Role of Ocean Water in Vadose Hydrology of Coastal Dunes

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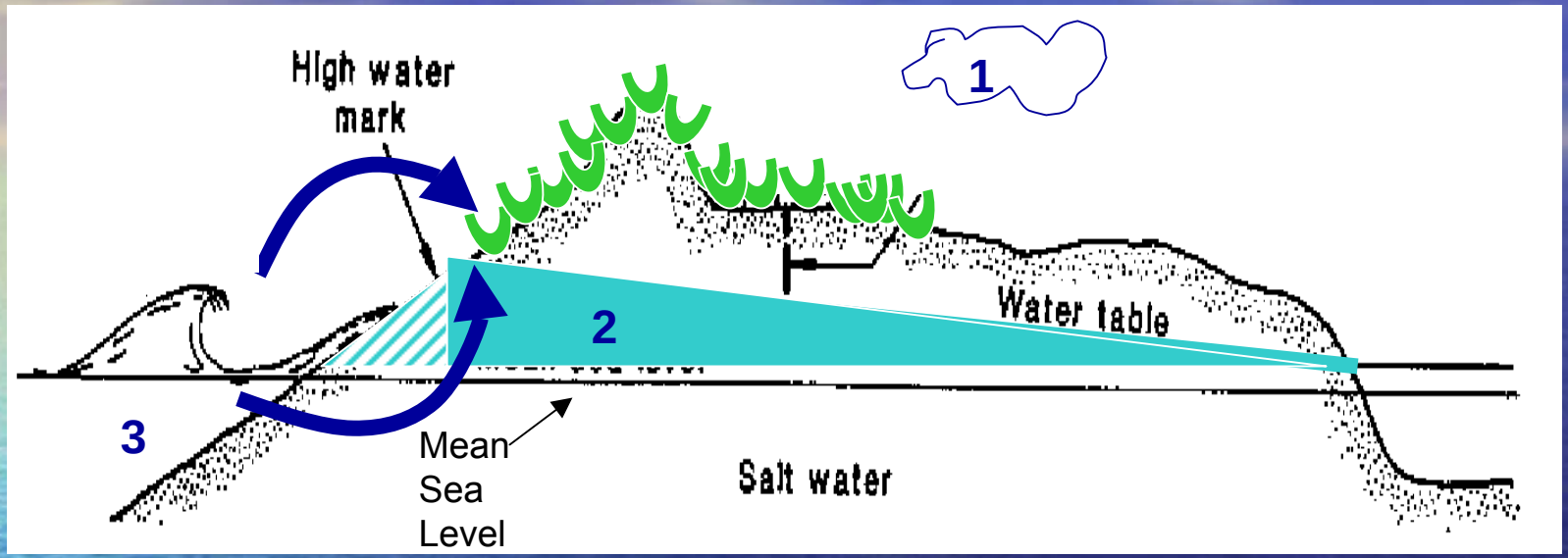
Sea Level Rise...

Coastal Dunes

We do not understand Vadose hydrology and its interaction with vegetation.

General Hydrology of a Island



(Neilson 1994)

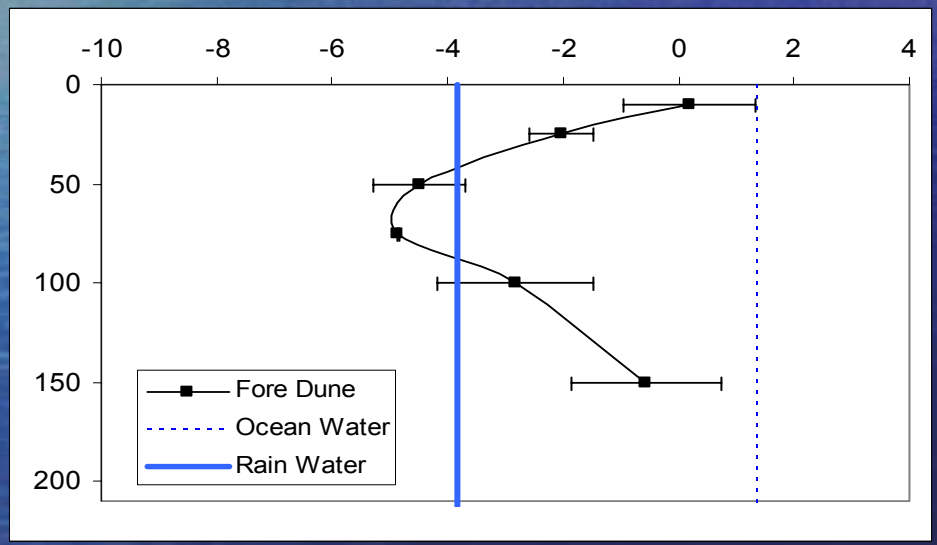
1. Rain water
2. Ghyben-Hertzberg lens (Ground Water)
3. Ocean water may mix into dune soils via:
   a. Above ground by Salt Spray
   b. Below ground by Ocean Water intrusion into freshwater lens

Stable Isotopes of water

- Stable Isotopes are used to trace water movement on the dune and to identify water sources used by vegetation
- Isotopic signatures of ocean and fresh water is distinct as well as precipitation and ground water
- Oxygen O16/O18
- Hydrogen H1/D

Oxygen Data

d18O value of soil water (‰)



Project Question

- Does the Hydrogen Isotope Data agree with the Oxygen Isotope Data?

Map of Study Site

Methods

- Collected in fore dune, approximately 4-5m from high tide mark intriplicate parallel to the beach.
- Samples were collected every 10 to 25 cm throughout the vadose layer (0-150cm) using a soil auger.
- Collected during the dry season-Feb. 2002-stored in freezer until analyzed.


San Salvador, Bahamas

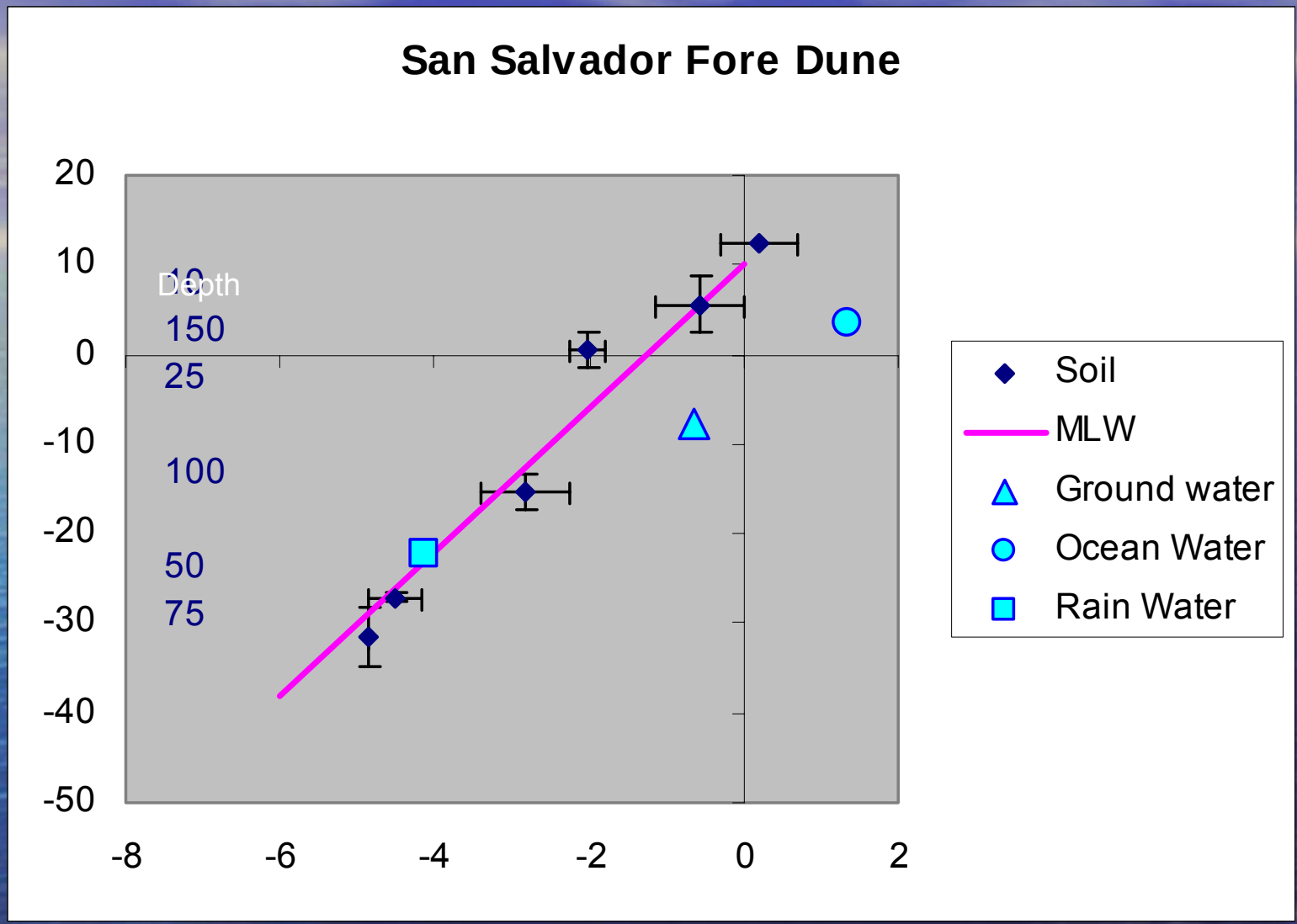
Methods

- Cryogenic Distillation of water (Ehleringer et. al 2001)
- (basically...vacuum water out of soil; use a nitrogen trap to freeze the water)
- Zn catalyst (Coleman et al. 1982) method

  to isolate the H2 gas.

  Analyzed H2 using a duel inlet mass spectrometer

Correct using a standard into delta notation


San Salvador Fore Dune
δD value of soil water (‰)
δ18O value of soil water (‰)
20
10
0
-10
-20
-30
-40
-50
-8
-6
-4
-2
0
2
Depth
10
150
25
100
50
75
Soil
MLW
Ground water
Ocean Water
Rain Water

Hypothesis 1: Evaporative enrichment

- At 10cm soil temperatures are high
- This is likely to cause water to evaporate out of the soil profile
- Evaporation causes enrichment of isotopes

Hypothesis 2:
D Excess

- Plants discriminate against D
- This could cause D excess in the soil
- Soil water moves vertically downwards
- We would expect the excess to accumulate in the deepest soil layers- 150cm.

Mass Balance Mixing Models

- Assumed the isotopic values of soil water were enriched in D
- With adjusted values we used mass balance equation to determine the % of ocean and rain water for each sample
- Using salinity we did a second mass balance model to determine % ocean and rain water for each sample
- Compared the results for the two models
  - If = we conclude dueterium enrichment

Results-150cm

- Mass balance mixing model: Isotopes predict composition of soil water
- corrected D = dRW (x) + dOcean (1-x)
- ocean water=83% rain water=17%
- Salinity Mixing Model
- soil salinity = Rain ppt (x) + Ocean ppt (1-x)
- Ocean water=81% rain water=19%
- They match

Results 10cm

- Mass balance mixing model: Isotopes predict composition of soil water
- corrected D = δD RW (x) + δD Ocean (1-x)
- Ocean water=69% rain water=31%
- Salinity Mixing Model
- soil salinity = Rain ppt (x) + Ocean ppt (1-x)
- Ocean water=66% rain water=33%
- They also match!

Conclusions

- Ocean water deposition via salt spray to shallow soil waters
- Evaporation changes the isotopic signature of D
- Ocean water deposition via intrusion to deeper soils
- Evidence for D excess (caused by D discrimination of plants)

Future Experiments

- Back Dune
- Three Different Sites-Bahamas, Key Biscayne
- Seasonal Effects-comparison studies

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