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Project Title: **Easy-to-Use Interface for Radar Data Quality Control and Error Estimation**

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Proposal Theme:	Theme 2: Technologies for Collaboration, Visualization, and Analysis; Theme 3: Disaster Monitoring or Response.

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Executive Summery:

The objective of this project is to develop an easy-to-use interface created by using GTK (GIMP Toolkit) and OpenGL (Open Graphics Language). This interface will be used with the existing radar level-II data processing capabilities at NSSL and NCEP (National Centers for Environmental Prediction) to track and check data quality problems and to estimate and monitor radar wind observation errors compared with model predictions and other observations. By minimizing manual operations and associated human errors (or inaccuracy), this interface will facilitate greatly the on-going developments and near-future applications of radar data quality control (QC) and error estimation (required by NCEP radar data assimilation). For its future upgrading, such an interface will be able to integrate and display data from a variety of sources (in addition to radar) for verifications and synthetic analysis of storm winds and invoke other scientific algorithms. All these will make the proposed interface a paradigm application for other developers.

This proposal builds upon the recent successes derived from four previous projects: the CRAFT (funded by the Oklahoma State Regents for Higher Education and HPCC), ESDIM (Environmental Services Data and Information Management Program), WDSS-II (Warning Decision Support System – Integrated Information), and the existing MS (Management System for Realtime Radar Wind Retrievals funded by FY03 HPCC). WSR-88D radar level II data will be obtained realtime through high speed internet, managed by LDM (Local Data Manager) system, and displayed using IRAS (Interactive Radar Analysis System). Built upon these infrastructures, the above desired interface will be developed by utilizing and upgrading the major functions in the existing WDSS-II based on GTK and OpenGL.

Now OpenGL has become widely used in the industry to support 2D and 3D graphic application developments. Both OpenGL and GTK are multi-platform software packages and have thousands of applications on all popular platforms. All these will make it possible for other users to easily install and use the proposed interface on their favorite platforms.

This proposal targets the FY04 HPCC Theme 2: Technologies for Collaboration, Visualization, and Analysis. The application of proposed interface fits Theme 3: Disaster Planning, Mitigation, Response and Recovery.

Problem Statement

Owing to the success of the Collaborative Radar Acquisition Field Test (CRAFT, funded by the Oklahoma State Regents for Higher Education and NOAA HPCC), real-time internet transmission of high-resolution level-II Doppler data becomes reality. A development plan to transmit level-II data real-time from all 158 WSR-88D radars and assimilate them into the operational numerical weather prediction (NWP) models has been firmly scheduled and is being vigorously implemented at NCEP. However, since raw level-II data are often contaminated due to various reasons, they cannot be directly used by the models without reliable data QC. In addition, to optimally assimilate Doppler wind observations in combination with the background wind fields provided by model predictions, it is necessary to know their error statistics. To solve these important and difficult problems, radar wind data QC and error statistic estimation capabilities are being developed by the PI's group at NSSL and CIMMS in collaboration with scientist at NCEP. So far, a prototype QC package has been delivered to NCEP for operational tests and applications. The development of this prototype QC package has been facilitated by the automated data processing and recording capabilities of the Management System (MS, funded by FY03 HPCC). The existing MS can be also used to compute and monitor the QC parameters (designed to detect data quality problems and quantify the related features and signatures extracted from level-II data) (Liu et al. 2003; Zhang et al. 2003).

Radar data quality problems are complex. The problems detected from in the Oklahoma KTLX radar showed different characters from those detected from 8 WSR-88D radars in the New England area. Clearly, radar data quality problems can have very different characters depending on geological regions, weather conditions, radar scan modes, and individual radar operations. The aforementioned QC package, however, was developed mainly based on KTLX observations and related ground truth verifications collected in Oklahoma area. While this QC package is being continuously improved and tested with KTLX data collected for different seasons under various weather conditions, it is also necessary to conduct extensive tests with WSR-88D radars in different regions for fine-tuning the QC parameters and related thresholds. Such extensive tests and fine-tunings will take unbearable manual operations unless the required human operations are greatly reduced by an easy-to-use interface. Such an easy-to-use interface is also necessary and critical for overcoming another main difficulty encountered by such extensive tests as described below.

The required ground truth verifications for KTLX data quality problems can be and have been collected mainly from NSSL dual-polarimatric radar KOUN (which is near the KTLX) in addition to satellite inferred images and rawindsonde observations. Similar verifications, however, are not available for most of the remaining 157 WSR-88D radars due to the lack of nearby dual-polarimatric radar observations. To avoid this difficulty, indirect tests can be and will be conducted by using the innovation analysis (Xu et al. 2003; Xu and Gong 2003) to estimate the radar radial-wind observation error biases and variances with and without the QC (or with and without fine-tuning the QC). The reduction of estimated observation errors due to the QC (or fine-tuned QC) should provide an objective measure for the effectiveness and acceptability of the QC (or fine-tuned QC). As the radar observation innovations will be computed by subtracting the (background) predictions by a NWP model, the background error covariances can be also estimated to improve the radar data assimilation. As the background error correlation distances exceed the coverage of a single Doppler radar, the innovation method will have to be applied to multiple, say, N ($\approx$ 10) radars. To compute the error statistics, sufficiently long time series (about 10^2 time levels in about 6×10^2 min $\approx$ 10 hrs) of such huge ($N \times 10^6$) data fields must be processed through the QC. The processed data must then be thinned (into super observations in consistent with the strategy planned at NCEP) or grouped (according to radar radial ranges that control the observation error correlation lengths) before the innovation covariances are computed. The covariances can be computed (for $N^2 \times 10^{12}$ pairs of data points) without thinning or grouping, but the computation will take too long time (months or even years of CPU time for data collected in 10 hrs from 10 radars). To process such huge amounts of data from multiple radars with the QC and fine-tuned QC, the aforementioned MS must be equipped with an easy-to-use interface for selecting radars, specifying analysis domain and resolution, designing various thinning and grouping strategies, and executing the innovation data pairing and covariance calculations. There will be a trade-off between the thinned or grouped data resolution and overall data coverage which must be determined timely and interactively based on the data stream and coverage from each radar over the concerned region. In addition, individual data fields, especially those cause significant increases in the estimated errors, need to be sampled (based on the QC parameters computed and monitored by the aforementioned existing MS) and displayed for detailed examinations. These operations cannot be executed timely as required without an efficient and user-friendly interface.

Proposed Solution

The proposed solution will leverage the recent successes derived from four previous projects: the CRAFT, the ESDIM, the WDSS-II and the existing MS (Management System for Real-time Radar Wind Retrievals, funded by FY03 HPCC). Real-time WSR-88D radar level II data and numerical model data can be obtained through high speed internet, managed by LDM (Local Data Manager) system and displayed using WDSS-II. The existing MS will be used to compute and monitor the QC parameters (designed to detect data quality problems). Built upon these infrastructures, the easy-to-use interface will be developed, in connection with the existing MS, by implementing and enhancing the following functions in WDSS-II based on GTK and OpenGL:

Region selection

The cursor can be used to draw a polygon on the desired display of radar observations to select a region and time window for data processing. This function will also allow on-screen displays and looping of selected radar data over the analysis domain, so suitable thinning and grouping strategies can be easily designed for the covariance calculations.

Data thinning and grouping

By using mouse-click functions on a pop-up menu, the user can specify a skip number, and/or define a range ring to select or design the desired thinning and grouping strategies. By clicking a button, the user can also invoke an algorithm to process the raw data, output the thinned and/or grouped data, and then display and loop the thinned and/or grouped data on the screen for visual examinations.

Mouse-click data processing

User can set the run specifications and input parameters (for selected thinning and grouping strategies, analysis time windows &, etc) and invoke an algorithm to execute the innovation data pairing and covariance calculations.

Monitoring data quality problems

The existing MS will be upgraded to monitor and record the estimated observation errors. When the estimated error exceeds a tolerable level, an automated procedure will flag the time window (over which the error is estimated) and send an alarm. As the involved data quality problems are targeted within the flagged time window, individual data fields can be further flagged and sampled from the flagged time window based on the QC parameters recorded by the MS. The flagged data fields can be examined in details by using the zoom-display function described below.

Zoom display of flagged data fields

Individual data fields flagged and sampled by the above procedure need to be displayed for visual examinations. As radar data have very high-spatial density, data quality problems often need to be examined with fast zoom-in displays (for detailed gate-by-gate checks) and zoom-out displays (for overall checks of the grand patterns of contaminated areas). The proposed zoom display will also to view the raw data field (PPI type scan image) in comparison with the processed data field (after the QC or fine-tuned QC). It will also allow the user to select any local areas on-screen and then invoke an algorithm by a mouse-click function to compute any QC parameter and related statistics over the selected areas (to verify the suspected types of contamination or detect new types of contamination).

The proposed interface will facilitate greatly the developments of radar data QC and error estimation at NSSL and their applications to operational radar data assimilation at NCEP. It can be also easily customized for different applications on different data sources. As the protocol of interface constructed, user will be able to add/withdraw new/old functions on the interface.

Analysis:

OpenGL is the premier environment for developing portable, interactive 2D and 3D graphics applications. Since its introduction in 1992, OpenGL has become the industry's most widely used and supported 2D and 3D graphics application programming interface (API), bringing thousands of applications to a wide variety of computer platforms. GTK+ is also a multi-platform toolkit for creating graphical user interfaces. Offering a complete set of widgets, GTK+ is suitable for projects ranging from small one-off projects to complete application suites. It has been proven that OpenGL and GTK are stable, reliable and scalable software.

WDSS-II has become very useful software platform for NSSL scientists to develop and test their algorithms. The display of WDSS-II allows users to view different data sources and products easily and interactively. The proposed easy-to-use interface will enrich and enhance the ability of WDSS-II. Most importantly, it will greatly improve the efficiency on developing radar data QC algorithm. As a visualization tool, it will help users to better understand observations and improve application products.

Performance:

Milestones

- Receive award notification and begin project — February 1, 2005
- Order hardware and software — February 15, 2005
- Complete detailed design — April 1, 2005
- Integrate into WDSS-II — August 1, 2005
- Complete all functions of the interface — September 1, 2005
- Complete tests — October 1, 2005

Deliverable

- The interface built in WDSS-II will be ready to use on October 2005**.**

References

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