2100: A world of wild weather
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Think back to the hottest summer you can remember. Now imagine a summer like that every year. For those of us who are still around by the end of the 21st century, this is what we can expect, according to a new index that maps the different ways that climate change will hit different parts of the world. The map reveals how much more frequent extreme climate events, such as heatwaves and floods, will be by 2100 compared with the late 20th century. It is the first to show how global warming will combine with natural variations in the climate to affect our planet.

"We hope it will help policy-makers gain a quick overview of the scientific facts without getting lost in the detail," says Michèle Bättig of the Swiss Federal Institute of Technology in Zurich, who created the index with colleagues after talking to delegates at the 2005 UN Climate Change Conference in Montreal, Canada. The index allows anyone to compare the severity of the predicted effect of climate change on a chunk of the Amazon rainforest, for example, with its effect on a corner of Antarctica.

The results are presented on a global map (see top image), in which the areas experiencing the greatest changes are shown in the darkest shades. Swathes of the tropics and high latitudes are coloured a foreboding brown, signifying the most marked changes.

Perhaps the most startling feature is how few areas remain unscathed. "This reinforces what much of the piecemeal climate science is telling us - that many places will face severe challenges," says Neil Adger of the UK's Tyndall Centre for Climate Change Research at the University of East Anglia in Norwich, Norfolk. In the coming decades people in these areas could find it difficult or impossible to adapt to the changed conditions, he adds.

For many parts of the world it seems this trend is already under way. Climate scientists announced last week that 2006 has been the hottest year on record for the US, topping nine years of almost continuous rises. Meanwhile, Europe experienced severe heatwaves in both 2003 and 2006, and for the UK 2006 was the warmest year since records began. Nor does it look as if the mercury is going to stop rising. In an energy technology outlook study published last week, the European Commission warns of stark changes for EU countries over the coming century, including shrinking forests, floods, drought and the drying out of fertile land - unless radical steps are taken to

**Image: Climate change index, with greater changes in darker shades**
**Image: Additional number of hottest years within a 20-year period**
**Image: Additional number of wettest (+) and driest (-) years within a 20-year period**

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combat climate change.

Yet in a global context, even these dramatic changes seem relatively modest. On Bättig's climate change index map Europe, the US and Australia are coloured in shades of yellow and orange, putting them at around 6 or 7 on the scale. Parts of South America's Amazon rainforest and Africa's Congo basin fare much worse, with a predicted climate change index of around 11 (Geophysical Research Letters, DOI: 10.1029/2006GL028159).

The index was calculated from nine separate indicators of climate change. These included years that are hot, dry or wet overall, and also those in which the months of June, July and August, or December, January and February, would be extremely warm, dry or wet. Bättig and her colleagues divided the world into squares measuring 375 by 375 kilometres, and for each indicator they identified the extreme climate events that in the period 1961 to 1990 would have been expected to occur in 1 year in 20.

Using three different global climate models, each based on a mid-range forecast for greenhouse gas emissions, they computed the likely change in frequency of these extreme events during the period 2071 to 2100. The changes were then weighted to provide a single number between 0 and 19 for each grid square. A value of 0 equates to all nine climate indicators remaining as 1-in-20-year events, whereas a value of 19 equates to all climate indicators becoming annual events.

"It is a very striking graphic," says Chris West, director of the UK Climate Impacts Programme at the University of Oxford. While other climate change indices have compared changes in average temperature or precipitation, this is the first global index based on climate extremes. "It focuses the debate on the big events we ought to be worrying about," says Tom Downing of the Stockholm Environment Institute and author of The Atlas of Climate Change.

The new index has its limitations. "Places that become hotter will face different problems to places that become wetter, but the index implies that they have the same level of risk," Downing says. Bättig has addressed this problem with separate maps for each climate indicator. The first of these, representing additional hottest years, shows the world in an ominous deep red (see Map). When it comes to overall temperature, 1-in-20-year temperatures are set to become annual events by the end of this century. "What we take now as a surprise will be normal", says Downing.

Meanwhile, Antarctica and the Arctic can expect exceedingly wet years to become 13 times more likely, while tropical regions like the Amazon rainforest and the Congo basin will suffer droughts around 13 times more frequently (see Map). Rainfall in places in the middle, like Australia and the southern US, is expected to remain fairly close to what it is now.

Where natural disasters now take their toll

Climate change is not the same as climate impact, as changes in temperature and precipitation will affect people in some regions far more than others. For example, sub-Saharan Africa is a drought hotspot, while some parts of south-east Asia are vulnerable to storms and flooding. Any changes in climate here could affect people more severely than, say, those in Europe.

Art Lerner-Lam and colleagues from Columbia University in Palisades, New York, have sketched out which natural disasters pose the greatest threat to life on a global map of their own (see bottom image, right). They produced their map by combining data on hazard frequency and intensity from the recent past with population density, GDP and geographical factors such as land use. This has already influenced organisations such as the World Bank in deciding which regions should be prioritised for emergency lending.

The next step will be to overlay the extent of climate change, as revealed by Bättig's index for example, and see how this affects the frequency and severity of future hazards. "We are working on
this right now," says Lerner-Lam.

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