NASA PRODUCTS TO ENHANCE ENERGY UTILITY LOAD FORECASTING

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ABSTRACT

Existing energy load forecasting tools rely upon historical load and forecasted weather to predict load within energy company service areas. Microclimates and weather events such as stalled fronts have proved particularly challenging for load forecasting. The shortcomings of load forecasts are often the result of weather forecasts that are not at a fine enough spatial or temporal resolution to capture local-scale weather events. This project aims to improve the performance of load forecasting tools through the integration of high-resolution, weather-related NASA Earth Science Data, such as temperature, relative humidity, and wind speed. The result of enhanced performance of these load forecasting tools is energy conservation and cost savings to energy users. Four companies are participating in operational testing — two natural gas companies, and two electric providers. Operational results comparing load forecasts with and without NASA weather forecasts have been generated since March 2010. In addition, Battelle has consulted with energy companies nationwide to document their information needs for long-term planning, in light of climate change and regulatory impacts. The project will conclude in 2011 with transitioning documented improvements from the in-

MOTIVATION

Current daily energy load forecasts have mean absolute percent error (MAPE) values of 5%-7% for natural gas companies, and 1%-3% for electric companies

Energy companies often use weather forecasts based on one or a few land-based weather stations, failing to capture larger patterns and microclimates across the area. Surface reporting stations and forecast sites are limited

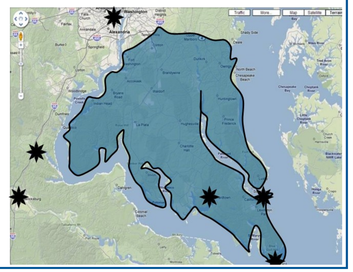
- Few and usually far apart
- Not in areas that are representative due to:
  - Terrain
  - Influenced by local effects
  - Far from population centers

Refinement to weather inputs could lead to substantial cost savings and more efficient use of resources

Weather data needs to be:

- Available in real-time (observations)
- Forecast at 1-3 hour intervals, 1-10 days out
- Parameters include Temperature (also daily max / min), Relative Humidity, Wind (speed / direction), Precipitation, Cloud cover, etc.

- NASA Historical Datasets
  - Daily data sets spanning January 1983 to present



GOALS

Objective: Develop applications of NASA products to meet the needs of energy companies for both short-term and long-term planning

1) Determine whether NASA satellite weather parameters improve energy load forecasts beyond existing ground-based weather inputs.
2) Conduct real-time testing and demonstrate the improvements in the load forecast possible with NASA parameters at selected utilities. Fine tune and document the benefits.
3) Transition documented improvements for sustained use of NASA resources by energy utilities nationwide'
4) Investigate NASA climate data, model products, and projections to identify those of potential value to utilities for long-term (seasonal to 40 years) planning. (e.g., climate change impacts on infrastructure, integration of renewable energy such as wind).

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PHASE 1: HISTORICAL TESTING

Goal: Compare load forecast results with and without NASA satellite weather forecasts

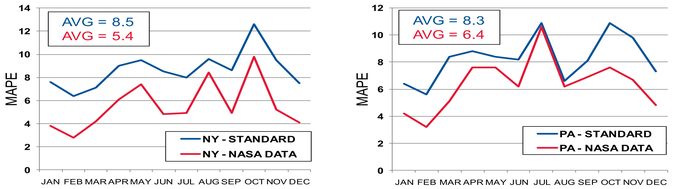
- **Monthly results show improvements in accuracy across the entire year with NASA weather forecasts**

See example below for two natural gas service areas:

– Peak demand months, most important, largest demand - up to 4.3 percentage pts improvement in accuracy

– "Shoulder" months (spring and fall), most variable weather, demand hard to predict – up to 3.7 percentage pts improvement

IMPROVEMENTS IN LOAD FORECAST ACCURACY WITH NASA WEATHER FORECASTS



PHASE 2: OPERATIONAL TESTING

Goal: conduct real-time testing of load forecasts with NASA weather forecasts. Fine tune and document the benefits.

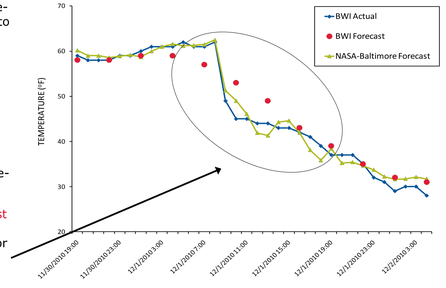
• Three utilities are currently conducting operational analysis using NASA weather forecasts, using duplicate load forecast models to test the actual load forecast improvements

Model 1: Standard ground-based weather forecasts

Model 2: NASA weather parameters and ground-based forecasts combined

• Model performance will be tracked to fine-tune the model inputs and improve load forecast results

• NASA weather forecasts have captured fast temperature changes associated with fronts far better than the ground-based forecast for the utilities' service areas



PHASE 3: NATIONWIDE TRANSITION

Goal: Transition documented improvements for sustained use of NASA resources by energy utilities nationwide, in a variety of load forecasting tools

- Third year of project has focused on transition:
  - Contributing improved forecast methods from SPoRT research to NWS National Digital Forecast Database
  - Developing methodology to help utilities analyze NASA weather forecasts and conduct statistical analysis to de-

STATISTICAL ANALYSIS

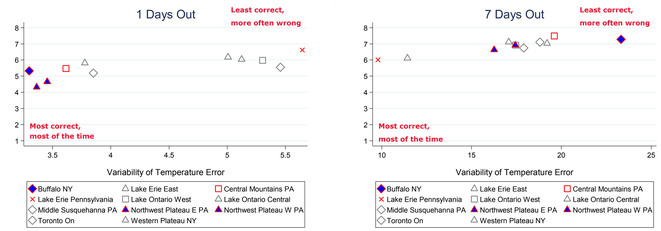
Including a large number of inputs in energy load forecasting models can sacrifice model performance. Therefore, additional weather forecast points should be evaluated for inclusion. The questions to be addressed by in deciding if and how to apply high resolution NASA/NDFD forecasts are:

1) Are the NASA/NDFD forecasts closer to actual weather than existing ground-based forecasts?
2) Of the available forecast points, are there certain points which will always or sometimes improve the forecast?
3) Will different subsets of forecast points improve the forecast in different situations, such as seasons or times of day?

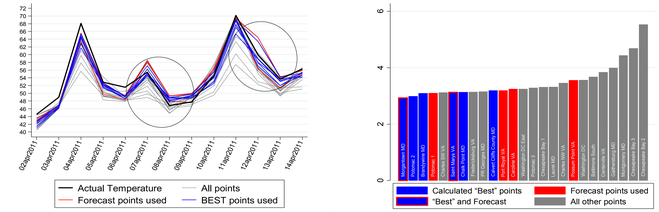
Available forecast points should be evaluated based on:

- Small difference between forecast and actual weather
- Low variability of forecast error (how often, how much forecast deviates from actual weather)

- NASA forecasts that are, on average, most similar to actual weather are not necessarily the best
- Blue filled points are "BEST" points selected using the factors above. Red points are "FORECAST" points currently used by the utility.
- "BEST" points selected based on 1 Day out weather forecast are not the best points according to 7 Day out forecast.



- Four out of six "BEST" points do not match the points used by the utility. Each °F degree improvement in forecast with "BEST" points resulted in 0.83MV decrease in Energy Load forecast error vs. 0.78MV decrease when "FORECAST" stations used
- "BEST" lines better estimate the actual weather (black line) during "shoulder months". (left plot)
- When NASA points arranged from smallest to largest temperature error, points with the least variability (more often correct) are not necessarily the points with the smallest temperature error. (right plot)



This scatter plot shows a positive relationship between Weather Forecast Error and Weather Adjusted Energy Load Error (energy "hindcast" using actual weather observations). The statistically significant relationship means that Weather Error Forecast error causes Energy Forecast Error. The relationship is rather weak, but the following factors will improve robustness of the statistical analysis:

- Current statistical analysis was done using only January—May 2011 data. Access to hourly actual temperatures, weather forecast, actual energy loads, and energy load forecast over the entire year (full range of temperatures) would allow a more accurate statistical model to better estimate the relationship between energy load forecast and weather forecast errors.
- Energy utilities have access to their own internal load forecast models, which will allow control over the choice of model inputs. Therefore, it will be possible to determine which combination of model inputs provides the best possible energy load forecast.