

GOESR3 Periodic Reporting

Reporting Period: July 2017 – December 2017 (1st half of FY17 funding cycle)

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Project Title: Data Assimilation of GLM Observations in HWRF/GSI System

Project Number: 410

Executive Summary

In this reporting period we focused on preparing for use of GLM lightning data. The reporting period addresses the FY17 Milestone #1: Prepare for using GLM lightning data in GSI data assimilation, with tasks: (1) Prepare the format of input lightning data for use in GSI (i.e.,BUFR), and (2) Optimize the transformation from lightning strikes to lightning flash rates for HWRF. Both tasks are successfully completed. Transformation of GLM observations to NCEP BUFR format is required by NOAA operational data assimilation system (GSI). Lightning observation operator in data assimilation requires lightning flash rates, rather than lightning strikes, making necessary to transform lightning strikes to lightning flash rate. In addition to standard calculation of flash rates we developed an optimized version of the flash rate transformation based on weighting by relative distances. In overview, the Milestone #1 has been successfully completed as planned.

Progress toward FY17 Milestones

All milestones and tasks covering the reporting period are successfully completed. The reporting period addresses the FY17 Milestone #1: Prepare for using GLM lightning data in GSI data assimilation, with tasks: (1) Prepare the format of input lightning data for use in GSI (i.e.,BUFR), and (2) Optimize the transformation from lightning strikes to lightning flash rates for HWRF.

1. Prepare the format of input lightning data for use in GSI (i.e.,BUFR)

Since the NOAA operational data assimilation system, hybrid Gridpoint Statistical Interpolation (hybrid-GSI), requires input observations to be in the NCEP BUFR format, the GLM observations have to be transformed to the BUFR format. Building on our previous work with Global Forecast System (GFS) data assimilation, we developed the transformation from binary format to BUFR format. In principle, we can transform from other common formats, such as NETCDF or HDF. The most challenging aspect of this work was to create BUFR mnemonic tables suited for a new observation such as GLM. Our algorithm was successfully completed and tested.

2. Optimize the transformation from lightning strikes to lightning flash rates for HWRF

GOES-R GLM data are the snap-shots of total lightning strikes. However, assimilation and forecast threat estimation of lightning planned in this project requires lightning flash rate. Therefore, preparation for GLM data assimilation needs to include a transformation from the original GLM strikes to lightning flash rates. Lightning flash rates (*FR*) are typically calculated as number of strikes (*NS*) per area and per time

$$FR = \frac{NS}{\Delta S \Delta T} \quad (1)$$

where ΔS denotes the area and ΔT denotes the time interval. Typical area units are square kilometers and time units are hours, i.e. the units of FR are $km^{-2}hr^{-1}$. A common approach is to use a regular horizontal grid to define the locations of flash rate observations, making the calculation of ΔS relatively easy. Resolution of the grid is chosen to be 10 km, approximately corresponding to an average resolution of GLM data. The time interval ΔT is typically chosen to correspond to the assimilation window, i.e. 6 hours for the current HWRf DA system.

The standard calculation of the FR is conducted in the immediate vicinity of each grid point, without an overlap. The process of calculating FR is schematically represented in Fig.1. The square area bordered by blue lines represents the area ΔS , and the strikes that contribute to the FR calculation at the central point are denoted by blue circles.

Although essentially correct, the standard calculation does not take into account the distances from the central point. Therefore, an improvement to the standard RF calculation can be to weigh lightning strikes according to their relative distance from the central grid point, with closer strikes having more impact on the FR calculation. Fig.2 illustrates how the relevant distances for the same setup as shown in Fig.1. The weighted FR calculation formula is

$$FR = \frac{\sum_{i=1}^{NS} \left(\frac{D}{d_i} \right)}{\Delta S \Delta T} \quad (2)$$

where the distance of the i -th lightning strike from the central point is denoted d_i . The quantity D is used as a normalization constant and is defined as $D = \sum d_i$. Therefore, $\left(\frac{d_i}{D} \right)$ is a relative distance of the lightning strike and $\left(\frac{D}{d_i} \right)$ is a relative weight. A closer inspection of Eq.(2) shows that if there is only one strike the flash rate is equal to the standard FR (e.g., Eq.(1)).

Plans for Next Reporting Period

In the next reporting period we plan to examine and adjust the lightning observation operator used in HWRf.

Additional Information

1. Interaction with operational partners –

A meeting with Avichal Mehra (lead of EMC HWRf group) and other members of the HWRf group Zhan Zhang and Zaizhong Ma, was held at EMC in November 2017. Discussion was related to various aspects of the project and the coordination with ongoing HWRf and data assimilation development. We also met with EMC data assimilation group, led by John Derber, and discussed future development of data assimilation at EMC.

2. Conference/workshop participation –

None.

3. Outside project publicity –

None.

4. Journal articles –

None.

Key Graphics

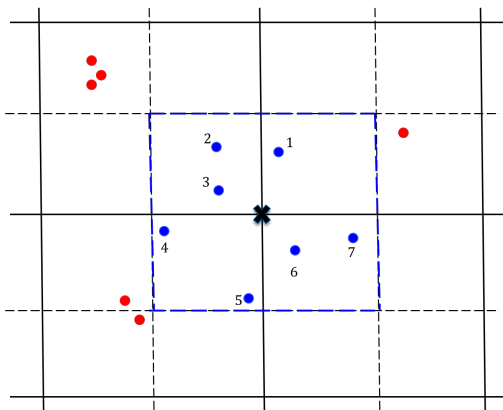


Figure 1

Figure 1. A schematic of calculation of the flash rate observations. The full black lines denote the gridded domain where FR observations are calculated (e.g., at 10 km resolution), and the dashed black lines denote the middle-line between the grid points. The black x-sign denotes the central grid point at which the FR calculation is performed, and the blue dashed line encompasses the area that impacts the calculation at the central point. The circles represent the lightning strikes: blue circles denote the strikes that impact the central point, and red circles the strikes that impact other points. Therefore, in this example, there are 7 lightning strikes that impact the central point.

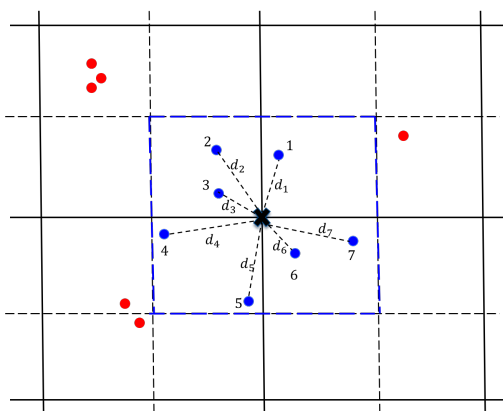


Figure 2

Figure 2. A schematic of *weighted* calculation of the flash rate observations. Associated with each lightning strike is also a distance from the central grid point at which FR is calculated. Relative weights are calculated based on distances, so that the FR is calculated as a weighted mean of surrounding lightning strike points.