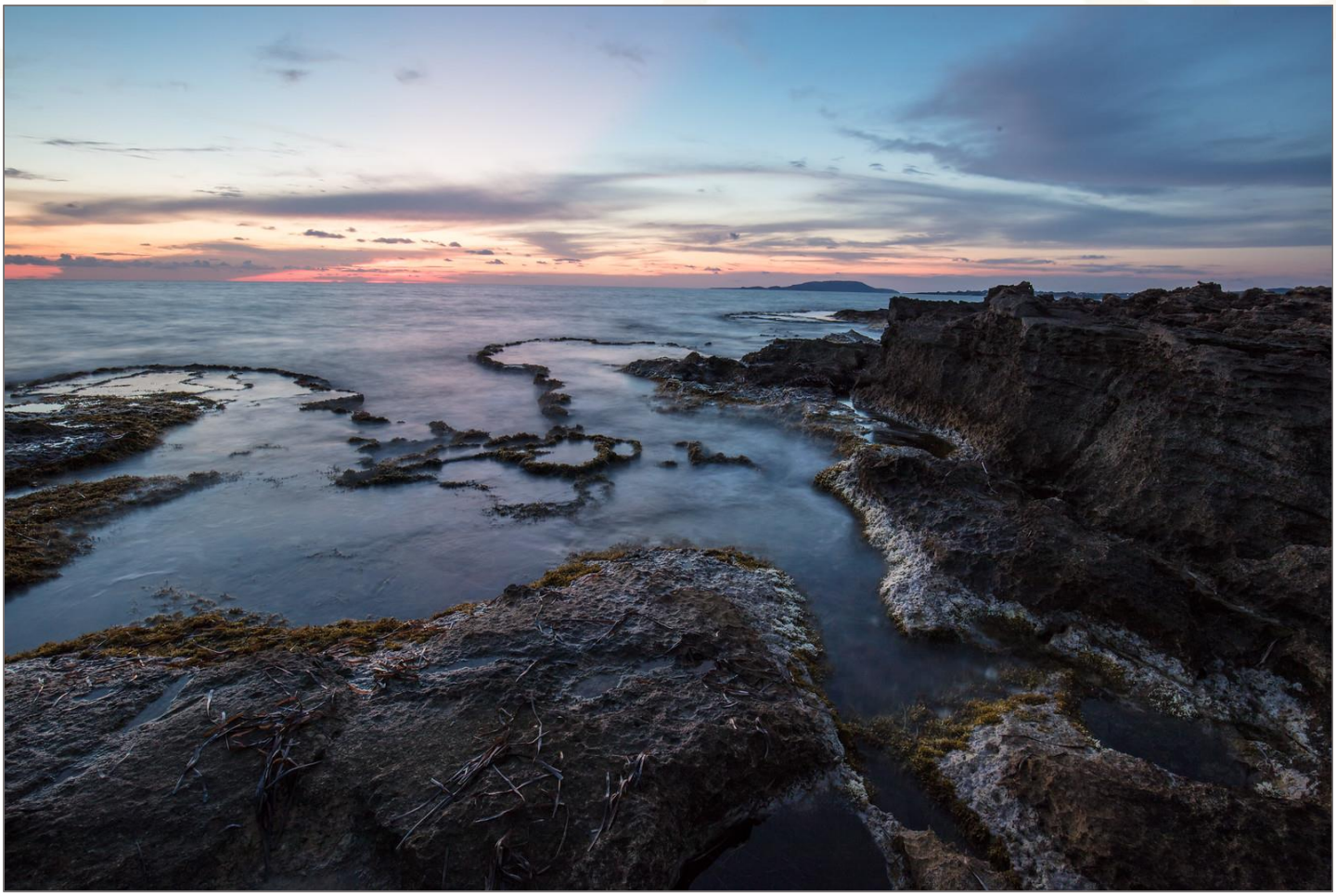
NAVARINO
ENVIRONMENTAL
OBSERVATORY

ANNUAL REPORT

2018



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TEMES
DEVELOPERS OF COSTA NAVARINO
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Foreword

Development that is sustainable for all people on our planet, for animals and for our nature requires a transition from a fossil-based society with a linear economy, to a bio-based one with a circular economy. We have to reach the Paris Agreement objective of keeping the increase in global average temperature to below 2 °Celsius, as well as we have to reach the United Nation's 17 global and indivisible goals for sustainable development, Agenda 2030.

The transition facing Greece, Sweden and the rest of the world is substantial and crucial. It involves, engages and affects us all. This transition places demands on our politicians and decision-makers, on companies, academic institutions and NGO:s, but also on us as individuals – it requires that we want, are able to and dare to break up with old values, change our habits and our way of life.

NEO is indeed now a well-established initiative with extensive networks and a successful track-record in terms of academic output and project implementation. A good example of this is the new EU H2020 research and innovation project COASTAL (Collaborative land-sea integration platform, https://h2020-coastal.eu) that started in 2018, marking a major break-through for NEO. NEO, through Stockholm University and our associated partner Hellenic Center for Marine Research, is for the first time actively engaged in such a large EU consortium.

It was a great pleasure for NEO to, in 2018, welcome the new NEO Director, Johan Kuylenstierna, adjunct professor at Stockholm University and the former Director of Stockholm Environment Institute. Based on our track record, since the start of NEO in 2010, and with the aim to further encourage research, education and communication activities focusing on sustainability and innovative solutions to environmental challenges, Johan proposed a new strategy that was discussed and decided upon by the Steering Committee. This indicative strategy high-lights the ambition of NEO to further engage in science-policy-practice interface processes, as a strategic partner in international, national and local initiatives to support sustainable development objectives. The goal is to stimulate and carry out research, science-policy interaction, education and capacity development and to cover all perspectives of sustainability; environmental, economic and social, from small local communities to the big global links.

I would like to thank our three partners, our scientists and students and the NEO management for contributing to making year 2018 another successful year with NEO and I am looking forward for even more exciting years to come.

Karin Holmgren
Chairperson of the NEO Steering Committee

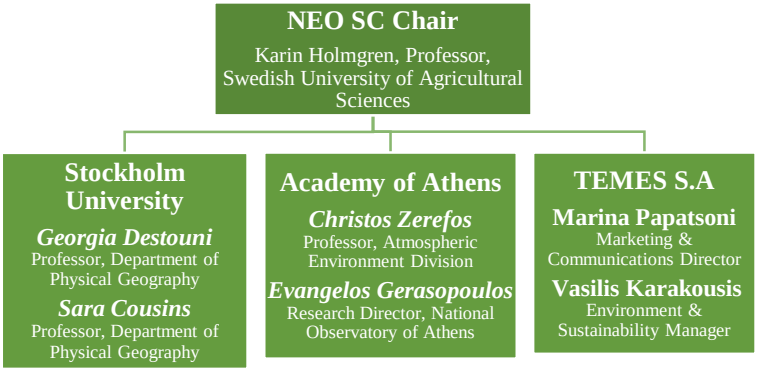
What is NEO?

Navarino Environmental Observatory (NEO), is an international cooperation between the academia and the private sector dedicated to research, education and science communication on the climate and environment of the Mediterranean region. Three partners constitute NEO: Stockholm University; Biomedical Research Foundation of the Academy of Athens; and TEMES S.A (Tourism Enterprises in Messina, SA). Located near Costa Navarino, Messinia, Greece, NEO is growing into a dynamic hub where scientists from all over the world conduct frontline research, develop new tools and methods, as well as meet to exchange knowledge and ideas.

NEO Structure

The *NEO Steering Committee* (NEO SC) consists of a chairperson and two delegates from Stockholm University, two delegates from Academy of Athens and two delegates from TEMES SA.

NEO management, consists of the NEO director (Johan Kuylenstierna, Adjunct Professor, Department of Physical Geography, Stockholm University) and the NEO Station Manager (Giorgos Maneas, PhD student at Department of Physical Geography, Stockholm University).



NEO Associated Members and networks

Since its start, NEO has gained several associated members, academic colleagues with which we collaborate. Our aim is to welcome more associated members from the private sector.

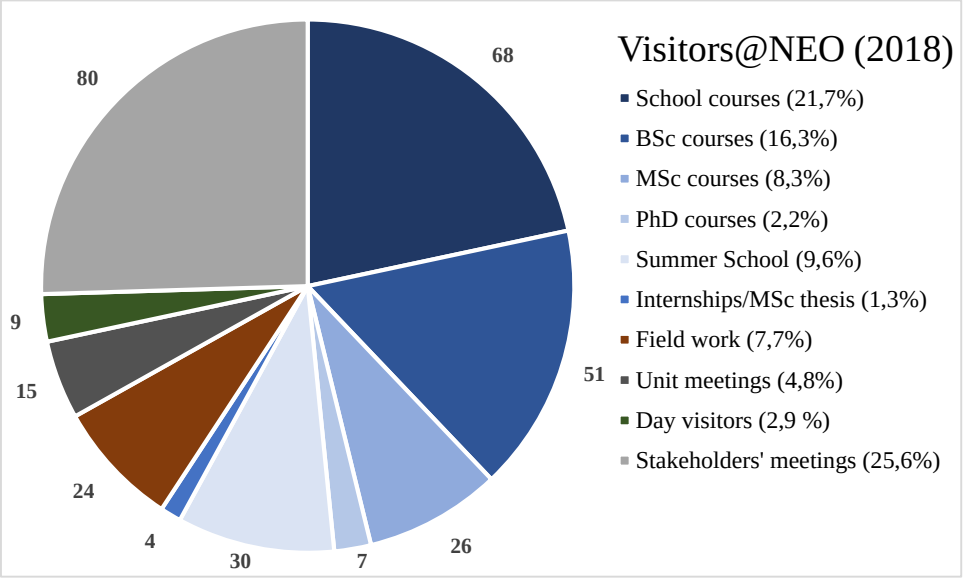
Table 1: NEO Associated members

Affiliation	Location
National Observatory of Athens	Athens, Greece
***Environmental Chemical Processes Laboratory (ECPL)**, Dep. of Chemistry - University of Crete*	Iraklion, Greece
***Laboratory of Atmospheric Physics (LAPUP)**, Dep. of Physics - University of Patras*	Patras, Greece
***Laboratory of Climatology, Climate Dynamics and Climate Change**, Dep. of Geography - Justus Liebig University Giessen*	Giessen, Germany
***Laboratory of Archaeometry**, Dep. of History, Archaeology and Cultural Resources Management - University of Peloponnese*	Kalamata, Greece
***Soil and Water Lab**, Dep. of Biological and Environmental Engineering, Cornell University*	Ithaca-NY, USA
***Laboratory of Tree-Ring Research**, University of Arizona*	Tucson, USA
***Department of Geography**, Johannes Gutenberg University*	Mainz, Germany
***Department of Archaeology and Ancient History**, Uppsala University*	Uppsala, Sweden

Furthermore, NEO has become a member of ***ACTRIS***, the European Research Infrastructure for the observation of Aerosol, Clouds and Trace Gases, ***GWEN***, a Global Wetland Ecohydrology Network, and ***LTER-Greece***, the Greek Long-term Ecosystem Research Network which is a collaborative network of scientists and their stakeholders engaged in long-term, site-based ecological, social and economic research in Greece.

2018 NEO activities at a glance

Recent NEO research initiatives, covering topics such as the effect of agriculture on biodiversity and water resources and the co-management of ecosystem services in Natura 2000 areas, illustrate our ambition to widen the scope of NEO inter-disciplinary research towards strategies for sustainable development of social-ecological systems and multifunctional landscapes in Messinia. To that end, NEO is gradually becoming a hub for sustainability research, contributing to local community. Under the umbrella of the COASTAL EU project, which was initiated in 2018, local and scientific knowledge will be combined to identify problems and develop practical and robust business road maps and strategic policy guidelines, aimed at improving land-sea synergy. Furthermore, we have developed a new indicative strategy that outlines the future ambition for further development of the NEO collaboration.



In 2018, NEO hosted *9 courses (School, BSc*, MSc and PhD level), *a summer school*, a *research unit meeting*, *several workshops with stakeholders*, *fieldwork visits* and *day visits*, resulting to a total of *313 visitors*. **Gialova wetland** has been the focus of several monitoring activities this year as well. New findings based on core sediments analysis, have provided insights on climate-societies interaction in the area, over the centuries. Monitoring of birds, basic water parameters, climatic factors and touristic pressure, generate data which are fundamental for the future management of the area. Since September 2018, **NEO atmospheric station** at Methoni has become part of the PANACEA National Research Infrastructure (PANhellenic infrastructure for Atmospheric Composition and climatE change). NEO researchers have produced 18 more international publications (8 published in scientific journals and 10 in international conferences).

Education

Activities @NEO station

Starting from the school level all the way to up to the PhD level, subjects studied during this year included geology, geomorphology, water resources, climate change, earth sciences, geography and interdisciplinary environmental management among others (Table 2). These courses were organized by several universities from Sweden, Greece and other European countries, and have attracted very many high esteemed scientists as lecturers or trainers. NEO in collaboration with the ACG (American College of Greece) have co-developed "The Gialova experience" field course, for the students following Environmental studies at ACG.

For second consecutive year, the Hellenic Association of Aerosol Research (HAAR) picked NEO to host its summer school (Table 2). This summer school is becoming of increasing impact as it has become an official training activity of ACTRIS/ESFRI and has early managed to concentrate the lights of many high esteemed scientists and pioneer companies in the field, that participated in the one-week program that combined

introduction to theory, hands on training on instrumentation and real measurements at NEO's station in Methoni. The participants as well as the international audience of Post-Docs and PhD students that took the courses, are excellent ambassadors and significantly contribute to the visibility of NEO's activities and facilities offered. Another highlight of this year was the PhD course "***Trans-Disciplinary Research (TDR) for Sustainability Sciences"***, a real example of how a group of PhD students can work together to co-create and codevelop a tailor-made course adding to their knowledge and experience.

Table 2: Educational activities @NEO station during 2018.

Course in	Level	Affiliation
Natural disasters form a natural- and social science perspective	Upper secondary school	Värmdö Gymnasium, Stockholm
Environmental sciences		Hersby Gymnasium, Stockholm
Geology, geomorphology and water chemistry		Nynäshamns Gymnasium, Stockholm
The Gialova experience!	Bachelor	American College of Greece, Athens
Climate, Climate Change Impacts: Greece		Dep. of Geography, Justus-Liebig University of Giessen
Cultural Heritage Materials and Technologies	Master	Dep. of History and Archaeology, University of Peloponnese
Plant Biodiversity and evolution - a global perspective'		Dep. of Biology Education, Stockholm University
Meaningful Engagement Trip	Mixed	American College of Greece, Athens
Theory and practice of aerosol chemistry and engineering for climate, air quality, emissions and health effects, by means of In-Situ and Remote Sensing Observations	PhD Summer School	Hellenic Association of Aerosol Research (HAAR)
Trans-Disciplinary Research (TDR) for Sustainability Sciences	PhD	Dep. of Physical Geography, Stockholm University

Master thesis/ Internships

Two Greek interns, Angeliki Kaplani a master student following the "Environmental Management and Physical Planning" Master course at Stockholm University and Georgia Tsikini, a bachelor student at the Polytechnic University of Chania from the Department of, spent in two months at NEO Station working on Ecosystem Services and pressures at Voidokilia and Navarino bay.

In total 2 MSc theses related to NEO have been completed and presented at Stockholm University in 2018 (Table 3). One thesis from the MSc programme in ***Hydrology, Hydrogeology and Water Resources*** and one from the MSc programme in ***Landscape Ecology,*** both related to NEO relevant research on Environmental monitoring and management of Gialova Lagoon. Sofia Maniatakou, a master student at the program "***Social-Ecological Resilience for Sustainable Development***", Stockholm Resilience Centre, visited NEO station for 5 weeks during October/November 2018, and she is expected to submit and present her thesis in June 2019.

Table 3: Completed MSc thesis related to NEO in 2018.

Title	By	Supervisor, co-supervisor	Master Programme
A comparison of the avian soundscapes of organic and conventional olive groves in Messinia, Southwest Greece	David Myers	Håkan Berg, Giorgos Maneas	**Landscape Ecology** Dep. of Physical Geography, Stockholm University
The spatial variability of salinity and water flux estimate in Gialova Lagoon, Greece"	Kim Lundmark	Stefano Manzoni, Giorgos Maneas	**Hydrology, Hydrogeology and Water Resources** Dep. of Physical Geography, Stockholm University

Figure 1: Picture selection from educational activities @NEO station during 2018.

Outreach

Events and café-NEO meetings

In February 2018, Professor Georgia Destouni, Stockholm University, gave a well appreciated talk about NEO, at an event in Stockholm organised by The Hellenic Foundation of the Nordic Countries entitled "***Never let a crisis go to waste, Science and Business for a Sustainable Life"***. In October, NEO's Director Johan Kuylenstierna, Adjunct Professor, Stockholm University, gave a presentation at the ***2nd Sustainability Summit for South-East Europe and the Mediterranean***, organized by the Economist under the auspices of H.E. the President of the Hellenic Republic, Mr. Prokopios Pavlopoulos.

Figure 2: The café-NEO meeting at Baba-Yaga café bar in Kalamata, with Dr. Evangelo Gerasopoulos as invited speaker.

Two technology oriented ***café-NEO*** meetings took place in Kalamata; one describing the early steps of technology in the antiquity and the other introducing the locals to the concept of "smart cities" and discussing the solutions that technology can offer to the modern environmental pressures at the urban landscape (Table 4). Two more ***café-NEO*** were organized in Patras city, the first dealing with mitigation and adaptation to climate change and the second with the impact of plastics and micro-plastics on the environment and health.

Table 4: Café-NEO meetings

Title	Location	Date	Invited speaker
Kalamata - Smart city	Kalamata, Baba-Yaga café bar	April 16	Dr. Evangelos Gerasopoulos, National Observatory of Athens
The Antikythera Mechanism	Kalamata, Vino-banco café bar	May 8	Professor Xenophon Moussas, University of Athens
Past climate variability, future projections and ways to mitigate the impacts and adapt to future conditions	Patra, Gefyres cafe	November 21	Professor Athanasios Argiriou, University of Patras
Plastics and micro-plastics and their impact on the environment and health	Patra, Gefyres cafe	December 8	Ass. Professor Hrisi Karapanagioti, University of Patras

Workshops and day visits @NEO

Fifteen members from the ***Climate Science and Quaternary Geology*** research unit at the Department of Physical Geography, Stockholm University made a visit to NEO during April, 2018. The main purpose was for the team to learn more about the NEO station as a resource for teaching and research, to become familiar with interesting aspects of the nearby environment, to make contacts with Greek scientists, and to stimulate the internal team building.

The ***Swedish Organization of Sport Promotion***, which is under the auspices of the King of Sweden, visited NEO to learn about our research, education and outreach activities.

The ***Swedish Ambassador in Greece***, Charlotte Sammelin, met with NEO station manager Giorgos Maneas at NEO, during a day visit which included a presentation about NEO activities, and a walk to Gialova lagoon wetland.

COASTAL - Collaborative Land-Sea Integration Platform, No 773782

Engaging local stakeholders

Under the umbrella of the COASTAL project, in 2018, NEO hosted and facilitated 6 sectoral workshops bringing together more than **70 local stakeholders** from the sectors of agriculture, local industry, fishing, tourism as well as representatives from the public sector, universities, institutes and NGOs. The 6 sectoral workshops were co-organised by HCMR (Hellenic Centre of Marine Research) and NEO and were held at the premises of NEO, in Messinia Greece, from July to October 2018. During the workshops, the participants showed enthusiasm and were happy to be given the opportunity to meet and discuss about common issues within their sector. **Similar discussions had never taken place before and this was a unique experience for all people involved**. The aim of these workshops was to gain local knowledge, which will be combined with other data from the area and generate inputs for modelling Land-Sea interactions. The "chaotic" mind-maps will be further analysed and translated to Causal Loop Diagrams (CLD) and Fuzzy Cognitive Maps (FCM).

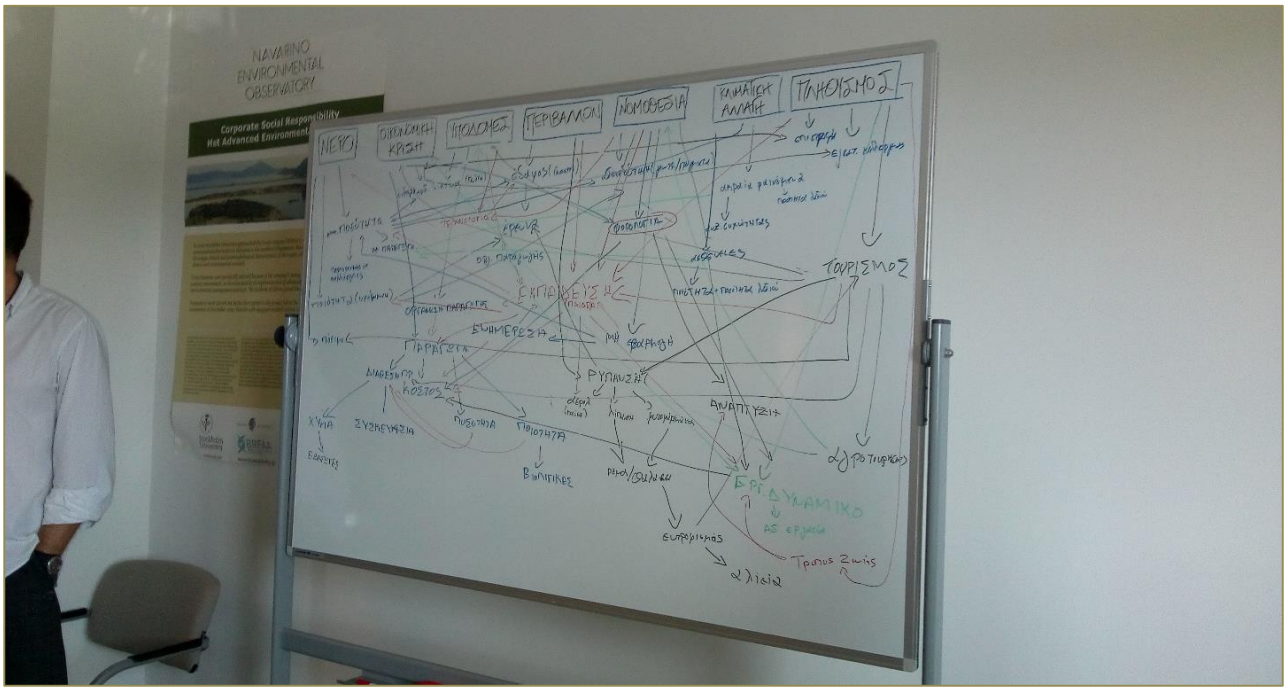


Figure 3: A mind mapping of interactions based on discussions with farmers and agronomists.

Research

Atmospheric research

The long term monitoring of aerosol physical, chemical and optical properties, atmospheric trace gases, different solar radiation components as well as meteorological parameters is the main focus of the atmospheric research activities conducted at NEO. The observations aim at shedding light on the factors that control the levels and variability of the species above as well as to discriminate the relevant contribution from long range transport versus local sources.

After 5 years of continuous measurements, the main results have been collected and synthesized in two scientific publications in the Proceedings of the International Conference on Meteorology, Climatology and Atmospheric Physics. Part I focus was on the "Long-term variability of aerosol optical properties", which is essential for understanding the climate forcing due to aerosols, through absorption and scattering of solar radiation. The study of the covariance with another background location in the area (Finokalia, Crete), enabled to shed light on the regional aspects of aerosol optical properties in the Eastern Mediterranean. At NEO the higher measured levels of both scattering and absorption was related to continental originated air masses as they were encountered under northerlies. Air masses coming from Istanbul, Eastern Europe and W. Asia (NE sector), on the other hand, were found to contribute to enhanced levels on Crete Island. Apart from the hematite content (Sahara dust events), locally or regionally transported black carbon (olive branches burning for NEO and wildfires for Finokalia) amplifies absorption, while increased scattering is also attributed to sulfate aerosol. Part II, "Chemical composition and sources of aerosols", examined PM_{10} aerosol samples during an intensive summer time campaign. Samples were analyzed for the main ions, trace elements, organic and elemental carbon and Positive Matrix Factorization (PMF) was applied to the chemical composition data in order to identify and apportion aerosols to their sources. Aerosol chemical mass closure calculations indicated that carbonaceous aerosol, dust and non sea-salt sulfate were the major constituents at NEO contributing, about 1/4 each to the PM_{10} mass, followed by ammonium and sea salt accounting for about 10% each. Both studies serve as a reference for the design of dedicated campaigns within the frame of PANACEA.

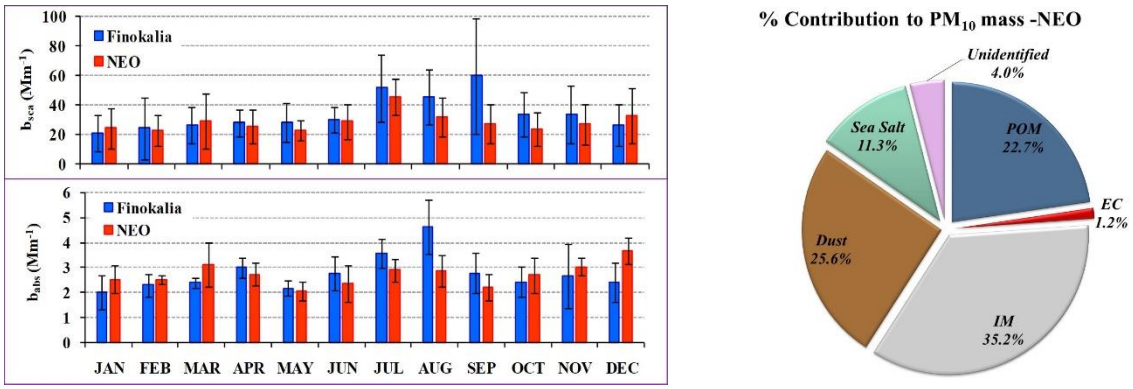


Figure 4: (left) Seasonal variation of scattering and absorption of solar radiation by aerosols at NEO and Finokalia, **(right)** main chemical aerosol components at NEO (where POM=primary organic matter, IM=inorganic matter, EC=elemental carbon).

PANACEA, standing for "PANhellenic infrastructure for Atmospheric Composition and climatE change (PANACEA)" (http://panacea-ri.gr/), was launched in September 2018. PANACEA, as part of the Hellenic Research Infrastructures (RI). The RI is actively linked with both ACTRIS/ESFRI and ICOS/ERIC, the relevant European Infrastructures that target aerosol, clouds, trace gases and the carbon observation, and aims at developing a coordinated system for monitoring of atmospheric composition, solar radiation variations, climate change and related natural hazards in Greece, merging all existing facilities and upgrading its infrastructure. NEO, as part of PANACEA, serves as one of the 3 sites selected in Greece to concentrate national and international efforts in the study of atmospheric composition and its relevance to climate change.

Water research

The water research undertaken by the team of Professor Georgia Destouni aims at advancing our understanding of key natural and human-driven environmental and societal processes and changes with impacts on water availability and quality in Greece and the Mediterranean region. Moreover, it aims at developing improved and novel methods and tools for process and change quantification that can support effective strategies for sustainable management of national and regional water resources. In previous NEO work, the team has, for example, investigated and identified tipping points for seawater intrusion into coastal groundwater under rising sea level and other hydro-climatic changes, and cost-efficient management measures for coastal aquifers via recharge with treated wastewater and desalination of brackish groundwater. In coordinating and leading the Global Wetland Ecohydrology Network (GWEN, www.gwennetwork.se), which was initiated at NEO in 2011, the team has also investigated status and challenges for research, engineering and management of wetlands as possible large-scale nature-based solutions for management of water resource availability and quality under ongoing and future regional and global change.

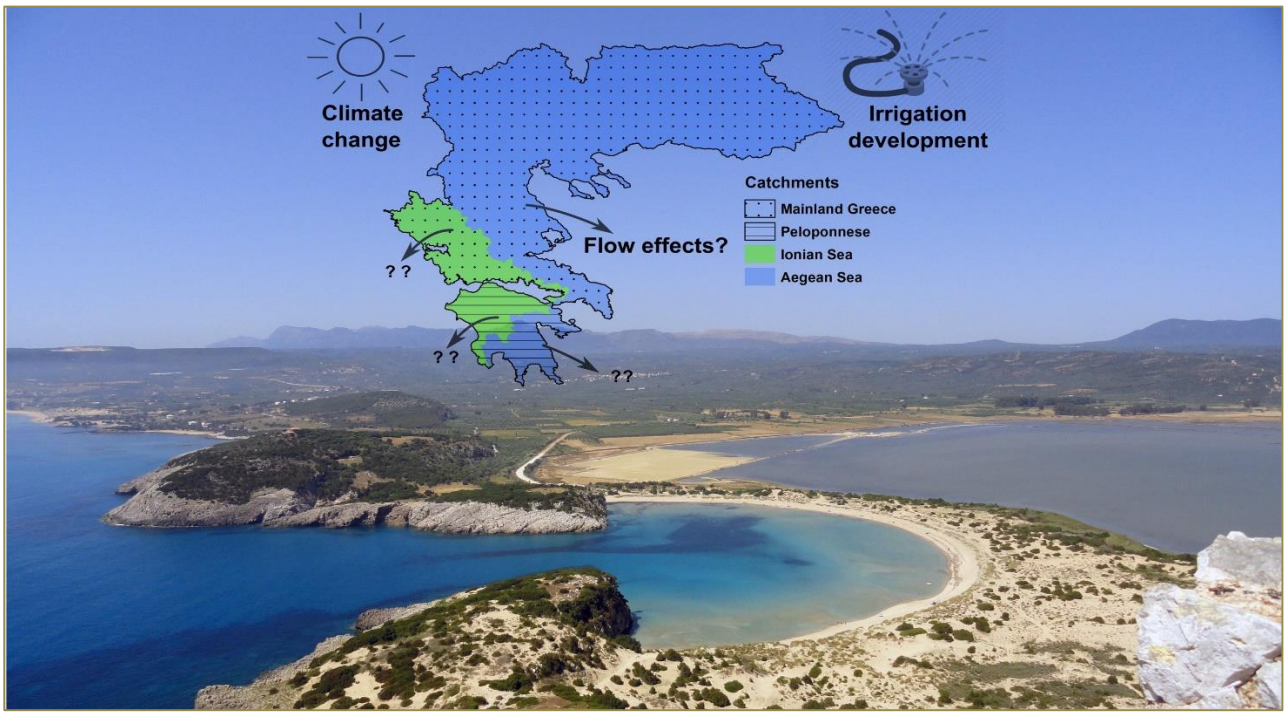


Figure 5: Illustration of study by Destouni and Prieto (2018), featuring in the journal cover with short story: https://www.mdpi.com/2073-4441/10/11; photo by NEO. Study results show that average precipitation over Greece has decreased from 1930–1949 to 1990–2009, driving decrease in the runoff flux of freshwater through landscape (stream networks in) and the evapotranspiration flux from the landscape to the atmosphere (combining evaporation and plant transpiration of water). Agricultural irrigation has also increased over the same time, driving further decrease in runoff and increase in evapotranspiration. In combination, average runoff over Greece has decreased by around 75 mm per year, implying smaller availability of annually renewable freshwater and associated smaller freshwater discharges from Greece to the Mediterranean Sea. Furthermore, average evapotranspiration has increased by around 26 mm per year, implying more water going to support vegetation and crops in the Greek landscapes, and thereafter being lost to the atmosphere and feeding precipitation elsewhere.

A central NEO research result published in 2018 by the team of Professor Georgia Destouni (Destouni and Prieto, 2018) has revealed substantial impacts of atmospheric climate change and irrigation developments in the landscape on freshwater availability in Greece, from earlier (1930–1949) to recent (1990–2009) conditions (Figure 5). In combination over Greece, average runoff has decreased by around 75 mm per year while average evapotranspiration has increased by around 26 mm per year. These results imply less freshwater flowing through the Greek landscapes and associated smaller freshwater discharges to the Mediterranean Sea, while more water goes to support the landscape vegetation and crops and is thereafter lost to the atmosphere, feeding precipitation elsewhere. Several more team activities and publications in 2018 with NEO relevance are further described in the following. (i) The new EU H2020 research and innovation project COASTAL (https://h2020-coastal.eu) started in 2018, linking the team's research on inland-coastal-sea interactions in Sweden and

Greece. (ii) Two new NEO-relevant EU COST Action projects with team partnership (and membership in the management committee) were approved in 2018: DAMOCLES - Understanding and modeling compound climate and weather events, 2018-2022, https://www.cost.eu/actions/CA17109/#tabs|Name:overview; and FIRElinks - Fire in the Earth System: Science and Society, 2018-2022, https://www.cost.eu/actions/CA18135/#tabs|Name:overview. (iii) A new study from the NEO-initiated global wetland ecohydrology network GWEN was published in 2018 (Thorslund et al., 2018). (iv) Finally, several new team studies were published in 2018 for different parts of the world that pave the way for forthcoming analogous applications to Greece and the Mediterranean region on: human-driven (agricultural, urban, other sector) impacts and possible solutions for water quality (Destouni and Jarsjö, 2018; Levi et al., 2018); drought occurrences and impacts (Orth and Destouni, 2018); water-related ecosystem services (Quin and Destouni, 2018; Hamel et al., 2018); and nature-based solutions for sustainable urbanization (Engström et al., 2018; Kalantari et al., 2018; Pan et al., 2018).

Past societies and climate co-evolution

Domesticated Landscapes of the Peloponnese

This project aims to understand human-environmental dynamics on the Peloponnese during 7 000 years from the Neolithic to the Roman period.

During 2018, Marin Finne, a former NEO PhD student, kept working in the Domesticated Landscapes of the Peloponnese project funded by the Swedish Research council, together with Erika Weiberg and Anton Bonnier, at the Department of Archaeology and Ancient History, Uppsala University. In 2018 Martin got involved in the work of devising a new method that utilize published archaeological surface finds (legacy data) to estimate past land use areas. Much work was also devoted to synthesize different types of data, e.g. climate and archaeological settlement, collected during the previous years to understand how climate variability may have impacted on past societies on the Peloponnese.

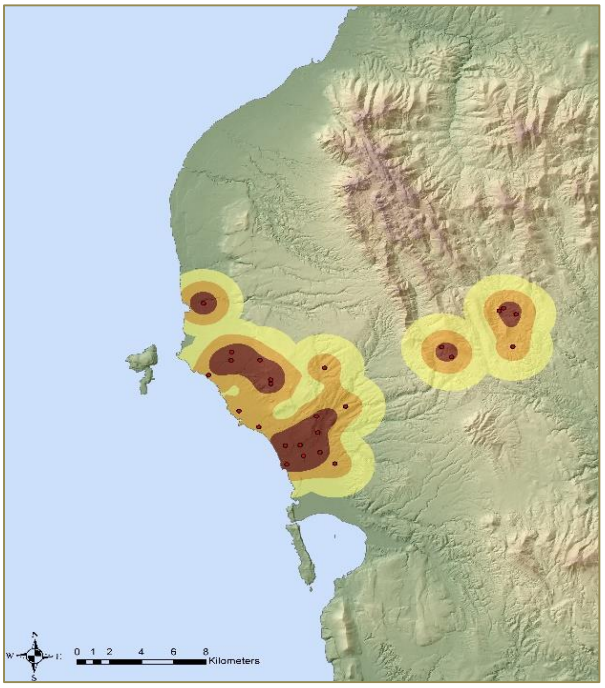


Figure 6: Modeled area of possible land use in Messenia during the Hellenistic time period (i.e. ca. 300 to 30 BCE) based on published archaeological survey finds. The picture was made by Anton Bonnier

Holocene environmental changes in the Peloponnese peninsula, SW Greece based on multi-proxy sediment records

As part of his PhD thesis at the Department of Physical Geography, Stockholm University, Christos Katrantsiotis aims to contribute to a better understanding of climate evolution and the related drivers in the central-eastern Mediterranean over the last 6000 years, a period of centennial-millennial climate changes whose nature is not well-understood. For the purpose of the investigation, sediment cores were retrieved from the Agios Floros fen and the Gialova lagoon in SW Peloponnese and the Ancient Lake Lerna in NE Peloponnese. The cores were analyzed for different biological (diatoms/pollen) and geochemical proxies (lipid biomarker compounds from plants). The location of sites on SW-NE transect aims to establish a network of paleoclimatic data from different climatic zones of the Peloponnese. This further enables us to stress local

climate differences and provide a more accurate assessment of the regional climatic variability and its connection to the large-scale atmospheric patterns.

During 2018, the results from the Gialova Lagoon were published in the journal 'Quaternary Science Review'. The study shows three major shifts from dry/warm to wet/cold periods in SW Peloponnese over the last 3600 years. In addition, during 2018, a sediment core from the Lake Lerna was analyzed and the results were published in the journal 'Global and Planetary Change'. In the same paper, the climate records from SW and NE Peloponnese were also compared revealing sometimes opposing and sometimes similar signals between the two areas over the last 5000 years. This has been attributed to the relative dominance of high-latitude and low-latitude atmospheric patterns over the peninsula.

Tree-ringing

In a centennial–to–millennial scale context, proxy–based climate reconstructions are required to assess current climatic trends and changes in the amount, frequency and intensity of extremes, and to evaluate the full range of projected forcing impacts. Particularly in the Mediterranean region, an improved spatial distribution of high–resolution proxy archives is needed to expand our knowledge about pre–instrumental climate variability patterns and their relationship with natural forcing's at regional to continental scales. At high–elevation sites in the Mediterranean region tree-growth is influenced by an interaction of temperature and precipitation constraining the use of tree–ring width (TRW) as a temperature proxy.

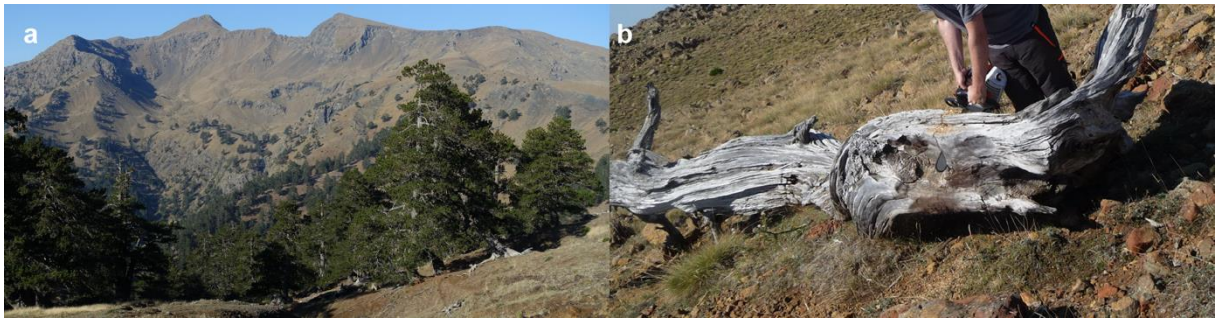


Figure 7: (a) Typical shape of the tree–line environment at the eastern foothills of Mt. Smolikas in northwestern Greece with open stands of Pinus heldreichii and (b) sampling of dead trunk.

The team has developed the first millennium–length reconstruction of late summer (August–September) temperatures for the Mediterranean region by compiling 132 maximum latewood density (MXD) series of living and relict Pinus heldreichii trees from a network of four high–elevation sites in the Pindus Mountains of Greece (Figure 7). Analysis of temperature extremes reveals the coldest summers occurred in 1035, 1117, 1217, 1884 and 1959 and the coldest decades were 1061–1070 and 1811–1820. The warmest summers occurred in 1240, 1296 and 1474, and the warmest decades were 1141–1150 and 1481–1490.

Co-management of Ecosystem Services in Gialova Lagoon wetland and surrounding areas

Research done in close cooperation with different stakeholders aim to develop multifunctional landscapes that can help to enhance and diversify the local economy, while still sustaining critical ecosystems and associated ecosystem services. Monitoring and analyses of socio-ecological parameters in the nearby coastal lagoon (Gialova lagoon) and adjacent streams, rivers and cultivated land, aiming to provide viable alternatives for long-term sustainable tourism and agriculture were initiated in 2016. The research takes into account resilience to future climate changes and minimization of the impact of tourism and agriculture on the Natura 2000 sites, exploiting the expertise and experience of local stakeholders. The work is based on the PhD work of Giorgos Maneas, his supervisor Dr. Håkan Berg, his co-supervisor Dr. Stefano Manzoni both Ass. Professors at the Department of Physical Geography, Stockholm University and a number of master students who during the

last 2 years have contributed significantly to this direction. Since 2018, the area is also added as one of the six case studies of the COASTAL EU project, adding to our understanding and to the capacity to reach the local community.

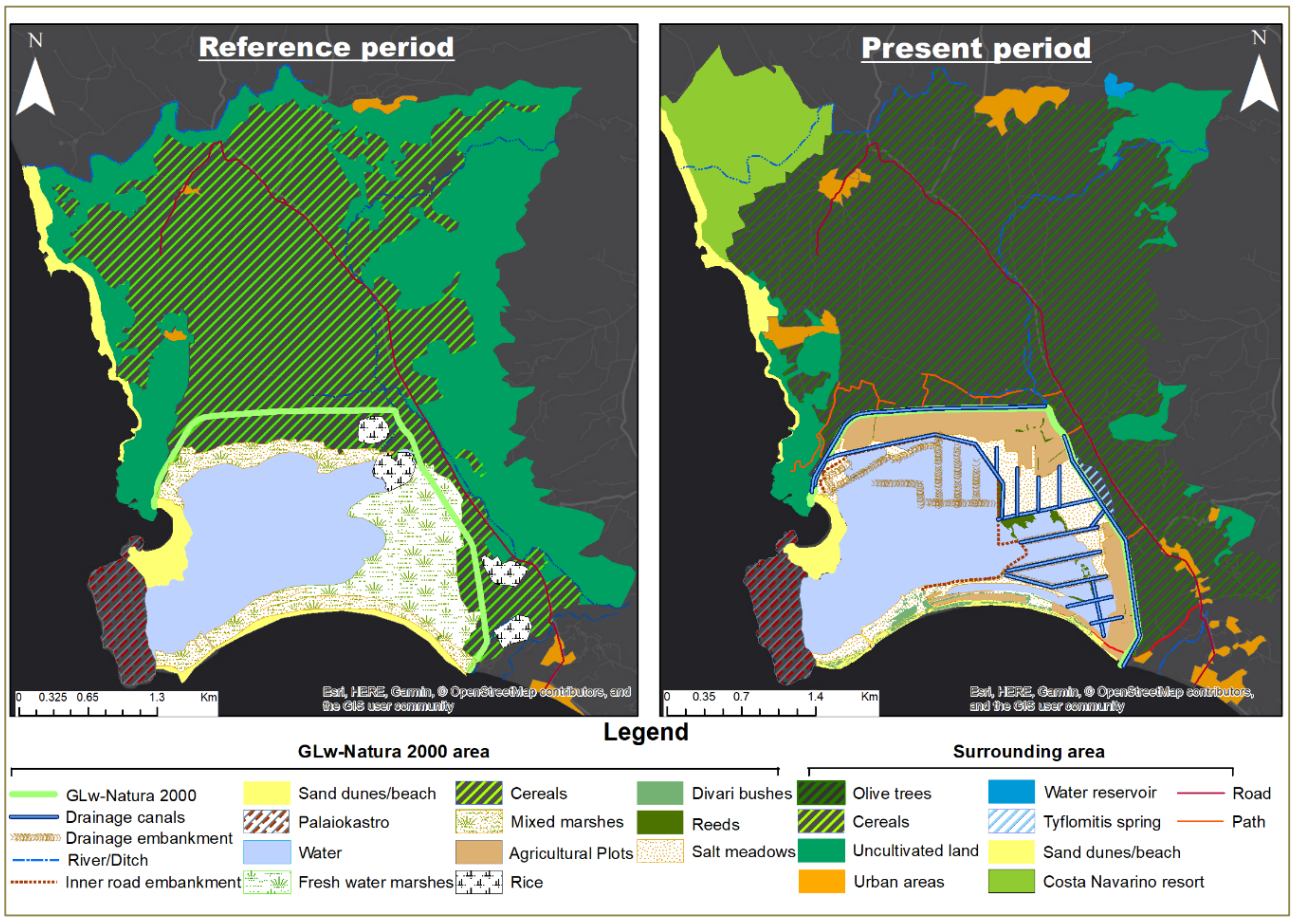


Figure 8: Land cover and major land uses in GLw-Natura2000 and the surrounding area in the past (prior to 1960) and present periods. The map of reference conditions was created in ArcGIS based on a 1945 b/w aerial photograph, interpretation of a historical map and interviews with the Key Informants. The map of present conditions was based on a 2010 Google Earth image and field observations in 2010 and 2018. The classification of the coverage of cereals (reference) and olive trees (present) in the surrounding area was based on the type of crop dominating the landscape.

In 2018, a review paper was published about the area focusing on how human activities have altered the functions of Gialova Lagoon wetland and surrounding areas during the last 70 years, adding to a more holistic approach of the local socio-ecological system (Maneas et al., 2019; Figure 8). A two-year monthly bird monitoring was finalized in November, providing detailed bird data for the first time, a basic prerequisite for the future management of the area (a manuscript is in preparation on this topic). To that direction, during summer 2018 we also completed a monitoring of the touristic pressure on the sensitive beach ecosystems, work which was implemented by the master student Angeliki Kaplani as part of her internship at NEO. While monitoring of water quality and environmental conditions in and around Gialova lagoon continues, a model describing water fluxes and salt fluxes in the lagoon was developed. Understanding these fluxes is key to assess changes in water quality in the lagoon, but measuring them is challenging, requiring a modelling approach. Preliminary model results indicate that about 60% of water inputs to the lagoon are from surface and groundwater sources, and 40% from rainfall. Outputs of water are mostly due to evaporation (75%) and saline water loss (25%). A manuscript is in preparation on this topic. A comparison between organic and conventional olive Farming in Messenia (Berg et al., 2018), showed that organic farming could provide a competitive and sustainable alternative to conventional olive farming in Messenia. A follow up study, using acoustic methods for estimating bird diversity in the surrounding area, was implemented by master student David Myers. This study, which is already submitted for a publication, shows that olive groves under organic

agriculture had significantly higher values for the Acoustic Complexity Index (ACI) and Bioacoustic Index (BIO) indices, supporting higher biodiversity. A water related Ecosystem Services (ES) approach, was the basic element around which another master student, Sofia Maniatakou (master student at the Stockholm Resilience Centre) approached the local community to understand how locals value these ES, at the nearby villages. The "***Trans-Disciplinary Research (TDR) for Sustainability Sciences"*** PhD course, complemented the work undertaken so far under the umbrella of COASTAL (sectoral workshops), by capturing local dynamics in Causal Loop Diagrams mainly through interviews. Both activities, pave the way for more focused discussions with local stakeholders which along with robust research are considered to be the cornerstone for the integrated management of this and other Natura 2000 areas in Greece and Europe.

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