NOAA ROSES Semi-Annual Report

Reporting Period: September 2020 – February 2021 (1st report)

PI: Jaime Daniels (NOAA/STAR)

Co-I(s): James Carr (Carr Astronautics), Houria Madani (Carr Astronautics), and Wayne Bresky (IMSG, Inc.)

Project Title: New Fused GEO+LEO Multi-Satellite Product: Stereo-Winds from Collocated ABI and VIIRS Datasets

Executive Summary

This project involves the development, validation, and demonstration of a new GEO-LEO stereo-winds product using an ABI-family imager instrument (aboard GOES-16/17, Himawari-8, and GEO-KOMPSAT 2A) as one eye and the VIIRS instrument (aboard S-NPP, NOAA-20) as the other. This new capability will be an extension of the GEO-GEO stereo winds capability developed by STAR's Winds Science Team that will further extend stereo winds coverage. Use of a stereo approach offers a direct method of cloud height assignment that rely only on the geometric parallax observed from two different vantage points. This approach does not rely on cloud microphysical properties or explicit knowledge of the atmospheric thermal structure, both of which, can challenge infrared-based cloud height retrieval approaches in certain conditions. As a result, the stereo approach produces highly accurate cloud-top heights that enable highly accurate height assignments to be determined for satellite winds. The GEO-LEO stereo winds quality will be quantitatively determined and characterized by comparing them to rawinsonde and aircraft winds observations. GEO-LEO stereo winds will generated over select time periods and made available to NCEP and other operational Numerical Weather Prediction (NWP) centers for data assimilation experiments aimed at assessing their value to the accuracy of global and regional NWP forecasts.

Progress toward FY20 Milestones and Relevant Findings

- ABI-VIIRS MATLAB Prototype

  The MATLAB stereo winds prototype software has been successfully updated to include the capability to retrieve VIIRS-GEO stereo winds using the VIIRS I-bands (I1 or I5) or M-bands (M1 or M15). Use of the M15 band (versus the I5 band) offers a better resolution match to the ABI band 14 (2.7 ration versus 5.3) and has less radiometric noise. We have run experiments where the M15 and I5 wind-height retrieval performance versus B02 GEO-GEO winds are nearly identical, indicating that the extra resolution offered by the I5 band does not make a big difference in the stereo wind retrievals. In addition, the M-band data is

less voluminous and is easier to work with and process. For all these reasons, we are leaning to use the VIIRS M-band data.

Here we present results of two test cases where VIIRS I-band data (I1 and I5) were used together with the corresponding GOES-16 CONUS ABI data to generate GOES-VIIRS stereo winds on 14 Nov. 2020 18:36Z.

Test Case 1 (Visible Stereo Winds)

- CONUS B02 and B14 with J1-VIIRS I1 and I5
- Date/Time: 14 Nov. 2020 18:36Z

Once all the required VIIRS data are acquires and successfully read, the first step in the process that needed to be done was to remap the VIIRS data to the GOES-R fixed grid. Figure 1 shows the result of this process for the VIIRS I1 Band for one of the time steps. Once done for both time steps (t_0-delt; t_0+delt), then the G16-ABI/N20-VIIRS stereo winds could be generated. The retrieved NOAA-20 VIIRS (I1 band)/GOES-16 ABI (band 2) stereo wind ellipsoid heights (left), wind u-components (center), and wind v-components (right) are shown in Figure 2. Histograms of these retrieved components are shown in Figures 3 and 4. The histogram of the stereo wind ellipsoid heights shown in Figure 4 show that the majority of the winds are assigned at low levels (<4km) of troposphere.

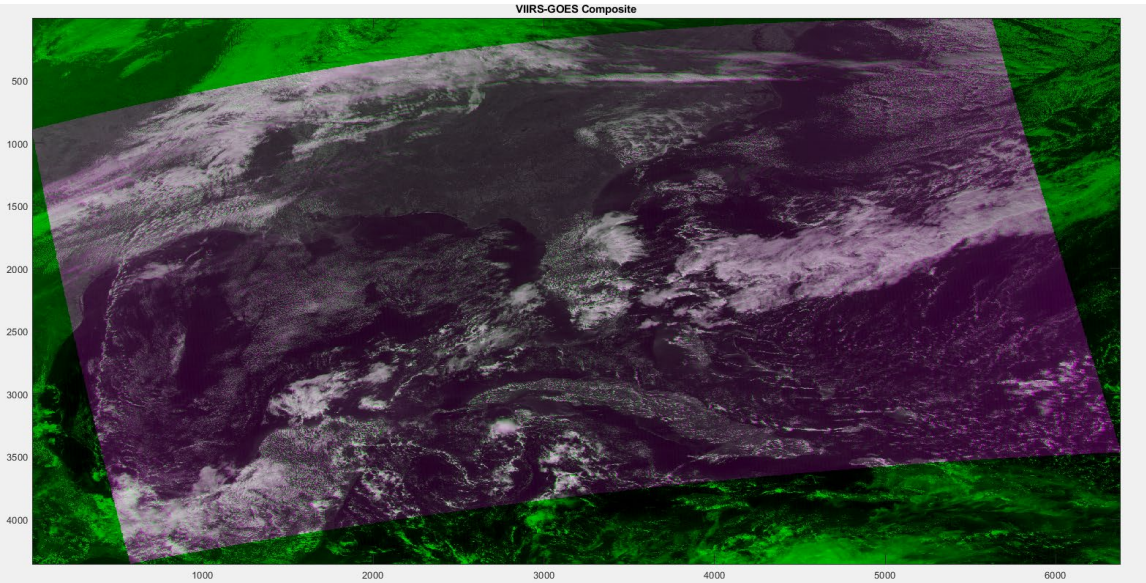

Figure 1. VIIRS Band I1 remapped to GOES-16 ABI CONUS grid

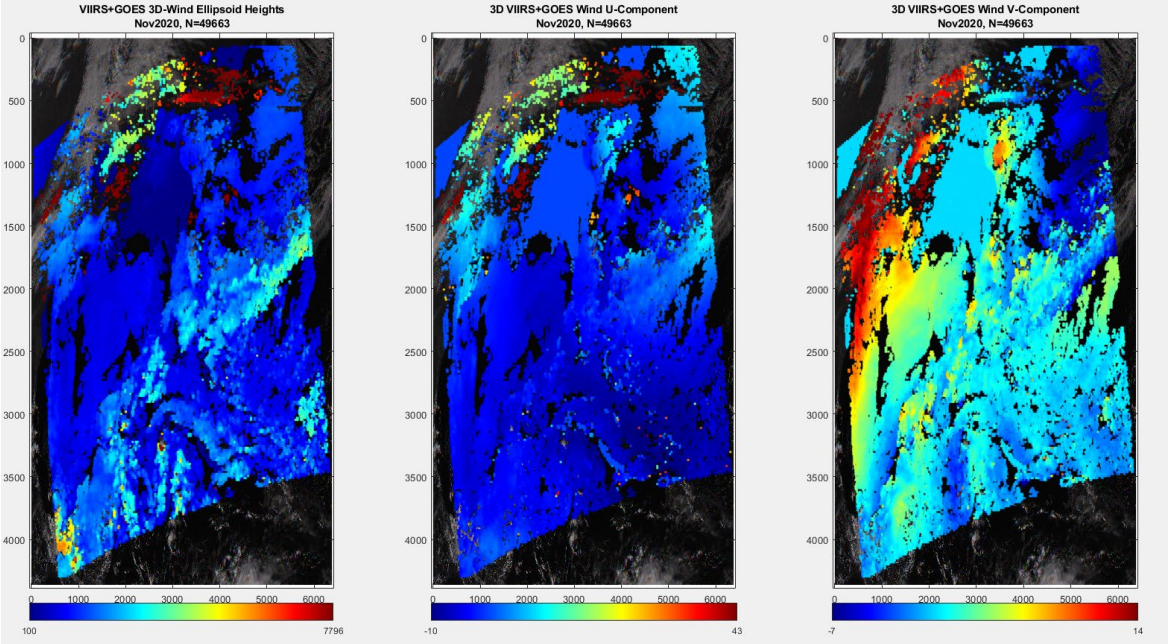

Figure 2. Retrieved NOAA-20 VIIRS (I1 band)/GOES-16 ABI (band 2) stereo ellipsoid heights (left), wind u-component (center), and wind v-component (right) valid on 14 Nov. 2020 18:36Z

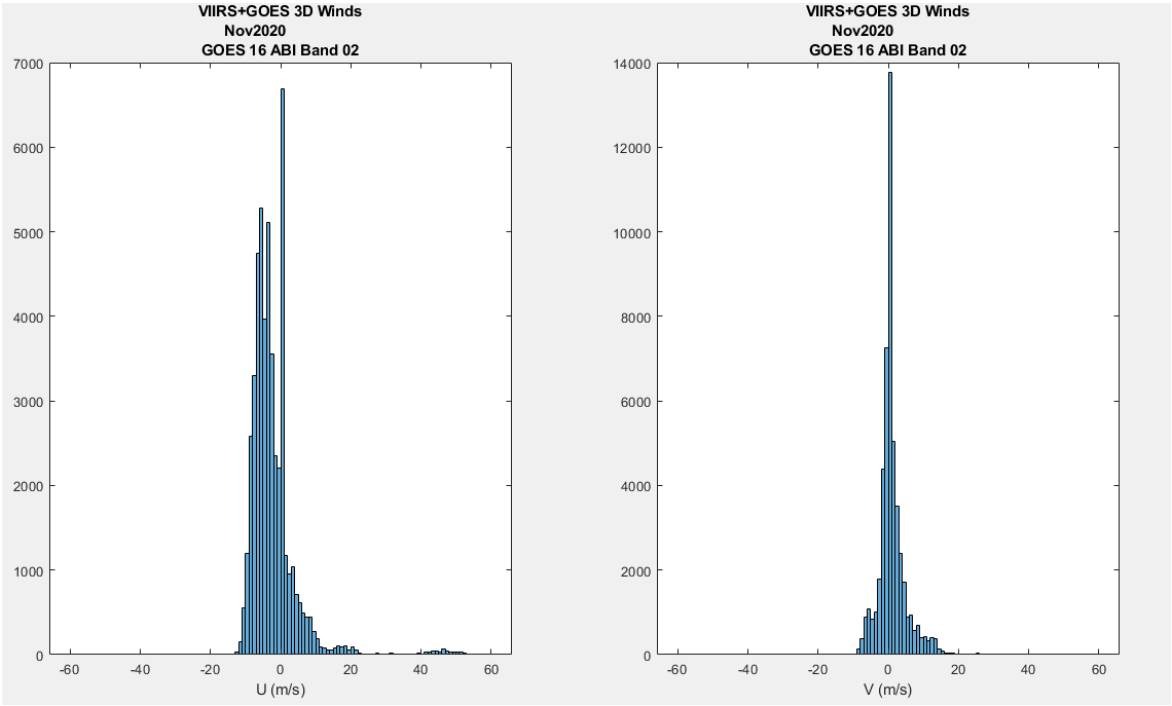

Figure 3. Histograms of the retrieved u- and v- wind components shown in Figure 2.

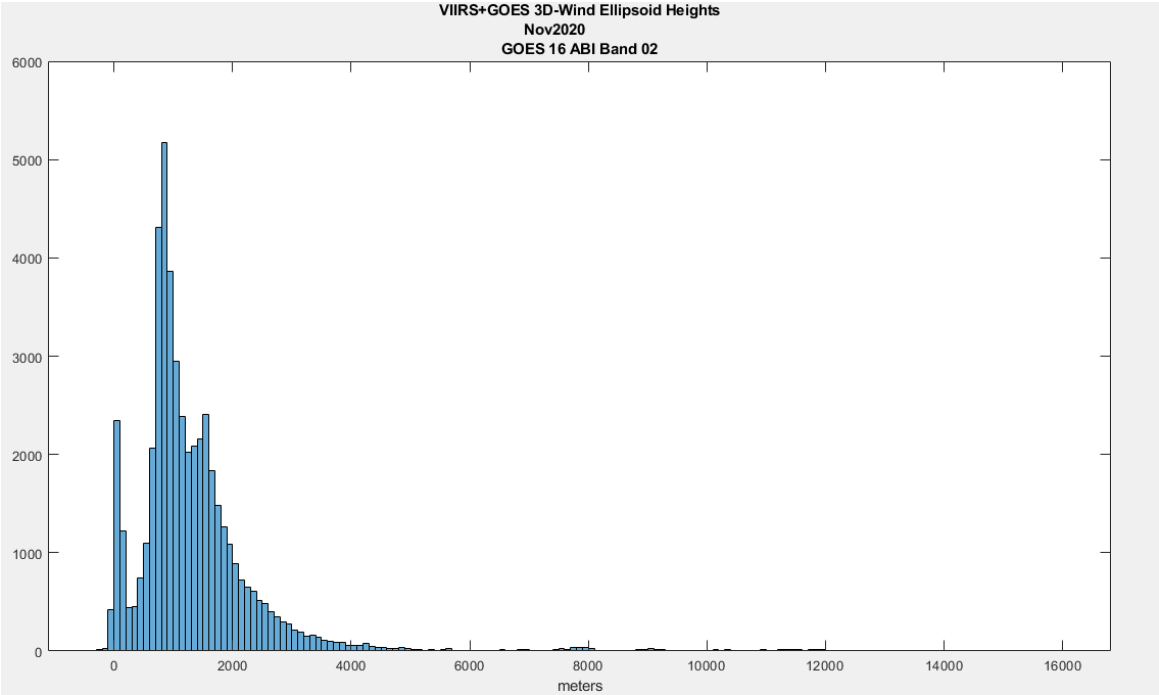

Figure 4. Histogram of the retrieved wind ellipsoid height (m) shown in Figure 2.

Validation of the stereo approach involves validating tracked stationary ground points under clear-sky conditions. The ground-point retrievals provide an excellent indication of the accuracy of the stereo retrievals since the expected velocities (zero) and elevations of tracked ground points from terrain models are known. Figure 5 shows *ground point* verification plots for NOAA-20 VIIRS (I1 band)/GOES-16 ABI (band 2) stereo winds retrievals on 14 Nov. 2020 18:36Z. A visual inspection of the sites that were classified as ground points confirms the correctness of their classification, although this is more difficult for IR scenes. The mean errors for this case are 77m, 0.05 m/s, and 0.1 m/s for the height, u-wind component, and v-wind component, respectively. This is a good result and is a clear indication that the stereo algorithm has been successfully applied to the GOES16-ABI and NOAA-20 VIIRS image pairs.

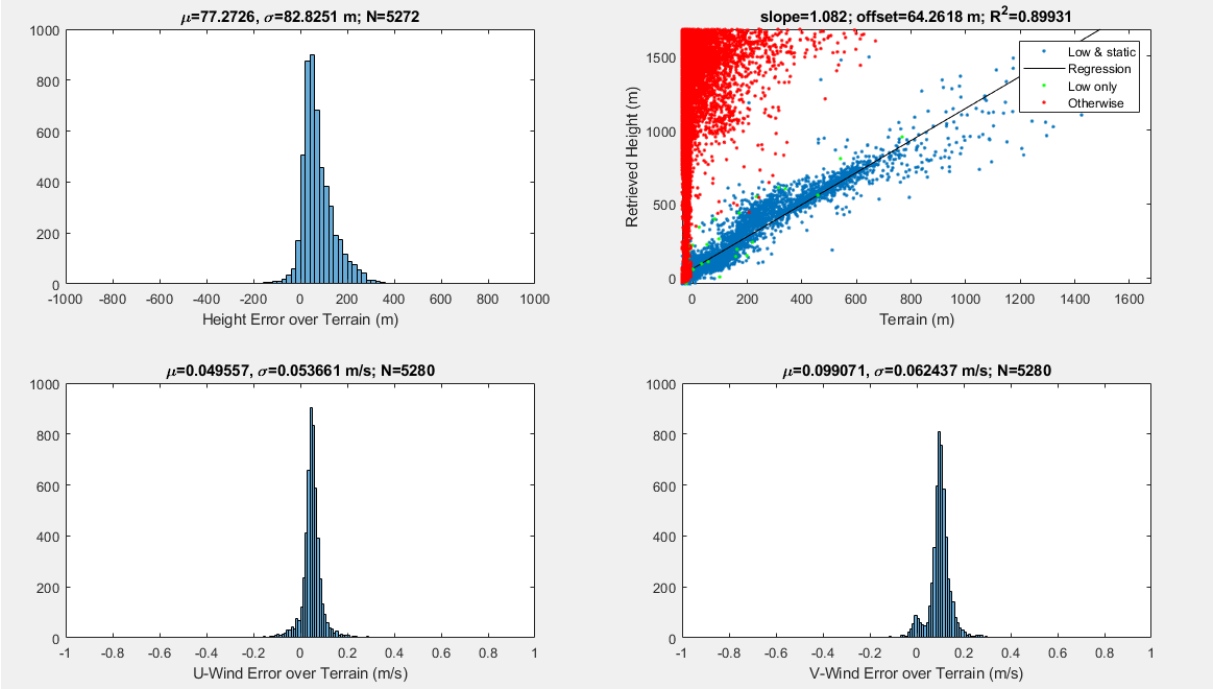

Figure 5. Comparison of ground point NOAA-20 VIIRS (I1 band)/GOES-16 ABI (band 2) stereo winds retrievals (14 Nov. 2020 18:36Z) against known terrain height (from elevation model) and expected (ie., zero) wind speed.

Test Case 2 (LWIR Stereo Winds)

- CONUS B02 and B14 with J1-VIIRS I1 and I5
- Date/Time: 14 Nov. 2020 18:36Z

Figure 6 shows the VIIRS Band I5 remapped to the GOES-16 ABI fixed grid. Figure 7 shows the retrieved NOAA-20 VIIRS (I5 band)/GOES-16 ABI (band 14) stereo wind ellipsoid heights (left), wind u-components (center), and wind v-components (right). Histograms of these retrieved components are shown in Figures 8 and 9. Unlike the stereo winds retrieved with the visible imagery, these LWIR stereo winds are retrieved at upper levels (> 10 km) of the troposphere which would be expected.

With the results obtained from these two cases, we can confidently say that we have completed the development of the ABI-VIIRS MATLAB protype. Our efforts are involved with the transition this capability to the version STAR's Satellite Application Processing Framework (SAPF) that we are currently using to generate the GOES-GOES stereo winds. These efforts are described in the next section.

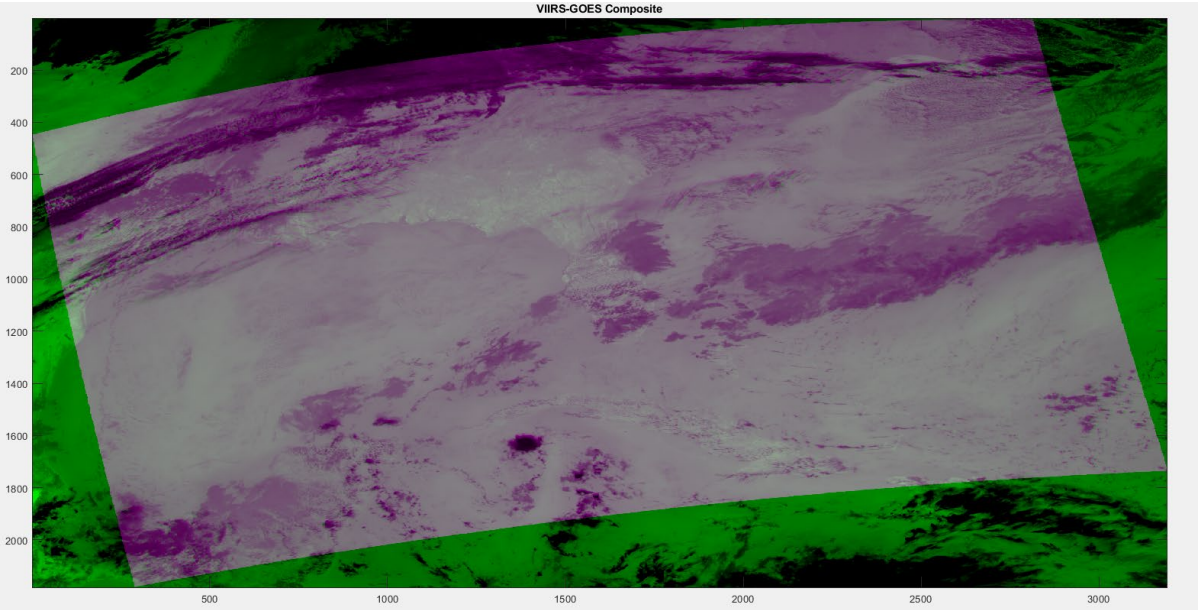

Figure 6. VIIRS Band I5 remapped to GOES-16 ABI grid

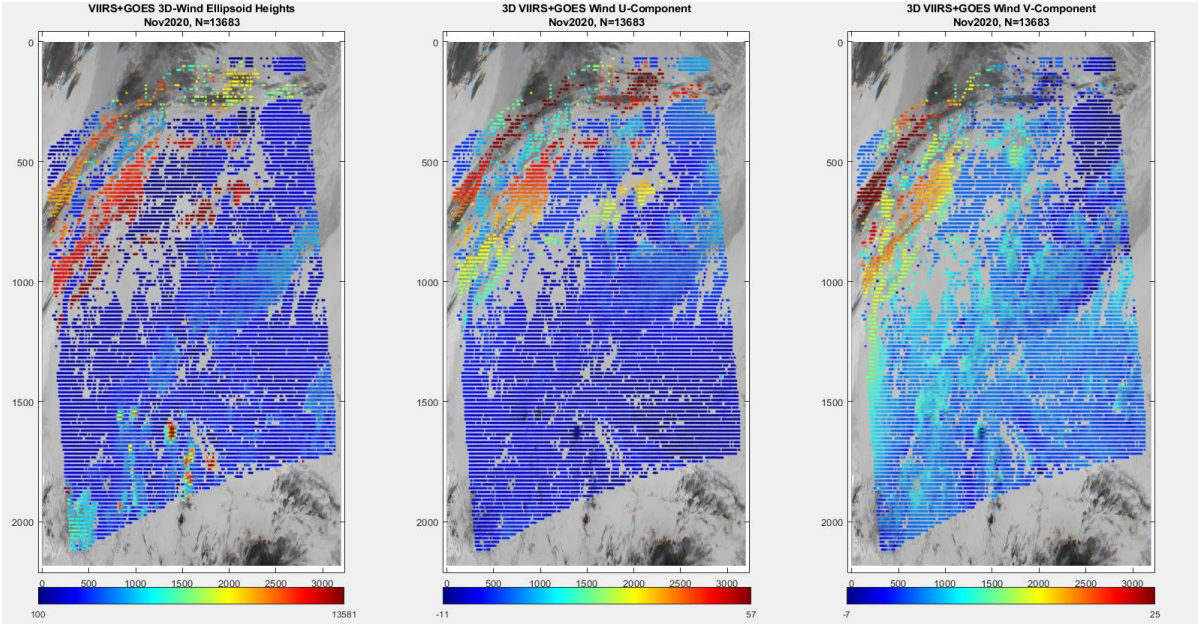

Figure 7. Retrieved NOAA-20 VIIRS (I5 band)/GOES-16 ABI (band 14) stereo ellipsoid heights (left), wind u-component (center), and wind v-component (right) valid on 14 Nov. 2020 18:36Z

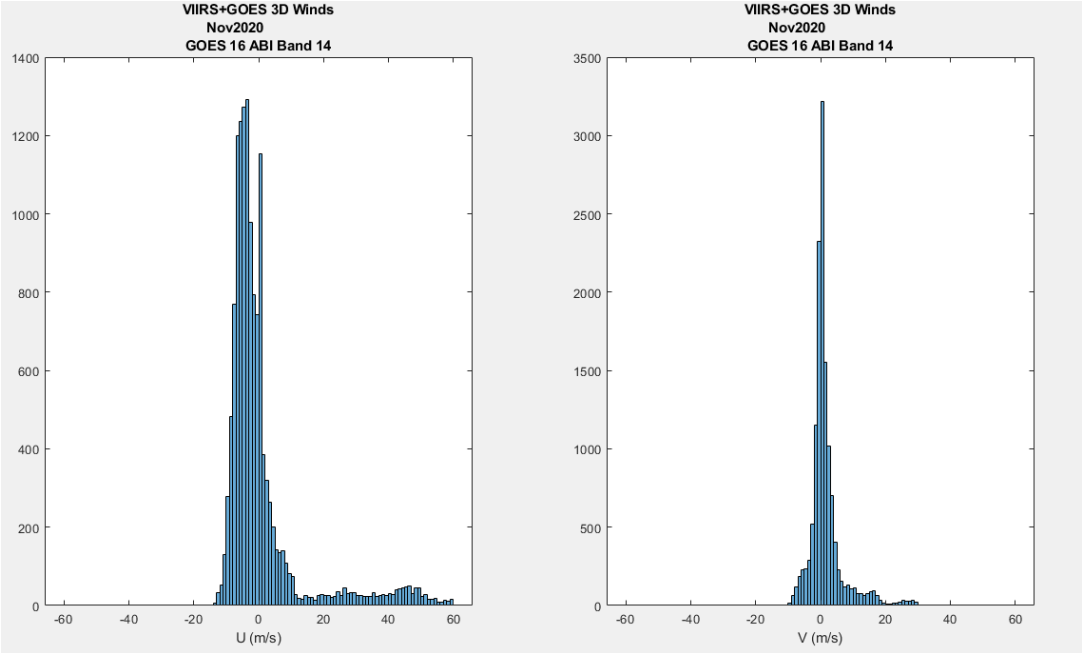

Figure 8. Histograms of the retrieved u- and v- wind components shown in Figure 7

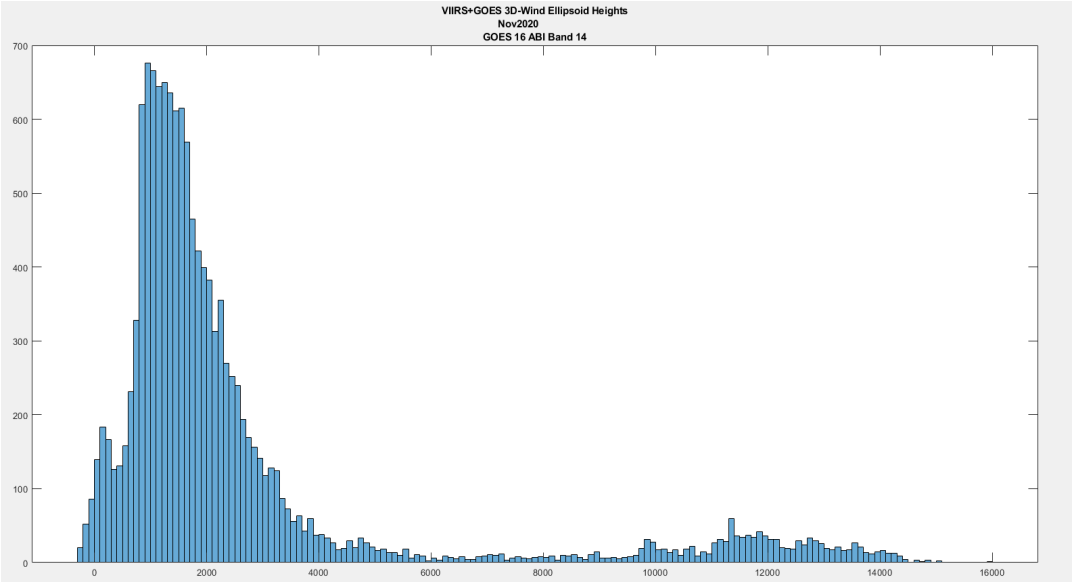

Figure 9. Histogram of the retrieved wind ellipsoid height (m) shown in Figure 7

- Migrate ABI-VIIRS to the STAR Algorithm Processing Framework

  Work is progressing well on the migration of the new ABI-VIIRS stereo capability added to the MATLAB prototype and discussed above. Time was spent investigating and understanding what VIIRS datasets (L1b data granules and geolocation files) were available in STAR's Central Data Repository (SCDR) and CLASS, how the data was

stored, and what the file-naming conventions were. A good understand of all of this was achieved and necessary to build the capability to process these data.

The next effort to tackle was to decide how to move forward with the development of the image remapping software in STAR's Satellite Application Processing Framework (SAPF). Numerous software changes were made to the prototype MATLAB remapping software (used for the GOES-GOES stereo winds) to accommodate VIIRS data. We need to decide whether to convert the new remapping MATLAB software to Fortran 90 or to make use of the existing open source Polar2Grid software *(https://www.ssec.wisc.edu/software/polar2grid/)* developed at the Cooperative Institute for Meteorological Satellite Studies (CIMSS) at the University of Wisconsin and funded by NOAA. Work is being done now to install the Polar2Grid library and test its use to ensure that it can reproduce the remapped VIIRS data generated with MATLAB software. We are currently leaning to use this open source code library to perform the remapping function since this software is already being used in NOAA/NESDIS's operational polar wind product processing. Furthermore, using the Polar2Grid library would be a good system engineering practice that would minimize a later research to operations effort of the GEO-LEO stereo winds capability and improve the maintainability of the software.

Plans for Next Reporting Period

- Complete software development and testing of the remapping software
- Generate GOES-VIIRS stereo winds in STAR's Satellite Application Processing Framework environment for several case studies and verify results.
- Begin scripting to enable an end-to-end demonstration of the GOES-VIIRS stereo winds in STAR's Satellite Application Processing Framework environment