Vicarious CalVal of airborne hyperspectral data – results from CEOS Tuz Golu campaign

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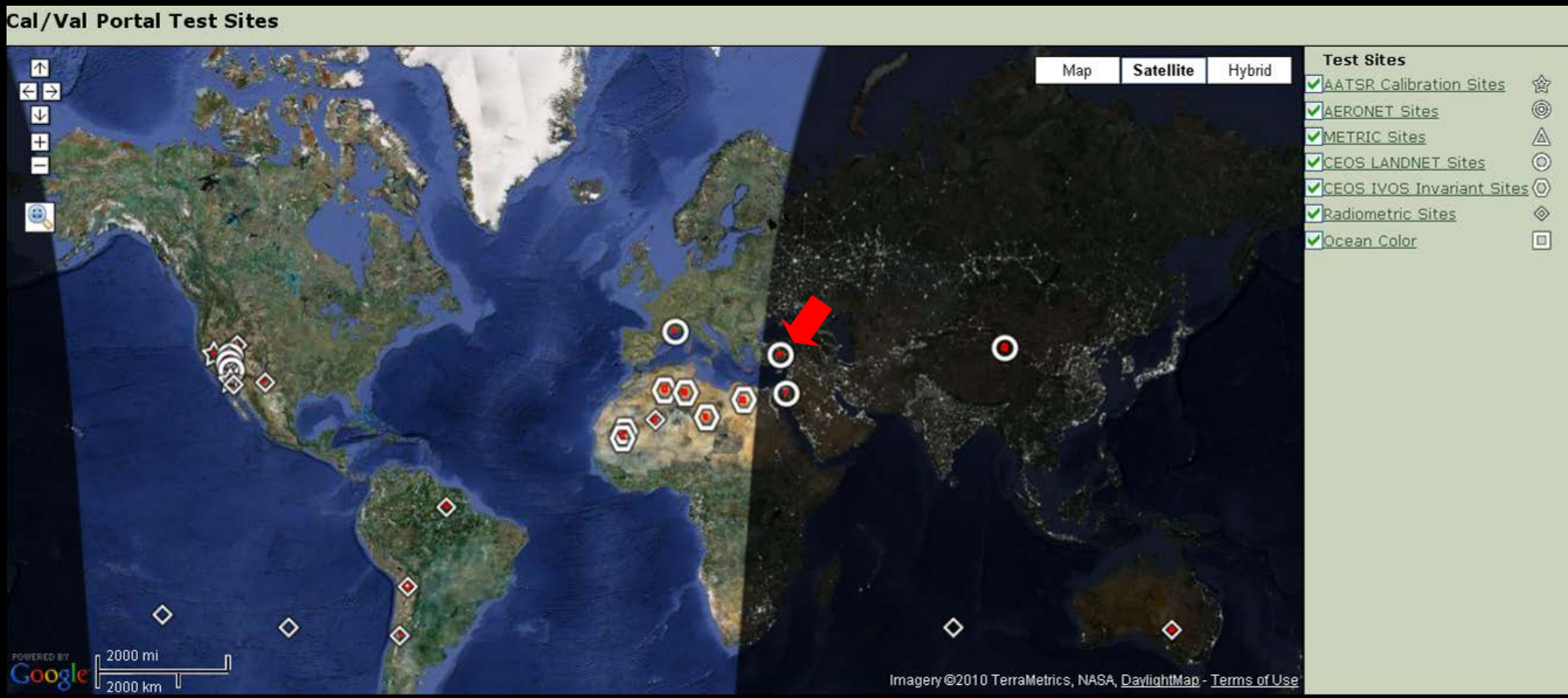
CEOS CalVal Sites



http://calvalportal.ceos.org

CEOS WGCV pilot – Comparison of techniques/instruments used for the vicarious calibration of Land surface imaging through a ground reference standard test site 2009

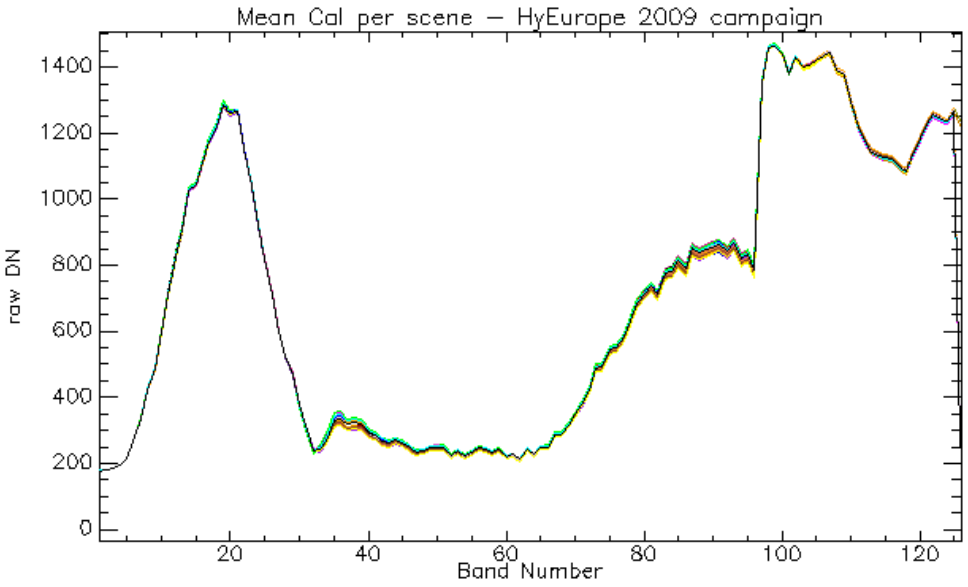
The Airborne HyMap Spectrometer

www.hyvista.com

Spectral Configuration			
Module	**Spectral range**	**Bandwidth across module**	**FWHM**
VIS	0.45 – 0.89 µm	15 – 16 nm	15 nm
NIR	0.89 – 1.35 µm	15 – 16 nm	15 nm
SWIR1	1.40 – 1.80 µm	15 – 16 nm	13 nm
SWIR2	1.95 – 2.48 µm	18 – 20 nm	17 nm

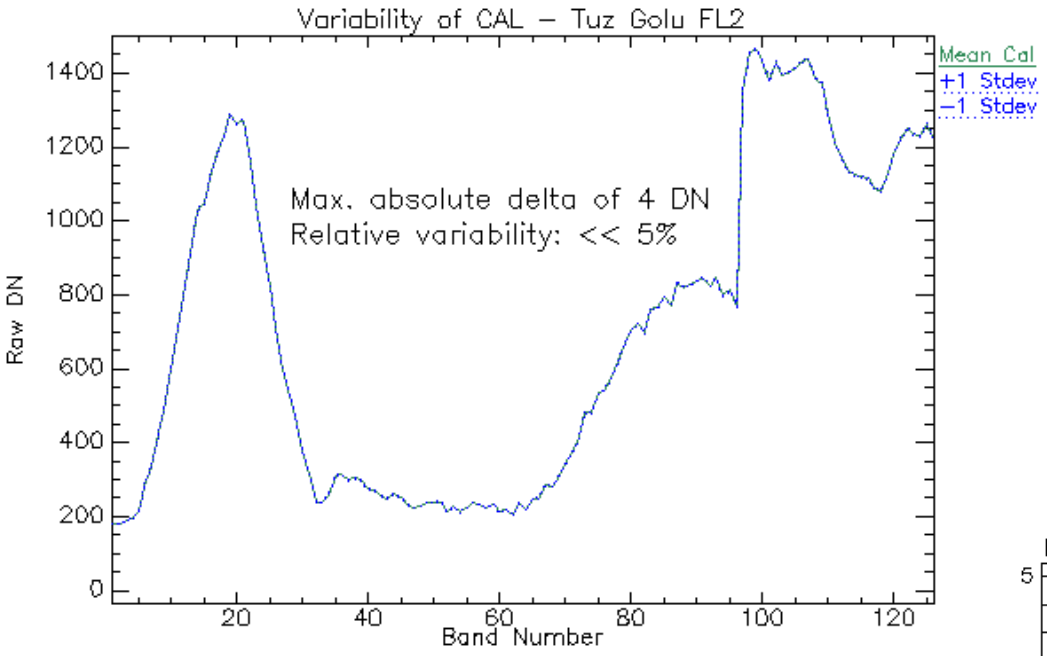
Spatial Configurations	
IFOV	2.5 mr along track 2.0 mr across track
FOV	61.3 degrees (512 pixels)
Swath	2.3 km at 5m IFOV (along track) 4.6 km at 10m IFOV (along track)

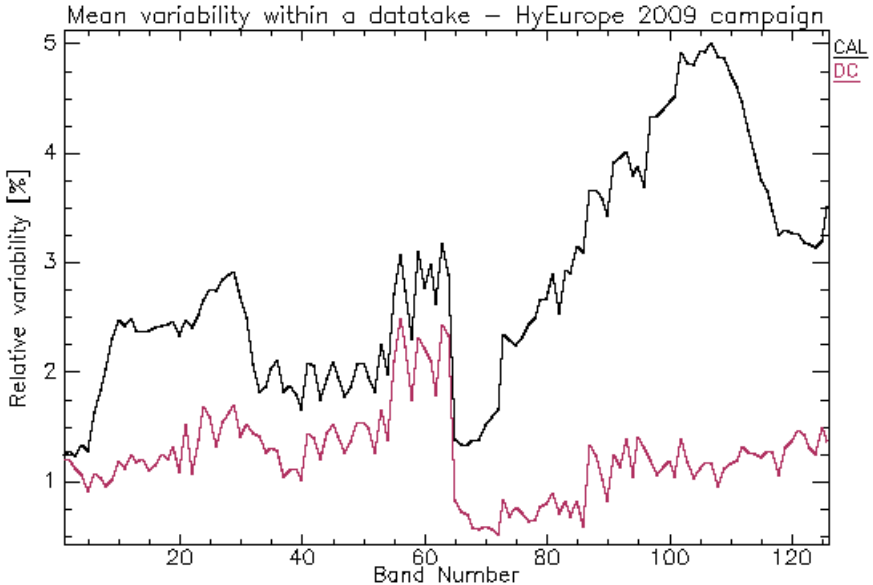
Stability within HyEurope 2009 campaign



Stability within campaign of ~ 100 flightlines

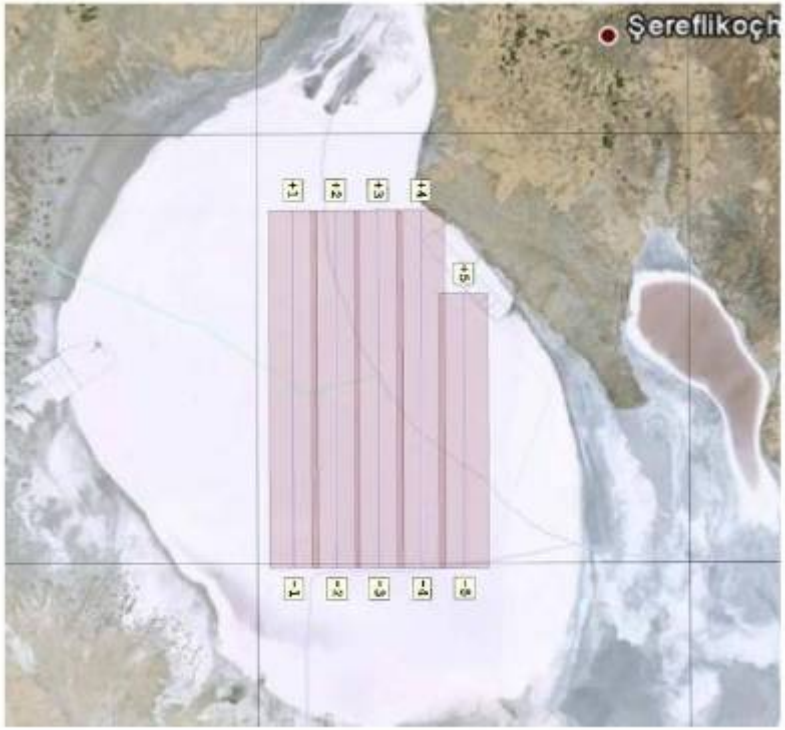
Stability within a single datatake





HyMap Data Acqusition, Sept. 1, 2009

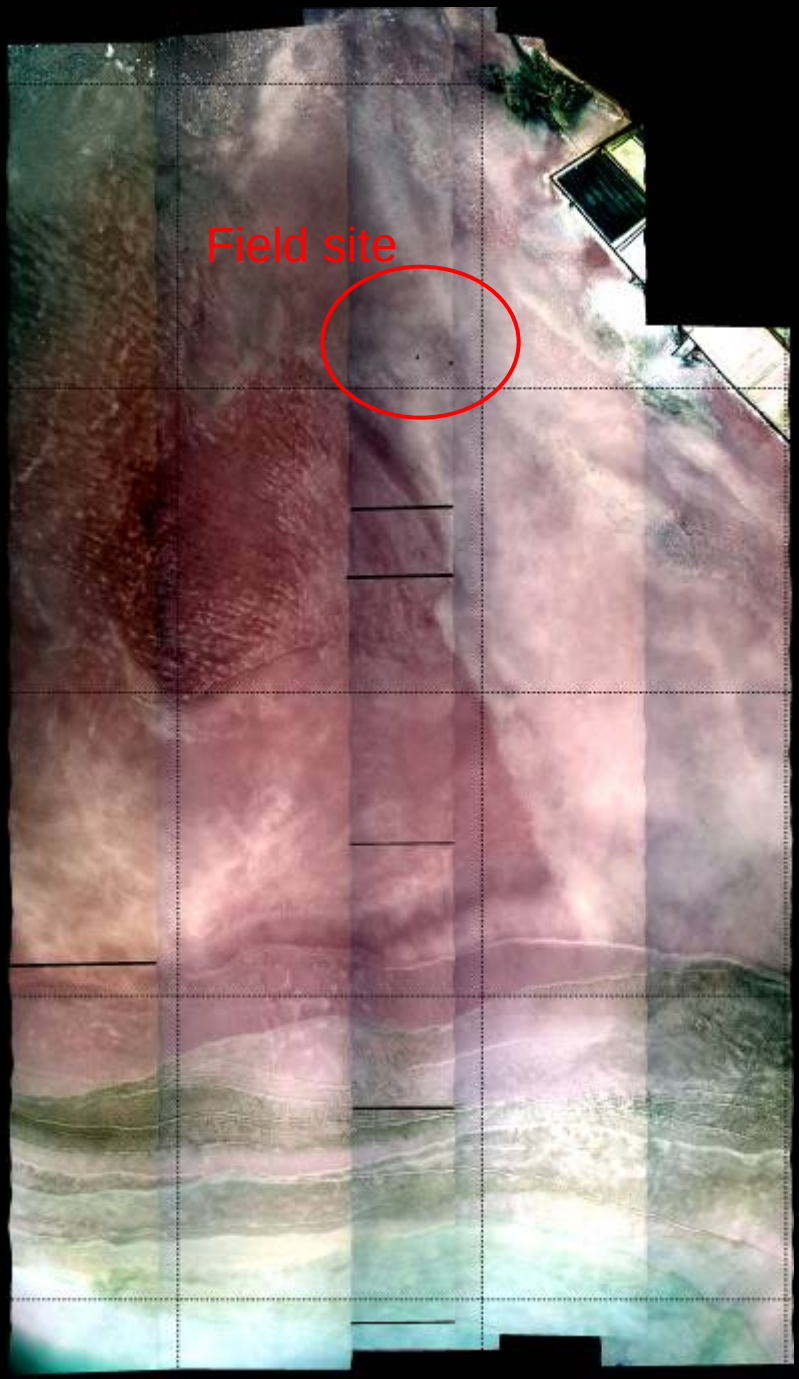
Line-#	Time (UTC)	Flight azimuth (0° =N, 180° =S)	Flight altitude (asl)	Solar zenith	Solar azimuth
1	8:54	359°	3600 m	23.9°	146.4°
2	9:14	0°	3600 m	21.8°	158.0°
3	8:46	179°	3600 m	24.9°	142.3°
4	9:04	179°	3600 m	22.7°	152.0°
5	8:35	0°	3600 m	26.4°	137.1°



Overflights conducted by DLR
(OpAiRS service)
http://www.opairs.aero

HyMap Data Processing

- Laboratory calibration and system correction (HyVista)
- Additional in-flight calibration for Tuz Golu data
  - Fine adjustment of spectral and radiometric calibration by DLR
  - Based on field spectra acquired by Tubitak Uzay during overflight
  - Additional check using field spectra measured during CEOS campaign by DLR
- Ortho-rectification to UTM grid using ORTHO software
- Atmospheric correction using ATCOR4 software



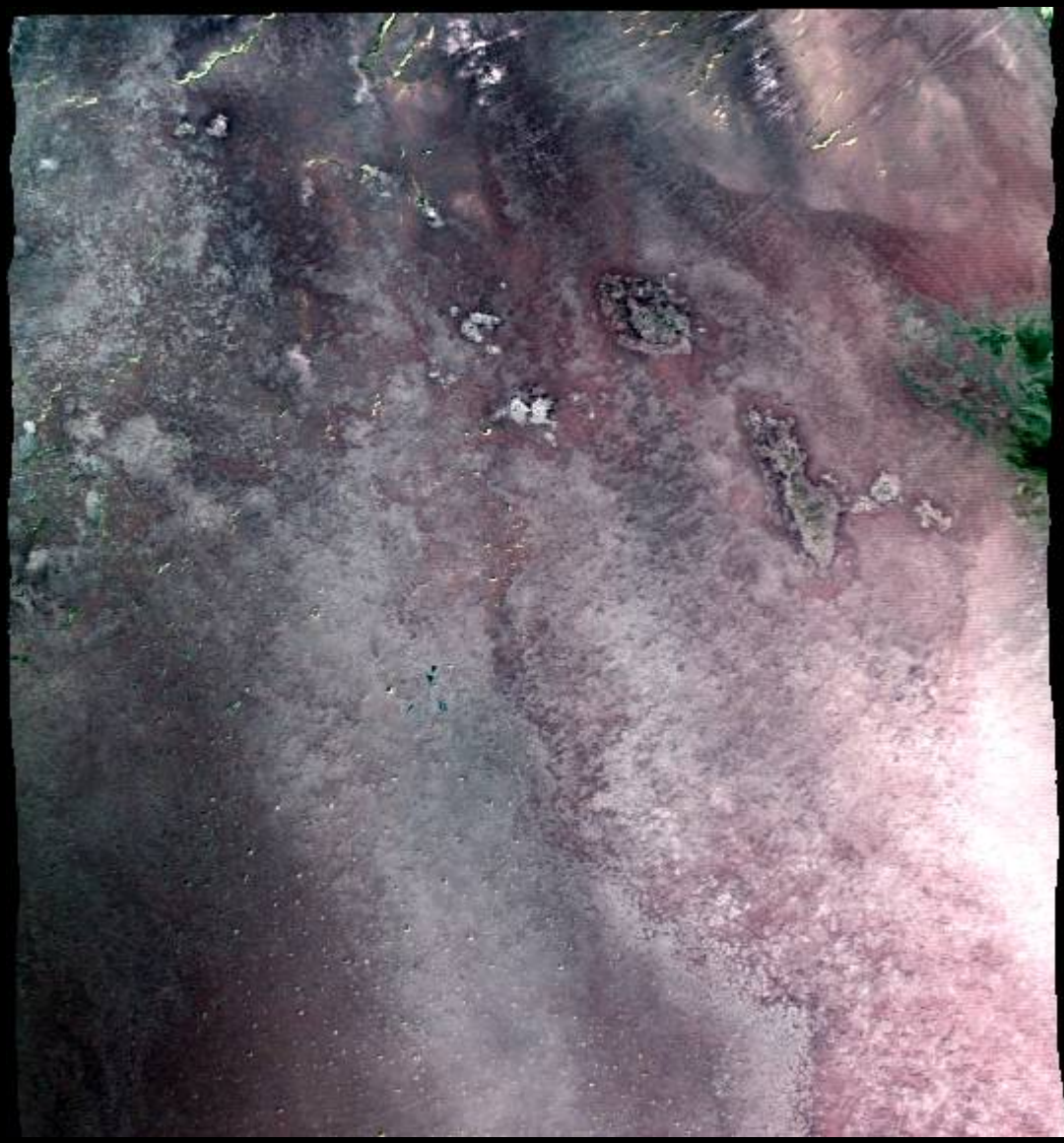
HyMap Imagery „Tuz Golu“

Mosaic of 5 ortho-rectified flightlines

- Calibrated at-sensor radiance,
  true color composit,
  nonlinear image stretching for visualization,
  no cross-track normalization

- Data drops in two flightlines
  (horizontal black bars)

- Dotted lines: UTM raster, 5km spacing



HyMap Imagery „Tuz Golu“

Details of FL2 (subset)

- Calibrated at-sensor radiance,
  true color composit,
  nonlinear image stretching for visualization,
  no cross-track normalization

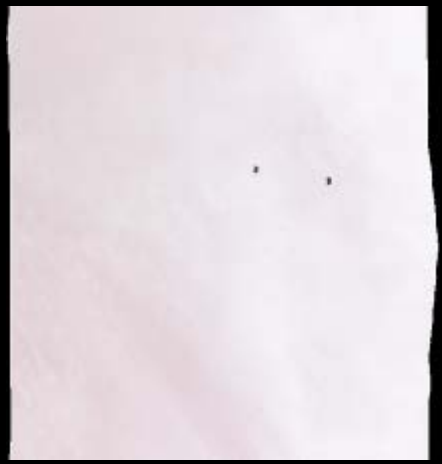
- 100% zoom, pixel size: 6m

HyMap Imagery „Tuz Golu“

Subset including the test area

- Calibrated at-sensor radiance,
  true color composit,
  nonlinear image stretching for visualization
  no cross-track normalization

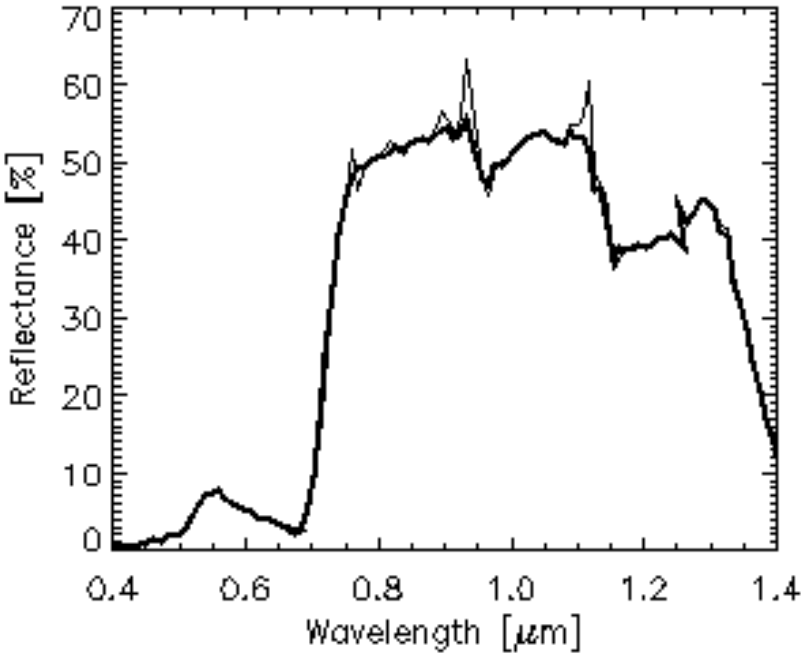
- 100% zoom, pixel size: 6m



Linear stretch (for comparison)

Spectral In-Flight Calibration using ATCOR

Approach: carry out multiple atmospheric corrections, thereby shift channel center wavelengths until reflectance spectrum shows minimum deviations with respect to smoothed spectrum



$$\chi^2 = \sum_{i=1}^{N} \left[\rho_i(\delta) - \rho_i^{smooth} \right]^2 = 0$$

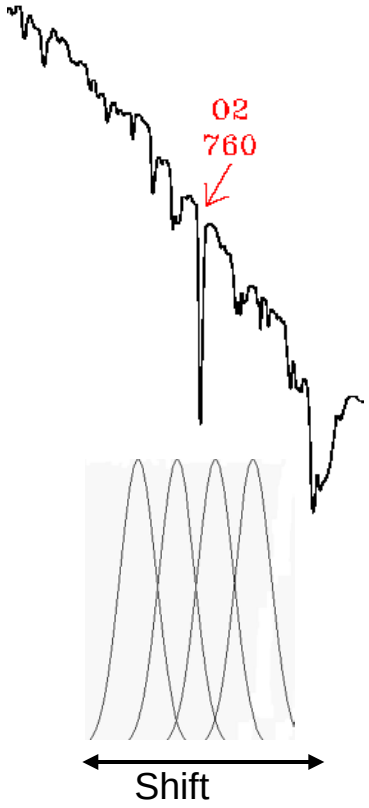
thin: before spectral calibration
thick: after calibration

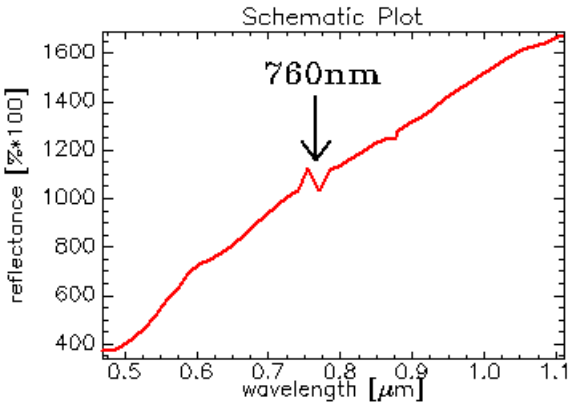
AVIRIS spectrum

Guanter, L., Richter, R., and J. Moreno (2006)

Spectral Calibration – Approach

Approach:
carry out **multiple atmospheric corrections**, thereby shift channel center wavelengths until reflectance spectrum shows minimum deviations with respect to smoothed spectrum





Resulting reflectance spectrum

Guanter, L., Richter, R., and J. Moreno (2006)

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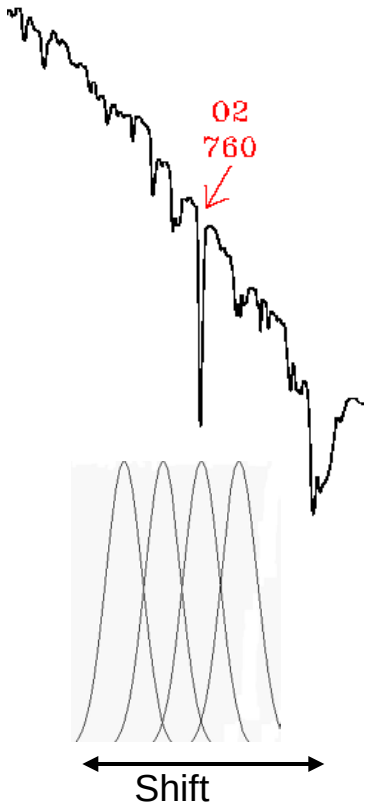
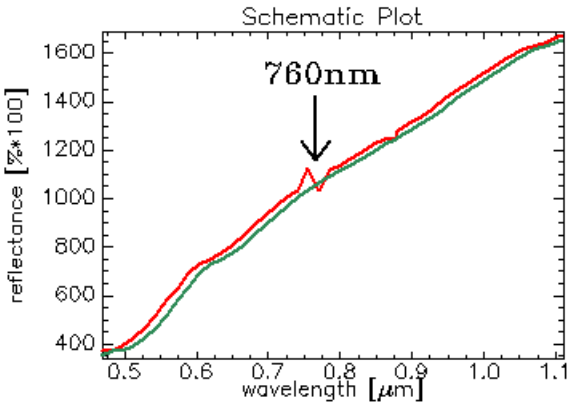




Resulting reflectance spectrum

Guanter, L., Richter, R., and J. Moreno (2006)

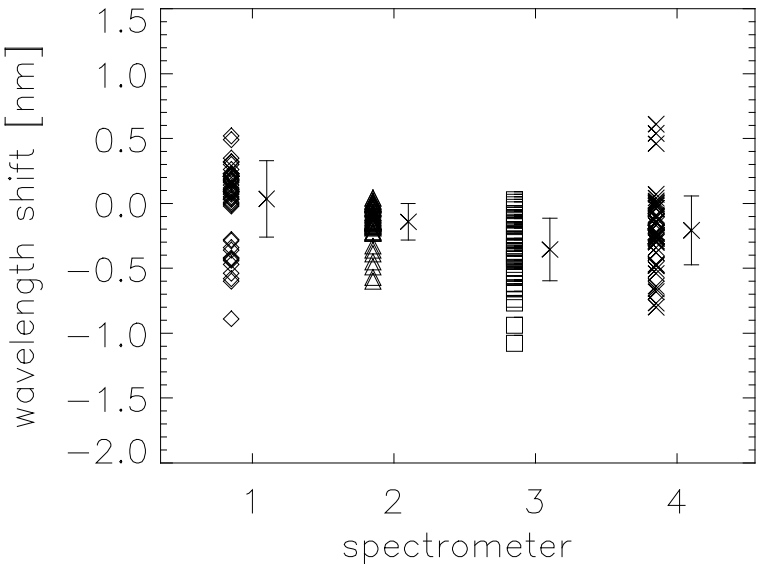
Spectral In-Flight Calibration: Results

- For Tuz Golu:

HyMap detector array	Estimated shift in [nm]
1	1.81
2	-0.49
3	-1.07
4	-0.90

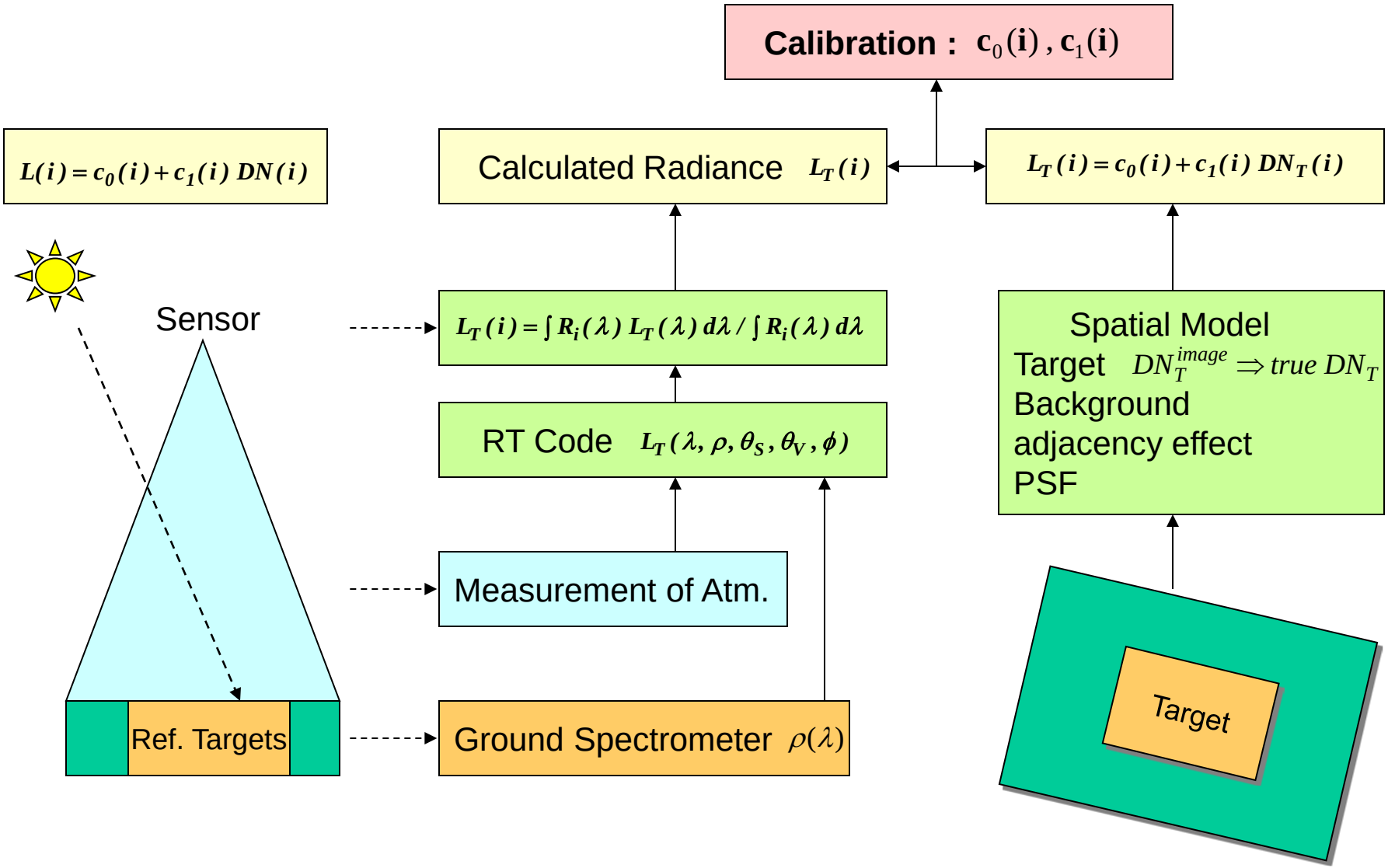
For comparison: HyMap FWHM: ~17 nm

Typical uncertainties related to the approach:
0.25 nm – 0.50 nm
(estimated using a Monte-Carlo study,
see EUFAR DJ2.1.2)



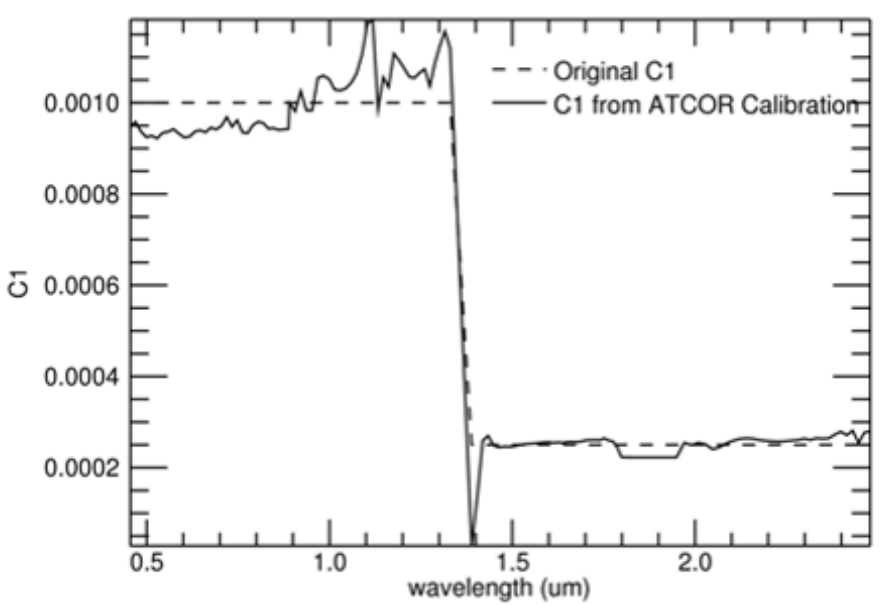
EUFAR DJ2.1.2 - Beekhuizen, J., M. Bachmann, E. Ben-Dor, J. Biesemans, M. Grant, G.B.M. Heuvelink, A. Hueni, M. Kneubuehler, E. de Miguel, A. Pimstein, E. Prado, I. Reusen, T. Ruhtz, M. Schaale 2009: Report on full error propagation concept. EUFAR FP7 JRA2 deliverable DJ2.1.2.

Radiometric In- Flight Calibration using ATCOR

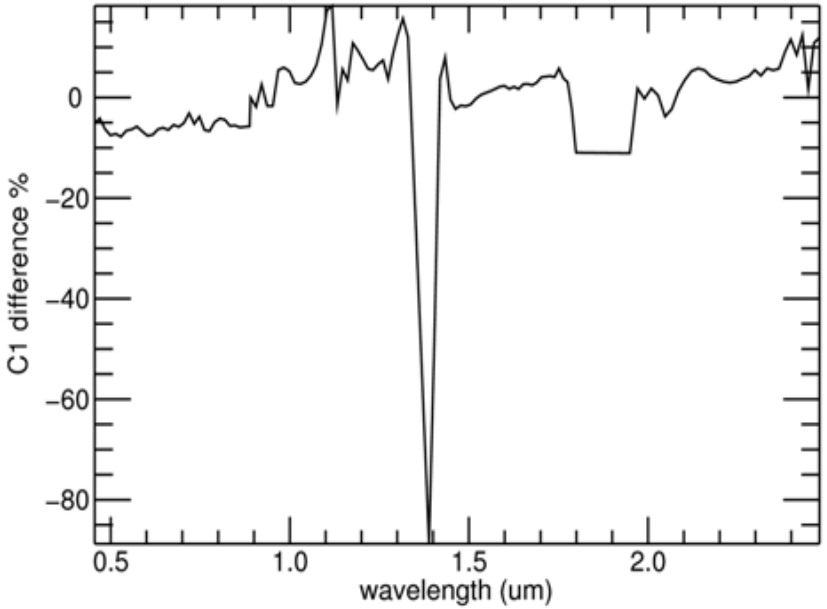


Measurement **Radiative Transfer Model** **Spatial Model**

Radiometric In-Flight Calibration: Results



Bandwise gain factors based on laboratory calibration and in-flight calibration conducted for Tuz Gölü.



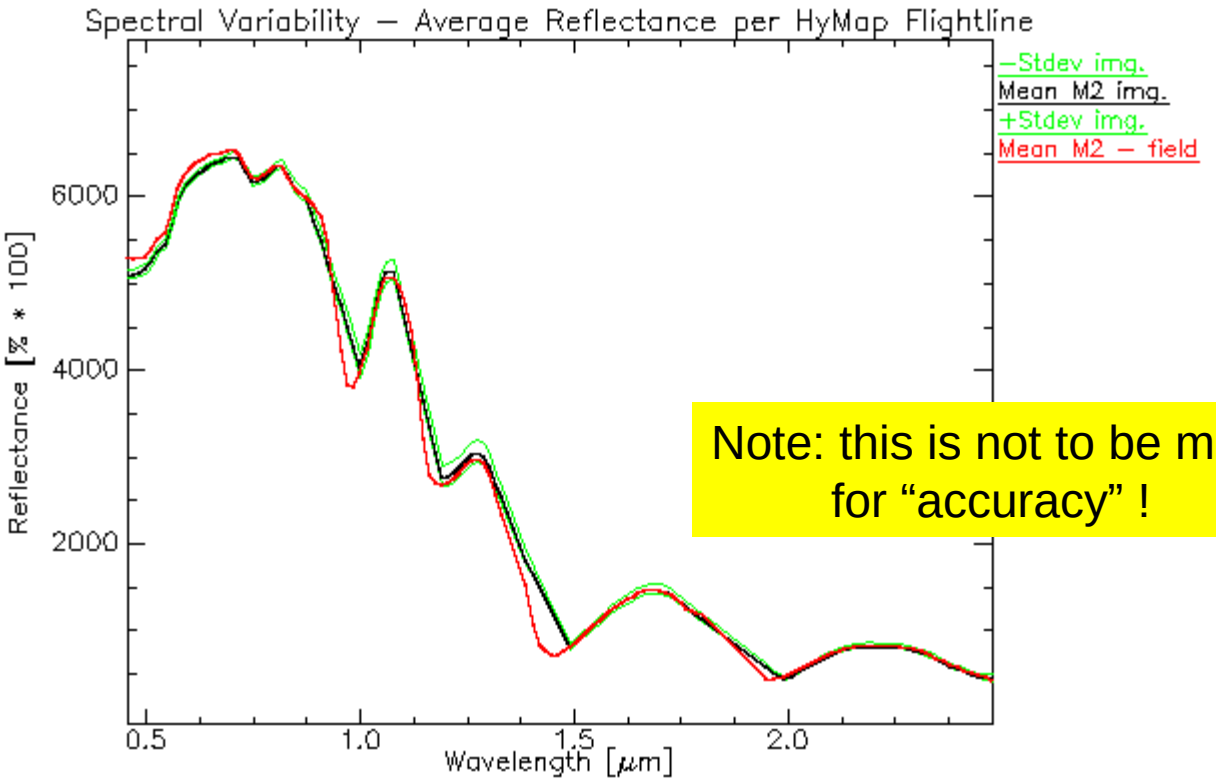
Relative changes in bandwise gain factors between laboratory and in-flight calibration

Typical uncertainties related the approach: ~ 5-10% in ground reflectance (EUFAR DJ2.1.2)

=> implicitly includes other sources of uncertainty such as field measurements, atmospheric correction, …

EUFAR DJ2.1.2 - Beekhuizen, J., M. Bachmann, E. Ben-Dor, J. Biesemans, M. Grant, G.B.M. Heuvelink, A. Hueni, M. Kneubuehler, E. de Miguel, A. Pimstein, E. Prado, I. Reusen, T. Ruhtz, M. Schaale 2009: Report on full error propagation concept. EUFAR FP7 JRA2 deliverable DJ2.1.2.

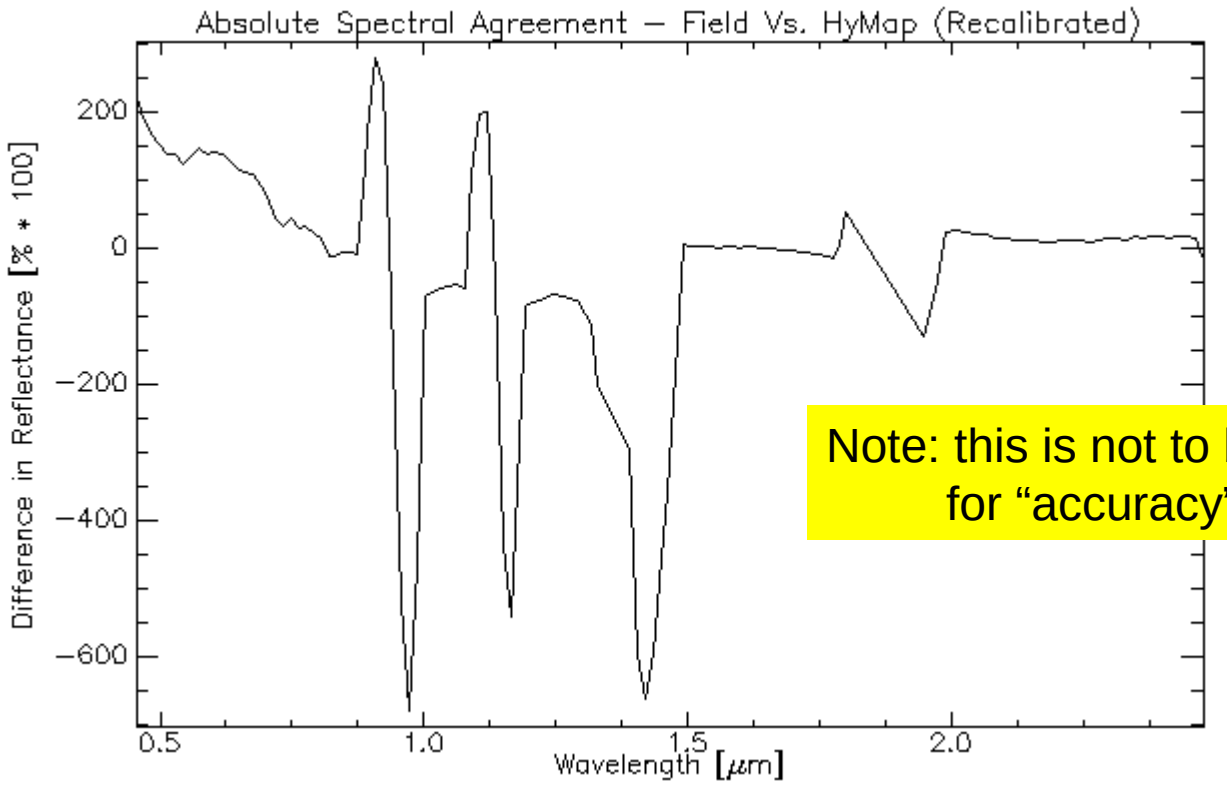
Radiometric In-Flight Calibration: Results



Note: this is not to be mistaken for “accuracy” !

Comparison of atmospheric corrected image spectra to field spectra acquired during overflight by Tubitak Uzay

Radiometric In-Flight Calibration: Results



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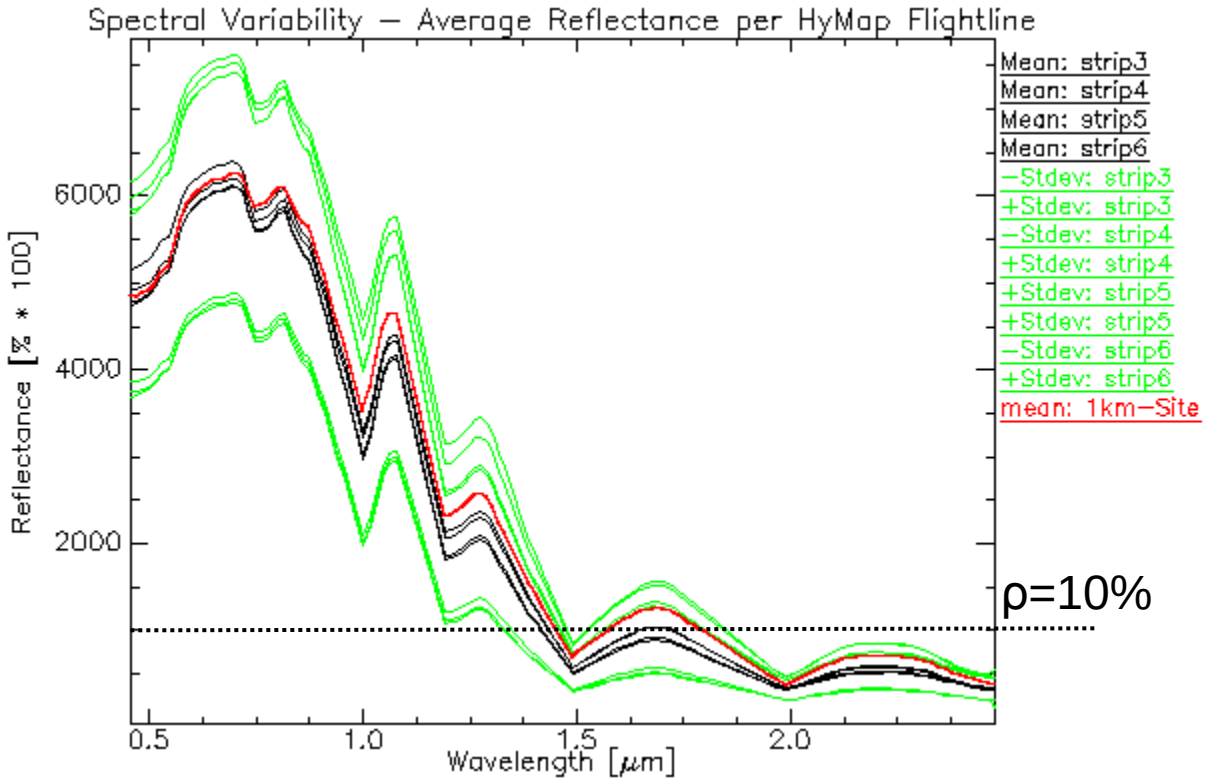
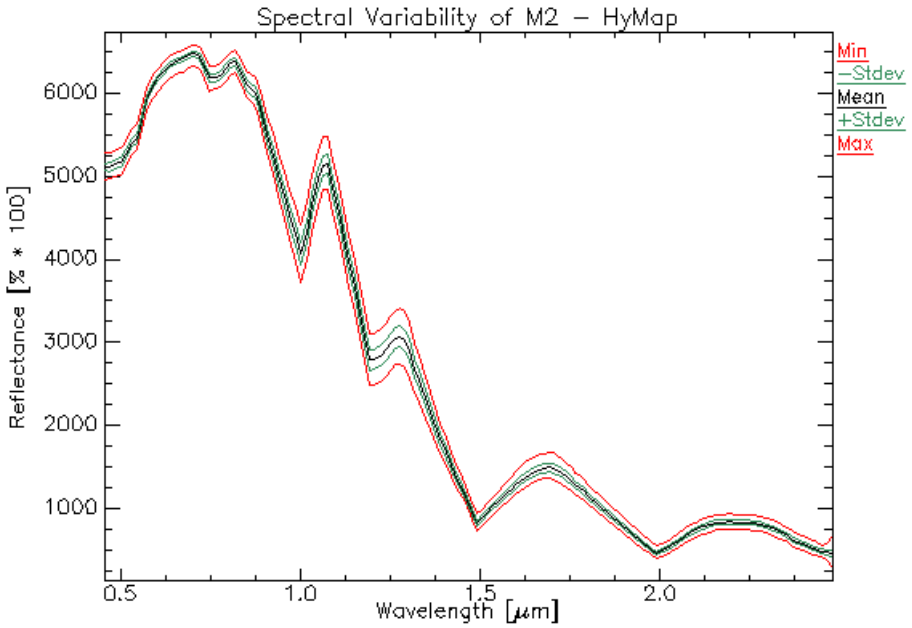
Comparison of atmospheric corrected image spectra to field spectra acquired during overflight by Tubitak Uzay

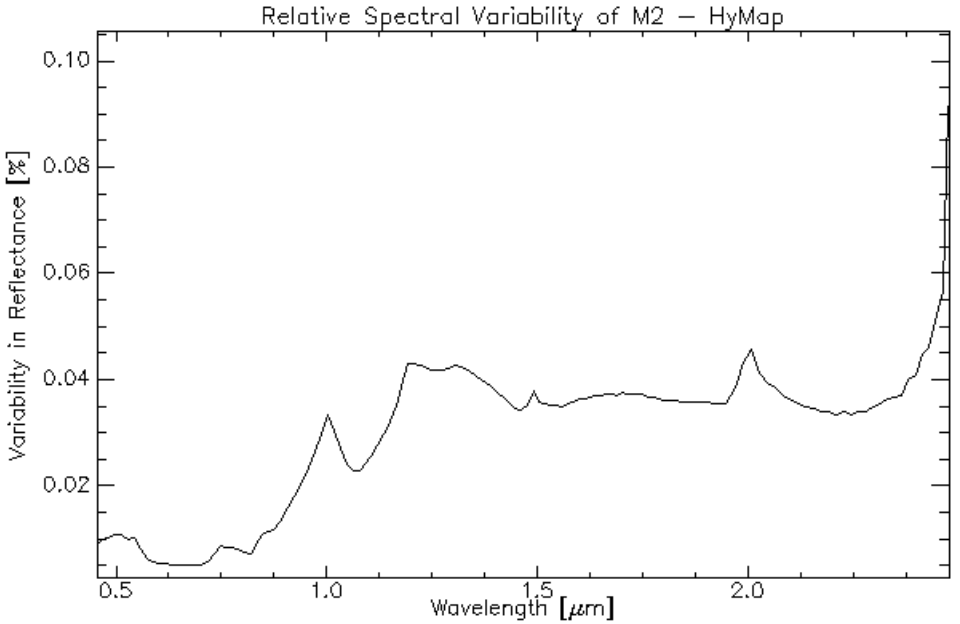
Site Characterization – overall – based on HyMap



Site Characterization – M2 – based on HyMap



Absolute spectral variability of M2



Relative spectral variability of M2

Area of M2: 300m x 100m

Summary

- Within pilot comparison HyMap data supporting ongoing field measurements & sat.-based CalVal activities
  - See upcoming NPL REPORT DQL OR (RES) 042
- Reflectance values derived by HyMap in good agreement with ground measurements (but no independent validation…)
- Site characteristics: bright in VNIR (ρ>50%), low reflectance in SWIR (ρ ~10%)
- Changing water content in the salt layer affecting reflectance behavior
  - Variability during day (evaporation)
  - Homogeneity in reflectance of smaller areas (300m x 100m) within 5% relative
  - Overall spatially “heterogeneous” – scale to be analyzed
- CEOS Key Comparison 2010 without airborne data acquisition
  - See *calvalportal.ceos.org*

Thank you for your attention!

Acknowledgements:

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CEOS Tuz Golu Campaign 2009