Early Adoption of GOES-R Baseline Products in NWS/NESDIS Operations

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NOAA/NESDIS/TPIO Contract Support for NOSIA Refresh

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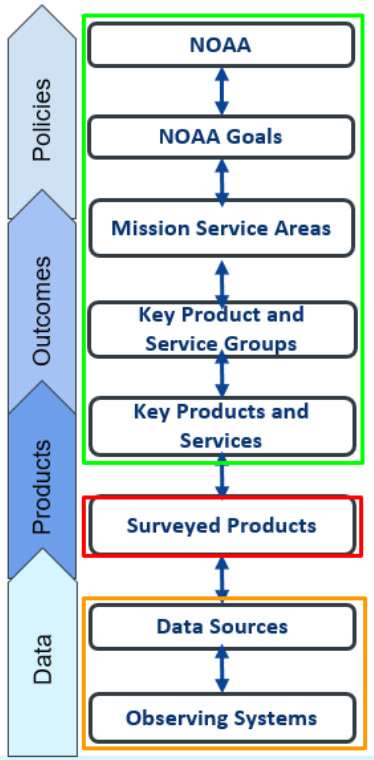
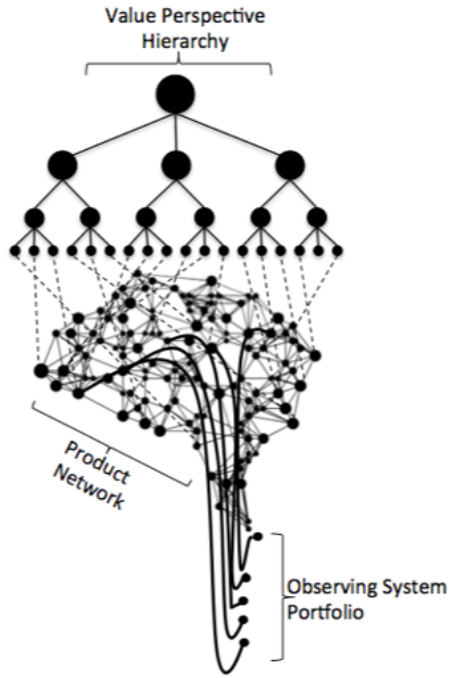
NOAA Observing System Integrated Analysis (NOSIA) Refresh

- This year we began surveying NWS and NESDIS business units to update NOSIA (2013-15).
- NOSIA is a diagnostic graph that links NOAA's portfolio of observing systems, including the GOES-R Program, through a highly interconnected network of products and services through a large number of mission outcomes grouped by "Mission Service Area". We call it the "NOAA Value Tree"
- Graph comprises >25K nodes, >125K edges
- Although work is ongoing, this is to report on our initial findings, specifically on the GOES ABI imagery relevance to specific operations and performance.





NOSIA-II Modifications

GOES-R Series ABI/GLM are Innovations

Objective: Understand preferences for and performance of

- Innovative ABI Products throughout the now-cast to warning decision-making time frame.
- Improved refresh rate
- Visual identification of specific phenomena relevant to mission support products
- Lightning information from GLM

This is where human-interpretable imagery flows into operational decision-making.

GOES-R Series Imagery Products

- More than a million possible level 1b and level 2 imagery products from GOES-R Series Advanced Baseline Imager (ABI) to support operations.
- NWS/MDL/AWIPS-II and N-AWIPS serve a pre-defined list of dozens of these products for Operations.
- STAR and CIMMS Development and CIRA Training have helped GOES-R Program Office Inculcate Benefits and Uses before Launch took place.
- NOSIA Refresh Surveyed operational business units of the NWS & NESDIS on 65 of these products to identify their operations-specific channel preferences and performance satisfaction estimates.

- Channels

  $n = 16$

- Channel Differences

  $n(n-1)$

- RGB's of Channels

  $n(n^2-1)$

- RGB's of Channel Differences

  $[n+n(n-1)]n(n^2-1)$

- Multiply that by Tailored Gamma Distributions of the brightness values = hundreds of millions of base imagery products.

AWIPS GOES Imagery Products Surveyed in NOSIA Refresh

Channel
Channel-01 (0.47 um) Blue Band
Channel-02 (0.64 um) Red Band
Channel-03 (0.86 um) Veggie Band
Channel-04 (1.37 um) Cirrus Band
Channel-05 (1.61 um) Snow/Ice Band
Channel-06 (2.24 um) Cloud Particle Size Band
Channel-07 (3.90 um) Shortwave Window Band
Channel-08 (6.19 um) Upper-Level Tropospheric Water Vapor Band
Channel-09 (6.93 um) “Mid-Level Tropospheric Water Vapor” Band
Channel-10 (7.34 um) “Lower-level Water
Channel-11 (8.44 um) Cloud-Top Phase Band
Channel-12 (9.61 um) Ozone Band
Channel-13 (10.33 um) Clean IR Longwave
Channel-14 (11.21 um) IR Longwave Window Band
Channel-15 (12.29 um) Dirty Longwave Window Band
Channel-16 (13.28 um) CO2 longwave infrared

Specialized Products
Aerosol Optical Depth Product
Clear Sky Masks Product
Cloud Base Height Product
Cloud Optical Depth Product
Cloud Particle Size Distribution Product
Cloud Top Height Product
Cloud Top Pressure Product
Cloud Top Temperature Product
Derived Motion Winds Product
Derived Stability Indices Product
Flight Icing Threat
Fog (Blended) Product
Land Surface Temperature Product
Lightning Detection: Events, Groups & Flashes Product
Precipitation (Type/Rate) Product
Sea Surface Temperature (Skin) Product
Temperature / Moisture Vertical Profiles Product
Total Precipitable Water Product

Channel Differences
Vegetation Indices GOES R-U Channel Difference (0.64 - 0.86)
Split Window Difference (SWD) GOES R-U Channel Difference (10.33 - 12.29)
Night Fog Difference GOES R-U Channel Difference (10.33 - 3.9)
Split Cloud Phase GOES R-U Channel Difference (11.21 - 8.44)
Fire/Hot Spot Characterization GOES R-U Channel Difference (2.24 - 1.61)
Fog GOES R-U Channel Difference (3.9 - 10.33)
Cloud and Moisture Imagery (CMIP) GOES R-U Channel Difference (6.19 - 0.64)
Split Ozone Profile GOES R-U Channel Difference (9.61 - 10.33)
Split Snow GOES R-U Channel Difference (1.6 - 0.64)

RGB's of Channel Differences
Air Mass RGB (6.19 - 7.34, 9.61 - 10.33, 6.19)
Ash RGB (12.29 - 10.33, 11.21 - 8.44, 10.33)
CIMSS Natural Color RGB (0.64, 0.86, 0.47)
Day Cloud Convection RGB (0.64, 0.64, 10.33)
Day Cloud Phase Distinction RGB (10.33, 0.64, 1.61)
Day Convection RGB (6.19 - 7.34, 3.9 - 10.33, 1.61 - 0.64)
Day Land Cloud RGB (1.61, 0.86, 0.64)
Day Land Cloud Fires RGB (2.24, 0.86, 0.64)
Day Ocean Cloud Convection RGB (0.86, 0.86, 10.33)
Day Snow-Fog RGB (0.86, 1.61, 3.9 - 10.33)
Daytime Composite #1 RGB (0.64, 1.61, 11.21)
Daytime Composite #5 RGB (0.64, 0.86, 0.64)
Differential Water Vapor RGB (7.34 - 6.19, 7.34, 6.19)
Dust RGB (12.29 - 10.33, 11.21 - 8.44, 10.33)
Fire Temperature RGB (3.9, 2.24, 1.61)
Icing RGB (0.64, 0.86, 1.61)
Nighttime Microphysics RGB (3.9, 10.35, 12.3)
Nighttime Microphysics RGB (12.29 - 10.33, 10.33 - 3.9, 10.33)
Simple Water Vapor RGB (10.33, 6.19, 7.34)
SO2 RGB (6.93 - 7.34, 10.33 - 8.44, 10.33)

Who we've spoken to so far…

Red-Green-Blue (RGB) Phenomenological Queuing

HI – Human Intelligence: Immediate Visual Interpretation as input to Operational Service Decision-Making

Business Unit Name	Product Name
NWS Alaska Region Arctic Testbed & Proving Ground	WFO National Digital Forecast Database (NDFD)
Aviation Weather Center	Airmen's Meteorological Information (AIRMET) Ceiling and Visibility
	Aviation Area Forecast
	Significant Meteorological Information (SIGMET) Convection
	Significant Meteorological Information (SIGMET) Dust and Sand
	Significant Meteorological Information (SIGMET) Icing
	Significant Meteorological Information (SIGMET) Turbulence
National Ice Center	Antarctic Iceberg Database
	Arctic Shipping Routes
	Weekly (Hemispheric) Arctic Sea Ice Analysis
	Weekly (Hemispheric) Antarctic Sea Ice Analysis
Alaska Aviation Weather Unit	Significant Meteorological Information (SIGMET) Volcanic Ash
Satellite Applications Branch	Manual Dvorak Intensity Classifications and Positions
	Satellite Precipitation Guidance Message Product (SPENES)
Weather Forecast Office Bismark, ND	Severe Thunderstorm Warning and Severe Weather Statement
Weather Forecast Office Buffalo, NY	Winter Storm Warning
Weather Forecast Office Huntsville, AL	Flash Flood Warning and Flash Flood Statement
Weather Forecast Office Oklahoma City, OK	WFO National Digital Forecast Database (NDFD)
Weather Forecast Office San Diego, CA	Fire Weather Watch
	Hot Spot Notifications
	Red Flag Warning
	Site Specific Fire Weather Spot Forecast
	Terminal Aerodrome Forecast

Who we're going to visit …

Site	Name	Tentative Date
NSSL	OAR National Severe Storms Laboratory	Winter 2020
NCEP-SPC	NWS Storm Prediction Center	Winter 2020
WFO-OUN	NWS Weather Forecast Office, Oklahoma City, OK (Norman)	Winter 2020
NCEP-NHC	NWS National Hurricane Center	Spring 2020
NCEP-OPC	NWS Ocean Prediction Center	Spring 2020
NCEP-WPC	NWS Weather Prediction Center	Spring 2020
ESRL	OAR Earth System Research Laboratory	Spring 2020
NCEP-SWPC	NWS Space Weather Prediction Center	Spring 2020
WFO-BOU	NWS Weather Forecast Office, Denver/Boulder, CO	Spring 2020
NCEI-CCOG	NESDIS National Centers for Environmental Information Center for Coasts, Oceans, and Geophysics	Spring/Summer 2020
NCEI-CWC	NESDIS Center for Weather and Climate	Spring/Summer 2021
NCEP-EMC	NWS Environmental Modeling Center	Summer 2020
NWC	NWS National Water Center	Summer 2020
OSPO-SPB	NESDIS Office of Satellite and Product Operations Satellite Products Branch	Summer 2020

Volcanic Ash Advisories	**85**		Always areas for improvement
Environmental Atmosphere Dispersion Model	60	75	Could meet user needs without these data, but would have fairly significant degradation
Ash3d Volcanic Ash Dispersion Model USGS	40		Not as user friendly as HySPLIT
Hybrid Single Particle Lagrangian Integrated Trajectory Model Dispersion Predictions, Operational	60		More interactive; can do more things with, can make changes and we are allowed more inputs
Environmental Atmosphere Model	60	70	Have other data in real-time, but necessary for looking out beyond a few hours
Atmospheric Models: International-proxy	10		
National Blend of Models	10		
North American Mesoscale Model	30		Full array of information; second to GFS due to lack of coverage beyor
High-Resolution Ensemble Forecast	10		
Finite Volume Cubed Sphere dynamic core based Global Forecast System	40		Full array of information. Most important atmospheric model
Geostationary Visible/Infrared Imagery	40	80	Big hit, can't meet requirements very well
GOES-R ABI Support to Volcanic Ash Advisories	**60**		Most of AOR uses GOES 16/17
Meteosat Second Generation SEVIRI	10		
Himawari AHI	30		Useful for far western pacific (as well as for ash coming from eastern
Global Seismographic Network	82	60	It helps and gives us an idea, but there are so many other sources of
In-Situ Upper Air	65	75	Can still do product, but will have some limitations
GOS Upper Air Network	50		Not a lot of upper air stations where there are active volcanoes
Upper-air Rawinsonde Network	50		Useful (but not a significant loss)
Polar Visible/Infrared Imagery (Low Resolution)	75	70	
JPSS VIIRS	35		two most important are SNPP and JPSS
SNPP VIIRS	35		two most important are SNPP and JPSS
AQUA MODIS	15		
TERRA MODIS	15		
Polar Visible/Infrared Imagery (Medium Resolution)	84	70	Very slight impact; does give some information that
Landsat Operational Land Imager	30		
Landsat Thermal Infrared Sensor	70		Plume definition can be seen with this sensor
Volcanic Monitoring	60	70	Somewhat significant impact. Could meet customer requirements, bu significantly degraded
Human Reports	2		Primarily from PIREPs (and even then quite rare)
USGS Volcano Observatories	25		Equally important to Int'l observatories(however, not as many active
International Volcano Observatories	25		Important, as many active volcanoes outside US
Remote Video Monitoring	48		
Flightradar24 Sweden	84	70	Slight impact
NOAA/CIMSS Volcanic Cloud Monitoring	70	80	Picks up ash from cloud-covered volcanoes, as well as nighttime eruptions. Lots of information provided by this data source. CIMSS continually improving it. Over time, this data source will become more important

Performance (Satisfaction) Scale

100	**Ideal**	Meets all requirements and exceeds some
90	**Fully Satisfied**	Meets all requirements
80	**Good**	Meets all major requirements, with minor limitations
60	**Fair**	Meets most major requirements, with significant limitations
40	**Poor**	Fails to meet many major requirements, but provides some value
20	**Very Poor**	Fails to meet most major requirements, but provides minor value
1	**No Capability**	Provides no value

GOES-R ABI Support to Volcanic Ash Advisories	80		AI could be added; not a product just yet
ABI 1-Minute Refresh	79	80	Not necessary for operations
ABI 5-Minute Refresh	1	80	
ABI Base Products	1	80	
GOES-R Channel-02 (0.64 um) Red Band	15		
GOES-R Channel-06 (2.24 um) Cloud Particle Size Band	1		
GOES-R Channel-07 (3.90 um) Shortwave Window Band	4		
GOES-R Channel-08 (6.19 um) Upper-Level Tropospheric Water Vapor Band	1		
GOES-R Channel-09 (6.93 um) Mid-Level Tropospheric Water Vapor Band	1		
GOES-R Channel-10 (7.34 um) Lower-level Water	1		
GOES-R Channel-11 (8.44 um) Cloud-Top Phase Band	1		
GOES-R Channel-12 (9.61 um) Ozone Band	2		
GOES-R Channel-13 (10.33 um) Clean IR Longwave	4		
GOES-R Channel-14 (11.21 um) IR Longwave Window Band	4		
GOES-R Channel-15 (12.29 um) Dirty Longwave Window Band	4		
GOES-R Channel-16 (13.28 um) CO2 longwave infrared	2		
Air Mass RGB (6.19 - 7.34, 9.61 - 10.33, 6.19)	4		
Ash RGB (12.29 - 10.33, 11.21 - 8.44, 10.33)	15		
CIMSS Natural Color RGB (0.64, 0.86, 0.47)	5		
Dust RGB (12.29 - 10.33, 11.21 - 8.44, 10.33)	8		
Nighttime Microphysics RGB (12.29 - 10.33, 10.33 - 3.9, 10.33)	12		
SO2 RGB (6.93 - 7.34, 10.33 - 8.44, 10.33)	8		
Split Window Difference (SWD) GOES R-U Channel Difference (10.33 - 12.29)	5		
Fire/Hot Spot Characterization GOES R-U Channel Difference (2.24 - 1.61)	2		

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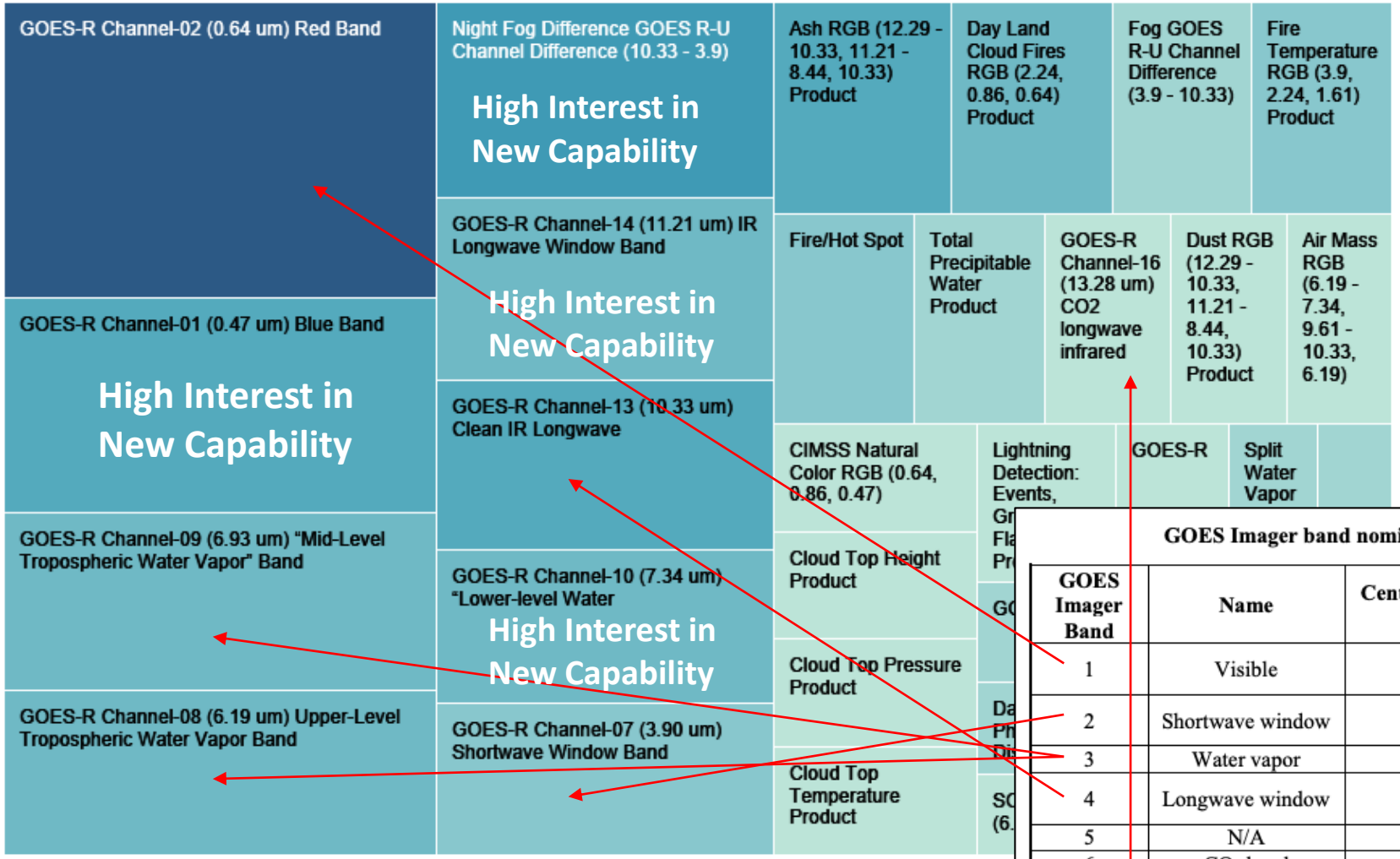
Advanced Baseline Imager (ABI) Channel/Baseline Product Dependence



Overall Dependence On Baseline Product (Box Size)

GOES Imager band nominal wavelengths (GOES-12 through 15)

GOES Imager Band	Name	Central Wavelength (µm)	Objective
1	Visible	0.63	Cloud cover and surface features during the day, smoke, etc.
2	Shortwave window	3.9	Low cloud/fog, fire detection, winds, etc.
3	Water vapor	6.48	Upper-level water vapor, winds, etc.
4	Longwave window	10.7	Surface or cloud-top temperature, precipitation, etc.
5	N/A	N/A	N/A
6	CO_2 band	13.3	CO_2 band: Cloud detection, etc.

Geostationary Lightning Mapper (GLM) Dependence

Product Name	Impact	Performance
Airmen's Meteorological Information (AIRMET) Ceiling and Visibility	0.28%	70
Aviation Area Forecast	2.57%	80
Fire Weather Watch	0.41%	80
Flash Flood Warning and Flash Flood Statement	0.47%	90
Hot Spot Notifications	1.43%	80
Red Flag Warning	0.41%	80
Severe Thunderstorm Warning and Severe Weather Statement	5.07%	75
Significant Meteorological Information (SIGMET) Convection	4.06%	75
Significant Meteorological Information (SIGMET) Turbulence	0.52%	90
Site Specific Fire Weather Spot Forecast	1.43%	80
Winter Storm Warning	0.11%	85

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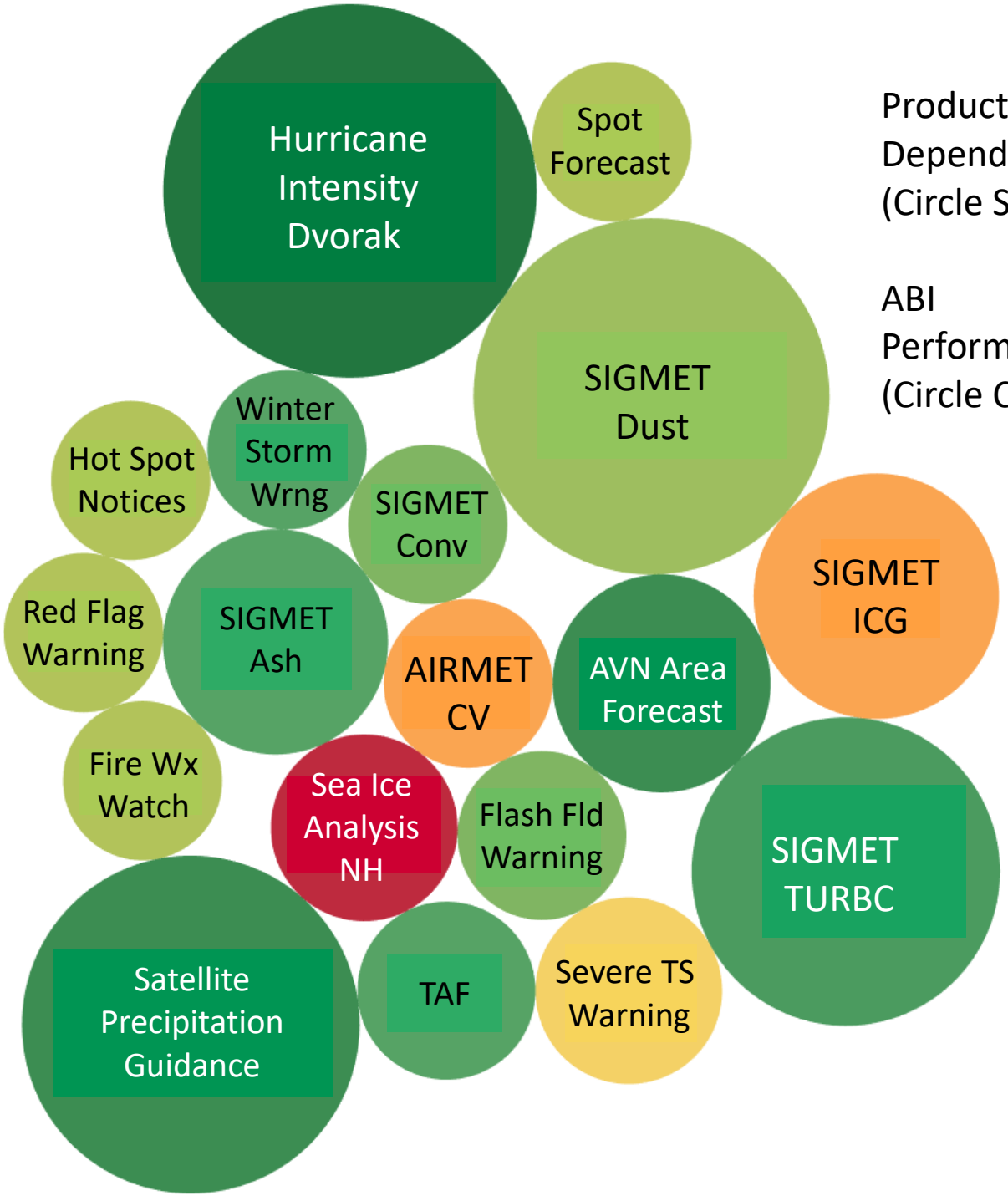
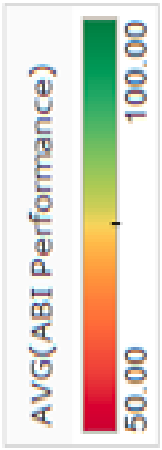


Product Dependence (Circle Size)

ABI Performance (Circle Color)



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	Imager	ABI
Average Performance Score	78.5	82.8
Standard Deviation	10.2	11.1
Population	34	19

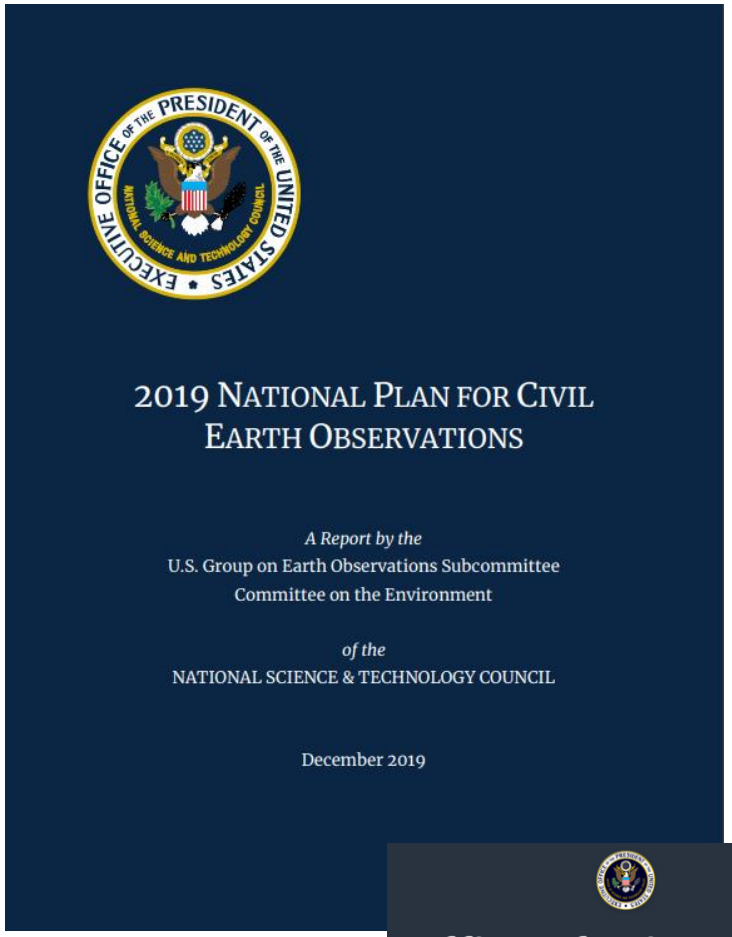
What the Service SME's say…

- "Fantastic Imagery!" "GOES-16-17 is a game changer with 5 min CONUS Refresh"
- "Major improvement in Ash Detection Product"
- "Huge Contribution to the WFO Mesoscale Analysis"
- "Vis Fog Difference" and "Dust RGB" products are very important.
- Daytime Red visible channel (2) just as important as the nighttime microphysics products
- Tropical Storm support still needs the entire Geostationary Constellation + Himawari / Meteosat SG
- There is some sensitivity to the "loop heat pipe" issue in the western deployed GOES-17
- "Derived Fire Temperature for alerts still takes too long"
- Mesoscale 1-min imagery prioritized by the Senior Duty Met at WPC. Takes about ½ hour

- Parallax issue remains for northern latitudes

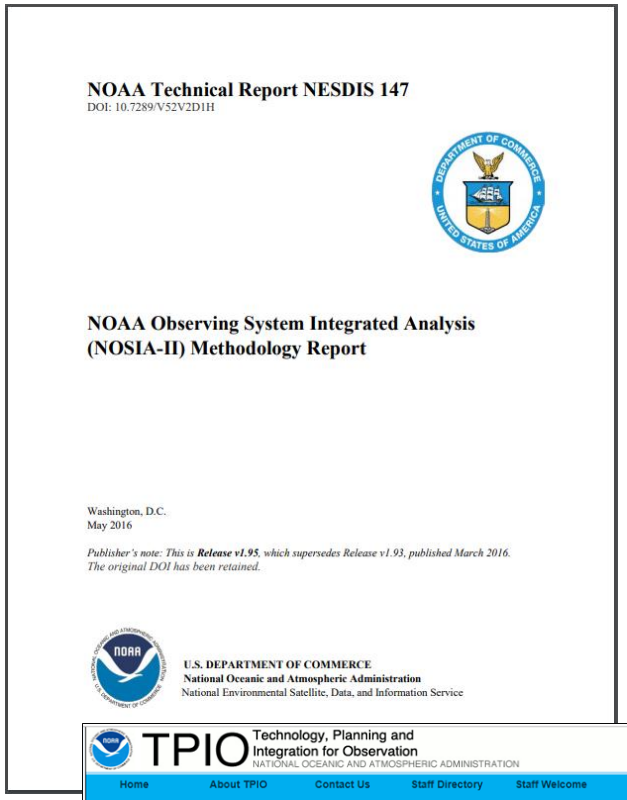
“ Prioritize the availability and continuity of Earth observations ”

“ Articulate the value of Earth observations ”



IDA/Science and Technology Policy Institute

US Geological Survey



NOAA’s Technology Planning and Integration for Observation