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From supercomputers to PCs: A revolutionary development in weather prediction software

Yes, you are really witnessing a revolution in the making. Weather modelling will never be the same henceforth. The creative abilities of not just dozens, but hundreds and even thousands of scientists, engineers and programmers can now be easily unleashed to bring about dramatic progress in modelling global atmosphere. On **page 1114** of this issue, Ravi S. Nanjundiah and U. N. Sinha, the architects of this stunning accomplishment, have given a very readable account of their success in entirely rewriting the atmospheric general circulation model such that it could be on any computer – even a PC!

One of the most important applications of supercomputers is predicting the weather. In fact, India's first supercomputer (a Cray) was bought exclusively for that purpose. This was necessary, but not sufficient. The other, perhaps even more crucial item was the software to be used in weather prediction. The GCMs (General Circulation Models) used for this purpose are sets of highly complex computer programs, written generally by a large, multidisciplinary team working together closely and intensely for many years. This is because of the large number of different processes that affect the atmosphere – solar radiation, rotation of the earth, turbulent winds, clouds and so on. Inputs from experts in all these fields go into the building of the model – and programming experts make it efficient and operational. Most of the packages have evolved into their present form over the last twenty years or more, and like any evolved complex object, contain many constituents that are outdated, redundant or suboptimal. However, the various parts of the program are so intricately interlinked that trying to improve one section of the software could easily mess up some other section – one can as well try to improve a dinosaur using techniques of genetic engineering.

This is not to say that those who developed these global models were at fault. They were very successful in their own way, overcoming the serious hurdles of those times – insufficient speed and insufficient memory. The very ingenious short-cuts and tricks which allowed their models to run in a very efficient manner also made the programs very difficult (if not impossible) for others to understand. In short, weather modelling was possible only on supercomputers, and only with the help of huge and complex programs that were difficult to understand and very risky to modify. Consequently, research and training in this subject was possible at very few places, and was a very tedious and long-drawn out process.

In the meanwhile, major changes were taking place in the computer world. Power of supercomputers of yesterday is surpassed by the desktop computers of today. More advanced compilers make it easier to write more efficient programs. The emphasis is no longer on optimizing for speed and memory; what is critical is to write easily comprehensible code so that others can easily improve upon it.

With this changed scenario in mind, Ravi S. Nanjundiah and U. N. Sinha have entirely rewritten the software (the weather prediction model developed by Kalnay and colleagues, and being used at the National Center for Medium Range Weather Forecasting) to make it compact and efficient enough for running it on any computer – even a PC. They have very modestly called their efforts 'reengineering the software by exploiting the features of FORTRAN 90' – a modern and far more powerful descendent of the Old Faithful Fortran 77. They have considerably underplayed their major contribution – which consisted of being able to understand the entire model – with the whole of physics, engineering, numerical analysis and programming that had gone into the making of the GCM. Secondly, they have been able to figure out the sets of complex Fortran programs written by many others over many years (a feat even more astounding that the previous one – generally, one is unlikely to understand one's own program when examined after a gap of a few weeks!). As if this was not enough, they have reduced the size of the program from over 40,000 lines to just about 18,000, a reduction of 55%. Even more importantly, the program has been so well streamlined that it compiles without alterations on many different computers! And finally (and best of all), it is written in such a way that understanding and modifying the code has become very easy. In other words, one doesn't have to be Ravi S. Nanjundiah or U. N. Sinha to be able to make changes in the program – even you and I can do it!

It is this last feature (easy understandability and modifiability) that makes this a revolutionary development. The research and manpower training on atmospheric models is no longer a domain of the handful of centers with access to supercomputers. These activities can now be taken up virtually in any university department, or even a college. The most crucial part, however, is that a better integration routine, a better radiation model, or a finer geographical resolution can easily be incorporated in the model as and when, as and where, they become available. In other words, floodgates for a decentralized development have been thrown open. What linux is to operating systems, this software will be to atmospheric modelling!

In fact, the authors have (once again, modestly) highlighted the potential of their software for research conducted in the country. This is too restrictive. A global model, by definition, will be of interest to the whole world – and this software is therefore capable of helping the atmospheric modelling community across the globe. (If they were to convert the code to 'C', and keep it on their website as 'open source', the world will indeed beat a path to their door – i.e. homepage!)

Now that it has been done for atmospheric modelling, one wonders how many other fields are waiting for such activities to be taken up. In a much quoted, brilliant article (The Cathedral and The Bazaar) available on the web, Eric Raymond had eloquently contrasted the two styles of software development – The Cathedral (centralized, formal, accessible to a chosen few) vs The Bazaar (decentralized, informal, enabling participation from everyone). What Ravi Nanjundiah and U. N. Sinha have shown on **page 1114** of this issue is a model of scientific computing which should inspire many others to unshackle their fields as well from the constraints of the Cathedral style of development and usher in the Bazaar style – more vibrant, more efficient and incomparably faster.

N. V. Joshi

Robust MT data processing for probing Indian lithosphere

Geoelectromagnetic methods have great discriminating power in delineating deep structure and composition of the earth, as these methods can utilize large bandwidth of external and internal electromagnetic disturbances in probing the earth, from long period secular variations to short period magnetospheric/ionospheric disturbances. One such method, the magnetotelluric method (MT), involves measurement of time varying electric and magnetic fields at the earth's surface and using ratios of their spectra to estimate the distribution of electrical conductivity inside the earth, which are further interpreted in terms of compositional and temperature distributions. One of the usual assumptions in analysing these data sets is the assumption of uniform distribution of the source fields. This assumption permits one to take these as stationary time series and to use least squares statistical methodology. However there are several geophysical causes affecting the observed time series which make the time series nonstationary. For dealing with such cases, various robust statistical techniques have been developed which are not so sensitive to small departures from usual assumptions, for instance, from stationarity. On **page 1108** Bhattacharya and Shalivahan present such a technique and apply it to MT data over Dhanbad-Dalma-Singhbhum-Badampahar section. The results show that signal to noise ratio can be improved very significantly by adopting this technique. Further, the so-called dead band effect can also be removed in the processing. The authors recommend using robust techniques along with additional measurements at a remote reference site. The Department of Science and Technology has contributed immensely in promoting the development and use of MT techniques at several centres in the country for determining the deep structure of the Indian lithosphere to constrain associated geological processes. A large data set over various geological terrains is now available. The use of such robust techniques on these data sets will go a long way in obtaining reliable estimates of the structure, composition and thermal state of the Indian lithosphere.

R. N. Singh