



Surface Biology and Geology

# **SBG Research and Applications (R&A) Traceability: Decadal Survey to PLRA L1 Requirements**

D. Schimel and the SBG R&A Team



# Key Messages

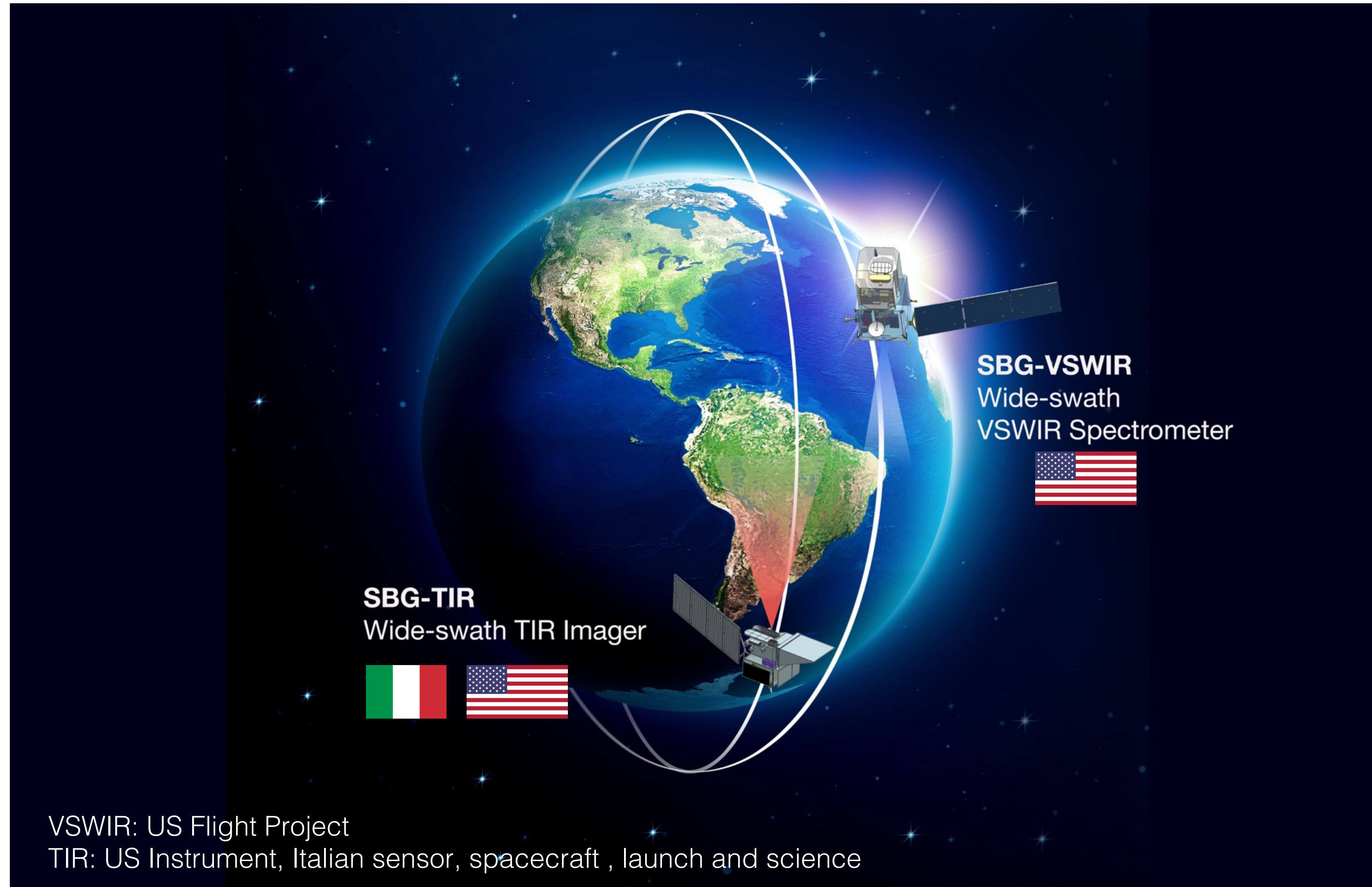
- 1. SBG will meet Decadal Survey and Earth2Action priority objectives and enable transformative science and applications.**
- 2. SBG is on track with mission design, science algorithms and workflow, calibration and validation plans and international collaboration. SBG benefited from substantial investment to mature algorithms and science prior to Phase A.**
- 3. The SBG mission as envisioned succeeds when both TIR and VSWIR launch as soon as possible and operate together as long as possible**

**SBG enables discovery in science areas critical for environmental management while also providing critical products for immediate use**





# What is the Surface Biology and Geology Mission?



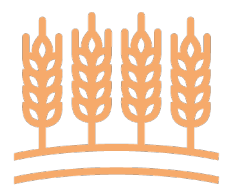




# Decadal survey questions and associated applications



H-1. How is the water cycle changing?  
(3 observables)\*



Global Food  
Security

E-1. What are the structure, function, and  
biodiversity of Earth's ecosystems?  
(7 observables)



Conservation  
and Biodiversity

S-1. How can large-scale geological  
hazards be accurately forecast?  
(5 observables)

H-2. How do anthropogenic changes in  
climate, land use, water use, and water  
storage, interact and modify the water  
and energy cycles?  
(4 observables)



Agriculture and Water  
Resources

E-2. What are the fluxes between  
ecosystems and the atmosphere, the  
ocean, and the solid Earth, and how and  
why are they changing?  
(1 observable)



Conservation  
and Biodiversity

S-2. How do geological disasters directly  
impact the earth system?  
(3 observables)



Strategic Mineral  
Resource Mapping

C-3. How large are the variations in the  
global carbon cycle?  
(1 observable)



Urban Heat and Health



Fire Ecology and Risk

W-3. How do spatial variations in  
surface characteristics modify transfer  
between domains?  
(1 observable)



Fire Ecology and Risk

H-4. How does the water cycle interact  
with other Earth system processes to  
change the predictability and impacts of  
hazardous events and hazard chains  
(1 observable)



Algal Bloom and Water  
Quality Mapping

E-3. What are the fluxes (of carbon,  
water, nutrients, and energy) within  
ecosystems?  
(2 observables)



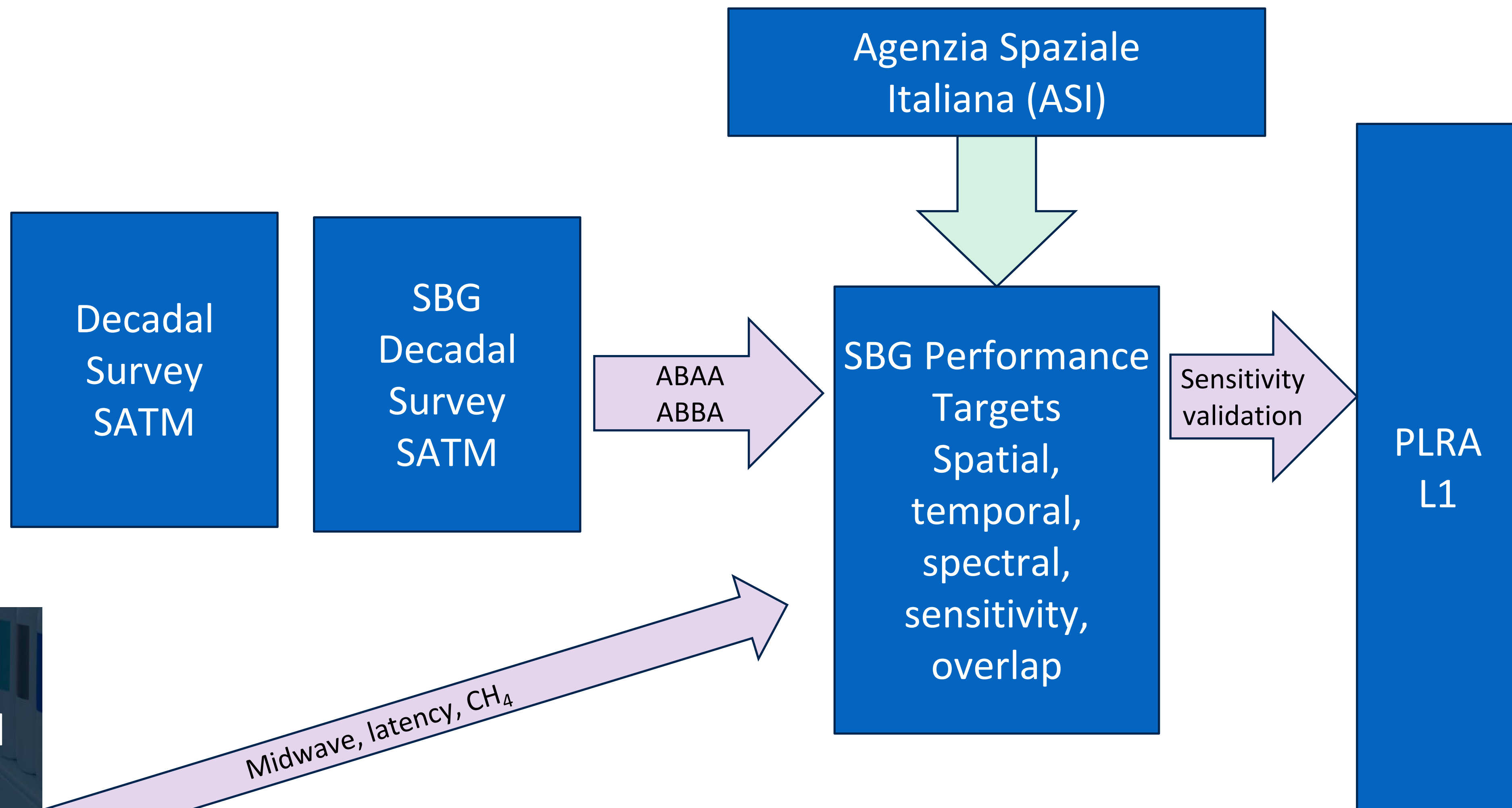
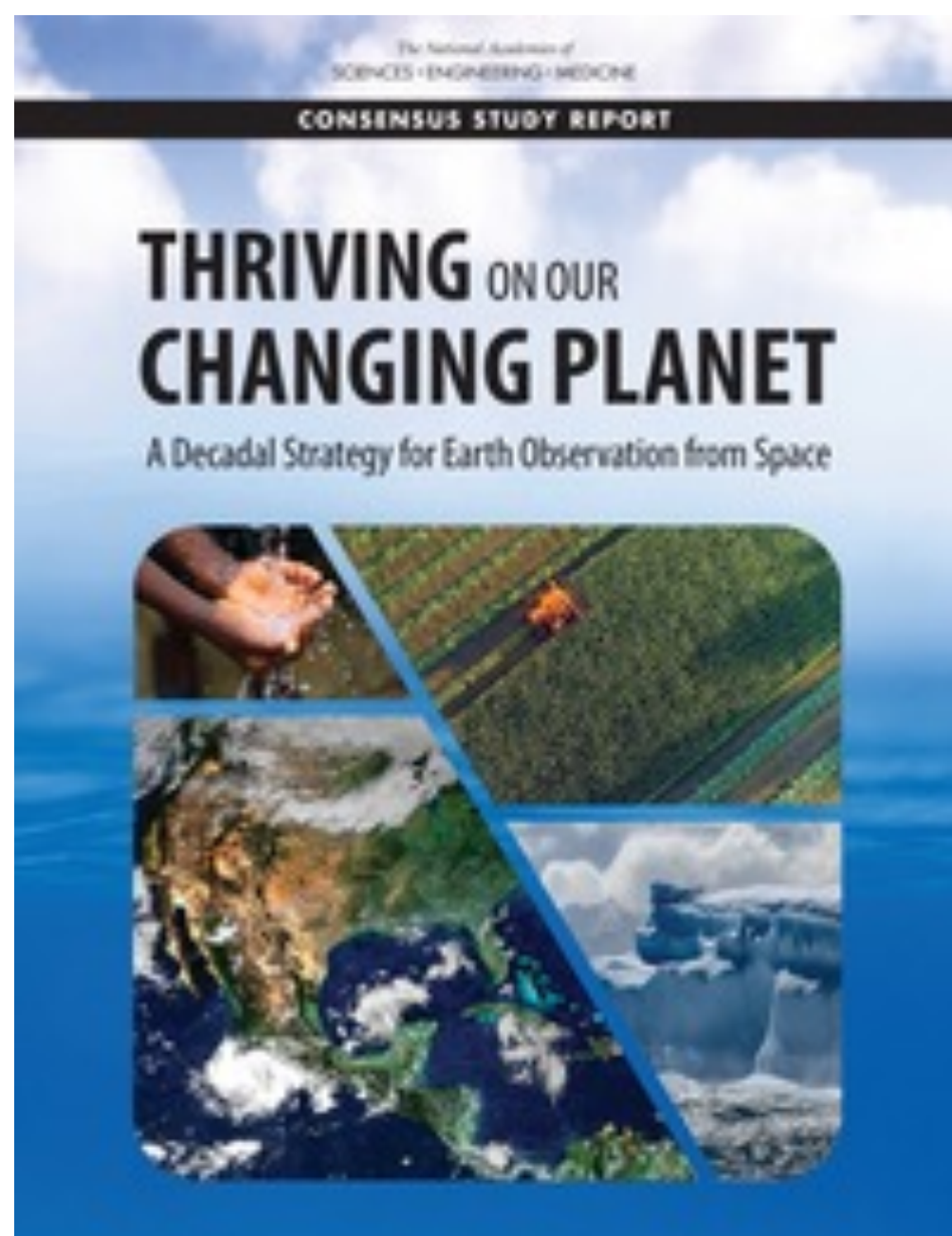
Coral Reef  
Ecosystems

\* % of objectives met is calculated at  
the individual geophysical observables  
level





# Flow of Traceability from the DS to the SBG Mission PLRA







# Source of traceability and tasks

The Decadal Survey defined a set of objectives, questions and **needed performance** (expert judgment) for five research and applications focus areas:

- The set of **performance needs** contains incompatible options (eg global coverage versus diurnal sampling). The SBG architecture study was directed to seek a solution meeting the largest number of DS needs within a cost cap, recognizing this would be a “70%” solution.
- Performance needs for each of > 30 questions and associated data product were each binned into three levels, A, B, and C from most to least demanding for spatial resolution, temporal revisit spectral resolution/channels and sensitivity (NeDT or SNR).
- We sorted the SBG SATM to find the solution that satisfied the largest number of DS questions using four parameters for each wavelength (TIR and VSWIR) plus temporal overlap as most of the questions call for products from both instruments.
- All performance targets were validated by the Mission using extant data, simulation and theory to confirm they were fit for purpose to produce the designated geophysical products.





# 7/10 Decadal Survey observables require TIR/VSWIR overlap

One year: Proof of concept

Seasonal changes in one hemisphere

Short-term monitoring. Low event sample sizes

Initial energy flux calculations

Two years: Development of products

Volcano compositional and mechanical changes

Capture entire events, both hemisphere growing seasons

Increased sample size of events

Three+ years: Earth System Science & Earth Action

Support Earth System modeling

Earth system variability/IAV

Applied science adoption





# SBG Performance Targets from Architecture Study (i.e., SBG PLRA Level 1 Requirements)

		International Data Harmonization (26/28 observables fully met)	Baseline (16/28 observables fully met)	Threshold (11/28 observables fully met)
Mission & Instrument Parameter				
VSWIR	Spatial Resolution	30 m	30 m	40 m
	Temporal Resolution	8 days*	16 days*	22 days*
	Spectral Resolution	10 nm	10 nm	20 nm
	Wavelength Range	380-2500	380-2500	400-2500
	Sensitivity (SnR)	400 (VNIR) / 250 (SWIR)	400 (VNIR) / 250 (SWIR)	300 (VNIR)/200 (SWIR)
TIR	Spatial Resolution	60 m	60 m	100 m
	Temporal Resolution	~1 day	3 days	3 days
	Spectral Range	5 Bands + MWIR	5 Bands + MWIR	4 Bands
	Sensitivity (NedT)	0.2 K	0.2 K	0.4 K





# SBG VSWIR flight project is mature

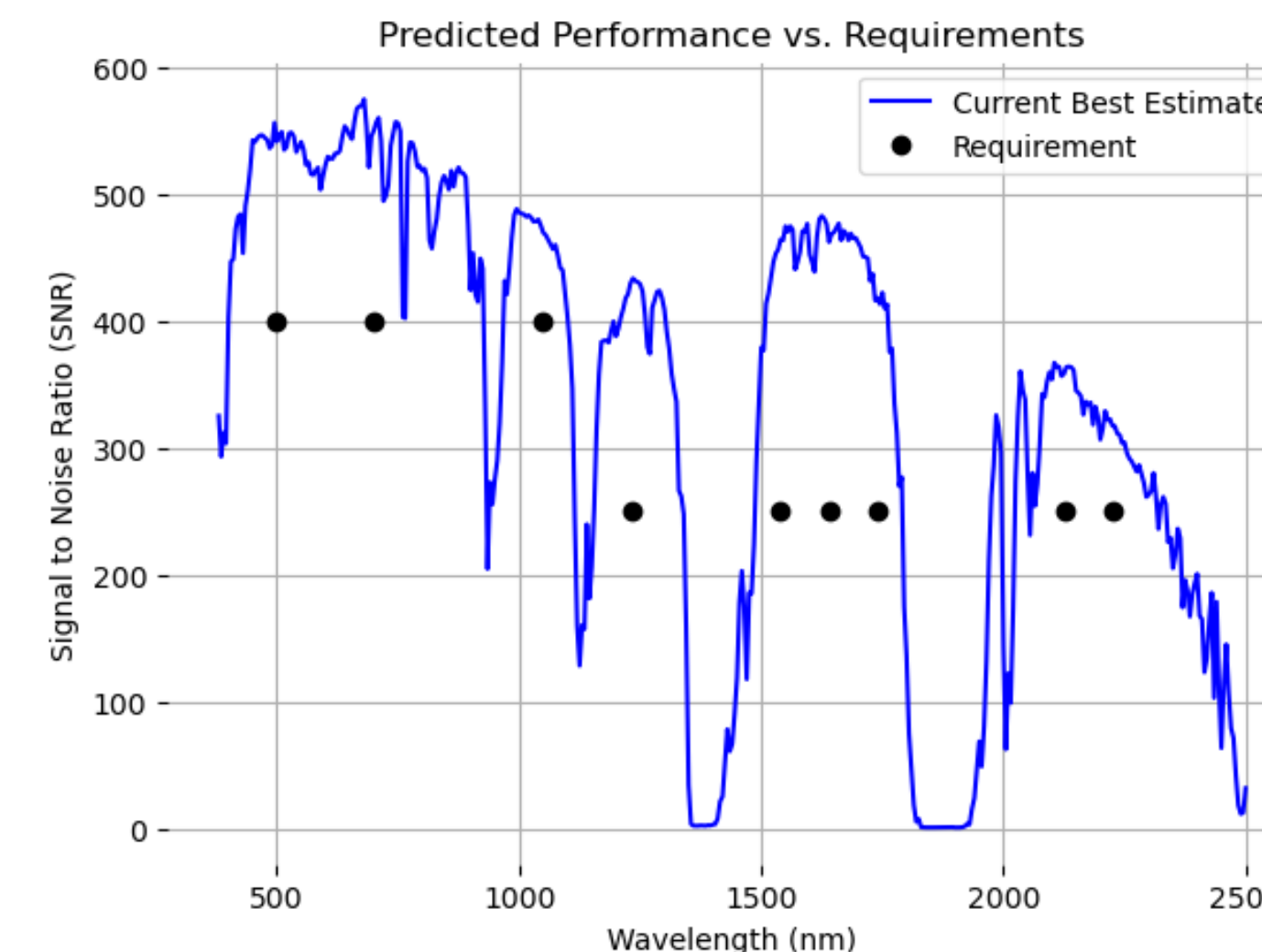
SBG-VSWIR builds from the CPM and EMIT spectrometers, meeting decadal survey performance requirements with margin.

EMIT has already achieved best-in-class uniformity and SNR performance on orbit, demonstrating data quality sufficient for SBG objectives.

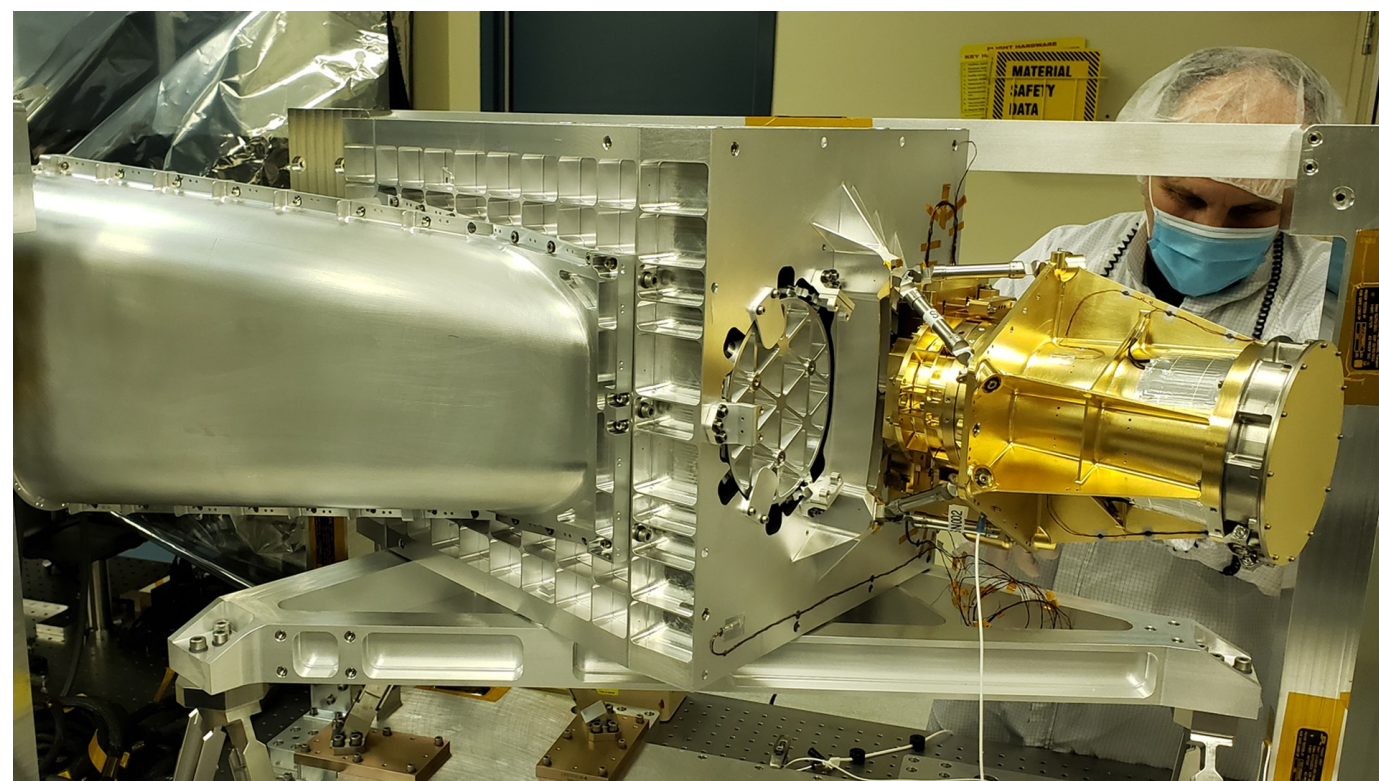
All SBG technologies are TRL 6 or better with critical components (grating, slit, detector) proven in prior missions.

The workforce is available, and resources are the only barrier to progress.

## VSWIR Modeled Performance



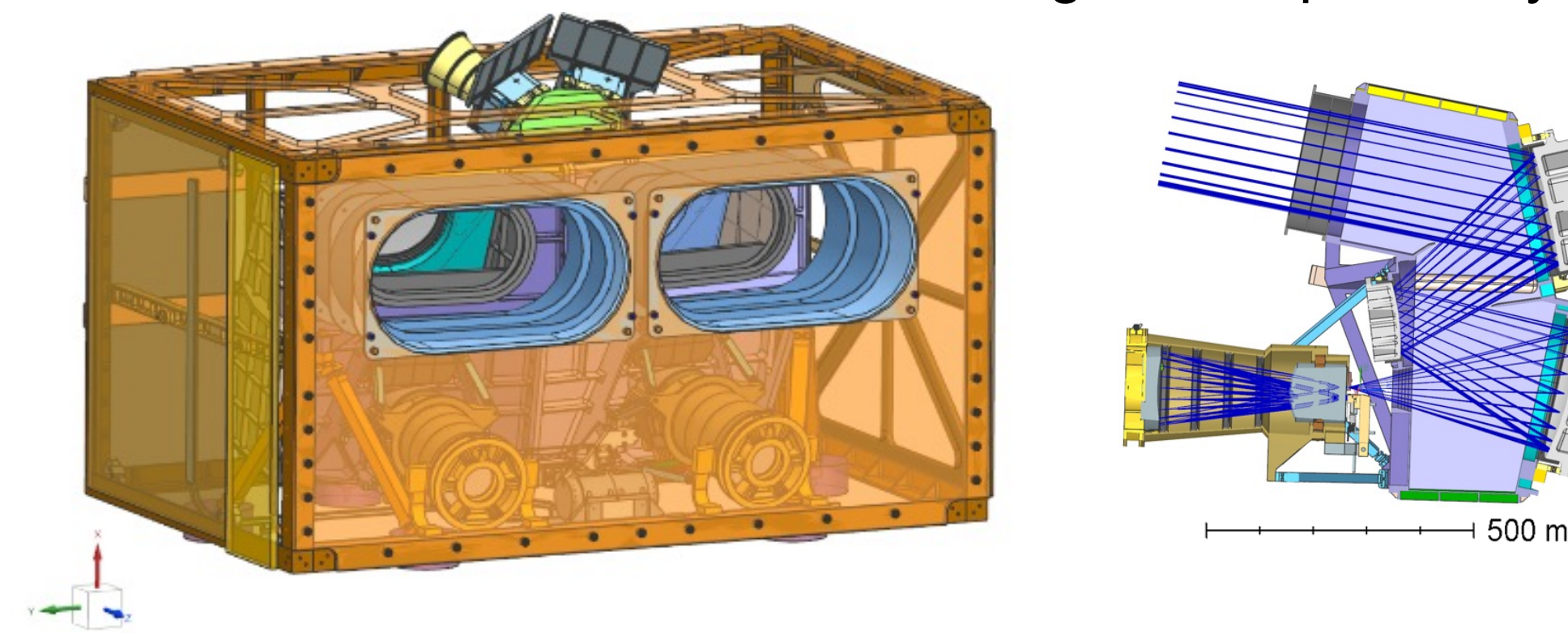
EMIT (On orbit from July 2022)



CPM (Delivered Sept. 2023)



SBG-VSWIR Notional Design and Optical Layout



**SBG-VSWIR will provide an order of magnitude better coverage making it NASA's primary instrument to enable direct greenhouse gas mitigation**



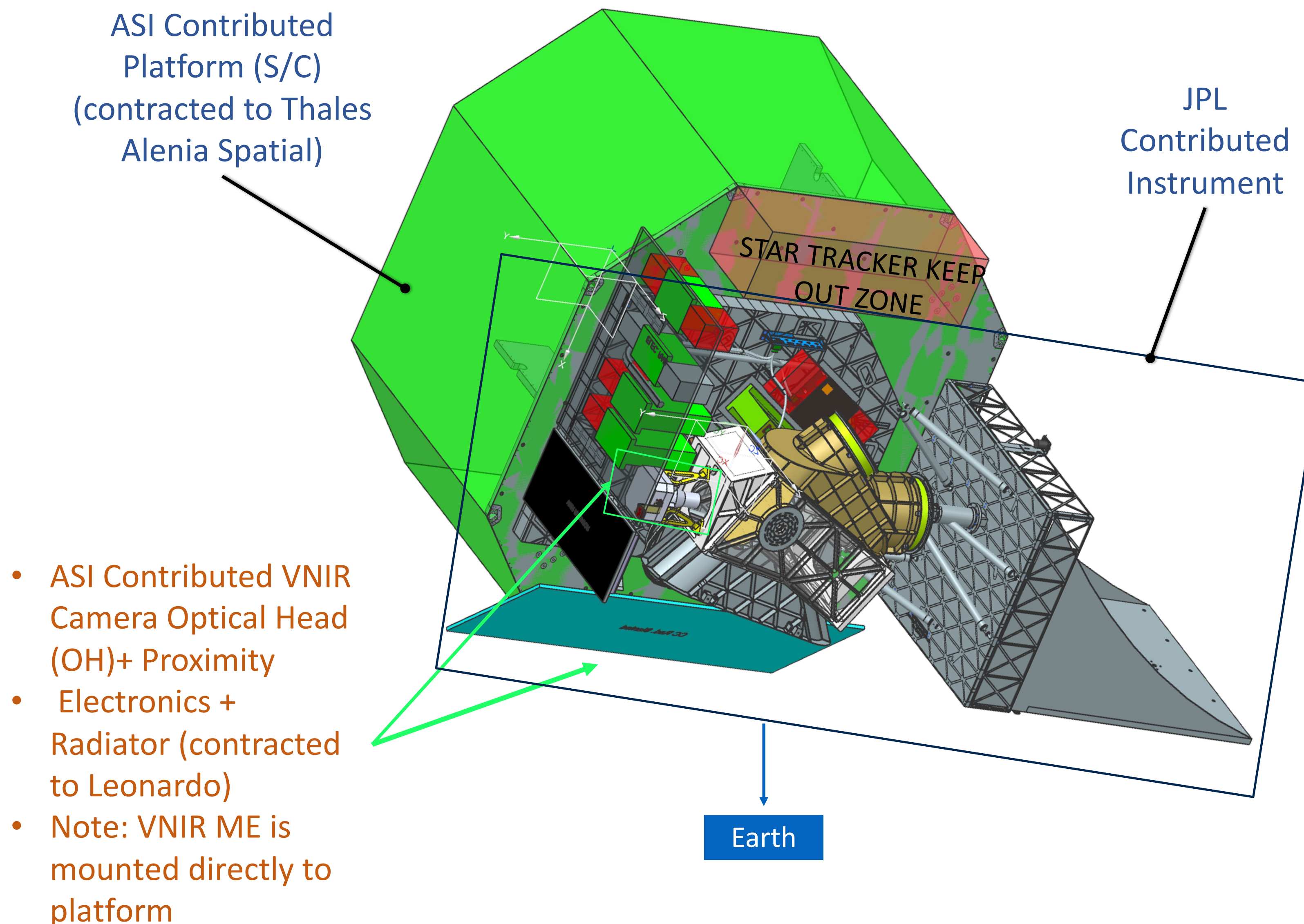


# SBG TIR instrument project is mature

The TIR Instrument builds on the ECOSTRESS success, algorithms and data workflows

ECOSTRESS provides the highest-resolution evapotranspiration product, used in breakthrough science and agricultural, water quality and urban applications

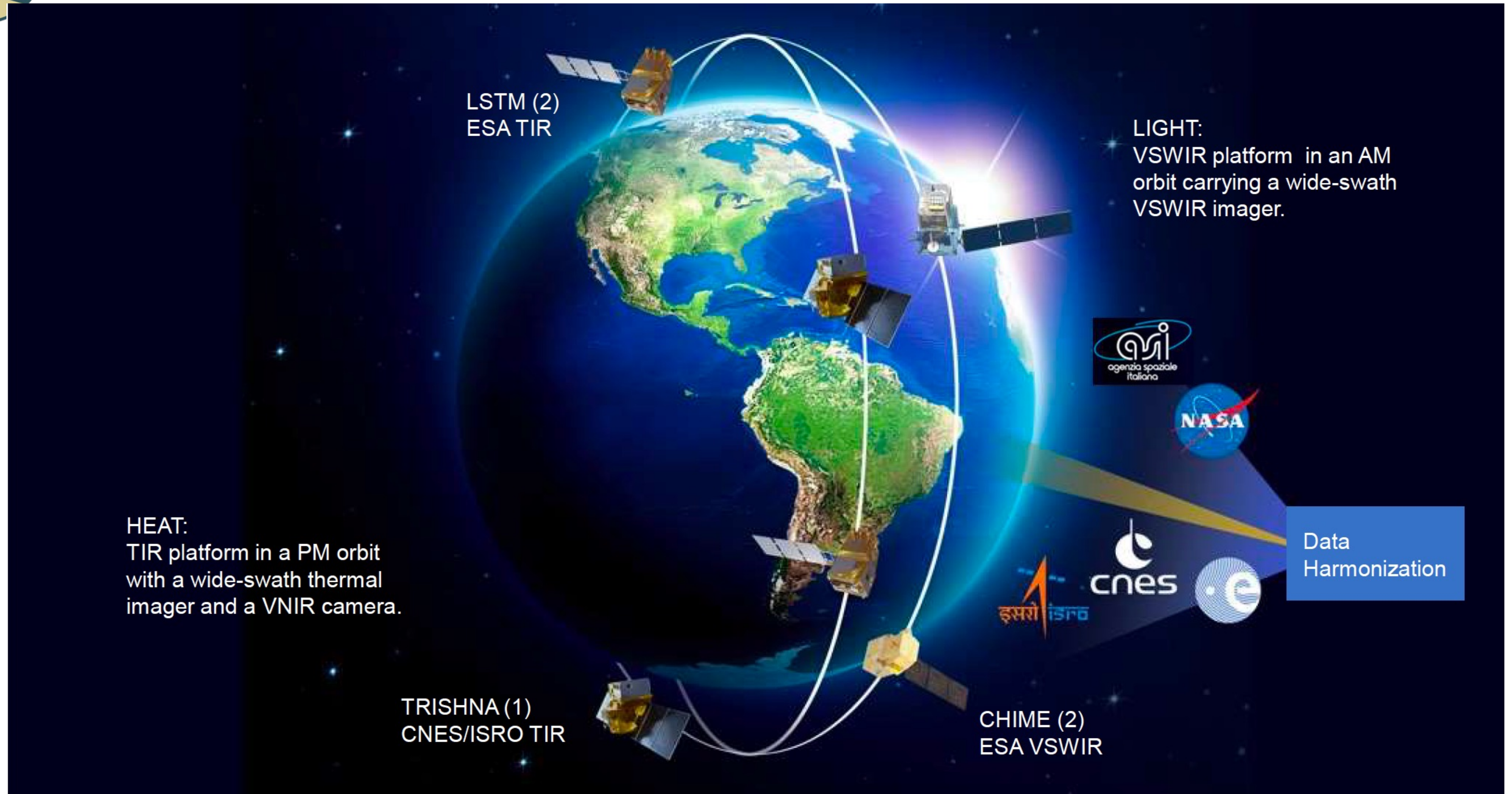
All components are TRL 6 or better. Current issues are engineering solutions to ASI spacecraft accommodation







# International Harmonization







# SBG Extends Science to Action through Applications

“Critical minerals ... are essential to our national security and economic prosperity... The U.S. is increasingly dependent on foreign sources for many of the processed versions of these minerals.”

- Executive Order 14017 on critical mineral and material supply chains

“Water management in drought-prone areas is really hard.

I rely on scientists for production-ready evapotranspiration models, so we have defensible decision-making.”

- Water Manager

“Fire conditions change fast, so I worry about not having accurate maps and forecasts.

Improved fuel and moisture maps are the biggest unmet need, and they can't come soon enough.”

- Utility Company

## SBG's Community Assessment Report (CAR) builds on:

**SBG applications working group**  
225+ members

**SBG User Needs & Valuation Studies**  
560+ respondents | 90+ interviews

**Precursor efforts**  
Airborne, ECOSTRESS, EMIT

**Mission Architecture**  
synergize research and applications  
in SATM

**Mission Requirements**  
research and applications informed  
TIR channels, revisit, latency

**Community Engagement**  
science, applications and data systems, e.g. SISTER, SHIFT, GLEON





# Inclusion and Diversity Strategy



## You're Invited!

**To join the Surface Biology and Geology (SBG) Collaborations Group**

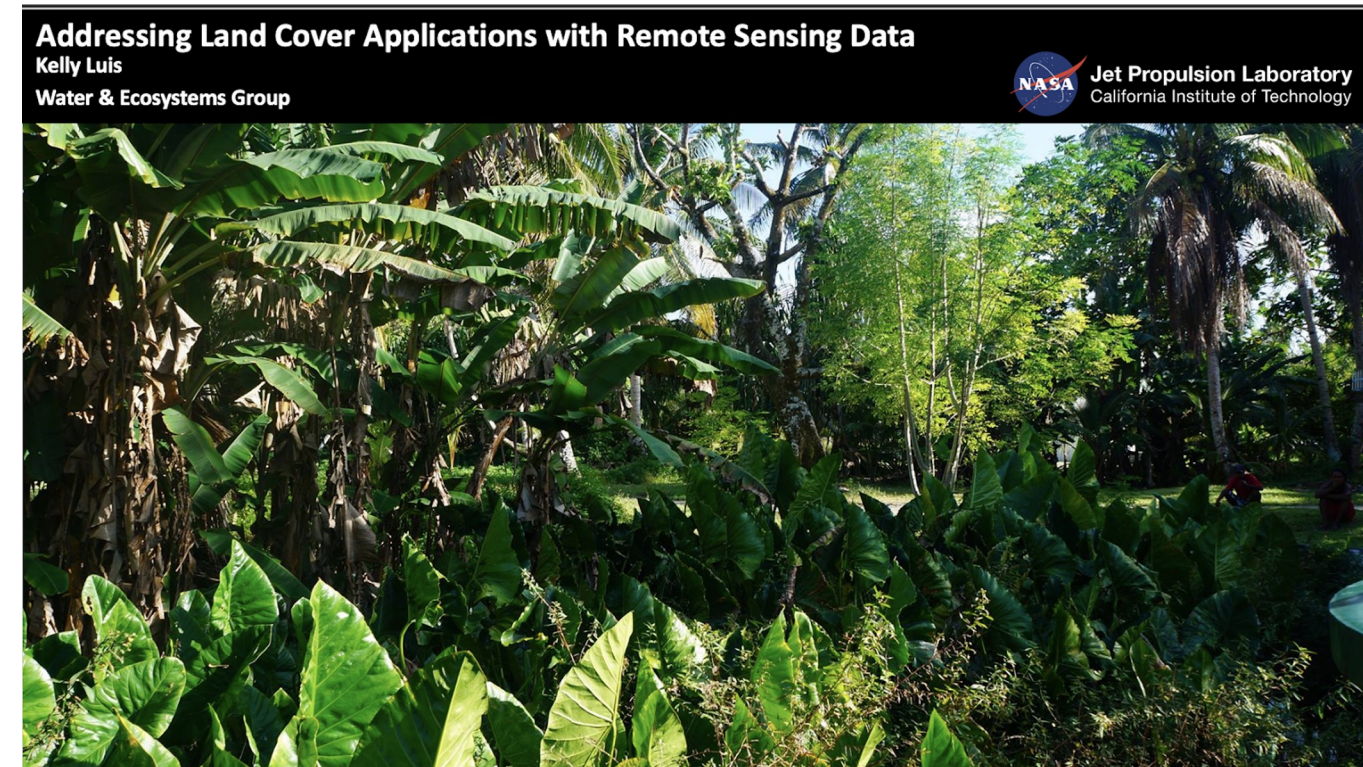
This group focuses on building connections and collaboration with diverse partners and community members. We host bi-weekly virtual meetings where we share ideas, build community, and host meaningful discussions that ensure the SBG satellite is developed in alignment with community needs and feedback.

Scan to learn more about the SBG Mission:



Scan to join the Collaborations Group:





## CREATING ETHICAL SPACE WITH GWEN BRIDGE

Hosted by SBG Collaborations

SEPTEMBER 15TH, 2023  
3:00 PM EST/  
12:00 PM PST

**GWEN BRIDGE**

**SPEAKER**



Gwen is a Saddle Lake Cree Nation member and has worked for over 20 years with First Nations, all levels of government, and the private and nonprofit sectors across North America, developing relationships and strategies that advance reconciliation. Gwen has been negotiating initiatives and advising on strategies and policies that recognize and implement Indigenous Knowledge, such as in the proposed South Okanagan Similkameen National Park Reserve. Gwen has also recently advised the BC government on better considering indigenous knowledge in collaborative land use planning and forestry-related climate change considerations.

Support to local government includes developing strategies and principles for becoming "Cities of Reconciliation" and advising on climate change policy and economic development engagement strategies. Indigenous-led conservation focuses recently include the Smeikmix Protected Area and caribou habitat conservation advancement in the territory of the Okanagan Nation Alliance. A recent focus is advancing an understanding of the ecological, economic, and equity-based partnership mechanisms to support our collective reconciliation agenda through training. Other clients include First Nations and First Nation organizations, Parks Canada, US National Parks Service, National Geographic Society additional nonprofits, regional and municipal governments including Metro Vancouver, other consulting firms, the University of Washington, Blue Quills University, BC Ministries of Environment, Indigenous Relationships, and Reconciliation, Forests, and Land, Water and Resource Stewardship. Gwen is an Adjunct Professor in the Faculty of Forestry at UBC. Gwen has a Master of Science in Forest Hydrology from the University of Alberta.

Link to join meeting:  
<https://jpl.webex.com/jpl/j.php?MTID=m41dfd9dfff9f073ec700f76596b68903>





# Inclusion and Diversity Strategy

## Ongoing activities:

- **Ethically build new partnerships**  
Partnerships and recruiting with Minority Serving Institutions
- **Work collaboratively with diverse groups**  
Bi-Weekly Meetings with Indigenous Partners
- **Reconcile open science and data sovereignty**  
Partnering with JPL's Native Engagement
- **Provide resources for communities and stakeholders to use SBG data**  
Networking and Training Session at National Tribal and Indigenous Climate Conference for Environmental Professionals

## SBG Collaborations Strategies

- 1 Identify how to responsibly nurture existing partnerships and ethically build new partnerships.
- 2 Work collaboratively with diverse communities and stakeholders to ensure SBG applications support community needs.
- 3 Meaningfully include and involve community partners in SBG's development and implementations.
- 4 Provide adequate resources for communities and stakeholders to utilize SBG data.
- 5 Integrate open science initiatives with data equity principles throughout the SBG mission.

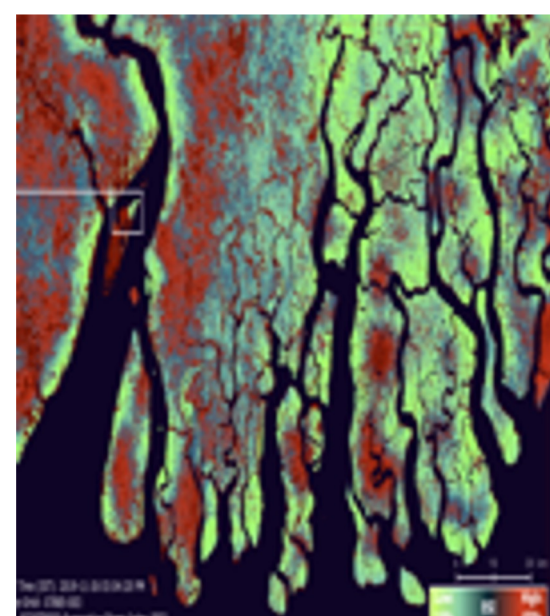




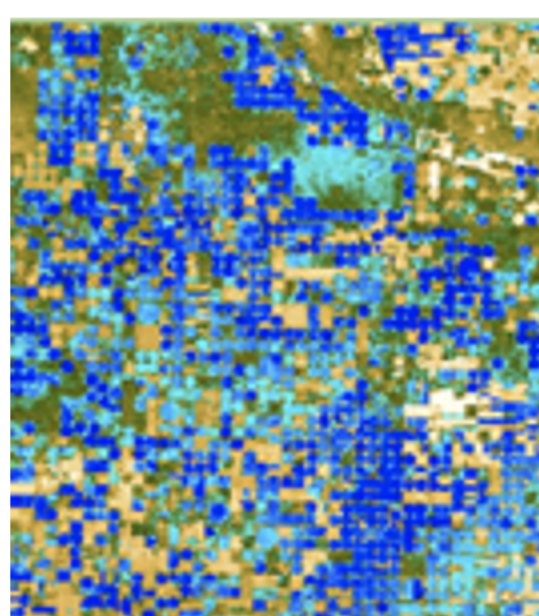
# SBG Precursor accomplishments

Building a science and applications community through **synergy** with other missions to quantify SBG potential to address Decadal Survey priorities and develop an inclusive workforce ready to **maximize future SBG** data to advance science that benefits society.

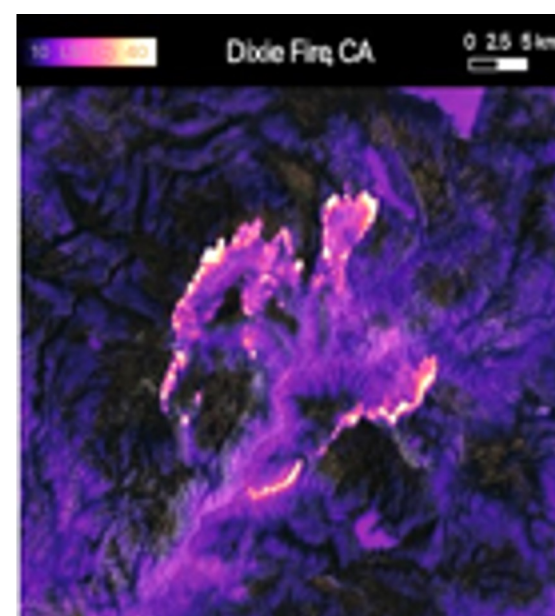
## *ECOSTRESS*



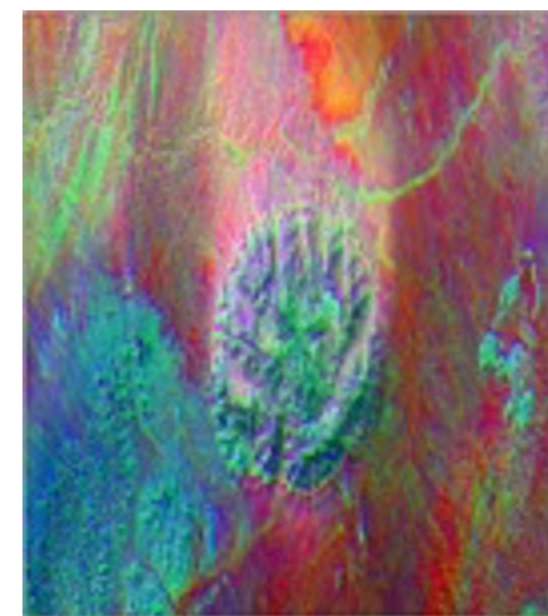
Natural Ecosystems



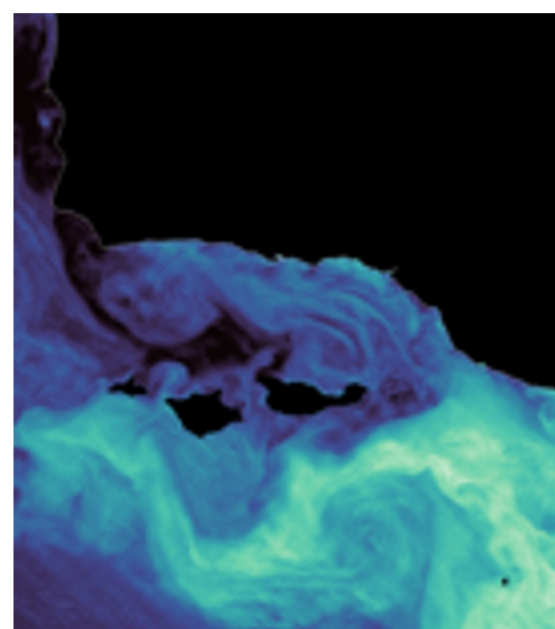
Agriculture



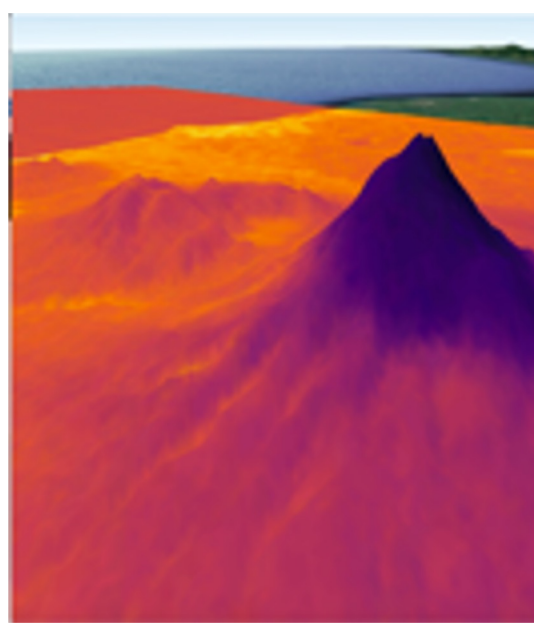
Wildfires



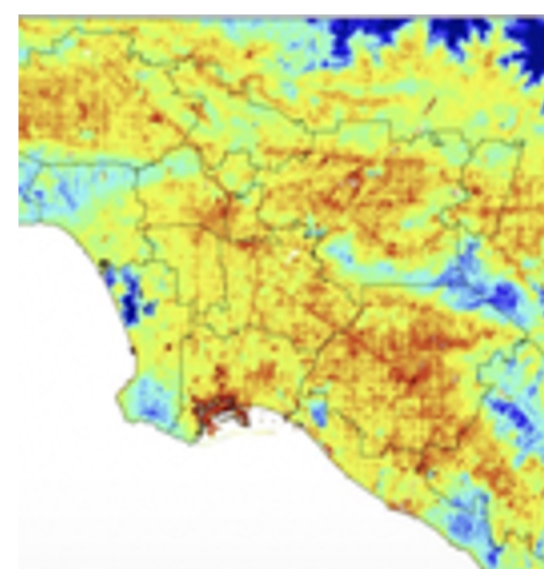
Mineralogy



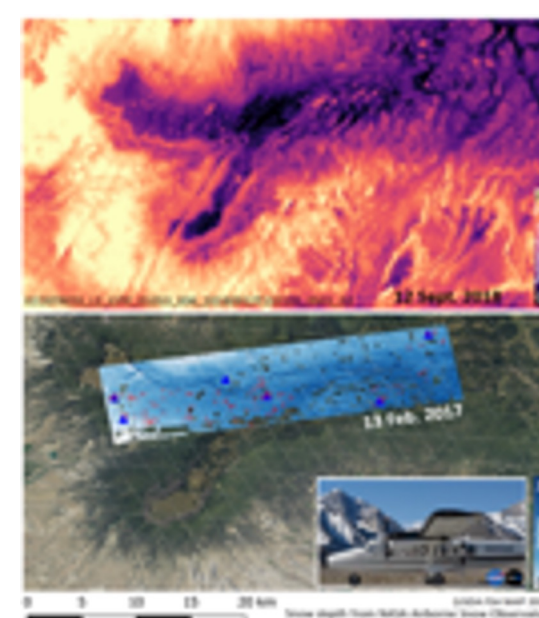
Coastal Ecosystems



Volcanoes

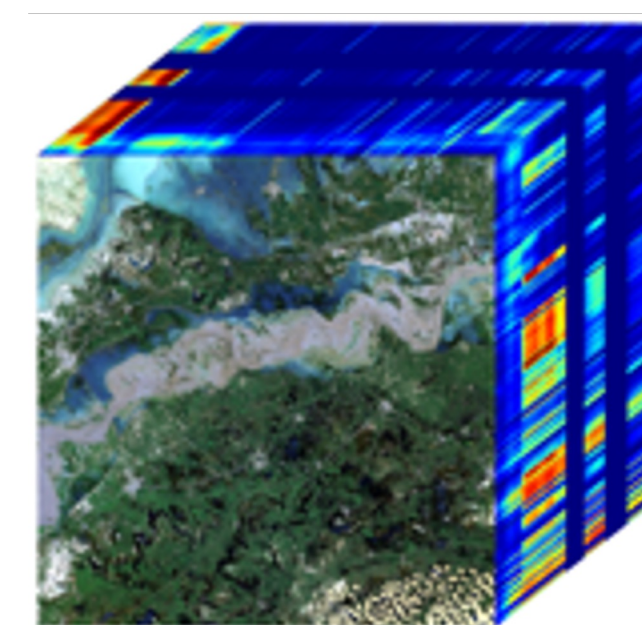


Urban Heat and Public Health

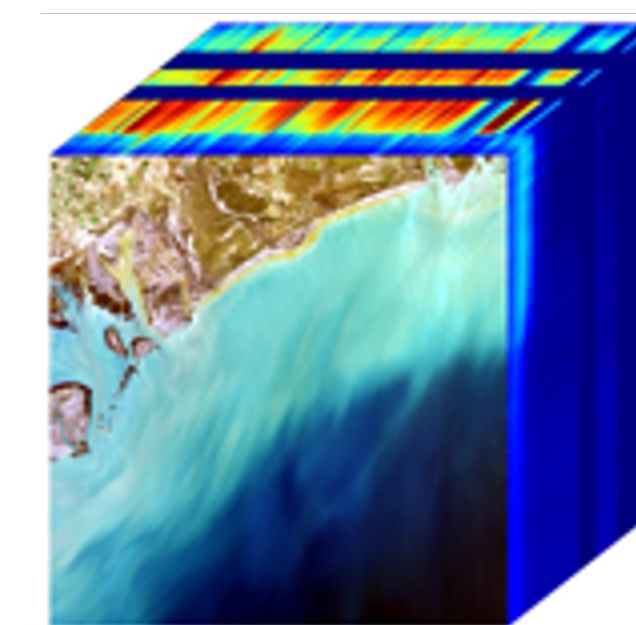


Cryosphere and Water Resources

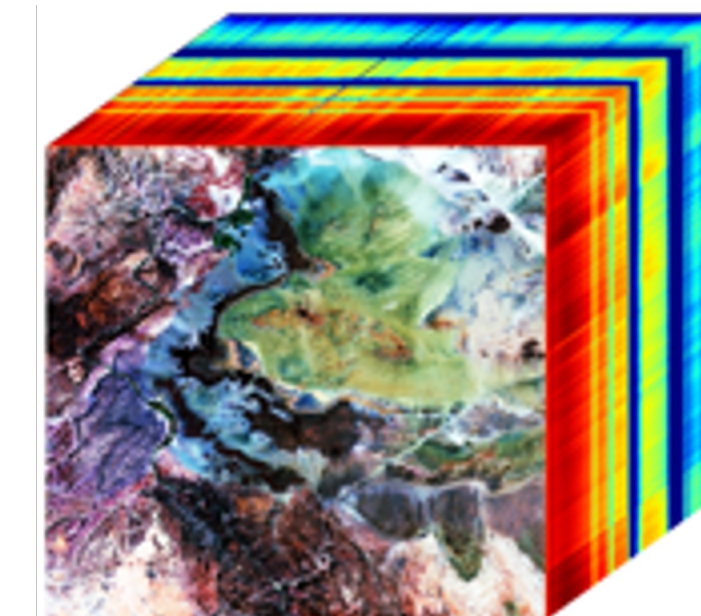
## *EMIT*



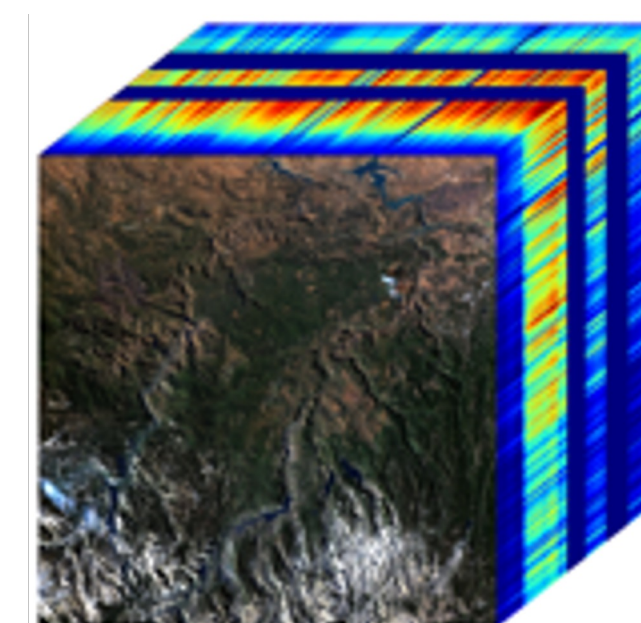
Natural Hazards



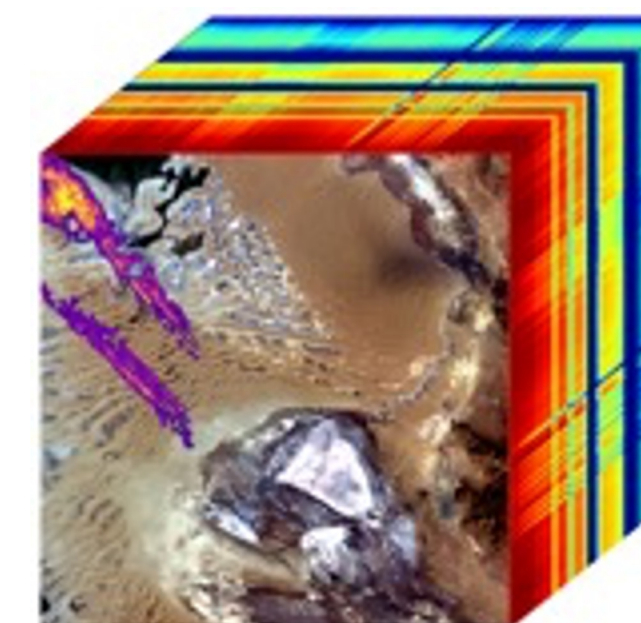
Benthic habitat, water quality



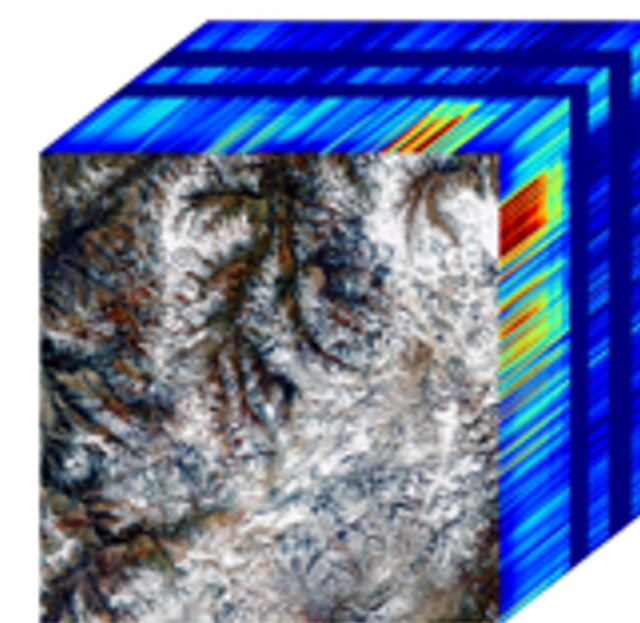
Mineral mapping



Vegetation health and functional traits



Greenhouse Gas Emissions



Cryosphere and Water Resources





# SBG Precursor accomplishments



Airborne Visible / Infrared Imaging Spectrometer

**AVIRIS**  
NEXT GENERATION



Operational since 2009  
Covers North American Arctic study region



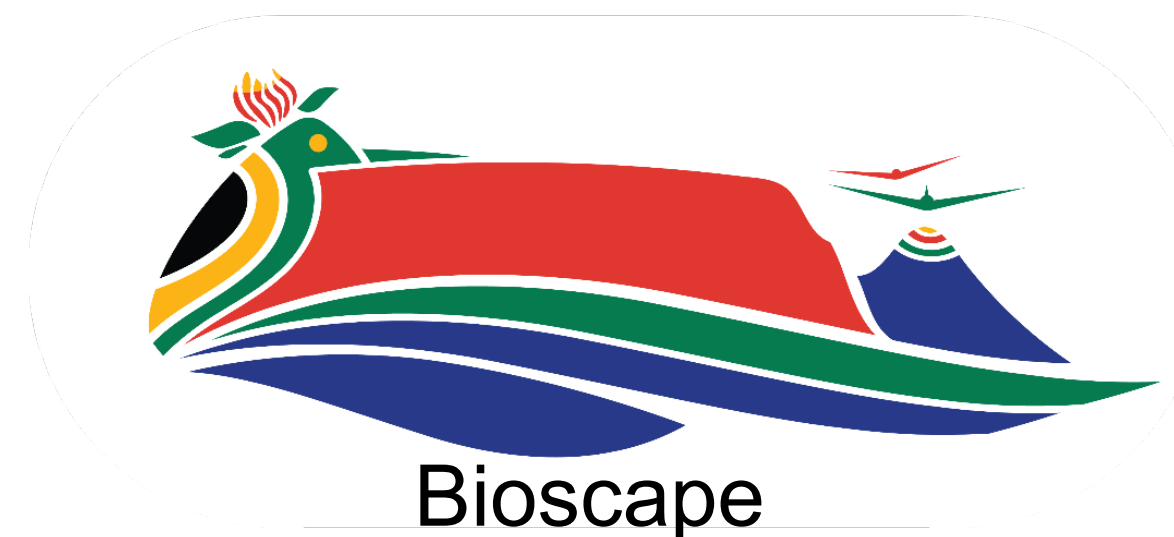
Operational since 2012  
Covers Europe and North America



2022 SBG flight campaign  
Field season in Southern California



Operational since 2023  
Pilot study in California fire regions



Operational since 2023  
Covers South Africa study region

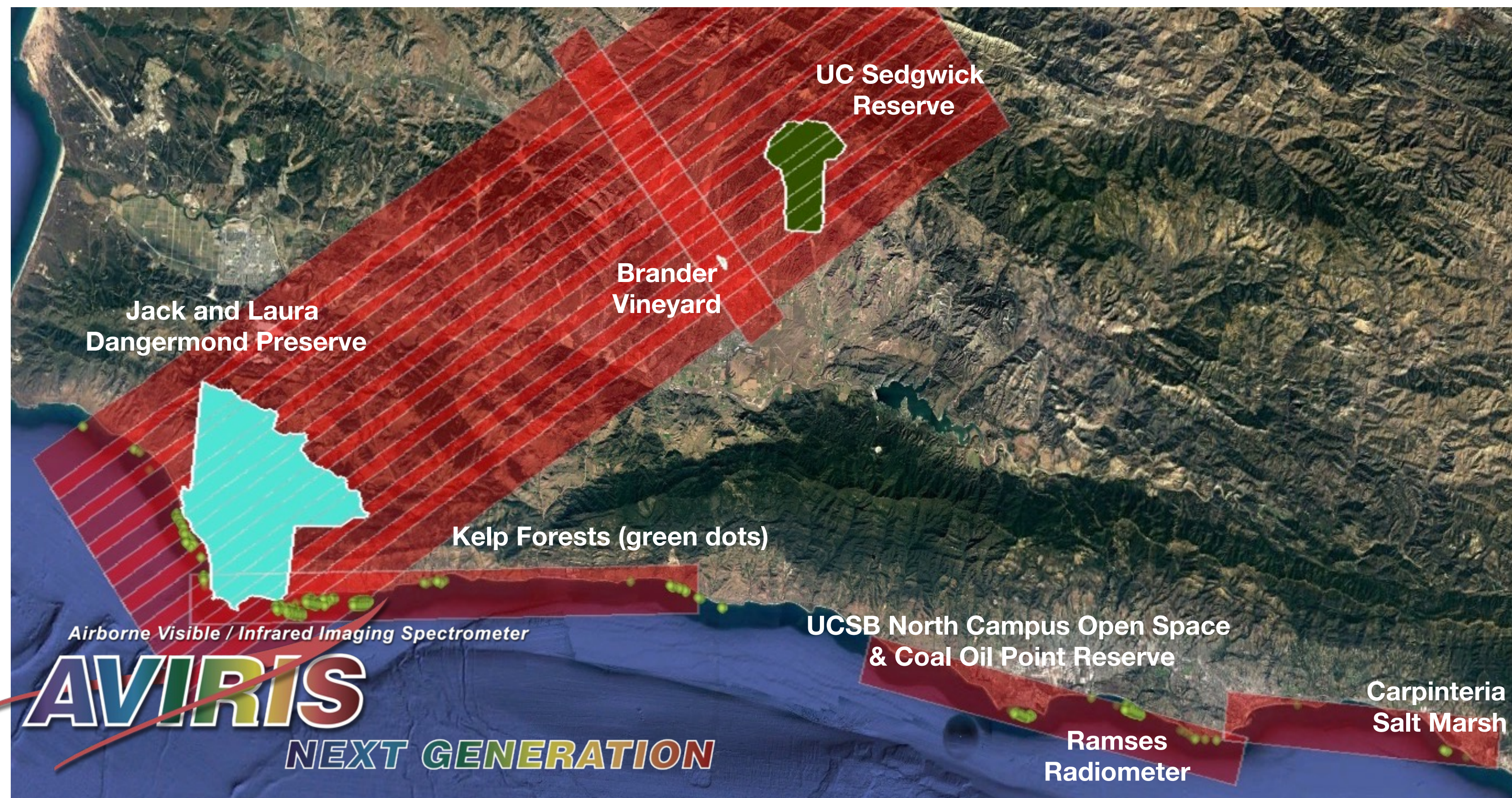




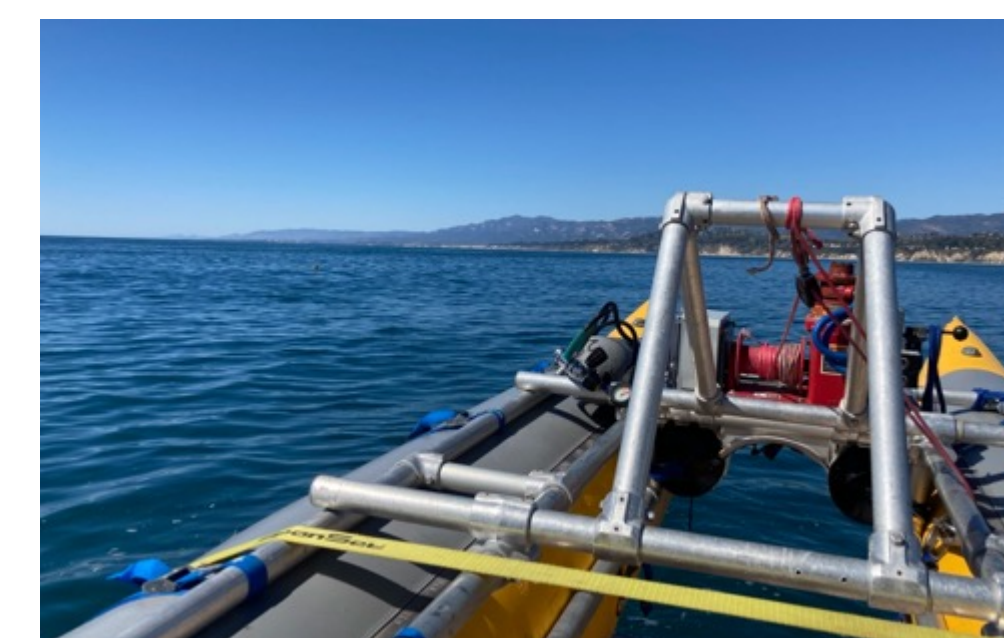
# SHIFT: SBG High-Frequency Timeseries



Many SBG objectives from the Decadal Survey require rapid revisit, but no sub-seasonal, high-repeat airborne data were available to assess VSWIR temporal information content & algorithm performance



Weekly VSWIR acquisitions in Santa Barbara County, paired with diverse *in situ* measurements, to characterize value of temporal repeat. HyTES flight mid-season.



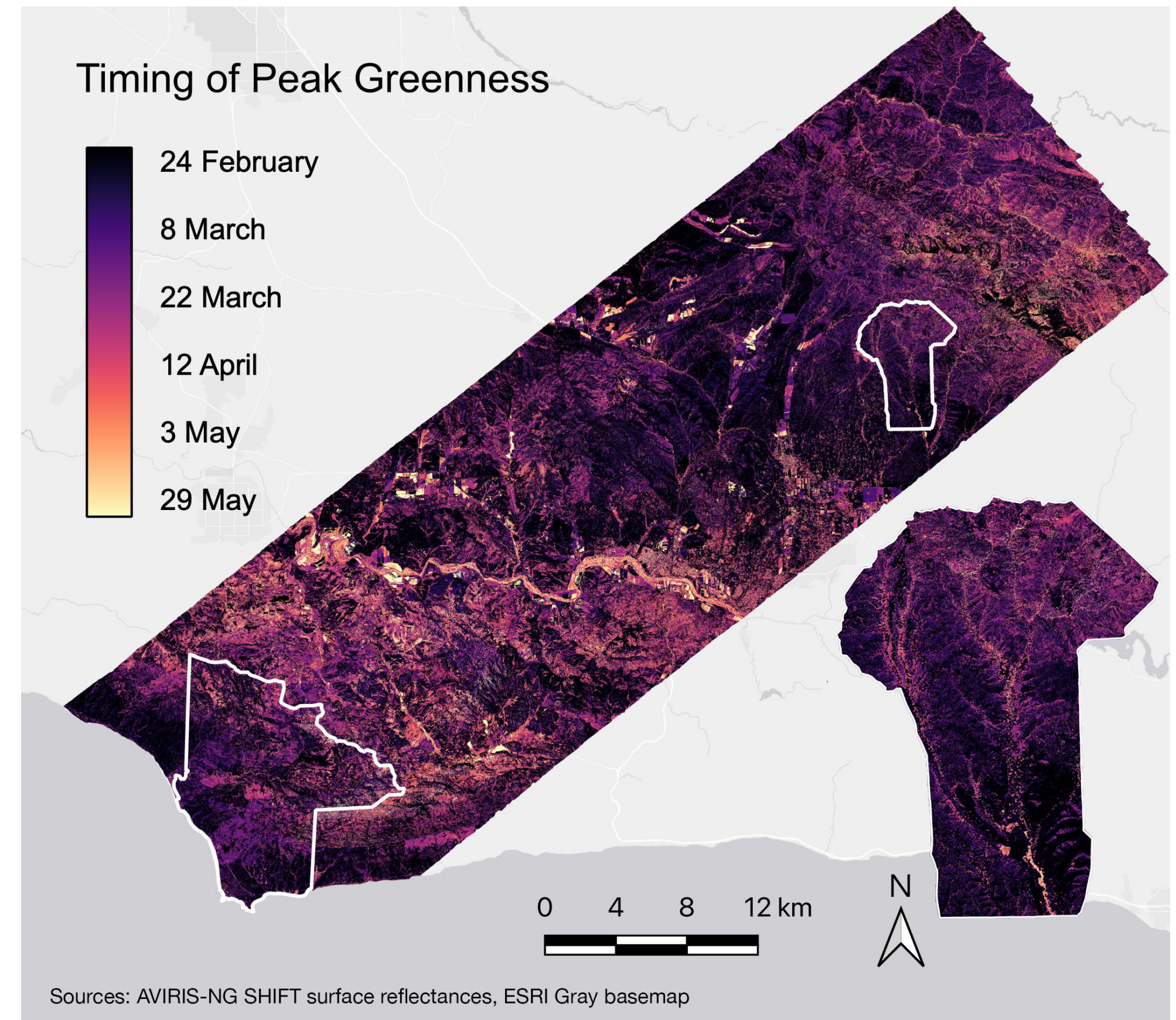
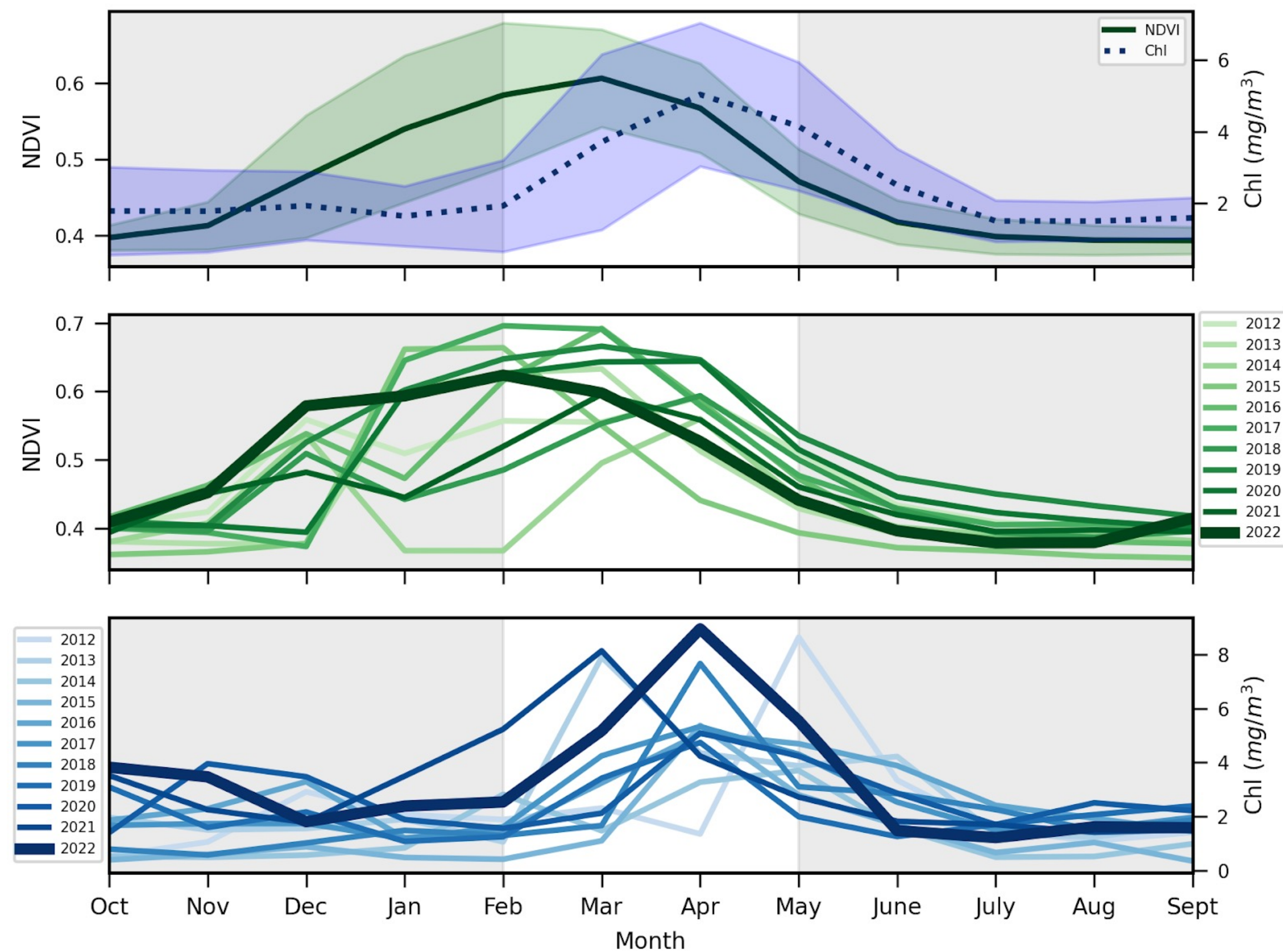




# SHIFT: SBG High-Frequency Timeseries



## Satellite derived seasonality of aquatic & terrestrial systems



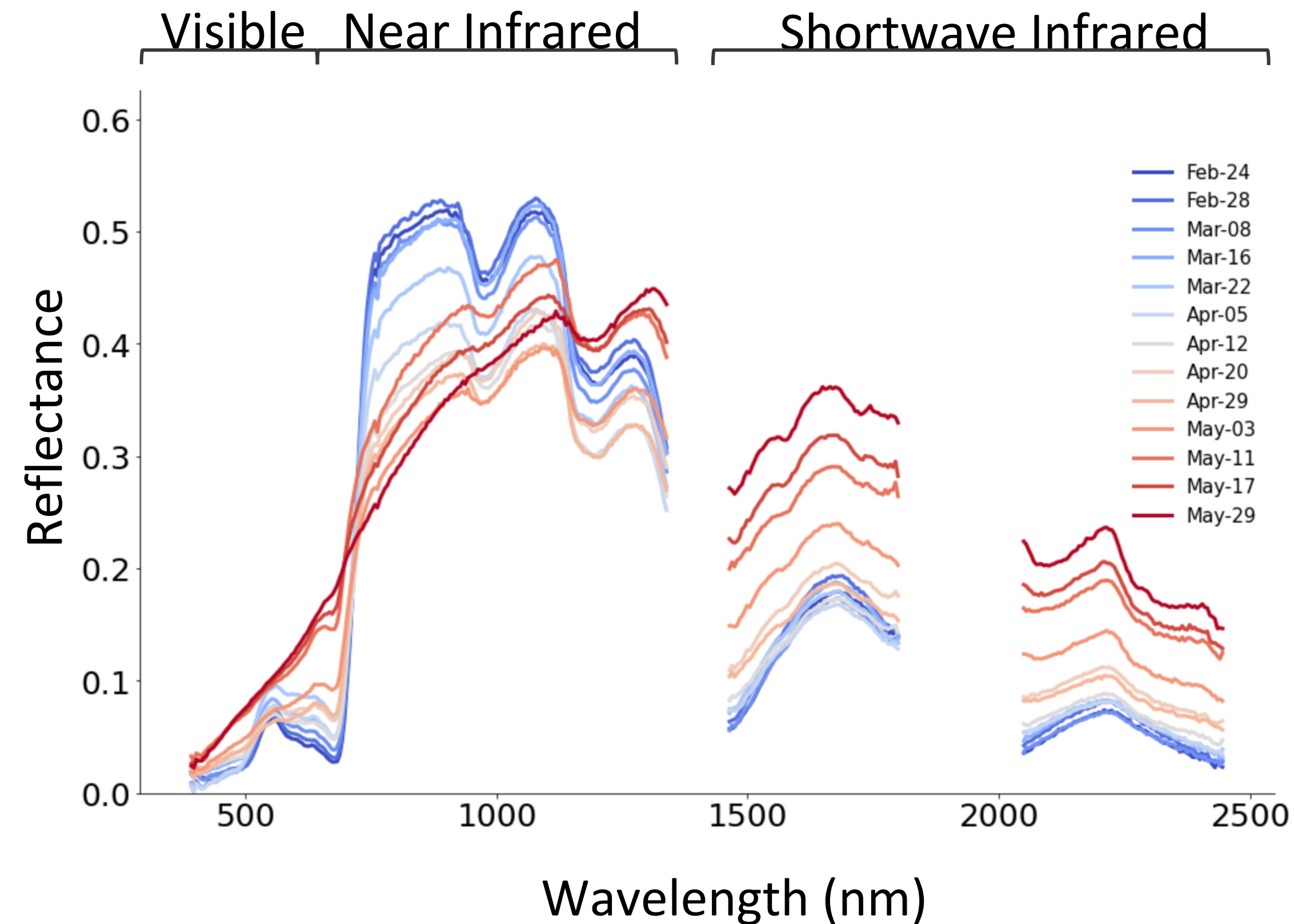
Greenness varies in time ..... and space.







# ***SHIFT***: Rapidly changing plant functional characteristics revealed by spectroscopy



**Spectroscopy adds process information to multispectral time series**  
Greenness changes reflect complicated changes to leaf area and leaf optical properties diagnostic of functional change.  
*Changes were faster than anticipated!*







# Open Science

---

SBG already complies with NASA Open Data Policies:

- The SBG Mission will be fully compliant with SBD-41a
- SBG developed science strategy through open Working Groups- no applications process
- SBG open science team meetings with hundreds of community members
- All software development not impacted by ITAR/EAR/USML has been developed in the open (GitHub)
- SBG has gone through the NASA process to release science relevant software

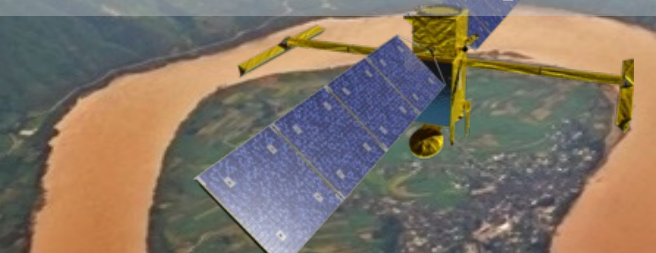
**“It is Science Mission Directorate (SMD) policy, consistent with NASA and Federal policies, that information produced from SMD-funded scientific research activities be made publicly available.” SPD- 41a**





# An SBG centric view for the watercycle

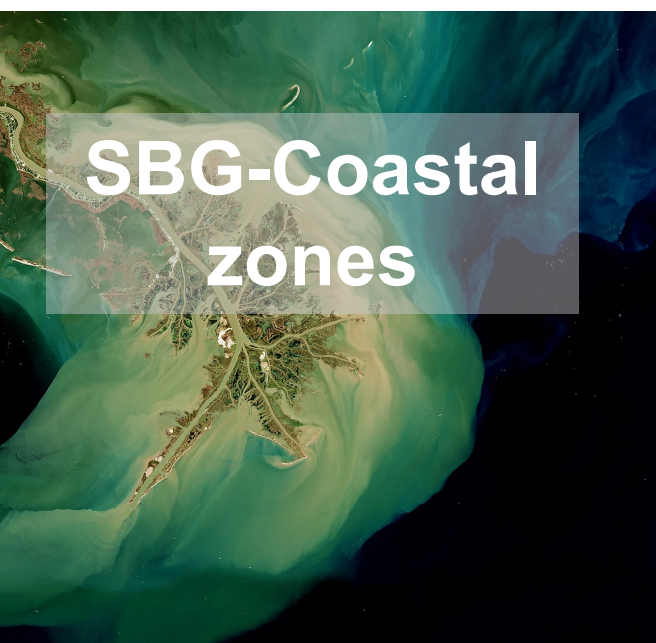
**SBG/SWOT-**  
Sediment and  
nutrient transport



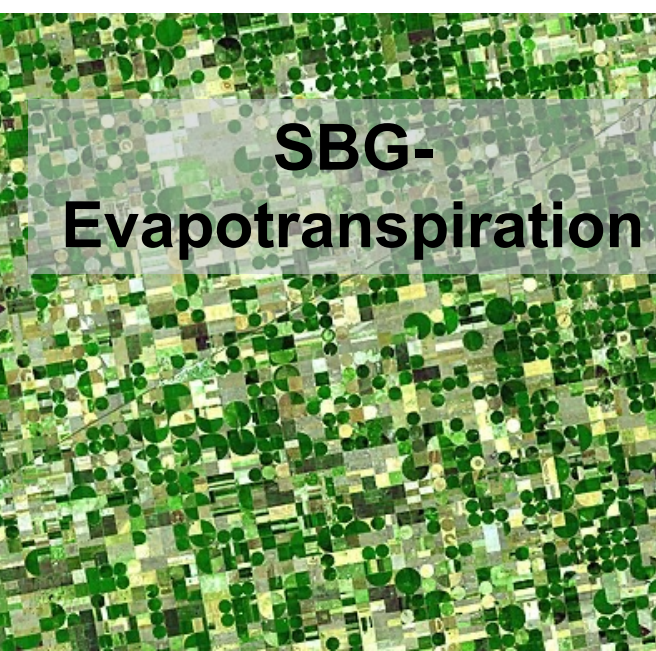
**SBG-Snowmelt**



**SBG-Coastal  
zones**

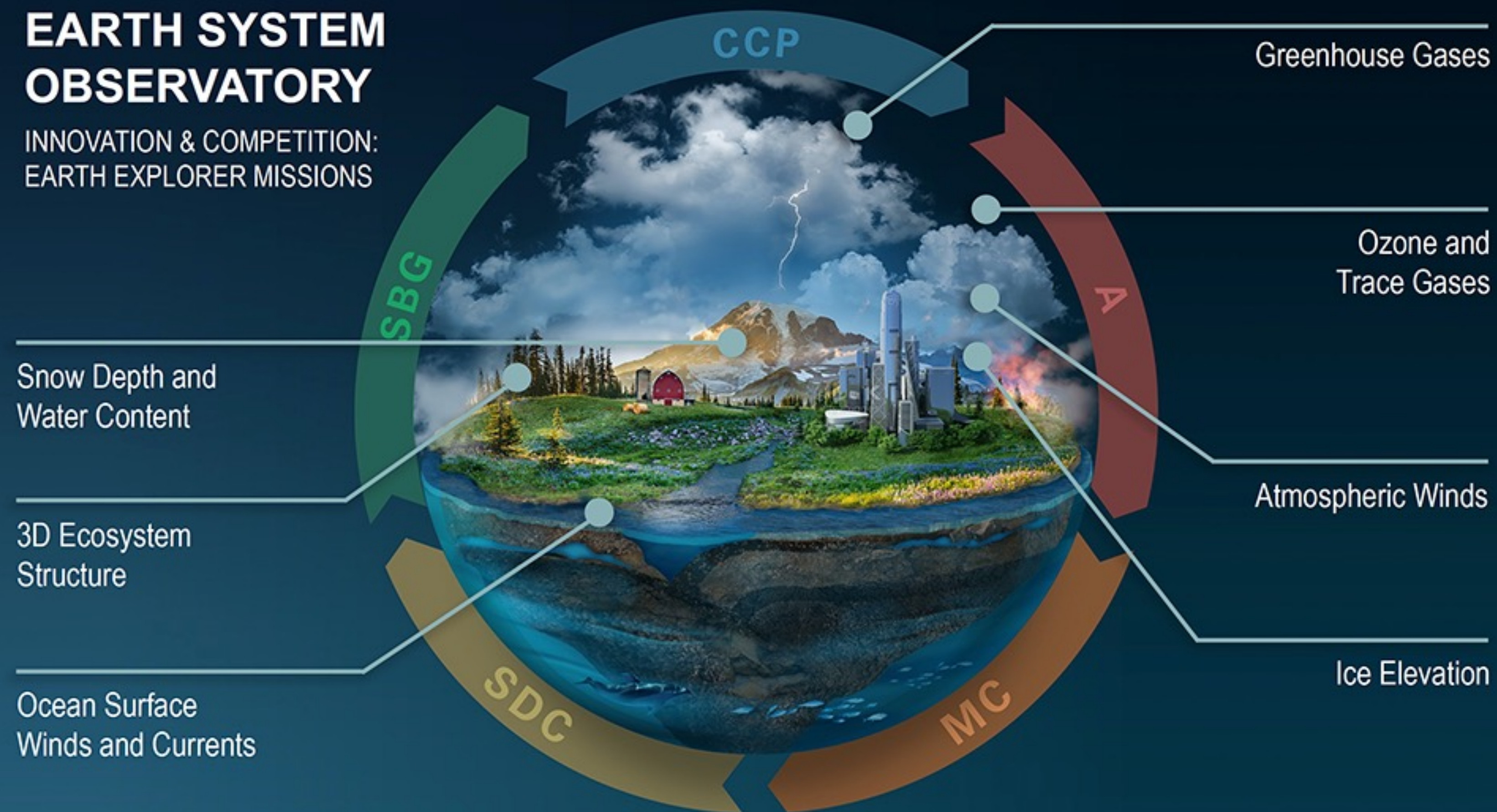


**SBG-**  
Evapotranspiration

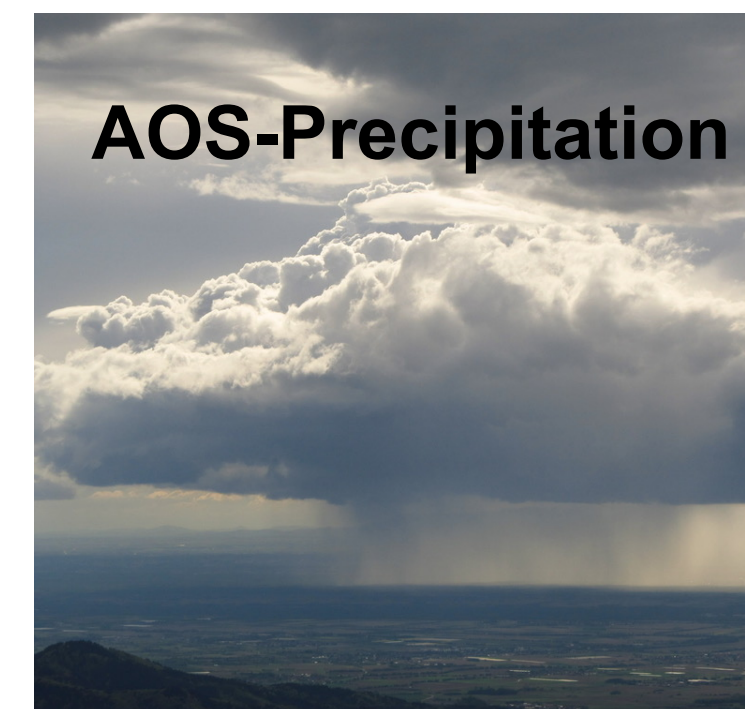


## EARTH SYSTEM OBSERVATORY

INNOVATION & COMPETITION:  
EARTH EXPLORER MISSIONS



**AOS-Precipitation**



**GRACE-C-Total  
Water Storage**







# Take Home Messages

---

1. SBG will meet Decadal Survey and Earth2Action objectives to enable actionable discovery, science and applications.

2. SBG is progressing with mission design, science algorithms and workflow, calibration and validation plans and international collaboration and benefited from substantial early investment in algorithms, workflow and campaigns prior to Phase A.

3. The SBG mission succeeds when TIR and VSWIR launch as closely together as possible and operate together as long as possible.

- SBG traceability results are documented in the SBG JGR Special Issue:  
[https://agupubs.onlinelibrary.wiley.com/doi/toc/10.1002/\(ISSN\)2169-8961.EARTHLVGCLR](https://agupubs.onlinelibrary.wiley.com/doi/toc/10.1002/(ISSN)2169-8961.EARTHLVGCLR)
- The baseline mission **fully enables 16 of 28** of the Geophysical Observables assigned to SBG.
- The threshold mission **retains 11 of 28** of the baseline observables.
- **International data harmonization** with TIR and VSWIR missions increases effective revisit and allows **fully meeting** an additional **10 of 28** of the observables assigned to SBG.
- SBG traceability flows from the DS to the SBG SATM to the subset of ABAA ABBA Performance Targets, to refined L1 requirements and TIR/VSWIR-specific traceability matrices.





Surface Biology and Geology