Influence of climate on the vineyard and wine

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The project

MASGRAPE

adoption of a Multidisciplinary Approach to Study the GRAPEvine agro-ecosystem: analysis of biotic and abiotic factors able to influence yield and quality

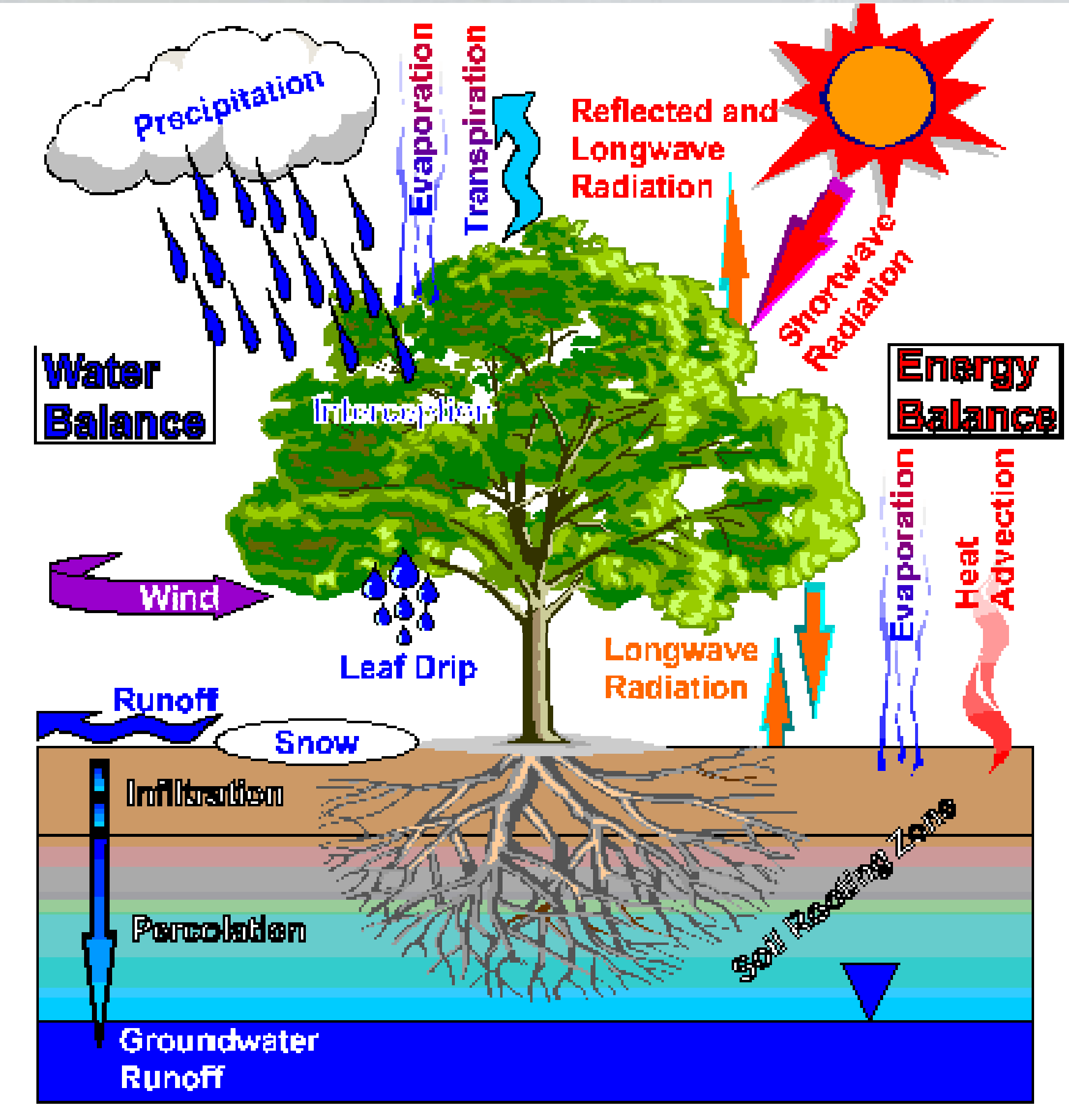
develop tools to manage vineyards and improve wine quality

Project phases

- experimental activity
- historical survey

- Plant pathologists
- Physiologists
- Agricultural entomologists
- Agronomists
- Physicists
- Chemists
- Wine companies

The model



The LSPM

(*Land Surface Process Model*)
(Cassardo et al., 1992)

Diagnostic model

Vegetation – 1 layer BIG LEAF

PARAMETERS:

- minimum stomatal resistance
- leaf diameter
- roots depht
- canopy albedo
- vegetation heigh
- vegetation cover fraction
- Leaf Area Index (LAI)

2 simulations

The model physics

Turbulent fluxes, flux-gradient law and Ohm analogy

$$H = \rho c_p \overline{w'\theta'}$$

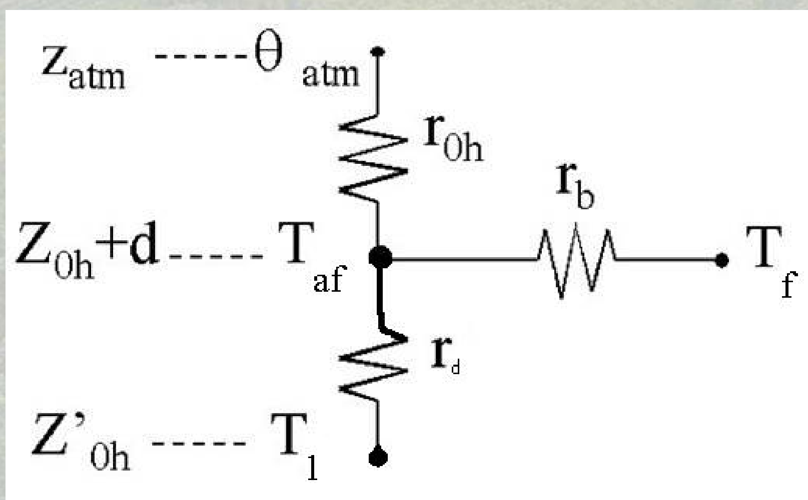
$$H = -k\frac{dT}{dz}$$

Ohm analogy

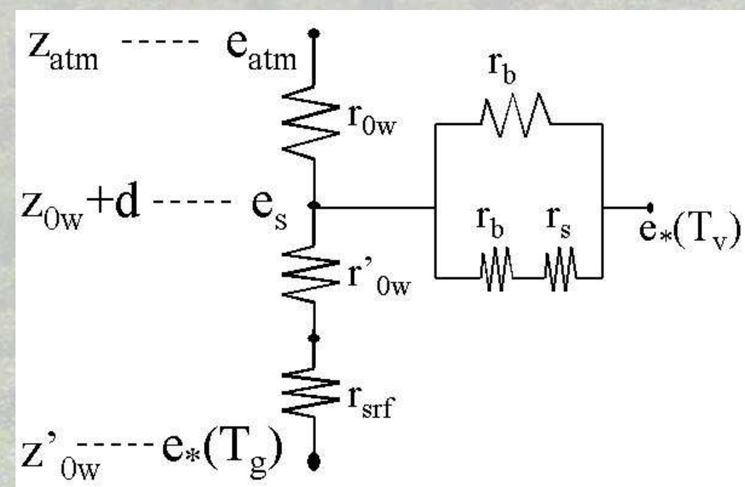
$$H = H_f + H_g$$

$$H_f = \rho_a c_p s_b \left(T_f - T_{af}\right)\sigma_f$$

$$H_g = \rho_a c_p s_d \left(T_1 - T_{af}\right)\left(1-\sigma_f\right)$$



Sensible heat flux for a vegetated surface



Latent heat flux for a vegetated surface

Why we have used the model?

Verification of stomatal conductance of *Nebbiolo* grapevine*

- First experiment in vineyard (gauge of trade gases)
- Check the meteorological and physiological links, through the stomatal conductance key
- LSPM: new local parametrization for transpiration in dependence on the
  air temperature and humidity, PAR and CO_2
- Decrease for Nebbiolo stomatal conductance for CO_2 concentrations higher than the environmental values (climate)

Main reference: Prino S., Spanna F., Cassardo C. 2009

The measurements (I)

activity under controlled environment

Indipendent and continuous temperature, humidity, radiation and CO_2 level management

phytotrons

The measurements (II)

activity in winegrape fields

2009 vegetated season – I measurements campaign in 3 vineyard site (Monferrato, Langhe)

Measured parameters:

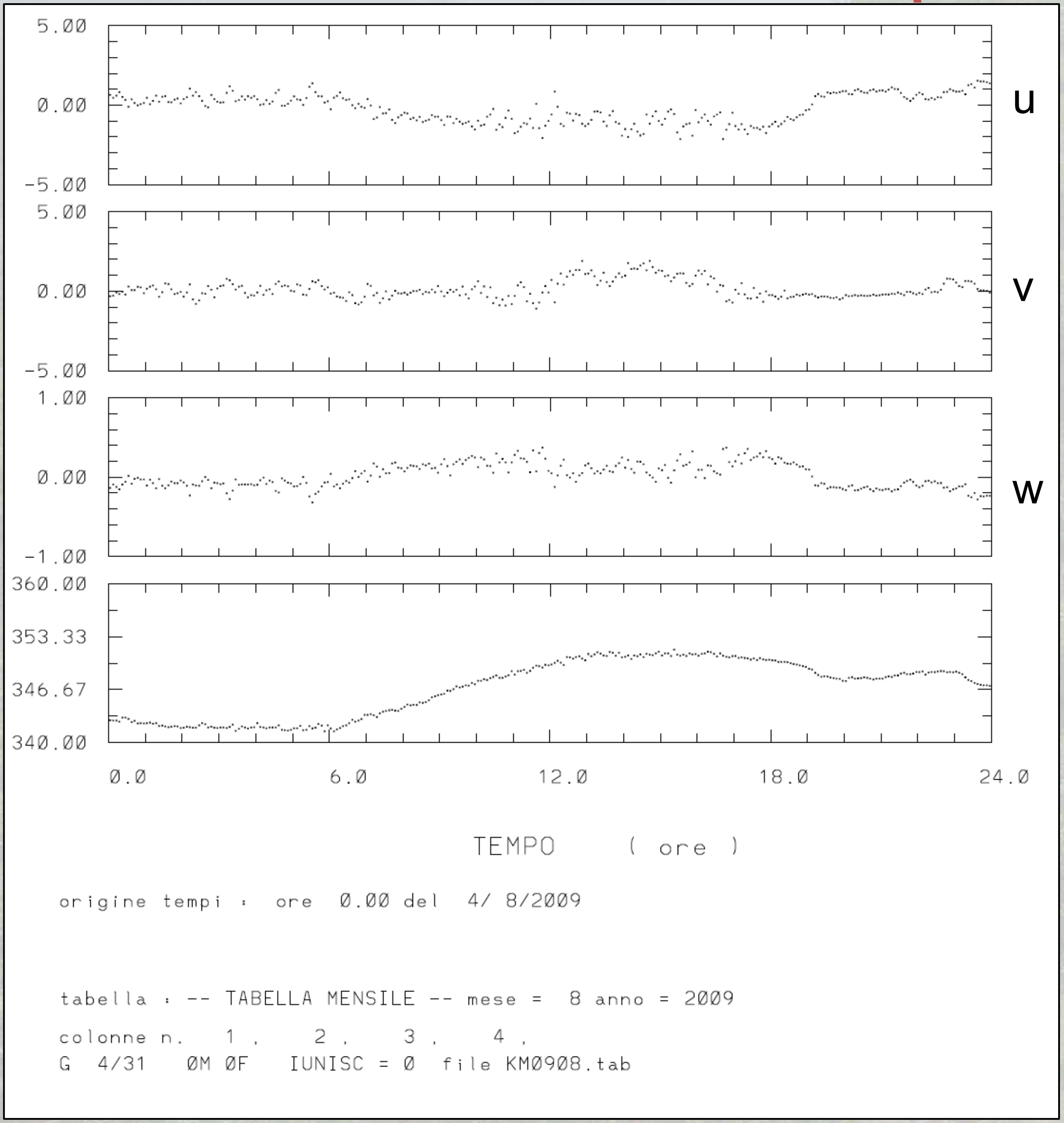
- Air temperature (slow and fast)
- Wind speed (slow and fast)
- Air humidity (slow and fast)
- Soil temperature
- Soil moisture
- Turbulent heat fluxes
- Solar global radiation
- PAR
- Other parameters relevant to evaluate phenological phase and plant growth phase

FAST RESPONSE SENSORS:
sonic anemometers and kripton hygrometer measurements

Example of data: wind and sound speed

Cocconato (AT)
August 4, 2009
5 min mean values

$$C = \sqrt{\gamma_d R_d T_s}$$



Fluxes derivation from measurements

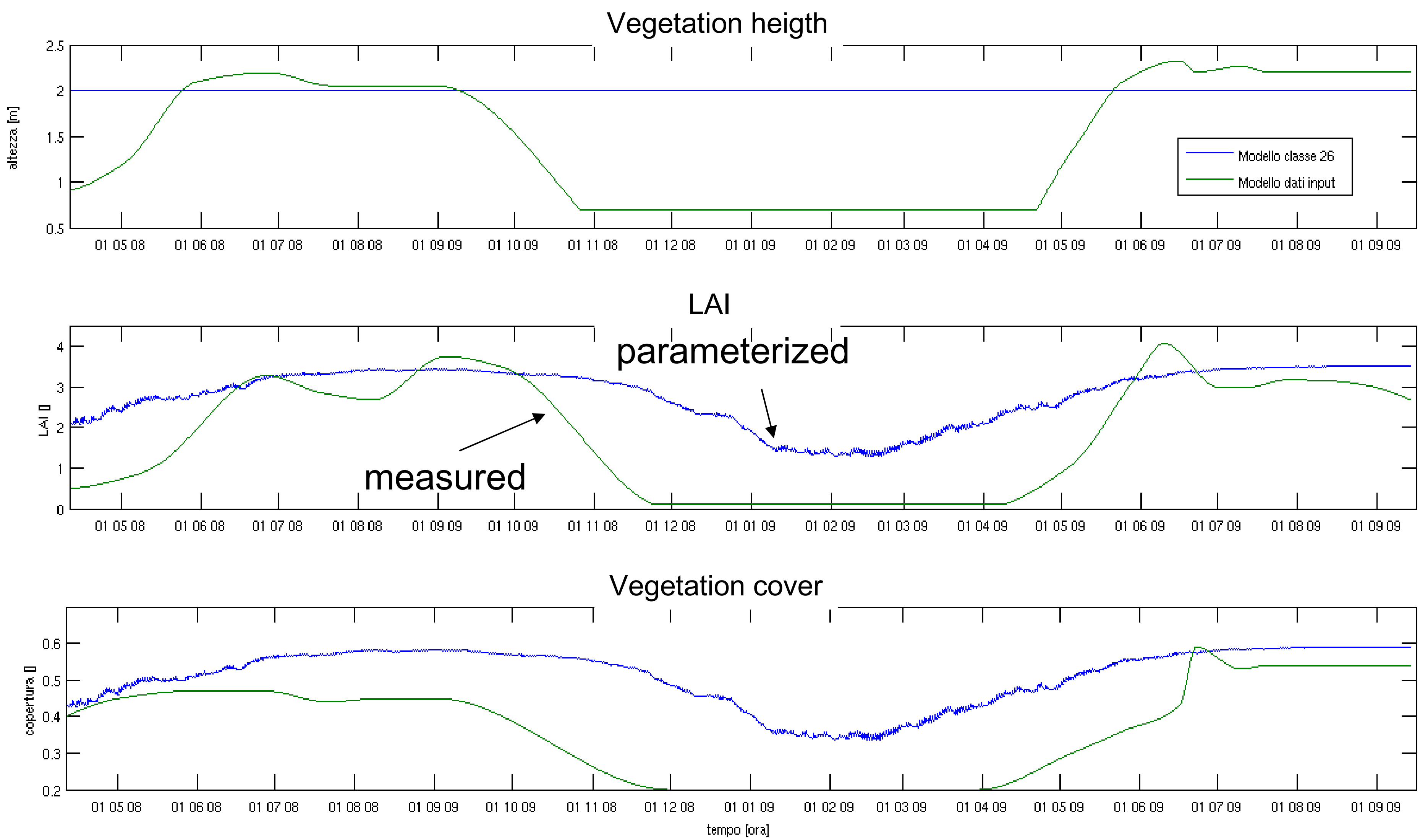
$$\begin{cases} \tau = -\rho \overline{u^{'} w^{'}} \\ H = \rho c_p \overline{w^{'} \theta^{'}} \\ L = \rho \overline{w^{'} q^{'}} \end{cases}$$

$$T_s = \frac{C^2}{\gamma_d R_d}$$

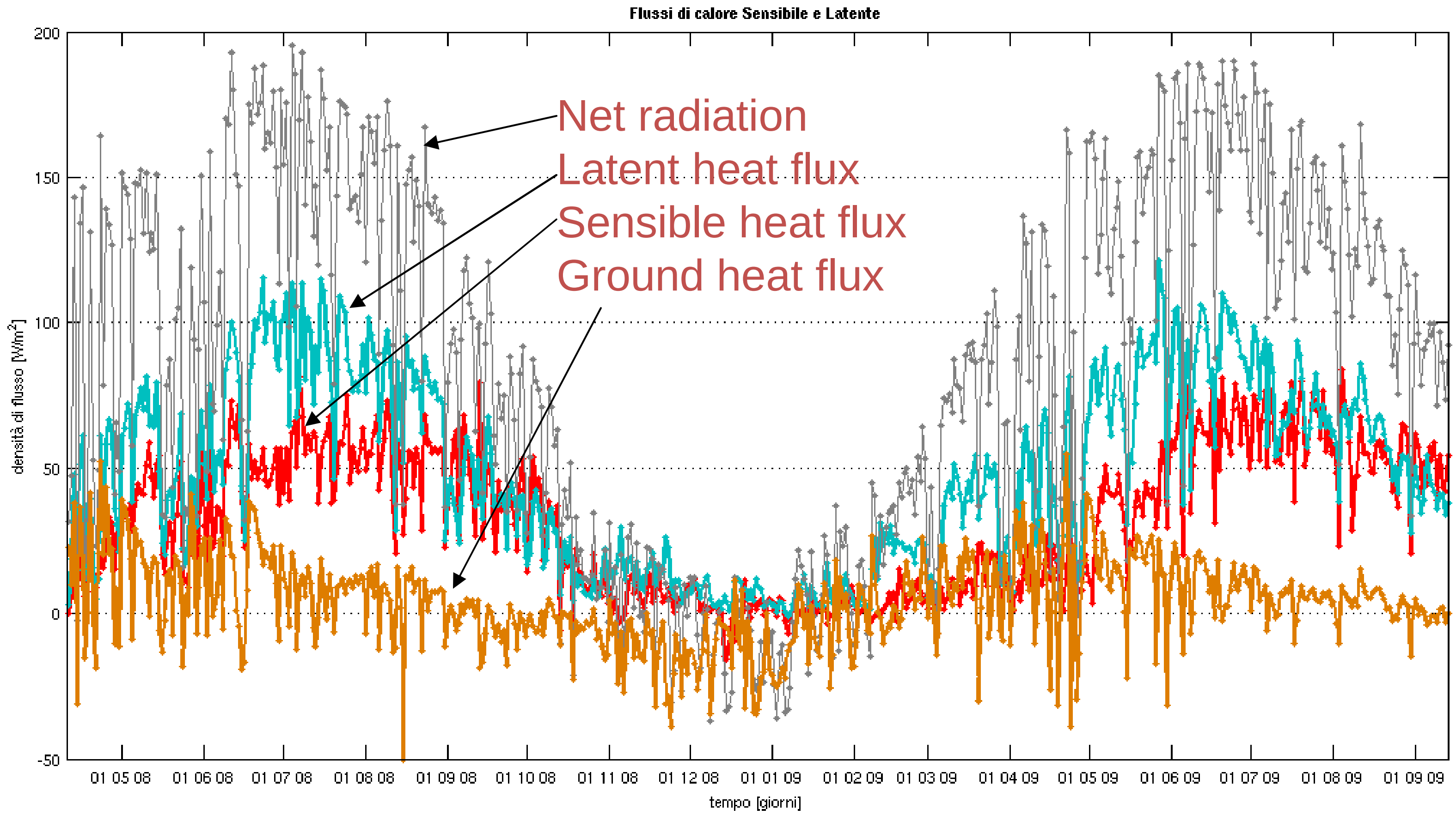
$$T_s^{'} = \overline{T_s} - T_s$$

$$H = \rho_a c_p \overline{w^{'} T_s^{'}}$$

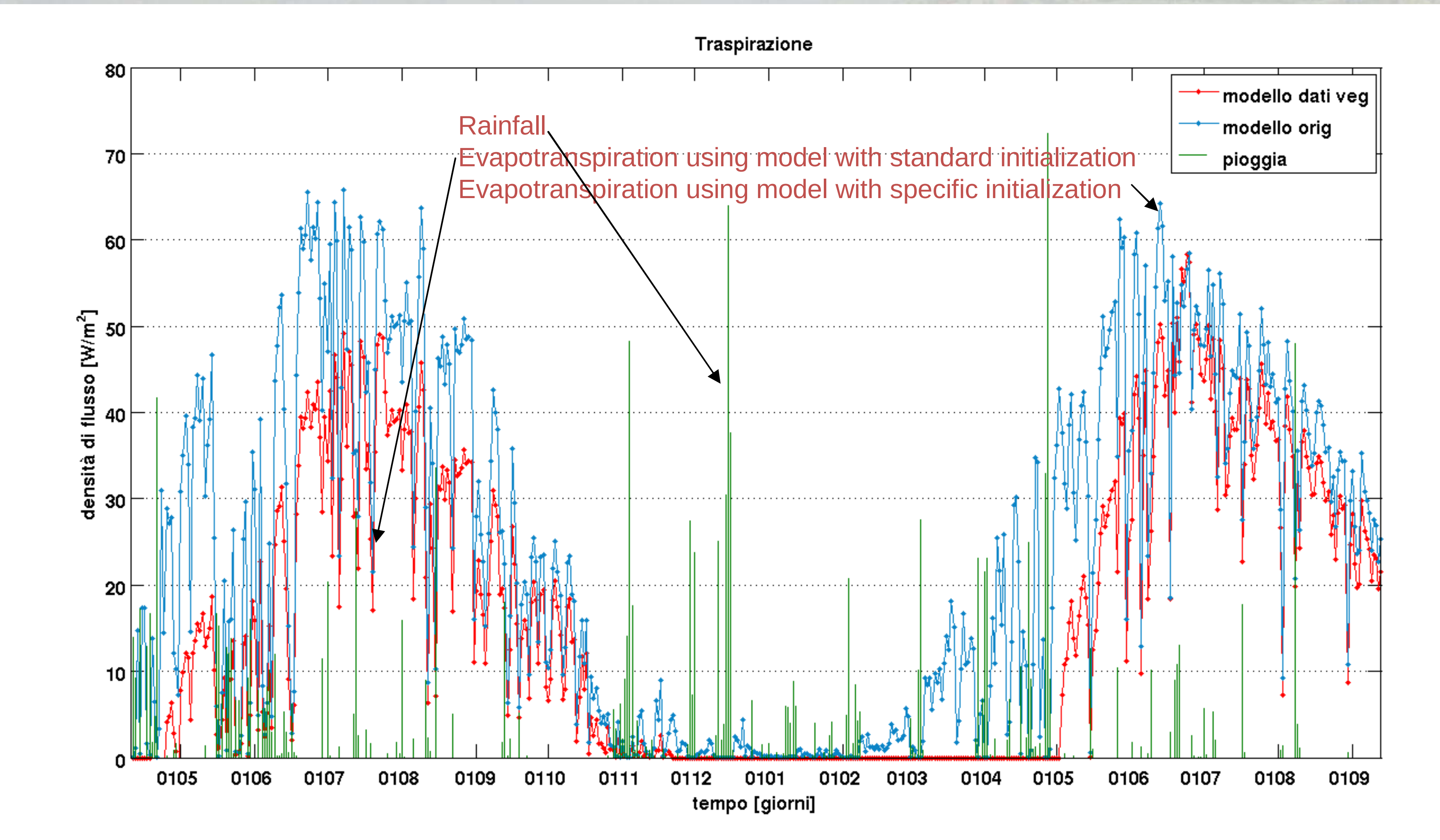
2008 - 2009 LSPM simulations: vegetation parameters

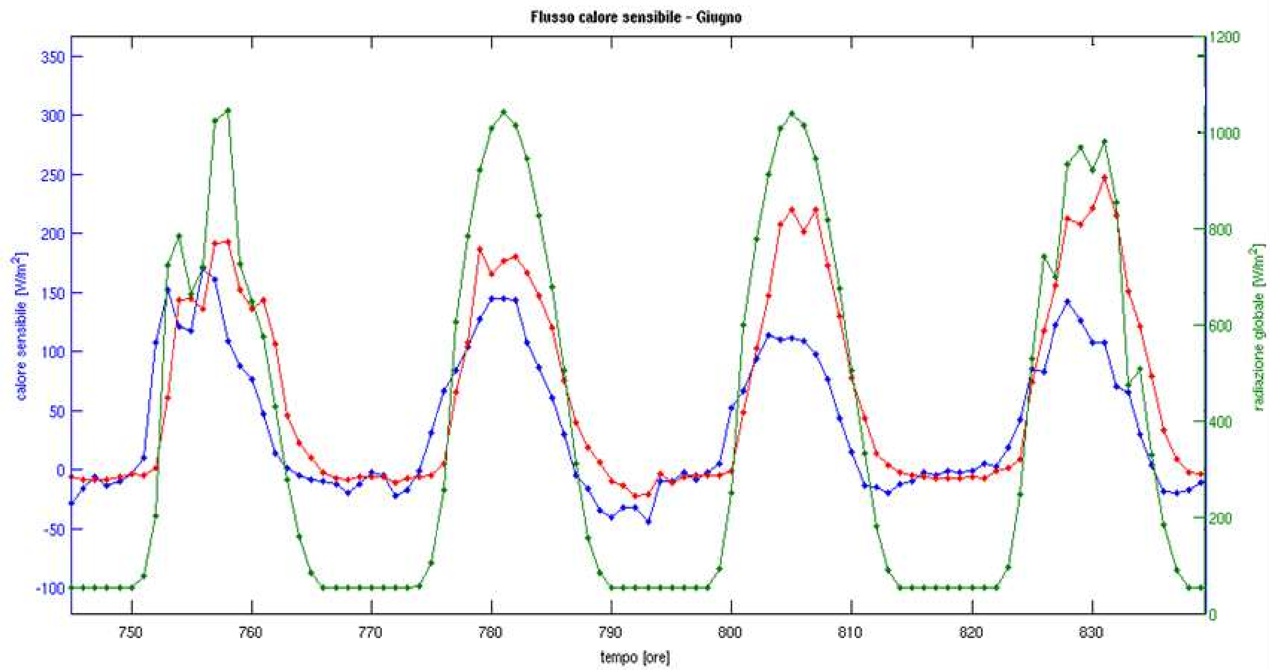


2008 - 2009 LSPM simulations: energy balance



2008 - 2009 LSPM simulations: hydrological quantities



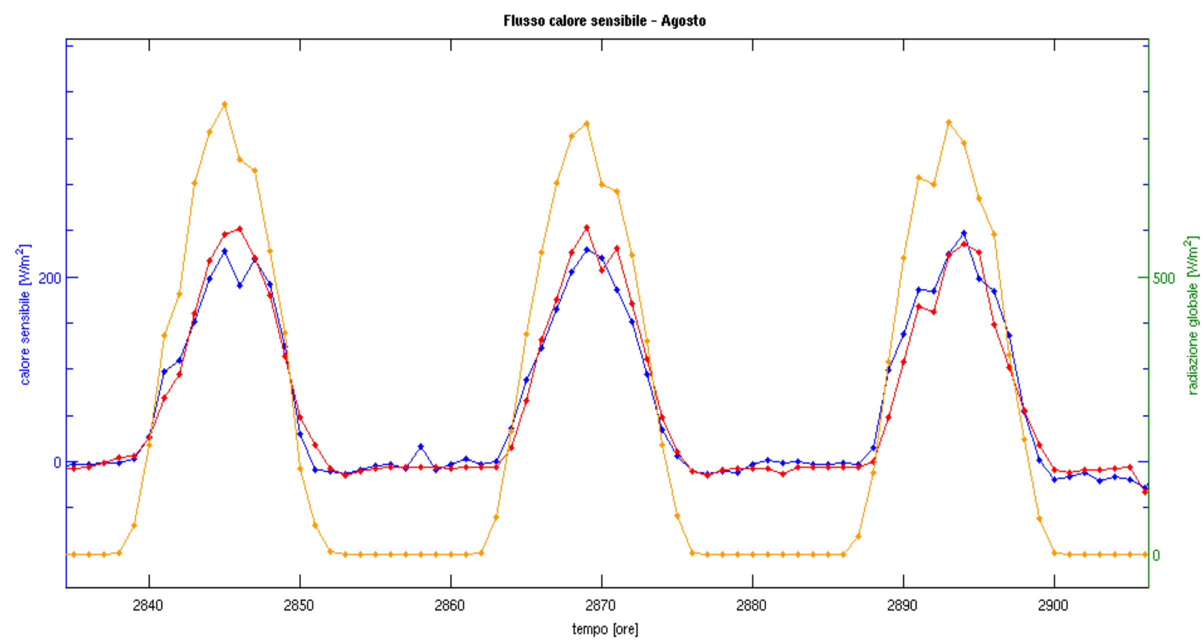


Intercomparison between measured data (with sonic anemometer) and LSPM output

Global radiation on the right axes

At the beginning of the season LSPM overstimate data

At the end the the correlation is quite good

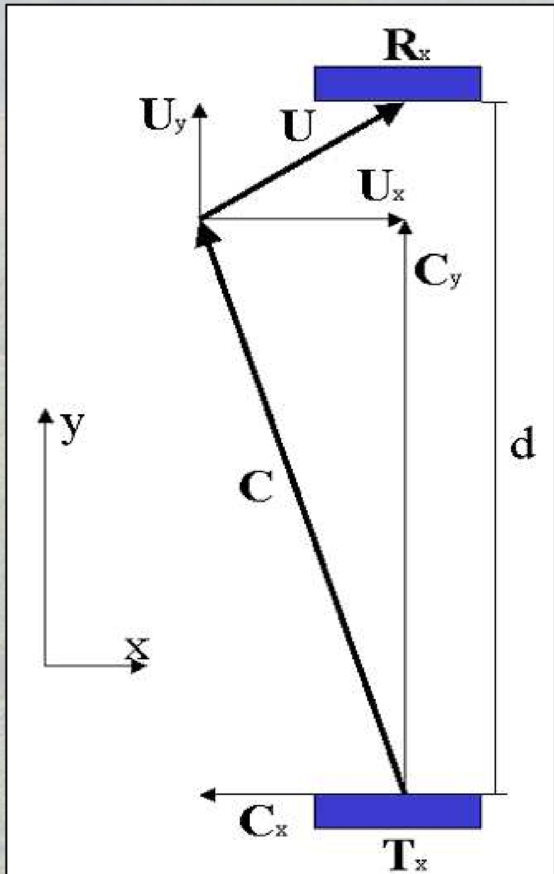


Work in progress...

- II year campaign
- sensitivity LSPM test on vegetation parameters
- calculation of latent heat fluxes and comparison with the model
- hydrological balance

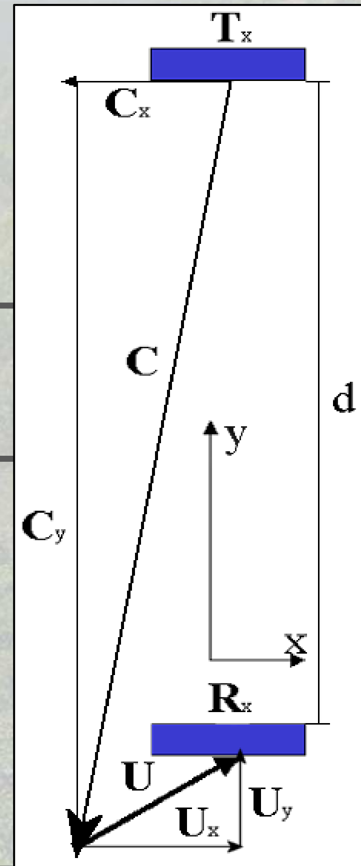
...final junction of researchers units

Sonic Anemometer: theory of operation
Air and sound speed calculations along each pair of transducers' axes



$$d = t_1\left(C_y + U_y\right)$$

U constant in (t_1+t_2)



$$d = t_2\left(C_y - U_y\right)$$

$$C_y = d\left(\frac{1}{t_1} + \frac{1}{t_2}\right)$$

$$U_y = d\left(\frac{1}{t_1} - \frac{1}{t_2}\right)$$

Krypton hygrometer: theory of operation
Lambert-Beer's law – water vapour radiation absorption at Kr picks (123.58 e 116.49 nm)

- krypton hygrometer KH20 for measuring water vapor fluctuations in the air
- KH20 = K-H_2O → effects of water vapor on Kripton absorption
- Typically used with a sonic anemometer for measuring latent heat flux using Eddy Covariance technique
- KH20 sensor uses a krypton lamp emitting two absorption lines: major line at 123.58 nm and minor line at 116.49 nm
- Both lines are absorbed by water vapor
- A small amount of the minor line is absorbed by oxygen
- KH20 cannot measure absolute water vapor concentrations but only its fluctuations

Componente verticale della velocità del vento e fit planare

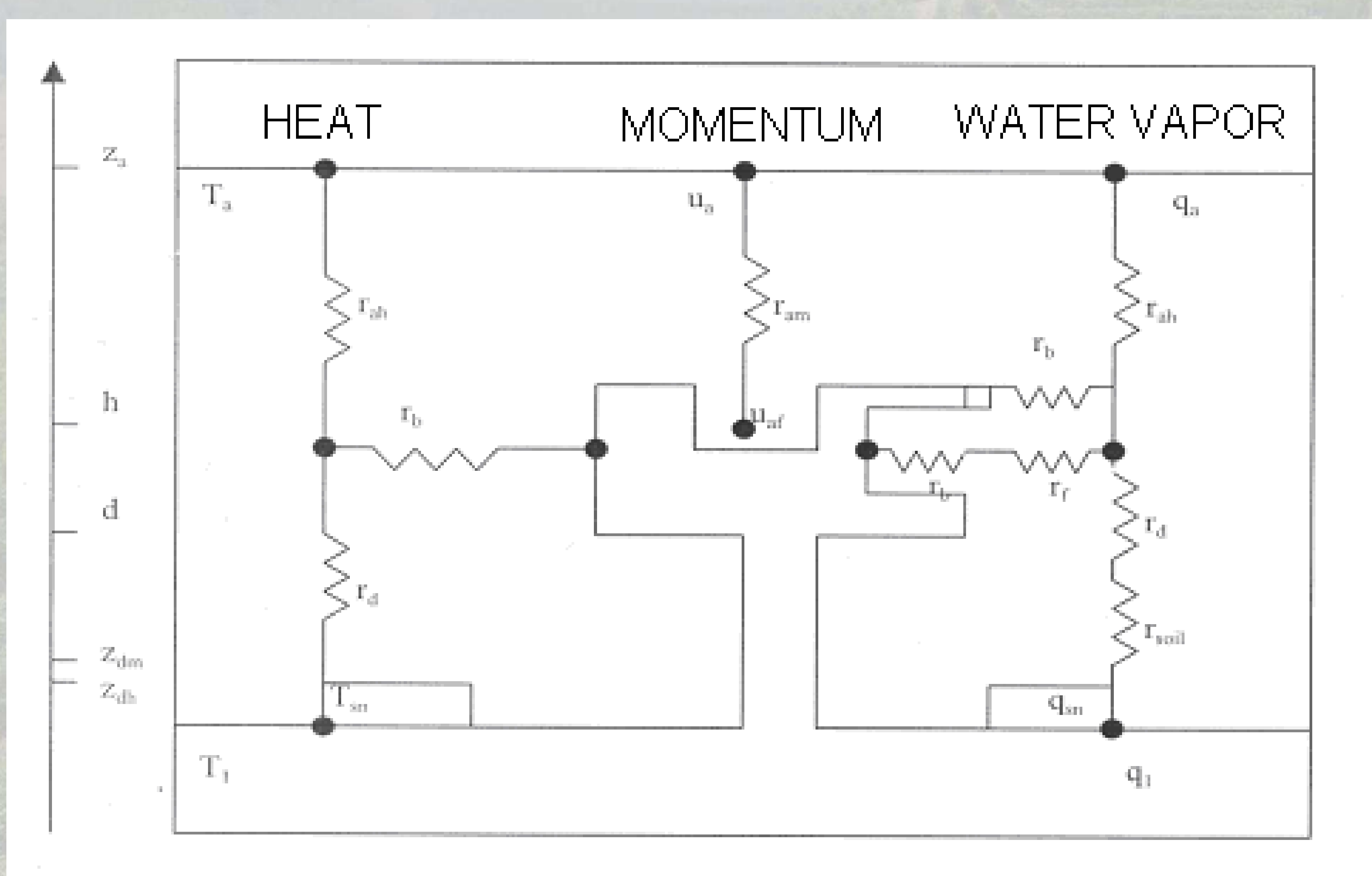
Flussi turbolenti misurati normali al piano del moto medio

$$\overline{w} = 0$$

Individuazione di un piano fisso specifico del sito su un lungo periodo (FIT PLANARE)

Calcolo del flussi ogni 30'

- z fissa (perpendicolare al piano)
- x-y variano nel tempo: *u* allineata lungo la direzione del vento medio (// al piano)


HEAT
MOMENTUM
WATER VAPOR
z_a
T_a
u_a
q_a
r_{ah}
r_{am}
r_{ah}
r_b
h
r_b
u_{af}
d
r_b
r_f
r_d
r_d
r_{soil}
z_{dm}
z_{dh}
T_{sn}
q_{sn}
T_1
q_1