
NEWSLETTER

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EPM Project 21GRD02 BIOSPHERE: An introduction

An increased atmospheric ionization by cosmic rays and solar UV radiation has significant effects on atmospheric chemistry and dynamics: it triggers electron-induced reactions that lead to formation of free radicals in the atmosphere which further participate in catalytic ozone loss cycles. Since ozone shields the Earth from harmful UV rays from the Sun, its depletion would lead to an increase of the biologically active UV radiation flux, with significant implication

for human health, plants, marine ecosystems, and biogeochemical cycles. While ionization of chlorine-containing anthropogenic molecules by solar UV radiation has long been recognized as an explanation for ozone depletion in the stratosphere, the role of cosmic rays and, in particular, low-energy cosmic electrons remain largely unexplained. These electrons interact with atmospheric gases of both natural and anthropogenic origin and can affect, thereby significantly the chemistry and dynamics of the ozone layer. Therefore, there is an urgent need to combine ground-breaking observations by modern satellite technologies and ground-based in situ/remote sensing with scientific expertise in biology, chemistry, environment, and radiation protection to study how such combined radiation fields can shape our natural habitat, affect the evolution of the biosphere, and impact our health status.

The European Partnership on Metrology project 21GRD02 BIOSPHERE (Metrology for Earth Biosphere: Cosmic rays, UV radiation and fragility of ozone shield) aims at developing for the first time the necessary tools, methodologies and metrological framework needed to evaluate the mutual impact of cosmic rays and biologically active UV radiation on the Earth's biosphere. This project will provide traceable metrological data on cosmic ray fluxes, solar UV spectra, and the total ozone column which are key to assessing the role of cosmic rays as climate drivers and aims to identify and quantify correlations between them. For the first time, fundamental data on the interaction of low-energy cosmic ray-induced electrons with relevant atmospheric gases of both natural and anthropogenic origin will be determined. These include collision cross sections for the molecular processes such as dissociative electron attachment, molecular fragmentation and ionization. The

impact of combined cosmic and UV irradiation on human health will be assessed by investigating structural and functional damages inflicted by such mixed radiation fields in human normal (non-malignant) cells such as primary skin fibroblasts and keratinocytes, blood monocytes and lymphocytes and other endothelial cells. Genomic, epigenetic, and transcriptomic changes that might be responsible for cells' radiosensitivity and possible long-term dysfunction will be assessed.

The consortium of 21GRD02 BIOSPHERE includes 22 leading European institutions (see Fig. 1) that contribute their competence, knowledge and experience with regard to environmental monitoring, space research, atmospheric chemistry, medicine and biology and radiation protection.



Fig. 1 Institutions participating in the BIOSPHERE consortium.

Additional information about the consortium, project goals, work packages, list of publications, and upcoming events can be found on the project website at <https://www.euramet-biosphere.eu/>.

Measurement campaigns to identify and quantify the relationship between cosmic rays, solar UV radiation, and anthropogenic emission

To study the effects of cosmic rays on the ozone shield, the correlation between extraterrestrial radiation (primary cosmic rays and solar UV radiation) in space and secondary cosmic radiation (SCR) on the ground needs to be determined and

quantified. This requires simultaneous modeling and traceable measurements of (i) ground-level muon and neutron fluxes, (ii) terrestrial solar UV radiation, and (iii) the total ozone column.

Simultaneous measurements of SCR (muons and neutrons), the UV radiation spectrum, and the ozone column will be performed at four European sites that provide the necessary infrastructure for accurate measurement of atmospheric profile parameters and have different anthropogenic emission inventories to account for the influence of anthropogenic emissions on ozone dynamics.

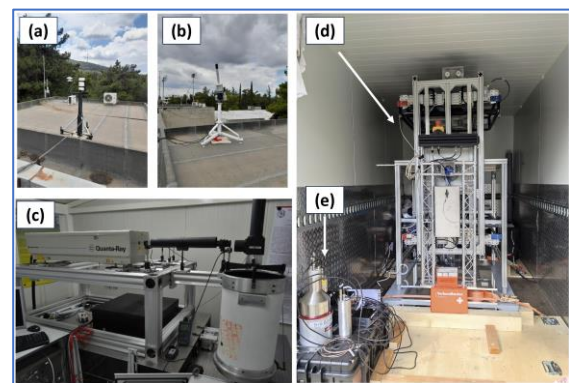


Fig. 2 Images of some selected instruments installed at the NCSR-DEM station in Athens: (a) UVB pyranometer, (b) UV spectroradiometer BTS-Solar, (c) EOLE Multiwavelength Raman lidar, (d) position sensitive-muon detector composed of 40 EJ-200 plastic scintillators, and (e) portable neutron detector system based on liquid scintillator.

The first measurement campaign is currently taking place at the NCSR-DEM station in Athens. The campaign started on June 1, 2023 and will run through August 31, 2023 with 10 instruments being used simultaneously: UVB pyranometer and GUV-511 multichannel filters radiometer (BIRA-IASB), UV spectroradiometer BTS-Solar (GGO), ³He neutron detector (BFKH), portable neutron detector system based on liquid scintillator (UJF CAS), mobile muon

detector based on plastic scintillator and portable gas-based muon detector (PTB), and CIMEL Sun photometer, EOLE Multiwavelength Raman LIDAR, DEPOLE Depolarization LIDAR and temperature/aerosol LIDAR (Raymetrics and NTUA).

Ozone depletion and atmospheric dynamics due to cosmic ray-induced electrons

Ethanol is of current interest in the field of climate physics. It is one of the most promising future sources of renewable energy that can be made from various plant materials. Owing to its lower global warming potential, this biofuel is increasingly replacing traditional fossil fuels. The growing use of ethanol as an energy carrier, however, is causing a rise in the concentration of volatile organic compounds in the Earth's atmosphere. Electron-collision-induced dissociation processes of these compounds, initiated by primary as well as secondary cosmic rays, can lead to the production of reactive species which may impact the ozone balance in the upper atmosphere. For the quantitative description of these processes, comprehensive electron interaction cross sections of ethanol are needed. Differential elastic scattering cross sections of electrons on ethanol were experimentally determined for electron energies between 30 and 800 eV for scattering angles θ of 30° to 150° in steps of 15° . The experimental data were compared to theoretical values calculated using different models. Furthermore, the integral elastic cross sections and momentum transfer cross sections were determined using the experimental results of this work and the modified independent atomic model which was used to extrapolate the measured values to the scattering angles below 30° and above 150° .

The results have been published in Eur. Phys. J. D (2023) 77:52, <https://doi.org/10.1140/epjd/s10053-023-00632-6>.

Proton flux variations during Solar Energetic Particle Events

An anti-correlation between the proton fluxes trapped in the magnetic field of the Earth and the solar cycle of 11 years has been detected by the measurements of the Energetic Particle Telescope (EPT) on board the PROBA-V satellite. At solar minimum, the fluxes are higher at the northern border of the South Atlantic Anomaly (SAA). A splitting of the SAA was observed from 9.5 to 13 MeV corresponding to a double proton belt. The solar cycle modulation of the inner belt is mainly due to losses by increased atmospheric interactions during solar maximum. The last maximum activity appeared in 2014 and the next one is thus expected in 2025. Such periods correspond to stronger Solar Energetic Particle events that inject energetic protons at high latitudes (like those in January 2014, June 2015 and September 2017). Galactic cosmic rays that generate atmospheric neutrons are on the contrary maximum during minimum solar activity. This was in 2019-2020 for the last solar cycle.

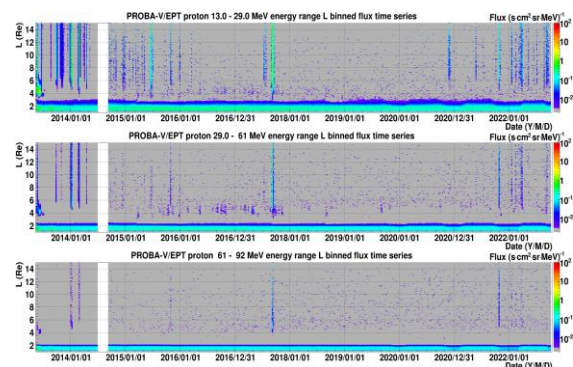


Fig. 3 Proton flux (in blue) observed by PROBA-V/EPT for 13-29 MeV (upper), 29-61 MeV (middle) and 61-92 MeV (bottom) as a function of time from 7 May 2013 up to October 2022.

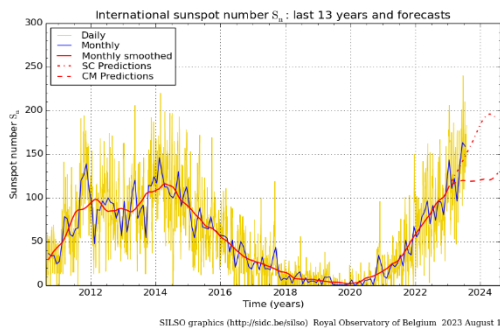


Fig. 4 Solar activity cycle illustrated by sunspot numbers (daily in yellow, monthly in blue, smoothed monthly sunspot in red) for the last 13 years and 12-month ahead predictions (www.sidc.be)

The results have been published in Journal of Geophysical Research: Space Physics, 128, e2022JA031202.

<https://doi.org/10.1029/2022JA031202>

Biological investigations on cells exposed to single and combined irradiation fields of SCR and UV radiation

Experiments to assess the biological impact of a combined exposure of human normal proliferating CRL 9855 monocytes and primary lymphocytes (non-malignant) to SCR (energetic protons) and UVB radiation, in terms of cellular viability and proliferation, DNA damage and stress gene expression have been performed at the PTB Ion Accelerator Facility in July 2023. More details of these experiments will be given in the next issues.

Past events

Metrology for Climate Action 2022

The Metrology for Climate Action 2022 was organized by BIPM, WMO, and EURAMET and was held as an online workshop on 26-30 September 2022

(<https://www.bipmwmo22.org/>). The aims of the workshop were: (a) To present progress and identify requirements for further development of advanced measurements,

standards, reference data, comparisons, calibration supporting the physical science basis for and adaptation to climate change, and (b) To identify stakeholders' metrology needs, assess current metrological techniques, analyses, and modeling capabilities, and identify gaps in quantifying greenhouse gas emissions and uptake for effective actions on mitigating climate change and its impacts.

During this workshop, the coordinator (Faton Krasniqi, PTB) presented the objectives of the BIOSPHERE, including the operational capacity, needs and the impact, in a poster presentation and participated actively in the online meetings for Topic Specific Recommendation Development Sessions. The topics covered within the workshop included (1) Atmospheric chemistry and physics, (2) Oceans and hydrology, (3) Earth Energy Balance, (4) Biosphere monitoring, and (5) Cryosphere Monitoring. During online sessions for recommendations on key technical challenge areas for metrology over the next decade, the coordinator, on behalf of BIOSPHERE consortium, recommended WMO and BIPM to investigate the need for research into identifying and quantifying the relationship between cosmic radiation and ozone depletion and the impact this has on health and ecosystems. These recommendations were included in the workshop report that has been published on June 20, 2023 and is available on the BIPM website

(<https://www.bipm.org/documents/20126/27085544/RapportBIPM-2023-03.pdf/57b00234-2bd0-09e1-8d4f-4aaed2ae45fd?version=2.4&t=1687244959519&download=true>).

EURAMET TC-IR 2023

The Technical Committee for Ionising Radiation (TC-IR) is concerned with the metrology of ionising radiation related to

medical, industrial, environmental, scientific and radiation protection applications. During the TC-IR meeting, the advances of BIOSPHERE were presented in an invited talk by Faton Krasniqi (PTB) in February 2023.

48th Annual Meeting on Radiation Protection

BFKH had an oral presentation at the 48th Annual Meeting on Radiation Protection about Metrology for Earth Biosphere: Cosmic rays, ultraviolet radiation and fragility of ozone shield, in Gyula, Hungary, 18-20 April 2023 for an audience of about 100 scientists.

ConRad 2023

The 25th Nuclear Medical Defense Conference, ConRad 2023-Global Conference on Radiation Topics- Preparedness, Response, Protection and Research-was held in Munich from May 8th to 11th 2023. This unique conference is hosted by the Bundeswehr Institute of Radiobiology, which is affiliated to the University of Ulm in Munich. ConRad 2023 places special emphasis on two topics highlighted in separate key sessions next to in-depth views into several fields portrayed in key lectures. The first key session “Medical impacts of the use of nuclear weapons and countermeasures” discussed the impacts after the explosion of nuclear weapons as well as the possibilities of suitable countermeasures. In the second key session “Internal radiation by radionuclides of emergencies and therapies”, a platform for mutual exchange on previous scenarios was provided. In the proven concept of this conference, further subjects comprised the presentation of new insights in radiation epidemiology, medicine, biology, physics and radiation protection, including effects of electromagnetic fields and non-ionizing radiation in biological systems, radiation biology: diagnosis related studies and

radiosensitivity studies. A contribution by Faton Krasniqi (PTB) on BIOSPHERE goals was presented.

EURADOS Annual Meeting 2023

The European Radiation Dosimetry Group (EURADOS) is a network of 81 European institutions (Voting Members) and more than 600 scientists (Associate Members). A presentation introducing the BIOSPHERE project and showing some preliminary results was given by Faton Krasniqi (PTB) in the WG3 (Environmental dosimetry) of EURADOS Annual Meeting in June 2023. Iva Ambrozova participates in Working Group 11 on High energy radiation fields, every year and especially on January 26-27, 2023, in Seibersdorf, Austria. Marek Sommer also gave a presentation about the characterisation of novel neutron detector for measurements of secondary cosmic radiation in June 12-14, 2023, Porto, Portugal.

SOLAR WIND 16

The 16th International Solar Wind Conference was held in Pacific Grove, California, June 12-16, 2023. Organized by the Space Sciences Laboratory – University of California Berkeley, the three-annual Solar Wind Conference covered all aspects of solar wind physics for around 200 specialists of the field. Viviane Pierrard, head of the WP5 of Biosphere communication, was solicited to give an **invited** talk as scene-setter about the acceleration of solar particles.

11th RAD 2023



The 11th International Conference on Radiation, Natural Sciences, Medicine, Engineering, Technology and Ecology was held at Herceg Novi, Montenegro, from June 19 to June 23, 2023 with around 300 participants. An oral presentation about the progress made in the project Biosphere about space radiation variations during Solar Energetic Particle events and geomagnetic storms was given by Viviane Pierrard from BIRA-IASB.

IWORID 2023

The International Workshops on Radiation Imaging Detectors are held yearly and provide an international forum for discussing current research and developments in the area of position sensitive detectors for radiation imaging, including semiconductor detectors, gas and scintillator-based detectors. Carlos Granja from ADVACAM gave a talk about selective detection, spectrometry and particle tracking of protons, electrons, and muons with their MiniPIX telescope in Oslo (Norway), 25-29 June 2023.

SIGMAPHI 2023

The International Conference on Statistical Physics 2023 was held in Chania, Greece, from 10 to 14 July 2023 with around 300 participants. Viviane Pierrard gave an invited talk about the velocity distribution of solar particles.



Note: an invited seminar about AtRIS simulations of the effects of Galactic cosmic rays on the terrestrial atmosphere was given by Alexandre Winant, PhD student at BIRA-IASB, to University of Kiel (Germany) on 25 April 2023.

Upcoming events

ELC 2023

M. Gidarakou will give a poster presentation at the 4th European Lidar Conference (ELC 2023), held on 13-15 September 2023 in Cluj-Napoca, Romania about Aerosol, Temperature and Water Vapor profiling during the BIOSPHERE Athens Campaign (June-August 2023).

ASTROMEET2023

The 2nd International meeting on Astronomy and Astrophysics will be held on Dubai (UAE) from 16 to 18 October 2023. The ASTROMEET is an event which gathers together a huge amount of variety specialists, experts, scientists, students, even ordinary people who like to know more about the future development of astronomy and astrophysics. An invited oral presentation about the Space radiation variations during Solar Energetic Particle events in the framework of the Biosphere project will be given by Viviane Pierrard from BIRA-IASB.

European Space Weather Week 2023 (ESWW23)

The ESWW is the main annual event in the European Space Weather and Space Climate calendar. It is an international meeting organised annually within the European Region in collaboration with prominent members of the European space weather and Space Climate community. It began as a forum for the European Space Weather community and has since grown into an international event with global attendance. This year, ESWW will be held on 20-24 November 2023 in Toulouse (France). A presentation dealing with forecast of radiation belt electron fluxes will be given by Edith Botek from BIRA-IASB.

Note: an invited seminar will be given by Viviane Pierrard from BIRA-IASB at Mullard Space Science Laboratory, England, on 20 September 2023 about the acceleration of solar particles.

Our publications

- 1) Comparison of radiation belts electron fluxes simultaneously measured with PROBA-V/EPT and RBSP/MagEIS instruments. Winant, A., Pierrard, V. & Botek, E. Accepted in *Ann. Geophysicae*.
- 2) Prediction of radiation belts electron fluxes at a Low Earth Orbit using neural networks with PROBA-V/EPT data. Botek, E., Pierrard, V., & Winant, A. (2023). *Space Weather*, 21, e2023SW003466. (<https://doi.org/10.1029/2023SW003466>)
- 3) Combined experimental and theoretical study on the elastic electron scattering cross sections of ethanol. Dinger, M., Park, Y., Hepperle, P. and Baek W.-Y., *Eur. Phys. J. D* 77, 52 (2023). (<https://doi.org/10.1140/epjd/s10053-023-00632-6>)

- 4) More than Meets the Eye: Integration of Radiomics with Transcriptomics for Reconstructing the Tumor Microenvironment and Predicting Response to Therapy. Logotheti, S., Georgakilas, A.G. *Cancers* 2023, 15, 1634.

(<https://doi.org/10.3390/cancers15061634>)

- 5) Proton flux variations during Solar Energetic Particle Events, minimum and maximum solar activity and splitting of the proton belt in the South Atlantic Anomaly, Pierrard V., S. Benck, E. Botek, S. Borisov, A. Winant (2023), *Journal of Geophysical Research: Space Physics*, 128, e2022JA031202.

(<https://doi.org/10.1029/2022JA031202>)

- 6) Intense Storm at Low Earth Orbit and Geostationary Transfer Orbit. Viviane Pierrard, Alexandre Winant, Edith Botek, Jean-François Ripoll, Mélanie Cosmides, David M. Malaspina, Geoffrey D. Reeves and Scott A. Thaller, Simultaneous Observations of the 23 June 2015 Intense Storm at Low Earth Orbit and Geostationary Transfer Orbit, *URSI Radio Science Letters*, Vol 4 (2022) doi: 10.46620/22-0016

- 7) Modeling of the cold electron plasma density for radiation belt physics. Ripoll J-F, Pierrard V., Cunningham G.S., Chu X., Sorathia K.A., Hartley D.P., Thaller S.A., Merkin V.G., Delzanno G.L., De Pascuale S. and Ukhorskiy A.Y. (2023), *Front. Astron. Space Sci.* 10:1096595. doi: 10.3389/fspas.2023.1096595

- 8) Radiation Type- and Dose-Specific Transcriptional Responses across Healthy and Diseased Mammalian Tissues. Sagkrioti, E.; Biz, G.M.; Takan, I.; Asfa, S.; Nikitaki, Z.; Zanni, V.; Kars, R.H.; Hellweg, C.E.; Azzam, E.I.; Logotheti, S.; Pavlopoulou, A.; Georgakilas, A.G. *Antioxidants* (2022) 11, 2286. (<https://doi.org/10.3390/antiox11112286>)

9) Clustered DNA Damage Patterns after Proton Therapy Beam Irradiation Using Plasmid DNA. Souli, M.P.; Nikitaki, Z.; Puchalska, M.; Brabcová, K.P.; Spyratou, E.; Kote, P.; Efstathopoulos, E.P.; Hada, M.; Georgakilas, A.G.; Sihver, L. *Int. J. Mol. Sci.* (2022) 23, 15606.
<https://doi.org/10.3390/ijms232415606>

Acknowledgments

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EPM 21GRD02 BIOSPHERE was launched in October 2022. It is supported by a broad global scientific community within climate research, space research, biology and medicine, atmospheric chemistry, radiation protection and metrology.

For the time being, the project BIOSPHERE has established the following collaborations by a Letter of Agreement (in the order of signature date): Collaborators by signed letters of agreement:

1. Bundeswehr Institute of Radiobiology, Germany,
2. UK Health Security Agency (Radiation Effects Department), United Kingdom,
3. University of Naples Federico II (Radiation Biophysics Laboratory), Italy,
4. Biomedical Research Foundation of the Academy of Athens, Greece.