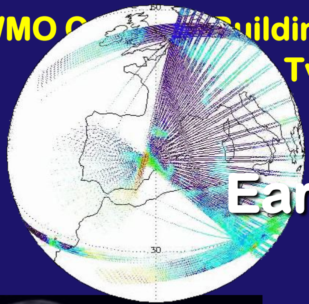
# Remote Sensing Applications for Land/ Atmosphere Interactions: Surface Net Radiation

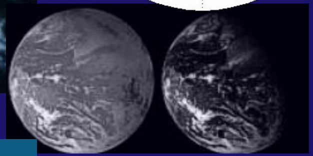
- Introduction
- Our Objective: Deriving Surface Energy Balance Fluxes from Net Radiation Measurements
- Estimation of Surface Net Radiation from Operational Meteorological Measurements
- Derivation of surface net radiation from top of the atmosphere GERB fluxes by means of linear models and neural networks
- Using the synergy GERB/SEVIRI and micrometeorological data to study the relationship between surface net radiation and soil heat flux

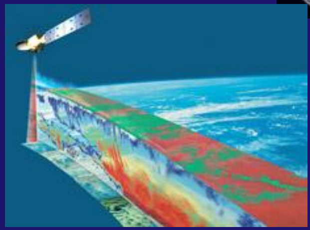
Ernesto López Baeza (Ernesto.Lopez@uv.es)
& Climatology from Satellites Group
University of Valencia. Faculty of Physics
Dept of Earth Physics & Thermodynamics

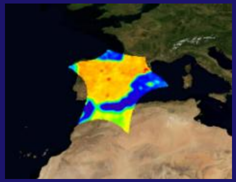


# Climatology from Satellites Group

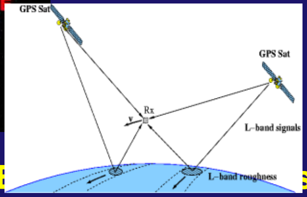
## Earth Observation Missions Where we are Involved













- CERES (*Clouds and the Earth's Radiant Energy System*) NASA
- GERB (*Geostationary Earth radiation Budget*) EUMETSAT
- EarthCARE (*Earth Clouds, Aerosols and Radiation Explorer*) ESA/JAXA
- SMOS (*Soil Moisture and Ocean Salinity*) ESA
- SMAP (*Soil Moisture Active and Passive*) NASA
- SENTINEL-3 ESA
- EPS/MetOp (*EUMETSAT Polar System*) EUMETSAT/ESA
- PARIS (*Passive Reflectometry and Interferometry System*). Now GEROS GNSS-R (*Global Navigation Satellite System - Reflectometry*) ESA

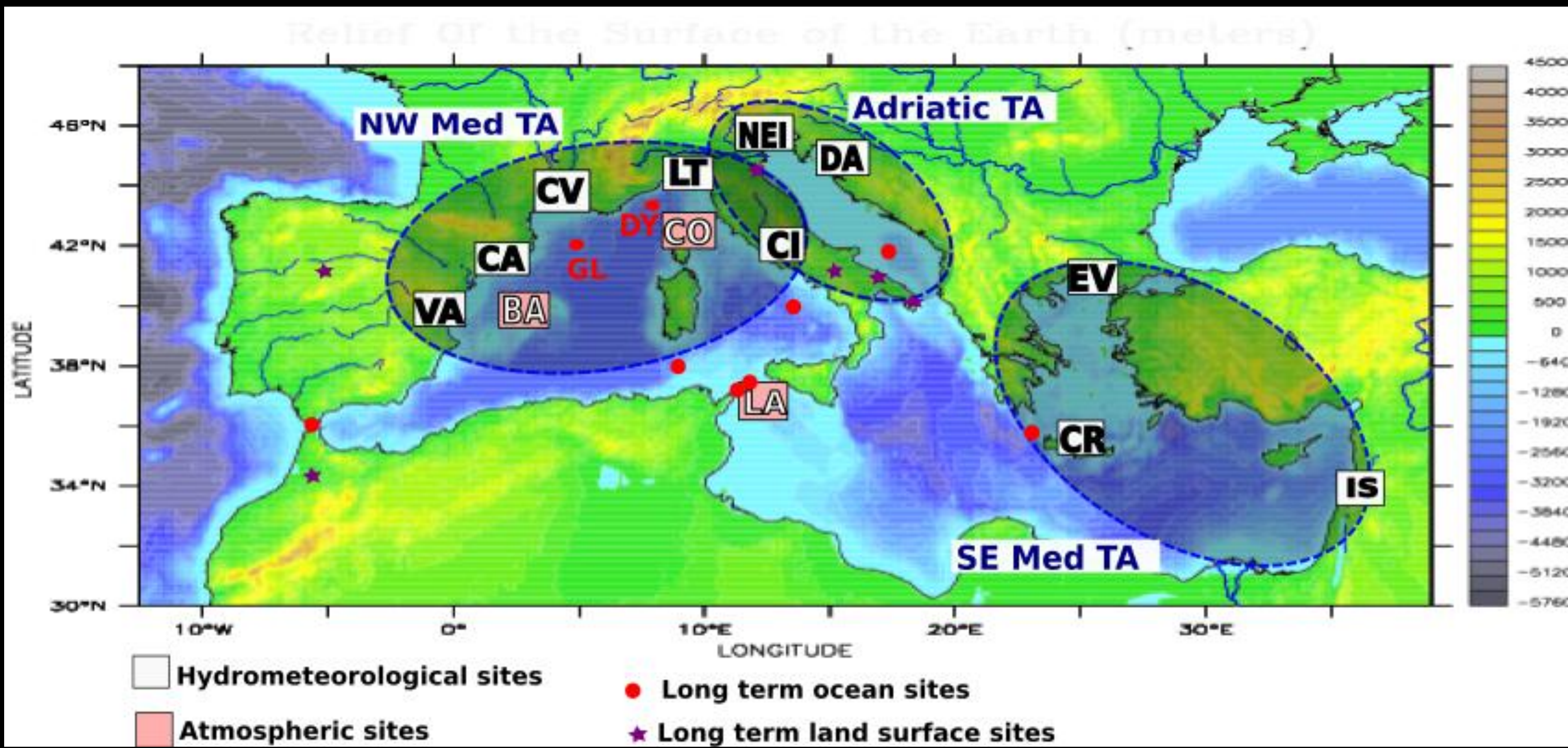
Joint COSPAR – WMO Capacity Building Workshop on Satellite Remote Sensing, Water Cycle and Climate Change
Tver University, Russia, 20-31 July, 2014

# HyMeX

## Hydrological Cycle in Mediterranean Experiment

for us

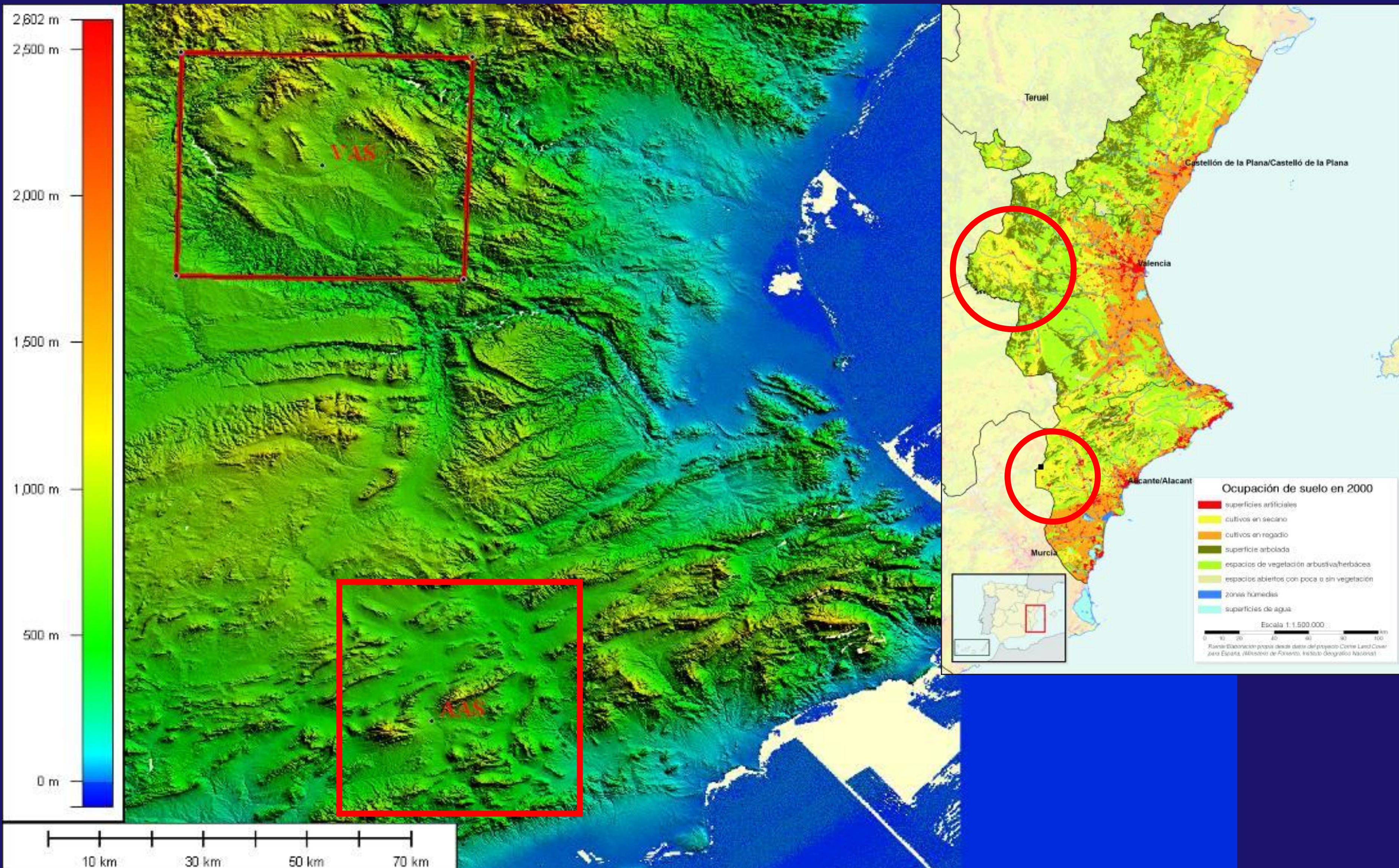
# Definition of an Experimental Observatory of the Water Cycle



# Valencia & Alacant Anchor Stations

(Most?) suitable area in Europe for validation of low spatial resolution remote sensing data and products


HR MERIS, 23 March 2002

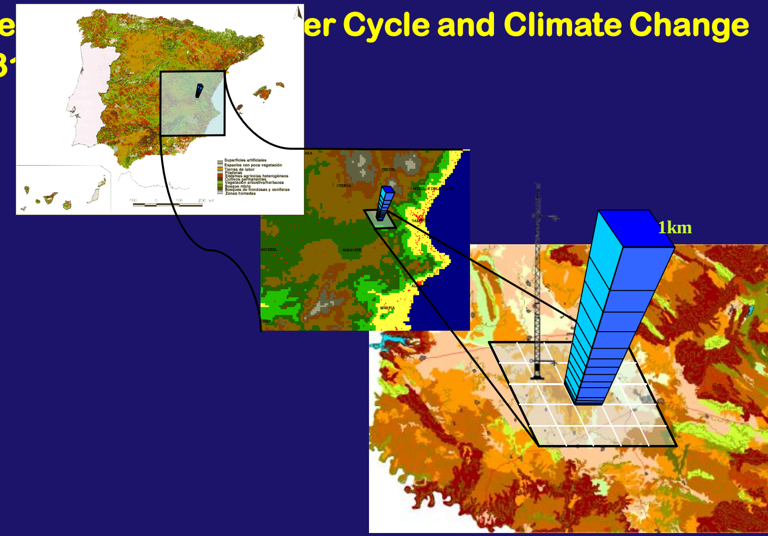

2,602 m
2,500 m
2,000 m
1,500 m
1,000 m
500 m
0 m
10 km
30 km
50 km
70 km
VAS
AAS
Teruel
Castellón de la Plana/Castelló de la Plana
Valencia
Alicante/Alacant
Murcia
Ocupación de suelo en 2000
superficies artificiales
cultivos en secano
cultivos en regadio
superficie arbolada
espacios de vegetación arbustiva/herbácea
espacios abiertos con poca o sin vegetación
zonas húmedas
superficies de agua
Escala 1:1.500.000

GERB/CERES Ground Validation Campaign June 2003

GERB/CERES Ground Validation Campaign February 2004

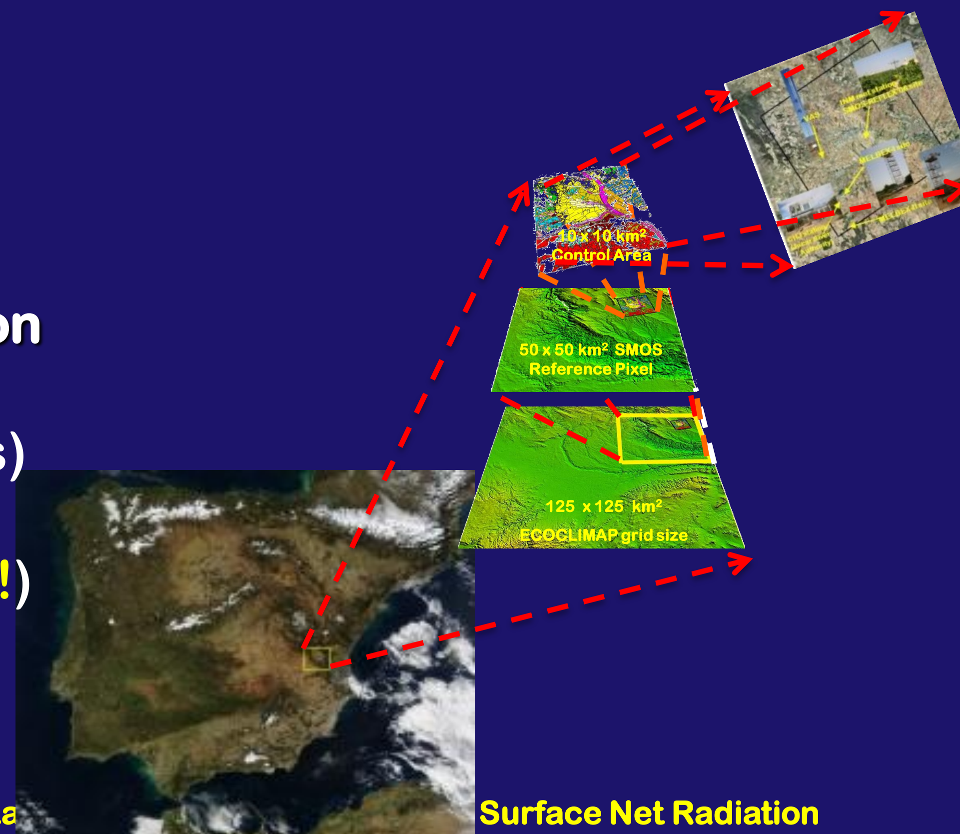

accounting for non-homegeneities of the area

# Research Lines




## Validation of Low Spatial Resolution Remote Sensing Data and Products (or *Making Sense of Satellite Data*)

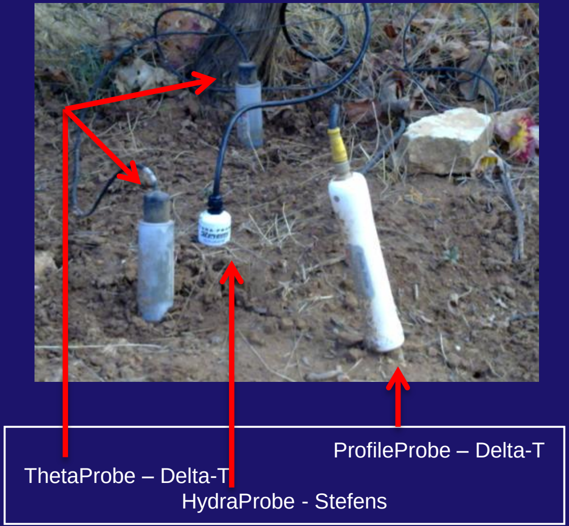
- **Validation Sites Characterization**
  - Valencia Anchor Station
  - Alacant Anchor Station
- **Use of Meteorological Models**
- **Development of Validation Methodologies**
  - Radiation (Clouds & Aerosols)
  - Soil Moisture
  - Biophysical Products (NEW!!!)
  - GNSS-R (NEW)

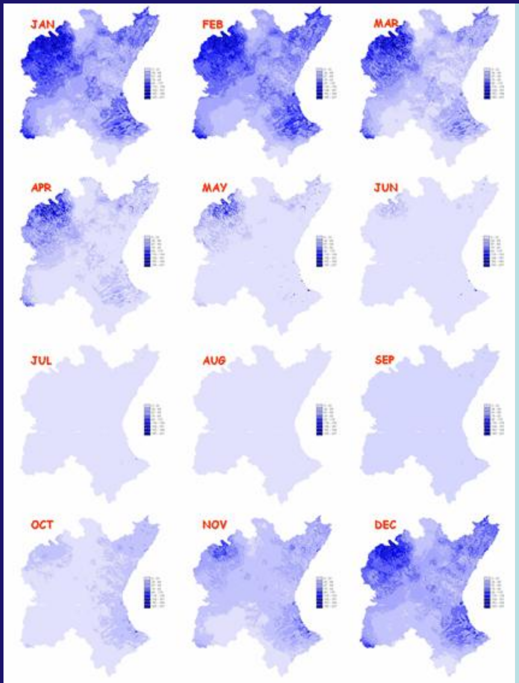


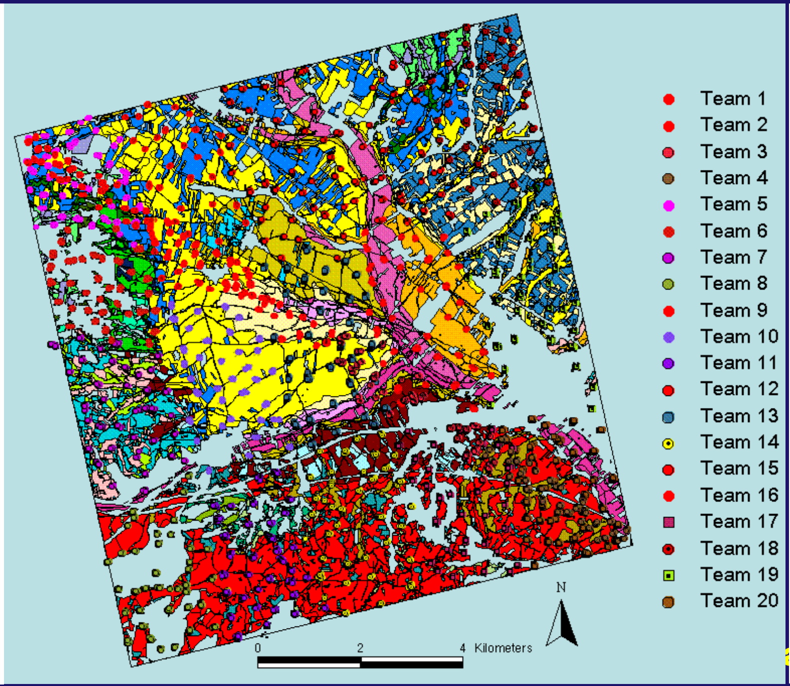
# Research Lines

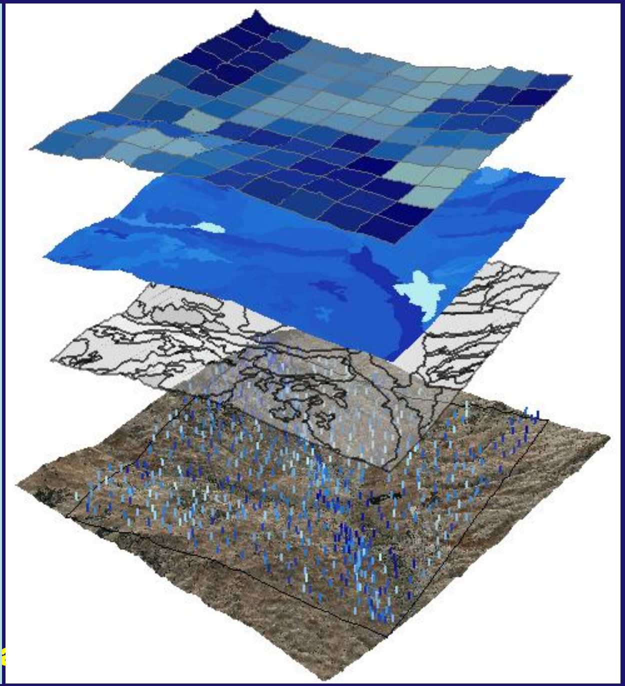
## Soil Moisture from Passive Microwaves (*Estimation of Soil Moisture from Space*)

- **MELBEX (*Mediterraneam Ecosystem L-Band Characterization Experiment*)**
  - Matorral & Shrubs
  - Vineyards
- **Eddy-Covariance Methods**
- **Network of Soil Moisture Measurements**
- **Testbed for Soil Moisture Measuring Instruments Intercomparison**

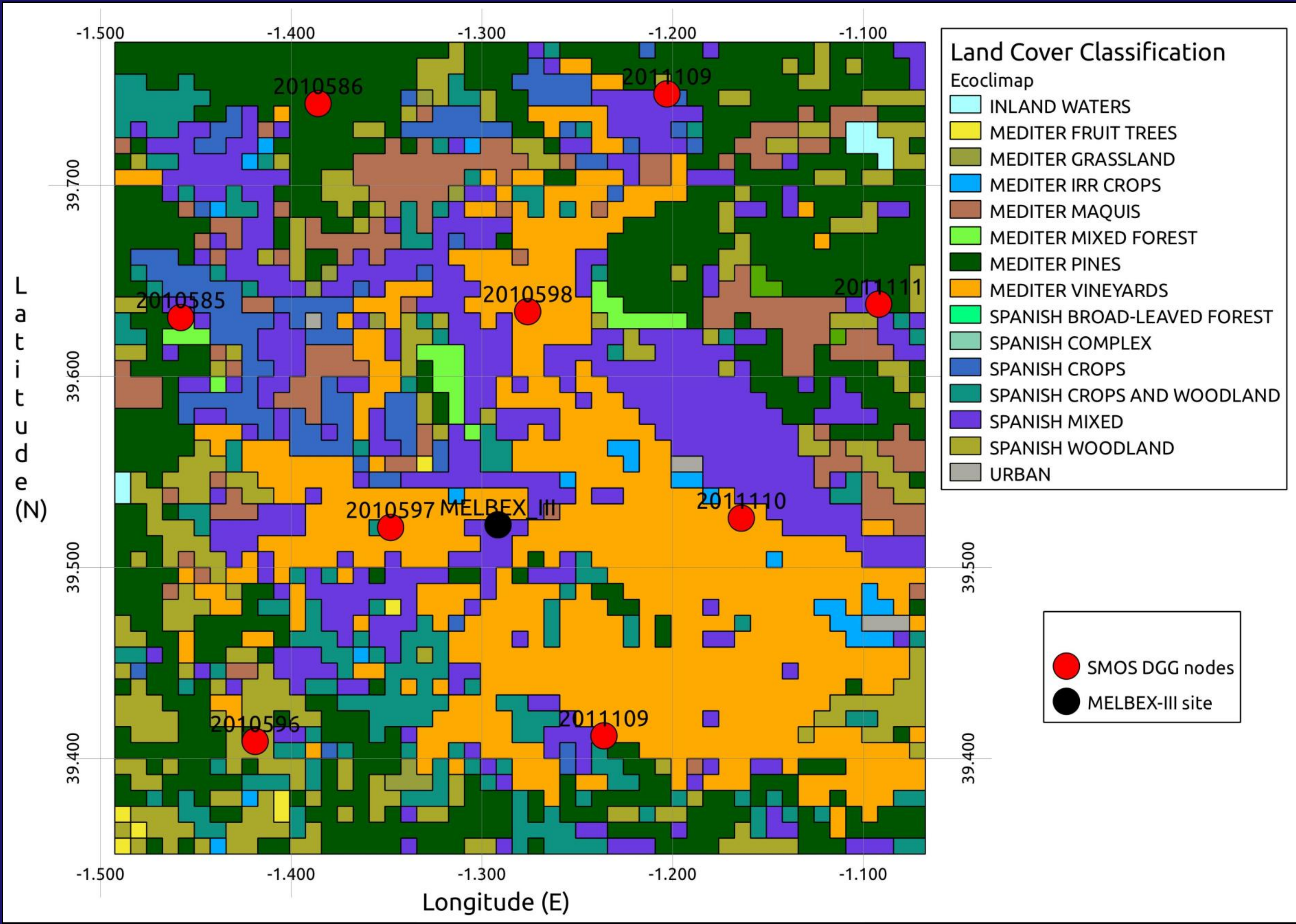


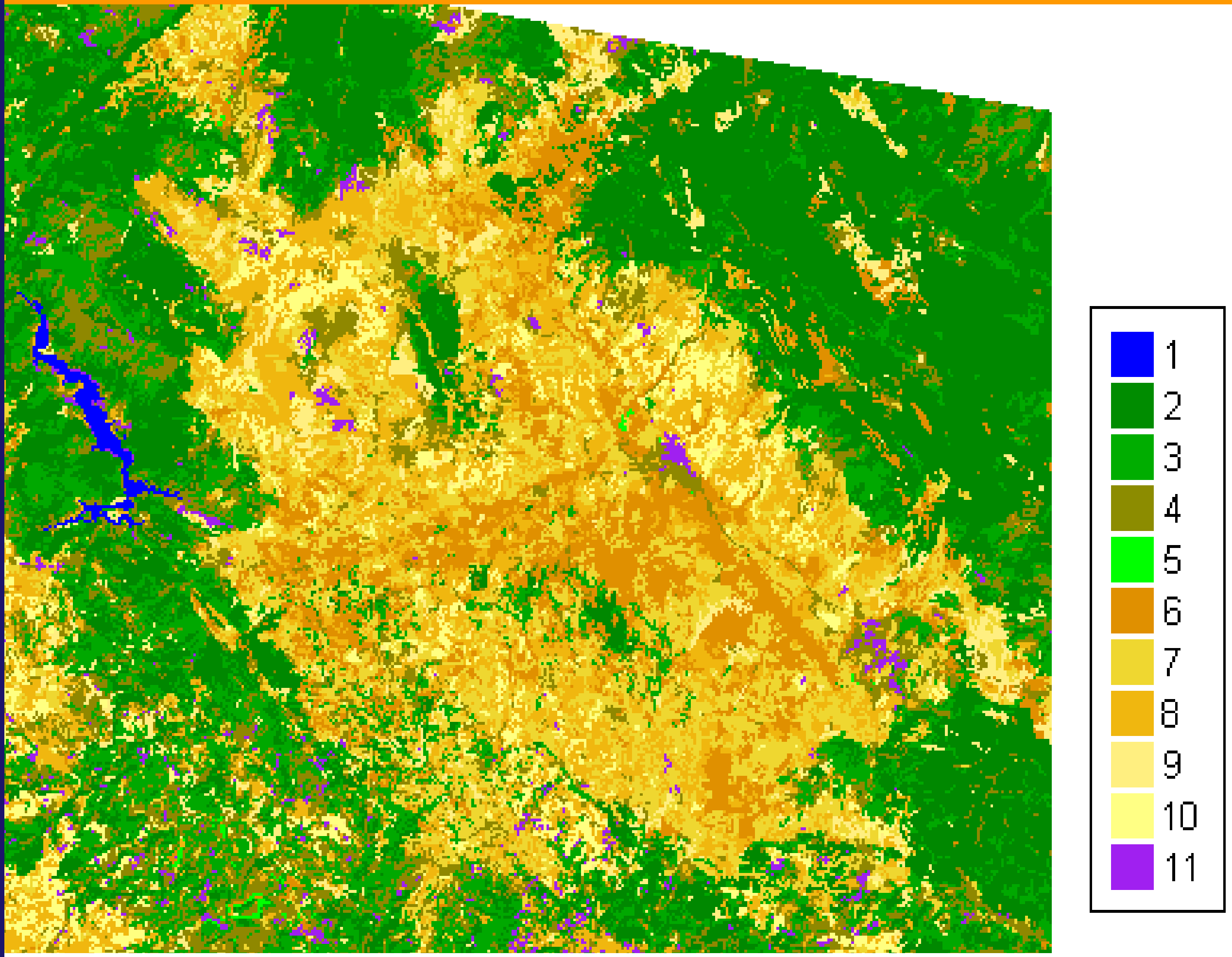



# ECOCLIMAP Land Use Map

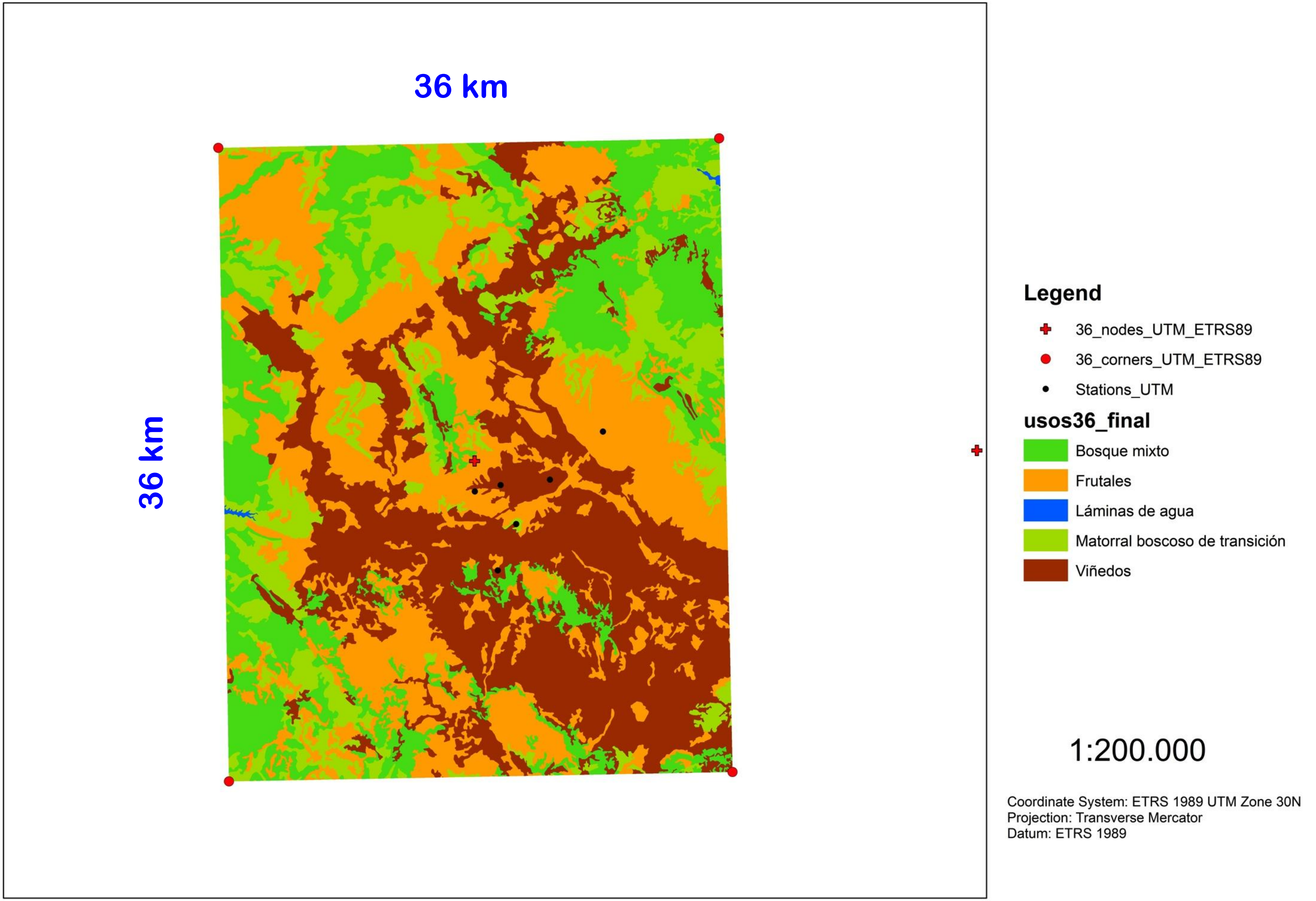


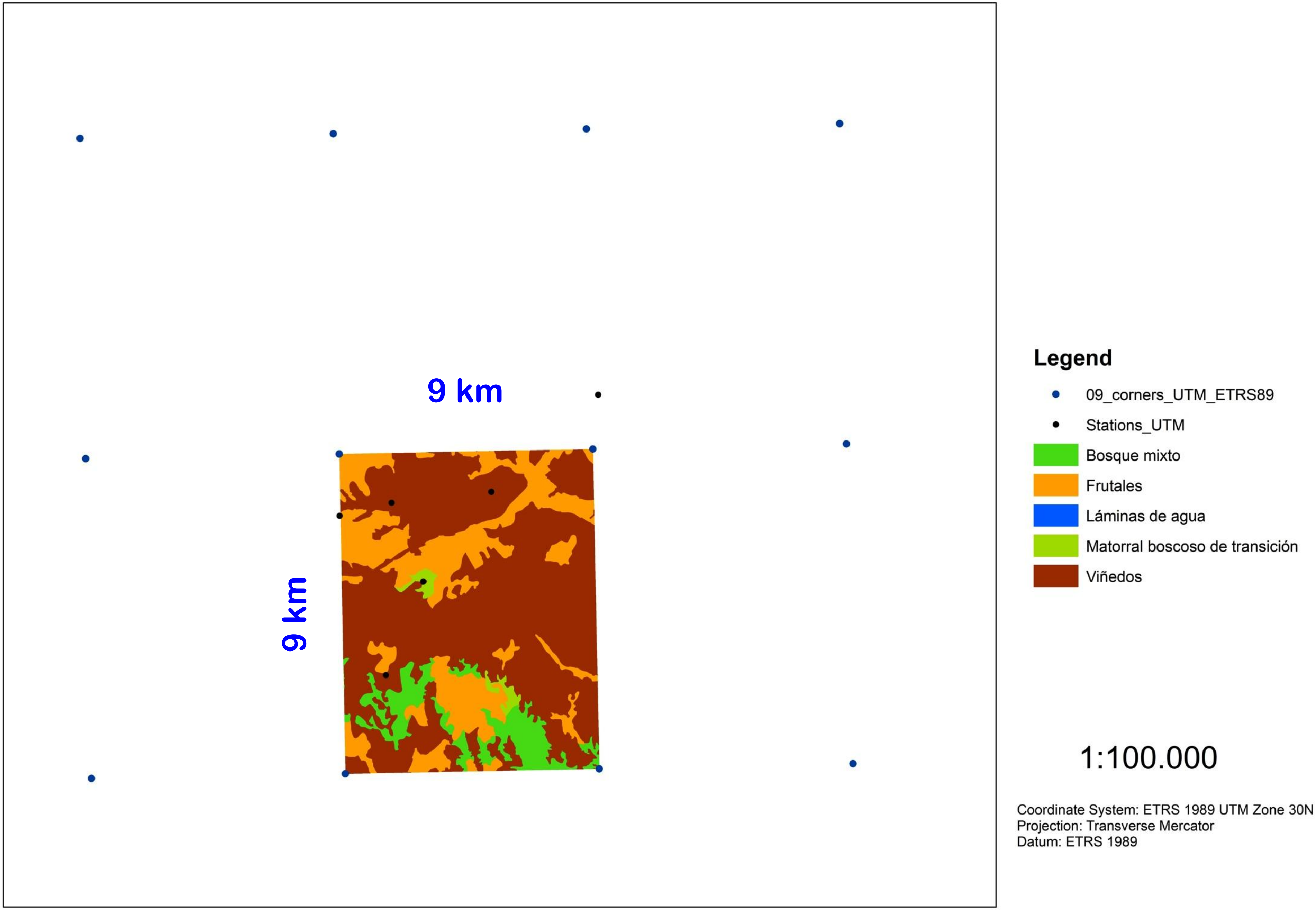
# Classified LANDSAT image (5th July 2003): 11 categories for the Valencia *Anchor Station* area (50 x 50 km²)



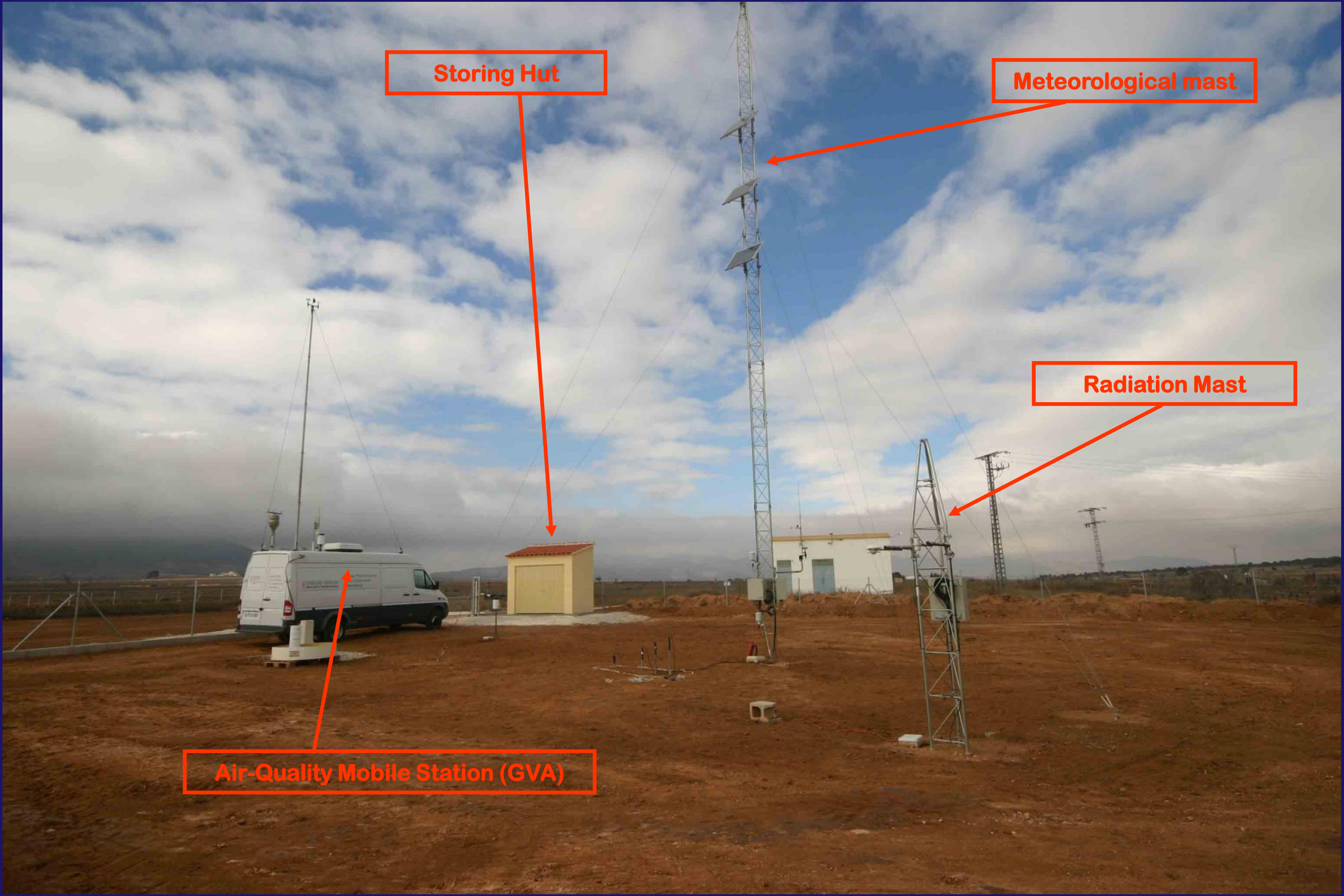

1: Water, 2:Pine trees, 3: Low-density Pine trees,4: Shrubs, 5: Irrigated, 6: Vineyard, 7: Low-density vineyard, 8: Very low density, 9: Dry crops, 10: Bare soil, 11: Degraded

# almond-, pine-, olive-tree areas

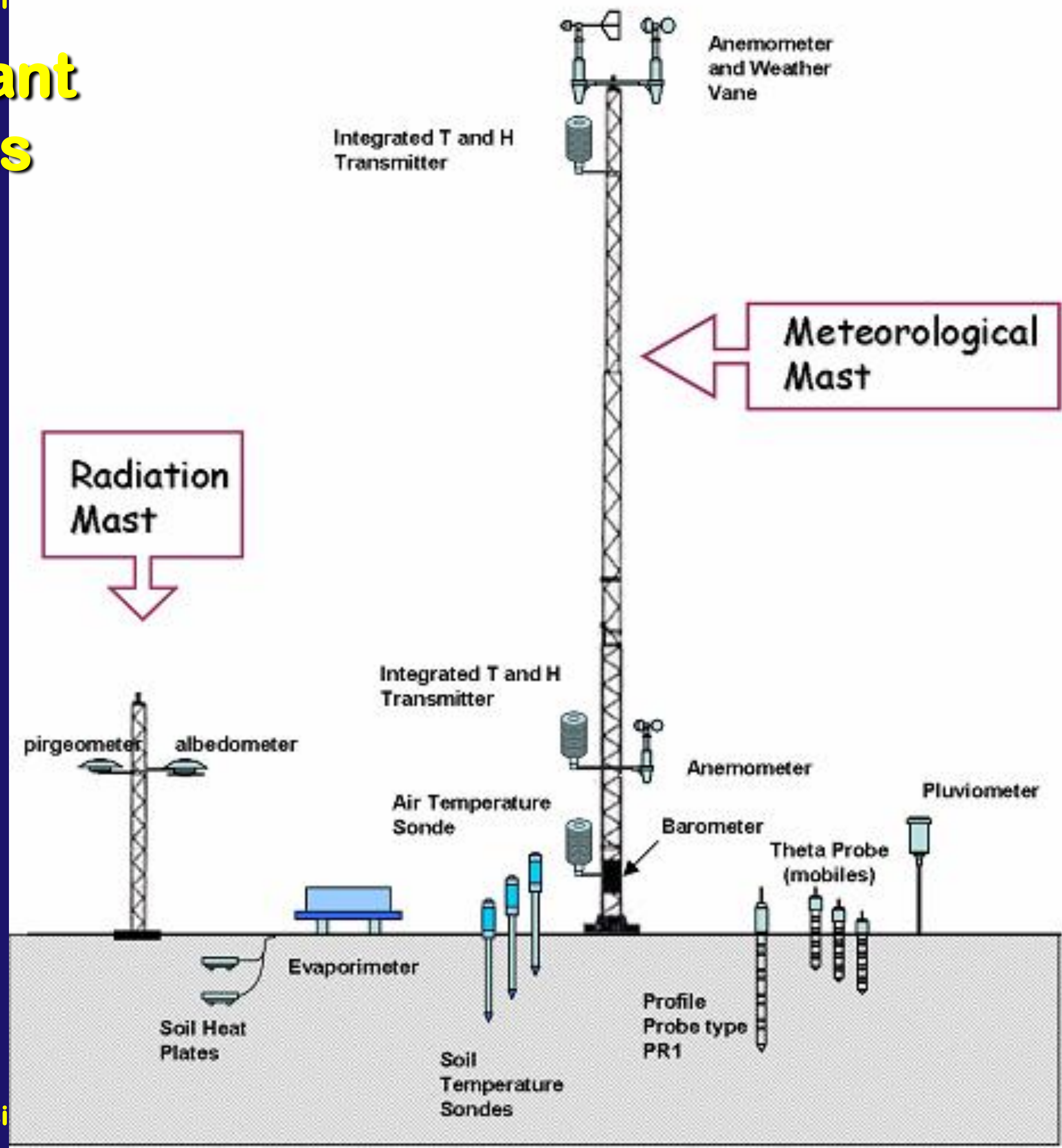

36 km
36 km
Legend
36_nodes_UTM_ETRS89
36_corners_UTM_ETRS89
Stations_UTM
usos36_final
Bosque mixto
Frutales
Láminas de agua
Matorral boscoso de transición
Viñedos
1:200.000
Coordinate System: ETRS 1989 UTM Zone 30N
Projection: Transverse Mercator
Datum: ETRS 1989

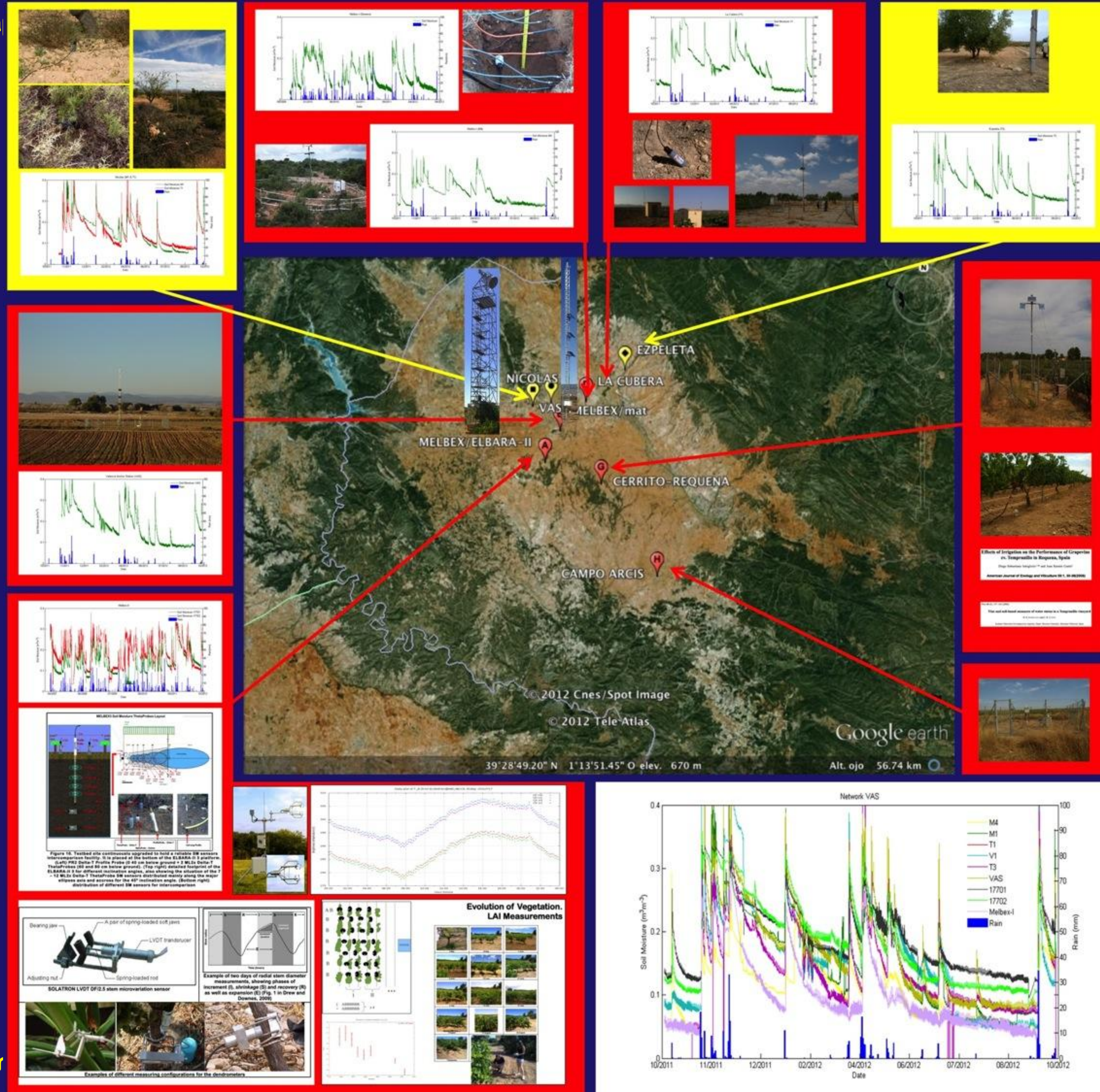

9 km
9 km
Legend
09_corners_UTM_ETRS89
Stations_UTM
Bosque mixto
Frutales
Láminas de agua
Matorral boscoso de transición
Viñedos
1:100.000
Coordinate System: ETRS 1989 UTM Zone 30N
Projection: Transverse Mercator
Datum: ETRS 1989

# Alacant Anchor Station



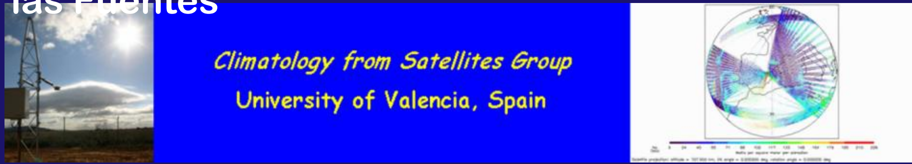
# Valencia & Alacant Anchor Stations




EZPELETA
NICOLAS
LA CUBERA
VAS
MELBEX/mat
MELBEX/ELBARA-II
CERRITO-REQUENA
CAMPO ARCIS
© 2012 Cnes/Spot Image
© 2012 Tele Atlas
Google earth
39°28'49.20" N 1°13'51.45" O elev. 670 m
Alt. ojo 56.74 km
Network VAS
M4
M1
T1
V1
T3
VAS
17701
17702
Melbex-I
Rain
Soil Moisture (m³m⁻³)
Rain (mm)
Date
10/2011
11/2011
12/2011
02/2012
04/2012
06/2012
07/2012
08/2012
10/2012
Evolution of Vegetation.
LAI Measurements
SOLATRON LVDT DF/2.5 stem microvariation sensor
Examples of different measuring configurations for the dendrometers

# Acknowledgment


- Spanish Research Programme on Space, Ministry for Education & Science
- General Directorate for Climate Change, Dept. for Environment. Regional Gov. of the Valencian Autonomous Community
- European Space Agency (ESA) (SMOS)
- (NASA) (SMAP)
- CNES (Centre National des Etudes Spatiales) – TOSCA Program
- Irrigation Technology Service, Valencian Institute for Agricultural Research
- Jucar River Basin Authority. Office for Hydrological Planning
- Meteorological State Agency of Spain (AEMet)
- Bodegas IRANZO, Caudete de las Fuentes
- Bodegas y Viñedos de Utiel
- Bodega "La Cubera", Utiel
- Mr Nicolas Guaita and Rafael Giménez, Caudete de las Fuentes

# Remote Sensing Applications for Land/Atmosphere Interactions: Surface Net Radiation

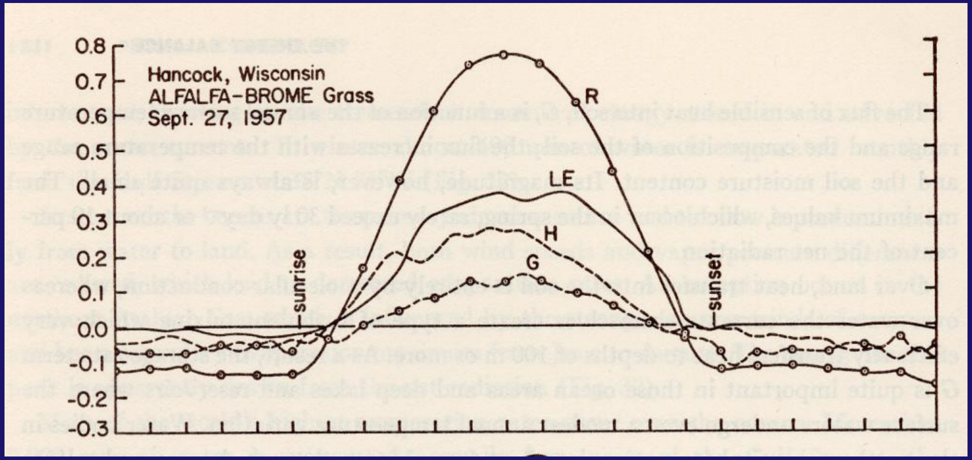
**Our Objective:**

**Deriving**

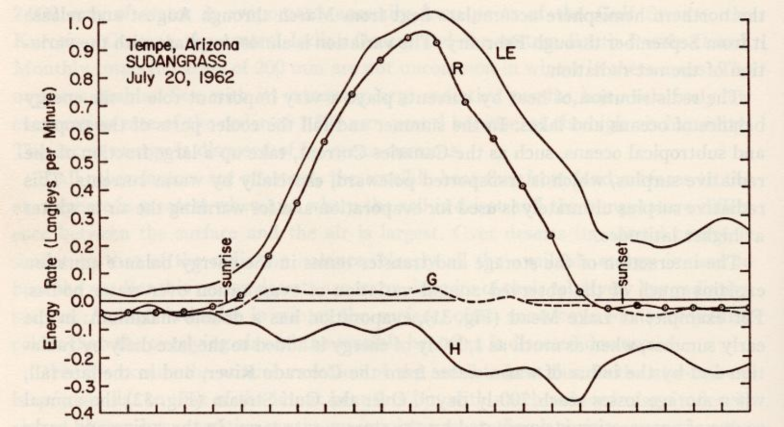
**Surface Energy Balance Fluxes from**

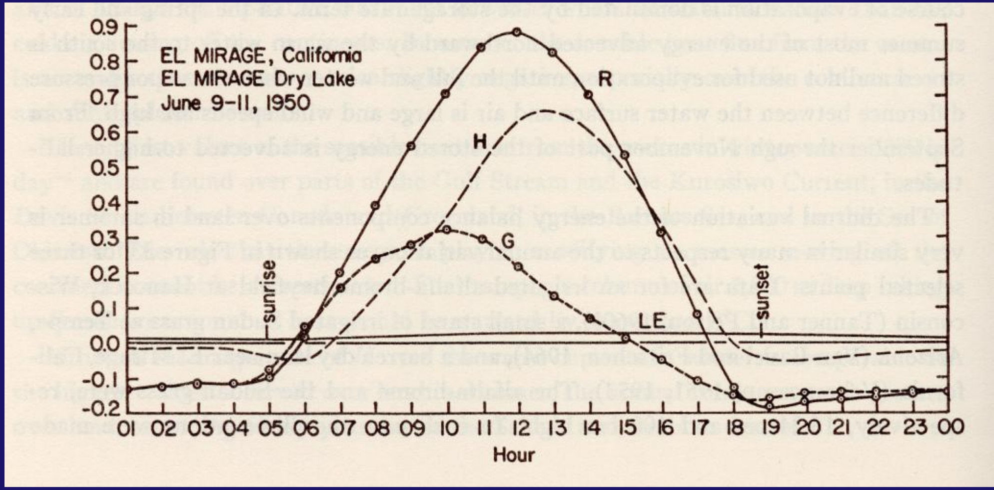
**Net Radiation Measurements**

# Examples of Average Diurnal Variations of the Surface Energy Balance. (Sellers, 1965)

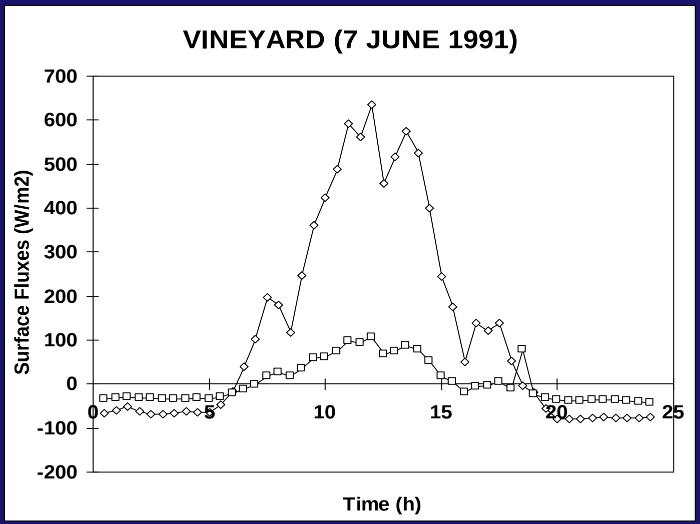


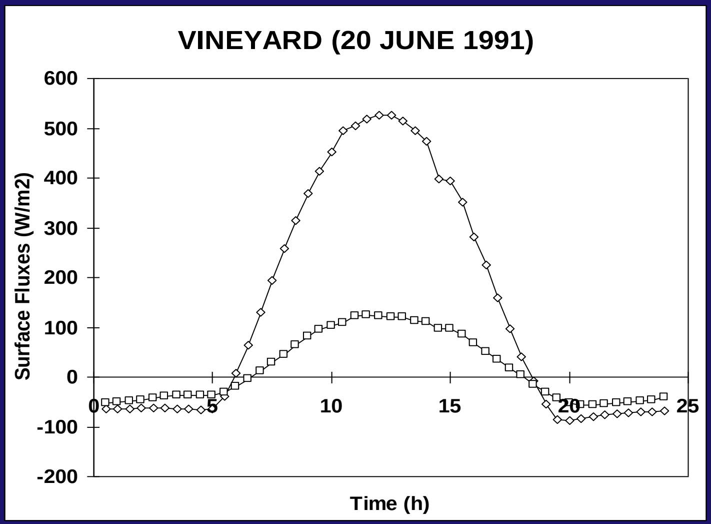

$$Rn = H + \lambda E + G$$

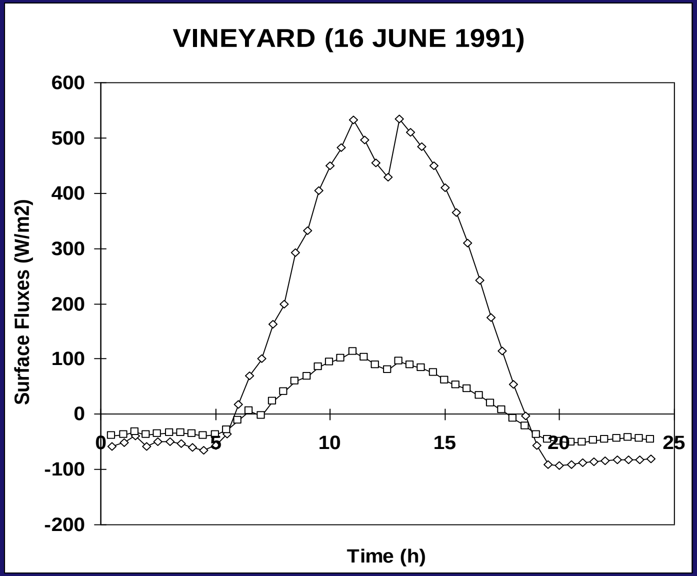


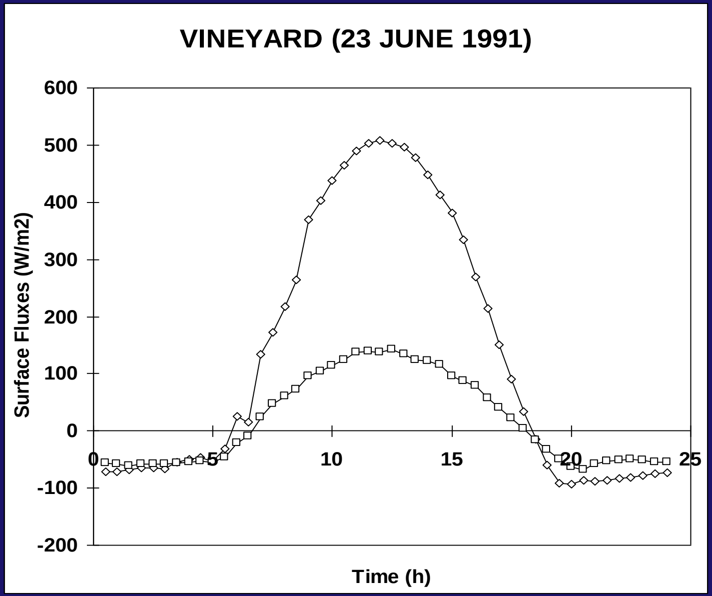



# Examples of Diurnal Variations of Surface Net Radiation and Soil Heat Flux. (EFEDA data base)



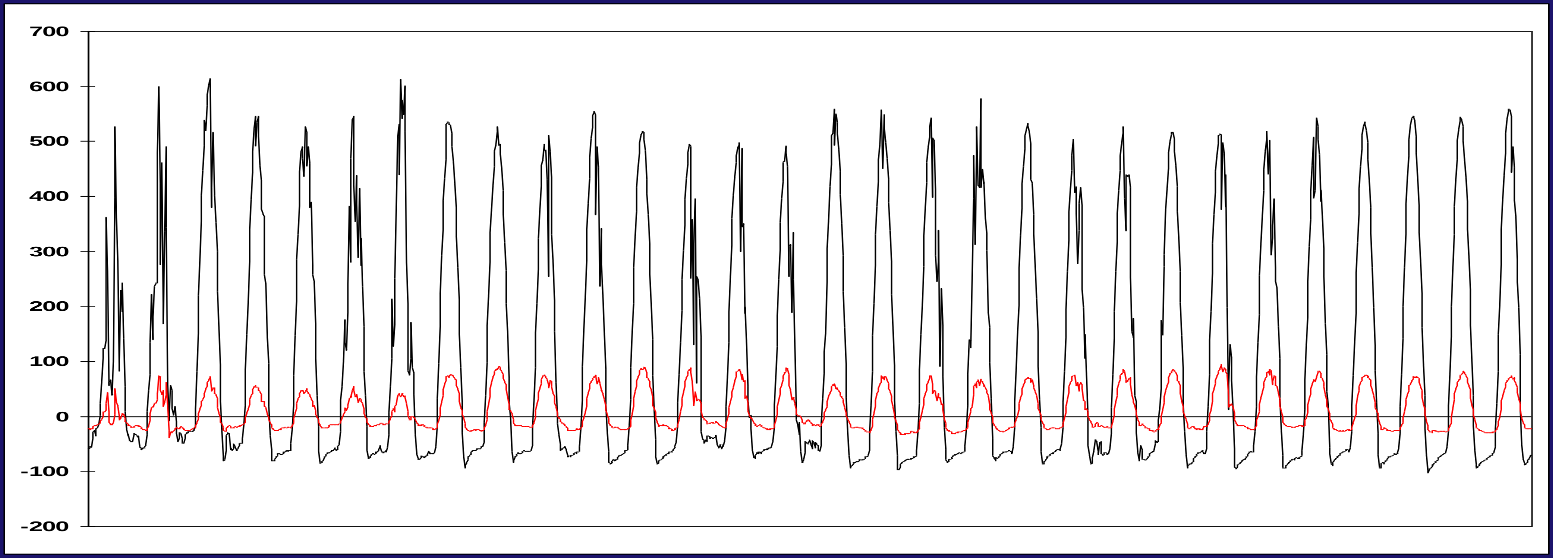



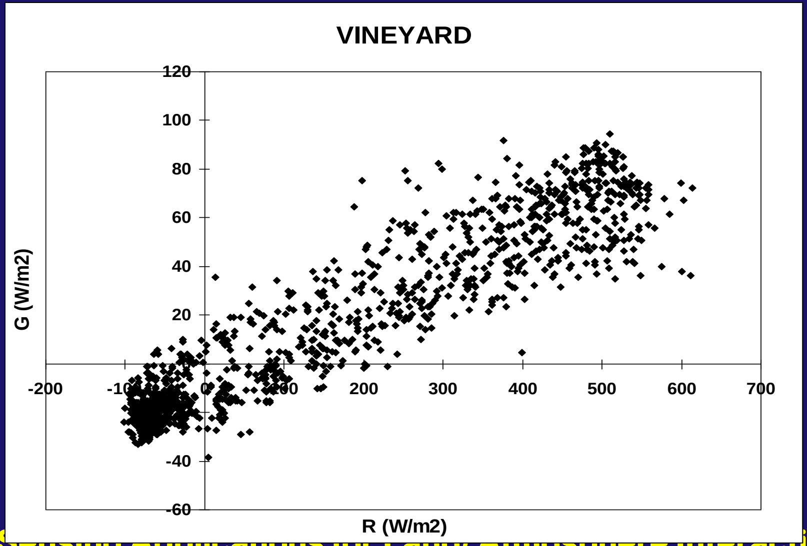



# Surface Net Radiation and Soil Heat Flux

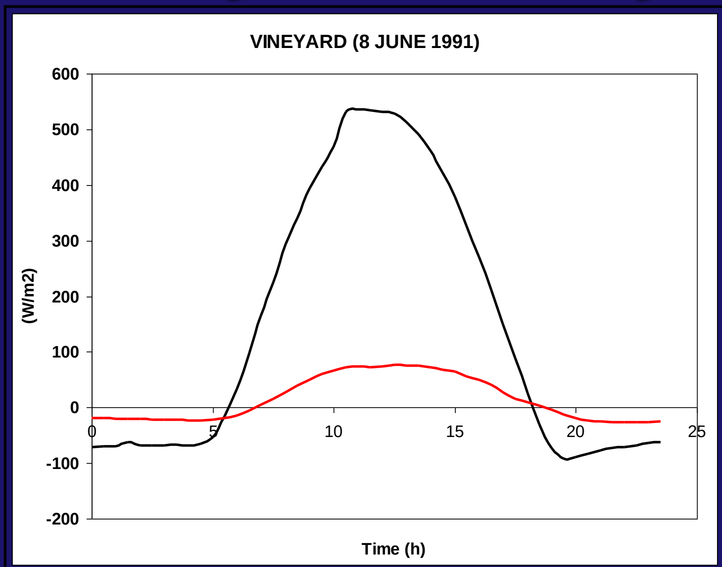
# 1 – 30 June 1991 (EFEDA data base)

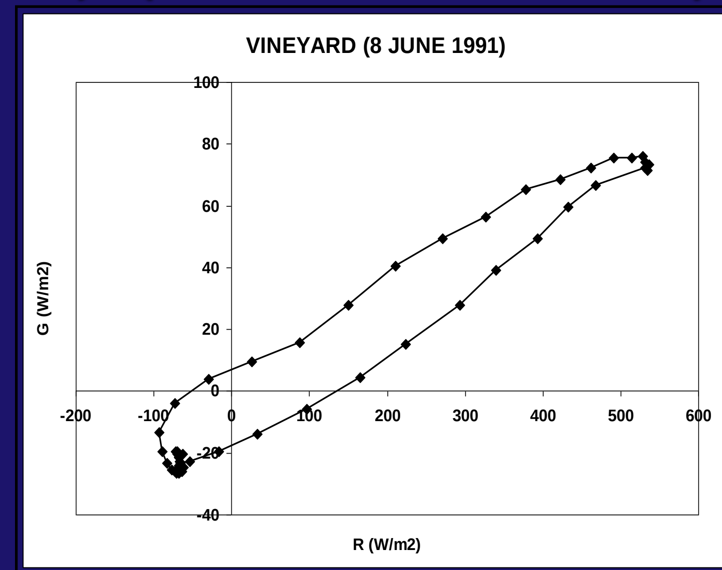


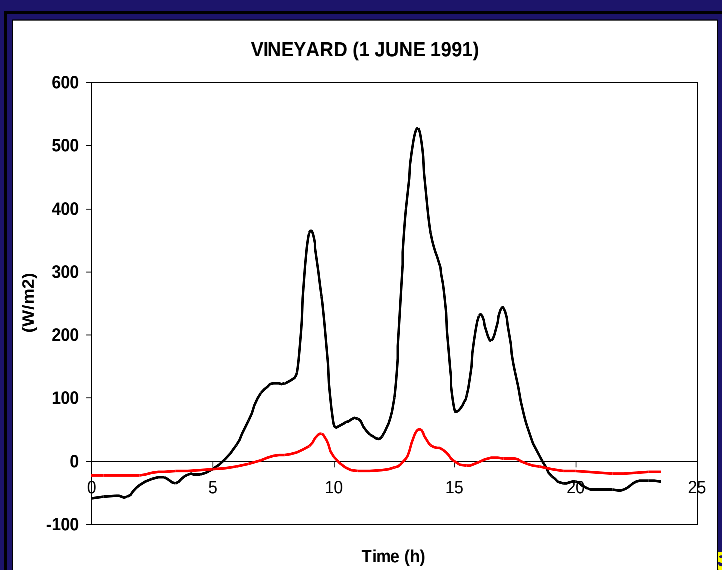



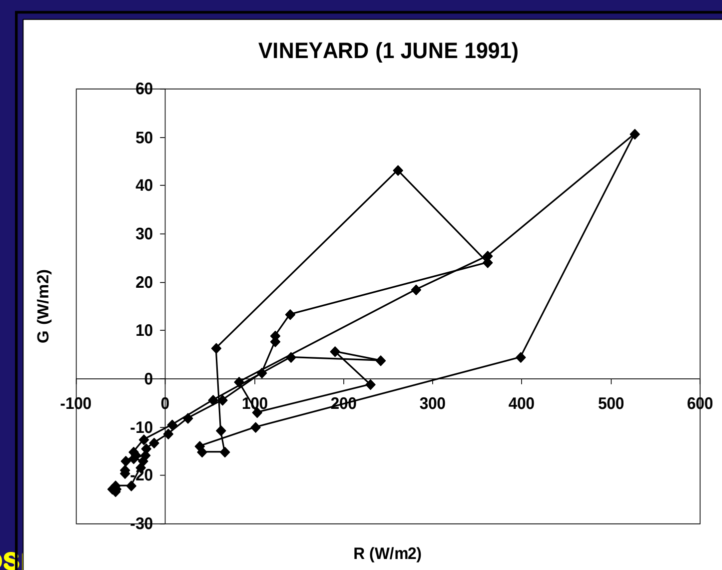
# Surface Net Radiation and Soil Heat Flux

# (two very different days June 1991). (EFEDA data base)



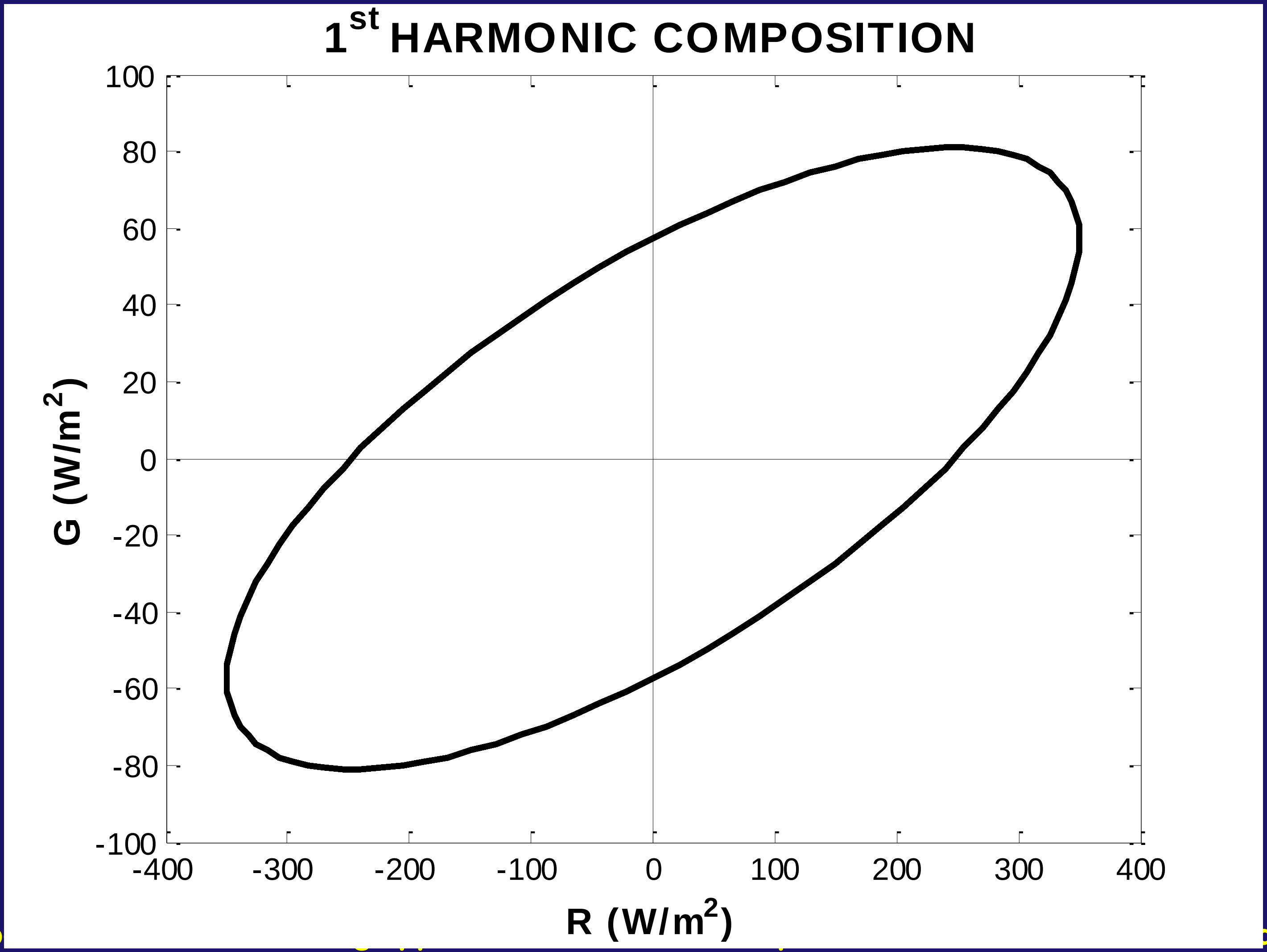



# Surface Net Radiation and Soil Heat Flux

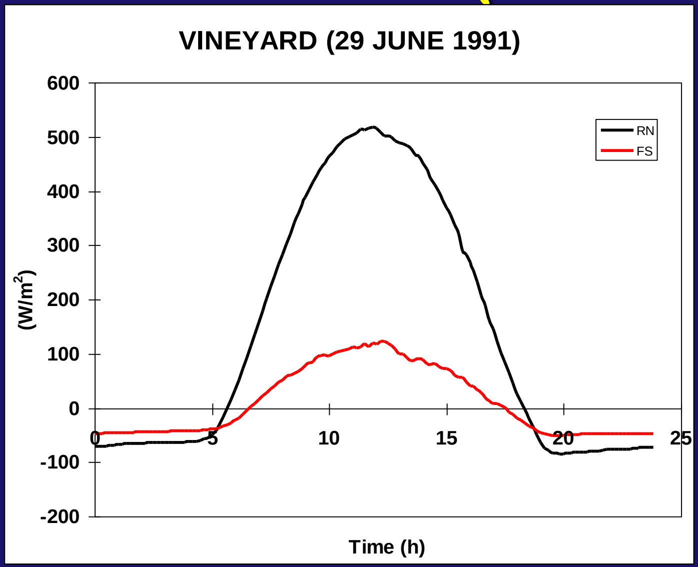
# (a generic behaviour, June 1991). Basic Physics!!!

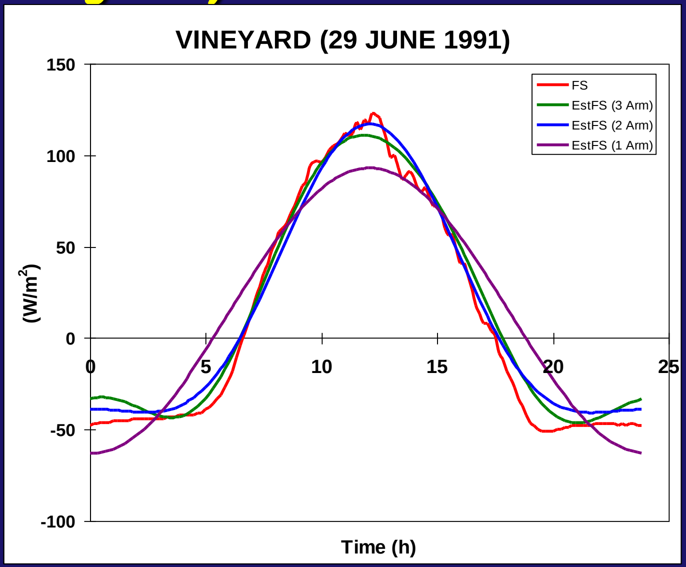


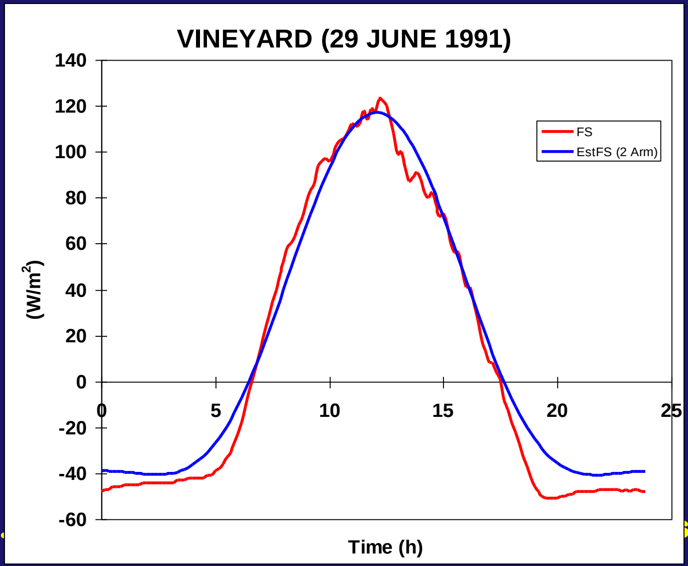

 

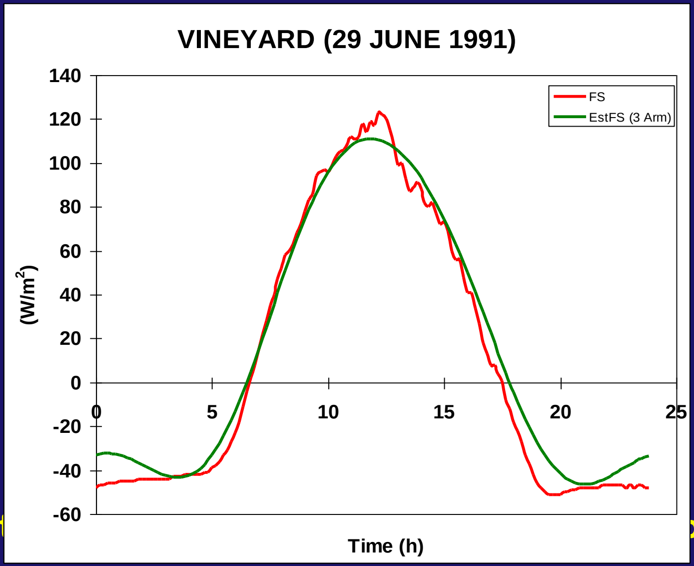
# Surface Net Radiation and Soil Heat Flux

# (Harmonic Analysis)

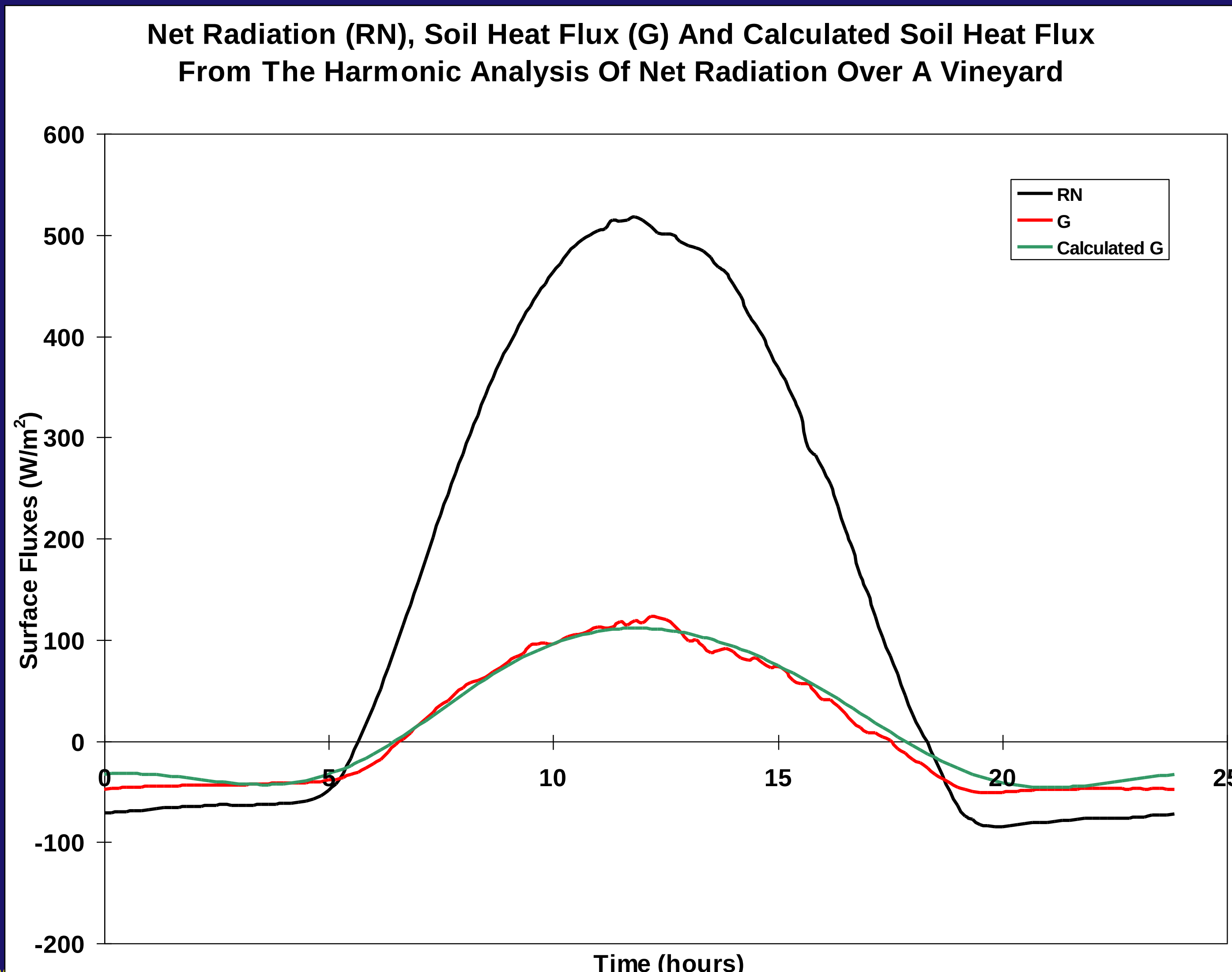


# Deriving Soil Heat Flux from Surface Net Radiation



# Extrapolation and Generalisation

- From point measurements to GERB net radiation data
- Parameterisation of surface type
    - Scene identification from SEVIRI
- Influence of soil moisture
    - Synergy with SMOS
- Extend to the other surface energy fluxes
    - Latent heat flux
    - Sensible heat flux
- Necessity of a suitable validation site
    - For example, the *Valencia Anchor Station* Site

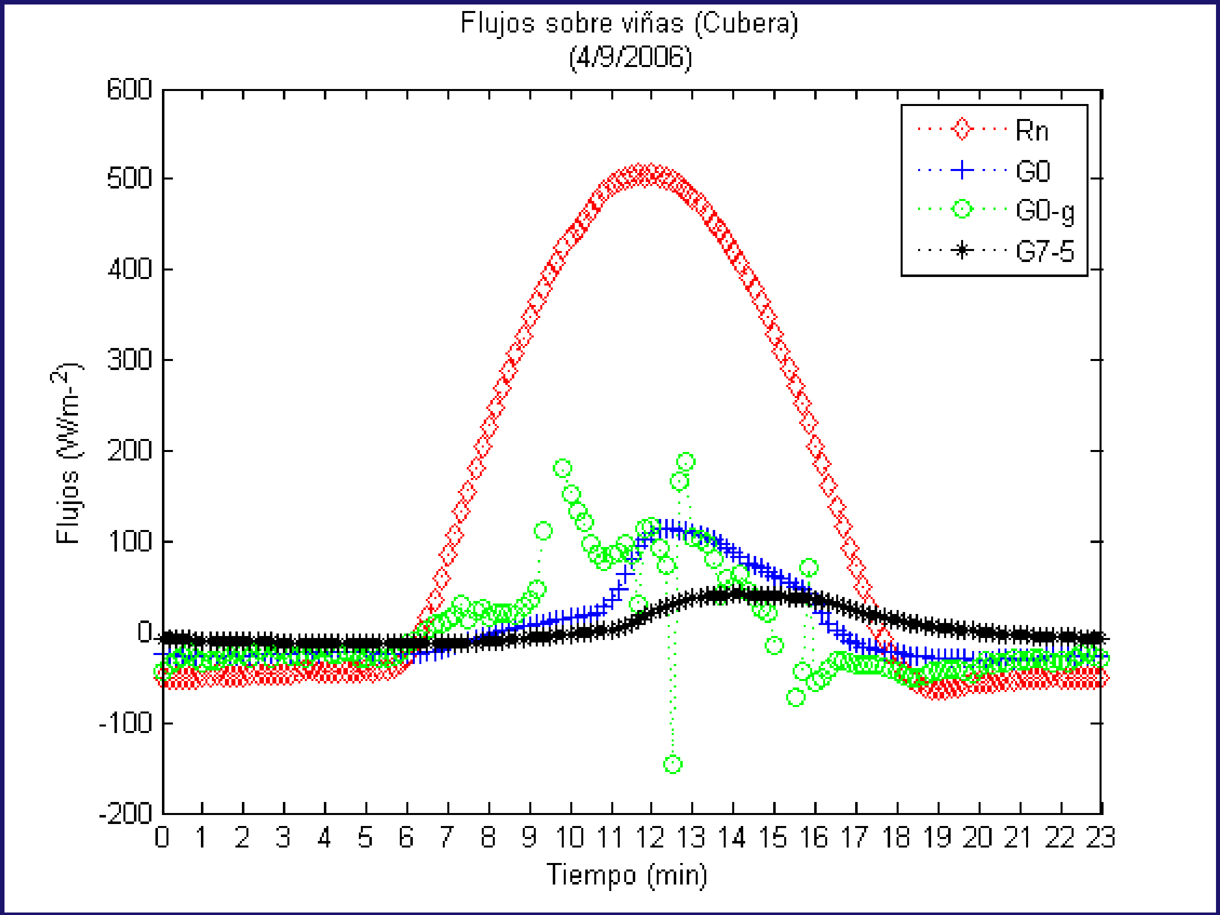
# Estimation of Surface Net Radiation from Operational Meteorological Measurements

# Why obtain surface net radiation

The knowledge of net radiation at the surface is of fundamental importance because it defines the total amount of energy available for the physical and biological processes that take place at the surface, such as evapotranspiration, air and soil warming ...


Usually, it is measured with net radiometers
but
they are expensive instruments, difficult to handle, require constant care and also involve periodic (and difficult???) calibration.

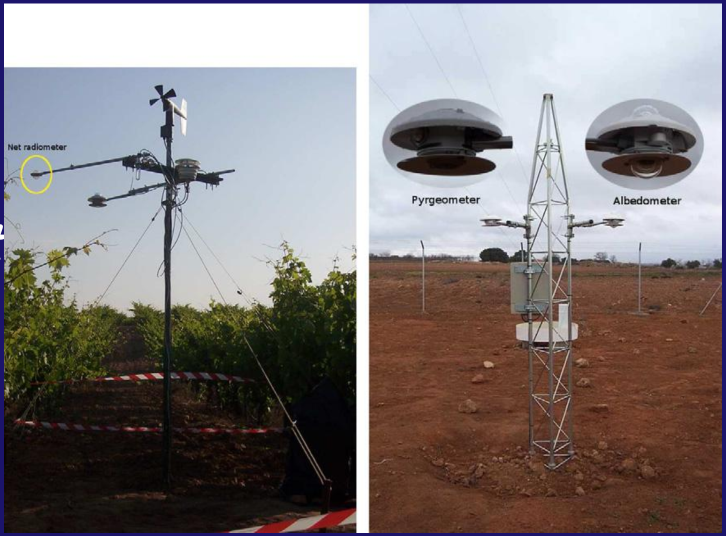
Develop a suitable methodology to estimate *Rn* at the surface using meteorological variables operationally measured at conventional meteorological stations




Using artificial neural networks

- input parameters meteorological quantities
- output parameter "*in situ*" *Rn* measurements from pyrradiometers

# Field Campaigns and Data Sets




vineyards & bare soil

*Data set 1 (FESEBAV 2007)* (*Field Experiment on Surface Energy Balance Aspects over the Valencia Anchor Station area*)

- 19th June to 18th September, 2007
- Mobile met station in a field of vines
    - Lat 39° 31' 23'' N Lon 1° 17' 22'' W, altitude of 796 m asl

# Field Campaigns and Data Sets

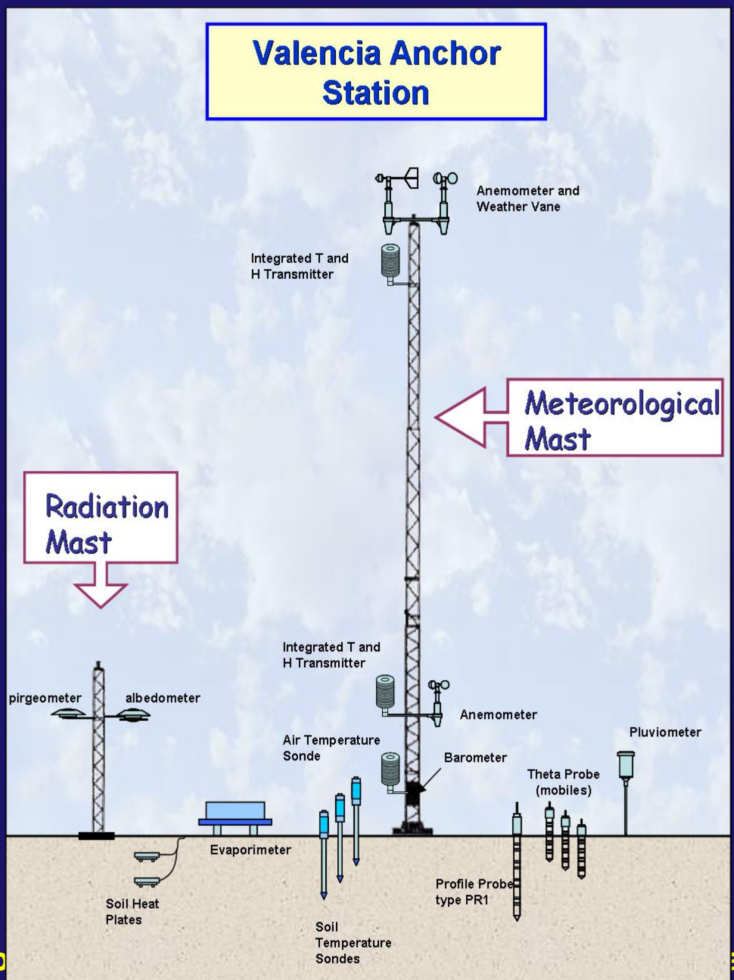
matorral

# Field Campaigns and Data Sets

vineyards & bare soil

*Data set 2 (VAS)* Valencia Anchor Station

- Lat 39° 34’ 15’’ N Lon 1° 17’ 18’’ W, altitude of 813 m asl




Change

*Estima*
*using a*
*approa*

*Antoni*
*Olivas,*
*Ernest*

**Table 3** Statistical values of the 10-min meteorological parameters utilized as input parameters in the ANN models for the training and validation set

| Meteorological parameters | Statistics | | | |
|---|---|---|---|---|
| | Min | Max | Mean | Std |
| Wind velocity (m s$^{-1}$) | 0.0 | 5.05 | 1.22 | 0.73 |
| Wind direction (deg) | 0.0 | 359.90 | 158.98 | 92.81 |
| Air temperature (°C) | 8.81 | 39.92 | 21.83 | 6.45 |
| Surface temperature (°C) | 10.63 | 61.91 | 28.85 | 13.12 |
| Soil temperature at 5 cm depth (°C) | 14.16 | 41.70 | 25.84 | 6.12 |
| Relative humidity (%) | 6.89 | 99.30 | 54.74 | 25.87 |
| Soil moisture at 5 cm depth (m$^3$ m$^{-3}$) | 0.07 | 0.29 | 0.09 | 0.03 |
| Soil heat flux at depth of 7.5 cm (W m$^{-2}$) | −22.54 | 50.68 | −8.49 | 18.46 |
| Net radiation[a] (W m$^{-2}$) | −73.33 | 741.30 | 144.94 | 231.24 |

*Min* minimum, *Max* maximum, *Std* standard deviation

[a] Net radiation was considered as output parameter in the ANN models

**Theoretical and Applied Climatology**

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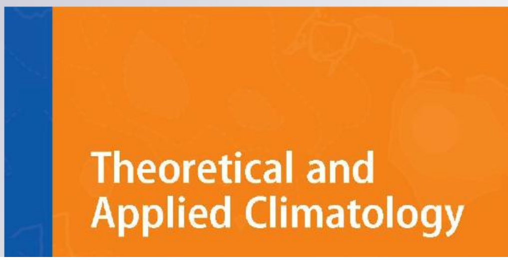
Theor Appl Climatol
DOI 10.1007/s00704-011-0488-7




. WS: Wind speed; AT: air temperature;
idity; RN: net radiation.

| ) | AP (mb) | RH (%) | RN (W/m$^2$) |
|---|---|---|---|

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journal homepage: www.elsevier.com/locate/eswa

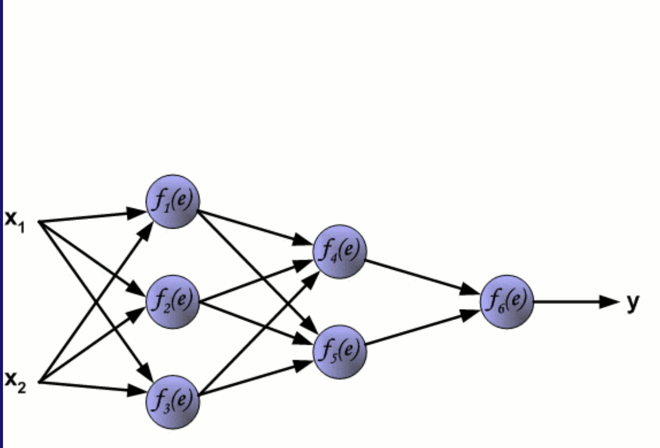

# Modelling net radiation at surface using "*in situ*" netpyrradiometer measurements with artificial neural networks ☆

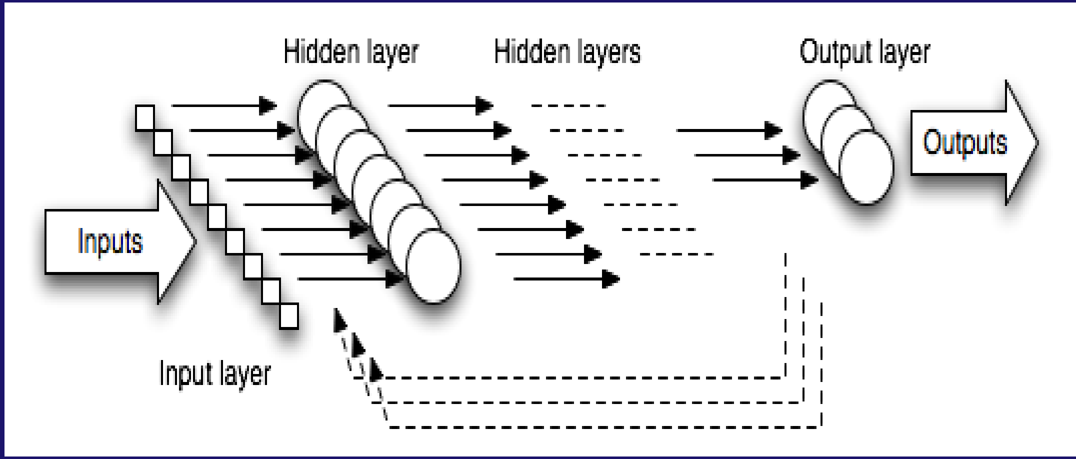
Antonio Geraldo-Ferreira [a,b], Emilio Soria-Olivas [c], Juan Gómez-Sanchis [c,*], Antonio José Serrano-López [c], Almudena Velázquez-Blazquez [d], Ernesto López-Baeza [b]

# Methodology

The neural network used in this work is the **Multi-Layer Perceptron (MLP)**

A layered arrangement of individual computation units known as artificial neurons. Neurons from a specific network are grouped together in layers that form a fully connected network. The first layer contains the input nodes, which are usually fully connected to hidden neurons and these are, in turn, connected to the output layer.




Scheme of a fully-connected multilayer perceptron. *In our case, only one output neuron is necessary, since only one variable (net radiation) is predicted at each time.*

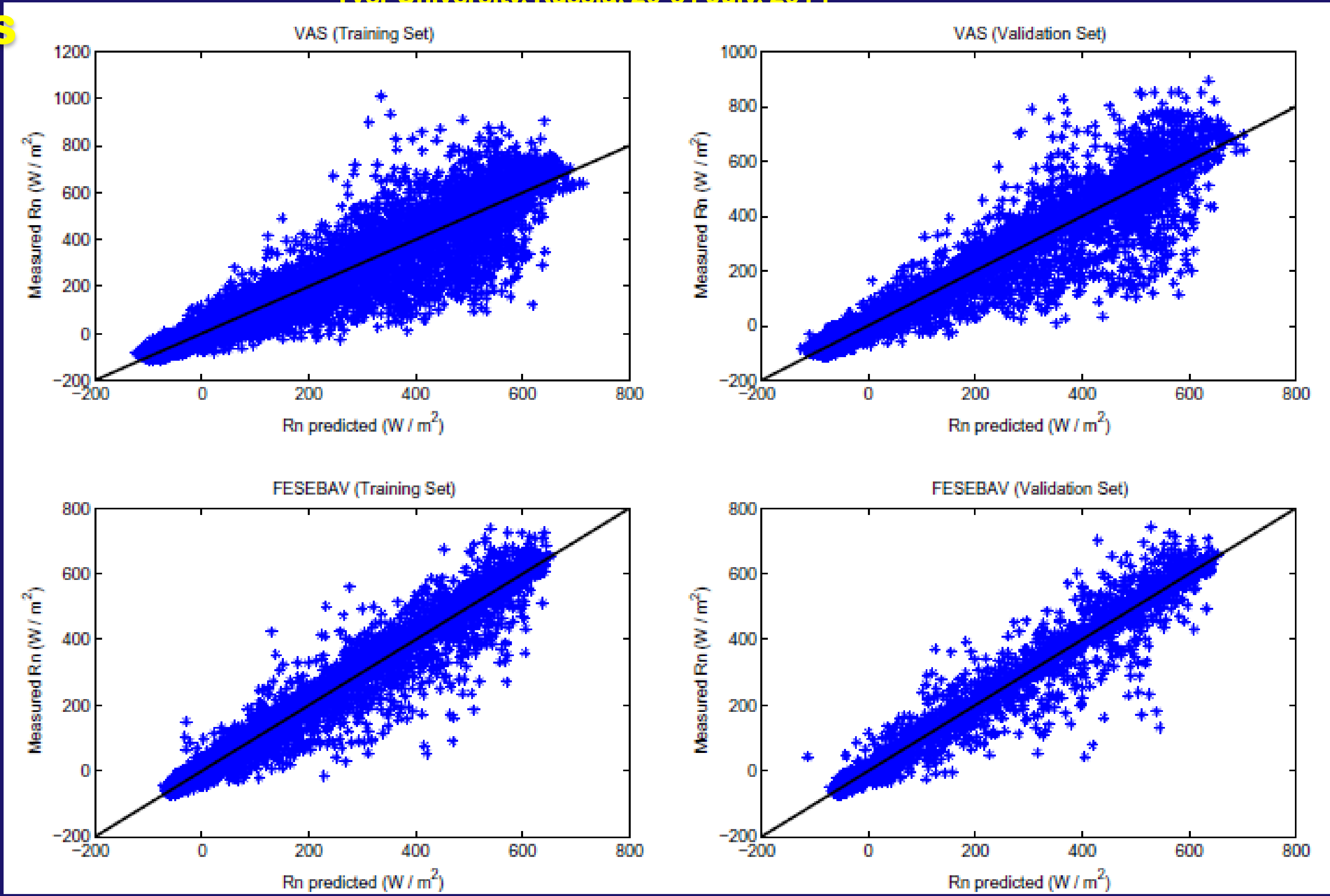
## Input variables

- wind speed
- air temperature
- atmospheric pressure
- relative humidity

## Output variable

- net radiation measured at the surface

# Results




Linear regression between net radiation predicted by the neural network model vs actual measured values of surface net radiation

# Results

**Table 2**
Performance indices for FESEBAV data set.

| FESEBAV data set | MAE ($W/m^2$) | RMSE ($W/m^2$) | ME ($W/m^2$) | *a* | *b* |
|---|---|---|---|---|---|
| Training set $N = 8832$ | 19.46 | 35.56 | −0.38 | 0.97 | 3.73 |
| Validation set $N = 4416$ | 21.65 | 39.88 | 0.027 | 0.97 | 4.46 |

**Table 3**
Performance indices for VAS data set.

| VAS data set | MAE ($W/m^2$) | RMSE ($W/m^2$) | ME ($W/m^2$) | *a* | *b* |
|---|---|---|---|---|---|
| Training set $N = 15,744$ | 34.55 | 61.36 | 0.65 | 1.00 | 0.30 |
| Validation set $N = 7872$ | 36.47 | 65.07 | −0.26 | 0.99 | 0.46 |

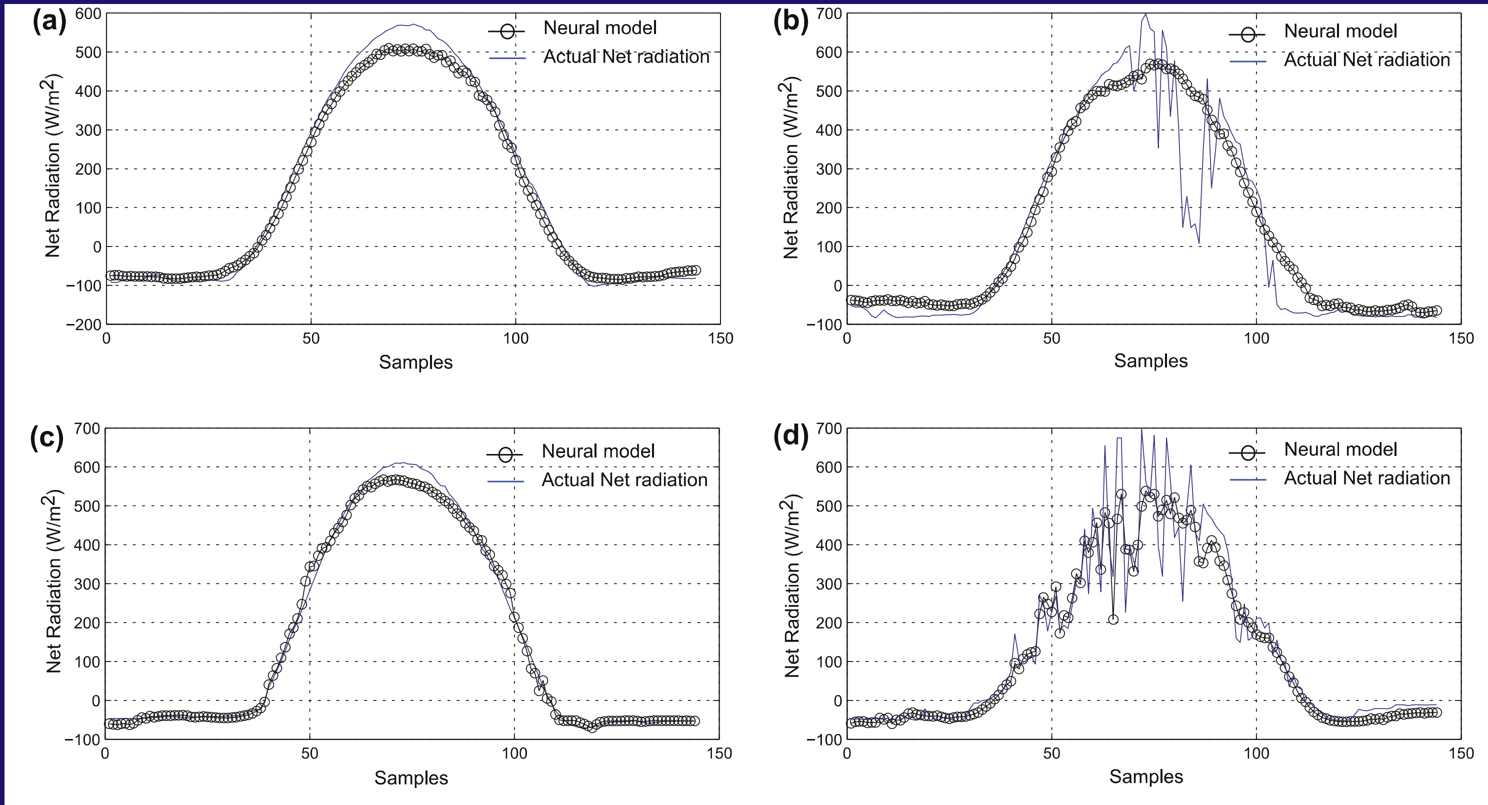



**Fig. 5.** Measured Rn values (···) and neural model prediction (-o-) for: (a) cloudy free-day, 2-7-2007, VAS data set; (b) cloudy day, 21-5-2007, VAS data set; (c) cloudy free-day, 15-8-2007, FESEBAV data set; (d) cloudy day, 26-6-2007, FESEBAV data set.

# Results

Performance indices in sunny/cloudy days.

| | MAE ($W/m^2$) | RMSE ($W/m^2$) | ME ($W/m^2$) |
|---|---|---|---|
| *FESEBAV data set* | | | |
| Cloudy days *N* = 8784 | 24.74 | 43.85 | 0.44 |
| Sunny days *N* = 4464 | 11.41 | 17.21 | −1.17 |
| *VAS data set* | | | |
| Cloudy days *N* = 17,712 | 41.64 | 71.46 | −0.34 |
| Sunny days *N* = 5904 | 15.84 | 22.38 | 2.41 |

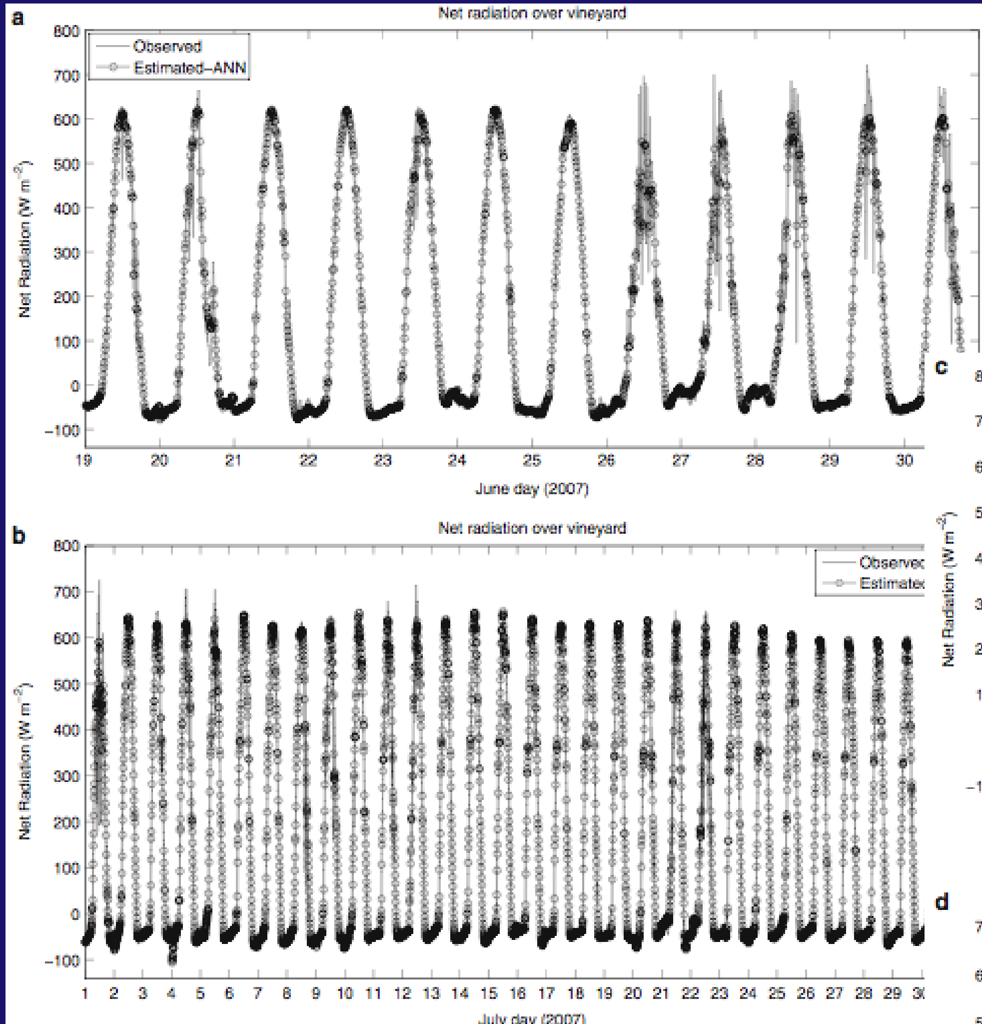



Fig. 7 Ten-minute $R_n$ averages measured (*lines*) and calculated by the ANN model (*dots*) for: a June 2007, b July 2007, c August 2007, and d September 2007

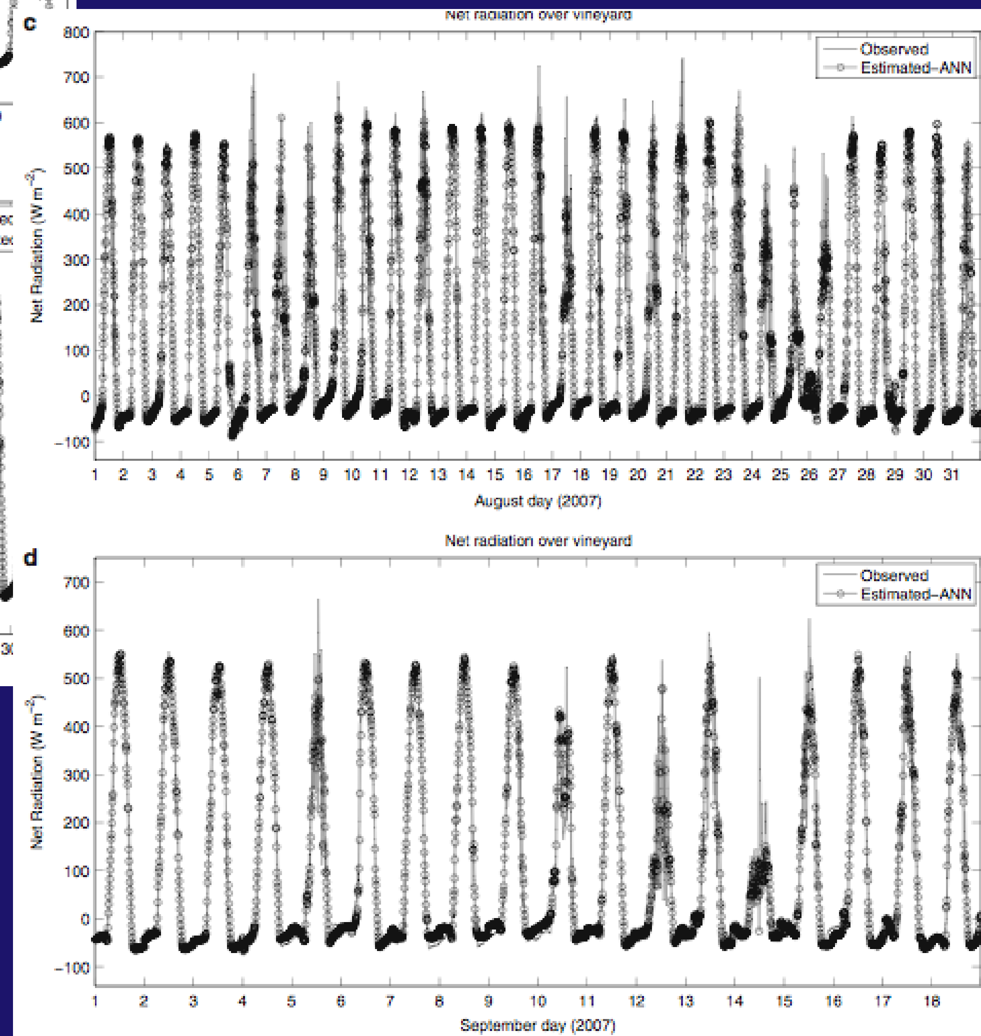
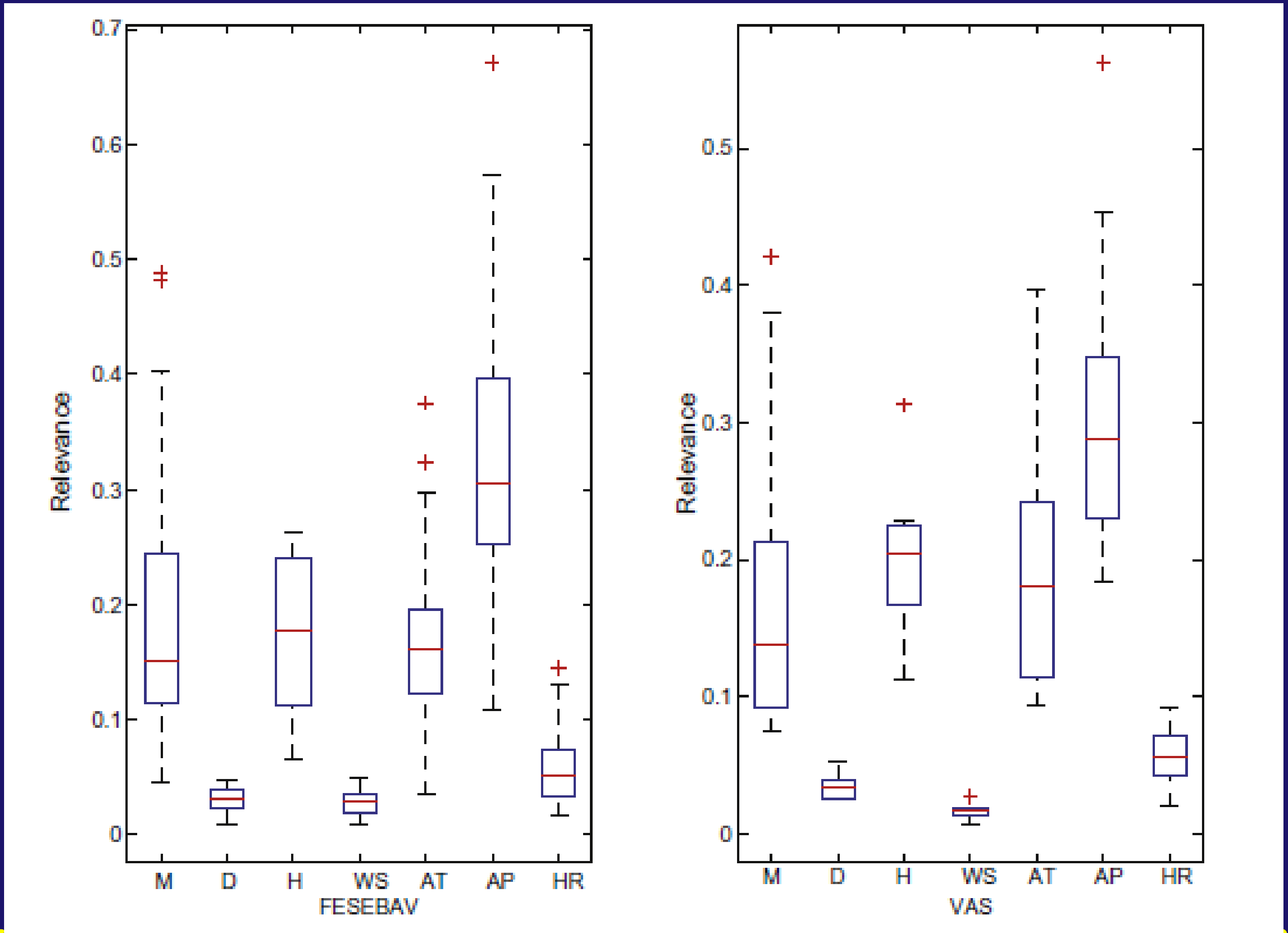



Fig. 7 (continued)

# Results

## Sensitivity Analysis

Relevance of input variables. The inputs are: Month (M), Day (D), Hour (H), wind speed, air temperature, atmospheric pressure and relative humidity.



# Partial conclusions

- Ability of neural models to replace (to an acceptable error) the use of radiometers for the measurement of surface net radiation, from conventional operational met parameters
  (earlier we had tried with more variables)

- A sensitivity analysis shows the relevance of the input variables
  atmospheric pressure being more relevant

- Need to be done for other surface types

# Derivation of surface net radiation from top of the atmosphere GERB fluxes by means of linear models and neural networks

# Motivation

Provide an improved method for estimating $R_N$ at surface, covering totally the diurnal cycle of $R_N$, with high temporal resolution (15 min)

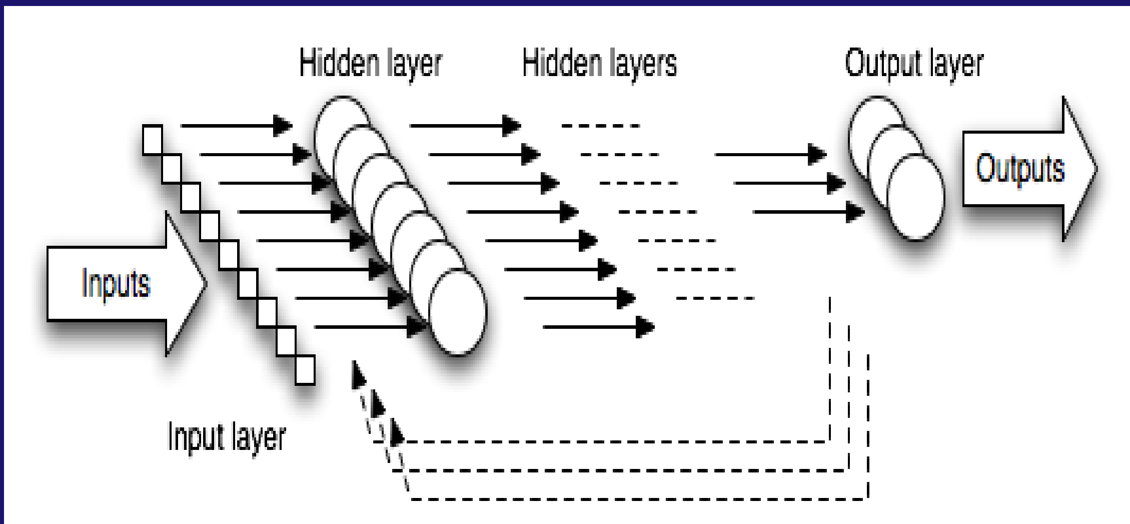
# Data used

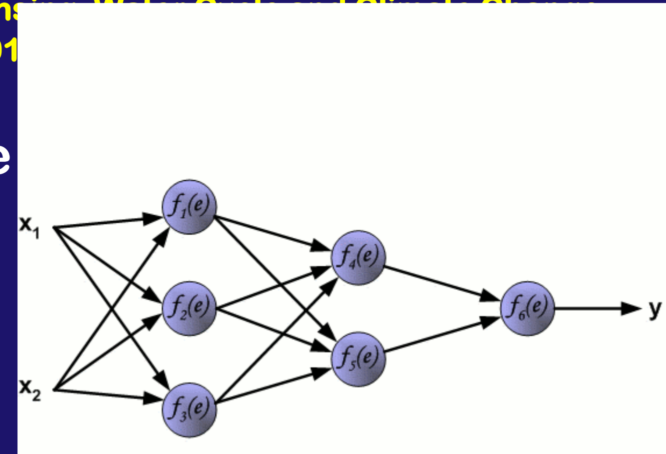
| Input variables | Output variable |
| --- | --- |
| • GERB (Geostationary Earth Radiation Budget) TOA fluxes<br>  • TOT Channel [0.32 µm - 100.0 µm]<br>  • SW Channel [0.32 µm to 4.0 µm ])<br>  • LW = TOT – SW | • net radiation measured at the surface<br>  • Valencia Anchor Station (bare soil)<br>    • 31st July – 6th August, 2006 & 19th June – 18th August 2007<br>  • FESEBAV<br>    • matorral<br>      • 31th July - 5th August, 2006<br>    • vineyard<br>      • 19th June - 18th September, 2007 |

In order to have the same temporal resolution, in situ measurements (10 min frequency) were linearly interpolated to the hour of the satellite image acquisition (15 min frequency)

# Methodology

The neural network used in this work is also the **Multi-Layer Perceptron (MLP)**.




Scheme of a fully-connected multilayer perceptron. *In our case, only one output neuron is necessary, since only one variable (net radiation) is predicted at each time.*

All sky conditions -both cloudy days and cloudy free-days- were considered in the analysis. Three **input variables** were selected for the neural network model (**solar zenith angle (SZA), TOA shortwave and longwave fluxes**). The objective or **output variable** was **Net Radiation** measured at surface.

## Input variables

- **SZA,TOA SW & LW fluxes**

## Output variable

- **net radiation** measured at the surface

From the GERB-1 and VAS data set, independent parts are used to train and validate the AAN model, and a Multivariate Linear Regression (MLR) model used as reference for comparison with the AAN model

# Results

## Statistical values of the input parameters to the ANN and MLR models for the training / validation set

| Parameters | Basic Statistics for VAS data set | | | | |
|---|---|---|---|---|---|
| | Minimum | Maximum | Mean | Std | N |
| Shortwave flux at TOA (W $m^{-2}$) | 0 | 715.81 | 103.70 | 117.22 | 6399 |
| Longwave flux at TOA (W $m^{-2}$) | 125.56 | 350.69 | 284.85 | 26.14 | 6399 |
| Net radiation at surface (W $m^{-2}$) | -113.0 | 713.50 | 117.58 | 224.08 | 6399 |

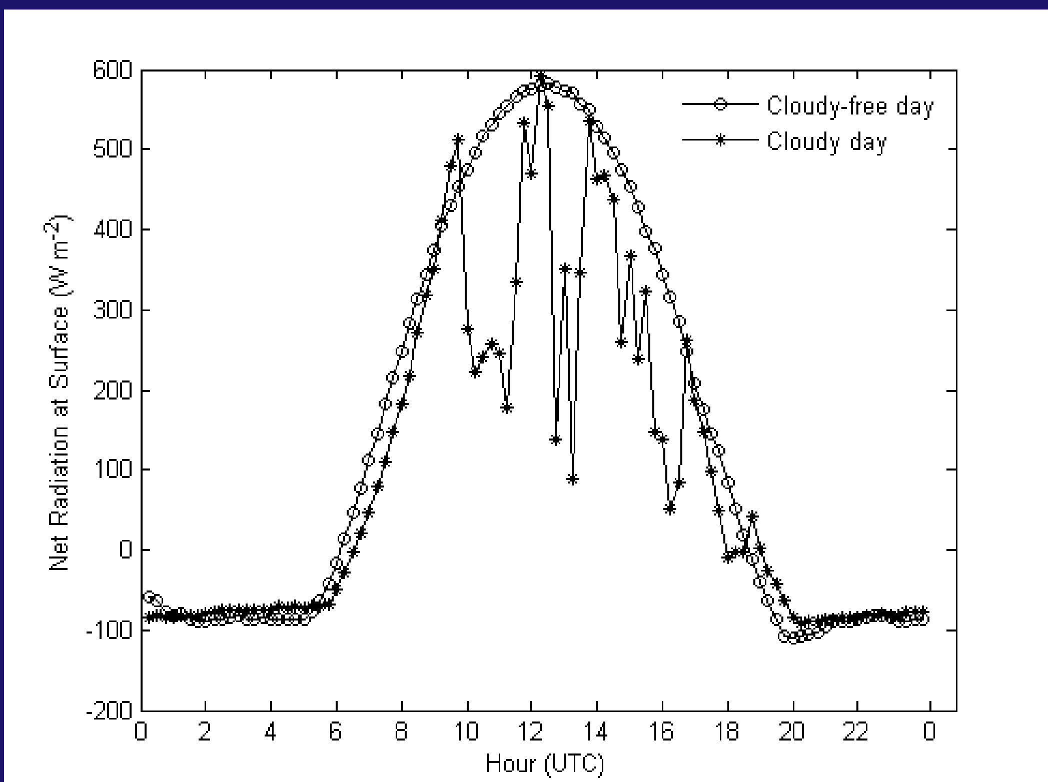



**Figure shows the diurnal course of $R_N$ for two typical days with and without clouds. The diurnal cycle of $R_N$ in cloudy-free days shows a regular form but it is irregular in cloudy days.**

**Observed diurnal course of net radiation at VAS for two different days: 22nd July (cloudy day) and 12th August,2007 (cloudy-free day)**

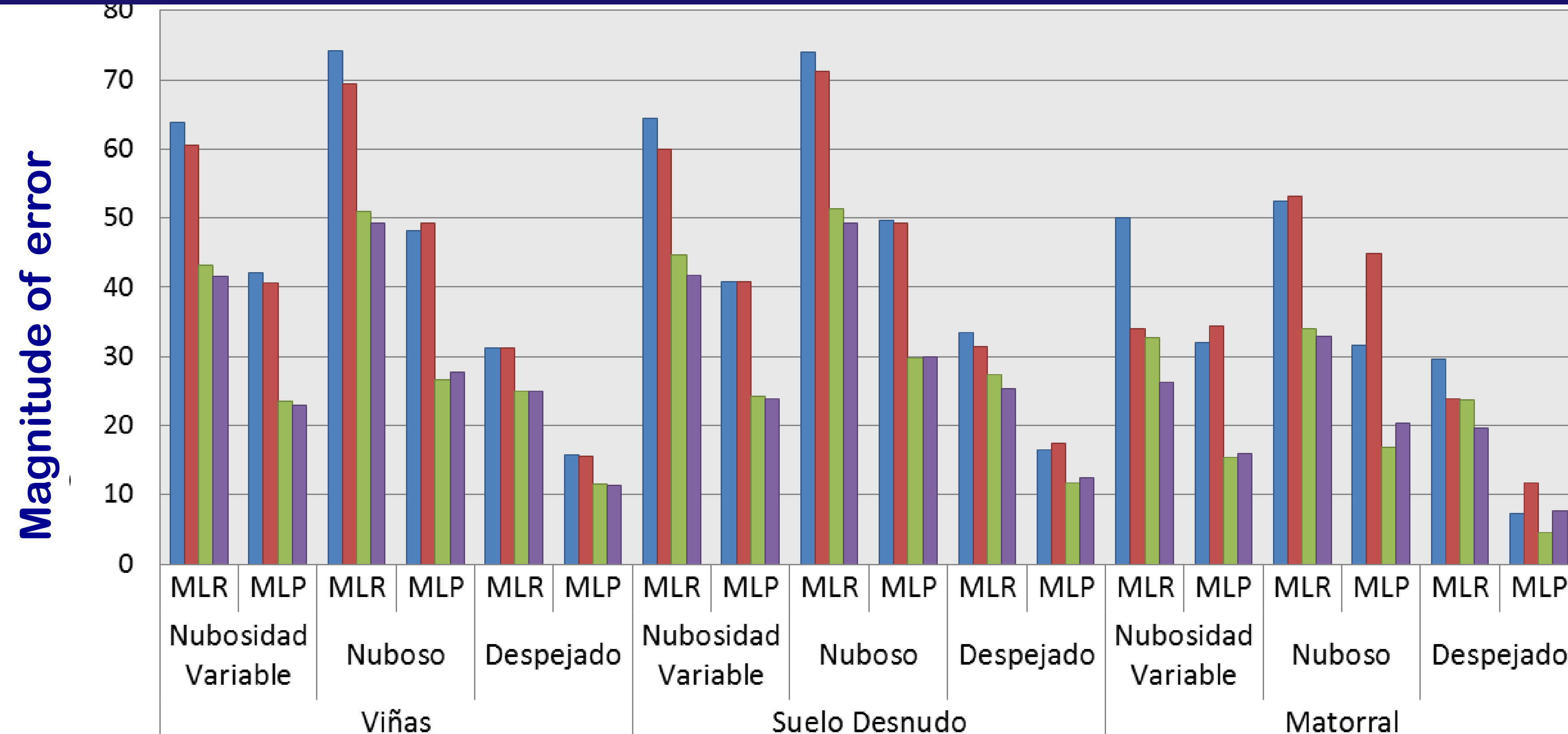
# Results

**MLR: Multivariate Linear Regression Model**

| Land uses | Sky conditions | $R_n = \beta_0 + \beta_1 SZA + \beta_2 SW + \beta_3 LW$ | | | | Statistical | N |
|---|---|---|---|---|---|---|---|
| | | $\beta_0$ | $\beta_1$ | $\beta_2$ | $\beta_3$ | $R^2$ | |
| VINEYARDS | *Overall Conditions* | 344,46 | -210,27 | -42,88 | 16,37 | 0,89 | 5735 |
| | *Cloudy days* | 335,79 | -202,79 | -46,33 | 20,52 | 0,86 | 3862 |
| | *Cloudless days* | 367,61 | -137,12 | 62,19 | -3,96 | 0,97 | 1873 |
| BARE SOIL | *Overall Conditions* | 295,46 | -196,19 | -51,64 | 2,67 | 0,87 | 6399 |
| | *Cloudy days* | 288,20 | -200,12 | -57,65 | 0,78 | 0,84 | 4245 |
| | *Cloudless days* | 307,79 | -154,98 | 9,16 | 7,29 | 0,96 | 2154 |
| SCRURB | *Overall Conditions* | 367,39 | -126,37 | 18,79 | 91,75 | 0.93 | 472 |
| | *Cloudy days* | 350,19 | -106,74 | 25,66 | 112,69 | 0.93 | 288 |
| | *Cloudless days* | 410,71 | 64,61 | 213,14 | 39,72 | 0.98 | 184 |

# Results

## Error indices -both for MLP and MLR- as well as the standard deviation of the models results for the training and validation data sets




| | Viñas | | | | | | Suelo Desnudo | | | | | | Matorral | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Nubosidad Variable | | Nuboso | | Despejado | | Nubosidad Variable | | Nuboso | | Despejado | | Nubosidad Variable | | Nuboso | | Despejado | |
| | MLR | MLP | MLR | MLP | MLR | MLP | MLR | MLP | MLR | MLP | MLR | MLP | MLR | MLP | MLR | MLP | MLR | MLP |
| RMSE_entr | 63,90 | 42,03 | 74,11 | 48,26 | 31,24 | 15,73 | 64,32 | 40,81 | 73,92 | 49,62 | 33,41 | 16,45 | 50,05 | 32,01 | 52,33 | 31,53 | 29,52 | 7,30 |
| RMSE_valid | 60,45 | 40,71 | 69,43 | 49,31 | 31,23 | 15,52 | 60,03 | 40,79 | 71,15 | 49,30 | 31,33 | 17,50 | 33,94 | 34,38 | 53,15 | 44,79 | 23,93 | 11,64 |
| MAE_entr | 43,16 | 23,48 | 50,90 | 26,64 | 24,90 | 11,58 | 44,61 | 24,22 | 51,39 | 29,84 | 27,40 | 11,74 | 32,70 | 15,41 | 34,04 | 16,81 | 23,70 | 4,54 |
| MAE_valid | 41,58 | 22,93 | 49,34 | 27,66 | 24,95 | 11,25 | 41,82 | 23,88 | 49,36 | 29,89 | 25,43 | 12,42 | 26,17 | 15,95 | 32,84 | 20,29 | 19,63 | 7,66 |

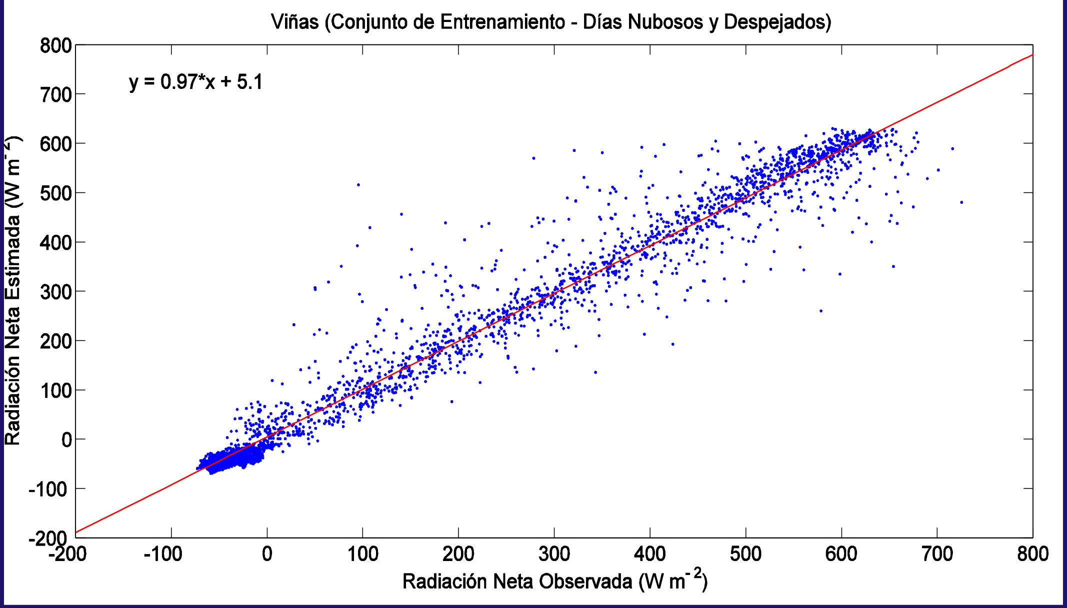
The neural models performance is better than that obtained for the linear models

**RMSE: Root mean square error; MAE: Mean Absolute Error; ME: Mean Error**

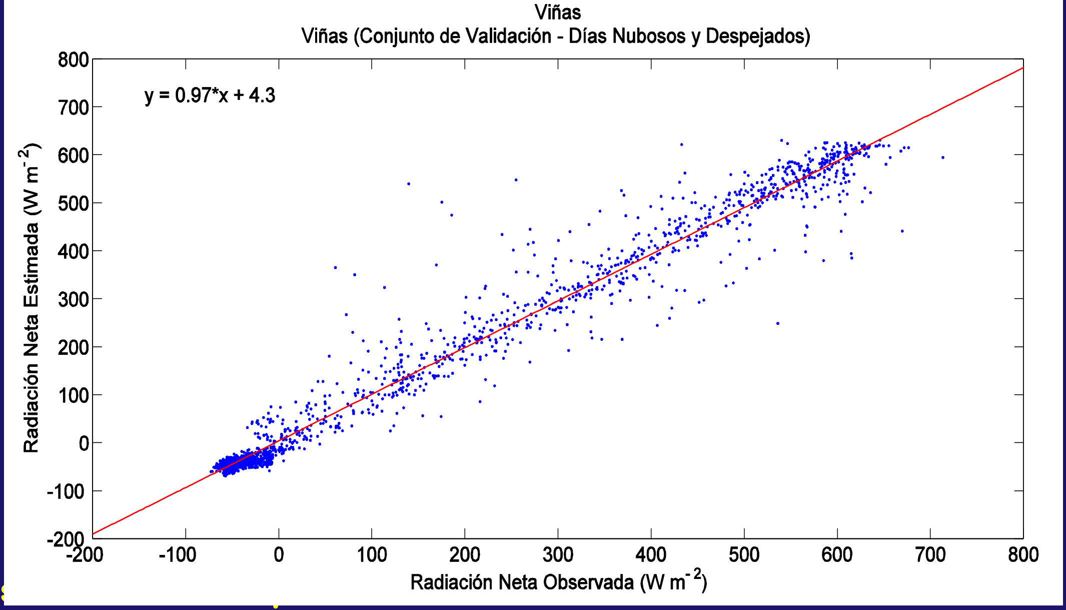
# Results Scatter plots between $R_N$ estimated by MLP and $R_N$ measured in situ for training and validation set, considering:

## Land use: Vineyards

## All-sky conditions




Training set



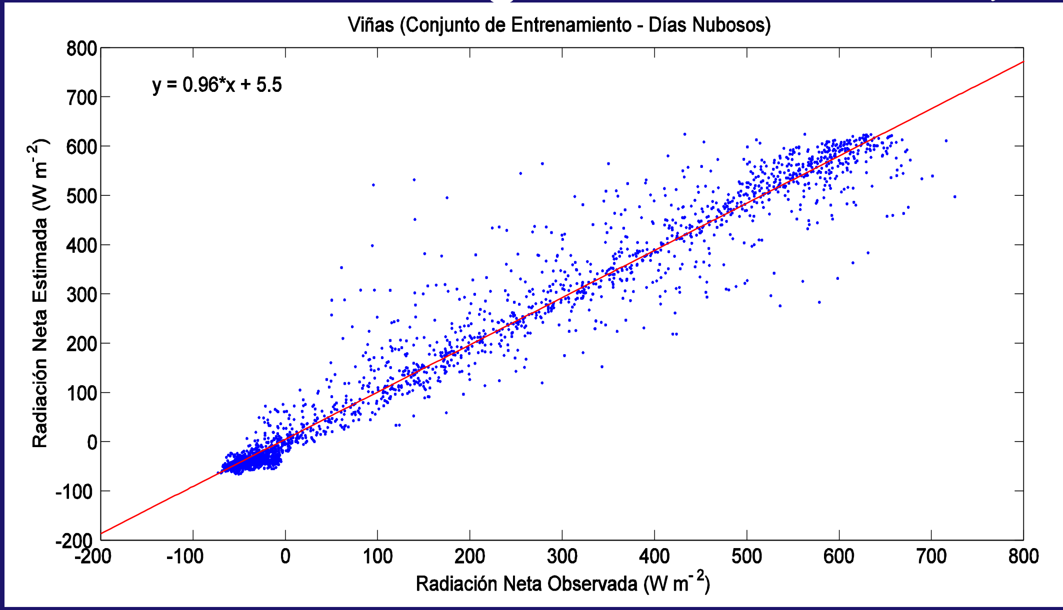

Validation set

# Results

## Scatter plots between $R_N$ estimated by MLP and $R_N$ measured in situ for training and validation set, considering:

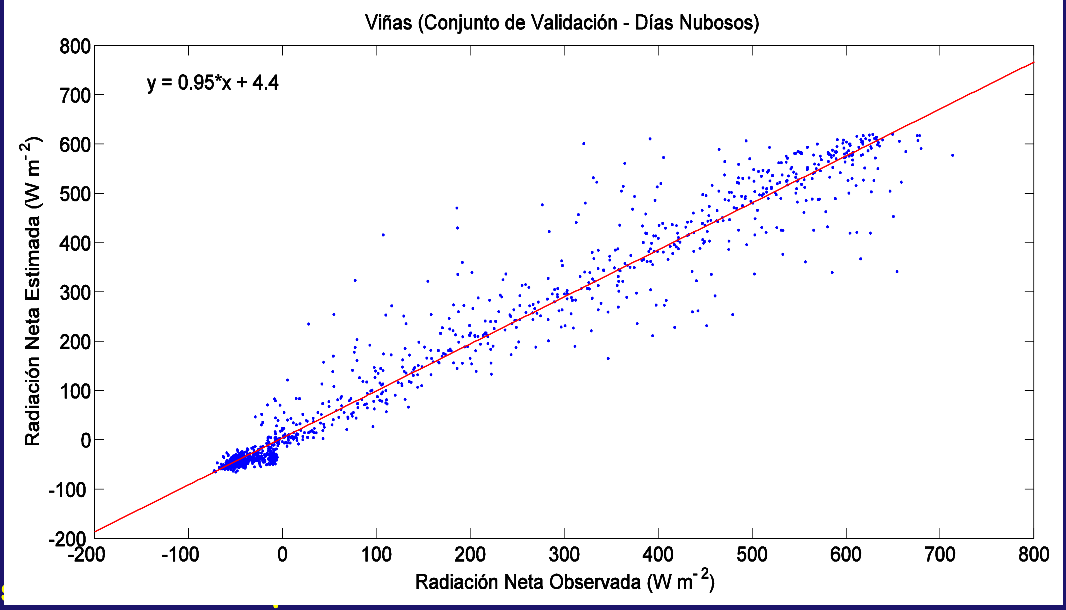
**Land use: Vineyards**

**Cloudy conditions**




Training set

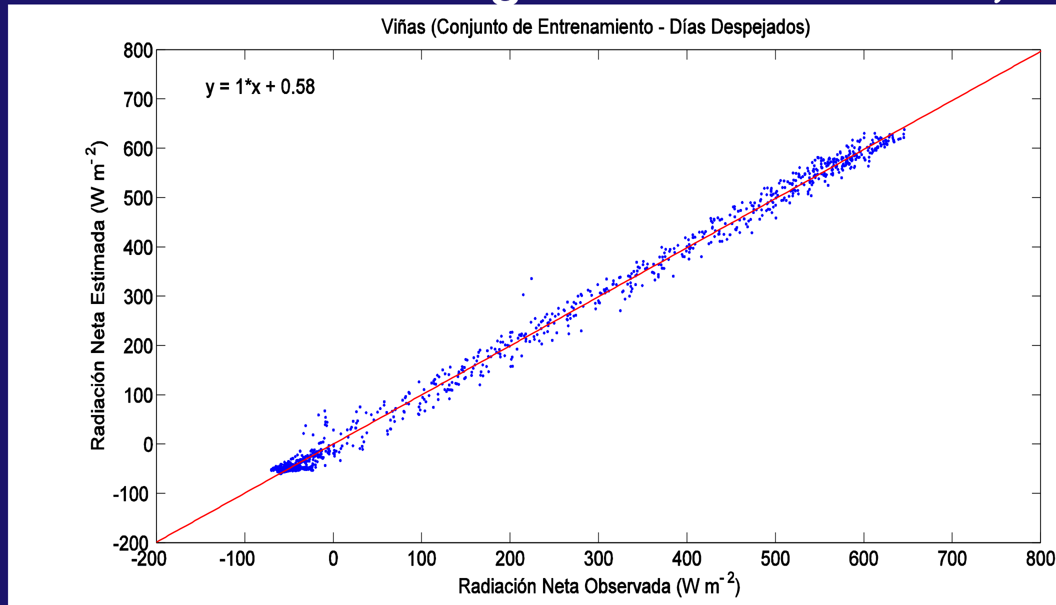
Validation set



# Results Scatter plots between $R_N$ estimated by MLP and $R_N$ measured in situ for training and validation set, considering:

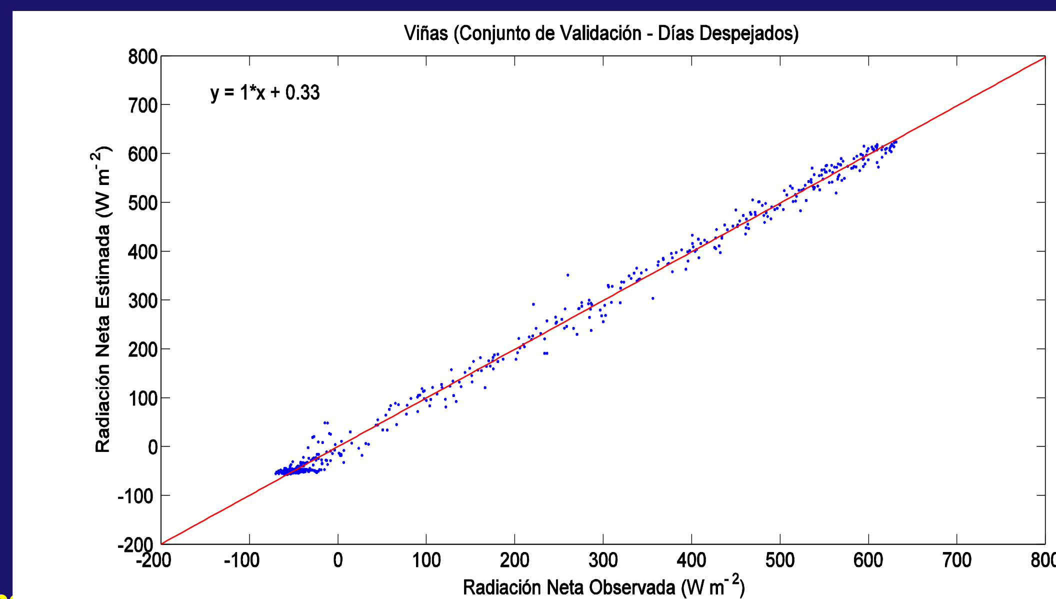
## Land use: Vineyards

## Clear-sky conditions




Training set

Validation set

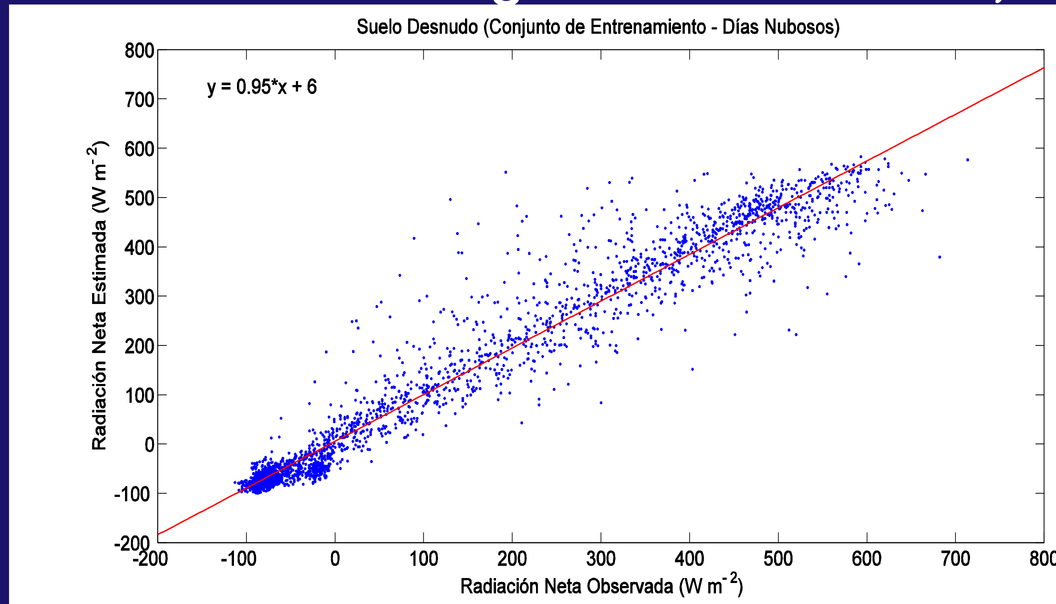


# Results

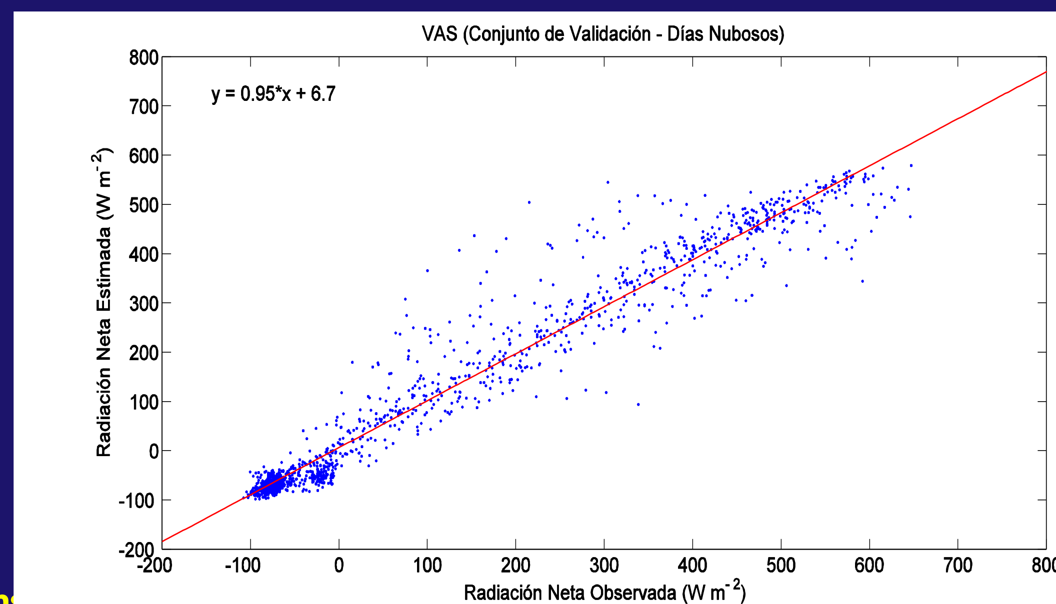
Scatter plots between $R_N$ estimated by MLP and $R_N$ measured in situ for training and validation set, considering:

**Land use: Bare soil**

**All-sky conditions**




Training set



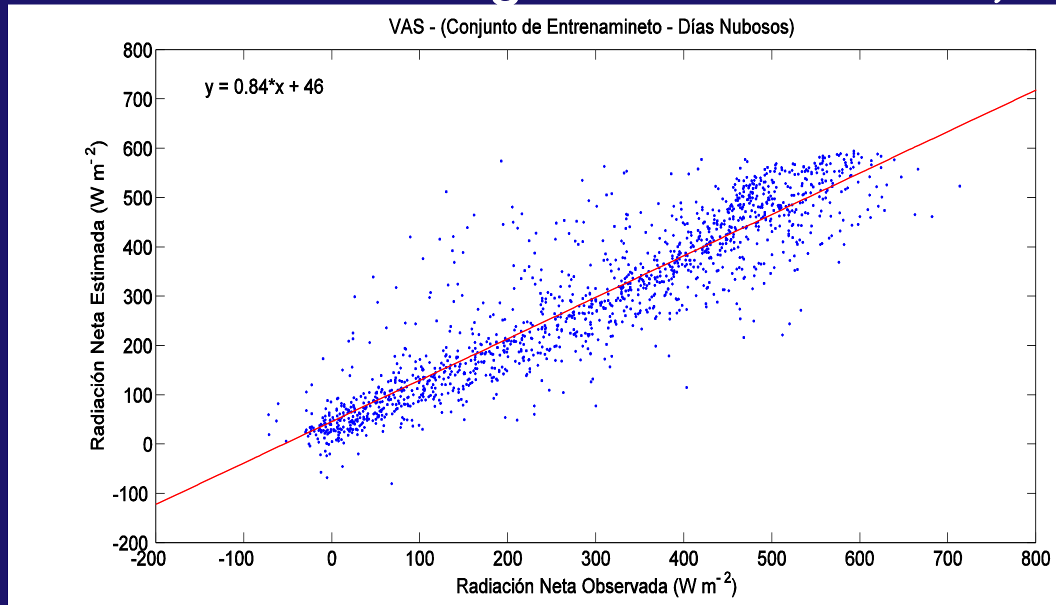

Validation set

# Results

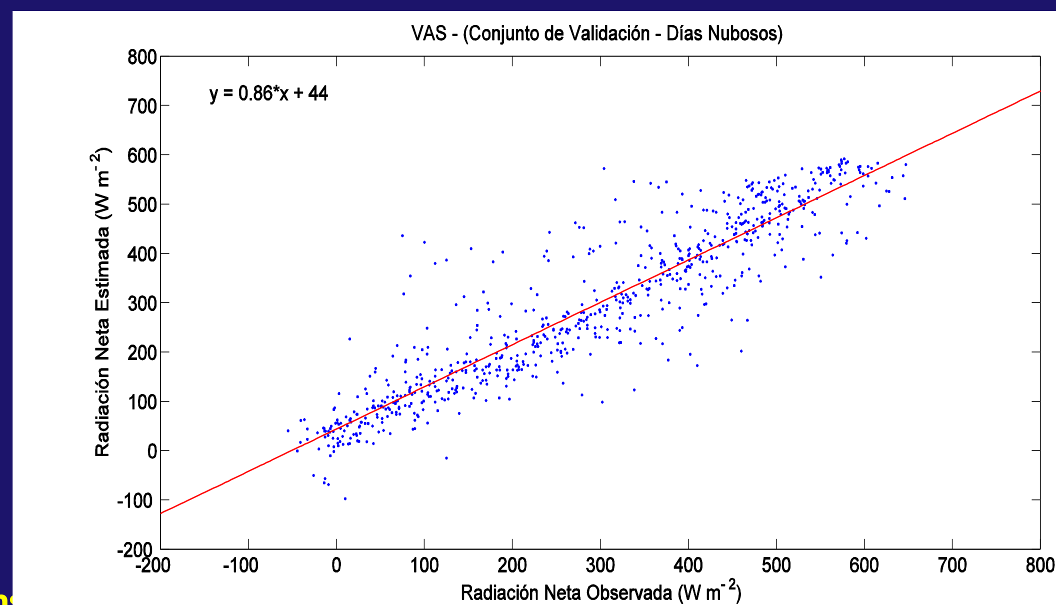
## Scatter plots between $R_N$ estimated by MLP and $R_N$ measured in situ for training and validation set, considering:

**Land use: Bare soil**

**Cloudy conditions**




Training set



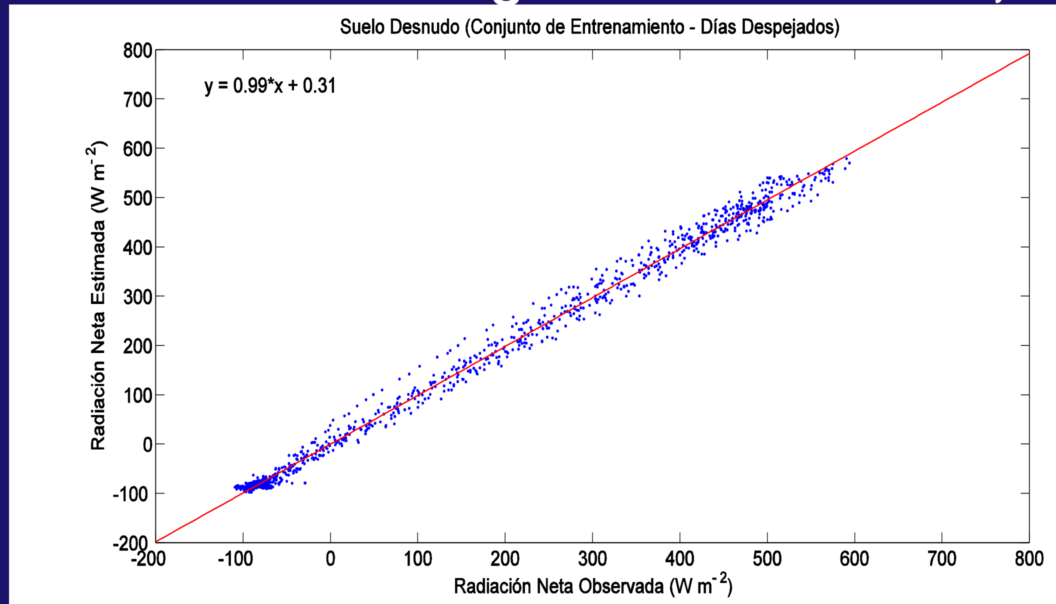

Validation set

# Results

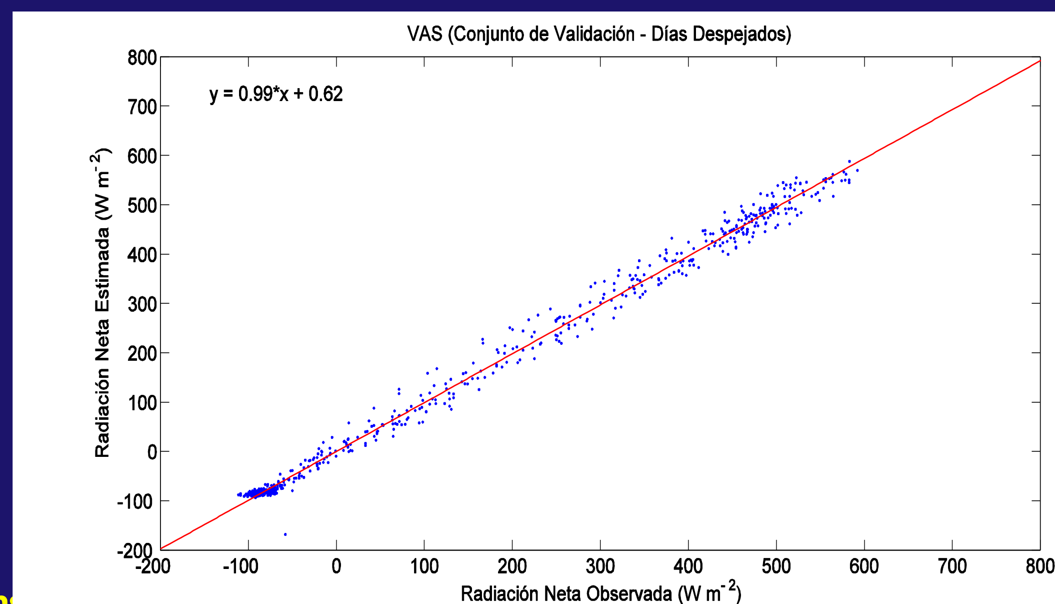
Scatter plots between $R_N$ estimated by MLP and $R_N$ measured in situ for training and validation set, considering:

**Land use: Bare soil**

**Clear-sky conditions**



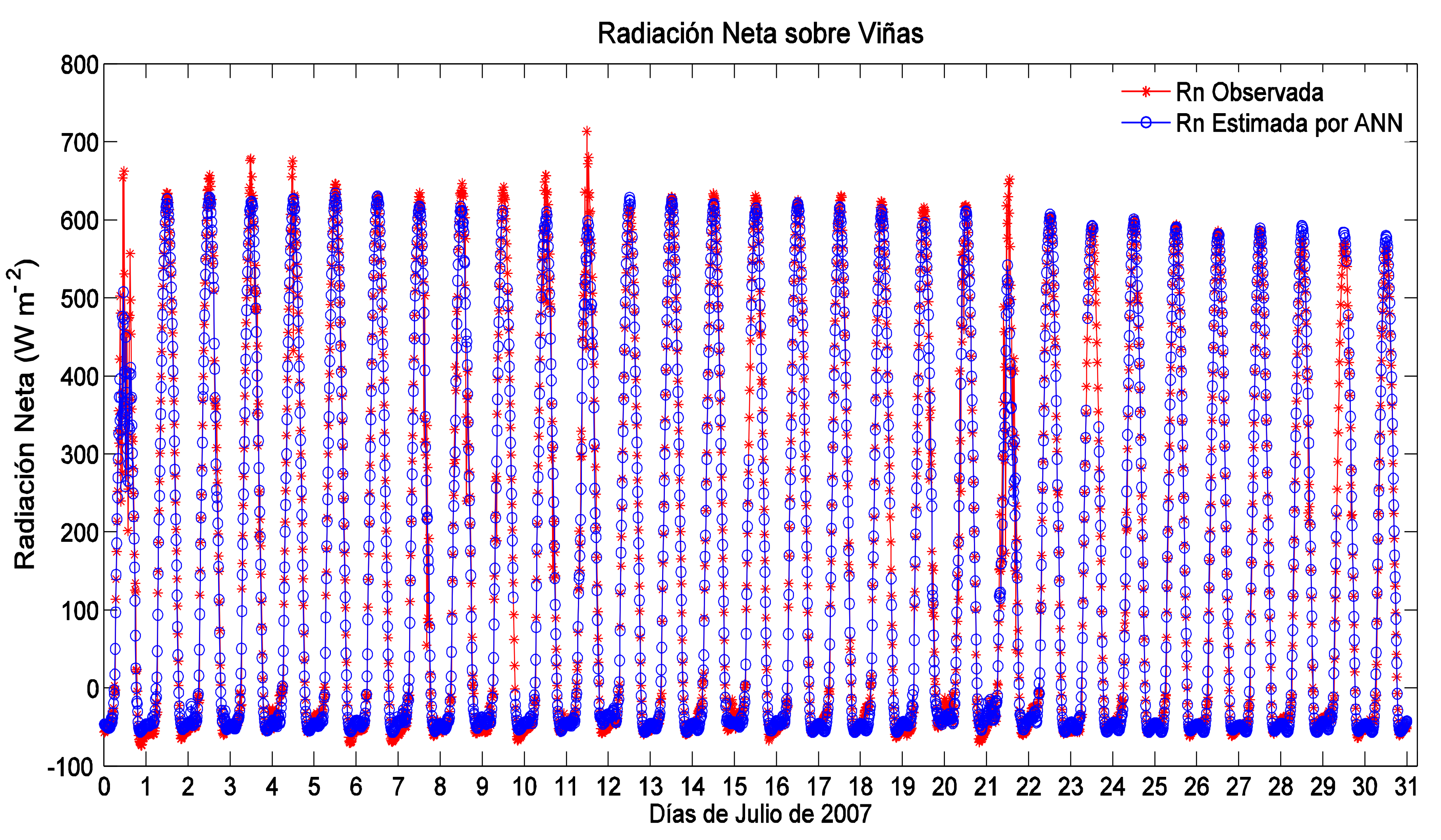

Training set




Validation set

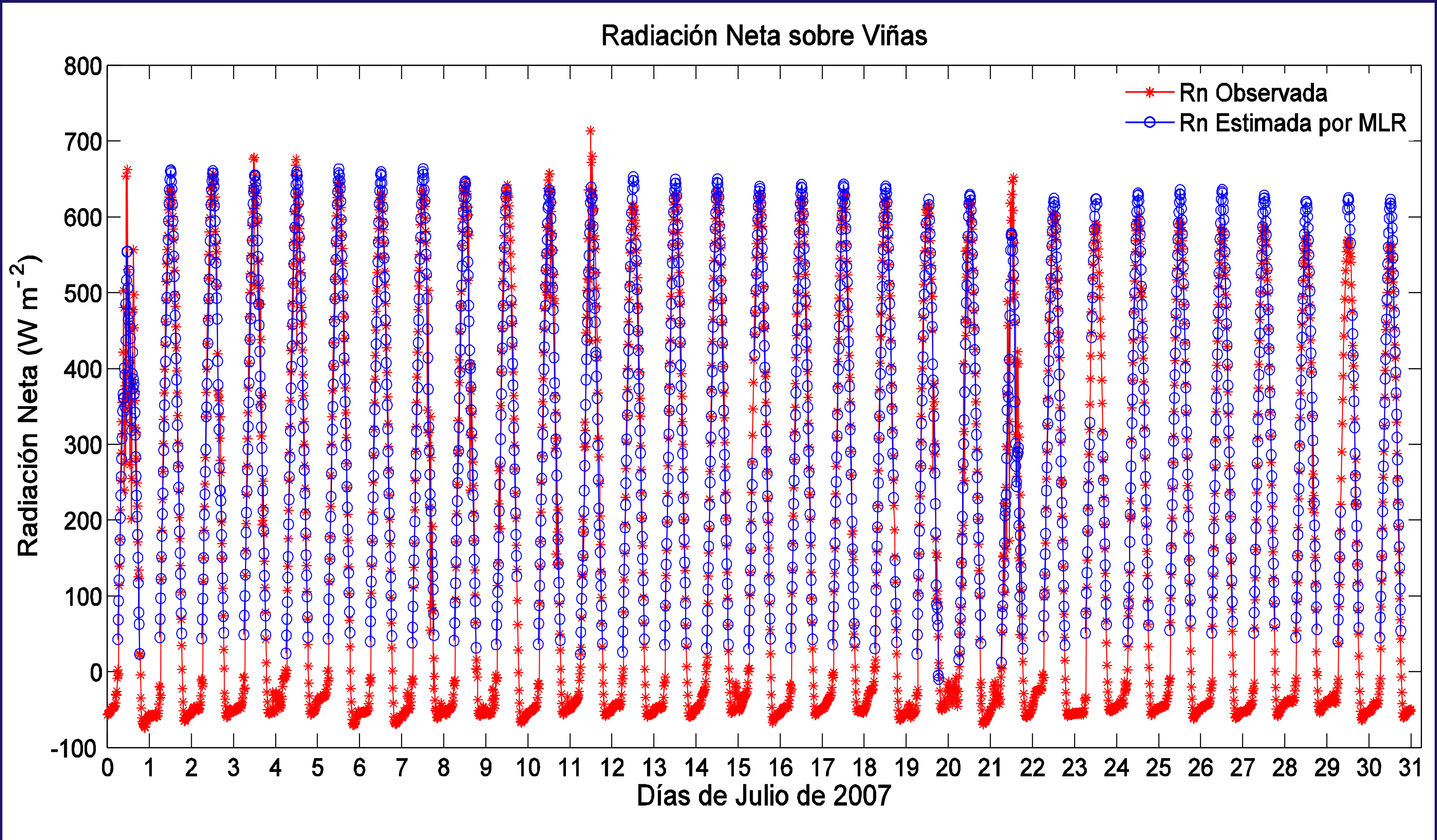
# Results

## Diurnal course of the desired signal, net radiation at the surface (red line), and the values provided by the neural network (MLP) (blue line) for all-sky conditions.



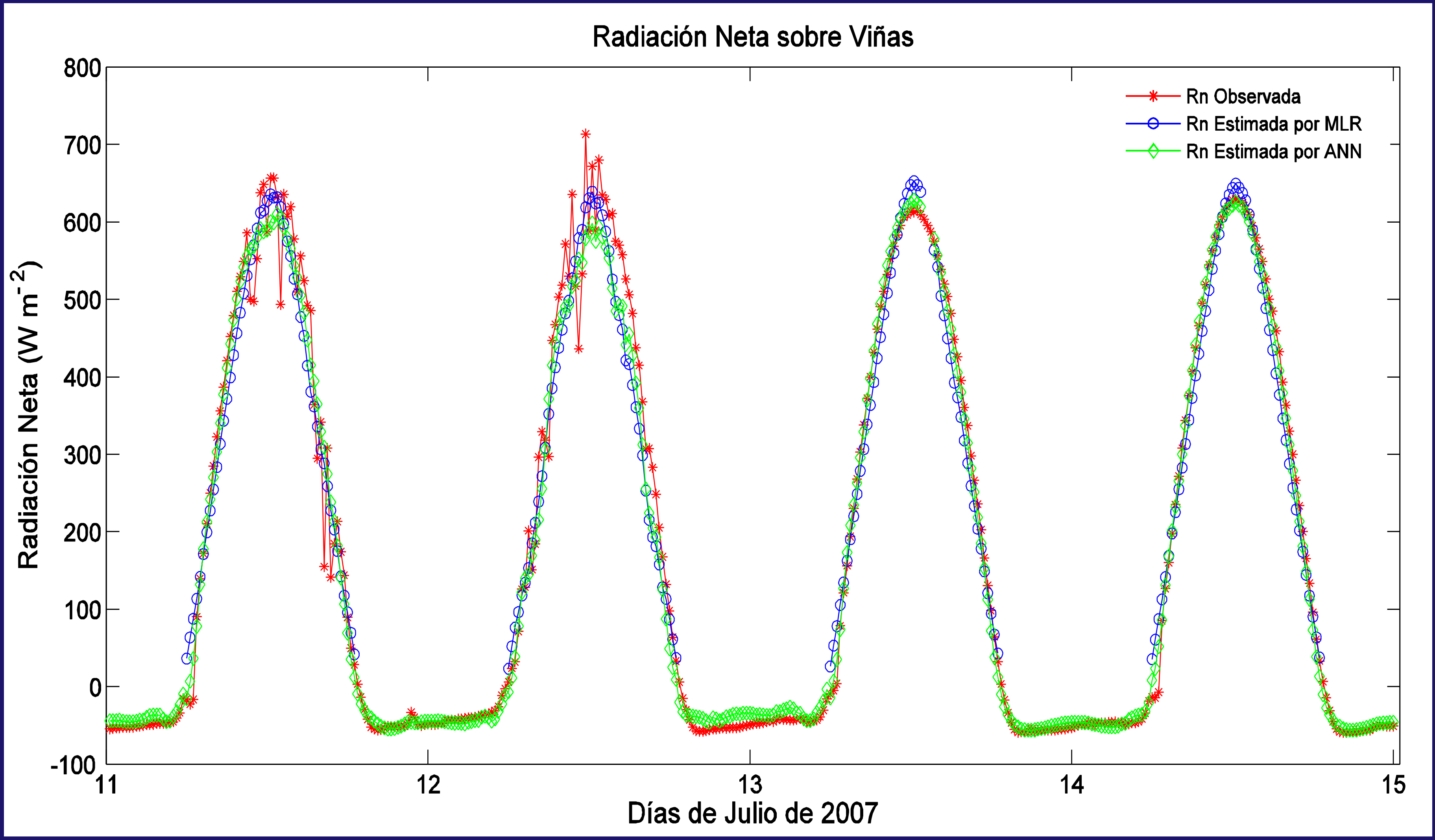
# Results

## Diurnal course of the desired signal, net radiation at the surface (red line), and the values provided by the multiple linear regression model (MLR) (blue line) for all-sky conditions.



# Results

Diurnal course of the desired signal, net radiation at the surface (red line), and the values provided by the multiple linear regression model (blue line), and by the neural model (green line) for all-sky conditions



# Partial conclusions

Artificial neural model proposed to model net radiation at the surface, from satellite measurements at the TOA

Good performance for both cloudy and clear-sky conditions as well as for all-sky conditions, for different land uses

Better performance than a multivariate linear model

Possibility of directly obtaining surface net radiation from TOA satellite flux measurements

# Using the synergy GERB/SEVIRI and micrometeorological data to study the relationship between surface net radiation and soil heat flux

# Methodology

Relationship between Rn and G according to Santanello and Friedl (2002)

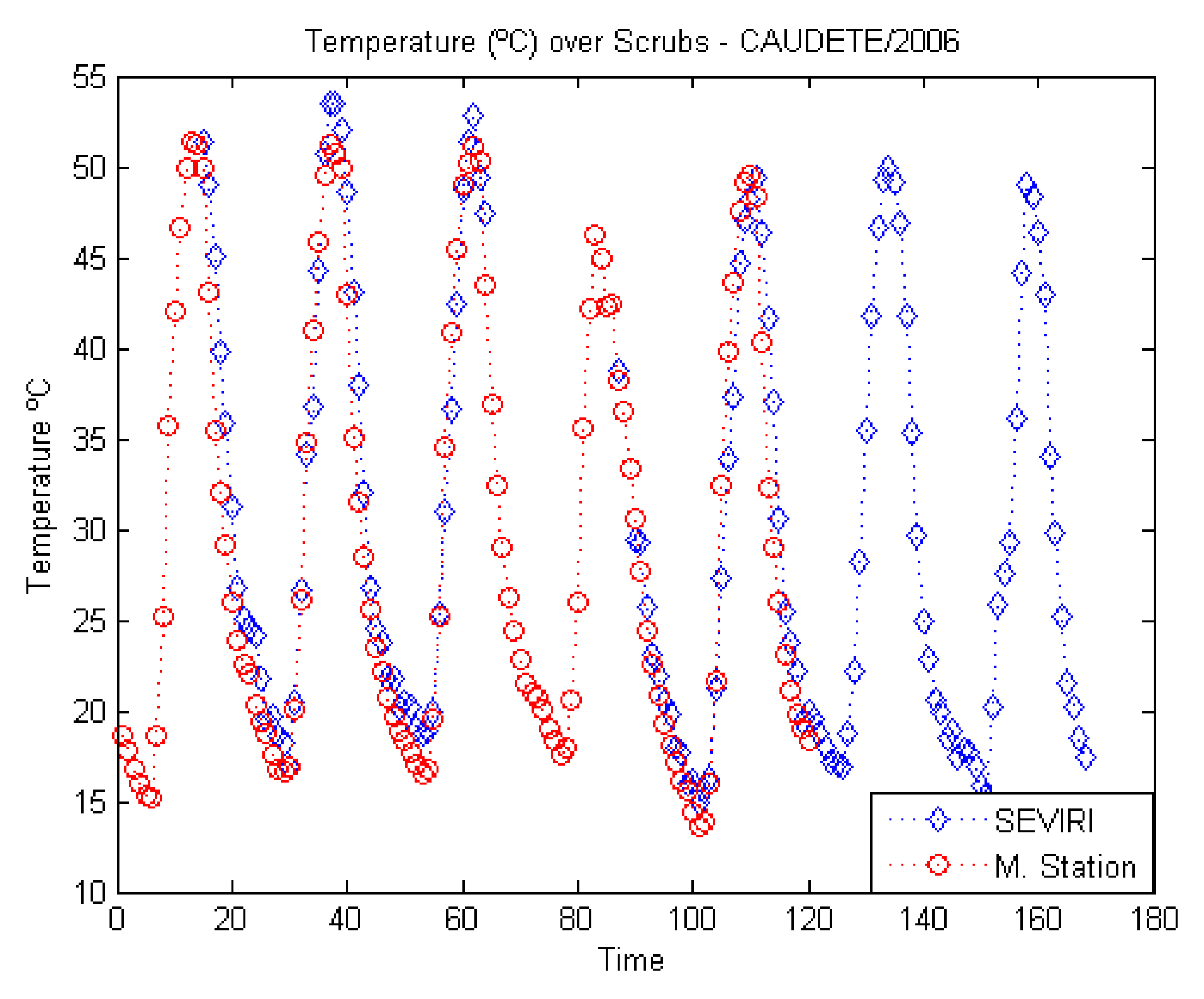
$$\frac{G}{Rn} = (0.0074\,\Delta T + 0.088)\cos\left(\frac{2\pi(t + 10800)}{B}\right)$$

B = (1729 * ΔT) + 65013 is a variable that depends on ΔT (Temp Max – Temp Min) and t is time (s)
B is assigned based on knowledge of soil type, moisture regimes, and seasonal dynamics in LAI.

Land surface temperature (LST) from SEVIRI and ground surface temperature from *Valencia Anchor Station* and micrometeorological station were used

# Results

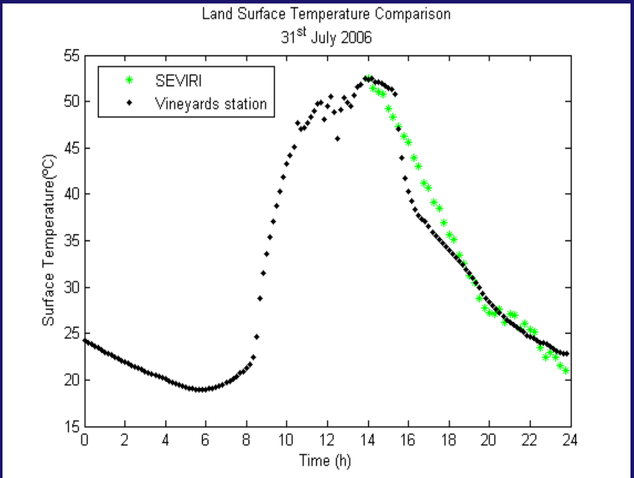
## Land surface temperature (LST) comparisons between SEVIRI and measured LST during 2006 field campaign in the scrubland

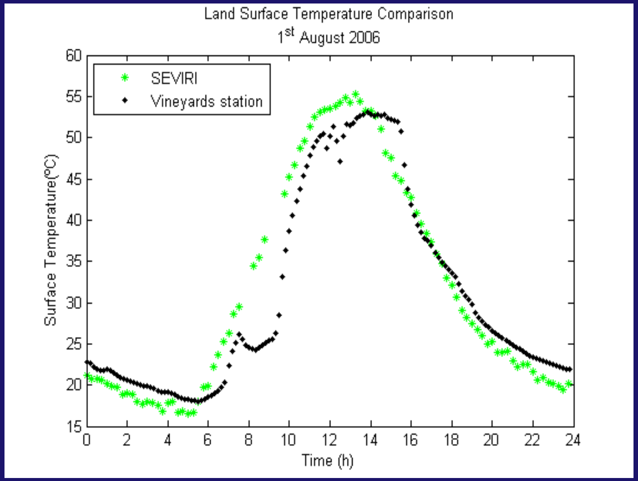


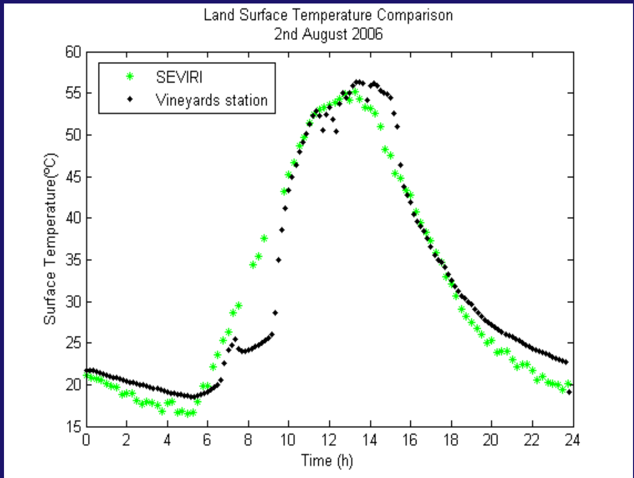

| | August 01, 2006 | August 04, 2006 |
|---|---|---|
| avg | 31.9 $^0$C (S) / 30.2 $^0$C (MS) | 28.7 $^0$C (S) / 27.8 $^0$C (MS) |
| std | 12.9 (S) / 12.5 (MS) | 12.2 (S) / 12.8 (MS) |
| rmse | 2.9 $^0$C | 3.8 $^0$C |

# Results

## Land surface temperature (LST) comparisons between SEVIRI and measured LST in vineyards (2006)



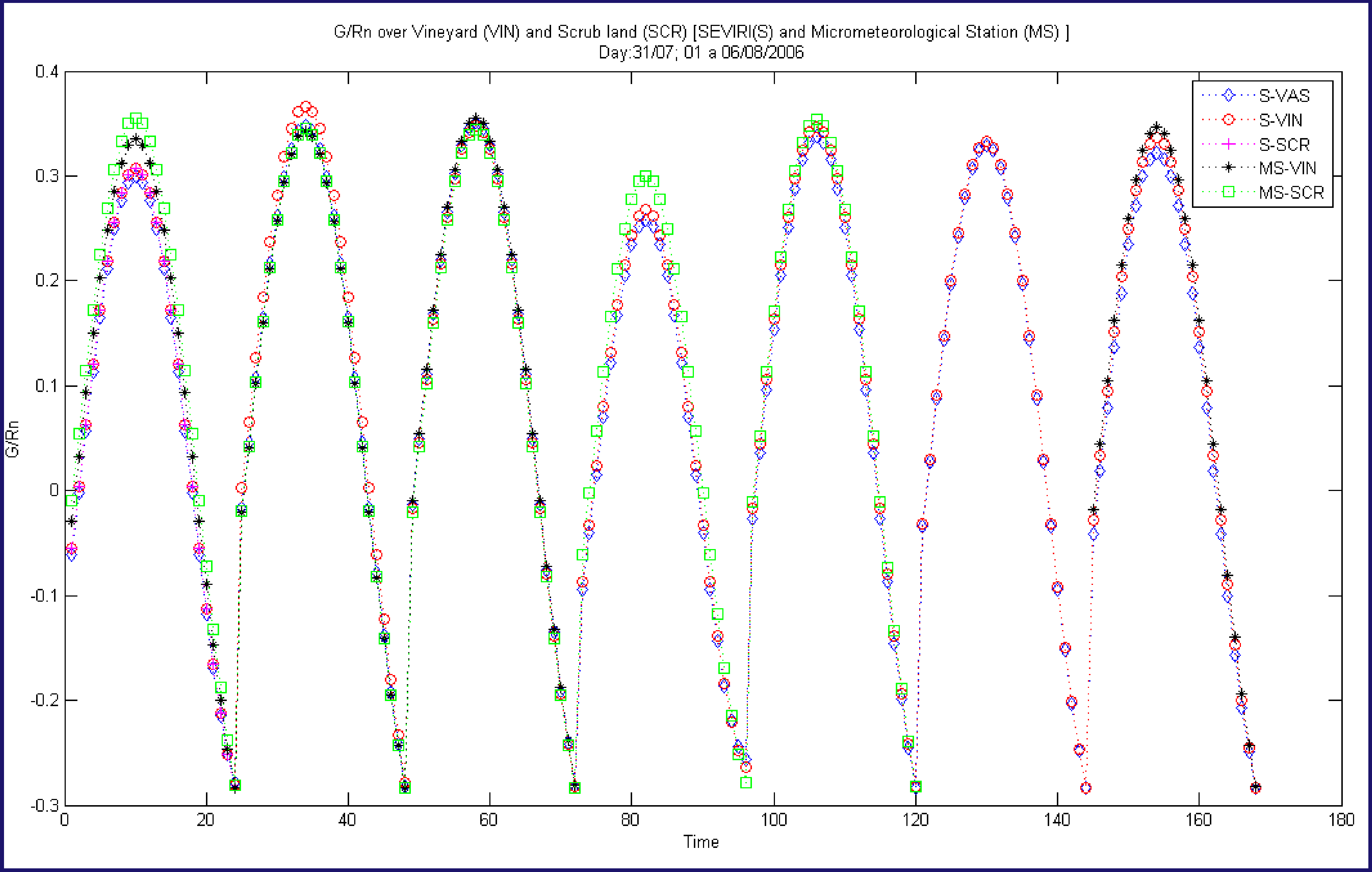




| | 31th July 2006 | 1st August 2006 | 2nd August 2006 |
|---|---|---|---|
| RMSE (ºC) | 2 | 3 | 3 |

# RESULTS

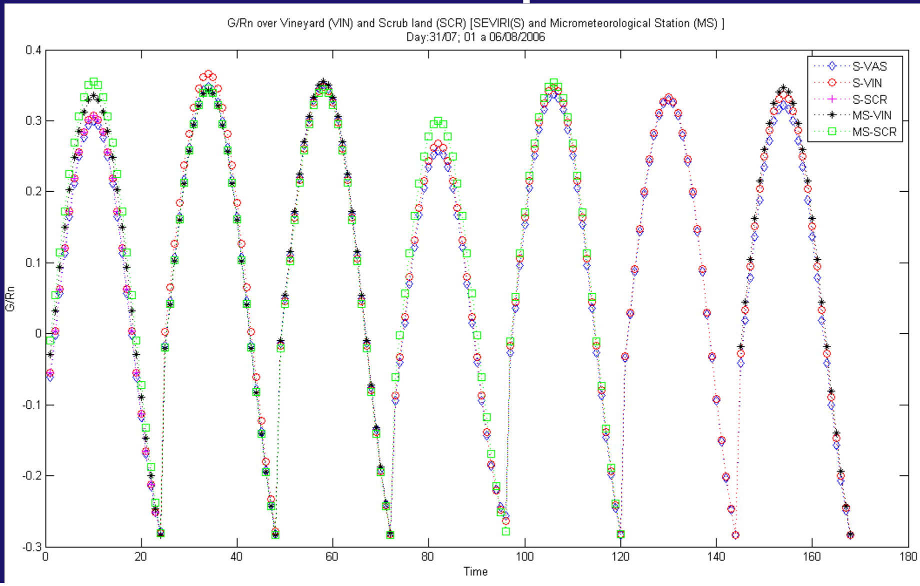


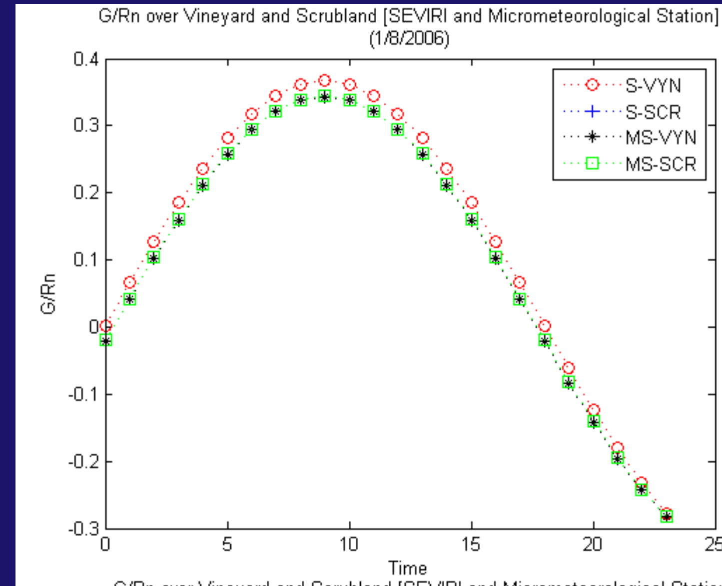
## G/Rn comparisons between SEVIRI and measured LST

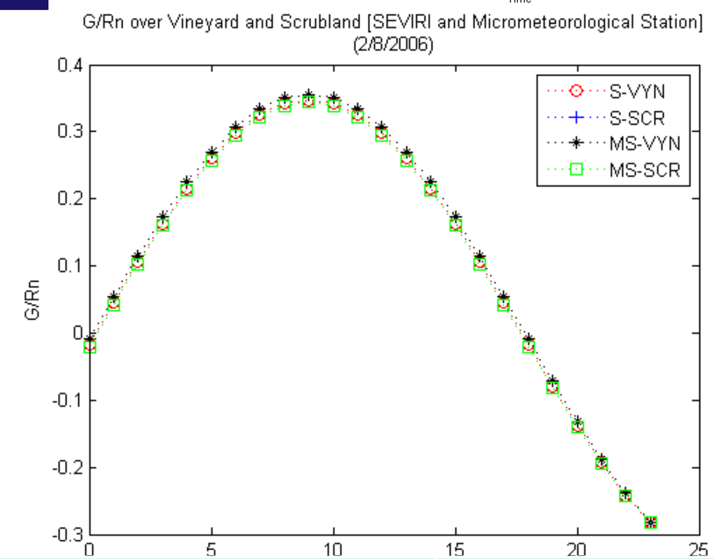


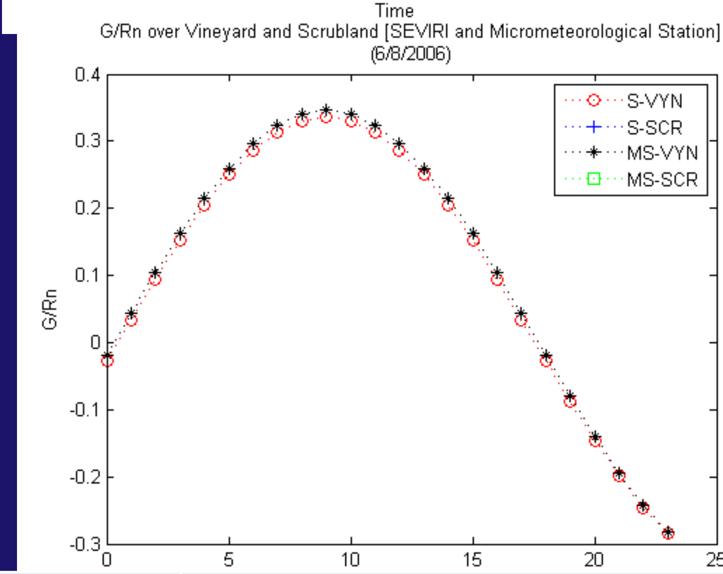
# RESULTS

## G/Rn comparisons between SEVIRI and measured LST




| | August 01, 2006 | August 02, 2006 |
|---|---|---|
| avg | 0.14 (S) / 0.12 (MS) | 0.12 (S) / 0.12 (MS) |
| std | 0.2 (S) / 0.2 (MS) | 0.2 (S) / 0.2 (MS) |
| rmse | 0.02 | 0.008 |

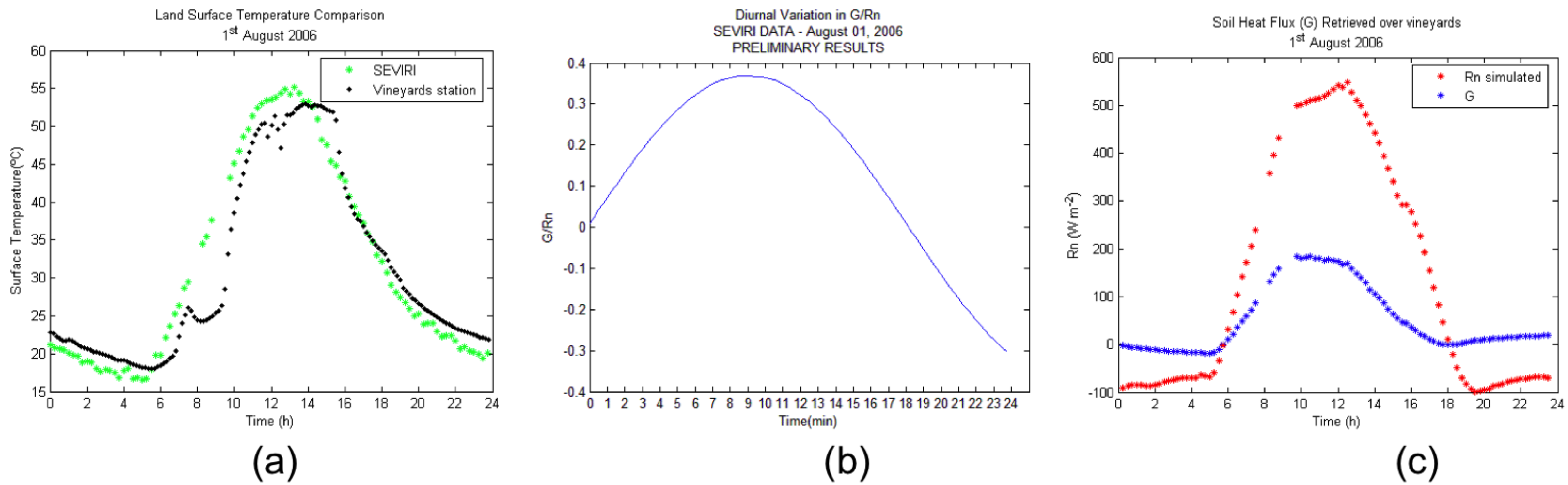
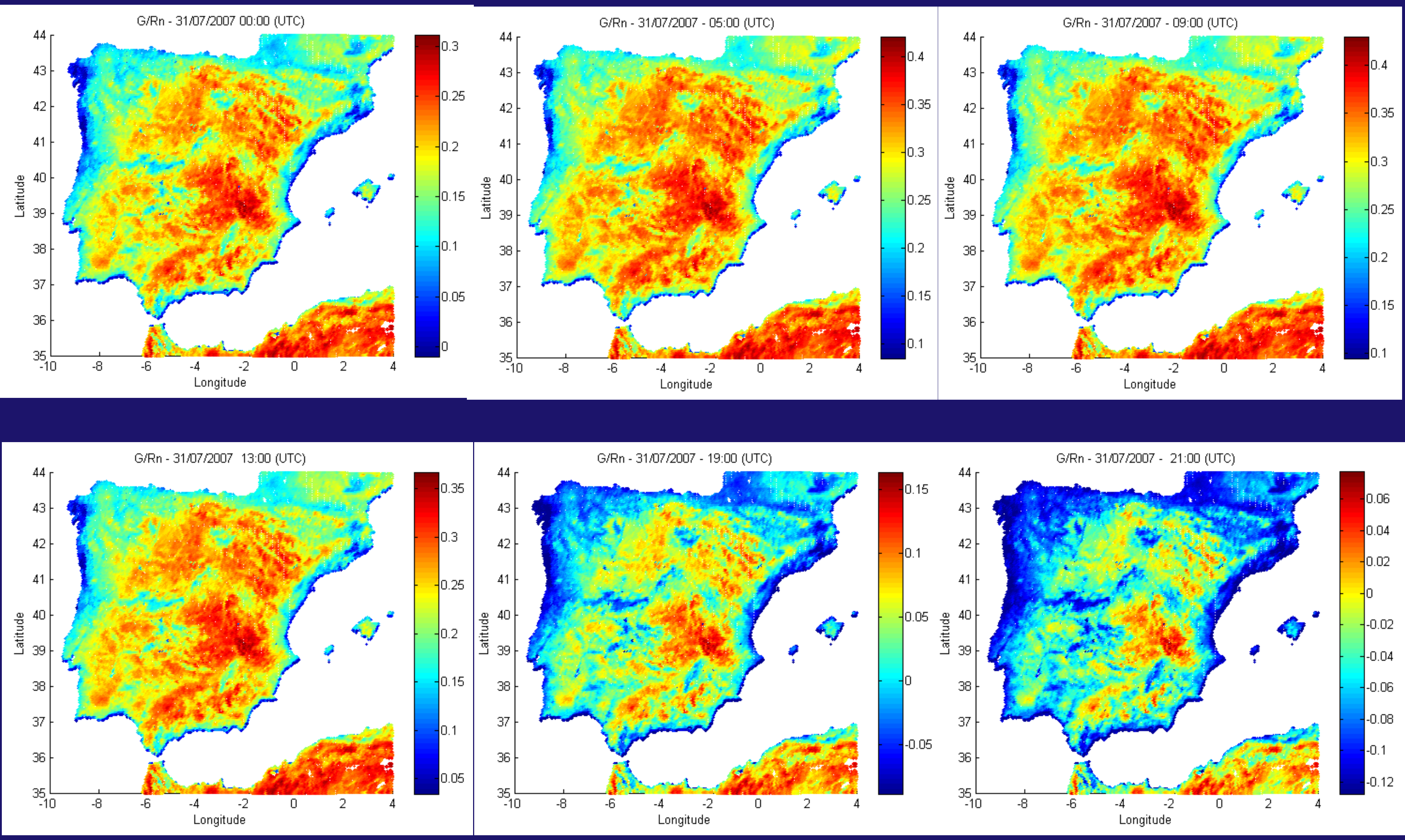



**Figura 3.** (a) Comparación entre la LST de SEVIRI y la de la estación micrometeorológica para el día 01/08/2006, (b) G/Rn simulado utilizando LST de SEVIRI,y (c), G estimado utilizando GERB_Rn simulado.

# RESULTS

## G/Rn from SEVIRI



## CONCLUSIONS AND FUTURE WORK

♦ For the studied cases (July 31, August 1 and 2, 2006) the LST comparison between SEVIRI and ground measurements, over a vineyard, show a good agreement (RMSE = 2, 3 and 3 $^oC$, respectively).

♦ From this preliminary study it is possible to visualize the possibility to use the synergy between GERB and SEVIRI in order to derive Rn , and consequently G at local or regional scales.

## FUTURE WORK

Use of LST from SEVIRI in the simulations to extend the methodology to wider areas .

We try now to extend and extrapolate these G estimations to larger areas, at satellite observation scales, to provide reliable estimations of G, directly derived from net radiation measurements, at adequate regional scales.

This extension of the methodology to remote sensing data is being carried out through the application of the synergy between GERB (Geostationary Earth Radiation Budget) and SEVIRI (Spinning Enhanced Visible and Infrared Imager) data to provide estimates of net radiation and surface temperature with a frequency of 15 min intervals