arm DDT

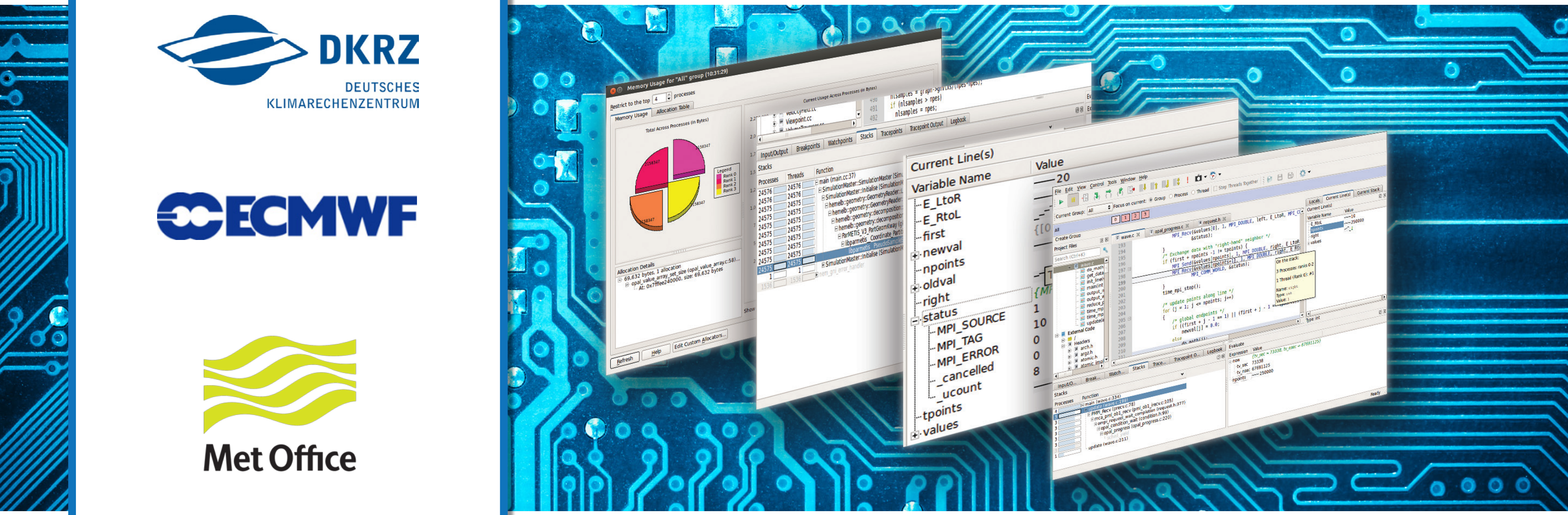
Weathering HPC challenges: Developing Code for Weather Forecasting and Climate Modelling

arm FORGE

DKRZ DEUTSCHES KLIMARECHENZENTRUM

ECMWF

Met Office



While the predictability – or seemingly lack thereof – of weather patterns is a headline-grabbing topic, great strides are being made to increase the fidelity and range of forecasts on both a local level and global scale. At the heart of this lie high-performance computing (HPC) and Arm DDT.

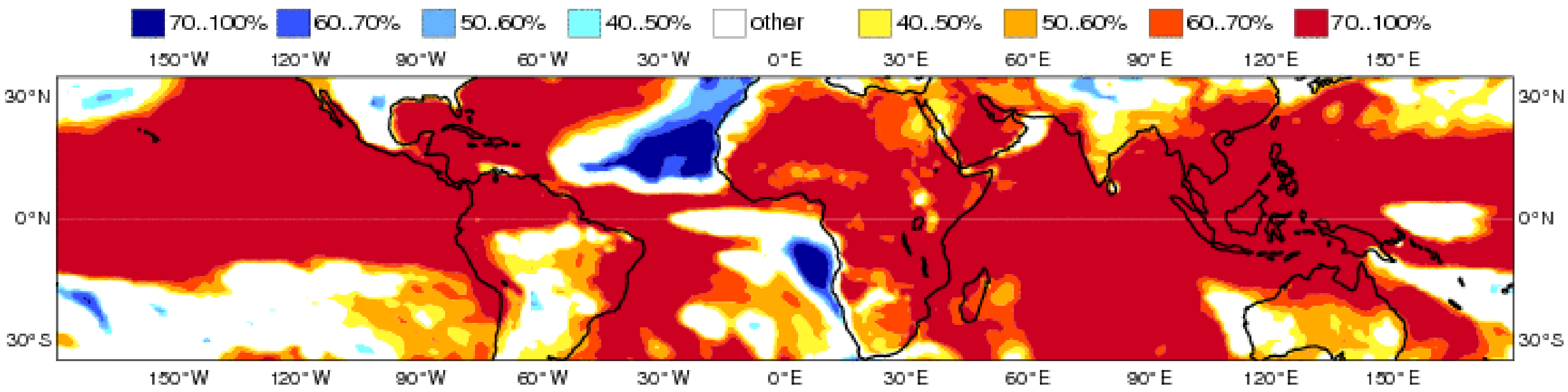
Dr Paul Selwood, manager of HPC optimisation at The Met Office, one of the world's leading weather forecasting and climate research organisations emphasizes the need for HPC, 'Over the past 30 years, we have been able to improve the accuracy of our forecasts by roughly one day per decade. This means that every 10 years, a forecast will have the same level of reliability at three days out that it previously did at two days out,' he said. 'HPC is absolutely central to what we do.'

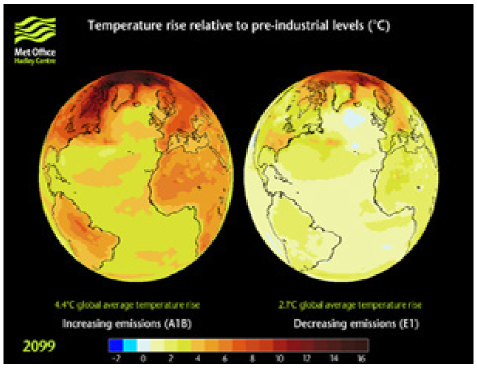
Capability needs consistency and reliability too – and unique demands are placed on HPC systems. The reliability of the code in particular can be of paramount importance given that operational runs must produce results to very tight timeframes. Ensuring that all bugs are removed from the system is therefore critical. With this in mind, both The Met Office in the UK and the European Centre for Medium-range Weather Forecasts (ECMWF) chose to deploy a powerful debugger, Arm DDT.

'Our developers using DDT say that it does what a good debugger is supposed to do, it does it fast and it does it in a very intuitive way,' said Mike Hawkins, head of the High Performance Computing and Storage Section at ECMWF. 'We needed a solution that could not only handle our very complicated code, but that could be used in a wide range of scales.

These scales range from people who are developing pieces of code on their desktop machines – or perhaps even on one or two nodes on the supercomputer – right up to a full configuration, which takes up to 100 nodes of our machine. Having the same tool work across that entire spectrum is of definite benefit to us.'

Likewise, the demands at The Met Office meant that any chosen debugger needed to be able to handle complex code development and porting work. 'DDT was one of the very few parallel debuggers that could fit in well with the types of workflows we have,' said Dr Paul Selwood. 'The right debugger can save everyone quite a bit of time, and that's what we're really trying to do with DDT – improve the time to solution for a development or investigation of a scientific problem.'



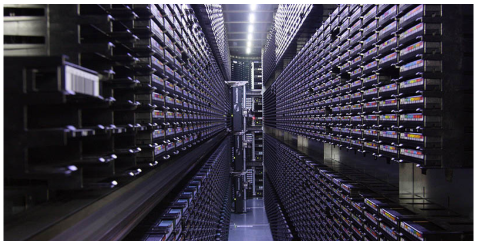


He added that within the new system, DDT has found a number of problems relatively quickly, which in turn has enabled those bugs to be fixed equally as fast.

Arm DDT ensures that even the most complex multi-threaded or multi-process software problems can be solved quickly and easily: Its speed and ability to highlight erroneous behaviour even at the high scales of weather or climate simulations is unique. It also maintains an automatic, always-on log of debugging activity so that users can easily go back and review the evidence for things that might have been missed at the time. Users see process and thread anomalies instantly with the parallel stack display – the scalable view that narrows down problems for any level of concurrency: from a handful of processes and threads to hundreds of thousands.

Arm DDT also lowers the risk of major changes during code development – by working with software version control systems to automatically log values of variables across all processes at each changed section of code. This enables users to track down exactly how and why a particular change introduced problems to the code. This is particularly useful for The Met Office which is taking the rather unusual step of utterly rewriting its codes with new algorithms. 'It's a different approach to programming compared to what we have traditionally used,' Selwood explained. 'It's a long-term project and it's going to take a while before we really see the benefit, but given the direction HPC architectures are heading in with ever increasing demands on parallelism and scalability, it's something we need to do. Our current codes are 30 years old and showing their age.'

Much like weather forecasting, climate modelling is fundamentally tied to high-performance computing. According to Thomas Ludwig, director of the German Climate Computing Center (DKRZ), climate modelling is not a single batch job issue, and the workflows are becoming increasingly complex. Chain jobs exist with these complex relationships, and programs are being composed of several binaries (e.g. atmosphere, ocean and coupler) that work at the same time. The demands are high as relevant computations need millions of core hours and produce hundreds of terabytes.



'The main challenges are the scalability of codes for an increasing number of cores and a rising amount of data that needs to be stored,' Ludwig explained. 'These are challenges we are yet to overcome. Scalability is a severe problem that perhaps has no solution – we simply have to continually work on it by analysing and improving code sections, and improving the load balance. As for the amount of data, we are looking into compression and re-computation.'

In terms of software tools, DKRZ has also deployed Arm DDT as the debugger of choice. Through Arm DDT, DKRZ staff can save time finding bugs and problems in applications, in particular for complicated user cases. And as HPC architectures evolve, Arm DDT will continue to be the world's most scalable and sought-after debugger.