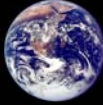


**SIAM Minisymposium
on Climate Change held at the San Diego Joint Meeting**

as interpreted by
Richard McGehee



**Seminar on the Mathematics of Climate Change
School of Mathematics
January 30, 2008**




**The San Diego Minisymposia
Two Minisymposia**

**SIAM Minisymposium: From Global Predictions to
Local Action**
Organized by Inez Fung, Chris Jones and Mary Lou Zeeman

**SIAM Special Session on Environmental
Mathematics: Some Mathematical Problems on
Climate Change and Geophysical Fluid
Dynamics**
Organized by Gerald North and Samuel Shen


http://www.bowdoin.edu/faculty/m/iseeman/state-of-the-planet/pdf/fung-jones-zeeman-mini-2008.pdf
http://www.bowdoin.edu/faculty/m/iseeman/state-of-the-planet/pdf/shen-north-mini-2008.pdf



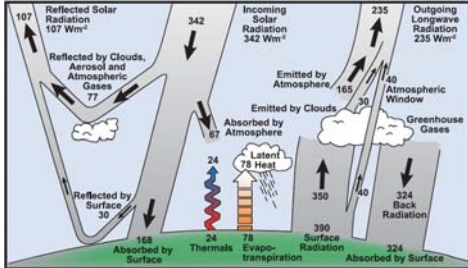
**The San Diego Minisymposia
Disclaimer**

I have not attempted a comprehensive report on all the lectures. Omission of a lecture means that I didn't understand it, I slept through it, or I couldn't reconstruct it from my notes.


Errors and omissions are entirely my responsibility and should not be ascribed to the speakers.



**The San Diego Minisymposia
Global Circulation Models**

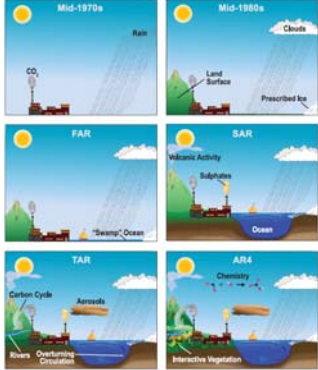


Historical Overview of Climate Change Science, IPCC AR4, p.96
http://ipcc-wg1.ucar.edu/wg1/Report/AR4WG1_Print_CH01.pdf




**The San Diego Minisymposia
Model Complexity**

“The complexity of climate models has increased over the last few decades. The additional physics incorporated in the models are shown pictorially by the different features of the modelled world.”

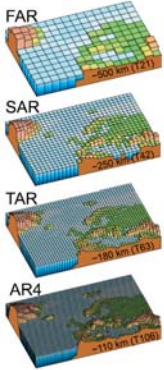


Historical Overview of Climate Change Science, IPCC AR4, p.96
http://ipcc-wg1.ucar.edu/wg1/Report/AR4WG1_Print_CH01.pdf




**The San Diego Minisymposia
Geographic Resolution**

Geographic resolution characteristic of the generations of climate models used in the IPCC Assessment Reports: FAR (IPCC, 1990), SAR (IPCC, 1996), TAR (IPCC, 2001a), and AR4 (2007).



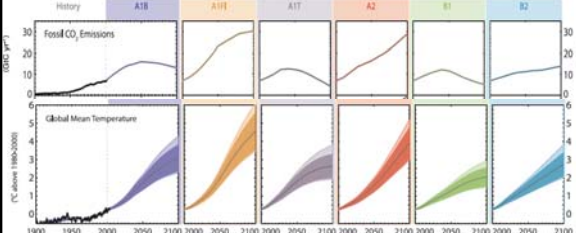
Historical Overview of Climate Change Science, IPCC AR4, p.96
http://ipcc-wg1.ucar.edu/wg1/Report/AR4WG1_Print_CH01.pdf




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IPCC Predictions

Despite increased sophistication, the variance of the predictions has not decreased dramatically.




Global Climate Projections, IPCC AR4, p.803
http://ipcc-wg1.ucar.edu/wg1/Report/AR4WG1_Print_CH10.pdf



The San Diego Minisymposia


Precipitation

Scaling Laws, Scale Invariance, and Climate Prediction



Message:
 Although temperature can be predicted consistently, precipitation cannot.
 If the model is run with increasing resolution, precipitation models show no sign of converging.


William Collins
 Lawrence Berkeley National Laboratory
 University of California, Berkeley
 National Center for Atmospheric Research



The San Diego Minisymposia

Clouds


Stochastic treatment of cloud-radiation interactions in climate models



Message:
 We don't know how to model clouds.
 It's important to figure out how.

Dr. Richard C. J. Somerville
 (Credit: Sylvia Bat Somerville)

Richard Somerville
 Scripps Institution of Oceanography




The San Diego Minisymposia

Clouds

"The strong effect of cloud processes on climate model sensitivities to greenhouse gases was emphasized further through a now-classic set of General Circulation Model (GCM) experiments, carried out by Senior and Mitchell (1993). They produced global average surface temperature changes (due to doubled atmospheric CO2 concentration) ranging from 1.9°C to 5.4°C, simply by altering the way that cloud radiative properties were treated in the model. It is somewhat unsettling that the results of a complex climate model can be so drastically altered by substituting one reasonable cloud parametrization for another, thereby approximately replicating the overall intermodel range of sensitivities."

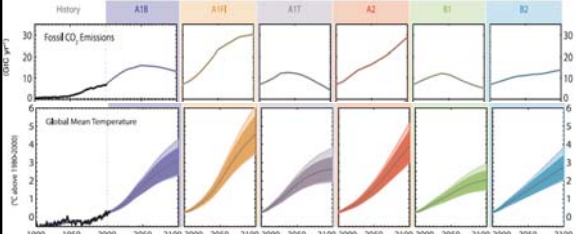
Historical Overview of Climate Change Science, IPCC AR4, p.114
http://ipcc-wg1.ucar.edu/wg1/Report/AR4WG1_Print_CH01.pdf



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IPCC Predictions

Perhaps much of the intermodel variance is explained by differences in the treatment of clouds.



Global Climate Projections, IPCC AR4, p.803
http://ipcc-wg1.ucar.edu/wg1/Report/AR4WG1_Print_CH10.pdf



The San Diego Minisymposia

Brown Clouds

Greenhouse Effect, Atmospheric Brown Clouds and Climate Change



Message:
 Pollution mitigates the global effect of the greenhouse gases.
 However, brown clouds can have the local effect of increasing temperature and decreasing precipitation.

V. Ramanathan
 Scripps Institution of Oceanography



The San Diego Minisymposia Brown Clouds

"Thus, our simulations suggest that absorbing aerosols in atmospheric brown clouds may have played a major role in the observed regional climate and hydrological cycle changes and have masked as much as 50% of the surface warming due to the global increase in greenhouse gases."

V. Ramanathan, et al, *Atmospheric brown clouds: Impacts on South Asian climate and hydrological cycle*, PNAS, 2005

<http://www.pnas.org/cgi/content/abstract/102/15/5326>



The San Diego Minisymposia Brown Clouds

"The researchers found that 'this brown cloud was as much as 50 percent of the background heating,' he says. 'We are sometimes thinking that aerosols might save us from global warming' by reflecting sunlight and dimming Earth below, but 'our study shows us not necessarily. While they may be cooling the globe, they are causing mischief in other places.'"



David Biello, "Brown Haze from Cooking Fires Cooking Earth, Too", *Scientific American*, August, 2007

<http://www.sciam.com/article.cfm?chanID=sa003&ref=feedburner&articleId=235006DA-E7F2-99DF-30481E19A0C76818>



The San Diego Minisymposia Global Atmospheric Circulation

Hysteresis in a Rotating Differentially Heated Spherical Shell of Boussinesq Fluid

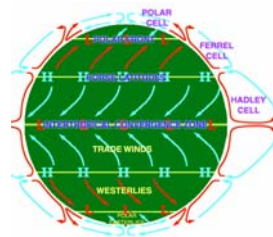
William F. Langford
University of Guelph

Message:

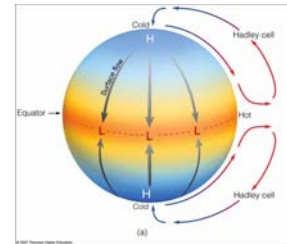
The global atmospheric circulation pattern has two steady states: three cells (today) and one cell (65 million years ago). Today we have ice on the poles. 65 million years ago, dinosaurs roamed the Antarctic.



The San Diego Minisymposia Global Atmospheric Circulation



Today



Cretaceous

<http://en.wikipedia.org/wiki/Image:AtmosphCirc2.png>
http://apollo.lsc.vcc.edu/classes/met130/notes/chapter10/single_cell.html



The San Diego Minisymposia Global Atmospheric Circulation

Macroturbulence and the General Circulation of the Atmosphere

Tapio Schneider
California Institute of Technology



Message:

You can't model global atmospheric circulation without modeling eddies.




The San Diego Minisymposia Global Atmospheric Circulation

Tapio Schneider & Christopher Walker, "Scaling Laws and Regime Transitions of Macroturbulence in Dry Atmospheres," *Journal of the Atmospheric Sciences* (in press)

"The scaling laws for the dependence of eddy fields on mean fields exhibit a regime transition, between a regime in which the extratropical thermal stratification and tropopause height are controlled by radiation and convection and a regime in which baroclinic entropy fluxes modify the extratropical thermal stratification and tropopause height. At the regime transition, for example, the dependence of the eddy flux of surface potential temperature and the dependence of the vertically integrated eddy momentum flux convergence on mean fields changes—a result with implications for climate stability and for the general circulation of an atmosphere, including its tropical Hadley circulation."

http://www.gps.caltech.edu/~tapio/papers/dry_scaling.pdf

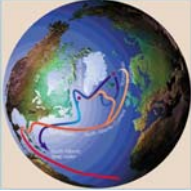
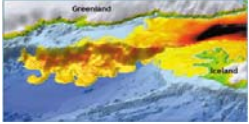


The IPCC Fourth Assessment Report


Ocean Circulation

Dynamics of grounded meridional abyssal flow

Gordon E. Swaters
University of Alberta


<http://pacific.math.ualberta.ca/gordon/misc/res.html>



The San Diego Minisymposia

Solar Cycles


Some Simple Models Used in Support of Climate Change Studies



Message:

Sunspot cycles correspond with surface temperature cycles, but can explain only about 20% of the variation.

Ka-Kit Tung
University of Washington




The San Diego Minisymposia

Solar Cycles

"By projecting surface temperature data (1959–2004) onto the spatial structure obtained objectively from the composite mean difference between solar max and solar min years, we obtain a global warming signal of almost 0.2K attributable to the 11-year solar cycle."

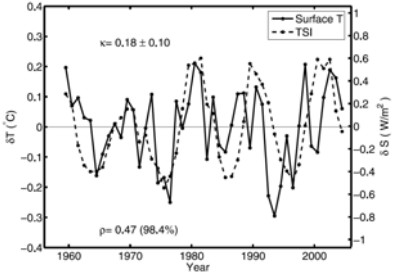
Charles D. Camp and Ka Kit Tung, "Surface warming by the solar cycle as revealed by the composite mean difference projection," *Geophysical Research Letters*, 2007

<http://www.amath.washington.edu/research/articles/Tung/journals/GRL-solar-07.pdf>



The San Diego Minisymposia

Solar Cycles



<http://www.amath.washington.edu/research/articles/Tung/journals/GRL-solar-07.pdf>



The San Diego Minisymposia

Self-Enforcing Treaties

Self-Enforcing Climate-Change Treaties



Message:

Game Theory can be used to design treaties that need no enforcement by an international body.

Roy Radner
New York University



The San Diego Minisymposia

Self-Enforcing Treaties

"Hence the GPO [Global Pareto Optimum] can be sustained by a 'trigger strategy' in which the players threaten to revert to the BAU [Business As Usual] (given the then current state) in the case of a defection."

Prajit K. Dutta & Roy Radner, *Self-Enforcing Climate-Change Treaties*, preprint

<http://www.columbia.edu/~pkd1/Treaty5.pdf>



The San Diego Minisymposia

Risk Assessment

The Mathematics of Climate Change

Message:


What is the cost of future environmental disaster? Should it be discounted?

Solved by using a convex combination of countable and purely finitely additive measures.



Graciela Chichilnisky
Economics Department
Columbia University

<http://www.chichilnisky.com/>




The San Diego Minisymposia

Really Simple Models


The 2007 IPCC Report: A 20th Century Mathematician Ponders the 21st Century Predictions

Message:

Very simple models can be informative.



Richard McGehee
University of Minnesota



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Really Simple Models

How to Make a “Pretty Good” Prediction of 21st Century Climate Change without a Computer

Assume that 54% of emitted CO₂ remains in the atmosphere.

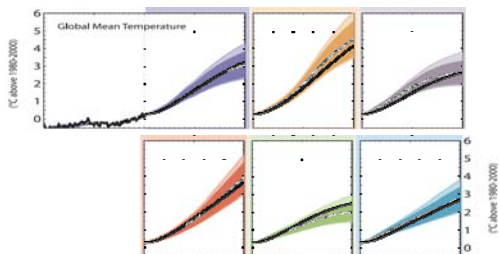

Assume that global mean temperature is a logarithmic function of atmospheric CO₂.

Assume a climate sensitivity of 3.3.



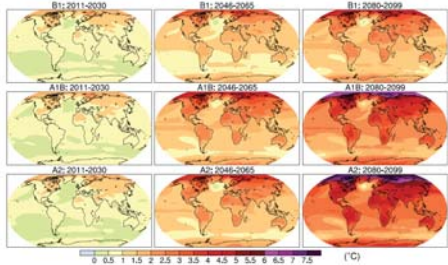
The San Diego Minisymposia

Really Simple Models

The San Diego Minisymposia

Surface Temperature Predictions



Global Climate Projections, IPCC AR4, p.766

http://ipcc-wg1.ucar.edu/wg1/Report/AR4WG1_Print_CH10.pdf