

Tropical Cyclone Dynamics – Syllabus

Spring term, 2010

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Course overview: The course will focus on basic dynamics of tropical cyclones and use them to explain tropical cyclone structure and intensity changes as well as their motion. Since there is no suitable textbook for the course, we will use some journal papers that are fundamental and updated to the topics to be discussed. We will also briefly discuss modeling and prediction of tropical cyclones with advanced numerical models. Key references (book chapters and review papers) will be given in the class. The lectures will be given in PowerPoint presentations. A handout lecture note summarizing each topic will be distributed just before each class.

Grading: Class participation 20%, term project 30%, and final exam 50%.

Topics:

1. An introduction to tropical cyclones

Definition, classification, climatology of tropical cyclone formation, tropical cyclone warning centers; an overview of axisymmetric and asymmetric structures of tropical cyclones, including spiral rainbands and polygonal eyewalls, and their potential importance to tropical cyclone structure and intensity changes.

2. Dynamic structure and dynamical balances in tropical cyclones

Dynamical balances of the primary circulation; the secondary circulation; frictional inflow boundary layer; dynamic structure, such as vorticity, angular momentum, inertial stability, etc.

3. Tropical cyclone genesis: Necessary conditions

A review of Gray's six necessary conditions of tropical cyclogenesis.

4. Tropical cyclone genesis: Large-scale control

Discussion of large-scale patterns of tropical cyclogenesis over the western North Pacific.

5. Tropical cyclone genesis: Mesoscale aspects

Some recent new perspective of tropical cyclogenesis, such as vortical hot towers.

6. Theories of tropical cyclogenesis

Cooperative growth of cumulus convection and synoptic scale vortices, linear and nonlinear CISK, wind-induced surface heat exchange (WISHE), and new challenges.

7. Maximum potential intensity (MPI)

Concepts of the maximum potential intensity (MPI), two MPI theories and

applications, and new challenges to the theories.

8. Balanced dynamics of tropical cyclones

Governing equations in cylindrical coordinates and axisymmetric balanced model (Sawyer-Eliassen balanced model) and its applications.

9. Dynamics of rapid intensification

Highlights of the nonlinear behavior of balanced vortices in response to diabatic heating and the effect of the inertial stability of the vortex core, and potential sensitivity to initial vortex structure.

10. Potential vorticity (PV) dynamics and PV mixing

PV concept, eddy processes, and PV mixing, axisymmetrization, and filamentation in the inner-core region of tropical cyclones.

11. Waves in tropical cyclones and wave-mean flow interaction

Gravity, inertia-gravity waves, and vortex Rossby waves in tropical cyclones; wave (eddy)-mean flow interactions.

12. Structure and intensity changes (1): Internal dynamics

Phenomenon and dynamics of eyewall cycle, interaction between eyewall and rainbands, PV mixing, and role of eddy processes.

13. Structure and intensity changes (2): Environmental influence

Vertical shear effect, trough interaction, translation, etc.

14. Structure and intensity changes (3): Ocean feedback

Ocean response (upwelling and inertial currents) and feedback, ocean eddy effects, and climatic implications.

15. Size change of tropical cyclones

Recent advancements in the dynamical control of inner-core size and size change of tropical cyclones, annular structure, concentric eyewall, role of diabatic heating in spiral rainbands.

16. Dynamics of tropical cyclone motion

Rossby-wave energy dispersion, beta-induced asymmetries, and beta drift of tropical cyclones, effect of vertical shear and vertical coupling, binary interaction, and orographic effect.

17. Climate aspects of tropical cyclones

Dynamical aspects of interannual variability of tropical cyclone activities, potential impact of global change on the formation and intensity of tropical cyclones.

18. Numerical modeling and prediction of tropical cyclones

A historical overview on tropical cyclone modeling and progress in numerical prediction of tropical cyclones.