A Model-Driven Sensor Web Simulator

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Using Sensor Webs to Improve Weather Prediction

Although numerous strides in weather forecasting were achieved in the past forty years, many of the operational concepts for today's observing systems remain essentially unchanged. Some improvements have been suggested to address this deficiency, such as the use of sensor webs.

Operational use of targeted observations that focus on "sensitive regions" of the forecast model could facilitate the evolution of predictive skill. A model-driven sensor web architecture utilizes the ability to find these sensitive regions and acquire additional or improved observations in those regions, in particular. A sensor web might consist of sensors on satellites and other platforms, ground systems, weather models and other components. The sensor web enables cooperative, real-time measurements and targeted observations that can be used to improve the operational efficiency and the forecast model's predictive skill.

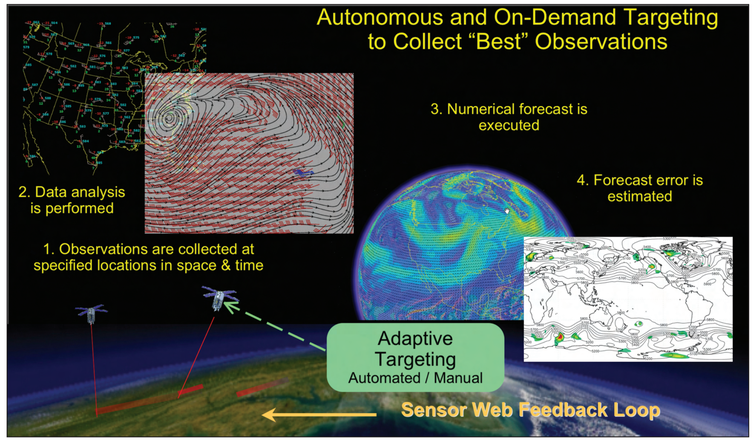

Figure 1 – Forecasts regions that are sensitive to error are targeted for additional observations.

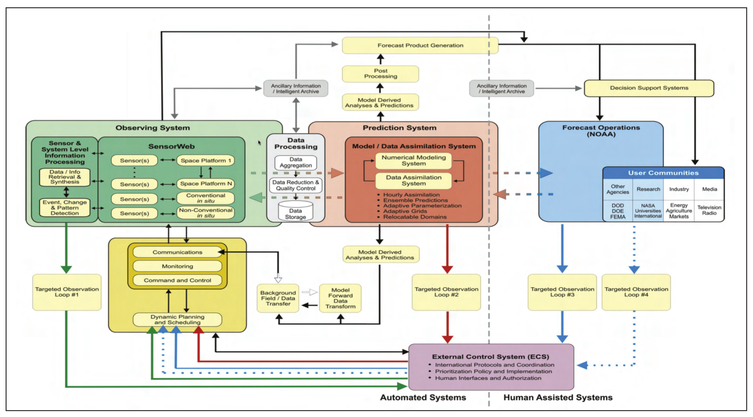

Figure 2 – A feedback-driven sensor web uses weather prediction to acquire the "best" target.

A Sensor Web Simulator

However, implementing a national sensor web system is risky. New technologies must integrate the pieces into a cooperative framework. Additionally, the mathematical complexities of data assimilation and the chaotic atmosphere do not guarantee improved predictive skill. Simulation of a sensor web is critical.

Therefore, NASA Goddard Space Flight Center is developing the Sensor Web Simulator. This tool simulates the behavior of a real-world, model-driven sensor web. It leverages Observing System Simulation Experiment (OSSE) technology to create simulated, global sensor observations. Through the use of a workflow tool and distributed services (Figure 3), the Sensor Web Simulator integrates the components and allows users to configure and simulate specific scenarios.

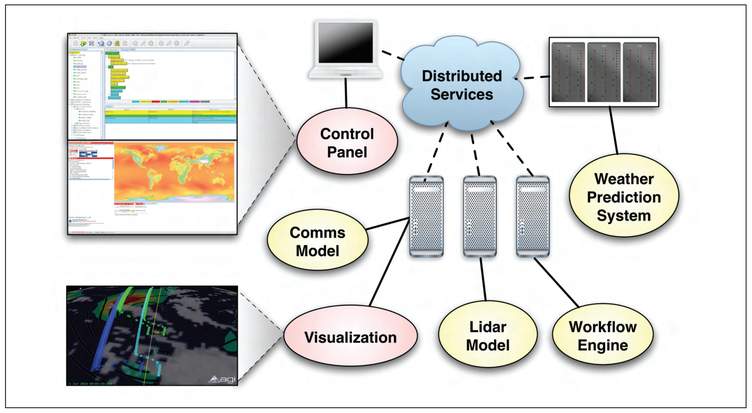

Figure 3 – The NASA Sensor Web Simulator is a distributed set of tools and model services.

Results of Targeted Global Wind Observing Sounder (GWOS) Lidar Simulation

The simulator is in the early stages of development, however, potential benefit has been demonstrated. The first experiment examined whether reducing the number of shots from the GWOS lidar instrument would significantly impact the forecast. This could potentially extend the mission life and reduce overall mission cost. Currently, the lidar instrument will operate in "survey mode," taking shots at regular intervals (smaller box in Figure 4). However, lidar shots could be eliminated if they have minimal impact on model accuracy. The simulated lidar instrument then becomes model-driven since it uses forecast data from the model to decide when to take shots. Large differences between measurements from the instrument and the expected model value would result in additional shots being taken by the instrument.

The experiment results suggest that reducing targeted lidar shots would not significantly impact the atmospheric state (Figure 5) and thus targeted measurements could be used to improve the overall lifespan of the instrument.

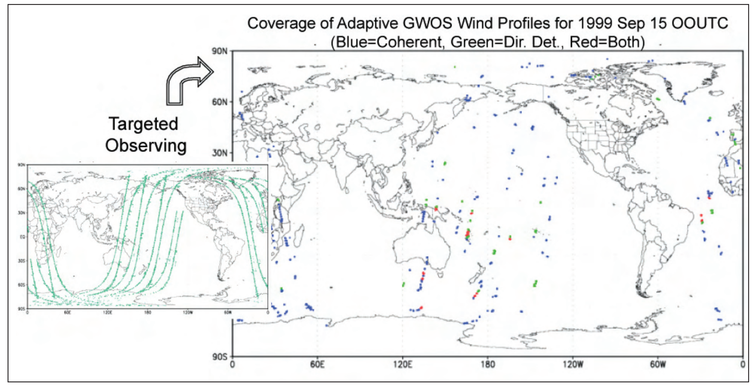

Figure 4 – Targeted observing greatly reduces the observations and improves instrument life.

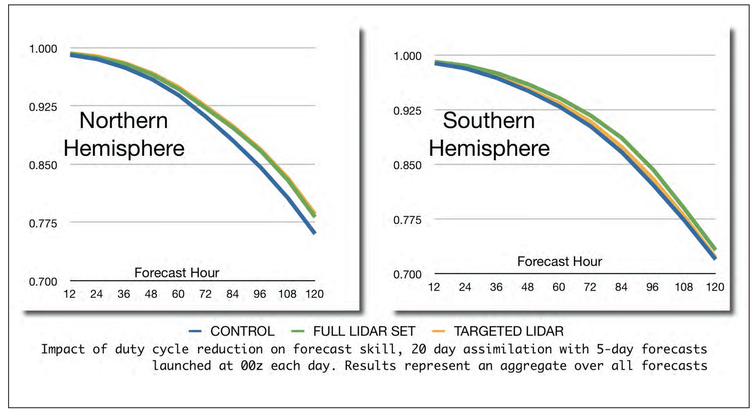

Figure 5 – Intelligently reducing lidar shots has little effect in the Northern Hemisphere.

Future Project Direction

NASA's Sensor Web Simulator project is currently focusing on achieving additional scenarios beyond the previously described GWOS lidar experiment, such as GOES-R scenarios. Future work was proposed that will expand the simulator software beyond a prototype into a fully integrated tool capable of simulating and analyzing multiple types of scenarios. The work will culminate in the release of a mission design tool for scientists and engineers at NASA.

Acknowledgments

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