

Proposal full title :

Improved management tools for water-limited irrigation :
combining ground and satellite information through models

Proposal acronym :

IRRIMED

TECHNICAL ANNEX

Proposal Number : ICA3-2002-10080

Region : MPC (Mediterranean Partner Countries)

Call ICFP502A3PR03 , Research area : b. ii (Efficiency in water use)

Objectives

The objective of this proposal is the establishment of tools to support efficient management for water used for irrigation as well as to test scenarios for long term sustainable policies. Accurate knowledge of water demand and use by irrigated agriculture is a key to an effective water management strategy. Therefore this project will bring researchers together with managers and other stakeholders to jointly evaluate research results and needs and set research priorities. This will facilitate the rapid assimilation of new technologies, analytical tools, and modelling approaches for a more efficient management of irrigation water resources.

The general scientific objective is the assessment of temporal and spatial variability of water consumption of irrigated agriculture under limited water resources condition.

Intensive measurement campaigns with sophisticated equipments will allow to combine ground and satellite measurements into models, to ultimately produce simple and robust methods to assess evapotranspiration (ETR) over large areas.

The specific objectives will encompass:

- accurate assessment of actual ETR over selected crop during the growing season, allowing to validate models and to update the crop calendar and crop water requirements
- remote sensing of crop extension and evolution during the growing season, to measure the actual acreages of the different crops
- refining existing methods for simple ETR estimation, to apply them spatially, deriving ETR maps from satellite data

The application of these results will be discussed in interaction with endusers (see WP6) in order to:

- Specify operational tools providing crop water use and requirements (temporal and spatial information), built upon simple and robust models tailored to the enduser specifications.
- Improve of water management master plans through more accurate methods, supplied with up-to-date inputs for more realistic scenarios assessment.

All these objectives will be pursued while keeping in view three aspects considered key elements for the success of the project:

- emphasizing the regional dimension
- ensuring long term development of the efforts initiated in the project (see WP7)
- disseminating the results to a wide audience (see WP 8)

Work plan

a) Introduction : overall structure

The consortium is build around two european institutions associated with seven partners from four MPCs, with a test site in each of them. Among the four test sites, the ones with larger and simpler features (flat terrain, large fields , recent irrigation network) will be used as the reference sites where 'intensive' field experimentation will take place. The project will be organised along the following steps to demonstrate the applicability of novel techniques and, last but not least, to train the partners from the Mediterranean countries in the use of these methods in practice. Due to the limited budget we will confine the field work to the use of to novel but simple-to-use simple methods of observations. During 2 workshops, more sophisticated techniques will be demonstrated.

Step 1 : Information system and land cover mapping

On each test site all existing environmental data relevant to the project will be compiled within a GIS to make it readily usable for the analysis, modelling and scenario phases. A series of high resolution remote sensing images (e.g. from SPOT 4 then 5 satellites) will be processed to determine the extension of irrigated areas, and to establish a map of the major crops (multi-temporal classification techniques).

Step 2 : Accurate ground measurement of ETR over selected crops

Over a selection of fields representing the most important crops, intensive measurements of parameters necessary to compute the energy balance and derive the ETR will be performed all along the full growing cycle. These will encompass meteorological data, heat and vapour fluxes with "easy-to-operate" scintillometry - combined with net radiation and soil heat sensors -, and eddy correlation technique during Workshops , as well as soil and vegetation condition. On each of the two 'intensive' site one crop will be monitored per year, the second year another cultures will be subjected to experiments, provided the data collection in the first year was successful.. This complete data set will be used alternatively to train the models then for validation.

Step 3 : Validation of a reference model (field level)

Using the expertise and recent developments available within the project a state of the art model (simulating the physical processes involved in soil-vegetation atmosphere transfers and vegetation growth) will be implemented to be used as reference for the next steps (benchmarking). This sophisticated model will be fine tuned for the crops subjected to the intensive measurements (see step 2) and coupled with satellite data acquired over the same plots for validation. All further ETR estimation approaches particularly the ones to be used with satellites images for ETR mapping will be tested against this model validated at the field level.

Step 4 : Evaluation and improvement of the classical FAO ETR estimation

In order to evaluate the performances of the classical FAO ETR estimation method (based on ETo and crop coefficients Kc, Allen 1998) it will be compared for the collected data set to both the actual ETR measured and to the reference model, to gauge the potential for improvement.

The results will lead to update the Kcs for the monitored crops, eventually to design new ones adapted to semi arid conditions, they will be cross validated with the reference model.

In parallel, the crop calendar estimated from FAO tables will be compared to the actual crop calendar as monitored from space, through the processing of a large number of images along the growing season (typically every two weeks). Selected crops well identified in the imagery will be closely monitored, allowing to update the FAO tables to the real local conditions.

Step 5 : Developing an ETR estimation usable with remote sensing data

From the previous step a better estimation of the ETR will be possible from the updated Kcs. Based on the actual measurements, simple relationships between Kcs and NDVI (a satellite derived 'greenness' factor) will be established, their domain of validity will be tested again using the well named reference model. Different $KC=f(NDVI)$ condition will be tested for the selection of crops.

Step 6 : ETR derived from high resolution remote sensing data

The relationships established in the previous step will then be applied to real remote sensing data using the data set collected during step 1, particularly to test and validate the improved SEBAL approach (see B4). Comparing the results obtained with measurements on the ground will allow to validate the method and define its limits.

Step 7 : ETR derived from low resolution remote sensing data

Once the Kcs are validated over large areas (aggregated) as a result of the experiments with the scintillometer, a method to derive ET_0 from meteorological satellite will be tested. The proposed method is based on a recent finding that ET_0 is determined primarily by radiation and next by temperature. This will be "translated" into a satellite-based operational system using the European second generation METEOSAT (MSG to be launched in 2002). If successful, the proposed method allows the mapping of ET_0 for the entire Mediterranean region at the pixel-scale of the MSG (about 7 by 7 km).

Step 8 : Testing scenarios

Once the methods discussed above are validated and usable routinely, they will be implemented in a user friendly interface to test different scenarios: changing land use, different crop calendar, even different climatic conditions.

b) Adequacy of chosen approach

The adequacy of the approach described in the above steps and the related risks can be evaluated along the following main aspects.

Ground experiments

Ground experiments are performed over a selection of four test sites, one in each Mediterranean partner countries. All of them are characterised by limited water resources, and a better monitoring of the performance of the whole irrigation system in order to increase the efficiency is in all cases critical. These 4 sites represent a wide array of irrigation situations in the Mediterranean region:

- large recent irrigated area with modern cultivation techniques
- large irrigated flat land on rather ancient agricultural land
- traditional oasis with mixed cultures

- additional irrigation from small dams

At the field level, the measurements include meteorological variables (temperature, wind speed, radiation, precipitation) as well as continuous measurements of evapotranspiration and of soil moisture. Evapotranspiration measurements will be mainly performed with eddy-correlation techniques and scintillometry in the two 'intensive' sites devoted to the development of the tools, and with the Bowen ratio approach for the two sites used to check the generality of the tools.

Justification :

- due to the variety of environmental conditions and crop cultivars, existing detailed and simple models (e.g. FAO) for estimating water requirements and water balance need ground measurements for validation
- Eddy-correlation technique is more complex and costly than the Bowen ration ones but much more robust in dry conditions
- Scintillometry is the only way to estimate evapotranspiration along several kilometre long transect and therefore to validate upscaling techniques.

Risk assessment : we believe that the level of risk is low.

- the european partners have a long background in micrometeorological and vegetation measurements, including several years of operation of eddy-correlation and scintillometry operation in arid countries.
- MPCs partners have already some experience in micrometeorological measurements and frequent exchanges with european scientists are planned, including through stays in Morocco, Syria, and Tunisia, and through training in Europe.
- The highest risk is to face very abnormal climate during the project that could limit the significance of the results. This risk is lowered by the use of detailed process models.

Validation of detailed reference models against in-situ data

Detailed reference models take into account most of the processes driving vegetation growth and water balance and they allow to simulate the interactions of processes. Once validated, and calibrated against ground measurements, they will be used to build simpler models with well documented performances. Reference models will provide a guide to explore the behaviour of simple models over a large range of situations.

We believe that the level of risk is very low :

- the models exist and their performance and robustness is at least partly documented. They can be run with PC computers.
- the european partners and several teams of MPC's have strong expertise in surface processes and crop modelling at various scale and under various climatic conditions.

Test and adaptation of simplified model against in situ-data and reference models

The basis for the simplified model is the widely used FAO approach for computing crop water requirements and evapotranspiration. Improvements and adaptations will mainly deal with calibration of Kc coefficients and phenology monitoring from satellite data.

The level of risk is negligible :

- the models exist and is well documented by FAO publications. The evolutions we planned are well understood and scientifically sound.
- the european partners and teams of MPC's already used it.

Use of remote sensing for upscaling

Land cover mapping with satellite will provide an up-to-date information of primary importance, often lacking in most MPC's. For example its essential for water allocation plans, for crude estimate of irrigation needs and for running crop and water balance models. Illegal or unknown water withdrawing, as well as the number and location of greenhouses can also be identified and mapped with satellite images.

Monitoring crop growth will be first performed over Morocco and Jordan, before extension over Syria and Tunisia. It requires higher time sampling which is feasible because of the moderate cloud cover in MPC's. The optimal temporal sampling versus accuracy will be assessed. Useful information for water management will rely on running the simple models with input of satellite data and GIS information.

The level of risk is low :

- the project relies on operational satellites. The failure of one satellite or instrument does not mean the end of the project.
- the european partners and some teams of MPC's have a strong background in the processing and use of satellite data for land surface monitoring and modelling.

General risk assessment

As already mentioned, the technical risks are probably low and plans for training additional MPC's personnel have been established.

The major risk for the success of such a project is the inability to exploit its final results, we have taken this into account by a strong involvement of end-users with a specific work-package for their continuous inputs and evaluation.

c) Work packages

The different tasks of the science plan described above in a series of steps, combined with the will to interact with the endusers and to disseminate the results in the large regional community has led us to organise the project in the following 8 workpackages, summarized in the list hereafter .

The number refers to the workpackage description, the leader designate the partner who is responsible for the realisation of that workpackage within the project, he will interact with the other partners to ensure a good progress within all involved teams.

Workpackages list

WPNo	Work package title	Leader	Deliverable/No
1	Building the information system	P3	
1.1	building the background information system		WP1.D1, D2, D6
1.2	acquisition of ground information		
1.3	building the satellite derived information		WP1.D3,D4, D5
2	Field micrometeorological measurements	P2	
2.1	installation of scintillometer, net. rad soil heat system in Morocco and Jordan; on site training ;		
2.2	implementation scint data in adapted SEBAL-method		
2.3	quality test and data archiving		WP2.D1, D3
2.4	training on micrometeorology		WP2.D2
3	Model developments	P1	
3.1	Implementation of reference model		WP3.D1
3.2	Comparison with FAO method		
3.3	development of a simple robust model		WP3.D2
4	Spatialisation using Remote Sensing	P1	
4.1	integration of ETR simplified model into GIS		WP4.D1, D2
4.2	follow up of actual crop development		WP4.D3,D4,D5
5	Building and testing scenarios	P7	
5.1	Scenario definitions		WP5.D1
5.2	Synthetic data set generation		WP5.D2
5.3	Scenario analysis		WP5.D3, D4
6	End-user requirements and specifications	P5	
6.1	End users typology		
6.2	First review of end users needs		WP6.D1
6.3	Feed back and review of end users needs		WP6.D2, D3
6.4	Discussion of implementation requirements		WP6.D3
7	Capacity building / ensuring sustainability	P8	
7.1	On site formation		WP7.D1
7.2	Workshops		WP7.D2,D3
7.3	Regional networking and knowledge sharing		WP7.D4,D5
8	Scientific steering and co-ordination	P1	
8.1	scientific steering		WP8.1
8.2	organising common activities		WP8.D2, D3
8.3	project communication		WP8.D4,D5
8.4	project reporting		WP8.D6

List of deliverables

Deliverable N°	Deliverable title	Delivery date²
WP1-D1	Digital information layers on the permanent features of the agricultural environment	12
WP1-D2	pre-processed low and high resolution Spot4 and 5 satellite image sets	10
WP1-D3	Global land use/.land cover map of the test sites	16
WP1-D4	Monthly map of extent of irrigation areas	18
WP1-D5	Crop identification and growing stage (NDVI) on selected area (zooming in)	14
WP1-D6	Building blocks of a global information system on the test site(in conjunction with WP5)	20

Deliverable N°	Deliverable title	Delivery date²
WP2.D1	Fully validated micrometeorological datasets on selected experimental plots	16
WP2.D2	Dedicated processing methods and relevant documentation manuals	17
WP2.D3	Software packages, e.g. to calculate actual ET from the collected scintillometric data	9

Deliverable N°	Deliverable title	Delivery date²
WP3.D1	simplified ETR model	18
WP3.D2	report on performance	24

Deliverable N°	Deliverable title	Delivery date²
WP4.D1	Digital map of water needs per crop over each test area (different time scale)	20
WP4.D2	irrigation water requirements (average year , humid/dry year)	20
WP4.D3	strategy for optimising scarce resource	24
WP4.D4	Digital diagnostic maps of ETR	29
WP4.D5	adaptation to small irrigated areas (TN, SY)	32