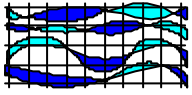


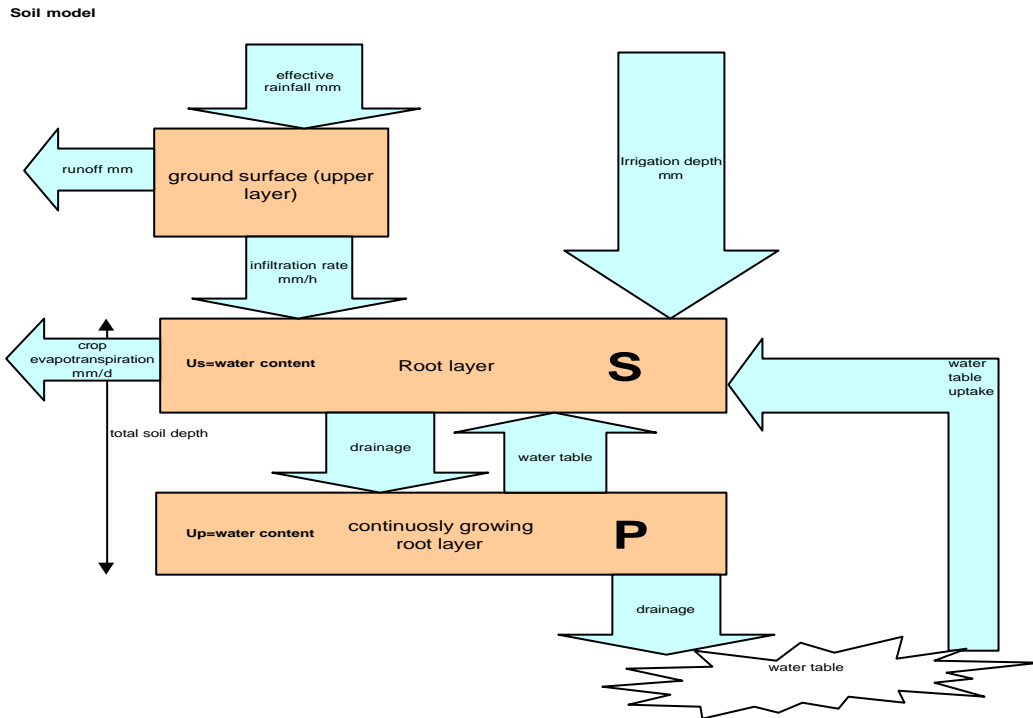
IRRINET: IT Irrigation Advisory Services for Farm Water Management

1. Water dynamics in soil.....	3
2. Crop growth.....	3
2.1. Crop development.....	3
2.2. Root system growth.....	3
3. Crop water requirements.....	4
3.1. Crop evapotranspiration under standard conditions.....	4
3.2. Crop evapotranspiration under non standard conditions.....	4
4. Water table contribution.....	4
5. Determination of the irrigation depth.....	5
6. IT Architecture of Irrinet.....	5
6.1. Web application.....	6
6.2. External data importation module.....	6
6.3. IrriSMS.....	7
7. Bibliography.....	7

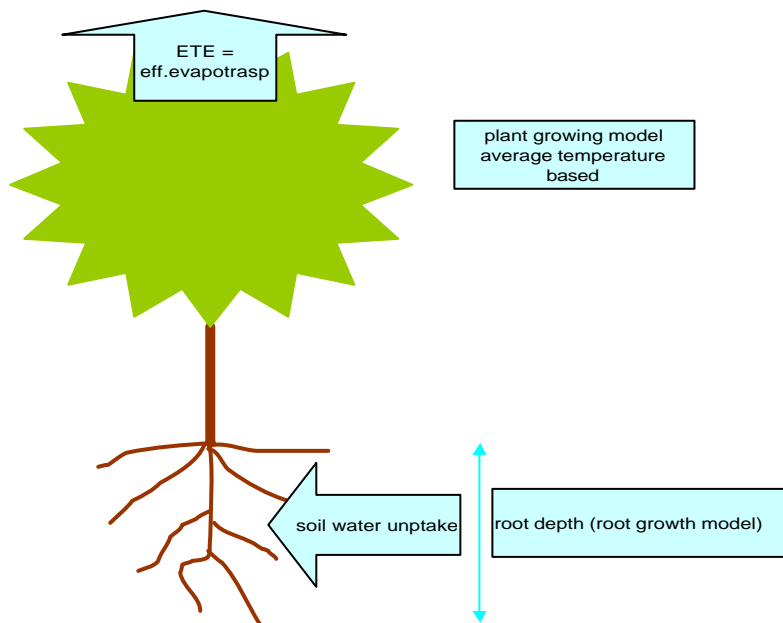


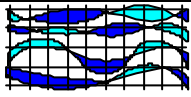
IRRINET: IT Irrigation Advisory Services for Farm Water Management service is based on a water balance model aimed at crop irrigation management at a field scale and therefore the processes and calculation simulated by the model reflect such aim. The model has a structure that is concerned with the soil-plant-atmosphere continuum. It includes the soil, with its water balance; the plant, with its development, growth; and the atmosphere, with its thermal regime, rainfall and evaporative demand

The model has been simply summarized in the following diagrams:



evapotranspirative model





The main processes simulated by the model are as follows:

1. **Water dynamics in soil.** It is the key process, the other processes simulated are affected by this calculation which is based on a tip in box model, hourly calculations and considering three different soil layers:
 - Soil surface layer: it take into account of the ground roughness created by tillage management
 - Root layer: this is the volume of soil explored by the roots. For fruit trees this is fixed, for other crops it varies over time, according to growth stages
 - Bottom layer: this is the layer below the “root layer” and will be explored in the next step by growing roots.

For the soil surface layer the soil’s ability to store rainfall, is estimated based on its roughness, which is generated by the different kinds of tillage. For the other two layers, the water storage is estimated applying pedotransfers based on the soil particle size.

Such pedotransfers have been empirically obtained using data provided by the Istituto Sperimentale per la Nutrizione delle Piante which has been the subject of extensive field trials.

For each step in the calculation process, water exchange (which is estimated to be constant for each step) between the various layers is evaluated and updated at the end of each step, on a continuity equation basis.

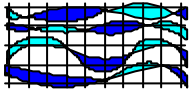
The model calculates run off fractions as difference between rainfall intensity, upper layer water storage and hourly soil infiltration rate. Run off is considered by the model as total loss.

The amount of water which penetrates is given by the maximum infiltration rate which is calculated based on the sorptivity and the hydraulic conductivity of the single layer, affected by the specific soil particle size.

Applying Driessen, the amount of water which moves between the layers of the soil profile is the water which exceeds single layer water storage; water drainage from the bottom layer is a total loss for the system.

The soil water content of the two lower layers (root and bottom layer) is available to meet crop water requirements.

2. **Crop growth** this refers both to the sequence of development phases, and to root system growth. The model does not take into account the accumulation of biomass.
 - 2.1. **Crop development** – Crop growth is simulated, according to the specific crop chronology, starting from the seeding, transplanting, or vegetative recovery for fruit crops. The change in crop stage is calculated by means of degree day, which are specific for each crop growth stage. There is a minimum threshold of such daily data, specific for each crop, as under this limit the crop does not grow. This data has been supplied by ARPA SMR, while the minimum threshold is derived from bibliographical research which has been adjusted using local historical data.
 - 2.2. **Root system growth** – According to the method proposed by F.Danuso for Bidrico models, root system growth is calculated based on a function which estimates the effect of

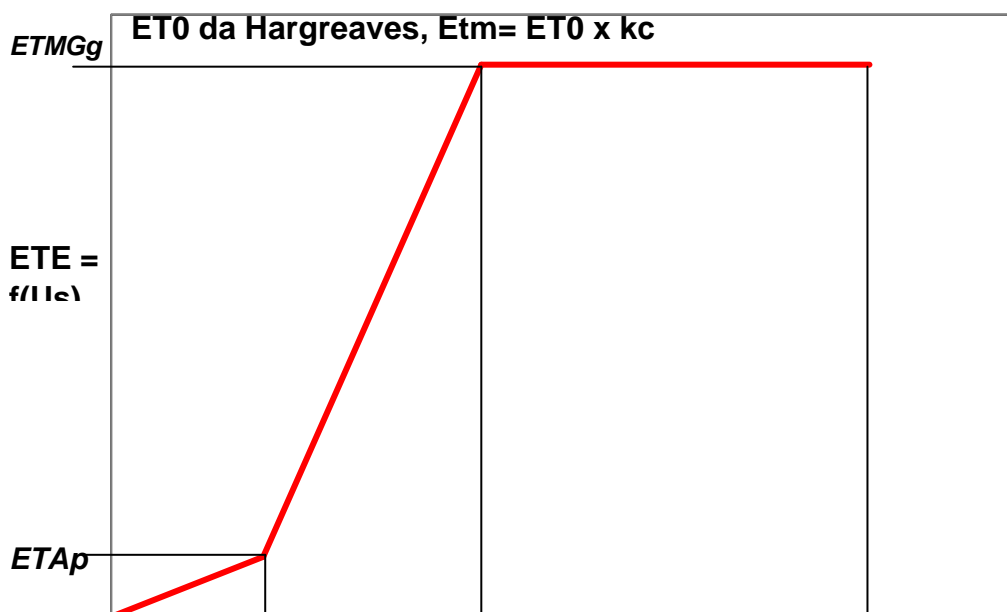


(i) daily temperature; (ii) soil water content of the layer beneath the roots; and (iii) the growth stage, on the theoretical maximum growth rate of each crop (provided by experimental research conducted by the CER on crops and soil in Emilia Romagna). For fruit tree crops a fixed layer which is constant over time has been used.

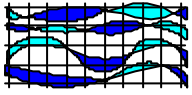
3. **Crop water requirements** – These are calculated applying the evaporation theory, following these steps:

3.1. **Crop evapotranspiration under standard conditions** - We obtain the evapotranspiration data under standard conditions, starting from crop evapotranspiration reference data (ET_0) provided daily by ARPA SMR (using Hargreaves equation) which refer to a 6.25 km^2 geographical grid covering the whole regional plain area. Then we apply the FAO k_c factor, specific for each crop and each growth stage and, in many cases, correct it with local research carried out by CER. The k_c factor is changed day by day, between stages, according to the continuity equation.

3.2. **Crop evapotranspiration under non standard conditions** – In this case non standard conditions means poor soil water content that causes water stress in crops. According to the FAO paper n.24 theory that set up a specific soil humidity level under which crops reduce their evapotranspiration rate, we calculate the real crop evapotranspiration under field conditions

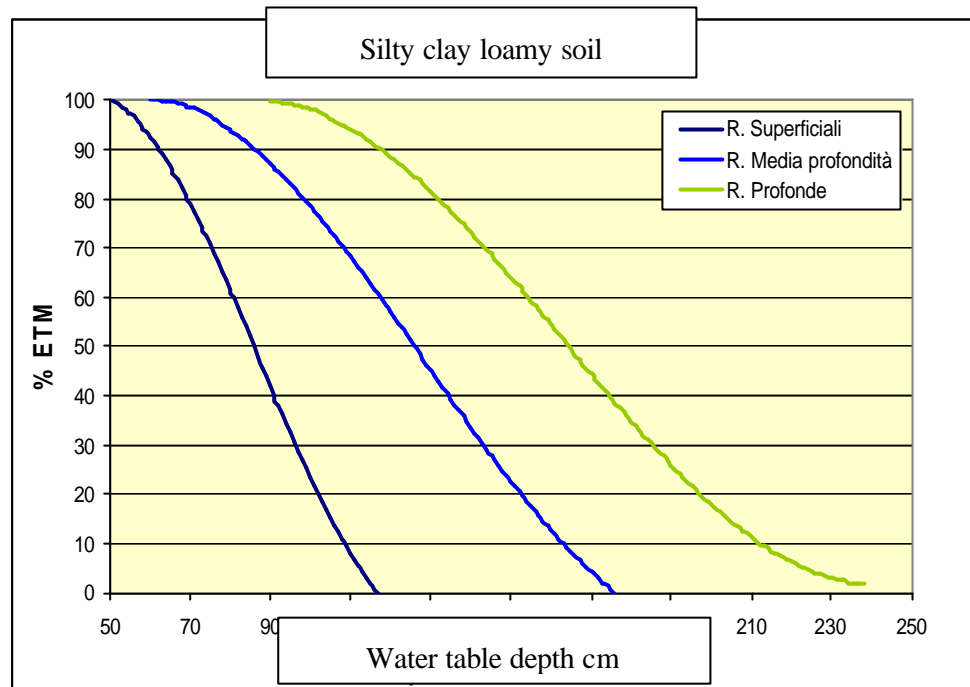


4. **Water table contribution** – The model does not evaluate the capillary rise from shallow water table but the water table contribution to crop water requirements expressed in terms of percentage of crop evapotranspiration. This is calculated using water table depth, soil particle size, crop soil water exploitation capacity and root system depth. Nine years research was carried out to find out the water supply reduction by applying constant water table depth to



several crops. We developed nine empirical equations which describe the relationship between (i) the percentage of crop evapotranspiration due to capillary rise from the water table, (ii) water table depth, (iii) three soil textural classes interacting with three crop clusters based on their root system depth and crop soil water exploitation capacity.

Below the graphics shows three equations of nine:



5. Determination of the irrigation depth

Once soil/plant water balance has been calculated, the model sets the water to be applied to the crop, i.e. the difference between the range values of the two soil water available thresholds. The values were calculated as a result of several years of field research, and are specific for each crop, growth stage and irrigation system (drip, flood, sprinkler). They are suited for better crop growth and to have maximum yield, changing day by day according to the continuity equation.

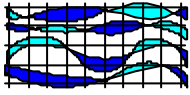
The model compares measured soil water content with the lower threshold daily; when the minimum value is reached, we calculate water irrigation depth as the difference between the thresholds.

The upper threshold may be equal to field capacity, or, usually lower to it, to avoid both soil water depletion not turned into yield, and to have a lot of dry soil to store rainfall.

The calculation of the irrigation depth plays a key role in the model, affecting the other steps so much that it characterizes the model as exclusively aimed at field scale irrigation.

6. IT Architecture of Irrinet

Irrinet was developed as a Web application by AltaVia srl (www.altavia.eu) in 1995. To date, the system has produced 3 main releases:



1.0 – 1995 first interactive web application in Italy for the agricultural sector

2.0 – 2002 adoption of new standards, SMS facility added

3.0 – 2007 multi-browser support, web service

The latest release has been developed using .NET (framework 2.0) and SQLServer2000 and is a complex system which is comprised of 3 main modules:

- Web application
- External data importation module
- IrriSMS module

6.1.Web application

The application has a three-level implementation design:

- Web Interface (ASPX)
- Data access layer (ADO.NET) for the data base access
- Business layer (VB) which includes the water balance algorithms

The application uses a relational database that includes more than 70 tables. The database is organised in informational areas according to the following scheme:

1. Knowledge base area
 - a. model configuration parameters
 - b. model and crop parameters (Kc, crop stages..)
 - c. lookup lists (managed crops, irrigation systems..)
2. Area information
 - a. Meteorological data
 - b. Water table depth data
 - c. Soil information
3. User information (registered users only)
 - a. User and farm description
 - b. Detailed crop description
 - c. User data
 - i. Rainfall
 - ii. Irrigation gifts
 - iii. Water table depth data
 - iv. Start and stop crop date

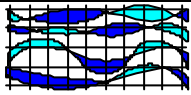
4. GIS data

The GIS maps are managed in ArcInfo format (shapefiles) and are stored in a directory outside the database. The polygon identifiers of the maps are dynamically linked to the information stored in the database (meteorological and water table stations, soil units..).

This allows information retrieval according to the user clicks on the GIS maps.

6.2.External data importation module

This module is an agent in charge of data upload which runs every hour. It uses both ASCII files and external web services and imports data into the database performing data consistency checks. The module is able to read data from several sources and several information providers.



6.3. IrriSMS

IrrisSMS is a server service which uses the same business layer and database as the web application and is in charge of:

- Building up the list of SMSs to be sent for a certain day
- Running the water balance and formatting the irrigation information for SMS
- Queuing the SMSs
- Calling the SMS gate provider
- Managing the required resend in case of wrong dispatching
- Logging the SMSs sent
- Alarm messaging for the server operators

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