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Book of Abstracts

Welcome to the 2nd Annual Climate and Atmosphere Research & Innovation in the Eastern Mediterranean and Middle East Workshop

Dear Colleagues,
Dear Friends,

It is with great pleasure that we welcome you to our 2nd Annual Climate and Atmosphere Research and Innovation in the Eastern Mediterranean and Middle East Workshop.

First, on behalf of the Scientific Committee and the Organizers, we would like to thank all of you for your participation at the workshop. In this booklet we are delighted to share with you an exciting program, reporting the main innovations in the field of atmospheric sciences with the participation of 53 invited talks discussing about the recent relevant advances in the field.

All this has been possible thanks to your contribution.

We do hope that you enjoy your attendance at our Virtual Workshop!

Jean Sciare - CARE-C, The Cyprus Institute

Scientific Committee

Jean Sciare, CARE-C, The Cyprus Institute, *Cyprus*

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Agenda

Opening Session		
09:00	**Welcome & Introduction to the Workshop**	
	Workshop introduction and opening	**J. Sciare** The Cyprus Institute
Air Pollution: From Observations to Models (Chair: M. Rami Alfarra)		
09:10	**Invited Speakers**	
	On the important of continuous comprehensive observations: From local clustering to regional air pollution	**M. Kulmala** UHEL, Finland
09:30	**Oral Presentations**	
	The FAIRMODE CT9 platform: Assessing sensitivity of model responses to emission changes towards effective emission reduction strategies	**B. Bessagnet** JRC, EU
	Long-range source apportionment of Black Carbon and Carbon Monoxide over Cyprus using FLEXPART and global emission inventories	**S.O. Nabavi** Cyl, Cyprus
	Ship plume modelling based on CALPUFF AND WRF: Towards a first estimate of individual ship NOx emissions from space	**A. Georgoulias** AUT, Greece
	Quantifying Nitrogen Oxides emissions in the EMME region using TROPOMI observations	**A. Rey-Pommier** LSCE, France
	Is residential wood burning an important issue in atmospheric chemistry, light absorption and radiative forcing over the Eastern Mediterranean?	**D. Kaskaoutis** NOA, Greece
	$PM_{2.5}$ sources in the East Mediterranean – Middle East city Beirut: Chemical characterization and contribution to ambient concentrations	**N. Fakhri** USJ, Lebanon
10:40	**Coffee Break (10 min)**	
New Instrumentation and Research Infrastructure (Chair: Efstratios Bourtsoukidis)		
10:50	**Oral Presentations**	
	Studying the transboundary transport of atmospheric aerosols in the EMME region	**F. Marenco** Cyl, Cyprus
	Retrieval of aerosol optical depth using an all-sky imager and machine learning	**C.P. Giannaklis** Univ. Patras, Greece
	Performance evaluation of high-resolution and low-cost air quality monitoring network employing the VAISALA-AQT530 sensors for assessing urban road traffic variability	**R. Papaconstantinou** Cyl, Cyprus
Atmospheric Dust (Chair: Franco Marenco)		
11:30	**Oral Presentations**	
	Does mineral dust influence new particle formation events?	**J. A. Casquero-Vera** UHEL, Finland
	Mineral dust properties within different atmospheric layers during two dust events over Cyprus (Cyprus Fall Campaign 2021)	**M. Kezoudi** Cyl, Cyprus
	Dust aerosol spatiotemporal variability and drivers	**N. Bounceur** NCM, Saudi Arabia
	Auxiliary task learning for early warnings of dust events: Evidences from the Eastern Mediterranean	**R. Sarafian** WIS, Israel
	Four types of dust events in Israel from a systematic classification	**D. Nissenbaum** WIS, Israel

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	EU-funded Trans-National Access opportunities of Atmospheric Research Infrastructure in the Eastern Mediterranean & the Middle East	**E. Bourtsoukidis** CyI, Cyprus
	Eastern Mediterranean & Middle East summer school opportunities	**T. Jokinen** CyI, Cyprus
Climate Modelling and Prediction (Chair: Georgiy L. Stenchikov)		
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	Climate and weather extremes in the Eastern Mediterranean and the Middle East	**G. Zittis** CyI, Cyprus
	Future changes of compound drought and heat wave events over Cyprus under global warming	**K. Philippopoulos** NKUA, Greece
	A multidecadal analysis of Mata's climate trends and extreme events, 1952-2022	**C. Galdies** Univ. Malta, Malta
	Comparison of projections of extreme precipitation indices for Jordan from high-resolution EURO-CORDEX and MASHREQ domain RCM simulations	**A. Jrrar** RSS, Jordan
14:30	**Coffee Break (10 min)**	
Air Pollution & Climate Change Impacts (Chair: Diana Francis)		
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	Strong control of aerosol-cloud interactions by emissions from the boreal forests	**T. Petäjä** UHEL, Finland
	Water stress and sustainability challenges: Evidence from Saharan African countries (SSA)	**D. Salman** MSA Univ., Egypt
	Can Electric Vehicles Improve Urban Air-Quality and Save Lives?	**C. Hadjistassou** Univ. Nicosia, Cyprus
	Quantifying the effect of temperature on human mortality in Cyprus in response to Air Quality and other environmental factors	**T. Economou** CyI, Cyprus
	Seasonal inhaled deposited dose of Particulate Matter in the respiratory system of urban individuals living in an Eastern Mediterranean city	**T. Hussein** INAR, Finland
	Large increases of in heat-related mortality burdens projected for the Middle East and North Africa under climate Change scenarios	**Y. Proestos** CyI, Cyprus
	Mediterranean cyclones and sevre weather warnings in Bulgaria	**S. Tsalova** Sofia Univ., Bulgaria
	Critical fire weather patterns of Greece: Forecasting extreme fire weather conditions in the medium-range	**G. Papavasileiou** NOA, Greece
	Developing a common approach to estimate future burnt area in the Mediterranean uncer various climate change scenarios	**A. Karali** NOA, Greece
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New Instrumentation and Research Infrastructure		
	A IDAR depolarization calibration approach using reference system	**A. Papetta** Cyl, Cyprus
	Cloud type identification using an all-sky imager system	**A. Kazantzidis** Univ. Patras, Greece
	Insights into the performance of low-cost optical particle sizers	**C. Loizides** Cyl, Cyprus
Air Pollution & Climate Modelling		
	Real-time air quality forecast over the Eastern Mediterranean using the WRF-CHEM model	**G. Georgiou** Cyl, Cyprus
	Detection and attribution of greenhouse gases and anthropogenic aerosols to compound heat index over Africa in CANESM5 large ensemble	**P. Adigun** Univ. Tsukuba, Japan
	Evaluation of urban representation in high resolution WRF simulations over the Eastern Mediterranean and Middle East	**K. Constantinidou** Cyl, Cyprus
	Utilising generalised additive models (GAMS) to estimate near-surface temperature from satellite land surface information	**A. Tzyrkalli** Cyl, Cyprus
	Assessing the added value of increasing horizon resolution in simulated compound heat and humid conditions over the MENA-CORDEX domain	**P. Hadjinicolaou** Cyl, Cyprus
	Projected heat stress under different levels of global warming with WRF Regional Cimate igh-resolution simulations for the MENA-CORDEX domain	**A. Ntoumos** Cyl, Cyprus
	A methodology for bridging the gap between regional and city-scale climate simulations for the urban thermal environment	**K. Koutroumanou** NKUA, Greece
	Acceleration of atmospheric chemical kinetics simulations through single-precision data structures and explicit vectorisation	**K. Sophocleous** Cyl, Cyprus
	Decomposing temperature variability in Global Mediterranean-type climate regions	**D. Urdiales Flores** Cyl, Cyprus
	An updated assessment of recent-past climate conditions in Cyprus	**G. Lazoglou** Cyl, Cyprus
	Intercomparison of the WRF-CHEM MODEL using Aeolus wind data with satellite-based products	**P. Kyriakidis** Cyl, Cyprus
Air Pollution Observations		
	Potential impact of working from home as an emission reduction measure in Cyprus	**C. McClintock** Cyl, Cyprus
	Cooking, Organic aerosols, and Air Quality at an Eastern Mediterranean urban environment	**I. Stavroulas** NOA, Greece
	Sources of size-resolved particle number concentrations at an urban location in Athens	**P. Kalkavouras** NOA, Greece
	PM2.5 in an urban industrial site in the East Mediterranean: Source apportionment and oxidative potential	**M. Fadel** ULCO, France
	Spatial variability of PM sources in Cyprus	**E. Bimenyimana** Cyl, Cyprus
	Possible influence of atmospheric micro nutrient deposition on the mucilage formation in the sea of Marmara: Preliminary results	**M. Kocak** METU, Turkey
	Massive dust loading during huge dust storm over Middle East during Spring and Summer 2022	**H. Panahifar,** AUT, Iran
17:45	**End of Workshop**	

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ORAL PRESENTATIONS

The significance of continuous comprehensive observations: From atmospheric clustering via feedback loops to regional air quality and global climate

Markku Kulmala
University of Helsinki

Currently the observations are typically fragmented into 1) greenhouse gases; 2) aerosols; 3) air quality; 4) trace gases; 5) ecosystems; 6) climate; 7) ... And the different scientific communities typically do not collaborate or even communicate with each other - although these kind of barriers do not exist in nature. However, in order to produce reliable data and in-depth understanding we need integrated approach to be able to answer global grand challenges like climate change, air quality, water and food supply. The integrated approach is also effective in impact and economy point of view. Therefore, we have developed a SMEAR (Stations for Measuring Earth surface Atmosphere relations) concept.

During the past two decades we have collected long term, continuous, comprehensive open data, furthermore the SMEAR II station (in Hyytiälä, Finland) has contributed to several Pan-European research infrastructure that are currently in the ESFRI Roadmap, such as ICOS (Integrated Carbon Observation System), ACTRIS (Aerosols, Clouds, and Trace gases Research Infrastructure), AnaEE (Infrastructure for Analysis and Experimentation on Ecosystems), and eLTER (Integrated European Long-term Ecosystem,critical zone and socio-ecological system Research Infrastructure). SMEAR has provided high-quality data, trans-national access, and contributed to the development of advanced technologies in many research fields. Due to its comprehensive concept, SMEAR is capable for providing data also to several global Earth Observation systems and networks, such as to WMO GAW, GEO-GEOSS, FluxNet, AERONET and SolRad-Net.

There are several benefits that can be gained (and has been already obtained) by the integration of scientific domains and co-location of diversity of methodologies and measurements (comprehensiveness). The most important impact of the integration and co-location is on the scientific results like quantification of feedback loops, understanding biogeochemical cycles (including water and carbon cycles) in details, understanding gas-to-particle conversion in quantified way and understanding interlinks of several processes. Actually it seems that the key in very many feedback loops and in biogeochemical cycles is what happened in molecular and cluster level (size range < 1nm – 3nm).

The information from different environments in all around the globe is, besides scientists and scientific communities, also crucial for policymakers and other stakeholders. There are also side benefits: for example the same staff can be utilized with several infrastructures simultaneously due to co-location. On the other hand, also the scale and opportunities for training new generation of scientists to use big data provided by SMEAR stations is important. Using the SMEAR-concept globally enables us to perform global feedback loop analyses, to find out new interactions, feedbacks and processes, and to collect new big data for future use to answer questions that we even cannot foresee yet (see also Kulmala, 2018).

As an example of the effectiveness of the integrated approach, we utilise the recently developed CarbonSink+ (Kulmala et al., 2020) concept. Forests cool the climate system by acting as a sink for carbon dioxide (CO_2) and by enhancing the atmospheric aerosol load, whereas the simultaneous decrease of the surface albedo tends to have a warming effect. Using the boreal forest environment (SMEAR II station) as an illustrative example, we estimated that accounting for the CarbonSink+ enhances the forest CO_2 uptake by 10–50 % due to the combined effects of CO_2 fertilization and aerosol-induced diffuse radiation

enhancement on photosynthesis. We further estimated that with afforestation or reforestation, i.e. replacing grasslands with forests in a boreal environment, the radiative cooling due to forest aerosols cancels most of the radiative warming due decreased surface albedos. These two forcing components have, however, relative large uncertainty ranges, resulting in large uncertainties in the overall effect of CarbonSink+. In future, it is crucial to study the CarbonSink+ in different environments globally.

References

Kulmala M. (2018) Build a global Earth observatory. Nature 553: 21-23.

Kulmala M ., Ezhova E., Kalliokoski T., Noe S., Vesala T., Lohila A., Liski J., Makkonen R., Bäck J., Petäjä T., and Kerminen V.-M. (2020). CarbonSink+ — Accounting for multiple climate feedbacks from forests, Boreal Env. Res. 25, 145-159

Authors

M. KULMALA[1], V.-M. KERMINEN[1], E. EZHOVA[1], P. HARI[1], O. PERÄKYLÄ[1], S.A.K. HÄME[1], A. LINTUNEN[1], H.K. LAPPALAINEN[1,2], J. AALTO1, L. AHONEN[1], R. TAIPALE[1], I. YLIVINKKA[1], P. SCHIESTL-AALTO[1], A. LOHILA[1,2], I. MAMMARELLA[1], T. VESALA[1], J. BÄCK[1], and T. PETÄJÄ[1]

1. Institute for Atmospheric and Earth System Research (INAR), University of Helsinki, Finland.

2. Finnish Meteorological Institute, Finland.

The FAIRMODE CT9 platform: assessing sensitivity of model responses to emission changes towards effective emission reduction strategies

Bertrand Bessagnet
European Commission - Joint Research Centre

Air quality models are essential tools for the assessment and prediction of the distribution of pollutant concentrations in the atmosphere. The Forum for Air Quality Modelling (FAIRMODE) in Europe was launched in 2007 to bring together air quality modellers and users in order to promote and support the harmonized use of models by EU Member States, with emphasis on applications under the European Air Quality Directive. In this directive, the use of modelling tools is recommended, in particular to evaluate air quality plans to curb air pollution.

In the framework of FAIRMODE and, in particular, in its Cross Cutting Task 9 (CT9), the set-up of a dedicated intercomparison exercise has been decided. The goal is to evaluate the robustness of air quality models when studying projections and to address the issue of the sensitivity of model responses to emission changes, in particular to identify, investigate and possibly reduce model discrepancies. This will allow for robust support to model users and developers, and, consequently, policy makers.

The goal of this presentation is three-fold: (i) presenting the FAIRMODE CT9 platform and the set of models involved, (ii) introducing the benchmark tool used to evaluate model differences, and (iii) providing a first evaluation of model responses to emission changes through the use of adequate statistical indicators.

Authors
Bertrand Bessagnet, Kees Cuvelier, Alexander de Meij, Alexandra Monteiro, Enrico Pisoni, Philippe Thunis, Angelos Violaris, Jonilda Kushta, Bruce R. Denby, Qing Mu, Eivind G. Wærsted, Marta García Vivanco, Mark R. Theobald, Victoria Gil, Ranjeet S Sokhi, Kester Momoh, Ummugulsum Alyuz, Rajasree VPM, Saurabh Kumar, Elissavet Bossioli, Georgia Methymaki, Darijo Brzoja, Velimir Milić, Arineh Cholakian, Romain Pennel, Sylvain Mailler, Laurent Menut, Gino Briganti, Mihaela Mircea, Claudia Flandorfer, Kathrin Baumann-Stanzer, Virginie Hutsemékers, Elke Trimpeneers

Long range source apportionment of Black Carbon and Carbon Monoxide over Cyprus using FLEXPART and global emission inventories

Seyed Omid Nabavi

Climate & Atmosphere Research Centre of Excellence - The Cyprus Institute

Recent studies show that effective pollution control strategies have led to a significant reduction in air pollution in Cyprus. However, the same studies attributed a large number of pollution episodes to the long-range transport of pollutants from regional sources. Black carbon (BC) and carbon monoxide (CO), with a lifetime of several weeks to several months in the troposphere, are considered reliable aerosol and gaseous pollutants to quantify the contribution of regional sources. This study aims to investigate the contribution of anthropogenic sources to atmospheric pollutants over the Eastern Mediterranean. Using FLEXPART, a Lagrangian dispersion model, the origin and residence time of air masses over Cyprus from Europe and the MENA region have been simulated with a temporal resolution of 3 hours for each day of 2019. Then, by coupling FLEXPART simulations to global emission inventories, including MACCity and CAMS-GLOB, the contribution of sources to CO and BC simulations in Cyprus was determined separately for each sector and country in the study area. Results show that CO concentrations are mainly modulated by sources in Turkey. Secondary sources are found in MENA (Iran, Iraq, and Syria) in the cold period of the year and Eastern (Ukraine and Russia) and Western Europe (Germany and Italy) in the warm seasons. While CAMS-GLOB simulations identify the main sources in agricultural (in the cold period) and residential (in the warm period) sectors, traffic sources have also been identified with the largest contributions in MACCity simulations. Regarding BC simulations, most sources are found in Turkey in the agricultural (in CAMS-GLOB simulations) and industrial (in MACCity simulations) sectors. Local sources were found influential only on the MACCity BC simulations. This can be attributed to uncertainties in the emission inventories and in the simulations of atmospheric residence times. Our results can inform policy- and decision-makers in implementing efficient abatement strategies, improving air quality, and reducing human exposure.

Authors

S. Omid Nabavi, Theodoros Christoudias

Ship plume modeling based on CALPUFF AND WRF: towards a first estimate of individual ship NOx emissions from space

Aristeidis Georgoulias
Aristotle University of Thessaloniki

Ships are strong emitters of nitrogen oxide (NOx = NO + NO2) with the global shipping fleet being responsible for a significant fraction the global nitrogen (N) emissions. To decrease NOx emissions, the International Maritime Organization (IMO) has implemented progressive regulations related to the ships' engine and fuel type. Unfortunately, ship emission monitoring and consequently enforcing regulations on a global scale is not possible at the moment. Recently, we showed that TROPOMI/S5P is capable of detecting ship NO2 plumes being also sensitive to the corresponding NOx emissions (Georgoulias et al., 2020). The next step is to develop methods to monitor the amount of NOx emitted from individual ships sailing in the open sea from space. Towards this direction, we have developed a 3-D ship plume modeling system based on the California Puff dispersion model (CALPUFF) and the Weather Research and Forecasting Model (WRF). Here, we present high-resolution plume simulations focusing on a container ship that sailed in the central Mediterranean on 2 July 2018 and a simple method that incorporates TROPOMI/S5P tropospheric NO2 satellite measurements, AIS ship location data, and wind field data from the ERA-Interim reanalysis that gives us a first estimate of the NOx emitted from the specific ship.

Georgoulias A.K., Boersma K.F., van Vliet J., Zhang X., van der A R., Zanis P., de Laat J., Detection of NO2 pollution plumes from individual ships with the TROPOMI/S5P satellite sensor, Environmental Research Letters, 15, 124037, doi:10.1088/1748-9326/abc445, 2020.

Authors
Aristeidis K. Georgoulias, Serafim Kontos, K. Folkert Boersma, Jasper van Vliet

Quantifying nitrogen oxides emissions in the EMME region using TROPOMI observations

Anthony Rey-Pommier

Laboratoire des Sciences du Climat et de l'Environnement / Climate & Atmosphere Research Centre of Excellence - The Cyprus Institute

Urban areas and industrial facilities are major sources of air pollutants, as they concentrate a large part of human activity and industrial production. For most of these pollutants, emission inventories are highly uncertain, especially in developing countries. In this context, satellite observations can be used to observe column densities of chemical species to constrain uncertainties in inventories. Here, we use three years of TROPOMI daily nitrogen dioxide (NO2) retrievals to map nitrogen oxides (NOx) emissions at high resolution in Egypt, Qatar and Cyprus. We use a flux-divergence scheme, which expresses NOx emissions as the sum of a wind transport term and a chemical sink term representing the reaction between NO2 and hydroxyl radical (OH). The model allows to identify major NOx hotspots. Among these, heavy industrial facilities, such as cement plants and fossil-fuel fired power plants, are characterized by a predominance of the transport term over the sink term. Heavily populated urban centers can also be identified, with a predominance of the sink term. In Egypt, our model is able to detect a weekly cycle in NOx emissions, reflecting Egyptian social norms, and to quantify the drop of emissions in 2020 due to the Covid-19 pandemic. In Qatar and Cyprus, emissions from isolated gas power plants can be quantified; they are consistent with the electricity consumption in these countries. These results demonstrate a high potential for satellite-based emission mapping at the scale of cities and countries, provided that a sufficiently large coverage of clear-sky days is available. The development of similar applications is likely to allow a better monitoring of global anthropogenic emissions.

Authors

Anthony Rey-Pommier

Is residential wood burning an important issue in atmospheric chemistry, light absorption and radiative forcing over the Eastern Mediterranean?

Dimitris Kaskaoutis
National Observatory of Athens

Biomass burning (BB) is a major source of absorbing OC that strongly contributes to radiative forcing at regional and global scales. Yet, in the Eastern Mediterranean, radiative impacts of absorbing aerosols over urban areas remain largely unknown.

This study examines spectral absorption properties of carbonaceous aerosols during winter and summer in Ioannina, Greece, one of the most heavily impacted by winter BB cities in the region. The analysis focuses on the concentrations of carbonaceous aerosols (including saccharides) through daily PM2.5 filter sampling, along with multi-wavelength Aethalometer monitoring. PM2.5 filter extracts were analysed spectrophotometrically for water-soluble (WS) and methanol-soluble (MeS) BrC absorption. Mass absorption efficiencies (MAE) of WSOC and MeS were calculated by dividing with respective mass concentrations. Radiative forcing estimates for WS_BrC, MeS_BrC relative to EC, were analysed for the first time in the Eastern Mediterranean.

Very high winter-mean OC concentrations (26.0 μg m-3) were observed, with an OC/EC ratio of 9.9, mean PM2.5 and BCwb levels of 57.5 and 4.5 μg m-3, respectively, and record-high levoglucosan (Lev) concentrations (mean: 6.0 μg m-3), revealing a severely BB-laden environment in winter. The water-soluble OC (WSOC) accounted for 56 ± 9% of OC, while the mean Lev/OC ratio (22%) was remarkably high. Very high BB contributions to OC (~92%), EC (~64%) and WSOC (~87%) were estimated via a levoglucosan mono-tracer method in winter. The WS_BrC absorption at 365 nm was 13.9 Mm-1, while that of MeS_BrC was 21.9 Mm-1. The MAE values for WS_BrC and MeS_BrC at 365 nm were calculated at 1.15 and 1.81 m2 g-1, respectively, during winter. The estimated radiative effects of WS_BrC and MeS_BrC relative to EC were 48.5% and 60.2%, respectively, in the 300–400 nm, indicating significant radiative impact of residential wood burning aerosols in the eastern Mediterranean during wintertime.

Authors
D.G. Kaskaoutis, D. Paraskevopoulou, G. Grivas, S. Bikkina, M. Tsagkaraki, K. Papoutsidaki, K. Tavernaraki, K. Oikonomou, I. Stavroulas, A. Bougiatioti, E. Liakakou, J. Sciare, E. Gerasopoulos, N. Mihalopoulos

PM 2.5 sources in the East Mediterranean-Middle East city Beirut: chemical characterization and contribution to ambient concentrations

Nansi Fakhri
Université Saint-Joseph, Beirut, Lebanon

Air pollution and climate change are important risk factors to the health of the East Mediterranean and Middle East (EMME) population in the coming decades. Therefore, identifying and quantifying pollution sources is crucial. A field campaign was conducted in 2014 during the warm season in the megapole of Beirut – Lebanon and showed PM2.5 concentration exceeding the WHO guidelines of 5 µg/m3 by a factor of six. Assessment of long-range transport using FLEXPART determined specific V/Ni ratios for air masses coming from Turkey and Eastern Europe, North Africa and Western Europe. Using more than 50 organic markers, the Carbon Preference Indices and the Wax% showed that anthropogenic emissions play an important role in Beirut. Moreover, PM2.5 source apportionment using positive matrix factorization (PMF) including both organic and inorganic species has been established for the first time in a Middle Eastern country. This study revealed that long-range transport of crustal dust and secondary sulfate were the dominant sources, accounting for ~ 35% of the measured mass. Results of this study clearly indicate the major role of road transport (25%) especially in the urban area, which is an important source of emissions in the region. The inclusion of organic molecular markers in PMF allowed the identification of 4 sources namely vegetation (2%), secondary organic aerosols (10%), cooking emissions (5%), and most importantly diesel generators (1%). Even though diesel generators presented a very small contribution in term of mass (~0.30 µg/m3) compared to other sources such as crustal dust (~6 µg/m3), the health risk associated with this source along with the one from road transport emissions would be detrimental when one considers metrics other than mass concentration, like the oxidative potential or the health risk assessment. These constitute the major sources of potent species in Beirut.

Authors
Nansi Fakhri, Marc Fadel, Fatma Öztürk, Melek Keleş, Minas Iakovides, Michael Pikridas, Charbel Abdallah, Cyril Karam, Jean Sciare, Patrick L. Hayes*, Charbel Afif*

Studying the transboundary transport of atmospheric aerosols in the EMME region

Franco Marenco

Climate & Atmosphere Research Centre of Excellence - The Cyprus Institute

I will present the newly formed Remote Sensing group at the Climate and Atmosphere Research Centre of the Cyprus Institute, and the group's ambitions for future development. The vision is to develop the tools and skills to enable the study of the transboundary transport of atmospheric constituents (and aerosols in particular). These particles can travel for hundreds or thousands of kilometres, crossing boundaries and transferring to regions distant from where they have been emitted. The interest, initially focused on Cyprus, is to pursue research across the EMME region by exploiting existing and new observational infrastructure, by taking part in intensive campaigns, and by integrating observations with a modelling component.

The key areas of development are: (1) long-term atmospheric observations and (2) intensive field campaigns, and (3) to provide high quality data to improve atmospheric simulations and predictions. A ground-based remote sensing network is growing within the stations of the Cyprus Atmospheric Observatory. To complement these observations, "remote" in-situ observations are also being pursued with the Unmanned Systems Research Laboratory using specific aerosol probes on-board UAVs.

Satellite observations increment the more accurate ground-based ones with the spatial dimension, and are essential to study the transboundary transport of constituents emitted by volcanoes, human activities, and desert regions, and one of the avenues for future development is to build expertise in the team on satellite retrievals for composition. Moreover, exploiting (or building) ground-based networks in the EMME region could be key in adding a ground-truth dimension to the spaceborne observations. The purpose of this presentation is in part to present the new group and in part to receive feedback on the ideas for the future of the team.

Authors

Franco Marenco

Retrieval of aerosol optical depth using an all-sky imager and machine learning

Christos-Panagiotis Giannaklis
University of Patras

Aerosol optical depth, or AOD, constitutes a foremost aerosol optical property since it represents a dimensionless quantity analogous to the total aerosol burden within an atmospheric column, or equally, the degree that aerosols attenuate the incoming solar radiation. Several remote sensing techniques, including ground-based measurements and satellite observations, exist for retrieving AOD on a global and regional scale. In this work, an alternative and affordable methodology to retrieve the spectral AOD is presented, using the information contained in the images of the whole sky dome from an all-sky imager (ASI) in conjunction with artificial intelligence. Temporally synchronized images and AOD measurements from an ASI and a sun-photometer (from AERONET) respectively, recorded in Athens, Greece for almost a year (2021), are used to train a machine learning model (XGBoost) to retrieve AOD. The XGBoost model has as input parameters the RGB (Red, Green, and Blue) color intensities at different scattering angles, along with the saturated area of the sun (the pixels of the image that are considered burnt) and solar position. AOD is retrieved in three spectral channels (440, 500, and 675 nm), corresponding to the RGB color intensities, and compared with independent, cloud-screened, and quality-assured measurements provided by the co-located AERONET sun-photometer. ASI-based AODs correlate adequately with AERONET measurements, encompassing coefficient of determination values of about 0.83. In addition, the retrieved AOD revealed mean biases of around 0.005, showing a slight overestimation against AERONET reference retrievals. This study reveals the potential of using an ASI to accurately retrieve AOD, and the retrieved AOD measurements can be used to improve air pollution and climate change studies.

Authors
Christos-Panagiotis Giannaklis, Stavros-Andreas Logothetis, Vasileios Salamalikis, Panagiotis Tzoumanikas, and Andreas Kazantzidis

Performance evaluation of high-resolution and low-cost air quality monitoring network employing the VAISALA-AQT530 sensors for assessing urban road traffic variability

Roubina Papaconstantinou

Climate & Atmosphere Research Centre of Excellence - The Cyprus Institute

Air pollution is a major concern of our modern societies, due to its adverse effects on the human health and environment. Despite that, the spatial distribution of Air Quality (AQ) monitoring networks is still limited for providing detailed mapping of the concentration of different pollutants over urban agglomerates. New cost-effective AQ sensors have the potential to significantly contribute in increasing the spatiotemporal resolution of AQ measurements, due to their low cost and compact dimensions. In this study, a high-resolution air quality network of seven VAISALA Air-Quality Transmitters (AQT530) and three Weather Transmitters (WXT) was created in the city of Nicosia, Cyprus, for assessing the level of air pollution at different points around the capital. These measurements will be used as input to a high-resolution model for air quality modelling and forecasting. The analysis of nearly yearlong measurements assesses the road traffic monitoring and provides new insights into the spatial variability of trace gases (NO2, NO, CO, O3) and aerosol mass concentration (PM10, PM2.5) within the city. The network of the seven VAISALA AQTs, underlined the role of high spatial resolution measurements for identifying pollution hotspots and classifying the different locations as: background, urban background, urban, traffic and heavy traffic.

Authors

R. Papaconstantinou, S. Bezantakos, C. Savvides, H. Jaakkola, and G. Biskos

Does mineral dust influence new particle formation events?

Juan Andres Casquero-Vera
University of Helsinki

Detailed knowledge on the formation of new aerosol particles in the atmosphere from precursor gases, and their subsequent growth, commonly known as New Particle Formation (NPF) events, is one of the largest challenges in atmospheric aerosol science. NPF events have a substantial contribution to aerosol particle number concentration and they affect the climate mainly via aerosol-cloud interaction. Despite the advance in the theoretical knowledge of NPF steps, large discrepancies have been found between the expected and observed properties of NPF under atmospheric conditions (Kulmala et al., 2014). High pre-existing particle loadings are expected to suppress the formation of new atmospheric aerosol particles due to high coagulation (CoagS) and condensation (CS) sinks. However, NPF events are regularly observed in conditions with high concentrations of pre-existing particles and even during intense dust intrusions (Casquero-Vera et al., 2020) that imply discrepancies between the observations and theory.

North African and Arabian desert areas are among the most important sources of dust in the world. Due to their proximity, the Mediterranean basin and Arabian regions are frequently affected by mineral dust transport from these desert regions, and events of dust have become more frequent and intense in the last years. Although NPF is not expected to occur during mineral dust events (because of high CoagS and CS by dust), NPF events have been observed in remote sites under dusty conditions (Nie et al., 2014; Casquero-Vera et al., 2020). The chemical composition of desert dust particles may be an important factor in the occurrence of NPF events during dust events. Laboratory and observational studies (Dupart et al., 2012; Nie et al., 2014) have revealed that the presence of TiO2 and Fe2O3 (which are common components of mineral dust) under UV light could promote the occurrence of NPF during dusty conditions. These components, acting as catalysts, are not consumed in the photo-catalytic reaction and can accelerate atmospheric photochemistry repeatedly.

The objective of this work is to study the occurrence of NPF events under the presence of mineral dust particles in dust-influenced areas. For this purpose, characterization of NPF events at different locations highly influenced by mineral dust has been done under dusty and non-dusty conditions. We utilized stations at different locations that have continuous measurements of aerosol size distribution in the fine and coarse fraction (SMPS and APS/OPS measurements) and we identified and classified the NPF events at each site. We also, determined the NPF event frequency, formation and growth rates and CS of the NPF events. The presence of mineral dust particles during NPF events is determined using APS/OPS measurements and validated with AERONET retrievals and satellite images. The study of mineral dust transport is done using HYSPLIT backward-trajectories that allow the identification of different dust sources. Additional measurements of cloud-cover and solar radiation are also analysed. The results for different stations from western Europe to Arabia show that NPF events are frequent in remote areas under the presence of mineral dust particles. Further work will relate NPF events with different desert dust regions that will serve to give insights about the impact of mineral dust chemical composition on NPF events.

Authors

J.A. Casquero-Vera, D. Pérez-Ramírez, H. Lyamani, L. Dada, S. Hakala, T. Hussein, P. Paasonen, K. Lehtipalo, F. Rejano, A. Casans, G. Titos, N. Pérez, S. Rodríguez, N. Kalivitis, A. Hyvärinen, A. Alastuey, F.J. Olmo, T. Petäja and L. Alados-Arboleda

Mineral dust properties within different atmospheric layers during two dust events over Cyprus (Cyprus fall campaign 2021)

Maria Kezoudi

Climate & Atmosphere Research Centre of Excellence - The Cyprus Institute

An intensive campaign focusing on mineral dust observations was conducted over Cyprus between 18 October and 18 November 2021. The main purpose of this campaign was to study mineral dust properties within different atmospheric layers. This involved 36 UAV flights along with ground-based active and passive remote-sensing observations during two distinct dust outbreaks. Unmanned Aerial Vehicle(UAV)-sensor systems allowed for cost-effective height-resolved atmospheric observations within the lower troposphere taking advantage of the private runway and dedicated airspace of the Unmanned Systems Research Laboratory(USRL; https://usrl.cyi.ac.cy/;Kezoudi et al., 2021) of the Cyprus Institute in Orounda(Nicosia, Cyprus).

The observed dust layers were found to be extending from ground up to 5,000 m Above Sea Level(ASL). The Aerosol Optical Depth at 500-nm measured by our sun-photometers was found to be above 0.2 during dust events, and on some days reached up to 0.5. From the UAV-based observations, mass concentrations of up to 350 μg/m3 were recorded from ground to ~3,000 m ASL with the presence of particles in coarse to giant sizes (up to 25 μm in diameter). Lower concentrations were observed between 3,000 m and 5,000 m ASL. The first dust event occurred between 25 October and 1 November, and HYSPLIT back-trajectories revealed that the observed air masses mainly originated from NE Sahara(Libya, Egypt). The second dust event was observed from 13 to 18 November 2021. HYSPLIT back-trajectories revealed that the air masses encountered at the beginning of the second event originated from the Middle East(Saudi Arabia, Syria), but the air mass origin switched to NW Saharan dust midways through the event.

The outcome of this study will be used for the assessment of regional and global dust forecast models. Feeding the models with height-resolved in-situ information by adding features on particle size, number and composition can improve model performance on predicting dust outbreaks.

Authors

Kezoudi M., Marenco F., Papetta A., Keleshis C., K. Kandler, Girdwood J., Stopford C., Wienhold F. G., Gao R. S. and Sciare J.

Dust aerosols spatiotemporal variability and drivers

Nabila Bounceur
National Center of Meteorology

The Kingdom of Saudi Arabia is extending its energy mix for power generation by investing in solar energy to be in line with the long vision of climate change mitigation and the perspective worldwide of reducing energy consumption. Any decision-making about the sustainable development of solar energy must rely on the assessment of solar resources while including uncertainties related to different factors affecting solar potential especially desert dust spatiotemporal variability. Indeed, spatial distribution and variability of desert dust have implications on climate and the environment but also affect socio-economic sectors such as solar energy production. Moreover, Saudi Arabia is affected by sand storms triggered among others by winds from multiple sources including the Sahara Desert. Therefore, we rely on high-resolution reanalysis data to assess the dust distribution and dust aerosol concentration spatiotemporal variability. Moreover, we provide statistical causality analysis between dust aerosols of multiple sizes and the climate variables (i.e. air temperature and wind speed) to asses the wind-dust relation. The influence that one variable has on another is dynamic hence we use adequate statistical approaches for the identification of dependency relations among the variables and the contribution each factor has on solar potential. Determining whether and where both solar potential, dust load, and humidity may change under actual condition and climate change, lead to a more adequate assessment of locations and technologies for any large-scale solar power project.

Authors
Nabila Bounceur, Jumaan Al Qahtani

Auxiliary task learning for early warnings of dust events: evidences from the Eastern Mediterranean

Ron Sarafian
Weizmann Institute of Science

Events of high dust loading are extreme meteorological phenomena with important climate and health implications, occurring frequently in the Eastern Mediterranean and the Middle East (EMME). Therefore, early forecasting is critical to mitigating their adverse effects.
Dust modeling is a longstanding challenge due to the multi-scale nature of the governing meteorological dynamics and the complex coupling between atmospheric particles and the underlying atmospheric flow patterns. Past studies suggest that a range of meteorological conditions are associated with dust emission over the global dust belt, most of all the Sahara desert, and its subsequent long-range transport to the EMME. Commonly, physics-based numerical modeling is used for dust forecasting. However, the assumptions regarding the underlying generative process make theory-driven dust event forecasts highly model-dependent.
In this work, we propose a Deep Neural Network model for dust events forecasting in 12 to 72 hours lead time. The model is based on meteorology and atmospheric data (e.g., sea-level pressure, winds, potential vorticity, aerosol-optical-depth, etc.), and in-situ PM10 measurements. It has a novel auxiliary-task framework designed to overcome the unique statistical learning challenges that the data poses. In this framework, in addition to the local PM10 forecast (primary task), we predict the regional PM10 field (auxiliary task), thus, leveraging valuable information from a correlated task.
We train the model over 18 years of three-hourly dust samples taken in Israel. Our model can forecast 76% of the events. Analysis shows that local dynamics drive most misclassified events, meaning that the coherent driving meteorology in the region holds a predictive skill. Further, we employ state-of-the-art explainable AI methods to reveal the spatio-temporal importance the network attributes to the predicting variables and find that it learns patterns that confirm recent findings regarding the factors that cause dust events in the EMME.

Authors
Ron Sarafian*; Dori Nissenbaum*; Shira Raveh-Rubin; Yinon Rudich
Department of Earth and Planetary Sciences, Weizmann Institute of Science, Rehovot 76100, Israel

Four types of dust events in Israel from a systematic classification

Dori Nissenbaum
Weizmann Institute of Science

Events of elevated dust concentrations are hazardous to society, and can cost each up to hundreds of million dollars. Suspended particulate matter of diameter 10 microns and less (PM10) are of particular concern as they are inhalable and can lead to multiple short- and long-term health problems. Accurate and timely forecasts of dust events are therefore valuable to mitigate their impact and allow for better societal protection. Previous studies highlighted the role of cyclones in the Mediterranean, North African coasts or the Arabian Peninsula. However, climatological understanding of the link between weather systems and the evolution of dust storms is currently lacking. Systematic classification of dust events can quantify and distinguish the governing weather systems and thus aid in their prediction.
Here, we use ground PM10 measurements in Israel to objectively identify a climatological set of extreme dust events between 2003-2018. By combining ERA5 and CAMS reanalyses we apply a new, unsupervised and unbiased method to classify these events. Four coherent types emerge, corresponding to events governed by Mediterranean cyclone, North African cyclone, Arabian anticyclone, and local factors, respectively. Having also different seasonality, these classes are insightful in mapping the meteorological conditions and weather systems governing the dust emission and transport towards Israel. In this context, slantwise-descending dry intrusions, yet to be explored in this region, are shown to be a key precursor dynamical feature common to the buildup of elevated dust concentrations in three of the clusters. The results suggest that dust events belonging to those three clusters hold a larger degree of predictability compared to the fourth (summer) cluster that is governed by more local (and less predictable) dynamics. The method is expandable to other regions around the world.

Authors
Dori Nissenbaum*; Ron Sarafian*; Shira Raveh-Rubin; Yinon Rudich

Improving weather and climate services in the Middle East and North Africa through the WISER MENA programme

Luke Norris
Met Office

Extreme weather, climate variability, and climate change remain significant and growing threats to sustainable development across Middle East and North Africa. The provision of co-produced weather and climate information services that are useful, usable and used enable people, governments and industry to anticipate, prepare and act, building resilience in a changing climate. The Weather and Climate Information Services (WISER) programme has been delivering transformational change in weather and climate information services uptake across Africa since 2016. It enabled enhanced information for over 3.3 million households and delivered over £200 million of socio-economic benefit. Following this success and responding to climate risks, the UK's Foreign, Commonwealth and Development Office (FCDO) asked the Met Office to adapt the concept to the MENA region. WISER MENA is a £5 million programme (2022-2026) aiming to deliver change in the generation and use of co-produced weather and climate services to support decision making at all levels, building resilience to the impacts of climate change.

The presentation will share key insights from the WISER MENA Scoping Report (July 2022). This report explores needs and opportunities for improved weather and climate information across the MENA region obtained through literature reviews and key informant interviews with stakeholders.
The report identifies thematic areas for opportunity for WISER MENA: understanding of, and demand for weather and climate information in the MENA region; build resilience to extremes by supporting vulnerable communities; enhance seasonal forecasting in the region; support to weather and climate service initiatives in the region. WISER MENA is now in further consultation with regional stakeholders to test and update evidence and assumptions on regional needs.
This presentation aims to bring attention to the WISER MENA programme and its relevance in addressing regional challenges, build a network of key stakeholders and align with similar activities ongoing in the region.

Authors
Veronesi, M., Ticehurst, H., and Khan, M.

EU funded Trans-National Access opportunities of Atmospheric Research Infrastructures in the EMME region

Efstratios Bourtsoukidis

Climate & Atmosphere Research Centre of Excellence - The Cyprus Institute

A large number of state-of-the-art atmospheric facilities are available in Europe to support related research activities. These, are typically embedded in atmospheric research infrastructures (RIs) that offer access and high-quality services to different user communities and user needs. The focus of atmospheric RIs is international by nature, and they are involved in supporting research of pressing global challenges such as climate change and air quality deterioration. The EU funded 'Sustainable Access to Atmospheric Research Facilities (ATMO-ACCESS)' project is the organized response of distributed atmospheric research facilities for developing a new model of integrating activities. Physical, remote and virtual access are now complemented with a training dimension, ensuring that new generations of researchers will acquire both knowledge and skills to optimally exploit all the tools for their research. In talk, the National RIs that operate in the wider East Mediterranean and Middle East (EMME) region (i.e. Cyprus and Greece) will be presented together with examples on research and training oriented activities. Finally, the currently active 3rd ATMO-ACCESS call for proposals will be presented alongside the processing procedure and hints for the applicants.

Authors

Efstratios Bourtsoukidis and the ATMO-ACCESS team

Climate change and weather extremes in the Eastern Mediterranean and the Middle East

George Zittis

Climate & Atmosphere Research Centre of Excellence - The Cyprus Institute

Observation-based and modelling studies have identified the Eastern Mediterranean and Middle East (EMME) region as a prominent climate change hotspot. While several initiatives have addressed the impacts of climate change in parts of the EMME, here we present an updated assessment, covering a wide range of timescales, phenomena and future pathways. Our assessment is based on a revised analysis of recent observations and projections and an extensive overview of the recent scientific literature on the causes and effects of regional climate change. Greenhouse gas emissions in the EMME are growing rapidly, surpassing those of the European Union, hence contributing significantly to climate change. Over the past half-century and especially during recent decades, the EMME has warmed significantly faster than other inhabited regions. At the same time, changes in the hydrological cycle have become evident. The observed recent temperature increase of about 0.45°C per decade is projected to continue, although strong global greenhouse gas emission reductions could moderate this trend. In addition to projected changes in mean climate conditions, we call attention to extreme weather events with potentially disruptive societal impacts.

Authors

Zittis G, Almazroui M, Alpert P, Ciais P, Cramer W, Dahdal Y, Fnais M, Francis D, Hadjinicolaou P, Howari F, Jrrar A, Kaskaoutis D G, Kulmala M, Lazoglou G, Mihalopoulos N, Lin X, Rudich Y, Sciare J, Stenchikov G, Xoplaki E & Lelieveld J

Future changes of compound drought and heat wave events over cyprus under global warming

Kostas Philippopoulos
National and Kapodistrian University of Athens

Compound events result from the combination of extreme events that amplifies their impacts through feedback mechanisms that contribute to increased societal risk. Compound events are an area of deep uncertainty, and this work focuses on providing insight into the probability of the occurrence of compound drought and heat wave events (CDHW) over Cyprus. The scope is to evaluate the current state of climate over the study area in terms of CDHW and to assess changes between the recent past/ present climate and multiple future sub-periods for two different representative concentration pathways (RCP 4.5 and RCP 8.5). Climate data are extracted from multiple bias-adjusted regional climate model simulations at a spatial resolution of 0.11 degrees. Extreme indices are used for identifying meteorological droughts and heat waves and in this work, the Standardised Precipitation Index (SPI) and the Excess Heat Factor (EHF) are employed. Total monthly precipitation records are used for calculating SPI and daily maximum and minimum temperature values for the EHF index. The extreme indices time series are further examined in terms of identifying and quantifying their trends using the Mann–Kendall non-parametric test and Sen's linear slope estimator. The climate projections results indicate an intensification of droughts and heatwaves and, particularly, in a compound manner. The complexity of the climate system poses a great challenge regarding the risk assessment associated with correlated compound drivers and the results of this work provide the required scientific evidence for improving the resilience and preparedness of the critical sectors affected by CDHW.

Authors
Kostas Philippopoulos, Constantinos Cartalis, Ilias Agathangelidis, Anastasios Polydoros, and Thalia Mavrakou

A multidecadal analysis of Malta's climate – trends and extreme events, 1952-2022

Charles Galdies
University of Malta

The latest extended analysis of climatological data collected over a period of 60 years over the Maltese islands (35.87oN; 14.47oE) will be presented. This work is based on a select list of essential weather and climatic elements observed between 1952 till 2022. The key highlights of this study include (1) Malta's annual mean air temperature is now around 1.5oC higher since 1952, which is equivalent to an increase of 0.2oC per decade; (2) observed rainfall has decreased by 10.3mm per decade; (3) the wind speed shows a declining trend of 0.8 knots; (4) the highest mean sea temperature shows a decadal increase of 0.4oC since 1978. Extreme events and climate anomalies with respect to the Climate normal of 1961-1990 have also been studied, especially those that have a compounding effect on the local climatology. A case study of 2016 will be presented, during which a number of record anomalies were observed for rainfall, air temperature, and atmospheric pressure. record monthly rainfall anomaly occurred contemporaneously.

Authors
Charles Galdies

Comparison of projections of extreme precipitation indices for Jordan from high-resolution euro-CORDEX and MASHREQ domain RCM simulations

Amna Jrrar
Royal Scientific Society

We present projections of future changes in precipitation and a set of selected extreme precipitation indices over Jordan for the intermediate future (2046-2065) relative to the baseline period (1986-2005), the indices are Consecutive Dry Days (CDD), Consecutive Wet Days (CWD), heavy precipitation days >10 mm (R10), very heavy precipitation days >20 mm (R20) and the Simple Precipitation Intensity Index (SDII). The comparative analysis is based on two ensembles, the first is an ensemble of 12 high-resolution EURO-CORDEX regional climate model (RCM) simulations covering the future period 2006-2100 under the influence of a no mitigation Representative Concentration Pathway (RCP8.5), and the second is an ensemble of six RCM simulations of the new Mashreq domain covering the future period 2015-2070, under the shared socioeconomic pathway SSP5-8.5.
While both ensembles agree that areas currently with highest rainfall amounts (north-west of the country) could have a reduction in precipitation by up to 20 %, they disagree on the sign of change in areas currently with low rainfall (eastern and southern regions), which appear to receive a higher amount of rain in the Mashreq domain ensemble, with these areas also showing an increase in CWD, R10, R20 and SDII.

Authors
Amna Jrrar and Dana Odeh

Strong control of aerosol-cloud interactions by emissions from the boreal forests

Tuukka Petäjä
Institute for Atmospheric and Earth System Research INAR / University of Helsinki

Boreal forest store carbon and acts as a carbon sink for the carbon dioxide. At the same time, the boreal forests emit volatile organic compounds and contribute to the formation of secondary organic aerosols. With observed data set from SMEAR II site in Hyytiäläl, I will show that the secondary aerosols produced in the boreal atmosphere alter warm cloud microphysics and cloud–aerosol interactions in synopic scales. Our observations show that there is a substantial increase in aerosol number and mass concentrations over the forest one to three days after clean marine air enters the forest environment. This is consistent with secondary organic aerosol number and mass formation. The changes in the aerosol population together with evapotranspiration from the biosphere, there are observed changes in the radiative properties of warm, low-level clouds. The modifications to the cloud droplet number concentration suggest that the boreal forests have the potential to mitigate climate change on a continental scale.

The presentation combines data from several recent papers on the biogenic aerosol - cloud -climate feedback analysis:

Petäjä et al. (2022) Influence of biogenic emissions from boreal forests on aerosol–cloud interactions, Nature Geosci. 15, 42-47, doi.org/10.1038/s41561-021-00876-0.

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Authors
Tuukka Petäjä

Water stress and sustainability challenges: Evidence from Saharan African Countries (SSA)

Doaa Sers Salman
MSA University

The study's aims are three folds: first assesses the driving factors affecting environmental performance in Sub-Saharan countries. The second investigates the impact of water scarcity on sustainable development in Sub-Saharan countries by using the available data for the environmental performance index (EPI) over the period 2000 to 2010 – which is the only complete and available time series. Third, identify the impact of carbon dioxide emission on EPI. An empirical dynamic autoregressive distributed lag (ARDL) approach is developed to study the long-term equilibrium and short-term adjustments using a panel for selected countries in Sub-Saharan countries.

Authors
Doaa Salman and Mohamad Mussad Ibrahim Rajab

Can Electric Vehicles Improve Urban Air-Quality and Save Lives?

Constantinos Hadjistassou

School of Sciences and Engineering-University of Nicosia

Objectives: Studies examining the link between traffic and residential heat pollutant emissions in Cyprus are scarce. This investigation has considered the levels CO, NOx, PM2.5, and PM10 and reconciled them with actual air quality measurements in Nicosia, Cyprus, during a 9-month period at an hourly resolution. Several scenarios were designed to address emissions and minimise human mortality risks in the city.
Methods: The GRAL dispersion model proposed here was used to project pollution levels. Nine different traffic scenarios were devised to estimate variations in concentration of PM2.5 and NOx under various policies, such as banning diesel passenger vehicles (PV), light duty vehicles (LDV), non-Euro 6 standards vehicles, stricter speed limits and a ubiquitous roll-out of electric passenger vehicles. Moreover, 4 distinct cases were analysed to year 2030 considering a fluctuation in traffic of ±20% whereas all vehicles conform to Euro 6 standards. Three additional policies examined the prohibition of diesel PV and LDV, 80% electric PV and outlawing fireplaces. Drawing on the findings of these scenarios and cases, the total cardiovascular and respiratory mortality rates at the capital of Cyprus, Nicosia, were deduced.
Results: The most promising scenario in terms of curbing emissions was to ban non-Euro 6 vehicles and diesel PV and LDV which could lower average NOx concentration, in Nicosia, from 52.9 μg/m3 to 15.0 μg/m3. If this policy were to be implemented, it could have saved 70% of the premature deaths tied to NOx emissions. For particulate matter, banning fireplaces and abandoning non-Euro 6 vehicles could lower average concentrations from 18.3 μg/m3 to 13.1 μg/m3, saving at least 30% of the people poised to lose their lives from particulate matter risks.
Conclusion: Our study has demonstrated that the most effective policies for curbing NOx emissions would be to ensure that all vehicles abide with the Euro 6 standards and, concurrently, ban diesel passenger and light duty vehicles. Lastly, phasing out domestic fireplaces appears to be the most promising solution for containing particulate matter, in 2030.

Authors
Evangelos Demetriou, Constantinos Hadjistassou

Quantifying the effect of temperature on human mortality in Cyprus in response to air quality and other environmental factors

Theo Economou

Climate & Atmosphere Research Centre of Excellence - The Cyprus Institute

We investigate the effects of temperature on human mortality on the island of Cyprus using 15 years of daily mortality data. A hierarchical statistical approach is used on daily mortality counts to characterise mortality incidence as a function of temperature over the past three weeks, modulated by various environmental factors including geographical location. The mortality data is stratified by age and gender to investigate whether different demographics are affected differently. Results indicate that temperature modulates mortality in an important way, much in line with other studies in other countries. When also considering the effect of humidity, the results are somewhat counterintuitive, while there is little evidence of an interaction between PM10 and temperature. Differences between the 5 districts are marginal, while different different age groups seem to respond differently to temperature. Season and gender do not seem to influence the temperature-mortality association much. The results are important since this is the first study to simultaneously quantify the temperature-lag effects on human mortality as a function of other variables, with important implications on how the response to temperature will change in the future.

Authors

Theo Economou

Seasonal inhaled deposited dose of particulate matter in the respiratory system of urban individuals living in an Eastern Mediterranean city

Tareq Hussein

Institute for Atmospheric and Earth System Research (INAR)

We present an estimation for the inhaled deposited dose rate in adult males and females during common exposure scenarios to urban background aerosols in an Eastern Mediterranean city (Amman, Jordan) based on a one-year database of measured particle number size distribution. The dose rates show seasonal variations reflecting the physical characteristics (i.e., modal struc-ture) of the particle number size distribution. An additional factor was the varying deposition fraction (DF) for different regions and different human activities (exercising versus resting). The total dose rate was 3 × 109–65 × 109 particles/h (PM2.5 and PM10 doses 1–22 μg/h and 9–210 μg/h; respectively) depending on the gender, activity, and season. Based on the particle number metrics, the inhaled deposited dose in the head, Tracheobronchial, and alveolar were 7%–16%, 16%–28%, and 56%–76%; respectively. Based on the PM2.5 metric, the corresponding dose rate was 9%–41%,13%–19%; and 46%–72% respectively. As for the PM10 metric, they were 25%–75%, 7%–35%, and 15%–55%; respectively.

Authors

Tareq Hussein

Large increases in heat-related mortality burdens projected for the Middle East and North Africa under climate change scenarios

Yiannis Proestos

Climate & Atmosphere Research Centre of Excellence - The Cyprus Institute

The Middle East and North Africa (MENA) is one of the world's most climate vulnerable regions and faces a unique set of environmental, socioeconomic, demographic and political challenges. We undertake a health impact assessment using bias-adjusted statistically downscaled CMIP6 SSP-based data and Bayesian inference to quantify current and future burdens of heat-related mortality in MENA and identify the most vulnerable countries. Under high emissions scenarios, most of the region will have experienced significant warming by the 2060s. Annual heat-related deaths of 123.4 per 100000 people are projected for MENA by end of century under a high emissions scenario (SSP5-8.5), but there would be a six-fold avoidance of heat deaths if global warming could be limited to 2°C (SSP1-2.6). Projections are far higher than previously observed in other regions, with Iran expected to be the most vulnerable country. Stronger climate change mitigation and adaptation policies are needed to avoid these impacts.

Authors

Yiannis Proestos, Shakoor Hajat, Jose Luis Araya-Lopez, Theo Economou and Jos Lelieveld

Mediterranean cyclones and severe weather warnings in Bulgaria

Stanislava Tsalova

Sofia University "St. Kliment Ohridski"

Mediterranean cyclones are the dominant synoptic scale patterns with a major impact on severe weather phenomena and are associated with 70% of weather related economical losses in Bulgaria. Since 2009 Bulgarian National Institute of Meteorology and Hydrology (NIMH) has issued 24-36 h ahead severe weather warnings as a contribution to the European Meteoalarm System (www.meteoalarm.org). For a 4-year period NIMH issued more than 500 weather warnings for heavy rain with risk of flooding, severe thunderstorms, gale-force winds, heat waves, forest fires, fog, snow or extreme cold with blizzards, avalanches or severe coastal tides. For the 2009-2021 period GNSS derived Integrated Water Vapor (IWV) from the only Bulgarian IGS station in Sofia will be used in conjunction with circulation classification types to analyze the water vapor transport for the days with Meteoalarm weather warnings in the region. Monthly climatology for warnings with yellow, orange and red codes will be prepared and analyzed.

Authors

Stanislava Tsalova,[1] Krasimir Stoev,[2] Anastasiya Stoycheva,[2] Guergana Guerova[1]

[1]Sofia University “St. Kliment Ohridski”, Physics Faculty, Department of Meteorology and Geophysics, 1164 Sofia, Bulgaria

[2]National Institute of Meteorology and Hydrology, 66 Tsarigradsko Shose blvd ,1784, Sofia, Bulgaria

Critical fire weather patterns of Greece: forecasting extreme fire weather conditions in the medium-range

Georgios Papavasileiou
National Observatory of Athens (NOA),
Institute for Environmental Research & Sustainable Development (IERSD), Greece

In this work we present a fire weather forecasting framework that employs the concept of critical fire weather patterns, developed and applied operationally by the METEO Unit of the National Observatory of Athens within the frame of the "FLAME" project. Identifying and characterising the critical fire weather patterns of a region is of great importance for developing early warning systems and supporting effective wildfire management, as well as for increasing awareness and preparedness of all the involved entities, including both the public and practitioners. Furthermore, considering climate projections over the Mediterranean, which indicate an environment more conducive to wildfire activity, the need for timely forecasting of extreme fire weather days becomes increasingly urgent. Within our fire weather forecasting framework, (a) we define the critical fire weather patterns of Greece, (b) we quantify the key fire weather conditions associated with each of them, and (c) we link each critical fire weather pattern with a different level of fire danger and expected fire behavior. For the purpose of this study, we use ERA5 reanalysis data, ERA5-based fire weather indices and burnt area data provided by the Hellenic Fire Corps. The main advantage of the presented forecasting framework is that it can be used for providing valuable information regarding the upcoming fire weather conditions even up to 10-12 days in advance. The operational use of the critical fire weather patterns started with the beginning of the 2022 fire season in Greece.

Acknowledgments
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Authors
Georgios Papavasileiou, Theodore M. Giannaros

Developing a common approach to estimate future burnt area in the Mediterranean under various climate change scenarios

Anna Karali
National Observatory of Athens (NOA)

Fires burn annually over 100,000 ha in the N Mediterranean and, over the 21st century, regional wildfires may double to triple in size. However, there is no single method used to estimate future Burnt Area (BA) throughout the Mediterranean. Most national fire management policies rely heavily on fire suppression and do not sufficiently address land management issues behind the inception and spread of fires. Over the past two decades the development of fire smart landscape management and Forest Landscape Restoration (FLR) highlighted the benefits of these integrated landscape management approaches, focused on fire prevention. Nonetheless, wildfire prevention is rarely transposed into existing knowledge management mechanisms and policies. In Southeast Europe, inadequate landscape governance mechanisms also hamper a proactive approach to fire prevention.

We developed a robust science-based methodology for estimating the Burnt Area (BA) under future climate change scenarios in regions located in Greece, Montenegro and southern France. At the target study areas fire danger modelling, utilizing the Fire Weather Index (FWI) and gridded observational meteorological data, established current fire danger conditions. Subsequently, the FWI, selected drought indices and meteorological variables were correlated against the regional BA data to create statistical projection models. Future fire danger will be calculated under RCP2.6, RCP4.5 and RCP8.5, with business-as-usual management, up to 2070. State-of-the-art regional climate models developed within the EURO-CORDEX initiative, will simulate future climate data that drive FWI and BA estimates. All data were sourced from EU-wide databases that are publicly accessible, for the methodology to be Mediterranean-wide applicable.

This methodology was developed for the project “MediterRE3 - REstoring REsilience of Mediterranean landscapes to REduce GHG emissions from wildfires” (https://www.euki.de/en/euki-projects/mediterre3/). The methodological approach permits up-scaling of the study results throughout the Mediterranean. It will enable stakeholders to formulate regional mitigation and adaptation plans and help them access new funding instruments.

Authors

Karali, A., van der Schriek, T., Varotsos, K.V., Kitsara, G., Giannakopoulos, C.

vPICO PRESENTATIONS

LIFE SIRIUS: A system for integrated environmental information in urban areas

Jonilda Kushta

Climate & Atmosphere Research Centre of Excellence - The Cyprus Institute

LIFE SIRIUS aims to improve governance in urban air quality planning and management, considering a holistic environmental approach through advancing knowledge, skills and competences of the responsible authorities, by providing a tangible pathway in order to scale-up and accelerate solutions aiming at tackling air quality issues, giving emphasis on health impacts and compound effects, and a robust framework for increasing awareness of environmental issues associated with poor air quality. The project brings together 7 partners of excellence from 3 EU Member States (Greece, Cyprus, Italy) with a representative geographical coverage concerning the targeted environmental problem (air quality), cross-cutting complementary competences and excellent track records in European projects.

LIFE SIRIUS will improve the quality of public authorities of the three targeted areas (Thessaloniki/Greece, Rome/Italy, Nicosia/Cyprus) at all levels in relation to preparatory, mitigation and adaptation actions foreseen in respective AQPs with two main goals: 1. To increase the capacity and improve the effectiveness and efficiency of public administration of the three regions involved in the project to upgrade the performance of AQPs in each city. 2 To develop common evaluation system regarding health effects of air pollution and future scenarios that will assess the evolution of the situation in selected future periods.

The project will develop an Environmental Management System as a vital decision support tool that will enhance AQPs and accommodate multidimensional elements for efficient and operational information flow, facilitate management decisions for corrective actions and enhance cooperation between decision-making bodies in the scope of AQP implementation.

Authors

Jonilda Kushta, Theodoros Christoudias, Daphne Parliari, Dimitris Melas

A lidar depolarization calibration approach using a reference system

Alkistis Papetta

Climate & Atmosphere Research Centre of Excellence - The Cyprus Institute

In this study, we will present a new approach for depolarization calibration of the Nicosia CIMEL CE376 lidar system, using the PollyXT in Limassol as a reference instrument. The presented method is also applied to the valuable measurements obtained during the Cyprus Fall 2021 campaign, which in synergy with the UAV-based in-situ measurements will be further analyzed to obtain the dust and other aerosol characteristics during the campaign. Understanding the aerosol vertical stratification can help in reducing the uncertainties related to aerosol radiative forcings which remain large. To achieve this, it is essential to know the aerosol characteristic shape, size and optical properties. Lidar depolarization measurements represent an excellent method to detect and quantify some specific aerosol types such as dust and volcanic ash, known as aerosol typing. However, an accurate calibration of the depolarization is required for good measurements and to subtract instrumental artefacts. Although the most accepted method for the calibration of the depolarization is the so-called +/-45 degrees method, in this case it did not yield a satisfactory calibration constant for the system, possible due to the cross talking effect. Instead, using observations in the free troposphere from the two lidars permitted to satisfactorily characterize the lidar: the applied methodology offers a promising opportunity to evaluate the depolarization calibration parameters of a lidar system, in cases where other methods do not suffice.

Authors

Alkistis Papetta, Franco Marenco, Maria Kezoudi, Rodanthi-Elisavet Mamouri, Argyro Nisantzi, Ioana Popovici, Philippe Goloub and Jean Sciare

Cloud type identification using an all-sky imager system

Andreas Kazantzidis
University of Patras

Clouds are pivotal in various disciplines of the atmospheric sciences. For instance, in solar irradiance forecasting studies, cloud information in terms of cloud base height, velocity, and type is the most challenging part concerning the forecast performance. In this study, a cloud type identification methodology is presented by exploiting the sky condition information as it is captured by an all-sky imager (ASI) system. More specifically, one-year (2021) continuous images of the whole-sky (180° view) derived from an ASI, installed at the station of the laboratory of atmospheric physics in Patras, Greece, are used to train and validate the performance of the applied methodology. In particular, the proposed methodology uses a k-Nearest-Neighbor algorithm, considering as inputs specific information derived from the ASI such as color intensity, the cloud coverage, the saturated area around the Sun, and the raindrop appearances and solar zenith angle. More specifically, the algorithm divides the clouds into seven groups: cumulus, cirrus-cirrostratus, cirrocumulus-altocumulus, stratocumulus, stratus-altostratus, cumulonimbus-nimbostratus, and clear-sky. The adequately good performance of the applied methodology is successfully tested by comparing the cloud type classification results against ground-based observations as recorded by the human eye of expert meteorologists. The findings of this work can be used in solar irradiance forecasting studies in order to improve their performance.

Authors
Andreas Kazantzidis, Panagiotis Tzoumanikas, Stavros-Andreas Logothetis, and Vasileios Salamalikis

Insights into the performance of low-cost optical particle sizers

Charis Loizidis

Climate & Atmosphere Research Centre of Excellence - The Cyprus Institute

Optical Particle Sizers (OPSs) are widely used for measuring size distributions of particles having sizes in the range of 0.2 – 20 μm. Their working principle is based on the light scattered by the sampled particles when those are passed through a focused light beam. Part of the scattered light is gathered by mirrors or lenses onto a photo-detector, producing a signal that is either continuous and proportional to the scattering events from an assemble of particles, or discrete with distinct pulses produced by scattering events from single particles. Although OPSs provide measurements that are proportional to the number concentration of the sampled particles, their measurements can be converted to fractional particulate mass concentrations – i.e., PM1.0, PM2.5 and/or PM10 – that are used for regulatory purposes. As a result, OPSs, albeit expensive, they are readily employed for ambient air particulate matter monitoring. To lift the limitation of their high cost, a number of manufacturers have developed low-cost and highly-portable OPSs instruments by using inexpensive components (i.e., optical systems and electronics), thereby warranting for further investigating the quality of the data they produce. In this work, we characterize the performance of a commercially available low-cost OPS using monodisperse PSL spheres of known sizes. Insights into the operating performance of this low-cost OPS are provided by analyzing its raw signals and comparing them with respective signals from reference-grade instruments.

Authors

Charis Loizidis and George Biskos

Real-time air quality forecasts over the Eastern Mediterranean using the WRF-CHEM model

George K. Georgiou

Climate & Atmosphere Research Centre of Excellence - The Cyprus Institute

We employ a regional, online coupled atmospheric chemistry and aerosol model to perform high-resolution, real-time air quality forecasts over the Eastern Mediterranean. The Weather Research and Forecasting model coupled with Chemistry (WRF-Chem) is used for daily, 3-day forecasts of regulated pollutants (NO2, O3, PM2.5) over the Eastern Mediterranean, applying three nested domains with horizontal resolutions of 50, 10 and 2 km, the latter focusing on Cyprus. Natural (dust, sea-salt, biogenic) emissions are calculated online, while anthropogenic emissions are based on the Emissions Database for Global Atmospheric Research – Hemispheric Transport of Air Pollution (EDGAR-HTAP) global emission inventory. A high spatial (1 km) and temporal (hourly) anthropogenic emission inventory is used for the island of Cyprus. The model skill in forecasting the concentrations of atmospheric pollutants is evaluated using measurements from a network of nine ground stations in Cyprus and compared with the forecasting skill of the EU Copernicus Atmosphere Monitoring Service (CAMS). The forecast of surface temperature, pressure, and wind speed is found to be accurate, with minor discrepancies between the modelled and observed 10 m wind speed at mountainous and coastal sites attributed to the limited representation of the complex topography of Cyprus. Compared to CAMS, the WRF-Chem model predicts with higher accuracy the NO2 mixing ratios at the residential site with a normalized mean bias (NMB) of 7 % during winter and −44 % during summer, whereas the corresponding biases for CAMS are −81 % and −84 %. Due to the high temporal resolution of the anthropogenic emission inventory, the WRF-Chem model captures more accurately the diurnal profiles of NO2 and O3 mixing ratios at the residential site. Background PM2.5 concentrations influenced by long-range transport are overestimated by the WRF-Chem model during winter (NMB = 54 %), whereas the corresponding NMB for CAMS is 11 %.

Authors

George K. Georgiou, Theodoros Christoudias, Yiannis Proestos, Jonilda Kushta, Michael Pikridas, Jean Sciare, Chrysanthos Savvides, Jos Lelieveld

Detection and attribution of greenhouse gasses and anthropogenic aerosols to compound heat index over Africa in CANESM5 large ensemble

Paul Adigun
University of Tsukuba

Observational evidence indicates that, during the last four decades, Africa has seen a major increasing trend in surface air temperature patterns, leading to increased temperature extremes. In this study, we investigate the possible contribution of anthropogenic forcing and greenhouse forcing to the observed increasing trend in extreme temperatures over the African continent using the Canadian Earth System model version 5 (CanESM5) large ensembles. We verified the model can reasonably capture the long-term patterns and magnitude and frequency of the thresholds of the temperature index considered, which are daily maximum annual temperature (TXx), daily minimum annual temperature (TNx), hot days when TXx is larger than the 90th percentile (TX90p), and hot nights when TNx is larger than the 90th percentile (TN90p). From 1950 to 2014, the linear trends show a significant increase in TXx and TNx of 0.03 °C/year and 0.02 °C/year, respectively, while TX90p and TN90p exhibit an increase of 0.18 °C/year and 0.15 °C/year, respectively. Our results show that aerosol (AER) forcing slows the pace at which the air's surface warms up, which in turn lessens the amount of warming. The observed significant increasing trend in surface air temperature and temperature extremes may be linked to GHG forcing. The two-signal analysis reveals that anthropogenic forcing (ANT) forcing had the most significant contribution across all four extreme indexes investigated. The three-signal analysis further reveals that greenhouse gas (GHG) aerosols (AER) and natural (NAT) signals are detected when three forcing components are taken into consideration. In TX90p, signals from GHGs, AERs, and NATs can be identified and distinguished over Africa. GHG signals can be detected in the vast majority of hot indexes considered, except for TX90p over central East Africa (CEAF). When all other indices are taken into account, GHG forcing plays the most dominant role. While aerosol forcing (AER) forcing slows the pace at which the air's surface warms up, natural forcing (NAT) is almost zero and can be neglected. Under the high-emission SSP245 and SSSP245-GHG scenarios, warming is expected to become more intense by the end of the 21st century, with TXx and TNx increasing by 5.5-6.0 °C.

Authors
Adigun Paul Ayodele, Akintomide Afolayan Akinsanola, Koji Dairaku, Ebiendele Eromosele Precious, Nguyen Ngoc Kim Hong

Evaluationn of urban representation in high resolution WRF simulations over the Eastern Mediterranean and Middle East

Katiana Constantinidou

Climate & Atmosphere Research Centre of Excellence - The Cyprus Institute

Urbanization influences the climate at local, regional and global scales as it induces substantial changes in land surface properties of an area, which in turn alter the surface energy balance, leading to higher land and air temperatures of cities. The temperature difference between the urban areas and their rural surroundings is characterized by the well know and studied Urban Heat Island (UHI) effect. A better understanding of the complex interactions between the urban surface and the atmosphere can be obtained with the help of urban canopy models (UCM) which parameterize the effects of urban environments on surface fluxes without representing buildings explicitly. The coupling of UCMs with climate models, is anticipated to enhance the ability to simulate prevailing climatic conditions over cities. Global and regional climate models run at increasing horizontal resolution can now resolve cities on the model grid depending on the land-cover information available, thus allowing improved representation of urbanization effects and more accurate local climate change projections.

This work presents the 3-year simulations (2000-2002) performed using the Weather Research and Forecasting model driven by ERA-Interim over the MENA-CORDEX domain at horizontal resolution of 16 km with an additional nest over eastern Mediterranean and the Middle East at 4 km resolution. The evaluation is focused over the city of Cairo analysing summer climatologies of the simulated air and land temperatures during day and night time along with the respective temperature differences of the urban and surrounding rural grid-boxes. A comparison of the model output is performed using ERA5-Land reanalysis dataset for air temperature and satellite observations of MODIS-TERRA for land temperature. Further evaluation is made by using the respective radiative and turbulent fluxes in order to diagnose the simulated urban and rural temperature difference.

Authors

Katiana Constantinidou, Panos Hadjinicolaou and Jos Lelieveld

Utilising generalised additive models (GAMS) to estimate near-surface temperature from satellite land surface information

Anna Tzyrkalli

Climate & Atmosphere Research Centre of Excellence - The Cyprus Institute

High temporal and spatial resolution air temperature is important for impact studies. The sparsity of weather stations across the MENA region means that the spatial coverage of air temperature is poor.
On the other hand, using land surface temperature derived from satellite measurements has a very high spatial coverage in the form of gridded data. In this work, we investigate the association between air temperature and land surface temperature as modulated by informative factors such as elevation, spatial location, distance from the coast, and level of urbanization.
We use data from 700 ground stations across the MENA region as well as MODIS land surface temperature at 1x1km spatial resolution and daily temporal resolution for a 21-year period (2000-2021). By utilising generalized additive models, we quantify the relationship between air and land temperature and use this to predict one from the other. The approach is in line with similar studies, most of which use monthly-based data, so the use of daily data here constitutes a novelty.

Authors
Anna Tzyrkalli, Theo Economou, Georgia Lazoglou and Panos Hadjinicolaou

Assessing the added value of increasing horizontal resolution in simulated compound heat and humid conditions over the MENA-CORDEX domain

Panayiotis Hadjinicolaou

Climate & Atmosphere Research Centre of Excellence - The Cyprus Institute

The added value of a regional climate model (RCM) (Rummukainen, 2016) refers to the improvement of aspects of the high resolution simulation compared to the forcing GCM's, and the supply of regional/local scale climate information relevant to climate change vulnerability and adaptation. For air temperature, the added value of higher RCM horizontal resolution (e.g. 12 km vs 50 km in EURO-CORDEX output) has not been established clearly from analysis of mean and extreme conditions in related studies (Kotlarski et al., 2014; Vautard et al., 2013). As a result of the global climate change in the last three decades, parts of the MENA (around the Gulf) and other areas around the globe (e.g. South Asia) exhibit concurrent hot and humid conditions whose extreme occurrences challenge the human thermal tolerance (Raymond et al., 2021).

In the only, to our knowledge, study evaluating heat stress in a similar context to this work, the added value of RCM vs GCM derived Wet Bulb Temperature WBT (mean and extremes) over Europe was indeed demonstrated, but there was no discernible difference in the RCM performance among the 50 km and 12 km output (Casanueva et al., 2019). Here we investigate the effect of increasing horizontal resolution with the WRF model used as an RCM, on the simulation of temperature and humidity with a focus in the optimal representation of summer hot and humid conditions in the MENA. The protocol for the new CORDEX CMPI6 dynamical downscaling requires RCM simulations with grid size of 25 km or less. We address these challenges by performing three runs driven by the ERA-Interim re-analyses at 50, 24 and 16 km for the period 2000-2004 and assess the influence and suitability of the varying horizontal resolution on the simulated summer WBT. For the evaluation of the various model runs, we utilise as a quasi-observational reference, the ERA5-Land, a spatially enhanced (9 km) re-analyses gridded dataset produced by ECMWF. We also exploit daily time-series from the Global Summary of the Day (GSOD) dataset.

Authors

Panos Hadjinicolaou[1], Athanasios Ntoumos[1], Katiana Constantinidou[1], Anna Tzyrkalli[1], George Zittis[1], and Jos Lelieveld[1, 2]

[1]Climate and Atmosphere Research Center, The Cyprus Institute (CARE-C/CYI) – 20 Konstantinou Kavafi Street, Nicosia, 2121, Cyprus

[2]Max Planck Institute for Chemistry (MPIC) – Hanh-Meitner-Weg 1, 55128 Mainz, Germany

Projected heat stress under different levels of global warming with WRF regional climate high-resolution simulations for the MENA-CORDEX domain

Athanasios Ntoumos

Climate & Atmosphere Research Centre of Excellence - The Cyprus Institute

Heat extremes are expected to increase in frequency and magnitude due to global warming, with the Middle-East – North Africa (MENA) region emerging as a prominent climate change hotspot, warming faster than the global average. In the present study, we examine the future extreme heat conditions in the MENA region under global warming increase of up to 4°C relative to the pre-industrial period. For this, WRF high-resolution regional climate simulations (at 24 km) are applied over the MENA-CORDEX domain for different 20-year periods corresponding to the current climate and three levels of global warming (+2°C, +3°C and +4°C). The future changes for the annual warmest day (TXx) and night (TNx) are presented as well as the projected levels of humid heat through the analysis of the Heat Index (HI) and wet-bulb temperature (TW). Results generally indicate a stronger warming over the northern part of the Mediterranean basin. At 4°C warming, simulations show excessive warming over 6°C in the northern part of the domain for the TXx and TNx index, warming much faster than the global average. At 2°C global warming, areas around the Persian Gulf are projected to exceed very dangerous thresholds of humid heat (HI > 51°C, TW > 30°C). Beyond 2°C global warming, the exceedance of these thresholds is much more widespread, with locations in the hottest areas of the domain reaching the TW survivability limit of 35°C. Furthermore, our findings suggest that extreme 1-in-20-years temperatures of the current climate will occur every few years even under 2°C of global warming. For stronger global warming, extreme dry and humid heat events are projected to become common-pace occurring multiple times within a year.

Authors

Ntoumos A., Hadjinicolaou P., Zittis G., Vautard R. and Lelieveld J.

A methodology for bridging the gap between regional- and city-scale climate simulations for the urban thermal environment

Konstantina Koutroumanou-Kontosi

National and Kapodistrian University of Athens

The main objective of this study is to bridge the gap between regional- and city-scale climate simulations, with the focus given to the thermal environment. A dynamic-statistical downscaling methodology for defining daily maximum (Tmax) and minimum (Tmin) temperatures is developed based on artificial neural networks (ANNs) and multiple linear regression models (MLRs). The approach involves the use of simulations from two EURO-CORDEX regional climate models (RCMs) (at approximately 12 km×12 km) that are further downscaled to a finer resolution (1 km×1 km). A feature selection methodology is applied to select the optimum subset of parameters for training the machine learning models. The downscaling methodology is initially applied to two RCMs, driven by the ERA-Interim reanalysis (2008–2011) and high-resolution urban climate model simulations (UrbClim). The performance of the relationships is validated and found to successfully simulate the spatiotemporal distribution of Tmax and Tmin over Athens. Finally, the relationships that were extracted by the models are further used to quantify changes for Tmax and Tmin in high resolution, between the historical period (1971–2000) and mid-century (2041–2071) climate projections for two different representative concentration pathways (RCP4.5 and RCP8.5). Based on the results, both mean Tmax and Tmin are estimated to increase by 1.7 °C and 1.5 °C for RCP4.5 and 2.3 °C and 2.1 °C for RCP8.5, respectively, with distinct spatiotemporal patterns over the study area.

Authors

Konstantina Koutroumanou-Kontosi[1,2] Constantinos Cartalis[1], Kostas Philippopoulos[1], Ilias Agathangelidis[1] and Anastasios Polydoros[1]

1. Department of Physics, National and Kapodistrian University of Athens, 15784 Athens, Greece
2. Climate and Atmosphere Research Center, The Cyprus Institute, 2121 Aglantzia, Cyprus

Acceleration of atmospheric chemical kinetics simulations through single-precision data structures and explicit vectorisation

Kyriacos Sophocleous

Climate & Atmosphere Research Centre of Excellence - The Cyprus Institute

Predicting atmospheric composition and how climate will change from a global to a local scale as atmospheric composition varies over time is one of today's greatest scientific challenges. Due to the widely different lifetimes of the species involved in atmospheric chemistry models, they are computationally stiff. As a result, the integration of atmospheric chemical kinetics consumes up to 85% of the computational resources needed by Earth system models. We have refactored a general atmospheric chemical kinetics solver system that retains accuracy (within 1%) and simulation stability while operating effectively in single precision floating point arithmetic. Our approach has been validated against high-precision semi-implicit methods and benchmarked against double-precision using seven common chemical mechanisms. It was shown to halve the required memory while reducing the number of integration steps by 1.5–3 times. In addition to mitigating memory constraints in file input/output (I/0) and climate-chemistry simulations, we exploit vectorisation through compiler intrinsic functions to increase data-level parallelism exposure to reduce the overall simulation time by a factor of two and improve scalability. Our results demonstrate that single-precision chemical kinetics can significantly reduce computational demands and/or allow to increase the complexity of climate-chemistry simulations.

Authors

Kyriacos Sophocleous and Theodoros Christoudias

Decomposing temperature variability in Global Mediterranean-type climate regions

Diego Urdiales Flores

Climate & Atmosphere Research Centre of Excellence - The Cyprus Institute

Mediterranean type-climate regions (MC) are characterized by a warm and dry summer season. Recent studies reveal that the observed temperature trends vary significantly between these regions, with the Mediterranean Basin warming faster than MC regions in the Americas, southern Africa and Australia. These differences in trends are attributed to various external or internal climate drivers. Nevertheless, the contribution of each driver is not well understood.

We carried out two analyses in order to achieve a basic knowledge of surface temperature variability components related to anomalies of monthly temperature for the last four decades (1980 to 2020). First, a composite analysis using the ERA5 reanalysis dataset (2-m temperature and soil moisture), trying to identify the importance of land-atmosphere interactions. Second, a reconstruction of monthly anomalies based on the methodology by Lean and Rind (2008), which considers global Carbon Dioxide (CO2), Local Soil Moisture, Zonal Volcanic Aerosols, ENSO, and Global Total Irradiance.

We find that across the Mediterranean-type climate regions the local signal of temperature for the driest and wettest years varies. It is stronger in Mediterranean Basin and southern Australia for dry and wet years (defined by the 10th and 90th percentiles respectively). Climate drivers play a fundamental role in surface temperature anomalies. For the northern hemisphere, the role of CO2 is more prominent (explains ~75% of temperature variability). Instead, in the southern hemisphere the relative importance of CO2 changes dramatically (below 60%), and other climate drivers, such as volcanic aerosols, explain most of the variability.

Authors

Diego Urdiales Flores, George Zittis, Panos Hadjinicolaou

An updated assessment of recent-past climate conditions in Cyprus

Georgia Lazoglou

Climate & Atmosphere Research Centre of Excellence - The Cyprus Institute

In the present study, we perform a comprehensive analysis of historical climate conditions in Cyprus, with the overall aim of identifying and updating observed trends and highlighting vulnerable climatic regions within the island. Such updated analysis based on recent meteorological information is currently missing for the region. Cyprus is located in the eastern Mediterranean climate change hot-spot, where, on the one hand profound warming is expected, while on the other hand, a less robust yet significant precipitation decrease could reduce the already limited water resources. This analysis focuses on near-surface air temperature, precipitation, and extreme weather indicators based on these climate parameters. In addition, we have also assessed indicators relevant for selected socio-economic sectors, including agriculture, ecology, energy and water resources. For facilitating parts of the analysis and the presentation of results, we have clustered the different regions of Cyprus in five classes of distinct hydro-climate regimes. Our results highlight a significant increase in temperature throughout Cyprus. This observed trend is more pronounced for maximum temperature during the summer and spring months. The moderating effect of the surrounding sea makes the coastal areas less vulnerable to temperature increases. In terms of precipitation, the southeastern coast and the inland areas near Nicosia are substantially drier and are more prone to further precipitation reductions due to climate change.

Authors

Lazoglou,G. and Zittis, G.

Inter-comparison of the WRF-CHEM MODEL using Aeolus wind data with satellite-based products

Pantelis Kiriakidis

Climate & Atmosphere Research Centre of Excellence - The Cyprus Institute

One of the most important factors towards improved mineral dust mobilization and transport modelling is the representation of wind fields, which determine dust emission and atmospheric lifetime. The Weather Research and Forecasting regional atmospheric model coupled with chemistry (WRF/Chem) is used to simulate the airborne dust concentrations for a two-month long period in autumn 2020. The model is driven by ECMWF IFS outputs produced with and without assimilation of Aeolus quality-assured Rayleigh-clear and Mie-cloudy wind profiles. Our experiments are performed over the broader Eastern Mediterranean region that is subjected frequently to dust transport, encompassing the major natural erodible dust sources of the planet. Dust-related model outputs (extinction coefficient, optical depth and concentrations) are qualitatively and quantitatively evaluated against satellite-derived datasets, LIVAS and MIDAS, providing vertical and columnar dust optical properties, respectively.

Overall, in cases of either high or low aerosol loadings, the model predictive skill is improved when the regional simulations are initialized with Aeolus wind assimilation. The improvement varies in space and time, with the inclusion of the assimilated wind profiles into IFS meteorological fields having a larger impact on the spatiotemporal distribution of dust particles during the fall compared to the spring months. During the case study of interest in October 2020, there is strong evidence of a better representation of the Mediterranean desert dust outbreak spatiotemporal patterns based on the assimilated experiment. Such improvements are driven by wind fields throughout the atmosphere affecting mobilization mechanisms through surface winds, and transport and removal processes. Comparison with MIDAS saw a remarkable improvement in the simulated AOD of the assimilated run over the central and eastern sectors of the Mediterranean and Middle East regions. Confirmed by the drastically reductions of the model biases (either positive or negative) and the increased correlation (up to 0.28).

Authors

Kiriakidis P., Christoudias T., Kushta J., Gkikas A., Papaggelis G., Sciare J.

Potential impacts of working from home as an emissions reduction measure in Cyprus

Corey McClintock

Climate & Atmosphere Research Centre of Excellence - The Cyprus Institute

Cyprus is obligated to report national projections of anthropogenic greenhouse gas emissions under Regulation (EU) 2018/1999 on the Governance of the Energy Union and Climate Action. Cyprus is also bound to the European Union "Fit for 55" emission reduction target of 55% by 2030. Yet Cyprus currently contrasts its small size with large energy usage. It had the fourth highest GHG emissions per capita in the EU-27 in both 2019 and 2020, with road transport accounting for approximately a quarter of these emissions. In April 2022, the European Commission and the International Energy Agency noted that while commuting accounts for one fourth of the oil used by cars in the EU, more than one third of jobs could be performed from home, with significant impacts if applied three days a week. Scaled roughly to the Cyprus road transport sector with a top-down approach, the same decrease in commuting would result in an annual reduction of approximately 106 Gg CO2 Equivalent. This reduction would make a notable contribution to estimated GHG and pollutant emission reductions for 2025 and 2030. These calculations are likely an underestimate, considering that Cyprus had the fifth highest number of cars per capita in the EU-27 in 2020, offers a limited public transport network, and suffers heavy traffic delays. Our results show that a proportion of the population working from home should be considered as an effective emissions reduction measure in Cyprus. This measure does not rival the projected impacts from introduction of natural gas, but it is competitive with many other emission reduction measures, and presents fewer implementation barriers. Primary impacts are significant enough to help Cyprus work toward emission reduction requirements, while secondary benefits could include improved traffic flow and thus air quality, as well as alleviations in Energy demands during a time of crisis.

Authors

McClintock, C., Kushta, J., Demetriou, D., Dubart, F., Violaris, A.

Cooking, organic aerosol and air quality at an Eastern Mediterranean urban environment

Iasonas Stravroulas

National Observatory of Athens (NOA),

Climate & Atmosphere Research Centre of Excellence - The Cyprus Institute

Organic aerosol (OA) represents a major mass fraction (20-90%) of submicron particles. Aerosol mass spectrometry has offered the possibility to gain insights into OA chemical composition in high temporal resolution, while source apportionment techniques can be used to differentiate between primary and secondary OA components. Typically, OA is analyzed into hydrocarbon-like OA (HOA), biomass burning OA (BBOA), oxygenated components (OOA), and a factor representative of cooking organic aerosol (COA). This study focuses on particle emissions during festivities in Greece closely related to large-scale meat grilling, trying to isolate and characterize COA and its impact on air quality. A prime example is the feast of "Fat Thursday", a traditional feast, associated with the culmination of Carnival festivities, when it is customary for the vast majority of the population to eat grilled meat. Another occasion of massive meat grilling is Easter Sunday. While it is typical for the urban population to celebrate Easter Sunday in the countryside, during 2020 – 21, due to COVID-19 lockdowns, most people celebrated in their cities resulting to urban air quality degradation events.

Given the above the temporal variability of the COA component, resolved by PMF (Positive Matrix Factorization) on ACSM (Aerosol Chemical Speciation Monitor) measurements in central Athens, is examined at seasonal, weekly and diurnal scales, searching for associations with recreational and cooking habits and indicating its potential to impact short- and long-term ambient exposure to OA. Next, the study focuses on the characterization of COA concentrations and contributions specifically for "Fat Thursday" and Easter Sunday days in consecutive years (with comparisons against control periods), producing also insights on a "realistic" ambient COA source profile related to meat grilling. Finally, the spatial extent of the COA impact on air quality during the cooking events is investigated at various locations using a PM2.5 measurement network in Greece.

Authors

Stavroulas, I., Bougiatioti, A., Grivas, G., Paraskevopoulou, D., Kaskaoutis, D.G., Liakakou, E., Petrinoli, K., Kalkavouras, P., Kourtidis, K., Gerasopoulos, E., Mihalopoulos, N.

Sources of size-resolved particle number concentrations at an urban location in Athens

Panayiotis Kalkavouras
National Observatory of Athens (NOA)

Ultrafine particles (UFP; d < 100 nm) are attracting the interest of the aerosol and health communities as an impactful pollutant with serious adverse effects to human health and the environment. Valuable information on UFP sources can be gained by the statistical analysis of particle number size distribution (PNSD) data. Cluster analysis is applied to isolate groups with high PNSD similarity, while Positive Matrix Factorization (PMF) modeling is used to quantify contributions of direct sources or atmospheric processes to size-resolved particle number concentrations (PNC) and related metrics. This study comparatively evaluates PNSD source apportionment methods in Athens, Greece. PNSD data (10-487 nm) collected during warm (Jun. to Aug. 2017) and cold (Nov. 2017 to Feb. 2018) periods at an urban background site of Thissio in central Athens are analyzed. Collocated measurements of regulatory pollutants (NOx, CO, O3), aerosol composition (BCff, BCbb, OA, ions) and meteorology are also utilized for the external validation of identified sources. Cluster analysis (k-means) was performed on hourly PNSD spectra. Five clusters related to i) high- and ii) low-traffic, iii) nucleation, iv) urban background aerosol and v) regional aerosol, were identified for both periods, while two clusters were related to nighttime anthropogenic activity and occurred both in the warm and cold period, the latter linked with biomass burning (BB). Clusters related to regional aerosol had the highest frequencies in both periods (30-45%) but low average PNC. Notably, cold-period BB had a considerable frequency (13%) while presenting the highest PNC among clusters. PMF analysis quantified the impact of sources, also related to those extracted by the cluster analysis. During summer, the mean PNC contribution of local sources was comparable (40% vs. 60%) to that of secondary processes (regional transport, area background, nucleation), however, the local contribution was significantly enhanced in the cold period due to residential BB.

Authors
Panayiotis Kalkavouras, Georgios Grivas, Iasonas Stavroulas, Aikaterini Bougiatioti, Eleni Liakakou, Evangelos Gerasopoulos, and Nikolaos Mihalopoulos

PM2.5 in an urban industrial site in the East Mediterranean: Source apportionment and oxidative potential

Marc Fadel
Université du Littoral Cote d'Opale

The East Mediterranean region faces elevated concentrations of PM resulting from transported pollution mixed with anthropogenic emissions (traffic, industrial, and residential emissions), and natural emissions (Saharan and African deserts) . It is considered as a hotspot of climate change where model projections show elevated temperatures by the end of the century leading to the increase of photochemical air pollution. Therefore, it is crucial to determine the sources of pollution and the species that contribute the most to the toxicity in order to develop efficient air quality strategies.

PM2.5 samples were collected between December 2018 and October 2019 in an urban site under industrial influence in Lebanon: Zouk Mikael region (ZK). ZK is characterized by the biggest power plant in the country which runs on heavy fuel oil, a high density of population (4,200 inhabitants/km2) along with high road traffic and the use of diesel generators for electricity generation.

PM2.5 samples were characterized for their carbonaceous fraction, water-soluble ions, elements, and organic species. Several tracer compounds were gathered in the PMF model to assess the contribution of the sources to PM2.5. Crustal dust and secondary ammonium sulfate contributed to 43% of PM2.5 mass. Vehicular and industrial emissions were two important sources at ZK contributing to 14% and 13% of PM2.5, respectively.

On the other hand, the oxidative properties of PM components were studied using the oxidative potential (OP) with two acellular methods: the ascorbic acid (AA) and the dithiothreitol (DTT) assays. The mean volume normalized OP-AAv value was 0.67 ± 0.29 nmol.min¬-1.m-3 and the mean OP-DTTv was 0.52 ± 0.32 nmol.min-1.m-3. A multiple linear regression approach was applied to the contribution of the sources obtained by PMF and the OP in order to estimate the contributions of PM sources to OP values. The results showed that local anthropogenic sources such as biomass burning (33% of OP-AAv and 9% of OP-DTTv), vehicular emissions (20% and 23%), and heavy fuel oil combustion (31% and 46%) contribute the most to the OP-AAv and OP-DTTv, respectively.

Authors
Marc Fadel, Dominique Courcot, Marianne Seigneur, Adib Kfoury, Gilles Delmaire, Gilles Roussel, Konstantina Oikonomou, Jean Sciare, Charbel Afif and Frédéric Ledoux

Spatial variability of PM sources in Cyprus

Elie Bimenyimana

Climate & Atmosphere Research Centre of Excellence - The Cyprus Institute

Located in the Eastern Mediterranean, Cyprus is surrounded by Middle East countries and lies at the crossroads of long-range transported air pollution from Africa, Europe and Asia (Lelieveld et al. 2002). Because concentration levels of air pollution and Particulate Matter (PM), especially, are particularly high in the region, they play a critical role in regional climate and could have major adverse health effects (Lelieveld et al. 2020). However, still very little is known on the main sources of PM affecting Cyprus and their geographical origin, preventing the definition and implementation of efficient local mitigation plans. In the framework of IAEA, AQ-SERVE and EMME-CARE research projects, 24-h integrated PM filter samples were collected continuously for a period of one year spanning from summer 2016 until summer 2017 and from October 2018 to October 2019 at various representative locations in Cyprus (urban backgrounds, traffic, and regional background) and analyzed with respect to 10 major ions, elemental and organic carbon, main carbohydrates (5 species), 28 major and trace metals and 104 trace organic compounds. To investigate the main PM sources affecting these different locations, source apportionment was performed using US EPA PMF5.0 (Paatero 1997) whereas the Lagrangian model FLEXPART along with the Potential Source Contribution Function (PSCF) helped to identify their geographical origin.

PM2.5 presented strong seasonal variability with higher concentrations during winter dominated by Particulate Organic Matter (POM) accounting for more than 50% as result of domestic heating. During summer, secondary aerosols such as ammonium sulfate was dominant due to enhanced photochemical activity. The highest concentrations of dust were observed during transition seasons (spring and autumn) due to Saharan and Middle East dust outbreaks. It is important to stress that dust represented 17% of the total PM2.5 mass concentration making it the third major components after POM and sulfate.

As for the spatial variability of PM components, NICTRA exhibited the highest levels for all PM components except nss-SO42- and sea salt which were slightly higher at LIMRES (coastal city).

Interestingly, fine dust level at LIMRES was as high as the one of NICTRA which is unexpected since the two sites have different typologies (residential and traffic) suggesting additional sources of dust at LIMRES such as industrial or/and construction activities.

Preliminary PMF source apportionment results indicate six main PM2.5 sources namely traffic, biomass burning, heavy oil, dust, sea salt and a Regionally-processed factor (mainly secondary in nature). The latter was predominant and contributed alone more than 30% at the urban sites and up to 60% at the regional background station; industrial and power plant emissions from eastern Europe and Turkey being responsible for this high loading in secondary aerosol and presented marked seasonality.

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Authors

Bimenyimana, E., Iakovides, M., Pikridas, M., Sciare, J., Mihalopoulos, N., Oikonomou, K., Vassiliadou, E., Savvides, C.

Possible influence of atmospheric micro nutrient deposition on the mucilage formation in the sea of Marmara: Preliminary results

Mustafa Kocak
Middle East Technical University - IMS

Based on the records in the Adriatic Sea, the mucilage events in the seas can be tracked back to the beginning of the 18th century. However, mucilage events are not limited by the Adriatic Sea, it has been increasingly reported from North Sea to the coastal seas of New Zeeland and the Sea of Marmara. In order to assess the possible influence of atmospheric input of micro-nutrients (such as Fe, Mn, Co, Zn, Cu, Cd) on mucilage formation, micro-cosm experiments were carried out by using surface waters of the Sea of Marmara. Two types of bioassay experiments were established as follow: (i) Macro nutrient additions (NO3, PO4 and Si) and (ii) macro/micro nutrient additions. There were no statistical differences for initial concentrations of nitrate, phosphate, silicate and Chl-a, in other words micro-cosm bottles were coincident. Unlike phosphate and silicate, assimilation of nitrate was influenced by the addition of micro nutrients. Chl-a did not show statistically significant different until the fourth day of the micro-cosm experiment. Chl-a macro/micro additions N10Mi1 and N1Mi1 reached up to 7.8 and 5.5 µg/L, being 3 and 2 times higher than control. Chl-a concentrations for macro nutrient additions N10 and N1 were about 40 % larger than those of control. In general, Chl-a for additions attained its maximum on the 8th day in the decreasing order N10Mi1 (12.9 µg/L) > N10 (9.6 µg/L) > N1Mi1 (9.1 µg/L) > N1 (7.3 µg/L). Except for N10, Chl-a concentrations diminished towards the experiment.

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Authors

Koçak, M., Başduvar, S., Örek, H., Uysal, Z., o., Kıyak, Nazlı, Ak Örek, Y

Massive dust loading during huge dust storm events over Middle East during Spring and Summer 2022

Hossein Panahifar

Amirkabir University of Technology

This study characterizes the optical, microphysical, and radiative properties of aerosols and their meteorological drivers during the SDS events occurred over the ME during Spring and summer 2022. A comprehensive set of multiple satellite including MODIS, VIIRS, CALIOP and ground-based observations combined with atmospheric reanalysis data have been used to monitor the SDS. Moreover, a long-term dust optical depth (DOD) dataset retrieved from MODIS measurements was also utilized to evaluate the historical ranking of the dust loading in the ME during dust events. The invasion of dust plumes greatly degraded the visibility over study area, with extreme low visibility recorded at most sites respectively. The CALIOP observations

show that during the SDS event the dust plume was lifted to an altitude of 4–8 km, and its range of impact extended from the dust source to the central Asia. The MODIS-retrieved DOD data registered these massive SDS events as the most intense episode in the same period in history over the past decades. Meteorological analysis revealed that these SDS events were triggered by an exceptionally strong cyclone generated at nearly the border of Syria and Iraq as well as at the southern part of Turkey in conjunction with a surface-level cold high-pressure system.

Authors

Hossein Panahifar and Farizeh Bayat