In-situ Radiometric Methods for Mapping Natural Gamma Radiation for Sediment Dynamics Evaluation in Coastal Areas

Cemile Kökçen Güven[1], Süleyman Fatih Ozmen[2,*], İdris Koraltan[1], Olgac Güven[3], Christos Tsabaris[4]

[1] *Institute of Science, Akdeniz University, 07070, Konyaaltı, Antalya, Turkey*

[2] *Akdeniz University, Vocational School of Technical Sciences, Nuclear Technology and Radiation Safety Programme, 07100, Antalya, Turkey*

[3] *Faculty of Fisheries, Akdeniz University, 07070, Konyaaltı, Antalya, Turkey*

[4] *Hellenic Centre for Marine Research, Institute of Oceanography, 46.7 Km Avenue Athens-Sounio, 19013, Anavyssos, Greece*

In this study, natural radiotracers were employed to investigate sediment dynamics along the coastline of the Eastern Mediterranean Sea at two locations: Lara and Manavgat. Radionuclide concentrations were measured using KATERINA II, an in-situ gamma ray spectrometer. Field measurements were conducted along 1-meter transects at a walking speed of approximately 1 meter per second, resulting in one radiation measurement per square meter. The study focused on isotopes such as 238U (214Bi), progenies of 232Th (208Tl and 228Ac), as well as 40K, along with total count rate (TCR) for natural radionuclides in the area. Total gamma counting, which involves the measurement of gamma rays emitted without energy discrimination, was utilized. Additionally, laboratory-based measurements were carried out in parallel to verify radionuclide concentrations. Statistical analysis using the R environment was employed to create radiological maps of the beach sands under investigation. The findings provided insights into areas of erosion and accumulation within the selected study regions.

* Presenting author email: fatihozmen@akdeniz.edu.tr

Characterization of Cosmic-Ray Neutron Sensors in neutron reference fields at PTB

M.A. Millán-Callado[1,*], M. Zbořil[1], P. Blahušiak[2], A. Di Chicco[1], M. Köhli[3], B. Lutz[1], R. Méndez[4], Z. Vykydal[5]

[1] *Physikalisch-Technische Bundesanstalt (PTB), Bundesallee 100, 38116 Braunschweig, Germany*

[2] *Slovak Institute of Metrology (SMU), Karloveská 63, Bratislava, 842 55, Slovakia*

[3] *Physikalisches Institut, Heidelberg University, Philosophenweg 12, 69120 Heidelberg, Germany*

[4] *Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas (CIEMAT), Avda. Complutense 40, 28040 Madrid, Spain*

[5] *Czech Metrology Institute (CMI), Okružní 31, 638 00 Brno, Czech Republic*

Soil moisture is a key variable in a wide range of research fields such as land-atmosphere interactions, hydrological studies, or climate change impact and strategies, including applications like climate-smart agriculture or flood and drought forecasting. The World Meteorological Organization (WMO) Global Climate Observing System (GCOS) defined soil moisture as an Essential Climate Variable (ECV), addressing the need to monitor soil moisture at different spatial and temporal scales.

Although there are different soil moisture observation systems able to cover different spatial scales, there is a lack of harmonization between the different methods and datasets. In this context, the SoMMet (Soil Moisture Metrology) project, funded within the framework of the European Partnership on Metrology of EURAMET[†], aims to develop robust metrological tools to support traceability and harmonization initiatives between these different methods.

The intermediate scale in soil moisture monitoring is covered by Cosmic Ray Neutron Sensing (CRNS), filling the gap between point-scale methods and remote satellite monitoring with km spatial resolution. A primary high-energy neutron field is produced by the interaction of cosmic rays with the atmosphere. These neutrons eventually reach the surface, being scattered and moderated by the hydrogen present in the soil moisture. CRNS is a non-invasive method that monitors soil moisture by detecting the fraction of neutrons backscattered in the soil from the incoming atmospheric neutrons.

As part of the SoMMet project activities, a set of three different commercial CRNS probes has been tested in the monoenergetic neutron reference fields at PTB (Physikalisch-Technische Bundesanstalt, Germany), with energies ranging between 24 keV and 5 MeV. These fields are SI-traceable to standards of neutron metrology.

In this work, the first results of these tests are shown. The aim is to improve the understanding of the detectors' performance under laboratory conditions and to serve as a benchmark to validate neutron transport models used to describe the detectors' response, which is the starting point of the characterization of these devices for their application in outdoor conditions.

* Presenting author email: angeles.millan-callado@ptb.de

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Development of interaction models in Geant4- DNA to simulate cosmic rays' effects on ion- molecules reaction in the atmosphere.

F. Nicolanti[1,2,*], B. Caccia[3], A. Cartoni[4] , R. Colalillo[5], D. Emfietzoglou[6], R. Faccini[1,2], S. Incerti[7], I. Kyriakou[6], M.Satta[4,8], H. N. Tran[7], C. Mancini-Terracciano[1,2]

[1] *Dep., Sapienza U. of Rome, Italy*

[2] *INFN, Sec. of Rome, Italy.*

[3] *ISS (Italian National Institute of Health), Italy.*

[4] *Chemistry Dep., Sapienza U. of Rome, Italy 5Med. Phys. Lab., U. of Ioannina Medical School, Greece.*

[5] *INFN Sec. of Naples and Federico II U. of Naples, Italy*

[6] *CENBG/IN2P3/CNRS, U. of Bordeaux, France.*

[7] *ISMN-CNR, Rome, Italy*

Background: Chemical reaction rates can change up to 10 orders of magnitude, depending on the ionization state of the species involved. Therefore, cosmic rays could significantly affect chemical reactions in the atmosphere, considering also that the ions produced are clustered nearby the primary ray. Our project aims to shed light on the rule of ions by exploiting the step-by-step Track Structure approach of the Geant4-DNA simulation toolkit, and implementing models in it to simulate electromagnetic interactions with molecules of interest for climatology. In this work we present the implementation of electron impact cross sections models for nitrogen and oxygen in Geant4-DNA, from the ionization threshold up to 10MeV.

Material and Methods: We implemented in Geant4-DNA new cross sections for electron impact ionization (including auto-ionization), electronic excitation, and elastic scattering with N2, O2 and CO2 molecules. We validated these models through the simulation of stopping power and range in the three materials and in a simplified Air medium composed by a mix of them. To study the impact of primary cosmic rays on atmospheric ionization a two-steps simulation was developed. First, the CORSIKA code was used to simulate the spectra of cosmic rays produced by primary protons at the beginning of tropopause, i.e. an altitude of 10 km. Subsequently, a Geant4 simulation was developed that imports CORSIKA outputs and track secondary electrons using the newly developed Geant4-DNA models to obtain the ion density produced. Additionally, dissociation and relaxation processes resulting from the electronic rearrangement of molecules after excitation and ionization were implemented in using branching ratios for dissociation products.

Preliminary results: The stopping power and range results reveal agreement within 5% with values from NIST ESTAR database and Gümüş model, thus benchmarking the implementation of cross section data in Geant-DNA. Preliminary results regarding the ion density and spatial distribution of ions produced in the lower atmosphere will be presented.

References

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