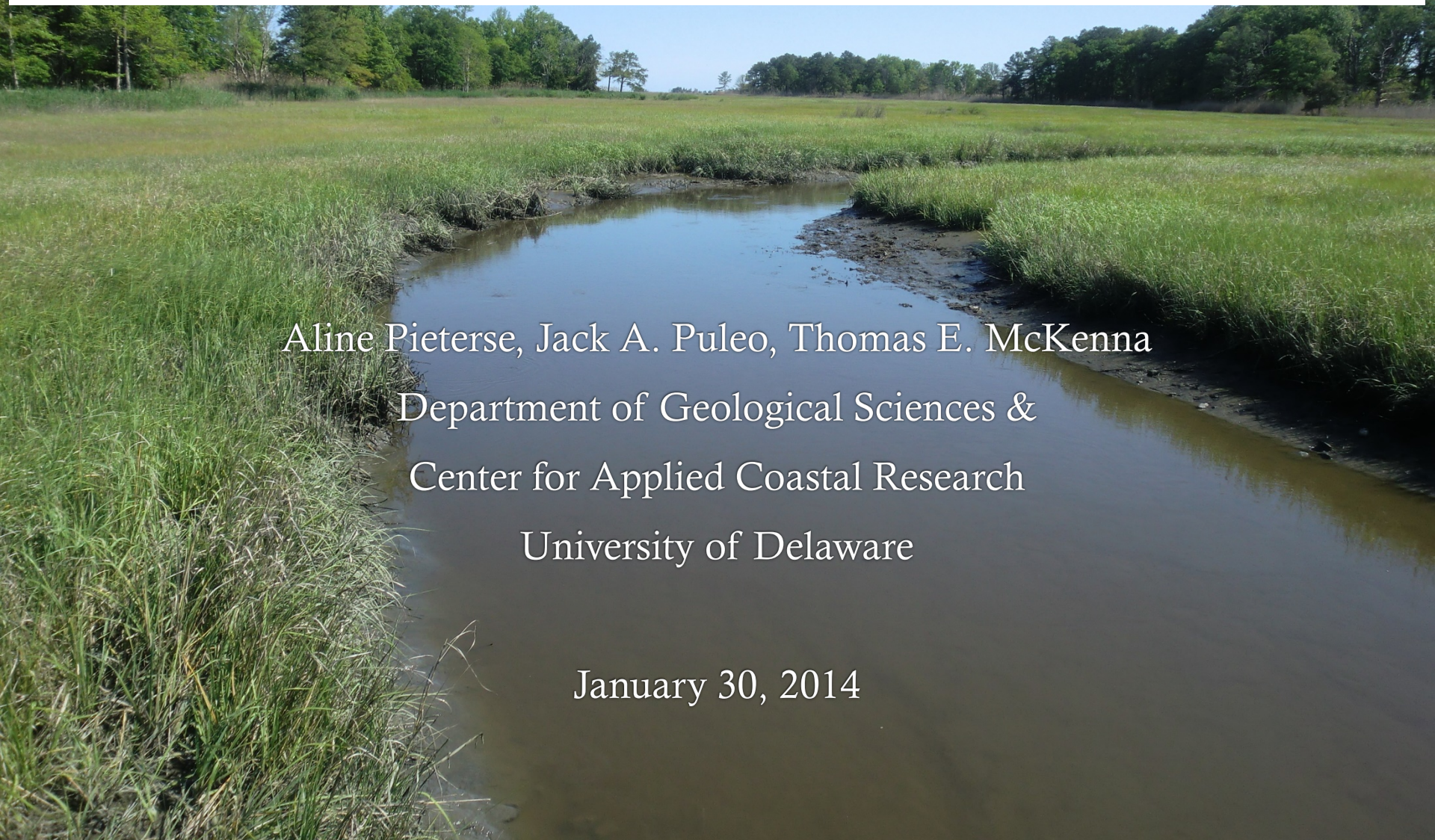
Flow characteristics and inundation of a tidal flat and saltmarsh in Kent County, Delaware



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Outline

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- Field experiment
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- Results
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- Conclusion

Introduction

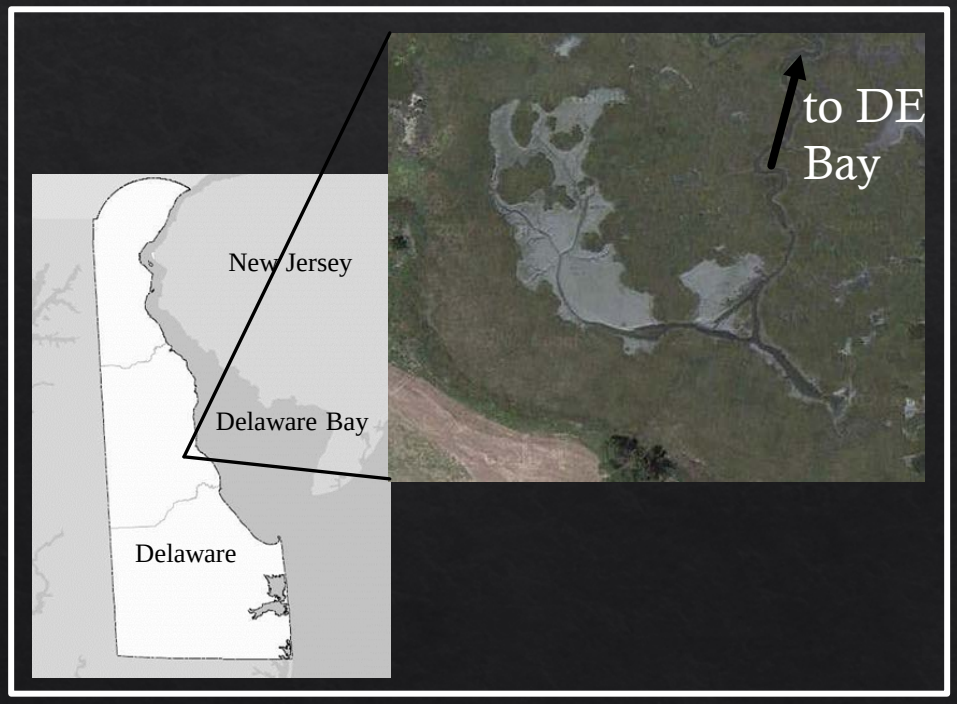
- Tidal wetlands: important environment
- Wetlands are degrading: accelerate with sea level rise.

- Soft, muddy environment: difficult to collect field data
- Collect near-bed, high-precision data in small tidal channels

- Quantify shear stress, turbulence kinetic energy
- Relate these parameters to sediment suspension

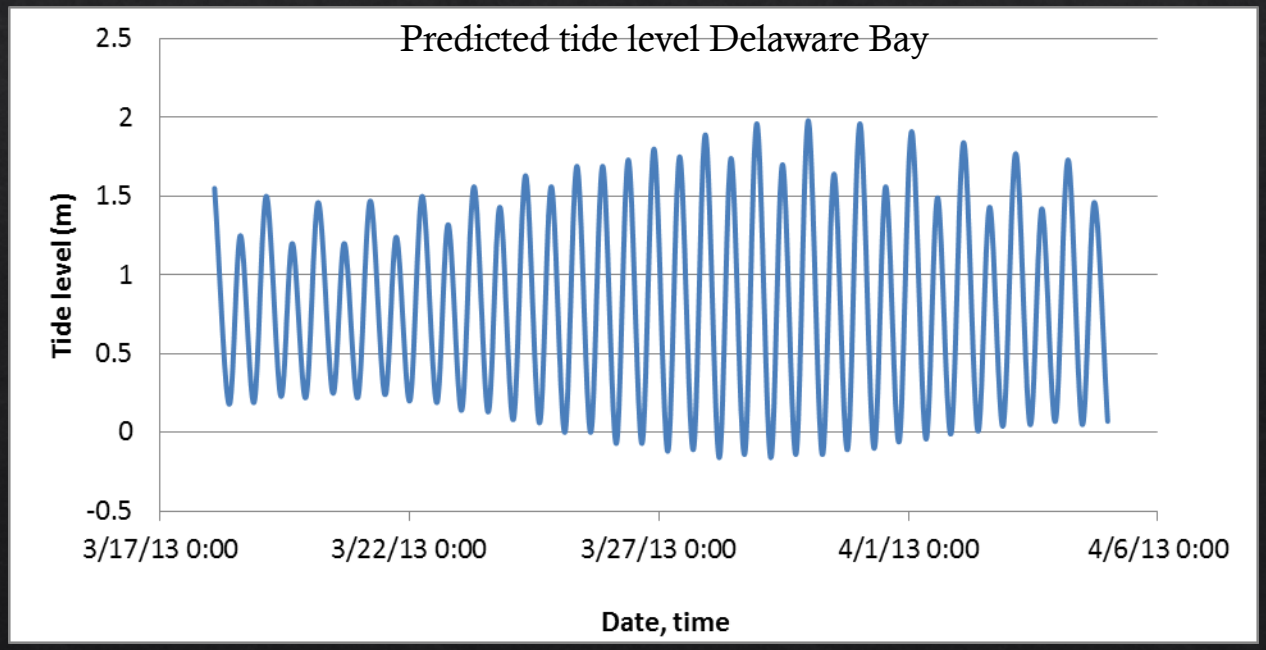
Field site

- Tidal wetland in Kent County, Delaware
- Tidal flat fed by a secondary channel of the Brockonbridge Gut
- Located 2 km inland of Delaware Bay



Field experiment

- 16-day field experiment
- 6 instrument stations in the channels and on the flat
- Data were collected from March 19th to April 3rd, 2013
- Spring and neap tidal cycle



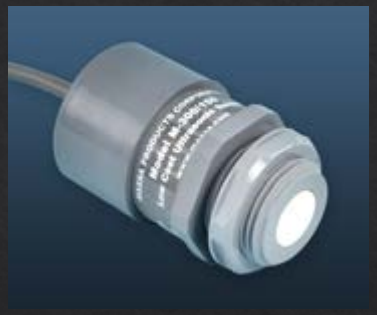
Field experiment

- 6 instrument stations
  - 1: “main” channel feeding the tidal flat
  - 2c and 2f: channel and adjacent flat
  - 3: tertiary channel
  - 4c and 4f: channel and adjacent flat
- “Main” channel: 1.5 m wide, 0.5 m deep at high tide
- Site 2c: 0.6 m wide, 0.1 m deep relative to tidal flat
- Site is dry during low tide, max water depth at high ~ 0.3 – 0.5 m

Field experiment

Range of instruments at each station:

- Pressure sensor (PT)
  - Pressure of water (+atmosphere)
- Ultrasonic distance meter (UDM)
  - Acoustic ping from above the water
  - Two-way travel time
- Optical backscatter sensor (OBS)
  - Point measurement of turbidity of the water
  - Calibrate with local sediment to get concentration from voltage
- AquaTroll CTD
  - Measure conductivity and convert to salinity



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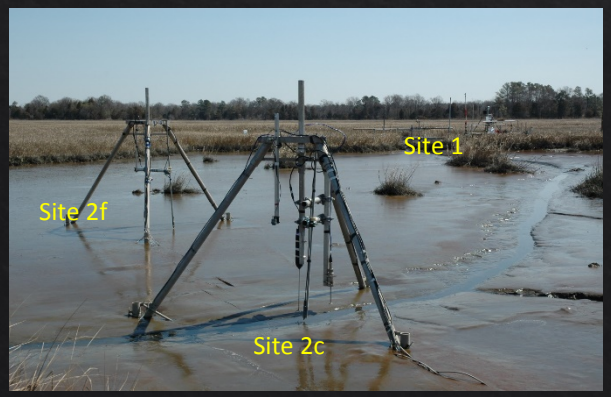
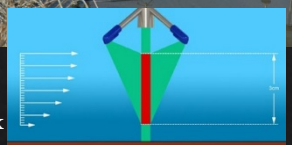
Field experiment

Velocity measurements:

- Electromagnetic current meter (EMCM)
  - Horizontal components of velocity (x and y)
  - Point measurement
- Orientation of sensors: local x and y is along and across-channel

- Three sites: acoustic Doppler profiling velocimeter
  - x, y and z
  - 30 mm profile, 1 mm increments
  - 100 Hz
  - Profile just intersects the bed
  - Also: bed location at 10 Hz





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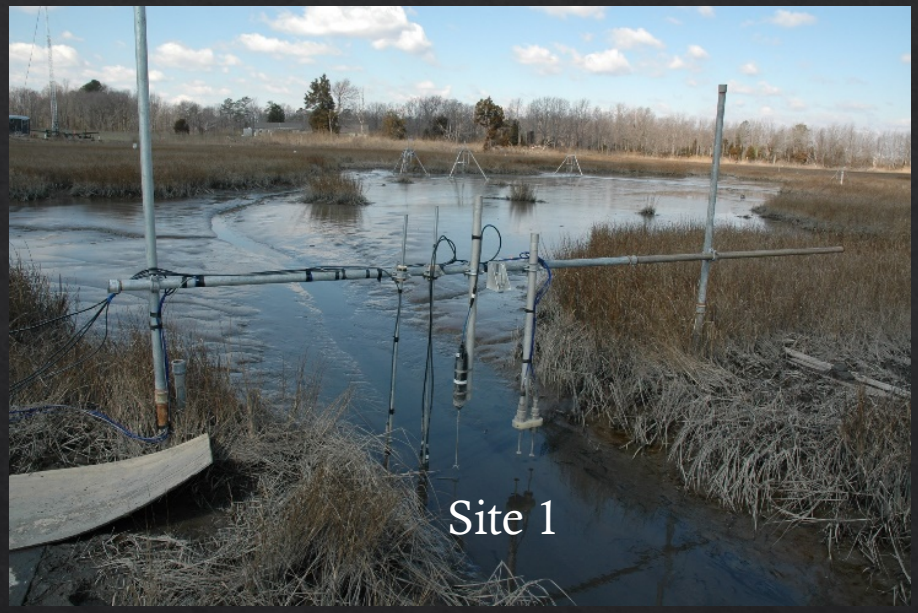
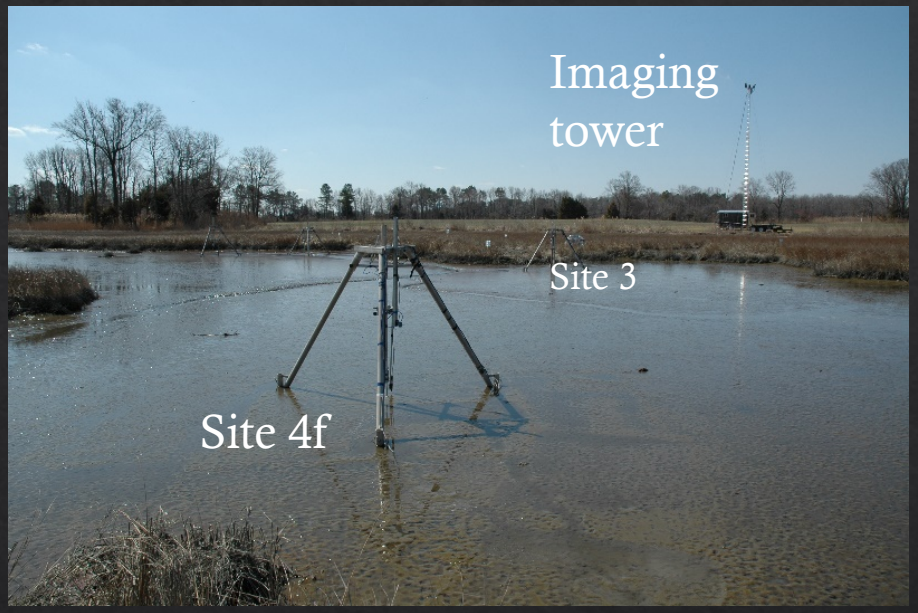
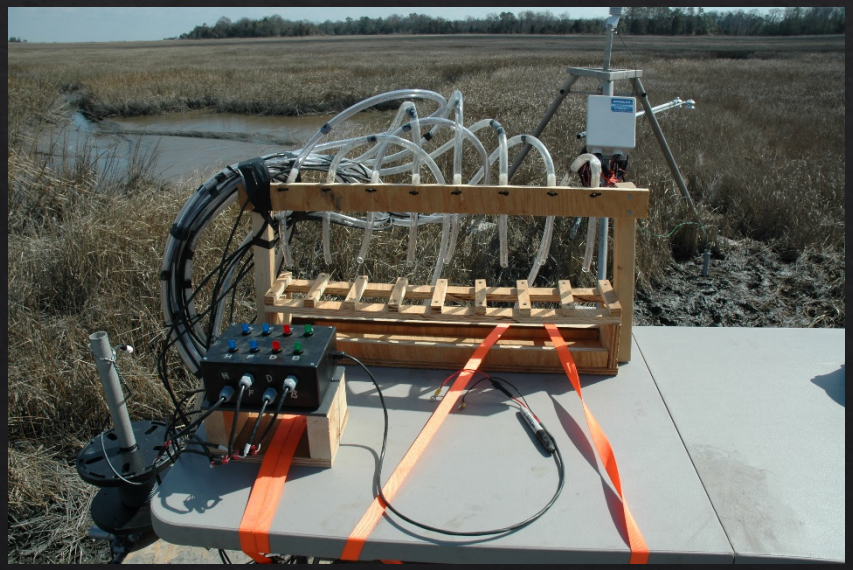
In-situ sensors





Water samples

- Water samples:
  - Twice during the experiment
  - Determine SSC
  - Every half hour for 25 hours
  - 8 pump vertical array
  - Recorded temperature and salinity of bottom and top water sample

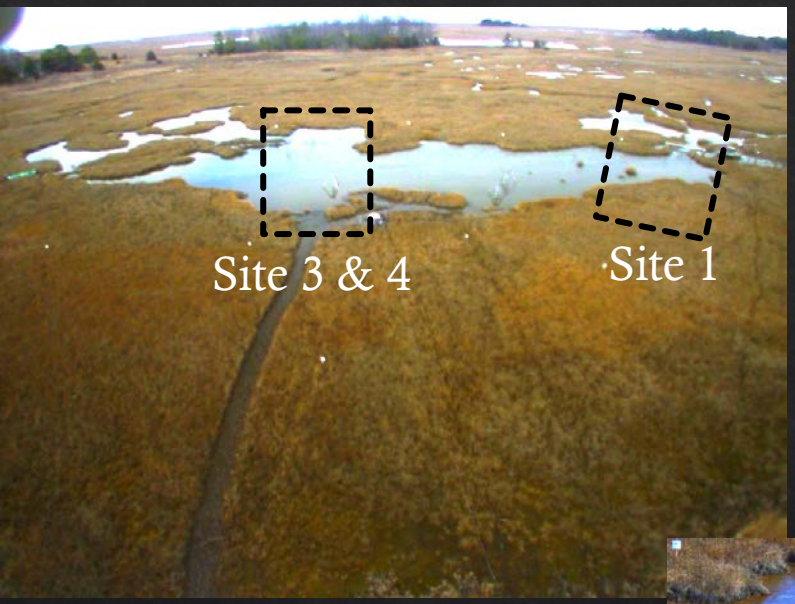


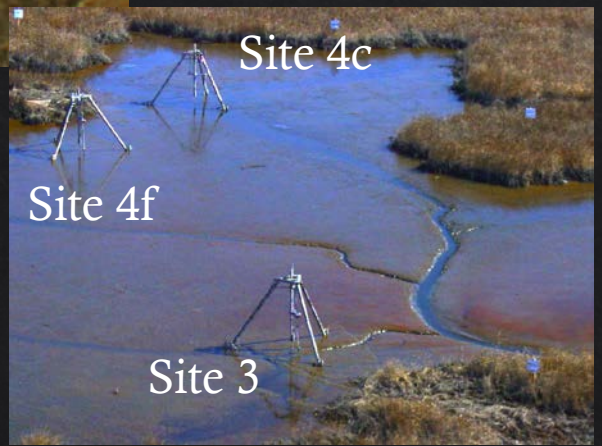
Imagers

- Look at larger spatial scales
- Inundation of marsh and surface flow velocity
- Mounted on a 20 m tower, located 50 m SW of tidal flat
  - RGB camera
  - NIR camera
  - TIR camera
- All measured continuously, taking an image every minute when the tower was up
- During rain events, the tower had to be taken down

Imagers – field of view

- Wide-angle lenses used during most of the experiment
- Several days zoom lenses were used on RGB and TIR imagers



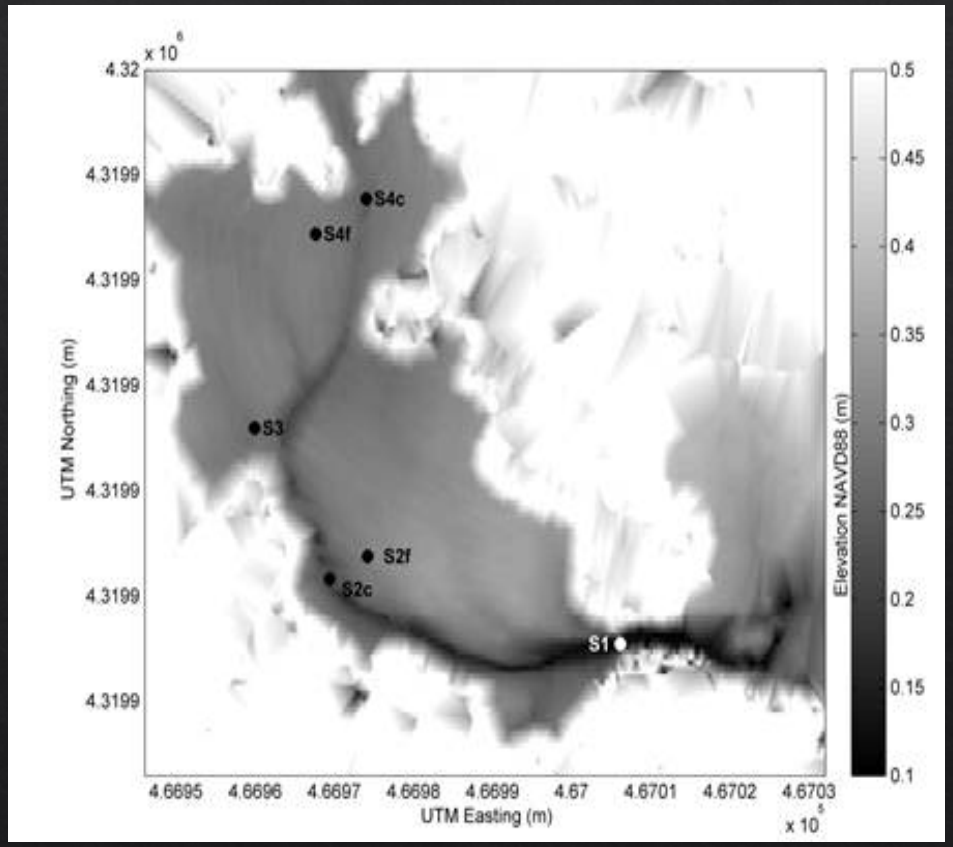


Bathymetry

- Bathymetry of tidal flat determined with especially designed survey sled, operated with ropes

Bathymetry

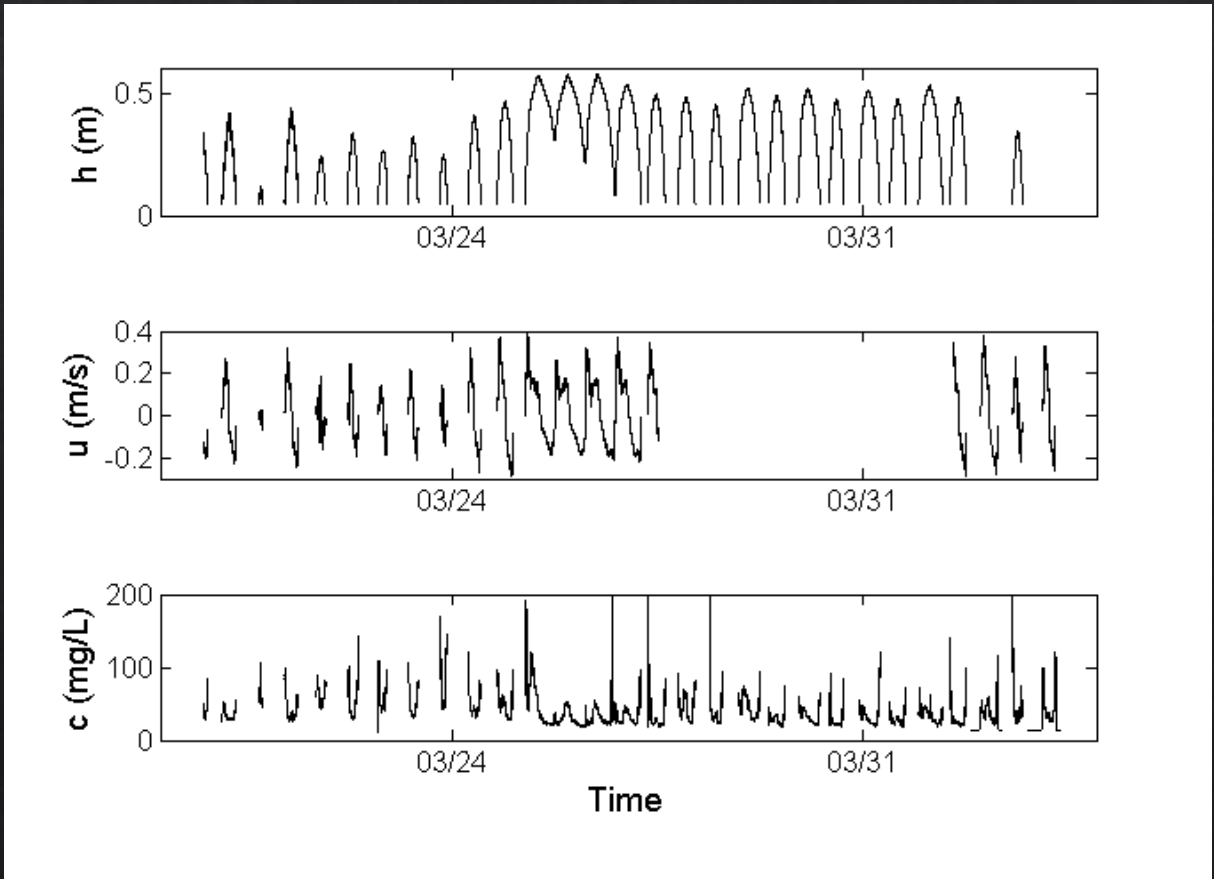
- Bathymetry of marsh and flat after interpolation



In-situ data

- Peak velocity and suspended sediment concentration near low tide
- Flow velocities up to 0.4 m/s

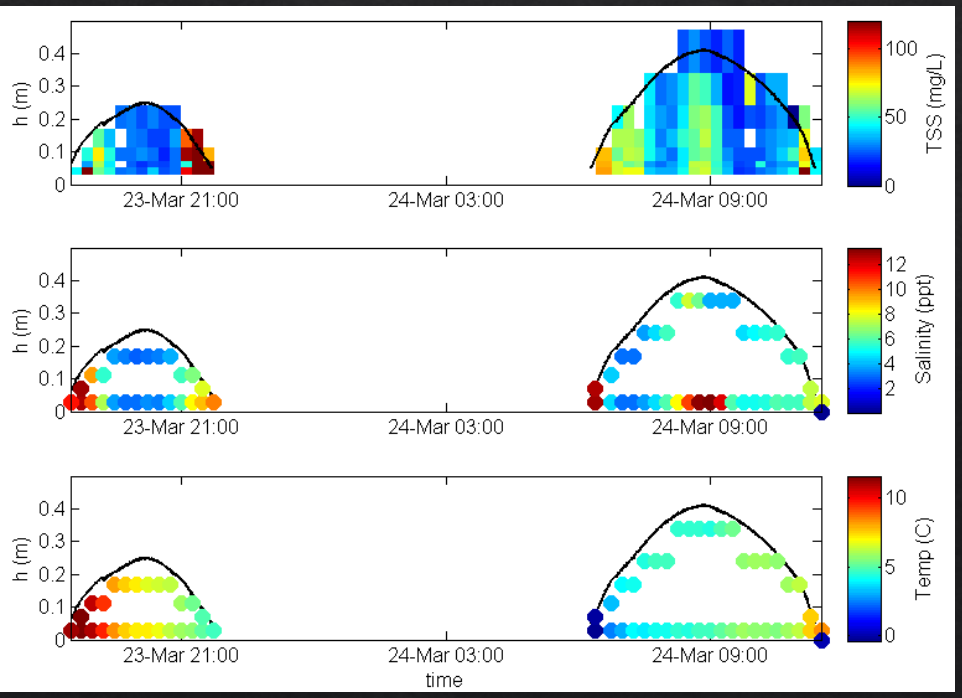
Site 1



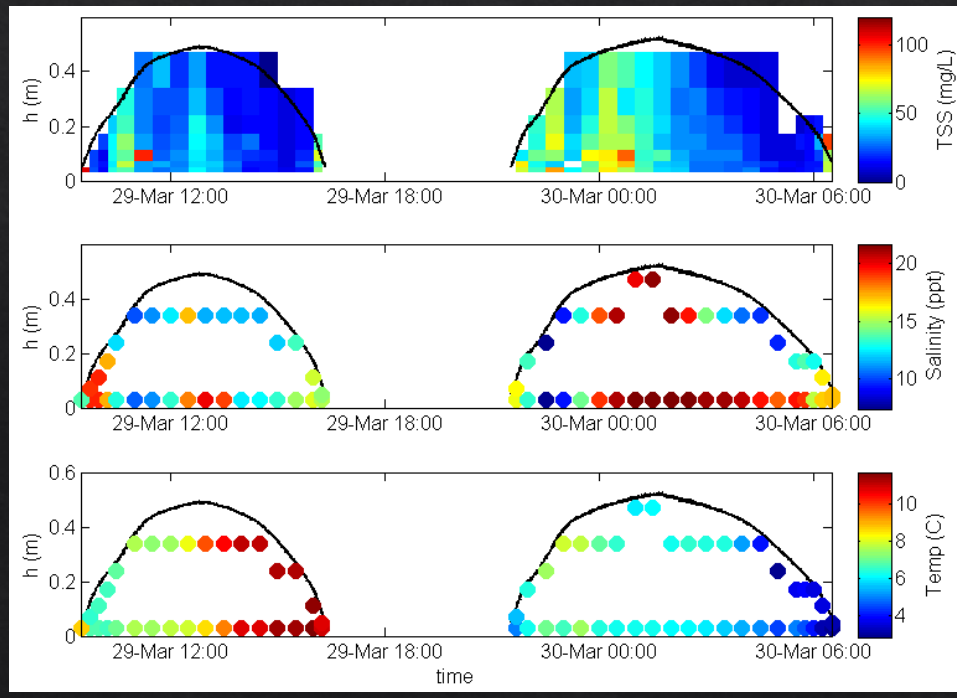
Water sample data

- Neap and spring tide water sampling
- Recorded temperature and salinity
  - Top and bottom water sample → interpolated

Neap tide



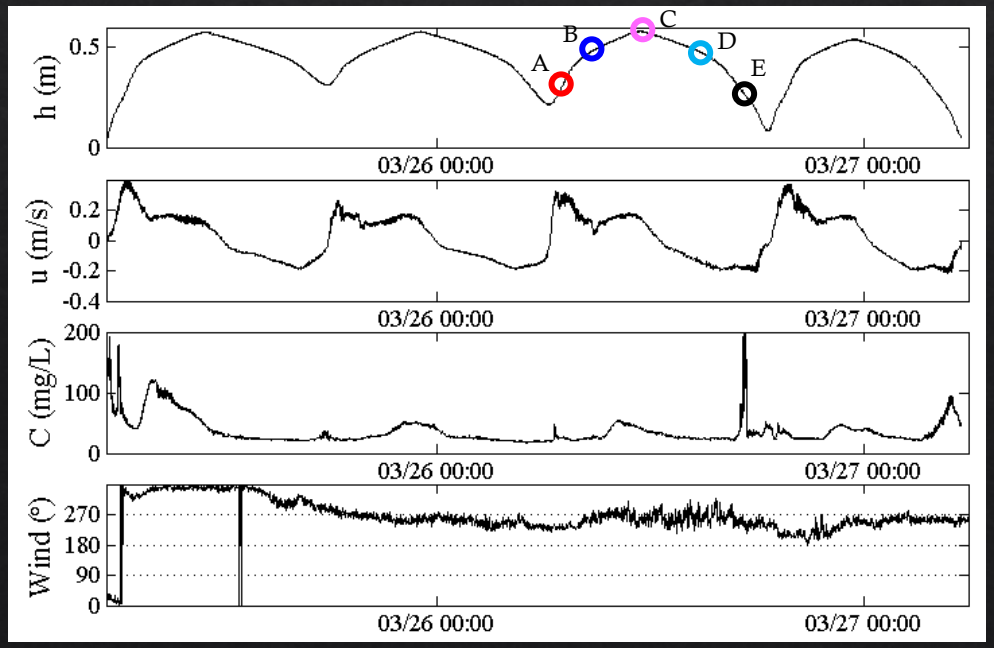
Spring tide



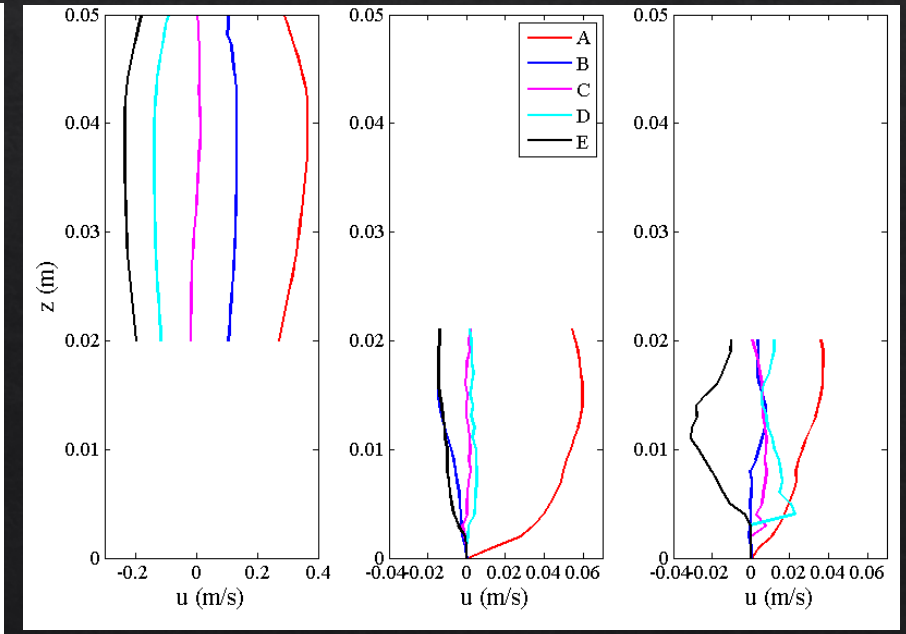
In-situ data

- Two day storm event
  - high water levels
  - continuous data
- Velocity profiles over a tidal cycle
  - Very small velocities except site 1

Site 1



Site 1 Site 2c Site 2f

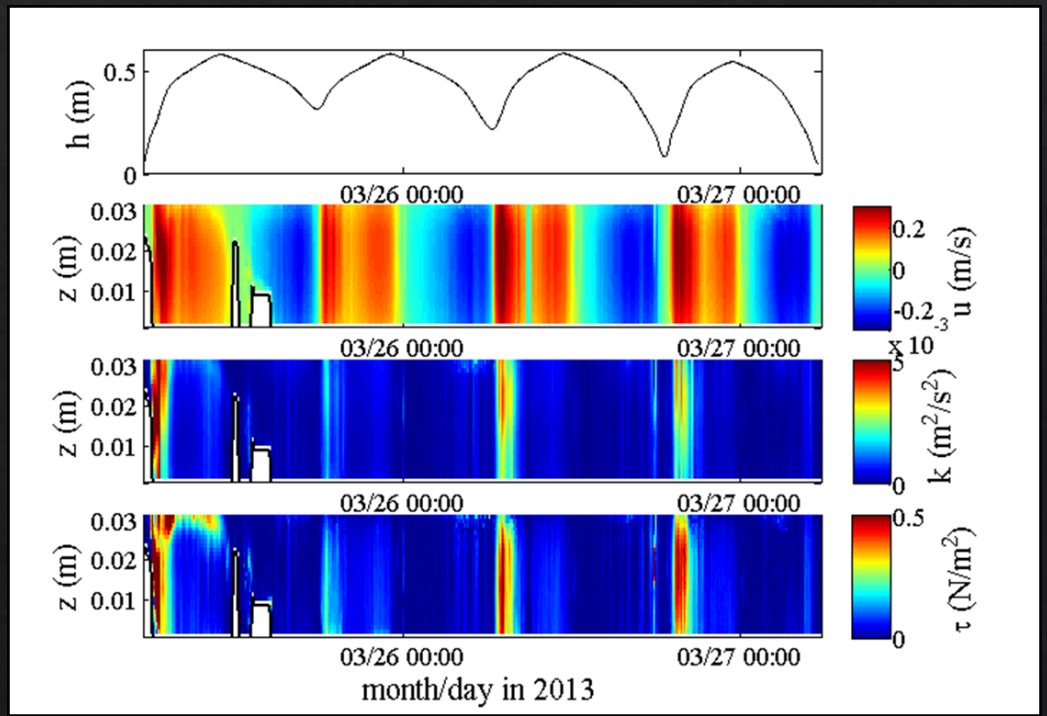


Results

- Near-bed velocity profiles, separate mean ($\bar{u}$) and fluctuating (u') components
- Computed turbulent kinetic energy (k) and Reynolds stress (τ)

$$k = 0.5(\langle u'^2 \rangle + \langle v'^2 \rangle + \langle w'^2 \rangle)$$

$$\tau = -\rho\sqrt{\langle u'w' \rangle^2 + \langle v'w' \rangle^2}$$

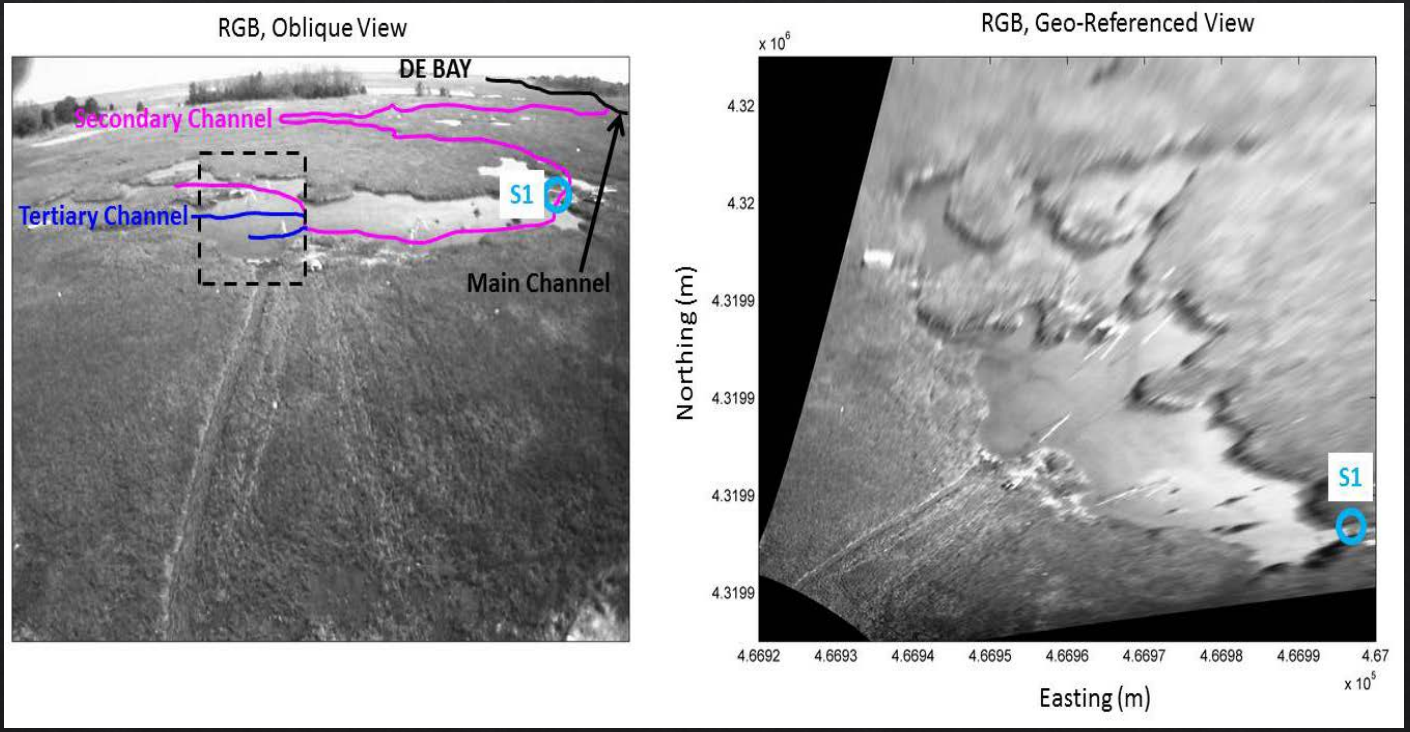


Site 1

z = 0 is bottom of measuring range

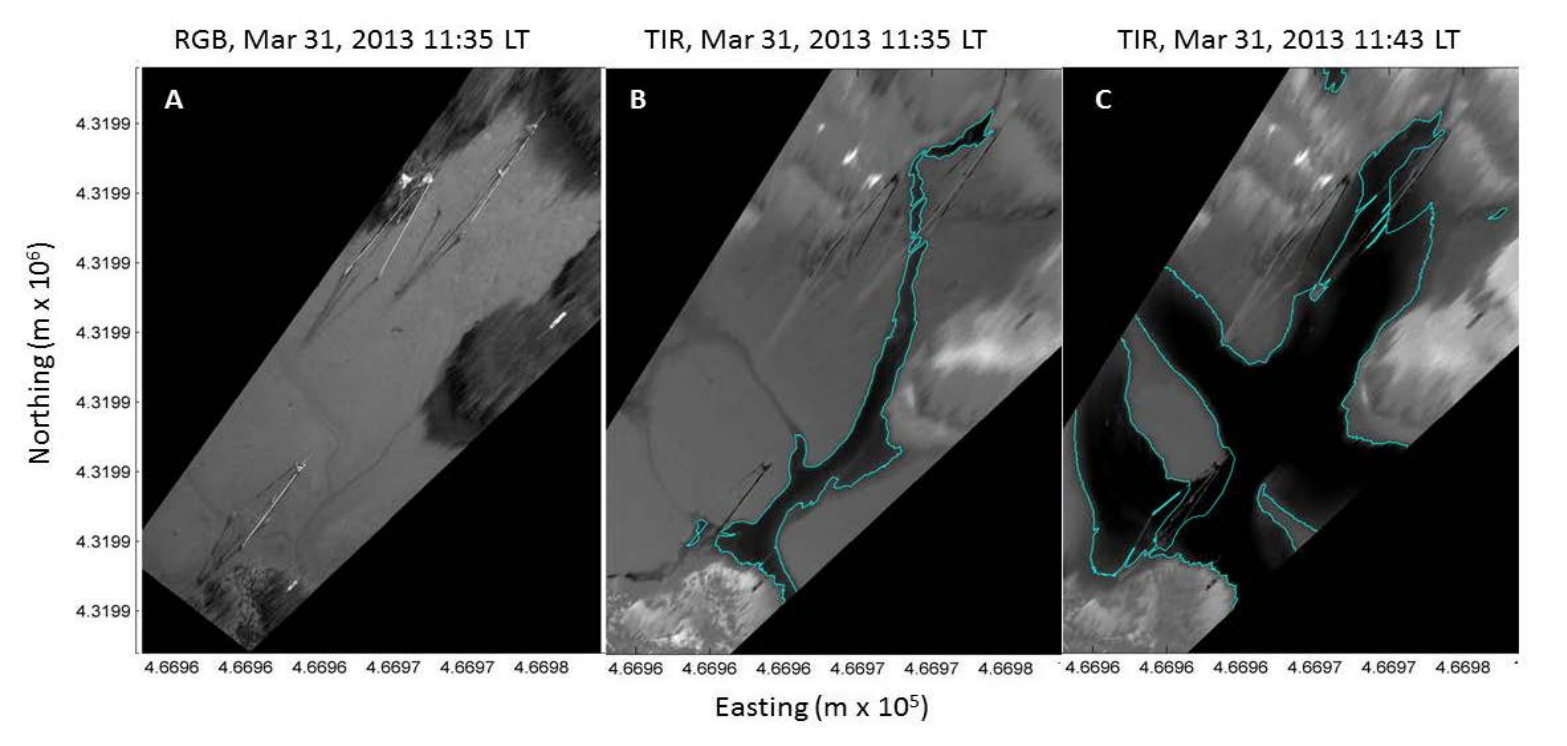
Imaging data

- Wide-angle RGB image
- Geo-rectified image following image transformation



Imaging data

- Narrow FOV of RGB and TIR image
- Difficulty in identifying water on the flat in RGB imagery
- Contours in B and C identify flooded areas



Conclusion

- Field experiment involved both in-situ instruments and imagery

- Flow velocity peaks close to low tide for both ebb and flood
- Suspended sediment concentration peaks around the same time
- Sediment suspension appears to take place under high flow conditions
- Largest turbulence magnitudes during flood

Acknowledgments

Field assistance was provided by:

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