A Pilot Study for Electromagnetic Surveying of Freshwater Resources Beneath the US Atlantic Continental Shelf

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Motivation:
Freshwater detected on the New Jersey Shelf

van Geldern et al. (2014)
Conceptual models to explain emplacement of freshwater to 50+ km offshore:

van Geldern et al. (2014)
Electrical Conductivity of Sediments and Fluids

Water conductivity as a function of salinity:

Resistivity (ohm-m) \(=\frac{1}{\text{Conductivity}}\)

- **seawater**
- **freshwater**
- **porous sediments**
- **oil, gas, hydrates**
Electromagnetic diffusion in a thin resistive layer:

• Controlled-source EM works for mapping offshore hydrocarbon layers (thin resistors)
• Offshore groundwater is an obvious application but has remained untested…
Controlled-Source Electromagnetic (CSEM) Method:

Surface-towed acquisition system for shallow water

- 336 m dipole transmitter, surface towed, 100 A current
- 4 towed receivers (250, 500, 750, 1000 m) offsets
- 10 seafloor EM/MT receivers
CSEM and MT survey off New Jersey and Martha’s Vineyard: September 3-14, 2015
Objectives for our EM/MT Survey:

- Demonstrate the capabilities of marine EM methods for mapping offshore hydrology
- Understand the spatial extent of chlorinity anomalies already detected in wells off New Jersey
- Test whether similar anomalies exist off southern New England
- Identify if freshwater is leaking into the ocean through localized discharge
Winch for towed receiver array and antenna cables
Towed EM receiver “Porpoise”

- Modified from seafloor OBEM logger
- Single 2 m electric dipole
- GPS mast with flashing strobe
- Designed to be towed under tension to reduce tilt noise
Transmitter antenna
Transmitter antenna

near electrode

far electrode (~350 m)
Transmitter power supply and controller
Surface Towed CSEM Movie
New Jersey Data:

- MT responses good to 100 Hz in 20-80 m water depths!
- Noisy wave band at 0.1 to 0.8 Hz for some stations, not all
- Data mostly 1D
- Two near-shore stations have large 3D skews at long periods

- Surface-Towed CSEM at 0.75 Hz:
Preliminary inversions of New Jersey data

- MT inversion
  - sees the aquifer

- Joint MT & surface-towed CSEM inversion
  - maps aquifer even better
  - inversion run on UCSD cluster, launched remotely from R/V Langseth
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