Submarine Groundwater Discharge (SGD): Contributions to GEOTRACES

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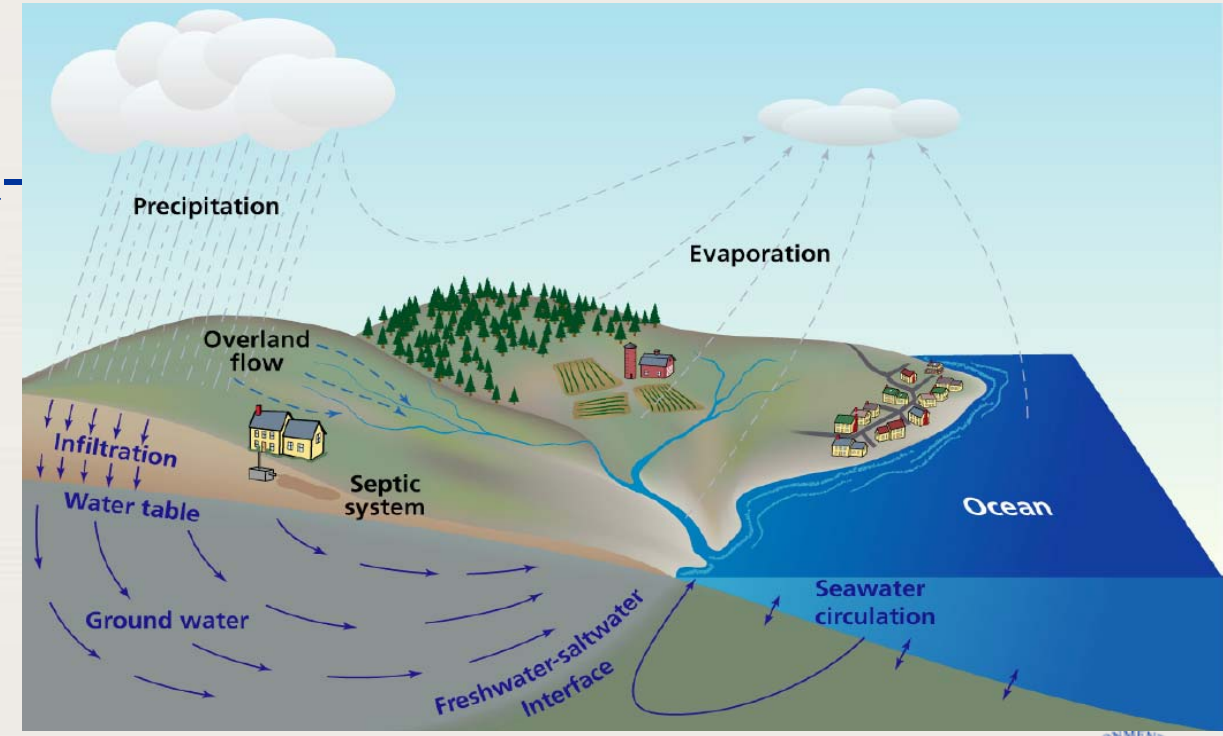
Submarine Groundwater Discharge (SGD)

Groundwater is a common transport route between land an sea for freshwater. The flow of groundwater towards the sea will occur wherever the hydraulic gradient on land is above mean sea-level and permeable paths connect continental aquifers to the seafloor (Johannes, 1980),



Mulligan and Charette, pers. com.

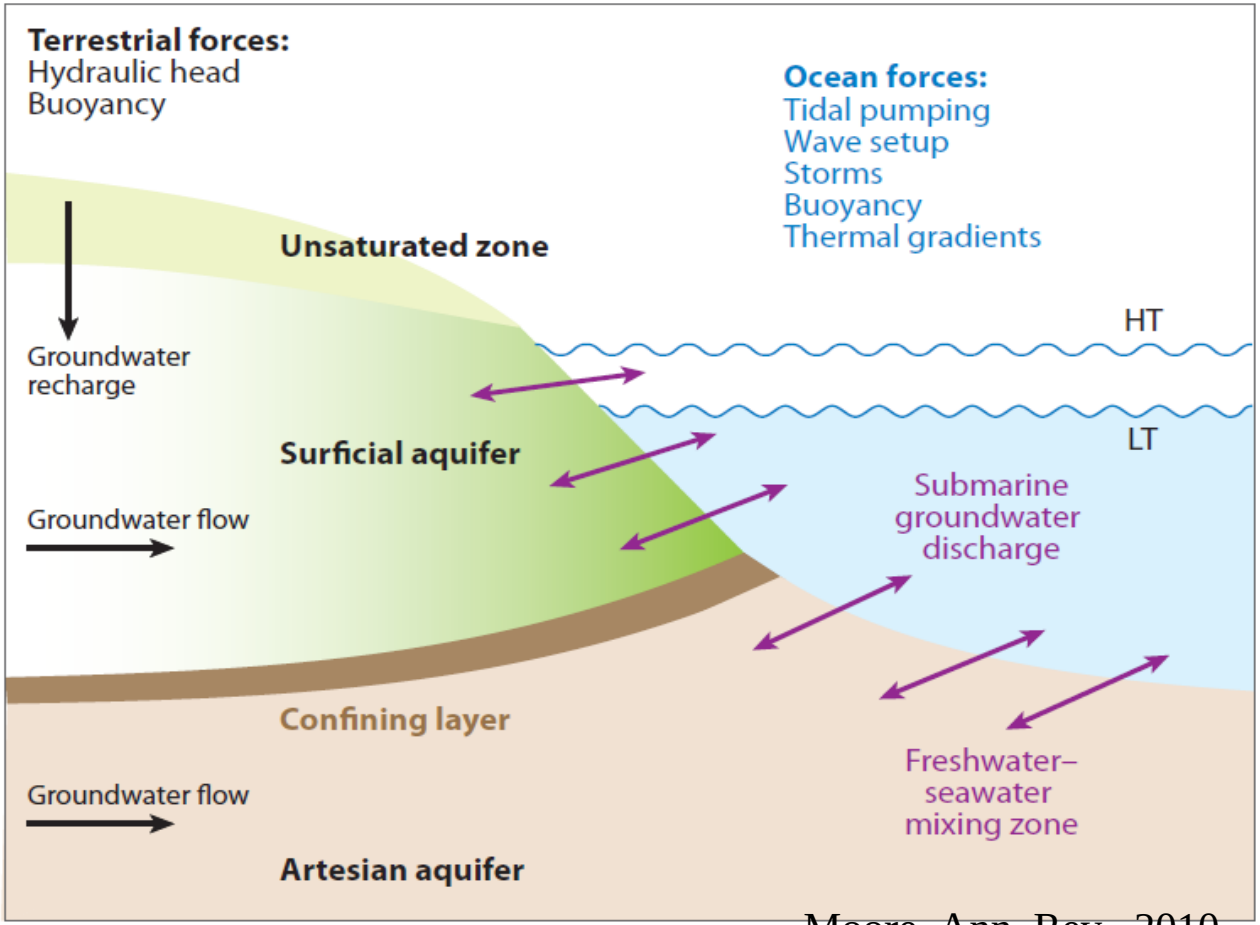
Definition SGD

Submarine **G**roundwater **D**ischarge (SGD) is the flow of water through continental margins from the seabed to the coastal ocean, *with scale lengths of meters to kilometers*, regardless of fluid composition or driving force (Moore, Ann. Rev., 2010).

(This definition eliminates stress flow and shallow bioturbation and bioirrigation.)

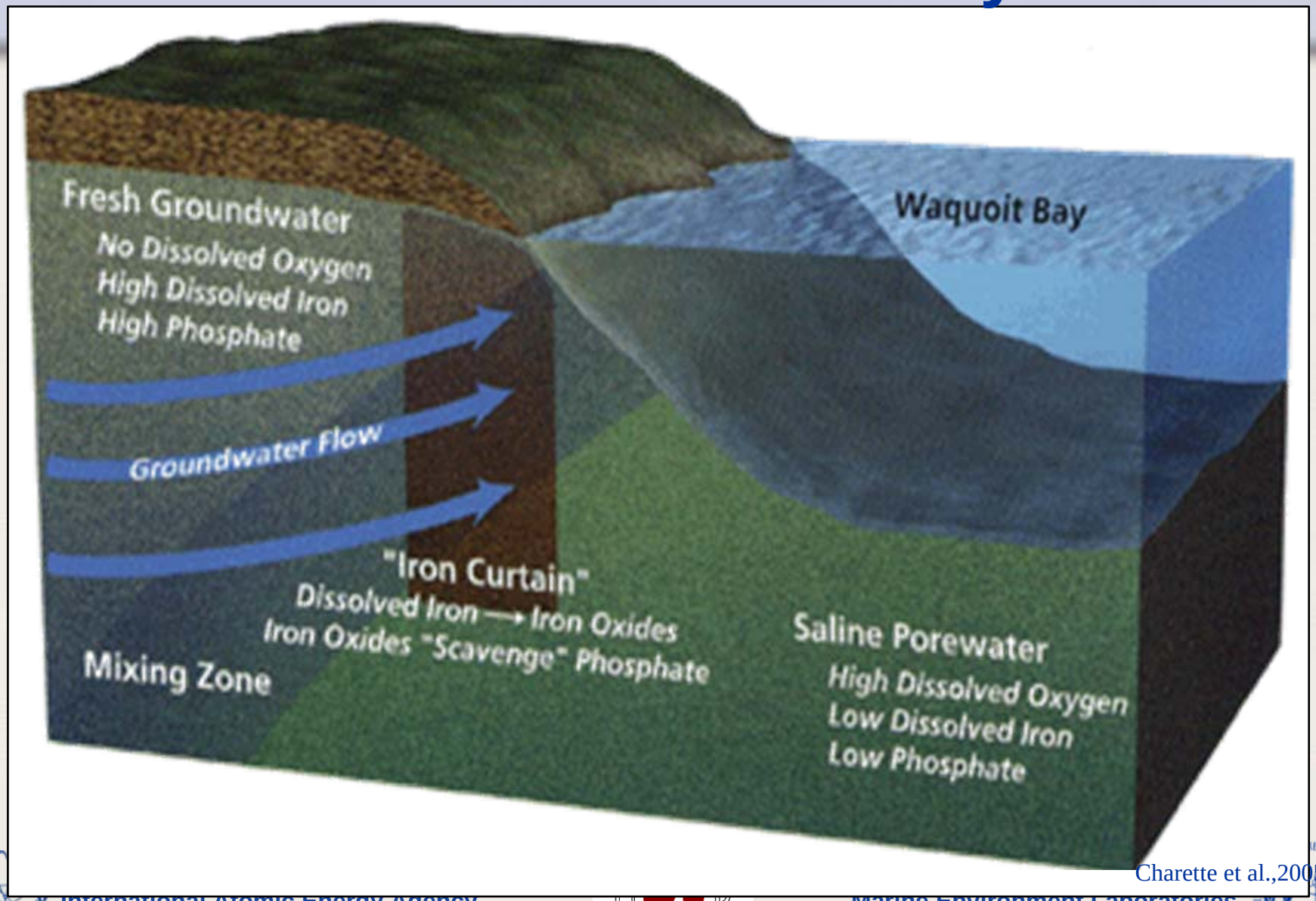
Types of SGD

1. Freshwater which, due to the hydraulic gradient, discharges directly into coastal waters
2. Recirculation of seawater caused by waves and tidal pumping
3. Combination of 1. + 2. most frequent
4. The freshwater-seawater mixing zone has been dubbed the **Subterranean Estuary** (Moore 1999)



Moore, Ann. Rev., 2010

Subterranean Estuary

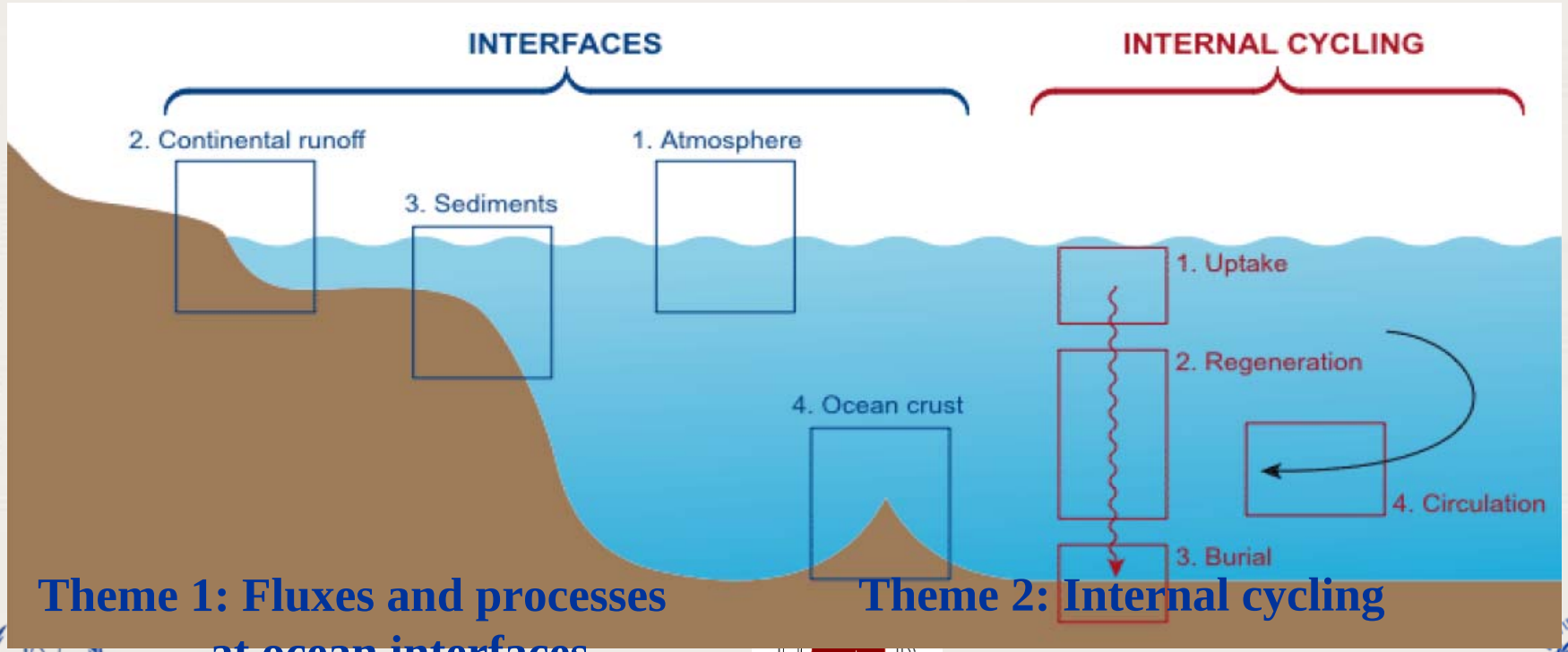


Charette et al.,2005

Why care about SGD in GEOTRACES

GEOTRACES mission

To identify processes and quantify fluxes that control the distributions of key trace elements and isotopes (┼ TEIs) in the ocean, and to establish the sensitivity of these distributions to changing environmental conditions



Theme 1: Fluxes and processes at ocean interfaces

Theme 2: Internal cycling

Facts and Figures

- SGD circa 5-10% of global freshwater sources to oceans
- In the Atlantic total SGD (freshwater plus recirculated seawater) is up to 80-160% of the river flux entering the Atlantic Ocean
- Dissolved material transports is much more important that water itself
- SGD may be a major pathway for micronutrients (e.g. iron, molybdenum)

Facts and Figures

Stains of oxidized iron on a beach along the Patos Lagoon, Brazil, coast are due to the input of SGD having high concentrations of reduced iron

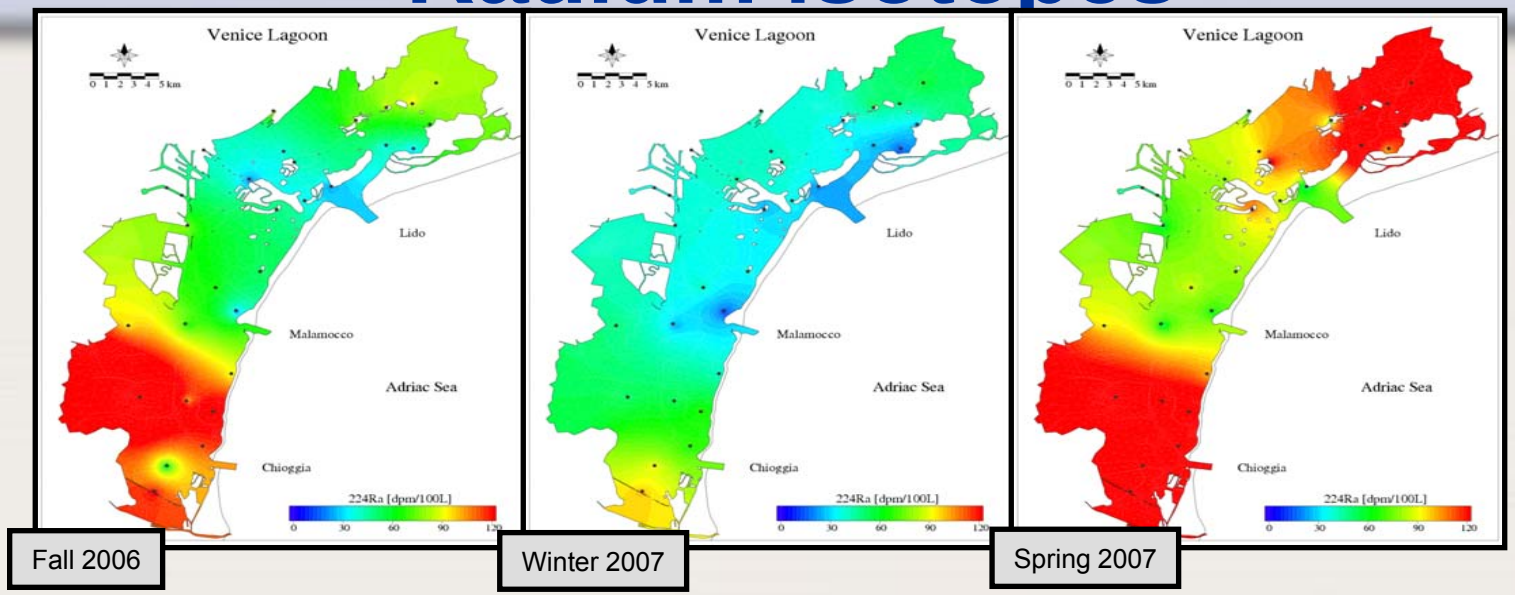
Facts and Figures (cont.)

- SGD important for the oceanic balance of Sr and Nd
- SGD is a source for coastal pollution (pesticides, heavy metals, monomethylmercury etc.)
- SGD nutrient inputs to the coastal zone rival those of rivers at regional and global scales
- N/P ratio fed into coastal system >>>16 because of differential sorption efficiency to solid phase of Phosphorus (P) and Nitrogen (N) species

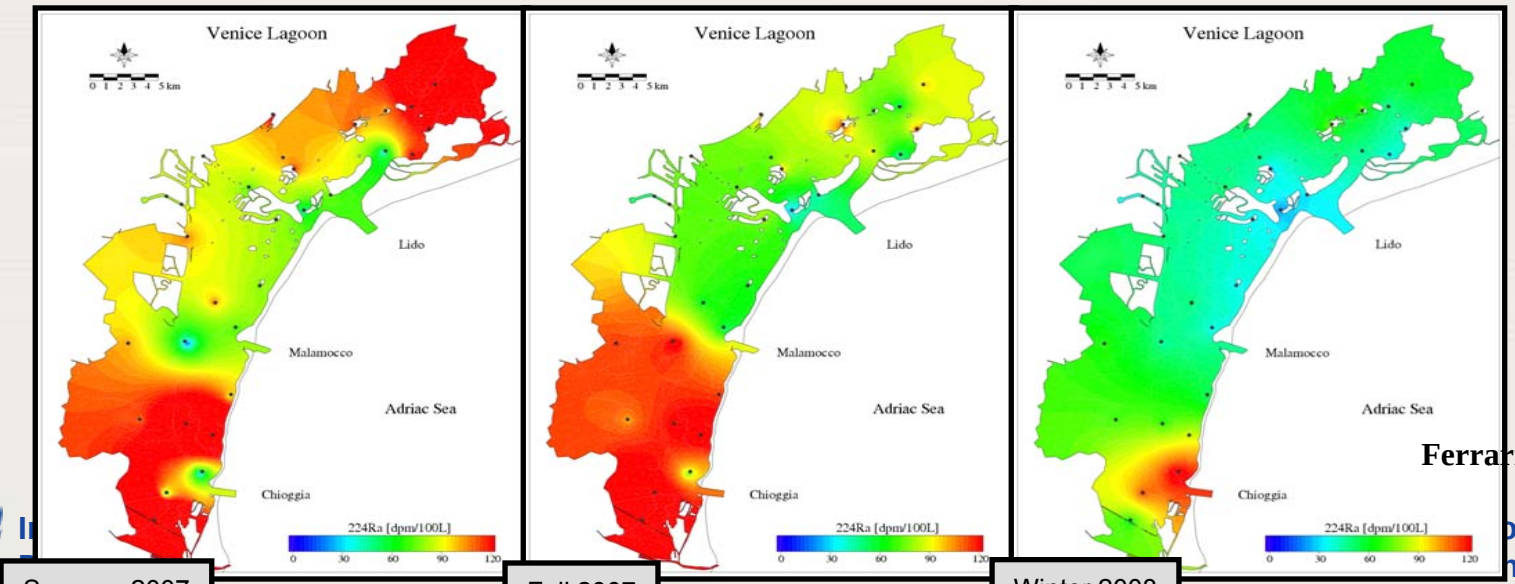
How to detect & quantify SGD

- **Hydrologic Models:** Physical principles to the flow of water in coastal aquifers (Darcy´s law, water budget, hydrograph separation).
- **Thermal Measurements:** Temperature contrast between groundwater and sea water.
- **Seepage Measurements:** Capture water seeping into surface waters.
- **Tracer Measurements:** Naturally occurring tracers (radium/radon) that have very different concentrations in groundwater and in seawater. Salinity for freshwater SGD

How to detect & quantify SGD : Radium isotopes



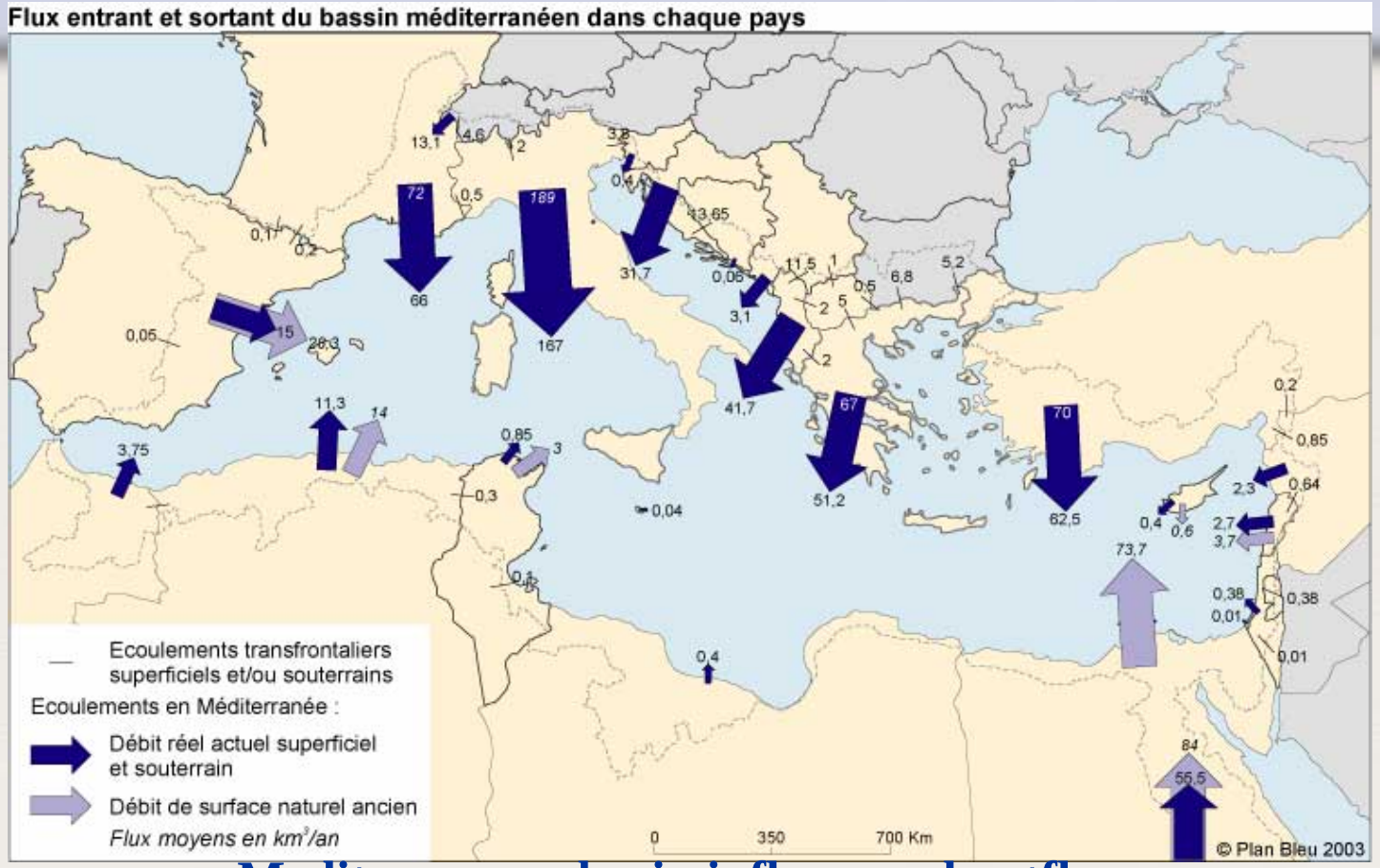
Fall 2006 | Winter 2007 | Spring 2007



Summer 2007 | Fall 2007 | Winter 2008

Ferrarin et al, 2008

SGD in the Mediterranean Sea



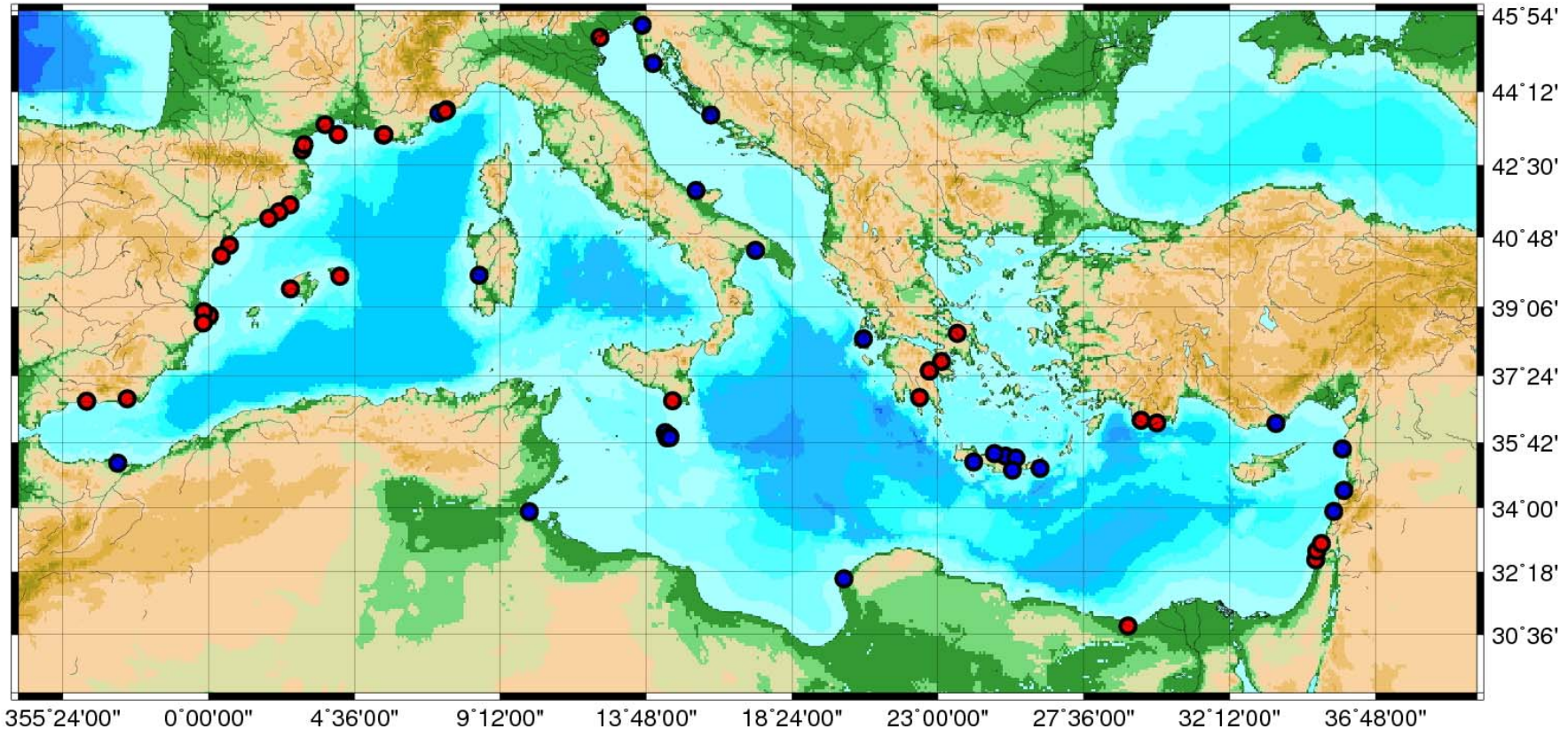
Mediterranean basin inflows and outflows

SGD (freshwater): 45 $km^3/y^{(a)}$ – 68 $km^3/y^{(b)}$

Rivers (Rhone, Po, Nile, Ebro, Tiber, Adige): 158 km^3/y

a) Plan Bleu, 2003
b) Zektser et al, 2007

SGD Sites in the Mediterranean Sea



- studied in detail
- inferred from salinity, thermo images, visual observations

Possible SGD research and strategy in GEOTRACES - Mediterranean Sea

- Quantify total SGD flux to the Mediterranean Sea
  => Radium isotope inventories in the upper water column
- Importance of SGD as a source for TEI´s (e.g. Nd, Fe, Sr)
  => determination of TEI´s fluxes at SGD sites;
  quantify margins/open ocean exchange (radium gradients)
- Consequences of climate change (sea-level rise, extension of estuaries, over exploitation, change in precipitation) on SGD? Additional release of trace elements/pollutants? Salinization of coastal aquifers?
  => Transect of sediment cores in subterranean estuaries. Models.
- Can we develop tracer techniques to detect and to quantify SGD on geological time scales?
  => TEI´s (e.g. Isotopes of Fe, Sr, $\delta^{18}O$) of authigenic phases (minerals, biogenic) at SGD sites

Major question (not related to GEOTRACES): Influence of SGD on oceanic carbon balance


Thank you for your attention!!!