PhD Defense Announcement
Yoonjin Lee
November 30, 2020 at 2:00 p.m.

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PhD Defense

Monday, November 30, 2020
2:00 p.m.

Defense
Virtual (Teams link to follow)

Post Defense Meeting
Virtual (Teams link to follow)

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USING GOES-16 ABI DATA TO DETECT CONVECTION, ESTIMATE LATENT HEATING, AND INITIATE CONVECTION IN A HIGH RESOLUTION MODEL

Convective-scale data assimilation has received more attention in recent years as spatial resolution of forecast models has become finer and more observation data are available at such fine scale. Significant amounts of observation data are available over the globe, but only a limited number of observations are assimilated in operational forecast models in the most effective way. One of the most important observation data for predicting precipitation is radar reflectivity from ground-based radars as it provides three-dimensional structure of precipitation. Many operational models use these data to create cloud analysis and initiate convection. In High-Resolution Rapid Refresh (HRRR), the cloud permitting operational model at National Oceanic and Atmospheric Administration (NOAA) that is responsible for short term forecasts over the Contiguous United States (CONUS), latent heating is derived from ground-based radars and added in the observed convective regions to initiate convection. Even though adding heating is shown to improve forecasts of convection, this cannot be done over ocean or mountainous regions where radar data is not available.

Geostationary data are available regardless of radar coverage and its data are provided in similar spatial and temporal resolution as ground-based radar. Currently, geostationary data are only used as a source of cloud top information or atmospheric motion vectors due to lack of vertical information. However, Geostationary Operational Environmental Satellites (GOES)-16 and -17 have high temporal resolution data that can compensate the lack of vertical information. From loops of one-minute visible images, convective clouds can be detected by finding a region with a constant bubbling. Therefore, this dissertation seeks a way to use these high temporal resolution GOES-16 data to mimic what radars do over land.

In the first two papers presented in the dissertation, two methods are proposed to detect convection using one-minute GOES-16 Advanced Baseline Imager (ABI) data. The first method explicitly calculates Tb decrease or lumpiness of reflectance data and finds convective regions. The second paper tries to automate this process using machine learning method. Results from both methods are comparable to radar product, but the machine learning model seems to detect more convective regions than the conventional method.

In the third paper, latent heating profiles for convective clouds are estimated from GOES-16. Once a convective cloud is detected, latent heating profiles corresponding to cloud top temperature of the convective cloud is searched from the lookup table created using model simulations. This technique is similar to spaceborne radar inferred latent heating developed for National Aeronautics and Space Administration (NASA)'s Global Precipitation Measurement Mission (GPM). Latent heating assigned from GOES-16 is shown to be similar to latent heating derived from Next-Generation Radar (NEXRAD) once they are summed up over each cloud.

Finally in the last paper, latent heating estimated by using the method from the third paper are assimilated into the Weather Research and Forecasting (WRF) model to examine impacts of using GOES-16 derived latent heating in initiating convection in the forecast model. Two case studies are presented to compare results using GOES-16 derived heating and NEXRAD derived heating. Results show that using GOES-16 derived heating sometimes produce deeper convection than it should, but it improves overall precipitation forecasts. This appears related to the much deeper column of heating assigned by GOES than the empirical relation used by the HRRR operational scheme. In addition, in a case when storms developed over Gulf of Mexico where radar data are not available, forecasts are improved using GOES-16 latent heating.