ΚΥΠΡΙΑΚΗ ΔΗΜΟΚΡΑΤΙΑ

ΔΙΑΡΘΡΩΤΙΚΑ ΤΑΜΕΙΑ
της Ευρωπαϊκής Ένωσης στην Κύπρο
οι ιδέες μας, πράξη και ανάπτυξη

ΕΥΡΩΠΑΙΚΗ ΕΝΩΣΗ

Η ΔΕΣΜΗ 2009-2010 ΣΥΓΧΡΗΜΑΤΟΔΟΤΕΙΤΑΙ ΑΠΟ ΤΗΝ ΚΥΠΡΙΑΚΗ ΔΗΜΟΚΡΑΤΙΑ ΚΑΙ ΤΟ ΕΥΡΩΠΑΪΚΟ ΤΑΜΕΙΟ ΠΕΡΙΦΕΡΕΙΑΚΗΣ ΑΝΑΠΤΥΞΗΣ ΤΗΣ ΕΕ
DESMI 2009-2010 IS CO-FUNDED BY THE REPUBLIC OF CYPRUS AND THE EUROPEAN REGIONAL DEVELOPMENT FUND OF THE EU

ΕΝΤΥΠΟ ΥΠΟΒΟΛΗΣ ΤΕΛΙΚΗΣ ΕΚΘΕΣΗΣ ΠΡΟΟΔΟΥ ΕΡΕΥΝΗΤΙΚΟΥ ΕΡΓΟΥ ΤΗΣ ΔΕΣΜΗΣ 2009-2010

FINAL PROGRESS REPORT FORM FOR RESEARCH PROJECTS FUNDED BY DESMI 2009-2010

ΤΙΤΛΟΣ ΕΡΓΟΥ **PROJECT TITLE**	**Air pollution monitoring from space in Cyprus**
ΑΝΑΔΟΧΟΣ ΦΟΡΕΑΣ **HOST ORGANISATION**	**Cyprus University of Technology**
ΣΥΝΤΟΝΙΣΤΗΣ ΕΡΓΟΥ **PROJECT COORDINATOR**	D. G. Hadjimitsis

ΔΕΣΜΗ 2009-2010

Ίδρυμα Προώθησης Έρευνας

ΟΔΗΓΙΕΣ ΥΠΟΒΟΛΗΣ ΤΕΛΙΚΗΣ ΕΚΘΕΣΗΣ ΠΡΟΟΔΟΥ / FINAL REPORT SUBMISSION GUIDELINES

Η **Τελική Έκθεση** υποβάλλεται σε ηλεκτρονική και έντυπη μορφή (σε δύο δεμένα αντίγραφα), το αργότερο δύο μήνες μετά την ημερομηνία λήξης του Έργου. Η Τελική Έκθεση περιλαμβάνει τρία μέρη:

The **Final Report** is submitted in electronic and print format (in two bound copies), within two months of the Project's completion date, at the latest. The Final Report comprises of the following three parts:

ΜΕΡΟΣ Α / PART A - Τελική Έκθεση Προόδου / Final Progress Report

Α.1. Γενικά Στοιχεία Έργου / General Project Information

Α.2. Περίληψη / Abstract

Α.3. Τελική Έκθεση Υλοποίησης Έργου / Final Project Implementation Report

Α.4. Πίνακας Δεσμών Εργασίας / Work Packages Table

ΜΕΡΟΣ Β / PART B – Παραρτήματα / Annexes

Β.1. Παράρτημα Β1 - Παραδοτέα του Έργου / Annex B1 – Project Deliverables

Β.2. Παράρτημα Β2 - Άλλες Πληροφορίες / Annex B2 - Other Information

ΜΕΡΟΣ Γ / PART C - Τελική Έκθεση Οικονομικών Πεπραγμένων / Final Financial Report

Η Τελική Έκθεση Οικονομικών Πεπραγμένων υποβάλλεται σε ξεχωριστό ειδικό έντυπο που είναι διαθέσιμο στον ιστοχώρο του Ιδρύματος Προώθησης Έρευνας σε μορφή αρχείου Excel.

The Final Financial Report is submitted in a separate form in excel format available on the Research Promotion Foundation's website.

Μ Ε Ρ Ο Σ Α / Ρ Α R Τ Α	
Α.1. ΓΕΝΙΚΑ ΣΤΟΙΧΕΙΑ ΕΡΓΟΥ / GENERAL PROJECT INFORMATION	
Επιχειρησιακό Πρόγραμμα **Operational Programme**	Αειφόρος Ανάπτυξη και Ανταγωνιστικότητα Sustainable Development and Competitiveness
Άξονας Προτεραιότητας **Priority Axis**	Κοινωνία της Γνώσης και Καινοτομία Knowledge Society and Innovation
Πρόγραμμα **Programme**	Αειφόρος Ανάπτυξη
Δράση **Action**	Αστικό και Δομημένο Περιβάλλον
Αριθμός Πρωτοκόλλου Έργου **Project Protocol Number**	**ΑΕΙΦΟΡΙΑ/ΑΣΤΙ/0609(ΒΕ)/12**
Τίτλος Έργου **Project Title**	Air pollution monitoring from space in Cyprus
Ανάδοχος Φορέας **Host Organisation**	Τεχνολογικό Πανεπιστήμιο Κύπρου
Συντονιστής Έργου **Project Coordinator**	***Δ. Γλ. Χατζημιτσής***
Ημερομηνία Έναρξης Έργου **Project Starting Date**	1/12/2010
Ημερομηνία Λήξης Έργου **Project Completion Date**	***31/01/2013***
Ημερομηνία Υποβολής Έκθεσης **Report Submission Date**	***/ /2013***
Εγκεκριμένη Επιχορήγηση **Approved Funding**	***119510,95 ΕΥΡΩ / EUR***
Ποσό που καταβλήθηκε από το ΙΠΕ (μέχρι στιγμής) **Funding Received from RPF** (so far)	***119510,95 ΕΥΡΩ / EUR***
Ποσό που δαπανήθηκε (μέχρι στιγμής) **Actual Expenses Incurred** (so far)	***…….. ΕΥΡΩ / EUR***

Στοιχεία Επικοινωνίας Συντονιστή Έργου / Project Coordinator's Contact Information	
Διεύθυνση **Address**	Αρχιεπισκόπου Κυπριανού 31, Λεμεσός, 3036
Τηλέφωνα **Telephone No.**	25002548
Τηλεομοιότυπο **Fax No.**	25002661
Ηλεκτρονικό ταχυδρομείο **Email address**	d.hadjimitsis@cut.ac.cy

Α.2. ΠΕΡΙΛΗΨΗ (μέχρι 500 λέξεις σε κάθε γλώσσα) / ABSTRACT (up to 500 words in each language)

Σύντομη περιγραφή της πορείας υλοποίησης του Έργου. Να δίνεται τόσο στα ελληνικά όσο και στα αγγλικά.
Short description of Project implementation. Should be provided both in Greek and English.

Air pollution is one of the most important issues concerning not only the scientific community but also the public services since the quality of atmosphere greatly affects the quality of life. This project has as main objective the development and the implementation of an algorithm for the estimation of ground-based concentrations of Particulate Matter – PM and indicative of atmospheric pollution using satellite remote sensing techniques. Aerosol Optical Thickness- AOT from MODIS sensor (Terra/Aqua) and sun-photometer measurements of AOT and concentrations of PM in conjunction with meteorological data (RH) as well as data of the Planetary Boundary Layer after the processing of lidar signals on daily basis gave more precise results. The researcher of HO collected the data in daily basis and after the procedure using the appropriate software, the data classify for the derivation of algorithm. The creation of this database comprises the basic elements in order to develop the algorithm for measuring the ground-based air pollution using only satellite data and this has not happened again in Cyprus. The knowledge of air pollution using remote sensing data will help greatly to protect the population and especially the vulnerable groups in case of high air pollution levels according to the laws of the European Union. The results of this research program are extremely encouraging. The remote sensing data can yield largely terrestrial data of aerosols by using ancillary meteorological data for each study area. The combined use of sun-photometer and PM impactors as well as the satellite data for the four main cities of Cyprus, gave a clear results that satellite data could be used in the future for monitoring ground PM concentrations. The initial measurements for Limassol and Nicosia were satisfactory. Limassol comprise the main study area and the volume of data in accordance with the number of instruments used can give greater punctuality, while the vertical structure of the atmosphere could provide information about the source of pollutants. Therefore a large amount of measurements have been made for the main study area and the area of Nicosia in different

weather conditions which allows better classification in various possible cases. These measurements will be continued for the rest of the project in order to confirm the results and to improve data accuracy.

Another result of the project was the PM characterization under different meteorological conditions for Nicosia and Limassol and a more detailed study of Limassol area using remote sensing data from the sun-photometer CIMEL (AERONET). Using michrophysical and optical properties of aerosols we categorize the type of aerosols and thus we better retrieved the algorithm combined the satellite derived AOT and the ground-based measurements of PM. Finally the statistical and chemical model developed and validated under the AIRSPACE project using the PM data retrieved from Harvard impactors and CUT's PM Dust tracks shows very promising results for the aerosol forecasting over Cyprus. The proposed methodology of the integrating use of satellite and in situ observations of the aerosols was applied successfully for the Limassol site and validated at the supportive sites of Larnaka and Nicosia.

Η ατμοσφαιρική ρύπανση αποτελεί ένα από τα σημαντικότερα θέματα που απασχολούν όχι μόνο την επιστημονική κοινότητα, αλλά και τις δημόσιες υπηρεσίες μιας και η ποιότητα του αέρα που αναπνέουμε επηρεάζει σε μεγάλο βαθμό την ποιότητα ζωής των ανθρώπων. Το έργο αυτό έχει ως βασικό στόχο την ανάπτυξη και την εφαρμογή ενός αλγορίθμου για την εκτίμηση των επίγειων συγκεντρώσεων αιωρούμενων σωματιδίων PM (Particulate Matter) ενδεικτικών της ατμοσφαιρικής ρύπανσης με τη βοήθεια Τεχνικών Δορυφορικής Τηλεπισκόπησης (Remote Sensing) από τους δορυφορικούς αισθητήρες Terra/Aqua MODIS με καθημερινές επίγειες μετρήσεις του Οπτικού Πάχους Αερολυμάτων (Aerosol Optical Thickness-AOT) και των συγκεντρώσεων PM σε συνδυασμό με μετεωρολογικά δεδομένα σχετικής υγρασίας (Relative Humidity – RH), καθώς και δεδομένα του ύψους του Πλανητικού Οριακού Στρώματος (Planetary Boundary Layer - PBL) από τα δεδομένα των σημάτων lidar που καταγράφονται και αναλύονται σε καθημερινή βάση. Η συλλογή των παραπάνω δεδομένων γινόταν καθημερινά από τον ερευνητή του ΑΦ και μετά από κατάλληλη επεξεργασία με τη βοήθεια των λογισμικών, κατατάσσονται για την εξαγωγή του αλγορίθμου AOT-PM. Η δημιουργία μιας βάσης δεδομένων από τις τεχνικές τηλεπισκόπησης που χρησιμοποιήθηκαν οδήγησαν στην ανάπτυξη και την εφαρμογή ενός αλγορίθμου, ο οποίος δίνει τη δυνατότητα υπολογισμού της σωματοδιακής ρύπανσης με τη χρήση μετρήσεων οπτικού βάθους των αερολυμάτων για την περιοχή της Κύπρου. Η γνώση της σωματοδιακής ρύπανσης μέσω της τηλεπισκόπησης θα συμβάλει σε μεγάλο βαθμό στη προστασία του πληθυσμού και κυρίως των ευπαθών ομάδων σε περιπτώσεις που τα επίπεδα ξεπερνούν τις επιτρεπόμενες τιμές βάση των νομοθεσιών της Ευρωπαϊκής Ένωσης.

Τα αποτελέσματα του ερευνητικού προγράμματος είναι εξαιρετικά ενθαρρυντικά. Τα δεδομένα τηλεπισκόπησης μπορούν να αποδώσουν σε μεγάλο βαθμό τα επίγεια δεδομένα σωματιδιακής ρύπανσης αφού συμπεριληφθούν και τα συμπληρωματικά μετεωρολογικά δεδομένα της υπό

μελέτη κάθε φορά περιοχής. Η επίγεια χρήση των ηλιακών φωτόμετρων σε συνδυασμό με τα όργανα μέτρησης συγκέντρωσης των αιωρούμενων σωματιδίων και τα δορυφορικά δεδομένα για τις τέσσερις πόλεις της Κύπρου, έδωσαν ένα ξεκάθαρο αποτέλεσμα σε ποιες περιοχές μπορεί να γίνει χρήση των δορυφορικών δεδομένων για την εξαγωγή των επίγειων συγκεντρώσεων των αιωρούμενων σωματιδίων. Έτσι οι μετρήσεις ήταν ικανοποιητικές για την περιοχή της Λευκωσίας και της Λεμεσού με δεδομένο ότι η Λεμεσός αποτελεί τη βασική περιοχή μελέτης και ο όγκος των δεδομένων καθώς και τα όργανα μετρήσεων που χρησιμοποιούνται μπορούν να προσδώσουν μεγαλύτερη χρονική ακρίβεια καθώς και την κατακόρυφη δομή της ατμόσφαιρας η οποία με τη σειρά της μπορεί να δώσει στοιχεία για την περιοχή προέλευσης των ρύπων. Επομένως μεγάλος όγκος μετρήσεων πραγματοποιήθηκαν για την κύρια περιοχή μελέτης καθώς και για την περιοχή της Λευκωσίας σε διαφορετικές μετεωρολογικές συνθήκες κάτι που επιτρέπει την καλύτερη κατάταξη των διαφόρων πιθανόν περιπτώσεων. Οι μετρήσεις αυτές θα συνεχιστούν και τον επόμενο χρόνο προκειμένου να γίνει επιβεβαίωση των μέχρι τώρα αποτελεσμάτων και να αυξηθεί η ακρίβεια των δεδομένων.

Ένα επιπρόσθετο αποτέλεσμα του έργου είναι η καλύτερη κατάταξη βάση των διαφορετικών μετεωρολογικών συνθηκών για τη Λευκωσία και τη Λεμεσό, και μια πιο λεπτομερής μελέτη για την περιοχή της Λεμεσού με τη χρήση των δεδομένων τηλεπισκόπησης από το ηλιακό φωτόμετρο CIMEL (AERONET), όπου με τη βοήθεια των δεδομένων των μικροφυσικών και οπτικών ιδιοτήτων των αερολυμάτων θα είναι εφικτή η καλύτερη κατανομή τους και κατά συνέπεια η εξαγωγή ενός ακριβή αλγορίθμου που θα συνδέει το δορυφορικά εξαγόμενο AOT και τα επίγεια δεδομένα PM. Τέλος, η ανάπτυξη και η αξιολόγηση του στατιστικού και χημικού μοντέλου για την εκτίμηση των συγκεντρώσεων των αερολυμάτων στην Κύπρο, που έγιναν με την χρήση των μετρήσεων που πραγματοποιήθηκαν από τους δειγματολήπτες κατασκευής του Harvard καθώς επίσης και με τα όργανα Dust track του ΤΕΠΑΚ, παρουσιάζουν πολύ ελπιδοφόρα αποτελέσματα σχετικά με την πρόβλεψη των συγκεντρώσεων των αερολυμάτων στην Κύπρο. Η προτεινόμενη μεθοδολογία της συνδυαστικής χρήσης των δορυφορικών και επιτόπιων μετρήσεων των αερολυμάτων εφαρμόστηκε με επιτυχία για την περιοχή της Λεμεσού και αξιολογήθηκε για τις περιοχές της Λάρνακας και της Λευκωσίας.

A.3. PROJECT IMPLEMENTATION (up to 1500 words per WP)

Work Package Title	WP1: Project Management				
Partner Code	HO	PA1	PA2	PA3	PA4
Personmonths per Partner (according to the Contract)	1,8	1	0,1	0,5	0,2
Personmonths Worked per Partner	1,8	1	0,1	0,5	0,2

Work Package Objectives (as described in Annex I of the Contract)

Briefly describe the **objectives** of this Work Package.

WP1 is committed to the co-ordination of all activities that related the management of the project. Indeed, such activities include the following: (a) project progress, (b) technical aspects management, (c) the establishment of communication between the project partners and with the Research Promotion Foundation (RPF), (d) the quality assessment of research results and project reports or deliverables, (e) and the preparation of all related legal documents, contracts and project's activity reports.

Work Description

Describe the Project Management **activities**, any problems that were encountered in managing the Network and how these were resolved.

The project coordinator, Assoc. Prof. Diofantos Hadjimitsis was leading the activities of the MC. The HO delivered the supervision of all project works and activities, clarification of needs, the publicity of all exported information and the implementation of research works. The HO was responsible for the technical and scientific overview of the project as a whole. Continuous communication between the consortium partner institutions have been an important factor in the project success. Robust and productive communication established through all the stages the projects. Three meetings where all project partners have been participated for detailed project review and evaluation, as well as preview and planning of project activities. These meetings included the kick-off meeting at the beginning of the project, a meeting halfway through the project and a project closing meeting. All the activities included in this WP given in the follow, have been delivered successfully.

1. Supervision of the project works
2. Requirements and priorities definition of the project.
3. Information and publicity.
4. Coordination of the level of project implementation
5. Writing of operation report within the project period.

Deliverables

Describe the Deliverables emerging from this **Work Package**. All **Progress Reports** (Six month, Interim and Final Progress Reports) submitted to RPF during project implementation should be included as Deliverables of Work Package 1.

D1: 6 month progress report delivered to RPF in order to be informed for the first 6 months of the project.

D2: 12 month progress report delivered to RPF in order to be informed for the first year of the project.

D3: 18 month progress report delivered to RPF in order to be informed for the 18 progress of the project.
D1, D2 and D3 include all Foundation's remarks of the reports and all potential checks that have been held.
D4: The present report is the Final progress report of the project (24 months) to be delivered to RPF. It also include :
1. The correspondence hard-copy or in electronic forms that applies to the project management during all its phases.
2. The project management document, including all appropriate tables and timetables for the the project implementation.
3. Agenda and minutes for the 3 meetings held (at the beginning, halfway through, closing).

Work Package Title	WP2: Dissemination and Exploitation of Results				
Partner Code	HO	PA1	PA2	PA3	PA4
Personmonths per Partner (according to the Contract)	1,2	1,2	0	0,5	0,2
Person months Worked per Partner	1,2	1,2	0	0,5	0,2

Work Package Objectives (as described in Annex I of the Contract)

Briefly describe the **objectives** of this Work Package.

The aim of the project's bunch was the editing of an informative issue regarding the diffusion and exploitation activities of the research's results. In this phase all the actions are aiming at informing all the involved factors in Cyprus are included, as well as the whole scientific society in national and international level, concerning the program, its aims, its progress and its results.

Work Description – Degree of Work Package Objectives Implementation

Describe the implementation of **activities** regarding dissemination and exploitation of results (**quantitative** information should be provided where applicable), the PA responsible for each activity, any problems that were encountered and how they were resolved, as well as any deviations from the initial objectives.

From the beginning of the project, the Dissemination and Exploitation Committee (DEC) have been formed. The DEC was responsible for the Quality Control and Quality Assurance of the project. The DEC had included one member from each participating organization with long publishing record in international journals and conferences. The main activities of this WP (which is lead by HO) consist of the activities of the DEC which are:

1. Meetings of the working teams.
2. Editing material which would describe the program and its results.
3. Submission for publication of project results at 2 international journals (e.g. Atmospheric Research Journal, International Journal of Remote Sensing, Remote Sensing of Environment, EGU, etc).
4. Presentation of project results at 3 International Conferences (e.g. SPIE, ISPRS, Air Quality – Science and Application International Conference, EGU, etc). HO will present project results to one International Conference (2 publications/2persons), PA1 (1 publication/1person) and PA4 (1 publication/1person).
5. Organisation of a workshop at national level for promoting the project results.
6. Development of a simple/static website for the presentation of project results.
7. Development of a simple brochure / leaflet in order to present the results of the project.

All the dissemination activities have been delivered without any problem.

Παραδοτέα
Deliverables

Describe the Deliverables emerging from **Work Package 2** including publications in peer-reviewed journals, organisation of local info days for the dissemination of Project results, participation in conferences abroad, patent applications, etc.

D5: Presentation of project results to the SPIE International conference at Prague on September 2011 from HO/ Presentation of project results to the SPIE International conference at Prague on September 2011 from HO. Additionally, HO present the project results to the IGAC 2012 conference at China, Beijing and to the ACTRIS General meeting at Lecce Italy, on September 2013.

D6: Presentation of project results to EGU General Assembly 2012 International Conference by

PA1
D7: Presentation of project results to 3rd International Conference by PA4 (e.g. SPIE, ISPRS, Air Quality – Science and Application International Conference, EGU, CEST, etc). The participation at an international conference of the PA4 partner was not feasible during the 2 years period of the project. Thus, the PA4 partners' studies were presented by HO scientific team at the SPIE 2011 conference.
D8: Publication of project results at Journal of Applied Remote Sensing.
D9: Submission for publication of project results at chapter in book named as: Remote Sensing for Environmental Surveillance.
D10: Workshop at national level for promoting project results. The Workshop has been halted at the Crowne plaza Limassol Hotel on 28 January 2013.
D11: Simple website presents the results of the project (http://blogs.cut.ac.cy/airspace/).
D12: Brochure / leaflet for the presentation of the results of the project (is given at the ANNEX B2).
The D5-D12 are given at the ANNEX B2 of the report

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Note: For the description of each additional Work Package the following Table template should be used.

Work Package Title	**WP3: Synergistic use of MODIS, Lidar and sun-photometer data for PM retrievals over Cyprus**				
Partner Code	HO	PA1	PA2	PA3	PA4
Person months per Partner (according to the Contact)	14	2	7,9	2	4,6
Personmonths Worked per Partner	14	2	7,9	2	4,6

Work Package Objectives (as described in Annex I of the Contract)

Briefly describe the **objectives** of this Work Package.

 Compile climatology for aerosol related parameters derived from MODIS sensors for the period 2002-2010.
 Optimise the PM – MODIS AOT statistical models by incorporating vertical AOT Lidar profiles, sun-photometer column integrated AOT and relative humidity measurements.
 Establish prediction of PM values from MODIS AOT data.

Work Description - Degree of Work Package Objectives Implementation

Describe the activities implemented in the frame of this Work Package (**quantitative** information should be provided where applicable), the PA responsible for each activity, any problems that were encountered and how they were resolved, as well as any deviations from the initial objectives.

In the framework of the WP3, the Level 2, 10x10km^2, MOD04 aerosol product (Terra satellite, Collection 051) was retrieved for the period 2001-2011 from NASA's Level 1 and Atmosphere Archive and Distribution System (LAADS). The AOD fields were extracted from the 'Optical_Depth_Land_And_Ocean' parameter which provides the AOD at 550nm derived via the dark-target algorithms and with best quality data. It should be pointed out though that although the initial work plan presented in WP3, the use of parameters related to aerosol size (i.e. Angstrom Exponent) was foreseen, no such climatology was included in the analysis since according to recent findings the Angstrom Exponent does not exhibit significant correlation with ground truth and thus, should not be used for any geophysical application (data usage **ftp://ladsweb.nascom.nasa.gov/allData/5/MOD04_L2/README**). The climatology study was conducted by the Project Parther No2 (National Observatory of Athens). The ten years climatology from MODIS data is given in the D13, at the ANNEX AS.
The second task of the WP3 was the development of a statistical model for the estimation of the PM concentration from AOT measurements using several atmospheric parameters. The first attempt, made use of the satellite AOT measurements from MODIS sensors. As mentioned at the interior progress report, the available MODIS AOT observations for the two years time period of the project (2010-2011) was limited compared to the ground based respective measurements performed by the CUT-TEPAK AERONET sunphotometer. Thus, finally the statistical model have been developed using the AERONET AOT data. A sensitivity study for the differences of the use of the ground based instead the satellite observations have been performed as well, in order to give the uncertainty of the model. The development of the model has been done by the HO team. The description of the statistical model is given in the Deliverable D14 at the ANNEX B2.

Methodology and Results

Describe in detail the methodology used and the results achieved in this Work Package.

Aerosol Climatology

In the present work, the Level 2, 10x10km^2, MOD04 aerosol product (Collection 051) were retrieved for the years 2001 to 2011 from NASA's Level 1 and Atmosphere Archive and Distribution System (LAADS). The AOD fields were extracted from the 'Optical_Depth_Land_And_Ocean' parameter which provides the AOD at 550nm derived via the dark-target algorithms and with best quality data (Remer et al. 2005). According to Remer et al. (2009), the AOD fields for this product have been respectively validated to within the error bounds of (0.04 + 0.05*AOD) and ± (0.05+0.15*AOD) at 550nm.

Based on the above AOD data, subsets for the area of Cyprus were extracted and mean monthly climatology maps were constructed for the period 2001-2011. For the area considered, the number of days with valid TERRA AOD measurements ranged approximately from 1000 to 2300 (which amount to 25%-57% time coverage) as shown in Figure 1. The highest number of valid measurements was observed over the central area of Cyprus (in the vicinity of Troodos Mountain) whereas near the coastline, this number decreased.

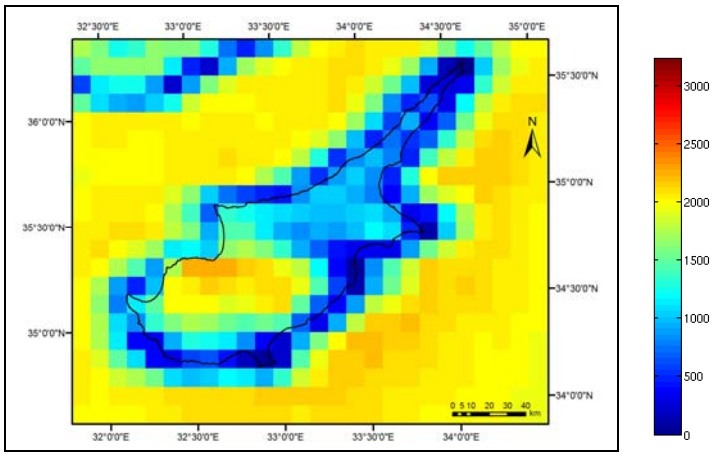


Figure 1: Number of valid TERAA AOD observations for the period 2001-2011

The maps for each month are presented in Figure 2. The seasonal cycle of the aerosol load is well depicted. Minima are observed during winter months and maxima during spring and summer when intense phenomena associated with dust transport from Sahara desert are encountered. Additionally, the respective monthly average values for the three urban sites of Nicosia, Larnaca, and Limassol (marked respectively as LE, LA and LM on the maps) and the background site of Ag. Marina, (marked as AM) have been calculated. In general, the background site is characterised by much lower aerosol loads throughout the year (ranging from 0.1 to 0.28) whereas the load for the urban sites is significant higher. Limassol (the main port city of the island) presents the highest values for the period January-May and Nicosia (the capital city) from June to December. For this latter period, Larnaca presents intermediate values. The two distinct maxima associated with dust transport phenomena are observed for all sites in May and August. The value for the first peak in May is approximately the same for all urban sites (~0.40) but for August, the AOD levels for Nicosia are higher (~0.45) compared to the other two urban sites (~0.35 for Larnaca and Limassol).

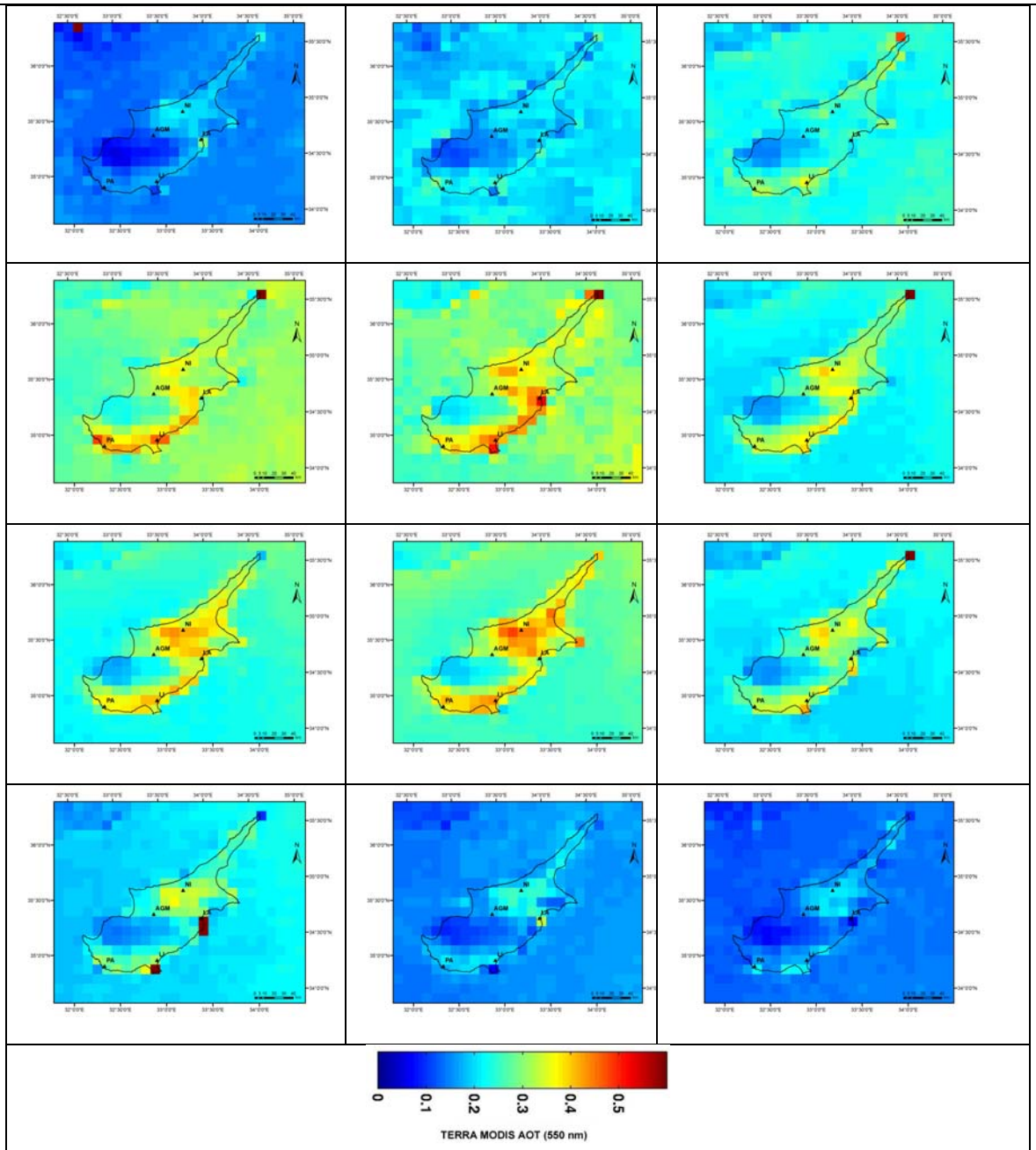


Figure 2: Monthly climatology maps for the area of Cyprus for the period 2001-2011. (LE, LA, LM, and AM mark the sites of Nicosia, Larnaca, Limassol and Ag. Marina)

The AOT climatology from the 10 years satellite observations of the MODIS sensors is presented at the D13 given at the ANNEX B2.

Aerosol Statistical Model

Based on the aerosol related dataset collected within the AIRSPACE project, a statistical model was performed for the estimation of the PM concentrations from AOT measurements. Using a general linear regression model, the ability of the AOT retrieved by the MODIS was used to predict ground-level PM_{10} concentrations in Limassol, Cyprus.

The proposed model by Yang L. et al. (2006) was defined as:

$Ln(PM_{10}) = \beta0 + \beta1\ (logAOT)+\beta2(logAng) +\beta3(WVdep)+ \beta4\ ln(T)+ \beta5\ ln(RH) + \beta6\ ln(WS) + \ldots. + \beta7(P)+ + \beta7(PBL)$

Where βi are the regression coefficients, T is the surface temperature, Wd the wind direction, Ws is the wind speed, PBL is the Planetary boundary layer height, AOT is the aerosol optical thickness and P is the pressure at surface level.

The available data set in AIRSPACE project are given in Table 2 :

Table 1: AIRSPACE dataset used for the statistical model

Aerosol Optical Depth	CIMEL
Angstrom Exponent	CIMEL
Total Column Water Vapour	CIMEL
PM 10	Dust Track TSI
PBL height	LIDAR
Meteorologiacal Data	METAR-LRCA (Akrotiri Air Base, Cyprus)

Based on the proposed methodology, the performance of the multi-regression model was examined by introducing one predictor (Xi) at the time, together with the initial predictor the AOT at 500nm (Xi i=0). For each predictor Xi the following options (j) were considered in order to increase the sensitivity of the model linked Xi :

# option	Type of parameter involved
1	Ln(Xi)
2	Xi
3	Deparcures from mean value of Xi
4	Ratio of mean value of Xi

For the above options (j=1 to 4), the one with the highest correlation coefficient (CCij) between predicted and measured PM_{10} was selected. In each iteration step k, the maximum values of the CCij = CCik were compared in order to select the predictor Xik with the highest positive impact. Due to the limited dataset, no evident seasonal dependence was found.

The results of the above sensitivity analysis are presented below. In Figure 3 the correlation coefficient between the predicted and measured PM_{10} is presented for 8 different models. It was observed that the maximum performance (CC=0.85) of the model was established when taking into account the following predictors (in strength order)

Table 2: Best correlation coefficients and regression coefficients derived

	CC= 0.853 βi	CC=0.850 βi
Constant Term	-4.11730E+00	-4.11142E+00
Ln(aod)	9.51612E-01	9.39917E-01
Ln(Angstrom)	2.98925E-01	2.99999E-01
Wavapour-mean(Wavapour)	-3.92571E-01	-3.83879E-01
Ln(Temp)	6.35723E-01	6.25974E-01
Humidity	7.90999E-03	8.31437E-03
Ln(Wind)	-9.66157E-02	-7.10540E-02
WindDir		-4.41082E-04

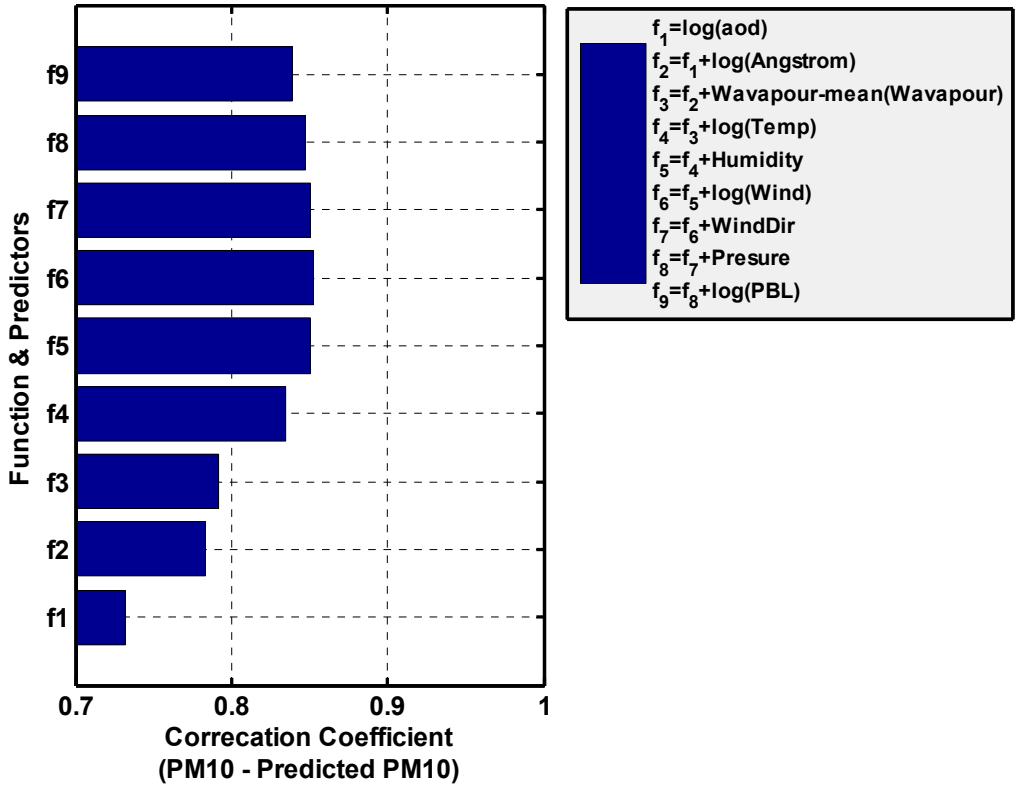


Figure 3: Correlation coefficient between the predicted and measured PM_{10} is presented for 8 different models.

The results of the above sensitivity analysis indicate the maximum performance of the model of the order of CC=0.85 for the following formula:

$$\ln(PM_{10}) = -4.11+0.939(\log AOT)+0.299(\log Ang)-0.384(WVdep)+0.626\ln(T)+0.0083RH-0.071\ln(W_S)$$

Finally, using formula 6 as the best model and the coefficients derived and shown in table 1 the correlation between the model prediction and the measured PM_{10} concentrations are given in **Figure 4**.

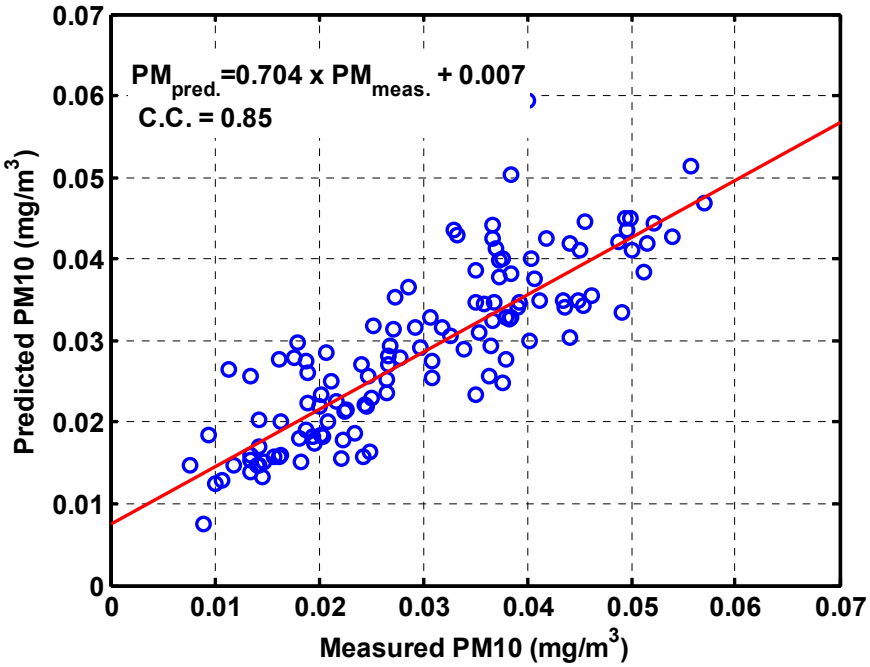


Figure 4: Comparison between predicted and measured PM_{10} at Limassol (Red line : linear fit)

Moreover, the extended description of the methodology and the development of the statistical model for the estimation of the PM levels from the AOT measurements is given at the D14 at the ANNEX B2.

Deliverables

Describe the Deliverables emerging from this Work Package.

D13: Climatology maps for aerosol related parameters retrieved from MODIS sensors covering the period 2002-2010. **The report is given in the ANNEX B2**
D14: Report on the methodology for PM retrievals over Cyprus from statistical models using MODIS AOT, Lidar data and RH measurements. **The report is given in the ANNEX B2**

Work Package Title	WP4:Ground measurements of AOT				
Partner Code	HO	PA1	PA2	PA3	PA4
Personmonths per Partner (according to the Contact)	13	1.3	2	3,5	1
Personmonths Worked per Partner	13	1.3	2	3,5	1

Work Package Objectives (as described in Annex I of the Contract)
The objectives of this WP are the following:
During the satellite overpass the following will be measured for an urban and industrial area in Limassol:
 To measure the AOT from the CIMEL sun-photometer and the Microtops II hand-heldsun photometers and create long-term database.
 To measure the PM_{10} & $PM_{2.5}$ using air pollution sampler
 To define the vertical distribution of aerosols using Lidar measurements and create long-termdatabase.
 To measure the spectral signatures of several pseudo-invariant targets in order to calibrate the retrieved AOT values from the implementation of an atmospheric correction algorithm.

Briefly describe the **objectives** of this Work Package.

- Ground based measurements of the AOT from the CIMEL sun-photometer and the Microtops II hand-held sun photometers for the creation of a long-term database. In situ ground based PM measurements using air pollution samplers.
- Lidar measurements for the determination of the vertical aerosol structure over Limassol Cyprus.
- In situ spectroradiometer measurements for the calibration of the retrieved AOT values.

Work Description - Degree of Work Package Objectives Implementation

Describe the activities implemented in the frame of this Work Package (**quantitative** information should be provided where applicable), the PA responsible for each activity, any problems that were encountered and how they were resolved, as well as any deviations from the initial objectives.

For the purposes of the project, Limassol was selected as the main ground based site for the development and the application of the AIRSPACE methodology. The main instrumentation used for the aerosol observation in a daily base was a backscatter-depolarization LIDAR system for the study of the vertical aerosol distribution as well as the sunphotometer for the columnar aerosol information, both located at the premises of CUT, in Limassol, Cyprus (34.675ºN, 33.043ºE, 10m above sea level) since 2010. The LIDAR records daily measurements between 08:00 UTC and 09:00 UTC (consistent with the MODIS overpass) and to perform continuous measurements for the retrieval of the aerosol optical properties such as depolarization ratio and backscatter coefficient over Limassol, inside the PBL and the lower free troposphere. Additionally, the AERONET sunphotometer provides daily aerosol information including AOT and size distribution. The used within AIRSPACE project instrumentation is given in the follow.

CIMEL Sunphotometer

The sunphotometer observations used in this study were performed by a CIMEL sun-sky radiometer, which is part of the AERONET Global Network (http://aeronet.gsfc.nasa.gov). The CIMEL sunphotometer allows for measurements of direct solar irradiance and sky radiance at 8 wavelengths; 340, 380, 440, 500, 670, 870, 1020 and 1640 nm. The technical specifications of

the instrument are given in detail by Holben et al. (1998).

The instrument is located on the roof of the building of the Department of Civil Engineering and Geomatics of Cyprus University of Technology (CUT) (34.675ºN, 33.043ºE elevation: 10 m). The CUT_TEPAK AERONET station is located in the center of Limassol, 500m away from the sea. The sunphotometric station has been in operation since April 2010. Figure 5 features the CUT-TEPAK AERONET Cimel sun-photometer.

Figure 5: CUT-TEPAK AERONET station

CUT LIDAR System

For the vertical distribution of aerosols, the LIDAR system located at CUT, in Limassol, Cyprus (34.675ºN, 33.043ºE, 10m above sea level) was used. The LIDAR records daily measurements between 08:00 UTC and 09:00 UTC (consistent with MODIS overpass) and provides continuous measurements for the retrieval of the aerosol optical properties over Limassol, Cyprus inside the Planetary Boundary Layer (PBL) and the lower free troposphere, thus providing information for the load, the size and the sphericity of the aerosols.

The LIDAR transmits laser pulses at 532 and 1064 nm simultaneously and collinear with a repetition rate of 20 Hz. This system is based on a small, rugged, flashlamp-pumped Nd-YAG laser with pulse energies around 25 and 56 mJ at 1064 and 532 nm, respectively. An achromatic beam expander reduces the divergence to less than 0.15 mrad. Elastically backscatter signals at two wavelengths (532nm, 1064nm) are collected with a Newtonian telescope with primary mirror diameter of 200 mm and an overall focal length of 1000 mm. The field of view (FOV) of the telescope is 2 mrad. The mirror and cover plate coatings are optimized for the wavelength range from 532 nm to 1064 nm. A plain cover plate protects the mirrors. Behind the field stop two plano-convex with a focal length of 80 mm output parallel rays. The LIDAR covers the whole range starting at the full overlap of the LIDAR (~300 m) up to tropopause level. Three channels are detected, one for the wavelength 1064 nm and two for 532 nm. The two polarization components at 532nm are separated in the receiver by means of polarizing beamsplitter cubes (PBC). A special optomechanical design allows the manual ±45°-rotation of the whole depolarization detector module with respect to the laser polarization for evaluating the depolarization calibration constant of the system. The CUT depolarization LIDAR operates at 532nm and it is possible to rotate the detection box including the polarization beam-splitter cube in order to calibrate the instrument (Freudenthaler et al., 2009). Firstly, the backscattered LIDAR signals (P and S) were recorded using the normal orientation of the LIDAR detection box. For the next two steps, the LIDAR detection box is rotated by ±45º, and the P and S signals are recorded. The operation principal of this method is based on the fact that same amount of energy is sent to P and S channels, at “opposite” directions (Freudenthaler et al., 2009). Photomultiplier tubes (PMTs) are used as detectors at all wavelengths except for the signals at 1064 nm (avalanche photodiode, APD). A transient recorder that combines a powerful A/D converter (12 bit at 20 MHz) with a 250 MHz fast photon counting system (Licel, Berlin) is used for the detection of 532 nm radiation, while only analog detection is used at 1064nm. The raw

signal spatial resolution is 7.5 meters. The CUT LIDAR system is featured in Figure 2.

Figure 2: CUT's Depolarization Lidar System

MICROTOPS Sunphotometer

For the study sites where CIMEL's data were not available, such as Nicosia, Larnaca and Paphos, a handheld MICROTOPS II sunphotometer was used to retrieve AOT measurements. The MICROTOPS II sun-photometer is equipped with five accurately aligned optical collimators and internal baffles to eliminate internal reflections. It provides AOT and water vapor retrievals at five channels, which are determined using the Bouguer-Lambert-Beer law. In order to achieve measurements with great accuracy, the sunphotometer was mounted on a tripod at the same location each time. To avoid cloud contamination, measurements were taken during cloud-free daylight hours. Figure 3 shows the MICROTOPS II handheld sunphotometer used.

Figure 3: MICROTOPS II handheld sunphotometer

Surface Monitoring

PM10 concentration monitoring

For the surface monitoring of the particulate matter (PM) concentrations, DustTrak (TSI, Model 8533) (Chan et al., 2002) was used at all selected sites. The DustTrak was selected to provide weekly monitoring of PM10 concentrations during morning hours from 08:00 to 13:00 UTC and records the PM temporal variability within a satisfactory time resolution. The instrument is located, on the roof of the Cyprus International Institute (CII) in Limassol, at 10 m above ground

level in order to avoid the measurements being affected by localized pollution such as passing cars. DustTrak's nominal flow rate is 1.7 l/min and is obtained by an internal pump integral to the sampler. The monitor is factory calibrated for the respirable fraction of standard ISO12103-1, A1 test dust (Arizona Test Dust), which is representative of a wide variety of aerosols. The instrument measures concentrations in the range of 0.001– 100 mg/m3, with a resolution of 0.1% of the reading or 0.001 mg/m3. Before each measurement, the instrument is zeroed and its flow rate is checked. PM10 concentrations have been recorded continuously since March 2011. Additionally, PM10 concentrations were also recorded by DustTrak (TSI, Model 8520) at Nicosia, Larnaca and Paphos. One TSI DustTrack has been operated by Frederick University since July 2011 and is located at the top of the Frederick University library building in Nicosia, at 10 m above ground level while the second DustTrack has been operated by CUT's scientific Team during 15-day campaigns at Larnaca and Paphos. All sampling points were selected to ensure exposure to wind and to be free of other obstacles. Figure 6 features the TSI Dust track used for monitoring of the PM at 10m above ground level. The device was programmed to begin PM10 recordings every morning at 08:00am UTC for a 5-hour period, to coincide with the satellite MODIS Terra and Aqua overpass (06:00-11:00 UTC), except at weekends.

Figure 6: TSI DUST-Track

PM10 sampling and elemental composition determinations

Under the AIRSPACE project, the Harvard School of Public Health (HSPH) and Cyprus International Institute for Environmental and Public Health (CII) were responsible for providing comprehensive and reliable data on the air pollution throughout Cyprus based on ground level measurements.

Air pollution near ground level measurement sites were established in the four cities of Cyprus: Nicosia, Larnaca, Limassol and Paphos. These sites were located at positions thought to be representative of air pollution in each city. In Nicosia, the site is located on the roof of the Frederick University library building, on the same site where the DustTrak and sunphotometer were operated. The Larnaca site is located in the center of the city, on the roof of the tax agency building. The Limassol site is located on the roof of the CII building in the center of the city and Paphos site is on the roof of the economics department of Paphos Municipality. In Figure 7 the setup of the Harvard samplers is presented.

The sampling commended on 12 January 2012 and ended on 12 January 2013. Samples were collected every six days, on 24-hr basis from 10:00 am to 10:00 am next day, at all sites except Limassol, where the sample collection was done every three days, since Limassol was the main location of the project. Samples were collected for PM2.5, PM10, EC-OC (elemental & organic carbon) and Nitrates using the Harvard Impactors. For quality assurance and control, collocated and blank samples were collected for each sample at the Limassol site, according to schedule. Standard Operating Procedure (SOP) was followed for each measurement at each site. Filters were collected and send to HSPH for chemical analysis. The measuring parameters include: fine

particles (PM2.5): mass, reflectance, nitrate, trace elements and EC-OC; and inhalable particle (PM10) mass, reflectance and trace elements. Chemical analysis included methods such as Thermal Optical Reflectance (TOR) to measure elemental and organic particle concentration, gravimetric mass determination and X-Ray fluorescence to determine trace elemental composition of PM2.5 and PM10. Samples up to 19 June 2012 have been analyzed; the remaining samples are under chemical process for analysis.

Figure 7: Harvard Samplers

Satellite observations

The Moderate Resolution Imaging Spectro-Radiometer (MODIS) observations from the TERRA and AQUA satellites both measuring spectral radiance in 36 channels (412–14200 nm), in with resolutions between 250 m and 1 km (at nadir) were used to provide a climatology for Cyprus. In polar orbit, approximately 700 km above the Earth, MODIS views a swath of approximately 2300 km resulting in near daily global coverage of Earth's land/ocean/atmosphere system. The swath is broken into 5-min ''granules'', each approximately 2,030 km long. Aerosol products are reported at 10 km resolution (at nadir). Details of file specification of MODIS L2 aerosol products can be found at the website http://modis.gsfc.nasa.gov/.

Additionally, Nicosia was selected as a validation site (in addition to the Limassol main site), for ground based measurements of PM_{10} and AOT. Two locations in Nicosia were used as test sites: Strovolos municipality building (N35.144°, 33.343° E) during the period September 2011 to December 2011 and Pallouriotissa Frederick University Research Centre building (N35.181°, 33.379° E) during the period February 2012 to June 2012 and the period October 2012 to January 2012. The Strovolos area is mainly commercial with heavy traffic at peak hours while the Pallouriotissa site is residential.

Finally for Larnaka, two sets of measurements took place: One using the Dust Track along with the Sun photometer for a period of three weeks in August of 2011 (8-26th) on a site at the centre of Larnaka city (N34.916°, 33.630° E) following the same protocol as before: PM_{10} recordings every morning at 08:00am UTC for a 5-hour period and subsequent measurements using the MICROTOPS sun photometer. Another set of measurements were provided by the Harvard Impactor station situated on top of the tax agency building (N34.919°, 33.631° E) in Larnaka. The said station provided measurements of PM_{10}, $PM_{2.5}$, EC-OC and nitrate concentrations.

Figure 6: Overview of the available instrumentations at the selected sites within AIRSPACE project. Limassol was the main site (LIDAR, AERONET, PM), Nicosia validation site (MicrotopsII, PM); 15 days campaigns were conducted at Larnaca and Paphos.

Figure 7: Satellite image of Limassol

The collection and the processing of the passive and active remote sensing measurements was performed by the new researchers of the Host Organization. The measurements at Nicosia have been performed by the Frederick University. Finally the in situ air pollution samplers have been contacted by the Harvard University.

Methodology and Results

Describe in detail the methodology used and the results achieved in this Work Package.

In the AIRSPACE project, both ground based and satellite observations were used to provide aerosol related information for South Eastern Mediterranean region. The first goal of AIRSPACE project was the validation of the satellite observation in Cyprus, an area affected by aerosol from different sources and surrounding by sea. The ground based observations performed over Limassol and Nicosia were used as the main sites for the validation of the satellite observations.

The in-situ data were collected in conjunction with satellite data (MODIS) to validate a novel statistical model developed within AIRSPACE using AOT retrievals to estimate air particulate pollution. All the collected data have been analysed by the HO team and used for the studies performed at D13 and D14, given at the ANNEX B2.

Παραδοτέα
Deliverables

Describe the Deliverables emerging from this Work Package.

D15: Database of ground-based measurements. **The database will be uploaded to the CUT server and will be available in the website of the project.**

Work Package Title	WP5:Forecast of aerosols				
Partner Code	HO	PA1	PA2	PA3	PA4
Personmonths per Partner (according to the Contact)	2	6	2	1	1
Personmonths Worked per Partner	2	6	2	1	1

Work Package Objectives (as described in Annex I of the Contract)

Briefly describe the **objectives** of this Work Package.

This WP aims to predict, in a 72-hour base, the weather and the air quality over Cyprus, and document the forecasting data in an attempt to compare them with ground-base measurements. The main objective is to identify the model misbehaviour and the systematic trends of the forecasts.

Work Description - Degree of Work Package Objectives Implementation

Describe the activities implemented in the frame of this Work Package (**quantitative** information should be provided where applicable), the PA responsible for each activity, any problems that were encountered and how they were resolved, as well as any deviations from the initial objectives.

Cyprus Meteorology Service was the responsible for the developments and the run of the chemical model for the PM forecast over Cyprus. The performance of the model has been checked using the ground based measurements performed within AIRSPACE project from the HO. The description of the model and the performance during a dust event are given at the D15. Additionally, the model limitations are summarized at the D16. Both deliverables are given at the ANNEX B2.

Methodology and Results

Describe in detail the methodology used and the results achieved in this Work Package.

Chemical Model

A high resolution atmospheric Chemistry General Circulation Model (AC-GCM) is used to study the emission, transport and deposition of dust in Cyprus, during a dust event over Eastern Mediterranean. The Modular Earth Sub-model System (MESSy version 2.41) is an earth system model, which is capable of running with multiple representations of processes simultaneously coupled to the core atmospheric general circulation model (ECHAM5). The model configuration used in the present study has a spectral resolution of T255L31 (0.5°, 50Km) and 31 vertical levels up to 10 hPa. The higher resolution simulations for better dust representation in the model are in great importance. The model output is averaged and stored over 5hr intervals, which provides an entire diurnal cycle after 5 days. The configuration also includes a simplified sulphate chemistry scheme allowing the production of sulphuric acid and particulate sulphate, which play an important role in transforming the dust particles from hydrophobic into hydrophilic, thus affecting their ability to interact with clouds and be removed by precipitation. The ammonia (NH_3) reaction with sulphate and corresponding coating with dust is also considered in this study. Since we concentrate on dust episodes we applied a reduced version of the atmospheric chemistry scheme, which does not account for secondary inorganic and organic aerosol species associated with air pollution. The model was nudged towards ERA40 reanalysis data to represent the actual meteorological conditions, according to a Newtonian relaxation data assimilation method. The model simulation was performed over the period September-October 2011 (with 15 days spin up time). In the following we largely concentrate on a period of reduced

visibility in Cyprus in late September.

Model Evaluation

The model results were evaluated using the AOD provided by the NASA AErosol RObotic NETwork (AERONET) available from http://aeronet.gsfc.nasa.gov. The data comparison represents the AOD for all aerosols simulated in the model as well as observed in the atmosphere at 550nm wavelength. The observed AOD was averaged over the 5hr output intervals as well as the averaged AOD over the same period from the model. Figure 1 shows the eight AERONET stations from which observational data were available during the simulation period and were used in this study. These stations are not necessarily located in dust-dominated regions but can be more strongly affected by other aerosol types, including air pollution.

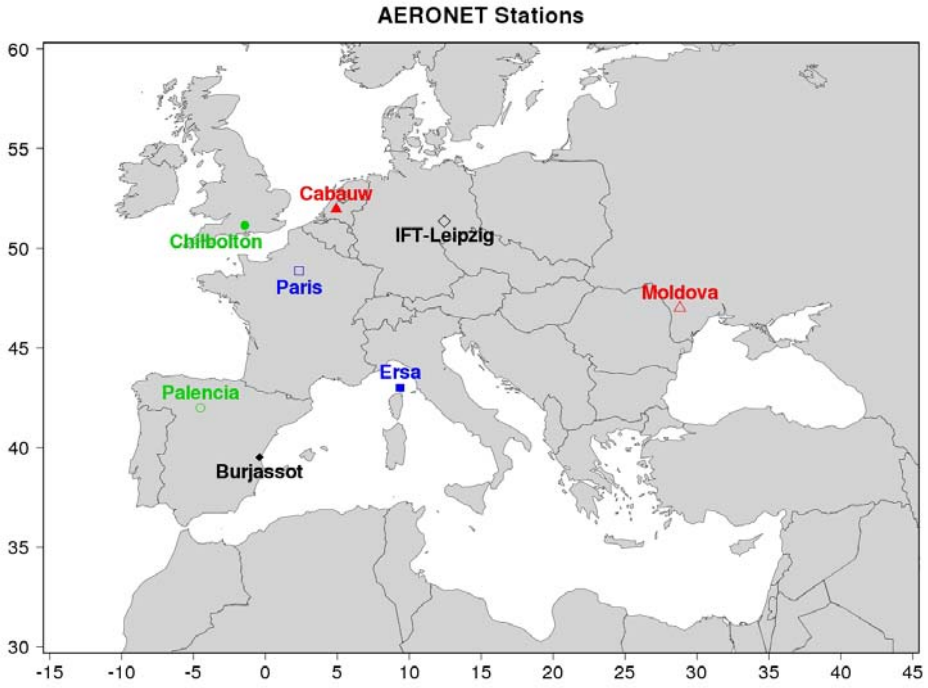


Figure 1. AERONET stations used to evaluate the model results

The scatter plot between the modeled and observed AOD is shown in figure 2. Different colors and symbols are used for each station ID (see legend). As shown in the figure, the model is capable of simulating the AOD in general. However, at some stations (Leipzig, Palencia, Paris) the model tends to underestimate the observed AOD. This is explained by the use of the reduced atmospheric chemistry scheme in the model that does not fully account for urban air pollution in addition to the unresolved physics at small scales in the global models.
Figure shows the time evolution of the AOD for different stations. As shown in the figure, the model is capable of simulating the AOD for all stations.

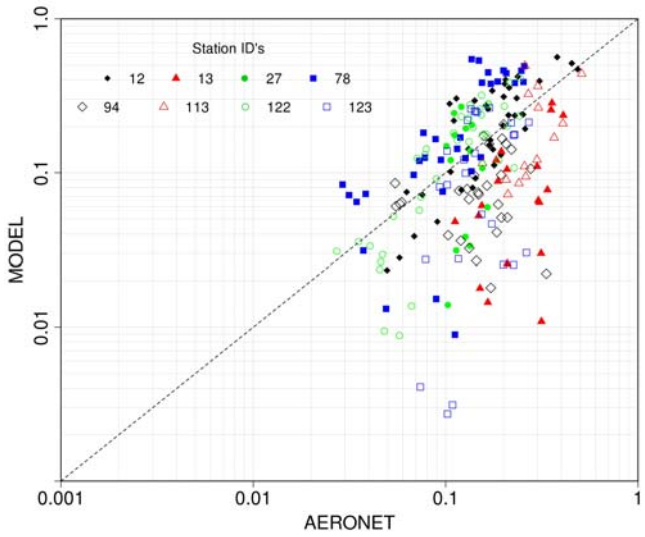
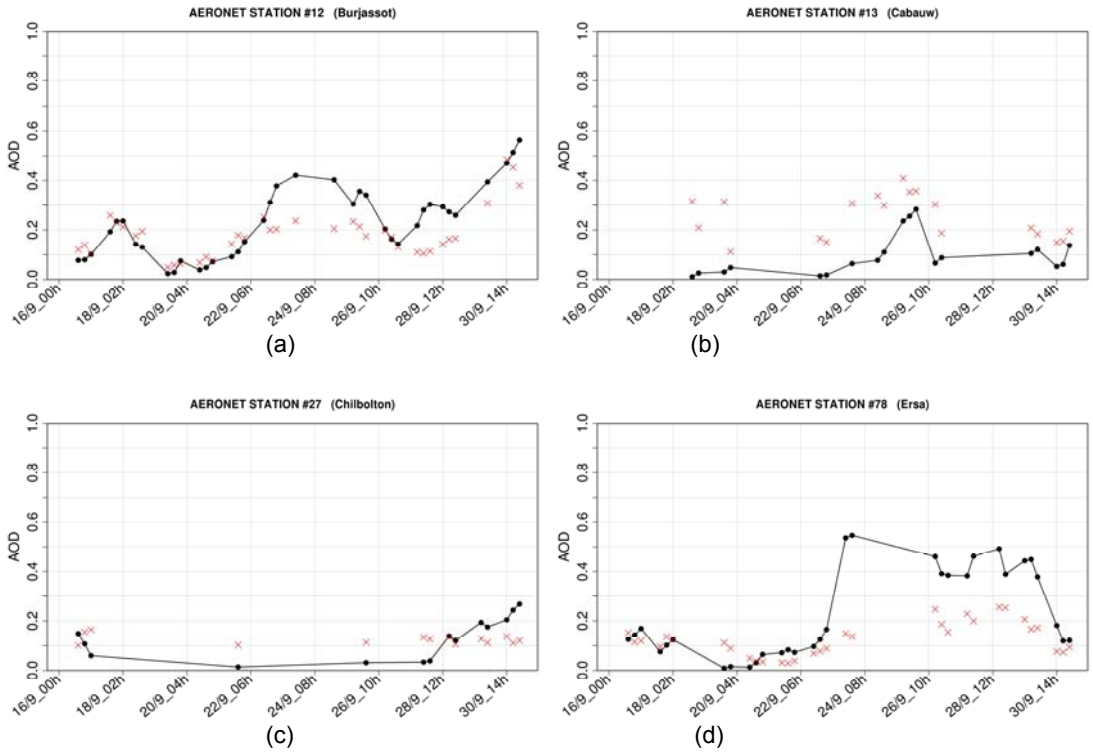


Figure 2. Scatter plot between modeled and observed AOD for different AERONET stations

As shown in figure 3a, the model is performing well at this station besides an overestimation in the period between 22-26th of September. This disagreement may result from local conditions that are not resolved by the model at this resolution. A similar tendency was also noticed at station Ersa (Figure d). The model underestimates AOD over the stations Cabauw and Moldova (Figure b and f). For the rest of the stations the model is in a very good agreement with observations in both magnitude and timing. In summary, the comparison between the modeled and observed AOD indicates the ability of the model to simulate the AOD rather well.



(a) (b)

(c) (d)

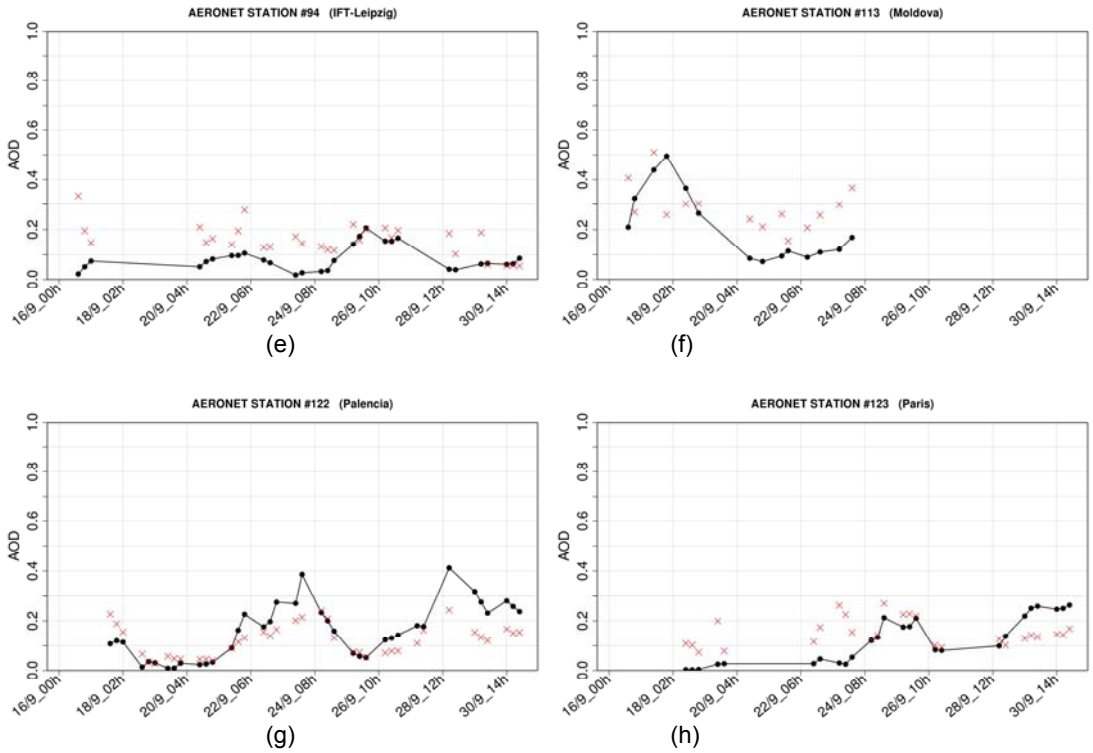


Figure 3. Comparison between the modelled (black) and observed (red) AOD for different stations

Furthermore, model AOT estimations have been compared with the available AOT measurements from CUT-TEPAK AERONET site. Figure 4 shows the time evolution of the AOT for the Limassol AERONET station together with the model results. As shown in Figure , the model is generally, in agreement with observations in both magnitude and timing for Limassol. The comparison between the modeled and observed AOT indicates the ability of the model to simulate the AOT adequately.

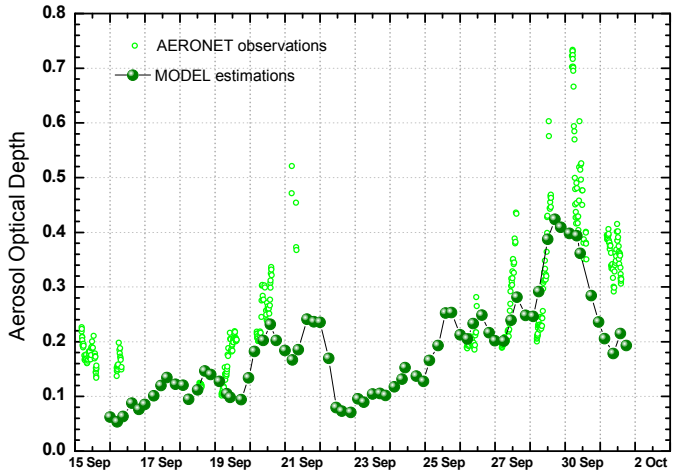


Figure 4: Comparison between the modeled (dark green) and observed (light green) AOT for Limassol AERONET on September 2011

Deliverables
Describe the Deliverables emerging from this Work Package. D16: Report of the forecast data and the comparison with ground measures. **The report is given in the ANNEX B2** D17: Report which identifies the model disadvantages and the projection trends. **The report is given in the ANNEX B2**

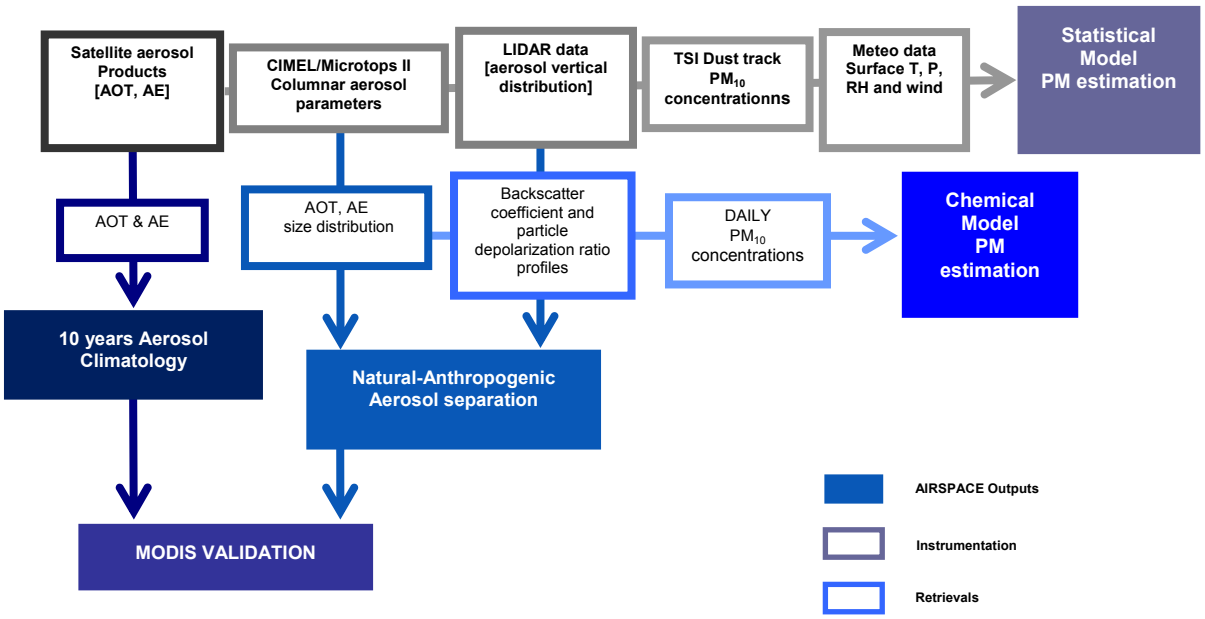
Α.4. ΠΙΝΑΚΑΣ ΔΕΣΜΩΝ ΕΡΓΑΣΙΑΣ / WORK PACKAGES TABLE

Δέσμη Εργασίας Work Package	Τίτλος Δέσμης Εργασίας Work Package Title	Έναρξη (μήνας) Start Month	Ολοκλήρωση (μήνας) End Month	Παραδοτέα Deliverables
WP1	**Project Management**	**1/12/2010 M1**	**30/11/2012 M24**	**D1, D2, D3, D4**
WP2	**Dissemination and Exploitation of Results**	**1/1/2011 M2**	**30/11/2012 M24**	**D5, D6, D7, D8, D9, D10, D11**
WP3	**Synergistic use of MODIS, Lidar and sun-photometer data for PM retrievals over Cyprus**	**1/1/2011 M2**	**30/9/2012 M22**	**D13, D14**
WP4	**Ground measurements of AOT**	**1/2/2011 M3**	**30/9/2012 M22**	**D15**
WP5	**Forecast of aerosols**	**1/9/2011 M10**	**31/7/2012 M20**	**D16, D17**

Α5. ΑΞΙΟΠΟΙΗΣΗ ΑΠΟΤΕΛΕΣΜΑΤΩΝ ΚΑΙ ΠΡΟΣΤΙΘΕΜΕΝΗ ΑΞΙΑ / EXPLOITATION OF RESULTS AND ADDED VALUE

Briefly describe the added value of Project results and ways for their exploitation.

The project has produced innovative significant results at national but also at international level. The dissemination of project results is included in the WP2 activities.
The continuous efforts during the project to inform and present the results to the relevant Organizations and Authorities lead the project researchers to adopt the innovative findings from this research and incorporate them into a new accomplished system. In particular, the dissemination and exploitation of the results consists the following:
1) Research papers have been written for publishing in open access book chapter in the area of remote sensing and air pollution, presenting the results of the project in international level.
2) Presentation of project results at international conferences.
3) Exploitation of the project results through the network of collaborators of the project Partners.
4) Development of a web-portal through which the project results are disseminating.
The project results could be used by government authorities and departments e.g. the Cyprus Meteorological Service and the Cyprus Department of Labour Inspection for monitoring particulate matter over Cyprus and globally using satellite remote sensing which is a more cost and time effective methodology, rather than traditional ground-base monitoring.
Furthermore, the methodology of the integrated use of the ground based and space born as well as of the remote sensing and in situ techniques in combination with the model estimations shows that the detailed height- and spectrally resolved characterization of aerosol mixing and layering is possible. Such detailed aerosol profiling is very useful for climate impact studies and aerosol corrections in the framework of satellite data processing. Vertical mass concentration profiles can be valuable for the validation of Atmospheric models and can be used for the estimation of the contribution of the long range air mass transfer to the air pollution.



AIRSPACE overall Methodology based on the integrated use of satellite and ground based remote sensing techniques

Μ Ε Ρ Ο Σ Β / P A R T B

ΠΑΡΑΡΤΗΜΑ Β1 / ANNEX B1

Επισυνάπτονται οποιεσδήποτε επιπρόσθετες πληροφορίες αναφορικά με το ερευνητικό Έργο, οι οποίες θεωρούνται απαραίτητες.

Please attach any additional information regarding the research Project considered necessary.

ΠΑΡΑΡΤΗΜΑ Β2 / ANNEX B2

Επισυνάπτονται τα Παραδοτέα του Έργου που μπορούν να δοθούν σε έντυπη μορφή σε **ένα μόνο αντίγραφο** (αριθμημένα σύμφωνα με το Συμβόλαιο).

Please attach **one copy** of all Project Deliverables which can be provided in print format (numbered according to the Contract).

<u>Σημείωση</u>: Η συλλογή και επεξεργασία δεδομένων προσωπικού χαρακτήρα που περιέχονται στις Εκθέσεις Προόδου οι οποίες υποβάλλονται στο ΙΠΕ για έλεγχο του οικονομικού & επιστημονικού αντικειμένου του Έργου, γίνεται με εμπιστευτικότητα και σύμφωνα με τον περί Επεξεργασίας Δεδομένων Προσωπικού Χαρακτήρα (Προστασία του Ατόμου) Νόμο του 2001 και τον Κανονισμό του ΙΠΕ σε Σχέση με τη Συλλογή, Επεξεργασία και Χρήση Δεδομένων Προσωπικού Χαρακτήρα, ο οποίος βρίσκεται αναρτημένος στην ιστοσελίδα του Ιδρύματος ().