Applications of natural radioisotopes to processes at the continent-ocean continuum

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Applications of natural radioisotopes within the framework of the INCT-TMCOcean

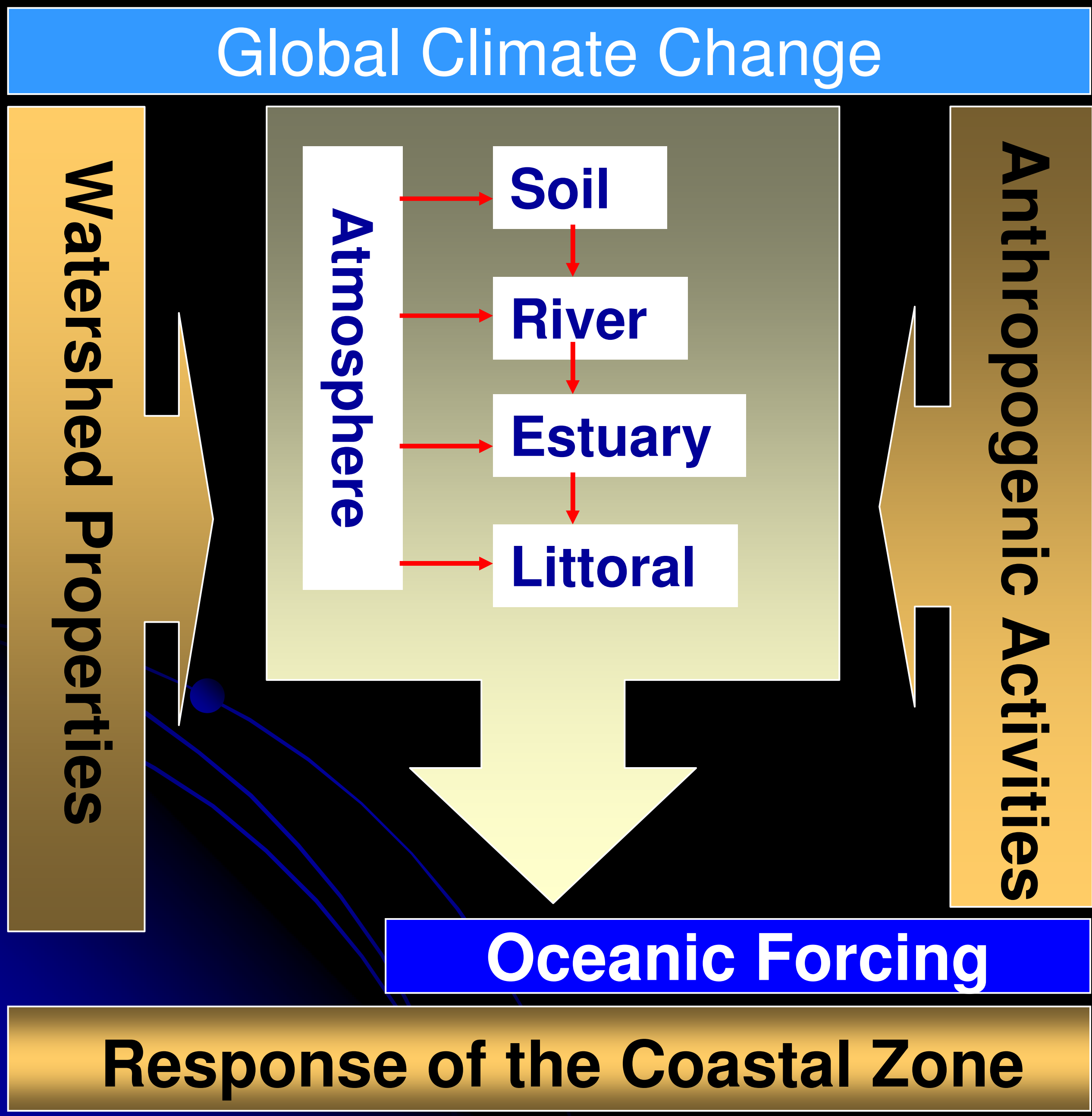
The INCT-TMCOcean major goals are:

- To study the transport, accumulation, cycling and biogeochemistry of nutrients, organic matter and trace metals in the land-ocean interface

- Compare them in different coastal systems along the east-northeastern coast of Brazil under different environmental situations, particularly on the behavior of the fluvial-estuarine continuum under semi-arid (northeastern coast) and sub-tropical humid (southeastern coast)

- To understand the impact of human development resulting in pressures from river damming, water diversion and basin transposition, urbanization, industrialization and agriculture.

The Continent-Ocean Continuum



Under this scenario, radioisotopes can be used as :

- *tracers of dynamic processes*
- *proxies of complexes reactions and environmental changes*
- *signatures of geochemical compartments.*
- *proper objects of study*

History of the application of radioisotopes in the continent ocean-continuum in Brazil

International Atomic Energy Agency (IAEA)
& International Commission on Radiological Protection (ICRP)
1966-1982 (e.g. Morro do Ferro Th project)

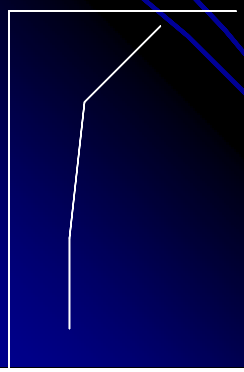
Comissão Nacional de Energia Nuclear
(CNEN)

IRD (RJ); IPEN (SP)

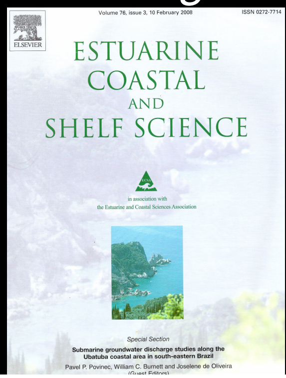
Universities

Pre-operational monitoring of Angra dos Reis Nuclear Plants

^{210}Pb & ^{14}C dating



Submarine Ground water Discharge SGD



Historical uses of radioisotopes in the continent-ocean continuum in Brazil

As tracers of their stable correspondent or an analogous element, *e.g.:*

- *Radioactive heavy metals as tracers of stable elements (^{51}Cr; Pfeiffer et al., 1980;1982; Chromium transport studies in Guanabara Bay estuary and food chains)*
- *Artificial radionuclides such as ^{137}Cs as tracer of micronutrient absorption)*

In vitro identification of transfer pathways between trophic levels or physiological mechanisms, e.g.

- *Organification reactions; Hg methylation (Guimarães et al., 2001); Cobalamin formation*
- *Bioaccumulation of metals: Sr-bioaccumulation by algae (Santos et al., 1988); heavy metal accumulation by marine animals (Weerelt et al., 1984)*

Chemistry of radionuclides in the environment

- *Content of artificial radionuclides in natural samples (e.g. Cs)*
- *Content of natural radionuclides in natural samples (e.g. Ra)*

Recent approaches in radionuclide applications in Brazil (Santos *et al.*, 2008)

Geochronology, as dating thorough decay half-lives
e.g. ^{14}C; ^{210}Pb in most studies on past and recent sedimentation rates; (e.g. Godoy et al., 1998a,b; Lacerda et al., 1999,2001; Mahiques et al., 2005; Marques et al., 2006)

As traces of water masses when isotopes are of known origin
e.g. Radium isotopes for submarine groundwater discharge mapping, mixing of water masses form different origins; (e.g. Godoy et al., 2006; Oliveira et al., 2003; 2006)

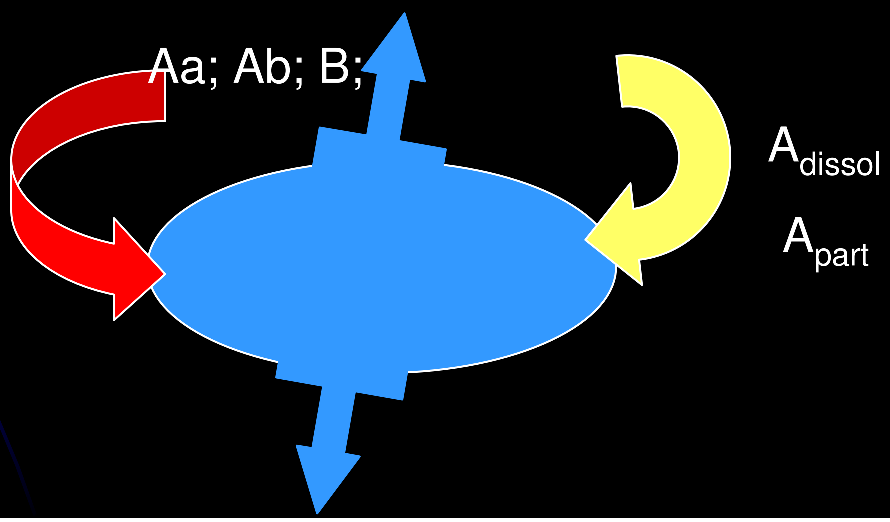
Sediment mixing rates and remobilization studies
e.g. 234Th, 7Be distribution in short sediment cores; (e.g. Smoak & Pachineelam, 1999)

Some other important applications, however, are still to be seek

1. Multi-source element cycling in estuaries and the continental shelf.

1.1. Relative contribution of different sources to the air-sea interface

1.2. Relative contribution of different element species in each sources

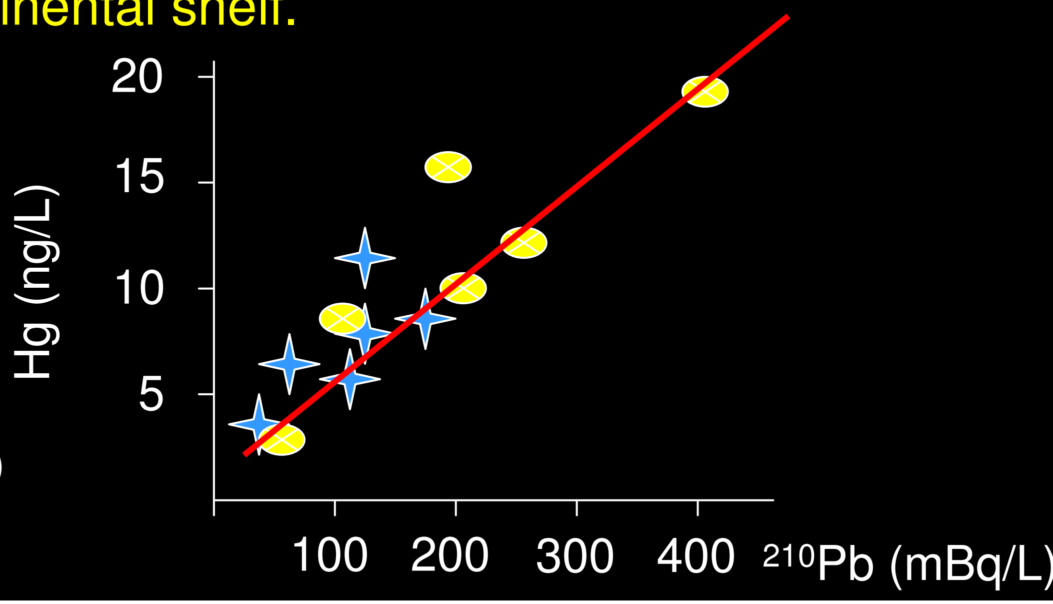


1.1. Hg transport through the continent-ocean continuum and cycling on coastal and shelf areas

- Formation, transport and deposition of HgII is extremely relevant since it's the precursors of monomethyl-Hg (MMHg) in natural environments.
- MM-Hg is the major species of Hg contamination of the biota and pathway of Hg exposure to human populations
- Particle-reactive natural radionuclides may be used as tracers of chemical reactions and physical mechanisms involved in the transfer of Hg to the continental shelf.

e.g.

Hg and ^{210}Pb in precipitation (Lamborg *et al.*, 2000)



1.1.Relative contribution of atmospheric Hg species to shelf waters

- ✓ Analogous removal mechanisms for HgII and ^{210}Pb.
- ✓ First order gas-to-particle conversions of volatile ^{222}Rn and Hg^0 to no-volatile particle-reactive *off springs* ^{210}Pb and Hg^{2+}.
- ✓ Universal constant ratio between Hg^{2+} and ^{10}Pb in wet deposition of: 0.32 pM.mBq^{-1}.

Some applications

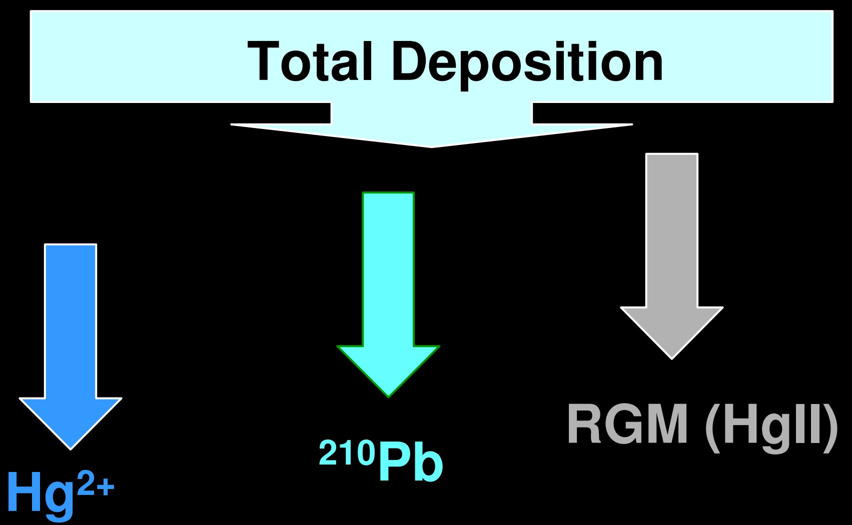
- ✓Estimation of atmospheric residence time.
- ✓Spatial Distribution of Hg fluxes.

e.g. global scale ^{210}Pb-derived Hg residence is time: 1.8 years; global pool of Hg in the atmosphere is 26 MM; through modeling based only on Hg measurements: 1.6 yr; 25 MM (Lamborg *et al.,* 1999)

1.2. Atmospheric Hg inputs to shelf areas

- **Removal from atmosphere mostly as wet deposition of Hg^{2+} follows the Hg/^{210}Pb constant**

- **Dry deposition of gas-phase ionic Hg as reactive gaseous mercury (RGM), could be assessed by displacement of the Hg ^{210}Pb**

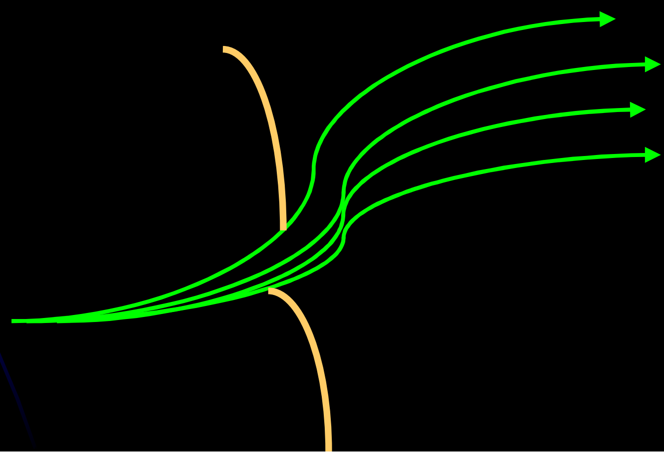


e.g. excessive primary production preferentially converting Hg0 to HgII not affecting ^{222}Rn conversion to ^{210}Pb; also a proxy of global changes

2. Mixing properties applied to non-conventional compartments

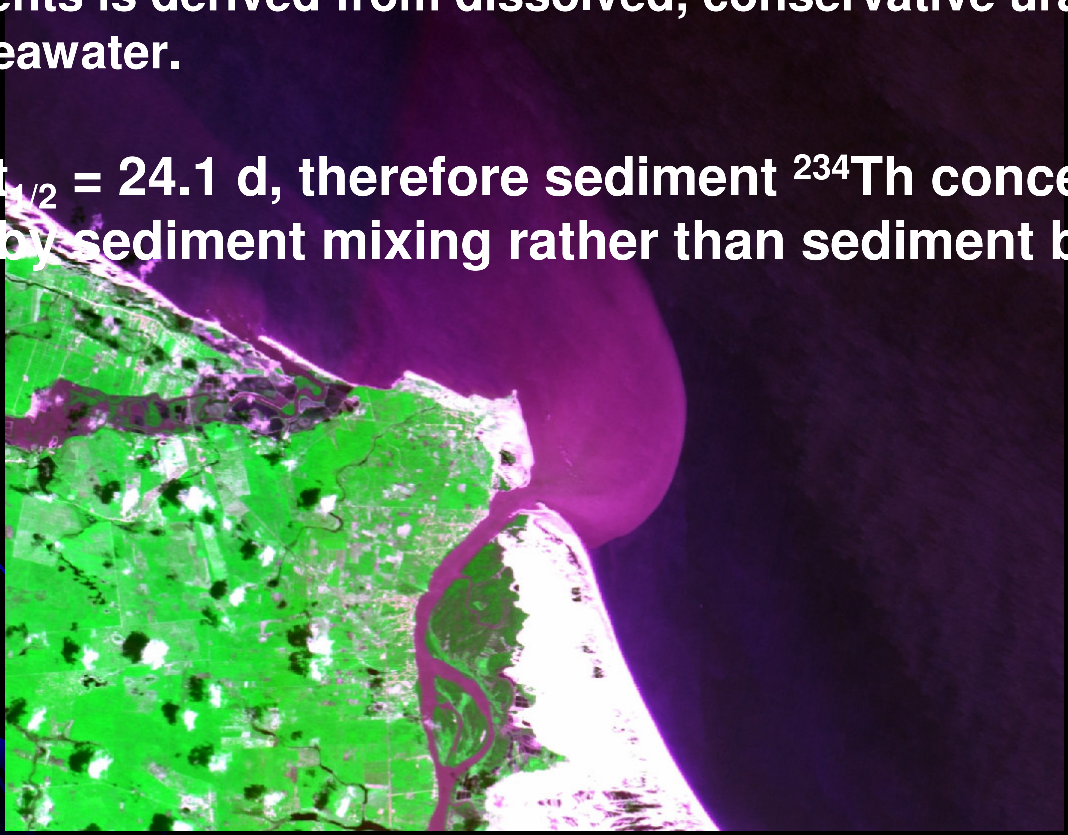
2.1. Seasonal fluvial plumes in the continental shelf

2.2. Proxies to climate change impacts

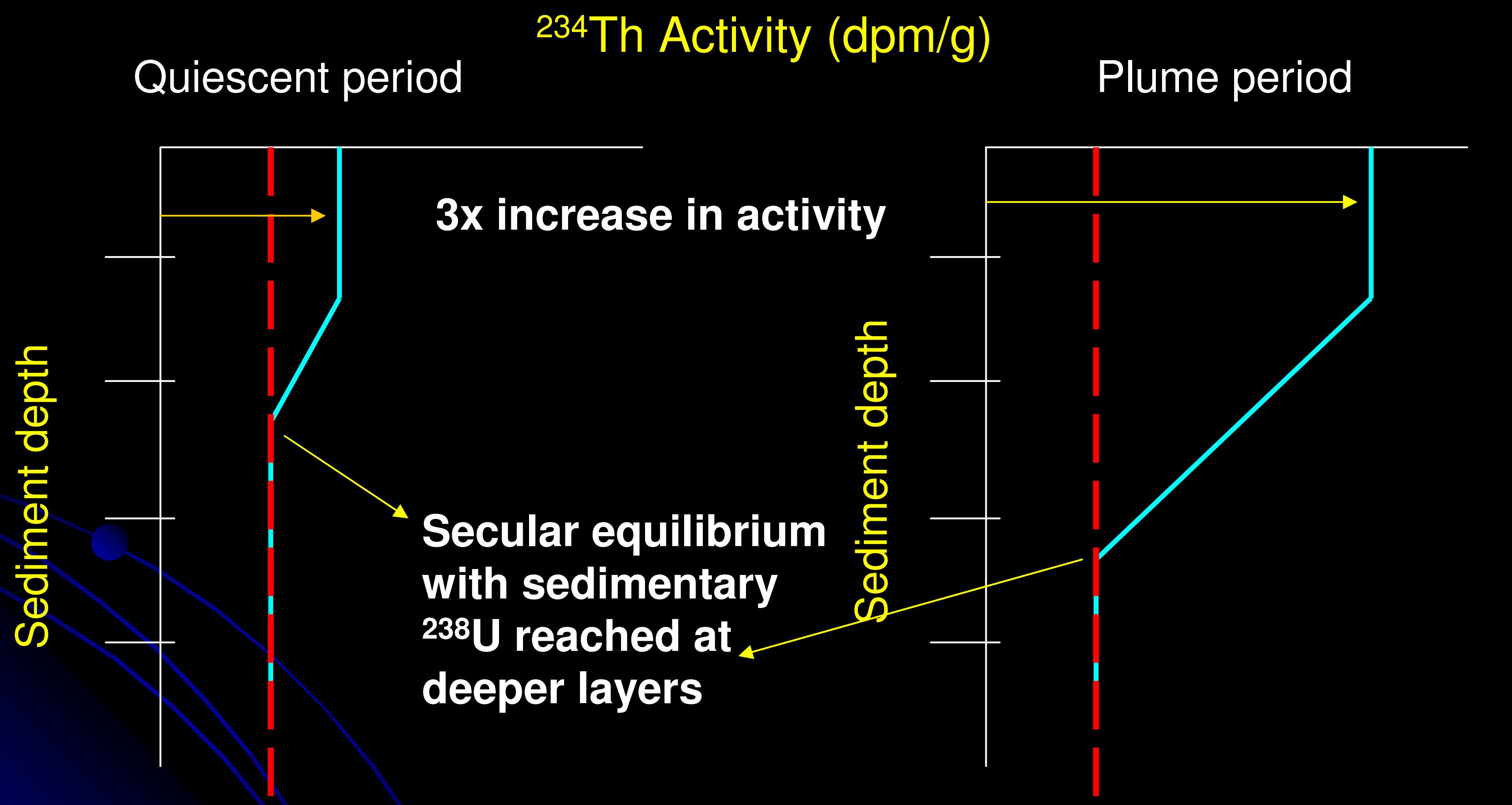


2.1. Export of sediments and associated metals from rivers plumes to shelf areas in semi-arid coasts

- Fluvial inputs to semi-arid coasts are restricted most of the year
- Rainy season plumes may be viewed as a mixing event
- ^{234}Th in sediments is derived from dissolved, conservative uranyl carbonate in seawater.
- ^{234}Th decay: $t_{1/2}$ = 24.1 d, therefore sediment ^{234}Th concentrations is controlled by sediment mixing rather than sediment burial.



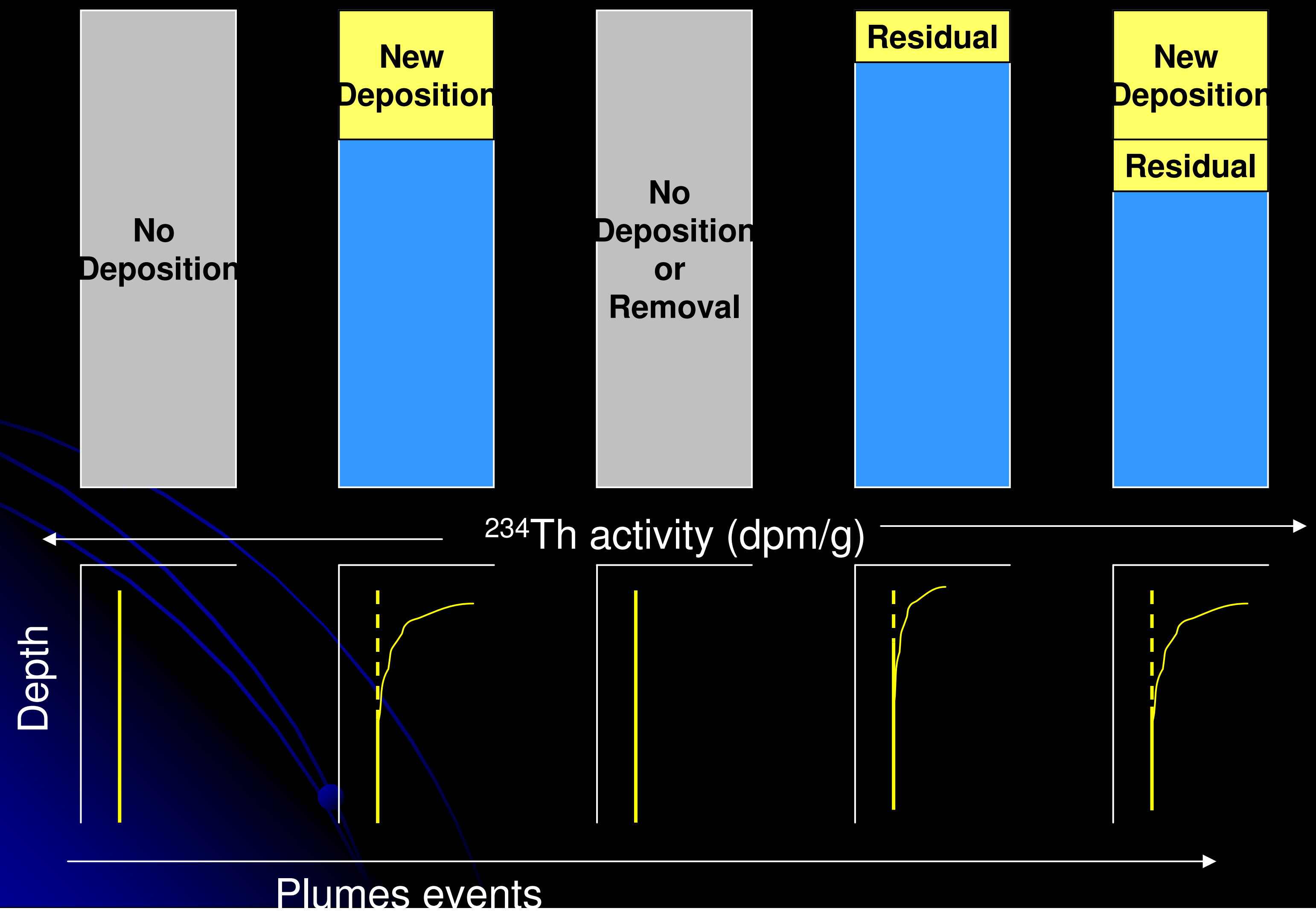
2.1. Reproduction of a result by Kersten et. al. (2005) originally for bottom sediments prior to and after a gale event. Could a river plume under semi-arid condition provide similar results?



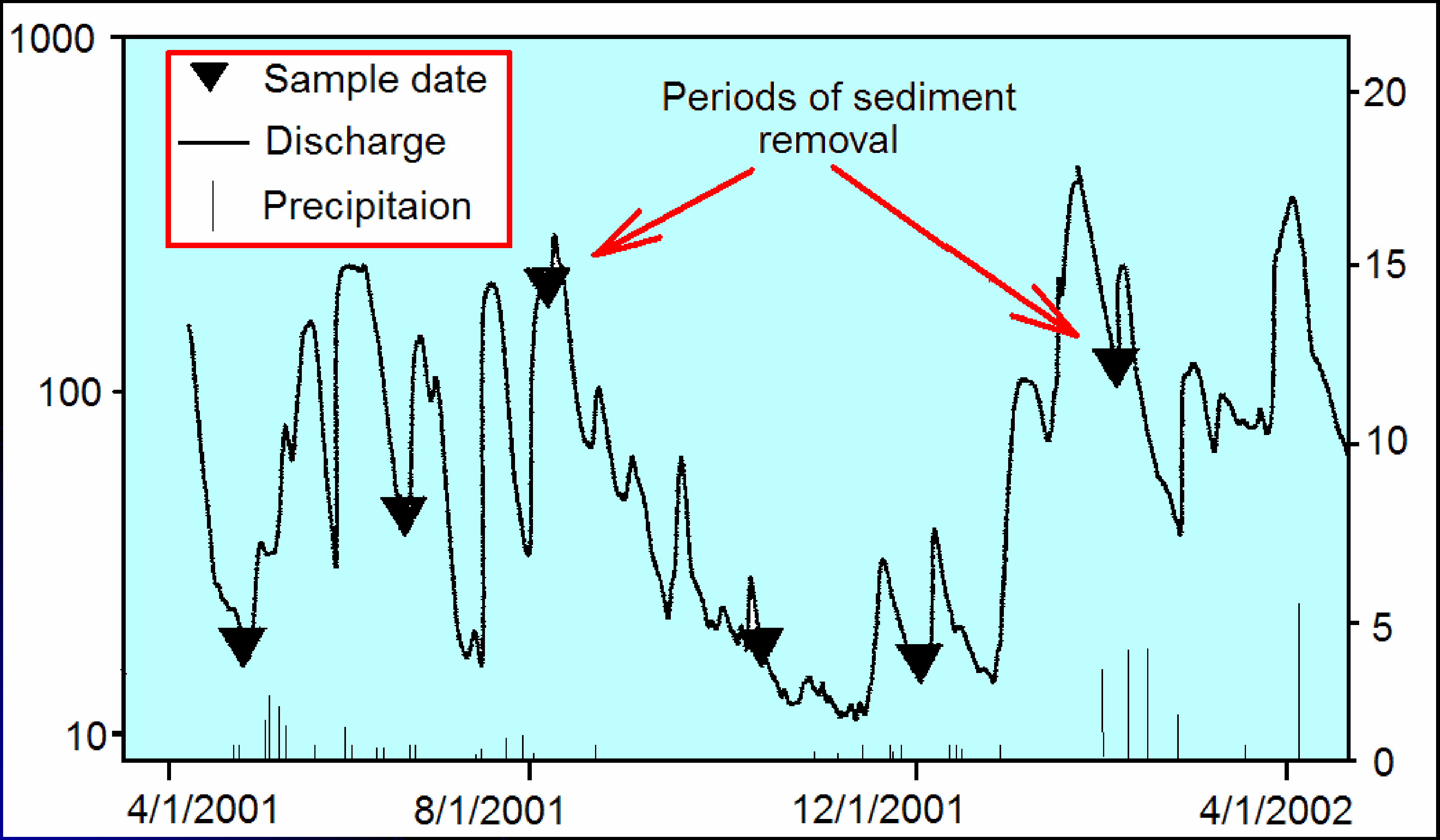
Low bioturbation, slow sediment deposition

Wave-driven erosion, redeposition admixture of ^{234}Th-laden suspended sediment

2.2. Coupling mixing events with nutrient/metal sediment-water interface dynamics (Giffin & Corbett, 2003).

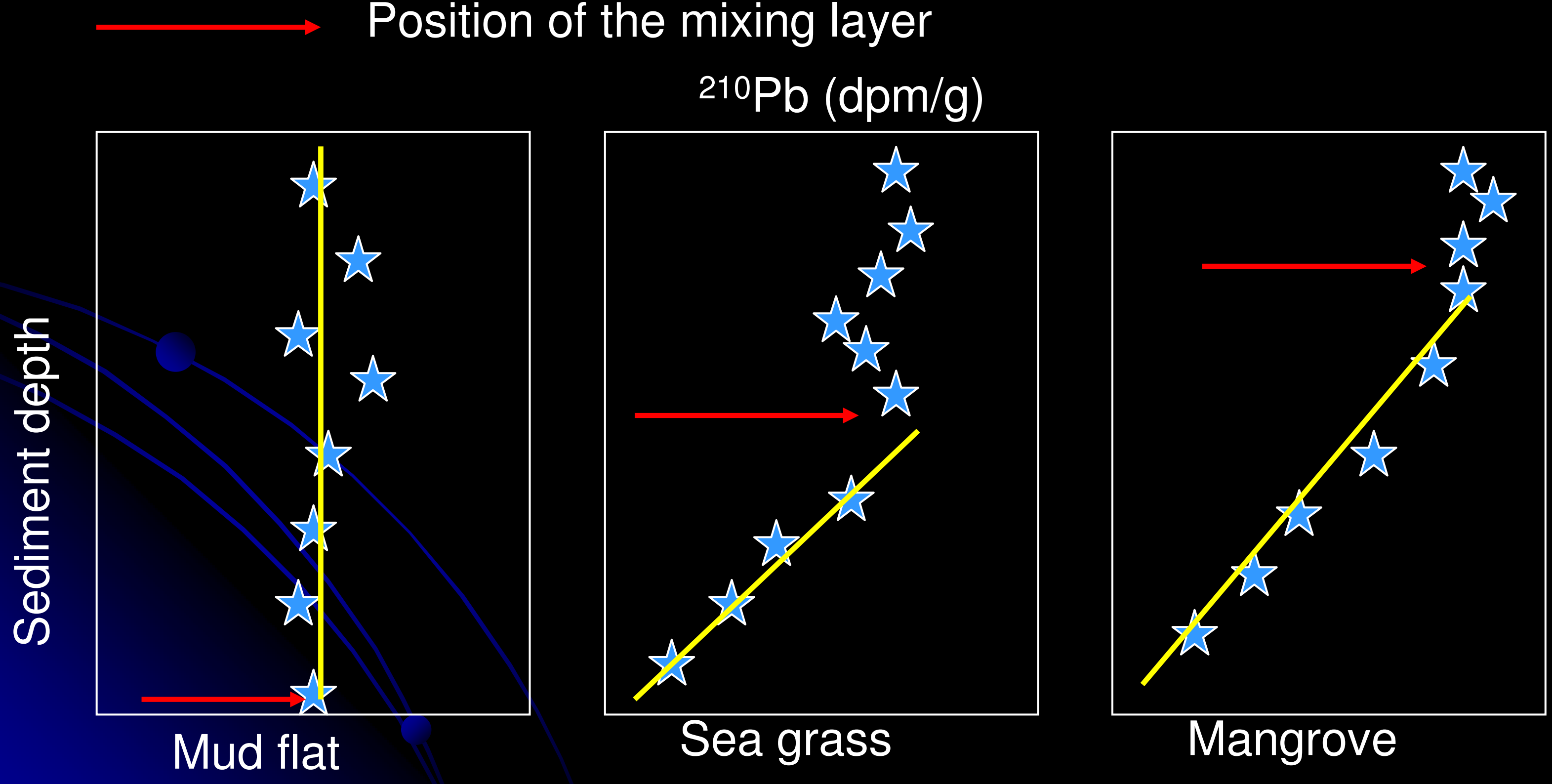


2.2. Inventories of ^{7}Be and ^{234}Th to characterize periods of sediment removal and association with climatology (Giffin & Corbett, 2003).



2.2. Vertical extension of the mixing layer as a proxy to the impacts of climate change on coastal areas in the tropics

Smoak & Pachineelam (1999), among others showed the relationship between erosive forces and the extension of the mixing zone in intertidal sediments, with longer (up to 30 cm) mixing layers in mud flats sediments, followed by sea grass-colonized areas (10-15 cm) to mangroves (0-4 cm).



2.2 Potential application in climate change studies

- Earlier signs of effects of climate change are important for mitigation efforts and sediment processes are believed to be one of the first affected (UNESCO, 1984)

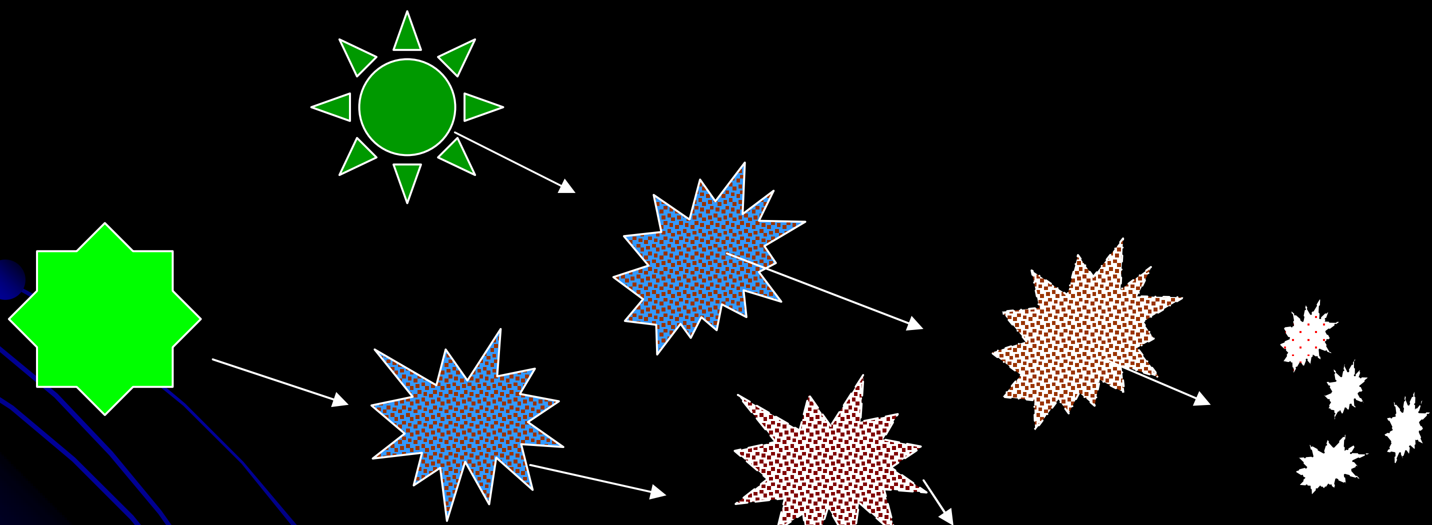
- Mangroves shows relatively constant rates of sediment mixing through the tropics, since it is highly influence by the nearly homogeneous ecology of this ecosystem worldwide, and vary through a very limited range from 0 to 4.0 cm of depth.

- Radioisotope analysis is relatively simple to be applied in long term monitoring stations already in existence worldwide (UNECO, 1984)

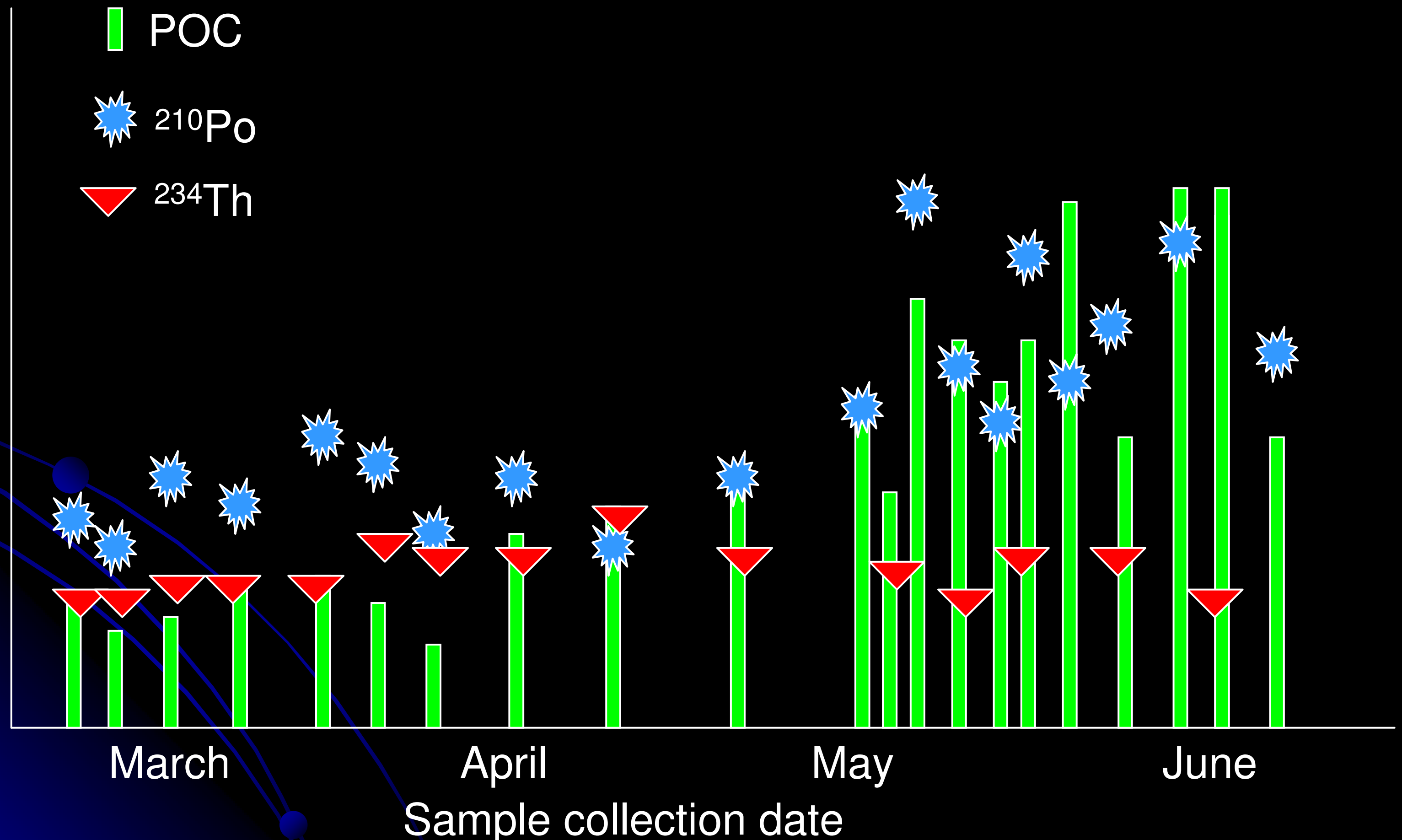
- Should changes in the extension of the sediment mixing zone be monitored as a proxy and early sign of climate change impacts on mangrove dominated coastlines?

3. Changing organic and inorganic matter state through transport pathways

3.1. Organic matter decay through river-shelf transport

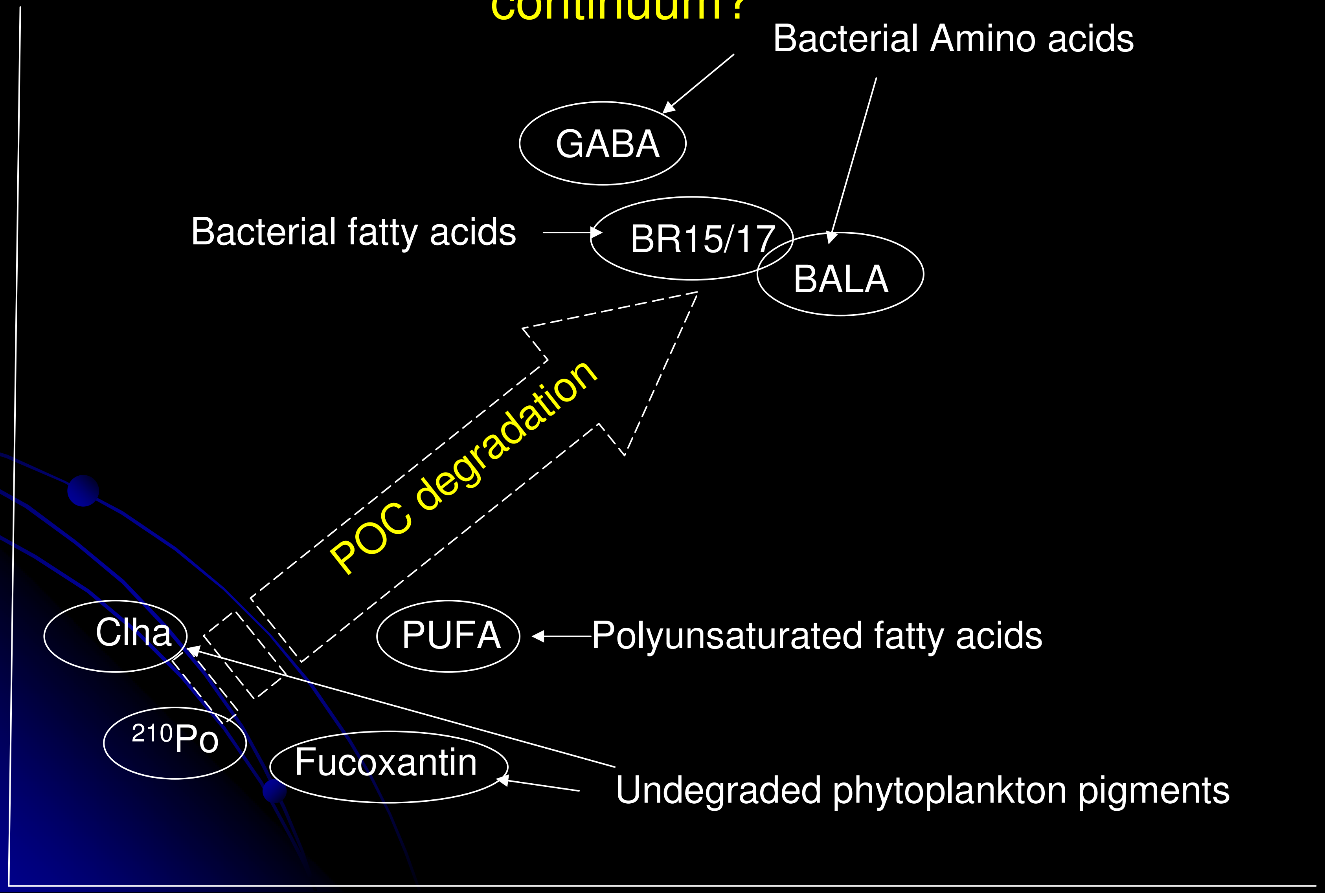


3.1. ^{210}Po and ^{234}Thin SPM relationship with POC in the Mediterranean (Stewart *et al.*, 2007), follow changes in relative SPM composition. Does it at the continent-ocean continuum ?



^{210}Po in SPM relates to non-degraded POC in the Mediterranean (Stewart et al., 2007). Can it be used to follow organic matter decomposition and structural changes at the continent-ocean continuum?

3.1



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Thank You