Thermal Tail Subtraction Algorithm

Overview

Algorithm for removal of the thermal tail/excess from OVIRS data. This algorithm uses OTES-derived brightness temperatures for computing the thermal radiance contribution to be subtracted.

Contingency: In the case that OTES is not operational, the contingency plan is to fit the OVIRS tail itself for estimating surface temperatures. The algorithm to do that computation is more complex and is not described here. We stress that the use of OVIRS itself to estimate temperatures is a contingency in the (unlikely) event of a loss of OTES and is not included in the baseline plan described here.

History

Initial Draft: 29 May 2014

Update: 5 Aug 2014, 15 October 2014, 10 Nov 2014, 26 Feb 2015, 11 Mar 2015, 18 Feb 2016

Reviewed: 18 Feb 2016 by Cristina Thomas

Update: 27 July 2016 by Josh Emery to include changes made in the leadup to SPOC testing and to clarify the contingency case from the baseline case.

Update: 26 August 2016 by Vicky Hamilton to specify that the relevant temperature from OTES is cal/val-produced brightness temperature (as opposed to the kinetic temperature derived from SAWG's E-T separation).

Algorithm Description

1. Read in the one dimensional OVIRS calibrated radiance spectrum, uncertainties, and wavelengths as well as brightness temperatures and uncertainties from corresponding (where corresponding means obtained near simultaneously, as determined by comparison of SCLK values or close in distance) OTES measurements.
2. Calculate the Planck function (W/cm^2/um/sr) at OVIRS wavelengths using the OTES-derived brightness temperature.
3. Subtract thermal flux from OVIRS spectra to leave only the reflectance component of the OVIRS spectrum.
4. Propagate uncertainties through Planck calculation and thermal radiance subtraction.
5. Pass back out (1) OVIRS spectrum and uncertainties with the thermal excess removed, (2) calculated thermal radiance spectrum (and uncertainties) that was subtracted, and (3) the emissivity used for the Planck function calculation (currently set to 1.0).
6. Note that this function is called by a "wrapper" program that puts the inputs in the right format and adds some information to the header of the final fits file to be saved with thermally corrected data. This header information includes: thermal excess removal method, name of input OVIRS data file, name of input OTES temperature file, versions of IDL, operating system, and system architecture used to run the program.

Example Processing and Output

Sample input:

IDL> thermalexcess, ovirsspectrum, ovirswaves, otestemp, ovirsspectrum_corrected, thermout, emis

Where:

INPUTS:
ovirsspectrum - a 2-D array containing columns of radiance, uncertainty, and quality flag [nlam x 3]
Expect units of W/cm^2/um/sr
ovirswaves - a 1-D array containing column of wavelengths, µm
otestemp - The brightness temperature returned by OTES at the time of the spectral observation (floating point number).
OUTPUT:
ovirsspectrum_corrected - 2-D array containing corrected radiance, updated uncertainty, and the quality flag [nlam x 3]
thermout - 2-D array containing model thermal radiance that was subtracted, uncertainty in modeled thermal radiance, and a quality flag [nlam x 3]
emis - emissivity. At this point, assumed constant with wavelength. (floating point value)

Ancillary Data

Viewing geometry, measured surface temperature from OTES

As noted above, this algorithm is called by a wrapper program (ovirs_thermaltail_normal.pro) that takes the data from the wavelength interpolation step of the pipeline and prepares it for input into this algorithm. This current program operates on a spectrum-by-spectrum basis. The wrapper program includes a for loop that loops over all of the OVIRS spectra in a given input file, then saves the results of the thermal tail removal of all of those spectra to a single fits file.

The processing will use a three-tiered approach to finding the best OTES brightness temperatures to use:

1. Find OTES observation with near simultaneous SCLK (spacecraft clock time) value to the OVIRS spectrum
2. Find the closest (in space) OTES observation that completely overlaps the OVIRS spectrum. This criterion corresponds to the centers of the OTES and OVIRS spots being closer than 1 OVIRS spot radius, assuming that the OTES spot is 2x larger than the OVRIS spots.
3. Find the closest (in space) OTES observation to the OVIRS spectrum, even if overlap is not complete

A quality flag will be saved indicating which of these approaches was used for each spectrum.

References

Potential Searchable Data

1. The corrected spectrum.

2. The brightness temperature used for the thermal subtraction.

Other Notes

Future iterations can explore additional thermal excess removal methods. For example, if we want to investigate spectral features in the thermal excess region we might choose to do a fractional removal of the full thermal excess. We might also want to correct the data using the best fit temperature which may not be equivalent to the supplied OTES temperature (see contingency below). If special cases are used there may be additional searchable parameters.

The thermal tail subtraction algorithm was last validated in July 2015.

The current algorithm assumes that emissivity is constant with wavelength in the OVIRS region and is equal to 1.0. We have investigated allowing emissivity to be a free parameter, and have written a version of the algorithm that still assumes emissivity is constant with wavelength, but allows it to vary from 1.0. We have not finished testing this algorithm, but may consider implementing it once the testing is complete.

Observation Requirements

18 Feb 2016. The thermal tail subtraction will work for any OVIRS observation with a simultaneous OTES observation.

Work to go

Baseline: The algorithm is complete, but the SAWG is still discussing the preferred format for passing and storing data, so some modifications may take place as formats change.

Possible upgrade, but not required: The step of allowing emissivity to be a free parameter requires further testing to make sure we can catch unphysical solutions and compensate. Since this is not a required task, it has low priority. As such, it has been pushed aside for all of the other higher priority documentation and testing tasks this summer.

Contingency: The contingency algorithm, for the event of a complete loss of OTES, is in development. The remaining task involves development of appropriate statistical routines for minimizing data-model residuals to establish the best fit temperature and spectral emissivity along with appropriate uncertainty estimates. We anticipate about a month of work time to implement and test these algorithms. Our expectation is to have this completed by Oct 1, 2016.