# Nuclear & Isotopic Applications, Caribbean and Latin America Network: INCT-TMC*Ocean* International Cooperation Science Plan

Report of the Joint American Geophysical Union (AGU) pre-meeting workshop related to the Scientific Symposium Session: *NS06- Radioactivity in the Near Earth Surface Environment*

Scope of this session was to discuss the role of trace elements and their isotopes in environmental research and to establish a science plan for Latin American and Caribbean devoted studies.


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Joint American Geophysical Union (AGU) pre-meeting workshop on

# "Nuclear & Isotopic Applications, Caribbean and Latin America Network"

**Activity related to the Scientific Symposium Session:**
**NS06- Radioactivity in the Near Earth Surface Environment**

Scope of this session was to discuss the role of trace elements and their isotopes in environmental research and to establish a science plan for Latin American and Caribbean devoted studies.

## Sunday 8th August, 2010

All lectures took place at the Rafain Hotel and Convention Center

**Local Organizers:**

**Joselene de Oliveira (IPEN-CNEN/SP), José Marcus de Oliveira Godoy (PUC-RIO), Fernando Brenha Ribeiro (IAG-USP)**

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**REPORT**

**Workshop on "Nuclear & Isotopic Applications, Caribbean and Latin America Network"**

This session was organized by Joselene de Oliveira (IPEN-CNEN/SP), José Marcus de Oliveira Godoy (PUC-RIO), both researchers from the CNPq-INCT-TMCOcean, and Fernando Brenha Ribeiro (IAG-USP), and held in Foz de Iguaçu (Brazil) on Sunday 8th August 2010. The objective of the workshop was to discuss the role of radionuclides and stable isotopes in environmental research, with emphasis on estuarine, coastal and marine areas, and to establish a science plan for the Latin American (and Caribbean) region. Invited members of the round table panel were Dr. Luiz Drude de Lacerda (Labomar, UFC and CNPq-INCT-TMCOcean), Dr. Henry Bokuniewicz (Stony Brook University, USA), Dr. Ana Carolina Ruiz-Fernandez (ICML, Mazatlán, Mexico), Dr. Carlos Alonso Hernandez (CEAC, Cuba) and Dr. Daniel Marcos Bonotto (UNESP, SP).

The discussions held during the Round Table ***"Looking into future: applications of isotopes and nuclear techniques in Latin American and Caribbean Earth Sciences",*** chaired by Dr. Joan-Albert Sanchez-Cabeza (CIEMAT and Autonomous University of Barcelona, Spain) are reported in this report and science plan. The main objective of the session was to revise existing activities and elaborate ideas for potential future collaboration projects and/or programs among Latin American countries.

From the point of view of environmental research, the Latin America (LA) region is characterized by its vast dimensions and large range of resources, capabilities and research experience. Large-scale and complex research programs can only be implemented through the use of regional networks of expertise and resources, leading to the accomplishment of better scientific goals and increasing the funding success of well designed projects. One fundamental tool should be the setup of a **human capacity building program** on the use of nuclear, isotopic and related techniques based on existing knowledge and regional capacities which, with relatively modest resources, would rapidly strengthen the research network, tending to a desired critical mass of trained scientists and should allow effectively designing and implementing successful regional projects.

Nuclear techniques cannot be used in isolation. Multi-tracer studies, including stable isotopes, basic ecosystem parameters and the use of environmental proxies which measure could be easily achieved by means of less sophisticated technologies are needed to optimize the analytical effort made and support interpretation. A global approach to ecosystems must be used to achieve a better understanding of the processes studied. There is a need to develop methodologies/technologies that can be easily used in the region and allow the production of databases large enough to study complex environmental processes. As far as possible, projects should include modeling aspects which help to synthesize our understanding of the processes studied. Then, efforts should be

devoted to the most sensitive parameters which are likely specific of tropical environments.

Networks should be developed on an *ad hoc* basis. Although it is recognized that the existence of a database of laboratories, researchers and expertise (such as in Brazil) would be very useful, such an effort, which must be sustained in time, is out of reach of the scientific community. Existing association databases should be explored as an alternative. As far as possible, the proposed projects should have a full LA dimension, and global if at all possible.

Several specific initiatives were proposed and described during the workshop and we summarize them here under tentative project titles.

**Records of Global Change in LA**

Participants described the success of the IAEA Technical Cooperation Project RLA 7012 *"Use of nuclear techniques to address the management problems of coastal zones in the Caribbean region"*, which one of the objectives was to use the reconstruction of the history of pollution in sediment cores to evaluate human impact trends in the environment (i.e. Global Change). This effort should be extended to other LA zones with important human impacts that could lead to relevant Global Change records in lakes, dams, coastal lagoons and the coastal zone. Especial attention should be paid to land use change indicators, rapid agricultural and industrial development and the effect of environmental policies on reduction (or not) of erosion and pollutant fluxes. Pollutants of interest should include those globally transported and of concern, such as Hg and POPs. An effort should be made in the region to synthesize published results. It is suggested that some research is also carried out on other potential environmental archives such as corals and tree rings. The results obtained under the RLA 7012 project should profit from a comparison with results from coastal and marine areas in Brazil and Argentina, where numerous studies have recently described the history of pollution by using dated sediment cores in a manner similar to what is presently being carried on under the RLA 7012. This may be obtained by establishing a task force to review the existing data, prepare a publishable report and study ways of integration with RLA 7012 database.

**Dry coastal ecosystems as analogues of future Climate Change**

All climate projections indicate that the global earth surface temperature will increase by 3 - 6 ºC by 2100. This will be accompanied in many LA areas by decreasing rainfall and, therefore, water shortage, in particular under semiarid climates and at the continent-ocean interface. Future conditions of some coastal ecosystems can be found in dry coastal ecosystems, which have naturally adapted to water shortage conditions. A careful analysis and understanding of these ecosystems, by using advanced methodologies such as the use of nuclear techniques, can provide clues for adaptation to Climate Change in the future in other regions. A similar reasoning could be used to propose other ecosystems in South America as analogues of tropical ecosystems in the future. The project addresses terrestrial, aquatic and marine ecosystems, by studying the ecosystem functioning from the terrestrial catchment (notably erosion processes), through the coastal zone to the open ocean.

**Sea level rise**

In regions of small tectonic activity, salt-marshes (under temperate climate) and mangroves (under tropical and subtropical climates) accretion can be good indicators of sea-level rise. A selection of LA salt-marshes and mangrove settings, for which good geological knowledge exists, could be used a regional network of sea level rise records in LA. Similarly, some mangroves in the Caribbean (Bahamas), northern Brazil and French Guiana, also have been the subject of sea-

level change studies using radioisotopes as tracers. The network results can be checked against direct measurements with tide gauges, where available and trends observed in the last 100 years could be used to validate climate model projections in the region (regional coupled ocean-atmosphere models).

**Effects of patchy ocean fertilization on atmospheric carbon dioxide and biological production: export production assessed by $^{234}$Th:$^{238}$U disequilibrium**

Increasing oceanic productivity by fertilizing nutrient-rich regions with iron has been proposed as a mechanism to offset anthropogenic emissions of carbon dioxide. Iron limitation appears to be especially important in explaining why large diatoms do not grow in regions such as the tropical Pacific and Southern Ocean where concentrations of surface macronutrients such as phosphate and nitrate are high. A century after the initial experiments carried out on iron fertilization in small oceanic regions (a few hundred kilometers on a side), the reduction of atmospheric carbon dioxide is between 2 % and 44 % of the initial pulse of organic carbon export to the abyssal ocean. Natural radionuclides of the uranium decay series have been widely used in to study of chemical scavenging processes and particle transport in marine environments. In the oceanic water column, $^{234}$Th (half-life= 24 days) is produced in solution from decay of dissolved $^{238}$U and can rapidly scavenged onto particles. For such reasons, this tracer can be used to estimate fluxes of particulate organic carbon. Measurement of the POC/$^{234}$Th ratio and C on the particles is combined with $^{234}$Th flux to estimate the sinking flux of terrestrial and marine POC. Two complementary approaches have been used to quantify the flux of carbon and sinking particles in the oceans. First, falling particles are collected with large conical or cylindrical traps. Second, information has been gathered based on abundances of natural radionuclides in seawater and suspended matter.

**Application of nuclear and isotopic techniques to study sediment-water interactions on the Amazon shelf**

In order to improve our knowledge on the fluxes of matter, chemical elements and tracers transported from the continent to the ocean together with their impact on the chemistry of the oceans. Amazon provides the largest freshwater input as well as enormous dissolved (including nutrients) and particulate loads to the Atlantic Ocean, with little human impact. Therefore, the Amazon shelf appears to be as one of the largest source of dissolved elements to the Atlantic Ocean. When the river outflow mixes with oceanic waters, the turbidity decreases and large diatom blooms are observed. This creates a strong $CO_2$ drawdown leading to a significant sink of atmospheric $CO_2$. During mixing of fresh and saline waters in the Amazon estuary, internal processes can change the chemical composition of the river-water. Dissolved species (e.g. Fe, REE, Cd, etc.) and colloids, which were chemically equilibrated with fresh water undergoes chemical reactions. Exchange of both dissolved and particulate matter occurs along the

salinity gradient, and between the sediments in the bottom of the estuary and overlying water. In addition, a considerable biological activity occurring in the estuarine surface waters of Amazon controls the fates of the nutrients (Si, P, N) and micronutrients (Fe, Co), as well as the fates of substances brought onto the shelf (REE, Nd, $^{210}$Pb) from offshore as the results of local (estuarine and shelf) water circulation. Although there is data available in the literature on Cu, Ni, Cd and REE distributions, almost nothing is known about the pathways and transformations of transition metals and isotopes in the Amazon estuary. Measurements of geochemical tracers on all available phases (dissolved and solid, from colloids to sediments) into the estuarine mixing zone will allow a solid description of the composition of the material resulting from the continental weathering and deposited on the margin. Several tracers of source and pathways can be applied, including rare earths, isotopes of iron, beryllium and lead, and radionuclides (radium and thorium isotopes).

**The geochemistry of dissolved inorganic carbon in groundwater and carbon fluxes to the coastal ocean**

In global carbon cycle research, coastal wetlands and salt marshes have not been a focus of study, probably because of their limited sizes. However, extremely high $pCO_2$ levels have been seen in these waters, suggesting that $CO_2$ inputs from underground aquifers to the coastal zone may be a significant source of carbon to coastal sea and atmosphere. Recent studies in this field have demonstrated that groundwater transport is important in some systems and this is not totally surprising given that a majority of the world's freshwater is stored underground. For example, groundwater discharge to lakes and rivers has been used to explain the observed high partial pressure of $CO_2$ in river waters. Carbon dioxide geochemistry has been studied in a few groundwater systems and it was shown that land and mineral forms give different signatures to the groundwater chemistry. $CH_4$ generation in freshwater, $SO_4^{2-}$ reduction in saline sediments and $CO_2$-controlled hydrolysis of Na-feldspar, have been cited as the most important competing processes in coastal groundwater geochemistry. Measurements of carbon dioxide parameters (pH, DIC, total alkalinity and calculated $pCO_2$) along with concentrations of calcium, magnesium, sulfide and sulfate can be used to study diagenetic processes occurring at the freshwater-seawater interface in shallow groundwater aquifers and the relevance of dissolved inorganic carbon (DIC) fluxes to coastal settings.

**Water resources under a Global Change scenario**

Climate change models projections indicate that, under most scenarios, water shortage will be important in many regions of LA. Also, human population is rapidly growing in many areas, especially near the coasts, increasing pressure on the aquifers. This will affect both terrestrial ecosystems and human population and monitoring/research should be carried out to promptly identify vulnerabilities. Small island developing states (SIDS) and semiarid coastal areas have been pointed out

as sensitive scenarios to water shortage due to Global Change. Once many stable isotopes, $^{222}$Rn and natural Ra isotopes are powerful tools to track sources, sinks and investigate saline intrusion and estimate fluxes in hydrological cycle, this project could be linked to existing initiatives such as on-going IAEA water resources project, the International Waters Program (UNDP) and various biosphere-atmosphere programs (such as LBA Project on course in the Brazilian Amazon region). The project will also address the issue of changing water quality under Global Change scenarios.

**The effect of submarine groundwater discharge (SGD) on the Ocean**

The exchange of groundwater between land and sea is an essential component of the hydrological cycle. Submarine groundwater discharge provides globally important fluxes of nutrients, micronutrients (Fe, Al, Mn), carbon, metals and pollution to coastal ecosystems. SGD composition very often differs and is site dependent, since it is a function of biogeochemical reactions that modify water chemistry in continent-ocean interface. At least for some coastal regions, SGD might have an important impact on the global chemical fluxes to the oceans. Processes associated with SGD have been slow to receive attention from mainstream hydrologists, oceanographers and geochemists. Recent studies recognized that these processes may be relevant in the formation of dolomite and could constitute a source of nutrients to coral reefs and coastal communities. Further evidence of SGD comes from the distribution of chemical tracers in the coastal ocean. These tracers originate within aquifer-marine interface and can provide integrated flux estimates of discharge not possible by other means. Tracer techniques often apply naturally occurring radionuclides from the uranium and thorium decay series that have high concentrations in groundwater relative to coastal waters and low reactivity in the coastal ocean. $^{222}$Rn and Ra isotopes are excellent tracers to quantify SGD and have been used to estimate fluxes of various substances to coastal ecosystems. The four naturally occurring radium isotopes are mobilized in groundwater and sediment pore water via processes associated with their production and sub-sequent geochemical interactions at solution/particle surface interface. Measurements of the distribution of theses isotopes in shallow coastal settings can provide evidence that groundwater is being discharged through the sub-tidal seafloor. One of the objectives of this proposal plan is to carry out a regional balance of the chemical impact of SGD to the Atlantic Ocean.

**Carbon sinks**

The ocean margin, from the land to the edge of the continental slope, is a zone of intense biogeochemical interactions. It is in this zone that the particulate burden carried by rivers encounters seawater, hydraulic gradients permit sub-tidal discharge of groundwater to the coastal ocean, organic carbon cycling is well developed and scavenging of reactive chemical species is intense. Determining the fluxes associated with these processes is often difficult, but natural radionuclides form a group of collective tracers that are useful in this regard.

The role of soils, water and sediments as carbon sinks under a Global Change scenario are an important contribution to the Climate Sciences. Several radionuclides can be used to quantify the relevant processes, such as $^{210}$Pb, $^{7}$Be, $^{234}$Th and radiocarbon. Important scientific questions to address are i) the short term transport of C associated to particles, ii) the accumulation of C with soils and sediments, iii) the long-term preservation of C with buried soils and sediments and iv) the role of sediment remobilization to release C and other substances (such as nutrients) to the water column. The ultimate objective is to provide total balance of C in key ecosystems such as dry lands, tropical forests, coastal lagoons, etc. It is also possible to follow the evolution of C burial by coupling radiocarbon with $^{210}$Pb, $^{7}$Be and $^{234}$Th in sediment cores from the continental shelf, which will also serve as a proxy to anomalies in continental runoff.

**Assessment of potential enhancement of naturally-occurring radioactivity levels in LA and Caribbean environments**

Naturally occurring radiation is a major contributor to the public exposure to ionizing radiation. The ability to safely use mineral resources and store radioactive residues for long times is dependent on our understanding of the environmental conditions that mobilize natural radionuclides from U and Th series. This usually requires an understanding of the mechanisms of dissolution and transport in groundwater systems. Also, increasing attention has been paid to the radiological quality of water for human consumption, as reflected in drinking water recommendations adopted by many countries. Nuclear techniques must be applied in LA and Caribbean region for environmental surveillance purposes, to achieve radiation protection standards for drinking water supplies and to assess the impact of NORM industries, such as the oil and gas plants. More efficient and less complex methods, easy to be adopted by most laboratories in the region, will be developed and transferred to the participant countries.

**Final Considerations**

Developing the right tools to study and get responses to climate change in countries of LA and Caribbean requires that we understand our climate, scenarios and the science behind it. The Intergovernmental Panel on Climate Change (IPCC) has identified this as a top research priority, and nuclear technology offers powerful tools for conducting such research.

Similarly, isotopes are tools for understanding and monitoring key phenomena that help to regulate today's climate and offer important information about ongoing climatic shifts. Such phenomena include the cycling of tremendous amounts of heat and carbon through the body of the world's seas and ocean. These cycles act as natural climate stabilizers, but they cannot indefinitely accommodate the increasing amounts of atmospheric heat and carbon that are being absorbed by the oceans. Rising ocean temperatures and carbon concentrations are currently destabilizing key marine ecosystems, such as coral reefs and mangrove systems, and food webs upon which millions of people depend for both their sustenance and their livelihoods.

Another key phenomenon is the hydrological cycle, which moves water from the oceans to the atmosphere through evaporation, to land through precipitation, and back to the oceans through rivers and other water pathways. This critical conveyor belt of water also reflects the state of our climate. Already, it is being substantially impacted by changes in temperature and weather patterns, with widespread and harmful impacts on many freshwater resources and the communities that rely on them.

It was suggested that this meeting should be followed up by a series of specific meetings to develop the human capacity building program and the specific projects identified, once leaders are identified. Funding alternatives exploited during this meeting were at the international level: International Atomic Energy Agency (IAEA) through the Technical Cooperation Projects, Global Environmental Fund (GEF), National Science Foundation (NSC), International Oceanographic Commission (IOC-UNESCO) and Scientific Committee on Oceanic Research (SCOR); and at national Brazilian level: The National Council for Scientific and Technological Development (CNPq), São Paulo Research Foundation (FAPESP) and Rio de Janeiro Research Foundation (FAPERJ).

This draft document was reviewed by Dr. Bokuniewicz, Dr. Drude de Lacerda and Dr. de Oliveira and shall be presented to the working group for final evaluation and definition of future work strategies and sustainability.

*Round Table Chairman*
*Joan-Albert Sanchez-Cabeza*
Foz de Iguaçu, 9/Augus

**Annexes:**

Workshop agenda

Rationale

Participant list

WORKSHOP AGENDA

**Sunday, August 8th**

**9:00 – 9:30 OPENING SESSION**

**Welcome remarks and introduction**

Dr. José Marcus de Oliveira Godoy

Chemistry Department - Pontíficia Universidade Católica do Rio de Janeiro, PUC-RIO, Rio de Janeiro, Brazil

**Session relevance for future partnerships and capacity building strategies (IAEA, UNESCO, GEOTRACES)**

Dr. Joselene de Oliveira - Laboratório de Radiometria Ambiental, Instituto de Pesquisas Energéticas e Nucleares, IPEN-CNEN/SP, São Paulo, Brazil

**9:30 - 10:00 KEYNOTE LECTURE**

Dr. Michael Schubert - Helmholtz Centre for Environmental Research – UFZ, Germany

**Using Radon-222 as Environmental Tracer in Applied Geosciences**

Coffee break, 30 minutes

**10:30 - 11:00 KEYNOTE LECTURE**

Dr. Henry Bokuniewicz - School of Marine & Atmospheric Science , Stony Brook University, New York, USA

**Short-lived Radium isotopes to track and assess submarine groundwater fluxes to Shelter Island and Great South Bay, NY**

**11:00 - 11:30 KEYNOTE LECTURE**

Dr. Joan Albert Sànchez Cabeza - Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas – CIEMAT, Madrid, Spain; Universitat Autònoma de Barcelona, Spain

**Use of Nuclear Techniques in Marine Sciences**

**11:30 - 12:00 IAEA ARCAL**

Dr. Ana Carolina Ruiz-Fernández - Universidad Nacional Autónoma de México, ICML, Mazatlán, México

**Use of nuclear techniques to address the management problems of coastal zones in the Caribbean region, RLA/7/012**

**12:00 - 12:30 IAEA ARCAL**

Dr. Carlos Alonso-Hernandez - Centro de Estudios Ambientales de Cienfuegos, CEAC, Cienfuegos, Cuba

**Designing and implementing systems for early warning and evaluation of the toxicity of harmful algal blooms in the Caribbean Region, applying advanced nuclear techniques, radioecotoxicological evaluations and bioassays, RLA/7/014**

**12:30 - 13:00 OUTPUTS FROM PREVIOUS IAEA CRP**

Dr. Joselene de Oliveira - IPEN-CNEN/SP, São Paulo, Brazil

**Nuclear and isotopic techniques for the characterization of submarine groundwater discharge (SGD) in coastal zones, IAEA RC12151**

Lunch break, 60 minutes

**14:00 - 14:30 ONGOING BRAZILIAN CNPq NATIONAL PROJECT**

Dr. Luiz Drude de Lacerda – Inst. de Ciências do Mar, Labomar, Univ. Federal do Ceará, UFC, Ceará, Brazil

**Characterization of SGD and coastal mixing rates at the continent-ocean interface using natural isotopes, INCT-TMCOcean CNPq n$^{o}$ 573.601/2008-9**

**14:30 - 15:00 ONGOING BRAZILIAN CNPq NATIONAL PROJECT**

Dr. José Marcus de Oliveira Godoy - Chemistry Department, PUC-RIO, Rio de Janeiro, Brazil

**Radioactive pollutants in Brazilian marine environments**

**15:00 -15:30 IAEA ARCAL**

Dr. Daniel Marcos Bonotto – Inst. de Geociências, UNESP, Rio Claro, São Paulo, Brazil

**Occurrence of natural radioactivity in Aquifer Guarani groundwaters**

Coffee break, 30 minutes

**16:00 - 17:00 ROUND TABLE**

**Looking into future: applications of isotopes and nuclear techniques in Latin American and Caribbean Earth Sciences**

Chair: Dr. Joan Albert Sànchez Cabeza – CIEMAT, Madrid, Spain

Speakers: Dr. Luiz Drude de Lacerda – UFC, Labomar, Ceará, Brazil

Dr. José Marcus de Oliveira Godoy – PUC-RIO, Rio de Janeiro, Brazil

Dr. Fernando Brenha Ribeiro
Instituto de Astronomia, Geofísica e Ciências Atmosféricas, IAG/ USP, São Paulo, Brazil

Dr. Henry Bokuniewicz – Stony Brook University, New York, USA

Dr. Ana Carolina Ruiz-Fernández – ICML, Mazatlán, México

Dr. Joselene de Oliveira – IPEN/CNEN-SP, São Paulo, Brazil

Dr. Daniel Marcos Bonotto – UNESP, Rio Claro, SP, Brazil

**17:00 - 18:00 ESTABLISHING WORKING GROUPS**

**WG1 - Terrestrial environmental studies**

**WG2 - Coastal and marine environmental studies**

Working Groups Summaries and Final Considerations

# Rationale

Trace elements and isotopes play important roles in the ocean as nutrients, as tracers of processes now and in the past, and as contaminants. Their biogeochemical cycling has direct implications for research in such diverse areas as the carbon cycle, climate change, ocean ecosystems and environmental contamination. Trace elements serve important roles as regulators of ocean processes, including marine ecosystem dynamics and carbon cycling. Estuarine environments clearly are dynamic areas of enhanced biological productivity and nutrient recycling. These environments very often receive nutrient-rich fresh waters, which stimulate the production and growth of marine phytoplankton. Commonly, the presumption is made that the blooms of algal material occurring near the mouths of rivers are controlled solely by the flux of nutrients coming down the dispersal system. For some large world rivers, however, shelf circulation also must be considered as an important source of nutrients. Geochemical tracers are used in oceanography to examine sources, establish time scales and elucidate processes. Natural occurring uranium isotopes ($^{238}U$ and $^{235}U$) and $^{232}Th$ are the long-lived parent nuclides for three decay series, containing many different elements that may be used as tracers both in terrestrial and marine environment. The difference between working with uranium and thorium series radionuclides and other trace metals lies in the fact that elements in these series spontaneously transmute into completely different elements in a highly predictable manner. This natural sequence is analogous to a controlled experiment in which an extremely soluble species is replaced by one that is particle-reactive. Chemists use such experiments in the laboratory to understand the kinetics of particle exchange reactions and geochemists use the production of these species to study reactions in the natural environment. Radionuclides of the uranium and thorium decay series reveal information not possible from studies of trace metals, because the source functions of the radionuclides can usually be quantified more accurately. Information on time scales of certain processes (e.g. colloid aggregation, sorption and desorption reactions, sediment re-suspension) can be obtained if the geochemical behavior of the radionuclide system being used to track the process is well established. This pre-meeting workshop was proposed to discuss the ultimate role of trace elements and their isotopes in environmental research and to establish a science plan for the Latin American and Caribbean devoted studies. Radionuclide tracers will be used in a multi-disciplinary study to: (1) determine the kinetics of sorption and colloid aggregation for particle-reactive species; (2) evaluate the shoreward transport and interaction of offshore waters; (3) quantify the amount of bottom-sediment reworking; (4) investigate the desorption of ions from particles; and (5) perform an overall assessment of submarine groundwater discharges sources and fluxes in Latin American and Caribbean countries.

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