The Advent of Operational Digital Forecasts

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Meteorological Development Laboratory

Bob Glahn Symposium

January 6, 2015

Coming of the Digital Age for Official NWS Forecasts

- Operational Numerical Models
- Model Output Statistics (MOS)
- Interactive Forecast Preparation (ICWF, IFPS, NDFD)

Benefits of Interactive Forecast Preparation

- Maximizes ***human contribution*** to forecast process
- Provides more ***forecast detail*** in time and space
- Enables more ***effective communication*** with users (e.g., graphics)
- Increases the ***usefulness*** of NWS forecasts to customers and partners

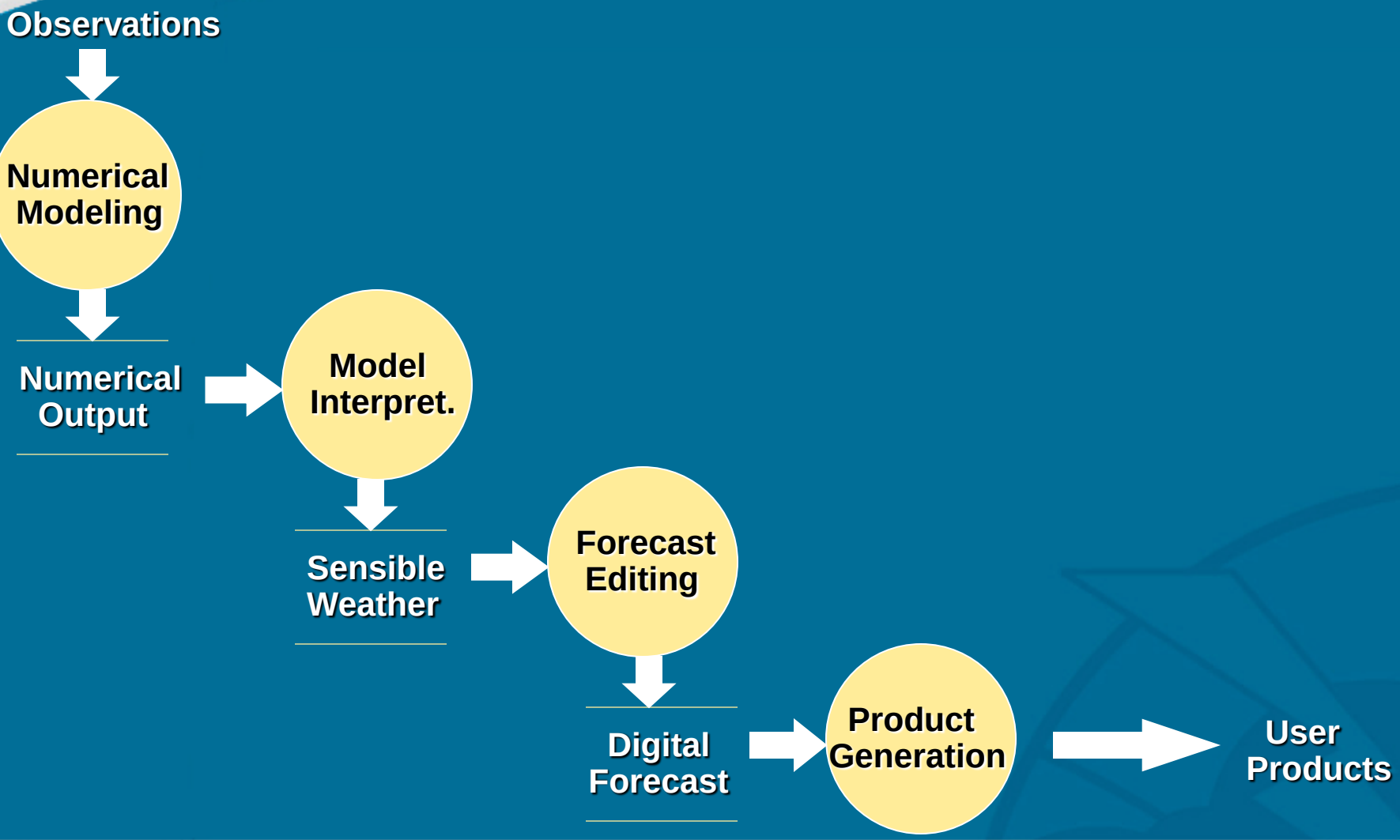
How does IFPS work?

- A 7-day ***digital forecast database*** is established at each WFO
- Forecasters ***interactively modify*** the contents of the database according to the latest observations and model guidance
- NWS text, tabular, voice, and graphical ***products are generated*** from the database
- The ***database itself*** is provided as an NWS product to customers and partners

Approaches to Forecaster Interaction

- **Matrix Editing**
  - *Interactive Computer Worded Forecast (USA)*
  - *SCRIBE (Canada)*
- **Grid Editing**
  - *Graphical Forecast Editor (USA and Australia)*
  - *Graphic Editing Module (Korea)*
  - *MICAPS Grid Editing (China)*
- **Object Editing**
  - *Forecast Production Assistant (Canada)*
- **Interactive Model Interpretation**
  - *Slider Bars (USA)*
- **4D Field Modification**
  - *HORACE OSFM (UKMET)*

The Digital Forecast Process



The Digital Forecast Process

The Human in the Loop

Observations

Numerical Modeling

Numerical Output

Model Interpret.

Sensible Weather

Forecast Editing

Matrix Editing

Digital Forecast

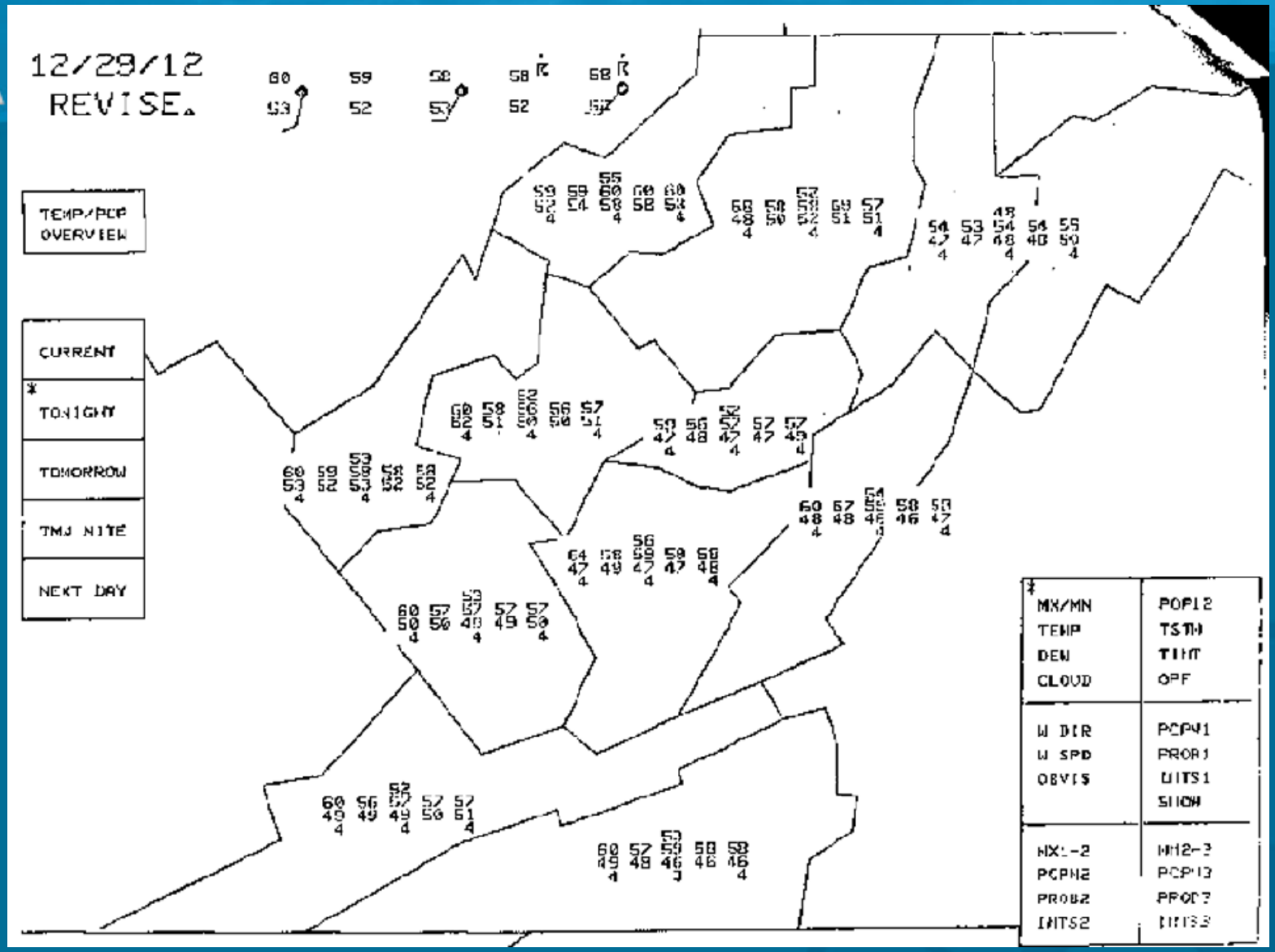
Product Generation

User Products

Matrix Editing

ICWF Interactive Guidance Revisor

(1988)



Matrix Editing

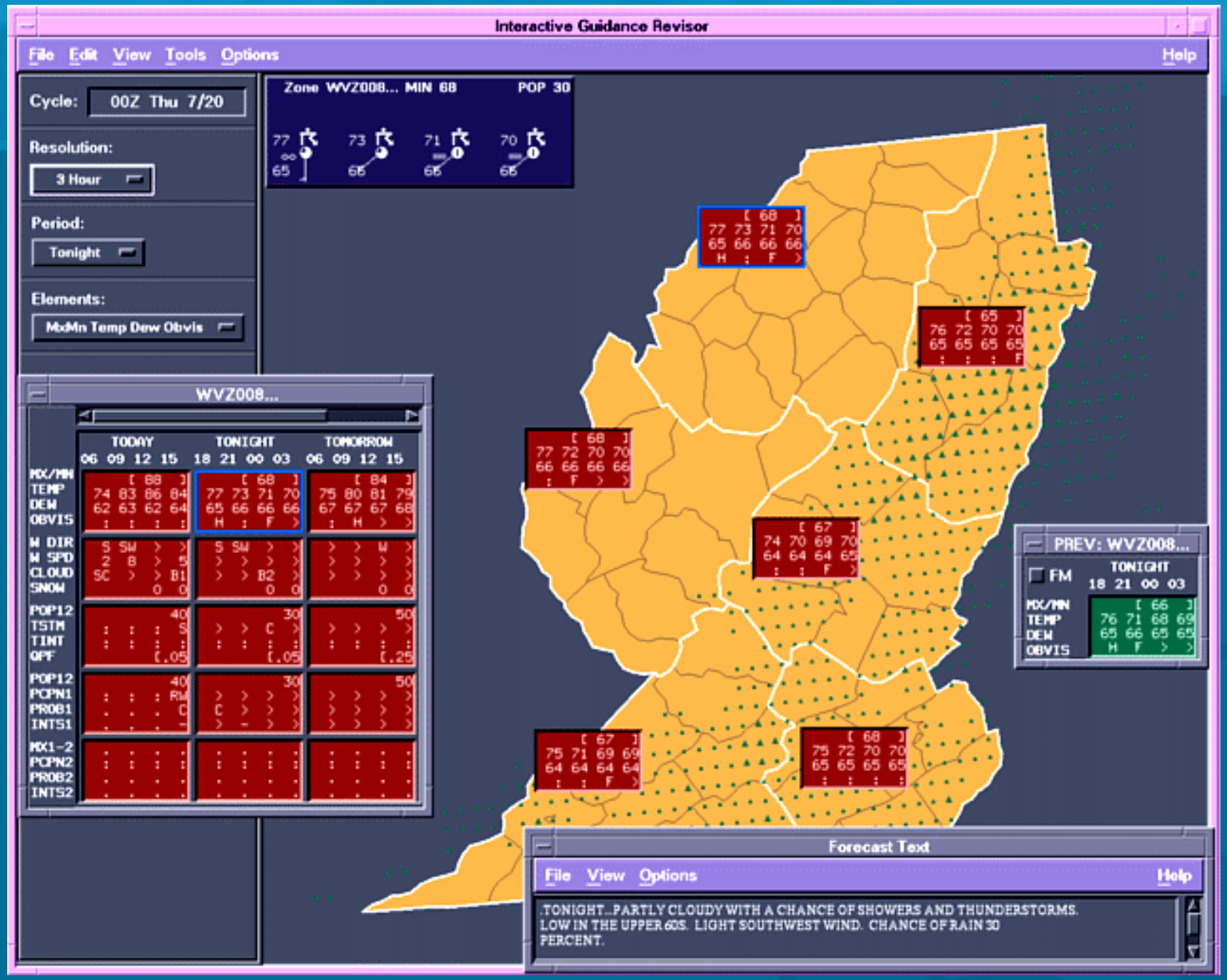
IFPS Interactive Guidance Revisor

Alan Rezek – MIC (retired)

Matrix Editing

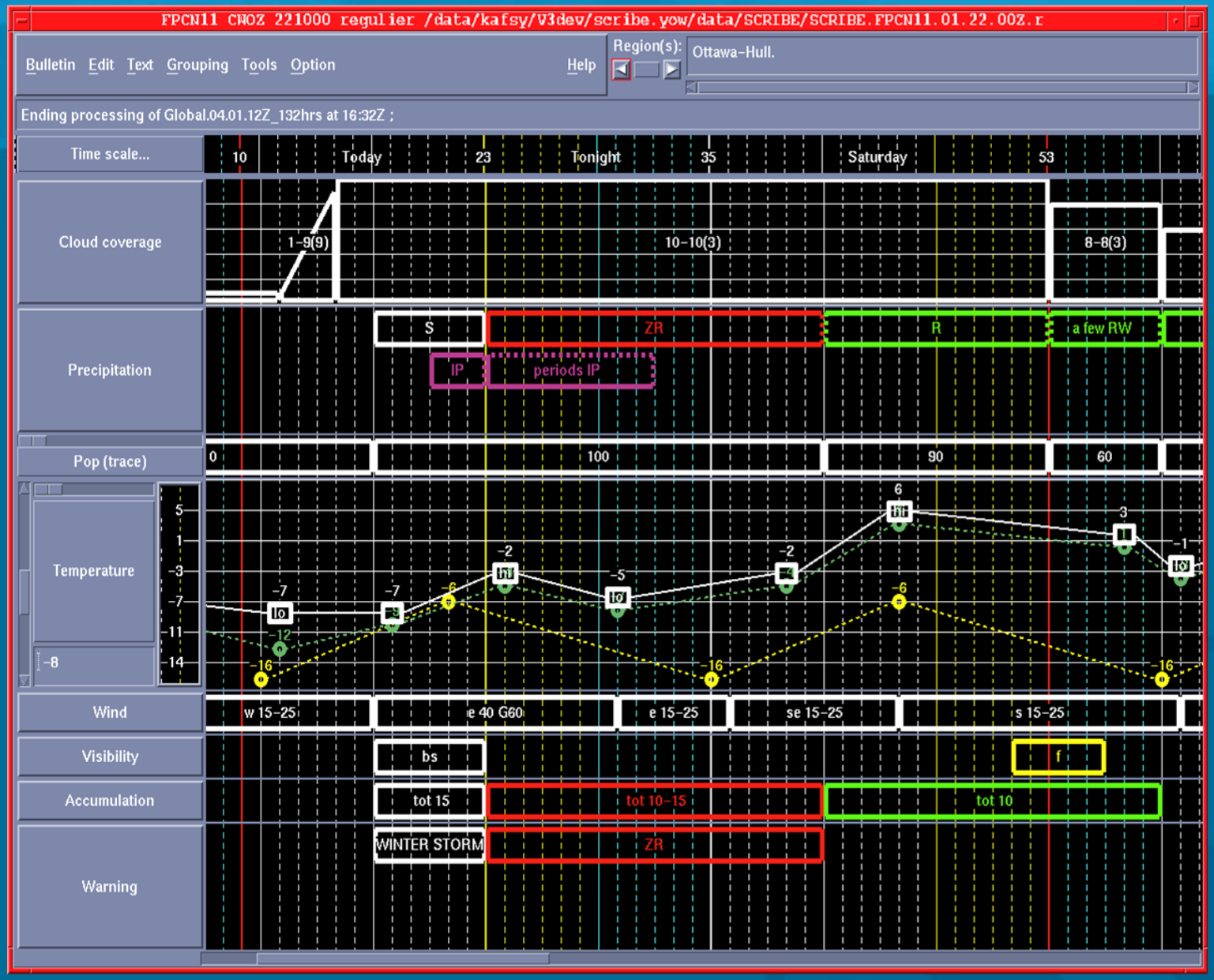
IFPS Interactive Guidance Revisor

(2000)



Matrix Editing

Canada's SCRIBE



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Grid Editing

Matrix Editing

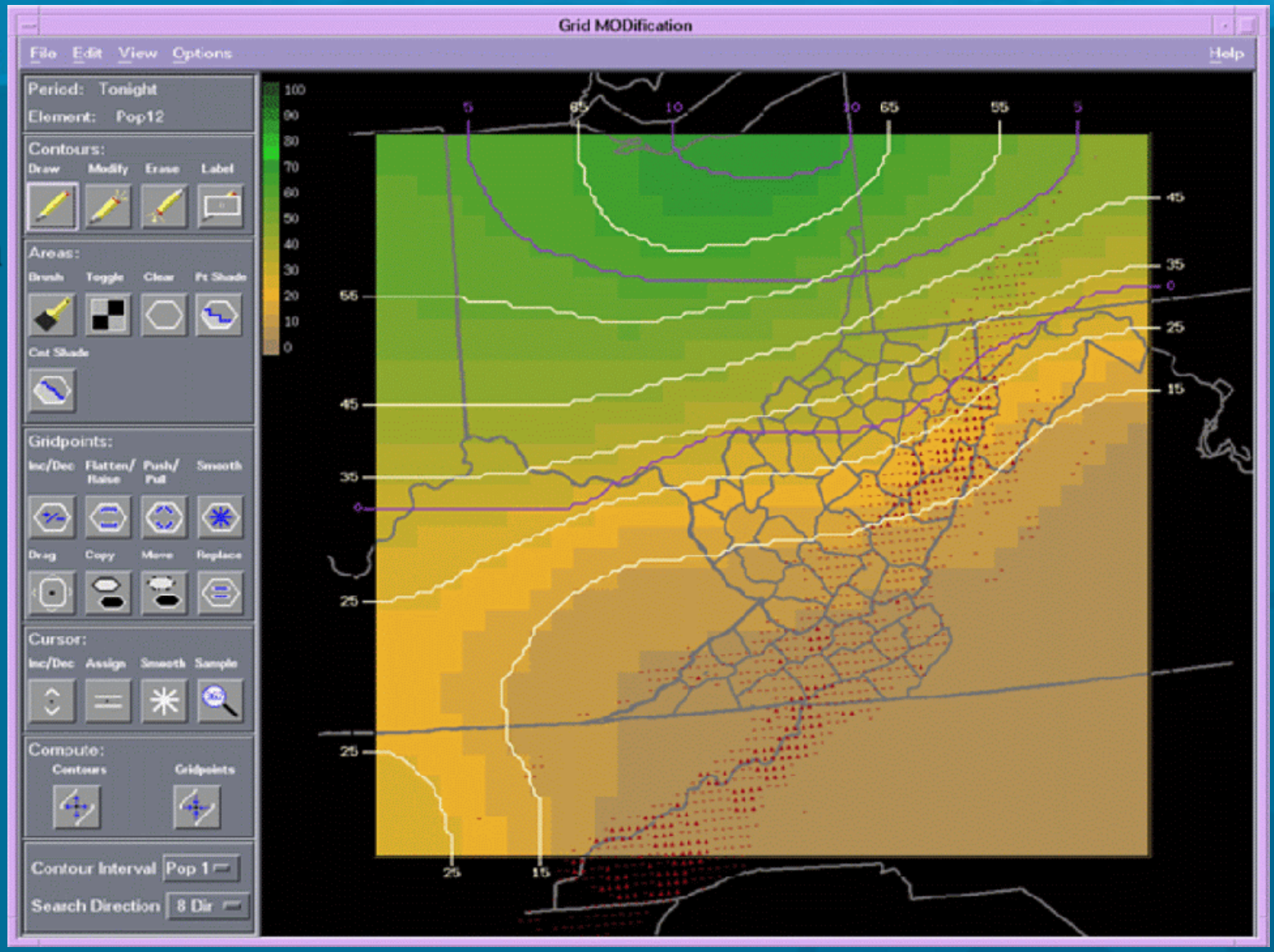
Digital Forecast

Product Generation

User Products

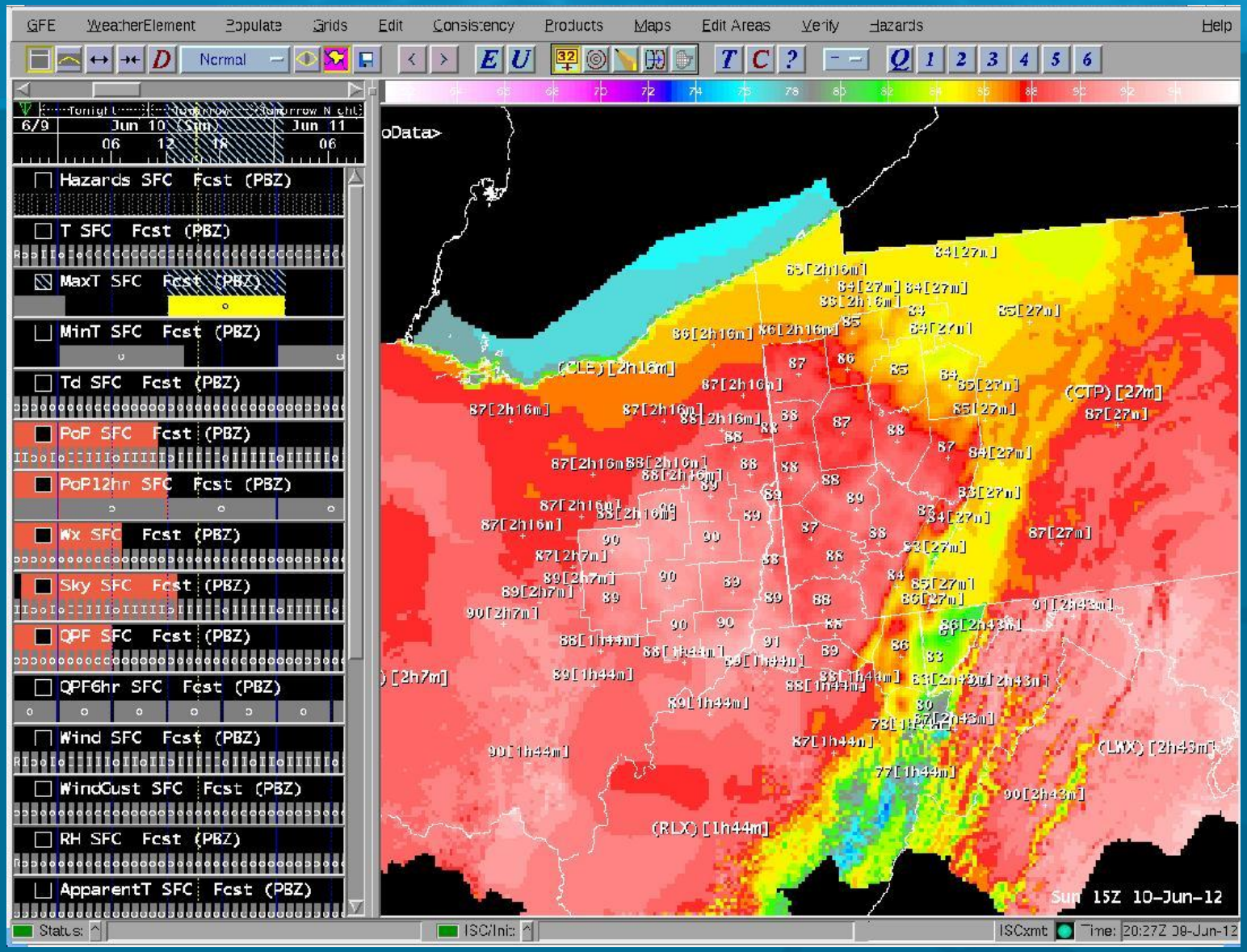
Grid Editing

ICWF Grid Modification
(1994)



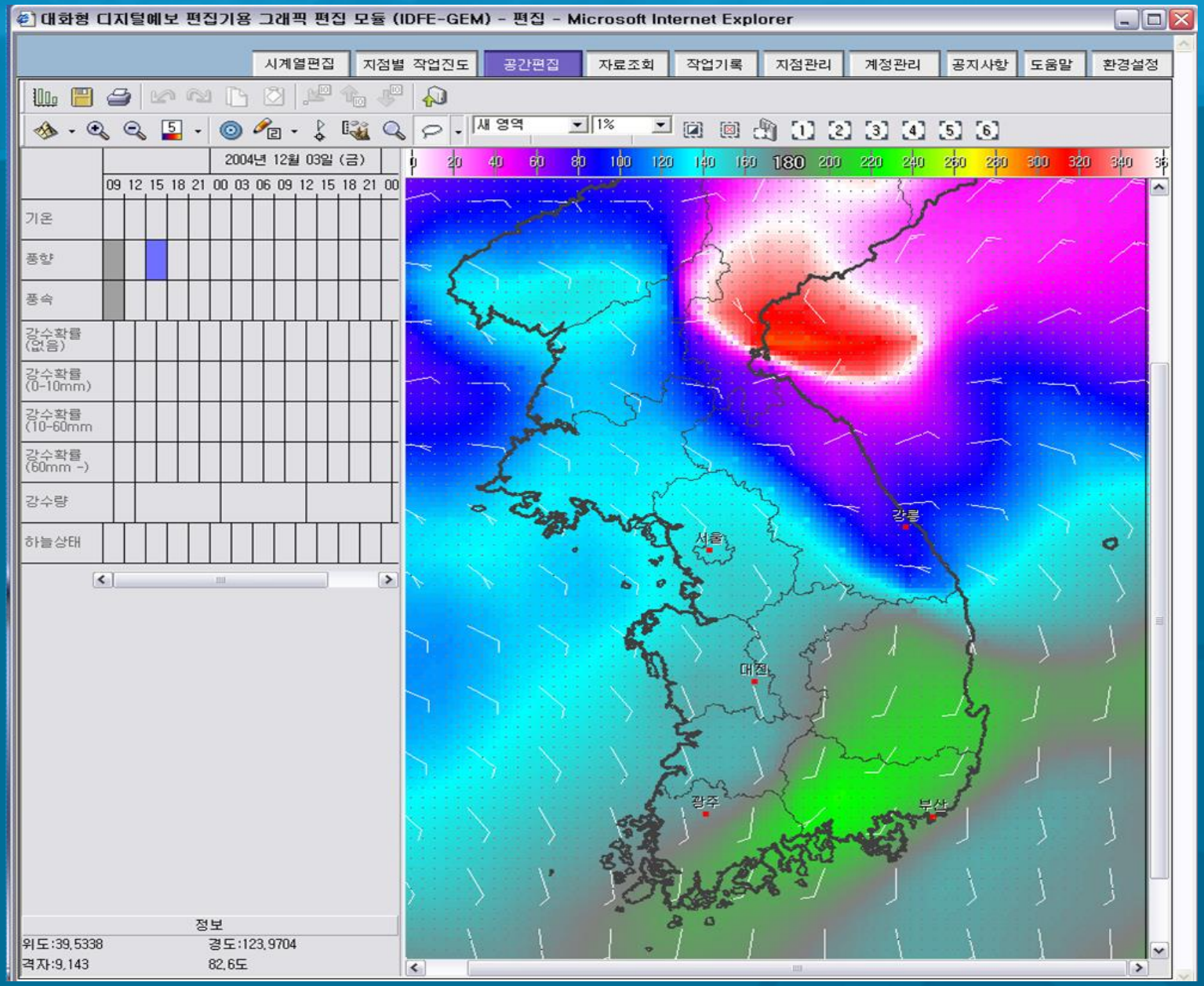
Grid Editing

IFPS Graphical Forecast Editor
(2012)



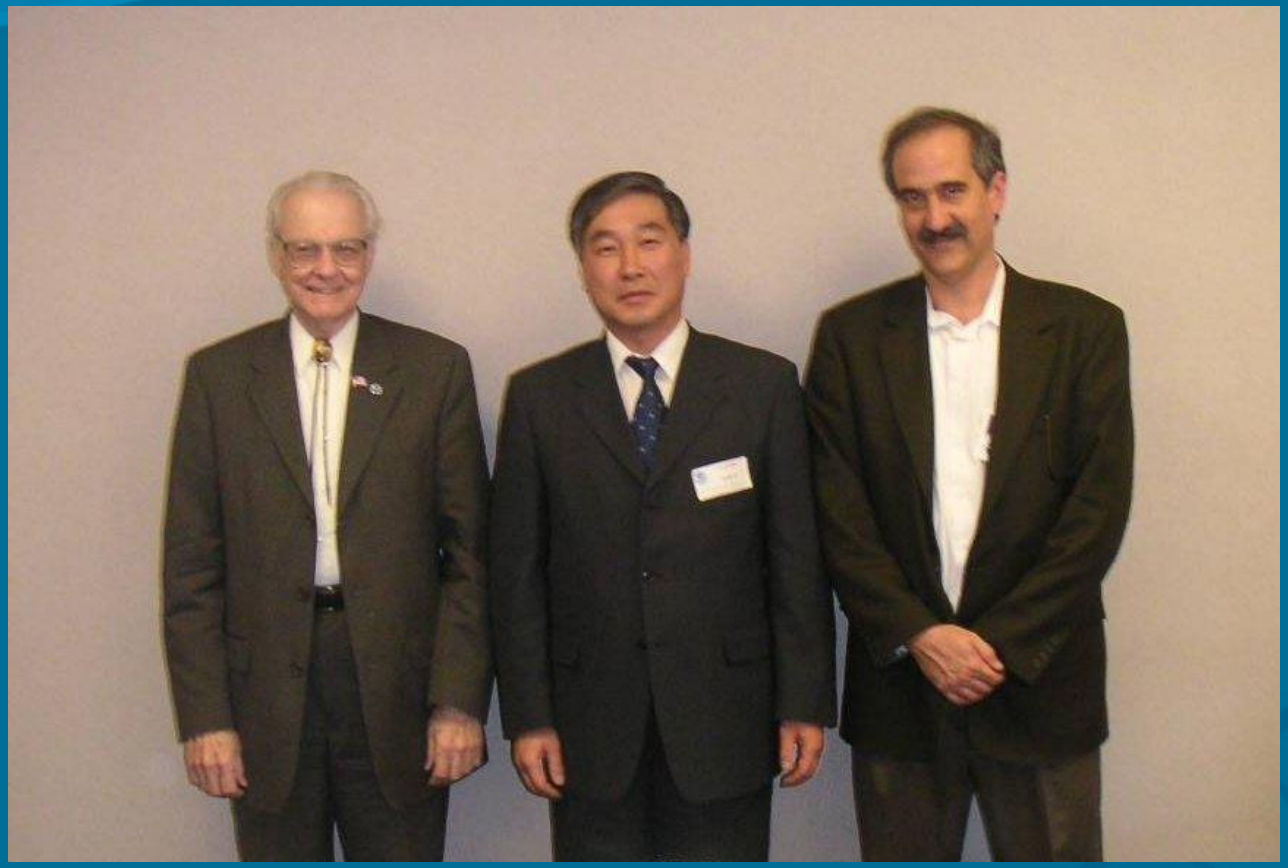
Grid Editing

KMA Graphic Editing Module



Grid Editing

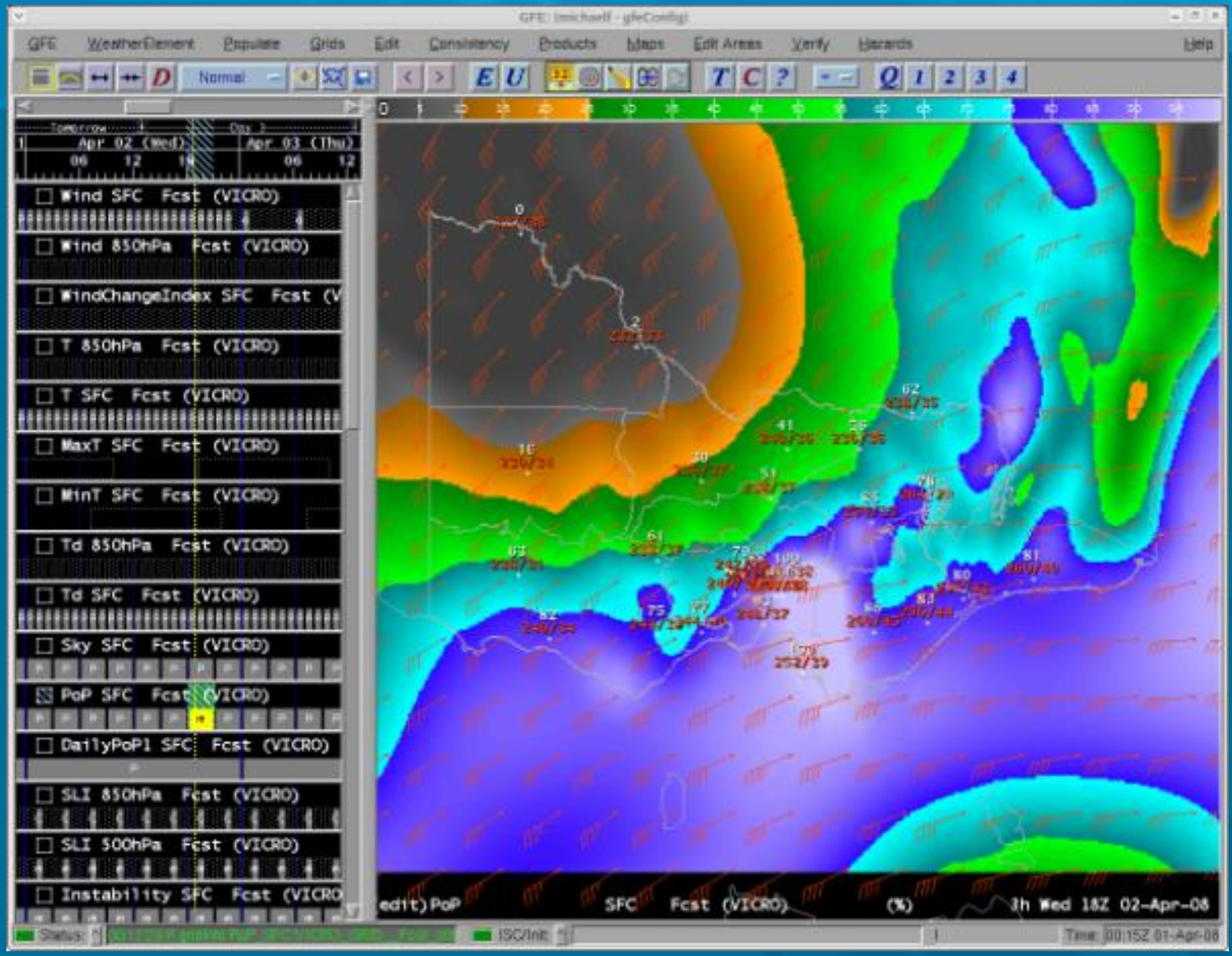
KMA Graphic Editing Module



Dr. Bob Glahn, Dr. Kyung-Sup Shun (deceased), David Ruth

Grid Editing

BoM Graphical Forecast Editor



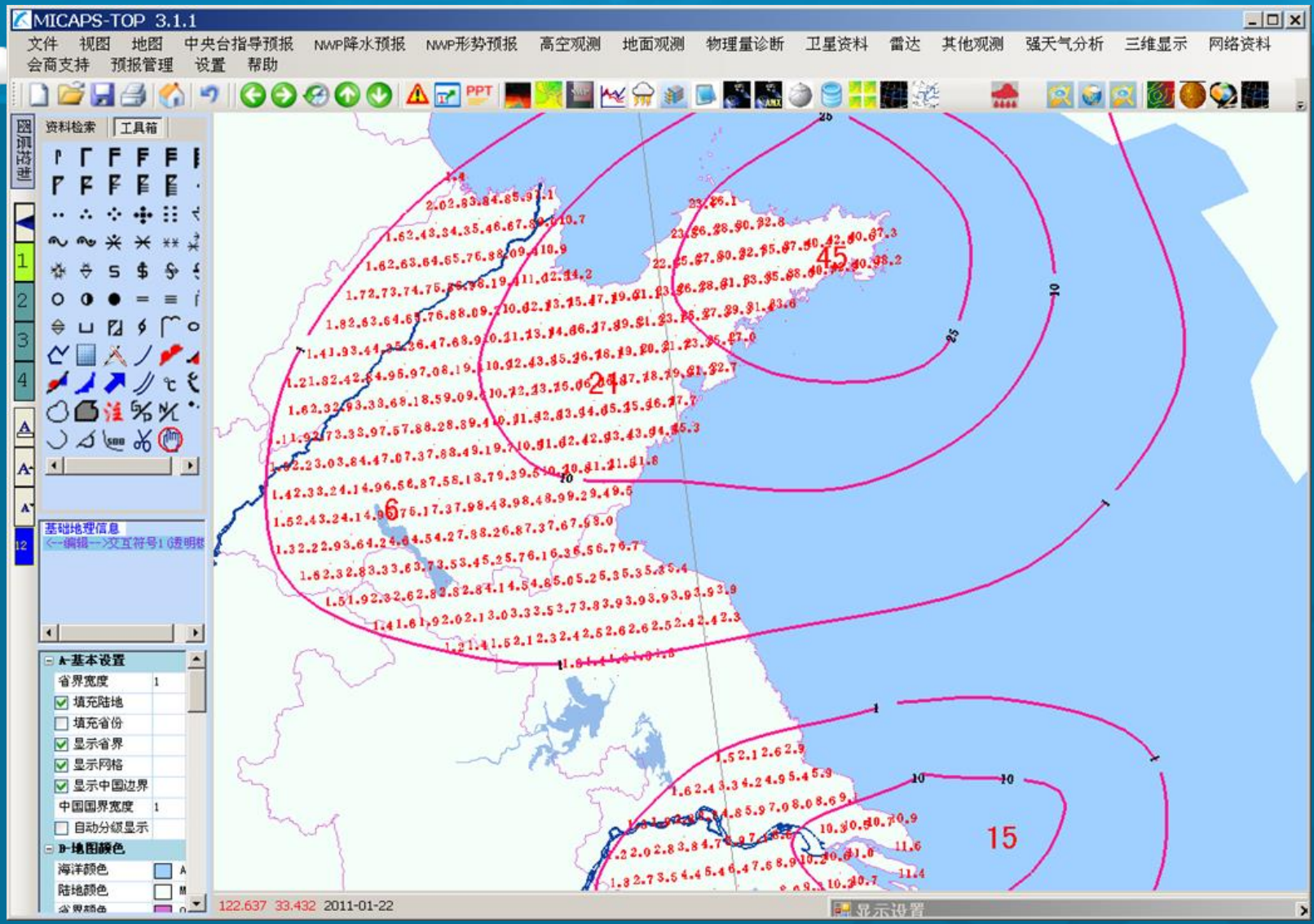
Grid Editing

BoM Graphical Forecast Editor

Carl Bullock, John Bally, Dr. Tom Keenan, David Ruth

Grid Editing

CMA MICAPS Grid Editor



The Digital Forecast Process

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Numerical Output

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Sensible Weather

Forecast Editing

Object Editing

Grid Editing

Matrix Editing

Digital Forecast

Product Generation

User Products

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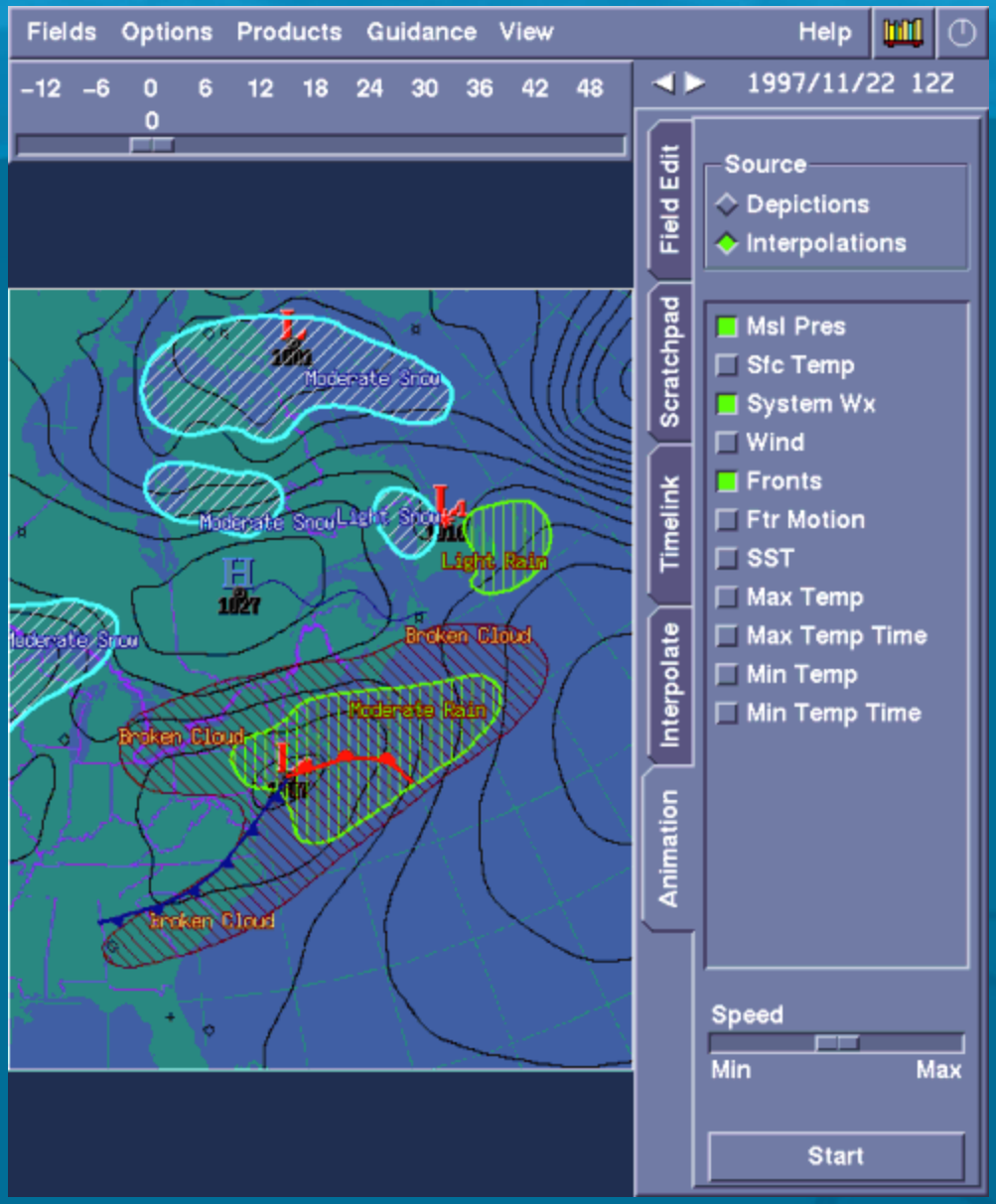
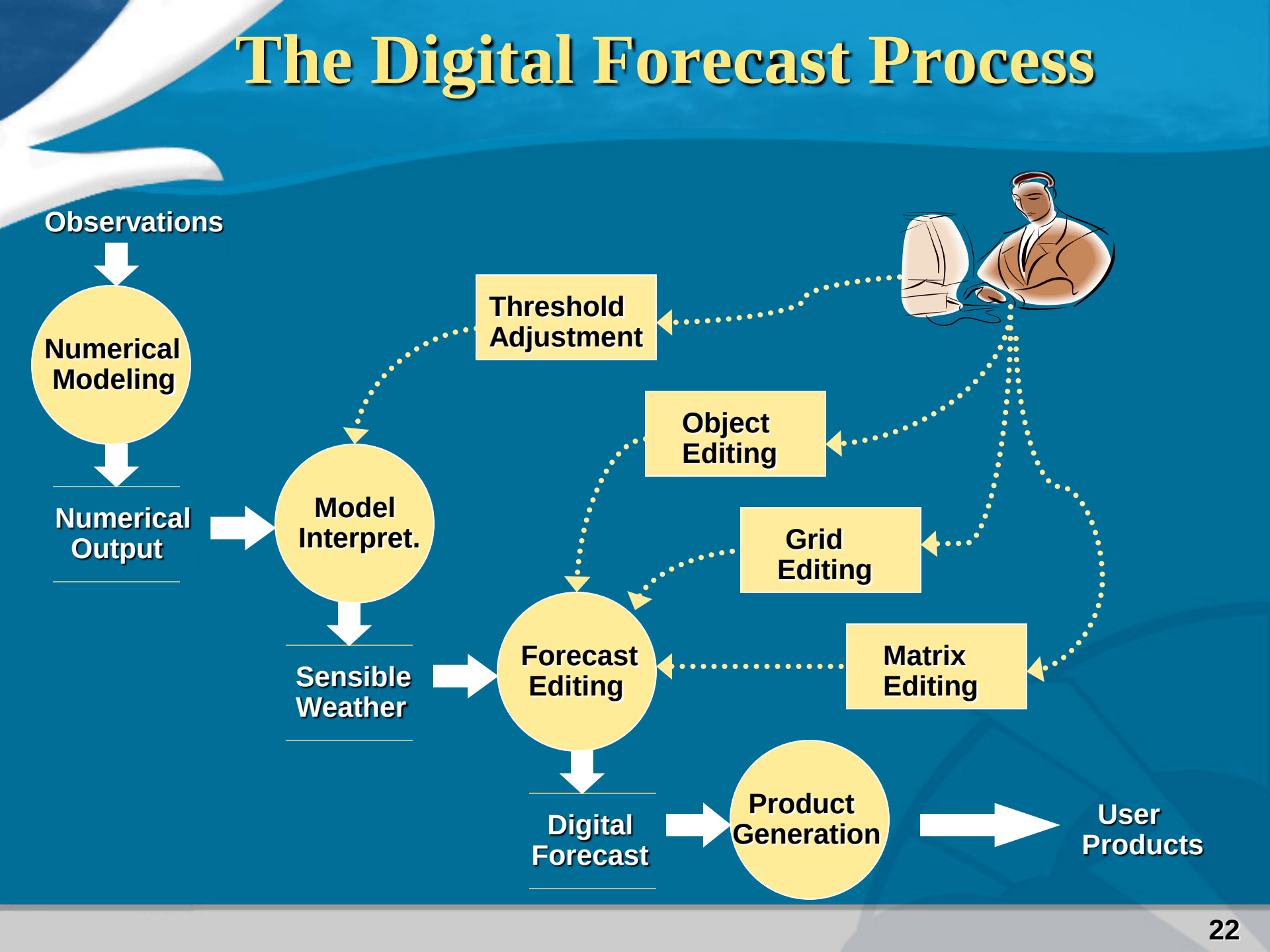
Canada's Forecast Production Assistant

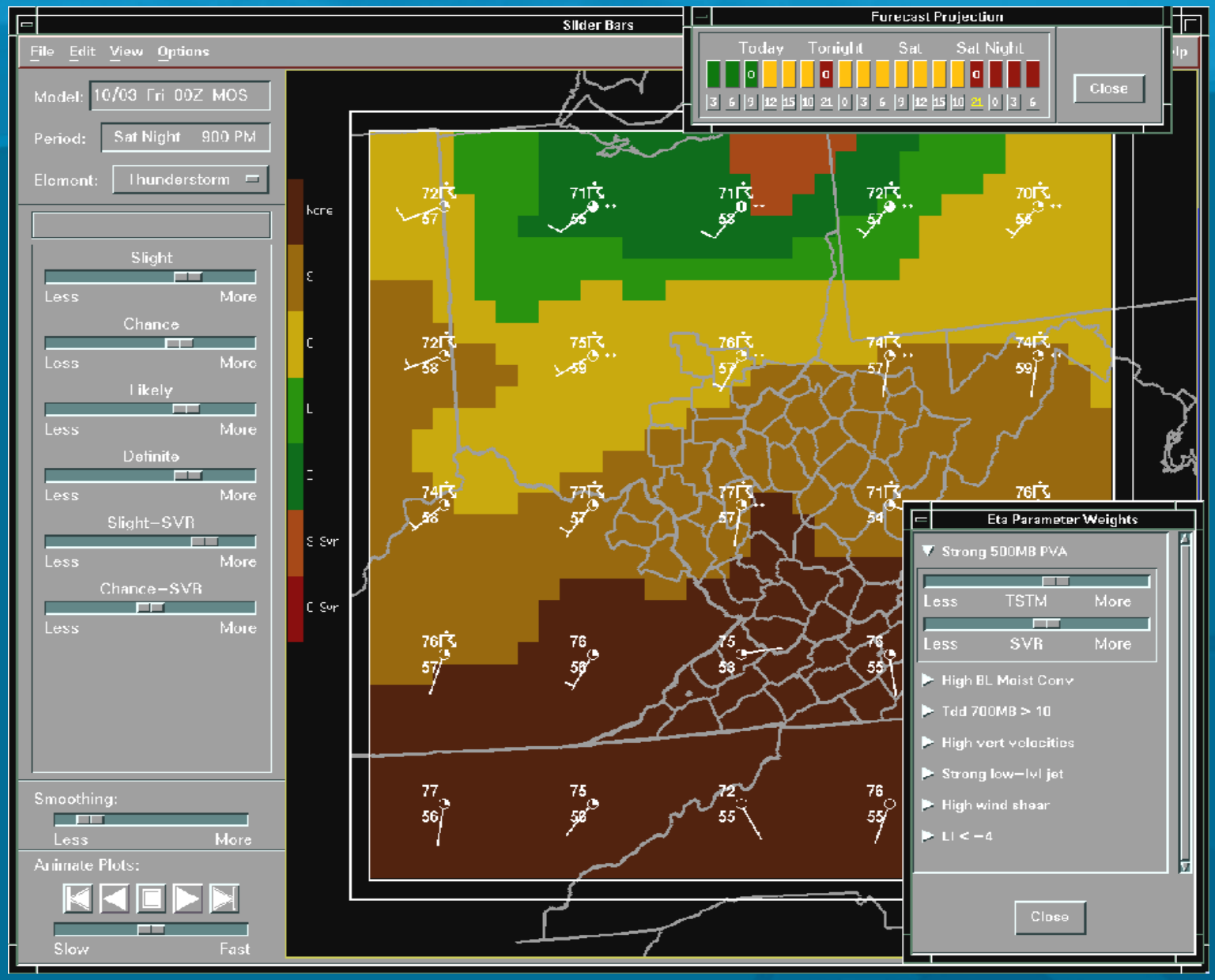


The Digital Forecast Process



Threshold Adjustment

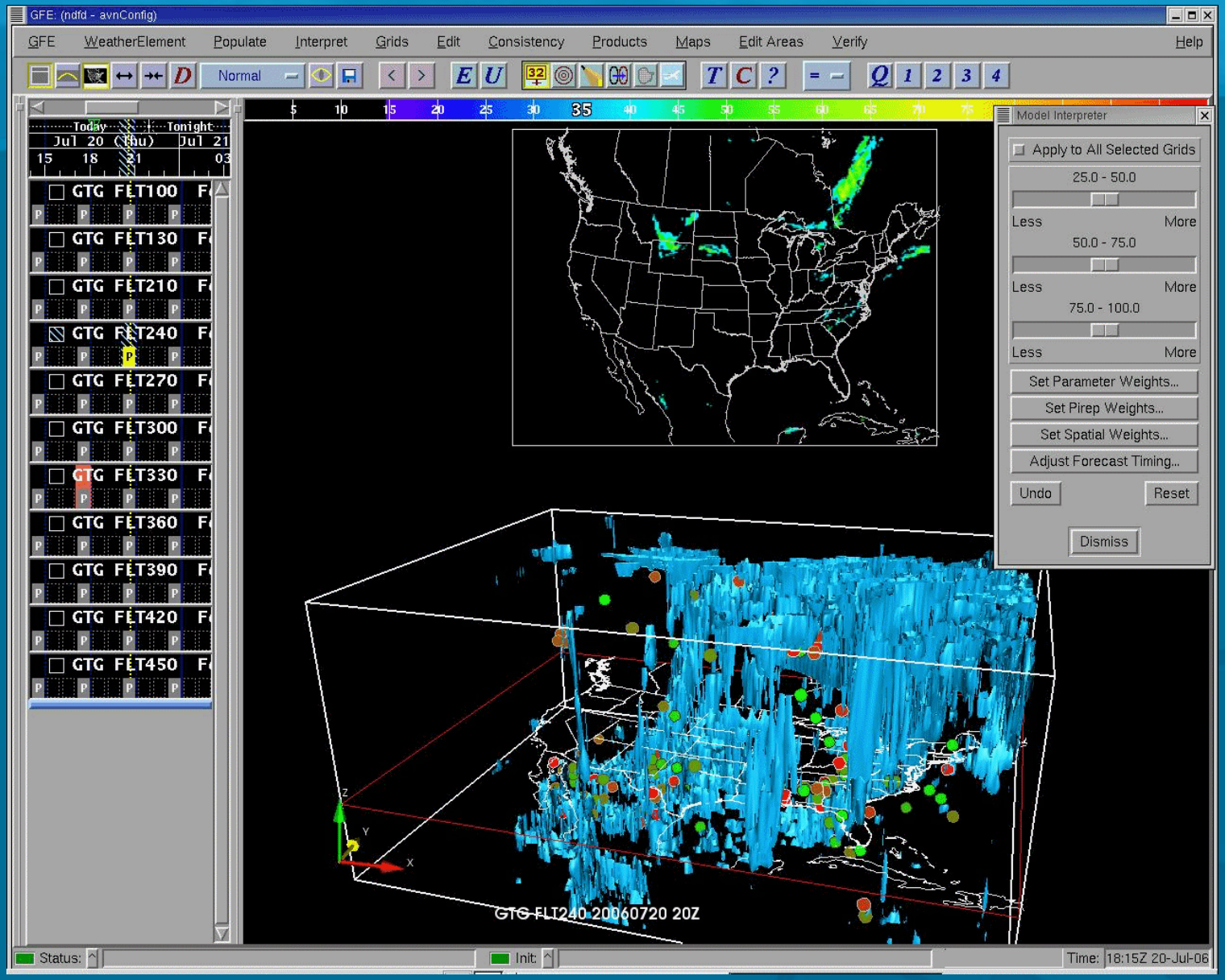
IFPS Slider Bars
(2000)



Threshold Adjustment

Interactive Calibration of a 4D Datacube

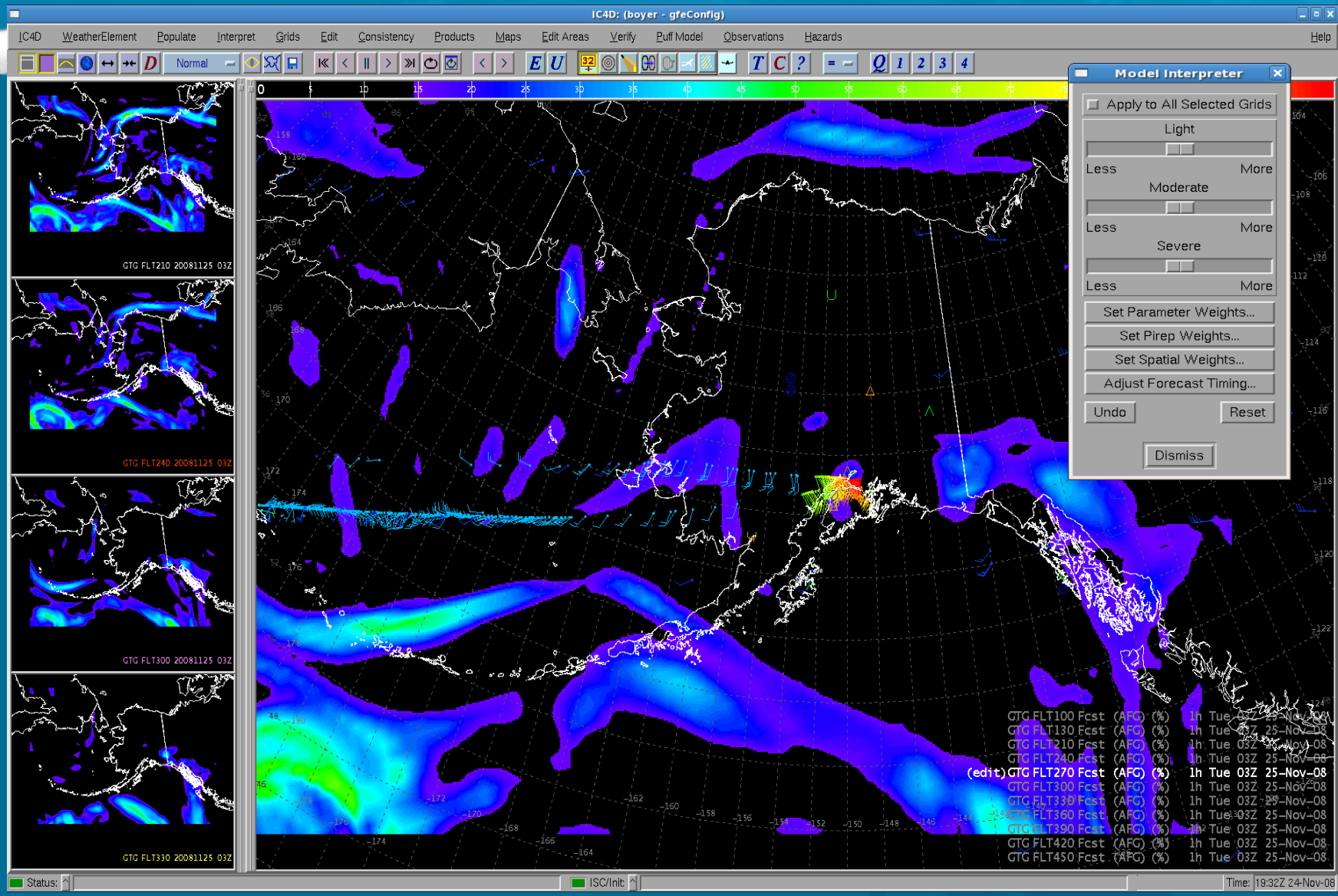
(2006)



Threshold Adjustment

IC4D

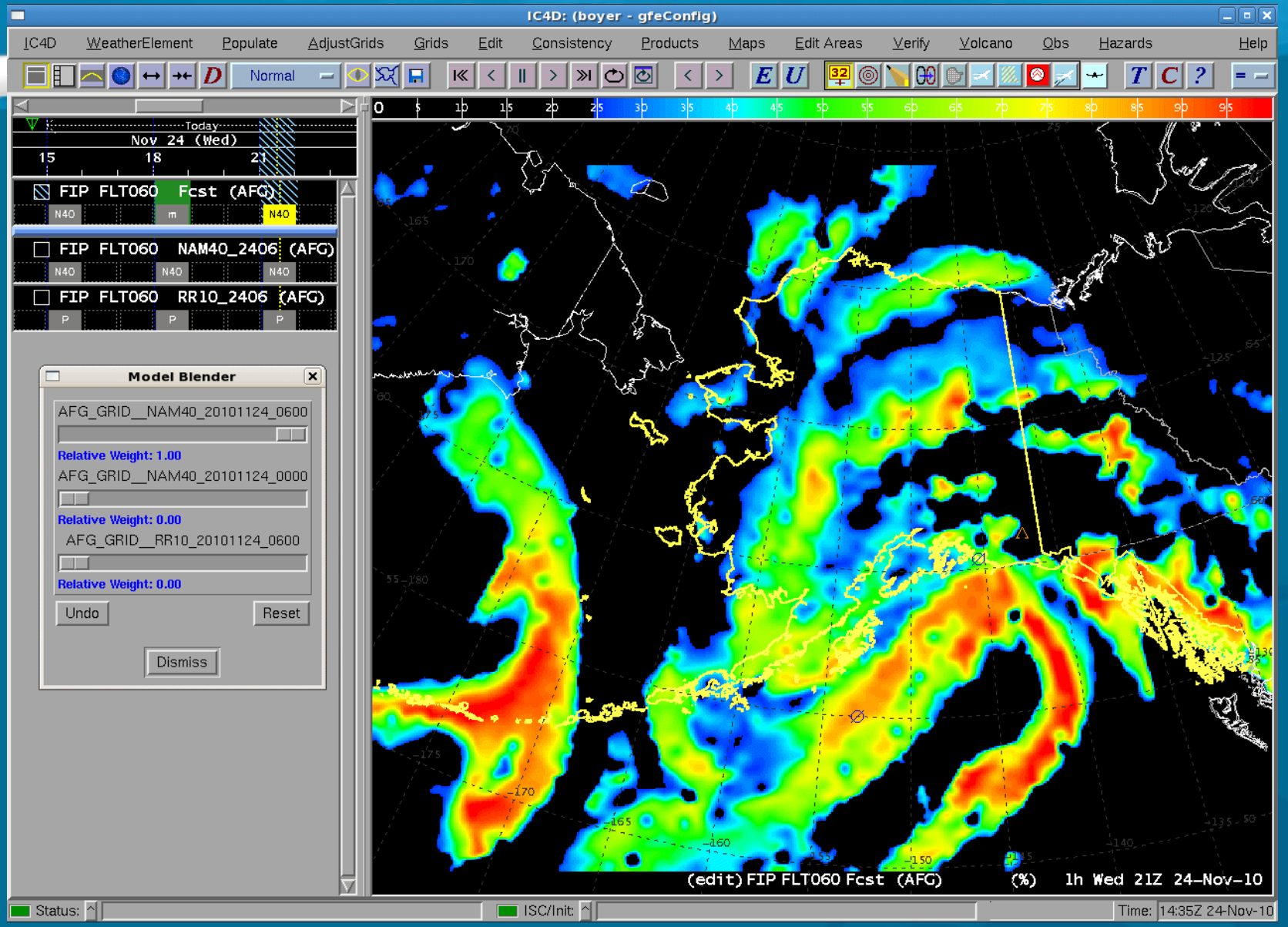
(2008)



Threshold Adjustment

IC4D

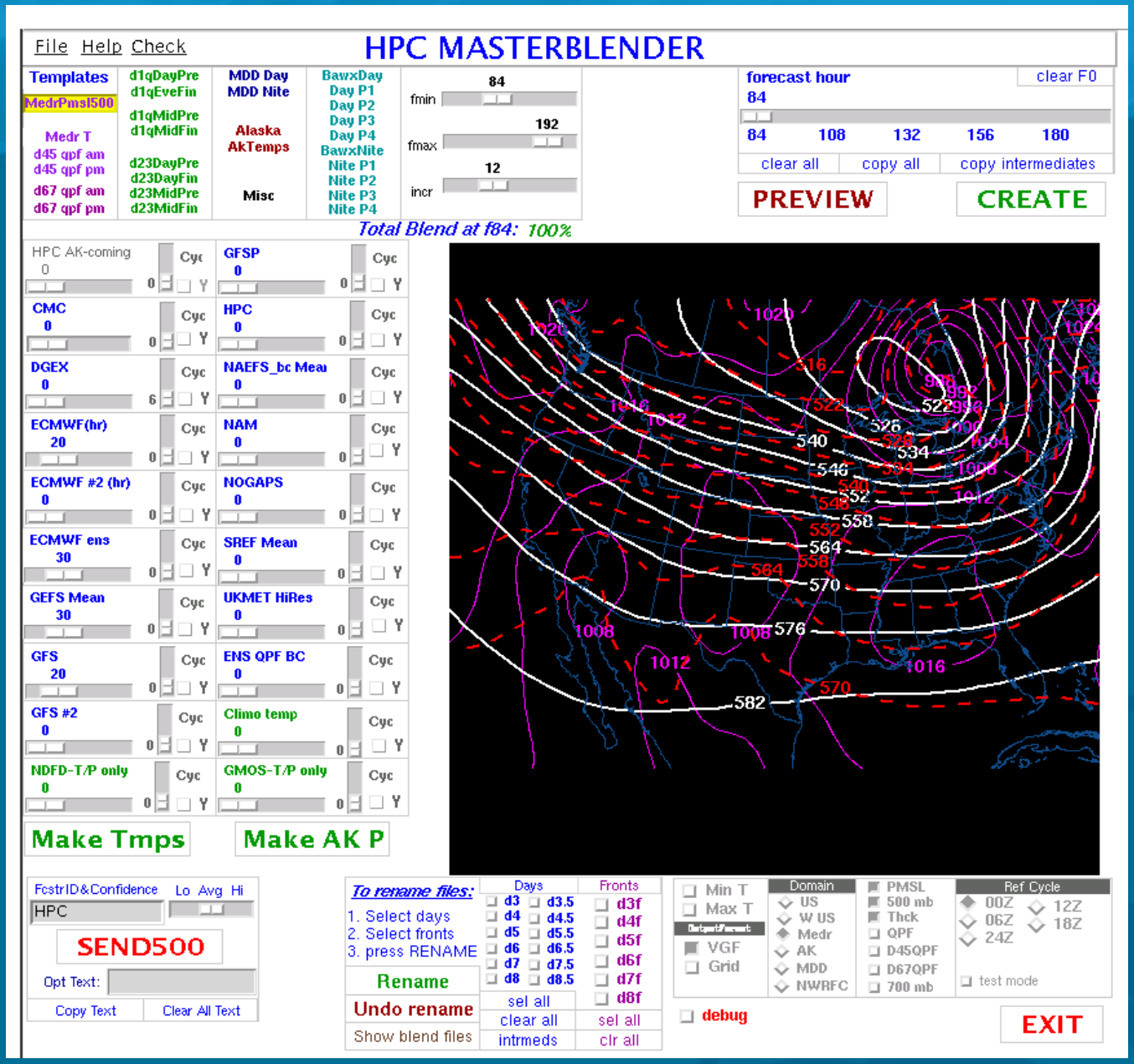
(2010)



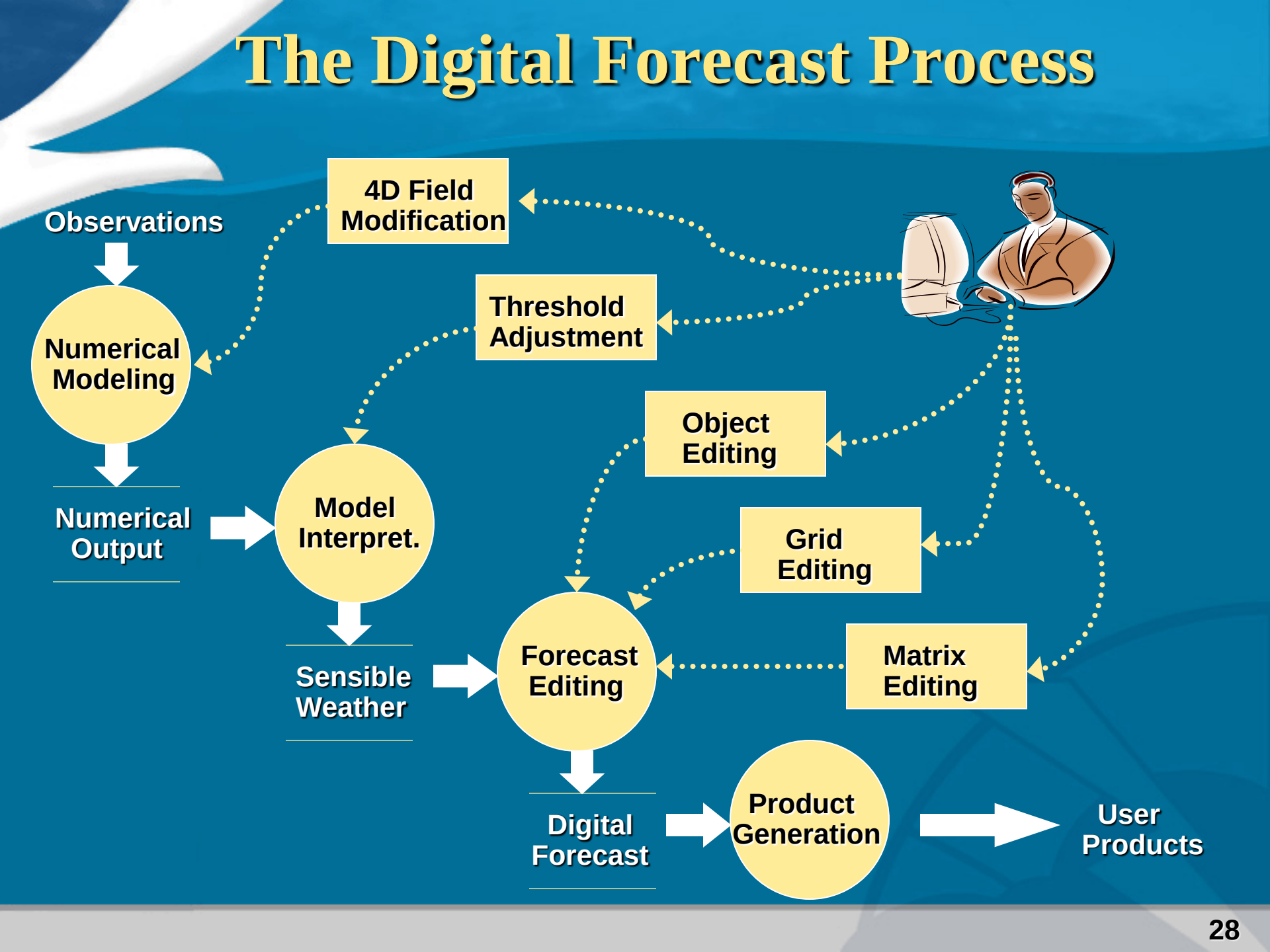
Threshold Adjustment

WPC Model Blender

(2014)

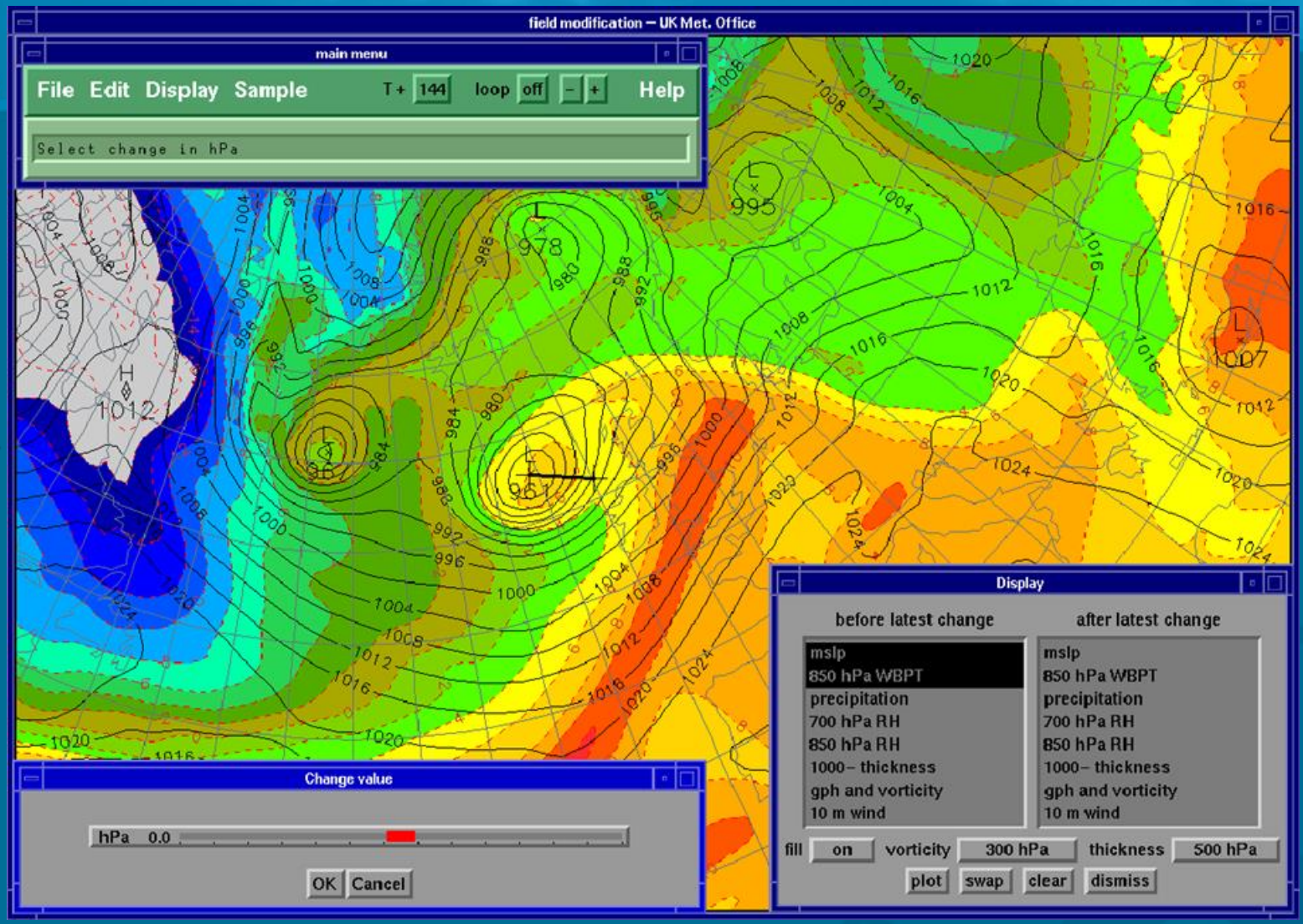


The Digital Forecast Process

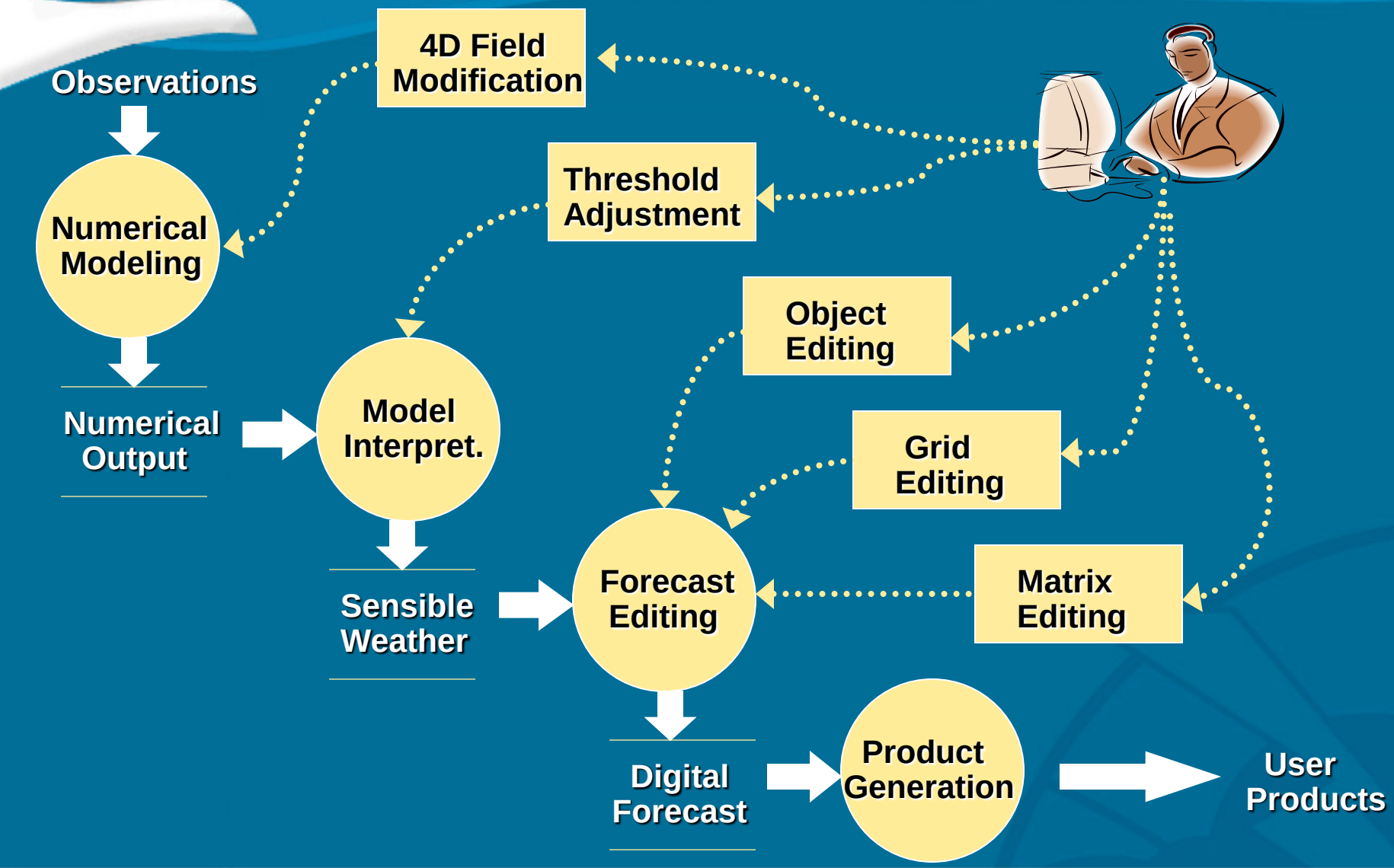


4D Field Modification

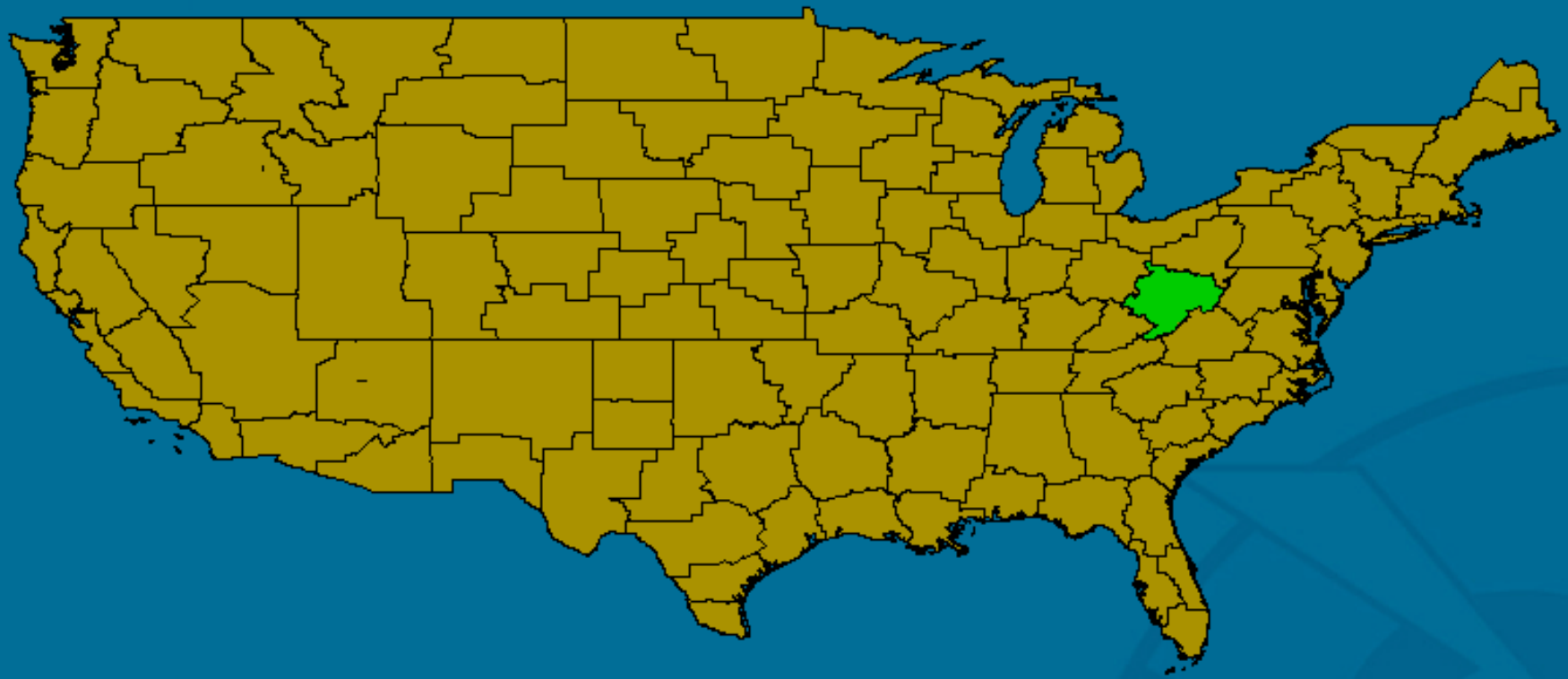
UKMET HORACE On Screen Field Modification



The Digital Forecast Process



Road to an official NDFD 1988 - 2004



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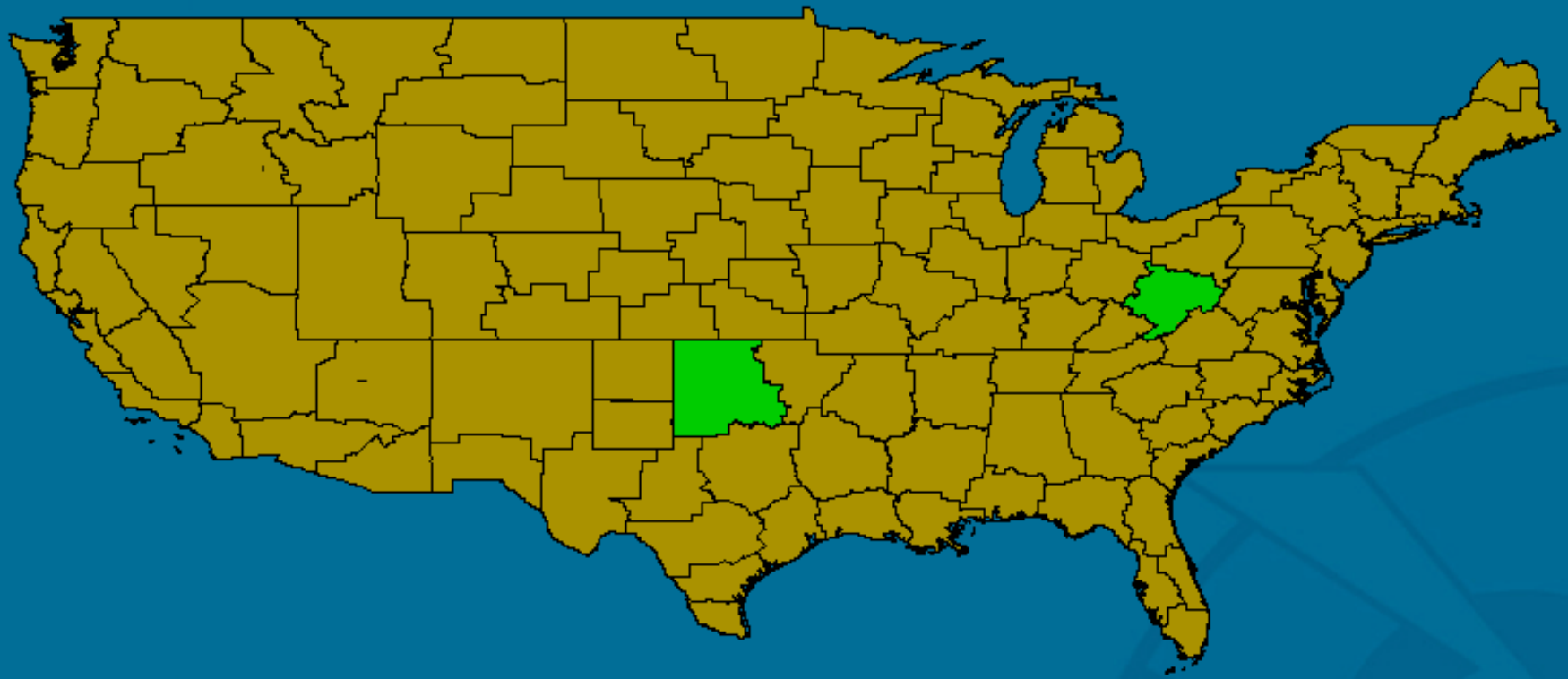

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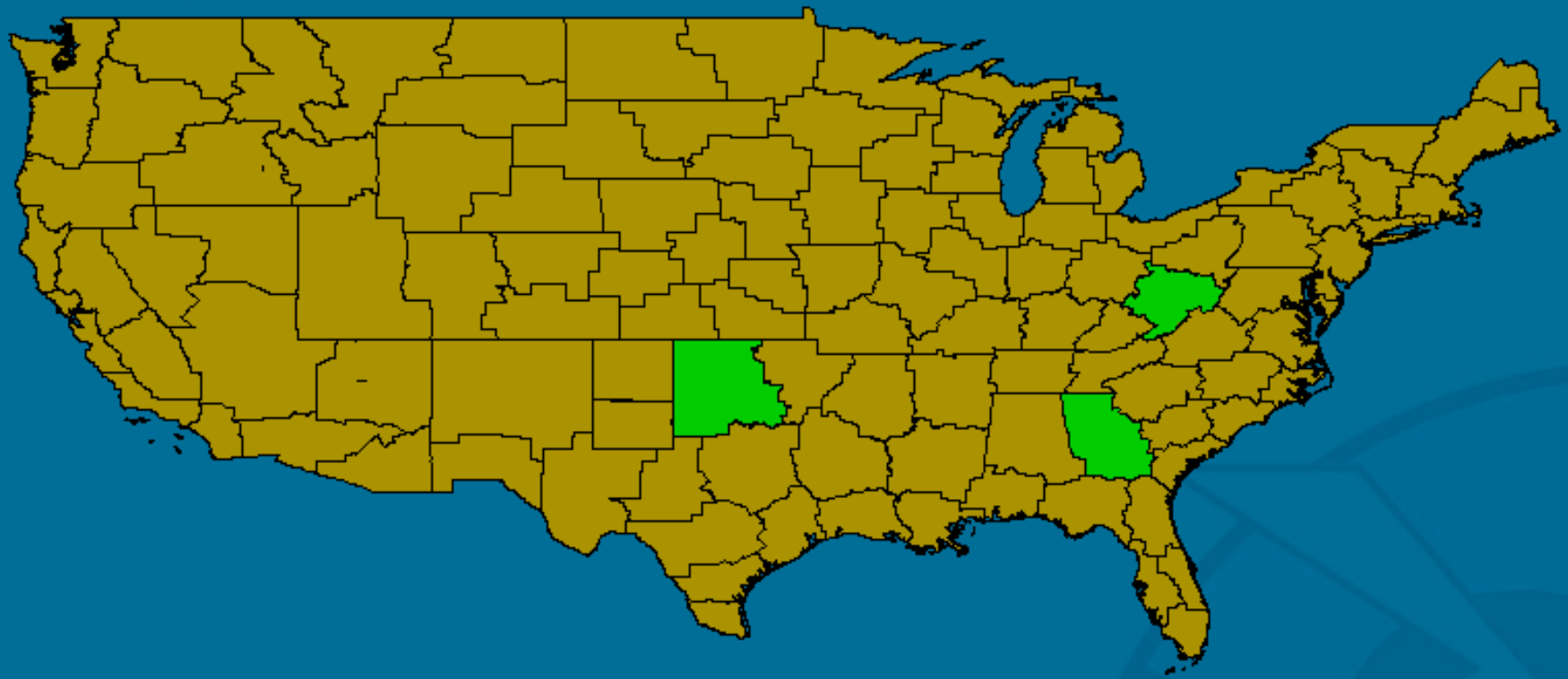

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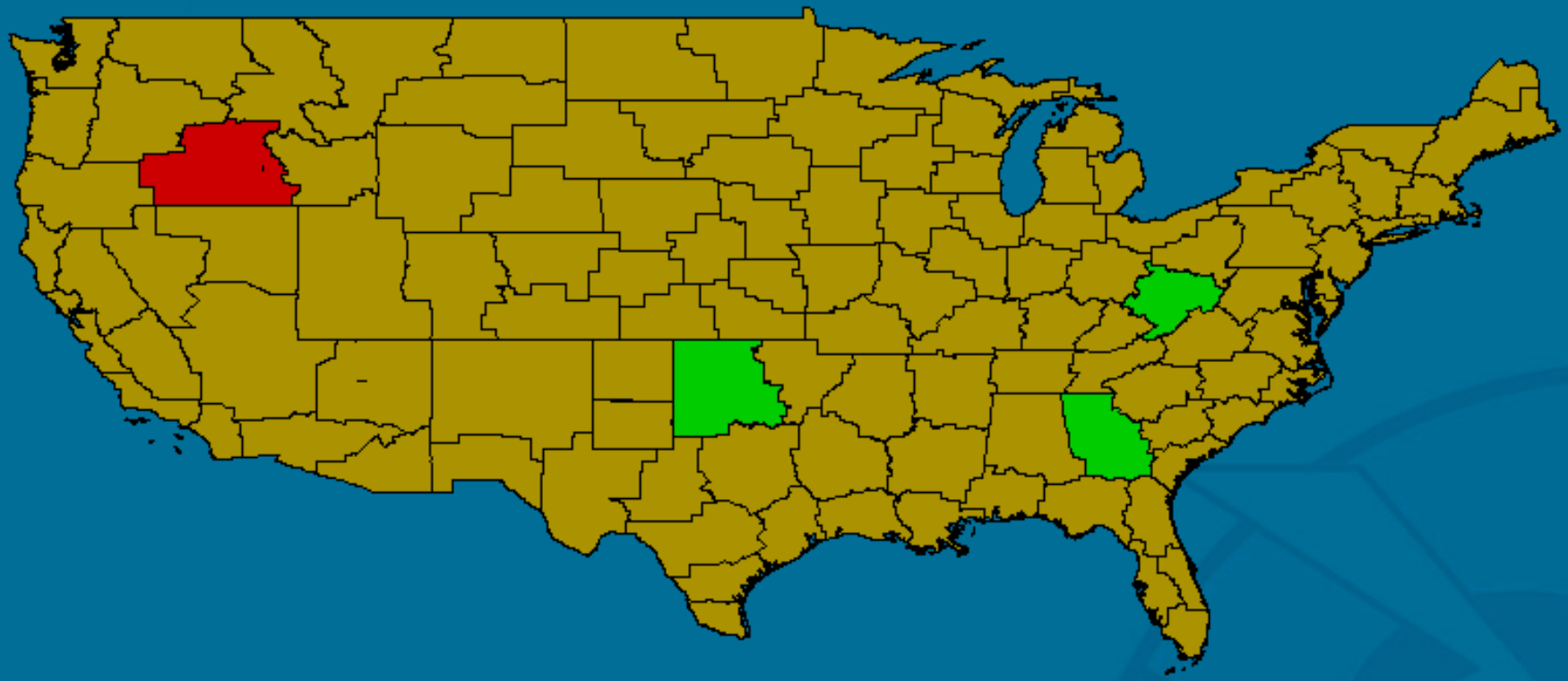

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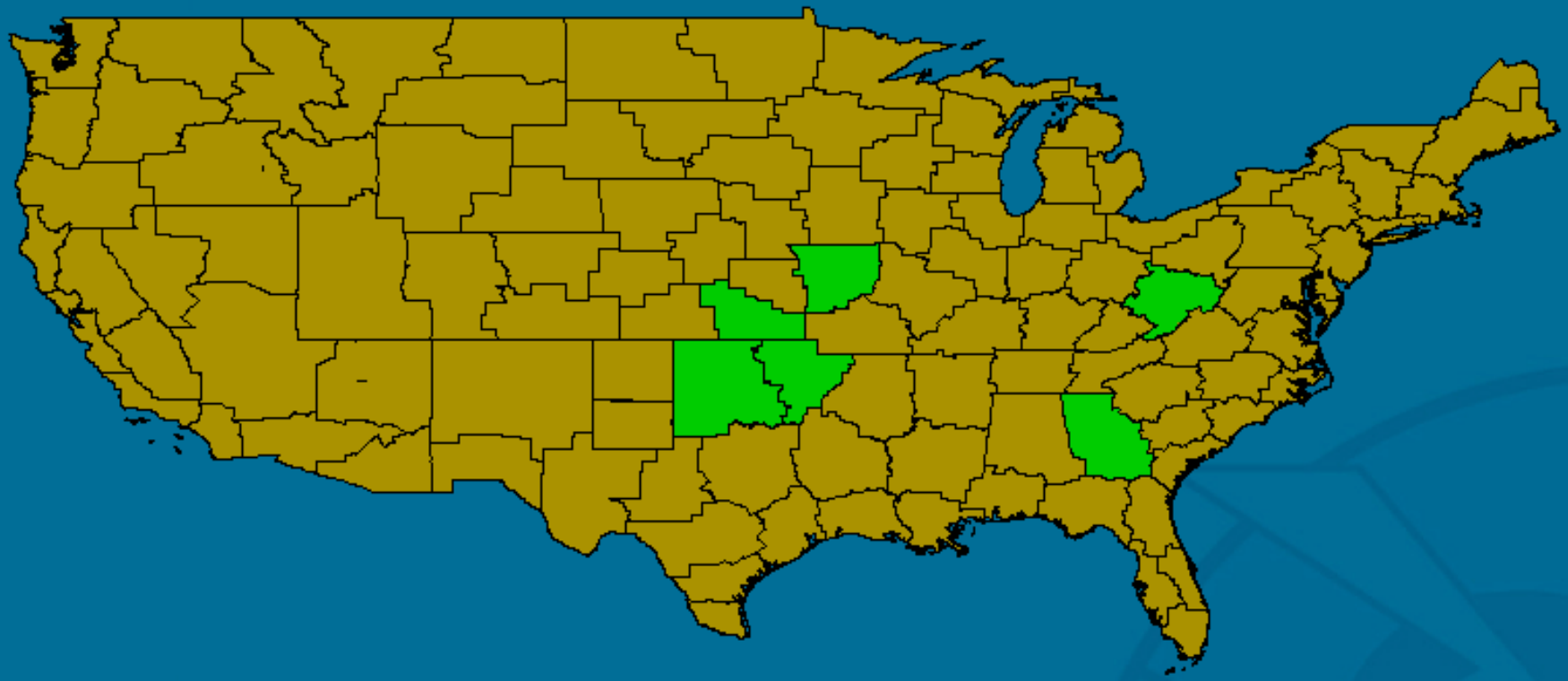

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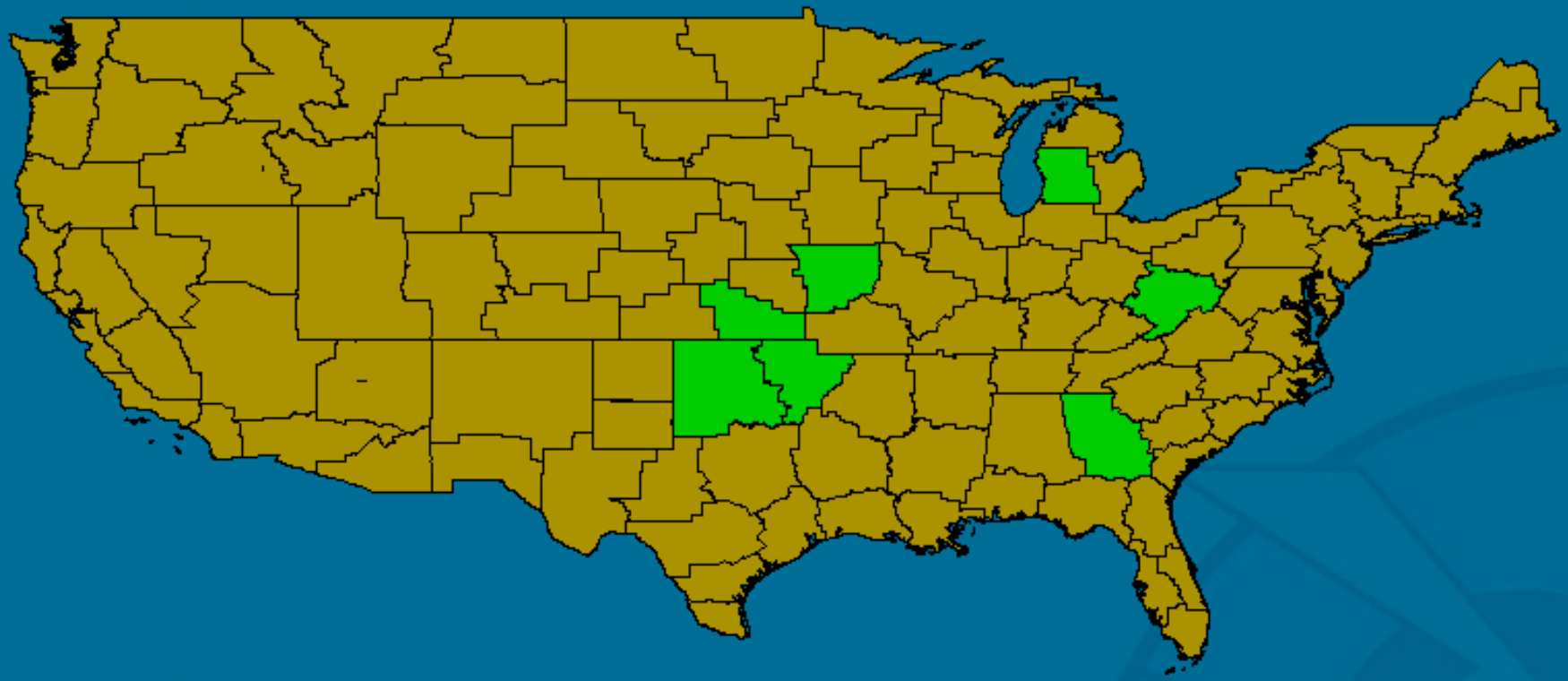

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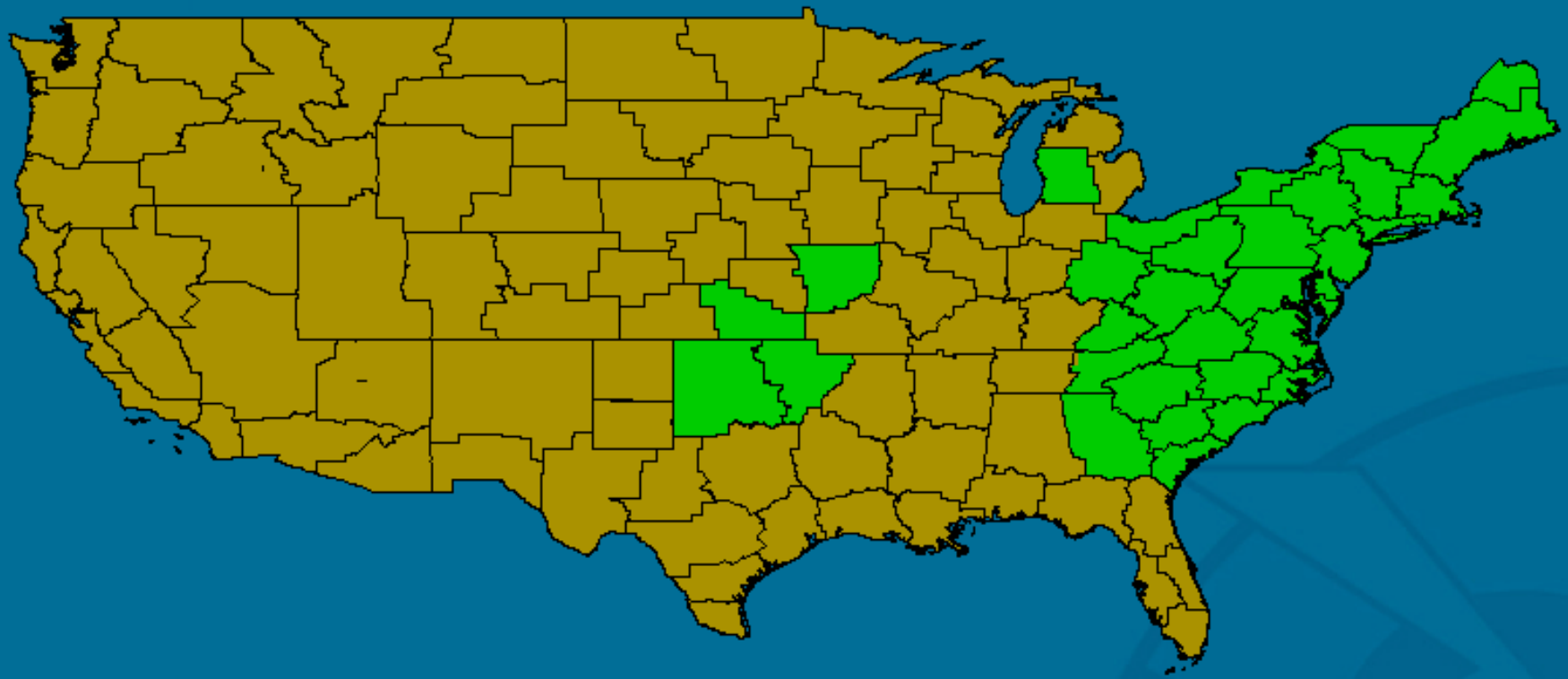

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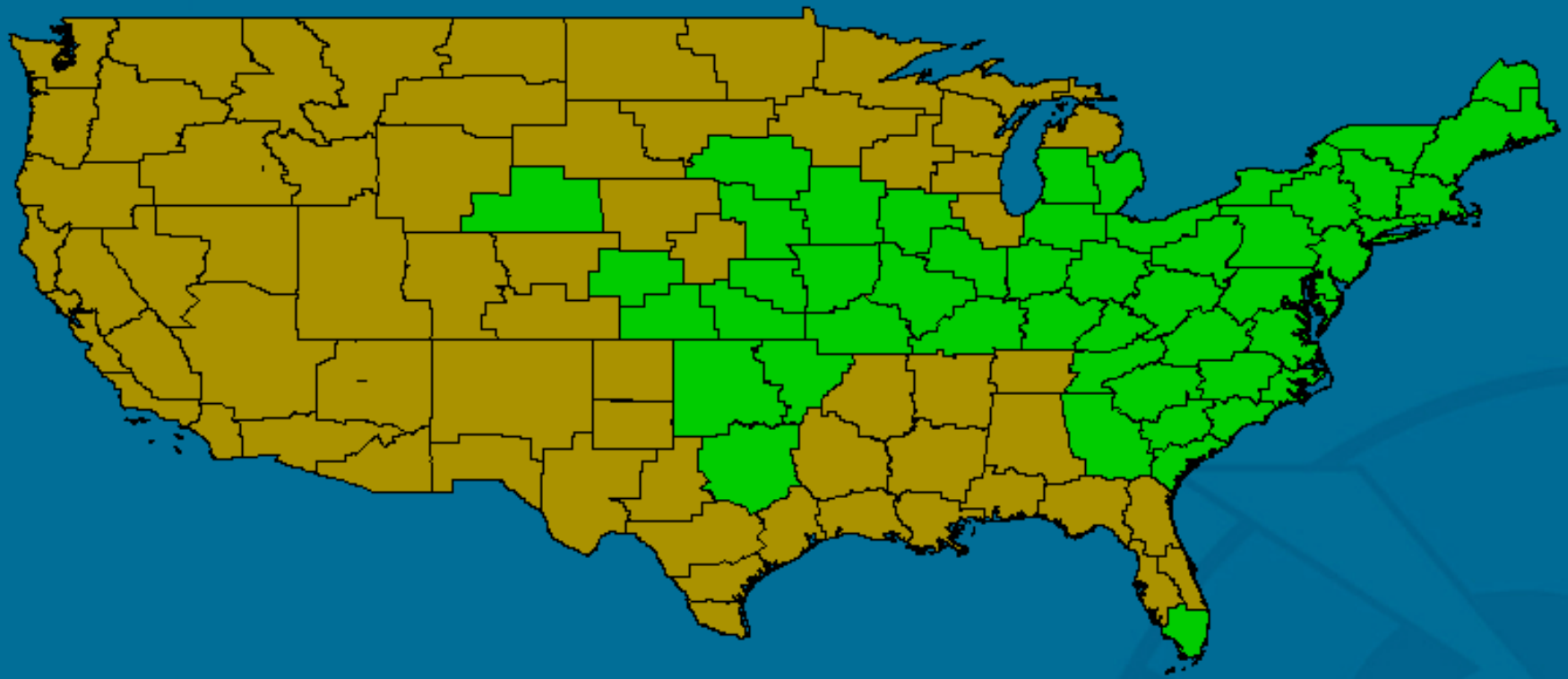

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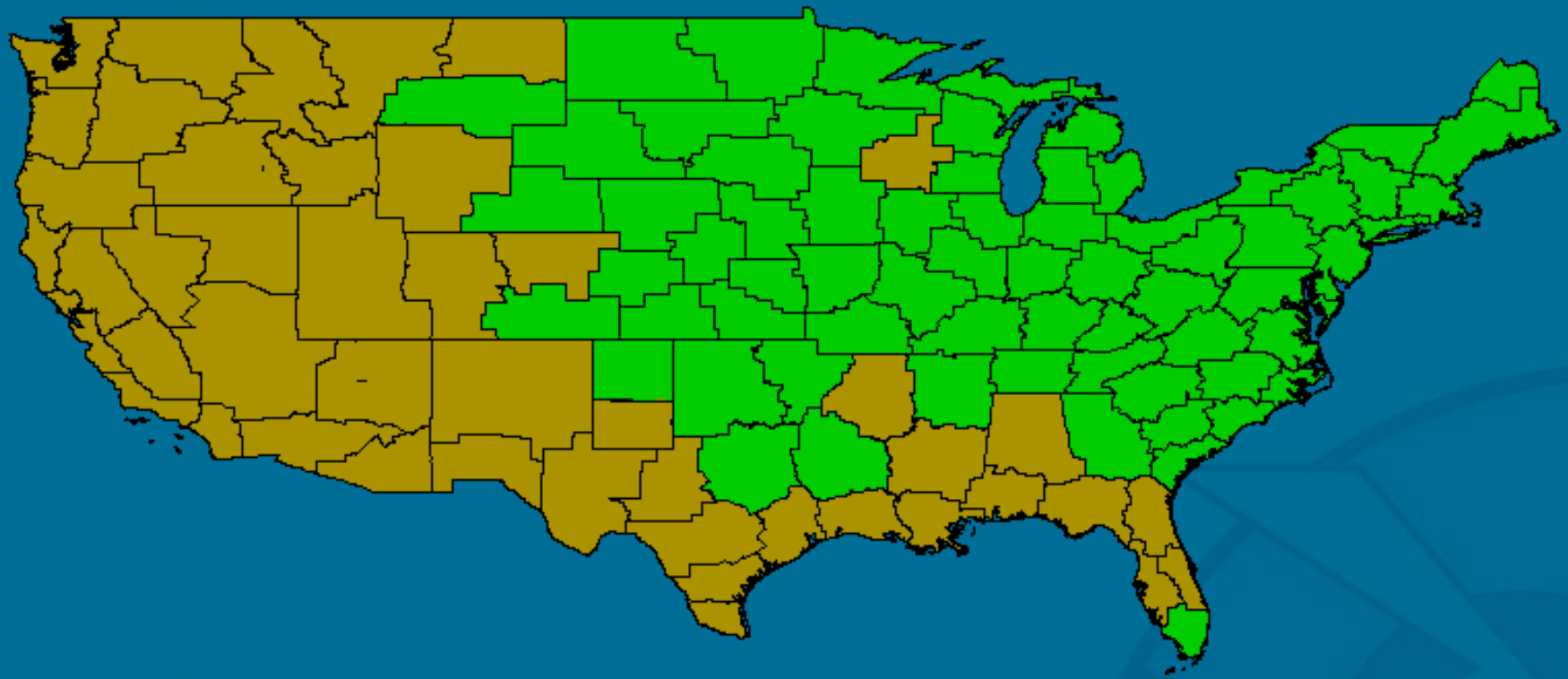

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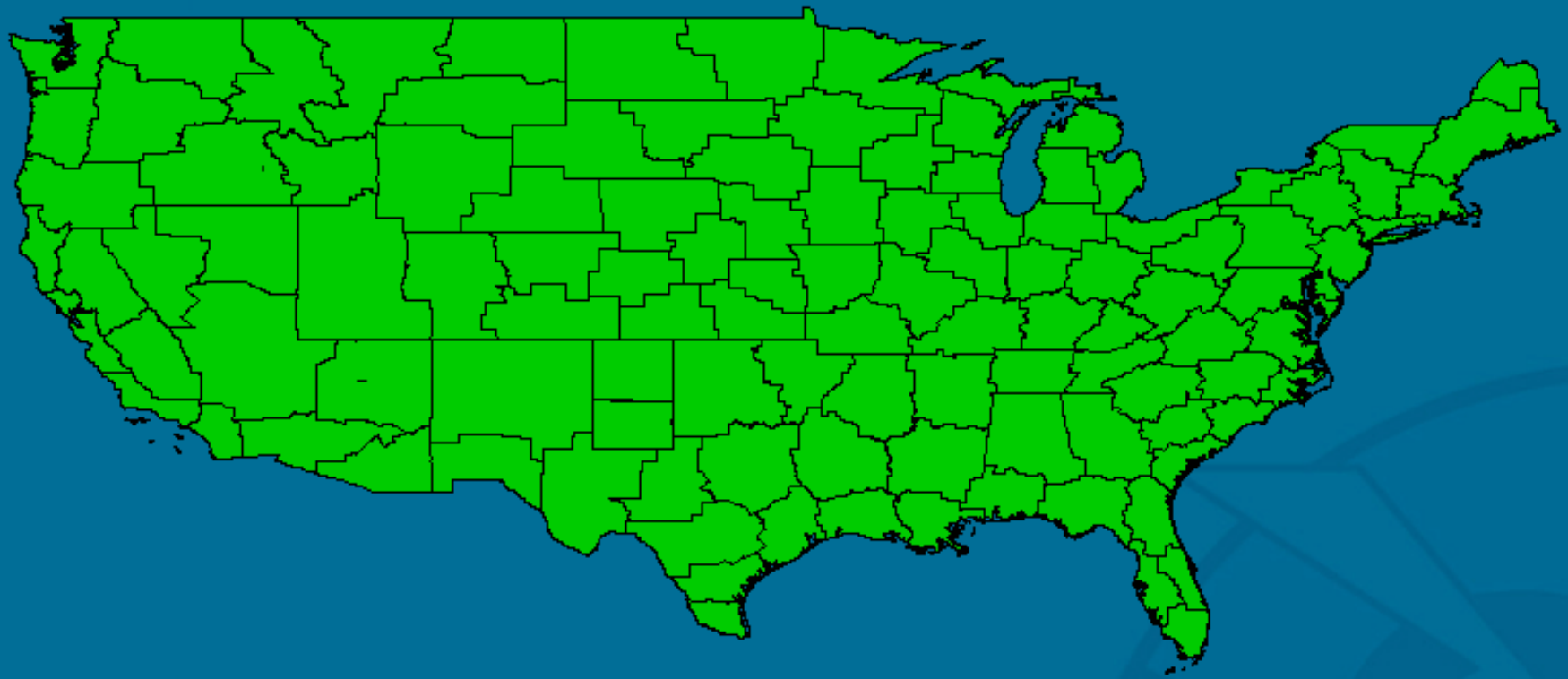


National Digital Forecast Database (NDFD)

- *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*

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

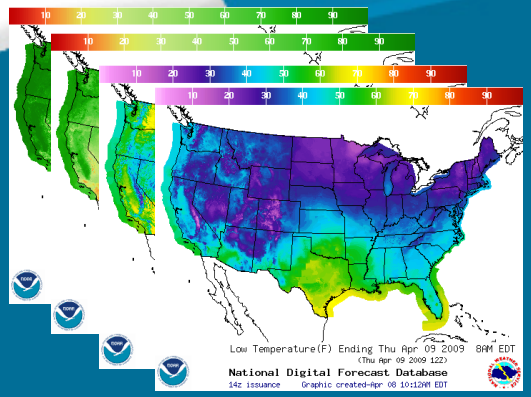
THE NATIONAL ACADEMIES
Advisers to the Nation on Science, Engineering, and Medicine

NWS Flagship Service - 2007

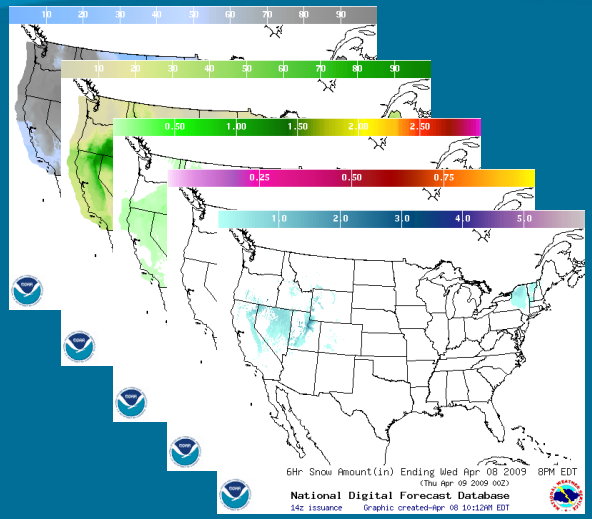
"The NDFD is now our flagship service, so we need to ensure it provides the most accurate and current information possible. "

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

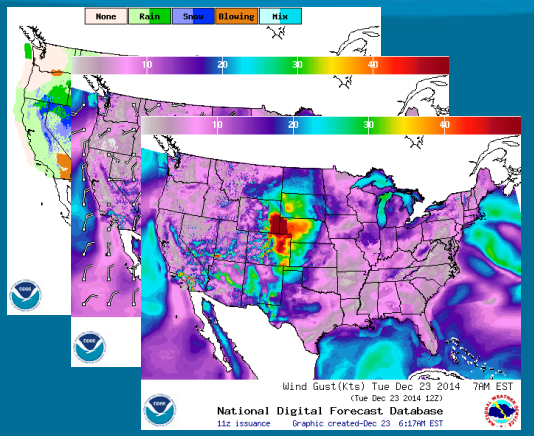
Operational NDFD Elements



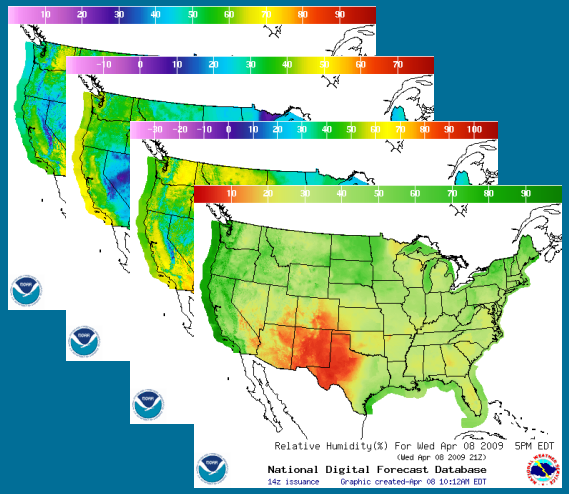
MaxRH, MinRH, MaxT, MinT



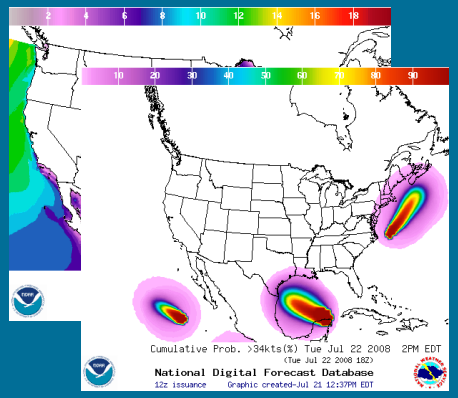
Sky, PoP12, QPF, Ice, Snow



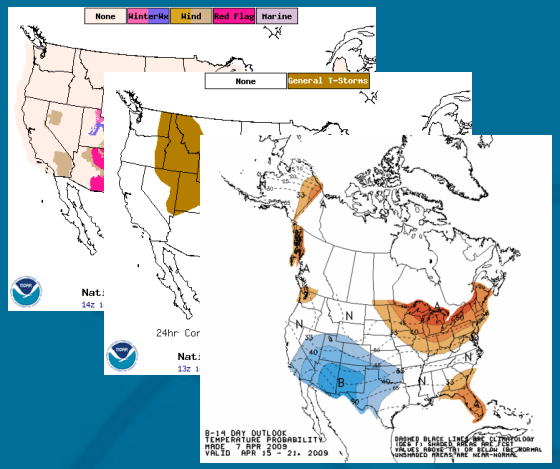
Weather, Wind, Wind Gusts



Temp, Dew, AppT, RH

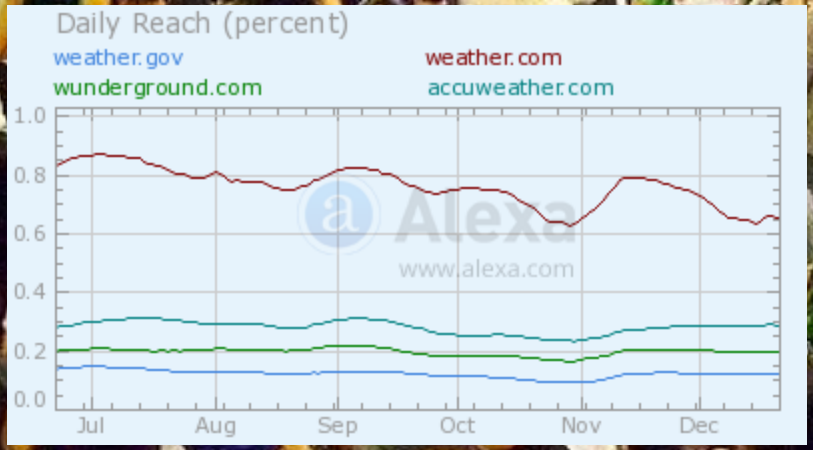


Wave Height, Tropical Winds



Hazards, Convection, Climate Outlooks

The Limited Reach of Weather.gov



Source: www.alexa.com

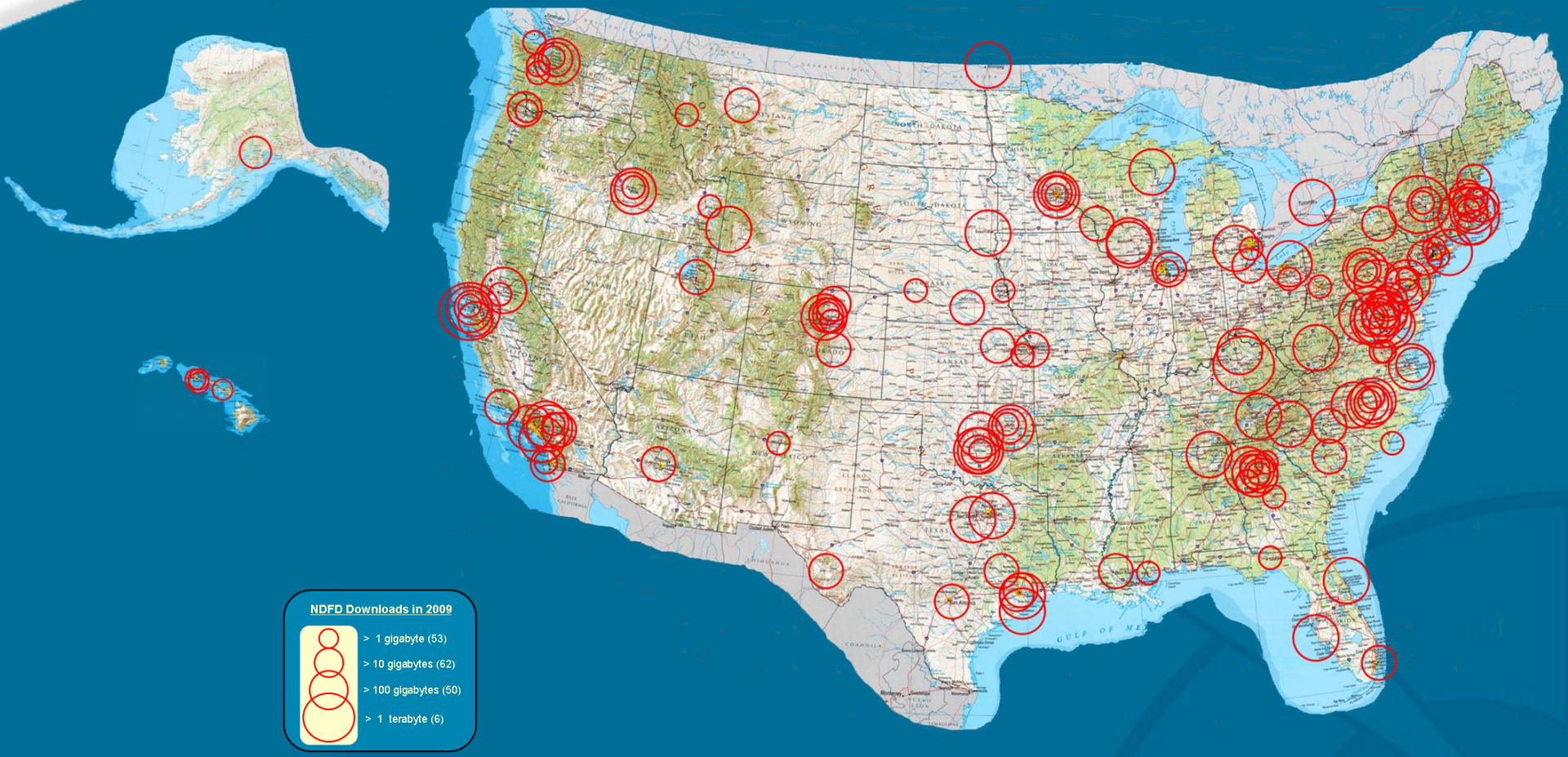
The Unlimited Reach of NDFD

NDFD

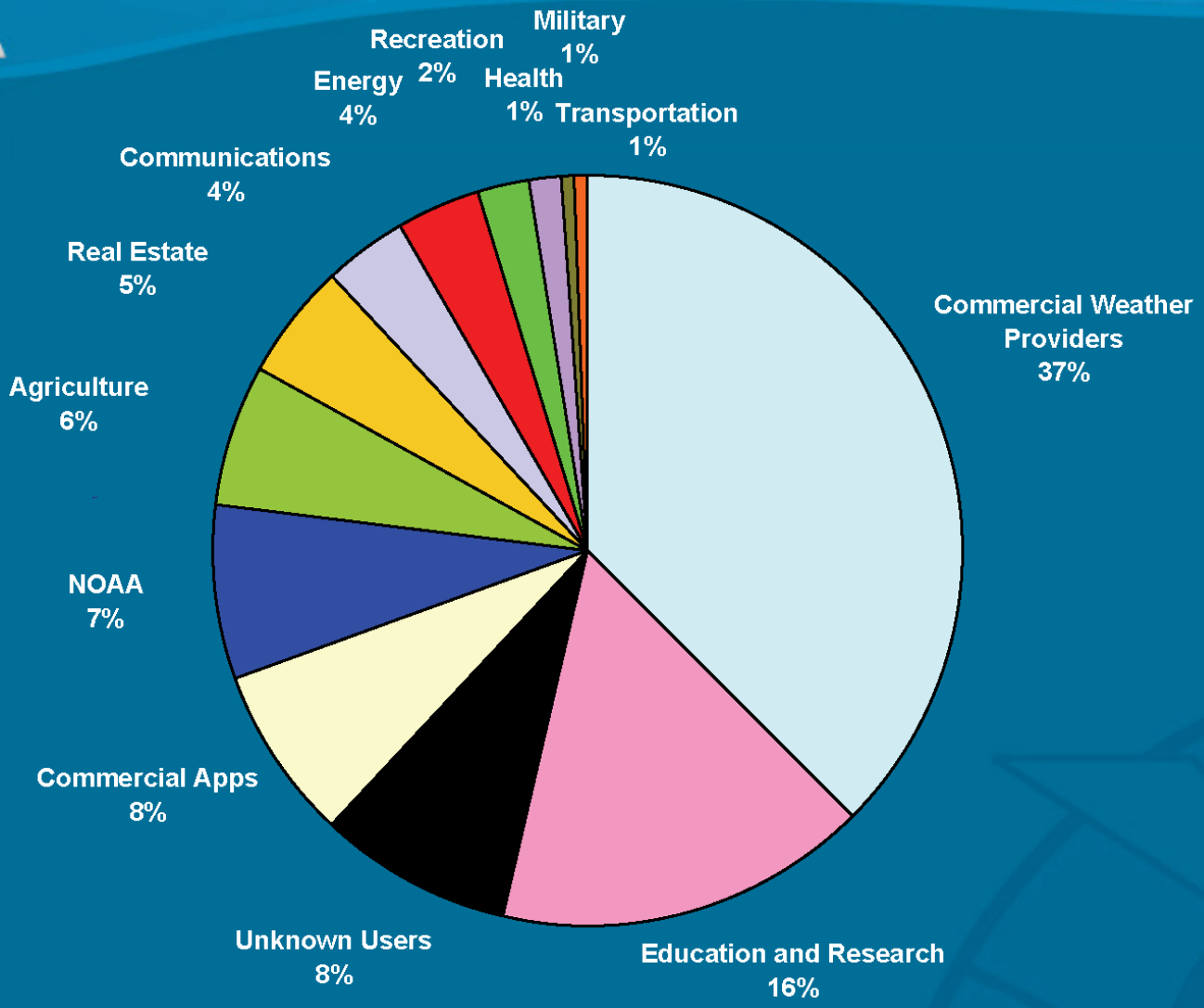
GRIBv2
- 250,000 files/day
- 700 gb/day
- ~200 users

SOAP/REST/XML
- 34,000,000 requests/day
- 900 gb/day
- ~15,000 users

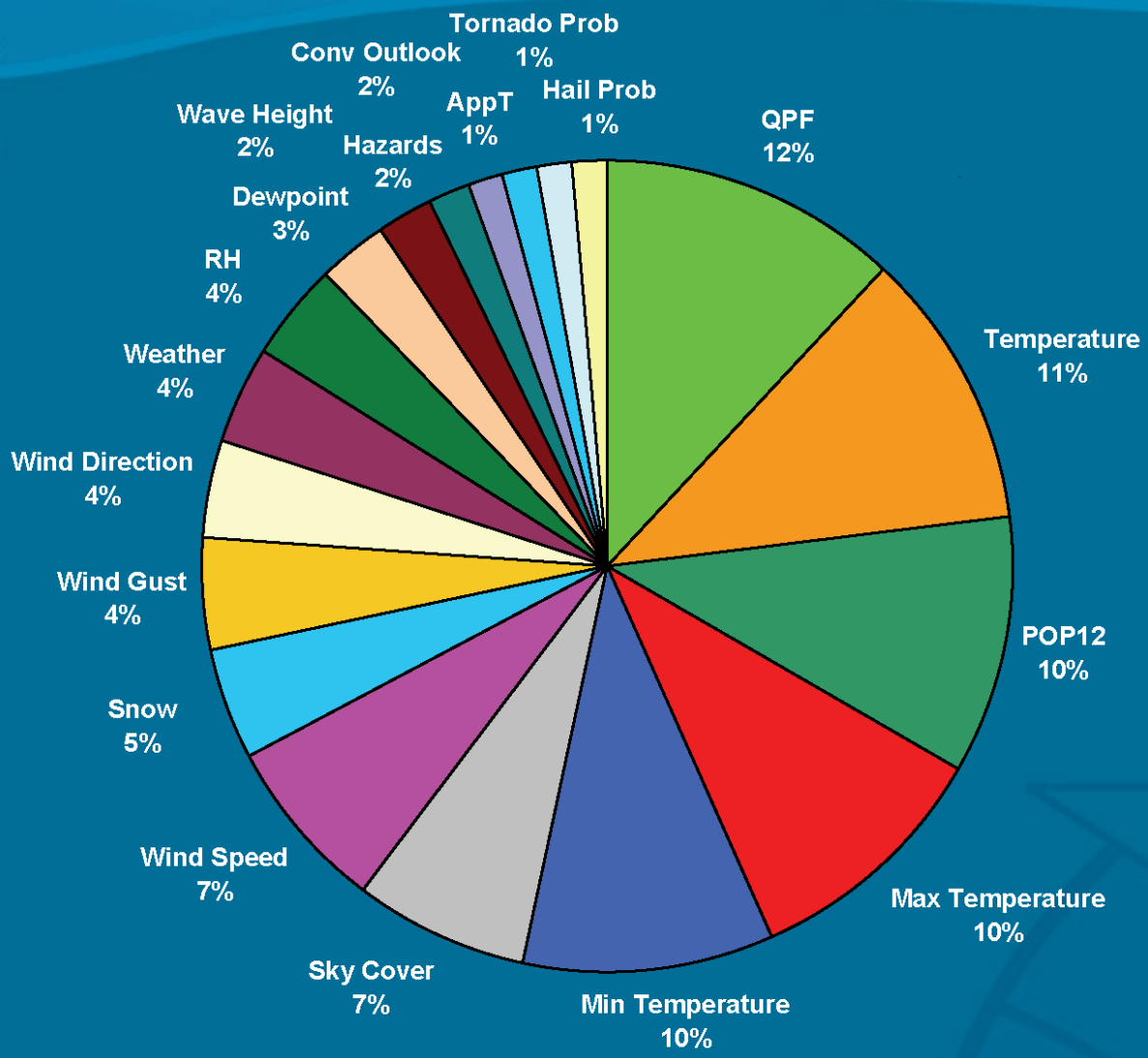
Who downloads NDFD grids?



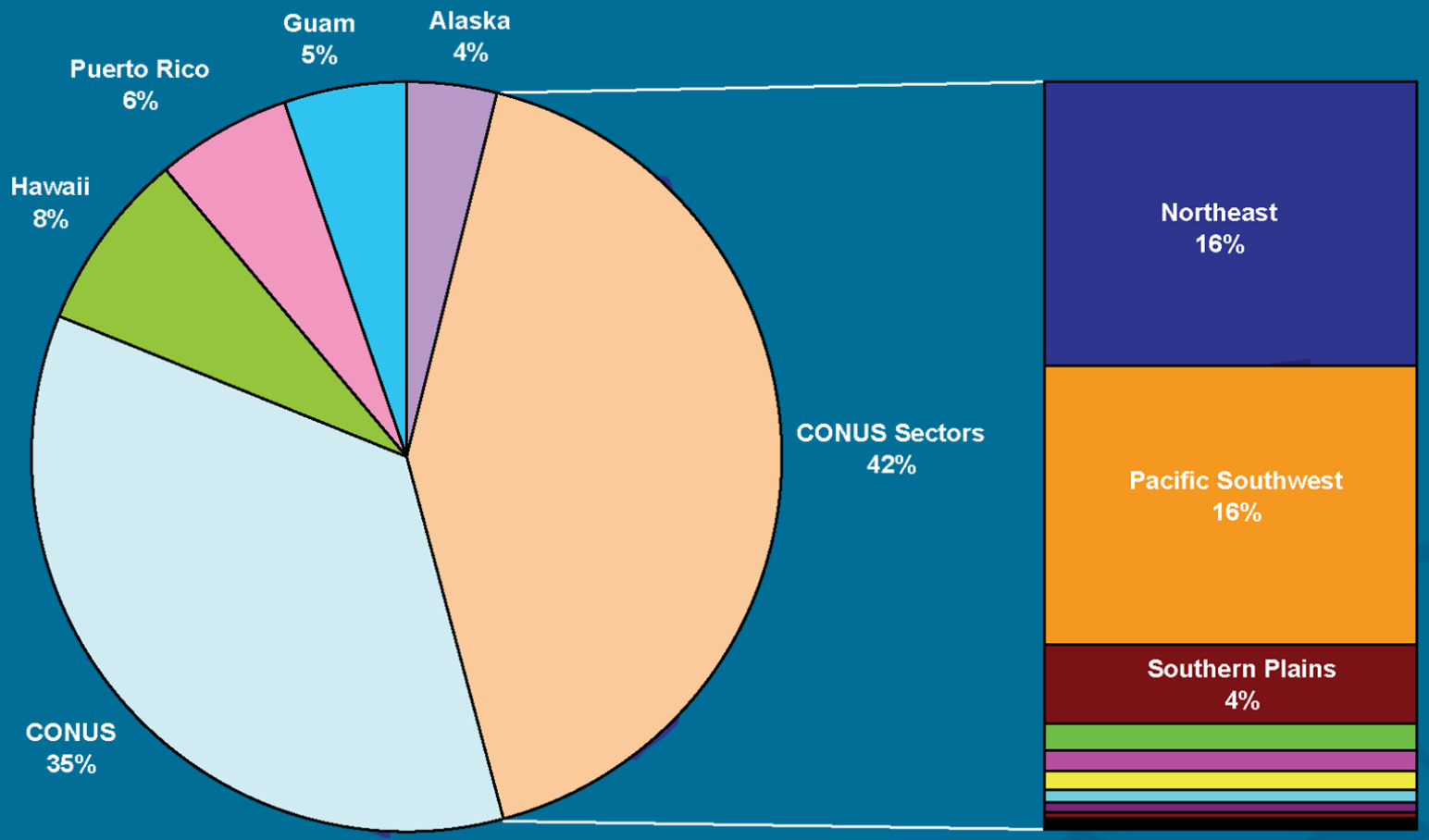
Profile of NDFD grid users



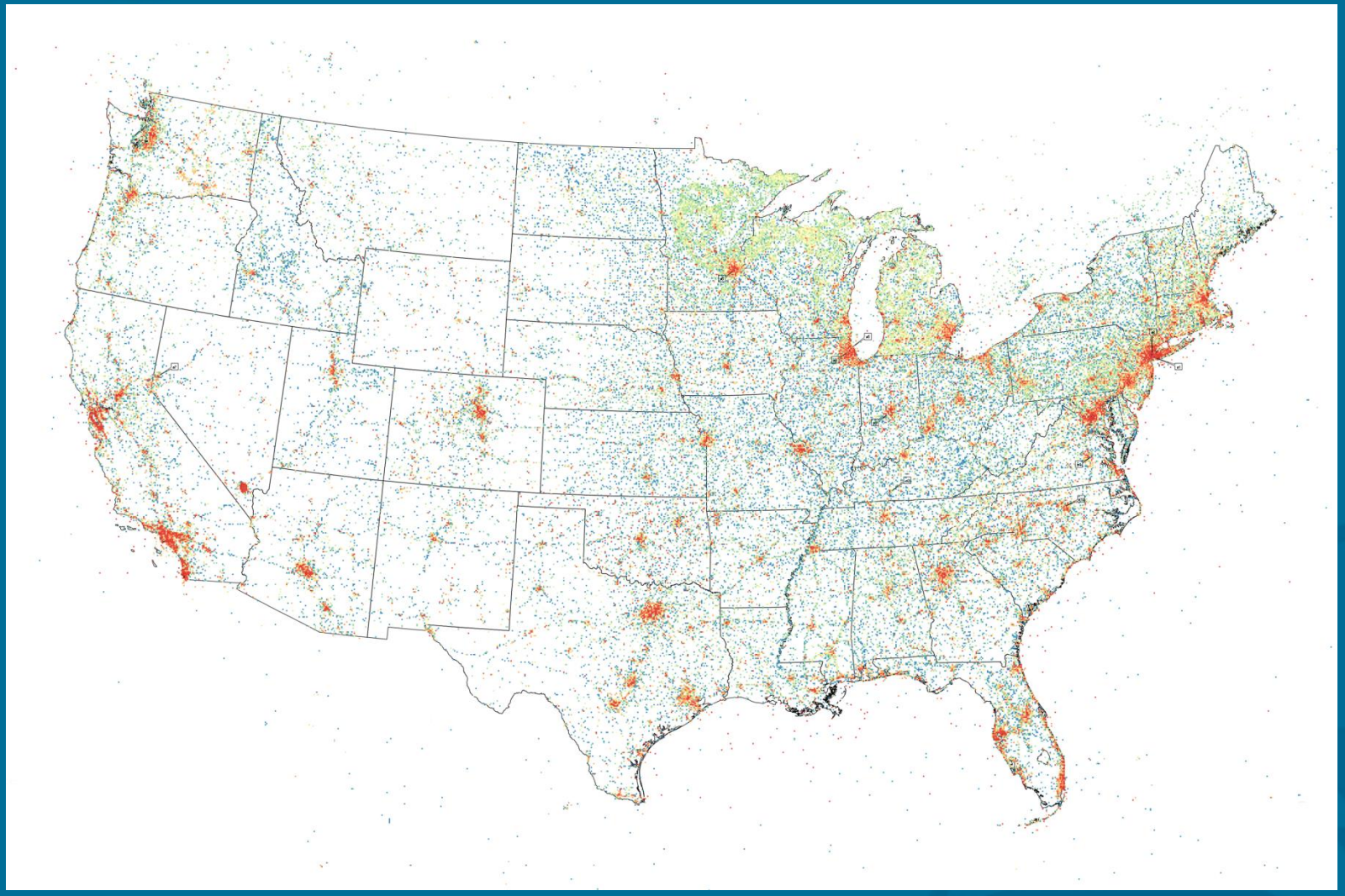
Grid Downloads by Element



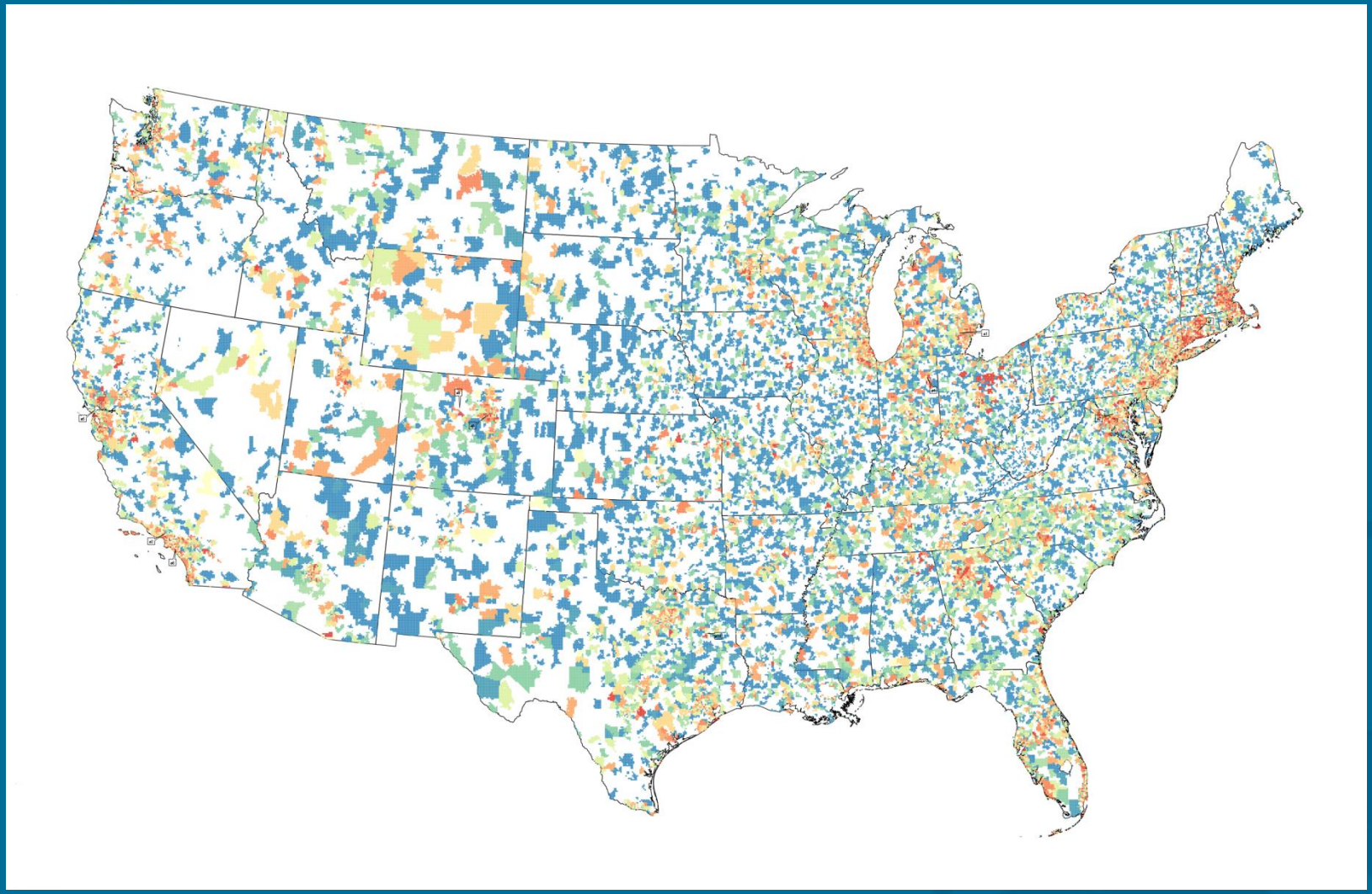
Grid Downloads by Geographic Sector



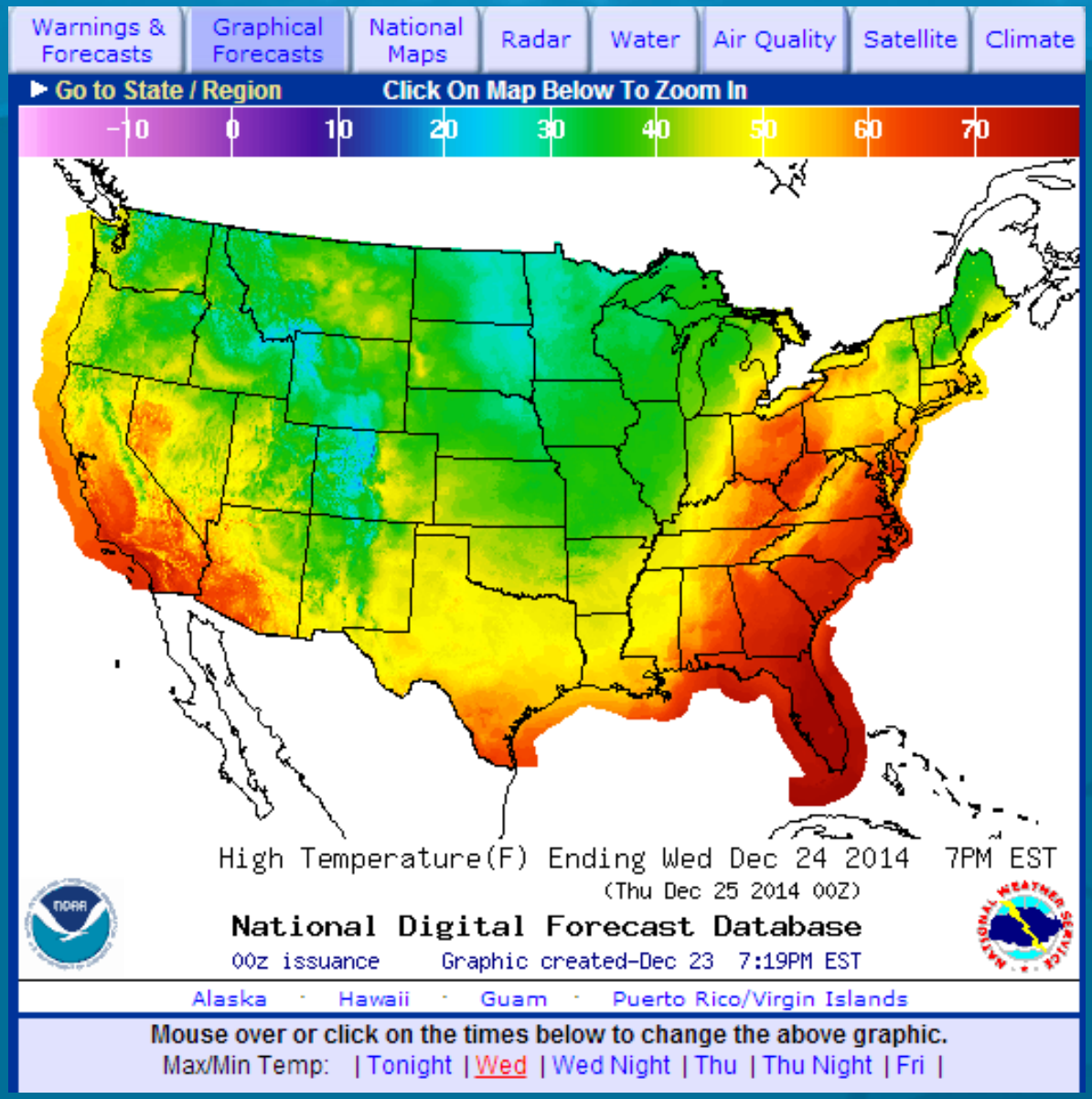
Points requested via NDFD XML



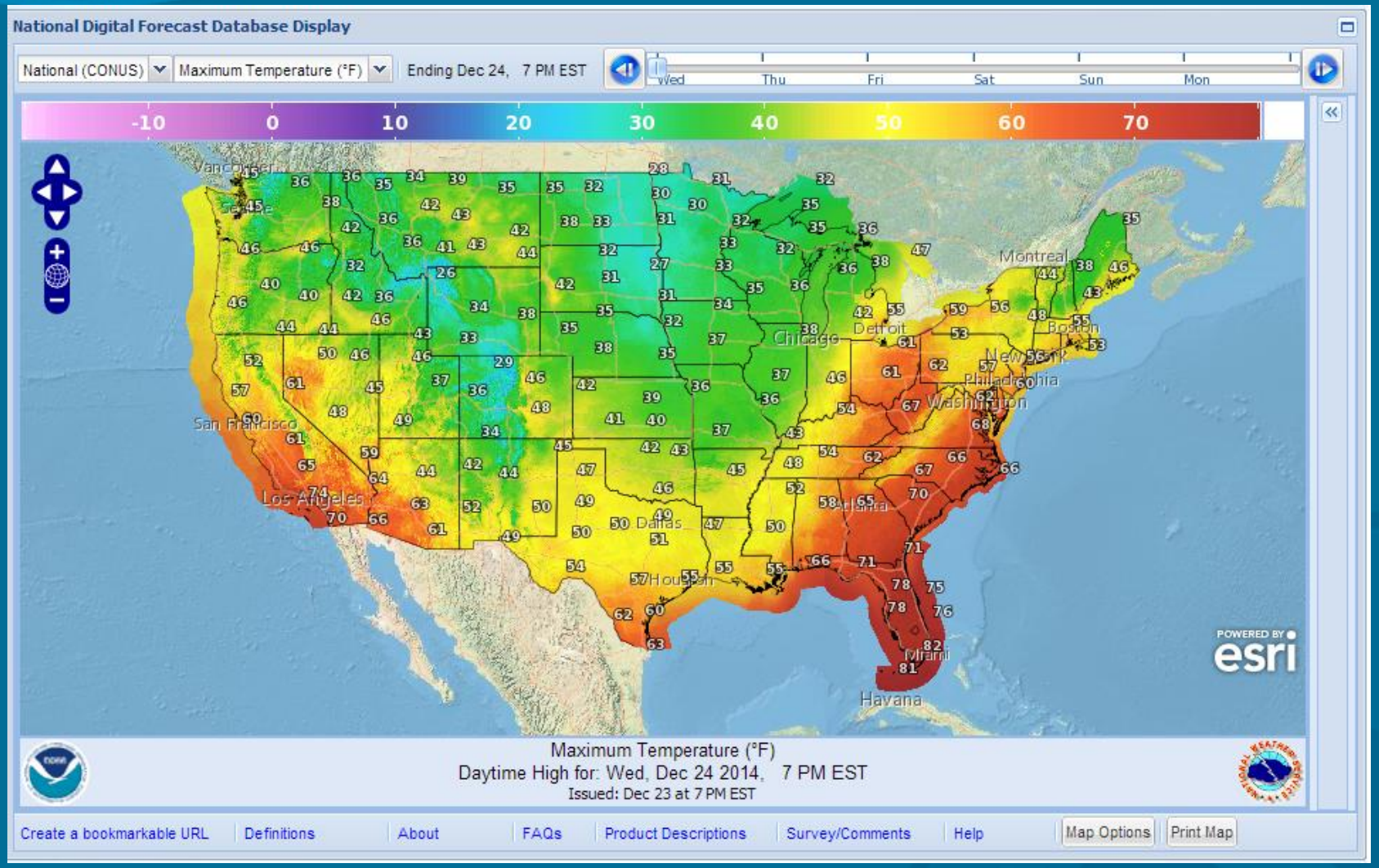
Zips requested via NDFD XML



NDFD Graphics



NDFD Map Viewer



NDFD Border Consistency

National Weather Service

National Digital Forecast Database

Home | Consistency | Timeliness | Completeness | Summary | Integrity | Latency | Verification

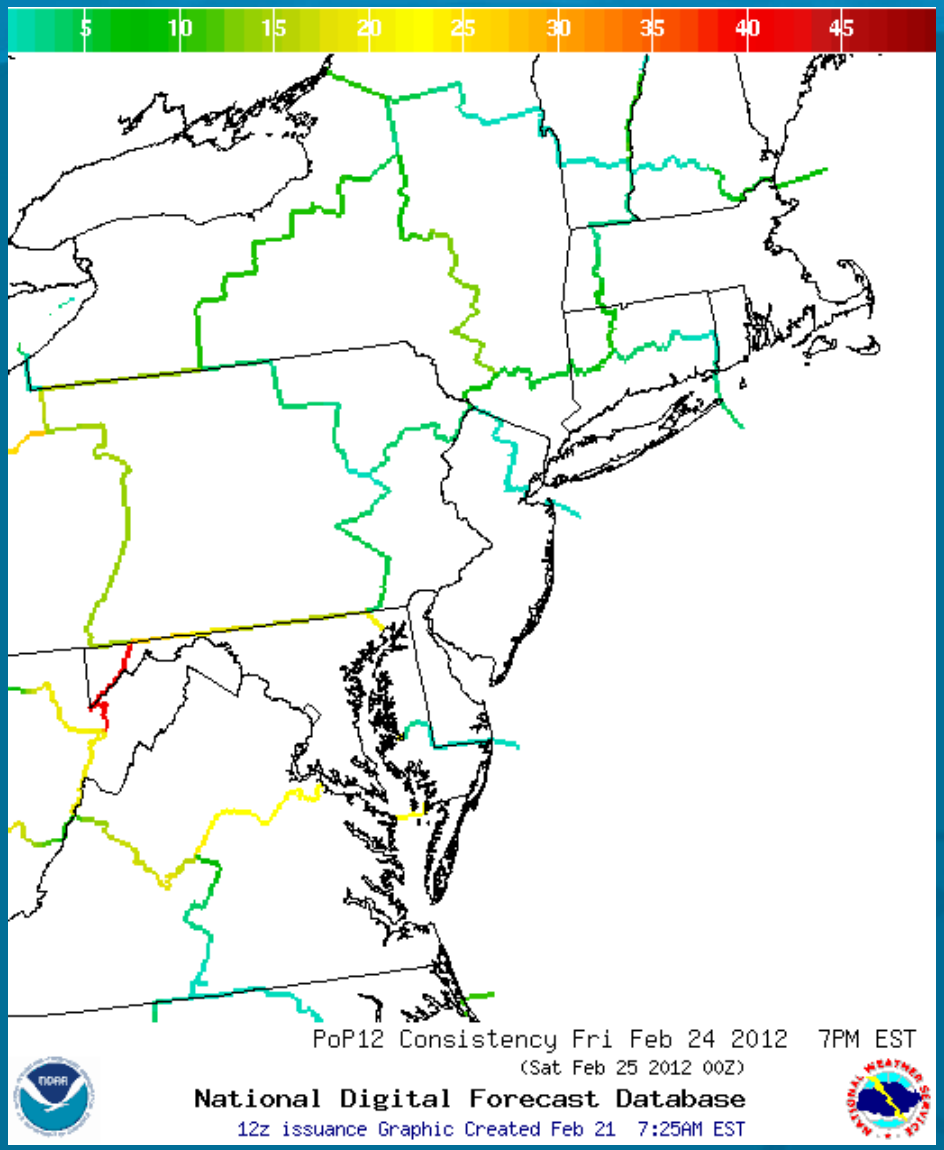
WFO Consistency Summary for WFO: KLWX

Explanation of statistics and methodolgy used.

WFO	MaxT	MinT	PoP12	QPF	Sky	SnowAmt	T	Td	WaveHeight	WindDir	WindSpd	RH	ApparentT	WindGust	IceAccum	MaxRH	MinRH	ALL
KPBZ	100.00	83.33	53.85	9999.00	88.33	9999.00	95.00	95.00	9999.00	100.00	100.00	96.67	83.33	100.00	9999.00	100.00	100.00	93.21
KPHI	100.00	100.00	84.62	9999.00	100.00	9999.00	98.33	98.33	9999.00	100.00	100.00	100.00	100.00	97.50	9999.00	100.00	100.00	98.77
KRLX	71.43	100.00	100.00	9999.00	86.67	9999.00	78.33	81.67	9999.00	100.00	100.00	83.33	71.67	100.00	9999.00	100.00	83.33	87.32
KRNK	100.00	100.00	100.00	9999.00	93.22	9999.00	95.00	100.00	9999.00	100.00	100.00	100.00	98.33	100.00	9999.00	100.00	100.00	98.31
KAKQ	100.00	100.00	84.62	9999.00	100.00	9999.00	98.33	96.67	91.67	100.00	100.00	98.33	100.00	100.00	9999.00	100.00	100.00	98.54
KCTP	85.71	100.00	92.31	9999.00	95.00	9999.00	95.00	96.67	9999.00	100.00	100.00	100.00	98.33	100.00	9999.00	100.00	83.33	97.24
ALL	92.86	97.22	85.90	9999.00	93.87	9999.00	93.33	94.72	91.67	100.00	100.00	96.39	91.94	99.60	9999.00	100.00	94.44	95.43
Day0	9999.00	9999.00	9999.00	9999.00	9999.00	9999.00	9999.00	9999.00	9999.00	9999.00	9999.00	9999.00	9999.00	9999.00	9999.00	9999.00	9999.00	9999.00
Day1	100.00	9999.00	83.33	9999.00	98.48	9999.00	96.97	84.85	100.00	100.00	100.00	84.85	96.97	100.00	9999.00	100.00	9999.00	94.87
Day2	83.33	100.00	91.67	9999.00	96.50	9999.00	94.44	100.00	100.00	100.00	100.00	98.61	90.97	99.30	9999.00	100.00	83.33	97.10
Day3	100.00	100.00	83.33	9999.00	100.00	9999.00	91.67	97.92	100.00	100.00	100.00	100.00	91.67	100.00	9999.00	100.00	100.00	97.07
Day4	100.00	83.33	66.67	9999.00	100.00	9999.00	75.00	79.17	50.00	100.00	100.00	100.00	83.33	100.00	9999.00	100.00	100.00	89.18
Day5	100.00	100.00	83.33	9999.00	79.17	9999.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	9999.00	9999.00	100.00	83.33	96.04
Day6	100.00	100.00	100.00	9999.00	91.67	9999.00	100.00	100.00	9999.00	100.00	100.00	100.00	95.83	9999.00	9999.00	100.00	100.00	98.31
Day7	66.67	100.00	91.67	9999.00	66.67	9999.00	87.50	91.67	9999.00	100.00	100.00	100.00	83.33	9999.00	9999.00	100.00	100.00	87.95
by_Length	93.65	97.56	86.70	9999.00	94.29	9999.00	94.16	95.47	88.80	100.00	100.00	97.15	93.63	99.98	9999.00	100.00	94.49	95.60
Spatial_Variability	9.78	6.46	7.77	9999.00	12.71	9999.00	7.25	4.77	0.34	8.52	3.30	15.57	10.54	5.09	9999.00	16.56	15.65	9999
Temporal_Variability	22.49	23.33	76.86	9999.00	81.49	9999.00	35.78	31.43	2.52	103.28	9.66	57.16	43.28	13.32	9999.00	33.52	16.24	9999

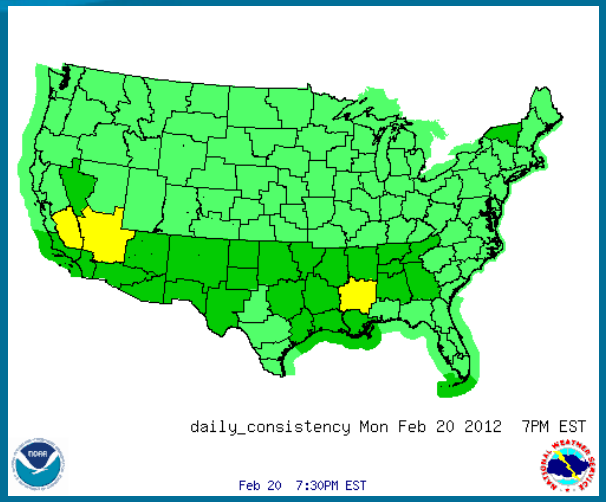
Table Created: 2012-02-21 12:04

NDFD Border Consistency

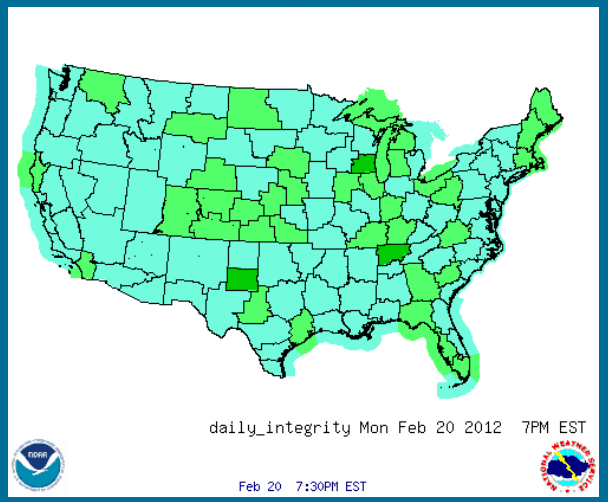


Daily/Weekly/Monthly Scores

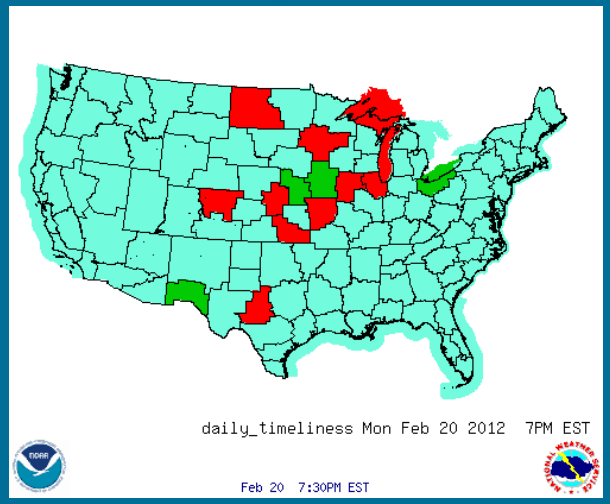
Consistency



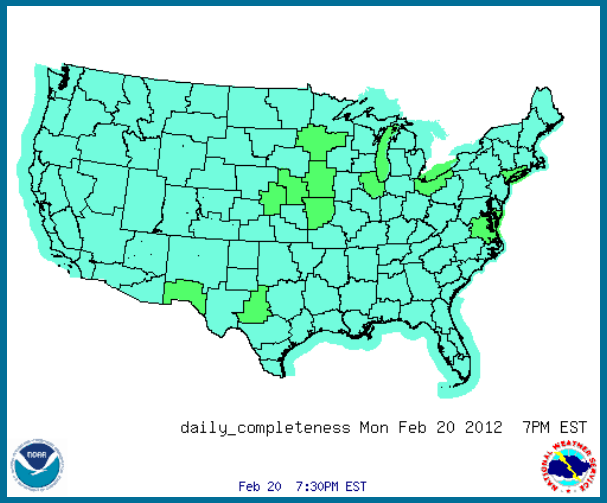
Integrity



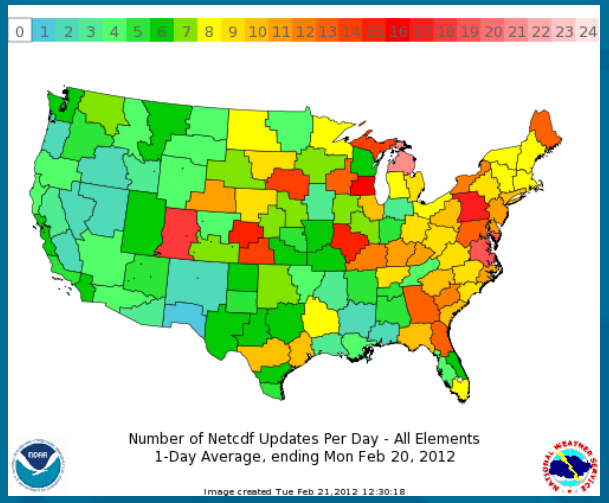
Timeliness



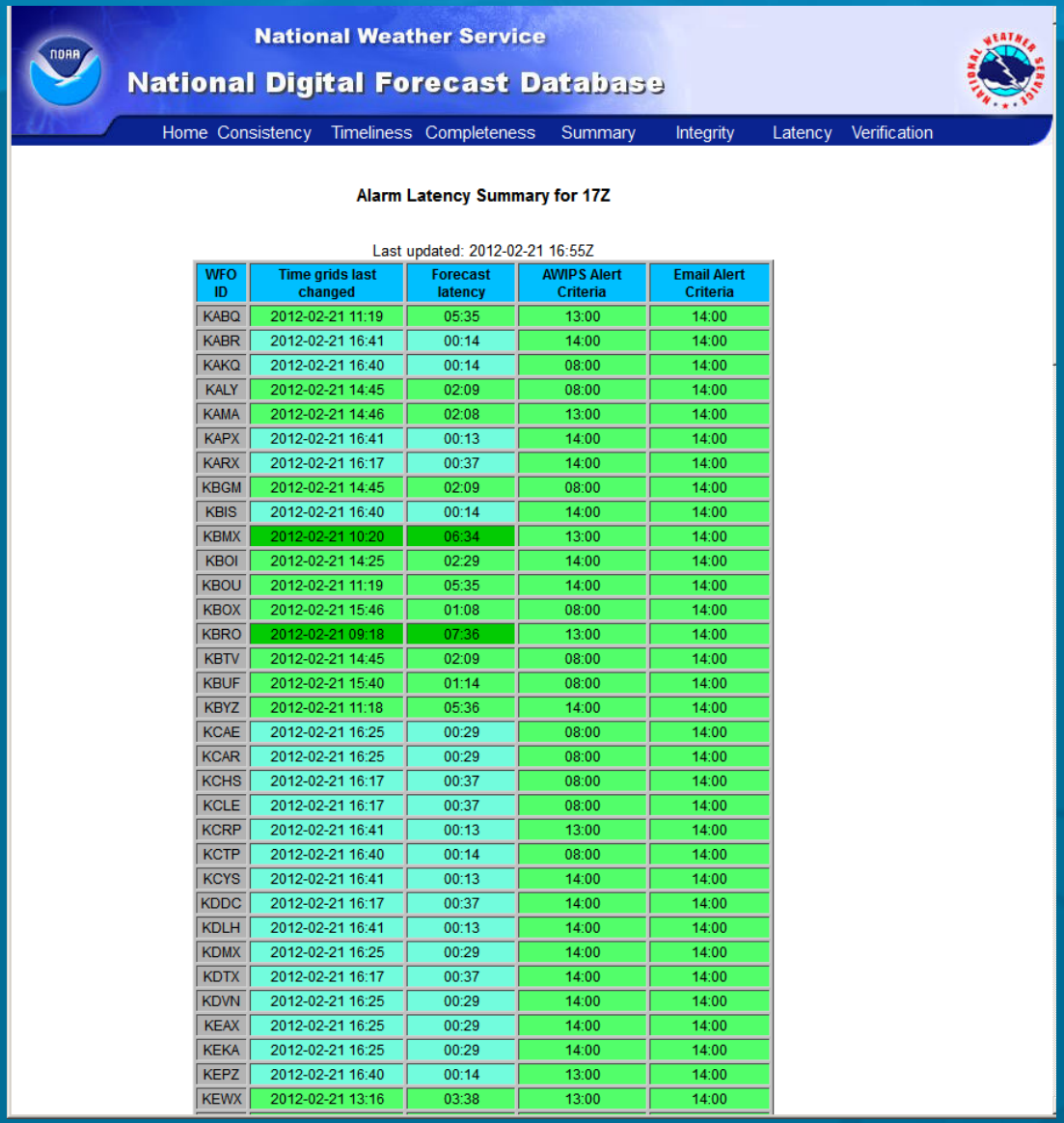
Completeness



Latency



NDFD Latency Alerts



National Weather Service

National Digital Forecast Database

Home Consistency Timeliness Completeness Summary Integrity Latency Verification

Alarm Latency Summary for 17Z

Last updated: 2012-02-21 16:55Z

WFO ID	Time grids last changed	Forecast latency	AWIPS Alert Criteria	Email Alert Criteria
KABQ	2012-02-21 11:19	05:35	13:00	14:00
KABR	2012-02-21 16:41	00:14	14:00	14:00
KAKQ	2012-02-21 16:40	00:14	08:00	14:00
KALY	2012-02-21 14:45	02:09	08:00	14:00
KAMA	2012-02-21 14:46	02:08	13:00	14:00
KAPX	2012-02-21 16:41	00:13	14:00	14:00
KARX	2012-02-21 16:17	00:37	14:00	14:00
KBGM	2012-02-21 14:45	02:09	08:00	14:00
KBIS	2012-02-21 16:40	00:14	14:00	14:00
KBMX	2012-02-21 10:20	06:34	13:00	14:00
KBOI	2012-02-21 14:25	02:29	14:00	14:00
KBOU	2012-02-21 11:19	05:35	14:00	14:00
KBOX	2012-02-21 15:46	01:08	08:00	14:00
KBRO	2012-02-21 09:18	07:36	13:00	14:00
KBTV	2012-02-21 14:45	02:09	08:00	14:00
KBUF	2012-02-21 15:40	01:14	08:00	14:00
KBYZ	2012-02-21 11:18	05:36	14:00	14:00
KCAE	2012-02-21 16:25	00:29	08:00	14:00
KCAR	2012-02-21 16:25	00:29	08:00	14:00
KCHS	2012-02-21 16:17	00:37	08:00	14:00
KCLE	2012-02-21 16:17	00:37	08:00	14:00
KCRP	2012-02-21 16:41	00:13	13:00	14:00
KCTP	2012-02-21 16:40	00:14	08:00	14:00
KCYS	2012-02-21 16:41	00:13	14:00	14:00
KDDC	2012-02-21 16:17	00:37	14:00	14:00
KDLH	2012-02-21 16:41	00:13	14:00	14:00
KDMX	2012-02-21 16:25	00:29	14:00	14:00
KDTX	2012-02-21 16:17	00:37	14:00	14:00
KDVN	2012-02-21 16:25	00:29	14:00	14:00
KEAX	2012-02-21 16:25	00:29	14:00	14:00
KEKA	2012-02-21 16:25	00:29	14:00	14:00
KEPZ	2012-02-21 16:40	00:14	13:00	14:00
KEWX	2012-02-21 13:16	03:38	13:00	14:00

NDFD Latency by Element

National Weather Service

National Digital Forecast Database

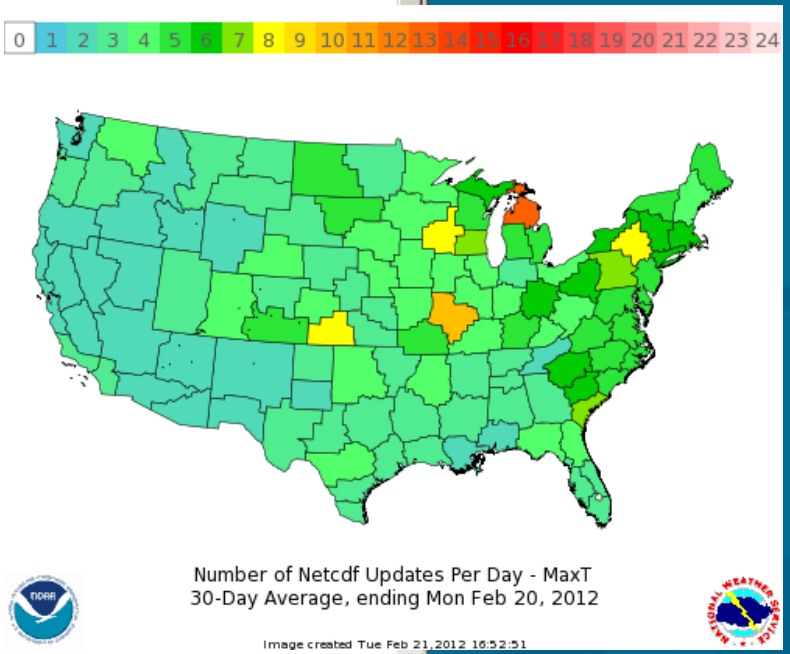
Home Consistency Timeliness Completeness Summary Integrity Latency Verification

Monthly NetCDF Update Summary

For each WFO, we count the number of distinct hours per day that we receive an updated NetCDF Grid.
For the weekly and monthly averages, we average the daily counts over the previous 7 and 30 days, respectively.

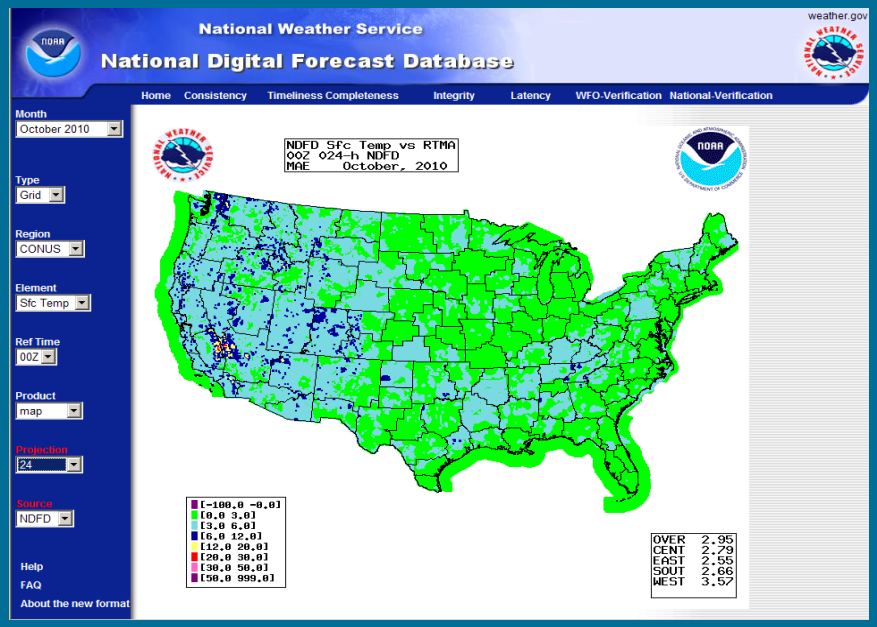
Show/Hide Extended Elements

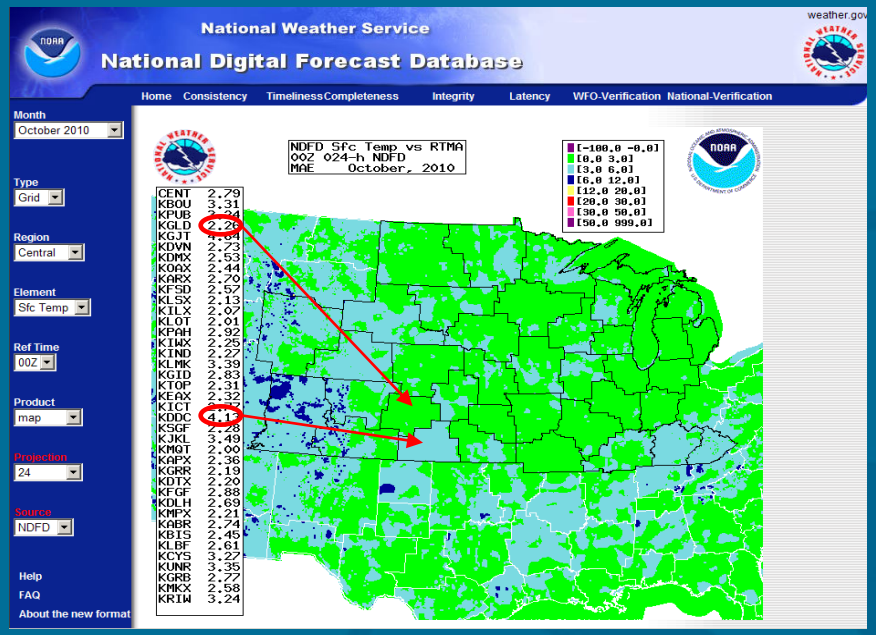
WFO	All Elements	IceAccum	MaxT	MinT	PoP12	QPF	Sky	SnowAmt	T	Td	WaveHeight	WindDir	WindGust	Wx
KABQ	2.5	1.6	2	2	2.3	2.2	2.1	2.1	2.3	2.2	0	2	2	2.3
KABR	11.2	2.8	4.9	4.4	4.5	3.5	6.1	3.3	9.9	9.6	0	7.6	7.6	5.3
KAKQ	15.7	3.1	5.4	5.1	7.3	5.4	6.3	3.9	9.3	9.5	6.4	7.9	7.7	7.5
KALY	8.3	2.7	5.5	6.1	6.7	5.7	7.1	5.5	7.9	7.9	0	6.2	6.3	6.7
KAMA	4.7	1.9	2.9	2.7	3	3.2	3.3	2.8	3.8	3.8	0	3.1	3.5	3.5
KAPX	20.6	2.2	13	13.6	6.1	4.4	6.6	4.2	20.1	19.7	3	19.5	19.5	6.7
KARX	15.2	7.9	8.1	6.9	9.4	8.8	11.1	8.5	11.8	12.8	0	11.2	11.4	10
KBGM	9.6	6.4	7.7	7.8	8.1	8.6	8.1	7.4	8.9	8.9	0	7.6	7.6	8.4
KBIS	8.7	3.6	5.1	5	5.1	3.9	6.6	3.8	8.1	8.1	0	6	6	5.6
KBMX	5.2	1.2	3.2	3.2	3.7	4.8	3.7	1.3	4.6	4.6	0	2.6	4.5	4.3
KBOI	2.9	0	2.2	2.1	2.3	2.4	2.3	2.4	2.3	2.3	0	2	2	2.6
KBOU	5.2	0	3	3.1	4.4	4.1	3.8	4.2	3.6	4	0	4	4.1	4.4
KBOX	8.9	3.2	5.7	5.5	6.5	5.4	7.3	3.4	8.1	8	3.4	7.3	7.9	7.1
KBRO	5.1	0	2.6	2.1	3.3	3.3	3	0	3.1	3.3	3	2.9	3.4	3.6
KBTV	8.5	4	5.4	5.4	5.8	8.2	8.3	5.2	8.1	8.1	0	6.4	8.2	6
KBUF	10.3	3.6	6.1	5.7	7.7	6.7	6.1	6.4	7.7	7.5	10.3	6.2	6.4	7.9
KBYZ	4.4	0	2.7	2.7	3.6	3.6	3.7	3.5	3.3	3.2	0	3.2	3.5	3.7
KCAE	12.3	4.8	5.9	4.6	7.9	6.2	7.8	4.9	9.7	9.3	0	7.1	7.2	8.4
KCAR	11.5	1.8	4.6	4.2	5.9	6.7	7.2	7.2	8	6.6	3.5	4.7	4.9	8.1
KCHS	9.1	7.5	7	7.2	7.1	7.9	7.5	7.7	8.3	7.9	5.6	6.6	6.6	7.3



NDFD Gridded Verification

- Elements include Temperature, Dewpoint, and Wind Speed on CONUS 2.5km grid
- Includes comparisons to Gridded MOS (GMOS), Downscaled NWP Guidance (DNG), and WPC guidance grids on matched sets
- Monthly MAE and Bias images available for every 12 hours out to 168 hours
- Plots provided for CONUS, CONUS regions, and Alaska
- Based on Real-time Mesoscale Analysis (RTMA)





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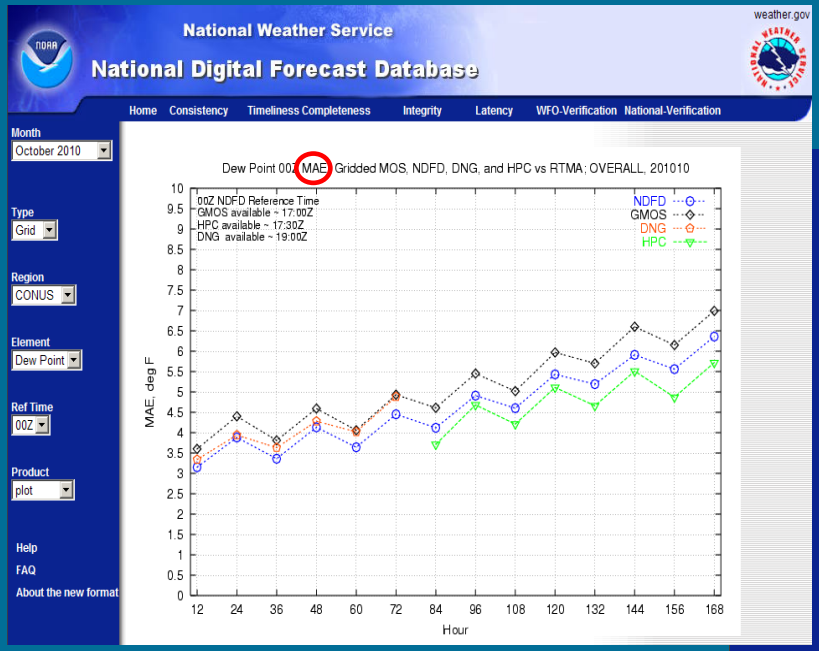
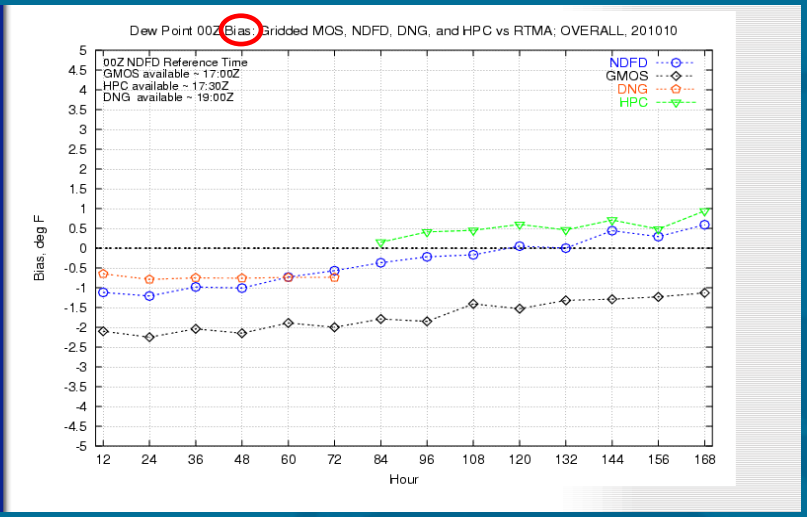
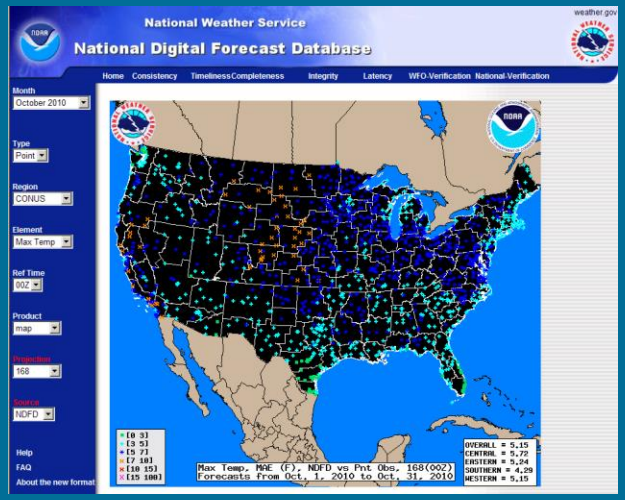
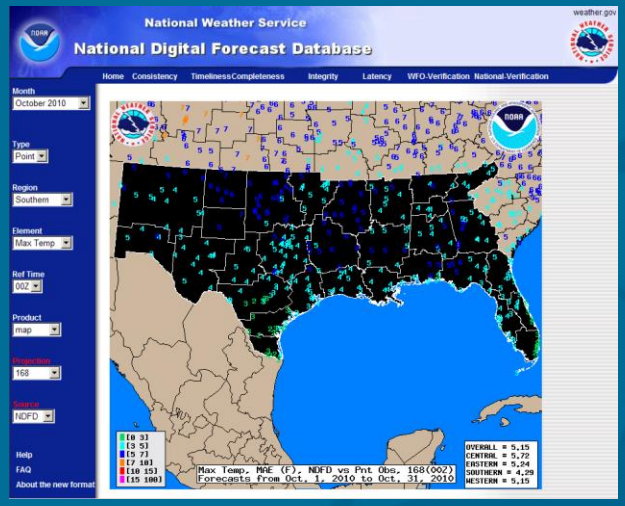




NDFD Point Verification

- Elements include MaxT, MinT, PoP12, Temperature, Dewpoint, RH, Wind Direction, Wind Speed, Wind Gust, Sky Cover, and Weather
- Monthly maps available for CONUS and CONUS regions for all NDFD projections from 3 to 168 hours
- Charts show all NDFD projections from 3 to 168 hours for CONUS, CONUS regions, Alaska, Hawaii, Guam, and Puerto Rico
- Includes comparisons to station MOS, gridded MOS (GMOS), Downscaled NWP Guidance (DNG), and HPC guidance on matched sets
- Forecasts obtained from grids using a nearest-neighbor technique with special handling for mountains and coastlines





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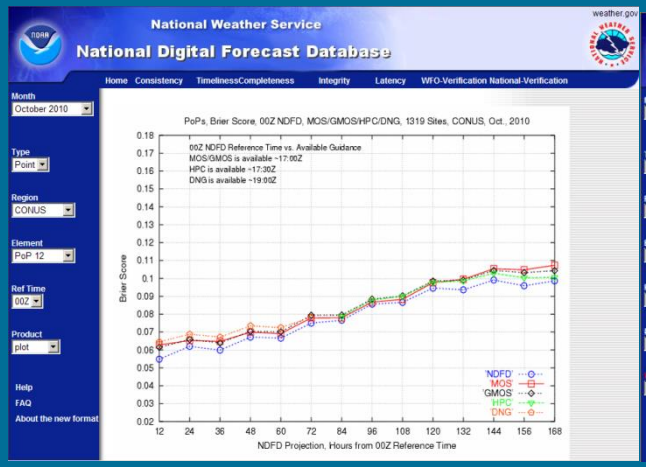
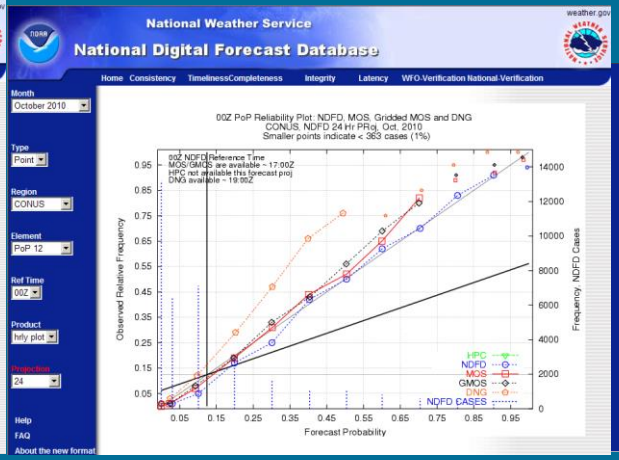
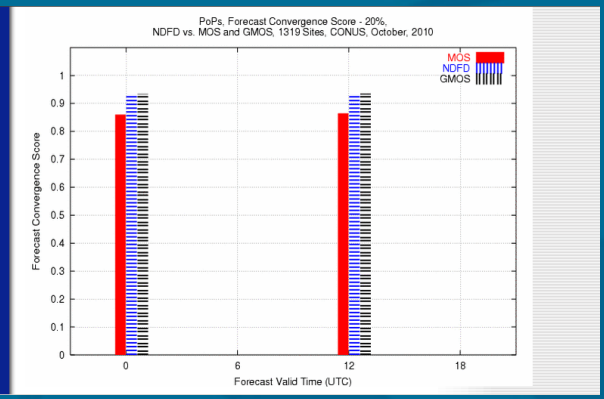
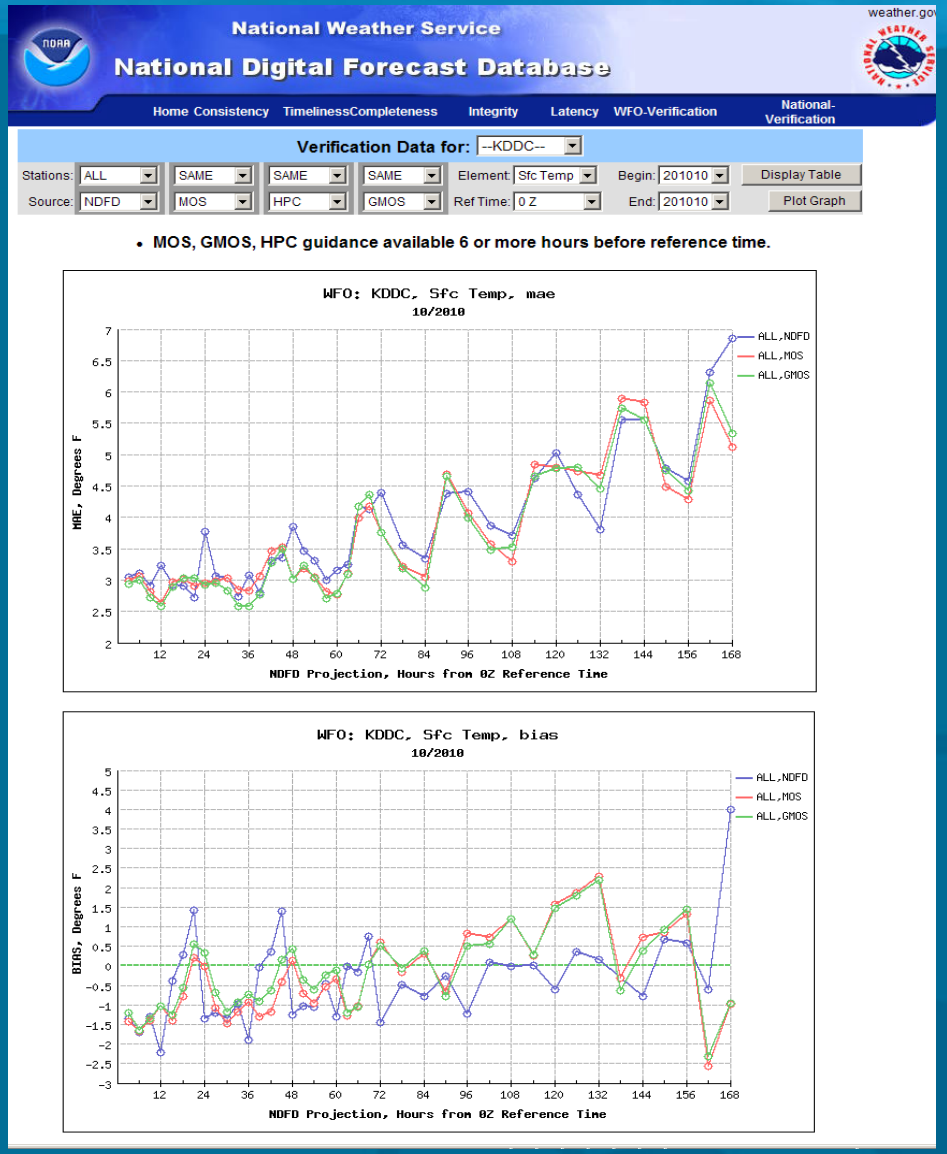






Interactive Charts Online

- Charts and tables produced interactively for MaxT, MinT, PoP12, Temperature, Dewpoint, RH, Wind Direction, Wind Speed, Wind Gust, and Sky Cover for WFOs and stations in CONUS
- Monthly scores available online for nearly 10 years (beginning April 2005).
- Includes comparisons with station MOS, Gridded MOS, Downscaled NWP Guidance, and HPC guidance.
- Shows scores for Regions, WFOs, and individual stations



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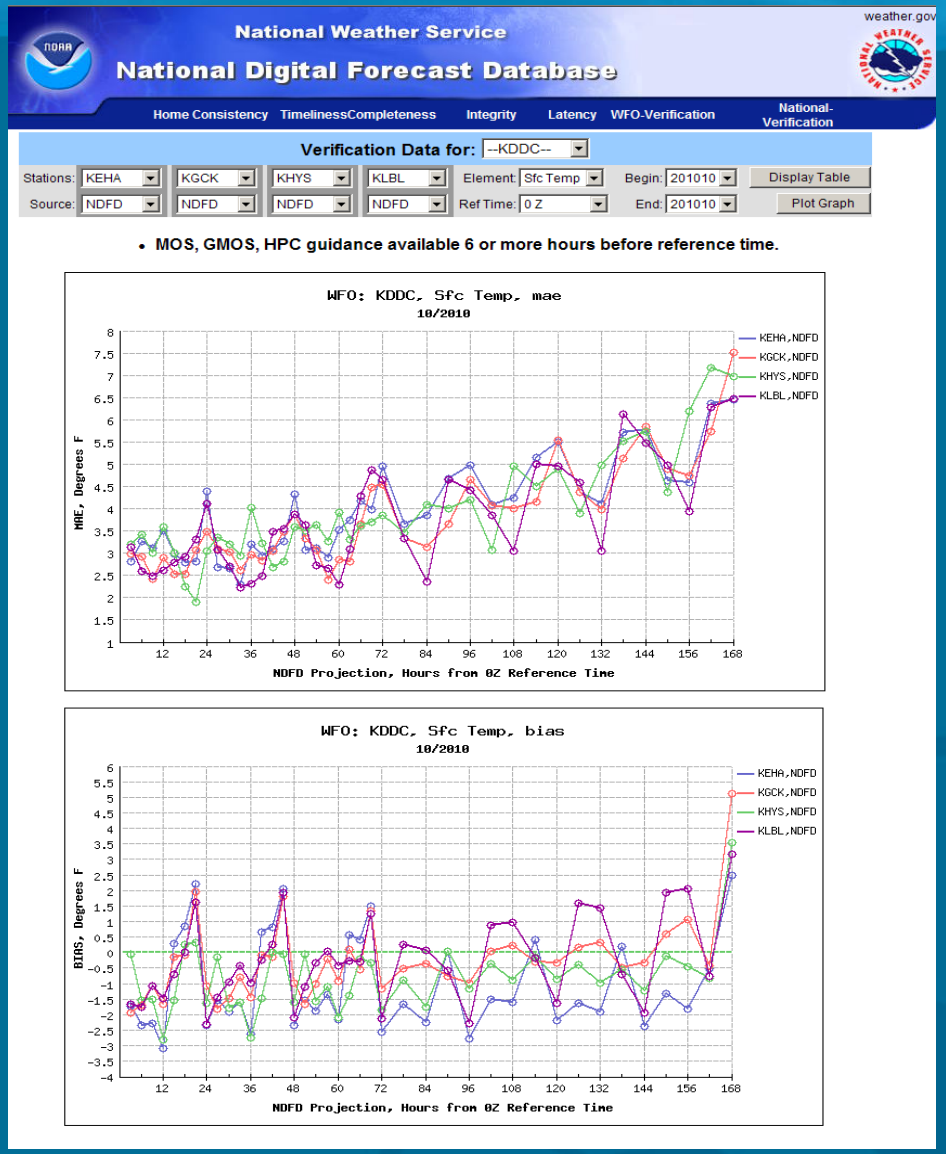
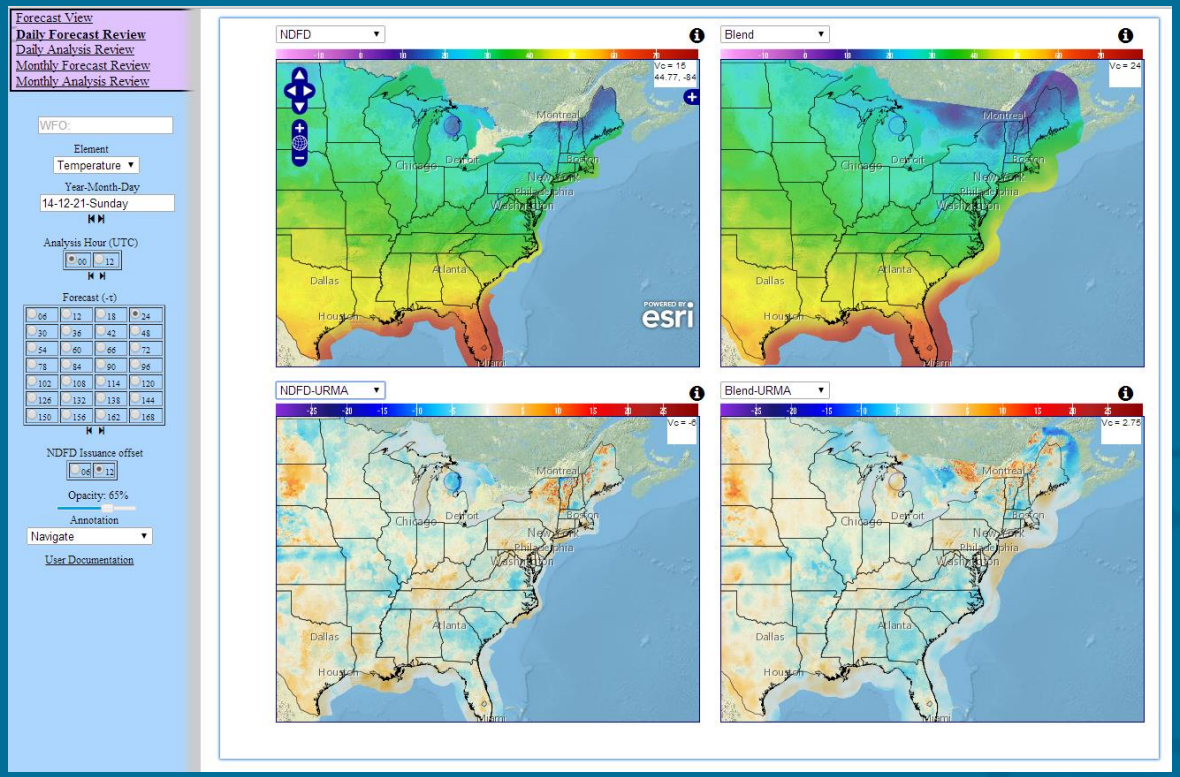


NDFD Comparative Viewer

- Compares NDFD, Blend, GMOS, EKDMOS, ECMWF, and WPC forecasts side-by-side
- Compares RTMA, URMA, LAPS, and BCDG analyses side-by-side with accepted and rejected observations at points
- Provides daily review and monthly summary statistics



The Path Forward

Weather-Ready Nation:
Saving Lives and Livelihoods

- Facilitate improvements to RTMA/URMA
- Tune blended model guidance to URMA
- Relieve forecasters of the need to routinely edit grids
- Provide impact decision support services based on accurate and consistent digital information in a Common Operating Picture