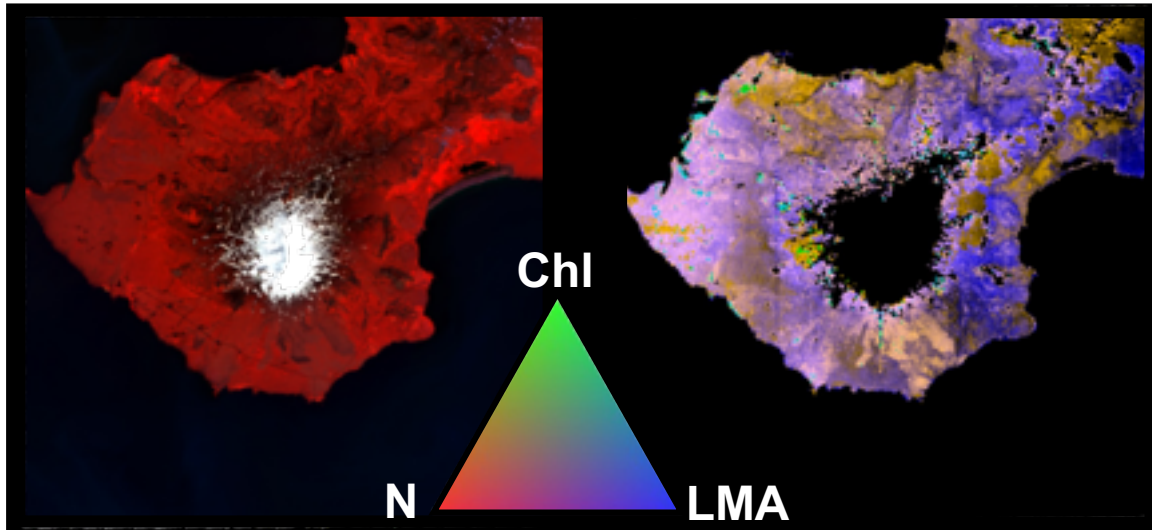## Obectives: Reduce Risk for SBG Mission

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

Period of Performance: Five (5) years from inception (i.e., through FY25)

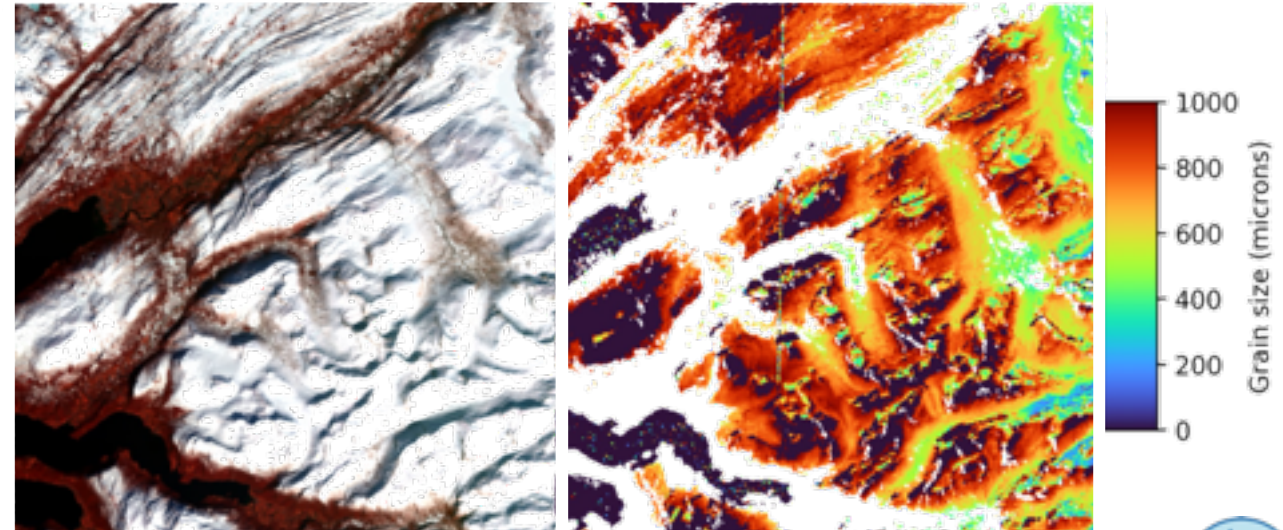**ORNL and LP.DAAC have been designated as the official DAAC(s) for SISTER products**

Vegetation Biochemistry
PRISMA Snæfellsjökull, Iceland July 2, 2020

Snow grain size
PRISMA Surnadal, Norway April 21, 2020

SISTER: SBG Space-based Imaging Spectroscopy and Thermal pathfindER

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

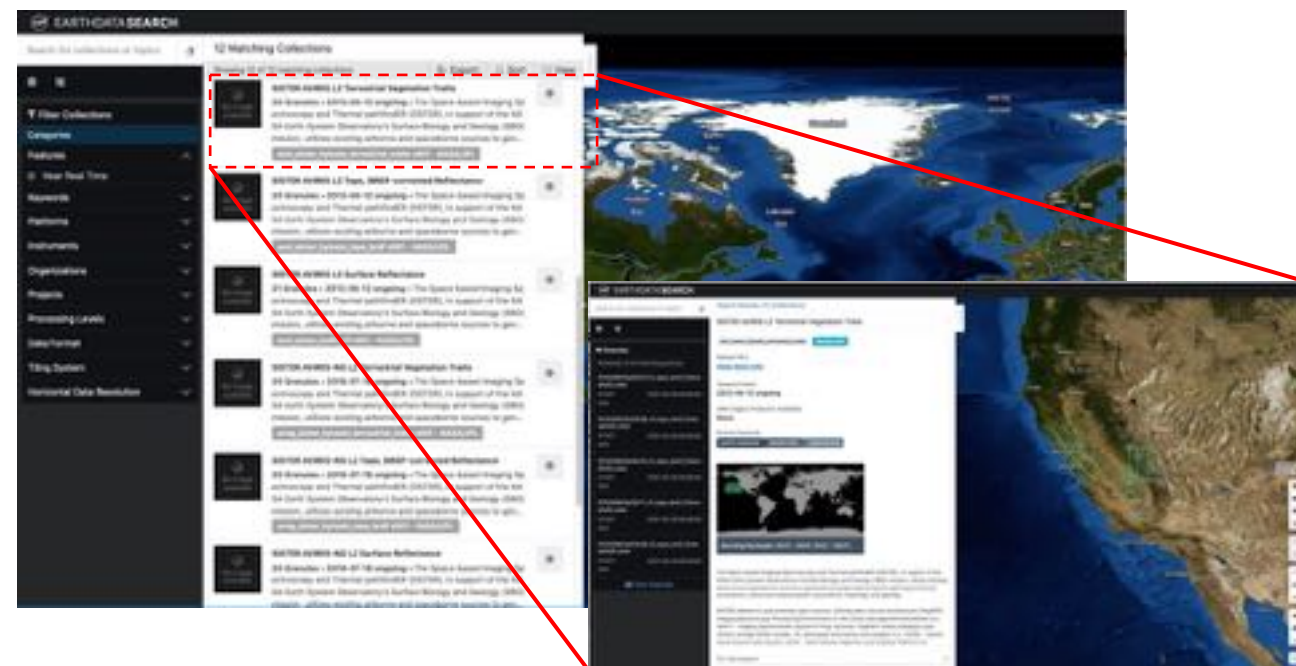| FY21 (Oct 2020 – Sept 2021)	FY22-23 (Oct 2021 – Sept 2023)	FY24-25 (Oct 2023 – Sept 2025)
Prototype workflows & system components	Implement select prototype L2B+ algorithms	Adapt workflows based on emerging SBG ATBDs
Deliverable: *Distribute land & water reflectance for community evaluation / feedback*	**Deliverable:** *Distribute prototype L2B+ products for community evaluation / feedback*	**Deliverable:** *Refine and redistribute prototype SBG products for community evaluation / feedback*

- Provide guidance on continued algorithm development, including cal/val needs

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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 complete
  - Hyperion L2 reflectance using ISOFIT in process

- *NASA Jet Propulsion Laboratory*
  - Select* AVIRIS-Classic, AVIRIS-Next Generation, DESIS and PRISMA scenes for surface reflectance and uncertainties; topo, BRDF-corrected reflectances; select L2+ algorithms
  - *More scenes, data streams, and workflows (e.g., aquatic, snow/ice, geology) will continuously be incorporated – bringing data from EMIT and EnMAP into workflows*

SISTER: Prototype SBG Algorithms & Products

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

SBG Algorithm Class	SBG Algorithm Products (examples)
CORE Algorithms	
Earth Surface Temperature and Emissivity	Land Surface Temperature* and Emissivity
VSWIR Reflectance	Land and Water Reflectances, BRDF Corrections, Albedo
Cover Classifications	Cloud, Water, Land Cover, Plant Functional Types, etc.
PRODUCT Algorithms	
Terrestrial Ecosystems	
Vegetation Traits	Nitrogen, LMA, Chlorophyll, Canopy water
Evapotranspiration	ET*, Evaporative stress index
Proportional Cover	GV, NPV, Substrate, Snow/Ice, Burned Area
Geology/Earth Surface	
Substrate Composition	Mineral type*, Fractional abundance*, Soil types and constituents
Volcanic Gases and Plumes	SO_2, Volcanic ash
High Temperature Features	Volcanic temperature anomalies (lava temperature), Forest fires
Aquatic and Coastal Ecosystems	
Water Biogeochemistry	Pigments, CDOM, Suspended particulate matter
Water Biophysics	Diffuse light attenuation, Inherent optical properties, Euphotic depth, PAR
Aquatic Classification	Phytoplankton functional types, Floating vegetation, Benthic cover, Wetlands
Snow and Ice	
Snow albedo	Albedo, Grain size, SSA, Light absorbing particles, Fractional cover

Leverages ECOSTRESS and EMIT algorithms

SISTER: Prototype SBG Algorithms & Products

SISTER will implement select L2B+ algorithms (informed by the Algorithms and Applications Working Groups) to generate prototype SBG products for community evaluation and engagement
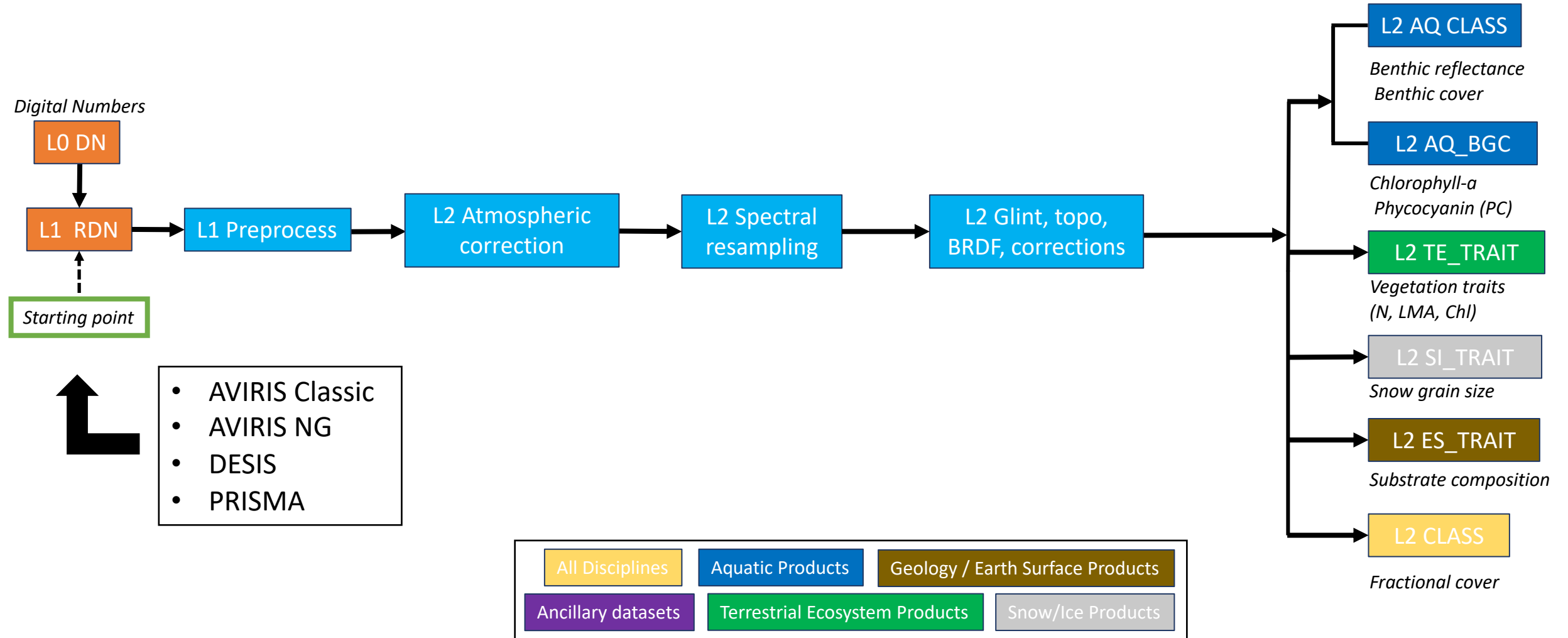
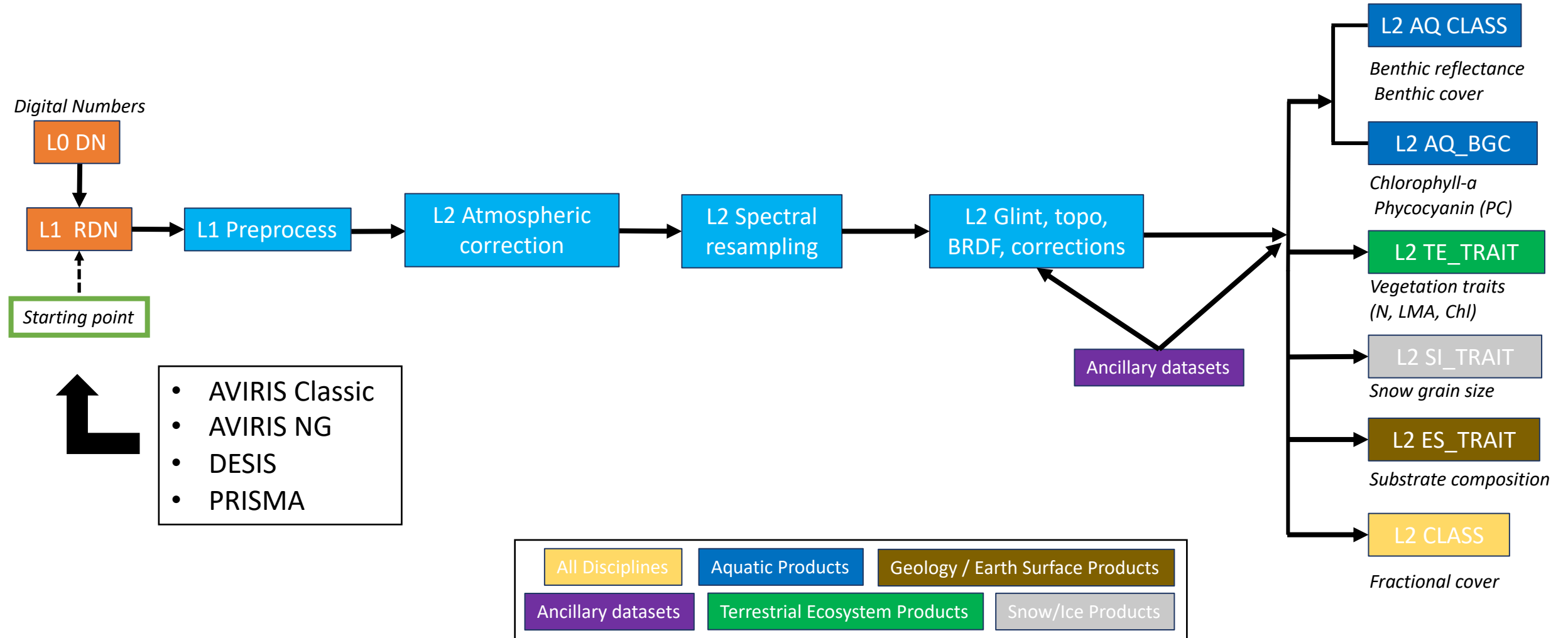| SBG Algorithm Class	SBG Algorithm Products (examples)
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Snow and Ice	
Snow albedo	Albedo, Grain size, SSA, Light absorbing particles, Fractional cover

Leverages ECOSTRESS and EMIT algorithms

Additional Products

- Wildfires
- Greenhouse gases
- Biodiversity (α, β)
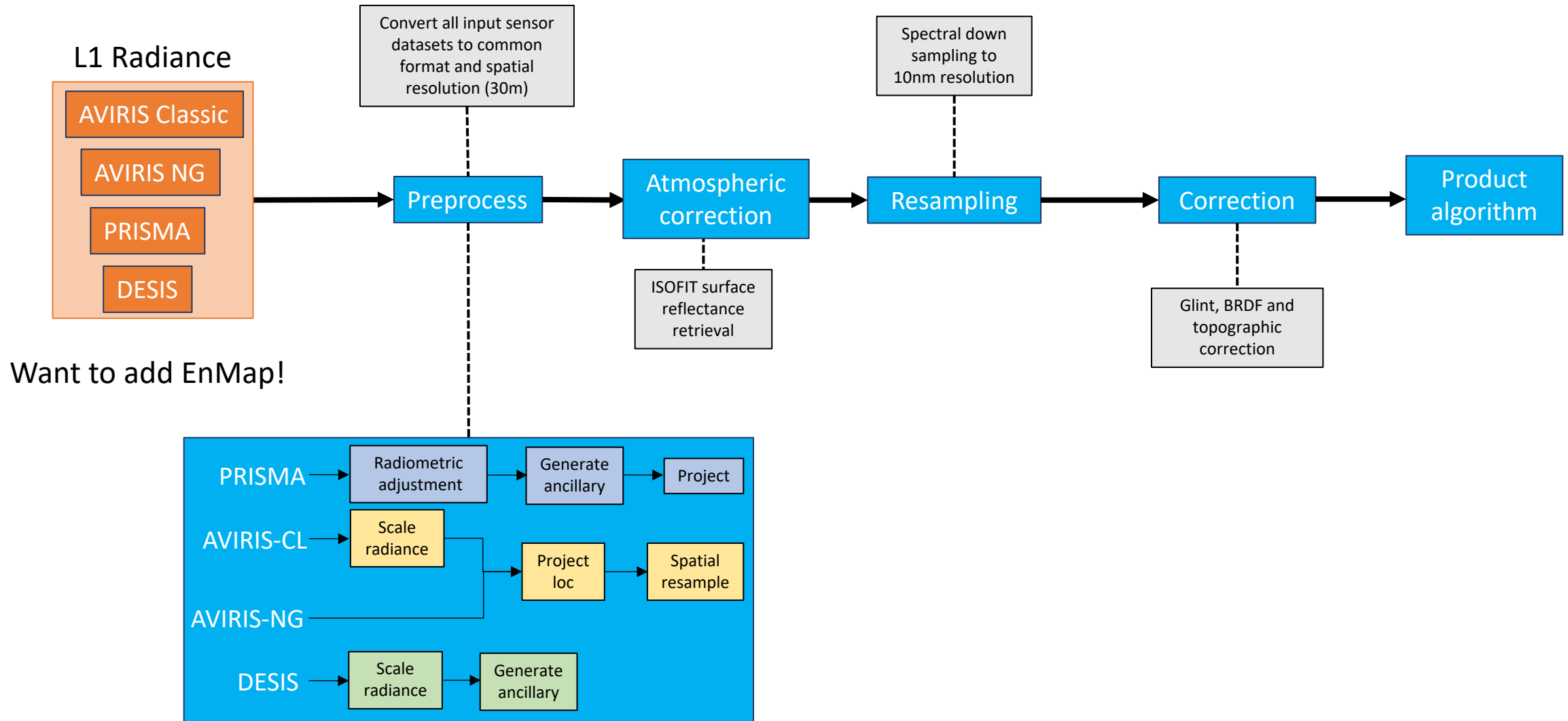- Vegetation species composition
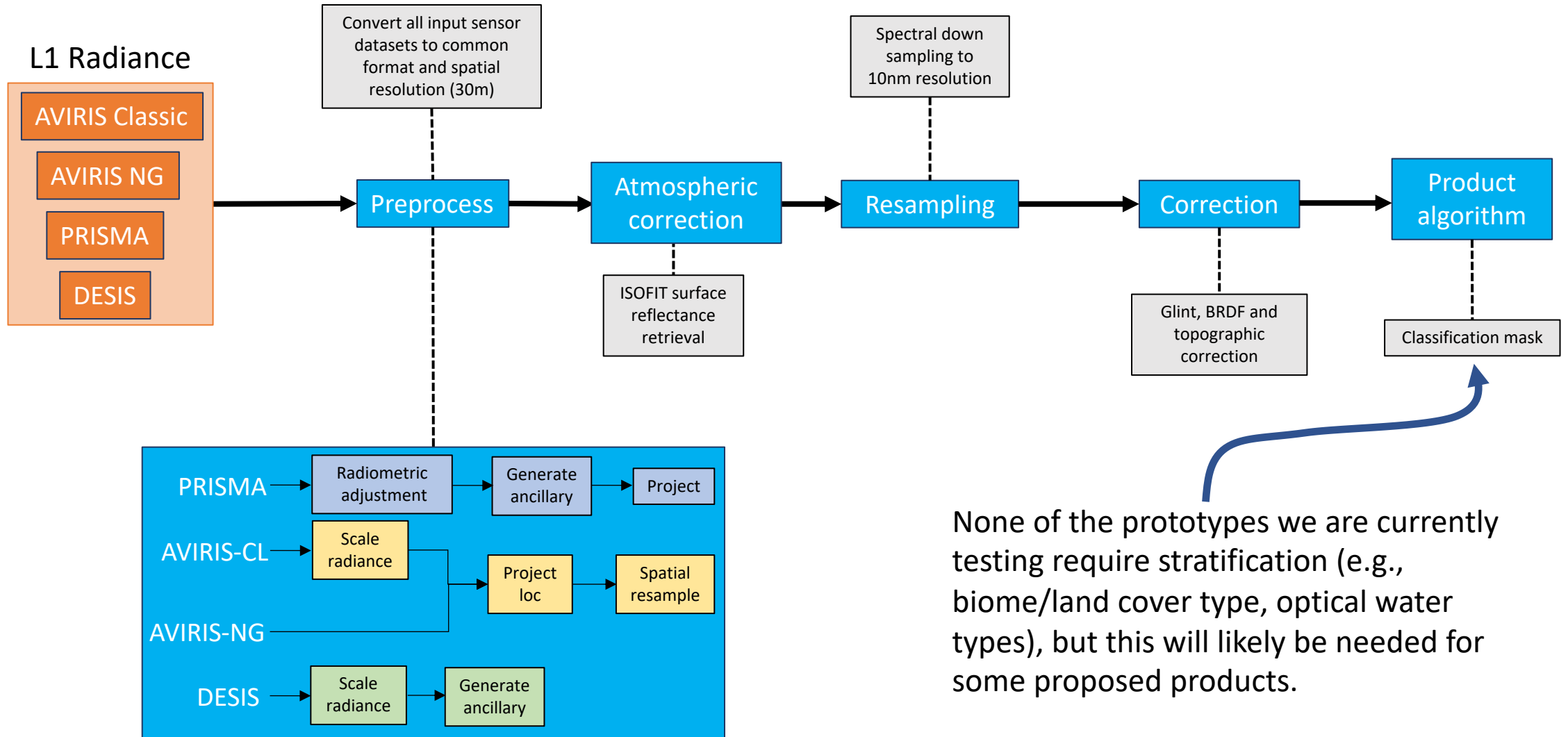
SISTER VSWIR Prototyping Workflow

SISTER VSWIR Prototyping Workflow

SISTER Cloud Processing Platform

- Scalable platform running on AWS
- Multi-Mission Algorithm and Analysis Platform (MAAP)
- Jupyter notebook driven

SISTER VSWIR Workflow Production Run #1 (Last Week)

SISTER VSWIR Workflow Production Run #1

SISTER Preliminary Validation

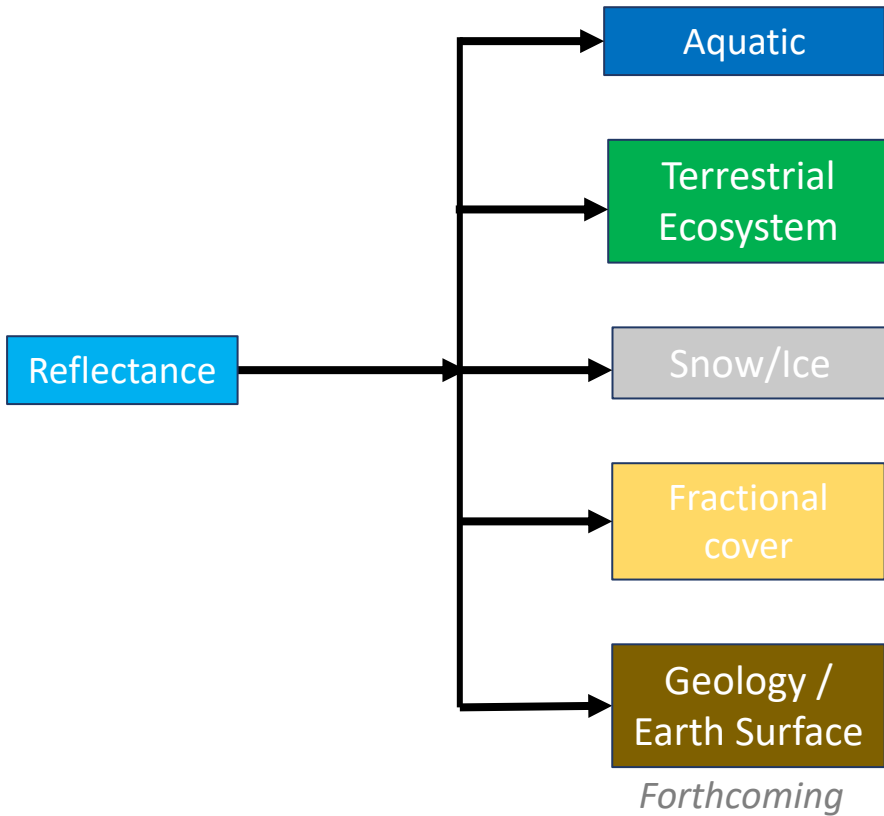## RadCalNet
Railroad Valley, NV
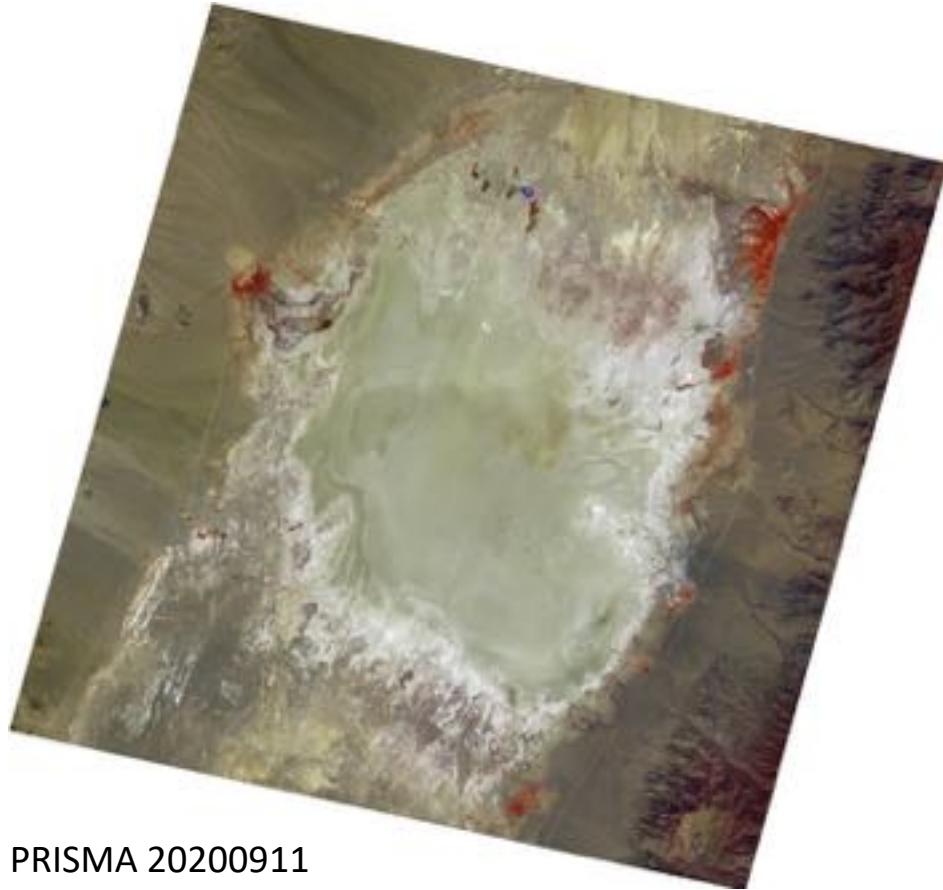
PRISMA 20200911
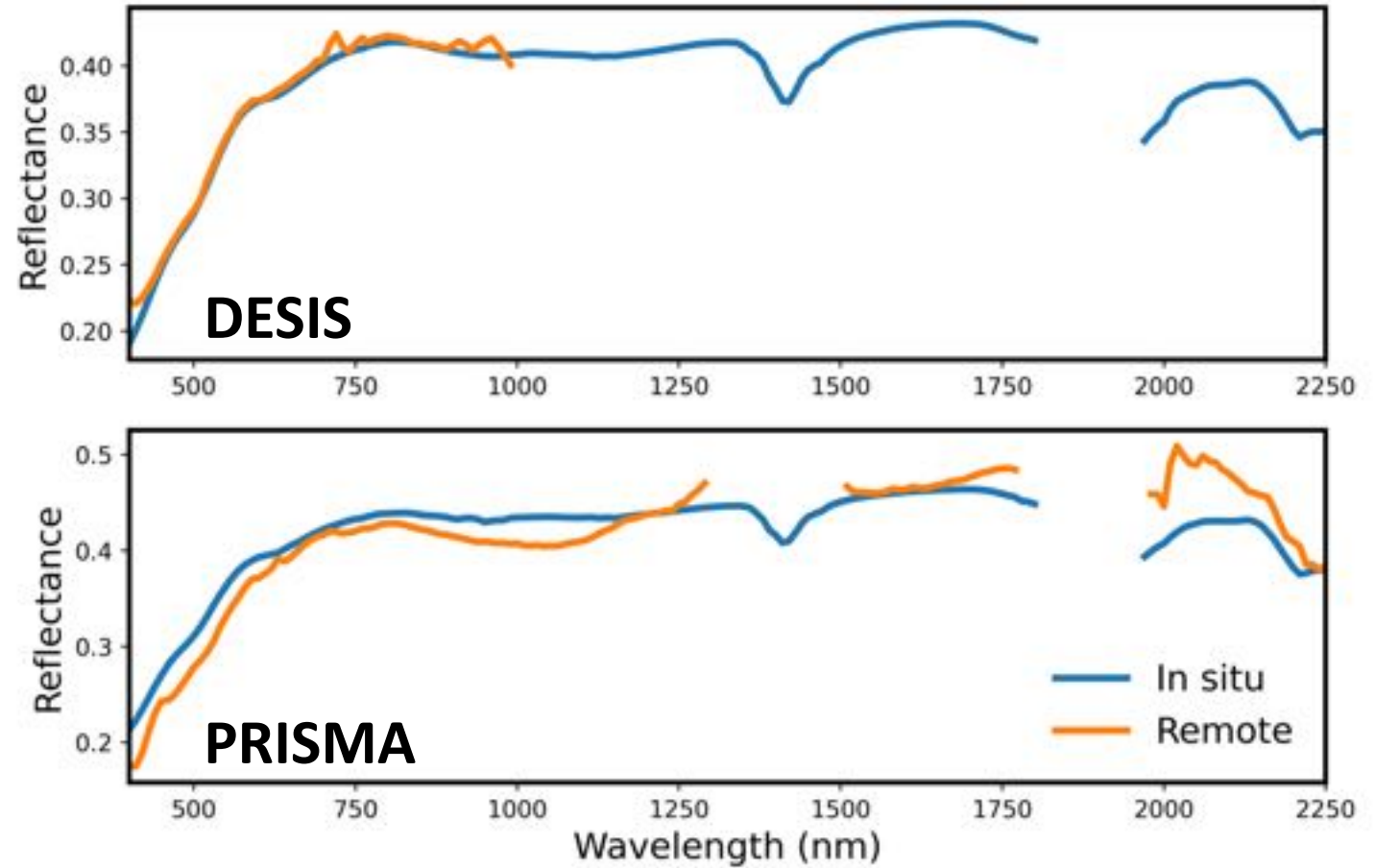
SISTER VSWIR Prototype L2B Workflow

SBG Algorithm Class	SBG Algorithm Products (examples)
CORE Algorithms	
Earth Surface Temperature and Emissivity	Land Surface Temperature* and Emissivity
VSWIR Reflectance	Land and Water Reflectances, BRDF Corrections, Albedo
Cover Classifications	Cloud, Water, Land Cover, Plant Functional Types, etc.
PRODUCT Algorithms	
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Vegetation Traits	Nitrogen, LMA, Chlorophyll A+B, Canopy water
Evapotranspiration	ET*, Evaporative stress index
Proportional Cover	GV, NPV, Substrate, Snow/Ice, Burned Area
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Aquatic Classification	Phytoplankton functional types, Floating vegetation, Benthic cover, Wetlands
Snow and Ice	
Snow albedo	Albedo, Grain size, SSA, Light absorbing particles, Fractional cover

Reflectance →
- Aquatic
- Terrestrial Ecosystem
- Snow/Ice
- Fractional cover
- Geology / Earth Surface

Forthcoming

Legend:
- All Disciplines
- Aquatic Products
- Geology / Earth Surface Products
- Ancillary datasets
- Terrestrial Ecosystem Products
- Snow/Ice Products

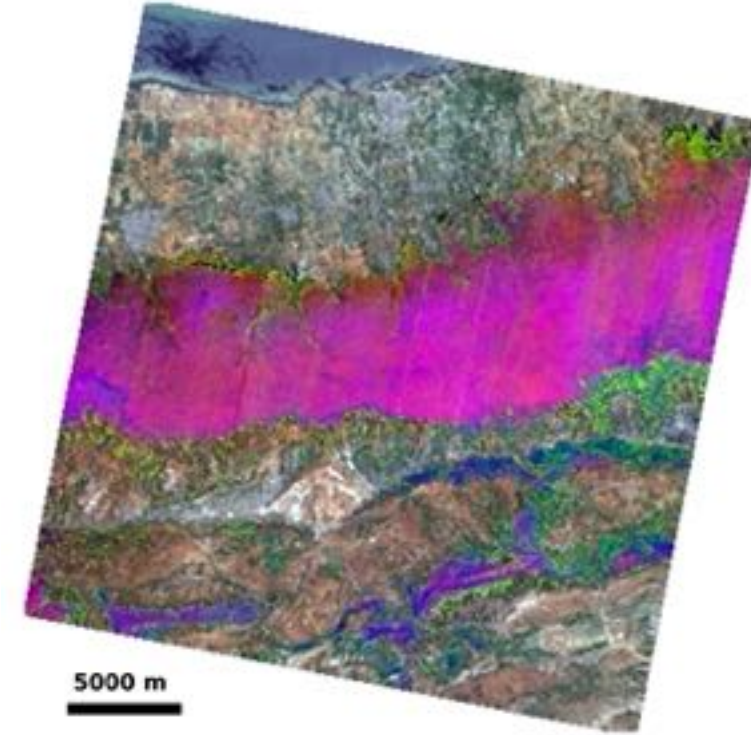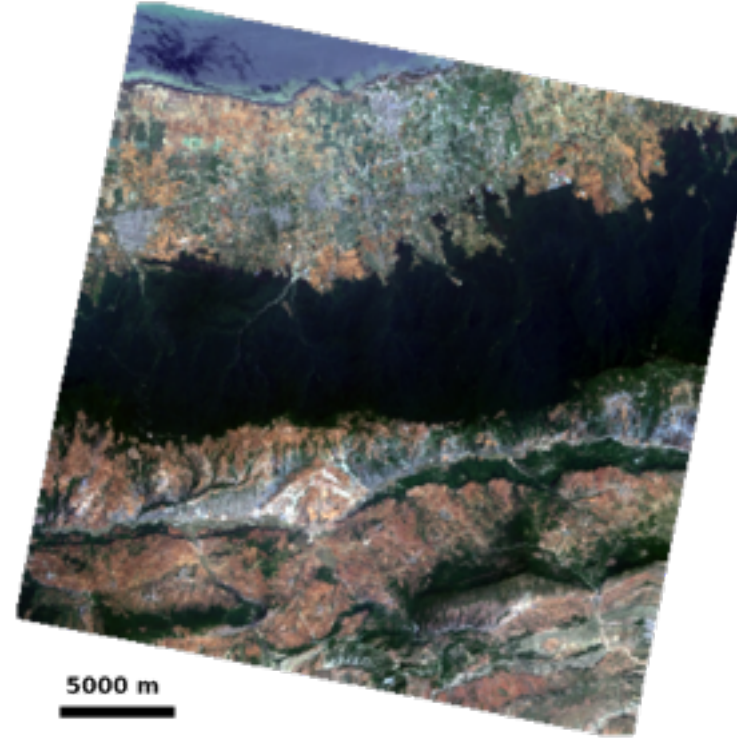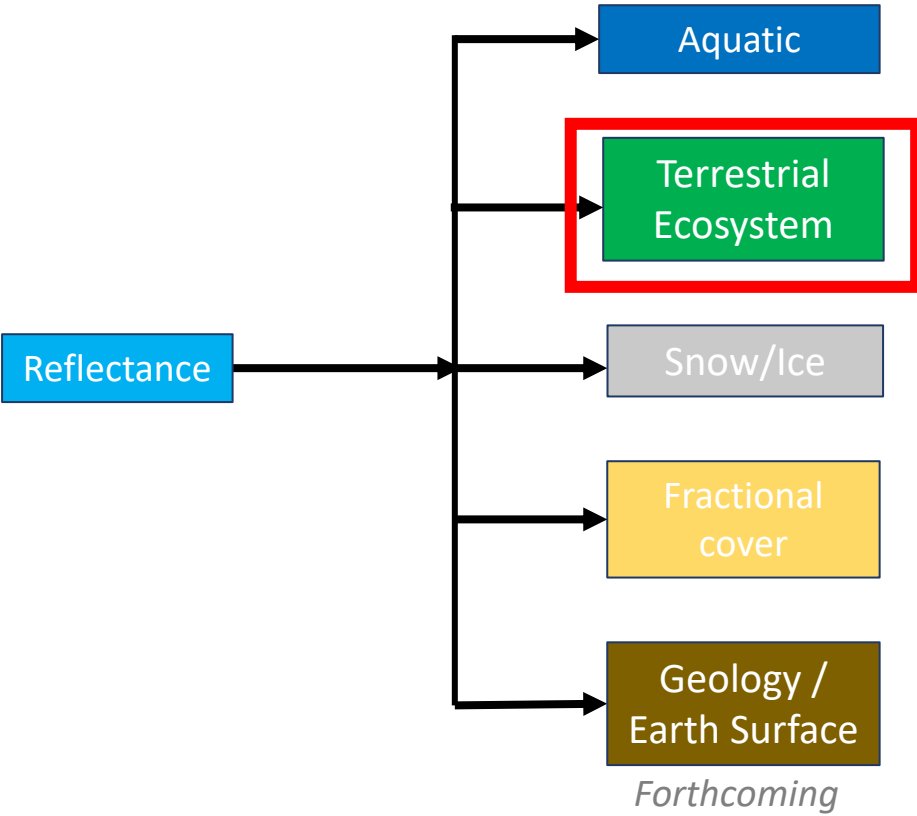# SISTER VSWIR Prototype L2B Workflow – Aquatic biogeochemistry
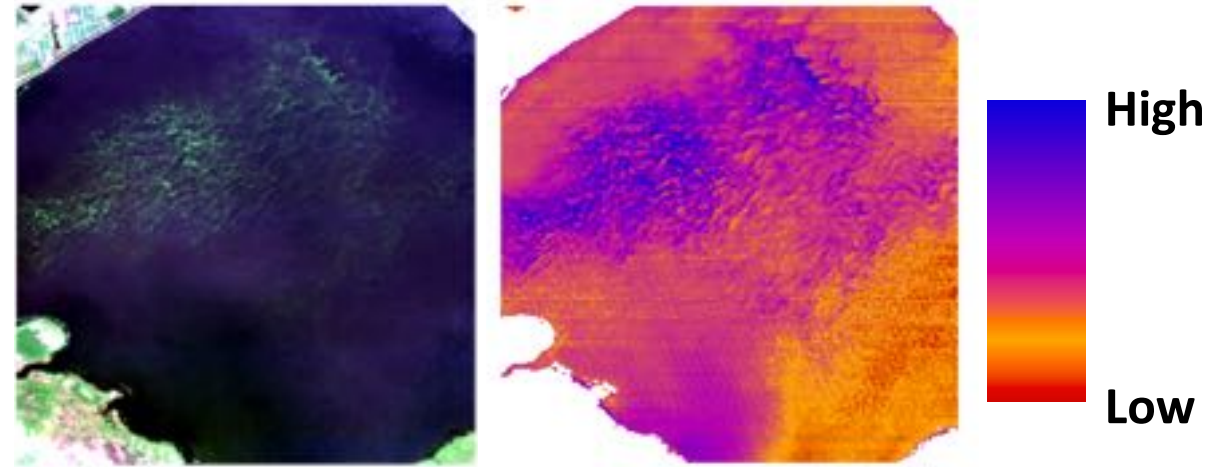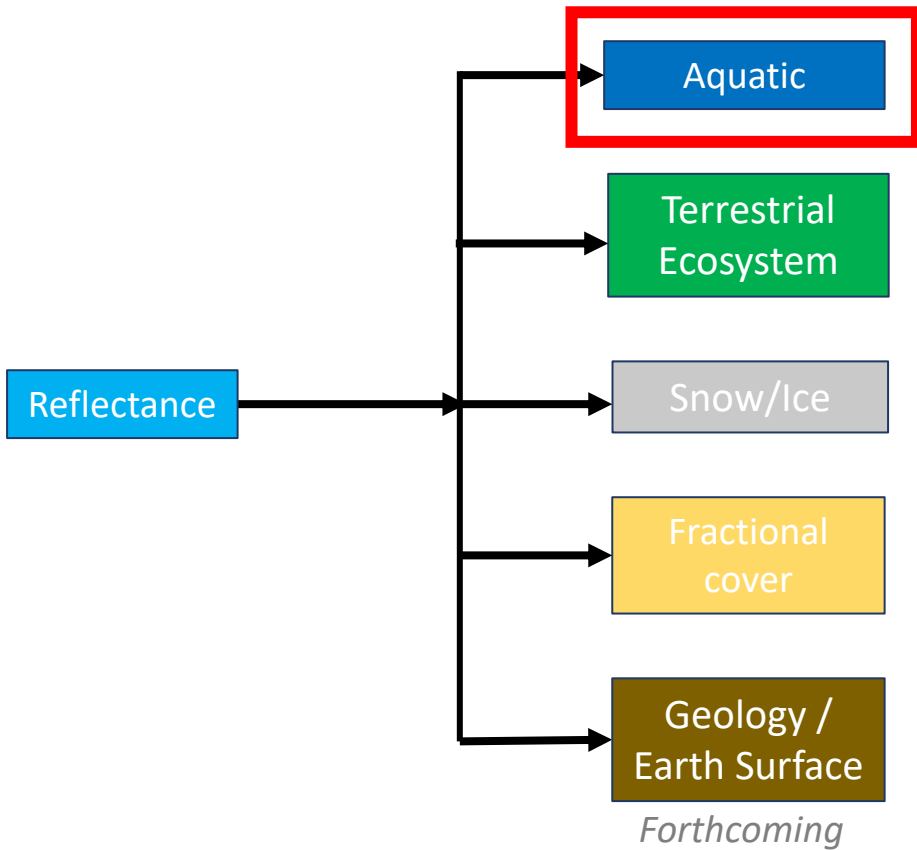
Phycocyanin (O'Shea et al. 2021)
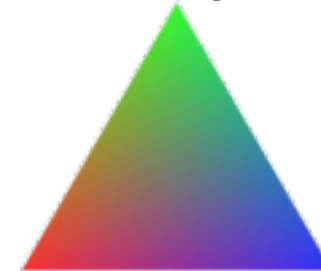PRISMA, Lake Okeechobee, Florida
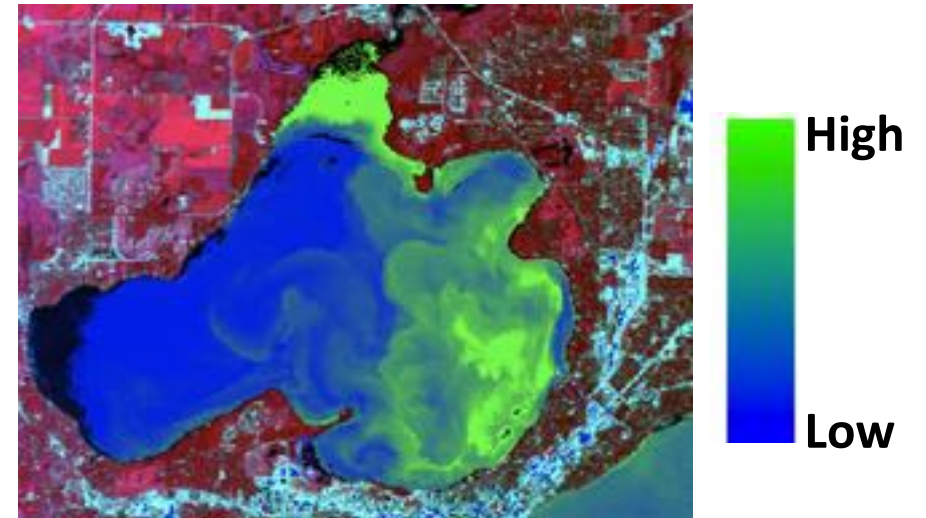
Chlorophyll A (Pahlevan et al. 2021)
AVIRIS Classic, Lake Mendota, Wisconsin

SISTER VSWIR Prototype L2B Workflow – Terrestrial ecosystem
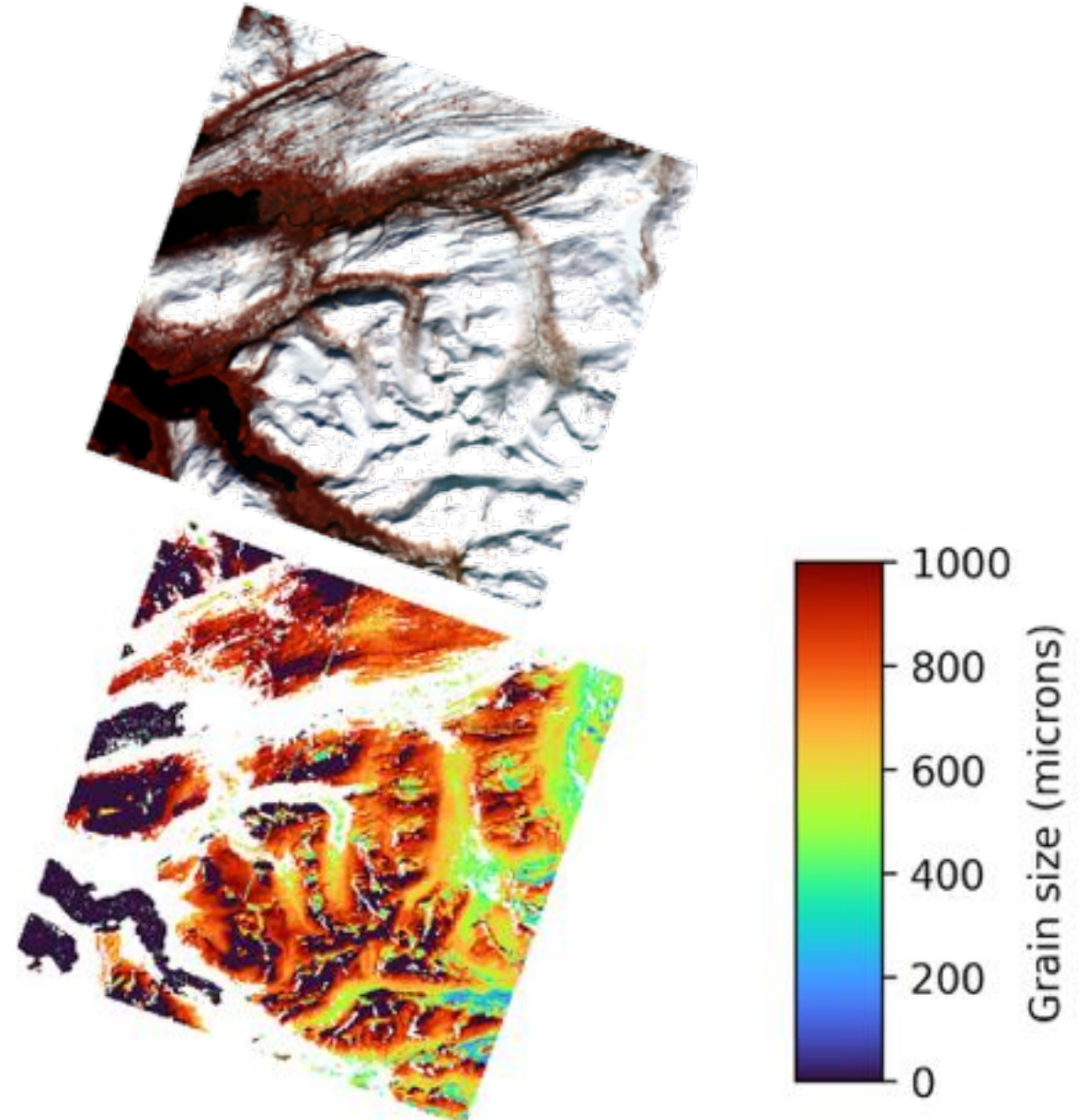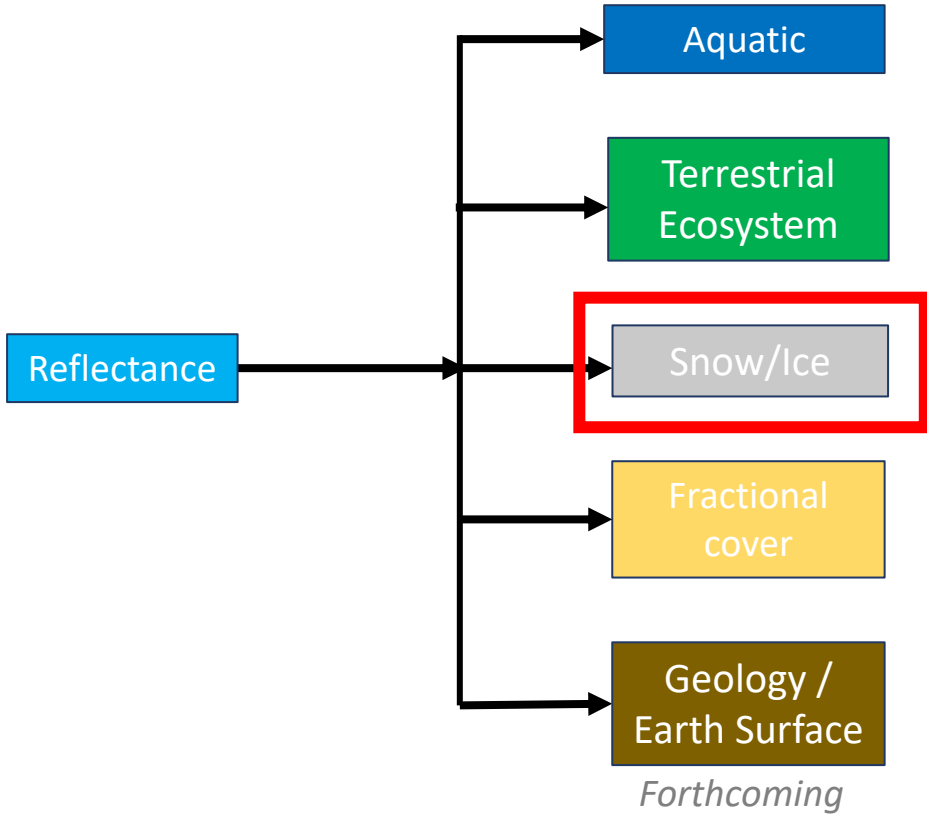

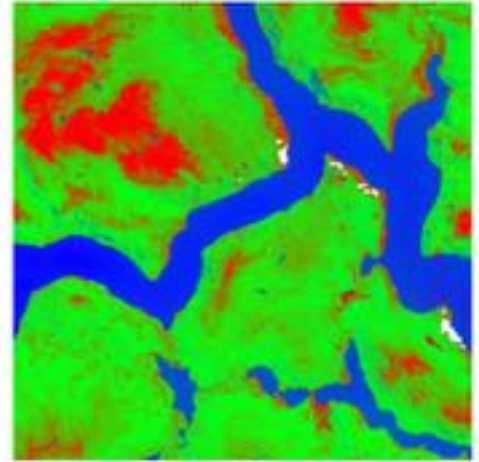PRISMA Caspian Hyrcanian Forest, Iran

SISTER VSWIR Prototype L2B Workflow – Snow/ice

Aquatic

Terrestrial Ecosystem

Reflectance

Snow/Ice

Fractional cover

Geology / Earth Surface

Forthcoming

| All Disciplines | Aquatic Products | Geology / Earth Surface Products |
| Ancillary datasets | Terrestrial Ecosystem Products | Snow/Ice Products |

Grain size (microns)

1000

800

600

400

200

0

Snow grain size (Nolin and Dozier 2000)

SISTER VSWIR Prototype L2B Workflow – Fractional cover

Reflectance

- Aquatic
- Terrestrial Ecosystem
- Snow/Ice
- Fractional cover
- Geology / Earth Surface

Forthcoming

| All Disciplines | Aquatic Products | Geology / Earth Surface Products |
| Ancillary datasets | Terrestrial Ecosystem Products | Snow/Ice Products |
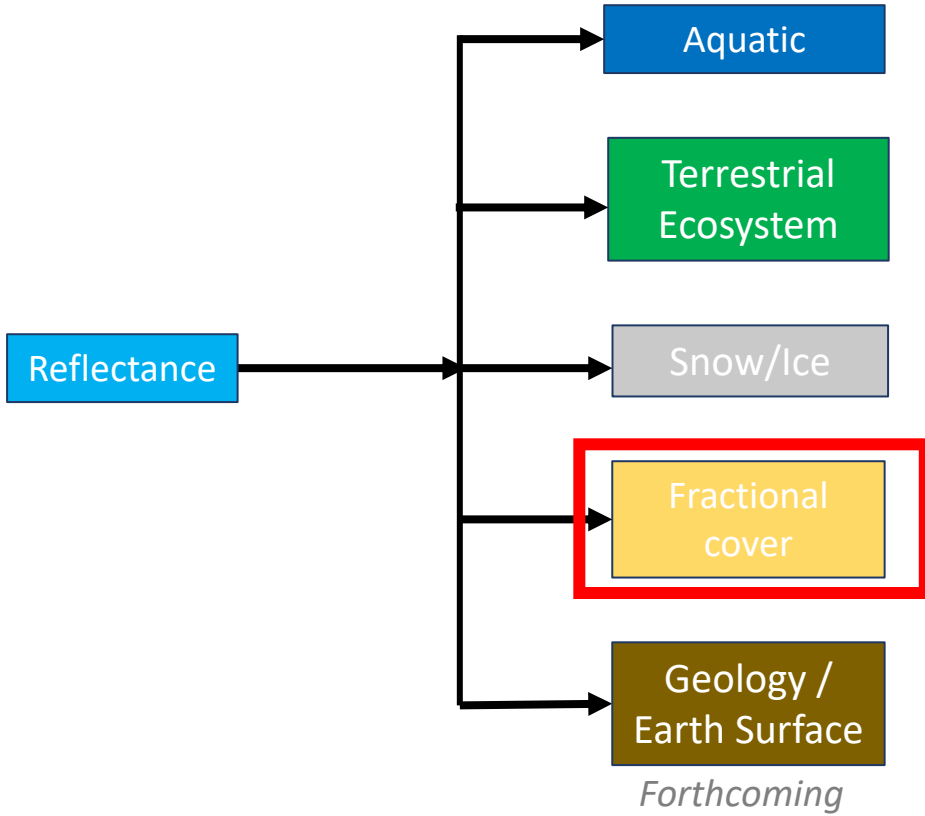
PRISMA Luster Allmenning, Norway
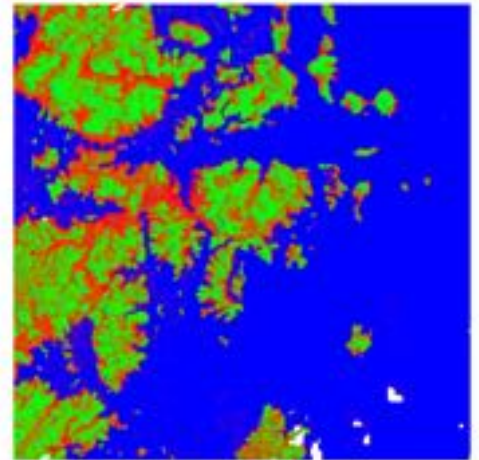
PRISMA Geoje, South Korea

Soil

Vegetation

Water

Fractional Cover (EMIT Science Team)

Next Steps

- First production run using the on-demand system was last week (performed on a selection of images from PRISMA, DESIS, AVIRIS-NG, AVIRIS-Classic) across multiple project areas including SHIFT, ABoVE, etc.
- Set up distribution mechanism with ORNL and LP.DAAC
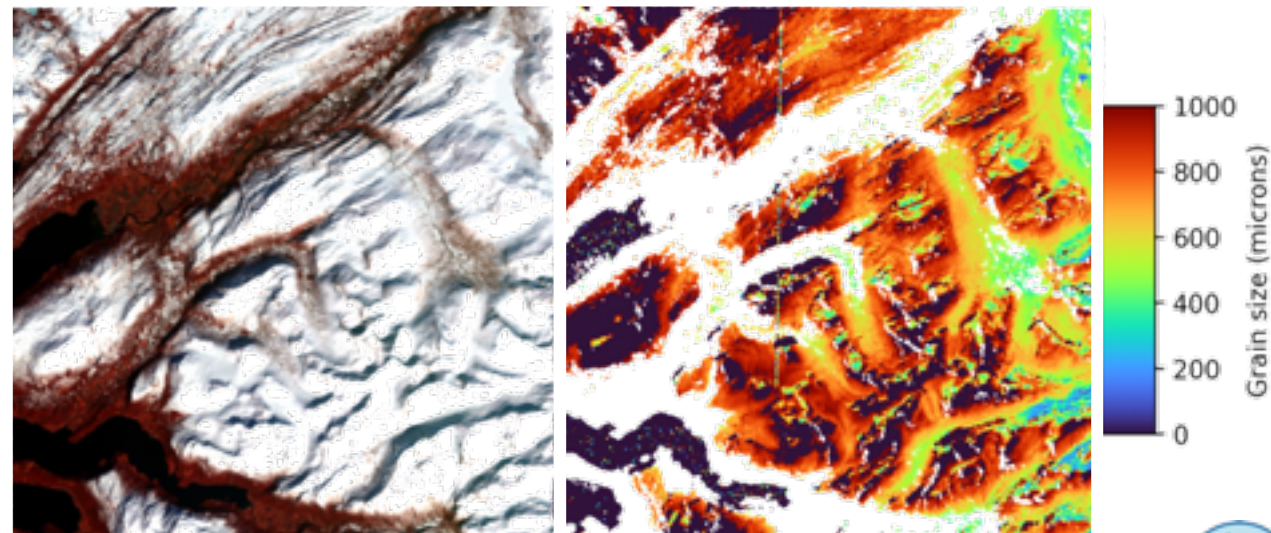- Implement prototype geology products based on EMIT algorithms

Vegetation Biochemistry
PRISMA Snæfellsjökull, Iceland July 2, 2020
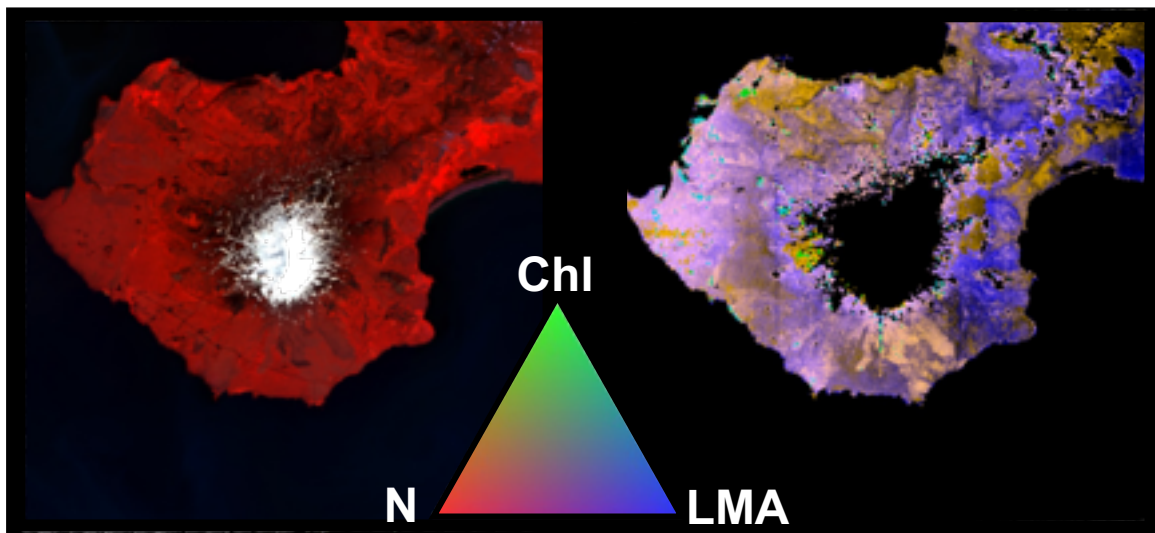
Snow grain size
PRISMA Surnadal, Norway April 21, 2020

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

Activities at NASA Ames Research Center (1/2)

- Completed processing the 55-TB Hyperion data to top-of-atmosphere radiances (L1)
- Currently checking consistency of Hyperion surface reflectance results using ISOFIT (L2, Figs 1, 2, 3 & 4)
- We are releasing science pipeline control software (Ziggy) under NASA's Open-Source Software Initiative in October 2022
- Next Steps: Incorporate contemporary Landsat/Sentinel georeferencing for Hyperion data in collaboration with USGS
- Future work: incorporate L3 algorithms for vegetative traits and/or aquatic studies to processed Hyperion data
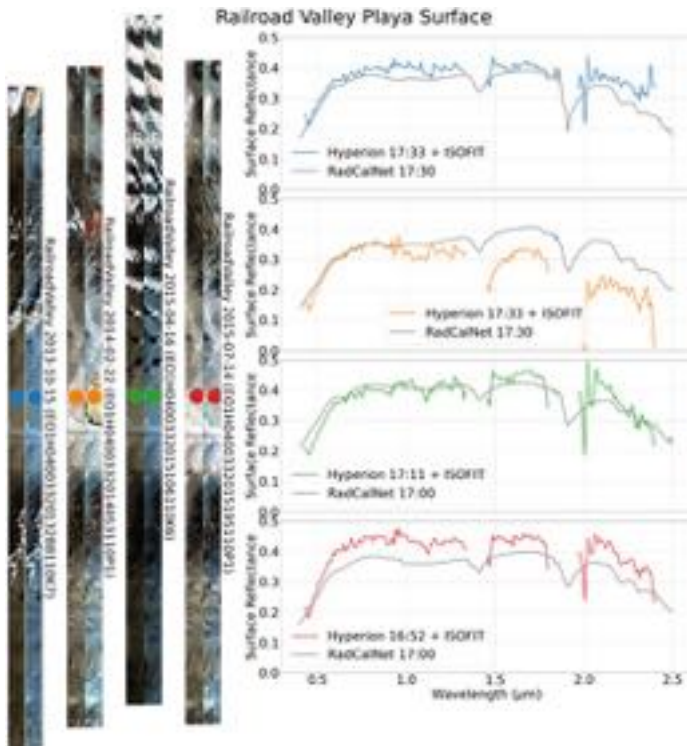- Completed analysis of cost to process SBG data at HECC from L0 to L2 (Table I)

Figure 1. Comparison of RadCalNet measurements with Hyperion surface reflectance retrievals for scenes observed in Railroad Valley.
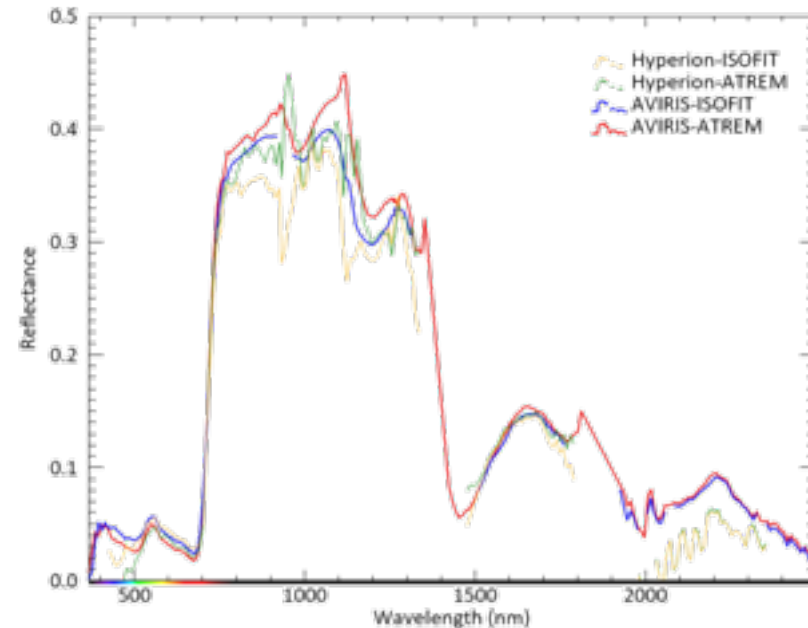

Figure 2. Comparison of surface reflectance spectra retrieved with the Hyperion and AVIRIS sensors, each with ISOFIT and ATREM retrieval algorithms. The results are shown for a vegetation site near Half Moon Bay, CA, observed on April 30, 2015.

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

Activities at NASA Ames Research Center (2/2)

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- Next Steps: Incorporate contemporary Landsat/Sentinel georeferencing for Hyperion data in collaboration with USGS
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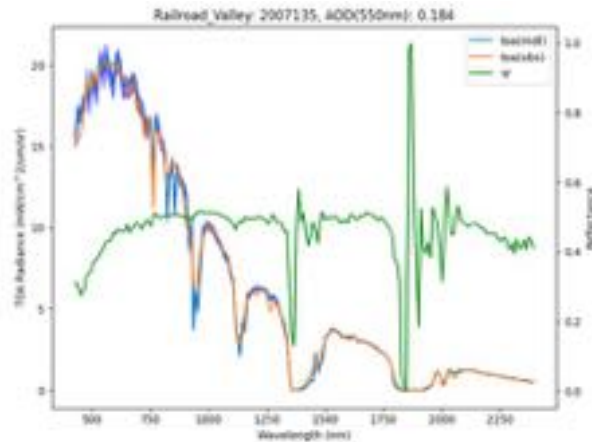- Completed analysis of cost to process SBG data at HECC from L0 to L2 (Table I)

Figure 3. Comparison of surface reflectance spectra retrieved with the Hyperion and AVIRIS sensors, each with ISOFIT and ATREM retrieval algorithms. The results are shown for a vegetation site near Half Moon Bay, CA, observed on April 30, 2015.
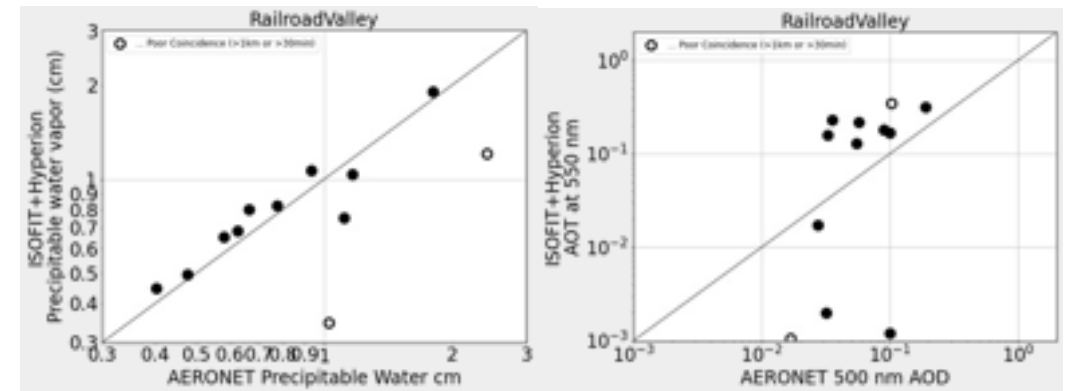

Figure 4. Comparison of Hyperion ISOFIT atmospheric products (left: water vapor, right: aerosol optical depth) with AERONET observations at Railroad Valley.

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

Phil Townsend (University of Wisconsin, Madison) – Co-Lead

Michelle Gierach (JPL) – Co-Lead, JPL Center Lead

Ben Poulter (GSFC) – GSFC Center Lead

Ian Brosnan (ARC) – ARC Center Lead

Adam Chlus (JPL) and Jon Jenkins (Ames)