4.3 **ASSIMILATION OF LIGHTNING DATA INTO RUC MODEL CONVECTION FORECASTING**

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1. MOTIVATION

Lightning data have been used experimentally as part of the NOAA Rapid Update Cycle (RUC) assimilation method for improving cloud/hydrometeor/convection initialization. Lightning data can be used to supplement initial information on existence of convection, along with radar and satellite data and a short-range background model forecast. Radar reflectivity data is generally not available over oceanic areas and terrain-blocked areas, regions where lightning data can provide additional information. Lightning data provide conditional convection information: existence of strokes implies that convective clouds are present, but absence of strokes does not imply that convective clouds are not present. This conditional lightning information has been used within the RUC analysis to force convection to become active in the subsequent RUC model. The RUC cloud/hydrometeor analysis combines GOES and METAR cloud data with the previous 1-h RUC forecast, with radar reflectivity and lightning data in an experimental version, allowing intercomparison to ensure consistency between these data types, each with possible error modes. This initial and relatively simple technique for including lightning data will be described at the conference, along with examples of its effect.

Lightning data can contribute toward an important problem for short-range numerical prediction, initialization of cloud and hydrometeor fields. Forecasts of cloud, fog, ceiling/visibility, stable and convective precipitation are dependent on accurately initializing these fields. Aviation and other transportation activities require considerable improvement from current skill level for ceiling and visibility forecasts. Model-based predictions of these fields are the main source of guidance beyond a few hours. Initial conditions for forecast models need to take into account current conditions reported by current surface observations, satellite, radar, and even lightning data, a development effort now underway for the Rapid Update Cycle (RUC).

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2. CURRENT OPERATIONAL RUC CLOUD ANALYSES

The RUC cycles full-resolution 5 species of cloud (water and ice) and precipitation (rain, snow, graupel) hydrometeor fields, with the capability for updating these fields from observations. In the operational RUC run at NCEP, GOES cloud-top data are used to update these fields to improve RUC cloud initial conditions (since 2002, described in Benjamin et al. 2004a). Each hour, the RUC cloud analysis combines the following sources of information:

- 1-h RUC explicit 3-d hydrometeor (cloud water, rain, ice, snow, graupel (forecast)
- GOES/NESDIS cloud top product (pressure and temperature) to build and clear clouds from 1-h forecast
    - o Building – add cloud water or ice, saturate water vapor.
    - o Clearing – remove cloud water/ice, subsaturate
    - o Checks for convective/marine cloud situations
- Surface (METAR) cloud layer and visibility data.

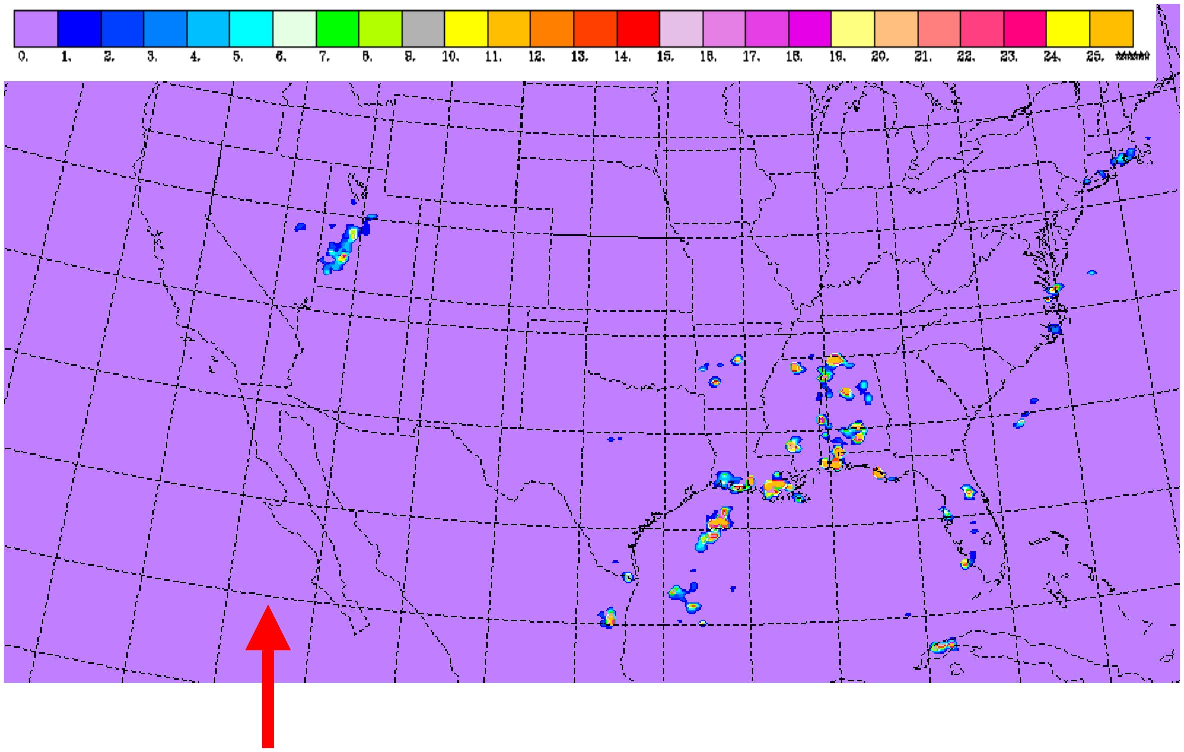
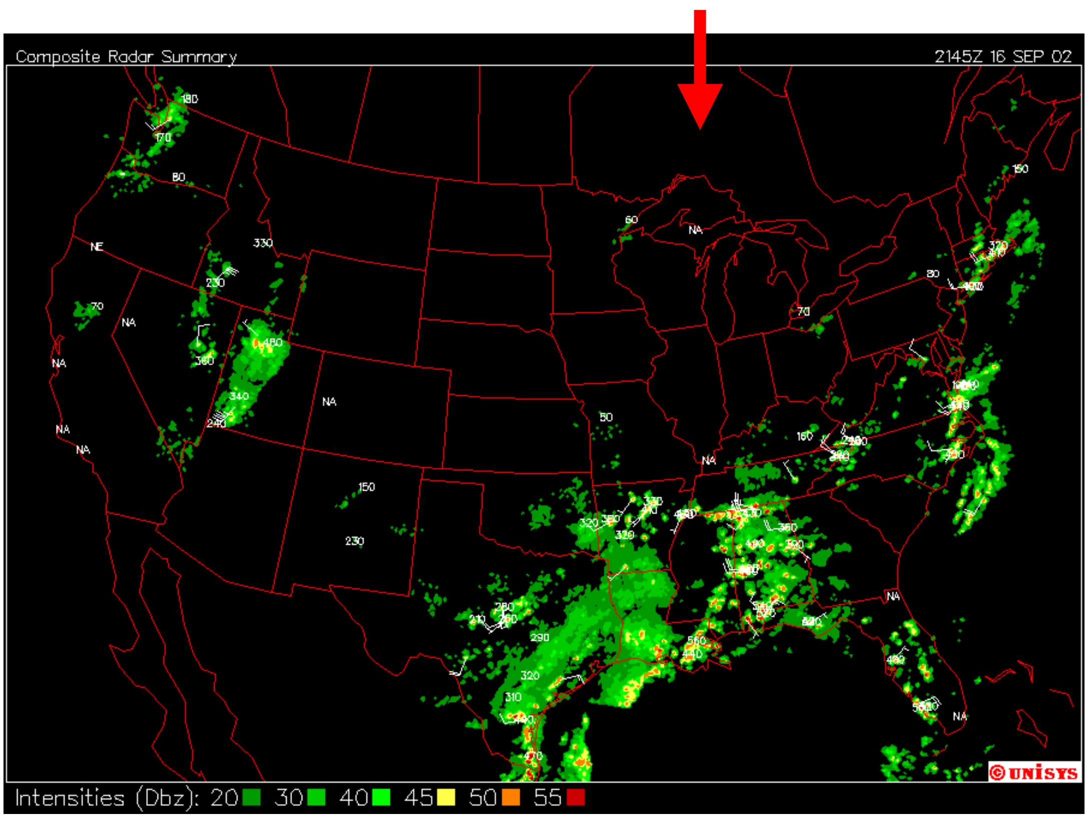


Figure 1. Lightning stroke density (strokes/hour) within 20-km grid boxes mapped onto 20-km RUC grid. 2000-2100 UTC 16 Sept 2002.

Figure 2. Composite radar summary valid 2145 UTC 16 September 2005. (courtesy Unisys)



In the GSD experiment version of the RUC, we add the following observation types in the RUC assimilation:

- Radar reflectivity and lightning – used in GSD test versions of the RUC.

3. METHODOLOGY FOR LIGHTNING ASSIMILATION

A simple technique is used to assimilation lightning data. Indicators of convective activity are 'assimilated' into a 1-h convective precipitation field in the RUC. The background field is the previous actual 1-h RUC model forecast. Previously, the only convection indicators were 1) GOES 'effective cloud amount' and 2) radar reflectivity. If intensity was available (e.g., through radar reflectivity), the 1h convective precipitation was set accordingly through a ZDR relationship. With the addition of lightning data, a simple relationship from lightning strokes/hour were converted into a precipitation intensity. An example of lightning stroke density on the RUC 20-km grid is presented in Fig. 1 for a case in September 2002, showing coastal and offshore convective activity. In this case, the radar summary (Fig. 2) confirms the presence of convection in these same locations, but the use of lightning data can indicate the presence of convection further offshore (not in this case) out of the range of radar data.

The 'analyzed' 1-h convective precipitation field is then passed into the RUC forecast model. Currently, if the convective precipitation field exceeds 2 mm/h, then a convective inhibition in the RUC convective parameterization (Grell/Devenyi, Benjamin et al. 2004a) is bypassed to force convection for the first 30 min IF positive CAPE is present.

This usage of lightning data in this very preliminary manner can be extended further, but at least is consistent with the one-sided information from lightning data: it clearly shows presence of convection with a crude relationship to convective precipitation, but absence of lightning strokes cannot confirm the absence of convective activity.

5. FUTURE WORK

Much stronger constraints from lightning data can be used for cloud/hydrometeor variational assimilation in the future to improve model initial conditions over oceans and other areas without radar data. It can be combined with satellite microwave data to confirm presence of convection.

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