Continuity of Cloud Top Pressure and Cloud Infrared Thermodynamic Phase by Combining CrIS and VIIRS Measurements

FIRST YEAR REPORT

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Introduction

This report summarizes results for the period August 2014 - May 2015, encompassing most of the first year of funding for this particular effort. Good progress has been made; this summer our software will be applied to global merged VIIRS+CrIS data. Our basic goal is this: VIIRS provides infrared (IR) measurements for only window channels. For inference of cloud height and cloud phase, we really need more information, specifically measurements within the 15-µm CO₂ band. These measurements began in 1978 with HIRS (High resolution Infrared Radiometer Sounder) on the NOAA polar-orbiting platforms, with Terra/Aqua MODIS, and also the HIRS/IASI (Infrared Atmospheric Sounding Interferometer) sensors on the Metop polar-orbiting platforms. Since VIIRS was not provided with such a channel, we have developed a method to build one at the VIIRS spatial resolution of 750m using a fusion approach with VIIRS and CrIS. In other words, we are adopting a computer science approach to build a critical channel from VIIRS and CrIS. Our approach will also be applicable to future platforms that contain both an imager and an IR sounder.

Additionally, Dr. Baum serves as the S-NPP Atmosphere Discipline Lead and has been active in organizing the team’s activities.

First Year Activity

The following tasks have been started:

1. The software to fuse (or merge) VIIRS and CrIS data has been developed and tested on global data. The software is written in Python and the output is in NetCDF4. More specifically, this software builds upon an Atmosphere SIPS
format called the Intermediate File Format (or IFF) developed for VIIRS data. The IFF essentially takes the 85-sec VIIRS files for each channel and builds a 5-minute MODIS-like granule. This is especially useful for the VIIRS software developers. Our software builds on the IFF by providing CrIS data in two ways. First, a high spatial resolution (750m) VIIRS channel is constructed based on the MODIS 13.3-µm response function using our data fusion approach. An example is discussed later in this report. Second, CrIS spectral radiances are integrated using the MODIS 15-µm channel (bands 33-36) response functions and are provided for the VIIRS pixels that fall within each individual CrIS field-of-view (FOV). This software package now works at the Atmosphere SIPS, where any quantity of VIIRS+CrIS Level-1B data can be constructed.

2. We are working with Dr. Andrew Heidinger (NOAA/NESDIS/STAR) to integrate the 13.3-µm pseudo-channel into a cloud processing package called ACHA, which is a 2nd generation acronym for the AWG Cloud Height Algorithm; AWG refers to the Algorithm Working Group established by NOAA for the GOES-R Advanced Baseline Imager (ABI). The ACHA is an existing, well-tested operational package for inferring cloud heights using an optimal estimation approach. The integration of our pseudo-channel data into ACHA is now underway. We also note that ACHA has been integrated into the Atmosphere SIPS, where the application to global data will be performed.

3. As Atmosphere Discipline Lead, there are several items to note. First, the PI developed a set of web pages for the Atmosphere Team (http://www.ssec.wisc.edu/suomi_npp/Atmosphere_Team). While there may be a more organized effort in the future by the NASA S-NPP project, we needed something to document our work in the meantime. Additionally, we have built pages for our team to document our work as it unfolds (http://www.ssec.wisc.edu/suomi_npp/clouds). As a team, we decided to provide products in staged deliveries to LAADS; the deep blue and dark target aerosol products will be ready much sooner than the cloud products. Discussions regarding Level-3 were initiated at the recent MODIS-VIIRS science team meeting; the SIPS will be instrumental in assisting this development.

4. We submitted a small proposal to the NASA S-NPP project to provide a VIIRS radiance simulator for the team. This is something that was not funded but is quite important for simulating both aerosol and cloud radiances. At the recent MODIS-VIIRS science team meeting, the PI was informed that this small effort would be funded through an add-on to the existing grant. This work will be done jointly between the PI’s host organization and Dr. Ping Yang at Texas A&M University.

**Second Year Plans**

We are working our way through the remaining issues to achieving global cloud top height and IR phase products from VIIRS+CrIS. We are currently integrating the new VIIRS+CrIS granules of Level 1B data into ACHA. Once our VIIRS+CrIS 13.3-µm channel has been integrated into ACHA, there are several efficiencies that will be achieved. First, ACHA is well tested for both regional and global data analyses as it is part of the NOAA operational polar-orbiting and geostationary cloud retrieval package.
developed by Dr. Heidinger. Second, ACHA’s optimal estimation system can easily incorporate either IR window channels as well as the additional 13.3-µm channel that we are providing. Third, this package incorporates a radiative transfer model that will provide the cloud emissivities and cloud emissivity ratios necessary for developing and implementing the IR phase algorithm. Note that the cloud emissivities and ratios were adopted for the MODIS Collection 6 production IR phase algorithm. The ACHA package has been incorporated into the Atmosphere SIPS where it will be applied to global data; subsequently we will evaluate the results through comparison with MODIS Collection 6 products and also CALIPSO match-ups. The VIIRS+CrIS 13.3-µm channel is invaluable for the IR phase algorithm development because it provides information unavailable from solely the IR window channels, i.e., it provides information content to discriminate between low and high clouds. As with the cloud heights, the VIIRS cloud phase will be evaluated through comparison with MODIS and also the CALIPSO cloud phase product.

**Research Highlights**

To create a 13.3-µm pseudo channel, high spatial resolution VIIRS IR window bands (at 8.5, 10.8, and 12 µm) are spatially downsampled to match the lower spatial resolution of the high spectral resolution CrIS using geographic colocation information from both instruments. The target 13.3-µm channel is built at this same lower spatial resolution using the selected 13.3-µm spectral response function (band 33 of MODIS). The resulting co-located VIIRS and CrIS data have the same spatial resolution. Subsequently a mapping function is built from the VIIRS IR window channel to the desired output 13.3-µm channel. This mapping function is now applied the VIIRS data at high spatial resolution. The vector of radiance values and its corresponding geographic coordinates use a k-d tree data search algorithm to find the closest five CrIS FOVs among the low-resolution training data set in the five-dimensional space representing the three input IR window bands and two additional geographic dimensions (Cross et al. 2013).

A comparison of MODIS and our VIIRS+CrIS 13.3-µm radiances is shown in Figure 1. This scene was recorded over the eastern Atlantic Ocean on April 17, 2015 at 1435 UTC (MODIS) and 1440 UTC (VIIRS), VIIRS and MODIS measurements were recorded within 5 minutes of each other. The similarity of the detailed radiances between the two scenes is remarkable. Note that the constructed pseudo channel covers the complete swath of the 750 m VIIRS measurements. Because the CrIS swath is narrower than the VIIRS swath, the constructed radiance uncertainty increases in the part of the VIIRS swath that lies outside the CrIS data; this uncertainty is being evaluated using MODIS+AIRS data (MODIS has the actual 13.3-µm measurements with which to compare with the constructed radiances) and will be included in the optimal estimation algorithm so that the uncertainties are carried forward into the other retrievals.
Figure 1: a. Measured MODIS Band 33 (13.3-µm) radiances from a 5-minute granule on April 17, 2015 at 1435 UTC over the eastern Atlantic Ocean. High clouds are white, low clouds are dark grey, and ocean is dark. (b) A 5-minute scene constructed from VIIRS+CrIS data from an overpass about 5 minutes later than the Aqua overpass.