Environmental Turbulence from Clouds through the Ocean

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Abstract

This meeting is a continuation of a tradition starting with the IUTAM Symposium on Geophysical Turbulence in 1962 in Marseilles, continued with the IUTAM Symposium on Geophysical Turbulence in Boulder in 1997. Test2

Organisation

Organisers:

Ian Castro (Southampton), Darryl Holm (ICL), Robert Kerr (Warwick), Sergey Nazarenko (Warwick), and Christos Vassilicos (ICL)

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EPSRC grant for the Warwick Turbulence Symposium. EPSRC/UK Platform grant on Turbulence. Mathematics Interdisciplinary Research at Warwick (MIR@W), UWERN/Natural and Environmental Research Council, U.S. Office of Naval Research Global.

Background

Geophysical and environmental turbulence is of huge importance for weather forecasting and climate modelling, aviation and sea navigation, prediction of natural hazards, etc. This area has experienced significant growth and advances over the last decade thanks to improved understanding of the underlying processes and to the increased computational power available.

To examine these issues, as part of the year-long Warwick Turbulence Symposium at the University of Warwick, United Kingdom, we will hold a four day meeting 14 March-17 March, 2006 on: "Environmental Turbulence from Clouds through the Oceans" supported by the Warwick Turbulence Symposium, the EPSRC/UK Platform Grant on Turbulence and the UK Met Office.

A one day workshop on 13 March 2006 (Day 0) discussing "Theoretical and computational issues in environmental turbulence" will precede the main meeting and is supported by the MIR@W programme of the Warwick Mathematics Institute.

The predictive power of operational forecasting remains far from perfect because even the most powerful supercomputers cannot resolve the important small-scale processes in turbulence on an operational basis. Even the most optimistic extrapolations of computer development do not leave any hope that this problem will be solved soon just by direct increase in computational power. Until recently, turbulence in geophysical flows has usually been parametrised as a diffusive process. With more powerful computers, better codes, better parametrisations and improved observations, many more of the details of turbulence have become important. Thus, we should aim at finding better models of the unresolved (subgrid) scales. Further, much work remains to be done in establishing the role of waves in the small-scale dynamics of atmospheric and oceanic turbulence, studying the mechanisms responsible for air-sea exchanges (momentum, gas, sea spray and moisture), formation of rain clouds and the rain dynamics. Another important question to study is how underwater turbulence interacts with the free surface motions. These processes affect, for example, the spreading of oil slicks and the mixing of CO2 and oxygen to deeper layers in sea-water. Finally, we mention boundary layer turbulence as a classical example important in both atmospheric science and industrial fluid dynamics. This workshop will discuss recent progress in the above fields and will particularly encourage interaction between theoreticians and researchers involved with practical applications including experimentalists.

The objective of these meetings is to complement presentations of some of the latest developments with discussions among some of world's experts to discuss the state of the field and where it will be going.

Questions that would be addressed include: Where does turbulent physics, modelling and parametrization matter the most? Where are its effects least understood? What are some surprising effects of turbulent mixing in the environment?

Four specific regimes whose mixing will be discussed include: the clouds, air-sea interface, upper ocean mixing and deep ocean mixing. For clouds the focus would be warm rain formation via cloud mixing, cluster formation and other effects. For the oceans, three recent missions would be discussed: CBLAST - Coupled Boundary Layer Air-Sea Transfer. CLIMODE - Studies of the "Eighteen Degree Water" layer from the Gulf Stream. DOME - Dynamics of Overflow, Mixing and Entrainment that relates to deep water mixing.

Day 0 - A prelude - Theoretical and Computational Issues in Environmental Tubulence

- C V Tran - St Andrews - Vanishing enstrophy dissipation in 2DNS
  - Comments - Heuristic proof of vanishing enstrophy dissipation in two-dimensional Navier-Stokes Turublence in the inviscid limit. Does this by considering the enstrophy and palinstrophy equations, then assuming power law spectral regimes.
- P Bartello - McGill - Theoretical and computational issues in geophysical turbulence
  - Comments - There is little evidence for balance even for $Ro = 0.09$
- V Zeitlin - Paris - Parametric excitation and nonlinear dynamics of equatorial waves
  - Comments - Nonlinear dynamics in the semi-transparent equatorial waveguide using resonant excitation of Rossby and Yanai waves and their interaction. A two layer resonant shallow water model is used. Generates a Landau equation.

- B Dubrulle - Sarclay - A Les-Langevin model for turbulence
  - Comments - Using the estimated sub-grid velocities obtained by a Gabor transformation as the forcing, a Langevin equation for the subgrid scale terms is obtained.

Day 1 Cloud Mixing

- L Collins - Cornell - Clustering or Particles in Turbulence : Early Cloud Development
  - Comments - History of inertial particle simulation going back to Maxey; Squires and Eaton; Balachandar thesis; Sundaram and Collins; Bec.

    Which terms are important in the drag? "Basset" history versus Stokes drag. What types of interactions: rebound, coalescence, interpenetration. Reviews laws for collision rates as functions of fluid and particle properties.
- J Hunt - UCL - Turbulence enhanced coalescence of settling particles in rainclouds
  - Comments - Importance of gravitationally driven clustering versus simple collisional clustering. Then discusses very inhomogeneous turbulence near interfaces and in swirling flows.
- R Shaw - Michigan Tech - Turbulence and clouds: A measurement perspective
  - Comments -
- A Fouxon - Israel - Role of cloud turbulence in the formation of rain
  - Comments - How do radii affect the collision rates?
- B Devenish - Met Office - Acceleration statistics in turbulence
  - Comments - Does multifractal acceleration statistics based upon steepest descent and She-Leveque. The model is in reasonable agreement with simulations done in Rome.
- S Malinowski - Warsaw - Small-scale mixing in clouds
  - Comments -

Day 2 Wind-Ocean Interactions

- P K Taylor - Southampton - The structure of the Marine Cloud Topped Boundary Layer
  - Comments - From top to bottom get 1) Decoupled cloud layer. 2) Near surface influence of waves. 3) Waves. In the ITCZ near the equator.
- K Melville - Scripps - Wave-Induced Turbulence in the Upper Ocean
  - Comments - CBLAST. Wave breaking a bubble production. Starts with Langmuir waves á la Craik-Leibovich. Shows a lab experiment using a laser line to show a transition from 2D waves to 3D waves. Runs a similar experiment in the San Diego marina. In high winds, all scales seem to be breaking.

- S Belcher - Reading - Wind-Wave Interactions
  - Comments - Wind-wave interactions with Sullivan and McIntyre.
- M Stiassnie - Technion - Temporal and spatial growth of wind waves
  - Comments -
- G Levina - Perm, Russia - Theoretical and Experimental Modelling of Intensive Atmospheric Vortices
  - Comments - Discusses influence of rotation and helicity

Posters:

- R Kerr and G King - Warwick - Scaling laws in the tropical marine boundary layer
- E Hascoet - Imperial - Clustering of inertial particles falling through turbulence
- C Keylock - Leeds - Interaction between a turbulent boundary layer, suspended particles and a fence with a fractal structure

Day 3 Upper Ocean Coupling

- J Marshall - MIT - Mixing and restratification in the upper ocean
  - Comments - Discusses the 18 degree water that forms from the low PV warm pool. Heat fluxes between the ocean and atmosphere are highly variable and depend largely upon the relative positions of the warm and cool water. The flux of fluid into the 18 degree water from the low PV warm pool is estimated by balancing the heat flux out of the 18 degree water into the atmosphere and a slow diffusion of fluid from the low PV warm pool into the 18 degree water. This overestimates the flux of fluid. The solution is to assume that the diffusion is turbulent.
- J Simpson - Bangor - Measurements and models of turbulence in shelf seas
  - Comments - Mixing in the pycocline of the shelf seas. Measurements in a Welsh estuary from teh Prince Madog. FLY is a profiler with a bendy velocity probe at its tip. Shelf seas tend to have a stabilising part near the edge of the shelf.
- A Martin - Southampton - Stirring Vegetable Soup
  - Comments -
- P Berloff - Cambridge - Midlatitude Ocean-Atmosphere Model: Decadal Variability and Dynamics
  - Comments -
- D Acreman - Met Office - Tuning and Validation of Ocean mixed layer models
  - Comments -
- G P King - Lisbon/Warwick - Variability of surface circulation
  - Comments -

Day 4 Deep Ocean

- R Hallberg - GFDL - Representing Gravity Current Entrainment in Large-scale Ocean Models
  - Comments - Entrainment, if it occurs, must occur during the downflow through the lighter layers. Warmer outflows mix less, an example being the Mediterrean outflow. Bulk entrainment schemes are being developed.
- S Legg - Princeton - Making practical progress in representing turbulent processes in ocean models
  - Comments - Deep mixing. Are surface tides dissipated in the shallow bottom boundary layer?
- P Korn - Hamburg - Development of an ocean-atmosphere model on icoahedral grids - the first steps
  - Comments - ICON - Isocahedral Nonhydrostatic General Circulation Model. Conservation of discretised equivalent of global invariants is important.
- M Piggott - Imperial - Modelling environmental flows at a range of scales using adaptive methods
  - Comments - Find hexagonal meshes for studying shear flows at boundaries.
- V Shrira - Keele - Non-traditional Coriolis terms and mixing in the deep ocean
  - Comments - Wave guide in the Garrent-Munk stratification on a β-plane.