SPECIAL TOPICS (AMP/MPO)
SYLLABUS

Course Title: Lagrangian Fluid Dynamics and Predictability

Instructor: M. J. Olascoaga, A. Mariano

Course Description: The goal of the course is provide the student with an introduction to a set of mathematical tools for the analysis of Lagrangian motion in oceanic and atmospheric flows.

Prerequisites: Consent of instructors. The student should be familiar with the mathematics of ordinary and partial differential equations. No prior knowledge of dynamical systems theory is required. It is desirable that the student be familiar with MATLAB, which will be extensively used during the course.

Main Textbook:

Samelson, R. M., and S. Wiggins (2006). *Lagrangian Transport in Geophysical Jets and Waves.* Springer.

Lagrangian Analysis and Prediction of Coastal and Ocean Dynamics. Griffa, A., D. Kirwan, A.J. Mariano, T. Ozgokmen, and T. Rossby, editors. Cambridge University Press.

Bennett, A. (2006). *Lagrangian Fluid Dynamics.* Cambridge Monographs on Mechanics.

Complementary Bibliography:

Tabor, M. (1989). *Chaos and Integrability in Nonlinear Dynamics.* John Wiley and Sons.

Ottino, J. M. (1989). *The Kinematics of Mixing: Stretching, Chaos and Transport.* Cambridge.

Grading:

- Assignments (50%).
- Examination I (25%).
- Examination II (25%).

Topics (number of weeks in parenthesis):

1. Lagrangian Observations. Analysis of Lagrangian Observations. (1)
2. Dynamical systems. Incompressible 2D flow. The streamfunction. Phase space. Properties of the Phase space. Maps. (1)
3. Steady waves and meanders. Stagnation Points. Linearization near Stagnation Points. Material Manifolds of Stagnation Points. (1 1/2)
4. Integrability of Lagrangian motion. Action-Angle variables. KAM theorem. Chaos. (1 1/2)
5. Nonsteady waves and meanders. (1 1/2)
6. Hyperbolic trajectories, stable and unstable manifolds, and Lagrangian Coherent Structures. (2)
7. Lobes, transport, flux, and flux exchange. (1)
8. Transport barriers. (1)

9. Transport and vorticity dynamics. (1)
10. Stochastics methods: The Langevin and Fokker-Planck equations. (1)
11. Lagrangian predictability. Inverse lagrangian prediction problem. (1)
12. Assimilation of Lagrangian data. (1/2)