Early Precipitation as a Predictor of Total Precipitation (informal report)

Introduction

If one adds up monthly precipitation figures over the year in cumulative fashion, the resulting sum climbs by fits and starts to the final figure. In years of high precipitation the climb is faster, on average, than in years of low precipitation. It should be obvious that, in the same statistical spirit, the six month figure for high precipitation years will *tend* to be higher than the six-month figure for low precipitation years. In other words, the six-month accumulation makes a reasonably good predictor for the coming total. Surprisingly, the three-month figure turns out to be nearly as good.

The following crude “text graphics” scatter diagram illustrates the principle:

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total prec (mm)

|1200                                    *                  *
|1100
|1000                                     *
| 900                                              *
| 800              □
| 700                *     *      *
| 600               *
| 500
| 400

        _________________________________________________________
          |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |    1st quarter prec. (mm)
                      100            200            300
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First Quarter Precipitation as a Predictor of Total Precipitation

The general trend is upward with increasing first-quarter precipitation. Each point represents first quarter precipitation vs total precipitation, treated as coordinates. The small square indicates roughly the position of the point for 2003. The three points on the line for 700 mm are not actually collinear, thanks to the crude representation used, the first two being half a line below and the third being half line above. In the next section we shall calculate a ratio that amounts to a regression line for these points. In particular, the slope of this line becomes the predictive ratio.

A Simple Method of Prediction

Recently, we have gotten into the long-range prediction business by using the precipitation over January, February and March (first quarter) to develop an idea of what the rest of the year may hold:

> "By mid-February last I had the notion that we were in for a cool, wet spring. The notion was brought on by the pattern of precipitation to that point, as well as the knowledge that we were in a La Nina year. At this point in 2012 we have the year's figure for first-quarter precipitation, an accurate predictor of expected precipitation about 7 times out of ten . . . I am predicting a better-than-average year for precipitation, as well."
>
> *Newport Bulletin*, April 7 2011

The actual precipitation figure turned out to be a record over the last 12 years, our total time of presence at Newport Forest.

The table below displays the total precipitation over the first quarter, as well as the year's total, for each of the last 10 years. Although rainfall was measured in

year	3 mo.	ann. prec	ratio
2003	73	803	11.0**
2004	95	654	6.9
2005	140	667	4.8
2006	233	1020	4.4
2007	189	674	3.6
2008	350	1227	3.5
2009	297	926	3.1
2010	99	744	7.5
2011	224	1243	5.5
2012	129	n/a	

Three-month, total precipitation, and ratios for recent years

the same manner from 2000 to 2002 as up to the present time, snowfall was not;

the snowpack was simply measured and then converted into an inferred snowfall. This is a poor way to measure equivalent water input to the property. Starting in 2003, but with two months already based on the older method, we kept a snowgauge on the property that could be heated on site to measure the depth of the corresponding water. Thus, while we have accurate precipitation data for 2004 through 2012, the figures for 2003 are somewhat suspect.

If one divides the year's total precipitation by that of the first three months, the resulting ratio gives an approximation to the expected increase for the remainder of the year. In short, if one multiples first quarter precipitation by this ratio, one obtains a prediction for the year's total precipitation. The obvious way to use the ratios is to take their average and use the resulting number to predict total precipitation for the coming year. How good is the prediction?

We have calculated two averages, a nine-year average with 2003 included, and an eight-year average with 2003 excluded (for the reason given earlier). To calculate such averages, we have added up the three-month data, then divided by the sum of the annual data:

nine-year average: 4.70
prediction for 2012: 606.3

eight-year average: 4.41
prediction for 2012: 568.9

The predicted total precipitation figures are reasonably close, given variability in the data. This raises the question, however, of just how variable such predictions are likely to be. Using the average ratio for the eight-year data, we can make "predictions" for the previous years, calculate their variance with respect to the respective actual annual figures, and establish the following interval statistics.

At 90% "confidence", the interval that results is [342, 796]. In other words, to the extent that variability in the data used are typical of the long term, we can be 90% certain that the expected annual precipitation for 2012 will lie within the interval just given, that is, we are 90% certain of receiving between 342 and 796 mm of precipitation over all of 2012 (with 129 mm of that already fallen).

It may be remarked that even the upper bound of 796 mm is far from stellar.

Regional Precipitation and Drought

Since the average precipitation over all reporting weather stations is somewhat higher closer to Lake Erie, it seemed logical to compute regional averages over an area next to the lake but deep enough to include Newport Forest and well beyond it. We therefore define the *Erie Region* as consisting of that part of southern Ontario bordered by Lake Erie on the south and including all land that is 30 km or less from Lake Erie.

The following precipitation data are taken from the Canadian Climate Normals database which includes all precipitation since 1974. The average annual precipitation figures from the following (Erie) Regional weather stations appear below:

Aylmer:	988.8 mm
Chatham:	886.7 mm
Delhi:	1009.8 mm
Harrow:	929.6 mm
Kingsville:	894.4 mm
Nanticoke:	1022.6 mm
Pt Stanley	1040.4 mm
Ridgetown:	968.9 mm
St Thomas:	1016.6 mm
Average:	973.1 mm

The average precipitation for Newport Forest over the last eight years is 884 mm. This distinctly lower figure resulted from the occurrence of four exceptionally dry years.

The word “drought” has no precise formal definition, since it is a purely relative term. A lowered precipitation that resulted in “drought” for one area might well be the average for another, where growing conditions are generally different. In spite of the lack of precision, the US Geological Survey defines three kinds of drought, as follows:

> Meteorological drought: A period of abnormally dry weather sufficiently prolonged for the lack of water to cause serious hydrologic imbalance in the affected area. (whatever that means)

> Agricultural drought: A climatic excursion involving a shortage of precipitation sufficient to adversely affect crop or range production.
>
> Hydrologic drought: A period of below average water content in streams, reservoirs, Groundwater aquifers, lakes and soils.

During the exceptionally dry years of 2004, 2005, 2007 and 20010, but particularly 2004-05, there were many observable “adverse effects” in the form of trees with dying tops, trees with pronounced leaf-curl (from drying stress) and the deaths of newly planted saplings. We shall take the four annual figures, namely their average, as a provisional “drought” baseline. The average is 684.8 mm. For ease of use, we shall round this figure up to 700 mm and define any year with 700 mm or less precipitation as a “dry” year, three such years in succession constituting a “drought” in a regional sense.

Conclusion: It appears that 2012 will be a dry year, possibly *very* dry.

A. K. Dewdney

March 28 2012