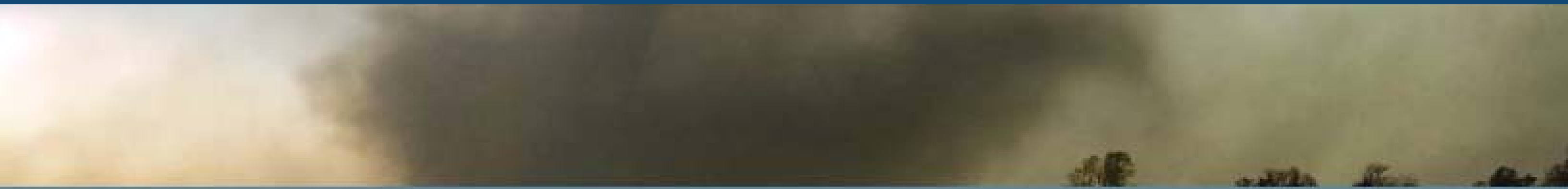
Results of the *Clarus* Regional Demonstrations

Evaluation of Enhanced Road Weather Forecasting



The *Clarus* Initiative is a research effort of the U.S. Department of Transportation Intelligent Transportation Systems Joint Program Office and the Federal Highway Administration's Road Weather Management Program to develop and demonstrate an integrated weather observation data management system that can reduce the impact of adverse weather conditions on surface transportation.

Under this initiative, a data management system was developed to accept, quality check, and disseminate the weather and road condition data collected by environmental sensor stations installed along the nation's roads. This system is called *Clarus*. In a complementary effort to explore the value of the data disseminated from the *Clarus* system, two regional demonstrations were conducted. These demonstrations developed, tested, and evaluated five use cases for *Clarus* data. This flyer summarizes the results of an independent evaluation of the first use case, Enhanced Road Weather Forecasting, which supports the other four use cases.

In particular, the evaluation explored the impact of *Clarus* data on the following weather and road condition forecasting tools, which support each of the use cases:

- Local Analysis and Prediction System (an analysis tool used to initialize weather forecast models)
- Weather Research and Forecasting Models
- Road Condition Forecasting Models
- Pavement Precipitation Accumulation Estimation System (a precipitation estimation tool).

Local Analysis and Prediction System (LAPS)

The weather community uses LAPS to generate a set of weather analyses and forecasts by integrating data from several sources including NexRad radar, satellite observations, and surface observations. LAPS generates estimates of current weather conditions, which function as the starting point for a weather forecast model.

The independent evaluation found that integrating *Clarus* data into the LAPS estimation process resulted in LAPS weather condition estimates that matched more closely with observations than those without *Clarus* data.

The *Clarus* data impacted the LAPS estimates about half the time. In these instances, the LAPS estimates more closely matched observations about 70 percent of the time for surface temperature, more than 60 percent of the time for relative humidity, about 55 percent of the time for wind speed, and 50 percent of the time for dew point temperature and surface pressure. A value of 50 percent indicates the impact was about the same as random changes to the data. A value greater than 50 percent indicates an improvement.

Weather Research and Forecasting (WRF) Models

WRF models (atmospheric forecasts) take estimates for initial conditions from tools like LAPS and use weather physics to determine future weather conditions. The evaluation examined whether the use of *Clarus* data with the WRF models resulted in improved weather forecasts. The inclusion of *Clarus* data in the WRF forecasts impacted the forecast results, but did not significantly improve agreement between the forecasts and *Clarus* observations.

The systems used to estimate initial weather conditions for WRF models do not consider the full complexity of the weather physics built into the forecasting models. Thus, WRF models often make large changes to those initial conditions during the first forecasts hours, generating inaccurate weather forecasts that wash away small differences in the initial conditions. This appeared to be the case with the impact of the *Clarus* data on the WRF forecasts—the changes in the LAPS estimates were washed out while the forecast model initialized, meaning *Clarus* neither helped nor hurt the WRF output.

Road Condition Forecasting Models

Changes to the pavement surface temperature are driven by two often competing factors—the atmospheric conditions above the pavement and the subsurface conditions beneath the pavement. Road condition models forecast future road conditions by estimating initial pavement and subsurface conditions, forecasting future atmosphere conditions, and using a pavement and subsurface model to estimate the impact of the forecast atmospheric conditions on the pavement and subsurface conditions. The evaluation used *Clarus* observations to estimate the initial pavement and subsurface conditions and to improve the atmospheric weather forecasts at the site.

Including *Clarus* data in the site-specific air and road temperature forecasts provided improved agreement between the forecasts and the observations. During the early hours of the forecast, the average improvement was almost 2 degrees Celsius, perhaps because the availability of observations resulted in more accurate estimates for the model initial conditions and more accurate forecasts of atmospheric conditions early in the forecast period. The forecasts made using *Clarus* data continued to be better on average than those made without *Clarus* data for the first 24 hours.

Pavement Precipitation Accumulation Estimation System (PPAES)

Clarus data was also used in a PPAES to improve radar-based estimates of the presence of precipitation. The evaluation found that the use of *Clarus* data in the PPAES analysis both enhanced real-time precipitation estimates under some circumstances as well as degraded estimates in other situations. In particular, the PPAES analysis with *Clarus* data was more effective than radar alone at estimating when and where precipitation occurred during winter months, particularly at higher latitudes and for locations relatively far from the nearest weather radar station. However, the PPAES analysis with *Clarus* data was more likely to indicate that precipitation occurred where it did not (i.e., generate false alarms) than to indicate that precipitation did not occur where it did.

These results are consistent with known limitations of radar precipitation measurements, such as overshoot (where radar observations miss precipitation forming at lower elevations) and low reflectivity of snow particles to radar signals (causing radar to underestimate wintertime precipitation). Thus, using the PPAES model with *Clarus* data helped improve precipitation estimates in the circumstances where radar observations are weakest.

Conclusion

The evaluation demonstrated the benefits of using *Clarus* surface observations to enhance weather and road weather forecasting and estimation systems. While the *Clarus* data did not appreciably improve the atmospheric forecasts, it did improve the estimates for the initialization data that fed those forecasts. The *Clarus* data resulted in significantly improved road temperature forecasts for the first 24 hours, especially in the early hours of the forecast. When used with the PPAES model, the *Clarus* data was more effective than radar alone at estimating precipitation, particularly in the winter months and at locations further removed from weather radar stations.

Taken together, this use case captures the value of *Clarus* data in supporting road weather management decision support systems.

All photos unless otherwise attributed are courtesy of the Federal Highway Administration Road Weather Management Program.

U.S. Department of Transportation
Road Weather Management
1200 New Jersey Avenue, E86-205
Washington DC 20590

Paul Pisano
202-366-1301
E-mail: paul.pisano@dot.gov
http://ops.fhwa.dot.gov/Weather/index.asp

"Anytime, Anywhere Road Weather Information"

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