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Reporting Period: July 2016 – December 2016 (1st half of FY16 funding cycle)

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Project Title: Towards providing forecasters with better identification and analysis of severe PyroConvection Events using GOES-R ABI and GLM Data

Project Number: 244

Executive Summary

The primary goal of this effort is to use geostationary and polar-orbiter satellite data to investigate the impact of wildfire events that become pyroconvective, meaning that plumes quickly grow to incredible heights over the course of hours and become pyroCumulonimbus, or pyroCb. The pyroCb events inject huge amounts of emissions into the upper troposphere and even into the lower stratosphere. The emissions contain soot, mineral dust, and “brown carbon” (or BC; complex light absorbing organic
material). The PyroCb blog (http://pyrocb.ssec.wisc.edu) documents notable pyroCb events as they unfold, provides information to NWS forecast offices as well as the general public, and also supports scientific research that will eventually makes its way into the peer-review literature. New pyroCb events are added continually so that we will have a record of the events for the duration of the blog (roughly 2013-2017 fire seasons). In the first two years (2013-2014), the blog recorded about 20-25 events per year. In 2015, we recorded over 60 events. These events occurred during one of the strongest El Ninos on record. Additionally, the higher temporal resolution of Himawari-8 now permit the documentation of PyroCb events that could not be discerned previously. The past year reverted to more normal number of events. A graduate student, Anna Sienko, is now pursuing a M.S. on this PyroCb work at UW-Madison, with Prof. Grant Petty as her advisor. She is investigating the use of a Heidke skill score (Petty and Li, 2013) to investigate whether there is some predictive capability for PyroCbs based on meteorological conditions. She is additionally performing radiative transfer calculations to investigate the impact of heavy smoke aerosol in the vicinity of cumulonimbus anvils and other high-level clouds. Anna Sienko should finish the requirements for the M.S. degree by the end of the summer semester, 2017.

In the recent period, we worked with Dr. Elisabeth Weisz (SSEC) and her graduate student, Rebecca Schultz, to gain more understanding of atmospheric stability from their analysis of hyperspectral IR data from sensors such as AIRS, CrIS, and IASI. Dr. Weisz developed a regression-based approach to infer atmospheric properties such as temperature and moisture profiles that could be quite informative for the study of these extreme pyroconvection events. Rebecca Schultz anticipates completing her M.S. degree by the end of the spring semester, 2017.

The blog focuses on the more practical, operational aspects of pyroCbs, such as inspection of the OMPS Aerosol Index to identify regions of high-altitude absorbing aerosols, the presence of lightning in the plumes, determination of smoke injection height, and the use of HYSPLIT model trajectories to gain a sense of the plume dispersion.

Un fortunately, this effort was not chosen for continuation by NOAA, so the blog will continue into the 2017 fire season until the available funding is depleted.

**Progress Toward FY16 Milestones**

- Documented hundreds of notable pyroconvection events (both pyroCb and pyroCu); collected pertinent data necessary for detailed case studies and posted results on the PyroCb blog (http://pyrocb.ssec.wisc.edu).
- Integrated CALIPSO lidar products, OMPS Aerosol Index, GOES, VIIRS and MODIS data into the blog posts. Himawari-8 has also provided extraordinary imagery for several PyroCb events.
- Integrate HYSPLIT model trajectories with satellite image analysis where necessary.
- Build expertise with Heidke skill score to better understand if there is some predictive capability for PyroCbs based on meteorological conditions.
- Perform radiative transfer calculations to gain insight into smoke-ice cloud interactions, with application to geostationary imager data.
- Working with products from hyperspectral IR sounders such as CrIS and AIRS for regions with significant biomass burning to provide greater understanding of atmospheric stability in the vicinity of the pyroCb events.
**Plans for Next Reporting Period**

The blog will continue until funding is depleted. Given the interest by the public, the aviation community, different biomass burning communities around the world, weather interests, and more, some thought should be given towards continuation of this work.

Anna Sienko is performing her Masters work on this topic and is making good progress. She has been learning how to run a radiative transfer model (discrete ordinates) to obtain cloud and smoke signatures in visible though infrared wavelengths, and also works with atmospheric stability parameters in the vicinity of the pyroCbs. We will continue to work with Dr. Elisabeth Weisz to integrate products from hyperspectral IR data. For the duration of this effort, Anna Sienko will continue to work on her graduate research and prepare a publication before her anticipated graduation date in late summer, 2017.

**Additional Information**

1. Interaction with operational partners –

2. Conference/workshop participation – Anna Sienko and Rebecca Schultz (both grad students at UW-Madison) gave posters related to pyroCbs at the AMS Satellite Conference held in Madison, Wisconsin in August, 2016.

3. Funding concerns – We hope that this work will continue somewhere/somehow once the funding winds down for this project.

4. Outside project publicity – Our PyroCb blog is sometimes cited by other blogs that are writing about extreme fire events. Additionally, we now provide information on quickly unfolding events via a Twitter account: @PyroCb_CIMSS.

5. Journal articles –

**Plans for the next Reporting Period:**

- Continue study of pyroconvection case studies and document pertinent results; this will occur primarily through the two graduate students.
- Continue to document new pyroCb events as they occur.
- Continue to perform radiative transfer calculations to gain some insight as to the radiometric signatures of smoke-cloud interaction in the satellite data.
- Document the findings in Year 3 via relevant conference presentations and begin to prepare a peer-reviewed publication from the graduate student research.
Figure 1: A GOES-14 image of the Pioneer Fire in central Idaho on 21 August, 2016. The top panel shows the 0.63–µm (visible channel) reflectances, the middle panel shows the 3.9–µm Medium Wave Infrared (MWIR) brightness temperatures, and the bottom panel shows the 10.7–µm (Infrared Window) brightness temperatures, with surface reports plotted in yellow. A large smoke plume was evident in the visible image as it moved eastward; several hot spots are noted (red pixels) in the middle panel that indicate the active fires. While the cloud-top IR window brightness temperature did not quite reach the -40°C threshold to be classified as a pyroCb, a 1-km resolution NOAA-19 AVHRR image revealed a minimum IR brightness temperature of -48°C.