Level 2 processing of AVIRIS HyspIRI preparatory campaign measurements

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The Signal, Calibration, and Atmospheric Correction
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

\[ r_{obs}^* (l,q,f,q_0,f_0) = p \frac{L_{obs}(l,q,f,q_0,f_0)}{[m_0 F_0(l)]}, \]

Radiance

Path reflectance

\[ r_{obs}^* (l,q,f,q_0,f_0) = \left[ r_{atm}^* (l,q,q_0,f_0) + t_d(l,q_0) t_u(l,q) \frac{r(l)}{1 - s(l)r(l)} \right] T_g(l,q,q_0), \]

Surface reflectance

Atmospheric transmittance

Scattering terms from 6s code

\[ r = \left( r_{obs}^* / T_g - r_{atm}^* \right) / \left[ t_d t_u + s \left( r_{obs}^* / T_g - r_{atm}^* \right) \right]. \]

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

AVIRIS Calibrated Radiance 677 pixel swath

x,y,z coordinates of pixel centers (Boardman)

18m nearest neighbor resampling

30m Gaussian resampling

60m Gaussian resampling

HyspIRI NEdL added

ATREM

ATREM

ATREM

Products:

18m, 30m, 60m obs

18m, 30m, 60m radiance

18m, 30m, 60m water vapor

18m, 30m, 60m reflectance

L2: The atmospheric correction component

Products:

- AVIRIS Calibrated Radiance 677 pixel swath
- xyz coordinates of pixel centers (Boardman)
- 18m nearest neighbor resampling
- 30m Gaussian resampling
- 60m Gaussian resampling
- HyspIRI NEDL added

Orthorectified Radiance

Wavelength tuning

ATREM with simultaneous (three phase) H$_2$O retrieval

Residual suppression

Orthorectified Reflectance

Ivanpah calibration flight 2014: initial comparison of uncorrected reflectances

f140331r06

AVIRIS spectrum (uncorrected)

In situ “Black” ASD

Reflectance

Wavelength (nm)
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

10 nm sampling

Transmittance

Wavelength (nm)

- 0.00 mm PW
- 0.10 mm PW
- 1.00 mm PW
- 10.0 mm PW
- 50.0 mm PW
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$_2$O vapor, liquid, and ice

- Liquid water or ice absorption can bias H$_2$O 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)

2013 Flight data shows improved decorrelation of surface water and H$_2$O vapor

Yosemite Box vegetation and granite features

H$_2$O vapor retrieved with a band ratio. $R^2$: 0.57

H$_2$O 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$_2$O absorption and UV channels.
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
Atmospheric Correction for Global Mapping Spectroscopy: ATREM Advances for the HyspIRI Preparatory Campaign

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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, those 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
Backup slides
The ATREM Approach

Apparent reflectance

\[ r_{\text{obs}}^* (l, q, f, q_0, f_0) = p \frac{L_{\text{obs}}(l, q, f, q_0, f_0)}{[m_0 F_0(l)]}, \]

Radiance

Solar flux

Path reflectance

Surface reflectance

Atmospheric transmittance

Scattering terms from 6s code

\[ r_{\text{obs}}^* (l, q, f, q_0, f_0) = \left[ r_{\text{atm}}^* (l, q, q_0, f_0) + t_d(l, q_0) t_u(l, q) \frac{r(l)}{1 - s(l) r(l)} \right] T_g(l, q, q_0), \]

From [Gao and Green 2010]
Absorption is modeled for 7 gases

ATREM retrieves water vapor for each pixel using 0.94 and 1.14 μm H₂O band depths

Vertical profiles use 20-layer atmospheres

[Gao and Green 2010]