Surface Biology and Geology (SBG)

SBG TIR Low Latency Products Update

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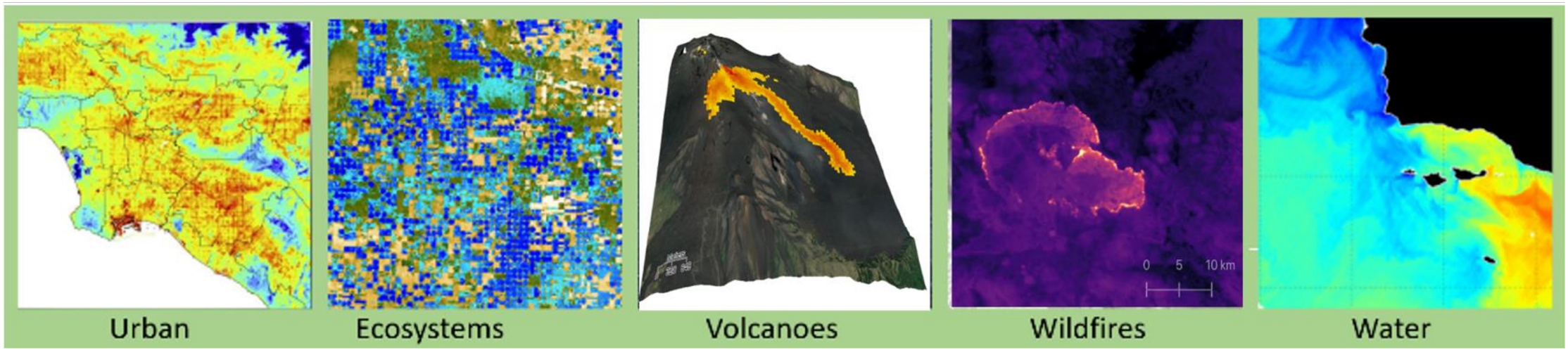
Objectives and priorities

- Key Decadal Survey Questions were clarified and expanded by R&A community in 5 areas:



Urban	Ecosystems	Volcanoes	Wildfires	Water
• VNIR 30m • 2 VNIR Bands • High spatial resolution TIR • Frequent revisit	• VNIR 30m • 2 VNIR Bands • High spatial resolution TIR • Frequent revisit	• VNIR 30 m • High 3-5 um saturation • TIR band placement for SO_2 and mineral composition	• High 3-5 um saturation • MIR band placement for FRP	• Two longest TIR bands for split window • High sensitivity and accuracy for water temperature

Different research areas have different requirements, some unique, some common

SBG Applications Objectives and Priorities

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: DECADAL SURVEY APPLICATION OBJECTIVES ACROSS ALL FIVE DS FOCUS AREAS

SBG: TIR Applications Summary

SBG-TIR's baseline scope is required by multiple application areas and lower latency adds benefits

- **Water resources, agriculture, and food security**
  - 8-16 day revisit can result in substantial temporal gaps in understanding current conditions on water stress, drought, irrigation advisories (Anderson et al, ECOSTRESS / Landsat interoperability)
  - 100-m is considered too coarse
  - 3-day revisit is a substantial benefit, but daily would be even better depending on the agriculture app

- **Wildfire risk, resilience and management**
  - **Active fires:** SBG-TIR would benefit USFS fire operator access to relevant data needed to respond to active fire events
  - Pre-fire risk reduction: Fuel condition/health can be used to inform areas that are highly vulnerable to wildfires, including forest treatment decisions
  - Post-fire recovery: Landscape recovery and conversion is better; ECOSTRESS helps us better resolve these processes, SBG-TIR will provide continuity here (though temporal may be less critical compared with spectral / spatial)

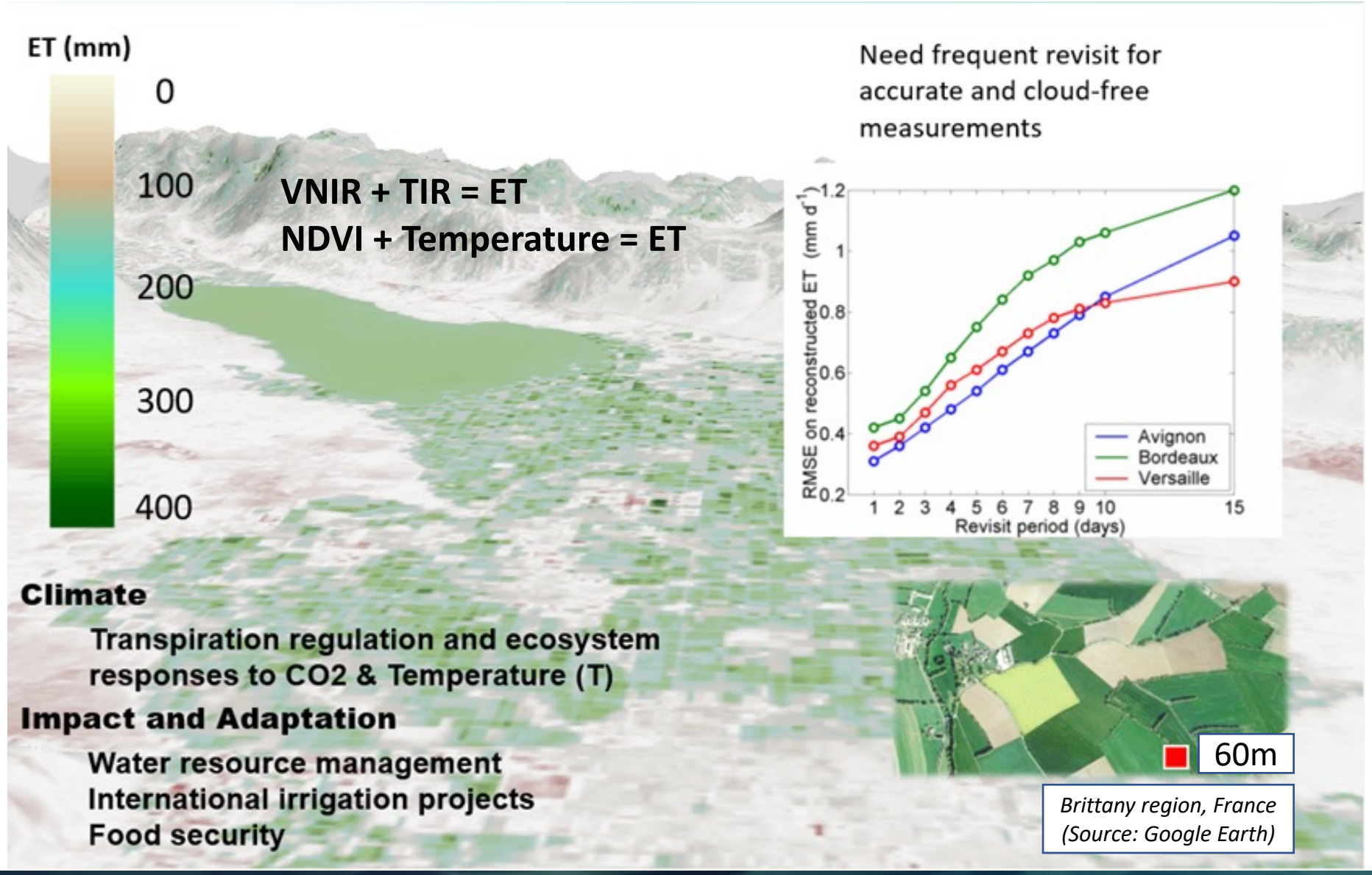
- **Volcanic and other geologic hazard response**
  - Geologic hazards require frequent revisit and on finer spatial scales that would allow partners to make timely, urgent decisions regarding distribution of aid, hazard monitoring / evolution, and other resource allocation decisions

- **Urban heat island / public health response to heat waves**
  - SBG-TIR would generally benefit state and county public health agencies plan for and respond to heat stress, which is one of the most significant sources of health-related deaths each year. This community needs even finer spatial resolution than what is proposed, but they still stand to benefit.

- Biodiversity / Conservation – TIR needed for understanding vegetation stress and response to drought. disease and other hazards, understand invasive species; used to assess inform location for restoration and monitoring of impacts; used to assess degraded thermal conditions in inland and coastal waters with MPAs; temporal revisit of 3 days is not critical, except in tropics / or other areas with frequent cloud-cover

Benefits from more frequency revisit / better latency

Example 1: Revisit and latency are critical for agriculture applications that utilize ET



ECOSTRESS used to deliver irrigation advisories to farmers

Pixel: Min Adviced Water (mm/d)

0.00
6.00
12.00
18.00
24.00
30.00

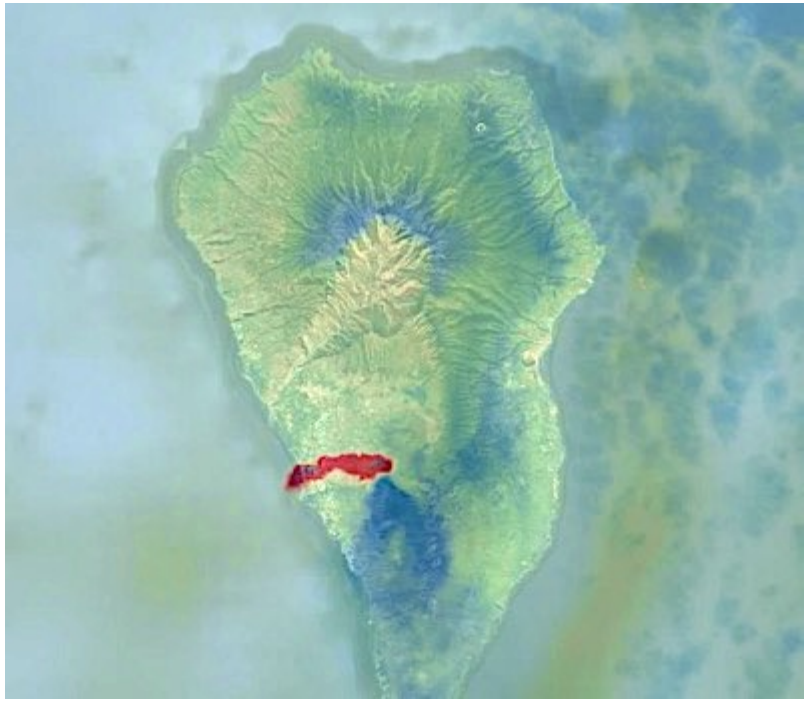
"Bringing ECOSTRESS Information to farmers" - IrriWatch CEO Wim Bastiaanssen

IrriWatch integrates ECOSTRESS data into high quality estimates of water use and delivers irrigation advisories to over 18,000 fields in 25 countries around the world.

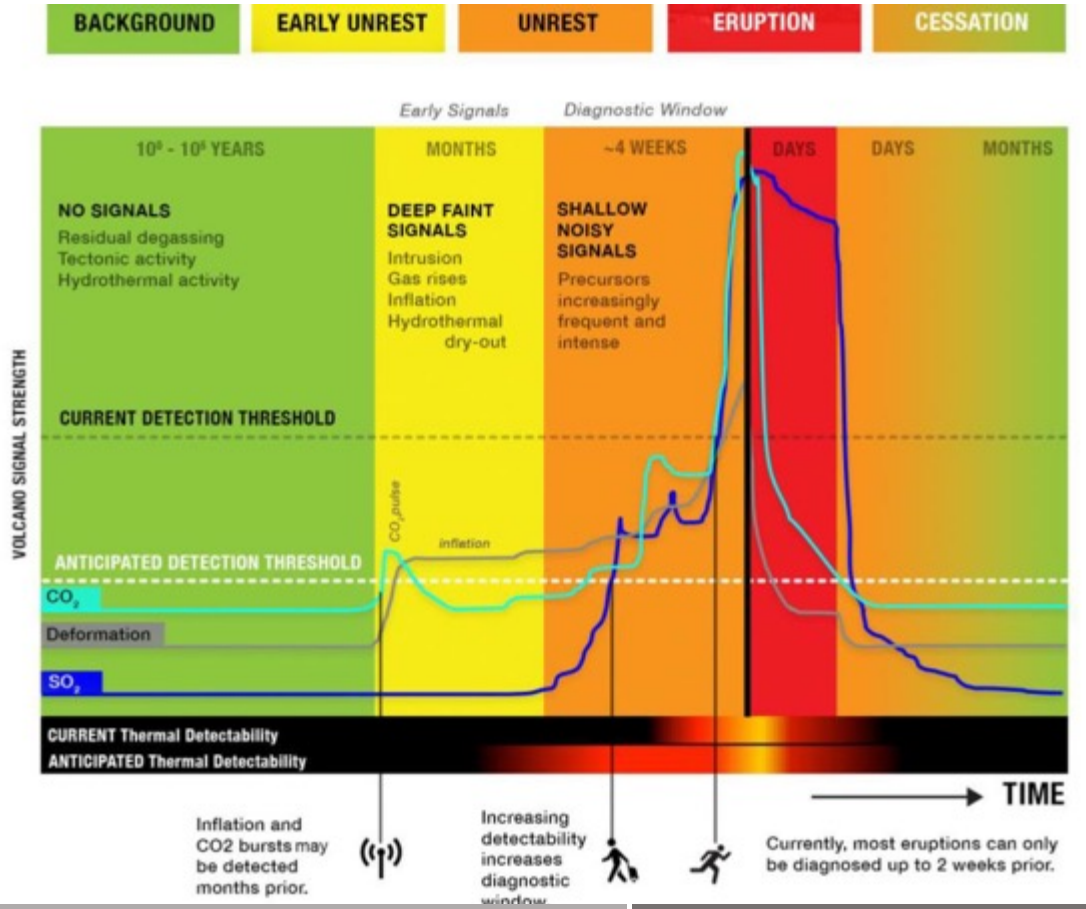
IrriWatch

Example 2: Improved Latency and Revisit Mitigating Geologic Hazards

Societal Challenge: globally, > 450 volcanoes with on-going eruptions/activity + increasing human population that could be severely impacted.



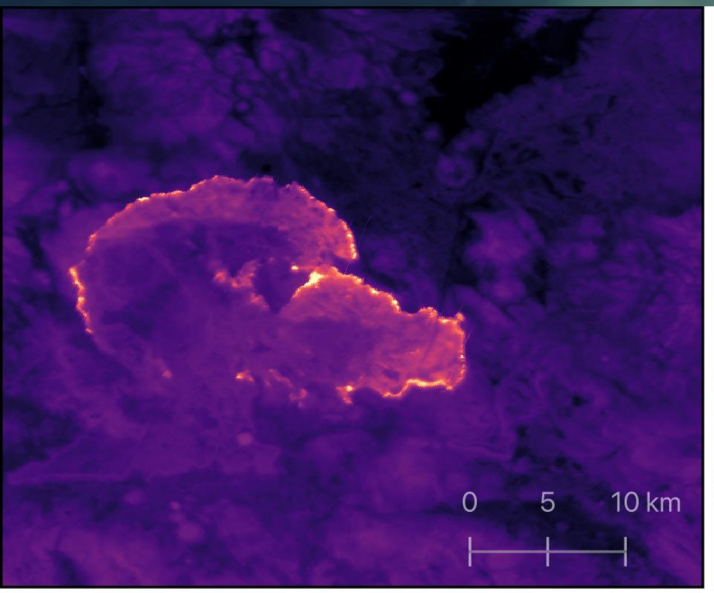
High temperature features low latency product could be used to identify impacted areas.

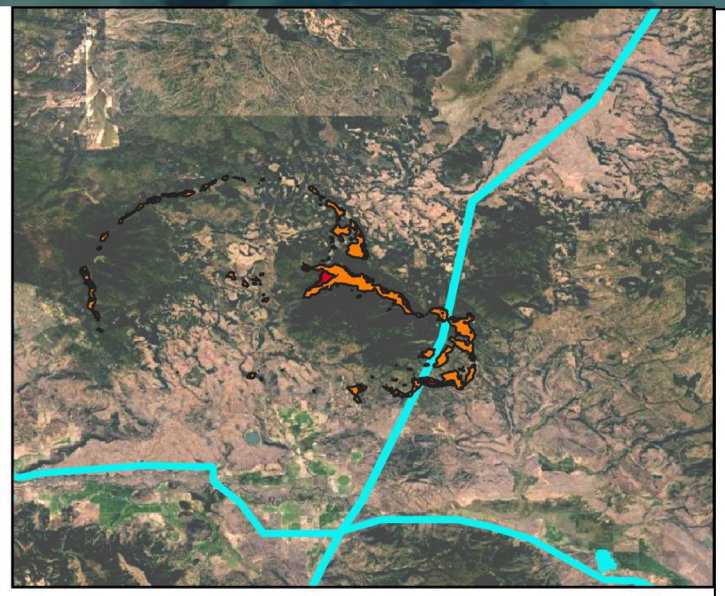


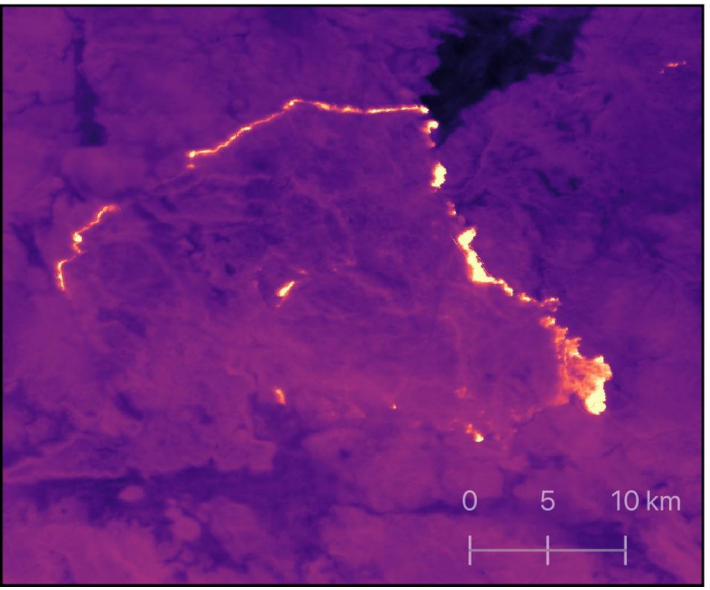
Observatories conduct background monitoring	Observatories under heightened alert & activity

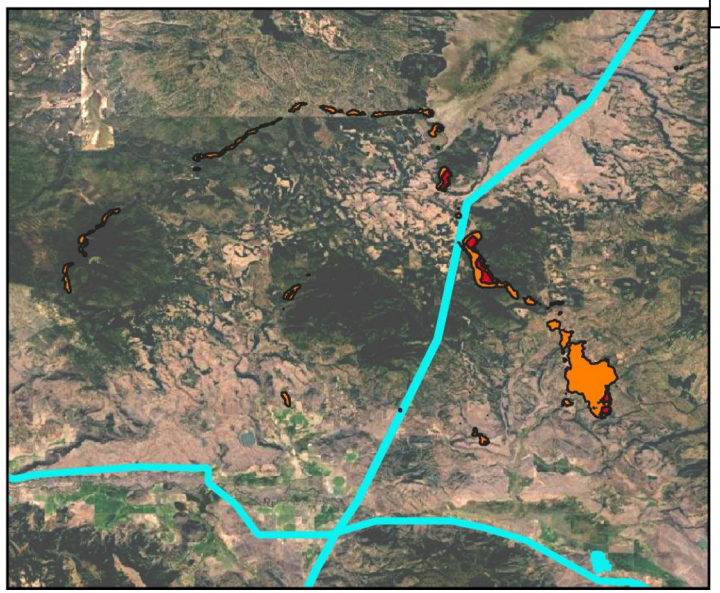
Decision relevant information from SBG:
Unrest detection & confirmation based on observables;
Decision support data from observables

Example 3: Improved Latency and Revisit For Wildfires









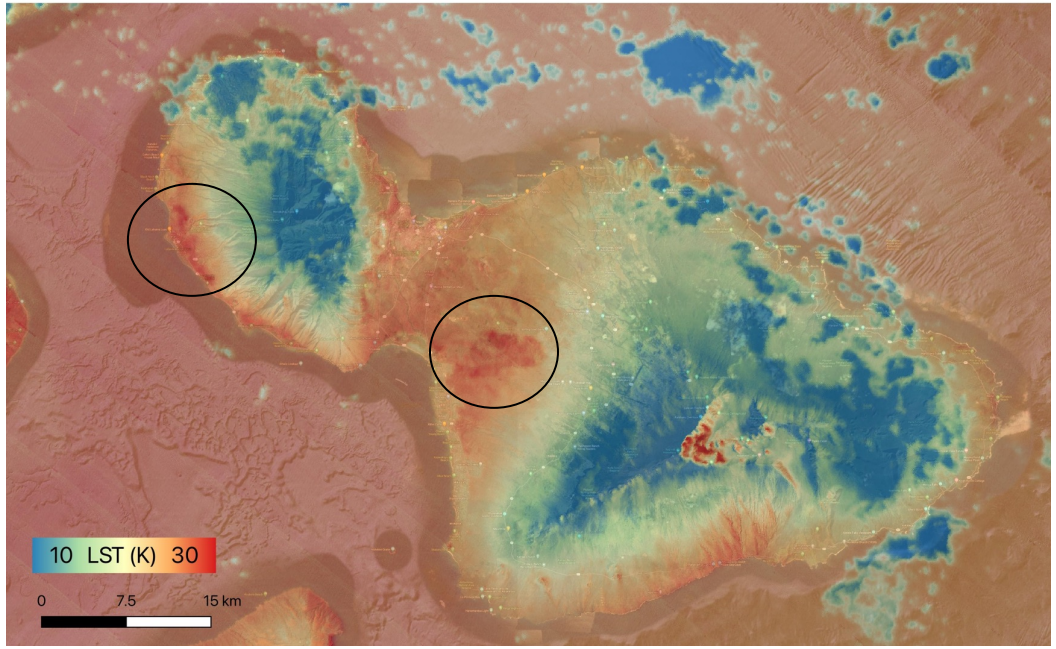
"ECOSTRESS allows us to use the [fire maps] from last night in the morning…this is what's required if you're going to put data into the hands of incident commanders." -- USGS podcast with PNNL and USFS

ECOSTRESS imagery is integrated into an operational active fire response tool by PNNL to support USFS fire operators and responders.

ECOSTRESS data for Hawaii Wildfires

K. Cawse-Nicholson

ECOSTRESS image acquired over Maui
on August 12th, 2023, at 07:30am local time.



Land surface temperature (LST) for the island of Maui, Hawaii, showing the Lahaina wildfire on the west coast. A clear hotspot can be seen around Lahaina, and some inland fires near Red Hill, Haleakala. The ocean is warmer than the surrounding land since it is from 07:30 am local time, but the land will heat up quickly as the day goes on.

https://maps.disasters.nasa.gov/arcgis/home/webmap/viewer.html?useExisting=1

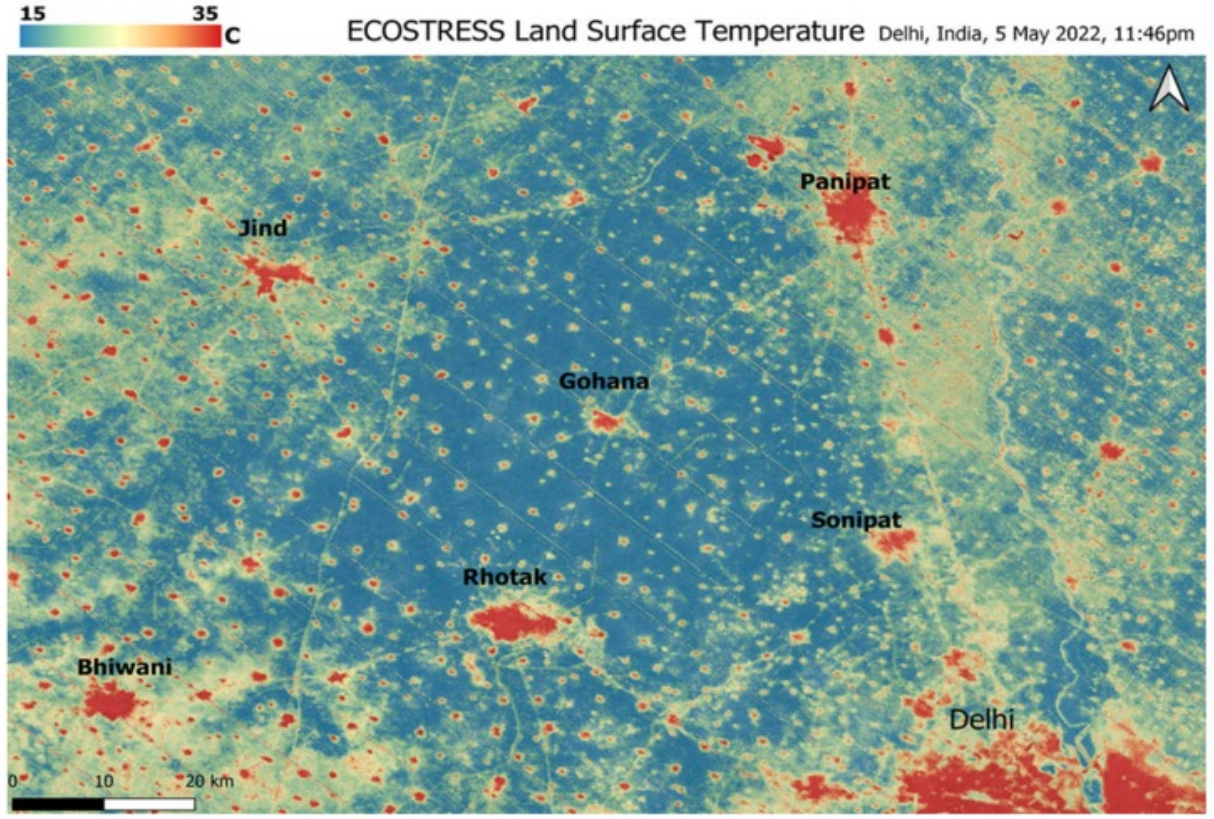
A devastating wildfire began on August 8th 2023 in Lahaina on the Hawaiian island of Maui. Extreme winds exacerbated the effects of this wildfire.

Data & Results: Data from the ECOsystem Spaceborne Thermal Radiometer on Space Station (ECOSTRESS) land surface temperature data was used to map the fire in the first couple days following ignition. This data was shared with NASA Earth Science Disasters Program, and is hosted on their ArcGIS online platform.

Significance: The high resolution (~70 m) data from ECOSTRESS is available every 3 to 5 days at a low latency of (~24 hours). This is important for quickly pinpointing the location and spread of wildfires.

Example 4: Improved Latency and Revisit For Urban Heat

NASA's ECOSTRESS Detects 'Heat Islands' in Extreme Indian Heat Wave



NASA's ECOSTRESS instrument made this image of ground temperatures near Delhi (lower right), around midnight on May 5. The urban "heat islands" of Delhi and smaller villages peaked at 102 degrees Fahrenheit (39 degrees Celsius) while nearby fields were about 40 degrees Fahrenheit cooler.

Credits: NASA/JPL-Caltech

"The greatest benefit of SBG may be to developing countries where a large percentage of the urban population is vulnerable to heat stroke and death. Such maps can save lives."

- RTI Report International Aid Worker

TIR Low Latency Products

Product Name	Joint product	Product Level	Tiled	Requires TIR and VNIR	Day/Night
Swath Top of Atmosphere TIR Calibrated Radiance Instantaneous L2 Global 60 m	N	L1	Y	N	D and N
Tiled Surface Temperature and Emissivity **Low Latency** Instantaneous L2 Global 60 m	N	L2	Y	N	D and N
Tiled Cloud Mask **Low Latency** Instantaneous L2 Global 60 m	N	L2	Y	N	D and N
Tiled Elevated Thermal Features **Low Latency** Instantaneous L2 Global 60 m	N	L3	Y	N	D and N
Tiled ET **Low Latency** Instantaneous L2 Global 60 m	N	L2	Y	N (uses LL STARS)	D only
Tiled **Low Latency** Volcanic Activity L4 Global 60 m	N	L4	Y	N	D and N

TIR Low Latency Products

Product Name	Joint product	Product Level	Tiled	Requires TIR and VNIR	Day/Night
Swath Top of Atmosphere TIR Calibrated Radiance Instantaneous L2 Global 60 m		1	Y	N	D and N
Tiled Surface Temperature and Emissivity **Low Latency** Instantaneous L2 Global 60 m		2	Y	N	D and N
Tiled Cloud Mask **Low Latency** Instantaneous L2 Global 60 m	N	L2	Y	N	D and N
Tiled Elevated Thermal Features **Low Latency** Instantaneous L2 Global 60 m	N	L2	Y	N	D and N
Tiled ET **Low Latency** Instantaneous L2 Global 60 m	N	L3	Y	N (uses LL STARS)	D only
Tiled **Low Latency** Volcanic Activity L4 Global 60 m	N	L4	Y	N	D and N

Fires, Urban Heat, Volcanoes

TIR Low Latency Products

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Swath Top of Atmosphere TIR Calibrated Radiance Instantaneous L2 Global 60 m	N	L1	Y	N	D and N
Tiled Surface Temperature and Emissivity **Low Latency** Instantaneous L2 Global 60 m	N	L2	Y	N	D and N
Tiled Cloud Mask **Low Latency** Instantaneous L2 Global 60 m	N	L2	Y	N	D and N
Tiled Elevated Thermal Features **Low Latency** Instantaneous L2 Global			Y	N	D and N
Tiled ET **Low Latency** Instantaneous L2 Global 60 m			Y	N (uses LL STARS)	D only
Tiled **Low Latency** Volcanic Activity L4 Global 60 m	N	L4	Y	N	D and N

Agriculture and Water Resources

Differences Between Low Latency & Standard Products

Product Name	Differences in Processing / Inputs
Swath Top of Atmosphere TIR Calibrated Radiance Instantaneous L2 Global 60 m	• L1C does not contain VNIR products • No orbital correction metadata from ASI for low latency
Tiled Surface Temperature and Emissivity **Low Latency** Instantaneous L2 Global 60 m	• Uses Low Latency L-1 Product • Uses GEOS5 atmospheric data from forecast (instead of GEOS—FP)
Tiled Cloud Mask **Low Latency** Instantaneous L2 Global 60 m	
Tiled Elevated Thermal Features (ETF) **Low Latency** Instantaneous L3 Global 60 m	• No atmospheric correction (operates on Top of Atmosphere LL radiance product), thus producing Brightness Temperature data • Being designed to operate on a reduced number of bands (e.g., 3.98, 11.35, 12 μm) • Likely will be a simplified statistical threshold approach rather than the more time-intensive machine learning approach being tested
Tiled ET **Low Latency** Instantaneous L2 Global 60 m	• NDVI/albedo from 3-days prior from STARS • Uses GEOS5 atmospheric data from forecast • Uses 1-algorithm for ET (not JET ensemble) • Uses Low Latency L-2 Product
Tiled **Low Latency** Volcanic Activity L4 Global 60 m	

Summary & Next Steps

- 6 Low-Latency products are under development by product leads
  - **L-1 Radiance** Tom Logan
  - **L-2 LSTE** Glynn Hulley
  - **L-3 ET** Gregory Halverson
  - **L-3 / L-4 ETF** and VA Mike Ramsey, Vince Realmuto
- Algorithm development; and ancillary data set selections
- Algorithm selection for processing time and accuracy
- Uncertainty quantification / error budgets
- Working code examples