ATMO610 – Tropical Climate and Weather – Syllabus

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Course Description: This is a core survey course that will discuss aspects of tropical meteorology from planetary to convective scales. In part I, I will approach the subject related to tropical climate; and in part II, I will cover the subject related to tropical weather. Since there is no one textbook that satisfies the needs of this course, I will prepare a lecture note and pass it to you by email before each lecture.

Term Project: Each student is required to make a 10-15 minute presentation on a topic or a component of a topic in lecture 12 and 13 listed in part II below, based on class reading, additional references, or original research. A written report (~10 pages with single space, Time New Roman font, size 12, including illustrations) is due in a week after the presentation. This will give you an opportunity to grasp the major concepts, research progress, and unresolved issues and to provide the vision for possible future research efforts in the area. (Presentations will be scheduled in early May and discussion with individuals about the choice of topics will start from middle March with guidelines.

Grading: Grade will be determined based on mid-term exam (35%), final exam (35%), project presentation and report (20%), and class participation (10%).

Part I. Tropical Climate

Lecture 1. An Introduction to the Tropics
Definition of Tropics and a tour of the course.

Lecture 2. Scale Analysis of Tropical Motion
Scale analysis of atmospheric motion, non-dimensional scaling parameters.

Lecture 3. Energy Balance of Earth Climate System
Radiation, surface heat flux, SST, latent heating.

Lecture 4. Hadley Circulation, Jet Stream, and Global Precipitation
ITCZ, and jet streams, and global precipitation.

Lecture 5. Gill Model for Tropical Planetary Circulation
Atmospheric response to internal heating and horizontal adjustment by waves.

Lecture 6. Madden-Julian Oscillation: Dominant Mode of Large-scale Convection
Climatology, structure, seasonality, and dynamics.

Lecture 7. Subtropical Climate: Subtropical High, Trade Winds, and TUTTs
Subtropical high; trade wind structure – inversion, winds, and clouds; TUTTs.

Lecture 8. Monsoons
Definition, climatology, and dynamics of monsoon onset.

Lecture 9: Equatorial Oceanography
Equatorial upwelling, coastal upwelling, thermodynamic air-sea interaction.

Lecture 10: Bjerknes Feedback and the Walker Circulation/Cold Tongue
Tropical air-sea interaction, walker circulation, and cold tongue complex.

Lecture 11: El Nino/Southern Oscillation (ENSO)
El Nino, La Nina, the Southern Oscillation, and global influence, ENSO cycle and theories.

Lecture 12. Stratospheric Quasi-Biennial Oscillation (QBO) and Tropical Biennial Oscillation (TBO)
Phenomena, structure, and variation.

Part II. Tropical Weather

Lecture 1. Fundamentals for atmospheric convection

Static stability and buoyancy; conditional and convective instability and convective available potential energy (CAPE); convective inhibition, cumulus convection.

Lecture 2. Cumulonimbus clouds, thunderstorms

Cumulonimbus cloud life cycle, updrafts and downdrafts, interaction with large-scale environment: entrainment/detrainment.

Lecture 3. Bulk properties of convection from large-scale heat & moisture budgets

Large-scale heat and moisture budgets of tropical convection (Q_1 and Q_2).

Lecture 4. Cumulus parameterization

Concept, different approaches, a bulk cloud model and its application to a mass flux cumulus parameterization.

Lecture 5. Mesoscale convective systems

Squall lines, cloud clusters.

Lecture 6. Fundamentals for synoptic disturbances in the Tropics

Inertial stability, barotropic and baroclinic instabilities, CISK, and WISHE.

Lecture 7. Disturbances in trade winds

Easterly waves and TUTT cells: their structures and formations, and impacts.

Lecture 8. Subtropical cyclones (Kona lows)

Concept, Kona lows: their formation, structure, and impact.

Lecture 9. Tropical cyclones: Structure and Energetics

Storm scale structure, inner core axisymmetric and asymmetric structures, and energetic.

Lecture 10. Tropical cyclones: genesis, intensification, and maximum potential intensity

Necessary conditions, formation processes, inertial stability and nonlinear response, and Carnot engine and superintensity.

Lecture 11. Tropical cyclones: Motion

Environmental steering, beta-drift.

Lecture 12. Diurnal variation of precipitation systems in the Tropics

Diurnal variations of the lifecycle of convection and convective systems over land and ocean.

Lecture 13. Local, regional, and terrain effects

Land-sea breeze, terrain effect, etc.