



HyspIRI

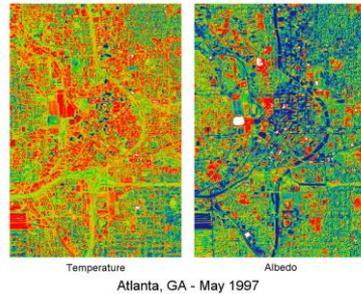
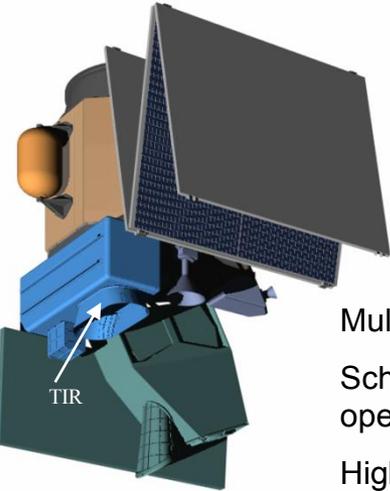
Short Summary of the TIR Instrument and Science Measurement Baseline

NASA Earth Science and Applications Decadal Survey

Simon J. Hook and HyspIRI Group



HyspIRI Thermal Infrared Multispectral (TIR) Science Measurements



Multispectral Scanner

Schedule: 4 year phase A-D, 3 years operations

High Heritage

Science Questions:

TQ1. Volcanoes/Earthquakes (MA,FF)

– How can we help predict and mitigate earthquake and volcanic hazards through detection of transient thermal phenomena?

• TQ2. Wildfires (LG,DR)

– What is the impact of global biomass burning on the terrestrial biosphere and atmosphere, and how is this impact changing over time?

• TQ3. Water Use and Availability, (MA,RA)

– How is consumptive use of global freshwater supplies responding to changes in climate and demand, and what are the implications for sustainable management of water resources?

• TQ4. Urbanization/Human Health, (DQ,GG)

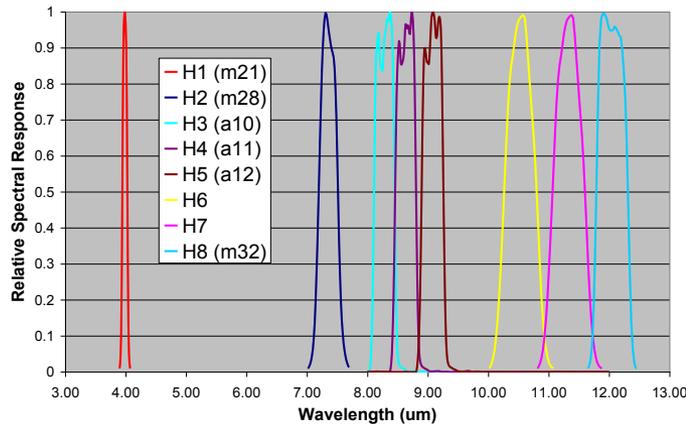
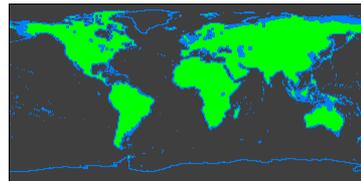
– How does urbanization affect the local, regional and global environment? Can we characterize this effect to help mitigate its impact on human health and welfare?

• TQ5. Earth surface composition and change, (AP,JC)

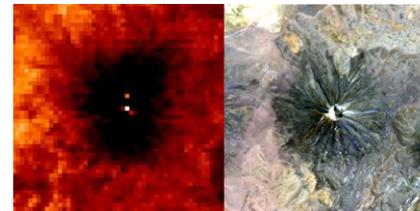
– What is the composition and temperature of the exposed surface of the Earth? How do these factors change over time and affect land use and habitability?

Measurement:

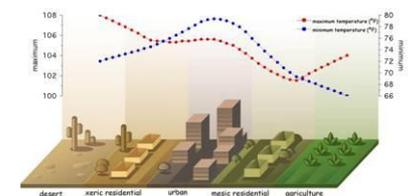
- 7 bands between 7.5-12 μm and 1 band at 4 μm
- 60 m resolution, 5 days revisit
- Global land and shallow water



Andean volcano heats up



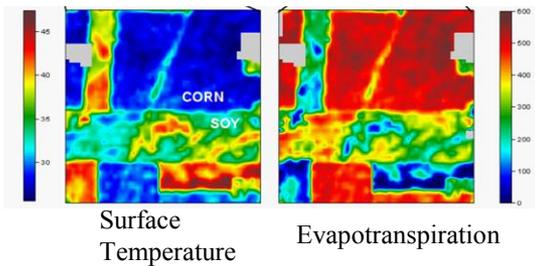
Urbanization



Volcanoes



Water Use and Availability





TIR Overarching Science Questions



- **TQ1. Volcanoes/Earthquakes (MA,FF)**
 - How can we help predict and mitigate earthquake and volcanic hazards through detection of transient thermal phenomena?
- **TQ2. Wildfires (LG,DR)**
 - What is the impact of global biomass burning on the terrestrial biosphere and atmosphere, and how is this impact changing over time?
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 - How is consumptive use of global freshwater supplies responding to changes in climate and demand, and what are the implications for sustainable management of water resources?
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Wildfires



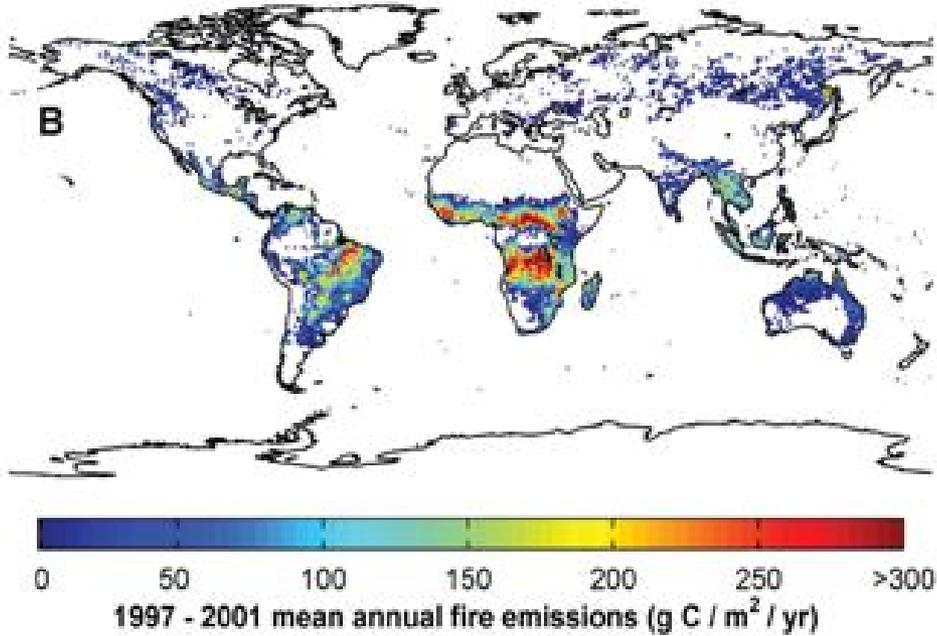
- How are global fire regimes changing in response to, and driven by, changing climate, vegetation, and land use practices? [DS 198]
- Is regional and local scale fire frequency changing? [DS 196]
- What is the role of fire in global biogeochemical cycling, particularly trace gas emissions? [DS 195]
- Are there regional feedbacks between fire and climate change?



Measuring global fire emission is necessary for reducing the uncertainty in carbon emissions from biomass burning



Global average biomass burning estimates range from 20 – 40 % of all global C emissions.



Van der Werf et al., 2010

Fires occur worldwide need a GLOBAL Mapping Mission, emissions vary regionally



HyspIRI-TIR will measure Radiative Energy that has been shown to yield precise estimates of Biomass Combusted



- Historically calculated using Seiler & Crutzen (1980) approach:
Biomass combusted = Area Burnt x Fuel Load x Combustion Efficiency

- More recently Fire Radiative Energy approach
Biomass combusted = Radiative energy or heat yield

(Since the heat yield (*kJ/kg*) of vegetation fuel is ~ constant, measuring the energy released on burning and knowing the heat yield allows the amount of biomass burned to be calculated.)

- For both methods:

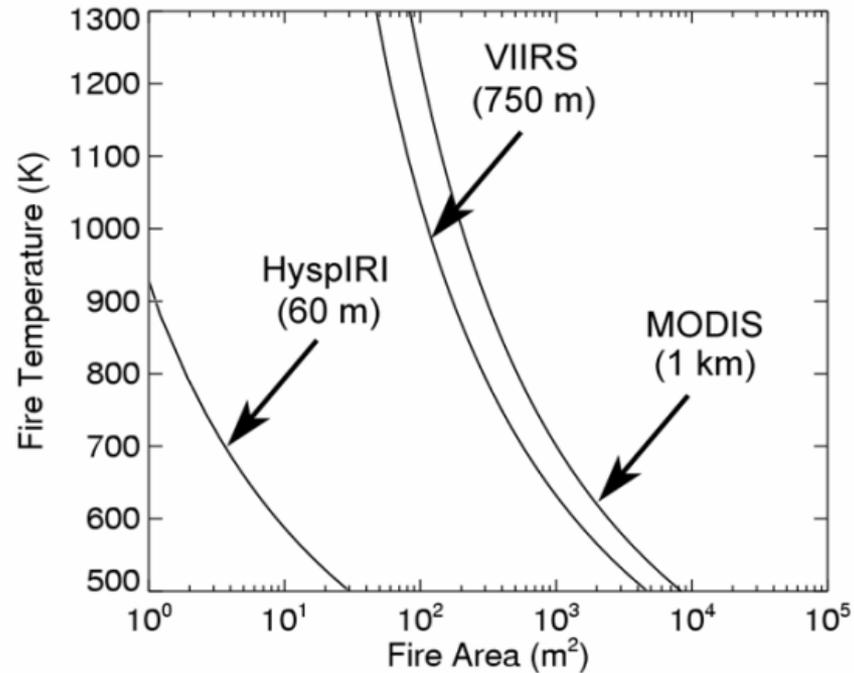
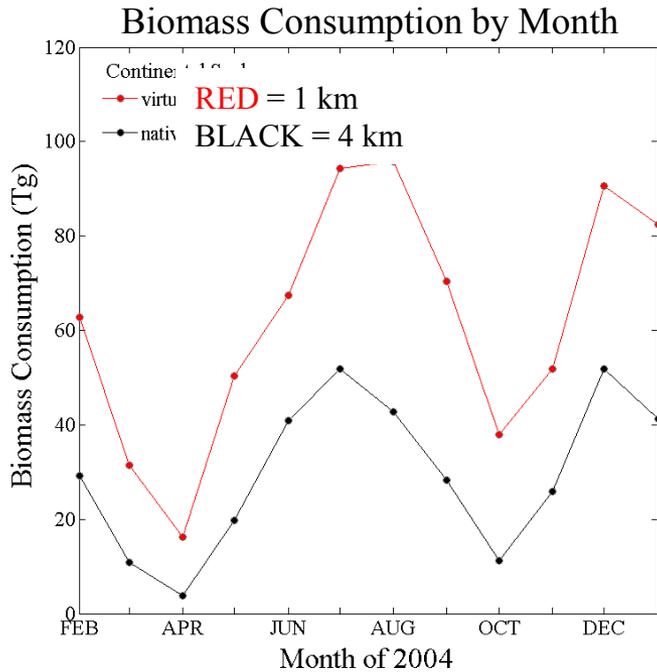
$$Biomass\ combusted \times Emission\ factor = Carbon\ released$$

Emission factors are obtained for given cover type
e.g. forest vs peat





HyspIRI-TIR Provides Orders of Magnitude Improvement in Measurement Capability



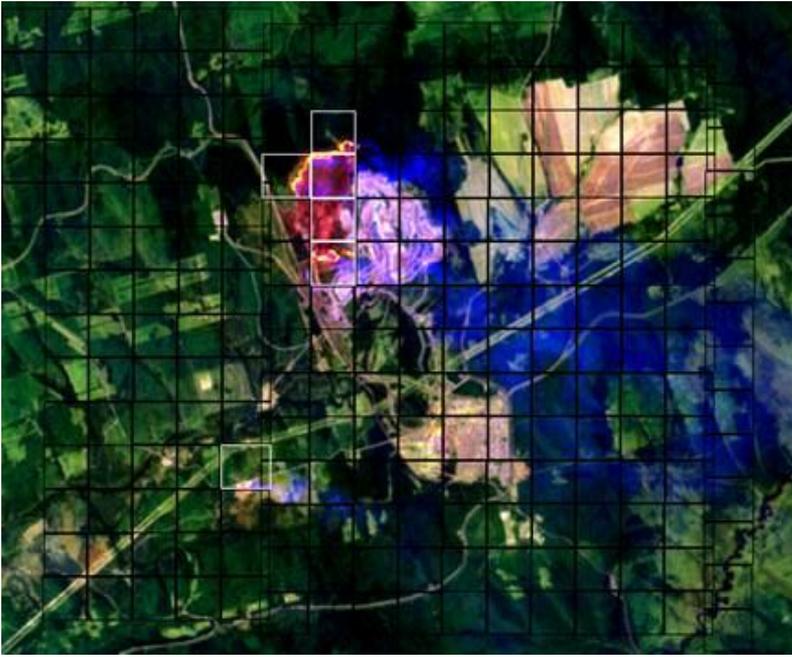
- HypsIRI-TIR measures very small fires as well as large fires. Small fires have a disproportionately large carbon contribution
- Global carbon contribution from peat, agricultural and deforestation fires unknown because cannot be measured with current sensors but see a large discrepancy between 1km MODIS and 4km GOES



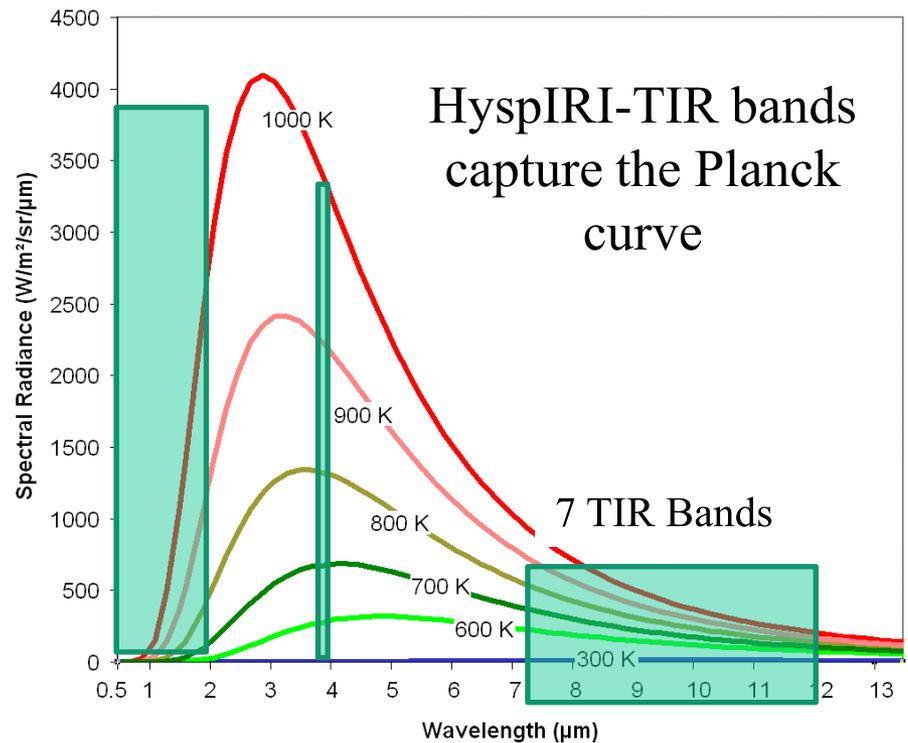
Measuring carbon fire emissions requires measurements in the Mid and Thermal Infrared



- Greater sensitivity due to shift in emission peak with temperature
- Measure radiance rather than temperature and avoid mixed pixel problem



MODIS only detects white boxes (1kmX1km) does not provide information on the fire front or smouldering part of fire



Thermal emission peaks in the MIR (3-5 μm) region for fire temperatures ranging from ~ 650 K (weak smouldering) to ~ 1400 K (strong flaming). MIR is far more sensitive to hot targets than TIR.

5/28/2011



Water Use and Availability



- How is climate variability (and ENSO) impacting the evaporative component of the global water cycle over natural and managed landscapes? [DS 166, 196, 203, 257, 368]
- What are relationships between spatial and temporal variation in evapotranspiration and land-use/land-cover and freshwater resource management? [DS 196, 203, 368]
- Can we improve early detection, mitigation, and impact assessment of droughts at local to regional scales anywhere on the globe? [DS 166, 196, 203, 368]; How does the partitioning of Precipitation into ET, surface runoff and ground-water recharge change during drought?
- What areas of Earth have water consumption by irrigated agriculture that is out of balance with sustainable water availability? [DS 196, 368]
- Can we increase food production in water-scarce agricultural regions while improving or sustaining quality and quantity of water for ecosystem function and other human uses? [DS 196, 368]



High Spatial and Temporal Resolution Required to Accurately Measure Evapotranspiration (ET)

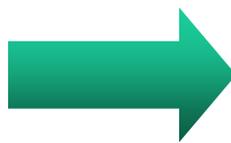
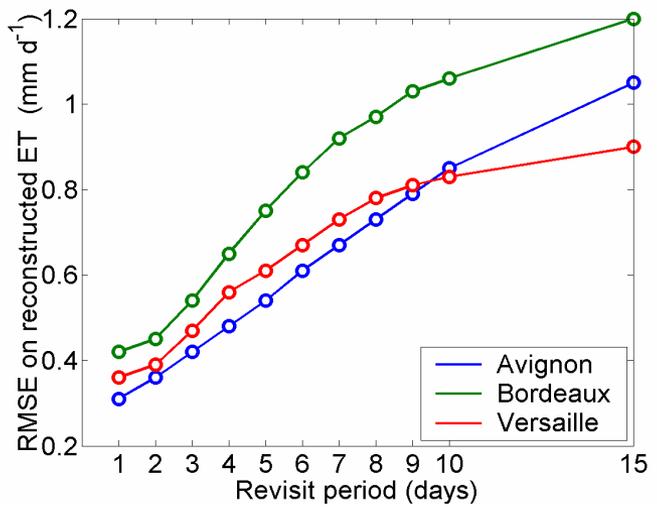


High spatial resolution: access to the local scale (field, urban district...)



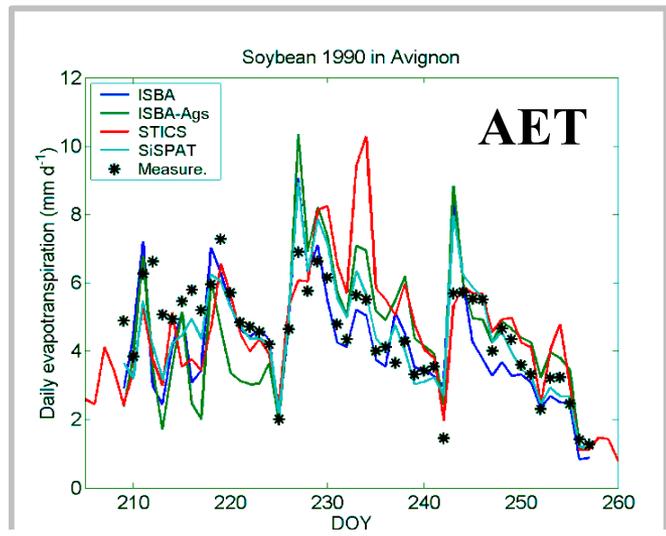
1 km box

1 km data does not capture field scale variation

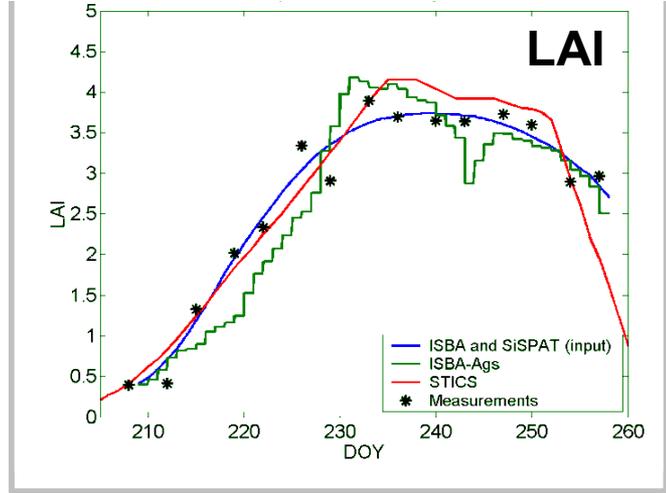


High revisit: rapid response to surface forcing (water status, meteorological conditions...)

5-day revisit minimizes error on ET Estimation



ET is very dynamic compared with LAI



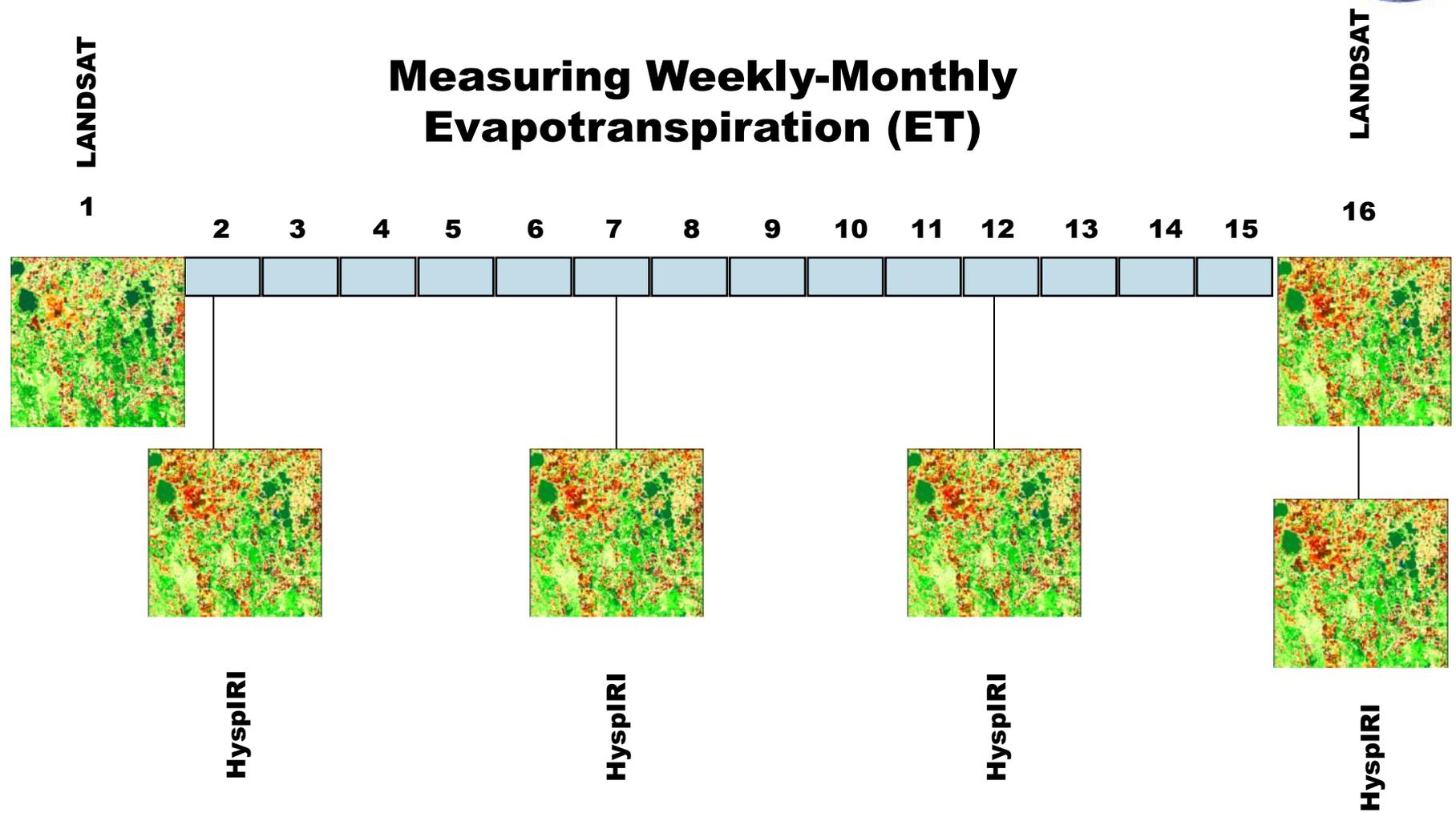
Courtesy Jean-Pierre Lagouarde, INRA, France



Evapotranspiration and Water Use and Availability



Measuring Weekly-Monthly Evapotranspiration (ET)



HypsIRI-TIR provides ET data every 5 days, allows weekly-monthly measurement
And expectation for a cloud-free scene (typically 1 in every 3 data takes)



Science Measurements

Summary Measurement Characteristics



Spectral

Bands (8) μm	3.98 μm , 7.35 μm , 8.28 μm , 8.63 μm , 9.07 μm , 10.53 μm , 11.33 μm , 12.05 μm
Bandwidth	0.084 μm , 0.32 μm , 0.34 μm , 0.35 μm , 0.36 μm , 0.54 μm , 0.54 μm , 0.52 μm
Accuracy	<0.01 μm

Radiometric

Range	Bands 2-8= 200K – 500K; Band 1= 1400K
Resolution	< 0.05 K, Linear Quantization to 14 bits
Accuracy	< 0.5 K 3-sigma at 250K
Precision (NEdT)	< 0.2K
Linearity	>99% characterized to 0.1 %

Spatial

IFOV	60 m
MTF	>0.65 at FNy
Scan Type	Push-Whisk
Swath Width	600 km ($\pm 25.5^\circ$ at 623 km altitude)
Cross-Track Samples	10,000
Swath Length	15.4 km (± 0.7 -degrees at 623km altitude)
Down-Track Samples	256
Band-to-Band Co-registraion	0.2 pixels (12 m)
Pointing Knowledge	1.5 arcsec (0.1 pixels)



Science Measurements Characteristics Continued



Temporal

Orbit Crossing

10:30 am sun synchronous descending

Global Land Repeat

5 days at equator

OnOrbit Calibration

Lunar View

1 per month {radiometric}

Blackbody Views

1 per scan {radiometric}

Deep Space Views

1 per scan {radiometric}

Surface Cal Experiments

2 (d/n) every 5 days {radiometric}

Spectral Surface Cal Experiments

1 per year

Data Collection

Time Coverage

Day and Night

Land Coverage

Land surface above sea level

Water Coverage

Coastal zone -50 m and shallower

Open Ocean

Averaged to 1km spatial sampling

Compression

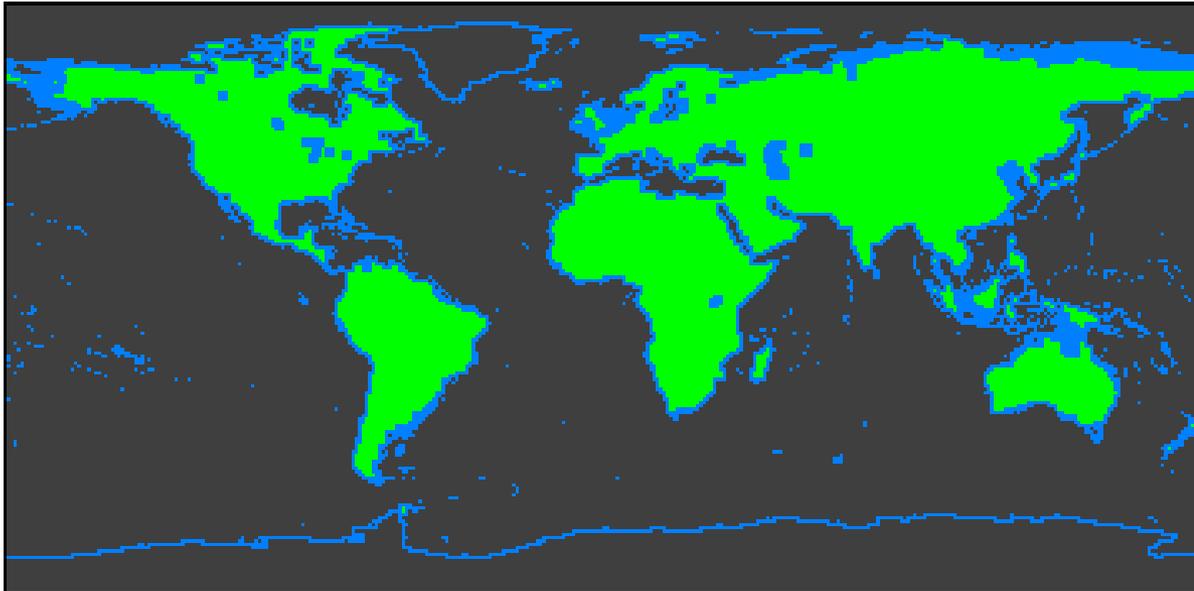
2:1 lossless



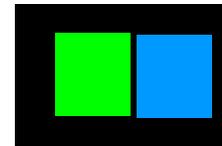
Mission Concept Operational Scenario



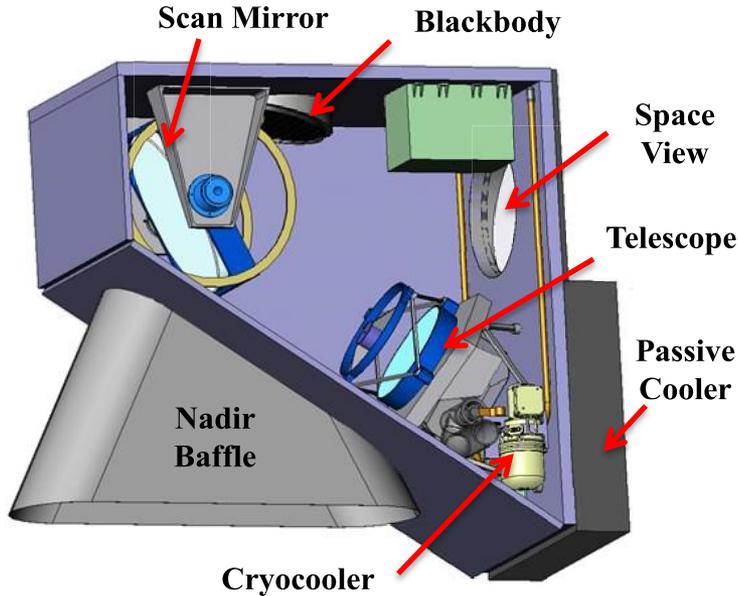
- Following arrival at science orbit, the baseline data acquisition plan is established. Collect data for entire land surface excluding sea ice (Arctic and Antarctic) every 5 days at 60 m spatial resolution in 8 spectral bands
- Data are downlinked and transferred to the science data processing center where calibration and baseline processing algorithms are applied.
- Level 1, 2 products are delivered to the scientific community and general users to pursue the science questions
 - With appropriate cloud screening, compositing, spatial, and temporal subsetting



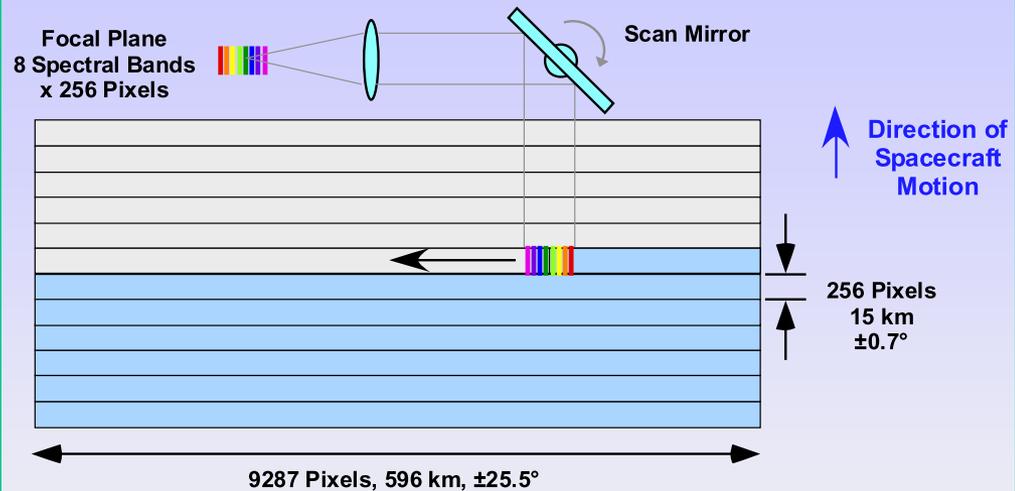
Land and coastal
acquisition



TIR Instrument Concept

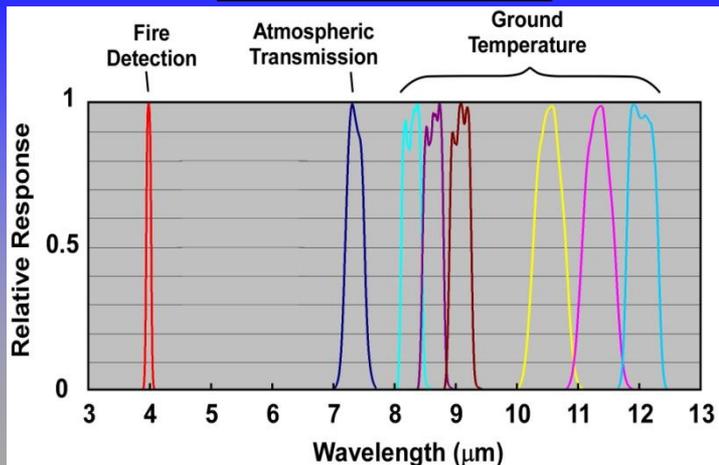


Scanning and Data Rate



- 60 m Pixel Footprint at Nadir
- Time-Averaged Science Data Rate 0.020 Gbps
- Assuming 14 bits, 2:1 Compression, 31% Land
- Scan Mirror Rotation Rate 14.2 RPM
- Pixel Dwell Time 32 microseconds

Spectral Bands



Mass and Power (JPL Team X)

- Mass CBE 60 kg
- Power CBE 103 W



Summary



We have developed a sets of science questions that are well aligned with the HypsIRI Mission called for in the NASA Earth Science and Applications Decadal Survey. The mission has strong relevance to both climate and society.

We have reviewed and refined these questions that relate to both science and applications objectives and developed traceability to a set of science measurements.

We have established a high heritage and low risk approach for acquiring the HypsIRI VSWIR and TIR science measurements