JP1.28 3D MULTI-RADAR REFLEVTIVITY MOSAIC FOR THE CIWS DOMAIN

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1. INTRODUCTION

En route severe weather has been identified as a principal contributor to delays at airports nationwide. Many existing operational severe storm products within en route airspace are limited due to their development from single radar fields. Nevertheless, FAA Air Route Traffic Control Centers (ARTCCs) usually encompass multiple radar umbrellas, and the life cycle of an individual storm may span a large region that requires two or more radars for better monitoring of storm characteristics and evolution.

A 3D, high-resolution multi-radar reflectivity mosaic scheme has been developed (Zhang et al. 2001). The creation of a 3D radar mosaic allows users and algorithm developers the benefit to use and develop a wide variety of products and displays that more fully depicts the evolution and lifecycle of storms. Examples include more physically realistic horizontal or vertical cross-sections. Gridded radar data can also be easily combined with information from other data sources such as satellite data, 3D lightning data, model analyses or forecast fields increasing its value in the overall forecast and warning process. Single radar algorithms could be expanded to utilize data from multiple radars and other environmental data to more accurately determine storm attributes.

The 3D mosaic has been running in real-time for several regions including Arizona, Oklahoma, and the Carolinas region. It uses an adaptive Barnes interpolation scheme to grid reflectivity fields from multiple radars onto a common Cartesian grid. A distance-weighted averaging scheme is used to mosaic overlapped observations (Zhang et al., 2001). The scheme also includes a gap-filling function that performs bilinear interpolation in the data gaps between the high tilts in Weather Surveillance Radar – 1988 Doppler (WSR-88D) Volume Coverage Pattern (VCP) 21 and 11. The real-time products have been shown to be very useful in providing three-dimensional, high-resolution regional reflectivity fields and derived products.

The 3D mosaic scheme is currently under testing for real-time operations for the Federal Aviation Administration (FAA) Corridor Integrated Weather System (CIWS) domain. This domain contains high-density observations from existing FAA and National Weather Service (NWS) radars (http://www.ll.mit.edu/AviationWeather/CIWS.pdf) in the congested en route corridors.

The application of the 3D high-resolution reflectivity mosaic in the CIWS domain can take advantage of the high-density data from WSR-88Ds, Terminal Doppler Weather Radars (TDWRs) and other aviation radars to provide useful information to en route traffic flow managers. The 3D mosaic depicts storm locations, storm lifecycle characteristics, and other potential storm severity information. These automated and rapidly updated products will provide air traffic controllers with the ability to manage the airspace more effectively, to reduce controller workload, and to significantly mitigate costly delays.

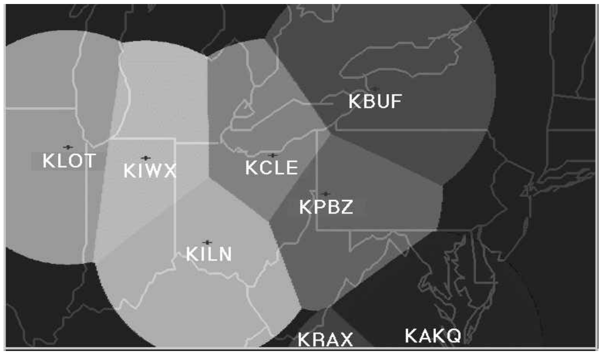

Fig. 2.1 Radar coverage in the analysis domain for the real-time 3D reflectivity mosaic for the FAA northeast corridors.

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The initial test results are reported in this paper.

2. DOMAIN SETUP

Figure 2.1 shows the 3D mosaic domain for the FAA northeast corridor (Chicago-New York) - one of the most highly congested en route corridors. The shaded regions indicate the lowest and unblocked coverages (up to 300 km range) by individual radars. Shown in Fig. 2.1 are 8 WSR-88D radars (KAKQ, KBUF, KCLE, KILN, KIWX, KLOT, KPBZ, and KRAX) that are connected via the Collaborative Radar Acquisition Field Test (CRAFT, Droegemeier et al., 2001) network. This infrastructure allows for the transmission of archive level II data for real-time use and for the archival of the WSR-88D data at the National Climatic Data Center (NCDC). More radars are expected to be joined in the CRAFT network in the near future. Fig. 2.2 shows a significantly improved coverage for the same domain with only two more radars added (KOKX and KDTX).

The domain shown in Fig. 2.1 is very large (~1500km x 650km) and is thus computationally impractical for running a high-resolution 3D multi-radar mosaic with a rapid update cycle. A "joint-tiles" mosaic strategy is proposed to take advantage of multi-processor server/computers. The large domain is divided into three sub-domains (tiles). The horizontal resolution is ~1 km x 1 km and vertical resolution varies from 250m near surface to 1km at the top of the domain. Each tile has 481 x 641 x 21 grid points. The 3D mosaic scheme is run on the three tiles separately and simultaneously. Fig. 2.2 shows the three tiles that are joined together to encompass the entire CIWS domain.

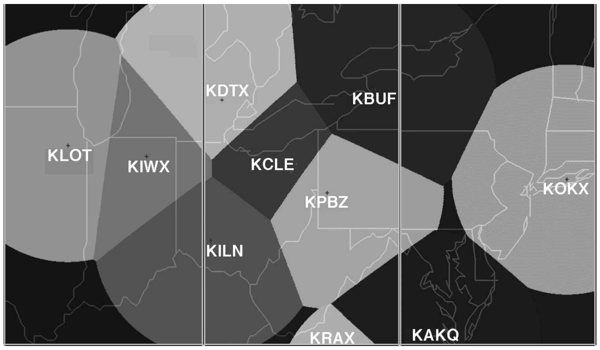

Fig. 2.2 Three tiles that make up the analysis domain shown in Fig. 2.1. Note that there are two more radars added in the coverage map.

3. CASE STUDIES

Two cases were selected for testing the 3D mosaic scheme in the FAA CIWS corridor. Case 1 is a widespread winter precipitation case from Jan. 30, 2001 and Case 2 is a convective case that occurred on June 2, 2001. Table 3.1 summarizes the radar data used in each case and their respective volume coverage patterns.

Table 3.1 WSR-88D radar data used for each case and their respective volume coverage patterns (VCP).

Case1: Winter case (1/30/01, 0400 UTC)	**Case 2: Summer case** (6/2/01, 1000 UTC)
KBUF, VCP 21	
KCLE, VCP 21	KCLE, VCP 21
KDTX, VCP 21	KDTX, VCP 21
KILN, VCP 21	
KIWX, VCP 21	KIWX, VCP 21
KLOT, VCP 21	KLOT, VCP 21

These cases were chosen because they each present different issues in real-time radar ingest, gridding, mosaic, and display. Case 1 is widespread and thus relies on reflectivity from multiple radars. Managing a greater volume of data in real-time would be quite challenging. The "joint-tiles" mosaic strategy is adequately tested using results from Case 1. Case 2 isn't as widespread as the previous case, but contains lots of detail in the reflectivity fields. It will be determined if the mosaic resolution and objective analysis parameters are set to capture finer detail associated with convective echo.

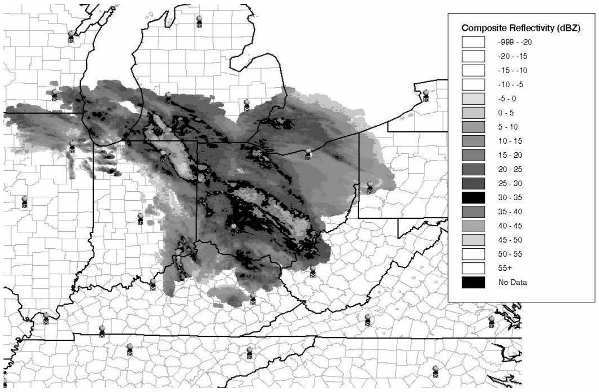

Fig. 3.1 Composite reflectivity image derived from all three tiles of the 3D mosaic reflectivity field for the winter case.

Figure 3.1 shows a composite reflectivity product derived from the 3D mosaic for Case 1. This product takes the maximum reflectivity from each grid column and maps it into 2D space. The 3D mosaic was run on each sub-domain, and Fig. 3.1 was created by joining together the three separate tiles. Notice how the image remains smooth and consistent in spite of it having been created by segmentation of the data (ie., there are no seams present at the tile boundaries). The horizontal resolution of the product is ~1 km x 1 km and manages to capture lots of fine detail in the CIWS region.

Figure 3.2 shows a similar composite reflectivity image as in Fig. 3.1, but for Case 2. Most of the echo resides in the westernmost tile, so the “joint-tile” mosaic scheme isn’t really tested with this case. There appears to be lots of detail present in this product with the convective storm. Parameters used in the adaptive Barnes objective analysis scheme are set so that details present in the raw data are maintained.

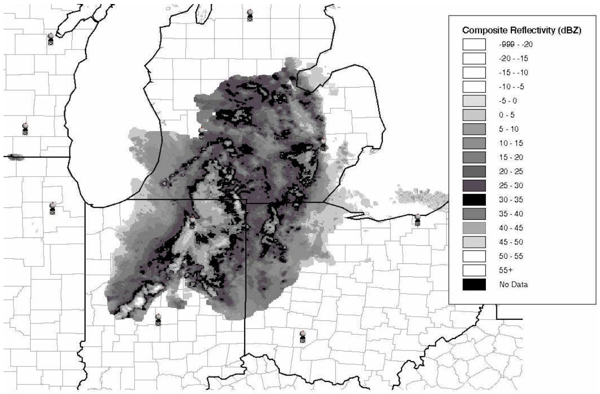

Fig. 3.2 Same as in Fig. 3.1, but for Case 2.

The mosaic has been run for 5 time levels for both cases. The average CPU for each tile is ~90s for the winter case (with 6 radars, all in VCP 21) and ~50s for the summer case (4 radars, all in VCP 21). Since the fastest volume scan update rate for the WSR-88Ds is 300s, it is very practical to run the mosaic in real-time for the CIWS domain.

4. SUMMARY

A high resolution, 3D multiple radar reflectivity mosaic scheme will be running in real-time over the CIWS domain that covers the FAA north east corridors. The strategy is to divide the large domain into three tiles and to run the 3D mosaic scheme in parallel. The resultant analysis grids can be combined to obtain any 3D subset grid within the large domain.

Two cases, one from the winter of 2000 and one from the summer of 2001 have been used to test the strategy. It was shown that with the parallel processes, a high-resolution 3D grid of radar reflectivity can be generated for the FAA CIWS domain in a rapid update rate that’s comparable with the WSR-88D volume scan strategies. When joined together, the analysis tiles show seamless combination. Moreover, the adaptive Barnes objective analysis technique provides for the gridding of the data in 3D, and yet maintains high quality and resolution present in the raw data.

5. FUTURE WORK

Additional radar data, such as from the TDWR will be integrated into the 3D mosaic to increase the data coverages for the en route corridors, especially at lower altitudes. In addition, efforts are underway to combine winds from numerical models with radar observations to yield 3D, gridded wind fields and derived products. Lastly, tests are being conducted to ensure the mosaic scheme can accommodate radars having much more frequent scanning cycles, as will be the case with phased-array radar.

REFERENCES

Droegemeier, Kelvin, K. Kelleher, et. al., 2001: Project CRAFT: A Test Bed for Demonstrating the Real Time Acquisition and Archival of WSR-88D Base (Level-II) Data, *Bull. of the Amer. Meteor. Soc*., *(in review*).

Zhang J., J.J. Gourley, K. Howard, and B. Maddox, 2001: Three-dimensional gridding and mosaic of reflectivities from multiple WSR-88D radars. *Preprints, 30th International Conference on Radar Meteorology.* 19-24 July 2001, Munich, Germany. 719-721.