

## TIME TABLE

TIME	Monday August 26	Tuesday August 27	Wednesday August 28	Thursday August 29	Friday August 30
9.00 - 9.45	Registration	Ghil	Ghil	Emanuel	Bracco
9.45 - 10.30	Ghil	Ghil	Ghil	Emanuel	Bracco
11.00 - 11.45	Ghil	Emanuel	Emanuel	Bracco	Provenzale
11.45 - 12.30	Provenzale	Emanuel	Emanuel	Bracco	Provenzale
14.00 - 14.45	Dijkstra	Dijkstra	Dijkstra	Fraedrich	
14.45 - 15.30	Dijkstra	Dijkstra	Dijkstra	Fraedrich	
16.00 - 16.45	Fraedrich	Fraedrich	Fraedrich	Provenzale	
16.45 - 17.30	Fraedrich	Seminar	Bracco	Provenzale	
17.30 - 18.30	Seminar	Poster Session	Poster Session	Seminar	

## ADMISSION AND ACCOMMODATION

Applicants must apply at least one month before the beginning of the course. Application forms should be sent on-line through our web site: <http://www.cism.it> or by post.

A message of confirmation will be sent to accepted participants. If you need assistance for registration please contact our secretariat.

The 700,00 Euro registration fee includes a complimentary bag, four fixed menu buffet lunches (Friday not included), hot beverages, on-line/downloadable lecture notes and wi-fi internet access.

A limited number of participants from universities and research centres who are not supported by their own institutions can be offered board and/or lodging in a reasonably priced hotel. Requests should be sent to CISM Secretariat by **June 26, 2013** along with the applicant's curriculum and a letter of recommendation by the head of the department or a supervisor confirming that the institute cannot provide funding. Preference will be given to applicants from countries that sponsor CISM.

Information about travel and accommodation is available on our web site, or can be mailed upon request.

Please note that the centre will be closed for summer vacation the first three weeks in August.

*For further information please contact:*

CISM  
 Palazzo del Torso  
 Piazza Garibaldi 18  
 33100 Udine (Italy)  
 tel. +39 0432 248511 (6 lines)  
 fax +39 0432 248550  
 e-mail: [cism@cism.it](mailto:cism@cism.it)

Centre International des Sciences Mécaniques  
 International Centre for Mechanical Sciences  
 ACADEMIC YEAR 2013  
 The Troger Session



## THE FLUID DYNAMICS OF CLIMATE

Advanced School  
coordinated by

**Antonello Provenzale**  
 National Research Council, Torino  
 Italy

**Klaus Fraedrich**  
 University of Hamburg  
 Germany

**Udine August 26 - 30 2013**

# THE FLUID DYNAMICS OF CLIMATE

Climate dynamics offers some of the most intriguing scientific problems in science, as well as a set of applied issues of central importance, such as the definition of mitigation and adaptation strategies, the assessment of the potential risks associated with climate change (droughts, floods, extreme events, sea level rise) and the social, economic and geopolitical implications of global warming.

Many of the components of the climate system are in fluid state, such as the atmosphere, the hydrosphere and the cryosphere. As an evolution of the well-established discipline of geophysical fluid dynamics, founded more than fifty years ago, the emerging theme of "climatic fluid dynamics" is now at the heart of the efforts devoted to understanding and modeling the climate system.

The objective of this course is to make students and researchers with a general background in fluid dynamics familiar with the fluid aspects of the climate system. The course will bring together contributions from diverse fields of the physical, mathematical and engineering sciences. The addressed audience is composed of doctorate students, postdocs and researchers working on different aspects of atmospheric, oceanic and environmental fluid dynamics. It will also be useful for researchers interested in quantitatively understanding how fluid dynamics can be applied to the climate system, and for climate scientists willing to gain a deeper insight into the fluid mechanics underlying climate processes.

The course outline includes:  
- A general introduction to the fluid dynamics of climate, including the role of stratification, rotation, and the issues related to the many interacting spatial and temporal scales in the climate system.

- The dynamical systems approach to ocean and climate dynamics. Specific topics will include the North Atlantic Oscillation, El Niño, the Atlantic Multidecadal Oscillation, the Dansgaard-Oeschger events and the Pleistocene Ice Ages.  
- The physics of radiative and convective heat transfer and radiative convective equilibrium, including a discussion of the character of convection and tropical cyclones in changing climates and how they may serve to regulate climate.  
- A description of the climate system in terms of data and model hierarchies and the problem of climate predictability. Discussion of an equation of state for the Earth's continental climates to describe vegetation, rivers, lakes and glaciers, their means, sensitivities and variability.  
- The working of coupled general circulation models, with a general overview of their strength and weakness and including the role of parameterizations. Quantification of model uncertainty, especially

considering that state-of-the-art climate models contain many sources of uncertainty.  
- The dynamics of the global hydrological cycle in the climate system and its representation in global climate models. Regional scale climate dynamics, with examples from the Mediterranean, the Arctic and the Himalayas, and climatic downscaling.

During the school the following seminars will also be delivered:

**Jost von Hardenberg** - CNR, Torino, Italy  
*2 seminars on:* The atmospheric circulation and aerosols in the climate system: transport, modelling and comparison with data.

**Imre Janosi** - Eotvos University, Budapest, Hungary  
*1 seminar on:* Laboratory experiments on climate and large-scale geophysical flows.

# INVITED LECTURERS

**Annalisa Bracco** - Georgia Institute of Technology, Atlanta, GA, USA  
*5 lectures on:* Coupled general circulation models: The Good, the Bad and the Ugly. Parametrizations: Physical processes and model representation. Parameter sensitivity and optimization. Uncertainty quantification.

**Henk Dijkstra** - Utrecht University, The Netherlands  
*6 lectures on:* Dynamical systems approach to the climate system: The North Atlantic Oscillation, El Niño, the Atlantic Multidecadal Oscillation, the Dansgaard-Oeschger events and the Pleistocene Ice Ages.

**Kerry A. Emanuel** - Massachusetts Institute of Technology, Cambridge, MA, USA  
*6 lectures on:* Physics of radiative and convective heat transfer in the atmosphere. Multiple equilibrium states in unsaturated atmospheres. Physics of convective intransitivity, spontaneous development of cloud clusters and tropical cyclones. Character of clusters and cyclones in changing climates and their role in regulating climate.

**Klaus Fraedrich** - University of Hamburg, Germany  
*6 lectures on:* Climate, Chaos and Catastrophes; Bridging in time (long term memory and extremes), in space (teleconnections and dynamical causes of extremes), and in models (synchronisation and largest Lyapunov exponent). Land cover: Vegetation, rivers, lakes, and glaciers.

**Michael Ghil** - Ecole Normale Supérieure, Paris, France and University of California, Los Angeles, CA, USA  
*6 lectures on:* The climate system as a fluid-dynamical system. Some basic facts of atmospheric and oceanic life: rotation and stratification. Low-frequency variability (LFV) in the atmosphere and the oceans. Paleoclimate and the role of ice sheets.

**Antonello Provenzale** - National Research Council, Torino, Italy  
*5 lectures on:* The global hydrological cycle. Precipitation, evapotranspiration and runoff. Large-scale transport in the climate system. Climate dynamics at regional scale and interaction between different climatic regimes.

# PRELIMINARY SUGGESTED READINGS

H.A. Dijkstra. Nonlinear Physical Oceanography. Springer 2005.

M. Ghil and S. Childress. Topics in Geophysical Fluid Dynamics. Springer 1987.

J. Marshall, R.A. Plumb. Atmosphere, ocean and climate dynamics. Academic Press 2008.

F.W. Taylor. Elementary Climate Physics. Oxford Univ. Press 2005.

K.A. Emanuel. Atmospheric Convection. Oxford Un. Press 1994.

K. Mc Guffie, A. Henderson-Sellers. A climate modeling primer. Wiley 2005.

J.P. Peixoto and A.H. Oort. Physics of Climate. American Institute of Physics, 1992.

G.K. Vallis. Atmospheric and Oceanic Fluid Dynamics. Cambridge Univ. Press, 2006.

# LECTURES

All lectures will be given in English. Lecture notes can be downloaded from CISM web site, instructions will be sent to accepted participants.

# THE FLUID DYNAMICS OF CLIMATE

Udine, August 26 - 30, 2013

## Application Form (Please print or type)

Surname \_\_\_\_\_

Name \_\_\_\_\_

Affiliation \_\_\_\_\_

Address \_\_\_\_\_  
\_\_\_\_\_

E-mail \_\_\_\_\_

Phone \_\_\_\_\_ Fax \_\_\_\_\_

### Method of payment upon receipt of confirmation (Please check the box)

*The fee of Euro 700,00 includes IVA/VAT tax and excludes bank charges*

- I shall send a check of Euro \_\_\_\_\_
- Payment will be made to CISM - Bank Account N° 094570210900, VENETO BANCA - Udine (CAB 12300 - ABI 05035 - SWIFT/BIC VEBHIT2M - IBAN CODE IT46 N 05035 12300 09457 0210900). Copy of the receipt should be sent to the secretariat
- I shall pay at the registration counter with check, cash or VISA Credit Card (Mastercard/Eurocard, Visa, CartaSi)

**IMPORTANT: CISM is obliged to present an invoice for the above sum. Please indicate to whom the invoice should be addressed.**

Name _____
Address _____ _____ _____
C.F.* _____
VAT/IVA* No. _____ (* Only for EU residents or foreigners with a permanent business activity in Italy)

### Only for Italian Public Companies

- I ask for IVA exemption (ex law n. 537/1993 - art. 14 comma 10).

Privacy policy: I understand that data received via this form will be used only to provide information about CISM and its activities, within the limits set by the Italian legislative decree no. 196/2003 and subsequent amendments.

Complete information on CISM's privacy policy is available at [www.cism.it](http://www.cism.it).

I have read the "Admission and Accommodation" terms and conditions and agree.

Date \_\_\_\_\_ Signature \_\_\_\_\_