Ocean and Coastal Initiative Session

2020 STAR JPSS/GOES-R Proving Ground Risk Reduction Summit

1500 to 1630, Tuesday, 25 February 2020

NCWCP Auditorium

1500 to 1630 Session

Time (hhmm)	Duration (min)	Presenter	Topic
1500	5	Lance, V.	Setting the session goals and NOAA CoastWatch/OceanWatch/PolarWatch as interface between providers and users
1505	10	Ignatov, Alexander	ACSPO updates and SST EDR activities
1515	10	Wang, Menghua	MSL12 updates and Ocean Color EDR activities
1525	10	Ford, Mike	NMFS
1535	10	Tomlinson, Michelle	NOS
1545	10	Kurapov, Alex	NOS
1555	10	Sienkiewicz, Joseph	NWS
1605	25	Audience and all speakers as panelists	Panel/ Audience Discussion
1630		Adjourn Session (Posters to follow)	

Advancing Ocean Satellite Data into Applications, Information and Decisions: NOAA Coastwatch/Oceanwatch/Polarwatch

Veronica P. Lance

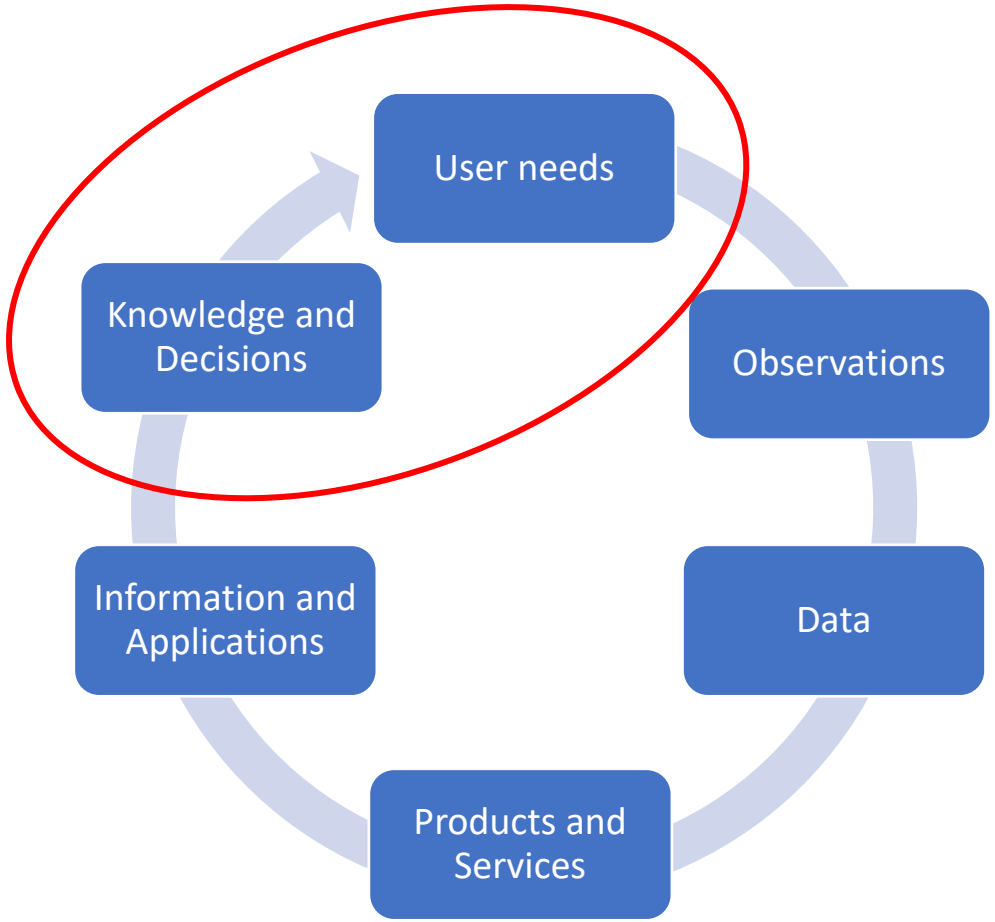
And the

NOAA CoastWatch/OceanWatch/PolarWatch Team

Questions

- Where are the gaps in operational satellite ocean/coast/water data or data products?
- What barriers to access and use are perceived by stakeholders?
- How do we fill these gaps and bridge these barriers?
- Where are the opportunities for expanding the number and types of applications that could benefit from satellite data?
- What resources do data providers need to support users?

Value Chain (loop) of Observations to Knowledge and Decisions

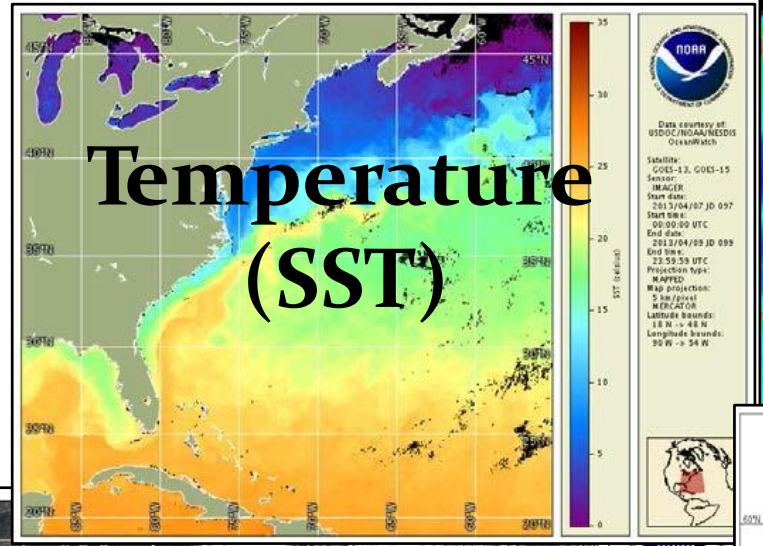


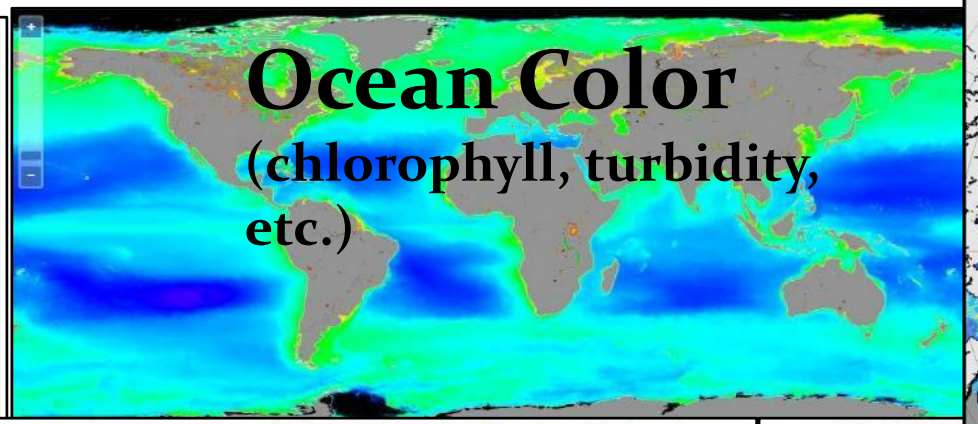
User-driven needs

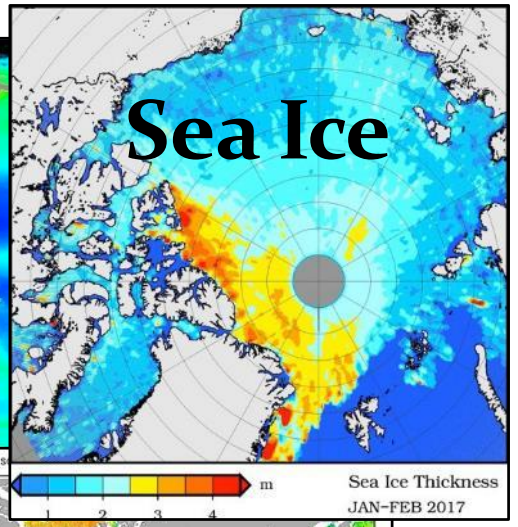
- Observations (sensor measurements)
- Data (~from bytes to geophysical parameters)
- Data Products and services (~from swath/granule to merged, mapped, anomalies, etc., data viewers and portals)
- Information and applications (combine data types, fusion, outside information, get the full picture, data assimilation in models, etc.)
- Knowledge to inform decisions and actions (e.g., downstream models, communication tools)

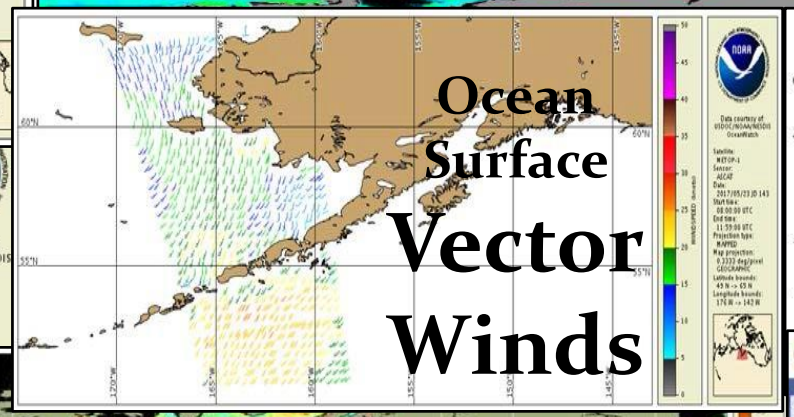
There are gaps

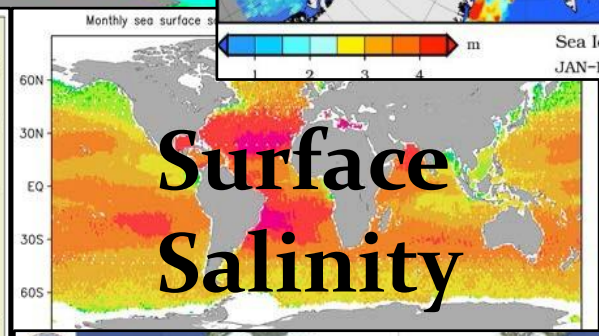
Ocean (Water) Parameters from SPACE

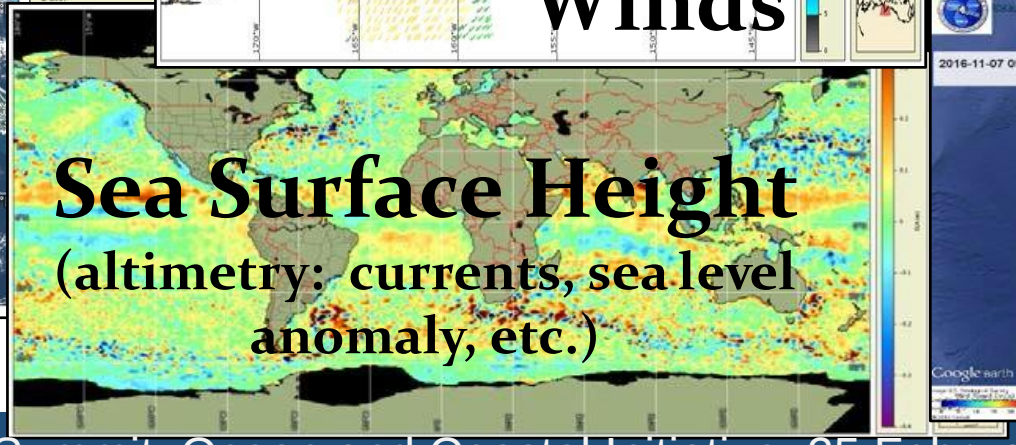


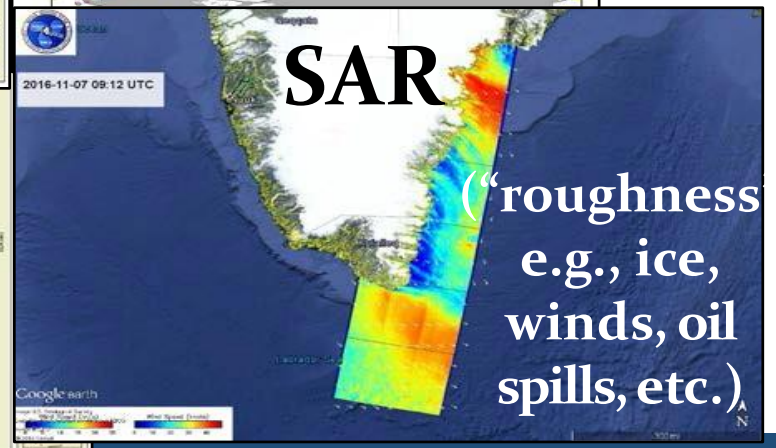












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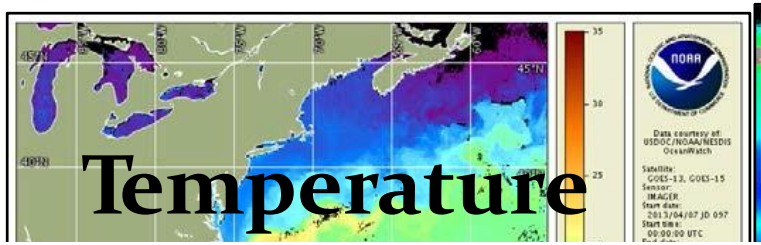
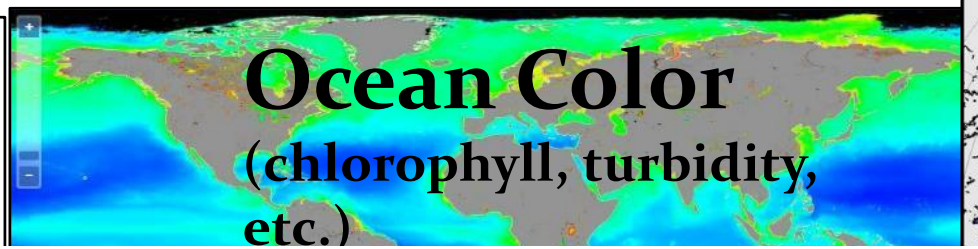
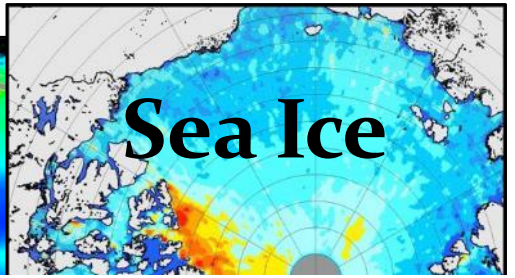
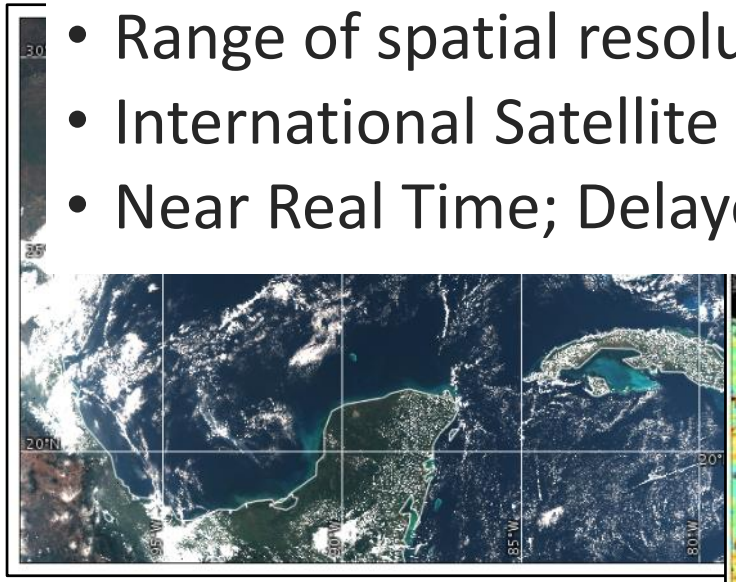
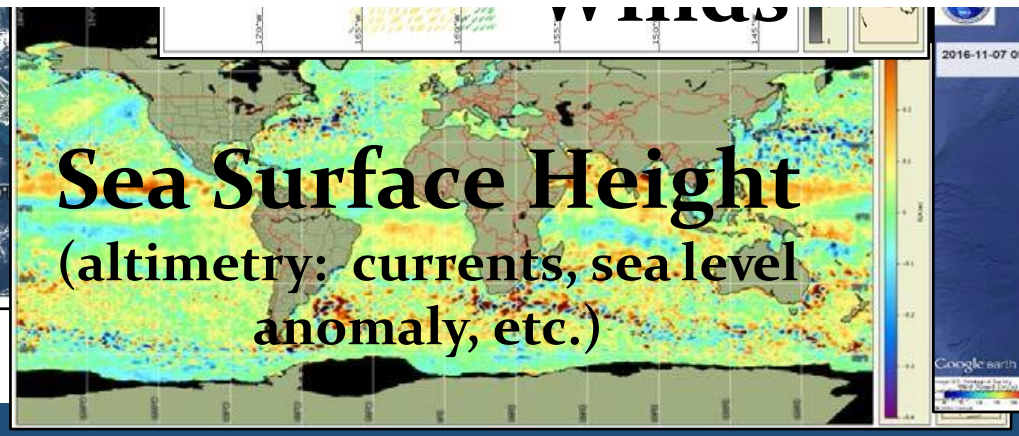


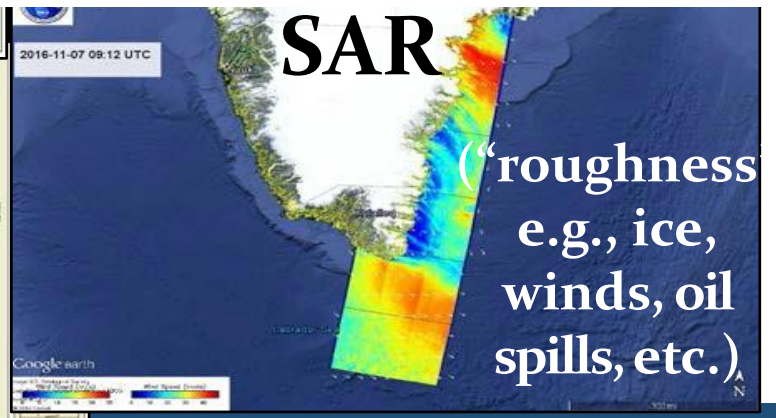




- Polar orbiting (spatial coverage); Geostationary (temporal coverage)
- Across electromagnetic spectrum
- Active; Passive
- Range of spatial resolutions
- International Satellite Missions (NOAA and non-NOAA data)
- Near Real Time; Delayed, Reanalyzed







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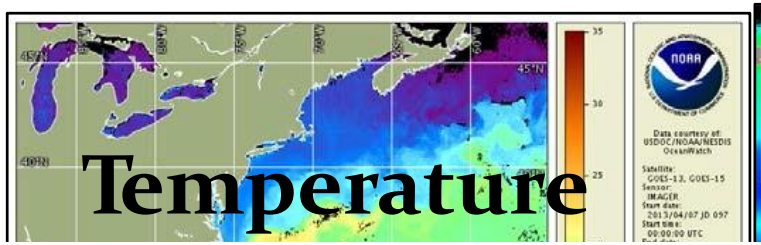

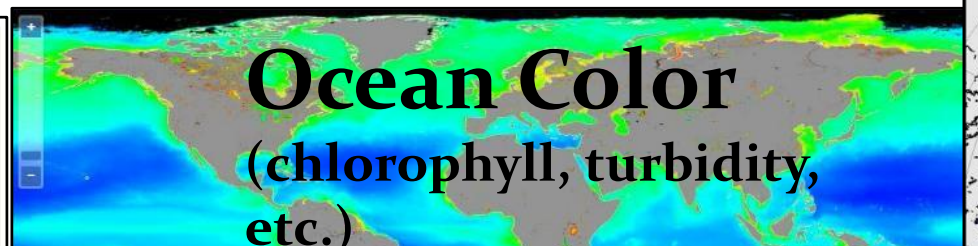

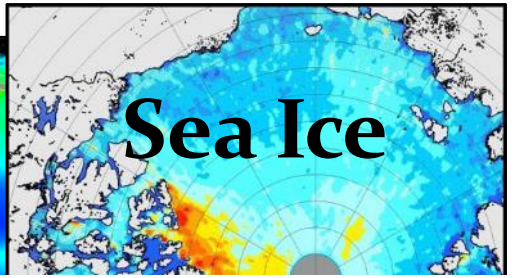

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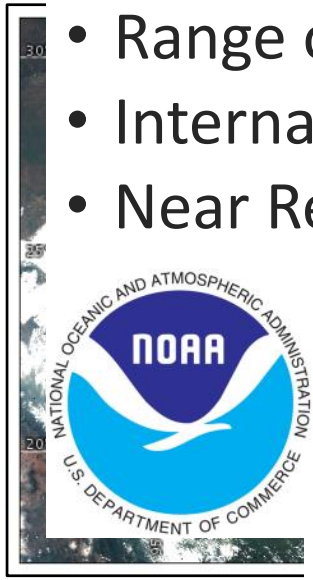
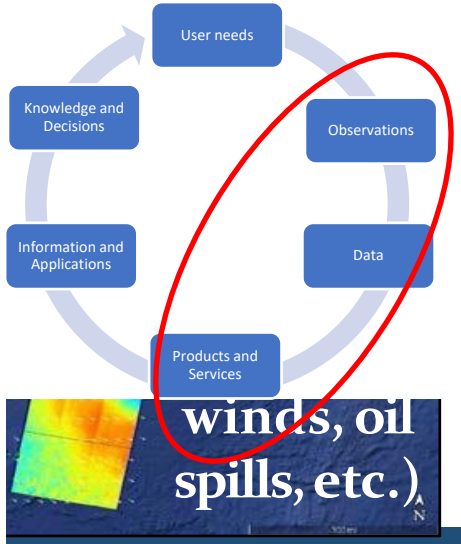


At NOAA/NESDIS/STAR – Specialized science teams for every parameter

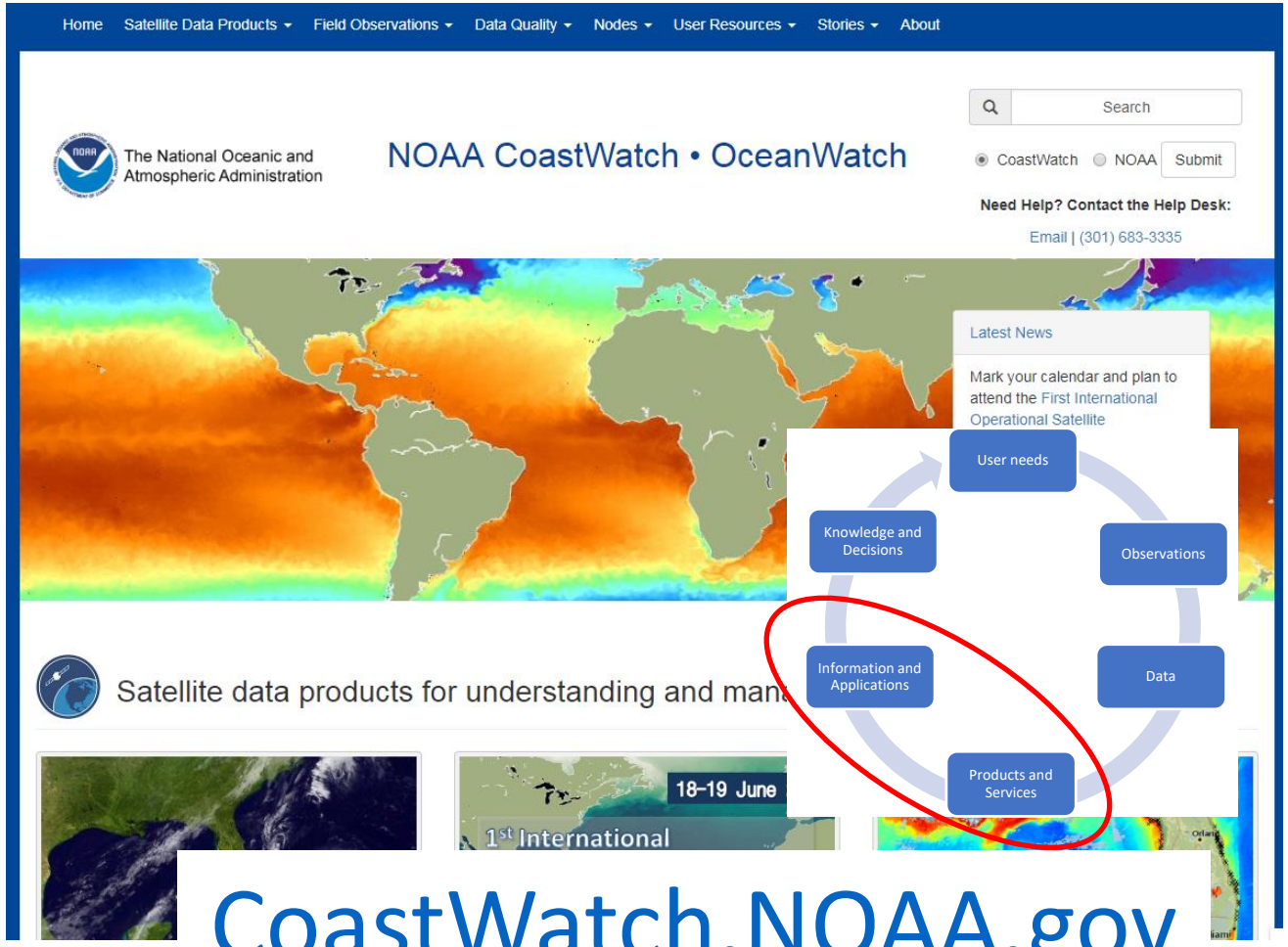
"STAR brings the power of satellite remote sensing science to all NOAA missions."



NOAA CoastWatch/OceanWatch/PolarWatch a.k.a. "CoastWatch" Free and Open Data/Products/Services

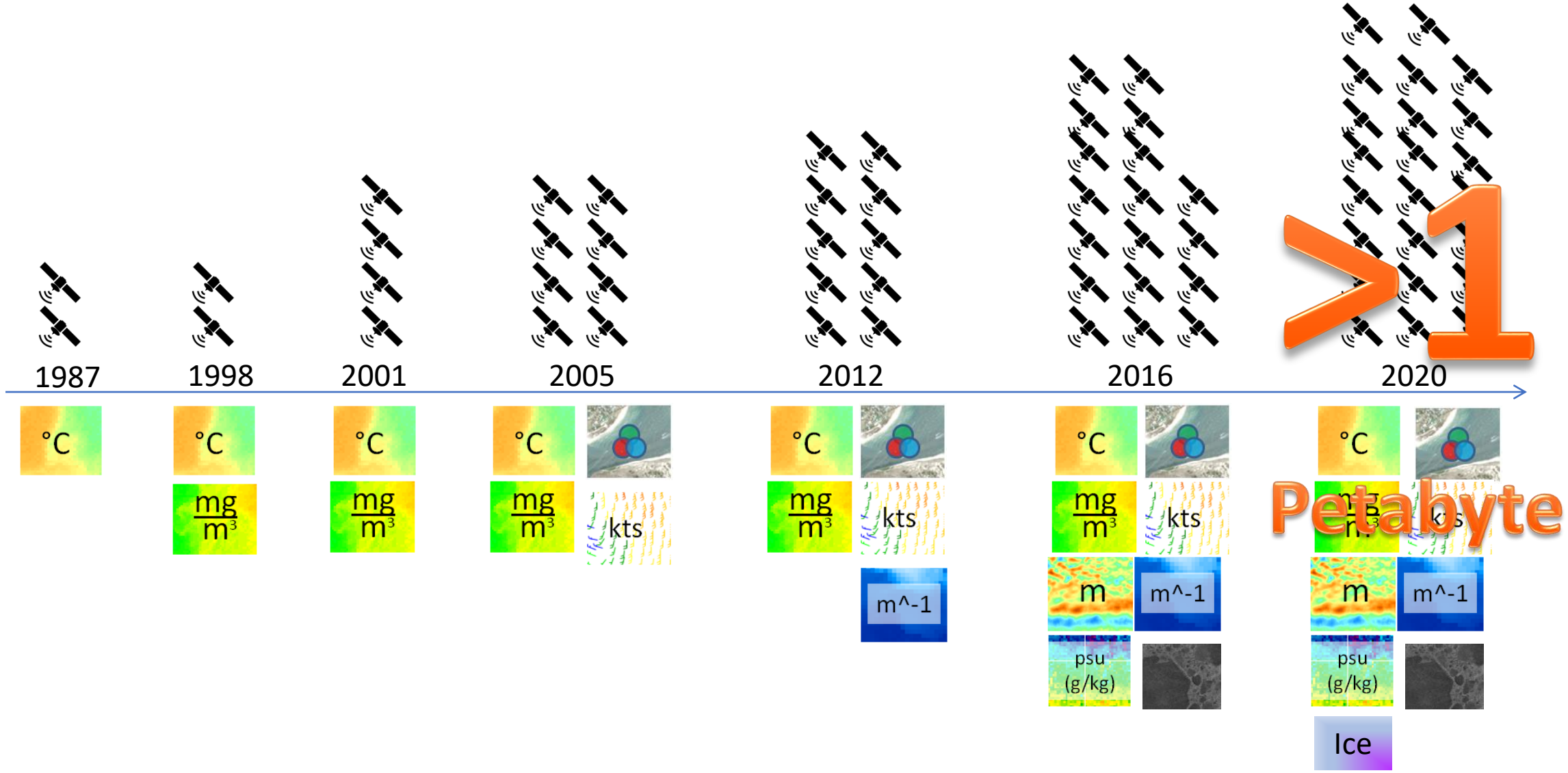
Adding value to ocean/aquatic satellite data

- Data Search and Access
- Product Descriptions
- Value added product development
- Data monitoring (quality/quantity)
- Transition new products
- Outreach, training, education
- User engagement
- Research and collaboration
- Feedback to satellite science



CoastWatch.NOAA.gov

CoastWatch Data, 30+ years



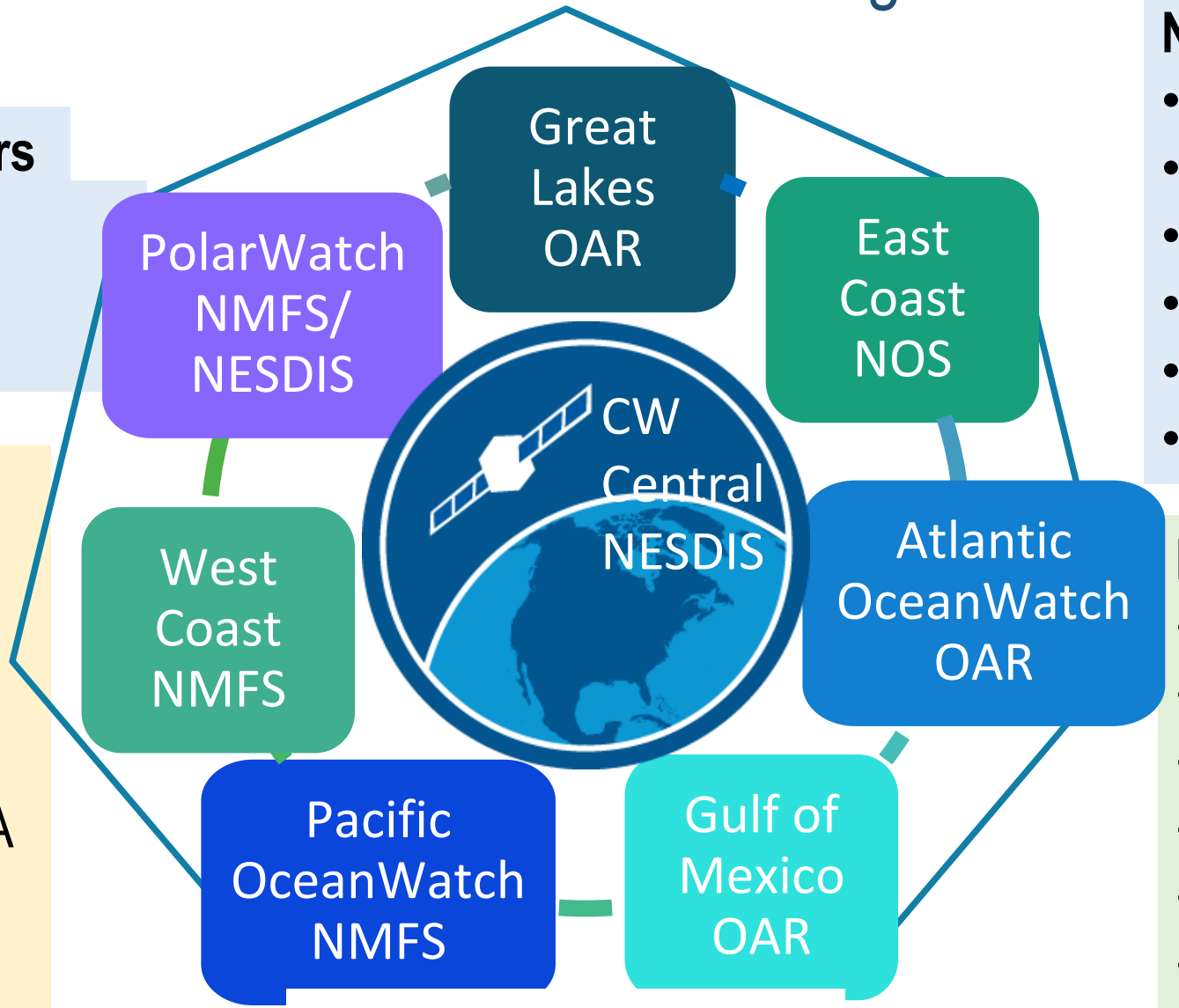
NOAA CoastWatch/OceanWatch/PolarWatch Program

NOAA Data Providers

- SOCD
- STAR
- OSPO
- NCEI
- OAR
- NWS

External Data Providers

- USGS
- NASA
- Copernicus; EUMETSAT; ESA (Sentinels)
- JAXA



"HUB and SPOKES"

NOAA Users

- NESDIS
- NMFS
- NOS
- NWS
- OAR
- OMAO

External Users

- Federal Agencies
- State Agencies
- Commercial
- Academia
- International
- General Public

NOAA CoastWatch/OceanWatch/PolarWatch Program

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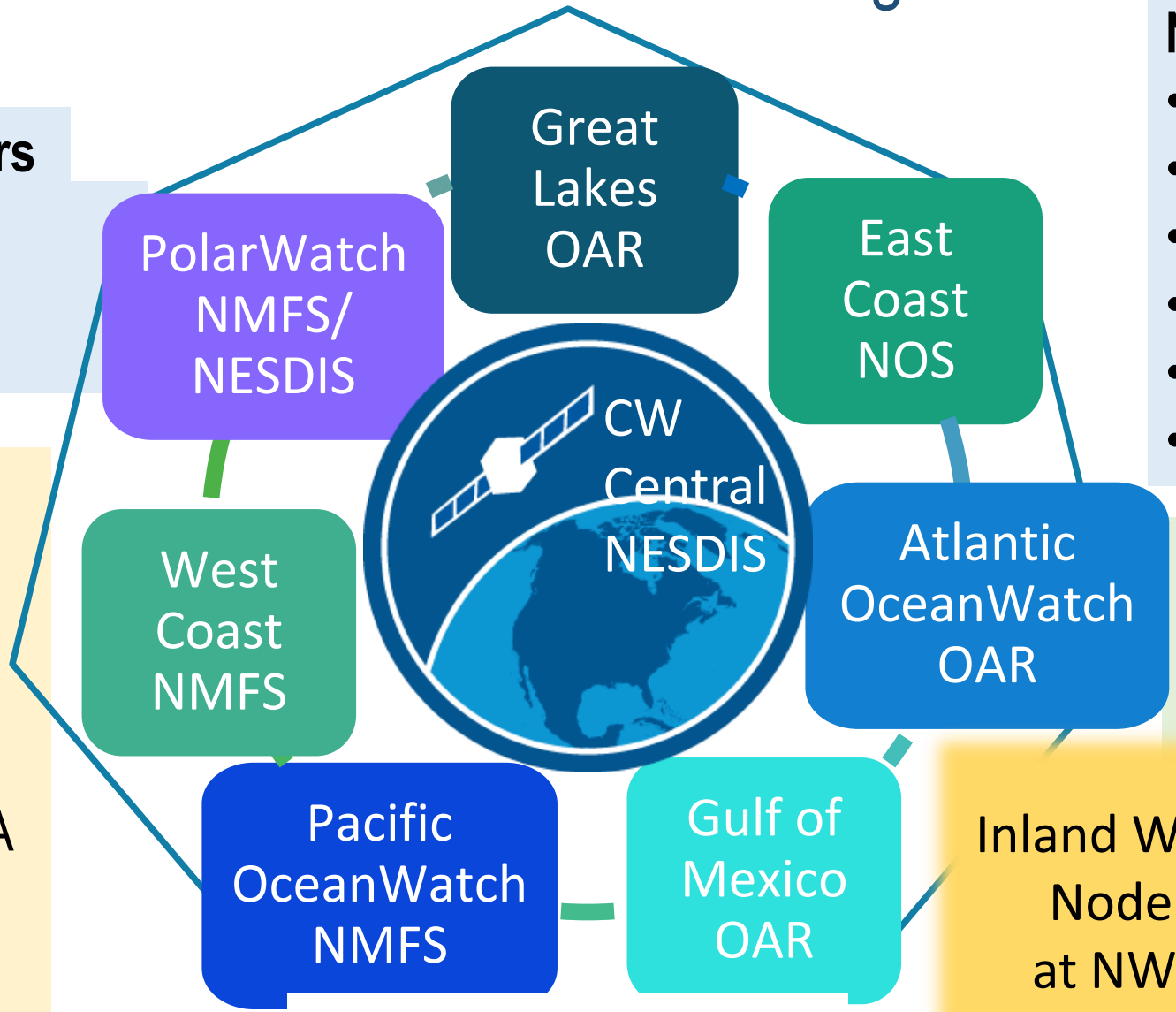

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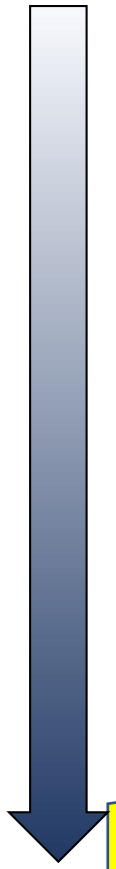
CoastWatch Nodes help users access and use satellite data



Provide access to datasets with data servers

Develop tools and tutorials to help users access and use data

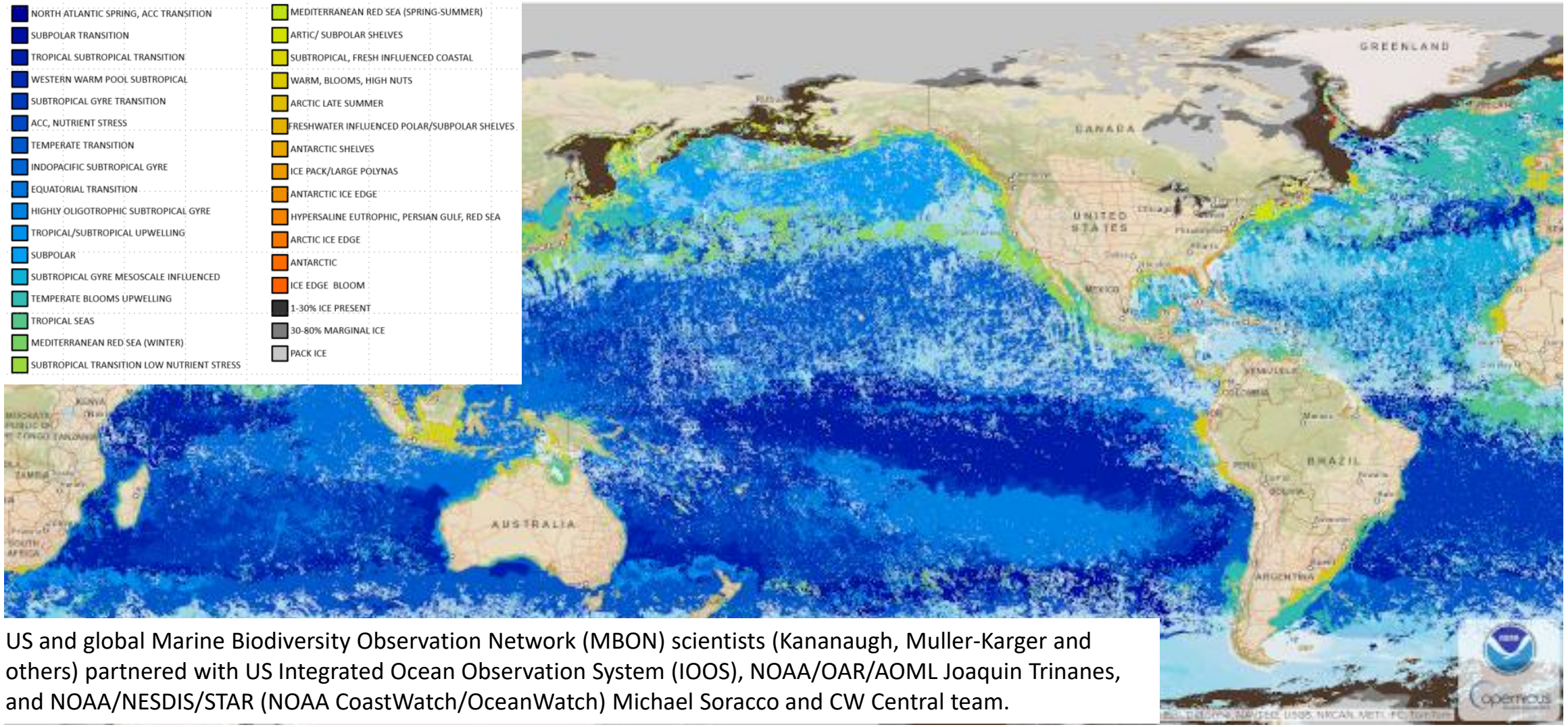
Provide training and hands-on assistance

Find or create value-added products in response to users needs

Collaborate directly with users on projects

The CoastWatch Nodes are Value-Added Providers

Example #1: Satellite input - Model output: e.g., Seascapes Product



US and global Marine Biodiversity Observation Network (MBON) scientists (Kananaugh, Muller-Karger and others) partnered with US Integrated Ocean Observation System (IOOS), NOAA/OAR/AOML Joaquin Trinanes, and NOAA/NESDIS/STAR (NOAA CoastWatch/OceanWatch) Michael Soracco and CW Central team.

https://coastwatch.noaa.gov/cw/satellite-data-products/multi-parameter-models/seascape-pelagic-habitat-classification.html

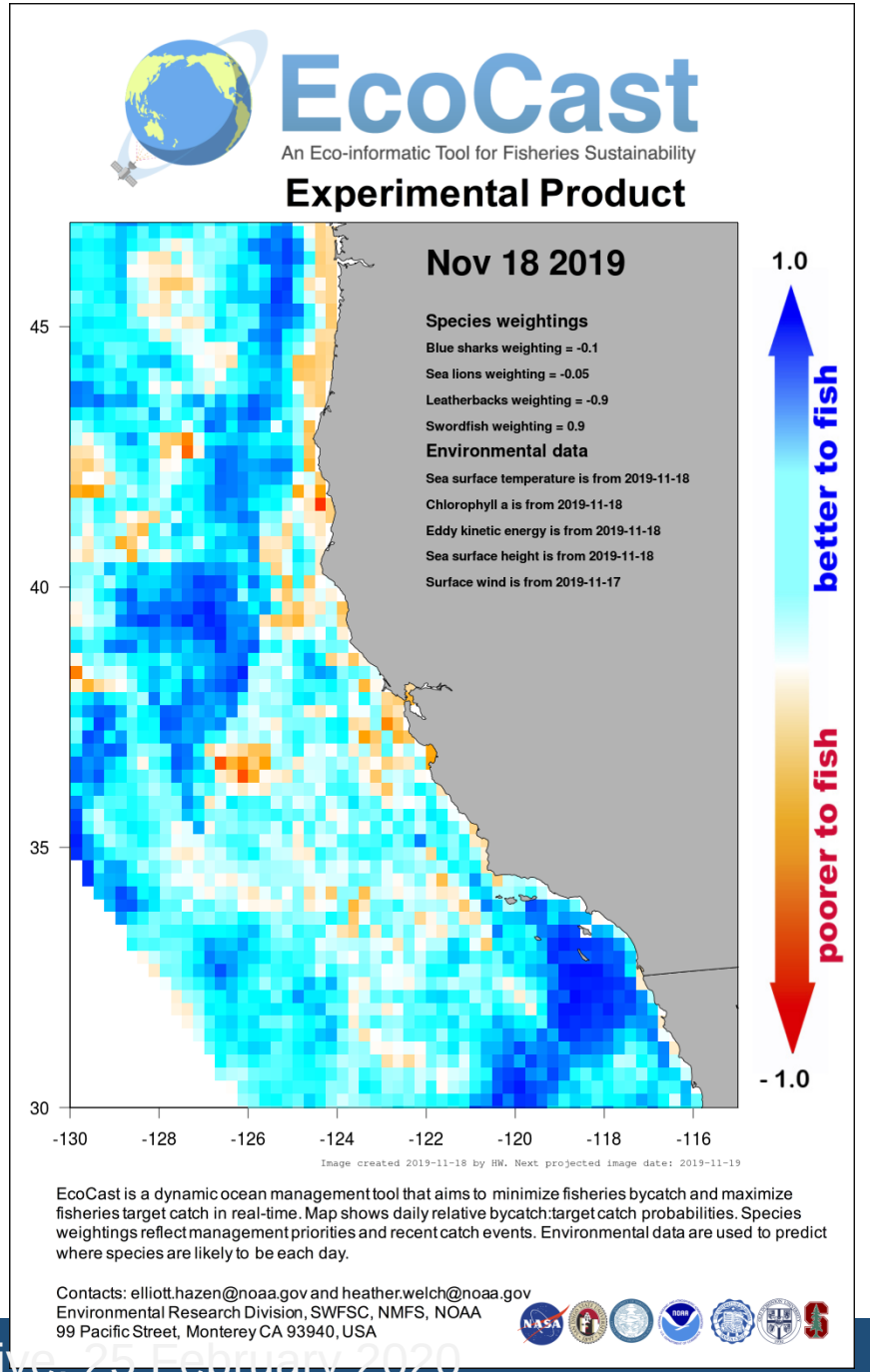
Example #2: EcoCast

Satellite observation inputs: SST, chl, EKE, SSH, winds

Application: Bycatch avoidance
Distributed through: CW West Coast Node

This project is funded in part through JPSS/PGRR

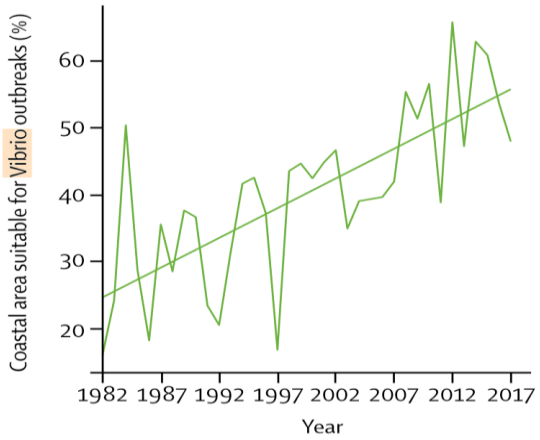
Courtesy: Elliot Hazen, Heather Welch, NMFS SWFSC developers and Dale Robinson, operations production West Coast Node
https://coastwatch.pfeg.noaa.gov/ecocast/map_product.html



Example #3: Vibrio Suitability Index derived using daily satellite SST

Satellite observation input: SST

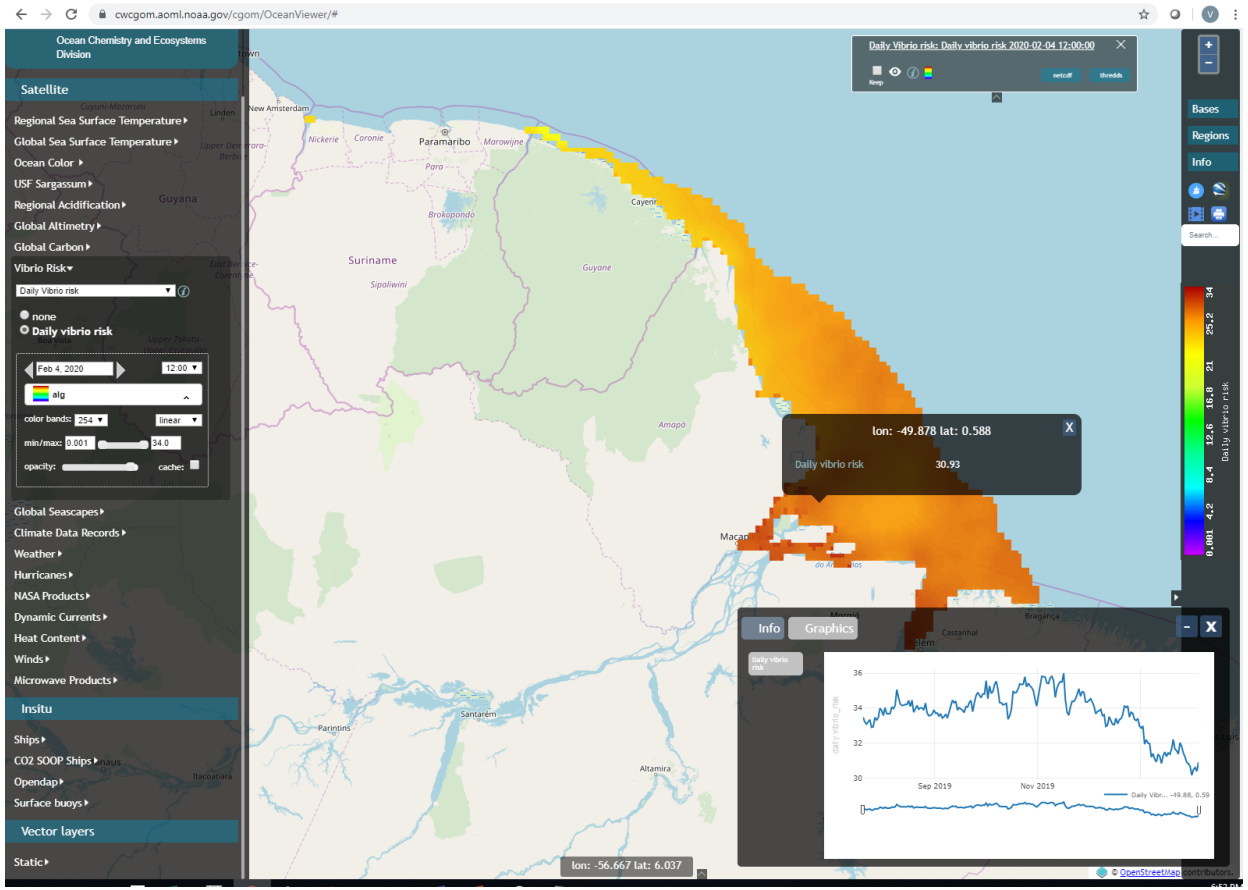
Applications: Human health; environmental management, seafood handling regulations, etc.



Lancet figure 7c- The percentage of coastal area suitable for Vibrio infections has increased in the northeastern USA around 27%.

Watts, Amann, Arnell, et al., 2018, The Lancet, The 2018 report of the Lancet Countdown on health and climate change: shaping the health of nations for centuries to come.

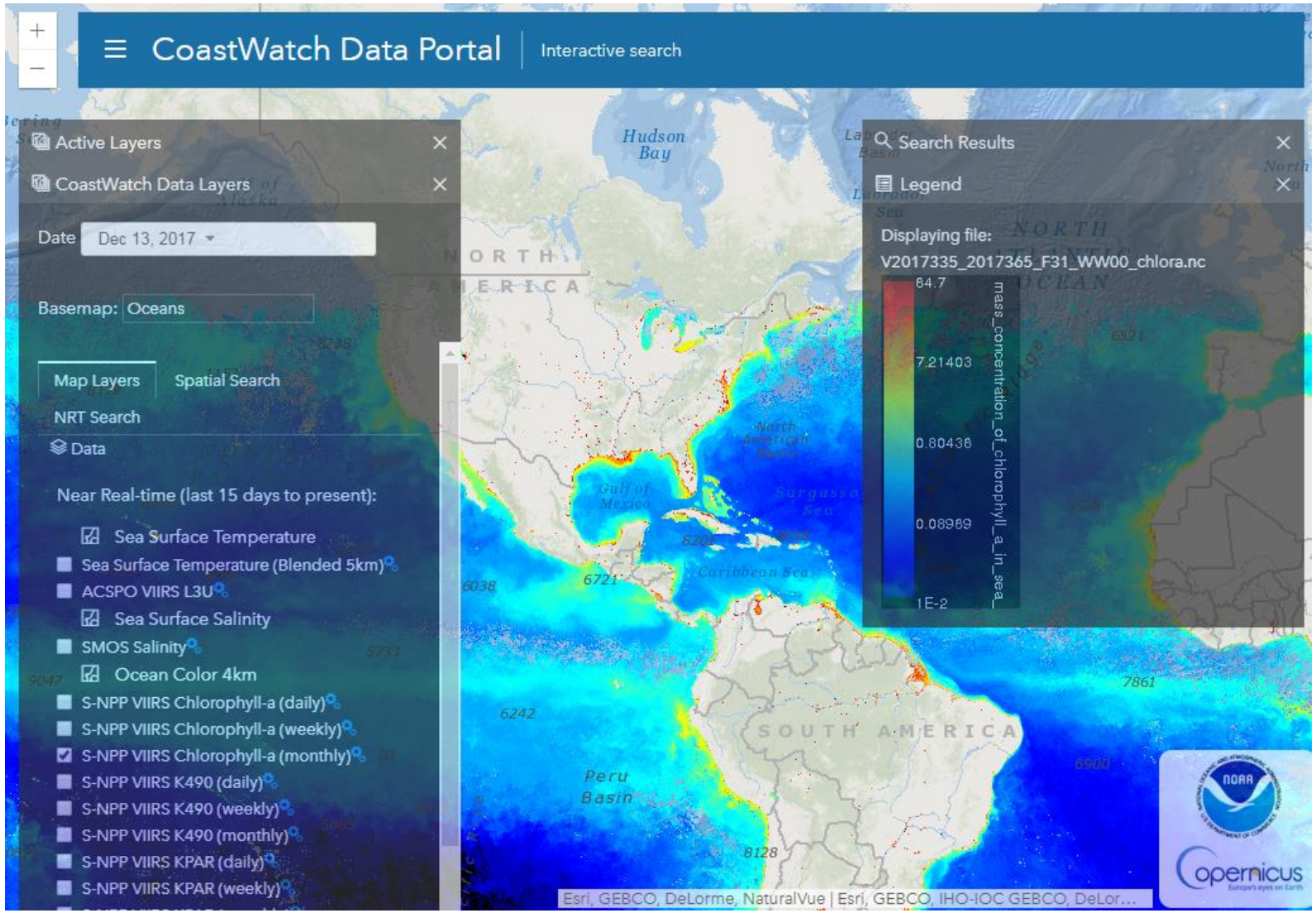
http://dx.doi.org/10.1016/S0140-6736(18)32594-7



Courtesy of Joaquin Trinanes, Atlantic OceanWatch and OAR/AOML

Data Portal

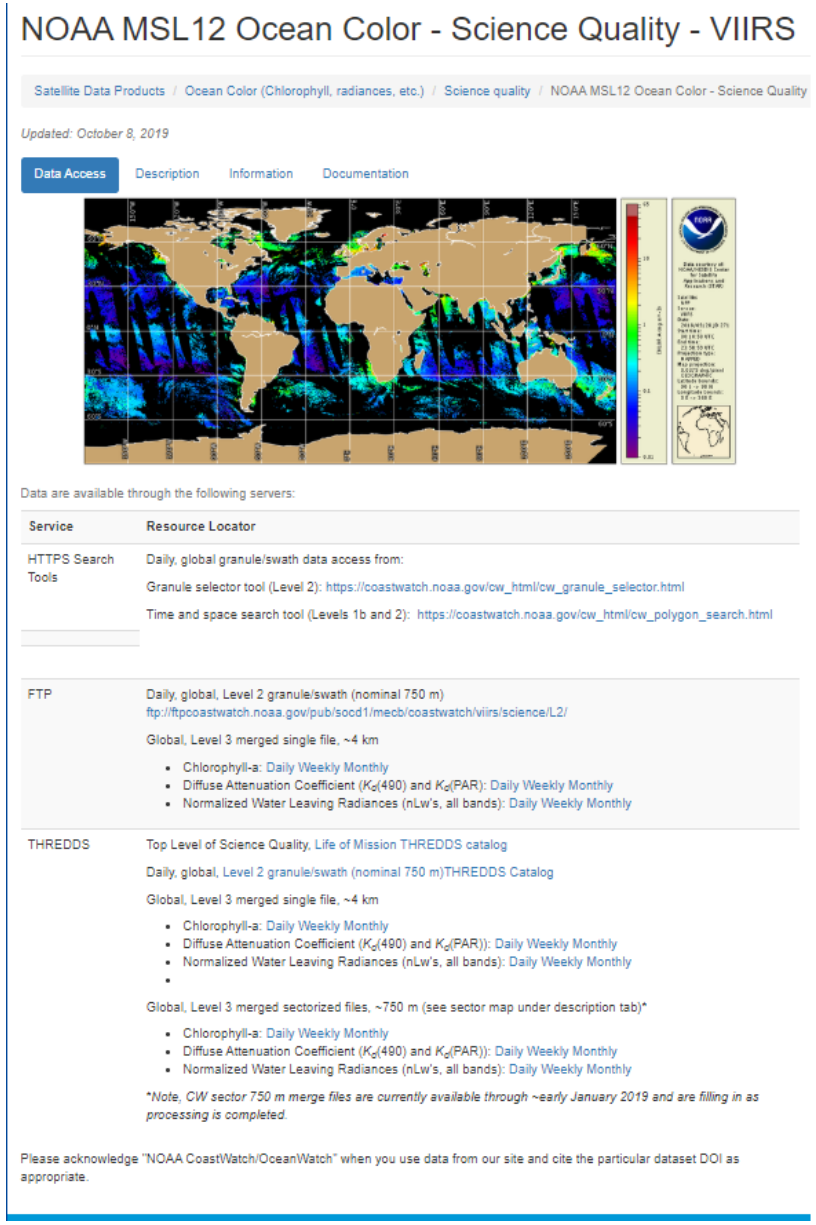
- Visualize
- Layer
- Probe
- Subset
  - Time
  - Space
- Download



https://coastwatch.noaa.gov/cw_html/cwViewer.html

Satellite Data Products Pages

- Data Access
  - THREDS
  - ERDDAP
  - FTP
  - NRT
  - Science Quality, RAN or Delayed Mode
- Description text
- Standardized tabular product information
- Documentation
- NetCDF, see metadata



NOAA MSL12 Ocean Color - Science Quality - VIIRS

Satellite Data Products / Ocean Color (Chlorophyll, radiances, etc.) / Science quality / NOAA MSL12 Ocean Color - Science Quality

Updated: October 8, 2019

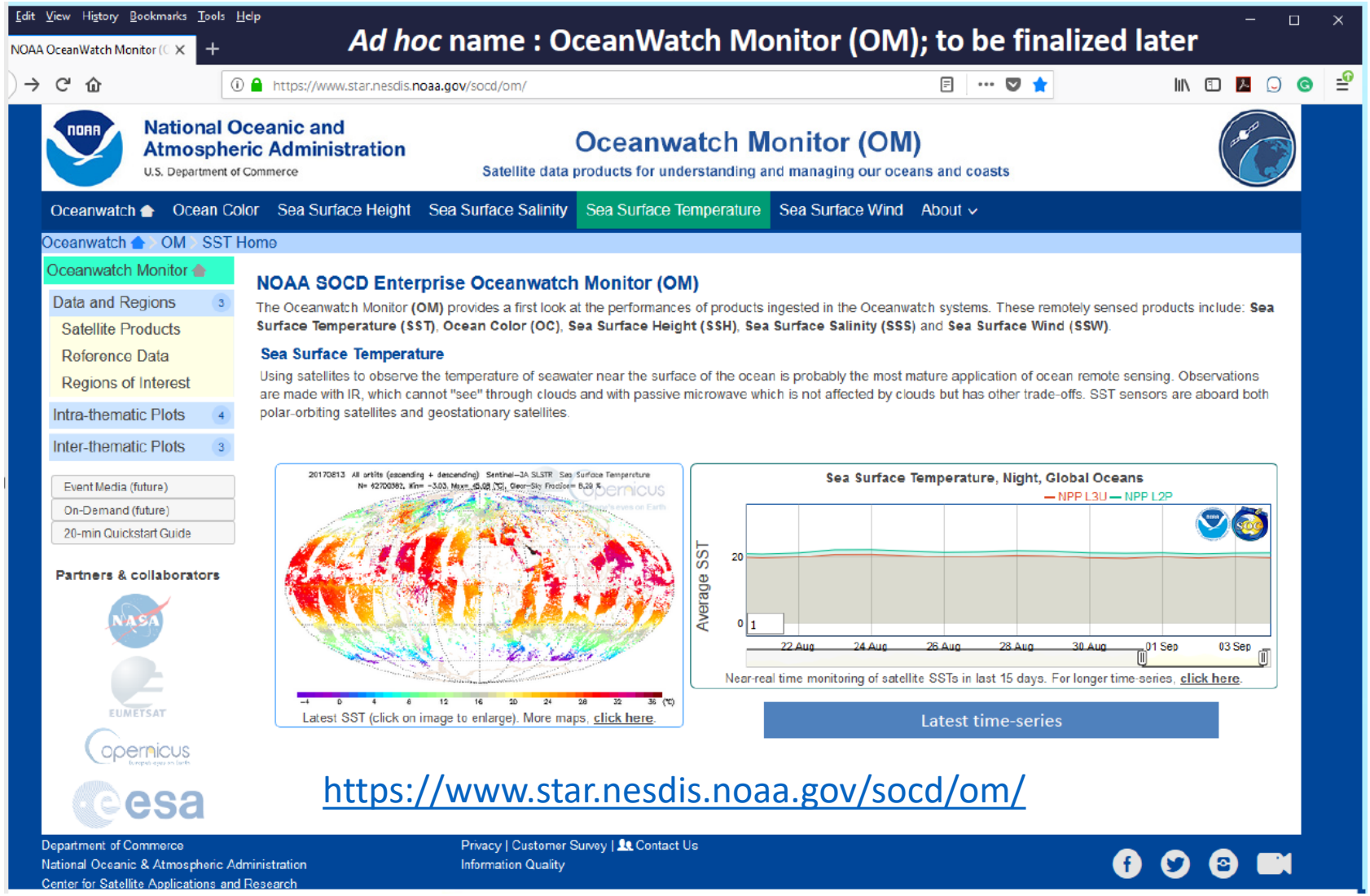
Data Access | Description | Information | Documentation

Data are available through the following servers:

Service	Resource Locator
HTTPS Search Tools	Daily, global granule/swath data access from: Granule selector tool (Level 2): https://coastwatch.noaa.gov/cw_html/cw_granule_selector.html Time and space search tool (Levels 1b and 2): https://coastwatch.noaa.gov/cw_html/cw_polygon_search.html
FTP	Daily, global, Level 2 granule/swath (nominal 750 m) ftp://ftpcoastwatch.noaa.gov/pub/socd1/mecb/coastwatch/viirs/science/L2/ Global, Level 3 merged single file, ~4 km • Chlorophyll-a: Daily Weekly Monthly • Diffuse Attenuation Coefficient (K_d(490) and K_d(PAR): Daily Weekly Monthly • Normalized Water Leaving Radiances (nLw's, all bands): Daily Weekly Monthly
THREDDS	Top Level of Science Quality, Life of Mission THREDDS catalog Daily, global, Level 2 granule/swath (nominal 750 m)THREDDS Catalog Global, Level 3 merged single file, ~4 km • Chlorophyll-a: Daily Weekly Monthly • Diffuse Attenuation Coefficient (K_d(490) and K_d(PAR)): Daily Weekly Monthly • Normalized Water Leaving Radiances (nLw's, all bands): Daily Weekly Monthly Global, Level 3 merged sectorized files, ~750 m (see sector map under description tab)* • Chlorophyll-a: Daily Weekly Monthly • Diffuse Attenuation Coefficient (K_d(490) and K_d(PAR)): Daily Weekly Monthly • Normalized Water Leaving Radiances (nLw's, all bands): Daily Weekly Monthly **Note, CW sector 750 m merge files are currently available through ~early January 2019 and are filling in as processing is completed.*

Please acknowledge "NOAA CoastWatch/OceanWatch" when you use data from our site and cite the particular dataset DOI as appropriate.

OceanWatch Monitor



- Maps
- Timeseries
- Hovmöller Diagrams
- Reference Data Sets

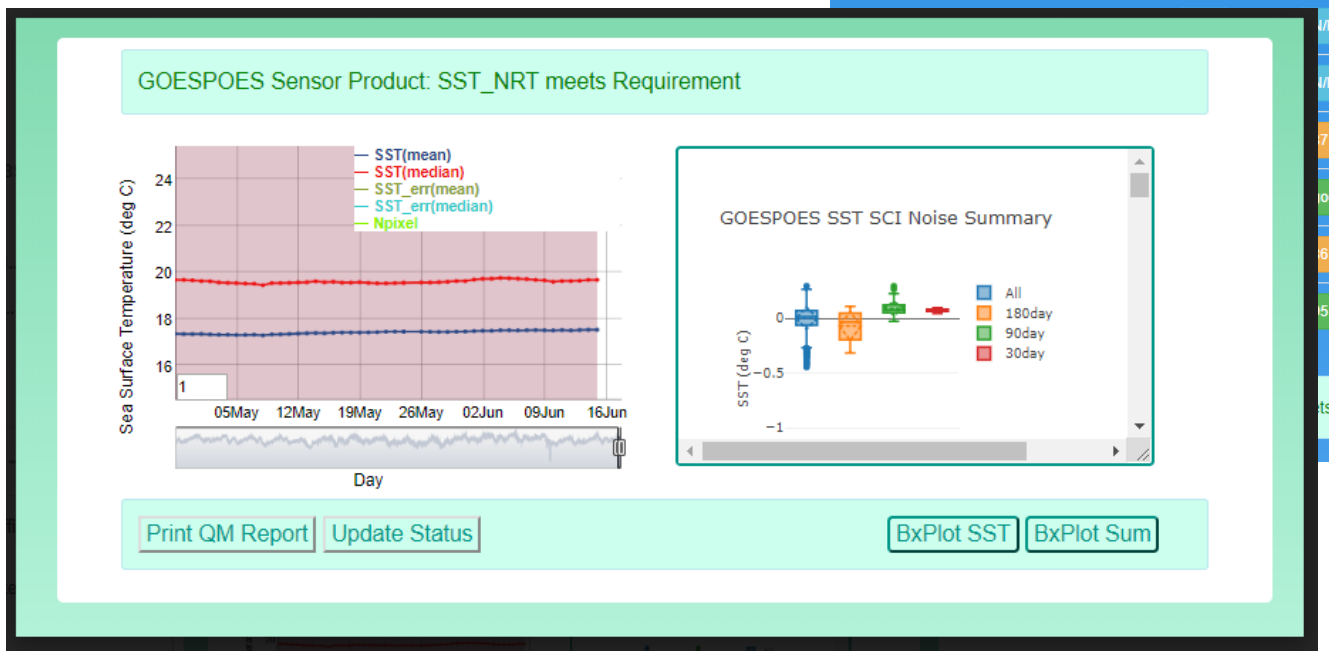
Data Performance and Availability Tracking

- Monitors data
  - availability
  - stability
- Quantitative, statistics

Color Latency Summary:

Sensor	Chlor_a	Kd490	KdPAR	nLws	Anomaly	Imagery	L2	L4	QMetric
VIIRS-NPP-NRT-Global	good	good	good	good	N/P	N/P	95 %	good	good
VIIRS-N20-NRT-Global	good	good	good	good	N/P	N/P	good	good	good
OLCI-S3A-NRT-Global	95 %	95 %	N/P	95 %	N/P	N/P	good	N/A	95 %
OLCI-S3B-NRT-Global	good	good	N/P	good	N/P	N/P	good	good	good
VIIRS-NPP-SCI-Global	good	good	good	good	N/T	N/T	93 %	good	good
VIIRS-N20-SCI-Global	N/P	N/P	N/P	N/P	N/P	N/P	TBD	TBD	TBD
	/P	N/P	N/P	N/P	N/P	N/P	TBD	TBD	TBD
	/P	N/P	N/P	N/P	N/P	N/P	TBD	TBD	TBD
	7 %	87 %	87 %	TBD	N/T	95 %	good	87 %	
	ood	good	N/P	TBD	N/T	good	N/P	92 %	
	6 %	N/P	86 %	TBD	N/T	good	86 %	86 %	
	5 %	N/P	95 %	TBD	N/T	good	95 %	77 %	

ts Requirement :: 100 %



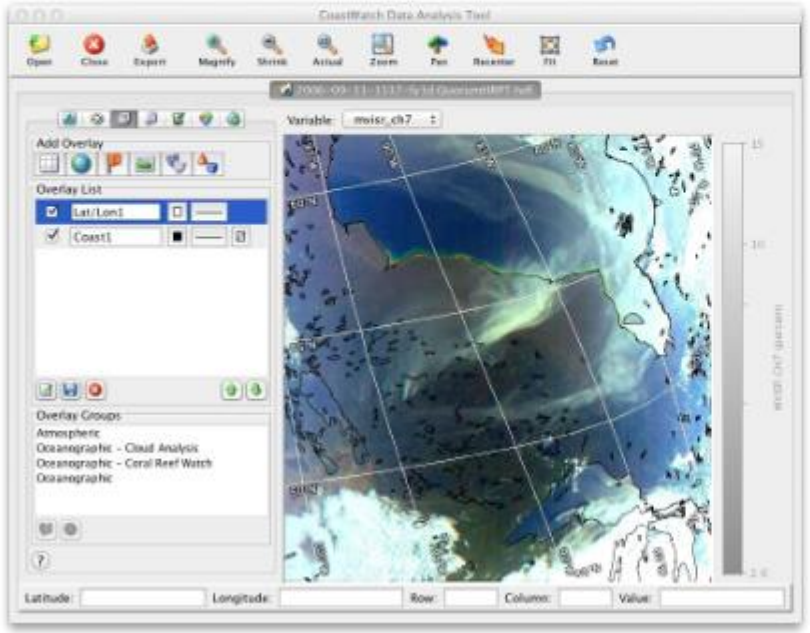
https://www.star.nesdis.noaa.gov/sod/mecb/coastwatch/NRT-QA/QM_Reports.html

CoastWatch Utilities and CDAT Software

CoastWatch Utilities 3.5.0

User Resources / CoastWatch Utilities 3.5.0

Updated: September 25, 2019



- Work with earth science data created by NOAA CoastWatch / OceanWatch.
- View and convert data in various formats: HDF 4, NOAA 1b, and NetCDF 4.
- Interactive and batch processing tools.
- Windows, Linux, and Mac OS X.
- Functionality includes:
  - **Information and Statistics**
  - **Data Processing**
  - **Graphics and Visualization**
  - **GeoRegistration and Navigation**
  - **Network**
- Documentation: YouTube training videos and user manual

https://coastwatch.noaa.gov/cw/user-resources/coastwatch-utilities.html

NOAA CoastWatch Satellite Training

Coastwatch.info@noaaa.gov

https://coastwatch.noaa.gov/cw/user-resources/satellite-data-training-courses.html

Upcoming full 3-day courses

- **Anchorage, AK** - 7 to 9 April 2020, Alaska Fisheries Science Center in association with National Parks Service
- **Charleston, SC.** – 23-25 June 2020 - in association with Hollings Marine Laboratory

Future Directions, Challenges, Opportunities

- Knowing our users (and what they use, how they access, etc.)
  - Fully mine and exploit data access logs (no required "registration" process)
  - Data product database development including key users
  - Proactively and systematically asking permission for users to be identified for specific purposes
  - Establish an online user forum
- Overcoming language barriers to make satellite data products more understandable
  - Increasing the number of in-person, hands-on training classes
  - Improve online self-learning materials ("Learning Portal")
  - Develop university (at UMD?) course and/or curriculm
- Improve user interactive experiences on website
  - Data visualization
  - Data searches and access
  - Quality tracking
  - Themed portals
  - Event tracker
- Identify and develop new value added products and services
  - L4 analysis, models, parameter "fusion" products, etc. that serve specific or multiple applications
  - transition them to CW operations
  - In situ databases and satellite matchups
  - Institue an Inland Water Node?

New Inland Water Node?

- Grow the definition and implementation of STAR "moderate assurance" for specific, identified and vetted users
  - Quantification
  - Infrastructure IT requirements
  - Conveying benefits/limitations of datasets (both content and technical) to users
- Document history and future of CoastWatch - NOAA Heritage Program award for NOAA's 50th anniversary
- Unify the appearance ("brand") of the CW/OW/PW program without detracting from the benefits of node autonomy

Annual VIIRS Ocean Color Cal/Val Science Meeting, tomorrow, 9:00 to ~5:00, Wednesday, 26 February, 4102 ESSIC Building Univ. of MD

NOAA CoastWatch/OceanWatch/PolarWatch Annual Science Meeting
11-14 May 2020 at NCWCP, College Park, MD

Contact information for the nodes, central office and program

CoastWatch Central

Contact email and helpdesk
coastwatch.info@noaa.gov

Website
coastwatch.noaa.gov

CoastWatch/OceanWatch/PolarWatch Program

Program Manager
Veronica Lance
veronica.lance@noaa.gov

Central Pacific OceanWatch

Ops Manager
Melanie Abecassis
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Node Manager
Evan Howell
evan.howell@noaa.gov

Website
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Great Lakes

Ops Manager
Songzhi Liu
oar.glerl.cw@noaa.gov

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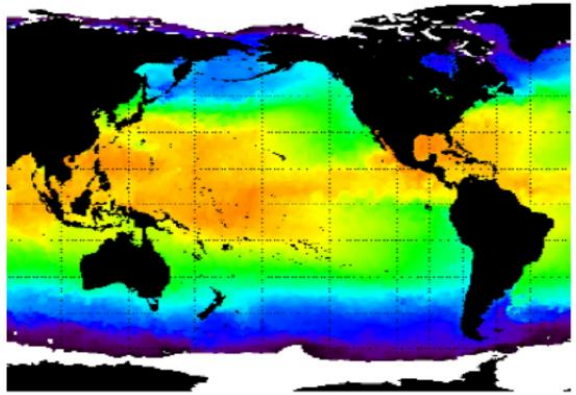
First International Operational Satellite Oceanography Symposium



First
International
OPERATIONAL
SATELLITE
OCEANOGRAPHY
Symposium

18 to 20 June 2019
National Climate and
Weather Prediction Center
College Park, MD USA

2nd In'tl OSO Symposium
Spring 2021
Germany

NOAA

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Questions?

CoastWatch.NOAA.gov

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NOAA SST Products & Priorities

Alexander Ignatov

ACSPO L2/3: Olafur Jonasson, Irina Gladkova, Boris Petrenko, Yury Kihai, Victor Pryamitsyn, John Sapper, Dean Hinshaw, Frank Johnson, Haifeng Zhang, Lars Hunger

Geo-Polar Blended L4: Andy Harris, Eileen Maturi, John Sapper

NOAA; GST Inc; CCNY

SST supported by NOAA JPSS, GOES-R and PSDI Programs

Content

- ACSPO SST Products
  - Polar: Hi-Res ~1km: NPP/N20 VIIRS, Metop-A/B/C AVHRR FRAC, Terra/Aqua MODIS. *In 2022, J2/VIIRS & Metop-SG/MetImage will be launched.* Lo-Res (~4km): NOAA-7 to -19 AVHRR GAC.
  - GEO: Hi-Res (~2km) G16/17 ABI & H08 AHI. *In 2021, GOES-T/ABI & MTG/FCI will be launched.*
  - In situ data (iQuam): Used for Cal/Val of satellite SSTs, and by many (inter) national users.
  - SST Monitoring: SQUAM, ARMS, iQuam

- Priorities suggested by users (mostly, Fisheries)
  - **Data Fusion/Blending**: ACSPO L3S (feature preserved/gaps) & Geo-Polar Blended L4 (gap free)
  - **Long-term reprocessed records ("Reanalyses", RANs)**: L2 → L3U → Fused L3S → Blended L4
  - **Thermal Fronts**: Coming in ACSPO v2.80, Sep'2020 (initially, from NPP/N20 VIIRS)
  - **Data Access/Archive**: NASA PO.DAAC; NOAA NCEI and Coast Watch

New NOAA and EUMETSAT Polar and Geostationary Constellations

JPSS VIIRS		GOES-R ABI (Himawari-8/9 AHI, GK2A AMI)	
Nadir: 0.74km Swath edge(67º) 1.5km		Nadir: 2km Swath edge(67º): 12km	
Global: Twice daily		FD: 10 min	
λ, µm	*Spec NEDT, K @300K*	*λ, µm*	*Spec NEDT, K @300K*
3.7	0.11	3.9	≤ 0.10
8.6	0.05	8.4	≤ 0.10
10.8	0.07	10.3	≤ 0.10
12.0	0.07	11.2	≤ 0.10
–	–	12.3	≤ 0.10

J2/N21 VIIRS & Metop-SG MetImage to be launched in 2022

JPSS/GOES-R carry VIIRS/ABI sensors with superior spatial/temporal resolution, more & better positioned SST bands, and improved radiometric performance

GOEST/18 ABI & MTG FCI will be launched in 2021

GAC/FRAC AVHRRs and MODISs are also (re) processed in ACSPO

Advanced Very High Resolution Radiometers (AVHRR)

✓ FRAC/1km: Metop-A/B/C operational + RAN1 underway

✓ GAC RAN2 will extend RAN1 (2002-18) back to 1981

Moderate Resolution Imaging Spectroradiometers (MODIS) – 1km

✓ Processed internally in STAR (input in L3S)

✓ No MODIS RAN yet. Priority: JPSS/GOES-R & AVHRR GAC/FRAC

ACSPO Data Products & Sizes (GB/Sensor/Day)

Polar: 10-min granules (144/day)

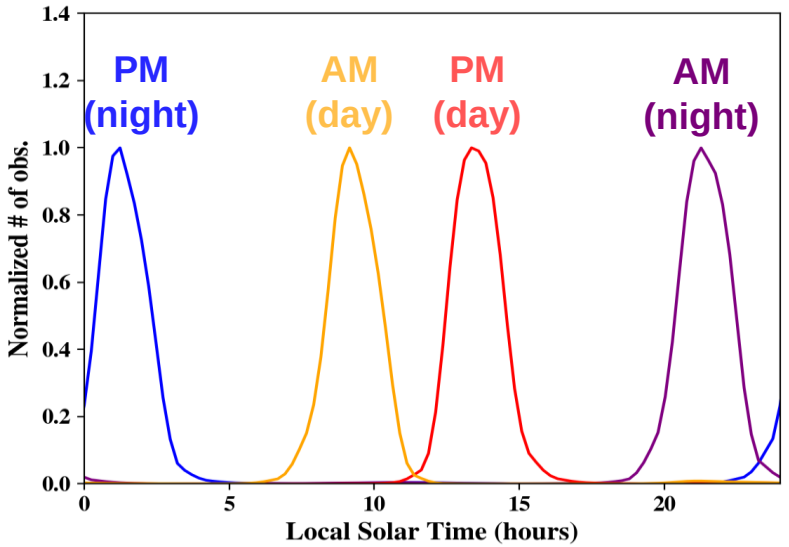
Satellites	Sensor	L2P	0.02° L3U
NPP/N20/N21	VIIRS	26.0	0.5 (×58)
Metop-A/B/C	AVHRR FRAC	8.0	0.5 (×16)
NOAA-7 to -19	AVHRR GAC	0.7	0.5 (×1.5)
Terra/Aqua	MODIS	7.5	0.5 (×16)
Metop-SG	MetImage	~8.0	~0.5 (×16)

Geo: 1-hr FD granules (24/day)

Satellites	Sensor	L2C	0.02° L3C
G16/G17/G18	ABI	1.0	0.6 (×1.6)
H08	AHI	1.0	0.6 (×1.6)
MTG	FCI	1.0	~0.6 (×1.6)

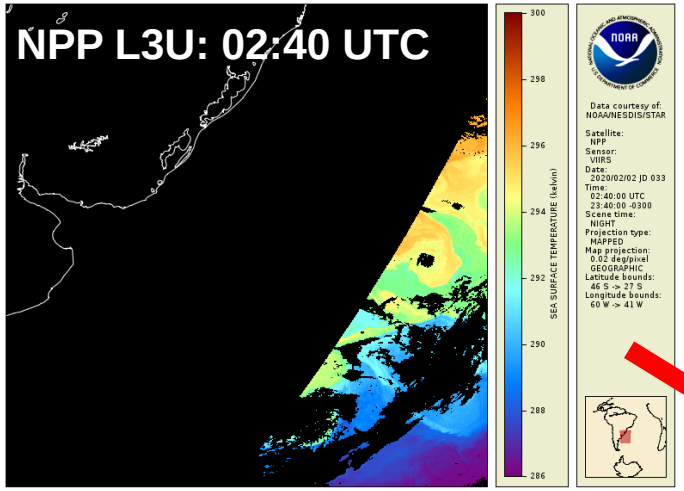
- All ACSPO products are available in two flavors: L2 (swath) and L3 (0.02° gridded)
- Smaller L3's preferred by many users

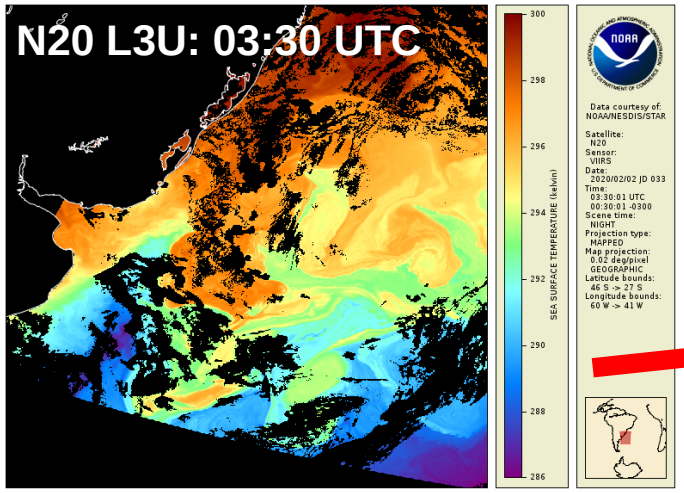
- **Many users requested "one, sensor-agnostic SST" (L3S/4)**
- **0.05º Geo-Polar Blended L4 available**
- **Four 0.02º L3Ss are tested: PM (NPP/N20 VIIRSs) & mid-AM (Metop-A/B/C AVHRR FRACs), Day & Night**
- **Aqua/Terra MODISs, N21 VIIRS, Metop-SG MetImage will be added in L3S, and records extended back in time**

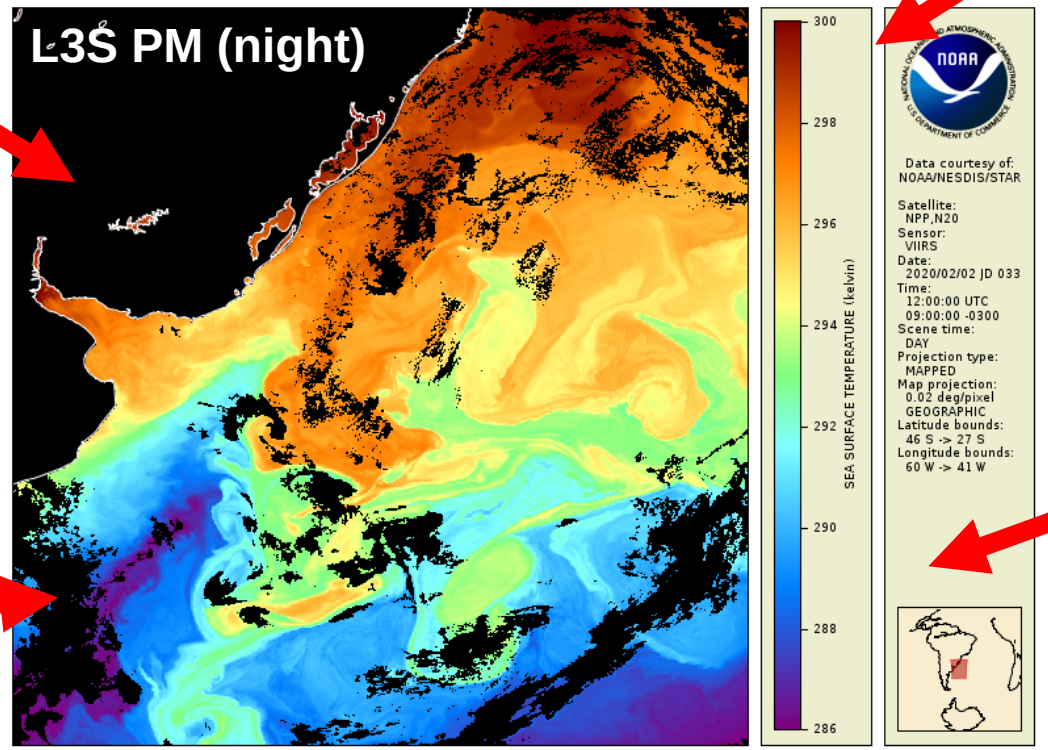


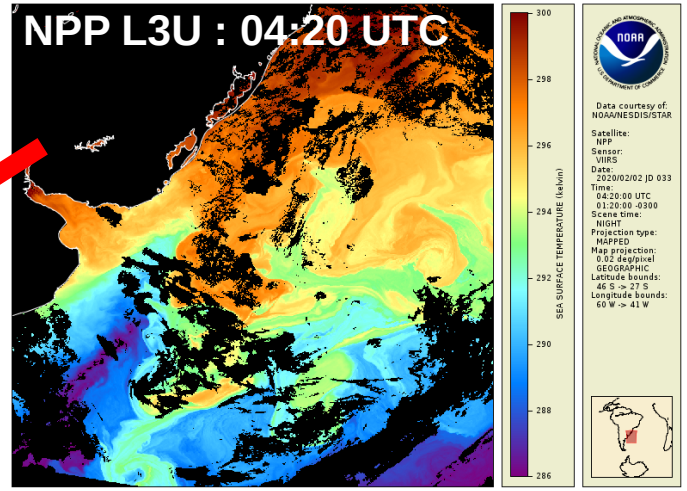
PM-Night 0.02º L3S over Brazil Current (2 Feb 2020)

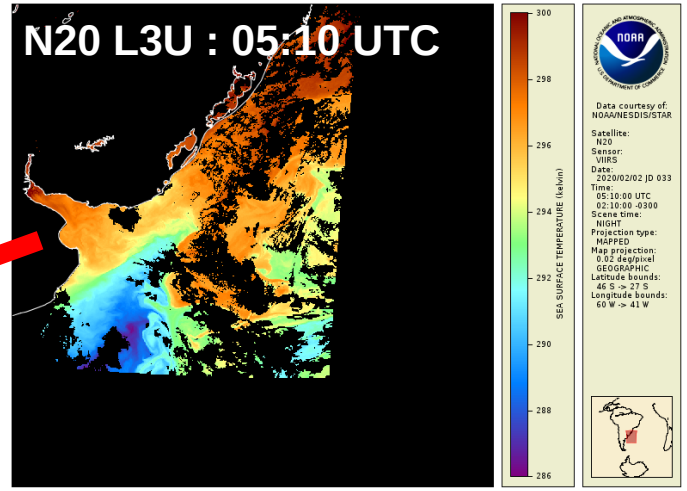
- 4 VIIRS overpasses: 2×NPP and 2×N20
- Improved coverage compared to individual L3U
- Feature resolution preserved/improved
- Experimental data available for interested users





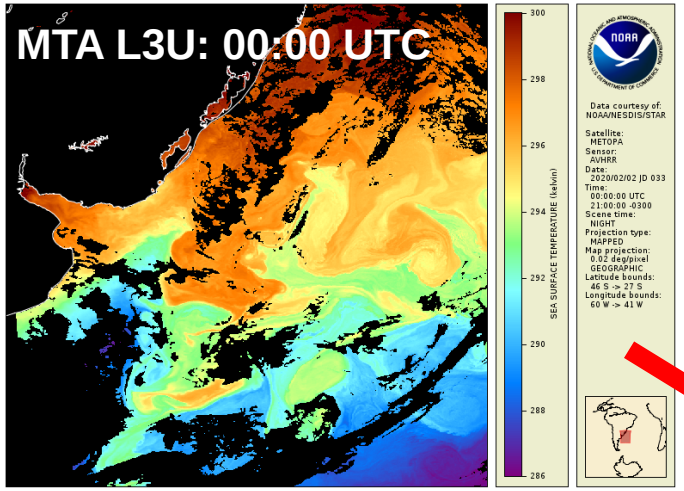


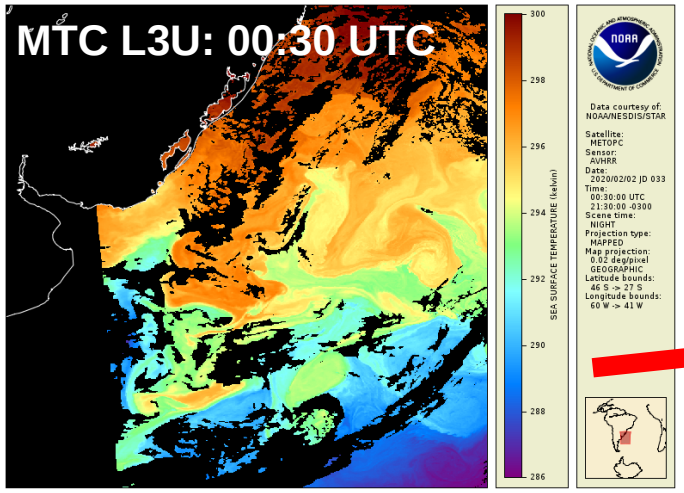


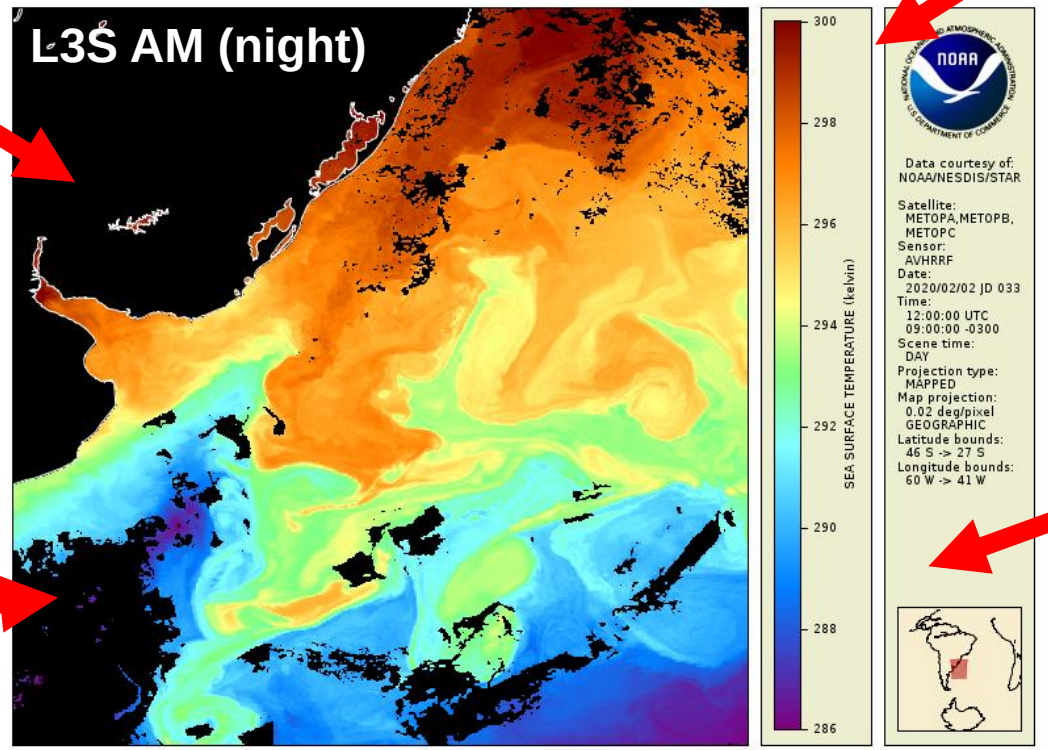


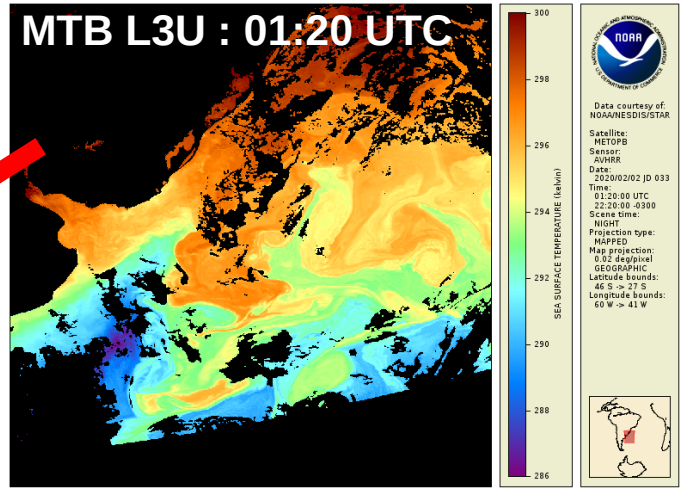
AM-Night 0.02º L3S over Brazil Current (2 Feb 2020)

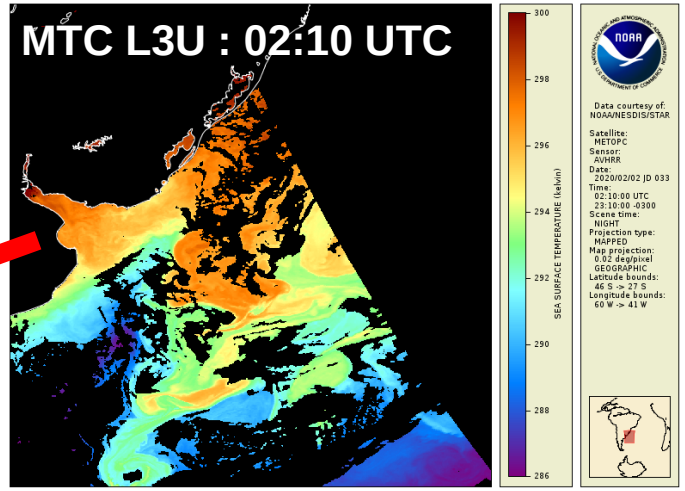
- 6 Metop overpasses: 2×A+2×B+2×C (4 shown)
- Improved coverage compared to individual L3U
- Feature resolution preserved/improved
- Experimental data available for interested users





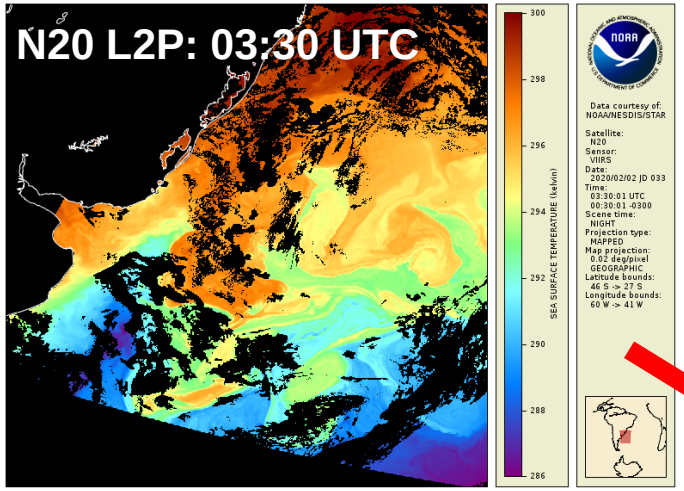


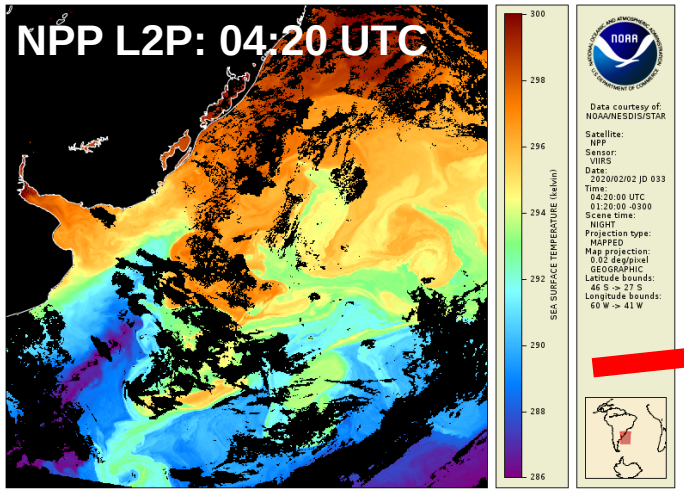


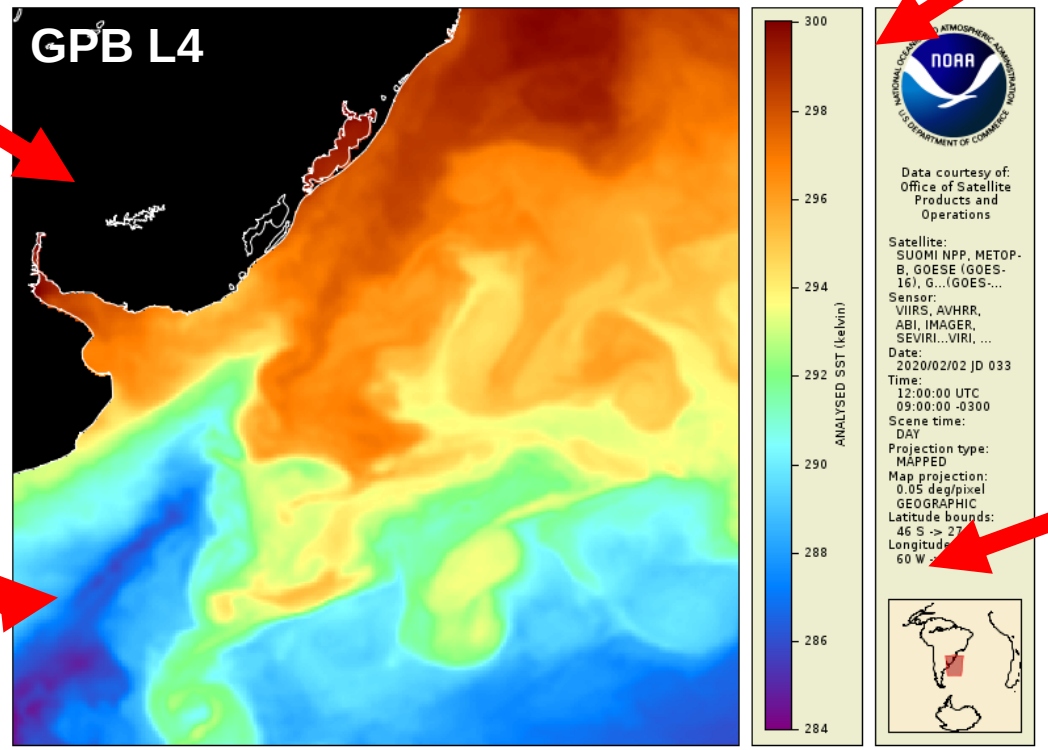


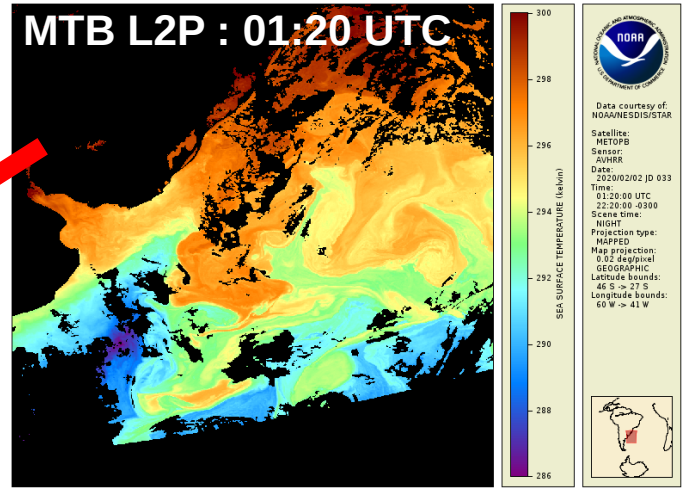
Geo-Polar Blended 0.05º L4 over Brazil Current (2 Feb 2020)

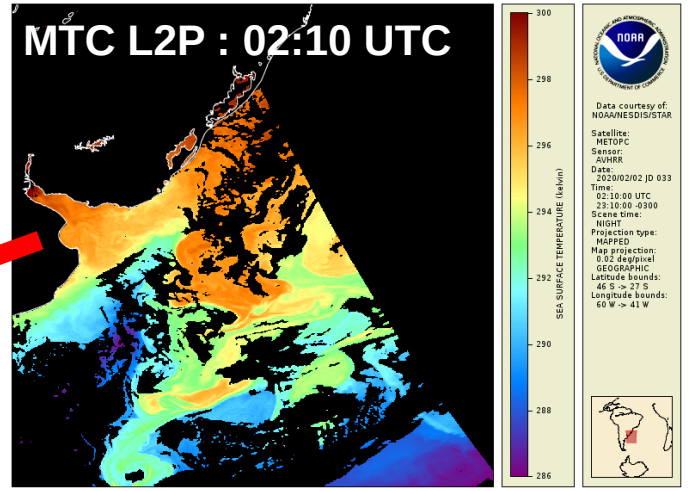
- Gap-free L4 analysis product produced at NOAA. Lower spatial resolution than L3U/L3S
- Ingests L2P SST from NPP/N20 VIIRS, Metop-B/C AVHRR, G16/17 ABI, H08 AHI, MSG-SEVIRI
- Contact Eileen Maturi/Andy Harris for GPB data



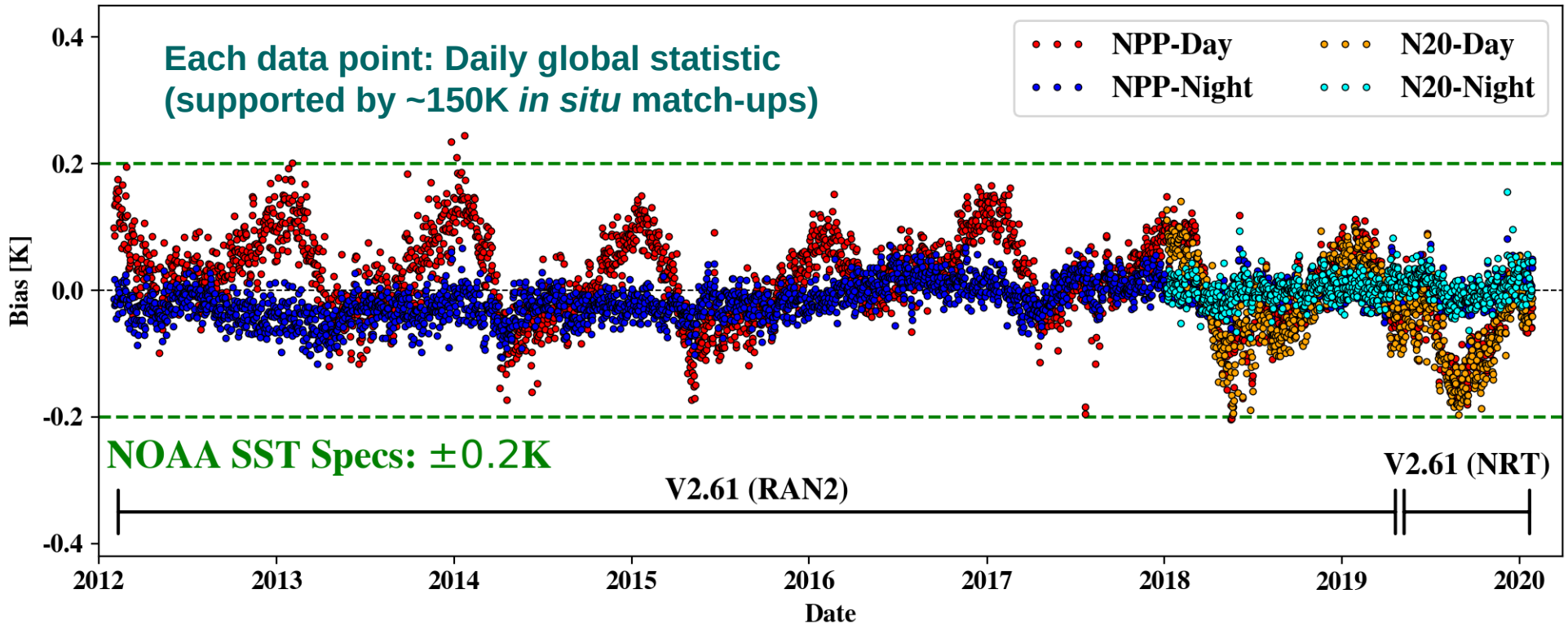






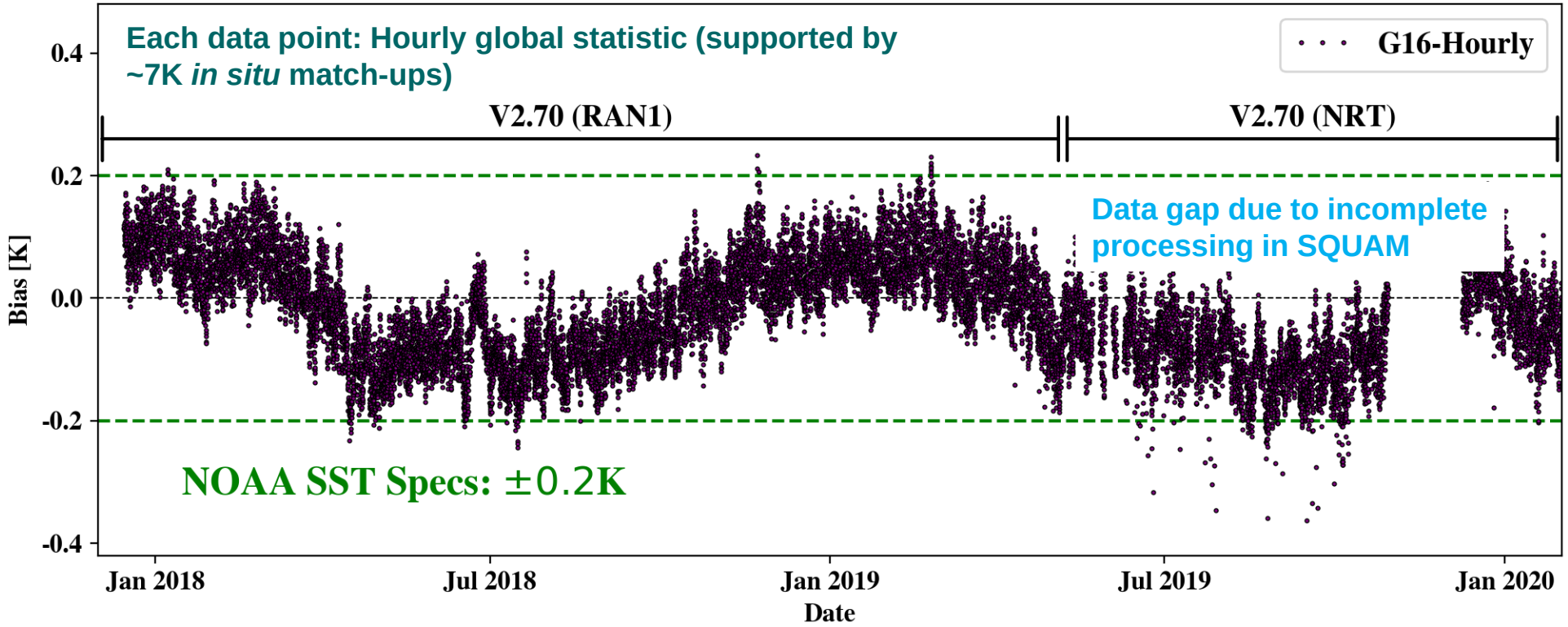


VIIRS RAN2 minus *i*Quam2 (Drifters + Trop. Moorings) SST



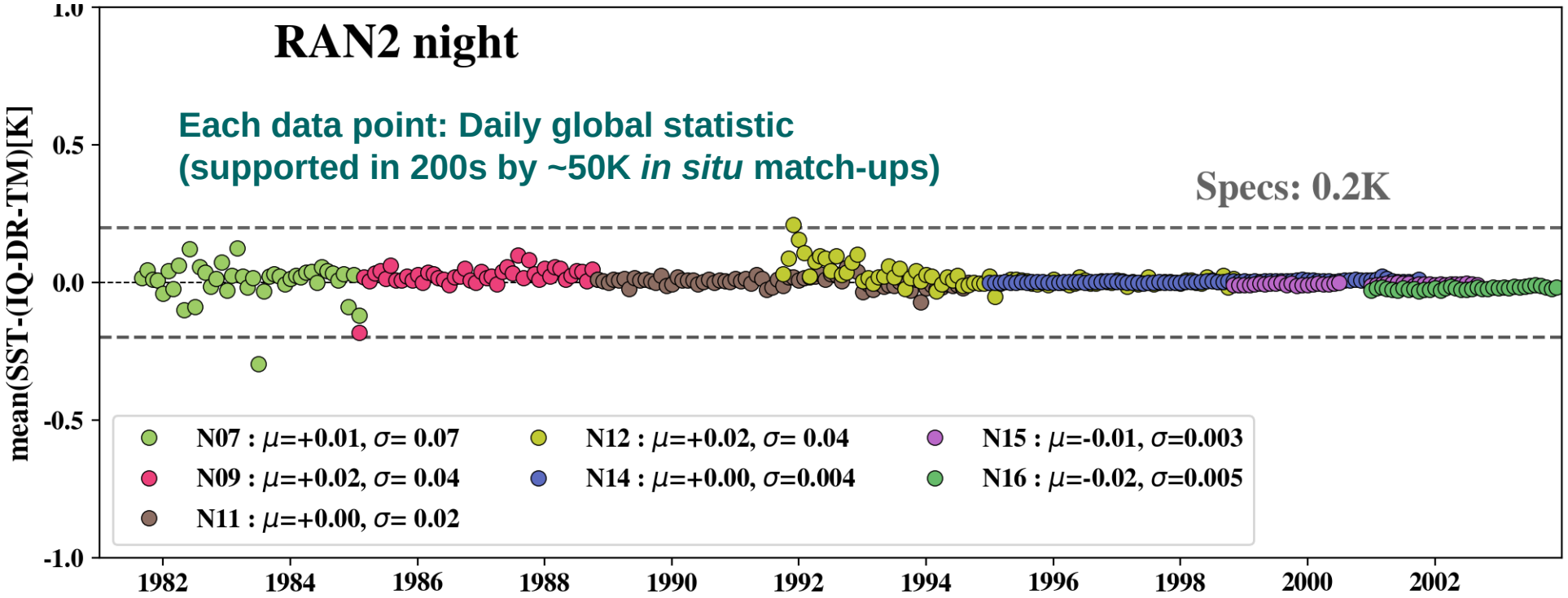
- NPP and N20 SSTs consistently reprocessed with ACSPO v2.61 constituting “VIIRS RAN2”
- RAN2 (Feb’12 – Apr’19) supplemented w/NRT operational processing at OSPO Apr’19-on
- RAN2+NRT data are archived w/PO.DAAC & NCEI. L3U available on NOAA CoastWatch

G16/ABI RAN1 minus *i*Quam2 (Drifters + Trop. Moorings) SST



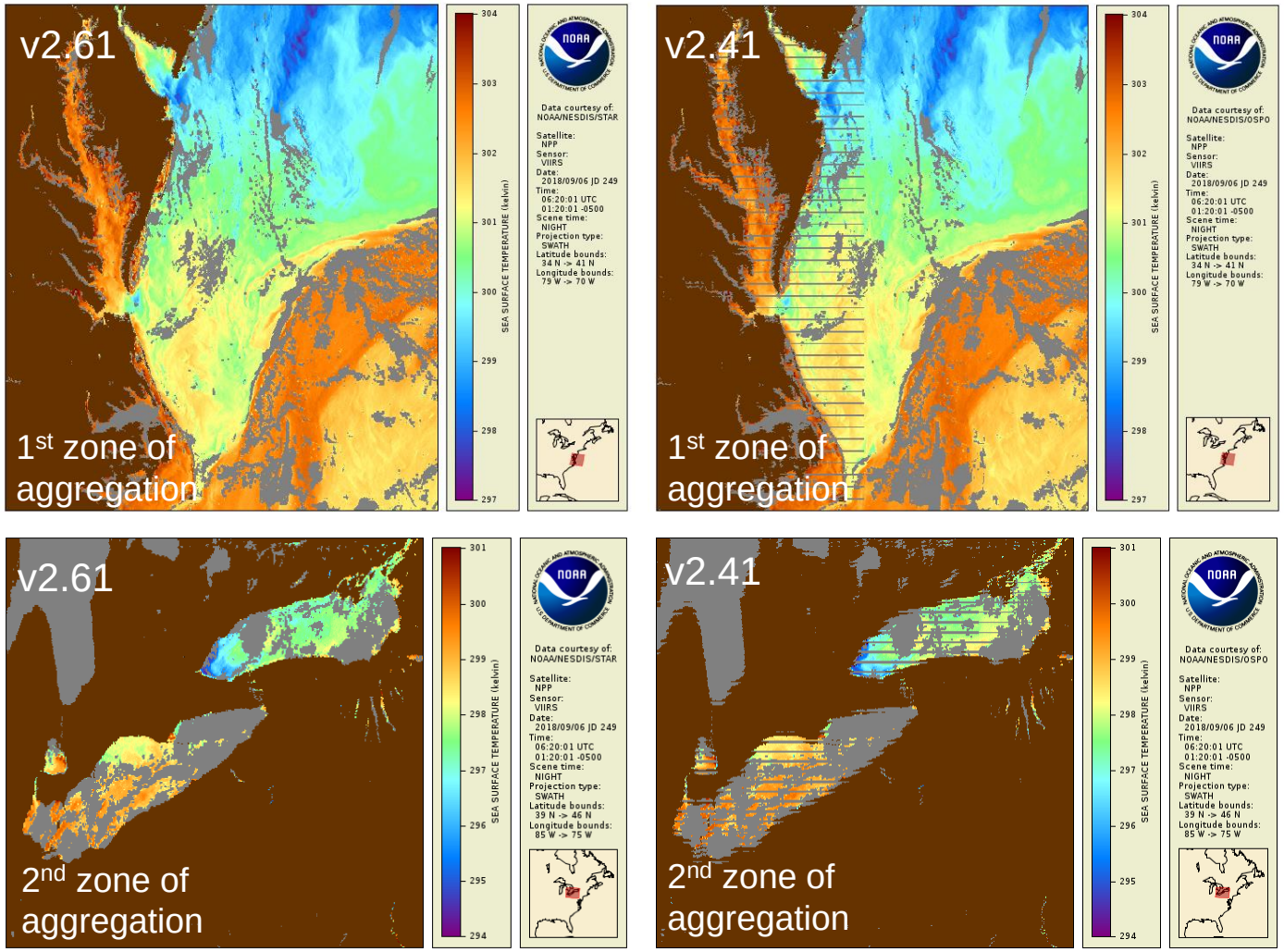
- G16 SSTs consistently reprocessed w/ACSPO v2.70 from Dec'18 – Apr'19 constitute 'ABI RAN1'. Data from Apr'19-on continue w/NRT processing in NOAA CW.
- G16 RAN1+NRT L2/3C archived w/PO.DAAC, NCEI & CW
- G17 and H08 RANs are planned. GOES-T & MTG FCI will be processed when launched

AVHRR GAC RAN2 (Beta01) minus *i*Quam2 (Drifters + Trop. Moorings) SST

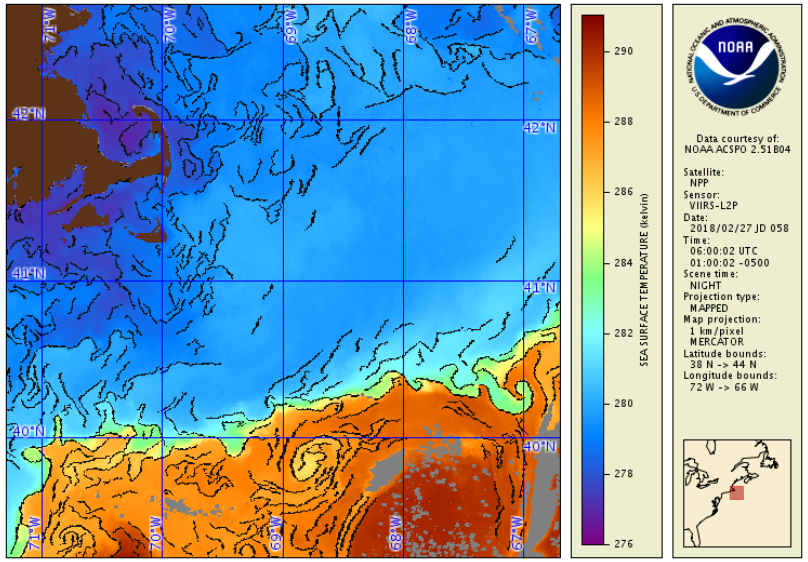


- AVHRRs on NOAA satellites show many instabilities and sensor artifacts. To mitigate those, satellite SST is linked to in situ data using a ±45day sliding window
- RAN2 Beta01 performance statistics (coverage, mean bias & Std. Dev. wrt in situ data) compare favorably to other available reprocessed AVHRR records (Pathfinder, CCI)

In ACSPO 2.61, BT & SST L2P imagery has been resampled, to prepare for front detection in ACSPO v2.80 (Sep 2020)

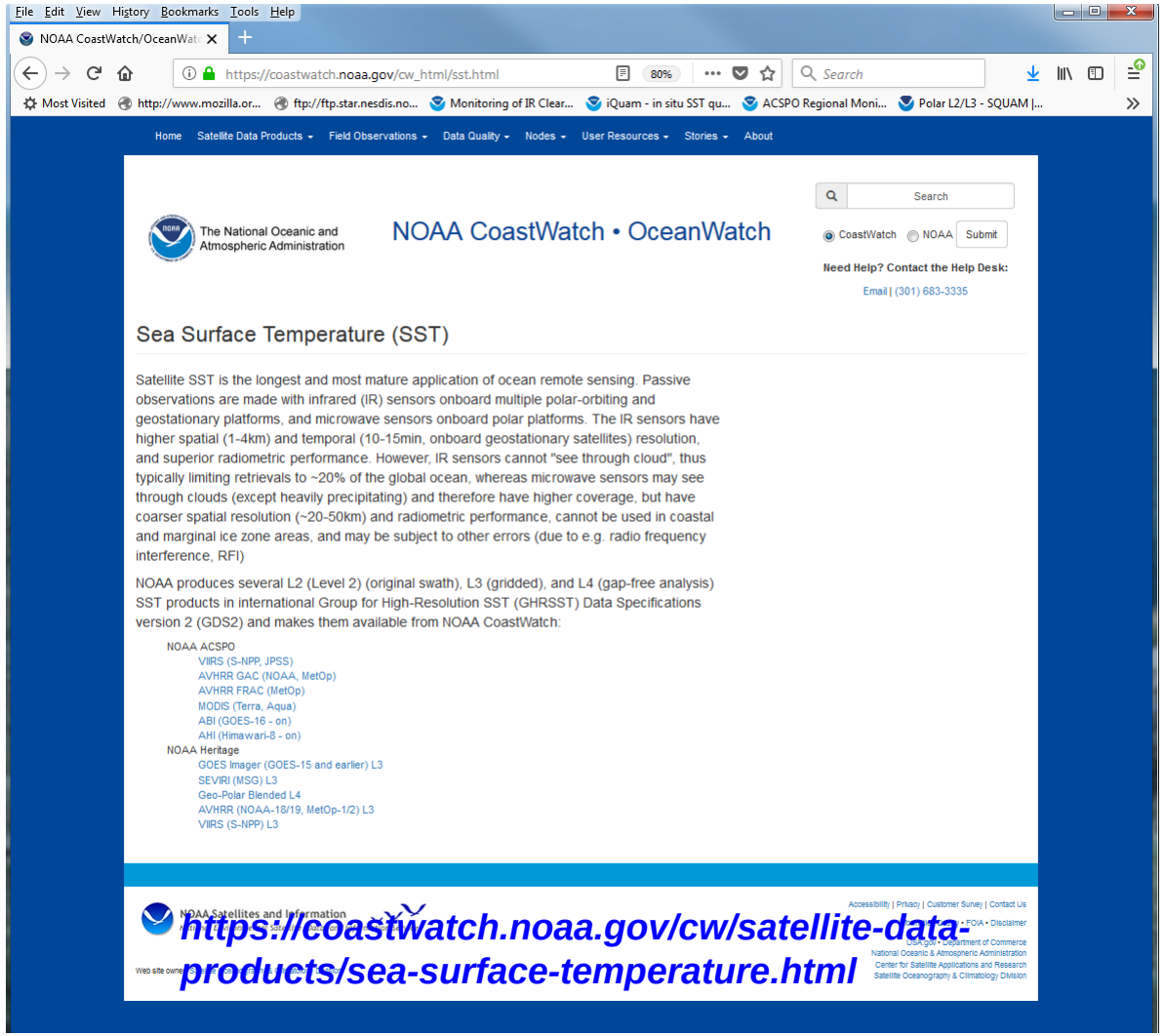


- VIIRS & MODIS are multi-detector sensors, affected by bow tie deletions and distortions
- In ACSPO 2.61, BTs used in SST retrievals were resampled (Gladkova et al., 2016)
- ACSPO is now ready for pattern recognition & thermal fronts detection.
- Thermal Fronts will be first reported in ACSPO v2.80 planned for delivery to ops in Aug 2020



ACSPO Data Access

- ✓ NOAA PDA (“Product Distribution & Access”; formerly “Data Distribution Server”) – Operational (NPP/N20 VIIRS L2P/L3U, G16/G17 ABI L2P/L3U, AVHRR GAC/FRAC L2P/L3U; MODIS L2P/L3U)
- ✓ EUMETCast – Operational (NPP/N20 L3U)
- ✓ NOAA Coast Watch – Pre-Archive. Also provides links to all ACSPO products archived in e.g. PO.DAAC, NCEI
- ✓ NASA PO.DAAC – Archive (NPP/N20 VIIRS L2P/L3U; G16/17 ABI L2P/L3C)
- ✓ NOAA NCEI – Archive (NPP/N20 VIIRS L2P/L3U; In the future G16/17 ABI L2P/L3C)



Current SST Priorities

1. **Get ready for 4 new launches in 2021-22**
   - 2021: GOES-T ABI and MTG FCI
   - 2022: J2/N21 VIIRS and Metop-SG MetImage
2. **Perform L2/3 RANs from individual sensors**
   - Hi-res polar: VIIRS (NPP/N20), AVHRR FRAC (Metop-A/B/C), MODIS (Terra/Aqua)
   - Hi-res geo: ABI (G16/17) and AHI (H08)
   - Low-res polar: AVHRR GAC (1981 – ~2018) from NOAA-7 to -19
3. **Aggregate into Fused L3S / Blended L4s and generate L3S/L4 RANs**
   - Aggregate individual L2P/3Us into feature resolving L3S & gap-free L4
4. **Derive thermal fronts & append in ACSPO files as 2 extra layers**
   - A flag is set to indicate presence of front in pixel
   - Strength of front (K/km) reported in fronts; NaN otherwise
5. **Archive all L2/3/4 products, to facilitate access for users**
   - NASA PO.DAAC; NOAA NCEI; NOAA CW

Thank You!

VIIRS Global Ocean Color Products

Menghua Wang &

The Ocean Color Team

NOAA/NESDIS/STAR
E/RA3, Room 3228, 5830 University Research Ct.
College Park, MD 20740, USA

JPSS/GOES-R Proving Ground Risk Reduction Summit, College Park, Maryland, Feb. 24-28, 2020

Website for VIIRS ocean color images, data and Cal/Val:
http://www.star.nesdis.noaa.gov/sod/mecb/color/

Acknowledgements: This work was supported by JPSS/VIIRS funding. We thank MOBY team for in situ optics data, NASA SeaBASS in situ data, and VIIRS Cal/Val PIs and their collaborators in support of VIIRS Cal/Val activities.

VIIRS/OLCI/SGLI Spectral Bands for Ocean Color

VIIRS has ocean spectral bands similar to **MODIS**

VIIRS on Suomi National Polar-orbiting Partnership **(SNPP)**, Oct. 28, **2011**, VIIRS-NOAA-20, **Nov. 18, 2017**, Joint Polar Satellite System (**JPSS**)-2 **J2**, ~2021, **and J3 & J4** (up to ~**2038**)

VIIRS (SNPP)†		OLCI (Sentinel-3A)†		SGLI (GCOM-C)†	
Ocean Bands (nm)	Other Bands (nm)	Ocean Bands (nm)	Other Bands (nm)	Ocean Bands (nm)	Other Bands (nm)
410 (M1)	638 (I1)	413	400	412	380
443 (M2)	862 (I2)	443	620	443	
486 (M3)	1600 (I3)	490	674	490	
—	—	510	681	530	
551 (M4)	*SWIR Bands*	560	709	565	*SWIR Bands*
671 (M5)	1238 (M8)	665		673.5	1050
745 (M6)	1601 (M10)	754	*SWIR Bands*	763	1630
862 (M7)	2257 (M11)	865	1020	868.5	2210

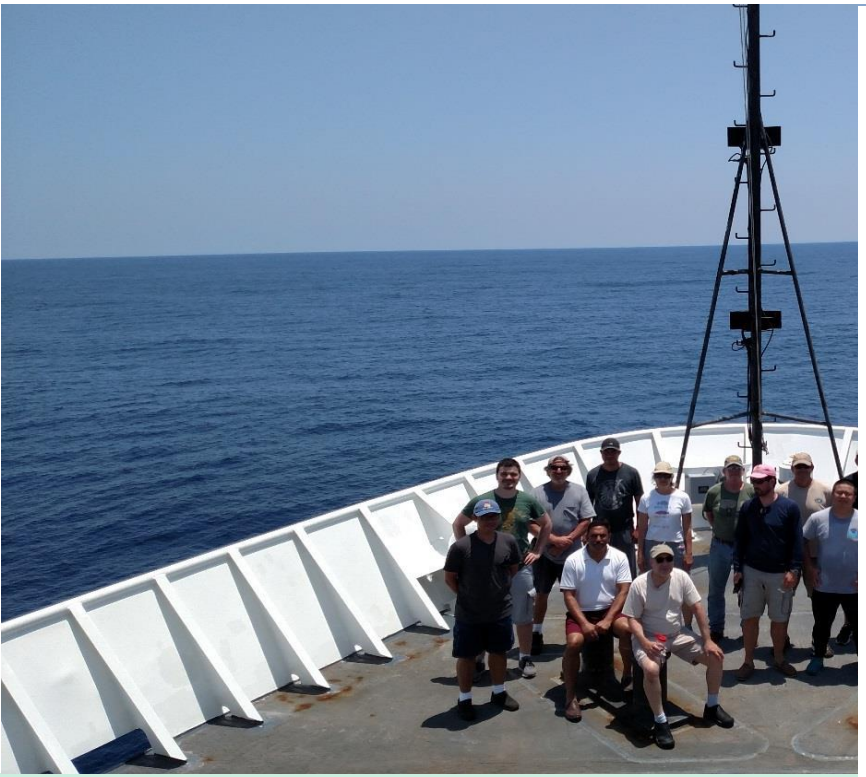
†Nominal center wavelength

Spatial resolution for VIIRS M-band: 750 m, I-band: 375 m

Menghua Wang, NOAA/NESDIS/STAR

End-to-End Ocean Color Data Processing

- NOAA Ocean Color Team has been developing/building the capability for the **End-to-End** satellite ocean color data processing including:
  - Level-0 (or Raw Data Records (RDR)) to Level-1B (or Sensor Data Records (SDR)).
  - Level-1B (SDR) to ocean color Level-2 (Environmental Data Records (EDR) using the Multi-Sensor Level-1 to Level-2 (MSL12) ocean color data processing.
  - Level-2 to global Level-3 (routine daily, 8-day, monthly, and climatology data/images).
  - Validation of satellite ocean color products (in situ data and data analysis capability).
- Support of in situ data collections for VIIRS Cal/Val activities, e.g., **MOBY**, **AERONET-OC** sites (3 sites operation, added **Lake Erie site**), **NOAA dedicated Cal/Val cruises** (2014, 2015, 2016, 2018, **2019**, **2020**, ….,)
- **On-orbit instrument calibration (solar and lunar) for ocean color data processing:**
  - J. Sun and M. Wang, "Radiometric calibration of the VIIRS reflective solar bands with robust characterizations and hybrid calibration coefficients," *Appl. Opt.*, **54**, 9331–9342, 2015.
- **On-orbit vicarious calibration using MOBY in situ data:**
  - M. Wang, W. Shi, L. Jiang, and K. Voss, "NIR- and SWIR-based on-orbit vicarious calibrations for satellite ocean color sensors," *Opt. Express*, **24**, 20437-20453, 2016.
- **RDR (Level-0) to SDR (Level-1B) data processing** (efficient RDR to SDR processing)**:**
  - Sun, J., M. Wang, L. Tan, and L. Jiang, "An efficient approach for VIIRS RDR to SDR data processing," *IEEE Geosci. Remote Sens. Lett.*, **11**, 2037–2041, 2014.
- **Ocean Color Viewer** (**OCView**)—Online display and monitoring of ocean color product imagery.
- **O**cean **C**olor **D**ata **A**nalysis and **P**rocessing **S**ystem (**OCDAPS**)—IDL-based VIIRS ocean color data visualization and processing package
  - Wang, X., X. Liu, L. Jiang, M. Wang, and J. Sun, "VIIRS ocean color data visualization and processing with IDL-based NOAA-SeaDAS", *Proc. SPIE 9261*, 8 Nov. 2014.
- **Work with users to meet their requirements.**



Dedicated VIIRS Cal/Val Crui

NOAA Ship *Okeanos Explorer*

9-18 May 2018

The fourth Cal/Val cru

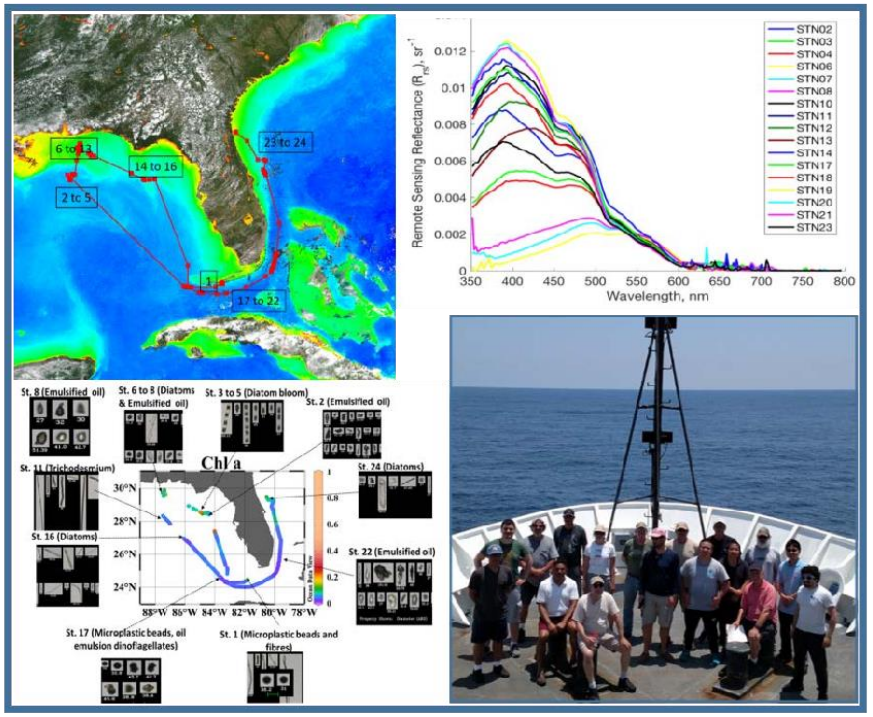
The 5th OC Cal/Val cruise was successfully completed in September 2019!

The 6th OC Cal/Val cruise will be carried out in March 2020!

NOAA Technical Report NESDIS 152

DOI: 10.25923/scyb-qf42

Report for
Dedicated JPSS VIIRS Ocean Color
Calibration/Validation Cruise
May 2018



Washington, D.C.
May 2019

National Oceanic and Atmospheric Administration
National Environmental Satellite, Data, and Information Service

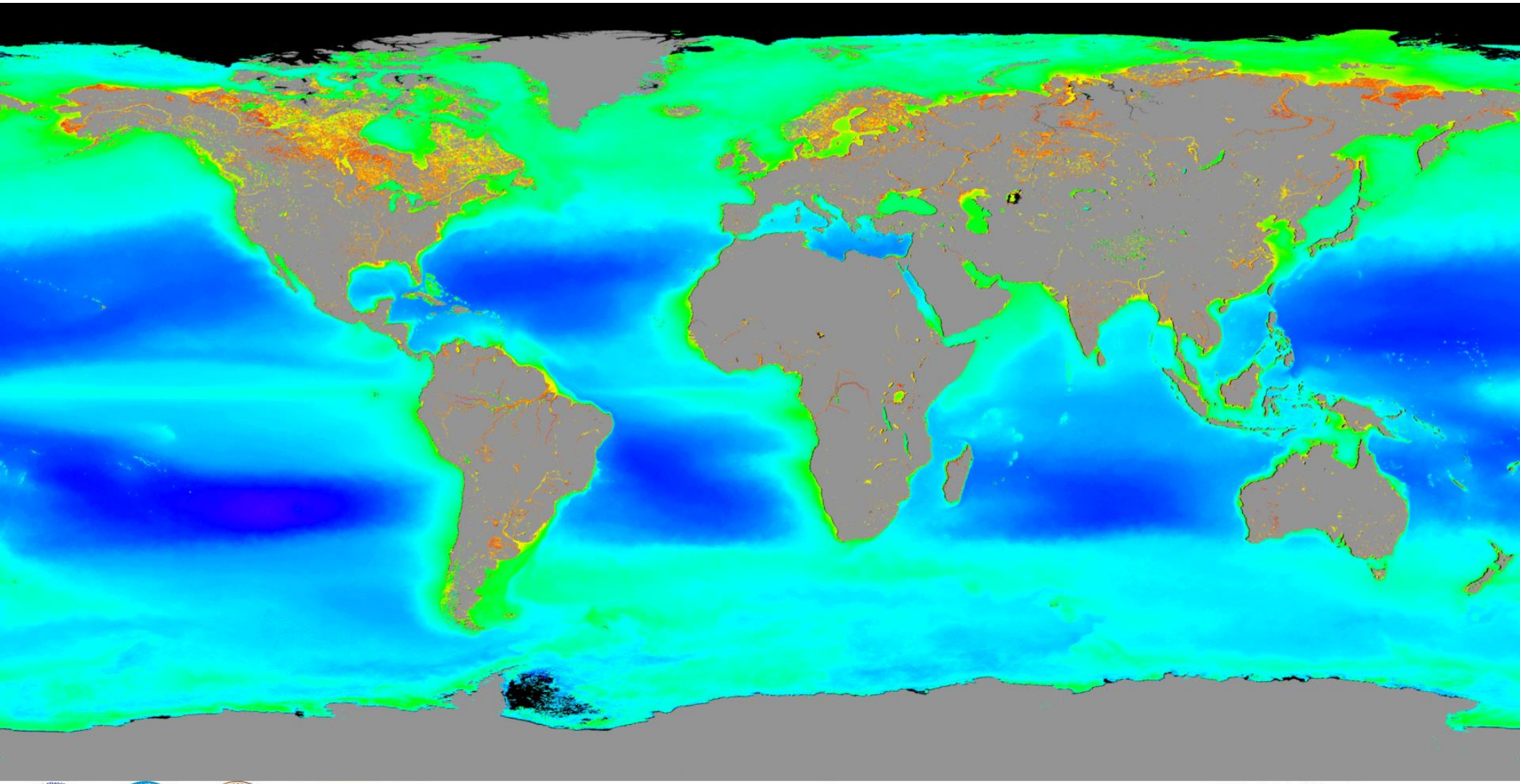
Summary of VIIRS Ocean Color EDR Products (Updates--Based on Users Input)

- **Inputs**:
  - VIIRS M1-M7, I1, and the **SWIR** M8, M10, and M11 bands SDR data
  - Terrain-corrected geo-location file
  - Ancillary meteorology and ozone data
- **Operational (Standard) Products (10)**:
  - Normalized water-leaving radiance (nL_w's) at VIIRS visible bands M1-M5, and **I1 (638 nm)**
  - Chlorophyll-a (Chl-a) concentration
  - Diffuse attenuation coefficient for the downwelling spectral irradiance at the wavelength of 490 nm, $K_d(490)$
  - Diffuse attenuation coefficient of the downwelling photosynthetically available radiation (PAR), $K_d(\mathrm{PAR})$
  - **QA Score** for data quality ($nL_w(\lambda)$ spectra) (*Wei et al.*, 2016)
  - Level-2 quality flags
- **Experimental Products (29):**
  - Inherent Optical Properties (IOP-a, IOP-a_{ph}, IOP-a_{dg}, IOP-b_b, IOP-b_{bp}) at VIIRS M2 or other visible bands (M1-M5) from the Quasi-Analytical Algorithm (QAA) (*Lee et al.*, 2002), improved over coastal and inland waters (**Shi and Wang, 2019**).
  - Photosynthetically Available Radiation (PAR) (*R. Frouin*)
  - Chl-a from ocean color index (OCI) method (*Hu et al.*, 2012; *Wang and Son*, 2016)
  - Others, e.g., user specific products (e.g., **Chl-a anomaly** and **Chl-a anomaly ratio**)

➢ Data quality of ocean color EDR are extremely sensitive to the SDR quality. It requires **~0.1%** data accuracy (degradation, band-to-band accuracy…)!

VIIRS Climatology Ocean Color Product Image

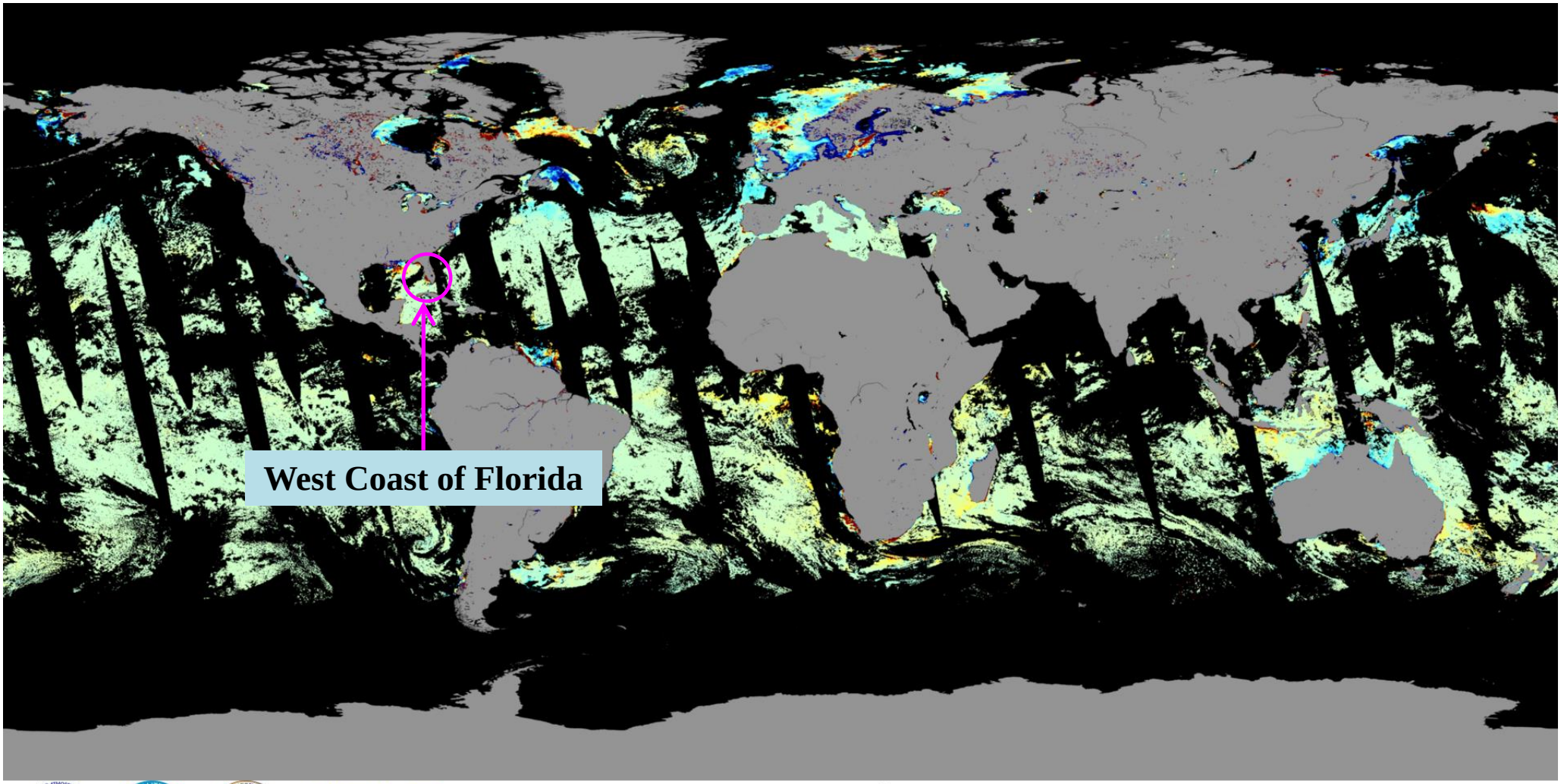
SNPP (2012–2019)



MSL12 with the NIR-SWIR data processing system is used for VIIRS

Menghua Wang, NOAA/NESDIS/STAR

VIIRS-SNPP Chl-a Anomaly Products
(July 26, 2018)



Global daily NRT Chl-a anomaly and anomaly ratio are routinely produced!

Menghua Wang, NOAA/NESDIS/STAR

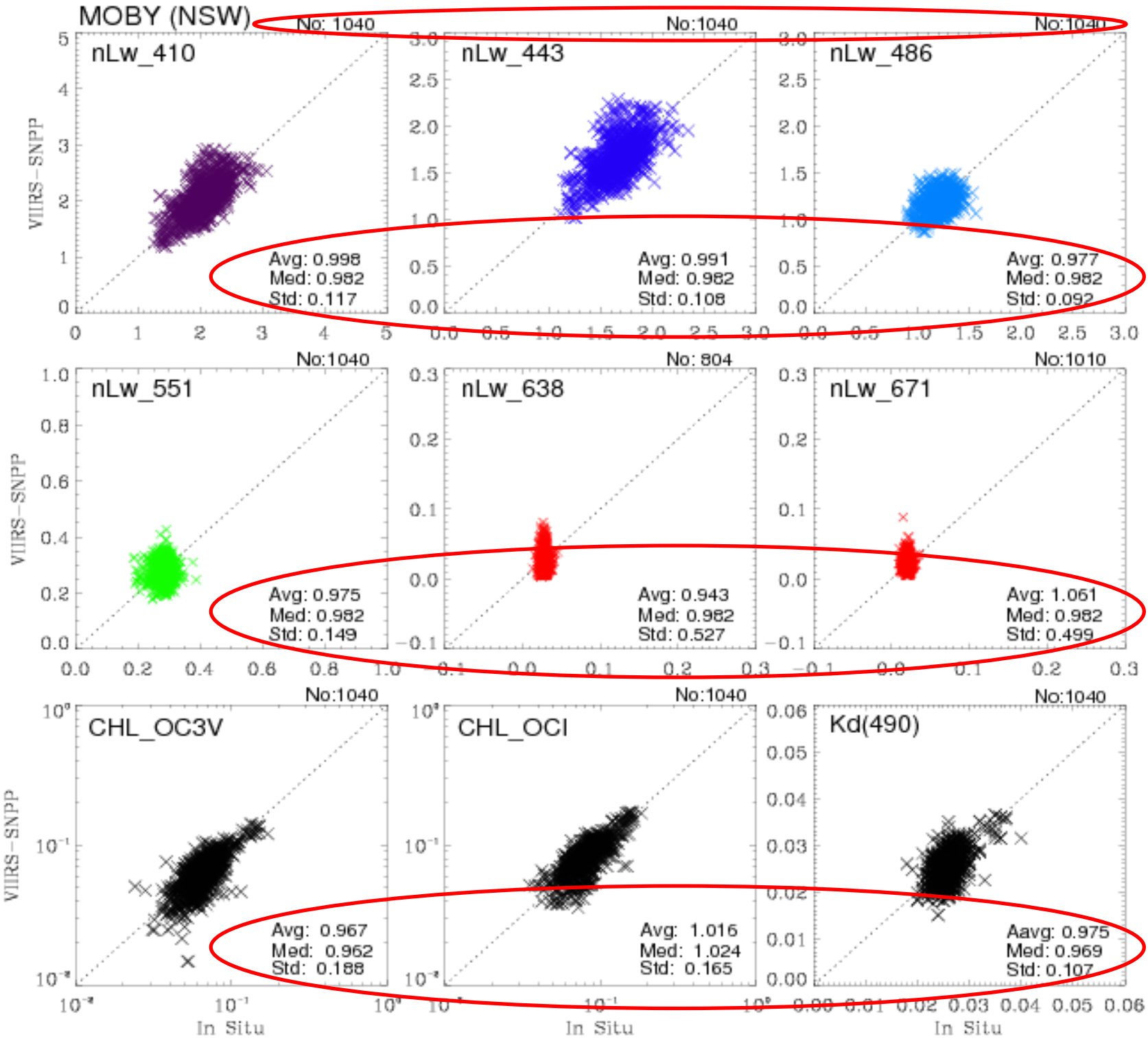
Matchup of

MOBY In Situ

&

VIIRS-SNPP

(NIR-SWIR)

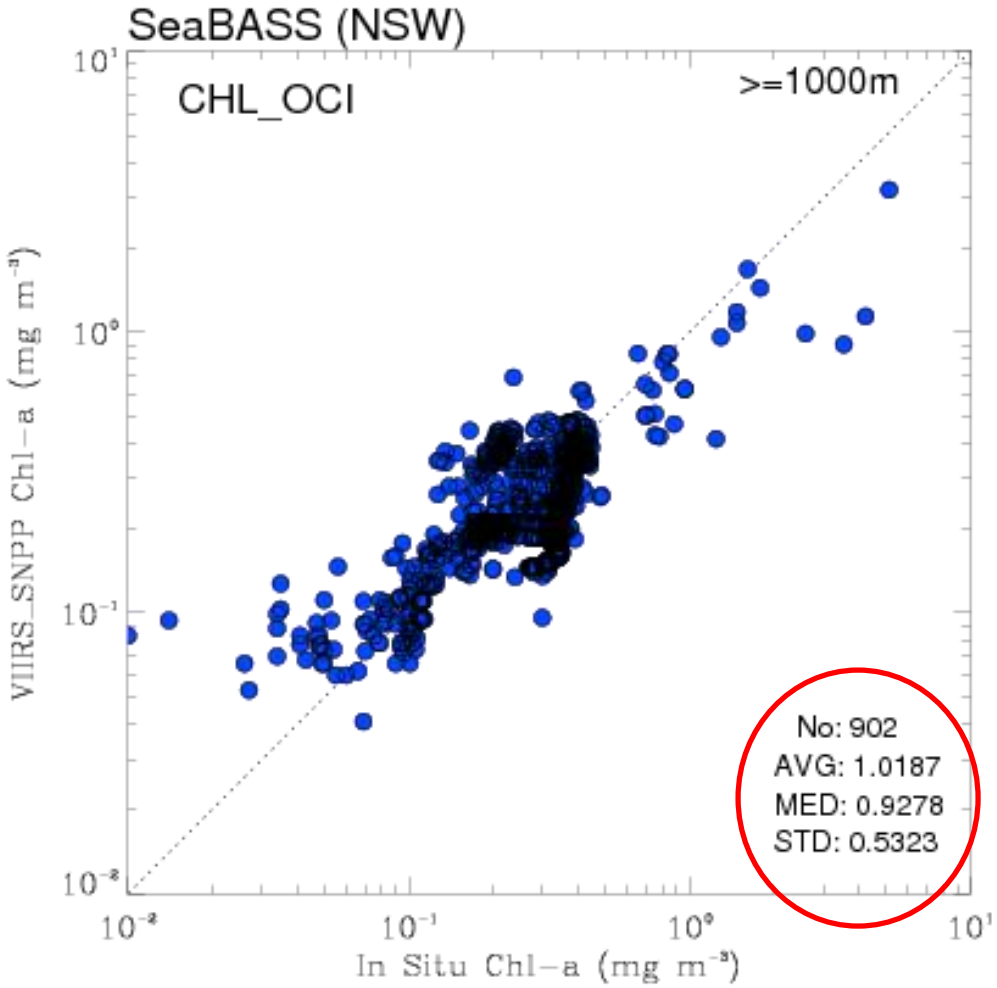


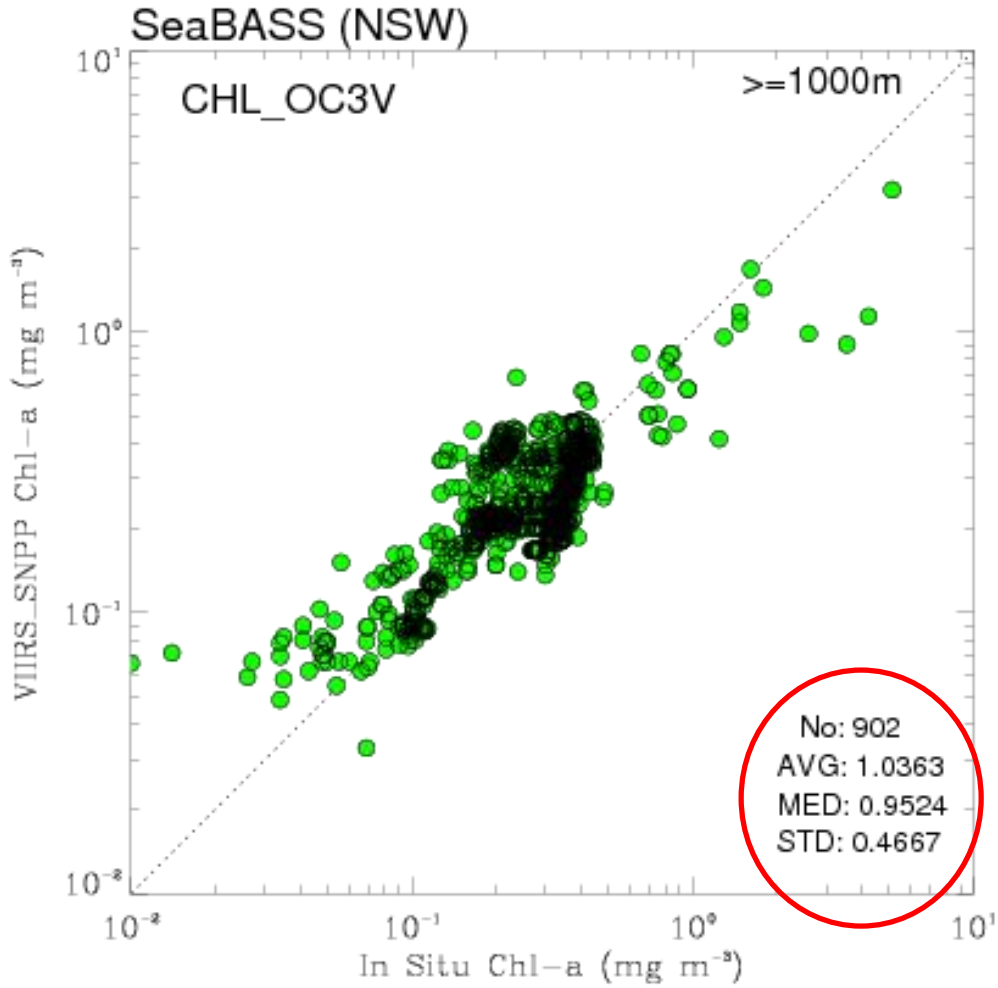
MOBY

Matchup of Chl-a

VIIRS-SNPP (NIR-SWIR) VS. SeaBASS In Situ

Over Global Deep Water



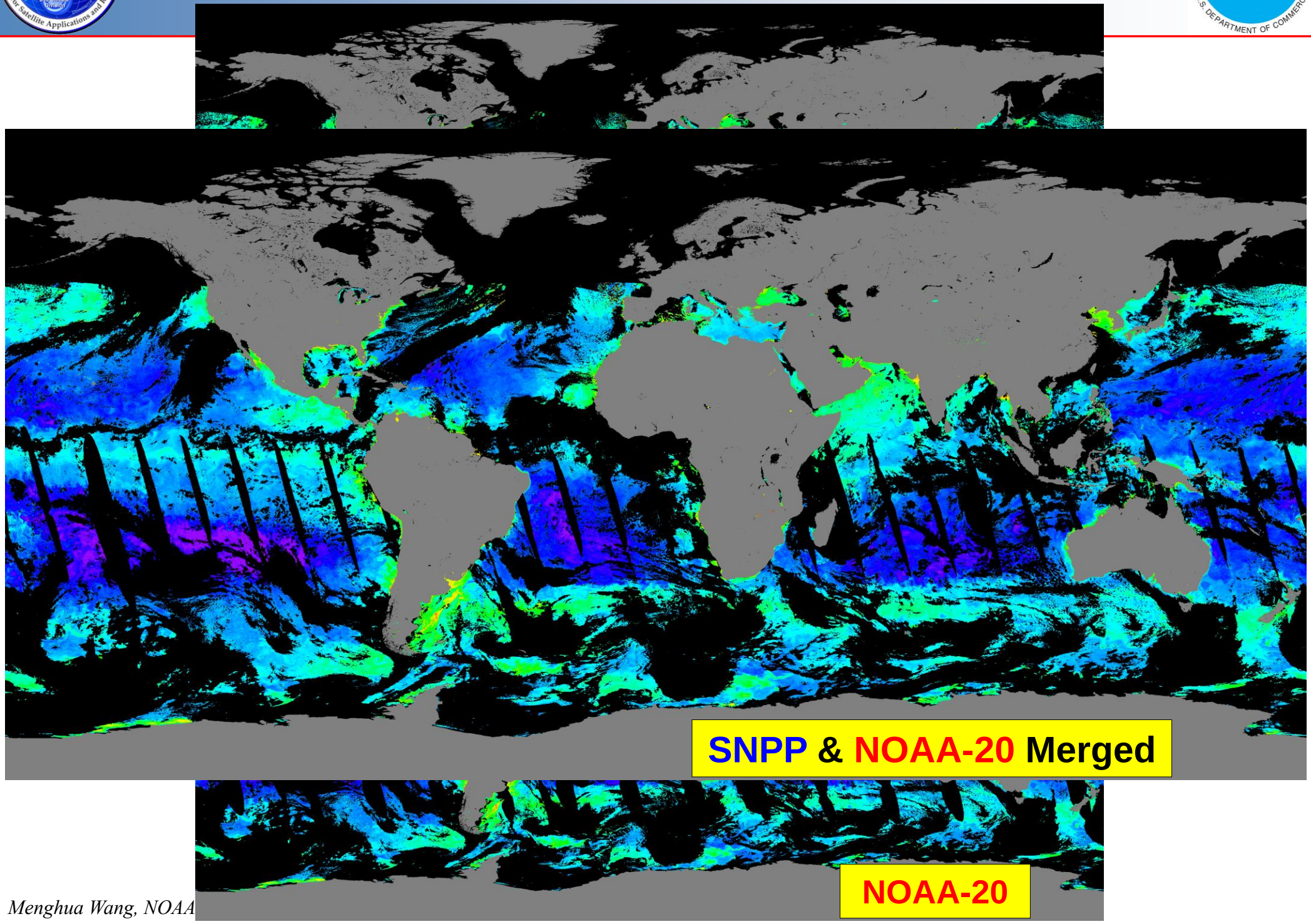


Menghua Wang, NOAA/NESDIS/STAR

SeaBASS

VIIRS-SNPP and NOAA-20 Chl-a Images

(January 6, 2018)



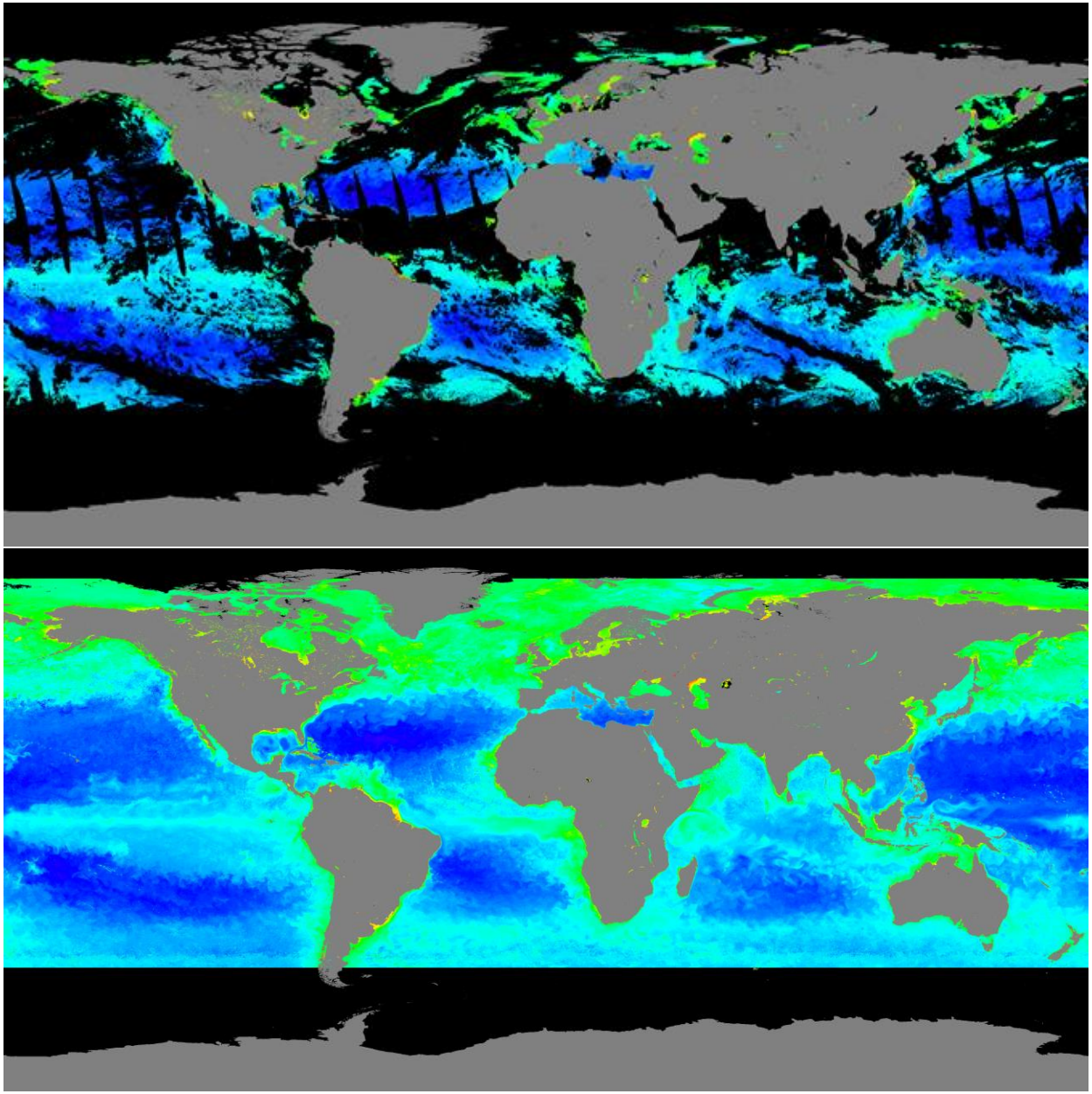
Menghua Wang, NOAA

Example of Gap-filled Products

Global 9-km Chl-a Level-3 images (June 21, 2018)

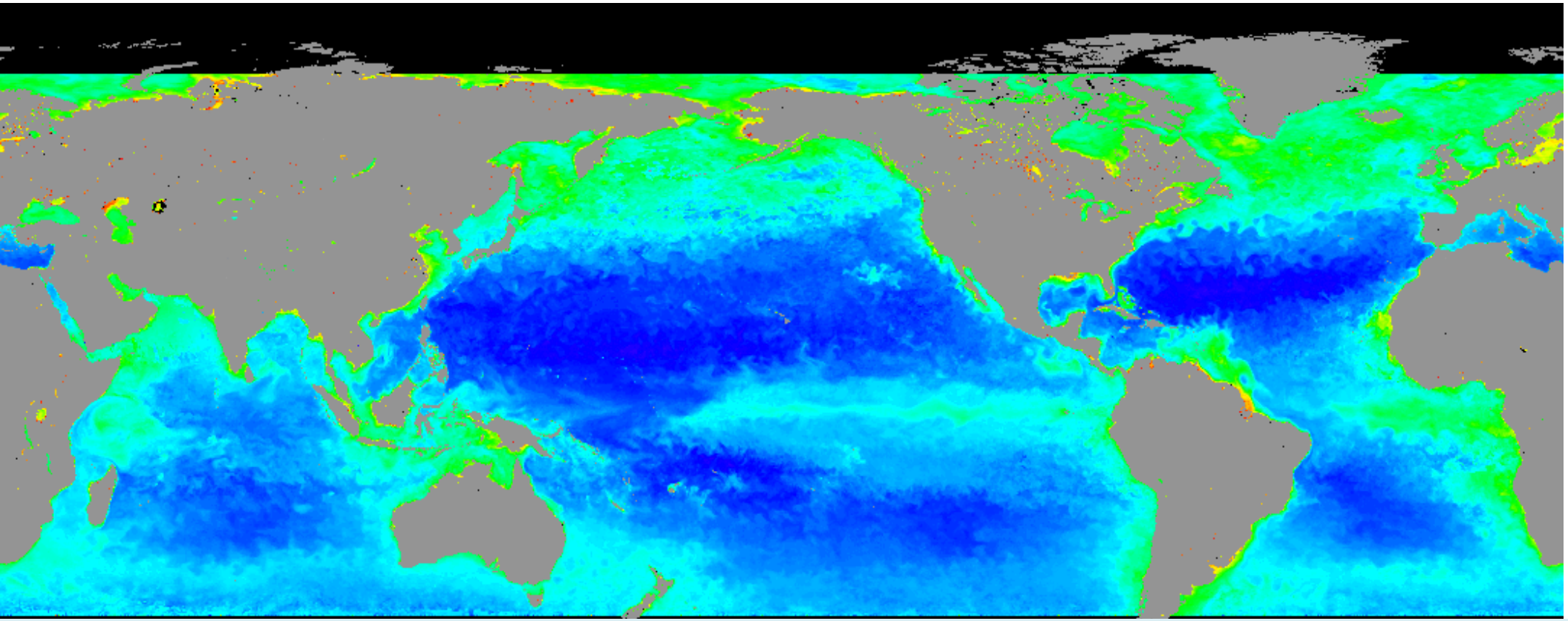
Merged product

Gap-filled Product



Menghua Wang, NOAA/NESDIS/STAR

Gap-free Global Daily Chl-a Movie



Liu, X. and M. Wang, "Filling the gaps of missing data in the merged VIIRS SNPP/NOAA-20 ocean color product using the DINEOF method," *Remote Sens.*, **11**, 178, 2019. https://dx.doi.org/10.3390/rs11020178

Liu, X. and M. Wang, "Gap filling of missing data for the VIIRS global ocean color products using the DINEOF method," *IEEE Trans. Geosci. Remote Sens.*, **56**, 4464–4476, 2018. https://dx.doi.org/10.1109/tgrs.2018.2820423

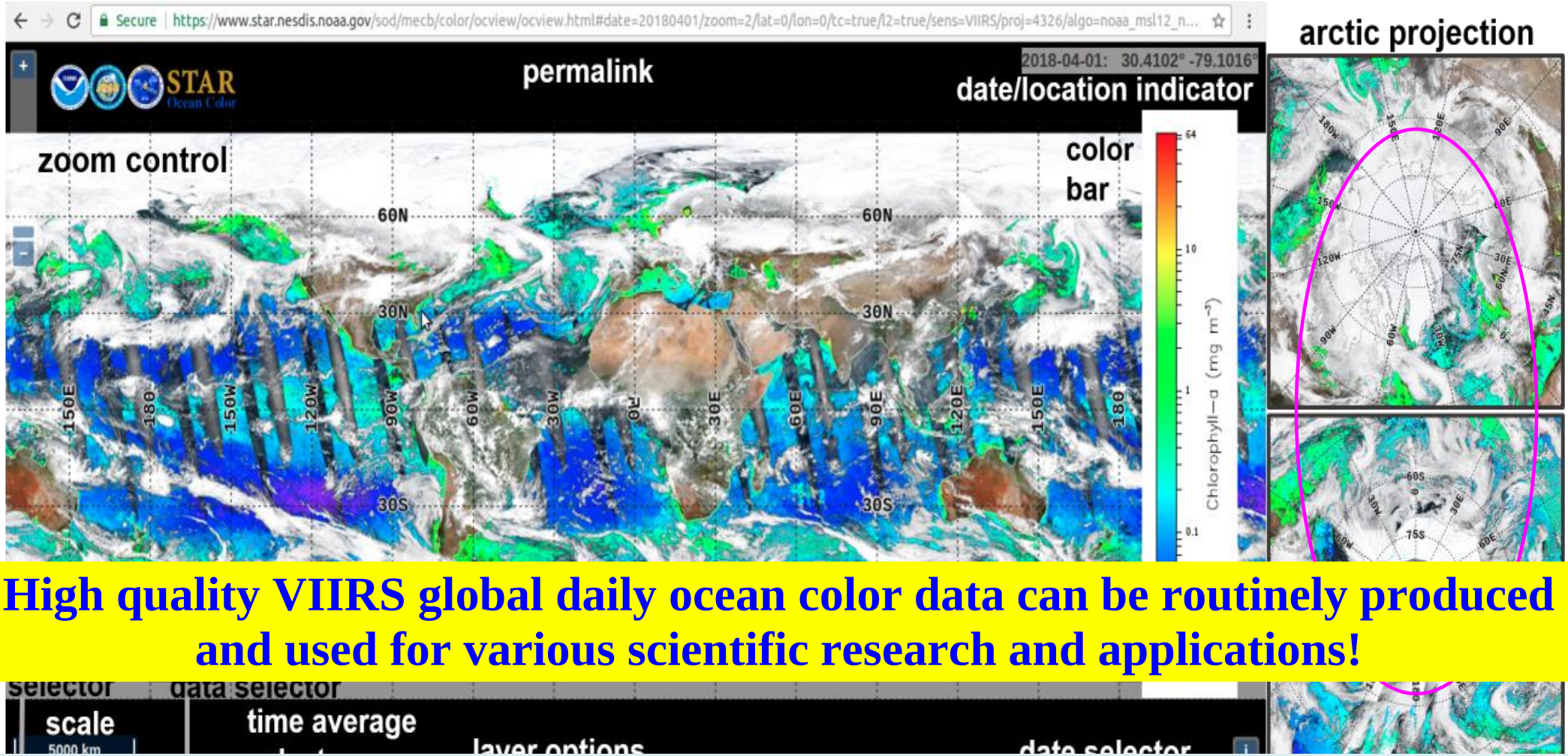
SNPP and NOAA-20 measurements

Chlorophyall—a (mg m⁻³)

Gap-free daily global Chl-a data are now routinely produced and available through CoastWatch!

Menghua Wang, NOAA/NESDIS/STAR

Ocean Color Viewer (OCView)



High quality VIIRS global daily ocean color data can be routinely produced and used for various scientific research and applications!

Mikelsons, K. and M. Wang, "Interactive online maps make satellite ocean data accessible" Eos, 99, 01 May 2018, https://doi.org/10.1029/2018EO096563.

http://www.star.nesdis.noaa.gov/sod/mecb/color/

Menghua Wang, NOAA/NESDIS/STAR

SATELLITE SUMMIT 2020

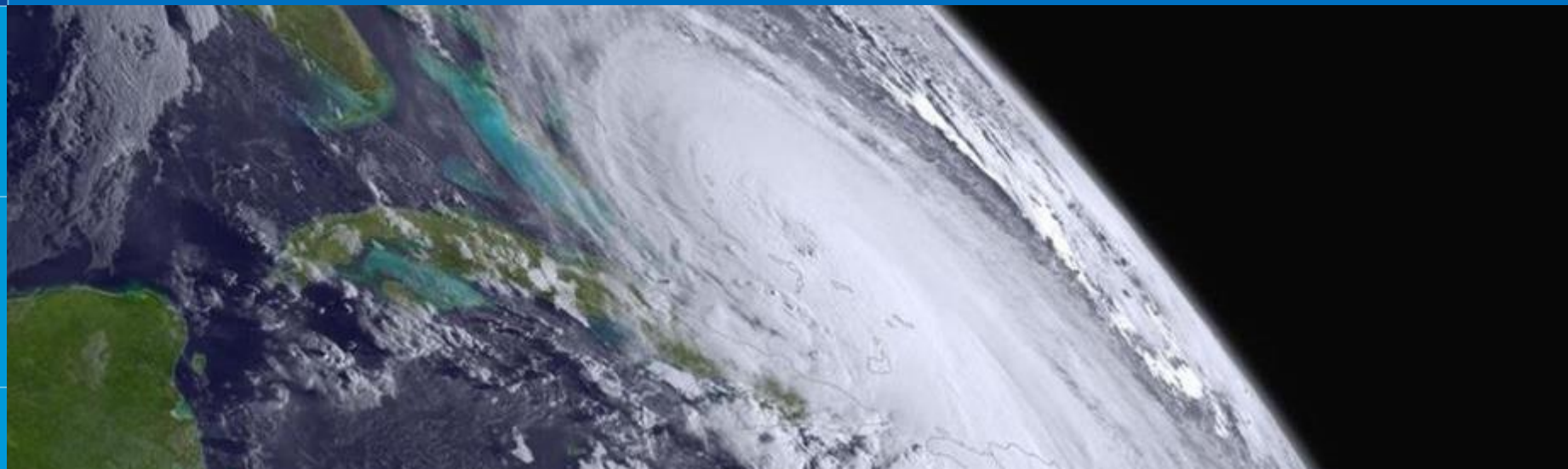
NATIONAL MARINE FISHERIES SERVICE NMFS

Mike Ford, Oceanographer, NMFS Office of Science & Technology

NOAA

Satellite and Information Service

February 2020



MISSION AREAS

- Sustainable Fisheries: *Ending overfishing & rebuilding fish stocks.*

- Protected Resources: *Protect, recover and conserve listed species, marine mammals, and their habitats. Response to strandings and entanglement.*

- Congressional Mandates: *Magnuson-Stevens Act, Endangered Species Act, Marine Mammal Protection Act, National Environmental Policy Act, Oil Pollution Act, RESTORE (Resources and Ecosystems Sustainability, Tourist Opportunities, and Revived Economies of the Gulf Coast States) Act*

- Developments: *Changing ocean conditions, regular ecosystems status reports, forecast tools*

U.S. Commercial Fisheries and the Seafood Industry

Landings and Values, 2018

National Totals

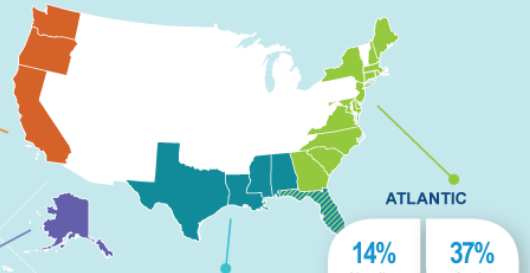
9.4 billion pounds -5.3% from 2017

$5.6 billion +2.8% from 2017

Highest Value Species Groups*

LOBSTER	CRABS	SALMON	SCALLOPS	SHRIMP
$684 million	$645 million	$598 million	$541 million	$496 million

Regional Totals**



PACIFIC	ATLANTIC	ALASKA	GULF OF MEXICO
12% of landings	14% of landings	58% of landings	16% of landings
13% of value	37% of value	32% of value	16% of value

* Ex-vessel value

** Hawaii contributed less than 1% of U.S. volume and 2% of U.S. landings value. The Great Lakes contributed less than 1% of U.S. landings and landings value.

NOAA FISHERIES

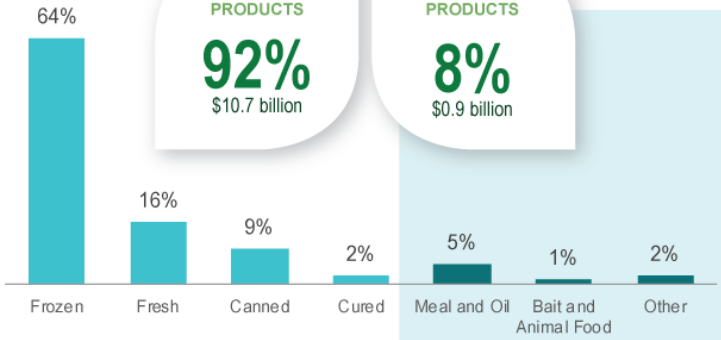
Value of Processed Fisheries Products, 2018*

(Processed from domestic catch and imported products)

Value by Type

EDIBLE PRODUCTS **92%** $10.7 billion

INDUSTRIAL PRODUCTS **8%** $0.9 billion



Top Species Processed

$1.98 billion 1.6 billion pounds

SHRIMP $990 million 305 million pounds

SOCKEYE SALMON $940 million 193 million pounds

TUNA $836 million 384 million pounds

COD $745 million 292 million pounds

* Free on Board (FOB) value of processed products.

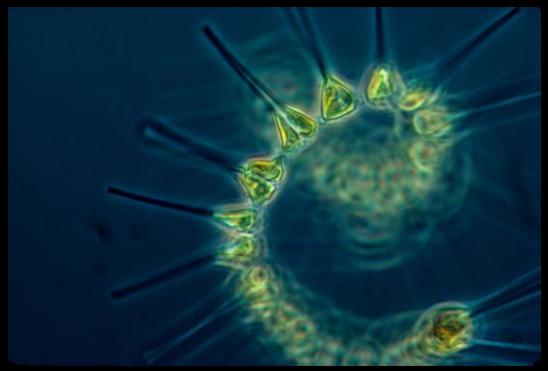
NOAA FISHERIES

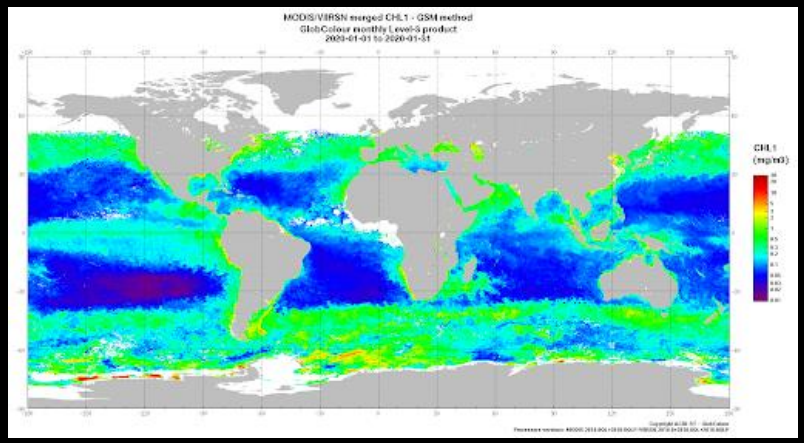
Fisheries of the United States, 2018 NMFS

OCEAN COLOR – SUSTAINABLE FISHERIES, PROTECTED SPECIES

- LONG-TERM TIME SERIES OF OCEAN COLOR
  - Accurate [chl], US EEZ, continental shelf scale, survey operating areas scale
  - Multisensor, stitched together
  - Unified & coherent ocean color times series
    - Better for NMFS models, forecast tools

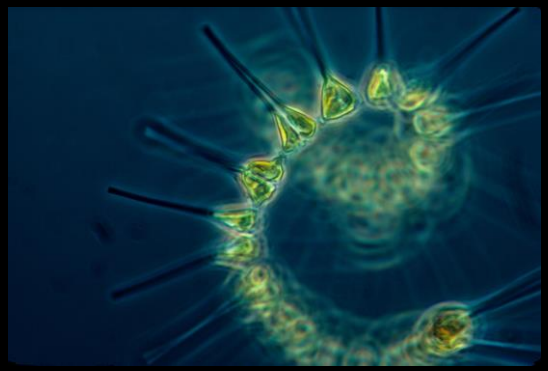
- PHYTOPLANKTON FUNCTIONAL GROUPS
  - Expand R&D currently in PGRR
  - Incorporation of more sensors

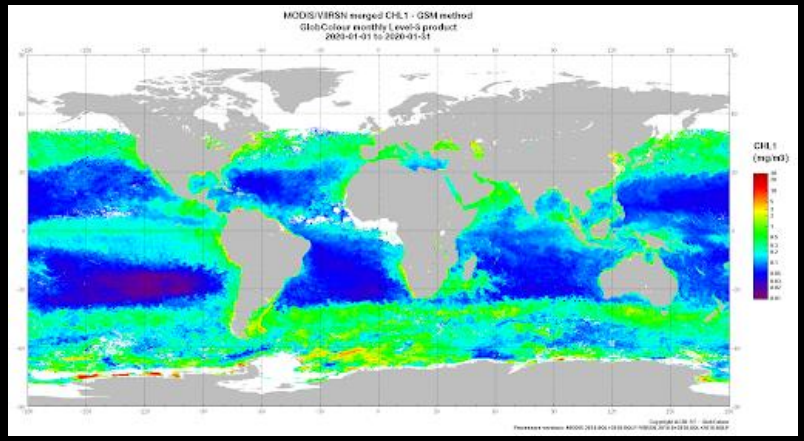




OCEAN COLOR – SUSTAINABLE FISHERIES, PROTECTED SPECIES

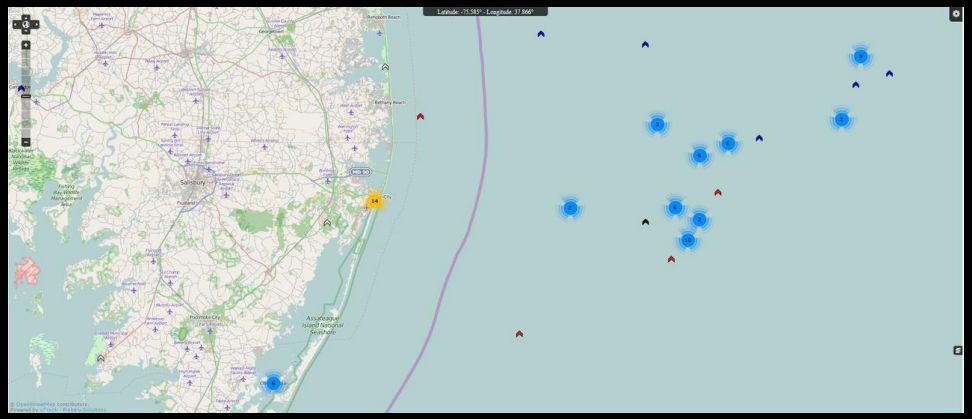
- REGIONAL COUPLED OCEAN MODELS
  - Satellite chlorophyll complements simulation of 3D biogeochemical profiles
  - JPSS, GEO connections to these modeling teams
- BREAKING 8d COMPOSITE – GEO – OC?
  - Model, forecast performance
- BEYOND VIIRS
  - Sensor development aimed at NASA PACE capabilities for planned NOAA follow-on





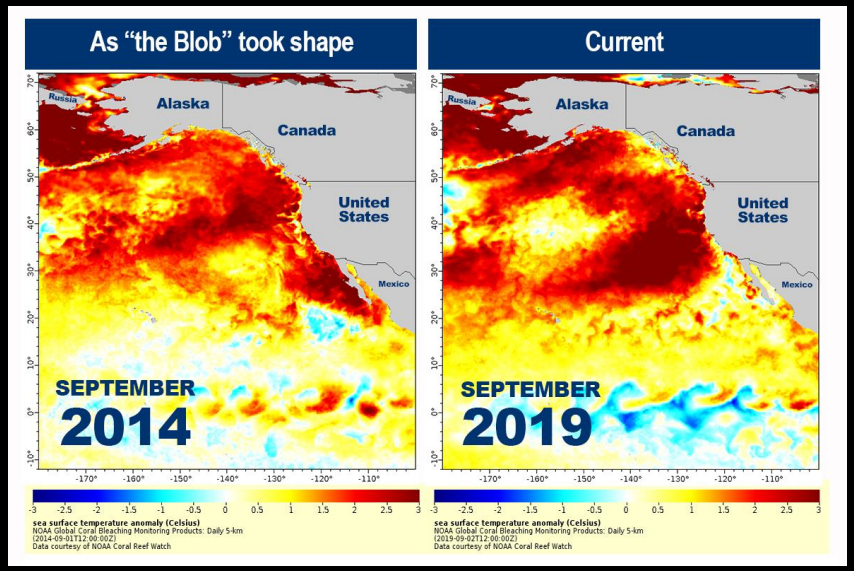
SATELLITE SURVEILLANCE – LAW ENFORCEMENT: SUSTAINABLE FISHERIES, PROTECTED SPECIES

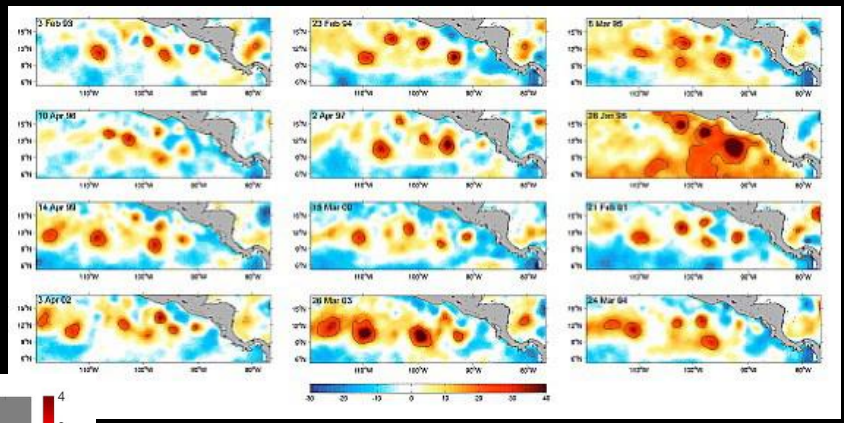
- ENFORCEMENT EFFORTS:
  - Keep US fishermen competitive in world market
  - Level playing field globally
  - Combat Illegal, Unreported, Unregulated (IUU) Fishing
- VESSEL TRACKING
  - Vessel identity, location, activities
  - Actionable information for investigations, prosecutions
- MONITORING, SURVEILLANCE FOR:
  - Foreign fishing and support vessels for illegal fishing in US EEZ
  - Illegal transshipment of seafood in US EEZ, high seas
  - Illegal fishing in closed areas/marine protected areas
  - Activity related to North Atlantic Right Whale ship speed rule, esp. with AIS off

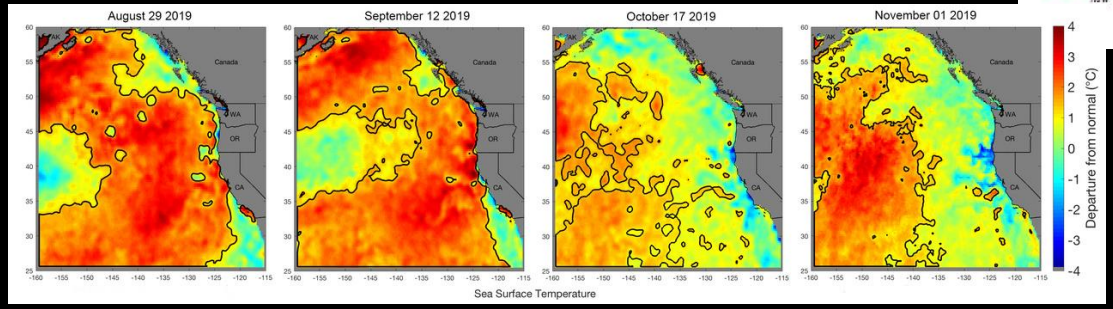


OCEANOGRAPHY – SUSTAINABLE FISHERIES, PROTECTED SPECIES

- SEA SURFACE HEIGHT (SSH)
  - Increased resolution needed
  - Fuels models, products
- SEA SURFACE TEMPERATURE (SST)
  - Maintain accuracy, coverage
  - Key to models, products



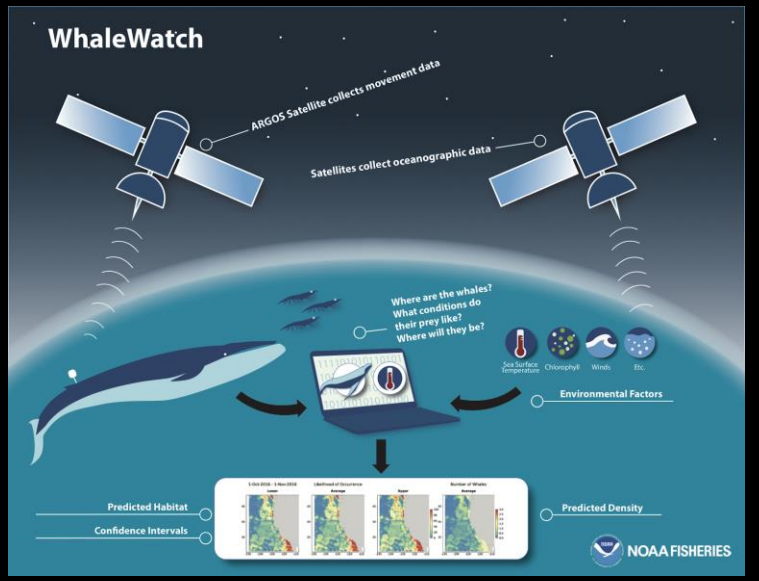


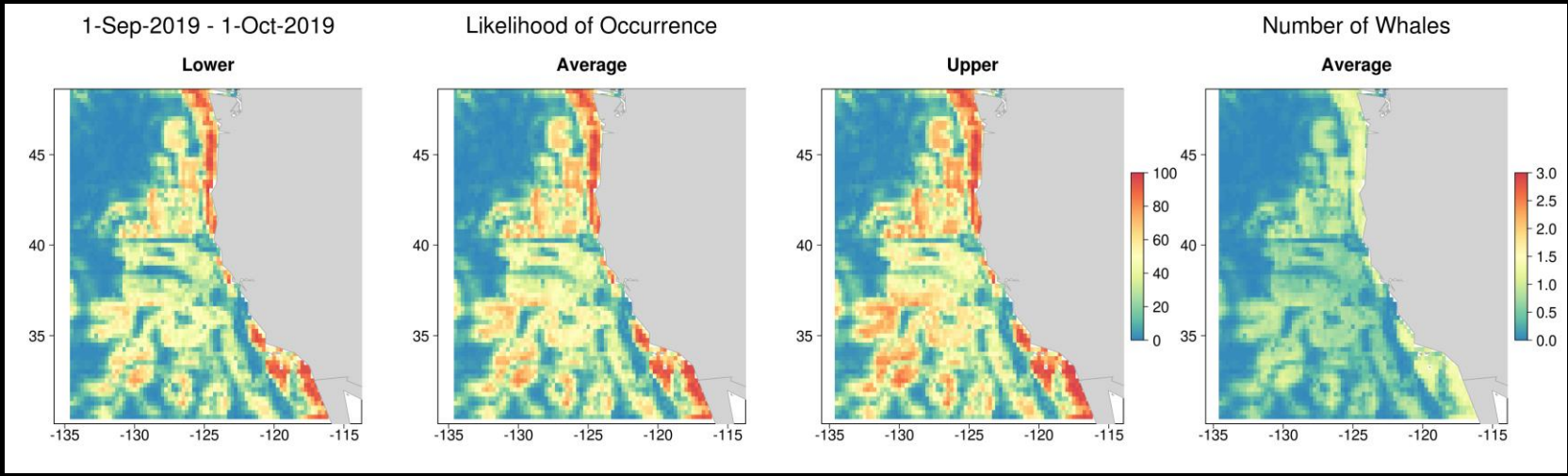


FORECAST SYSTEMS: SUSTAINABLE FISHERIES, PROTECTED SPECIES

- Turtle Watch
- Whale Watch

- REQUIREMENTS
- PIPELINE
- PERFORMANCE IMPROVEMENTS






THANK YOU
Mike Ford – michael.ford@noaa.gov

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NOS Requirements JPSS/GOES-R Summit

Shelly Tomlinson
Oceanographer
National Centers for Coastal Ocean Science/NOS
CoastWatch East Coast Node Manager

SCIENCE SERVING COASTAL COMMUNITIES

Application Areas

- Ecological Forecasting and Harmful Algal Bloom Monitoring/Forecasting in lakes, estuaries and coastal areas
- Event response for HABs
- Water Clarity/Quality
  - Guidance or National Geodetic Survey LIDAR missions
  - Guide diver missions
  - Support water quality models
  - Ocean planning (macroalgae/shellfish aquaculture)
- Chlorophyll-a as input to models
  - C-HARM forecast model for HABs of California

Requirements

- 1 km or better resolution
- Daily repeat
- Spectral resolution with sufficient bands for coastal water quality and bloom applications
- Multiple ocean color images a day could assist in bloom detection despite clouds
- Robust Atmospheric correction needed in lakes, coastal/estuarine waters

Satellite Comparison for bloom applications

Satellite	Spatial	Temporal	Key Spectral
MERIS 2002-12 OLCI Sentinel-3 2016-	300 m *OK*	2 day *good*	10 (5 on red edge) *good*
MODIS high res Terra 1999; Aqua 2002	250/500 m *OK*	1-2 day *good*	4 (1 red, 1 NIR) *marginal*
MODIS low res	1 km *poor*	1-2 day *good*	7-8 (2 in red edge) *OK*
VIIRS	750 m *poor*	1-2 day *good*	7-8 (1 red, no fluorescence 681 nm or red edge 709 nm) *marginal*
GOES-R	1-2 km *poor*	Every 15 m *good*	2 visible, no green band *poor*

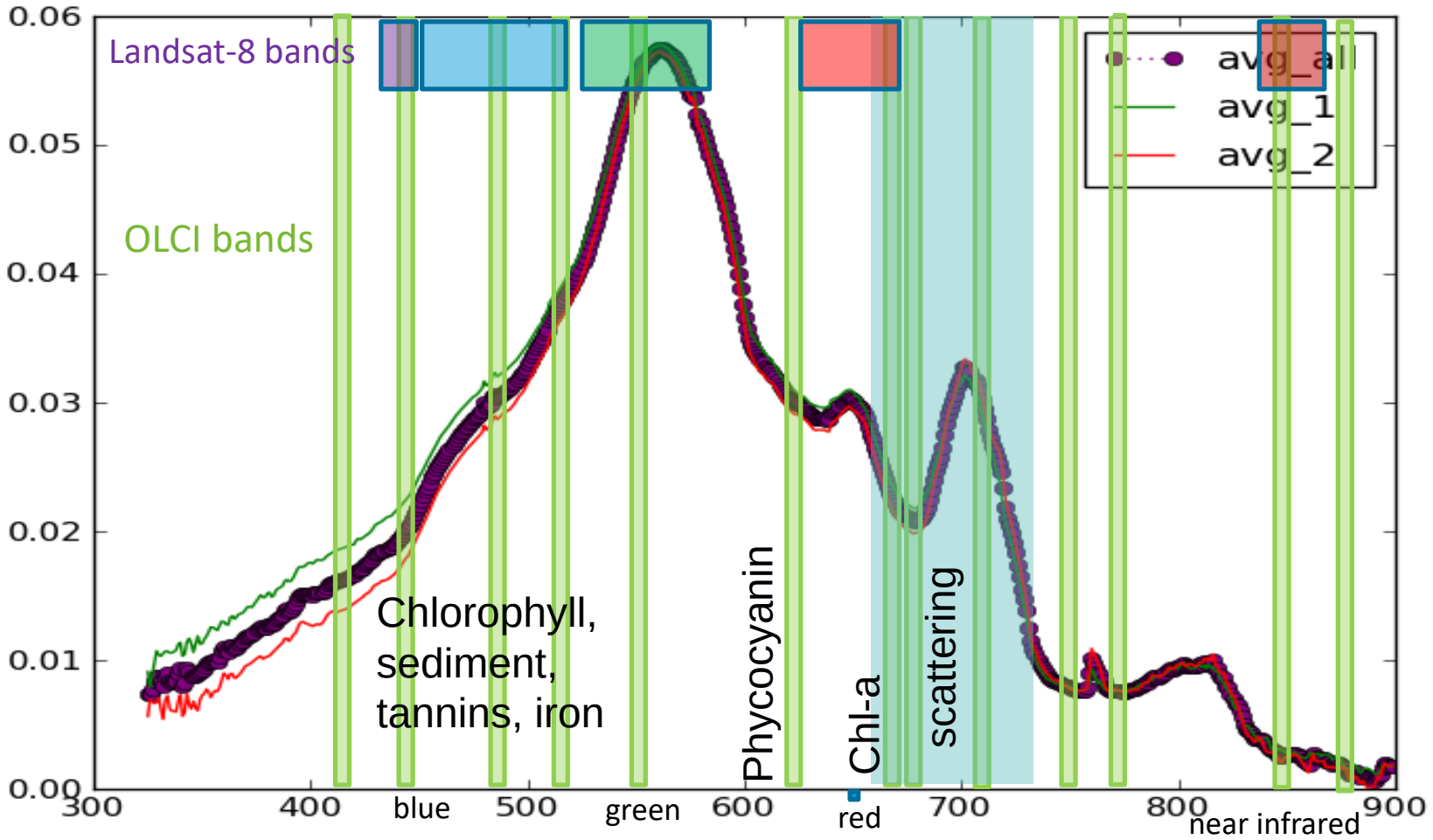
Clouds take out 1/2 to 2/3 of imagery – GOES could help

Some sunglint is not a problem for our algorithms

Minimum resolution, 3 pixels across (2 mixed land/water)

Red and Red-edge bands for discrimination in estuaries and lakes (OLCI and Landsat)

spectra from *Microcystis*



Atmospheric correction difficult, spectral shape algorithms with Rhos for blooms

Landsat runs out of information content to discriminate everything

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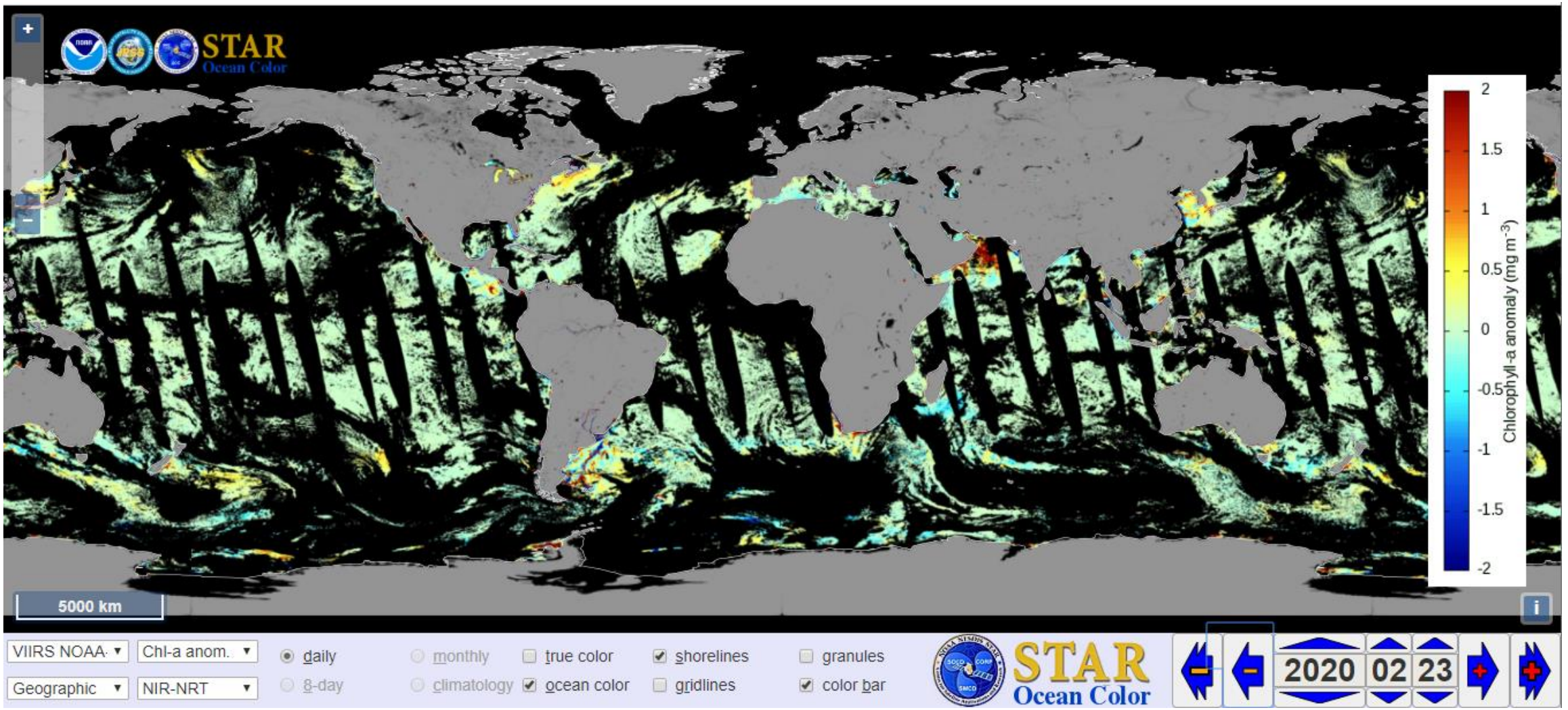
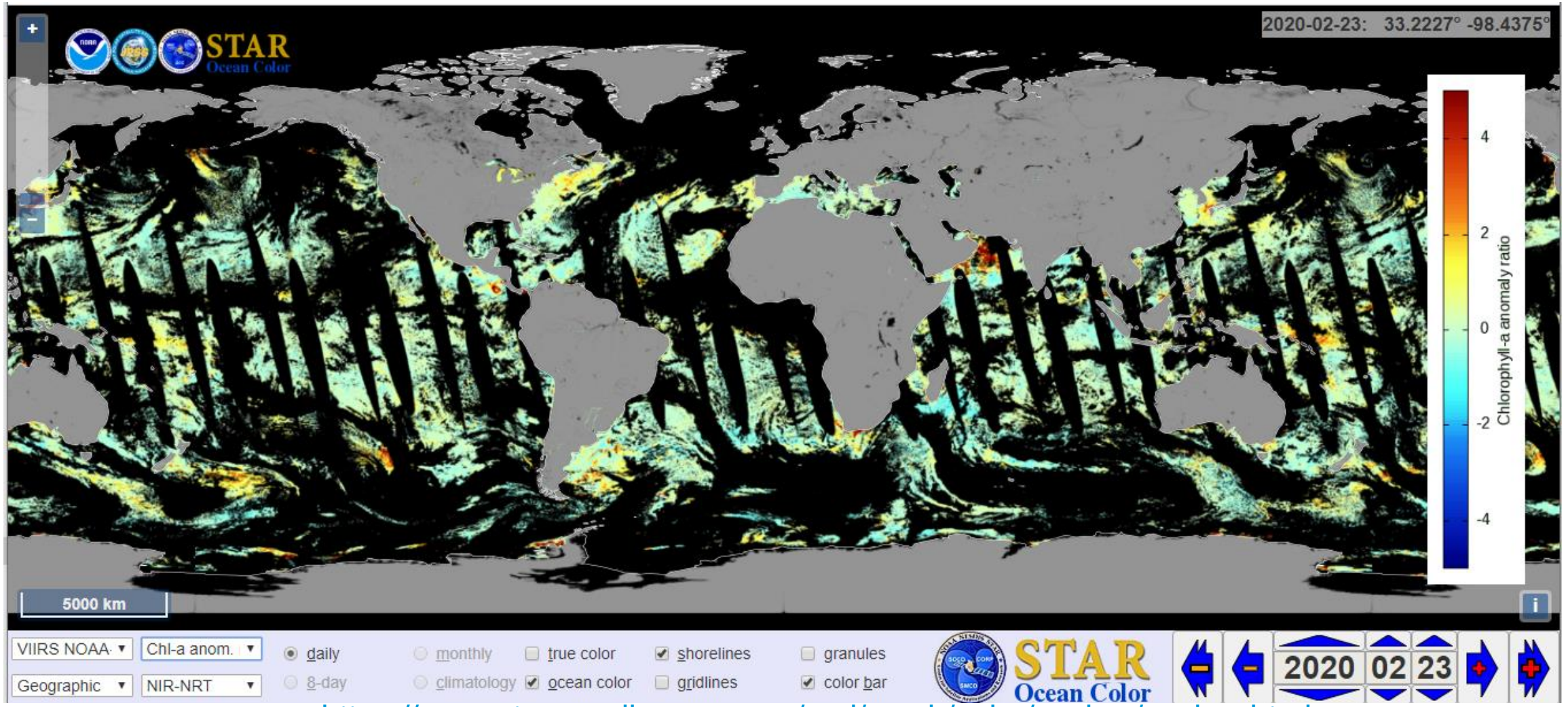
VIIRS Chl Anomaly for Event Response for New Blooms



https://www.star.nesdis.noaa.gov/sod/mecb/color/ocview/ocview.html

VIIRS Chl Anomaly Ratio for Event Response for New Blooms



https://www.star.nesdis.noaa.gov/sod/mecb/color/ocview/ocview.html

Kd Water Clarity Products

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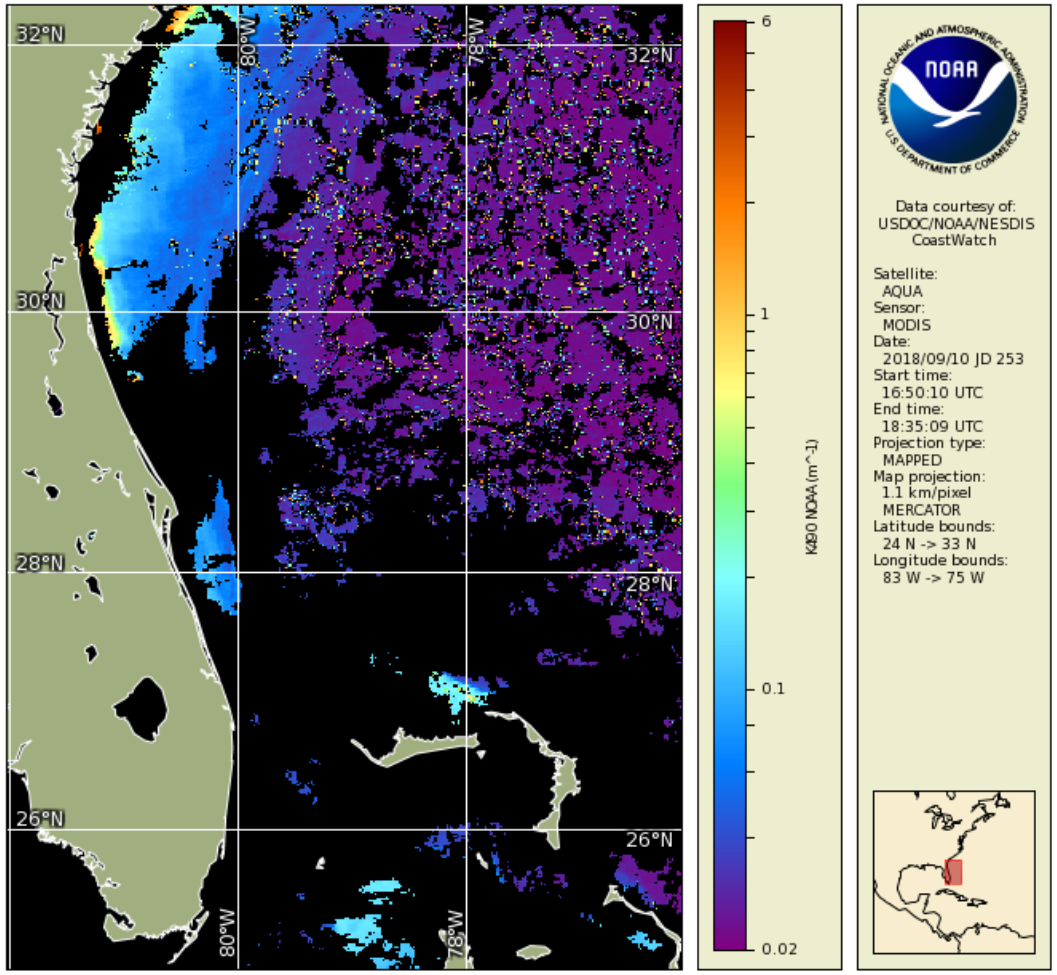
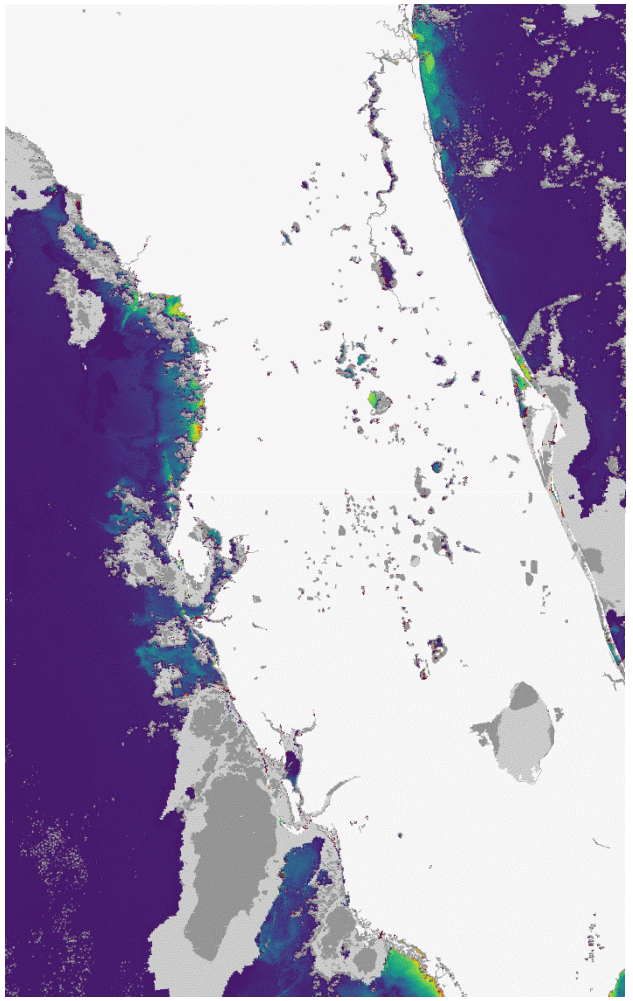
CoastWatch 1 km MODIS



NOS/NCCOS 250 m Kd



750 m

VIIRS Kd490

VIIRS KdPAR

Also available

Following Wang et al. (2009), with switch to Modified Mueller (2000) Kd for Case 1

$$K_d^{hires} = 2.8 \times \left[\frac{R_{rhos}(645) - R_{rhos}(858)}{R_{rhos}(469) - R_{rhos}(858)}\right] - 0.69$$

OceanReports

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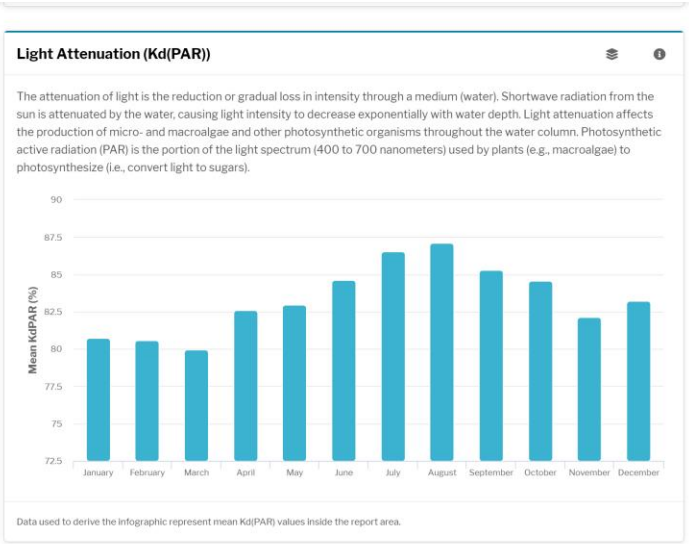
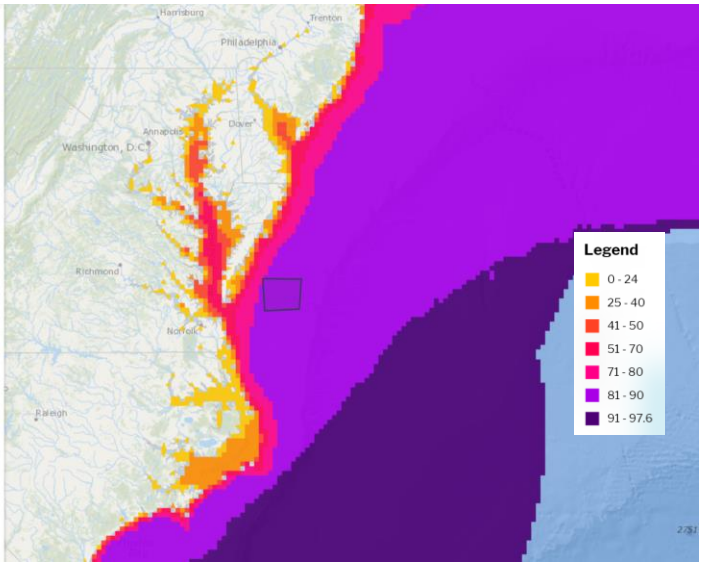
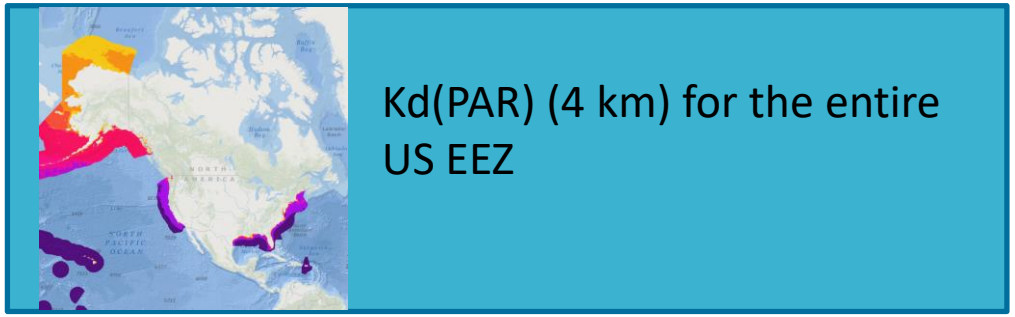
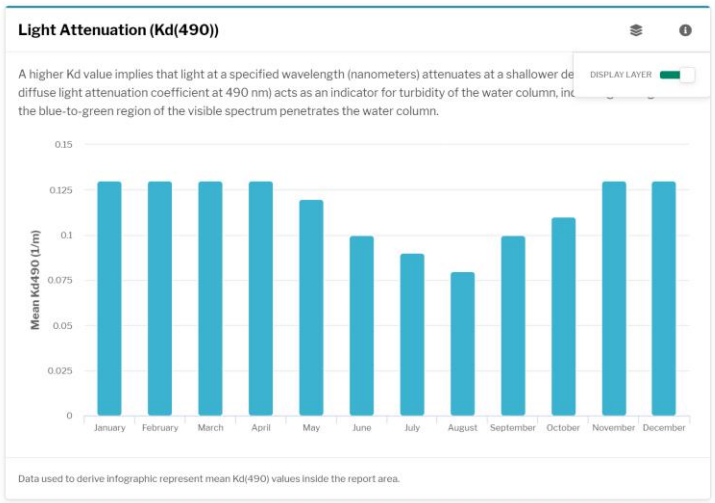


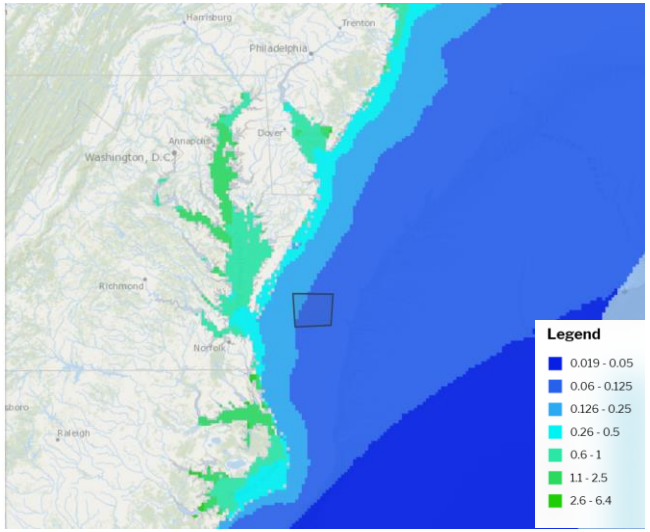


Kd(PAR) data represent a six-year (2012-2017) composite and were processed by NOAA at a 4-kilometer resolution. The raw data included those from both the Moderate Resolution Imaging Spectroradiometer (MODIS) and Visible Infrared Imaging Radiometer (VIIRS). The layer viewable on the map shows the annual average.

Interpreting Output: For example, a higher mean Kd(PAR) percentage indicates greater availability of photosynthetically active radiation to promote photosynthesis.







The value of Kd(490) represents the rate at which light at 490 nanometers is attenuated with depth. For example a Kd(490) of 0.1/meter means that light intensity will be reduced one natural log within 10 meters of water. Thus, for a Kd(490) of 0.1, one attenuation length is 10 meters.

(https://oceanservice.noaa.gov/ocean/ocean-reports/)

Slide courtesy of Lisa Wickliffe, NCCOS

Northeast Ocean Data Portal
(MODIS) (Chl-*a* Fall)

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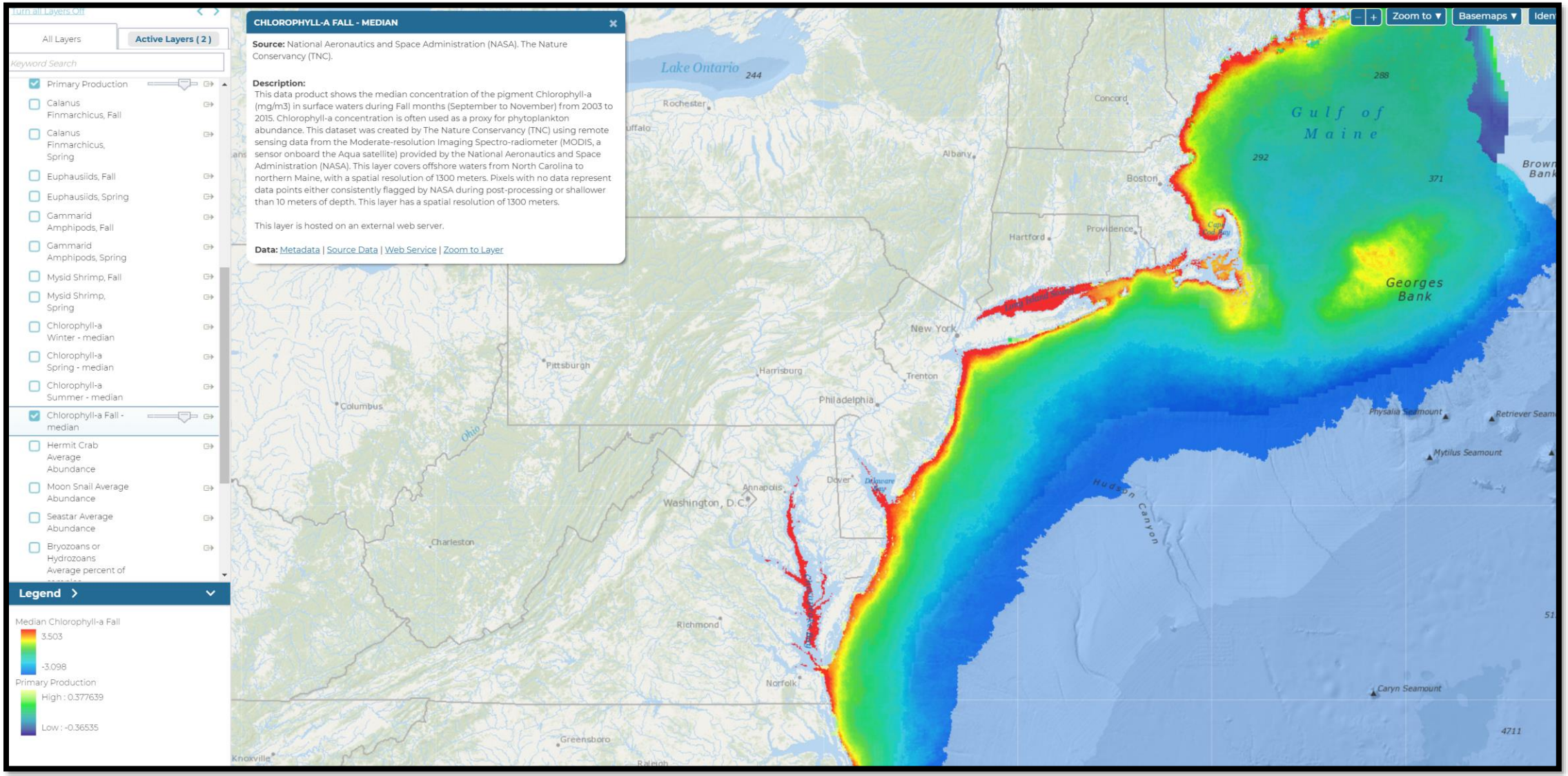

Slide courtesy of Lisa Wickliffe, NCCOS

California Harmful Algae Risk Mapping (C-HARM) System

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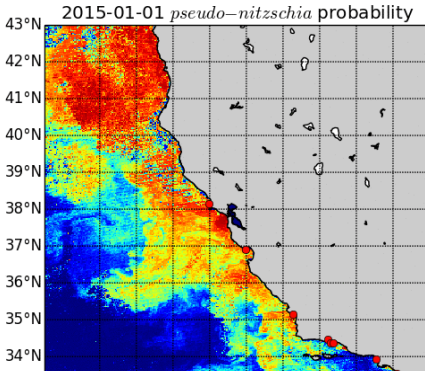
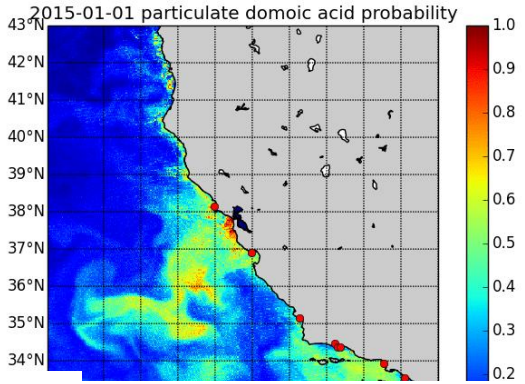
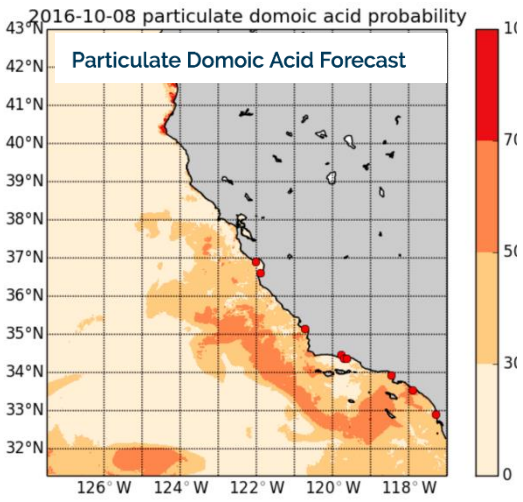
Interactive Data Portal C-HARM Nowcasts and 3-day Forecasts
http://www.cencoos.org/data/models/habs/

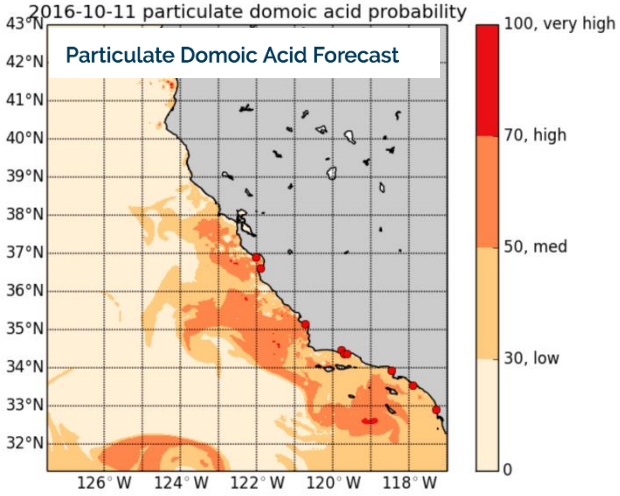
Probability Maps





Risk Maps based on stakeholder feedback





MODISA:
488, 555 nm
Chla

Modeled:
SSH, SST

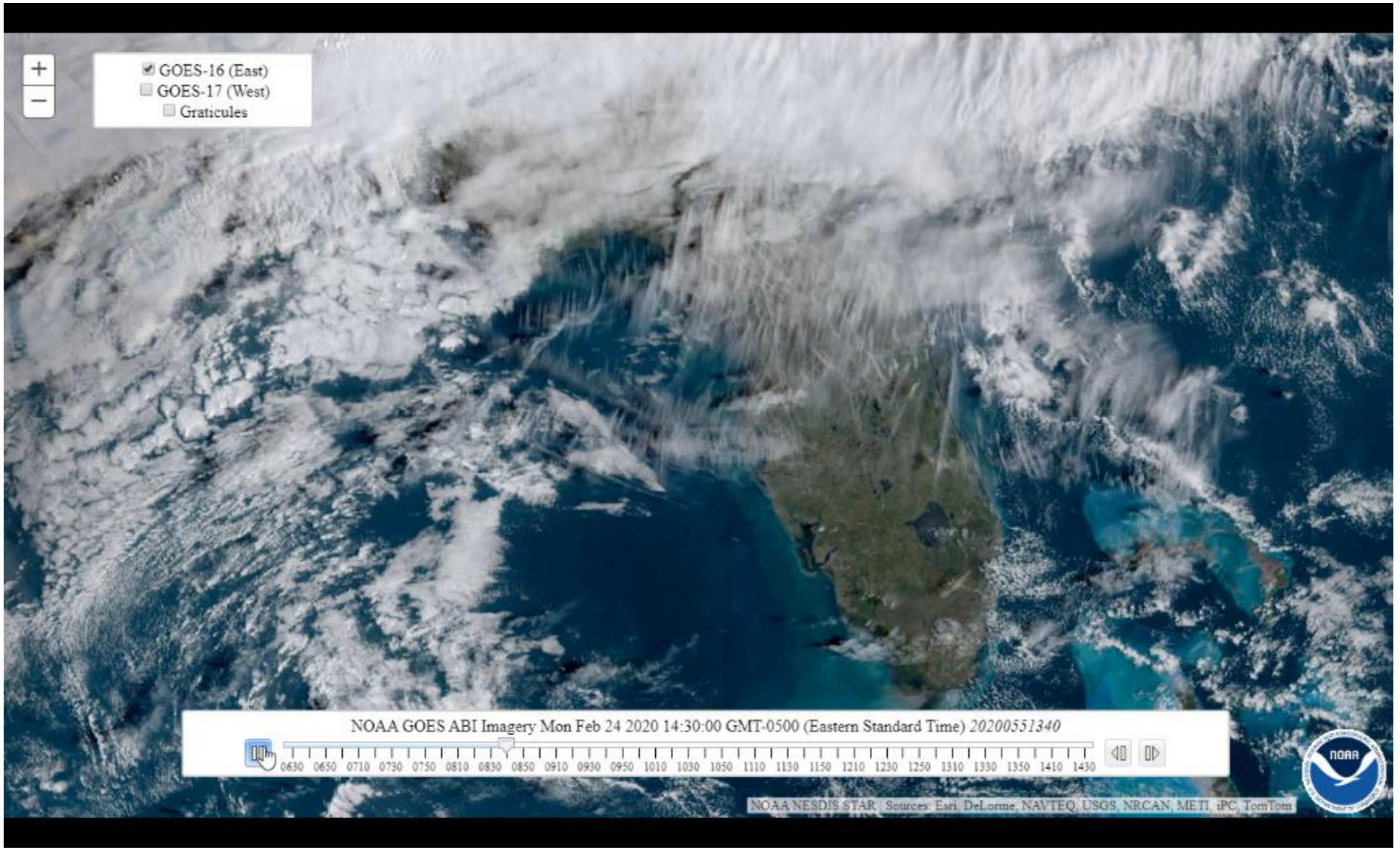
Validating switch to VIIRS now

Slide courtesy of C. Anderson, SCCOOS

NOAA · Sea Grant California · IOOS Integrated Ocean Observing System · NASA · Ocean Protection Council · CeNCOOS · Southern California Coastal Ocean Observing System

GOES Ocean Color for Improved Monitoring of Transient Features

NCCOS | NATIONAL CENTERS FOR COASTAL OCEAN SCIENCE



Better monitoring with clouds (bloom detection, etc).

Need better spatial and spectral resolution for coastal issues

Slide courtesy of Michael Soracco, CoastWatch

The US West Coast Ocean Forecast System (WCOFS)

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In collaboration with
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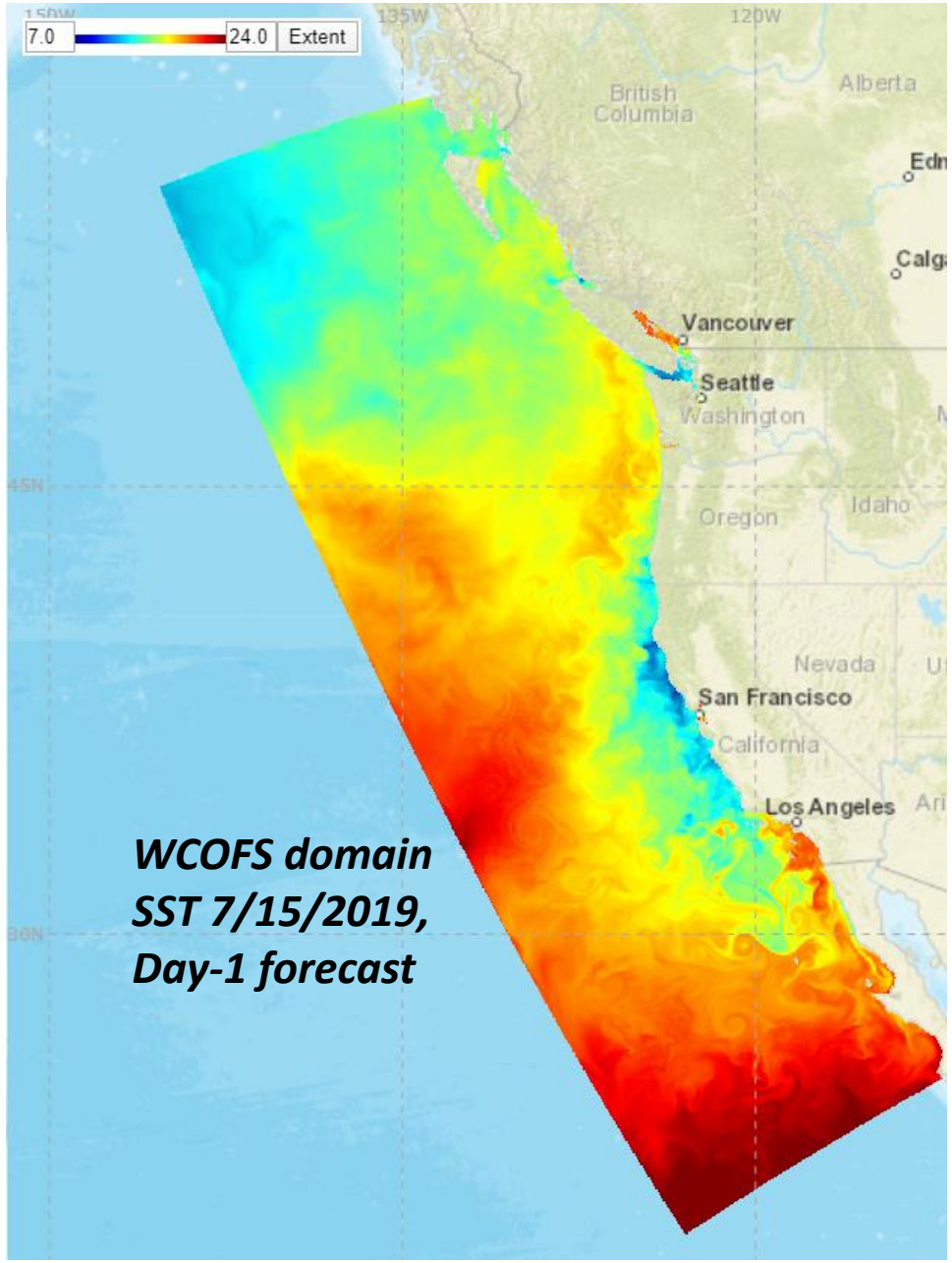
E. Leuliette, A. Ignatov (NOAA/NESDIS/STAR)

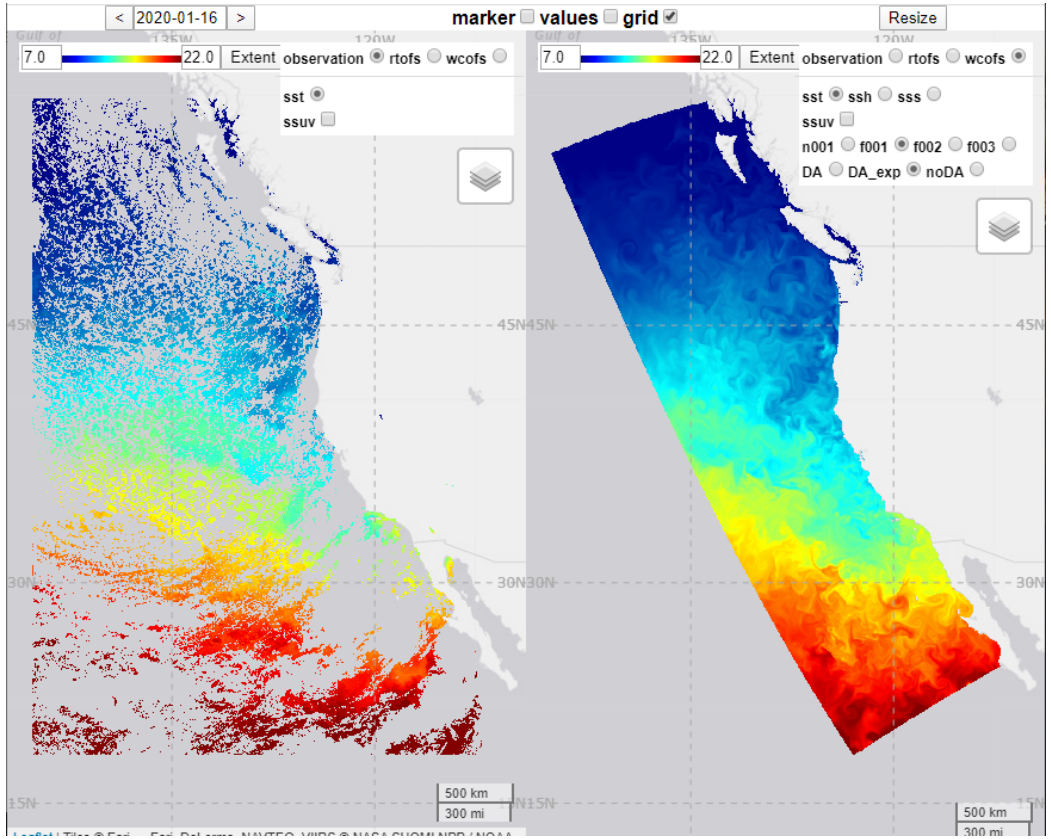
Status update:

- Real-time application (dev mode)
- https://coastaloceanmodels.noaa.gov/WCOFS/Viewer/
- Assimilation of satellite SST (NPP L3U), alongtrack altimetry (5-satellite homogenized ADT), surface currents from coast-based high-frequency radars (HFR)
- Daily updates of 3-day forecasts of currents, temperature, salinity, total sea level, etc.
- Operational transition is planned for Nov 2020



Model details [Kurapov et al. Oce Dyn. 2017, JGR 2017]**:**

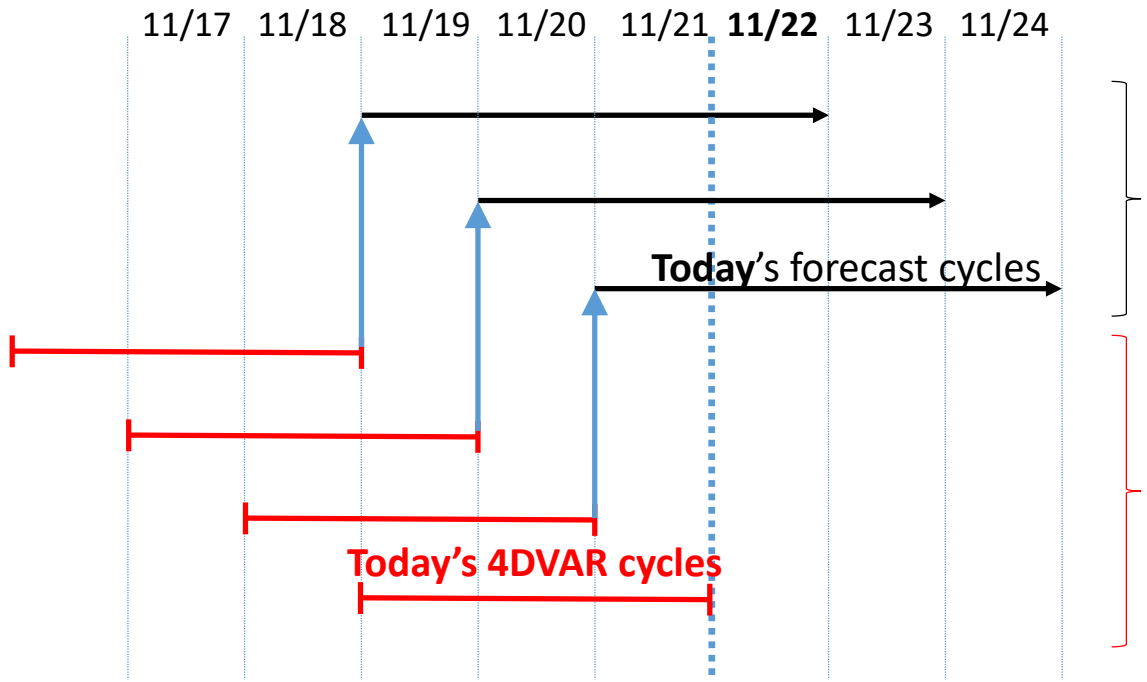
- Dynamics are based on the Regional Ocean Modeling System (ROMS): fully nonlinear, baroclinic, free-surface, Boussinesq approximation, advanced higher-order numerics, vertical turbulence parameterization, terrain-following vertical coordinates
- Alongshore extent: 24N-54N (MEX-US-Canada)
- 4-km horizontal resolution / 40 terrain-following vertical levels
- Atmospheric forcing: NOAA NAM wind, heat flux – bulk flux formulation, precipitation. Transition to FV3 GFS must be anticipated.
- Open boundary forcing: NOAA RTOFS (non-tidal), TPXO (tidal)
- Major river discharges



Shown: (LEFT) VIIRS SST, (RIGHT) day-1 SST forecast, 16 Jan 2020

ROMS 4DVAR implementation:

- Daily, in 3-day windows
- Initial conditions are corrected
- Routine assimilation of HFR uv+SST+SSH



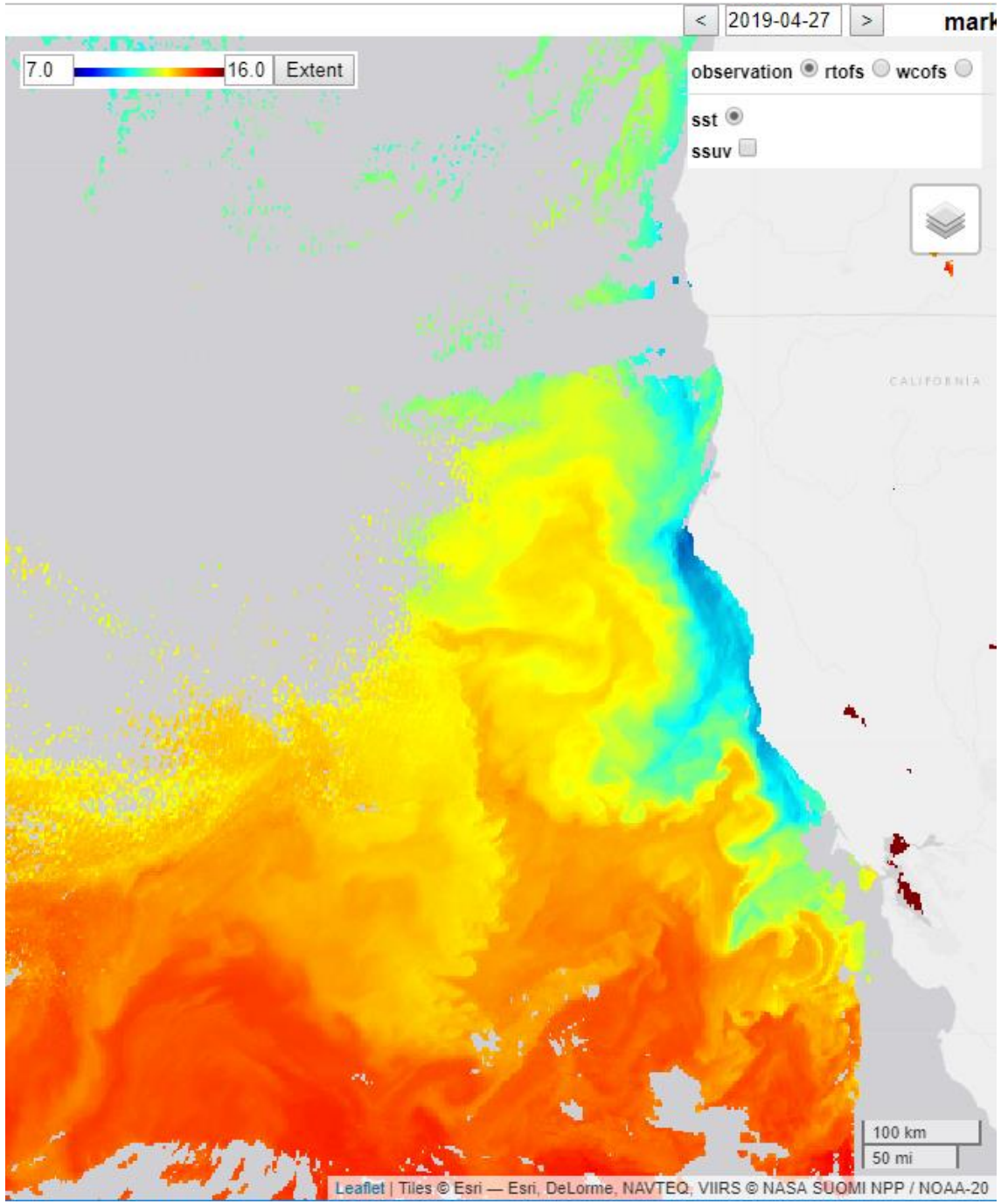
Solid lines: present DA system (HF+SST)

The ocean forecast system, OFS (WCOFS: daily updates of 3 day forecasts)

The assimilation system (everyday cycle over the past 3 days): correct initial conditions at the beginning of each assimilation cycle, to better fit observations over the 3-day interval

WCOFS: assimilated data (1)

Satellite SST (NPP VIIRS Level 3)



(a mosaic of nightly SST passes of Central and Northern California, 27 Apr 2019)

WCOFS: assimilated data (2)

Absolute dynamic topography (ADT) from 5 altimeters

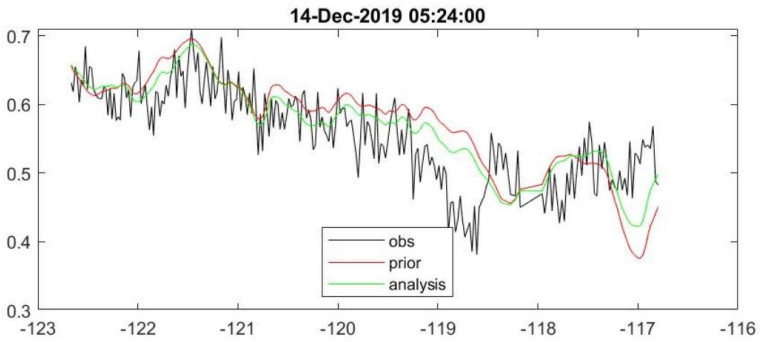
To match the de-tided observation and WCOFS forecast, model-derived tides are added to the data [following J. Wilkin's, Rutgers U., advice]

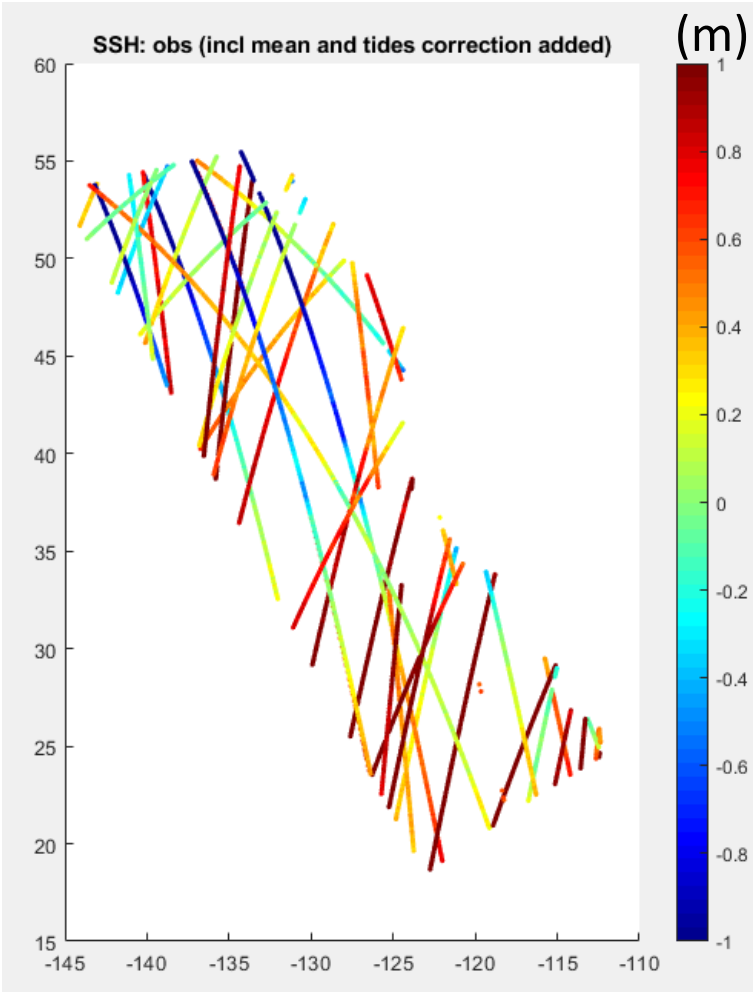
Shown:

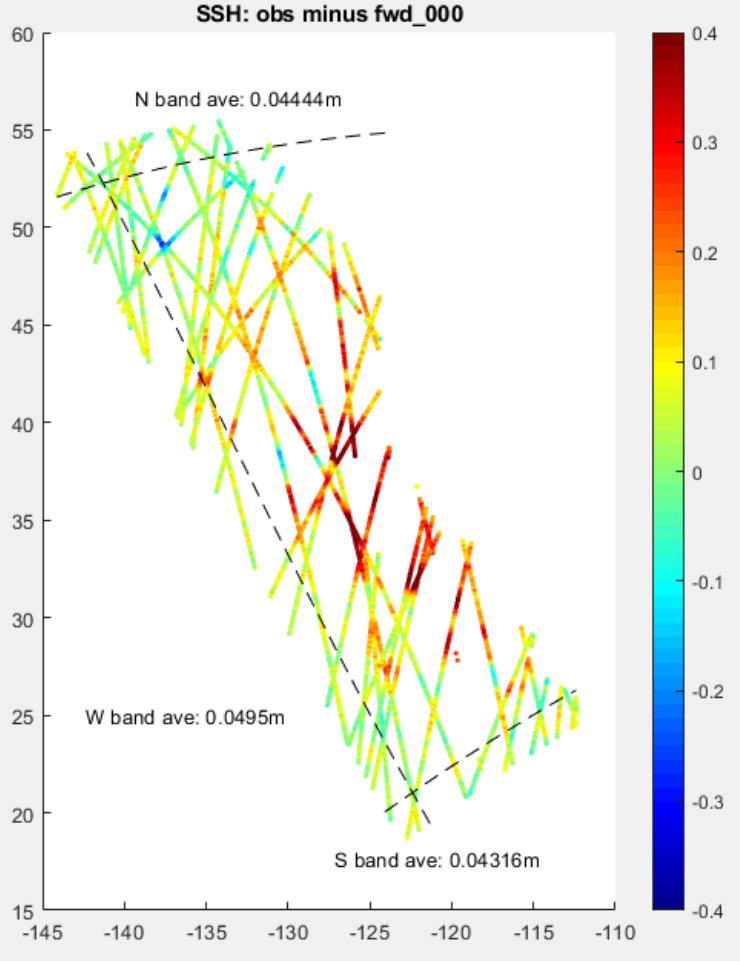
(LEFT) observed ADT+8 model tidal constituents, all the altimetry passes in a 3 day window (some time in November, 2019)

(RIGHT): obs minus WCOFS prior SSH

(BOTTOM, black): an example of alongtrack ADT





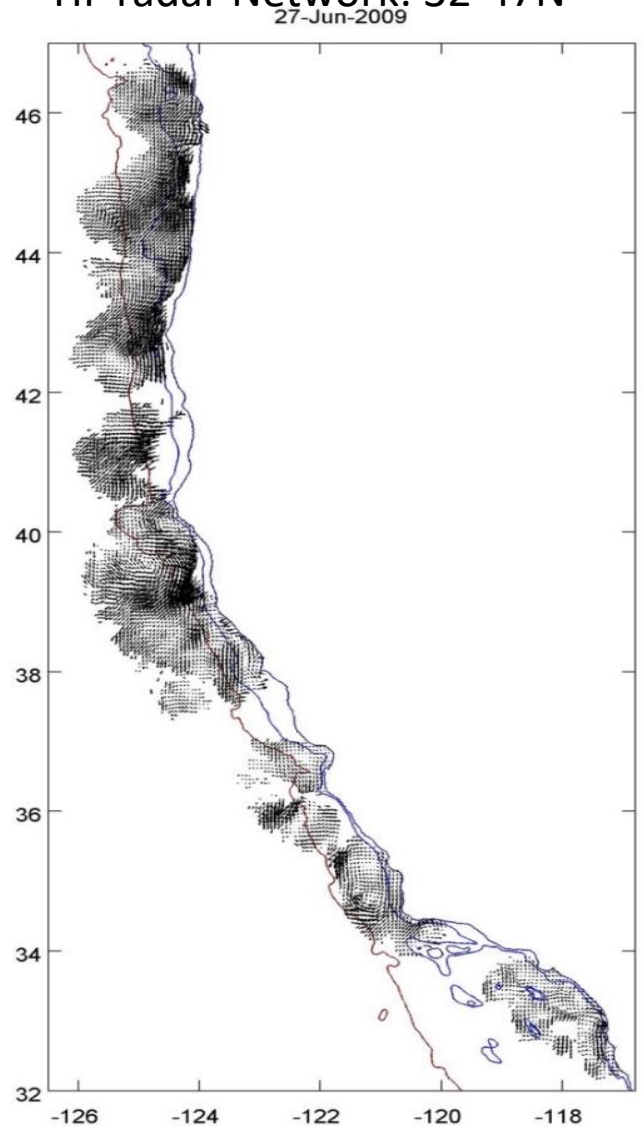


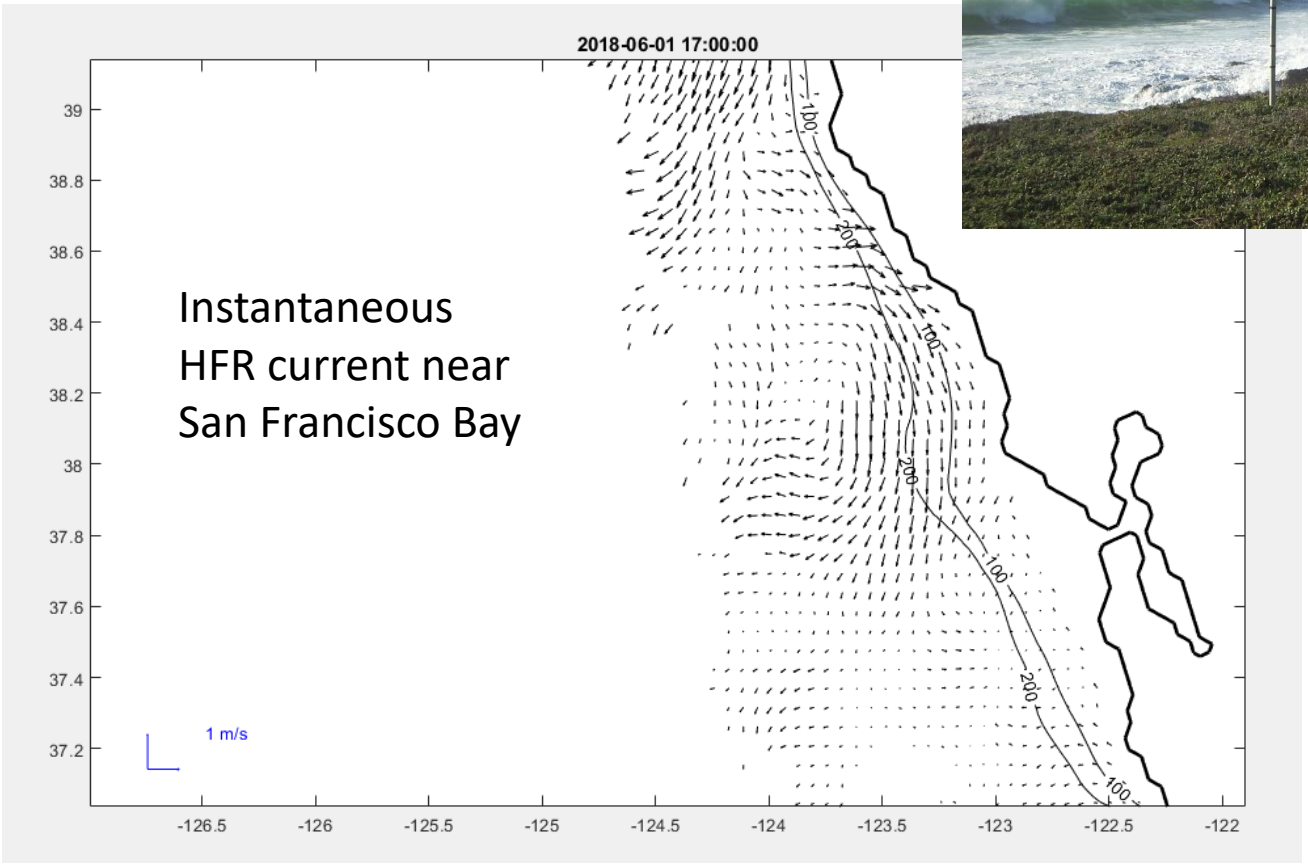
WCOFS: assimilated data (3)

HF radar surface currents:

- mapped uv (6km res),
- hourly

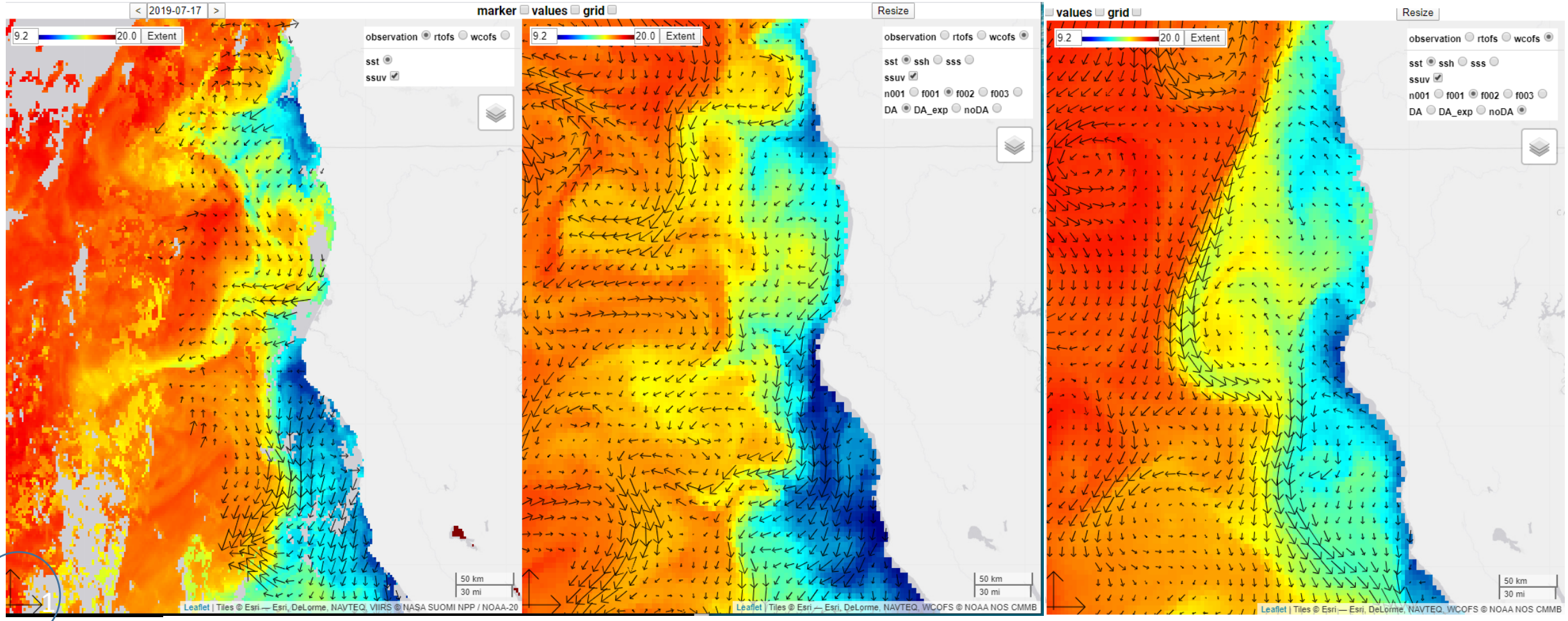
US West Coast
HF radar Network: 32-47N





DA impact: improved surface temperature and currents forecast

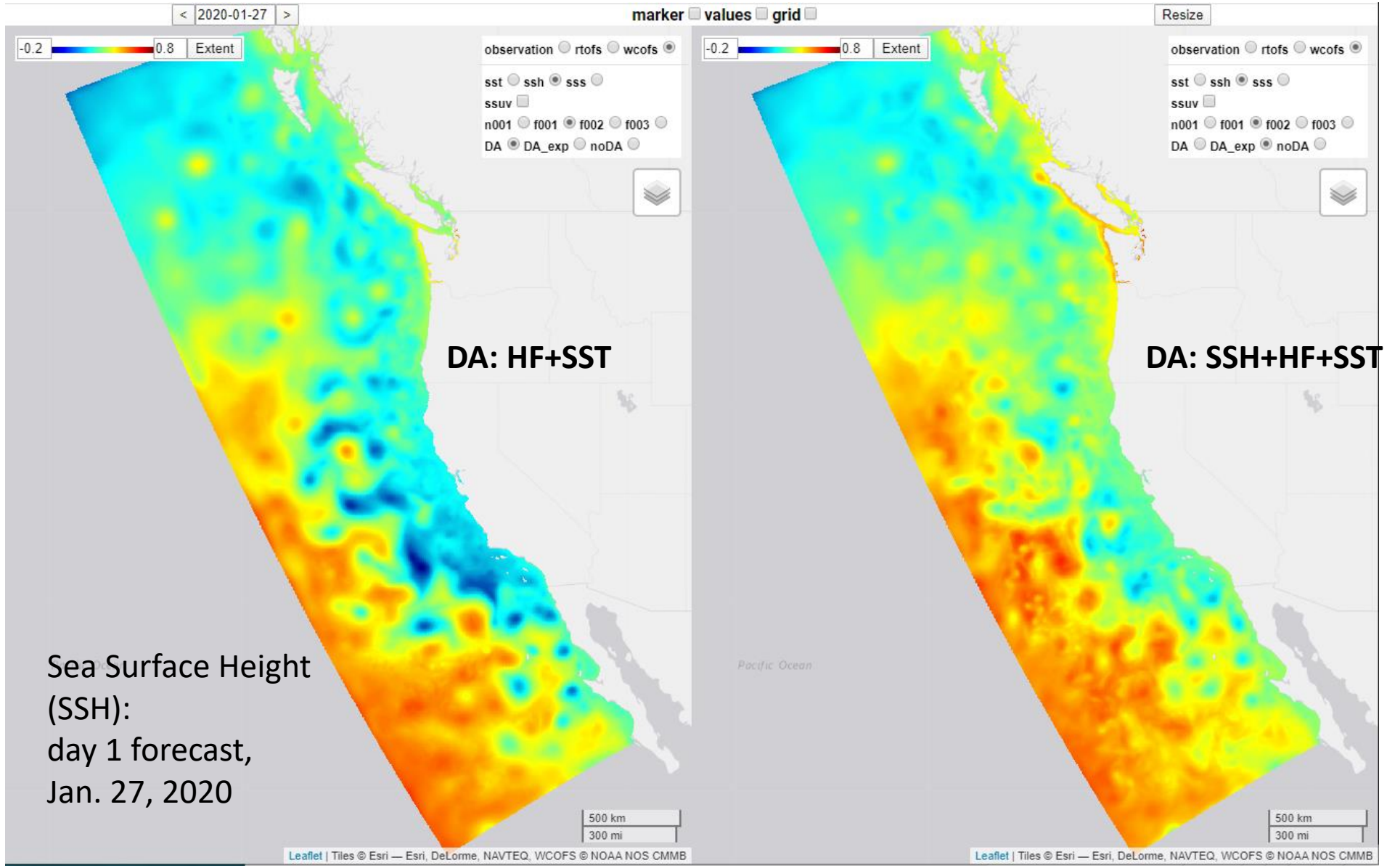
Observations (SST, daily-ave uv) Day-1 forecast, DA (Jul 17, 2019) Day-1 forecast, no DA



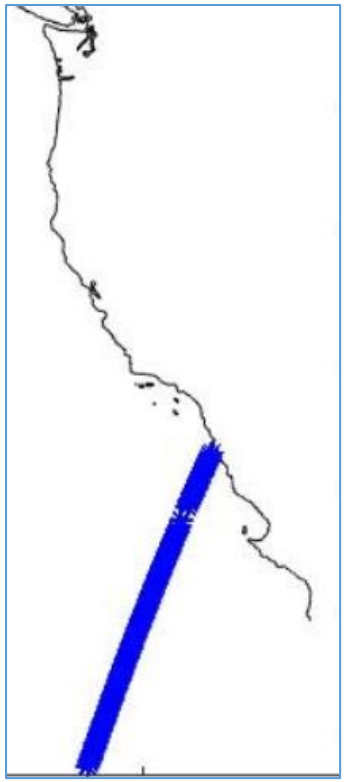
Scale: 1 m/s

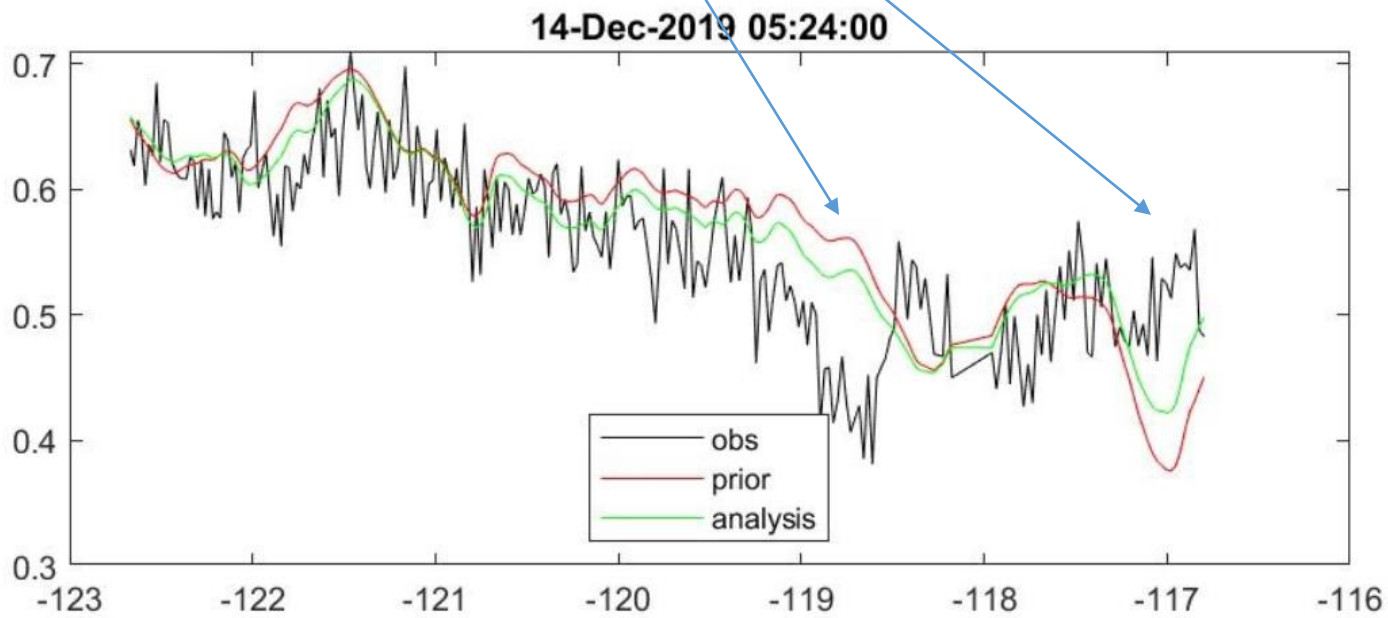
Graphics from the WCOFS Viewer, https://coastaloceanmodels.noaa.gov/WCOFS/viewer/

Altimetry assimilation corrects the large scale alongshore surface pressure gradient:



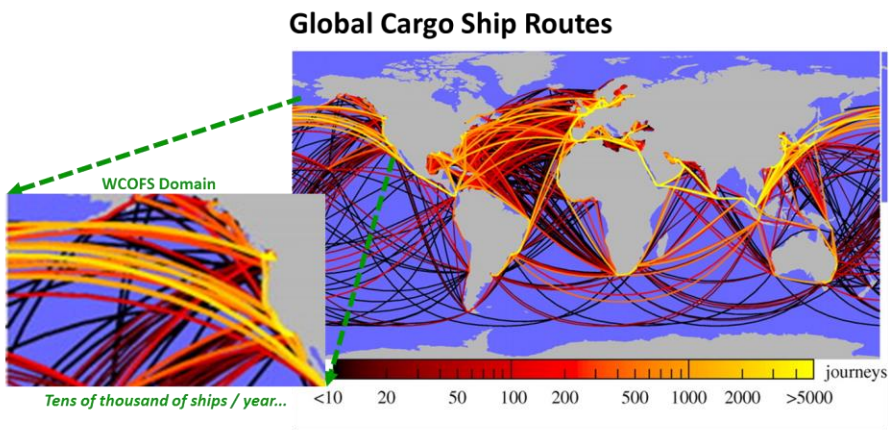
Assimilation improves fit to alongtrack altimetry but not always effective improving features associated with mesoscale eddies:





Users and uses:

- Navigation (commercial ship routing... fuel conservation): surface currents
- Fisheries (commercial/recreational): fishing operation planning (SST fronts, surface mixed layer depth, currents... e.g., crab pots retrieval)
- Environmental hazard response & search and rescue (surface flow trajectories)
- Ocean circulation forecasts are a base for coupled biogeochemical models (hypoxia on the shelf), pathogen predictors (harmful algae blooms), etc.
- Total water level: e.g., beach flood / erosion warnings
- Boundary conditions for higher resolution coastal ocean, estuarine, nearshore models



All cargo ships > 10,000 GT during 2007, **plus tankers and bulk ships (less regular routes)**

Kalusa *et al.*, J. R. Soc. Interface (2010)

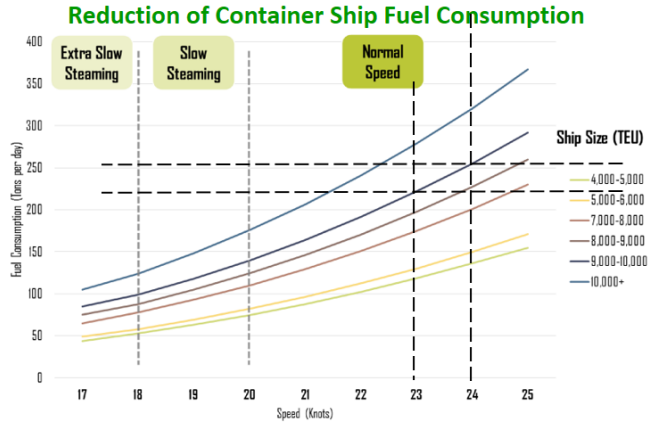


Diagram from:
Notteboom, T. and P. Carriou (2009) "Fuel surcharge practices of container shipping lines: Is it about cost recovery or revenue making?". Proceedings of the 2009 International Association of Maritime Economists (IAME) Conference, June, Copenhagen, Denmark.

- https://people.hofstra.edu/geotrans/eng/ch8en/conc8en/fuel_consumption_containerships.html

Image courtesy of PIL

Needs: include more data, learn about the combined impact of the data, impact on unobserved fields

SST:

- Include more data (N20, G17, microwave SST)
- Understand biases between the SST data sets
- Understand SST diurnal cycle in the data and model

Altimetry:

- Fitting eddy-like structures vs. fitting the large-scale mean
- Impact on alongshore coastal currents

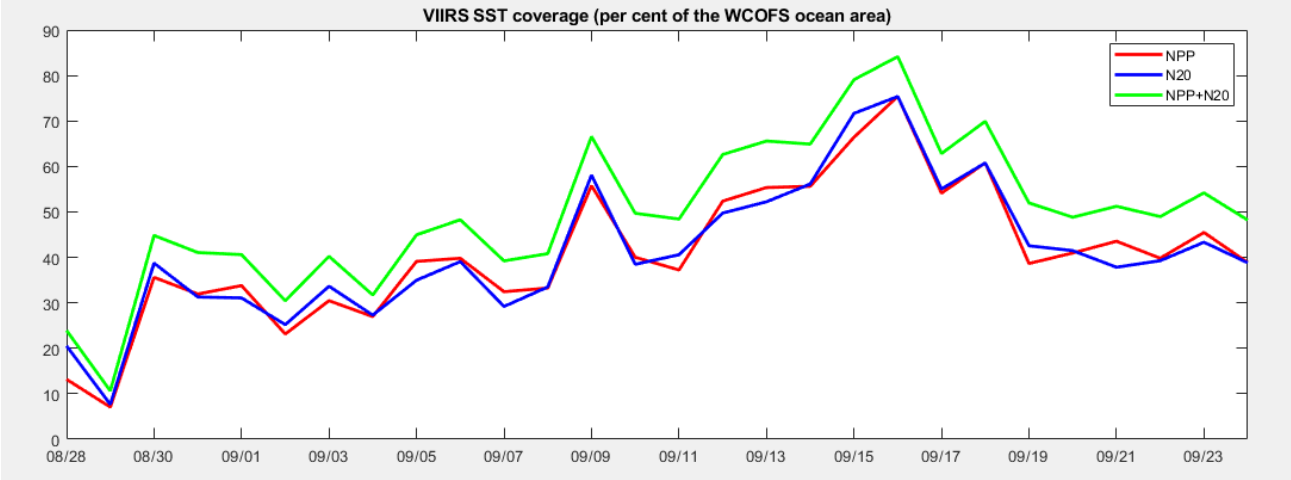
Sea surface salinity (SSS):

- Assess the utility of SMAP, SMOS: bias, seasonal cycle, limitations, etc.

In-situ observations (in combination with sat):

- Argo floats, glider hydrographic sections

Daily coverage by each of the VIIRS SST L3U products (NPP, NOAA20) (% of the WCOFS ocean domain area) and by their combination, Aug-Sept 2018



Needs (Cont.):

Learn from the NWP community about pre-assimilation data quality control protocols

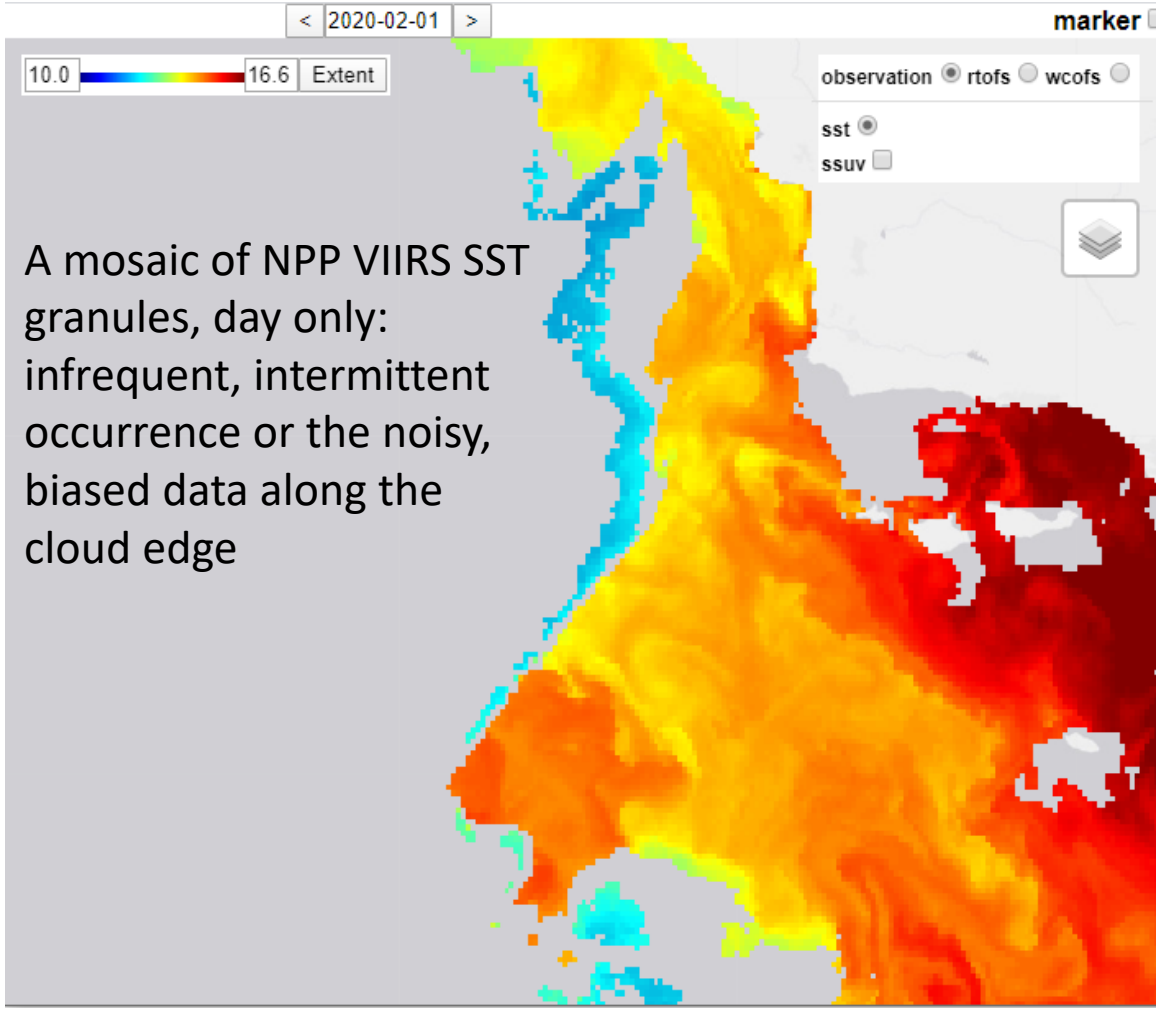
- Are NWP assimilation data assimilation systems fully automatic or require (allow) operator involvement to clean / reject observations?

Artificial intelligence (AI) applications:

- e.g., combine in-situ and satellite observations (SST, water leaving radiance), statistical models to provide constraints on SSS

Visualization for QC and dissemination, user feedback

SUMMARY: Given adequate resources, we will be able to resolve outstanding scientific issues, to fully utilize the power of satellite observations, leading to improved oceanic forecasts in support of navigation, fisheries, environmental hazard response, search&rescue, and many other public uses



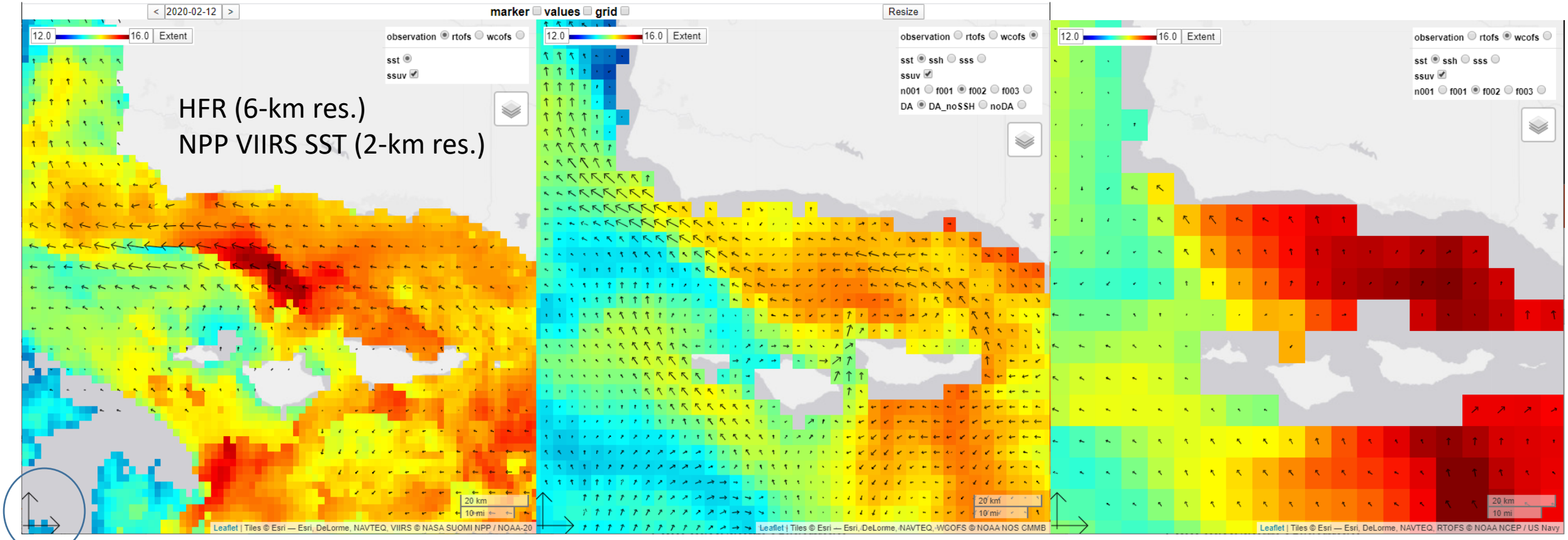
Additional slides:

Focus on variability in the Exclusive Economic Zone (EEZ):

Observations (SST, daily-ave surf uv)

Day 1 forecast (WCOFS)

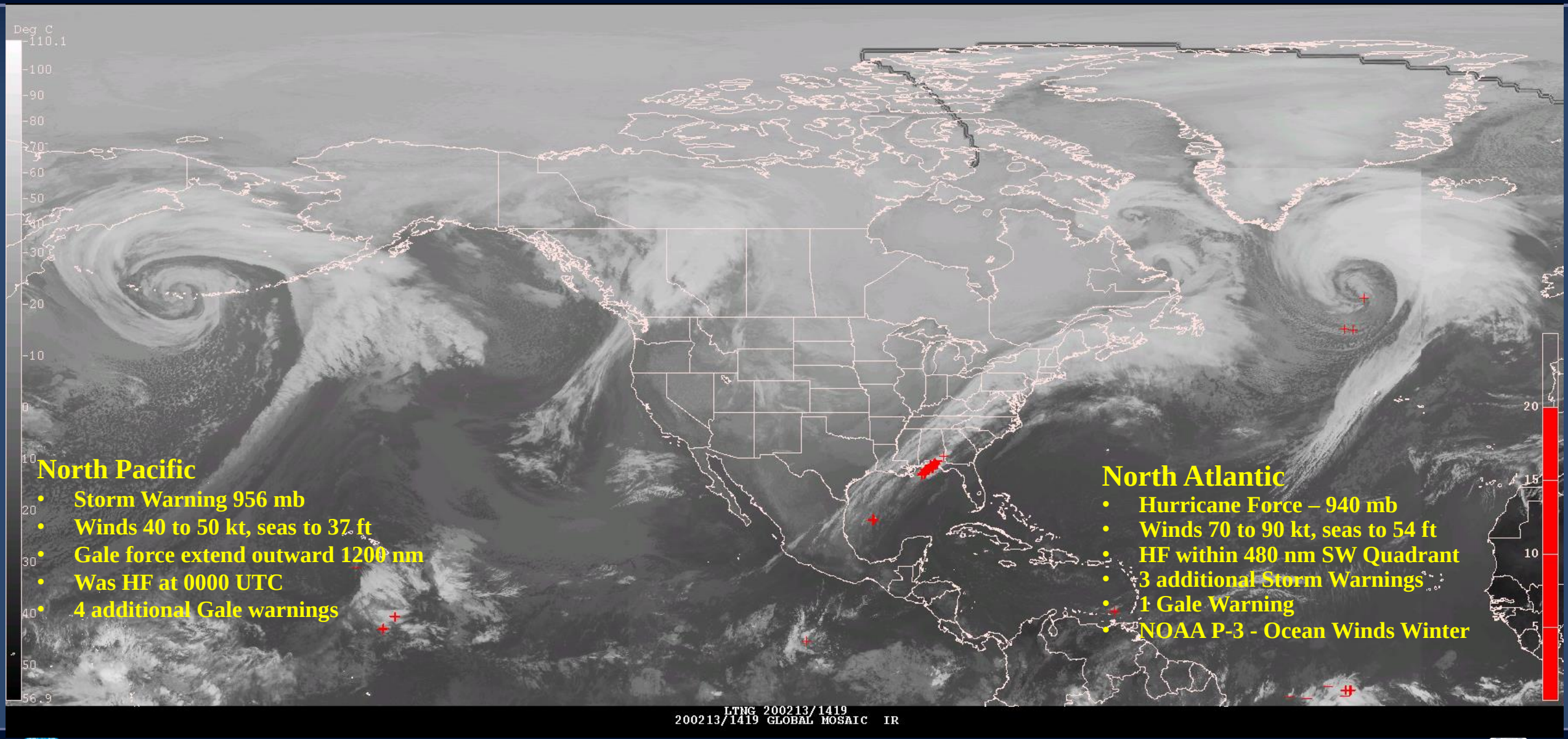
Global 1/12th^{o} res RTOFS



Scale: 1 m/s

Surface current scale:
1 m/s

Extreme Maritime Weather – 1419 UTC 13 Feb 2020



North Pacific

- Storm Warning 956 mb
- Winds 40 to 50 kt, seas to 37 ft
- Gale force extend outward 1200 nm
- Was HF at 0000 UTC
- 4 additional Gale warnings

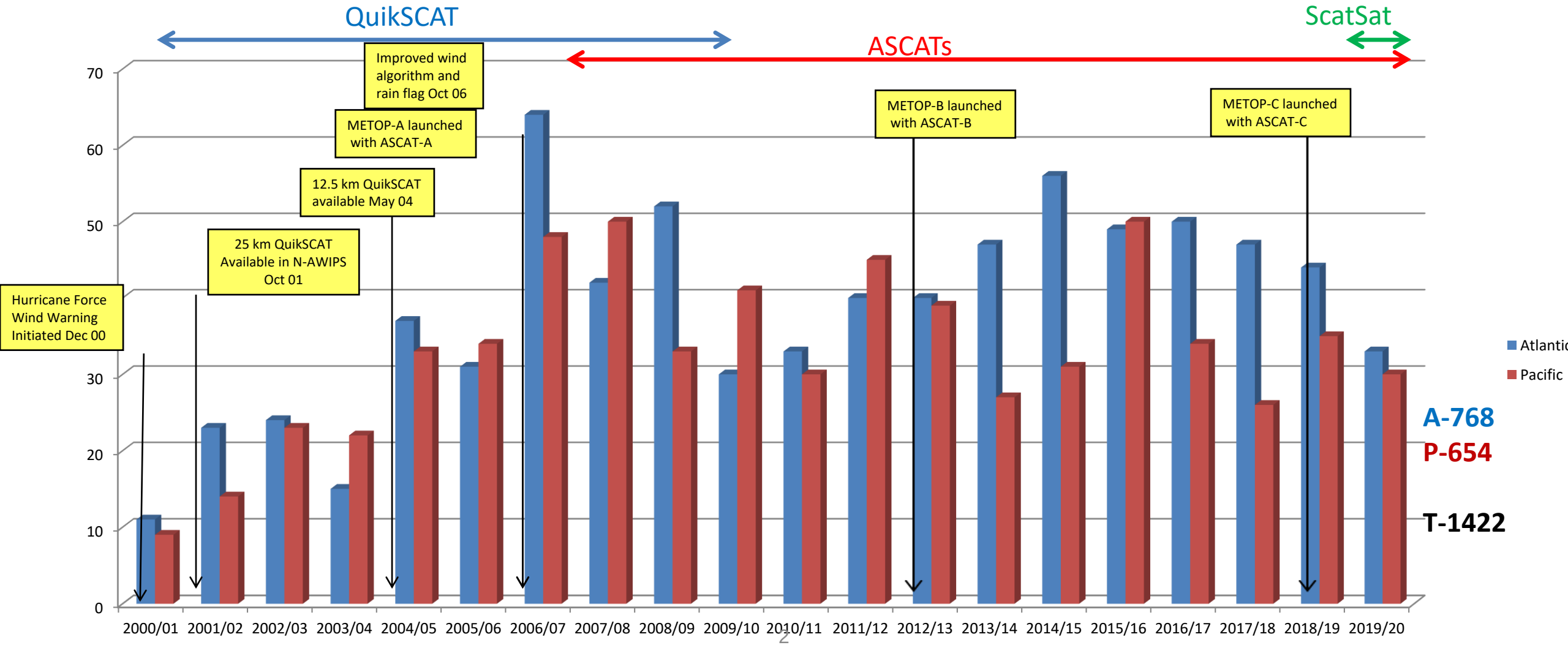
North Atlantic

- Hurricane Force – 940 mb
- Winds 70 to 90 kt, seas to 54 ft
- HF within 480 nm SW Quadrant
- 3 additional Storm Warnings
- 1 Gale Warning
- NOAA P-3 - Ocean Winds Winter

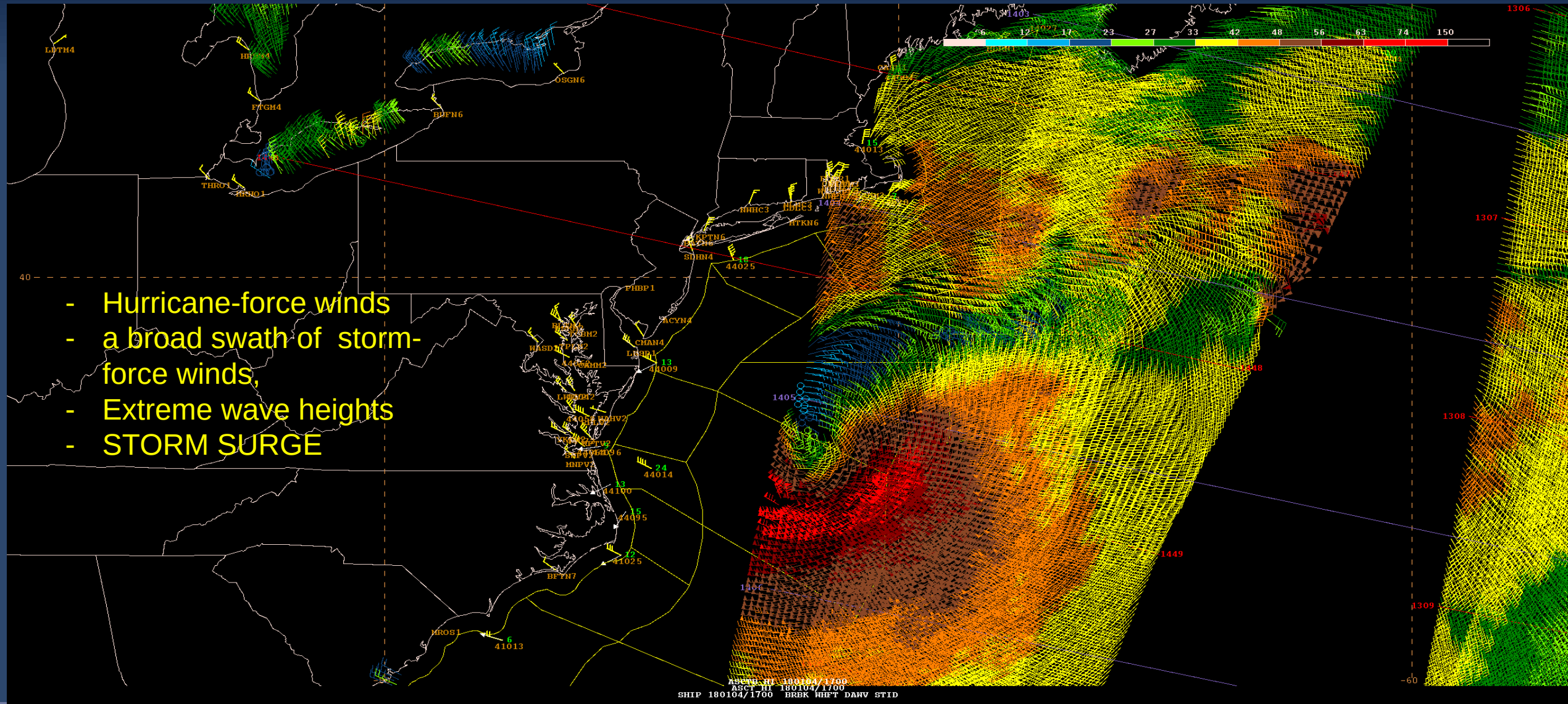
Joe Sienkiewicz

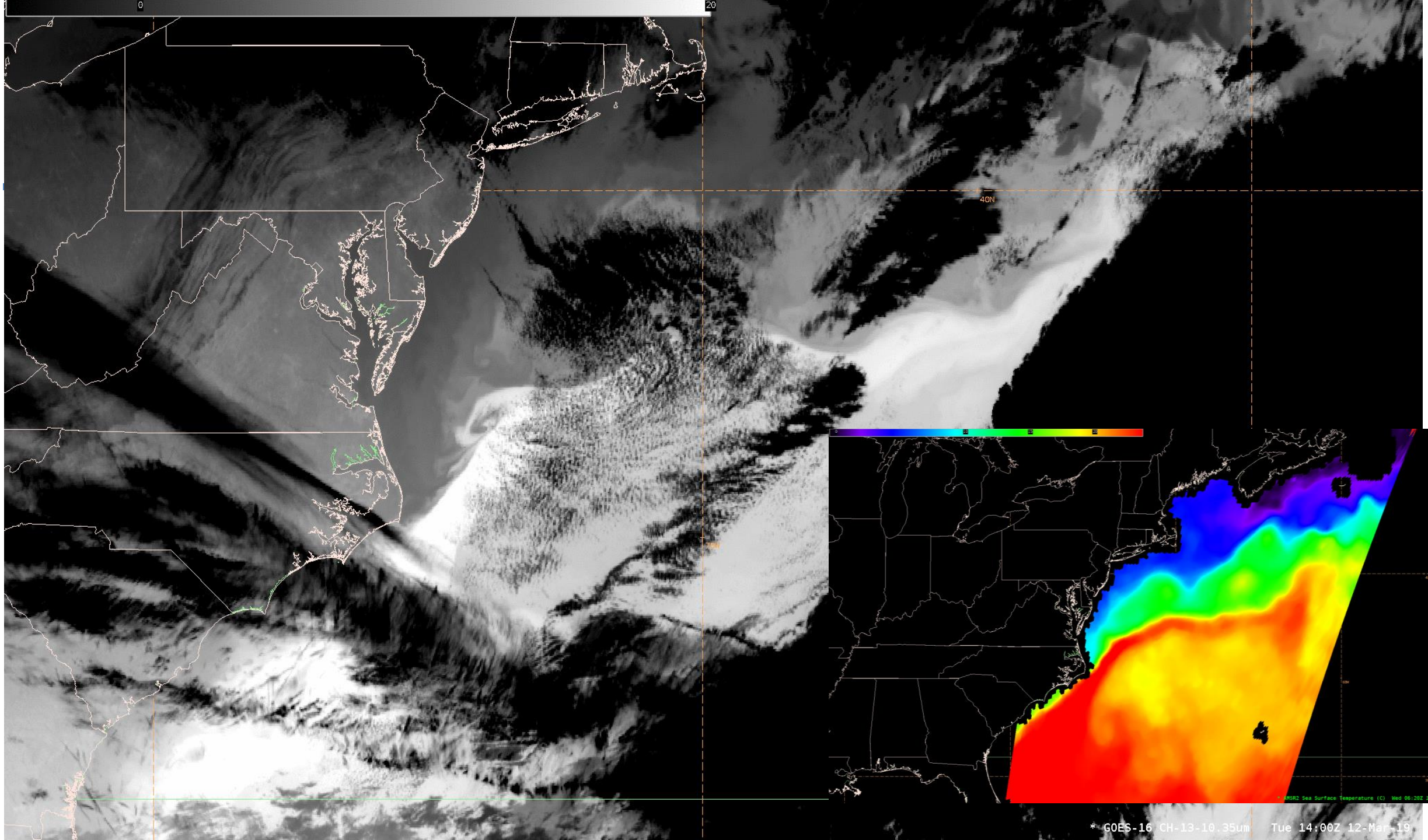
Ocean Prediction Center

Hurricane Force Extra-Tropical Cyclones 2001-2020



ASCAT A, B January 4, 2018

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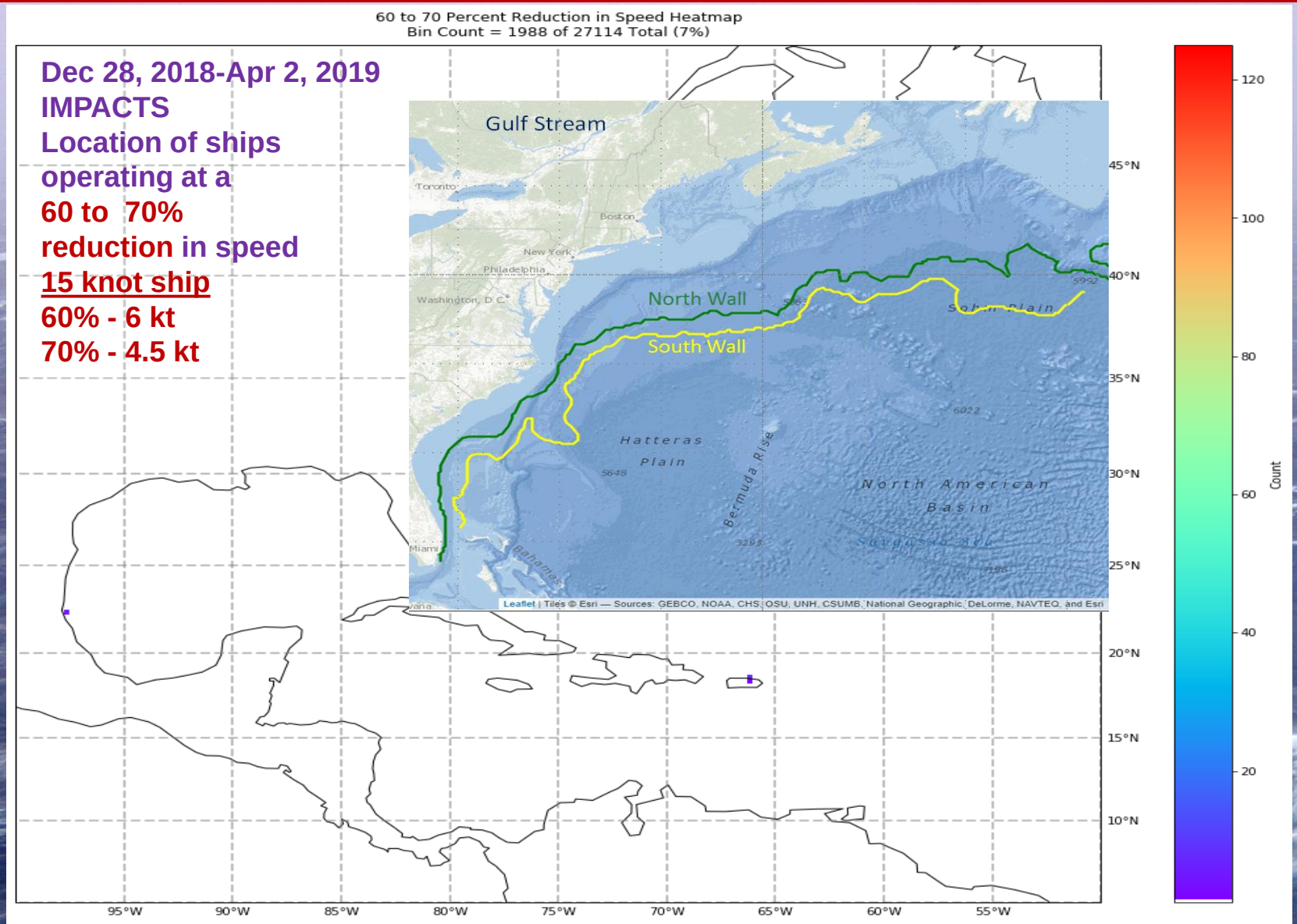
40N
* AMSR2 Sea Surface Temperature (C) Wed 06:20Z 13-Mar-19
* GOES-16 CH-13-10.35um Tue 14:00Z 12-Mar-19

Extreme Maritime Weather – Challenge – Observations, Prediction



Thoughts – going forward

- Improved services are linked directly to observations
- Continue to focus on extremes (tropical and extra-tropical continuum)
  - winds, (scatterometry)
  - waves,
  - ice,
  - storm surge
- Underutilized capabilities (i.e., oceanic lightning, polar data)
- Ocean
  - Geostationary capability revealing the complexity (SST, circulation)
  - Much more to waves than height – full spectra
  - Current – we infer at a scale much coarser than nature and impacts