DWL Operations within a Sensor Web
Modeling and Data Assimilation System: Recent Results

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A model-driven sensor web is an Earth observing system that uses information derived from data assimilation systems and numerical weather prediction models to drive targeted observations made from earth-orbiting spacecraft as well as from atmospheric- and ground-based observing systems.
**Demonstrate** the value of implementing sensor web concepts for meteorological use cases

**Quantify** cost savings to missions

**Quantify** improvement in achieving science goals

**Design and Build** an integrated simulator with functional elements that will allow multiple “what if” scenarios in which different configurations of sensors, communication networks, numerical models, data analysis systems, and targeting techniques may be tested
TIME SERIES of monthly mean anomaly correlations for 5-day forecasts of 500hPa heights for various operational models (CDAS frozen as of 1995) - Northern Hemisphere

“Anomaly Correlation”

An expression of how well predicted anomalies correspond to observed anomalies

One metric of predictive skill of weather forecasts

Improvements in predictive skill over the past several decades have been gradual; the sensor web provides an opportunity for a “revolutionary” impact

Source: Fanglin Yang, Environmental Modeling Center, National Centers for Environmental Prediction, NOAA
Errors in temperature forecasts lead to errors in the prediction of electrical loads for large utilities

San Francisco, May 28, 2003
Temperature forecast error of about 5ºC
Electrical load underestimated by 4.8GW
“On the spot” energy purchase required

$10 million impact in a single day

Use Case: Decadal Survey
Mission 3D Wind Lidar

Global Wind Observing Sounder (GWOS)

Orbiting GWOS at 400 km

Return light: t+3.9 ms, 30 m, 4.4 μrad
Second shot: t+200 ms, 1535 m, 227 μrad
First Aft Shot t+81 s

Nadir tilt rate - 1.1 μrad/ms
90° fore/aft angle in horiz. plane

5 Hz Laser Shown

Telescope Modules (4)

Application of Sensor Web Concepts

- **Simulation 1: Extend Mission Life via Power Modulation**

- Conserve power / extend instrument life by using aft shots only when there is “significant” disagreement between model first guess line-of-sight winds and winds measured by fore shots
  - Lidar engineers have recently suggested reduced duty cycles may increase laser lifetimes
  - Duty cycles that are on the order of 10 minutes “on” and 80 minutes “off” may be very beneficial to mission lifetime
- Will require model’s first guess fields be made available on board the spacecraft -- requires engineering trades be performed for on-board processing, storage, power, weight, communications
Simulation 1 Results

Lidar data deleted when there is “adequate” agreement with the numerical model’s first guess wind fields.

Designed to simulate suppression of the aft shot of the lidar.

Result: Nearly 30% of the lidar’s duty cycle may be reduced -- IF there is no discernible impact to forecast skill!
Simulation 1 Results

Northern Hemisphere

Full lidar set and targeted lidar set are nearly identical - indicating a reduced duty cycle may be possible

Southern Hemisphere

Results in the Southern Hemisphere are more ambiguous; some indication of degradation due to targeting is evident

Impact of duty cycle reduction on forecast skill, 20 day assimilation with 5-day forecasts launched at 00z each day. Results represent an aggregate over all forecasts.
Simulation 2: Better Science via Targeted Observations

- Goal is to target two types of features to help improve predictive skill:
  - “Sensitive regions” of the atmosphere: those regions where the forecast is highly responsive to analysis errors
  - Features of interest that may lie outside of the instrument’s nadir view
    - Tropical cyclones
    - Jet streaks
    - Rapidly changing atmospheric conditions
- Would require slewing
- Would require optimization to choose between multiple targets
- Studies have shown that targeted observations can improve predictive skill (difficult to implement operationally)

Studies have shown the adjoint technique to be effective for adaptive targeting\(^\dagger\). Testing with this technique will occur during years 2-3 in coordination with NASA’s Global Modeling & Assimilation Office.

Selecting Specific Targets

Potential Targets with GWOS Lidar Coverage 1999 Sep 15 06UTC
Green=no slew, Red=right slew, Blue=left slew. Rank Shown in Box.
Simulation 2: Adaptive Targeting
Sensor Web Simulator Design

During 2007 most elements of the lidar use case (1-5) were executed “by hand” to help aid in the design of the simulator prototype.

Five separate Observing System Simulation Experiments (OSSEs) were conducted that concluded:

- Under certain situations, the lidar duty cycle may be reduced 30% without impacting forecast skill.
- Under certain situations, having the model task the lidar to perform a roll maneuver improves detection of features of interest 30% (tropical cyclones, jet streaks, rapidly changing atmospheric conditions).

SIVO Workflow Tool (“NASA Experiment Design”)

Selected as the “glueware” to sequentially execute components 1-6 and manage data flow.

1 The OSSEs performed were based upon a 20 day assimilation cycle during September 1999. Although the use cases have been examined by GMAO scientists they have not undergone a rigorous scientific review and the results should not be considered scientifically valid. OSSEs presented here are to validate engineering processes of the simulator.
DOPPLER LIDAR SIMULATION MODEL
VERSION 4.2
Online Web-based User’s Guide
S. A. Wood  G. D. Emmitt  L. S. Wood  S. Greco
In Spring, 2008 Simpson Weather Associates, Inc. established the Doppler Lidar Simulation Model version 4.2 onto an Apple dual quad processor computer for the SensorWeb project. SSH, the network protocol that allows data to be exchanged over a secure channel between two computers, was installed and tested. SWA and SIVO were able to test the push/pull and communications functionality successfully. SIVO was able to push DLSM inputs to SWA and request model simulations. The DLSM was successfully executed and SIVO was able to retrieve DWL coverage and DWL line-of-sight wind products for a six hour simulation in less than 2 minutes.
NEAR FUTURE PLANS

• Line of Sight wind operator for the assimilation models

• Integrate Satellite Toolkit into the workflow tool to provide satellite location and attitude inputs

• Establish the T511 and T799 nature runs into DLSM database format including generating aerosol, molecular and cloud optical property databases

• Build the slewing capability into the scanner model

• Integrate into the Sensor Web the SWA cloud motion wind model

Global OSSEs (maybe mesoscale OSSEs - hurricanes)