12.3 NATIONAL DIGITAL FORECAST DATABASE DESIGN AND DEVELOPMENT

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1. INTRODUCTION

The National Weather Service (NWS) has undertaken the development of a National Digital Forecast Database (NDFD) that will enable NWS customers and partners access to digital forecasts produced by forecasters at NWS offices nationwide. The NDFD, when complete, will contain a seamless mosaic of digital forecasts from more than 120 field offices (Ruth and Glahn 2003). NDFD mosaics are composed of grids of forecast elements produced at each Weather Forecast Office (WFO) by using the Interactive Forecast Preparation System (IFPS). By late 2003, IFPS will be implemented at all NWS WFOs (Ruth 2002).

The availability of high-resolution forecast data on a national scale allows for the creation of a wide range of graphic, text, and image products by the NWS as well as its customers and partners. Such products include:

- Forecast text and meteograms for any NDFD gridpoint.
- National and regional images with animation.
- Digital forecast data compatible with Geographic Information Systems (GIS).

One of the challenges in the design and development of an NDFD is to collect grids from WFOs and service centers and make them available to NWS customers and partners in a timely manner. Fig. 1 depicts the NDFD functional architecture. It shows the path by which forecast grids from WFOs and other service centers are ultimately made available to end users. On platforms where NDFD software resides, the architecture breaks into two main components. The first, the NDFD central server, acts as the collection point for incoming forecast grids. Mosaics are created and will be sent through the Advanced Weather Interactive Processing System (AWIPS) firewall to the second component, an NDFD web server at the NWS headquarters. Additionally, NDFD mosaics are sent to an FTP server where NWS customers and partners may download data in "bulk" quantities. Software running on the NDFD web server will handle interactive requests for data from users via the internet.

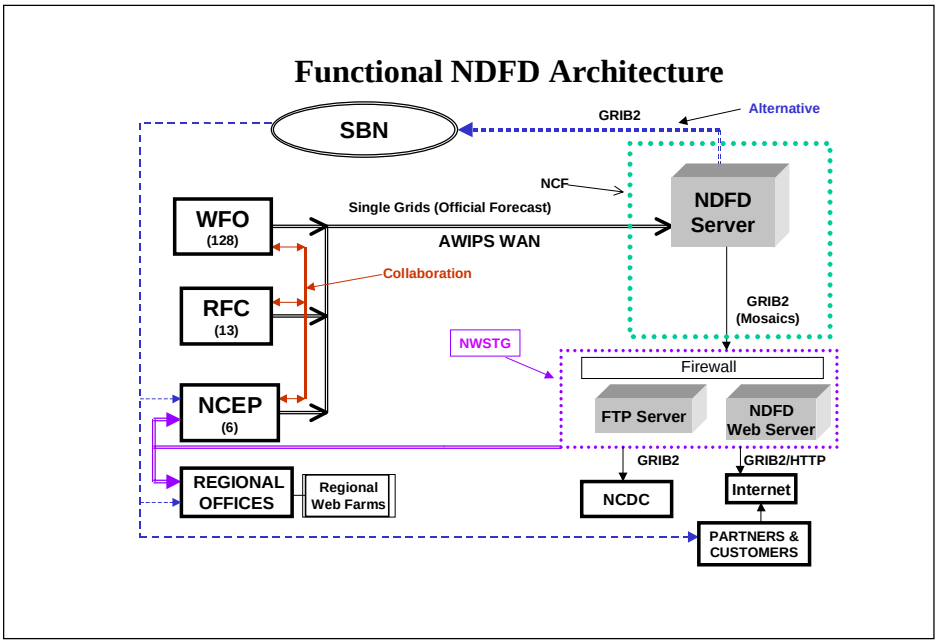

Figure 1: Functional NDFD architecture.

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Forecast mosaics made available on the web server are intended for less intensive but more user-specific data access. NDFD web server software will also reside at NWS Regional "web farms" that will function as mirror sites for NDFD data. At some point in the future, NDFD mosaics may also be transmitted over the AWIPS Satellite Broadcast Network (SBN).

This paper describes the process by which digital forecast data produced at WFOs and NWS service centers is transformed into national-scale products and made available to the public. NDFD software is currently being developed at the Meteorological Development Laboratory (MDL) at the NWS headquarters. Images from the initial prototype of the NDFD were first made available in March 2002 to a handful of WFOs participating in the experiment. By summer 2003, grids from all WFOs in the conterminous United States (CONUS) will be available experimentally.

2. THE NDFD CENTRAL SERVER

When forecasters are prepared to publish their latest forecast grids to the NDFD, IFPS software at the WFO encodes the grids in GRIdded Binary data format (GRIB) prior to transmission to the NDFD central server via the AWIPS WAN. Only grids that have been updated since the last transmission are sent by the WFO. Decoding software on the NDFD server unpacks the encoded grids and stores the data to a Relational Database Management System (RDBMS). A decoder process kicks off once every 5 minutes on the NDFD server. This allows the NDFD to be updated on a near-continuous basis with forecasts from WFOs and service centers. Every grid received is stored into the database as a unique entity. In addition to the actual data, metadata such as geographical location, grid valid time and forecast issuance time are stored. Issuance time for a forecast grid is the time at which a WFO wants that grid to become the official forecast.

NDFD mosaics are created on a routine basis (currently, once an hour) from individual WFO grids stored in the database. For each weather element, at every forecast projection, the database is searched for new WFO grids. If a new WFO grid is found, that grid's issuance time is compared to the current time. If the issuance time has been reached, the grid is added to the appropriate mosaic. The AWIPS 227 grid with 5-km grid mesh length is the grid upon which NDFD mosaics are based. Mosaics lie on a sub-domain of this grid, with a size of 1073x689 gridpoints. An identification grid that maps the domain of every WFO to the NDFD grid is used to produce mosaics. Each mosaic is stored to the RDBMS after it has been created or updated.

Another process runs on the NDFD central server that checks consistency of forecasts between neighboring WFOs. Overlapping gridpoints along WFO boundaries are analyzed for each weather element grid and forecast values are compared to predetermined discrepancy thresholds. Gridpoints where thresholds are exceeded are flagged and used to compute forecast consistency statistics. Additionally, consistency images are generated that display discrepancies for overlapping points along WFO boundaries (Fig. 2).

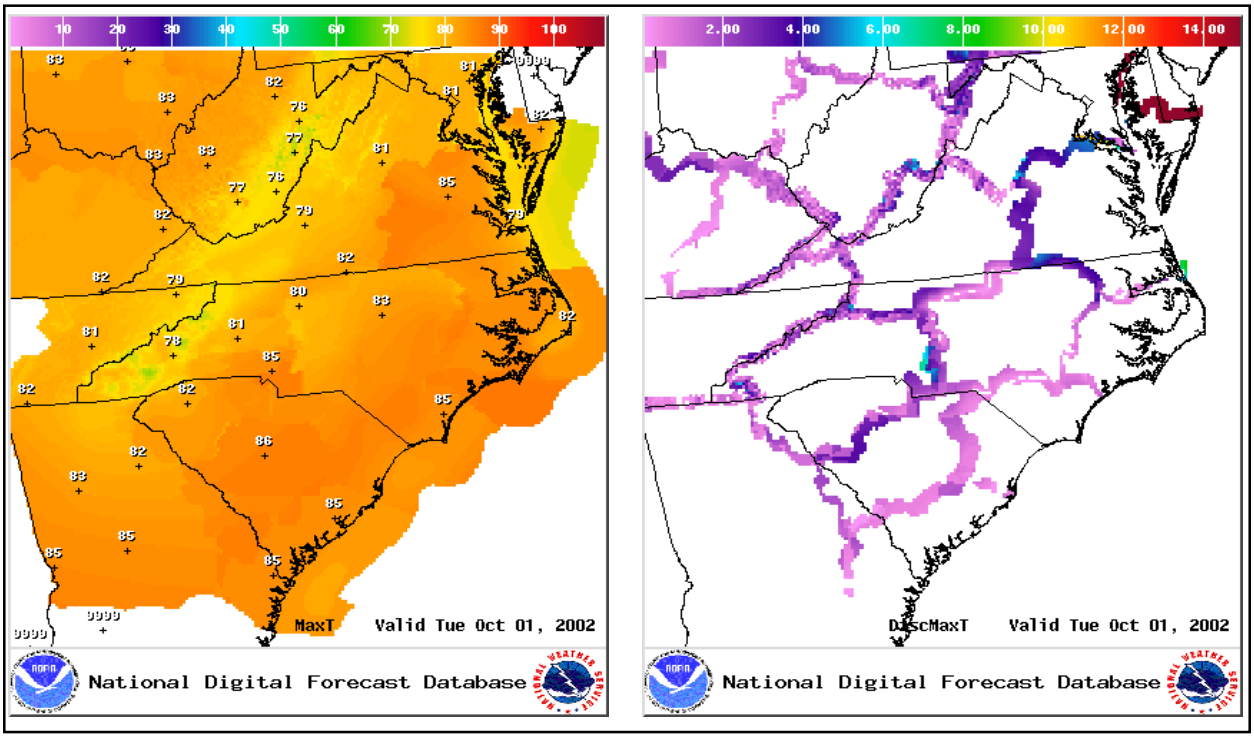

Figure 2: NDFD Mosaic of MaxT and an image of discontinuities along WFO boundaries for the mid-Atlantic sector.

Once all mosaics have been produced for a given issuance of the NDFD, they are encoded in GRIB format. The encoded grids are transmitted to an FTP server and an NDFD web server at the NWS Telecommunications Gateway (NWSTG). Additionally, mosaics are sent to the National Centers for Environmental Prediction (NCEP). Encoded NDFD mosaics are created for the CONUS, and also a set of 16 smaller sectors within the CONUS.

3. NDFD WEB SERVICES

NDFD software will reside on a web server at the NWS headquarters. Encoded mosaics will be decoded on the web server as they are received from the NDFD central server. Unlike the RDBMS on the central server, the RDBMS on the web server will be configured to store NDFD data as individual points in the database. Each gridpoint will be stored as a unique entity with associated locational, temporal, and weather element-specific metadata. Two critical requirements for the RDBMS on the web server are optimized capabilities for handling geospatial data types as well as the ability to handle the tremendous load of simultaneous queries expected as the public begins to access NDFD data.

NDFD web services are designed to give users flexible access to forecast data while hiding the underlying implementation of the database. For purposes of data integrity and server security, users are never allowed direct access to the relational database itself. Table 1 shows an example of a typical request to the NDFD database and how web services work to provide the data requested by the user.

Table 1: NDFD Web Services example.

Client PC	*NDFD Web Services web server*	*RDBMS server (on web server)*
Use API to request NDFD data via SOAP		
	Receive SOAP request for data	
	Validate request	
	Formulate SQL query	
	Connect to RDBMS	
	Send SQL query to RDBMS	
		Receive SQL query
		Execute query
		Return data to Web service
	Compress data in GRIB2 format	
	Wrap GRIB2 message in XML	
	Send XML back to client PC via SOAP	
API unwraps XML		
API decodes GRIB to raw data		
Client build product with raw data		

Initially, a user makes a request to obtain data by using an Application Programmer Interface (API) that resides on the user's platform. The query is generated by the API and sent to the NDFD web server via a Simple Object Access Protocol (SOAP) request. The SOAP request is received at the web server and checks are made to validate the request. This validation ensures, among other things, that the request makes sense and is not excessively large. Once the request passes validation, a Structured Query Language (SQL) command is generated to fetch the user-requested data from the RDBMS.

Prior to returning the data to the user, the data are compressed into GRIB format and the entire set of data is wrapped in an eXtensible Markup Language (XML) message. An API on the user platform unwraps and decodes the data, making it available for user-defined applications. NDFD web services will allow data to be quickly and easily obtained for user-specified geographic regions, time ranges, and weather elements. They also provide a standardized method to query and retrieve data from the NDFD.

4. FUTURE PLANS

Design and development of NDFD software is an ongoing effort at MDL. Current tasks include the addition of non-CONUS areas (e.g., Alaska and Hawaii). These regions must be uniquely handled within the design framework of the NDFD due to their size and differing grid definitions. In the future, the NDFD will also include grids of 3-dimensional aviation forecast elements. A software improvement that may be implemented is the addition of a geospatial-type database on the NDFD central server for increased mosaic generation performance. Examples of APIs used to access NDFD data via web services will be provided to NWS customers and partners to promote end-user development of applications that take advantage of this growing wealth of available data. Through the high-resolution digital forecast data contained within the NDFD, the NWS will give its customers and partners increasing access to one of its primary assets, the knowledge and experience of its forecasters.

5. REFERENCES

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