# A&OS 180/229: Mesoscale numerical modeling

Class meetings: Lecture – MWF 11-12 (in MS 7124B); Lab – F 12-2 (in MS7101)
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Class notes: http://www.atmos.ucla.edu/~fovell/AOS180/ModelingNotes2005.pdf (**Warning:** over 10MB.)
VMO reference: http://www.atmos.ucla.edu/~fovell/AOS180/vmo.pdf

Overview: Numerical simulation of atmospheric fluid flow from both theoretical and applied settings. You will construct a two-dimensional model and apply it to interesting phenomena. The course is taught from the perspective of mesoscale atmospheric convection, but the tools acquired and lessons learned are generally applicable to a wide range of atmospheric and oceanic phenomena on a variety of temporal and spatial scales.

This course has historically been offered in "tutorial mode", in which class participation, programming assignments and a final term project take the place of formal exams. **Participation and attendance is required.** Absences are very strongly discouraged and advance notification is expected.

General course outline:

- *Weeks 1-2.* Introduction.

  Theory: Numerical solution of simple ODEs; review of basic dynamics; Taylor series and other tools.

  Application: Compute model base state, including mean profiles of potential temperature, vapor mixing ratio, pressure, density, relative humidity and geometric height, from a given thermodynamic sounding.

- *Week 3.* Assess convective instability of input sounding.

  Theory: Review of basic thermodynamics; isobaric saturation adjustment. Numerical solution of simple integrals (trapezoidal rule). Basic equations. "Quasi-compressible" framework.

  Application: Calculate convective instability of the sounding, using isobaric saturation adjustment.

- *Weeks 4-5.* Set up model base grid.

  Theory: Finite difference approximations to one- and two-dimensional hyperbolic partial differential equations. Consistency and stability; CFL criteria. Grid staggering.

  Application: Set up code to implement model on two-dimensional, staggered grid in a laterally periodic domain.

- *Weeks 6-7.* Model test problem: a buoyant thermal.

  Theory: Background on thermals: structure, evolution.

  Application: Introduce buoyant thermal into model; compare results with theory and among students. Provoke linear computational instability.

- *Week 8.* Add temporal and spatial smoothing to model.

  Theory: Nonlinear computational instability and aliasing.

  Application: Numerical diffusion.

- *Weeks 9-10.* Adapt model to specific projects.

  Theory: Other dynamical frameworks (anelastic, Boussinesq, fully compressible). Adjoint models.

  Application: Past student projects have included: simulation of a simple cloud, density currents, Rayleigh convection, sea-breeze and urban heat island circulations, atmospheric response to maintained heat sources, transport of passive tracers; assessment of sensitivity to artificial acoustic wave speed adjustment and to different numerical schemes.