

National-scale environmental data analysis for shipping and transport: The National Research Infrastructure EN.I.R.I.S.S.T.

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Abstract

This paper presents the state-of-the-art research conducted as part of EN.I.R.I.S.S.T. regarding the emerging impact of shipping and transport to the environment. More specifically, it presents the digital platforms and services that are developed as part of the research infrastructure and are related to environmental sciences. The first is the “EcoMarpol Platform”, which caters for collecting and analyzing pollution-driven data as well as calculating the environmental imprint (atmospheric emissions, waste production, chemical pollution of marine waters and sediments) of maritime activities. This platform additionally includes the online monitoring of in-port emissions from shipping and pollution from ship-to-ship transfer operations or accidents and the environmental risk assessment management. The other platform is the “Passenger Sustainable Travel Platform”, as part of which a tool for calculating aircraft emissions (CO₂ and air pollutants) will be developed and applied in the Greek airspace and airports.

Keywords: in-port emissions, airport emissions, waste production, research infrastructure.

1. Introduction

The EN.I.R.I.S.S.T. (Intelligent Research Infrastructure for Shipping, Supply chain, Transport and Logistics) Project is co-financed by Greece and the European Union, European Regional Development Fund. The vision of EN.I.R.I.S.S.T. is to develop a centre of excellence for research in shipping, land and air transport, targeting the majority of the trip chain levels (e.g., short/long trips, transport hubs/ports, last mile services etc.). This is a unique attempt to create a Research Infrastructure (R.I.) in Greece as the country records champion performance in various transport related domains topping world shipping

and being a major port, transshipment and land transport node within Europe. The Project aims at creating a knowledge-based data repository and a comprehensive toolset able in their combination to support policy decisions and promote new and existing fields of research in the R.I. related domains and research areas. EN.I.R.I.S.S.T. aims to become the first intelligent research infrastructure in the field of shipping and transport in Europe, formulating a business intelligent platform that will combine business analytics and visualization techniques and technology. The R.I. under construction is envisaged that - in an intelligent, automated and shared manner - will process and make available data, information, and intelligence on commodity and passenger flows. EN.I.R.I.S.S.T. includes 8 participating universities (University of the Aegean, National Technical University of Athens, University of Piraeus, University of West Attica, Aristotle University of Thessaloniki, University of Thessaly, Democritus University of Thrace, University of Peloponnese), three national research centers (National Center for Scientific Research “Demokritos”, Centre of Planning and Economic Research, Hellenic Centre for Marine Research (HCMR) and professional associations and foundations, parks and Museums which participate as associate partners providing dissemination channels, data and support along with various government agencies/authorities.

The challenge for creating an intelligent infrastructure and to efficiently store and manipulate large volumes of available historical and ‘live’ data from all disparate information sources in the areas covered by EN.I.R.I.S.S.T. (shipping, land and freight travel, environment, energy, tourism, financial markets) is a key task of the R.I. The aim is to enhance and customize machine learning algorithms, data mining approaches, and interfaces for handling and process data from various

sources and develop necessary research results that can significantly help the research community in Greece and beyond with EU in the centre through the provision of specific services which will be made available through the five different platforms of the R.I. There is a strong sustainability and environmental dimension in all of the Platforms and Services planned which is considered to allow it to become a multifaceted economic, research and development actor/institution, embedded in the Greek mainland while participating in building and sustaining local and regional networks and flows of knowledge, linking them with global ones.

However, the two platforms more directly focusing on sustainability and environmental services are the EcoMarpol with services related to the sustainability of the Greek maritime environment and the Passenger Sustainable Travel Platform which are presented in Sections 2 and 3 following the introduction.

2. Platform “EcoMarpol”

The Hellenic Seas, and especially its coastal areas, is a region receiving intense anthropogenic pressure resulting in pollutant discharges. Furthermore, the Hellenic Seas host a dense network of both international and national transport/trade maritime traffic routes interconnecting the Mediterranean Sea to the Black Sea and the numerous inhabited islands to the mainland. Owing to the above, the Hellenic Seas receive petroleum inputs as a result of ship discharges. A high number of maritime incidents that caused pollution by oil, most of which small in scale have been reported in the area over the past four decades (Kostianoy and Carpenter, 2018). Three major Hellenic organizations active on environmental research regarding the marine environment are collaborating within EN.I.R.I.S.S.T. in developing the platform “EcoMarpol”, a Web-based GIS tool providing bridging scientific results and public services related to shipping, pollution and the marine environment.

2.1. Environmental profile of the different areas of the Greek seas

One of the services provided by EcoMarpol will be maps of marine areas’ use, as obtained by recent Marine Spatial Planning projects, including marine protected areas, Natura 2000 regions etc., where the Geographical Information will be accompanied by corresponding national and E.U. regulation and legislation. The concentration of this information to one platform will be especially useful for marine planners and decision makers, as well as activities such as fisheries, tourism, environmental crisis management etc.

2.2. Port reception facilities for shipping waste management.

Maritime transport has a serious impact on the marine environment either by liquid and solid waste production on board or by accidents and chemical loads. Ports are

responsible of providing facilities for reception of sewage and solid wastes (Wilewska-Bien and Anderberg, 2018). Waste classification and management methods on board and in ports are based on the International Convention for the Prevention of Pollution from Ships (MARPOL 73/78). Current situation in solid waste management in ships, ports and marinas in Greece was reported along with a rough estimation of the quantities of solid waste produced from passenger ships. The main objective is to develop a maritime transport, accident, and waste management observatory. The service will be hosted on EcoMarpol platform and will provide information regarding types of waste produced from maritime transport, as well as a marine debris management service.

In supporting the development of new paths of marine tourism and cruise lines, the “EcoMarpol” platform will provide geographical information on the capacity of Hellenic ports to accept and manage wastes from shipping.

2.3. Ship-generated pollution platform

Since the introduction of steam engines, any vessel steaming in the seas is a point source of atmospheric primarily, and marine to a lesser degree, pollution. Today, marine shipping is considered as a significant global contributor of Greenhouse gases (IMO, 2015). As a result of the growing environmental crisis, each State has undertaken the responsibility to monitor, manage and gradually reduce its emissions, and this includes marine shipping and transport as well. EN.I.R.I.S.S.T. contribution to this domain will be the development and application of a pollution estimator, both atmospheric and marine, which could, when combined with AIS information provided by platforms such as Marine Traffic, could provide assessments of transport and marine traffic contribution to pollution over selectable time and marine domains.

2.4. Chemical pollution of seawater and sediments

One of the services of EcoMarpol platform focuses on collecting/analyzing data on the impact of maritime activities on the marine environment in both coastal and offshore/open-sea areas of interest, i.e., ports, national/international shipping/trade routes etc. The dataset will provide a wide overview on (a) pollution levels and biogeochemical mechanisms driving the distribution of petroleum hydrocarbons and other chemical contaminants in marine sediments, sinking and suspended particulate matter, and (b) maritime incidents which resulted in marine pollution in the Hellenic Seas. An important add is a set of stations monitored under the implementation program of the Marine Strategy Framework Directive (Directive 2008/56/EC) for the Hellenic Seas, for which the Institute of Oceanography of HCMR is responsible.

3. “Passenger Sustainable Travel Platform”

Air transport constitutes an important part of global economic development. At the same time, aviation has a significant impact on climate change and air quality. Recent statistics indicate that civil aviation emitted in 2019

around 915 million tons of CO₂, which accounts for about 2% of human-induced carbon emissions (ATAG, 2021).

As part of EN.I.R.I.S.S.T., a tool for calculating aircraft fuel consumption and emissions will be developed and applied in the Greek air transport network. The tool will include the operations during both the climb-cruise-descent (CCD) phase to consider the impact of a variation on climate change and the Landing/Take-off (LTO) phase to account for the impact on air quality. It will extend the work that has already been conducted in Pagoni and Psaraki (2014) and Loo et al. (2014) by updating the calculations with more recent air traffic data as well as by accounting for the latest aircraft types currently being used in the Greek air network. The modelled emissions include HC, CO and NO_x for LTO phase, while CO₂ emissions are computed both during the CCD and LTO cycles. The emissions outputs will be presented in “emissions maps” of the Greek territory to enable the identification of critical emission spots including routes, airports and flight category. In addition, analysis by season will be conducted to assess the impact of demand volatility mainly driven by tourism on the environmental aspect of aviation.

The results of the “Passenger Sustainable Travel Platform” will provide useful insights to policy makers who are interested in implementing policies to mitigate aircraft emissions, aviation stakeholders (e.g. airlines, airports) who would be willing to monitor the environmental impact of their operations, as well as researchers.

4. Discussion

A literature review of the anticipated impacts of shipping and air transportation to the environment has been presented. In addition, the relevant digital platforms and services that the national Intelligent Research Infrastructure for Shipping, Supply chain, Transport and Logistics (EN.I.R.I.S.S.T) develops are discussed, while illustrating how their results can be used from the research community, academia, industry and policy makers.

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The development of platforms focusing on environmental services offered to Greek ports and shipping industry could contribute to the improvement of waste management practices, to continuous monitoring of waste and marine debris production and finally to the reduction of the environmental footprint of shipping.

Preliminary results regarding surface sediments from 43 offshore and open/deep sea locations in the wider Aegean Sea reported by Hatzianestis et al., (2020), indicate that total levels of petroleum related hydrocarbons fall within a range comparable to those previously reported for non-polluted coastal and offshore/deep sea locations in the eastern Mediterranean Sea (EMS) and worldwide (Parinos et al., 2013). An enhanced maritime activity related imprint is evident in surface sediments of the central Aegean Sea, which in combination with main water mass circulation patterns largely determine petroleum-related hydrocarbons distribution in the south Aegean/Cretan Sea. Similar patterns have been reported by Parinos et al., (2013) for open/deep sea surface sediments in the wider EMS, highlighting the importance of the intensity of sources and differences in transport pathways and/or phase associations of anthropogenic fossil hydrocarbons, on their overall distribution and fate. Moreover, data regarding sinking particulate matter in the deep Ierapetra Basin, 4300 m depth, reported by Pedrosa et al., (2021) highlight an increased flux of fossil related anthropogenic compounds to the deep EMS.

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