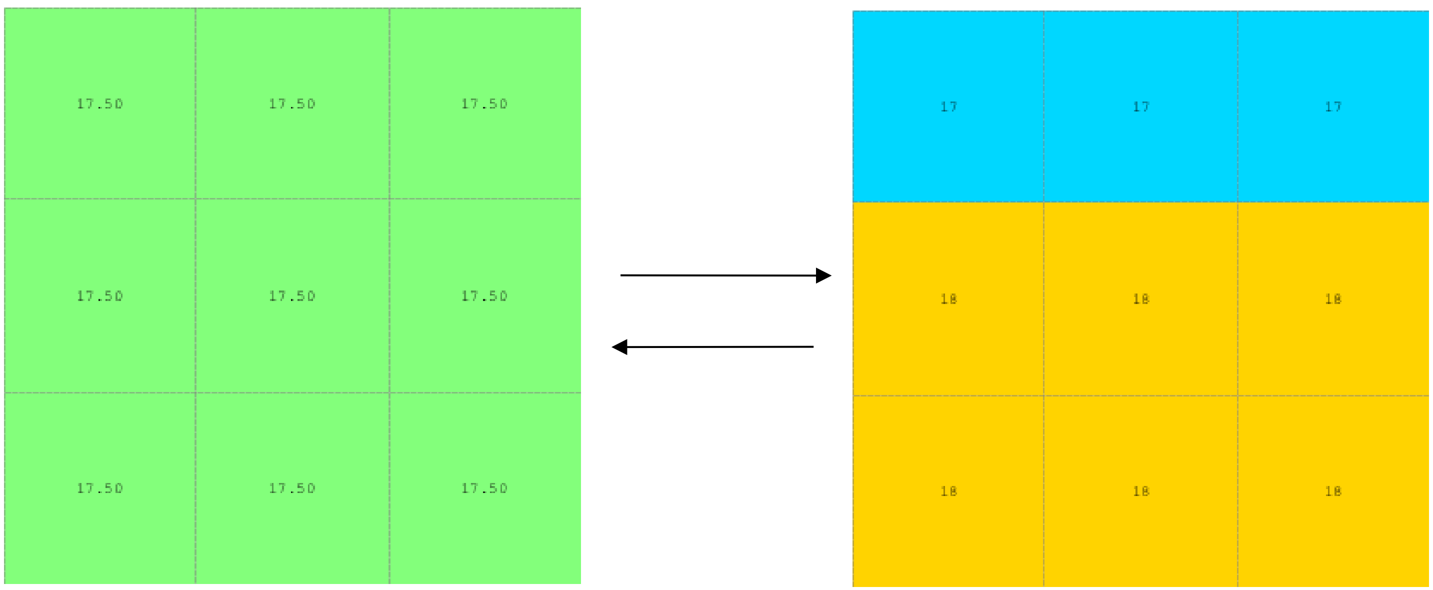
In situ Satellite



Bias = 0.16˚C
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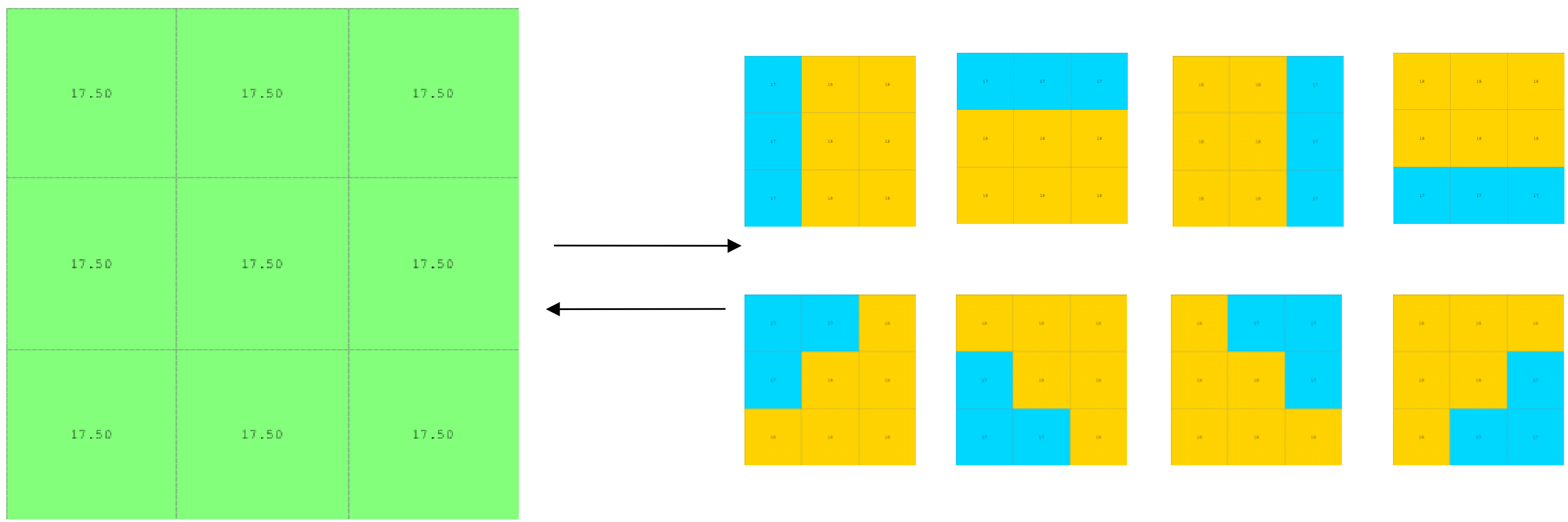
Statistics vs Geometry

Matchup

In situ

Satellite



Same statistics
Different geometries...

How consistent are SST gradients from GHRSST Level 4 datasets?

Datasets

6 GHRSST Level 4 SST (2016-2018)

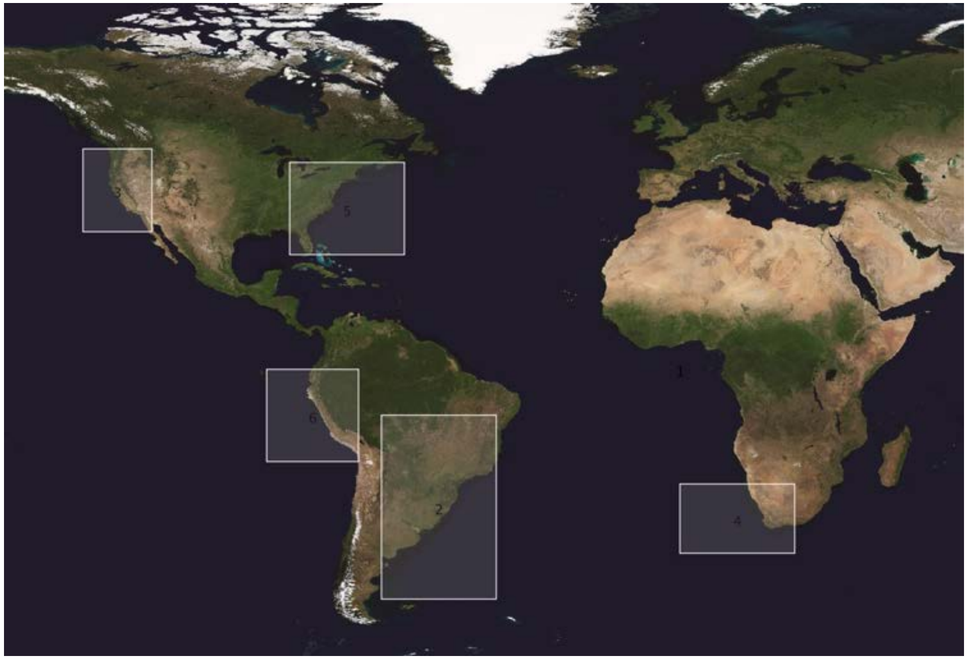
- Canadian Meteorological Center **CMC**
- Naval Oceanographic Office **K10**
- Remote Sensing Systems **REMSS_MW_IR**
- UK MetOffice **OSTIA**
- Danish Meteorological Institute **DMI**
- NASA/JPL Multiscale Ultrahigh Resolution **MUR**

All data downloaded from PODAAC and reprojected to a 0.1°Lat/Lon grid

Datasets

Comparison over 5 regions

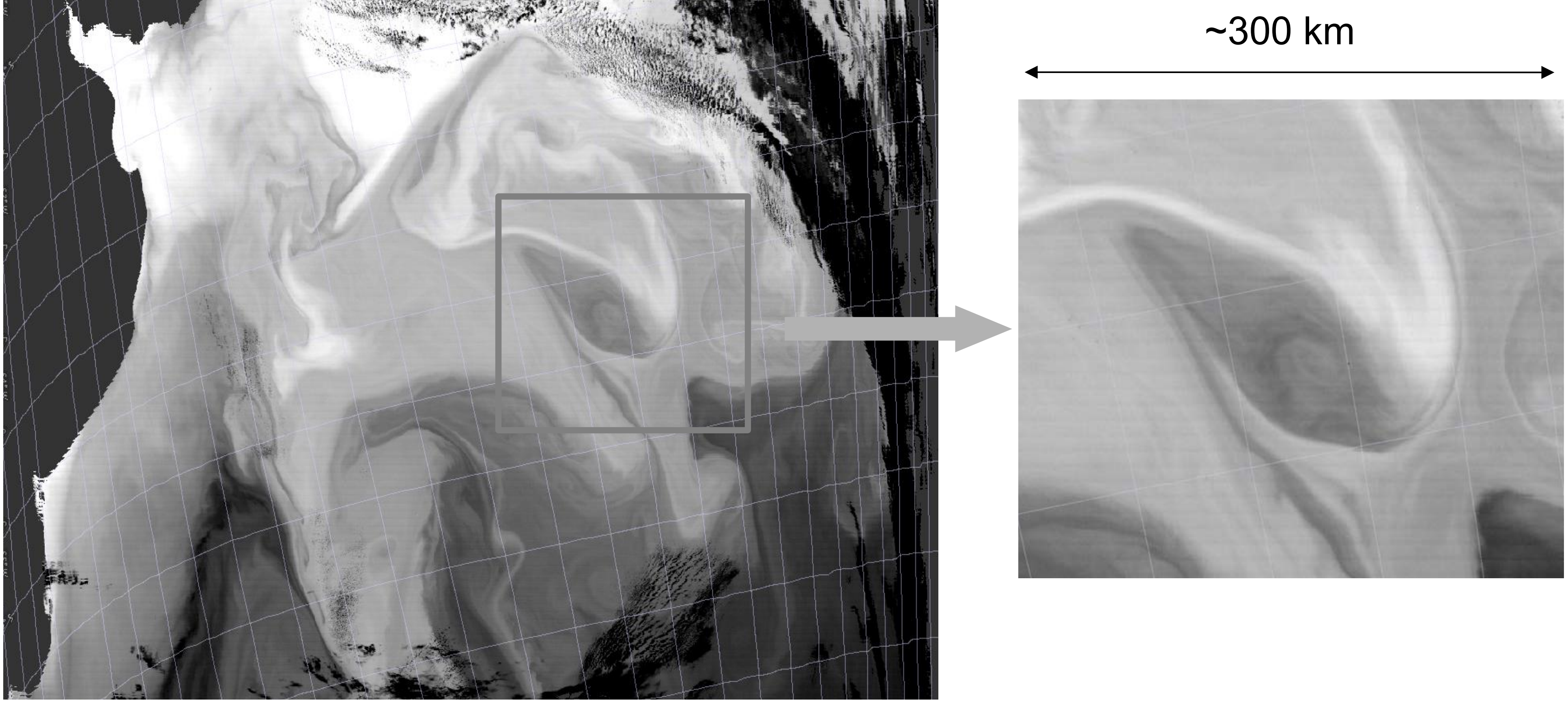
- Brazil-Malvinas confluence region
- California Current System
- Agulhas current and retroflection zone
- Gulf Stream
- Peruvian Upwelling System



Datasets

		INFRARED						MICROWAVE				
	In situ	MODIS	AVHRR	VIIRS	ABI	GOES	SEVIRI	AMSR-E	AMSRE-2	TMI	GMI	WINDSAT
CMC	✓		✓	✓					✓			
K10			✓			✓		✓				
REMSS		✓		✓				✓	✓	✓	✓	✓
OSTIA	✓		✓		✓		✓			✓		
DMI		✓	✓	✓			✓		✓			
MUR		✓	✓					✓				✓

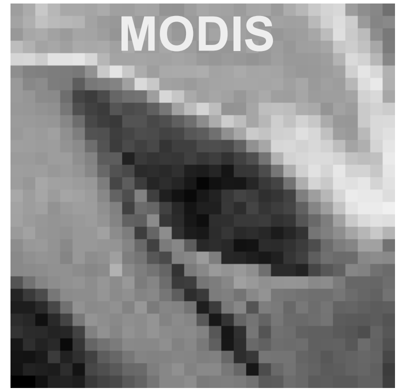
Feature resolution



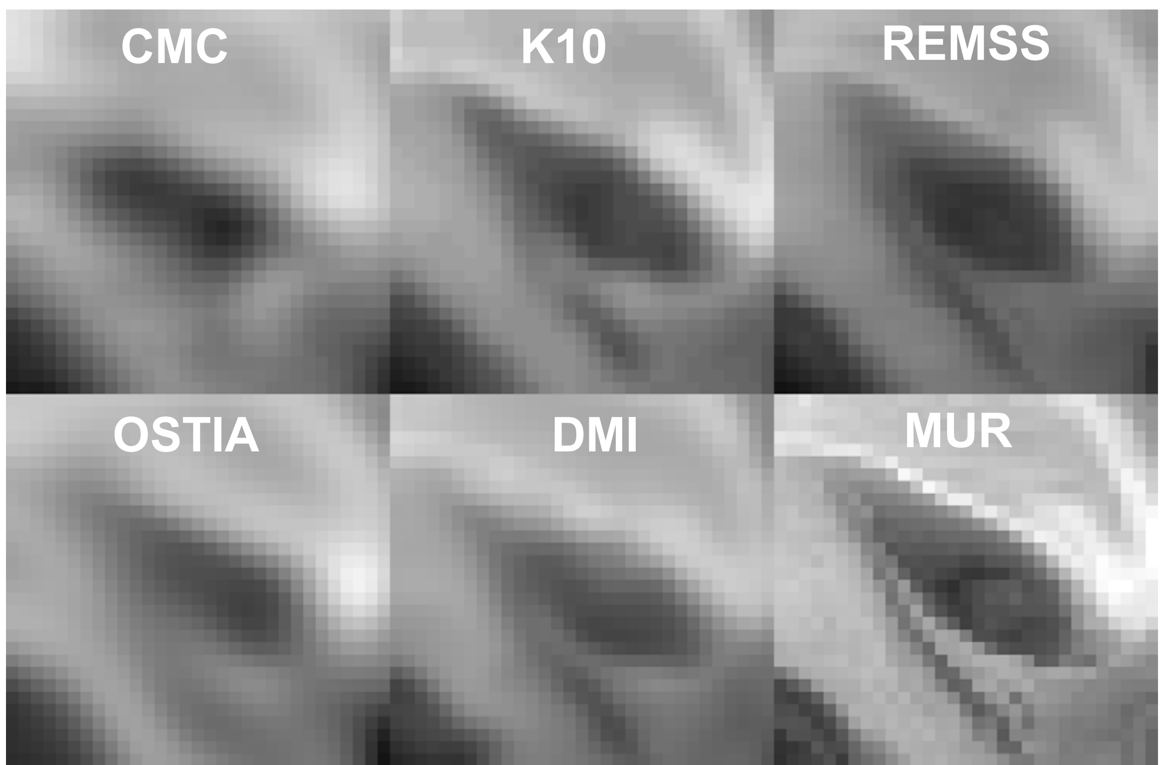
Aqua MODIS
Dec 31 2018, Brazil-Malvinas (Level 2P, 1 km)

Feature resolution

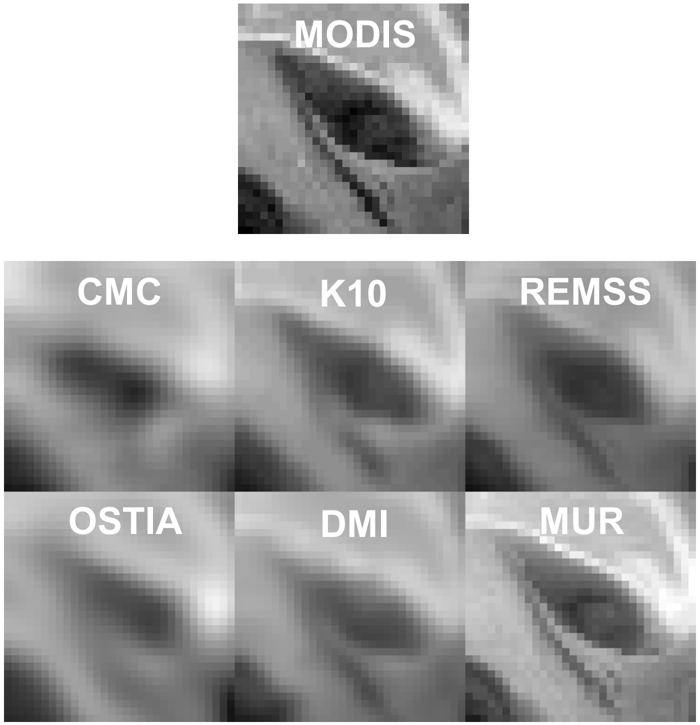
Level 3U
(0.1° grid)



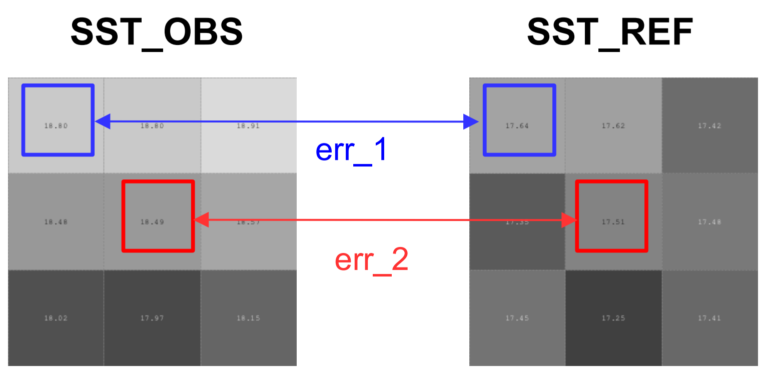
Level 4
(0.1° grid)



Feature resolution



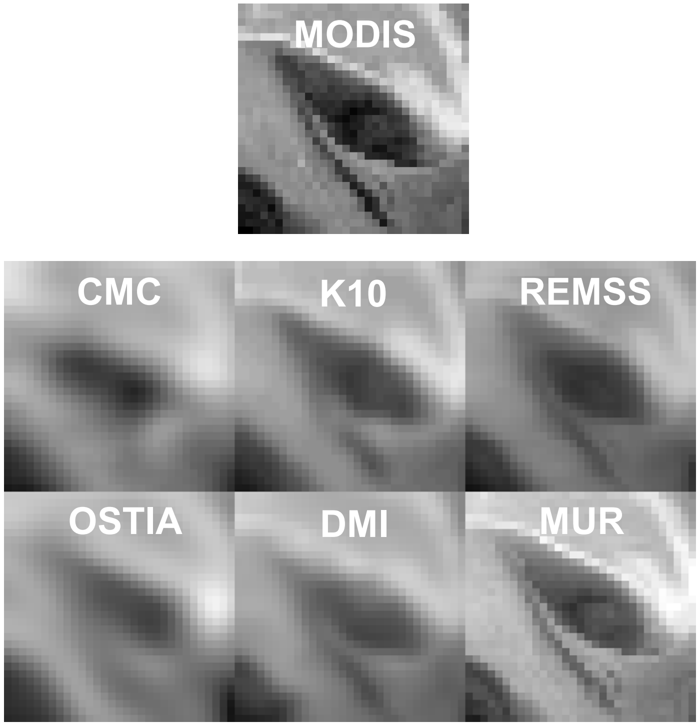
	Bias	Stdv	MSE
CMC	0.32°	0.59°	**0.46**
K10	0.28°	0.37°	0.22
REMSS	0.00°	0.41°	0.17
OSTIA	0.34°	0.48°	0.35
DMI	0.29°	0.55°	0.39
MUR	0.65°	0.23°	**0.47**



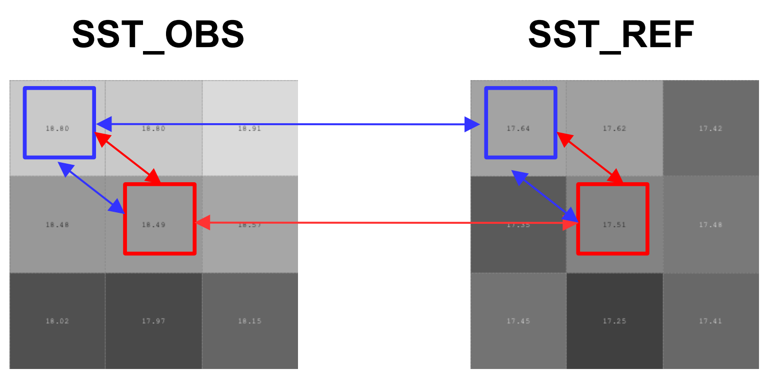
Mean Squared Error

MSE = $(err\_1^2+err\_2^2+....)/N$

Feature resolution



	Bias	Stdv	MSE	SSIM*
CMC	0.32°	0.59°	0.46	0.59
K10	0.28°	0.37°	0.22	0.79
REMSS	0.00°	0.41°	0.17	0.76
OSTIA	0.34°	0.48°	0.35	0.66
DMI	0.29°	0.55°	0.39	0.72
MUR	0.65°	0.23°	0.47	**0.91**

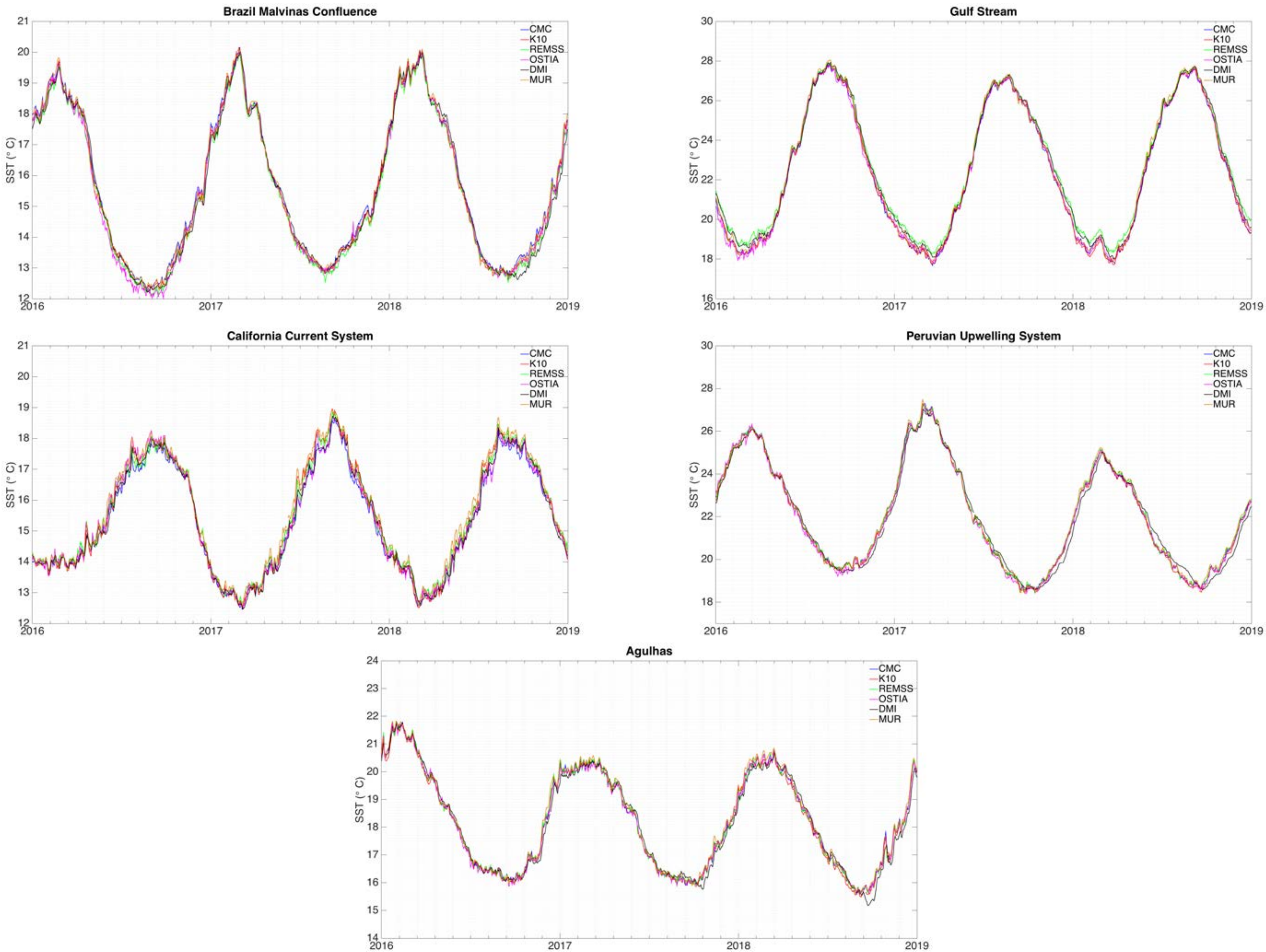


*** Structural similarity (SSIM) index**

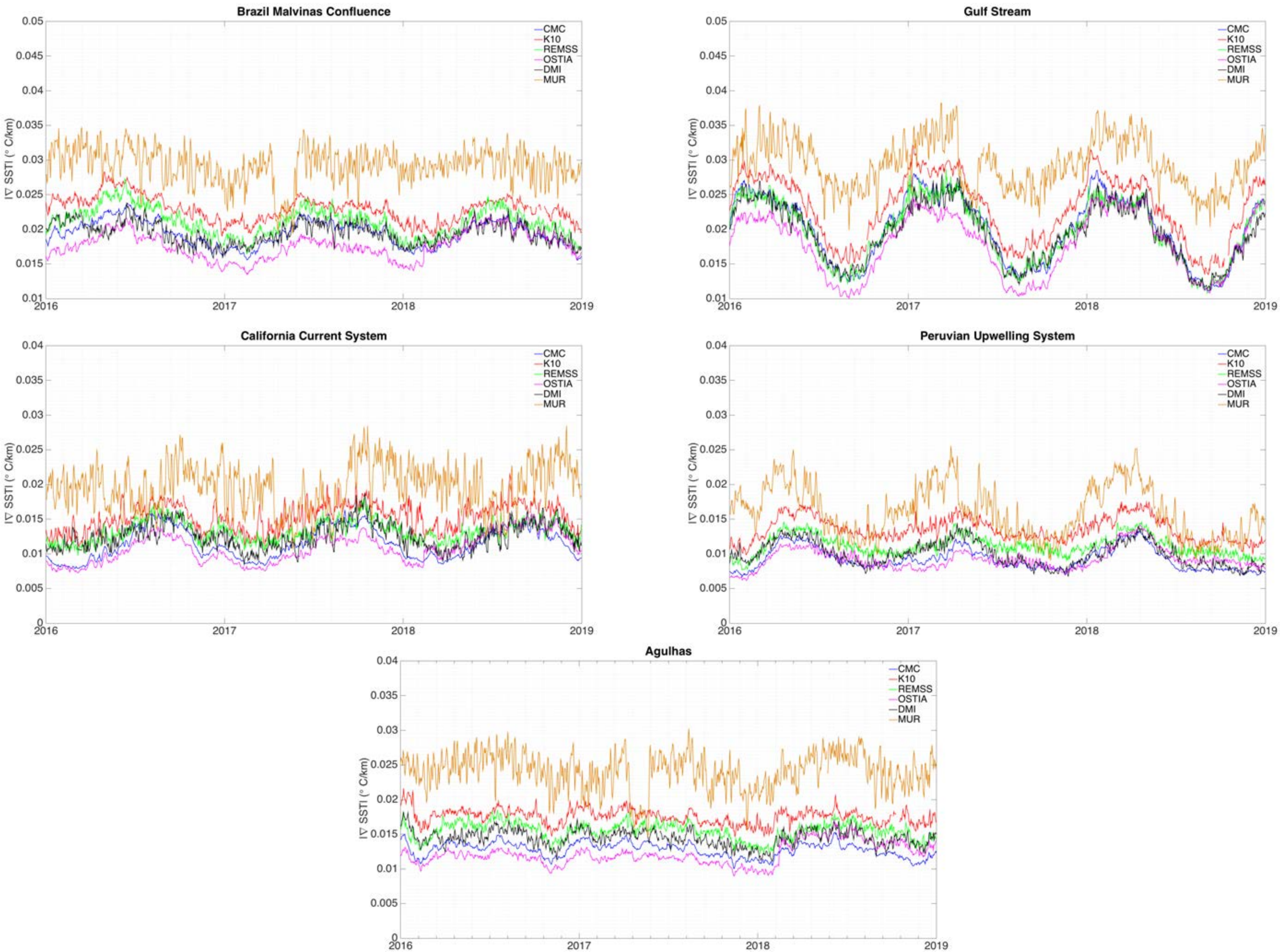
Wang, Zhou; Bovik, A.C.; Sheikh, H.R.; Simoncelli, E.P. (2004). "Image quality assessment: from error visibility to structural similarity". IEEE Transactions on Image Processing. 13 (4): 600–612

Citations May 2019 > 21400

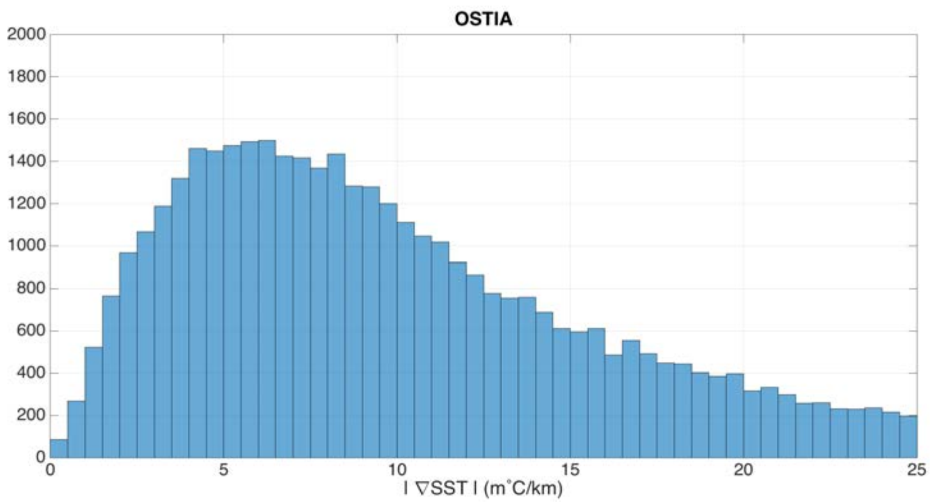
Interannual variability: SST

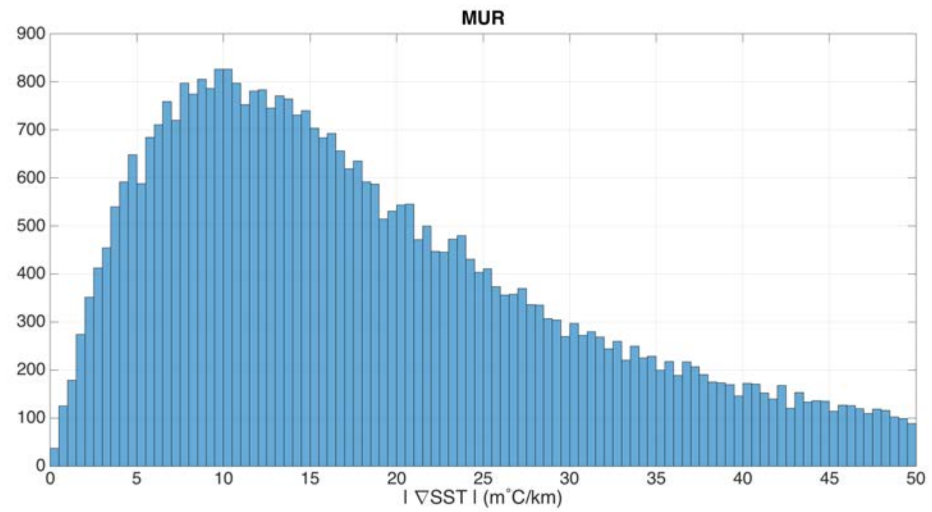


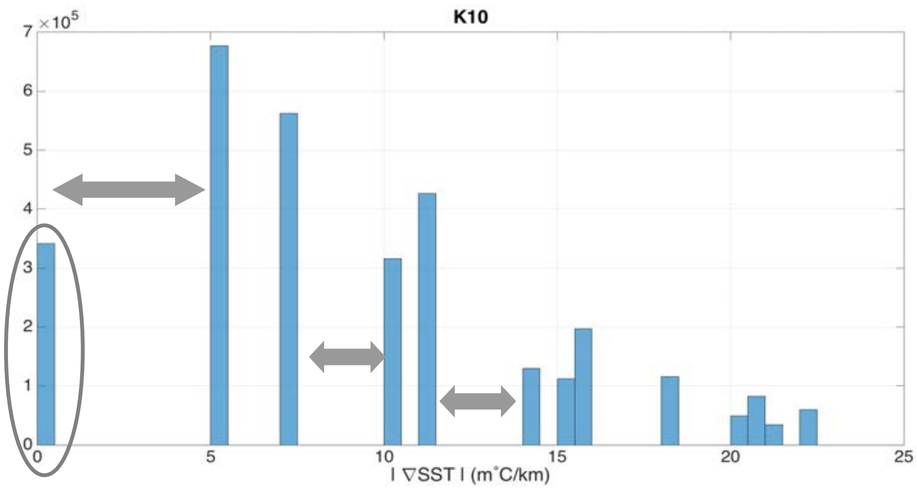
Interannual variability: |∇SST|



Histogram of |∇SST|

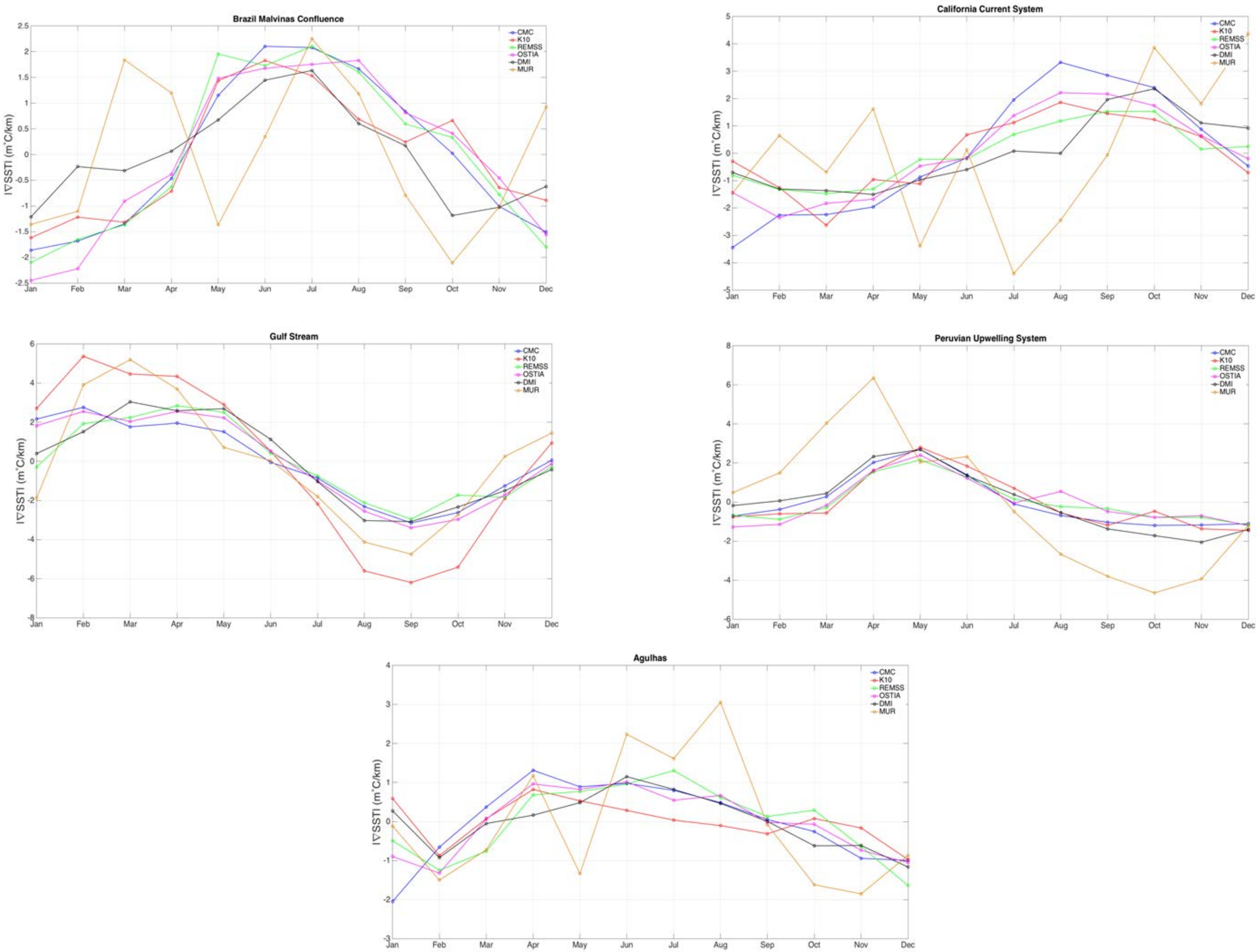




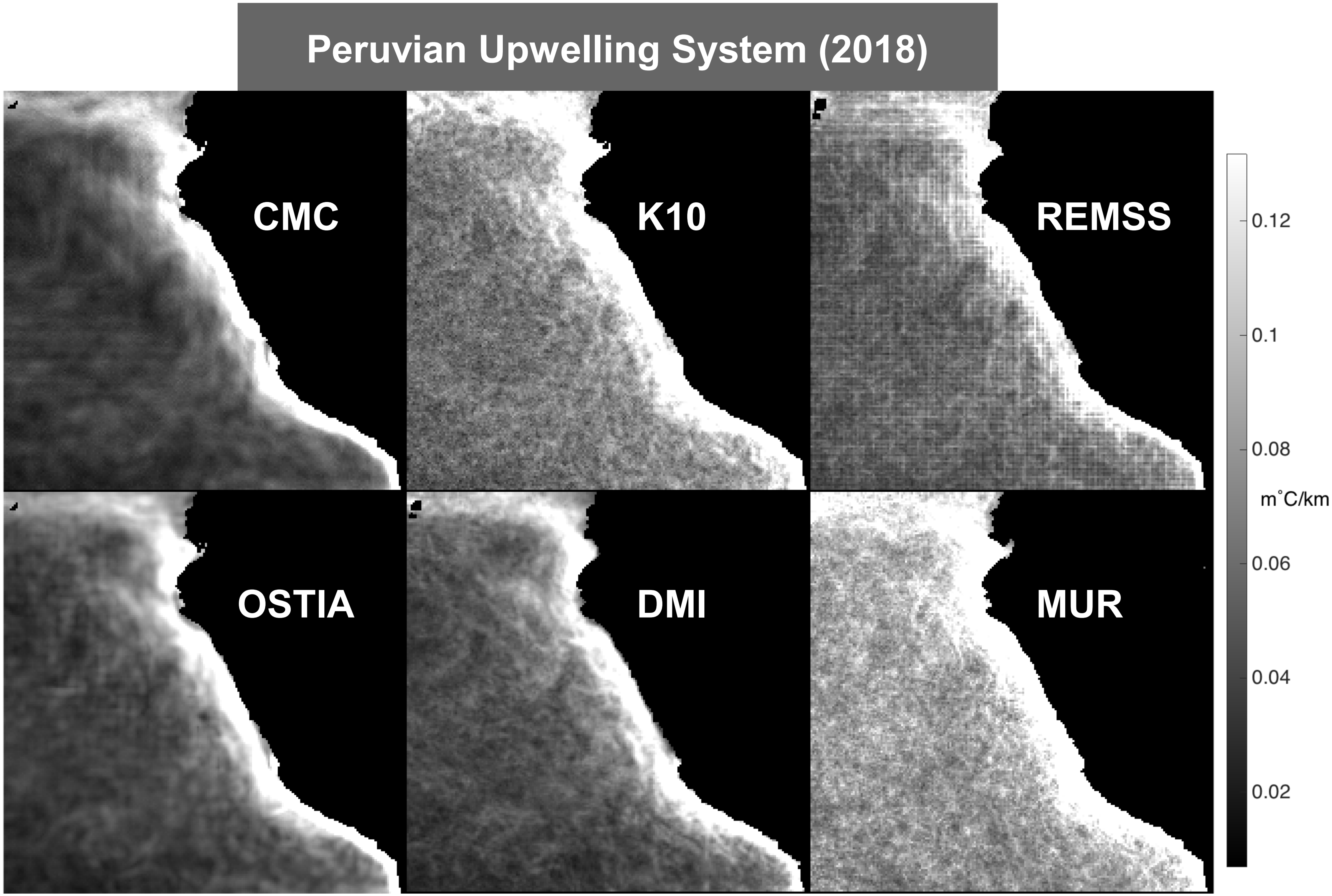


Histogram of SST gradient magnitudes from Level 4 (Daily, Global)

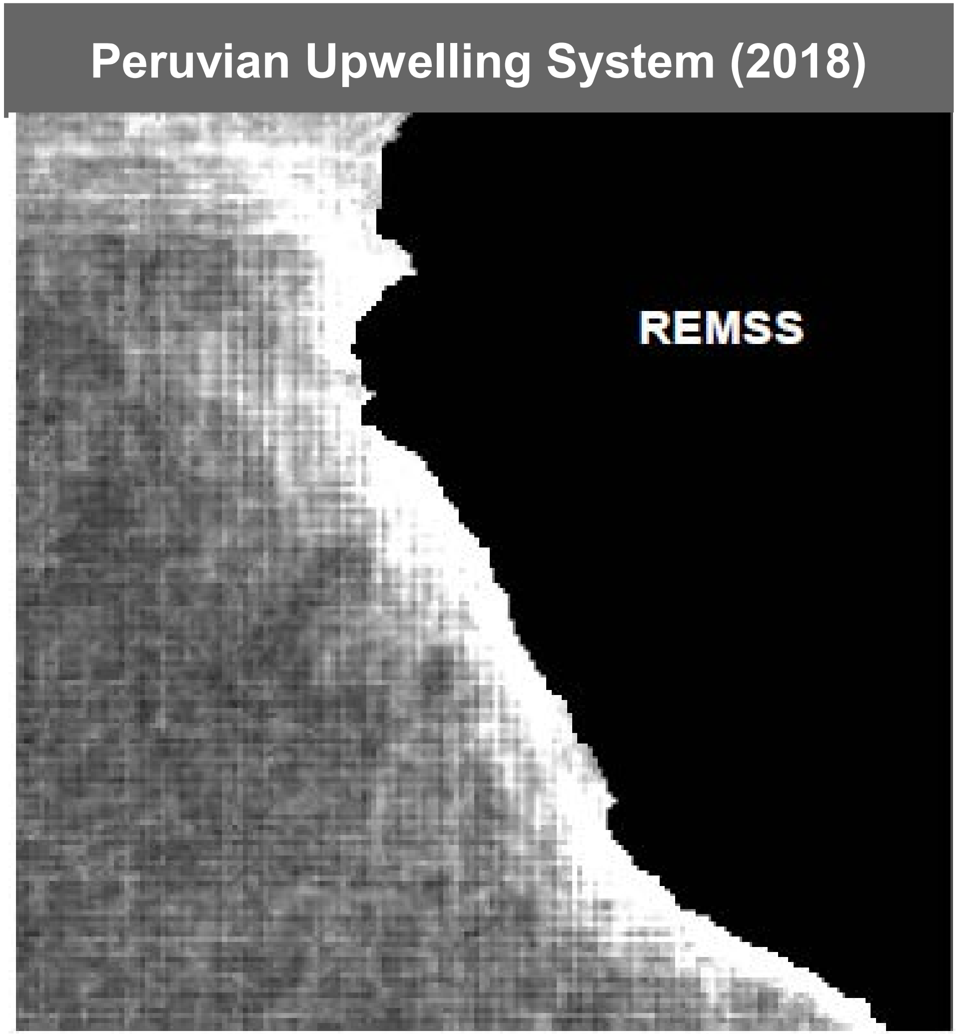
Annual Cycle: |∇SST|



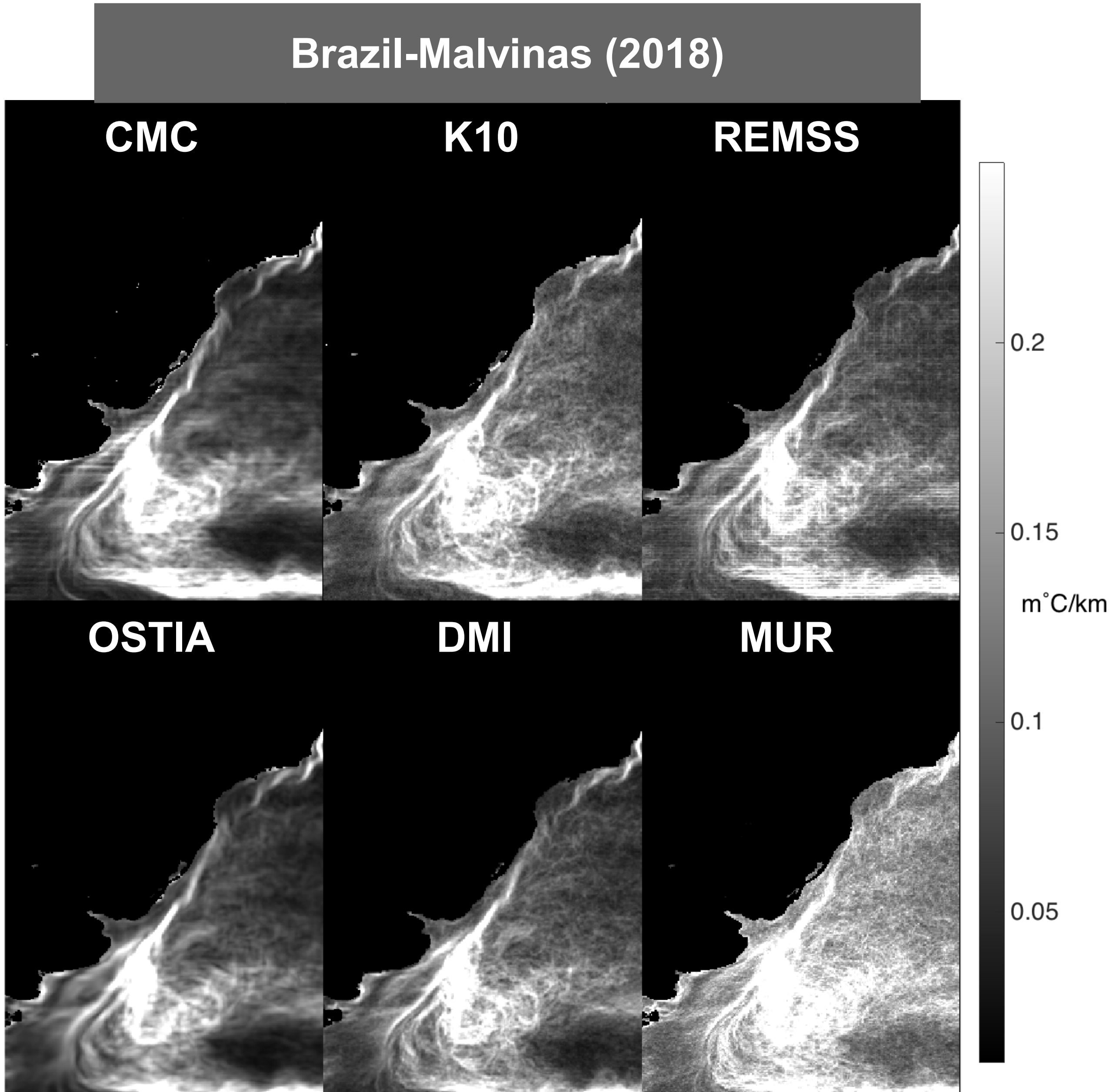
Annual Maps: $|\nabla SST|$



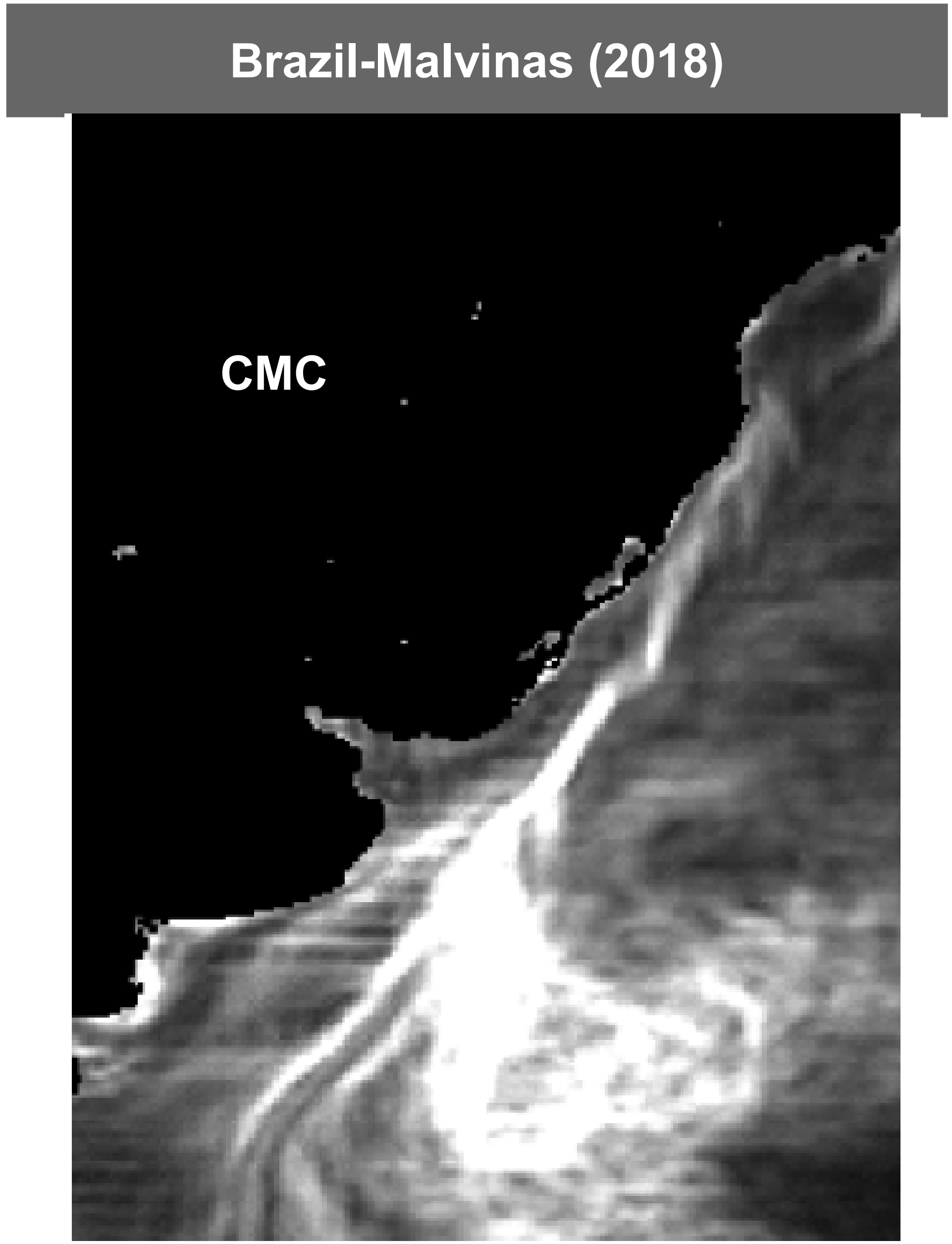
Annual Maps: $|\nabla SST|$



Annual Maps: $|\nabla SST|$



Annual Maps: |∇SST|

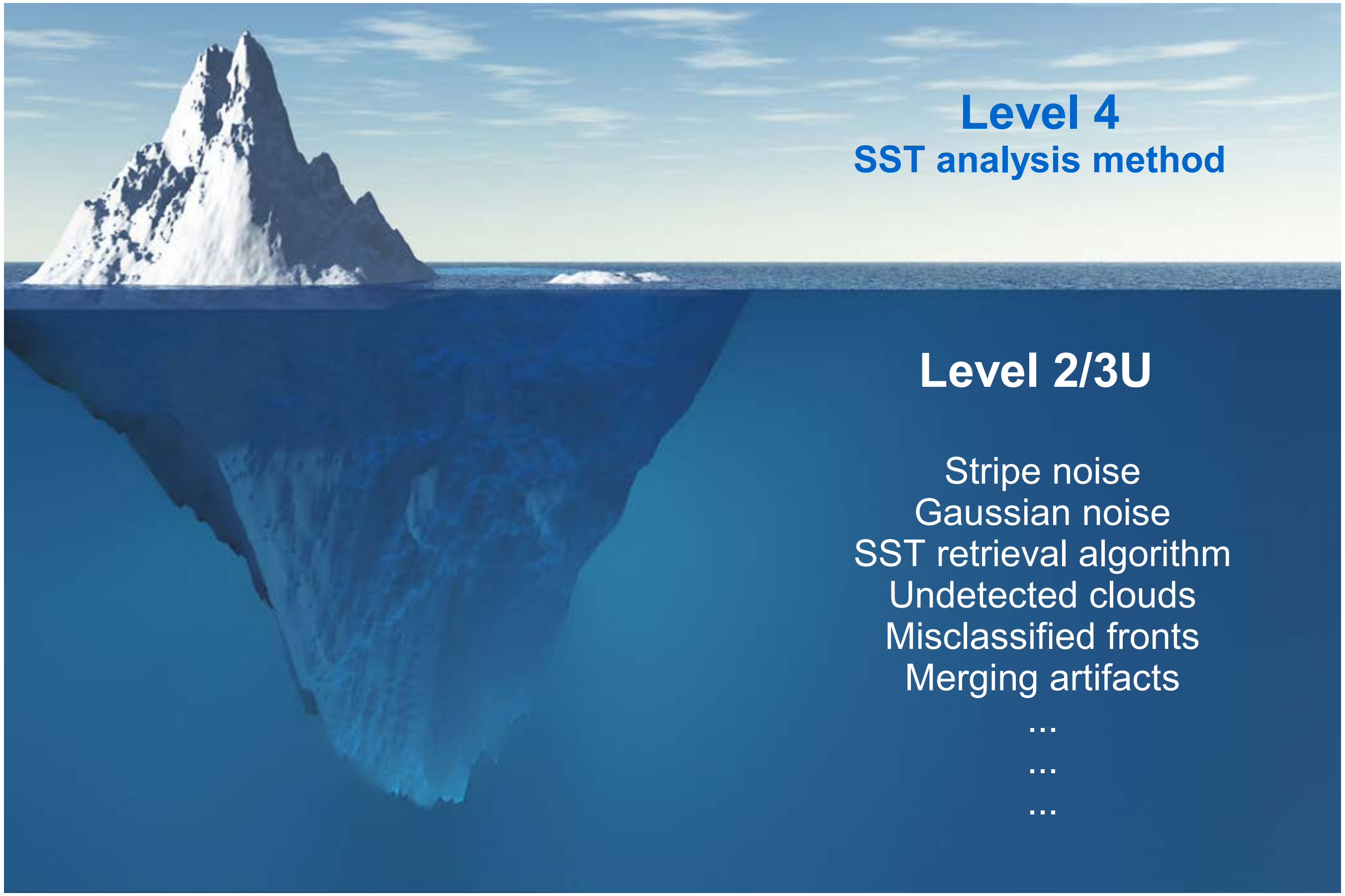


Conclusion

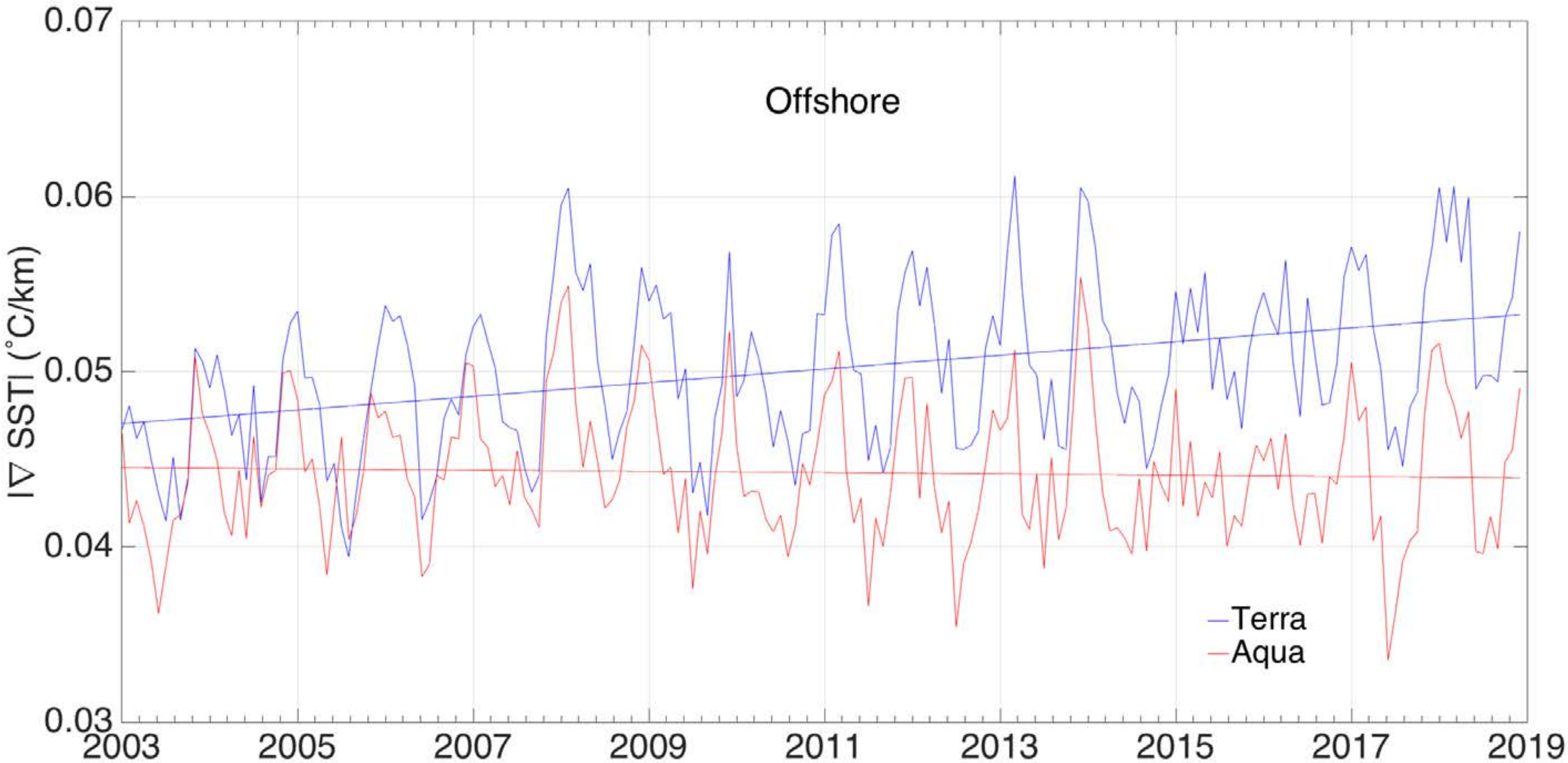
- The magnitude of SST gradients from Level 4 products shows major differences in space and time despite consistency of SST
- Differences originate from the SST analysis **AND** the Level 2 data ingested
- Statistical metrics (Bias, Stdv, MSE) do not quantify the “geometrical quality” of SST fields (i.e., Statistical validation ≠ Geometrical validation)
- Validation of SST gradients requires new methods and metrics

Conclusion

Differences in SST gradients



Case study
SST gradients from Level 2 MODIS
California Current System



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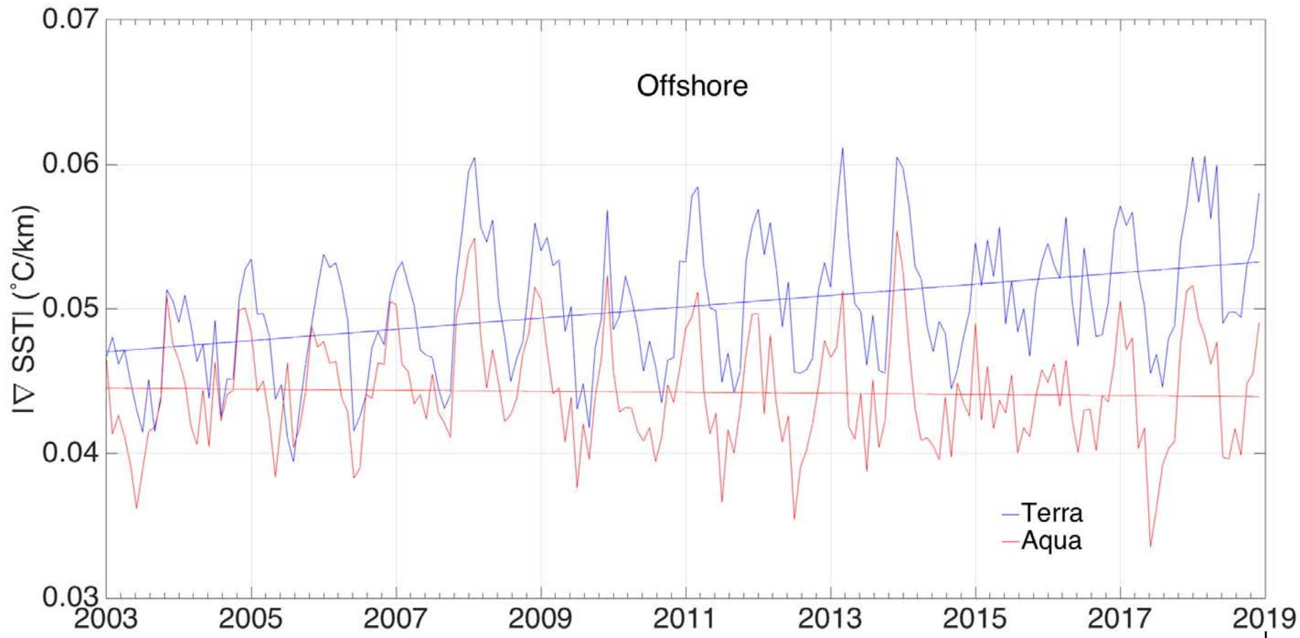

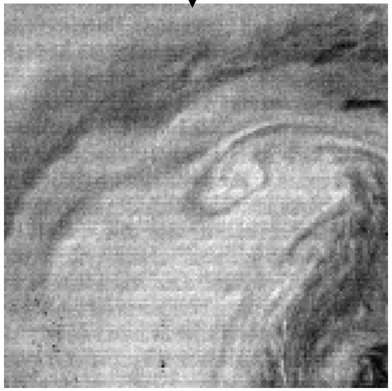

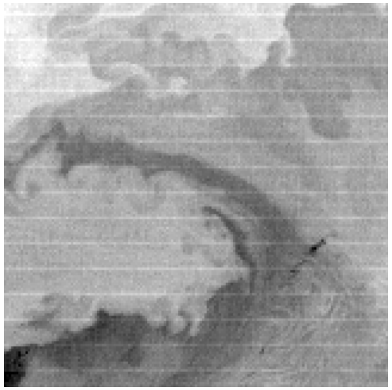

Increasing trend of SST gradients on Terra MODIS due to continuous degradation of detectors in channels used for SST

Thank you! Questions?