NOAA SATELLITE PROGRAM and Applications

Mitch Goldberg
Chief, Satellite Meteorology and Climatology Division

Image:
MODIS Land Group,
NASA GSFC
March 2000

Dr. Lubchenco's New Vision

National Oceanic and Atmospheric Administration

Dr. Jane Lubchenco

NOAA Mission

To understand and predict changes in Earth's environment and conserve and manage coastal and marine resources to meet our nation's economic, social, and environmental needs

- **NOAA's Priorities**

1. Ensure continuity of climate, weather, and ocean observations, both *in situ* and from space
2. Development of a National Climate Service
3. Improve weather forecasts & disaster warnings
4. Eliminate overfishing and ensure the sustainability of marine fisheries
5. Promote sustainable, resilient, and healthy coastal communities
6. Strengthen Arctic science and stewardship

NOAA Organizational Chart

CORPORATE FUNCTIONS

Under Secretary of Commerce for Oceans & Atmosphere & Administrator
Dr. Jane Lubchenco

Assistant Secretary of Commerce for Oceans & Atmosphere and Deputy Administrator
Vacant

Deputy Under Secretary for Oceans & Atmosphere
Mary M. Glackin

Chief of Staff
Margaret Spring

Deputy Assistant Secretary for International Affairs
Dr. James M. Turner

Deputy Assistant Secretary for Oceans & Atmosphere
Vacant

Deputy Chief of Staff
Jeff Payne (A)

Office of Decision Coordination & Executive Secretariat
Kelly Quickle

Program Coordination Office
Jeff Payne (A)

Office of Military Affairs
LT Col David Miller, USAF
CAPT Mike Angove, USN

General Counsel
Lois Schiffer

Legislative Affairs
John Gray

Communications
Justin Kenney

Workforce Management
Eduardo Ribas

Education
Louisa Koch

Chief Information Officer/High Perf. Computing & Comm.
Joe Klimavicz

Program Analysis & Evaluation
Stephen D. Austin

Chief Administrative Officer
William Broglie

Chief Financial Officer
Maureen Wylie

Federal Coordinator for Meteorology
Sam Williamson

Acquisition & Grants
Mitchell J. Ross

Marine & Aviation Operations
RADM Jonathan W. Bailey

LINE OFFICES

Assistant Administrator
Oceanic & Atmospheric Research (OAR)
Dr. Rick Spinrad

Assistant Administrator
National Ocean Service (NOS)
David Kennedy (A)

Assistant Administrator
National Environmental Satellite, Data & Information Service (NESDIS)
Mary Kicza

Assistant Administrator
National Marine Fisheries Service (NMFS)
Dr. Jim Balsiger (A)

Assistant Administrator
National Weather Service (NWS)
Dr. Jack Hayes

Assistant Administrator
Program Planning & Integration (PPI)
Laura Furgione

MISSION GOALS

Ecosystem
Dr. Steve Murawski

Climate
Dr. Chet Koblinsky

Weather & Water
Edward Johnson (A)

Commerce & Transportation
Ashley Chappell (A)

MISSION SUPPORT

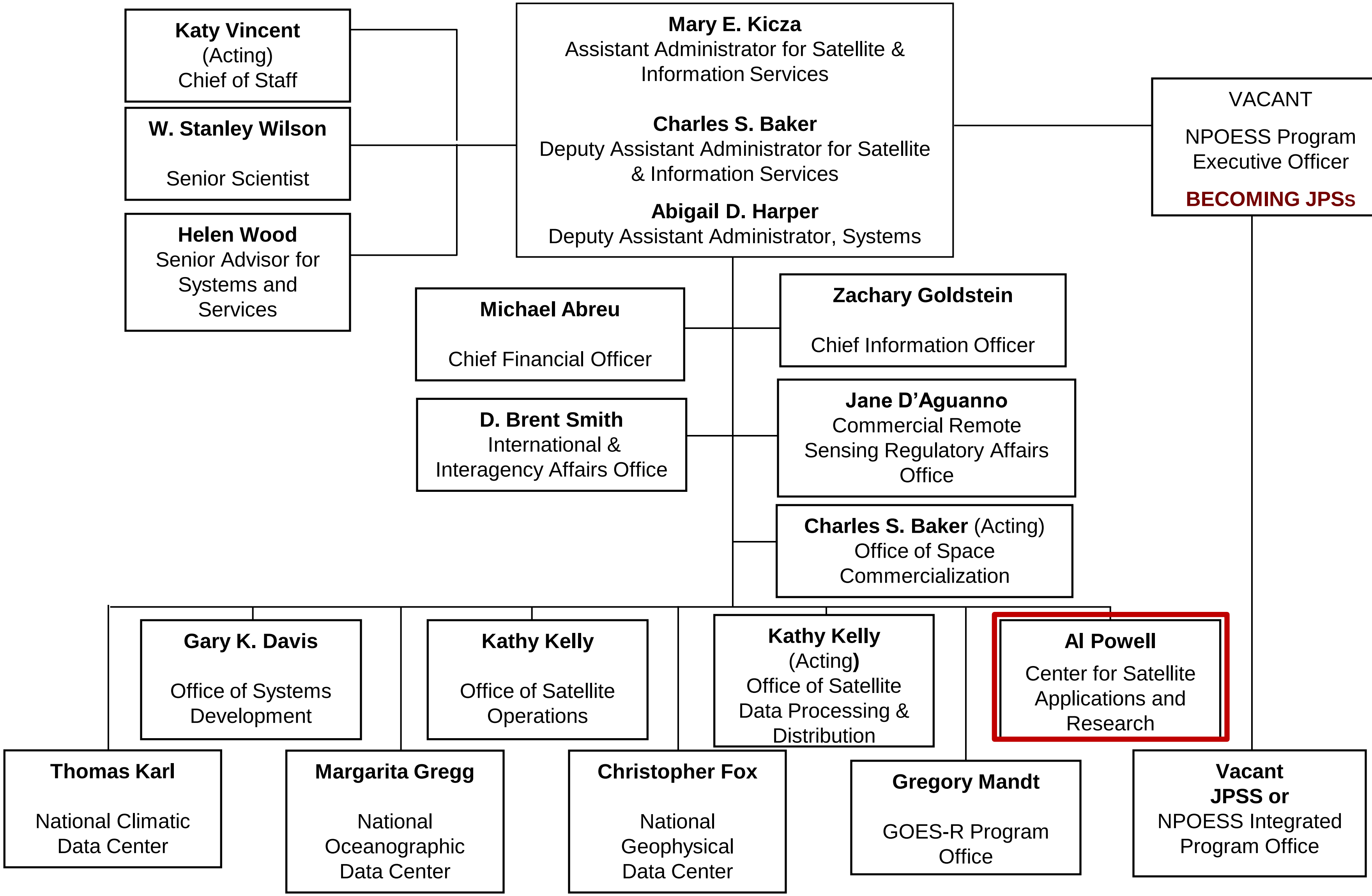
Satellite Services
Michael Crison

Modeling & Observing Infrastructure
Kenneth McDonald

Fleet Services
Tajr Hull

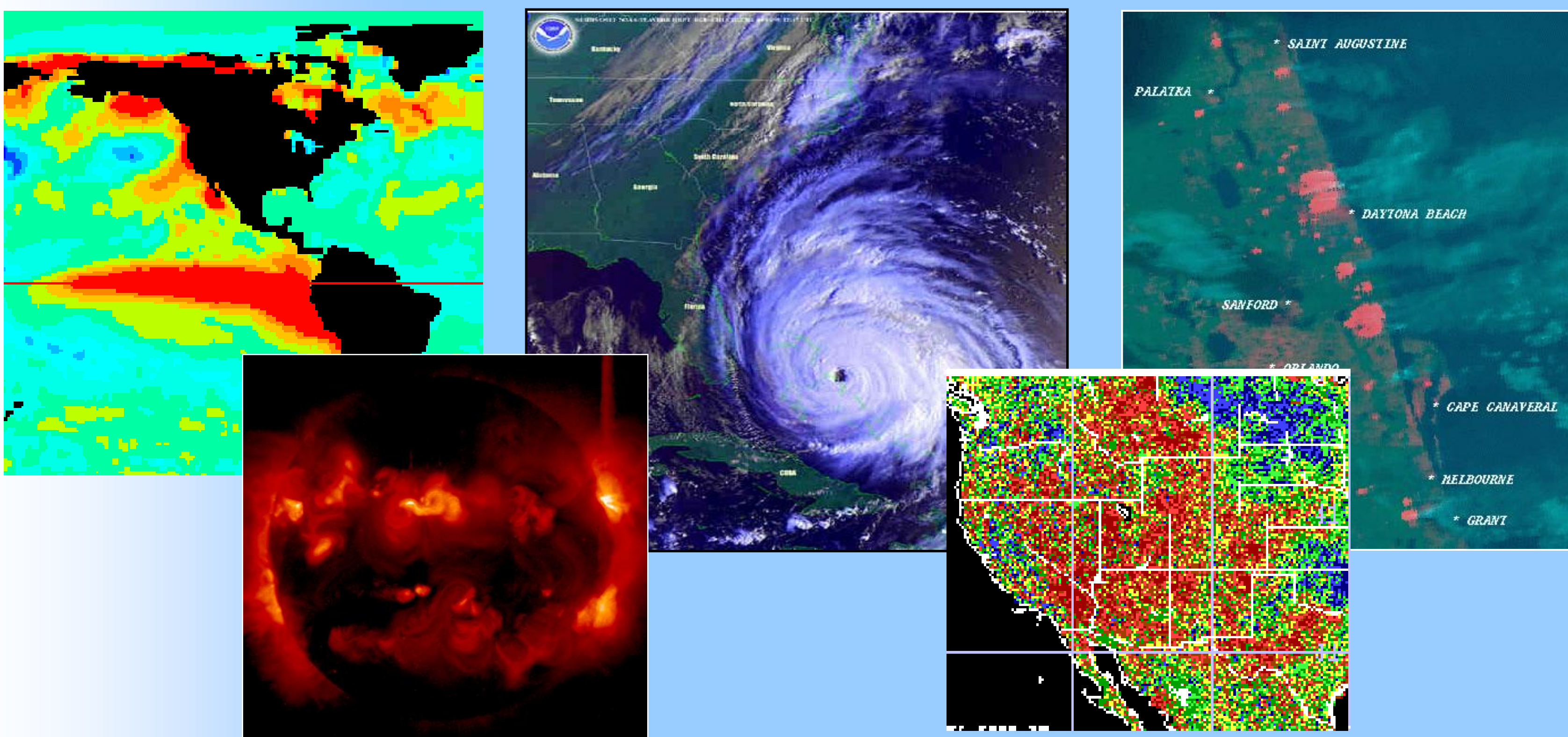
Leadership & Corporate Services
William Broglie

NESDIS Organizational Chart

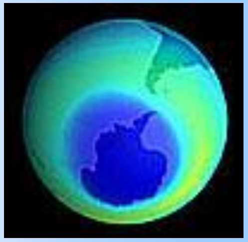


NOAA’s Environmental Information Service

NOAA, through the National Environmental Satellite, Data, and Information Service (NESDIS), provides a space-based environmental operational remote sensing capability that makes improved weather, climate, and ocean assessments and predictions possible.



NOAA Satellite Applications

- Weather analysis, warnings and prediction
- Climate monitoring and prediction
- Environmental hazards monitoring
- Oceanic monitoring and prediction
- Vegetation, agricultural, and hydrological applications
- Atmospheric, oceanic, and climate research

NOAA Satellite Products

- **Atmosphere**
  - Temperature soundings
  - Moisture soundings
  - Winds
  - Clouds
  - Aerosols
  - Earth Radiation Budget
  - Precipitation
  - Ozone

- **Ocean**
  - Surface temperature
  - Ice cover
  - Surface winds
  - Color
  - Sea level

- **Land**
  - Vegetation condition
  - Snow pack characteristics
  - Other land characteristics (e,g., albedo, skin temperature, soil wetness, insolation)
  - Fire locations/Smoke Plumes

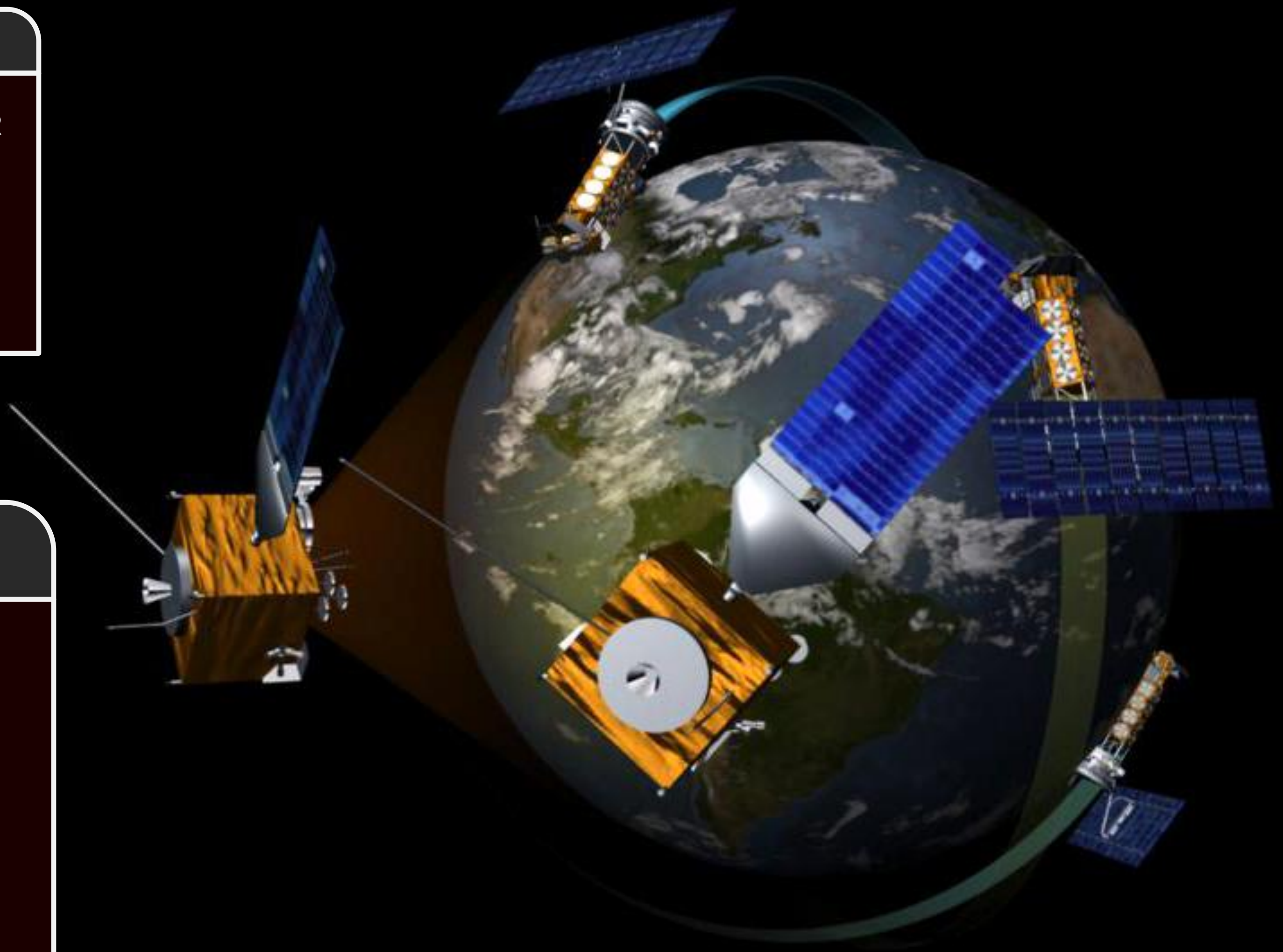
Satellite Constellation

NOAA Operational

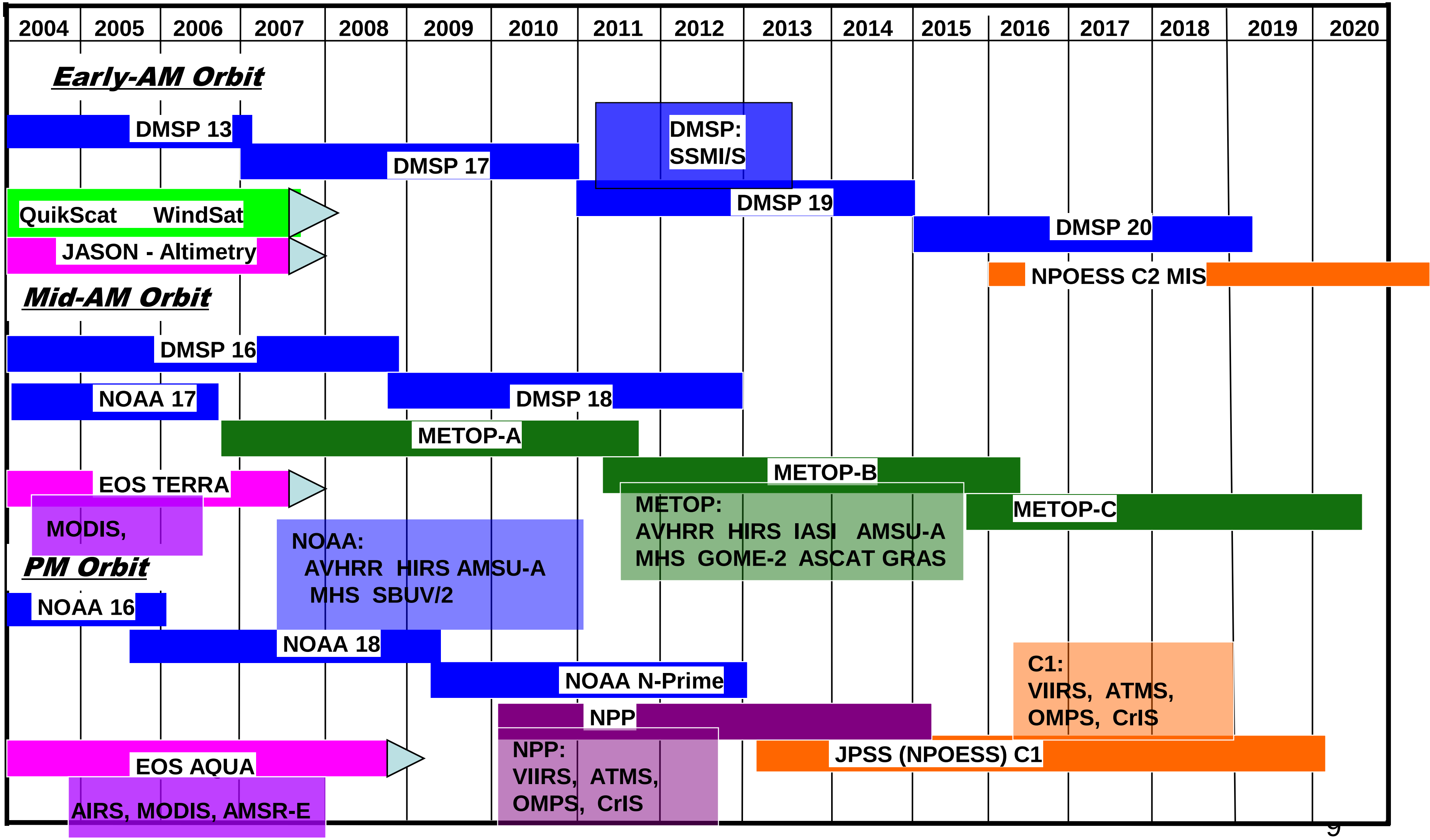
GEO	GOES East GOES West	GOES-R
LEO	DMSP Metop NOAA	JPSS

Example International Systems

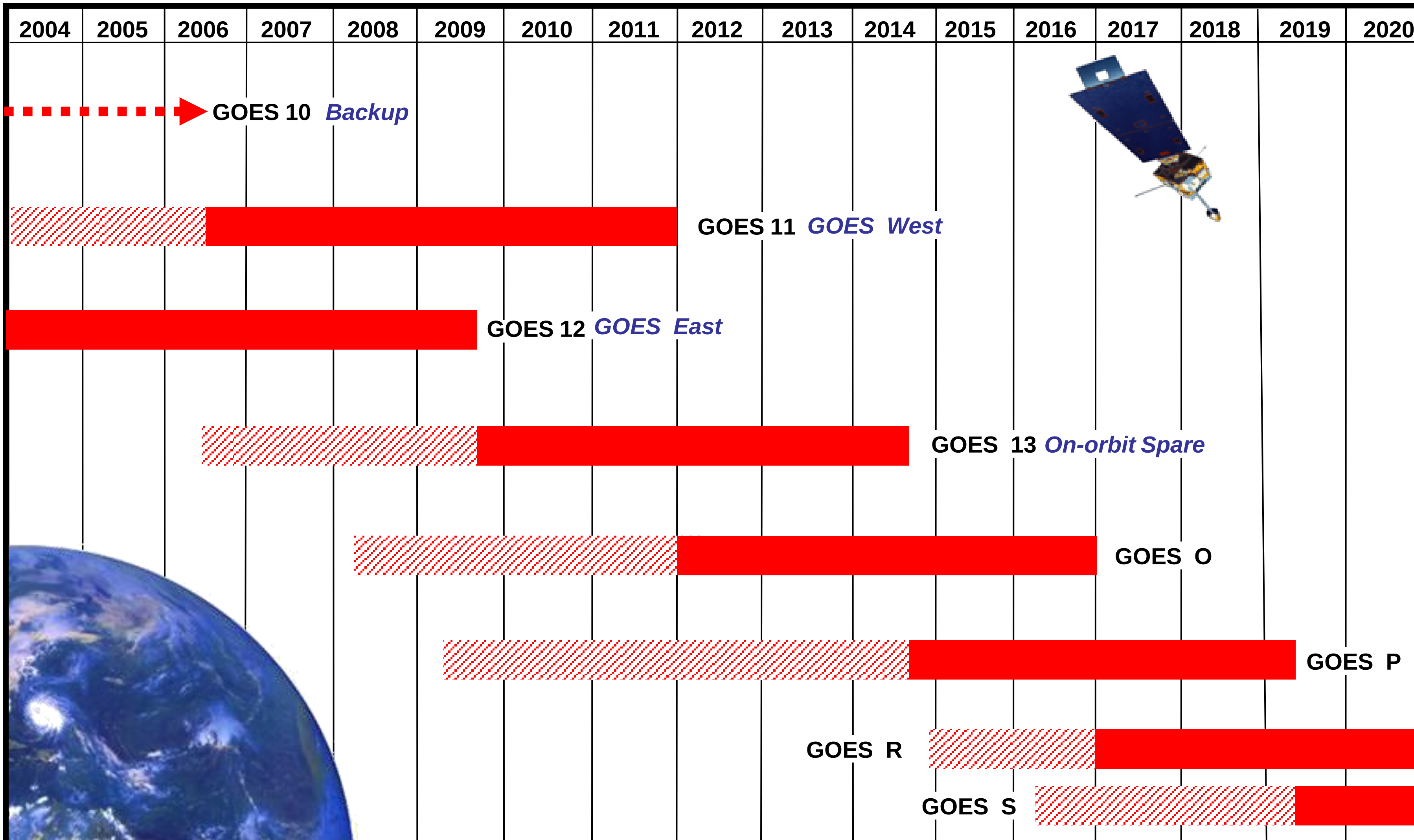
GEO	MSG INSAT METEOSAT FengYun	Europe India Japan China
LEO	Jason-2/3 CLARREO DESDnyl SMAP ICESat-II COSMIC	France NASA NASA NASA NASA Taiwan



US Planned Missions - Polar



NOAA Planned Missions - Geostationary



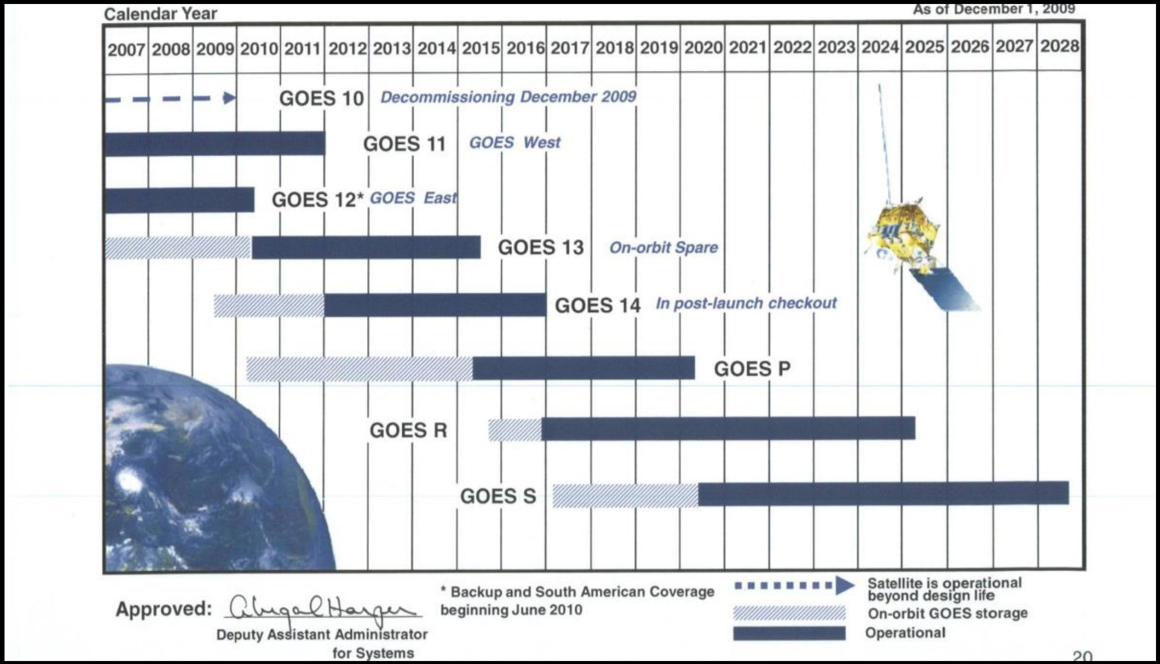
On-orbit GOES storage

Operational

Satellite is operational beyond design life

GOES-R series

- GOES-R series is a follow-on to the existing line of NOAA's geostationary satellites
- GOES-R Instruments:
  - Advanced Baseline Imager (ABI) - Geostationary Lightning Mapper (GLM)
  - Extreme Ultra Violet and X-Ray Irradiance Sensors (EXIS)
  - Solar Ultra Violet Imager (SUVI) - Space Environment In-Situ Suite (SEISS)



Approximate spectral and spatial resolutions of US GOES Imagers

Box sizes represent detector sizes

	~ Band Center (um)	GOES-6/7	GOES-8/11	GOES-12/N	GOES-O/P	GOES-R+
Visible	0.47					
	0.64					
Near-IR	*0.86*					
	1.6					
	1.38					
	2.2					
Infrared	3.9					
	6.2					
	6.5/6.7/7	14km "MSI mode"	8	4		2
	7.3					
	8.5					
	9.7					
	10.35					
	11.2					
	12.3					
	[illegible]					

Partners

- Operational Satellite Programs
  - POES, GOES, JPSS (NPOESS), EUMETSAT, DMSP, GOES-R
  - JASON, JAXA GCOM, COSMIC (GPS), MODIS, etc.
- NASA
  - Collaborative work on new satellite science, JPSS and Decadal Survery Missions
- Cooperative Institutes
  - NOAA's academic and research partners
- International Missions
  - Provide opportunities to leverage additional satellite data (EUMETSAT, ESA JAXA, ISRO, etc.)

Overview of JAXA SGLI instrument

GCOM-C SGLI characteristics	
Scanning Type	SGLI-VNR Push-broom electric scan (VN & P) SGLI-IRS Wisk-broom mechanical scan (SW & T)
Observation Channel (see details in next page)	SGLI-VNR (Visible & Near infrared) Non-Polarized Observation 11 channel Polarized Observation 2 channel
	SGLI-IRS Shortwave infrared 4 channel Thermal infrared 2 channel
Swath	1150km cross track (VN & P) 1400km cross track (SW & T)
Digitalization	12bit
Polarization	3 polarization angles for P
observing direction	Along Track 0, +45 deg and -45 deg for P Nadir for VN, SW and T

SGLI channels

CH	λ	$\Delta\lambda$	L_{std}	L_{max}	IFOV
	nm		VN, P: $W/m^2/sr/\mu m$ T: Kelvin		m
VN1	380	10	60	210	250
VN2	412	10	75	250	250
VN3	443	10	64	400	250
VN4	490	10	53	120	250
VN5	530	20	41	350	250
VN6	565	20	33	90	250
VN7	670	10	23	62	250
VN8	670	20	25	210	250
VN9	763	8	40	350	1000
VN10	865	20	8	30	250
VN11	865	20	30	300	250
SW1	1050	20	57	248	1000
SW2	1380	20	8	103	1000
SW3	1640	200	3	50	250
SW4	2210	50	1.9	20	1000
T1	10800	700	300	340	500
T2	12000	700	300	340	500
P1	670	20	25	250	1000
P2	865	20	30	300	1000

Comparison with VIIRS

CH	λ	Δλ	L_{std}	L_{max}	IFOV
	nm		VN, P: $W/m^2/sr/\mu m$ T: Kelvin		m
VN1	380	10	60	210	250
VN2	412	10	75	250	250
VN3	443	10	64	400	250
VN4	490	10	53	120	250
VN5	530	20	41	350	250
VN6	565	20	33	90	250
VN7	670	10	23	62	250
VN8	670	20	25	210	250
VN9	763	8	40	350	1000
VN10	865	20	8	30	250
VN11	865	20	30	300	250
SW1	1050	20	57	248	1000
SW2	1380	20	8	103	1000
SW3	1640	200	3	50	250
SW4	2210	50	1.9	20	1000
T1	10800	700	300	340	500
T2	12000	700	300	340	500
P1	670	20	25	250	1000
P2	865	20	30	300	1000

Table title: SGLI channels

VIIRS Sensor Bands

		Band No.	Wave-length (µm)	Horiz Sample Interval (km Downtrack x Crosstrack): Nadir	End of Scan	Driving EDRs	Radi-ance Range	Ltyp or Ttyp
VIS/NIR FPA	Silicon PIN Diodes	M1	0.412	0.742 x 0.259	1.60 x 1.58	Ocean Color Aerosols	Low High	44.9 155
		M2	0.445	0.742 x 0.259	1.60 x 1.58	Ocean Color Aerosols	Low High	40 146
		M3	0.488	0.742 x 0.259	1.60 x 1.58	Ocean Color Aerosols	Low High	32 123
		M4	0.555	0.742 x 0.259	1.60 x 1.58	Ocean Color Aerosols	Low High	21 90
		I1	0.640	0.371 x 0.387	0.80 x 0.789	Imagery	Single	22
		M5	0.672	0.742 x 0.259	1.60 x 1.58	Ocean Color Aerosols	Low High	10 68
		M6	0.746	0.742 x 0.776	1.60 x 1.58	Atmospheric Corr'n	Single	9.6
		I2	0.865	0.371 x 0.387	0.80 x 0.789	NDVI	Single	25
		M7	0.865	0.742 x 0.259	1.60 x 1.58	Ocean Color Aerosols	Low High	6.4 33.4
CCD		DNB	0.7	0.742 x 0.742	0.742 x 0.742	Imagery	Var.	6.70E-05
S/MWIR	PV HgCdTe (HCT)	M8	1.24	0.742 x 0.776	1.60 x 1.58	Cloud Particle Size	Single	5.4
		M9	1.378	0.742 x 0.776	1.60 x 1.58	Cirrus/Cloud Cover	Single	6
		I3	1.61	0.371 x 0.387	0.80 x 0.789	Binary Snow Map	Single	7.3
		M10	1.61	0.742 x 0.776	1.60 x 1.58	Snow Fraction	Single	7.3
		M11	2.25	0.742 x 0.776	1.60 x 1.58	Clouds	Single	0.12
		I4	3.74	0.371 x 0.387	0.80 x 0.789	Imagery Clouds	Single	270 K
		M12	3.70	0.742 x 0.776	1.60 x 1.58	SST	Single	270 K
		M13	4.05	0.742 x 0.259	1.60 x 1.58	SST Fires	Low High	300 K 380 K
LWIR	PV HCT	M14	8.55	0.742 x 0.776	1.60 x 1.58	Cloud Top Properties	Single	270 K
		M15	10.763	0.742 x 0.776	1.60 x 1.58	SST	Single	300 K
		I5	11.450	0.371 x 0.387	0.80 x 0.789	Cloud Imagery	Single	210 K
		M16	12.013	0.742 x 0.776	1.60 x 1.58	SST	Single	300 K

ESA Sentinel 2 2012 10:30 ECT (Descending) Twin Satellites

Instruments	Products/Applications
• Wide-swath high resolution super spectral imaging • 13 bands: 443 -2190 nm • Spectral resolution: 15 – 180 nm • Spatial resolution: 10, 20, 60 m, swath:290 km • Twin satellites, revisit time 5 days • 7 year life	• *Land cover, usage, and change detection maps* • *Land variables: leaf chlorophyll and water content and leaf area index, vegetation index.* • *Risk mapping: fire monitoring, burnt scar* • *Fast images for disaster relief.*

NOAA Interest: Cal/Val & Product Validation Reference Instrument, Data access by NOAA via ESA archive (real-time not necessary)

ESA Sentinel 3 2013 10:00 ECT (Descending) Twin Satellites (7 years)

Instruments	Products/Applications
• Ocean and Land Color Instrument (OLCI): 1270 km swath, 300m spatial, 21 bands (400 – 1020 nm) • Sea and Land Surface Temperature (SLST) : dual scan 1675 km swath nadir,/750 km backward, ~ 1km spatial, 9 bands (550 – 1200 nm) • Ku/C Radar Altimeter (SRAL) • Microwave Radiometer (MWR) 23.8, 36.5 GHz (wet troposphere correction for SRAL)	• *sea and land colour data, in continuation of MERIS (Envisat)* • *sea and land surface temperature, in continuation of AATSR (Envisat)* • *sea-surface and land-ice topography, in continuation of Envisat altimetry* • *along-track SAR for coastal zones, in-land water and sea ice topography* • *vegetation products through synergy between optical instruments*

NOAA – High Interest: Ecosystems, W&W, Climate/ Ocean Color, Land and Sea Surface Temperature, Vegetation Product, Altimetry, Real-time access required

Center for Satellite Applications and Research (STAR)

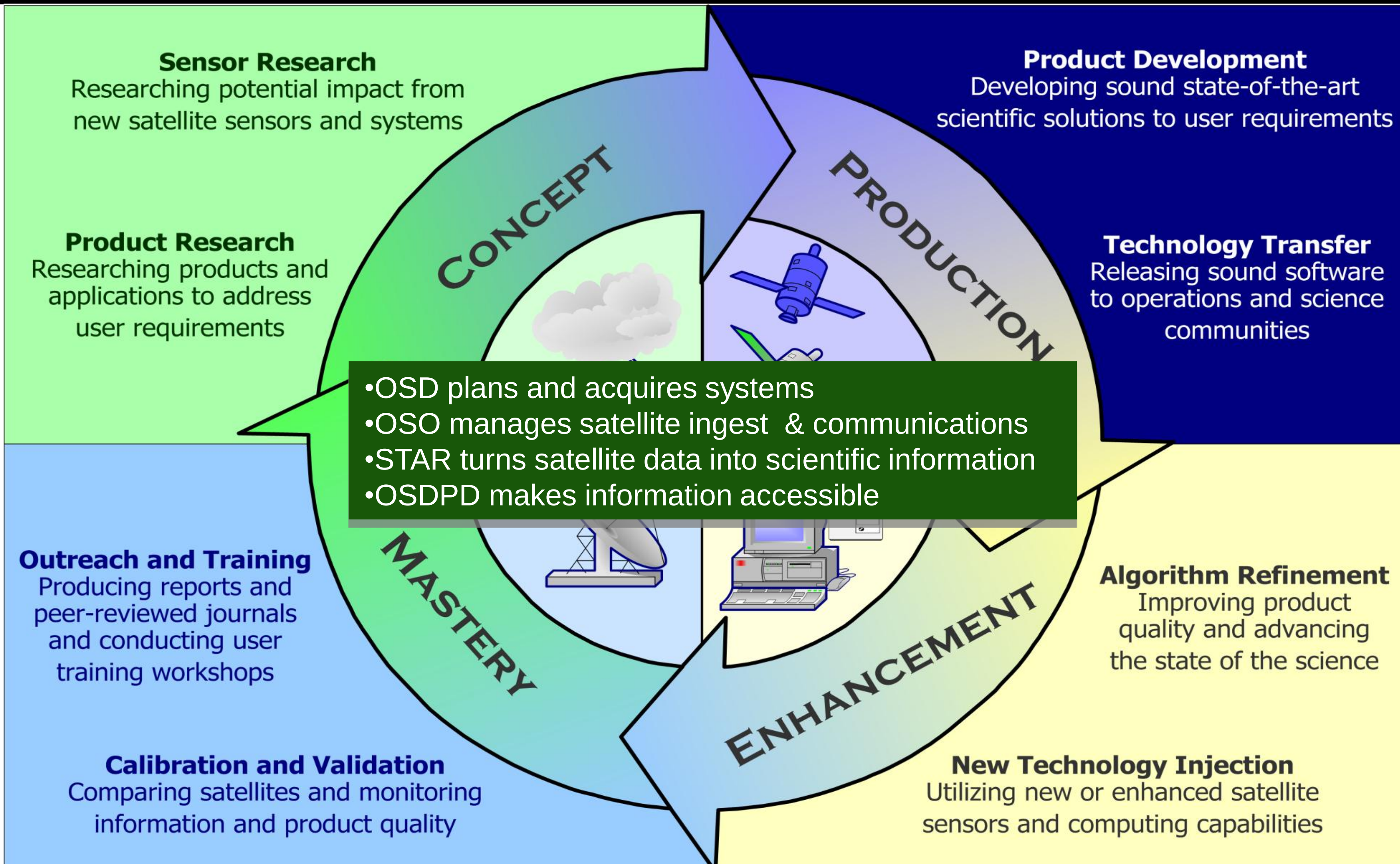
Mission

To accelerate the transfer satellite observations of the land, atmosphere, ocean, and climate from scientific research and development into routine operations,
and offer state-of-the-art data, products, and services to decision-makers.

STAR ORGANIZATION

- Director
  Al Powell
  - Deputy Director
    Michael Kalb
    - Executive Officer
      Mike Goldberg
    - Senior Scientist
      Vacant
    - Administrative, Budget & Grants Staff (Tina East, Patty Mayo, Susan Devine, Tammie Herrin, Juanita and Trivita Horton)
    - Technical Support
      Joe Brust
    - Senior Data Assimilation Scientist
      Sid Boukabara
    - **Satellite Meteorology & Climatology Division**
      Mitch Goldberg 35
      - Environ. Monitoring and Climate Branch
        Ivan Csizar 12
      - Satellite Calibration & Data Assimilation Branch
        Fuzhong Weng 12
      - Operational Products Development Branch
        Jaime Daniels (acting) 9
    - **Cooperative Research Program Division**
      Ingrid Guch 19
      - Regional & Mesoscale Meteorology Branch
        Mark DeMaria 6
      - Advanced Satellite Products Branch
        Jeff Key 7
      - Satellite Climate Studies Branch
        Ralph Ferraro 5
      - Cooperative Institute for Research In the Atmosphere (CIRA)
      - Cooperative Institute for Meteorological Satellite Studies (CIMSS)
      - Cooperative Institute For Climate Studies (CICS)
      - Cooperative Remote Sensing Science & Technology Center (CREST)
      - Cooperative Institute for Oceanographic Satellite Studies (CIOSS)
    - **Satellite Oceanography & Climatology Division**
      Paul Digiacomo 23
      - Ocean Dynamics & Data Assimilation Branch – Laury Miller 9
      - Marine Ecosystems & Climate Branch
        Celso Barrientos (act) 7
      - Satellite Ocean Sensors Branch
        Sasha Ignatov 6

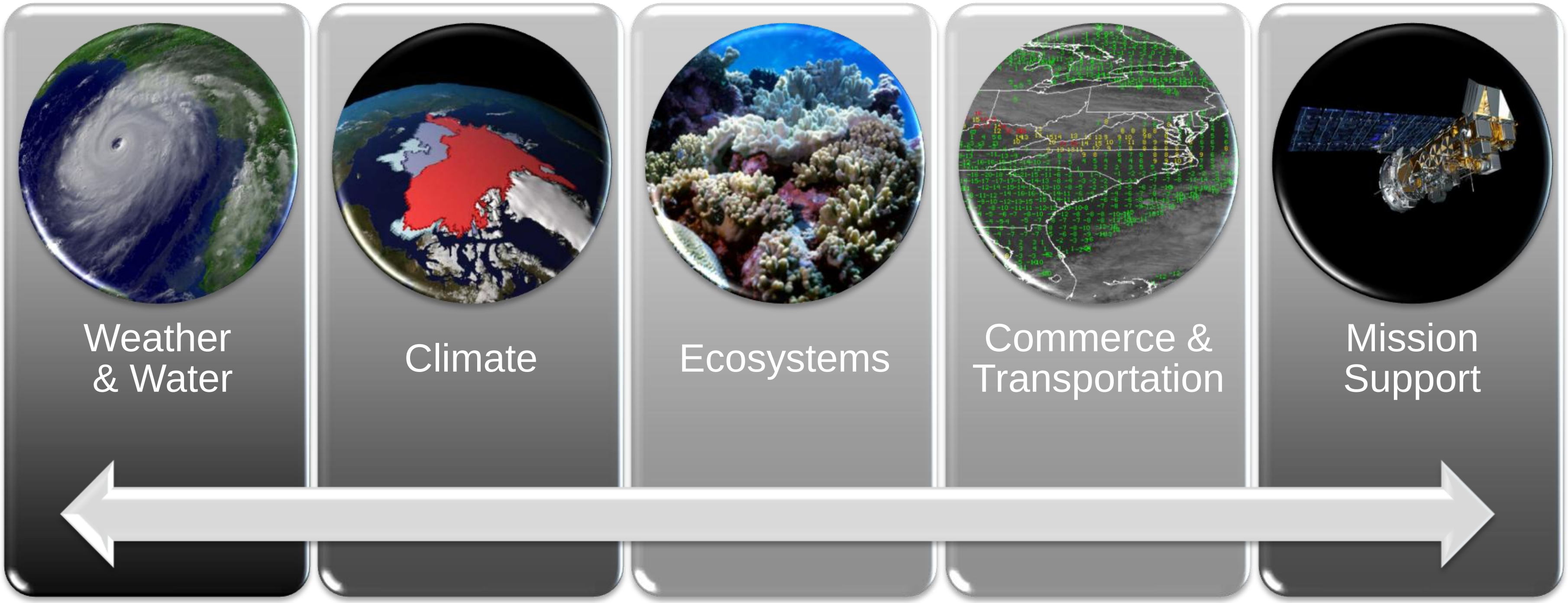
STAR Activities



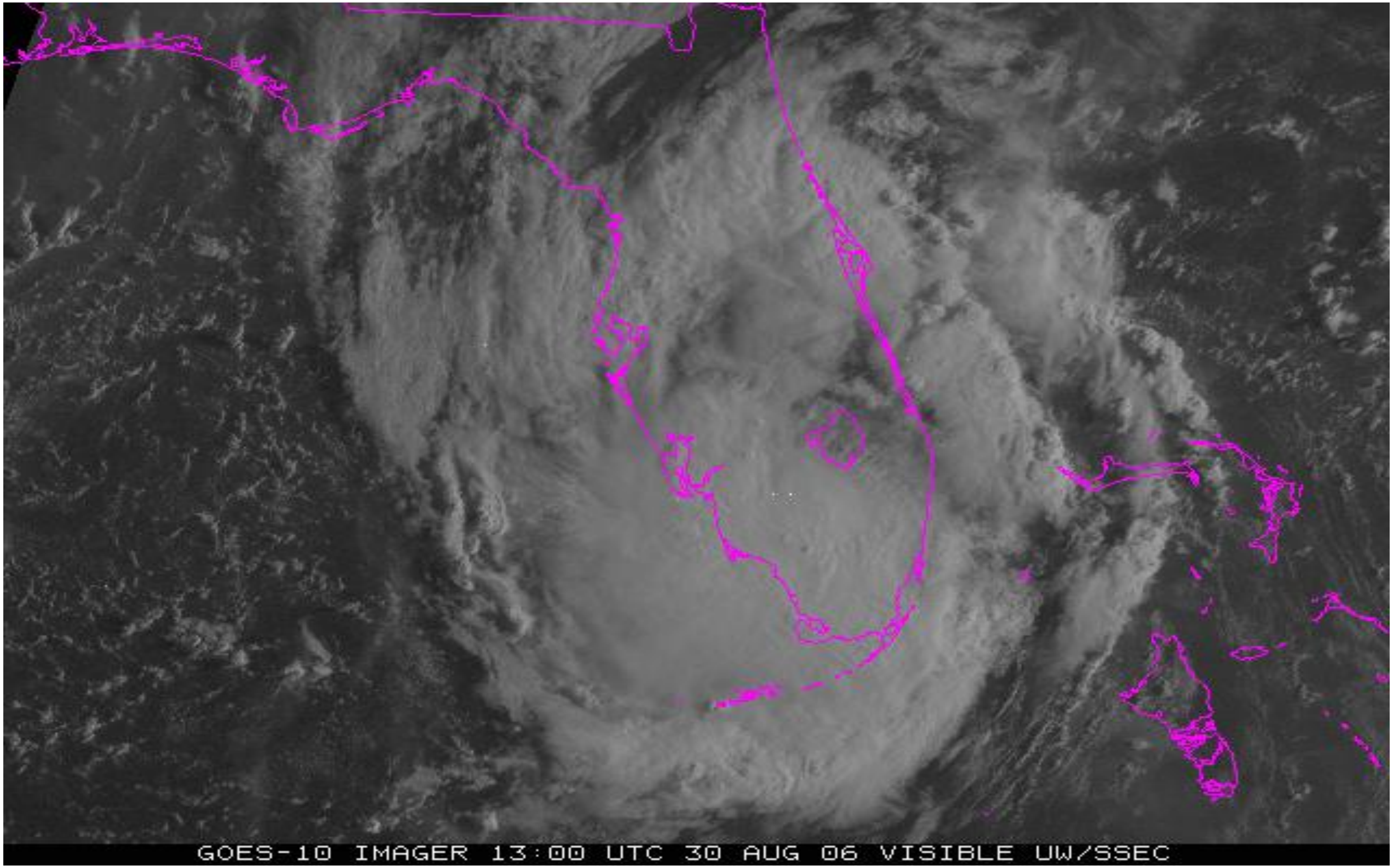
- OSD plans and acquires systems
- OSO manages satellite ingest & communications
- STAR turns satellite data into scientific information
- OSDPD makes information accessible

STAR: where the transformation of satellite data into useful environmental information occurs

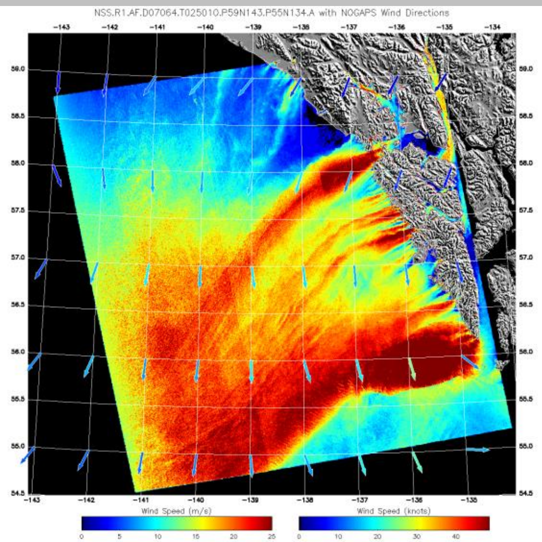
Supporting NOAA's Goals



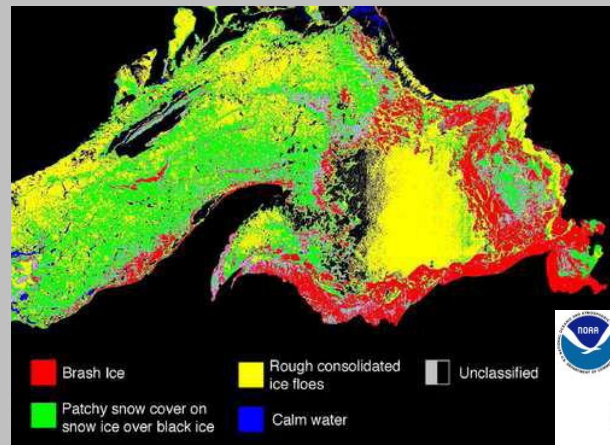
Ernesto – 1 min resolution



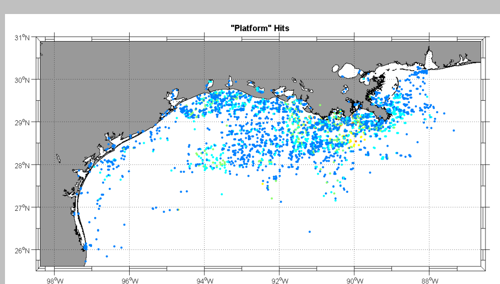
STAR Research/Development of SAR- derived Ocean Products



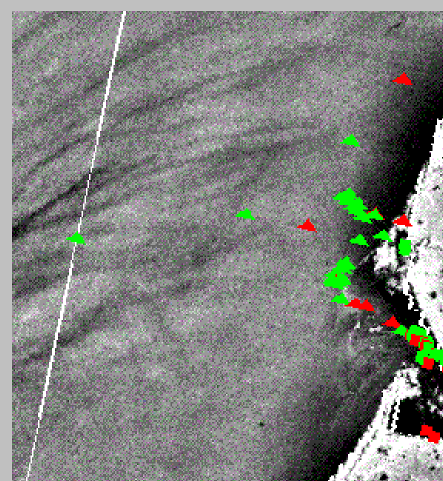
High-Resolution Winds – Gap winds in Southeast Alaska



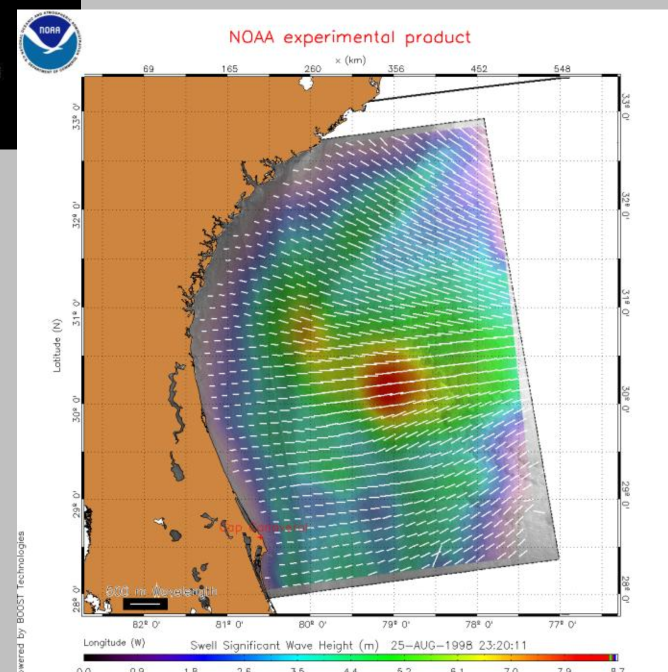
Sea and Lake Ice – Fresh water ice type in Lake Superior



Hurricane Hazard Response - oil platform changes and oil spill mapping

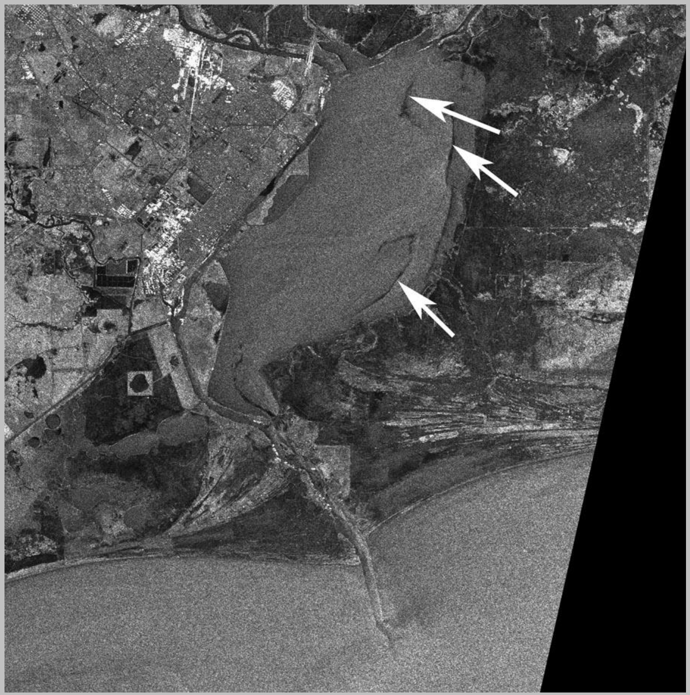


Vessel Positions Salmon Fleet, Alaska



2D Wave Field – Significant Wave Height of ocean swell waves

Towards an Operational Oil Spill Response Capability



Oil in Sabine Lake (TX/LA border)
one day after landfall of Hurricane Rita
Radarsat-1 9/25/2005

Oil spill response capability was requested by the NOAA/NOS Emergency Response Division

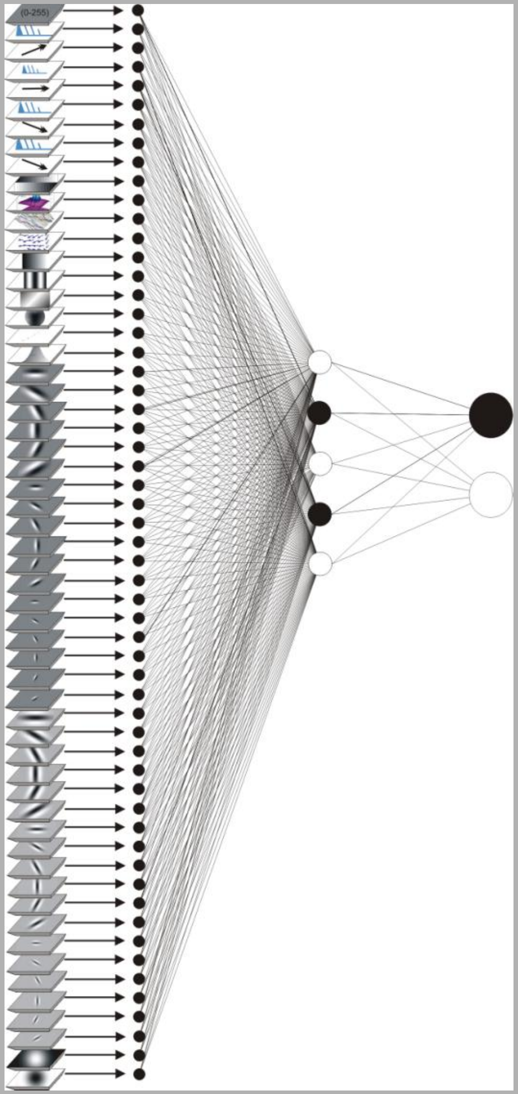
Applications include monitoring ports, oil facilities, marine sanctuaries, and coastal regions for:

1. Survey of oil released from hurricane damage to U.S. oil infrastructure (platforms, pipelines, tanks)
2. Mapping spills after accidents (ship groundings, pipeline leaks)
3. Detecting Illegal bilge pumping (port, estuary, coastal)

Steps to an Operational Oil Spill Mapping Capability
in the NOAA/NESDIS/Satellite Analysis Branch

1. Manual analysis using SAR and Sun glint imagery
2. Interactive analysis and quality control with guidance from oil spill mapping algorithms
3. Quality control of fully automated oil spill maps processed from remote sensing imagery

Oil Spill Mapping with a Texture Classifying Neural Network Algorithm (TCNNA)

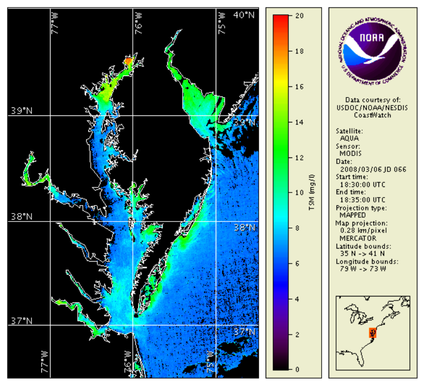


Parameters Used:

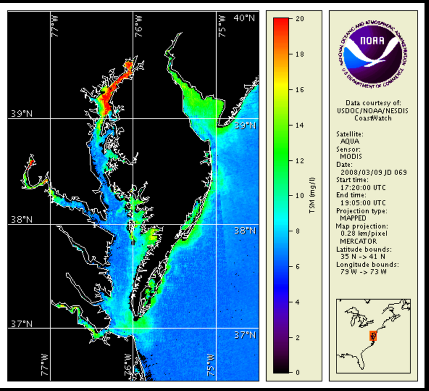
- 8bit pixel value
- Wind
- SAR Angle of Incidence
- Sea Surface Height
- Geostrophic Currents
- Neighborhood Texture
- Filter Reaction

Developing Tools to Monitor Runoff Events in the Bay

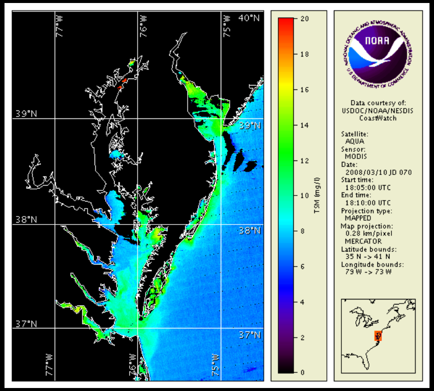
March 6, 2008



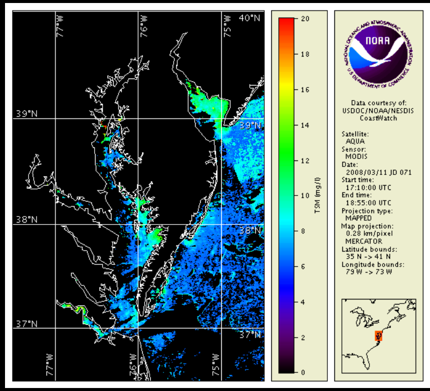
March 9, 2008



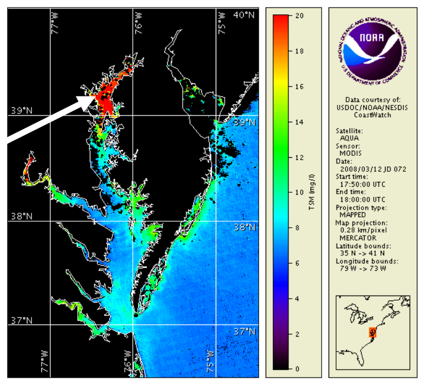
March 10, 2008



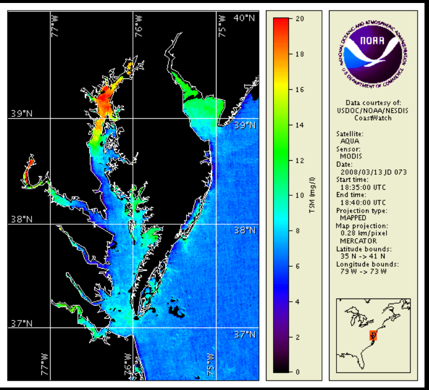
March 11, 2008



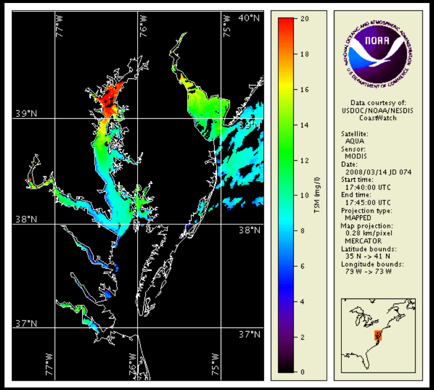
March 12, 2008



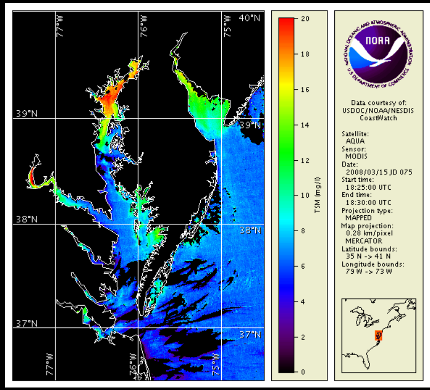
March 13, 2008



March 14, 2008

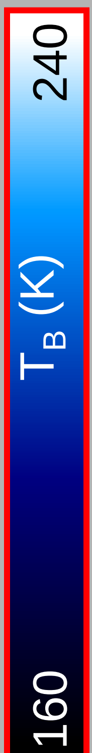


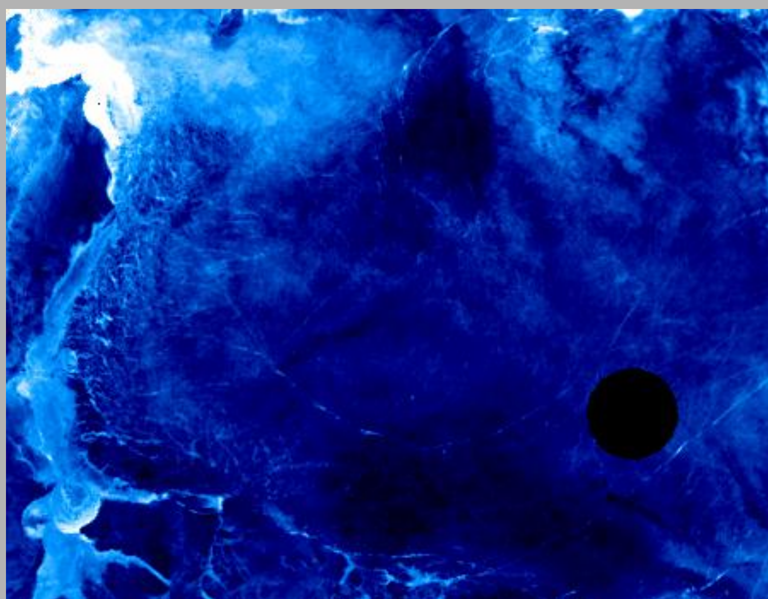
March 15, 2008



The satellite ocean color products developed by the COCE Team can be utilized to monitor sediment sources and quantify sediments loads into the Chesapeake Bay. Above: The evolution of high sediment loads in the Northern Chesapeake Bay is demonstrated during a record rain event in the Chesapeake Bay Watershed during March 2008.

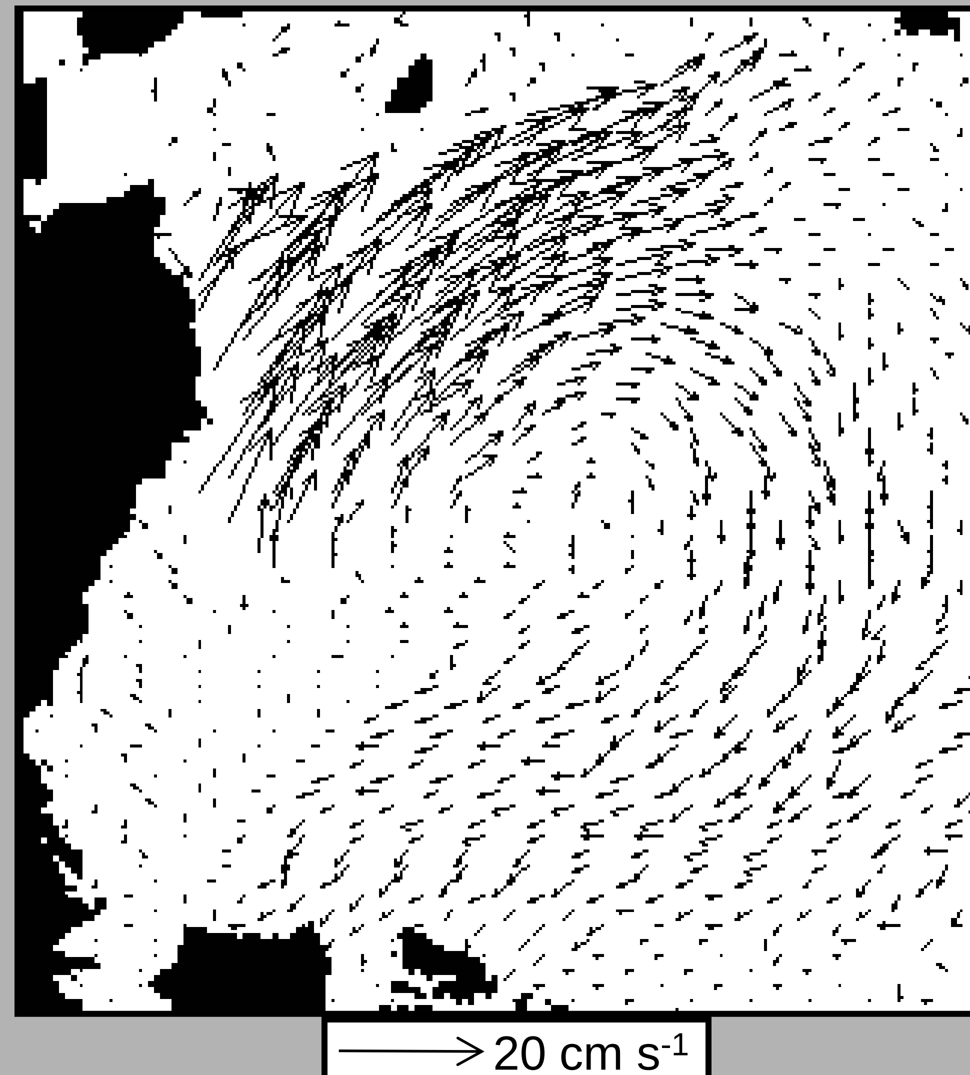
Sea Ice Dynamics From AMSR-E Ice Drift Vectors



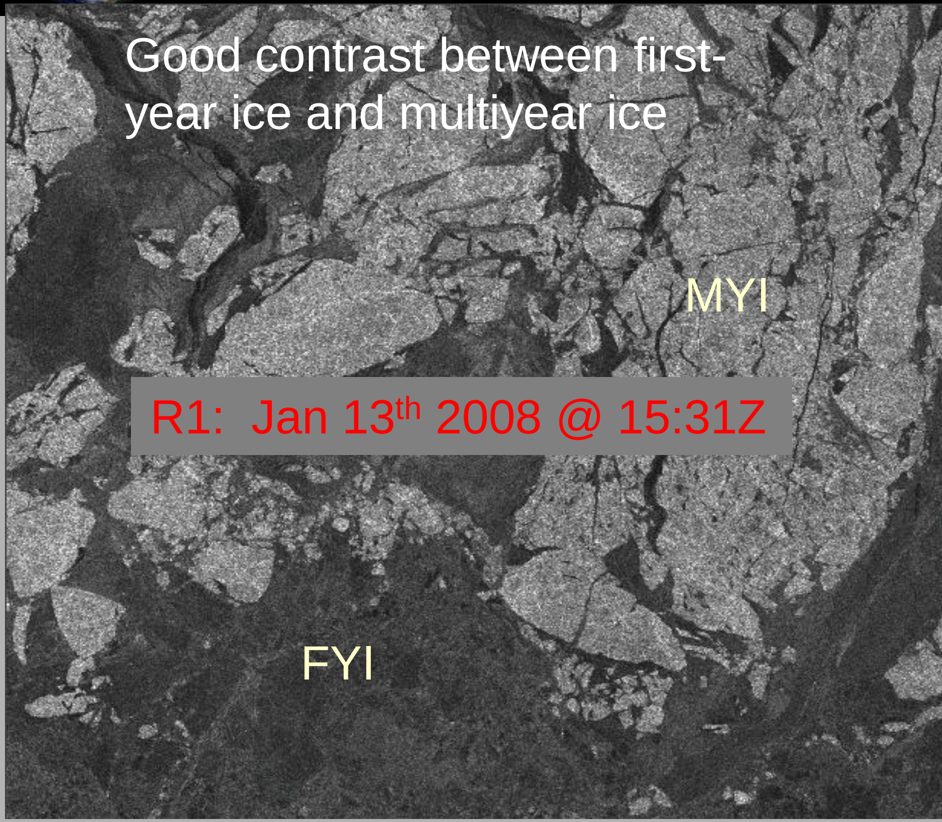


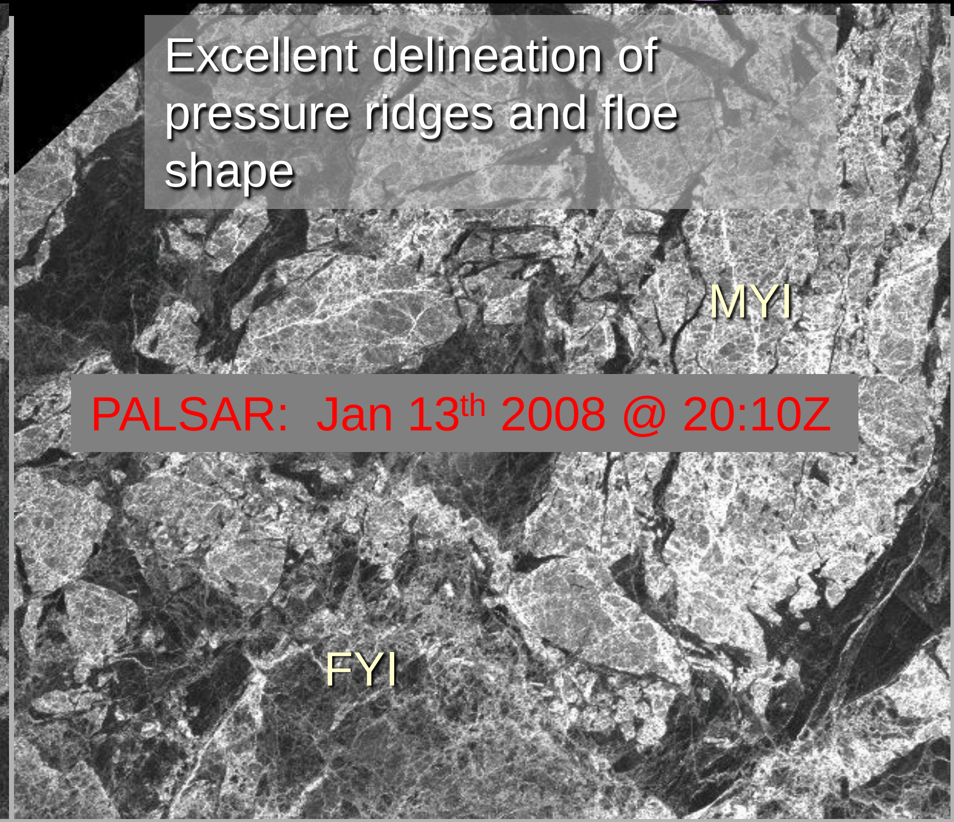
89V GHz T_Bs, 1 – 31 March

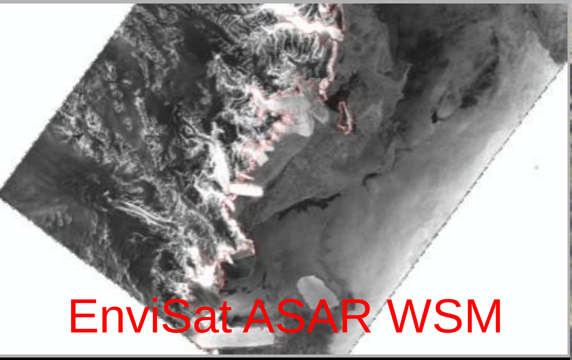
Drift vectors at 6.25 km Resolution

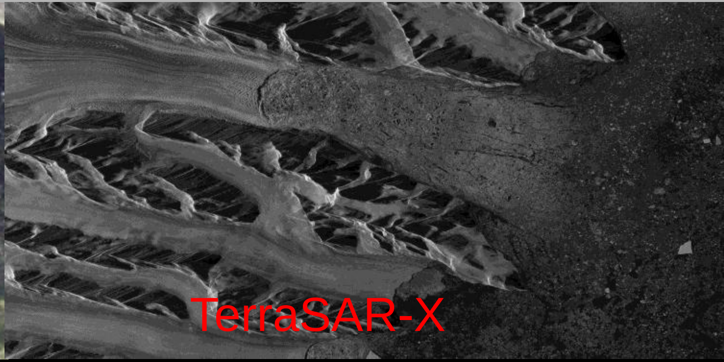


Multiband/Multi-Polarization Research





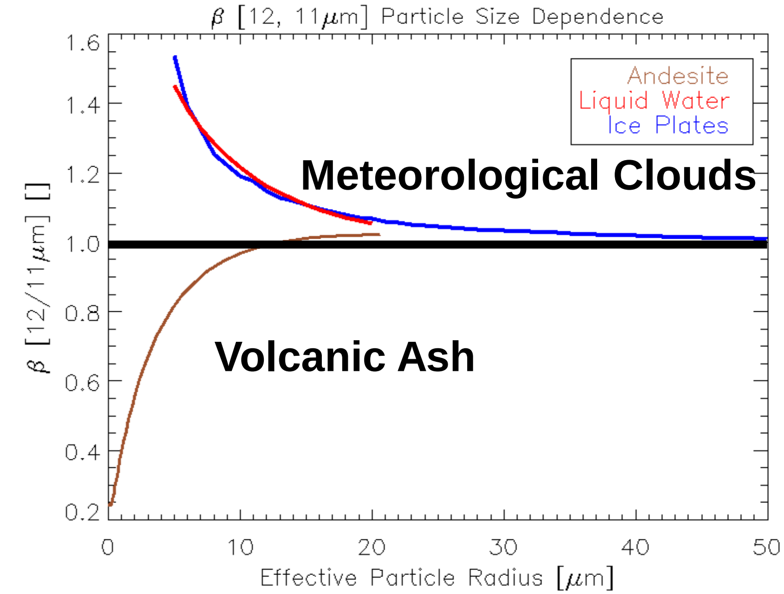




Ash Detection Method

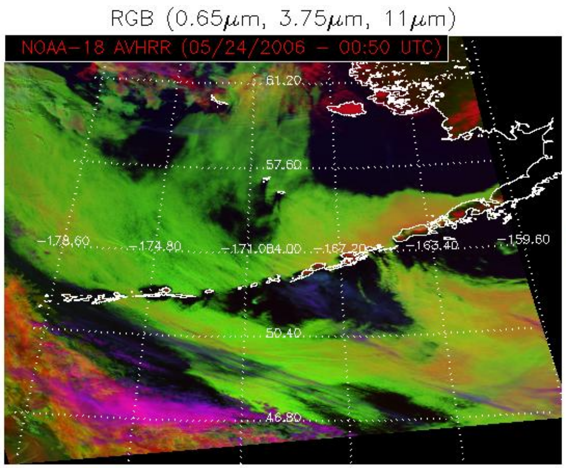
Algorithm Innovation #1: Spectral

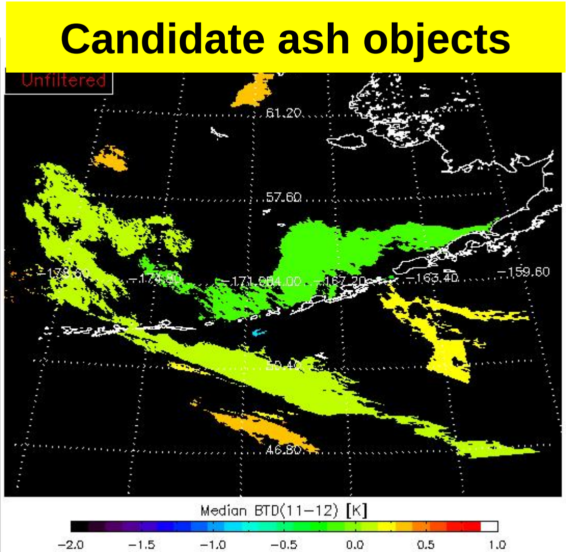
- In lieu of traditional brightness temperature differences, the ash detection algorithm utilizes effective absorption optical depth ratios (β-ratios) (Pavolonis, 2010a and Pavolonis 2010b), which isolate the desired microphysical signatures.



Algorithm Innovation #2: Spatial

- Spatially connected candidate volcanic ash pixels are grouped into cloud objects. Spectral and spatial object statistics are used to determine which objects are ash clouds.





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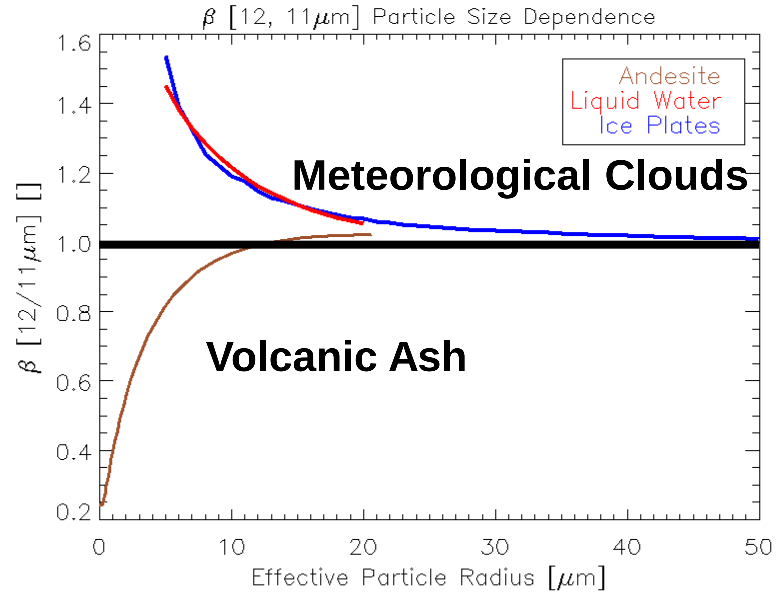

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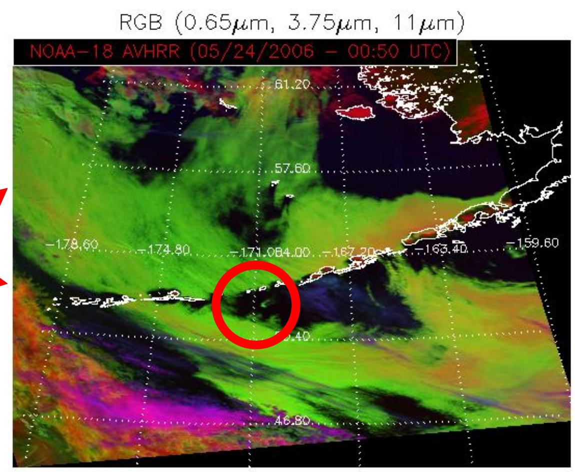
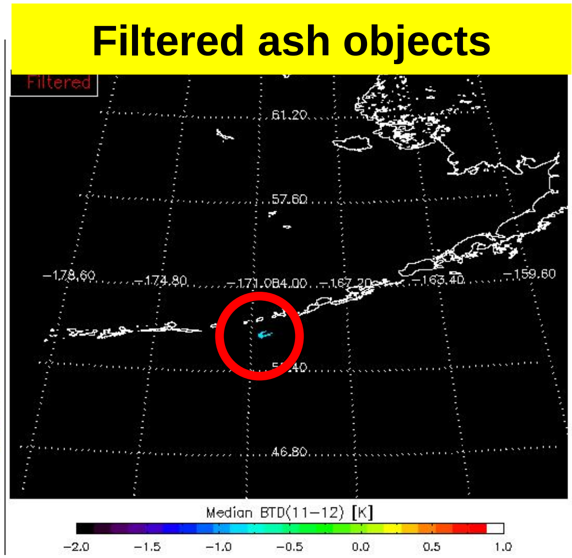
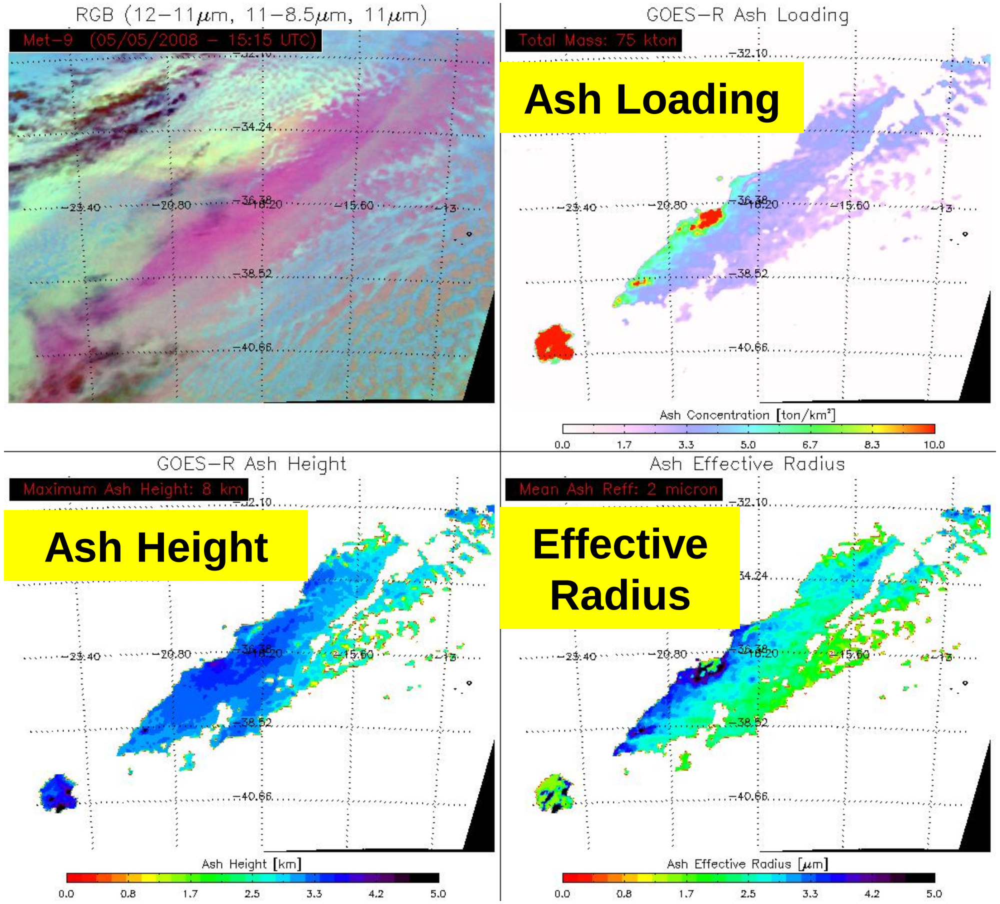




Ash Retrieval Method

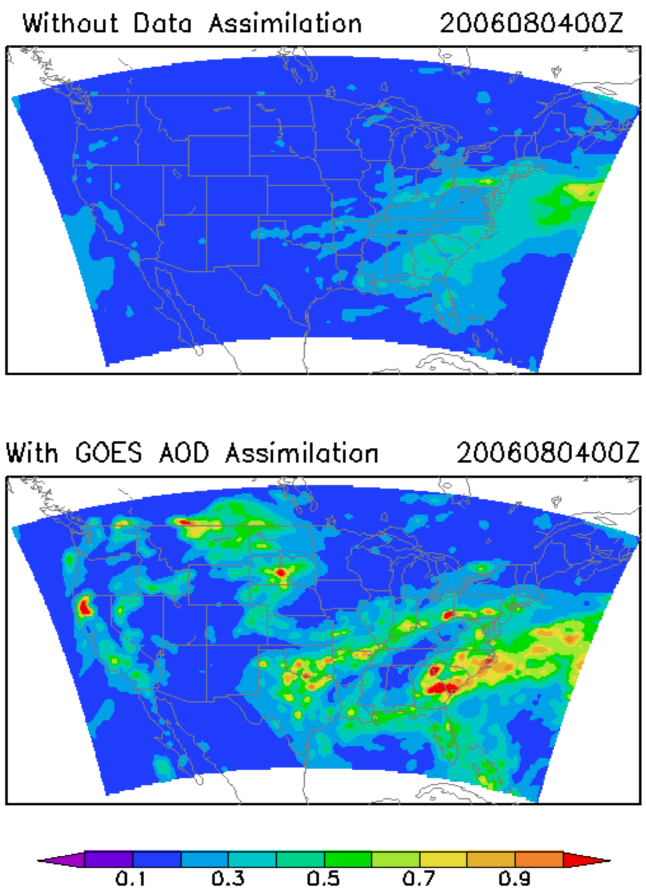
- An optimal estimation technique (Heidinger and Pavolonis, 2009) is applied to ash pixels to retrieve cloud temperature, emissivity, and a micro-physical parameter.
- The retrieved parameters are used to estimate cloud height, effective particle radius, and ash mass loading.
- An error estimate for each of the retrieved parameters is a by-product of the optimal estimation approach.
- These products can be used to improve ash dispersion and fallout forecasts.

Quantitative Ash Products

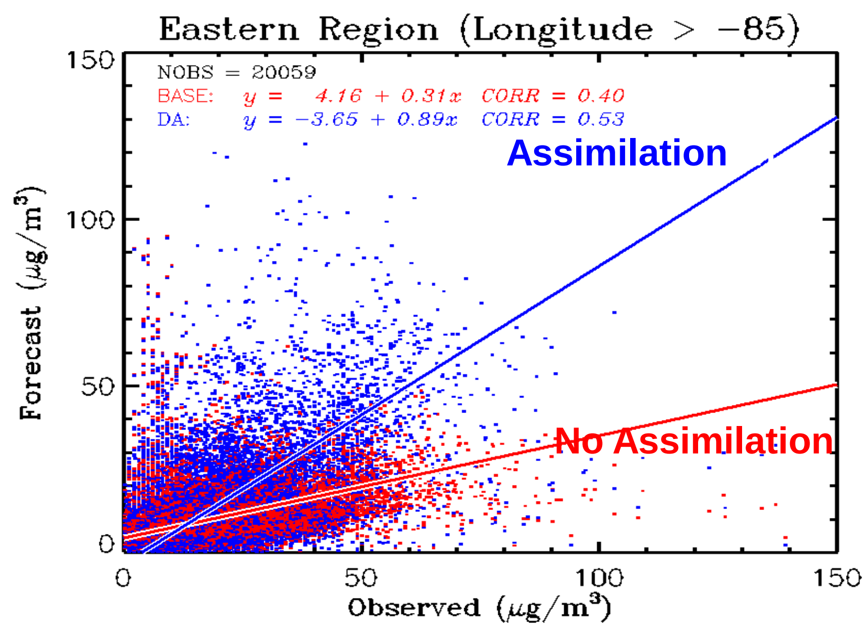


Air Quality Applications of NOAA Operational Satellite Data

Modeling and Assimilation



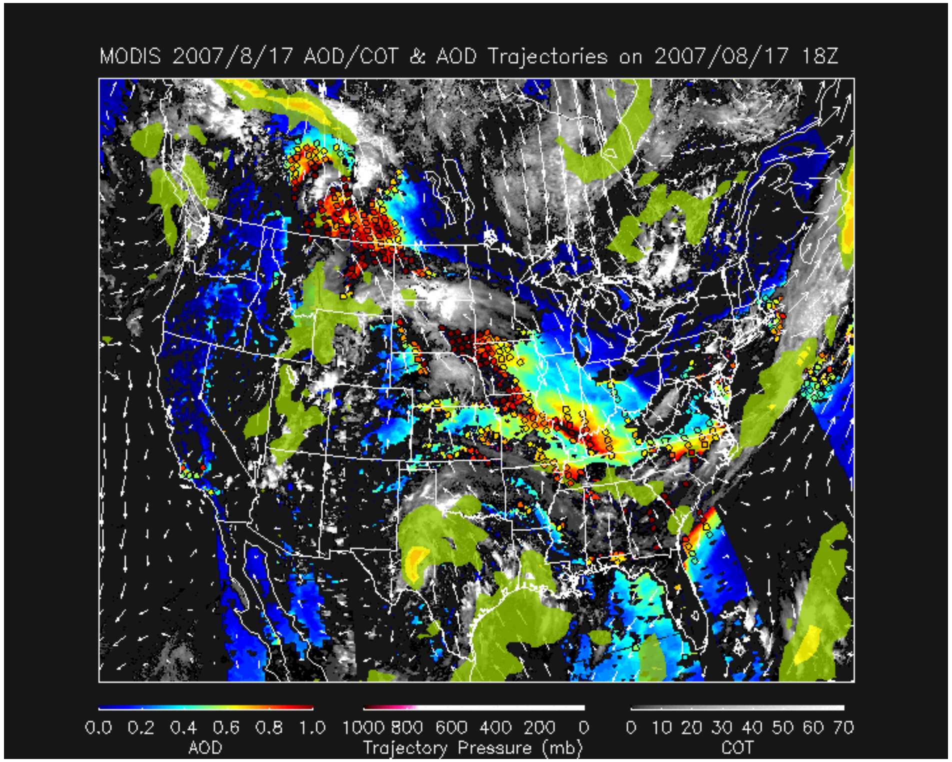
- **Assimilation of GOES Aerosol Optical Depth (AOD) in a NOAA-EPA Weather and Research (WRF)/Community Multiscale Air Quality (CMAQ) model shows improved aerosol predictions for an eastcoast pollution episode**

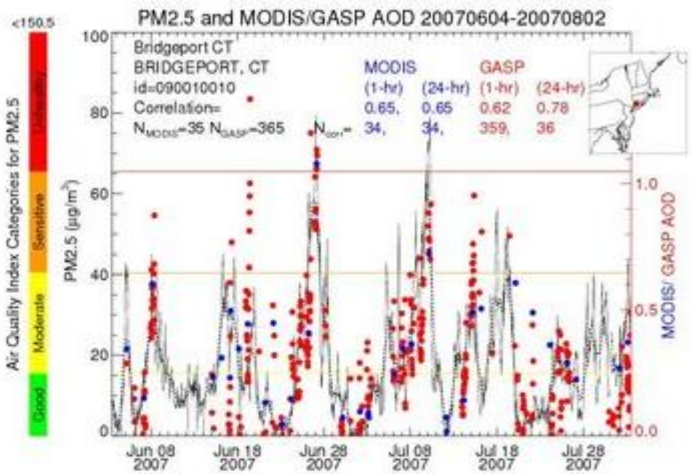


Significance: Accounting for missing sources and sinks in the model via aerosol data assimilation helps improve particulate pollution predictions. NWS is mandated to deploy nationwide PM2.5 forecasts early next decade. This research will help NWS meet its mandate.

Air Quality Applications of NOAA Operational Satellite Data

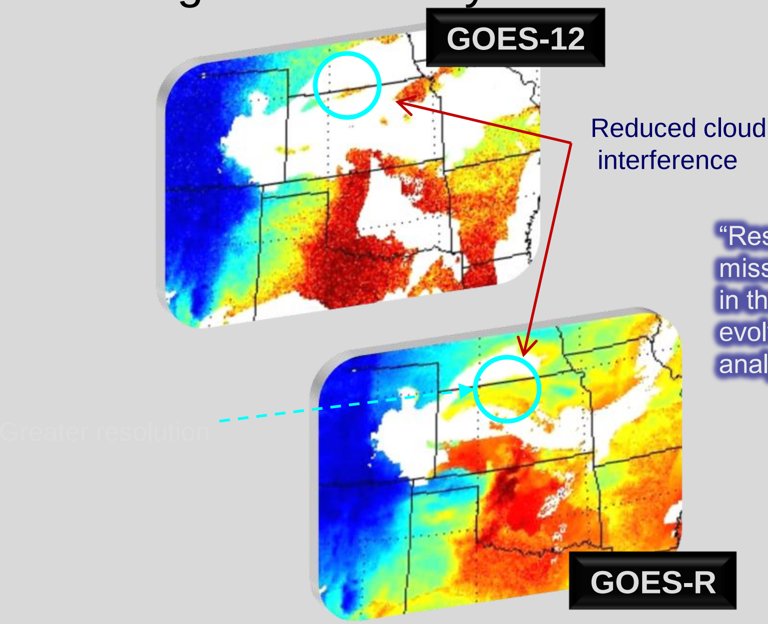
Integrated observations, products and synthesis to support air quality forecasters





WE ARE:
PREPARING THE NEXT GENERATION OF PRODUCTS

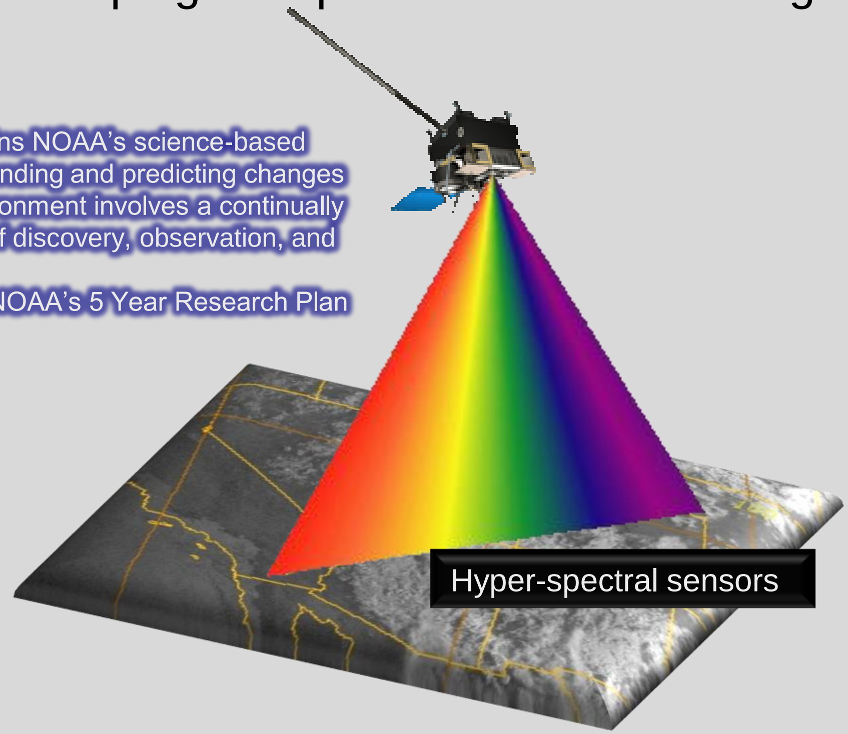
Increasing the accuracy of satellite remote sensing



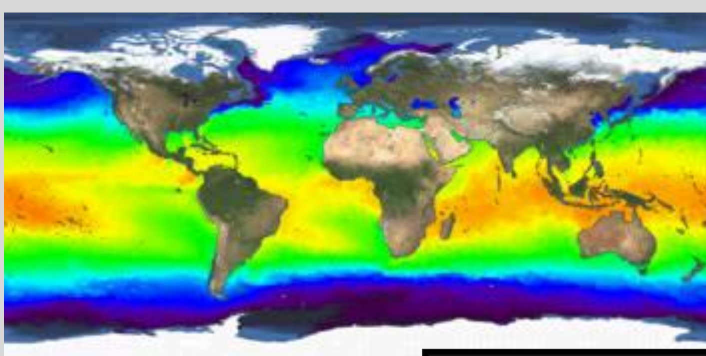
Developing new products and technologies

"Research underpins NOAA's science-based mission…understanding and predicting changes in the Earth's environment involves a continually evolving process of discovery, observation, and analysis..."

—NOAA's 5 Year Research Plan



Integrating satellite products



Blended GOES and POES SST

WE ARE:

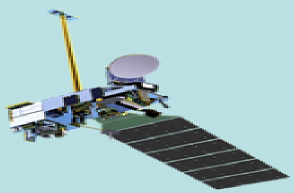
CHANGING THE WAY THINGS WORK

POES | GOES | Aqua | METEOSAT | MTSAT | DMSP

POES Algorithm Processing | GOES Algorithm Processing | Aqua Algorithm Processing | Meteosat ... Processing | ... Algorithm Processing | DMSP Algorithm Processing

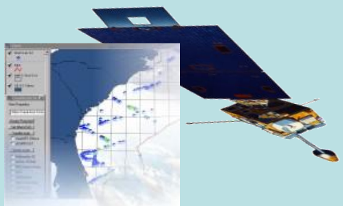
POES pro... | ... | ... products | METEOSAT products | MTSAT products | DMSP products

OLD ERA: Software and algorithms tailored to specific satellite data streams

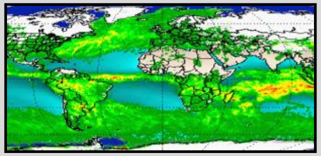



NEW ERA:

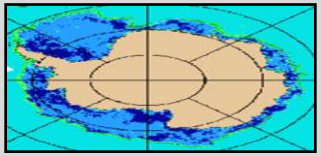
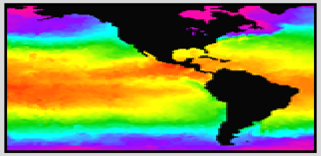
Satellites and Measurements from GEOSS

Integrated Algorithm and Product Processing System

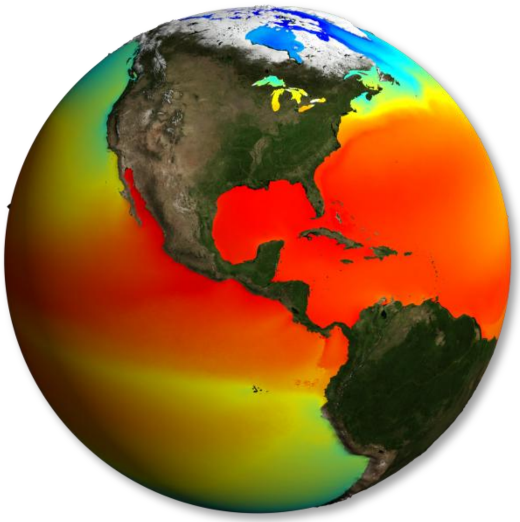
Best earth observations & products

Software and algorithms support a variety of satellite and in-situ data streams

Planning for Future Research to Operations Opportunities

- **Operational missions: POES, GOES, JPSS(NPOESS), GOES-R, EUMETSAT, JASON, etc.**
- **Future NASA Earth Science Missions:**
  - **NASA science teams and public workshops for future NASA Earth Science missions**
  - Global Precipitation Mission
  - Glory -- Total Solar Irradiance, Aerosol Polarimetry
  - Aquarius – Sea-surface Salinity
  - NRC Decadal Survey
    - SMAP -- Soil Moisture
    - ICESAT 2 – Ice Sheet Climatology
    - DesDynl – Ice Concentration
    - CLARREO – Absolute calibration standard, GPSRO
    - ACE -- Polar-orbiting atmospheric properties and ocean color
    - GeoCAPE – Geostationary Atmospheric Composition & Ocean Color
    - SWOT – Altimetry
- **NOAA/NESDIS provides funds to study future instruments:**
  - **Example:** GeoSTAR (Instrument Incubator Program) - geostationary microwave imager



STAR OUTREACH

- University Partnerships
  - STAR Cooperative Institutes (CIMSS, CIRA, CICS, CIOSS)
  - NOAA's Educational Partnership Program (CCNY)
- Training
  - Training Material Development (VISIT and COMET)
- Conference and Workshop attendance
- NOAA's Environmental Visualization Laboratory

Outreach is a core component of STAR's mission and role

NESDIS & STAR Challenges

- Increased numbers of research and international satellites and sensors;
  - (1) Multi-Spectral, Multi Sensor, Multi Platform (Satellite, In Situ , Model) capabilities with (2) More sophisticated & NEW product applications WITH integrated, merged and blended products
- "Climate from Space" – unique challenge
  - (1) Continuity of Observation Record, (2) Long-term reanalysis, (3) Calibration and Inter-calibration among satellites
- Support international commitments (GEOSS, CEOS, GEO, WMO, etc.)
- Access to high performance and super-computing resources
- Long-term Science Maintenance (Life cycle algorithm support)
- Drive to maximum efficiency
  - (1) Develop Enterprise-wide solutions, (2) Re-use and leverage capabilities, (3) Repeatable, efficient and consistent processes (CMMI Level 3)

STAR's future is diverse with more instruments, algorithms & unique opportunities

Significant Event Imagery

- Operational Significant Event Imagery team produces high-resolution imagery of significant events.
- http://www.osei.noaa.gov/