VIRTUAL WORKSHOP

CLIMATE AND ATMOSPHERE RESEARCH & INNOVATION IN THE EASTERN MEDITERRANEAN & MIDDLE EAST

11th and 12th October 2021

Regional Climate Change Initiative Republic of Cyprus

This event is funded by the European Union's Horizon 2020 research and innovation programme under grant agreements 871115 and 856612 and the Cyprus Government

Book of Abstracts

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Welcome to Climate and Atmosphere Research & Innovation in the Eastern Mediterranean & Middle East Virtual Workshop

Dear Colleagues,
Dear Friends,

It is with great pleasure that we welcome you to our 'Climate and Atmosphere Research & Innovation in the Eastern Mediterranean & Middle East Virtual Workshop'. First, 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 latest concerning the science of climate change and air pollution in the form of 7 invited talks and a selection of 38 oral and 21 virtual PICO presentations with 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

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Scientific Committee

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

Prof. Markku Kulmala, University of Helsinki, *Finland*

Prof. Jos Lelieveld, Max Planck Institute for Chemistry, *Germany*

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PROGRAM - DAY 1 (11 October 2021)

https://climatechange2021.org/workshops/

All times are in (Cyprus) EEST

Opening Session		
09:15	**Welcome & Introduction to the Workshop**	
	Workshop Introduction & Opening	**J. Sciare**, Cyl Cyprus
Atmospheric Modelling and Prediction (Chair: T. Christoudias)		
09:30	**Invited Speakers**	
	Human driven changes in atmospheric deposition of nutrients to the ecosystems	**M. Kanakidou** Univ. Crete, Greece
	Air Quality modelling and forecasting in the Arabian Peninsula: Research & Applications	**C. Fountoukis** QEERI, Qatar
	Oral Presentations	
	Real-time Air Quality forecasting over the Eastern Mediterranean with WRF/CHEM	**G. Georgiou** Cyl, Cyprus
	Modelling Air Quality in the Middle East during the 2017 AQABA campaign	**S. Osipov** MPIC, Germany
	Satellite-derived emission trends: Uncertainties and implications for atmospheric modelling	**J. Kushta** Cyl, Cyprus
11:00	**Coffee Break**	
Air Pollution and Impacts (Chair: N. Mihalopoulos)		
11:10	**Invited Speakers**	
	A quick look at the Chemistry-Aerosol Mediterranean Experiment (ChArMEx) legacy	**F. Dulac** CEA-LSCE, France
	Non-methane hydrocarbons in the East Mediterranean and Middle Region	**E. Bourtsoukidis** Cyl, Cyprus
	Oral Presentations	
	Regional background sources of submicron organic aerosol in the Eastern Mediterranean	**M. Pikridas** Cyl, Cyprus
	Assessment of the spectral absorptions by Black and Brown Carbon for different sources: Application in Athens	**D. Kaskaoutis** NOA, Greece
	Characteristic of New Particle Formation in Cyprus	**R. Baalbaki** Univ. Helsinki, Finland
	Satellite-based observations of aerosol-cloud relationships under different water vapor conditions over the Eastern Mediterranean	**S. Stathopoulos** DUTH, Greece
	Relationship between Aeronet and Modis-based Aerosol Optical Depth with surface PM10 over Cairo (Egypt)	**Ahmed Sara said** EMA, Egypt

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	Premature mortality from exposure to ambient PM2.5, Black and Organic Carbon in the EU-27	**N. Paisi** Cyl, Cyprus
13:00	**Lunch Break**	
Atmospheric Dust (Chair: F. Marenco)		
14:00	**Invited Speakers**	
	Dust storms in the MENA region: Atmospheric drivers, characteristics, and impacts	**D. Francis** Khalifa Univ., UAE
	Oral Presentations	
	Light Absorption properties of aeolian dust – case studies of storm events	**B. Alfoldy** Aerosol doo, Slovenia
	Vertically resolved optical and physical characterization of aerosol layers over Amman employing CALIPSO satellite data	**H. Panahifar** IASBS, Iran
	Large-scale atmospheric patterns and PM10 pollution: The contribution of the Saharan oscillation	**K. Kenza** GDM, Morocco
Climate Modelling and Prediction (Chair: P. Hadjinicolaou)		
15:00	**Invited Speakers**	
	Impact of Global Warming on regional climate over the Arabian Peninsula	**G. Stenchikov** KAUST, Saudi Arabia
	Oral Presentations	
	Sensitivity analysis of WRF model PBL schemes in simulating temperature extremes over the Middle East - North Africa (MENA) region	**A. Ntoumos** Cyl, Cyprus
	Rainfall-Aerosols Interactions at time Scales of Minutes to Days with Focus over the EMME region and Mediterranean Climate	**P. Alpert** Tel Aviv Univ., Israel
	Utilizing weather station, satellite, and population datasets to estimate urban heat island over locations in the Middle East and North Africa (MENA) region	**A. Tzyrkalli** Cyl, Cyprus
15:50	**Coffee Break**	
vPICO session on Atmosphere & Climate Modelling and Prediction (2 minutes each) (Chair: P. Papazoglou)		
16:00	Urban representation in High resolution WRF simulations over the region of Eastern Mediterranean and the Middle East	**K. Constantinidou** Cyl, Cyprus
	Tin-Copula Bias-Correction method for model-derived maximum temperature in the MENA region	**G. Lazoglou** Cyl, Cyprus
	The impact of assimilating Aeolus remote sensing wind data on regional aeolian dust	**P. Kiriakidis** Cyl, Cyprus
	Assessment of reanalysis datasets against radiosonde observation over Eastern Mediterranean region	**R. Hassan** EMA, Egypt
	First near-real-time characterization of fine particulate matter (PM) and volatile organic compounds (VOCs) in Cairo Megacity (Egypt)	**A. Christodoulou** Cyl, Cyprus

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	C2-C12 NMHC measurements in two sites with contrasted characteristics in the Greater Athens area over the period 2015-2019	**E. Liakakou** NOA, Greece
	The effect of spatial and altitudinal distribution of air parcels in the Eastern Mediterranean basin on PM10 and PM1 composition	**K. Dimitriou** NOA, Greece
	Optical properties and the curvature effect in spectral scattering and absorption coefficients for key aerosol types identified in Athens	**D. Kaskaoutis** NOA Greece
	Air quality and cloud effects on surface solar radiation over urban and rural areas in Greece	**A. Georgoulias** AUTH, Greece
	Methane and non-methane hydrocarbons concentrations and sources in an Eastern Mediterranean island (Cyprus)	**E.Germain Piaulenne** CyI, Cyprus
	Characterization of fine and coarse atmospheric particulate matter from Beirut suburb using PIXE technique	**R. Mohamad** CNRS, Lebanon
	Monitoring of atmospheric aerosols pollution over Egypt based on satellite and ground-based observations	**N. Zanaty** NARSSS, Egypt
	Assessment of the intensity of dust events over Egypt with Climate Change scenarios	**Z. Salah** EMA, Egypt
16:30	**End of Workshop DAY 1**	

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PROGRAM - DAY 2 (12 October 2021)

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Climate Change and Weather extremes (Chair: J. Lelieveld)		
09:30	**Invited Speakers**	
	Future projections of High-Impact extreme weather events in the EMME region	**G. Zittis** Cyl, Cyprus
	Oral Presentations	
	Climate Change projects for Greece in the 21st century from a High-resolution Euro-CORDEX ensemble	**A. Georgoulias** AUT, Greece
	Spatio-temporal characteristics of observed air temperature 1981-2020 trends in the Middle East North Africa (MENA) from the CRUTEM4.6 dataset	**P. Hadjinicolaou** Cyl, Cyprus
	Projected changes in temperature and precipitation extremes in Egypt by the REGCM4	**Z. Salah** EMA, Egypt
	Projecting the potential evapotranspiration of Egypt using a high-resolution regional climate model (REGCM4)	**S. Rateb** EMA, Egypt
	City, Citizens, and Climate crisis in the East Mediterranean: From Global Climate predictions to the citizens experience	**M. Neophytou** Univ. Cyprus, Cyprus
	Effects of rapid coastal urbanization on local near-surface climate variables in the Middle East	**E. Elhacham** Tel Aviv Univ., Israel
	Future climate change impact on wildfire danger over the Mediterranean: The case of Greece	**A. Rovithakis** TUC, Greece
11:10	**Coffee Break**	
Greenhouse Gases & Remote Sensing (Chair: M. Vrekoussis)		
11:20	**Oral Presentations**	
	Methane Budgets and inverse modelling in the Eastern Mediterranean and Middle East	**X. Lin** LSCE, France
	Comparison of methane emissions reported in bottom-up inventories against atmospheric inversions in the Eastern Mediterranean and Middle East region	**Z. Tzompa Sosa** LSCE, France
	Aggregation of greenhouse gas emissions over Cyprus and international reporting obligations	**F. Dubart** Cyl, Cyprus
	First columnar greenhouse gases in the Eastern Mediterranean and Middle East region by TCCON Nicosia	**C. Rousogenous** Cyl, Cyprus
	Quantifying Nitrogen Oxides emissions in Egypt using satellite observations	**A. Rey-Pommier** LSCE, France
	Variability and trend of precipitable water vapor, lower stratospheric water vapor, methane, nitrogen dioxide, and temperature in Alexandria city, Egypt, using MERRA2	**M. Abdelfattah** Cairo Univ., Egypt
	Observatory for the waterborne air pollution in the Eastern Mediterranean	**E. Yfantis** CMMI, Cyprus

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New Instrumentation (Chair: A. Maisser)		
12:40	**Oral Presentations**	
	Employing low-cost particulate matter sensors for developing cost-effective aerosol instruments	**S. Bezantakos** CyI, Cyprus
	Performance assessment of low-cost air quality sensors through long-term observations over Nicosia, Cyprus and the effect of meteorological conditions	**R.Papaconstantinou** CyI, Cyprus
	A new mobile platform of ACTRIS for cost-effective atmospheric profiling with UAV-sensor systems	**M. Kezoudi** CyI, Cyprus
13:10	**Lunch Break**	
Education & Training opportunities (Chair: C. Leontiou)		
14:20	**Oral Presentations**	
	MEDCYCLONES COST Action: A European Network for Mediterranean cyclones in weather and Climate	**E. Flaounas** HCMR, Greece
	Climate Change competencies in Education	**L. Riuttanen** Univ.Helsinki, Finland
	Addressing Climate Change by educating young Europeans towards a sustainable and socially just economy	**D. Cochliou** Univ. Nicosia, Cyprus
	Teaching systems thinking in Climate Change and sustainability education	**M. Äijälä** Univ.Helsinki, Finland
	Learning researcher skills while working in small groups on real scientific questions and data and in a multi-disciplinary and multicultural course is motivating for teachers and students	**T. Ruuskanen** Univ.Helsinki, Finland
	Climate-related education: on-line approach in COVID times	**T. Kryvomaz** Kyiv Univ., Ukraine
15:20	**Coffee Break**	
vPICO session on Climate Change & Weather extremes (2 minutes each) (Chair: P. Papazoglou)		
15:30	Atmospheric energetics under different CMIP6 climate scenarios	**S. Michaelides** CyI, Cyprus
	A pragmatic approach to statistical modelling of big spatio-temporal climate data	**T. Economou** CyI, Cyprus
	Statistical disaggregation and bias-adjustment of CMIP6 variables for climate change impact studies at global and regional scales	**Y. Proestos** CyI, Cyprus
	Wildfire sensitivity on climate drivers in the Eastern Mediterranean	**M. Grillakis** TUC, Greece
	Climate Change implications on the operational safety of civil protection emergency practitioners in the Eastern Mediterranean Middle East	**P. Papazoglou** CyI, Cyprus
	A low-cost CO2 commercial NDIR sensor for UAV atmospheric applications	**Y. Liu** CyI, Cyprus

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	Novel UAS for environmental monitoring during natural disasters	**C. Keleshis** CyI, Cyprus
	Performance characterization of a newly developed atmospheric pressure interface time of flight mass spectrometer (API-TOF MS)	**F. Schmidt-Ott** CyI, Cyprus
16:00	**End of Workshop**	

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INVITED SPEAKERS

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Human driven changes in atmospheric deposition of nutrients to the ecosystems

Maria Kanakidou
Environmental Chemical Processes, Department of Chemistry, University of Crete

Terrestrial and marine ecosystems are key to the formation of atmospheric oxygen with oceans being responsible for about half of the oxygen in the atmosphere. They are also a major source of food for humanity and without the ocean phytoplankton carbon dioxide in the atmosphere would have been about 200 ppm higher. The sink of carbon dioxide by carbon sequestration depends on the availability of nutrients to the ecosystem, since nutrients are essential for the ecosystem functioning. The relative abundance of them available to an ecosystem is also important because favoring the development of certain species against others can lead to biodiversity losses. Nutrients equilibria of both land and marine ecosystems have been disturbed during the Anthropocene period.

Material of natural and/or anthropogenic origin, particularly aerosols, deposited from the atmosphere to the Earth's surface can act as a source of nutrients for the ecosystems, in particular into the open ocean, and affect nutrient's equilibrium and thereby carbon sequestration and climate. Atmospheric acidity is a key driver of solubility changes of nutrients, making them readily available to the ecosystems, and is following the human-driven changes in the emissions of acidic and basic compounds into the atmosphere (mainly sulfur and nitrogen emissions).

We will discuss recent global modeling studies that are based on laboratory and field experiments focusing on the biogeochemical cycles of nitrogen, iron and phosphorus, the role of atmospheric acidity and organics, how these cycles have been impacted by human activities and potential consequences for the ecosystems and carbon sequestration.

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Air Quality Modelling and Forecasting in the Arabian Peninsula: Research & Applications

Christos Fountoukis
Qatar Environment and Energy Research Institute

The Middle East and North Africa region include approximately half of the global dust emissions, accounting for 500-1000 Tg yr-1 while large uncertainties in these estimations still remain. Although dust storms originating from the North Africa region have been thoroughly investigated, severe dust events within the region of the Arabian Peninsula have received less attention even though they affect large population centers in the region as well as impact the surrounding marine ecosystem. At the same time, anthropogenic air pollution in the greater area of the Eastern Mediterranean and Middle East is changing due to extensive land conversion, intense industrialization and rapid population change in large metropolitan areas. We have applied the online-coupled meteorology-chemistry Weather Research and Forecasting (WRF-Chem) model over the Middle Eastern domain in both retrospective simulations and in operational forecasting mode, with a focus on regional dust storms and urban pollution in high spatial resolution. Model predictions of gaseous and aerosol concentrations are evaluated against intensive measurements taken from a network of measurement stations throughout Doha, Qatar. Current and future activities of our ongoing AQBOOK project will be discussed which include the development of an early warning system for various parameters such as extreme solar radiation, heat index, dust storms, air quality health index and others. The AQBOOK project is expected to evolve, from an air quality research and development product into a commercial service platform that will successfully address pollution management markets in the hot desert climate of the greater region, at hyper-local, urban and regional scales. To that end, the utilization of additional modelling systems and/or measurement campaigns from regional collaborations/partnerships is highly desirable.

Authors

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A quick look at the Chemistry-Aerosol Mediterranean Experiment (ChArMEx) legacy

Dulac François
CEA/LSCE

This presentation aims at both illustrating advances in atmospheric chemistry obtained during the decadal Chemistry-Aerosol Mediterranean Experiment (ChArMEx) and introducing its review book in press entitled "Atmospheric Chemistry in the Mediterranean Region".

The project ChArMEx was initiated in France in 2007 and integrated into the Mediterranean Integrated Studies at Regional and Local Scales (MISTRALS) 2010-2020 multidisciplinary research programme on the Mediterranean region and its future. ChArMEx aimed at an updated assessment of the atmospheric pollution and its impacts in the Mediterranean region, and of their evolution in the next decades. The project has federated an unprecedented international experimental effort in the region, mainly driven by several large regional summer field campaigns in 2012-2014, including various airborne means deployed from the boundary layer to the upper troposphere. More recently (spring 2017) ChArMEx co-organised a joint oceanographic campaign on air-sea biogeochemical interactions with MERMEX, the marine ecosystems component of MISTRALS. ChArMEx also included many more local field studies in various specific environments from Mediterranean forests to large harbour cities, several years of in situ monitoring efforts, large scale remote sensing and extensive modelling efforts. A few original results will be presented on VOC emission inventories in urban environments, ozone and dust observations with quasi Lagrangian drifting balloons, improvement of particulate air quality forecast using lidar monitoring assimilation, aerosol radiative forcing and its impact on regional precipitation, ultrafine particles, and deposition at sea. Many more results can be found in a ChArMEx special issue including more than 105 papers (https://acp.copernicus.org/articles/special_issue334.html; see also https://lsce.ipsl.fr/charmex for a complete list of peer-reviewed articles and ChArMEx-related PhDs.

Finally, the ChArMEx community edited book in 2 volumes, co-authored by 100 scientists from 15 different countries, is introduced. It synthesizes several decades of research on atmospheric chemistry and its impacts in the Mediterranean region, and issues recommendations for future research.

Authors

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Non-methane hydrocarbons in the East Mediterranean and Middle Region

Efstratios Bourtsoukidis

Climate & Atmosphere Research Centre of Excellence - The Cyprus Institute, Cyprus

Atmospheric non-methane hydrocarbons (NMHCs) have been extensively studied around the globe due to their importance to atmospheric chemistry and their utility in emission source and chemical sink identification. The Middle East accommodates more than half of the world's known oil and gas reserves and is considered as a global hot-spot of NMHCs as fossil fuel exploitation releases large amounts of these gaseous pollutants into the atmosphere. The abundance of NMHCs and NOx in combination with the intense photochemistry in the region, results in extremely high ozone mixing ratios and overall deterioration of the regional air quality. Here, we examine all available observations, aiming to evaluate the current emission inventories and identify the present research needs. Shipborne NMHC measurements made around the Arabian Peninsula during the AQABA (Air Quality and climate change in the Arabian BAsin) ship campaign and in-situ observations in Nicosia (Cyprus) and Cairo (Egypt) provide unique information on the sources and atmospheric fate of NMHCs in the East Mediterranean and Middle East (EMME) region. We identify and characterize a strong overlooked underwater source over Red Sea and we investigate episodes with exceptionally high NMHC concentrations in Nicosia and Cairo. Our results demonstrate the significance of NMHCs in the EMME region and define the experimental strategies of the Climate and Atmosphere Research Center (CARE-C) of the Cyprus Institute that aims to address the dynamic nature of the NMHC source strength and hydrocarbon composition that is driven by political, socioeconomic, and environmental decisions.

Authors

Bourtsoukidis E., Christodoulou A., Germain-Paulenne E., Gross V., Lelieveld J., Mattaios V., Paris J.-D., Pozzer A., Sauvage S., Williams J., and Sciare J.

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Dust storms in the MENA region: Atmospheric drivers, characteristics, and impacts

Diana Francis
Khalifa University

The Middle East and North Africa (MENA) region is the home of the two largest dust source areas in the world, namely the Sahara and the Arabian Peninsula deserts. Dust activity in these regions is controlled by atmospheric forcings which vary seasonally, annually and interannually. Although emitted from limited areas, atmospheric dust can travel over very long distance and its impacts can be observed in other continents. Being sporadic and heterogenous in nature, dust storms represent a challenge for current climate studies and large uncertainties in climate change projections. In this presentation, I will present an overview of the known atmospheric drivers, characteristics and impacts of dust storms in the MENA region and their link to the larger-scale circulation and climate.

Authors

Diana Francis

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Impact of Global Warming on regional climate over the Arabian Peninsula

Georgiy Stenchikov
King Abdullah University of Science and Technology (KAUST)

Like other desert regions, the Arabian Peninsula (AP) warms 30-50% faster than the Globe with a seasonally asymmetric temperature trend, stronger in summer than winter. The distribution of projected warming is not spatially uniform, decelerating in the coastal areas affected by breezes.

AP climate exhibits visible natural variability with a characteristic time scale of 60 years. It is affected by teleconnections governed by Arctic Oscillation, Indian Monsoon, African ITCZ shift, and Atlantic Multidecadal Oscillation. The pronounced local forcing is associated with desert dust that significantly modulates the radiative fluxes over the entire region. Dust also affects regional seas, the Red Sea and Arabian Gulf, producing the climatological short-wave cooling over the southern Red Sea that reaches 60 W/m2 in summer.

We analyzed the regional warming over the AP using output from the ensemble of the IPCC AR6 models and found that in the RCP8.5 scenario, by the end of the 21st century, the central parts of the AP in summer could warm more than 7 K. The coastal areas are projected to be 1-2 K cooler than the hotspot in the central AP. The radiative dust cooling significantly affects temperature and evaporation over the Red Sea and must be accounted for in the long-term regional climate projections.

Authors

Georgiy Stenchikov

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Future projections of High-Impact extreme weather events in the EMME region

George Zittis

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The Eastern Mediterranean and the Middle East (EMME) region is a climate change hot-spot that is currently warming almost two times faster than the global average and more rapidly than other inhabited parts of the world. This warming, related to human activities, is projected to intensify, mainly during the summer season. At the same time, due to atmospheric circulation and dynamics changes, mean precipitation is projected to decrease in many regions, particularly in the eastern Mediterranean. Besides changes in mean climate conditions, extreme events of high impact on societies and ecosystems are expected to increase in intensity and frequency. Such events relevant for the region are extreme heatwaves, prolonged droughts, and torrential rains events that can cause loss of lives, shortages of energy and water resources, damage to critical infrastructure, agricultural yield losses, and also affect other socio-economic activities. Based on the latest scientific findings, state-of-the-art regional climate projections, and an extensive literature review, here we present an overview of future changes in the characteristics of such events for the wider EMME region.

Authors

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ORAL PRESENTATIONS

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Real-time Air Quality forecasting over the Eastern Mediterranean with WRF/CHEM

George Georgiou
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We employ the regional coupled meteorology-atmospheric chemistry WRF/Chem model to perform daily, 3-day air quality forecasts over the Eastern Mediterranean, focusing on Cyprus. Dust emissions from the major dust sources in the region, sea-salt and biogenic emissions are calculated online, while a high (1km, hourly) spatiotemporal resolution-anthropogenic emission inventory is used for the island of Cyprus. The model skill to forecast the concentrations of atmospheric pollutants is evaluated using measurements from a dense network of 9 ground stations in Cyprus and inter-compared with the forecast from the EU Copernicus Atmosphere Monitoring Service - CAMS. The WRF/Chem model forecasts surface temperature, pressure, and wind speed accurately, with minor differences in 10m wind speed between model and observations at coastal and mountainous stations attributed to limitations in the representation of the complex topography. The WRF/Chem model achieves lower normalized mean bias between the predicted and observed NO2 mixing ratios at the urban sites (-7% during winter and -44% during summer) compared to CAMS (-81% during winter and -84% during summer). The diurnal profiles of NO2 and O3 mixing ratios at the urban sites are captured more accurately by the WRF/Chem model due to the high temporal resolution of the anthropogenic emission inventor. Background PM25 concentrations are overestimated by the WRF/Chem model during winter (NMB = 54%) whereas the corresponding NMB for CAMS is 11%. The advances in the predictive skill of real-time air quality forecasting models can reduce health risk and population exposure to air pollutants.

Authors

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Modelling Air Quality in the Middle East during the 2017 AQABA campaign

Sergey Osipov

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A unique mixture of vast natural and abundant anthropogenic emissions gives rise to a distinct type of air pollution in the Middle East. The anthropogenic influence in the region is profound and is manifested by its share of emissions in the global context. Nevertheless, the naturally enhanced mineral dust concentrations are conventionally assumed to dominate air pollution in the Middle East, often disregarding the uncertain role of human-induced trace gases and aerosols. Primarily, the lack of observational constraints represents a modeling challenge and hampers our understanding of the ambient air quality in the region.

In this work, we present an overview of the atmospheric composition and the consequences for air quality in the Middle East. We employ a comprehensive set of observations, collected around the Arabian Peninsula during the 2017 AQABA (Air Quality and Climate Change in the Arabian Basin) ship campaign, to characterize the atmospheric chemistry, identify the key pollutants and evaluate the model simulations. We show that the indigenous sources, long-range transport, and intense tropospheric photochemistry cause challenging ambient air conditions in the Middle East and produce levels of O3, NO2 and particulate matter (PM) concentrations that violate the WHO guideline concentrations almost permanently. We find that health-hazardous fine particulate matter (PM1) in the marine boundary layer is primarily of anthropogenic origin and largely consists of sulfate, ammonium, organic aerosols, and black carbon. Our analysis shows that the anthropogenic aerosols in the accumulation (fine) size mode often contribute more than half of the column aerosol optical depth and, thus exert a profound radiative forcing on climate, on par with the abundant dust aerosols. Finally, we assess the adverse health effects attributable to the long-term PM2.5, \O3 and NO2 exposure in the Middle East, indicating its equivalence with the excess mortality by the ongoing COVID-19 pandemic.

Authors

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Satellite-derived emission trends: Uncertainties and implications for atmospheric modelling

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Atmospheric modelling systems are core methodologies for policy applications and hazard assessment studies. A vital component of these tools consists of accurate emission fluxes from industrial, residential and natural sources. The main input information to these inventories comprises of reported anthropogenic activities and associated emissions, procedures that are usually legislated by air quality and emission directives. The compilation of emission inventories however is a complex and time-consuming process that is conducted at frequencies that may not capture changes caused by unforeseen factors such as geopolitical and/or economic forcings. Eastern Mediterranean and the Middle East (EMME) is a region that frequently experiences such events. EMME includes a large number of countries that do not adhere or are not obliged to report detailed emissions and projections and as such, following up on alterations in the emission landscape of the region is a challenging task. Therefore, the use of current and next generation satellite information can open a new area in operational forecasting and scientific assessment of air quality and emissions in this complex region with past, current and projected societal, financial and geo-political influences. In this work we identify and elaborate on the discrepancies of emission inventories in the region and the use of satellite data for their timely update. Utilizing the EDGAR-HTAP emission inventories compiled by the Joint Research Center for the year 2010, we use a model-based methodology to update them based on satellite-derived trends for two main gaseous pollutants, nitrogen oxides and sulphur dioxide. Model simulations with the current and modified emission inventory are used to assess the discrepancies derived. We also apply the methodology at global scale and we discuss the uncertainties of the method and its implications for regional and global air quality modelling.

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Regional background sources of submicron organic aerosol in the Eastern Mediterranean

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Positive matrix factorization (PMF) is a widely applied method used in combination with Aerosol Mass Spectrometry for apportioning submicron Organic Aerosol (OA) sources. However, PMF assumes that each OA source's characteristics (profiles) are constant throughout the sampling period, which may not be always valid for a large dataset covering several seasons with contrasted oxidation capacity. To cope with this problem, the rolling mechanism (Parworth et al., 2015; Canonaco et al., in prep.) is applied. Instead of running PMF over the whole period, a smaller PMF time window can shift over the whole sampling period with a step of 1 day, which allows the source profile to vary with time. By considering, the temporal variabilities of the OA sources, this technique can not only capture the static sources existing all the time, but can also resolve the sources within shorter time periods. Both, rolling and traditional PMF are applied here on unit mass resolution mass spectrometric information of submicron OA obtained by an Aerosol Chemical Speciation Monitor (ACSM, Aerodyne Inc) for a 2-year period (2015-2016) at the Cyprus Atmospheric Observatory (CAO), a remote site in the island country of Cyprus (35 02′ 17′′N–33 03′ 28′′E). Cyprus is located in the eastern Mediterranean basin, at the crossroads of long-range transported air masses from Europe/Africa/Asia. While it is most frequently (»68% per year) impacted by northerly air masses influenced by emissions from eastern Europe and Turkey, it is also affected by air masses that have spent a few days over the Mediterranean Sea (Marine, 8% per year) and regions that include arid areas from North Africa and the Middle East at the same extent (»10% per year).

Based on traditional PMF applied for every season of the 2-year dataset, three factors were identified, namely; more oxidized organic aerosol (MO-OA), less oxidized organic aerosol (LO-OA) and a hydrocarbon-like organic aerosol (HOA). The latter exhibits a very distinct seasonal cycle that peaks during winter reaching 13% of OA but cannot be identified, during the summer months suggesting photochemical degradation of HOA at that period. However, the seasonal variability of source regions cannot be ruled out. Air masses originating from the Middle East not only exhibit higher than average total OA mass but also elevated HOA concentrations by a factor ranging between 2-3 (compared to the annual average) and are more frequently identified during autumn and winter months. Unlike HOA, the two factors that represent aged OA do not exhibit a pronounced seasonal cycle. The MO-OA is dominating throughout the year, accounting for at least half of OA, similar to other observations performed in the E. Mediterranean (e.g. Hildebrandt et al., 2010). The LO-OA, which typically accounts for 30-40% of the OA, changes its diurnal characteristics with season. During autumn and winter only one peak is observed after 18:00 UTC. During spring and early summer, a second peak, between 09:00-12:00 UTC, is additionally observed and could be explained by the combination of high photochemistry and strong local VOC emissions from the forested area of the Troodos Mountain nearby the sampling site.

Rolling PMF was conducted with a 14-day window, shifted over the entire 2-year period with a step of 1 day. The effect of air mass origins on OA source profiles is further investigated. Correlations between the seasonal cycle of each identified factor against a proxy of the oxidation capacity of the atmosphere, is also attempted.

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Assessment of the spectral absorptions by Black and Brown Carbon for different sources: Application in Athens

Dimitris Kaskaoutis

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We describe a new approach using a combination of common assumptions for the differentiation of spectral absorption from aethalometer measurements into five components related to black and brown carbon (BC, BrC) and for sources of fossil-fuel combustion, biomass burning and secondary organic aerosol formation. For the discrimination of BrC absorption, the assumption of AAE=1 for pure BC was considered, while via appropriate AAEff and AAEbb values using the Aethalometer model approach in the measured data, the contributions of fossil fuel and biomass burning to total absorption were apportioned. Furthermore, the minimum R2 method, using a wavelength-dependent primary ratio (Abs/BC)pri was used for the estimation of spectral absorption due to secondary organics. This approach was firstly applied in urban background Athens during winter (Dec. 2016–Feb. 2017). The contributions of each of the five components to the spectral absorption are examined on seasonal and diurnal basis. At 370 nm, the absorption due to BCff contributed 36.3% on average, exhibiting a higher fraction (58.1%) during daytime, while the mean BCbb absorption was estimated at 18.4%. The mean absorption contributions due to BrCff, BrCbb and BrCsec were 6.7%, 32.3% and 4.9%, respectively. The AbsBCff and AbsBrCff components maximized during the morning traffic hours, as expected, while the AbsBCwb and AbsBrCwb escalated during nighttime and were highly related with biomass-burning tracers (nss-K+, Delta-C), and with organic aerosol components related to fresh and fast oxidative biomass burning (BBOA and SV-OOA). Multiple linear regression was used to attribute BrC absorption to five organic components and to determine their absorption contributions and efficiencies, revealing maximum contributions from BBOA (33%) and SV-OOA (21%). Sensitivity analysis was performed in view of the methodological uncertainties and supported the reliability of the results, which can be applied at any environment and have important implications for radiative transfer models.

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Characteristic of New Particle Formation in Cyprus

Rima Baalbaki

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Atmospheric new particle formation (NPF) is a significant source of global aerosol particle number load and cloud condensation nuclei (CCN). Therefore, it has been the focus of many research studies in the past 20 years ranging from atmospheric observations to chamber experiments and conceptual and modelling studies. These studies aim to understand the NPF mechanism, its characteristics, how and when NPF takes place and eventually how it affects global climate. The conditions governing NPF have been shown to vary in different environments. In this context and within the framework of the Eastern Mediterranean and the Middle East – Climate and Atmosphere Research Centre (EMME-CARE) project, we performed one-year continuous measurements of aerosol particles down to ~ 1 nm in diameter. The study aimed to examine the frequency, characteristics and drivers of NPF at a background site in Cyprus. This talk will present the main findings of our observations and an outlook for future studies.

Authors

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Satellite-based observations of aerosol-cloud relationships under different water vapor conditions over the Eastern Mediterranean

Stavros Stathopoulos

DUTH

The current study investigates the annual and seasonal aerosol-cloud relations under different water vapor conditions over urban and rural subregions of the Eastern Mediterranean. We utilized a decade (July 2002-December 2012) of Aerosol Optical Depth at 550 nm (AOD), Water Vapor at clear sky (WV), Cloud Cover (CC), Cloud Optical Depth (COD) and Cloud Top Pressure (CTP) data from the Moderate Resolution Imaging Spectroradiometer (MODIS) satellite sensor. In addition, we used anthropogenic AOD (AODanthr) and dust AOD (AODdust) data that were produced from a combination of satellite, chemical-aerosol-transport model and reanalysis data. Over all regions, seasons and WV bins, CC is found to increase with increasing total, anthropogenic aerosol and dust loading, pointing towards the aerosol invigoration effect on clouds. COD for AOD<0.5 is found to increase with increasing AOD, while for AOD>0.5, to decrease or remain constant, irrespective of WV amount. Anthropogenic COD is observed to be larger than dust COD. Moreover, CTP in spring and summer months is found to decrease with increasing AOD and CC, while in autumn and winter months and for high WV concentrations, CTP decreases with increasing aerosol loading.

Authors

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Relationship between Aeronet and Modis-based Aerosol Optical Depth with surface PM10 over Cairo (Egypt)

Ahmed Sara said
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The densely populated Cairo suffers from serious air quality problems caused by human activities (transportation, factories, and open-air burning of waste…). This is in addition to the dust-laden winds blowing from the arid regions of Egypt (such as the Western and Eastern Deserts). Besides, lack of rain, atmospheric stability in some seasons, and poor urban planning (tall buildings and narrow streets), result in a poor ventilation favouring the trapping of pollutants close to the surface. This paper studies the variation of one of the most important pollutants affecting air quality in Cairo, namely the airborne particulate matter with aerodynamical diameter <10 µm (PM10), by analysing the correlation between its surface concentration measured at an urban/residential location and the aerosol optical depth (AOD) obtained from the 1) Aerosol Robotic Network (AERONET) and 2) Moderate Resolution Imaging Spectroradiometer (MODIS: AQUA and TERRA) during three years (2012-2014). Moreover, the PM10 concentrations of the MERRA-2 reanalysis are compared to the observations of the same period. The results indicate that the monthly means of AOD values range between 0.2 and 0.5 over Cairo. The maxima of the AOD are recorded in spring because of the frequent dust storms associated with the Khamasin depressions and in autumn as a result of the stability of the atmosphere and the burning of the agriculture waste. The ground-based PM10 concentrations and the AOD from AERONET, MODIS/AQUA and MODIS/TERRA are well correlated (r= 0.86, 0.84, and 0.83, respectively). This suggests that the aerosols are mostly confined to the vicinity of the surface and are usually not transported in elevated layers. In addition, the good performance of the MERRA-2 surface PM10 products (r = 0.81 with the measurements) enables us to use them for documenting the long term (1980-today) variability of the aerosol concentration above Cairo.

Keywords: Cairo; PM10; Aerosol optical depth; MODIS; AERONET, MERRA-2

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Premature mortality from exposure to ambient PM2.5, Black and Organic Carbon in the EU-27

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Exposure to particulate matter less than 2.5μm in diameter (PM2.5) can result in multiple health implications among humans, including excess mortality from lung cancer, cardiovascular, respiratory, and other non-communicable diseases. Globally, up to nine million excess deaths per year may be attributed to exposure to ambient PM2.5. This estimate does not account for the potential differential toxicity of PM2.5 components (like black and organic carbon). Different emission sources and formation pathways can result in particulates of different sizes, shapes, surface charges, chemistry, and thus different toxicity. Given the design of the exposure-response functions, it is difficult to assess the health impacts of each PM2.5 component separately. Here, we use the Weather Research and Forecasting with Chemistry (WRF-Chem) model and a recently developed exposure-response function (Global Exposure Mortality Model – GEMM) to estimate excess mortality associated with long-term exposure to ambient PM2.5 for the year 2015 in the EU. We further attribute the estimated excess mortality to the fractions of black and organic carbon (BC+OC) in PM2.5, based on the assumption that BC+OC are twice more toxic than other PM2.5 components, being supported by toxicological and epidemiological studies. We estimate that an annual total of 392,000 (CI: 353,000-431,000) excess deaths is associated with exposure to ambient PM2.5, of which 65,000 (58,700-71,200) deaths (~17%) are associated with BC+OC exposure (with BC+OC being twice more toxic than other PM components). This fraction corresponds to 564 deaths/year per 100,000 population. Under the equal toxicity assumption, the BC+OC attributable mortality is reduced to 31,000 deaths (28,000-34,000) per year (~8%), which corresponds to 267 deaths/year per 100,000 population. Although the level of BC+OC toxicity is not well known, our results suggest that countries with higher BC+OC emission sources (e.g. from road transport and residential combustion) would gain much in terms of health benefits if they prioritize these sectors in air pollution mitigation strategies.

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Light Absorption properties of aeolian dust – case studies of storm events

Balint Alfoldy
Aerosol d.o.o

Aeolian dust is a significant component of the atmospheric particulate matter that can persistently determine the air quality especially in desert environments. On the other hand, mineral dust particles can be transported over a regional and even a global scale and affects the global radiation budget. Moreover, high mineral dust exposure poses significant health risk.

Although mineral dust particles weakly absorb the light in the UV and short visible wavelength bands, it is possible to detect them optically in high concentration cases, if the interference of other, stronger absorbing particles (such as black carbon, BC) can be avoided. This can be achieved by an aerodynamic separation between the coarse mode mineral particles and the fine mode black carbon particles using the virtual impactor (VI) technique. On the other hand, dust storms offer an alternative and unique opportunity for the investigation of mineral dust absorption since negligible contribution of combustion related particles can be assumed during these events.

In this paper we present major dust storm cases from the Arabian desert, when the optical behavior of mineral dust particles was recorded real-time using a multi wavelength Aethalometer (AE33, Aerosol d.o.o., Slovenia). The instrument measures the light absorption of the particles at seven wavelengths with a minimum of 1 second time resolution. PM10 aerosol mass concentration was simultaneously measured so the mass absorption cross-section (MAC) could be determined for 7 wavelengths. Complex behavior of the wavelength dependency of the MAC number was observed following a power-law relationship with different exponents for the long and short wavelengths.
This work provides more information about the absorption properties of the mineral dust particles that can be further used for specifying the aerosol source apportionment by the VI technique.

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Vertically resolved optical and physical characterization of aerosol layers over Amman employing CALIPSO satellite data

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IASBS

The land of Jordan is located in the south of Syria, west of Iraq, northwest of Saudi Arabia and the east of Israel. Jordan's climate is influenced by the aridity of the Arabian desert and the humidity of the EM. The vertical profile of aerosol optical and physical properties is investigated over Amman utilizing the CALIPSO Level 2 products from May 2018 to March 2019. The CALIOP signal has averaged for a horizontal resolution of 50km (around Amman). Then a two-step POLIPHON method is applied to separate dust and non-dust contributions, and retrieved appropriate vertical profile of aerosol mass concentration. Two high volume samplers (Model: MCV CAV-A/mb) used for measuring concentration of particulate matters (PM2.5 and PM10) as the main ground-based instruments in this study. All evaluated CALIPSO profiles have been analyzed to identify the height distribution of lofted layers over Amman from May 2018 to June 2019 (not shown). In addition to aerosol type classification with respect to depolarization ratio, the top heights and the depths of the lofted aerosol layers are determined. The highest frequency of occurrences for top height of lofted layer, which mostly (51%) contain polluted dust aerosols, observed from 0.5 to 2.5 km agl with a second smaller peak at 3.5 km agl. Regarding the depths of the observed lofted layers, the maximum frequency occurs with 40 % of cases with below 0.5 km depth and a few cases with less than 4.5 km. The monthly variation of dust, polluted dust and pollution aerosol observed by the CALIPSO from May 2018 to June 2019 is also investigated (not shown). According to this result, the Amman atmosphere mostly impacted by high polarizing dust aerosols ($\delta p>0.25$) particularly from March to June. The atmosphere is also contaminated by less polarizing pollution particles ($\delta p<0.75$) from October to February.

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Large-scale atmospheric patterns and PM10 pollution: The contribution of the Saharan oscillation

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Nowadays, air pollution and climate change are the greatest atmospheric challenges for societies, and they will continue to be in future decades. These environmental issues are highly connected, mainly through atmospheric processes and meteorological conditions.

PM10 is an urban air pollutant, emitted by industry and traffic activities and widely impacted by weather conditions and meteorological factors. When in high concentrations, PM10 has significant impacts on the human health, wellbeing and environment. Moreover, it can cause the decrease of visibility, smoke, haze, and smog. In Morocco, air pollution is responsible for more than 13,000 deaths each year. This represents about 7% of all deaths thus the 8th largest mortality risk factor. More than 12,000 deaths are attributable to fine particles. Casablanca is a metropolis whose rate of urbanization and population density are the highest in Morocco, it concentrates many industrial units and a large vehicle fleet. Marrakech is one of the most populated cities in the country where the motorization rate has increased during the recent years. These both metropolitan cities have various sources of pollution by PM10, yet the few studies that have been led on particle pollution at the level of these two cities, didn't go beyond presenting air data and comparing them with standard limits. The main goal of this study is to evaluate the concentrations of PM10 at the scales of Casablanca and Marrakech, and provide a characterization of their relationship with large scale atmospheric circulation through assessing their statistical correlations with the North Atlantic Oscillation (NAO) and the Mediterranean Oscillation (MO) indexes. This work is based on PM10 daily measured data between 2013 and 2016.

First, we assessed PM10 correlations with climate indexes (NAO and MO), then we characterized the contribution of large-scale atmospheric patterns related to PM10 extreme events. Yet, the novelty of this research is the creation of a new climate index to characterize the oscillation, in the country's southern desert, between the Saharan depression and the Azores high. Time series of the new Saharan Oscillation Index (SaOI) were calculated.

This study has demonstrated the relationship between MO and PM10 averages and has shown that particulate pollution, in the study area, is partly induced by continental northeasterly to southwesterly flow. This flow is triggered by the Saharan trough and managed by the High-pressure area in the north. Assessed SaOI related correlations confirm the relationship between this index, PM10 averages and MO and NAO indexes in winter. The Saharan Oscillation is the new relevant key to understand pollution by fine particles worldwide.

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Sensitivity analysis of WRF model PBL schemes in simulating temperature extremes over the Middle East - North Africa (MENA) region

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A correct representation of the planetary boundary layer (PBL) is critical to achieve realistic simulations, especially regarding surface variables for regional climate simulations. In this study we examine the sensitivity of the performance of the Weather Research and Forecast (WRF) model to the use of three widely used PBL schemes with emphasis on heat extremes. This study aims (i) to explore the differences among the WRF simulated air temperature extremes resulting from the choice of PBL schemes and (ii) to reveal the most suitable scheme for application in the Middle-East - North Africa (MENA) domain. The schemes under evaluation are the Mellor–Yamada–Janjic (MYJ), Yonsei University (YSU), and the asymmetric convective model, version 2 (ACM2). We performed 11-year (2000-2010) simulations over the MENA region at 24km resolution. The simulations have been compared with the ERA5 reanalyses for several variables, including maximum and minimum 2-meter air temperature and indices of extremes. Analysis of the model biases was based on MENA region maps comparison for every scheme as well as on several statistical metrics. Results indicate that model biases strongly vary according to geographic area, with simulations showing good performance in some regions and substantial biases in others.

Authors

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Rainfall-Aerosols Interactions at time Scales of Minutes to Days with Focus over the EMME region and Mediterranean Climate

Pinhas Alpert
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Rainfall and aerosols play major roles in the Earth climate system and substantially influence our life. Here, the focus is on the local near-surface aerosol/rainfall correlations with time scales of minutes to days. We investigated 29 experiments including 14 specific rain events, with time resolutions of daily and 60, 30, and 10 min at 10 stations in Israel and California. The highest negative correlations were consistently at a positive lag of about 150 min where a positive lag means that the aerosol time series follows that of the rain. The highest negative value is suggested to be the probable outcome of immediate scavenging along with the rise in aerosol concentration after rain depending on aerosol sources, hygroscopic growth, and transport. The scavenging dominance is expressed by the mostly negative lag-correlation values in all experiments. In addition, the consistent lack of significant correlation found at negative lags suggests a weak aerosol effect on precipitation. Take-away message: The capability of an advanced high-resolution most advanced global climate model to capture these new findings on rainfall-aerosol relations will be assessed over the EMME region with the abovementioned stations over Israel for the Mediterranean climate. The significance of these findings for Mediterranean climate modeling, will be highlighted.

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Utilizing weather station, satellite, and population datasets to estimate urban heat island over locations in the Middle East and North Africa (MENA) region

Anna Tzyrkalli

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Local weather and climate conditions are affected by the presence of cities, through their perturbation of the surface energy balance. A well-known manifestation is the Urban Heat Island (UHI) in which land surface and near surface air temperatures are higher over a city compared to its rural surroundings. In order to determine and project this local warming additionally to the large-scale global warming, reliable, observation based UHI estimates are necessary for the evaluation of high-resolution, urban resolving climate model simulations. In this work, we explore the suitability of air temperature station records, in conjunction with urbanization data derived from land and population data, to provide credible urban-rural temperature differences for the MENA region.

Specifically, for air temperature we utilize daily and sub-daily timeseries from the Integrated Surface Database (ISD), resulting in more than 400 station records for the MENA. We subsequently characterize the degree of urbanization of these stations using the gridded, 1km x 1km GHSL Settlement model (GHSL SMOD) data that calculate 8 classes of urban and rural spatial entities from built-up area (Landsat) and population (CIESIN Gridded Population of the World) data. Examples of the derived UHI magnitude from the identified station pairs will be shown, and the associated assumptions and limitations of the followed approach will be discussed.

Authors

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Climate Change projections for Greece in the 21st century from a High-resolution Euro-CORDEX ensemble

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Due to the increasing number of various extreme events, directly or indirectly related to climate change, such as fires, floods, and heat waves, the public and political awareness about climate change is continuously increasing in Greece. The need for assessing climate change and its impacts, and establishing mitigation measures, is acknowledged more than ever. Within the framework of the national project CLIMPACT (National Network on Climate Change and its Impacts) we went through an assessment of the expected changes in climate-related parameters and indexes over the country for the near-future (2021-2050) and the end-of-the-century (2071-2100) periods relative to 1971-2000. Our results are based on an ensemble of 11 state-of-the-art high-resolution EURO-CORDEX simulations for three different GHG concentration scenarios (RCP2.6, RCP4.5, and RCP8.5). Indicatively, the near surface temperature is expected to increase by 1.2 oC (~9%) and 1.6 oC (~12%) in the near future according to the optimistic RCP2.6 and the extreme RCP8.5 scenarios, respectively. For the end of the century, the corresponding changes are 1.4 oC (~11%) and 4.3 oC (~33%). Under RCP8.5, the number of hot days (days with maximum temperature greater than 35 oC) is expected to increase by about six times (29.4 days) and tropical nights (days with minimum temperature greater than 20 oC) by three times (57.9 days) by the end of the century. Precipitation is expected to decrease by -0.1 mm day-1 (~-4%) in the near-future period under RCP2.6 and then increase reaching the same levels as the reference period. Under RCP8.5, a decrease of -0.4 mm day-1 (~-16%) is expected for the end of the century. The number of consecutive dry days is expected to increase by 15.4 days (~30%) at the end of the century. Overall, our results point towards a definitely warmer and possibly drier future, especially under RCP8.5.

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Spatio-temporal characteristics of observed air temperature 1981-2020 trends in the Middle East North Africa (MENA) from the CRUTEM4.6 dataset

Panos Hadjinicolaou

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Observed temperature trends in the Middle East-North Africa (MENA) region, are updated and assessed for their temporal and spatial features and investigated for possible influence from urbanisation. Monthly mean temperature time-series of more than 200 stations from the CRUTEM4.6 dataset are used for the derivation of annual and seasonal temperature linear trends for 1981-2020. Strong warming is indicated with a MENA station average annual trend equal to 0.39 °C/decade and a faster warming rate for spring (0.45 °C/decade) and summer (0.49 °C/decade). The stations are characterised as very rural or urban with the use of the urban and built index from the MODIS dataset, with two different approaches (adjacent grid-box and average of neighbouring grid-boxes). Depending on the approach, an overall small urbanisation effect is discernible on the temperature trend. Compared to the value for all stations reported above, the annual trend becomes 0.35 °C/decade for the very rural stations and 0.47 °C/decade for the urban stations.

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Projected changes in temperature and precipitation extremes in Egypt by the REGCM4

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Climate change is one of the most pressing challenges facing the world as it affects almost every aspect of our lives. This study explores simulated and projected changes in maximum temperature and precipitation in Egypt by the end of the twenty-first century using the output of the Regional Climate Model RegCM4, based on the MPI-ESM-MR General Circulation Model as initial and boundary conditions considering two greenhouse gas emissions scenarios, RCP4.5, and RCP8.5. The climate indicators, proposed by the Expert Panel on Climate Change Detection and Indicators (ETCCDI), were used to investigate extreme weather events via the Climate Data Operator (CDO) program. Compared with the reference period 1986-2005, substantial changes in temperature extremes have been noticed under the two emission scenarios, and the differences in the projected temperature changes under the two RCPs begin to emerge after the 1950s. These changes include a decrease in extremely cold temperatures and an increase in extremely high temperatures. While in the case of precipitation, there are no fundamental changes in most of Egypt's cities characterized by low rainfall.

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Projecting the potential evapotranspiration of Egypt using a high-resolution regional climate model (REGCM4)

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This study aims to use the regional climate model (RegCM4) to examine the influence of climate change on potential evapotranspiration (PET) of Egypt under two future scenarios. To address such a topic, the calculated PET is first corrected in the historical period with respect to the long-term gridded PET data (Climate Research Unit; CRU) using a linear regression model (LRM) between RegCM4 and CRU. After that, the LRM is used to correct the two future scenarios Representative Concentration Pathways (RCP4.5 and 8.5) of the period 2006-2100. The RegCM4 was downscaled by the medium resolution of the Earth System Model of the Max Planck Institute (MPI-ESM-MR) with 50 km horizontal grid spacing over Middle East and North Africa (MENA) and then nested over Egypt with 20 km horizontal grid spacing. The results showed that the RegCM4 is able to capture the monthly variability of PET with respect to the CRU; furthermore, the RegCM4 overestimates/underestimates the PET depending on the location under consideration. Also, the simulated PET was notably improved when the LRM was used. Such improvement is indicated by a low mean bias and a high standard deviation ratio (close to unity) between the corrected PET and CRU. In addition, the future PET projects a strong increased trend under the RCP8.5 scenario; meanwhile the future PET projects a weak increased trend under the RCP4.5 scenario.

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City, Citizens, and Climate crisis in the East Mediterranean: From Global Climate predictions to the citizens experience

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Climate change is expected to aggravate urban microclimatic conditions with direct impacts on human morbidity and mortality. Several models have been developed to predict different climate change scenarios. However, there is lack of detailed information on how climate change is going to affect urban microclimate and human health. This study presents high-resolution Unsteady Computational Fluid Dynamics simulations to study the impact of climate change on urban microclimatic conditions and pedestrian thermal comfort for a real heterogeneous urban area. Two scenarios are considered: (i) current meteorological conditions, and (ii) future meteorological conditions predicted based on numerical climate prediction models. The simulated scenarios cover the city of Nicosia in Cyprus - in Eastern Mediterranean Region and the results of the simulations have been validated using an extensive laboratory and field measurements experimental campaigns in Nicosia. In order to connect the the resulting temperature field with thermal comfort and mortality an assessment based on Universal Thermal Comfort Index (UTCI) equivalent temperature was conducted and epidemiological studies relating heat stress with mortality were used. Our results show that air temperature increase could lead up to 3 times higher heat related mortality. In addition, the total surface of areas within very strong heat stress conditions based on UTCI thermal stress zones is expected to be enlarged up to 600% at late morning hours with expected additional consequences in biodiversity.

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Effects of rapid coastal urbanization on local near-surface climate variables in the Middle East

Emily Elhacham

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Rapid coastal urban development is characteristic to the EMME region. The potential impact of such rapid coastal urbanization on the local climate is illustrated here by focusing on Dubai. Dubai is one of the fastest growing cities in the world over the last two decades. Its urbanization centers along its coastline – in land, massive skyscrapers and infrastructure have been built, while in sea, unique artificial islands have been constructed.

We explore the effects of this extreme urbanization on the near-surface climatic variables, based on MODIS data, Landsat and in-situ observations. Studying the coastline during the years of intense urbanization (2001-2014), we show that the coastal surface urban heat island has nearly doubled its size, expanding towards the newly developed areas. This newly developed zone also exhibited the largest temperature trend along the coast, exceeding 0.1°C/year on average.

Overall, we found that over land, temperature increases go along with albedo decreases, while in sea, surface temperature decreases and albedo increases were observed particularly over the artificial islands. These trends in land and sea temperatures affect the land-sea temperature gradient which influences the breeze intensity. The above findings, along with the increasing relative humidity shown, directly affect the local population and ecosystem, exacerbate the thermal comfort, adding additional burden to this area.

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Future climate change impact on wildfire danger over the Mediterranean: The case of Greece

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Recent studies have shown that temperature and precipitation in the Mediterranean are expected to change, indicating longer and more intense summer droughts that even extend out of season. In connection to this, the frequency of forest fire occurrence and intensity will likely increase. In the present study, the changes in future fire danger conditions are assessed for the different regions of Greece using the Canadian Fire Weather Index (FWI). Gridded future climate output as estimated from six regional climate models from the Coordinated Regional Downscaling Experiment (CORDEX) are utilized. We use three Representative Concentration Pathways (RCPs), consisting of an optimistic emissions scenario where emissions peak and decline beyond 2020 (RCP2.6), a mid-of-the-road scenario (RCP4.5) and a pessimistic scenario, in terms of mitigation, where emissions continue to rise throughout the century (RCP8.5). The FWI projections were assessed for two future time periods, 2021-2050 and 2071-2100, comparing to a reference time period in the recent past 1971-2000. Based on established critical fire risk threshold values for Greece, the future change in days with critical fire risk were calculated for different Greek domains. The results show that future fire danger is expected to progressively increase in the future, especially in the high-end climate change scenario, with southern and eastern regions of Greece exhibiting increases in the FWI that exceed 20 FWI units, on average. Furthermore, southern Crete, the Aegean Islands, the Attica region, as well as parts of eastern and southern Peloponnese are predicted to experience a larger increase in the fire danger, with an additional 12-17 potential fire days in the distant future (2070-2100) when compared to the reference period, under the RCP8.5 scenario.

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Methane Budgets and inverse modelling in the Eastern Mediterranean and Middle East

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Anthropogenic greenhouse gas (GHG) emissions in the Eastern Mediterranean and Middle East (EMME) have increased fivefold over the last five decades. Emission rates in this region were 3.4 GtCO2eq/yr during the 2010s, accounting for ~7% of the global anthropogenic GHG emissions. Among various GHGs emitted, methane (CH4) is of particular interest, given its stronger global warming potential relative to CO2 and the role of EMME as a key oil and gas producing region. Bottom-up inventories reported that the anthropogenic CH4 emissions in EMME were ~22 Tg/yr in the 2010s, of which ~60% were contributed by oil and gas sectors. As inventory-based estimates often suffer from uncertainties in emission factors and activity statistics, independent budget estimation based on atmospheric observations, preferably at regional or national scales, are required to verify inventories and evaluate effectiveness of climate mitigation measures. Meanwhile, the availability of satellite CH4 observations in the recent decade (notably GOSAT XCH4 and TROPOMI XCH4) provide new opportunities to constrain CH4 emissions in this region previously underrepresented by ground-based observational networks. Here, we propose a study of CH4 inverse modeling over EMME, using a Bayesian variational inversion system PYVAR-LMDz-SACS developed by LSCE. The system takes advantage of the recent progress in satellite observations and the zooming capability of the atmospheric transport model LMDz to infer CH4 emissions in EMME at a resolution of ~50km. With these datasets and modeling tools, we aim to assess the variations in CH4 emissions in EMME at the scales where decision-making and climate actions take place.

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Comparison of methane emissions reported in bottom-up inventories against atmospheric inversions in the Eastern Mediterranean and Middle East region

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The oil and gas sector is the primarily emission source of anthropogenic methane (CH4) emissions in the Eastern Mediterranean and Middle East (EMME) region. Emissions from this sector have rapidly increased over the last decades and they represent on average 75% of total anthropogenic CH4 emissions. This study presents results of atmospheric inversions over the EMME region and compares them to available emission inventories. Inversions tend to estimate higher CH4 emissions compared to emission inventories for countries in the EMME region. This difference might be partially explained since ultra-emitting events, consisting of very large and sporadic emissions, are not considered by emission inventories. Ultra-emitters are especially important for EMME countries, such as Kazakhstan and Turkmenistan, where ultra-emitter emissions represent ~70% of total reported fossil fuel emissions. This study also considers emissions derived from regional inversions using S5P-TROPOMI atmospheric measurements at the scale of regional extraction basins for oil, gas and coal. Here, we assumed that those basins are already counted as part of the national CH4 budgets from in-situ and GOSAT inversions. Two major oil and gas basins in the EMME region were considered as specific areas where many individual wells and storage facilities are concentrated. Emissions from the basin comprising Iraq and Kuwait represent ~38% of the total estimated fossil emissions from the Arabian Peninsula. This basin estimation encompasses four of the highest oil-producing fields in the world. The basin estimation from inversions for Iran (2.5 TgCH4) represents ~68% of fossil fuel estimated emissions from inversions and ~59% of report bottom-up inventories. Our integrated results help understand and compare the most recent emission estimates for the EMME region and the importance of its oil and gas emission sector.

Authors

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Aggregation of greenhouse gas emissions over Cyprus and international reporting obligations

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The greenhouse gas emissions inventory reporting is essential to monitor the GHG concentrations in the atmosphere with the aim to stabilise them at a level that would reduce dangerous human-induced interference with the climate system. For the reporting of emissions, after obtaining data from governmental bodies and the national statistical service, the calculation is carried out after the IPCC 2006 guidelines. Tier 1 but also higher methods are used. The last national inventory report for Cyprus was for 2019. GHG emissions in 2019 were 8841 Gg CO2 eq. Total national emissions increased by 58.7% between 1990 and 2019 and decreased by 0.34% between 2018 and 2019. Energy is the largest contributor to the total national GHG emissions, with 74.4% of the total emissions. In January 2020, the globe found itself in front of a health crisis, the COVID-19 pandemic. The government of Cyprus took immediately action in order to prevent massive contamination, announcing restrictions to the extent of a mandatory national 'lockdown'. The energy demand patterns during spring 2020 changed drastically with an important impact on the CO2 emissions related to the energy sector. The decrease in CO2 emissions during the confinement was estimated. The maximum CO2 emissions decrease from the energy generation sector was in April 2020, with -25% less emissions than in April 2019, while the decrease of CO2 emissions from road transport and aviation for the same month was -62% and -87% respectively. The COVID-19 pandemic restrictions and impact on emissions is likely to influence the pathway of CO2 emissions for the future.

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First columnar greenhouse gases in the Eastern Mediterranean and Middle East region by TCCON Nicosia

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The Eastern Mediterranean and Middle East (EMME) region, with its population of more than 400 million people, is identified as one of the primary climate change "hot spots" worldwide, experiencing adverse impacts ranging from extreme weather events to poor air quality. Projections show that these phenomena are expected to further exacerbate in the coming decades. At the crossroads of Europe, Africa, and Asia, the island of Cyprus, in the middle of the EMME, receives long-range pollution from various anthropogenic and natural sources. To assess the variability and amounts of greenhouse gases (GHG) contributing to radiative forcing in the area, we have set up, in 2019, a new Total Carbon Column Observing Network (TCCON) site, the TCCON Nicosia, at The Cyprus Institute. Herewith, we present the first results; columnar amounts of the main GHGs in the region, namely carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O) and carbon monoxide (CO). The TCCON Nicosia site was validated against the World Meteorological Organization (WMO) reference scale in June 2020 with the first AirCore campaign in Cyprus. The WMO scale ensures common accuracy among observations from different platforms, i.e. in-situ, ground- and space-based remote sensing. The existing data set of two (2) years of GHG data, together with the results of the AirCore comparison, are presented. Interestingly, two of the AirCore flights revealed elevated GHG levels in the upper troposphere, transferred by the Asian Summer Monsoon Anticyclone (ASMA). The latter provides evidence that long-range transported pollution originating in southeast Asia can reach the Eastern Mediterranean.

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Quantifying Nitrogen Oxides emissions in Egypt using satellite observations

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Urban areas and industrial facilities, which concentrate most human activity and industrial production, are major sources of air pollutants, with serious implications for human health and global climate. For most of these pollutants, emission inventories are highly uncertain, especially in developing countries. Satellite observations of the TROPOMI instrument, onboard the Sentinel-5 precursor, can be used to observe daily nitrogen dioxide (NO2) column densities with a high spatial resolution to overcome inventories weaknesses.

Here, we use two years of TROPOMI retrievals to map nitrogen oxides (NOx) emissions in Egypt with a top-down model based on the continuity equation which links emissions with wind transport and chemical processes. After evaluating the reliability of the parameters involved in this model, we find that total emissions of NOx in Egypt are dominated by the reaction between NO2 and OH. However, in urban and industrial areas, they can be locally dominated by the spreading of pollution with the wind.

Moreover, the model appears to be very sensitive to horizontal wind and OH concentrations. Although it is able to detect a weekly cycle in NOx emissions which is reflecting Egyptian social norms, to quantify the drop of emissions in 2020 due to the Covid-19 pandemic, and to highlight an seasonnality which is consistent with the electricity consumption in the country, uncertainties remain high. The model overestimates NOx emissions by 25.0% compared to CAMS inventory estimates, and significantly differ in terms of annual cycle, illustrating the needs for additional data to improve the relevance of inventories.

These results demonstrate a high potential for satellite-based emission mapping at the scale of cities, regions and countries, provided that a sufficiently large coverage of clear-sky days is available.

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Variability and trend of precipitable water vapor, lower stratospheric water vapor, methane, nitrogen dioxide, and temperature in Alexandria city, Egypt, using MERRA2

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Background: Alexandria is a coastal city that lies over the Mediterranean Sea and is known for its tourism importance, moreover it is considered one of the largest cities in the Mediterranean region and receives the highest amount of rainfall compared to the other Egyptian locations due to the intensification of midlatitude cyclones over the Mediterranean region in winter, thus it is vital to investigate the variability and trend of different climatic variables that might cause a change of climate over this city.

Purpose: We aimed at investigating the trend of the surface temperature and 500 hPa temperature along with the main greenhouse gases (water vapor and methane), and nitrogen dioxide which is from the main air pollutant, and the lower stratospheric water vapor which is also considered a greenhouse gas due to its radiative effect, for the period 1980 to 2020. Additionally, we analyzed the correlation between temperature and specific humidity over 13 pressure levels from the surface to 50 hPa.

Methods: We obtained the data from Modern-Era Retrospective analysis for Research and Applications, Version 2 (MERRA2), which is the latest reanalysis produced by NASA, the data spatial resolution is 0.5° x 0.625° with monthly temporal resolution. For trend estimation ordinary linear regression method was performed and Pearson correlation (r) was used to investigate the linear relationship between temperature and specific humidity. In order to test the significance of the trend and correlation student t-test was used.

Results: The outcomes revealed a significant increase over Alexandria in precipitable water vapor and surface temperature along with the 500 hPa air temperature, also a significant increase observed in the nitrogen dioxide concentration, however, since 2017 the trend turned out to be negative. Methane showed a significant increase at a constant rate. The correlation between specific humidity and temperature is strongest at the surface and decreased upward to the middle of the troposphere, then it turned out to be negative in the upper troposphere and lower stratosphere.

Conclusion: Alexandria city is warming at the surface along with the upper levels, water vapor accounts for the surface warming which could be observed by the very strong positive correlation (r = 0.97), however, it is not responsible for the upper warming which suggests the role of methane. Nitrogen dioxide has started to decrease in 2017 due to the decrease of congestion which accompanied the new road projects over all of Egypt.

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Observatory for the waterborne air pollution in the Eastern Mediterranean

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Development of a real-time CO2 emissions monitoring platform, an “Observatory”, which will monitor emissions from ships in the Eastern Mediterranean. The platform will be an Observatory to monitor waterborne air pollution by collecting real-time information from vessels, processing this using emissions modelling algorithms, and then releasing this information on a real-time basis via the internet. The real-time monitoring with the aid of automated input from the Automatic Identification System (AIS) and/or marine traffic will estimate/calculate the CO2 emissions of ships based on their speed and sea-state. In addition, the related hazardous emissions (SOx, NOx, CO, PMs, unburned HCs) will be estimated. The Observatory will also estimate the accumulated, generated pollution in the Eastern Mediterranean region due to regional shipping routes, which will allow users to understand the total impact in the area (including the implications for public health and the environment).

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Employing low-cost particulate matter sensors for developing cost-effective aerosol instruments

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The development of miniature and low-cost particulate matter (PM) sensors over the past few years has resulted in a variety of systems, a lot of which are already commercially available. While most of the low-cost PM sensors can be used directly (i.e., out of the box) for conducting PM measurements, they can be also incorporated in integrated in-line systems for characterising aerosol particles. The latter refer to systems which apart from the low-cost PM sensors include the user interface for operation, and even (depending on the application) the interface for achieving networking capabilities, as well as the necessary software for performing data analysis Certain limitations of the low-cost PM sensors (e.g., inaccurate results at high relative humidity conditions, passive or weak sample flow system, limited use only to direct sampling, electronics/software related uncertainties, etc.) can be overcome by embedding them in cost-effective integrated instruments. In this work we assess the key performance characteristics (i.e., sizing and counting efficiency) of the newest models of the Alphasense OPCs with the scope of incorporating the most suitable one into a cost-effective Optical Particle Spectrometer. Additional tests were also carried out at a range of temperatures and pressures, simulating conditions that can be encountered at specific ground-outdoor environments and/or onboard lightweight aerial platforms. Our results show that low-cost PM sensors such as the Alphasense OPC have good potential in being incorporated in integrated cost-effective instruments. Modifications (hardware and software) that increase the performance and the applicability of the final product are necessary.

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Performance assessment of low-cost air quality sensors through long-term observations over Nicosia, Cyprus and the effect of meteorological conditions

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Air quality (AQ) is a major concern of modern civilization, due to its adverse effects on the human health and the climate. Scientific instrumentation is employed for measuring the AQ and for assessing its impacts on humans and the environment. However, the number of AQ monitoring sites worldwide is limited due to the high possess and maintenance costs of the equipment, resulting in low spatiotemporal resolution of such observations. The importance of the later is highlighted in all recent studies, especially those concerning highly divert and variable micro-environments, such as cities and indoor spaces. Modern, 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. Electrochemical sensors can fulfil the above task, however, numerus studies have shown that their performance depends on a number of factors (e.g., environmental conditions, sensor quality, maintenance and calibration etc.). Eastern Mediterranean and Middle East (EMME) region is recognized as a hot spot of atmospheric pollution and climate change, therefore the need of dense AQ monitoring is of high importance. In this work the performance of a number of low-cost AQ sensors was investigated by contacting collocated (i.e., with reference instruments), two-year long, measurements in field conditions, at the Nicosia, Cyprus traffic AQ station. The results show that, the low cost sensors are capable of capturing the variability of the AQ, however not under all conditions and with lower accuracy than the reference instruments. One of the key factors for the discrepancies between the Low-cost AQ sensors and the reference instruments is the effect of the meteorological conditions. Despite the absolute discrepancies, LCS have high potential to be used for AQ networks by further post-processing through algorithms or calibration models.

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A new mobile platform of ACTRIS for cost-effective atmospheric profiling with UAV-sensor systems

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In-situ data can provide a great deal of information about the atmospheric environment that affects almost all aspects of human life. Despite the wealth of data emanating from in-situ atmospheric observations, there is a clear lack of cost-effective measurements conducted within the first kilometers of the troposphere, the lowest level of the atmosphere. Vertically resolved observations can provide essential input for validating remote-sensing retrieval algorithms and evaluating atmospheric models by giving unique information relevant to air quality, long-range transport of pollutants, radiative forcing, cloud formation, etc.

The Unmanned Systems Research Laboratory (USRL; https://usrl.cyi.ac.cy/) of the Cyprus Institute is a recently upgraded research infrastructure dedicated to Unmanned Aerial Vehicle (UAV)-based atmospheric research, development, testing, innovation, and training. USRL is currently the only mobile platform of the EU Research Infrastructure Aerosol, Clouds and Trace Gases Research Infrastructure (ACTRIS), offering UAV-sensor solutions that can be used everywhere in Europe for intensive field campaigns through a transnational access scheme and compliance with the drone regulation set by the European Union Aviation Safety Agency (EASA).

The USRL infrastructure in Cyprus consists of a private paved UAV runway with private overhead aerospace granted permanently by the Cyprus Civil Aviation Authorities, a fully-equipped electromechanical workshop dedicated to the development of UAVs and atmospheric sensor integration, and a mobile Ground Control Station (GCS) for real-time control and monitoring of the unmanned flights. The USRL airfield resides at a rural background site of Cyprus, close to the Cyprus Atmospheric Observatory (CAO), another national facility of the ACTRIS network.

The USRL fleet vehicles vary in type, size and mass, depending on the payload and specific application. The USRL UAVs are equipped with a range of robust in-situ sensors used to provide both trace gases and aerosols observations. These UAV-sensor systems have the capacity to provide dense profiling of the lowest atmospheric layers (0-4km altitude) and to perform 3D mapping of plumes close to emission point (e.g., characterization of stack emissions). There is also an ongoing plan for potential stratospheric measurements by utilizing a novel UAV-balloon-sensor system.

Since 2009, the USRL is participating in national and international research projects dedicated to: (i) the better understanding of aerosol-cloud interactions (EU FP7 BACCHUS), (ii) the profiling of aerosol absorption properties in contrasted atmospheric environments (H2020 ACTRIS-2), (iii) the vertical distribution of air pollutants below and above the planetary boundary layer over Cyprus (national RIF AQ-SERVE and ACCEPT), (iv) the aerosol size distribution over the Mediterranean Sea / Red Sea, and Arabian Gulf (AQABA oceanographic cruise), (v) the validation of Aeolus satellite (dust) products (ESA project ASKOS), (vi) the characterization of ship emissions (JPI Oceans Mate), and (vii) the provision of transnational access for research, development, and training (EU H2020 ACTRIS IMP and ATMO-ACCESS). Herewith, we present a brief overview of the major scientific and technical achievements of USRL and highlight its potential use for future field campaigns.

This project has received funding from the European Union's Horizon 2020 EMME-CARE project (grant agreement No 856612), The European Space Agency, and the Cyprus Research and Innovation Foundation AQ-SERVE project (RIF INTEGRATED/0916/0016). ACTRIS IMP (www.actris.eu) is supported by the European Commission under the Horizon 2020 – Research and Innovation Framework Programme, H2020-INFRADEV-2019-2, Grant Agreement number: 871115

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MEDCYCLONES COST Action: A European Network for Mediterranean cyclones in weather and Climate

Emmanouil Flaounas
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Cyclones are the main weather modulators in the Mediterranean region and constitute a major environmental risk, often producing windstorms and heavy rainfall. Moreover, cyclones play a key role in the regional climate variability by controlling the oceanic circulation and regional water cycle, and by mobilizing and transporting large amounts of dust from North Africa.

Despite the recent achievements of the scientific community to provide deeper insight into the atmospheric processes and impacts associated with Mediterranean cyclones, there are still unaddressed scientific challenges that require a coordinated approach. In addition, the lack of direct interaction between academic researchers and weather/climate prediction scientists working in operational centres inhibits the efficient exploitation of fundamental research results to improve atmospheric models in a tangible way. Therefore, it is undeniable that there are potentially large societal benefits from improving cyclone predictions for weather and climate timescales.

Efficient networking between stakeholders, operational weather forecasters and researchers is timely and essential to address both challenges of research coordination and operational implementation of scientific results into weather and climate services. The MedCyclones COST Action will coordinate the activities of researchers in meteorology and climatology and scientists from weather/climate services with the main aims to provide a deeper understanding of Mediterranean cyclones and to improve significantly the European capacity to predict their environmental and climate impacts.

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Climate Change competencies in Education

Laura Riuttanen

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The urgent societal need for climate action requires climate change expertise. But who is a climate change expert? What is the role of atmospheric and Earth system science higher education? We examined what competencies do atmospheric and Earth system scientists teach in selected degree programmes in seven European countries, and how they view the importance of various competencies for the students to learn (Riuttanen et al. 2021). We found that the atmospheric and Earth system scientists taught and valued the highest the traditional academic competencies related e.g. to critical thinking and applying knowledge. The normative, strategic and interpersonal competencies of sustainability were generally less valued and taught. The largest gaps between estimated importance and inclusion in teaching were found in competencies such as developing new ideas, interpersonal competency, making arguments and looking for solutions, critical thinking, collaboration and communication skills. Alarmingly, the atmospheric and Earth systems scientists in our study did not see themselves as climate change experts. We foresee here a need to define climate change competencies and discuss them within the community of atmospheric and Earth system scientists.

In the research project "Learning of the competencies of effective climate change mitigation and adaptation in the education system", (https://blogs.helsinki.fi/climatecompetencies/) we aim further to study the climate change competencies and how they are learned. In collaboration with Finnish Meteorological Institute and University of Helsinki atmospheric and educational sciences, we study Climate University online courses (www.climateuniversity.fi), produce new courses that utilize climate data, and develop a pedagogical model for optimal learning of the climate competencies.

Reference:

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Addressing Climate Change by educating young Europeans towards a sustainable and socially just economy

Despina Cochliou
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For many years, our attention was primarily on preventing natural disasters by building infrastructure to protect people and communities mainly in the developed world where financial resources are available. For countries with scarce financial resources, developing policies to protect people from climate change has not been an easy task. Nevertheless, climate change has worsened and people around the globe are affected in both well-developed countries and less developed of the southern hemisphere with the same tragic results loss of human life, destruction of property, and finally nature devastation and loss of natural resources.

The ecological calamities considered a result of economic, social, and political inequality because they are interlinked. In this respect turning our attention towards building an economy that promotes the wellbeing of all people – in Europe, as well as other parts of the world, needs to become the main strategy for ameliorating the consequences of climate change. An economy that overwhelms unfair constructs at the global level rather than preserving them allows all people rather than contemplate power to some countries and appreciates rather than destructs nature. To this end, it is imperative to educate young people towards a sustainable and socially just economy achievable for all people around the globe.

Based on research findings generated within the project “End Climate Change, Start Climate of Change” this paper will demonstrate how the current economic model affects climate change. It also aims to discuss the main root causes for climate-induced economic deprivation and how to educate young people to achieve a well-being economy in the future.

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Teaching systems thinking in Climate Change and sustainability education

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Systems thinking (ST) has been identified as a major competence needed to tackle wicked (sustainability) problems, of which anthropogenic climate change is an archetypical example. However, inclusion of ST in modern education system remains lackluster. In this work, theory and literature for incorporating ST into higher education as well as recommended pedagogical practices for its teaching are explored.

Literature identifies ambiguousness of the central concepts like 'systems thinking' and 'sustainability' is a barrier to their education, as presently there exist no universally agreed definitions of the terms (Hofman-Bergholm, 2018). While many schools of thought co-exist, significant common ground between the viewpoints can be found to adequately frame ST. Namely, systems thinking can be understood as an amalgam of language, methods and attitudes (Monat & Gannon, 2015), which together can be used as a framework for planning ST teaching in education.

The nature of many wicked sustainability problems necessitates a transdisciplinary approach to teaching and learning, as well as pre-requisite context knowledge. The students' existing, linear mental models, often counterintuitive functioning of complex systems, and physiological limits of human cognitive capacity pose additional challenges in learning of ST. Pedagogical approaches such as problem-based learning, interdisciplinary teamwork, using simulations (Cavana & Forgie, 2018) are recommended. The assessment of ST learning is also challenging, but methods like close-ended tools and evaluation rubrics have been developed for assessment ST learning (York et al., 2019).

This study provides advice for teaching, designing and evaluating ST related courses, materials and pedagogical models in current and future climate and sustainability education.

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Learning researcher skills while working in small groups on real scientific questions and data and in a multi-disciplinary and multicultural course is motivating for teachers and students

Taina Ruuskanen
University of Helsinki

The society is facing Grand Challenges, such as climate change and air quality problems that require new education strategies where knowledge from several fields of science are combined. We present a research intensive course model (Lauri et al, 2020) where interdisciplinary student groups work on real scientific data and questions and learn transferrable skills (Ruuskanen et al., 2018). The concept is based on our experiences organizing more than 50 research-intensive short courses and other multidisciplinary course over the past 20 years.

Methods of teaching on the course are data analysis of real scientific questions and real scientific data in groups, a few expert lectures, discussions with experts and peer support, and grading is based on the groups' oral presentations and written report. Our studies show that students enjoy the setting provided by the multidisciplinary intensive course and feel that they learn transferable skills, especially on data-analysis, during it.

Learning researcher skills while working in small groups on real scientific questions and data in a multidisciplinary and multicultural course is motivating for both teachers and students (Ruuskanen, et al., 2018). We recommend the course method for research groups in atmospheric sciences who are training future generation of researchers and experts.

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Climate-related education: on-line approach in COVID times

Tetiana Kryvomaz

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Erasmus+ ClimEd ("Multilevel Local, Nation- and Regionwide Education and Training in Climate Services, Climate Change Adaptation and Mitigation"; 2021-2023; climed.network) international project is aimed at development of competency-based curricula for continuous comprehensive training of specialists in the field of climate services and additional education in climate change for decision-makers, experts in climate-dependent economic sectors, and public. European and Ukrainian partners share experiences.

The ClimEd Trainings (http://climed.network/events/climed-trainings), in total 7, are carried out during project and focused on training the faculty/ teaching/ research staff and postgraduates at the ClimEd Universites and collaborating organizations in advanced educational and information-and-communication technologies for building a flexible multi-level integrated practice-based education system in the field of Climate Services, Climate Change Adaptation and Mitigation. Due to covid pandemic situation, trainings were organised as online events. The online trainings were divided into 3 parts: online lecturing; home-work-assignments as group projects; and final oral presentations with evaluation and feedbacks, discussions, and awarding certificates. Trainings also include questionnaires distributed among participants: evaluation of the training, and evaluation of own learning outcomes.

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VPICO PRESENTATIONS

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Urban representation in High resolution WRF simulations over the region of Eastern Mediterranean and the Middle East

Katiana Constantinidou

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Urbanization causes significant changes in land surface properties of a region, which alter the surface energy balance. A well-known and studied effect is the urban heat island (UHI) which characterizes urban areas with much higher temperatures than their surrounding rural regions. UHI might not affect global temperatures but its effect at local and regional level is evident.

This study introduces the efforts made to simulate the effect of urbanization on the climate over the eastern Mediterranean and the Middle East (EMME). Two high resolution simulations at 16 km and 4 km are performed over the EMME domain using the Weather and Research Forecasting (WRF) model coupled with NoahMP land surface scheme for the summer period (June-July-August, JJA) of 2000. The default bulk urban parameterization scheme is implemented first, which assigns fixed values for land properties such as surface albedo, roughness length etc, appropriate for the resolved urban areas. The effect of the model horizontal resolution and the grid-box land type on the 2-meter air temperature, and therefore on the induced UHI, are investigated in this work. For this purpose, the results of pairs of stations (urban-rural) from the two simulations are compared with station observations.

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Tin-Copula Bias-Correction method for model-derived maximum temperature in the MENA region

Georgia Lazoglou

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Global and regional climate models' prediction accuracy is limited, often with systematic biases between the model output and observed conditions. The present research aims to minimize the biases between the maximum temperature simulated by a global (HadGEM3) and a regional (WRF) climate model for the period of 2006-2014, based on the ERA5 reanalysis data, used as a proxy for observations (calibration period 1981-2000). For the bias correction, a new approach with the TIN-Copula method (combination of Triangular Irregular Networks-TINs and Copulas), suitable for gridded datasets is used. The methodology applies TINs to define the grids to which the corrections are made, and copulas for analyzing the dependence between the reanalysis and simulated data during the calibration period. The dependence structure is then used for the bias adjustment. Our methodology is applied to the Middle East and North Africa MENA-CORDEX domain, where extreme heat conditions prevail, which are projected to accelerate during the 21st century. Besides to the entire area, a detailed analysis was performed for six sub-regions. Our results indicate that the maximum temperature output of both models diverges from the ERA5 reanalysis, especially during summer. In several sub-regions and seasons, discrepancies are highest for the HadGEM3 model, which has a much coarser resolution than WRF. The effectiveness of the TIN-Copula method was tested spatially, temporally and based on two relevant climate indices (daily maximum temperature (TXx) and warm spell duration index (WSDI)), showing that it minimizes model biases.

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The impact of assimilating Aeolus remote sensing wind data on regional aeolian dust

Pantelis Kiriakidis

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Short-term dust forecasts using simulations from Numerical Weather Prediction (NWP) models are initialized from meteorological fields. With the launch of the Aeolus wind lidar in 2018, developed by the European Space Agency, wind vector component profiles along the line of sight of the instrument have been recorded. These datasets, which include Rayleigh-clear and Mie-cloudy winds, can be assimilated into the NWP input data and have the potential to improve predictive capability.

We aim to demonstrate the potential improvement of short-term dust forecasts via the assimilation of Aeolus wind profiles. Towards the derivation of novel and unique scientific outcomes, regional modelling simulations using the WRF-Chem model, initialized with IFS meteorological fields with and without assimilated Aeolus L2B data, are performed, and a variety of reference datasets are utilized for the assessment of the potential improvements on dust forecasts.

Simulations were carried out over the spring and autumn aeolian dust seasons, from April to May, and September to November 2020. The model outputs for both scenarios have been compared to observations, in terms of Aerosol Optical Depth, sourced from AERONET, and particulate matter concentrations, from the EMEP. Preliminary findings show that the inclusion of the Aeolus assimilated data improves the statistical correlation of Autumn simulations to observations with an improvement in the Index of Agreement of 0.72 for AOD, for the Agia Marina station in the East Mediterranean region. For the simulations during the Spring period there were no significant differences resulting from assimilation. Towards a thorough assessment of the assimilation of the Aeolus data in the model system, remote sensing observations of 3-D multi-wavelength aerosol/cloud based on CALIPSO and EARLINET can be used. Highlighting the benefits and the necessity of Aeolus data on dust research paves the way for future operational satellite missions.

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Assessment of reanalysis datasets against radiosonde observation over Eastern Mediterranean region

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The aim of this study is to assess the accuracy of the ERA-5 and ERA-Interim against the upper air sounding observations in troposphere over the Eastern Mediterranean Region. This study compares geopotential height (Z), air temperature (T), dew point temperature(Td) and relative humidity (RH) from ERA-5 and ERA-Interim with the observations of nine meteorological stations with different climate, at different isobaric levels (850, 700, 500, and 200 hPa) during 2000-2017. Mean bias, root mean square error, correlation coefficient, and standard deviation ratio of radiosonde and surface data against reanalysis datasets calculated in the statistical analysis. Both reanalysis data show a strong correlation with observed variables, except with dew point temperature and relative humidity at upper troposphere. The mean values of Z, and T from both grid dataset are generally consistent with the radiosonde values, whereas considerable bias in the mean Td, and RH exists and increase upper upwards. Therefore, the reanalysis datasets can be used to compensate the lack of radiosonde observation. The impact of North Atlantic Oscillation Index (NAOI) on the upper air temperature was also examined in the study. A negative relationship founded between NAOI and temperature at levels (850, 700, 500 hpa) and a positive relationship at 200 hpa.

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First near-real-time characterization of fine particulate matter (PM) and volatile organic compounds (VOCs) in Cairo Megacity (Egypt)

Aliki Christodoulou
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The Cairo agglomeration is the largest city in the Mediterranean basin and one of the largest in the world. This megacity regularly experiences severe deterioration of its air quality throughout the year, subjected to increased levels of Particulate Matter (PM) of natural and anthropogenic origin. The underlying (photo)chemical mechanisms, physical processes as well as the sources of atmospheric pollution in Cairo megacity remain poorly documented and need to be further evaluated and assessed.

This study presents the first-ever, high-time resolution observations of the chemical composition of PM1 (sub-micrometer PM) and its organic gas precursors in Cairo megacity during a 2-month winter period (27th November 2019 until 29th January 2020). A comprehensive suite of online and offline instruments had been set up on the roof top of the premises of the National Research Centre, an urban background site located close to the city centre. The overall objective of this campaign was aiming at assessing the variability and sources of chemically-resolved PM1 pollution in the megacity during wintertime. The online measurement equipment employed on site included: i) an Aerosol Chemical Speciation Monitor (Q-ACSM, Aerodyne Inc.) recording the chemical composition of non-refractory PM1 aerosol (NR-PM1), ii) a Scanning Mobility Particle Sizer (SMPS, TSI 3080) measuring the submicron aerosol size distribution and iii) a 7-l Aethalometer (Magee Scientific, AE-33) monitoring the concentration of Black Carbon (BC). Off-line analysis of 6-h integrated co-located PM1 filter samples was also performed, for major ionic species and carbohydrates, elemental/organic carbon, as well as trace metals. Ancillary trace gases including air quality-relevant pollutants (NOx, O3, CO) and speciated VOCs at a high time resolution were also measured. This unique database is presented here and will be further exploited to investigate the complex urban atmospheric chemistry of the Cairo megacity and to understand the links between gaseous precursors and Secondary Organic Aerosol formation.

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C2-C12 NMHC measurements in two sites with contrasted characteristics in the Greater Athens area over the period 2015-2019

Eleni Liakakou
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Despite the role of Volatile Organic Compounds (VOCs) on the formation of ozone (O3) and secondary organic aerosol (SOA), there is limited monitoring of their levels, sources and impacts on atmospheric chemistry over the last two decades in Greece. Time resolved observations (resolution of 30 minutes) of non-methane hydrocarbons (NMHC) with 2 to 12 carbon atoms, were continuously conducted by means of automatic gas chromatographs from October 2015 to February 2017 at an urban background site in Thissio, Athens and during 2019 at a coastal urban location in Piraeus Port, Greece. A decrease on the NMHCs levels was observed for Athens relative to the past years, whereas the Port environment was investigated for the first time, including a thorough study of the factors determining the emissions of the compounds of interest in both sites. The differences on the prevailing anthropogenic activities between the two areas were clearly reflected at the spatial distribution of the dominant emission sources, highlighting the role of biomass burning in the center of Athens even on the levels of the typical characterized biogenic compounds such as the monoterpenes. Even for common types of processes such as traffic, differences were reported between the two areas, reflecting the non-uniformity of the emissions on local scale. The air quality implications of our measurements including their contribution on secondary atmospheric pollutants that potentially contribute to severe air pollution episodes were also under consideration.

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The effect of spatial and altitudinal distribution of air parcels in the Eastern Mediterranean basin on PM10 and PM1 composition

Konstantinos Dimitriou
National Observatory of Athens

The Eastern Mediterranean Basin (EMB) has been recognized as an important "climatic hot spot". Aerosols are widely recognized as important players of climatic forcing and thus their transport routes in EMB must be thoroughly analyzed. Therefore, we implemented the newly conceived three dimensional (3D) version of Concentration Weighted Trajectory (CWT) model in three vertical layers (0m ≤ Layer 1 < 1000m, 1000m ≤ Layer 2 < 2000m and 2000m ≤ Layer 3), in order to reveal the effect of the spatial and altitudinal orientation of incoming air masses on PM10 and PM1 constituents in the EMB. Fine and ultrafine aerosol composition measurements were obtained from the Agia Marina Xyliatou rural background site situated on the island of Cyprus and were combined with 3D-CWT algorithm. During cold period (16 October to 15 April), high levels of Secondary Inorganic Aerosols (SIA), PM1-bound K^+, carbonaceous aerosols (EC and OC) and Pb were coupled with the prevalence of Eastern airflows from the Middle East in Layers 1 and 2, thus the impact of fossil fuel combustion and biomass burning was highlighted. On the contrary during warm period (16 April to 15 October) the Northern Etesian winds in all layers enhanced the levels of SIA and PM1-bound K^+ due to transport mainly from Turkey. Besides biomass burning, the sources of PM10-bound K^+ comprised sea salt and crustal contributions which therefore appear to enrich the coarse fraction of K^+ aerosols. Dust transport from the Sahara desert and the Middle East was detected primarily in Layer 1 during cold period triggering episodes of PM10-bound Al, Fe, Mn, V and Ca^+2, whilst sea salt compounds (Na^+, Cl^- and Mg^+2) were conveyed over Cyprus mainly along with West – Northwest marine airflows. Consequently, different types of air masses have a significant effect of the aerosol mixture over EMB.

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Optical properties and the curvature effect in spectral scattering and absorption coefficients for key aerosol types identified in Athens

Dimitris Kaskaoutis
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We describe a new approach using a combination of common assumptions for the differentiation of spectral absorption from aethalometer measurements into five components related to black and brown carbon (BC, BrC) and for sources of fossil-fuel combustion, biomass burning and secondary organic aerosol formation. For the discrimination of BrC absorption, the assumption of AAE=1 for pure BC was considered, while via appropriate AAEff and AAEbb values using the Aethalometer model approach in the measured data, the contributions of fossil fuel and biomass burning to total absorption were apportioned. Furthermore, the minimum R2 method, using a wavelength-dependent primary ratio (Abs/BC)pri was used for the estimation of spectral absorption due to secondary organics. This approach was firstly applied in urban background Athens during winter (Dec. 2016–Feb. 2017). The contributions of each of the five components to the spectral absorption are examined on seasonal and diurnal basis. At 370 nm, the absorption due to BCff contributed 36.3% on average, exhibiting a higher fraction (58.1%) during daytime, while the mean BCbb absorption was estimated at 18.4%. The mean absorption contributions due to BrCff, BrCbb and BrCsec were 6.7%, 32.3% and 4.9%, respectively. The AbsBCff and AbsBrCff components maximized during the morning traffic hours, as expected, while the AbsBCwb and AbsBrCwb escalated during nighttime and were highly related with biomass-burning tracers (nss-K+, Delta-C), and with organic aerosol components related to fresh and fast oxidative biomass burning (BBOA and SV-OOA). Multiple linear regression was used to attribute BrC absorption to five organic components and to determine their absorption contributions and efficiencies, revealing maximum contributions from BBOA (33%) and SV-OOA (21%). Sensitivity analysis was performed in view of the methodological uncertainties and supported the reliability of the results, which can be applied at any environment and have important implications for radiative transfer models.

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Optical properties and the curvature effect in spectral scattering and absorption coefficients for key aerosol types identified in Athens

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Aerosol type classification using in situ measurements was performed for the first time in Athens, Greece based on Absorption Ångström Exponent (AAE) and Scattering Ångström Exponent (SAE) values, derived from aethalometer and nephelometer measurements, respectively during a period of three years. Using a common aerosol classification scheme and appropriate threshold values, seven key aerosol types were identified and analyzed in view of their seasonal, monthly and diurnal variation. A Black Carbon (BC)-dominated type was the most frequent (76.3%), representing a background atmosphere with dominance of fossil-fuel combustion, while a mixed Brown Carbon (BrC)-BC type represented the 14.3% of the cases. The BrC type was associated with the highest scattering and absorption coefficients during winter nights, representing the impact from residential wood burning. Dust mixed with urban pollution corresponded to 1.2% of the cases, while large particles mixed with BC the 5.3%. Furthermore, two aerosol types characterized by weak spectral absorption (AAE<1) exhibited low fractions (<2.5%) representing aging processes and BC coating with organic and inorganic species and were differentiated between small and large particles. Submicron aerosol chemical composition inferred from ACSM measurements was analyzed for each aerosol type. Furthermore, the aerosol properties were examined on contrasting months, December 2017 with abundance of wood-burning emissions, and March 2018 under abnormal dusty conditions. For these months, the "curvature effect" of the spectral scattering and absorption coefficients was examined for the different aerosol types, indicating a negative curvature (concave curves) of scattering for the BC and BrC types, while dust presented mixed results. The absorption curvature was positive (convex curves) for BC, BrC and dust and increased with higher fractions of dust or BrC from wood burning. This approach provided new insights in the differentiation of aerosol types, although more analysis is needed to examine if findings are reproduced in other environments.

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Air quality and cloud effects on surface solar radiation over urban and rural areas in Greece

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Here, the effect that two basic air quality indexes, aerosols and tropospheric NO2, on surface solar radiation is studied along with the effect of liquid and ice clouds over 16 locations in Greece, in the heart of the Eastern Mediterranean. We use state-of-the-art satellite-based observations and climatological data for the 15-year period 2005-2019 and a radiative transfer system based on a modified version of the Santa Barbara DISORT Atmospheric Radiative Transfer (SBDART) model. Our SSR simulations are in good agreement to ground- and satellite-based products. Liquid clouds dominate with an annual radiative effect of -36 W/m2, with ice clouds (-19 W/m2) and aerosols (-13 W/m2) following. The radiative effect of tropospheric NO2 is smaller by a factor of 2 (-0.074 W/m2). Under clear skies, the radiative effect of aerosols is about 3 to 4 times larger than for liquid and ice cloud covered skies while the radiative effect of tropospheric NO2 doubles. All the parameters exhibit a distinct radiative effect seasonal cycle. Finally, the SSR levels increase during the period 2005-2019 (trends ranging from +0.01 to +0.52 W/m2/year) which is mostly related to a decrease of the aerosol optical depth and the liquid cloud fraction.

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Methane and non-methane hydrocarbons concentrations and sources in an Eastern Mediterranean island (Cyprus)

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Continuous, methane and non-methane hydrocarbon (NMHC) observations are currently performed at a suburban background site of the capital city of Nicosia, Cyprus. Methane is a potent greenhouse gas but its sources remain poorly quantified in the Eastern Mediterranean and Middle East (EMME) region. Light alkanes, such as ethane (C2H6), are co-emitted by fossil fuel (oil and gas) activities and are promising tracers for quantifying the methane emissions from this sector. Cyprus is an ideal location for studying the composition of air masses of varied origin and different emission source signatures at a regional scale. A Picarro G2401 analyzer and two fieldbased Gas Chromatography Flame Ionization Detectors (GC-FID, airmoVOC and airmoBTX, Chromatotek) are deployed and an extensive dataset is generated. Our aim is to use these observations for identifying regional and local anthropogenic methane sources, for assessing tropospheric background concentrations, while evaluating the significance of long-range transported versus local sources. Methane observations are performed in Nicosia since February 2020. Since February 2021, we are additionally conducting NMHC (C2-C12) measurements, that include both anthropogenic (alkanes, alkenes, aromatics) and biogenic (isoprene, monoterpenes) compounds. These species allow the identification of emissions sources that originate from the industrial, agricultural, urban and energy production sectors. Our initial observations suggest strong local methane and NMHC sources. To evaluate the significance of the hotspots, we perform comprehensive analyses on the static observations and in addition, we are employing mobile measurements using cars and bicycles (with Picarro and LGR-GLA133). We also provide evidence for long-range transport, including the ability to trace and study the contribution of methane emissions from Middle Eastern oil and gas operations. Our measurements will ultimately provide a better understanding of pollution sources at local and regional scale in the Eastern Mediterranean region.

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Characterization of fine and coarse atmospheric particulate matter from Beirut suburb using PIXE technique

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In this work, it is investigated the elemental composition of fine and coarse air particulate matter PM2.5 and PM10-2.5 collected during 2014-2016 in a suburb area of Beirut, using the ISAP®1050e sampler having a combined inlet. The collection of fine particles was carried out on thin Teflon filters while the coarse ones were collected by impaction using a custom-made polypropylene ring foil. Beside gravimetric measurements, the characterization of the elemental content of the two-fraction mode, fine and coarse particles, were analyzed using proton induced X-ray emission technique PIXE. It will be more focused on the elemental composition of the fine fraction PM2.5. Depending on the volume of pumping air in 24-h, PIXE is used to determine the concentration of Na, Mg, Al, Si, S, Cl, K, Ca, Ti, V, Cr, Mn, Fe, Ni, Cu, Zn and Pb as ng/m3 of air. For each sample, there was a clear dependence of the elemental content of PM, as well as their total mass, on weather conditions as well as on the type of pollution sources, such as car traffic, diesel power generators, sea salt, dust storm episodes and others. Some results will be highlighted with the dedicated experimental setup.

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Monitoring of atmospheric aerosols pollution over Egypt based on satellite and ground-based observations

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Egypt suffers from high rates of aerosol pollution, which threatens human health and the environment. The driving forces of aerosol pollution in Egypt are either of local and/or regional as well as natural and/or anthropogenic sources. Studying the aerosols climatology requires powerful sources of data with professional analysis tools. Therefore, this research was carried out to monitor the aerosols' properties in Egypt's atmosphere based on remote sensing techniques. A time series of Moderate Resolution Imaging Spectroradiometer (MODIS) and Aerosol Robotic Network (AERONET) data were explored during the period 2012–2019 on a daily basis. Investigation of aerosol optical depth (AOD) and Ångström exponent (AE) correlation were performed to detect the different aerosol size and type in Egypt. Data shows that spring had the highest anomaly of AOD, originating from regional and national sources, followed by summer and autumn seasons. The high AOD in spring was associated with a low Ångström exponent (AE) which indicates the presence of course-mode particles that originated naturally from desert and/or sea spray. On the contrary, the high AE in summer and autumn demonstrated the prevalence of fine-mode anthropogenic aerosols (e.g., smoke particles) from local biomass burning. Based on MODIS-fire data analysis, a high number of fire incidents was observed over Egypt from September to November, which contributes to the presence of autumn aerosols across the country. Doing a regression analysis between MODIS and AERONET AOD to validate the data, gives a strong correlation coefficient (r = 0.76). In conclusion, the seasonal aerosols over Egypt may be either from natural causes, mainly dust particles transported from the Western desert and maritime particles produced over the Mediterranean Sea—particularly in coastal areas in case of high wind speed—and/or anthropogenic aerosols from local activities such as transportation or industry and biomass burning.

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Assessment of the intensity of dust events over Egypt with Climate Change scenarios

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Dust in the air poses serious risks to human health, as non-inhalable particles larger than 10 micrometers in size can cause skin irritation and eye infections. In addition to the impact of dust deposits on irrigation canals, covering transport routes, and affecting the quality of river water, besides their negative effects on agriculture, as it reduces crop productivity by burying seedlings, damaging plant tissues, reducing hotosynthesis activity as well as increasing soil erosion. Therefore, it was necessary to find an appropriate tool indicating what might happen to the frequency and intensity of dust based on different IPCC scenarios (RCP4.5 and RCP8.5). An indicator was calculated via Climate Data Operator (CDO) tool using the maximum daily dust concentration simulated by the IPCC regional climate model (RegCM4) over Egypt and MENA region. The dust intensity is classified according to the percentage as follows: normal (percentile 75th), high (90th), very high (95th), and very high (99th).

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Atmospheric energetics under different CMIP6 climate scenarios

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This study examines whether different future climate scenarios, as they are adopted in Phase 6 of the Coupled Model Intercomparison Project (CMIP6), can lead to different regimes in the energetics components of the Lorenz's energy cycle. The four energy forms on which this investigation is based on are the Zonal and Eddy components of both the Available Potential and Kinetic Energies. The permissible conversions between these forms of energy, the diabatic generation of the components of Available Potential Energy as well as the dissipation of the Kinetic Energy components are also studied.

The climate projections in the period from 2015 to 2100 produced by the HadGEM3-GC3.1-LL model have been used; these are driven by a set of Shared Socioeconomic Pathways (SSP's) based on new future pathways of societal development but also incorporating the previously used Representative Concentration Pathways (RCPs). In this respect, the following three concentration-driven scenarios under Tier 1 of ScenarioMIP are used:ssp126: A scenario with low radiative forcing by the end of the century, following the RCP2.6 global forcing with SSP1 socioeconomic conditions; radiative forcing reaches a level of 2.6 W/m2 in 2100;ssp245:A scenario with medium radiative forcing by the end of the century, following the RCP4.5 global forcing with SSP2 socioeconomic conditions; radiative forcing reaches a level of 4.5 W/m2 in 2100;ssp585: A scenario with high radiative forcing by the end of century, following the RCP8.5 global forcing with SSP5 socioeconomic conditions.

In addition, the historical data from the same cohort, covering the period from 1910 to 2014, have been used for comparative purposes.

The energy balance and time series of the energetics components under different SSP-based scenarios show that different scenarios yield diverse energetics regimes, consequently impacting the Lorenz's energy cycle and its underlying physical processes.

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A pragmatic approach to statistical modelling of big spatio-temporal climate data

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The anlysis of climate change impacts involves the utilisation of climate model output. Questions such as "what is the probability that temperature will exceed a high threshold for five consecutive days and how will this change in the futute?" are quite common. Statistical modelling of climate model output can be used to answer such questions. Such approaches however do not always scale well with big data sets and are often too complicated to even interpret appropriately. Here we present a way of analysing such data using the (well-established) idea of moving averages in conjunction with penalised smoothing splines. A Bayesian interpretation of the approach means full quantification of the associated uncertainty of this method which is both scalable and paralleliseable. We present the approach in quantifying temperature, precipitation and humidity changes over the UK using regional model output.

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Statistical disaggregation and bias-adjustment of CMIP6 variables for climate change impact studies at global and regional scales

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The latest IPCC Summary Report for Policymakers (as of August 9, 2021), based on the analysis of large amounts of climate data and model simulation output provided by tenths of Earth System Models in the latest Coupled Model Inter-comparison Project (CMIP6), corroborates that anthropogenic GHG emissions induce climate change. Hence, the geo-climatic crisis manifested in more frequent and severe extreme weather events in several regions around the planet highlights the need for more accurate climate model projections for the next decades and beyond. However, systematic biases introduced to the global climate model data, mainly due to the under-representation of orographic forcing, limits their suitability for climate change impact assessments, especially at regional scales, unless further steps are taken to account for these biases.

We present actionable state-of-the-art statistically downscaled bias-adjusted data, using model projections from a selection of ten different CMIP6 participating models. The CMIP6 ensemble includes global daily data with a native nominal resolution of 100 km for near-surface temperature (tas) and relative humidity (hurs) variables and four IPCC Shared Socioeconomic Pathway (SSP) scenario experiments (SSP1-26, SSP2-45, SSP3-70, and SSP5-85) that span the period 1980-2100. For the bias calibration of the original CMIP6 simulations, we used the global daily, 50 km, WFD-ERA5-v1.0 reanalysis (proxy observations) data over 1980-2014.

Combining the Climate Imprint and Quantile-Delta-Mapping algorithms and leveraging high-performance computing resources, we statistically disaggregate and bias-adjust the original coarse horizontal resolution (100 km) CMIP6 tas and hurs variables, generating new global daily fields at the higher spatial resolution of 50 km while preserving the climate change signal of the original projections. The bias-adjusted products are currently being utilized in research studies of hot weather extremes, e.g. in the Middle East and North Africa, that aim to project heat stress and heat-related mortality in the 21st century.

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Wildfire sensitivity on climate drivers in the Eastern Mediterranean

Manolis Grillakis
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Observed trends towards drier and warmer climate in the Mediterranean region are projected to continue due to accelerated climate change, leading to increased fire risk. Wildfires are an integral part of Mediterranean ecosystems. Yet, wildfires pose threat to human lives, or cause health implications from associated air quality degradation. Here, we assess the sensitivity of burned area, on four affecting climate variables (temperature, relative humidity, wind speed at noon, as well as daily rainfall) and a composite wildfire danger index, the Canadian Fire Weather Index (FWI). We use meteorological reanalysis data and the MODIS observed burned area for the 2001-2015 period. Results show that climate variables and FWI correlate well with the burned area, while sensitivities may vary by burned area land use types. Our findings support the better understanding of the climatic control on wildfires and hence aim towards a more proactive wildfire management in the climate change sensitive region of East Mediterranean.

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Climate Change implications on the operational safety of civil protection emergency practitioners in the Eastern Mediterranean Middle East

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Climate Change is recognized as a "multiplier" of threats, hazards and risks to civil safety and security, by more and more international bodies and organizations with responsibilities in Civil Protection, Disaster Preparedness, and Emergency Management (e.g. International Association of Emergency Managers, European Union Civil Protection Mechanism, UN Security Council). The Eastern Mediterranean Middle East (EMME) is expected to be among the most impacted regions globally, as several studies and works have shown it to be a climate change "hot-spot". Being at the "front line" of crises and emergencies, Practitioners of all emergency and disaster-related disciplines are called to respond to more frequent and more intense events, which are posing continuously growing pressures and threats to their safety during operations. Thus, a more thorough understanding of climate change implications on operational safety, jointly by both communities of Climate Scientists and of Emergency Practitioners, will help to formulate more adapt technologies, measures and policies for operational safety. Our Conference-contribution here is placed within the discourse developing the Climate Change – Civil Protection nexus, and specifically aims to pose operational safety considerations for Emergency Practitioners in the particular region of the EMME.

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A low-cost CO2 commercial NDIR sensor for UAV atmospheric applications

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Unmanned Aerial Vehicles (UAVs) have the potential to fill in gaps in greenhouse gases (GHG) observations by providing high resolution vertical profiling, horizontal mapping of fluxes and 3D measurements close to the ground. UAVs can ultimately allow better characterizing the spatial distribution of various GHG sources and sinks. To achieve these goals, important efforts are currently put towards the development of compact, lightweight, low powered and highly accurate GHG sensors on UAVs.

This study aims to develop and validate a UAV-CO2 sensor system to map specific source emissions close to the ground. The CO2 sensor used here is the High-Performance Platform (HPP 3.2, SenseAir AB) of a total weight 1058g including battery. Prior to its integration in the UAV, the CO2 sensor accuracy and linearity tests were performed in laboratory. Allan Deviation showed the sensor precision to be within ±1ppm at 1 Hz. Corrections due to temperature and pressure changes were performed using specific formulas obtained from chamber experiments. Field (manned aircraft) tests were performed, where the P/T correction equations were evaluated for two CO2 sensors which were compared against an airborne reference instrument (Picarro G2401-m), which showed the precision onboard was within 2ppm. After laboratory tests and field deployment, the HPP CO2 sensor was integrated into a quad-copter for vertical take-off & landing (VTOL) in urban environments to map (every 20-min) atmospheric CO2 over the city of Nicosia (Cyprus). These flights provide us with useful insights into the CO2 point emissions close to the ground and have the potential to map the dispersion plume accurately.

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Novel UAS for environmental monitoring during natural disasters

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Natural disasters are events which can cause loss of life or damage in property, therefore it is critically important to respond rapidly. Recently, Unmanned Aerial Systems (UAS) or drones, showcased their great potential in providing essential Emergency Response capabilities and support for First Responders. Despite their increasing use, many lack performance characteristics, essential for rapid deployment and reliable operation during the potentially challenging conditions of a natural disaster situation.

Over the last few years, the Unmanned Systems Research Laboratory (USRL) has developed unique expertise in the development of high performance UAS, leveraging their capacities with always having in mind to overcoming the above challenges and get the most out of them for Natural Disaster monitoring needs. The novel UAS are made of advanced composite materials, hence they are lightweight and robust, offering relatively large endurance and range as well as the highest take-off weight to payload ratio. They have been designed and developed for optimal performance in the worst possible conditions, so they are compact, powerful, extremely fast, with high agility, accuracy and stability. Furthermore, their rapid deployment (<5 minutes) makes them ideal for emergency response operations. The firmware of their Flight Controller as well as their Ground Control Software have been specifically developed by the USRL team to allow fine tuning and intelligent automated control resulting in furtherly enhanced flying performance. Last but not least, they can easily adapt a wide range of imagers and sensors for monitoring the physical, chemical and radiative environmental parameters during a Natural Disaster.

It is envisioned that these new UAS-sensor systems will reliably support the First Responders in any condition as well as providing the scientists with valuable in-situ information for better understanding of the Natural Disaster phenomena.

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Performance characterization of a newly developed atmospheric pressure interface time of flight mass spectrometer (API-TOF MS)

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The Atmospheric Pressure Interface Time of Flight Mass Spectrometer (APi-TOF MS) has proven itself as a useful tool for the chemical characterization of atmospheric ions and clusters, largely contributing toward a better understanding of new particle formation in the atmospheric environment (Junninen et al., 2010). Here we describe a preliminary characterization of a newly developed APi-TOF MS that, according to the manufacturer (Fasmatech), is capable of providing high mass resolution, high duty cycle and high sensitivity.

The instrument consists of an aerolens - ion funnel configuration installed in the fore vacuum region (> 1mbar), followed by a segmented RF ion guide to thermalize and trap ions at 10-2 mbar and a low-pressure RF hexapole ion guide combined with a set of DC lenses to deliver ions into the extraction region of an orthogonal TOF mass analyser (cf. Fig. 1). The design of the instrument allows for versatile measurement and the coupling of a high-flow/high-resolution parallel-plate Differential Mobility Analyzer (DMA) at the inlet capillary (SEADM Mode P5) for two-dimensional ion mobility – mass-to-charge ratio measurements. The DMA-MS setup allows for detailed studies on the physiochemical characterization of clusters and their stability, relevant for fundamental studies on atmospheric nucleation and aerosol-based nanotechnology.

Preliminary measurements have shown a mass resolving power up to 40,000 (full-width-half-maximum). A mass detection range between 30 and 2100 Da has been experimentally confirmed for RFs of 2.36 and 1.43 MHz. The mass accuracy of the instrument is ±3 ppm after external mass calibration. These specifications exceed those reported by commercial aerosol mass spectrometers. Preliminary measurements also showed a maximum transmission of 0.2% for ionic clusters of 410 Da.

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