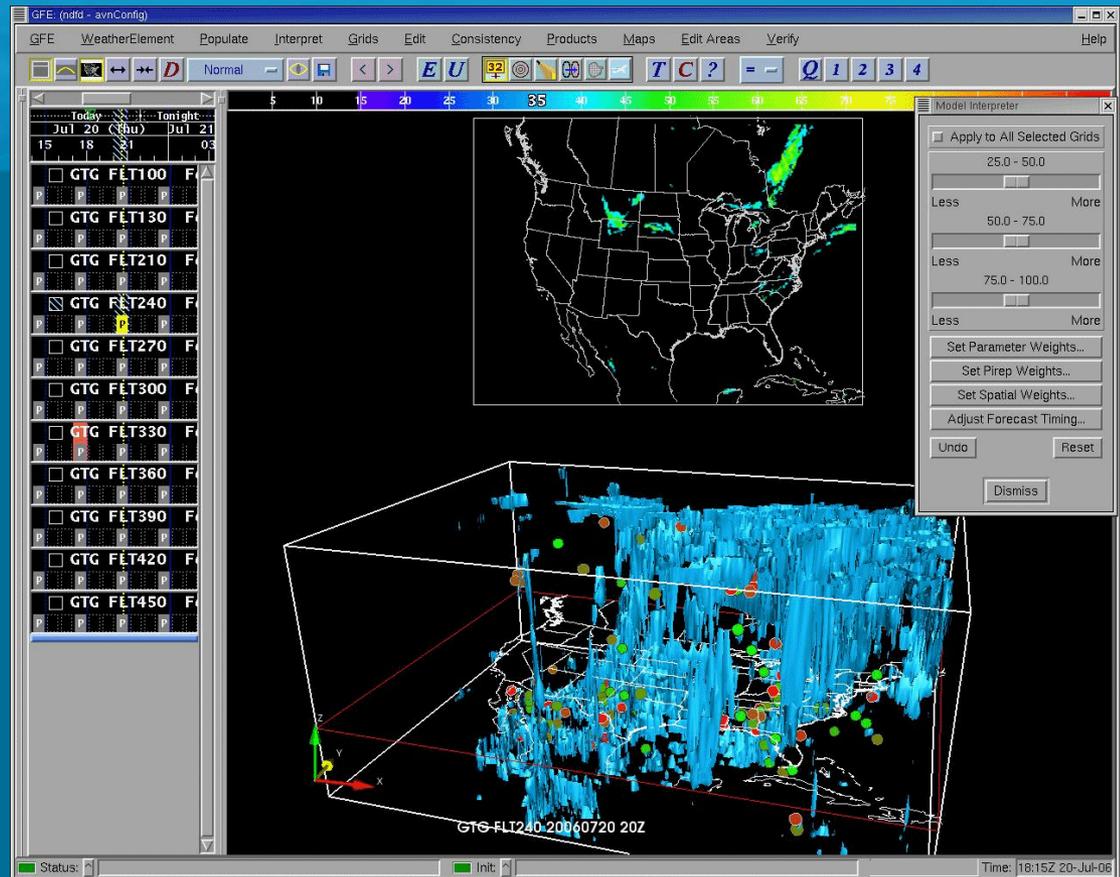


MDL Support for Aviation in the Digital Age

*David Ruth
Meteorological Development Laboratory
National Weather Service, NOAA*

*Aviation Weather Community Forum
April 2009*





The NWS Strategic Plan - 1999

Deliver a credible, timely, and relevant suite of seamless weather, water, and climate products and services which exploit technology to the fullest to meet customer and partner needs.

- Post NWS products and data on the Internet in graphic-oriented format (2002)
- Prepare and disseminate NWS forecast products in digital form (2003)



The National Academies - 2003

RECOMMENDATIONS (cont.)

5. The NWS should make its data and products available in Internet-accessible digital form. Information held in digital databases should be based on widely recognized standards, formats, and metadata descriptions to ensure that the data from different observing platforms, databases, and models can be integrated and used by all interested parties in the weather and climate enterprise.

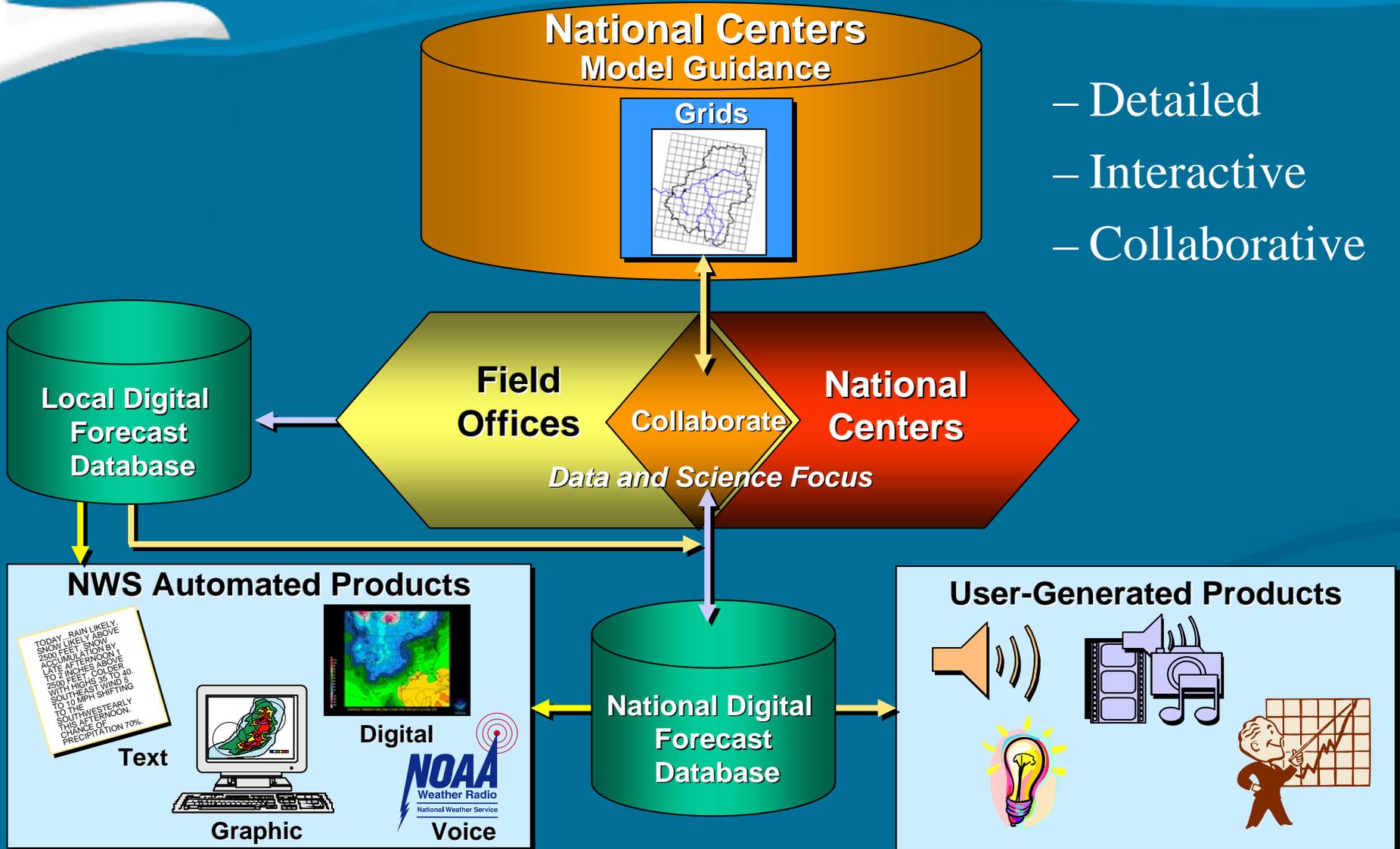
- The National Digital Forecast Database is a major undertaking with major benefits

National Digital Forecast Database (NDFD)

- *Contains a seamless mosaic of NWS digital forecasts*
- *Is available to all users and partners – public and private*
- *Allows users and partners to create wide range of text, graphic, and image products*



How is NDFD Produced?



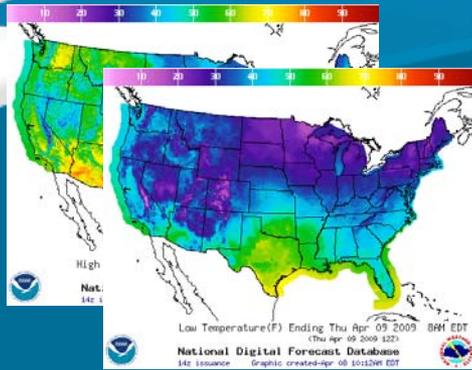
New NWS Flagship Service



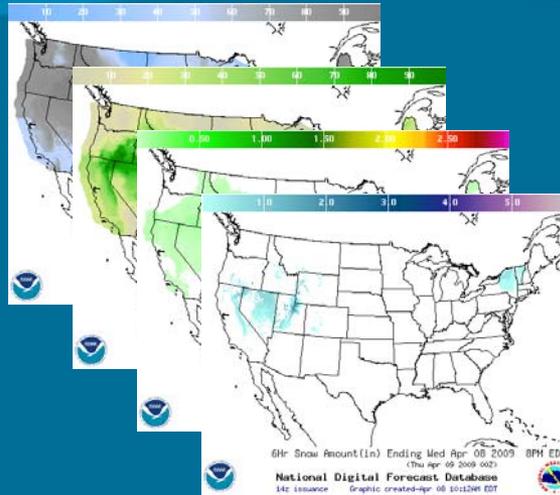
“The NDFD is now our flagship service, so we need to ensure it provides the most accurate and current information possible. “

**Mary M. Glackin, Acting Director, National Weather Service
NWS Focus - July 5, 2007**

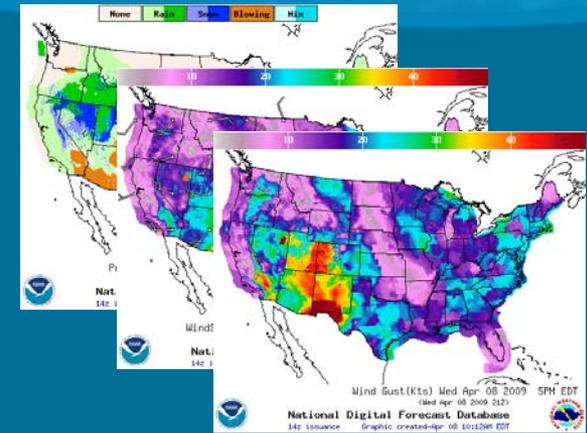
Current NDFD Elements



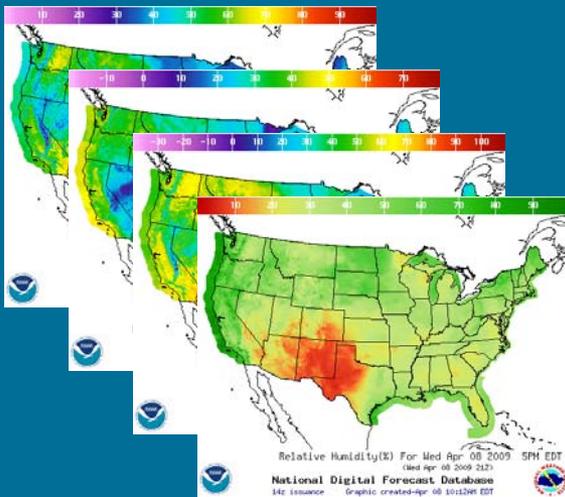
MaxT, MinT



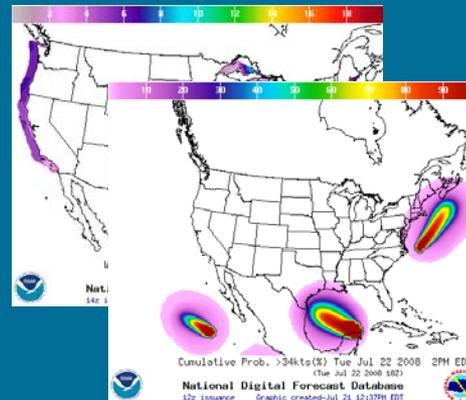
Sky, PoP12, QPF, Snow



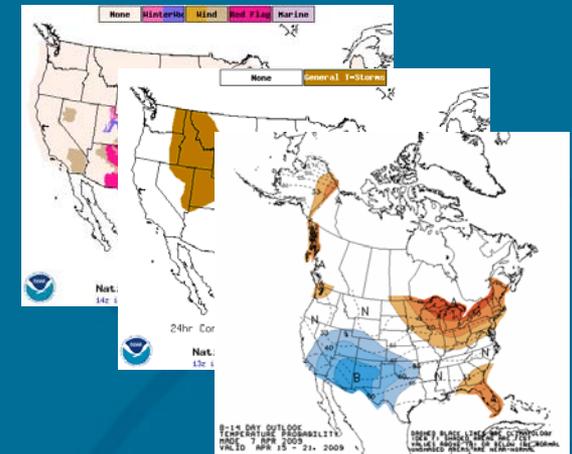
Weather, Wind, Wind Gusts



Temp, Dew, AppT, RH



Wave Height, Tropical Winds



Hazards, Convection, Climate Outlooks

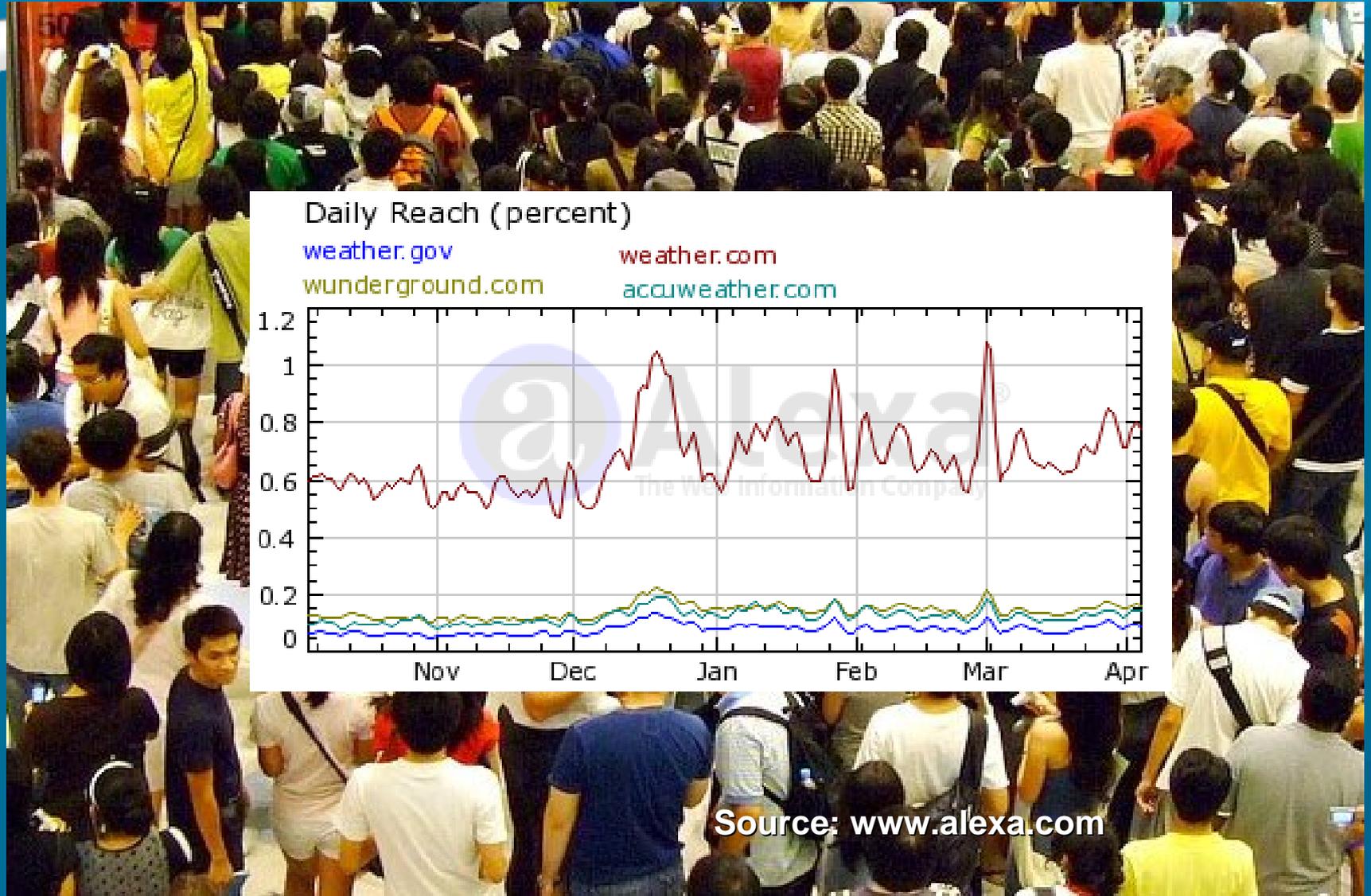
A Future Role of NDFD



- “All support facilities will have a common forecast and communications toolset of hardware and software, including the NWS National Digital Forecast Database (NDFD). The NDFD is a step toward the NextGen 4D Weather Cube.”
- “We currently have a National Digital Forecast Database (NDFD) and a National Digital Guidance Database (NDGD), the foundation and building blocks for moving forward into the NextGen era.”

**excerpted from NWS response to FAA’s CWSU Requirements Document
May 9, 2008**

The Limited Reach of Weather.gov



Source: www.alexa.com

The Unlimited Reach of NDFD

HAMweather



Univ of Texas Astronomy



GRIBv2

- 100,000 files/day
- ~200 users



SOAP/XML

- 2,000,000 requests/day
- ~10,000 users

Shareware



Chumby



Federal Agencies



The Weather Network

	4pm	6pm	7pm	10pm
TEMPERATURE	16°C	17°C	16°C	14°C
COVERAGE	Cloudy with showers	Cloudy with showers	Cloudy with showers	Cloudy with showers
P.O.P.	30%	20%	20%	20%
WIND	SW 19 kph	SW 22 kph	SW 24 kph	SW 26 kph
HUMIDITY	62%	62%	69%	75%
SEA	trace	trace	trace	trace

	4am	6am	7am	10am
TEMPERATURE	14°C	14°C	14°C	17°C
COVERAGE	Cloudy with showers	Cloudy with showers	Cloudy with showers	Cloudy with showers
P.O.P.	30%	30%	60%	60%
WIND	SW 25 kph	SW 18 kph	SW 22 kph	SW 28 kph
HUMIDITY	82%	82%	87%	68%
SEA	trace	trace	less than 1m	less than 1m

From Tuesday Afternoon to Wednesday Morning we expect 1.5cm of rain.

Real Estate Data



Energy Production



Web Icons



Civil Aviation



PASDA Map Services



Dow Home Products



Weather Bug



Custom Weather



QuickCast



Hurricane Alley



Weather Central TV



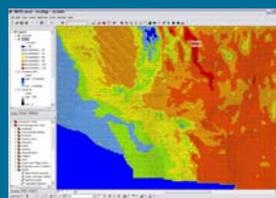
FORECA



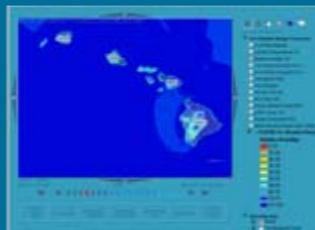
AccuWeather



ESRI GIS



Fire Danger



Agricultural Weather

UKAWC Point Agricultural, Lawn & Garden Forecast Outlook

(Based on 10% National Digital Forecast Database)

LAUREL / NEW AGR Co., MD

DATE	TEMP	WIND	WIND DIR	WIND SP	WIND GSP	REL HUM	PRECIP	WIND DIR	WIND SP	WIND GSP	REL HUM	PRECIP
10/04/08	65	10	SW	10	15	65	0.00	SW	10	15	65	0.00
10/05/08	65	10	SW	10	15	65	0.00	SW	10	15	65	0.00
10/06/08	65	10	SW	10	15	65	0.00	SW	10	15	65	0.00
10/07/08	65	10	SW	10	15	65	0.00	SW	10	15	65	0.00
10/08/08	65	10	SW	10	15	65	0.00	SW	10	15	65	0.00
10/09/08	65	10	SW	10	15	65	0.00	SW	10	15	65	0.00
10/10/08	65	10	SW	10	15	65	0.00	SW	10	15	65	0.00
10/11/08	65	10	SW	10	15	65	0.00	SW	10	15	65	0.00
10/12/08	65	10	SW	10	15	65	0.00	SW	10	15	65	0.00
10/13/08	65	10	SW	10	15	65	0.00	SW	10	15	65	0.00
10/14/08	65	10	SW	10	15	65	0.00	SW	10	15	65	0.00
10/15/08	65	10	SW	10	15	65	0.00	SW	10	15	65	0.00
10/16/08	65	10	SW	10	15	65	0.00	SW	10	15	65	0.00
10/17/08	65	10	SW	10	15	65	0.00	SW	10	15	65	0.00
10/18/08	65	10	SW	10	15	65	0.00	SW	10	15	65	0.00
10/19/08	65	10	SW	10	15	65	0.00	SW	10	15	65	0.00
10/20/08	65	10	SW	10	15	65	0.00	SW	10	15	65	0.00
10/21/08	65	10	SW	10	15	65	0.00	SW	10	15	65	0.00
10/22/08	65	10	SW	10	15	65	0.00	SW	10	15	65	0.00
10/23/08	65	10	SW	10	15	65	0.00	SW	10	15	65	0.00
10/24/08	65	10	SW	10	15	65	0.00	SW	10	15	65	0.00
10/25/08	65	10	SW	10	15	65	0.00	SW	10	15	65	0.00
10/26/08	65	10	SW	10	15	65	0.00	SW	10	15	65	0.00
10/27/08	65	10	SW	10	15	65	0.00	SW	10	15	65	0.00
10/28/08	65	10	SW	10	15	65	0.00	SW	10	15	65	0.00
10/29/08	65	10	SW	10	15	65	0.00	SW	10	15	65	0.00
10/30/08	65	10	SW	10	15	65	0.00	SW	10	15	65	0.00
10/31/08	65	10	SW	10	15	65	0.00	SW	10	15	65	0.00

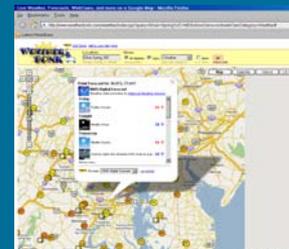
Armed Forces



State Government



Google Maps



Weather Underground



nowCOAST



Hydro One



University Research



NDFD – the future

- Spatial resolution that better resolves complex terrain
- Hourly temporal resolution (#1 customer request)
- More frequent than hourly updates
- Additional forecast elements
 - *Fire weather, marine, ...*
 - *Probabilistic*
 - *Digital forecasts from NCEP service centers*
 - *4D grids capable of supporting Next Generation Air Transportation System*

NDGD characteristics

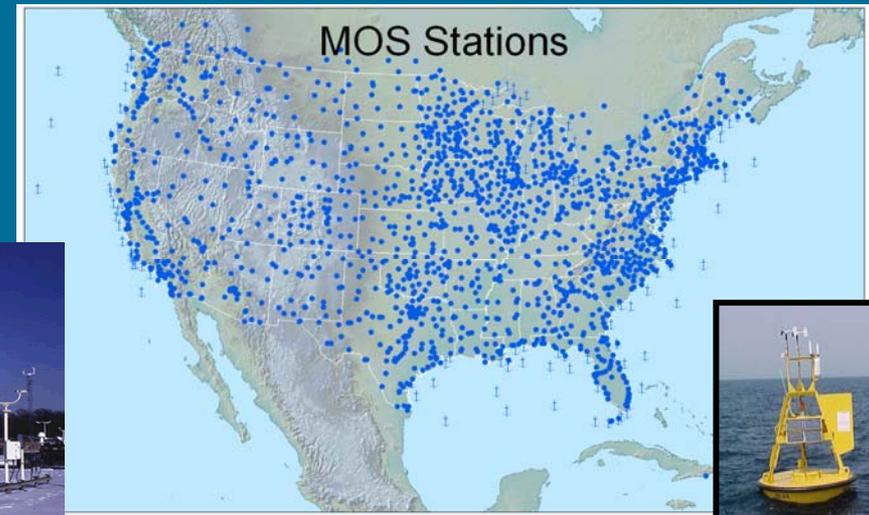
- Contains guidance – not the official NWS forecast.
 - *Forecasts and observations of sensible weather elements that relate to and supplement the NDFD*
 - *Digital data that help in the use and interpretation of NDFD such as model probabilities, climatological normals, and NDFD verification scores*
- Unlike NDFD, NDGD is not always current (may be updated per a fixed schedule rather than as needed).
- Unlike NDFD, NDGD is not always consistent in time and space, among elements, or with other NWS forecast products.

Model Output Statistics (MOS)

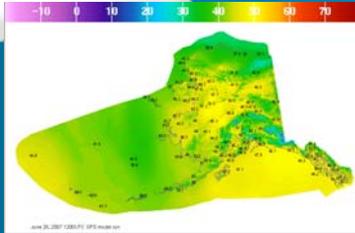
Objective technique for generating weather element guidance from numerical weather model output for projections of 3 hours to 14 days in advance

```
GFS MOS (MAV) KEWI GFS MOS GUIDANCE 1/31/2008 1800 UTC
DT /FEB 1 /FEB 2 /FEB 3
HR 00 03 06 09 12 15 18 21 00 03 06 09 12 15 18 21 00 03 06 12 18
N/X          32          47          33          52          27
TMP 33 32 34 34 36 40 44 44 39 38 38 37 36 41 49 51 42 35 32 31 49
DPT  9 15 22 27 31 35 37 37 34 29 28 27 25 24 22 22 24 27 27 27 30
CLD OV OV OV OV OV OV OV OV FW CL FW CL SC SC FW FW BK SC BK OV OV
WDR 09 07 07 06 06 06 05 12 27 26 26 26 27 28 28 28 10 00 00 00 32
WSP 03 04 07 07 10 12 11 07 11 15 11 08 03 07 07 06 01 00 00 00 05
P06      1   74  100   92   14    0    5    4    5  7  8
P12      77      100      20      8      8
Q06      0    2    4    4    0    0    0    0    0  0  0
Q12      2     5     0     0     0     0
T06      0/ 0  3/ 0  5/ 0  6/10  0/ 8  0/ 1  1/ 1  0/ 9  0/ 0  1/ 1
T12      7/ 0      6/10      1/ 1      1/ 9  2/ 1
POZ 11 10 11 28 36 21  8  4  5  4  7 12 20 15 12  4  6  7  7  5  4
POS 60 59 26 13  2  0  5  4  3 40 41 32 30 11  7  4  2  3  1  5  2
TYP S  S  R  Z  Z  R  R  R  R  R  S  R  S  R  R  R  R  R  R  R  R
SNW          0
CIG 8  8  7  6  3  2  3  3  7  8  8  8  8  8  8  8  8  8
VIS 7  7  7  7  5  2  3  4  7  7  7  7  7  7  7  7  7  7
OBV N  N  N  N BR BR BR BR N  N  N  N  N  N  N  N  N
```

- GFS-based through 7 days
- NAM-based through 84 hours



Gridded MOS (GMOS)

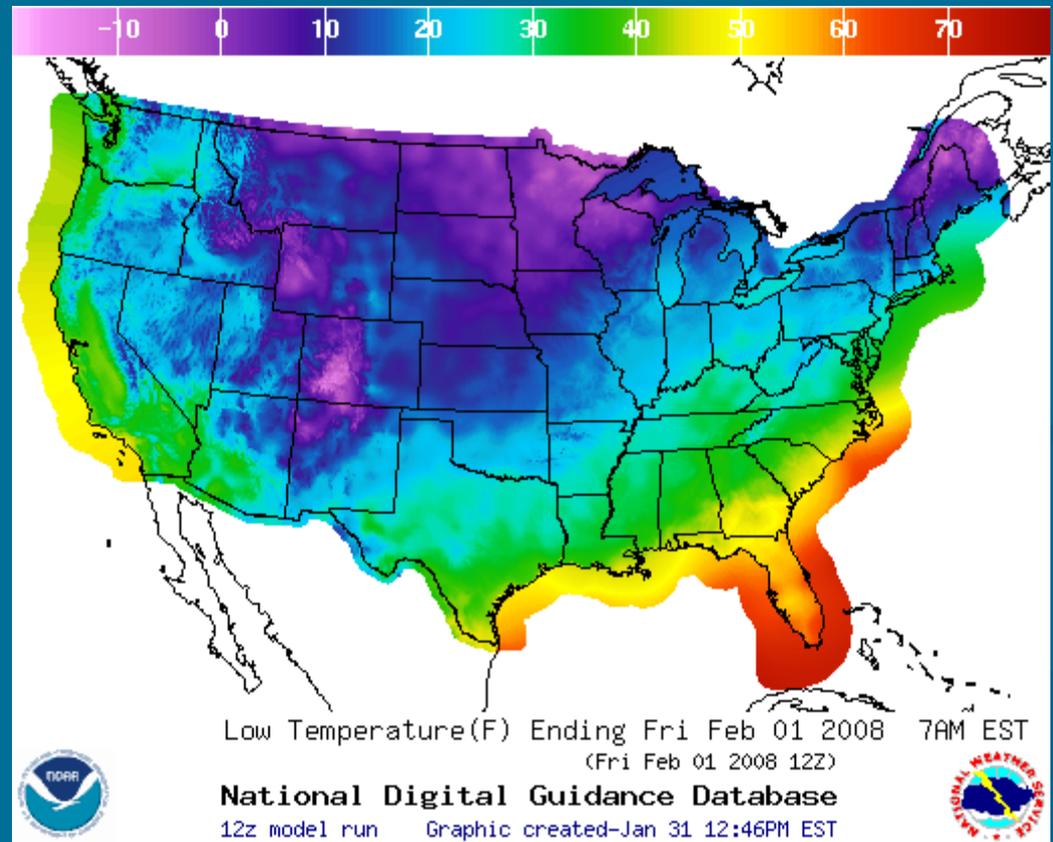


Downscales MOS to a fine-resolution grid with skill comparable to station-oriented guidance

Guidance available out to 192 hours

Current Elements:

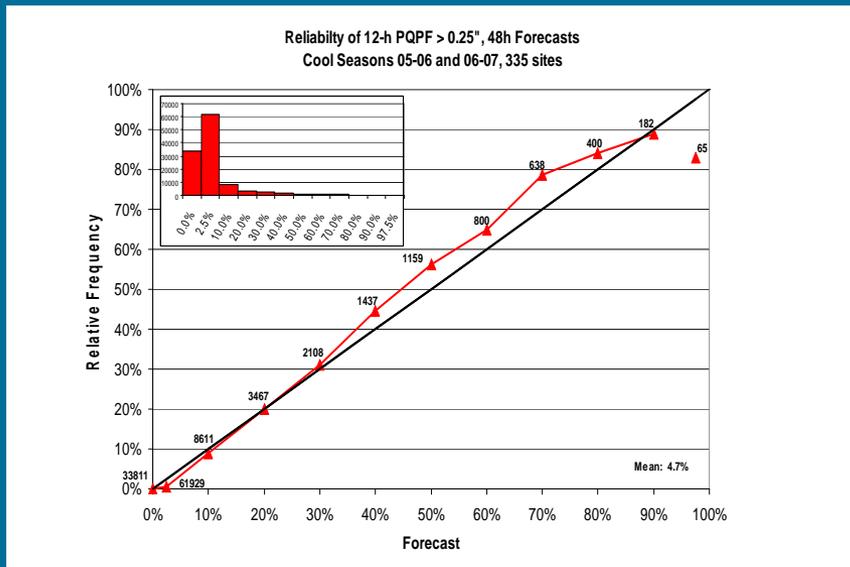
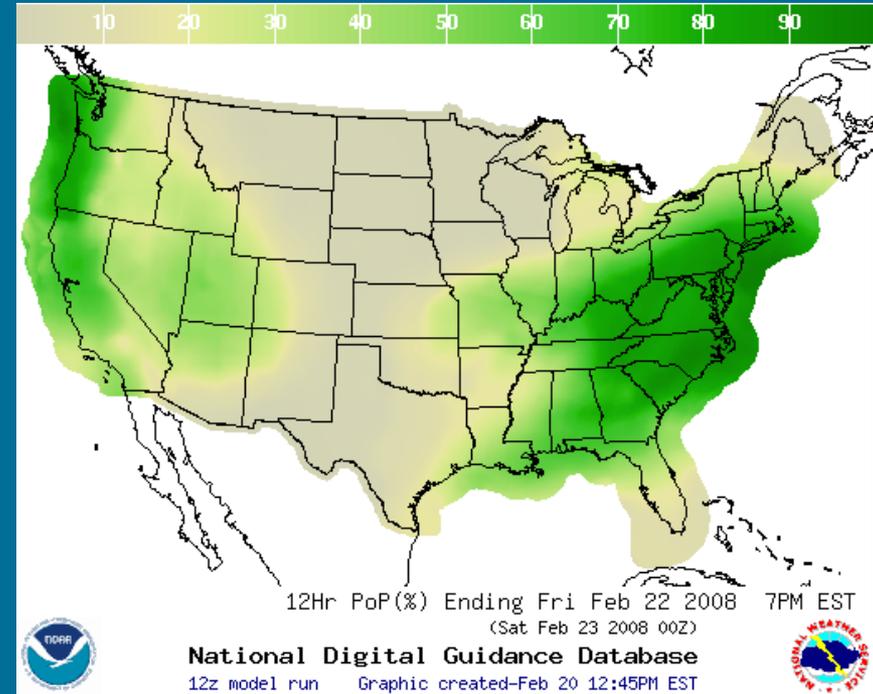
- *Surface Temperature*
- *Dew Point*
- *Max/Min Temperature*
- *Wind Speed/Direction*
- *Wind Gusts*
- *Probability of Precipitation*
- *Precipitation Amount*
- *Opaque Sky Cover*
- *Snowfall Amount*
- *Relative Humidity*
- *Probability of Thunderstorms*



MOS Event Probabilities

Partial List:

- Prob. of Precipitation
- Quantitative Precipitation Amounts
- Prob. of Thunderstorms
- Precipitation Types
- Sky Cover Categories
- Visibility Categories

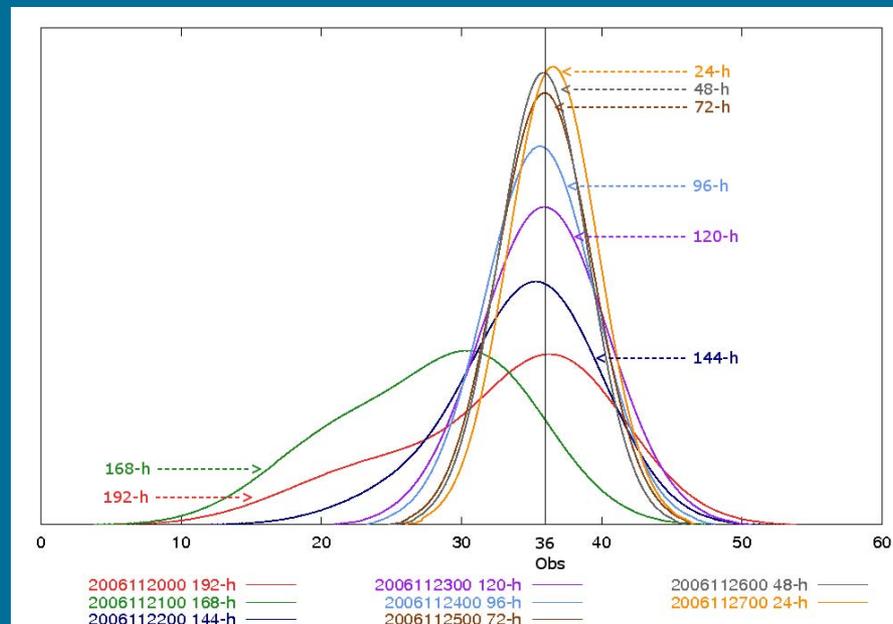


- Produces probability forecasts from a single run of NWP model
- Reflects the predictability of the event
- Produces reliable probabilities

Ensemble MOS

Ensemble Kernel Density MOS (EKDMOS)

- Provides reliable probabilistic forecasts of temperature, dew point, daytime maximum temperature, and nighttime minimum temperature.
- Applies linear regression principles to ensemble output.



Local Aviation MOS Program (LAMP)

Updates MOS guidance for next 25 hours at 1-h increments

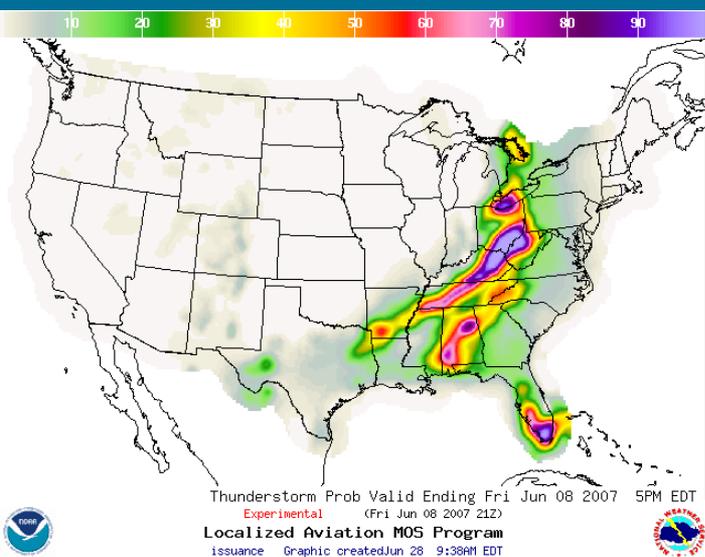
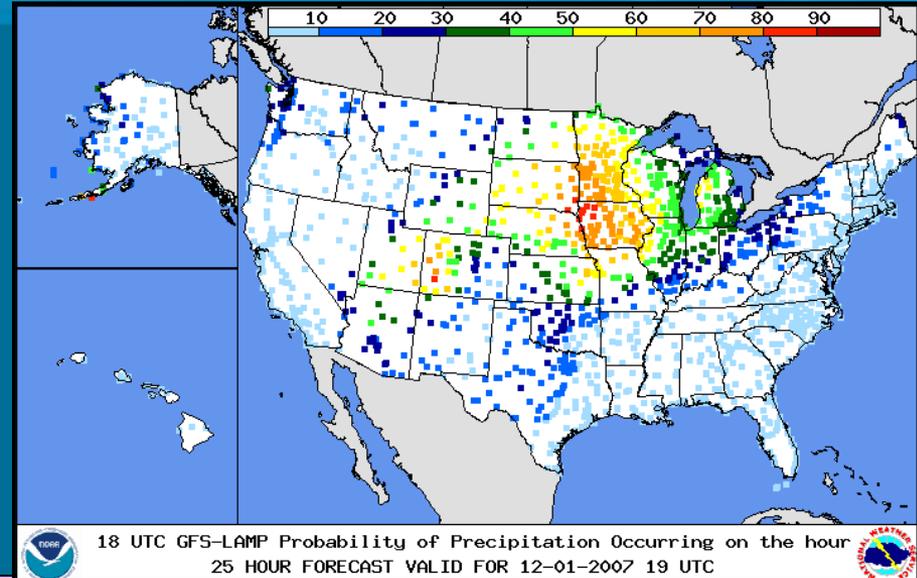
Station Guidance (~1600 stations)

- ❖ all elements; CONUS, Alaska, Hawaii, Puerto Rico

Gridded Guidance (20 km)

- ❖ Thunderstorms; CONUS

Runs hourly 24x/day



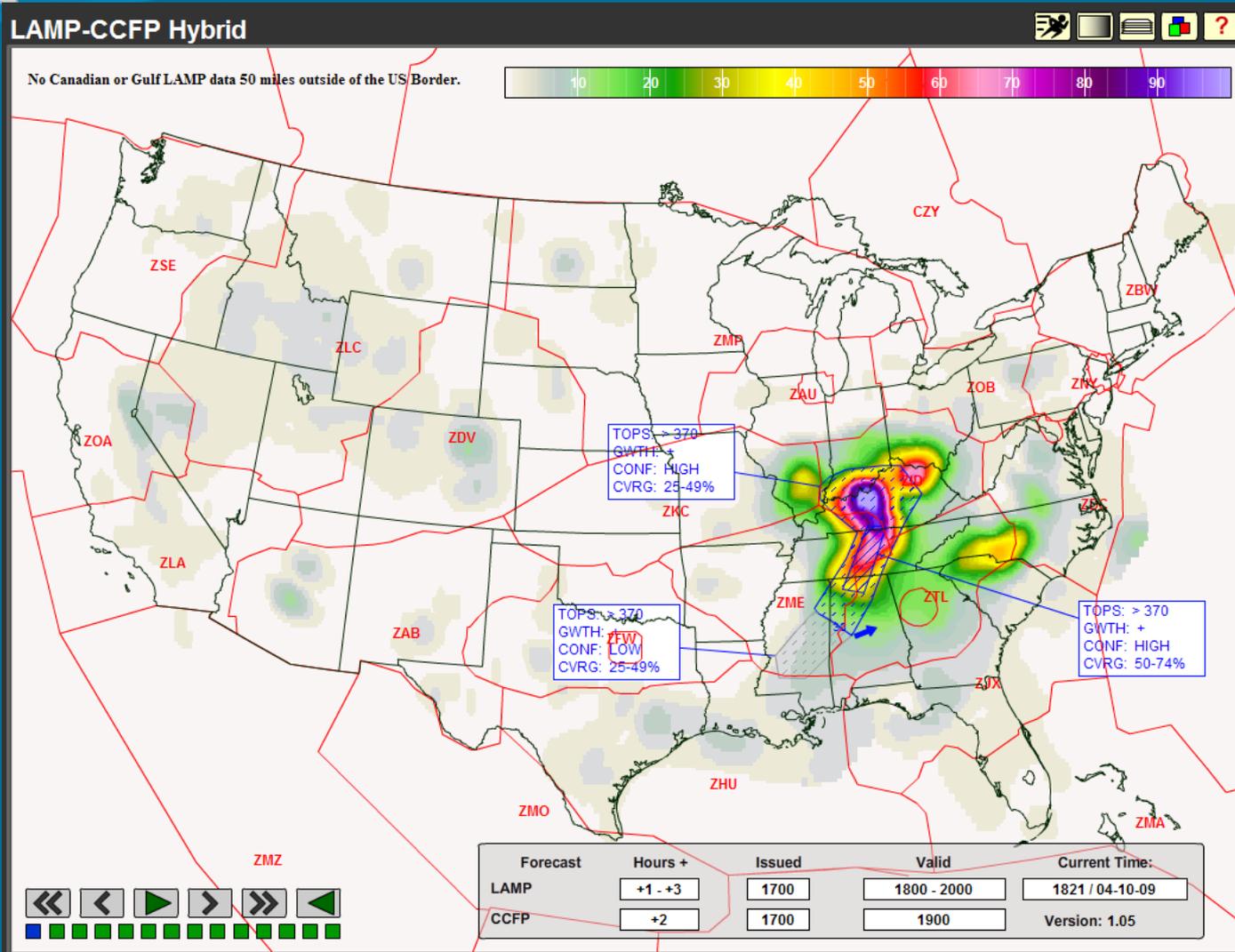
DSM	GFS LAMP GUIDANCE 11/30/2007 1800 UTC																								
UTC	19	20	21	22	23	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19
TMP	27	28	28	27	25	23	23	24	24	24	24	24	25	25	26	27	28	27	27	28	30	32	33	34	
DPT	2	2	2	2	2	2	3	5	6	7	8	9	10	11	12	14	16	18	18	20	22	24	26	28	32
WDR	33	33	33	35	02	06	09	10	11	12	12	12	12	12	11	11	11	11	11	11	12	12	12	12	12
WSP	10	09	08	07	05	04	05	05	05	06	07	07	08	09	09	11	13	15	15	16	17	16	16	15	17
WGS	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	24	23	22	24	
PP0	0	0	0	0	0	0	0	1	1	2	3	3	10	17	22	28	33	36	44	51	58	64	69	72	73
PC0	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	Y	Y	Y	Y	Y	Y	Y
P06																					24			100	
TP2				0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	1	1				1	
TC2				N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	
POZ	1	1	1	1	1	2	3	3	3	3	3	3	4	2	3	13	25	26	28	26	26	24	22	19	
POS	98	99	99	99	99	98	97	97	97	97	97	97	97	98	97	81	59	47	42	40	38	32	31	30	27
TYP	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	
CLD	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	SC	
CIG	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	
CCG	7	6	6	7	6	7	7	6	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	
VIS	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	
CVS	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	
CBV	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	

25-hour period starting: 18Z Friday, November 30 for DES MOINES (KDSM) IA

[Return to station list](#) or select another station (hit Submit above) [Text Bulletin](#)

Precipitation	LAMP Y/N Occur	OBS Y/N Occur	LAMP Pcp6	LAMP Probability
18Z Friday, November 30				
00Z Saturday, Dec 01				

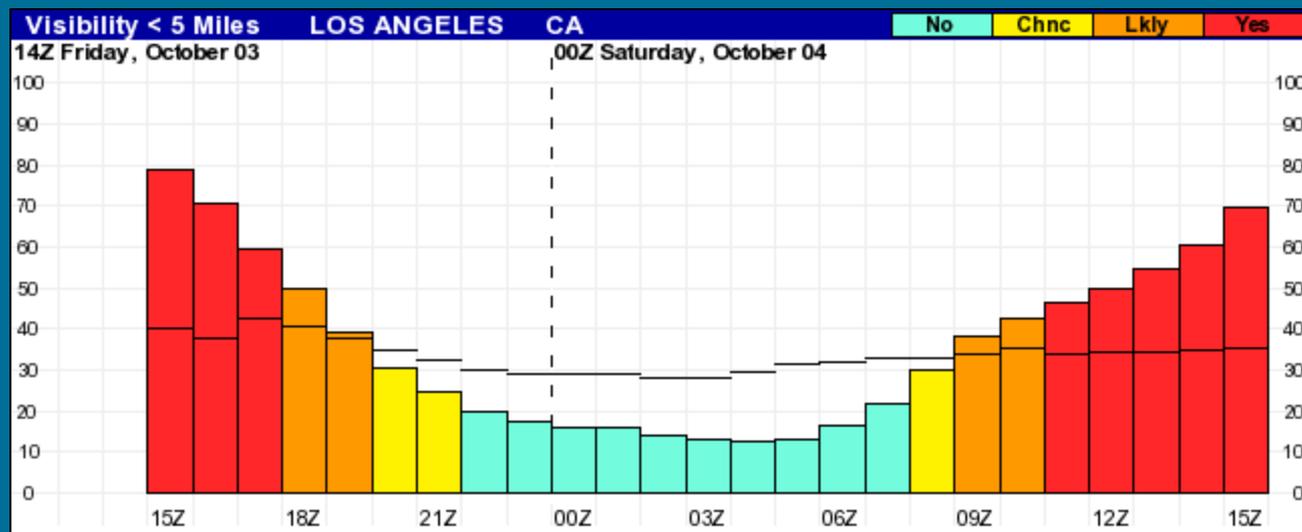
Partner use of LAMP Thunderstorm Grids via NDGD



LAMP Event Probabilities and Thresholds

Available for:

- Ceiling height and conditional ceiling height
- Visibility and conditional visibility
- Probability of precipitation occurring on the hour
- Conditional probabilities of freezing and frozen



<http://www.nws.noaa.gov/mdl/gfslamp/uncertform.php>

Upcoming LAMP improvements

- *Gridded LAMP from station LAMP*
 - *Temperature and dewpoint*
 - *Wind*
 - *Probabilities of Ceiling Height*
 - *Ceiling Height*
 - *Probabilities of Visibility*
 - *Visibility*
- *Inter-hour updates using SPECI observations*
- *Gridded analysis of aviation observations for use in verification of LAMP grids*
- *Gridded LAMP Convective Cloud Tops*



Data Cube Fusion

- Blend model guidance into NDFD in a manner that results in forecasts that are consistent:
 - *in time*
 - *in space*
 - *among elements*
 - *with prior updates*
- For example, assume NDFD sky and weather and employ LAMP probabilities conditioned on weather to provide matching ceiling and visibility grids.



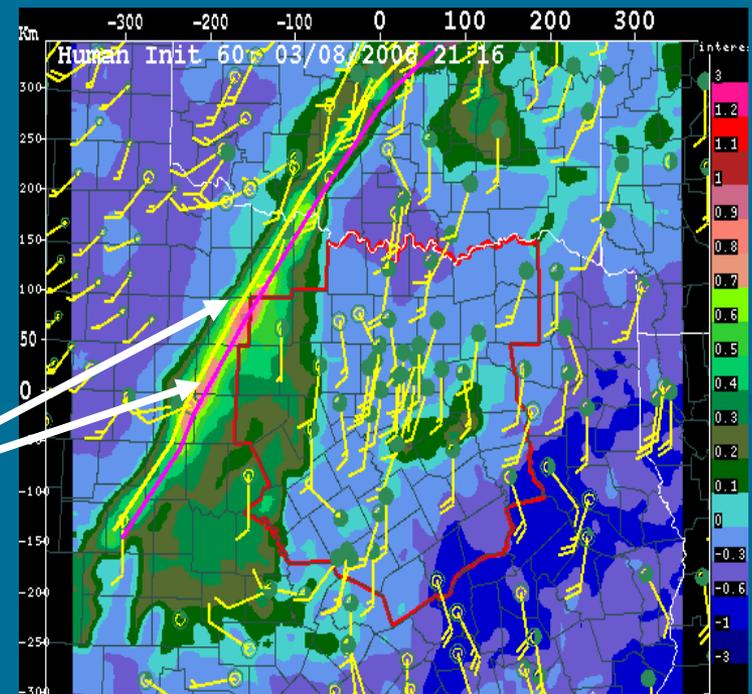


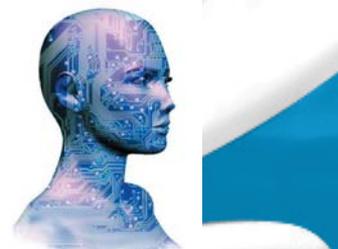
Thunderstorm Auto-nowcaster

- Provides very high resolution gridded nowcasts of thunderstorms for support of air traffic management, public severe weather warnings, and nowcasts
- First ever fully-interactive real-time forecaster modeling system
- Working with NCAR to extend experiment from 2 to 6 ARTCCs

Impact of human-entered boundary:

- interest is increased near boundary
- reddish areas are where new storms are expected in 60 min





Threshold Adjustment w/ IC4D

IC4D: (boyer - gfeConfig)

WeatherElement Populate Interpret Grids Edit Consistency Products Maps Edit Areas Verify Buff Model Observations Hazards Help

Normal [Navigation icons]

- Employs guidance from a variety of model sources and observations
- Maintains time-space continuum of fine-resolution model guidance
- Currently being tested in the Alaska and Pacific Regions
- Planned for future testing at Aviation Weather Center

Model Interpreter

Apply to All Selected Grids

Light

Less Moderate More

Less Severe More

Less More

Set Parameter Weights...

Set Pirep Weights...

Set Spatial Weights...

Adjust Forecast Timing...

Undo Reset

Dismiss

GTC FLT100 Fcst	(AFC) (%)	1h Tue 03Z 25-Nov-08
GTC FLT130 Fcst	(AFC) (%)	1h Tue 03Z 25-Nov-08
GTC FLT210 Fcst	(AFC) (%)	1h Tue 03Z 25-Nov-08
GTC FLT240 Fcst	(AFC) (%)	1h Tue 03Z 25-Nov-08
(edit) GTC FLT270 Fcst	(AFC) (%)	1h Tue 03Z 25-Nov-08
GTC FLT300 Fcst	(AFC) (%)	1h Tue 03Z 25-Nov-08
GTC FLT330 Fcst	(AFC) (%)	1h Tue 03Z 25-Nov-08
GTC FLT360 Fcst	(AFC) (%)	1h Tue 03Z 25-Nov-08
GTC FLT390 Fcst	(AFC) (%)	1h Tue 03Z 25-Nov-08
GTC FLT420 Fcst	(AFC) (%)	1h Tue 03Z 25-Nov-08
GTC FLT450 Fcst	(AFC) (%)	1h Tue 03Z 25-Nov-08

Status: [] ISC/Init: [] Time: 19:32Z 24-Nov-08

Accessing the Weather Cube Solution

Enhance NDFD capabilities to serve as a node of the WIDB.

- Heterogeneous, federated database system.
- Exchange data and metadata as NDFD and SAS forecasts are updated.
- Respond to data queries relayed from WIDB.

Continue development and testing of OGC-compliant XML access to the WIDB.

- Evaluation/comparison of data exchange technologies.
- Data retrieval from the WIDB for complex four-dimensional areas.

