Surface Biology Geology Designated Observable

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Charts from 8th Community Webinar
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SBG Project Team

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

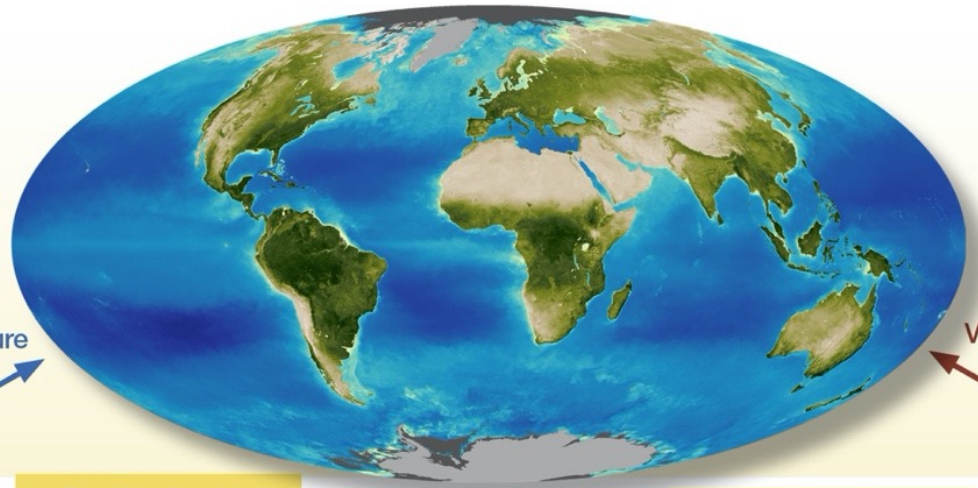
Measurement Needs

Surface Processes

DS Science Questions

W-3. How does the surface affect exchanges?

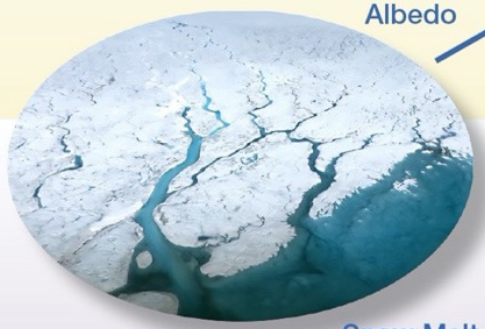
- Albedo
- Light absorbing impurities
- Snow Grain size
- Land surface temperature
- Eavapotranspiration
- Water quality



- 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

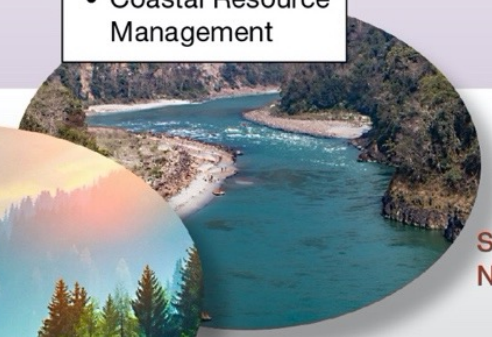
Water Use

- 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: MOST AND VERY IMPORTANT RESEARCH AND APPLICATIONS OBJECTIVES ACROSS ALL FIVE DS FOCUS AREAS

HYDROLOGY

H-1. How is the water cycle changing?

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.

H-4. Hazards, extremes, and sea level rise. How does the water cycle interact with other Earth system processes to change the predictability and impacts of hazardous events.

WEATHER

W-3. How do special variations in surface characteristics (influencing ocean and atmospheric dynamics, thermal inertia and water) modify transfer between domains?

ECOSYSTEMS AND NATURAL RESOURCES

E-1. What are the structure, function, and biodiversity of Earth's ecosystems, and how and why are they changing in time and space?

E-2. What are the fluxes of carbon, water, nutrients, and energy between ecosystems and the atmosphere, the ocean, and the solid Earth, and how and why are they changing?

E-3. Fluxes within ecosystems. What are the within ecosystems, and how and why are they changing?

CLIMATE

C-3. How large are the variations in the global carbon cycle and what are the associated climate and ecosystem impacts?

SOLID EARTH

S-1. How can large-scale geological hazards be accurately forecast in a socially relevant time frame?

S-2. How do geological disasters directly impact the Earth system and society following an event?

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

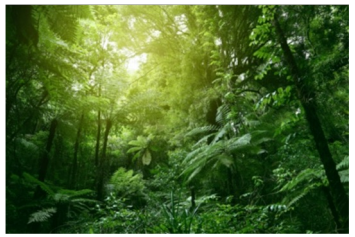
Reduce the impacts of drought, such as crop loss and famine, on global scales

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

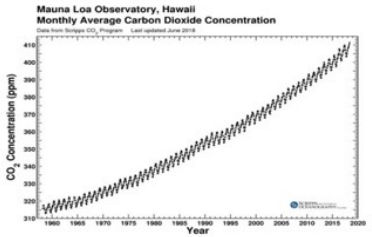
Mineral mapping for exploration efforts and reduction of environmental hazards

Forecast aviation hazards and support emergency response for volcanic eruptions

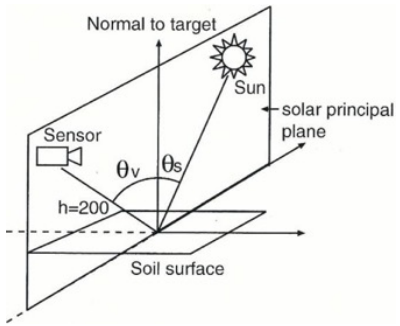
Landslide risk assessment with improved substrate map land cover maps

SBG: KEY RESEARCH AND APPLICATIONS REQUIREMENTS

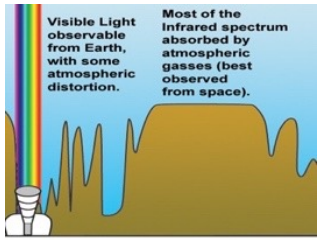
COVERAGE: The system must provide **global coverage** to address the global scope of the science including the coastal ocean and inland waters.



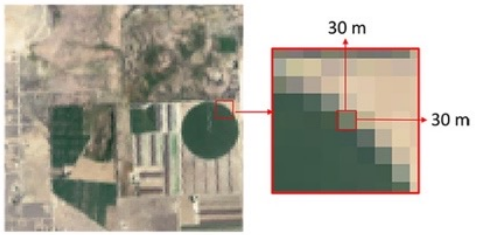
STABILITY AND DURATION: Measurements must be able to detect **long term changes** for addressing dynamics of the Earth System.



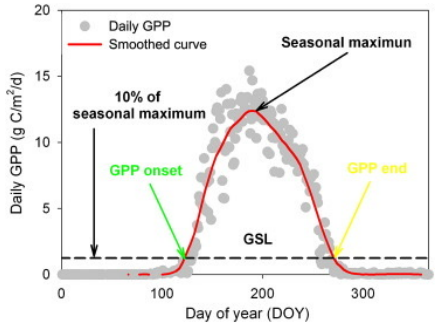
GEOMETRY: The system's orbit must allow for **consistent sun-sensor geometry** for consistency in retrievals and for calibration and validation, and provide for global coverage, as above (polar orbit).



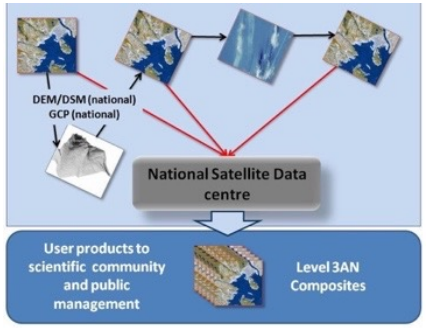
RANGE, RESOLUTION AND SENSITIVITY: Visible to Shortwave Infrared **(VSWIR; 400-2500 nm)** imaging spectroscopy and multi-spectral thermal infrared **(TIR; 4 - 12 μm)** measurements to observe "diversity" in ecosystem function. Radiometric performance driven by aquatic targets.



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

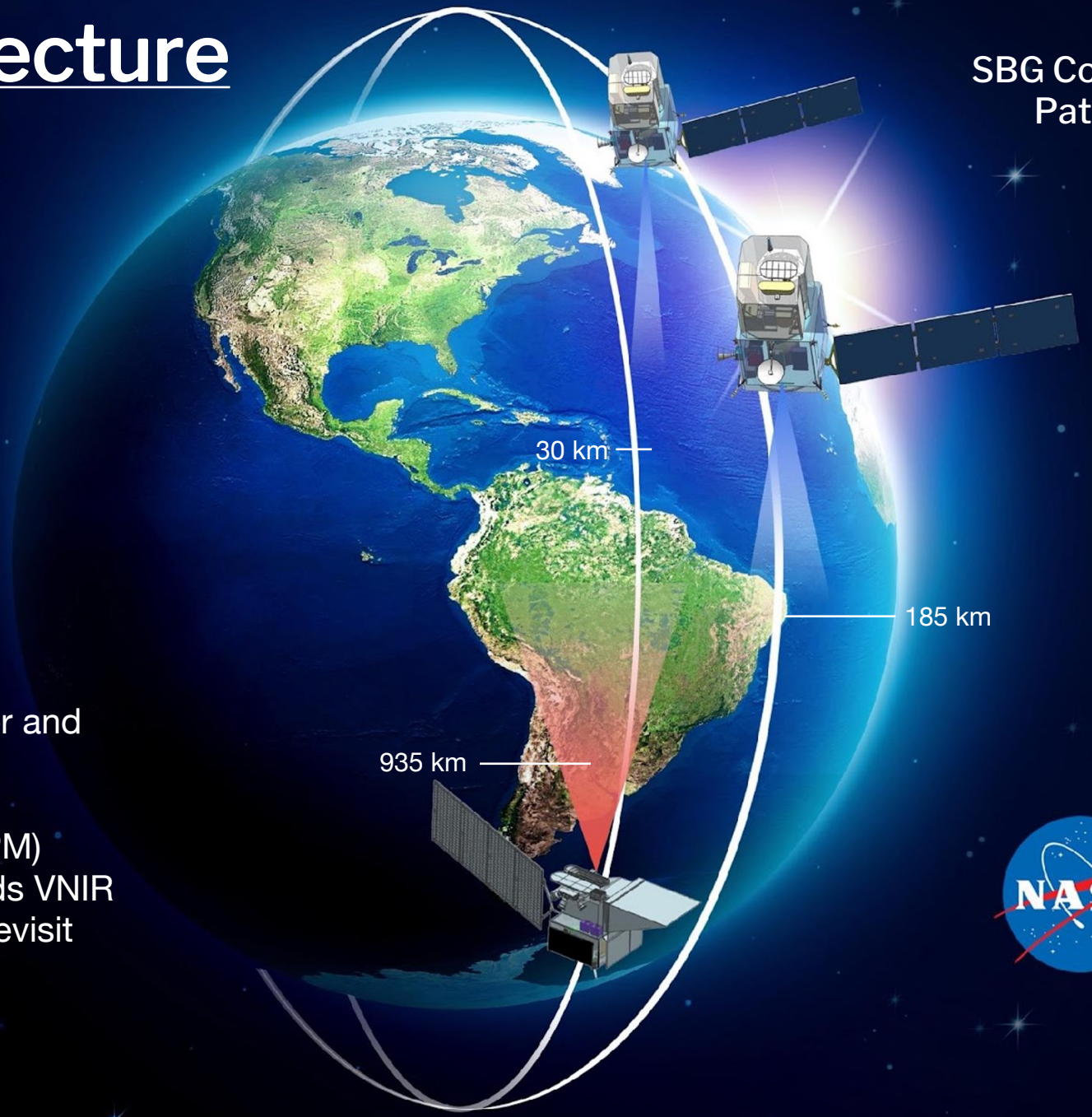


REVISIT: The SBG observing system temporal resolution must be adequate to capture **synoptic and seasonal variation** as well as observe **rapid or transient changes** related to Earth system events such as fires, landslides, volcanic activity and anthropogenic incidents.



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

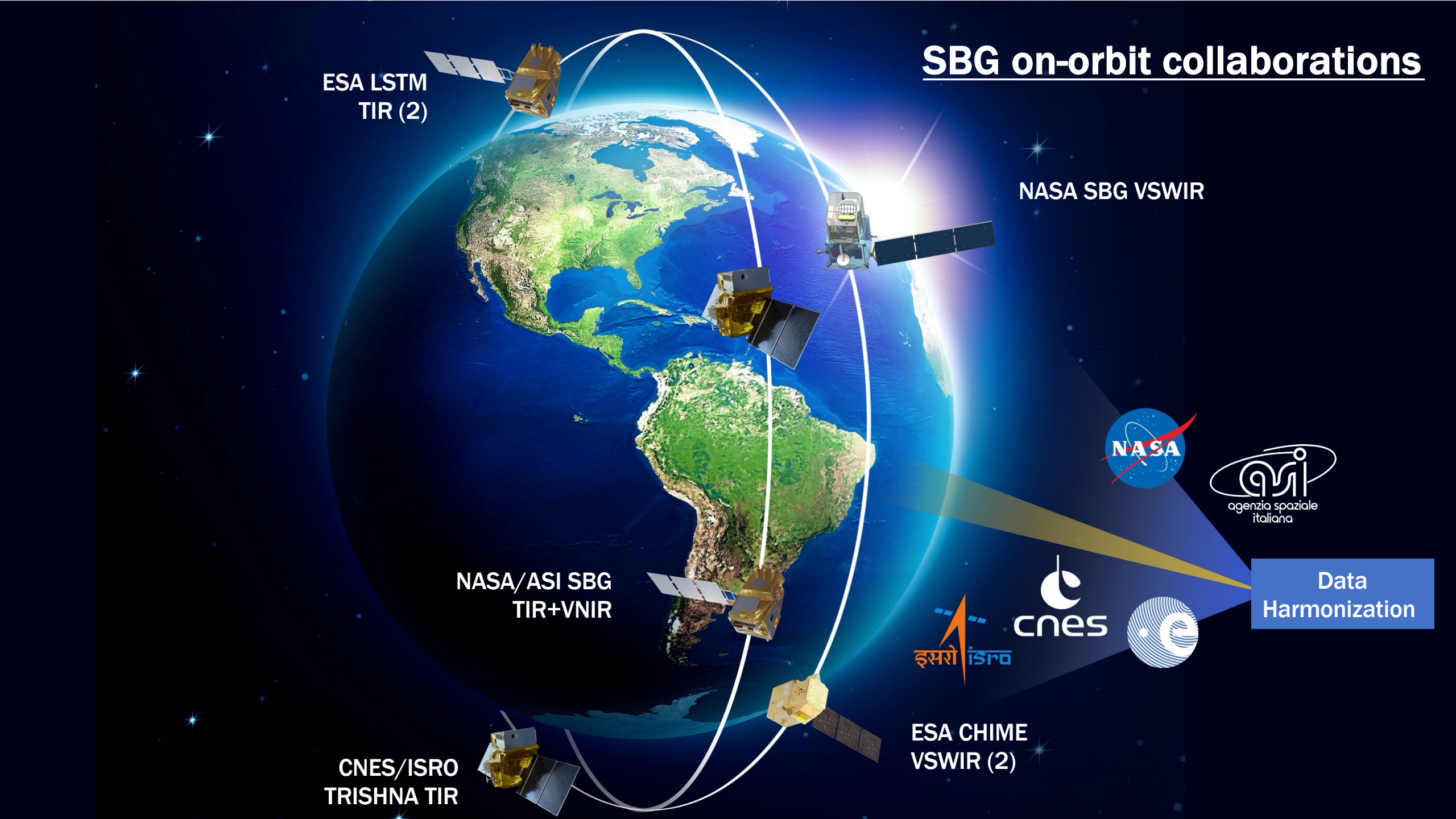
Sun-sync orbit (late AM)
185 km swath
16 day revisit
10 nm, 200+ bands
30 meter GSD
High SNR and radiometric performance
~5 deg off-nadir tilt

SBG Heat

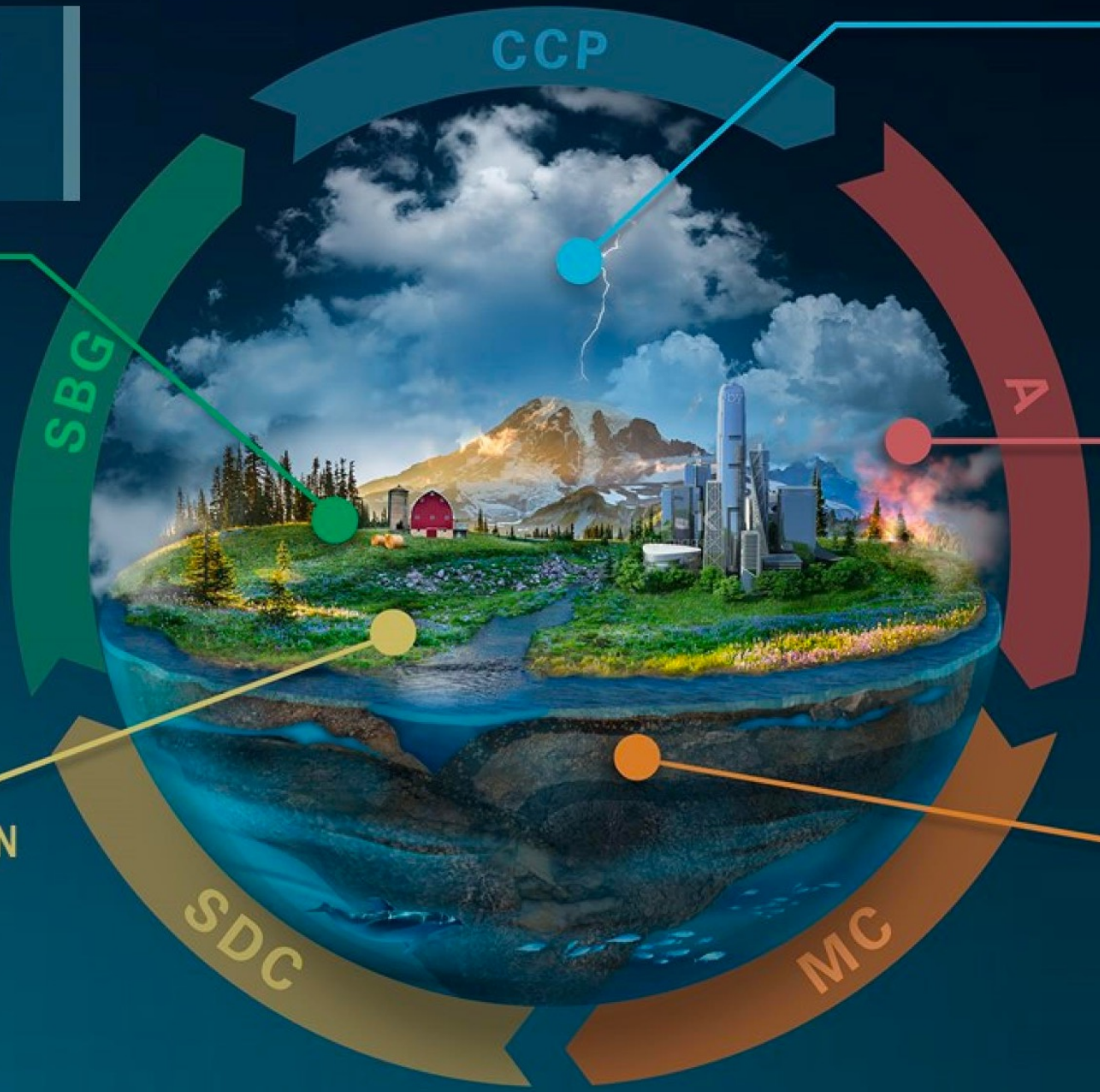
Wide-swath TIR imager and ASI VNIR camera

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

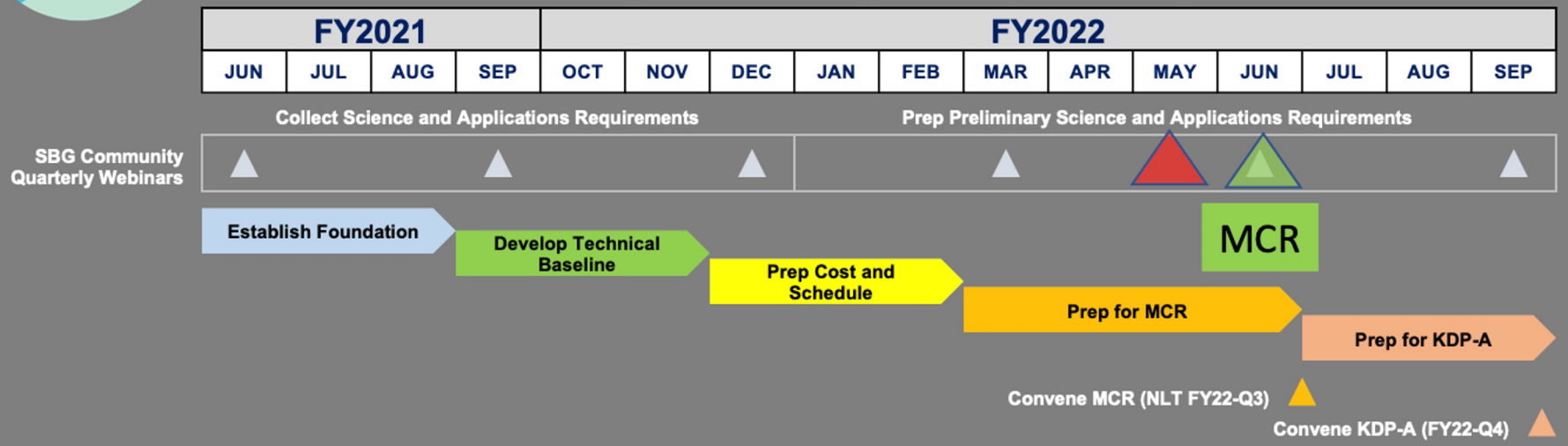
SURFACE DEFORMATION AND CHANGE

Earth Surface Dynamics

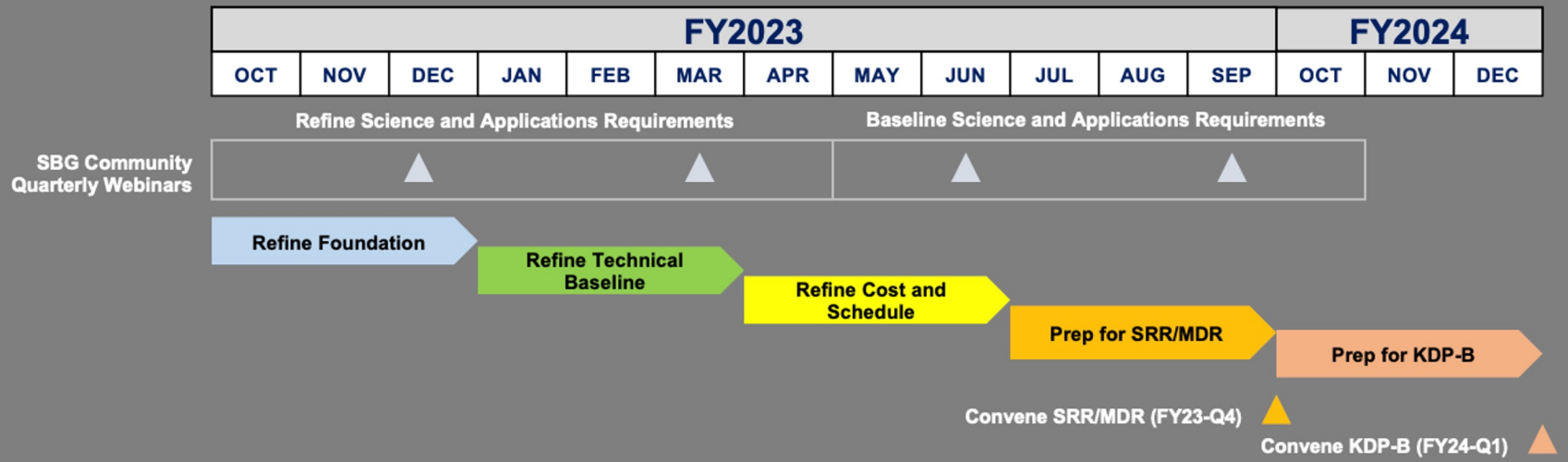
Credit: nasa.gov

Surface Biology and Geology (SBG)

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

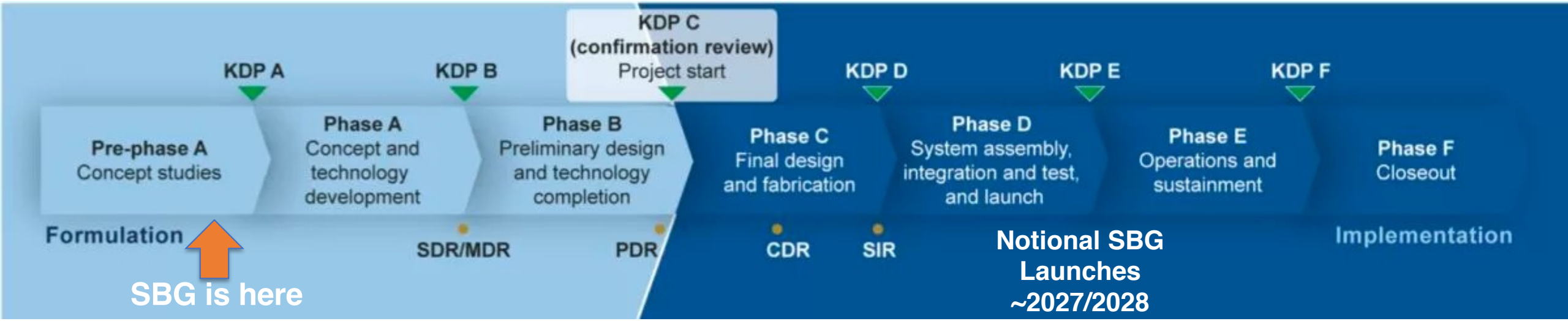


Phase A (Concept Study Phase) Schedule - Notional



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

NASA Project Lifecycle



SBG Applications 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

SBG Applications

Team: Jeff Luvall (MSFC), Christine Lee (JPL), Stephanie Schollaert Uz (GSFC), Nancy Glenn (BSU), Karen Yuen (JPL) and 200+ community members

- Community Assessment Report
- RTI User Needs and Valuation studies
- SBG/GLEON fellowship applications open
- SBG Applications Working Group – next meeting March 24

To join the SBG Apps group, visit http://tinyurl.com/SBGApplicationsWG

Google Public Drive
https://tinyurl.com/SBGApplicationsWGPublicDrive

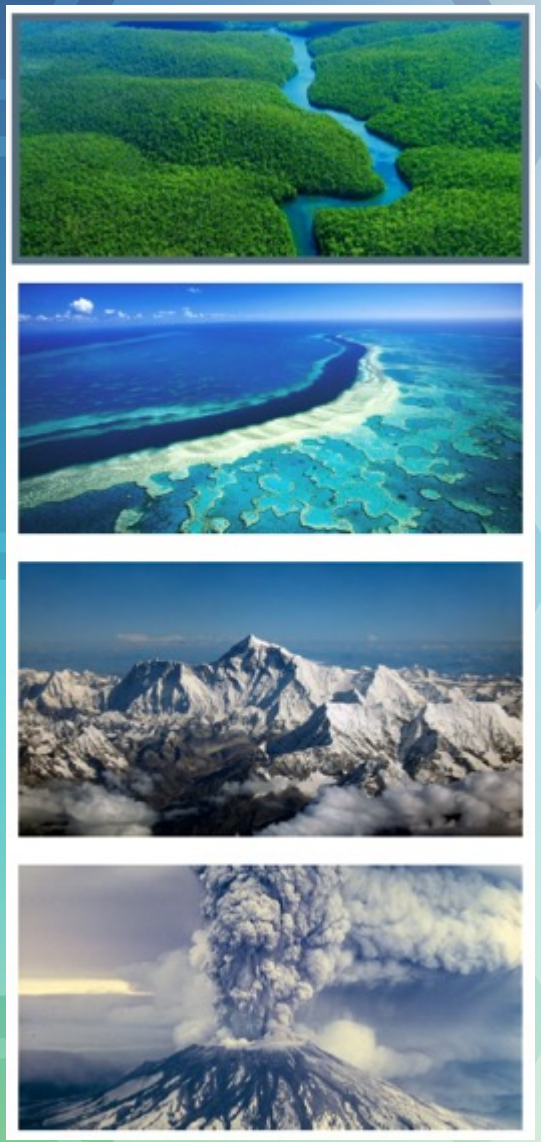
SBG Applications – Summary of Contributions to Architecture

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.

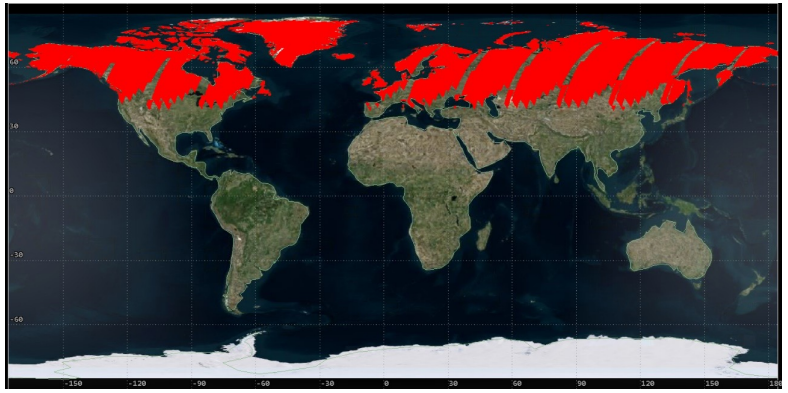
Key Application Driver: The addition of a 4 um channel to support the high temperature characterization of fires and volcanoes



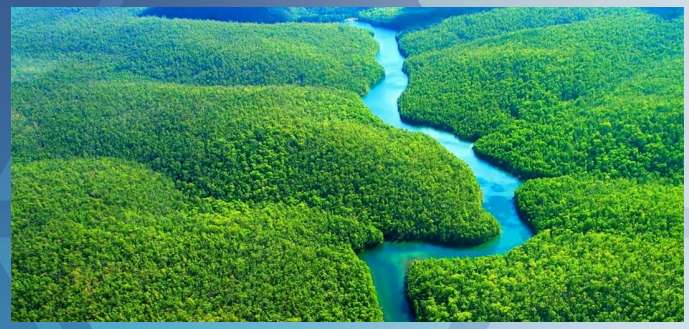
Cal/Val Working Group

- 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.



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)

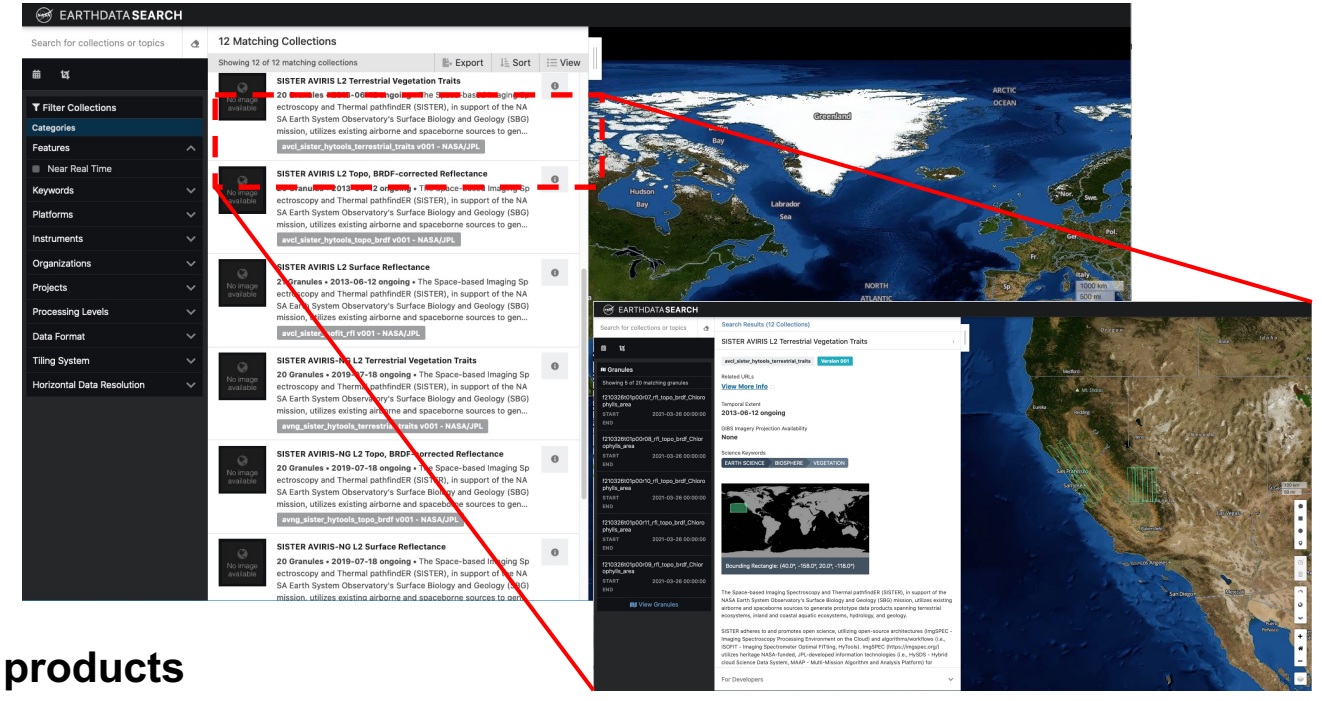
Adapt workflows based on emerging SBG ATBDs

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+*

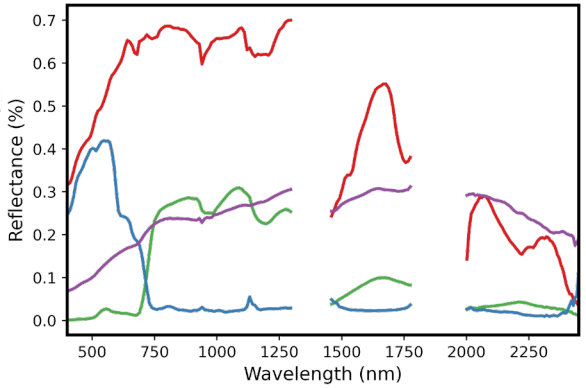


ORNL and LP.DAAC will be the official DAACs for SISTER products

SISTER: Prototyping SBG Algorithms using PRISMA and DESIS

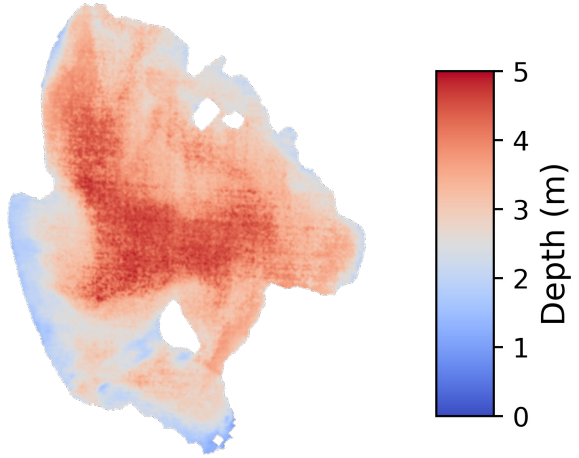
ISOFIT (Thompson et al. 2018)

PRISMA



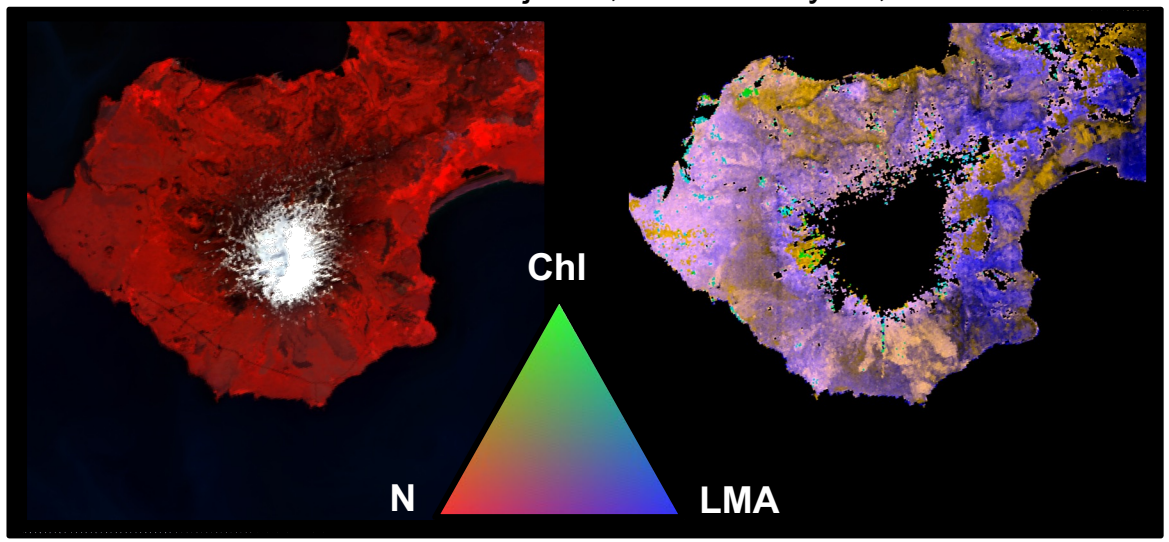
Bathymetry (Thompson et al. 2016)

DESIS Lago Trasimeno, Italy June 04, 2021



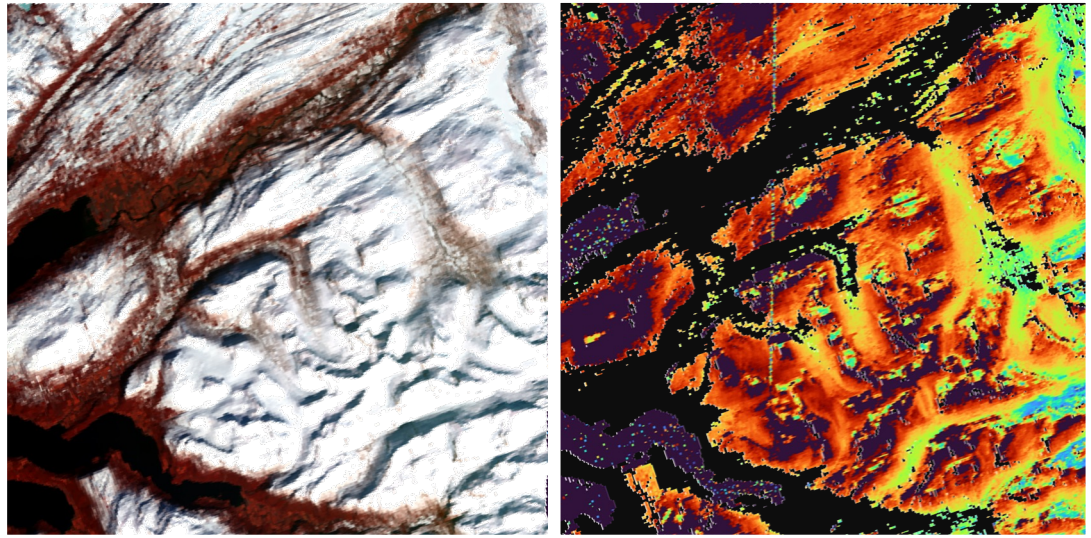
Vegetation Biochemistry

PRISMA Snæfellsjökull, Iceland July 02, 2020



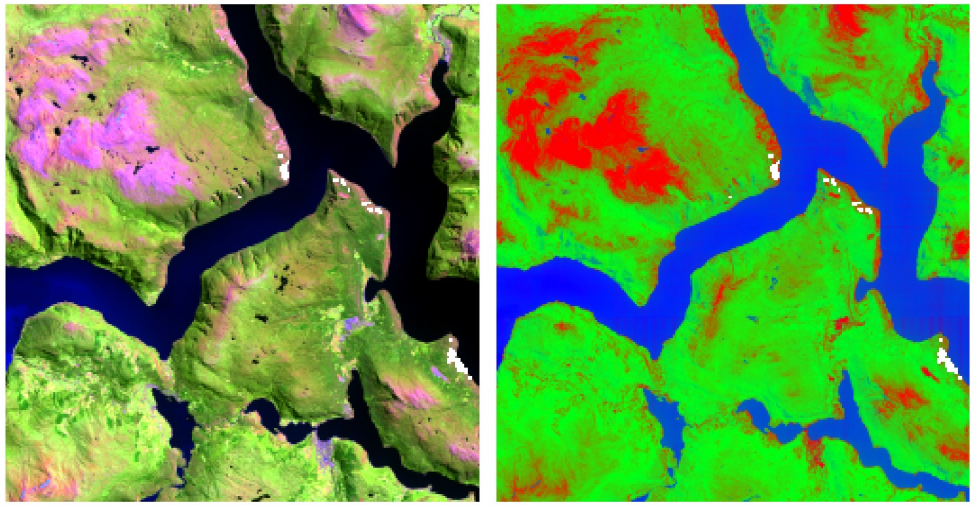
Snow grain size (Nolin and Dozier 2000)

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

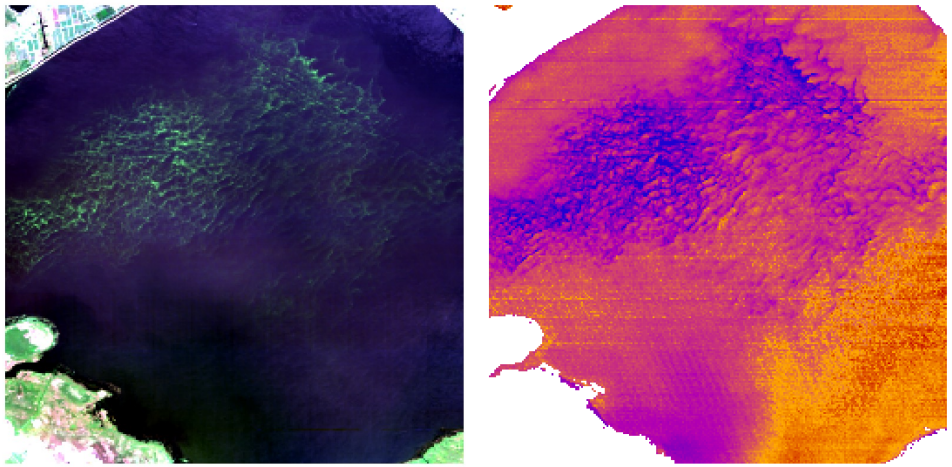


Soil

Vegetation

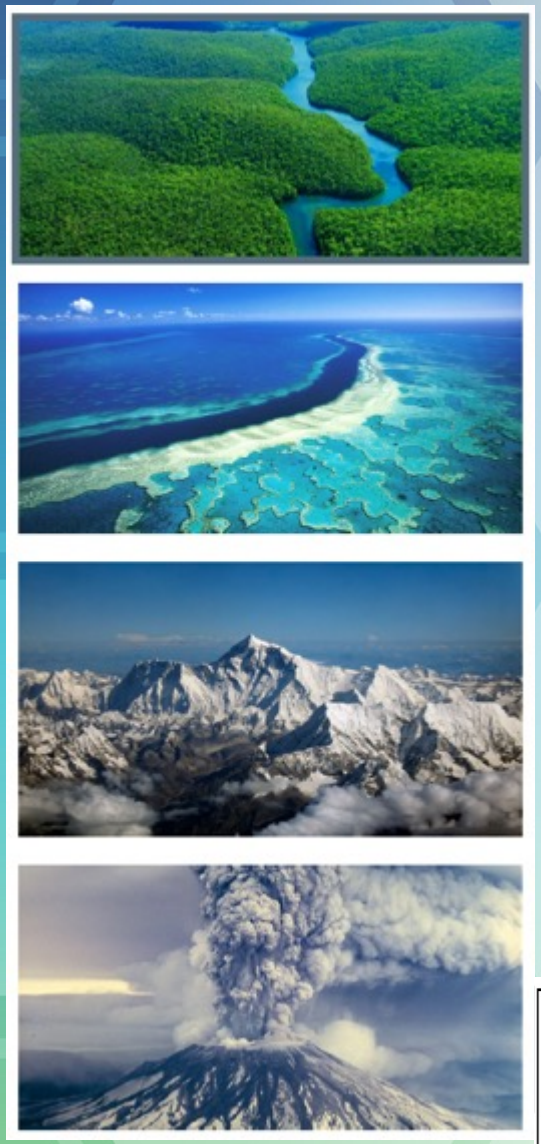
Water

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



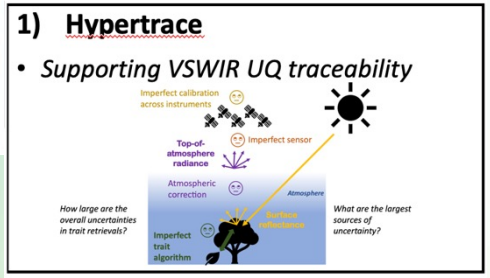
High

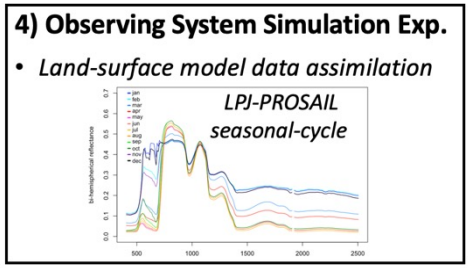
Low

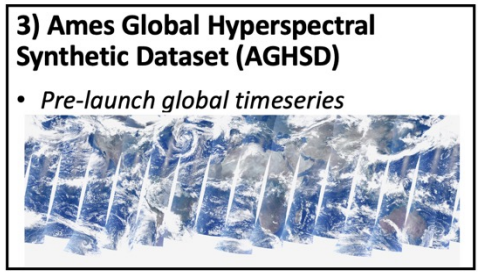


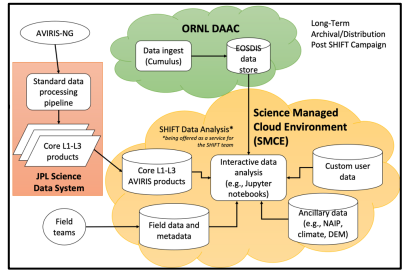
MEET-SBG: Modeling End-to-End Traceability in support of SBG

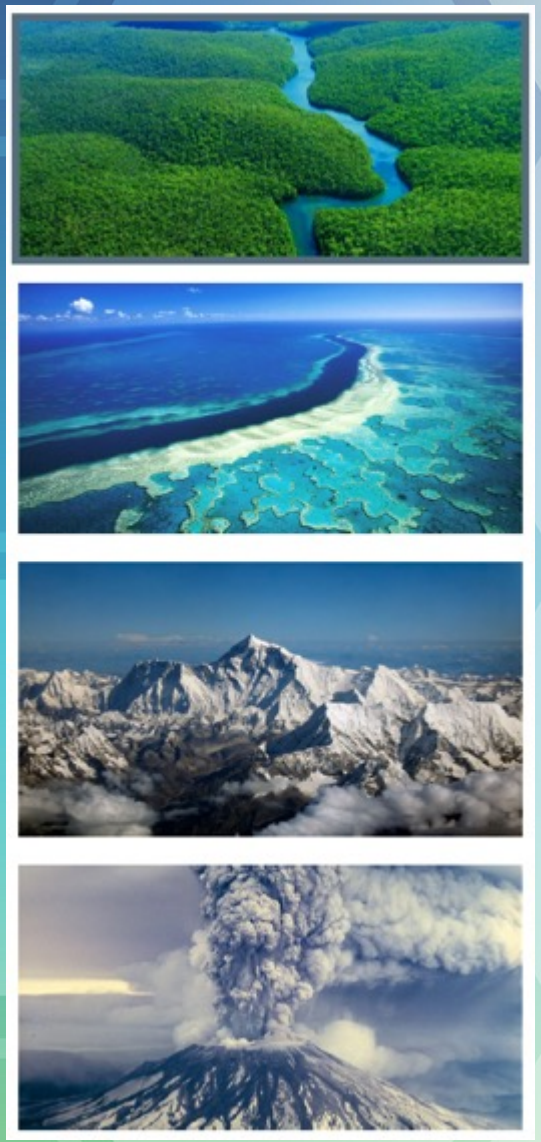
1. Science Value Trades Study
   - Terrestrial algorithm performance and glint avoidance
2. Observing system simulation experiment
3. Synthetic data generation
4. Science data system synergies with SISTER and SHIFT





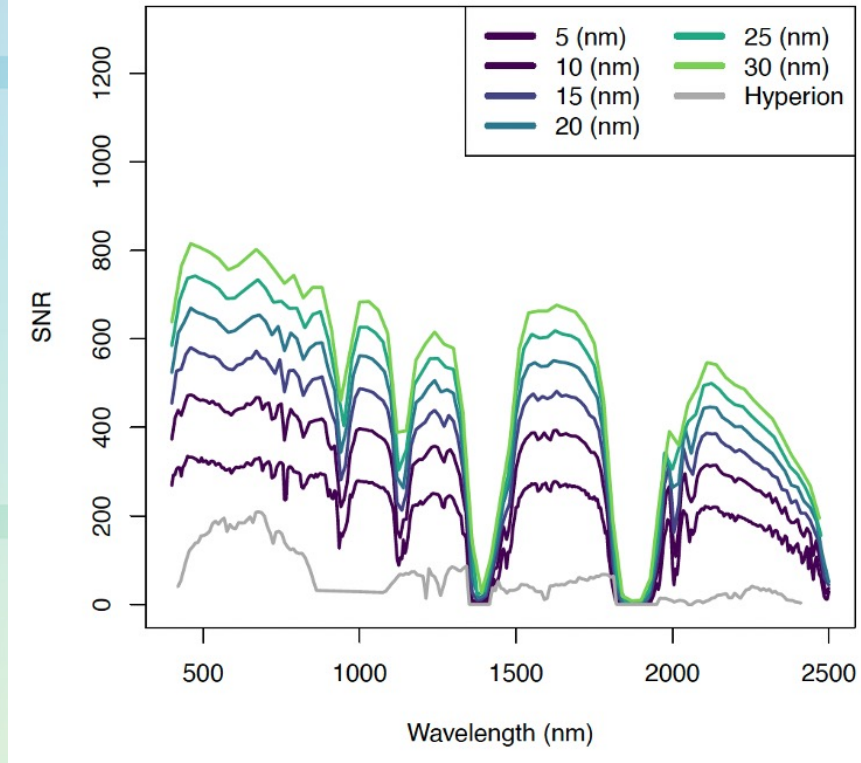


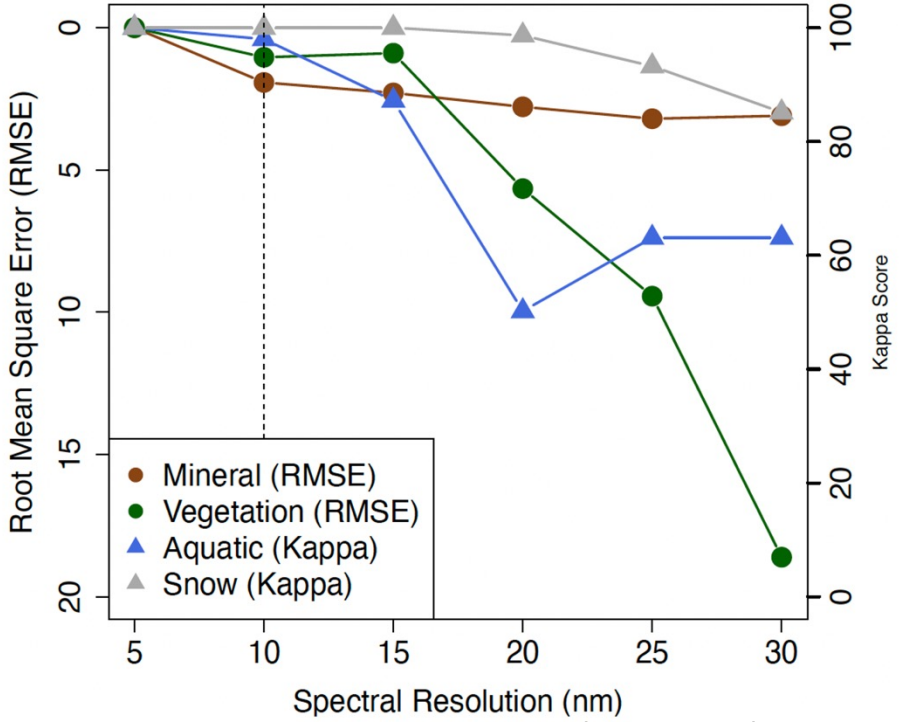




MEET-SBG: Modeling End-to-End Traceability in support of SBG

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

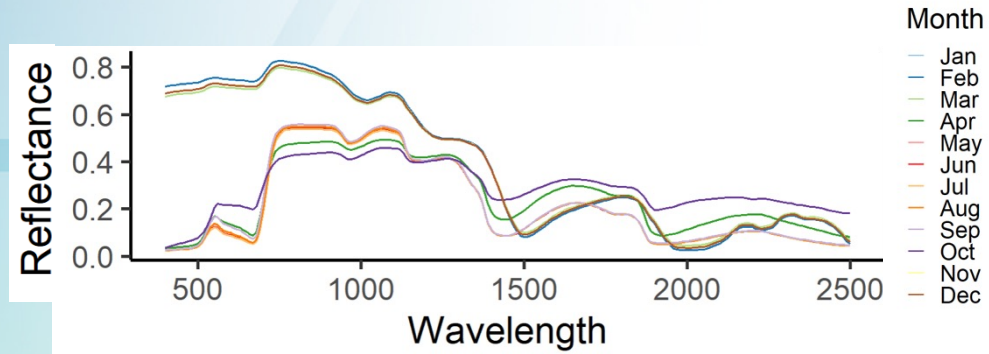


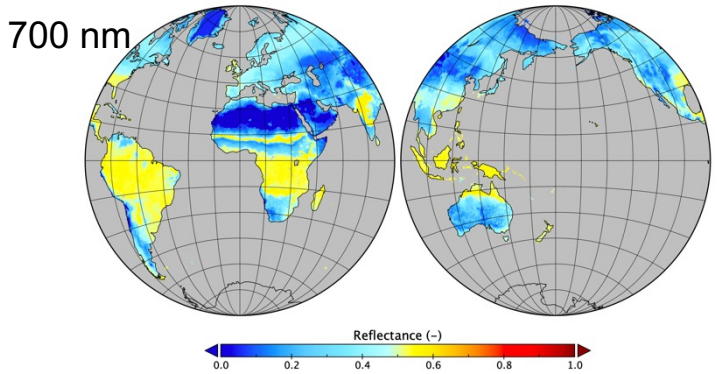


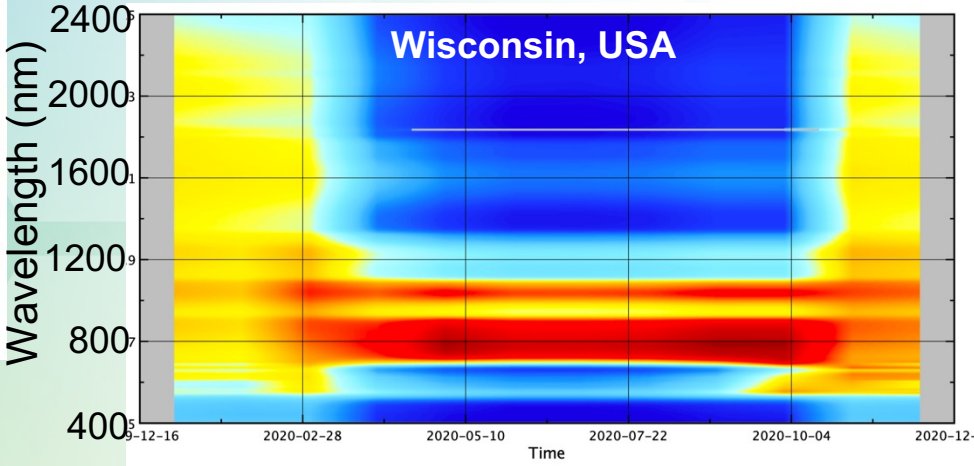
Raiho (submitted)
Cawse-Nicholson (in prep)

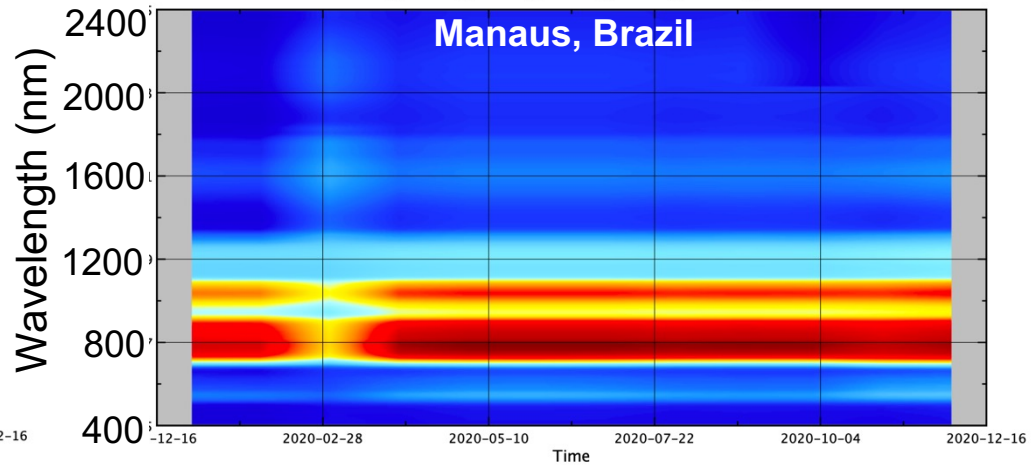
MEET-SBG: Modeling End-to-End Traceability in support of SBG

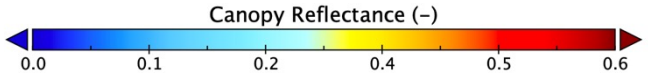
- **Observing system simulation experiment**: LPJ-Prosail
  - Spectra simulated each day for entire global land surface







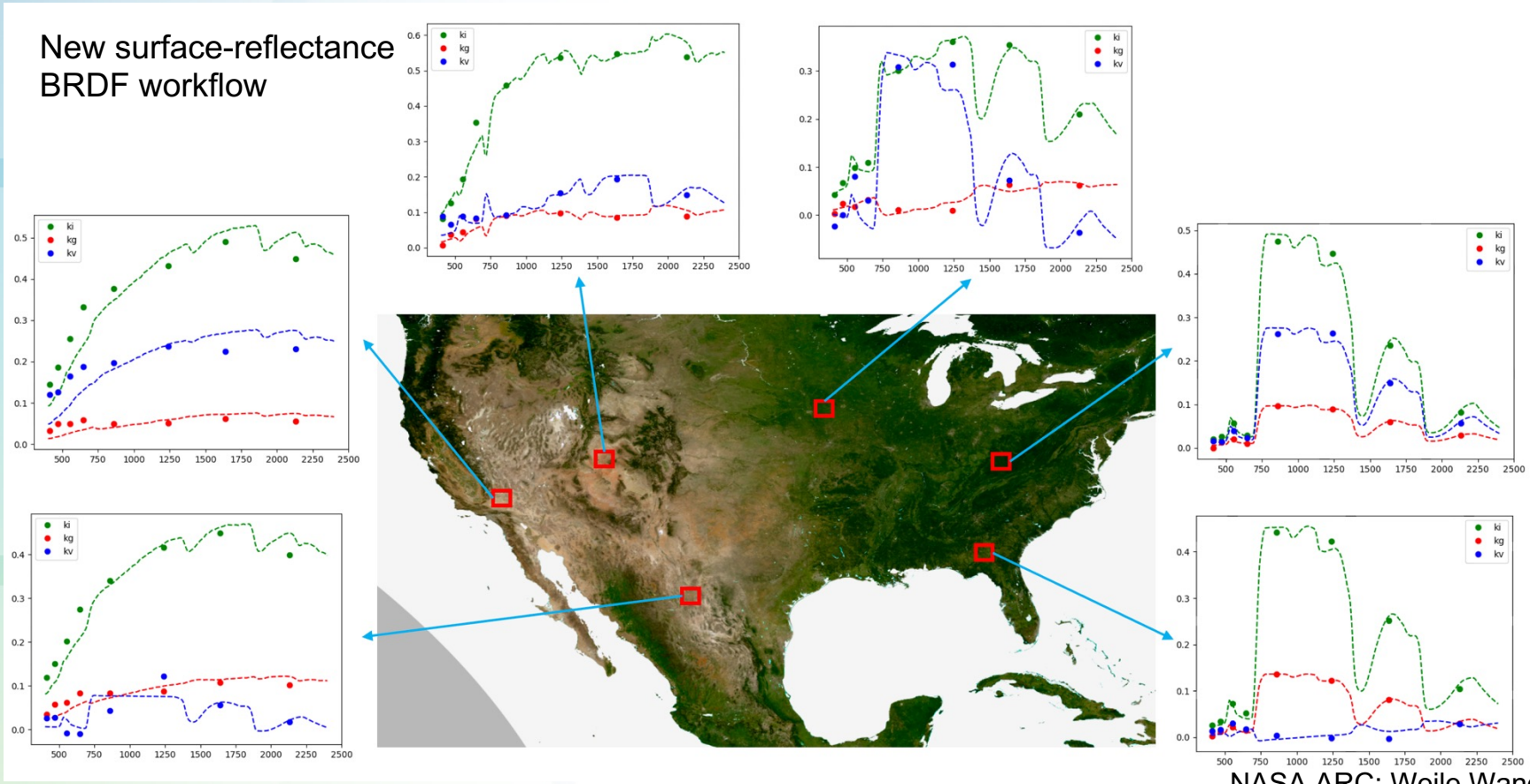




MEET-SBG: Modeling End-to-End Traceability in support of SBG

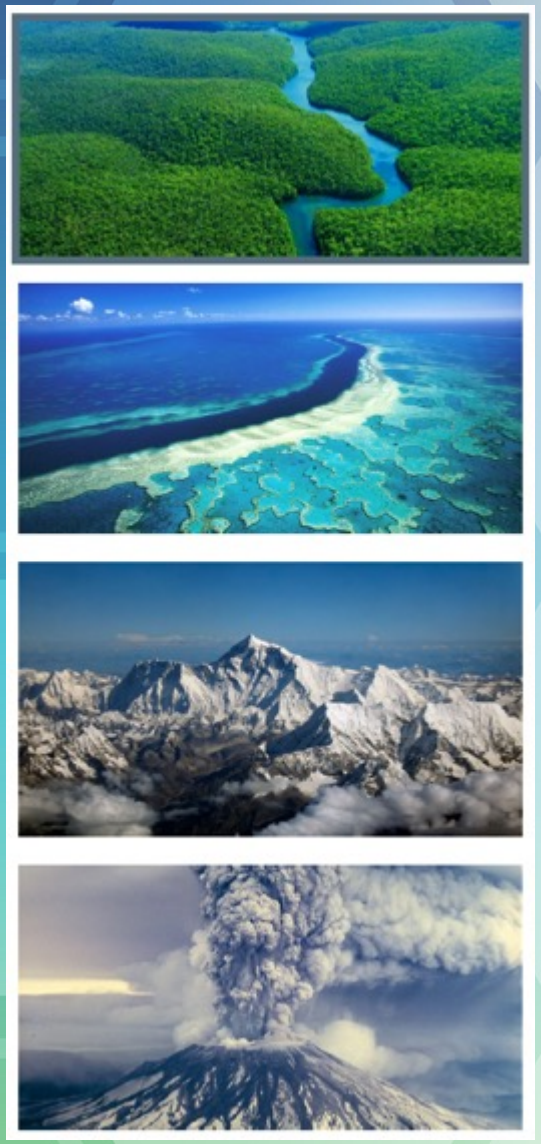
- **Synthetic data generation**: Ames Global Hyperspectral Synthetic Dataset (AGHSD) version 2: Surface Reflectance

New surface-reflectance BRDF workflow



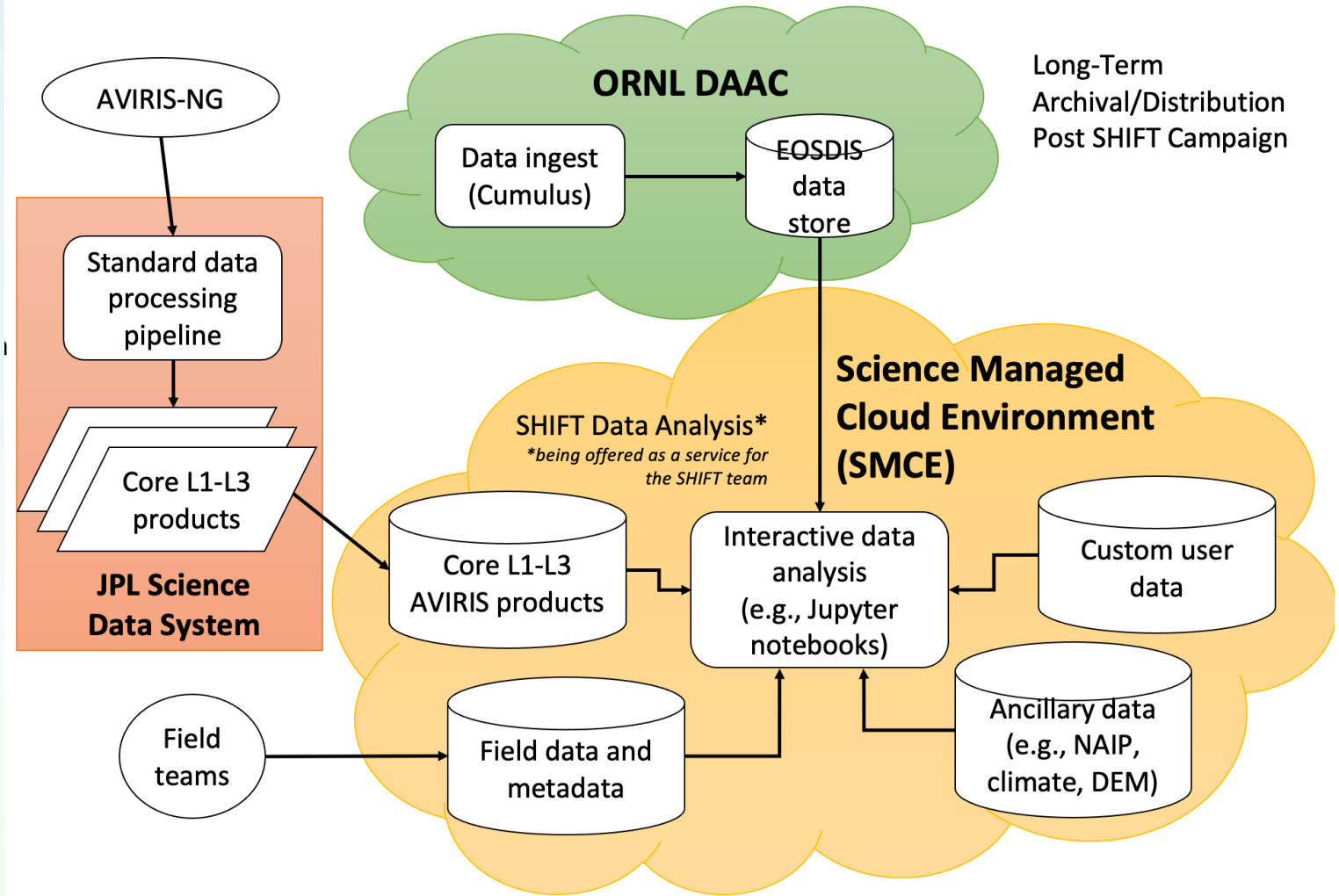
NASA ARC: Weile Wang & Jennifer Dun

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



ACIX-III Atmospheric Correction Intercomparison Exercise

ACIX-III is the third Atmospheric Correction Intercomparison Exercise, and includes comparison activities for land and water. ACIX-III is specifically focused on hyperspectral imagery, and intercomparisons of methods will employ data from PRISMA. This is an important activity moving forward for understanding differences among approaches that may be used by forthcoming spaceborne missions. This website provides details on participation in ACIX-III:

https://earth.esa.int/eogateway/events/1st-workshop-of-acix-iii-land-aqua-and-cmix-ii

Important information: There will be a workshop of ACIX-III (and CMIX-II, focused on cloud masking on 20-21 June 2022 at ESA/ESRIN in Frascati, Italy.Participation in ACIX and CMIX activities are open to all scientists who:

1 are the original developers of the atmospheric correction and/or cloud-masking processor to be inter-compared,

2 are authorized by the original developer to run the AC/CM processor on his/her behalf,

3 agree on submitting the AC/CM processing results within the required constraints (deadline, format, etc.).



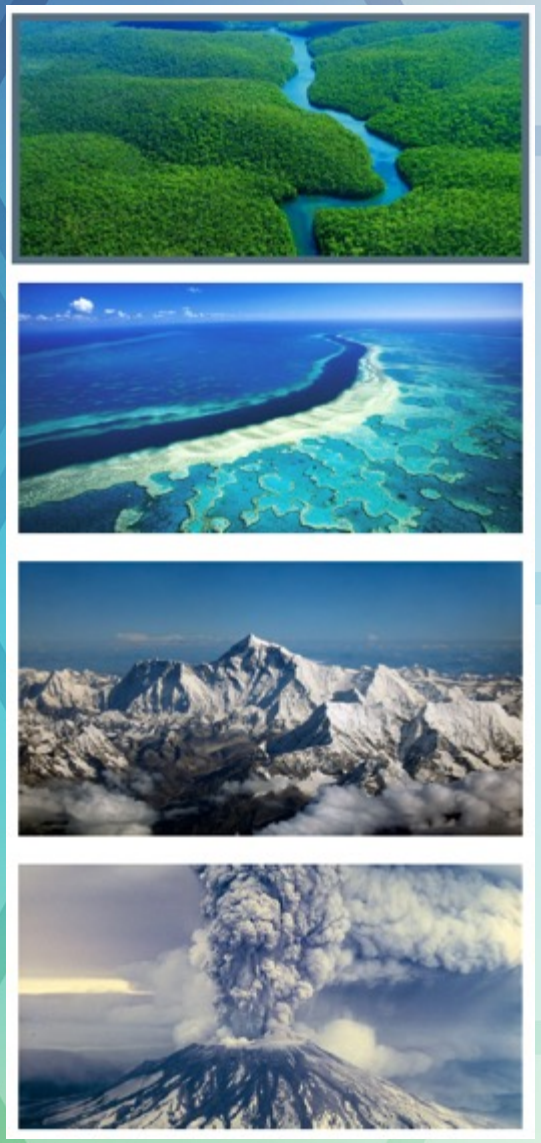

Field Campaign WG

- Co-leads: Ryan Pavlick, Dana Chadwick
- 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