Observers and data assimilation

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Data assimilation is the problem of estimating the state of a system using noisy and partial observations of the system. In many applications such as earth sciences or engineering, the systems are modeled using partial differential equations and are highly nonlinear. One of main tools for this state estimation problem is the analysis of observability and construction of appropriate observers for these systems. The main aim of this project will be to undertake this investigation for a class of PDE inspired by applications, which are all some approximations of Navier-Stokes equations for fluid flow. Some examples of such models are the Burgers' equation and shallow water equations, possibly multi-layer models of these type. We will also undertake numerical investigations to understand the efficacy of the theoretical techniques we develop.

The objectives of the project are

- Develop new data assimilation methods, based on nudging or observers
- Study and compare these new schemes with state-of-the-art data assimilation techniques (e.g. 4D-VAR, Kalman filters, …) on several fluid flow models
- Study theoretically and numerically the observability condition for these models (for instance, is it possible to recover the bottom layer from the knowledge of the upper layer? Or to recover pressure from velocity?)
- Obtain theoretical convergence results and compare with numerical experiments.