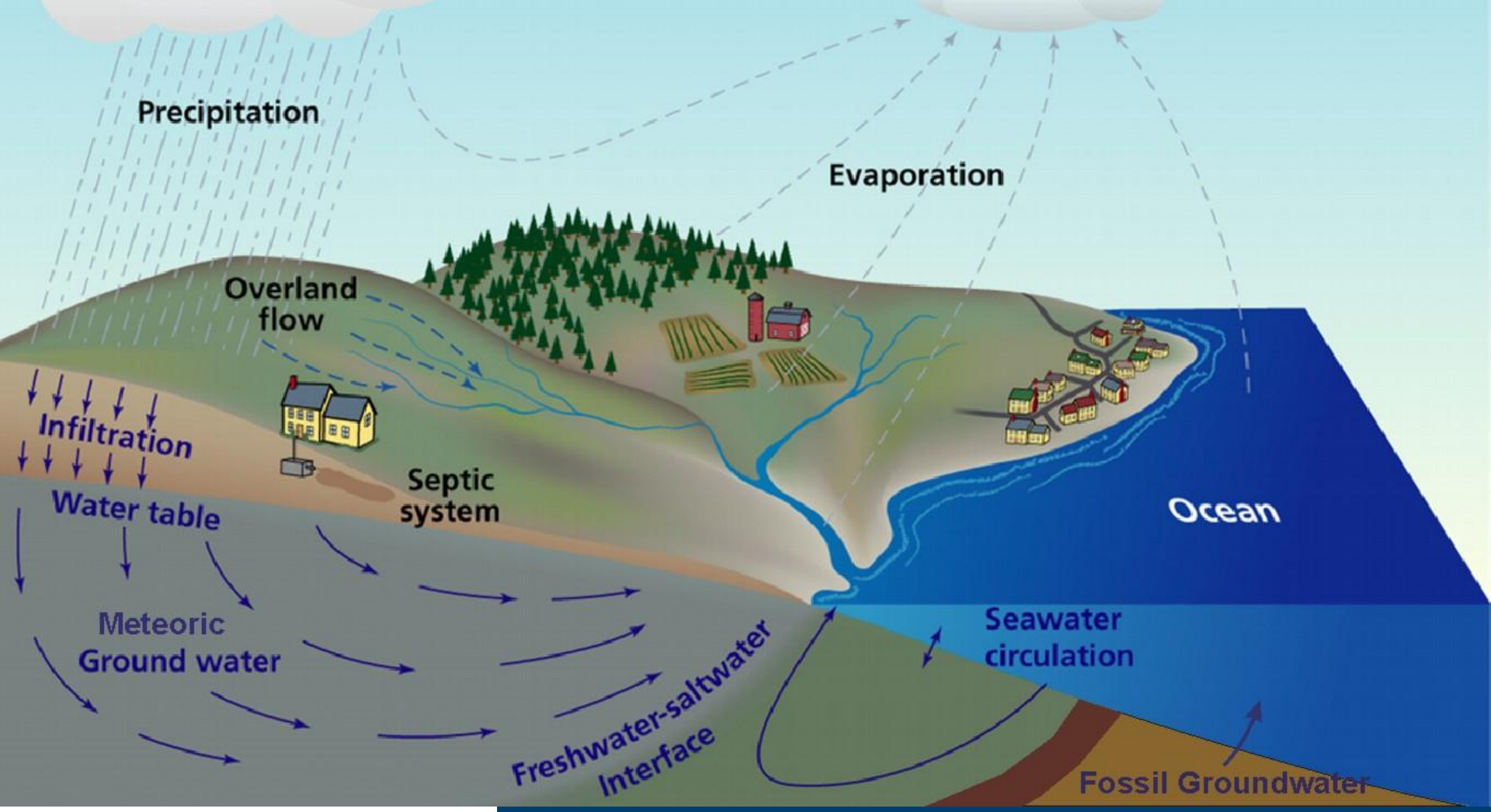

Investigation of Submarine Groundwater Discharge Applying a Remote Sensing / Tracer Approach

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Submarine Groundwater Discharge - SGD

SGD is of world-wide relevance because…

… it influences the condition of the near-shore marine environment.

- Contaminated SGD may have detrimental impact on fragile coastal ecosystems, such as coral reefs.
- Nutrient-laden SGD may lead to eutrophication or/and harmful algal blooms.

… it influences the water budget of coastal aquifers.

- SGD results in the uncontrolled loss of freshwater to the sea, water that could rather be used for drinking and irrigation purposes.

Submarine Groundwater Discharge - SGD

Since SGD is a large-scale process, efficient SGD investigation requires a stepwise downscaling approach.

1.) Large-scale SGD localization applying remote sensing techniques

- ***Thermal patterns*** in the coastal sea using satellite data (Landsat 7)
- ***Digital elevation model*** based on satellite data (SRTM) for terrestrial water accumulation modeling
- Satellite data that allows and ***lithology typification*** and ***structural lineament analysis*** for terrestrial water accumulation modeling

2.) Medium-scale survey using easily detectable tracers in the coastal sea

- Standard water parameters (salinity) allow rough SGD localization.
- Radon distribution patterns in the coastal sea indicate SGD locations precisely.

3.) Small-scale investigation for SGD quantification in hot spot areas

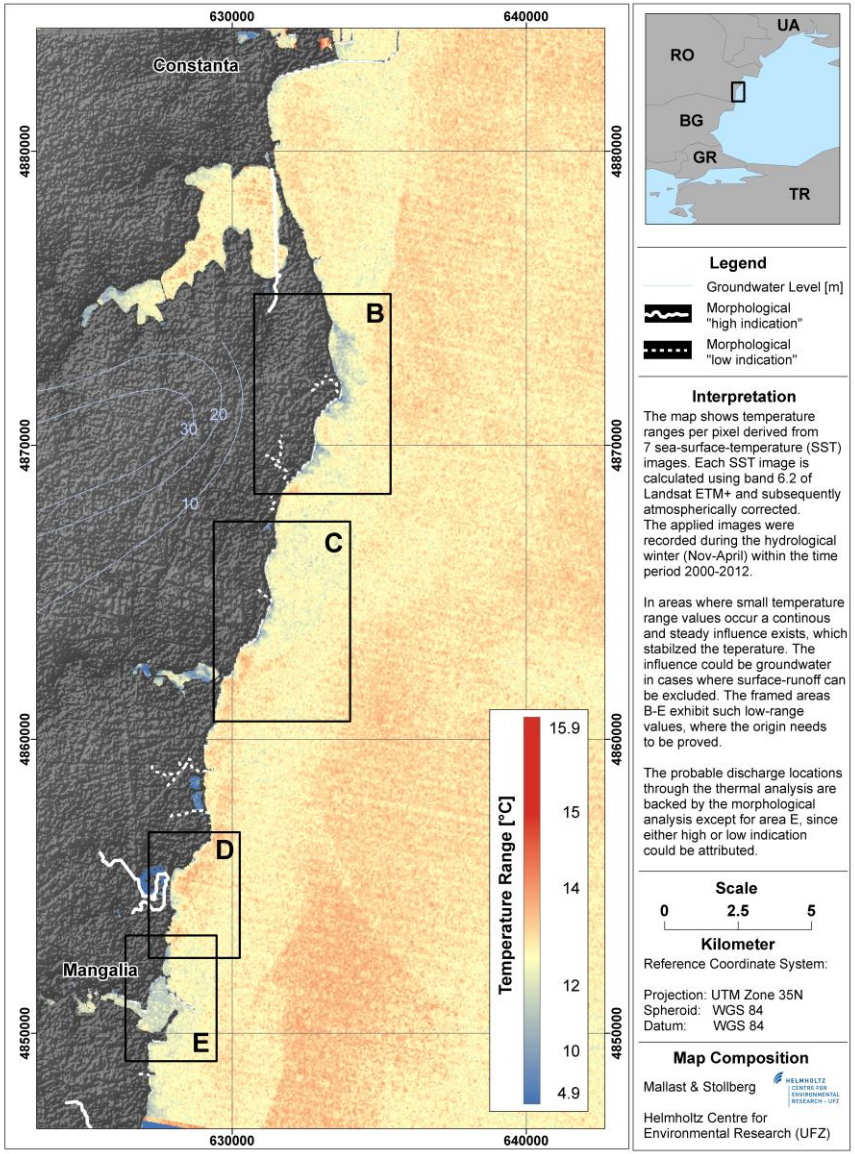
- Stable isotope signatures allow quantification of discharge rates.
- Radium species indicate water residence times flow paths in the coastal sea.

Thermal Patterns at Constanta Coastline

SST patterns in the coastal sea based on Landsat 7 ETM data

Sea Surface Temperature (SST) information achieved from high resolution Landsat-7 Enhanced Thematic Mapper (ETM) data may give a first indication of SGD occurrence.

Low temperature range patterns (blue color index) may indicate constant groundwater input.



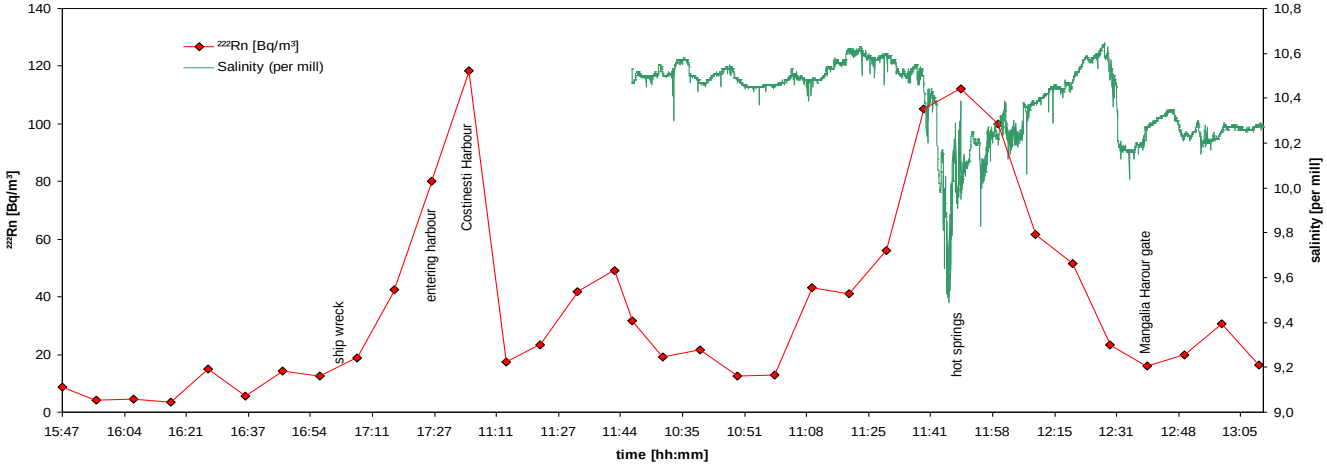
Radon Patterns at Constanta Coastline

^{222}Rn is the perfect SGD indicator because …

- It shows much higher concentrations in groundwater than in seawater.
- Radon maxima in the coastal sea indicate SGD locations precisely.
- Concentration patterns can be mapped by straightforward coastal cruises.

SGD locations can be verified and discharge rates can roughly be quantified using the radon distribution pattern along the shore line.

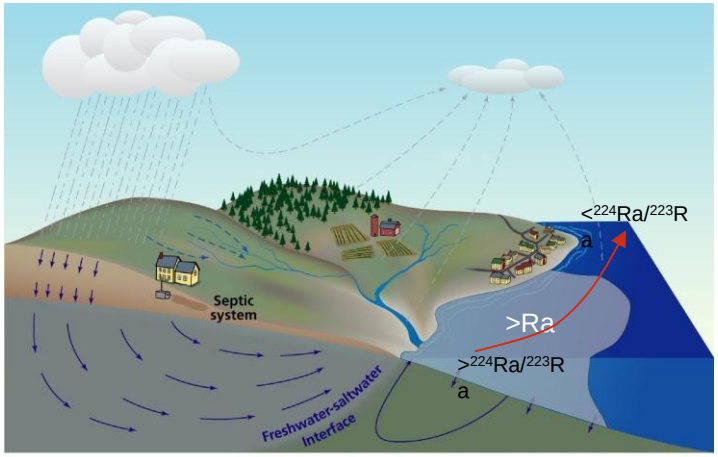
Preliminary results:



Isotope Patterns at Constanta Coastline

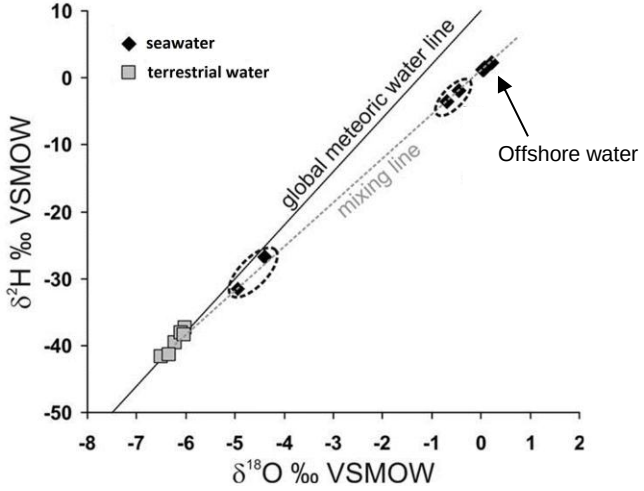
- **Radium species indicate flow paths in the coastal sea because …**

The concentration ratio of the short-lived ^{224}Ra and ^{223}Ra changes quickly as *f* (t) thus indicating residence times and flow paths of the discharged groundwater in the coastal sea.



- **Stable Isotopes allow quantification of discharge rates.**

Due to the distinct stable isotope signatures of groundwater and seawater (^{18}O & ^{2}H) mixing ratios of the two water types can be determined.



Submarine Groundwater Discharge - SGD

Conclusion

- SGD is an issue of major proportions on a world-wide scale.
- It might have detrimental impact on the coastal environment.
- In arid climate zones the loss of fresh water might be relevant.
- SGD investigation requires a stepwise approach.
- Applicable data include:

1.) satellite-based remote sensing techniques
give information about of coast and hinterland

2.) Tracer distribution patterns in the coastal sea (^{222}Rn)

3.) Radium ratios and stable isotope signatures