8th SBG Community Webinar

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THE SURFACE BIOLOGY AND GEOLOGY DO IS DEFINED WITH CONSIDERABLE DETAIL IN THE DECADAL SURVEY

SBG is key to understanding in five research and applications focus areas:

- Terrestrial and aquatic ecosystems
- Hydrology
- Weather
- Climate
- Solid Earth

The Decadal Survey defines the implementation as two sensors "*Hyperspectral imagery in the visible and shortwave infrared; multi- or hyperspectral imagery in the thermal IR*":

1. "….a moderate spatial resolution (30-45 m GSD), hyperspectral resolution (10 nm; 400-2500 nm), high fidelity (SNR = 400:1 VNIR/250:1 SWIR) imaging spectrometer is needed for characterizing land, inland aquatic, coastal zone, and shallow coral reef ecosystems"
2. "….30-60 m TIR observations in the 10.5-11.5 µm and 11.5-12.5 µm spectral regions are needed with a 2-4 day revisit frequency" [1]

1) Note, this specification was updated based on recent work and community engagement to optimize for the DS-specified science and applications.

SBG SCIENCE AND APPLICATIONS AT A GLANCE

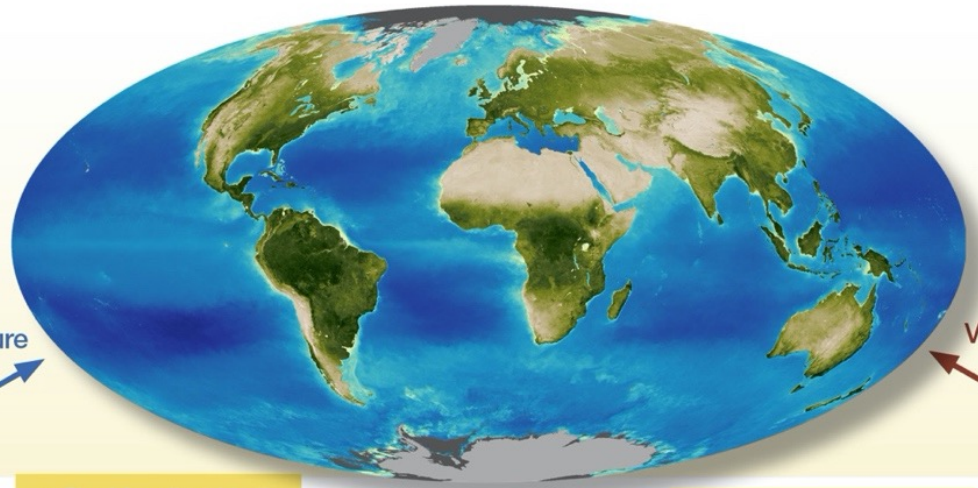
Measurement Needs

Surface Processes

DS Science Questions

W-3. How does the surface affect exchanges?

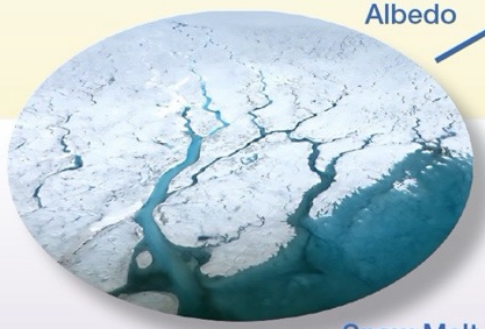
- Albedo
- Light absorbing impurities
- Snow Grain size
- Land surface temperature
- Eavapotranspiration
- Water quality



- Air Quality
- Public Health

Temperature
Albedo

Volcanic Emissions



- Plant functional traits
- Canopy structure
- Leaf area index
- Fire severity
- Sediment
- Chlorophyll
- CDOM
- Coral cover
- Kelp

C-3. The Carbon Cycle

- Volcanic gases
- Lava temperatures
- Volcanic lakes
- Mineral composition
- Newly exposed substrate

Snow Melt

Greenhouse Gases

Vegetation State, Fire

- Water Resources
- Agriculture
- Drought Monitoring

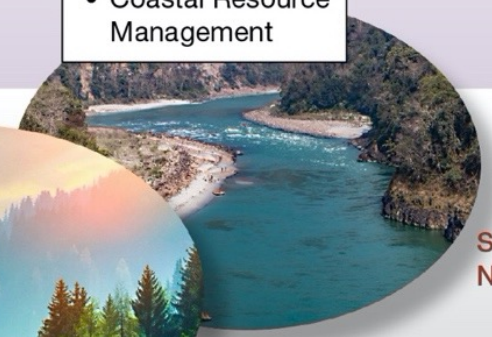
Water Use

- Hazards Monitoring and Response

Surface Water

- Water Quality
- Coastal Resource Management

- Fire Risk and Response
- Conservation and Ecoforecasting
- Land Management



Sediments
Nutrients

Sediments
Nutrients

H-1,2 Flows of water and energy

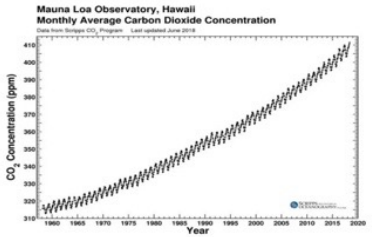
E-1,2,3 Earth's ecosystems

S-1,2 Geological hazards

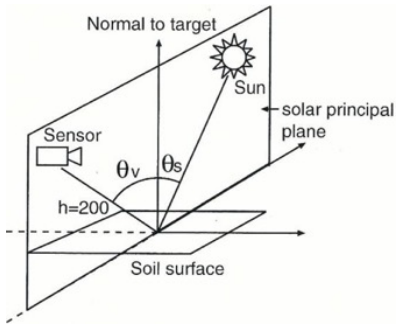
Societal Applications

SBG: KEY RESEARCH AND APPLICATIONS REQUIREMENTS

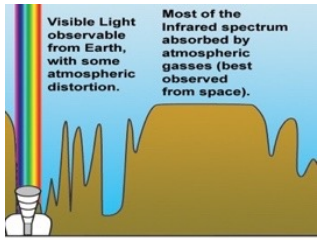
COVERAGE: The system must provide **global coverage** to address the global scope of the science including the coastal ocean and inland waters.



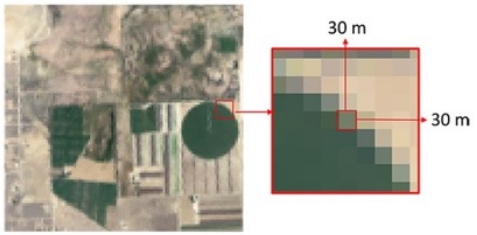
STABILITY AND DURATION: Measurements must be able to detect **long term changes** for addressing dynamics of the Earth System.



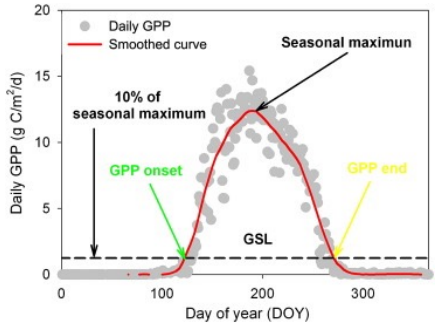
GEOMETRY: The system's orbit must allow for **consistent sun-sensor geometry** for consistency in retrievals and for calibration and validation, and provide for global coverage, as above (polar orbit).



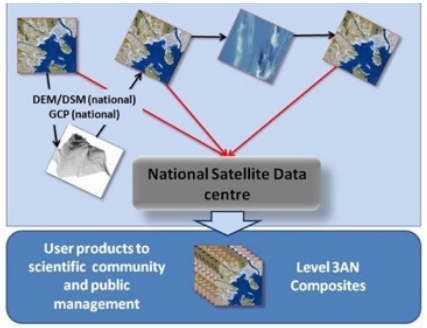
RANGE, RESOLUTION AND SENSITIVITY: Visible to Shortwave Infrared **(VSWIR; 400-2500 nm)** imaging spectroscopy and multi-spectral thermal infrared **(TIR; 4 - 12 μm)** measurements to observe "diversity" in ecosystem function. Radiometric performance driven by aquatic targets.



SPATIAL RESOLUTION: The observing system must provide **high spatial resolution** (30 and 60 m for VSWIR and TIR)

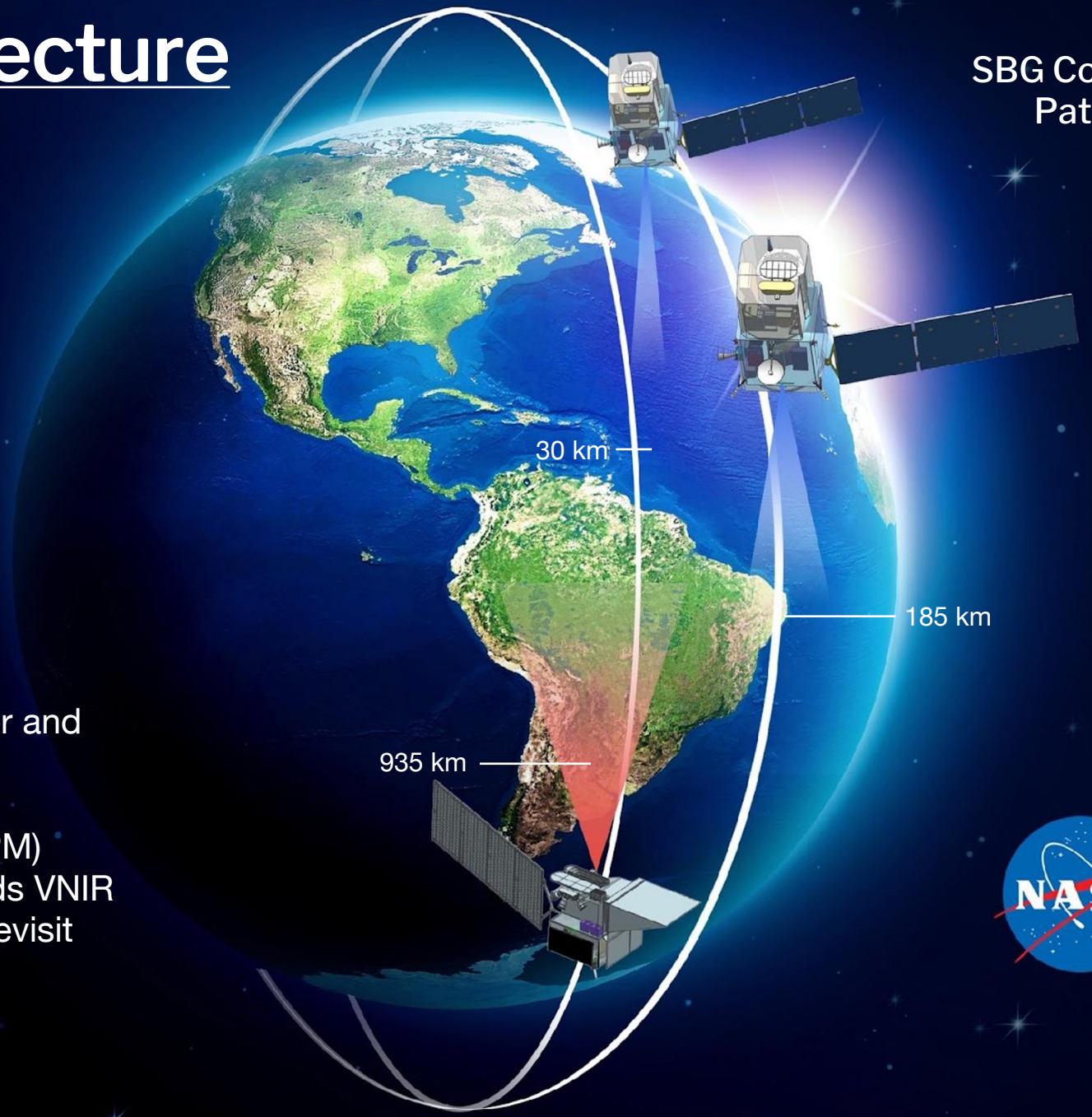


REVISIT: The SBG observing system temporal resolution must be adequate to capture **synoptic and seasonal variation** as well as observe **rapid or transient changes** related to Earth system events such as fires, landslides, volcanic activity and anthropogenic incidents.



LATENCY: **Low latency,** the time between an event and data access, must be low enough to support time-sensitive applications, ≤ 24 hours.

SBG Architecture



SBG Constellation Pathfinder

SBG Light

Wide-swath VSWIR spectrometer

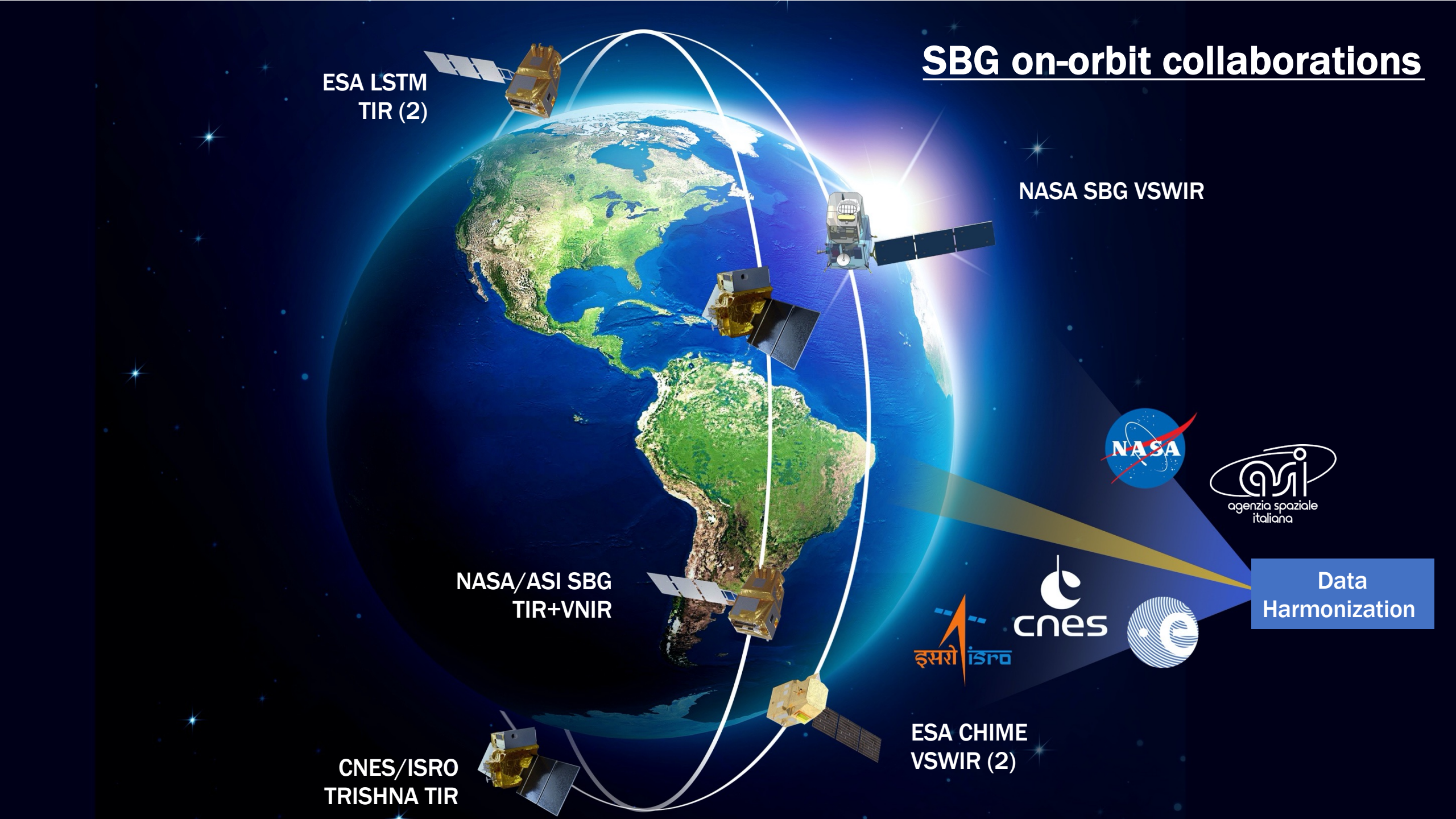
Sun-sync orbit (late AM)
185 km swath
16 day revisit
10 nm, 200+ bands
30 meter GSD
High SNR and radiometric performance
~5 deg off-nadir tilt

SBG Heat

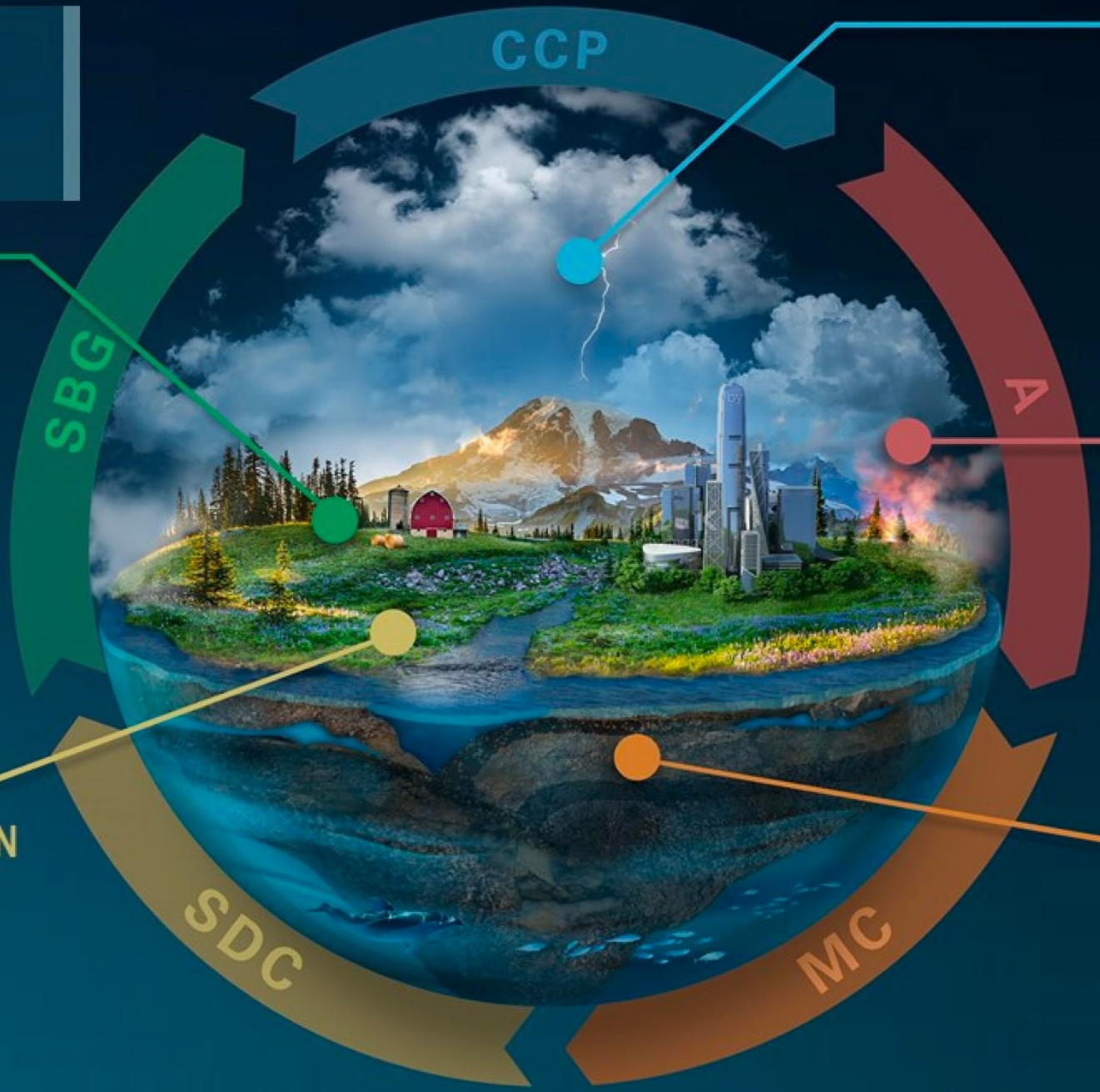
Wide-swath TIR imager and ASI VNIR camera

Sun-sync orbit (early PM)
5+ bands TIR, 2+ bands VNIR
935 km swath, 3 day revisit
60 meter GSD
0.2K NeDT

SBG on-orbit collaborations



EARTH SYSTEM OBSERVATORY



CLOUDS, CONVECTION AND PRECIPITATION

Water and Energy in the Atmosphere

AEROSOLS

Particles in the Atmosphere

MASS CHANGE

Large-scale Mass Redistribution

SURFACE BIOLOGY AND GEOLOGY

Earth Surface & Ecosystems

SURFACE DEFORMATION AND CHANGE

Earth Surface Dynamics

Credit: nasa.gov

SBG WILL DELIVER MAJOR APPLIED SCIENCE ACROSS SECTORS

AGRICULTURE, FOOD SECURITY AND SURFACE WATER MANAGEMENT

Improve “crop per drop” by assessing vegetation water stress over irrigated agriculture

Improve water supply management through better characterization of snow properties and estimated reservoir inflows

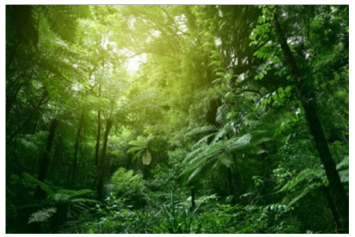
Reduce the impacts of drought, such as crop loss and famine, on global scales

WATER QUALITY AND COASTAL ZONES

Support early detection of and response to harmful algal bloom formation

Protect sensitive aquatic habitats by monitoring/reducing water pollutant loading, particular in coral reefs and other sensitive ecosystems

Water surface temperature and impacts on marine biodiversity



CONSERVATION

Support biodiversity understanding and protections by mapping invasive species composition, structure, distribution; support removal and restoration efforts

Monitoring of endangered species habitat; provide alerts of disease mortality of impacted vegetation, including insect infestation

Biodiversity hotspots and priority conservation areas, 30 x 30 plans

WILDFIRE RISK AND RECOVERY

Fuel mapping (cover type, extent, status) for wildfire danger management

Post fire severity assessment and recovery, including prediction of areas with higher likelihood of debris flows

DISASTERS AND NATURAL HAZARDS

Detect and track oil spill events and

Support active fire mapping and response

Improve mitigation of heat wave events for vulnerable populations

GEOLOGY APPLICATIONS

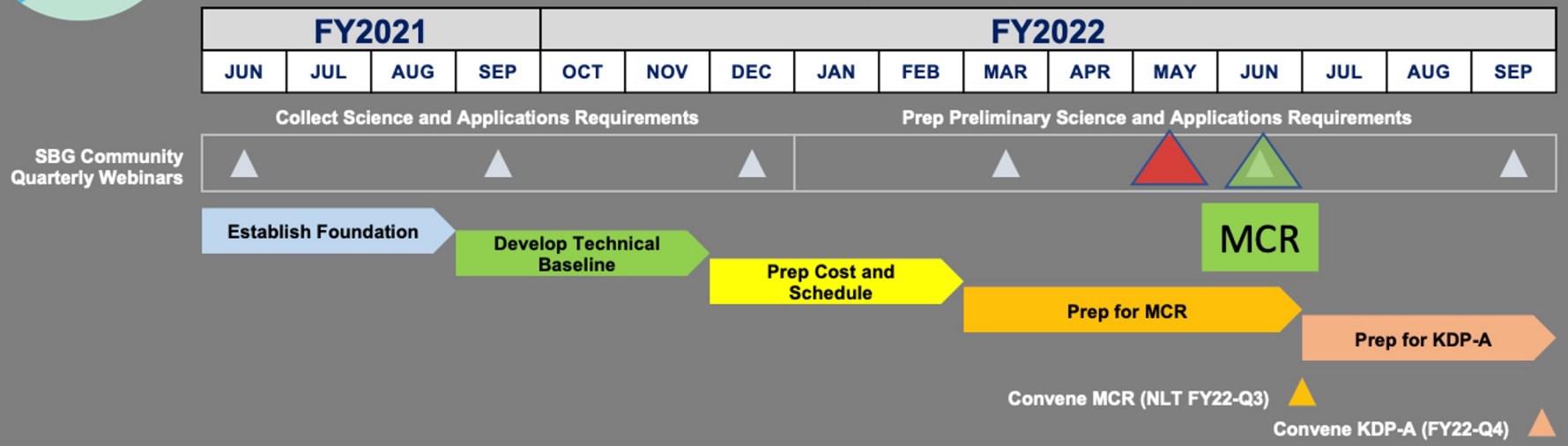
Mineral mapping for exploration efforts and reduction of environmental hazards

Forecast aviation hazards and support emergency response for volcanic eruptions

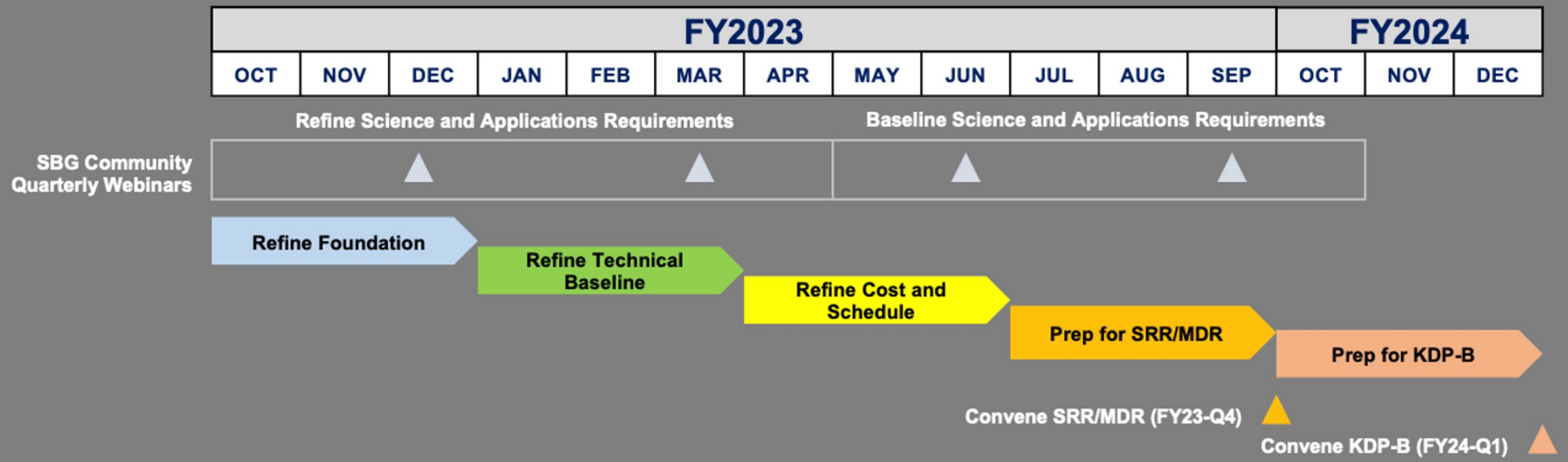
Landslide risk assessment with improved substrate map land cover maps

Surface Biology and Geology (SBG)

Pre-Phase A (Pre-Concept Study Phase) Schedule

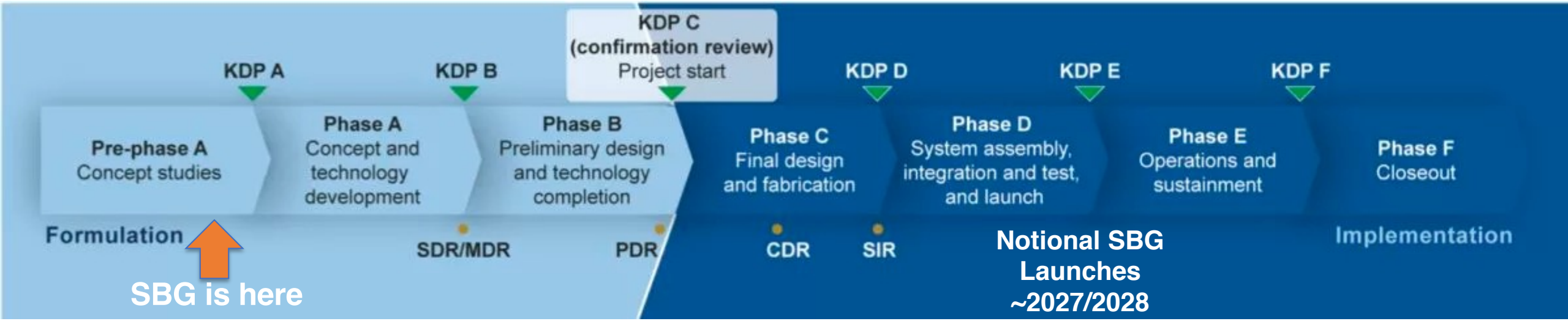


Phase A (Concept Study Phase) Schedule - Notional



Pre-Decisional Draft: For planning and discussion purposes only.

NASA Project Lifecycle



SBG Applications Overview

- SBG study structure and the role of applications
- Assessment of SBG applications community
- Impact of applications in SBG missions architecture
- Next steps

SBG Applications Working Group Charter

The Applications Working Group will recruit, coordinate and integrate input on applications needs, data product requirements and training/education and other needs:

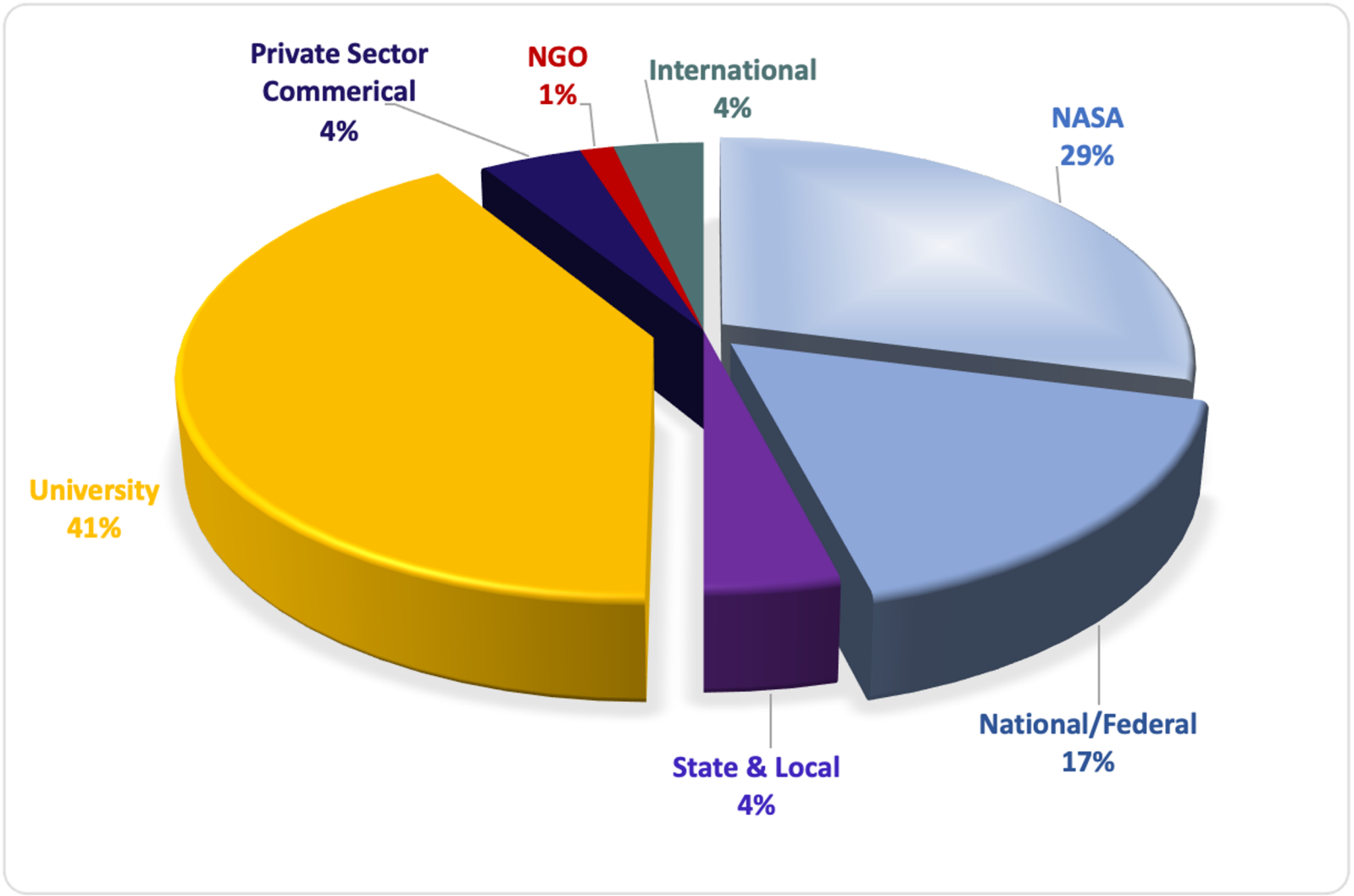
- Identify key applications requirements, latency, revisit, specific products.
- Cultivate stakeholders and end users via joint activities, workshops, thematic working groups, and design and dissemination of tailored SBG data products.
- Characterize the SBG Communities of Practice and Potential and produce a SBG Community Assessment Report.

SBG Applications Working Group Activities

Working Group (~225 members) Activities

- Monthly meetings (30-50 attendees)
  - Interface and engage community
  - Feature SBG relevant applications
  - Obtain community feedback on specific topics (e.g., develop ATM, training needs) for mission planning

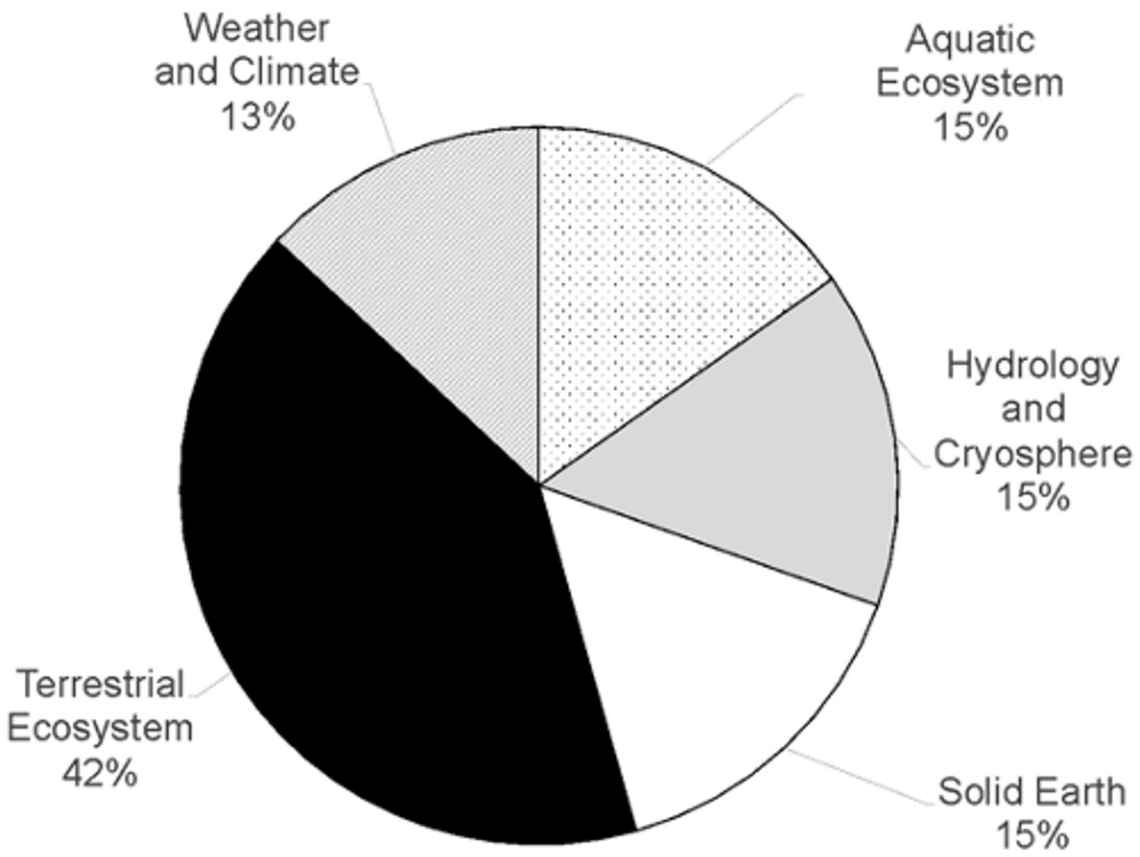
Sector participation in the SBG Applications Working Group. As of May 2022, there are approximately 225 participants.

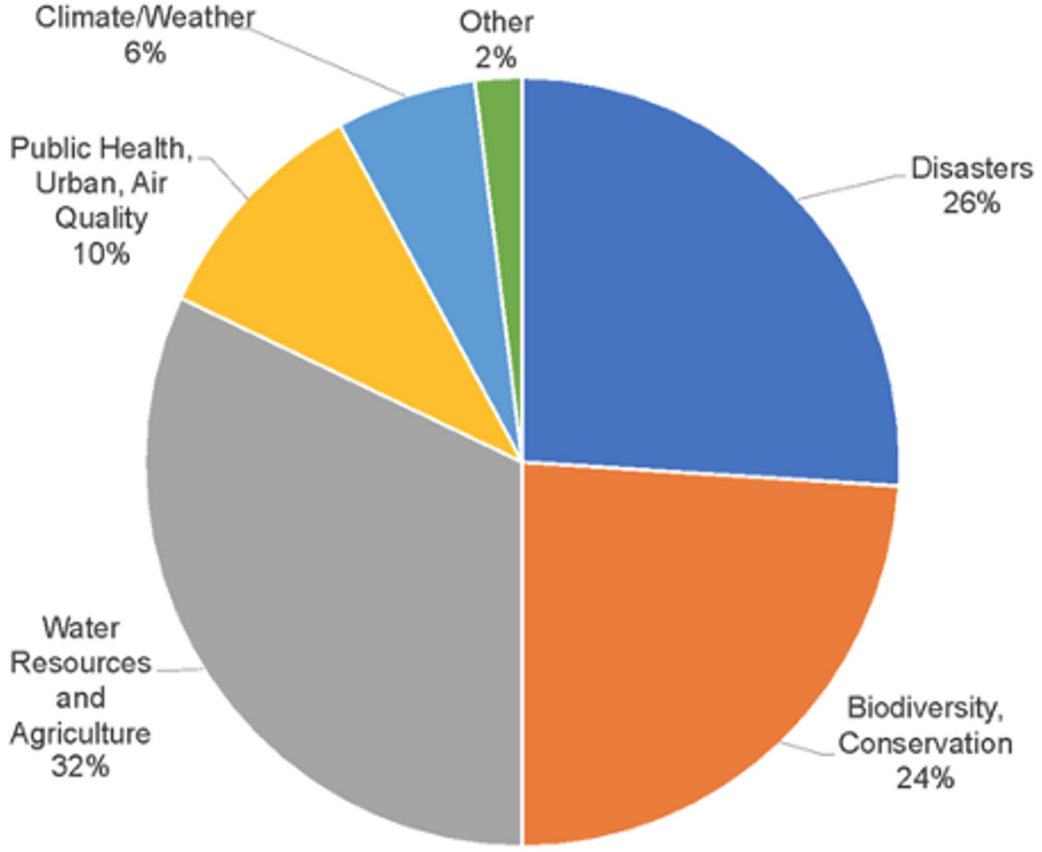


SBG Applications Traceability Matrix and Summary

Decadal Survey Science Topics, Questions, Objectives, and Geophysical Observables					SBG Example Geophysical Variables and Capabilities												
Topic	DS Science Question	DS Science/Application Objective	Priority	DS Suggested Biogeophysical Parameters	Key SBG Geophysical Parameters	VSWIR Spatial	VSWIR Temporal	VSWIR Range	VSWIR Sensitivity	TIR Spatial	TIR Temporal	TIR Range	TIR Sensitivity	VSWIR/TIR Coincidence	References	Enabled Applications * = With 48 hr Latency	DO Synergies
Global Hydrological Cycles and Water Resources	**H-2.** How do anthropogenic changes in climate, land use, water use, and water storage, interact and modify the water and energy cycles locally, regionally and globally and what are the short- and long-term consequences?	**H-2a.** Quantify how changes in land use, water use, and water storage affect evapotranspiration rates, and how these in turn affect local and regional precipitation systems, groundwater recharge, temperature extremes, and carbon cycling.	Very Important	Latent heat flux. 3 (desirable) to 6 hour (useful) resolution during daytime intervals and at 1 km spatial scale with better than 10 W/m2 accuracy. Requires temperature of soil and vegetation separately at 40-100m spatial resolution, accuracy of +/- 1K, at temporal frequency to resolve the diurnal cycle. Albedo of soil and vegetation separately to an accuracy to estimate absorption of solar radiation to 10 W/m2, at weekly intervals at field scale, 30-60m spatial resolution.	VSWIR Spectral surface reflectance	≤60 m	≤8 days for global coverage*	≤380 - ≥2500 nm, @ ≤10nm							R2, R3, R7, R8, R14, R27,R28	EA3, EA8*, EA9, some E1-a. applications.	A-CCP
					TIR emissivity					<60 m	≤3 days for global coverage*		≤1K Absolue, ≤0.2K NeDT / band		R4, R5, R8, R27	EA8*, EA14*, EA 30*	A-CCP
					Evapotranspiration rates of vegetation canopies with 10% uncertainty (multiple times of day)	≤30 m		VNIR multiband		60-100 m	≤3 days for global coverage*	≥5 bands in 8-12 um	≤1K Absolue, ≤0.2K NeDT / band	On same day	R4, R5, R8, R13, R23, R27, R32, R36	EA3, EA7*, EA12, EA13, EA23	A-CCP
					Surface temperature (multiple times of day)					<60 m	≤3 days for global coverage*	≥5 bands in 8-12 um	≤1K Absolue, ≤0.2K NeDT / band		R4, R5, R8, R27	EA8*, EA12, EA13, EA14*, EA30*	A-CCP
Marine and Terrestrial Ecosystems and Natural Resource Management	**E-1. Ecosystem Structure, Function, and Biodiversity.** What are the structure, function, and biodiversity of Earth's ecosystems, and how and why are they changing in time and space?	**E-1a.** Quantify the global distribution of the functional traits, functional types, and composition of vegetation spatially and over time; **E-1c.** Quantify the physiological dynamics of terrestrial and aquatic primary producers.	Very Important, Most Important	**Chemical properties of vegetation, aquatic biomass, and soils. (Land, inland aquatic, costal zone, and shallow coral reef):** Spectral radiance (10nm; 380-2500nm); GSD = 30-45m; Revisit = ~15 days; SNR = 400:1 VNIR/250:1 SWIR @ 25% reflectance; IT of ~5 ms.	Biogeochemical traits of aquatic biomass, including ocean color pigmentation and productivity (coastal)	≤30 m	≤16 days for global coverage*	B'	SNR ≥400 VNIR, SNR ≥250 SWIR, accuracy ≤10%						R17, R8, R41, R42, R43	EA27, EA28*, EA29*, EA43	
					Terrestrial Veg. functional traits, types, composition	≤30 m	≤16 days for global coverage*	≤380 - ≥2500 nm, @ ≤10nm	SNR ≥400 VNIR, SNR ≥250 SWIR, accuracy ≤10%						R3, R8, R10, R16	EA9, EA10, EA11, EA15, EA16, EA17, EA18, EA19*, EA20, EA21, EA22, EA24, EA31*, EA33, EA34, EA35, EA43, EA45, EA46	
Earth Surface and Interior	S-1. How can large-scale geological hazards be accurately forecast in a socially relevant time frame?	S-1a. Measure the pre-, syn-, and posteruption surface deformation and products of Earth's entire active land volcano inventory with a time scale of days to weeks.	Most important	**Ground-surface composition and changes over time.** Hyperspectral VNIR/SWIR (at the ~ 30 m spatial scale) and TIR data (at the ~ 60 m spatial scale) with 1-2 week revisit time, acquiring continuously for periods of weeks to months prior to an eruption to detect trends and change	Land surface temperature (active volcanoes)	≤30 m	≤16 days for global coverage*	≤380 - ≥2500 nm, @ ≤10nm		60-100 m	≤5 days for global coverage*			VNIR within 3 days	R6	EA42, EA30*	
					Fractional coverage and silicate composition of lava flows, lahars, ash deposits (active volcanoes)	≤30 m	≤16 days for global coverage*	≤380 - ≥2500 nm, @ ≤10nm		60-100 m	≤5 days for global coverage*	≥5 bands in 8-12 um		VNIR within 3 days	R8, R15	EA36*, EA38*, EA39, EA42	
				Gas emissions, plume composition, particle size and temporal changes (high spatial resolution). Multi- to hyperspectral VNIR/SWIR (at ~30 m) and TIR data (at ~60 m) with ~1 week revisit time. Acquiring continuously prior to and during eruptions to detect trends and measure eruptive emissions.	Gas and particle concentrations (active volcanoes)	≤30 m	≤8 days for global coverage*	≤380 - ≥2500 nm, @ ≤10nm	SNR ≥400 VNIR, SNR ≥250 SWIR, accuracy ≤10%	60-100 m	≤5 days for global coverage*	≥5 bands in 8-12 um		VNIR within 3 days		EA37* EA41, EA42	

SBG Applications Areas





SBG Applications – Latency Analysis

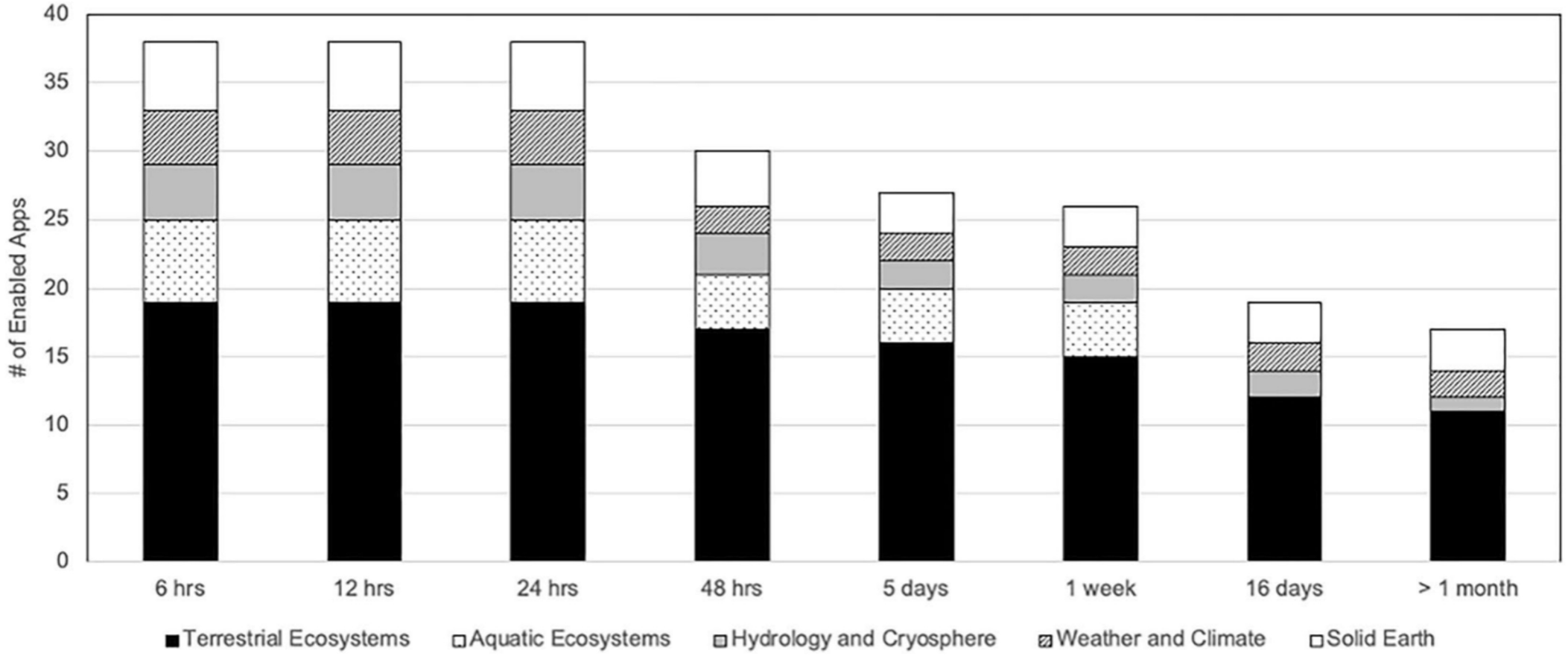
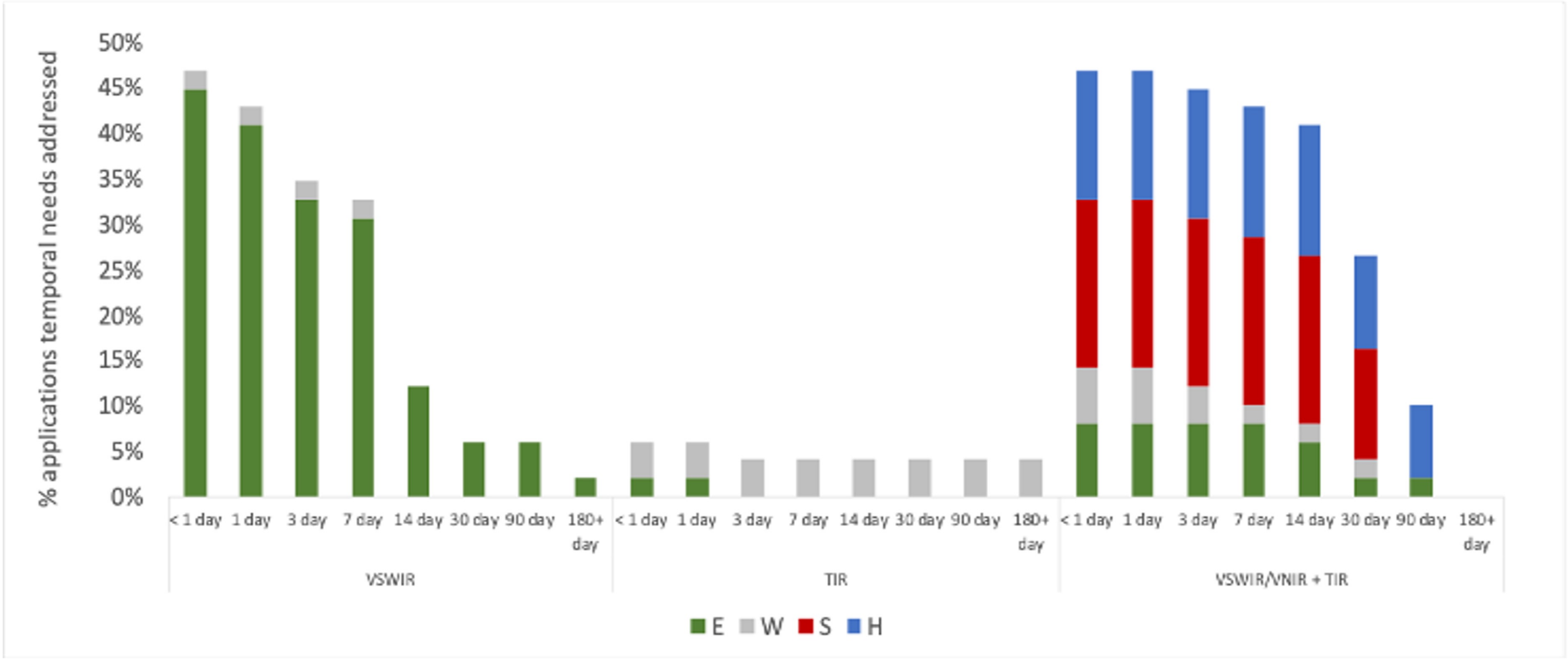


Figure 2. 24 hour latency (acquisition to L2+) would enable 78% of applications possible with the current capability set ((Stavros et al., 2022)), which is the maximum possible in the current configuration.

SBG Applications – Temporal Analysis



Many applications needed both better revisit from VSWIR (<16 day - SBG) and would benefit from better revisit from TIR+VNIR (< 3 day)

SBG – Latency and Applications

	Ecosystems	Solid Earth	Hydrology & Cryosphere	Weather & Air Quality
Event-driven (<6 hrs)	• Support active fire mapping and response • Detect and track oil spill events	• Active volcanic eruptions, resulting in evacuations • Forecast aviation hazards associated with volcanoes	• Detecting and monitoring flood, including extent and impacts	• Tracking and reporting on extreme weather events and impacts
24-48 hours	• Early detection of and response to algal blooms • Marine heat waves / coral bleaching • Continue monitoring oil spills and fires	• Continued monitoring of active volcano, landslide, debris flow events	• Water use for agriculture (irrigation needs) • Continued flood monitoring • Snow conditions	• Improve mitigation of heat wave events, urban heat island • Air quality emissions (fires, gas leaks, dust)
Weeks to months	• Post fire severity assessment / recovery • Biodiversity for conservation, and restoration • Fisheries • Carbon accounting	• Landslide and debris flow risk assessment • Mineral resource mapping	• Food security and Aid Distribution • Flash drought detection and monitoring • Agricultural runoff • Agriculture disease and runoff	• GHG emissions from land conversion • Chronic air quality concerns and environmental justice • Vectorborne disease habitat

SBG Example Applications

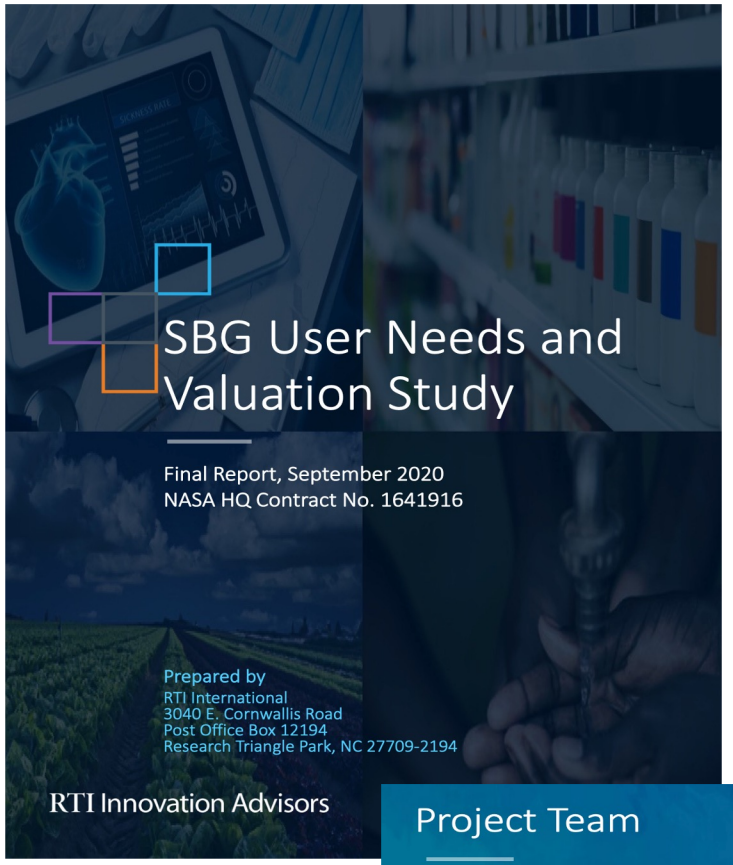
SBG Applications – Summary of Contributions to Architecture

Key Application Driver: A 24 hour latency (acquisition to L2+) would enable 78% of applications possible with the current capability set ((Stavros et al., n.d.)), which is the maximum possible in the current configuration

Key Application Driver: A < 1 day revisit of both VSWIR with TIR/VNIR satisfied the greatest number (76%) of the 49 enabled applications' temporal needs.

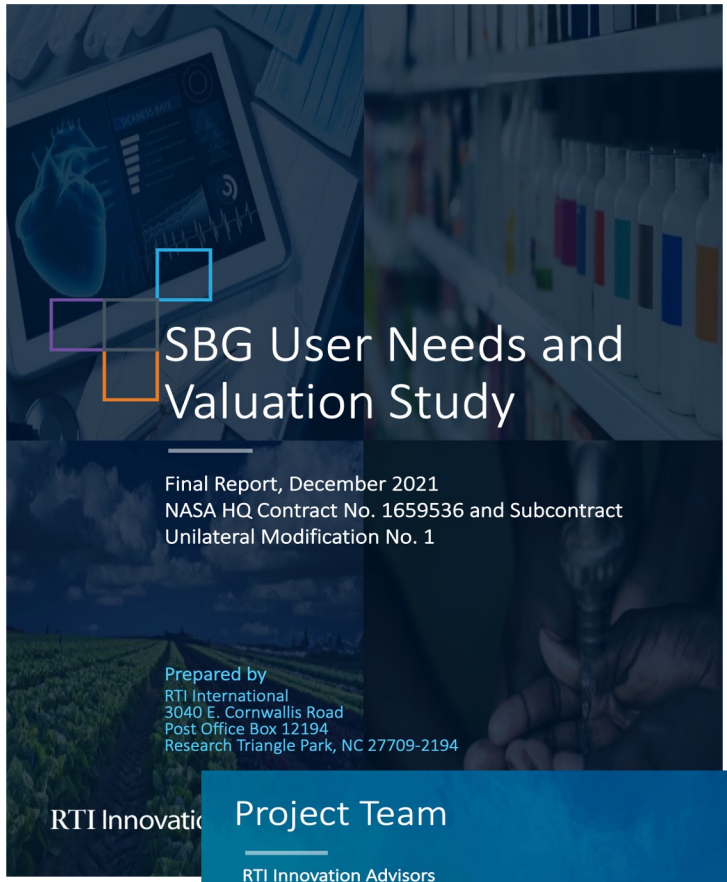
Key Application Driver: Inclusion of a Visible Near InfraRed camera (VNIR) with the TIR platform for coincident albedo/thermal measurements – largely to improve evapotranspiration estimates.

Key Application Driver: The addition of a 4 um channel to support the high temperature characterization of fires and volcanoes



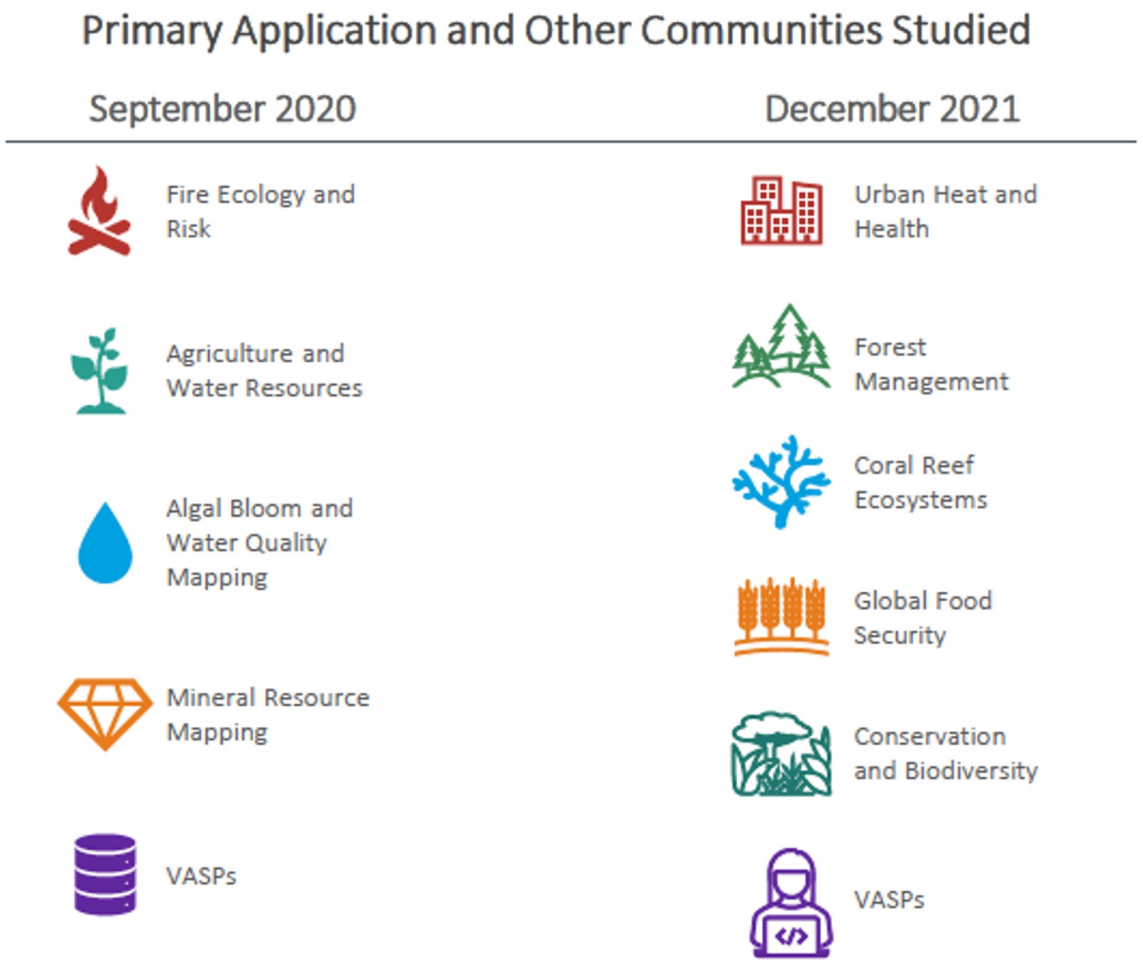
A fundamental aspect of the user studies was to engage private-sector, nongovernmental organization (NGO), and local municipal EO users not traditionally engaged by NASA for science mission planning.

Categorically identifying and engaging this type of nontraditional user was paramount to successfully studying their needs.



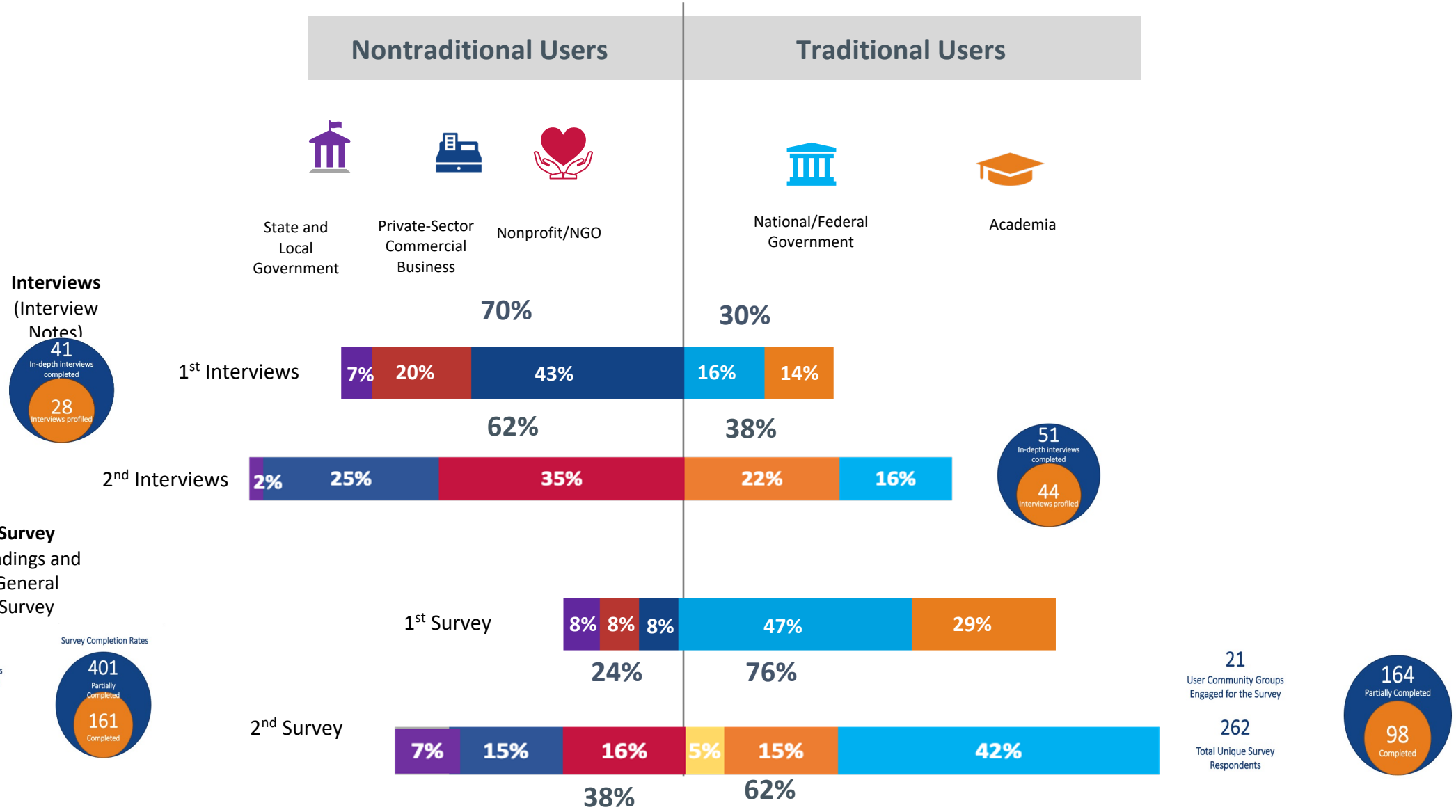
SBG applications community assessment (RTI)

Summary of areas surveyed / studied

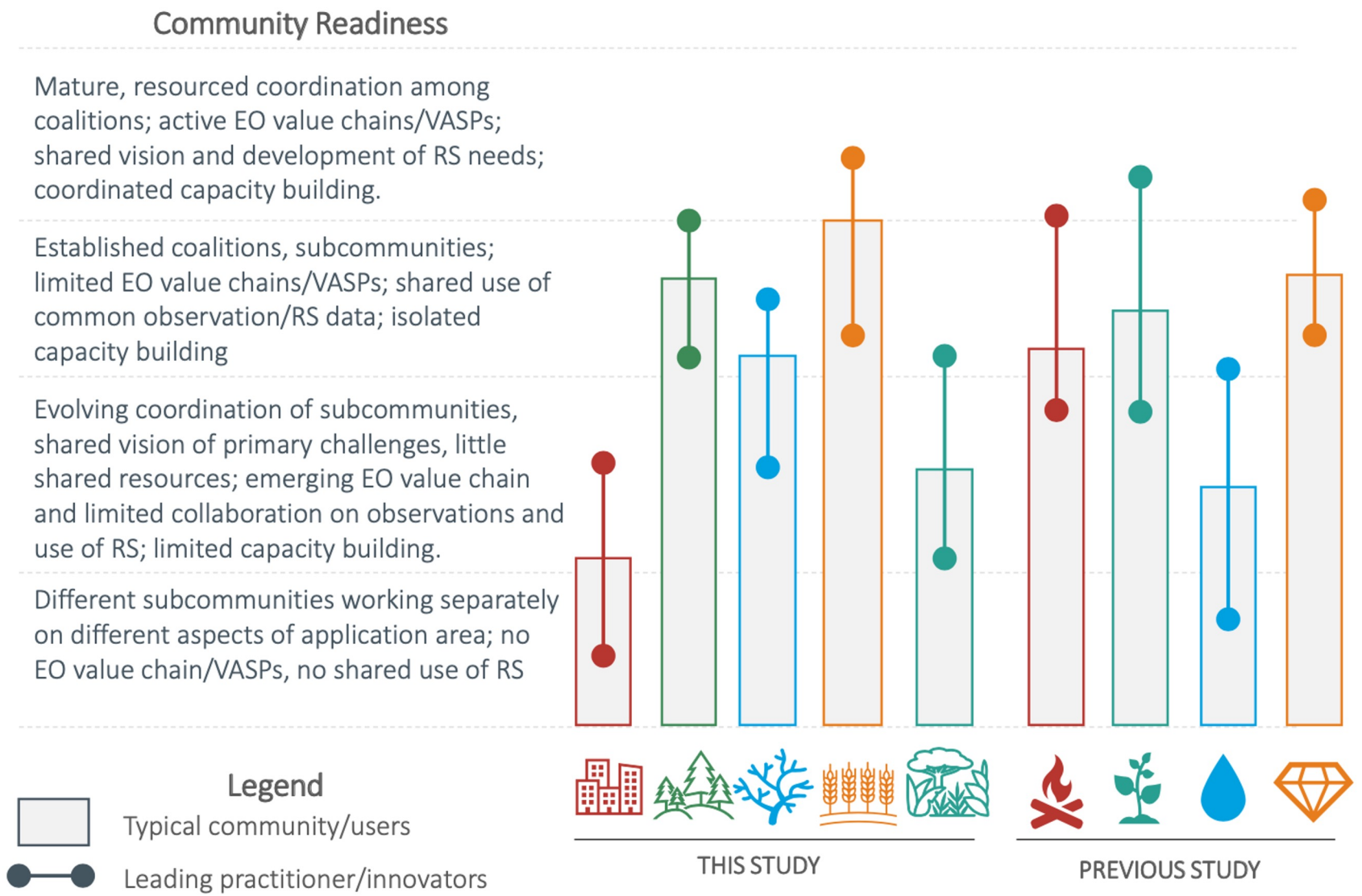


- 560+ individuals surveyed regarding SBG capability needs
- 94 interviews in total across all 11 thematic areas
- SBG will be able to provide benefit to most application areas studied when considering spatial and temporal decision scales

User Communities Sampled



RTI study and CAR can be used to inform a community engagement plan and materials



Agriculture / water resources

Agriculture

Key Use Cases of SBG Data/Products	National	Regional	Field	Plant
Ag and Water resource				
Drought Monitoring				
Crop type/composition/healthy monitoring				
Crop residue/monitoring				
Food security/yield forecasting				

Agriculture

Key Use Cases of SBG Data/Products	Annual Seasonal	Monthly	Biweekly	Weekly	Daily
Ag and Water resource					
Drought Monitoring					
Crop type/composition/healthy monitoring					
Crop residue/monitoring					
Food security/yield forecasting					

Observations and impacts

- Input into SBG project: With the shift to precision farming and practice, users need precise and timely data, and more advanced monitoring and models. Temporal resolution is as important as spatial and near daily monitoring is desired.
- For U.S. farmers who use Variable Rate Technology (VRT), SBG may provide an increase of greater than $30M annually through improved revenue and savings, where a conservative estimate is 10-20% increase over current profits while using VRT.

Expert Interview Quotes:

"If we can build field-scale maps and models for monitoring crop type, growth and health, we can advise small holders and build business in new ways. This will improve farming practices and food security in food-challenged regions." - Large Agri-Products Co., Digital Agronomist

"We are not good at forecasting because we do not have great models, and we have a hard time making trade-offs without the objective information we need" - Ag Water Manager

Fire

Fire

Key Use Cases of SBG Data/Products	National	Regional	Field	Plant
Pre fire Fuel Mapping				
Post Fire Fuel Mapping				
Fire risk Model				
Vegetation Mgmt				
Risk Mitigation				
Operations/Planning Changes				

Fire

Key Use Cases of SBG Data/Products	Annual Seasonal	Monthly	Biweekly	Weekly	Daily
Pre fire Fuel Mapping					
Post Fire Fuel Mapping					
Fire risk Model					
Vegetation Mgmt					
Risk Mitigation					
Operations/Planning Changes					

Observations and impacts

- Input into SBG project: There is an urgency and need for better fire risk maps and models. SBG can significantly make improvements and augment active adoption by partnering with the coordination agencies.
- Just in improving remote sensing accuracy, SBG may have a value of >$30M to larger utilities in fire-prone states alone. The liability for significant wildfires over the last decade has totaled billions of dollars and SBG has the potential to better mitigate the risks of wildfires.

Expert Interview Quotes:

"With better SBG Data, we could vastly improve our fire models and simulations. Without accurate moisture and fuel type data, our models can be 90% off. - Fire Risk Model Developer

"We often don't even know when or where prescribed burns are happening, and we can't tell how it impacts the likelihood of wildfires… Prescribed fire reduces wildfire, but without better data to support that we can't shape better policies and oversight." - State Fire Manager

Mineralogy

Mining

Key Use Cases of SBG Data/Products	National	Regional Greenfield	Regional Brownfield	Site
Greenfield/Brownfield exploration				
Geologic Process, surveys				
Mine Opening/Operations/Monitoring				
Environment/health/regulatory monitoring				

Mining

Key Use Cases of SBG Data/Products	Annual Seasonal	Monthly	Biweekly	Weekly	Daily
Greenfield/Brownfield exploration					
Geologic Process, surveys					
Mine Opening/Operations/Monitoring					
Environment/health/regulatory monitoring					

Observations and impacts

- Input into SBG project: Current RS data are are used but has limited exploration and more operational environmental applications. SBG spatial and temporal resolutions will help a well funded industry seek step changes in capabilities and vastly improve survey works.
- The use of SBG could potentially reduce initial exploration time and expenses significantly, potentially reducing from 3 years to 3 months the time needed for large tracks of land. This use has the potential to reduce exploration costs by 60%-70%.

Expert Interview Quotes:

"Our teams want mineral maps, not data. This community sees the potential for SBG and is excited about the prospects" - Spectral geologist at mining company

"SBG datasets used for exploration can enable whole new kinds of monitoring of water, vegetation and emissions to ensure safe and sustainable practices for the industry" - Applied researcher

Algal Blooms/Water Quality

Algal Blooms

Key Use Cases of SBG Data/Products	National	Regional	Inlet Estuary	Site
Regional Scale water body quality monitoring				
Early warning of harmful algal blooms				
Shellfish site water chemistry				
Watershed/source pollution/nutrient monitors				

Algal Blooms

Key Use Cases of SBG Data/Products	Annual Seasonal	Monthly	Biweekly	Weekly	Daily
Regional Scale water body quality monitoring					
Early warning of harmful algal blooms					
Shellfish site water chemistry					
Watershed/source pollution/nutrient monitors					

Observations and impacts

- Input into SBG project: Global hyperspectral and TIR coverage are key benefits of SBG for wide area monitoring. The 30m resolution is adequate, although low latency is preferred.
- SBG may have a value of >$700M in annual benefits to the US Shellfish industry. SBG data can help in screening key environmental attributes that increases average productivity by 200% because of better siting of shellfish farms. This impact would be applicable for major shellfish types and across the United States.

Expert Interview Quotes:

"There is no way to test everywhere in the field, so better targeting of when and where to test would save a lot of time and help keep people healthy." - State Water Official

"Monitoring for HABS is great, but not much you can do about them. But finding new sites for high-growth shellfish farms will create a new industry," - Shellfish Farm Owner

Urban heat

URBAN HEAT AND HEALTH	National	Large City	Block	Roof
Mapping programs,* heat health and mitigation management, policy, MRV				
Heat alerts,* high-resolution urban maps for heat alerts and policy making				
Albedo/reflectivity/emissivity studies, urban infrastructure/surface surveys				
Targeted heat mitigations,* siting cool buildings, cool roads, urban vegetation				

URBAN HEAT AND HEALTH	Annual Seasonal	Monthly	Weekly	Daily
Albedo/reflectivity/emissivity studies, urban infrastructure/surface surveys				
Mapping programs,* heat health and mitigation management, policy, MRV				
Targeted heat mitigations,* siting cool buildings, cool roads, urban vegetation				
Heat alerts,* high-resolution urban maps for heat alerts and policy making				

Observations and impacts

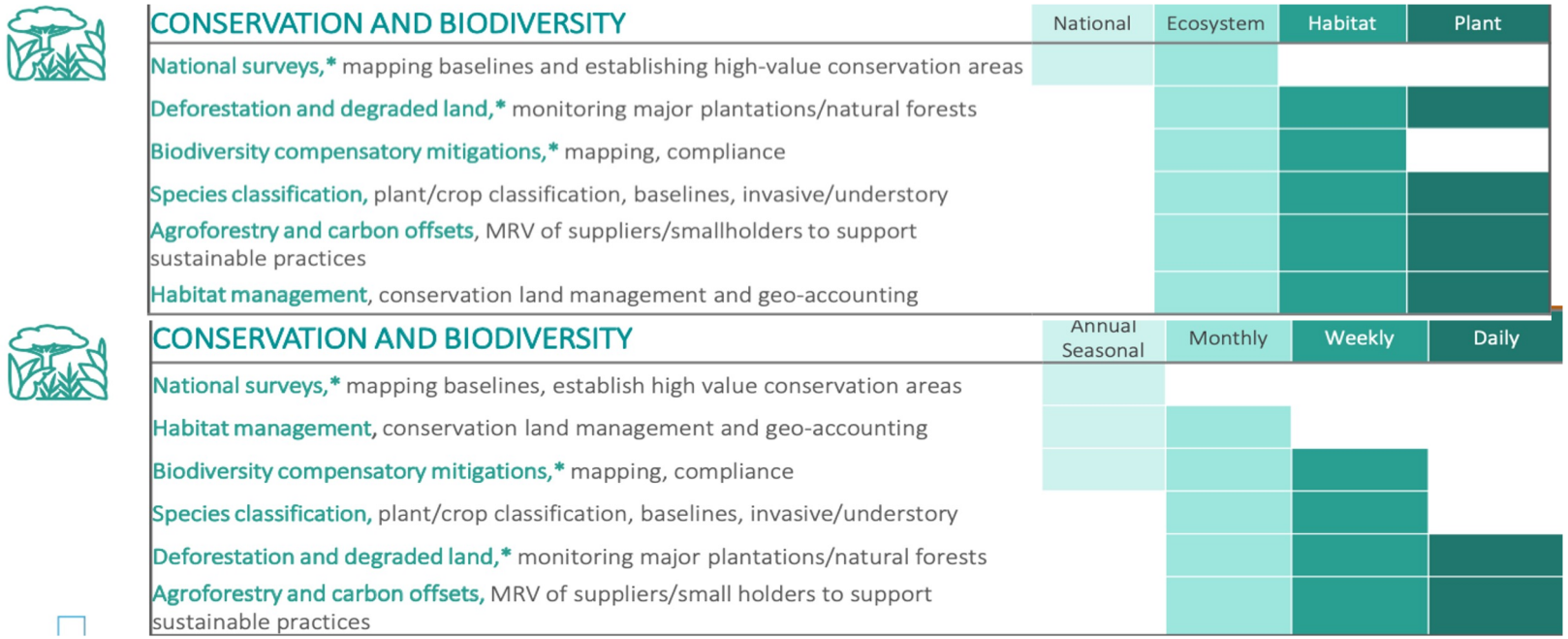
- Input into SBG project: urban heat applications would benefit from more frequent revisits, particularly during heat wave events; this is a key benefit of international partnering with LSTM and TRISHNA
- In the U.S. alone, there are at least 5,000 heat-related deaths that occur each year, which could be avoided with better urban mitigation strategies such as canopies. Experts note that SBG, particularly when combined with sociodemographic data, could help prevent these deaths.

Expert Interview Quotes:

"The greatest benefit of SBG may be to developing countries where a large percentage of the urban population is vulnerable to heat stroke and death. Such maps can save lives." - International aid worker

"ECOSTRESS is a great resource, but we don't have staff who can manipulate remote sensing data. We are lucky to have NASA experts provide us with images." - City agency

Biodiversity / conservation



Observations and impacts

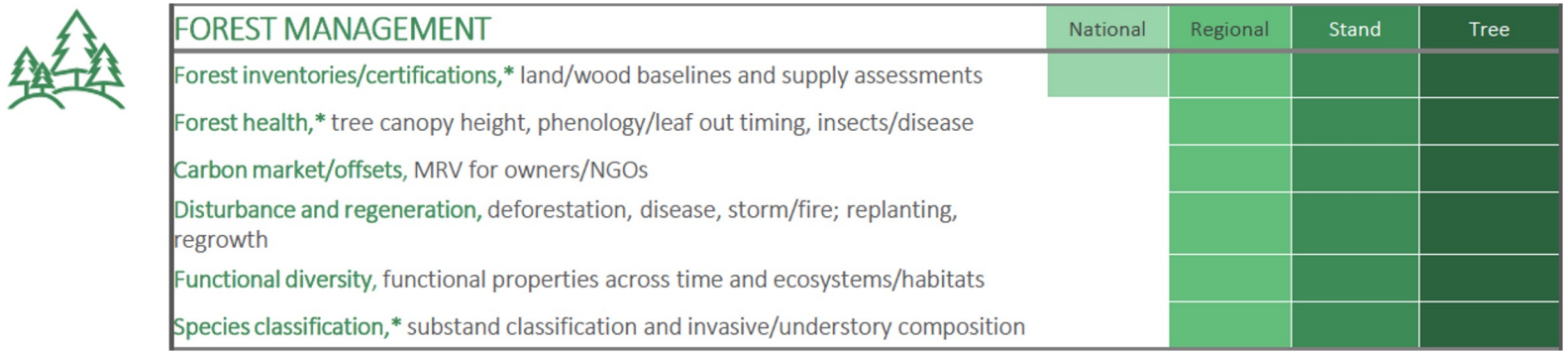
- Input into SBG project: biodiversity conservation community needs information about ecosystem classification and species mapping. This can be taken under consideration when considering baseline / threshold targets.
- Community will continue to need custom training, with value-added service providers representing a key partner in translating NASA data to information.

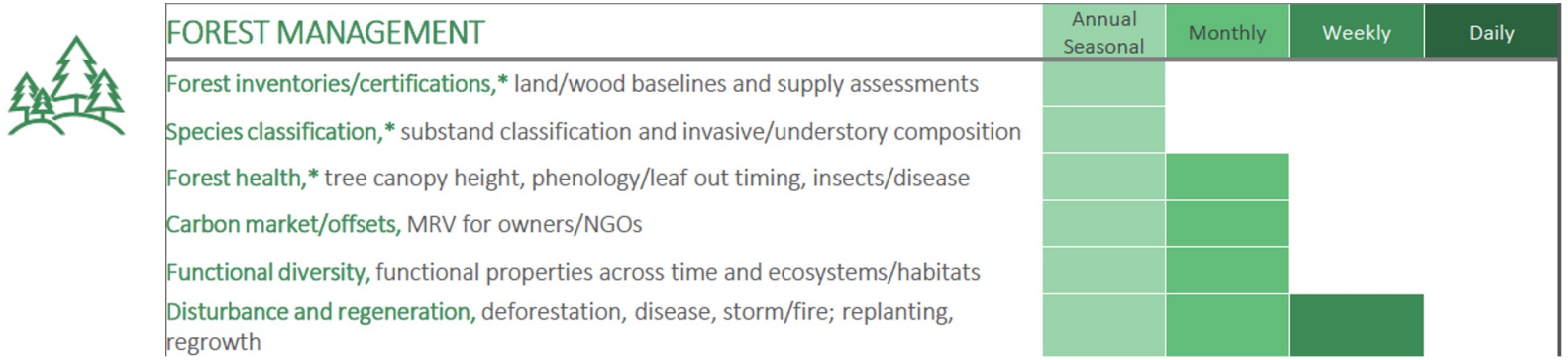
Expert Interview Quotes:

"To use SBG, we need to develop the applied science of what we do to create species maps, then we can help conservation NGOs. We need capacity building to help non-researchers" - conservation research institute / boundary organization

"We have made big public commitments to protect species, which consumers care about. …NASA can provide certainty and consensus on (biodiversity) metrics." - global consumer brand company

Forest management





Observations and impacts

- Input into SBG project: existing forest management applications would combine RS data with ground data to maintain study continuity. More frequent revisits could expand applications for phenology, harvest activity, disease and drought detection.
- If SBG can improve commercial timberland management, it can lead to annual benefits between $52M and $105M per year.

Expert Interview Quotes:

"If NASA could improve USFS products with better annual RS products that would be great!" - R&D Head - Pulp/Paper Commodity Manufacturer

"The future of RS in forestry and forest conservation will be hyperspectral." - Senior R&D and GIS Group Lead

Coral reef applications

CORAL REEFS	National	Reef	Colony	Coral
Marine spatial planning,* to sustain reefs and tourism				
Coastal resilience planning,* mapping and reef management				
Capture/predict bleaching events, monitor temperature and coral condition				
Disturbance monitoring, nutrient/pollution influx, wave action, temperature, etc.				
Restoration and replanting,* site and monitor				
Condition and composition, health, resiliency across time				

CORAL REEFS	Annual Seasonal	Monthly	Weekly	Daily
Marine spatial planning,* to sustain reefs and tourism				
Coastal resilience planning,* mapping and reef management				
Condition and composition, health, resiliency across time				
Restoration and replanting,* site and monitor				
Capture/predict bleaching events, monitor temperature and coral condition				
Disturbance monitoring, nutrient/pollution influx, wave action, temperature, etc.				

Observations and impacts

- Input into SBG project: Demonstrating HIS at 30m can address the most needed new observations and provide insight at the coral colony level and improve relocation success.
- Coral reefs … can be the backbone of a region's entire tourism industry, providing direct and indirect local jobs... Approximately 30% of the world's reefs are accessible from nearby land and support reef-related tourism is estimated to be close to $40B.

Expert Interview Quotes:

"Having frequent TIR revisits at 60-meter resolution will really help us understand thermal stress, especially near shore where NOAA data are too coarse to capture dynamic coastal situations." - Senior Coral Reef Researcher

"I think another great and totally unaddressed use of this data would be for mapping and monitoring sea grass and macroalgae." - Reef Restoration, Relocation and Monitoring Specialist

Food security

GLOBAL FOOD SECURITY	National	Regional	Field	Plant
Global/regional agriculture statistics,* estimates of crop yield and productivity				
Hazard events/trend monitoring,* onset, extent, and prediction of drought and floods; anomaly detection				
Land quality surveys, for suitable land, soil maps, conversion, regenerative Ag				
Food insecurity interventions,* regional models for improved interventions				
Land and field assessments, cropland, crop type classification, monitoring				
Carbon markets,* improved indicators/models for soil carbon, certification, MRV				

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Food insecurity interventions,* regional models for improved interventions				
Land quality surveys, for suitable land, soil maps, conversion, regenerative Ag				
Land and field assessments, cropland, crop type classification, monitoring				
Hazard events/trend monitoring,* onset, extent, and prediction of drought, floods, and anomaly detection				

Observations and impacts

- Input into SBG project: experts felt that SBG has the greatest potential to improve condition monitoring using 3-day TIR for better LSTM and ET/ESI models for rapid hazard events and HIS for cropland stress monitoring.
- Using SBG improved early warning models in resilience building activities could imply additional savings of $14M to $43M, depending on an optimistic (15% improvement) or pessimistic (5% improvement).

Expert Interview Quotes:

"The promise of SBG is a global set of hyperspectral plant "signatures" vs. limited multispectral data points." - Spectral Agronomy Researcher

"What is a game changer about SBG is the thermal 3-day and global scale; it would unlock our ability to map some parts of the world." - Digital Ag startup, R&D Lead

Proposed next steps: Community Engagement

Goal 1: Engage new and traditionally underrepresented communities
Goal 2: Engage the next generation of scientists
Goal 3: Co-develop applied science use cases
Goal 4: Interface and collaborate actively with NASA-designated DAAC
Goal 5: Develop community-specific resources through open science and applications practices

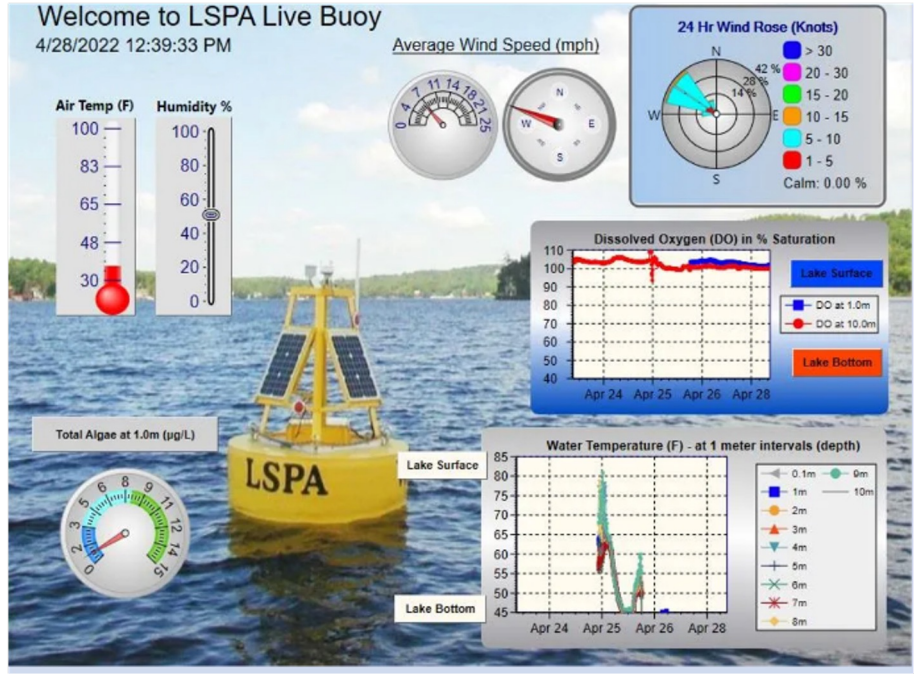
Collaborate and build on lessons learned from other mission applications

- PACE and GLIMMR
- ECOSTRESS
- EMIT
- And many others!

RTI studies provides initial introduction between SBG and application area/sector, particularly for organizations that are outside of our conventional user community

SBG-GLEON Lake Expedition 2022

- Supports science formulation for SBG through a transdisciplinary Global Lakes Ecological Observatory Network (GLEON) team including 9 graduate students
- Develop their technical skills for satellite data analysis, synthesis with in situ data, modeling of inland lake water quality
- Engage GLEON and NASA networks toward calibration/validation of satellite products using open source models
- Learn science and teamwork skills, present, document in publications



Use satellite and in situ data to study biological processes governing the health of lakes and lake metabolism

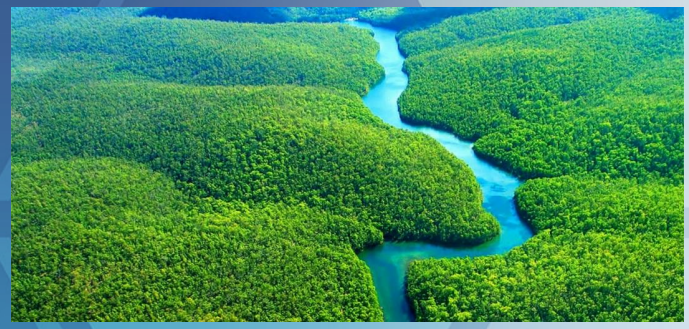
Summary

- Applications are fully integrated and consulted throughout mission study, examples include engineering design session, collaboration on SHIFT airborne campaigns and SBG-SISTER
  - SBG is the first to integrate apps at architecture stage
  - SBG has shown that apps and science can be considered synergistically, which provide a more comprehensive set of needs driving architecture and measurement discussions and decisions (i.e. hardware, latency)
  - Applications can have unique technical needs not covered by science alone, such as low latency

- Applications experience (ROSES, programs, mission applications) will be critical for informing next stage in implementing open science and applications practices to ensure accessibility and information exchange

Thank you!

Welcome to Lawrence Friedl, NASA Earth Sciences, Director of Applied Sciences



Algorithms Working Group

- Team: K. Cawse-Nicholson, P. Townsend, 250+ community members
- Deep dive – early outcomes:

PRODUCT	MATURITY	GREATEST NEED
Snow products	High	In situ data in glaciers and below-canopy snow
Evapotranspiration	High	Data fusion and improved latency
High Temp Features	High	High spatial resolution (<5 m) thermal data over lava
Substrate Composition	High (minerals)	VSWIR/TIR fusion
Proportional Cover	Medium	Complimentary combination of algs from different fields
Volcanic Gas&Plumes	Medium	Improvements in computational efficiency
Water Biogeochem	Medium	Analysis of applicability and compatibility of PACE algorithms for coastal and inland waters, at SBG GSD
Vegetation Traits	Low	Global in situ and remote sensing data
Substrate Composition	Low (soils)	Global in situ and remote sensing data
Water Biogeophysics	Low	In situ water column data
Aquatic Classification	Low	Global datasets; build upon biogeochem & biogeophysics products to produce applications-ready data

SISTER: SBG **S**pace-based **I**maging **S**pectroscopy and Thermal pathfind**ER**

For more information, please email sbg@jpl.nasa.gov , or mgierach@jpl.nasa.gov and ptownsend@wisc.edu or ian.g.brosnan@nasa.gov and jon.Jenkins@nasa.gov directly

Primary Objectives & Timeline

- Prototype architectures and workflows to generate prototype high-dimensional, high-value SBG data
- Distribute prototype SBG data for community evaluation and training

FY21 (Oct 2020 – Sept 2021)

Prototype workflows & system components

Deliverable: *Distribute land & water reflectance for community evaluation / feedback*

FY22-23 (Oct 2021 – Sept 2023)

Implement select prototype L2B+ algorithms

Deliverable: *Distribute prototype L2B+ products for community evaluation / feedback*

FY24-25 (Oct 2023 – Sept 2025)

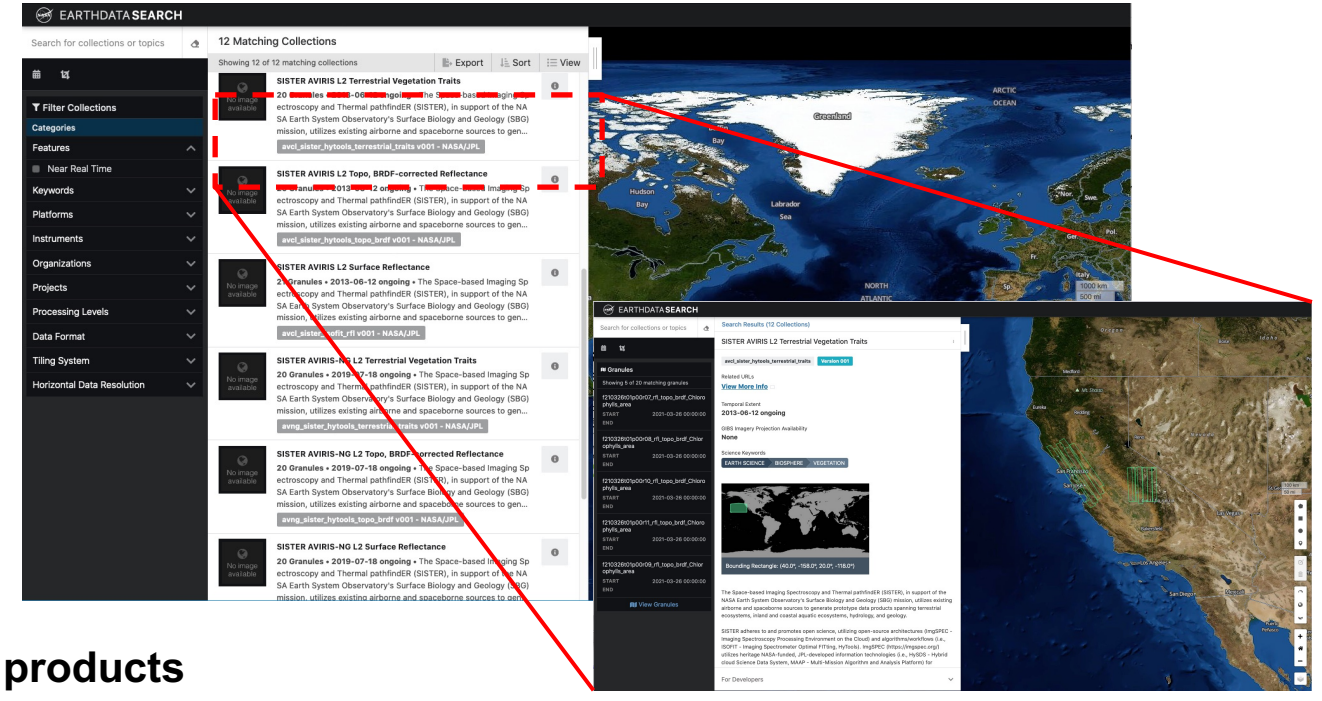
Adapt workflows based on emerging SBG ATBDs

Deliverable: *Refine and redistribute prototype SBG products for community evaluation / feedback*

Prototype Data Available To-Date

- *NASA Ames Research Center*
  - Global Hyperspectral Synthetic Data (AGHSD) is available at https://data.nas.nasa.gov/aghsd/data.php
  - Global Hyperion L1 radiance; Global L2 reflectance (in progress), investigating contemporary georectification tools
- *NASA Jet Propulsion Laboratory*
  - Select* AVIRIS-Classic, AVIRIS-Next Generation, and PRISMA scenes for surface reflectances and uncertainties; topo, BRDF-corrected reflectances; terrestrial vegetation traits

**More scenes, data streams, and algorithms (e.g., aquatic, snow/ice, geology) will continuously be incorporated in FY22+*



ORNL and LP.DAAC will be the official DAACs for SISTER products

SISTER: Prototype SBG Algorithms & Products

SISTER will implement select L2B+ algorithms (informed by the Algorithms and Applications Working Groups) to generate prototype SBG products for community evaluation and engagement

SBG Algorithm Class	SBG Algorithm Products (examples)
CORE Algorithms	
Earth Surface Temperature and Emissivity	Land Surface Temperature* and Emissivity
VSWIR Reflectance	Land and Water Reflectances, BRDF Corrections, Albedo
Cover Classifications	Cloud, Water, Land Cover, Plant Functional Types, etc.
PRODUCT Algorithms	
Terrestrial Ecosystems	
Vegetation Traits	Nitrogen, LMA, Chlorophyll, Canopy water
Evapotranspiration	ET*, Evaporative stress index
Proportional Cover	GV, NPV, Substrate, Snow/Ice, Burned Area
Geology/Earth Surface	
Substrate Composition	Mineral type*, Fractional abundance*, Soil types and constituents
Volcanic Gases and Plumes	SO2, Volcanic ash
High Temperature Features	Volcanic temperature anomalies (lava temperature), Forest fires
Aquatic and Coastal Ecosystems	
Water Biogeochemistry	Pigments, CDOM, Suspended particulate matter
Water Biophysics	Diffuse light attenuation, Inherent optical properties, Euphotic depth, PAR
Aquatic Classification	Phytoplankton functional types, Floating vegetation, Benthic cover, Wetlands
Snow and Ice	
Snow albedo	Albedo, Grain size, SSA, Light absorbing particles, Fractional cover

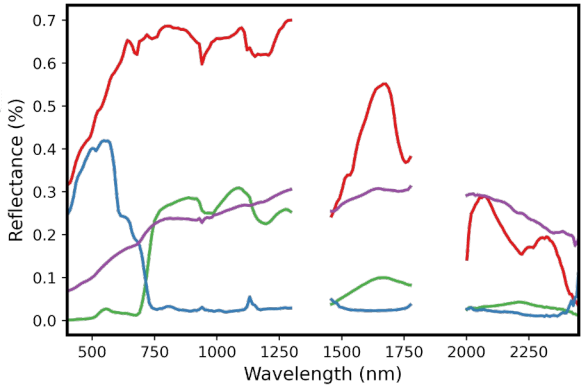
**Leverages ECOSTRESS and EMIT algorithms*

Cawse-Nicholson et al. 2021

SISTER: Prototyping SBG Algorithms using PRISMA and DESIS

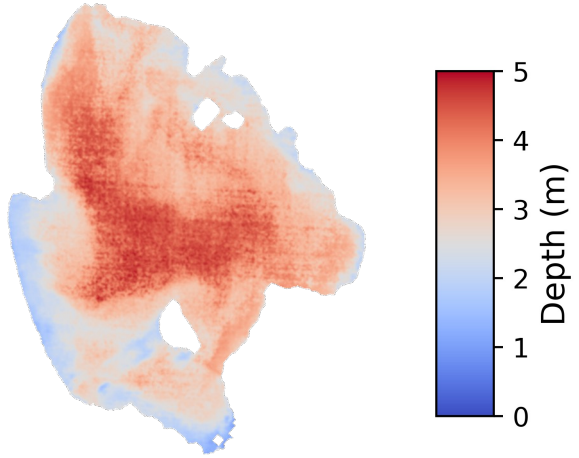
ISOFIT (Thompson et al. 2018)

PRISMA



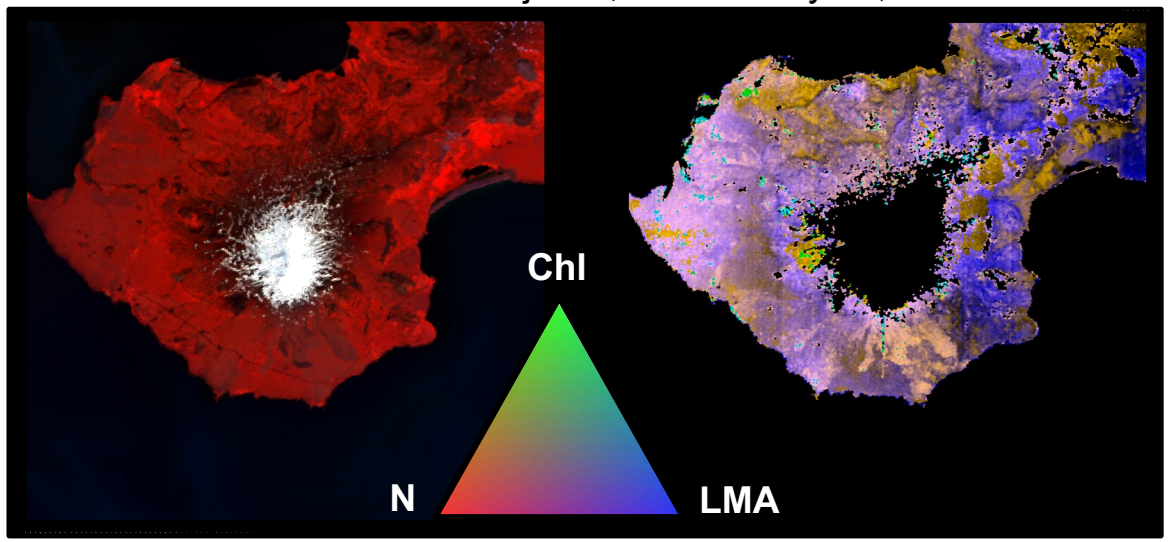
Bathymetry (Thompson et al. 2016)

DESIS Lago Trasimeno, Italy June 04, 2021



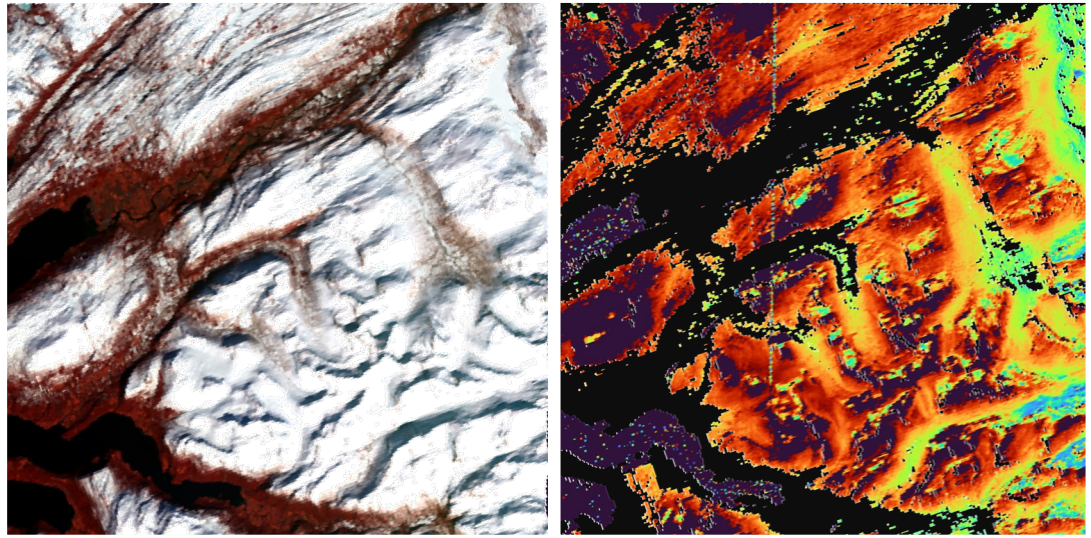
Vegetation Biochemistry

PRISMA Snæfellsjökull, Iceland July 02, 2020



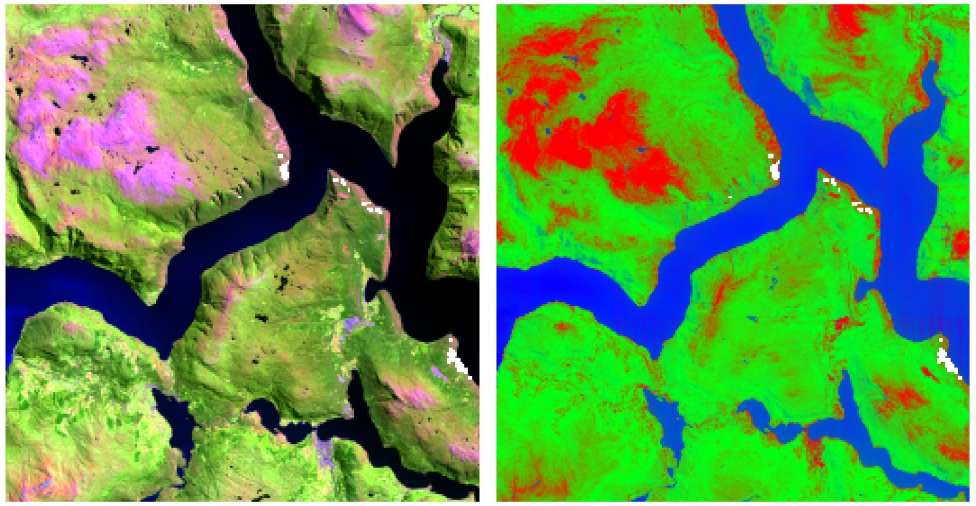
Snow grain size (Nolin and Dozier 2000)

PRISMA Surnadal, Norway April 21, 2020



SISTER: Prototyping SBG Algorithms using PRISMA and DESIS

Fractional Cover (EMIT Science Team)
PRISMA Luster Allmenning, Norway July 23, 2021

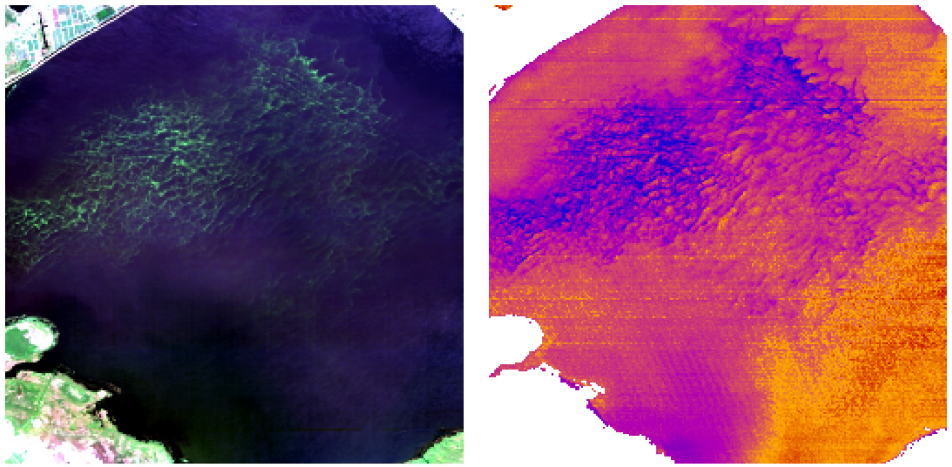


Soil

Vegetation

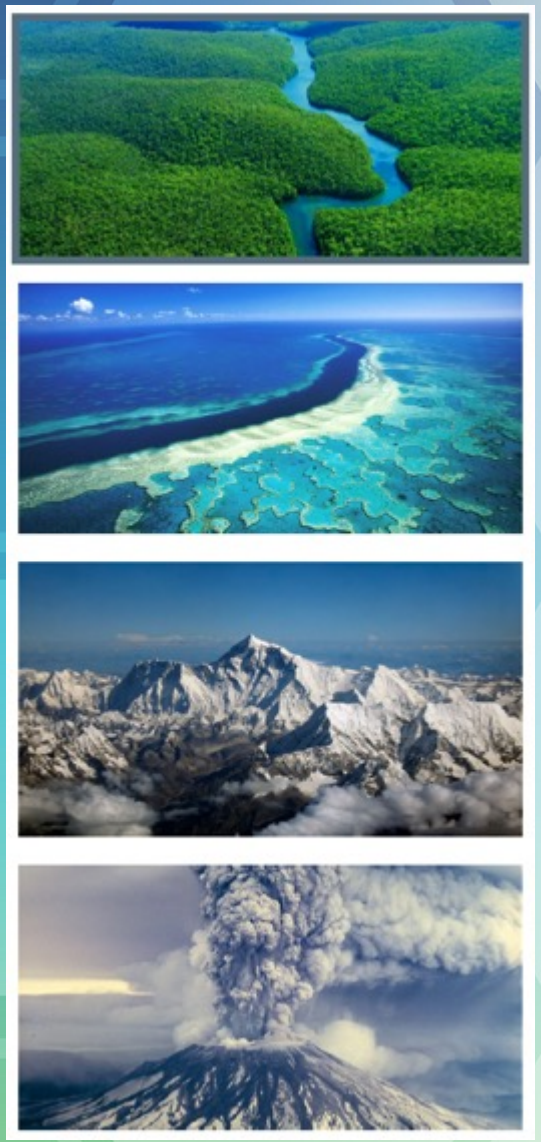
Water

Phycocyanin (O'Shea et al. 2021)
PRISMA Lake Okeechobee, Florida June 26, 2020



High

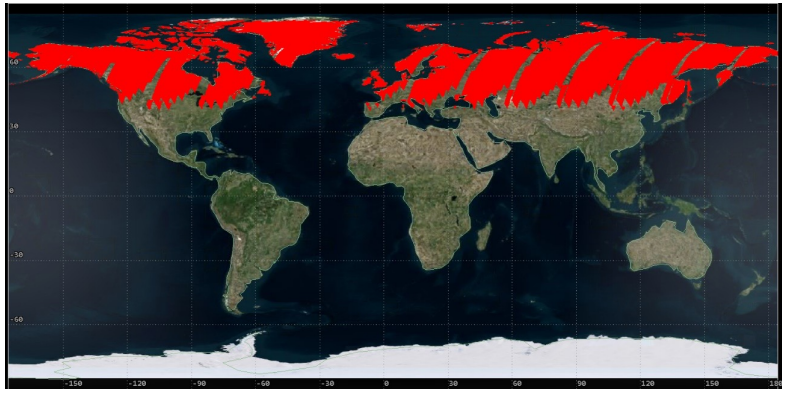
Low



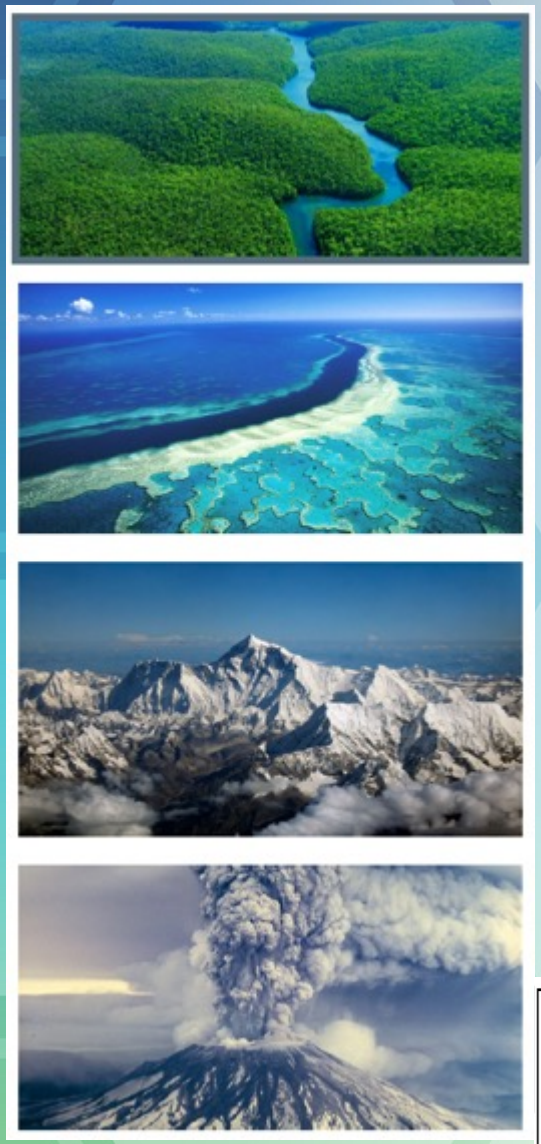
Cal/Val Working Group

- Team: Kevin Turpie, Ray Kokaly, 100+ community members
- Goals: Support mission development radiometric, thermal, spectral and geometric calibration and validation strategies and identifying resources, methods and standards supporting data product validation.

- Recent Achievements:
  - Submitted manuscript on SBG Cal/Val concepts for JGR-B.
  - Presented at 2022 Ocean Science Meeting annual meeting on inter-calibration strategies and challenges with PACE and GLIMR.
  - Continued orbit modeling for intercalibration SBG, CHIME, LSTM and TRISHA, Landsat, Sentinel 2, CLARREO pathfinder and SCR.

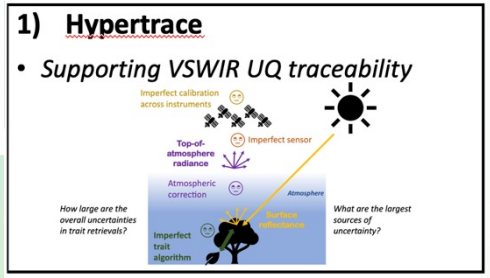


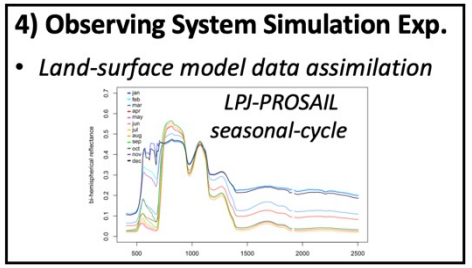
2 months of near-simultaneous terrestrial observations between SBG VSWIR and PACE.

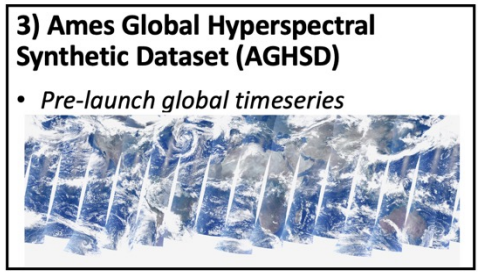


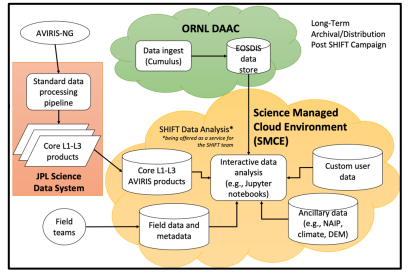
MEET-SBG: Modeling End-to-End Traceability in support of SBG

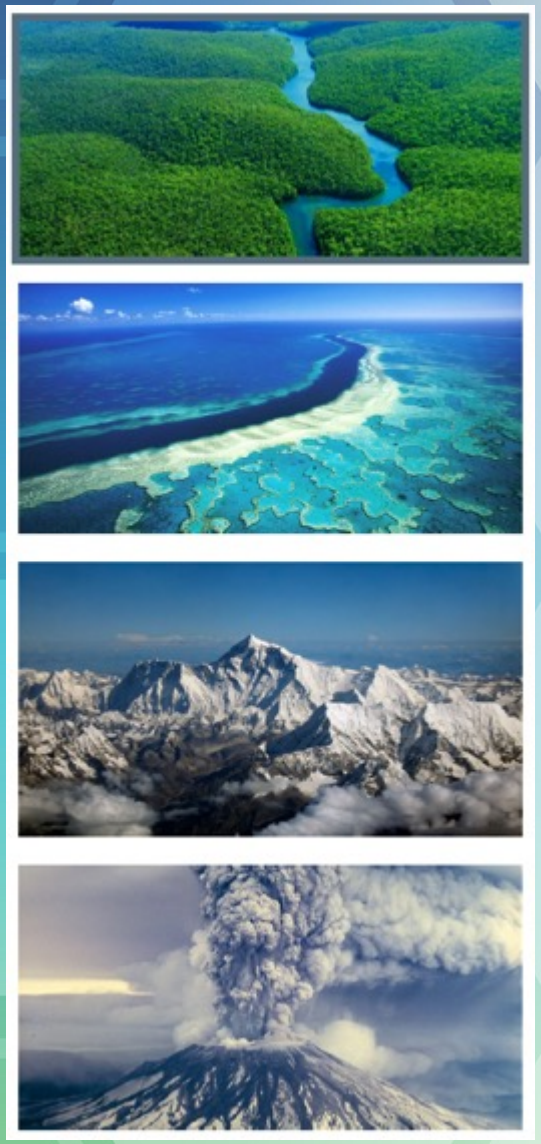
1. Science Value Trades Study
   - Terrestrial algorithm performance and glint avoidance
2. Observing system simulation experiment
3. Synthetic data generation
4. Science data system synergies with SISTER and SHIFT





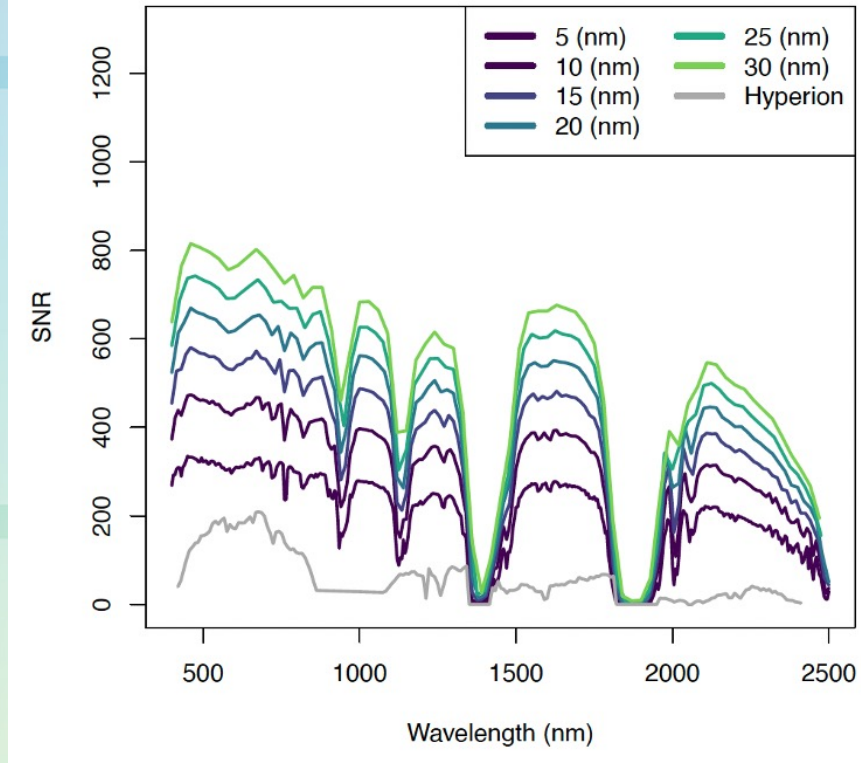


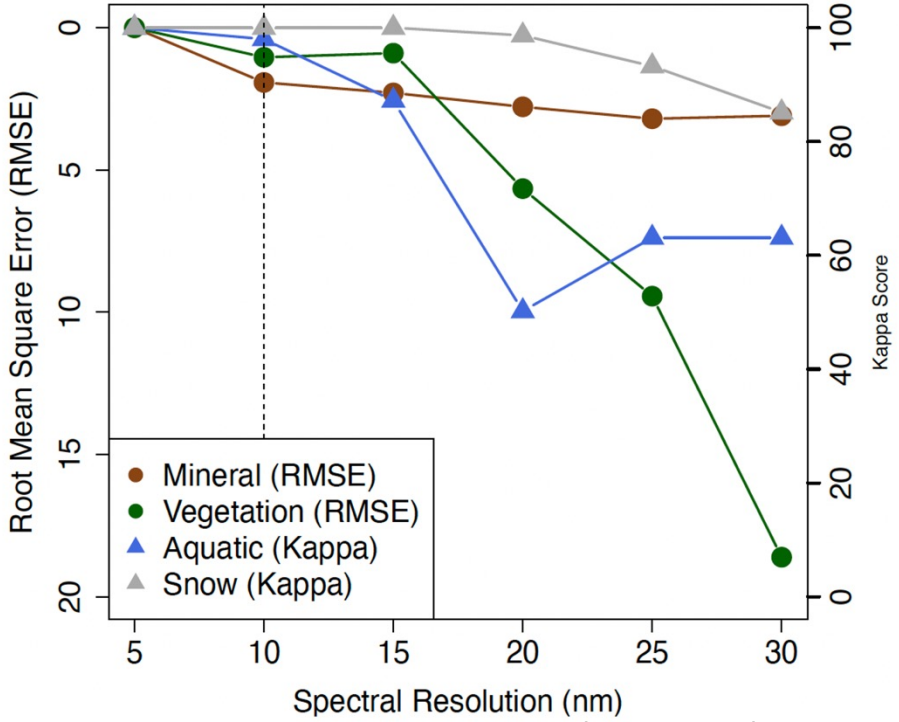




MEET-SBG: Modeling End-to-End Traceability in support of SBG

- **Science Value Trades Study:**
- Extending Hypertrace framework to evaluate instrument tilt and glint avoidance effects on algorithm performance

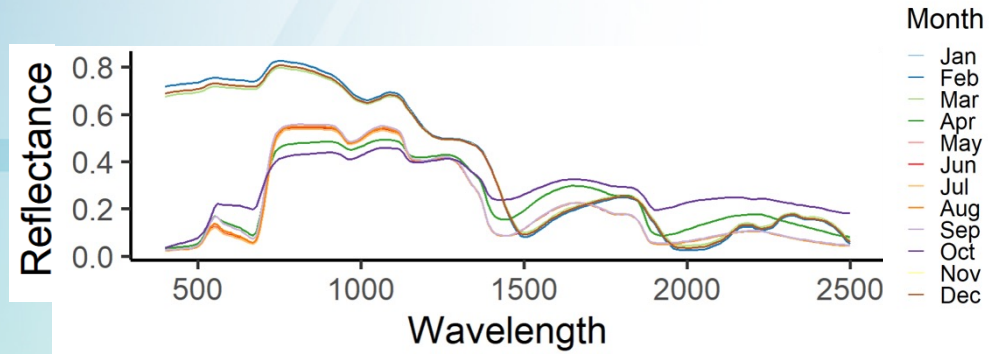


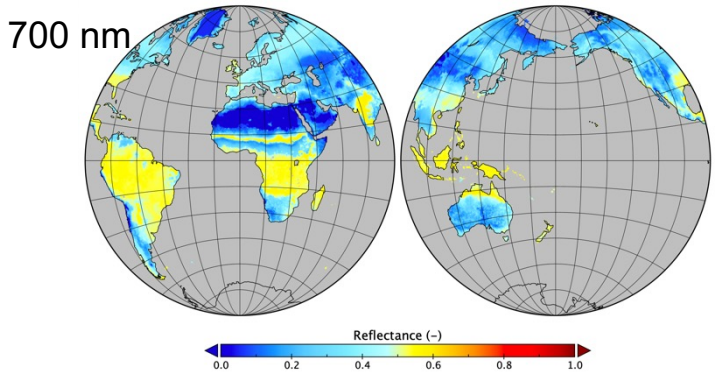


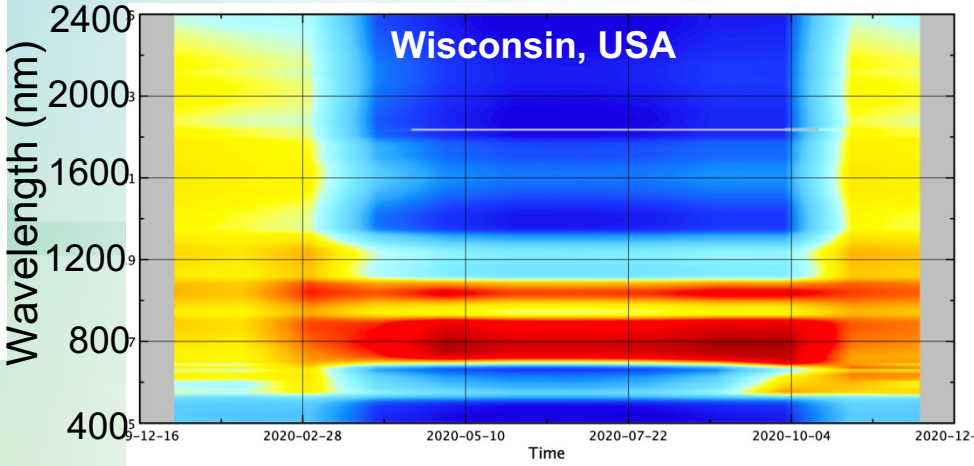
Raiho (submitted)
Cawse-Nicholson (in prep)

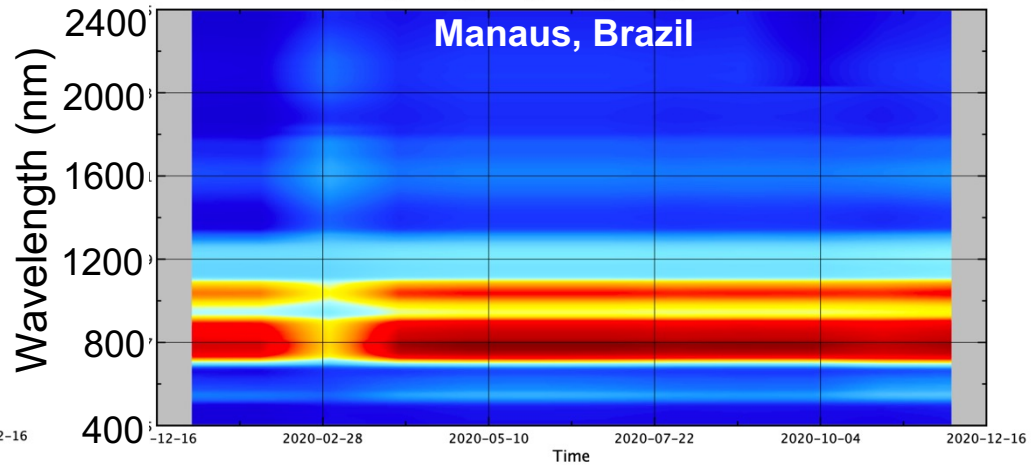
MEET-SBG: Modeling End-to-End Traceability in support of SBG

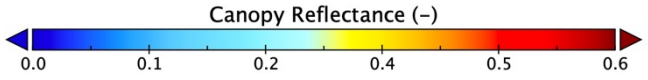
- **Observing system simulation experiment**: LPJ-Prosail
  - Spectra simulated each day for entire global land surface







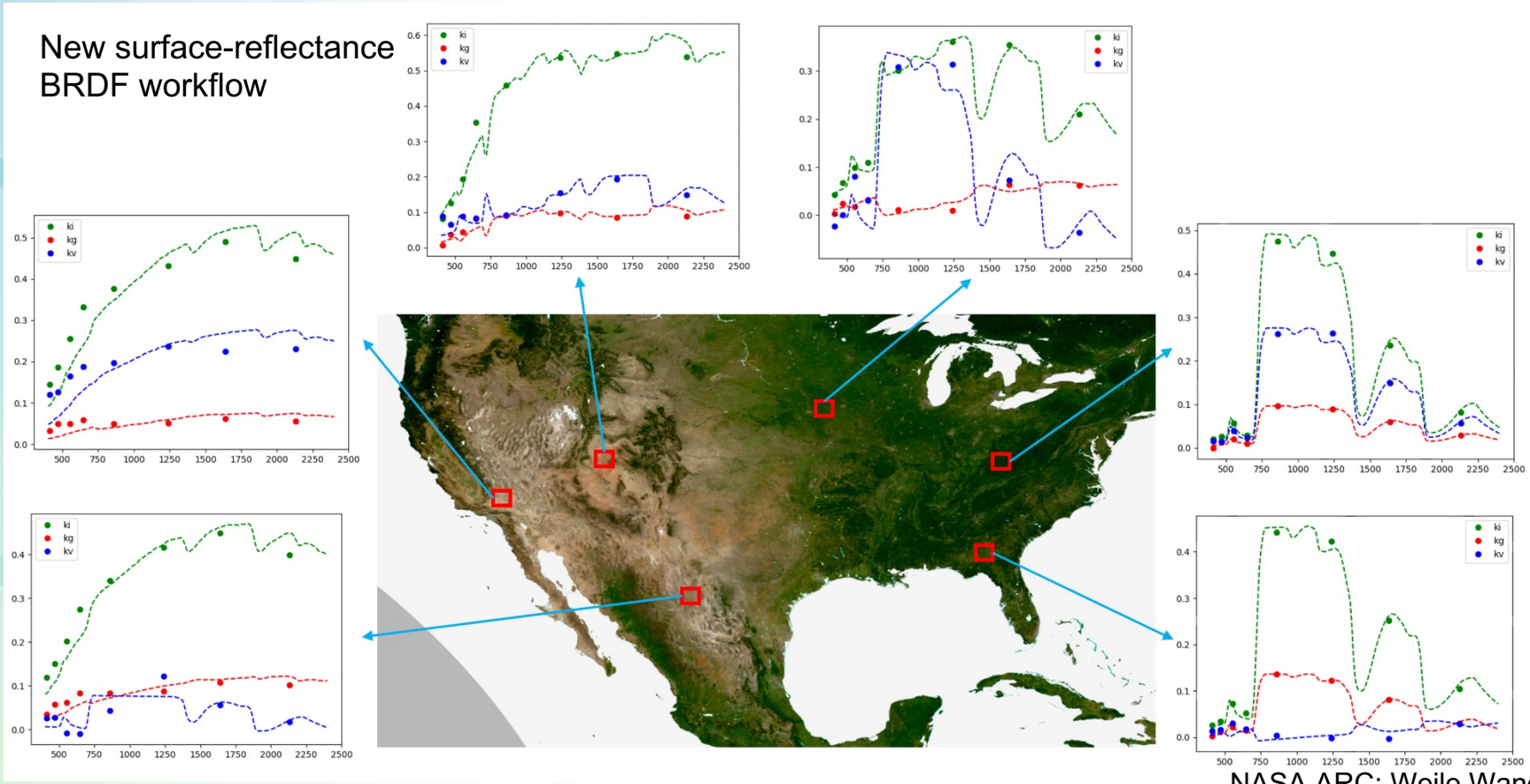




MEET-SBG: Modeling End-to-End Traceability in support of SBG

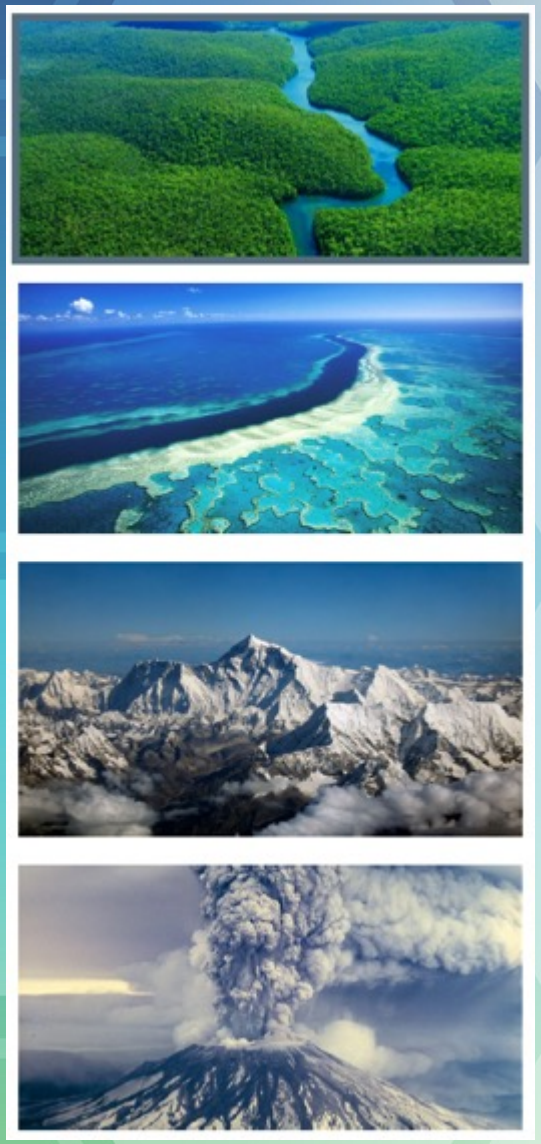
- **Synthetic data generation**: Ames Global Hyperspectral Synthetic Dataset (AGHSD) version 2: Surface Reflectance

New surface-reflectance BRDF workflow



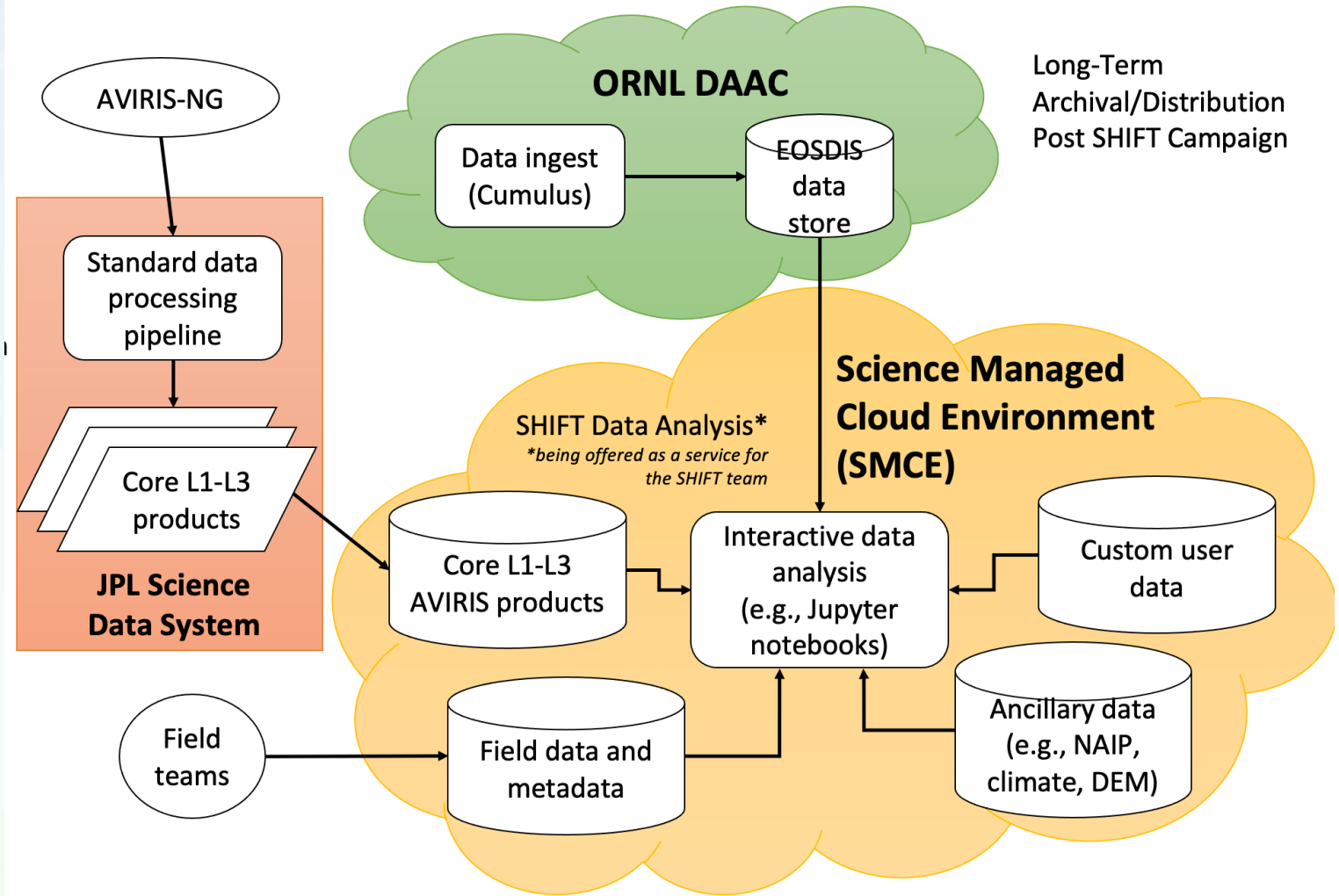
NASA ARC: Weile Wang & Jennifer Dun

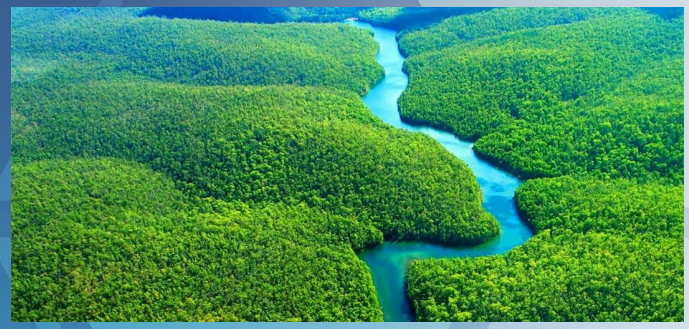
https://data.nas.nasa.gov/aghsd/



MEET-SBG: Modeling End-to-End Traceability in support of SBG

- **Science Mission Cloud Environment (SMCE)** to support SHIFT





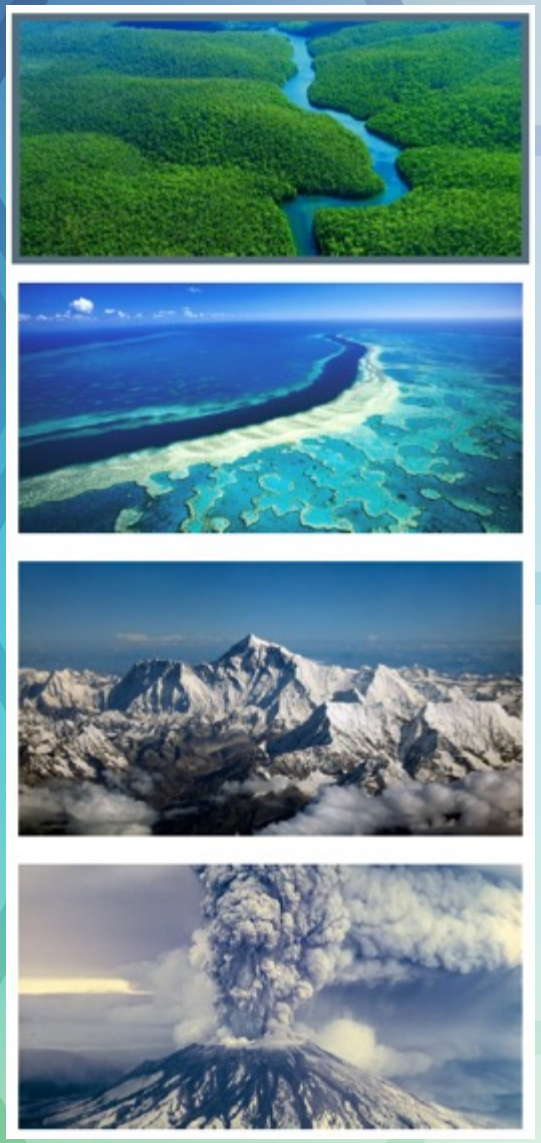
Field Campaign WG

- Goals: support mission concept development by scoping and executing SBG-led field campaigns and coordinating with other relevant field activities
- SBG High Frequency Timeseries
- Tracking/coordinating with ABoVE, BioSCape, SnowEX, HyTES Europe, ARCSIX, NEON AOP, CarbonMapper, etc
- Scoping potential campaigns to address/support:
  - Algorithm development/testing
  - Applications Early Adopters
  - Cal/Val prototyping and cross-calibration
  - Issues of scale
  - Synergies with other ESO missions

SHIFT: SBG HIgh-Frequency Timeseries

- Collect the first openly-available airborne VSWIR spectral imagery dense time series at an approximately weekly cadence over a period of significant phenological change.
- Enable the NASA SBG team to conduct traceability analyses related to science value of revisit without relying on multispectral proxies.
- Enable testing algorithms for consistent performance over seasonal time scales, and testing end-to-end workflows including community distribution.
- Provide early adoption test cases to SHIFT application users, and incubate relationships with basic and applied science partners at the UC Santa Barbara Sedgwick Reserve and The Nature Conservancy.

SHIFT: SBG HIgh-Frequency Time series



SBG Opportunities for Involvement

- In-person SBG community workshop in 2022 (Oct 12-14, DC area)
- Internship programs at JPL and other NASA centers:
  - Dave Schimel (dschimel@jpl.nasa.gov)
  - Ben Poulter (Benjamin.poulter@nasa.gov)
- SBG working groups: ongoing, regular meetings and seminars
  - Algorithms (kcawseni@jpl.nasa.gov)
  - Modeling (benjamin.poulter@nasa.gov)
  - Calibration/Validation (kturpie@umbc.edu)
  - Applications (christine.m.lee@jpl.nasa.gov
  - SHIFT (katherine.d.chadwick@jpl.nasa.gov)
- Email us (seriously we want to hear from you): sbg@jpl.nasa.gov
- Join the conversation at the SBG Community Slack