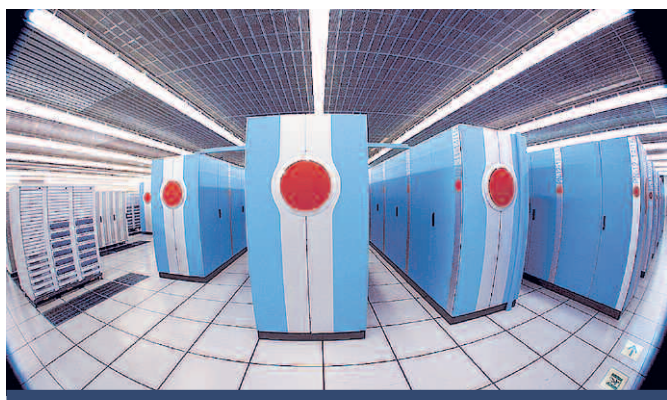


In the animation at www.earthsimulator.org red dots represent heavy rainfall, some of these develop into hurricanes or typhoons. Sea ice at the poles grows and shrinks with the seasons. You can even see how tropical downpours develop through the day and sweep across continents. Note also how the Greenland ice sheet deflects weather systems.



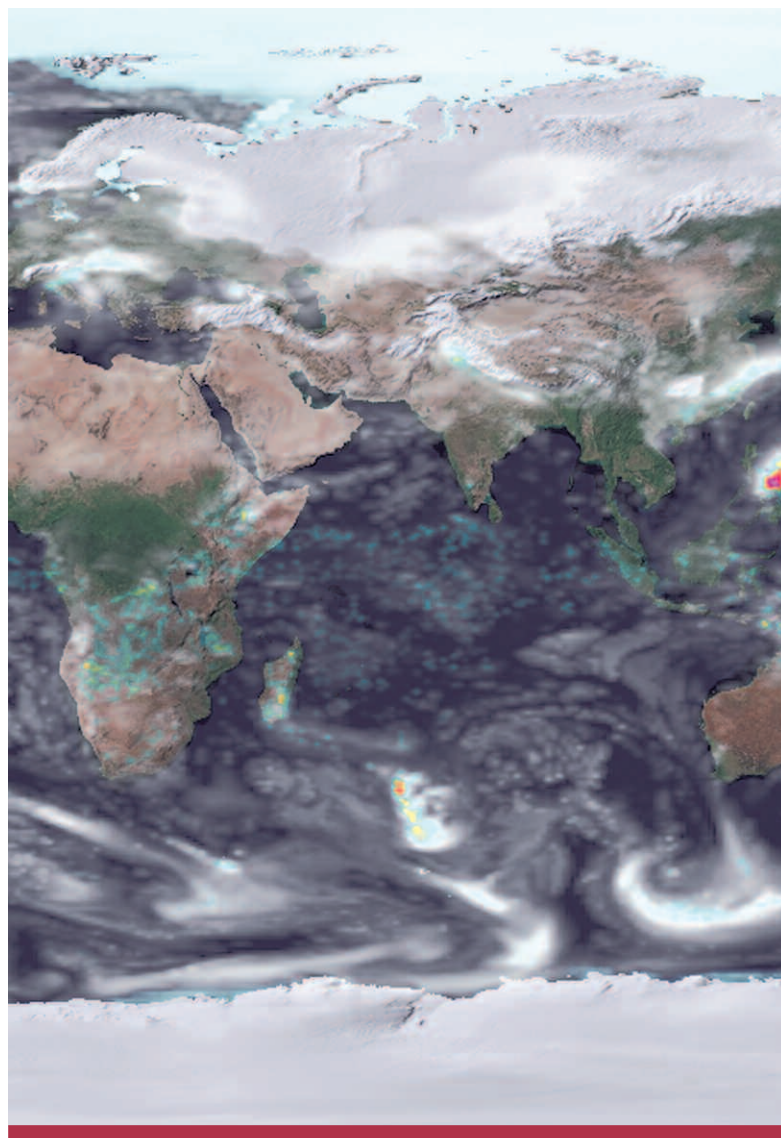
Earth Simulator captures the planet's climate in stunning detail: hurricanes, typhoons and regional rainfall patterns. John Donners tells us how.

The Earth Simulator is one of the fastest supercomputers in the world available to climate researchers. It is located in Yokohama, Japan, and scientists from the UK, as part of the UK-Japan Climate Collaboration (UJCC), are now using it for very large computer simulations.

Scientists devised the Earth Simulator after a United Nations meeting in Kyoto in 1997 to reduce uncertainties in climate simulations. It is installed in a building that protects it against lightning, earthquakes and other disasters, and it can compute in one second what would have taken 1000 years on a supercomputer from 1950. Maybe the red dot on every cabinet of the Earth Simulator acknowledges HAL 9000, the intelligent computer from the movie *2001: A Space Odyssey*.

A climate simulation can be seen as a large digital camera that makes a picture of the atmosphere and the oceans every hour. A camera with a higher resolution allows you to see many more details that help to interpret the picture. Our aim was to see what we can learn about the global climate from the details. However, that is much easier said than done, and we soon ran into problems.

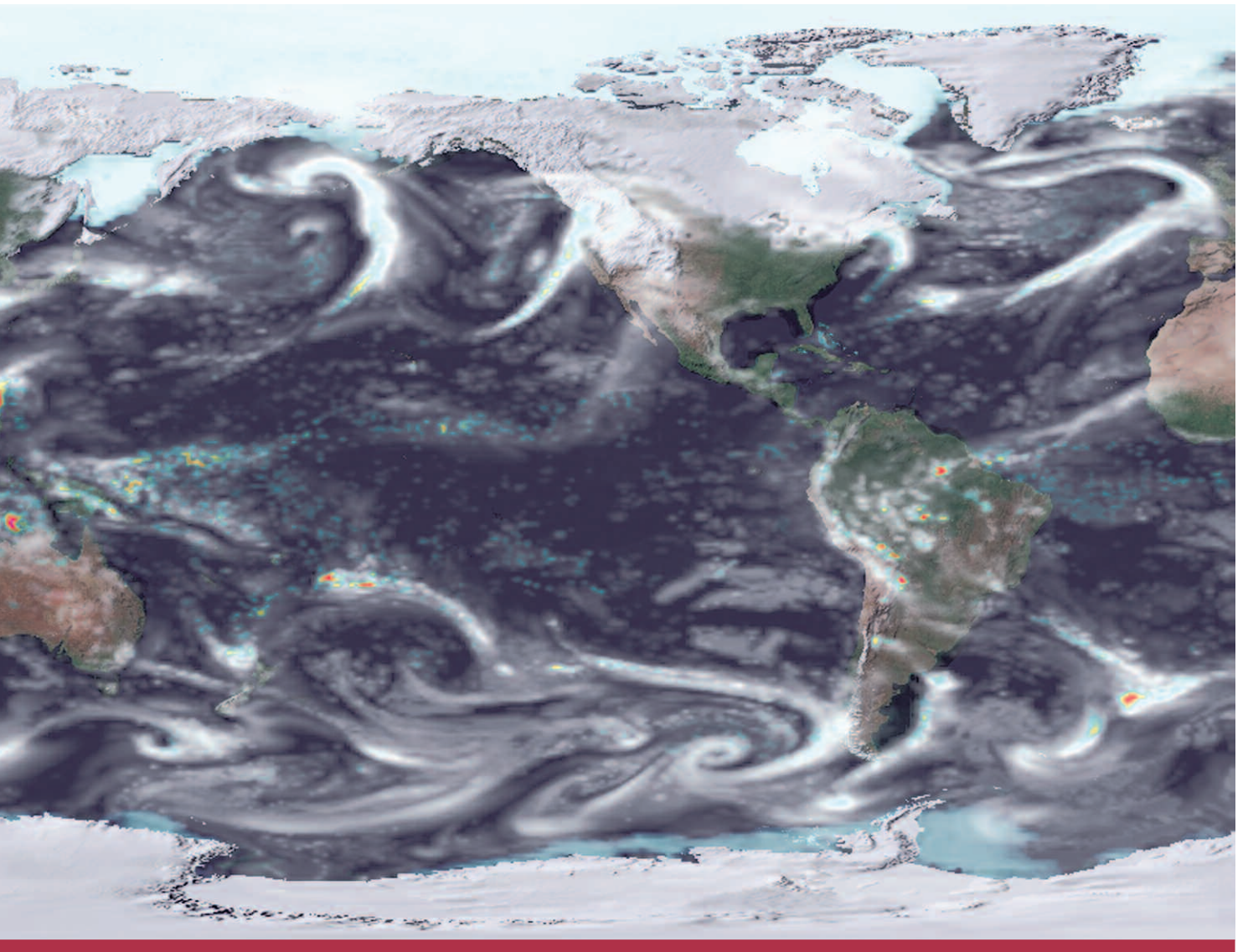
One of the most urgent issues was how could we use all that computing power efficiently, since the Earth Simulator is structured quite differently from supercomputers in the UK.



Simulating

Compare a Ferrari to a Volvo on a road with speed bumps: the Ferrari races up to the speed bump, but then needs to brake and the Volvo can catch up. Luckily, we could remove most of the high speed bumps, which more than doubled the speed of our model and enabled us to simulate the climate globally in more detail than before.

Some important phenomena have already emerged out of our increased resolution. Firstly, tropical instability waves, sharp wiggles in the ocean that are too small for 'normal' climate models, transport heat to the equator and hence warm up the tropical ocean. This is important to properly simulate El Niño Southern Oscillation, an indispensable ingredient of any state-of-



ing planet **Earth**

the-art climate simulation. Secondly, the Earth Simulator allows us to more accurately represent mountain ranges and so the model 'rains' in the 'right' places. In coarser resolution models the Alps causes rain in Paris. Where it rains is important because this affects crop and tree growth. Yes, it is this detailed. And thirdly, our highest resolution model simulates typhoons and hurricanes, known to cause severe damage. Of course it won't predict exactly when they will occur, but the model can tell us whether we can expect to see more in a warmer world and whether their intensity or path will change. New simulations will include increasing carbon dioxide concentrations in the atmosphere in line with current trends. This should give us

better estimates of changes in extreme weather due to climate change, which is of great interest to government and industries: Hurricane Katrina, by itself, killed more than 1800 people and caused over \$81 billion dollars worth of damage.

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See www.earthsimulator.org.uk for animations of Earth Simulator in action and to browse through our catalogue of simulated climate pictures.