Summary of Professional Accomplishments

1. Name

Marcin Paszkuta

2. Diplomas, degrees conferred in specific areas of science or arts, including the name of the institution which conferred the degree, year of degree conferment, title of the PhD dissertation

- Bachelor's degree in computer physics, Higher School of Pedagogy in Słupsk, 1999;
- Master's degree in physics, specialisation: computer physics, Pedagogical Academy in Słupsk, 2001;
- Doctor of Earth and related environmental sciences, specialisation in Geophysics (Géophysique Interne), Institute de Physique du Globe de Paris (IPGP), Paris, France, 2005, PhD thesis entitled. "Coupled transport phenomena in callovo-oxforidan media" (oryg. "Phenomenes de transport qou-ples dans argilites callovo-oxforidan") defended with distinction (Appendix 5).

3. Information on employment in research institutes or faculties/departments or school of arts

- since 2006 - Department of Oceanography and Geography, University of Gdańsk, assistant professor, (from 2012 to 2016, as vice-director at the Institute of Oceanography).

4. Description of the achievements, set out in art. 219 para 1 point 2 of the Act.

a. title of scientific achievement:

Development and use of satellite remote sensing of the cloud cover over the Baltic Sea

b. list of publications making up the scientific achievement

A1. Krężel, A.; Kozłowski, L.; **Paszkuta**, M., 2008, A simple model of light transmission through the atmosphere over the Baltic Sea utilizing satellite data. Oceanologia 50, 125–146. (IF: 2.427).

(My contribution to the paper consisted of concept planning, data collection, data analy-sis, preparation of the publication, performance of laboratory/experimental analyses, analysis of the literature, analysis of the results, preparation of the database, preparation of the discussion, proofreading of the manuscript).

A2. Krężel, A., and **Paszkuta**, M., 2011, Automatic Detection of Cloud Cover over the Baltic Sea. Journal of Atmospheric and Oceanic Technology, 28, 9, 1117-1128, https://doi.org/10.1175/JTECH-D-10-05017.1. (IF: 2.075).

(My contribution to the paper consisted of concept planning, data collection, data analy-sis, preparation of the publication, performance of laboratory/experimental analyses, analysis of the literature, analysis of the results, preparation of the database, preparation of the discussion, proofreading of the manuscript).

A3. **Paszkuta**, M.; Zapadka, T.; Krężel, A., 2019, Assessment of cloudiness for use in environmental marine research. Int. J. Remote Sens. 40, 9439–9459. https://doi.org/10.1080/01431161.2019.1633697. (IF: 3.266)

(My contribution to the paper consisted of concept planning, data collection, data analy-sis, preparation of the publication, performance of laboratory/experimental analyses, analysis of the literature, analysis of the results, preparation of the database, preparation of the discussion, proofreading of the manuscript).

A4. **Paszkuta**, M.; Zapadka, T.; Krężel, A., 2021, Diurnal variation of cloud cover over the Baltic Sea. Oceanologia. https://doi.org/10.1016/j.oceano.2021.12.005. (IF: 2.427)

(My contribution to the paper consisted of concept planning, data collection, data analy-sis, preparation of the publication, performance of laboratory/experimental analyses, analysis of the literature, analysis of the results, preparation of the database, preparation of the discussion, proofreading of the manuscript).

A5. **Paszkuta**, M., 2022, Impact of cloud cover on local remote sensing – Piaśnica River case study. Oceanological and Hydrobiological Studies, vol.51, no.3, 283-297. https://doi.org/10.26881/oahs-2022.3.04. (IF: 0.91)

A6. **Paszkuta**, M.; Krężel, A.; Ryłko, N., 2022, Application of Shape Moments for Cloudiness Assessment in Marine Environmental Research. Remote Sens. 14, 883. https://doi.org/10.3390/rs14040883. (IF: 4.848)

(My contribution to the paper consisted of concept planning, data collection, data analy-sis, preparation of the publication, performance of laboratory/experimental analyses, analysis of the literature, analysis of the results, preparation of the database, preparation of the discussion, proofreading of the manuscript).

The total Impact Factor of the publications listed above is 15,953.

c. a discussion of the scientific objective of the above work and the results achieved, together with a discussion of their possible use

Introduction

In recent years, the use of satellite information has become very popular. The effects of this popularity can also be observed in the field of Natural sciences. There are several reasons for this success, including: accessibility, comprehensiveness, low cost or growth prospects. Unfortunately, the rapid development of modern satellite techniques is often not followed by research methods. A prime example of this negative symbiosis is satellite remote sensing of cloud cover. Operational research methods that work well on a global scale often fail in regional analyses. The resulting uncertainties can distort the identification of Earth and marine processes relevant to the discipline of Earth and related environmental sciences.

Observations of the relationship between radiation and cloud cover are popular with researchers in the Earth and related environmental sciences. However, in the case of the marine environment, this appears to be an area that is still poorly understood. Of course, this may not matter in a global perspective, but for a reliable assessment of the state of the Baltic Sea, it is important to enrich and update the knowledge of research methods. Therefore, I have set **the development and use of satellite remote sensing of cloud cover over the Baltic Sea** as the primary objective of my long-term work. This required me to achieve several subordinate research goals, the most important of which are:

I. analysis of the individual characteristics of the Baltic Sea with respect to the interaction between radiation and cloud cover, comparison and experimental studies of existing and operational detection algorithms;
II. develop an algorithm and method for cloud detection according to the obtained characteristics of the Baltic Sea, perform statistical analyses, determine uncertainties;
III. use the results in a comprehensive study of the Baltic Sea.

I have documented the realisation of the above objectives in a collection of conference presentations and publications that make up the proposed habilitation proceedings.

The core scientific achievement is a series of six thematically related publications based on my research between 2008 and 2022. During this period, I simultaneously carried out an implementation project with scientific potential, SatBaltic (B3)[1] and served as Deputy

[1] Citations according to Appendix 4

Director of the Institute of Oceanography (2012-2016). These were absorbing activities that delayed the realisation of the above-mentioned objectives. The interdisciplinary nature of the research carried out, the complexity of the phenomena at the interface of modern technology, physics and oceanology, the analyses in the field of geographical information systems or artificial intelligence, required the collaboration and participation of specialists from various fields in the work presented. For this reason, most of the papers presented are co-authored, but in all of them I am the first or equal author and/or correspondence author. Statements of co-authors of publications can be found in Appendix 6. List of citations according to Appendix 4.

In Earth satellite observations, cloud cover is an obstacle, and the presence of clouds excludes data from further analysis. Therefore, I initially treated cloud cover as an obstacle to making environmental measurements at the sea surface. Over time, however, I proposed a new view and analysis of cloudiness in terms of long-term sea level change. I suggested that cloudiness statistics are good markers of climate change, including in the context of the North Atlantic Oscillation (NAO) index. I confirmed the results experimentally and standardised them to a common cloud cover (*cc*) parameter. This allowed me to take an optimal approach to the assessment of ocean processes, which requires multi-year time series and a consistent measurement method. Using experimental results, I showed that the proposed new method indicates the direction and rate of sea change. In the course of the work, I collected a stable - multi-year - empirical dataset of total, diffuse and reflected radiation, which is particularly valuable as it concerns a sea area where systematic long-term observations are difficult to make. I have not found similar and common empirical studies in the literature. The collected data have been published on the platforms: https://www.satbaltyk.pl and https://ecudo.pl/.

In the following section, I have presented my scientific development together with the most relevant elements of the performance described. Other achievements resulting from the provisions of the Act are described in the next section.

<u>Discussion of the scientific achievement</u>

I started my research in 2006 at the Department of Physical Oceanography of the Institute of Oceanography in Gdynia, Faculty of Oceanography and Geography, University of Gdansk. My research consisted of analysing the relationship between solar radiation and cloudiness over the Baltic Sea. I supplemented the existing theoretical model of Solrad (Krężel 1998)[2] with the latest information from the orbit level**. I developed an original algo-**

[2] Krężel A., 1997, A model of solar energy input to the sea surface, Oceanol. Stud.,26 (4), 21–34

rithm for the assimilation of satellite data for the classification of cloud areas. At this stage, my achievement was to increase the accuracy of the theoretical model estimating the amount of solar radiation reaching the sea surface. This was the subject of the first publication (A1) proposed to demonstrate a habilitation. My research enabled me to carry out a National Science Centre project entitled "Automatic detection and interpretation of cloud cover in the Baltic Sea area" (B1), of which I was the main and only scientific performer. Due to the high temporal and spatial variability of cloud cover, I decided to use data from the geostationary Meteosat Second Generation (MSG) satellites of the European Space Agency. For the first time in my research, I integrated modern technology into a model of light transmission through the Baltic Sea atmosphere. This allowed me to obtain more reliable information on the amount of radiation in the spectral range from 300 to 1000 nm than that derived from meteorological models. Further development was guaranteed by a project of the Ministry of Science and Higher Education entitled "Qualitative - Unsupervised Detection of Cloud Cover in the Baltic Sea Region" (B2). **Due to the increasing quantity and quality of satellite information, in my research work I developed an original activation method of an unsupervised system for oceanographic analysis based on a precise cloud mask (A1, A2**). I established the input conditions for radiation and reduction of unwanted effects of the variable geometry of the system of the National Oceanic and Atmospheric Administration (NOAA) series of circumpolar platforms owned by the US space agency. The above represents the documented achievement of the first (I) of the stated sub-objectives.

In the paper (A2) I presented a procedure for the daily identification of cloudy areas in the sea. I have automatically obtained information about the state of the atmosphere, by determining characteristics derived from diurnal and seasonal changes in the sea. I made it possible to process large amounts of satellite data to study physical, chemical and biological processes. Working in an unsupervised mode, I determined the value of the impact of inaccurate cloud estimation on the results of satellite analysis of the sea. The main objective of the five-year (2010-2016) SatBaltic project, of which I was a scientific performer, was to prepare the technical infrastructure and establish operational procedures for satellite monitoring of the Baltic Sea environment (C4, C5). My task was to provide satellite cloud maps. They appeared as one of the first and key products of the system in operational mode, were maintained long after the end of the operational period of the project (practically until the replacement of the MSG instrument by Meteosat Third Generation - MTG in 2022) and are still developed today within the framework of the statutory activities of the University of Gdansk (UG). My participation in the project was of a scientific nature, as it allowed me to put the originally developed detection method into practice for the first time.

The new and original formulation of the author's method, the rapidly changing nature of the phenomenon both in time and space, the limited number of reliable sources of information for comparisons with land, the constantly developing satellite technology and, indeed, the lack of an unambiguous definition of cloudiness (Spänkuch et al. 2022)[3], resulted in unavoidable uncertainties. Therefore, in order to identify and reduce uncertainties, I have continued to observe and analyse regional and local variability in the years following the end of the project by carrying out planned research tasks within the framework of statutory research at the Institute of Oceanography UG.

In a subsequent paper (A3), **I first proposed the simultaneous assimilation of satellite imagery and Solrad and M3D numerical models (Kowalewski 1997)[4]. In an authoritative manner, I characterised the absolute difference between the amount of radiation modelled for a cloudless atmosphere and that reaching the satellite instruments in real time. I determined the relationship between the cloudiness parameter and the value obtained. The invention of a new and original method, in addition to its scientific value, increased the potential of satellite cloudiness detection.** I obtained a correlation with instantaneous radiation measurements from a ship and from the Prof. Krzysztof Skóra Marine Station of the University of Gdansk on Hel (SMUG). I determined the effectiveness of the comparison on the basis of the Hanssen-Kuiper result. From the comparison of the data of the Satellite Application Facility on Climate Monitoring (CMSAF) I found out that the solution correctly classified the areas in 88%, the accuracy of the satellite map was set at 46% with an overestimation error of 54%. The detection accuracy was 44% and the underestimation error was 56%. When comparing the modelling results, I showed 71% correctly classified areas, satellite map accuracy of 35% and overestimation error of 65%. The detection accuracy was 36% and the underestimation error was 64%. I found the agreement between the satellite measurements (Cohen's kappa coefficient) and the model to be 98-99%. This allowed me to observe cloud changes in the Baltic Sea region more accurately than before. I compared the obtained results, e.g. the average monthly cloudiness, with different operational, model and lidar data. I demonstrated the difference between my solution and approaches derived from

[3] Spänkuch, D., Hellmuth, O., Görsdorf, U., 2022, What is a cloud? Toward a more precise definition?, Bull. Am. Meteorol. Soc.,103, E1894–E1929., https://doi.org/10.1175/BAMS-D-21-0032.1

[4] Kowalewski, M., 1997. A three-dimensional, hydrodynamic model of the Gulf of Gdańsk. Oceanol. Stud. 26 (4), 77—98

forecast models. I have found that my solution is a better representation of the real state of the atmosphere on a regional scale than global scale models. Through my results I demonstrated the differentiation of cloudiness assessments depending on the model used (CMSAF, UMPL - Unified Model for Poland). I estimated the mean annual cloudiness of the Baltic Sea to be 58.5%. This value is repeatable by other solutions based on different methods and sources (MODIS - Moderate Resolution Imaging Spectroradiometer), including lidars (CALIPSO - Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation).

I presented detailed conditions of regional cloud assessments for estimating top-down components of the radiative budget. I found that most of the uncertainty in comparisons combining satellite data with model data and with in-situ measurements comes from differences caused by temporal and spatial shifts. Ideally, I would expect the measurement data used for comparison to be maximally congruent in time and space, and for the observer himself to be absolutely objective. Unfortunately, as my many years of practice have taught me, ground-based (or rather surface-based) observations of cloudiness are still poorly systematised, although they can be replaced by indirect measurements (e.g. amount of radiation). Temporal convergence is very difficult to achieve; spatial convergence (e.g. obtaining a map resolution such as the observer's visual range) is possible, but currently extremely challenging. In my opinion, statistical operations seem to be a reasonable compromise. In the case of the Spinning Enhanced Visible and InfraRed Imager (SEVIRI) radiometer on the MSG platform over the Baltic Sea, the area used is several kilometres^2 compared to a point measurement. To be consistent and keep a realistic time factor, I set the differences to 5 minutes, with a resolution deviation of up to 3×3 km. With such a regime, in addition to the technical conditions and taking into account the size and the fast changing nature of the phenomenon under study, with the average wind speed in the area under study (about 3.5 m s-1) and the minimum size of the imaging cell (9 km2), I obtained a guarantee that in case of a change in the front, the cell with the total cloud cover would not change its status with the assumed temporal and spatial intervals (I estimated that the cloud statistically moves about 1 km in 5 minutes). This framework of assumptions significantly reduces the number of measurements that can be compared, but unfortunately maintains a rather high, but reasonable, measurement uncertainty. The results of this research are described in a publication (A3), proposed as a proof of achievement, where I consistently pursued the first (I) and partly the second (II) of the stated sub-objectives.

Another set of results, presented in a paper (A4), dealt with the relationship between satellite and model data. For instantaneous data, I found that satellite solutions are more accurate than model solutions, regardless of solar angle. I showed that in the statistical approach, model estimates improve under the assumption of appropriate solar zenith angle regimes, although they are still inferior to satellite observations, regardless of the detection algorithm compared (CM SAF or SatBaltic). The analyses carried out allowed me to conclude that it is difficult to find a universal cloud detection solution for different applications, both day and night. Therefore, I presented dedicated solutions. I came to the conclusion that the evaluation of cloudiness for the longwave radiation budget should be different from that intended for the shortwave radiation (A4).

In the absence of an unambiguous definition of cloudiness and the characteristics of the sea, obtained over many years, I developed a common denominator in the form of a dimensionless product, which I provisionally named *cc*. I used it to determine the magnitude of cloudiness and to develop maps adapted to empirical measurements of environmental parameters of the sea. The instantaneous *cc* over the Baltic Sea, which I estimated from satellite information, can vary by up to several tens of per cent between day and night. I found that this difference could be due to both meteorological conditions and the different algorithms used for day and night. I presented an optimised algorithm which I supplemented with updated radiation modelling information. I calculated the existing diurnal difference in the amount of *cc* over the Baltic Sea and found that this difference is not always explained by the physical properties of the atmosphere. Unfortunately, I did not find any reliable information to confirm that the changes are significant enough to alter the atmospheric circulation and increase or decrease the size of the clouds by a few percent, which would suggest a natural cause. However, I have successfully used the results to determine average cloud metrics. I have described the above results in a publication (A4) which documents the achievement of parts one and three (I and III) of the stated sub-objectives.

Empirically confirming the reliability of the estimation of the amount of solar radiation reaching the sea surface was very challenging for me due to the long study period. I made measurements (2010-2018) of total and diffuse radiation using the commercial MFR-7 instrument on SMUG, which I compared with modelling results using satellite data. To reduce the uncertainty, I averaged the results to the time constant of the instrument, day and month. The results I obtained confirmed the effectiveness of using satellite-based methods for radiation estimation together with cloud detection over the sea, with assumed and unavoidable uncertainties. I presented comparative analyses based on measurements of different types of radiation (total, direct and diffuse) broken down by spectral bands. I used the empirical results to determine the accuracy of the satellite estimates. My in-situ measurements are original and of high scientific value, as this is the first time that this type of information has been obtained for multi-year series under marine conditions. The corresponding point measurement range was assigned to the satellite image cell measurement. The method consisted of comparing radiation-averaged values, thus reducing measurement uncertainties. According to the experimental results, I showed that the optimised detection method is effective on a regional scale and parameterises the satellite image features in an appropriate way. I have described the results of the experiments in two publications (A5 and A6) proposed to demonstrate the scientific achievement, thus documenting the achievement of the third (III) of the set sub-objectives.

Further work of mine has focused on the application of satellite-based cloud detection for the assessment of radiation over the Baltic Sea to study perennial transformations (E1, E2, E3).

<u>Prospects for scientific development</u>

In the publication (A5) I carried out an environmental study of the Piasnica estuary, which represents a highly dynamic morphological transect. I presented information on the acquisition of comprehensive and much needed data in environmental sciences on the transformation of the marine coastal zone. The original method described above provided me with an alternative to systemic solutions for eliminating sources limiting remote sensing of the Earth's surface. I carried out several representative experiments, compiling different seasons and lengths of measurement series over the southern Baltic Sea, the Gulf of Gdansk and the coastal zone of the sea. I found that locally more than 96% of the cloud areas were correctly identified by Sentinel-2/MultiSpectral Instrument. Although the percentage for Sentinel-3/Ocean and Land Colour Instrument was lower (92%), it was still a very good result, which I explained by the higher quality of the information. The river length analyses were successful. To the best of my knowledge, this is one of the first works of its kind that includes local analyses of elements of the Polish coast with active characterisation of satellite signal changes. I recommend caution in the implementation of automatic detection methods with ever increasing data quality. I propose the publication A5 for the demonstration of the scientific achievement as the realisation of the third (III) of the defined sub-objectives.

In the publication (A6) I described an innovative method for cloud classification using the theory of shape moments with invariants. I determined the values of the moments with invariants from available satellite maps. These form a new and valuable dataset of geometric scene parameters representing cloudiness. In my research, I adapted the obtained datasets to the needs of machine learning and deep machine learning. I tested the effectiveness of the method by comparing the entropy results of the input maps after removing areas masked by different methods. I found that one way to effectively complement cloud detection at regional and local scales could be to introduce additional geometric parameters at the raw digital satellite image level. I confirmed that conventional methods of removing noise to obtain a homogeneous map can lead to the loss of important features of the satellite image, thus reducing the accuracy of detection. The method is currently being trained on various oceanographic (e.g. acoustic) datasets. My results also show the potential of the method of moments to support existing methods for estimating sea surface cloud cover for climatological purposes. I have described the above results in a publication (A6), which documents the achievement of the third (III) of the stated sub-objectives.

The title objective of the thesis required me to develop an original method, taking into account the characteristics of the Baltic Sea, and it proved to be quite a technical challenge to provide operational facilities for processing model and satellite information. The construction and installation of satellite data receiving stations or the integration of numerical models required me to provide mass storage facilities and implement processing procedures.

In order to verify the uncertainty of the new method, I planned and carried out a series of land (or rather surface) measurements. I planned the execution of these measurements from probably the most tactically favourable point for conducting "land-based marine measurements" in Poland - SMUG. Such a choice ensured me continuity and stability in carrying out long-term marine measurements, which are important for environmental studies. For the processing of satellite data and in-situ measurements characterising the Baltic Sea basin, I developed a methodology and working techniques in accordance with world standards. Among other things, I had to take into account the peculiarities of handling numerical data or the effects of the Multifilter Rotating Shadowband Radiometer (MFR-7) for measuring different types of radiation in selected spectral ranges. The above results have been proposed for publication in the Journal of Atmospheric and Oceanic Technology under the title "The effects of the MFR-7. "Empirical verification of satellite data on solar radiation and cloud cover over the Baltic Sea" and are currently under review.

I have collected an extensive dataset for temporal and spatial analyses. The period of data examined, more than 30 years, allows conservative climatological conclusions to be drawn (World Meteorological Organization 2017)[5]. I examined changes in the magnitude and extent of cloud cover from three decades (1988-2022) of marine satellite observations. I conducted the study based on my own method of radiative transfer through the atmosphere and available operational sources characterising the cloud cover index. **In order to systematise the different data series, I introduced a normalised *cc* index. The determination of *cc* in combination with the NAO climatological index can provide new insights into the direction of global change (A4).** I examined long-term trends and changes using monthly averages. Based on my studies, I found that the rate of change is high and preserved over most of the sea, except for an anomaly that occurs over the Gulf of Finland (E1, E2, E3). The above theses have been proposed for publication in the Journal of Atmos-pheric and Oceanic Technology under the title. "Baltic Sea cloud cover as a climate indicator" and are currently under review.

My results suggest that the Baltic Sea region responds dynamically to the changes observed in the global ocean. In my work I have not explained the causes or effects of the observed changes, only their direction and speed. I have observed that the proportion and amount of *cc* over the Baltic Sea is systematically decreasing, and that this trend is becoming more pronounced with time. I have found that changes in the amount, height and thickness of cloud cover can be a consequence of global warming. This is because the balance between the warming and cooling effects of clouds at different levels is changing. Using satellite methods, I have essentially found (without a full analysis of the lower levels, as the nature of satellite work does not allow this): a loss of low-level clouds in favour of mid-level clouds, with high clouds remaining constant. However, high-level clouds are optically thinner and tend to have a warming effect, while low-level clouds have the opposite effect. This is related to the phenomenon of transmission and reflection of solar radiation (also from the sea surface) (E1, E2, E3).

I have demonstrated the realisation of the scientific achievement and the stated research objectives by: presentation of my own decision algorithm, development of an original and numerical model-supported method, proposals of an advanced mathematical theory for the analysis of form moment images with invariants, performance of multi-year series of marine empirical data, analysis of long-term changes of the Baltic Sea also in global reference. The presented solution to the title problem of regional cloud

[5] World Meteorological Organization, 2017, WMO Guidelines on the Calculation of Climate Normals. WMO-No. 1203, ISBN: 978-92-63-11203-3, https://library.wmo.int/index.php?lvl=notice_display&id=20130 Accessed 23 Dec 2022

detection is reliable and independent of external sources, and the quality of the information can be continuously improved and developed by modern techniques such as artificial intelligence. The solution to the regional cloud detection problem is an important contribution to the substantive development of science. At its core is my original and original approach, which is not yet available in the literature. To the best of my knowledge, at the time I undertook this research, no scientific centre had processed large-scale satellite reports from the interface between solar radiation analysis, cloud cover and the Baltic Sea environment. As the research I initiated was of a novel nature, the resulting uncertainties can be considered justified.

The series of thematically related publications I have presented is a snapshot of the path I have taken in developing my research interests. Two further publications in the research areas are under consideration for publication. The scientific work discussed also has a practical dimension, as it has become the basis for the implementation project SatBaltic, which has made maps of various cloud characteristics available on a public platform. The habitat work I have developed has a novel character. It is an original addition to the issues related to satellite remote sensing of cloudiness for marine research that have been reviewed in the world literature.

5. Presentation of significant scientific or artistic activity carried out at more than one university, scientific or cultural institution, especially at foreign institutions

2001 Institut P'CNRS, Futuroscope, France, Research trainee (6 months);
2001-2005 IPGP, France, PhD thesis;
2005-2006 IPGP, France, PostDoc (6 months).

I started my research work (2001) at the Institut P'CNRS, Futuroscope - Poitiers, France, where I did a research internship immediately after my second degree. The main topic of my internship was the numerical study of percolation probabilities in fracture networks. The problem consisted of solving 2nd order differential equations with boundary conditions for the macroscopic transport of matter and energy. The result of my work was a numerical code to determine the changes under the influence of different forces and fluxes. This made it possible to assess the rates of transformation in simulated continuous media. The results obtained allowed me to undertake a third level study (2001-2005) at the IPGP doctoral school in Paris, developing my interests under the guidance of Dr Pierre Marie Adler. To solve the theoretical problems, I needed the practical determination of the main macroscopic transport coefficients, i.e. diffusion coefficient, heat flux, electrical conductivity and osmosis, as well as the coupled coefficients, i.e. Soret (thermodiffusion) coefficient and electrokinetic coefficient, the determination of which became the main focus of my thesis. To this end, I first collaborated with ANDRA (National Agency for Radioactive Waste), where I designed and successfully carried out experiments to determine the desired coefficients for the callovo-oxforidate media provided, and carried out computer simulations to determine, among other things, the rate of environmental change. The work involved finding a compromise between solution concentrations and temperature gradients small enough to apply the phenomenological laws governing coupled phenomena, but large enough that measurement uncertainties did not dominate the observed phenomena. In general, I found that the Soret coefficient can be important in extreme situations, depending on the direction of the temperature flux and how chemical diffusion can be effectively stopped or retarded (C8). The results were applied in-situ to work on a radioactive waste repository in the south of France. The second part of my thesis was related to the study of electrokinetic phenomena, mainly electroosmosis, for Schlumberger - Total. I was able to demonstrate the existence of coupling phenomena and determine their order of magnitude. The results were used in the oil industry, ultimately in the exploration of deposits from the bottom, replacing carboxylene beads with river sand. A series of experiments on electro-osmotic coefficients showed that they depend on the magnitude of thermal and chemical gradients, osmotic coefficients generally depend on the porosity of the medium and vary with solution concentration (C7).

<u>Verifying the symmetry of the coupled macroscopic transport coefficients</u>

Another scientific achievement I made after my third degree, during a research fellowship of several months funded by the French government, was the comparison of coupled macroscopic transport coefficients. I obtained experimental and theoretical results characterising the simultaneous transport of mass, heat, solute and current through compact porous media. I determined the value of the characteristic length (Debye) derived from the conductivity and permeability of the electrokinetic coefficients. I found that the macroscopic Soret coefficient in porous media is five times higher than in free solution. I confirmed this latter measurement by an original and novel technique based on membrane potential. I discovered that additional couplings to electrical phenomena are responsible. I performed numerical simulations of random particle stacks for common geophysical parameters. The experimental results obtained were found to be in good agreement with the numerical results, while maintaining the critical values. I proved that non-diagonal coupled coefficients can be derived from diagonal coefficients with acceptable accuracy. This is of great importance in earth and related environmental sciences, and especially in interior geophysics, as it allows to reduce the research time focused on symmetric coefficients, to confirm difficult and expensive studies, and to verify the correctness of the theory of macroscopic transport of matter and energy. I published the results of my research during my fellowship in the cited literature. I successfully confirmed the symmetry theory of the coupled coefficients of macroscopic transport proposed by Onsager (C1, C2, C3).

Between 2010 and 2016, I participated as one of the scientific performer in the implementation work with scientific potential of the SatBaltic (B3) project, in which UG acted as a consortium member. The aim of my work was to determine the influence of factors limiting the transfer of solar energy in the atmosphere. I presented and verified a scheme for assessing the radiation budget at the surface of the Baltic Sea. I used data from different sources: satellite and model data. One of the main products of my work was a satellite cloud mask, which produced maps of the different components of the radiation budget up to ten times per day. I developed a scheme to produce instantaneous, daily and monthly maps, algorithms and data assimilation in the system. I carried out empirical verification based on data collected at SMUG.

During my career at the University of Gdansk, I was involved in various research and scientific activities, more or less related to my main scientific interests, in the pursuit of which I was able to apply my knowledge and comprehensive research methods. These activities were motivated by the internal policy of the Faculty of Oceanography and Geography at the University of Gdansk, which encourages interdisciplinary research on the sea.

In 2007-2008 I was involved in research on spectral analysis of solar inflow to the sea surface as part of the inter-institutional FerryBox project (D7).

On several occasions I have participated in research cruises in the Baltic Sea and field surveys on SMUG, where I have made measurements of solar radiation reaching the sea surface.

The properties of the marine atmosphere are influenced in many ways by physical processes. This directed my activities towards research with broader interdisciplinary themes, where relationships between optical properties were essential to fully explain the behaviour of the phenomena and processes under study. This research resulted in a series of interdisciplinary publications and conference presentations combining topics at the interface of oceanography, computer science, mathematics and marine physics (C4, C5, C6, E1, E2, E3). In these, I dealt with the study of short and long wave radiation at the sea surface, new methods of data classification, possibilities of analysis at the local level from the satellite level. These topics were carried out in cooperation with the Pedagogical Academy in Słupsk, the Pedagogical Academy in Cracow, the Cracow University of Technology, the University of Rzeszów and the Institute of Oceanology PAS in Sopot. Examples of this type of research problem include strategies to search for changes in structures and the relationships between them for the purposes of machine learning, as well as updating data sources for environmental analyses at the local level or long-term in-situ analyses of marine sources.

My long-term observations of the amount of cloud cover over the Baltic Sea are the basis for assessing the climatological effect of the amount of solar radiation reaching the sea surface, which can have a decisive influence on environmental change, also in relation to the transformation of the world ocean.

The peer-reviewed publications and conference presentations on the Baltic Sea and satellite methods summarise my knowledge of the regional characteristics of satellite surveys and their importance and impact on the local environment.

Having worked for UG for many years, I have gained a wealth of experience in planning, organising and carrying out complex marine surveys. I have a wealth of knowledge and experience in working with specialist database handling and analysis software.

Since 2006, I have been involved in nine projects, four of which were scientific research projects, while the others were research support activities, such as setting up research and teaching infrastructure or databases. In three of them I was the manager.

I made valuable contributions to the introduction of new measurement techniques and specialised research equipment. This work, complemented by internal studies, culminated in the installation of satellite data receiving stations: Meteosat on the building of the UG Institute of Oceanography and NOAA on the building of the former UG Rector's Office, a specialised marine physics laboratory in the UG WOIG building in Gdynia, a commercial shading tape radiometer for in-situ measurement of total, diffuse and direct radiation on SMUG. Together with the developed software and meteo station, this set of instruments was a research tool of the Remote Sensing and Spatial Analysis Laboratory of WOIG UG from 2010 to 2018. I developed an inter- and recalibration methodology for the above mentioned instruments for long-term analysis of the sea. The instrument allowed to study the relationship between the amount of solar radiation and the atmosphere in different spectral bands.

The amount of satellite information growing daily made me aware of the need to develop an archiving system. I began to work on creating a system for collecting and sharing data. The issues I had to learn about on this occasion, although not directly related to my primary research objective, significantly broadened my knowledge and skills. This was the beginning of my technical activity, which I have continued for many years in parallel with my scientific work.

6. Presentation of teaching and organizational achievements as well as achievements in popularization of science or art

Teaching achievements:

- Since I started working at UG in 2006, I have been involved in teaching with students. As a Lecturer I successfully give lectures for which I have developed the content (author's programme) of the following subjects: Mathematics (Oceanography I, Geology I), Mathematics with Statistics (GWiOZW I), Physics (Oceanography I, Geology I), Hydrophysics (GWiOZW I), Fundamentals of Marine Physics (Hydrography II) and Marine Thermodynamics (Oceanography II). I use a combination of problem-based lectures to stimulate the students, as well as classroom and laboratory exercises, which are particularly useful in experimental courses. I have taught several remedial courses in higher mathematics for first-year students (2015 - 2021) and developed a course in English MDL;
- As a supervisor, I have been involved in the preparation of 8 undergraduate and postgraduate theses in satellite remote sensing;
- As a inventor, I participated in a project with research potential: Programme for the Implementation of Modern Elements of Education at the University of Gdañsk from the European Social Fund, a project co-financed by the European Union from the European Social Fund under the Human Capital Operational Programme (2008-2011);
- As a manager, I was the hypothesis creator and originator of the research within the UG Teaching Innovation Fund of the project entitled Retrofitting the Marine Physics Laboratory (2012-2013);
- Paper presented Paszkuta, M. Professional practice and other ways of activating the teaching-learning process of students Seminar on Good Academic Habits in the Natural Sciences - Activating methods of education (2014);
- Paper presented Paszkuta, M. How to assess professional practice? Seminar on Good Academic Habits in the Natural Sciences - Assessment in Academic Teaching (2014);
- I am the author of a chapter in a didactic monograph: Paszkuta M. Apprenticeships and other ways of activating the students' educational process. In: Bolałek J, Szymczak E, Sadoń-Osowiecka T, editors. Good study habits in natural sciences. Libron Publishing - Filip Lohner; 2015. pp. 97-107;

- I participated in the implementation of the specific research NoZ na Internship - an internship programme for students of Earth Sciences" with the number POWR.03.01.00-00-S183/17, POWR.03.01.00-IP.08-00-SP2/17 (2016);
- I am a member of the UG Academic Tutoring Group (since 2015); I have been a reviewer for several papers in the journal Tutoring Gedanensis (2016-2020);
- I participated as a inventor in a project with research potential: "Programme for the Development of the University of Gdansk (ProUG)", implemented within the framework of the Operational Programme for the Development of Knowledge Education (POWER) on the basis of Contract No. POWR.03.05.00-00-Z308/17-00 (2018-2019),
- I was a member of the organising teams for the new courses: Hydrography (2019-2020), Applied Physical Oceanography (2021-2022);
- Presentation of the degree programme Applied Physical Oceanography, Conference - Students and Businesses "University of Gdansk Educates Personnel for Offshore Wind Energy" (2022);
- Lecture Paszkuta, M. Artificial Intelligence as a key component in inspiring education through Authentic Inquiry, International Conference "STEAM & AI in Education". XII International Scientific Seminar "Science - Society - Didactics", Krakow, Poland (2023).

<u>Organisational achievements:</u>

- I was Deputy Director of the Institute of Oceanography for Teaching during the 2012-2016 term;
- I have been the Departmental Co-ordinator for Apprenticeships, which I organised from the outset (2008-2012);
- I have chaired departmental selection committees (2010-2018);
- I was the project manager for the UG Teaching Innovation Fund - Upgrading the Marine Physics Laboratory (2012-2013);
- I was a member of the Council of the Institute of Oceanography (2012-2016);
- I have been Chair of the Programme Boards of the Oceanography and Water Management and Water Resources Protection courses at UG (2012-2016);
- I was involved in the preparation of documentation and surveys related to the institutional accreditation of the Polish Accreditation Commission for the courses of Oceanography, Geology, Water Management and Water Resources Protection (2012 and 2020);
- I have served as chairman of examination boards (2014-2023);
- I was a member of the Erasmus+ Selection Committee (2016);
- I am a member of the Faculty Council of WOiG UG (since 2021).

Achievements popularising science:

- Together with my students and graduates, I participated in all editions of the Baltic Science Festival, later held at the Experience Science Centre in Gdynia (2006-2018);
- I participated in the development of promotional materials including posters, exhibitions, flyers and a website to promote oceanography and the Institute of Oceanography (2008-2018);
- I worked with the SatBaltic research team to popularise the science and consolidate the results of the system, I gave interviews for Polish TV and Polish Radio Jedynka, during Polish Radio picnics and at the Copernicus Science Centre in Warsaw (2008-2018);
- As Vice-Director of the Institute of Oceanography UG, I actively promoted marine sciences and participated in numerous meetings at the level of state authorities, EU and local administrations, as well as international forums for the promotion of oceanography (2012-2016);
- I led the "Oceanographic Workshops for Young People" project (educational project co-financed by the Gdynia City Council KB/420/RO/81/W/2014) (2012-2016);
- I organised departmental stands at the Academy Fair in Gdañsk (2012-2018);
- As a lecturer, I developed and delivered an international course in English within the European University of the Seas Marine Data Literacy - Project Mode #3, entitled Assessment of cloudiness for use in environmental marine research, which paved the way for scientific cooperation and the implementation of a series of training courses with young scientists from European and African countries (2022-2023).

7. Apart from information set out in 1-6 above, the applicant may include other information about his/her professional career, which he/she deems important.

- Member of the Remote Sensing Section of the Space and Satellite Research Committee of the Polish Academy of Sciences;
- Member of the Marine Physics Section of the Marine Research Committee;
- Honoured with a special mention and recognition by the SatBaltic Project Manager (2011, 2014);
- Honoured with the National Education Commission Medal (2016);
- Honoured with a special mention and recognition from the Rector of UG for his commitment and special contribution to the European University of the Seas (2019-2022);
- Honoured with a Team Rector's Award 2 st for outstanding organisational commitment - Marine Data Literacy MLD (2022).

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(Applicant’s signatur

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