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P8.6 TAMDAR, THE RAPID UPDATE CYCLE, AND THE GREAT LAKES FLIGHT EXPERIMENT

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1. INTRODUCTION

The TAMDAR (**T**ropospheric **A**irborne **M**eteorological **D**ata **R**eporting) sensor (Daniels et al., 2004) is designed to measure winds, temperature, humidity, turbulence, and icing from regional commercial aircraft. These data are downlinked via satellite to a ground-based processing center and are generally available to users within one minute of actual measurement. The sensor was developed in response to a need to provide data in regions not currently covered by the Meteorological Data Collection and Reporting System (MDCRS) (Moninger et al., 2003). MDCRS provides data from six major airlines, primarily above 30,000 ft, and below that near major airports. TAMDAR, by contrast, will provide data primarily below 25,000 ft and at regional airports.

AirDat LLC (http://www.airdat.com/) of Raleigh, NC and Evergreen, CO designed the sensor, under contract with the NASA Langley Research Center.

TAMDAR sensors will be installed on 64 turboprop Saab 340 aircraft (Fig. 1.) by Fall 2004. These aircraft, operated by Mesaba airlines (dba Northwest Airlink) will report data for a six month period called the Great Lakes Flight Experiment.

We will receive these data at NOAA's Forecast Systems Laboratory (FSL), make them available to eligible users in a variety of ways (discussed below), compare them with data from other sources such as radiosondes and profilers, and ingest them into the publicly available Rapid Update Cycle (RUC) data assimilation and forecast system (Benjamin et al., 2004a).

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Figure 1. A Saab 340 aircraft operated by Mesaba Airlines.

2. THE GREAT LAKES FLIGHT EXPERIMENT (GLFE)

Figure 2 shows the routes of the Saab-340 aircraft that will carry the TAMDAR sensor for the GLFE. These aircraft make over 400 flights daily to 75 airports, thus providing more than 800 soundings for a total of over 25,000 daily observations in the region shown. This number can be compared with the approximately 100,000 wind and temperature observations over the entire contiguous U. S. from aircraft that currently provide MDCRS data. It is evident that the GLFE will increase the total number of aircraft-based observations significantly over the Midwest.

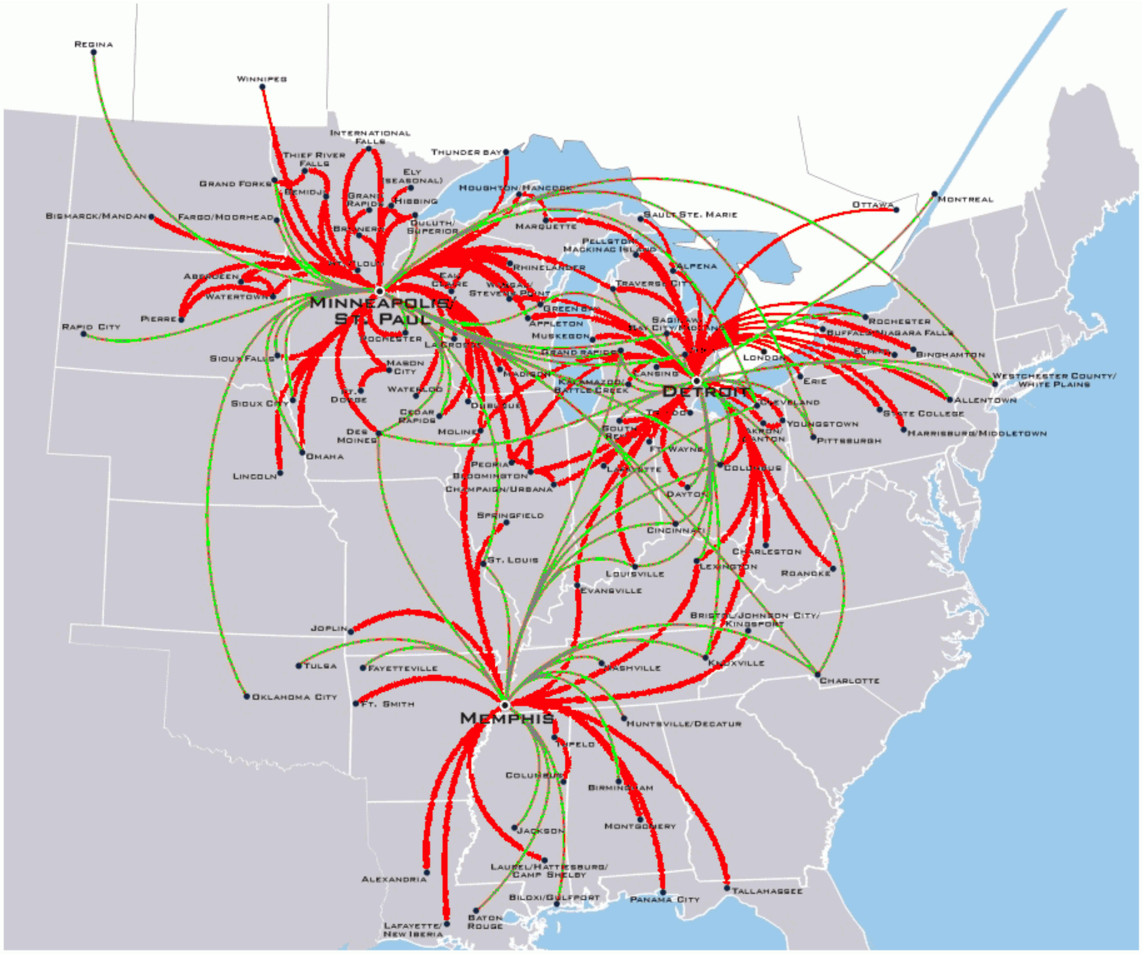

Figure 2. Mesaba routes, with Saab-340 routes highlighted in red.

3. DATA ACCESS

These data will be available in real time in the following ways:

- On a public website operated by AirDat LLC (http://www.airdat.com/) that will show only TAMDAR data.
- On AWIPS, the weather workstation used in NWS forecast offices, which will show TAMDAR data along with a wide variety of other data and model analyses and forecasts.
- On restricted portions of a website operated by FSL (http://acweb.fsl.noaa.gov/) that will show TAMDAR data along with all other weather-related data provided by commercial aircraft. (See this website for information about access restrictions.)
- Through FSL's Meteorological Assimilation Data Ingest System (MADIS) (http://www-sdd.fsl.noaa.gov/MADIS/, Barth et al., 2002) as netCDF files containing the data shown on the FSL website and additional quality control information. (Real-time files have the same restrictions as the FSL website, but data more than 48 hours old are publicly available.)

4. DATA EVALUATION

NOAA will evaluate the TAMDAR data in several ways, such as

- Through daily use by operational forecasters at NWS forecast offices. The GLFE data will be used as MDCRS data have been used for several years (Mamrosh et al., 2001). That is, plan views of aircraft tracks and sounding displays will be used to keep close track of changes in weather conditions. The GLFE data will provide higher spatial and temporal resolution than has previously been available except near major airports. Moreover, the GLFE data will include humidity, turbulence and icing data, not generally available through MDCRS. NWS forecasters will document those cases in which the GLFE data make a notable difference in their forecast decisions. Documentation will be provided in Area Forecast Discussions and special reports.

- By direct comparison between wind, temperature and humidity data from TAMDAR and from radiosonde (see e.g., Benjamin et al., 1999). This will be facilitated by extra radiosonde launches to be made at one of the three Mesaba hub airports (Minneapolis, Detroit, or Memphis) by the University of Wisconsin transportable sounding team (http://cimss.ssec.wisc.edu/aeri/, Feltz et al., 2003).

- Through verification of TAMDAR turbulence and icing data against voice pilot reports (PIREPS) and possibly against automated turbulence reports reported by some United Airlines aircraft (Cornman et al., 2004). We expect these comparisons to be rather qualitative due to two constraints. First, the reliability of the time and location of PIREPS will make comparison with TAMDAR reports difficult. Second, recently uncovered potential problems in the current implementation of the turbulence algorithm on United Airlines may or may not turn out to be correctable. (A newer algorithm has been developed that will avoid these problems, but this has not yet been implemented operationally.)

- Via case studies. Particularly interesting cases will be analyzed and documented, both at FSL and NWS forecast offices. We are interested both in cases for which 1) the RUC performs notably differently (better or worse) when TAMDAR data are ingested than when they are not and 2) the TAMDAR data provide new insights for operational weather forecasters into specific weather events.

- By analysis of error characteristics revealed in RUC data assimilation (see section 5).

- By analysis of relative skill results of RUC analyses and forecasts that use TAMDAR data, and those that withhold them (see section 6).

5. RUC DATA ASSIMILATION

TAMDAR data will be ingested in real time into a development version of the RUC. The RUC assimilates recent observations every hour by using the previous hour's 1-h model forecast as a background to produce a new estimate of atmospheric fields (Benjamin et al., 2004b). Specifically, the observation-minus-forecast residuals (*innovations*) are analyzed to produce an estimate of the *forecast error field,* also called the *analysis increment.*

Observation quality control (QC) in the RUC is primarily based on a "buddy check" between neighboring observations. Before buddy check or other quality control procedures proceed, gross quality control tests (range limits, wind shear, lapse rate) are applied to all observations. The buddy check considers observation innovations rather than the observations themselves. This is an important distinction because it means that any known anomaly in the previous forecast has already been subtracted out, improving the sensitivity of the QC procedure to actual errors. The RUC buddy check is based on an optimum interpolation method which produces an estimate at the observation point from the innovations of a group of up to eight nearby buddy observations. This strategy is similar to that described by Benjamin et al. (1991). If the difference between the estimated and observed innovations exceeds a predefined threshold, the observation is flagged. For each observation, the QC check is repeated, removing one of the buddies at a time to increase the robustness of the check. Observations from the same platform (i.e., the same aircraft) are not allowed to verify one another. The RUC analysis, including QC, is described in more detail in Benjamin et al. 2004b.

This test with TAMDAR data will be the first use of aircraft moisture observations. Adjustment of QC tuning for the TAMDAR moisture observations will be made, as needed. The RUC analysis already assimilates in situ aircraft observations of wind and temperature.

We will develop statistics of the innovations of TAMDAR wind, temperature, and humidity from the RUC QC check to verify the extent to which the TAMDAR sensors meet initial specifications. We will also study the time history of the innovations of each sensor to see how robust each is against the rigors of an operational environment.

6. RUC STATISTICAL ANALYSIS

In order to assess the extent to which TAMDAR observations may improve model forecasts, we will *retrospectively* run two identical versions of the RUC, one using TAMDAR data ("RUC-T") and one not ("RUC-S", for "Standard").

We will run both models for specific time periods covering a variety of weather events during the GLFE, totaling 8 weeks. We will then verify the models against radiosondes and wind profilers over the region of the RUC domain well covered by TAMDAR observations. We hope in this way to be able to demonstrate a statistical difference between the skill of the RUC-T and RUC-S. The extensibility of any such results will of course be limited by the short 8 week time period, but we believe that the information will be valuable nonetheless.

7. CONCLUSION

Systems such as TAMDAR, which provide high temporal- and spatial-resolution wind and temperature data in the lower troposphere at a large number of regional airports, have the potential to lead to a substantial improvement in weather forecasting. Moreover, the high-resolution humidity data produced by TAMDAR is unprecedented, and may provide substantial benefits. However, TAMDAR has only been tested in the laboratory and on research aircraft so far (Daniels et al., 2004). The GLFE, which will subject the

TAMDAR sensor to the rigors of daily operations, will provide the necessary proof that the sensor can provide valid data day in and day out—or not.

Should the sensor data prove robust, documentation of the effects of the use of the data in the RUC model and in operational forecasting will provide necessary information to potential future users of the data about their potential value.

8. ACKNOWLEDGMENTS

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