Whither weather in parallel?

This refers to the informative review by B. K. Basu on 'Usability of parallel processing computers in numerical weather prediction' (*Curr. Sci.*, 1998, **74**, 508–516). I had the privilege of attending that fateful meeting at DST 23 November 1992, which was the prelude to the projects reviewed in the above paper. The meeting was attended by representatives of the computing as well as weather modelling community. To some, the meeting was largely a formality to bless the procurement of the next version of a multi-crore Cray YMP supercomputer, with all its strings attached. Their agenda was merely to determine which version of the compiler to ask for and what debugging features should be on it. Even the Cray representatives were in the audience to take notes. It came somewhat as a surprise, when the Secretary, DST, wondered aloud whether Indian scientists would be willing to take up the challenge of demonstrating the awesome weather prediction code on their own parallel computing systems. They did. DST proceeded to invest some 10% of the price of the Cray to fund four different groups in the country to implement the T-80 code (standard on the Cray-XMP) on their systems. The budget covered manpower costs as well as substantial hardware procurements. Within months, the code was operational on the NAL Flosolver and in a couple of years, all the different groups had got the code operational. NCMRWF and Basu in particular, put in a lot of effort to assist the different groups in assessing the quality of computation as is evident in the above paper.

The project was unique in the history of Indian science. Here was a centrally-funded exercise of immense application potential and serious computational effort that was actually carried out to its logical conclusion, rather than extended indefinitely and inconclusively. However, while the project appears to have concluded one now wonders what next? Did we have to spend so much money to merely confirm that the T-80 code was executed on Indian parallel computers, but not necessarily as fast as the 'operational requirement'?

To this writer's mind, the project has thrown up several new questions and perhaps also a few answers: How significant is the question of CPU efficiency? Yes. We now see that parallel computers deliver only some 6–8% of their peak power. But how do parallel computers rate in terms of 'bang for the buck'? The new 4-processor NAL machine cost Rs 12 lakhs to string together. It is faster than the Cray XMP. What is the significance of precision? The Cray was touted all along as a 64-bit machine whose precision was indispensable to make the right predictions. This project actually demonstrated that one can go far enough with 32-bit. As one would have expected, it actually showed that the quality of inputs is much more important than the precision of computations. Obviously, one can't go very far with 64-bit arithmetic while our measurements of inputs are largely in the 4 to 8 bit range of precision. What is the 'effort' in translating sequential code to parallel? If four different teams in the country did it at some 5% of western manpower cost, does effort really serve as an argument? Can we instead look at this trained manpower as an asset that can be used to parallelize newer codes, hopefully of our own development and custom designed to model *our* sub-continent? Or does the manpower have to disperse as EOUs to work on the Y2K problem? If it hasn't done so already, can it be harnessed to contribute to the *quality* of Indian weather prediction? Indian parallel machines obviously can't beat the latest Cray. If they did, Cray Research would not have been worth being taken over. The bottom line is, can parallel machines predict the weather, and do so at acceptable speed and with acceptable quality? The results of the project review appear to suggest they in fact do.

Several positive conclusions can be drawn from the projects. Indian groups were able to demonstrate that they have not merely been waving their arms about achievements in parallel computing. The T-80 code was considered by some to be beyond the comprehension of our parallel computing scientists. It was not. The myth that only a vector supercomputer can do the job was demolished. Also, it was discovered that the T-80 code had been engineered with system calls to use special design features of the Cray. The code was therefore not 'standard FORTRAN', rendering any comparison with other machines patently unfair. Nevertheless, the speed of computing achieved by Indian parallel machines appears to be impressive. The bottom line here is that we should be able to predict the weather faster than it happens. If the NCMRWF criterion is 15 minutes per day, we should have a 14-day prediction in three and a half hours. This is a demanding speed. It in fact begs the question. 'What is the system doing the rest of the day that can't be done by smaller systems?'. Even so, today's parallel computation technology in the country surely is able to beat even this spec. If the 8-processor i860-based system did a day's prediction in 70 minutes back in 1996, the new NAL 4-processor machine does the same job in 11 minutes – even this machine could do a 14-day computation in under 3 hours.

A major outcome of the parallel computing effort in the country and the T-80 parallelization exercise in particular is the reinforcement of the belief that tools are only as good as the people who handle them. For decades, Soviet scientists sent the shivers down the spine of the 'free world' with their accomplishments in aeronautics, space and nuclear science. They did so without the kind of tools including computers that we in Third World India take for granted. At the other extreme, we have groups, with world class infrastructure, who spend a lifetime doing little else apart from talking about 'capability' and harnessing more of it. In this context, the achievements of at least some of the parallel computing groups in the country are laudable.

The ultimate customer for the weather prediction effort is possibly the farmer. He doesn't even realize how instrumental he was in inducting all this technology to predict the weather. Floods, drought and the monsoons continue to put him on edge almost as much as they did decades ago. And the charming lady on TV continues to inform us everyday that 'rain or thundershowers are likely in one or two places' and 'there will be no significant change in day temperature'. While we now have information on how well parallel machines compute code, we still don't know how well *the code predicts the weather*. Obviously, this involves weather scientists and the enormous infrastructure they require to keep a tab on the inputs of today that determine the weather of tomorrow. What is the cost of predicting weather? What are the returns? How much are we willing to invest on fundamental research to understand weather better? Particularly, on weather that is relevant to *our* sub-continent, like the monsoons. How relevant is the T-80 or next version of code to the Indian context? Our land borders are strung with sophisticated radars ready to track enemy planes in the event of a war. Do we still have money left for hardware like digital radar along the coasts and at metropolitan centres to give accurate short term pictures of *daily* interest to fishermen and city dwellers? What is the investment on such infrastructure and how is such investment affected by the choice of which computer is installed at the NCMRWF? Is there an off-the-shelf solution like Microsoft Outlook or Netscape that comes packaged for weather prediction with the Cray or some other import? Is the challenge perhaps in the nitty gritty of collecting readings from the soil, the seas, the stratosphere and the mountains? Or perhaps in getting a large group of foot soldiers, technicians, engineers and scientists scattered round the country to work together? Or maybe in weaning 'whizz-kids' from the keyboard and mouse and onto the fields? In short, can someone paint the broad picture?

Judging from the reaction of a national daily (*The Hindu*, 7 April 1998), Basu's paper has served its purpose: the ground is being prepared for another ambitious procurement. DST can justifiably take the credit for having got most of the parallel computing groups in the country to rise to the challenge of weather computation. However, this vision was obviously not far-sighted enough to tackle the next challenge.

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TECHNICAL COMMENTS

Major tectonic elements of western Ganga basin

The article 'Some major tectonic elements of Western Ganga basin based on analysis of Bouguer anomaly map' (Mishra, D. C. and Laxman, G., *Curr. Sci.*, 1997, **73**, 436–440) is based on the spectral analysis of Bouguer anomalies and residuals obtained by fitting a second order surface to the Bouguer anomalies.

Data limitations

The map used is presumably the NGRI Bouguer anomaly map published on $1:5 \times 10^6$ scale and some maps on 1:250,000 scale available with the authors. The accuracy and source of the primary data are not given. If these maps are the same which were compiled by the gravity group of the NGRI in the 1960s, then the interpretation by using interpolation, as the digitization would imply, does not justify the used numerical techniques. The reason is that such interpolation amounts to assuming that some higher derivatives do not exist which is not true as the gravity field satisfies the La'Place equation. Also, the digitization at a uniform grid interval means that different wavelengths have been mixed together. This makes illogical, then, to break the field again into spectra for power analysis and use the same as a basis for interpretation. It amounts to reinterpreting the assumptions introduced to begin with.

Moreover, the accuracy of the compiled data with which I also was associated does not warrant any reliance on 'kinks' which could just as well be the artifacts of contouring and beyond the error limits of the compilation.

Boundary of the Ganga basin

The authors state that the Ganga basin extends up to the Main Boundary Thrust (MBT) along which the Indian plate is presumed to have subducted below the Eurasian Plate. The India–Eurasia plate boundary is at least 300 km to the north from the MBT[2–4].

Their figure 4 shows the Ganga basin to extend southwesterly from Moradabad through Aligarh to a point south of Jaipur (app. 76°E, 26°15'N), though in the text (p. 436), they state the Ganga basin to be 'an east–west oriented basin along the Himalayan foothills'. It is wrongly stated (p. 436) that the Bouguer anomaly amplitudes vary from – 50 mGals to – 300 mGals over the Ganga basin. Their figure 1 does not show such a variation. The lowest contour shown is – 220 mGals in the NE corner of the map. On the NGRI Map[1], the –300 mGals contour falls far to the north in the neighbourhood of Badrinath.

This makes correlation of Bouguer anomalies with geographical limits of the basin, to say the least, out of context.

The presumed Delhi–Haridwar ridge and the Delhi–Sargodha ridge

The statement that the Delhi–Haridwar Ridge is 'the most important feature' of the map on figure 4 along with a block uplift east of Delhi' is unwarranted. The data limitations apart, as pointed out above, figure 4 does not show the con-