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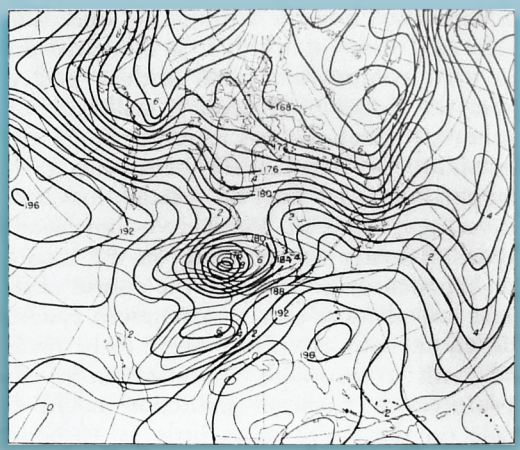

125th Anniversary
AMS
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About the cover: 63 years since ENIAC broke the ice (see page 1113)

63 Years Since ENIAC Broke the Ice

The cover displays two examples of the use of computers to predict weather. The one at upper left is a figure taken directly from the 1950 *Tellus* paper "Numerical integration of the barotropic vorticity equation" by Jule Charney, Ragnar Fjørtoft, and John von Neumann. This paper describes the very first attempt to gauge the plausibility of weather prediction by electronic computer, on the ENIAC computer at the Aberdeen Ballistic Research Laboratories. The second example shows the result of an emulation of this original computation, run on a mobile phone a few years ago by Peter Lynch, the author of a review of a book on mathematics and weather prediction in this issue.

The computation by Charney et al. started by recording weather data manually on a 19×16 grid covering much of North America, and then advanced through eight three-hour steps to yield a one-day forecast. It took about three months to set up the machine and about twenty-four hours to run. Of course this pioneering run required a great deal of experiment, and the machine was almost unbelievably awkward to work with. But nonetheless encouraging—meteorology has never looked back. This first effort required a lot of overhead that was already unnecessary a short time later. After the run, the grid data output by the machine was then recorded, again presumably by hand, as smooth contour lines which, roughly speaking, measured pressure.

The program, originally written by Lynch in Matlab, was translated into a version of Java by his son Owen. The original data used by Charney et al. was not available, but around 2000 NCEP-NCAR had performed a reanalysis of weather data for the preceding fifty years, and Lynch relied on this, using the same grid as the earlier project. PHONIAC executed the main loop of the twenty-four-hour forecast in less than one second. The graphic was of course also produced by machine, and in spite of appearance contains as much information as the earlier smooth graphs.

Lynch comments:

> The first computer forecast was made using an equation called the barotropic vorticity equation (BVE).
>
> The term "barotropic" means that the atmosphere is represented by a single layer of fluid. Under appropriate approximations, it is possible to show that the "absolute vorticity" is conserved. That is, the sum of planetary vorticity f (spin due to the earth's rotation) and relative vorticity ζ (spin due to the motion of the fluid) keeps its original value as a parcel of fluid moves along. Therefore the equation to be solved is
>
> $$(D/Dt)(f + \zeta) = 0$$
>
> where D/Dt is the Lagrangian derivative (i.e., follows the flow). This is nonlinear, making the problem difficult. The equation enables us to predict the vorticity ζ (of course f is constant in time).
>
> Due to balance in the atmosphere, the vorticity ζ and the pressure p are intimately connected, and we can get p from ζ. For technical reasons, we use the height of a fixed pressure surface, rather than the pressure of a fixed height surface.
>
> So, instead of specifying pressure at 5.5 km, we talk about the height of the 500 hPa (hectoPascal or millibar) surface, typically about 5,500 meters. The choice of 500 hPa is made because it is, in a sense, half way up: about fifty percent of the mass of the atmosphere is below and fifty percent above. Also, the divergence is small there (which is one of the key approximations made in getting the BVE equation).
>
> The heavy lines on the *Tellus* plots show the height of the 500 hPa surface. The height pattern shows where the main features of high and low pressure (or maximum and minimum heights of the pressure surface) are located. These are related to the weather patterns (in simple terms, high pressure good, low pressure bad; but it's more complicated).

A firsthand account of the ENIAC project can be found in the article "The ENIAC computations of 1950" in volume 60 (1979) of the *Bulletin* of the American Meteorological Society (the other AMS), by G. W. Platzman. You can find an account of what went into the phone program in the article "Forecasts by PHONIAC" in the November 2008 issue of the journal *Weather*.

The article by Charney et al. was published in volume 2 of the journal *Tellus*, and we wish to thank the journal for permission to use it. We also wish to thank Peter Lynch for much help and advice. The photograph of the mobile phone was taken from `http://commons.wikimedia.org/wiki/File:Nokia6300-2008-04-23.jpg`.

—Bill Casselman
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