



The Hebrew University of Jerusalem  
The Institute for Advanced Studies

Winter school on

**Reducing the uncertainty in the prediction of  
global warming**

Institute of Advanced Studies, Jerusalem, Jan 12-16, 2009

[http://www.as.huji.ac.il/workshops/global\\_warming/](http://www.as.huji.ac.il/workshops/global_warming/)

All lectures will take place at the Feldman Building, on the Givat Ram Campus

Organizers: Isaac Held (GFDL/ Princeton University) and Eli Tziperman (Harvard University), Hezi Gildor (Weizmann Institute).

## Outline

While we expect the discussions and lectures at the workshop to range over a variety of issues in climate dynamics, we do plan to try and take the title of this workshop seriously, focusing as much as is possible on the problem of the climatic response to increasing carbon dioxide. More specifically, we will encourage a focus on the basic question of the magnitude of the climate response to increasing greenhouse gas concentrations, although we realize that a narrow focus on "climate sensitivity" defined in terms of global mean temperature may be too limiting. Whether or not they have worked on this issue directly, we hope that all of the lecturers will take this opportunity to take a fresh look at this problem and think about how their expertise can be relevant for reducing uncertainty. By bringing together a group of researchers who have specialized in different aspects of the climate problem, our hope is that we might actually be able to generate some new ideas, or (more realistically perhaps) inspire students who will then go on to generate these new ideas. Speakers and students are invited to surprise us all with novel ways of thinking about the climate response to increasing carbon dioxide that we have not anticipated. About two-three lectures a day are planned, with plenty of time for discussions.

Students are strongly encouraged to participate via the student poster session, questions during lectures, summary of previous-day lectures (details TBA), student-led panel discussion, etc.

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## Reading list

A background reading list is available at <http://www.gfdl.noaa.gov/ih/jerusalem.html>.

## Student poster session

Organized by Ian Eisenman, <ian at gps.caltech.edu>; For session program:  
[http://gps.caltech.edu/~ian/poster\\_session.pdf](http://gps.caltech.edu/~ian/poster_session.pdf)

## Program

### Sunday, Jan 11, 2009: **ARRIVING**

- 18:30 - Dinner for participants from abroad at HaIvrit Restaurant, Givat Ram Campus (18:15 gathering at the entrance to the Park Hotel/ Dan Panorama Hotel for joint walk/drive to campus)

### Monday, Jan 12, 2009: **INTRODUCTION**

- 8:00-9:00 - registration
- 9:00 - Eliezer Rabinovici (IAS Director)  
Greetings
- 9:30-11:00 - **Eli Tziperman:** (Harvard University)  
*Introduction to some of the relevant nonlinear concepts, bifurcations, surprises and irreversible changes; examples of novel dynamics that may complicate the analysis of climate responses.*
- 11:00 - coffee break
- 11:30-13:00 - **Jim McWilliams:** (UCLA)  
*Structural stability of the climate attractor, can the uncertainty be reduced?*
- 13:00 - Lunch, Belgium house
- 14:30 - 17:00 - **Isaac Held:** (GFDL/ Princeton University)  
*Climate sensitivity, introduction to some of the reductive and holistic approaches towards quantifying climate sensitivity, primarily from a linear perspective.*
- 15:30 - coffee break
- 18:00 - reception and dinner

### Tuesday, Jan 13, 2009: **CLOUDS**

- 08:30 - **Brian Mapes:** (University of Miami)  
*Uncertainty due to moist convection and cloud feedbacks.*
- 10:00 - coffee break
- 10:30 - **Dennis Hartmann:** (University of Washington)  
*Cloud feedbacks – observational constraints.*
- 12:30 - Lunch, Belgium house
- 14:00 - **Kerry Emanuel:** (MIT)  
*Cloud and hurricane feedbacks.*
- 15:30 - coffee break
- 16:00-18:00 - *student poster session*  
Organized by Ian Eisenman, <ian at gps.caltech.edu>; For session program:  
[http://gps.caltech.edu/~ian/poster\\_session.pdf](http://gps.caltech.edu/~ian/poster_session.pdf)

### Wednesday, Jan 14, 2009: **LOOKING BACK FOR CLUES**

- 08:30 - **Peter Huybers:** (Harvard University)  
*Constraints on sensitivity based on ice ages and last millennium climate reconstructions.*
- 10:00 - coffee break
- 10:30 - **Sylvie Joussaume:** (LSCE, France)  
*Paleoclimatic constraints on sensitivity.*
- 12:30 - Lunch, Belgium house
- 13:30-18:30 - A guided tour of Jerusalem

### Thursday, Jan 15, 2009: **OCEANS, AND... CLIMATE VARIABILITY**

- 08:30 - **Hezi Gildor:** (Weizmann Institute)  
*Uncertainties in sub-mesoscale and small scale ocean mixing and their climate implications.*
- 10:00 - coffee break
- 10:30 - **Jochem Marotzke:** (Max Planck Institute for Meteorology)  
*Climate feedbacks involving the large scale ocean dynamics.*
- 12:30 - Lunch, Belgium house
- 14:30 - **Geoff Vallis:** (GFDL/ Princeton University)  
*Mechanisms of Climate Variability from Years to Decades*

- 19:00 - conference dinner: at Tarassa restaurant.

**Friday, Jan 16, 2009: PUTTING IT ALL TOGETHER**

- 09:00 - *A student-led discussion of a panel composed of all lecturers.*
- 10:30 - coffee break
- 11:00 - *A student led debate: is the IPCC an overestimate or an underestimate of the actual climate sensitivity?*
- 12:30 - Lunch, HaIvrit restaurant on campus.
- 14:00 - departure

## Lecture abstracts

**Brian Mapes** I will consider whether cloud field changes in a warmer world can be anticipated at the critical few watt mean accuracy. Ideally our reasoning should be firmly grounded in robust responses of climate models, physical principles, and observations, and must account for the multi-scale structure of cloudiness.

**Dennis Hartmann** Tropical Clouds and Climate. I would focus on recent observational studies and what they tell us about the potential role of clouds and convection in climate change, focusing principally on the Tropics and on the two dominant marine cloud regimes, deep convective cloud and boundary layer cloud. I might also talk about how we can use observations to attempt to validate models and understanding. For deep convective clouds I would focus on the emission temperature (Fixed Anvil Temperature Hypothesis), and the peculiarly weak effect that convective clouds over warm pools have on the net radiation balance at the top of the atmosphere, using observations and a modest amount of modeling. For boundary layer clouds, I would discuss some recent results obtained using MODIS and CloudSat, which show an interesting effect of aerosols, we think.

- Brief overview of the Earth's Energy Budget and Role of Clouds. (Brian Mapes might already have done this, so brief.)
- Deep Convective Clouds: What controls the temperature of tropical convective cloud tops? Their vertical extension and the Fixed Anvil Temperature Hypothesis.
- Deep Convective Clouds: The net radiative effect is small, why?
- Deep Convective Clouds: The relationship of cloud properties to precipitation rates.
- Deep Convective Clouds: Do they moisten or dry the atmosphere?
- Deep Convective Clouds: Are cloud-resolving models the answer?
- Boundary Layer Clouds: They dominate cloud forcing, cloud feedback and its effect on climate sensitivity in models.
- Boundary Layer Clouds: New observations from MODIS/CLOUDSAT the roles of drizzle and aerosols.

References: Kubar, T.L., D.L. Hartmann and R.Wood, Radiative and Convective Driving of Tropical High Clouds, *J. Climate*, 20, 5510-5526.

**Eli Tziperman** Nonlinear effects such as bifurcations and hysteresis leading to possible jumps in climate state due to small parameter change, and to irreversible changes. Examples based on ice albedo and convective cloud feedbacks.

**Geoff Vallis** Discusses and reviews some of the mechanisms that may be responsible for climate variability on yearly to decadal timescales. The discussion is organized around a set of mechanisms that primarily involve the atmosphere, the ocean, or the coupling between the two. We choose an example of each, try to explain what the underlying mechanism is, and set it in the context of climate variability as a whole. All of the mechanisms are in principle deterministic, although in

at least one of them we do not care about the details of the process that give rise to the variability and in that case a stochastic description may be the most economical and insightful.

**Isaac Held** A basic introduction to the factors controlling the magnitude of the climatic response to increasing greenhouse gases will be presented. The notions of climate forcing, climate sensitivity and feedback analysis will be introduced from the perspective of fitting simple models to observations (or more complex models). The central results from the 4th IPCC assessment will be reviewed and observational constraints provided by 20th century warming, the response to volcanic eruptions, and the structure of internal variability of temperature and radiative fluxes briefly introduced. Examples will be provided of the limitations of various approaches as time permits.

**Hezi Gildor** I plan to discuss small-scale horizontal and vertical mixing. I will present observations of mixing, parametrization of mixing, and the sensitivity of models to the way mixing is parametrized (e.g. stability of the MOC under different parametrization of vertical mixing).

**Jim McWilliams** Atmospheric and oceanic computational simulation models successfully depict chaotic space-time patterns, flow phenomena, dynamical processes, and equilibrium distributions that mimic nature. This is accomplished through necessary but non-unique choices for discrete algorithms, parameterizations, and coupled contributing processes that introduce inherent and ultimately irreducible imprecision. Testing and coping strategies are discussed.

**Jochem Marotzke** Fundamentals - effects of (ocean) heat capacity on estimates of climate sensitivity, both from a theoretical perspective and concerning estimates from the instrumental record. Decadal climate prediction - what is going on, and prospects of the "seamless prediction" philosophy (seasonal to decadal to centennial) potentially aiding in reducing uncertainty of our knowledge of future warming.

**Kerry Emanuel** Although there is much concern about the possible effects of climate change on global tropical cyclone activity, less work has been done on possible tropical cyclone feedbacks to the climate system. In this presentation, I will argue that aggregation of convection in general, and tropical cyclones in particular, lead to a considerable drying of the atmosphere, owing to the very high precipitation efficiency found in the storms. This drying increases the outgoing longwave radiative flux, cooling the system down. Since self-aggregation appears to increase with temperature, this feedback is negative leads, in principle, to a self-organized critical state in which convection is always on the verge of self aggregation, at least at high temperature. I will also show the tropical cyclones have a profound effect on the upper ocean through their vigorous mixing of the first few hundred meters, and discuss possible ramifications of this mixing for climate.

**Peter Huybers** Constraints on sensitivity based on ice ages and last millennium climate reconstructions: Topics will include inference of local climate sensitivity from paleoclimate observations, estimation of global climate sensitivity from local observations, distinguishing between CO<sub>2</sub> and other forcings, and nonlinearities in climate sensitivity. Finally, whereas the probability distribution of climate sensitivity has been characterized as having a fat upper tail, a case is made that paleoclimate observations permit for thinning the probability of exceedingly catastrophic changes.

**Sylvie Jousaume** Paleoclimatic constraints on climate sensitivity: Past climates offer a unique opportunity to evaluate climate models used for future climate projections on climate conditions different from present-day. They allow to investigate the mechanisms of climate change and the role of feedbacks. Results from the Paleoclimate Modelling Intercomparison Project on the last glacial maximum and the mid-Holocene will be presented.