

ANNUAL REPORT ON GEOTRACES ACTIVITIES IN FRANCE

April 1st, 2018 to March 31st, 2019

New scientific results

- More realistic oceanic particle field improved the ^{230}Th and ^{231}Pa modeling

^{230}Th and ^{231}Pa are frequently used tracers to investigate particle transport in the ocean and past ocean circulation rate. In order to correctly reproduce their distribution by modelling, it is crucial to use realistic particle field. This point was challenged using the NEMO-PISCES model by adding dust lithogenic particles (van Hulten et al., 2018). The GEOTRACES field database allows comparison of the simulated and the measured distributions. The result show improved match between them (Figure 5). The next step is the integration of nepheloid and hydrothermal particles to go further to this direction.

van Hulten, M., Dutay, J. C., and Roy-Barman, M., 2018. Geosci. Model Dev. 11, 3537-3556.

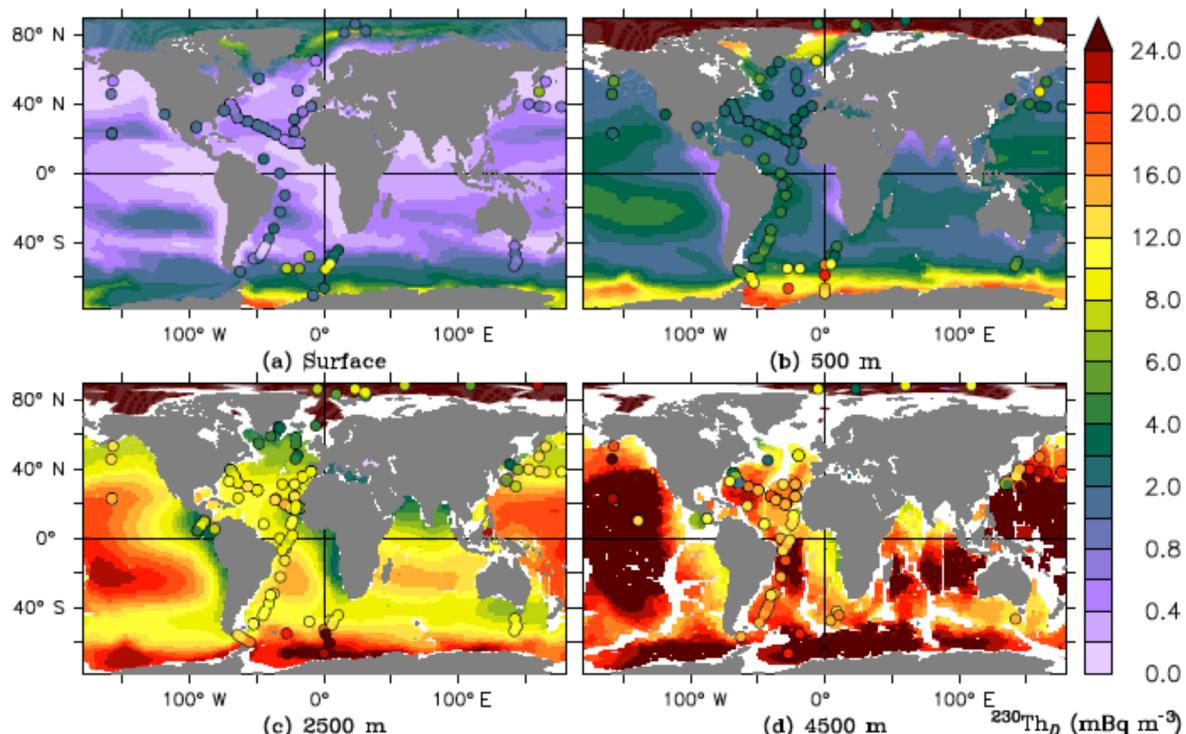


Figure 5. Modeled dissolved ^{230}Th activity (mBq m^{-3}) at four depth levels (colored background) and GEOTRACES field database (circles). (a) Surface, (b) 500 m, (c) 2500 m and (d) 4500 m.

- The Mediterranean Sea Ba budget revisited: more intense mean particulate Ba cycling than previously estimated

The distribution of dissolved Ba in the Mediterranean Sea water (GEOTRACES GA-04S MedSeA cruise) and concentration of Ba and ^{226}Ra in groundwater discharge were determined to revisit Ba budget. Dissolved Ba concentration increases from the inflowing Atlantic surface water to the intermediate/deep Mediterranean waters (Figure 5a). This increase cannot be explained by evaporation and river discharge. Dust deposition is

estimated to be a negligible source. Submarine discharge can significantly contribute to the Ba budget but large uncertainty exists. The correlation between dissolved Ba and Apparent Oxygen Utilization (AOU) supports that organic matter remineralization drives the release of Ba (Figure 5b). Therefore, higher Ba concentration at deeper water depths suggests active particulate Ba cycling and/or Ba dissolution in the sediment.

Roy-Barman, M., Pons-Branchu, E., Levier, M., Bordier, L., Foliot, L., Gdaniec, S., Ayrault, S., Garcia-Orellana, J., Masque, P., and Castrillejo, M., 2019. Chem. Geol. 511, 431-440.

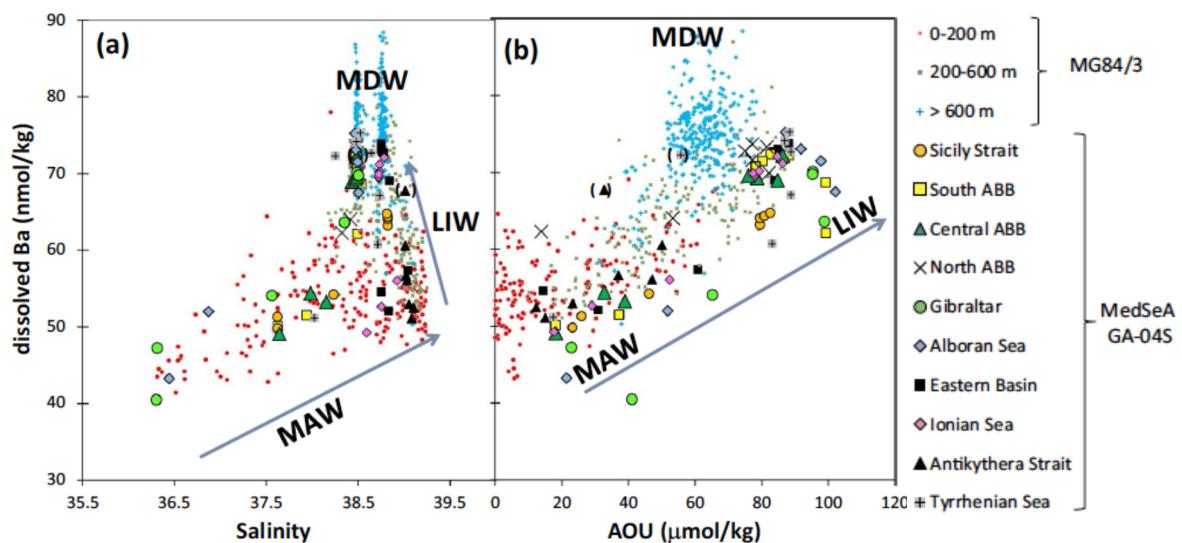


Figure 6. Dissolved Ba in the Mediterranean Sea during the GA-04S MedSeA and the M84/3 cruises. (a) Relationship with salinity and (b) with AOU. MAW: Modified Atlantic Water. LIW: Levantine Intermediate Water. MDW: Mediterranean Deep Water. ABB: Algero Balearic Basin.

Cruises

- SWINGS cruise (PIs: C. Jeandel and H Planquette). The ship time is secured on the Marion-Dufresne for early 2021. To raise the funds for works at sea and in the lab, ANR project was submitted (result will be published in July 2019).
- GEOTRACES Amazon M147 cruise (PIs: Andrea Koschinsky and Martin Frank, 19/04/2018 - 21/05/2018): involvement of LEMAR in this project for the measurements of humic-like substances.
- TONGA cruise (PIs C. Guieu and S. Bonnet): Cruise planned in November 2019.
- GLACE cruise (PI M. Lehmann): cruise planned August-September 2019
- SCALE cruises (PI: T. Mtshali, CSIR, South Africa): Southern Ocean Winter (July-Aug 2019) and Spring (Oct-Nov 2019) cruises. Participation of the LEMAR Trace Metal Team for the analyses of DFe, SFe, PFe and humics / Funding form PHC PROTEA and Isblue (PI: E. Bucciarelli).
- Not GEOTRACES-labelled but potentially interesting for the community: Opportunity Cruise on OISO transect on-board R/V Marion Dufresne from La Réunion to Kerguelen

Island in the South-West Indian Ocean and Southern Ocean (Jan – Feb. 2019) to perform processes studies on the impact of atmospheric aerosols (dust and volcanic ashes) on phytoplankton productivity (Project ITALIANO).

New projects and/or funding

- Co-funding for French clean sampling container (10k€ LEGOS).
- LEFE-INSU project INTERFERIC for Fe isotope measurements of PANDORA and GEOVIDE samples (17k€ for 3 years).

GEOTRACES workshops and meetings organised

- Joint Workshop GEOTRACES-PAGES in 3-5 December 2018 in Aix-Marseille (64 participants). We were local organizers. Eleven French participants.
- C. Jeandel, and E. Masferrer participated at the DMC, and C. Jeandel, K. Tachikawa and E. Masferrer participated at the SSC in Taiwan.
- Participation at the Awesome OCIM workshop, 1 2 August 2018, Boston, USA (David Gonzalez-Santana, PhD student). <http://www.geotrades.org/meetings/meetings-by-year/eventdetail/331/-/introduction-to-the-awesome-ocim>
- During the 2019 IMBeR Open Science Conference in Brest (15-21 June 2019) (Géraldine Sarthou is member of the scientific Committee), there will be a Town Hall (Wednesday, lunch time) dedicated to Biogeoscape (convenors Alessandro Tagliabue (Univ Liverpool, UK), Ingrid Obernosterer (LOMIC, Banyuls/mer, France), and Géraldine Sarthou (LEMAR, Brest, France)).
- K. Pahnke and M. Behrens (Oldenburg Univ, G), visited LEGOS researchers to go further on the collaborations around the SW Pacific activities. M. Behrens and F. Lacan plan to share particle samples collected during EUC-Fe.

Outreach activities conducted

- The highlights on articles related to GEOTRACES are written by C. Jeandel and E. Masferrer.
- C. Jeandel co-edited the ELEMENTS special issue on GEOTRACES with V. Hatje (UFB, Brasil) and Z. Chase (UTAS, Hobart).

Other GEOTRACES activities

- Collaborations with S. Michael and J. Resing, from WU (USA). Susanna has got a Chateaubriand French funding.
- Collaboration with R. Francois (C. Jeandel via Marie Curie return post-doc of M. Grenier)
- Collaboration with M. Charette (E. Le Roy, GEOTRACES Pacific cruise).
- Collaboration with University of La Palmas: Ana del Carmen Arriola Velasquez at LEGOS Jan-Mar 2019 Erasmus).
- Collaboration with J. Garcia-Orellana, UAB on SGD (PhD thesis Simon Bejannin).

Status of clean sampling equipment or in situ pumps

Acquisition of a new clean sampling container: 70 k€ (CEELT project).

New GEOTRACES or GEOTRACES-related publications (published or in press) 28 peer-reviewed journal articles (France GEOTRACES investigators are lead authors or co-authors).

- Castrillejo, M., Casacuberta, N., Christl, M., Vockenhuber, C., Synal, H. A., García-Ibáñez, M. I., Lherminier, P., Sarthou, G., Garcia-Orellana, J., and Masqué, P., 2018. Tracing water masses with ^{129}I and ^{236}U in the subpolar North Atlantic along the GEOTRACES GA01 section. *Biogeosciences* 15, 5545-5564.
- Chavagnac, V., Saleban Ali, H., Jeandel, C., Leleu, T., Destrigneville, C., Castillo, A., Cotte, L., Waeles, M., Cathalot, C., Laes-Huon, A., Pelleter, E., Nonnotte, P., Sarradin, P.-M., and Cannat, M., 2018. Sulfate minerals control dissolved rare earth element flux and Nd isotope signature of buoyant hydrothermal plume (EMSO-Azores, 37°N Mid-Atlantic Ridge). *Chem. Geol.* 499, 111-125.
- Cheize, M., Planquette, H. F., Fitzsimmons, J. N., Pelleter, E., Sherrell, R. M., Lambert, C., Bucciarelli, E., Sarthou, G., Le Goff, M., Liorzou, C., Chéron, S., Viollier, E., and Gayet, N., 2018. Contribution of resuspended sedimentary particles to dissolved iron and manganese in the ocean: An experimental study. *Chem. Geol.* <https://doi.org/10.1016/j.chemgeo.2018.10.003>.
- Cossa, D., Heimbürger, L. E., Pérez, F. F., García-Ibáñez, M. I., Sonke, J. E., Planquette, H., Lherminier, P., Boutorh, J., Cheize, M., Menzel Barraqueta, J. L., Shelley, R., and Sarthou, G., 2018. Mercury distribution and transport in the North Atlantic Ocean along the GEOTRACES-GA01 transect. *Biogeosciences* 15, 2309-2323.
- Fonseca-Batista, D., Li, X., Riou, V., Michotey, V., Deman, F., Fripiat, F., Guasco, S., Brion, N., Lemaitre, N., Tonnard, M., Gallinari, M., Planquette, H., Planchon, F., Sarthou, G., Elskens, M., LaRoche, J., Chou, L., and Dehairs, F., 2019. Evidence of high N₂ fixation rates in the temperate northeast Atlantic. *Biogeosciences* 16, 999-1017.
- Gdaniec, S., Roy-Barman, M., Foliot, L., Thil, F., Dapoigny, A., Burckel, P., Garcia-Orellana, J., Masqué, P., Mört, C.-M., and Andersson, P. S., 2018. Thorium and protactinium isotopes as tracers of marine particle fluxes and deep water circulation in the Mediterranean Sea. *Marine Chemistry* 199, 12-23.
- González, A. G., Cadena-Aizaga, M. I., Sarthou, G., González-Dávila, M., and Santana-Casiano, J. M., 2018. Iron complexation by phenolic ligands in seawater. *Chem. Geol.* <https://doi.org/10.1016/j.chemgeo.2018.10.017>.
- Grenier, M., Garcia-Solsona, E., Lemaitre, N., Trull, T. W., Bouvier, V., Nonnotte, P., van Beek, P., Souhaut, M., Lacan, F., and Jeandel, C., 2018. Differentiating Lithogenic Supplies, Water Mass Transport, and Biological Processes On and Off the Kerguelen Plateau Using Rare Earth Element Concentrations and Neodymium Isotopic Compositions. *Frontiers in Marine Science* 5.
- Guieu, C., Bonnet, S., Petrenko, A., Menkes, C., Chavagnac, V., Desboeufs, K., Maes, C., and Moutin, T., 2018. Iron from a submarine source impacts the productive layer of the Western Tropical South Pacific (WTSP). *Scientific Reports* 8, 9075.
- Jeandel, C. and Derek, V., 2018. New Tools, New Discoveries in Marine Geochemistry. *Elements* 14, 379-384.
- Klar, J. K., Schlosser, C., Milton, J. A., Woodward, E. M. S., Lacan, F., Parkinson, I. J., Achterberg, E. P., and James, R. H., 2018. Sources of dissolved iron to oxygen minimum

zone waters on the Senegalese continental margin in the tropical North Atlantic Ocean: Insights from iron isotopes. *Geochimica et Cosmochimica Acta* 236, 60-78.

- Le Roy, E., Sanial, V., Charette, M. A., van Beek, P., Lacan, F., Jacquet, S. H. M., Henderson, P. B., Souhaut, M., García-Ibáñez, M. I., Jeandel, C., Pérez, F. F., and Sarthou, G., 2018. The ^{226}Ra -Ba relationship in the North Atlantic during GEOTRACES-GA01. *Biogeosciences* 15, 3027-3048.
- Lemaitre, N., Planchon, F., Planquette, H., Dehairs, F., Fonseca-Batista, D., Roukaerts, A., Deman, F., Tang, Y., Mariez, C., and Sarthou, G., 2018a. High variability of particulate organic carbon export along the North Atlantic GEOTRACES section GA01 as deduced from ^{234}Th fluxes. *Biogeosciences* 15, 6417-6437.
- Lemaitre, N., Planquette, H., Planchon, F., Sarthou, G., Jacquet, S., García-Ibáñez, M. I., Gourain, A., Cheize, M., Monin, L., André, L., Laha, P., Terryn, H., and Dehairs, F., 2018b. Particulate barium tracing of significant mesopelagic carbon remineralisation in the North Atlantic. *Biogeosciences* 15, 2289-2307.
- Menzel Barraqueta, J. L., Klar, J. K., Gledhill, M., Schlosser, C., Shelley, R., Planquette, H., Wenzel, B., Sarthou, G., and Achterberg, E. P., 2018a. Atmospheric aerosol deposition fluxes over the Atlantic Ocean: A GEOTRACES case study. *Biogeosciences Discuss.* 2018, 1-25.
- Menzel Barraqueta, J. L., Schlosser, C., Planquette, H., Gourain, A., Cheize, M., Boutorh, J., Shelley, R., Contreira Pereira, L., Gledhill, M., Hopwood, M. J., Lacan, F., Lherminier, P., Sarthou, G., and Achterberg, E. P., 2018b. Aluminium in the North Atlantic Ocean and the Labrador Sea (GEOTRACES GA01 section): roles of continental inputs and biogenic particle removal. *Biogeosciences* 15, 5271-5286.
- Oms, P.-E., Bailly du Bois, P., Dumas, F., Lazure, P., Morillon, M., Voiseux, C., Le Corre, C., Cossonnet, C., Solier, L., and Morin, P., 2019. Inventory and distribution of tritium in the oceans in 2016. *Sci. Total Environ.* 656, 1289-1303.
- Rodellas, V., Stieglitz, T. C., Andrisoa, A., Cook, P. G., Raimbault, P., Tamborski, J. J., van Beek, P., and Radakovitch, O., 2018. Groundwater-driven nutrient inputs to coastal lagoons: The relevance of lagoon water recirculation as a conveyor of dissolved nutrients. *Sci. Total Environ.* 642, 764-780.
- Roy-Barman, M., Pons-Branchu, E., Levier, M., Bordier, L., Foliot, L., Gdaniec, S., Ayrault, S., Garcia-Orellana, J., Masque, P., and Castrillejo, M., 2019. Barium during the GEOTRACES GA-04S MedSeA cruise: The Mediterranean Sea Ba budget revisited. *Chem. Geol.* 511, 431-440.
- Sarthou, G., Lherminier, P., Achterberg, E. P., Alonso-Pérez, F., Bucciarelli, E., Boutorh, J., Bouvier, V., Boyle, E. A., Branellec, P., Carracedo, L. I., Casacuberta, N., Castrillejo, M., Cheize, M., Contreira Pereira, L., Cossa, D., Daniault, N., De Saint-Léger, E., Dehairs, F., Deng, F., Desprez de Gésincourt, F., Devesa, J., Foliot, L., Fonseca-Batista, D., Gallinari, M., García-Ibáñez, M. I., Gourain, A., Grossteffan, E., Hamon, M., Heimbürger, L. E., Henderson, G. M., Jeandel, C., Kermabon, C., Lacan, F., Le Bot, P., Le Goff, M., Le Roy, E., Lefèuvre, A., Leizour, S., Lemaitre, N., Masqué, P., Ménage, O., Menzel Barraqueta, J. L., Mercier, H., Perault, F., Pérez, F. F., Planquette, H. F., Planchon, F., Roukaerts, A., Sanial, V., Sauzède, R., Schmechtig, C., Shelley, R. U., Stewart, G., Sutton, J. N., Tang, Y., Tisnérat-Laborde, N., Tonnard, M., Tréguer, P., van Beek, P., Zurbrick, C. M., and Zunino, P., 2018. Introduction to the French GEOTRACES North Atlantic Transect (GA01): GEOVIDE cruise. *Biogeosciences* 15, 7097-7109.

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- Shelley, R. U., Landing, W. M., Ussher, S. J., Planquette, H., and Sarthou, G., 2018. Regional trends in the fractional solubility of Fe and other metals from North Atlantic aerosols (GEOTRACES cruises GA01 and GA03) following a two-stage leach. *Biogeosciences* 15, 2271-2288.
- Sutton, J. N., André, L., Cardinal, D., Conley, D. J., de Souza, G. F., Dean, J., Dodd, J., Ehlert, C., Ellwood, M. J., Frings, P. J., Grasse, P., Hendry, K., Leng, M. J., Michalopoulos, P., Panizzo, V. N., and Swann, G. E. A., 2018. A Review of the Stable Isotope Bio-geochemistry of the Global Silicon Cycle and Its Associated Trace Elements. *Frontiers in Earth Science* 5.
- Tamborski, J., Bejannin, S., Garcia-Orellana, J., Souhaut, M., Charbonnier, C., Anschutz, P., Pujo-Pay, M., Conan, P., Crispi, O., Monnin, C., Stieglitz, T., Rodellas, V., Andrisoa, A., Claude, C., and van Beek, P., 2018. A comparison between water circulation and terrestrially-driven dissolved silica fluxes to the Mediterranean Sea traced using radium isotopes. *Geochimica et Cosmochimica Acta* 238, 496-515.
- Tamborski, J., van Beek, P., Rodellas, V., Monnin, C., Bergsma, E., Stieglitz, T., Heilbrun, C., Cochran, J. K., Charbonnier, C., Anschutz, P., Bejannin, S., and Beek, A., in press. Temporal variability of lagoon-sea water exchange and seawater circulation through a Mediterranean barrier beach. *Limnol. Oceanogr.*
- van Hulten, M., Dutay, J. C., and Roy-Barman, M., 2018. A global scavenging and circulation ocean model of thorium-230 and protactinium-231 with improved particle dynamics (NEMO-ProThorP 0.1). *Geosci. Model Dev.* 11, 3537-3556.
- Viet, P., Grenier, M., Cravatte, S., Michael, S., Jacquet, S., Belhaj, M., Nachez, Y., Germineaud, C., and Jeandel, C., in press. Dissolved Rare Earth Elements distribution in the Solomon Sea (Pandora, GEOTRACES cruise GP#12) *Chem. Geol.*
- Zurbrick, C. M., Boyle, E. A., Kayser, R. J., Reuer, M. K., Wu, J., Planquette, H., Shelley, R., Boutorh, J., Cheize, M., Contreira, L., Menzel Barraqueta, J. L., Lacan, F., and Sarthou, G., 2018. Dissolved Pb and Pb isotopes in the North Atlantic from the

GEOVIDE transect (GEOTRACES GA-01) and their decadal evolution. Biogeosciences 15, 4995-5014.

Completed GEOTRACES PhD or Master theses

- M. Tonnard (PhD in cotutelle University of Brest/University of Tasmania), Biogeochemical cycle of iron: distribution and speciation in the North Atlantic Ocean (GA01) and the Southern Ocean (GIpr05) (GEOTRACES) in 2018.
- S. Bejannin (PhD) “Submarine groundwater discharge along the French Mediterranean coastline” in 2018.
- M. Lagarde (Master) in 2018. She started her PhD (2018-2021).

GEOTRACES presentations in international conferences

Intl Goldschmidt Conf. Boston, 2018

- Cheize M., H. Planquette, D. Gonzalez-Santana, H. Whitby, A. Gourain, T. Holmes, V. Guyader, Y. Germain, M. Roudaut, C. Cathalot, G. Sarthou, E. Pelleter, Y. Fouquet, High resolution particulate trace metals dispersion from the TAG hydrothermal vent (Mid-Atlantic Ridge).
- Grenier, M., Francois, F., Soon, M., Baconnais, I., Pham, V., Jeandel, C., Ocean circulation and land-ocean exchanges off the north eastern Canadian coasts as told by dissolved geochemical tracers.
- Gonzalez-Santana D., A. Lough, N. J. Wyatt, L. Artigue, M. C. Lohan, H. Planquette, G. Sarthou, dFe(II) variability across hydrothermal vents in the Mid Atlantic Ridge.
- Lagarde, M., Lamaitre, N., Planquette, H., Grenier, M., Belhaj, M., Jeandel, C., Particulate Rare Earth Elements behavior in the North Atlantic (GEOVIDE cruise).

The 7th Kaplan Symposium, Eilat, Israel, 2019

- Lagarde M., Lemaitre N., Planquette H., Grenier M., Belhadj M., Jeandel C., Particulate Rare Earth Elements behavior in the North Atlantic (GEOVIDE cruise).
- Pham V., Jeandel C., Belhadj M., Nachez Y., Grenier M. Land-ocean processes traced by Rare Earth Elements in the Solomon Seas (Pandora-GEOTRACES).

7th international Ra-Rn workshop, Delmenhorst (Germany), July 2018

- Le Roy E, Sanial V., van Beek, P. Lacan F., Souhaut M., Charette M.A., Paul B. Henderson, Deng F., Henderson G.M., Distribution of dissolved ^{227}Ac along the GA01 section in the North Atlantic.

IAEA Environment Laboratories, Monaco, December 2018.

- Van Beek P., Joint EC-JRC/IAEA workshop on low-level radioactivity measurements and applications (JEILORA)

Submitted by Kazuyo Tachikawa (kazuyo@cerege.fr).