# Present and Future Hyperspectral VSWIR Spaceborne Instruments

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# Why Hyperspectral VSWIR for Geology?

## Multispectral vs Hyperspectral

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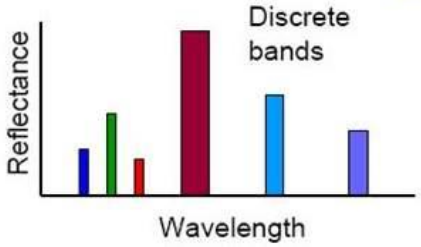
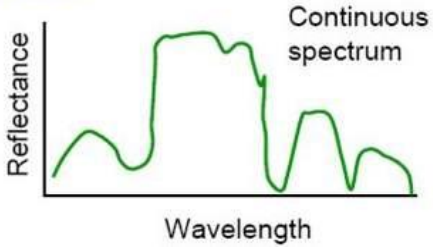
**Multispectral**

**Hyperspectral**

Each pixel




**Few fixed bands**

- minimum identification
- low confidence
- field knowledge and lab-analysis required

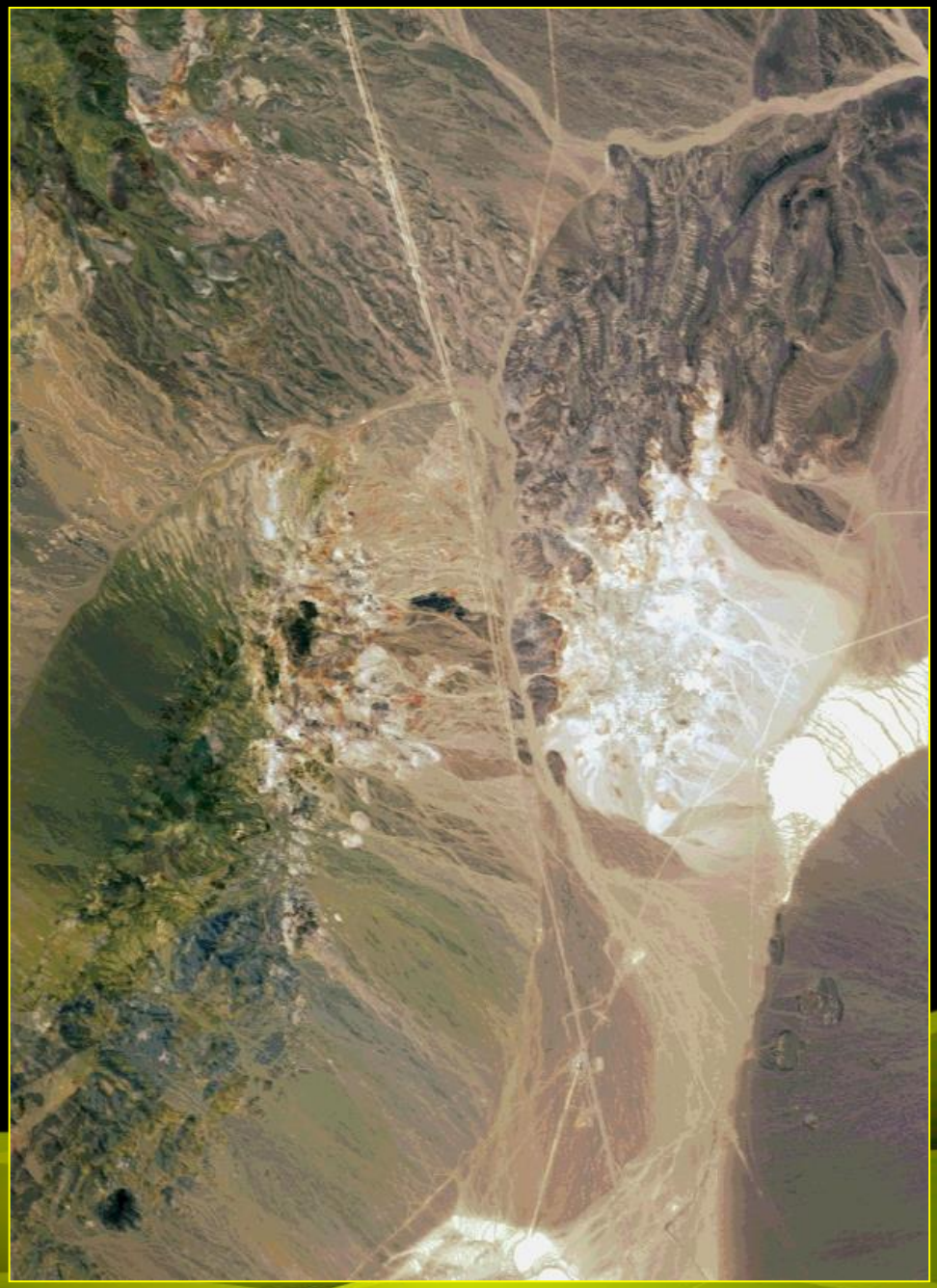
**Contiguous bands**

- maximum identification
- high confidence
- data base usable
- spectral unmixing

Cuprite Mining District, Nevada, USA

Gold-silver deposits

Alteration: silicified, opalized, argillized





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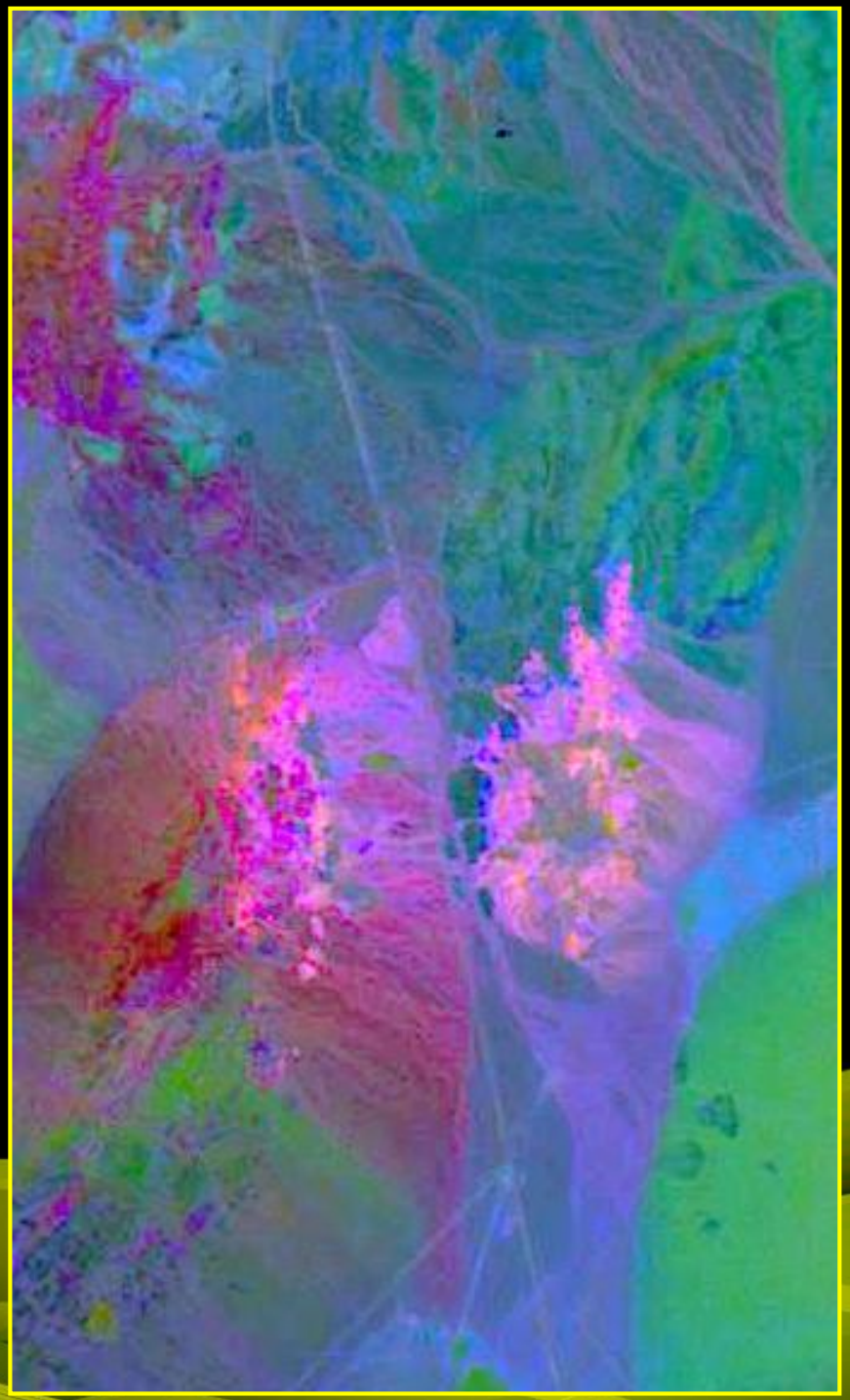
Landsat multispectral data, 7 bands; band ratios. Alteration assemblage in pink/magenta: hydrous minerals (kaolinite, alunite, etc.)



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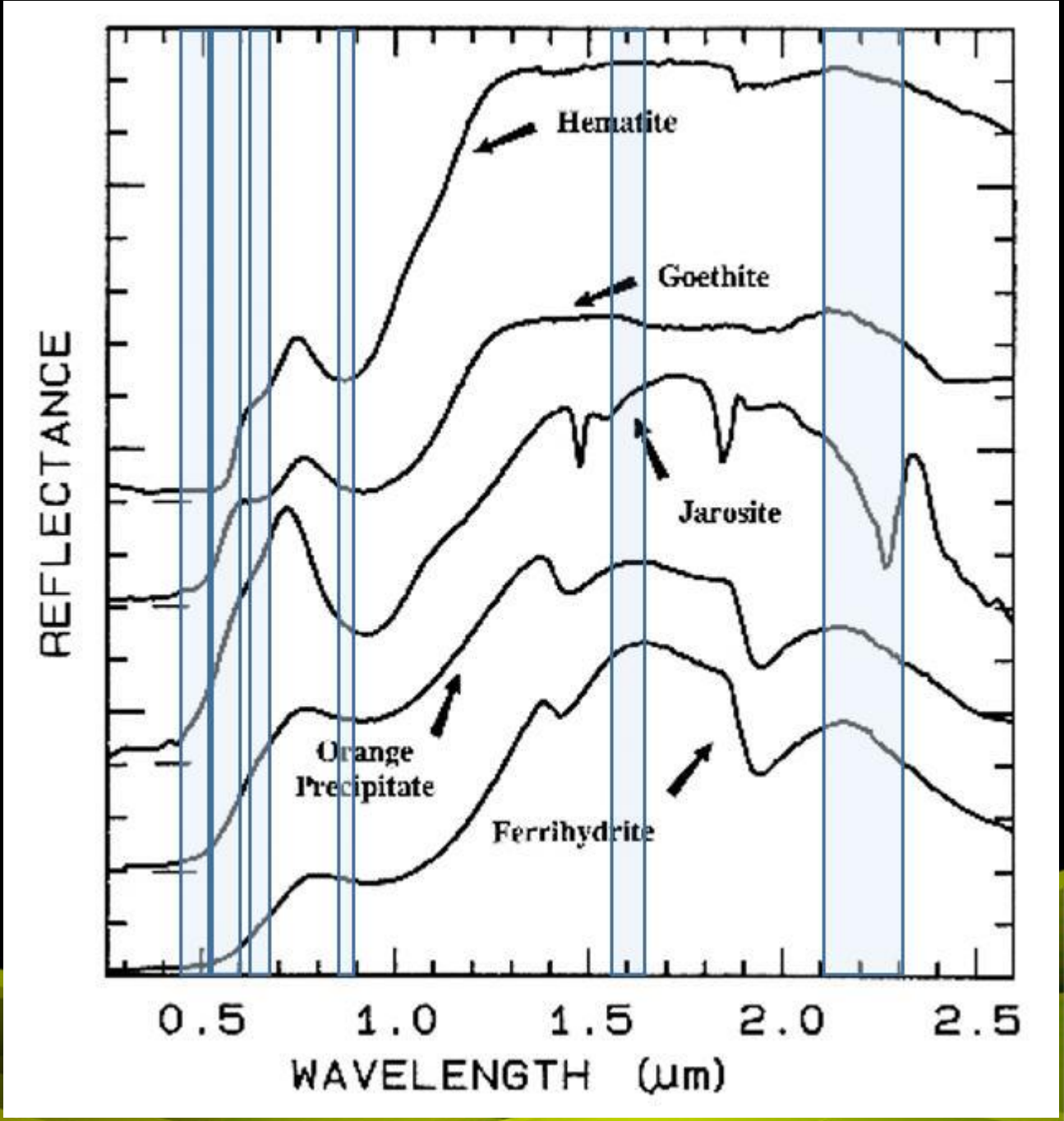
# Spectra of Iron minerals

0.4-1.3 um data for iron species; Landsat bands are blue bars

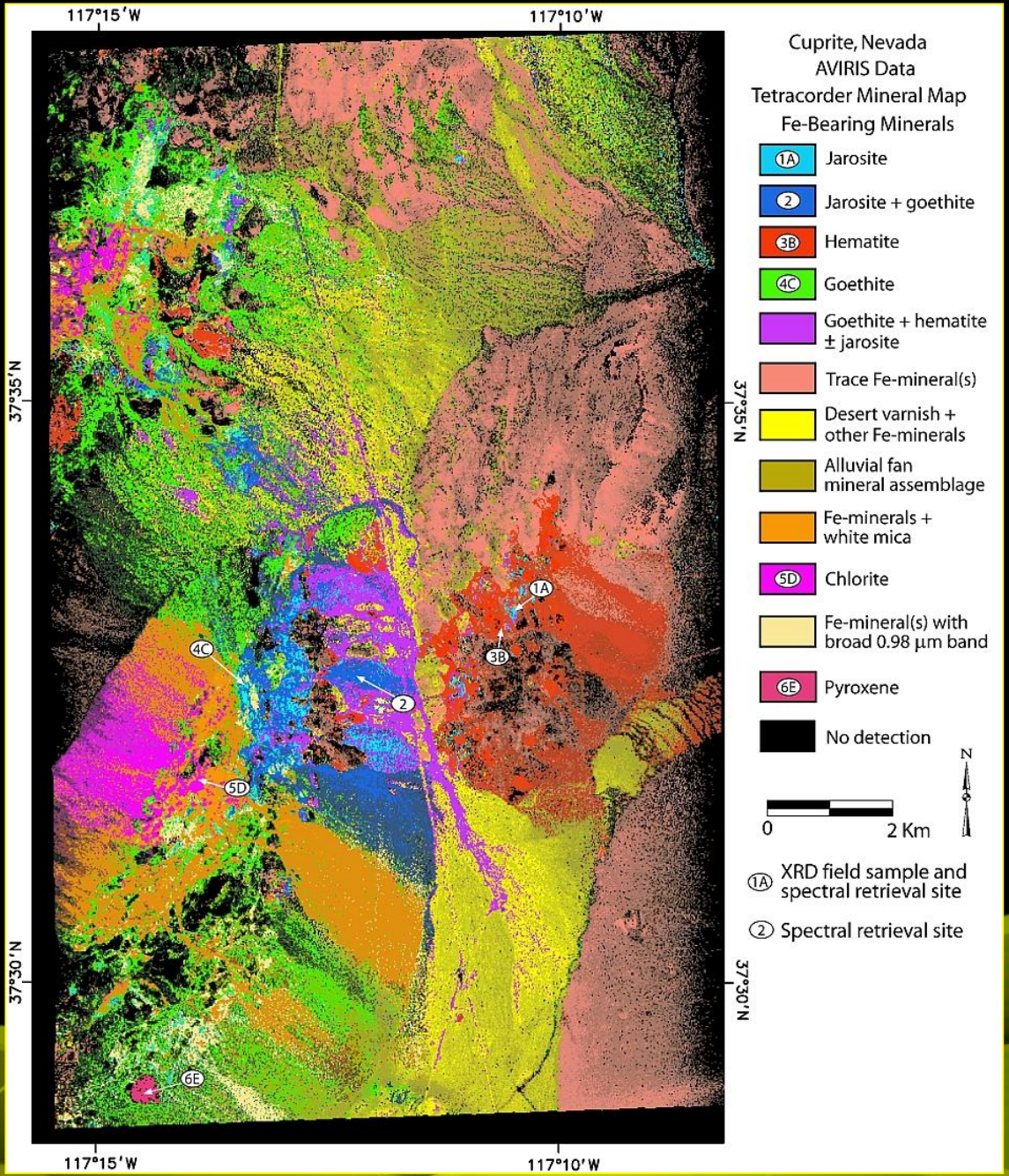
Jarosite, goethite, hematite, ferrihydrite



Airborne hyperspectral VNIR data; ~100 bands

0.4-1.3 um data for iron species

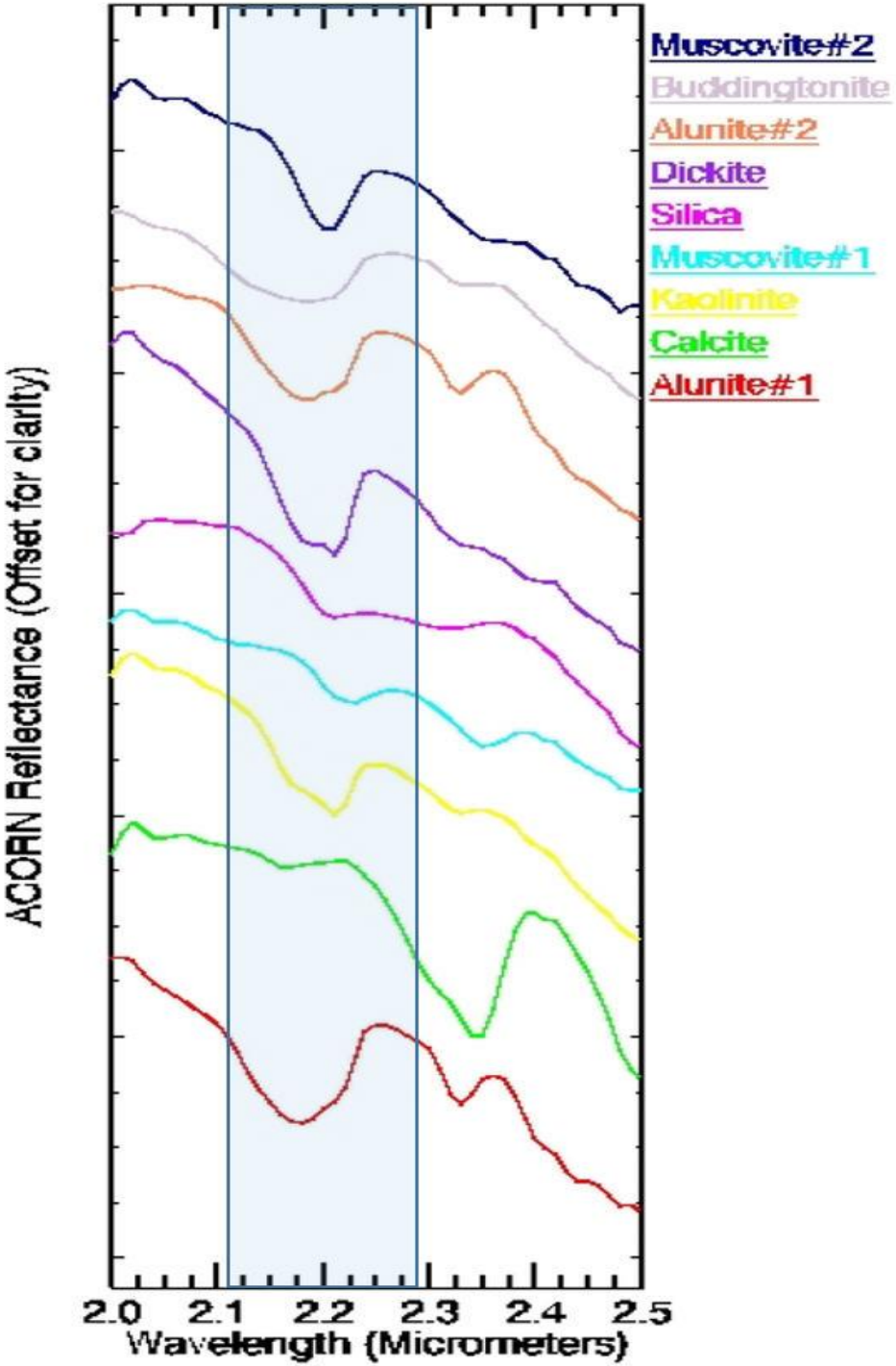
Jarosite, goethite, hematite, chlorite



Spectra of hydrous minerals in short-wave infrared (SWIR)

2.0-2.4 um data for clays, carbonates species

Alunite, kaolinite, dickite, montmorillonite, muscovite, carbonate, chlorite, chalcedony, halloysite

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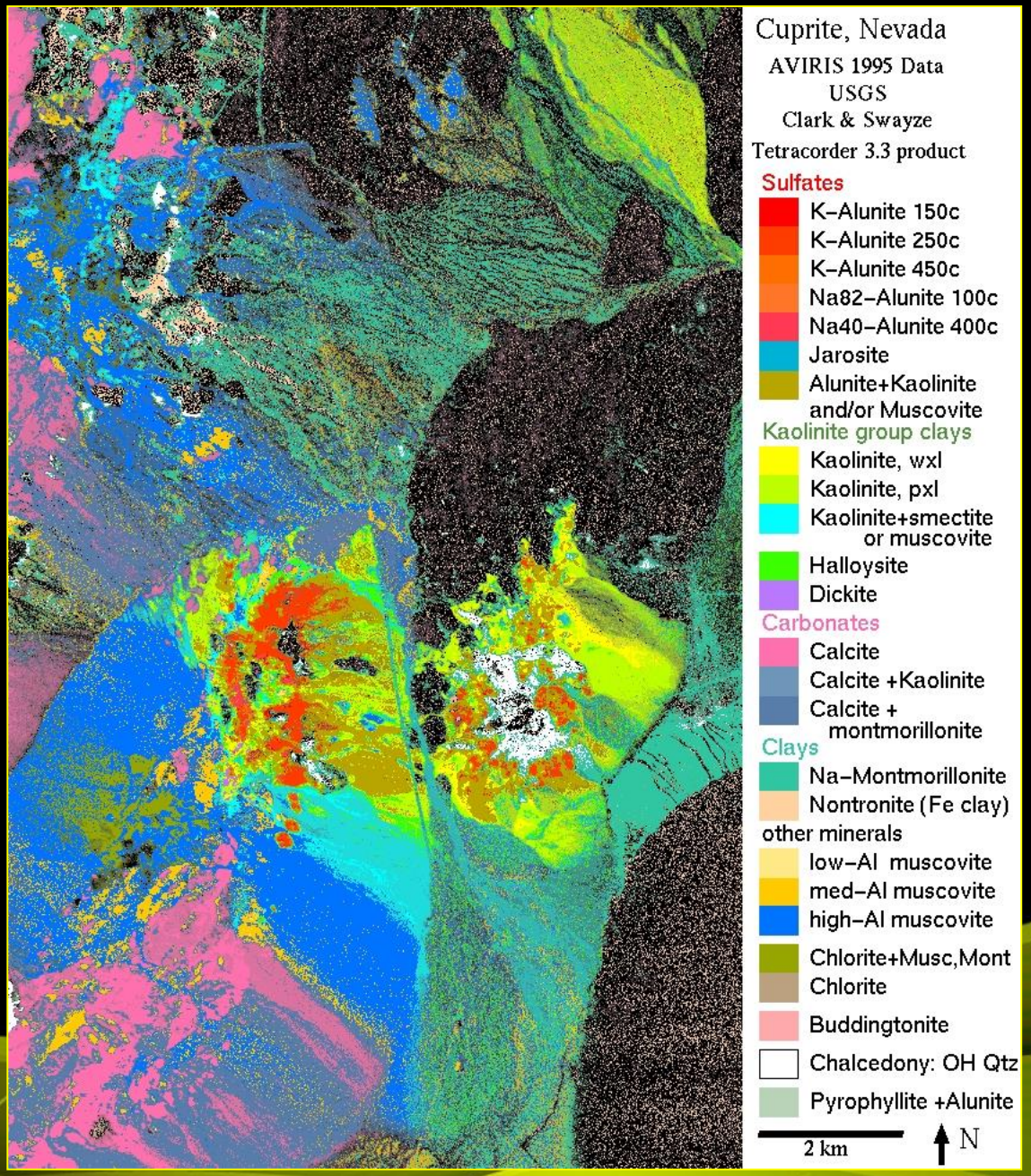
Airborne hyperspectral SWIR data; ~100 bands

1.3-2.4 um data for clays, carbonates

Alunite, kaolinite, dickite, montmorillonite, muscovite, carbonate, chlorite, chalcedony, halloysite



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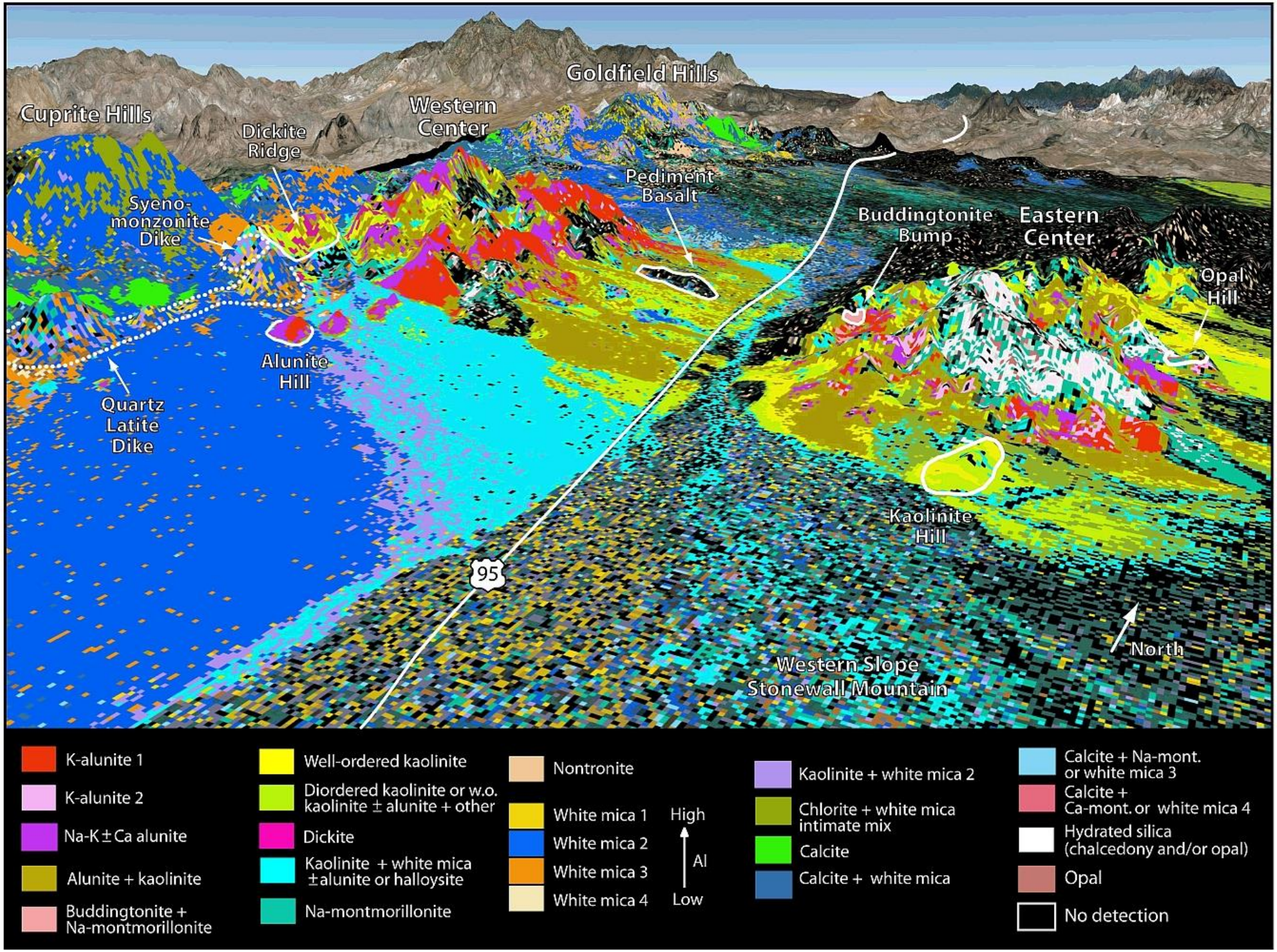
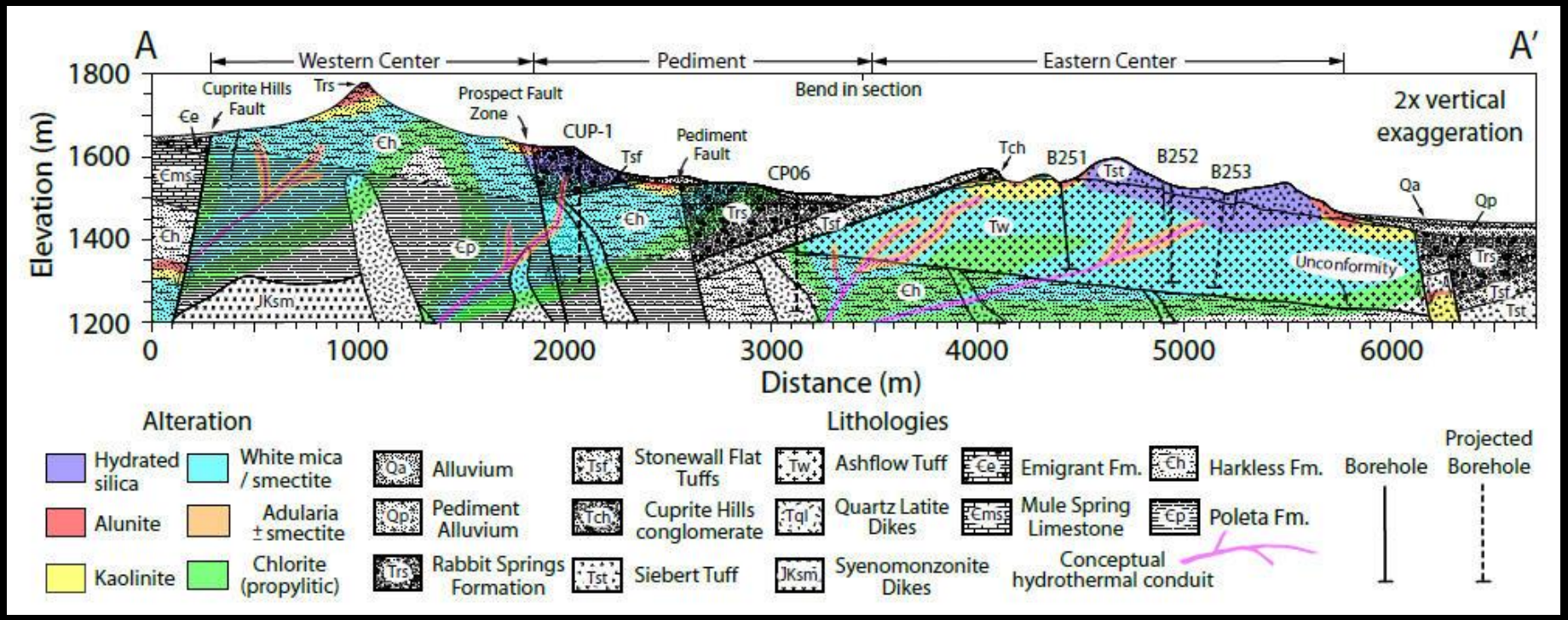

Goldfield Hills
Cuprite Hills
Western Center
Dickite Ridge
Pediment Basalt
Syeno-monzonite Dike
Buddingtonite Bump
Eastern Center
Opal Hill
Alunite Hill
Quartz Latite Dike
Kaolinite Hill
95
North
Western Slope Stonewall Mountain
K-alunite 1
K-alunite 2
Na-K ± Ca alunite
Alunite + kaolinite
Buddingtonite + Na-montmorillonite
Well-ordered kaolinite
Diordered kaolinite or w.o. kaolinite ± alunite + other
Dickite
Kaolinite + white mica ±alunite or halloysite
Na-montmorillonite
Nontronite
White mica 1
White mica 2
White mica 3
White mica 4
High
Al
Low
Kaolinite + white mica 2
Chlorite + white mica intimate mix
Calcite
Calcite + white mica
Calcite + Na-mont. or white mica 3
Calcite + Ca-mont. or white mica 4
Hydrated silica (chalcedony and/or opal)
Opal
No detection




Evidence suggests that Cuprite is a late Miocene low-sulfidation adularia – sericite type hot spring deposit overprinted by late-stage steam-heated advanced argillic alteration.

# Hyperspectral VSWIR Spaceborne Instruments

Michael Abrams, Jet Propulsion Laboratory, California Institute of Technology



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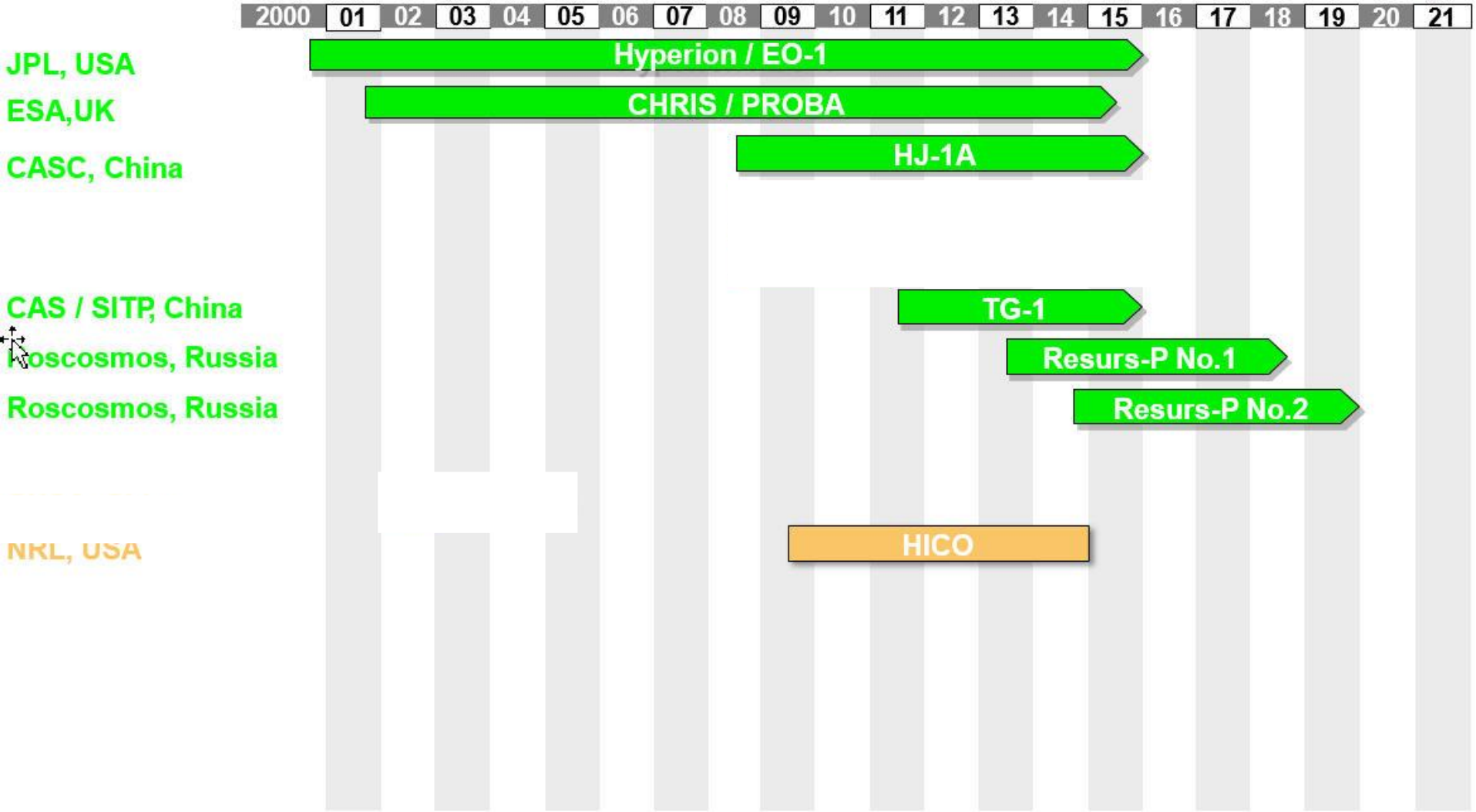
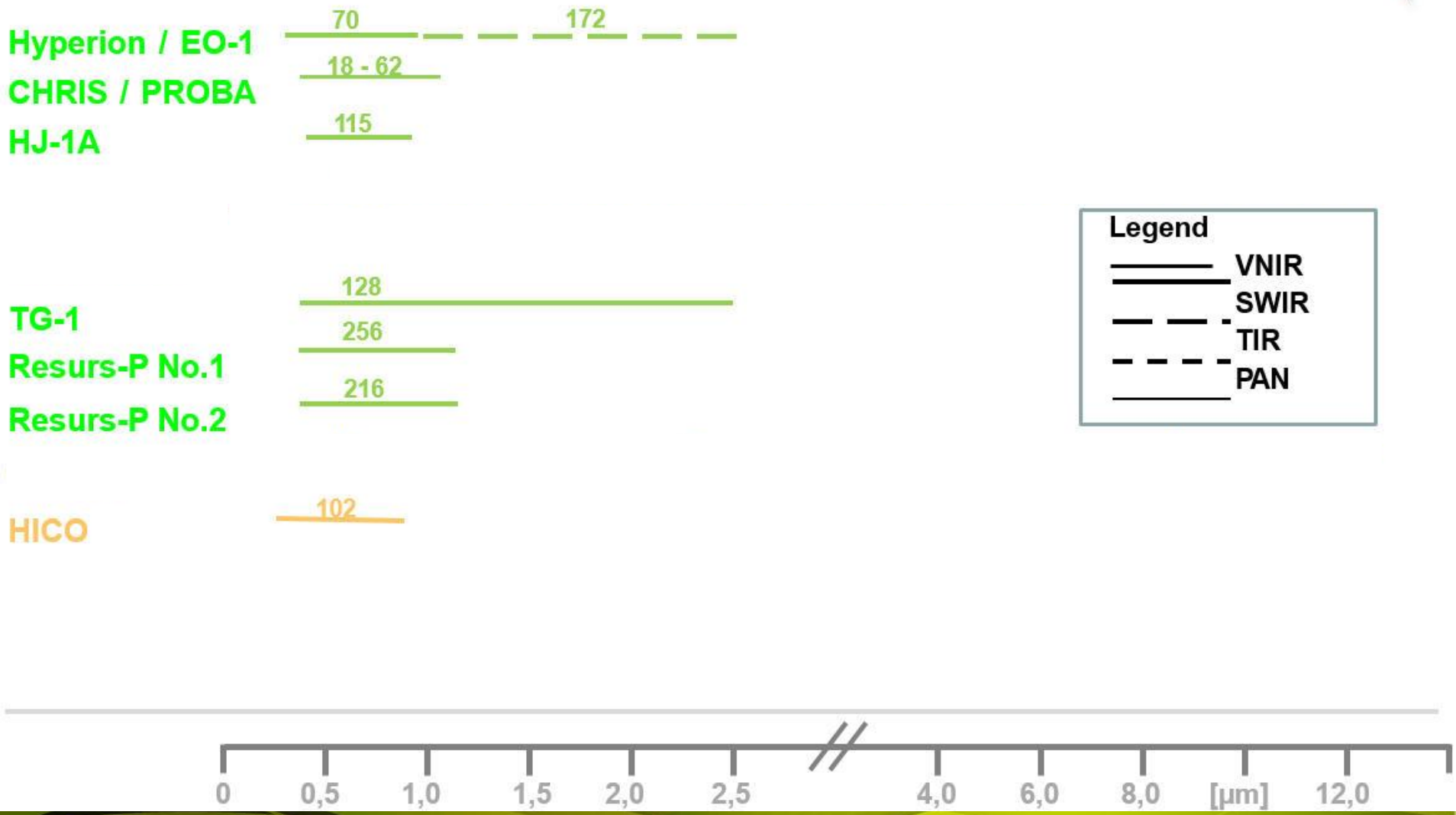
# Running and terminated IS EO missions

## *Launch and life time*



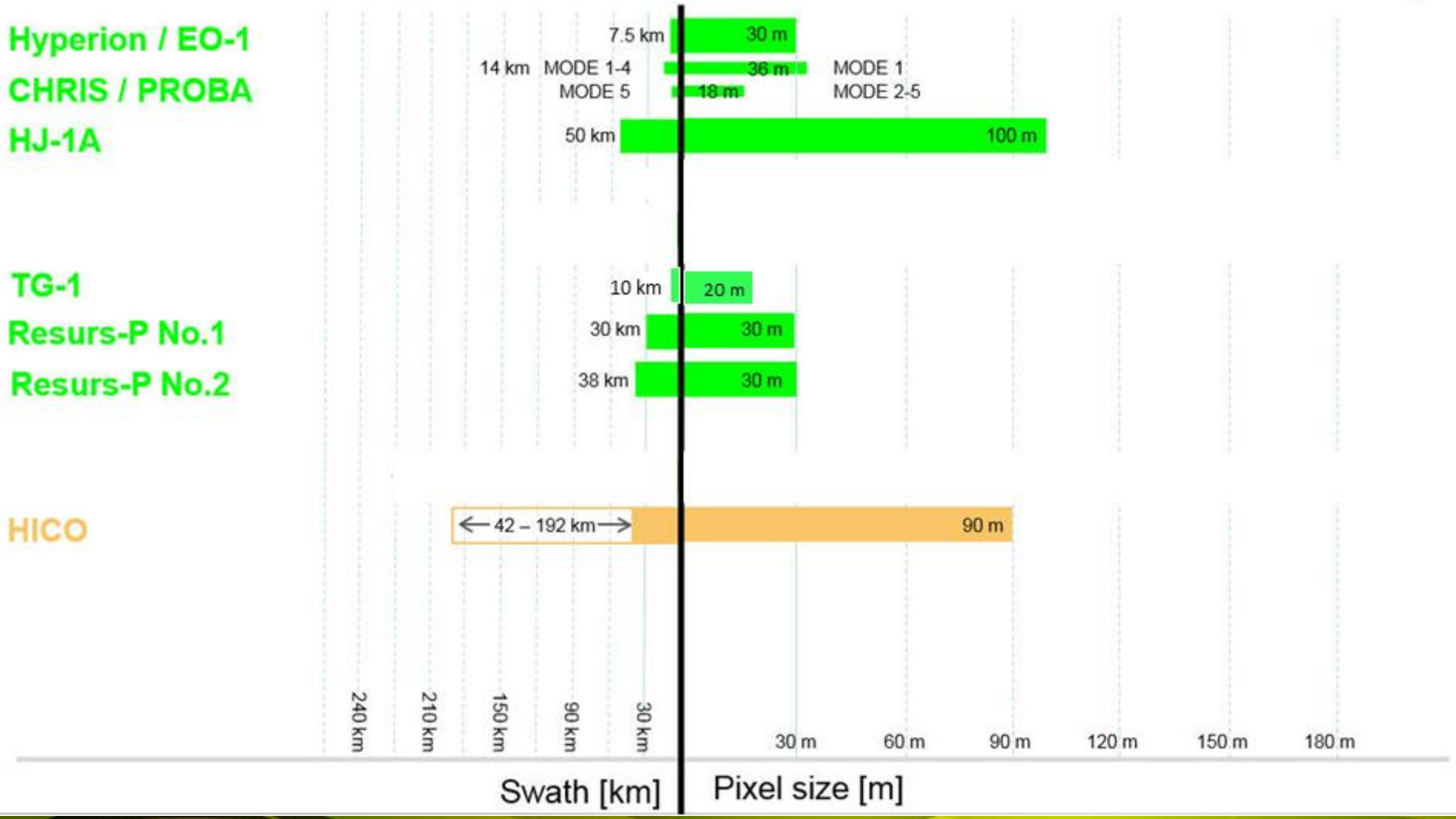
# Running and terminated IS EO missions

## *Spectral characteristics*



# Running and terminated IS EO missions

## *Spatial characteristics*



# Future Hyperspectral VSWIR Missions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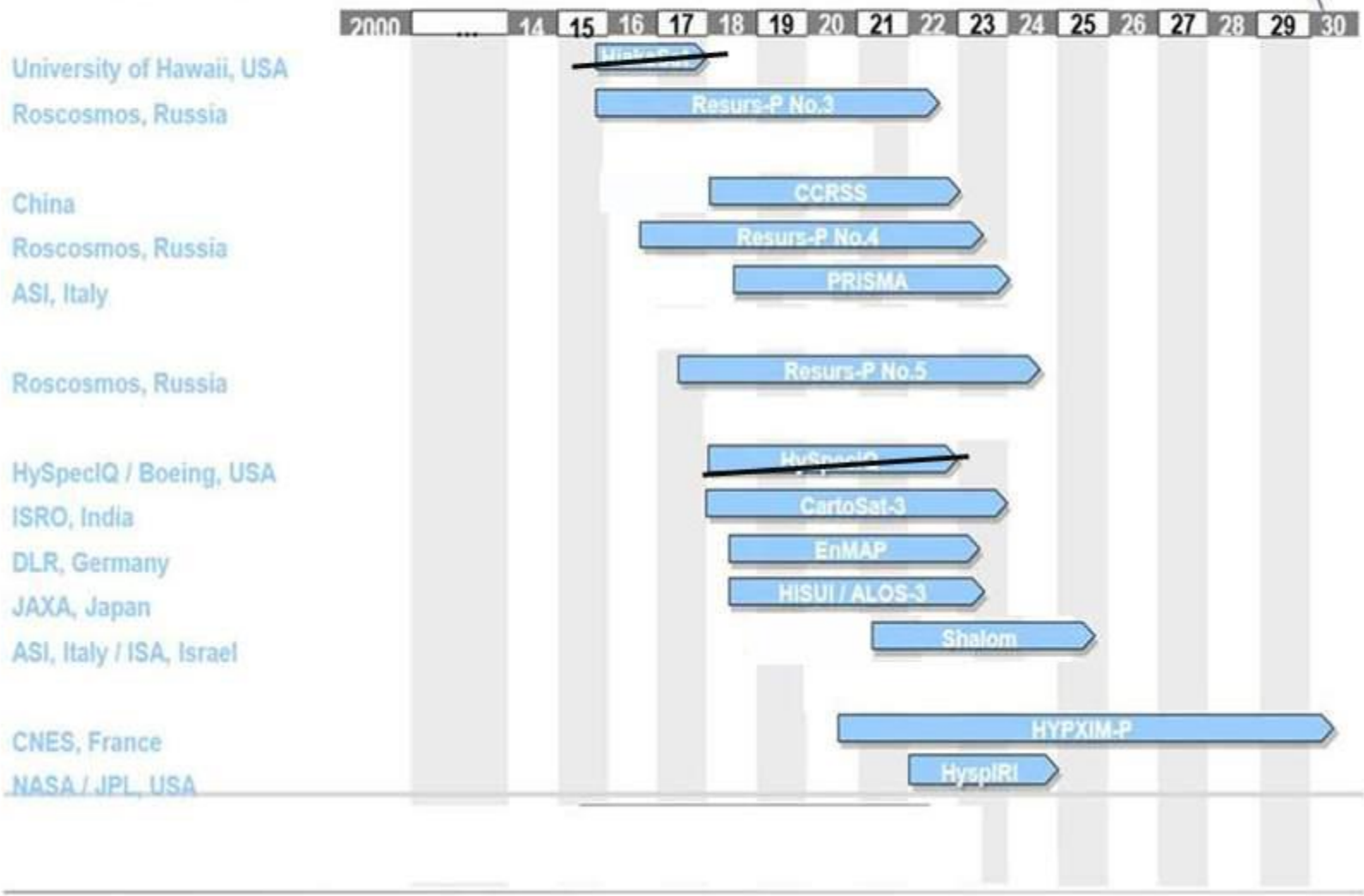
# Future IS EO missions

## *Launch and life time*



# Future IS EO missions

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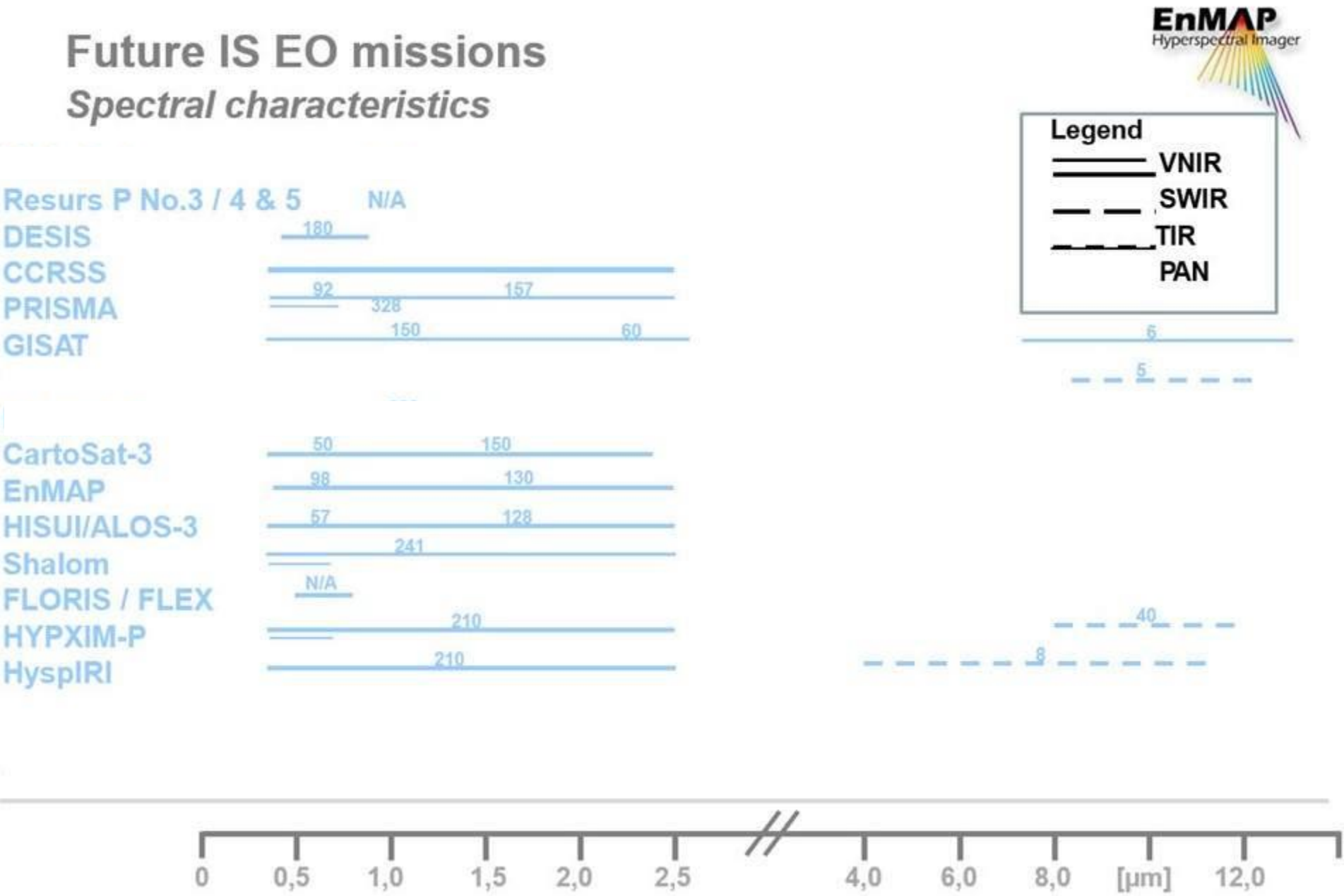
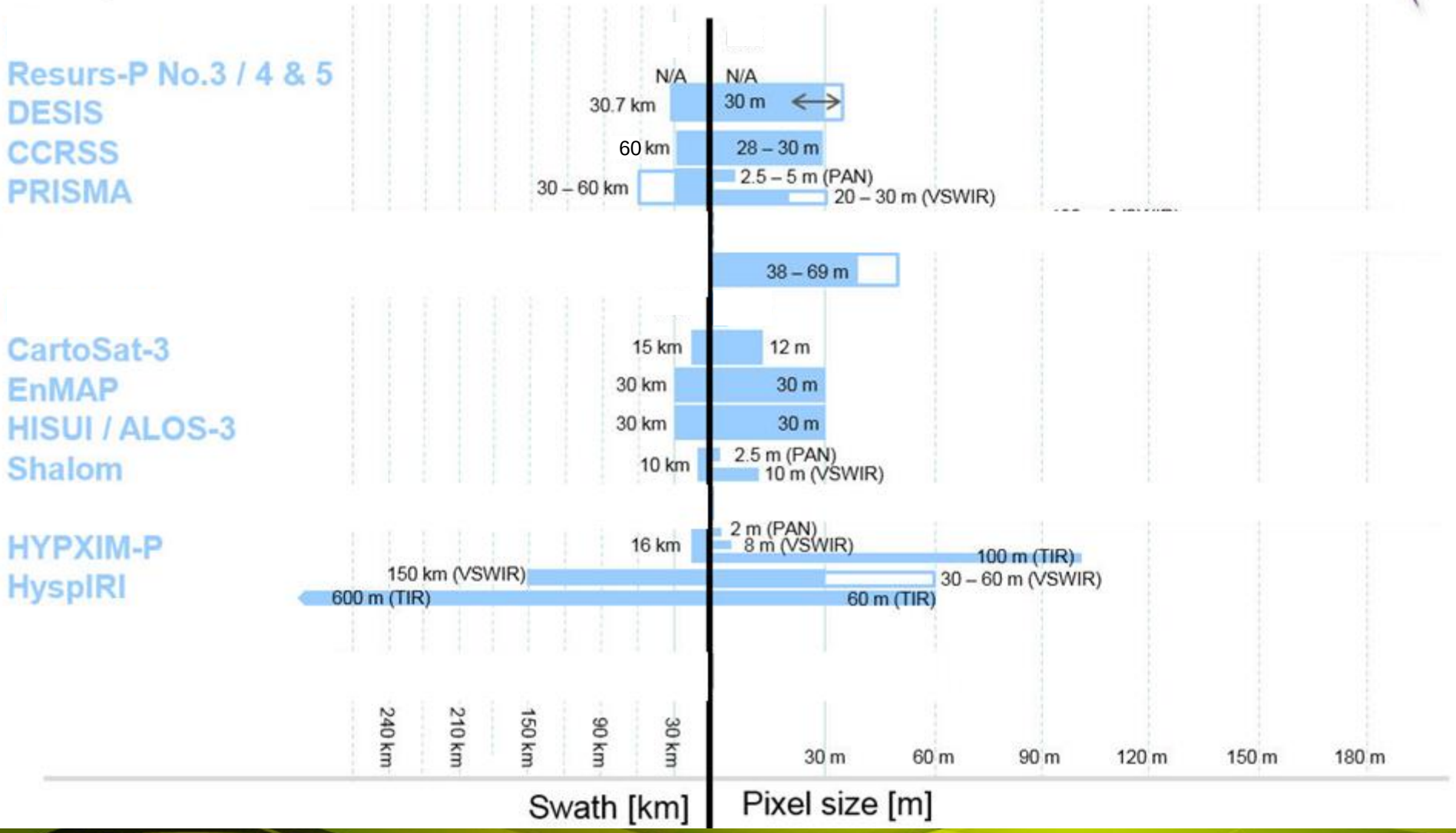


# Future IS EO missions

## *Spatial characteristics*



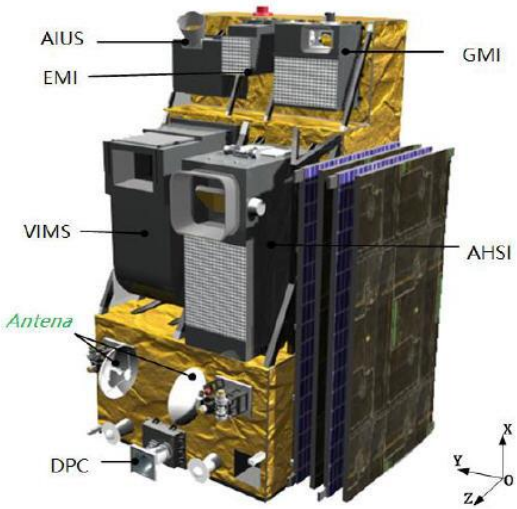
# China High Resolution Earth Observation System

## GF-5 satellite specification and major orbit parameters

| Orbital Type | Sun synchronous orbit |
|---|---|
| Nominal orbital altitude | 708.45km |
| Dip angle | 98.218 |
| Orbital flat period | 98.805min |
| Eccentricity ratio | E<0.0001 |
| Flight cylinder number every day | 14.57 |
| Orbital intercept | 24.731 |
| Local time of descending node | 13:30 |

**Sensors onboard GF-5**

- Advanced Hyperspectral Imager (AHSI)
- Visual and Infrared Multispectral Sensor (VIMS)
- Greenhouse-gases Monitoring Instrument (GMI)
- Atmospheric Infrared Ultraspectral (AIUS)
- Environment Monitoring Instrument (EMI)
- Directional Polarization Camera（DPC）



# China's GF-5

AHSI VSWIR Hyperspectral Scanner

0.4-2.5 um, 318 channels

20m/40m pixels, 60km swath

Nov 2018 launch, 8-year lifetime

Global coverage??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# HyspIRI Objectives and Approach

## Key Science and Science Applications

**Climate:** Ecosystem biochemistry, condition & feedback; spectral albedo; carbon/dust on snow/ice; biomass burning; evapotranspiration

**Ecosystems:** *Global* biodiversity, plant functional types, physiological condition, and biochemistry including agricultural lands

**Fires:** Fuel status; fire frequency, severity, emissions, and patterns of recovery *globally*

**Coral reef and coastal habitats:** *Global* composition and status

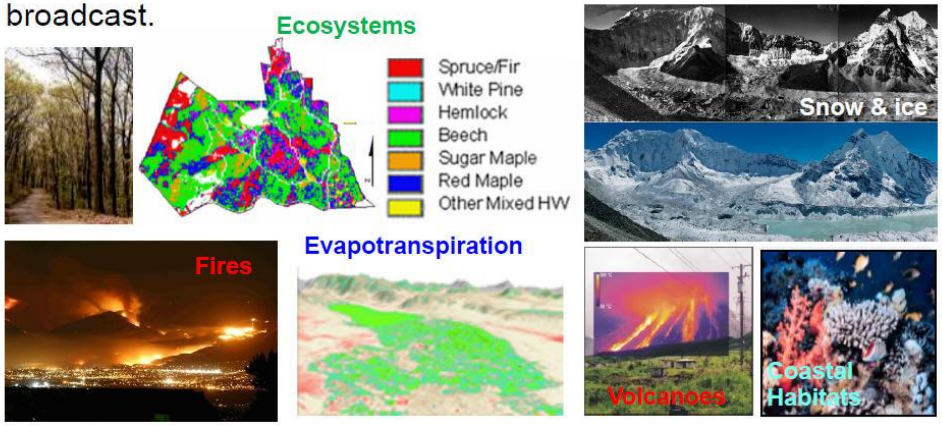
**Volcanoes:** Eruptions, emissions, regional and *global* impact

**Geology and resources:** *Global* distributions of surface mineral resources and improved understanding of geology and related hazards

**Applications:** Disasters, EcoForecasting, Water, Health/AQ

## Mission Urgency

The HyspIRI science and applications objectives are critical today and uniquely addressed by the combined imaging spectroscopy, thermal infrared measurements, and IPM direct broadcast.




## Measurement

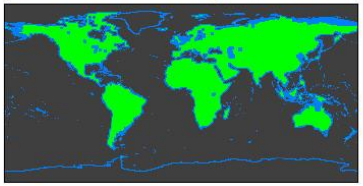
**Imaging Spectrometer (VSWIR)**

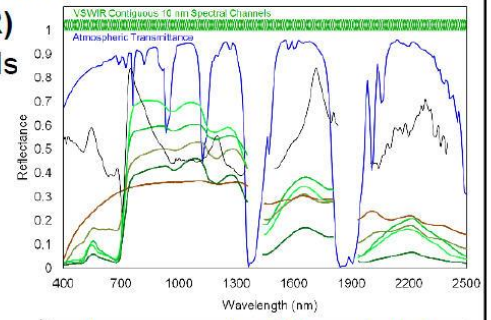
- 380 to 2500nm in ≤10nm bands
- 60 m spatial sampling*
- 19 days revisit*
- Global land and shallow water

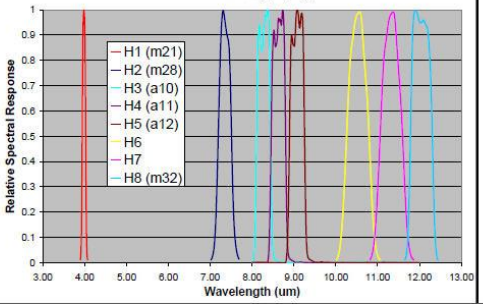
**Thermal Infrared (TIR):**

- 8 bands between 4-12 µm
- 60 m spatial sampling
- 5 days revisit; day/night
- Global land and shallow water

**IPM-Low Latency data subsets**






## Mission Concept Status

**Level 1 Measurement Requirements:** Vetted by community and stable

**Payload: VSWIR** Imaging Spectrometer, **TIR** Multi-spectral Radiometer, and **Intelligent Payload Module (IPM)**

**Full Mission original option**: Mature

**Separate Small Mission option:** Pegasus-based solutions identified and studied

***SLI Support:** HyspIRI VSWIR evolving to 30m at 185km swath

**ECOSTRESS TIR:** Selected EVI for ISS

**VSWIR Dyson Option:** Technology/Science ISS Demonstration

**Summary**: The HyspIRI mission measurement requirements and baseline instruments approach are mature and stable with good heritage, low risk and modest cost. Now exploring a range of instrument and data options to save cost, per guidance letter.

# SUMMARY

- Future looks promising for hyperspectral VSWIR sampling missions:
  *EnMAP (Germany), Resurs-P No. 3 (Russia), HISUI (Japan), Cartosat-3 (India), PRISMA (Italy),*

- Lack of funded, manifested global mapping VSWIR missions:
  *CCRSS GF-5 (China)*—maybe global?
  *HyspIRI* – waiting for funding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