6.7 PRACTICAL APPLICATIONS OF EXTRAPOLATED dProg/dt IN AWIPS

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1. INTRODUCTION

The dprog/dt tool, available in D2D on AWIPS, allows a forecaster to see forecast charts from older model cycles in chronological sequence, each valid at the same target time. The idea is that the trend contains additional information than would be available from the newest run alone. One reason may be that model initialization includes errors from the previous run which are never fully corrected each cycle.

But the AWIPS dprog/dt feature doesn't display the next chart in the sequence; it only shows the charts already available. No calculations are made, and it is left to the forecaster to imagine what the next chart would look like.

This article deals with extrapolating the sequence quantitatively to produce these "next" charts from a "run" that would otherwise never be seen because the next cycle would already be started.

Qualitatively, the next chart in a sequence of linear adjustments would continue that trend into the next "run". But when three or more charts are used in dprog/dt, the trend is usually non-linear, and the next chart in the sequence is often too complicated to calculate mentally.

2. METHOD

A very good mathematical function for extrapolation is the serpentine curve, which is essentially a two-point distance weighting function. This curve does better than a polynomial fit, which often extrapolates out of control beyond the given set, although it can be made to fit every member of the set. The serpentine curve instead extrapolates toward the mean value of the set. It can be generalized to fit many values, and it can be adjusted via a blending parameter (referred to as **a**) to fit maxs and mins at every member of the set, or reproduce a polynomial fit, or anything in between. Determining **a** is the hard part, and it is usually done empirically. **a** can also vay geographically. One value of **a** may be best for the Eta on the CONUS211 grid while a different value may be best for the Western U.S.. But once **a** has been determined it must remain constant throughout the given area in order not to disturb the spatial gradients.

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Even more importantly, **a** must be the same for every field in the model, or else meteorological relationships may be damaged. The idea is that a linear blend of two or more Etas, each of which is internally valid, should also be internally valid, provided each Eta is treated as a sealed unit.

Another way to optimize extrapolation is to test every blending parameter from 0 to 2 at intervals of .01 to see which works best. Denoting these also by **a**, with two runs a blend is made by multiplying the newer run by **a**, multiplying the older run by (1-**a**), and summing the two terms. This method yields different results than the serpentine fit. Note that the sum of **a** and (1-**a**) is 1 (meaning one chart). If **a** =1 then (1-**a**) is zero, and only the newer run is used. If **a**<1 then 0<(1-**a**)<1, and the blend is between the newer and older runs. It is only when **a**>1 and (1-**a**)<0 that the trend is continued. For example, **a**=2 yields a linear trend: If the old value is 3, and the new value is 5, the next value would be 2 x 5 - 1 x 3, which is 7, i.e., a linear continuation. When the old value is 0 and the new value is 1, repeated blending converges to 1/(2-**a**). So, **a**=2/3 converges to .75, i.e., 3/4 of the way from the old to the new value. Arbitrary starting values v_0 and v_1, (with 0<**a**<2) converge to:

$$v_\infty = \frac{v_1 + (1-a)\, v_0}{2-a} \qquad (1)$$

3. RESULTS

Values of **a** were tested for Eta 500 hPa height and 700 hPa temperature forecasts during the period 01 July, 2001 through 31 August, 2001, a total of 124 runs. 12, 24, 36, 48, and 60 hour forecasts were verified against the eventual 0 hour initializations. For example, the 24 hour forecast from two runs ago was used with the 12 hour forecast from one run ago, and verified to the current 0 hour chart. Results for serpentine and non-serpentine extrapolations are summarized in Table 1.

The most surprising results came with the 12 hour 500 hPa heights. Over the entire CONUS211, the verifying chart opposed the 24-12 hour trend almost every time, at least 120 of 124 runs. That means the 12 hour forecast consistently overcorrected the 24 hour forecast when averaged over all grid points. The indicated 24-12 hour trend was almost never followed. A blend of about 3/8 of the 24 hour forecast with 5/8 of the 12 hour forecast verified about 5% better than the 12 hour forecast alone. Over the Western U.S., the gain was much larger, about 37% for serpentine vs 16% for non-serpentine blends, but in both blends the trend was followed more often than over the CONUS211.

Using three runs (not shown), the 36-24-12 trend was opposed 121 out of 124 times, using a blend of about .66 of the 12 hour plus .31 of the 24 hour and .025 of the 36 hour forecasts to achieve about 6% better accuracy than the 12 hour forecast alone.

Of course, the above data used the best **a** in each set, and **a** is never known beforehand. Unfortunately, the **a** values displayed wide variance, so using the mean of them resulted in much less improvement, and on some days, worse forecasts. For example, 20 of 62 00Z forecast blends over the Western U.S. were worse than the 12 hour forecast alone, by as much as 32.7%. (The best individual improvement was 39.8%). Within the Western U.S, improvements using the mean **a** were largest in the southern Rockies and eastern Montana, and smallest off the California coast.

For 700 hPa temperature, the signal was weaker: Over the CONUS211 the 24-12 hour trend was opposed about 105 times out of 124 with an average improvement of only about 1.7%. Over the Western U.S. the improvement was about 4%.

As forecast length increased, the signals inherent in the trends weakened, possibly because the forecasts themselves were less likely to be headed in the right direction, and often reversed themselves in later runs.

Our results showed that there was not much information to be found in the trends of successive Eta runs, but they did show that it was usually better to oppose the 24-12 hour trend when forecasting for the first 12 hours.

4. FUTURE PLANS

We plan statistical tests on the AVN and MRF, and detailed tests to determine geographical distributions of improvement (likely to be more significant over smaller areas). There may be ways to select **a** in advance based on the trend of **a** in days past.

5. ACKNOWLEDGEMENT

The author would like to acknowledge Tim Barker (NWFO, Boise, ID) for creating the blended charts and organizing the many model charts used in this study, as well as providing valuable insights and suggestions.

6. REFERENCES

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TABLE 1

ETA	24-12 hr	36-24 hr	48-36 hr	60-48 hr	48-24 hr
500hPa ht serp CONUS211	6.3% .569 (4)	1.8% 1.086 (39)	2.4% .657 (41)	1.6% .841 (39)	1.4% .923 (44)
500 hgt noserp CONUS211	4.9% .661 (3)	1.6% .905 (40)	2.3% .900 (41)	3.5% .796 (39)	1.5% .960 (42)
500 hPa ht serp Western U.S.	36.8% .115 (18)	1.4% 1.008 (45)	7.7% 1.250 (61)	22.0% 1.37 (43)	1.9% 1.11 (59)
500 hgt noserp Western U.S.	16.3% .542 (18)	6.8% .879 (45)	9.1% .984 (60)	11.6% .727 (42)	7.8% .95 (60)
700hPa T serp CONUS211	2.5% .801 (22)	0.4% .926 (19)	0.4% .866 (16)	1.3% .803 (12)	1.3% .925 (31)
700 T noserp CONUS211	1.1% .902 (19)	1.4% .836 (18)	1.5% .815 (15)	2.2% .744 (11)	1.1% .922 (32)
700 T serp Western U.S.	3.3% .892 (55)	3.3% 1.004 (55)	3.2% 1.22 (43)	5.2% .793 (40)	9.7% 1.083 (61)
700 T noserp Western U.S.	4.4% .903 (54)	4.9% .907 (55)	5.5% .837 (43)	5.9% .777 (39)	4.9% .966 (61)

Each box contains improvement (%) of the blend over the newer forecast alone, best **a** (multiplier of the newer forecast), and the number of times (out of 124 total forecasts) where the blend continued the trend.