NOAA's Integrated Observing System

JACIE

April 12, 2016

NOAA Satellite and Information Service

Dr. Mitch Goldberg, NESDIS Chief Scientist for JPSS

NOAA NESDIS Mission & Challenge

Our mission is to deliver accurate, timely, and reliable satellite observations and integrated products and to provide long-term stewardship for global environmental information in support of our Earth Observation mission.

Our challenge is to provide these observations and products reliably while improving the information content and evolving to stay current with the expanding complexity of the Earth Observing contributors

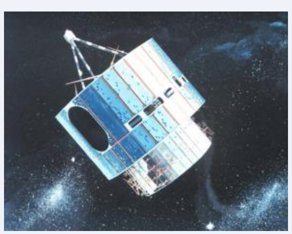
Supporting NOAA's Mission

NOAA is a science-based services agency engaged with the entire Earth system science enterprise.

NOAA's Top Four Priorities:

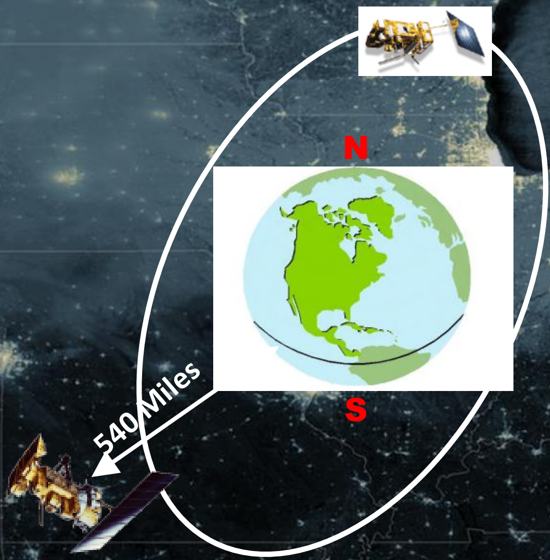
1. To provide information and services to make communities more resilient
2. To evolve the National Weather Service
3. To invest in observational infrastructure
4. To achieve organizational excellence

Weather Observations Have Seen Several Transitions

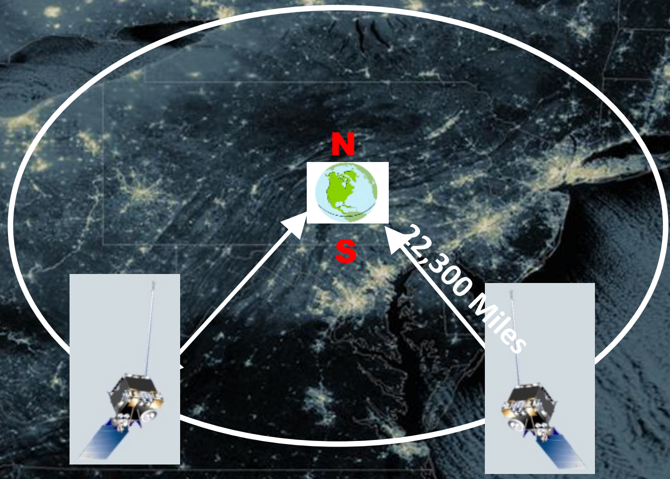
1960	1980	2000	2020	2040
Tiros-1 launch in April 1960. 48° inclination. Nimbus-1 launch in Aug. 1964. First infrared sensor. Tiros-9 launch in 1965. “Cartwheel configuration.” First polar orbit.	NOAA-6 launch in June 1979. First AVHRR. NOAA-8 launch in March 1983. Physically larger and had more power than their predecessors	NOAA-15, 16, 17. Heavier and more microwave channels. NOAA-18, 19 Direct orbit insertion. JPSS development. NOAA + EUMETSAT IJPS agreement Nov. 19, 1998.	JPSS series operational. 22 channel imager. Next-gen CrIS & ATMS.  Jason-2/3 COSMIC-2 GNSS RO EON-MW	?
GOES-1 launch in 1975. 	GOES-I (GOES-8) launch in 1994. GOES-I through –M. Three-axis stabilized. First independently operating sounder and imager. GOES-10 launched as on-orbit spare.	GOES-N/O/P operational. Imager and Sounder with flexible scan control.  GOES-R development.	GOES-R through –U operational. Himawari 8 Next-gen ABI. First lightning mapper from GEO. Next generation development	

NOAA's Observational Paradigm Has Been: Two Orbits, One Mission

Polar-orbiting Operational Environmental Satellites (POES) Followed by S-NPP and JPSS-1 thru -4



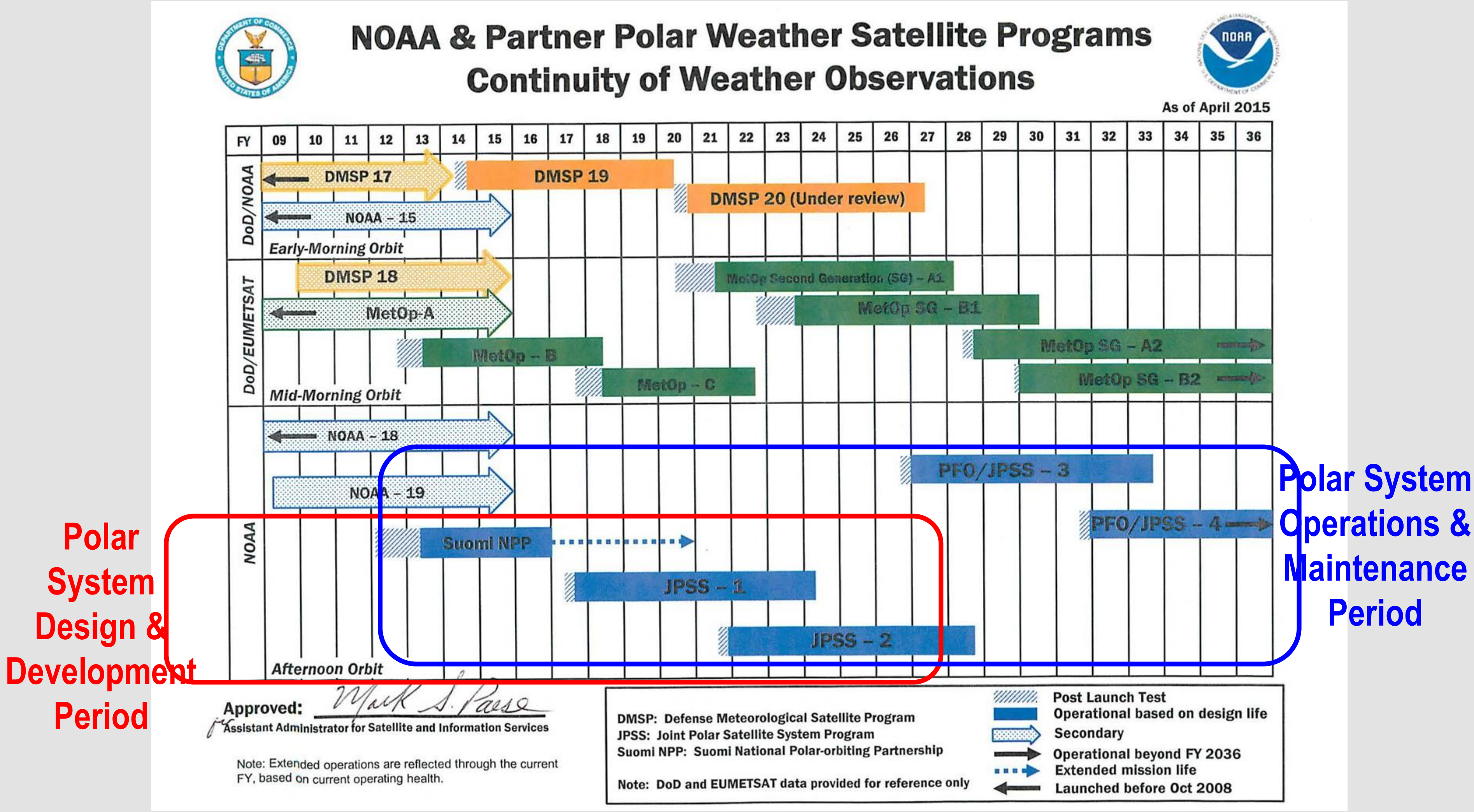
Geostationary Operational Environmental Satellites (GOES), Followed by GOES-R thru -U



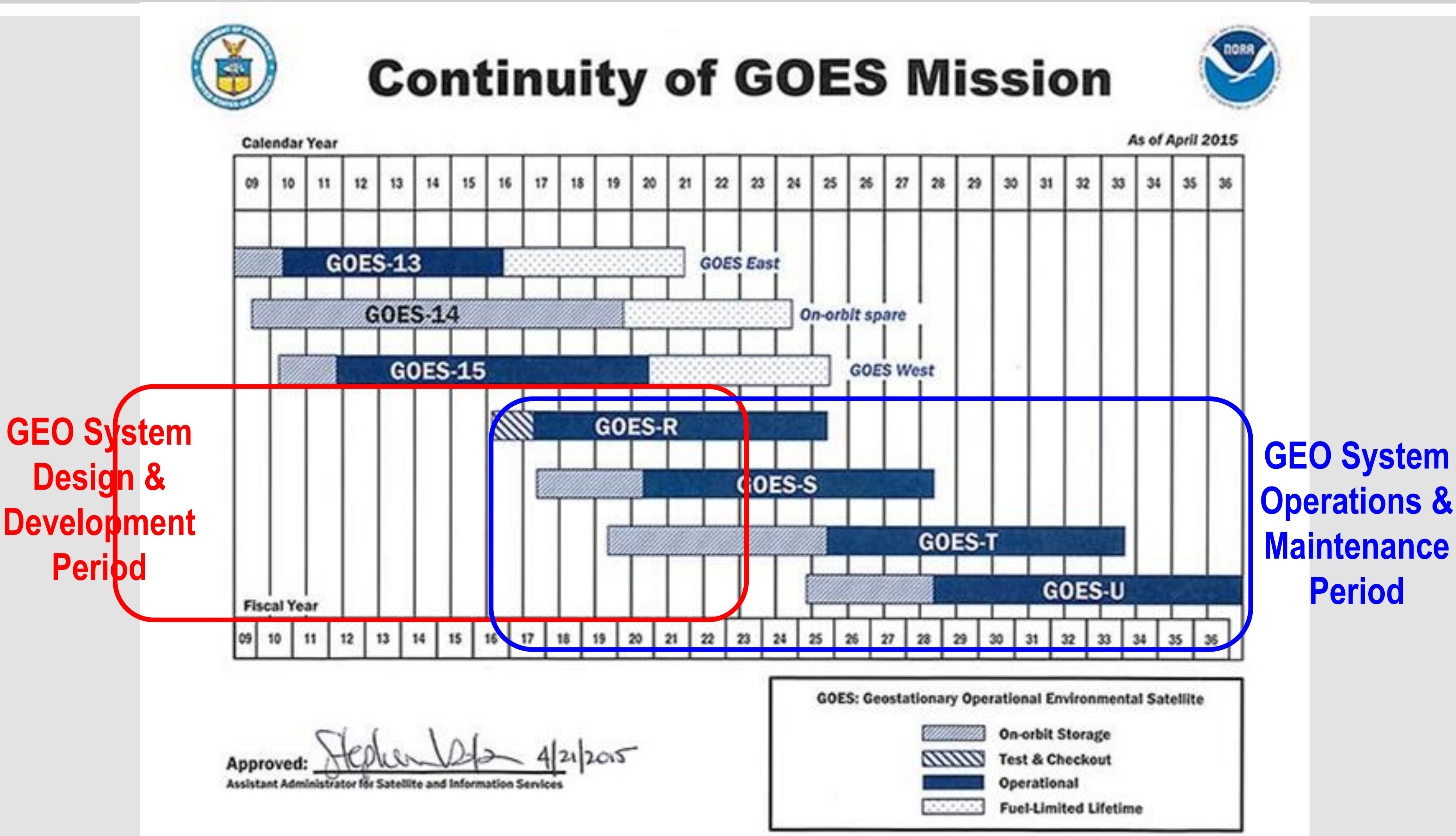
NOAA/NASA

S-NPP image of North America

Polar Flyout Chart

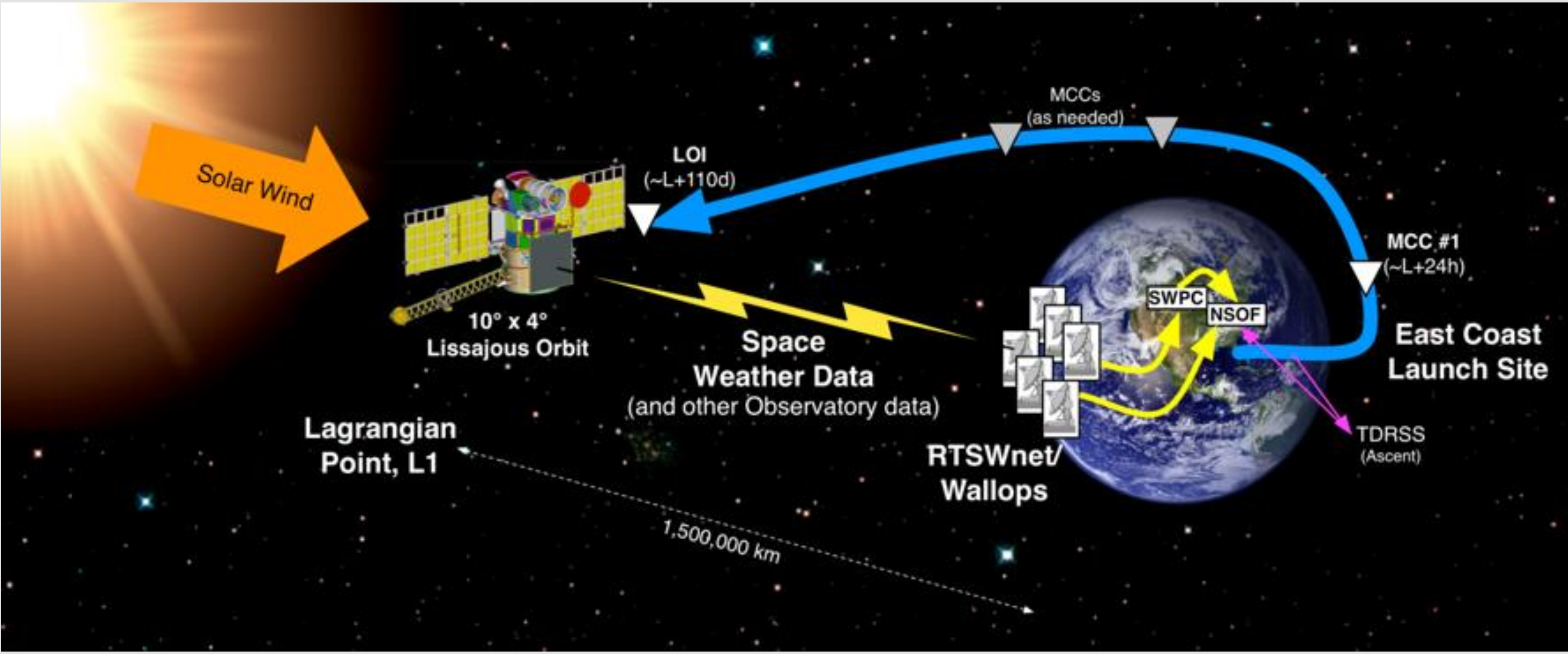


GOES Flyout Chart



Space Weather Observations: DSCOVR + GOES

DSCOVR, a joint NOAA/NASA/DoD mission, is the country's first operational space weather mission providing data to NOAA's Space Weather Prediction Center from L1.
NASA and other research assets continue to provide critical observations from L1 and elsewhere.

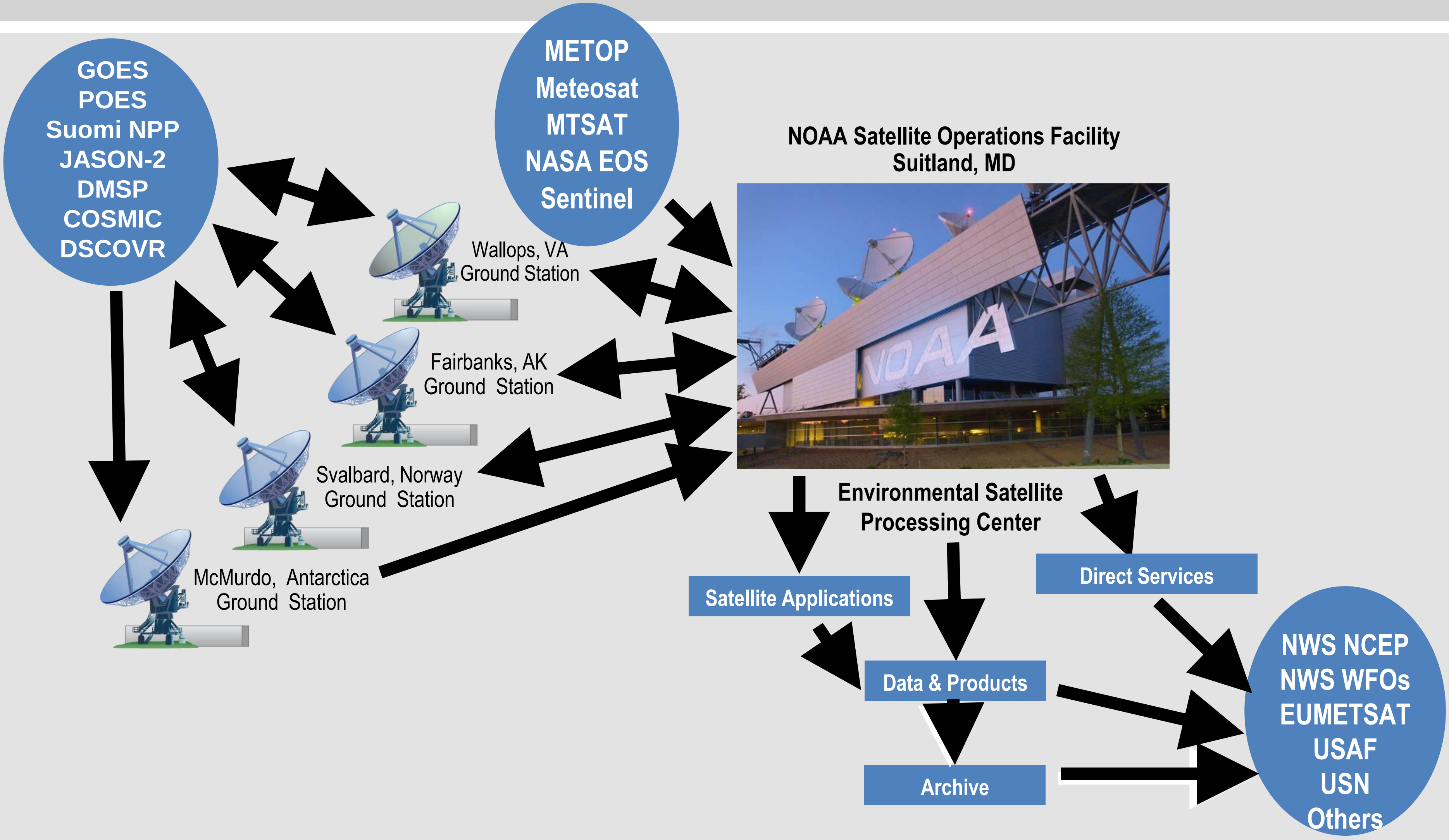


DSCOVR will succeed NASA's ACE mission in providing solar wind measurement continuity from the L1 orbit

Our Observations Involve Much More than NOAA

- NASA and ESA research satellites
- DOD, EUMETSAT & JMA operational satellites
- EC Sentinel satellites

Current Data Flow Supports NOAA Objectives



Turning Data into Information

- We need ions
  related to
  - Data fo
  - Data qu
  - Data ov
  - Data co

Increasingly, more of our products fuse different data sets, so we must learn to do that fusion efficiently and reflexively, regardless of where the data come from, and with confidence that the fusion will produce reliable information

Maximize the Return On Investment of the Nation’s Earth Observing Satellites Systems

- **Ensure a high scientific quality satellite data stream**
  - Data Calibration
  - Data & Product Validation
  - Quality Control Algorithms
  - Support to Operations
  - Science Update/ Maintenance
- **Develop science to maximize the utilization of the different satellite data**
  - Geophysical Algorithms
  - Radiative Transfer Modeling
  - Data Assimilation
  - Engage w External Research (academia, etc)
  - Support Nation’s Operational Partners (NCEP, Navy, AFWA) through JCSDA
- **Analyze and interpret data for decision making purposes**
  - Climate Variability Assessment
  - Hurricane Research
  - Satellite Impact Assessment-OSSE
  - Env. Data Products (volc. Ash, precip., flooding, snow etc)
  - Future Satellite Readiness (JPSS, GOES-R)

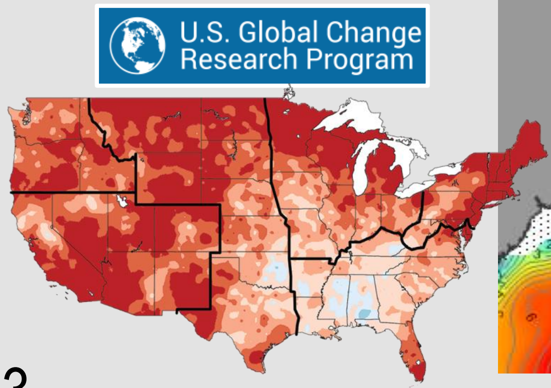
Examples of NOAA NCEI* Satellite Products

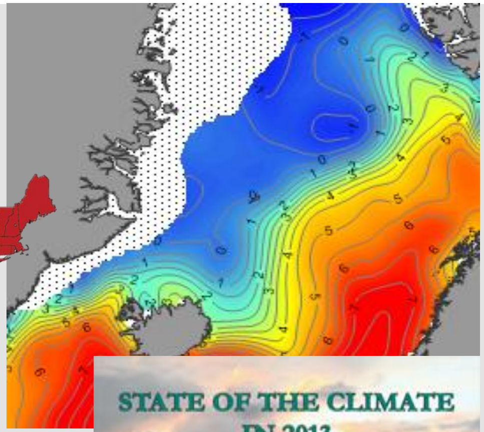
**National Centers for Environmental Information*

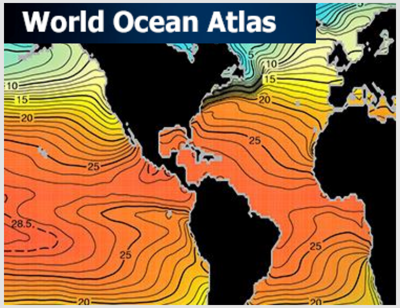
	Daily/Weekly	Monthly	Seasonal – Annual	Annual to Decadal
Local	Snowfall Impact Index – FEMA, disaster response	Heating & Cooling Degree Days – Energy Sector	Temperature & Precipitation Outlooks – Agriculture	Coastal Digital Elevation Models (DEM) – Hazard Mitigation
Regional	Hurricane Tracks – Emergency Planners	Solar Activity/Sun Spots – Power Distribution	Billion $ Disasters, Climate Extremes Index – Insurance	Climate Normals – Construction, Infrastructure, Agriculture
National & Global	Tsunami Warning – Emergency Managers	Global and U.S. Climate Summaries – Numerous Sectors	STATE OF THE CLIMATE IN 2013 Annual State of the Climate Reports – Scientists	IPCC & National Climate Assessments – Gov't Policymakers

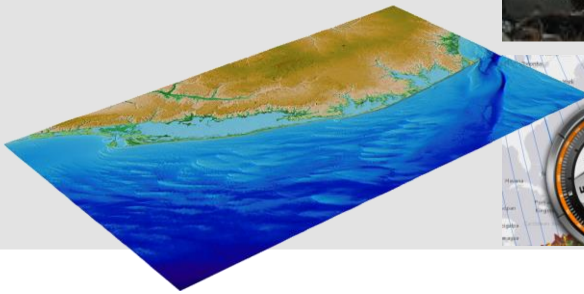
Where do NCEI Products Appear?

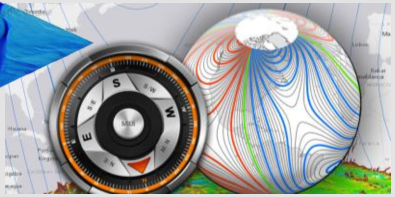
- •Climatological Atlas of the Nordic Seas and Northern North Atlantic
- •World Ocean Atlas 2013
- •National Climate Assessment
- •BAMS State of the Climate in 2013
- •Explaining Extreme Events of 2013 from a Climate Perspective
- •Extended Continental Shelf (ECS) Project
- •Post-Sandy Digital Elevation Model
- •World Magnetic Model for 2015-2020





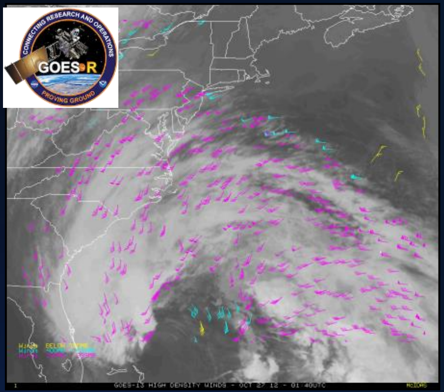




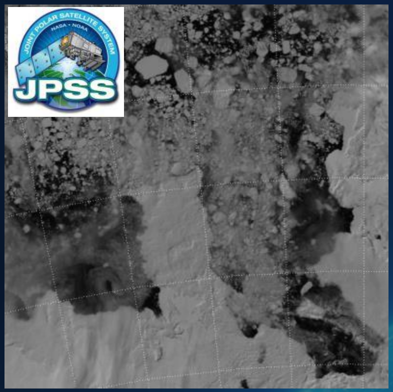


Satellite Proving Ground

Supporting demonstration and utilization of new capabilities by the end users
Facilitating the transition of GOES-R and JPSS to operations
Incorporating user feedback for product improvements

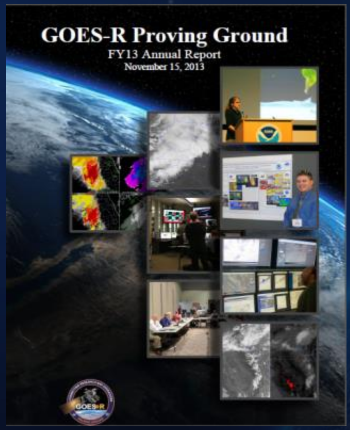


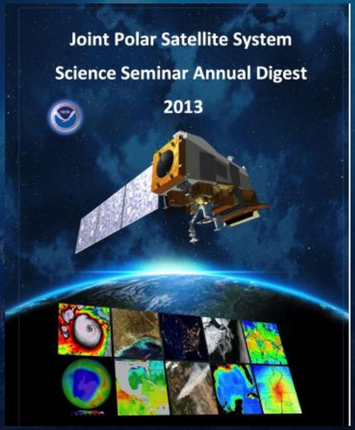
Hurricane Sandy-
GOES High Density
Atmospheric Motion Vectors

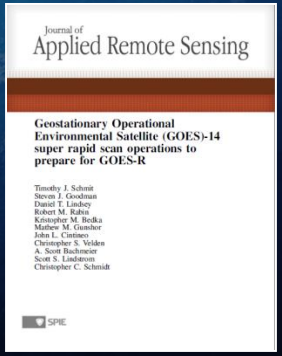


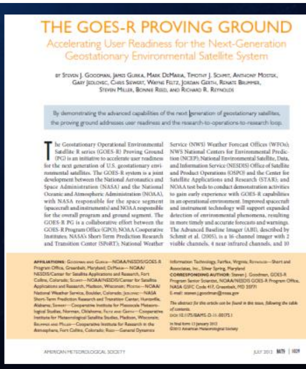
S-NPP Day/Night Band
Ice Detection

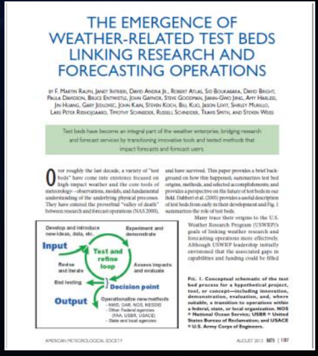
NOAA Hazardous Weather Testbed (HWT)



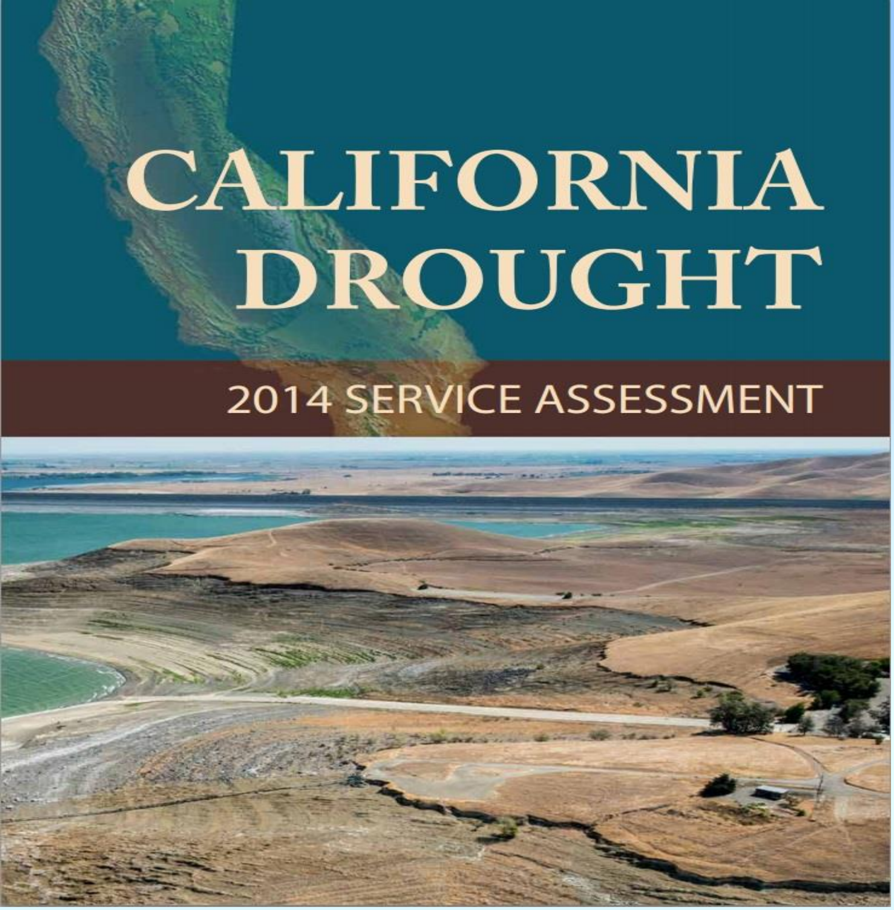


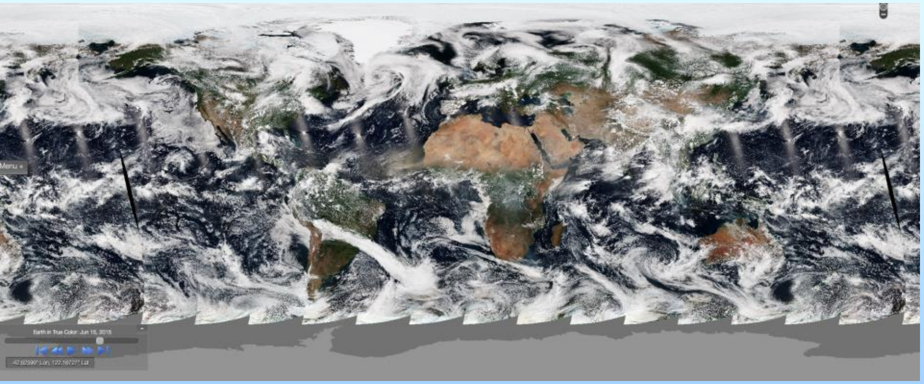


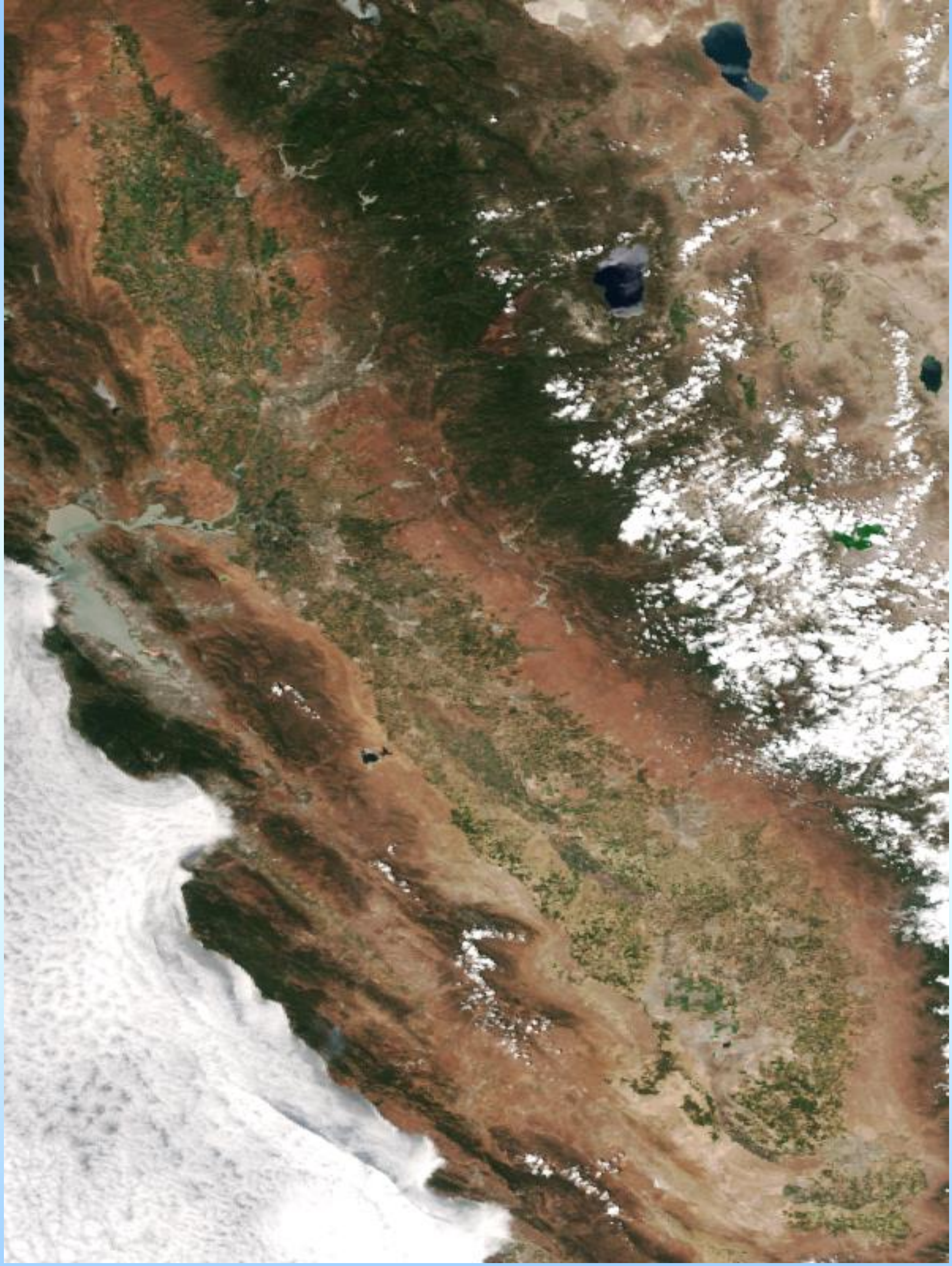




http://www.goes-r.gov/users/proving-ground.html



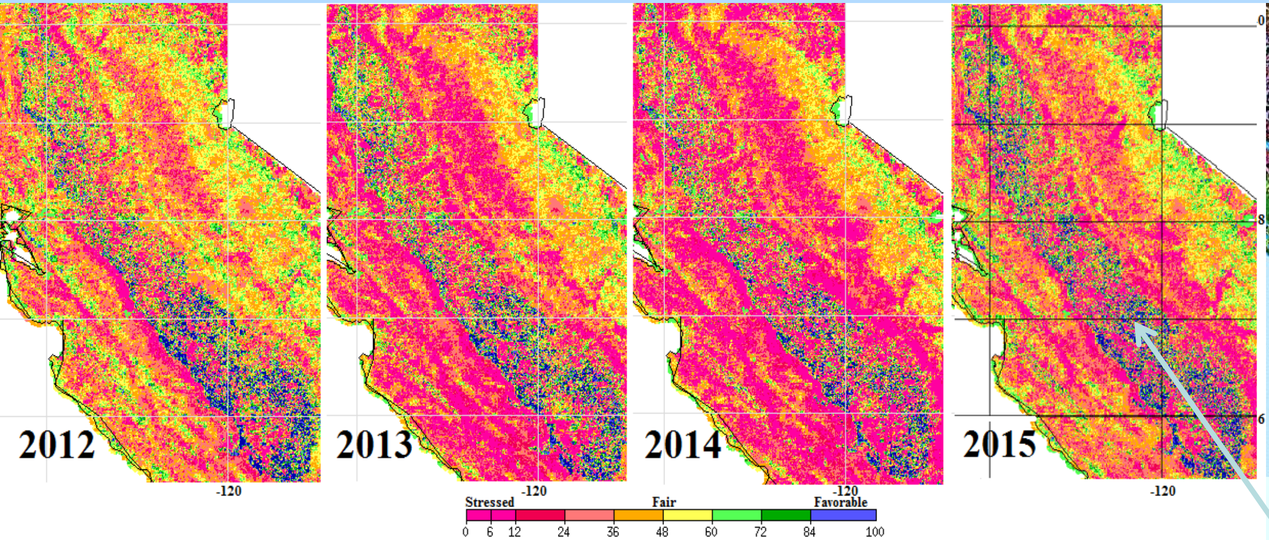




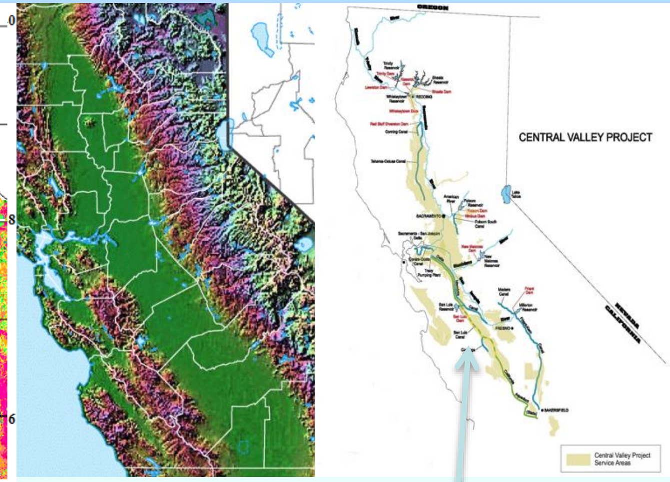
http://www.nnvl.noaa.gov/view/#TRUE

VIIRS True Color Imagery June 11, 2015

VIIRS 500m resolution gridded **vegetation health (VH)** provides indication of vegetation stress – VH is a departure index from a 30 year climatology based on AVHRR



S-NPP/VIIRS-500m Vegetation health, June 12, USA, California, Central Valley



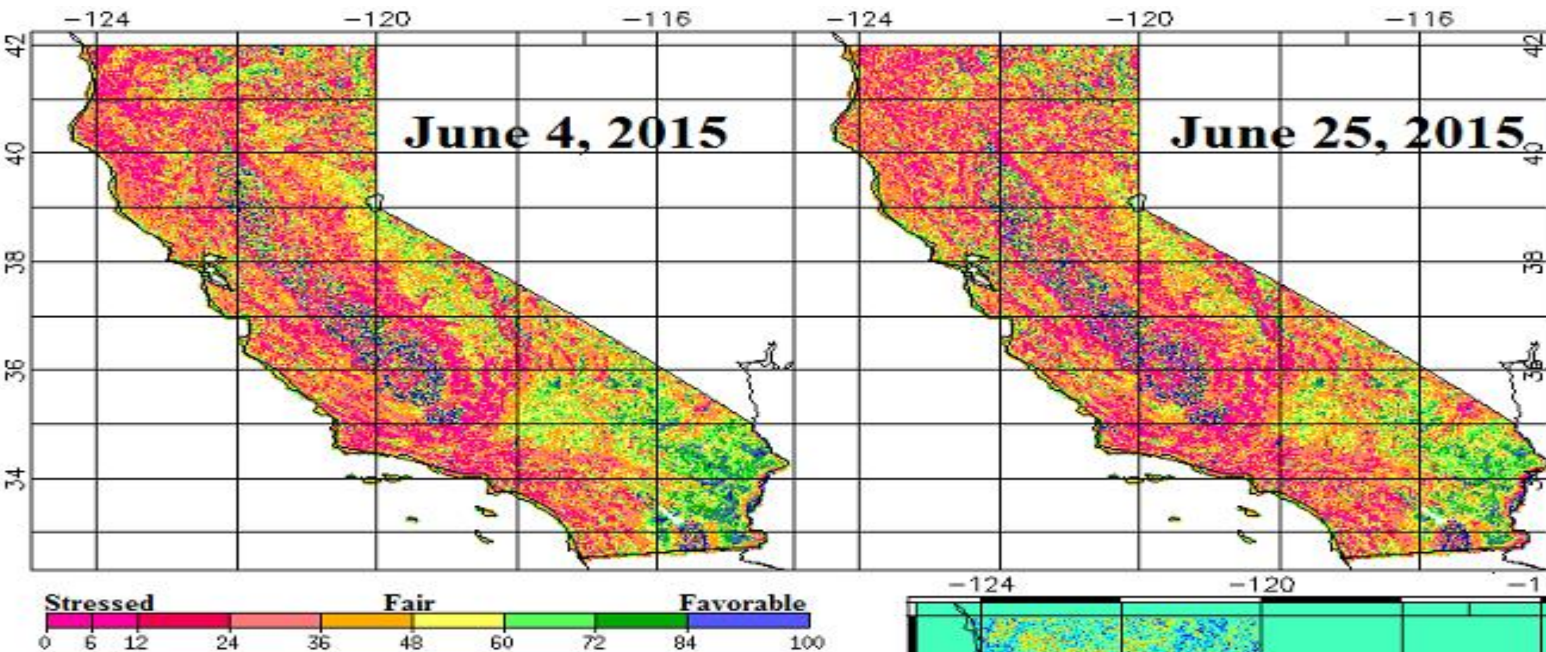
June 2012 –2015 Vegetation Health – Note improvement in 2015 due to late spring precipitation which increased vegetation. (temporary reprieve since snow pack is low and dry summer setting up).

Blue areas show irrigation, If irrigation is cutback, depending on the magnitude, VIIRS VH maps in the central valley can be used for monitoring

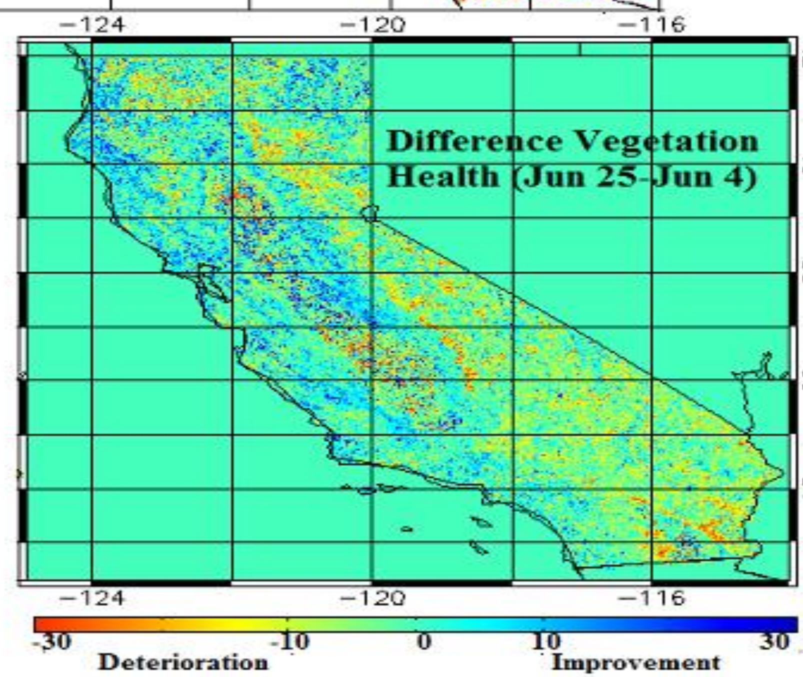
Irrigation areas shown in upper right map

NOAA Service Report on the 2014 California Drought included the need to use remote sensing for assessments of temporal changes in the Central Valley configuration, channel shapes, vegetation cover….

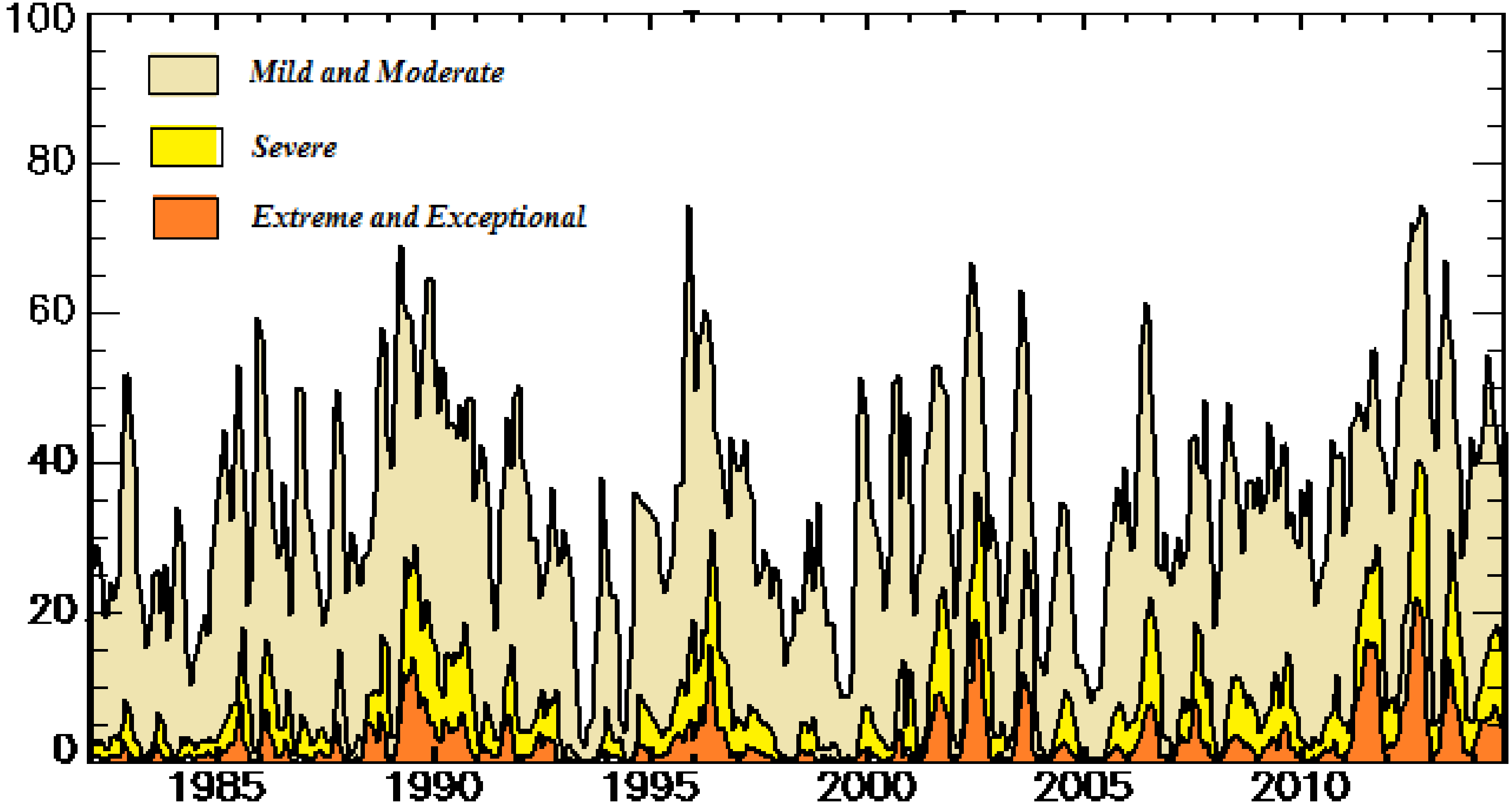
Vegetation Health California June 2015



Vegetation Health
S-NPP/VIIRS 500 m
California



Percent Western US under Drought



Drought Area & Intensity by weeks: Western United States, 1982-2014

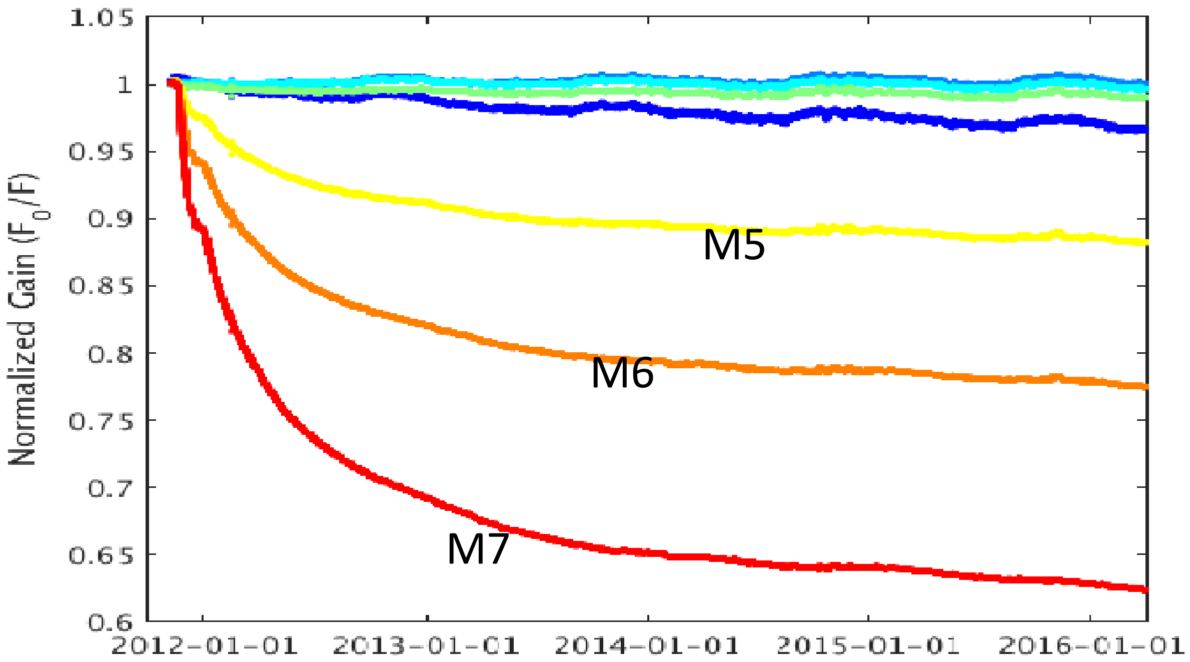
VIIRS reflective solar band stability and accuracy since launch

VIIRS Reflective Solar Band Degradation

- **Small degradation (<1% per year) in the shorter wavelength bands (M1-M4) further ensures confidence in stability**

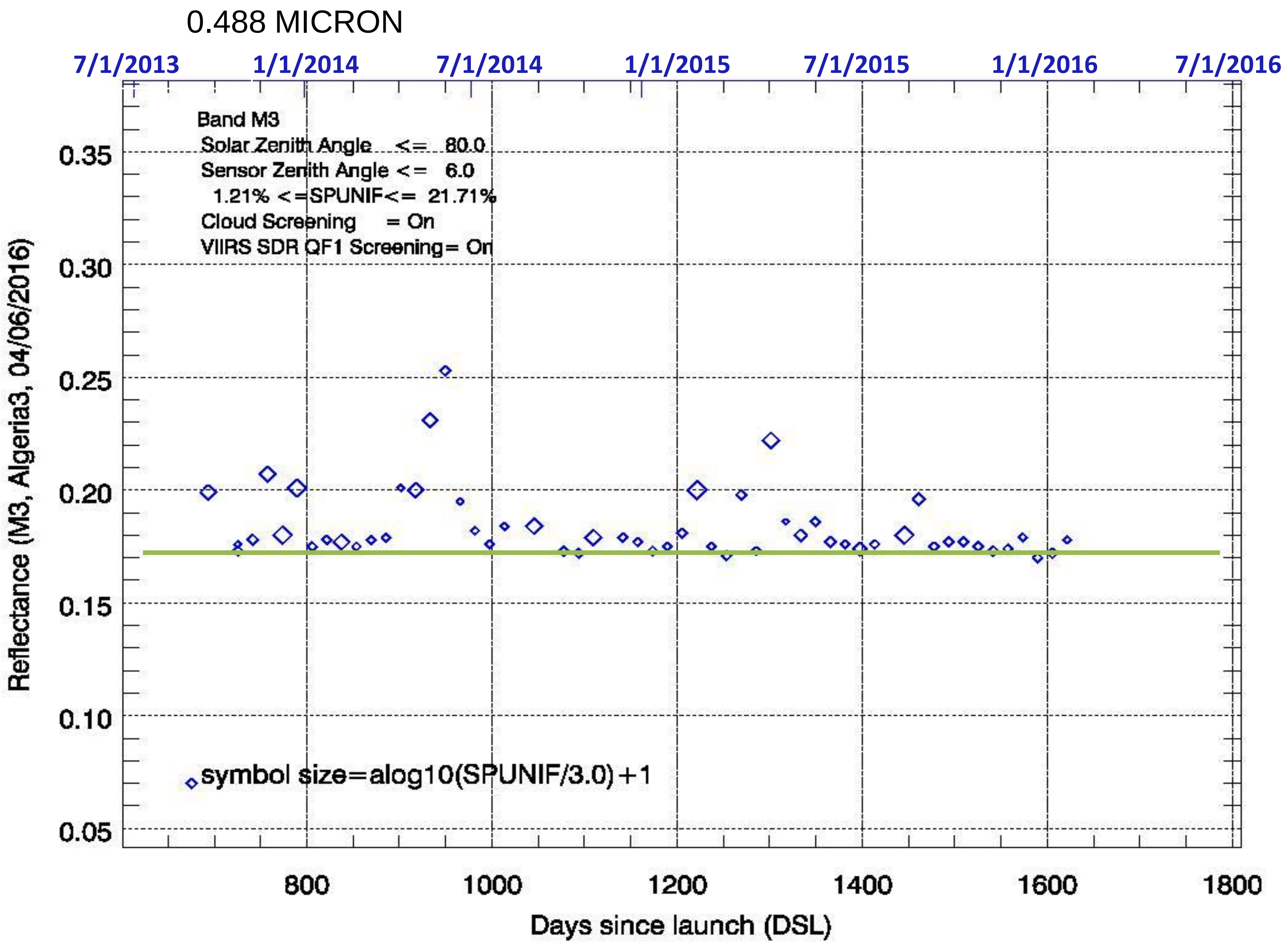
(degradation effect is compensated through daily calibration update)

- **Large degradation in M7, M6, M5 due to RTA mirror contamination prelaunch:**
  - degradation is leveling off;
  - minimal impact on accuracy due to daily updates with RSBAutocal;
  - impact on noise performance is small due to large margins.



Suomi NPP VIIRS normalized gain change since launch

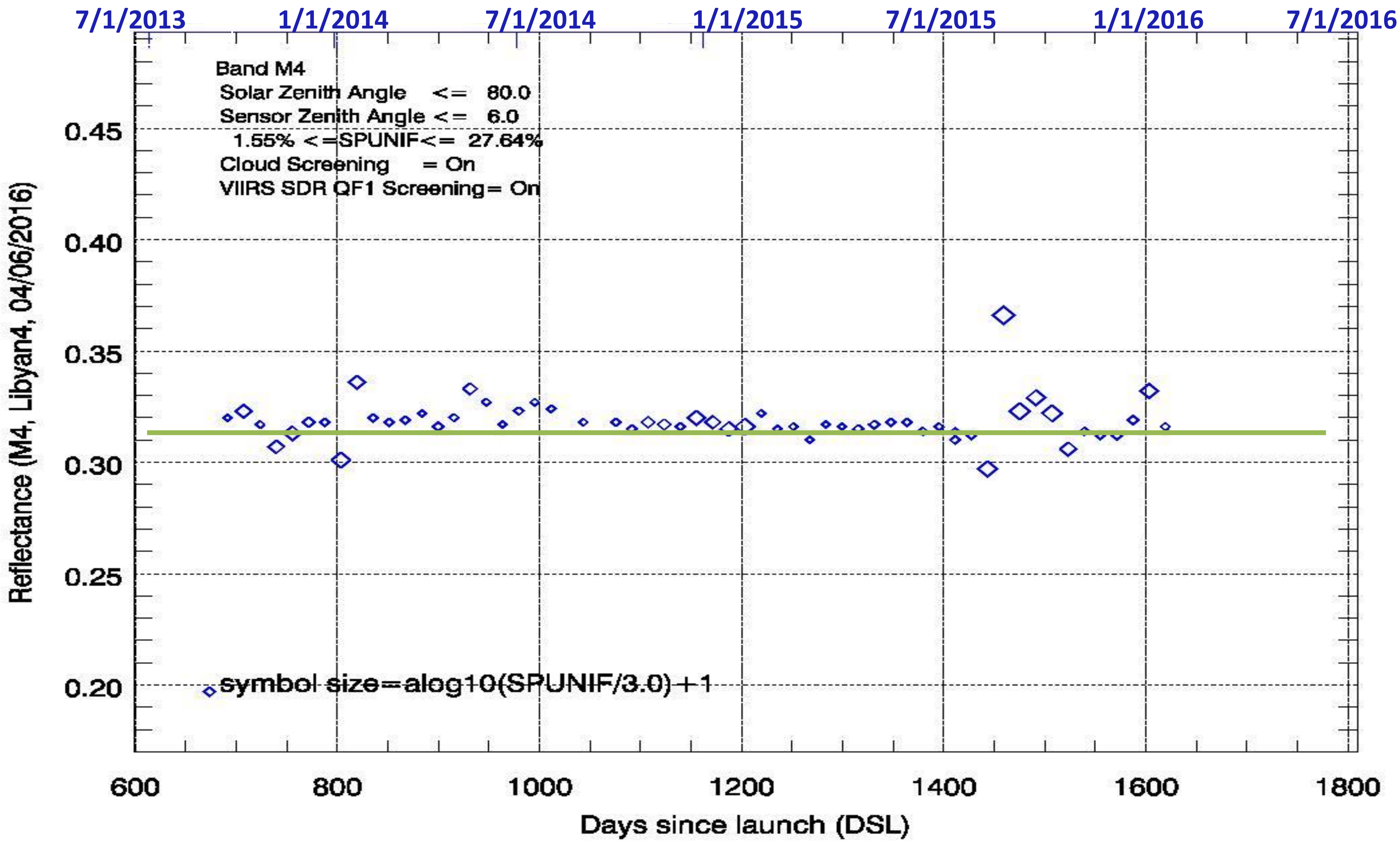
Solar Diffuser Stability Monitor (SDSM),
a ratioing radiometer incorporated in VIIRS
that alternately views the SD, the sun and an internal dark reference



VIIRS reflective solar bands are radiometrically very stable. Figure shows the stability based on desert observations is better than 1% since launch for M3 (blue band). More than 30 sites are used for routine monitoring

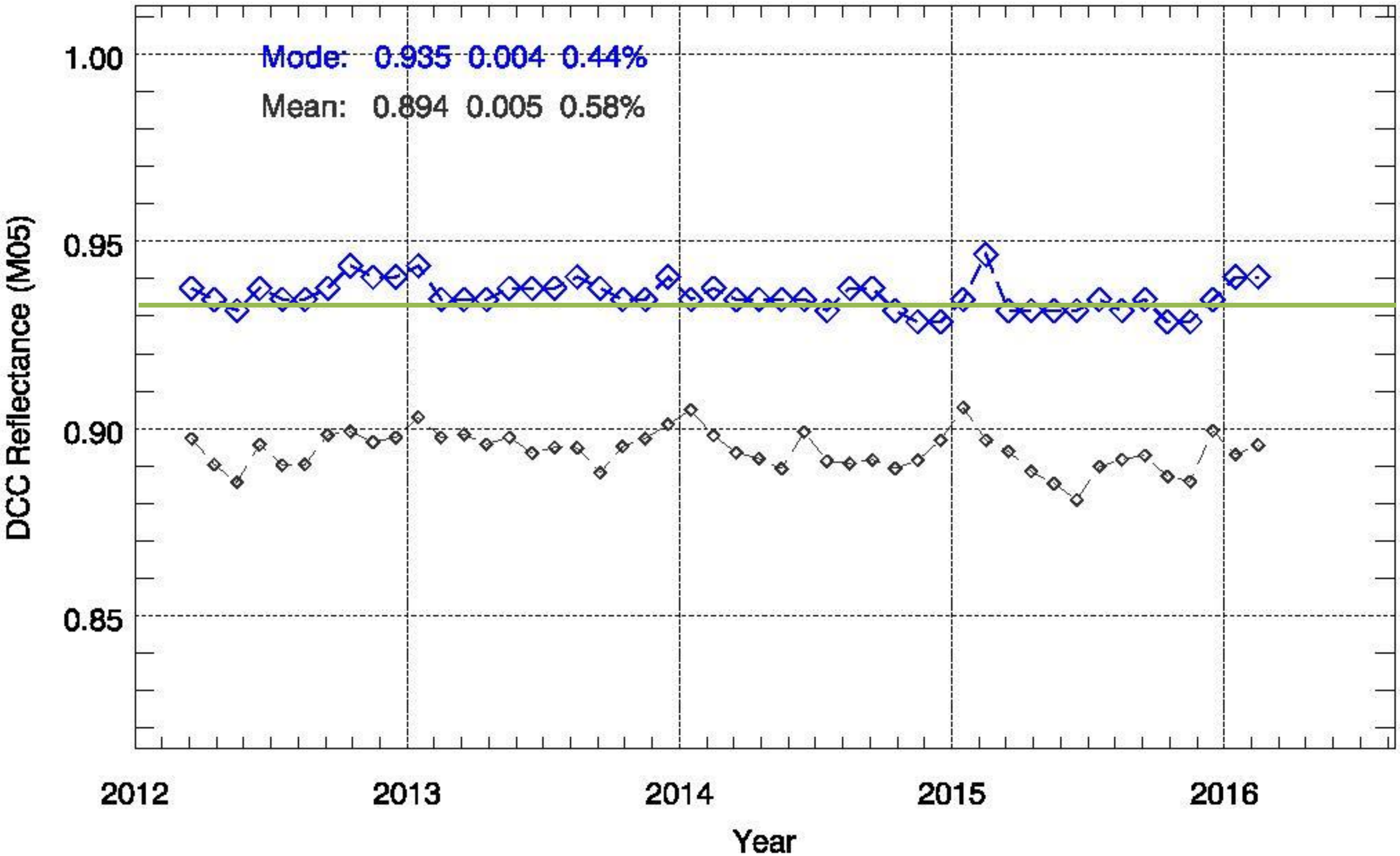
(symbol size represents standard deviations for the samples mostly due to clouds)

0.555 MICRON



VIIRS reflective solar bands are radiometrically very stable. Figure shows the stability based on desert observations is better than 1% since launch for M4 (green band). (symbol size represents standard deviations for the samples mostly due to clouds)

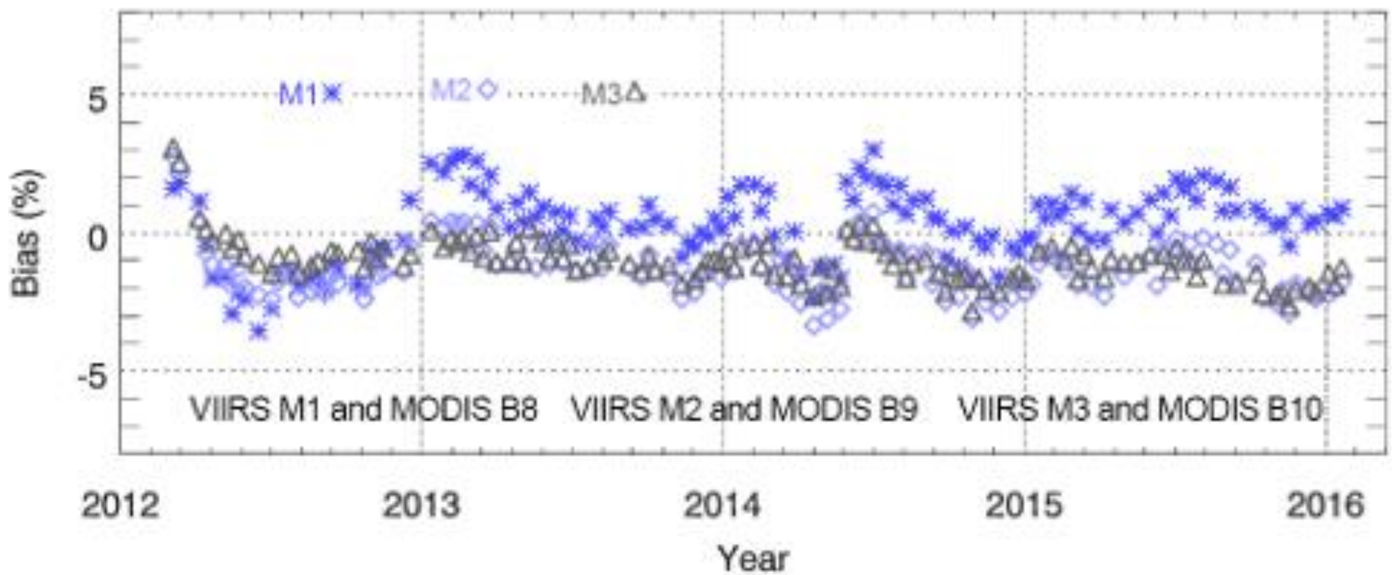
0.672 MICRON



In addition to desert sites, Deep Convective Clouds (DCC) are used for monitoring the VIIRS calibration stability . Figure shows the stability based on DCC observations is better than 0.5% since launch for M5 (red band).

Intercomparison with MODIS at SNOs in the low latitudes

0.412, 0.445, 0.488 MICRON

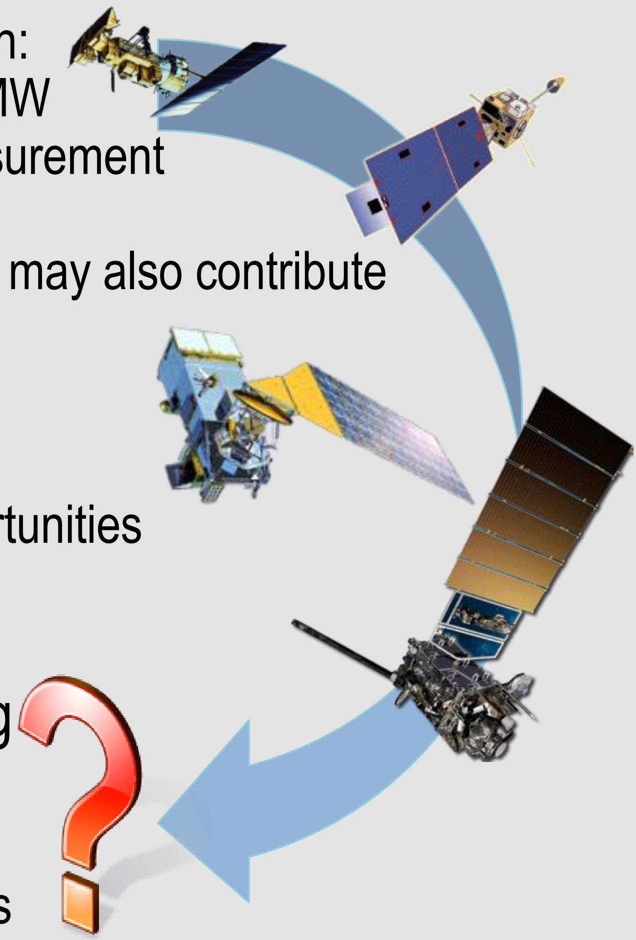


VIIRS observations are compared with those from MODIS routinely. Figure shows that VIIRS and MODIS are in good agreement at the Simultaneous Nadir Overpass observations (M1-M3 shown). VIIRS is as accurate as MODIS (if not better).

Based on extensive analysis and longterm monitoring, we found that VIIRS can be used as a replacement for MODIS as an on-orbit reference, especially with the aging of MODIS. This is currently being assessed by the WMO GSICS community.

What's Next? Moving Beyond "Two Orbits"

- We are broadening our "polar satellite" LEO perspective
  - Core POES/JPSS satellites through ~2038 augmented with:
    - Cosmic-2 RO mission, Earth Observing Nanosatellite-MW
    - Additional complementary evolving and emerging measurement capabilities, from NASA and elsewhere
    - Smallsats or hosted payloads, alone or in constellation, may also contribute



- We will also broaden our GEO perspective
  - GOES-R series through ~2036, possibly augmented with:
    - Alterative architectures, including hosted payload opportunities
    - Possibly to include alternative orbits

- Increasingly, the services we provide will be driving towards more integrated data products, merging:
  - Across platforms, both LEO and GEO
  - Across Agencies, using observations from multiple sources
  - Across public-private domain

Achieving the New NESDIS Architecture

“Develop a space-based observing enterprise that is flexible, responsive to evolving technologies, and economically sustainable”

-FY15 NOAA Annual Guidance

- This will be implemented with a Paradigm shift affecting all aspects of NESDIS
  - NESDIS to develop plan for transition to future in FY15
  - Conduct Analysis of Alternatives, Build Architecture Options in FY15–16
  - Conduct Concept Development Studies, Technology Risk Reduction in FY17+ (budget permitting)

- We seek an End-to-End Solution, considering all elements of the Earth Observing System
  - Focus the space observation constellation to achieve flexibility, leverage technology, and achieve greater efficiencies
  - Establish Enterprise Ground to maximize efficiencies, minimize complexity, and reduce cost both in the ground system and in the development of operational data products
  - Establish program management and integration structures to minimize overhead, simplify interfaces, and enable flexibility in execution and acquisitions
  - Establish Enterprise Architecture and Enterprise Systems Engineering and Integration as a core competency of NESDIS
  - Partner with NASA, other Labs, Industry, and Academia to leverage investments in science and technology to enable more frequent and predictable refresh opportunities

Addressing Needs Across NOAA

WEATHER READY NATION

1. Aviation Weather and Volcanic Ash
2. Fire Weather
3. Hydrology and Water Resources
4. Marine Weather and Coastal Events
5. Hurricane/Tropical Storms
6. Routine Weather
7. Severe Weather
8. Space Weather
9. Tsunami
10. Winter Weather
11. Environmental Modeling Prediction
12. Science, Services and Stewardship

National Weather Service

HEALTHY OCEANS

1. Ecosystem Monitoring, Assessment and Forecast
2. Fisheries Monitoring, Assessment and Forecast
3. Habitat Monitoring and Assessment
4. Protected Species Monitoring
5. Science, Services and Stewardship

National Marine Fisheries Service

RESILIENT COASTS

1. Coastal Water Quality
2. Marine Transportation
3. Planning and Management
4. Resilience to Coastal Hazards and Climate Change
5. Science, Services and Stewardship

National Ocean Service

CLIMATE

1. Assessments of Climate Changes and Its Impacts
2. Climate Mitigation and Adaptation Strategies
3. Climate Science and Improved Understanding
4. Climate Prediction and Projections

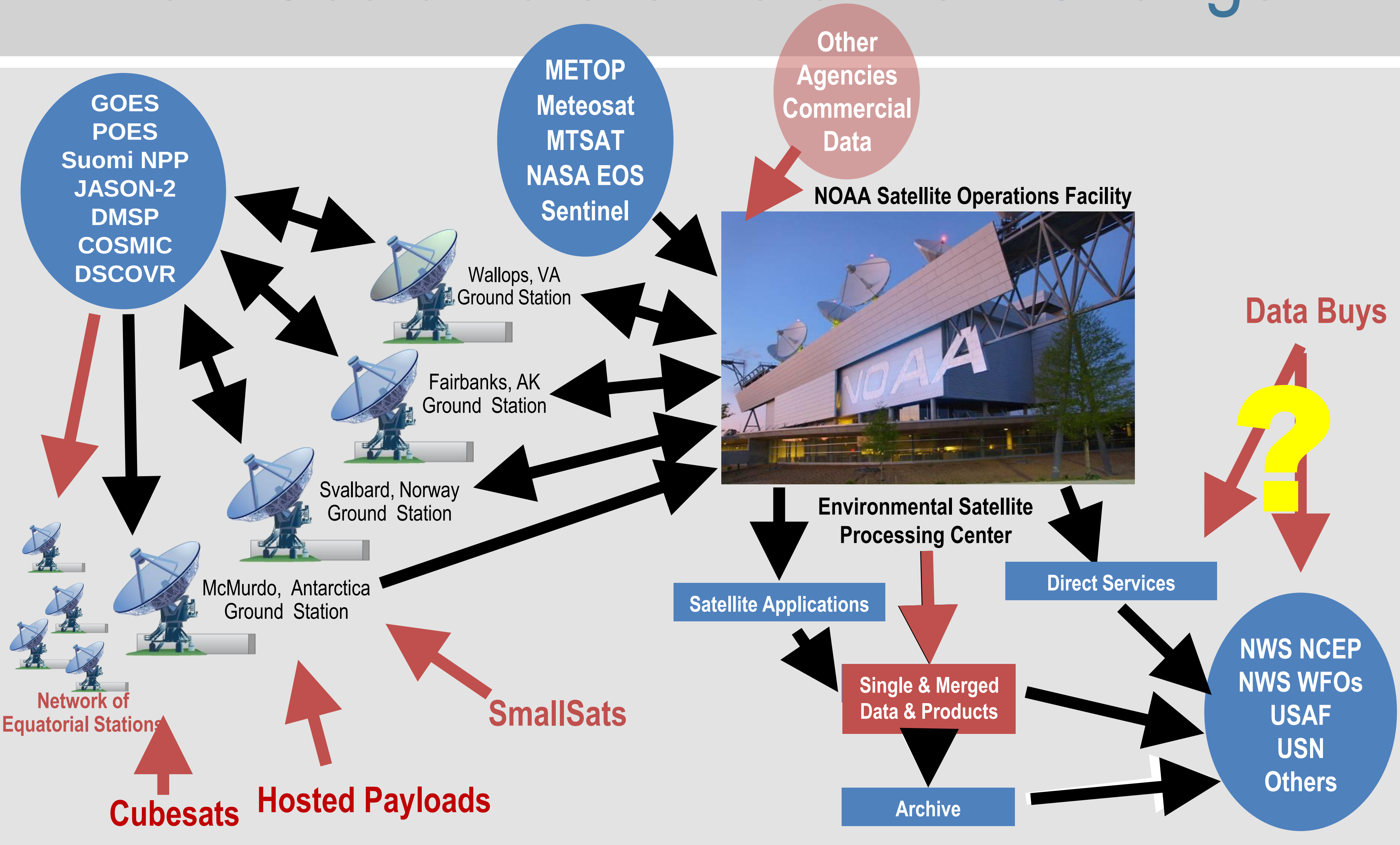
Office of Oceanic and Atmospheric Research

NOAA Mission Service Areas by Line Office

Implementation Characteristics for Architecture Studies

1. **Comprehensive**.
   The trade space must consider a wide range of possible options and solutions and not be anchored on the single satellite multiple measurement paradigm.
2. **Requirements Driven**.
   The studies must include an aggressive and comprehensive look at the requirements definition ***AND*** prioritization upfront and throughout. This area will require a broad NOAA and Administration commitment.
3. **Affordability.**
   We must consider the satellite and system end-to-end cost and technical readiness at the start and throughout the study, not only as a late activity assessment, to ensure we are building best value into the system.
4. **Traceable & Transparent.**
   We need to be transparent with our approach and execution, with pre-planned engagement activities with all NOAA LOs, within the USG (OMB, OSTP, NASA, DOD), and with the public (industry, users, customers) throughout the iterative study. The level of details shared and included will vary, but the spirit of engagement must be consistent.

How Could Future Data Flow Change?

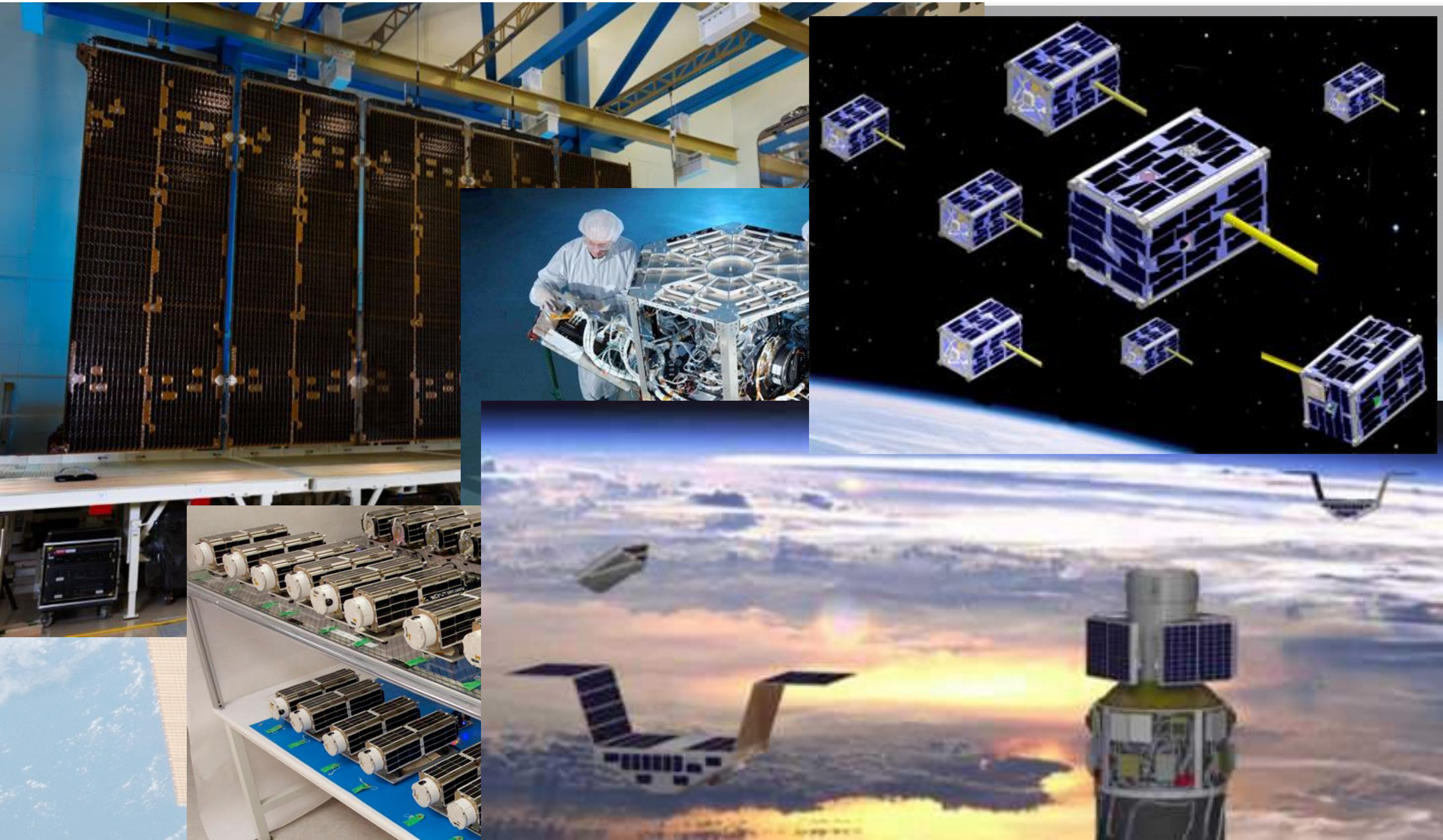


What Community Changes Could Change Our Operating Paradigm?

- Access to space
- Satellite technologies
- Data Integration, Quality, Ownership, Continuity

Access to Space

Satellite Technologies



Questions?