Principle Component Analysis of IASI spectra with a focus on Non-uniform Scene Effects on the ILS

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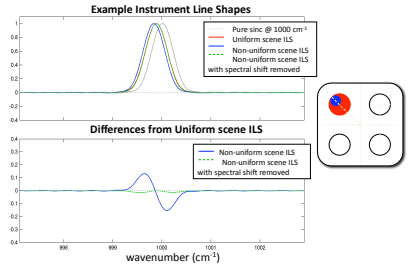
Summary

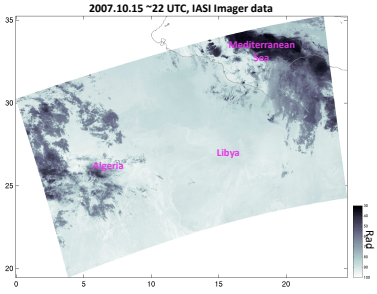
- Principle Component Analysis (PCA) is a useful tool for identifying and characterizing sensor characteristics. This investigation focuses on the effects of scene non-uniformity on the ILS.
- Scene non-uniformity within the IASI footprints manifests primarily in spectral shift artifacts, and these are found to be largely characterized by a single PC/eigenvector when using dependent set PCA.
- Preliminary results suggest that spectra reconstructed with this "spectral shift" PC excluded have a large portion of the non-uniform scene ILS effects removed. For the example granule shown here, ±30 ppm shifts are reduced to ±4 ppm.
- More work needs to be done to study the accuracy, robustness, and computational efficiency of this correction approach, including (a) the use of synthetic principle components, (b) comparison with physics-based corrections, and (c) the impact of the corrected data on retrievals.

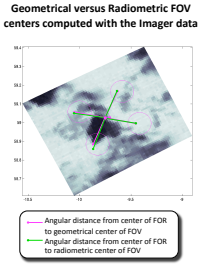
Simulated impact of spatially non-uniform scenes on the Instrument Line Shape (ILS)

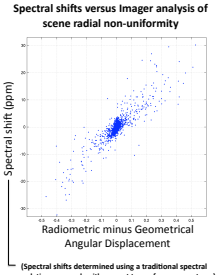


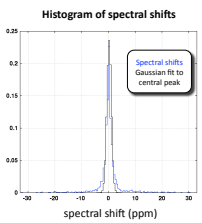
The primary effect of a non-uniform scene on the ILS is a spectral shift; ILS *shape* effects are secondary.

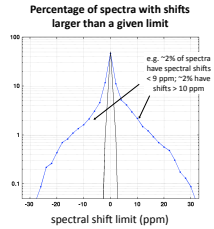
Frequency and Magnitude of the Effects











The spectral shifts, which correlate well with analysis of the imager data, are as large as +/- 30 ppm for this typical granule.

PCA of IASI Spectra

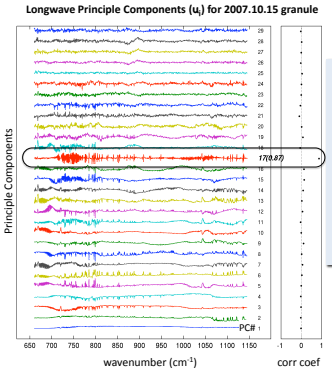
Y = *N* columns of differences from the mean spectrum, **y−<y>**

Singular Value Decomposition gives **U**, Λ, and **V** such that $\mathbf{Y} = \mathbf{U}\Lambda\mathbf{V}^T$ where **D** is diagonal and $\mathbf{U}^T\mathbf{U} = \mathbf{V}^T\mathbf{V} = \mathbf{I}$

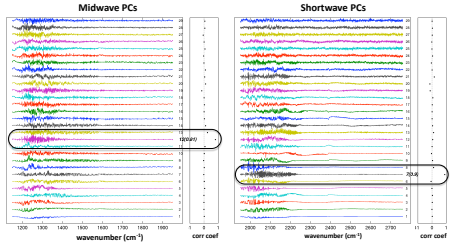
The j^{th} spectrum $\mathbf{y}_j$ can then be reconstructed as a sum of vectors (components) $\mathbf{u}_i$ with coefficients $\mathbf{c}_{ij} = \lambda_i \mathbf{v}_{ij}^T = \mathbf{U}^T(\mathbf{y}_j - \langle \mathbf{y} \rangle)$:

$$\mathbf{y}_j = \langle \mathbf{y} \rangle + \sum_i \mathbf{c}_{ij}\,\mathbf{u}_i$$

Considerations:
- **The sample size**
- **Dependent vs. Independent set PCs**
- **Noise normalization (*y*/*NEDN* vs. *y*)**
- **The number of PCs to use in the reconstructions**
- **Entire spectrum or band by band**

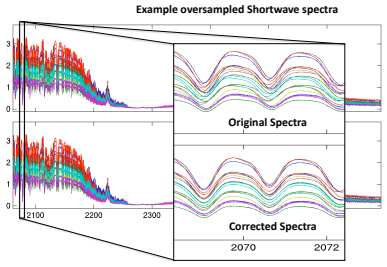


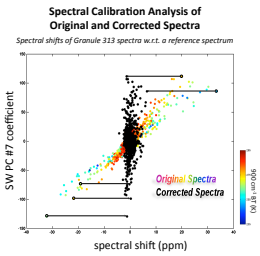
For each spectral band, individual PCs are found to have high correlation with a pure spectral shift signature, and to contain the primary signature associated with non-uniform scene ILS effects.

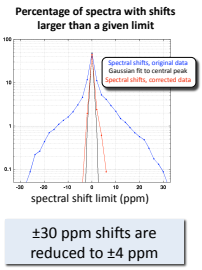


Non-uniform scene ILS corrections

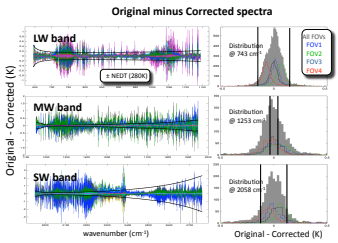
Involves reconstruction of the spectra with the "spectral shift" PC coefficients set to zero.



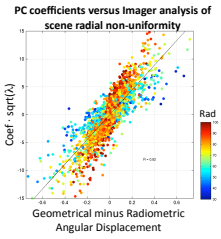


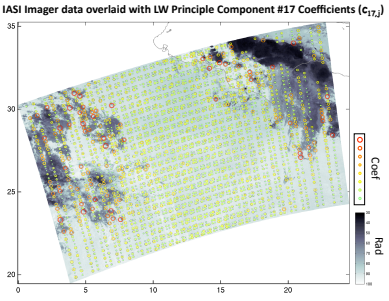


±30 ppm shifts are reduced to ±4 ppm



The coefficients of the "spectral shift" component also display the spatial characteristics associated with non-uniform ILS effects.





International TOVS Study Conference, 16th, ITSC-16, Angra dos Reis, Brazil, 7-13 May 2008. Madison, WI, University of Wisconsin-Madison, Space Science and Engineering Center, Cooperative Institute for Meteorological Satellite Studies, 2008.