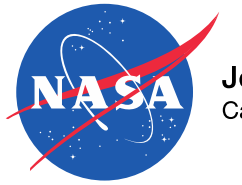

Jet Propulsion Laboratory
California Institute of Technology

Level 2 processing of AVIRIS HyspIRI preparatory campaign measurements

David R. Thompson, Bo Cai Gao[1], Robert O. Green, Dar A. Roberts[2], Philip E. Dennison[3], Sarah Lundeen, Yasha Mouradi
Jet Propulsion Laboratory, California Institute of Technology
[1]Naval Research Laboratory [2] University of California, Santa Barbara [3] University of Utah

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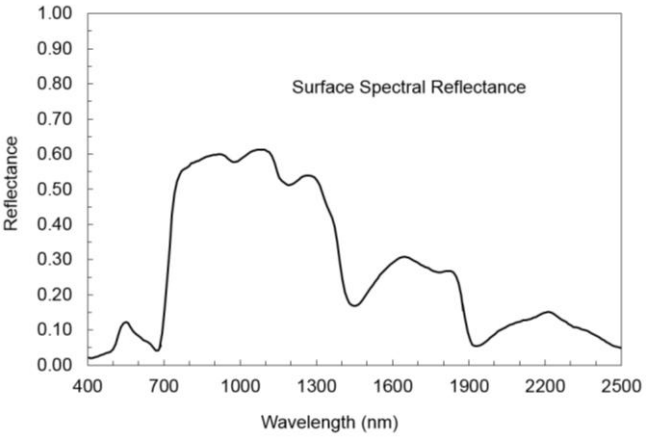
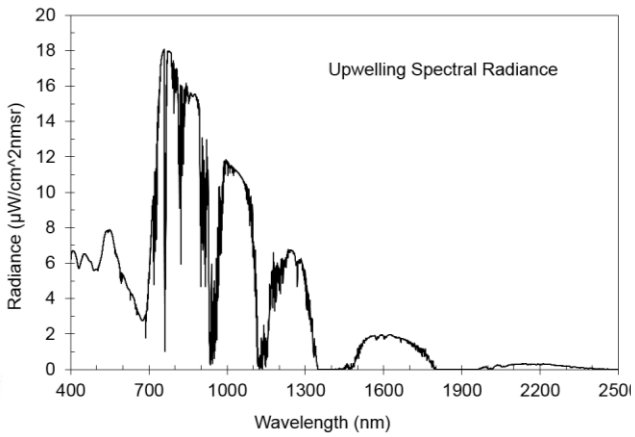
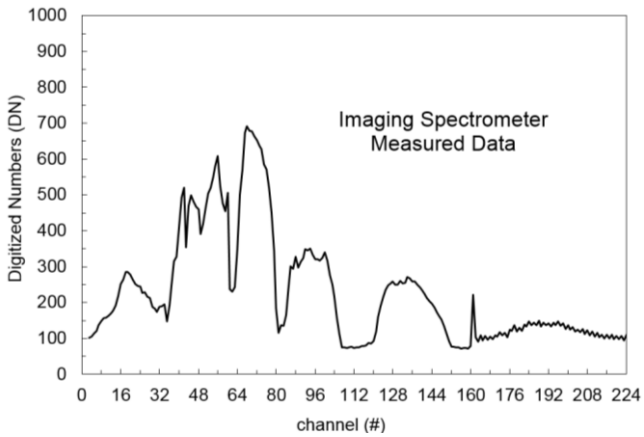
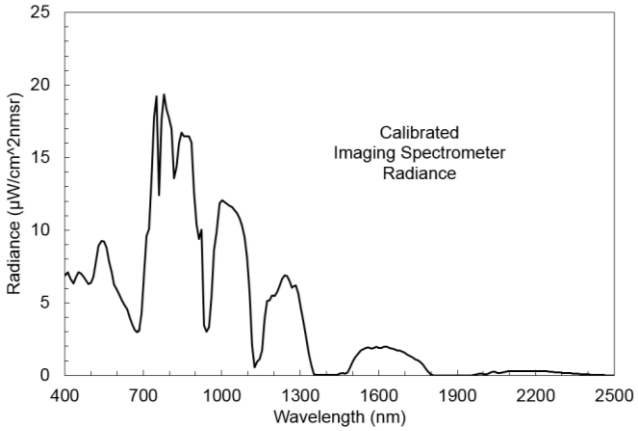
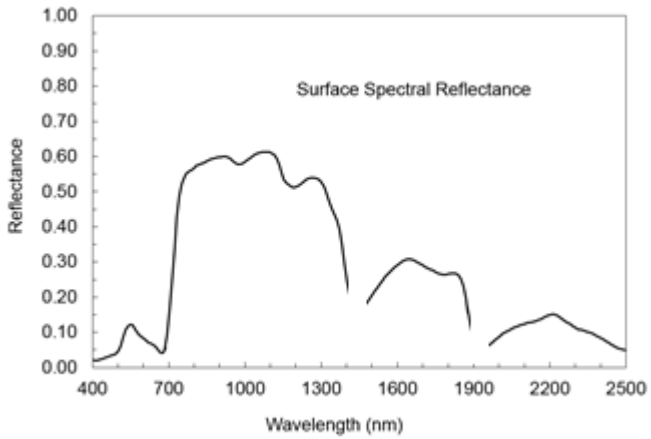
The Signal, Calibration, and Atmospheric Correction







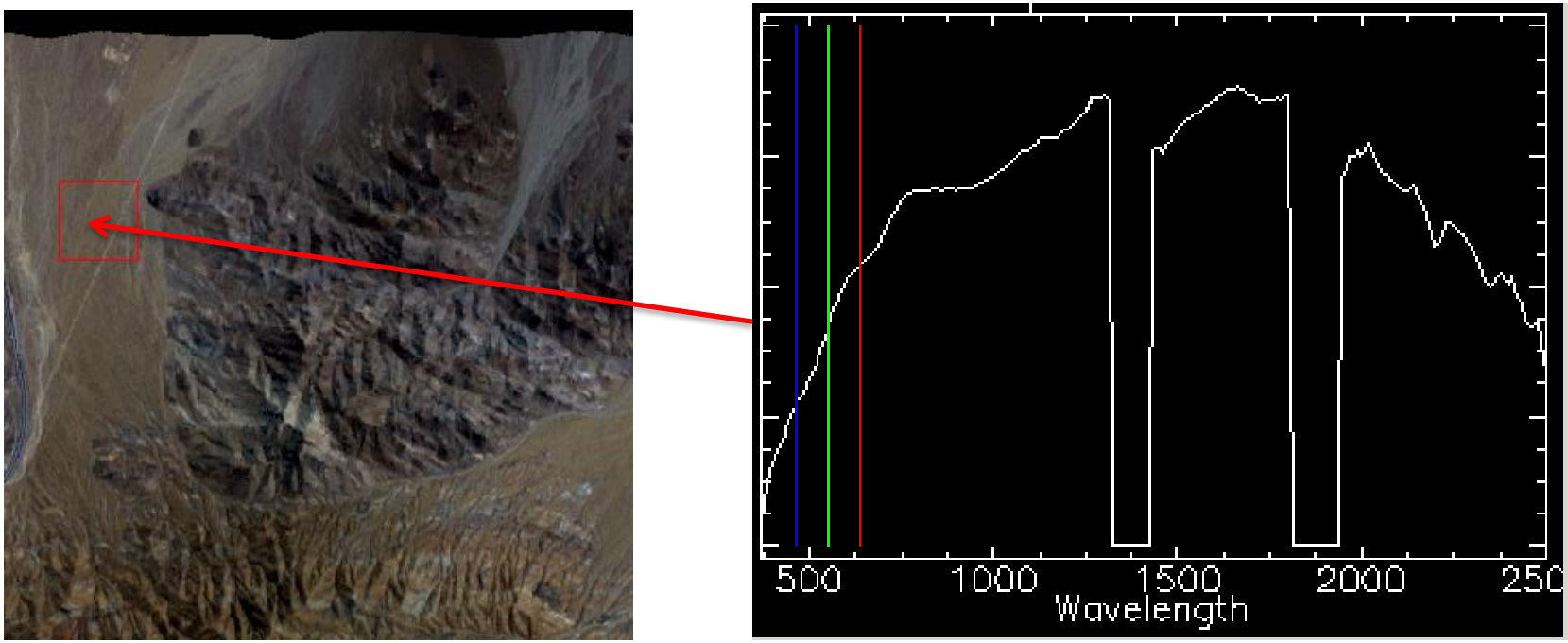




HyspIRI Atmospheric correction objective

Produce smooth, accurate “ASD-like” reflectance spectra

- Automatically that can be scaled to HyspIRI satellite rates
- For a full range of atmospheric and observation conditions



The ATREM Approach: Radiative Transfer Based

Apparent reflectance — Radiance — Solar flux

$$r^*_{obs}(l,q,f,q_o,f_o) = p\, L_{obs}(l,q,f,q_o,f_o) \;/\; [m_o\, F_o(l)],$$

Path reflectance — Surface reflectance — Atmospheric transmittance

$$r^*_{obs}(l,q,f,q_o,f_o) = [r^*_{atm}(l,q,q_o,f_o) + t_d(l,q_o)\, t_u(l,q)\, r(l)/(1 - s(l)r(l))]\, T_g(l,q,q_o),$$

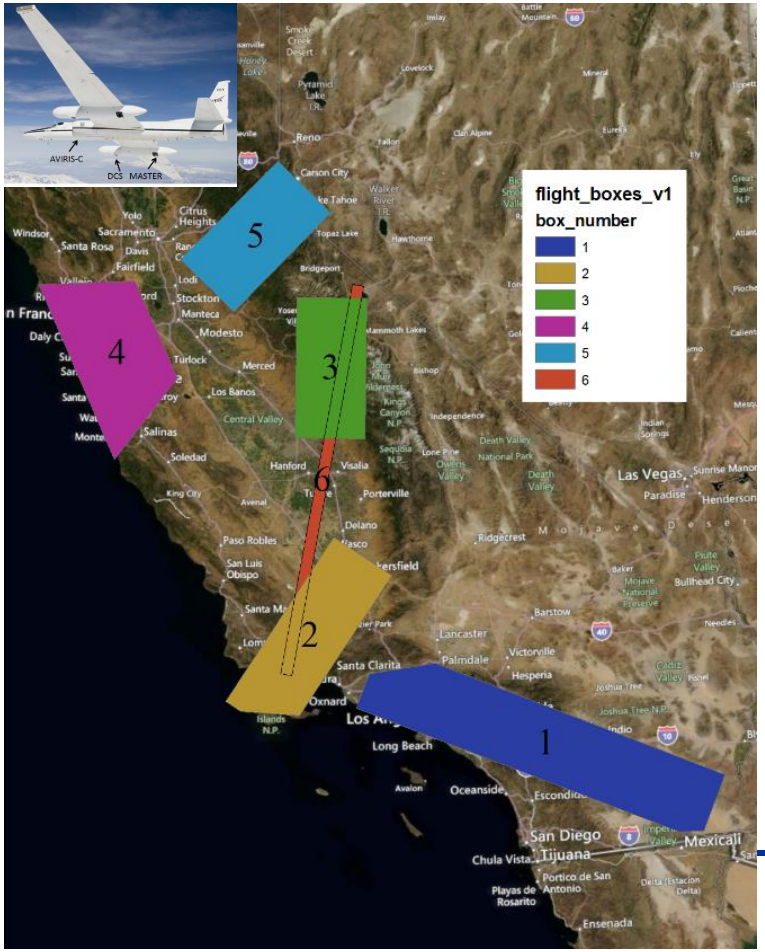
Scattering terms from 6s code

$$r = (r^*_{obs}/T_g - r^*_{atm}) \;/\; [t_d\, t_u + s\,(r^*_{obs}/T_g - r^*_{atm})].$$

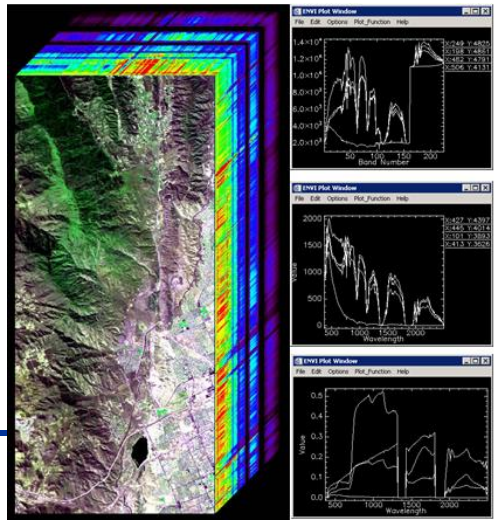
From [Gao and Green 2010]

HyspIRI Preparatory Airborne Campaign Third Year Added

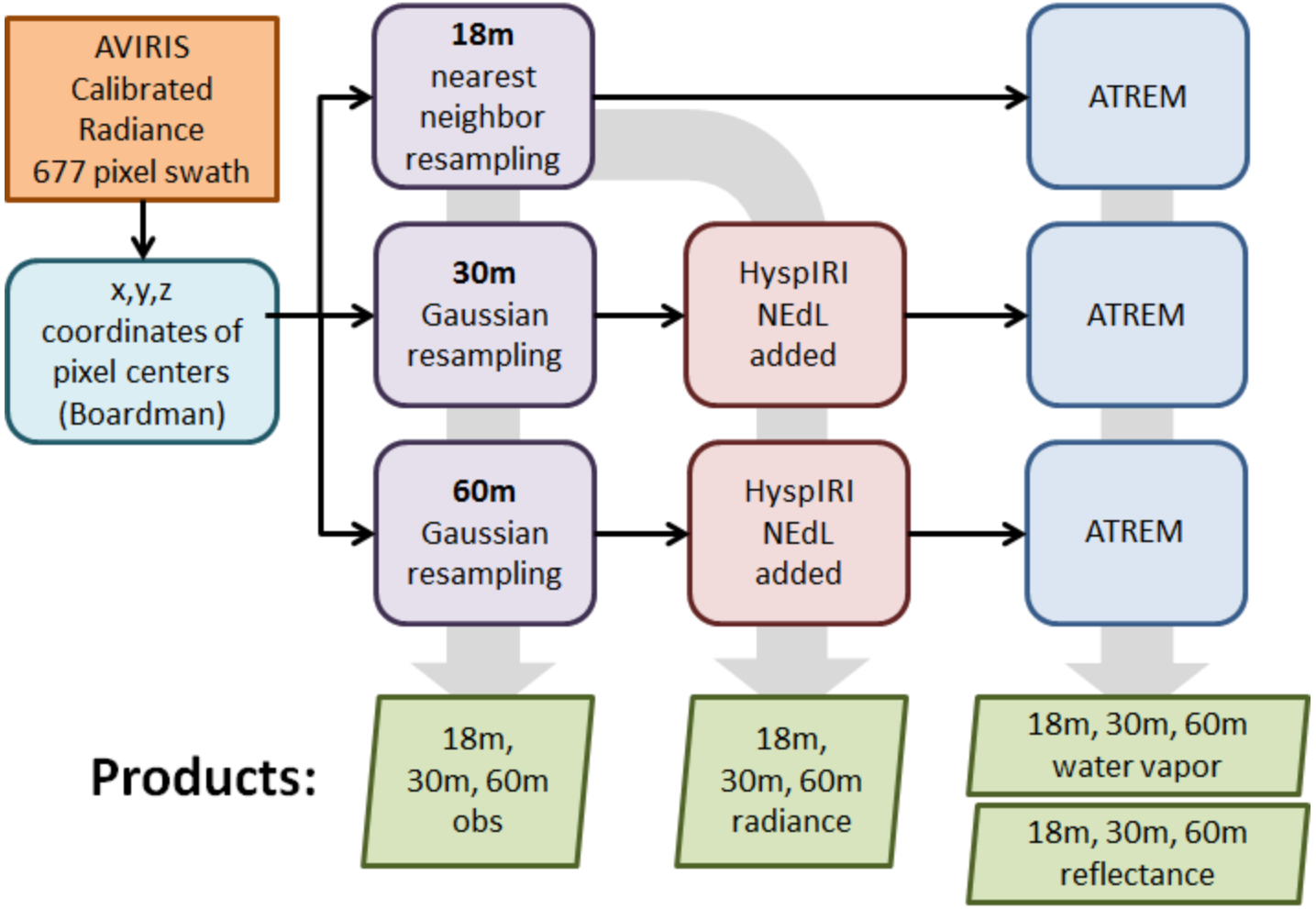
- Support R&A HyspIRI Preparatory Science Campaign
  - science team with 14 PIs
  - Delivered Level 1 and Level 2 data products
- Ecosystems, Seasonal, Climate, Coastal, Urban, Resources
- 6 zones, 3 seasons, 2 years



- **Objective: Advance HyspIRI Mission Science, Algorithm and Processing Readiness**
  - *Ecosystem composition, function, biochemistry, seasonality, structure, and modeling*
  - *Coastal ocean phytoplankton functional types, habitat*
  - *Urban land cover, temperature, transpiration*
  - *Surface energy balance*
  - *Atmospheric characterization and local methane sources*
  - *Surface geology, resources, soils, hazards*

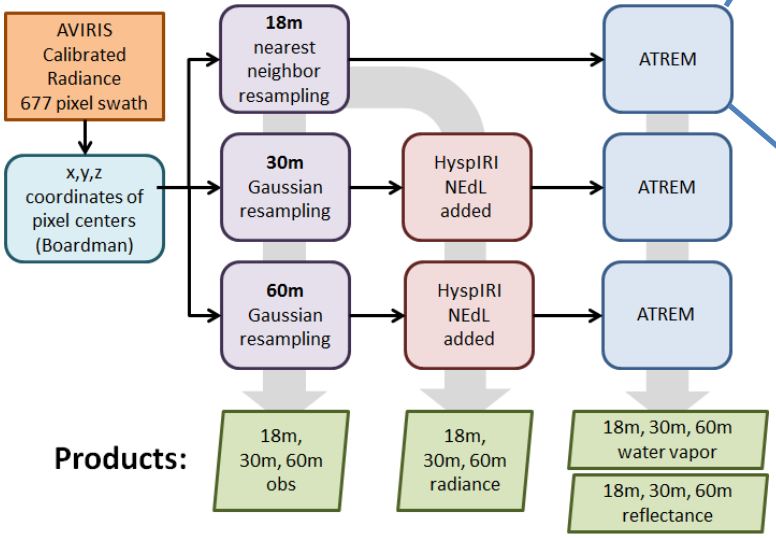


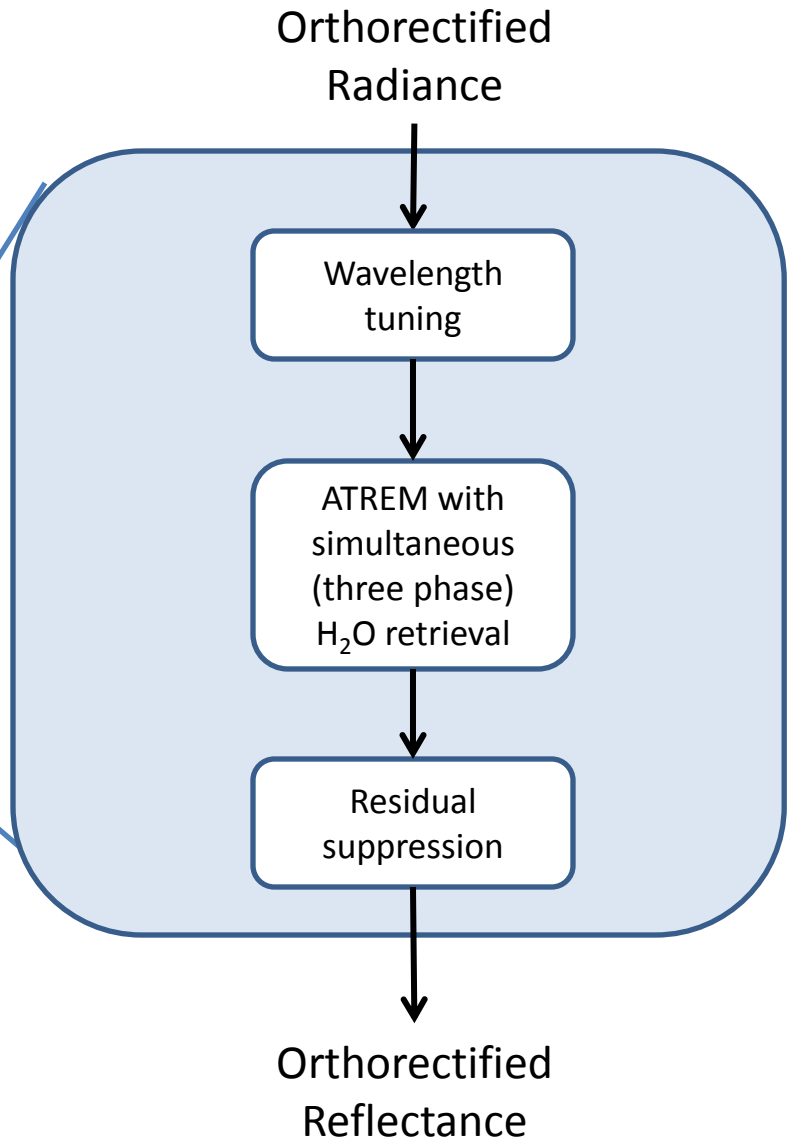
HyspIRI simulated data products



http://aviris.jpl.nasa.gov/data/AV_HyspIRI_Prep_Data.html

L2: The atmospheric correction component

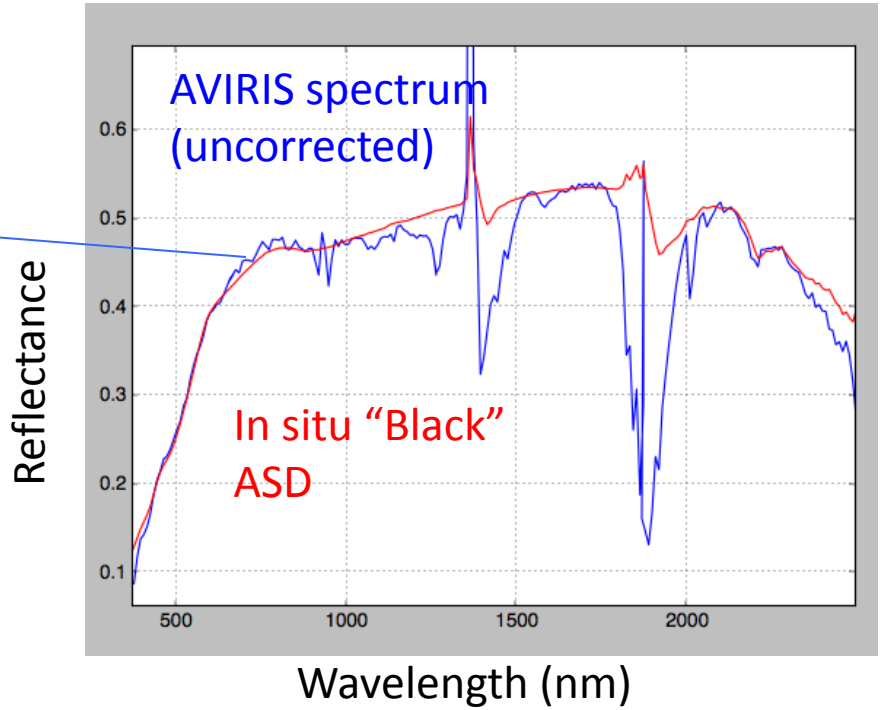




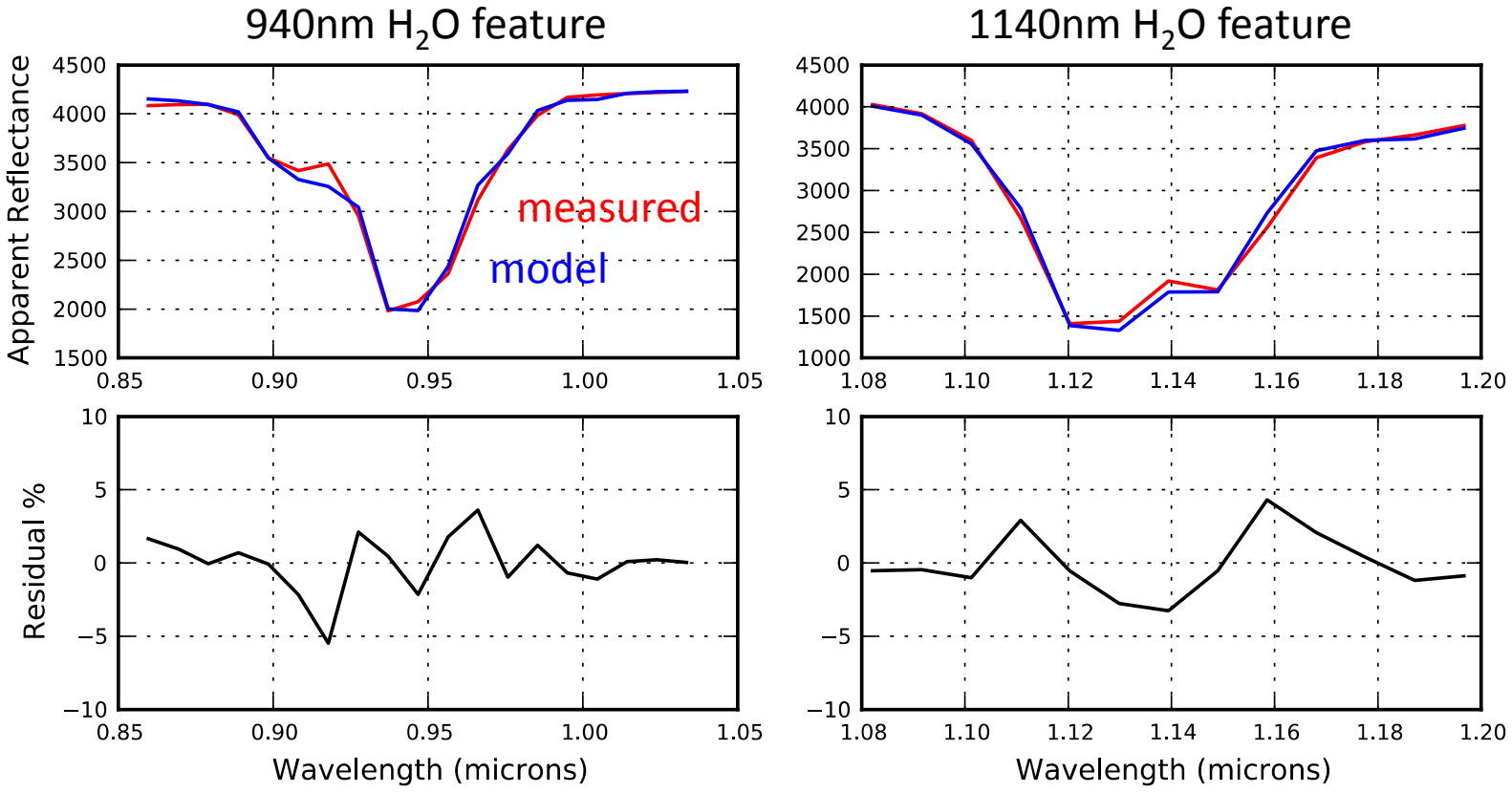
http://aviris.jpl.nasa.gov/data/AV_HyspIRI_Prep_Data.html

Ivanpah calibration flight 2014: initial comparison of uncorrected reflectances

f140331r06



Wavelength validation with Ivanpah atmospheric features (2014)

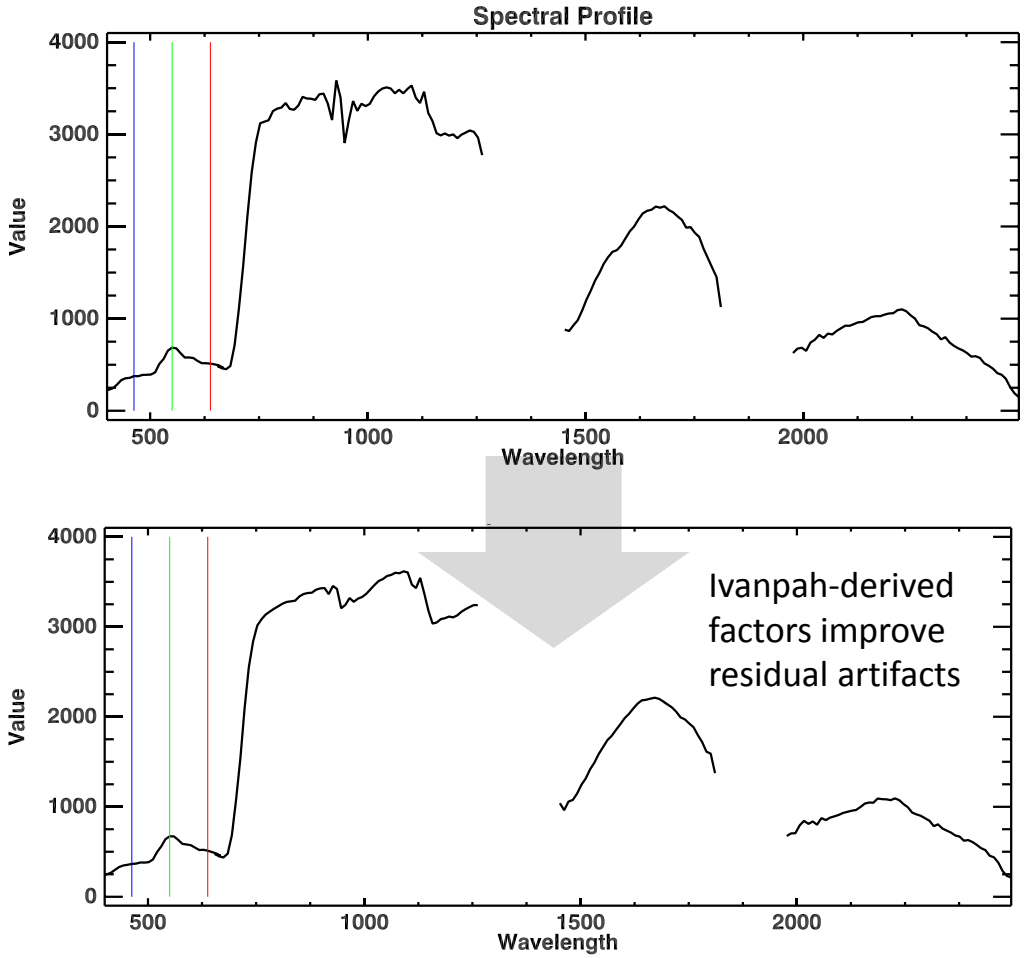


Final converged adjustment of 0.3nm is consistent with no change

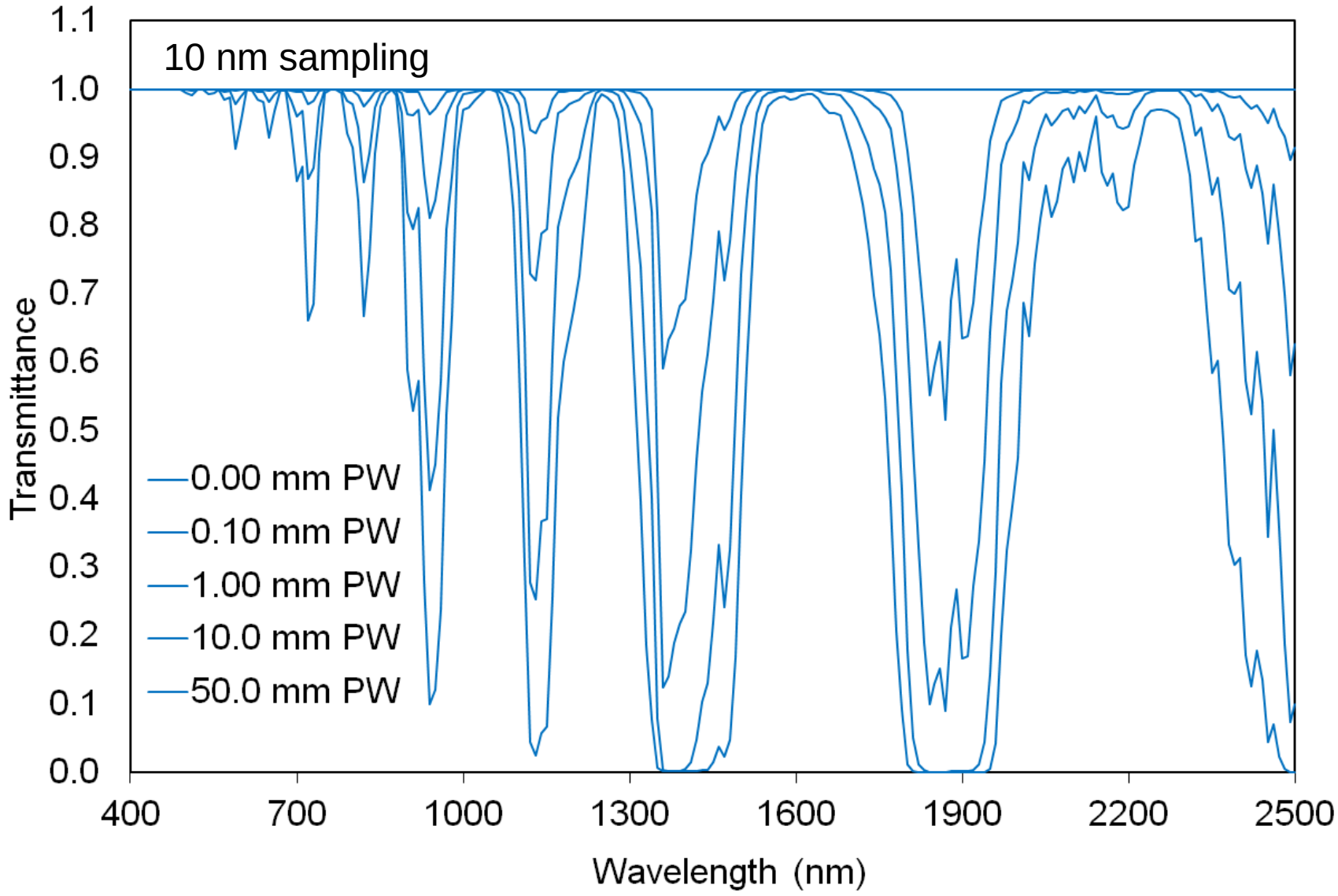
Ivanpah 2014 provides new residual suppression factors

Shown: A typical vegetation spectrum from the “soda straw” flightline

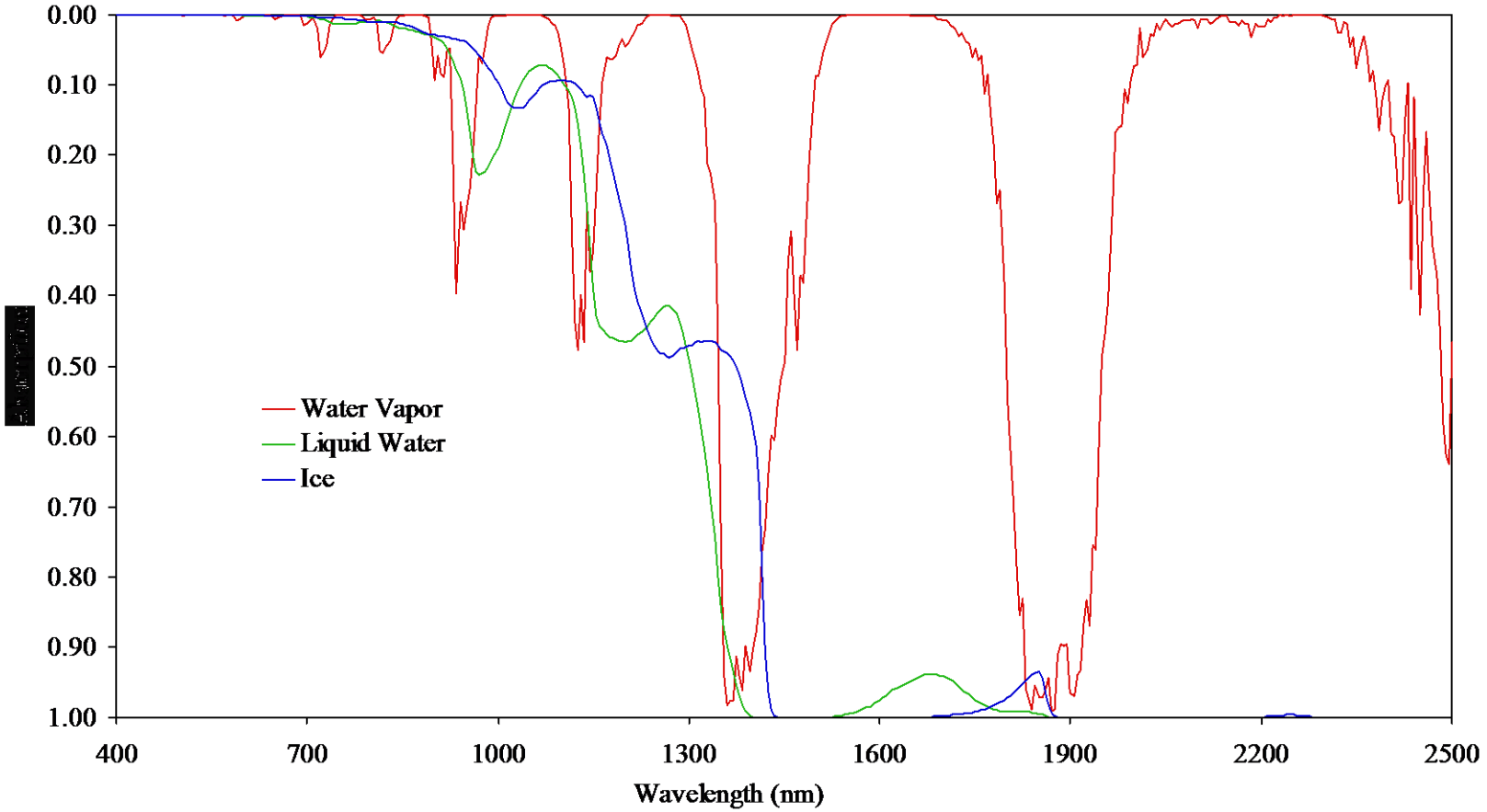
Initial results are promising, but we may still recalculate these factors on the most recent Ivanpah flight to avoid Cirrus contamination.



Atmospheric Water Vapor



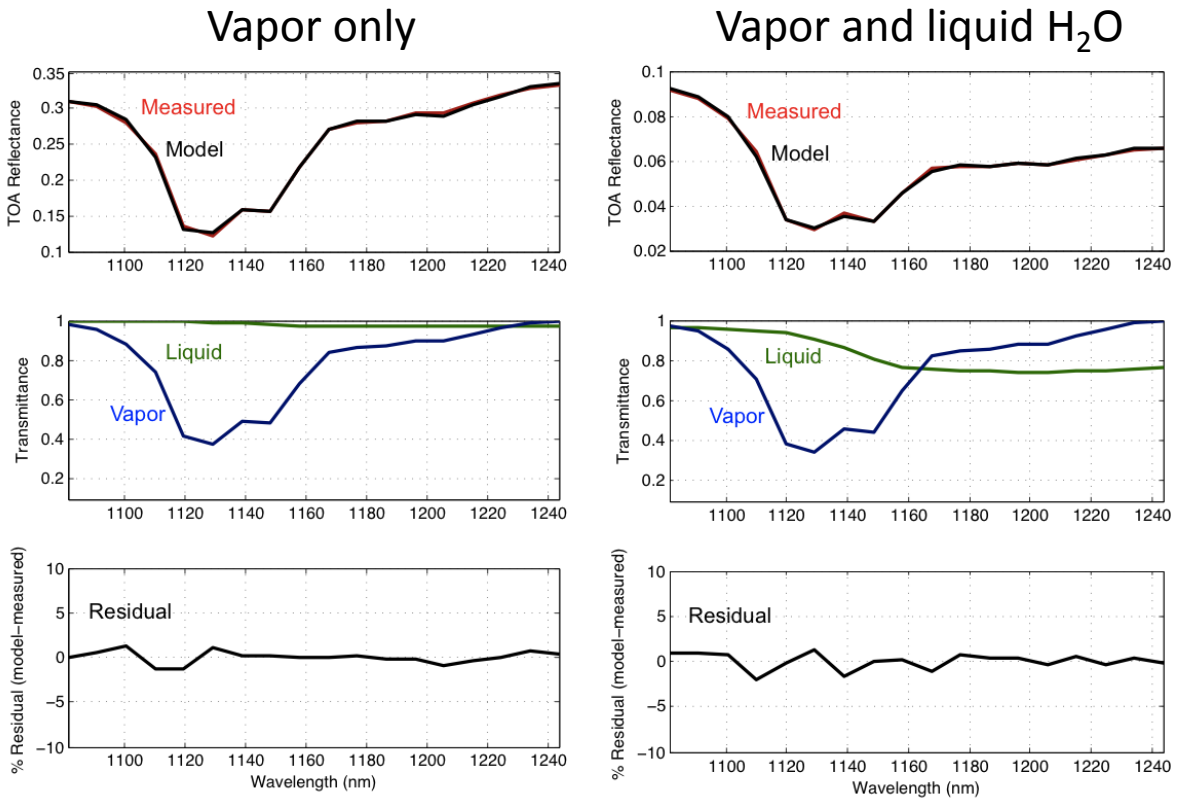
Absorption of Water Vapor, Liquid and Solid in the Solar Reflected Spectrum



The absorption bands of the three phases of water near 1000 nm are overlapping, but displaced for the three phases of water

New: simultaneous retrieval of H_2O vapor, liquid, and ice

- Liquid water or ice absorption can bias H_2O vapor retrievals based on band ratios
- Instead, we fit all three features simultaneously using the 1140nm region
- We formulate this as a log-linear nonnegative least squares problem (fast and stable)

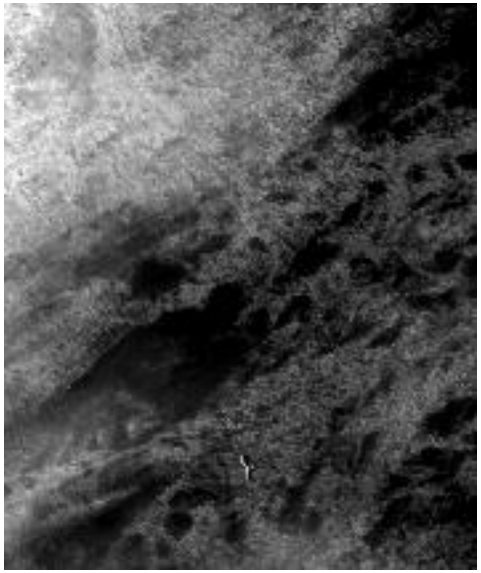


Thompson, Gao, Green, Roberts, Dennison, Lundeen (2014). Manuscript in preparation.

2013 Flight data shows improved decorrelation of surface water and H_2O vapor

Yosemite Box vegetation and granite features

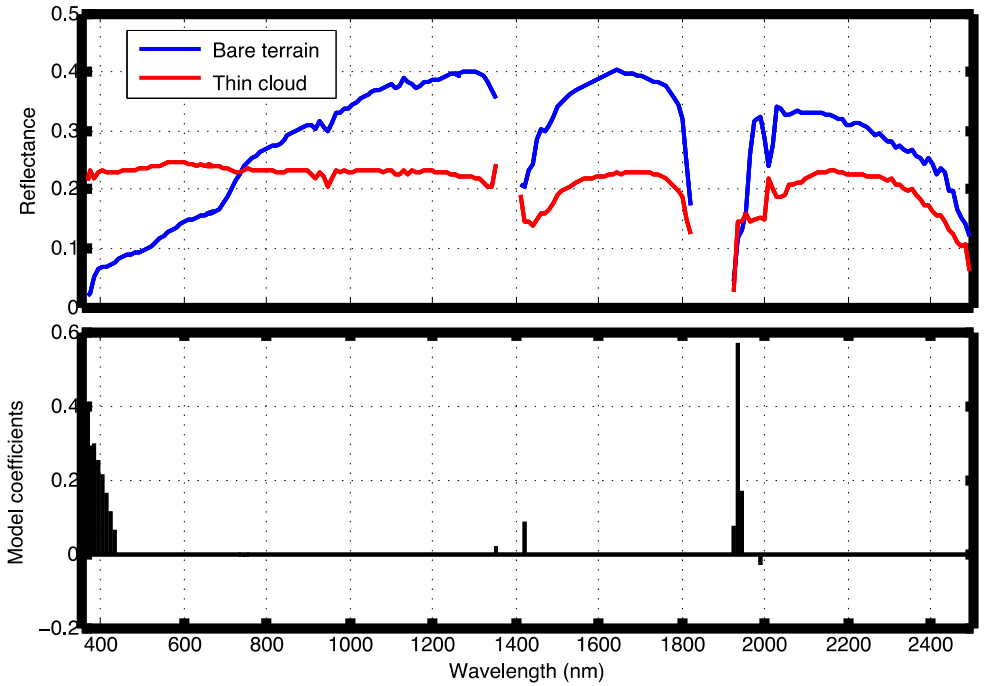
H2O vapor retrieved with a band ratio. R^2: 0.57



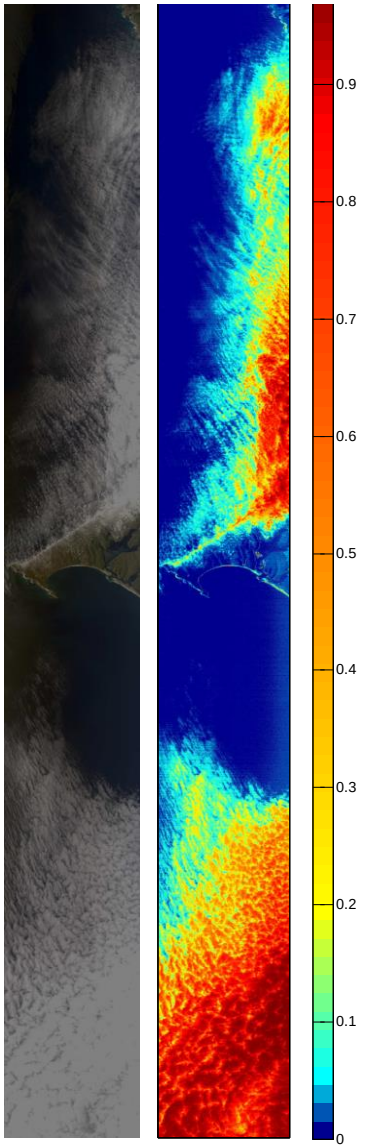
H2O vapor retrieved with a simultaneous fit R^2: 0.14

New cloud masks

Approach: Logistic regression, a linear probabilistic model. We fit a training set provided by Nina Kilham, Mateo Clark.
A regularization penalty ("L1 regularization") produces an interpretable model having mostly zero coefficients.
Model coefficients (below) Positive values favor clouds. The model gets most information from tropospheric H_2O absorption and UV channels.

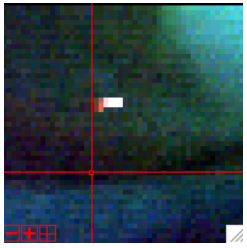


cloud probability maps

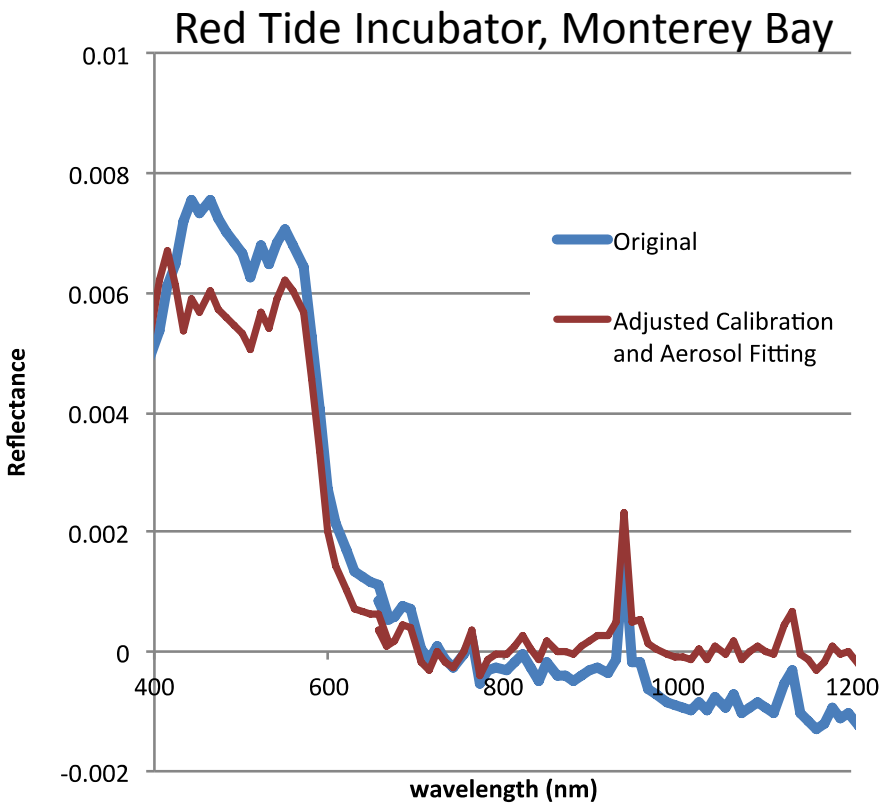


Improving reflectance results over ocean (work in progress)

1. Empirically adjust UV calibration using Ivanpah playa
   - Further refined by Bo-Cai Gao using cloud-top reflectances
2. Use SWIR channels to fit Aerosol Optical Depth in a marine aerosol model
3. Next step: formal comparison with in-situ Rrs. measurements



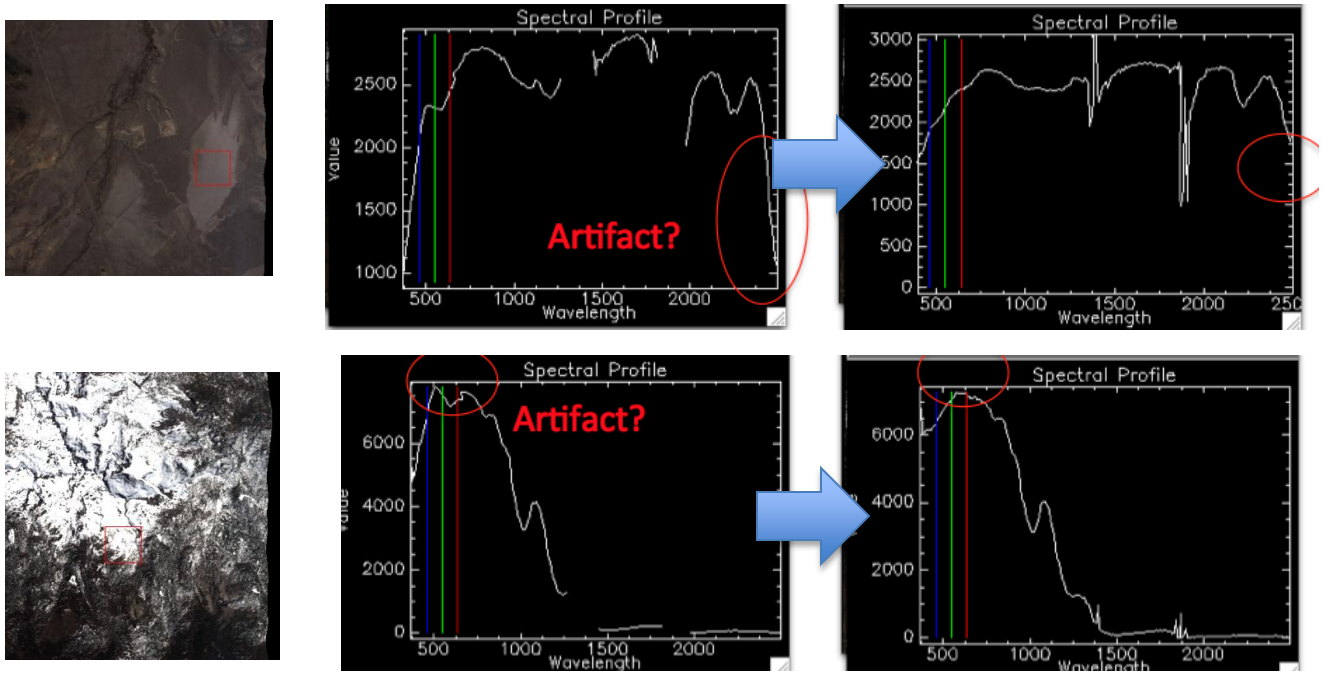
Red Tide Incubator, Monterey Bay (courtesy Raphe Kudela, Liane Guild, Sherry Palacios)



A note on residual suppression

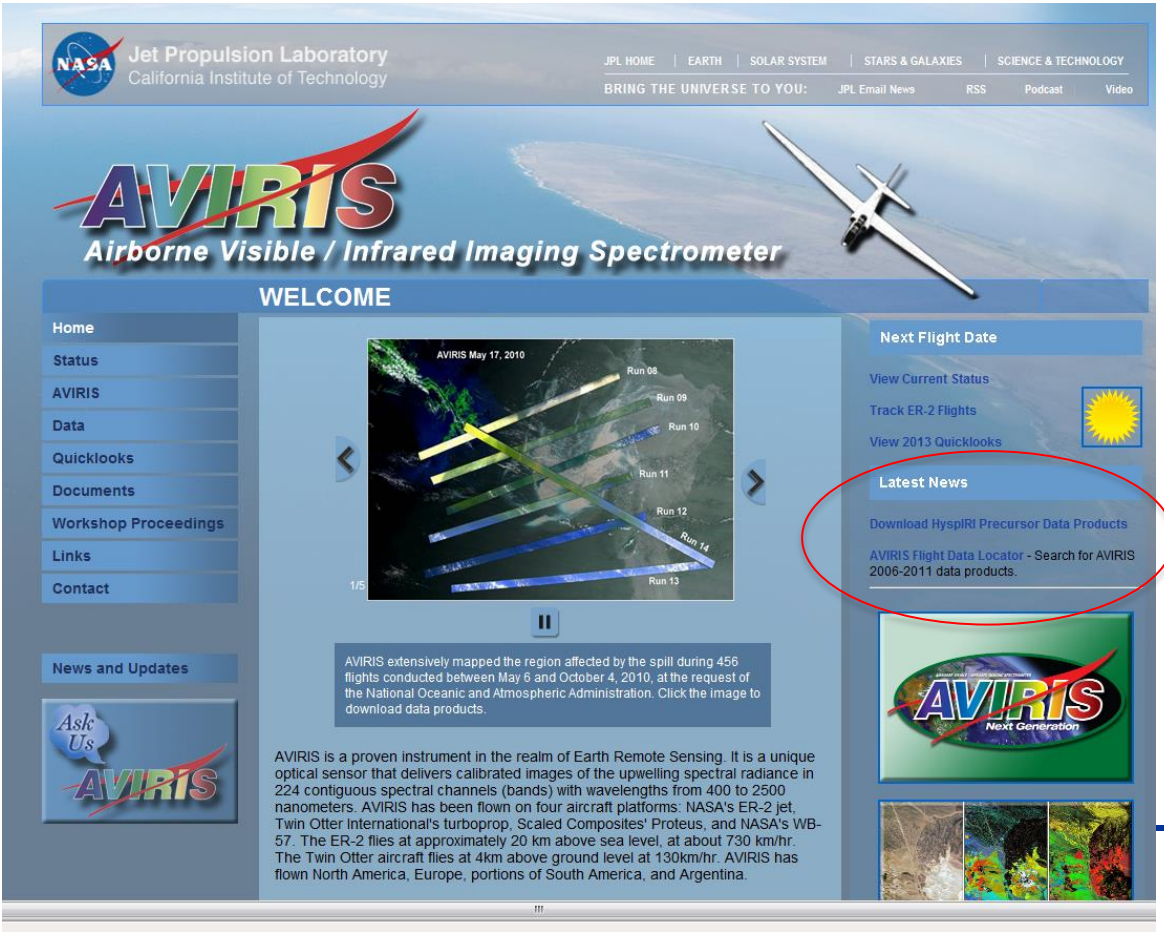
- We calculated revised residual suppression factors that can improve results on some older 2013 Hyspiri resampled data.

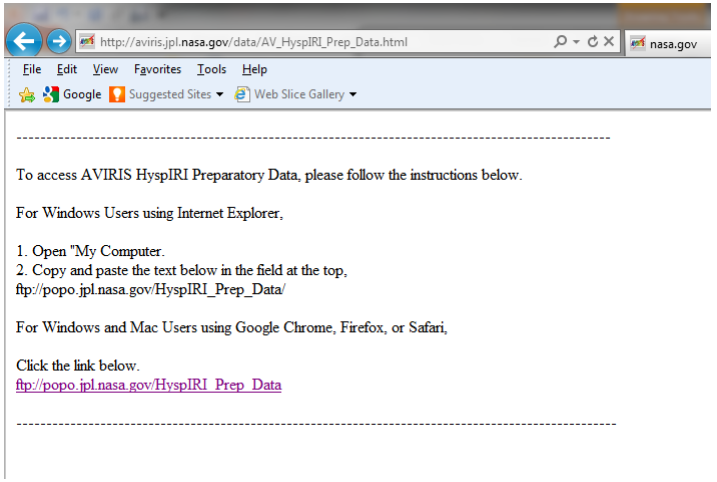
- Interested? contact David (david.r.thompson@jpl.nasa.gov) for more information on this correction.

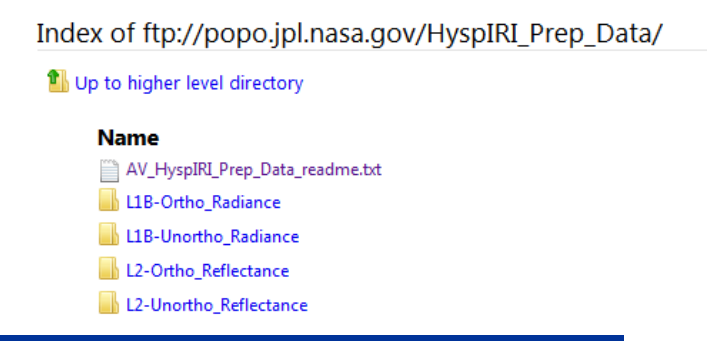


AVIRIS data: http://aviris.jpl.nasa.gov

- Via the quicklook locator
- Via dedicated ftp location
- Via hard disk all data







Special Issue Draft Paper

Atmospheric Correction for Global Mapping Spectroscopy: ATREM Advances for the HyspIRI Preparatory Campaign

David R. Thompson[1], Bo-Cai Gao[2], Robert O. Green[1], Dar A. Roberts[3], Philip E. Dennison[4], Sarah Lundeen[1]

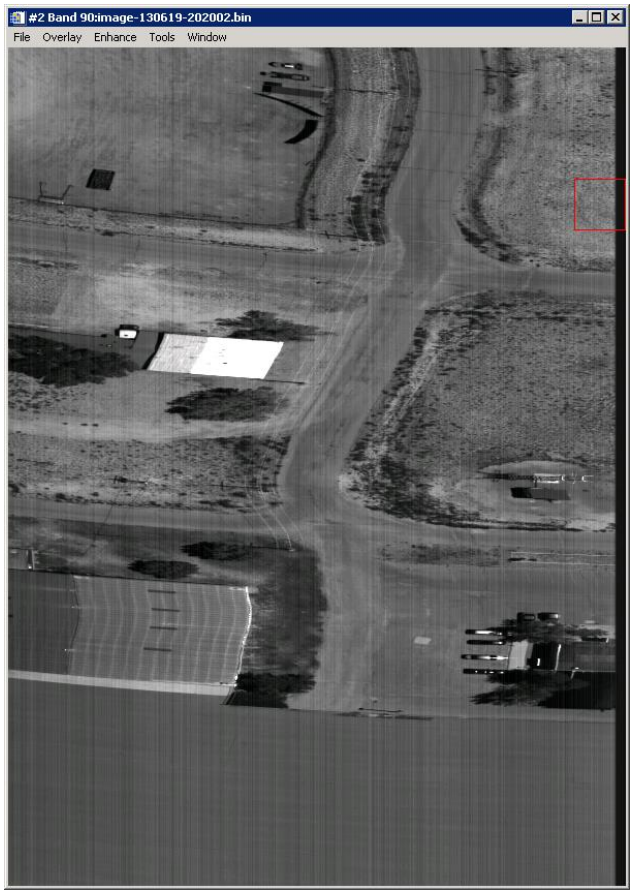
[1] Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA
[2] Naval Research Laboratory, Washington, DC
[3] University of California, Santa Barbara, CA
[4] University of Utah, Salt Lake City, UT

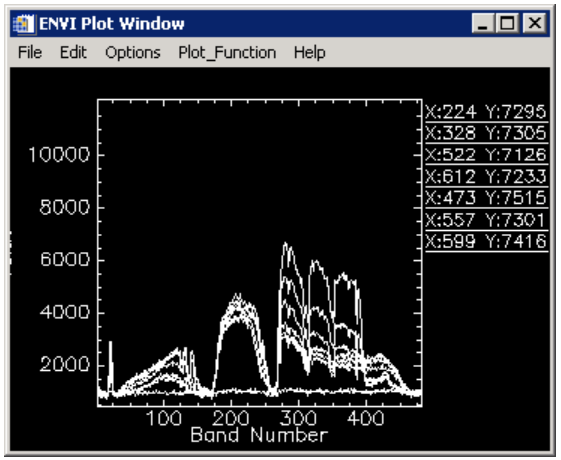
Abstract

Orbital imaging spectrometers such as the proposed Hyperspectral Infrared Imager (HyspIRI) mission promise global, multi-year, full-spectrum Visible Shortwave Infrared (VSWIR) reflectance maps. Monitoring the Earth's surface at high spectral resolution would significantly advance our understanding of changing ecosystems and land use. However, these applications depend on reliable correction of atmospheric scattering and absorption. The HyspIRI Preparatory Campaign is an airborne precursor mission comprised of multiple flights by the "classic" Visible Infrared Imaging Spectrometer (AVIRIS-C) over a wide geographic area. This article describes the atmospheric correction that we have implemented for the campaign. We first present the theoretical basis of our approach, which is grounded in the ATmospheric REMoval (ATREM) algorithm. We then describe new enhancements including retrieval of pressure altitude, which improves accuracy over widely varying topography, and joint retrieval of optical absorption for three water

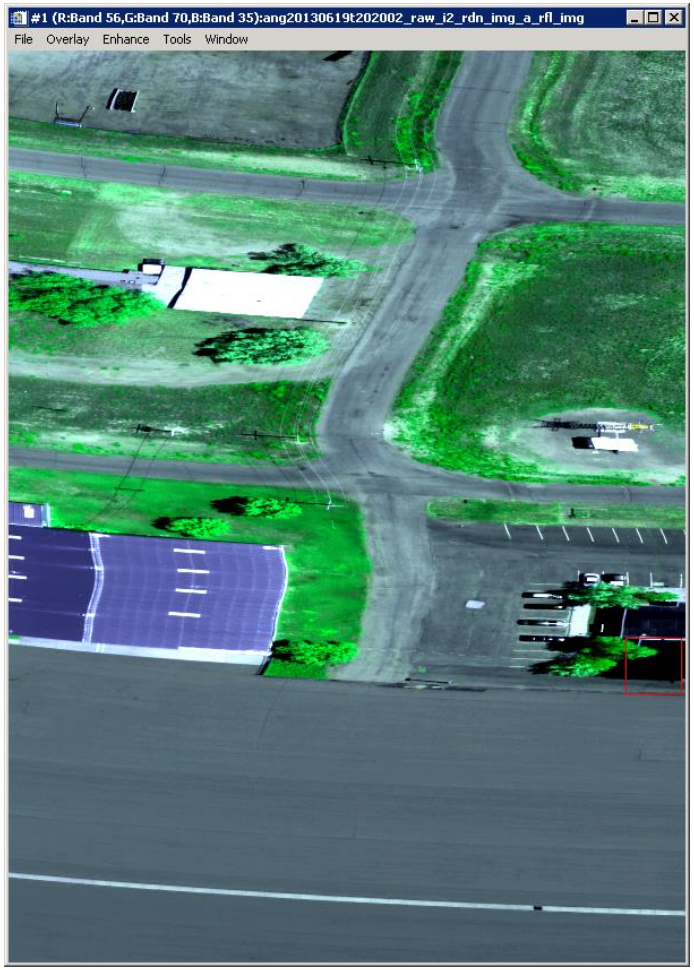
AVIRIS-Next Generation

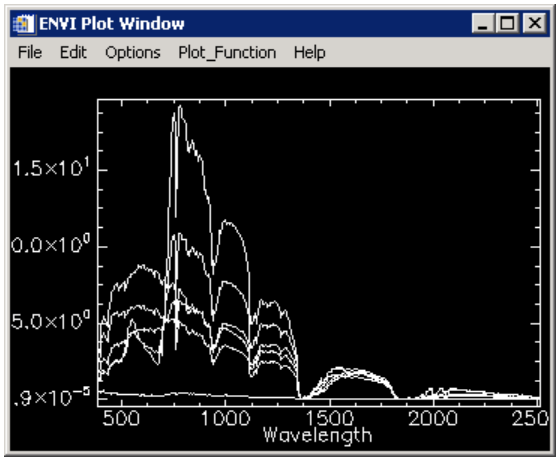
- Raw Data

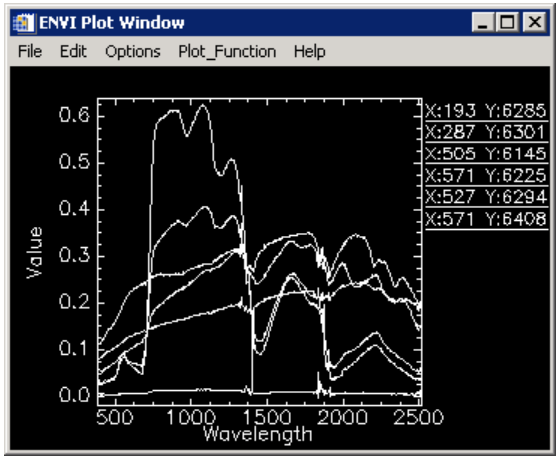




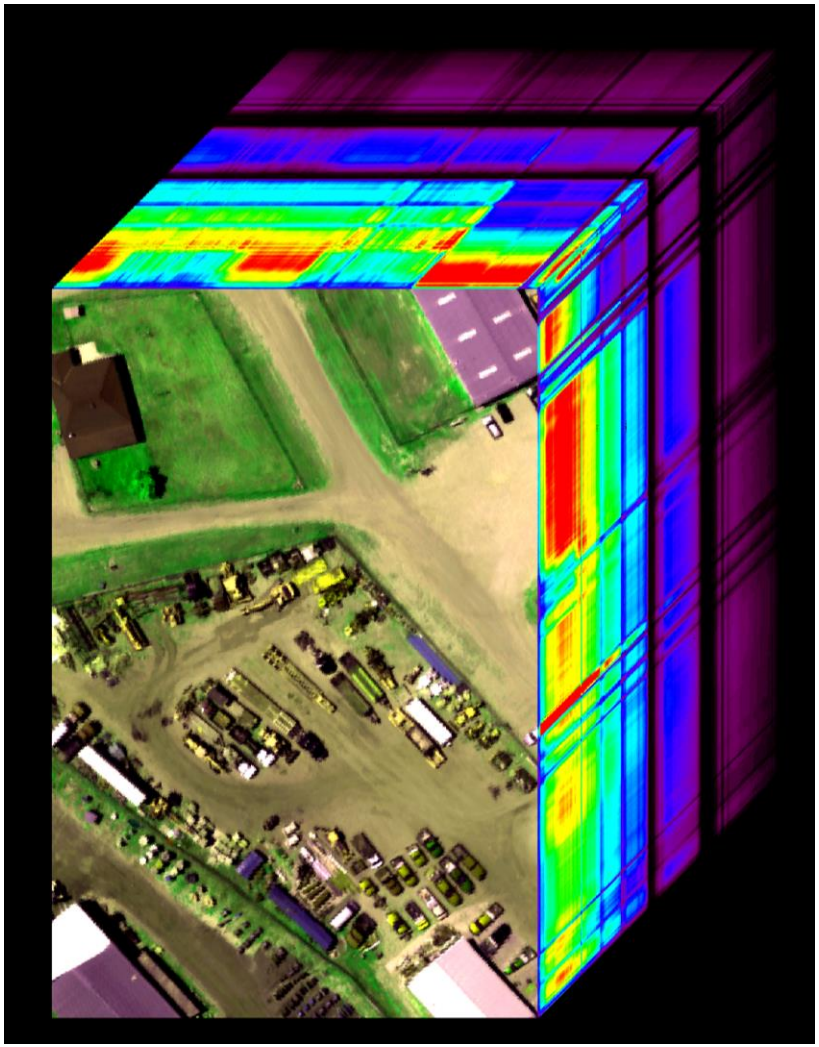
AVIRIS-NG Radiance and Atmospherically Corrected

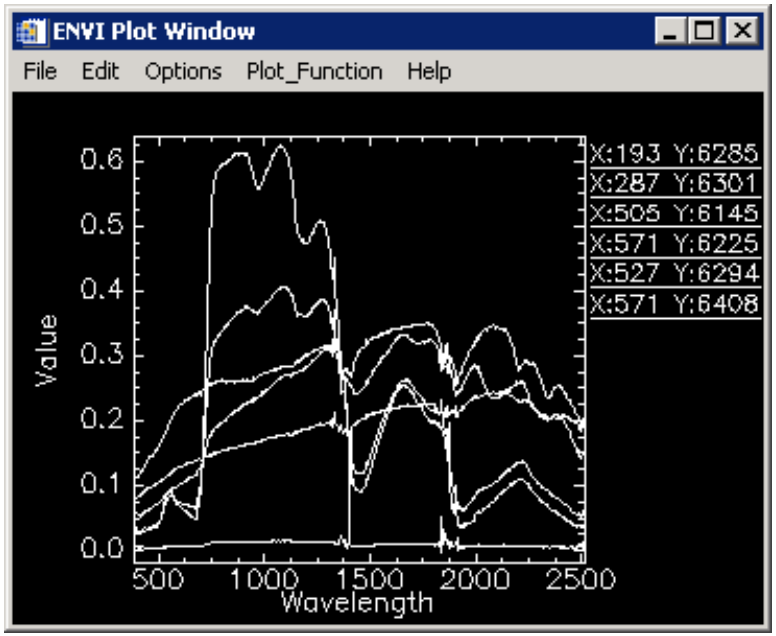




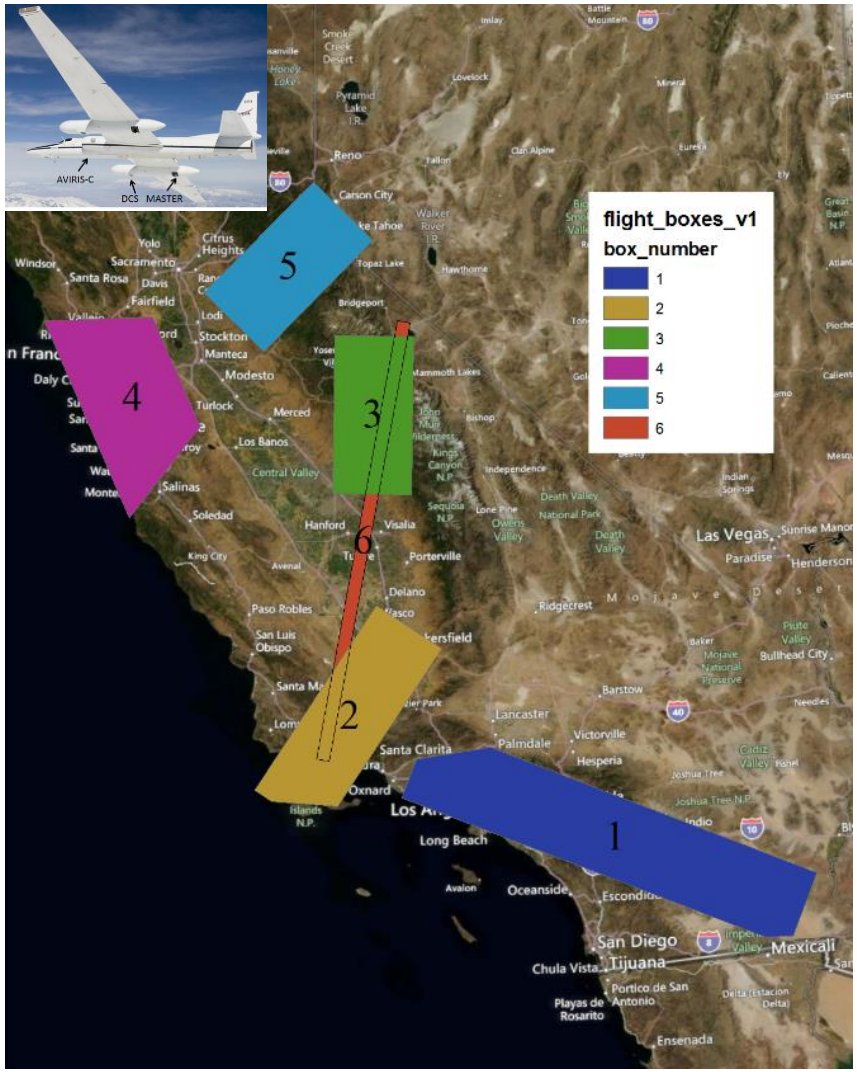


AVIRIS-NG Orthorectified





Questions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MASTER
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2
3
4
5
6
Reno
Carson City
Sacramento
Stockton
Modesto
Merced
Fresno
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Tijuana
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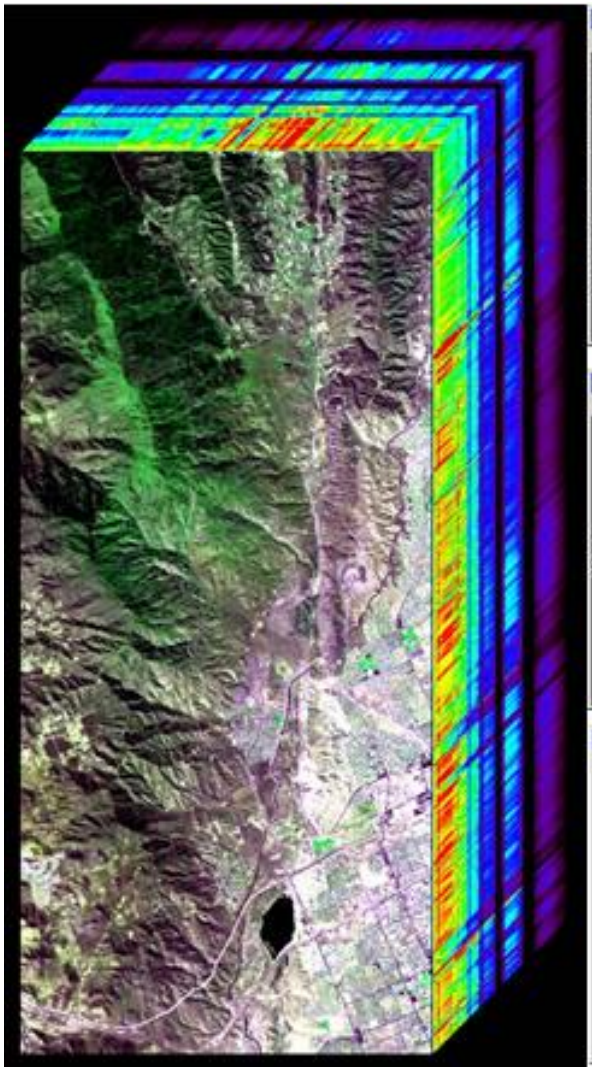
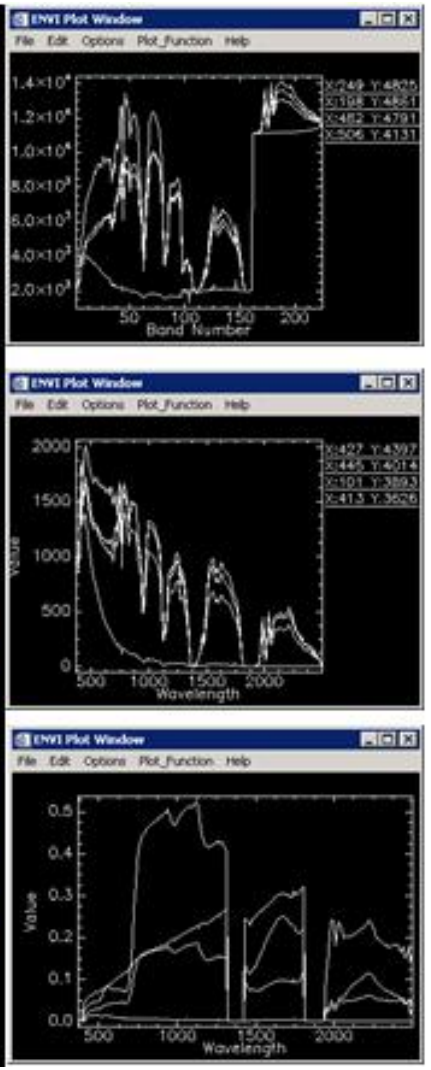
Ensenada




ENVI Plot Window
File Edit Options Plot_Function Help
Band Number
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ENVI Plot Window
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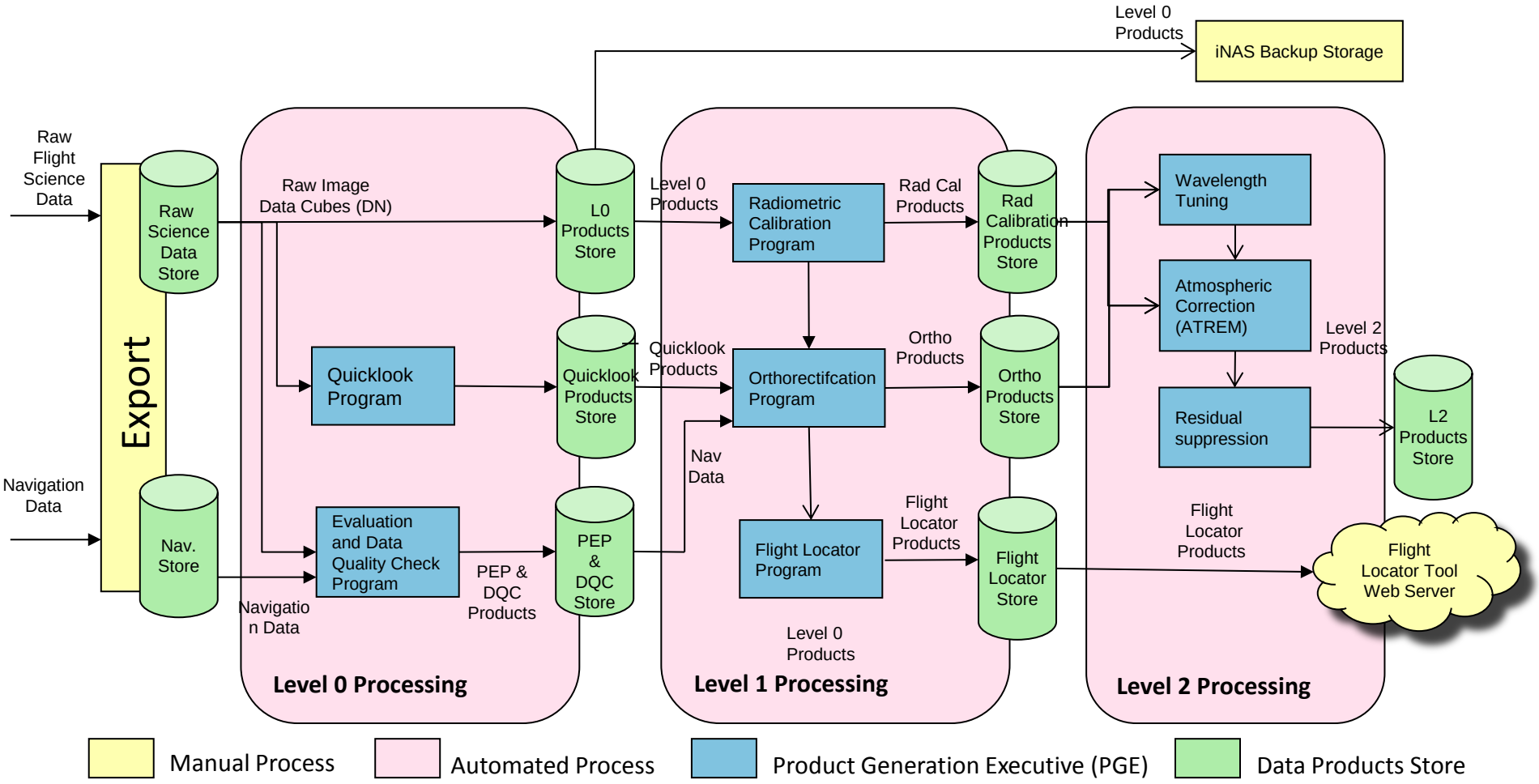
Wavelength

Backup slides

HyspIRI VSWIR pipeline



The ATREM Approach

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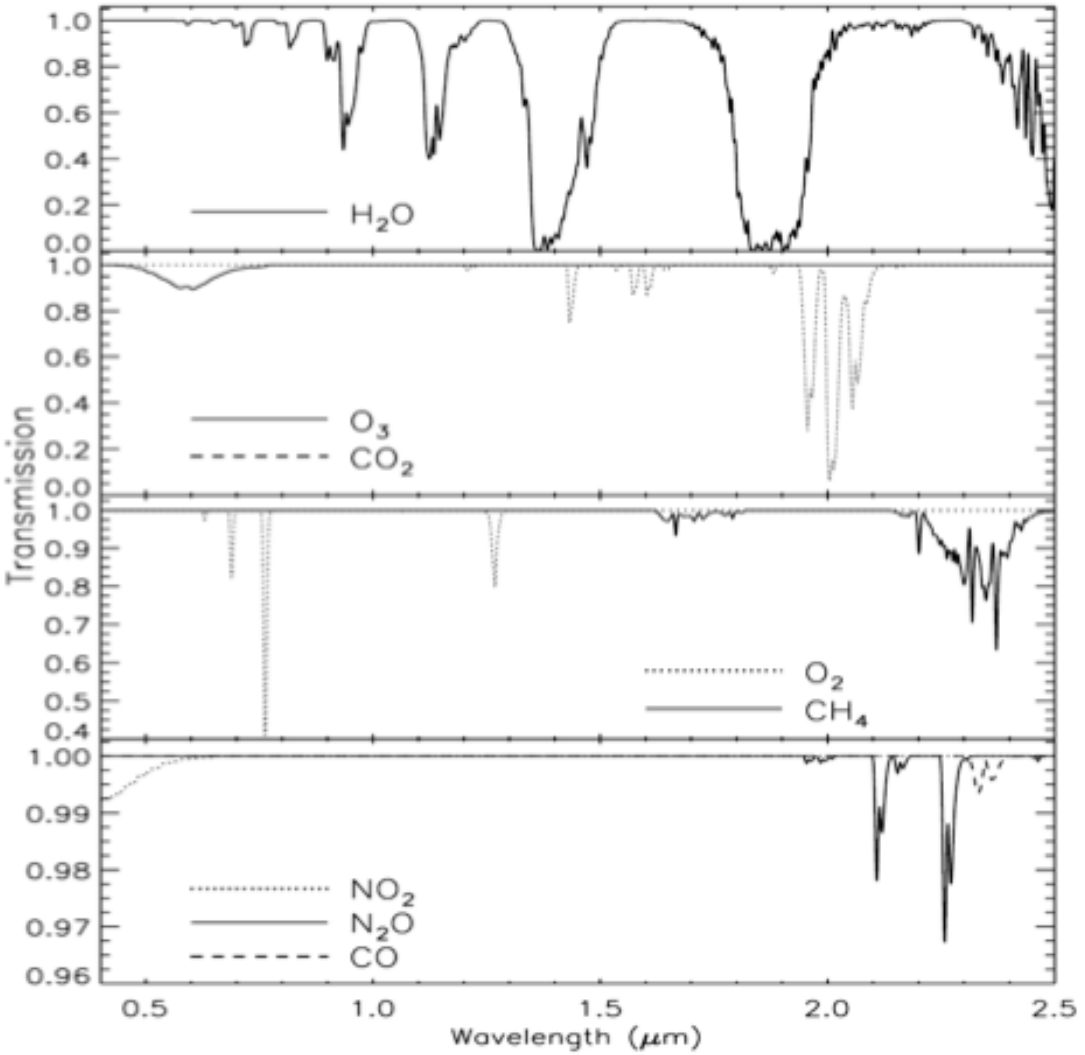
Scattering terms from 6s code

$$r = (r^*_{obs}/T_g - r^*_{atm}) \;/\; [t_d\, t_u + s\,(r^*_{obs}/T_g - r^*_{atm})].$$

From [Gao and Green 2010]

Typical transmittance



Absorption is modeled for 7 gases

ATREM retrieves water vapor for each pixel using 0.94 and 1.14 µm H_2O band depths

Vertical profiles use 20-layer atmospheres

[Gao and Green 2010]