

**The Development of
Atmospheric General
Circulation Models:
Complexity, Synthesis, and
Computation**

Forward (Isaac Held)

I. Introduction (Editors)

2. From Richardson to Early Numerical
Weather Prediction (Peter Lynch)

3. From Early Numerical Weather Prediction to
General Circulation Models for Climate
(Lennart Bengtsson)

4. The Evolution of Research Goals for General Circulation Models (Warren Washington and Akira Kasahara)

5. The Evolution of Complexity in General Circulation Models (David Randall)

6. Numerical Weather Prediction in the Era of Climate General Circulation Models (Cath Senior)

7. The Role of Observations in Developing and Evaluating General Circulation Models (V. Ramanathan)

8. The Societal Context of General Circulation Model Research and Development (James Fleming)
9. Coupling Atmospheric General Circulation Models to Oceans (Kirk Bryan)
10. Coupling Atmospheric General Circulation to Land, Chemistry, and Biology (Robert Dickinson)

**Journal of Advances in
Modeling Earth Systems
(JAMES)**

Partnership

- Center for Multi-scale Modeling of Atmospheric Processes (CMMAP)
- Institute of Global Environment and Society (IGES), which consists of the centers COLA and CREW

Roles of CMMAP and IGES

- CMMAP and IGES jointly design and operate the journal.
- CMMAP will function as Chief Editorial Office, handling submission, review, and online hosting.
- IGES will be represented on Advisory Board and Editorial Board, and will handle business aspects (e.g., collection of page charges).

Journal Advisory Board

- Charts the Journal's scientific direction
- Appointment/reappointment of Chief Editor and, in consultation with Chief Editor, appointment of the other editors
- Reviews the financial aspects of the journal, including page charge rate
- Reviews the performance of outside contractor, who provides publishing services

Chair Journal Advisory Board

Dr. James Kinter, Director
Center for Ocean-Land-Atmosphere Studies
Calverton, Maryland
kinter@cola.iges.org

Journal Editorial Board

Chief Editor: David Randall

Editor (Ocean Modeling)

Editor (Land Surface Modeling)

Editor (Paleoclimate)

Editor (Data Assimilation)

Editor (Convection)

Editor (Dynamics): Wayne Schubert

JAMES Management

Journal Coordinator: Rodger Ames

Journal Coordinator (Office of Chief Editor):
Cindy Carrick

Journal Coordinator (IGES): TBD

IT: Kelley Wittmeyer (CSU)

IT: Mostafa El-Kady (CSU)

Charlesworth

- England (West Yorkshire), USA (Philadelphia, Adrian Stanley), China (Beijing); Works with Nature Group, Allen Press, PLOS.
- Organize instructions to authors for submission in Word, LaTeX, etc.
- Provide layout and typesetting. Costs in range of \$9 to \$13 per page.
- Coordinate proofreading with authors.

Charlesworth

- Communication with abstracting and indexing services.
- Production of full articles in PDF, deliver XML for archival and production of online HTML.
- Assistance with publicity, alert services, etc.

Manuscript Flow

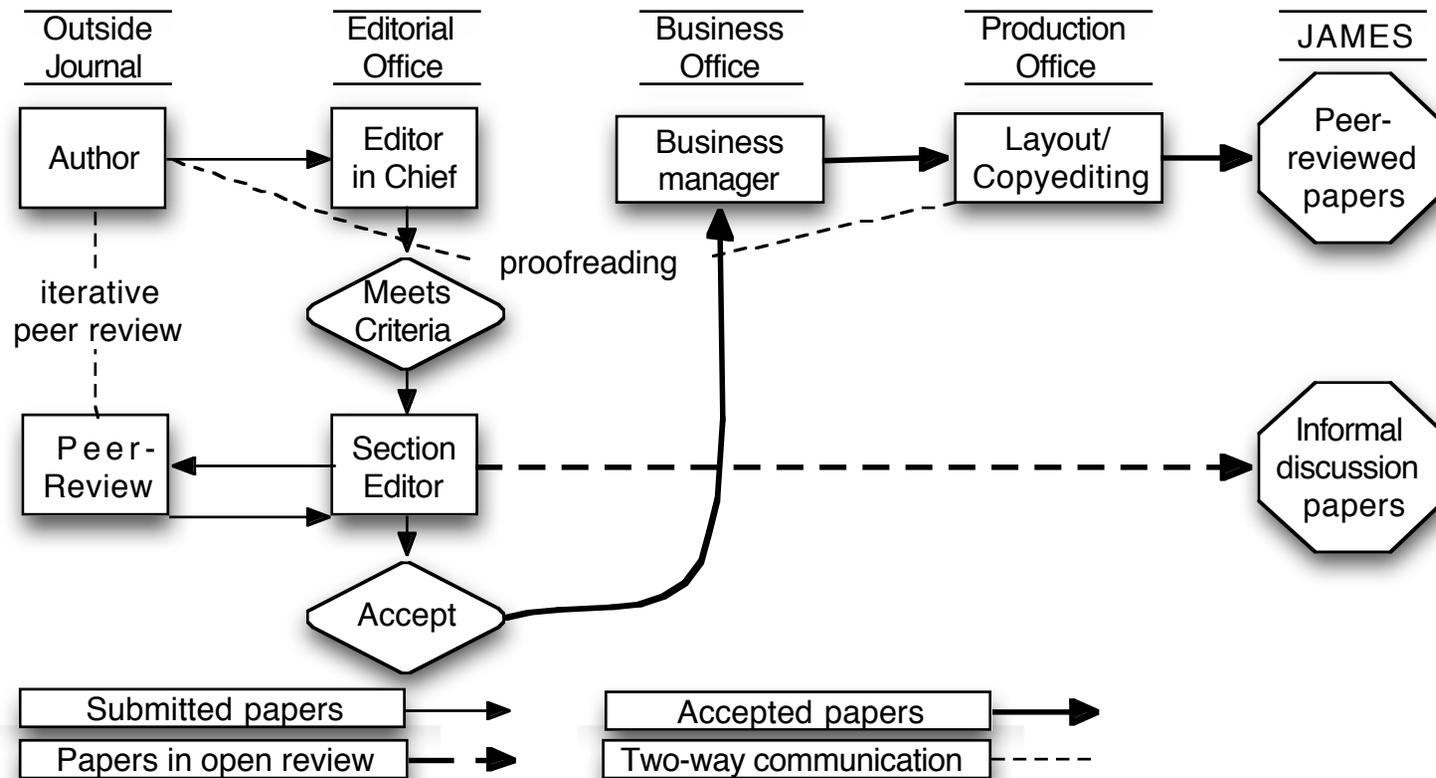


Figure 1. Proposed manuscripts flow in JAMES. Manuscripts are submitted to the Editor in Chief for initial review. Papers that meet the criteria of the journal are assigned to a section editor. The section editor sends the paper out for formal peer-review and, if the author has selected to participate, to the informal discussion section. Once a paper is accepted in formal peer-review it is then passed on to the business office for accounting purposes and then on to the production office for layout and copyediting. Following proofreading with the author the production office publishes the peer-reviewed paper directly to the online host, JAMES.

Timetable

January 2008: Charlesworth runs tests

February 2008: Composition of Advisory Board
and Editorial Board completed

March 2008: Sign contract with Charlesworth

April 2008: Journal website becomes available

May 2008: Call for papers

Dynamics in JAMES

- “In order to make the best attainable forecast of the future weather, it would be desirable to express the physical laws as exactly as possible, and determine the initial conditions as precisely as possible. Yet the ultimate achievement of producing perfect forecasts, by applying equations already known to be exact to initial conditions already known to be precise, if such a feat were possible, would not by itself increase our understanding of the atmosphere. It is only when we use systematically imperfect equations or initial conditions that we can begin to gain further understanding of the phenomena which we observe.”

Hierarchy of GCMs

Can JAMES help enhance the interaction of dynamics and global modeling?

Phillips' (1956) general circulation model was quasi-geostrophic and on a midlatitude beta-plane channel.

Can we construct a “quasi-geostrophic” general circulation model on the sphere?

Shallow Water Equations on Sphere

$$\frac{Du}{Dt} - \left(2\Omega \sin \phi + \frac{u \tan \phi}{a} \right) v + g \frac{\partial h}{a \cos \phi \partial \lambda} = 0,$$

$$\frac{Dv}{Dt} + \left(2\Omega \sin \phi + \frac{u \tan \phi}{a} \right) u + g \frac{\partial h}{a \partial \phi} = 0,$$

$$\frac{Dh}{Dt} + (\bar{h} + h) \left(\frac{\partial u}{a \cos \phi \partial \lambda} + \frac{\partial(v \cos \phi)}{a \cos \phi \partial \phi} \right) = 0,$$

Potential vorticity equation:

$$\frac{DP}{Dt} = 0,$$

$$\begin{aligned} P &= \frac{\bar{h}}{\bar{h} + h} \left(2\Omega \sin \phi + \frac{\partial v}{a \cos \phi \partial \lambda} - \frac{\partial(u \cos \phi)}{a \cos \phi \partial \phi} \right) \\ &= 2\Omega\mu + \left(\frac{\bar{h}}{\bar{h} + h} \right) \nabla^2 \psi - 2\Omega\mu \left(\frac{h}{\bar{h} + h} \right), \end{aligned}$$

Approximate potential vorticity:

$$P \approx 2\Omega\mu + \nabla^2 \psi - \frac{2\Omega\mu}{\bar{h}} h = 2\Omega\mu + q$$

“Quasi-geostrophic” Balance

Linear balance condition:

$$\nabla \cdot (2\Omega\mu\nabla\psi) = g\nabla^2 h$$

Slow variation of Coriolis:

$$\nabla^2(gh - 2\Omega\mu\psi) = 0$$

Local linear balance condition:

$$gh = 2\Omega\mu\psi$$

Quasi-Geostrophic Theory on the Sphere

$$\frac{\partial q}{\partial t} + \frac{1}{a^2} \frac{\partial(\psi, q)}{\partial(\lambda, \mu)} + \frac{2\Omega}{a^2} \frac{\partial\psi}{\partial\lambda} = 0,$$

$$\nabla^2\psi - \frac{\epsilon\mu^2}{a^2}\psi = q$$

Add forcing, friction, and stratification to get the spherical version of Phillips (1956).

Lamb's Parameter

$$\epsilon = \frac{4\Omega^2 a^2}{g\bar{h}} = \left(\frac{a}{(g\bar{h})^{1/2} / (2\Omega)} \right)^2$$

Lamb's Parameter	Equivalent Depth (m)	Gravity Wave Speed (m s ⁻¹)
10.	8809.	293.8
100.	880.9	92.91
1000.	88.09	29.38
10000.	8.809	9.291

Spheroidal Harmonics

$$\nabla^2 \mathcal{S}_{mn} - \frac{\epsilon \mu^2}{a^2} \mathcal{S}_{mn} = -\frac{\alpha_{mn}(\epsilon)}{a^2} \mathcal{S}_{mn}$$

When $\epsilon = 0$

$$\alpha_{mn}(0) = n(n+1)$$

$$\mathcal{S}_{mn}(0; \lambda, \mu) = P_{mn}(\mu) e^{im\lambda}$$

Rossby-Haurwitz Waves

$$\nu_{mn}(\epsilon) = \frac{2\Omega m}{\alpha_{mn}(\epsilon)}$$

This gives near perfect agreement with the eigenvalues of Laplace's tidal equations. No erroneous retrogression of ultralong waves.

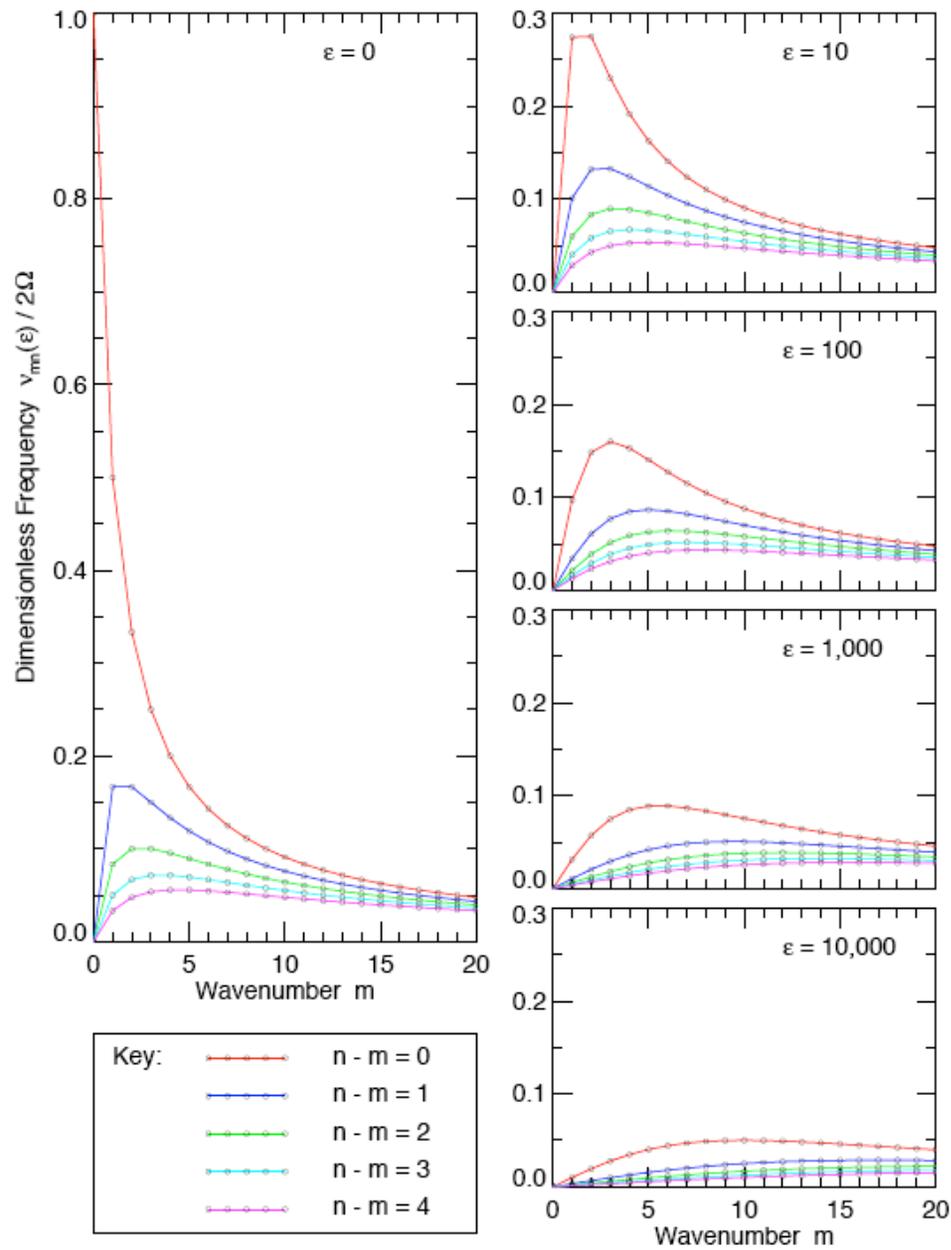


Figure 1: Dimensionless Rossby-Haurwitz wave frequencies, $\nu_{mn}(\epsilon)/2\Omega$, as a function of zonal wavenumber m for $\epsilon = 0, 10, 100, 1000, 10000$.

Rhines Length

Dynamics is wavelike if

$$2\Omega m / \alpha_{mn}(\epsilon) \gg a^{-1} [\alpha_{mn}(\epsilon)]^{\frac{1}{2}} V_{\text{rms}}$$

But dominated by turbulence if

$$2\Omega m / \alpha_{mn}(\epsilon) \ll a^{-1} [\alpha_{mn}(\epsilon)]^{\frac{1}{2}} V_{\text{rms}}$$

Anisotropic Rhines length defined by

$$\frac{m}{[\alpha_{mn}(\epsilon)]^{\frac{3}{2}}} = \frac{V_{\text{rms}}}{2\Omega a}$$

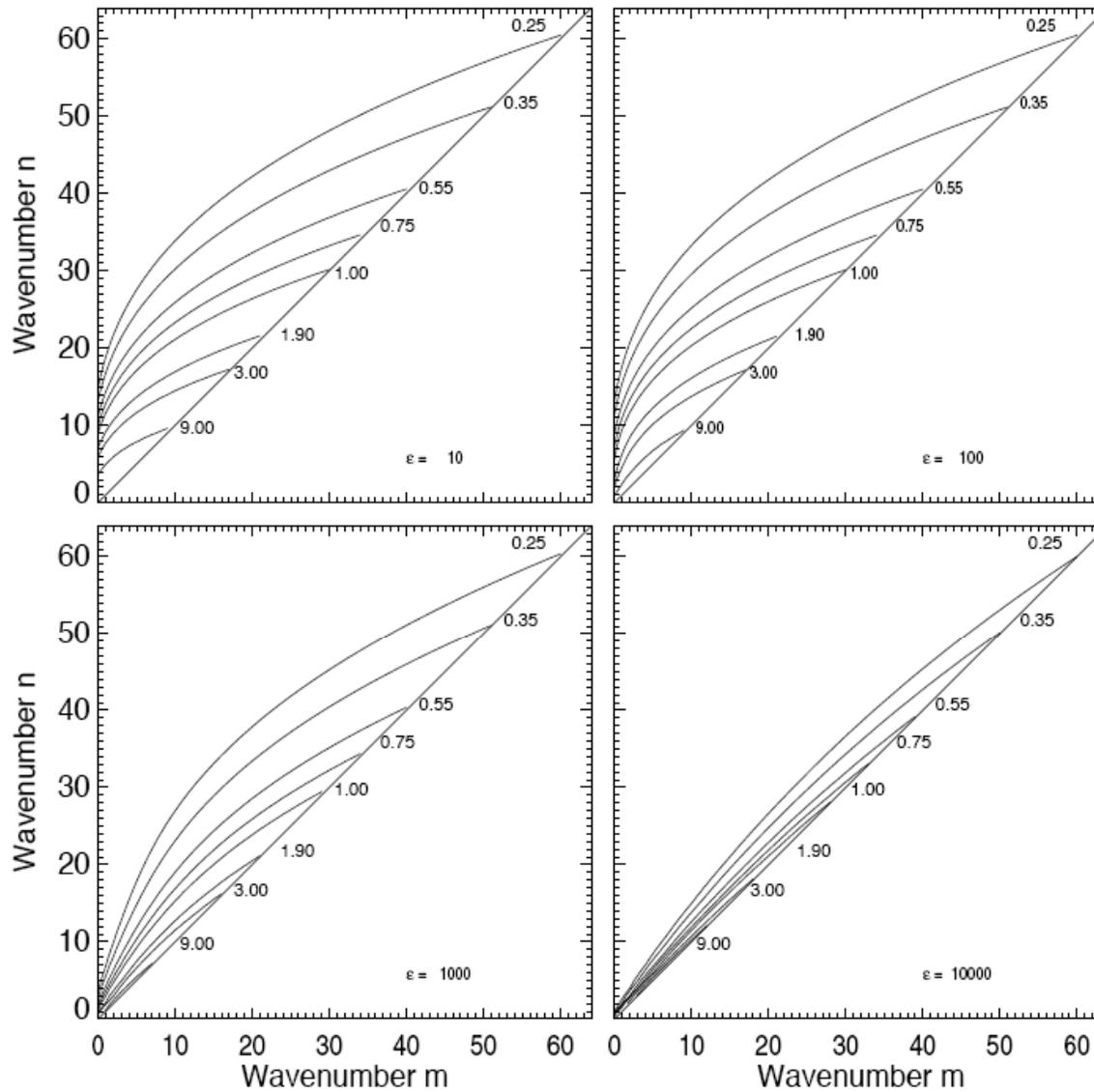


Figure 3: Anisotropic Rhines curves in the wavenumber plane of spheroidal harmonics $S_n^n(\lambda, \mu) = \mathcal{P}_n^m(\mu)e^{im\lambda}$, where m is the zonal wavenumber and n is the total wavenumber. The curves are based on (5.7), with the values of V_{rms} labeled in m s^{-1} on the right.

Dynamics in JAMES

- “It is only when we use systematically imperfect equations that we can begin to gain further understanding of the phenomena which we observe.”
Lorenz 1960.
- Dynamics papers in JAMES can aid in this goal of further understanding. Then, maybe dynamicists will not be rendered completely obsolete!!
- Jobs for “FOG’s”.

END

About JAMES

- JAMES will publish papers on scientific research dealing with all aspects of global environmental modeling, including both model design and applications.
 - > Detailed descriptions of global atmosphere, ocean, and land-surface models.
 - > Papers on parameterizations of various physical processes
 - > Papers on numerical methods
 - > Papers on data assimilation methods
 - > Papers on medium-range forecasting
 - > Papers on seasonal to inter-annual forecasting
 - > Papers on climate change simulations
 - > Papers dealing with other model applications
 - > Non-technical articles at the “*American Scientist*” level. Articles in this section will inform, in lay terms, the informed public as well as science educators at the K-12 level about advances in climate science. Another educational focus is to provide science educators alerts and/or information about educational resources related to climate science and/or climate modeling.