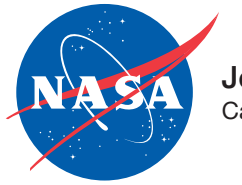

Jet Propulsion Laboratory
California Institute of Technology

The HyspIRI Preparatory Campaign Level 2 Reflectance Products

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Jet Propulsion Laboratory, California Institute of Technology
*Naval Research Laboratory

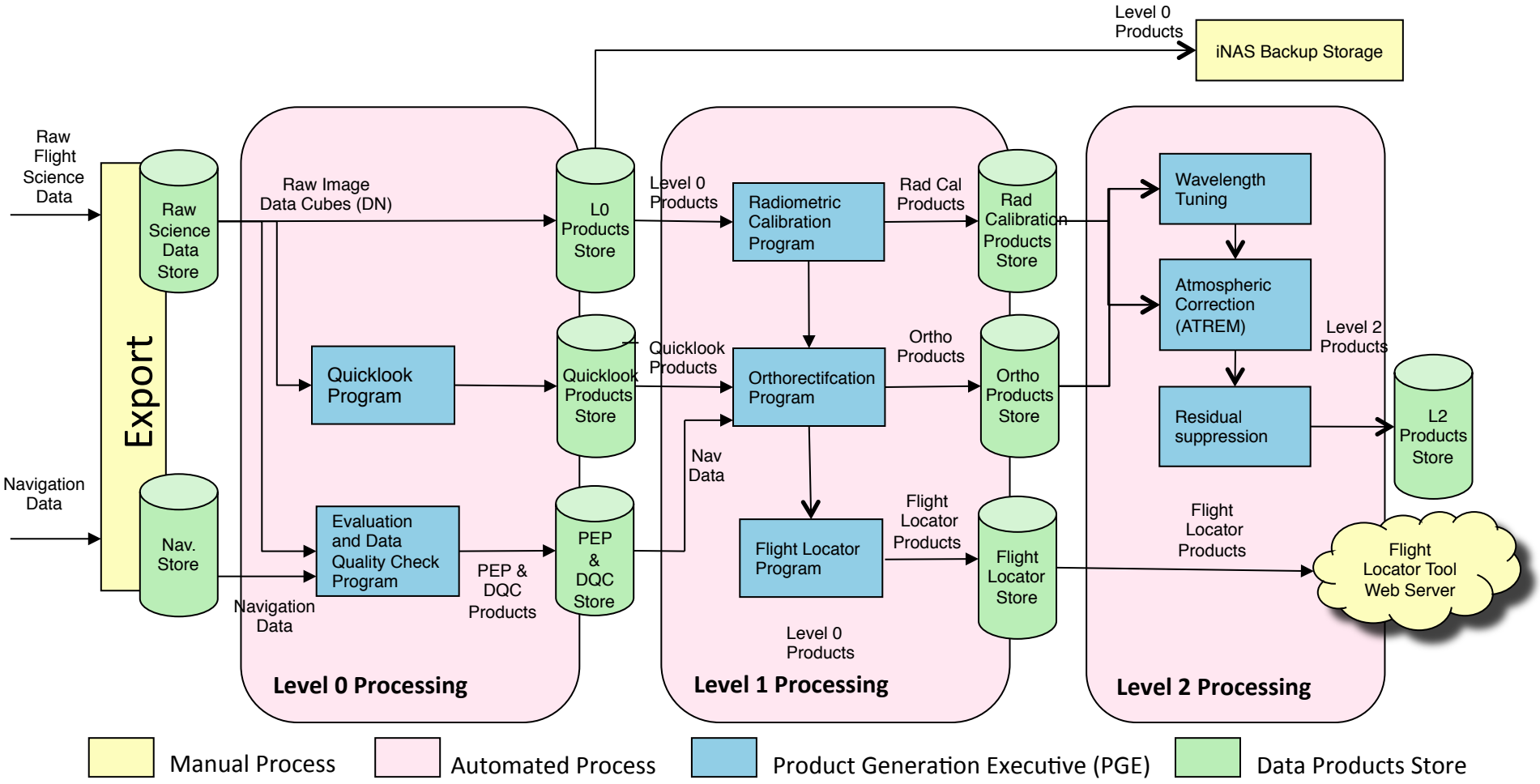
Agenda

- The ATREM Algorithm
- Upgrades from the airborne campaign
- What do the filenames mean?
- Future plans
- Your feedback!

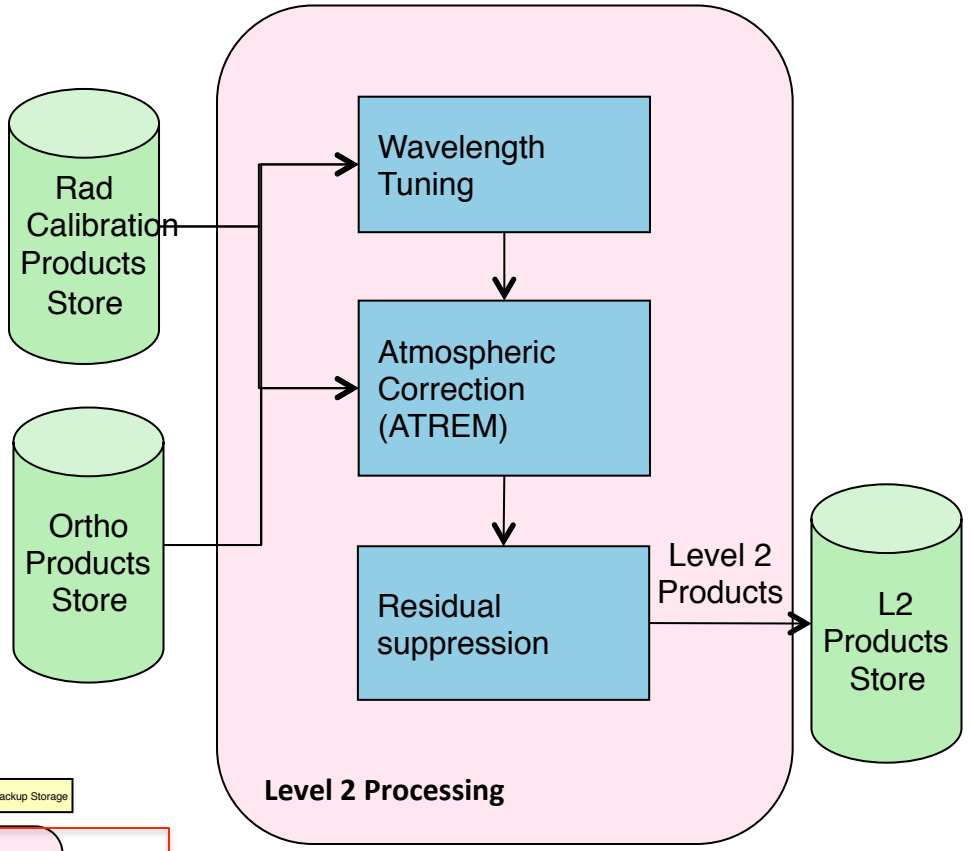
Goals

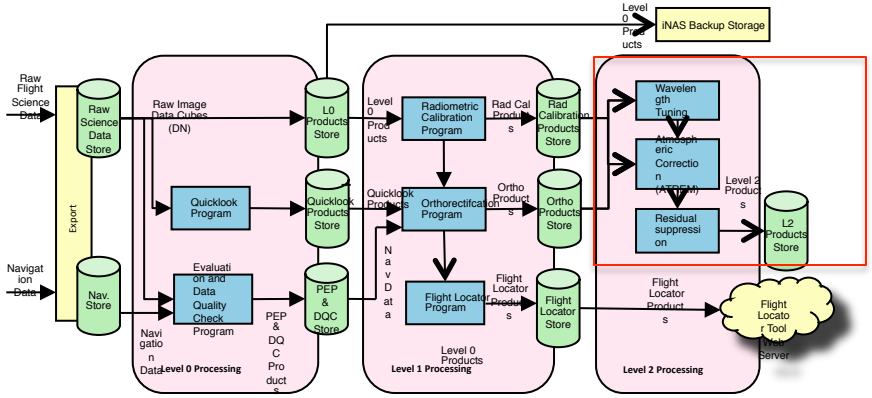
- Provide accurate L2 products for preparatory science campaign
- Refine techniques and software for HyspIRI mission
- Demonstrate scalability

HyspIRI VSWIR pipeline



Our focus


Rad Calibration Products Store
Ortho Products Store
Wavelength Tuning
Atmospheric Correction (ATREM)
Residual suppression
Level 2 Products
L2 Products Store
Level 2 Processing


Level 0 Products
INAS Backup Storage
Raw Flight Science Data
Raw Science Data Store
Raw Image Data Cubes (DN)
L0 Products Store
Quicklook Program
Quicklook Products Store
Navigation Data
Nav. Store
Evaluation and Data Quality Check Program
PEP & DQC Products
PEP & DQC Store
Export
Level 0 Processing
Radiometric Calibration Program
Rad Cal Products
Rad Calibration Products Store
Orthorectification Program
Ortho Products
Ortho Products Store
Flight Locator Program
Flight Locator Products
Flight Locator Store
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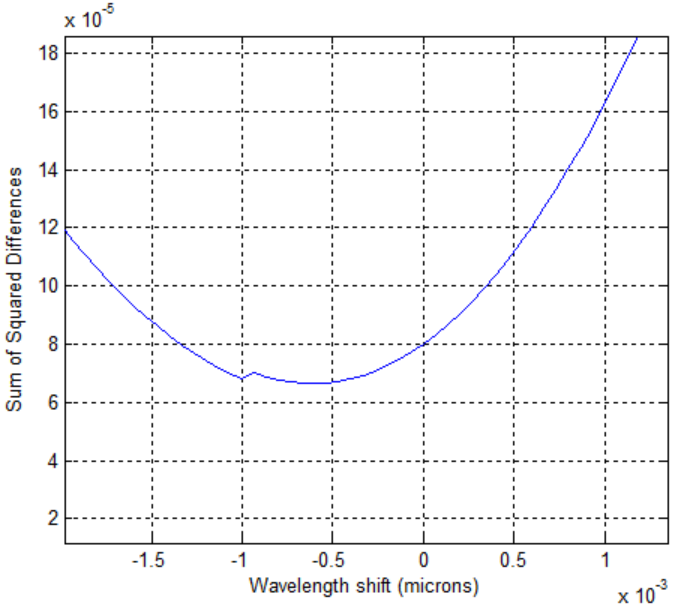
Flight Locator Tool Web Server
Level 2 Processing

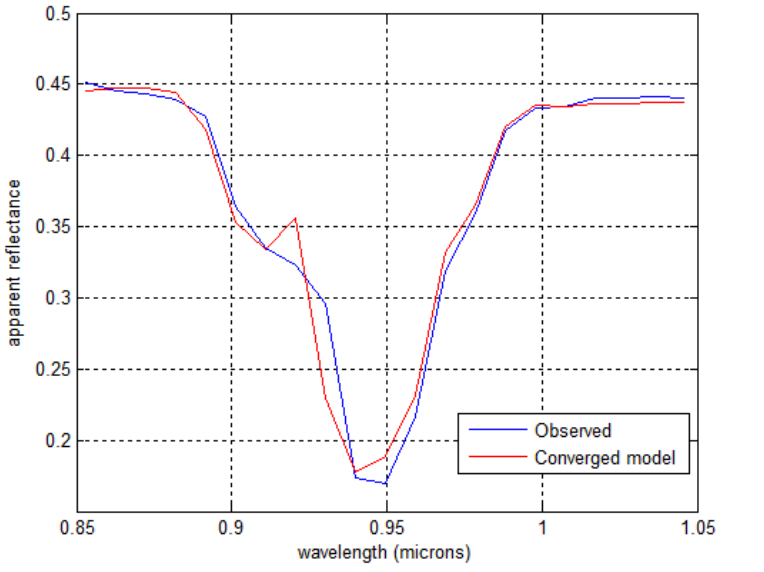
Wavelength tuning

1. Extract a radiance spectrum from Ivanpah overflight
2. Use the modified ATREM to generate an apparent reflectance spectrum and a synthetic transmittance spectrum of H_2O (here, at 3cm abundance)
3. Use STARPAC fitting program to find an offset to the standard 2012 AVIRIS Wavelengths resulting in the best match

Residual error shows best fit at -0.5nm



Observed (apparent reflectance) and model (transmittance) spectra



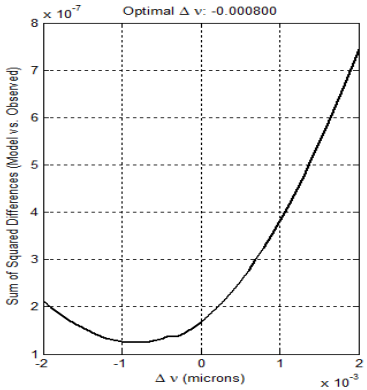
Wavelength tuning

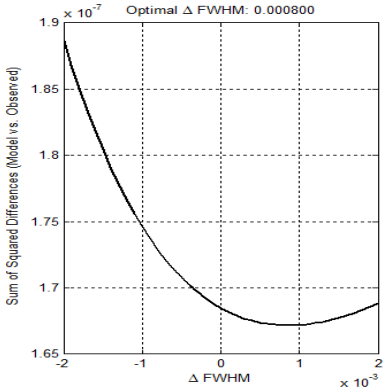
Frequency offset

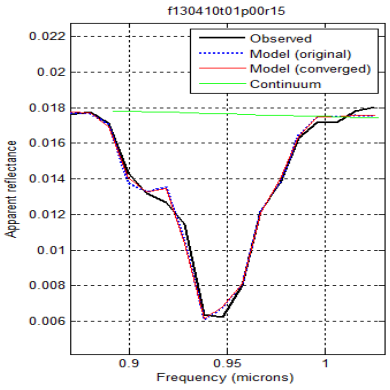
FWHM

f130411t01p00r15

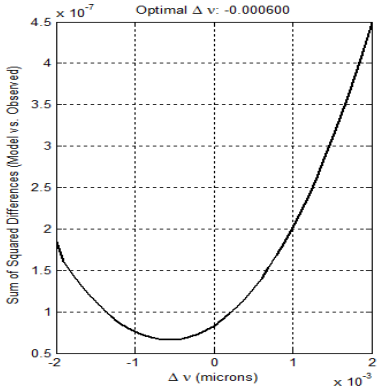
0.94 micron absorption

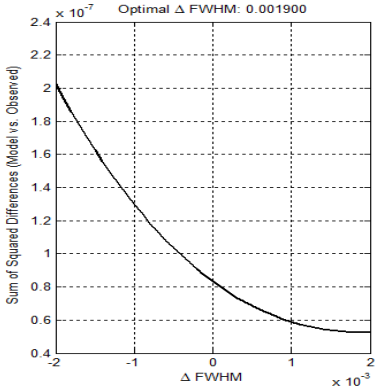


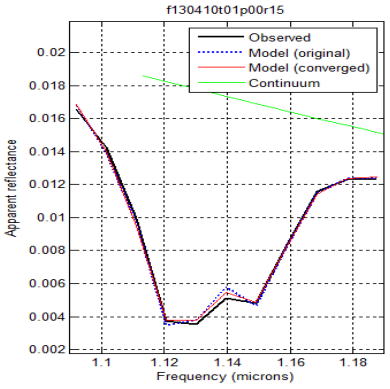




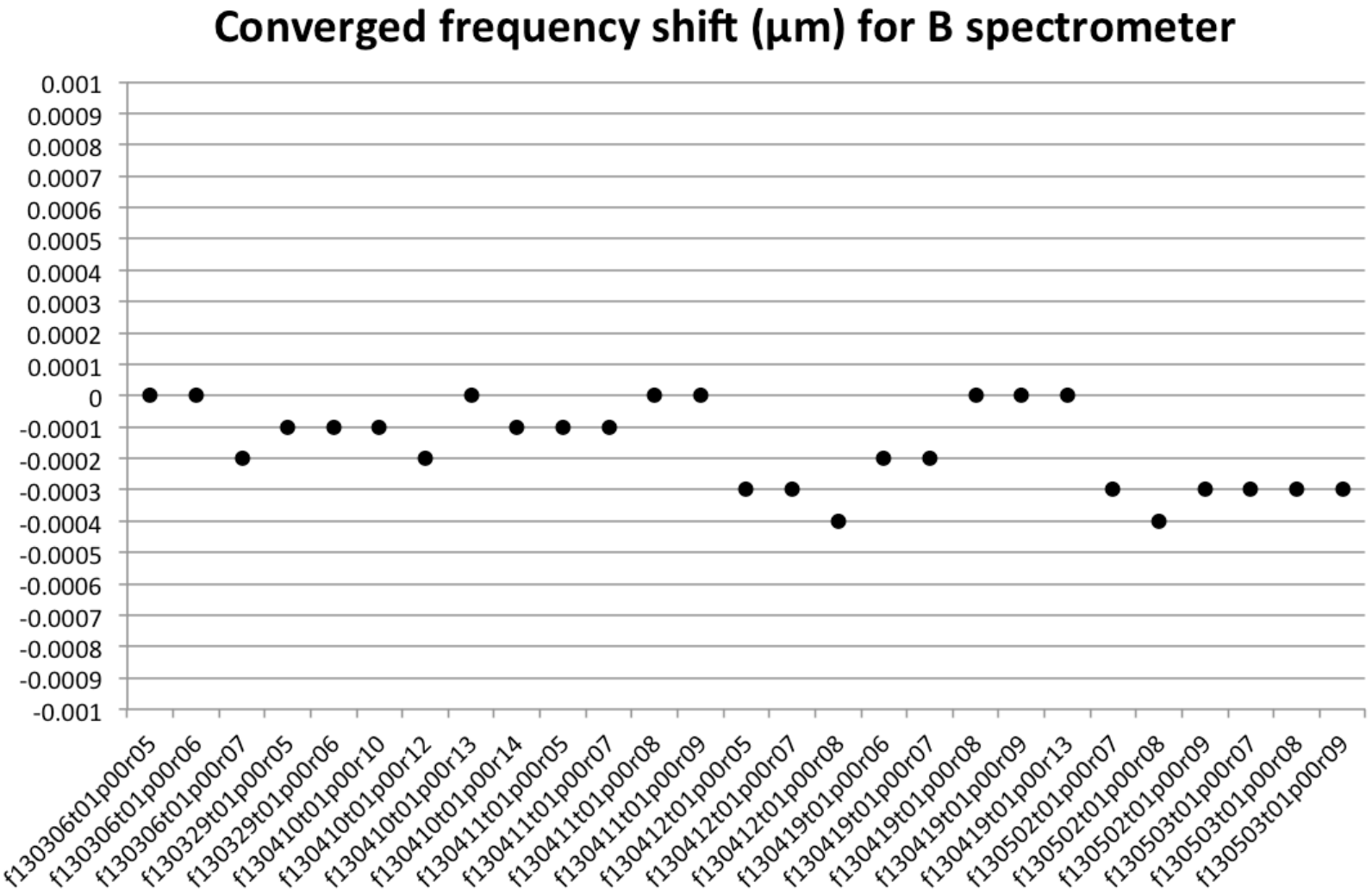
1.14 micron absorption



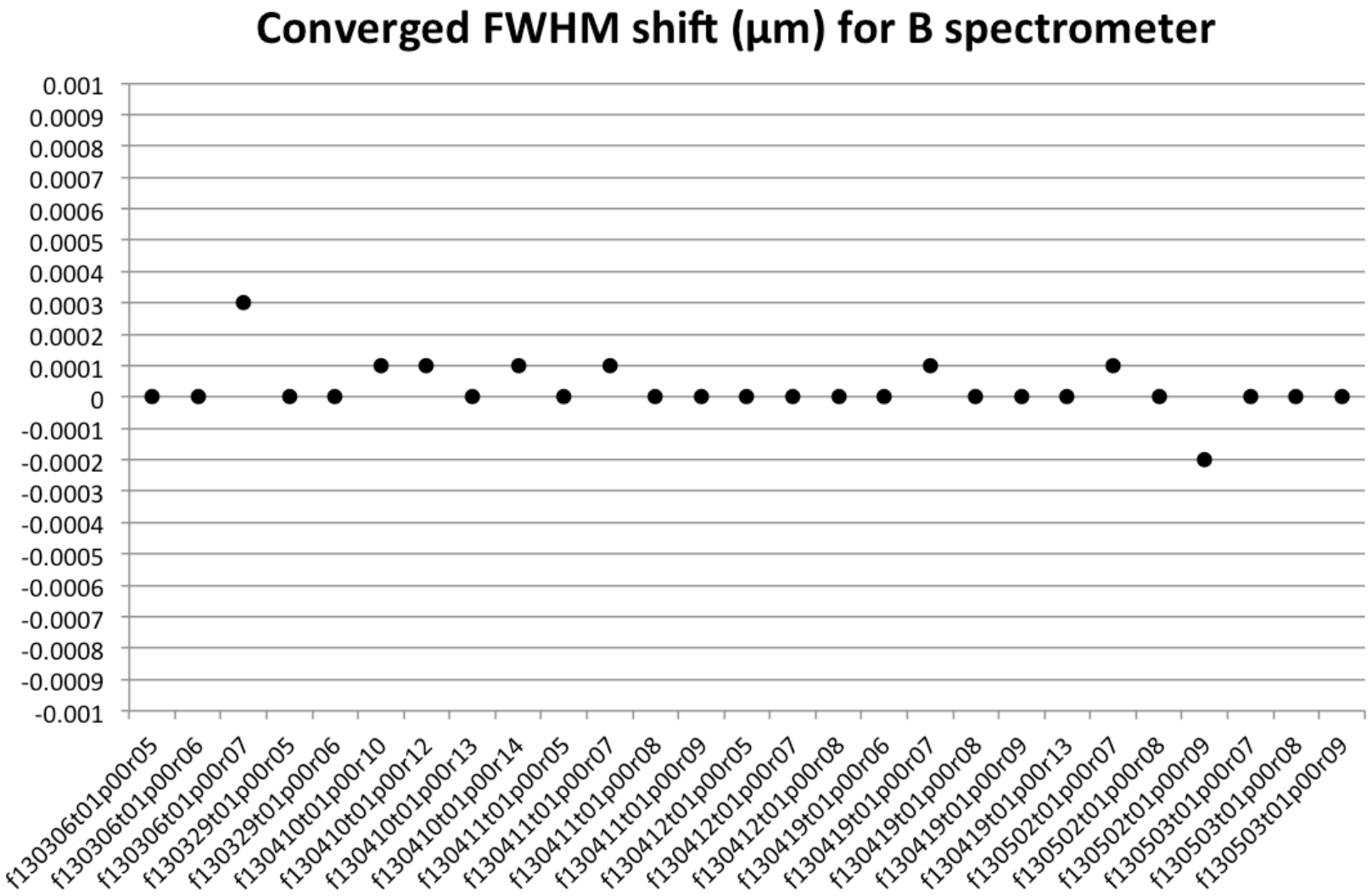




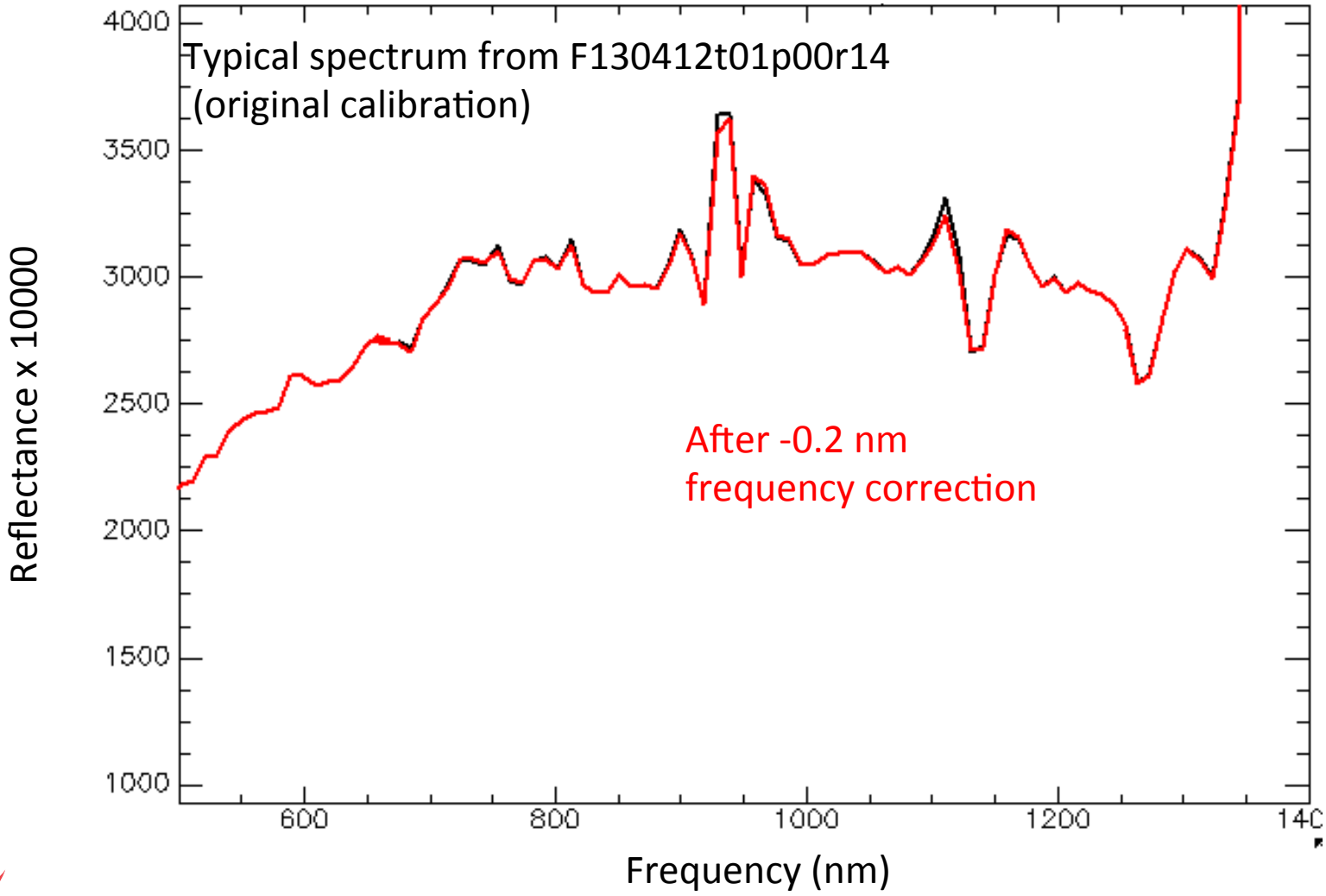
Wavelength Tuning



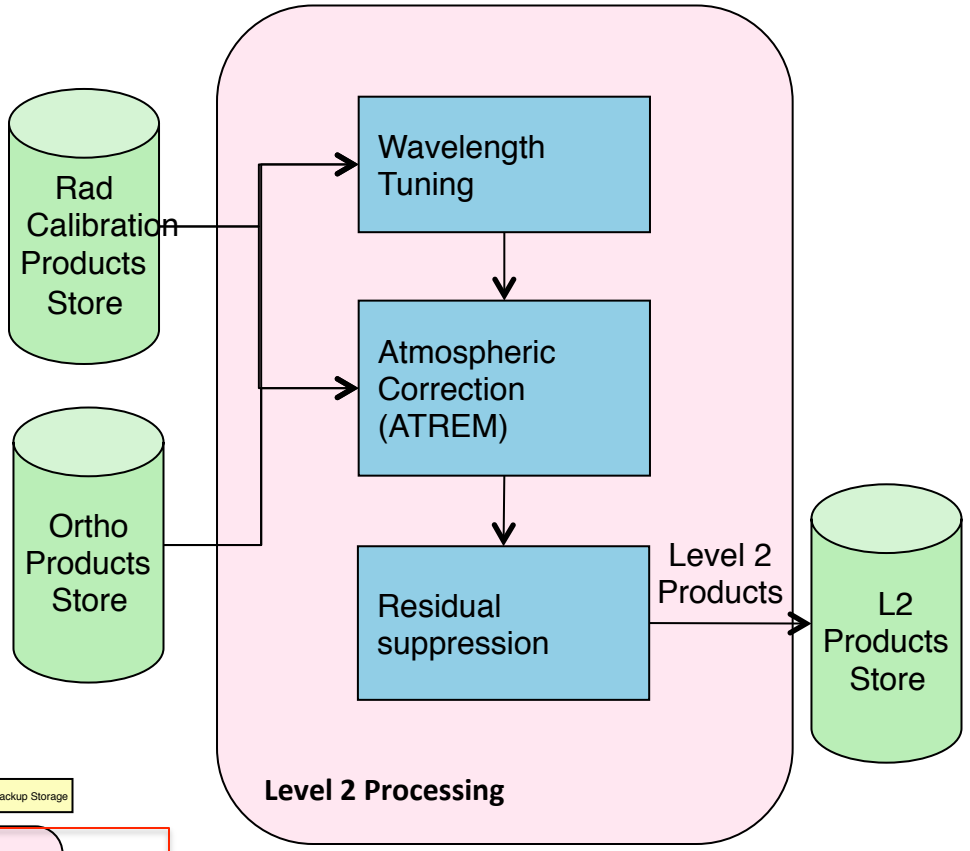
Wavelength tuning



Effect on reflectance spectrum



Our focus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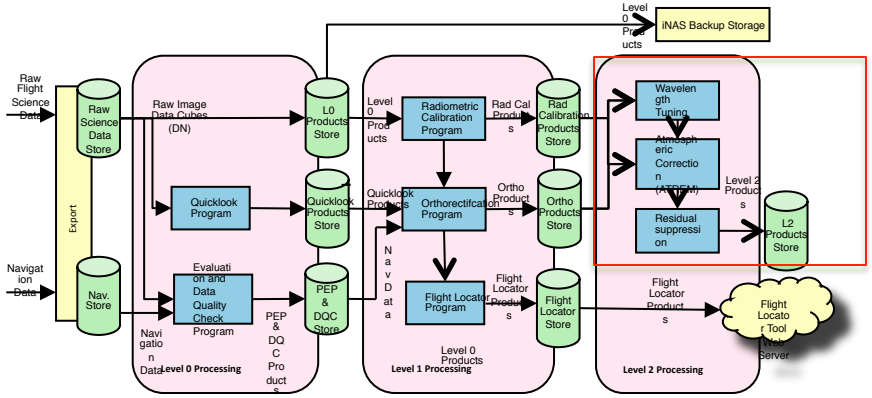
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Level 2 Processing

The ATREM Approach

Apparent reflectance Radiance Solar flux

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

From [Gao and Green 2010]

The ATREM Approach

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

From [Gao and Green 2010]

The ATREM Approach

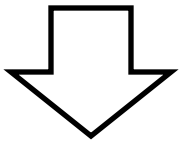
Apparent reflectance — Radiance — Solar flux

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

Path reflectance — Surface reflectance — Atmospheric transmittance

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

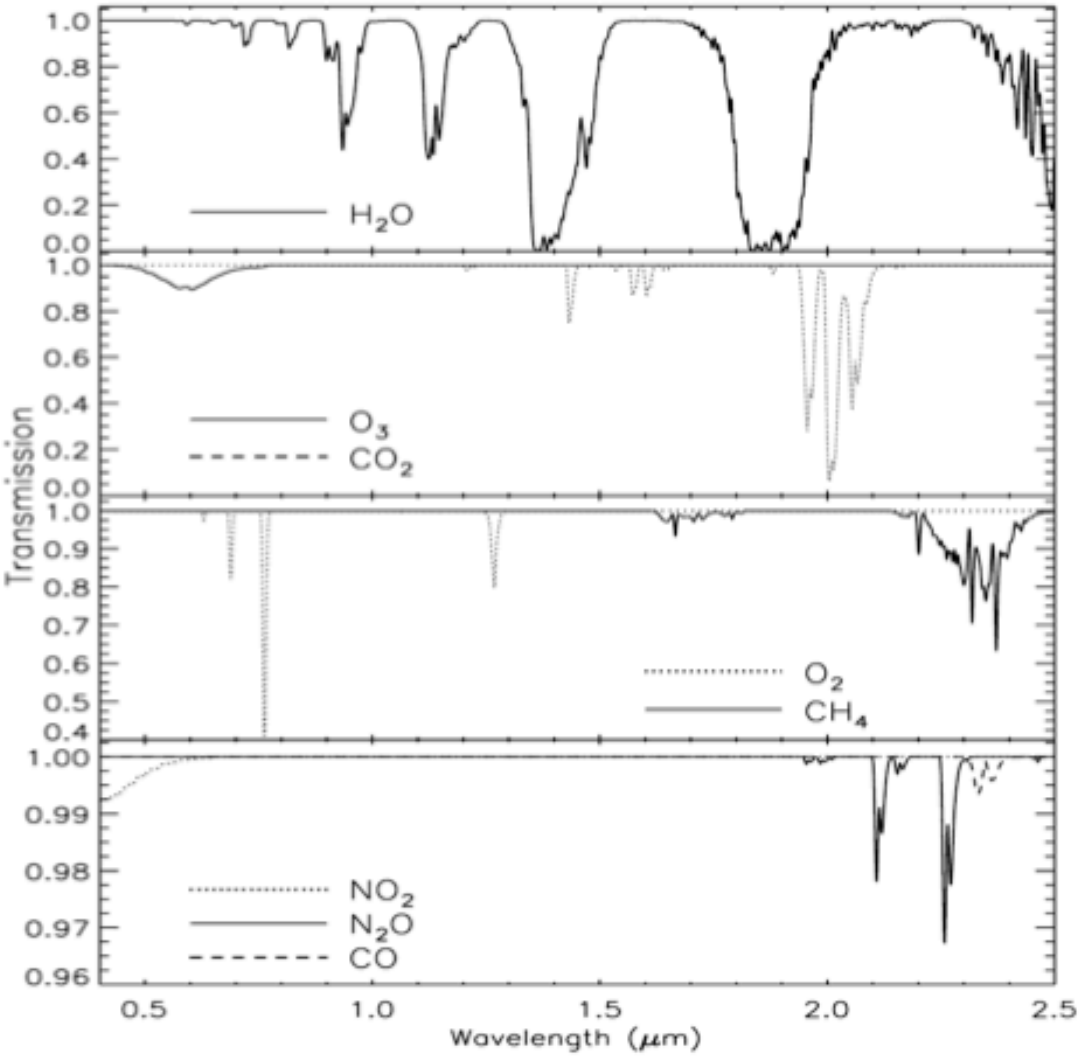
Scattering terms from 6s code



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

From [Gao and Green 2010]

Typical transmittance



Absorption is modeled for 7 gases

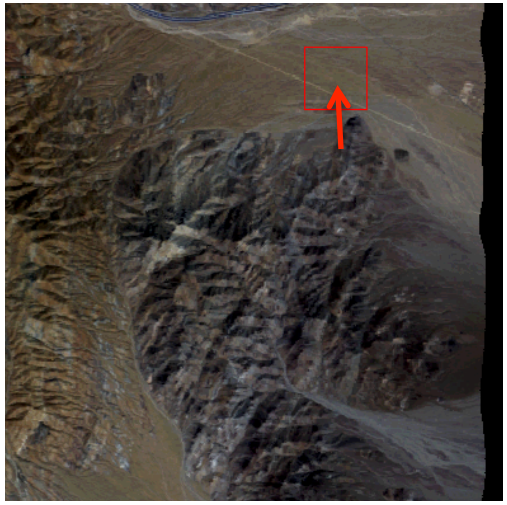
ATREM retrieves water vapor for each pixel using 0.94 and 1.14 µm H_2O band depths

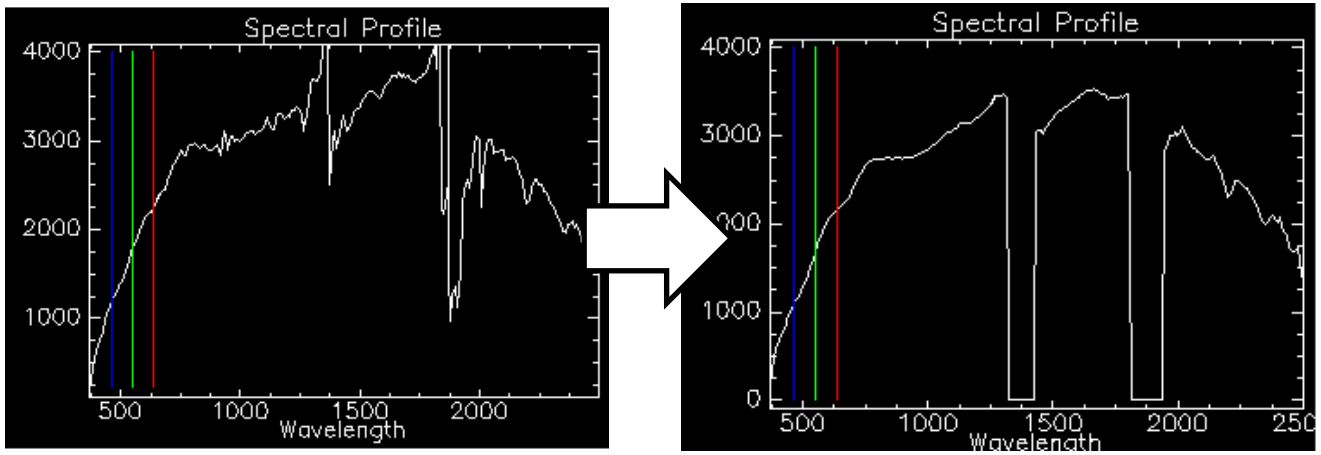
Vertical profiles use 20-layer atmospheres

[Gao and Green 2010]

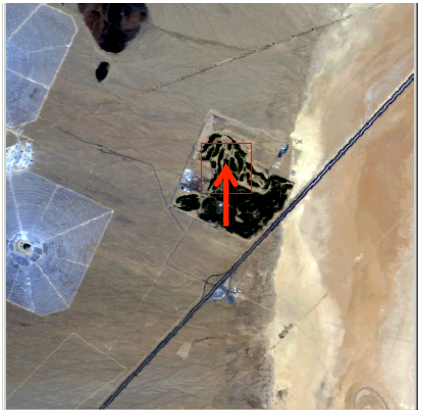
Residual Suppression

- A modified empirical line approach, adjusts spectrum using in-situ ground truth
- Fit multiplicative coefficients (one per channel)
- Calculate using in situ measurements from 20130503 calibration

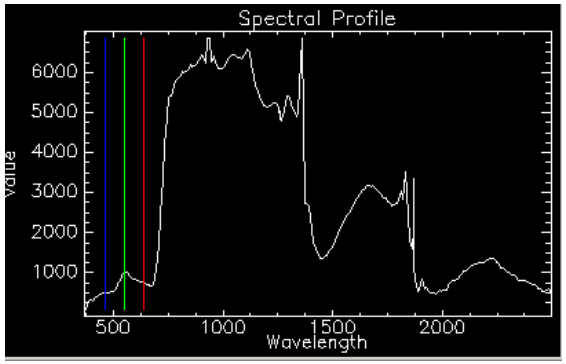




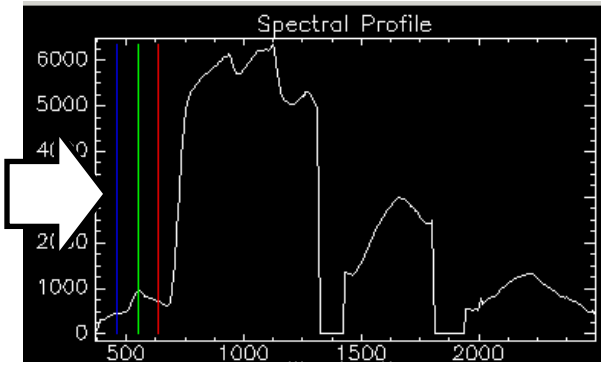
Vegetation (f130503t01p00r12)



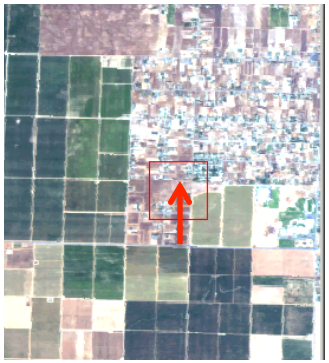
Initial output

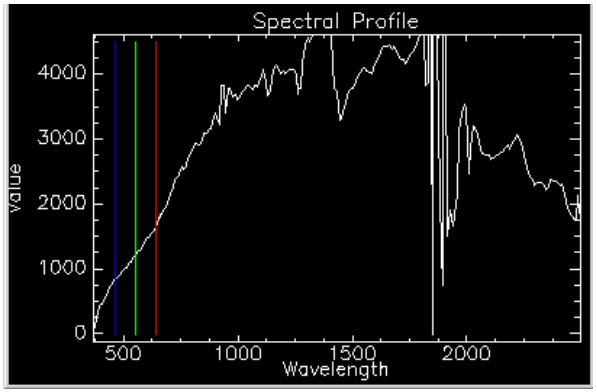


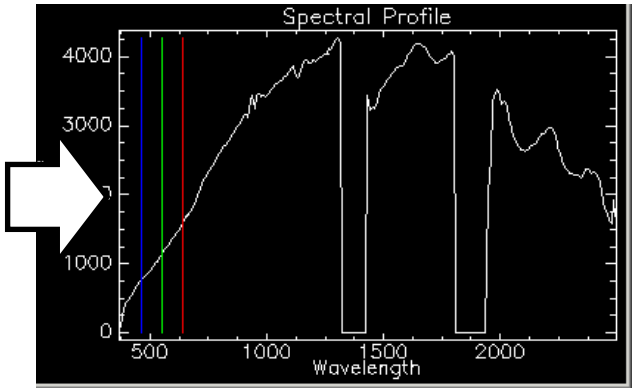
Final L2 product
(after residual suppression)



Bare Terrain (f130503t01p00r18)





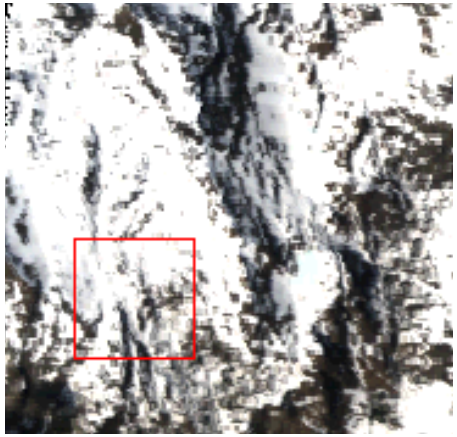


Agenda

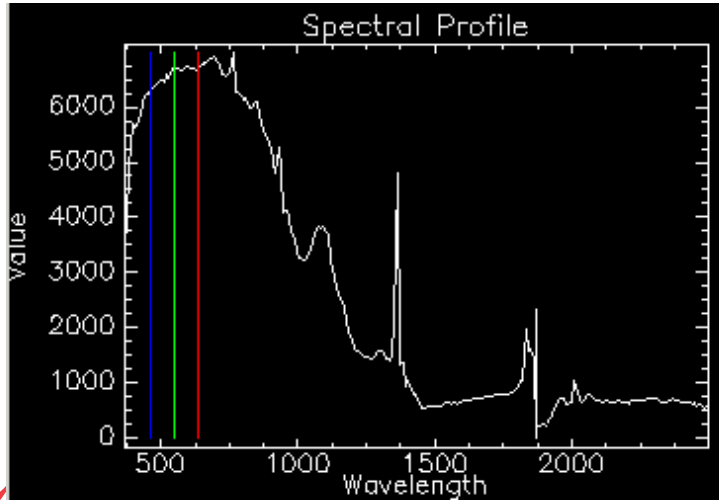
- The ATREM Algorithm
- Upgrades from the airborne campaign
- What do the filenames mean?
- Future plans
- Your feedback!

Problem: Surface pressure differences

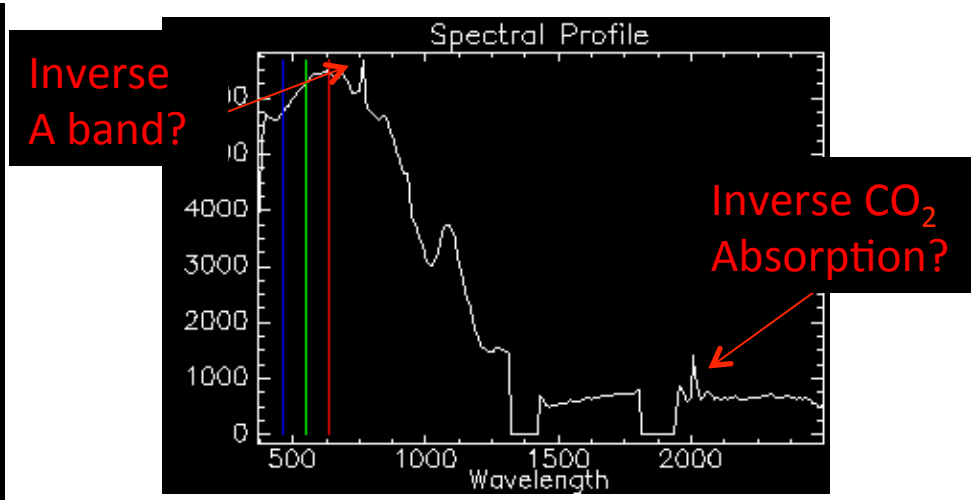
- A problem for flightlines with diverse altitudes
- A new challenge for orbital spectrometers



Uncorrected L2



Final L2 product (after residual suppression)



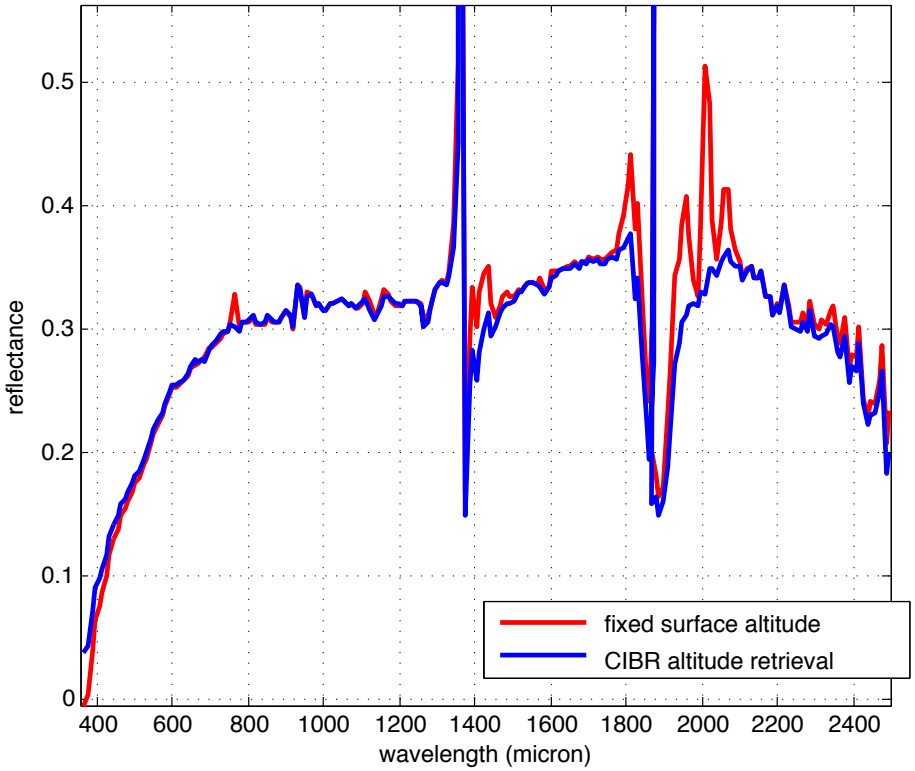
Solution: Retrieve Elevation

In advance

- Calculate scattering and transmittance values for 60 H_2O levels and 10 pressure levels

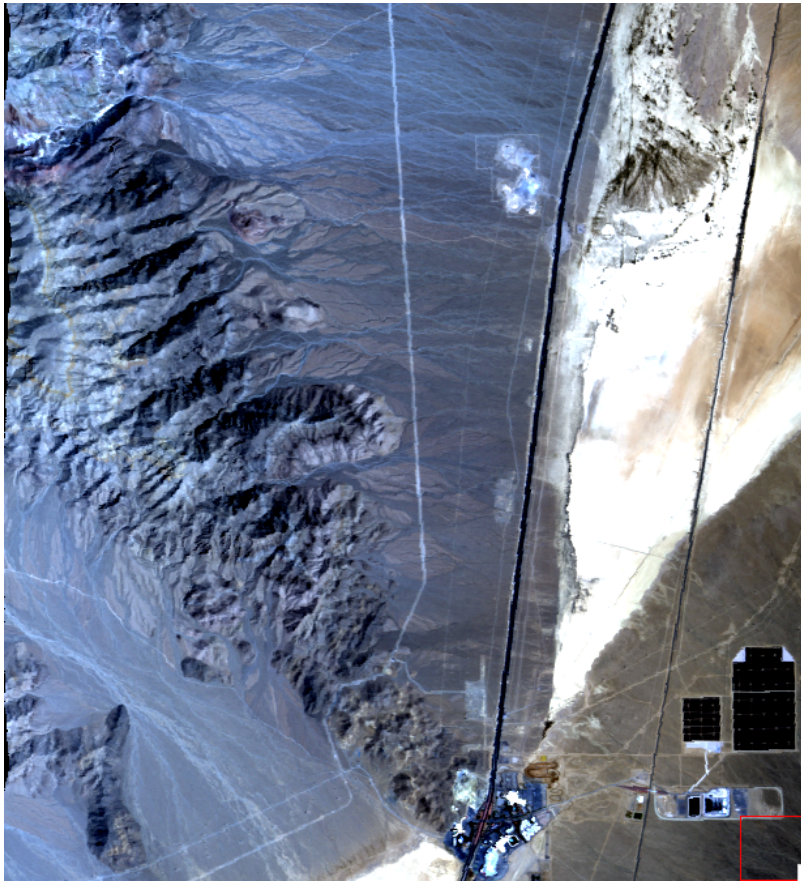
At runtime

- Retrieve H_2O from 0.94 µm band depth
- Retrieve pressure altitude from 0.76 µm oxygen A band depth
- Perform bilinear interpolation



Retrieved pressure altitudes

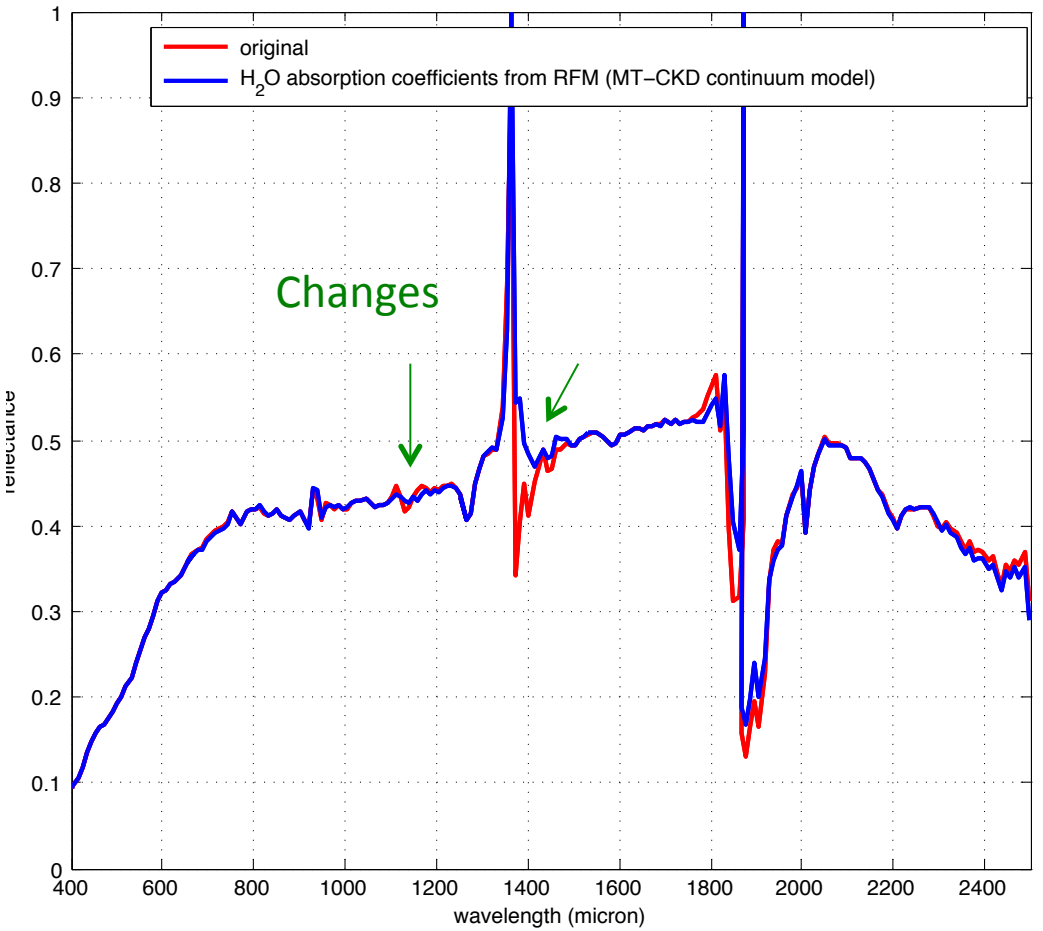
Original image (Ivanpah Playa)



Retrieved pressure altitudes

H_2O Line Lists and Continuum

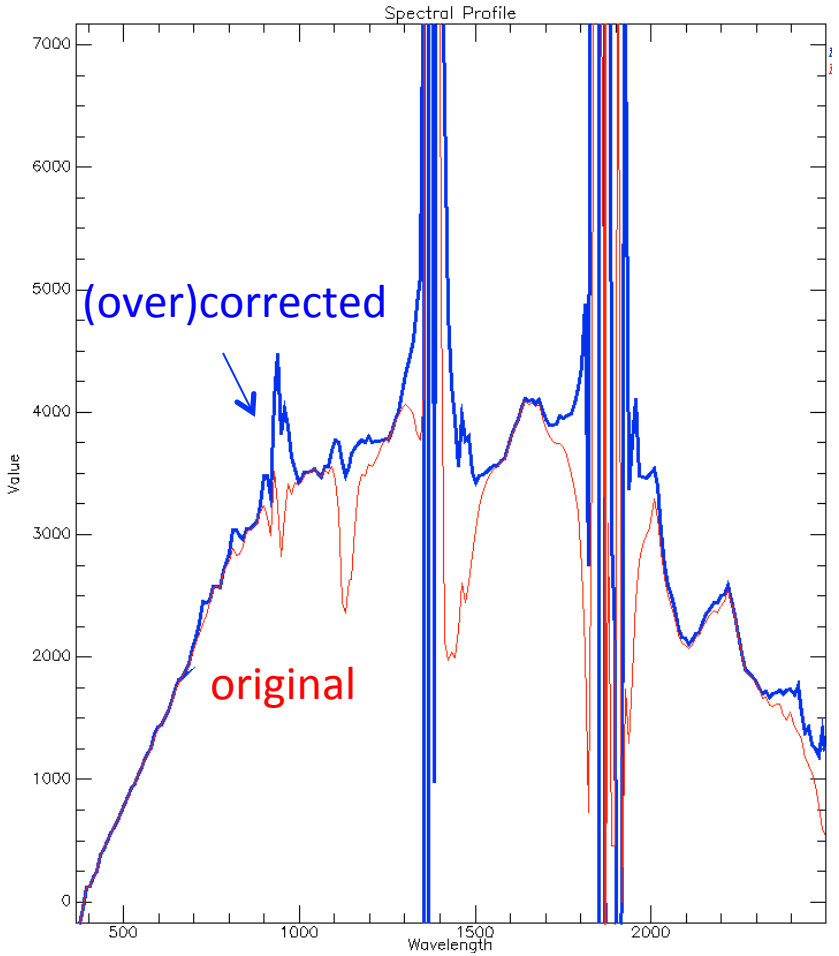
- Used H_2O gas absorption coefficients from HITRAN 2012
- Introduced AER MT_CKD Continuum
- Computed via Reference Forward Model (RFM) code



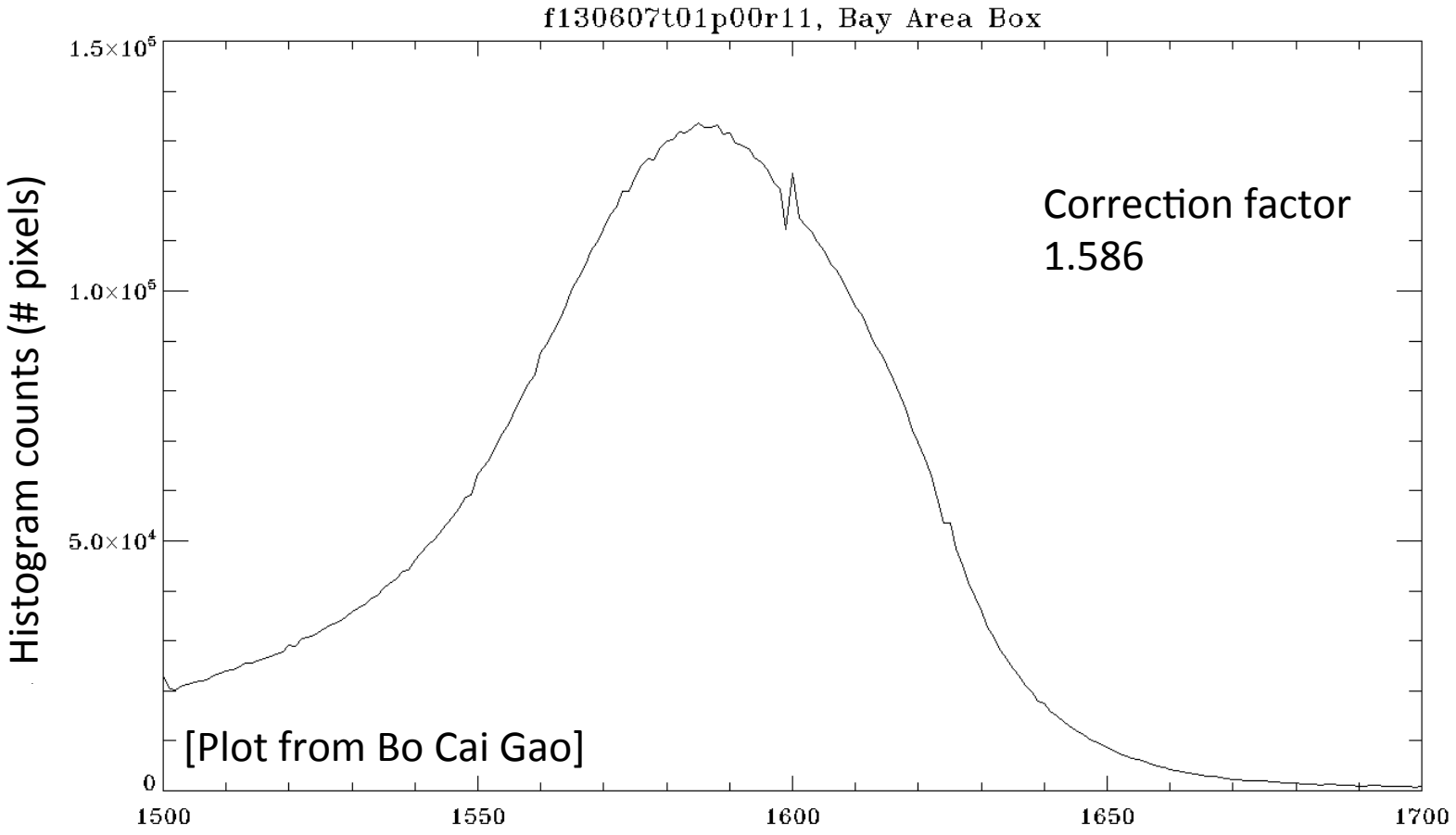
H_2O Band Strength Correction

Problem: discrepancy between calculated and observed H_2O band strengths

Solution: rescale gas absorption



H_2O Band Strength Correction



Agenda

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Filename interpretation

f130913t01p00r09rdn_e_sc01_ort_img	Calibrated radiance image
f130913t01p00r09refl_img	ATREM surface reflectance
f130522t01p00r12refl_elev_img	Retrieved Pressure Altitude (m)
f130522t01p00r12refl_h2o_vap_img	Retrieved Water Vapor (cm x 1000)
f130522t01p00r12refl_corr_img	Reflectance with residual suppression
f130522t01p00r12refl_corr_img.smth	residual suppression factors

Summary

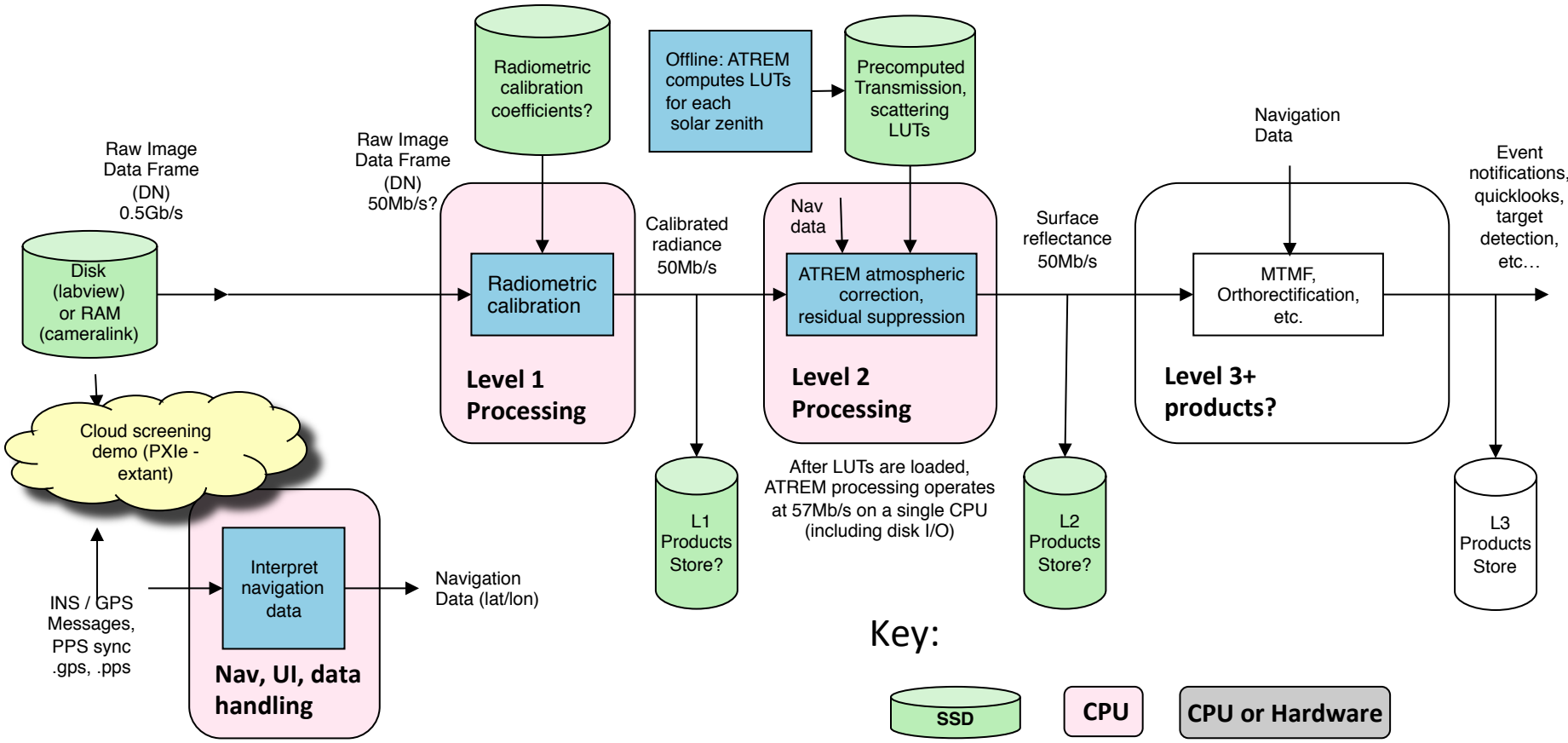
Original Orthorectified products

- ATREM
- Wavelength tuning
- Residual suppression

New Unorthorectified products

- ATREM
- Wavelength tuning
- Residual suppression
- Altitude retrieval
- H_2O corrections

Future: Portable pipelines can migrate onboard as needed



Questions / Feedback?