Assessing the Impact of Mobile, Multi-Source, Observations on Forecast Accuracy

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Abstract

Data from mobile, particularly airborne, sensors have been shown to be extremely impactful relative to increasing the fidelity of NWP model output (Barwell et al. 1985, Kruus 1986, Baeda et al. 1987, Benjamin et al. 1991, Smith and Benjamin 1994, Graham et al. 2000, Schwartz et al. 2000, Zapotocny et al. 2000, Zhang et al. 2016). However, most aircraft sensing platforms do not have a mechanism for recording moisture; sensing platforms that do have a means of measuring moisture often are not assimilated into numerical weather prediction models (Moniger et al. 2003, Hoover et al. 2017). An experimental study was designed to investigate the impact of assimilating in-situ measures of pressure, temperature and humidity into the Weather Research and Forecast (WRF) model using data collected during the PEMDAS Air-Land-Sea (ALS) field campaign. The PEMDAS designed Airborne Sensing and Prediction System (ASAPS) provided high-frequency (1Hz), in-situ, data-linked measures of pressure, temperature, and humidity across each of the three sources. Observations were assimilated into a regional NWP model with performance assessed relative to representative control runs using NCAR's Model Evaluation Tools verification package. Notable improvements for many parameters, including temperature and composite reflectivity are attributed to the inclusion of these high-frequency in-situ observations.

1. Background

OVERVIEW

- Aircraft data "most important" observation type (*Weygandt et al. 2017*)
- Airborne Sensing and Prediction System (ASAPS)
  - In-situ (1Hz) measures of pressure, temperature, humidity
  - Light-weight, flexible design for easy interface
  - Data linking capability enables real-time assimilation
- Air-Land-Sea field campaign launched to assess impact of real time sensing on NWP output

Sea—Boat on Lake Erie Buffalo, NY

Air—Avwatch Cessna 182, NY Airport

Land—SUV around Cicero, NY

PEMDAS TECHNOLOGIES & INNOVATIONS

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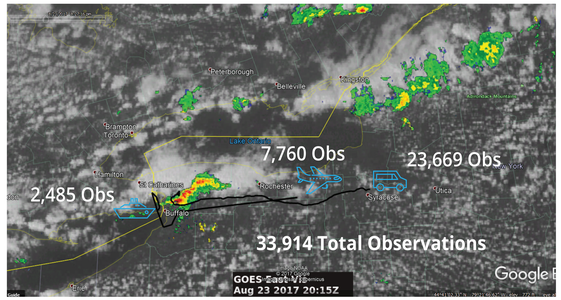
2. Data and Methodology



Platforms

Tracks associated with each of the observing platforms

- **Air Component**—ASAPS integrated onto Avwatch aircraft
  7,760 Observations
- **Land-Component**—ASAPS integrated onto SUV
  23,669 Observations
- **Sea-Component**—ASAPS integrated onto boat
  2,485 Observations

Overview

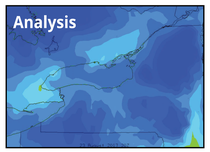
- Synchronized measures of in-situ pressure, temperature, and humidity were collected (1Hz sampling) and data linked in real time during a 2-hour campaign conducted in upstate New York on August 23, 2017.

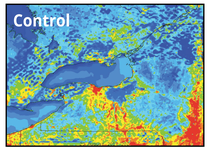
Model Configuration

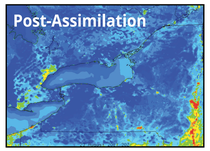
- Weather Research and Forecasting (WRF) ARW model
- 3km horizontal resolution covering state of New York
- High Resolution Rapid Refresh (HRRR) model provided initial conditions
- Data assimilated using four dimensional data assimilation and nudging techniques
- MET derived verification statistics computed relative to NCEP ADP Global Upper Air and Surface Observations.

3. Results

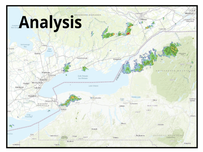
Surface Temperature

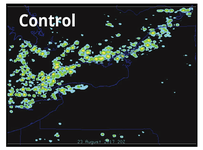


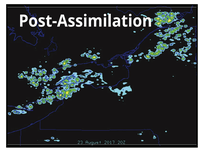




Composite Reflectivity







Surface Temperature

- **Control Run**—Significant warming of surface temperatures across domain relative to NLDAS analysis
- **Post-Assimilation Run**—significant reduction in errors with forecast surface temperatures more closely resembling NLDAS analysis

Composite Reflectivity

- **Control Run**—Relative to observed reflectivity, the model over-predicts convective activity, particularly along the northern edge of Lake Ontario and areas to the west
- **Post-Assimilation Run**—significant decrease in convective activity along the northern edge of Lake Ontario with better characterization of convection relative to observations

Root Mean Square Error Statistics

Variable	Pressure Levels	Control	Post-Assimilation
Temperature (°C)	1000-100	1.7	**1.4**
U Component (m/s)	1000-100	2.47	**2.1**
V Component (m/s)	1000-100	2.1	2.1
Relative Humidity (%)	1000-100	11.1	**10.1**
Geopotential Height (m)	1000-100	10.3	**4.5**

Verification Time: Aug 23, 2017 / 2000Z

4. Conclusions

- Mobile observations of temperature, moisture, and pressure were collected at 1Hz sampling rate at various locations across New York and assimilated into regional model
- Modeled surface temperature significantly improved (when compared to NLDAS analysis) with the Post-Assimilation run compared to the Control run
- Post-Assimilation modeled composite reflectivity showed significant reduction in convective activity to the west and north of Lake Ontario, more closely resembling observations
- Root Mean Square Error (RMSE) reductions realized throughout atmospheric column for temperature, U-wind component, relative humidity, and geopotential height (V-wind component relatively unchanged)
- ASAPS observations were shown to provide improvement to regional model performance