Observations of wave-sediment coupling on Atchafalaya Shelf, Louisiana, USA

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Field support provided by LSU & Tulane field support groups headed by D. Duncan and S. Dartez.

Supported by ONR

Outline

1. The Problem
2. Field Experiment
3. Some Results
4. Summary

1. The Problem

Wave propagation on muddy shelves:

- Shallow water;
- Large distances;

1. bottom interaction (mud-induced dissipation);
2. nonlinear evolution (3-wave are important).

There are models for mud-induced wave dissipation:

- Dalrymple & Liu, 1978 - Viscous Newtonian fluid.
- Jiang & Mehta, 1996 - Visco-elastic fluid.
- Mei & Liu, 1987- Bingham plastic.
- Yamamoto & Takahashi, 1985: Poroelastic solid.
- ...

Identify mud state $\mapsto$ apply model.

Assumptions:

- Single dissipation mechanism active
- Mud state stable

But

- Mud state responds to hydrodynamics

(de Wit, 1995, Sheremet et al. 2005, Kineke et al. 2006, and others);

Models should include mud feedback;

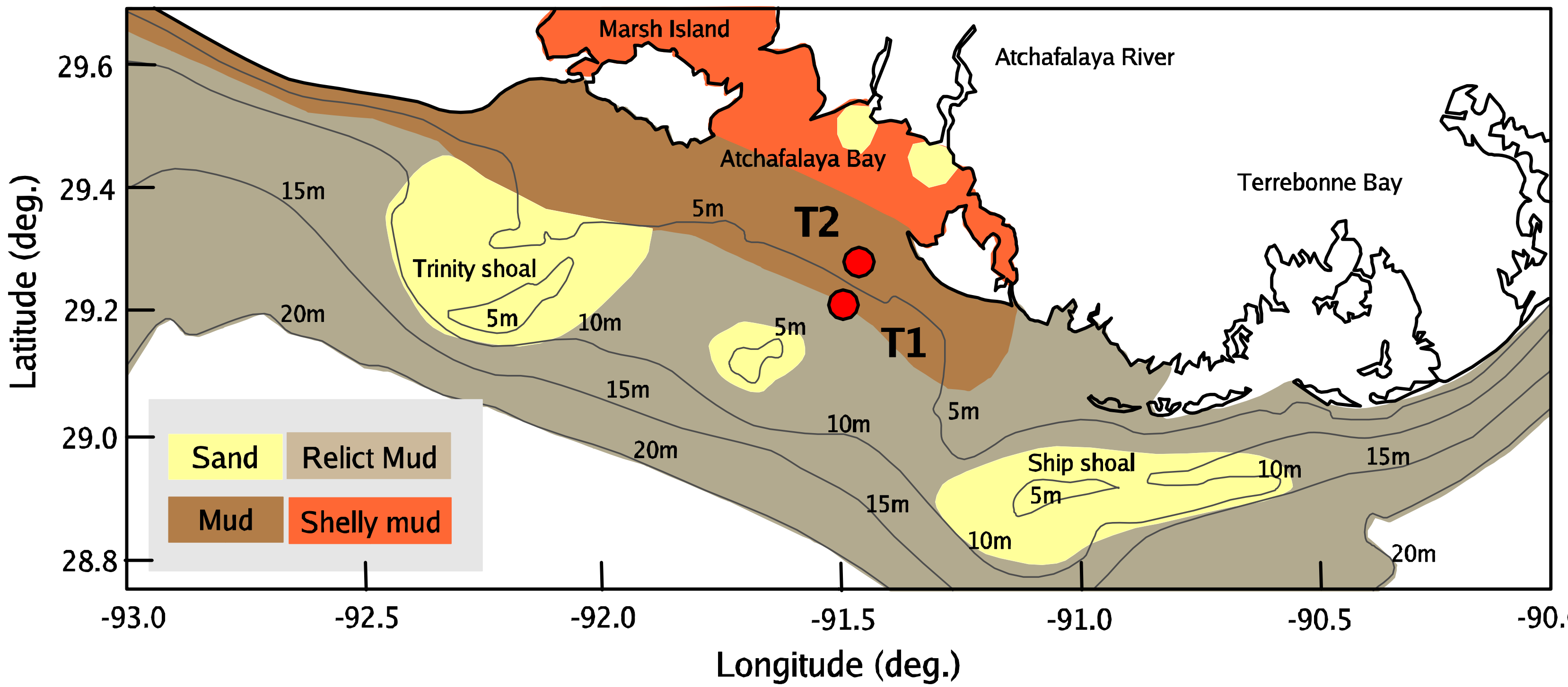
Mud feedback not understood;

Field observations are scarce;

No coherent, high-resolution observations of wave AND sediment dynamics

2. Field Experiment

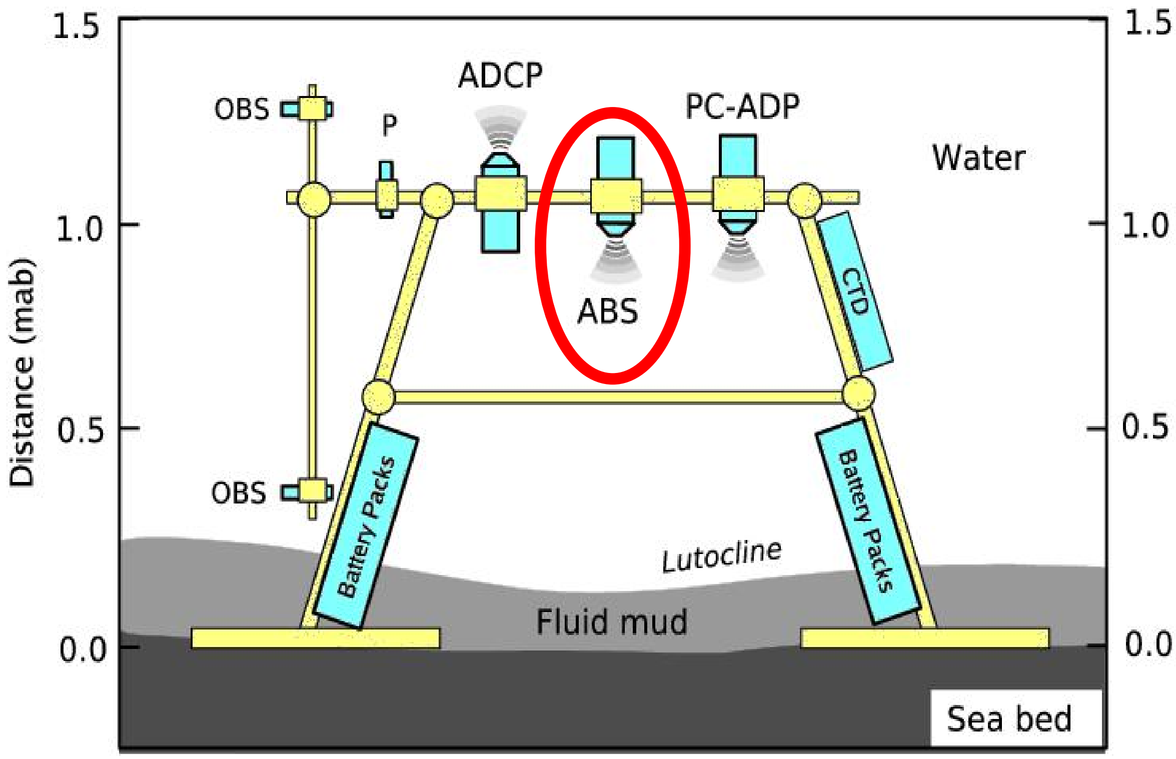
Site: Atchafalaya Shelf, 2006

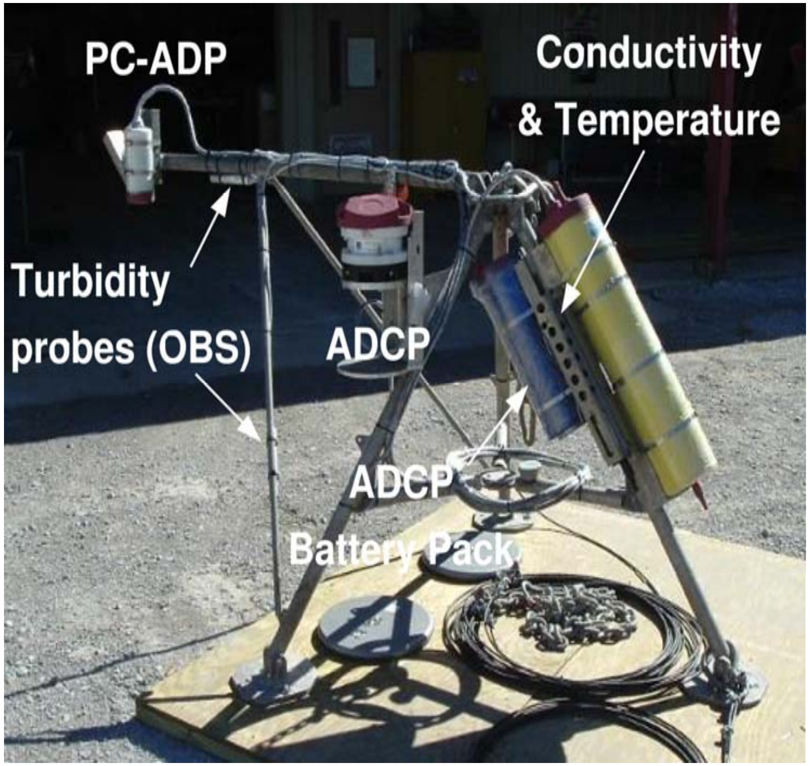


- Muddy shelf,
- Mild slopes (< 0.001)
- Large scales (50km)

Feb 13 - March 14,
Distance ~ 4 km

Instruments

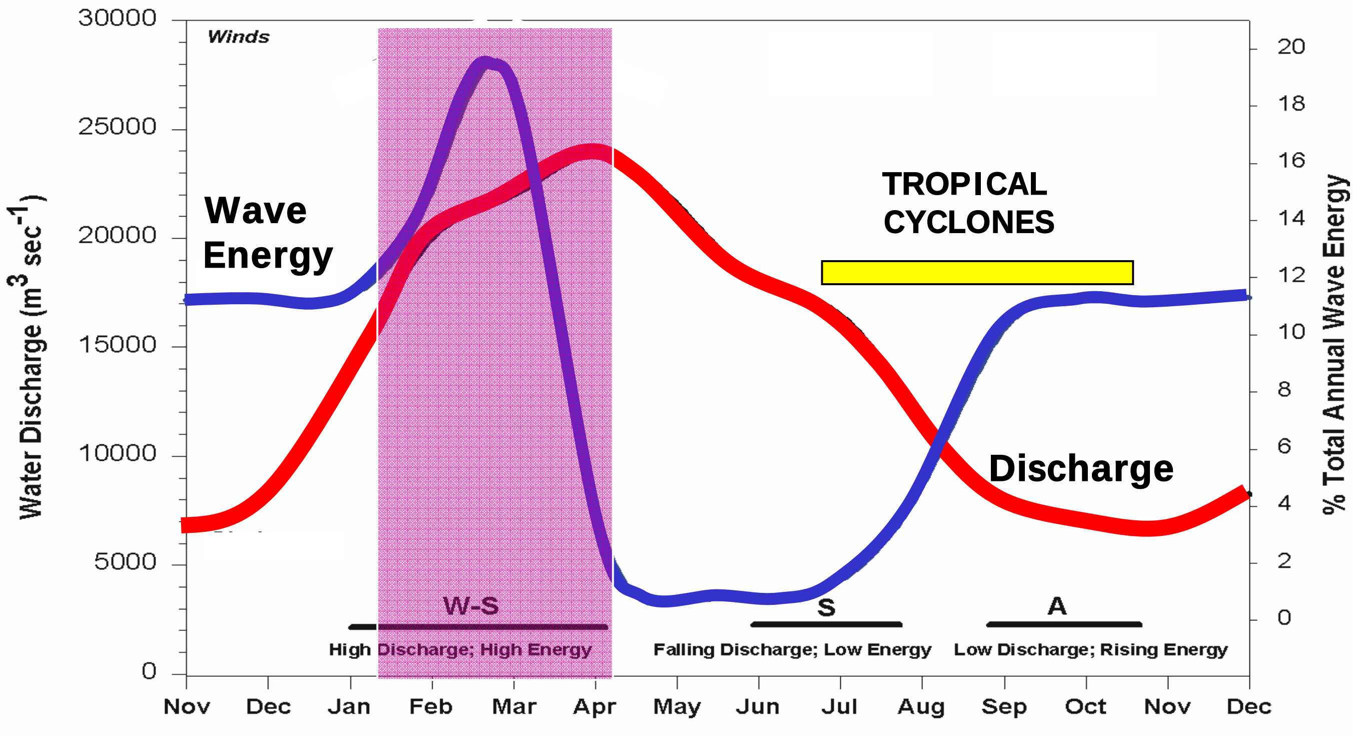




PC-ADP: 2Hz / 14 days; 17 bins, 3-cm high
First 50 cm above the bottom.

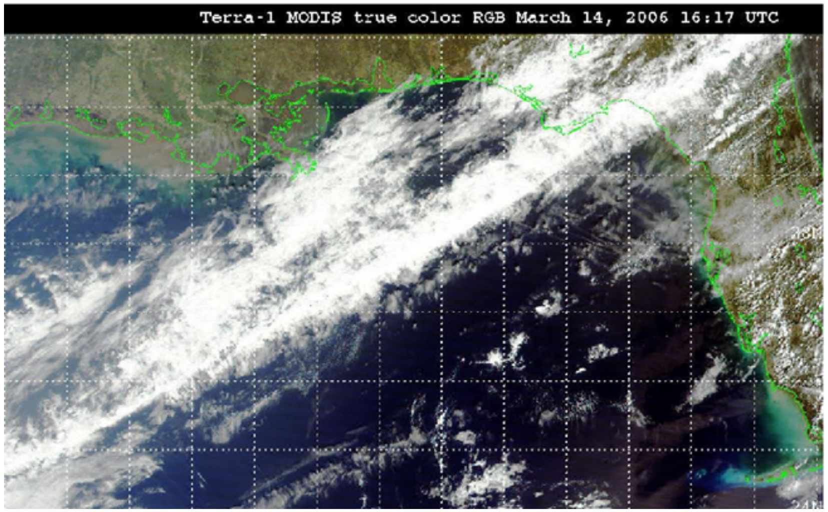
Climate:

High River Discharge
High Wave Energy

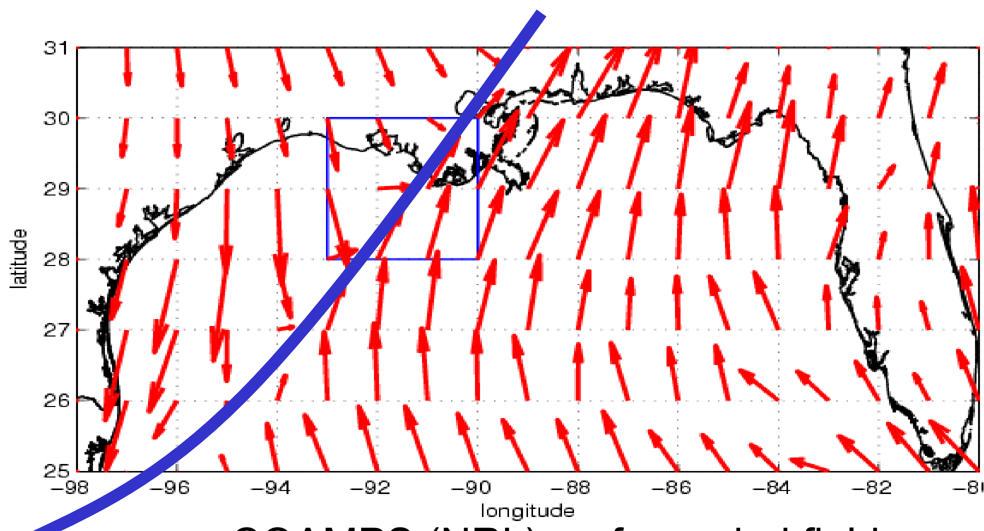


Best period: January -- March

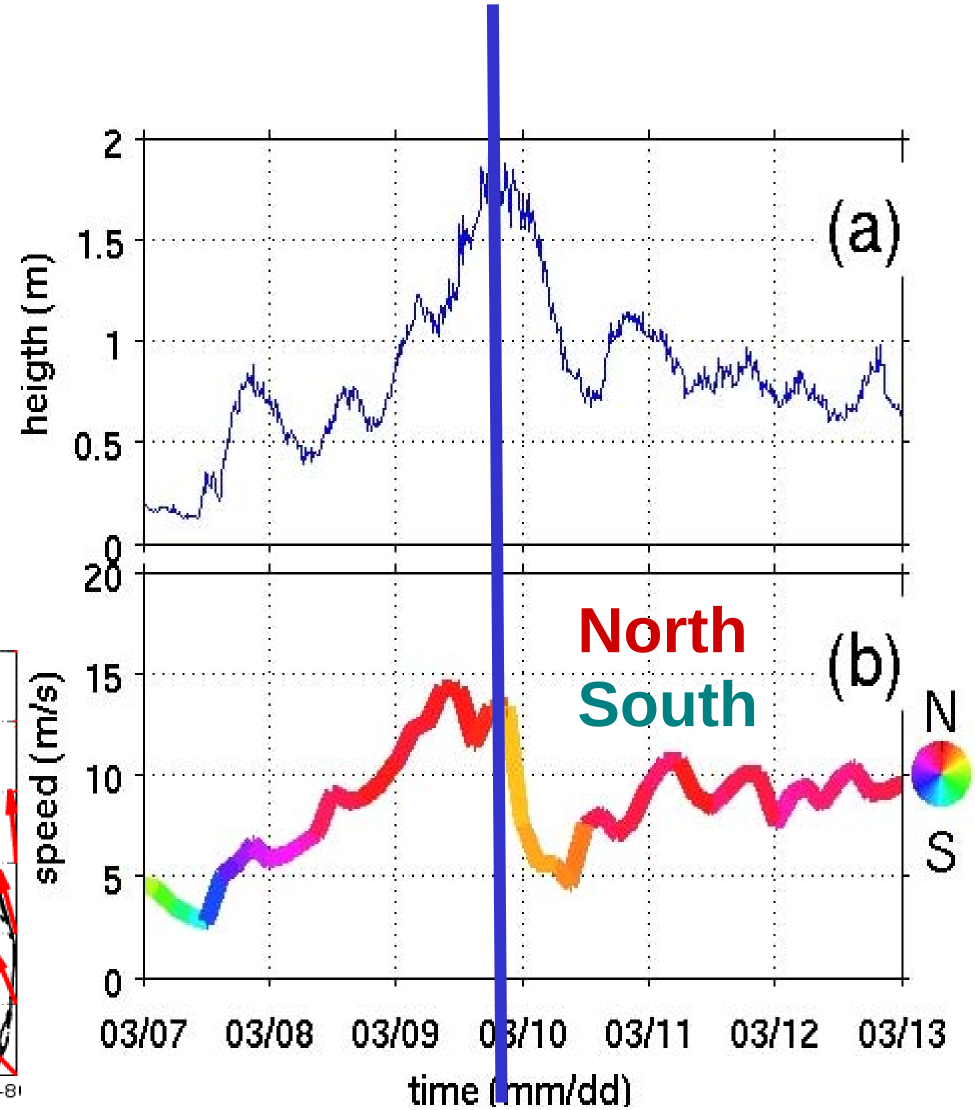
eather: Cold Front Passage, March 8-13 2006.

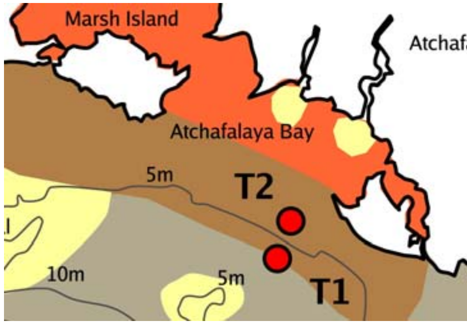


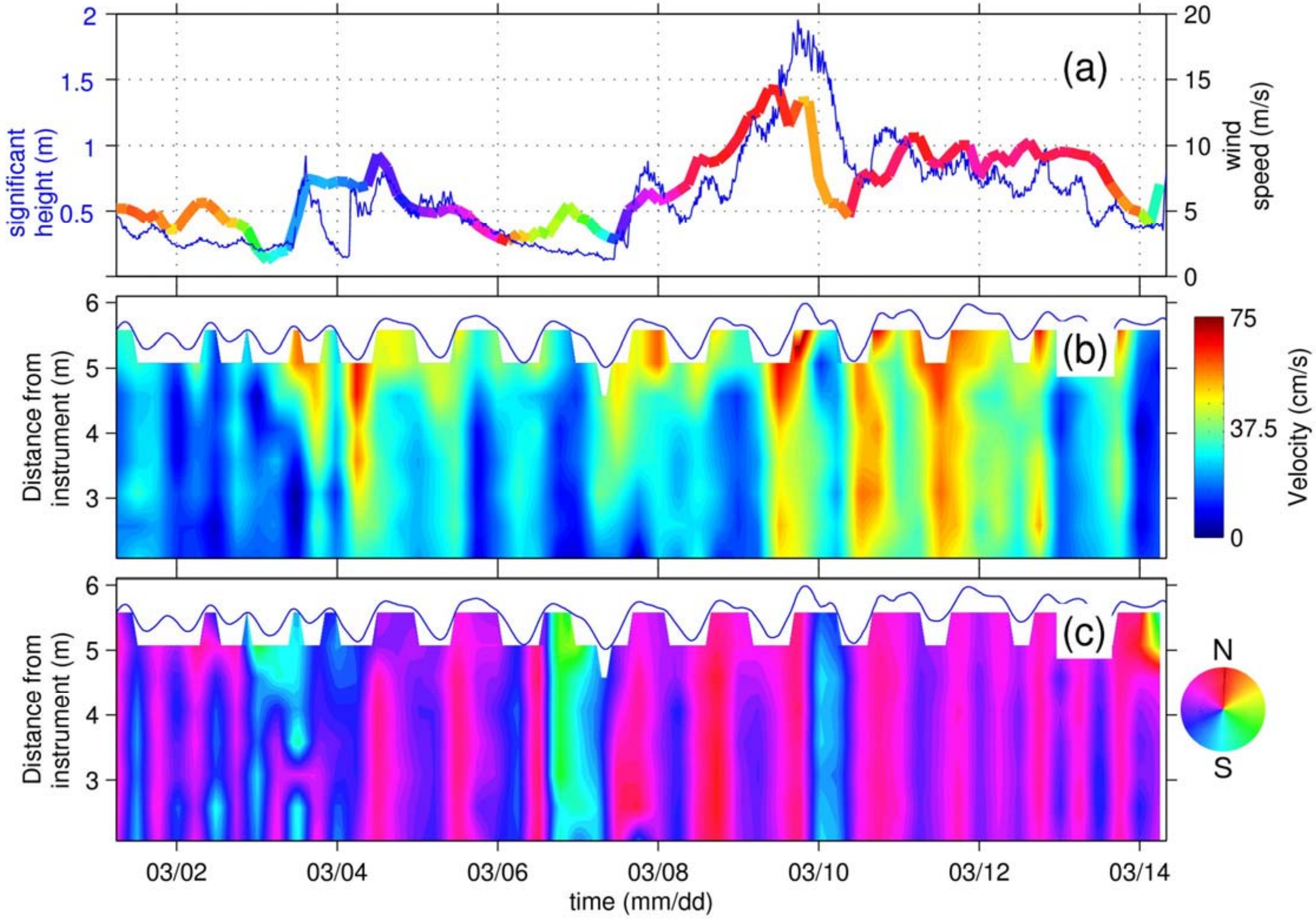
MODIS image, Earth Scan Lab, LSU



COAMPS (NRL) surface wind field



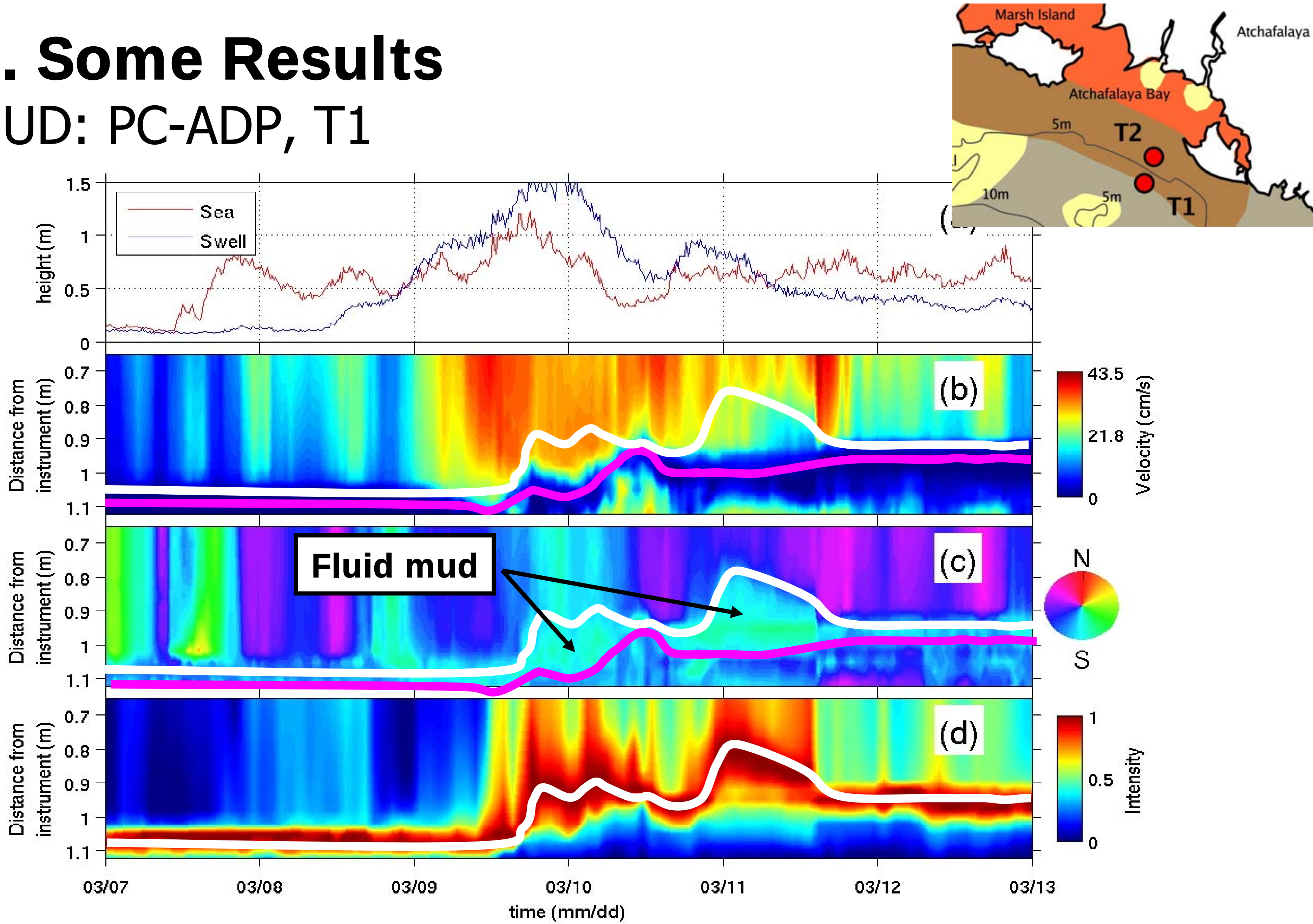




Mach 2 – 14, 2006

3. Some Results

MUD: PC-ADP, T1



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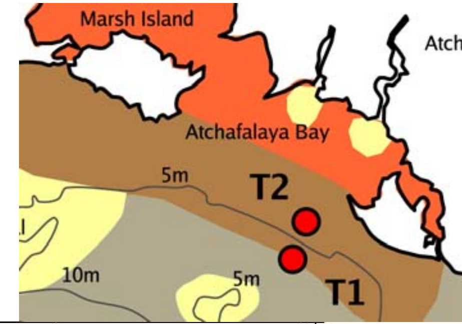
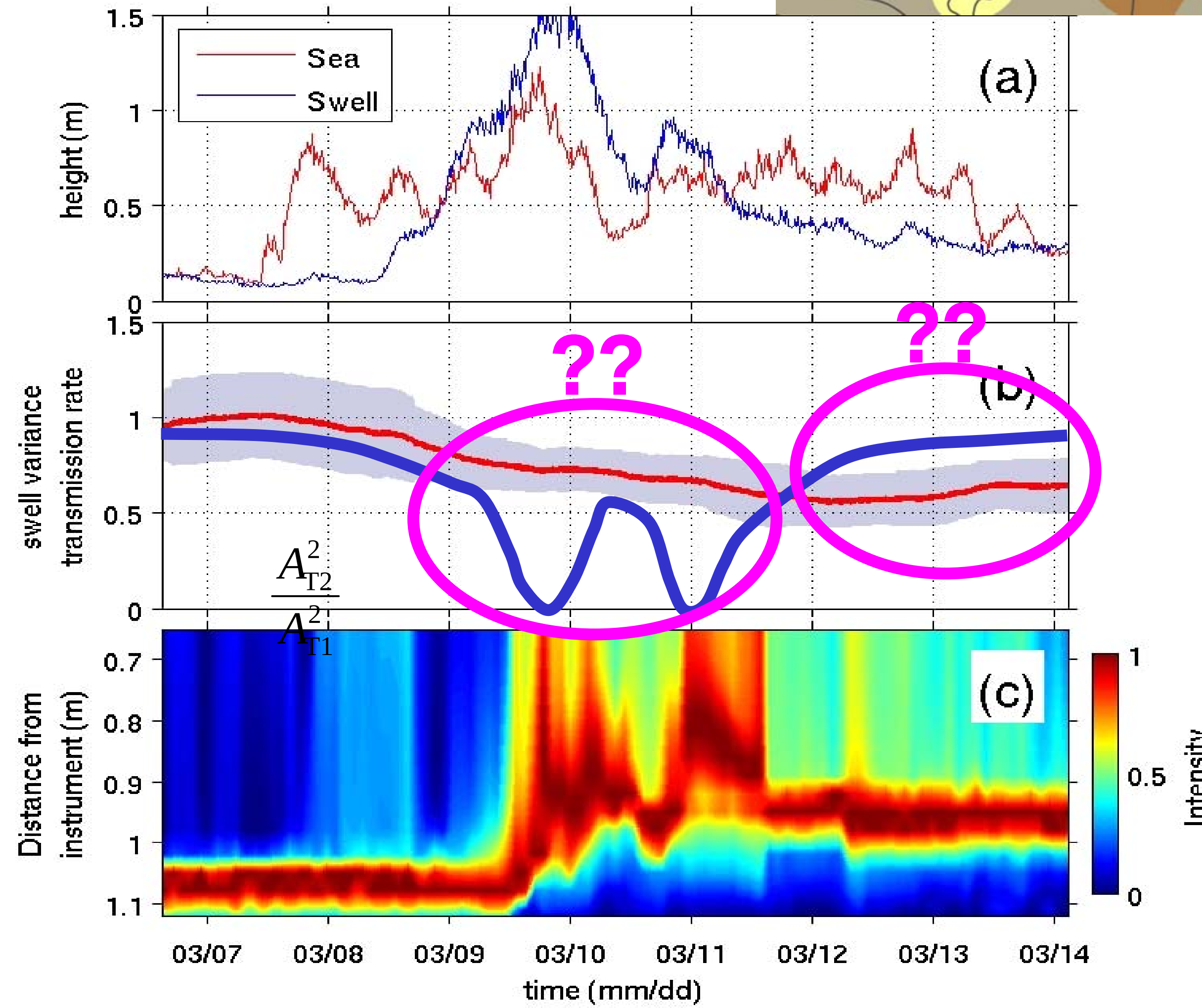
Waves: Net swell response, T1-T2



Energy dissipation 50%

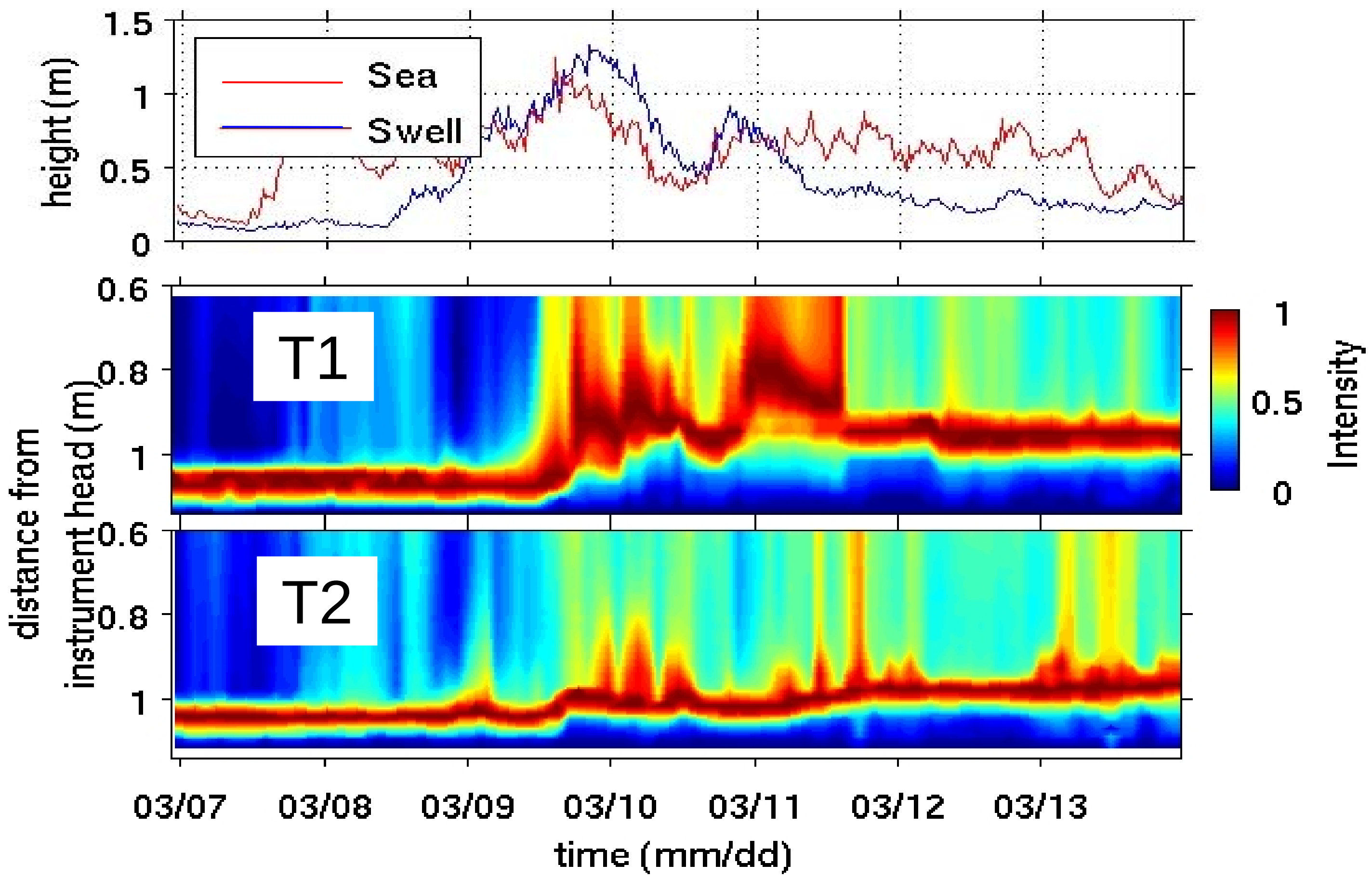
Active wave processes:

- Mud-induced dissipation
- Wave breaking
- Wind input
- Nonlinear interactions

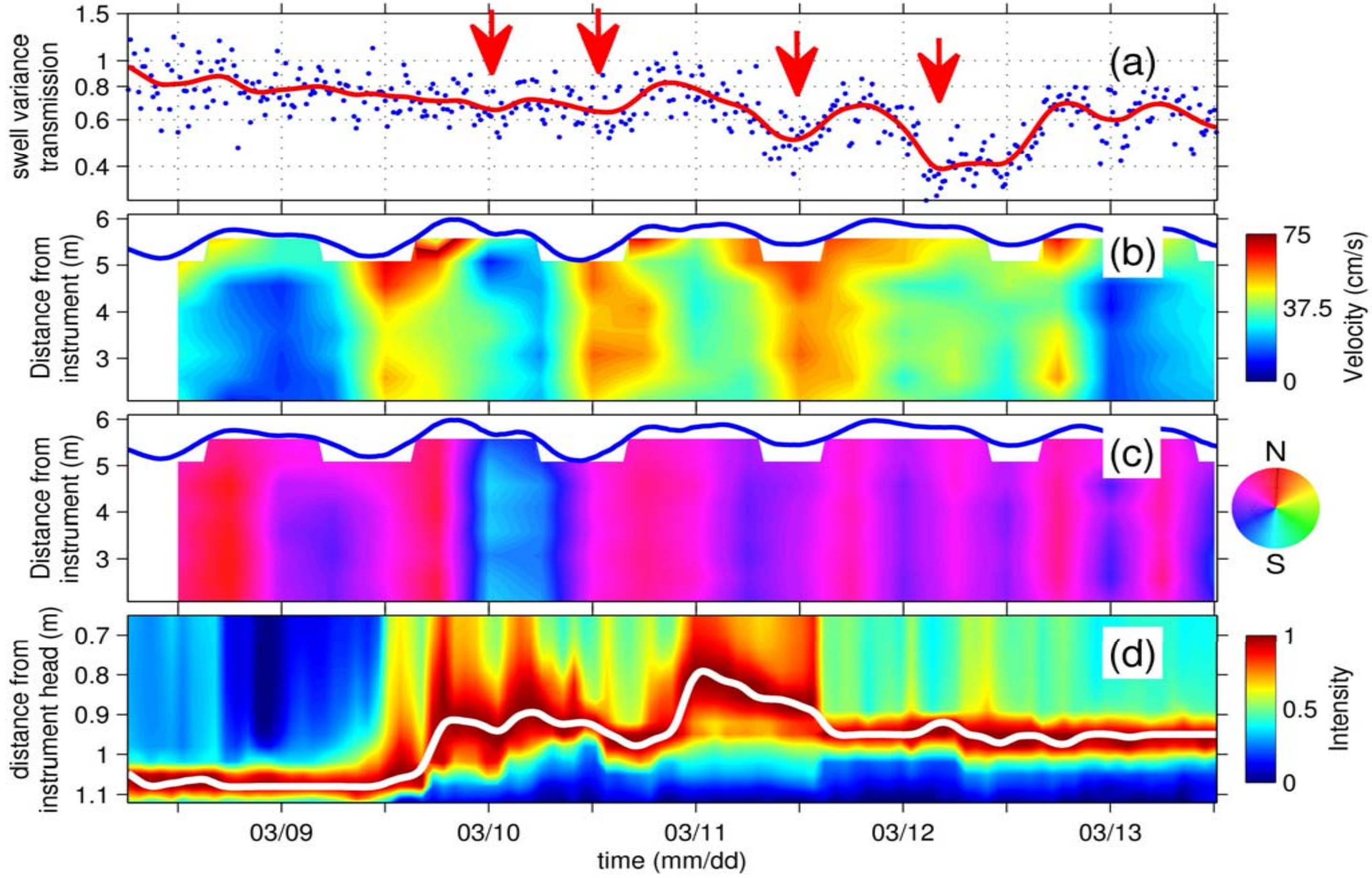


Questions:
Fluid mud effects?
Max dissipation after storm?

Fluid mud dissipative efficiency:
Does not blanket the entire shelf?



Fluid mud dissipattion efficiency:
Fluid mud dense/viscous enough?



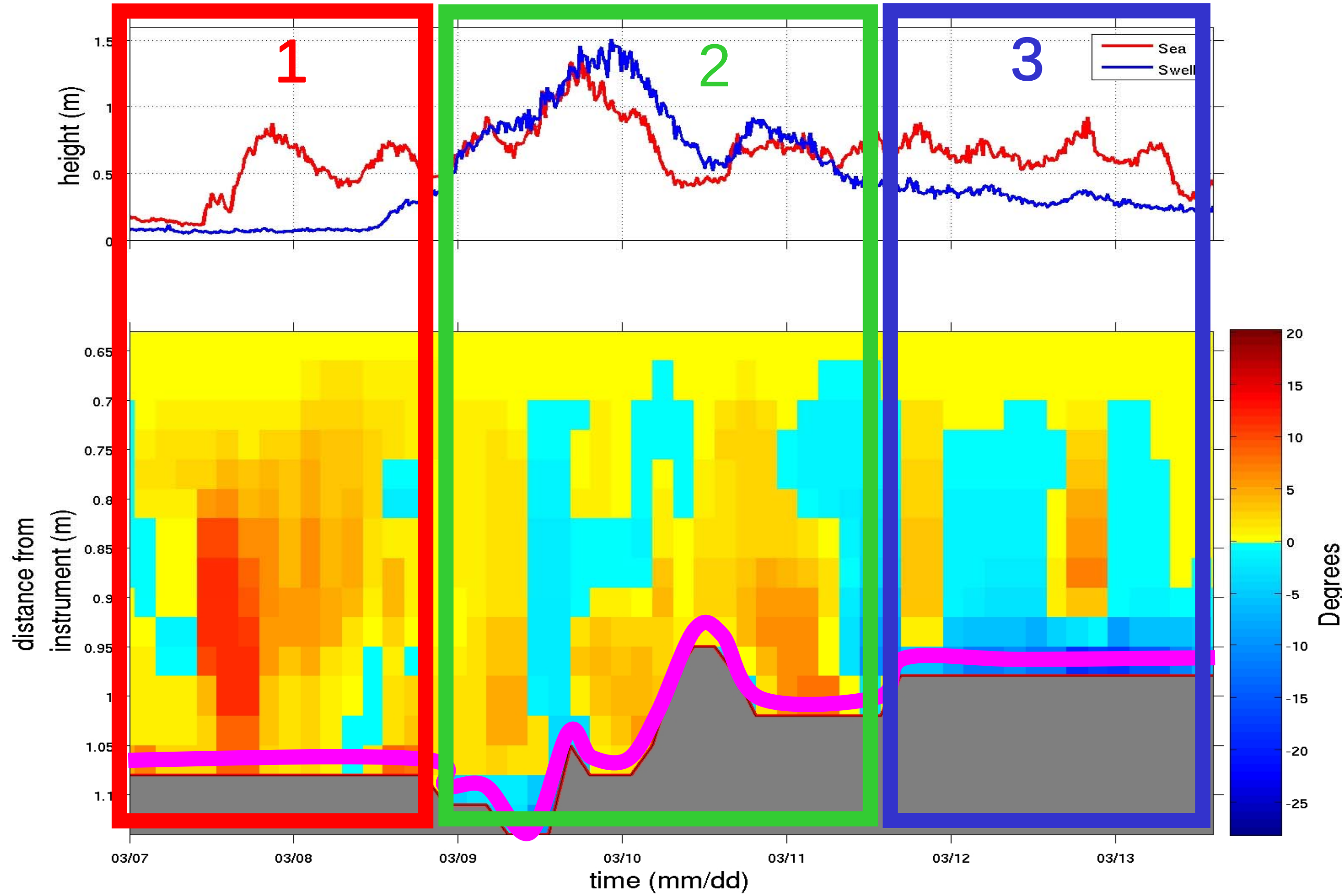
Why is dissipation increasing after storm?

Phase lag: PC-ADP, T1

1 Low swell energy
- Phase lead
- Solid seabed

2 High swell energy
- Vertical mixing
- Bed softens

3 Post-storm
- Soft mud
- Phase lag



Summary

- Fluid mud forms during storm (tripod sinks).
- Swell net dissipation 50% over 4 km.
- Fluid mud not effective dissipation mechanism in this area?
  - too diluted?
  - local effect?
- Dissipation increases *after* the storm.
  - Phase lag indicates rheology effects.
  - Soft bottom mud?
- Mud state changes during the storm.

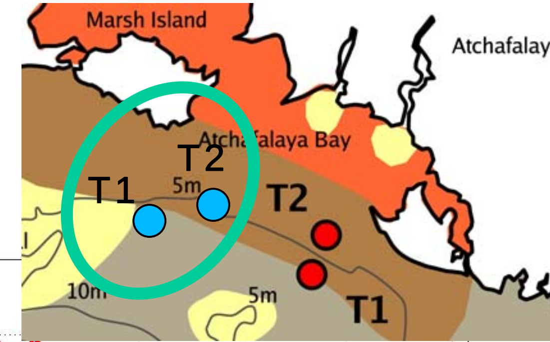
Thank you.

Future work:

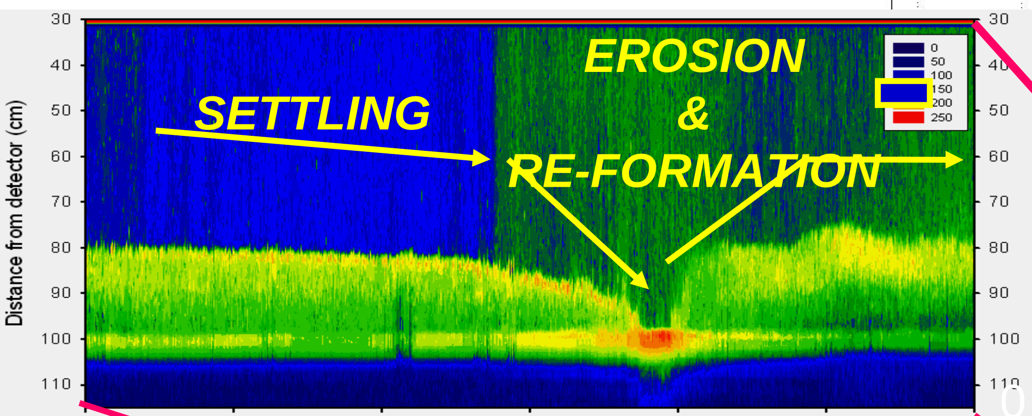
- Finish analyzing data set
- More experiments next year.

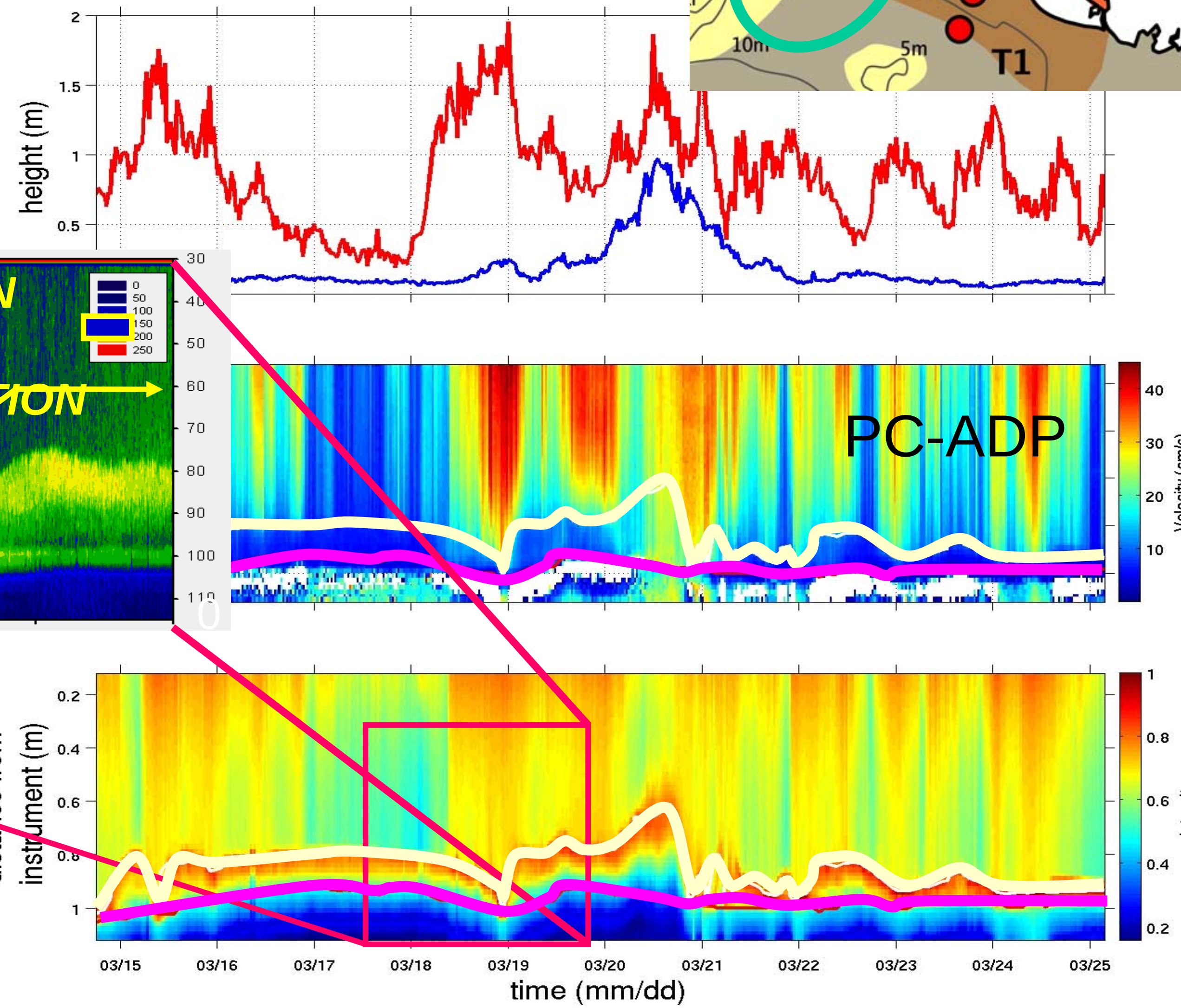
- Numerical modeling:
  - Separate mud induced dissipation from other processes
  - Validate wave and sediment transport models

March 15-25 Fluid mud events, T2



ABS

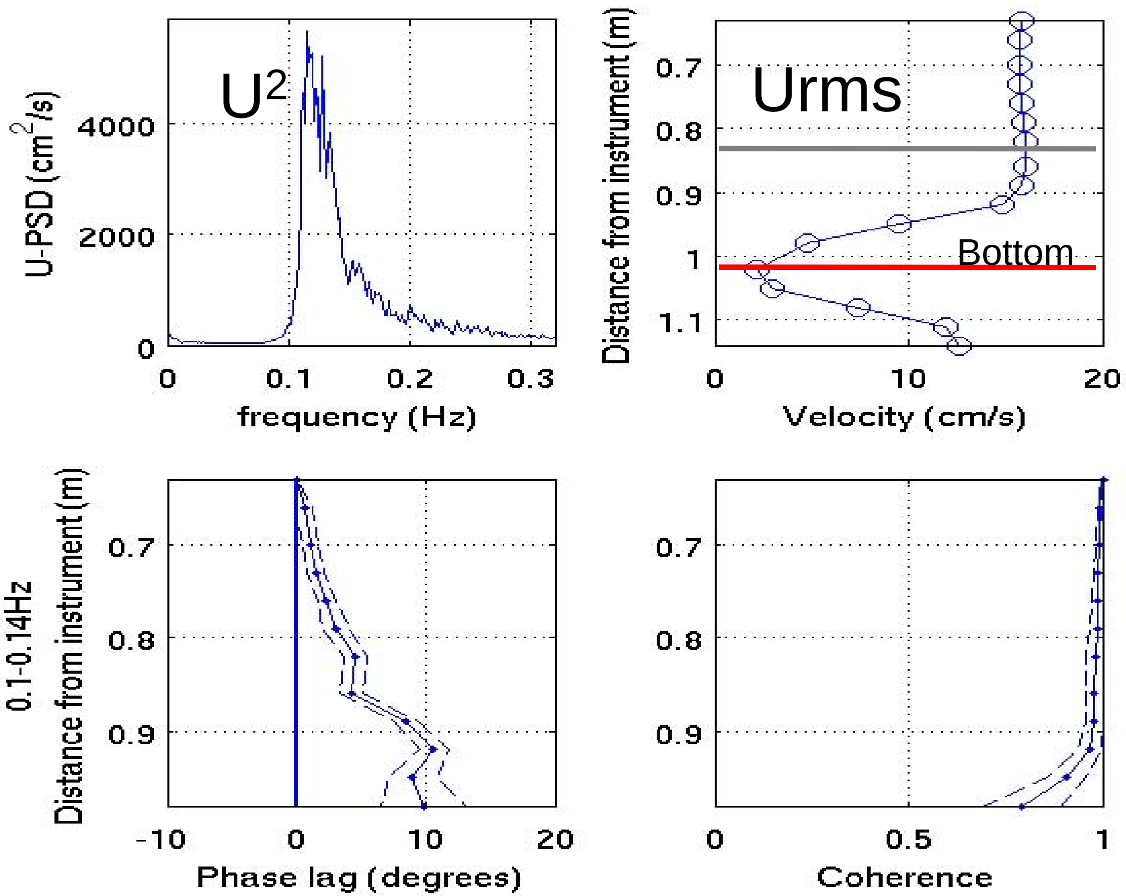


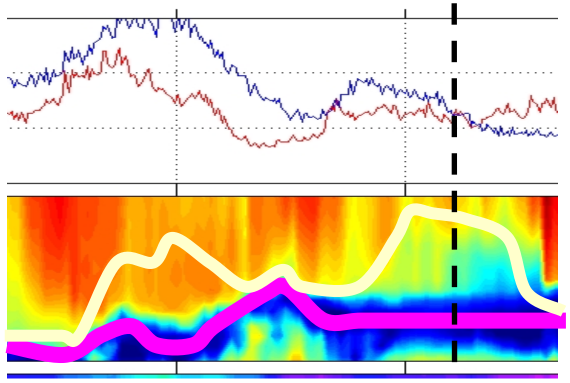


Near-stationary fluid muds appear more dense…

Why isn't fluid mud dissipative?

PC-ADP measurements, T1





Fluid mud rheology should introduce a phase lag in the boundary layer

Significance?
Too weak?
Too diluted?

We are working on calibration.