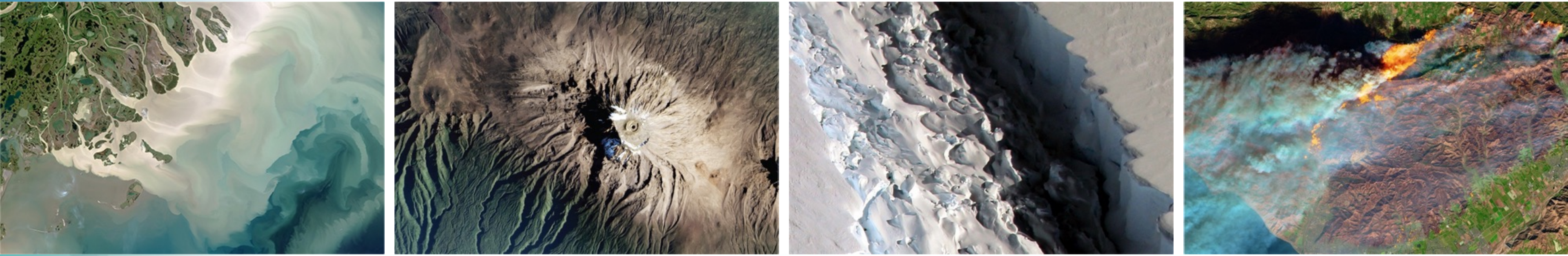
Jet Propulsion Laboratory
California Institute of Technology

SCIENCE



Surface Biology and Geology

An Observing System for Climate Impacts and Earth System Dynamics

David Schimel[1], Ryan Pavlick[1], Kerry Cawse-Nicholson[1], and the SBG team

Jet Propulsion Laboratory, California Institute for Technology

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:

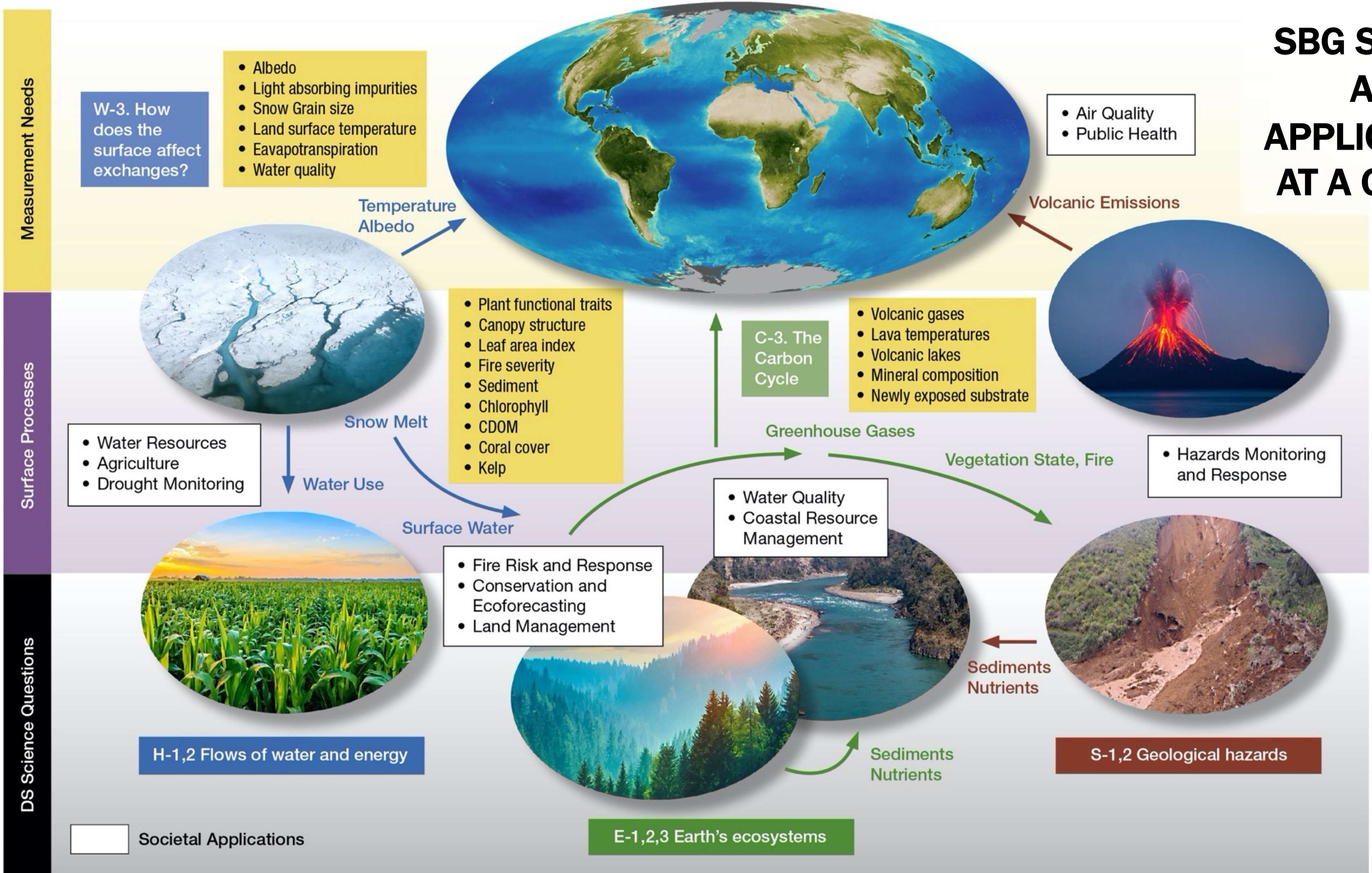
- Terrestrial and aquatic ecosystems
- Hydrology
- Weather
- Climate
- Solid Earth

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

Temperature Albedo

- Air Quality
- Public Health

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

Surface Water

- Hazards Monitoring and Response

- 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

S-1,2 Geological hazards

E-1,2,3 Earth's ecosystems

☐ 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: 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

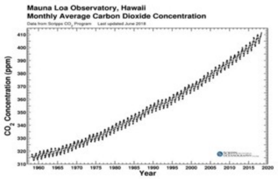
Mineral mapping for exploration efforts and reduction of environmental hazards

Forecast aviation hazards and support emergency response for volcanic eruptions

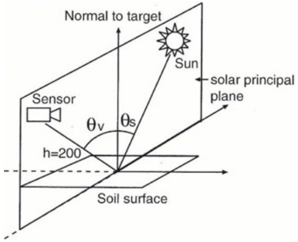
Landslide risk assessment with improved substrate map land cover maps

SBG: KEY RESEARCH AND APPLICATIONS REQUIREMENTS

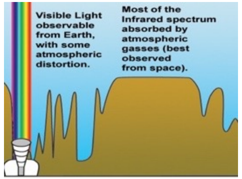
COVERAGE: The system must provide **global coverage** to address the global scope of the science including the coastal ocean and inland waters.



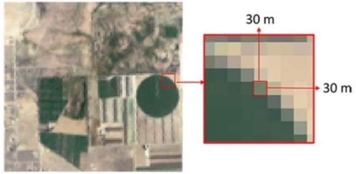
STABILITY AND DURATION: Measurements must be able to detect **long term changes** for addressing dynamics of the Earth System.



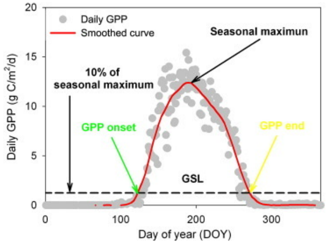
GEOMETRY: The system's orbit must allow for **consistent sun-sensor geometry** for consistency in retrievals and for calibration and validation, and provide for global coverage, as above (polar orbit).



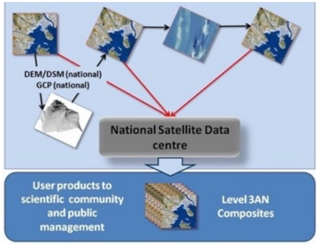
RANGE, RESOLUTION AND SENSITIVITY: Visible to Shortwave Infrared **(VSWIR; 400-2500 nm)** imaging spectroscopy and multi-spectral thermal infrared **(TIR; 4 - 12 *µ*m)** measurements to observe "diversity" in ecosystem function. Radiometric performance driven by aquatic targets.



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



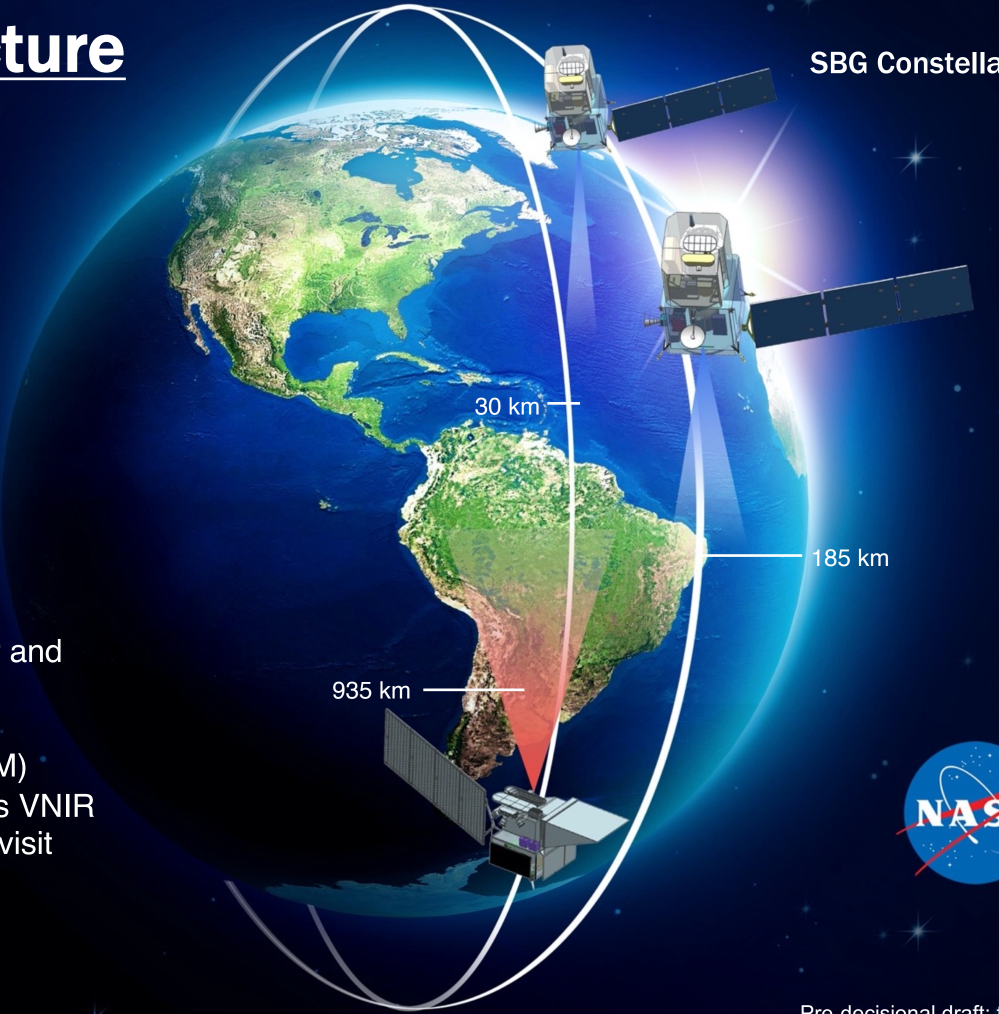
REVISIT: The SBG observing system temporal resolution must be adequate to capture **synoptic and seasonal variation** as well as observe **rapid or transient changes** related to Earth system events such as fires, landslides, volcanic activity and anthropogenic incidents.



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 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 Light
Wide-swath VSWIR
spectrometer

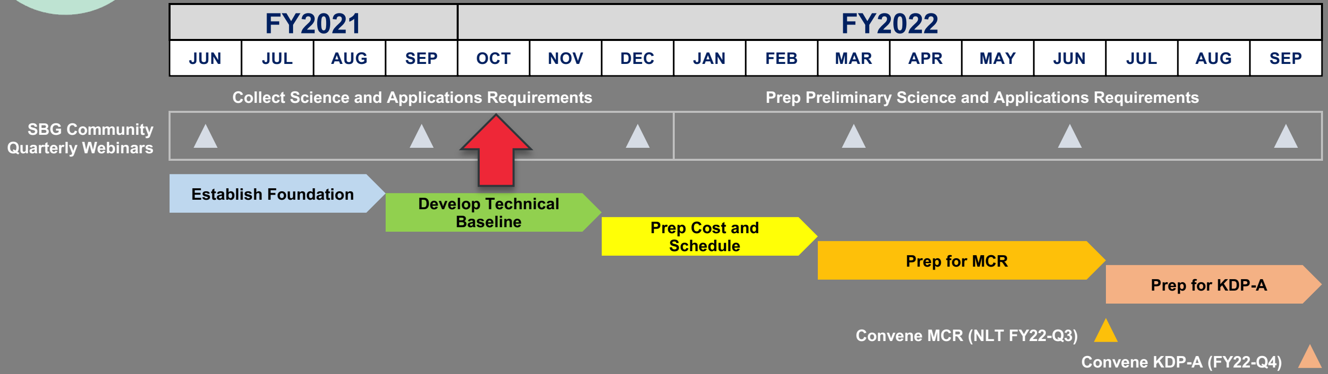
Sun-sync orbit (late AM)
185 km swath
16 day revisit
10 nm, 200+ bands
30 meter GSD
High SNR and
radiometric performance

Pre-decisional draft; for discussion and planning purposes only.


CO MITTED TO TRACEABILITY & TRANSPARENCY
EAFOOD STANDARDS
IKE NOWHERE ELSE
SETTING THE STANDARD FOR
FARM ANIMAL WELFARE
NO ADDED
HORMONES OR
ANTIBIOTICS
EVER
LOCAL
PERONI
Dominga
PALOMA SOUR

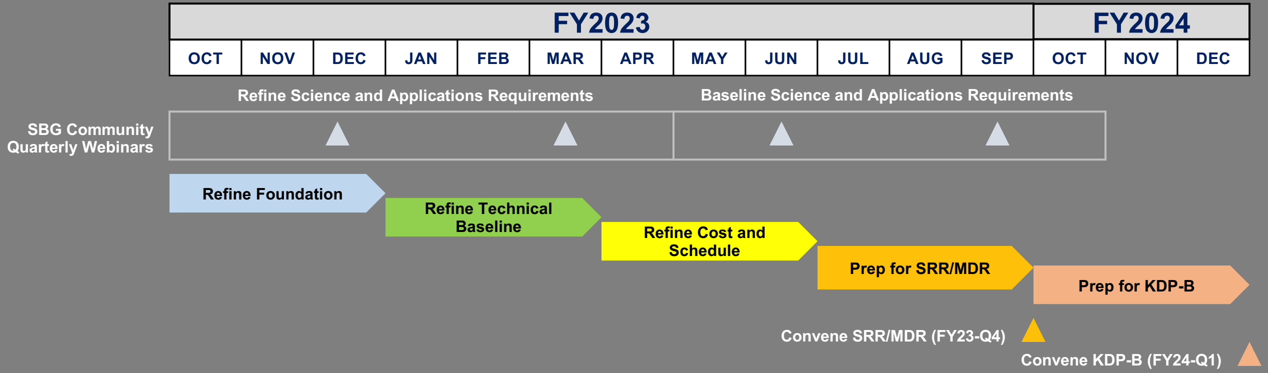
Surface Biology and Geology (SBG)

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



FY2021				FY2022											
JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP

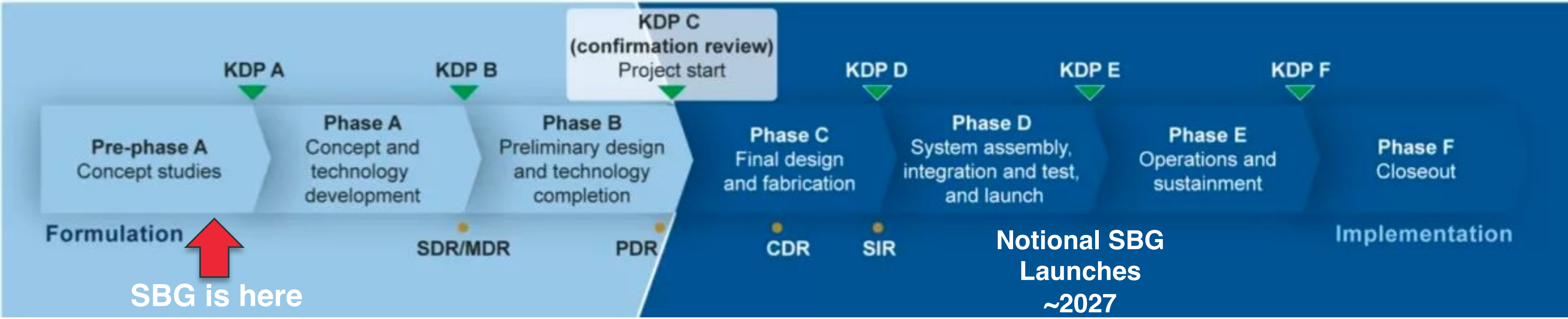
Phase A (Concept Study Phase) Schedule - Notional



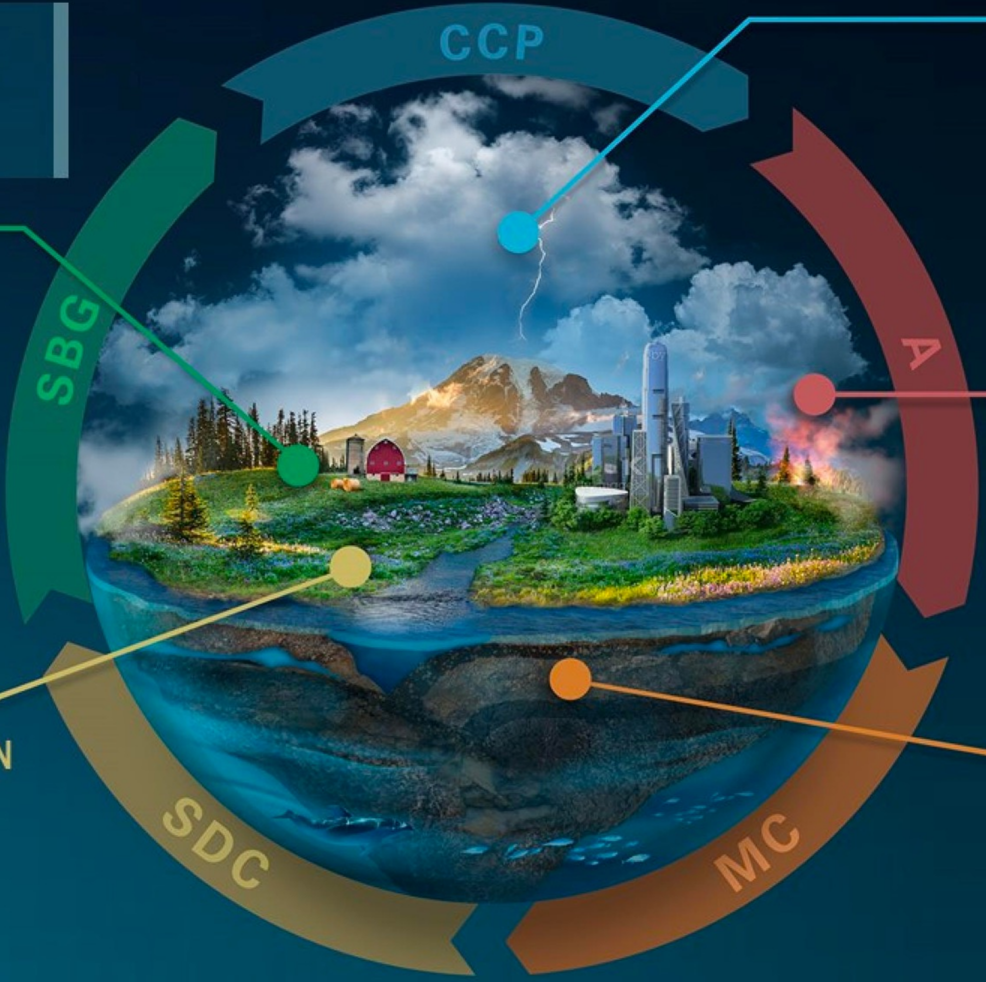
FY2023												FY2024		
OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC

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

NASA's Project Life-Cycle



EARTH SYSTEM OBSERVATORY



CLOUDS, CONVECTION AND PRECIPITATION

Water and Energy in the Atmosphere

SURFACE BIOLOGY AND GEOLOGY

Earth Surface & Ecosystems

AEROSOLS

Particles in the Atmosphere

SURFACE DEFORMATION AND CHANGE

Earth Surface Dynamics

MASS CHANGE

Large-scale Mass Redistribution

NASA Headquarters Perspective

Woody Turner

NASA Program Scientist,
Biological Diversity and
Ecological Forecasting

Laura Lorenzoni

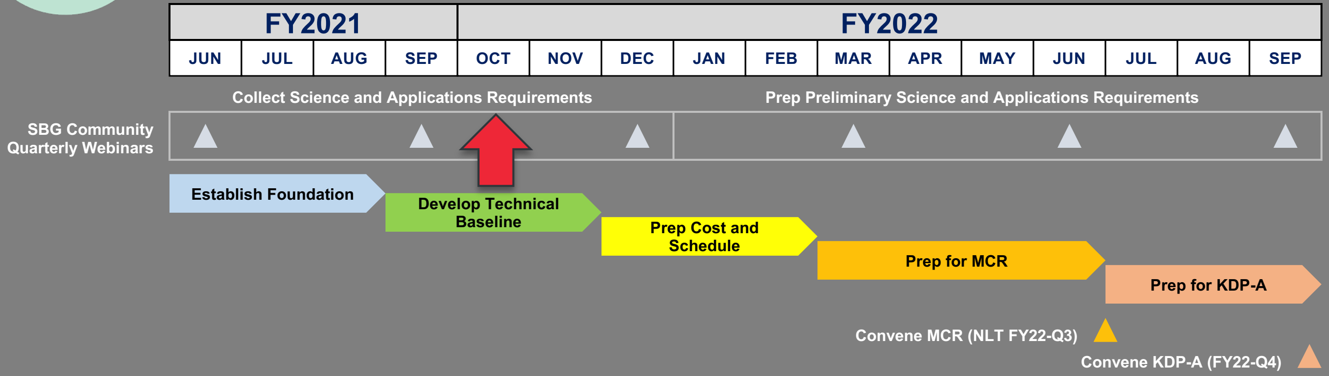
NASA Program Scientist,
Ocean Biology and
Biogeochemistry

Ben Phillips

NASA Program Scientist,
Earth Surface and Interior

Surface Biology and Geology (SBG)

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



FY2021				FY2022											
JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP

Collect Science and Applications Requirements

Prep Preliminary Science and Applications Requirements

SBG Community Quarterly Webinars

Establish Foundation

Develop Technical Baseline

Prep Cost and Schedule

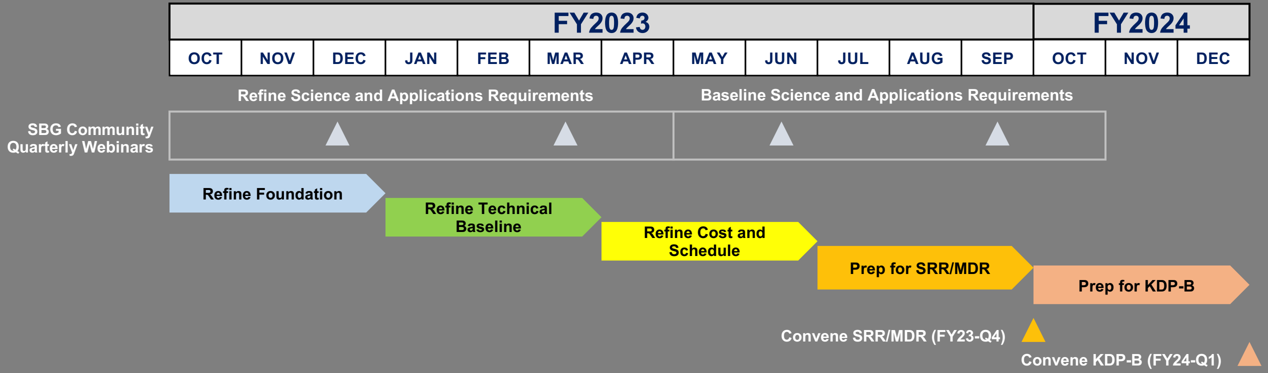
Prep for MCR

Prep for KDP-A

Convene MCR (NLT FY22-Q3)

Convene KDP-A (FY22-Q4)

Phase A (Concept Study Phase) Schedule - <u>Notional</u>



FY2023												FY2024		
OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC

Refine Science and Applications Requirements

Baseline Science and Applications Requirements

SBG Community Quarterly Webinars

Refine Foundation

Refine Technical Baseline

Refine Cost and Schedule

Prep for SRR/MDR

Prep for KDP-B

Convene SRR/MDR (FY23-Q4)

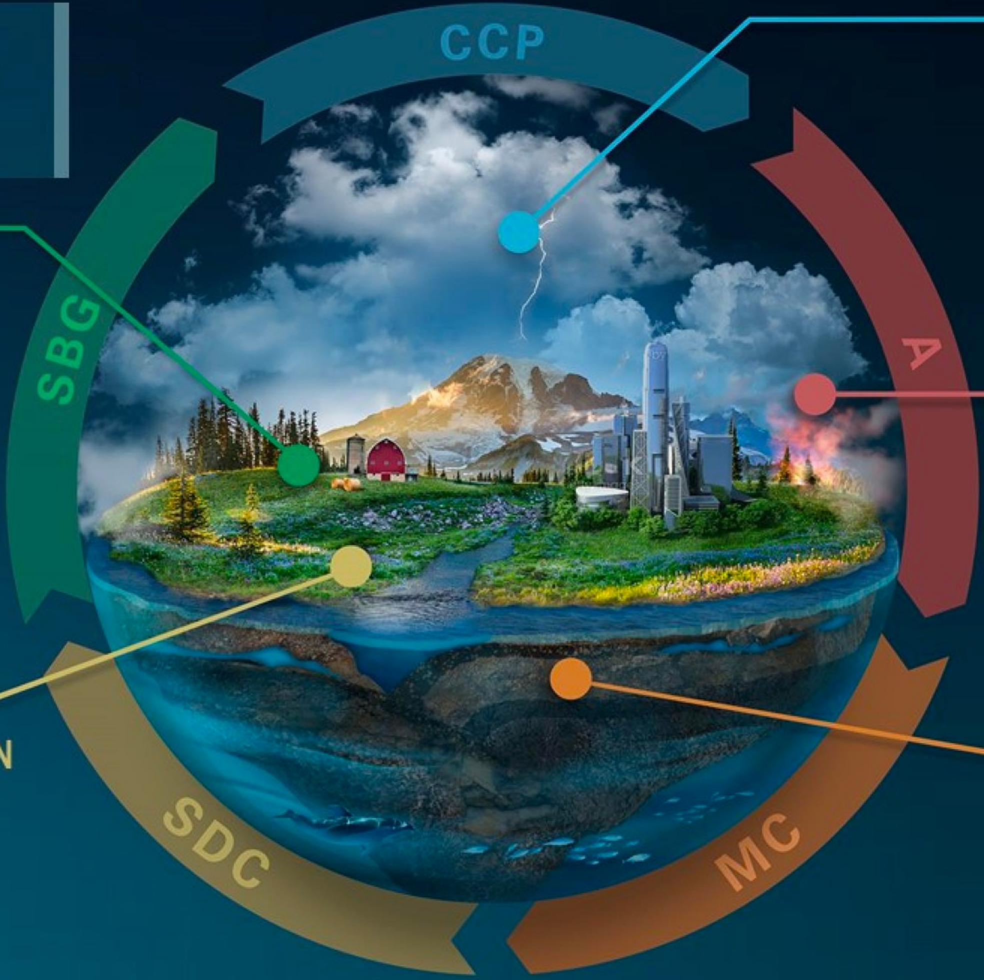
Convene KDP-B (FY24-Q1)

SBG – ASI Technical Interface Meeting

Rome, Italy (Hybrid meeting)

September 22-24, 2022

EARTH SYSTEM OBSERVATORY



SURFACE BIOLOGY AND GEOLOGY

Earth Surface &
Ecosystems

SURFACE DEFORMATION AND CHANGE

Earth Surface Dynamics

CLOUDS, CONVECTION AND PRECIPITATION

Water and Energy in
the Atmosphere

AEROSOLS

Particles in the
Atmosphere

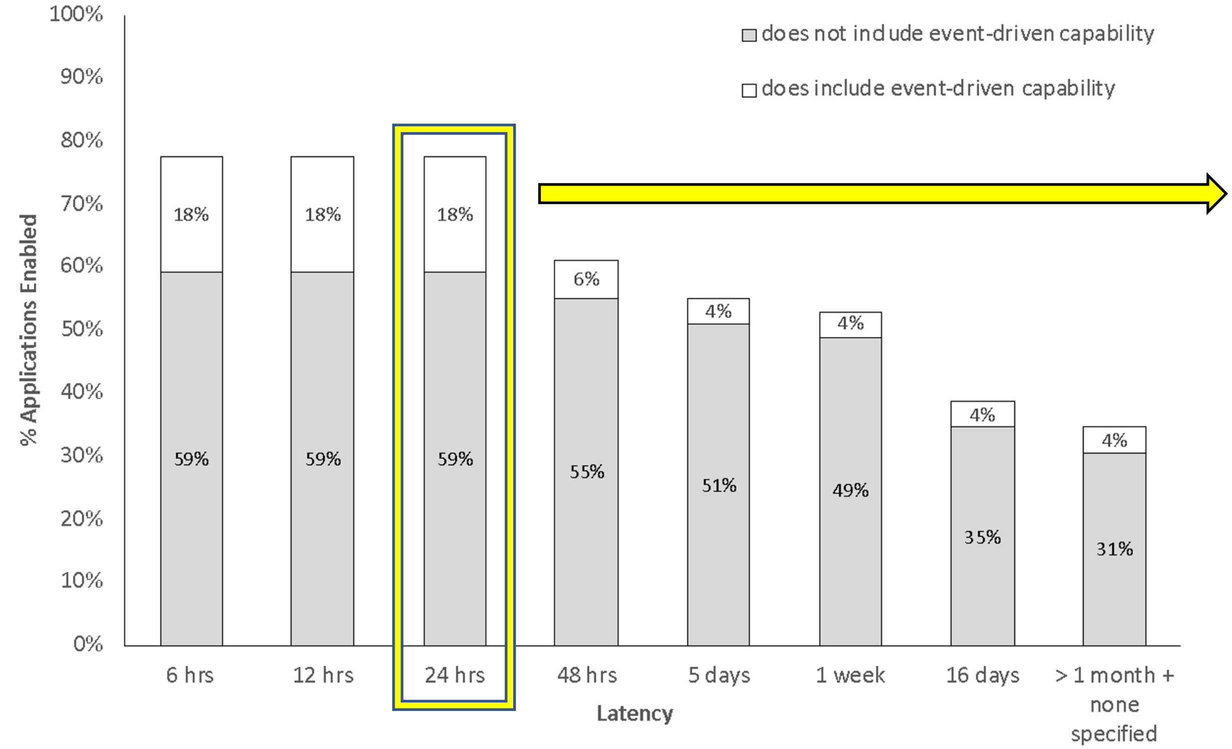
MASS CHANGE

Large-scale Mass
Redistribution

Earth System Observatory Data Latency and Ground Segment Study

Study Goal	Minimize product latency and support cross-ESO science product generation by evaluating flight hardware and ground system architectures ** maximize commonalities and efficiencies across missions **
Objectives	Seek approaches to minimize or reduce latency with respect to • Space to ground communications • Terrestrial communications • Level 0 processing (L1-4 processing will be considered separately)
Approach Summary	Space to Ground Architecture should • Enable higher-level processing to be conducted in a low latency manner • Consider any input data such as predicted orbit or ephemeris required to enable low latency processing Driven by science and applications latency requirements • Science goals or high value applications • Consider cost impacts of reducing latency further Include commercial and government options Workshops with study team members
Schedule Drivers	MCR milestones for SBG, AOS, MC
Study Leads	ESDIS / Aerospace (Karen Michael and Andy Mitchell) ESTO (Marge Cole and Ben Smith)

Other factors of applications value needs chart, which was used in the Architecture Study design targets for latency



How this input was used

- 24 hour latency with event-driven capability enables 77% of SBG SATM applications
- 24-hour latency target used in architecture design sessions
- Event-driven needs documented

The Meanings of “Open” in Open Source Science

Open (**Transparent**) Science

Both the scientific process and results should be visible, accessible and understandable.

Open (**Accessible**) Science

Data, tools, software, documentation, publications should be accessible to all (FAIR).

Open (**Inclusive**) Science

The process and participants should welcome participation by and collaboration with diverse people and organizations.

Open (**Reproducible**) Science

The scientific process and results should be open such that they are reproducible by members of the community.

Created by Gregor Cresnar
from Noun Project

OSS for ESO Mission Processing Study Goal

Identify and assess potential architectures that can meet the ESO mission science processing objectives, enable data system efficiencies, seek opportunities that support earth system science, and promote open science principles. Per the Project Authorization Letter, will evaluate options to expand participation in mission science beyond the funded science teams.

Aligns with the challenge set by NASA to create a single observatory that combines data from the ESO missions to understand the earth as a system and accelerate our ability to apply this understanding.

OSS for ESO Mission Processing Study Workshops

Workshop #1

October 19-20, 2021

Receive input from NASA Program Officers and ESO Missions regarding requirements, constraints, recommendations, and opportunities for science data processing

Workshop #2

February 2022

Understand the state-of-art in big data processing systems. Open invitation for agencies to share insights into their data processing approaches.

Workshop #3

August 2022

Receive results of the architecture study.

SBG Algorithms Working Group

- Team: Phil Townsend, Kerry Cawse-Nicholson, 250+ community members
- Goals: support mission concept development by assessing the *status* of *existing algorithms*, identifying gaps and opportunities, and assisting in traceability studies.
- Biweekly meetings:
  - Deep dive into proposed products to identify development needs
  - Average 43 members per deep dive (each focusing on a particular research specialty)
- Achievements:
  - More than 200 individual products identified
  - Narrowed down to 10 product suites
  - Manuscript published in RSE

SBG Modelling Working Group

- Team: Ben Poulter, Shawn Serbin, and many community members
- Cross-mission modeling exchange
    - Data modeling and simulations working group established with ESA’s CHIME mission
        - Sharing of E2E workflows, synthetic data & instrument models
- Fall 2021 webinar series
    - September: Drs. Kerry Cawse Nicholson & Ann Raiho
        - Intrinsic dimensionality & algorithm performance trades
    - October: Dr Derek Posselt
        - OSSE studies for AOS Designated Observable
    - November: Dr Fabian Schneider
        - Spatial resolution effects on VSWIR retrievals

SBG Cal/Val Working Group

- Team: Kevin Turpie, Ray Kokaly, 100+ community members (government, industry and research institutions)

- Goals: Support mission development by recommending radiometric, thermal, spectral and geometric calibration and validation strategies and identifying resources, methods and standards supporting data product validation.

- Weekly meetings:
  - ~4-6 per general meetings year.
  - Webinar Series (weekly): 52 speakers on 2020 & 2021 schedules

- Recent Achievements:
  - Completed the 2021 Webinar Series; slides and records are available.
  - Developing manuscript regarding SBG Cal/Val concept for JGR-B.
  - Presenting at paper at AGU annual meeting.
  - Looking at SBG, CHIME, LSTM and TRISHA orbits and intercalibration opportunities.
  - Considering Cal/Val synergies with PACE and GLIMR.

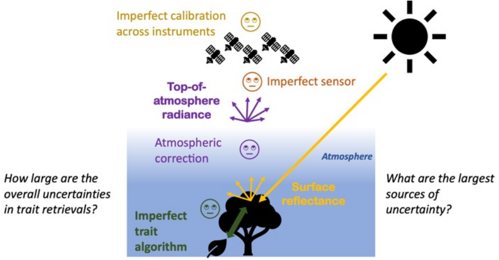
SBG Applications Group

- Team: Christine Lee, Jeff Luvall, Stephanie Uz, and 200+ community members
- Goals: Supports SBG mission development by recruit, coordinate and integrate input on applications needs, data product requirements and training/education and other needs
- Regular meetings:
  - ~8-12 per meetings and seminar talks per year
  - Slides and notes of past meetings are available
- Currently working with RTI International to develop SBG community assessments for urban heat and health, coral reef health, global food security, biodiversity, conservation, and deforestation/ reforestation.

Modeling End-to-End Traceability (MEET-SBG) Pathfinder

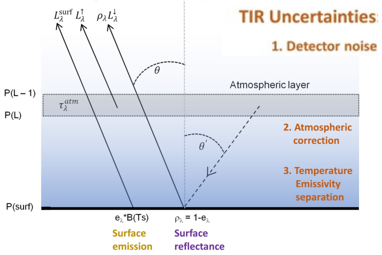
1) Hypertrace

- *Supporting VSWIR UQ traceability*



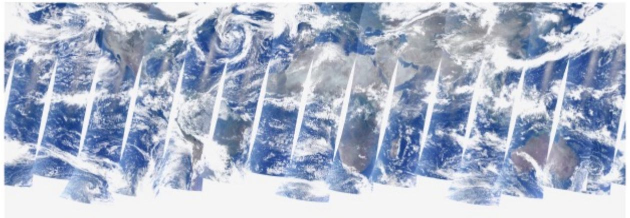
4) Temp. Emiss. Unc. Sim. (TeuSIM)

- *Supporting TIR UQ traceability*



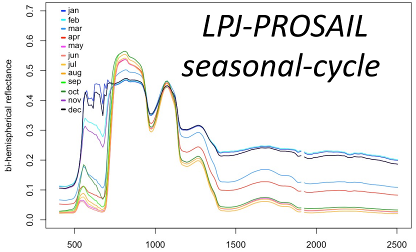
3) Ames Global Hyperspectral Synthetic Dataset (AGHSD)

- *Pre-launch global timeseries*



4) Observing System Simulation Exp.

- *Land-surface model data assimilation*



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

SISTER is an active collaboration between Jet Propulsion Laboratory (JPL), Ames Research Center (ARC), Goddard Space Flight Center (GSFC), industry, academic institutions, and non-profit organizations

Primary Objectives & Timeline

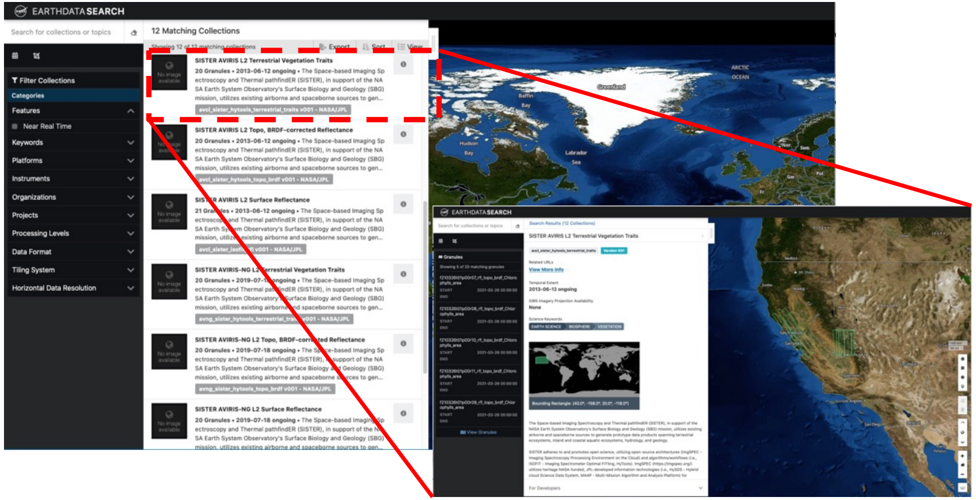
- Prototype architectures and workflows to generate prototype high-dimensional, high-value SBG data
- Distribute prototype SBG data for community evaluation and training

FY21 (Oct 2020 – Sept 2021)	FY22-23 (Oct 2021 – Sept 2023)	FY24-25 (Oct 2023 – Sept 2025)
Prototype workflows & system components	Implement select prototype L2B+ algorithms	Adapt workflows based on emerging SBG ATBDs
Deliverable: *Distribute land & water reflectance for community evaluation / feedback*	***Deliverable:*** *Distribute prototype L2B+ products for community evaluation / feedback*	***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
  - Hyperion L1 radiance and L2 reflectance in progress
- *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 workflows (e.g., aquatic, snow/ice, geology) will continuously be incorporated in FY22+*



12 Matching Collections

Showing 12 of 12 matching collections

SISTER AVIRIS L2 Terrestrial Vegetation Traits
20 Granules • 2013-06-12 ongoing • The Space-based Imaging Spectroscopy and Thermal pathfindER (SISTER), in support of the NASA Earth System Observatory's Surface Biology and Geology (SBG) mission, utilizes existing airborne and spaceborne sources to gen...
avcl_sister_hytools_terrestrial_traits v001 - NASA/JPL

SISTER AVIRIS L2 Topo, BRDF-corrected Reflectance
20 Granules • 2013-06-12 ongoing • The Space-based Imaging Spectroscopy and Thermal pathfindER (SISTER), in support of the NASA Earth System Observatory's Surface Biology and Geology (SBG) mission, utilizes existing airborne and spaceborne sources to gen...
avcl_sister_hytools_topo_brdf v001 - NASA/JPL

SISTER AVIRIS L2 Surface Reflectance
21 Granules • 2013-06-12 ongoing • The Space-based Imaging Spectroscopy and Thermal pathfindER (SISTER), in support of the NASA Earth System Observatory's Surface Biology and Geology (SBG) mission, utilizes existing airborne and spaceborne sources to gen...
avcl_sister_isofi[illegible]fl v001 - NASA/JPL

SISTER AVIRIS-NG L2 Terrestrial Vegetation Traits
20 Granules • 2019-07-18 ongoing • The Space-based Imaging Spectroscopy and Thermal pathfindER (SISTER), in support of the NASA Earth System Observatory's Surface Biology and Geology (SBG) mission, utilizes existing airborne and spaceborne sources to gen...
avng_sister_hytools_terrestrial_tra[illegible] v001 - NASA/JPL

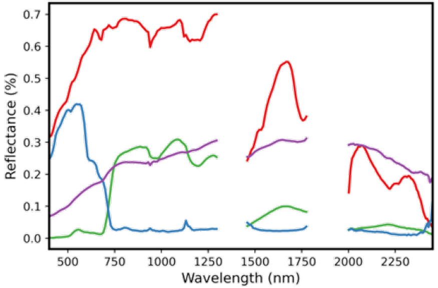
SISTER AVIRIS-NG L2 Topo, BRDF-corrected Reflectance
20 Granules • 2019-07-18 ongoing • The Space-based Imaging Spectroscopy and Thermal pathfindER (SISTER), in support of the NASA Earth System Observatory's Surface Biology and Geology (SBG) mission, utilizes existing airborne and spaceborne sources to gen...
avng_sister_hytools_topo_brdf v001 - NASA/JPL

SISTER AVIRIS-NG L2 Surface Reflectance
20 Granules • 2019-07-18 ongoing • The Space-based Imaging Spectroscopy and Thermal pathfindER (SISTER), in support of the NASA Earth System Observatory's Surface Biology and Geology (SBG) mission, utilizes existing airborne and spaceborne sources to gen...

SISTER: Prototyping SBG Algorithms using PRISMA and DESIS

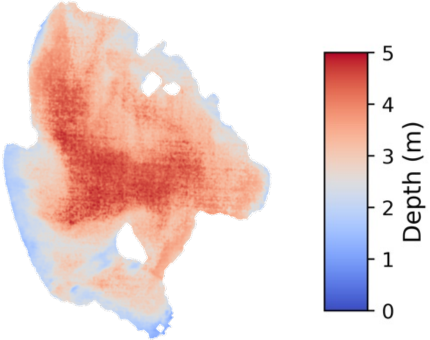
ISOFIT (Thompson et al. 2018)

PRISMA



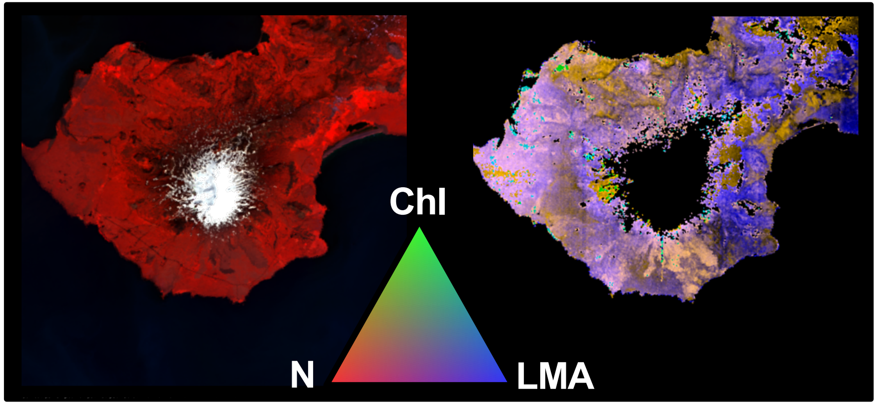
Bathymetry (Thompson et al. 2016)

DESIS Lago Trasimeno, Italy June 04, 2021



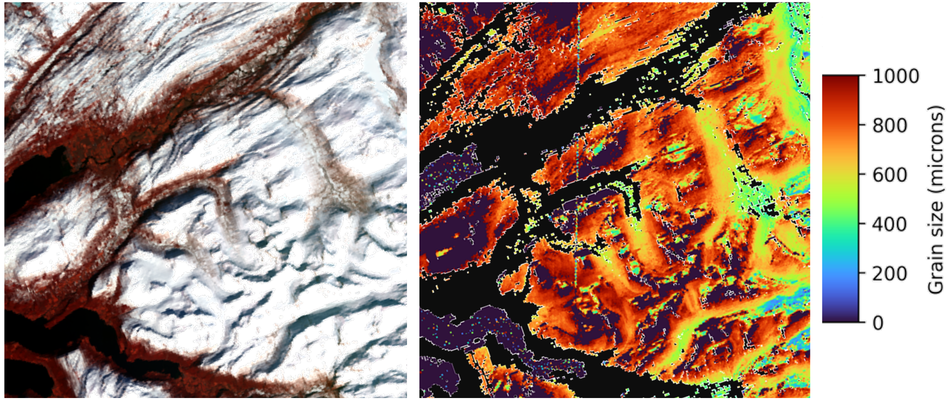
Vegetation Biochemistry

PRISMA Snæfellsjökull, Iceland July 02, 2020



Snow grain size (Nolin and Dozier 2000)

PRISMA Surnadal, Norway April 21, 2020



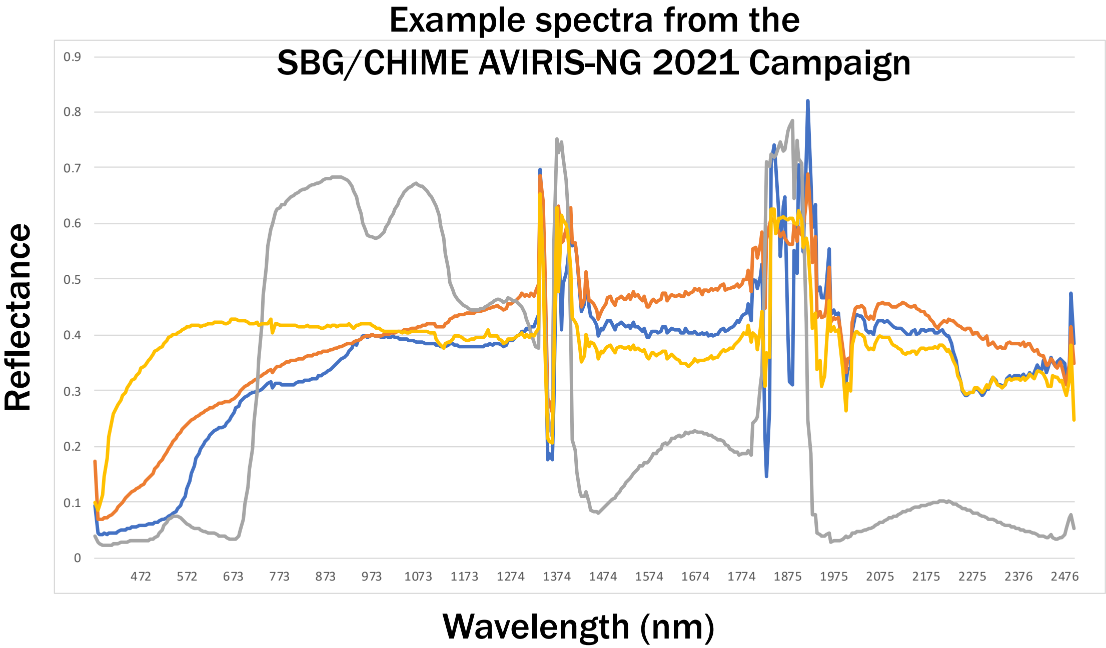
SBG-CHIME-UZH
2022
Joint Campaign

AVIRIS Next Generation

May – July
2022

180 flight hours
50+ sorties
9 countries

Dozens of
science field
teams



Example spectra from the SBG/CHIME AVIRIS-NG 2021 Campaign

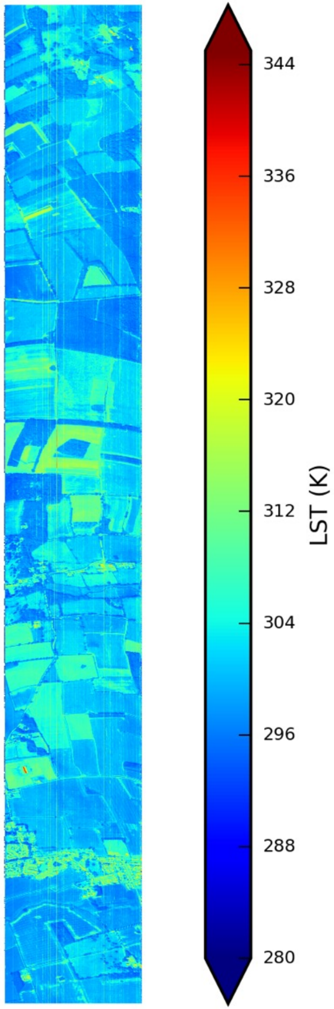
- Quicklooks and orthorectified radiances available at the JPL AVIRIS-NG data portal
- Reflectances processed with ISOFIT will be posted to the data portal soon

2021 HyTES Joint Campaign in the UK and Sweden

National Centre for
Earth Observation
NATURAL ENVIRONMENT RESEARCH COUNCIL

- July – August 2021
- 12+ sorties, hundreds of flight lines
- Products available at hytes.jpl.nasa.gov


New camera model for improved geolocation



Jet Propulsion Laboratory
California Institute of Technology

Intrinsic Dimensionality as a Metric for Mission Design

Kerry Cawse-Nicholson[1], Ann Raiho[2], Ben Poulter[2], David Schimel[1], David Thompson[1], Shannon Kian Zareh[1], Fabian Schneider[1], Philip Townsend[1], Kimberley Miner[1], Glynn Hulley[1], Charles Miller[1]

[1] Jet Propulsion Laboratory, California Institute of Technology
[2] NASA Goddard Space Flight Center

Intrinsic Dimensionality

- Defined as the dimension of the signal subspace (the number of image covariance eigenvalues greater than some threshold defined by noise)
- Can be thought of as the number of unique pieces of information contained in spectroscopic data (principal components)
- Hypothesis that ID can be used as a metric for science content as the result of different architectural decisions.

Intrinsic Dimensionality

$$X = S + \Delta$$

Image

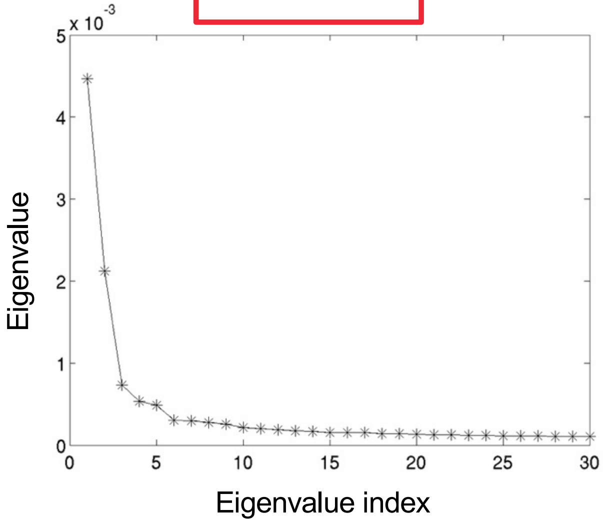
Signal

Noise

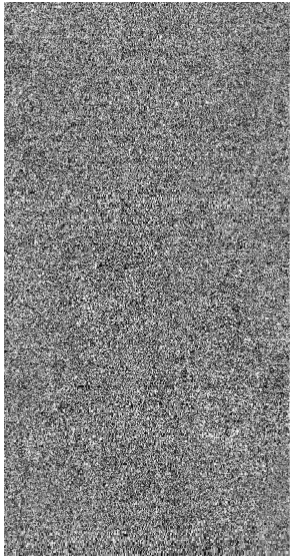
(Assuming centered and scaled data)

Principal component K

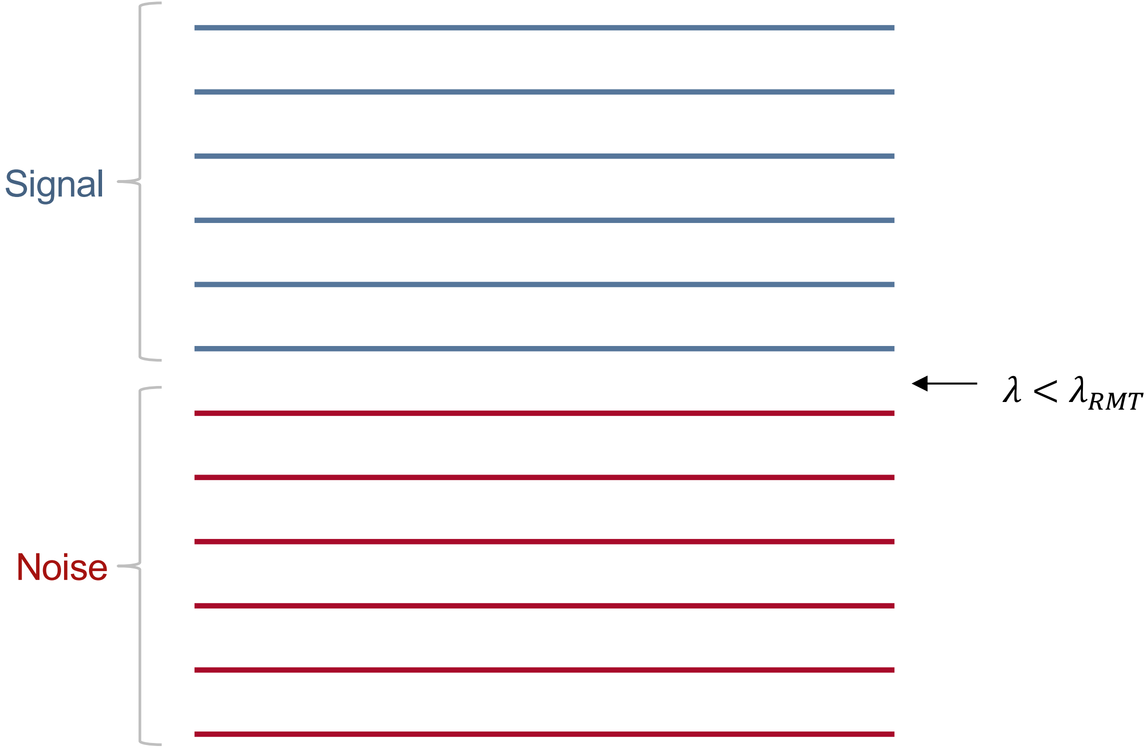
$$\boxed{X\,X^T}$$



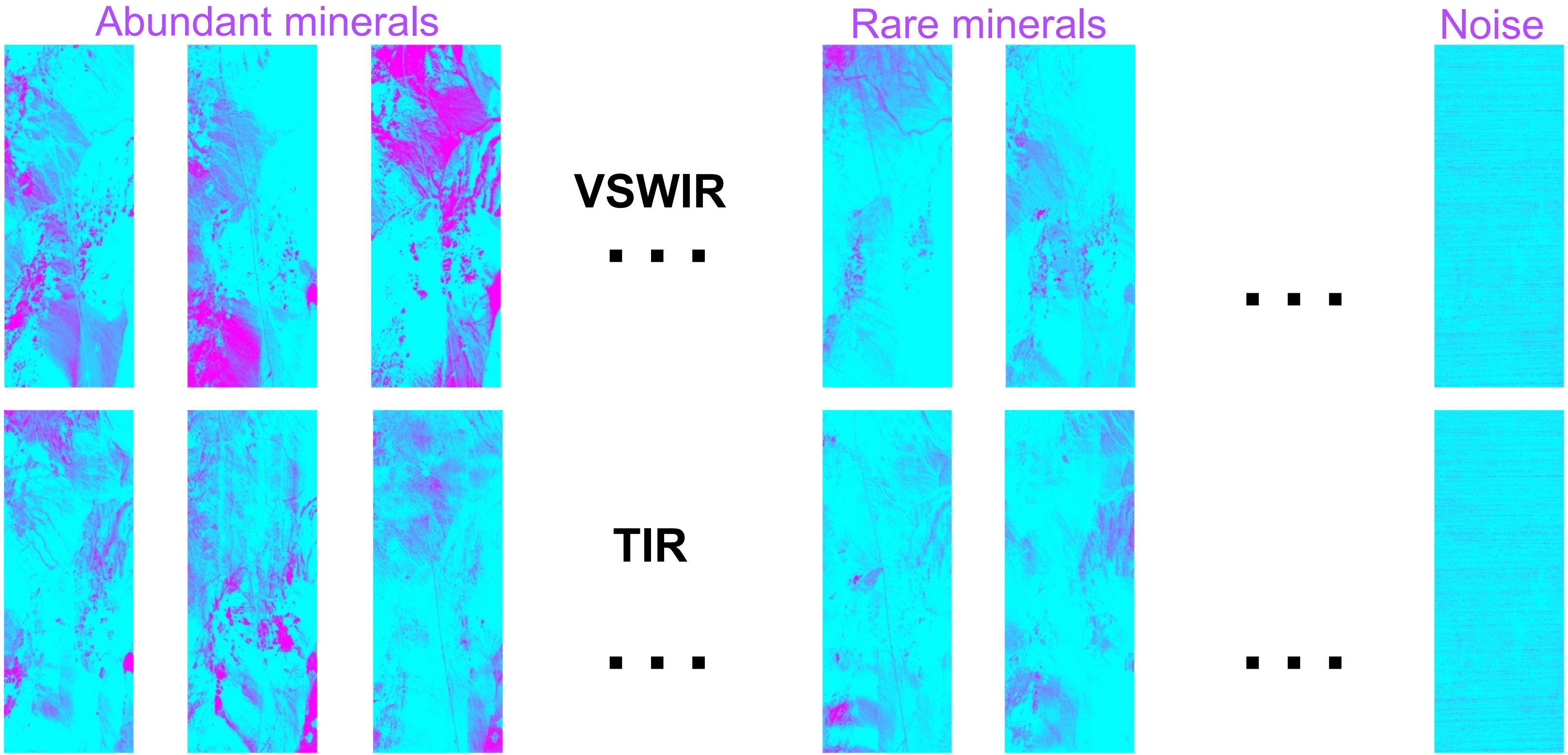
Principal component K+1



Random Matrix Theory



Visualizing dimensionality



Abundant minerals

Rare minerals

Noise

VSWIR

. . .

. . .

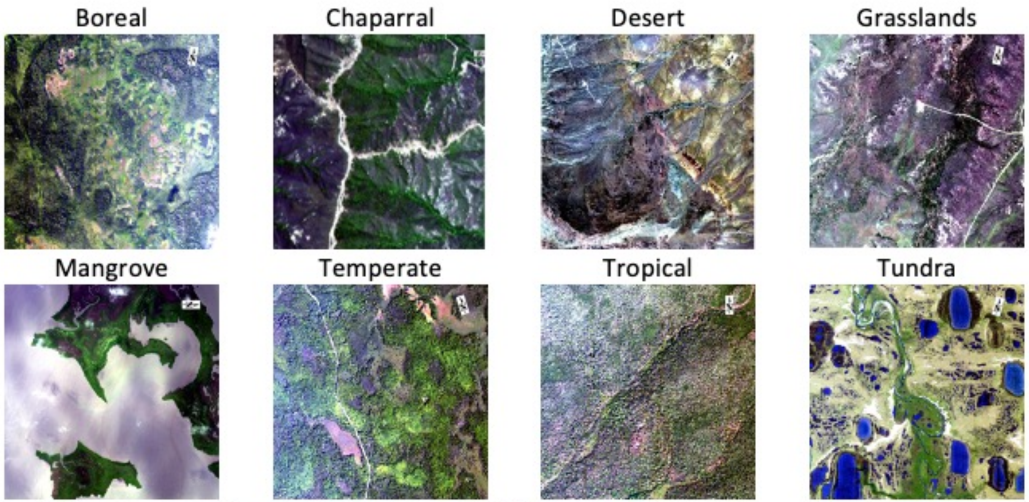
TIR

. . .

. . .

Airborne data used for this study

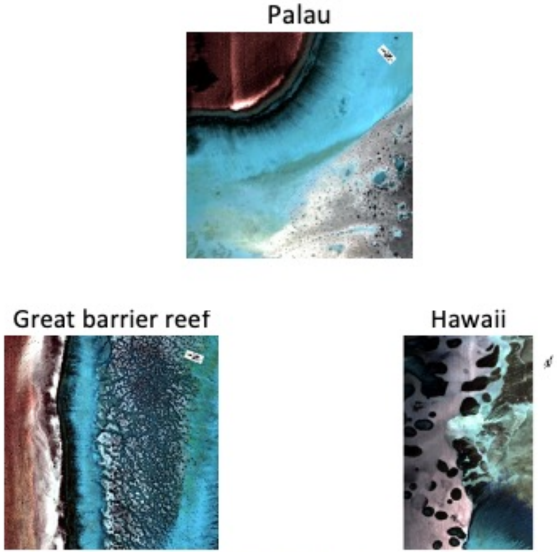
- NEON Sites: OSBS, UNDE, KONZ, DELA, SOAP, TEAK
- AVIRIS-NG and PRISM



Boreal Chaparral Desert Grasslands

Mangrove Temperate Tropical Tundra

Figure 1: RGB composites of subsets of AVIRIS-NG images over 8 different biomes.

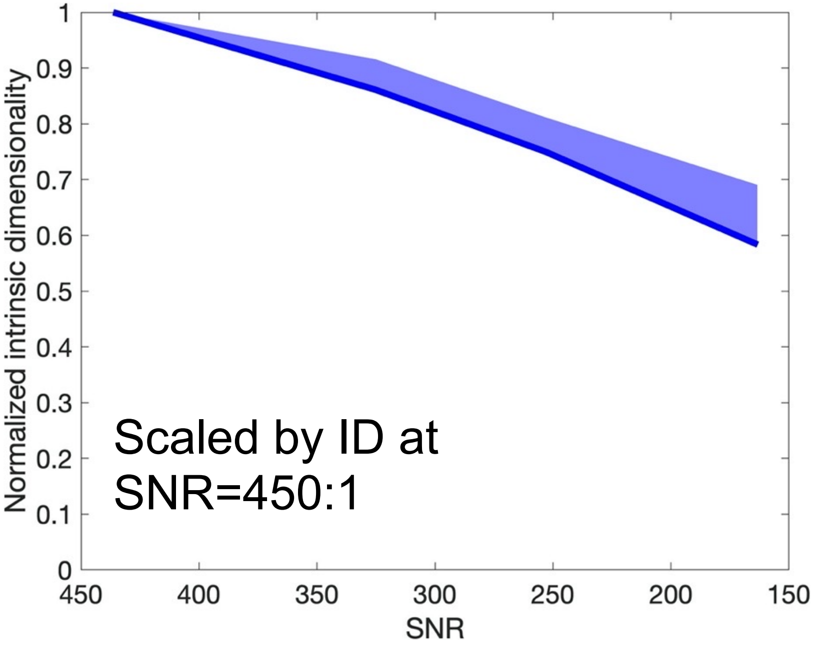


Palau

Great barrier reef Hawaii

Figure 2: RGB composites of subsets of PRISM images over three different regions.

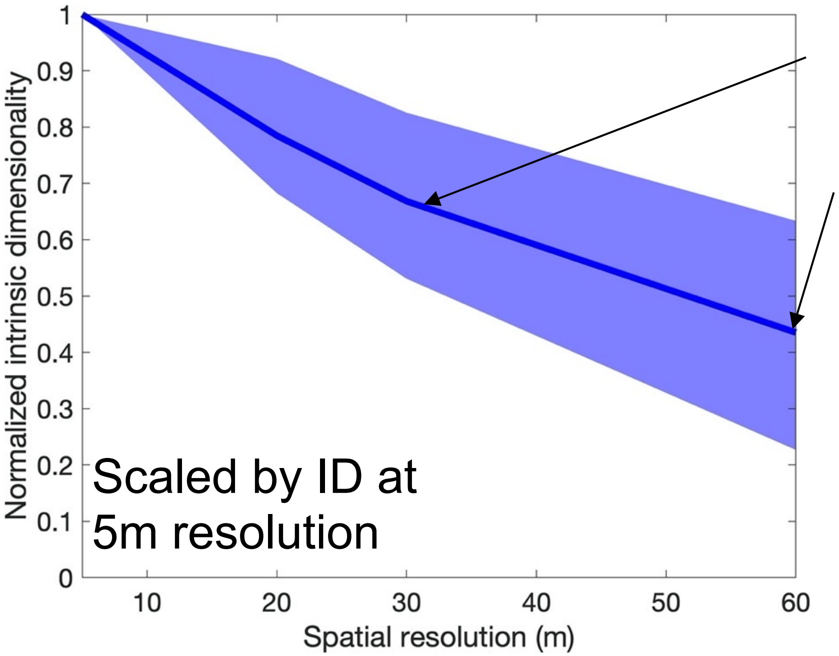
Information content as a function of noise



Scaled by ID at SNR=450:1

Scenes with wide, distinct spectral features are less significantly impacted by noise

Information content as a function of spatial resolution

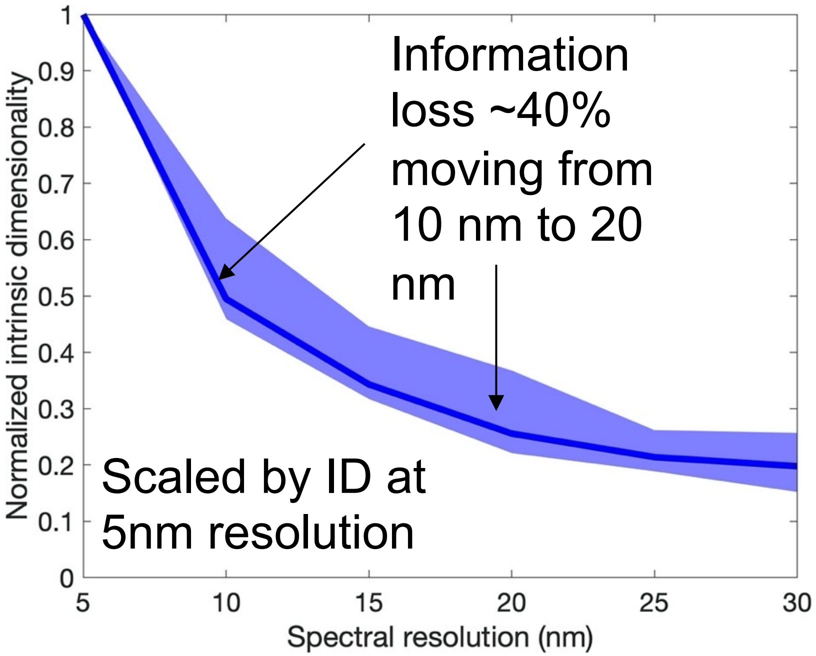


Scaled by ID at 5m resolution

~30% information loss moving from 30 m to 60 m

Data loss varies widely by scene heterogeneity

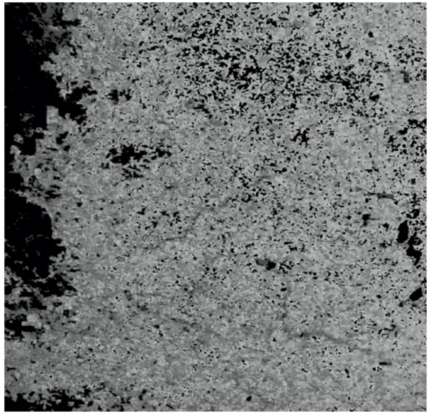
Information content as a function of spectral resolution



Information loss ~40% moving from 10 nm to 20 nm

Scaled by ID at 5nm resolution

VIIRS data for temporal analysis



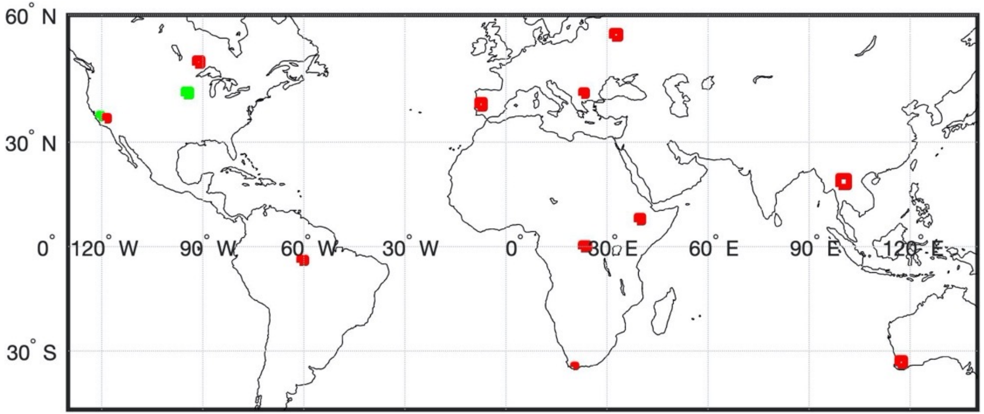
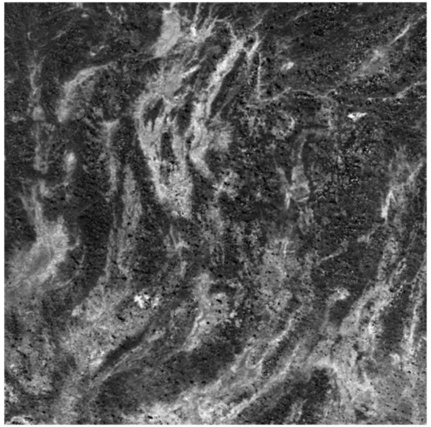
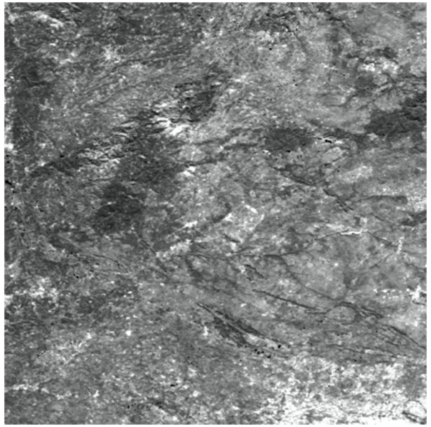
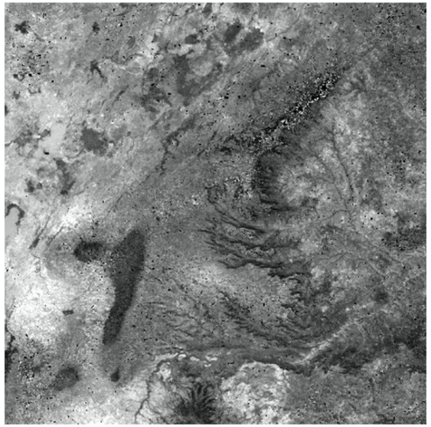
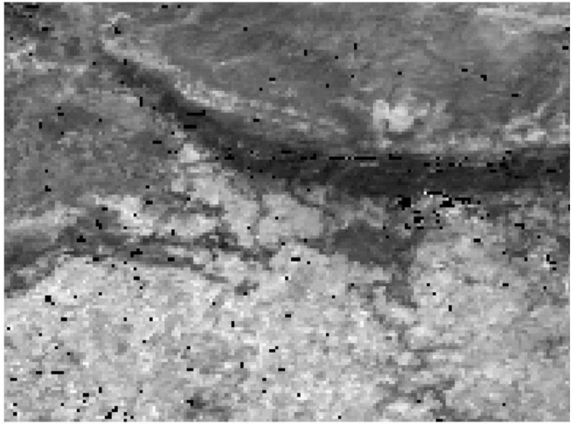


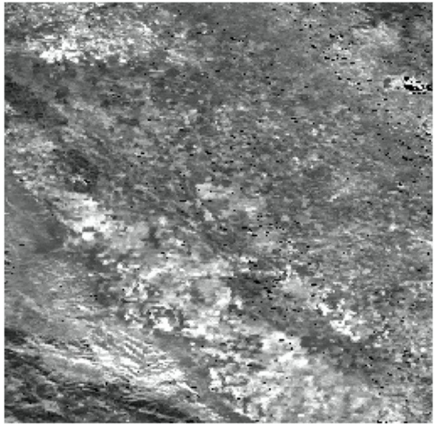
Figure 1: The biodiversity hotspots (red) and agricultural regions (green) selected for temporal dimensionality evaluation.



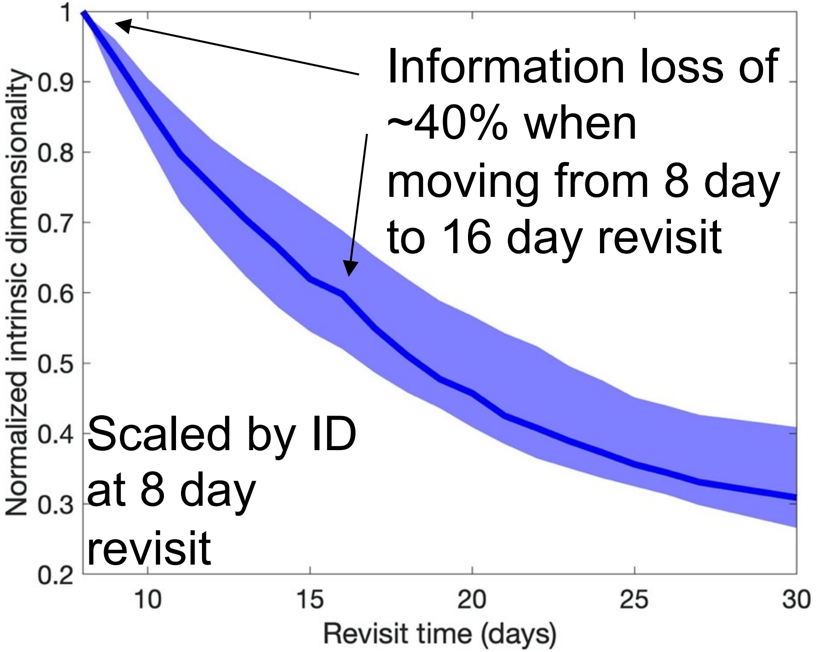








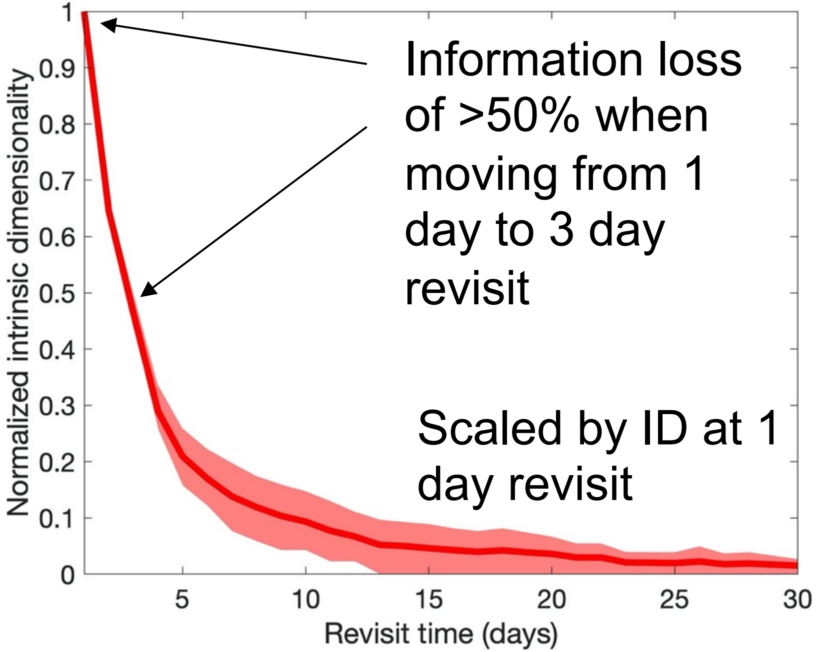
Information content as a function of revisit



ID for VSWIR

Information loss of ~40% when moving from 8 day to 16 day revisit

Scaled by ID at 8 day revisit



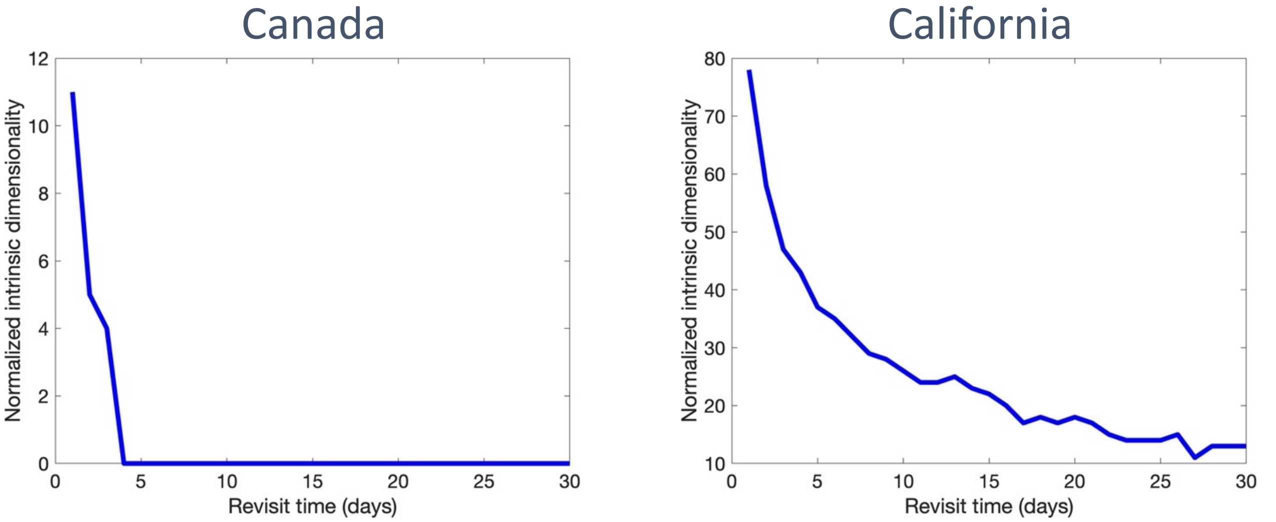
ID for TIR

Information loss of >50% when moving from 1 day to 3 day revisit

Scaled by ID at 1 day revisit

Shading represents the 25th and 75th percentile, and the solid line represents the median

Cloudiness impacts information content

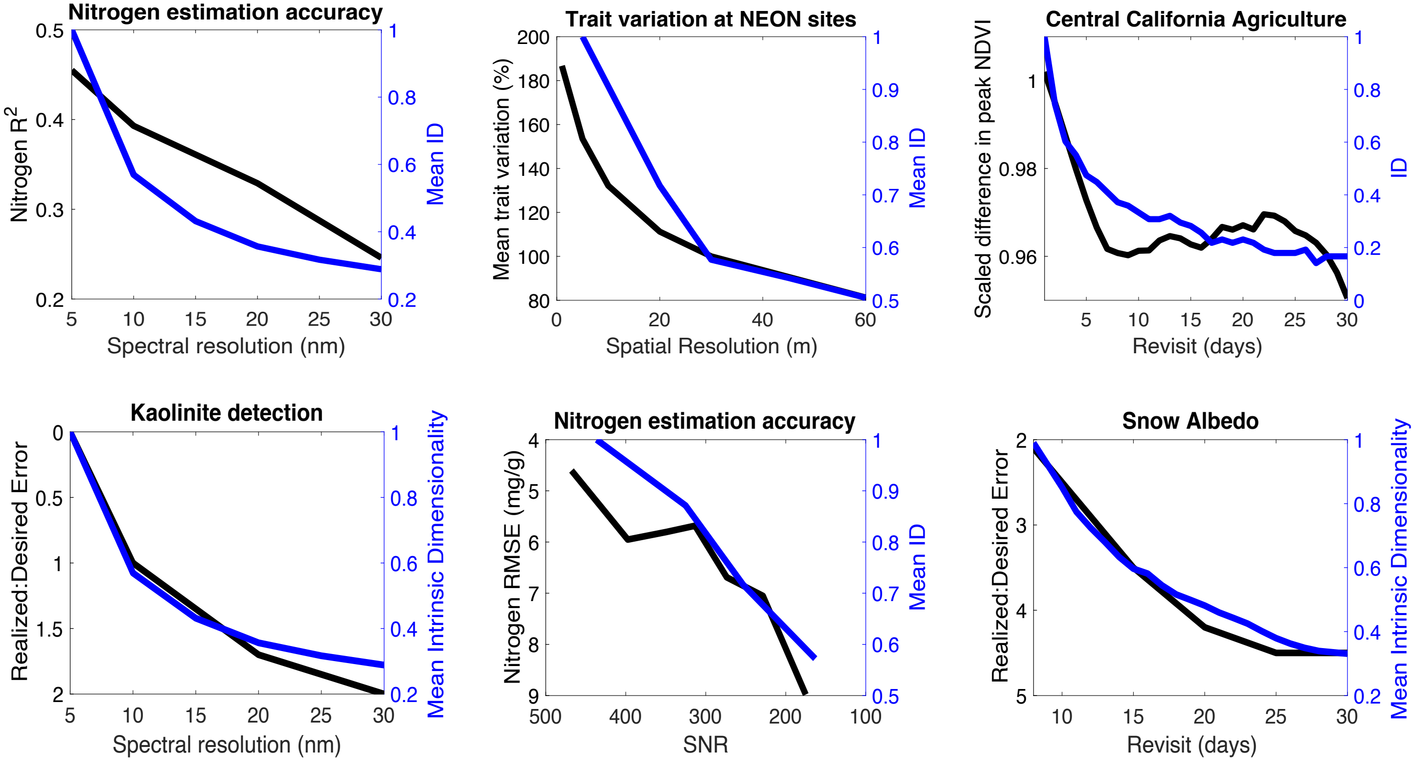


Canada

California

(Left) Temporal dimensionality in the visible quickly approaches zero in Canada, whereas some information is still obtainable even at higher revisits in California (right).

Intrinsic dimensionality covaries with physical variables



Ann Raiho, Fabian Schneider, Ting Zheng, Kyle Kovach

Summary

- Intrinsic dimensionality is an application-agnostic metric that can be can be used to integrate across the diverse geophysical parameters that may be retrieved from imaging spectrometers, rather than analyzing performance targets algorithm by algorithm
- ID decreases with increasing pixel size, increasing spectral bandwidth, decreasing revisit frequency, and decreasing signal to noise ratio

Jet Propulsion Laboratory
California Institute of Technology

jpl.nasa.gov

Jet Propulsion Laboratory
California Institute of Technology

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jpl.nasa.gov

PRISMA Mission update

Ettore LOPINTO – ASI

Prepared by: E. Lopinto, P. Sacco

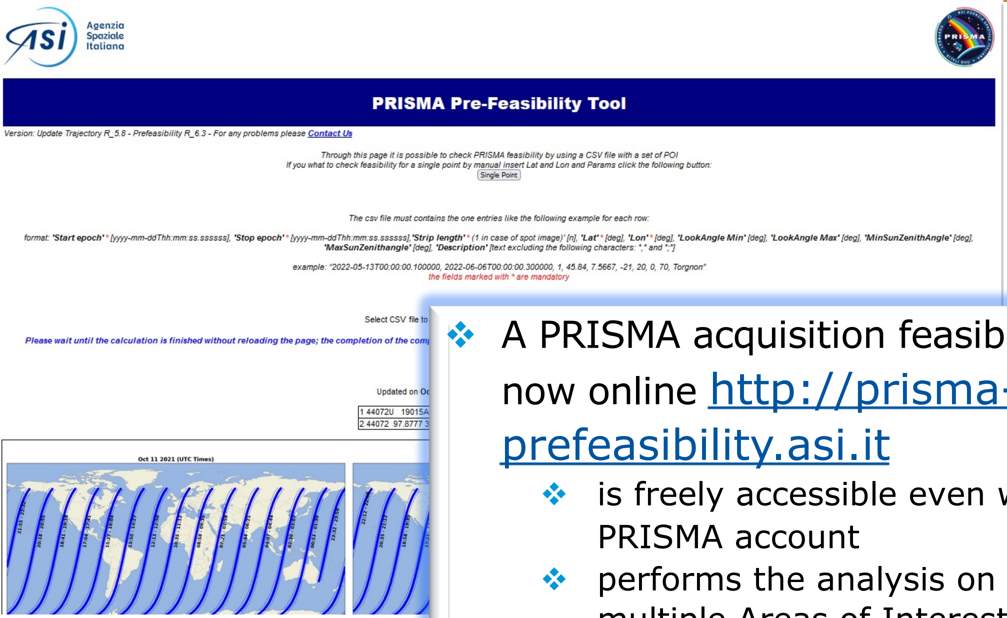
Acquisitions on CHIME sites

Site name							
211_AVIRIS_2020_LAEGE					1		1
235_AVIRIS_2020_PicStLoup	2				1		3
344_AVIRIS_2021_Huensrueck					1	1	2
345_AVIRIS_2021_Irlbach					1	1	2
346_AVIRIS_2021_Braccagni	4	4			1	1	10
348_AVIRIS_2021_Biancane	4						4
351_AVIRIS_2021_BNP					1		1
353_AVIRIS_2021_VeniceLagoon					1		1
355_AVIRIS_2021_Amyntaio		2	2		2		6
357_AVIRIS_2021_Anzecolar	2				1		3
359_AVIRIS_2021_Puechabon_6m	4	2	2		1		9
362_AVIRIS_2021_LaCalvilla	4	4	6	2	1	1	18
366_AVIRIS_2021_Desfina	4				2	1	7
371_AVIRIS_2021_FlowCountry	2	2			1		5
372_AVIRIS_2021_Dmmin	2				1		3
373_AVIRIS_2021_SeleRiver	2				1		3
374_AVIRIS_2021_Camarena	2				1	1	4
378_AVIRIS_2021_Jolanda	2	4			1		7
408_AVIRIS_2021_Evo	4				1		5
418_AVIRIS_2021_Kokkino	2				1		3
420_AVIRIS_2021_Veleuwe	2						2
Total acquisitions	42	18	10	2	21	6	99

- European ESA CHIME sites acquisitions with requests in the period 1-May to 31 Jul, performed at high priority and every 2 weeks
- Continued since today, but at a lower priority (the same used for the near #600 sites of interest routinely acquired worldwide) and with one request each month
- 99 Acquisitions on the CHIME sites from 01-May up to 11-Oct
- Acquisitions with these modalities will continue up to end of Oct 2021

Improvements

- The «quasi-Open» data policy will be further expanded, in order to also allow the commercial exploitation of the products but still maintaining the data completely free of charge (even for these applications)
- Specific rules will apply, e.g. based on nationality of the users, but are yet to be frozen (target is end of 2021)



Agenzia Spaziale Italiana

PRISMA Pre-Feasibility Tool

Version: Update Trajectory R_5.8 - Prefeasibility R_6.3 - For any problems please ***Contact Us***

Through this page it is possible to check PRISMA feasibility by using a CSV file with a set of POI
If you what to check feasibility for a single point by manual insert Lat and Lon and Params click the following button:

The csv file must contains the one entries like the following example for each row:

format: ***'Start epoch'*** * *[yyyy-mm-ddThh:mm:ss.ssssss],* ***'Stop epoch'*** * *[yyyy-mm-ddThh:mm:ss.ssssss],****'Strip length'*** * *(1 in case of spot image)' [n],* ***'Lat'*** * *[deg],* ***'Lon'*** * *[deg],* ***'LookAngle Min'*** *[deg],* ***'LookAngle Max'*** *[deg],* ***'MinSunZenithAngle'*** *[deg],* ***'MaxSunZenithangle'*** *[deg],* ***'Description'*** *[text excluding the following characters: "," and ";"]*

example: "2022-05-13T00:00:00.100000, 2022-06-06T00:00:00.300000, 1, 45.84, 7.5667, -21, 20, 0, 70, Torgnon"
*the fields marked with * are mandatory*

Select CSV file to

Please wait until the calculation is finished without reloading the page; the completion of the com

Updated on Oc

```
1 44072U   19015A
2 44072  97.8777 3
```

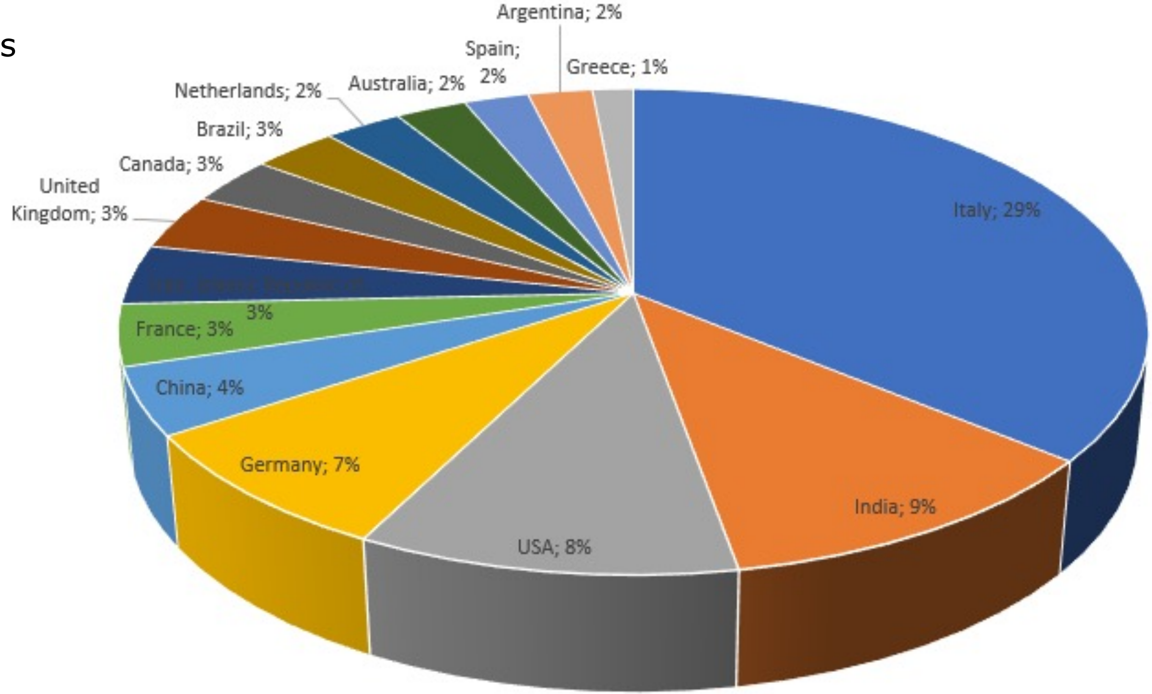
- A PRISMA acquisition feasibility tool is now online http://prisma-prefeasibility.asi.it
  - is freely accessible even without a PRISMA account
  - performs the analysis on a single or multiple Areas of Interest (AoI) described by the lat,lon of their central point
  - gives in output the UTC time at which the satellite has in view the AoI plus characteristic parameters of that view (roll angle, solar zenith angle)

Mission Statistics – User amount & nationality

998 Licenses to Use activated @ 11.10.2021

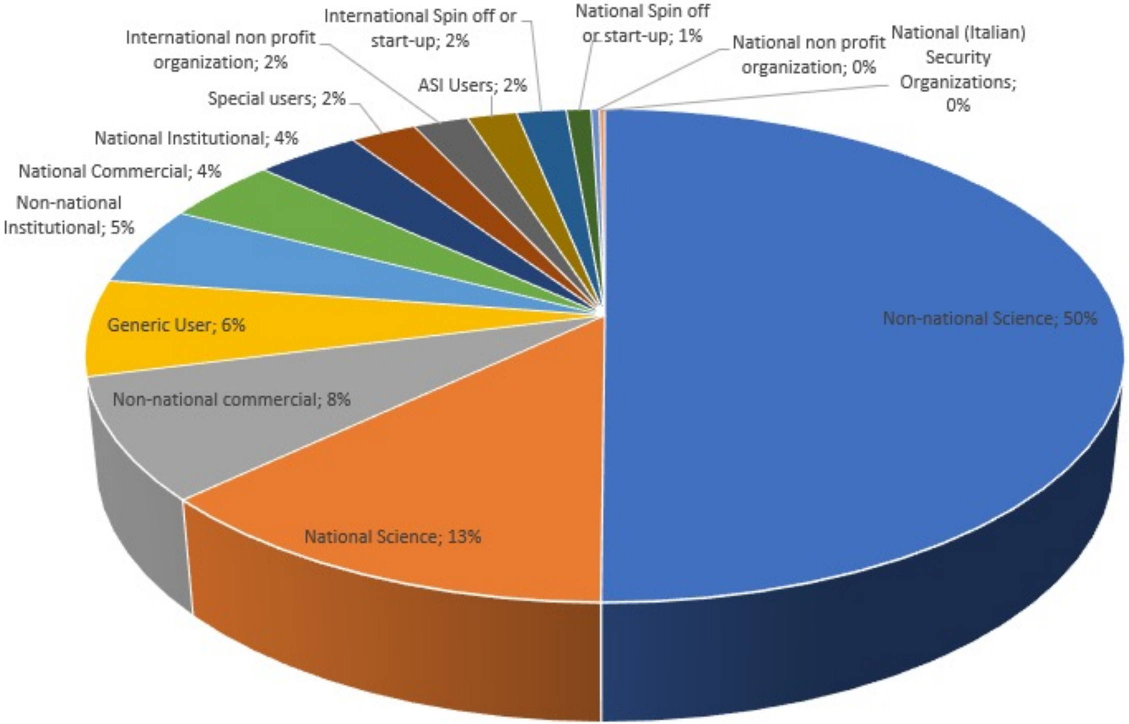
Showing the (statistically) most representative part of the user population:

- 15 nations covers **80%** of the users
- the Italian users are only **1/3**
- India, USA and Germany together account the **1/4** of the users

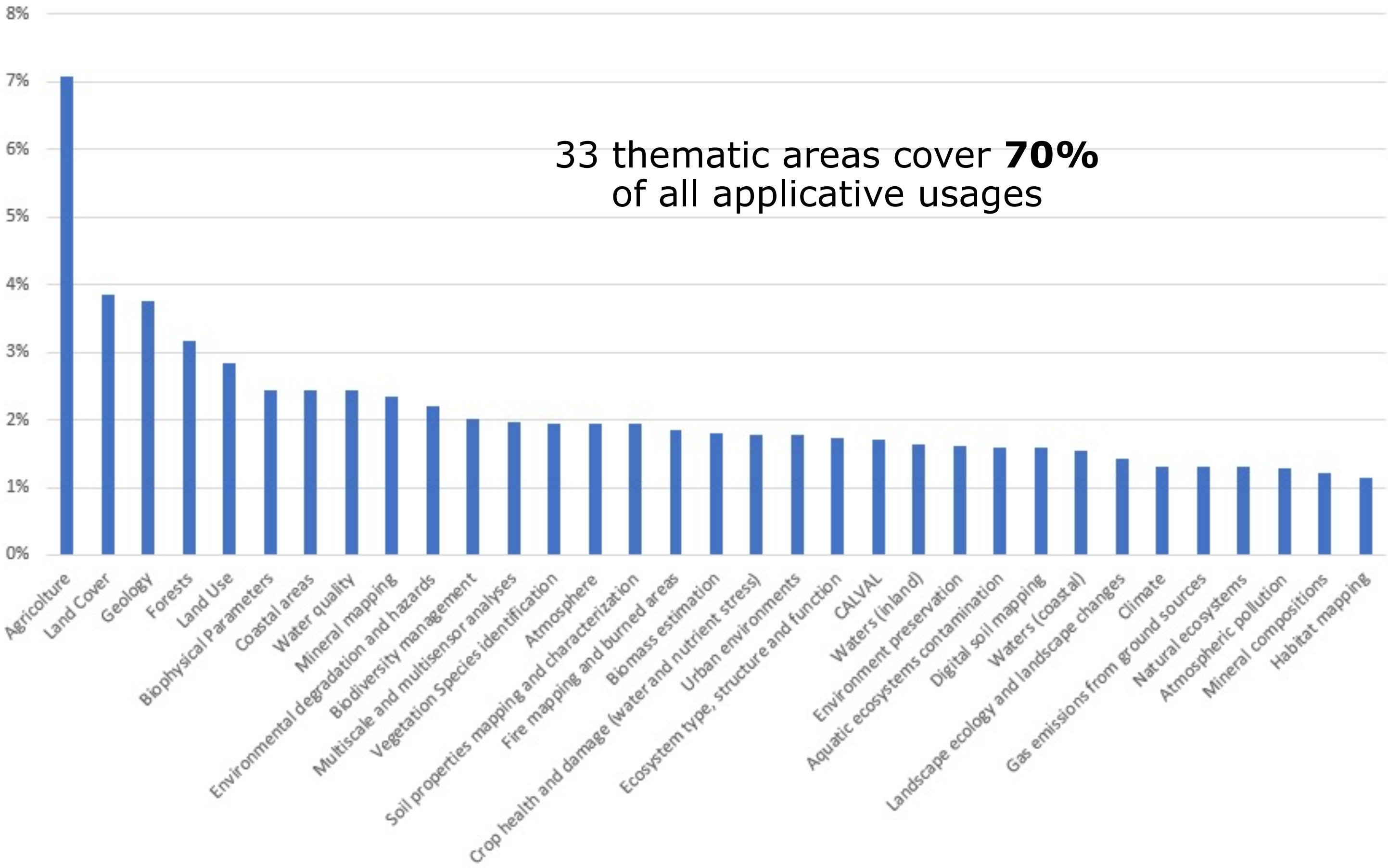


Mission Statistics – User category

- **63%** of the total users are scientists (**50%** of the users belongs to non-Italian Science and is the largest category)
- Institutional (**9%**) and commercial (**12%**) represents **21%** of total users
- Foreign commercial (**8%**) is two times the Italian commercial (**4%**)
- **6%** of user are still freelance!

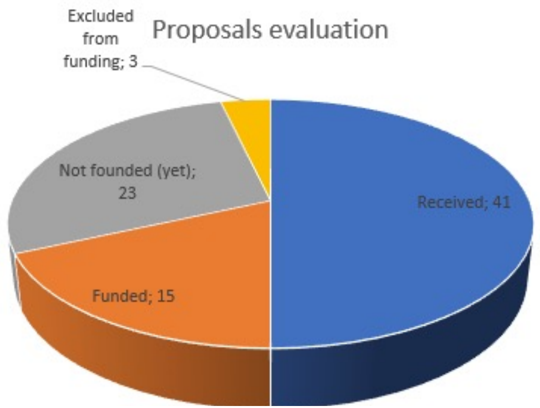


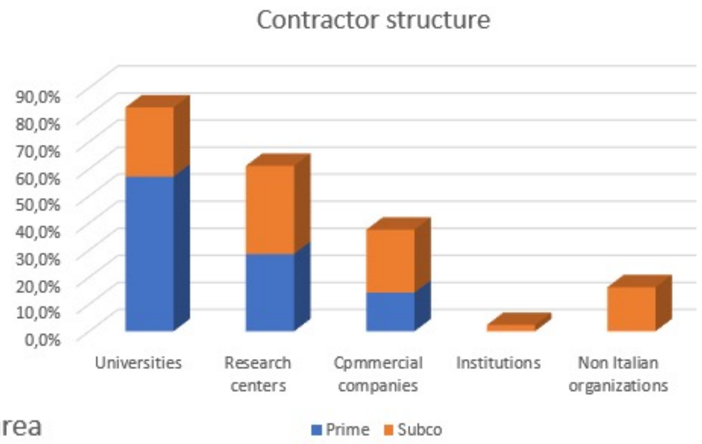
Mission Statistics – Use of data

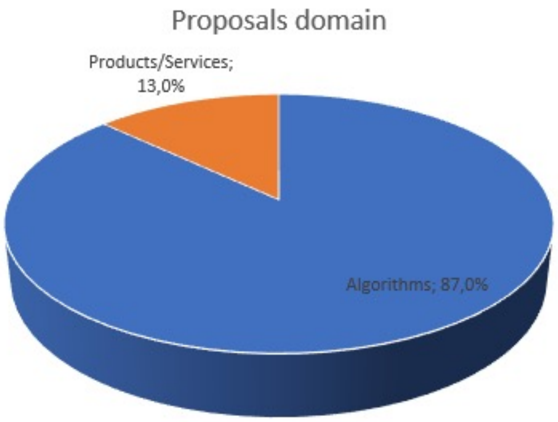


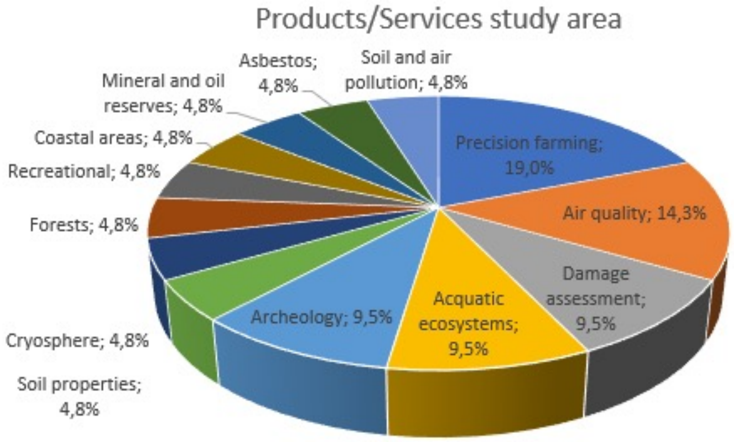
33 thematic areas cover **70%** of all applicative usages

PRISMA SCIENZA





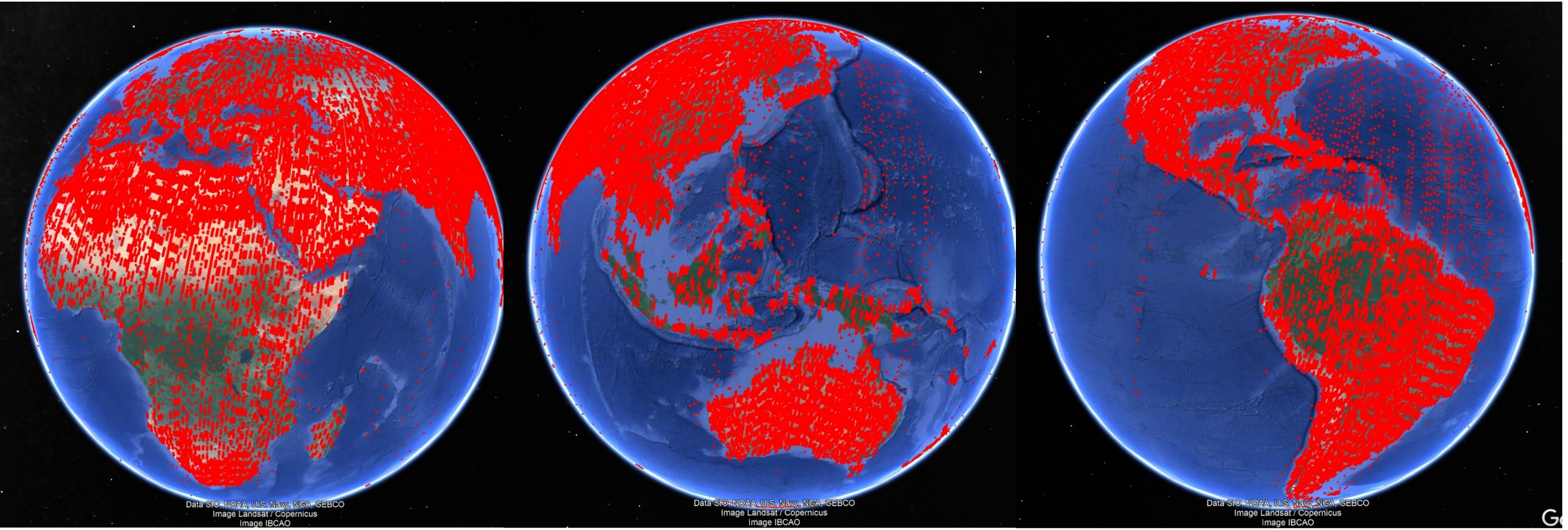




PRISMA scientific program, co-funded by ASI

- Budget ~3 M€ with max co-fund 200k€/proposal
- 41 proposal received, 15 will be (co-) funded, 23 are eligible
- Largest participation came from universities with algorithmic studies
- 5 themes accounts for 60% of study areas

Mission Statistics



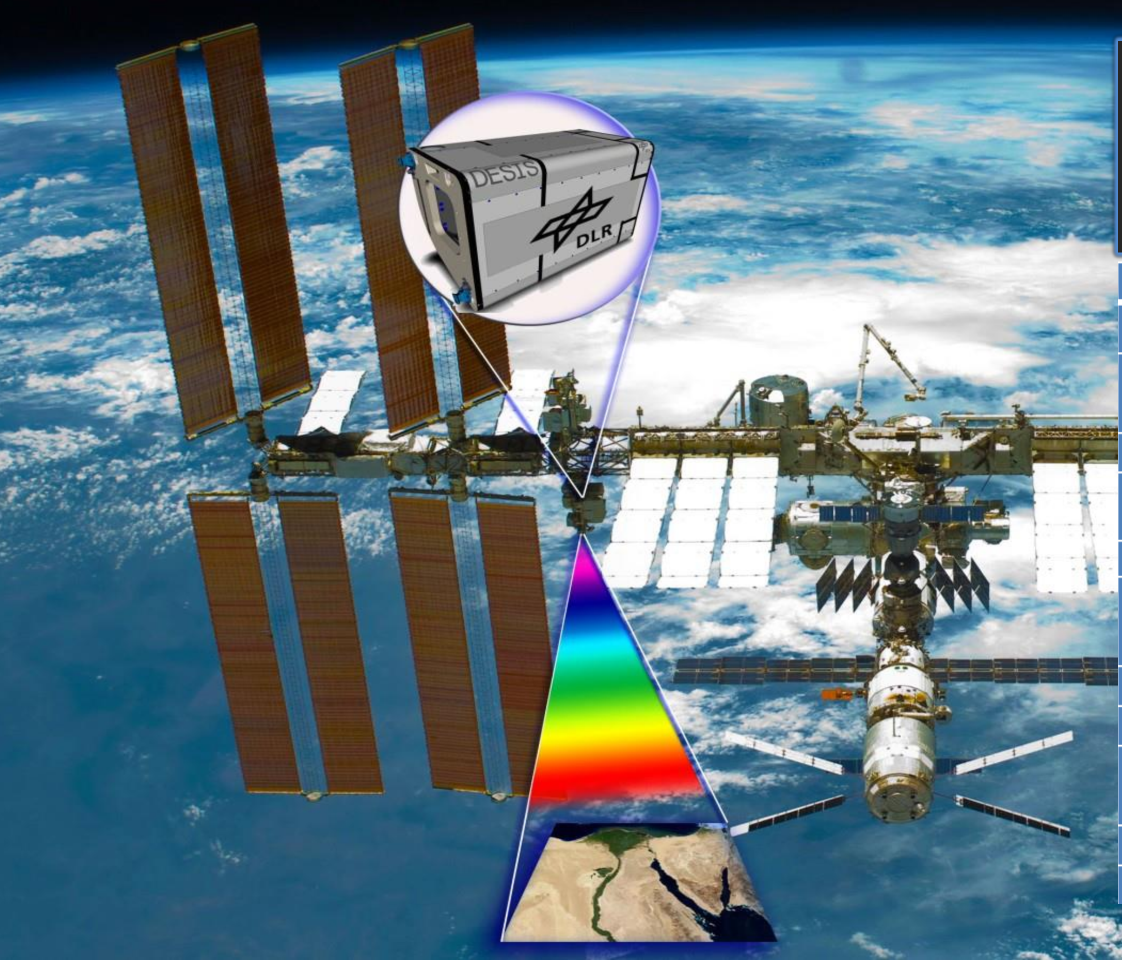
110k images (including those from the background mission) all over the world @31.08.2021; a new approach to background planning is going to be used to improve global land coverage

portal:
https://prisma.asi.it

Info, contacts, inquiries:
prisma_missionmanagement@asi.it

DESIS Mission - Update

German Aerospace Center (DLR)
12.10.2021, Online

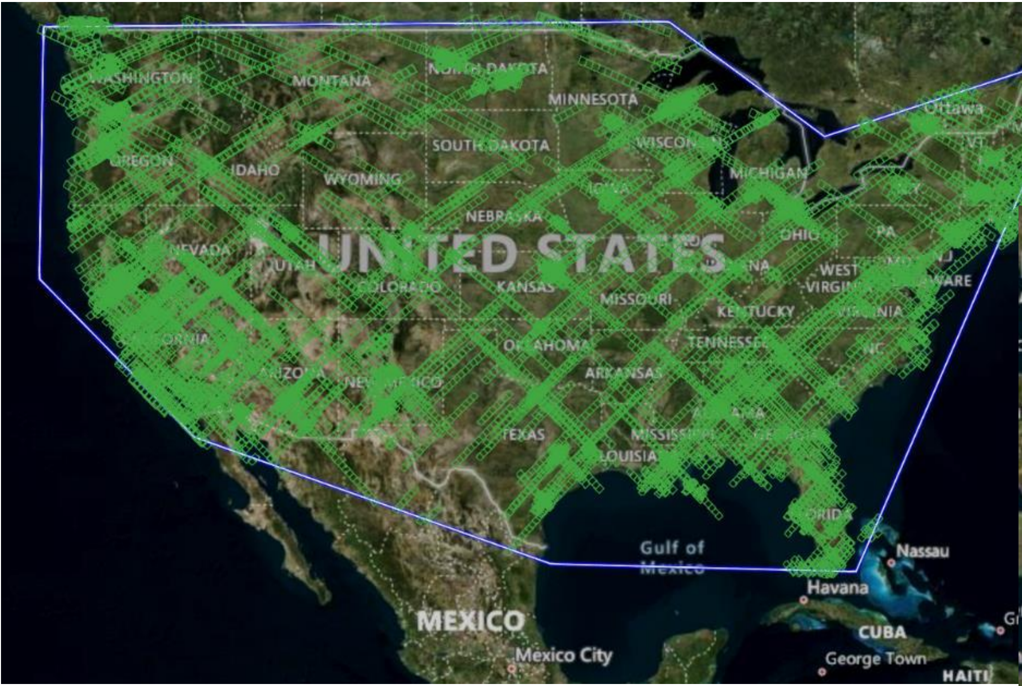


Teledyne Brown Engineering (USA) and **DLR** (Germany) have partnered to build and operate the **D**LR **E**arth **S**ensing **I**maging **S**pectrometer (**DESIS**) attached to the **M**ulti-**U**ser **S**ystem for **E**arth **S**ensing (**MUSES**) Platform on the ISS

Mission Instrument	**MUSES/DESIS**
Target lifetime	2018-2023
Off-nadir tilting (across-track, along-track)	-45° (backboard) to +5° (starboard), -40° to +40° (by MUSES and DESIS)
Spectral range	400 nm to 1000 nm
Spectral Sampling (res., acc.,bands)	2.55 nm, 0.5 nm, 235 bands. Binning: 118 , 79 , 60 bands
Spectral response	Gaussian shape, 3.5 nm FWHM
Software Binning (sampling distance, number bands)	Binning 2 (5.1 nm, 118 bands) Binning 3 (7.6 nm, 79 bands) Binning 4 (10.1 nm, 60 bands)
Radiometry (res., acc.)	13 bits, ~10%
Spatial (res., swath)	30 m, 30 km (@ 400 km)
SNR (signal-to-noise)	195 (w/o bin.) / 386 (4 bin.) @ 550 nm
Instrument (mass)	93 kg
Capacity (km, storage)	2360 km per day, 225 GBit

DESIS Status Acquisitions

- 27 August 2018 installed on International Space Station
- Since that time, DESIS has been providing hyperspectral data



World (Status July 2021)	
~60.000	scenes processed
<35%	of the land surface of the Earth
~29 TB	data in the archive

Note: DESIS is not a mapping mission

CHIME – ESA's imaging spectroscopy Copernicus mission

Different sites across Europe serving for different application

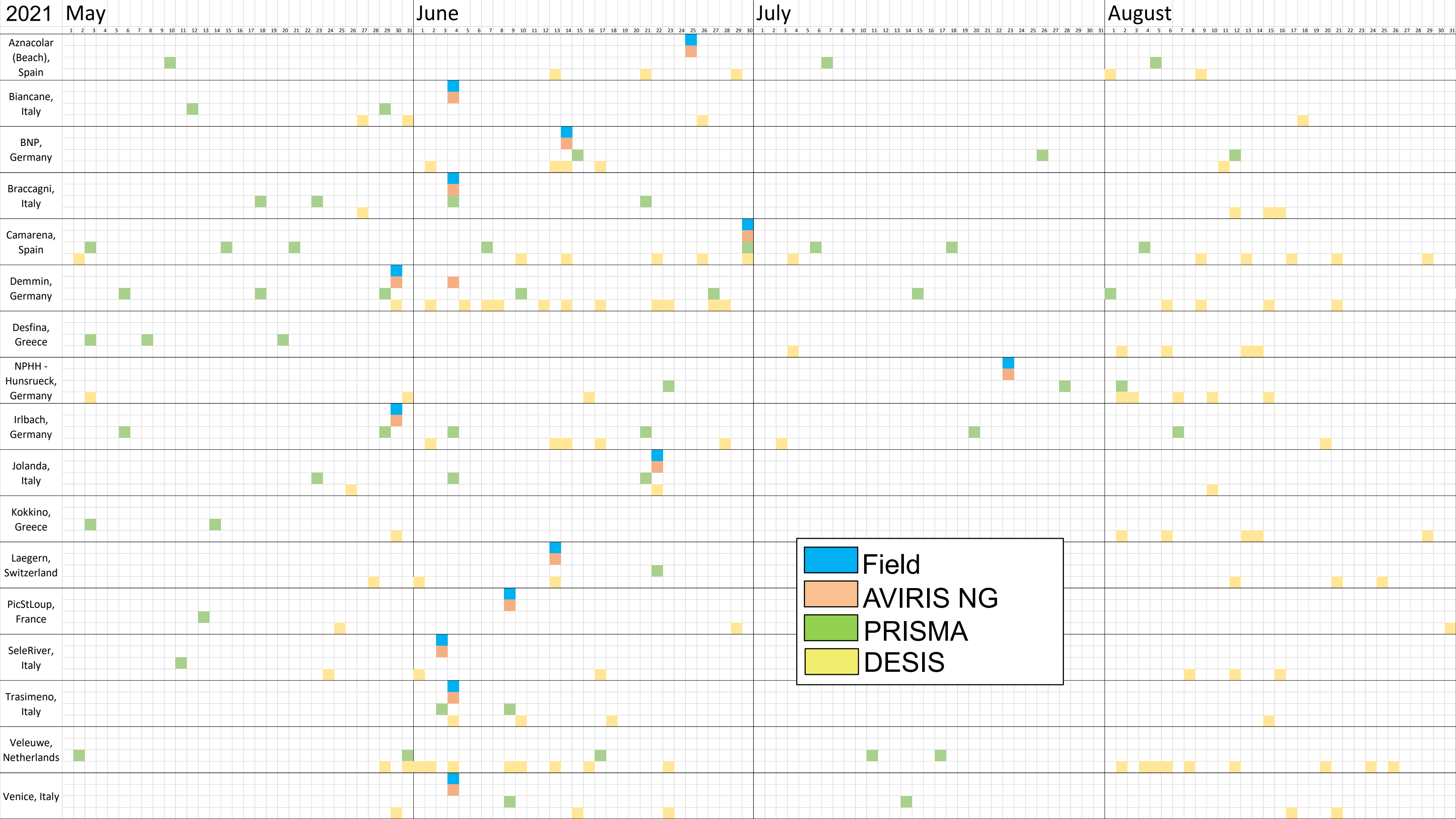
Each CHIME site is supported by a CHIME MAG member

CHIME preparatory campaign in 2020 and 2021

Supported by field, airborne and spaceborne measurements

12 High Priority Prototype Products (HPPPs) to cover initial key products (e.g. Canopy nitrogen, Soil Organic Carbon, Kaolonite) for potential operational development


27 sites across Finland, France, Germany, Spain, UK, Italy, Netherlands and Switzerland


2021
May
June
July
August
Aznacolar (Beach), Spain
Biancane, Italy
BNP, Germany
Braccagni, Italy
Camarena, Spain
Demmin, Germany
Desfina, Greece
NPHH - Hunsrueck, Germany
Irlbach, Germany
Jolanda, Italy
Kokkino, Greece
Laegern, Switzerland
PicStLoup, France
SeleRiver, Italy
Trasimeno, Italy
Veleuwe, Netherlands
Venice, Italy
Field
AVIRIS NG
PRISMA
DESIS

1st DESIS User Workshop

1st DESIS User Workshop

September 28th to October 1st, 2021

Virtual event

- 235 registrations
- 30 nations
- 53 presentations
- 10 sessions on 4 days

DLR responsible for scientific exploitation

Topic	# of Proposals
Urban Thematic Exploitation & Material Composition	2
Landcover & vegetation	6
Water Resources	7
Ocean Applications	4
Coastal Applications	7
Calibration	1
Natural Resources	9
Geology	4
Biodiversity	2
Others (e.g. methods development, data fusion)	4

~39% are related to water applications; VNIR (400 – 1000nm) & 2.5 nm spectral sampling

1st DESIS User Workshop - Outcome

- Wide range of applications even DESIS is only sensitive in the VNIR
- Tendency to use multitemporal data in order to map Earth system processes
  => data quality needs to be consistent over time
- ISS as EO platform with a complex observation geometry needs new ideas in data evaluation
  => e.g. value of acquisitions of different times during the day for photosynthesis analyses of vegetation
- Data access could be more automatized – up to date technology (APIs), data provisions on processing platforms such as HPC (High Performance Computing) …
- Less studies from ML/AI domain – why?

- Use of a new sensor that is available needs time – several studies emphasize that they are preliminary, DESIS as stimulator for more regular use of such data and method development? Good outlook for EnMAP, EMIT, CHIME, SBG …

1st DESIS User Workshop - Outcome

Important – clear explanation necessary about:

- manufacturing defects
- rapid change of performance below 450 nm
- limitation in automatic geolocation
- zero or negative values in L2A spectra
- the AOT uncertainties and the uncertainties in the BOA
- L2A processing over water pixels (put more effort into correction/ validation of water pixels / dark pixels)

sensors

MDPI

Article

Data Products, Quality and Validation of the DLR Earth Sensing Imaging Spectrometer (DESIS)

Kevin Alonso [1], Martin Bachmann [2], Kara Burch [3], Emiliano Carmona [1], Daniele Cerra [1], Raquel de los Reyes [1], Daniele Dietrich [2], Uta Heiden [2], Andreas Hölderlin [4], Jack Ickes [5], Uwe Knodt [6], David Krutz [7], Heath Lester [5], Rupert Müller [1,*], Mary Pagnutti [3], Peter Reinartz [1], Rudolf Richter [1], Robert Ryan [3], Ilse Sebastian [7] and Mirco Tegler [2]

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[6] Strategic services, DLR, Linder Höhe, 51147 Köln, Germany; Uwe.Knodt@dlr.de

[7] Institute of Optical Sensor Systems, DLR, Rutherfordstraße 2, 12489 Berlin, Germany; David.Krutz@dlr.de (D.K.); Ilse.Sebastian@dlr.de (I.S.)

* Correspondence: rupert.mueller@dlr.de

Thank you for your attention!

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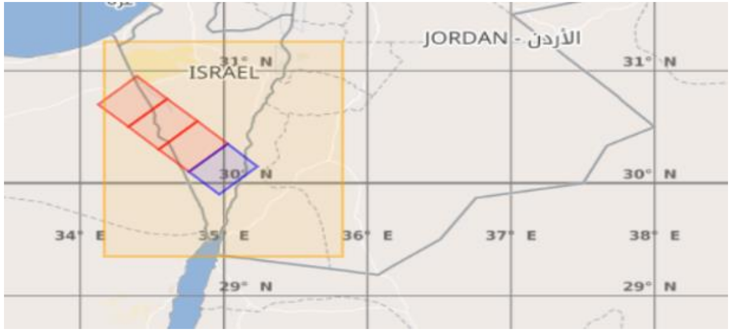
… and the whole DESIS Team!



Negev Desert / Israel, May 2021

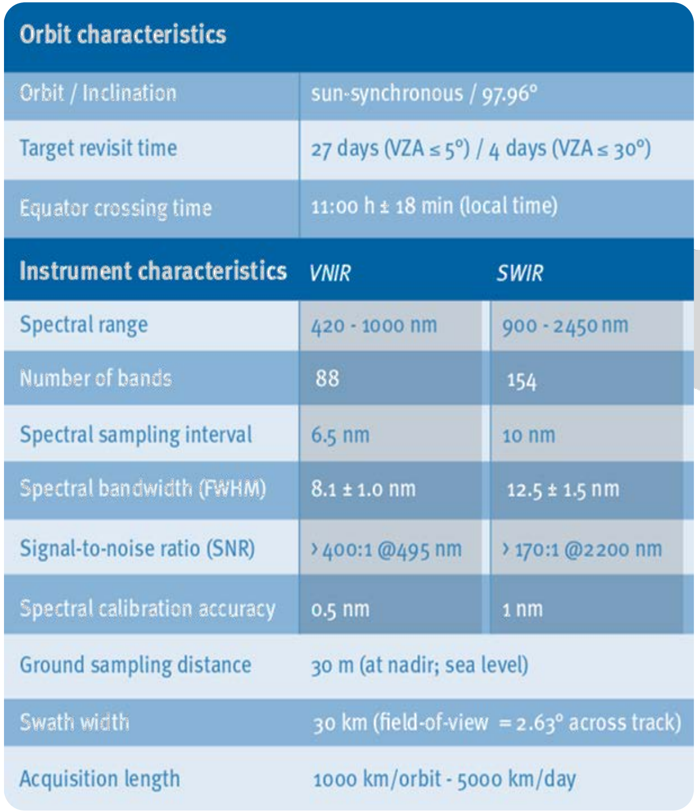
Current status of the EnMAP mission

Sabine Chabrillat (1), Karl Segl (1), Saskia Foerster (1), Luis Guanter (1, 2), Anke Schickling (3), Tobias Storch (4), Hans-Peter Honold (5), Sebastian Fischer (3)
And the whole EnMAP team

(1) Helmholtz Center Potsdam, GFZ German Research Center for Geosciences, Potsdam, Germany
(2) Universitat Politècnica de València, Valencia, Spain
(3) Space Administration, German Aerospace Center (DLR), Bonn, Germany
(4) Earth Observation Center (EOC), German Aerospace Center (DLR), Weßling, Germany
(5) OHB System AG, Weßling, Germany

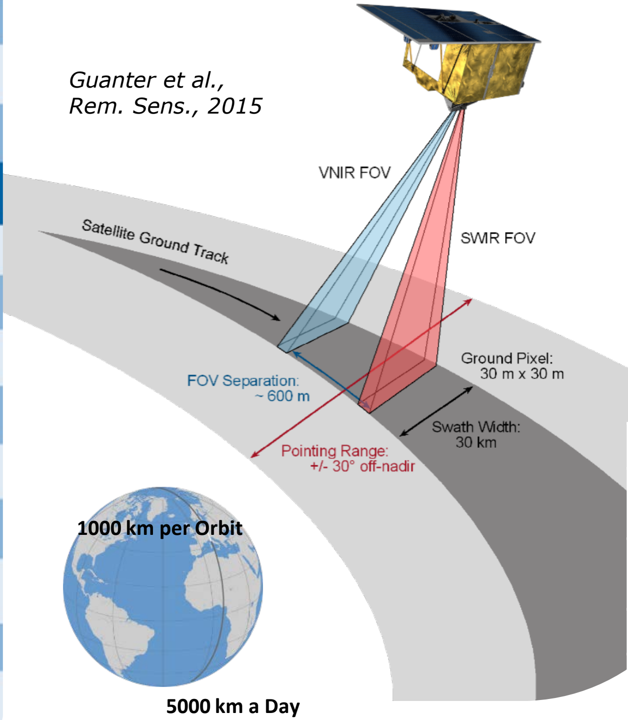
SBG community Webinar 12 Oct 2021

EnMAP mission and sensor parameters



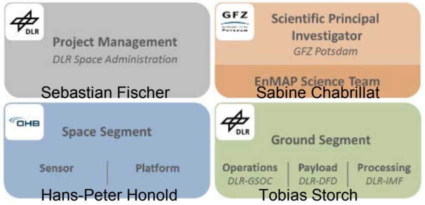
Orbit characteristics		
Orbit / Inclination	sun-synchronous / 97.96°	
Target revisit time	27 days (VZA ≤ 5°) / 4 days (VZA ≤ 30°)	
Equator crossing time	11:00 h ± 18 min (local time)	
Instrument characteristics	***VNIR***	***SWIR***
Spectral range	420 - 1000 nm	900 - 2450 nm
Number of bands	88	154
Spectral sampling interval	6.5 nm	10 nm
Spectral bandwidth (FWHM)	8.1 ± 1.0 nm	12.5 ± 1.5 nm
Signal-to-noise ratio (SNR)	› 400:1 @495 nm	› 170:1 @2200 nm
Spectral calibration accuracy	0.5 nm	1 nm
Ground sampling distance	30 m (at nadir; sea level)	
Swath width	30 km (field-of-view = 2.63° across track)	
Acquisition length	1000 km/orbit - 5000 km/day	

Guanter et al.,
Rem. Sens., 2015



1000 km per Orbit

5000 km a Day

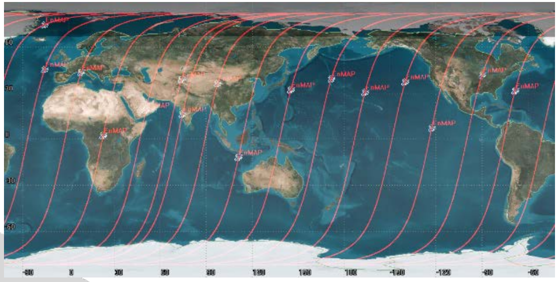


Sebastian Fischer

Sabine Chabrillat

Hans-Peter Honold

Tobias Storch



Flight Altitude	653 km
Coverage	Global in near-nadir mode
# of orbits / repeat cycle	398 orbits
# of images / day	Up to 166
Covered area / day	150.000 km^2

EnMAP status


Status 09.07.2021 ©DLR/OHB

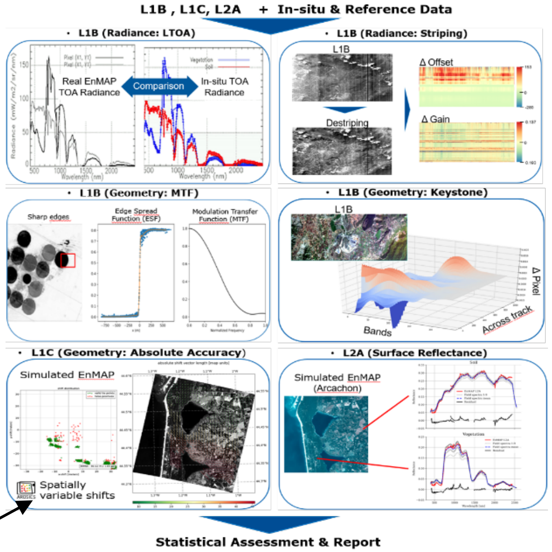
EnMAP satellite at TVAC preparation at IABG with the golden foil

- HSI instrument
  - HSI calibration & characterisation closed end-2020
  - Successfull HSI acceptance review Jan 2021
- Satellite
  - Satellite integration and finalisation closed, transport IABG Jun 2021
  - → Environmental test campaign (thermal, acoustic)
  - Functional characterization, 2d end-to-end test with GS
  - Flight acceptance review Oct 2020-Jan 2021
- Launch
  - Falcon 9 (Space X) rideshare
  - Launch 28.02-30.06.2022, reduced to 30d, Florida, USA
  - Data available to users after commissioning (6M) through EnMAP data portal
  - Mission life time: 5 years

EnMAP data products:
L1B: radiometrically-corrected and spectrally-characterized radiance data
L1C: geometrically-corrected L1B data
L2A: atmospherically-corrected L1C data

EnMAP calibration, validation, data quality control

- Pre-Flight Calibration & Characterization by space segment
- Commissioning
  - In-Flight Calibration by ground segment based on satellite equipment
  - Cal-val and data quality control activities by ground segment for all mission data
  - Validation activities by science segment : Product Validation Plan (L1B/L1C/L2A)
    - Independent validation effort
    - Estimation of quantitative error figures and potential error sources, report non-compliance & recommendation for improvement
    - Based on Level 1B/1C/2A products & in-situ and reference, airborne & spaceborne data
    - Support from the science community



Brell et al., Whispers 2021

In-situ / reference data
- Demmin/Camarena (agriculture, soils; S. Chabrillat)
- Lake Constance (water; A. Bracher)
- Munich North Isar (agriculture; T. Hank)
- Makhtesh Ramon (geology; E. Ben-Dor)
- Mammoth Mountain (snow; T. Painter)
- Ivanpah Playa (USA ; R. O. Green)
- Pinnacles (Australia; C. Ong)
- Amiaz Playa (Israel; E. Ben-Dor)
- RadCalNet (Railroad Valley, USA; Gobabeb, Namibia) , Hypernets, AERONET, PICS..

Airborne
- Demmin (HySpex on Cessna207)
- Lake Constance/Munich North Isar (TBD)

Spaceborne
- all, S2 (L1C REF), DESIS, PRISMA, EMIT..

Core sites International sites Network/others

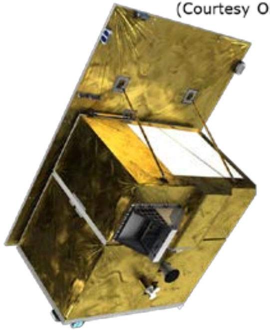
SBG-EnMAP potential areas of cooperation

- a) Cal/Val activities: Cross-calibration, sensor performance assessment, cal/val data collection
  - E.g. CP 2022
    - 3 sites in the US to provide field data to EnMAP
    - Airborne campaign?

- b) Science and applications: Campaigns and ground-truth data collection, algorithm and software development, publications

- c) Outreach activities: Education, training, community events and networking

- No exchange of funds and hardware


(Courtesy OHB)

Thank you for your attention

enmap.org

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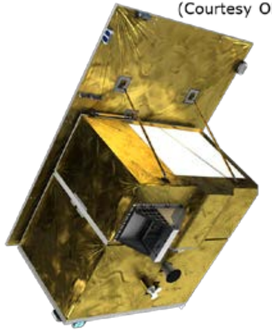
(Courtesy OHB)

Thank you for your attention

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SBG Items of Interest

- **AGU Call for Papers:** The Earth in Living Color
  - Open through **August 2022**
- **12th EARSeL Imaging Spectroscopy Workshop** (June 22-24, 2022)
  - Abstract deadline: TBA
- **NASA Open Source Science Workshop** (October 19-20)
  - Register now at earthdata.nasa.gov
- **AGU Fall Meeting 2021**:
  - **NASA SBG: The Earth In Living Color Town Hall**
    Tuesday, December 14, 2021, 9:15 – 10:15
  - **Advancing Global Imaging Spectroscopy and Thermal Infrared Measurements**
    Multiple Oral and Poster sessions, Monday, December 13, 2021
  - **Other relevant AGU FM and OSM sessions will be posted on the SBG website.**

SBG Opportunities for Involvement

- In-person SBG community workshop in 2022 (more details to come)
- 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
- Email us (seriously we want to hear from you): sbg@jpl.nasa.gov
- Join the conversation at the SBG Slack Channel