ATM 409-509 Atmospheric Precipitation Processes Fall 2016

Syllabus

Course Overview:

This course will focus on the: (1) application of fundamental dynamical and thermodynamical processes toward understanding atmospheric precipitation processes, (2) use of remote sensing technologies (radar and satellite) to generate precipitation estimates and mechanisms of integrated water vapor transport, (3) documentation of atmospheric conditions favorable for the occurrence of heavy precipitation, (4) global importance of "atmospheric rivers" originating in the tropics and subtropics to the occurrence of heavy rain events in higher latitudes, (5) analysis of case studies of flood-producing, heavy rain events to better understand the physical mechanisms governing heavy rainfall and to illustrate forecast challenges, and (6) use of a real-time quantitative precipitation forecasting (QPF) exercise to enable students to apply class concepts to real weather situations.

Instructor:
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Office Hours: Tuesday and Thursday 12:30 – 2:30 pm in ES-227

Teaching Assistant:
Philippe P. Papin, Office: ES-330; Ph: 864-313-2700; Email: ppapin@albany.edu
Office Hours: Wednesday and Thursday 1:00—2:00 pm in ES-330

Class (3 credits) Hours: Tuesday and Thursday 2:45–4:05 pm in ES-232

Course Requirements:

1. Two exams: Tentative dates: Th 6 Oct and Th 17 Nov 2016 (50%)
2. Semester project: 2000 words maximum (1500 words for ATM 409 students) due Th 1 Dec 2016 (30%)
3. Homework and QPF Exercise (last 5 classes) (20%)
4. Final Exam: None (oral presentations of class projects instead)

Reference Texts:

Bluestein, H., 1992, 1993: Synoptic-Dynamic Meteorology in Midlatitudes (I, II)
Holton, J. and G. Hakim, 2012: An Introduction to Dynamic Meteorology
Houze, R., 2014: Cloud Dynamics, Second Edition, Elsevier
Martin, J., 2006: Mid-Latitude Atmospheric Dynamics: A First Course

Class Materials:

Refereed journal articles, web-based information, and the real atmosphere

Course Outline:

1. **Forecast Verification:**

a) Verification metrics
b) State-of-the-art of quantitative precipitation forecasting

2. **An overview of Quasi-Geostrophic (QG) Theory:**

a) QG omega and Q-vector equations
b) QG height tendency and potential vorticity (QGPV) equations
c) PV thinking, Ertel PV, and dynamic tropopause perspectives
d) Applications of QG theory and PV thinking to rainfall forecasting

3. **The "Big Four" (Lift, Instability, Moisture, and Boundaries):**

a) Isallobaric processes
b) Jet-induced vertical circulations
c) Impact of atmospheric stability on vertical motion
d) A stability tendency equation
e) Trajectories versus streamlines
f) Precipitable water and integrated water vapor transport
g) Moisture budget equation and applications

4. **Satellite and Radar Interpretation:**

a) Satellite and radar physics
b) Applications

5. **Heavy Stratiform Precipitation:**

a) Winter storms
b) Banded precipitation events
c) Orographically influenced storms
d) Coupled jet-driven storms

6. Heavy Convective Precipitation:

a) Mesoscale convective systems (MCSs)
b) Mesoscale convective vortices (MCVs), bow echoes, and derechos
c) Training rain echoes along quasi-stationary fronts and boundaries
d) Predecessor rain events (PREs)
e) Landfalling and transitioning tropical cyclones

7. Atmospheric Rivers (ARs):

a) Narrow corridors of tropical moisture exports (TMEs)
b) ARs, TMEs, and warm conveyor belts (WCBs)
c) Dynamical/thermodynamical processes governing ARs, TMEs, and WCBs
d) Global distribution of ARs and links to flooding

8. Flooding Case Studies:

a) Synoptic-scale floods
b) Mesoscale and local floods
c) Mountain-induced floods
d) Desert floods
e) Tropical cyclone-related floods

9. Quantitative Precipitation Forecasting Exercise:

Five class periods in the real-time forecaster hot seat!

Students will work together in small groups (teams) to craft national quantitative precipitation forecast (QPF) maps using their class knowledge prior to the start of class. During class, the individual student teams will refine their forecasts and then present their QPF maps with one team leading the discussion. Subsequent teams will follow up by presenting similarities and differences in their forecast rainfall reasoning. A critical component of this discussion will be to employ sound, dynamics-based meteorological reasoning (and not simply regurgitate model QPF output) in order to highlight the relevant physical processes that are expected to govern the occurrence, location, distribution, amount, intensity, and type of the expected precipitation.