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PRELIMINARY RESULTS FROM A REAL TIME, TIME TO SPACE CONVERSION FOR SURFACE ANALYSIS

James Correia Jr* and Raymond Arritt
Department of Agronomy, Iowa State University, Ames, IA

1. Introduction

Fujita (1955) introduced a technique to incorporate off-time surface observations into a mesoscale surface analysis. Since then, only a handful of authors have presented this type of analysis. These authors have studied a wide range of phenomena including gravity waves (Koch et al. 1997,1999, Bosart et al. 1998), fronts (Miller et al. 1996) and severe convection (Stumpf et al. 1991, Knievel et al. 1998). Koch and Saleeby (2001) were the first to use the technique to detect gravity waves in a quasi-real time analysis system. They retrieved data from the ASOS network (5 minute observations) and processed the data through their gravity wave analysis system. Since the amount of data and number of stations used required an enormous download time, the system in that framework would not be ideal for real-time analysis.

Bosart (2003) noted that the MCS forecasting process hinges on operational detection of mesoscale features. He demonstrated this with an example of how a high quality research analysis shows wake troughs, bubble highs, and large amplitude inertia gravity waves that are missed on routine, hourly synoptic scale analyses.

Bosart argues quite convincingly,

> "progress in detecting, analyzing and forecasting important mesoscale weather systems is hindered by the inadequate synthesis of disparate observations and the lack of real-time high quality surface mesoanalyses on the mesoscale."

Here, we apply a time to space conversion (TSC) method to address the goal of detecting and analyzing mesoscale weather systems. In this preliminary analysis, we retrieve surface observations available over UNIDATA's Local Data Manager (LDM) system. We compare the time to space conversion technique to a well documented gravity wave case to show its usefulness. The second case involves the development of a bow echo and illustrates the use of 1 minute data from the Iowa AWOS network. The third case shows Hurricane Isabel as it came ashore in North Carolina.

2. Methodology

2.1 Data

The data used in this study are from standard surface airways observations (SAO). The data consist of hourly and special METAR reports from ASOS stations, 20-minute data from AWOS stations, hourly data from C-MAN, BUOYs and SYNOP stations, 1-minute observations from the Iowa Dept. of Transportation (DOT) AWOS network and 5-minute data from PAM stations during STORM-FEST. For the real-time portion of the analysis, Texas Tech's 5-minute mesonet data has also been utilized.

2.2 Technique

Surface data were decoded from METAR format into GEMPAK (Koch et al. 1983) surface files. The data records include the exact time the observation was taken along with latitude, longitude and station elevation, altimeter setting, temperature, dew point, wind speed and direction. These observations were then processed into the time to space conversion (TSC) program.

The analysis requires an analysis time, an advection vector, and a time increment. The advection vector is usually found by sampling the mean wind from 700-400 hPa from a nearby sounding. Koch and Siedlarz (1999) showed that a TSC analysis using one advection vector is comparable to that using many advection vectors over a limited area. This approach is subject to error when the feature analyzed is moving in an opposing direction to the mean wind. This occurs in our analysis in the latter two cases. The observed outflow boundary propagation determined from successive radar analyses was used because the directional difference between the mean wind and feature of interest was 90 degrees. The hurricane was affecting the local environment; thus the mean wind represented the wind field of the storm and not the propagation speed of the vortex itself. For this case we used the National Hurricane Center's storm motion vector averaged over the time period of 12 hours (or 3 advisories).

Here a time increment of ± 1 hour was chosen. To calculate the new position $X(t)$ of the observation, the product of the advection vector V and the time difference Δt between the observation and analysis time is taken. The resultant distance is then converted to a latitude and longitude increment which is added to the station location $X(t-\Delta t)$:

$$X(t) = X(t-\Delta t) + V\,\Delta t$$

The data from this observation are then recorded at the new location $X(t)$. These data are then fed back into GEMPAK to produce objectively analyzed grids via the Barnes analysis scheme (Koch et al. 1983). These data do not take into account a temporal interpolation or weighting; only the distance weighting has been considered. Grids of altimeter setting and temperature are produced then displayed.

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*Corresponding author address: James Correia Jr. Iowa State University, Ames, IA 50010, email address jimmyc@iastate.edu

3. Case Studies

3.1 STORM-FEST Gravity wave

This case was chosen due to both data availability and its recent attention in the literature (Rauber et al. 2001, Yang et al. 2001, Jewett et al. 2003, Koch and Siedlarz 1999). This gravity wave was analyzed using the mean product of pressure and wave normal wind perturbations by Koch and Siedlarz (1999, hereinafter KS99). In figure 1, the TSC analysis was performed for 23 UTC 14 February 1992. The wave fronts denoted by KS99 are overlaid on the pressure and temperature analysis. Even without temporal interpolation the TSC technique employed here captures the salient features identified by KS99. The pressure trough of their wave B- is easily identified while wave A- is more difficult to detect.

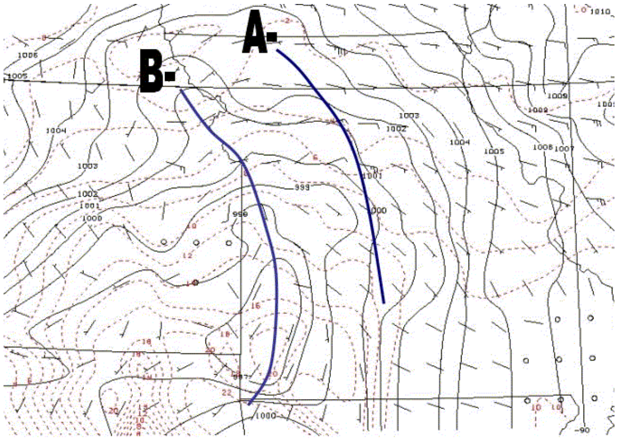

Figure 1: Time to space conversion of surface pressure (solid contour every 1 hPa), temperature (red dashed every 2 C) and wind barbs. Solid blue lines and corresponding letters reflect KS99 gravity wave positions.

3.2 4 June 1999

A long-lived bow echo event initiated over Iowa in the early morning and afternoon and propagated down to Alabama. Jankov and Gallus (2001) noted that initial condition errors may have contributed to their difficulty in simulating this case. This case was a prime candidate for TSC analysis because of high spatial and temporal resolution over Iowa.

Figure 2 shows the TSC analysis from 18 UTC. The outflow boundary can be identified in eastern Iowa extending to the southwest along a region of strong temperature gradient (temperature difference of 6K across the pressure ridge) and pressure ridge line. Also note the two regions of lower pressure within cold pockets behind the outflow boundary.

By 2000 UTC (figure 3), the outflow boundary

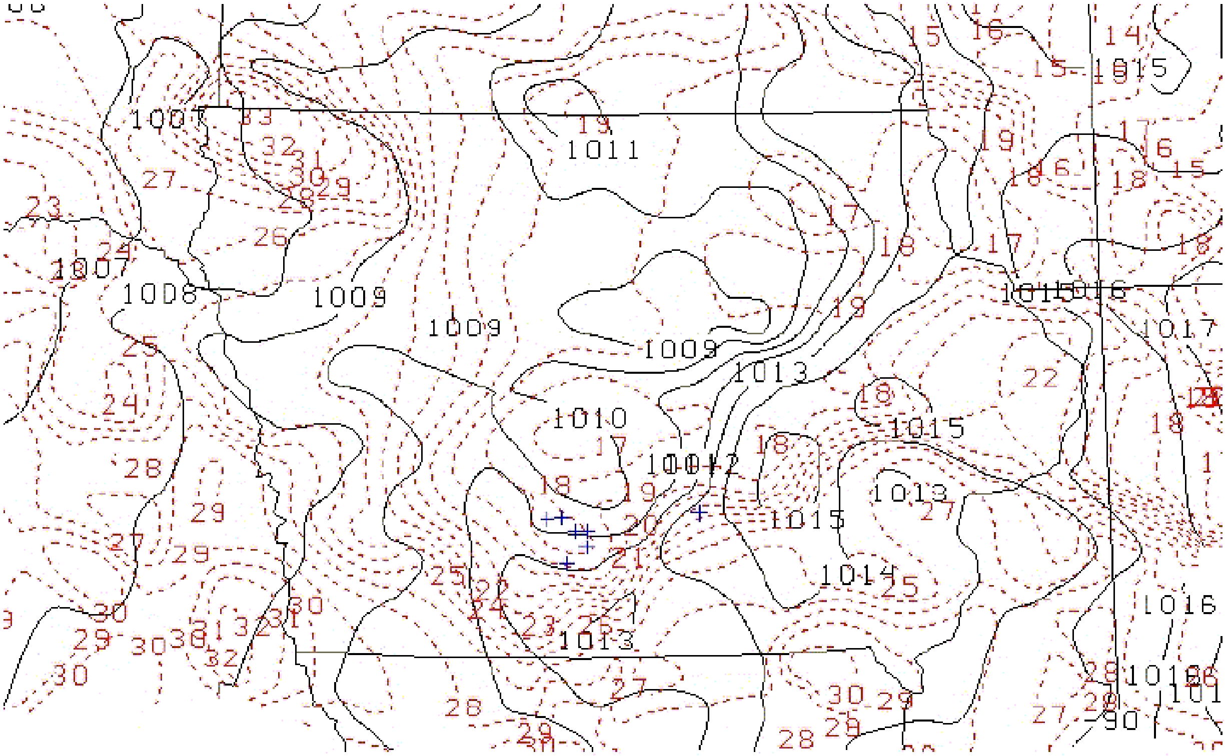

Figure 2: Time to space conversion of surface pressure (solid contour every 1 hPa), temperature (red dashed every 1 C), and storm reports received from 1648 –1800 UTC (blue crosses) at 1800 UTC 04 June 1999.

has propagated southeastward and the temperature gradient has doubled (temperature difference of 12 K) across the boundary.

3.3 Hurricane Isabel

Hurricane Isabel made landfall along North Carolina around 1700 UTC 18 September 2003. The TSC technique was applied to this case after landfall to see how well the analysis compared with operational central pressure and position estimates. At 2000 UTC (figure 4), the TSC analysis agrees well with the location of the hurricane center but differs in central pressure by 4 hPa. This difference was related to the limited number of stations sampling the hurricane center. In this case, the Barnes scheme is dominated by higher pressure observations. The pressure gradient is much stronger on the eastern side of the hurricane.

The pressure gradient remains strong on the eastern side of the hurricane 2 hours later (figure 5). The central pressure between the analysis and NHC observations at this time disagree substantially (by 9 hPa). The position estimate is fairly accurate.

4. Real-time statistics

In this section we explore the real time TSC system that we have been running over 9 subregions for the last several months. It can be found on the web at http://www.mesoscale.iastate.edu/jimmyc/rtgrav.html. The subregions represented are listed in Table 1 along with the sounding locations used for the regions' advection vector. The average number of TSC observations is compared to the number of hourly reports valid at the analysis time. The TSC analysis, on average, produces 5 times the observations on the same grid which results in a grid resolution of ~35 km over each subregion. These numbers are before gridding and may contain overestimates because of duplicate stations and stations outside the actual grid area.

The TSC analysis runs roughly 1 hour behind the current time. Currently the system runs at 40 minutes past the hour and ingests 100 minutes of data (as opposed to 120 minutes). It takes roughly twenty minutes to produce the TSC analysis over the 9 subregions.

Currently the analyses grid altimeter setting is converted to sea level pressure using the GEMPAK algorithm. Future work will compute an R value (or ratio of difference between station and sea level pressure to station pressure) as is done with ASOS stations. This will negate the topographic effects introduced by the use of altimeter setting.

5. Conclusions

- The TSC analysis without temporal weighting was tested for a published gravity wave case and found to be consistent.
- The second case study identified a strong outflow boundary as revealed by a region of strong temperature gradient and pressure ridge (bubble high).
- The TSC analysis of Hurricane Isabel

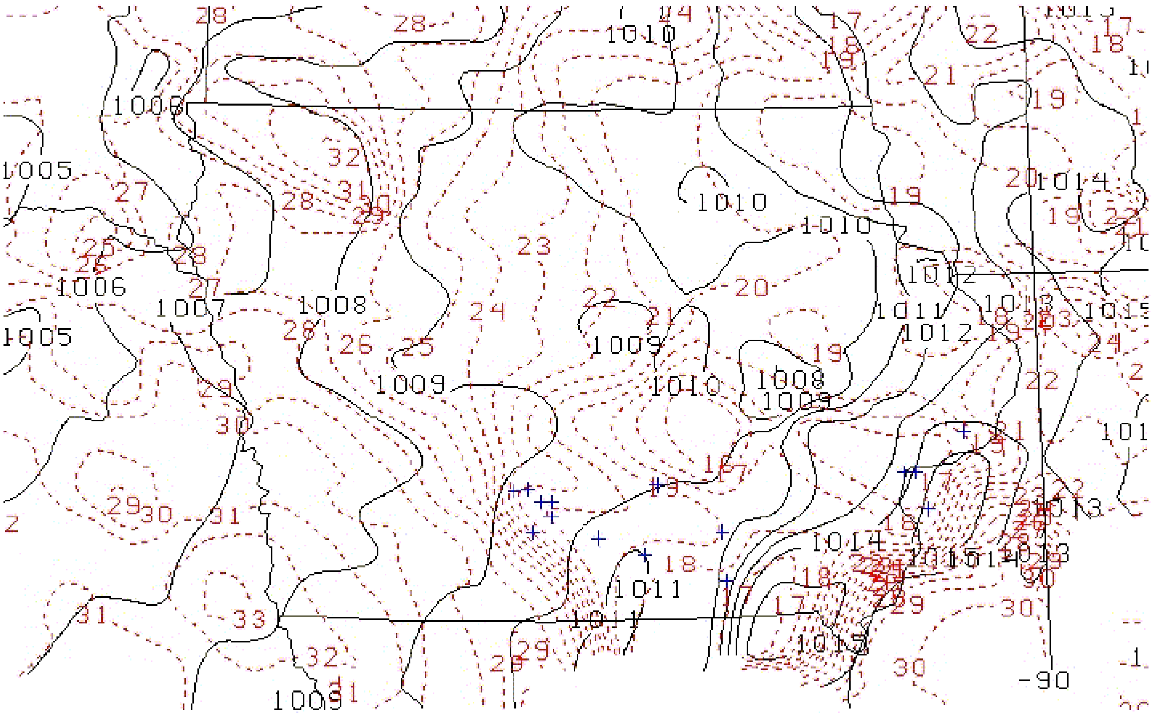

Figure 3: Same as figure 2 except for 2000 UTC 04 June 1999, except storm reports (blue crosses) valid from 1648 – 2000 UTC.

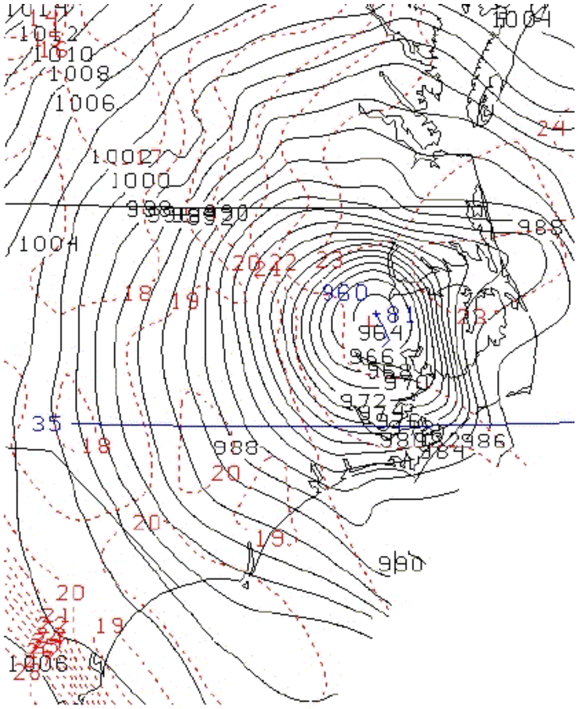

Figure 4: Time to space conversion of surface pressure (solid contour every 2 hPa), temperature (red dashed every 1 C), and standard plot depicting NHC central pressure, sustained wind speed, and speed and direction of motion used in TSC analysis at 2000 UTC 18 September 2003.

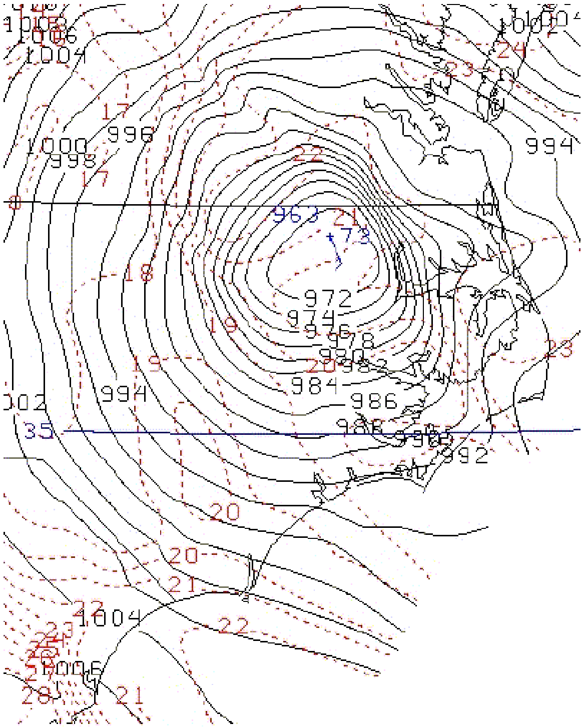

Figure 5: Same as figure 4 except for 2200 UTC 18 September 2003.

showed that the position estimate was accurate at the times analyzed but the central pressure was less accurate compared to NHC observations. This result represents the effect of the small scale nature of the hurricane center so the Barnes analysis smoothed the local minimum of pressure in the eye.

- The real time TSC analysis produces a three-fold increase in number of observations and is simple enough to run in real-time over a portion of the Midwest US.

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References upon request

Table 1: Chart of the 9 sub-regions used in the real time analysis, along with grid area (deg. Lat by deg. Lon.), radiosonde used in the advection vector calculation, number of hourly reporting stations and the number of TSC observations produced.

region	**Grid area**	**Radiosonde station**	**stations**	**TSC obs.**
IA	5×10	OAX	108	588
MN	6×10	MPX	139	753
SD	3×8	ABR	20	224
NE	4×9	LBF	41	251
KS	5×9	DDC	64	324
MO	5×10	SGF	85	476
AR	5×8	LZK	67	322
TX	6×7	AMA	82	901
OK	6×9	OUN	112	700