THE world is likely to heat up by an average of 11°C by the end of the century, the biggest ever study of global warming showed yesterday.

But the earth could be even hotter under some scenarios where temperatures could be up to 35°C hotter than present levels.

If true, the rise, at a rate of 0.1°C per ten years, would be dangerous for the world's climate system. It would change the weather patterns of the world, melt the polar ice caps and warm the seas, causing a surge in sea levels threatening the lives of billions of people.

The findings come from a study which took into account the warming effect of 100,000 homes in Britain, and is more than twice the rate of warming observed in the last 150 years.

Researchers David Brierley, from Oxford University, said, "A 11 degree warmer world would be an essentially different world."

"Warming is not constant at all latitudes and is much higher at the poles. The emissions could double world leaders need to take action on global warming and to prevent a rise in temperatures of more than 2°C."

BY SUEZ AUSTIN

That's how much hotter scientists believe the world will get ... and it will be worse in Britain.
Grand Ensembles: Confidence, Uncertainty and Probability in Climate Change Forecasts

Jim Hansen
MIT, EAPS
jhansen@mit.edu

Thanks to the climatedprediction.net team (esp. Myles Allen, Dave Stainforth, Lenny Smith) and the Climate@home team (esp. Bill Collins, Don Middleton, Alan Robock)
Global Circulation Models (GCMs)

Solve the Navier-Stokes equations on a latitude x longitude x height grid.

Parameterize processes too small to explicitly resolve e.g.:

- Clouds
- Convection
- Precipitation
- Atmospheric gravity waves
- Radiation
- Land surface effects
- Boundary layer effects
- Sea ice

Figure courtesy of Emily Black, University of Reading
How we account for sources of uncertainty

Natural variability: initial condition ensembles

Model uncertainty: multi-model ensembles

BC uncertainty: multiple scenarios
A Grand Ensemble with a general circulation model requires huge computing capacity

Hence climateprediction.net

> 100,000 participants from 150 countries (34,000 active)
> 84,000 simulations (each 45 years long)
> 6,000,000 model years (compare to 6400 for NCAR IPCC)
> 9,500 years of computing time
### Beta testing experience

**Unexpected behaviour of your model?**
Does your model behave differently than expected (e.g., losing timesteps, etc.)? Let us know...
- **Moderators:** David, Duncan
- **Topics:** 7
- **Posts:** 39
- **Last Post:** Sat May 31, 2003 12:04 pm

**Result and intermediate data upload**
Any strange behaviour in respect to uploading data or results?
- **Moderator:** cat
- **Topics:** 4
- **Posts:** 10
- **Last Post:** Mon Jun 2, 2003 9:16 pm

**Participation in the experiment**
Any remarks or suggestions about participating in our experiment?
- **Moderators:** David, Duncan
- **Topics:** 1
- **Posts:** 4
- **Last Post:** Fri May 23, 2003 2:56 pm

### Technical issues/queries/suggestions

**Computing efficiency**
Any concerns about efficiency of modelling or data compressing or something else?
- **Moderator:** post176
- **Topics:** 4
- **Posts:** 22
- **Last Post:** Mon Jun 2, 2003 6:15 pm

**Climate model on Linux, commandline option...**
We are planning releases for other systems - e.g., Linux, Mac OS X? Any comments, suggestions, ideas what else...
- **Moderator:** cat
- **Topics:** 3
- **Posts:** 13
- **Last Post:** Wed May 28, 2003 9:26 am

**Setup, debug, network install**
Comments/advice about such things as proxies, debugging, software parameters, memory leaks, etc. (shortly, things for geeks)
- **Moderator:** cat
- **Topics:** 7
- **Posts:** 45
- **Last Post:** Mon Jun 2, 2003 12:38 pm

**Other problems when running model**
Troubles with overloading your computer? Concerned that your laptop is not powerful enough? Advice?
- **Moderators:** post176, Dave, Duncan
- **Topics:** 3
- **Posts:** 15
- **Last Post:** Wed May 28, 2003 12:21 pm

### Climatology/climate science

**Extreme climate**
If you think you've got something pretty cool (or not) in your model, why not tell the others?
- **Moderator:** Simon
- **Topics:** 2
- **Posts:** 7
- **Last Post:** Mon Jun 2, 2002 9:53 pm

**Ocean, global warming**
Concerned about ozone and global warming in connection with this experiment?
- **Moderator:** Simon
- **Topics:** 2
- **Posts:** 3
- **Last Post:** Tue May 27, 2003 10:49 am

**General discussion**
General forum about discussing climate issues. If anything attracts more attention it can be spawned as a separate topic...
- **Topics:** 1
- **Posts:** 3
- **Last Post:** Tue May 27, 2003 11:29 am
climateprediction.net goals

- **Climate research:** quantifying uncertainty in forecasts of climate change.
- **Computational research:** develop systems to carry out public resource distributed computing (PRDC) modelling research.
- **Public awareness:** improve public understanding of the nature of uncertainty in climate prediction.
Climateprediction.net: experimental design

**First Experiment:**
Unified Model with thermodynamic ocean (HadSM3)
[Full climate resolution atmosphere: HadAM3; 3.75 x 2.5]

**Future Experiments:**
- Dynamic ocean release. Transient 20th century simulations.
- Paleo-simulations.
Frequency distribution of simulations and model versions

To find potentially realistic model versions we remove those which are unstable in the control.

The remaining negatively drifting 2xCO2 model versions are an unrealistic consequence of using a slab ocean.
Grand ensemble frequency distribution of climate sensitivity (~1000 members, 6 parameters)
Can we constrain the sensitivity?

- Observations do not constrain the distribution (annual mean temp, SLP, precip, and atm/ocn heat fluxes)
- Mt Pinatubo does not constrain the distribution
- LGM temperatures do not constrain the distribution

Do we really need so many simulations?

- **YES.** Standard approach of linearly combining output from runs with single parameter perturbations can have huge errors. Nonlinearity is important.
As of last week:
47,334 members, 21 parameters

Courtesy of Ben Sanderson
Climate @ home
A US effort to complement climateprediction.net

PIs: MIT, Rutgers, NCAR CGD, NCAR SCD, UCAR E&O

Collaborators: Oxford, RAL, LBL, Berkley, NOAA CDC

Climate@home – utilizes a dynamic ocean version of CCSM with an emphasis on cloud/aerosol interaction, distributed data management, and public outreach. Looking for extensive impacts and observation collaboration and for a generic framework (NWP, ENSO, paleo).
Help us with the Climate@home experimental design

• Aim is to produce results that are useful to as many people as possible.

• Tell us the hooks, observations, and output that need to be included so that the experiment is relevant to you.
Conclusions

- There are many sources of uncertainty in forecasts of future climate change.

- `climateprediction.net` results indicate we can’t yet rule out the possibility of extreme responses to relatively modest stabilization levels. Even current levels could lead to dangerous climate change.

- Climate predictions need to include uncertainty analyses. It comes hand in hand with confidence.

- `Climate@home` aims to make the model just another parameter.