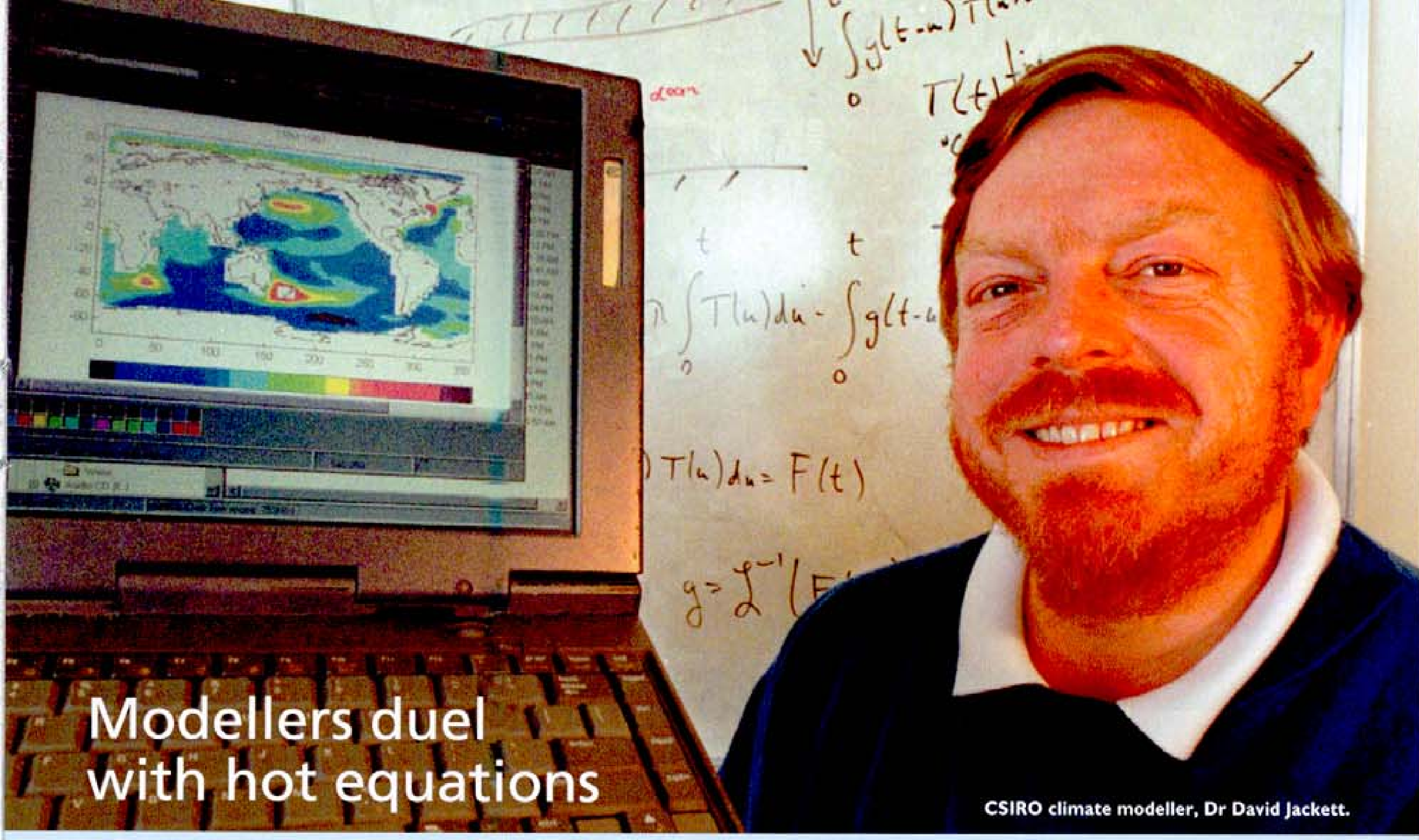

Modellers duel with hot equations

CSIRO climate modeller, Dr David Jackett.

IN 1996, the Intergovernmental Panel on Climate Change (IPCC) suggested global sea levels could rise between 20 and 86 centimetres by the end of next century, depending on greenhouse gas emissions. In making these projections, the IPCC relied on the work of ocean modellers: scientists who use powerful computers to answer basic questions about ocean behaviour.

More than half of projected sea-level rise is due to thermal expansion caused by heat entering the ocean from the atmosphere. Melting of the polar ice caps is the second largest contributor. Given the relative importance of ocean heat uptake, the accuracy of sea-rise forecasts depends to a large extent on the ability of modellers to translate this process into mathematics.

One of the models used as a basis for the IPCC estimates was developed by Dr Tom Wigley from the National Centre for Atmospheric Research (NCAR) at Boulder, Colorado, US and Dr Sarah Raper from the University of East Anglia, UK. Theirs is a relatively simple representation of climate change that is used to predict climate responses to a variety of greenhouse gas emission scenarios. Its accuracy is 'tuned' with more sophisticated, general circulation models (GCMs) that account for complex interactions between the Earth's oceans, ice and atmosphere.

General circulation models require enormous computing power, taking months or even years to complete a simulation. During the International Year of the Ocean, three GCMs, developed by the NCAR, the Hadley Centre in Bracknell, UK, and by CSIRO, will be run on the latest breed of super-computers. Their predictions will underpin the IPCC's next round of global warming and sea-level-rise estimates, and enable verification of 'simpler' models such and Wigley and Raper's.

Another modelling team with a keen interest in the GCM predictions includes Dr David Jackett and Dr Trevor McDougall from CSIRO Marine Research and Dr Matthew England from the University of New South Wales. They have developed a 'simple' climate model that includes in greater detail the major physical processes – such as ocean currents and eddies – that affect the transport of heat from to the ocean depths from the top 100 m.

Eddies are the oceanic equivalent of atmospheric highs and lows. They are circular patches of high or low water that form on the edge of strong currents, 100-200 km across and up to 1 km deep. Their circulation – clockwise or anti-clockwise currents of up to four knots – can last for several years, mixing temperatures, salinity and chemical properties, from the surface layer to the ocean interior.

Jackett and his colleagues believe their model of ocean heat uptake, if linked to the simple climate model used by the IPCC, would improve the accuracy of global warming and sea-level predictions. In September 1997, he took up an invitation to work with Raper on a comparison of the two models. They found that the Wigley/Raper model, in response to an expected slowing of ocean circulation with rising temperature, forecast an increase in future sea level rise, while the Australian model predicted a decrease.

'Interestingly, both observations can be understood as inevitable consequences of the mathematical assumptions of the models,' Jackett says. 'Our representation of ocean physics points to much less penetration of heat into the deep ocean. In terms of sea-level rise, this could mean a lesser increase – down by between 10-20% – in the IPCC estimates of future thermal expansion.

'At this stage it is not certain which of these behaviours is correct, since a complete analysis of how heat enters the interior ocean has yet to be made in one of the more complex global circulation models.'

Jackett says it is amazing, given the potential effects of sea-level rise, that such a fundamental question of how heat enters the ocean has not been fully answered. He says the analysis of climate data generated by the complex global climate models will provide scientists, both locally and abroad, with a much better understanding of the deep ocean's role in extracting heat from the climate system.