



NOAA

**Satellite and
Information
Service**

Sept. 29, 2020

The GEO-XO User Engagement Effort

Community Meeting on NOAA Satellites

Vanessa M. Escobar
Lead Scientist for GEO-XO User Engagement





Renew Our Focus on
User Engagement



Building From Our Experiences

“Our users expect and the Nation depends on (NESDIS) providing trustworthy, comprehensive environmental data and use-inspired products.”

Dr. Steve M. Volz



Navigating Legacy Data

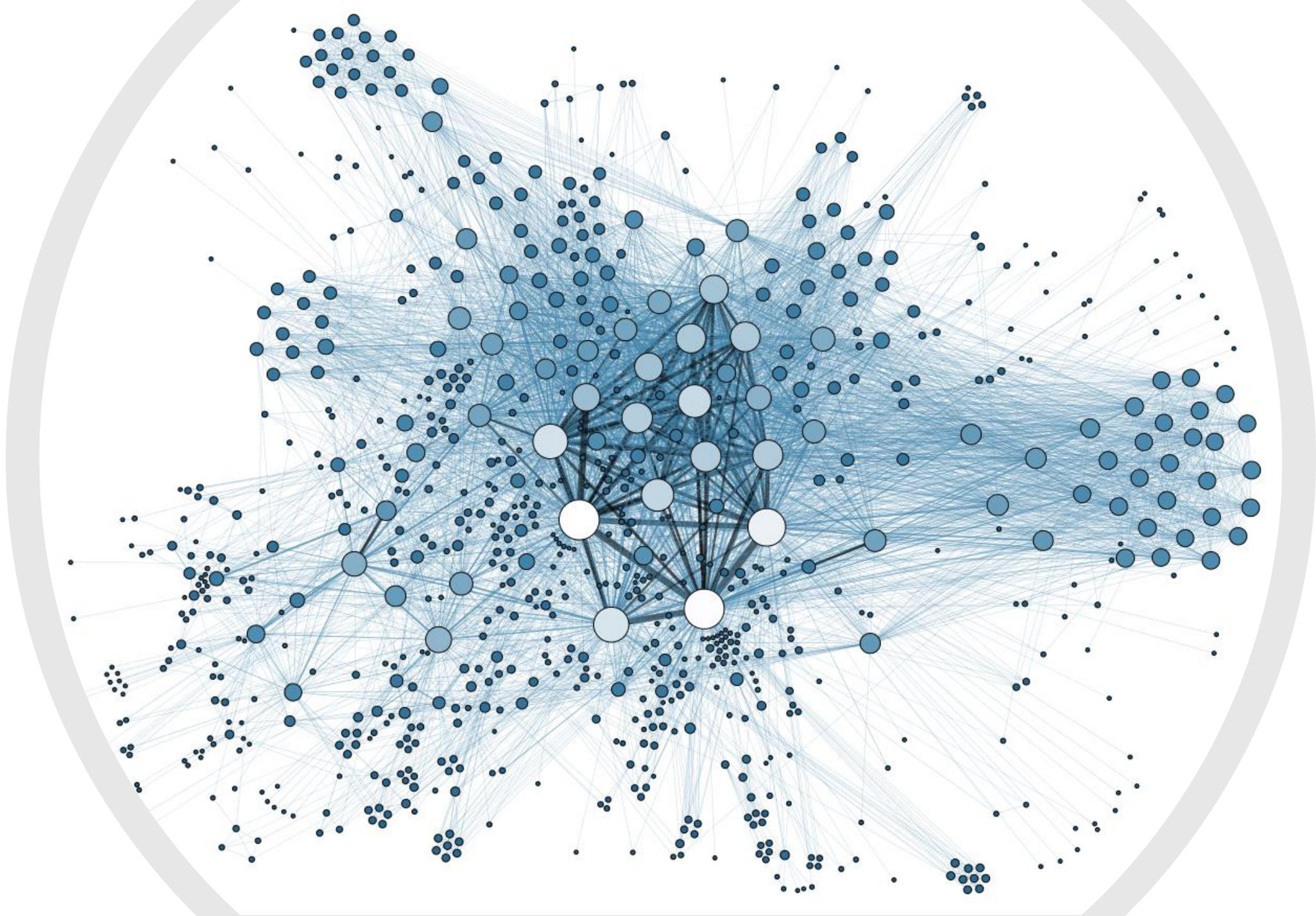
Internal Documentation

- NSOSA
- NOSIA
- SPRWG Conclusions

Public Documentation

- National Climate Assessment
- 2017 Earth Observations Decadal Survey
- 2017 Satellite Needs Working Group Report
- National Climate Assessment
- 2019 USGS and DOI Report on the Value of Earth Observations
- WMO Integrated Global Observing System Vision 2040
- 2017 NASA Earth Science Directive on Project Applications Program
- NASA Early adopter Program





The Framework

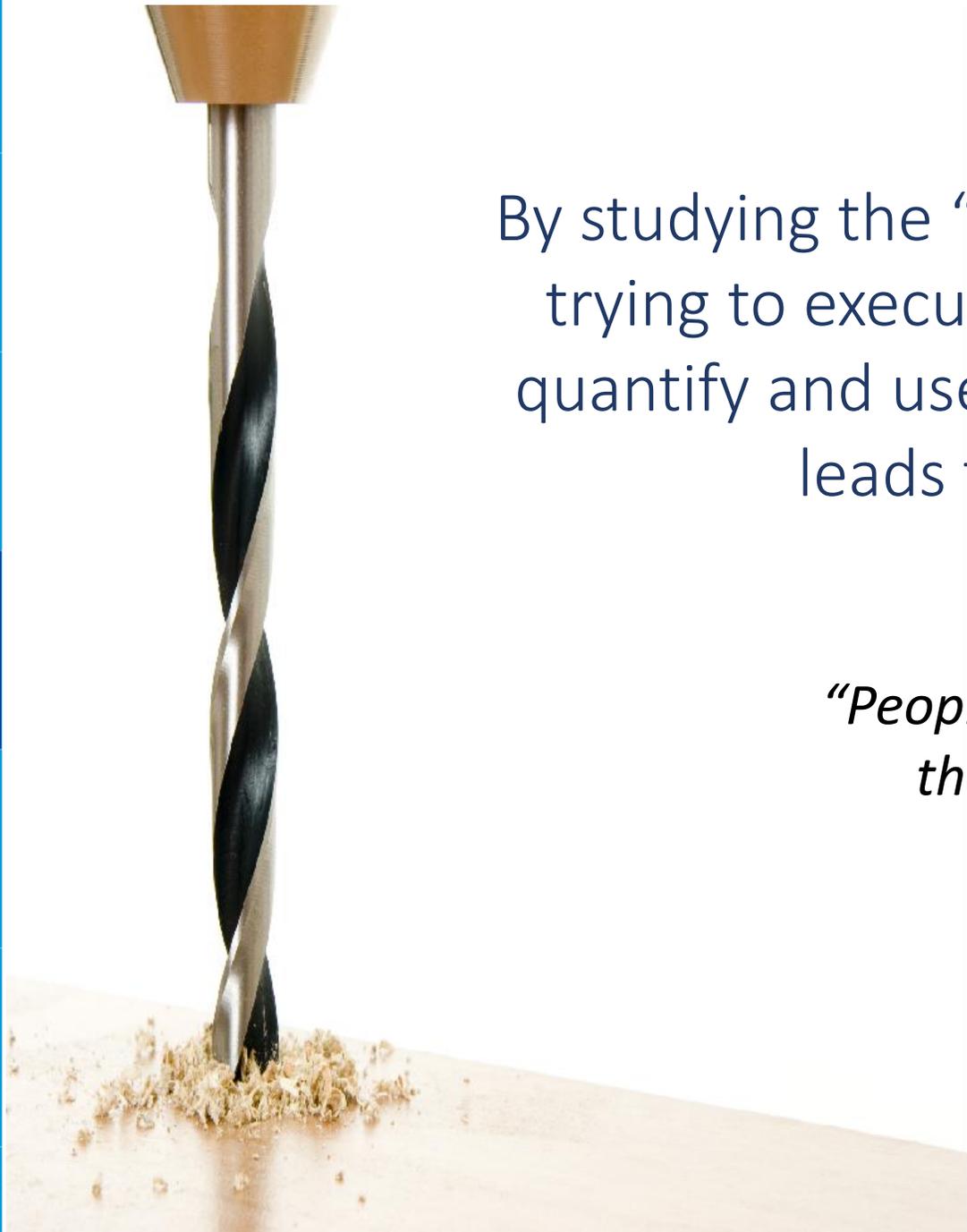
3 Key Strategies

- *Value of Information (VOI)*
- *Outcome Drive Innovation – Jobs to Be Done Theory*
- *User Feedback Tools*





Lives, resources,
supplies, time...



By studying the “underlying process” that people are trying to execute, it becomes possible to capture, quantify and use a new type of customer input that leads to predictable innovation.

*“People don’t want a quarter inch drill,
they want a quarter inch hole.”*



Tailoring the Information



- Identify the operational constraints and drivers affecting how stakeholders/users achieve their goals.
- Identify capability gaps and user needs in relevant use-cases.
- Explore how remote sensing data and capabilities can enhance various types of decision-making for external stakeholders during day-to-day operations, disaster incident response, and long-term studies and initiatives.
- Expand and enhance relationships between NOAA and external end-users of NOAA remote sensing products.

User Need Statement Translation

*Where does information go?
Who takes action?*

1

Potential Owner			
GEO	LEO	Enterprise Product Board	None of the Above-Not Relevant to NESDIS

2

User Information Target		
Product Generation	Product Delivery	Instrument

3

User Need Ranking	Capability Gap Ranking
-2 is low priority; 2 is highest priority	-2 is low priority; 2 is highest priority

4

Actions	
Decision Timeframe	XORWG translation to requirement

What is GEO-XO?

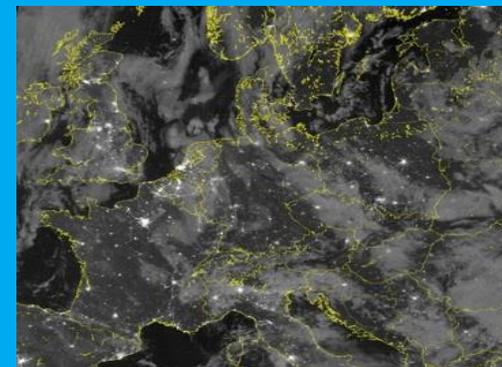
- **GEO-XO = Geostationary and Extended Orbits**
 - The initiative planning the missions to follow GOES-R
 - Will provide continuity for observations from geostationary orbit
 - Considering expanding capabilities to include observations from “Tundra” Highly Elliptical Orbit
- Includes government spacecraft and instruments or payloads hosted on commercial and/or partner spacecraft
- Potential use of commercial services for:
 - Communication relays
 - Observational data
- Planned for operation in the 2030-2050 timeframe
- Program scope & structure to be defined in formulation phase



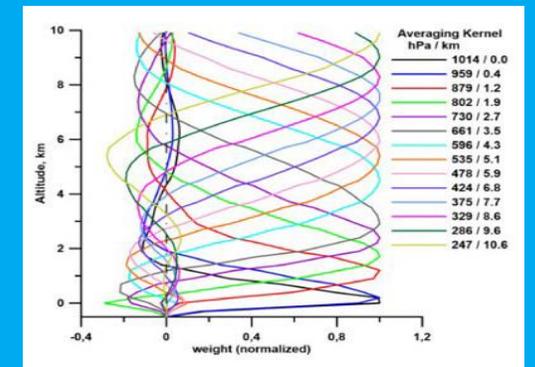
Visible Imagery



Lightning Detection

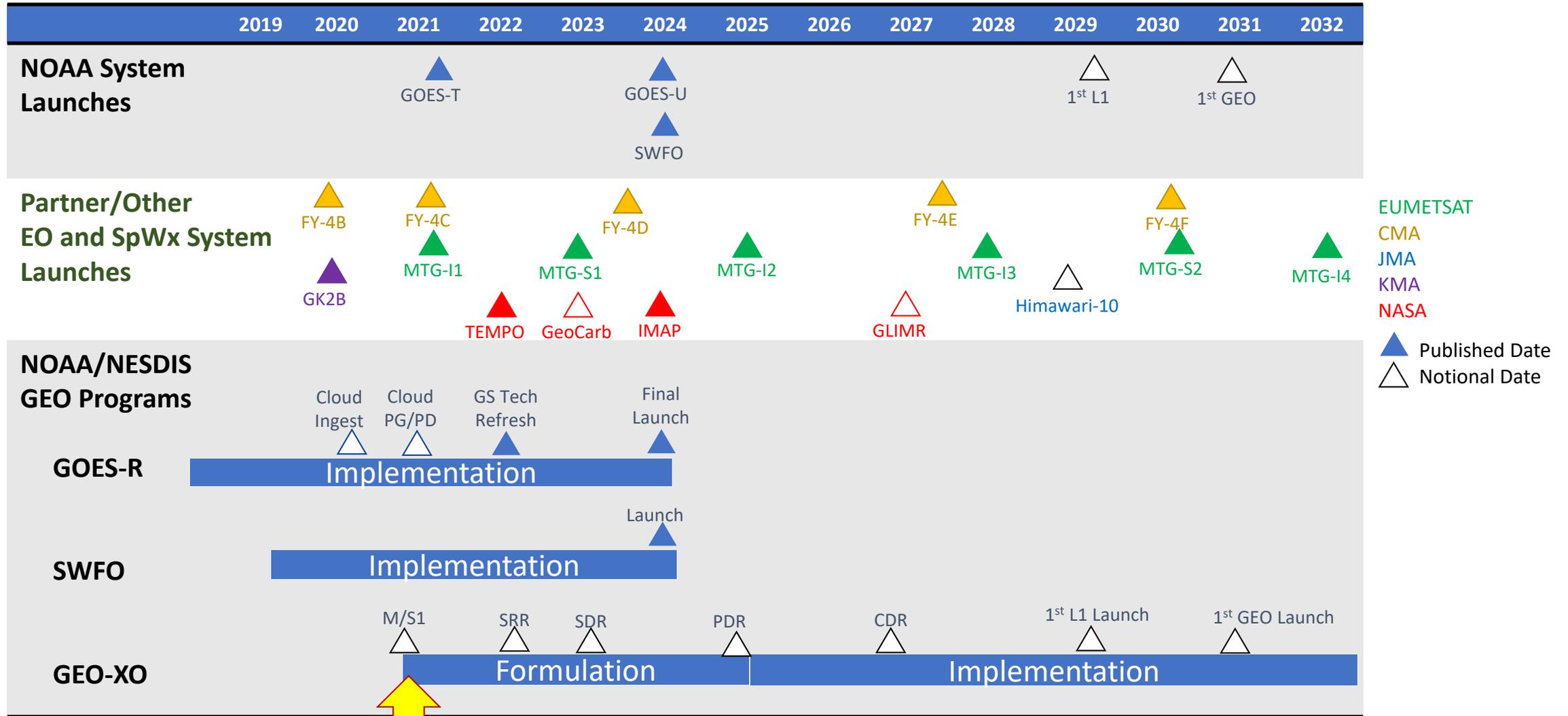


Day/Night Imagery



Sounding

The Next Decade of GEO



ALL DATES SUBJECT TO APPROVAL BY FUNDING AGENCIES; PARTNER DATES ARE FROM INTERNET SOURCES AND MAY NOT BE CURRENT

Awareness, Access, Availability

IT'S EASIER IF WE ALL PULL TOGETHER





NOAA GEO-XO Virtual Workshop Series



Fire Workshop



Wednesday, June 3, 2020

11:30 AM – 12:30 PM EDT

Hosted by:
National Environmental Satellite, Data, and Information Service

National Oceanic and Atmospheric Administration

Fire Workshop

June 3 – 5, 2020

178 Total Attendees



Human Health Workshop



Tuesday, July 28, 2020

11:00 AM – 12:00 PM EDT

Hosted by:
National Environmental Satellite, Data, and Information Service

National Oceanic and Atmospheric Administration

Human Health Workshop

July 28 – 31, 2020

207 Total Attendees



Weather Forecasting Workshop



Monday, July 20, 2020

11:00 AM – 12:00 PM EDT

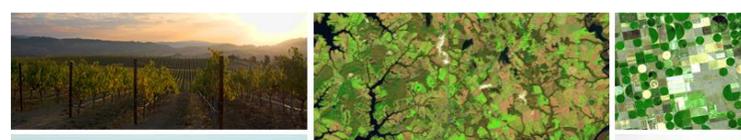
Hosted by:
National Environmental Satellite, Data, and Information Service

National Oceanic and Atmospheric Administration

Weather Workshop

July 20 – 24, 2020

233 Total Attendees



Agriculture Workshop



Tuesday, September 15, 2020

11:00 AM – 12:00 PM EDT

Hosted by:
National Environmental Satellite, Data, and Information Service

National Oceanic and Atmospheric Administration

Agriculture Workshop

September 15 – 18, 2020

152 Total Attendees



NOAA GEO-XO Virtual Workshop Series

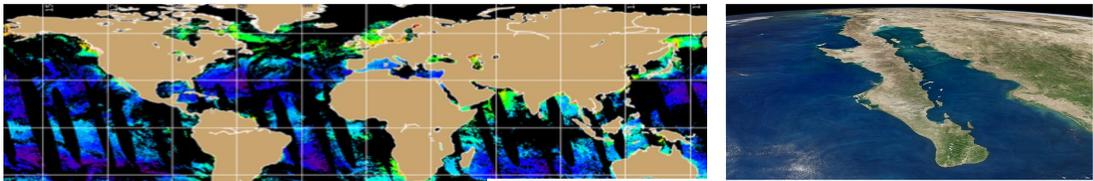


Led By National Academies of Sciences
Engineering and Medicine

June 16 - 17, 2020
September 9 -11 2020



Space Weather Workshop



In development and will follow an Oceans
community assessment

November 17-20, 2020



Oceans, Coastal and Inland Waterbodies Workshop



Tuesday, November 17-20 2020

Hosted by:

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





Over 700 through events and survey, and with a database of 2500 and growing.

300

Individuals
representing
U.S. Federal
Agencies

92

Individuals
representing
State, Local, Tribal,
and Territorial
Organizations

124

Individuals
representing
Academic
Institutions

112

Individuals
representing
the Private
Sector

83

Individuals
representing
International
Governments and
Institutions



Workshop

- (All)
- Agriculture
- Fire
- Health
- Oceans
- Weather

Stakeholders by Organization Type



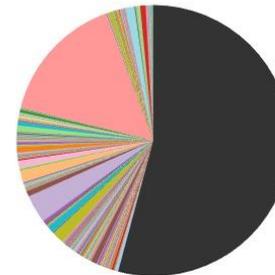
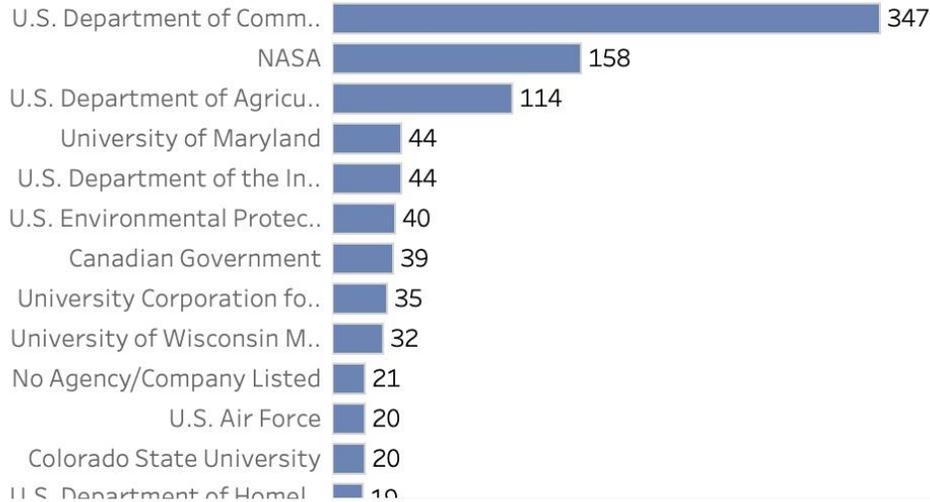
Agency Breakdown

Branch Breakdown

Display as:

Count ▼

Agency or Company



- 25th Operational Weat..
- 557th Weather Wing
- Acre
- Africa
- Agri Climate Smart Fin..
- Agricultural & Biologic..
- Agricultural Research ..
- Agriculture and Agri-F..
- Agriculture and Econo..
- Agriculture Finance
- Agriculture Finance an..
- Agriculture Strategic I..
- AgriLife Research
- Air Force Civil Engineer

Workshop Engagement and Attendance

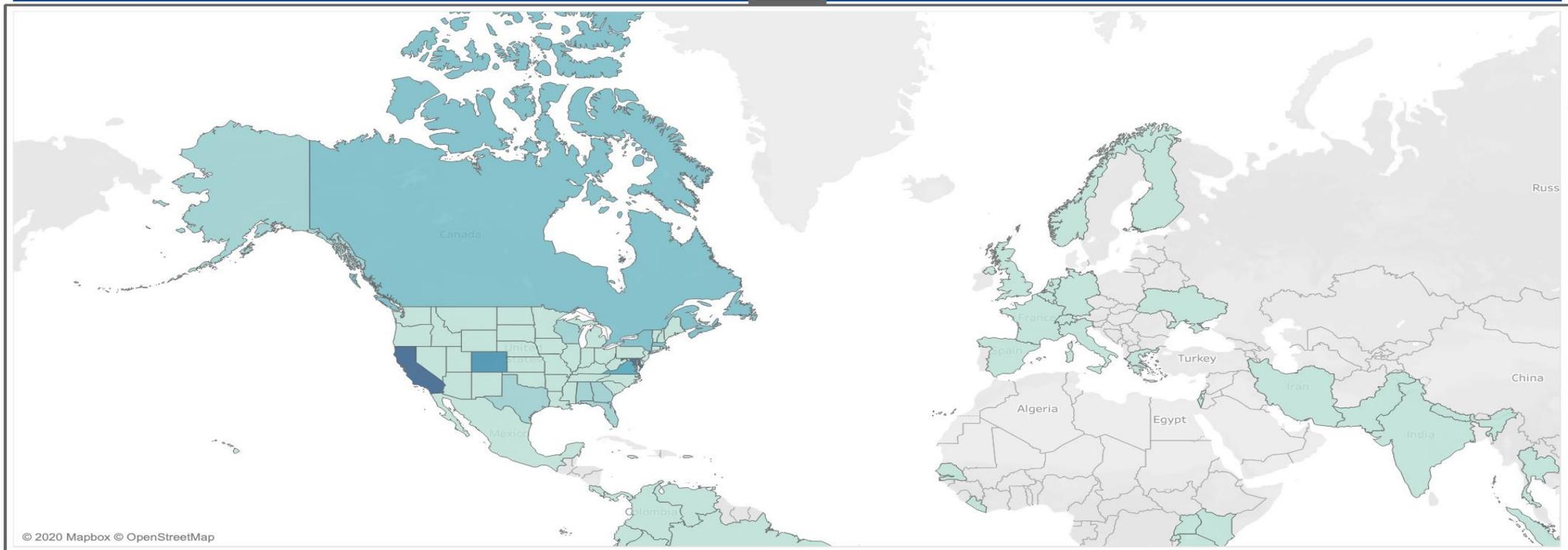
Stakeholders Tracked	Stakeholders Invited	Workshop Attendees*	Invited/Attendance Rate	Survey Returns
2,319	1,573	753	48%	319

Breaking down users by geolocation and areas of interest

Altshuler, Tom		Teledyne Marine	☁
Alvarado, Matt		Atmospheric and Environmental Research	⊕
Ambrosia, Vince		NASA [ASP]	🔥
Amirshahi, Pouyan		U.S. Department of Commerce [NOAA]	☁
Ammann, Caspar		University Corporation for Atmospheric Research	🌿
Amos, Helen		NASA [GSFC]	⊕
Andersen, Bret		U.S. Department of Agriculture [Forest Service]	🔥

🌿 Agriculture
🔥 Fire
⊕ Health
☁ Oceans
☁ Weather
■ Attended
■ Did not attend

Stakeholder Map



Topics have yet to be completed: Agriculture and Land Use (scheduled for Sept 12 - 15, 2020); Oceans (not yet scheduled)



Please contribute to
our upcoming
discussions

Your feedback is our
progress!

Thank You
Vanessa.Escobar@noaa.gov



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GEO-XO User Engagement Effort with the Fire Community

Community Meeting on NOAA Satellites

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Fire Workshop

June 3 – 5, 2020
178 Total Attendees



Planning Organizations

U.S. Department of Agriculture Forest Service
Geospatial Technology and Applications Center
Geospatial Management Office
Fire Imaging Requirements Matrix-by mission

NASA Earth Sciences Disasters Program

National Oceanic and Atmospheric Administration (NOAA)

- Climate Program Office
- National Marine Fisheries Service
- National Ocean Service National Centers for Environmental Information (NCEI)
- Center for Satellite Applications and Research (STAR)

Reference Documents

- Fourth National Climate Assessment
- National Interagency Fire Center Documentation



27

Individuals representing International Governments and Institutions

31

Individuals representing Academic Institutions

90

Individuals representing U.S. Federal Agencies

19

Individuals representing State, Local, Tribal, and Territorial Organizations

10

Individuals representing the Private Sector



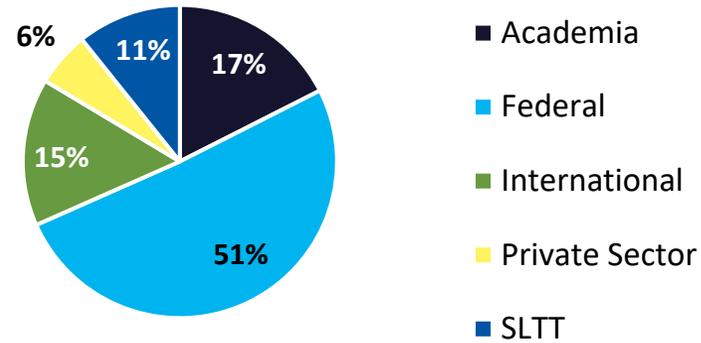


Fire Workshop Participation

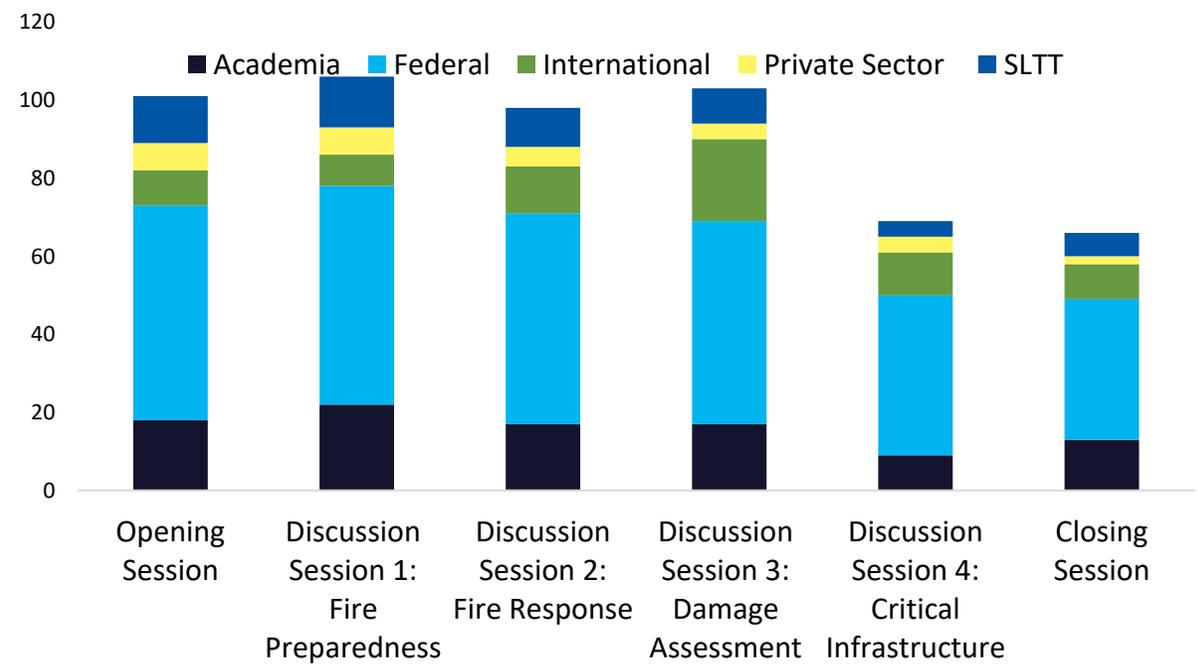


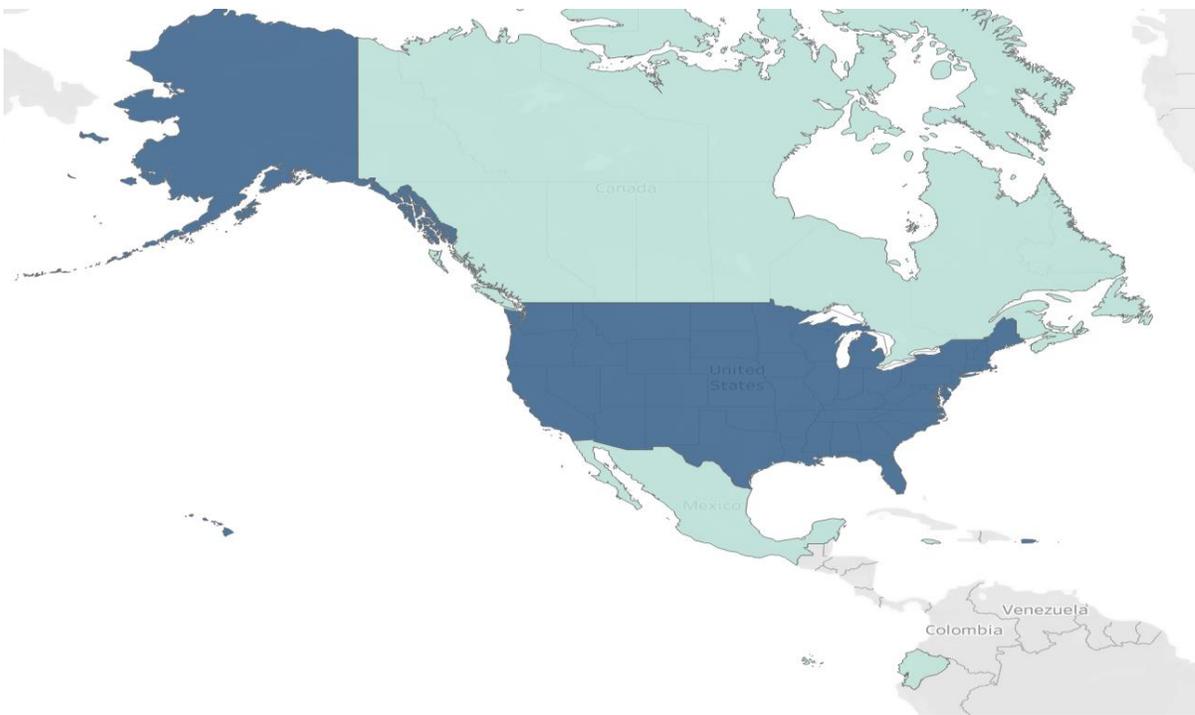
Time	Event	Number of Participants
Wednesday, June 3, 2020		
11:30 – 12:30 PM EDT	Opening Session	104
12:30 – 2 PM	Discussion Session #1: Fire Preparedness	109
3 – 5 PM	Discussion Session #2: Fire Response	105
Thursday, June 4, 2020		
12 – 2 PM	Discussion Session #3: Damage Assessment	107
3 – 5 PM	Discussion Session #4: Critical Infrastructure	71
Friday, June 5, 2020		
1 – 2:30 PM	Closing Session	67

Breakdown of Attendance by Sector

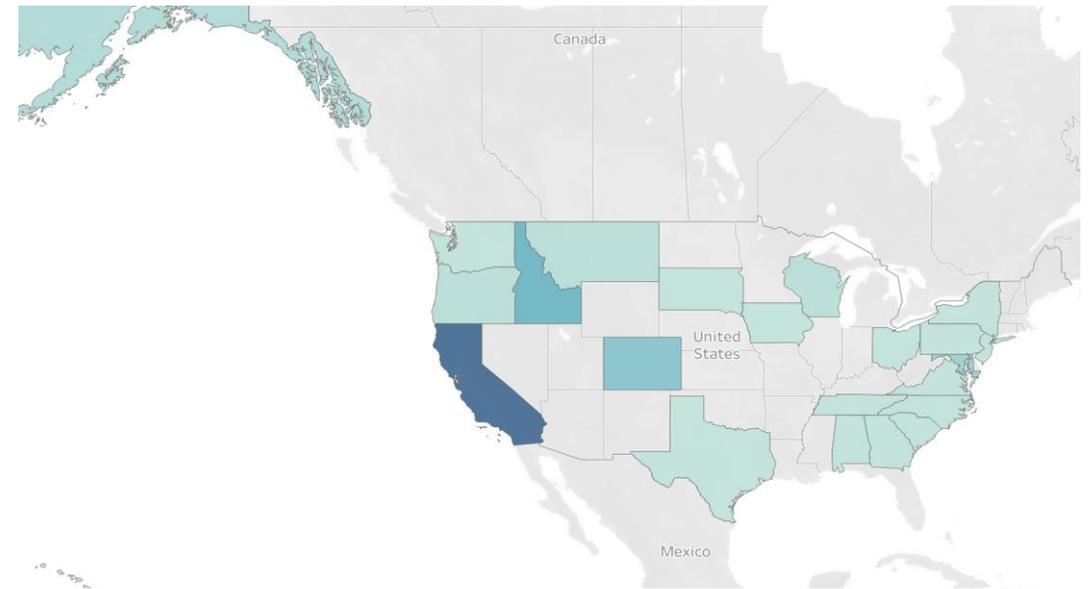


Number of Participants per Session, by Sector





- Fire capability gaps and needs driven by workshop feedback and USFS Fire Imaging Requirements (by mission) Matrix
- User Needs survey to prioritize top need for user requirements



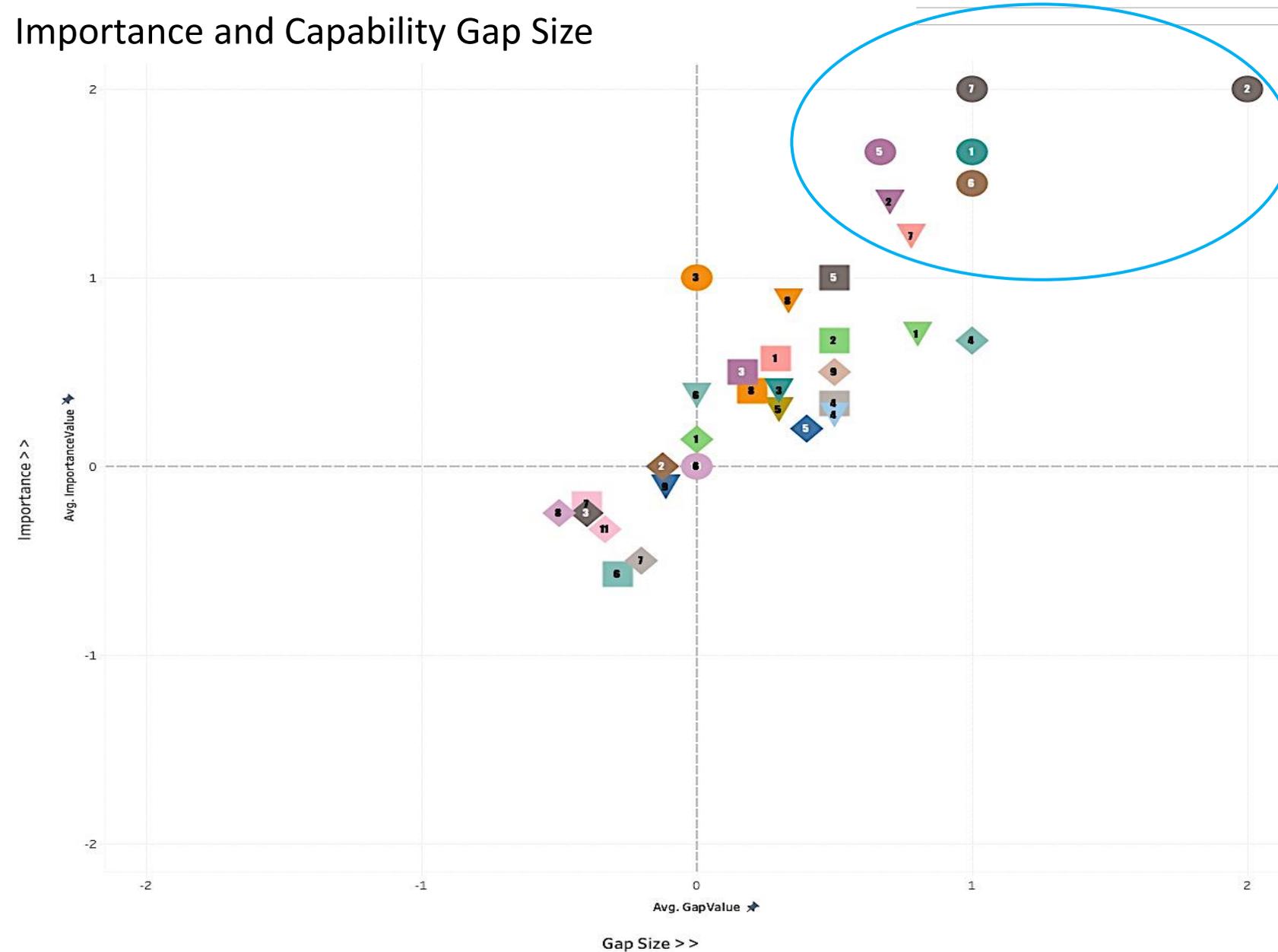
Fire Workshop Survey



Federal Government	State, Local, Tribal, or Territorial Government	Academia	Private Sector	Non-Profit Sector	Foreign National Government	Foreign State, Local, Tribal, or Territorial Government	Contractor to USGS	Federally Funded Research and Development Center	Public sector	Volunteer Fire Department
36	34	14	5	3	2	2	1	1	1	1

User Need Statement Quad Chart: Fire

Importance and Capability Gap Size



Highest Importance and Greatest Gap Size

Critical Infrastructure

- 2. It is difficult to get data quickly enough (latency) to fit within a decision horizon for public safety critical infrastructure changes (e.g., public safety power shutoffs).
- 7. Vegetation indices are not updated frequently enough to be fully leveraged in fire behavior forecasting.
- 5. Hotspot detection needs to be integrated into an automated alerting system to reduce latency.
- 1. GIS data compatibility and integration with other systems is limited.
- 6. In the complex context of WUI fires, imagery does not capture high enough detail on fire extent.

Fire Response

- 2. We need more reliable, timely, information to show where and when a fire starts.
- 7. The delay caused by the "Valley of Death" (the difference between a product being acquired by an agency and utilized by responders) is currently too long.

What did we learn?

Improvements

- **Smoke:** Nearly all aspects of wildfire are severely hampered by smoke and clouds limiting the utility of fire response awareness, and tracking/maintaining situational awareness at night
- **Fuels:** Vegetation indices and data need to be updated more frequently during the off-season, and integrated into fuel bed composition assessments.
- **Lightning:** Need an improved capability to track lightning strike locations to facilitate a quicker incident response, especially in rural areas with wide woodland swaths (e.g., Pacific Northwest, Alaska, Canada).
- **Mapping.** Fire intensity mapping (low vs high). Intermittent burning and smoldering fires are not spotted or captured effectively.

Access

- **Archives:** To historical wildfire data in order to
 - Compare previous fires to current fire events (including for predictive modeling and fire behavior estimations).
 - Justify wildfire-related budget and funding requests to state and local governments.
- **Format:** It is important to standardize data formats for sharing information across different stakeholder organizations.

Awareness

- For Wildland Urban Interface fires, current imagery does not capture high enough detail/resolution on **fire extent** nor is it available at **high enough temporal frequency**.



What is GEO-XO reviewing at this time?

User Needs Workshop Feedback	Plan	Decision Timeframe
1. The community needs help with fuels data (i.e., how wet or dry is the ground and vegetation)	<i>Do any of the Imager upgrades we are studying address this – the green channel?</i>	At conclusion of Imager Phase A study ECD Spring 2022
2. They would like to have our data provided in a GIS-friendly format	Will be considered in GEO-XO Ground System design	Ground System Phase A study 2024
3. First detection (for fire) from satellites is very rare – it's usually from the public. Satellites mainly used to monitor fire spread with time	<i>No action? Or say finer resolution 3.9um channel will increase # of fire detected by satellite? Or say GLM product on sustained duration flashes helps?</i>	N/A?
4. They suggest a combined GEO/LEO product with active fires	<i>Will be considered as a GOES-R/JPSS product?</i>	TBD
5. Request for a dual-gain ~3.9 micron band (allows for higher saturation temperature)	Dual gain 3.9um band be studied in Imager formulation	At conclusion of Imager Phase A study ECD Spring 2022
6. The most coarse resolution data that would be helpful for post-fire burn scar mapping is around 250 m, and they'd probably need more than just 1 VIS band (very unlikely from GEO or Tundra)	Increasing Vis channel resolution to 250m is being studied in Imager formulation	At conclusion of Imager Phase A study ECD Spring 2022
7. Smoke detection/tracking at night is difficult to impossible with current satellite technology. A GEO DNB could help with this.	Adding the DNB capability as a standalone instrument or built into another GEO-XO instrument is being studied in GEO-XO formulation	At conclusion of Imager and Sounder Phase A studies ECD Fall 2022
8. They need 1 km resolution 3.9 band	1km 3.9um band be studied in Imager formulation	At conclusion of Imager Phase A study ECD Spring 2022



Discussion

- What does fire planning and response look like in 2030?
- What information do we need to be successful?
- What is the biggest challenge today that we can plan to improve upon for the future?



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Sept. 29, 2020

GEO-XO User Engagement Effort with the Weather Forecasting Community

Community Meeting on NOAA Satellites

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Lead Scientist for GEO-XO User Engagement





Weather Forecasting Workshop

July 20 – 24, 2020.
233 Total Attendees



Planning Organizations	Reference Documents
<p>National Oceanic and Atmospheric Administration (NOAA)</p> <ul style="list-style-type: none"> National Weather Service National Centers for Environmental Information (NCEI) Center for Satellite Applications and Research (STAR) 	<ul style="list-style-type: none"> Fourth National Climate Assessment National Weather Service Directives

17
Individuals representing International Governments and Institutions

30
Individuals representing Academic Institutions

115
Individuals representing U.S. Federal Agencies

4
Individuals representing State, Local, Tribal, and Territorial Organizations

65
Individuals representing the Private Sector



Weather Forecasting Workshop Participation



Monday, July 20, 2020

11 AM – 12 PM EDT	Opening Session	124
1 – 4 PM	Discussion Session #1: Winter Weather	85
	Discussion Session #2: Marine Weather	43

Tuesday, July 21, 2020

12 – 3 PM	Discussion Session #3: Tropical Weather	80
	Discussion Session #4: Arctic Forecasting	59

Wednesday, July 22, 2020

12 – 3 PM	Discussion Session #5: Severe Storms	87
	Discussion Session #6: Climate Modeling	32

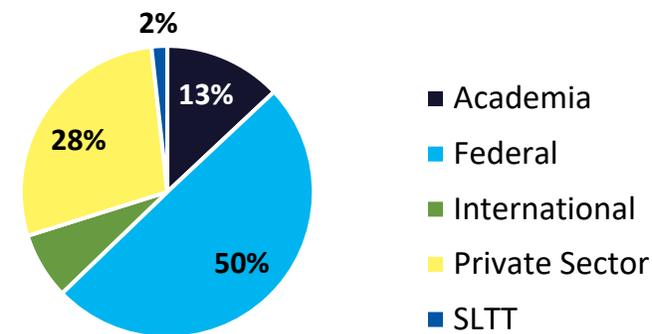
Thursday, July 23, 2020

12 – 3 PM	Discussion Session #7: Routine Weather Forecasting	88
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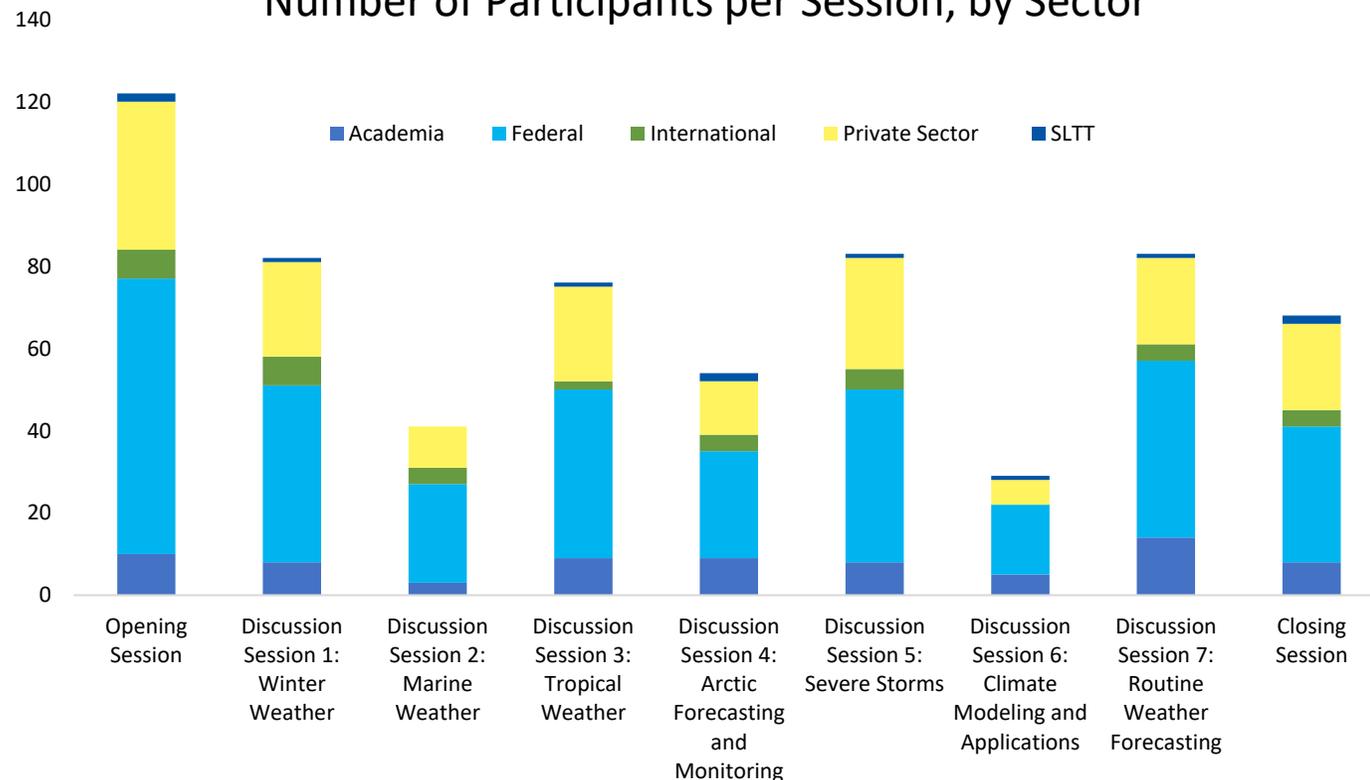
Friday, June 24, 2020

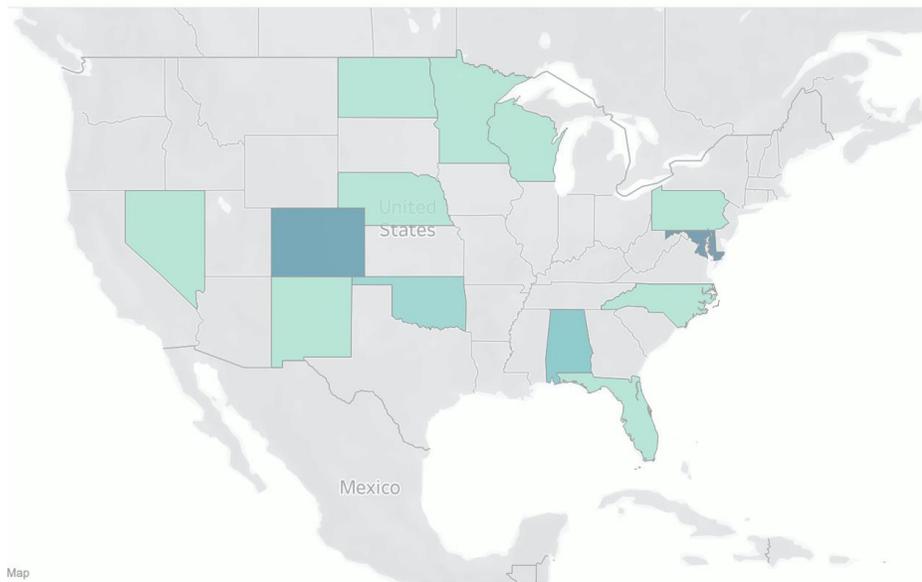
1 – 2:30 PM	Closing Session	71
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Breakdown of Attendance by Sector



Number of Participants per Session, by Sector





- Weather capability gaps and needs driven by workshop feedback
- NWS Center Interviews
- NWS feedback on priority needs and challenges by individual weather topic



Weather Forecasting Workshop Survey



Federal Government	Academia	State, Local, Tribal, or Territ..	Private Sector	Non-Profit Sector	Federally Funded Resear..	Gobierno de Chile	US Air Force Contractor
33	12	3	5	1	1	1	1



Winter Weather Session Poll

GLM (lightning) or DNB (low-light): What would be more useful for winter weather if a DNB from geostationary orbit was possible?



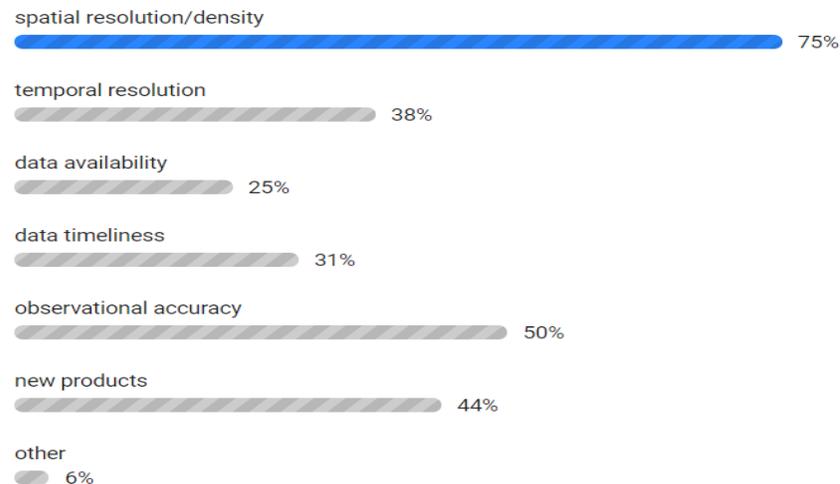
Tropical Weather Session Poll

What instrument in geostationary orbit would you most like to complement an imager to provide tropical weather services?



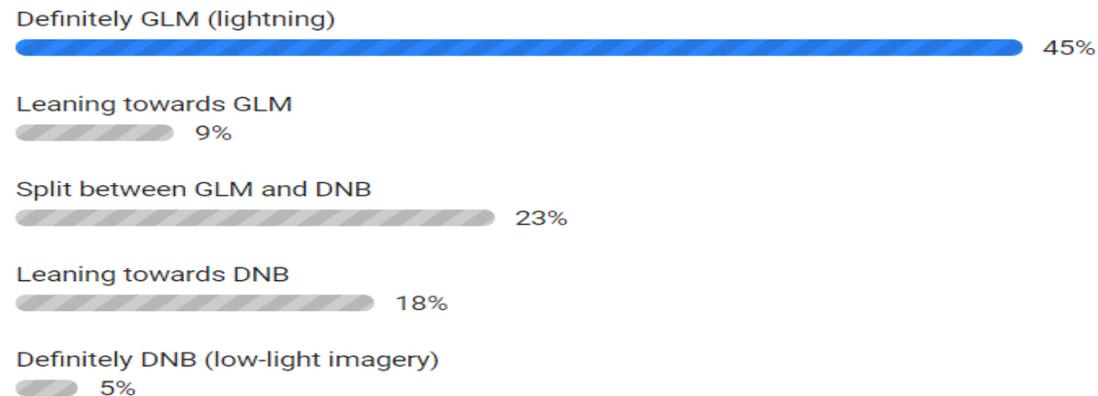
Routine Weather Session Poll

For Nowcasting, what satellite imagery and product improvements would you most like to see (select all that apply).



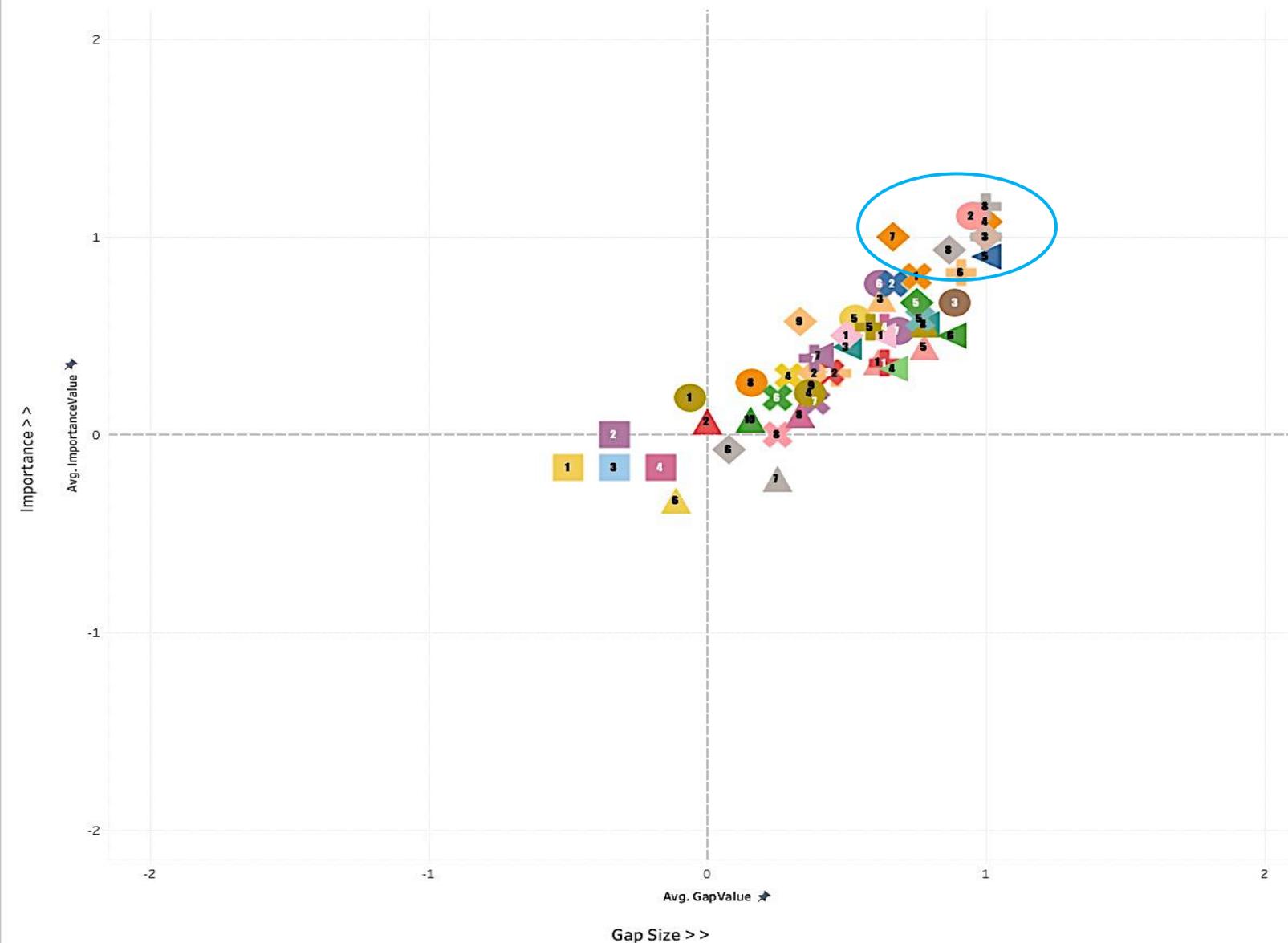
Severe Weather Session Poll

What would you rather have in geostationary orbit for severe weather detection and monitoring?



User Need Statement Quad Chart: Weather Forecasting

Importance and Capability Gap Size



Topic Legend
 ◀ Arctic Monitoring and Predict.. ■ Climate Modeling and Applica.. + Marine Weather ✖ Routine Weather Forecasting ● Severe Storms ◆ Tropical Weather

Highest Importance and Greatest Gap Size

Marine Weather
 8. High-resolution, high-accuracy, surface wind vectors over the ocean are not captured frequently, or available quickly enough.

Severe Storm
 2. Boundary layer measurements are not leveraged to their full potential.

Tropical Weather
 4. It is difficult to quickly and accurately track flood inundation following hurricane landfall.

Tropical Weather
 3. Increased accuracy in wind speed near the eye and eyewall of tropical cyclones would be helpful.

Marine Weather
 3. Tracking wave height, particularly in quickly changing conditions during marine weather events is difficult.

Topical Weather
 7. It is challenging for forecasters to accurately predict evacuation zones with enough lead-time for partner agencies to implement effective evacuation plans for communities (a minimum of 36 hours).

8. High-resolution, high-accuracy, surface wind vectors over the ocean are not captured frequently, or available quickly enough.

Arctic Prediction
 5. Observational data in northern areas (above 60N) is limited.

What did we learn?

Improvements

- Need more observational **data in northern areas** (above 60N).
- Greater accuracy in measuring **sea ice thickness**.
- Gaps in coverage of the **Pacific Ocean** have a detrimental effect on tropical and marine weather forecasting.

Challenges

- Still difficult to identify the **characteristics of snowfall**, such as composition, rate, and water equivalent, accurately.
- Still difficult to track weather conditions in the **boundary layer**, particularly in mountainous areas.
- It is difficult to forecast marine weather on **inland lakes**.
- Tracking **wave height**, particularly in quickly changing conditions during marine weather events is difficult.
- It is difficult to quickly and accurately track **flood inundation** following hurricane landfall.
- It is difficult to accurately forecast the **location and size of atmospheric rivers**.
- It is difficult to accurately **measure cloud moisture content**.

Access

- Data is not **centralized or easily accessible**.
- Metadata is not **standardized** across different climate datasets.
- Maintaining compatibility with **archival data is critical** to effective forecasting.





Discussion

- What does fire planning and response look like in 2030?
- What information do we need to be successful?
- What capability gaps do you face at this stage of forecasting?
- What is the biggest challenge today that we can plan to improve upon for the future?

What is GEO-XO reviewing at this time?

User Needs Workshop Feedback	Plan	Decision Timeframe
1. Data is not centralized or easily accessible.	<i>Send to the Enterprise Product Board</i>	Enterprise Cloud
2. It is difficult to quickly and accurately track flood inundation following hurricane landfall.	For GEO-XO, looking into improvements in VNIR spatial resolution, which can help with flood detection between clouds. For GOES-R and JPSS, an experimental flood detection product may be promoted to operations	Ground System Phase A study 2024
3. Forecasters lack data on the features and characteristics of the eyewall in a tropical cyclone.	GEO-XO is studying the possibility of a microwave sounder, which can help in the analysis of tropical cyclone structure beneath clouds	At conclusion of Imager Phase A study ECD Spring 2022
4. There is a need to improve sensing capabilities beneath mid-level cloud layers.	GEO-XO is studying the possibility of a microwave sounder, which can help see through clouds to layers below	At conclusion of Imager Phase A study ECD Spring 2022
5. Accuracy needs to be improved in rainfall rate data.	GEO-XO is studying the possibility of a microwave sounder, can improve the accuracy of satellite rainfall rate estimates	At conclusion of Imager Phase A study ECD Spring 2022
6. More information is needed on moisture trends and cloud moisture levels.	GEO-XO is considering an IR hyperspectral IR sounder, which can help retrieve and track atmospheric water vapor at multiple vertical levels	At conclusion of Imager Phase A study ECD Spring 2022
7. There is a need for a green visible band so that “True Color” products need not be estimated.	GEO-XO is strongly considering add a green band to its imager	At conclusion of Imager Phase A study ECD Spring 2022



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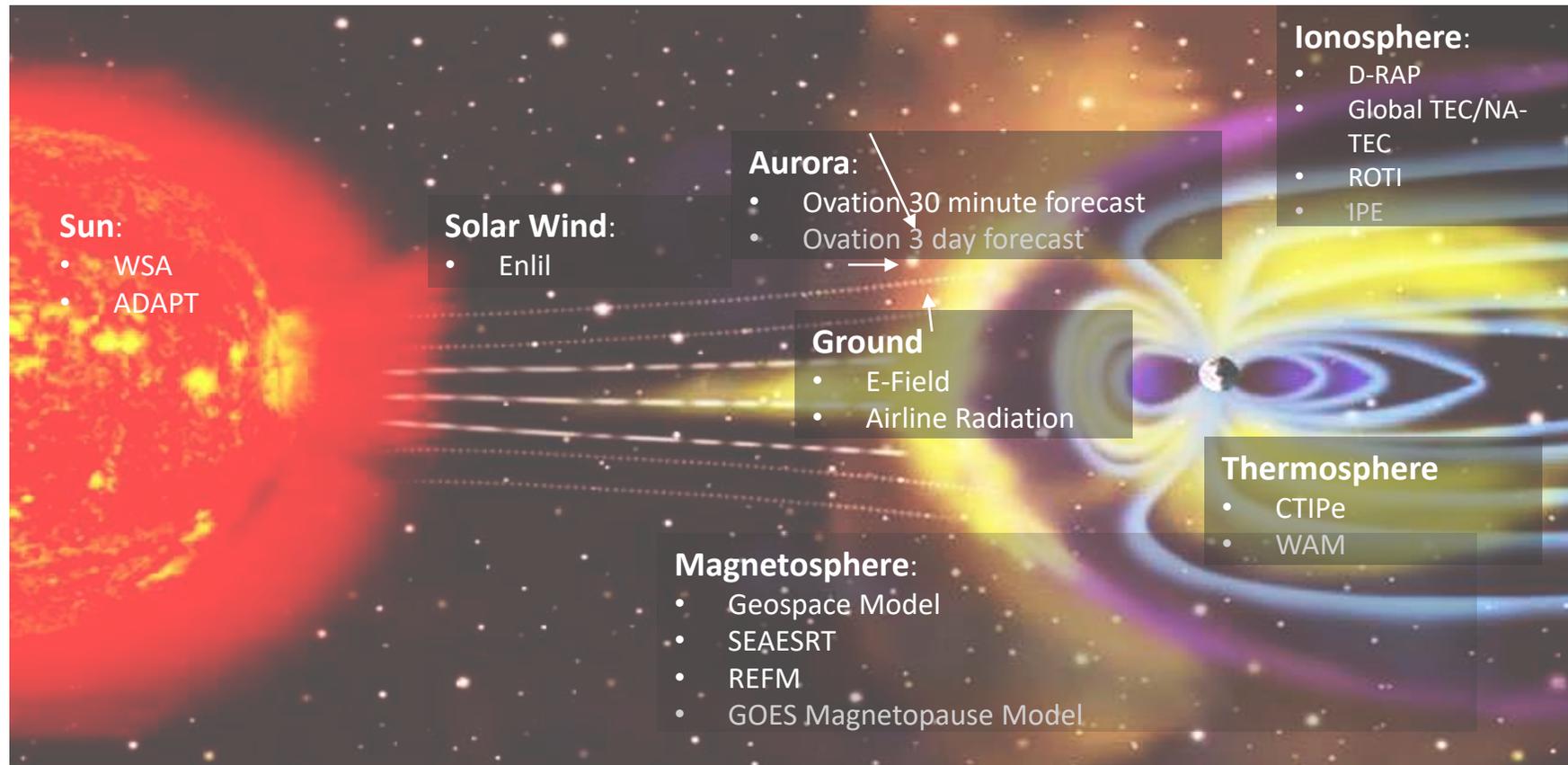
GEO-XO User Engagement Effort on the Space Weather Community

Community Meeting on NOAA Satellites

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Space Weather Study



Space Weather Benefits to Society

Electric Power Grid

- Adjust/reduce system load
- Disconnect components
- Postpone maintenance

Airlines

- Divert polar flights
- Change altitude

GPS/Navigation

- Postpone activities
 - Redo survey
- Use backup systems

Space Operations

- Postpone launch of satellite
- Turn off/safe instruments and/or spacecraft in orbit

Space Weather User Needs to Requirements

User Needs Statements

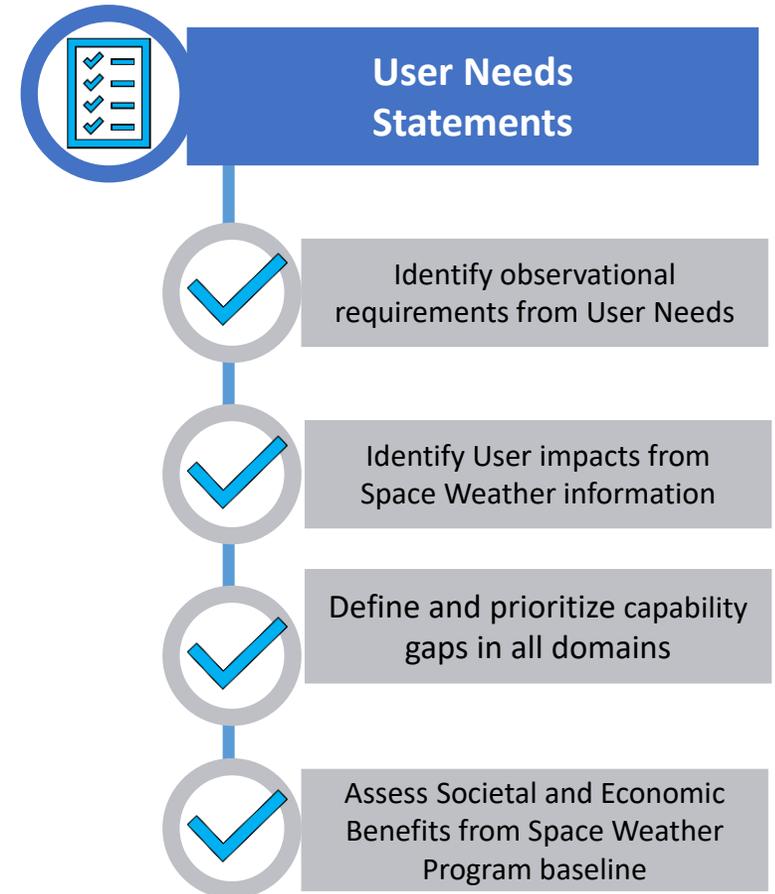
- Derived from the Consolidated Observational User Requirements List (COURL)
- Space Platforms Requirements Working Group (SPRWG), 2018
- Social and Economic Impacts of Space Weather in the United States, Abt Associates, Inc, 2017
- Customer Needs and Requirements for Space Weather Products and Services, Abt Associates, Inc 2019
- Economic Benefit Analysis of NOAA's Space Weather Products and Services to the Electric Power Industry, Eastern Research Group, Inc (RRG), August 2020

Observational Requirements derived from User Need Statements

- Working with Space Weather Prediction Center to trace the observations to user needs
- Prioritizing observations in different observational domains based on user needs
- Working to identify impacts on user's operational decisions
- Identifying gaps in those traces
- Future focused user engagements to fill in the gaps

Societal and Economic Benefits

- Working with NOAA Economics group to develop Societal and Economic Benefits from improves beyond present capabilities



National Academies of Sciences: Space Weather Workshops



Space Weather Operations and Research Infrastructure:
Workshop Parts 1 and 2

The National Academies of
SCIENCES ENGINEERING MEDICINE

June 16 – 17, 2020
September 9 -11 2020

Planning Organizations	Results
<ul style="list-style-type: none">• National Oceanic and Atmospheric Administration (NOAA)• National Academies of Science Meeting on Space Weather• NASA Space Weather• NOAA Space Weather Prediction Center (SWPC)• Department of Defense (DoD)• National Environmental Satellite, Data, and Information (NESDIS)	<ul style="list-style-type: none">• Large number of attendees (100+)• Great interchange during sessions• Many key user needs feedback• Still need to understand how space weather information is used in decision processes to fully evaluate societal and economic benefits

Key User Needs Feedback

Users need upstream solar wind monitoring capabilities.

Users need measurements of radio absorption, including non-derivative absorption in the D&E regions.

Users need improved magnetotail observations.

Measurements of the whole sun surface magnetic field is critical to space weather forecasting.

Global electron density profiles above 30 degrees with improved spatial resolution is a capability gap.

Ground-based neutron monitors are needed for improved measurements.

Additional heliospheric imagery is needed to improve space weather forecasting.

Users require off-sun-Earth line remote sensing, generalized beyond L5.

There is a need for atmospheric global distribution of winds, from the stratosphere to the thermosphere.

Improved measurements of auroral location and energy deposition are necessary.

Aviation radiation and dosimetry is lacking.

Low corona measurements (~1.05 - ~3 R_{sun}), including EUV and/or white light, would be helpful.

There is not adequate measurement of medium energy interplanetary protons.

Ionospheric scintillation is not well measured.

Users require improved solar disk imaging, including H- α white light intensity and dopplergrams, He 10830, LOS magnetic field, doppler velocity field, and vector magnetic field.

Users require off-sun-Earth line *in situ* magnetic, thermal plasma, and suprathermal measurements generalized beyond L5.

Exospheric hydrogen measurements (Lyman- α) need improvement.

Higher resolution in certain regions of the magnetotelluric survey is important.

Adding space weather forecasting instruments to NASA crew vehicles for the moon and Mars will improve measurements.

Improved measurements of off-sun-Earth line high energy protons and electrons will provide substantial value to human space flight and Earth.

Users need improved measurements of atmosphere neutral density and temperature, particularly in the mesosphere and lower thermospheres.

Measuring X-ray irradiance on the 3rd band will remove degeneracies in calculating temperature and emission measurements.

Ground-based magnetometers would improve space weather forecasting.

Ground- and space-based radio for solar and heliospheric measurements is critical.

Improved measurements of plasma, energetic particle, magnetic field, and wave environments in a wide range of orbits (GEO/GTS/MEO/LEO/Tundra) are critical.

Thermospheric neutral composition needs improved measurements.

Global ionospheric plasma drifts, focusing on the lower latitudes, are not well measured.

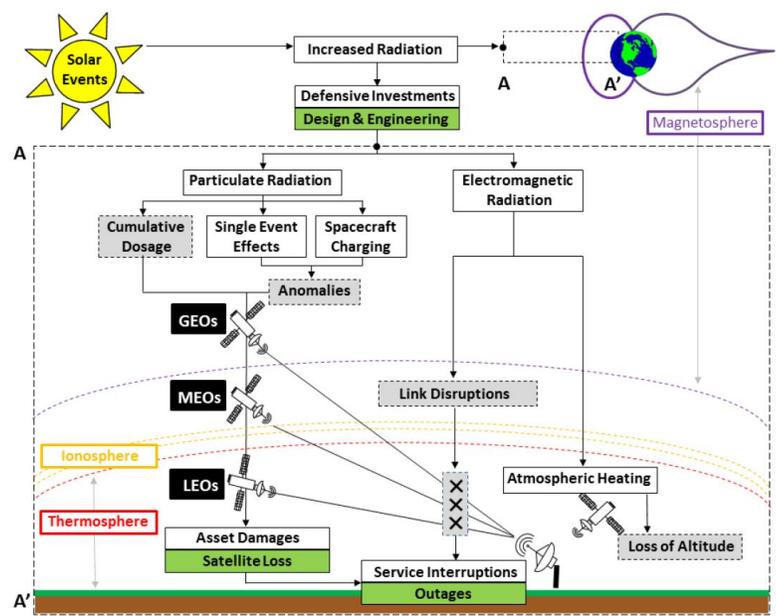
ULF waves need to be measured at the ground, which would offer additional benefits for EMPs.

Space Weather Societal and Economic Benefits Studies***

- Social and Economic Impacts of Space Weather in the United States, Abt Associates, 2017
- Customer Needs and Requirements for Space Weather Products and Services, Abt Associates, 2019
- Economic Benefit Analysis of NOAA's Space Weather Products and Services to the Electric Power Industry, Eastern Research Group, Inc (RRG), August 2020
- SWPC space weather observations to user impacts study
 - In progress
 - Identifying gaps for additional user engagements
 - Developing interview questions for focused user groups

Social and Economic Impacts of Space Weather in the United States: Key findings

- The 2017 Abt Associates study commissioned by NOAA was a comprehensive review of SpWx impacts on advanced technologies:
- It divided space weather impacts in several categories:
 - Electric power transmission and distribution
 - Satellite operations
 - GNSS applications
 - Commercial aviation
 - Emergency management (added in a followup report).
- Identified the major impact mechanisms, summarized the stakeholder perspectives, and estimated costs, reaching up to tens of millions (\$M) for two standard scenarios of moderate and extreme events:
 - Mitigating actions
 - Service interruptions
- Demonstrated the value of defensive investments and space weather research.
- Recommended further work into the value of NOAA's service investments and planning.



SpWx effects on satellite systems and resulting social and economic impacts [Abt, 2017]

Mission Type ¹	Typical Asset Values (per satellite)			
	Stakeholder Estimate ²	Derived Estimate ³		
		Manufacturing Revenue ⁴	2016 Launches (% of total) ⁵	Final Derived Estimate ³
Earth Observations	\$300,000	~\$1.7 b	64 (51%)	\$30 m
Commercial Communications	\$200-250 m	~\$2.2 b	20 (16%)	\$100 m
Navigation (GNSS)	\$200 m	~\$1.7 b	13 (10%)	\$100 m
Military Surveillance	\$1-2 b	~\$6.1 b	13 (10%)	\$500 m
Research & Development	\$10-20 m	~\$0.14 b	8 (6%)	\$20 m
Meteorology	\$150 m	~\$0.56 b	4 (3%)	\$100 m
Scientific	\$500-750 m	~\$0.70 b	4 (3%)	\$200 m
Civil/Military Communications	\$200-250 m	~\$0.83 b	2 (2%)	\$400 m
<i>Total</i>		\$13.9 b	126 (100%)	~\$20-500 m

Cost of satellites disruptions and losses in moderate space weather events [Abt, 2017]



Customer Needs and Requirements for Space Weather Products and Services key findings: Abt, 2019



- **Increased Forecast Precision and Lead-Time**

- “Interviewees across sectors expressed a desire for more precise forecasts. These forecasts would predict space weather events earlier. Earlier warnings with a greater degree of confidence in their accuracy would allow stakeholders to use forecasts to mitigate the impacts of space weather. If the accuracy of a forecast is not able to be improved, many stakeholders expressed a desire for some measure of confidence to be provided with a forecast to communicate the forecast’s certainty, such as through confidence intervals. However, improvements to the precision and warning time of forecasts are currently constrained by the limits of current science.”



- **Localized Forecasts**

- “Interviewees also consistently requested that forecasts be provided for more localized areas. Current forecasts used by interviewees provide warnings on a global scale, in general, and most stakeholders do not operate at that level. Forecasts that provide stakeholders with warnings on a sub-global scale would have more utility because stakeholders would have more confidence that the predicted space weather event would impact their operations and be more likely to take action based on the forecast. However, similar to improvements to the precision and warning time of forecasts, opportunities for improvements to the spatial scale of forecasts are limited by current science.”



- **Historical Data Products**

- “Interviewees across sectors expressed a desire for improved access to historical space weather data. These data are important for assessing past conditions to better understand relationships between observed/forecast conditions and historical impacts. These data in turn help with the development of mitigation strategies both by helping determine what actions would have been needed to avoid impacts, the potential level of impacts that might be avoided with certain measures, and how frequently events of varying severity might occur. Interviewees who currently use SWPC’s historical data for engineering and operations noted challenges in being able to readily access the data with the current website, easily select and retrieve data from particular periods of interest or search the data for using queries to return data on events with specific characteristics.”



- **Plain-Language Products**

- “Because of the relatively limited awareness and understanding of space weather in many sectors, interviewees emphasized the need for non-technical descriptions of space weather information. Interviewees believe current SWPC products are tailored for a scientific audience, which limits the ability for nonscientists to understand and fully incorporate pertinent information into their operations. If forecasts and other products included plain-language descriptions along with more technical information, the interviewees believe they would be useful for both scientific and non-scientific audiences.”



- **Impact-Based Products**

- “Interviewees across all sectors recommended SWPC provide products that tie space weather phenomena to sector-relevant impacts. For example, if users receive an alert warning them of potential GNSS errors rather than technical details of ionospheric scintillation, they will be more likely to review and revise operational decisions as necessary. Impact-based products were also viewed as a measure that could help bridge the gap between those who are very aware of space weather and those who are not. With this request, interviewees also noted that the SWPC could look to a number of other weather and forecast products produced by NOAA that interviewees believed might provide useful templates. A specific example offered was the tropical storm forecast maps that include information with respect to timing, location, potential severity of impacts, and uncertainty. A related element of this request concerned a desire for explicit recognition of times without events being tracked or forecast. Having an “all clear” status among the information the SWPC could provide was seen as beneficial for the relative certainty it would provide, which could be used to help schedule critical operations and maintenance activities.”

Economic Benefit Analysis of NOAA's Space Weather Products and Services to the Electric Power Industry, ERG, 2020 key findings:

Event size	Benefit of NOAA's Space Weather Products and Services per Event (\$1,000's)								
	20,000 Geographic Area Population			1,000,000 Geographic Area Population			50,000,00 Geographic Area Population		
	Low	High	Duration of interruption (hrs.)	Low	High	Duration of interruption (hrs.)	Low	High	Duration of interruption (hrs.)
K1-K6	\$1	\$245	0.083	\$1	\$56,963	0.083	\$1	\$110,765	0.083
K7	\$73	\$452	1	\$9,821	\$97,930	1	\$76,542	\$765,138	1
K8/K9-	\$4,040	\$14,061	8	\$924,809	\$3,236,753	8	\$7,343,295	\$25,701,453	8
K9	\$7,915	\$15,010	16	\$1,819,970	\$3,457,915	16	\$14,435,062	\$27,426,590	16

Constant Monitoring Benefits of NOAA's Space Weather Products and Services

- Decreased monitoring efforts
- Decreased defensive investments
- Less chance of lost revenue from sub-optimal operation
- Decreased costs from improper diagnostic efforts
- Less uncertainty
- Reduced cost associated with space weather monitoring information



Exemplar discussion questions (1 of 2)



- **Satellite operators:**

1. What space weather information is most helpful in aiding your protection operations against geomagnetic storms?
2. What operational impacts are there from space weather information?
3. How would these impacts change given improvements in space weather information?
4. Do you use surface charging conditions at LEO from space-based sources?
5. How would the accuracy of intensity and location affect your decisions? [need to measure low-energy ($\sim < 1$ keV) particle flux]
6. Would you use dielectric charging conditions at LEO in operational decisions?
7. How would the accuracy of intensity and location affect your decision, (use or not, affect your operational decision)? [need to measure energetic ($\sim > 1$ keV) particle flux]
8. Would you use current and historical dielectric charging conditions at MEO, GEO, HEO to make operational decisions? Would this be dependent on accuracy, timeliness or confidence? [need to measure energetic ($\sim > 1$ keV) particle flux]
9. What accuracy of neutral density and location is needed that would affect satellite drag at LEO producing critical orbit determination errors? [measure neutral density]





Exemplar discussion questions (2 of 2)



- **Communications users:**

1. How accurate in intensity and location does the current level of scintillation activity at LEO affect current operations?
2. What steps would you take to mitigate the effects?
3. What improvements in space weather information (timeliness, accuracy, confidence) would help to minimize the operational impacts due to space weather?



- **Electric power grid operators, others:**

1. What is your operating procedure when you receive a space weather alert or warning?
 2. Do you make operational decision to take mitigating steps based on present SWPC alerts and warnings other than preparing for potential steps or do you wait for ground system sensor data before taking actions?
 3. At what improvements to space weather information, (timeliness, warning time, confidence level, accuracy in intensity and locations) would help minimize the operational impacts of mitigation operations?
- 
- 



Slido

Discussion

- What does space weather look like in 2030?
- What information do we need to be successful?
- What is the biggest challenge today that we can plan to improve upon for the future?



NOAA
Satellite and
Information
Service

Sept. 29, 2020

GEO-XO User Engagement Effort with the Human Health Community

Community Meeting on NOAA Satellites

Vanessa M. Escobar
Lead Scientist for GEO-XO User Engagement





July 28 - 31, 2020
207 Total Attendees

Human Health Workshop



Planning Organizations

Reference Documents

Center for Disease Control and Prevention (CDC)

Environmental Protection Agency (EPA)

NASA Health and Air Quality applied Sciences (HAQAST)

National Oceanic and Atmospheric Administration (NOAA)

- Climate Program Office
- National Marine Fisheries Service
- National Ocean Service National Centers for Environmental Information (NCEI)
- Center for Satellite Applications and Research (STAR)

- Fourth National Climate Assessment



6

Individuals representing International Governments and Institutions

48

Individuals representing Academic Institutions

74

Individuals representing U.S. Federal Agencies

67

Individuals representing State, Local, Tribal, and Territorial Organizations

10

Individuals representing the Private Sector





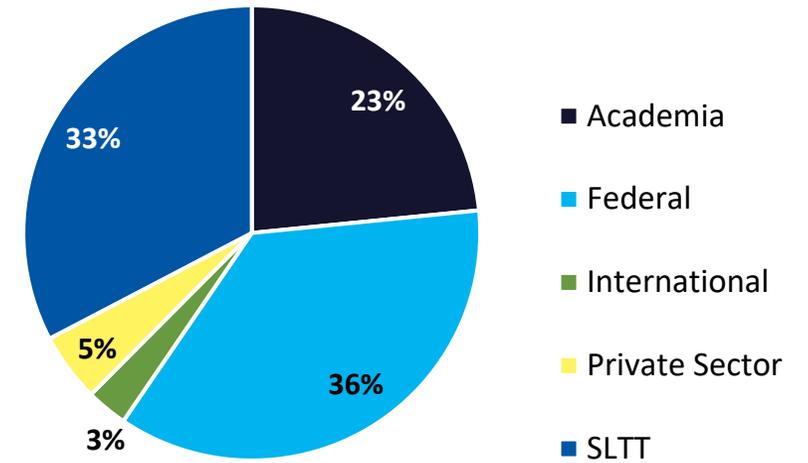
Human Health Workshop Participation



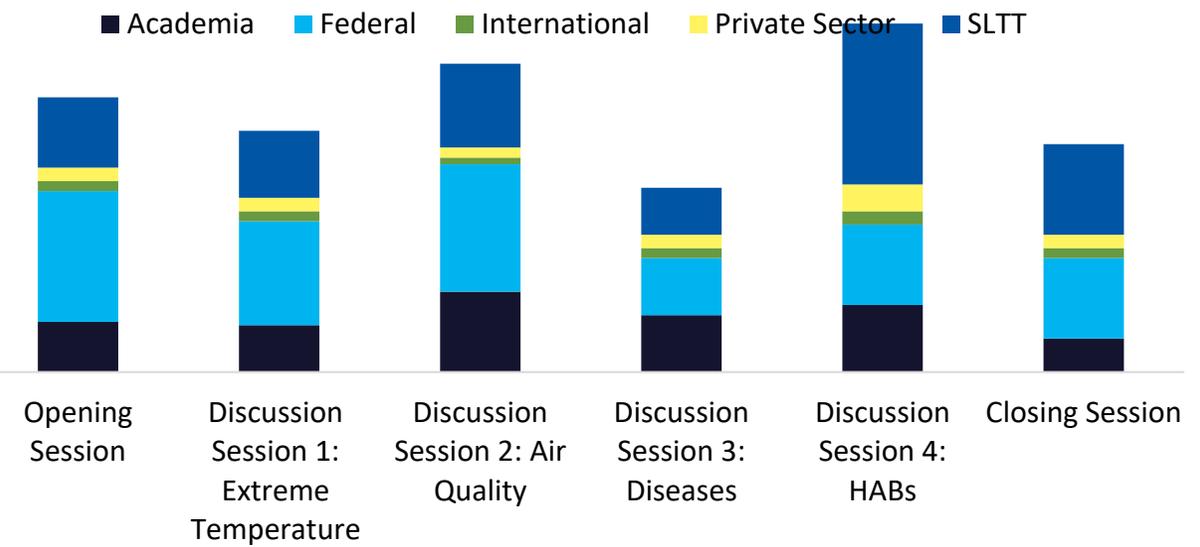
Time	Event	Number of Participants
Tuesday, July 28, 2020		
11 AM – 12 PM EDT	Opening Session	82
1 – 4 PM	Discussion Session #1: Extreme Temperature	71
Wednesday, July 29, 2020		
12 – 2 PM	Discussion Session #2: Air Quality	94
2:30 – 5 PM	Discussion Session #3: Diseases	56
Thursday, July 30, 2020		
12 – 3 PM	Discussion Session #4: Harmful Algal Blooms	106
Friday, July 31, 2020		
1 – 2:30 PM	Closing Session	68

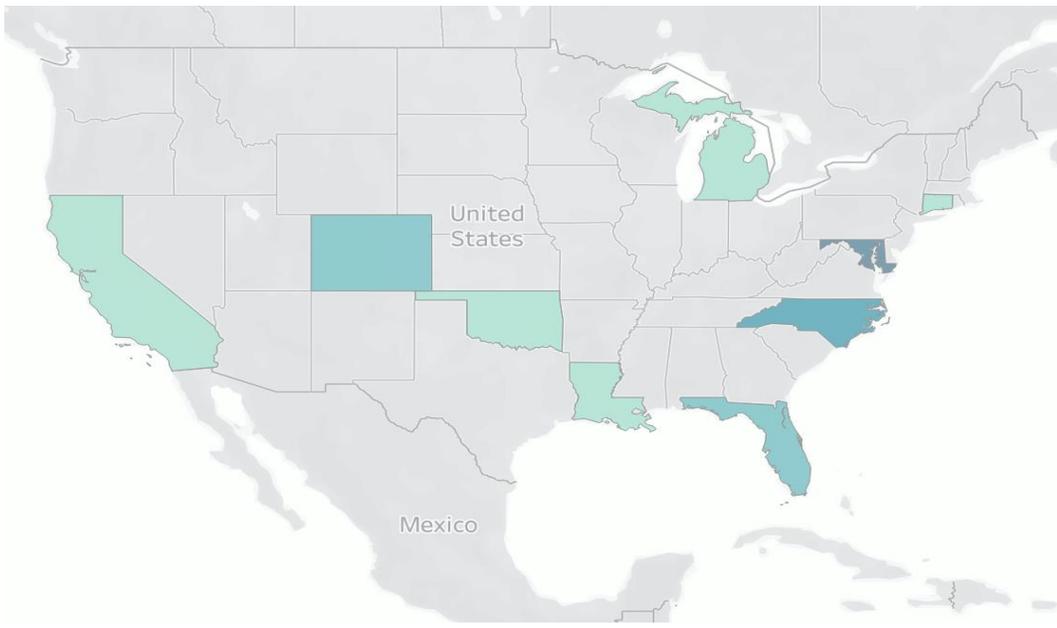


Breakdown of Attendance by Sector

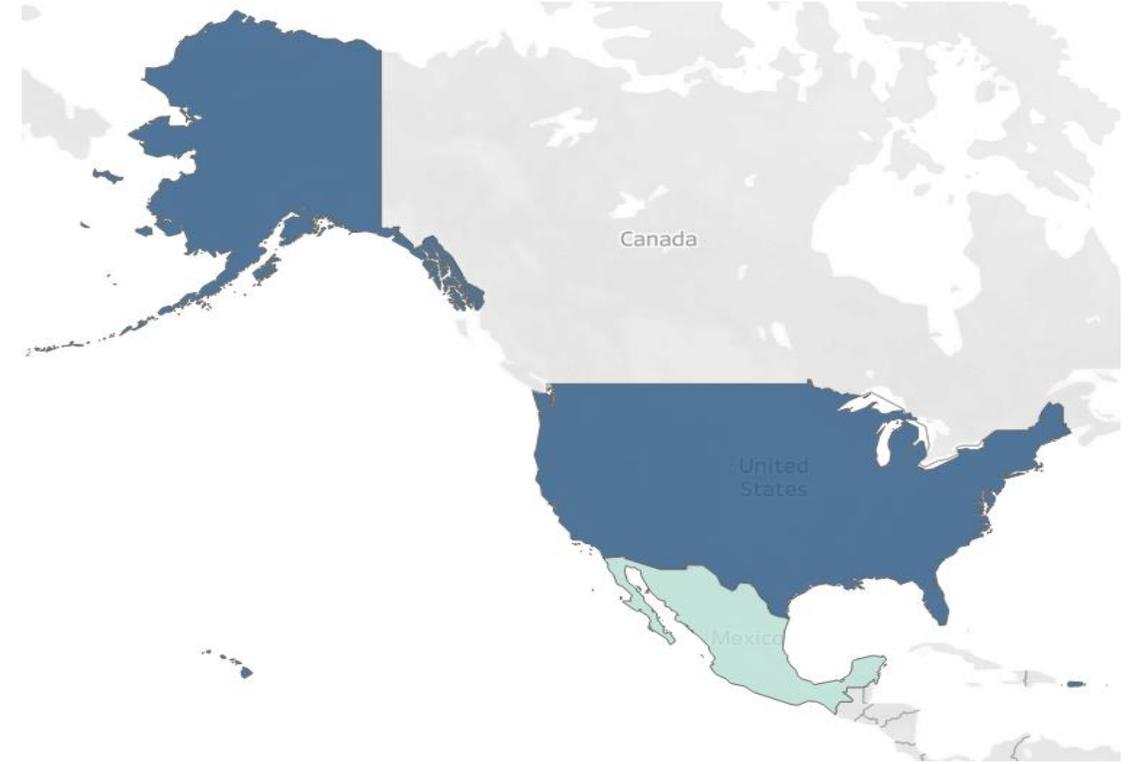


Number of Participants per Session, by Sector





- Coordinated scenarios with EPA and CDC reporting
- Human Health Interviews
- Leveraged existing user groups such as HAQAST and the Interagency Climate Change and Human Health Group (CCHHG)



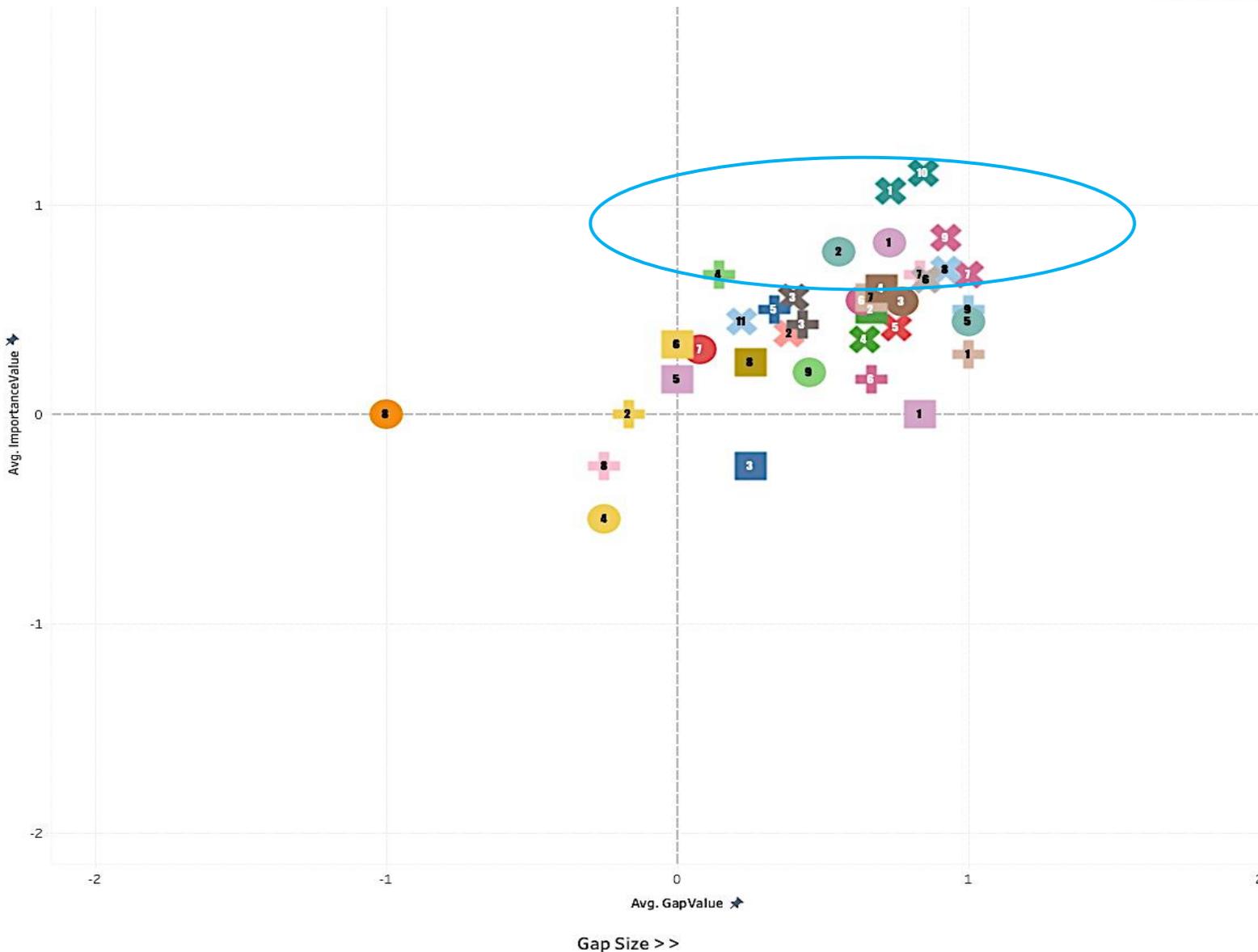
Human Health Workshop Survey



Federal Government	Academia	State, Local, Tribal, or Territorial Gov..	Private Sector	Non-Profit Sector	Contractor at Federal Governm..	Hospital
16	9	13	1	1	1	1

User Need Statement Quad Chart: Human Health

Importance and Capability Gap Size



Highest Importance and Greatest Gap Size

Harmful Algal Blooms

10. Spatial resolution is too low to detect HABs in small, inland water bodies.

1. Being able to detect HAB toxicity through remote sensing would significantly improve our ability to respond to an outbreak.

9. Data is not always available frequently enough to support the decision timeline for advisory issuance.

Air Quality

1. It is difficult to measure how high or low in the atmosphere (vertical profile) aerosols and other pollutants are.

1. Greenhouse gas composite gases are currently hard to sense in high detail.

Harmful Algal Blooms

8. Integrating ecological forecasting with physical forecasting of HABs would improve detection, monitoring, and prediction.

Harmful Algal Blooms

7. We don't have the right information to support understanding of the long-term impacts of low-level HAB exposure on human health.

Extreme Temperatures

7. Data is not available frequently enough to fully leverage tracking fish kills and unusual mortality events.

4. Additional data on air pollution levels during heat waves is necessary.

What did we learn?

Improvements

- Current spatial resolution is too low to help monitor and **track HAB events** for small, inland bodies of water.
- Identifying **HAB toxicity** or species via remotely sensed data would be incredibly helpful for public health, environmental, and ocean stakeholders.
- There is a need to **track aerosols at a finer resolution**, especially if pollution decreases in the U.S.
- **Improve warning systems.** For extreme air quality events and hazards, it is important to provide response partner with as much notice as possible to drive public warning decision making.
- Extreme temperature **data is not available frequently enough** to fully leverage tracking fish kills and unusual mortality events.

Challenges

- **Coordination across health data.** There is a disconnect between the overlays for public health information and remotely sensed data (i.e., public health information is often tracked via zip codes, which may not map to grids)
- **Merging track data.** It is important to track animal vector migration for disease, as well as changing human population land use patterns (i.e., tracking the development of neighborhoods near woods with Lyme disease).

Access

- For HAB events, **standardized** bulletins, graphics, and dashboards (e.g., the CyAN app) are helpful for driving decision making among relevant organizations and providing information to the public.



A Few of the Human Health Needs in Review by GEO-XO at this time?

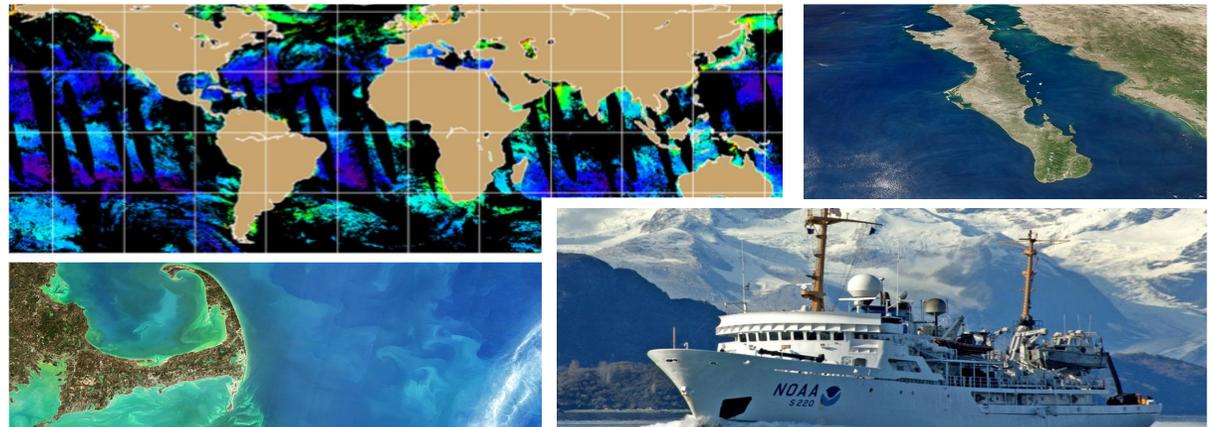
User Needs Workshop Feedback	Plan	Decision Timeframe
1. Data is not centralized or easily accessible.	<i>Send to the Enterprise Product Board</i>	Enterprise Cloud
2. Additional data on air pollution levels during heat waves is necessary.	GEO-XO is considering an atmospheric composition instrument that can help with air pollution characterization	Ground System Phase A study 2024
3. It is difficult to measure how high or low in the atmosphere (vertical profile) aerosols and other pollutants are.	GEO-XO is considering an atmospheric composition instrument that can help with air pollution characterization	At conclusion of Imager Phase A study ECD Spring 2022

Survey result for Human Health are still coming in!

Go here for the survey:

<https://geo-xo-satellites.wixsite.com/virtual-workshops/health-workshop>

More user needs will be reviewed by GEO-XO after the ocean color needs assessment-scheduled for October 2020



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Slido

Discussion

- What does air quality and water quality look like in 2030?
- What information do we need to address to be successful in supporting human health in the future?
- What is the biggest challenge we face today that we can plan to improve upon for the future?



NOAA
Satellite and
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Sept. 29, 2020

GEO-XO User Engagement Effort with the Agriculture Community

Community Meeting on NOAA Satellites

Vanessa M. Escobar
Lead Scientist for GEO-XO User Engagement





Agriculture Workshop

September 15 – 18, 2020

152 Total Attendees



35

Individuals representing International Governments and Institutions

18

Individuals representing Academic Institutions

65

Individuals representing U.S. Federal Agencies

3

Individuals representing State, Local, Tribal, and Territorial Organizations

Planning Organizations

Reference Documents

Canadian Government
Agriculture and Agri-Food Canada

- Fourth National Climate Assessment

NASA Harvest

- USDA Climate Indicators for Agriculture

U.S. Department of Agriculture
Agricultural Research Service
Office of Energy and Environmental Policy

- SMAP Early Adopters

National Oceanic and Atmospheric Administration (NOAA)
National Centers for Environmental Information (NCEI)
Center for Satellite Applications and Research (STAR)

- Socioeconomic Assessment of Soil Moisture from SMAP Early Adopters

31

Individuals representing the Private Sector



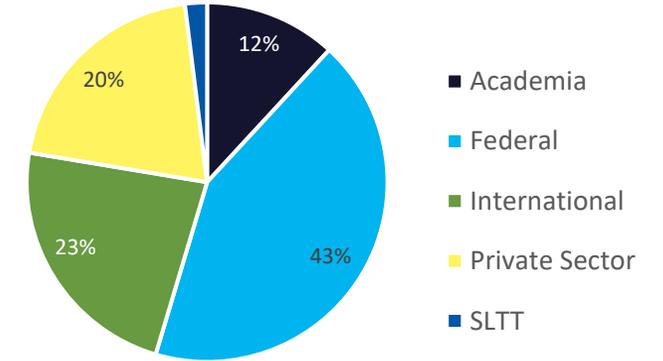


Agriculture and Land Management Workshop Participation

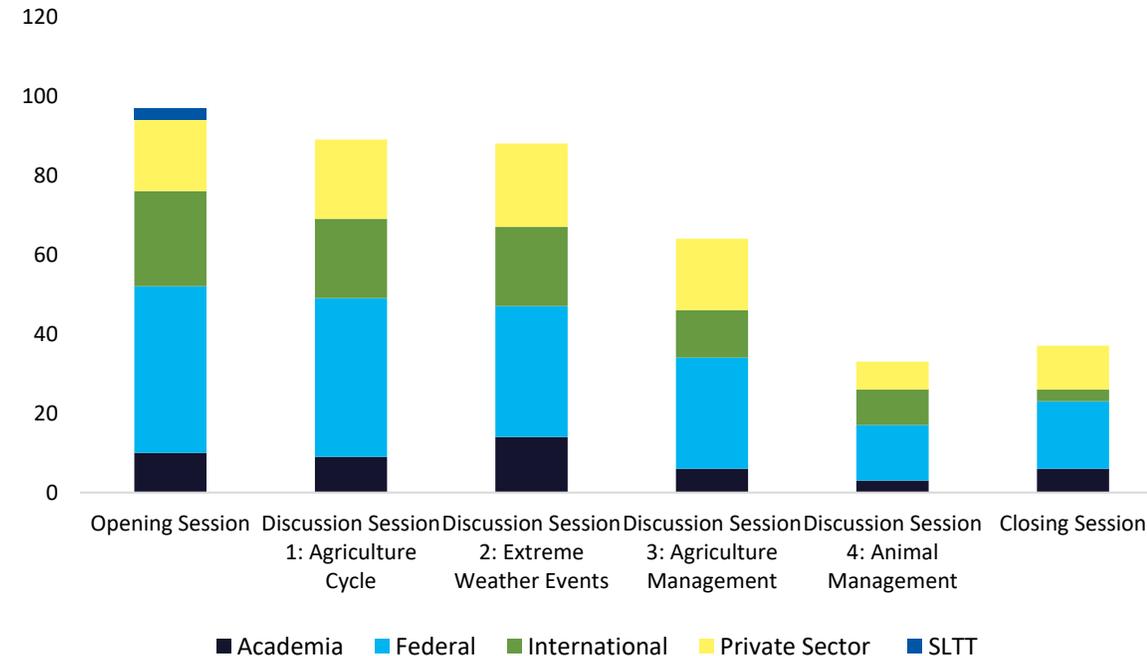


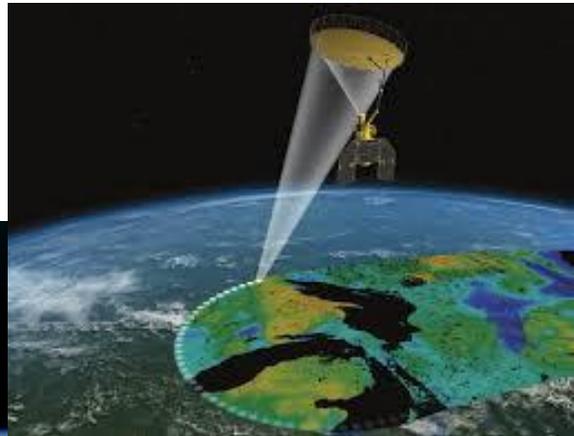
Time	Event	Number of Participants
Tuesday, September 15, 2020		
11 AM – 12 PM EDT	Opening Session	97
1 – 4 PM EDT	Discussion Session #1: Agriculture Cycle	89
Wednesday, September 16, 2020		
11 AM – 2:30 PM EDT	Discussion Session #2: Extreme Weather Events	88
Thursday, September 17, 2020		
11 AM – 2:30 PM EDT	Discussion Session #3: Agriculture Management	64
Friday, September 18, 2020		
11 AM – 2 PM EDT	Discussion Session #4: Animal Management	33
1 – 2:30 PM EDT	Closing Session	37

Breakdown of Attendance by Sector



Number of Participants per Session, by Sector





- Coordinated scenarios with EPA and USDA for scenario content and translation
- Leveraged existing user groups such as NASA Harvest, National Soil Moisture Network, FEWSnet SMAP Early Adopters Program, National Farmers Union, U/S Grain Council and American Poultry Association and various reinsurance and commercial farming groups.
- Assessed areas of the supply chain most relevant to the discussion



Agriculture Workshop Survey



What did we learn?

Improvements

- There is a need to improve **soil moisture data** tracking, accuracy, and availability.
- There is a lack of information regarding the level of confidence for **agriculture-related forecasts and outlooks**, which hinders agricultural decision making.
- **Soil moisture continuity** for the future and historical soil moisture record is lacking.

Challenges

- Understating **soil health** is a challenge with remote sensing data.
- Enhanced partnerships between agricultural stakeholders and private sector companies in order to **provide tools, information, and data most useful** to farmers and growers.
- Information is critical during the agricultural **pre-season and off-season**, as forecasts and outlooks drive decision making for seed and animal selection, insurance considerations, field planning, and other areas.

Access

- Stakeholders require as much **advance warning** as possible for extreme weather events (e.g., severe heat or cold, severe storms and hail) in order to take protective and mitigation actions.
- There is a need to **centralization information**, have consistent **data formats**, communicate on **data availability**, and **maintain trusted relationships**/points of contacts between organizations between agricultural end users and NOAA



Agriculture needs *already* in consideration by GEO-XO at this time

User Needs Workshop Feedback	Plan	Decision Timeframe
1. Data is not centralized or easily accessible.	<i>Send to the Enterprise Product Board</i>	Enterprise Cloud
2. Wavelengths that can see through clouds to compensate for gaps in IR visibility.	GEO-XO is studying the possibility of a microwave sounder, which can help detect levels beneath cloud	Ground System Phase A study 2024

Agriculture meeting concluded September 18th

Agriculture survey will be released in October and results will be shared with GEO-XO and NOAA for translation into user requirements.

Go here for the survey, coming soon!

<https://geo-xo-satellites.wixsite.com/virtual-workshops/agriculture-workshop>



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Discussion

- What does farming look like in 2030?
- What information do we need to help us plan for the changing future of farming and animal management?
- What is the biggest challenge today that we can plan to improve upon for the future?



NOAA

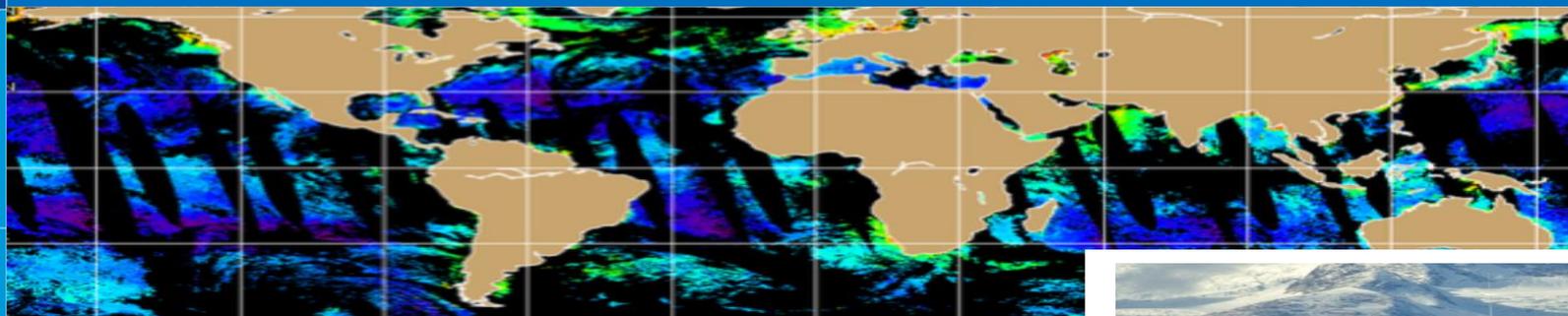
Satellite and
Information
Service

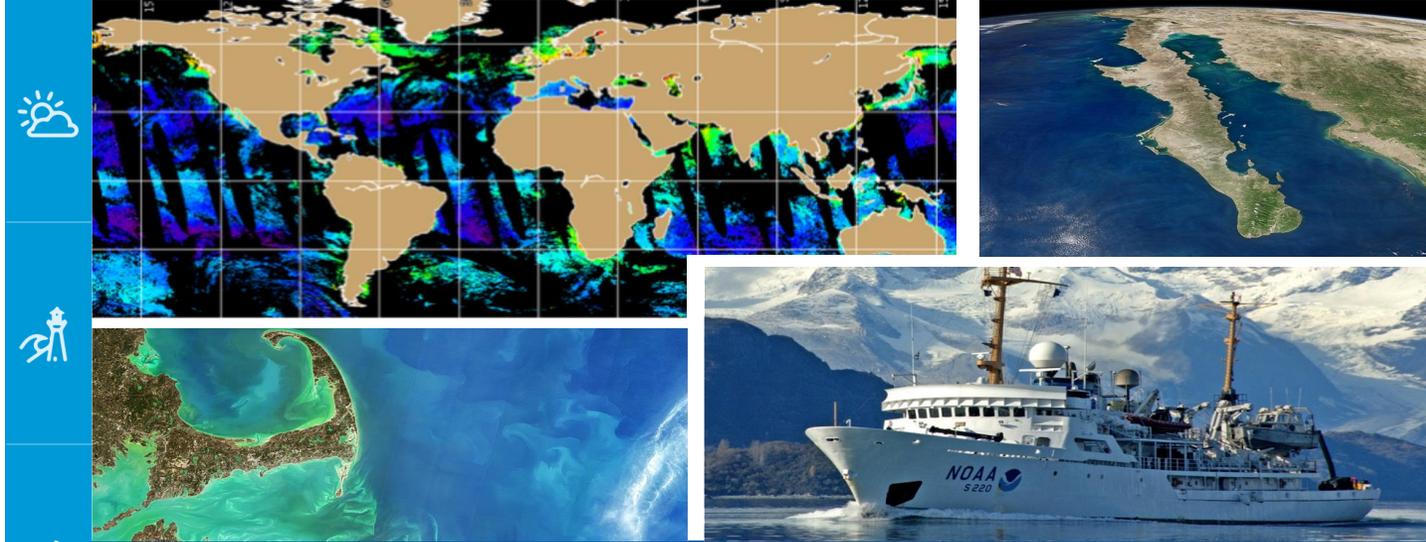
Sept. 29, 2020

GEO-XO User Engagement Effort on the Oceans Community

Community Meeting on NOAA Satellites

Vanessa M. Escobar
Lead Scientist for GEO-XO User Engagement





Oceans, Coastal and Inland Waterbodies Workshop

Tuesday, November 17-20 2020

Hosted by:

National Environmental Satellite, Data, and Information Service

National Oceanic and Atmospheric Administration



User needs statement being developed from most recent community reports

- IOCCG Report 2012, 2015, 2019, 2020
- Frontiers in Marine Science | Ocean Color (2019)
- WMO Integrated Global Observing System | 2040 Space Workshop (2015)
- JCOMM Ocean Observing System Report Card (2019)
- International Ocean Colour Science Meeting (2019)
- NASA Designated Observable Community Assessment for Surface Biology and Geology (SBG) for 2020
- PACE Early Adopters Program
- Geosynchronous Littoral Imaging and Monitoring Radiometer (GLIMR) instrument science development



Discussion

- What are some of the challenges our oceans face in 2030?
- What information do we still need in order to be successful?
- What is the biggest challenge today that we can plan to improve upon for the future?



“O.K., her mouth is full—run over and ask her if everything is O.K.”

Thank You!

Vanessa.Escobar@noaa.gov

You can find GEOXO workshop results, recordings and survey opportunities by going to the GEO-XO user event wiki:
<https://geo-xo-satellites.wixsite.com/virtual-workshops>