MAE578 Term paper (1st update, 9/29/2010)

Theme 1: Atmospheric convection and heat engine

Background

We have discussed in class that organized convection in the atmosphere usually requires these ingredients: (1) A vertical temperature difference maintained by external forcing (e.g., solar radiative heating of the surface) (2) Instability that occurs when the vertical temperature difference exceeds a certain threshold, (3) The ensuing overturning motion that transports heat/moisture upward within the convective tower to "neutralize" the vertical thermodynamic profile, and (4) A large-scale background flow that keeps the convective storm moving before it exhausts the "local" potential energy, thereby prolonging the life of the storm. Some of these features remind us how a heat engine works: By the classical Carnot cycle, an essential component of an engine is a temperature contrast. A net output of work (or kinetic energy) is accompanied by the heat transport from the hot side to the cold side of the engine. An external forcing (e.g., by burning of gasoline in our cars) is needed to maintain the temperature contrast in order to keep the engine going. Some scholars have tried to use this "heat engine" analogy to understand the efficiency of energy conversion in atmospheric convective systems. The "heat engine" in those theories can represent an individual convective tower or a large-scale structure (e.g., a hurricane) that consists of an ensemble of many convective cells. *The goal of this term project is to understand, and critique, the existing theories on the "heat-engine thinking" of atmospheric convection.* The following are a few selected papers that might serve as the entry points for a more comprehensive literature survey:

Emanual, K. A., 1991: The theory of hurricanes, *Annual Review of Fluid Mechanics*, **23**, 179-196

Renno, N. O., and A. P. Ingersoll, 1996: Natural convection as a heat engine: a theory for CAPE, *Journal of the Atmospheric Sciences*, **53**, 572-585

Makarieva, A. M., V. G. Gorshkov, B.-L. Li, and A. D. Nobre, 2010: A critique of some modern applications of the Carnot heat engine concept: the dissipative heat engine cannot exist, *Proceedings of the Royal Society, Series A*, **466**, 1893-1902

Be careful: the arguments presented in those papers are not the final words and not guaranteed to be correct. Follow-up studies have been published. It is your responsibility to perform a literature survey to bring the list of references up to date.

Your final report should consist of a clear summary, in your own words, of the major arguments that have been put forth by previous investigators on the heat-engine thinking of atmospheric convection. In addition, you should be able to judge the merit of the existing theories. If you agree or disagree with an argument in a paper, explain why. The clarity and depth of your discussion on the current state of knowledge will determine the score for the term paper. Use equations and diagrams while needed.

The suggested length of the term paper is 15 pages, single space, figures and references included. This is not a strict requirement. A shorter or longer paper is acceptable as long as it is of good quality. A general guideline for the preparation of the term paper will be released later. If Theme 1 does interest you, one or two more themes will be released by the mid-point of the semester. You can only choose one theme to work on for the term project.

Useful websites for literature search

ISI Web of Knowledge/Science (requires ASU IP address to access - use machines in your office or the libraries/labs); Choose "Web of Science". We will have a quick tutorial in class.
www.isiknowledge.com

Google Scholar (not as good as Web of Science but has free access)
scholar.google.com

Most journal articles that you would need for the term paper are available online. Some journals require subscriptions. In that case, check ASU library web site to see if ASU subscribe to those journals. If not, contact ASU library to arrange an inter-library loan. (This is the last resort that is seldom needed.)

Your first exercise would be to find out how/where to access the three papers listed in page 1, then use Web of Science to track newer papers that have cited those papers.