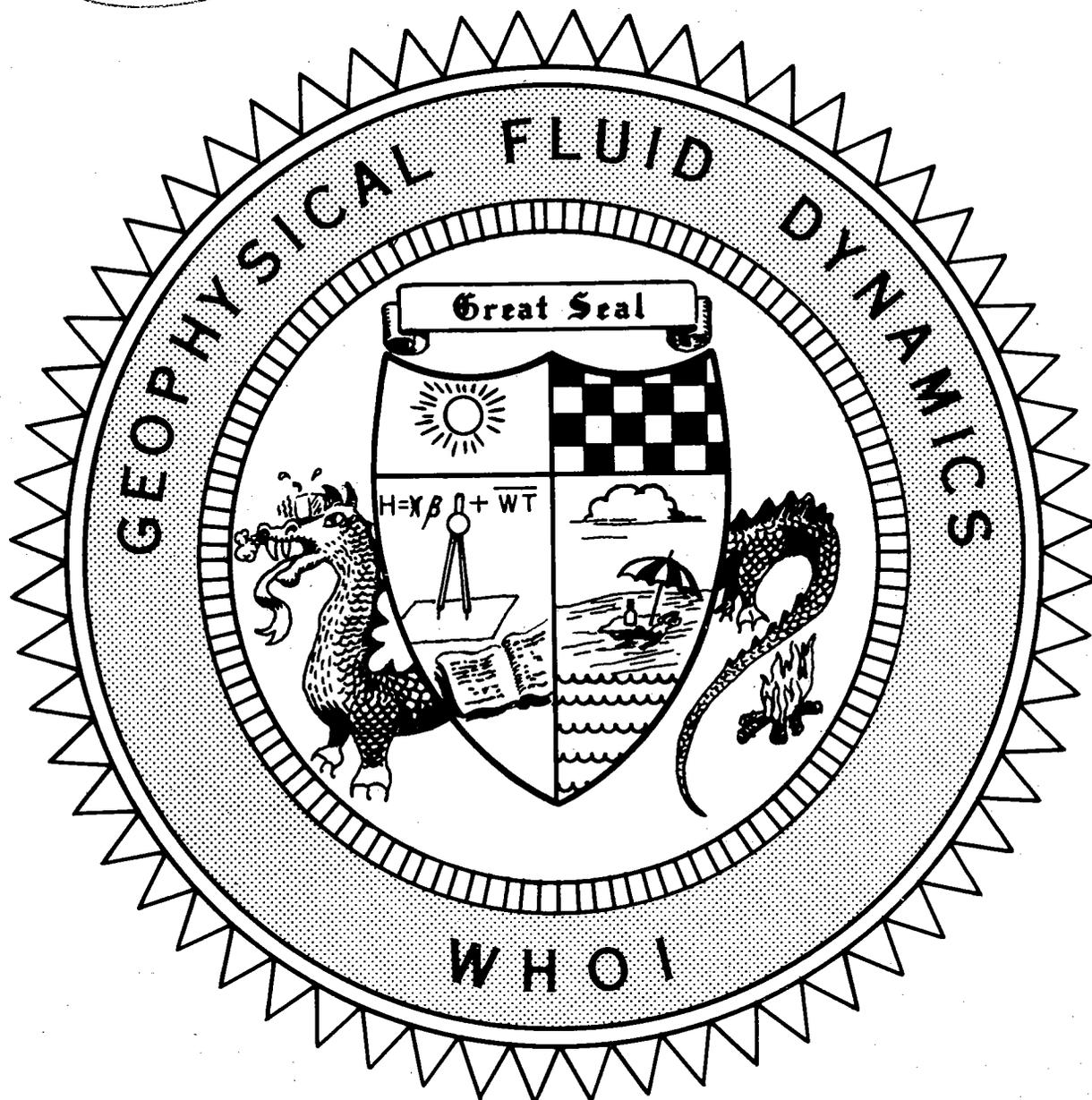


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Course Lectures  
Abstracts of Participants  
Fellows Project Reports

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**Dynamics of the Outer Planets**

1992 Summer Study Program  
in  
Geophysical Fluid Dynamics

by

Glenn Flierl, Director  
Andrew Ingersoll, Principal Lecturer  
Jun-Ichi Yano, Principal Lecturer  
Barbara Ewing-DeRemer, Staff Assistant

Woods Hole Oceanographic Institution  
Woods Hole, Massachusetts 02543

Summer 1992

**Technical Report**

Funding was provided by the National Science Foundation  
under Grant No. OCE8901012.

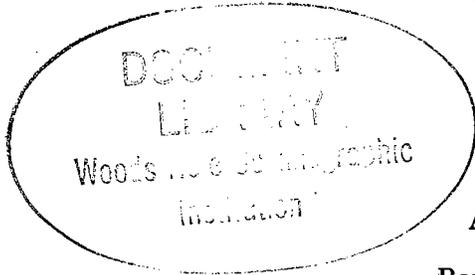
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**Approved for Distribution:**



**John W. Farrington**  
Associate Director for Education  
Dean of Graduate Studies





## Geophysical Fluid Dynamics Program

Summer of 1992

### Preface

The topic this summer was “The Dynamics of the Outer Planets.” Andrew Ingersoll gave an excellent review of the current understanding of the structure of the atmospheres of Jupiter, Neptune, Saturn, and Uranus. He presented the flow structures inferred from the information gathered by the Voyager probes and other observations. The models of the circulations of the interior and of the weather layer — the jets and vortices that we see in the images — were discussed. Jun-Ichi Yano gave further discussions on vortex dynamics in the lab, analytical, and numerical models as applied to the outer planets. Finally, Andy returned with a discussion of thin atmospheres (some so thin that they disappear at night) and new approaches to the dynamics of the interiors. These lectures provided a thorough background in both the data and the theory.

As usual, we had talks (or what are sometimes called interactive seminars!) from many visitors during the summer, some directly related to the main topic and others covering other new research in geophysical fluid dynamics. From these, the fellows and staff found new areas for collaborative research and new ideas which they may explore after the summer.

Finally, the summer was completed with talks from the fellows on their individual research during the summer. These reports reflect the thought and energy that went into learning new topics and formulating new problems. We look forward to seeing fuller versions of these in journal articles.

We gratefully acknowledge the support of the National Science Foundation and the Office of Naval Research. The assistance of Jake Peirson and Barbara Ewing-DeRemer, made the summer, once again, pleasant and easy for all.

### Fellows

<i>Name</i>	<i>Affiliation</i>
Rupert Ford	DAMTP, Univ. of Cambridge
Richard Holme	Harvard
Petros Ioannou	MIT
Ray LeBeau	MIT
Doug Parker	Univ. of Reading
Andrew Stamp	The Australian National Univ.
Louis Tao	University of Chicago
Phil Yecko	Columbia
Qingping Zou	Scripps Institute of Oceanography

**Staff and Visitors**

<i>Name</i>	<i>Affiliation</i>
Tadashi Asada	Cornell University
Neil Balmforth	Columbia University
Edward Bolton	Yale University
Eric Chaussignet	U. Miami, RSMAS
Bill Dewar	Florida State University
Tim Dowling	MIT
Brian Farrell	Harvard
Glenn Flierl	MIT
John Hart	U. Colorado
Herbert Huppert	DAMTP
Louis Howard	Florida State University
Andy Ingersoll	Caltech
Joe Keller	Stanford
Willem Malkus	MIT
Phil Marcus	Berkeley
Steve Meacham	Florida State University
Phil Morrison	U. Texas, Austin
Kirill Pankratov	WHOI
Lorenzo Polvani	Columbia
Larry Pratt	WHOI
Claes Rooth	U. Miami, RSMAS
Rick Salmon	Scripps Institution of Oceanography
Ted Shepherd	U. Toronto
Tom Solomon	U. Texas, Austin
Ed Spiegel	Columbia
Melvin Stern	Florida State University
George Sutryin	P.P. Shirsov Inst.
Charles Tresser	IBM
Geoff Vallis	Scripps Institution of Oceanography
George Veronis	Yale University
Andrew Woods	DAMTP
Jun-Ichi Yano	NCAR
Eliot Young	MIT

## GFD Schedule — 1992

- Mon. June 22, 10 AM  
Introduction and Planetary Slide Show  
*Andrew Ingersoll*
- Tues. June 23, 10 AM  
Zonal Jets on the Giant Planets  
*Andrew Ingersoll*
- Tues. June 23, 1:30 PM  
Tutorial on Geostrophic Dynamics
- PO Seminar, Tues. June 23, 3 PM Clark Lab  
Geostrophic Turbulence in the California Current  
*Goeff Vallis*
- Wed. June 24, 10 AM  
Interiors of the Giant Planets  
*Andrew Ingersoll*
- Wed. June 24, 1:30 PM  
Intro to computing facilities
- Thurs. June 25, 10 AM  
Vortices on the Giant Planets  
*Andrew Ingersoll*
- Thurs. June 25, 1:30 PM  
Initial Development of Eddies in High-Speed Zonal Flow  
*Tadashi Asada*
- Fri. June 26, 10 AM  
continued ...  
*Andrew Ingersoll*
- Fri. June 26, 1:30 PM  
Large Scale Waves and Vortices  
*George Sutyrin*
- Mon. June 29, 10 AM  
Dynamics of Vortices  
*Jun-Ichi Yano*
- Mon. June 29, 1:30 PM  
The Dynamics of Barotropically Dominated Vortices  
*William Dewar*
- Tues. June 30, 10 AM  
continued ...  
*Jun-Ichi Yano*

Wed. July 1, 10 AM

Io

*Andrew Ingersoll*

Wed. July 1, 1:30 PM

An Albedo Map and Circulation Model of Pluto

*Eliot Young*

Thurs. July 2, 10 AM

Anelastic, Isentropic, QG Approx. applied to the Atmospheres and Interiors of the Giant Planets

*Andrew Ingersoll*

Thurs. July 2, 1:30 PM

$\beta$ -convection: Chaos, Turbulence, and Zonal Jets

*John Hart*

Mon. July 6, 10 AM

Rings in a General Circulation Model: a Statistical Study

*Eric Chassignet*

Tues. July 7, 10 AM

On the Maintenance of Terrestrial Westerlies

*Ted Shepherd*

Wed. July 8, 10 AM

Jupiter's Winds and Arnold's Second Stability Theorem

*Tim Dowling*

Wed. July 8, 1:30 PM

Instability Caused by Oscillating Rotation

*Edward Bolton*

Thurs. July 9, 1:30 PM

Vortex Dynamics on a Sphere

*Lorenzo Polvani*

Fri. July 10, 10 AM

Experimental studies of flows in a rotating annulus: Barotropic instabilities and Hamiltonian transport

*Tom Solomon*

Mon. July 13, 10 AM

The Role of Eddies in Gulf Stream Entrainment

*Melvin Stern*

Tues. July 14, 10 AM

Discussion: Barotropic and Baroclinic Instability

*Formulation, Rayleigh and Arnol'd thms., Transient growth*

- Wed. July 15, 10 AM  
Discussion: Dynamical Systems
- Fri. July 17, 10 AM  
Vapor Flow in a Hot Rock  
*Andrew Woods*
- Tues. July 21, 10 AM  
Linear Thermal Convection in a Model Jupiter  
*Jun-Ichi Yano*
- Wed. July 22, 10 AM  
Timing Maps for Pulsatile Chaos  
*Neil Balmforth*
- Thurs. July 23, 10 AM  
Chaos and Turbulence in the Solar Cycle  
*Ed Spiegel*
- Mon. July 27, 10 AM  
Tidal Friction in the Outer Planets  
*Petros Ioannou*
- Tues. July 28, 10 AM  
Particle-driven Fluid Flows  
*Herbert Huppert*
- Wed. July 29, 10 AM  
Kida Vortices in Stratified Flows  
*Steve Meacham*
- Thurs. July 30, 10 AM  
Interaction between Eddies and Jets  
*Larry Pratt*
- Fri. July 31, 10 AM  
Instability of Shear Flows  
*Joe Keller*
- Mon. Aug. 3, 10 AM  
What is Potential Vorticity?  
*Rick Salmon*
- Tues. Aug. 4, 10 AM  
Hamiltonian Contour Dynamics  
*Phil Morrison*
- Wed. Aug. 5, 10 AM  
The Limitations of Balance Models  
*Rupert Ford*

- Thurs. Aug. 6, 10 AM  
Discussion Session: Dynamics of Disks
- Tues. Aug. 11, 10 AM  
Aspects of Renormalization  
*Charles Tresser*
- Wed. Aug. 12, 10 AM  
Generalized Stability Analysis: Application to Turbulent Transition  
*Brian Farrell*
- Thurs. Aug. 13, 10 AM  
Topographic Contour Dynamics for a Continuously Stratified Ocean  
*Kirill Pankratov*
- Mon. Aug. 17, 10 AM  
Vortex Dynamics in Zonal Flows  
*Phil Marcus*
- Mon. Aug. 17, 1 PM  
Pizza Lunch with a discussion of chaos and transistors  
*Lou Howard*
- Tues. Aug. 18, 10 AM  
Rotating Fluids: Theory vs. Experiments  
*Lou Howard*
- Tues. Aug. 18, 1:30 PM  
Jovian Vortices: Calculations, Conclusions, and Controversies  
*Phil Marcus*
- Thurs. Aug. 20, 10 AM  
Elliptical [Tidal] Instabilities and Planetary Dynamos  
*Willem Malkus*
- Fri. Aug. 21, 10 AM  
Dynamic Signatures of Ocean Climate Transients  
*Claes Rooth*
- Mon. Aug. 24, 1:30 PM  
Discussion session: Convection with Differential Horizontal Heating  
*George Veronis*
- Tues. Aug. 25, 10 AM  
Discussion session: Deep Jets and Shallow Spots?  
*Glenn Flierl*
- Fellows talks: Wed. Aug. 26, 10 AM  
Quasigeostrophy in a Baroclinic Planetary Interior  
*Richard Holme*

- Fellows talks: Wed. Aug. 26, 11:30 AM  
Generalized Two Layer Planetary Geostrophic Equations  
*Rupert Ford*
- Fellows talks: Thurs. Aug. 27, 10 AM  
Dynamical Aspects of Vortex Structure  
*Doug Parker*
- Fellows talks: Thurs. Aug. 27, 11:30 AM  
A Solitary Summer  
*Louis Tao*
- Fellows talks: Thurs. Aug. 27, 1:30 PM  
Stochastic Excitation of Perturbation Variance in Channel Flows  
*Petros Ioannou*
- Fellows talks: Thurs. Aug. 27, 3:00 PM  
Disks: Just the Place for a Spot  
*Phil Yecko*
- Fellows talks: Fri. Aug. 28, 10 AM  
Shear Flow Instability near Froude Number One: Theory and Experiments  
*Qingping Zou*
- Fellows talks: Fri. Aug. 28, 11:30 AM  
The Stability of Jupiter's Zonal Winds  
*Andrew Stamp*
- Fellows talks: Fri. Aug. 28, 1:30 PM  
A Dark Side Atmosphere on Io?  
*Ray LeBeau*

