Evaluation of the GOES-R Proving Ground Convective Initiation in the Plains: GOES East Convective Initiation Nowcast Products

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Introduction

It has been well documented that forecasting and detecting convective initiation (CI) is a challenging operational meteorology problem (Mecikalski et al. 2006; Sieglaff et al. 2010). In the plains of the United States, CI generally occurs within two primary regimes:

- During the afternoon when daytime heating creates a warm airmass conducive to conditional instability and
- During the late night or early morning hours when the low level jet is present and the conditional unstable source air is located above the boundary layer. This will be referred to as "nocturnal elevated convective initiation" (NECI).

The goal of this presentation is to describe a new evaluation project that is designed to determine the usefulness of the GOES-R Proving Ground convection initiation (CI) products for the Great Plains region (Figure 1). The project will investigate products developed and distributed by the Cooperative Institute for Meteorological Satellite Studies (CIMSS) at the University of Wisconsin (UW) and the Short-term Prediction Research and Transition Center (SPoRT) at the University of Alabama-Huntsville by the NWS forecaster. These products are designed to provide valuable information on a cloud field that has the potential to evolve upscale into convection. Two primary products are generated: a filtered cloud top cooling (CTC) rate, and from the CTC product, a CI nowcast is produced. The CI nowcast has three CI categories: pre-CI Cloud Growth, CI Likely, and CI Occurring. Previous research has shown that the CI products do a reasonably good job of indicating convection and can even provide positive lead times of the convection for the forecaster. However, the products can also have a significant false alarm rate. An assessment of atmospheric conditions during both positive and negative situations from the use of these products has not been thoroughly completed. Therefore, this research investigates when the convection initiation products works, as well as when the products do not work through an evaluation of the products related to the atmospheric conditions. The research will provide information to the forecaster regarding confidence levels and situations when the products will be beneficial to operations.

Figure 1: Proposed area of study

Methodology/Data

In order to determine the usefulness of the CI parameters for NWS forecasters, several specific research tasks are proposed. The major task will be to determine the POD, FAR, and lead times of the CI products and determine the atmospheric conditions during the CI events. This task is a continuation and expansion of the research performed by Sieglaff et al (2011). The thought is to collect all CI pixels, Pre-CI cloud growth, CI likely, and CI occurring when a parameter is calculated and follow the event through time to determine if convection occurred or not. Convection will be determined by using the radar reflectivity returns greater than a 35 dBZ value on the 0.5 degree elevation angle. As in the Sieglaff et al (2011) study, pixels will be grouped together where feasible and followed as a group. Once a CI parameter is identified, a data report will be made for the event and recorded for further analysis. An example of a possible data report is given in Table 1. We realize that the data report (and the parameters within) will change as we further develop the project. The logistics of the event will be gathered by student workers. The forecast conditions and possible reasons for positive detections or false alarms are to be determined by WFO OAX forecast personnel in conjunction with the student workers. In particular, we are looking for thermodynamic conditions that will aid the interpretation of the CI parameter. These conditions will be recorded in the data reports.

Table 1: Example of a data report format for POD and FAR cases

Event #	Rapid scan (yes/no)	Location		Time UWCI	CTC	Indication of Convection	dBZ >35	Time of event	Lead Time	Relationship to Ice exclusion zone
		Lat	Long							

Atmospheric Conditions							
Cloud type	Cloud features	MLCINH	MLCAPE	Cloud top WS	Cloud top WD	SPC category	Forecaster comments

Once the data reports are accumulated, we will investigate individual case events to see why CI worked or not. We would like to determine similarities atmospheric conditions and see how the CI product performed under these conditions. For example, preliminary analysis of several recent events shows problems with the CI parameter when there is a strong cap present (high CIN), as well as conditions characterized by an absence of CAPE. Obtaining multiple occurrences of similar events allows forecasting techniques to be developed and used in similar situations.

From the knowledge learned about the environmental conditions that support and do not support CI and/or NECI, other potential operationally useful tools could be developed to aid the use of the simulated GOES-R CI products such as the map shown in Figure 2. This is an example of a mock-up prototype product that could be developed to show exclusion zones where the products either will not be computed or where they will likely give erroneous results. Foe example, the UW developers already provide an "Ice Cloud Exclusion Zone" product to identify areas where the UWCI algorithm will not be exercised because of the ice cloud masking any potential CI below it. This product is critical to use alongside the CTC rate and the CI nowcast products as it allows the user to see where the algorithm will attempt to identify the CI.

Figure 2. A mock up of a prototype product with the ice cloud exclusion zone (orange) and capping exclusion zone (red) that would show where the CI algorithms cannot be computed.

Preliminary Case Studies

Kansas

Three CIMSS nowcasts were taken from a case study on 10 April 2011. Figure 3 illustrates a case in southeast Kansas where there was a nowcast of CI Likely, but the atmosphere was not conducive for CI or NECI due to a dry boundary layer and a stable atmosphere. These cumulus clouds did not grow into convective thunderstorms and no radar echoes were observed, thus this event would be considered a false alarm.

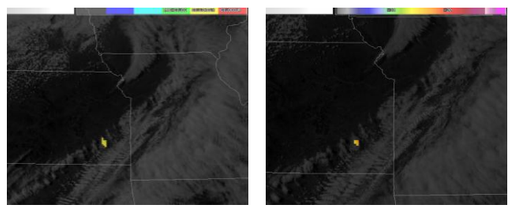

Figure 3. *(Left)* Goes East visible image in SE Kansas for 2040 UTC 10 April 2011 with CI Likely (yellow pixels) displayed. (*Right*) CTC rate ranging from -14.4K (15 min)$^{-1}$ to -17.0K (15 min)$^{-1}$ indicated by the colored pixels.

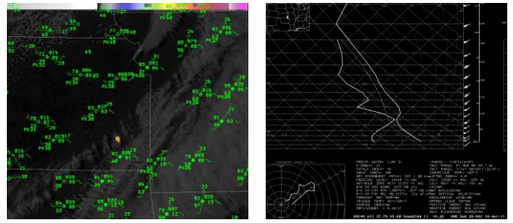

Figure 4. *(Left)* Goes East visible imagery at 2040 UTC 10 April 2011 for SE Kansas with surface observations. (*Right*) RUC 1hr forecast sounding for southeast Kansas valid 2000 UTC 10 April 2011.

Missouri

The environment over northeast Missouri was supportive of convective growth and a nowcast of CI Likely was identified (Figure 5). A radar echo of greater than 35 dbz occurred, so the case was considered a POD. Approximately one hour later, the Storm Prediction Center (SPC) issued Tornado Watch Number 122 for the area. In this environment, the mean layer convective available potential energy (MLCAPE) was approximately 1000 J KG^{-1} and the mean layer convective inhibition (MLCIN) was approximately 60-100 J KG^{-1} (Figure 6).

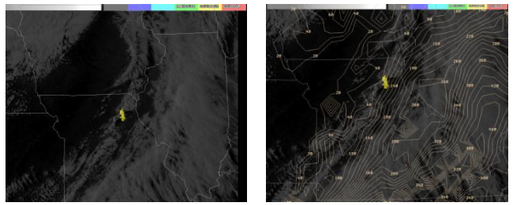

Figure 5. Goes East visible image in NE Kansas for 2210 UTC 10 April 2011 with CI Likely (yellow pixels) displayed. (*Right*) Overlaid with RUC 00hr mean layer (lowest 100 hPa) convective inhibition.

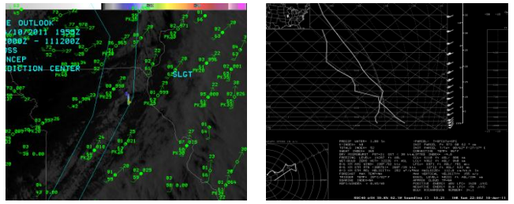

Figure 6. *(Left)* Goes East visible imagery at 2210 UTC 10 April 2011 for NE Missouri with surface observations and CTC rate ranging from -6.0K (15 min)$^{-1}$ to -14.5K (15 min)$^{-1}$ indicated by the colored pixels, SPC Convective Outlook valid from 2000 UTC 10 April 2011 to 1200 UTC 11 April 2011. (*Right*) RUC 1hr forecast sounding for northeast Missouri valid 2200 UTC 10 April 2011.

Wisconsin

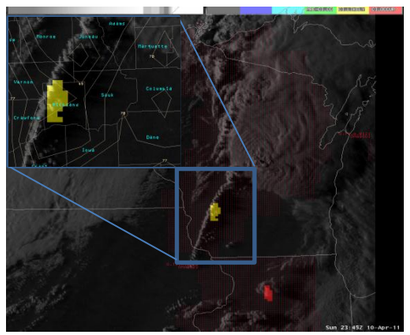

Figure 7. 2345 UTC 10 April 2011 GOES East visible image with nowcast showing CI Likely (yellow pixels) in SW Wisconsin and NWS Storm Prediction Center Tornado Watch number 120 valid from 2020 UTC 10 April 2011 to 0400 UTC 11 April 2011 (*shaded in red*). (*Insert*) Overlaid with RUC 01hr mean layer (lowest 100 mb) convective inhibition.

Convective initiation over southwest Wisconsin was also identified (Figure 7). A radar echo of greater than 35 dbz occurred, so the case was considered a POD. Tornado Watch Number 120 issued by the Storm Prediction Center (SPC) was in effect for the area at the time of the convective initiation. In this environment, the mean layer convective inhibition (MLCIN) was approximately 50 J KG^{-1} (Figure 7 insert).

Expected Outcomes

- Provide a quantitative assessment of the accuracy and predictability of the simulated GOES-R CI products
- Provide an assessment of atmospheric conditions that support positive detections and false alarms from the simulated GOES-R CI products
- Provide an assessment of atmospheric conditions that influence lead times of the simulated GOES-R CI products
- Provide an assessment of the UW and UAH CI algorithms
- Investigate "data fusion" techniques to combine the satellite data with other environmental data for more efficiency and meteorologically sound products.
- Provide developers with suggestions for improvements and possible additional tools or products
- Develop logical situational awareness and forecasting techniques for use of the simulated GOES-R CI products
- Document forecaster challenges using the simulated GOES-R CI products
- Develop forecaster training material for the use of the simulated GOES-R CI products

Summary

In order to determine the usefulness of the CI parameters for NWS forecasters, several specific research tasks are proposed. The major task will be to determine the POD, FAR, and lead times of the CI products and determine the atmospheric conditions during the CI events. The thought is to collect all CI pixels, Pre-CI cloud growth, CI likely, and CI occurring parameters and follow these parameters through time to determine if convection occurred or not. Convection will be determined by using the radar reflectivity returns greater than a 35 dBZ value on the 0.5 degree elevation angle. Pixels will be grouped together where feasible and followed as a group. Once a CI parameter is identified, a data report will be made for the event and recorded for further analysis. For positive detection cases, lead times will be analyzed. The events will be collected on a daily basis and then summarized on monthly and seasonal scales. Observed and modeled environmental data will also be collected to correlate positive and negative cases with various environmental characteristics.

At the conclusion of the research, a thorough statistical analysis will be performed on the convection initiation products' POD, FAR, and lead times. Of primary importance to operational forecasters will be an assessment of atmospheric conditions in which the products performed well and conditions in which they performed poorly. We expect to learn when the products will be the most beneficial to forecasters, as well as how to best incorporate environmental data into the use of the products to accurately predict where and when convection initiation will occur. This knowledge will also improve the forecaster's ability to maintain and improve situational awareness of the convective environment.

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