

Analyzing & Forecasting High Impact Events- CSTAR Activities at the University of Utah

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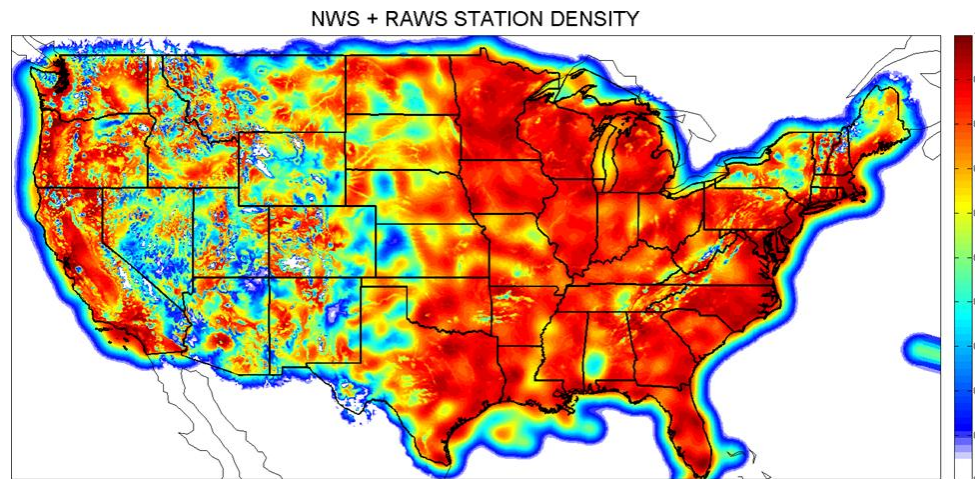
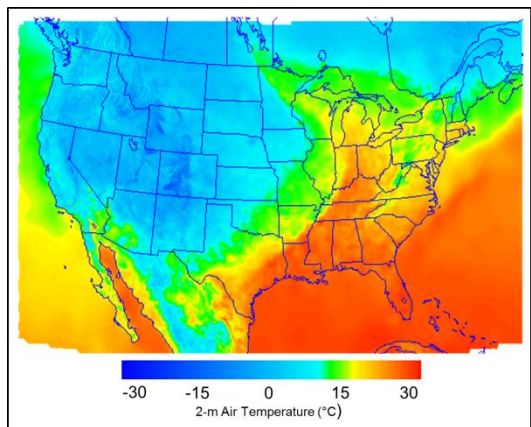
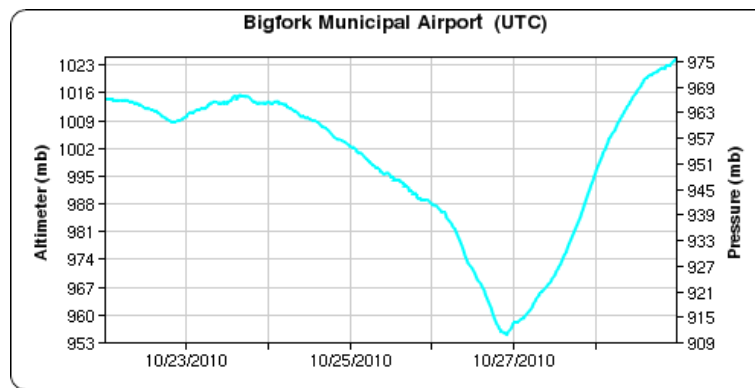
Station Search Help
Address

LINKS
Status
Help
ROMAN
Department of
Atmospheric Sciences

Login to My MesoWest
Login:
Password:

 Find us on
Facebook

MESO WEST
States
Click on a State to access weather observations



Outline

- Quick topics
 - U/Utah CSTAR project
 - Related fire weather efforts: ROMAN and GLFFC
- MesoWest
- Development of an efficient 2D variational approach comparable to the NCEP Real Time Mesoscale Analysis (RTMA)
 - Use analyses to estimate sensitivity of high impact weather events to mesonet type

NWS Collaborative Science, Technology, and Applied Research (CSTAR) Program



The [CSTAR Program](#) creates a cost-effective transition from basic and applied research to operations and services through collaborative research between operational forecasters and academic institutions which have expertise in the environmental sciences

- **1996-2007:** NOAA Cooperative Institute for Regional Prediction. Co-PIs Horel and Steenburgh
- **2007-2010:** Improved Monitoring, Analysis, and Prediction of High Impact Weather. Co-PIs John Horel, Jim Steenburgh, David Whiteman
- **2010-2013:** *Advancing Analysis, Forecast and Warning Capabilities for High Impact Weather Events. Co-PIs John Horel & Jim Steenburgh*



- Ten academic and six research faculty
- Wide ranging basic and applied research supported (~\$4 million annually) by federal agencies and other sources
- Mountain Meteorology Group
 - foster R&D to improve understanding and prediction of weather and climate processes in regions of complex terrain



Three NWS SCEP Students presently: Trevor Alcott, Jon Rutz, Kristen Yeager

CSTAR Project Goals

- identify high impact weather events through the continued development of data mining software using MesoWest & MADIS
- improve four dimensional analysis systems through R&D on sensitivity to boundary layer data assets, quality control procedures, and characteristics of the analysis systems in complex terrain
- advance short-to-medium range forecast capabilities for high-impact weather events over the western United States

Transfer of Applied Research To Operations

- MesoWest is a successful example of R&D supported by CSTAR
 - MesoWest is more than one of the many data pipes to MADIS
 - MySql relational database of current and archived data, metadata, software, and web displays integral to WFO office and IMET operations
- Evaluating the utility of mesonet observations for use in surface analyses and verification efforts (Myrick and Horel 2008; Horel and Dong 2010)
- Participating in the development and evaluation of the RTMA (Tyndall 2008; Tyndall et al. 2010)
- Quantitative forecasting of snowfall and liquid water equivalent, which is critical for preparing winter storm watches and warnings (Alcott and Steenburgh 2010)
- Identifying and predicting high impact weather events (Shafer and Steenburgh 2008, Steenburgh et al. 2009; West and Steenburgh 2010)

- Climatological study of SLR at Alta and Salt Lake City used to develop SLR algorithm for all of western Utah

- Snow-to-Liquid Ratio Variability and Prediction at a High-Elevation Site in Utah's Wasatch Mountains. Alcott & Steenburgh. Feb 2010. *WAF*

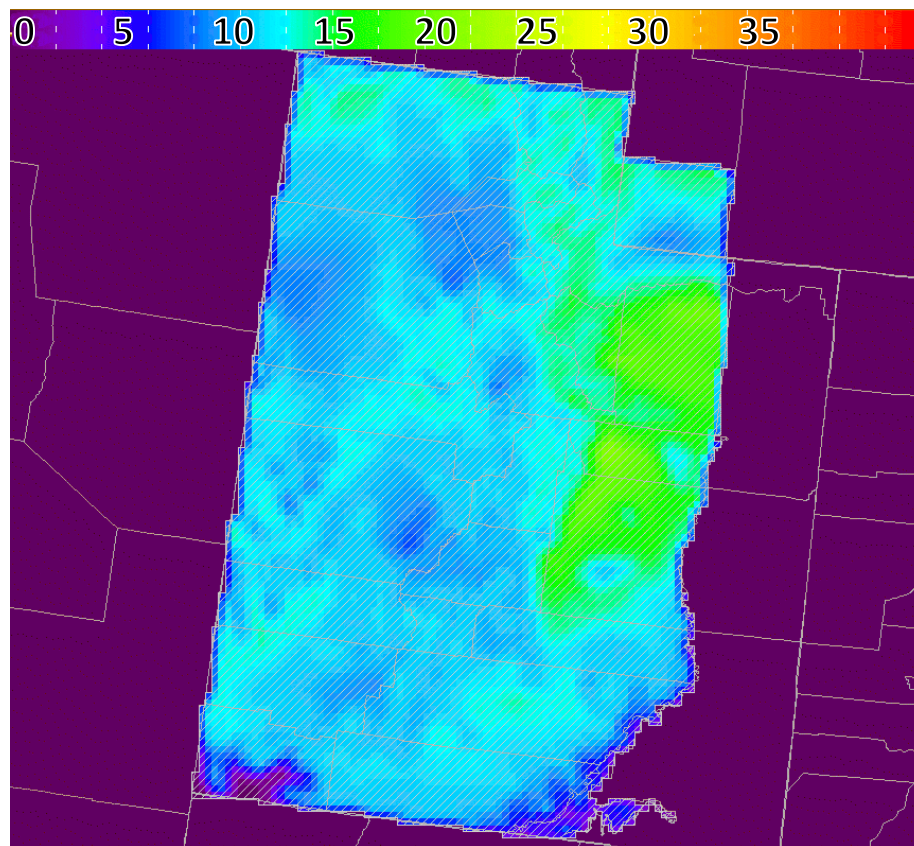
- Algorithm has been coded into a GFE (graphical forecast editor) smart tool to produce gridded forecasts of SLR, and in turn, snowfall amount.

- Replaces use of a single fixed ratio or unskillful empirical methods

- SLR tool is being used by most forecasters at WFO SLC, who report that it is improving (particularly mountain) snowfall forecasts.

Forecasting snow-to-liquid ratio

SCEP Student. Trevor Alcott

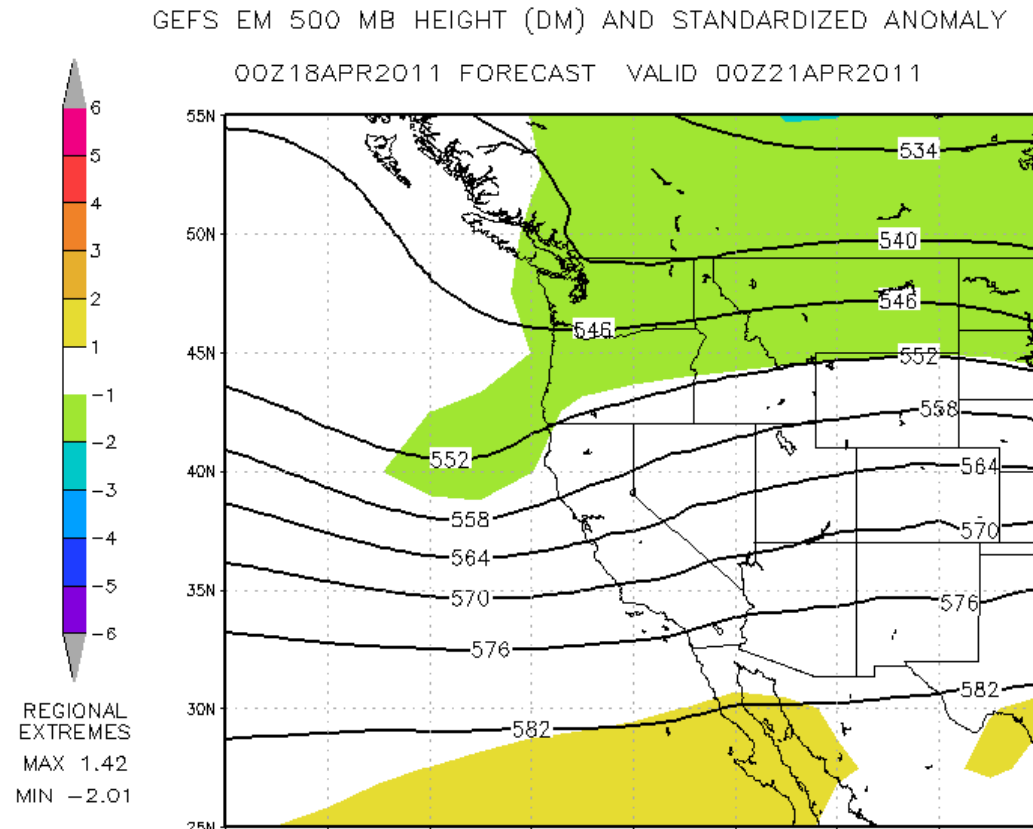


6-h SLR forecast valid 25-Dec-2008 6-12 UTC

Identification of High Impact Events with Standardized Anomalies

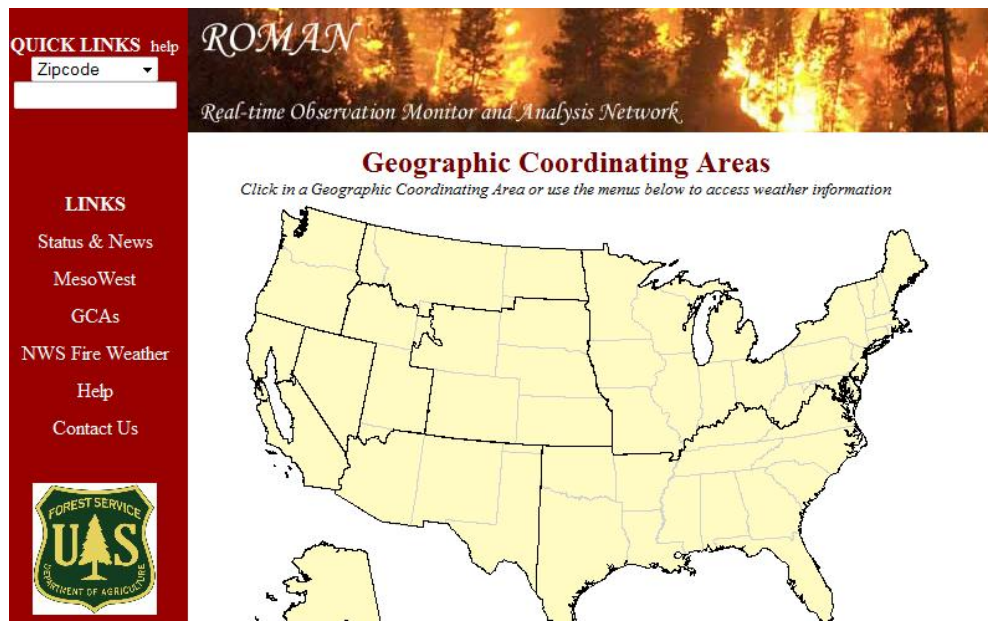
SCEP student Trevor Alcott & SLC SOO Randy Graham integrated standardized anomaly analyses and forecast products into operations (following work by Grumm)

<http://www.wrh.noaa.gov/slc/projects/anomalies/index.htm>.



High Impact Weather: Fire Weather

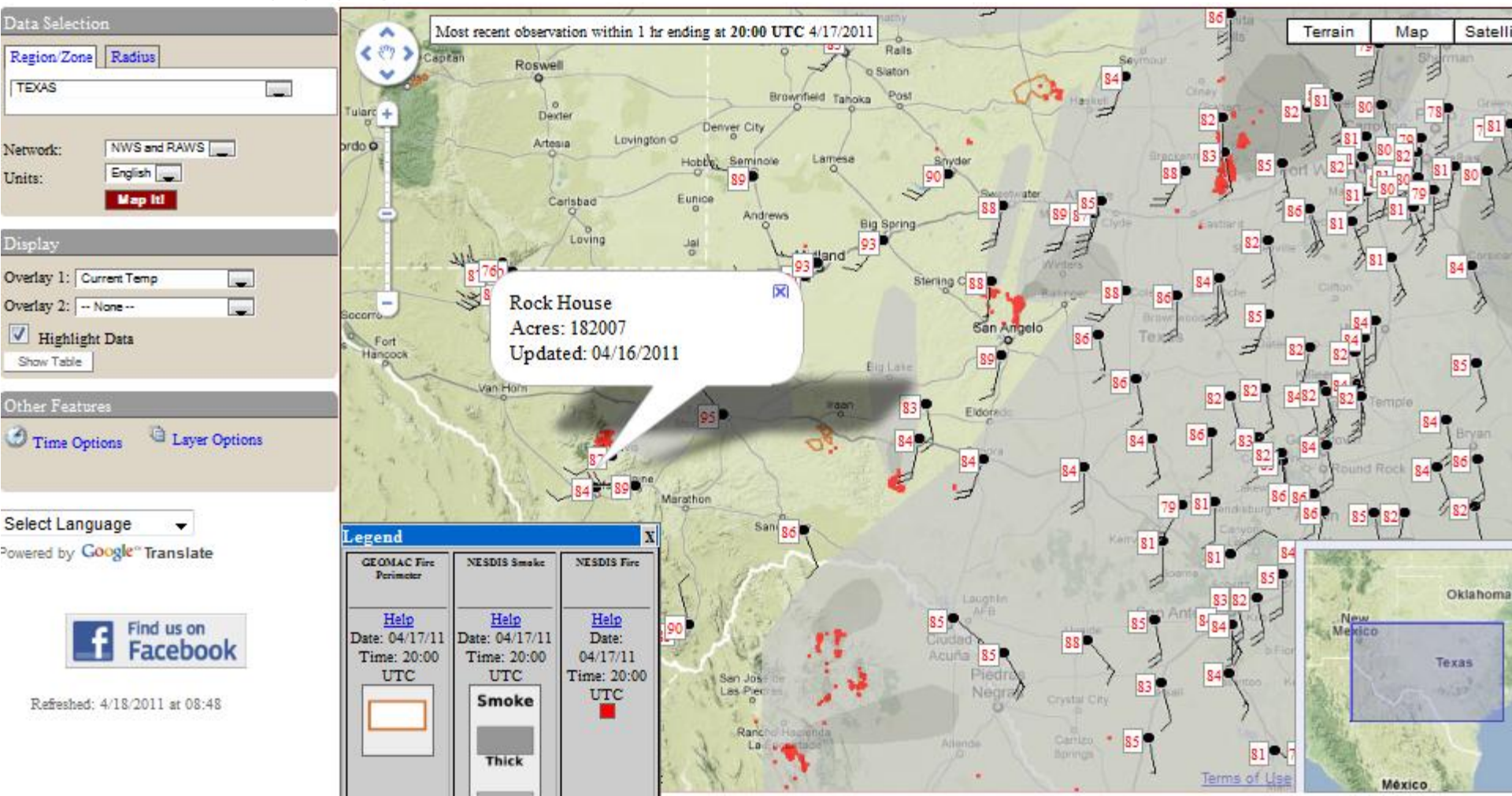
- ROMAN:
<http://raws.wrh.noaa.gov/roman/>
- NWS and land agency support
- Transitioning from NWS Western Region to Forest Service Kansas City IT hub
- Extensive use at WFOs and by IMETs



- As soon as RAWS deployed, information available for field use

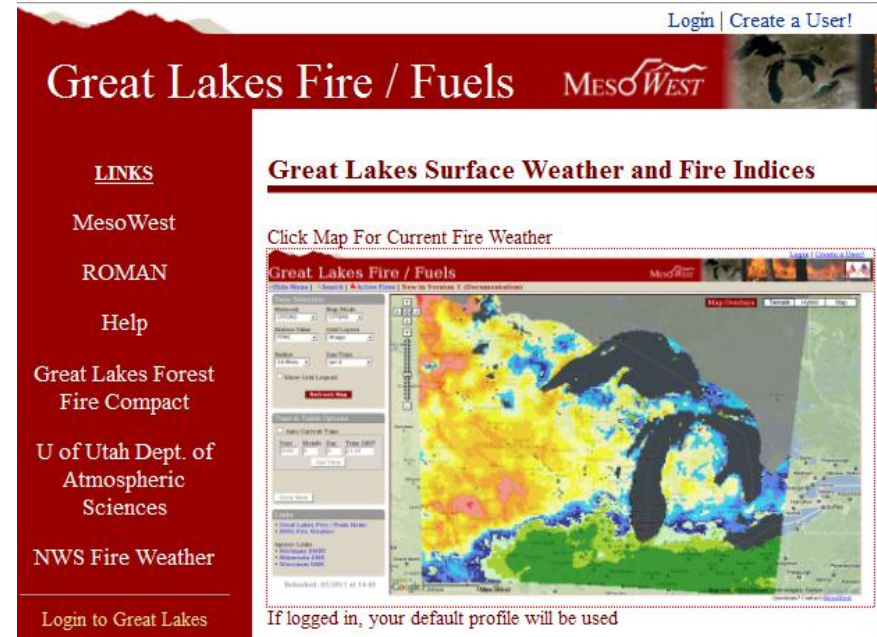
High Impact Weather: Fire Weather

- MesoWest: Integrating Weather and Other GIS Products

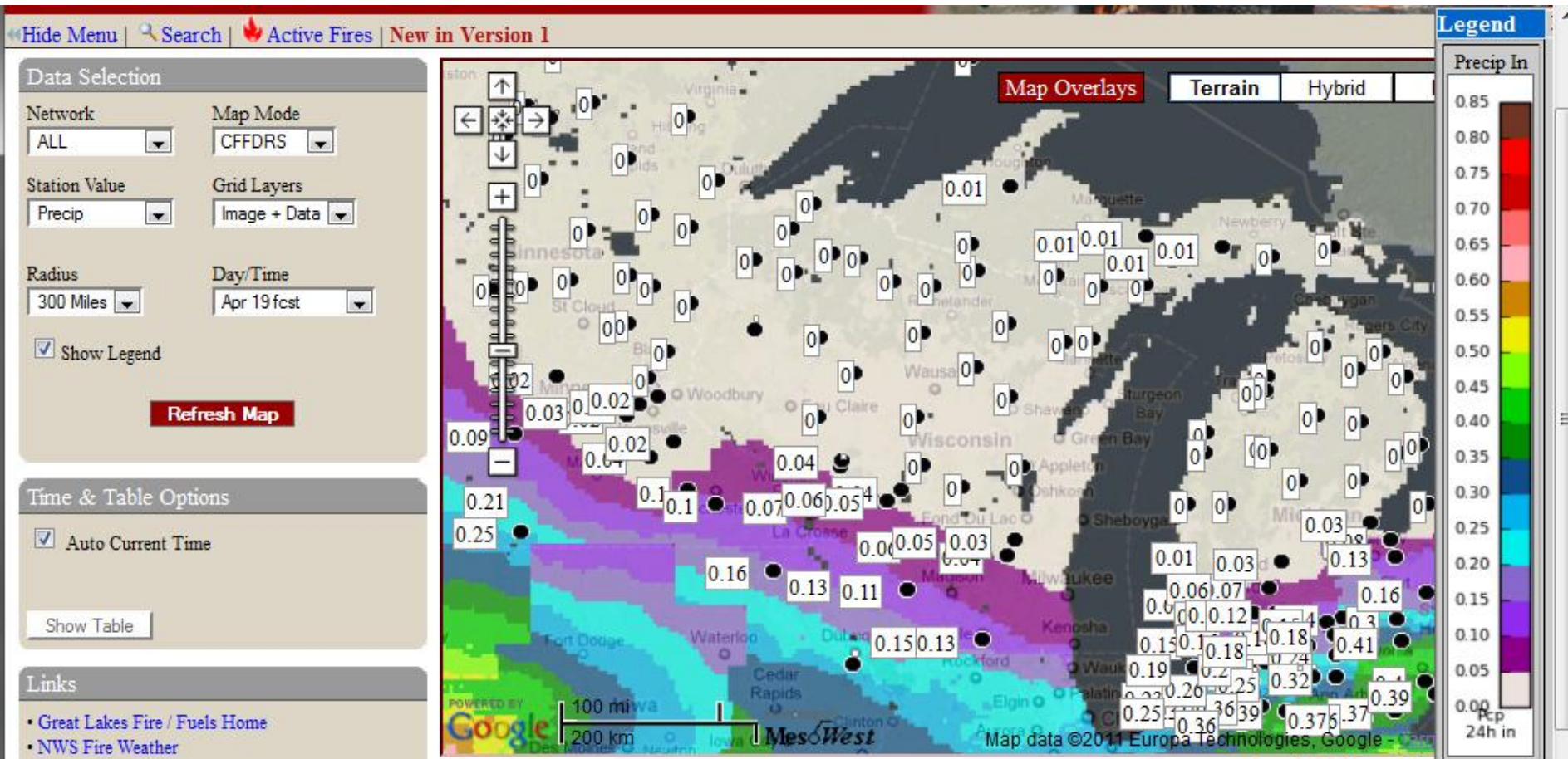


High Impact Weather: Fire Weather

- [GLFFC:](http://glffc.utah.edu)
<http://glffc.utah.edu>
- R&D support by Michigan, Minnesota, Wisconsin fire agencies via Great Lakes Forest Fire Compact
- Demonstrates developing tools that integrate observations and NWS forecast guidance for specific user applications



NDFD QPF 2 Day Forecast



2 Day Forecast of Fine Fuel Moisture Code

Data Selection

Network: ALL
 Station Value: FPMC
 Radius: 300 Miles
 Map Mode: CFFDRS
 Grid Layers: Image + Data
 Day/Time: Apr 19fcst

☒ Show Legend

Refresh Map

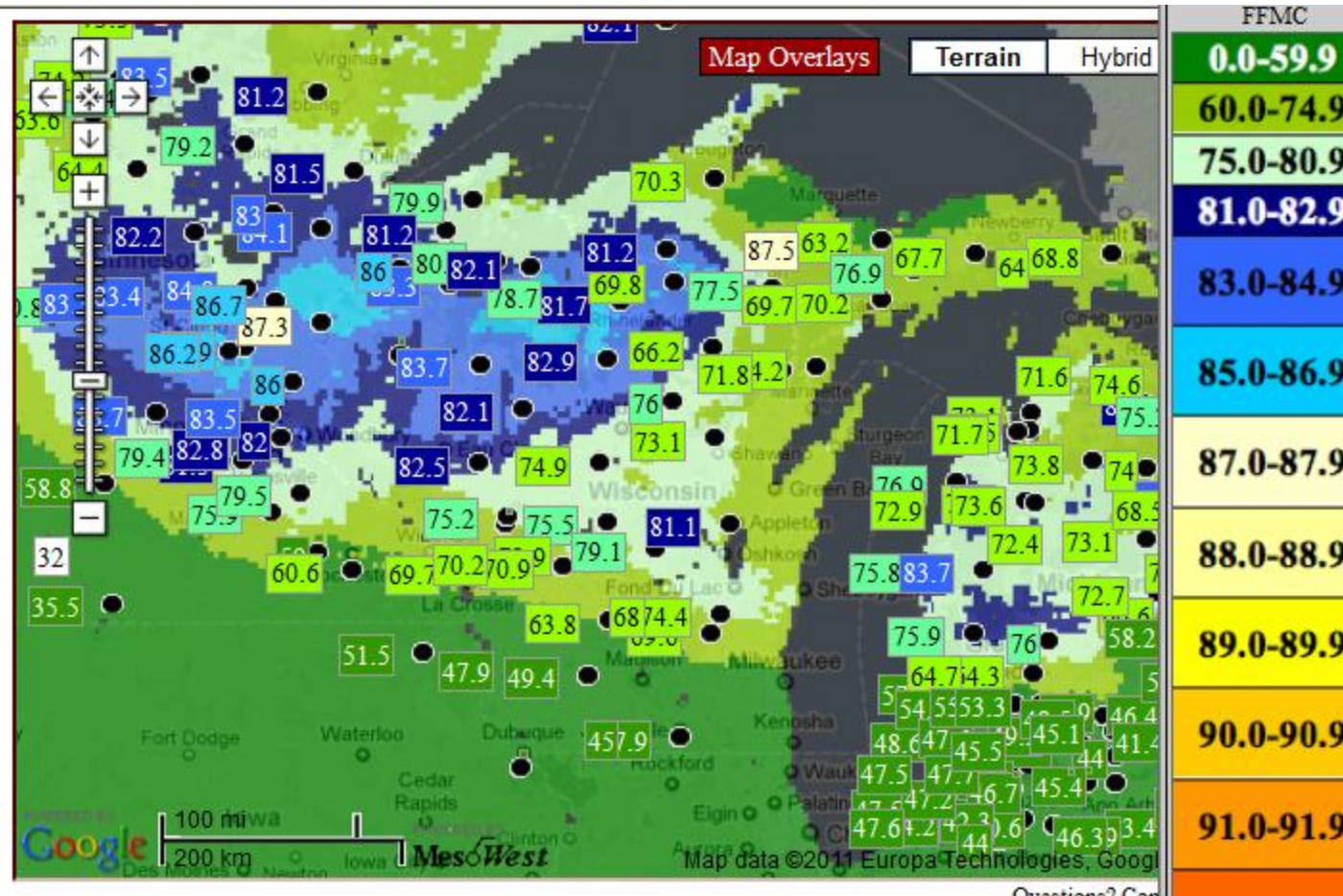
Time & Table Options

☒ Auto Current Time

Show Table

Links

- Great Lakes Fire / Fuels Home
- NWS Fire Weather



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OBSERVING WEATHER AND CLIMATE FROM THE GROUND UP

A NATIONWIDE NETWORK OF NETWORKS

Released December 2008

Committee on Developing Mesoscale Meteorological
Observational Capabilities to Meet Multiple National Needs

Board on Atmospheric Sciences and Climate

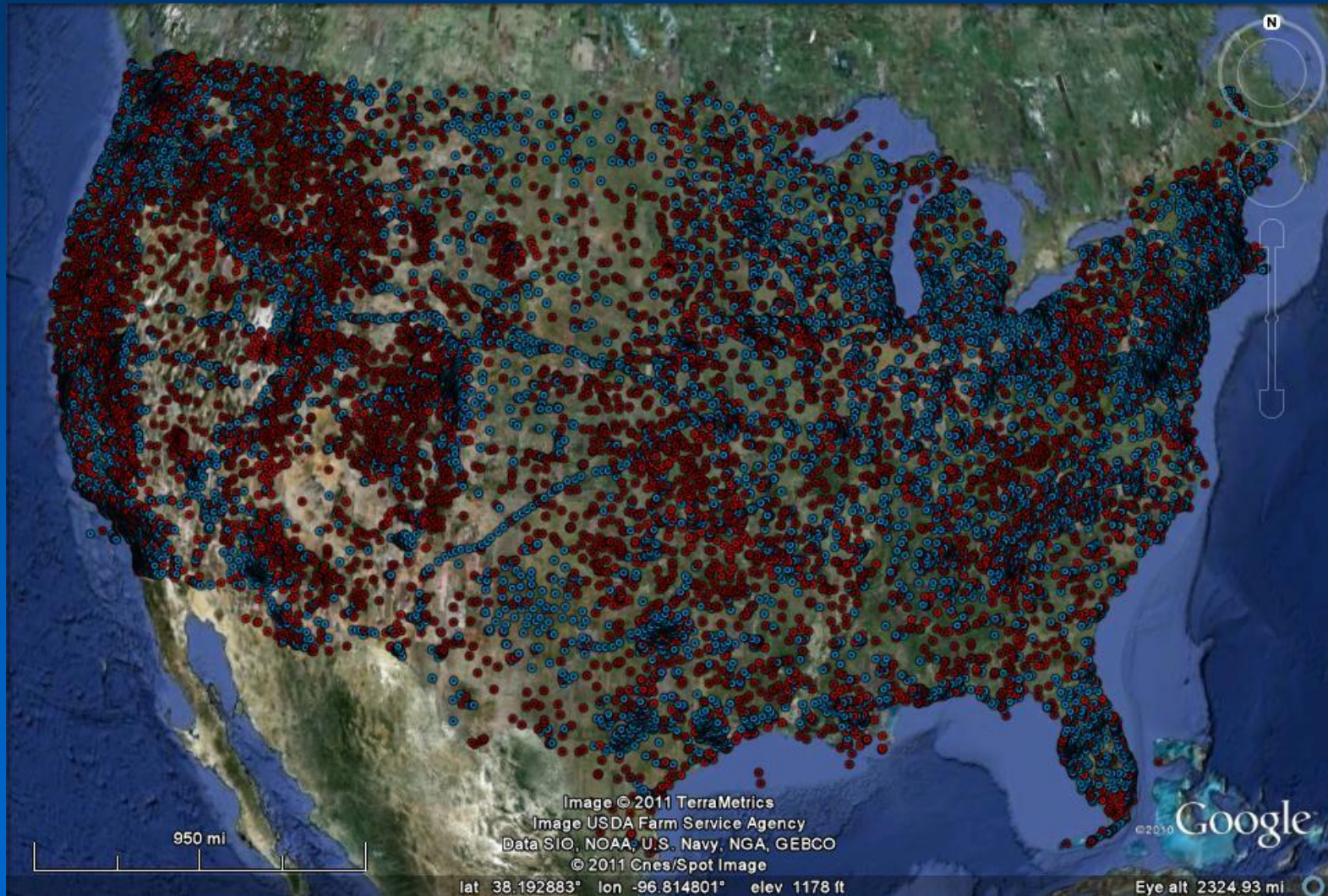


National Oceanic and Atmospheric Administration | Earth Systems Research Laboratory

Meteorological Assimilation Data Ingest System

- NOAA MADIS supports collection, integration, quality control, and distribution of NOAA and non-NOAA observations from over 60,000 surface stations from local, state, and federal agencies, and private networks, as well as upper-air datasets
- Access to an integrated, reliable, QC'd database containing real-time and archived datasets
- Runs operationally in real-time with a distributed architecture consisting of ingest and distribution services at the NWS TOC and processing at NCEP Central Operations

MADIS stations available publicly



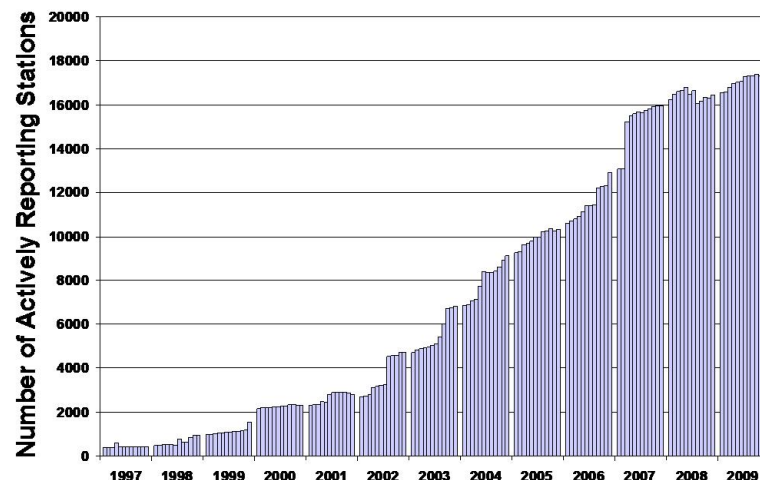
Federal vs. non-Federal

Existing Strengths on Which NNoN Can Build

- National framework in place: MADIS
 - Procedures to move data from local data sources to central repository in place: LDM
 - Personal relationships that foster acquisition and growth of data assets in place: local and regional mesonets
-
- All politics is local...
 - All observations are local...
- but coordination at a national level is essential

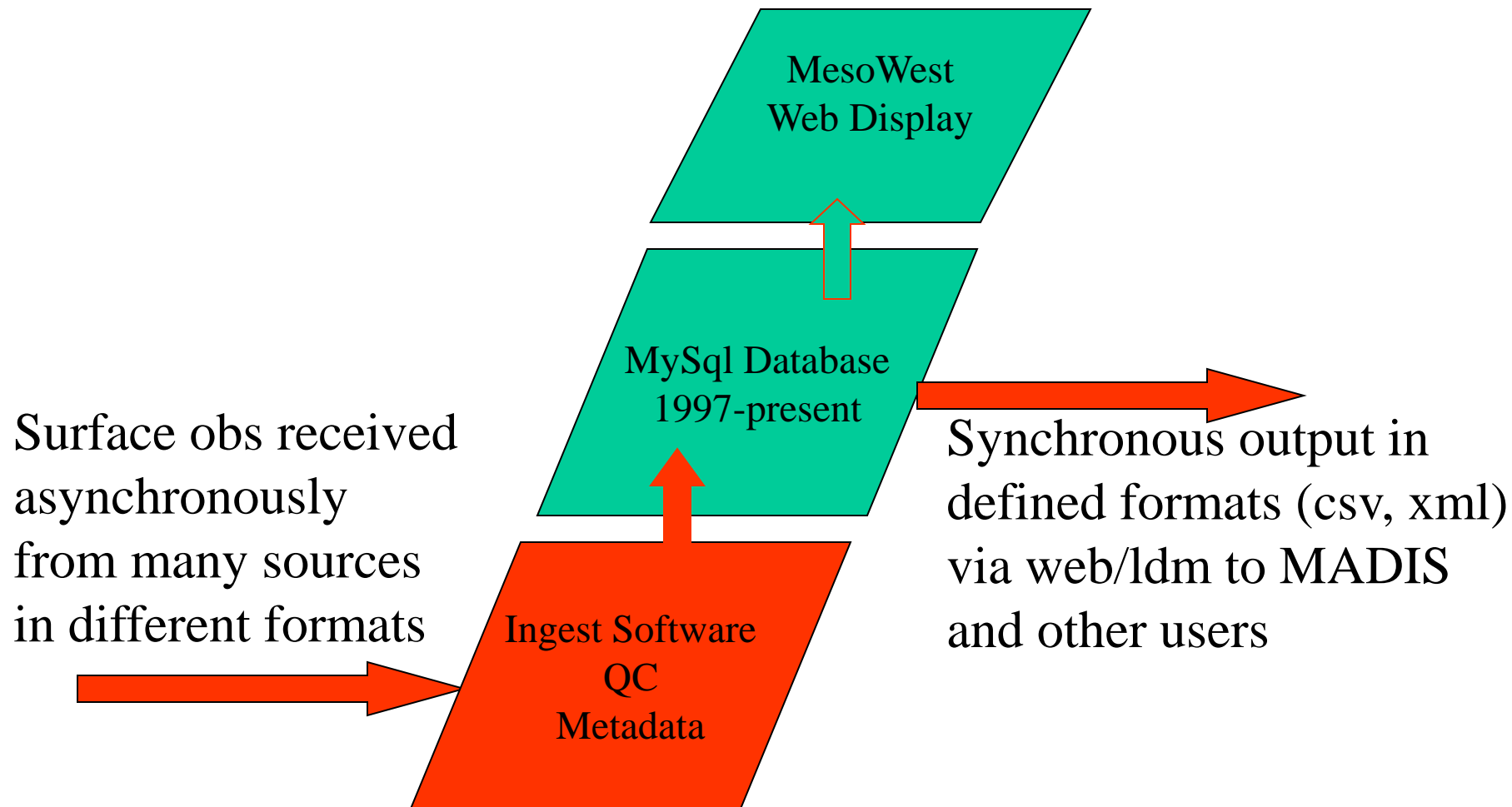
- MesoWest began fifteen years ago as grassroots effort to integrate the collection, archival, and distribution of weather observations available from now hundreds of sources
- MesoWest is used extensively in U.S. for operational, research, and educational use with specific applications developed for fire weather operations
- Based on coordination with staff of Western Region of the NWS, many WFOs, MADIS/ESRL, and data providers
- Provide access to nonproprietary data sources with very basic usage restrictions
- MesoWest supported by NWS, land agencies, other federal & state agencies, and, to a much more limited extent, commercial firms

MesoWest Growth



Access to current and retrospective data from 1997 to present

MesoWest Overview



Mesonet Status for past 2 hours (as of 10:30 AM MDT)

The number of stations that have reported divided by the total number of active stations.
Mesonets with summaries longer than 2 hours are indicated.

NWS_FAA	1959/2037	RAWS	1914/2148 1.5 hrs	DUGWAY	27/27	30 min
UTAH_DOT	60/68 1 hr	ARL_FRD	34/35 30 min	AVALANCHE	23/26	
TOOELE	24/24	SNOWNET	26/31 1.5 hrs	AQ	15/19	
ARL_SORD	26/28 1 hr	AGRIMET	88/90 12 hrs	MISC	3/5	
CAMPBELL	4/4	CANADA	561/579	MT_DOT	57/61 4 hrs	
WY_DOT	64/65 1 hr	LOXWFO	19/26 3 hrs	REC	0/0 4 hrs	
CUP	0/0	KENNECOTT	0/7	AZ_ALERT	37/37 30 min	
NV_DOT	62/73 1 hr	CBRFC	5/5 4 hrs	LAS_VEGAS	53/54 1 hr	
SNOTEL	729/756 4 hrs	MCSCN	13/20 24 hrs	MEXICO	60/60 1.5 hrs	
SCAN	128/154 6 hrs	CLR	0/0 30 min	UDWR	0/0	
SARC	1/1 12 min	MSI	1/2 1 hr	WX4U	0/0	
WA_DOT	91/98 3 hrs	NWAVAL	26/32 3 hrs	HMMN	30/30 1.5 hrs	
AZMET	23/23 24 hrs	WAAQ	17/19	IID	76/78	
CNRFC	16/29 4 hrs	DUDECD	20/24 30 min	BWFO_NWS	7/13	
CAIC	7/13	KSL	1/2 30 min	BTAVAL	12/17	
ODOT	55/67 30 min	CEMP	19/22 3 hrs	LANL	5/5	
GSE	8/8 12 hrs	PDTWFO	24/30 1 hr	MSOWFO	2/10 4 hrs	
GTFWFO	0/0	CARB	135/142 4 hrs	SHASVAL	4/4 6 hrs	
CALTRANS	16/17 1 hr	FAWN	36/36 1 hr	DOERD	0/0 30 min	
DRI	40/59 4 hrs	CDOT	73/78	UPR	355/406	
APRSWXNET	5521/6525	CIMIS	129/129 24 hrs	WHITEPINE	0/0 3 hrs	
GNP	2/1 12 hrs	GPSMET	75/88	WTEXAS	59/59 1 hr	
WIDOT	50/53 4 hrs	NWS_COOP	47/51 1.5 hrs	HPWREN	2/2 12 min	

Contributing Networks to MesoWest/MADIS

PIHWFO	1/1	HNXWFO	8/12 1 hr	GGWWFO	10/13 1.5 hrs
SGXWFO	62/68	SNOWBIRD	2/2 4 hrs	SUNCREST	0/0
FGZWFO	3/5 30 min	ODEQ	14/14 3 hrs	AKDOT	40/43
IADOT	54/58 1 hr	PQRWFO	13/18	MFRWFO	1/1
CPCRC	3/3 4 hrs	MAMMOTH	3/5	MARITIME	294/347
MEDOT	3/4	KYDOT	12/17	MDDOT	47/52
MNDOT	78/83	NDDOT	19/24	NEDOR	46/48
OHDOT	156/163	VADOT	38/44	NHDOT	16/16
HADS	2551/2623 4 hrs	AFGWFO	8/12	NCAWOS	105/117
NJNET	36/40	LKNWFO	0/2	PCMR	8/9 30 min
DEERVLV	0/6	SBCAPCD	14/15 1.5 hrs	PAWS	0/0 3 hrs
BCHYDRO	76/79 12 hrs	YAKIMA	6/7	USCG_PUGET	0/0 12 hrs
INDOT	25/26	AZDOT	17/17	MAWN	58/60
NOS-PORTS	64/64	NOS-NWLON	157/157	CRN	96/97
ODA	0/0 4 hrs	SFWMD	23/26	DCFV	0/3 12 hrs
CDPHE	8/9	MTRWFO	25/26 12 hrs	HNLWFO	18/21
HILL	1/1	NEMPPA	0/4	VTRANS	13/14
SCHWEITZER	1/2	SEWWFO	5/6	ME-CAR-Meso	5/5
AIRNOW	503/562 6 hrs	CA_HYDRO	35/84 4 hrs	FGNet	15/15
SDGE	88/88	CDEC	6/6	WUNDERG	4/28
PCAPS	0/8	DEOS	28/30	WSMR	14/22
EDW	14/14				

MesoWest paradigm:

Faciliate access to all available data & minimize hassle to data providers

- Give us basic metadata: lat/lon/elev/station name
- Tell us what variables you are measuring and in what format
- Do you want to push data to NWS WR or do we pull it?
- We'll do the rest
- We encourage local data providers to sign a data sharing agreement with the local WFO
- Ownership of data remains with the data provider
- Data are considered provisional- owner may wish to provide QC'd data to end users at later date

MESOWEST Region WISCONSIN

Product Surface Weather Maps

Go

Hide Menu Show Tables Search Active Fires Map Product: Default

Data Selection

Region/Zone Radius

25 Miles Click Point on Map →

Network: All Networks

Units: English

Map It!

Display

Overlay 1: Current Temp

Overlay 2: -- None --

☒ Highlight Data

Show Table

Other Features

Time Options

Layer Options

Select Language

Powered by Google Translate



Refreshed: 10/13/2010 at 09:29

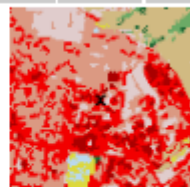
Waiting for gg.google.com...

Land cover data for WBB/U UTAH (WBB)

Class	Percent of area
Developed, Open Space	13%
Developed, Low Intensity	40%
Developed, Med Intensity	35%
Developed, High Intensity	12%

Percent computed based on 1km x 1km box around station

L/C Satellite Terrain



3km x 3km grid with an 'x' to mark station location

STATION INFO

VA033
 NAME: Rt 66 @ Rosslyn
 ALTITUDE: 38.89828
 LONGITUDE: -77.07061
 LEVATION: 132 ft
 NET: VADOT
 DATA COVER: 2001 USGS
 DATA COURTESY OF:
 Virginia Department of
 Transportation
 and
 Meteorological Assimilation
 Data Ingest System (MADIS)

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OTHER DISPLAYS

XML

RSS



Current Station Observations

Rt 66 @ Rosslyn

Observation Time: 10/13/10 @ 10:41 EDT 14:41 UTC Elevation: 132 ft OK

Weather Conditions

Temperature: 59 °F
 Dew Point: 34 °F
 Humidity: 39 %
 Wind: E at 4 MPH
 Peak Gust: 6 MPH

24 Hour Max/Min Events

Max Temperature: 82 °F
 Min Temperature: 54 °F
 Max RH: 62 %
 Min RH: 33 %
 Max Dew Point: 56 °F
 Min Dew Point: 34 °F
 Max Gust: 16 MPH

View:

Temp

Wet Bulb

Wind

Vector Wind

Wind Rose

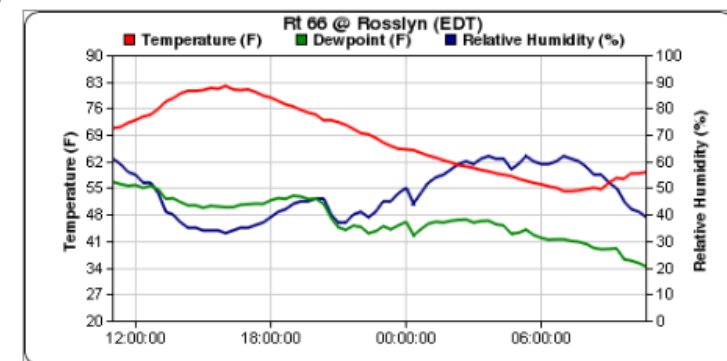
Pressure

Precip

Snow

Solar

Help

[Change to UTC Time](#)[Additional Tabular and Graphical Displays](#)[Download Data](#)

MESOWEST STATION INTERFACE - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://mesowest.utah.edu/cgi-bin/droman/meso_base.cgi?stn=VA033&unit=0&timetype=LOCAL

MesoWest Surface Weather Maps x MESOWEST STATION INTERFACE

Selected Profile: None Selected

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 NAME: Rt 66 @ Rosslyn
 ALTITUDE: 38.89828
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OTHER DISPLAYS

XML

RSS



Weather Conditions for VA033

Current time: October 13, 2010 - 11:31 EDT

Most Recent Observations at October 13, 2010 - 10:41 EDT

Graphical Links	With Prior Obs	10:41	Max since Midnight	Min since Midnight	24 Hour Max	24 Hour Min
Temperature	Temperature	59.2° F	65.1 at 0:01	54.2 at 7:01	81.9 at 16:01	54.2 at 7:01
Dew Point	Dew Point	34.3° F	46.7 at 2:41	34.3 at 10:41	55.8 at 12:01	34.3 at 10:41
Wet Bulb Temperature	Wet Bulb Temperature	47.2° F	54.5 at 0:01	46.8 at 8:41	62.6 at 13:01	46.8 at 8:41
Relative Humidity	Relative Humidity	39%	62 at 3:41	39 at 10:41	62 at 3:41	33 at 16:01
Wind Speed	Wind Speed	4 mph from E	6 at 3:01	2 at 9:21	8 at 15:41	1 at 18:41
Wind Gust	Wind Gust	6 mph	15 at 4:41	5 at 7:21	16 at 14:41	5 at 18:21

Tabular Listing: October 12, 2010 - 11:31 through October 13, 2010 - 11:31 EDT

Time(EDT)	Temperature	Dew	Wet Bulb	Relative	Wind	Wind	Wind	Quality
	°F	°F	°F	%	mph	mph	Direction	check
10:41	59.2	34.3	47.2	39	4	6	E	OK
10:21	58.8	35.2	47.4	41	2	6	NNE	OK
10:01	58.8	35.8	47.6	42	3	11	E	OK
9:41	57.4	36.2	47.1	45	5	11	NNW	OK
9:21	57.6	39.1	48.3	50	2	8	WNW	OK
9:01	56.3	38.9	47.6	52	3	8	NNE	OK
8:41	54.7	38.9	46.8	55	4	11	N	OK

MesoWest Questions?

- Send email to atmos-mesowest@lists.utah.edu
- MADIS or MesoWest teams can facilitate access to additional data assets
- We work with data providers who are willing to share their provisional data with limited restrictions on use of their weather information

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Motivation For Developing 2D Analyses

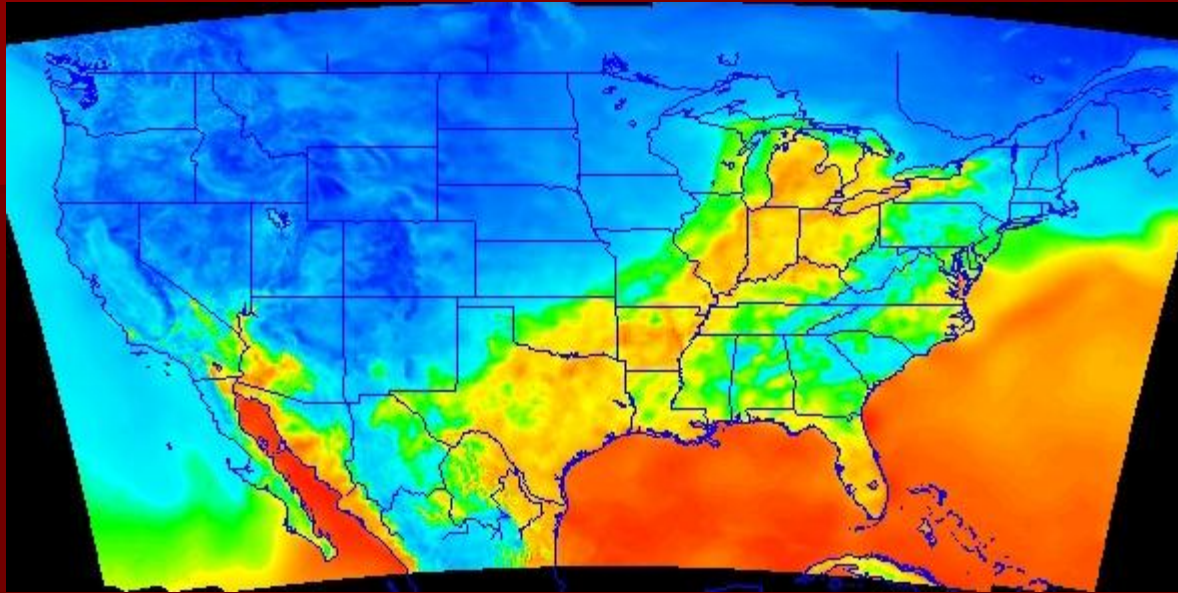
- High resolution (≤ 5 km) real-time surface analyses needed by forecasting community
 - NWS nowcasts, forecasts, and forecast verification
 - Wildfire management
 - Wind power forecasting
 - Transportation safety and management
 - Dispersion modeling
- NCEP's Real-Time Mesoscale Analysis (RTMA) developed in 2006 to meet these needs
 - 2DVar analysis of T , T_D , u , v , and p_s
 - Assimilates $\sim 15,000$ surface mesonet observations each hour

Analysis Approach

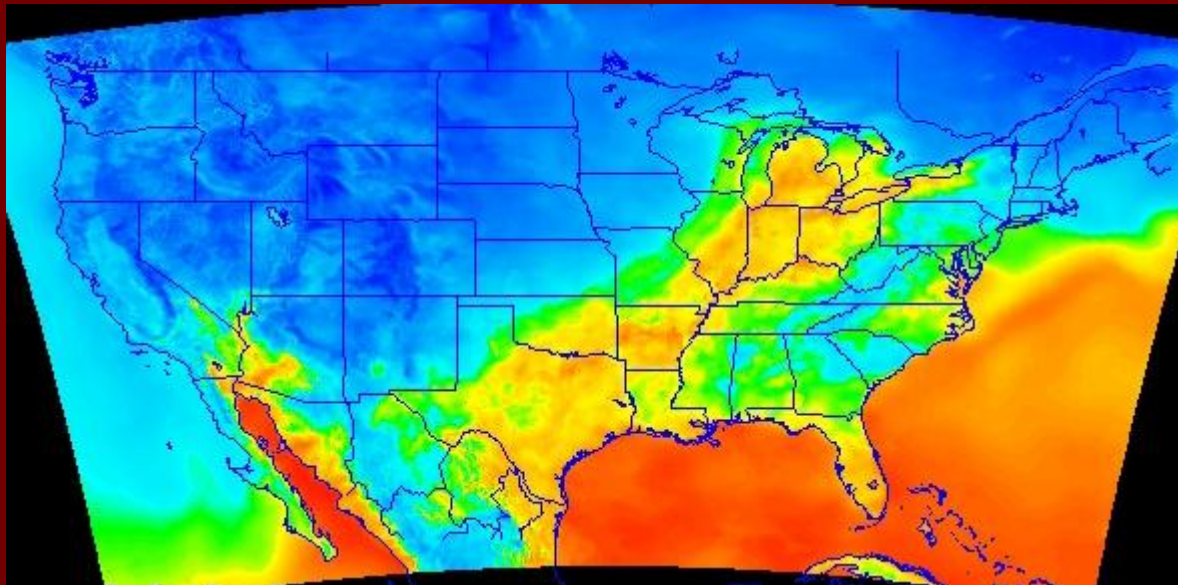
- Our prior research oriented towards improving the RTMA (Tyndall 2008; Tyndall et al. 2010) but difficult to use RTMA source code remotely
- Graduate student Dan Tyndall developed a 2D Variational analysis system in MATLAB
 - Utilizes observations background fields used by RTMA and observations available via MesoWest
 - Can generate CONUS scale analysis efficiently taking advantage of advanced MATLAB features:
 - Parallel processing
 - Code optimization through vectorization
 - Sparse matrices

Efficient 2D-Var analyses on CONUS Scale @ 5km

D. Tyndall (2011), Ph.D. Thesis. U/U



NCEP RTMA
Temperature



2DVAR U/U
Temperature

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One Contribution Towards Cost Effective Designs for National Networks

- Horel and Dong (JACM 2010)
- Provide guidance to land agencies on present distribution of Remote Automated Weather Stations (RAWS) with annual maintenance costs ~\$3 million
- Can NWS/FAA observations be used to supplement RAWS network?
- If other RAWS or NWS nearby, could some RAWS stations be less critical than others based on data denial experiments and other metrics and where are the critical gaps in the existing network?
- Final report led by Tim Brown, DRI, to NWCG Fire Environment Committee by April 30

An Efficient Objective Approach for Assessing the Impact of Mesonets

- A necessary step to integrate existing and future networks into a national network of networks is to assess the impact of existing mesonets
- The adjoint of the two-dimensional variational analysis system developed at the UU surface weather parameters can be used to assess objectively the sensitivity of the resulting CONUS-scale analyses to the source of the observations used in the analyses (Baker and Daley 2000 QJRM; Zhu and Gelaro 2008, MWR)
- The analysis system uses the 5 km resolution background fields used by the RTMA
- Roughly 12000 observations available each hour from many different mesonets are then used to modify the background grids and obtain hourly analyses

An Efficient Objective Approach for Assessing the Impact of Mesonets

- The sensitivity of the differences in weather parameters between the resulting analyses and the background fields are examined as a function of the various data assets:
 - NWS
 - RAWS
 - Air quality
 - Agriculture and hydro
 - Transportation
 - Local, state and regional networks (West Texas Mesonet or Oklahoma Mesonet)
 - Buoys and coastal observations
 - Public
 - Other federal and commercial networks
- Statistics for individual stations as well as for entire networks are obtained that help to identify network characteristics that strongly influence analyses
- Technique will be illustrated here in terms of a single analysis

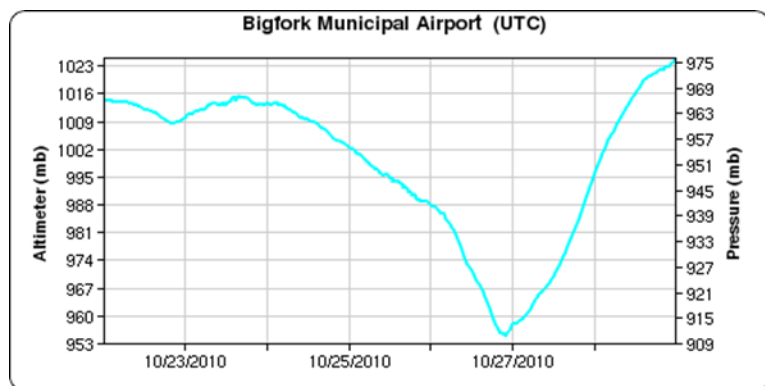
Consider a Specific High Impact Weather Event: October 26-27 2010



Figure 18. Visible satellite image of the "October Bomb" or the "Superstorm of October 2010" from 26 October 2010. [Return to text.](#)



Grand Marais, MN
October 27 15 UTC



Data Selection

Region/Zone Radius

150 Miles Click Point on Map →

Network: All Networks

Units: Metric

Map It!

Display

Overlay 1: Current Wind Speed

Overlay 2: -- None --

☒ Highlight Data

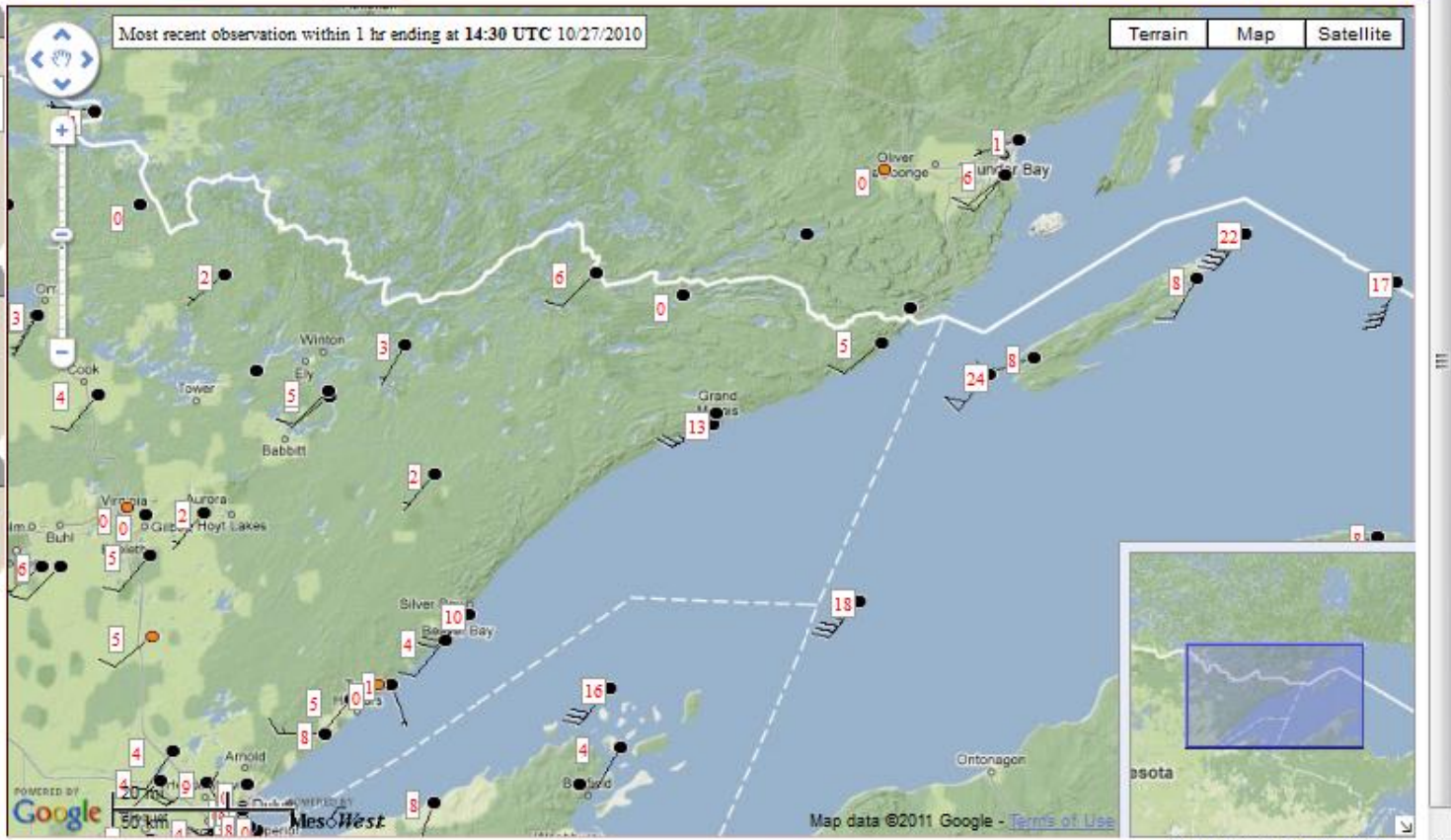
Show Table

Other Features

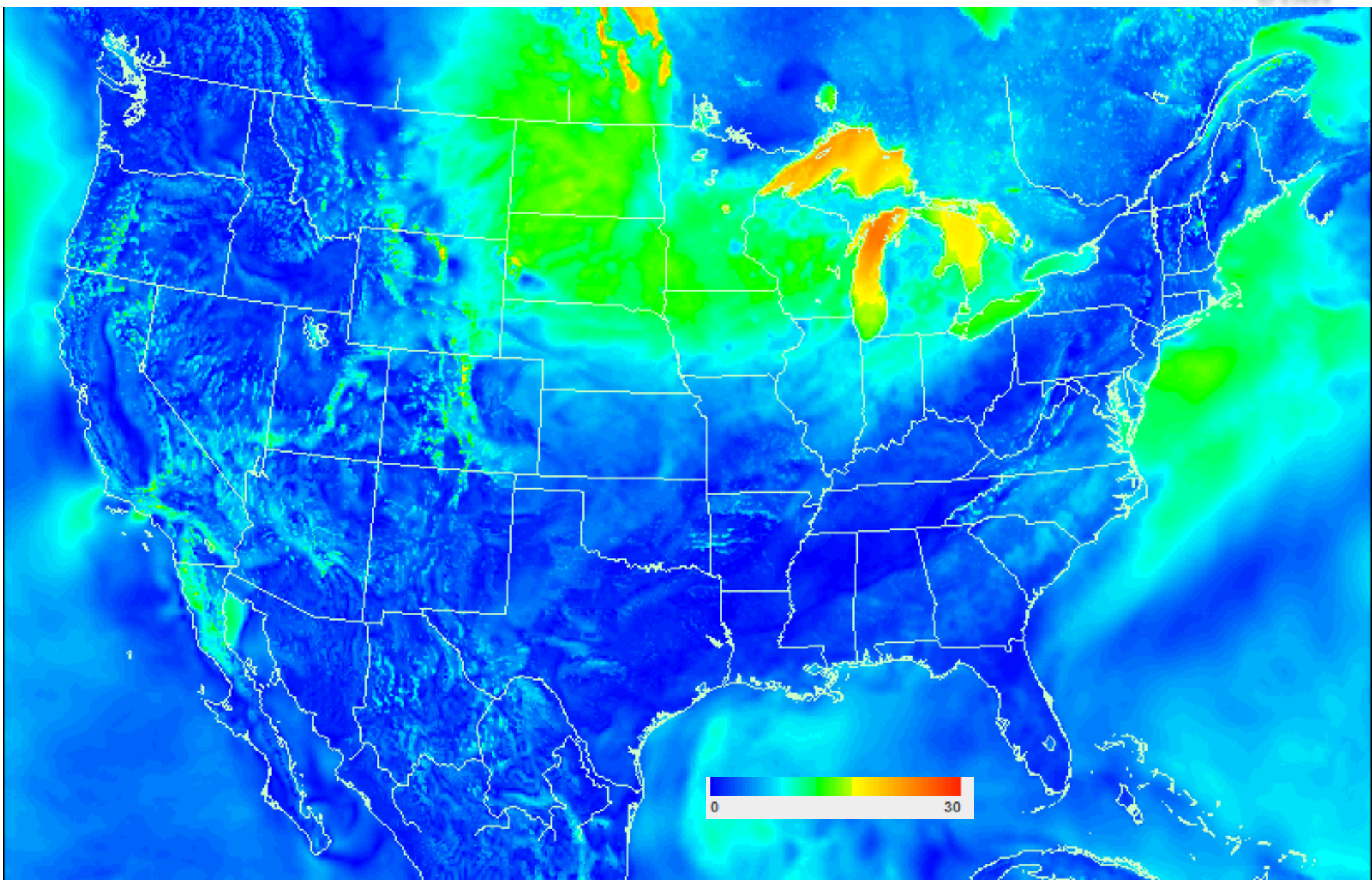
Time Options Layer Options

Select Language

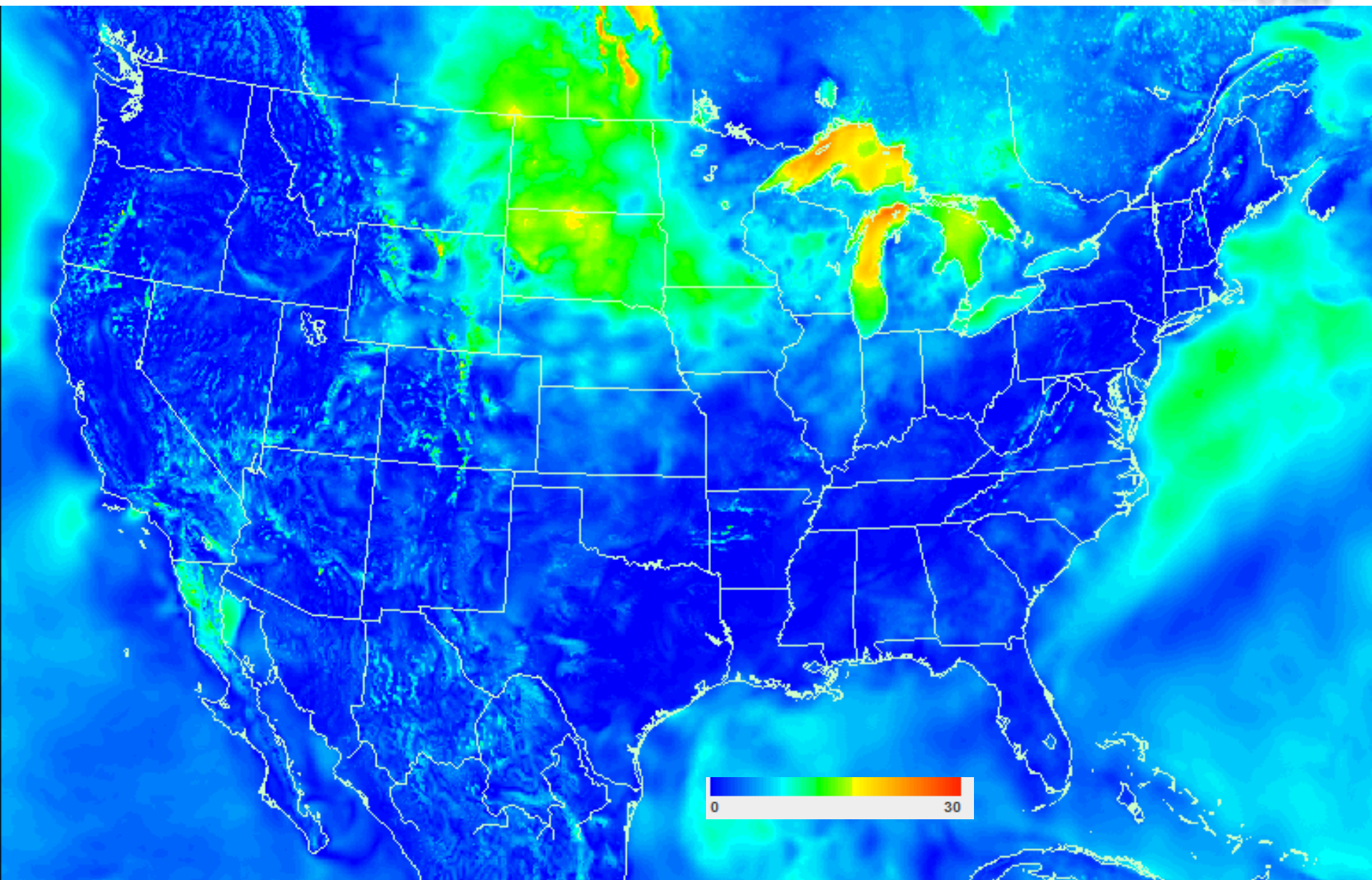
Powered by Google Translate



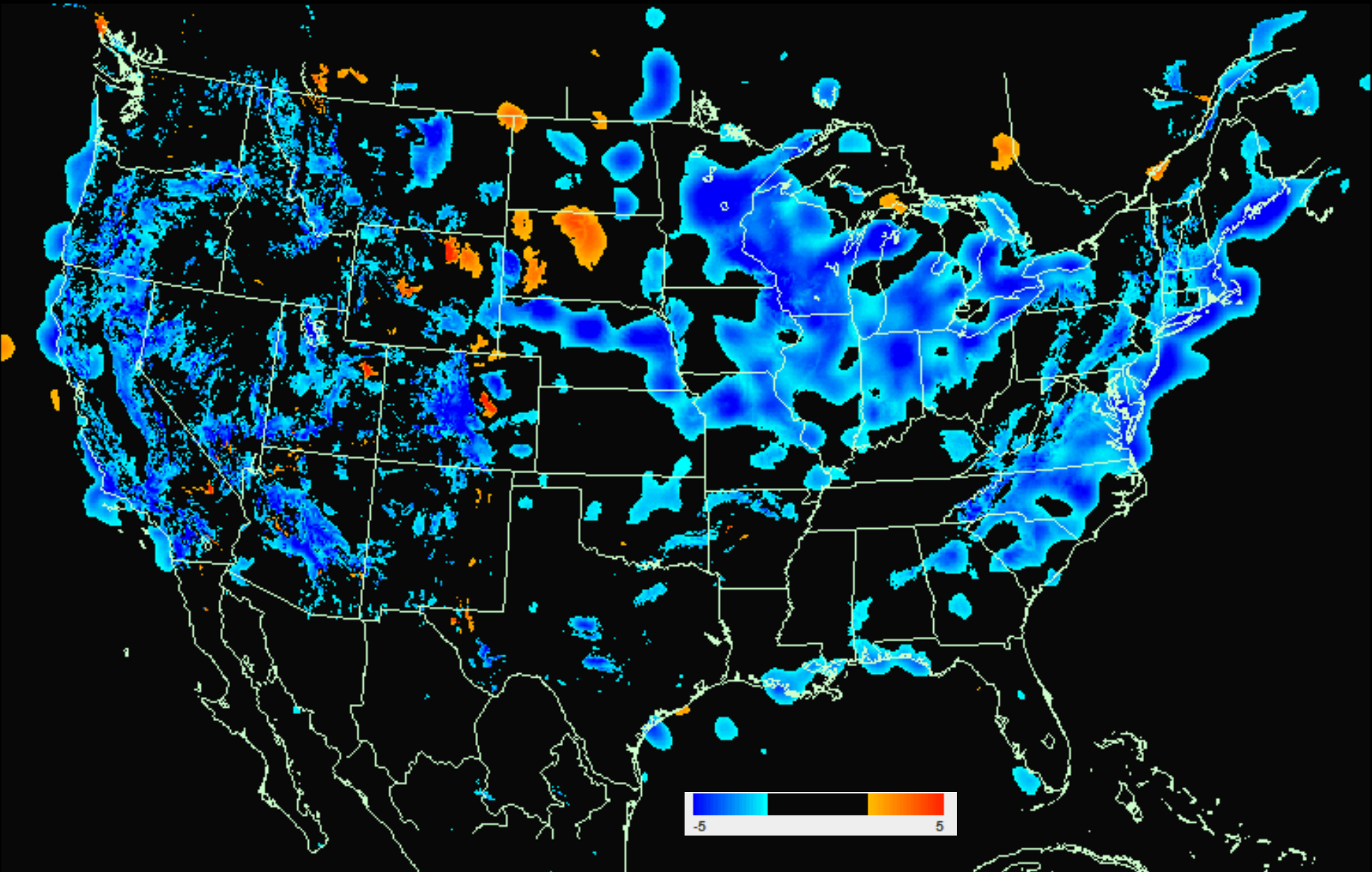
RUC Wind Speed Downscaled to RTMA Grid (m/s): 14 UTC 27 Oct 2010



UU Analysis Wind Speed (m/s): 14 UTC 27 Oct 2010



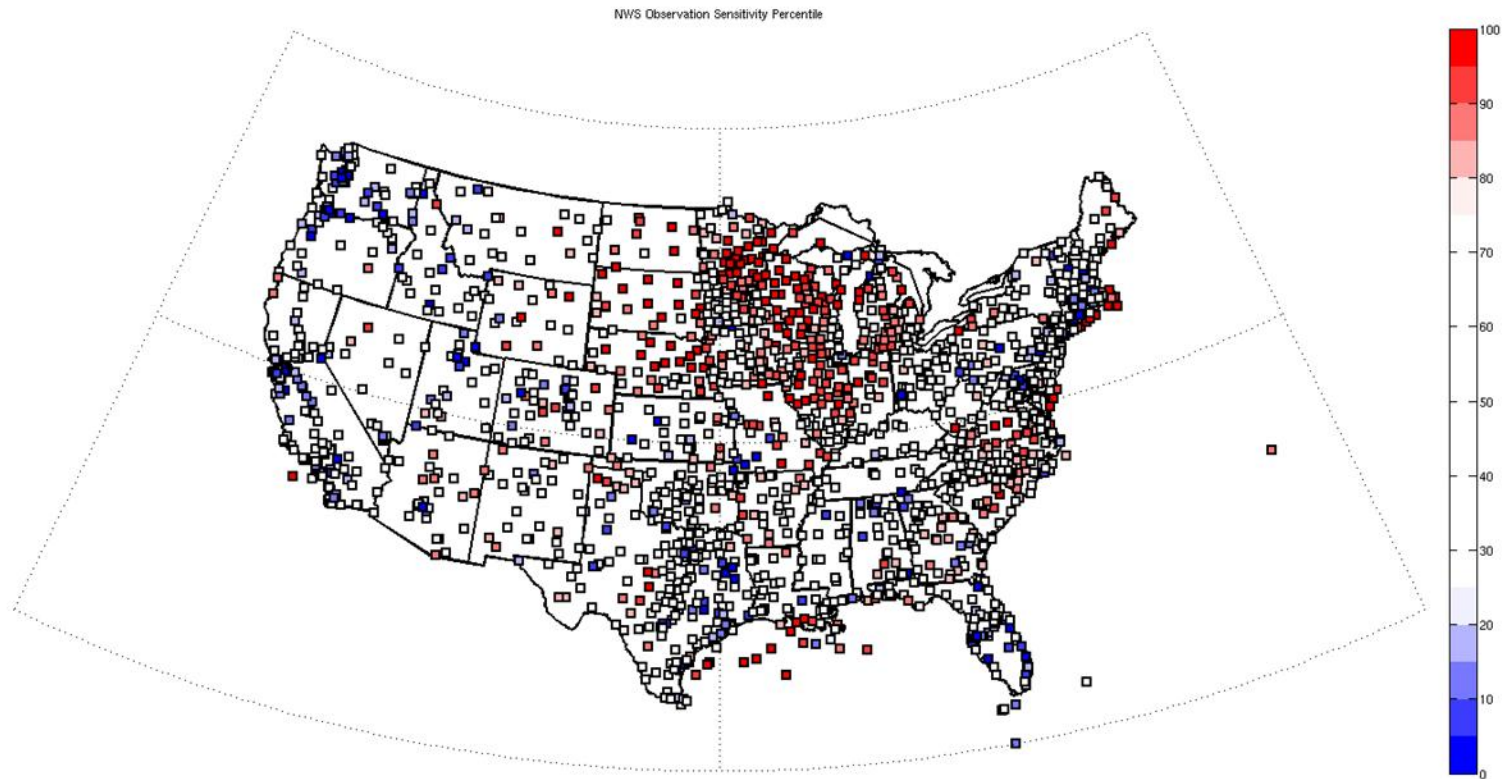
Adjustment of Background Wind Speeds by Observations (m/s):14 UTC 27 Oct 2010



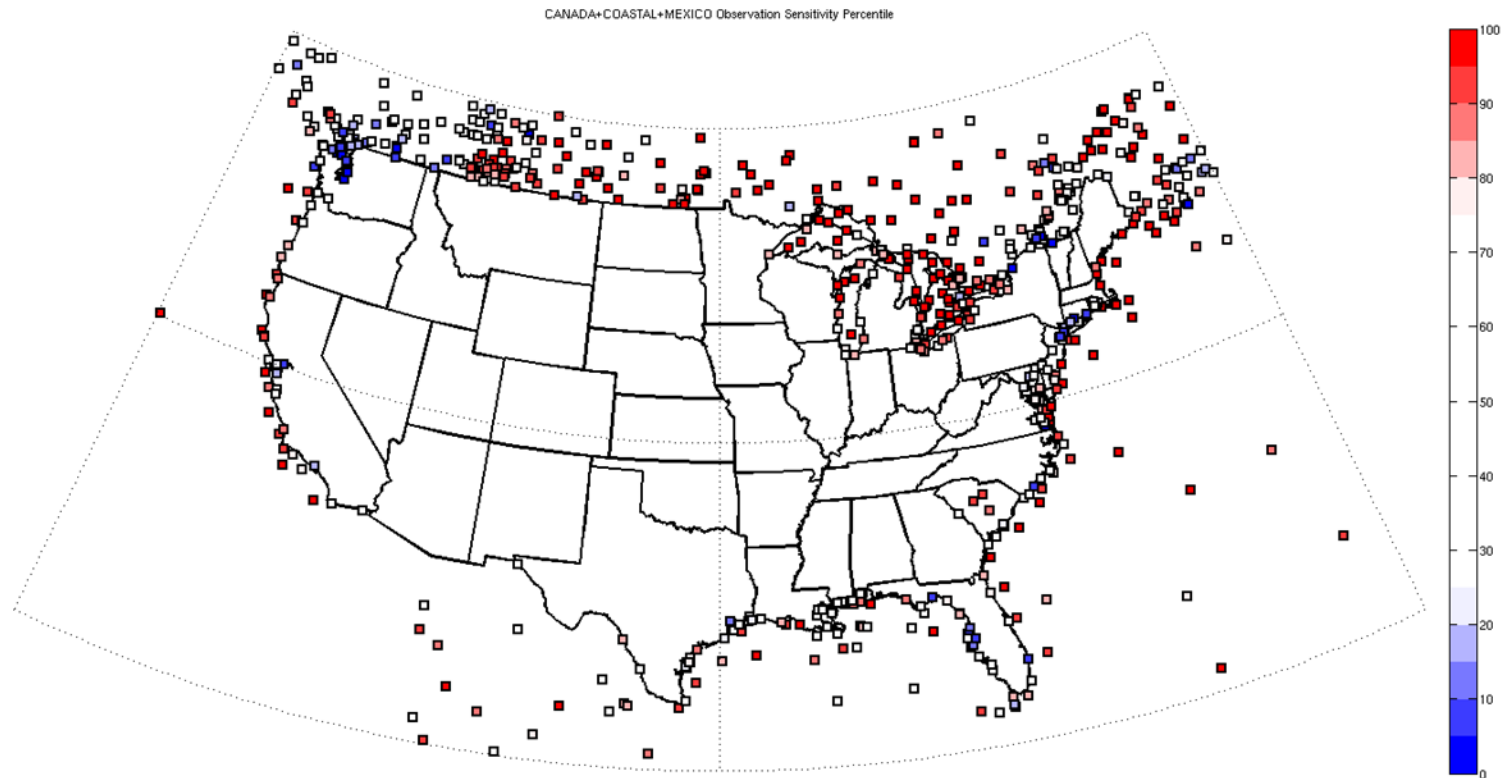
Summarizing Analysis Sensitivity as a Function of Network Type

- Define scalar aspect metric: root-mean squared difference between analysis and background
- Sensitivity computed from adjoint at each observation location (~11500 for wind)
 - depends on the analysis system characteristics (e.g., assumed background and observation errors)
 - **not** on the actual observed values
- Most sensitive locations: top 20 percent of the sensitivity values (**red**)
- Least sensitive locations: lowest 20 percent (**blue**)

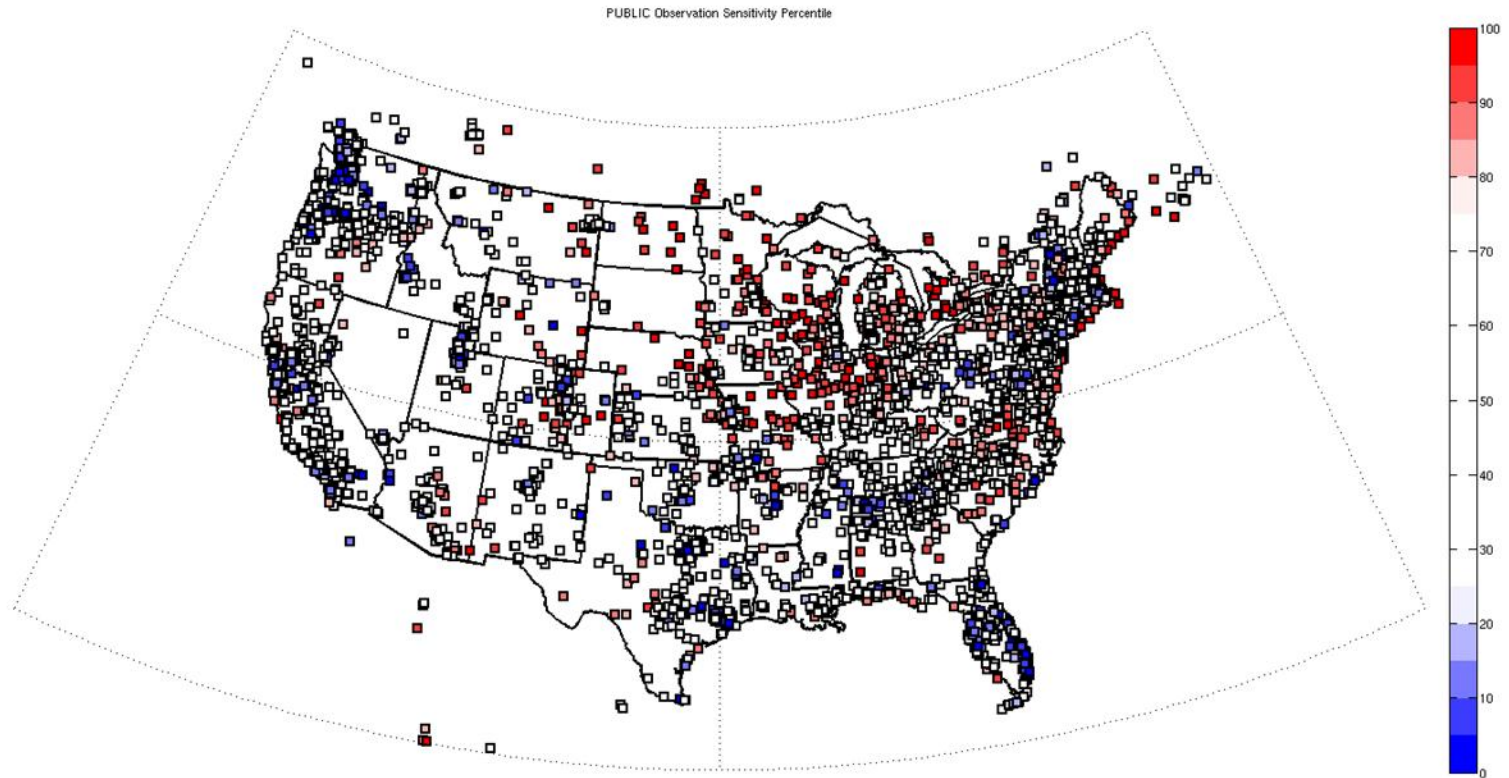
Sensitivity of 14 UTC 27 Oct 2010 Wind Speed to: NWS Observations



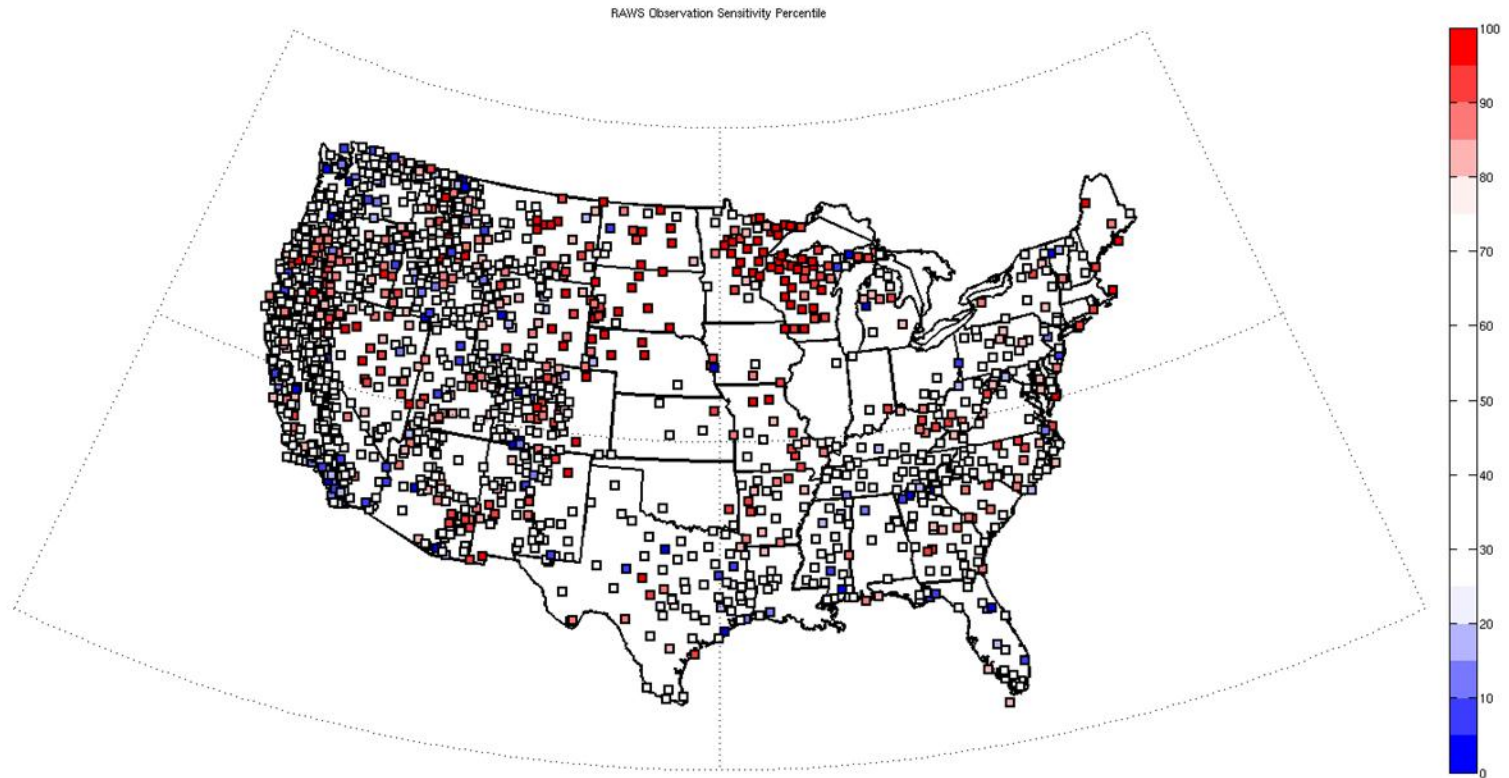
Sensitivity of 14 UTC 27 Oct 2010 Wind Speed to: Canadian, Mexican, and Coastal Observations



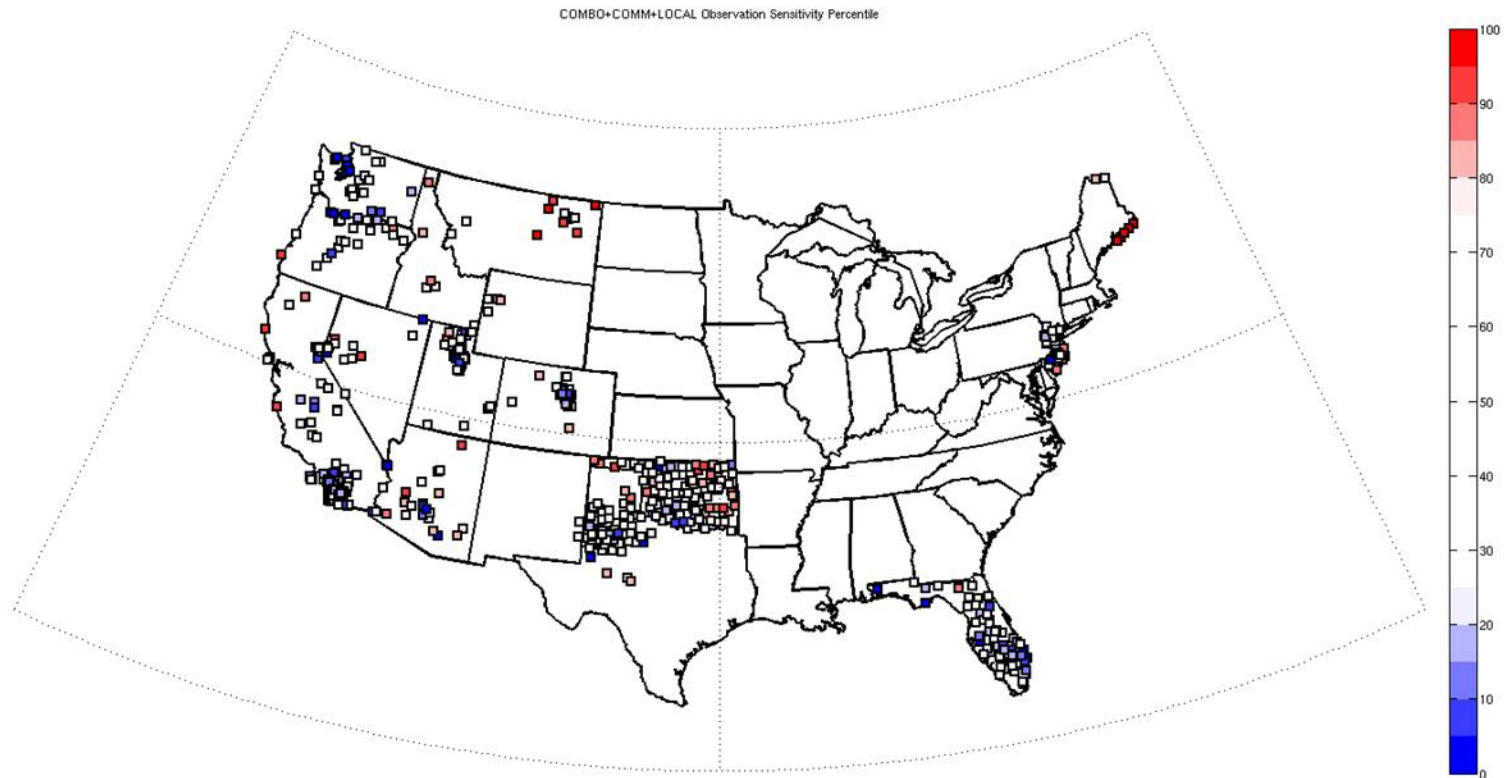
Sensitivity of 14 UTC 27 Oct 2010 Wind Speed to: Public Observations



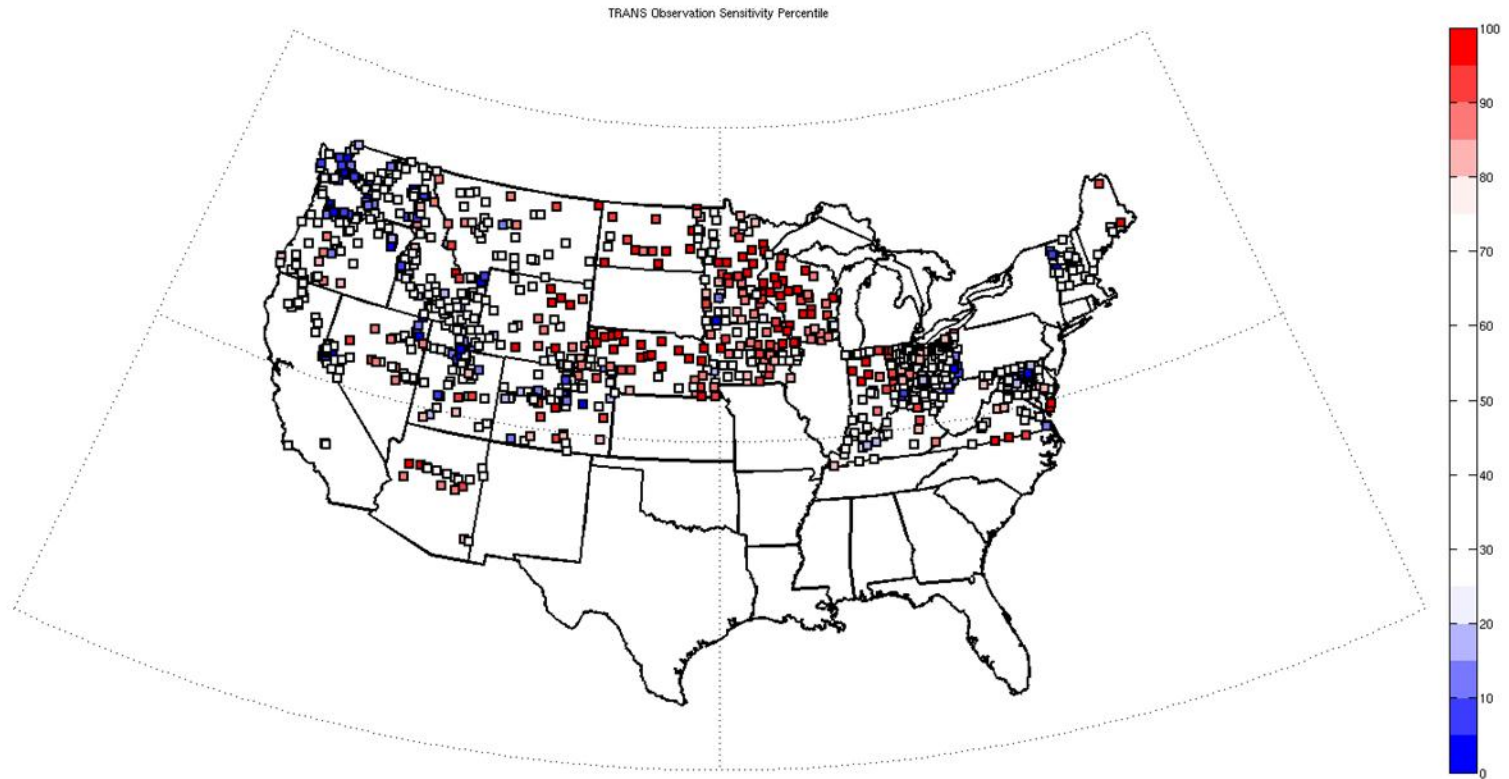
Sensitivity of 14 UTC 27 Oct 2010 Wind Speed to: RAWS Observations



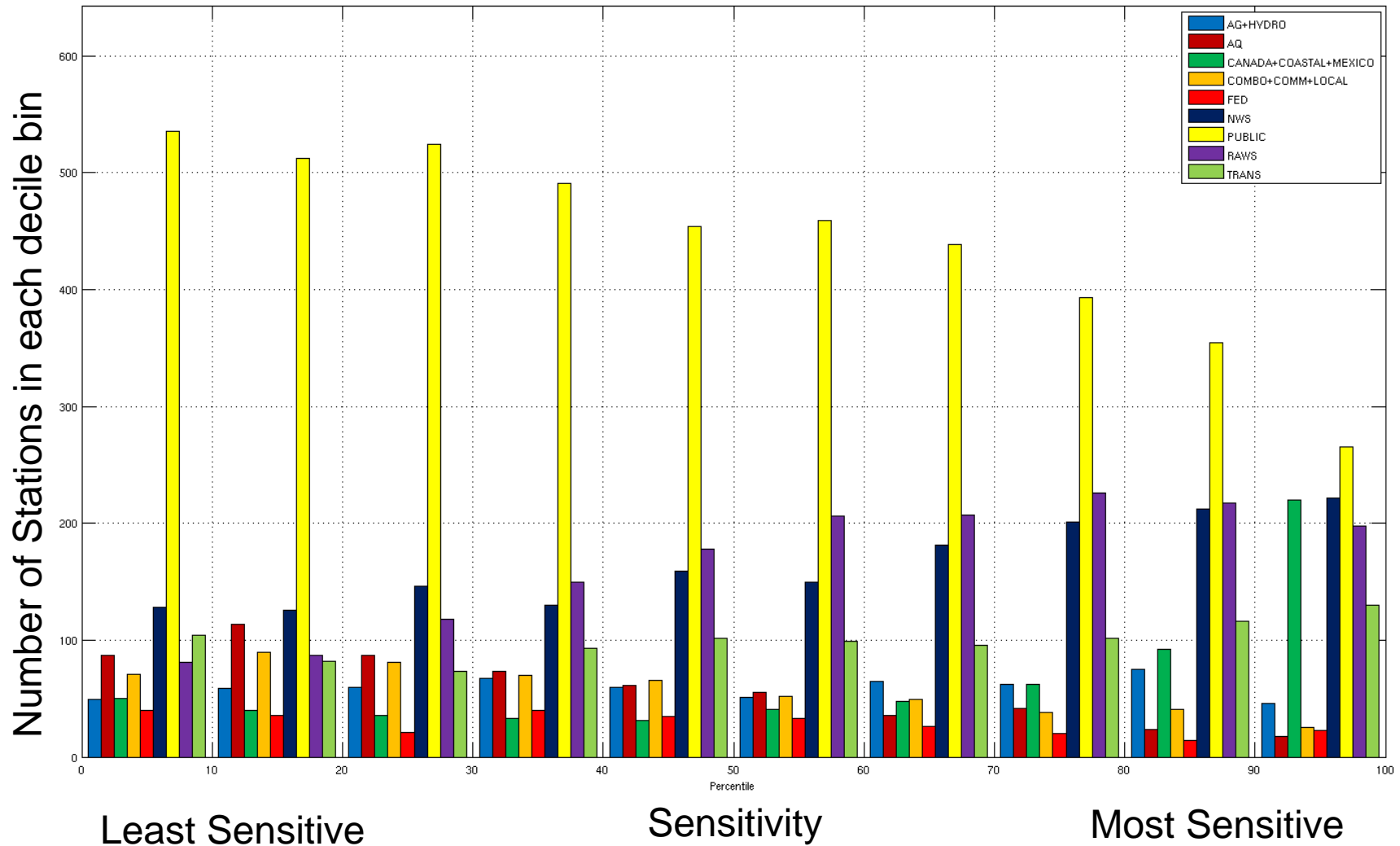
Sensitivity of 14 UTC 27 Oct 2010 Wind Speed to: Local, Regional, and Commercial Networks



Sensitivity of 14 UTC 27 Oct 2010 Wind Speed to: Transportation Observations



Summary of Sensitivity of 14 UTC 27 Oct CONUS Wind Speed Analysis to Network Type



Summary

- CSTAR program has led to:
 - extensive training of existing and future NWS employees
 - transfer to operations of basic and applied research from universities to national centers and field offices
- MesoWest is successful example of R&D of high relevance to the NWS
 - transfer to operations of some aspects of UU/MesoWest effort remain ill-defined
- UU analysis approach is highly efficient and portable
 - Can be run on linux or other operating environments with data supplied via THREDDS catalog and MesoWest database query
- Procedures in place to help assess sensitivity to network type on the basis of large samples of high-impact events
 - Results depend on appropriate choices for observational and background error
 - Critical step for design and implementation of national network of networks