Novel Methods for in situ Measurement and Simulation Hurricanes

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What are your area of research

- ThermoFluid Transport
  - Navier-Stokes simulations including shocks, turbulence, flow with interfaces
  - Nonlinear dynamic dimensionality reduction
  - Molecular dynamics of multi-phase flows (triple contact line)

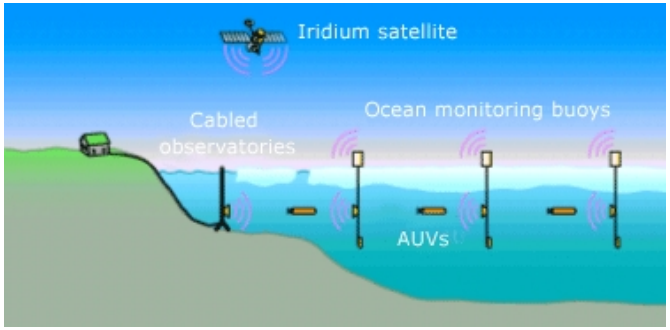
- Mobile Sensor Networking in Harsh Environments
  - Dynamic data driven simulations in harsh environments such as hurricanes
  - Coupled virtual and physical domain operations

Big Data: Example of Problems

- Hurricane Intensity and Track Predictions
  - Massive simulations in real time
  - Lack of accuracy due to lack of accurate boundary conditions

- Global Warming; Vertical Profiling in Polar Region
  - Lack of experimental data for accurate Prediction & simulation

Radial injection of energy necessitates vertical profiling.



Ice-tethered platforms for polar observation

Ice lead plume
(north of Point Barrow 2004)

Challenges

Dealing with Data and Model in vacuum might not be the best approach.

Usually with complex physics or data the questions are:

- How accurate/representative the model is,
- How accurate/representative the data are?

➔Resolution of the data/simulation, which dictate the size of the data, might be secondary.

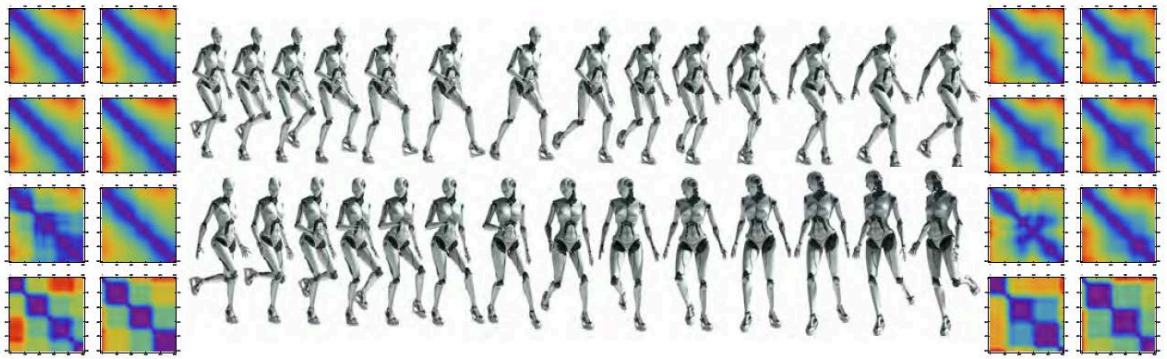
How to remedy that?

- Integrate and interlink the data/simulation (virtual) with measurement (physical)

This requires a bit different thinking about data, its collection, and interaction between measurement and simulation

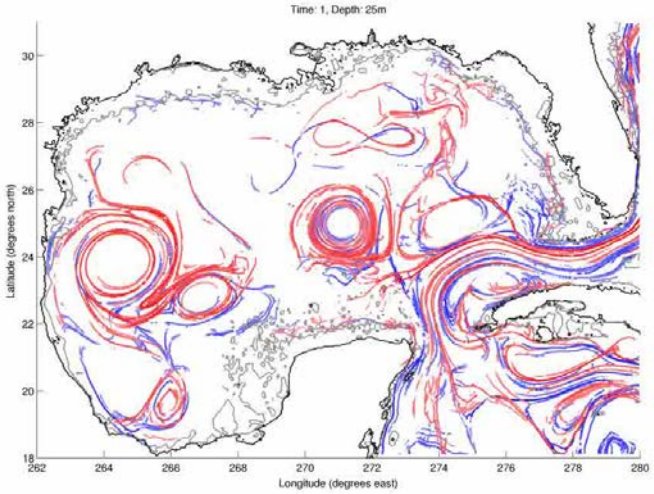
Furthermore, for dynamic data use the dynamics not just static data

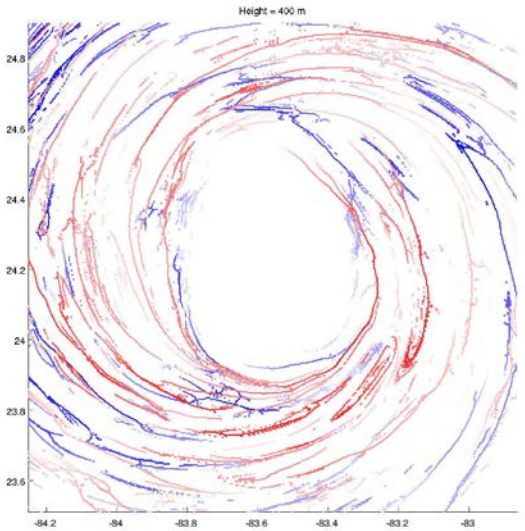
Sledge & Mohseni, submitted to IEEE Trans. Robotics



(2.2.1) Self-(dis)similarities extracted for a walking action conducted by two actors; note that only part of the action for the first actor is displayed above. The matrices on either side, going from right to left and top to bottom, are, respectively, those for the total model, the head region, the neck region, the hip region, the left hand, the right hand, the left foot and the right foot.

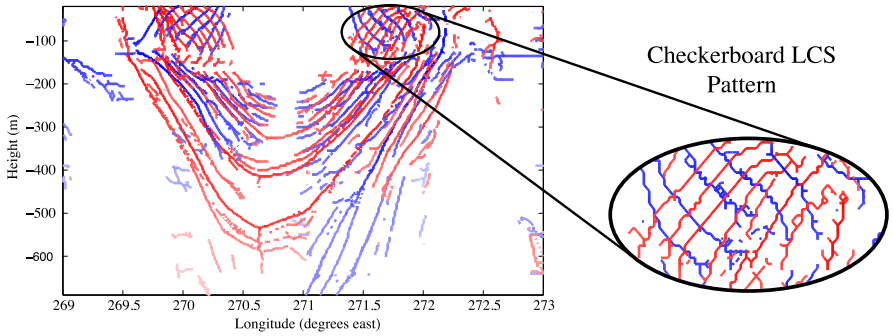
LCS Calculations in Geophysical flows



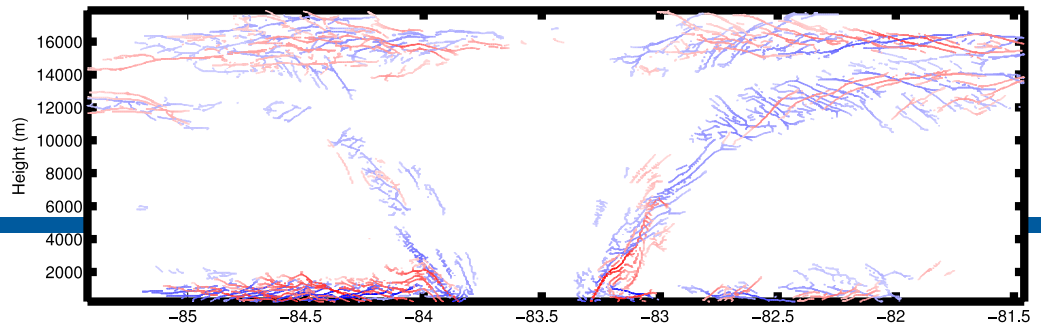


- Similar structures appear in hurricanes and ocean flows
  - Eddies
  - Vortices
  - Jets
- Turbulent mixing
- Complicated transport
- Boundary layer effects

Vertical cross section of a eddy



Vertical cross section of a hurricane



- D. Lipinski and K. Mohseni, A ridge tracking algorithm and error estimate for efficient computation of Lagrangian coherent structures, *Chaos*, 20, 017504, 2010.
- D. Lipinski and K. Mohseni, A fast algorithm for computing ridge surfaces of the three-dimensional finite time Lyapunov exponent field, *Submitted, Spring 2013*.

Example of Progress: Hurricane

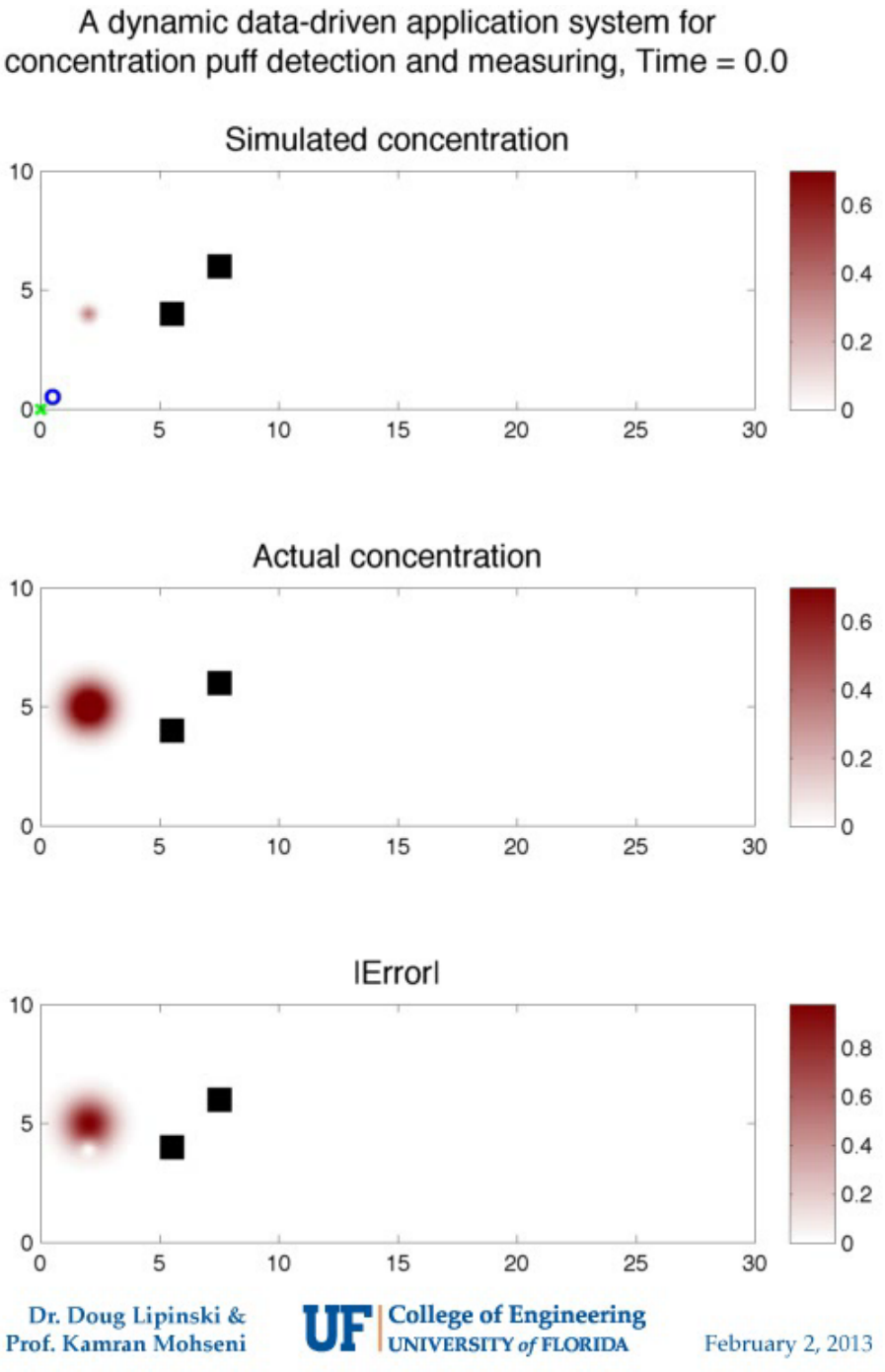
No Smart and data-driven control

Example of Progress: Hurricane

Smart and data-driven control of sensor nodes → massive improvement in prediction

Another Example

Plution/Chemical Dispersion in wind



Liqian & Mohseni, IROS 2012