MODELING THE CIRCULATION OF THE DEAD SEA

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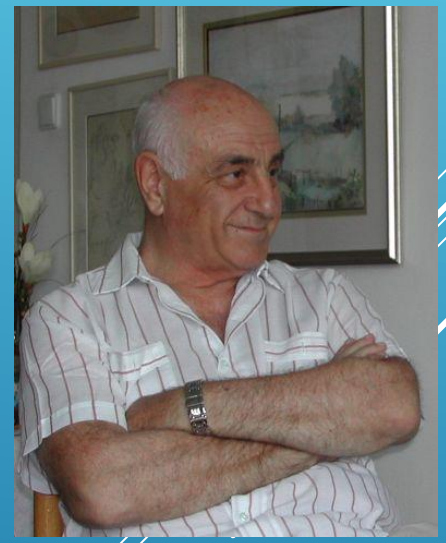
EGU 2015, Eastern Mediterranean and Arid Climate Oceanography: A Tribute to A. Hecht

MAJOR CONTRIBUTIONS OF ARTHUR HECHT:
FOUR DECADES OF PHYSICAL OCEANOGRAPHIC RESEARCH

- Dispersion of the Nile River fresh water plume (1950's and 60's)
  - Measurements along the continental shelf
- Systematic investigation of the hydrography of the SE Levantine Basin(1970's and 80's)
  - MC and POEM cruises
- Monitoring of the Dead Sea meteorology and hydrography (1990's)
  - Continuous measurements from a fixed buoy and periodic hydrographic cruises



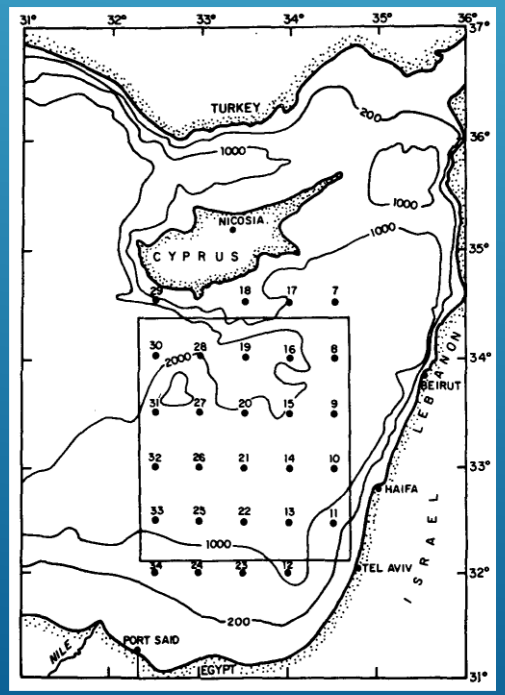
Dispersion of the Nile River fresh water plume

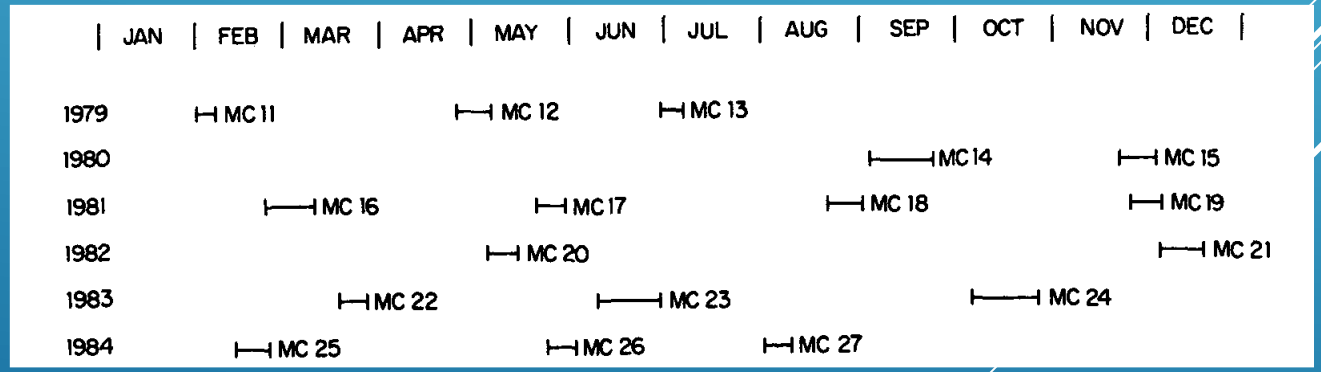
Hecht, A. 1964, On the turbulent diffusion of the Nile floods in the Mediterranean Sea. *Bulletin of the Sea Fisheries Research Station of Israe*l, **36**, 1-24.

Plume of low salinity water (36 psu or less) was observed as far north as Haifa in the months of August and September

Systematic investigation of the hydrography of the SE Levantine Basin

Hecht, A., N. Pinardi, and A. Robinson 1988, Currents, water masses, eddies, and jets in the Mediterranean Levantine Basin. *Journal of Physical Oceanography,* **18**, 1320-1353.





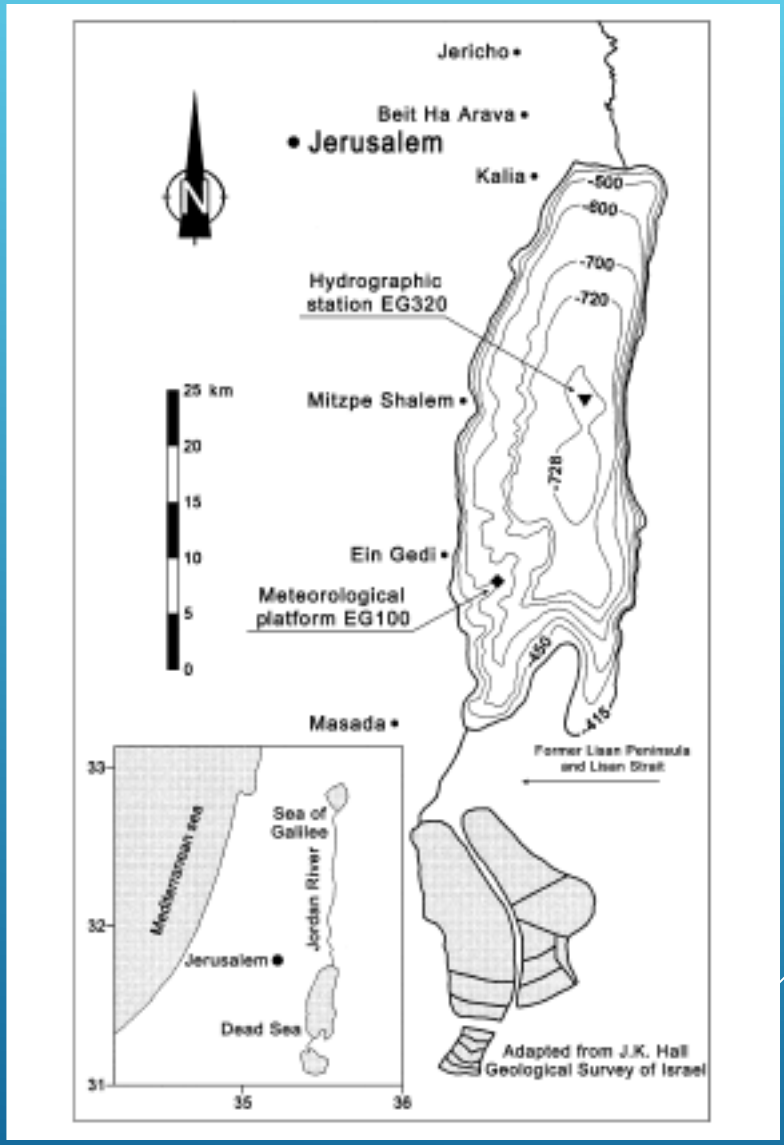
What about MC 1-10?

Monitoring of the Dead Sea meteorology and hydrography

Gertman, I. and A. Hecht, 2002, The Dead Sea hydrography from 1992-2000. *Journal of Marine Systems,* **35**, 169-181.

Hecht, A. and I. Gertman, 2003. The Dead Sea Meteorological climate. In: *Fungal Life in the Dead Sea*, E. Nevo, A. Oren, and S.P. Wasser (eds.), University of Haifa, pp/ 69-115.

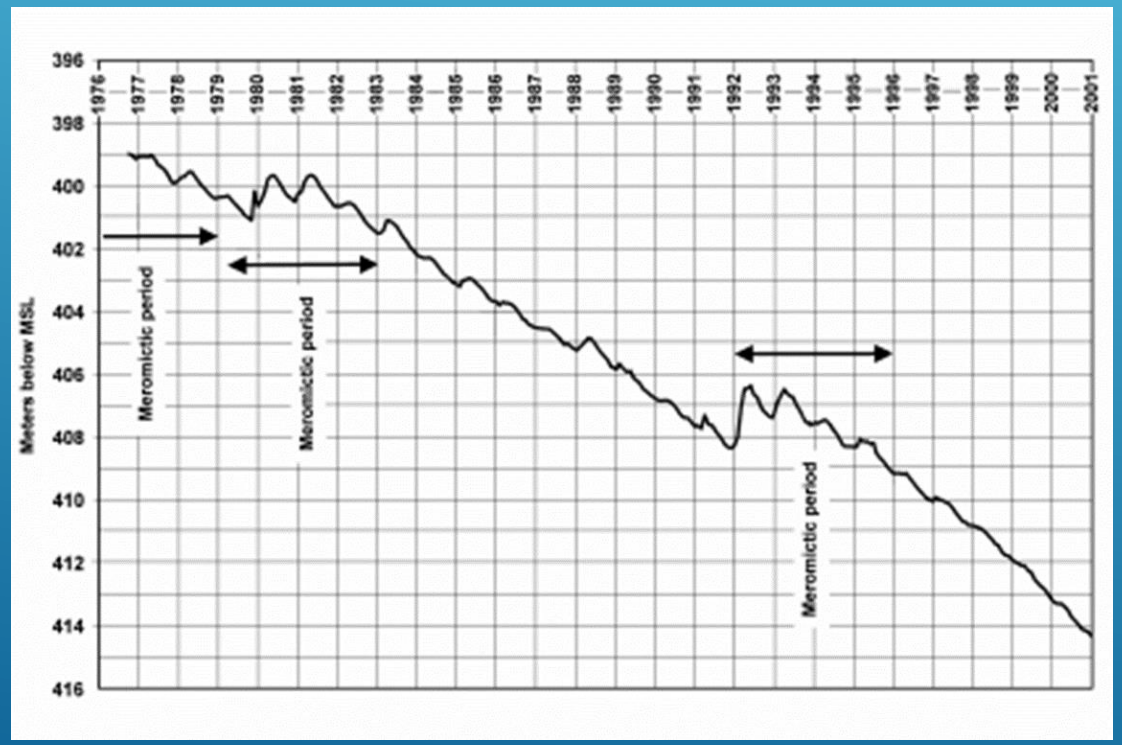
THE DEAD SEA AS SEEN FROM SATELLITE IMAGES IN 1987 AND MAP FROM 2001

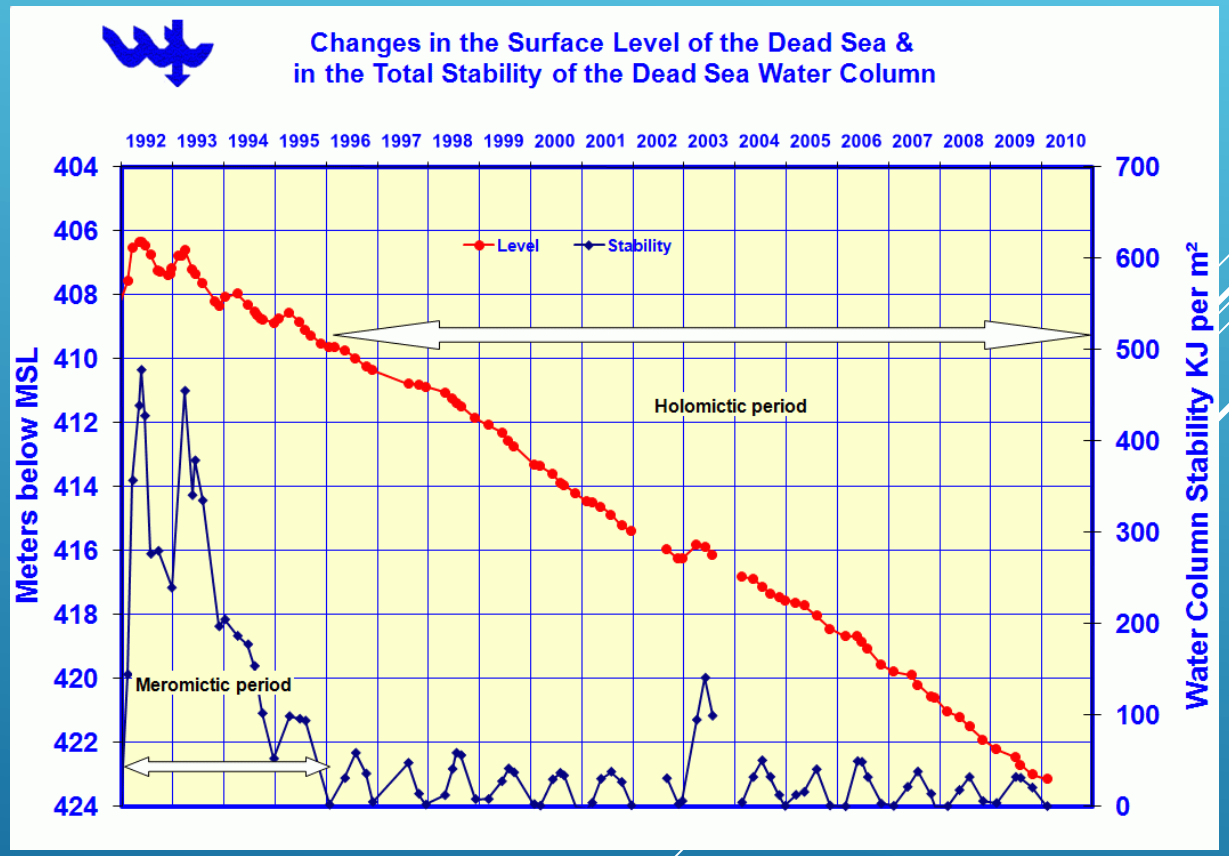


CHALLENGES IN MODELING THE DEAD SEA CIRCULATION

- Rapidly declining lake level
  - Transition to holomictic (complete overturning) leading to weakened stability (implications for vertical mixing scheme)
- Extremely high (and increasing) salinity and density
  - Modified equation of state
- Very sharp thermocline in summer
  - Requires high vertical resolution
- Double diffusion

RAPIDLY DECLINING LAKE LEVEL (≥ 1 m/y)





APPROXIMATE EQUATION OF STATE FOR PRESENT CONDITIONS

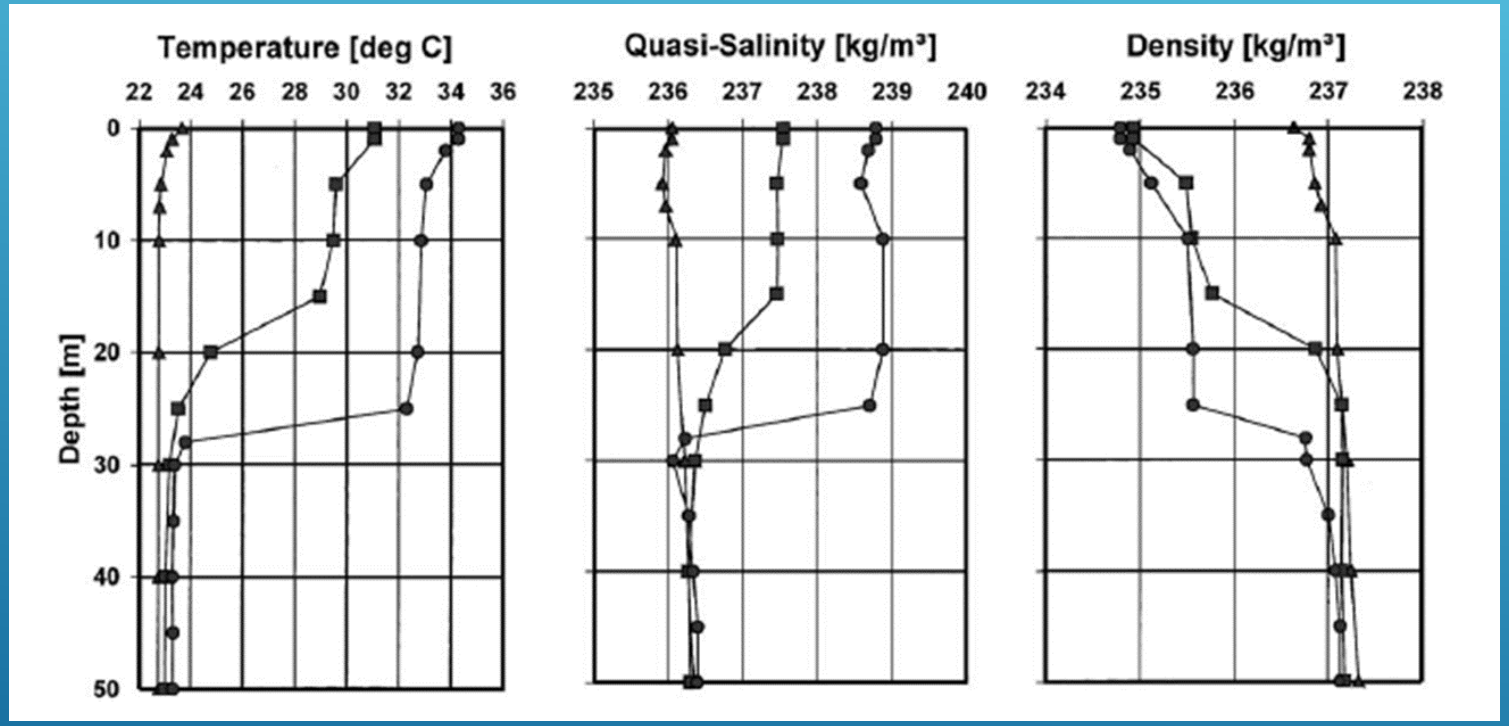
Gertman et al., 2010. Equation of state for the Dead Sea and Aral Sea. IOLR Report 12/2010

$$\sigma_T = 9.2837 - 0.24267*T - 1.17871E\text{-}3*T*T + 1.01708*\sigma_{32} + 5.70817E\text{-}6*\sigma 32*\sigma_{32} - 6.18976E\text{-}4*T*\sigma_{32}$$

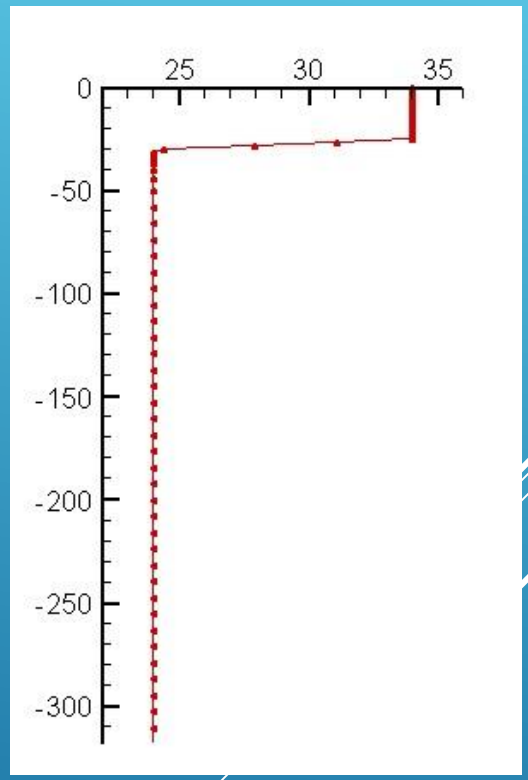
Where T is the temperature and σ_{32} is the quasi-salinity at 32°C

Valid for T ≈ 12 – 32°C and σ_{32} ≈ 150 – 250 kg/m3

VERTICAL RESOLUTION



From: Gertman and Hecht, 2002

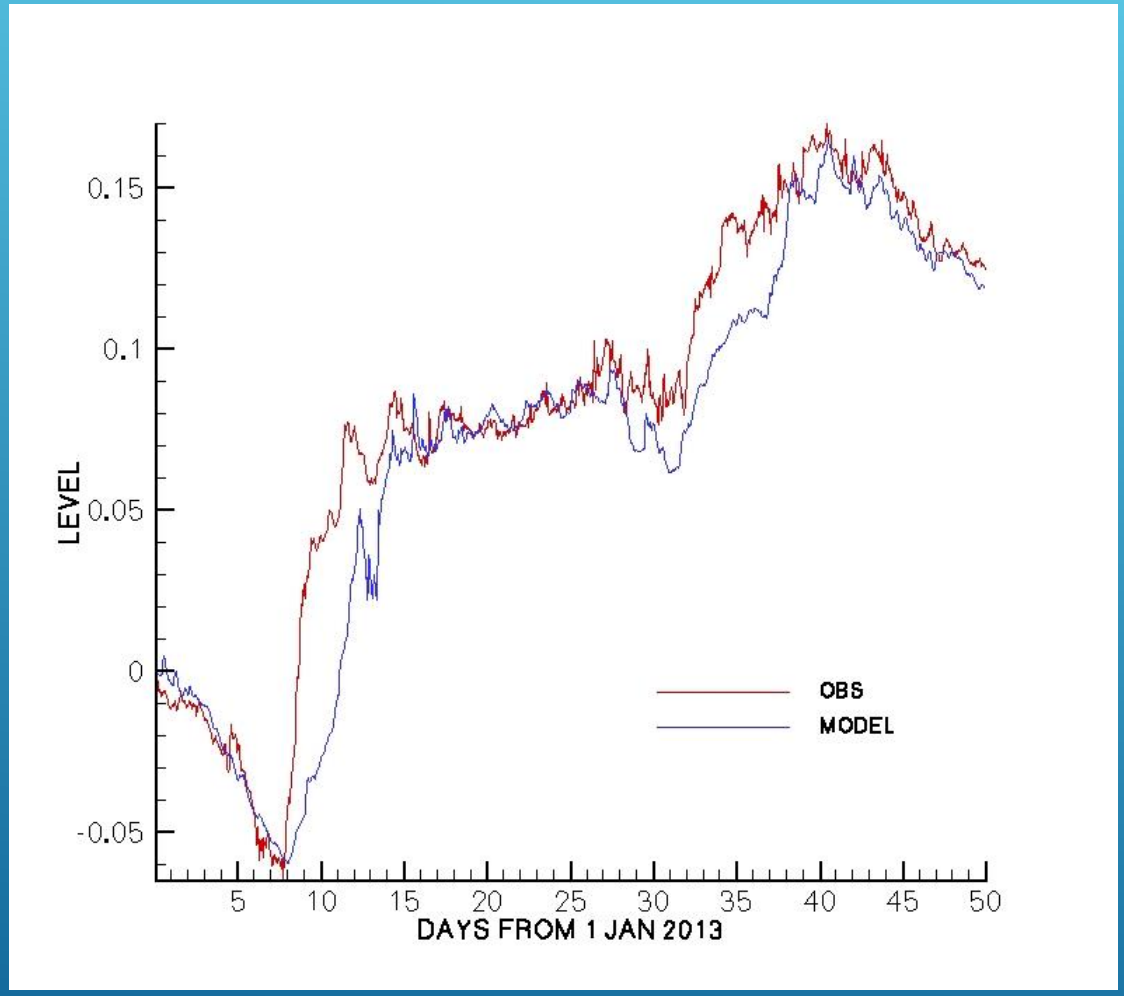


Summer initial conditions (model levels)

SIMULATIONS

- Princeton Ocean Model (POM)
- Digitized bathymetry from map (J. Hall)
- Idealized or simplified surface forcing
  - Typical diurnal wind cycle
  - Hourly meteorological measurements
  - Relaxation of SST to observed value
  - Uniform lakewide fresh water flux during floods
- Resolution
  - Horizontal: 1000 – 200 km
  - Vertical: 61 sigma levels
- Short to medium term simulations
  - Days to months

FLOOD (MEROMICTIC) EVENT OF JAN-FEB 2013



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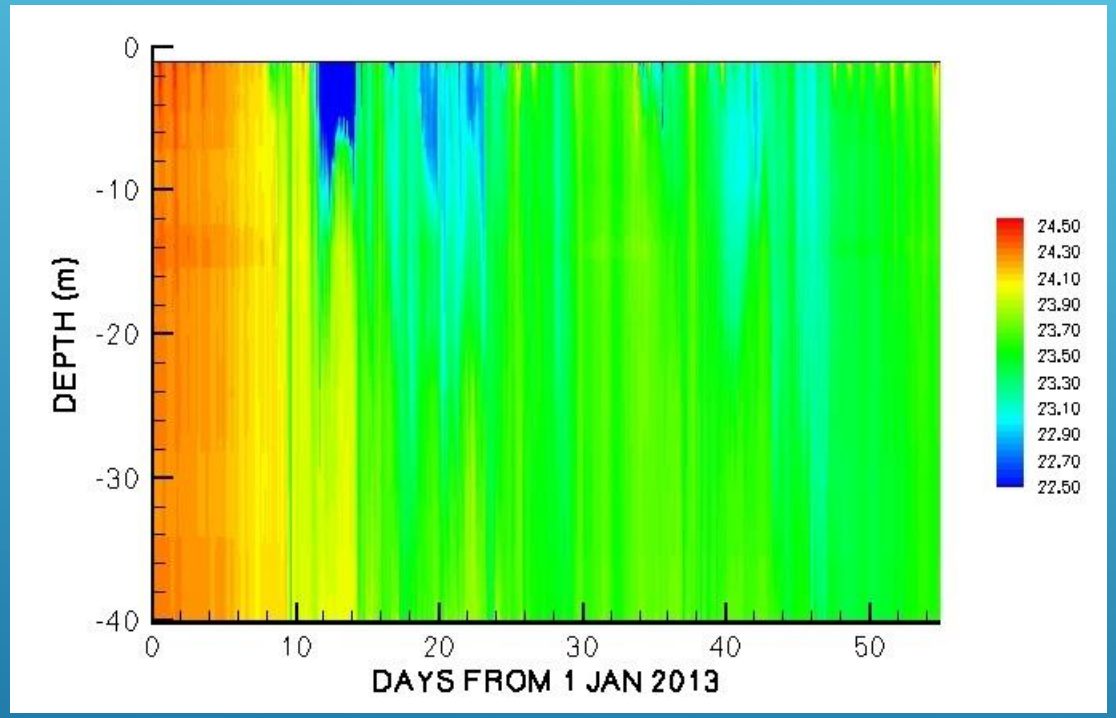
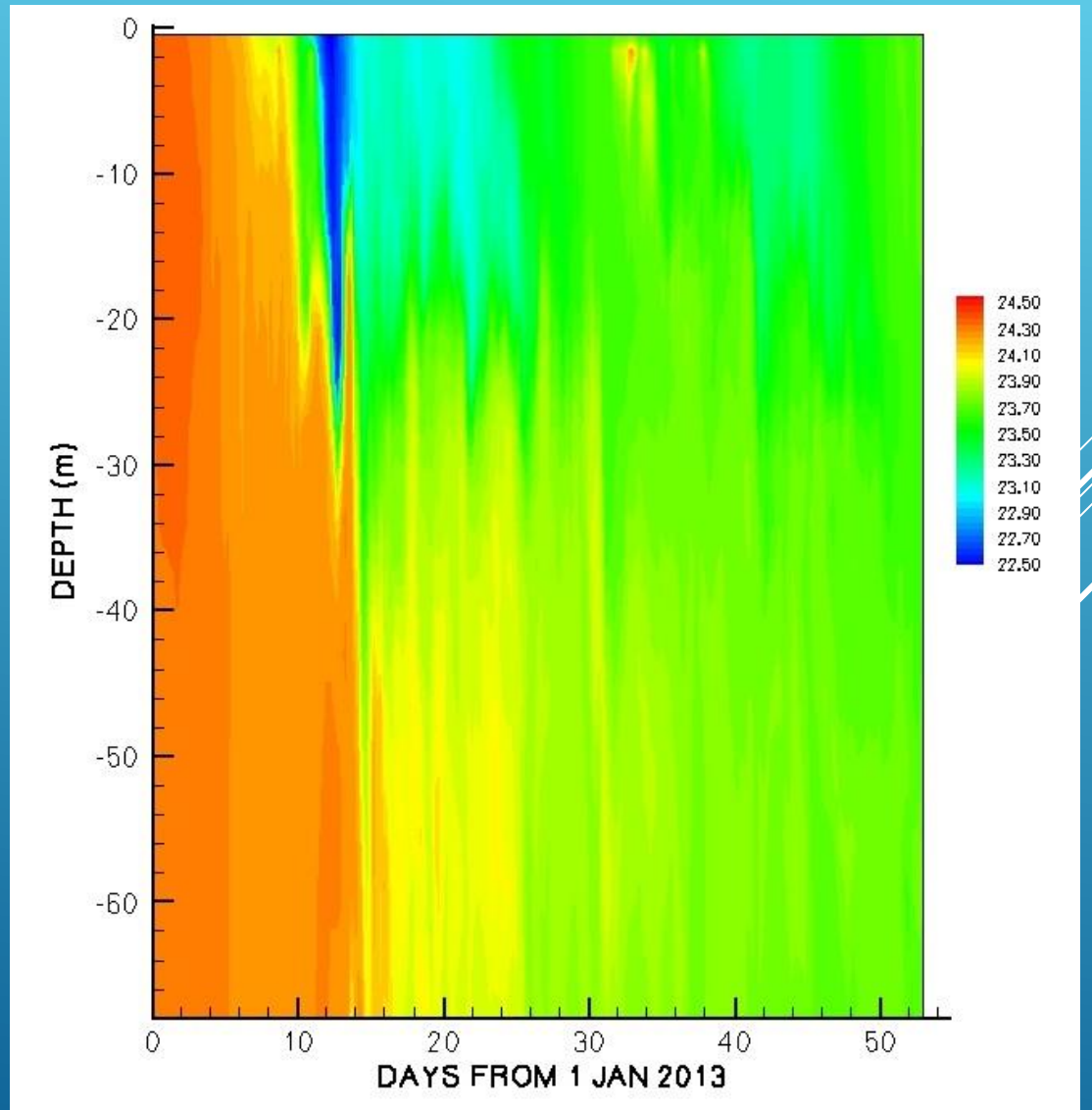
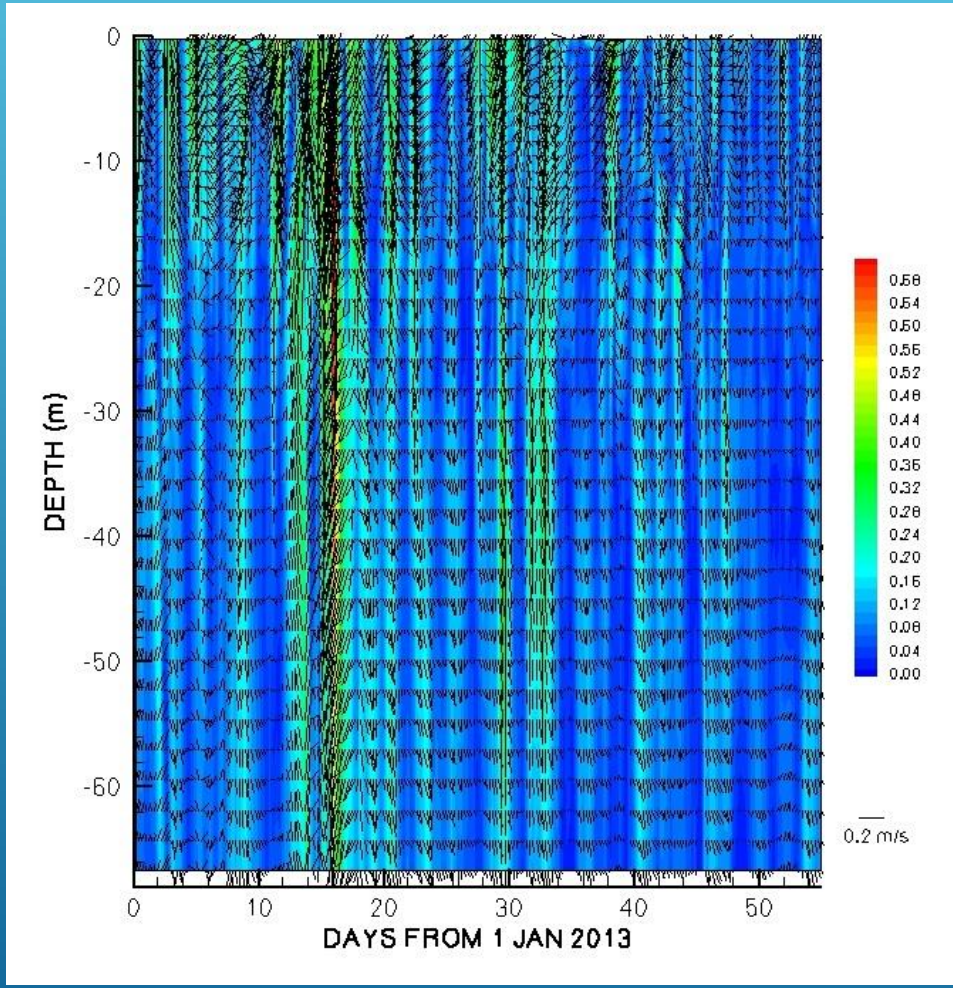


Observed temperature at EG-100

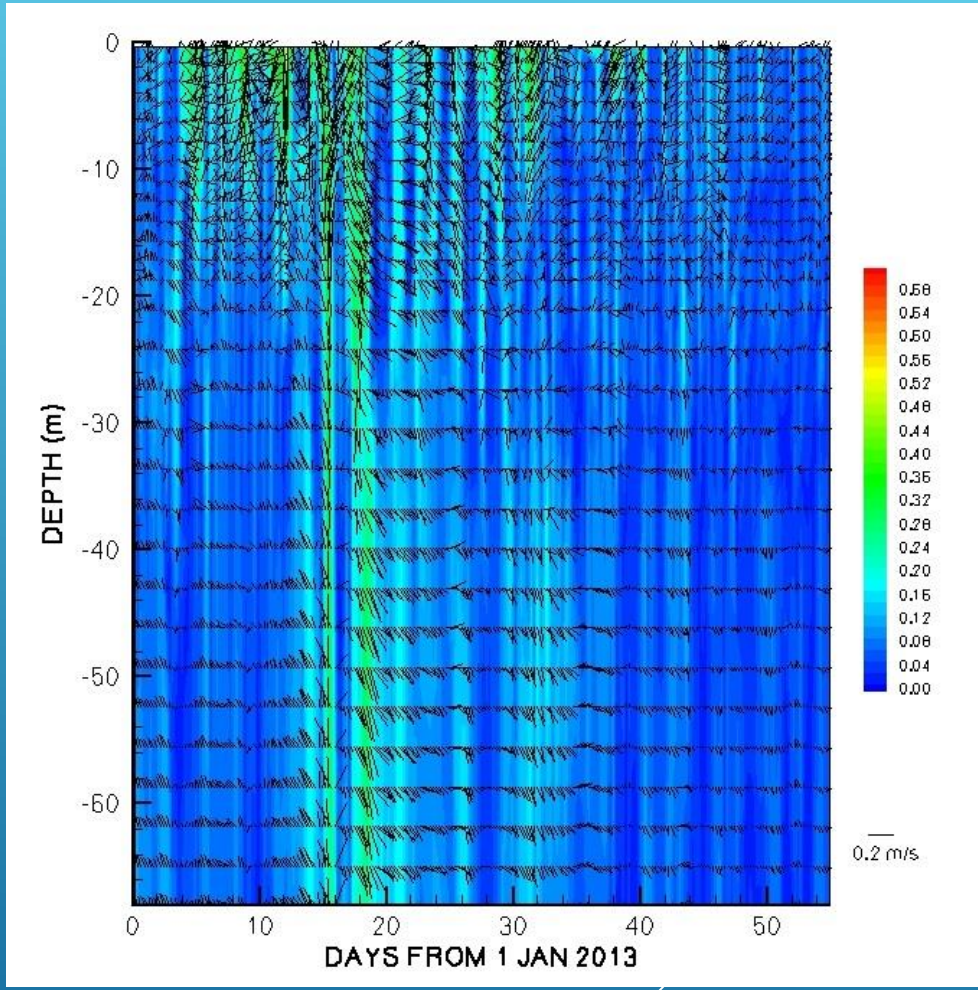


Simulated temperature

FLOOD (MEROMICTIC) EVENT OF JAN-FEB 2013



Simulated EG-55 currents



Simulated EG-100 currents

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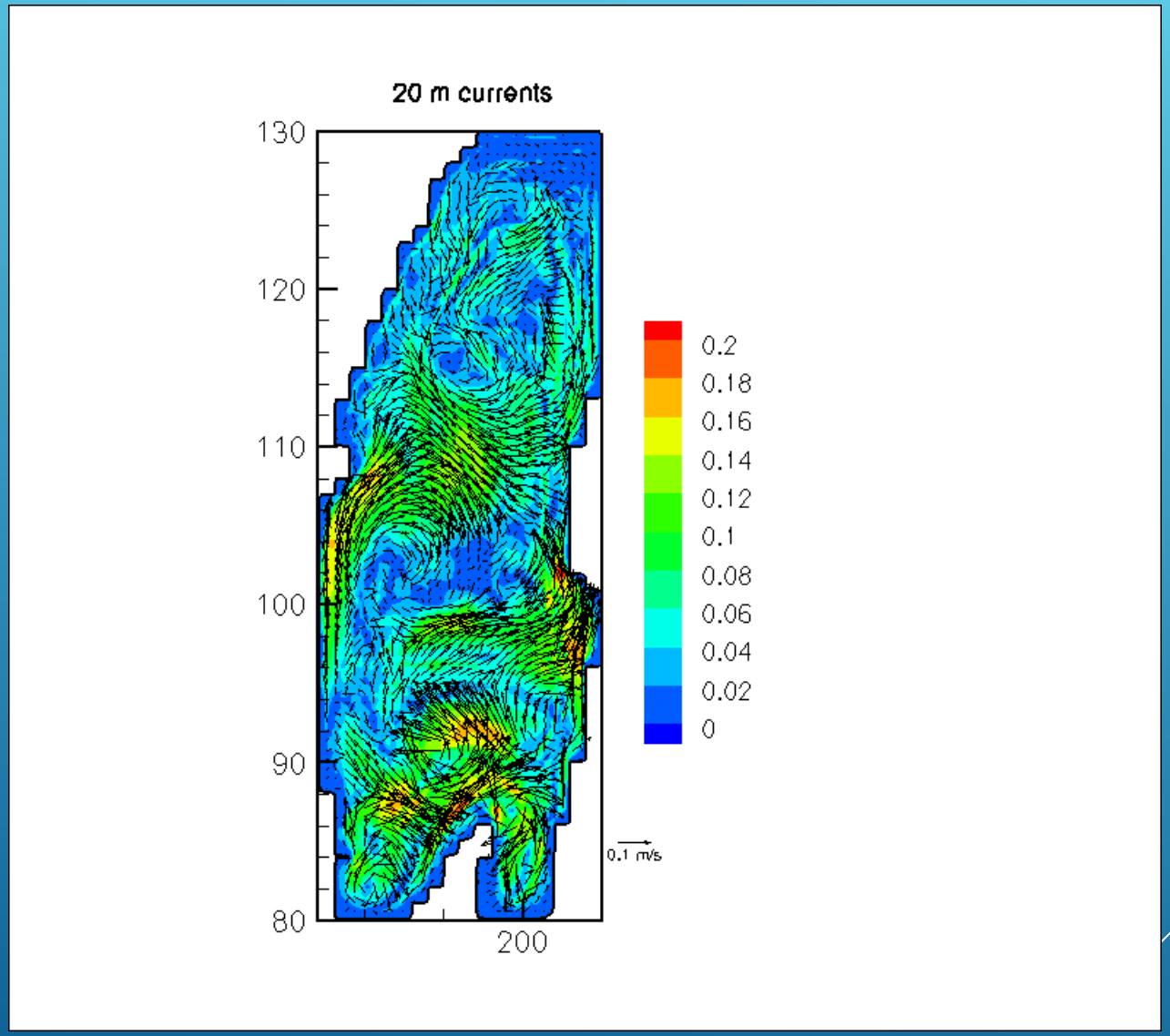

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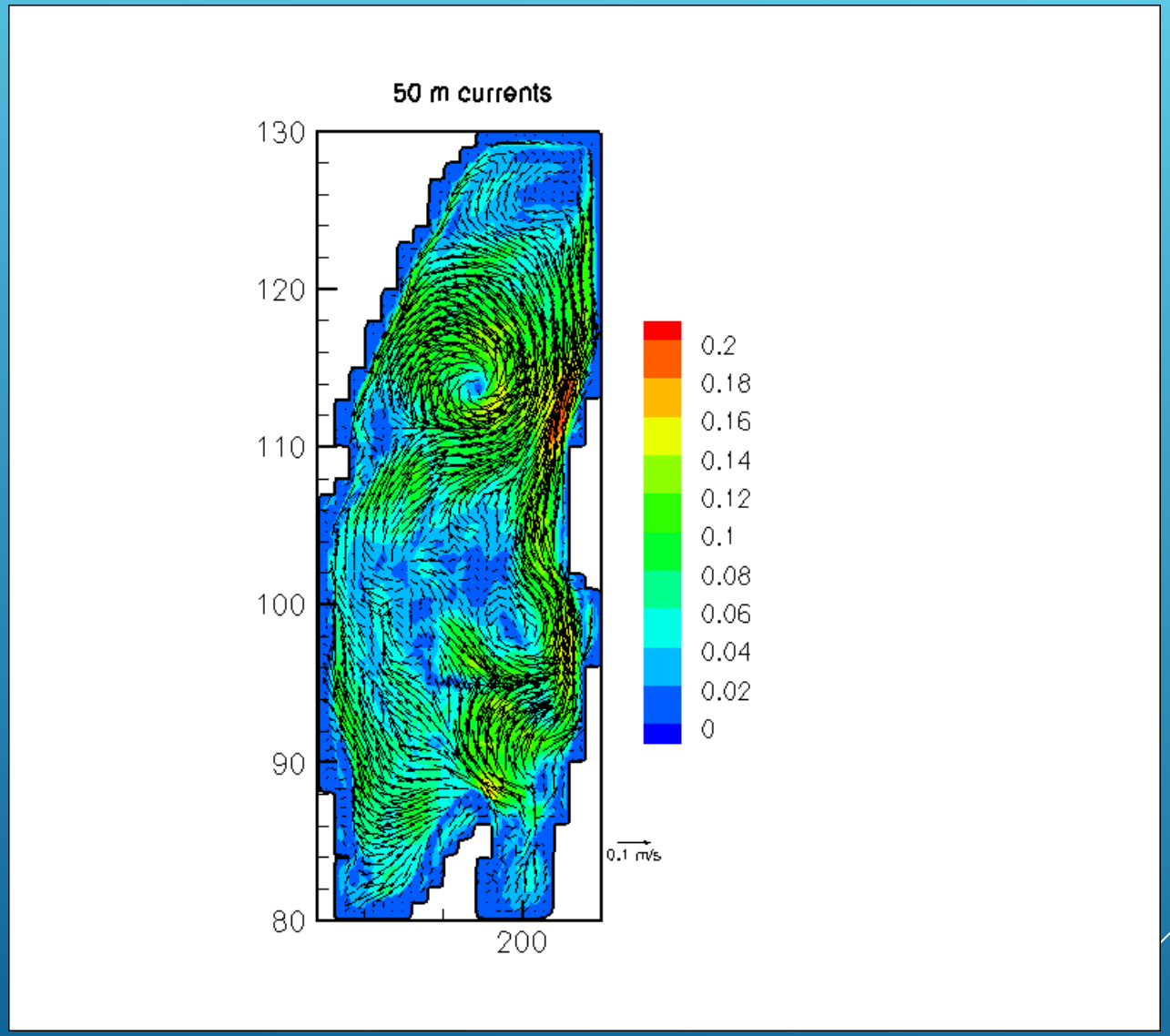

CONCLUSIONS

- The Dead Sea is a unique, extreme environment, desert enclosed, terminal lake
- Arthur Hecht's contribution to establishing a long term meteorological/limnological monitoring program has been invaluable for present, ongoing research
- Preliminary 3D model simulations of the circulation have produced interesting and encouraging results

FUTURE WORK

- Realistic, calibrated surface forcing (wind stress, heat and fresh water fluxes) including high resolution temporal and spatial variability
- Simulate additional unusual events
- Double diffusion
- Long term simulations
  - Wetting and drying to account for level decline
- Full equation of state including chemical kinetics
  - Computationally would be the Dead Sea analog of a biogeochemical model