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Virtual Research Presentation Conference

Remote VSWIR Imaging Spectroscopy for Global Discovery and Conservation Science

Principal Investigator: David R. Thompson (382B)*
Co-Is: Gregory P. Asner (ASU), Philip Townsend (U. Wisconsin), Charles E. Miller (JPL 329G)*
Program: SURP

Assigned Presentation #RPC-034

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

Jet Propulsion Laboratory
California Institute of Technology

Tutorial Introduction

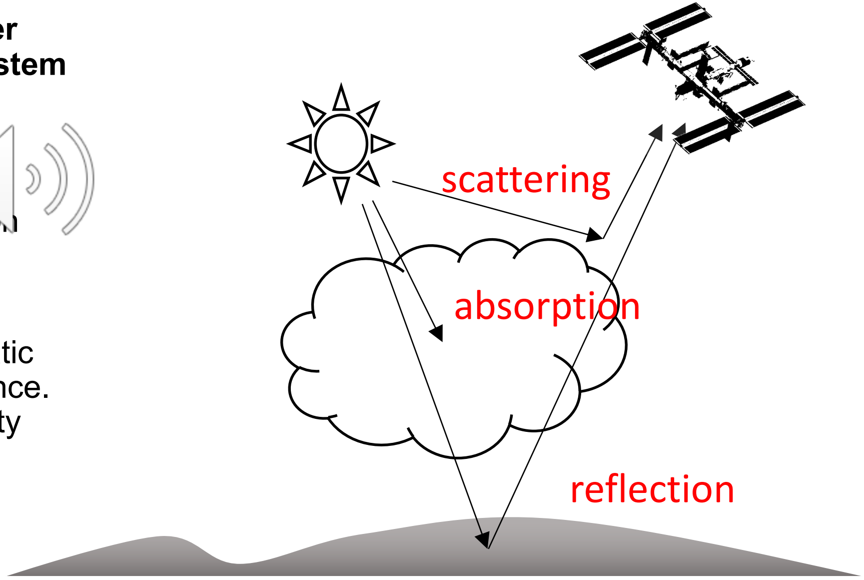
We are adapting the JPL VSWIR optimal estimation prototype, an advanced Bayesian imaging spectrometer atmospheric correction algorithm, for terrestrial ecosystem observations.

Specifically, we are:

1. Providing a standard, open source atmospheric correction that is easy to use by terrestrial ecologists, obviating sophisticated post-processing and commercial licenses.

2. Enabling dynamic aerosol and BRDF retrieval, for dramatic improvements in state of art ecosystem mapping performance. Optimal estimation methods have improved spectrum quality metrics by a factor of >7 on diverse validation datasets

3.Demonstrating formal uncertainty quantification and propagation which are traditionally lacking in imaging spectrometer atmospheric correction.



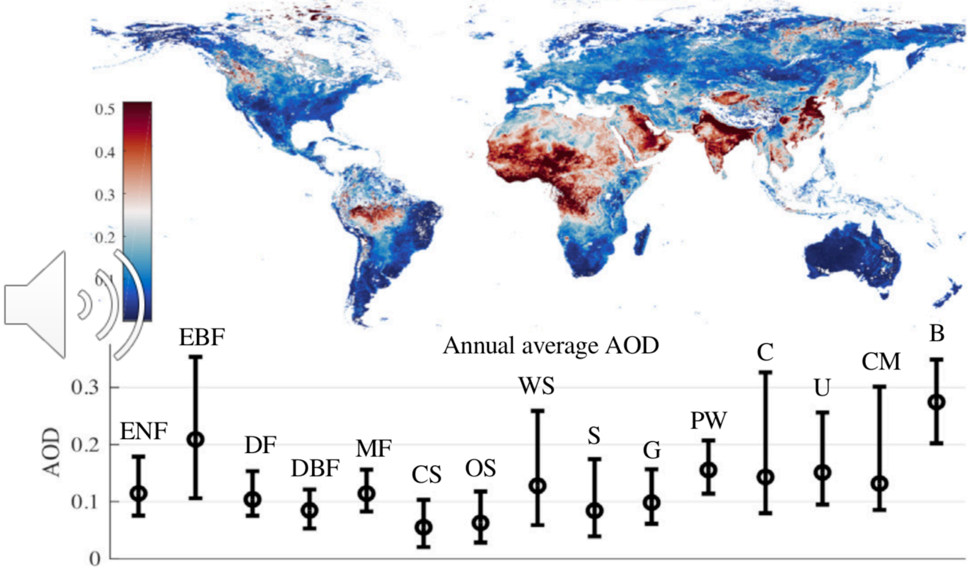
Problem Description

Remote Visible / ShortWave InfraRed (VSWIR) imaging spectrometers map spectral radiance from 380 - 2500 nm. Surface reflectance features in this interval reveal the chemistry and composition of Earth's terrestrial ecosystems.

Future global studies will challenge conventional algorithms, particularly atmospheric correction required to estimate surface ecosystem properties.

Rigorous algorithms developed at JPL offer a solution. Bayesian *Maximum A Posteriori* (MAP) optimization yields significant improvements in atmospheric correction accuracy for challenging atmospheres, and enables a rigorous treatment of measurement uncertainty.

Thompson et al, RSE 2019



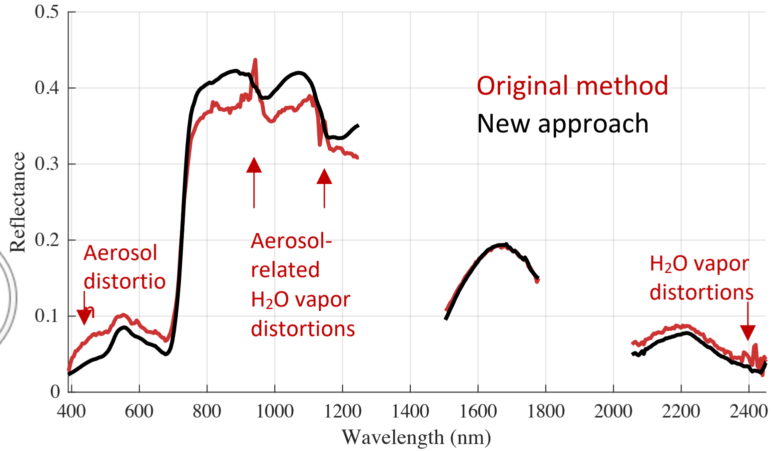
It will significantly advance the accuracy of the following Earth surface studies: (1) Historical AVIRIS-C, PRISM, AVIRIS-NG, and Hyperion archives; (2) reanalysis of data for CORAL, ABoVE, AVIRIS-NG India, and the HyspIRI precursor campaign; (3) upcoming sub-orbital and orbital investigations including recently-selected EVS-3 missions Delta-X and the designated "Surface Biology and Geology" (SBG) investigation.

Methodology

We will advance current retrieval methods with additional features that are important for terrestrial ecology.

1. **Topographical corrections** to account for illumination variability due to slope and horizon obscuration. Ecosystem trait estimates can be vulnerable to the balance between different levels of diffuse and direct solar illumination, making them particularly sensitive to such effects. A promising candidate approach by Soenen et al. (2005) uses readily-available geometric data.

Thompson et al, RSE 2019



2. Incorporate **Bidirectional Reflectance Distribution Function (BRDF) corrections and modeling,** since the multi-directional effects of tree canopies must be normalized to enable view-invariant estimation. BRDF corrections range from simple vector-normalization (Townsend et al.) to parametric strategies (Jensen et al., 2018) and model-based approaches (e.g. Ross-Li kernels).

3. **Validate** the combined atmospheric correction and topography/BRDF adjustments together with downstream algorithms using standard cross-validation methods.

Results

We have accomplished all the project objectives slated for the first project year**:**

- Coallate relevant Airborne Data for testing - The JPL team has identified airborne datasets to use as initial test cases.
- Face to Face technical exchange and ASU seminar - David R. Thompson visited ASU in October 2019 where he gave a seminar on JPL imaging spectroscopy.
- Demonstration of baseline retrievals using uncorrected data – ASU PhD student Megs Seeley has received and successfully run the existing radiative transfer models and atmospheric inversion algorithms.

Next steps:

- Incorporate vector-normalization BRDF corrections. Submit to the open-source repository, and evaluate vs. baseline.
- Evaluate topographic correction for use by the EMIT Mission
- Incorporate model-based BRDF corrections. Submit to the open-source repository, and compare with the alternatives.
- Comprehensive evaluation of BRDF- and Topography corrected data across a wide range of different ecosystems and view/solar geometries.
- Publication using empirical validation with held-out field data.

Publications and References

[1] Jensen, D., M. Simard, D. R. Thompson, K. Cavanaugh. Imaging Spectroscopy BRDF Correction for Mapping Louisiana's Coastal Ecosystems. *Transactions on Geoscience and Remote Sensing*, 56 (3), 2018.

[2] Soenen, S. A., Peddle, D. R., & Coburn, C. A., 2005. SCS+ C: A modified sun-canopy-sensor topographic correction in forested terrain. *IEEE Transactions on geoscience and remote sensing*, *43*(9), 2148-2159.

[3] Thompson, D. R., K. N. Babu, A. Braverman, M. Eastwood, R. O. Green, J. Hobbs, J. B. Jewell, M. Mishra, A. Mathur, V. Natraj, F. C. Seidel, P. Townsend, M. Turmon, 2019. Optimal Estimation of Spectral Surface Reflectance in Challenging Atmospheres, Remote Sensing of Environment, 232, 111258.

[4] Thompson, D. R., K. Cawse-Nicholson, Z. Erickson, C. Fichot, C. Frankenberg, B-C. Gao, M. M. Gierach, R. O. Green, D. Jensen, V. Natraj, A. Thompson, 2019. A unified approach to estimate land and water reflectances with uncertainties for coastal imaging spectroscopy, *Remote Sensing of Environment* 231, 111198, https://doi.org/10.1016/j.rse.2019.05.017

[5] Thompson, D. R., V. Natraj, R. O. Green, M. Helmlinger, B.-C. Gao, and M. L. Eastwood, 2018. Optimal Estimation for Imaging Spectrometer Atmospheric Correction. *Remote Sensing of Environment* 216, p. 355-373.