# GFE - The Next Generation

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**Abstract**

A major obstacle to the formulation of a systematic methodology within GFE is the disconnect between the sensible weather elements and the atmosphere (Scott and Proton, 2004). In other words, once a set of sensible weather elements is manipulated, it ceases to be physically associated with a 4-dimensional representation (4-D Cube) of the atmosphere. This disassociation renders the systematic use of NWP output in subsequent calculations, using Smart Tools and Procedures, problematic.

The archetype for gridded product generation, the On Screen Field Modification system (HORACE/OSFM), was developed by the UKMet Office in the late 1990s. Within the technology framework, the UKMet forecaster goes through the forecast process and applies subjective corrections to the atmosphere using the OSFM technique (Carroll, 1997). With OSFM internal consistency is maintained in the dynamic fields through momentum and hydrostatic balance on Potential Vorticity surfaces. Forecasts are derived from the modified representation of the atmosphere. Field modification in the NinJo project (Koppert, 2004) is an ambitious extension to concepts developed by the UKMet Office.

Is it possible, then, to construct a context within the current GFE that would allow a forecaster to maintain a suite of sensible weather element grids that is physically consistent with the 4-D Cube from which it is derived? The answer is not simple as GFE was never designed to perform this task (Scott and Proton, 2004).

This paper lays out a concept of operation, and a limited proof of concept for 4-D grid maintenance within GFE.

**Discussion**

As Brooks (1995) and others have noted, the relationship between forecasters and technology is complex. This relationship has become even more complex in the National Weather Service (NWS) with the implementation of the Interactive Forecast Preparation System (IFPS)/Graphical Forecast Editor (GFE). IFPS/GFE allows the NWS forecaster to interact with grids of what are termed sensible weather elements (SWEs) in the forecast digital database to generate a variety of products and services. The technology has completely revolutionized forecast operations within the NWS (Glahn and Ruth 2003)

There are a number of advantages to this approach as compared to traditional methods of forecast preparation (FSL 1999). The most obvious benefit is that IFPS/GFE allows a NWS Forecast Office to generate a consistent set of products spanning all programs and services. Another yet to be fully realized advantage is the fact that a digital database gives NWS users the ability to create dynamic, Tactical Decision Aids.

However, as other authors have pointed out, the IFPS/GFE process is not without problems. Maas (2002) believes that there are “major conceptual and technical deficiencies that threaten to undermine the institution's ability to provide skillful forecasts to the public and to other users.” Reynolds (2004) noted the difficulty associated with manipulating the large number of SWE grids at a temporal and spatial scale that is currently unresolvable. Reynolds and Doswell (2003) both question the soundness of utilizing NWS forecaster resources in this fashion.

Along a parallel track, Doswell (1986), Brooks, et. al. (1996), and Maas (2002) among others have raised the question of the changing role of the human forecaster in this era of rapid evolution in technology. As Doswell stated so eloquently, “…the challenge during this period of technological ferment is to figure out how to *put the science of meteorology back into the process of forecasting.”* Taken at face value a number of their recommendations would involve some sort of reorganization within the NWS, a change in the Directives that guide the organization, or a large scale reallocation of NWS resources. Regardless of the merit of these proposals, the suggestions are beyond the scope of this paper. With this in mind it is appropriate then to establish the framework for this paper.

**Framework for a Solution**

Figure 1 represents a generalized description of the forecast process, with an additional block that represents the major distinction technology has brought to the field of operational meteorology: The automated generation of the forecast product. Scott and Proton (2004) described in some detail what a next-generation system might look like (We refer interested readers to that paper if a more complete description is desired). A very brief summary is as follows:

1. **The system should accommodate how a meteorologist systematically approaches the job of weather forecasting;**

2. **The system should provide as close a connection as possible between the SWE’s and the 4-D representation of the atmosphere from which they were derived;**

3. **Meteorological knowledge should be lay predominately in the 4-D representation of the atmosphere, not the SWE’s.**

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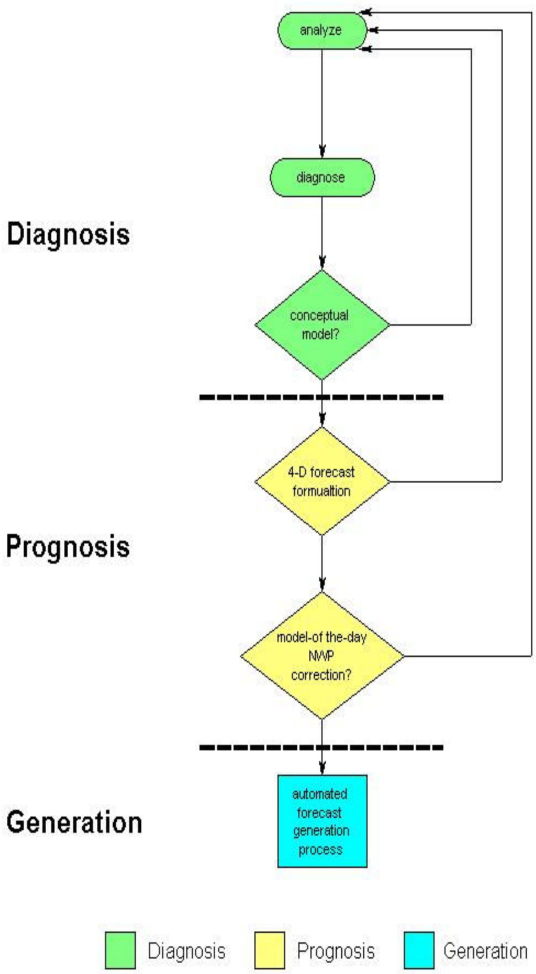


**Figure 1. The Forecast Process**

It is postulated then that a well designed forecast system is one that places the meteorologist in the best position to systematically add meteorological value to the forecast process, i.e., before the SWE's grids are generated (Figure 2). Scott and Proton (2004) stated that optimally the systematic correction should be applied "…directly to a 4-D representation of the atmosphere (the cause) before proceeding to the business of working with SWE's (the effects)." This loosely parallels what Doswell (2003) argued, "…a better place for (adding) that insight to be of value is *before* the models are run."

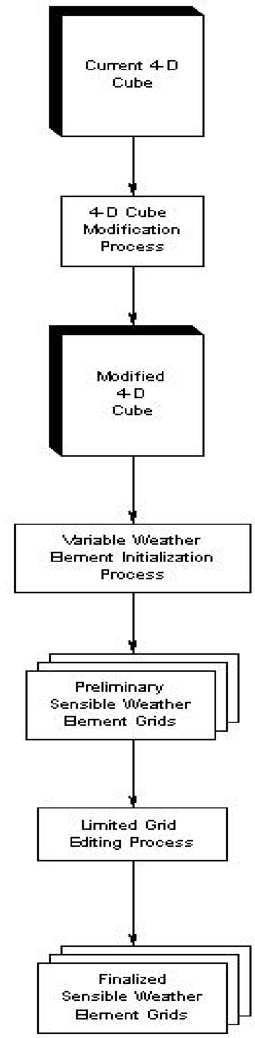


**Figure 2. The Grid Modification Process**

The UK Met Office has been successfully applying field modification techniques operationally for over 5 years in the medium range, and 2 years in the short range (Hewson 2004). The modification process is one where the forecaster makes a subjective assessment of the available model data (both deterministic and ensemble) before producing guidance (Grahamme 2002). Raw model data is modified in a consistent manner using OSFM, documented by Carroll (1997).

The OSFM is a powerful technique that allows a forecaster to modify the dynamical fields within 3D space. Changes to the dynamic fields at any single point in time are translated forward in time through a proprietary translation process. However the difficulty with the technique is that some 'sensible' weather elements (such as precipitation) are not tied to the dynamic fields, and must be modified with pragmatic cut, paste and advection tools (Grahamme 2002).

NinJo is a meteorological workstation project in joint development by a consortium of the German Meteorological Service, the German Military Geophysical Service, MeteoSwiss, the Danish Meteorological Institute, and the Meteorological Service of Canada (Koppert 2004). Beyond the standard workstation capability, NinJo possesses a component for interactive on-screen field modifications in a fashion analogous to the OSFM developed by the UK Met Office. However, in place of the proprietary UK Met Office translation process, the consortium is experimenting with utilizing a NWP mechanism to dynamically propagate modifications.

## Concept of Operation

Using Figure 2 as a template, a concept of operation (CONOP) for a Next Generation (NG) Grid Modification Methodology was devised that would allow a forecaster to use existing IFPS/GFE software in a fashion analogous to the above described OSFM and NinJo systems. Figure 3 outlines the methodology:

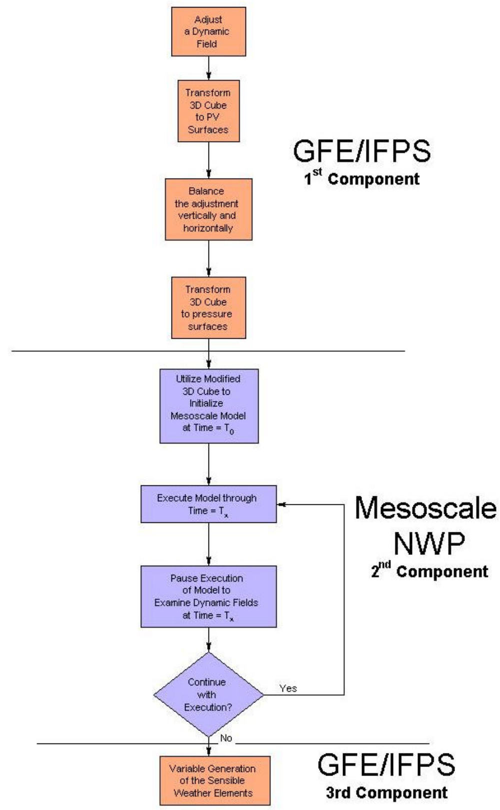


**Figure 3. Concept of Operation – NG Grid Modification Methodology**

A simplified CONOP may be seen in Figure 4 that better stratifies the functional areas within the NG methodology:

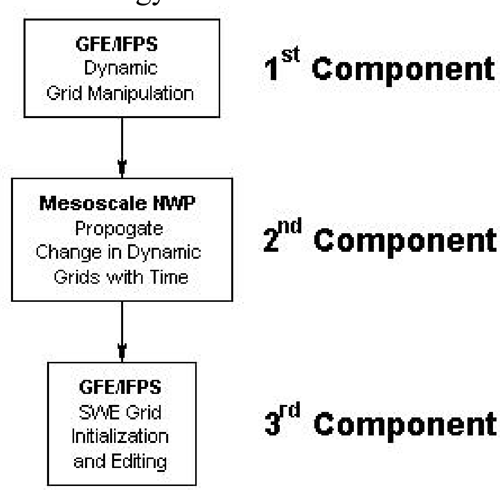


**Figure 4. Simplified Concept of Operation – NG Grid Modification Methodology**

As indicated in the preceding two figures, the NG CONOP completely transforms how IFPS/GFE is utilized in WFO forecast operations. IFPS/GFE metamorphoses from a tool to “draw” the forecasts (Mass 2003) to one that provides the forecaster the opportunity to systematically apply meteorological value to a 4D representation of the atmosphere from which the forecasts are derived.

**Proof of Concept**

Within the 1st component there were 4 major tasks, and all have been completed (Figure 3).

1. A Smart Tool was developed within GFE/IFPS that allows a forecaster to modify a dynamic field.
2. A Procedure was developed within GFE/IFPS that transforms the 3D Cube at a point in time onto Potential Vorticity surfaces.
3. A Procedure was developed within GFE/IFPS that rebalances the 3D Cube at a point in time horizontally and vertically.
4. A Procedure was developed within GFE/IFPS that transforms the 3D Cube at a point in time from Potential Vorticity surfaces back to pressure surfaces.

Within the 2nd component there were 3 major tasks to complete. However, the only task that has been completed is the implementation of the mesocale NWP model. The Weather Research and Forecast Model (WRF) is currently loaded and operational in diagnostic mode (as of October 20). The WRF model is currently being ported to a multi-node BEOWULF cluster for improved performance (for the initial proof of concept only a single forecast intervention will be allowed at time $T_{0)}$.

The 3rd component involves tasks already completed with the standard GFE/IFPS implementation.

Preliminary results from test cases should be available by mid December.

**The Future**

It cannot be emphasized enough that this is a proof of concept, and a work in progress. It is not the intention of the authors to represent this as any sort of finished product.

With that caveat, there are a number of tasks that remain to be completed:

1. Complete port to multi-node BEOWULF cluster.
2. Develop set of “1st guess” fields (e.g., ensembles) to aid the forecaster in the systematic adjustment of the dynamic field.
3. Develop process to allow intervention at multiple time steps.
4. Develop a rudimentary verification program.

**References:**

**Doswell, C.A. III** (1986): The Human Element in Weather Forecasting, *Nat. Wea. Dig*., **11**, 6-17.

Reynolds, R.W. 2004: Application Of Numerical Models In The Forecast Process - From National Centers To The Local WFO: NCEP Symposium.

Mass, C., D, 2002: IFPS and the Future of the National Weather Service *Weather* *and Forecasting:* Vol. 18, No. 1, pp. 75–79.

Glahn, H.R., and D. Ruth, 2003: The new digital forecast database at the National Weather Service. Bull. Amer. Meteor. Soc., 84, 195-201.

Brooks, H.E., 1995: in preparation for a presentation on Challenges for Technology Developers to be made at the 5th AES/CMOS Workshop on Operational Meteorology, 28 February-3 March 1995, Edmonton, Alberta and as part of an ongoing effort to define the future state of weather forecasting.)

FSL, 1999: An IFPS and Graphical Forecast Editor (GFE) Summary. [available on line at http://www-md.fsl.noaa.gov/eft/publications/brochure/brochure.html ]

Scott, C.A. and V.J. Proton, 2004: Development of a link from the 4-D cube to the derived sensible weather elements. Preprints, AMS 20th Conference on Weather Analysis and Forecasting/16th Conf. on Numerical Weather Prediction. Seattle, WA. Paper 4.7.

Brooks, H. E., J. Michael Fritsch, Charles A. Doswell III 15th AMS Conference on Weather Analysis and Forecasting, Norfolk, Virginia, 19-23 August 1996, 1**8.3** THE FUTURE OF WEATHER FORECASTING: THE ERAS OF REVOLUTION AND RECONSTRUCTION

Snellman, L.W., 1977: Operational forecasting using automated guidance. *Bull. Am. Meteorol. Soc.,* **58**, 1036-1044.

Hewson, T., 2004, The Value of Field Modification if Forecasting, UK Met Office Note.

Carroll, E.B. 1997. A technique for consistent alteration of NWP output fields. *Meteorological Applications*. Vol 4.

Koppert, H-J, 2004; NinJo Project Status 2004; European Working Group on Operational Workstations (EGOWS) 15th Meeting from June 14 - 17, 2004 in Potsdam, Germany

Doswell C. A., Note 2003, What does it take to be a good forecaster?

Grahamme, N., 2002, ADDING VALUE – THE FORECASTER'S ROLE. UK Met Office Note.