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

Observations
- Numerical Modeling
  - Numerical Output
    - Model Interpretation
      - Sensible Weather
        - Forecast Editing
          - Digital Forecast
            - Product Generation
              - User Products
The Digital Forecast Process

The Human in the Loop

Observations → Numerical Modeling → Numerical Output → Model Interpretation → Sensible Weather → Forecast Editing → Product Generation → User Products

Matrix Editing
Matrix Editing

ICWF Interactive Guidance Revisor (1988)
IFPS Interactive Guidance Revisor

Matrix Editing

Alan Rezek – MIC (retired)
Matrix Editing

IFPS Interactive Guidance Revisor (2000)
## Matrix Editing

### Cloud coverage

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### Precipitation

- **IP**: Intermittent precipitation
- **IP periods**: Intermittent precipitation periods
- **ZR**: Freezing rain
- **R**: Rain
- **a few RW**: A few rain showers

### Temperature

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### Wind

- **W 15-25**: West wind 15-25 km/h
- **E 15-25**: East wind 15-25 km/h
- **SE 15-25**: Southeast wind 15-25 km/h
- **S 15-25**: South wind 15-25 km/h

### Visibility

- **DS**: Reduced visibility

### Accumulation

- **Tot 15**: Total accumulation 15 cm
- **Tot 10-15**: Total accumulation 10-15 cm
- **Tot 10**: Total accumulation 10 cm

**Warning**: WINTER STORM

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*Canada’s SCRIBE*
ICWF Grid Modification (1994)
Grid Editing

IFPS Graphical Forecast Editor (2012)
Grid Editing

KMA Graphic Editing Module

Dr. Bob Glahn, Dr. Kyung-Sup Shun (deceased), David Ruth
BoM Graphical Forecast Editor

Grid Editing
Carl Bullock, John Bally, Dr. Tom Keenan, David Ruth
The Digital Forecast Process

Observations

Numerical Modeling

Model Interpretation

Numerical Output

Sensible Weather

Forecast Editing

Object Editing

Grid Editing

Matrix Editing

Digital Forecast

Product Generation

User Products
Canada’s Forecast Production Assistant
The Digital Forecast Process

Observations

Numerical Modeling
- Numerical Output
  - Model Interpretation
    - Sensible Weather
      - Forecast Editing
        - Threshold Adjustment
          - Object Editing
            - Grid Editing
              - Matrix Editing

Digital Forecast
- Product Generation
  - User Products
IFPS Slider Bars (2000)
Interactive Calibration of a 4D Datacube (2006)
Threshold Adjustment

IC4D (2010)
WPC Model Blender
(2014)
The Digital Forecast Process

- Observations
- Numerical Modeling
  - Numerical Output
  - Model Interpretation
    - Sensible Weather
    - 4D Field Modification
      - Threshold Adjustment
  - Forecast Editing
    - Digital Forecast
    - Product Generation
      - User Products
  - Object Editing
  - Grid Editing
  - Matrix Editing
4D Field Modification

UKMET
HORACE
On Screen
Field Modification
Road to an official NDFD 1988 - 2004
Road to an official NDFD 1988 - 2004
Road to an official NDFD 1988 - 2004
Road to an official NDFD 1988 - 2004
Road to an official NDFD 1988 - 2004
Road to an official NDFD 1988 - 2004
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Road to an official NDFD 1988 - 2004
Road to an official NDFD 1988 - 2004
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
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 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

Weather, Wind, Wind Gusts

Sky, PoP12, QPF, Ice, Snow

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

- Commercial Weather Providers: 37%
- Education and Research: 16%
- Commercial Apps: 8%
- Unknown Users: 8%
- NOAA: 7%
- Agriculture: 6%
- Real Estate: 5%
- Communications: 4%
- Energy: 2%
- Recreation: 1%
- Health: 1%
- Transportation: 1%
- Military: 1%
Grid Downloads by Geographic Sector

- **CONUS Sectors**
  - Conus: 35%
  - Pacific Southwest: 16%
  - Northeast: 16%
  - Southern Plains: 4%
  - Guam: 5%
  - Alaska: 4%
  - Hawaii: 8%
  - Puerto Rico: 6%
Points requested via NDFD XML
Zips requested via NDFD XML
NDFD Graphics

High Temperature (F) Ending Wed Dec 24 2014 7PM EST
(Thu Dec 25 2014 00Z)

National Digital Forecast Database
00z issuance Graphic created-Dec 23 7:19PM EST

Mouse over or click on the times below to change the above graphic.
Max/Min Temp: | Tonight | Wed | Wed Night | Thu | Thu Night | Fri |
NDFD Map Viewer

National Digital Forecast Database Display

Maximum Temperature (°F)
Daytime High for: Wed, Dec 24 2014, 7 PM EST
Issued: Dec 23 at 7 PM EST

Create a bookmarkable URL  Definitions  About  FAQs  Product Descriptions  Survey/Comments  Help  Map Options  Print Map
# NDFD Border Consistency

## National Digital Forecast Database

### WFO Consistency Summary for WFO: KLIW

**Explanation of statistics and methodology used.**

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Table Created: 2012-02-21 12:04
NDFD Border Consistency

PoP12 Consistency Fri Feb 24 2012 7PM EST
(Sat Feb 25 2012 00Z)
National Digital Forecast Database
12z issuance Graphic Created Feb 21 7:25AM EST
Daily/Weekly/Monthly Scores

Consistency

Integrity

Timeliness

Completeness

Latency

Consistency and Integrity maps for Daily/Weekly/Monthly Scores display regions with varying shades indicating consistency and integrity levels. Timeliness and Completeness maps show regions with different colors representing timeliness and completeness scores. Latency map uses a color scale to represent latency levels across different states.
## NDFD Latency Alerts

**Alarm Latency Summary for 17Z**

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<th>Time grids last changed</th>
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# NDFD Latency by Element

## 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.

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**Number of NetCDF Updates Per Day - MaxT**

30-Day Average, ending Mon Feb 20, 2012

Image created Tue Feb 21, 2012 16:32:33
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)
NDFD Gridded Verification

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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
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.
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.
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

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• Shows scores for Regions, WFOs, and individual stations
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

- 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