Demokritos
National Centre for Scientific Research

Institute of Nuclear & Radiological
Sciences & Technology, Energy & Safety

ENVIRONMENTAL RESEARCH LABORATORY

GHGs and AQ measurements over European cities using aerial and ground platforms as part of the ICARUS air pollution and climate change mitigation strategy

ICARUS

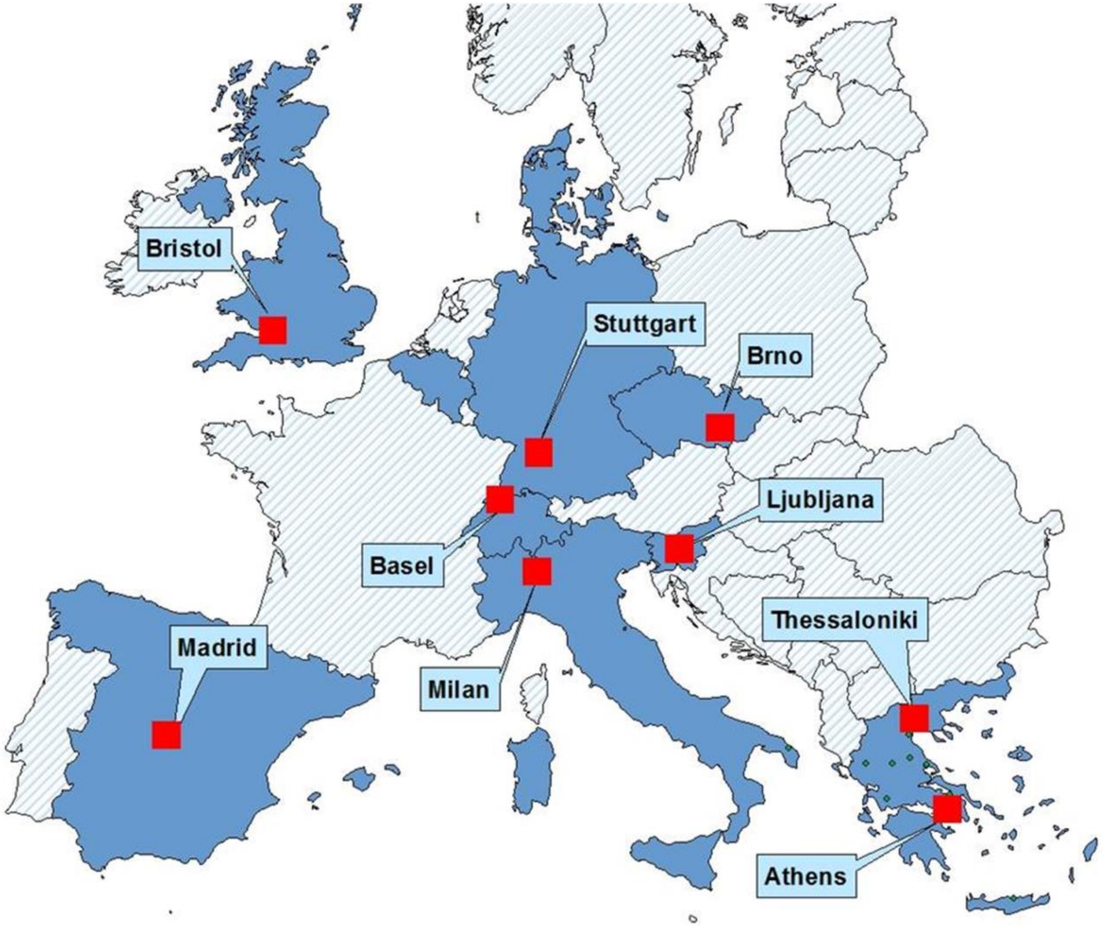
Th. Maggos, Th. Soulos, M. Lenarčič, D. Kocman, T. Kanduč , P. Panagopoulos, H. Flocas, Ch. Vasilakos, A. Gotti, S. Karakitsios, D. Sarigiannis

ICCCC 2018, Limasol, Cyprus

Demokritos
National Centre for Scientific Research

The Horizon 2020 "ICARUS" project (2016-2020)

"Integrated Climate forcing and Air pollution Reduction in Urban Systems"



18 partners from 9 EU countries

European Commission

HORIZON 2020

This project has received funding from the European Union's Horizon 2020 Research and Innovation Programme under Grant Agreement No 690105

Main objective of ICARUS project:

To develop integrated tools and strategies for urban impact assessment in support of air quality and climate change governance in EU Member States **leading to the design and implementation of appropriate abatement strategies to improve the air quality and reduce the carbon footprint in European cities.**

Detailed policies and measures for **Air Pollution** and **climate control** for the short and medium term (**until ca. 2030**) will be developed.

For the long term perspective (2050 and beyond) visions of **green cities** and explore pathways on how to start realizing these visions will be developed.

Each proposed **policy will be evaluated** for the following **effects/impacts**:

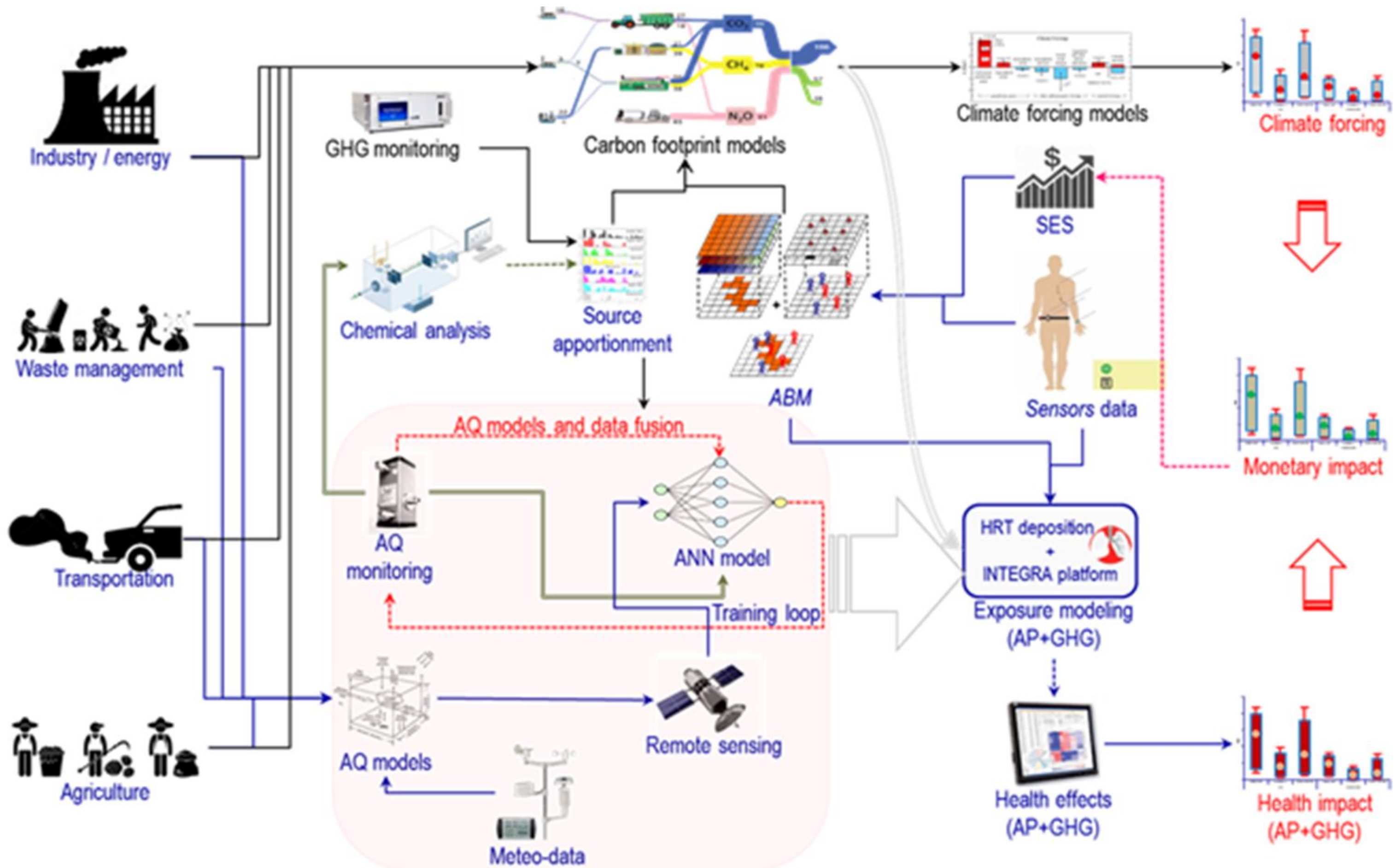
- Changes in **emissions and ambient concentrations** of air pollutants, greenhouse gases
- Changes in **the exposure to air pollutants** taking into account important indoor sources.
- Changes in the associated **impacts on human health**.
- **Societal and economic impacts**

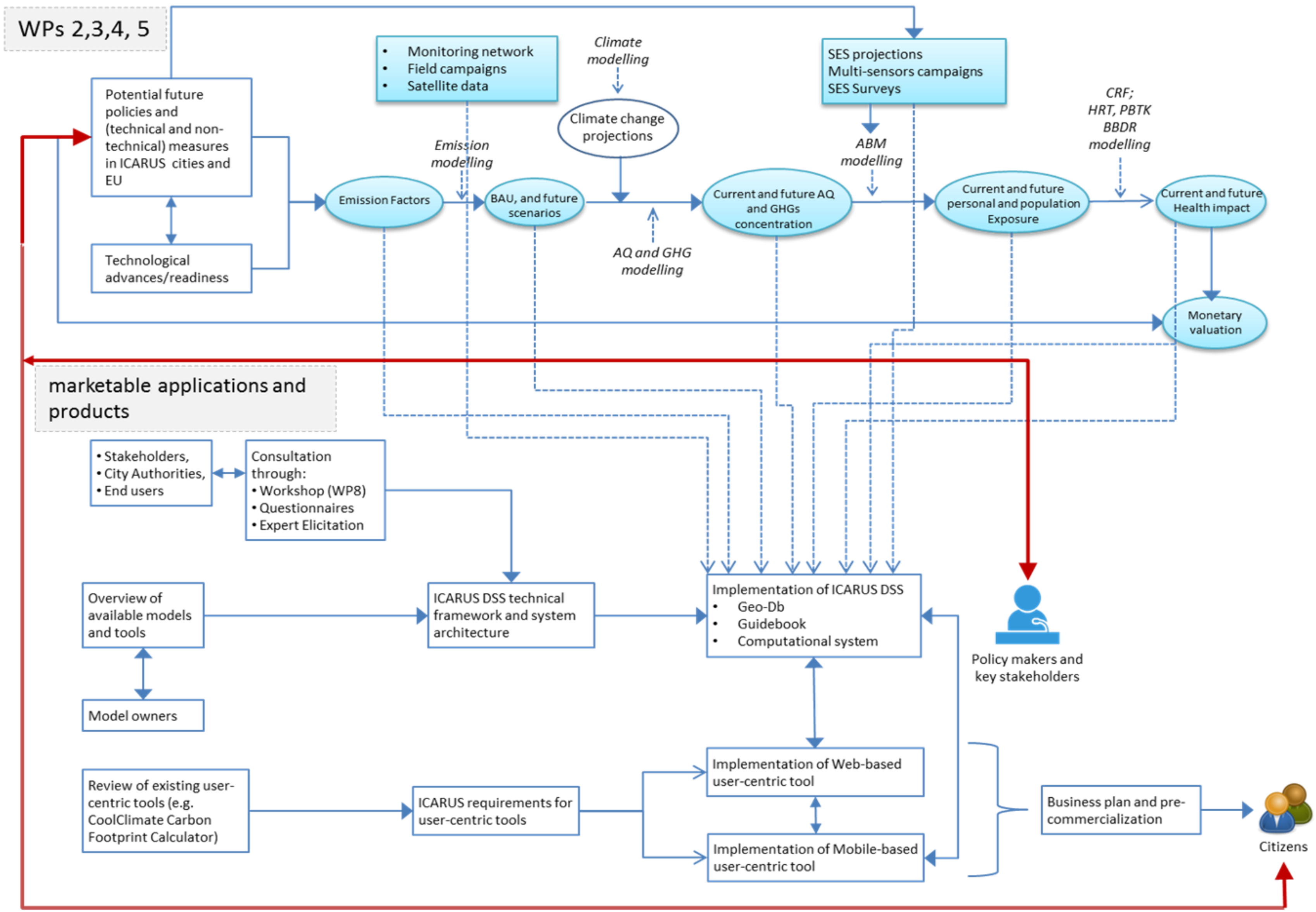
Furthermore:

- **Propose measures** of technological (i.e. measures that will lead to a reduction of emissions at the source) and non-technological (i.e. measures that induce behavioural changes) nature to reduce both carbon footprint and air quality burden (win-win solutions).
- **Develop visions of green cities**
- **Raise awareness of the citizen**s about the impacts on public health and the climate causes by their activities or with changes in their activities.

Marketable applications and Products

- DSS
- Citizen-centric tools


Industry / energy
Waste management
Transportation
Agriculture
GHG monitoring
Carbon footprint models
Climate forcing models
Climate forcing
SES
Chemical analysis
Source apportionment
ABM
Sensors data
Monetary impact
AQ models and data fusion
AQ monitoring
ANN model
Training loop
HRT deposition
+
INTEGRA platform
Exposure modeling (AP+GHG)
AQ models
Remote sensing
Meteo-data
Health effects (AP+GHG)
Health impact (AP+GHG)


WPs 2,3,4, 5
Potential future policies and (technical and non-technical) measures in ICARUS cities and EU
Technological advances/readiness
Monitoring network
Field campaigns
Satellite data
Climate modelling
Climate change projections
SES projections
Multi-sensors campaigns
SES Surveys
Emission modelling
ABM modelling
CRF; HRT, PBTK BBDR modelling
Emission Factors
BAU, and future scenarios
Current and future AQ and GHGs concentration
Current and future personal and population Exposure
Current and future Health impact
AQ and GHG modelling
Monetary valuation
marketable applications and products
Stakeholders,
City Authorities,
End users
Consultation through:
Workshop (WP8)
Questionnaires
Expert Elicitation
Overview of available models and tools
ICARUS DSS technical framework and system architecture
Implementation of ICARUS DSS
Geo-Db
Guidebook
Computational system
Policy makers and key stakeholders
Model owners
Review of existing user-centric tools (e.g. CoolClimate Carbon Footprint Calculator)
ICARUS requirements for user-centric tools
Implementation of Web-based user-centric tool
Implementation of Mobile-based user-centric tool
Business plan and pre-commercialization
Citizens

FIELD CAMPAIGNS

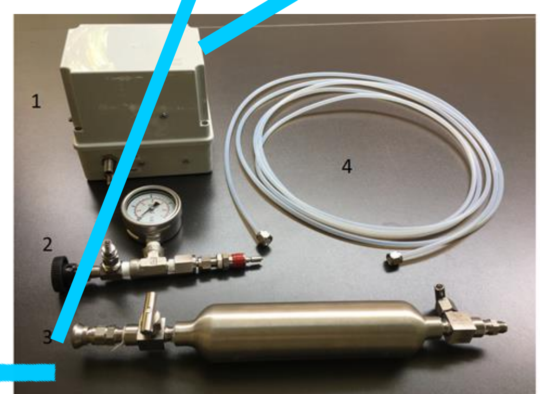
- **Ground based AQ & GHGs field campaigns in 6 ICARUS cities (3sites, 2 seasons)**
- **Aerial AQ & GHGs campaigns over 3 cities**

- **Personal Exposure Assesement field campaigns using low cost sensors – 100 volunteers/city in 9 ICARUS cities**

A N.A.S.A Awarded Light Manned Aircraft of <u>“ARTEMIS” Co</u> (ICARUS partner), named Pipistrel Virus Sw, was used to perform the aerial mapping.
The specific type of aircraft is specially designed for Aerial Environmental Monitoring as it is equipped with high-tech scientific equipment in order to provide i) Land Surveying measurements and ii) Accurate Environmental Data even to inaccessible areas using remote sensing techniques.

Infrastructure & Instrumentation

More specifically, for the needs of ICARUS project, a special design sampling equipment was mounted in the aircraft while sampling performed through inlets located under the wing.



Stainless steel canisters were filled with pressurized air using a special design pump in terms of shape and dimensions as well as its capability to pressurize sampled air up to 2 bars.

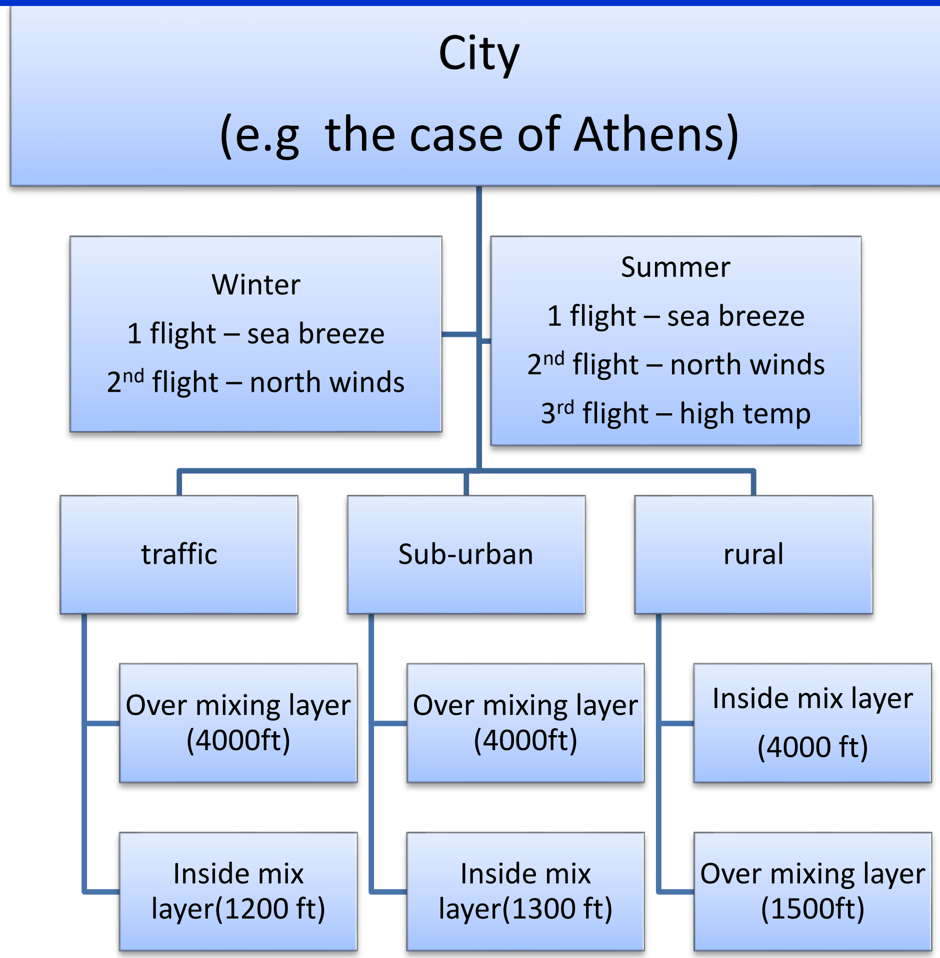
Aerial Sampling Procedure

The light aircraft performed aerial mapping over **<u>Athens, Thessaloniki and Ljubljana</u>** greater Area.

<u>The aerial sampling took place:</u>

- over a **rura**l, an **urban background** and a **traffic** area of each city.
- during **winter** and **summer** time
- under three different **weather conditions** which are the **most common and most critical in terms of pollution**
- for each one of the above conditions, samples were collected **inside and over the mixing layer**
- **detailed meteorological parameters** were provided by both the aircrafts instrumentation as well the **forecast models** available from the **Atmospheric Modelling group of University of Athens**.
- Samples were transferred to the lab for **GHGs** and **VOCs** analysis using a special design **GC-FID/ECD** chromatographic system and a **GC-FID** coupled with a thermal desorption system respectively

Example



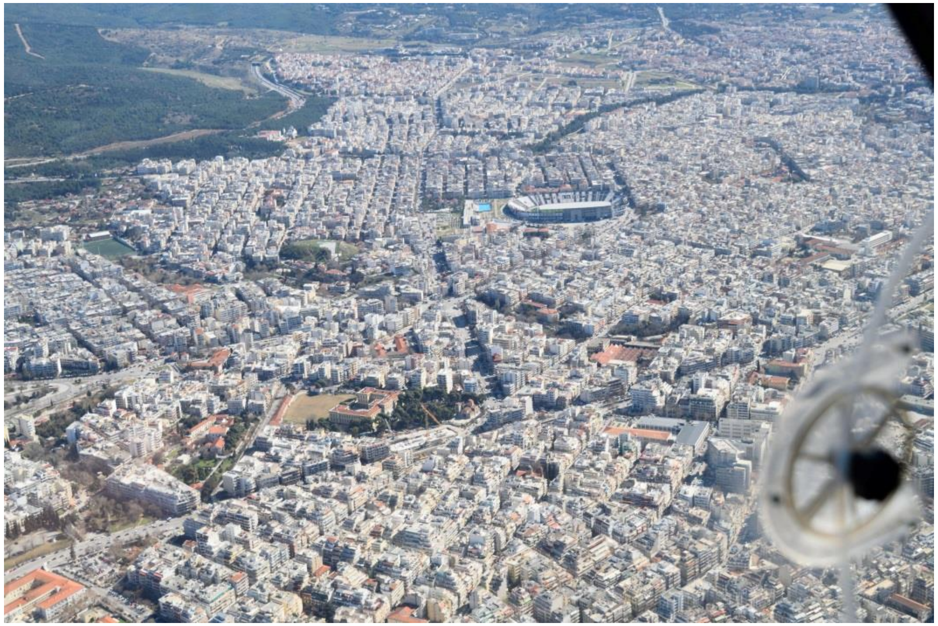
For each city collected: 15 VOCS & 15 GHGs above the mixing layer
15 VOCS & 15 GHGs inside the mixing layer
The corresponding ground level samples were also collected

Ref. Ares(2016)1512245 - 30/03/2016

Sampling during North Winds (Athens)

Sampling during Sea Breeze
(light South winds)

Sampling during North Winds
(Thessaloniki)



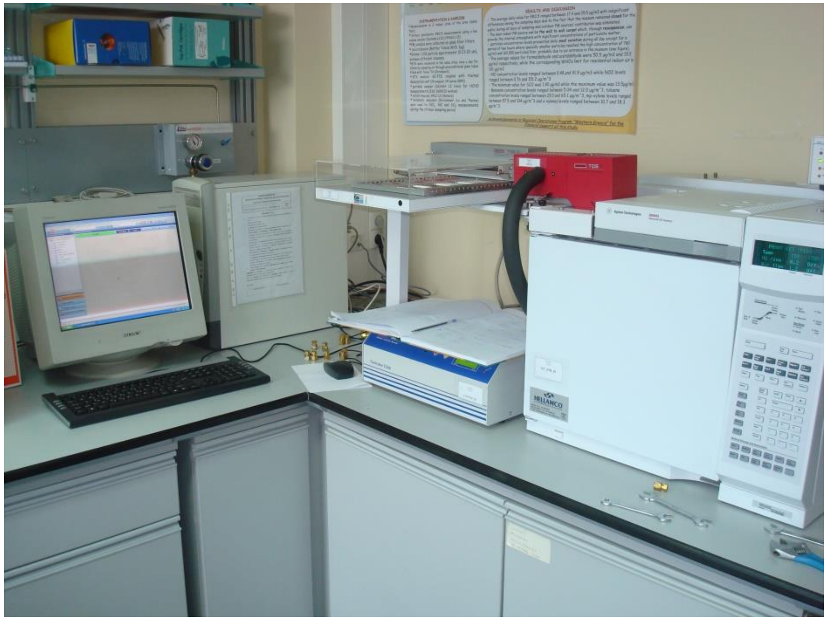
Sampling during sunny calm conditions (Ljubljana)

Sampling during cloudy – rainy conditions (Ljubljana)

Laboratory analysis

Key features: The special design greenhouse gas analyzer, TRACE 1300 GC from G.A.S (Global Analyzer Solutions) THERMO Scientific. Provides High-Precision concentration measurements **of greenhouse gases - CH_4, CO_2, N_2O, SF_6** - in air samples collected in canisters

Key features: Agilent GC-FID coupled with a Gerstel thermal desorption system. Provides concentration measurements of **volatile organic compounds**



Preliminary RESULTS

Up to now:

- ***Analysis of GHGs samples for the city of Athens, Thessalonikiand Ljubljana for both seasons and heights***
- ***VOCs analysis for all cities and correlation with meteo data are in process***

Table 1. GHGs mean values for both periods in all sampling sites (no temporal, spatial consideration)

	N2O (ppb)		**SF6 (ppt)**		**CH4 (ppm)**		**CO2 (ppm)**	
City	Over Mix Layer	In ML	Over Mix Layer	In ML	Over Mix Layer	In ML	Over Mix Layer	In ML
Athens	316	334	11.3	11.3	1.83	1.84	385.2	387.2
Thessaloniki	318	320	10.7	11.4	1.86	1.89	392.9	395.0
Ljubljana	338	342	10.3	10.5	1.98	2.03	399	411

- *Without taking under consideration any temporal and spatial variation the concentration values inside the mixing layer are shown higher values for all GHGs*
- *SF6 didn’t present any significant variation*

Preliminary RESULTS

Table 2. GHGs mean values for both periods over the different sampling sites (no temporal consideration)

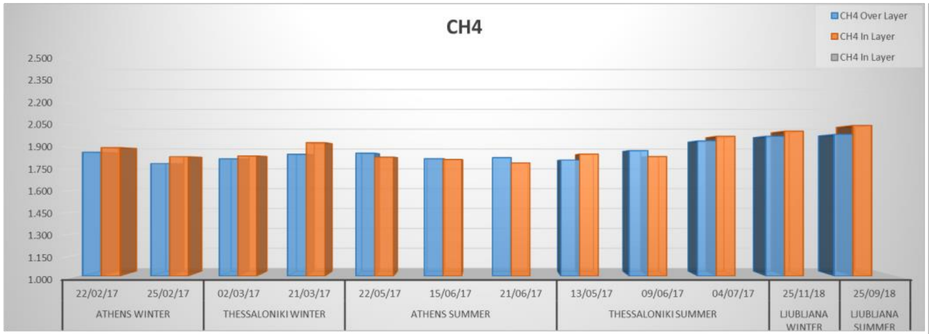
Athens	N2O (ppb)		SF6 (ppt)		CH4 (ppm)		CO2 (ppm)	
	Over Mix Layer	In Mix Layer	Over Mix Layer	In Mix Layer	Over Mix Layer	In Mix Layer	Over Mix Layer	In Mix Layer
Rural	312.3	340.9	11.1	11.3	1.82	1.81	379.5	388.5
Suburban	318.7	332.3	11.4	11.1	1.85	1.84	387.9	385.3
Traffic	319.0	329.1	11.4	11.5	1.83	1.85	386.9	388.0

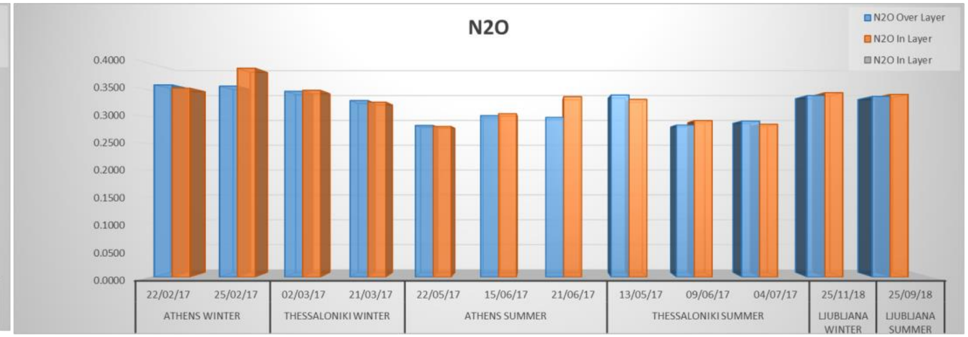
Thessaloniki	N2O (ppb)		SF6 (ppt)		CH4 (ppm)		CO2 (ppm)	
	Over Mix Layer	In Mix Layer	Over Mix Layer	In Mix Layer	Over Mix Layer	In Mix Layer	Over Mix Layer	In Mix Layer
Rural	316.8	316.9	10.7	11.2	1.85	1.89	392.5	395.0
Suburban	321.7	316.7	10.9	11.4	1.88	1.88	393.5	397.2
Traffic	317.4	330.1	10.5	11.6	1.86	1.90	392.9	392.7

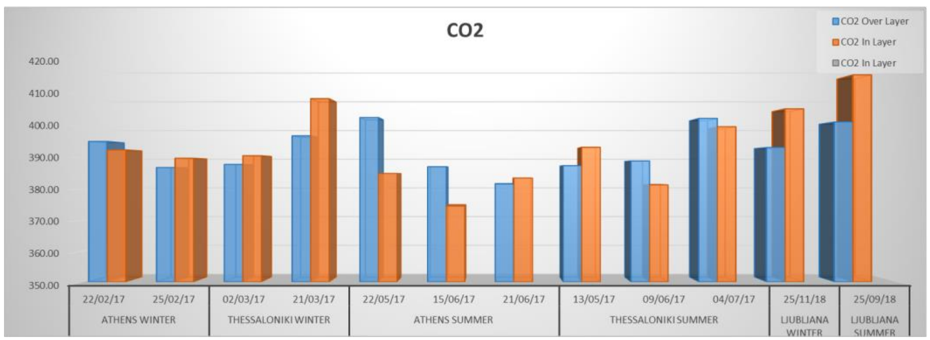
Ljubljana	N2O (ppb)		SF6 (ppt)		CH4 (ppm)		CO2 (ppm)	
	Over Mix Layer	In Mix Layer	Over Mix Layer	In Mix Layer	Over Mix Layer	In Mix Layer	Over Mix Layer	In Mix Layer
Rural	337	342	10.1	10.5	1.97	2.02	402	406
urban	339	344	10.6	10.5	1.99	2.04	398	416

- *No significant differences are observed between suburban and traffic site. Due to the large scale of sampling area that aircraft covers we can should consider suburban and traffic site as an “over the city” site.*
- *Slight differences are observed between the rural and over the cities concentrations without a specific trend*

Preliminary RESULTS







	Over ML		In ML	
	Average Winter	Average Summer	Average Winter	Average Summer
N2O (ppb)	346	305	352	311
SF6 (ppt)	10.5	11.7	11.2	11.5
CH4 (ppm)	1.86	1.86	1.90	1.88
CO2 (ppm)	394	393	397	390

- *Slightly higher concentrations were observed during the winter campaigns over all cities*

Demokritos
National Centre for Scientific Research

ARTEMIS ENGINEERING
CONSULTANTS AEROSURVEY

Thank You for your Attention

ICARUS

Ref. Ares(2016)1512245 - 30/03/2016

BACKGROUND

The advantages of aerial mapping

- Aircrafts are ideal for both fast-response investigations and routine, long-term measurements in the field of topography and environmental quality.

- Aircrafts are capable of greater speed, and therefore greater range and spatial coverage during a short time period when compared to surface research platforms.

- An aircraft surveys reach across a wide range of environmental and geographic conditions.

- Aircraft-mounted sensors provide data with much of the appeal of the aerial view provided by satellites, but with much greater specificity, spatial and temporal resolution, scheduling flexibility, and they can provide resolution adaptable to phenomena of interest.