QUANTITATIVE PRECIPITATION (QPF) AS A FOUNDATION FOR A SYSTEMATIC METHODOLOGY IN GFE

P2.8

Carven Scott, Jim Nelson, Victor Proton, Shaun Baines, and Chris

Abstract

There are innumerable GFE methodologies currently in vogue across the NWS: some systematic, and some not. The GFE software design allows the forecaster an unlimited number of degrees of freedom to manipulate the sensible weather element grids. However, the lack of a consistent set of methodologies has become an impediment to the maturation of GFE (Scott and Proton, 2004).

In recognition of this necessity the WFO Anchorage instituted a standard methodology based on the Quantitative Precipitation Forecast (QPF). The premise is simple: If the forecaster can focus on, and accurately evaluate the location and amount of precipitation that will occur, the forecaster will likely have a good handle on the other forecast fields.

One of the benefits of the QPF methodology is that it allows for a direct relationship among the HPC QPF forecaster, the RFC-HAS forecaster, and the forecast office. In addition the standard approach has permitted the Anchorage office to develop a number of Smart Tools and Procedures that systematically derive a number of other related fields that would otherwise be manipulated independently by hand. This environment allows for better internal and external coordination of sensible weather element grids.

Though the QPF methodology is still a work in progress, results have been very encouraging to this point.

* *Corresponding author's address*: National Weather Service, 6930 Sand Lake Road, Anchorage, AK 99502

Background Information

This paper emerged from the "Short Term Forecast" Manual developed for the forecast staff at WFO Anchorage. The methodology presumes the forecaster has traversed the "Forecast Funnel" (Snellman 1977), and is prepared to apply a conceptual model to systematically modify the sensible weather element (SWE) forecast database. Based on the aforementioned "Forecast Funnel", the forecaster is asked to navigate the 72 hour forecast database following a fairly rigorous strategy both in the order in which grids are manipulated, and in Smart Tool selection. The benefit to a strict methodology:

- SWE grids will be more likely to be internally consistent;
- better shift to shift consistency;
- fewer grids to manipulate.

This paper is not meant to describe in detail the entire AFC methodology. What is portrayed are some of the unique components, and enough information to provide insight into how a systematic methodology can be constructed.

CONCEPT OF OPERATION

The concept of operation is simple: Complete the highest number of grids systematically with the fewest keystrokes. Minimize the degrees of freedom in order to maintain scientific, and internal consistency. A schematic of the grid production process may be seen in Figure 1.

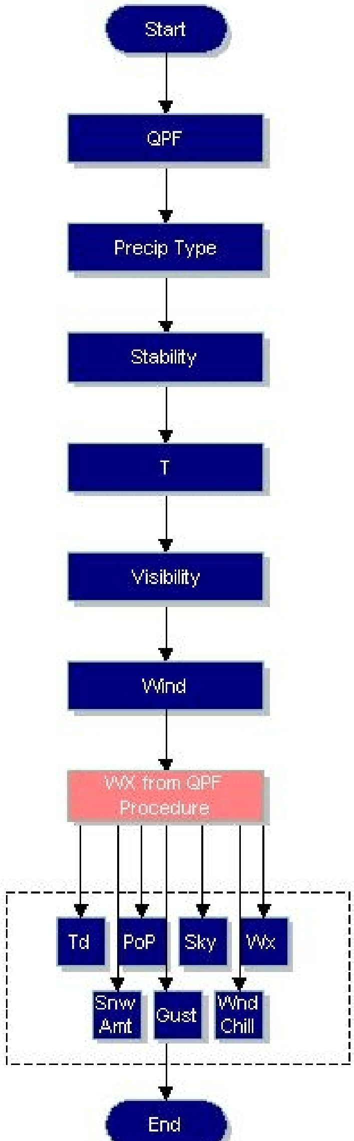

Figure1. Flowchart of the AFC Grid Production Process

One of the design principles of the methodology was to force the forecaster to spend time focusing on mission critical items such as "how much water equivalent will fall", rather than non-critical items such as PoP. The methodology also allows the forecaster to systematically build the Weather grid (**WX)** from components. Currently a number of offices spend lot of time creating, editing, and performing consistency checks on the Weather grid. The Weather grid is generally not edited at the Anchorage Office. An additional benefit of using components to build the forecast is that programs and tools based on local studies are applied in a much more systematic fashion (e.g., local fog studies).

Quantitative Precipitation Forecast (QPF)

In the AFC methodology, the **QPF** grid is the single most important grid the forecaster will manipulate. As stated previously, it is postulated that if one can accurately evaluate the location and amount of precipitation that will occur, one will likely have a good handle on the other forecast fields. More importantly one should be able to systematically derive a number of other related fields from a reasonably good QPF.

QPF is arguably the most difficult quantity for a meteorologist to forecast. However, to quote Hewson (2004), "…that for the vast majority of meteorological probability distributions – i.e. those which are unimodal - the center (or mode) can be very conveniently represented by the 'deterministic' forecast. This forecast then provides an essential focal point about which any lower probability alternatives can be visualized to lie." Thus as an alternative to probabilistic QPF (which is currently not a part of NWS operations), the methodological emphasis is on forecasting the correct category of water equivalent (QPF) at any grid point. With six (6) contours and seven (7) classes, the forecaster's focus is to determine the category of expected precipitation at any grid point (the categories loosely correspond to precipitation rates as specified in the FMH-1).

The QPF is fairly unique in that the NCEP/HPC routinely provide the forecasts to all CONUS NWS field offices. HAS forecasters at the various RFC's massage the NCEP/HPC QPF guidance to inject knowledge at a sub-synoptic scale. This guidance is, in turn, passed to the forecast offices where forecasters add knowledge of mesoscale and local effects. The first guess fields would provide a convenient coordination and collaboration tool among forecast offices.

Precipitation Type (PTYPE) Grid

The Precipitation Type (**PTYPE)** grid is unique to the AFC methodology. The grid is fairly straightforward in that the forecaster is asked to identify three precipitation type categories: liquid, mixed, and frozen (Figure 2). Note especially that “frozen” does not refer to “freezing” precipitation (e.g., freezing rain). This an important distinction as “frozen” is referring to either snow, or ice/snow pellets. The forecaster is asked to specify the areas(s) where the state of the atmosphere will only precipitate frozen precipitation.

Mixed precipitation means exactly what it says: a mixture of liquid and frozen precipitation in an area. It is important to note here again that “mixed” does not refer to “freezing” precipitation (e.g., freezing rain). The third category, liquid, denotes a region where the forecaster has indicated the precipitation will be composed only of liquid precipitation.

Since the **PTYPE** grid explicitly excludes “freezing rain”, one may wonder how “freezing rain” is systematically reflected in the grids. During the “**AFC_Wx_Proc**” procedure (executed after all primary grids are completed) a “sanity” check is performed in the **WX** grid (looking at factors such as the **T** grid, etc.). A comparison is made between the value the forecaster has entered for **PTYPE** at a grid point and the **T** grid. The **WX** is modified from liquid to “freezing rain” if the **T** value is 32F or less. A similar check will compare T grid and PTYPE grid values to ensure that frozen precipitation is not forecast where T is greater than ~39F for unstable, or ~35F for stable conditions (defined later).

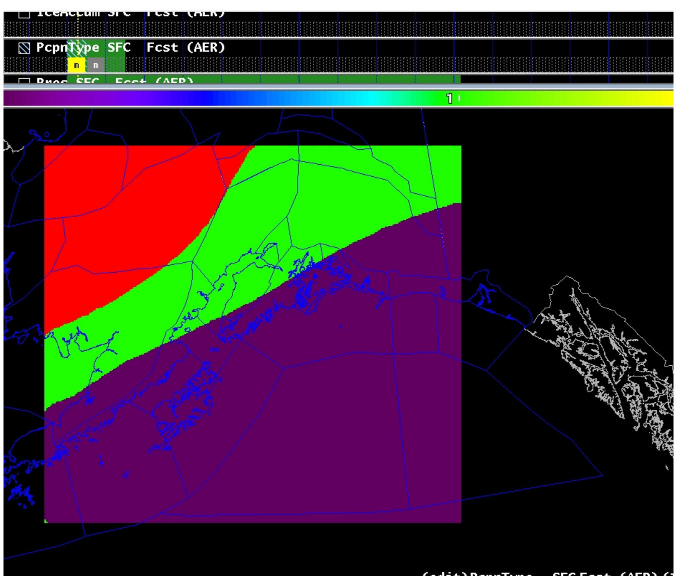

Figure 2. PTYPE Grid in Edit Mode

STABILITY Grid

The **STABILITY** grid is the basis for assigning the character of the precipitation for the **WX** grid. As seen in Figure 3, the concept for stability has been greatly simplified. The forecaster is asked to identify the region in which he expects the atmosphere to be unstable (convective instability). The unstable area is highlighted in red (note the grid point value within the area is 1). A value of 2 is indicates areas of sufficient instability to support thunderstorm activity. Outside the highlighted area the forecaster expects the atmosphere to be stable (non-convective, or stratiform) with a grid point value of 0 (see table 1).

The **STABILITY** grid is used not only to determine the character of the precipitation (stratiform, shower, thunderstorm), but it is used to fine tune other derived fields, such as the **PoP** grid. For example for a given QPF value the PoP should be a little higher for a stratiform versus a shower event. The stability grid also is used to tune other derived grids such as the Dew Point, Wind Gust, Visibility, and Lightning Activity Level.

For instance the planetary boundary layer (PBL) temperature and dew point profile has a different characteristic depending on whether the atmosphere is stable, or unstable. The AFC methodology takes advantage of these generalized characteristics to infer knowledge of the dew point. In a stable profile, with no precipitation (from **QPF**), no reduction to visibility (see **VISIBILITY** in the next section), and wind speeds less than 10 knots a standard PBL profile is used to derive a dew point, and determine the value of the wind gust grid. In an unstable environment, with precipitation (from **QPF**) forecast, and sustained wind speeds of 20 knots a different PBL profile is used. A different algorithm is used to derive the wind gust, precipitation type (showers), and the dew point.

The **STABILITY** also ultimately affects the precipitation type that is used in the derived **WX** grid. Referring back to the PBL profile, a “sanity” check is run during the **WX** grid creation that takes into account the fact that frozen precipitation occurs at higher surface temperatures (**T**) in an unstable atmosphere than a stable one (because of the lapse rate).

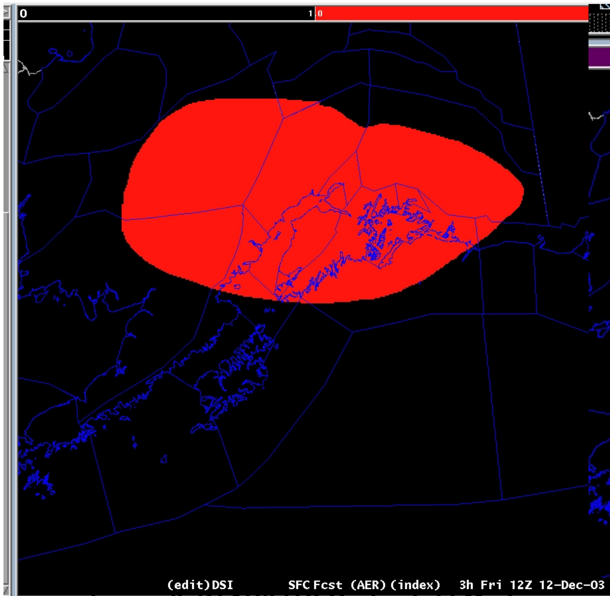

Figure 3. STABILITY Grid in Edit Mode

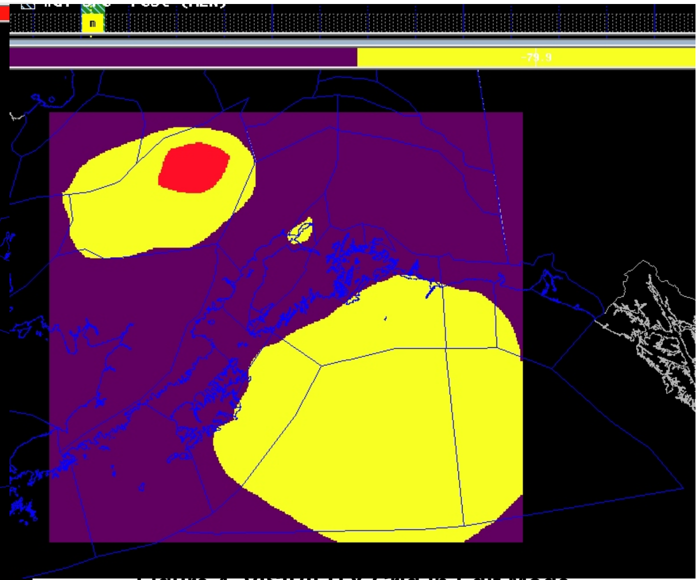

Figure 4. VISIBILITY Grid in Edit Mode

Stability Category	Corresponding DSI Grid Point Value
Stable (stratiform)	0
Unstable (convective)	1
Thunderstorm	2

Table 1. STABILITY Categories with Corresponding Grid Point Values

VISIBILITY Grid

The **VISIBILITY** grid allows the forecaster additional control over the derived **WX** grid. An example of the **VISIBILITY** grid may be seen in Figure 4 (note from Table 2 the 11 categories of Visibility).
One of the unexpected benefits of providing an independent **VISIBILITY** and **STABILITY** grid to edit is that these grids supply additional information to characterize the dew point temperature (**Td**), and the relative humidity (**RH**) grids. For example, if the meteorologist forecasts “dense fog”, and a **T** value of say 35F with no precipitation in the **QPF** at a grid point, the **Td** will be adjusted to reflect saturation, 100% **RH** (35F). Analogously if “ patchy fog” is forecast with the above described situation, the **Td** will be adjusted to reflect near saturation 95% **RH** (34F). Additionally the **VISIBILITY** grid makes it simple to extract the visibility reduction information, and derive input to the **HAZARDS** grids.

Visibility Category	Corresponding Visibility Grid Point Value	Visibility Range
No reduction to Visibility	0	Visibility >= 6SM
Patchy Fog	1	Visibility < 6SM and > ¼ SM
Areas of Fog	2	Visibility > ¼ SM
Dense Fog	3	Visibility <= ¼ SM *
Blowing Snow	4	Visibility > ¼ SM
Blowing Snow	5	Visibility <= ¼ SM *
Blowing Dust	6	Visibility > 1 SM
Blowing Dust	7	Visibility <= 1 SM *
Smoke	8	Visibility > ¼ SM
Dense Smoke	9	Visibility <= ¼ SM *
Ashfall	10	*

Table 2. VISIBILITY Categories with Corresponding Grid Point Values

***3 [results in Dense Fog Advisory]**
***5 [When accompanied by winds >= 25 mph results in Blowing Snow Advisory; when accompanied by winds >= 35 mph results in Blizzard Warning]**
***7 [Results in Blowing Dust Advisory]**
***9 [Results in Dense Smoke Advisory]**
***10 [Results in Dense Smoke Advisory]**

DERVIVED FIELDS

To this point the discussion has been completely focused on a few of the unique independent grids, from a methodological perspective. For the AFC methodology to work, these independent grids (plus others not explicitly described such as **T** and **WIND**) must be completed in order for the "AFC_Wx_Proc" Procedure to create all of the derived grid fields, with the desired effects.

There are number of fields that are derived automatically:

- **SnowAmt**
- **Td**
- **Relative Humidity**
- **MaxT**
- **MinT**
- **WindChill**
- **HeatIndex**
- **WindGust**
- **Sky**
- **PoP**
- **FrzgSpray**
- **Hazards**
- **IceAccum**

Documentation on the Smart Tools used to generate each of the grids is available in the AFC Methodology Manual, but is beyond the scope of this paper.

CONCLUSION

The standardization of the GFE methodology at the Anchorage Forecast Office was borne out of necessity. The Anchorage Office is the only office in the NWS with two separate IFPS/GFE domains. The number of grid points in each of the domains represents the highest of any in the NWS. The QPF-based methodology provided an organizing principle for the forecast production focused on the NWS mission statement.

The QPF methodology is not perfect and remains a work in progress. There are issues (such as the relationship between PoP and QPF) that have proven difficult to surmount. However, feedback from the staff, the quality and consistency of the grids, and the mitigation of intra-office collaboration issues all point to the positive impact the methodology has had in forecast operations.

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