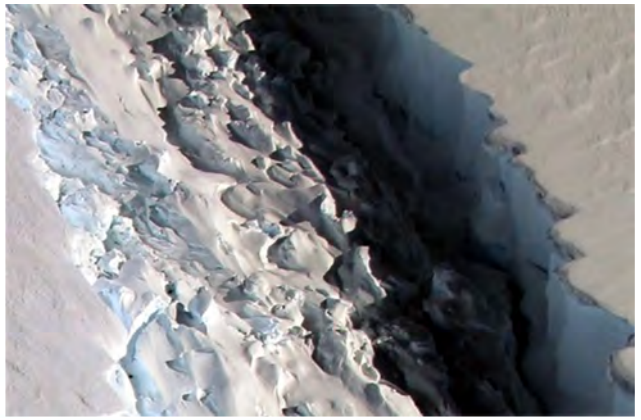
SCIENCE

EARTH SYSTEM OBSERVATORY






Surface Biology and Geology

Overview and SDS Implications

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

SBG has a very broad research and applications constituency:

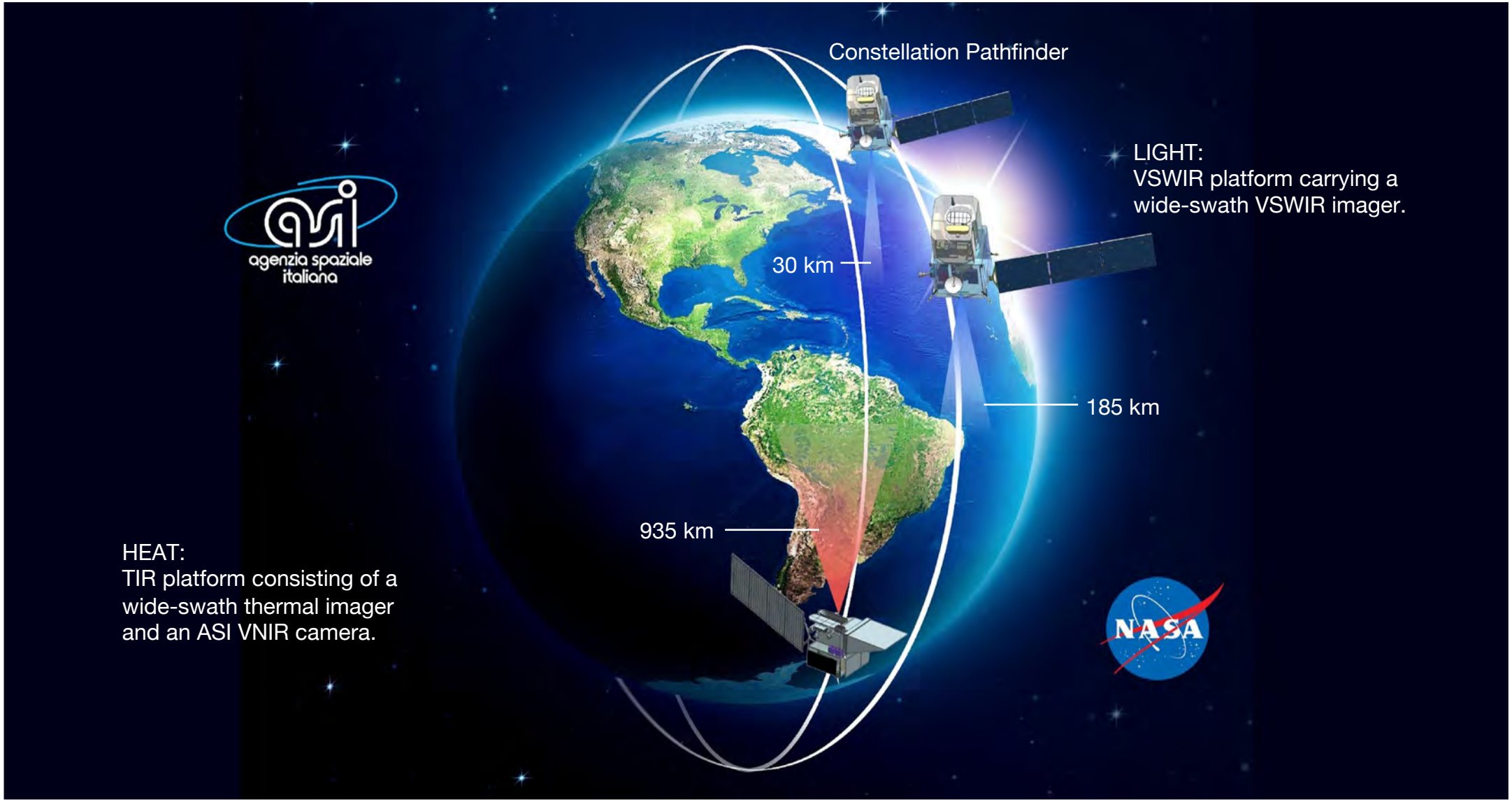
- Terrestrial and aquatic ecosystems – fire, conservation and biodiversity, agriculture and forestry
- Hydrology – snow, evapotranspiration, consumptive water use, water quality
- Weather – Surface energy balance, severe weather
- Climate – carbon-climate feedbacks, CH_4 sources and mitigation, point sources
- Solid Earth – Volcanic hazards, landslides, mineral exploration, mineland management

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*":

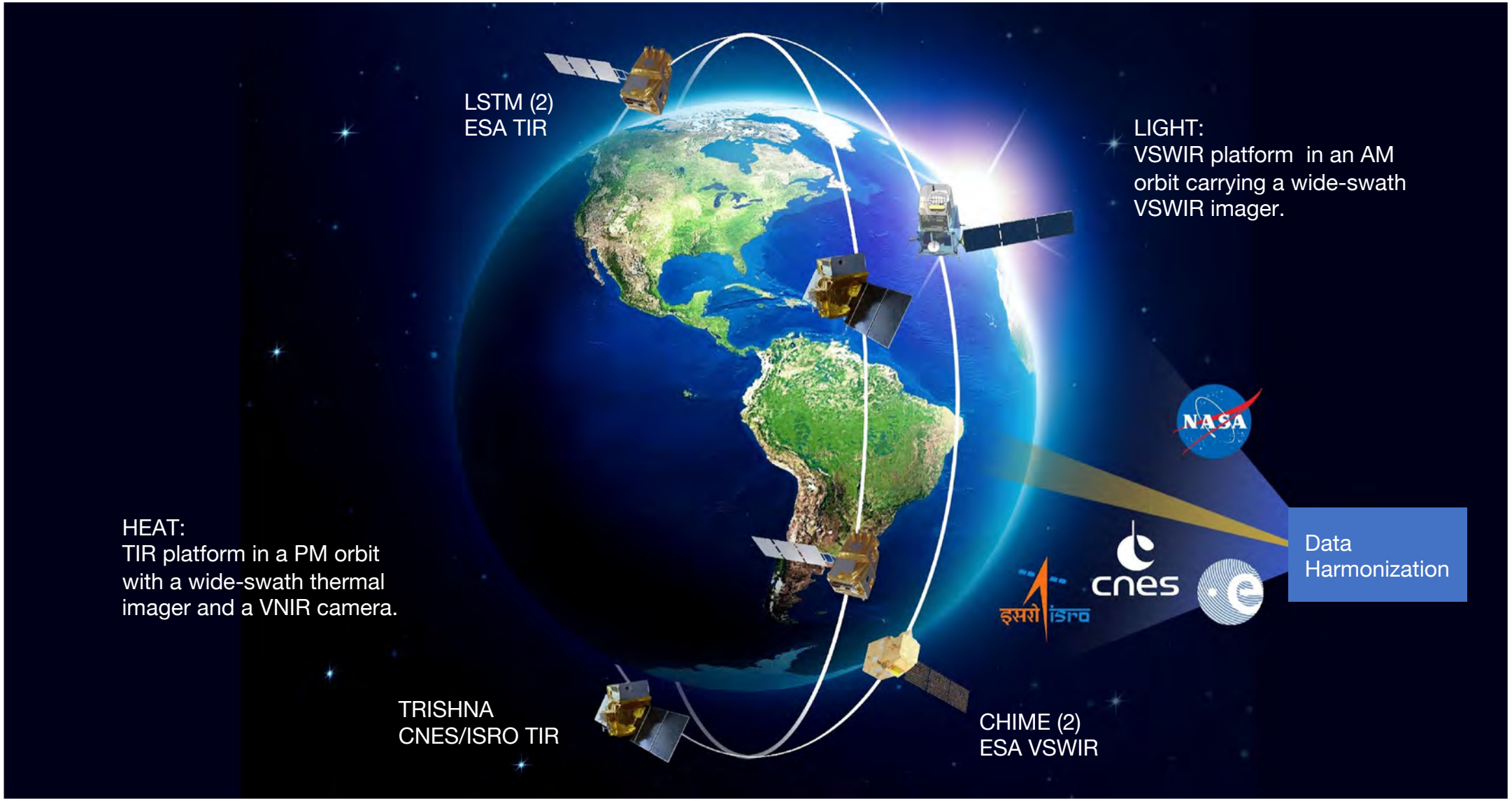
1. "….a moderate spatial resolution (30-45 m GSD), hyperspectral resolution (10 nm; 400-2500 nm), high fidelity (SNR = 400:1 VNIR/250:1 SWIR) imaging spectrometer is needed for characterizing land, inland aquatic, coastal zone, and shallow coral reef ecosystems"
2. "….30-60 m TIR observations in the 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.

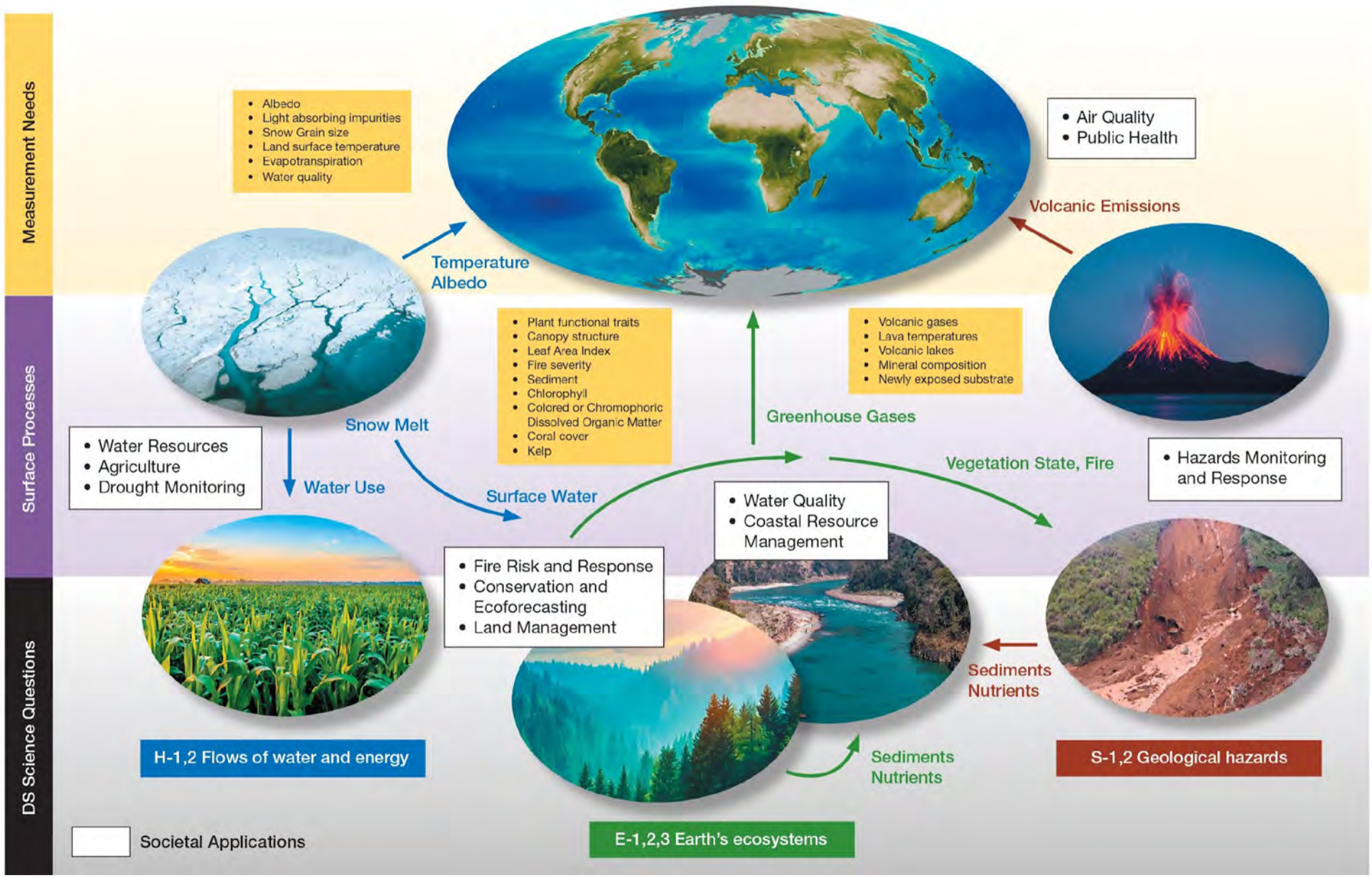
What is SBG?


Constellation Pathfinder
LIGHT:
VSWIR platform carrying a
wide-swath VSWIR imager.
30 km
185 km
935 km
HEAT:
TIR platform consisting of a
wide-swath thermal imager
and an ASI VNIR camera.
agenzia spaziale
italiana
NASA

SBG ESA On-Orbit Collaborations



SBG enables a wide range of data products and can support application-ready data (ARD)



SBG anticipates synergistic science and applications with with all the ESO observatories and the I

Solid earth
Aerosols — ATMOS
Gases — SBG
Surface Deformation — NISAR
Surface Composition and Geologic Hazards — SBG

Watersheds
Precipitation — ATMOS
Ice Mass Evolution — NISAR
Snow Albedo and Melt — SBG
Total water storage-MC

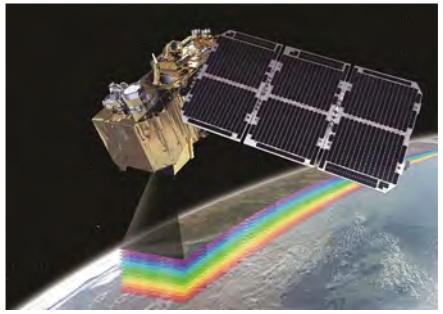
Ecosystems and agriculture
Boundary Layers — ATMOS
Ecosystem Structure — NISAR
Vegetation Type and Physiology — SBG

Land-sea continuum
Phytoplankton, Organic Matter, Sediment — SBG, GLIMR, PACE, Boundary layers-ATMOS

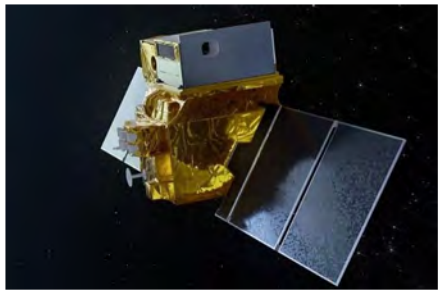
Applications and research needs lead to data harmonization for frequent revisit

INTERNATIONAL COLLABORATION

- **Reducing revisit and observing events:** Open data sharing and product harmonization with CHIME (VSWIR), LSTM and TRISHNA (TIR) reduces intervals between observations, and increases research and applications opportunities.
- **International collaboration on calibration and validation:** unprecedented data quality and engagement through use of terrestrial and aquatic networks for vicarious calibration and validation activities on six continents.

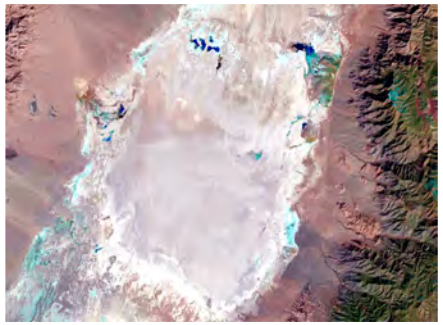


ESA CHIME



CNES/ISRO TRISHNA

ESA LSTM



CAL/VAL

SBG and Open Science

- Committed to NASA data policy and standards,
- Currently focused on moving away from legacy proprietary codes,
- Open source code repositories in use,
- Tools being developed for easy user-supplied algorithm execution.
- HIGH NUMBER OF POTENTIAL PRODUCTS DICTATES AN INNOVATIVE SDS SOLUTION

SBG has 10 Core product suites

Product Suite
Snow
Water biogeochemistry
Water biophysics
Aquatic classification
Substrate composition
Volcanic SO2 and ash
High temperature features
ET
Plant functional traits
Proportional cover

Product suites may:

- Combine wavelength regions (eg, evapotranspiration uses TIR and VNIR),
- Have elements from both wavelength regions (some mineral retrieved in TIR, others in VSWIR,
- Be derived in only one wavelength region (most aquatic products are VSWIR only),
- Be used synergistically (LST and canopy chemistry to infer photosynthetic capacity),
- Require international harmonization to retrieve critical time scales (vegetation seasonality in cloudy regions.
- Require higher level products and application-friendly formats to be application-ready,
- For some of these products, alternate algorithms have value-users may want to implement bespoke processing for particular situations.

The SBG Algorithms Working Group identified nearly 200 potential products: sandbox?

One of 10 focus area tables

Table 1
Snow products possible from SBG, including their dependencies, requirements for solar zenith angle (SZA; degrees), view zenith angle (VZA; degrees), and heritage.

Products	Dependencies	External	Max SZA	Max VZA	VSWIR	MWIR	TIR	Mission/ Instrument Heritage	Spatial Areas
Snow fraction	Cloud Filter, Reflectance		75	45	X		X	ASO, AVIRIS-C, AVIRIS-NG,	Terrestrial cryosphere
Snow albedo	Cloud filter, HDRF reflectance, TOA radiance, surface temp, snow algae	Snow/sea ice discriminator	75	45	X			ASO, AVIRIS-C, AVIRIS-NG,	Terrestrial cryosphere
Snow/ice surface temperature	Cloud filter, thermal radiance						X	ECOSTRESS	Terrestrial cryosphere
Snow - light absorbing particles	Cloud filter, HDRF corr. Reflectance		75	45	X			ASO, AVIRIS-C, AVIRIS-NG	Terrestrial cryosphere
Snow algae concentration	Cloud filter, HDRF corr. Reflectance		75	45	X			ASO, AVIRIS-C, AVIRIS-NG	Terrestrial cryosphere
Snow grain size	Cloud filter, HDRF corr. Reflectance		75	45	X			ASO, AVIRIS-C, AVIRIS-NG	Terrestrial cryosphere

Table 10
The geology products possible from SBG, including their dependencies, view zenith angle (VZA) requirements, and heritage (values are not shown where no studies were reported to quantitatively define said limits).

Products	Dependencies	External Data	Max SZA	Max VZA	VSWIR	MWIR	TIR	Mission/ Instrument Heritage	Spatial Areas
Mineralogy (including mixtures)	Terrestrial Spectral Reflectance, Fractional cover, emissivity	Digital Elevation, Spectral libraries			X	X	X	AVIRIS, ASTER, Hyperion, Landsat, HyTES AHS	Global
Naturally occurring asbestos	Terrestrial Spectral Reflectance, Fractional cover	Lithologic and vegetation cover maps			X			AVIRIS-C AVIRIS-NG	Global
Acid mine drainage	Terrestrial Spectral Reflectance	Digital Elevation, spectral libraries			X			AVIRIS-C AVIRIS-NG Hyperion	Global
Soils (texture, organic carbon, water content, clay mineralogy, degradation)	Terrestrial Spectral Reflectance, Fractional cover, emissivity	Elevation, veg communities Spectral libraries			X	X	X	AVIRIS, ASTER, Hyperion, MODIS, Landsat, HyTES AHS	Global
Soil erosion	Terrestrial Spectral Reflectance, Fractional cover, emissivity	Elevation, veg communities Spectral libraries			X	X	X	AVIRIS, ASTER, Hyperion, Landsat.	Global
High-temperature volcanic and wildfire phenomena (thermal anomaly detection, fire and lava temperature and area)	VSWIR and MWIR (~ 4 μm) for high temps, TIR radiance for ambient temps, Terrestrial Spectral Reflectance, emissivity	Historical reflectance/ emissivity, spectral libraries	Night-time observations beneficial for VSWIR-based temperature estimation		X	X	X	AVIRIS, MASTER, HyTES, ASTER, MODIS, VIIRS, Hyperion PRISMA	Global
Volcanic SO_2 and Ash Emissions (volcanic plumes and clouds, SO_2 and ash content, CO_2 plumes)	TIR radiance (7–12 mm) to measure SO_2 and ash absorption/emission, -SWIR to measure aerosol scattering	Surface elevation and emissivity, Plume thickness and altitude, Profiles of atmospheric temperature and water vapor			X		X	MASTER, HyTES, ASTER, MODIS, VIIRS, AIRS, SEVIRI, IASI	Global
Post-Event Monitoring	Terrestrial Spectral Reflectance, emissivity, surface temperature	Historical baseline			X	X	X		

Ten of 10 focus area tables

10 Research and Applications areas, ~200 products

SDS drivers: Applications

- SBG has a large and diverse applications community (per apps WG).
- Most of the participants do not have the skills or the tools to work with L2+ data products but require application-ready data (per RTI report)
- Low latency is critical for many applications (per RTI).
  - Some require regular low-latency data (agriculture), some require episodic (volcanos, fires)
- Ease of access will be critical for users not traditionally involved in the global geospatial community—how can products be simple to access and use and how intuitively “GIS-able”.

SDS drivers: Data harmonization, data fusion and partnerships

- The notional concept for SBG only achieves 30-50% of desired revisit (1 vs 3 days, 8 vs 16 days).
- International collaboration with ESA, CNES and ISRO can lead to ~1/8 day revisits for TIR and VSWIR.
- Rapid ingest of partner data, cross-calibration and fusion to common time/space grids needed to enable seamless use.
- Even higher revisit or downscaling could be achieved for some uses by LANDSAT/Sentinel/commercial fusion/harmonization for some applications

SDS drivers: SBG in the ESO + POR

- SBG community has identified numerous joint science areas requiring multi-sensor data, eg:
  - Water cycle
  - Surface energy balance and boundaries layers
  - “Mountains to the sea”, water, minerals, nutrients, organic matter transport
- SBG science will undoubtedly benefit from interoperable ESO and POR data, despite variation in time/space discretization, data fusion needed.
- SBG research and applications would benefit from a common high-level SDS.
- ESO + NASA POR + (SBG) harmonized international data.

Schedule, schedule, schedule

- SBG could greatly benefit from Open Science and an Open Science, cross-ESO SDS.
- SBG is implementing Open Science practices in algorithm and pathfinder activities.
- SBG will baseline some ESO and OSS capabilities as part of the mission baseline if not otherwise planned and will benefit from any additional cross-ESO and user-oriented open science capabilities.

Current status and needs

- The SBG team has embraced open science and implemented early open science measures in pathfinder activities.
- SBG has well-defined needs for advanced and innovative SDS capabilities
- An algorithm sandbox for users would have direct benefits, with 200+ potential products, and large data volumes,
- SBG would benefit from a cross-ESO common science and applications platform
- SBG would benefit L2+ products flowing into a common SDS for synergistic and high level product generation and open distribution,
- growth in users and accelerated transition to societal benefits requires L3 and higher products,