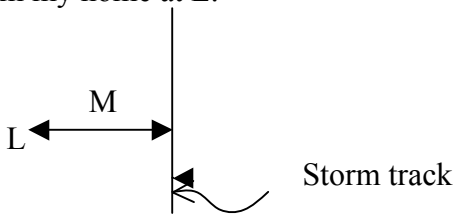
How Little Mistakes Can Lead to Big Differences in Outcomes: The Weather

J. Sussman February 25, 2010

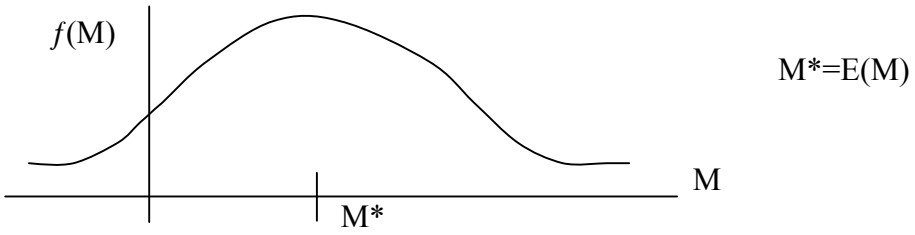
This is a highly simplified view of a complex physical phenomenon—a winter storm—intended to provide some lessons in why little mistakes in predicting events can lead to big differences in outcomes that people care about. It was "inspired" by the snowstorm that recently did not happen in the Boston Metro area.

In mid-February, a large storm front was approaching Boston, leading to dire forecasts of heavy snow, in turn leading to many event cancellations and school closings. I live 17 miles west of the city and instead of a snowstorm ended up with a dusting of less than ½". In Boston itself, the streets were merely wet. So let's see how this "mistake" happened.

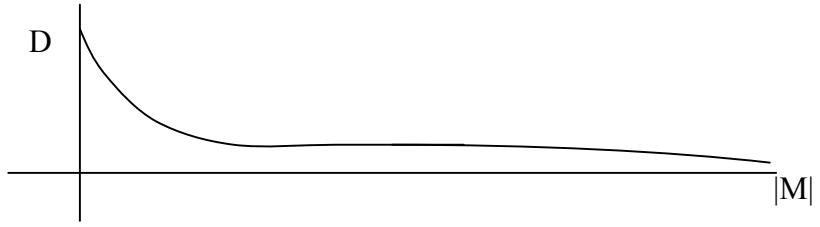
Consider the following diagram. It shows a hypothetical storm track (the vertical line) passing some distance M from my home at L.



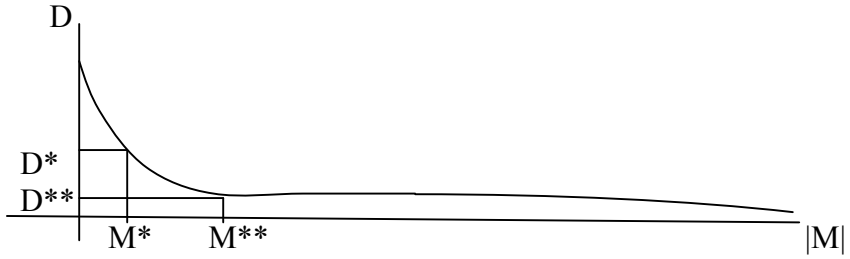
We know M is a random variable which, let us assume, we can characterize by a probability density function (pdf). We also know that the pdf changes over time. As the storm approaches, we usually can be more confident about M, so the pdf will exhibit less variance. But let's not worry about that.



Now let's further assume we know the relationship between M and the amount of snow D that my home sees. Again, we recognize this is a gross oversimplification. The snowfall will change as the storm parameters change (intensity which is a function of time, velocity of the storm—the slower it is, the more snow falls--, and doubtless other factors).



Suppose the prediction for the storm track is M* from my house. Likely, the meteorologist would use the mean value of M – i.e. M* for that guess. This means the prediction for snow depth is D*, in this instance 12". But suppose the storm shifts and the actual value (instantiation) of M is M**



So the actual snowfall is D**; in the instance of the storm that lead to this note, D** is a much smaller number than the predicted amount, like just about zero!

On National Public Radio the next day, the indication was that the meteorologists missed the storm track by about 40-50 miles. In the grand scheme, maybe that is a pretty good prediction—the "little mistake" in the title of this note. Maybe the meteorologists were popping bottles of champagne to celebrate how close their prediction had come to the actual track. But if D* is 12" and D** is about zero, that is a pretty big difference **in outcomes** as observed by the "stakeholders," such as people being impacted by the storm and making plans based on the predictions.

Now it can work the other way too, of course. There have been occasions when I have shoveled 12" of "snow flurries after midnight" off my driveway the next morning.

So why can't we make better predictions? Well, that's a story for another day.

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