P 2.38

GIFTS Far Field Diffraction and Focal Plane Misalignment Analysis

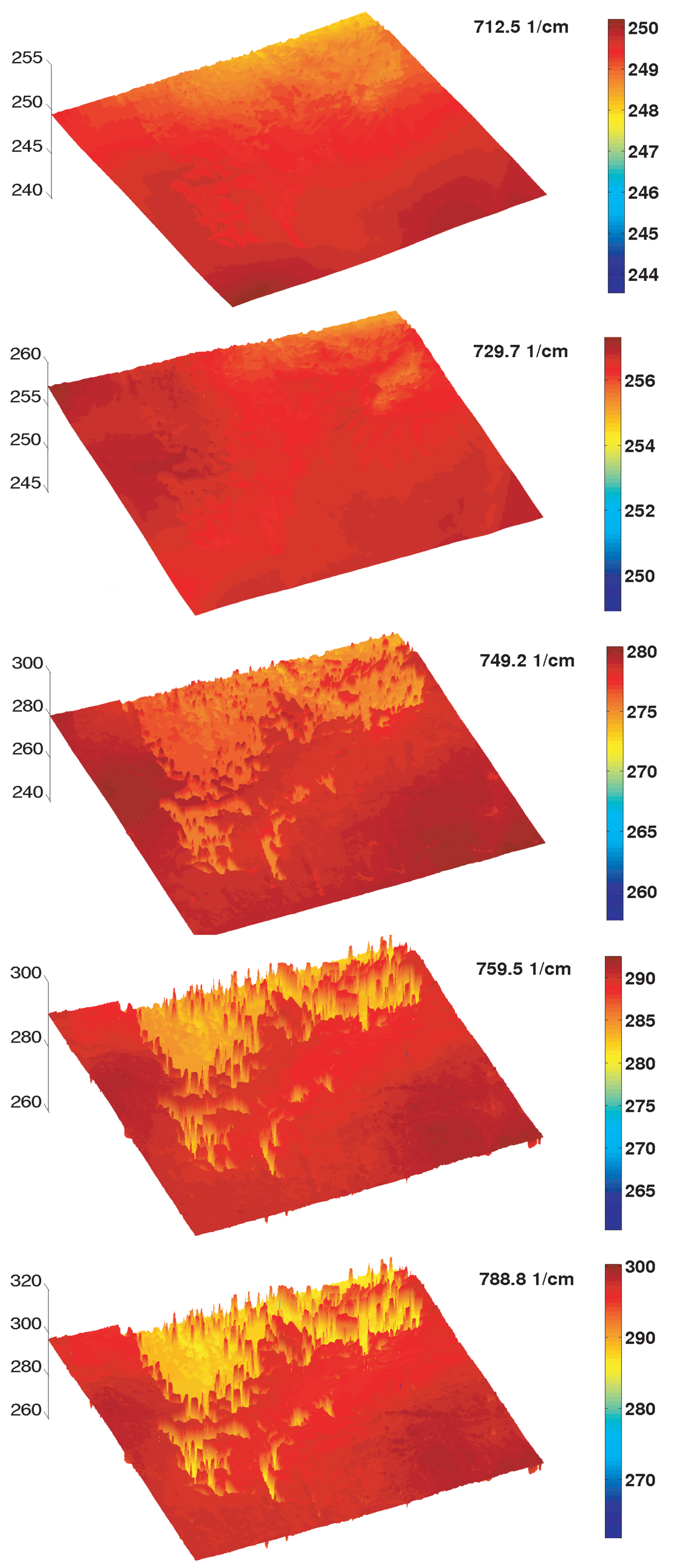
Erik R. Olson*, Robert O. Knuteson, Hank Revercomb, Jun Li, Hung-Lung Huang

Space Science and Engineering Center, University of Wisconsin–Madison

Purpose

The focus of this work is to identify how diffraction effects and focal plane misalignments will affect the data from the GIFTS instrument.

Test Data

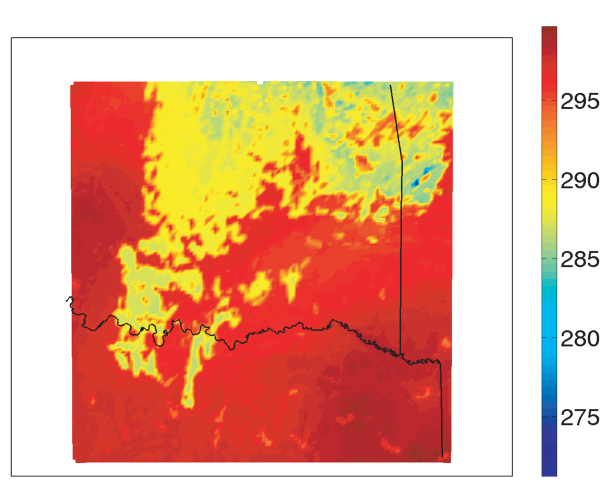


GIFTS simulated data was created at 1.33-km resolution for the study of diffraction and misalignment effects. The MM5 model was used to recreate the atmospheric conditions during the International H2O Project (IHOP). Top of the atmosphere radiances at 1.33-km resolution are then produced by the GIFTS fast model.

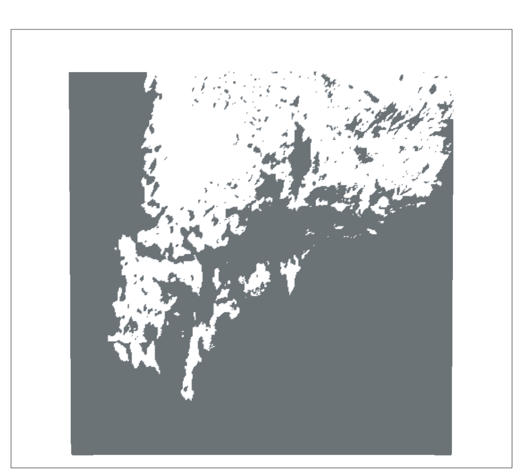
Left: Plots of the test case data for wavenumbers with wieghing functions that peak at successively lower altitudes.

Right:

A 4-km resolution control case was produced by averaging a 3 by 3 array of these radiances.



Below is a plot of the cloud location in white, with grey representing clear.

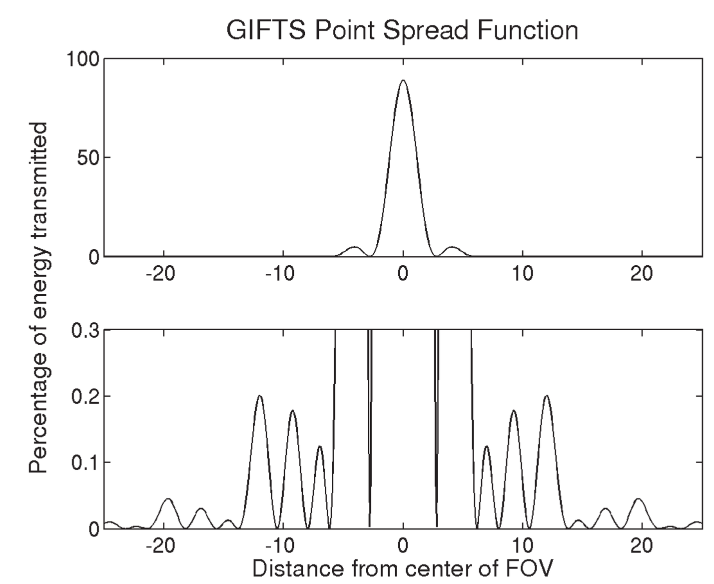


Diffraction

Large differences in emitted radiances from adjacent areas can vary greatly due to clouds or surface changes. These areas of large gradients can exacerbate the small contributions from areas outside the specified FOV. The most susceptible part of the GIFTS spectra to problems with diffraction are areas with longer wavelength (greater diffraction) and low atmospheric absorption (large temperature gradients).

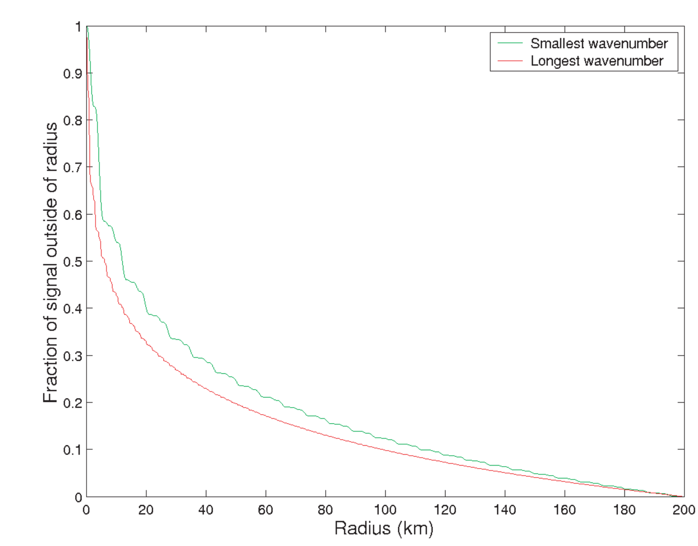
$$PSF = \frac{1}{1-\varepsilon}\left\{\left(\frac{2\ J_1\left[1,\pi rd/\lambda h\right]}{\pi rd/\lambda h}\right)-\left(\frac{2\varepsilon^2\ J_1\left[1,\pi\varepsilon rd/\lambda h\right]}{\pi\varepsilon rd/\lambda h}\right)\right\}^2$$

λ is the wavelength, d is the telescope diameter, ε is the central obscuration diameter ratio, r is the radial distance from the FOV center to the edge, J_1 is a first-order Bessel function, and h is the altitude of the instrument orbit.

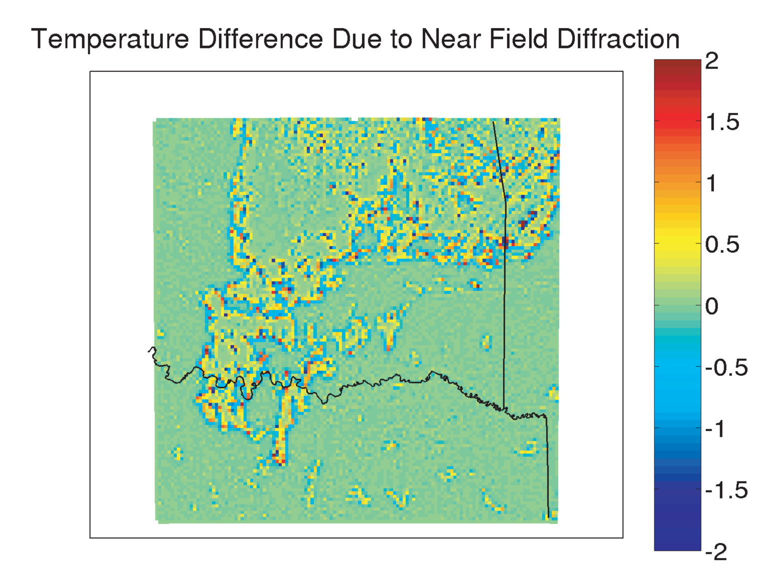


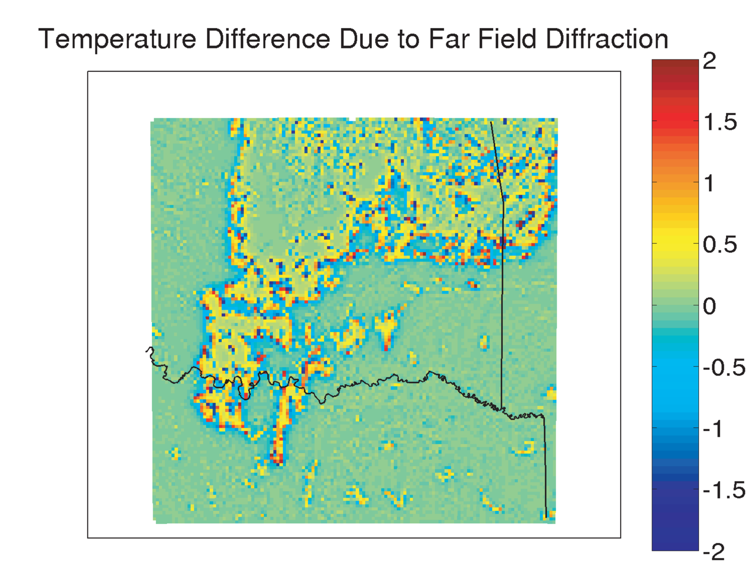
Above and Right: Optical point spread formula for a diffraction limited telescope and a plot of the function for the GIFTS insrument.

Right: A plot of this function shows that the contribution to the detector signal drops off rapidly with distance from the center of the FOV, but the total contribution from an area outside a specific radius can be significant due to the r^2 dependence.



The effect of neighboring scenes was calculated for two different point spread function distances. The first set of calculations is referred to as the near field diffraction effect and is a convolution of the point spread function over an 11 by 11 array of 1.33-km simulated data points. This leads to a near field cutoff of 14.6 km. The results are averaged to 4-km resolution and show the largest differences near cloud boundaries where the brightness temperature changes are most abrupt.

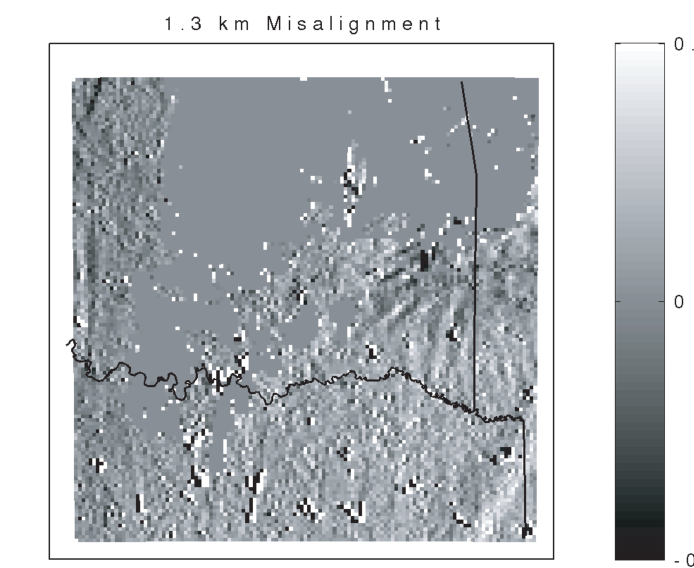




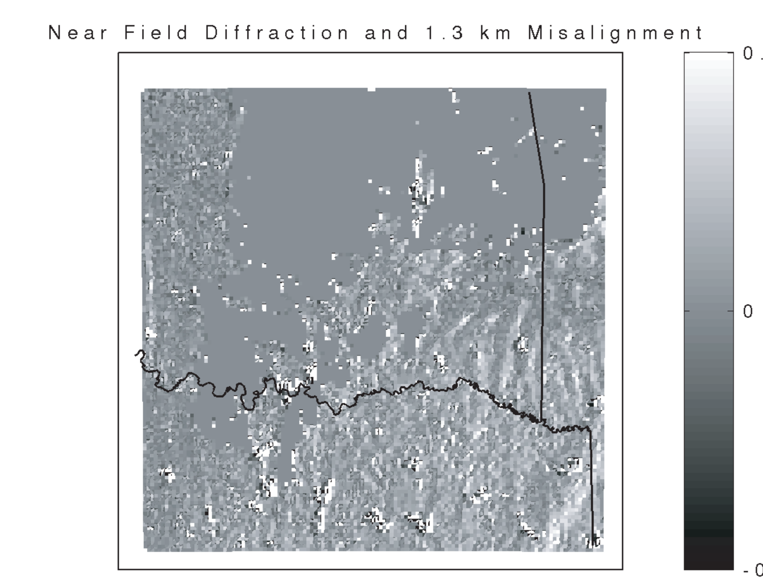
Above Right: The second set of calculations is for the far field diffraction effects. The point spread function was convolved with a 259 by 259 array of 1.33-km data yielding a 344 kilometer wide far field domain. Since the simulated dataset only contains 384 by 384 points, 128 points in each direction were mirrored beyond the original data to accomodate the large diffraction domain.

Misalignment

The GIFTS instruments uses two focal planes to cover different regions of the spectrum. Small errors in the alignment of the focal planes will cause the field of view for the two bands to be slightly different. This can create problems for algorithms like the temperature and water vapor retrievals, which use data from both spectral regions.

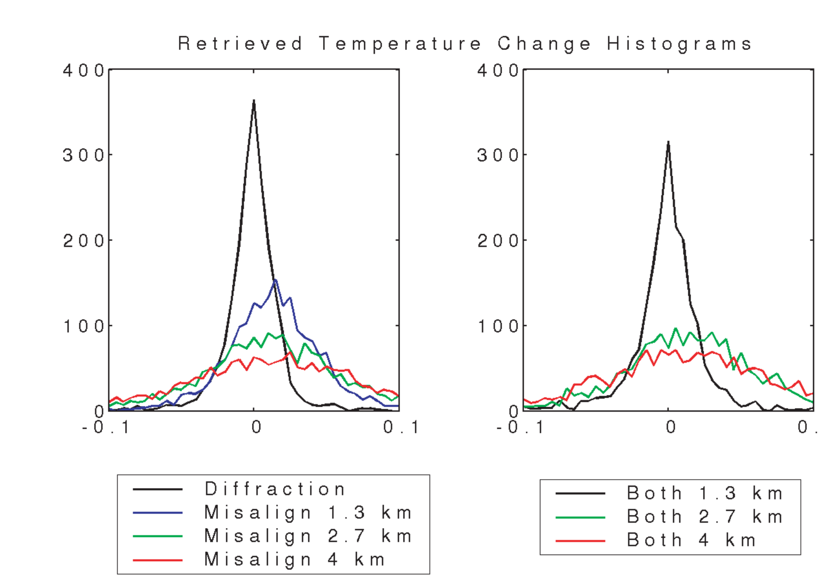


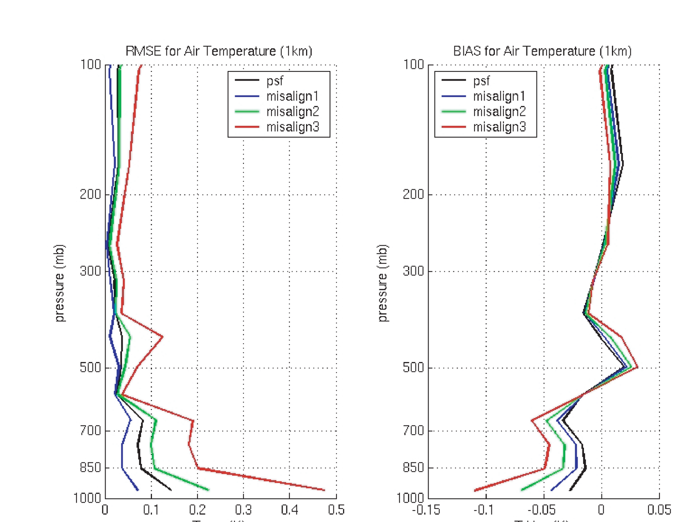
To simulate the misalignment, the short–midwave focal plane data is shifted a variable amount to the left. These shifts are either the distance of one (1.3 km), two (2.7 km), or three (4 km) high resolution pixels. The results are then either averaged to a four kilometer FOV or if diffraction effects are to be applied, the data is convolved with the point spread function before being averaged.



Right:

Differences in the 850 MB retrieved temperatures for the 1.3 km misalignment case and the combined diffraction and misalignment case. The histograms of these images as well as the 2.7 km and 4 km misalignment retrieval differences are also included.





The retrieval results presented above represent just one level of the temperature retrieval. Although the 850 MB level has some of the largest errors, a comprehensive and systematic study of all levels as well as the water vapor retrievals would be a useful next step.

Acknowledgements: We would like to thank NASA for their support of this effort under contract NAS1-00072.

* Corresponding author: erik.olson@ssec.wisc.edu