Coordinating and integRating state-of-the-art Earth Observation Activities in the regions of North Africa, Middle East, and Balkans and Developing Links with GEO related initiatives towards GEOSS

D4.5 – Pilot Activity Report – Adaptation to Climate Change

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Executive Summary

The objective of this deliverable is to present the final results of the Adaptation to Climate Change (ACC) pilot. ACC achievements and weaknesses are highlighted to reflect the feasibility of the pilot tasks towards regional climate challenges.

Project Information

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Call Identifier: SC5-18b-2015, Integrating North African, Middle East and Balkan Earth Observation capacities in GEOSS.

Project GA number: 690133

Project Title: GEO-CRADLE - Coordinating and integRating state-of-the-art Earth Observation Activities in the regions of North Africa, Middle East, and Balkans and Developing Links with GEO related initiatives towards GEOSS.

Project Beneficiaries:

ID	Participant Organisation Name	Country	Logo
1	National Observatory of Athens (NOA) - **Coordinator**	Greece	
2	Interbalkan Environment Center (IBEC)	Greece	
3	Center for Environment and development for the Arab Region and Europe (CEDARE)	Egypt	
4	Research and Studies Telecommunications Centre (CERT)	Tunisia	
5	Tel Aviv University (TAU)	Israel	
6	Cyprus University of Technology (CUT)	Cyprus	
7	TUBITAK UZAY Space Technologies Research Institute (UZAY)	Turkey	
8	Space research and technology institute (SRTI)	Bulgaria	
9	National Institute of R&D for Optoelectronics (INOE)	Romania	
10	University of Ss Cyril and Methodius (USCM)	FYROM	
11	Institute for Nature Conservation in Albania (INCA)	Albania	
12	Institute of Physics Belgrade (IPB)	Serbia	
13	CIMA Research Foundation (CIMA)	Italy	
14	Academy of Athens (AOA)	Greece	
15	INOSENS (INS)	Serbia	
16	European Association of Remote Sensing Companies (EARSC)	EU	
17	EURISY	EU	
18	EuroGeoSurveys (EGS)	EU	
19	World Radiation Center (PMOD/WRC)*	Switzerland	

*Note: Switzerland is not requesting financial contribution from the EC

Table of Contents

1. ACC Pilot Description

GEO-CRADLE introduces the Adaptation to Climate Change (ACC) pilot in order to support the sustainability of regional EO infrastructures and trigger needed synergies that will contribute to the achievement of GEOSS targets and to the uptake of relevant EO-based Copernicus services in the RoI. The pilot aims to provide the necessary support and coordination to existing infrastructures in order to deliver consolidated information and knowledge for the long term strategic planning on adaptation and mitigation to climate change and air quality, which are of high importance for the RoI.

The ACC pilot paves the ground for the holistic monitoring and forecasting of region-specific atmospheric components, ECVs and hazards, in line with the standards and vision of GEOSS and Copernicus for information extraction and service delivery regarding the Climate SBA. Specifically, the GEO-CRADLE ACC provides 3 services on respective thematic pillars as these were concluded by the GEO-CRADLE consortium and the feedback from WP2/WP3:

1. **Desert Dust services**
2. **Regional Climate Change services**
3. **Air Quality services**

2. Link of ACC with gap analysis, user needs and regional priorities

The gap analysis performed in WP2/WP3 reveals the maturity indicators and user needs related to climate change in the RoI (D3.3, D4.1). Special effort is given on optimizing the ACC services in order to meet the level of accuracy and timely provision required by the users. The services are tailored to the user needs through continuous interaction with end-users from targeted ACC-representative sectors and respective end-users as already identified in WP2/WP3 and in the conclusions of the Morocco and Cyprus meetings (see also Appendix for endorsement letters).

The needs identification and maturity indicators are shown for 4 sub-regions:

1. **FYROM and Albania,**
2. **Serbia, Romania, Bulgaria,**
3. **Greece, Cyprus, Turkey,**
4. **Morocco, Tunisia, Egypt, Israel.**

In order to keep track of specific needs per sub-region, superscripts with the above numbers are put in the related keywords. From all the reported needs, the ones - directly and indirectly- related to climate information are grouped in 4 sub-sectors:

a) Air quality

Air quality and air pollution information is a common concern for all countries of the RoI. More specifically, there is the need for *aerosol information*[3] (levels and types, i.e. natural and anthropogenic, dust, biomass burning aerosols), as well as for the *greenhouse gases and pollutants* (e.g. CO_2), not only as concentration[3], but also as emission[1,2] levels. Last, there is a concern on the identification of the contaminated areas and sites. In particular, the needs are focused on *the location of pollution sources*[2,3,4] (e.g. mines[3], industries[3,4]), as well as the extent of *their pathway and discharge*[2,4].

b) Meteorology

The need for data and information related to weather and climate is expressed by all countries of the RoI. Specific meteorological and climatic variables are requested, such as: *air temperature*[1,2,3] and *dew point*[3] (in ˚C), *wind* (speed in m/s and direction in deg)[2,3], *relative humidity* (%)[3], *rain* and *snowfall*[1,2], *snowstorms*[1,2], *hail*[1,2], spring frost[1,2], *cloud cover* (continuous variable as a percentage)[3], *water evaporation*[4] and *humidity evapotranspiration*[4]. Last, with respect to radiation, the *global horizontal*, *direct normal* and *solar irradiance* are requested (monthly & seasonal climatology values in W/m^2)[3], as well as the *UV radiation*[2].

c) Natural risks

The need for monitoring and assessment of natural risks (using the weather and climate information, expressed as needs above) is declared by all countries in the RoI, with emphasis on *floods*[2,3,4], but also on *soil*[2], *erosion*[2] and *fire*[2] risks. Specific information is requested for the mapping of *flood extent*[3] and the identification of the *flood* type[3] (rainfall, fluvial, coastal, groundwater, depth, velocity).

d) Other climate-related issues

These include the concern about issues related to *biodiversity*[2,3], such as the mapping of protected sites, the listing of protected and invasive species, the identification of the pressures on biodiversity the identification of *forest types*[2] and the conservation status of species and habitats. Also, information for the *environmental noise*[2,3], with special reference to the cities (e.g. traffic noise) is mentioned.

From the results of WP2 and WP3 we concluded in a list of potential end-users for the application of the ACC pilot:

1. **Tourism sector**: TEMES and Costa Navarino for dust forecasting
2. **Meteorological agencies**: Cyprus Meteorological Service for dust forecasting
3. **Aviation**: Ministry of Civil Aviation of Egypt for dust forecasting
4. **Insurance companies**: AXA for Climate Change services
5. **Agriculture sector**: Ministry in Serbia for Climate Change services

Based on this information three thematic areas have been identified for ACC:

2.1 Desert Dust

The need for the real time monitoring and forecast of dust transport with a special focus on the provision of user specific information in SE Europe, N Africa and the Middle East is endorsed in ACC pilot through the integration of state of the art EO and modeling activities to convey comprehensive information to end users. Specifically the service is important for the following end-user sectors:

- **Public Sector (Weather and Climate Services, Ministry of Environment):** Understanding the role of dust in weather and climate is crucial for the designation of adaptation and mitigation policies for climate change.
- **Energy Sector:** The efficiency of Concentrated Solar Power Systems (CSP) is affected by dust depositions on the solar panels.

- **Fishery Sector:** Dust fertilization of the sea affects the production of phytoplancton at the areas of maximum dust deposition and thus affecting the availability of nutrients with impacts on fishery.
- **Aviation Sector:** Degradation of visibility due to dust transport is a regular threat for airport safety especially in Africa and the Middle East. Moreover, corrosion of dust inside the aircraft turbines decreases their life-time and increases the service and inspection needs.
- **Health Sector:** Several respiratory diseases are related to inhalation of fine dust particles and deposition in human lungs.

2.2 Regional Climate Change

The survey analysis indicated various levels of maturity regarding climate change awareness and EO/model data needs among the partner countries. A need for reliable open access climate data was expressed by all countries of the RoI. For ACC, the use of future climate data from high resolution model projections based on Regional Climate Models (RCMs) is essential. Moreover, the use of ensemble versus individual information for uncertainty estimates is also critical. Although there is plenty of open access information from RCMs in databases (CORDEX, ENSEMBLES, PRUDENCE), there is limited usability from non-experts, due to complexities in digging big databases and specific data formats. Usually intermediate users and end-users need information of essential climate variables or other climate indices in the simple form of a single time-series at certain point or region.

2.3 Air Quality

The aim of this activity within the ACC pilot focuses on the exploitation of the air quality forecasts of **Copernicus Atmospheric Monitoring Service (CAMS)**, in order to support the continuous provision of timely and accurate services related to atmospheric air quality. The vision of the activity is to ensure QC/QA air quality forecasts, initially based on CAMS products that in the long term will be incorporated into a unified chemical weather forecasting system coupled with city scale models for urban applications.

The service is important for the following end-user sectors:

- **Public Sector (Ministries of Environment and Health):** Understanding the contribution from discrete sources of air pollution for mitigation purposes and tracking the production and transport processes of air pollutants over the RoI.
- **Health Sector:** The adverse health impacts from both gaseous and particulate matter pollution is well documented, especially for sensitive groups of the population.
- **General Public:** Provision of timely and popularized information for well-informed citizens and built-up of resilient societies.

3. Pilot Applications

3.1. Desert Dust services for ACC

A large scale feasibility study has been conducted to represent the dust forecast capabilities, strengths and weaknesses over the AoI. The study took place during PRE-TECT campaign 1-30 April 2017 in Crete. A suite of state-of-the art atmospheric dust models has been operating during this period for the provision of forecasting fields for the columnar load of dust (Figure 3.1.1) and the vertical distribution of dust layers (Figure 3.1.2). All data have been registered and are available online at GEO-CRADLE portal (http://datahub.geocradle.eu/dataset/dear-clima) (Figure 3.1.3). A list of the available parameters at GEO-CRADLE portal is shown in Table 3.1.

Table 3.1 Available dust-related parameters in GEO-CRADLE ACC portal

Parameter	Instrument/model
Dust AOD	NMM-DREAM,NMM-DREAM_assim,DREAM8, CAMS
Dust Load	NMM-DREAM,NMM-DREAM_assim,DREAM8, CAMS
Surface Dust	NMM-DREAM,NMM-DREAM_assim,DREAM8, CAMS
Dust profiles	NMM-DREAM,NMM-DREAM_assim,DREAM8, CAMS
Satellite Dust AOD	U.K. Met Office MSG dust product
AOD	AERONET
Angstrom Exponent	AERONET
Aerosol Size Distribution	AERONET
Single Scattering Albedo	AERONET
Real part of the CRI	AERONET
Imaginary part of the CRI	AERONET
Extinction coefficient	CAPS
Scattering coefficient	CAPS
Absorption coefficient	CAPS
Equivalent Radar Reflectivity Factor	Cloud Radar
Doppler Velocity	Cloud Radar
Peak Width RMS	Cloud Radar
Linear De-Polarization Ratio	Cloud Radar
Backtrajectories forecast for Finokalia	FLEXPART
Attenuated backscatter	HALO Doppler lidar
Doppler Velocity	HALO Doppler lidar
Temperature and Humidity profiles	Microwave Radiometer
Range corrected signal at 1064nm	PollyXT lidar
Volume depolarization ratio at 532nm	PollyXT lidar
Range corrected signal at 532nm	PollyXT lidar
Volume depolarization ratio at 1064nm	PollyXT lidar
Multiwavelength aerosol classification	PollyXT lidar

PRE-TECT is clustered with a number of relevant projects and initiatives that contribute in an unprecedented amount of atmospheric information for the realization of ACC services:

- The D-TECT ERC project, aiming to assess the impact of particle electrification on desert dust dynamics and long-range transport.
- The A-LIFE ERC project, aiming to provide fundamental new understanding on aerosol absorption and its impact on dynamics.
- The LACROS facility of TROPOS in Cyprus.
- The ACTRIS ground-based stations at Finokalia and Limassol.
- The CAMS Copernicus Atmospheric Service, aiming to provide continuous data and information on atmospheric composition, supporting applications in a variety of domains including health, meteorology and climatology.
- The ECARS TWINNING EU project, aiming to boost INOE's research capacity in the domain of atmospheric remote sensing and create a pole of excellence in East Europe.
- The EUropean Facility for Airborne Research (EUFAR) to provide airborne atmospheric measurements during the campaign.

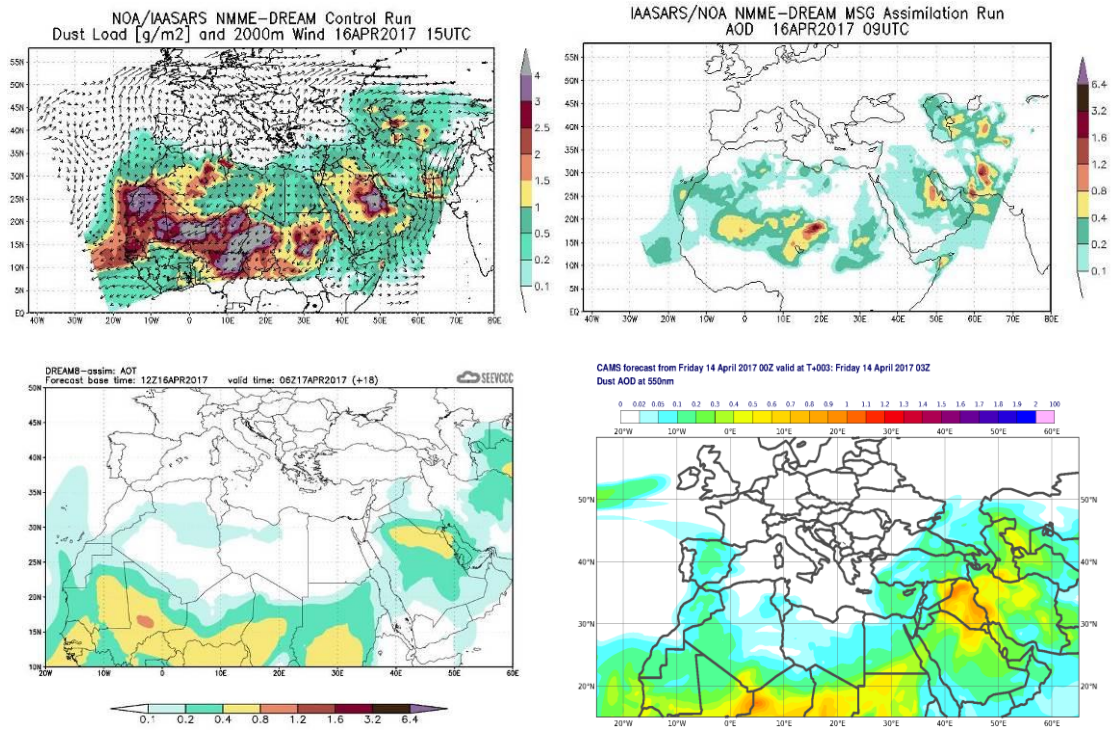

Figure 3.1.1 Examples of dust forecasts during PRE-TECT from different models and configurations. Clockwise: 1. NMM-DREAM control run with NCEP/GFS initial and boundary conditions, 2.NMM-DREAM with assimilation of dust AOD from MSG / SEVIRI, 3. DREAM8 with MODIS satellite assimilation and ECMWF initial and boundary conditions, 4.Copernicus CAMS dust forecast

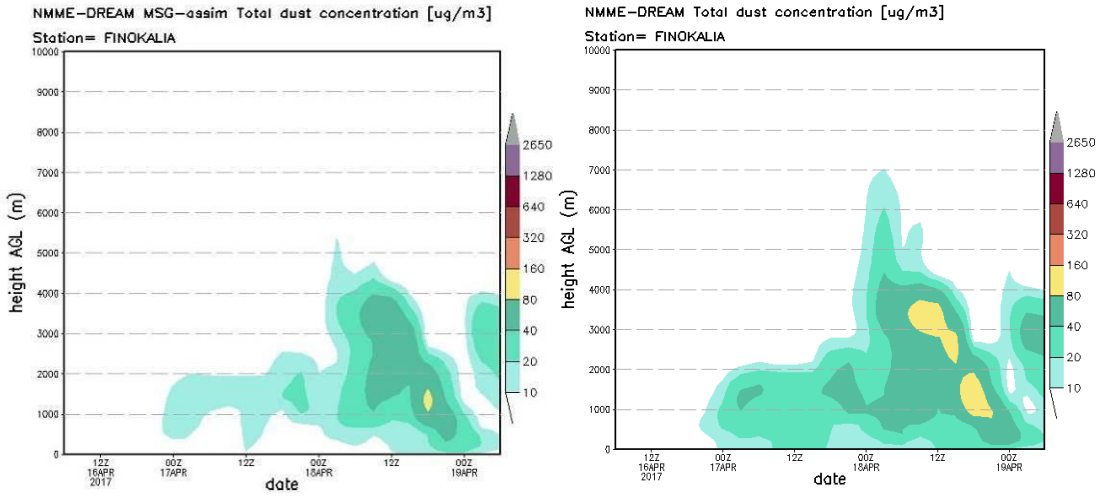

Figure 3.1.2 Examples of vertical dust layer forecasts at the stations of Finokalia with (left) and without (right) assimilation of EUMETSAT dust AOD.

Figure 3.1.3 Screenshot of the GEO-CRADLE ACC portal indicating the availability of instruments and modeling data

The importance of GEO-CRADLE dust service activities has been highly recognized by end-users from public authorities, academia and private sector including: The Algerian Meteorological Office, The Ministry of Electricity and Renewable Energy of Egypt, The

Kuwait Institute for Scientific Research, The Department of Meteorology in Cyprus, Balloonera Private Company in Serbia and the University of Belgrade Serbia (see Appendix for letters of support).

The ACC dust service creates a novel methodological standard with the colocation of model and instrument data which provides qualified and comparable information at user level that can be further exploited to generate additional products. At the same time, this feasibility study showcases the benefits from the complimentary use of capacities and synergies between the 31 different stakeholders that participated in the campaign (Figure 3.1.4). The replicability and scalability of the pilot depends mostly on the availability of remote sensing (ground and space), in-situ and modeling capabilities that was available during the campaign period. At a national/regional level it is possible that the same amount of information can be obtained however with certain limitations regarding the full availability of instruments and personnel. Nevertheless the methodology developed in GEO-CRADLE is clear and the same steps can be easily replicated for future dust applications. Also it is worth to mention that no negative impact was found during the pilot duration.

The long-term sustainability of such a solution to provide advanced dust forecast and analysis services at the AoI is at a significant degree dependent on additional funding and support by governmental authorities in order to support the necessary infrastructure and scientific capital. This pilot can be considered as a starting point for increasing the involvement and use of Copernicus data and can work as a paradigm for extending such services and products towards the implementation of GEO and GEOSS activities in the area.

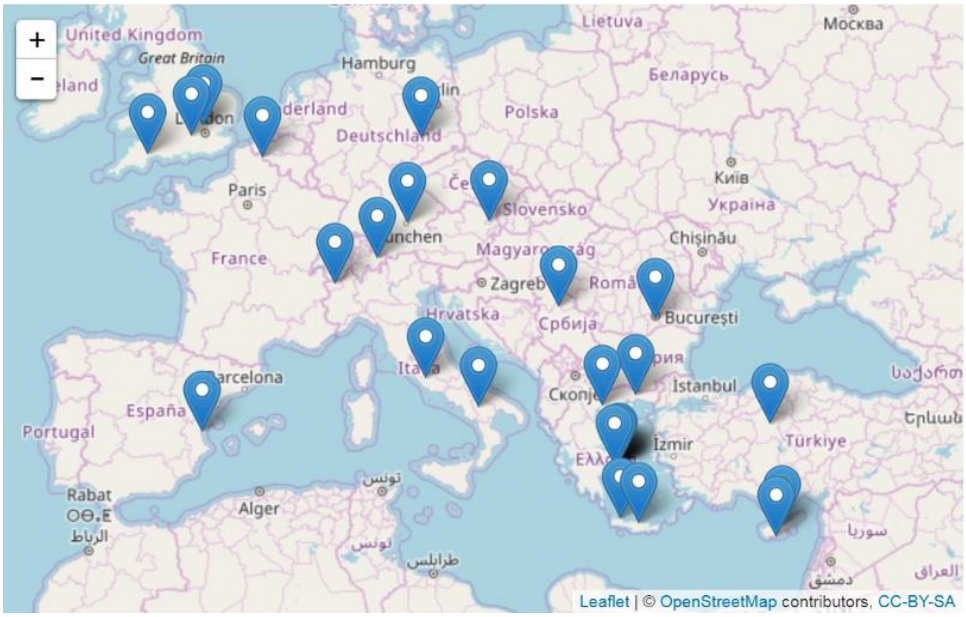

Figure 3.1.4 A wide consortium of research institutes universities and private companies participates in the pilot contributing to the instrumentation and expertise needed for the PRE-TECT campaign.

3.2. Regional Climate Change services for ACC

According to the above and to the proposed pilot action, a user friendly web tool was created to support both policy makers and individual end-users on climate change impacts. The Data Extraction Application for Regional Climate (**DEAR-Clima**) is a user-friendly interactive web application tool based at http://meteo3.geo.auth.gr:3838/ and registered at GEO-CRADLE data-hub (http://datahub.geocradle.eu/dataset/dear-clima) that visualizes and provides time series of essential climate variables and climate indices based on high horizontal resolution Regional Climate Model (RCM) simulations from the Coordinated Regional Downscaling Experiment (CORDEX) research program. Reliable and user-friendly open access of future climate change data from high resolution RCM projections is essential to support decision makers, stakeholders, intermediary users and end-users for climate change impacts, mitigation and adaptation.

In order to gain access to the data and visualization services a free registration is first required. A brief description on how to use the application comes as follows:

(1) provide longitude and latitude of the desired location
(2) select the temporal resolution for the timeseries
(3) select the climate variable or climate index for extraction/visualization
(4) press update to load the predefined dataset
(5) download (Download panel) or visualize (Graphical Options panel) the loaded timeseries.

The graphical environment of DEAR-Clima web application along with a timeseries visualization is presented in Fig. 3.2.

The domain covers the greater area of Europe including the Mediterranean and a part of N. Africa, with a high spatial resolution of 11°x11°. The approximate center of the boundaries is 27°N-72°N and 22°W-45°E, while the center point of the domain lies in 49.68°N and 9.75°E. The period covered extends from 1950 to 2100 and consists of two subperiods: (a) the historical period referring to 1950-2004 and (b) the future period referring to 2006-2100 under the influence of three Representative Concentration Pathways (RCPs) adopted by the IPCC for its fifth Assessment Report (AR5); rcp26, rcp45 and rcp85. The reference historical period for all simulations is defined as 1975-2004. The simulation experiments (see Table 3.2.1 for details) are a product of various RCMs driven by several Global Climate Models (GCMs). The application provides historical and future projections of various climate variables and indices which are presented in Table 3.2.2 and 3.2.3 respectively. The climate variables are available at yearly, monthly and daily basis, while the climate indices are calculated in yearly temporal basis.

During the 1st Periodic Reporting period, the ACC pilot established collaboration with several end-users through the expression of interest (letters of support) for the

development of a user-friendly regional climate web application. Within this framework DEAR-Clima was used to provide various high-resolution climatic data to the following organizations (see Appendix):

- The Regional Hydrology and Water Resources Sebou Basin Agency (ABHS) of Marocco to support climate change adaptation strategies for water resources and management sector in Marocco.
- The Department of Infrastructure and Rural Development of the School of Rural and Surveying Engineering of the National Technical University of Athens (NTUA) to support climate change adaptation strategies for water resources and management sector in Greece.
- The Centre for the Assessment of Natural Hazards and Proactive Planning (CANaH) of the National Technical University of Athens (NTUA) to support climate change adaptation for natural hazards in Greece.

The DEAR-Clima web application is further indented for intermediary and end-users of the broader public/private sectors of tourism, agriculture, natural hazards and water management and provide timely and useful climatic information to support policy- and decision-makers. The impact of the project can be assessed by the number of end-users using the web tool application.

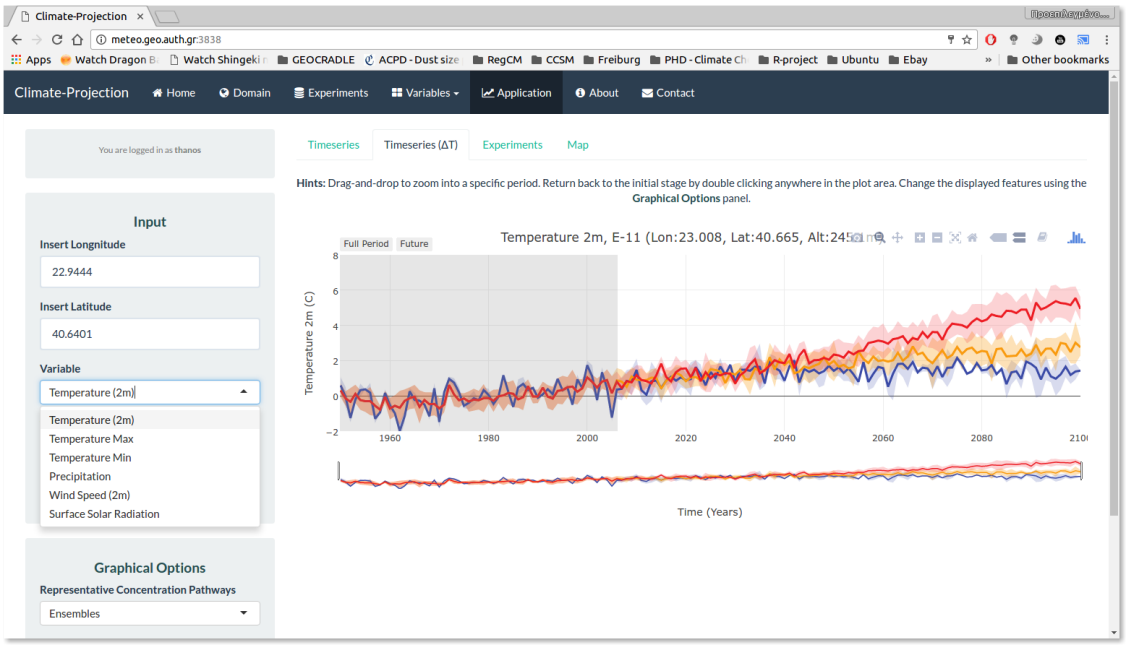

Figure 3.2 DEAR-Clima web application screenshot. The plot shows a multi-model ensemble time series at Thessaloniki (Greece) from 1950 to 2100 for the change in mean annual near surface temperature relative to the historical period 1950–2004. Time series of projections are shown for scenarios RCP2.6 (blue), RCP4.5 (yellow) and RCP8.5 (red) with bold lines indicating the annual means of the ensemble and with shaded areas the range of the respective ensemble members. The historical period is indicated with the grey shaded area.

Table 3.2.1 Description of simulation experiments processed in DEAR-Clima.

Scenario	Period	RCM	GCM
historical	1950.01-2005.12	CLMcom-CCLM4-8-17	CNRM-CERFACS-CNRM-CM5
historical	1950.01-2005.12	CNRM-ALADIN53	CNRM-CERFACS-CNRM-CM5
historical	1970.01-2005.12	SMHI-RCA4	CNRM-CERFACS-CNRM-CM5
historical	1950.01-2005.12	KNMI-RACMO22E	ICHEC-EC-EARTH
historical	1951.01-2005.12	IPSL-INERIS-WRF331F	IPSL-IPSL-CM5A-MR
historical	1970.01-2005.12	SMHI-RCA4	IPSL-IPSL-CM5A-MR
historical	1949.12-2005.12	CLMcom-CCLM4-8-17	MOHC-HadGEM2-ES
historical	1970.01-2005.12	SMHI-RCA4	MOHC-HadGEM2-ES
historical	1949.12-2005.12	CLMcom-CCLM4-8-17	MPI-M-MPI-ESM-LR
historical	1950.02-2005.12	MPI-CSC-REMO2009	MPI-M-MPI-ESM-LR
rcp26	2006.01-2100.12	CNRM-ALADIN53	CNRM-CERFACS-CNRM-CM5
rcp26	2006.01-2100.12	MPI-CSC-REMO2009	MPI-M-MPI-ESM-LR
rcp45	2006.01-2100.12	CLMcom-CCLM4-8-17	CNRM-CERFACS-CNRM-CM5
rcp45	2006.01-2100.12	CNRM-ALADIN53	CNRM-CERFACS-CNRM-CM5
rcp45	2006.01-2100.12	KNMI-RACMO22E	ICHEC-EC-EARTH
rcp45	2006.01-2100.12	IPSL-INERIS-WRF331F	IPSL-IPSL-CM5A-MR
rcp45	2006.01-2100.12	SMHI-RCA4	IPSL-IPSL-CM5A-MR
rcp45	2006.01-2099.11	CLMcom-CCLM4-8-17	MOHC-HadGEM2-ES
rcp45	2006.01-2099.11	SMHI-RCA4	MOHC-HadGEM2-ES
rcp45	2006.01-2100.12	CLMcom-CCLM4-8-17	MPI-M-MPI-ESM-LR
rcp45	2006.01-2100.12	MPI-CSC-REMO2009	MPI-M-MPI-ESM-LR
rcp85	2006.01-2100.12	CLMcom-CCLM4-8-17	CNRM-CERFACS-CNRM-CM5
rcp85	2006.01-2100.12	CNRM-ALADIN53	CNRM-CERFACS-CNRM-CM5
rcp85	2006.01-2100.12	KNMI-RACMO22E	ICHEC-EC-EARTH
rcp85	2006.01-2100.12	IPSL-INERIS-WRF331F	IPSL-IPSL-CM5A-MR
rcp85	2006.01-2100.12	SMHI-RCA4	IPSL-IPSL-CM5A-MR
rcp85	2006.01-2099.12	CLMcom-CCLM4-8-17	MOHC-HadGEM2-ES
rcp85	2006.01-2099.12	SMHI-RCA4	MOHC-HadGEM2-ES
rcp85	2006.01-2100.12	CLMcom-CCLM4-8-17	MPI-M-MPI-ESM-LR
rcp85	2006.01-2100.12	MPI-CSC-REMO2009	MPI-M-MPI-ESM-LR

Table 3.2.2 Climate variables provided by DEAR-Clima. Near surface stands for ~2m and downward surface solar radiation is set to be positive.

Climate Variable	Unit
Near surface daily average air temperature	^oC
Near surface daily maximum air temperature	^oC
Near surface daily minimum air temperature	^oC
Near surface wind speed	m/s
Precipitation	mm/day
Surface solar radiation	W/m^2
Surface air pressure	hPa
Near surface specific humidity	mg/kg

Table 3.2.3 Description of climate indices provided in DEAR-Clima.

	Climate Index	Description	Unit
DROUGHT	Consecutive Dry Days - CDD	$C(RR_{daily} < 1\ mm)$	days
	Consecutive Dry Days Periods - CDDP	$Periods(C(RR_{5days} < 1\ mm))$	periods
WET	Consecutive Wet Days - CWD	$C(RR_{daily} > 1\ mm)$	days
	Consecutive Wet Days Periods - CWDP	$Periods(C(RR_{5days} > 1\ mm))$	periods
HEAT	Summer Days - SU	$Tmax_{daily} > 25^oC$	days
	Consecutive Summer Days - CSU	$C(Tmax_{daily} > 25^oC)$	days
	Hot Days - HD	$C(Tmax_{daily} > 35^oC)$	days
	Tropical Nights - TR	$C(Tmin_{daily} > 20^oC)$	days
COLD	Frost Days - FD	$Tmin_{daily} < 0^oC$	days
	Consecutive Frost Days - CFD	$C(Tmin_{daily} < 0^oC)$	days
	Ice Days - ID	$C(Tmax_{daily} < 0^oC)$	days
	Heating Degree Days - HDD	$T_{daily} > 17^oC$	^oC/year
	Growing Season Length - GSL	$C(T_{daily} > 5^oC)$ to $C(T_{daily} < 5^oC)$	days

3.3. Air Quality services for ACC

Under the concept of the exploitation of the air quality forecasts of Copernicus Atmospheric Monitoring Service (CAMS) on the two prescribed axes (Sect. 3.3 in D4.1), the performed activities are described below.

CAMS evaluation

The evaluation of CAMS air quality products in the framework of GEO-CRADLE is based on the following two elements:

i. **selected CAMS parameters** according to the user needs identified in the RoI (Sect. 2.2.1 in D4.1) and

ii. data availability from the **PRE-TECT campaign** (April 2017).

This evaluation will be of great importance mainly for 2 reasons:

1) the utilized data are representative of the background air pollution in the RoI and

2) it will mainly involve species not (or poorly) subjected to the official validation procedures of CAMS.

Currently, needed data from the PRE-TECT campaign are being collected for quality control, and CAMS retrievals are automatically performed after the development of a dedicated algorithm.

Below, the selected CAMS outputs are coupled with observations (Table 3.3). As evident, the evaluation of $PM_{2.5}$ mass, PM_{10} mass, (Hydro-phylic, -phobic) elemental carbon (EC), (Hydro-phylic, -phobic) organic aerosol (OA), sulfate (SO4) aerosol, fine and PM_{10} dust particles, sea-salt aerosol (SSA), and greenhouse gases (CH4, CO2) will be performed, using state-of-the-art instrumentation. It should be noted that $PM_{2.5}$ and PM_{10} are retrieved from the European scale CAMS products, while the rest species are only provided as global outputs.

The possibility of incorporating model comparisons to airborne data will be explored, since PRE-TECT was clustered with EUFAR campaigns. Such a coupling will provide evaluation information on the vertical profiles of air quality, not performed in the frame of regular CAMS verification services.

Table 3.3 CAMS-to-PRE-TECT coupling for air quality evaluation in the RoI

PRE-TECT instrumentation, pollutants / CAMS species	PollyXT classification	Gas analyzers (Thermo, Horiba)	FH 62 I-R Termo (b – attenuation)	AE22 Magee Aethalometer	Aerosols Sampling (High/Low	PSAP	Picarro
PM10			*				
PM2.5					*		
Hydrophilic+Hydrophobic EC				*		*	
Hydrophilic+Hydrophobic OA					*		
Sulfate aerosol					*		
Sea Salt aerosol					*		
CO2							*
CH4		*					
O3		*					
NOx		*					
CO		*					
Dust aerosol	*						

CAMS uptake

Selected air quality species provided by CAMS services will be further exploited. The selection will be based on the outcomes of the aforementioned evaluation results, i.e. the poorly performed species will be excluded.

Both the European- and the global-scale air quality forecasts (for every hour up to 4-5 days in advance using either only the ensemble median or also the 7 different models) will be redirected to the GEO-CRADLE's portal, regionally adjusted to the RoI.

Air quality emissions have been also rated as 'important information', according to the regional needs' report of GEO-CRADLE (Sect. 2.2.1 in D4.1). This information is freely provided by CAMS as gridded data for the European area (TNO-MACC III emission inventory). The link for the relevant data provision (http://macc.copernicus-atmosphere.eu/services/esf/regional-emissions/data-request/) will be also provided through the GEO-CRADLE portal, to increase their visibility through the regional dimension.

Other activities

Supplementary air quality information and data that will be provided through the GEO-CRADLE portal are:

1. **9-year catalogue of desert dust episodes for the RoI**

Pathways of air pollution was highlighted as needed information in the frame of GEO-CRADLE (Sect. 2.2.1 in D4.1) for sources identification. An analysis of 4-day back trajectories towards E. Mediterranean (NOA site, Athens, Greece) has been performed from 2008 onwards. Initially, a catalogue of air mass transport from desert areas (mainly Africa) was created and then the PM_{10} mass levels and their chemical analysis (dust-tracers: EC, Fe, Al) for these days were used to flag the actual dust transport events. This catalogue will feed the GEO-CRADLE portal.

2. **In-situ measurement data**

The air quality data (**Error! Reference source not found.**) from Finokalia routine monitoring during the PRE-TECT campaign (all but dust) will be directly uploaded to the GEO-CRADLE portal.

4. APPENDIX

REPUBLIQUE ALGERIENNE DEMOCRATIQUE ET POPULAIRE

MINISTERE DES TRAVAUX PUBLICS ET DES TRANSPORTS
OFFICE NATIONAL
DE LA METEOROLOGIE
AVENUE KHEMISTI B.P 153 DAR EL BEIDA
ALGER

وزارة الأشغال العمومية و النقل
الديوان الوطني للأرصاد الجوية

Ref: 555/DG/233/CCN/ONM/17 July, 19th 2017

From: Mr. IHADADENE BRAHIM
Director General
Office National de la Météorologie
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Tel : +213 21 50 73 93
Fax: +213 21 50 88 49
Algiers, Algeria
Email: ihadadene.brahim@gmail.com

To

Pr. Hesham M. El-Askary, Ph.D
Professor of Remote Sensing and Earth System Science
Center of Excellence in Earth Systems Modeling and Observations
Director Graduate Programs in Computational and Data Sciences
Schmid College of Science and Technology

Dear Professor Hesham El-Askary,

We are writing to you regarding your participation as the regional coordinator for North Africa and the Middle East with the Centre for Environment and Development for the Arab Region and Europe (CEDARE) in the GEO-CRADLE (Coordinating and intergRating state-of-the-art Earth Observation Activities in the regions of North Africa, Middle East, and Balkans and Developing Links with GEO related initiatives towards GEOSS) project funded by the European Union, (grant agreement No 690133), under the H2020 's Framework Program-Climate action, environment, resource, efficiency and raw materials, whose PI is Haris Kontoes from the National Observatory of Athens, Greece). This project is of great importance for the integration of GEOSS (System of Systems on Global Earth Observation) Earth Observation Capacities at the region of North Africa, Middle East and the Balkans.

Saharan dust is the most abundant natural aerosol in North Africa and a major regulator of air quality conditions in the area. Inhalation of dust particles can lead to several health problems ranging from temporal irritation up to more severe lung and respiratory symptoms. For these reasons, as an Algerian Meteorological Service and regarding our multiple duties and missions, a timely forecast of the amounts and sizes of airborne dust particles could assist the policy makers to decide on the necessary resilience and mitigation measures related to public health and exposure limits. We need to establish the concentration thresholds of the sand in order to have alert classes (high, medium, low) based on intensity. We already recovered the layers necessary for this mapping, output of the climatic model, layer of the road network, yet your cooperation on that will be highly appreciated. We hope to have an early warning system for the road users (transportation) particularly in the Algerian Sahara region. Your cooperation will be key on providing information on the classification of the intensity of the concentration in relation with the danger classification.

Therefore, we are strongly interested in Adaptation to Climate change (ACC) dust pilot in the GEO-CRADLE project, which can be used as a proxy for the development of air quality services in Algeria and in North Africa. The thematic pillars of the ACC pilot namely, accurate desert dust forecasting, regional climate change services and air quality services are of great importance for us and we would like to show our extreme interest in all of them.

Thank you in advance for the valuable contribution.

Very truly yours,

Mr. BRAHIM IHADADENE
Director General of Office
National de la Météorologie
ALGERIA

Directeur Général par Intérim
IHADADENE Brahim

Ministry of Electricity & Renewable Energy
New & Renewable Energy Authority
(NREA)
Dr. Ibrahim Aboulnaga St., Ext. of Abbas El Akkad St,.
Nasr City, Cairo, Egypt

وزارة الكهرباء والطاقة المتجددة
هيئة تنمية واستخدام الطاقة الجديدة والمتجددة
شارع د . إبراهيم أبو النجا - إمتداد شارع عباس العقاد
حى الزهور - مدينة نصر - القاهرة

Hesham M. El-Askary, Ph.D
Professor of Remote Sensing and Earth System Science
Center of Excellence in Earth Systems Modeling and Observations
Director Graduate Programs in Computational and Data Sciences
Schmid College of Science and Technology

Dear Professor Hesham El-Askary,

We are writing to you regarding your participation as the regional coordinator for North Africa and the Middle East with the Centre for Environment and Development for the Arab Region and Europe (CEDARE) in the GEO-CRADLE (Coordinating and intergRating state-of-the-art Earth Observation Activities in the regions of North Africa, Middle East, and Balkans and Developing Links with GEO related initiatives towards GEOSS) project funded by the European Union, (grant agreement No 690133), under the H2020 's Framework Program-Climate action, environment, resource, efficiency and raw materials, whose PI is Haris Kontoes from the National Observatory of Athens, Greece). This project is of great importance for the integration of GEOSS (System of Systems on Global Earth Observation) Earth Observation Capacities at the region of North Africa, Middle East and the Balkans.

After our very successful collaboration with you and with the Geo-Cradle team on developing the Solar Atlas of Egypt, our interest is especially attracted by the possible combination of Adaptation to Climate change (ACC) dust pilot in the GEO-CRADLE project and the Solar Energy Nowcasting SystEm (SENSE) pilot for the provision of incoming radiation forecasts that can be used in concentrated solar power plant installations.

Radiative transfer is affected by both meteorological and air quality properties of the atmosphere. Temperature, humidity and clouds as well as aerosols such as desert dust can significantly modify the radiation budget. Especially for the case of concentrated power plants, dust depositions on the mirrors can be a major regulator of the overall system performance defining also the standard maintenance procedures. The thematic pillars of the ACC pilot namely, accurate desert dust forecasting, regional climate change services and air quality services are of great importance for us and we would like to show our extreme interest in all of them.

We as the Renewable Energy Authority of Egypt (NREA) are particularly interested in the above demonstrator pilots and we offer our endorsement for a possible application of the GEO-CRADLE services in Egypt as we did with the developed Solar Atlas.

Best regards

Sincerely Yours,
24.07.2017
Dr. Eng. Mohamed Mostafa El-Shahat
Vice Chairman for Studies, Researches & Technical Affairs

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El-Hay El-Sades, Nasr City,Cairo
Fax :(202) 22717173 - 22717172
Tel. Switch : 22725891, 2 , 3 , 4

ص . ب : ٤٥٤٤ مكتب بريد مساكن ضباط الصف
الحى السادس - مدينة نصر - القاهرة
فاكس : ٢٢٧١٧١٧٣ - ٢٢٧١٧١٧٢ (٢٠٢)
التليفونات العمومية : ٢٢٧٢٥٨٩١ , ٢ , ٣ , ٤

Kuwait Institute for Scientific Research معهد الكويت للأبحاث العلمية

Hesham M. El-Askary, Ph.D
Professor of Remote Sensing and Earth System Science
Center of Excellence in Earth Systems Modeling and Observations
Director Graduate Programs in Computational and Data Sciences
Schmid College of Science and Technology

Dear Professor Hesham El-Askary,

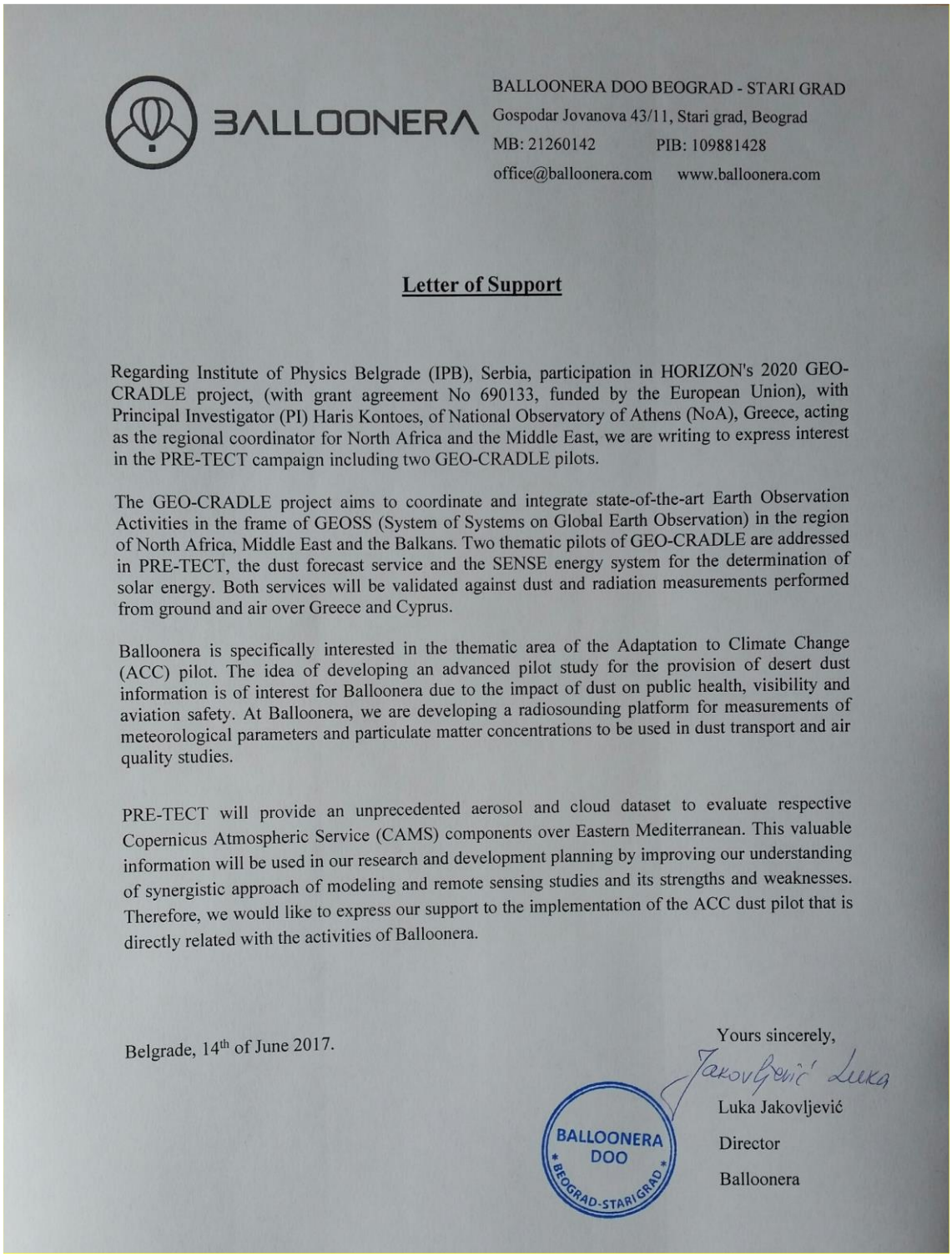
We are writing to you regarding your participation as the regional coordinator for North Africa and the Middle East with the Centre for Environment and Development for the Arab Region and Europe (CEDARE) in the GEO-CRADLE (Coordinating and integrating state-of-the-art Earth Observation Activities in the regions of North Africa, Middle East, and Balkans and Developing Links with GEO related initiatives towards GEOSS) project funded by the European Union, (grant agreement No 690133), under the H2020's Framework Program-Climate action, environment, resource, efficiency and raw materials, whose PI is Haris Kontoes from the National Observatory of Athens, Greece. This project is of great importance for the integration of GEOSS (System of Systems on Global Earth Observation) Earth Observation Capacities at the region of North Africa, Middle East and the Balkans.

The dust is the most abundant natural aerosol in North Africa and the Middle East and a major regulator of air quality conditions in the area. Inhalation of dust particles can lead to several health problems ranging from temporal irritation up to more severe lung and respiratory symptoms. For these reasons, a timely forecast of the amounts and sizes of airborne dust particles could assist the policy makers to decide on the necessary resilience and mitigation measures related to public health and exposure limits. We need to establish the concentration thresholds of the sand in order to have alert classes (high, medium, low) based on intensity. We already recovered the layers necessary for this mapping, output of the climatic model, layer of the road network, yet your cooperation on that will be highly appreciated. We hope to have an early warning system for the road users (transportation) particularly in Kuwait. Your cooperation will be key on providing information on the classification of the intensity of the concentration in relation with the danger classification.

Therefore, we are strongly interested in Adaptation to Climate change (ACC) dust pilot in the GEO-CRADLE project, which can be used as a proxy for the development of air quality services in Kuwait. The thematic pillars of the ACC pilot namely, accurate desert dust forecasting, regional climate change services and air quality services are of great importance for us and we would like to show our extreme interest in all of them.

Hamdy El-Gamily, Ph. D.
Hamdy 2017
23 / 7

GIS Section Head
Kuwait Institute for Scientific Research (KISR)
Email: hgamily@kisr.edu.kw



BALLOONERA

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Letter of Support

Regarding Institute of Physics Belgrade (IPB), Serbia, participation in HORIZON's 2020 GEO-CRADLE project, (with grant agreement No 690133, funded by the European Union), with Principal Investigator (PI) Haris Kontoes, of National Observatory of Athens (NoA), Greece, acting as the regional coordinator for North Africa and the Middle East, we are writing to express interest in the PRE-TECT campaign including two GEO-CRADLE pilots.

The GEO-CRADLE project aims to coordinate and integrate state-of-the-art Earth Observation Activities in the frame of GEOSS (System of Systems on Global Earth Observation) in the region of North Africa, Middle East and the Balkans. Two thematic pilots of GEO-CRADLE are addressed in PRE-TECT, the dust forecast service and the SENSE energy system for the determination of solar energy. Both services will be validated against dust and radiation measurements performed from ground and air over Greece and Cyprus.

Balloonera is specifically interested in the thematic area of the Adaptation to Climate Change (ACC) pilot. The idea of developing an advanced pilot study for the provision of desert dust information is of interest for Balloonera due to the impact of dust on public health, visibility and aviation safety. At Balloonera, we are developing a radiosounding platform for measurements of meteorological parameters and particulate matter concentrations to be used in dust transport and air quality studies.

PRE-TECT will provide an unprecedented aerosol and cloud dataset to evaluate respective Copernicus Atmospheric Service (CAMS) components over Eastern Mediterranean. This valuable information will be used in our research and development planning by improving our understanding of synergistic approach of modeling and remote sensing studies and its strengths and weaknesses. Therefore, we would like to express our support to the implementation of the ACC dust pilot that is directly related with the activities of Balloonera.

Belgrade, 14th of June 2017.

Yours sincerely,

Jakovljević Luka

BALLOONERA DOO * BEOGRAD-STARI GRAD *

Luka Jakovljević

Director

Balloonera

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TO WHOM IT MAY CONCERN

Regarding National Observatory of Athens (NoA), Greece, participation in HORIZON's 2020 GEO-CRADLE project, (with grant agreement No 690133, founded by the European Union), with Principal Investigator (PI) Haris Kontoes, acting as the regional coordinator for North Africa and the Middle East, with the Centre for Envoironment and Development for the Arab Region and Europe (CEDARE), the Institute of Meteorology, Faculty of Physics, University of Belgrade would like to express great concern. The project is of great importance for the integration of GEOSS (System of Systems on Global Earth Observation) Earth Observation Capacities at the region of the North Africa, Middle East and Balkans.

Institute of Meteorology specifically interested in the thematic area of the Adaptation to Climate Change (ACC) pilot. The idea of developing an advanced pilot study for the provision of desert dust information is of great importance for Institute of Meteorology due to the research interest on long-range transport of desert dust, especially for the potential benefits related to the research of numerical modeling of the whole process, since that Institute of Meteorology have long tradition in this area. Also, Institute of Meteorology is aware of the broader impact of this pilot due to the impact of dust on public health, visibility and aviation safety.

Therefore we would like to offer our endorsement to the implementation of the ACC dust pilot that is related to the activities of Institute of Meteorology, Faculty of Physics, University of Belgrade.

Lazar Lazić

prof. dr Lazar Lazić
Director of
Institute of Meteorology, Faculty of Physics, University of Belgrade

REPUBLIC OF CYPRUS
MINISTRY OF AGRICULTURE,
RURAL DEVELOPMENT
AND ENVIRONMENT

DEPARTMENT OF METEOROLOGY
1418 NICOSIA, CYPRUS

TO WHOM IT MAY CONCERN

Regarding National Observatory of Athens (NoA), Greece, participation in HORIZON's 2020 GEO-CRADLE project, (with grant agreement No 690133, funded by the European Union), with Principal Investigator (PI) Haris Kontoes, acting as the regional coordinator for North Africa and the Middle East, with the Centre for Environment and Development for the Arab Region and Europe (CEDARE), the Department of Meteorology (DoM) of Cyprus would like to express its great concern. The project is of great importance for the integration of GEOSS (System of Systems on Global Earth Observation) Earth Observation Capacities at the region of North Africa, Middle East and the Balkans.

DoM is specifically interested in the thematic area of the Adaptation to Climate Change (ACC) pilot. The idea of developing an advanced pilot study for the provision of desert dust information is of absolute importance for DoM due to the impact of dust on public health, visibility and aviation safety.
Especially, it is of high importance for DoM the study and the investigation of the failure of the dust models to forecast dust intrusion from regions of Middle East to Cyprus, such the case of September 2015. Therefore we would like to offer our endorsement to the implementation of the ACC dust pilot that is directly related with the activities of DoM, of the Ministry of Agriculture, Rural Development and Environment in Cyprus.

.....

Dr. Kleanthis Nicolaides
Director of
Department of Meteorology

MINISTRY OF AGRICULTURE RURAL DEVELOPMENT AND ENVIRONMENT
DEPARTMENT OF METEOROLOGY
REPUBLIC OF CYPRUS

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Vassilios A. Tsihrintzis, Ph.D., P.E., P.H.
Professor of Ecological Engineering and Technology
Centre for the Assessment of Natural Hazards and Proactive Planning
& Laboratory of Reclamation Works and Water Resources Management
Director, Department of Infrastructure and Rural Development
School of Rural and Surveying Engineering
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Skype address: vassilios.a.tsihrintzis
web: http://www.survey.ntua.gr/el/dep/40-tsixrintzis-vasileios.html;
http://naturalhazards.ntua.gr/el/people

March 7, 2017

TO WHOM IT MAY CONCERN:

We became aware of the HORIZON 2020 EU-funded project GEO-CRADLE (Coordinating and integrRating state-of-the-art Earth Observation Activities in the regions of North Africa, Middle East, and Balkans and Developing Links with GEO related initiatives towards GEOSS) under grant agreement No 690133, which is coordinated by the National Observatory of Athens (NOA), Greece with Principal Investigator (PI) Dr. Haris Kontoes (http://geocradle.eu/). This is an important project aiming to provide the necessary support and coordination to existing infrastructures, to deliver consolidated information and knowledge for long term strategic planning on adaptation and mitigation to climate change and air quality for North Africa, Middle East and Balkan.

Our Department of Infrastructure and Rural Development of the School of Rural and Surveying Engineering of the National Technical University of Athens would like to express our interest and support to GEO-CRADLE project. Specifically our Department is interested in the thematic area of the Adaptation to Climate Change (ACC). The pilot study of developing a user-friendly web application tool for the provision of future climate data from high resolution regional climate model projections for use by intermediary and end users on climate change adaptation strategies is of great importance for our Department in order to facilitate appropriate water resources planning and drought risk management.

Therefore, we would like to offer our endorsement to the implementation of this pilot study for regional climate change services for ACC that is directly related with the activities of our Department regarding water resources planning and drought risk management.

Sincerely,

Vassilios A. Tsihrintzis, PhD
Professor of Ecological Engineering and Technology

Royaume du Maroc
Agence du Bassin Hydraulique du Sebou

المملكة المغربية
وكالة الحوض المائي لسبو

03 AVR 2017

We became aware of the HORIZON 2020 EU-funded project GEO-CRADLE (Coordinating and integrRating state-of-the-art Earth Observation Activities in the regions of North Africa, Middle East, and Balkans and Developing Links with GEO related initiatives towards GEOSS) under grant agreement No 690133 which is coordinated by National Observatory of Athens (NOA), Greece with Principal Investigator (PI) Dr. Haris Kontoes (http://geocradle.eu/). This an important project aiming to provide the necessary support and coordination to existing infrastructures, to deliver consolidated information and knowledge for long term strategic planning on adaptation and mitigation to climate change and air quality for North Africa, Middle East and Balkan.

The Sebou Basin Agency - Morocco would like to express her interest and support to GEO-CRADLE project. Specifically our Department is interested in the thematic area of the Adaptation to Climate Change (ACC). The pilot study of developing a user-friendly web application tool for the provision of future climate data from high resolution regional climate model projections for use by intermediary and end users on climate change adaptation strategies is of great importance for our Department in order to facilitate appropriate water resources planning and drought risk management.

Therefore we would like to offer our endorsement to the implementation of this pilot study for regional climate change services for ACC that is directly related with the activities of our Department regarding water resources planning and drought risk management.

Directrice de l'Agence
du Bassin Hydraulique du Sebou
Signé : Samira EL HAOUAT

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E-mail: direction@abhsebou.ma :البريد الالكتروني Site web: www.abhsebou.ma :الموقع الالكتروني

ΕΘΝΙΚΟ ΜΕΤΣΟΒΙΟ ΠΟΛΥΤΕΧΝΕΙΟ
ΣΧΟΛΗ ΑΓΡΟΝΟΜΩΝ & ΤΟΠΟΓΡΑΦΩΝ ΜΗΧΑΝΙΚΩΝ
ΚΕΝΤΡΟ ΕΚΤΙΜΗΣΗΣ ΦΥΣΙΚΩΝ ΚΙΝΔΥΝΩΝ
ΚΑΙ ΠΡΟΛΗΠΤΙΚΟΥ ΣΧΕΔΙΑΣΜΟΥ
NATIONAL TECHNICAL UNIVERSITY OF ATHENS
SCHOOL OF RURAL & SURVEYING ENGINEERING
CENTRE FOR THE ASSESSMENT OF NATURAL HAZARDS
AND PROACTIVE PLANNING

March 28, 2017

TO WHOM IT MAY CONCERN

We became aware of the HORIZON 2020 EU-funded project GEO-CRADLE (Coordinating and integrRating state-of-the-art Earth Observation Activities in the regions of North Africa, Middle East, and Balkans and Developing Links with GEO related initiatives towards GEOSS) under grant agreement No 690133 which is coordinated by National Observatory of Athens (NOA), Greece with Principal Investigator (PI) Dr. Haris Kontoes (http://geocradle.eu/). This an important project aiming to provide the necessary support and coordination to existing infrastructures, to deliver consolidated information and knowledge for long term strategic planning on adaptation and mitigation to climate change and air quality for North Africa, Middle East and Balkan.

The Centre for the Assessment of Natural Hazards and Proactive Planning (CANaH) of the National Technical University of Athens, would like to express its interest and support to GEO-CRADLE project. Specifically, CANaH is interested in the thematic area of the Adaptation to Climate Change (ACC). The pilot study of developing a user-friendly web application tool for the provision of future climate data from high resolution regional climate model projections for use by intermediary and end users on climate change adaptation strategies is of great importance for CANaH, in order to assess water related natural hazards.

Therefore we would like to offer our endorsement to the implementation of this pilot study for regional climate change services for ACC that is directly related with the activities of CANaH regarding the assessment of water related natural hazards and proactive planning.

Sincerely,

Prof. George Tsakiris
Director of the Centre for the Assessment of Natural Hazards
and Proactive Planning

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