European Territorial Cooperation Programme
Greece - Italy
2007-2013

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Efficient Irrigation Management Tools for Agricultural Cultivations and Urban Landscapes

# IRMA

# Specialized research actions

# Evaluation of satellite images for evapotranspiration estimation

**WP6, Action 6.3., Deliverable 2**

www.irrigation-management.eu

## IRMA partners

**LP, Lead Partner, TEIEP**

**Technological Educational Institution of Epirus**

http://www.teiep.gr, http://research.teiep.gr

**P2, AEPDE**

**Olympiaki S.A., Development Enterprise of the Region of Western Greece**

http://www.aepde.gr

**P3, INEA / P7, CRea**

**Instituto Nazionale di Economia Agraria**

http://www.inea.it

**P4, ISPA-CNR**

**Consiglio Nazionale delle Ricerche - Istituto di Scienze delle Produzioni Alimentari**

http://www.ispa.cnr.it/

**P5, ROP**

**Regione di Puglia**

http://www.regione.puglia.it

**P6, ROEDM**

**Decentralised Administration of Epirus–Western Macedonia**

http://www.apdhp-dm.gov.gr

**WP6**

# Action 6.3. Evaluation of satellite images for evapotranspiration estimation

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## Deliverable 6.3.2.

## Research and report regarding valuation of satellite images for evapotranspiration estimation

Involved partners:

INEA (P3) / CREA (P7); TEIEP (LP)


TEIEP team:

Dr. Malamos Nicolaos, Mr. Kyrkas Demetrios


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**Efficient Irrigation Management Tools for Agricultural Cultivations and Urban Landscapes (IRMA)**


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# Deliverable description

In the framework of Action 6.3. the following deliverables are included:

| Del. | Title | Partner | Contribution |
|---|---|---|---|
| **6.3.1** | Supply of satellite images and GIS shapfiles | P3 | Supply of satellite images and relevant GIS shapefiles for the regions of Puglia. |
| **6.3.2** | Research and report regarding valuation of satellite images for evapotranspiration estimation | LP | Participation in the research for analysis of satellite images |
| **6.3.3** | Research and report regarding valuation of satellite images for evapotranspiration estimation | P3 | Field measurements for satellite images calibration, data processing and technical analysis, methods on using rs to estimate crop water requirements, evaluation of the new technologies, introduction on irrigation water management. |
| **6.3.4** | Research and report regarding valuation of satellite images for evapotranspiration estimation | P7 | Field measurements for satellite images calibration, data processing and technical analysis, methods on using rs to estimate crop water requirements, evaluation of the new technologies, introduction on irrigation water management. |

TEIEP (LP) participated in the research by providing data for the plain of Arta to INEA (P3) / CREA (P7). These included meteorological and ET information plus spatial information regarding topography, soil type and cultivations.

INEA (P3) / CREA (P7) developed a web geographical information system (web GIS), based on Landsat 8 satellite images, for the estimation of crop water requirements.

The system is available at: http://95.110.192.55/irma/

Deliverables 6.3.3 and 6.3.4 contain the full technical report regarding the development and the evaluation of the system.

# System development and outputs

Earth Observation is a technology mature to be transfer to operational applications in agricultural water management (Vanino, 2015). The application of Remote Sensing (RS) brings a significant contribution to assess the spatial/temporal variation of evapotranspiration over large areas. The main advantages of the RS approaches are:

- the observation can be repeated and constant,
- the availability of updated data and
- the greater overall economies compared to conventional detection methods.

while the main weaknesses are related to:

- the availability of adequate quality image: malfunction of sensors, cloudy cover,
- the necessity of water balance model and
- the necessity of ground based method to verify the results of EO results.

The main goals or this action of IRMA project were:

- to define water needs for agriculture with Earth Observation technologies and limited field measurements and
- to assist stakeholders to manage water in an optimal manner in water scarcity environments.

The system was developed to estimate the evapotranspiration and crop coefficients of crops by using satellite data in combination with agrometeorological data, field measurements and by adopting the FAO-56 approach (Allen et al., 1998).

The satellite data that were used came from:

- Landsat 8 images (medium resolution: 30x30m) and
- Rapid Eye images (high resolution 5x5m)

The daily metereological data that were used are:

- Temperature

- Humidity
- Wind speed
- Precipitation
- Evapotranspiration
- Atmospheric pressure
- Global radiation

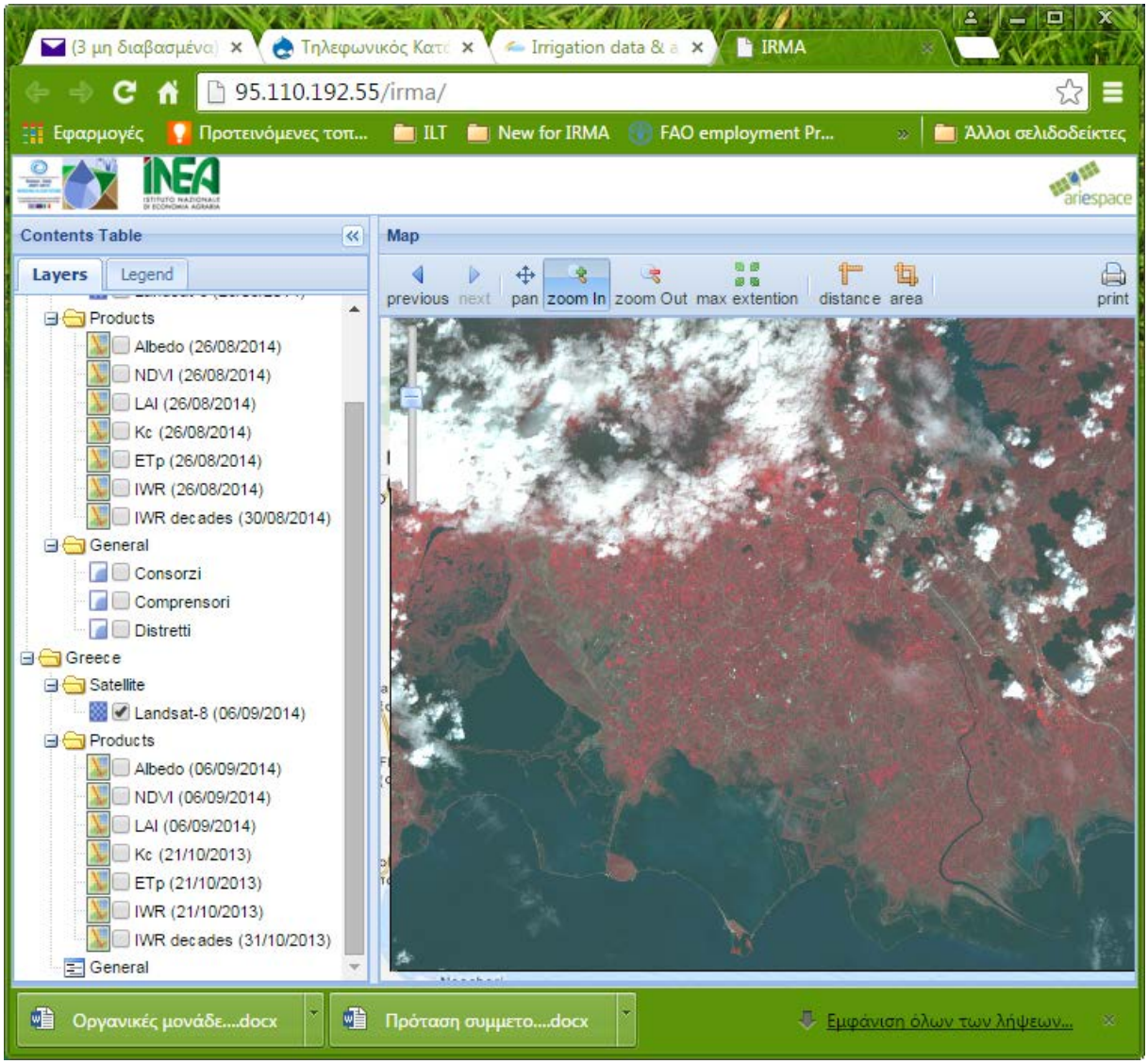
The FAO-56 method calculates the maximum evapotranspiration of $ETp$ of a canopy under standard conditions by using values of canopy variables such as the surface albedo and the Leaf Area Index (LAI). The $ET0$, calculated from the agro meteorological variables by using FAO-56, is used to calculate the value of Kc (according to the analytical method). FAO-56 is applied twice, once with standard values of albedo, LAI and crop height for a reference surface, and once by using the albedo, LAI and crop height from satellite images (D'Urso and Menenti, 1995).

Future scenarios that would capitalize the development of such a system (Vanino, 2015) are:

- Estimate the water volume in agriculture using remote sensing technology is an important tool to monitoring water status within the European union (EU) water framework directive (WFD, 2000)
- «The Global Monitoring for Environment and Security programme (GMES/COPERNICUS) can help Member States to identify irrigated zones that fail to match legal water-use permits» (EU - Water Blueprint, 2015)
- To Consortia level, to identify areas where water use is not authorized it's possible to use satellite images following these actions: a) monitoring irrigated areas with satellite data; b) identify parcels without water request and c) check of parcels identify both on video both in the field.

The system is available at: http://95.110.192.55/irma/

A series of indicative outputs of the system for the pilot area in Greece are presented below. Deliverables 6.3.3 and 6.3.4 contain the full technical report regarding the development and the evaluation of the system.



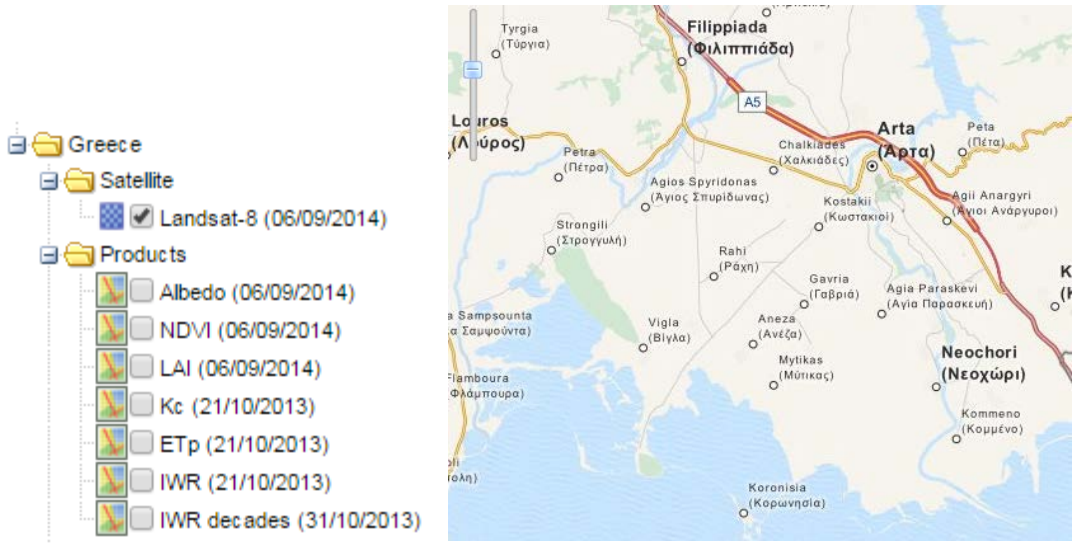




**Fig. 1 Generic screenshot of the web-GIS containing the Landsat image for the plain of Arta and the available layers for Greece**

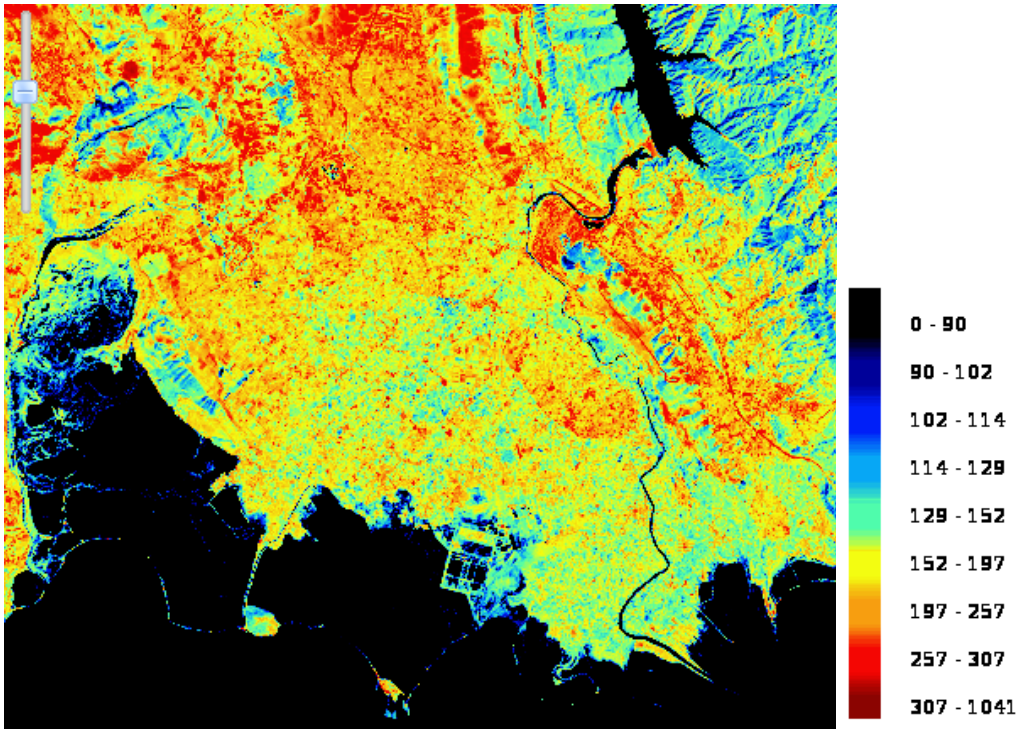



**Fig. 2 Albedo map (6/9/2014)**

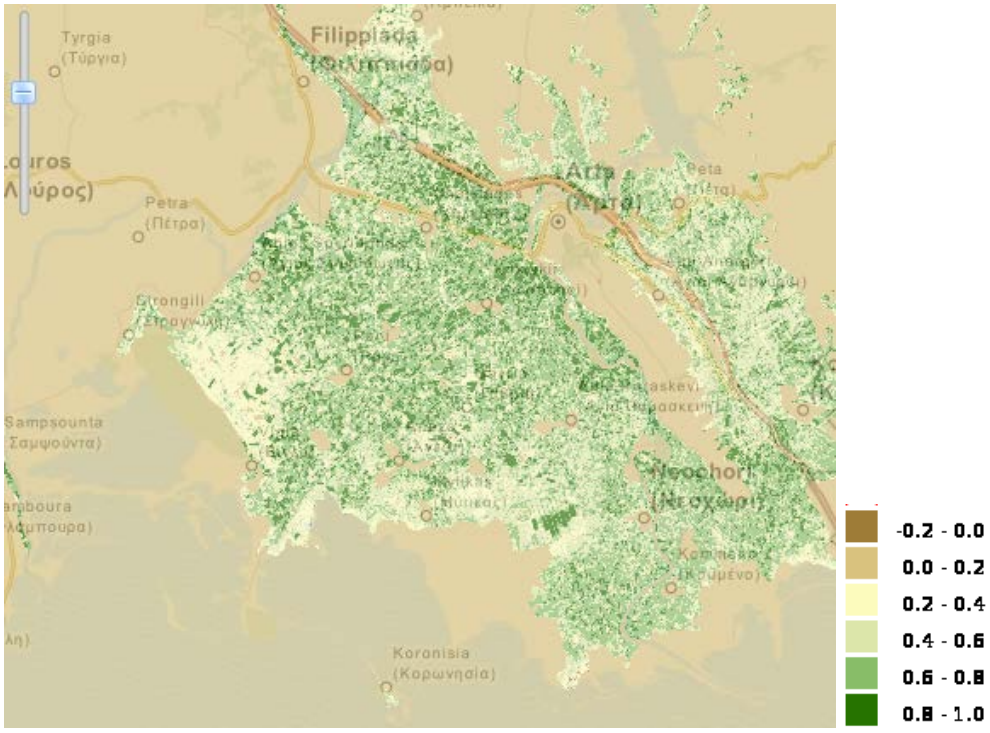



**Fig. 3 NDVI map (6/9/2014)**

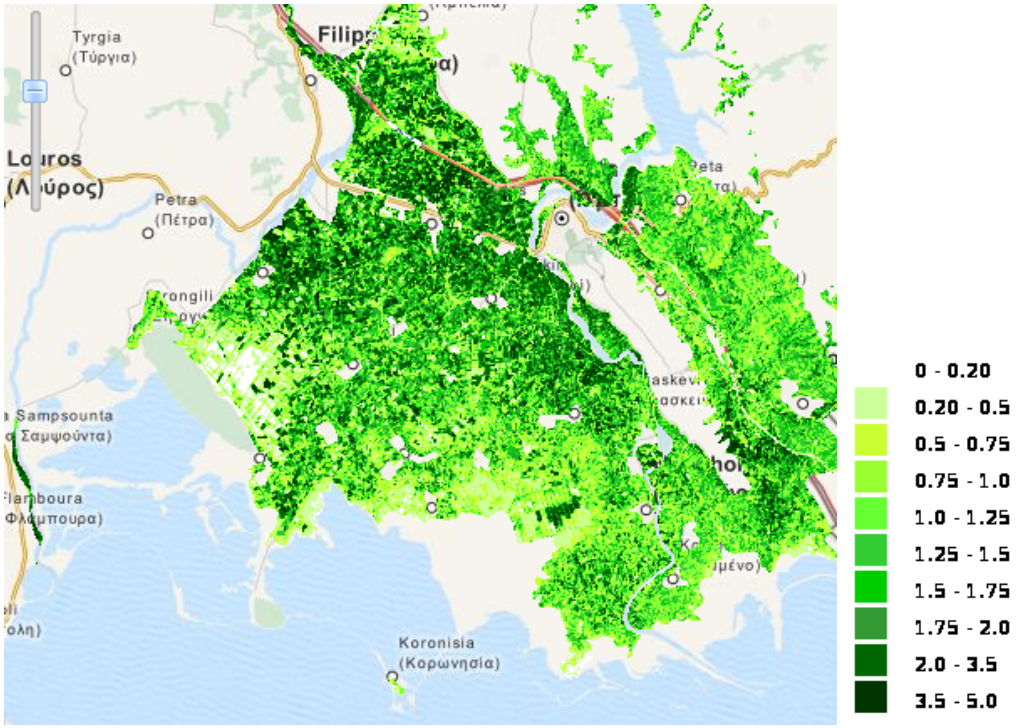



**Fig. 4 LAI map (6/9/2014)**

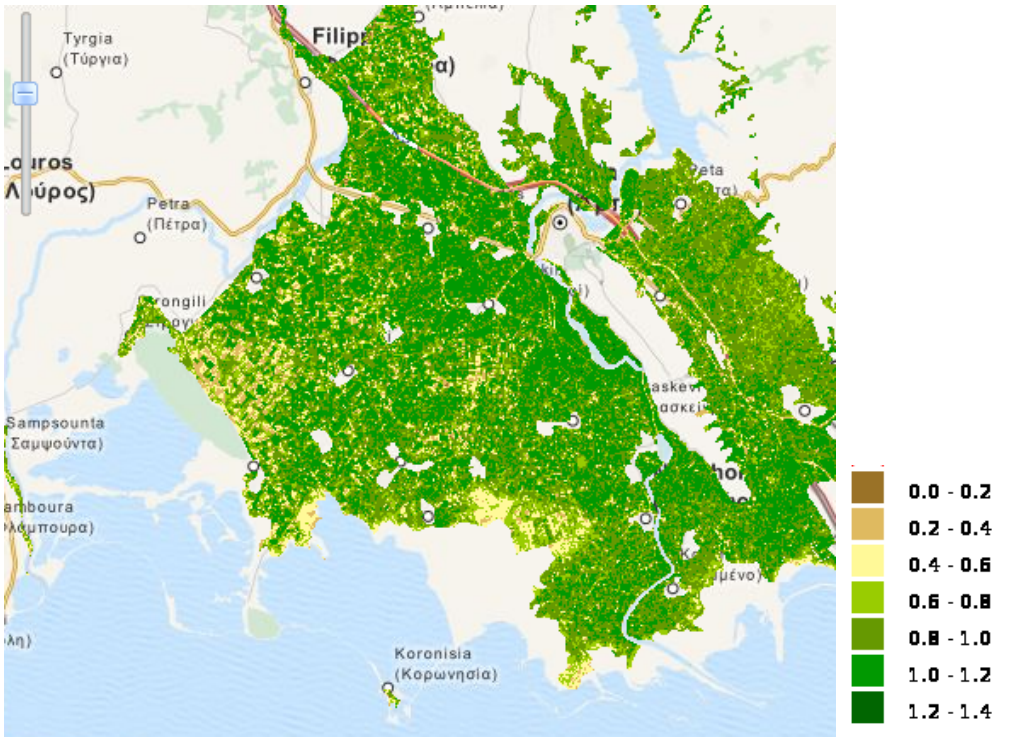



**Fig. 5 Kc map (6/9/2014)**

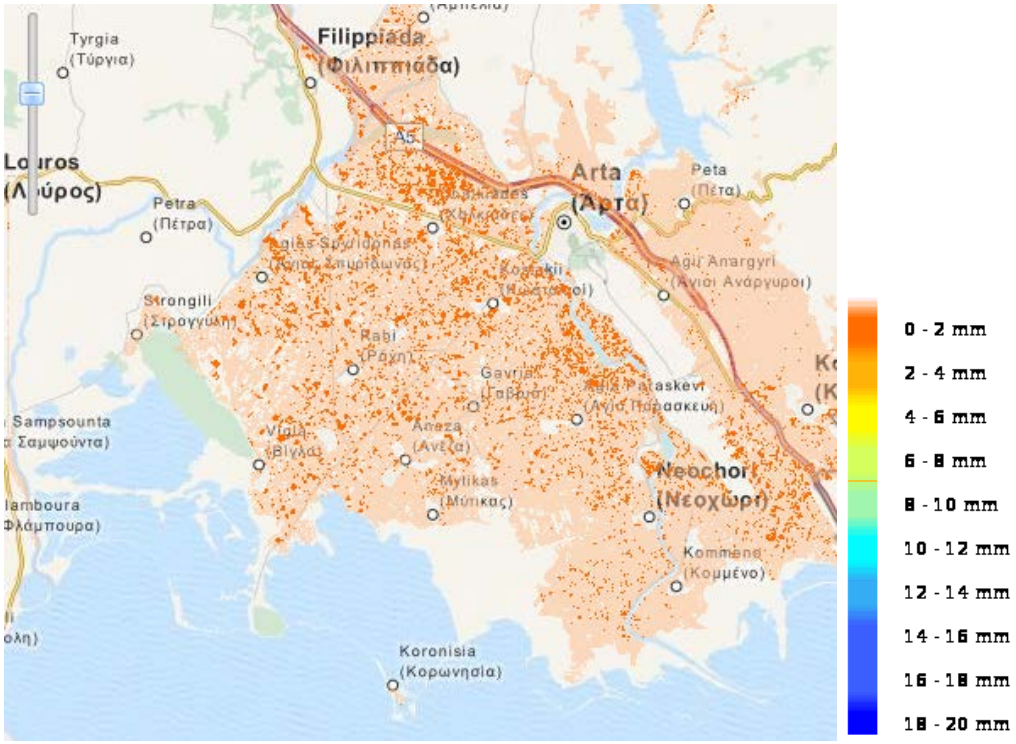



**Fig. 6 ETp map (6/9/2014)**

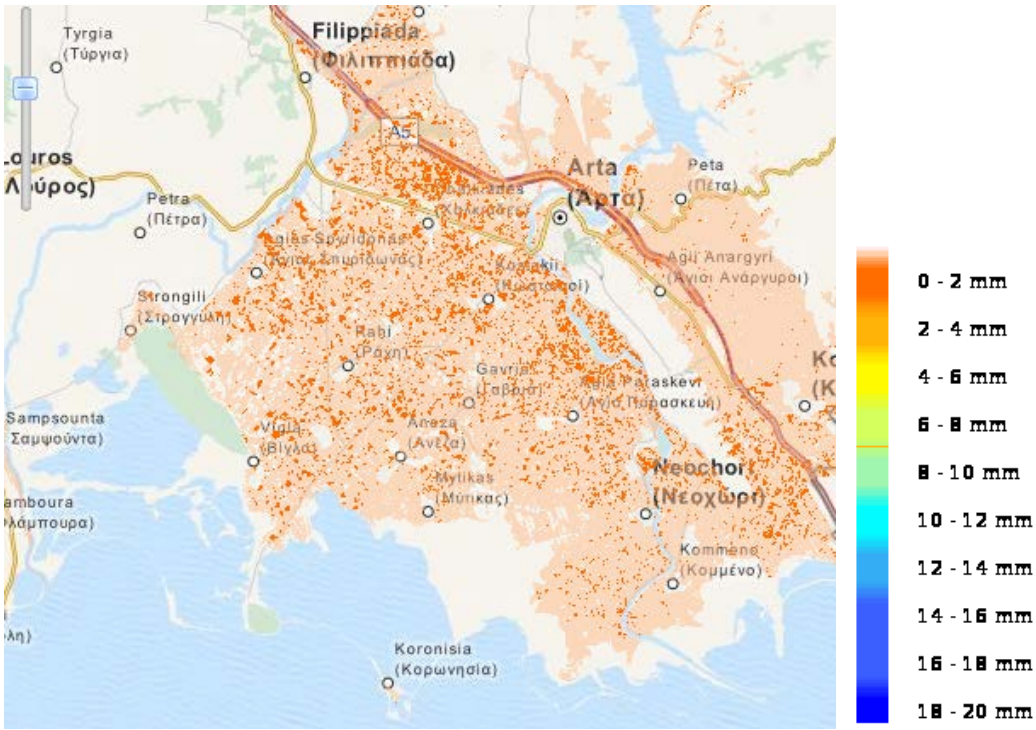
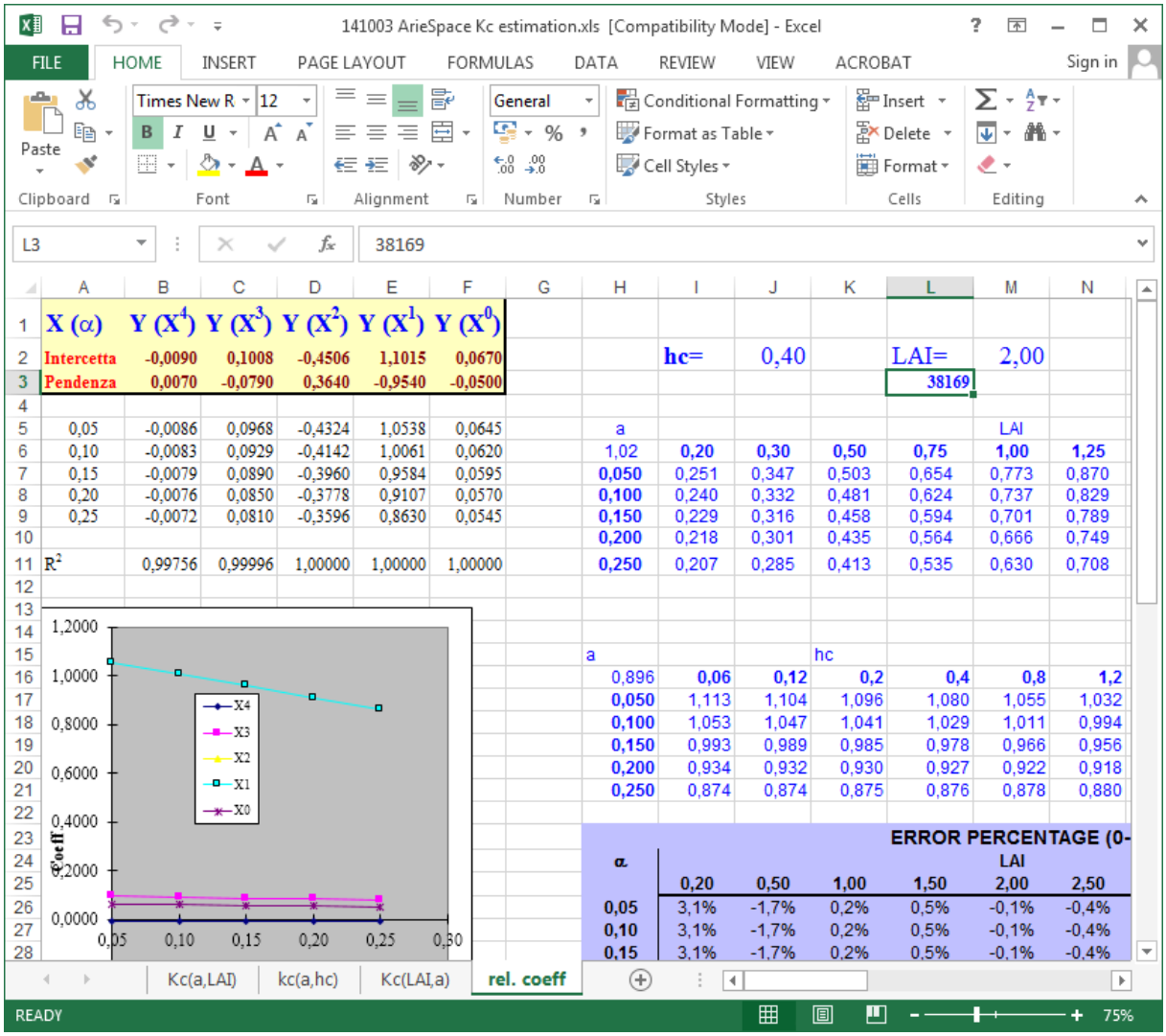



**Fig. 7 IWR map (6/9/2014)**



141003 ArieSpace Kc estimation.xls [Compatibility Mode] - Excel

| X (α) | Y ($X^4$) | Y ($X^3$) | Y ($X^2$) | Y ($X^1$) | Y ($X^0$) |
|---|---|---|---|---|---|
| Intercetta | -0,0090 | 0,1008 | -0,4506 | 1,1015 | 0,0670 |
| Pendenza | 0,0070 | -0,0790 | 0,3640 | -0,9540 | -0,0500 |
| 0,05 | -0,0086 | 0,0968 | -0,4324 | 1,0538 | 0,0645 |
| 0,10 | -0,0083 | 0,0929 | -0,4142 | 1,0061 | 0,0620 |
| 0,15 | -0,0079 | 0,0890 | -0,3960 | 0,9584 | 0,0595 |
| 0,20 | -0,0076 | 0,0850 | -0,3778 | 0,9107 | 0,0570 |
| 0,25 | -0,0072 | 0,0810 | -0,3596 | 0,8630 | 0,0545 |
| $R^2$ | 0,99756 | 0,99996 | 1,00000 | 1,00000 | 1,00000 |

hc= 0,40 LAI= 2,00 38169

| a | LAI | | | | | |
|---|---|---|---|---|---|---|
| 1,02 | 0,20 | 0,30 | 0,50 | 0,75 | 1,00 | 1,25 |
| 0,050 | 0,251 | 0,347 | 0,503 | 0,654 | 0,773 | 0,870 |
| 0,100 | 0,240 | 0,332 | 0,481 | 0,624 | 0,737 | 0,829 |
| 0,150 | 0,229 | 0,316 | 0,458 | 0,594 | 0,701 | 0,789 |
| 0,200 | 0,218 | 0,301 | 0,435 | 0,564 | 0,666 | 0,749 |
| 0,250 | 0,207 | 0,285 | 0,413 | 0,535 | 0,630 | 0,708 |

| a | hc | | | | | |
|---|---|---|---|---|---|---|
| 0,896 | 0,06 | 0,12 | 0,2 | 0,4 | 0,8 | 1,2 |
| 0,050 | 1,113 | 1,104 | 1,096 | 1,080 | 1,055 | 1,032 |
| 0,100 | 1,053 | 1,047 | 1,041 | 1,029 | 1,011 | 0,994 |
| 0,150 | 0,993 | 0,989 | 0,985 | 0,978 | 0,966 | 0,956 |
| 0,200 | 0,934 | 0,932 | 0,930 | 0,927 | 0,922 | 0,918 |
| 0,250 | 0,874 | 0,874 | 0,875 | 0,876 | 0,878 | 0,880 |

ERROR PERCENTAGE (0-

| α | LAI | | | | | |
|---|---|---|---|---|---|---|
| | 0,20 | 0,50 | 1,00 | 1,50 | 2,00 | 2,50 |
| 0,05 | 3,1% | -1,7% | 0,2% | 0,5% | -0,1% | -0,4% |
| 0,10 | 3,1% | -1,7% | 0,2% | 0,5% | -0,1% | -0,4% |
| 0,15 | 3,1% | -1,7% | 0,2% | 0,5% | -0,1% | -0,4% |



**Fig. 8 Kc calculation spreadsheet from ArieSpace**

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