

GOESR3 Periodic Reporting

Reporting Period: July 2019 –December 2019 (1st half of FY19 funding cycle)

Team Leads: R. Bradley Pierce (UW-SSEC) and Chris Velden (UW-CIMSS)

Team Members: Chris Schmidt, Jun Li, Ralph Petersen, Lee Crounce, Dave Stettner and Tim Olander (CIMSS), Tim Schmit (ASPB), Megan Bela (ESRL/CIRES)

Project Title: GOES-R High Impact Weather Research Theme

Project Number: 308

Overall Project Executive Summary

The CIMSS GOES-R High Impact Weather Research Theme focuses on two major high impact weather events: fires and severe storms. The objective of the fires component of the research is to improve NWS WFO and IMET situational awareness during wildfire events. The fires component has three sub-topics focusing on fire detection and characterization, smoke forecasting and data assimilation, and development of probabilistic estimates of lightning wildfire ignition sources. The severe storm component of this proposal aims to improve severe storms and hurricane analysis/prediction by building on mature research activities and applying novel GOES-R observing capabilities to leading-edge product and data assimilation methodologies.

FY19 funding to CIMSS was reduced over what was originally proposed, which has limited progress on certain elements of our research components. Specifically in this reporting period, the CIMSS “Fires component” outlined in the original proposal was not funded, but a project update based on prior funding is included for this report.

Severe Storms Component: Data Assimilation Studies (Jun Li)

Executive Summary

With ABI radiances and products available in real-time or near-real time (NRT), effective utilization of its data in convective-scale numerical weather prediction (NWP) is becoming more attractive. The reason is because assimilating these high temporal and spatial resolution data can improve high impact weather (HIW) forecasts. In collaboration with CIMMS/OU and NSSL, the GOES-16 ABI derived three Layered Precipitable Water (LPWs) and Cloud Water Path (CWP), along with NEXRAD radar observations are assimilated in a convective scale NWP called Warn-on-Forecast (WoF) analysis and forecast system for 0 – 6 hour short-range forecasts. It is found that ABI derived products, especially the three LPWs, can improve the short-range forecasts through providing more accurate near-storm environment. A manuscript on this study has been submitted to Monthly Weather Review.

Progress toward FY19 Milestones

1. Impact study on ABI LPWs in convective scale NWP for HIW forecasts

The ABI derived three LPWs and the Cloud Water Path (CWP), along with the NEXRAD radar observations are assimilated in a convective scale NWP system, and the impacts are examined with three severe weather events occurred in May 2017. In each case, radar and ABI derived CWP and LPW observations are assimilated into a WRF-ARW model using the NSSL hybrid Warn-on-Forecast (WoF) analysis and forecast system with deterministic 3DENVAR as assimilation system. This study examines deterministic 0-6 h forecasts launched from the hybrid 3DENVAR analyses for the three severe weather events. Three types of experiments are performed. One experiment assimilates radar observations including radial velocity and reflectivity accompanied with surface observations. Another one assimilates GOSE-16 ABI retrieved CWP and LPW in addition to the radar and surface observations. The third experiment assimilates no observations. It is found that satellite derived products, especially LPW, can help improve short-range forecasts through providing more accurate near-storm environment.

Figure JL1 shows the composite reflectivity from MRMS (the first column), forecasted composite reflectivity for CTRL (the second column), RAD (the third column) and RADSAT (the fourth column). The first row (a-d) is from the analysis at 2000 UTC, 10 May 2017; the second (e-h), third (i-l), fourth (m-p), fifth (q-t), sixth (u-x) rows are from 1h, 2h, 3h, 4h, 5h forecasts initiated at 2000 UTC respectively. Boxes in (f) and (g) indicate the locations of over prediction without using satellite observations during the assimilation cycles. It can be seen that when including ABI LPWs (RADSAT), the false alarm on Storm 1 is reduced (see the rectangle area).

Figure JL2 shows the Fraction Skill Score (FSS) for composite reflectivity forecasts against MRMS composite reflectivity for averaged four 0 - 3h forecasts in 10 May 2017 case. Larger value means better forecast. It can be seen that ABI provided added value on impact (red) when compared with Radar observations for short-range forecasts.

Plans for Next Reporting Period

The following remaining experiments will be conducted for next reporting period:

Impact study on spatial resolution for HIW forecasts, conduct ABI radiance and LPW assimilation with different spatial resolutions: 2 km, 6 km, and 10 km, respectively.

Additional Information

1. Interaction with operational partners – none in this reporting period
2. Conference/workshop participation – none in this reporting period
3. Outside project publicity – none in this reporting period
4. Journal articles – Pan et al. 2020: The Impact of Assimilating Satellite-derived Layered Precipitable Water, Cloud Water Path and Radar Data on Short-Range Thunderstorm Forecasts, Monthly Weather Review (submitted, under review).

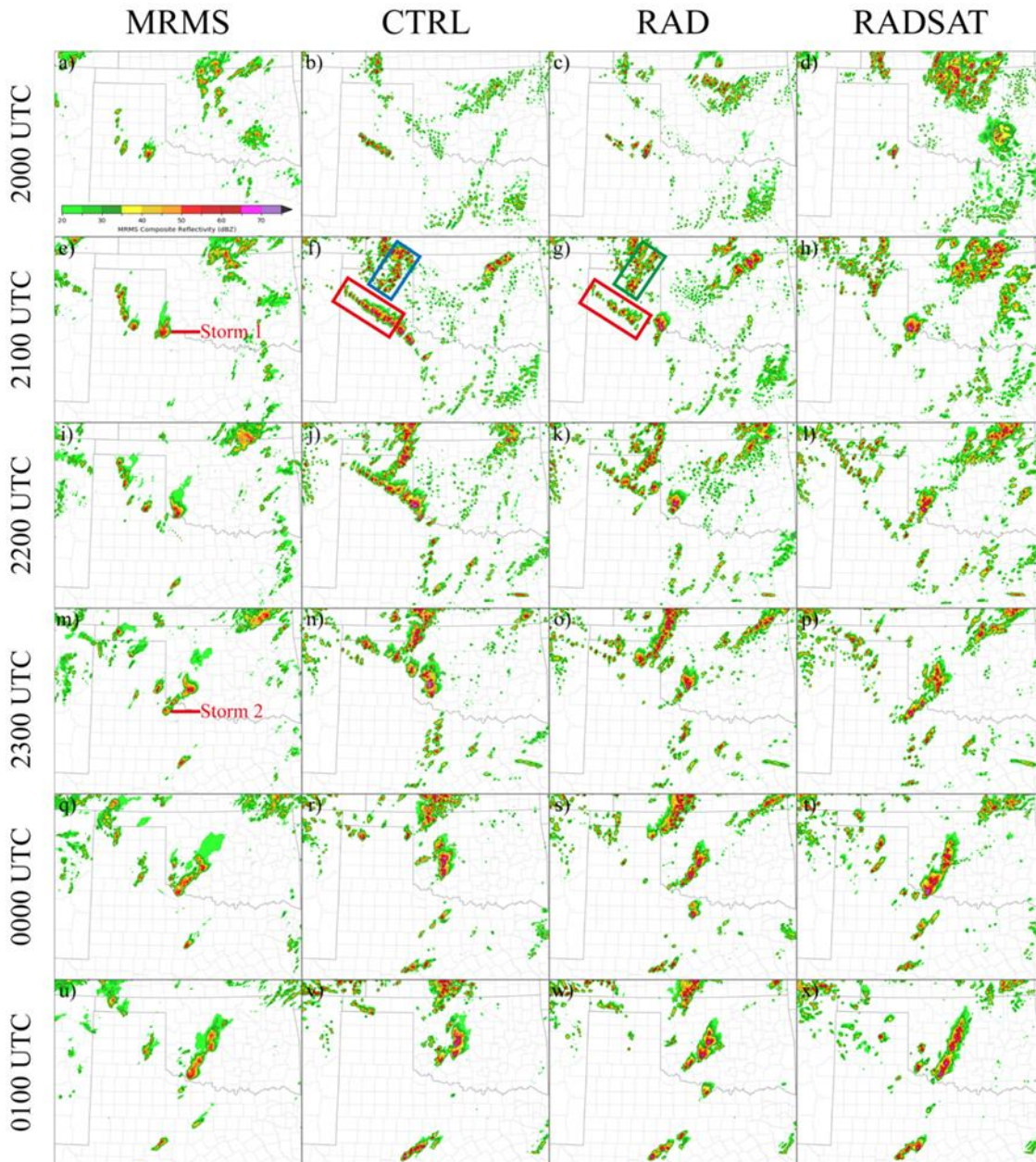


Figure J1.1. The composite reflectivity from MRMS (the first column), forecasted composite reflectivity for CTRL (the second column), RAD (the third column) and RADSAT (the fourth column). The first row (a-d) is from the analysis at 2000 UTC, 10 May 2017; the second (e-h), third (i-l), fourth (m-p), fifth (q-t), sixth (u-x) rows are from 1h, 2h, 3h, 4h, 5h forecasts initiated at 2000 UTC respectively. Boxes in (f) and (g) indicate the locations of over prediction without using satellite observations during the assimilation cycles.

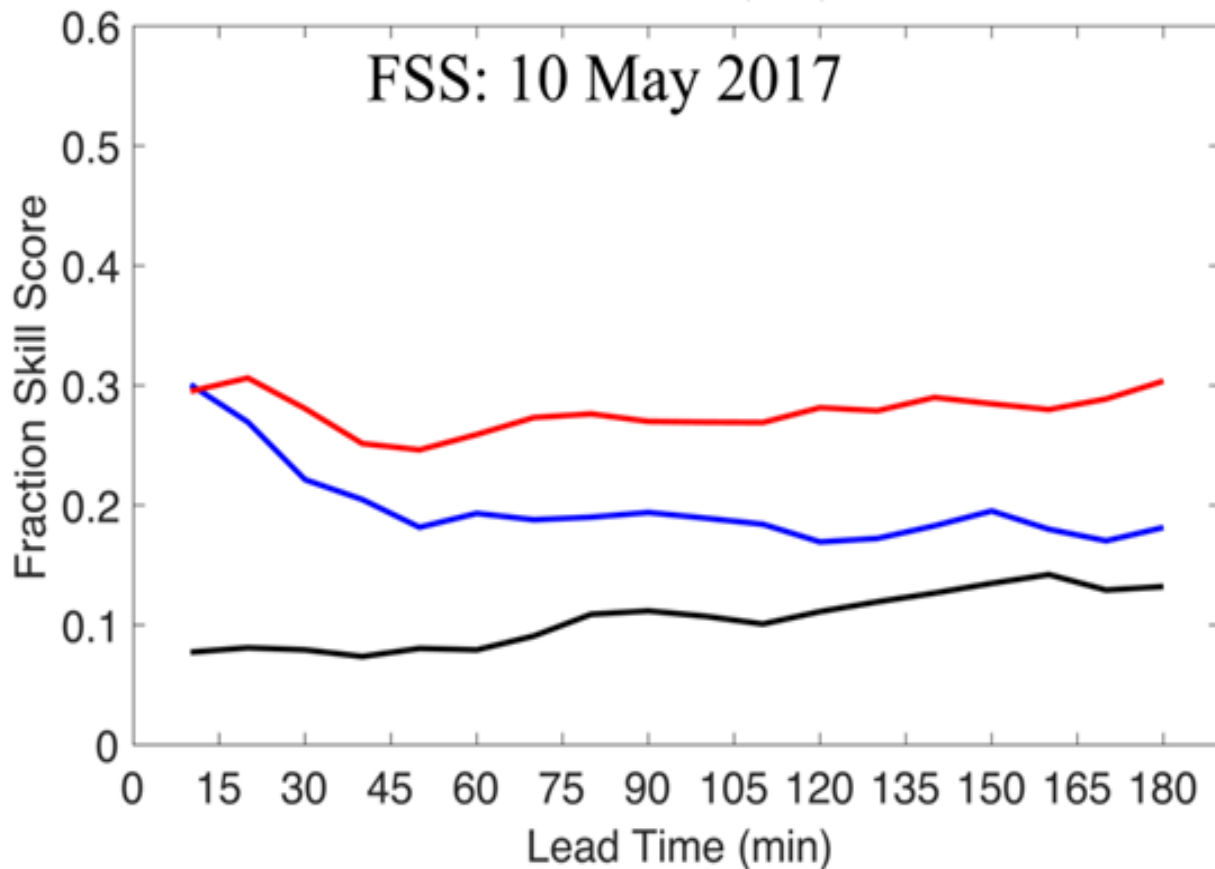


Figure JL2. The FSS for composite reflectivity forecasts against MRMS composite reflectivity for averaged four 0 - 3h forecasts in 10 May 2017 case. It can be seen that ABI provided added value on impact (red) when compared with Radar observations for short-range forecasts.

Severe Storms Component: Tropical Cyclone Applications (Velden, Stettner, Lewis, Olander)

Executive Summary

In FY19, the research foci under this component are 1) explore the application and assimilation of GOES-16 Atmospheric Motion Vectors (AMVs) on fine time and space scales to better characterize the evolving mesoscale flows into and around tropical cyclones, and 2) improve tropical cyclone characterization using GOES-16 derived products. The majority of effort and accomplishment was with 1) during this reporting period.

1) Application and assimilation of high-resolution Atmospheric Motion Vectors (AMVs)

One of the principle benefits from the GOES-R series is the improved temporal sampling of images from the ABI meso-scan mode. The rapid refresh (1-min.) allows for quantitative improvements in derived products such as AMVs over limited-domain (targeted) areas within the satellite FOV. Derived by tracking coherent cloud motions in successive VIS/IR images, AMVs have long stood as an important contributor of tropospheric wind information to NWP analyses and subsequent forecasts on the global scale. In this project, GOES-16 meso-scan imagery is explored to optimize AMV generation on space and time scales commensurate for tropical cyclone (TC) applications.

The reasons we are optimistic that the GOES-R series AMVs can be an important contributor to TC analyses derive from recent proxy studies. From these studies, our project has built on their lessons learned as we also take advantage of GOES-R series capabilities (real data) and new AMV derivation methods. We have then applied this philosophy to the production and optimization of TC-scale AMV datasets with the goal of extracting information that benefits the high-resolution analyses of wind fields in the TC vortex region and near-environment, and through assimilation impacts on hurricane model forecasts. In our approach, we utilize the new (and novel) GOES-R series tracking algorithm developed by the Algorithm Working Group, and focus on the smaller (TC vortex) scales for AMV derivation, quality control, and applications, taking advantage of what the improved ABI temporal and spatial sampling provides. The first goal was to optimize the algorithm settings, tuning, and AMV derivation path to increase the data density and improve the ultimate quality. This process is nearly complete based on extensive empirical testing and case study analyses. The details of the approach and methodology are described in a paper recently accepted in *Remote Sensing* (Stettner et al., 2019).

The other important step in realizing positive impact from the enhanced AMV information on TC model forecasts is the data assimilation process. Explorations using the operational HWRF model system are currently underway, and initial results are positive. These were presented in a previous report by collaborator Jun Li, and these findings were also recently published in the *Journal of Geophysical Research* (Li et al., 2019).

During this reporting period, our HWRF impact experiments have been focused on Hurricane Irma (2017), and can be summarized as follows:

- AMV IMPACT (the original impact experiment, using default gross-error and obs error values)
- AMV THIN (as in AMV IMPACT, but AMVs thinned to 25 km grid horizontally and 50 hPa vertically)
- AMV NEWERR (as in AMV IMPACT, but using modified gross error and obs error values)
- AMV IMPACT LGE (as in AMV NEWERR, but using increased gross error parameters to assimilate more AMV obs)
- AMV IMPACT LGE THIN (as in AMV IMPACT LGE, but with obs thinned to 25 km / 50 hPa grid)

To sum up the results of each HWRF experiment, there is consistency of impact w.r.t Hurricane Irma's track forecast (each of the experiments improves the track forecasts by 5 to as much as 15%). Intensity forecast results are largely mixed: improvement at some lead times, degradation at others. Our partner HWRF expert (Jason Sippel, AOML/HRD) suggests that it will be very tough to get any intensity improvement without using 4DENVAR. Unfortunately, this capability is not part of the publicly-available HWRF trunk right now, but it's something they're hoping to work on this summer.

We feel that we've probably exhausted most of what we can do with obs errors / thinning. In the meantime, we are collaborating with NOAA/HRD to conduct additional AMV assimilation and impact experiments with HWRF. We are currently running experiments without the HWRF default vortex initialization structure modifications -- this should at least allow for better cycling of the flow-dependent covariances (which the AMVs should help with quite a bit). Results of these experiments will be summarized in the next reporting period.

At the beginning of this reporting period (July), we began a real-time in-house demonstration of the enhanced AMV dataset generation during the 2019 Atlantic TC season. The demo generally went well, although there were some glitches and lessons learned. We captured most of the Hurricane Dorian event that can be used in case study analyses. The r/t datasets are triggered by automated processes and produced every 15 minutes when GOES-16 meso scans are targeting a TC. We utilize 1-min. image triplets for the AMV derivation, and dataset displays/plots are produced for real-time monitoring. We plan another such demo during the upcoming 2020 Atlantic TC season, with more inclusion of research/user partners for feedback, and to demonstrate operational readiness.

Following the r/t demo this year, our next step in conjunction with colleagues at NESDIS/STAR (Jaime Daniels) will be to transfer this processing strategy and methodology to NESDIS/STAR as a stepping stone for operational transition.

2) Improve TC characterization using GOES-R series derived products

a. ABI SAL product

The ABI allows for multispectral combination products similar to what are available from SEVERI. The Saharan Air Layer (SAL) split-window product is a popular diagnostic for users following the SAL when it interacts with TCs as the airmass traverses the Atlantic. We have adapted the SAL product to operate with GOES-16 imagery and it is part of the NHC Proving Ground suite of derived-image products.

b. ADT objective TC intensity estimates

Another important application of the ABI is towards improved TC intensity estimates. The Advanced Dvorak Technique (ADT) is an objective algorithm developed at CIMSS and now run in real-time operationally by NESDIS/OSPO and used extensively by NHC/CPHC. Our project aims to explore ways the GOES-16/17 TC intensity estimates from the ADT can be improved. In this reporting period, most of our ADT efforts have been helping STAR implement the latest version of the algorithm (v9.0, with the most recent science upgrades; Olander and Velden, 2019), and with GOES-17 product degradation assessment/mitigation during heat pipe anomaly periods. Our current research thrust is exploring the development of ADT intensity estimate confidence indicators based on statistical and AI approaches.

Plans for Next Reporting Period

The emphasis in the next reporting period will be on continuing the analysis of the TC-enhanced GOES-16 AMVs and refining assimilation strategies in the HWRF hurricane forecast model. We will work with our colleagues at NESDIS/STAR and NOAA/AOML/HRD to ensure significant algorithm upgrades found through testing and experimentation are prepared for transition to operational processing and eventual assimilation into the HWRF model.

For the ADT, a PSDI award is in place to facilitate the upgraded v9.0 implementation into OSPO. Our plan under this GOES-R3 HIW funding will continue R&D of an ADT intensity estimate quality indicator.

Additional Information

1. Interaction with operational partners – We are in communication with forecasters at NHC about the latest versions of our GOES-R series TC products, including involvement in the NHC PG.

2. Conference/workshop participation – Presentation of two GOES-R-related research projects at the 2019 joint AMS/EUMETSAT Satellite Conference, Sept-Oct, Boston:

- Improved Monitoring of the Evolving Upper-Tropospheric Wind Fields over the Core of Tropical Cyclones Aided By High Spatiotemporal Resolution GOES-16 Atmospheric Motion Vectors, C. S. Velden, CIMSS and D. Stettner, S. M. Griffin, R. Rabin, S. Wanzong, and J. Daniels.

- An Update on the CIMSS Satellite Consensus (SATCON) Tropical Cyclone Intensity Algorithm, C. S. Velden, CIMSS and D. Herndon.

3. Outside project publicity – Some of our work supported under this project was highlighted in a recently published book on GOES-R. A chapter dedicated to hurricane applications was written by C. Velden.

4. Journal articles –

Stettner, D.; Velden, C.; Rabin, R.; Wanzong, S.; Daniels, J.; Bresky, W. Development of Enhanced Vortex-Scale Atmospheric Motion Vectors for Hurricane Applications. *Remote Sens.* **2019**, *11*, 1981.

Olander, T.L. and C.S. Velden, 2019: The Advanced Dvorak Technique (ADT) for Estimating TC Intensity: Update and New Capabilities. *Wea. Fore.* **34**, 905–922, doi.org/10.1175/WAF-D-19-0007.1

Jinlong Li, Jun Li, Chris Velden, Pei Wang, Timothy J. Schmit, and Jason Sippel, 2019: Impact of rapid-scan-based dynamical information over the inner-core region of hurricanes from GOES-16 on HWRF hurricane track forecasts. *JGR*, <https://agupubs.onlinelibrary.wiley.com/doi/abs/10.1029/2019JD031647>.

Severe Storms Component: Nowcasting (Petersen, Crounce, Schmit)

Executive Summary

Overall Project Objective: The CIMSS NearCast system provides very-short-range predictions of existing GOES sounder products and has been tested at several NCEP Prediction Centers. It is currently being generalized for expanding and enhancing use of GOES-16 ABI products.

The NearCast system continues to be run in support of a variety of NOAA activities and has been applied to improve Convective Initiation (CI) enhancement using ‘legacy’ atmospheric temperature profiles and moisture profiles. Attention had focused not only on the future state of the moisture and thermal structure of the pre-storm environment, but also on developing new tools to monitor areas of predicted rapid changes in that environment using the increased GOES-16 sounder product frequency/resolution in an effort to reduce false alarms and increase probability of detection once convection occurs, thus improving

CI Product improvements at University of Alabama-Huntsville (UAH). Initial comparison of the existing CI-NearCast fusion techniques using the new GOES-16 NearCast products was also conducted, although no further work in this area was allowed due to funding shortfalls by our research partners on that part of the joint effort. The existing retrospective CI observation data base, however, provides a valuable validation medium for NearCasts. We hope to expand this work in the next year using newly available resources from this project.

In a related activity, efforts are underway to remove one of the largest shortcomings of existing CONUS-NearCast products, that being the large ‘data gaps’ in GOES-R IR sounder fields due to cloud cover. In this activity, moisture and temperature profiles derived from LEO IR and microwave instruments over land (which currently are not assimilated into most operational NWP systems over land) are used to fill the gaps between GOES-R IR-only retrievals. The NearCast system provides a means to time/space-adjust the less frequent LEO data to the times of the GOES-R products, and then projects them forward to present a continuous picture of the current and future moisture-thermal structure of the atmosphere needed for a wide range of forecast problems, including heavy precipitation forecasting. At the recommendation of JPSS leadership, we are shifting our focus to concentrate of full-resolution MiRS products.

Progress toward FY19 Milestones

Adding a short-range forecast component to merged GOES-R/LEO-Constellation profiles to increase the predictability of the pre-storm environment

Recent Progress: The generalized NearCast system has been tested in case study mode using both historical profiles from GOES-13 and in real time using GOES-16 ‘Legacy’ soundings at full spatial/temporal resolution. The system is being run in real time with results available to outside users.

Effort during this period have concentrated on providing initial winds and time-interpolated geopotential gradient tendencies needed for the new sigma version of the NearCast model. Considerable effort has been dedicated to understanding and correcting imbalances seen first when using the new, higher-resolution GFS output products that provide a partial basis in this work. The analysis revealed that a systematic approach to using terrain-following coordinates in a LaGrangian diagnostic-predictive model like the NearCast system has never been published. In Eulerian space, the parameter that provides geopotential gradient information is calculated as the small difference between two large components calculated along the sloping sigma surfaces, which can prove locally problematic in cases of extreme topographic gradients. If that approach is used for LaGrangian applications, the errors spread and become larger due to the need for spatial and temporal interpolation to the changing parcel locations as parcels move across areas with differing surface slopes. In effect, errors over highly sloped areas are not only confined to those areas but are felt by all parcels travelling across the area.

As an alternative, a ‘step-wise sigma’ approach, similar to that described by Mesinger for “Eta” coordinate models, is being applied. In essence, for each time step, parcels travel on their current isobaric surfaces to new locations, at which time, they ‘step up/down’ to a new pressure level defined by the surface pressure at that location. This approach reduces larger excursions of parcels in areas of highly sloped terrain noted using more traditional approaches. Final implementation is underway.

Near-real-time data sources are being used in regular execution of the merged GEO/LEO NearCast system over the CONUS. Inclusion of high-horizontal-resolution MiRS retrievals from S-NPP, JPSS and other platforms helps fill cloudy voids in existing GOES-IR-only NearCast products (See Fig. RP1 below).

Preparations for regular real time testing of the GEO/LEO system over the CONUS using alternative, higher resolution microwave data sets, however, require access to lower latency data sources, which we believe we may have identified. The MiRS data will allow inclusion of observations from many more polar microwave platforms than are available through NUCAPS processing and with much more detail (see figure below). When, and if, moisture retrievals become available from the GOES-west satellite, the NearCast system will be adapted to use real-time microwave retrievals around and over Alaska for our partners there and hopefully in western Canada. Documentation of the NearCast system planned for this period continues.

Plans for Next Reporting Period

Efforts during the last period have continued to be hampered by the departure of primary CIMSS employee to the NWS. Although the employee was not directly associated with this project, his primary colleague (who is essential to this project) has been seconded to fill in the empty gaps in other projects. As such, progress (as well as spending) on this project have been less than expected. This issue was lessened during the latter part of the reporting period.

When testing is completed, outputs from the real-time GEO/LEO NearCast runs over CONUS will be made available in both image and GRIB format for ready inclusion in AWIPS using existing CIMSS-to-AWIPS communications methods. Statistical methods will also be explored to accommodate difference in biases between the various observation sources, thereby improving the spatial and temporal continuity in the graphical forecast fields.

With our most recent funding addition, we will continue developing means to incorporate new GOES moisture/thermal profiles with increased temporal and spatial resolution (currently under development by others) and compare them with results using 'legacy' products, providing comparisons of isobaric and sigma versions of the NearCast model, as well as providing an independent 'benchmarks' for assessing efforts to incorporate GOES-R profiles over land in more sophisticated regional/storm scale data assimilation systems and NWP models. We also hope to revitalize the previous CI/NearCast false alarm reduction efforts using either with UAH or EUMETSAT CI products as available.

Additional Information

1. Interaction with operational partners – Establishing working relationships with equivalents to the former GOES-R Satellite Liaisons at applicable locations is essential. Provide guidance as requested.
2. Conference/workshop participation – None this period
3. Outside project publicity – Initial discussion with EUMETSAT about using LEO/GEO and CI methods developed planned for EUMETSAT Convection Working Group meeting in April 2020 but postponed due to Coronavirus.
4. Journal articles – NearCasting manuscript continues to be developed.

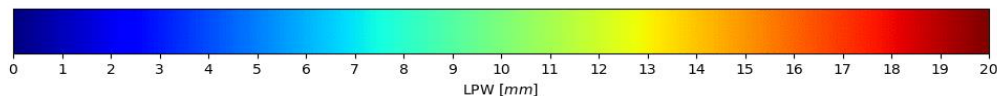
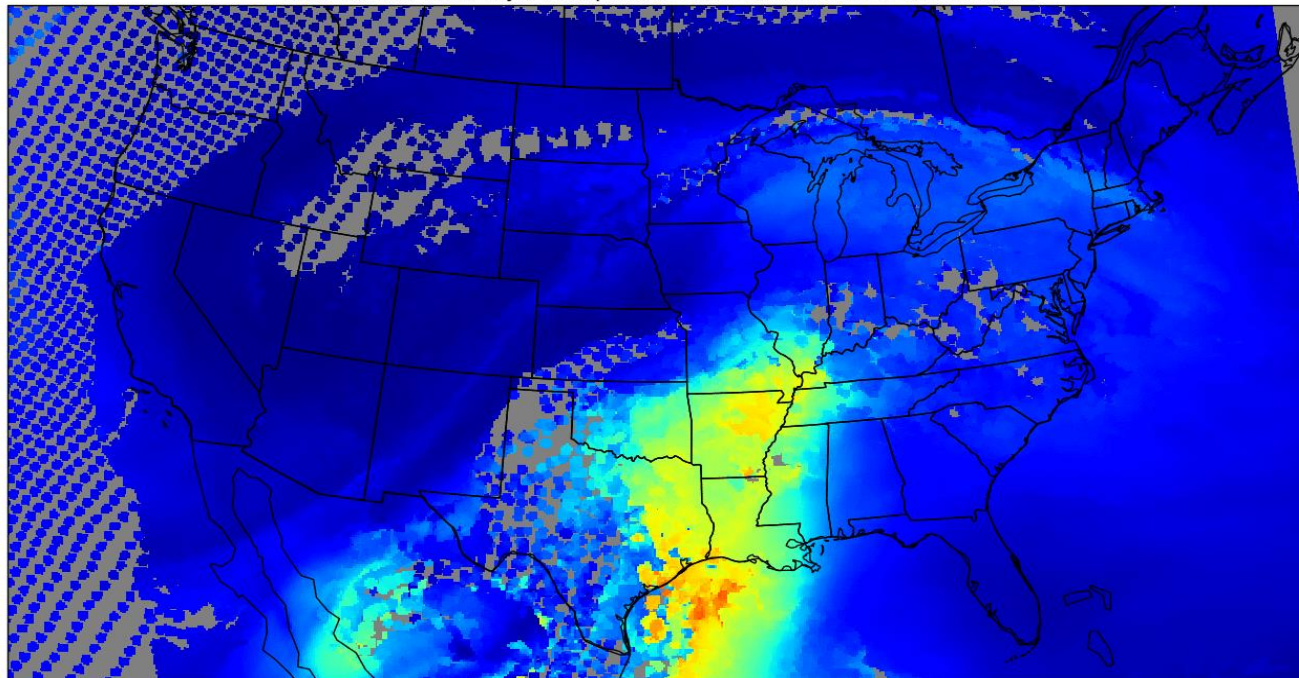
NearCast 0.7-0.3 σ Layer Precipitable Water valid 20200203 at 1901 UTC

Fig. RP1. Example of results of merging a sequence of GOES IR PW and MiRS microwave retrievals on 3 Feb 2020. The combined product, done in conjunction with a related JPSS supported project, shows utility for including microwave moisture profiles from multiple satellites providing MiRS data in providing detailed structure in data voids left in GOES IR observations in regions of clouds and high moisture content prior to substantial precipitation event.

Fires/Smoke Component (Schmidt, Bah)

Executive Summary

The Fires/Smoke component in FY19 continued development of the fire clustering algorithm and development of blended products that combine the FDCA, 10m winds, true color imagery, smoke mask, and lightning detection (and perhaps more) for AWIPS-2. In 2019 this project was utilizing leftover funds from the previous years. The fire clustering work was put on hold in light of discussions about the upcoming Fires Enterprise Algorithm. Development of the blended products continued, but the results were not considered adequate to proceed further. Late in 2019 the decision was made to redirect the remaining funds to support a new fire notification initiative from NOAA.

Progress toward FY19 Milestones

1) Clustering in time and space of FDCA fire detections

The conceptual model for temporal clustering of fire detections has been defined. For each time period, the fire algorithm produces its detections which are then clustered in space. Spatial clusters through time are then grouped by looking at intersections and proximity of those clusters over the multiple time steps. While temporal clustering for one ABI instrument could be achieved by simply comparing pixel locations on the fixed grid, during discussions about the design of the Fires Enterprise Algorithm for NOAA it became evident that the temporal clustering could be applied to any available platforms so long as the fire data is available. That would allow creation of “fire events” that carry the detection records along with composite FRPs for the various time steps. Implementation challenges include correcting the fire outlines for parallax, which requires developing a model that maps pixel edges to Earth locations taking into account the terrain using ray-tracing of a 3D, spherical model of the Earth. It was observed during the FIREX-AQ campaign that while GOES-16 and GOES-17 FDCA data was very valuable, the parallax offsets were problematic in regions at higher elevations. Such parallax offsets would also cause mismatches between the fire polygons. The development work was suspended at this point pending further design of the Enterprise Algorithm (still ongoing).

2) Blended products for AWIPS-2/AWIPS thin client

This task’s goal is to create a pre-packaged, low-bandwidth (i.e. one layer) image of ABI fire detection information and other useful information, such as winds, dewpoints, lightning detections, and true color imagery. In previous periods the initial images merging FDCA mask information with true color imagery was demonstrated using tools that could be ported to an operational system. However, adding meaningful wind fields proved time-consuming given data project conversion issues and a lack of appropriate tools. The work was suspended in lieu of the fire notification project.

3) Fire notification via e-mail or text pilot project, aka “Eaglewatch”

In fall of 2019 a team from NOAA contacted CIMSS seeking feedback on the geostationary fire product as part of an effort by NOAA to build better products for users. Both CIMSS and the NOAA team were simultaneously in contact with Geoffrey Berlin from the Department of Homeland Security, who had asked for a statement of work from Chris Schmidt regarding how to implement a fire notification system. Progress had stalled due to lack of available funding. The NOAA team took up the mantle and while funding was not immediately identified, the available funding remaining for the Fires component of this project was deemed sufficient to support at least the first steps of the pilot project. The beta test fit with the spirit of the original proposal and goals of this project. That kicked off in mid-December with initial software development and definition of areas of interest for the beta testers; southern California fire chiefs. Note: “Eaglewatch” is the current working name, but may not be the final name. It was decided to use the fire product made at SSEC, which is very similar to the operational FDCA, due to the shorter development time and availability of fire products for the Mesoscale sector scans that NOAA does not produce.

Plans for Next Reporting Period

The remaining funding will be used to develop the software that takes the fire detection product produced at SSEC, compares it to defined areas of interest, and pushes out notifications to the interested parties. Steps will be taken in the software to address issues like repeat detections, and regarding which users have differing desires and needs. The remaining funding will not cover much beyond the initial beta test/proof of concept.

Additional Information

1. Interaction with operational partners – Through participation in the “Eaglewatch” project, there were discussions with fire chiefs from various agencies, mostly in California but also in other states like North Carolina, as well as Donna McNamara regarding questions about FDCA access through PDA that were relevant to the design of the beta test.
2. Conference/workshop participation – None for this reporting period.
3. Outside project publicity – None at this time, however NOAA intends to create some kind of publicity for the beta test at a later date.
4. Journal articles – None

GOESR3 Periodic Reporting

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Team Lead: R. Bradley Pierce (UW-SSEC) and Chris Velden (UW-CIMSS)

Team Members: Chris Schmidt, Jun Li, Ralph Petersen, Lee Crouce, Dave Stettner and Tim Olander (CIMSS), Tim Schmit (ASPB), Megan Bela (ESRL/CIRES)

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The CIMSS GOES-R High Impact Weather Research Theme focuses on two major high impact weather events: fires and severe storms. The objective of the fires component of the research is to improve NWS WFO and IMET situational awareness during wildfire events. The fires component has three sub-topics focusing on fire detection and characterization, smoke forecasting and data assimilation, and development of probabilistic estimates of lightning wildfire ignition sources. This report details the contributions of the ESRL/CIRES team (led by Dr. Megan Bela) to the fire component of the CIMSS GOES-R High Impact Weather Research Theme.

Progress toward FY19 Milestones

Since 2016, an experimental smoke forecasting system, the High-Resolution Rapid Refresh coupled with Smoke (HRRR-Smoke) model, has been running at NOAA/ESRL at very high spatial resolution (3 km) over the contiguous U.S. (domains depicted in Figure 1). The HRRR-Smoke model is based on NOAA's HRRR numerical weather prediction (NWP) operational system. HRRR-Smoke uses a single tracer to simulate primary PM_{2.5} from fires. The tight coupling between meteorology and smoke aerosol through aerosol-radiation-cloud interactions within HRRR-Smoke enables forecasting of smoke impact on weather and visibility. For example, surface temperature differences as high as 15°F between HRRR runs with and without smoke were seen in Missoula, MT during fire season. The HRRR-Smoke experimental forecast products are disseminated to NWS forecasters and the public via a web-page and other real-time data-streaming tools. The transition of the smoke component of HRRR-Smoke to the operational HRRR system at NCEP is currently in progress.

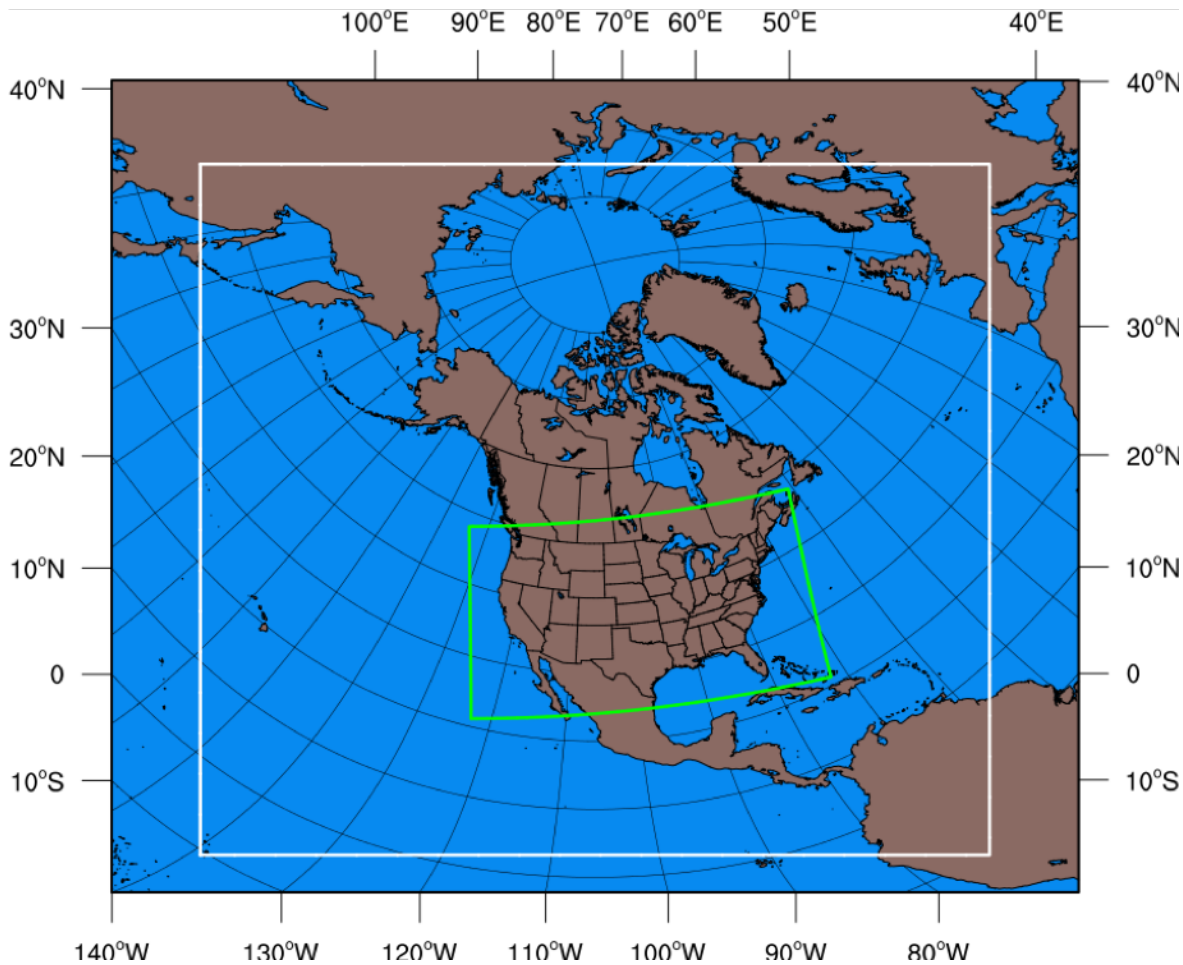


Figure 1. Operational weather forecast models at NCEP: RAP (white), 13km resolution HRRR model domains (green), 3km resolution (<https://rapidrefresh.noaa.gov/>)

The ESRL/CIRES team contributes to the fire component milestone “Support NWS smoke forecasting and assimilation.” During the July to December 2019 period, HRRR-Smoke was used by the Fire Influence on Regional to Global Environments and Air Quality (FIREX-AQ) field campaign for flight planning and support, as well as by U.S. wildfire managers and air quality forecasters to predict the impacts of smoke on firefighting operations and affected communities.

Evaluation is underway of HRRR-Smoke forecasts for the 2018 fire season. Figure 2 compares Aerosol Optical Depth (AOD) retrieved from the Visible Infrared Imaging Radiometer Suite (VIIRS) satellite with that predicted by the HRRR-Smoke forecast for August 20, 2018. HRRR-Smoke predicts the high AOD values (>1.8) seen by VIIRS over the Pacific Northwest (region denoted by oval) that were due to intense wildfire activity.

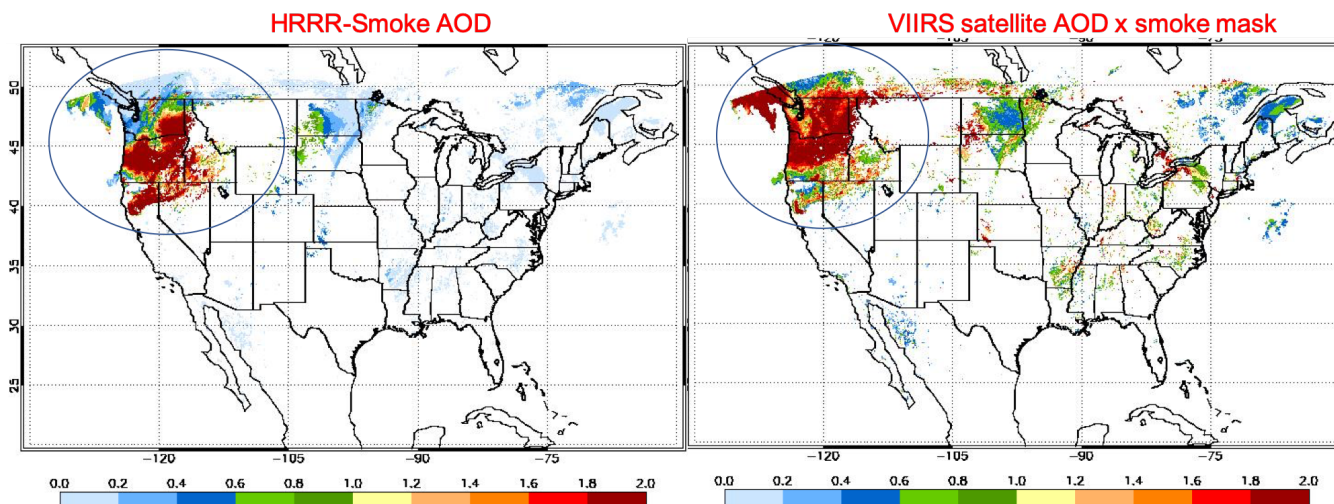


Figure 2. Forecast verification using the VIIRS AOD data, August 20, 2018

Currently, we are comparing HRRR-Smoke and WRF-Chem simulations of the 2018 fire season with surface observations. We have also initiated running WRF-Chem simulations of the 2019 fire season.

Plans for Next Reporting Period

As part of the milestone “Support NWS smoke forecasting and assimilation,” we will explore the development of GOES-R FRP based fire emissions for the HRRR-Smoke and WRF-Chem model systems. We will also continue work on evaluation of HRRR-Smoke and WRF-Chem simulations of the 2018/2019 fire seasons, comparing simulations with observations collected during the Western Wildfire Experiment for Cloud Chemistry, Aerosol Absorption and Nitrogen (WE-CAN), CU Trace Gas Emission Fluxes from Biomass Burning Sources (BB-FLUX), and FIREX-AQ field campaigns.

Additional Information

1. Interaction with operational partners –

Leading up to and during FIREX-AQ, Dr. Bela provided input for flight planning for the NOAA Twin Otter and UAV participation. Dr. Bela visited the DC-8 and Twin Otter operations centers in Boise for one week during the campaign and attended daily forecasting briefings and a science team meeting. While in the field, Dr. Bela set up a workflow for transitioning flight forecasting activities from the NASA DC-8 team to primarily NOAA Twin Otter operations. Dr. Bela then provided forecasting support for the Twin Otter, including use of HRRR-Smoke forecasts, during the remainder of the campaign.

2. Conference/workshop participation –

Bela, M. M., N. Kille, S. A. McKeen, R. Ahmadov, G. Pereira, C. Schmidt, R.B. Pierce, S.M. O'Neill, X. Zhang, S. Kondragunta, C. Wiedinmyer, and R. M. Volkamer, Emissions, Transport,

and Chemistry of Smoke from the Oct. 2017 Northern California Fires, Atmospheric Chemistry Gordon Research Conference, Newry, Maine, 28 Jul to 2 Aug 2019. (poster)

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3. Outside project publicity – None this period

4. Journal articles –

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