# Tropical Cyclones (ATMO614) – Syllabus

**Instructor:** Prof. Yuqing Wang, 956 5609, email: yuqing@hawaii.edu

**Course overview**: The course will focus on basic concepts and dynamics of tropical cyclones and use them to explain tropical cyclone, genesis, structure and intensity changes as well as their motion and climate variability. We will also briefly discuss numerical modeling and prediction of tropical cyclones with advanced numerical models. Since there is no suitable textbook for the course, we will frequently refer to relevant journal papers that are fundamental and updated to the topics being discussed. Key references will be given in the class or lecture notes. The lectures will be given in PowerPoint presentations. A handout lecture note summarizing each topic will be distributed just before each class by email.

**Grading:** Class participation 10%, term project 20%, and mid-term and final exams, each 35%.

**Topics that will be covered**

1. **An introduction to tropical cyclones**
   Definition, classification, climatology of tropical cyclone formation, tropical cyclone warning centers; axisymmetric and asymmetric structures of tropical cyclones, etc.
2. **Dynamic structure and dynamical balances in tropical cyclones**
   Primary circulation; secondary circulation; frictional inflow boundary layer; dynamic structure, such as vorticity, angular momentum, inertial stability, etc.
3. **Tropical cyclone genesis: Necessary conditions and genesis potential index**
   A review of Gray's six necessary conditions of tropical cyclogenesis and genesis potential index (GPI).
4. **Tropical cyclone genesis: Large-scale control**
   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**
   Review all existing proposed theories of tropical cyclogenesis.
7. **Maximum potential intensity (MPI)**
   Concepts of the maximum potential intensity (MPI), two MPI theories and applications, and new challenges to the MPI 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 replacement cycle, interaction between eyewall and rainbands, PV mixing, and role of eddy processes.
13. **Structure and intensity changes (2): Environmental influence**
    Vertical wind 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 and size change of tropical cyclones**
    Recent advancements in dynamical control of inner-core size and size change of tropical cyclones, annular structure, concentric eyewall, role of diabatic heating in spiral rainbands.
16. **Tropical cyclone motion**
    Steering concept, Rossby-wave energy dispersion, beta-induced asymmetries, and beta drift of tropical cyclones, effect of vertical shear and vertical coupling, binary interaction.
17. **Climate aspects of tropical cyclones**
    Interannual variability of tropical cyclone activities, potential impact of global change on the frequency 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.