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Preliminary investigation of the parameterisation of surface fluxes from heterogeneous land cover for the EFEDA area.

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Introduction.

The aim of this study is to provide rules of aggregation of the surface parameters for use in the mesoscale model. A 2D atmospheric model is used to study the aggregation of surface fluxes from this site, in particular, the effect of the juxtaposition of the dry and irrigated areas on the overall heat and moisture fluxes.

The Barrax site is situated in the west of the province of Albacete, 28 km from the capitol town (39°N,2°W). The land consists of 65% dry land (winter crops and fallow) and 35% irrigated land (corn and barley). The patches of irrigated crops are the order of 100 to 1000 m across. The site was extensively instrumented in the course of the EFEDA experiment. It provides an extreme, but realistic test site for aggregation of surface fluxes in SVAT models.

In a new experiment, some response of the irrigated vegetation to the humidity deficit is included.

Described below are some initial runs to establish the sensitivity of the aggregate descriptions to variations in surface resistance and roughness. Additional work will be required to test the model performance with the full data set.

Modelling strategy.

To provide initial conditions for the 2-D model, the model is first run in one-dimensional mode with a horizontally uniform surface and a horizontally uniform atmosphere. The model is initialised with constant profiles of wind velocity, potential temperature and relative humidity. After 20 hours, the atmosphere comes into equilibrium with the surface.

A pattern of heterogeneity is then imposed in the 2D model by perturbing the surface parameters, maintaining the same area average surface conditions, and the model is run for a further 10 minutes. After this time the atmosphere is in equilibrium with the new heterogeneous surface. The perturbations to the atmosphere only reach up to about 10 m, which is why the atmosphere can reach an equilibrium state in such a short time. In this study the model was run with a 1000 m domain: that is periodic irrigated and non-irrigated patches each 500 m across.

The values of heat and moisture fluxes and the humidity deficit across the domain can be used to obtain effective surface parameters that could be used to obtain the area average surface fluxes.

Boundary conditions for 2D model.

Values of mixed layer humidity, temperature and wind speed are necessary to run the model, with available energy, values of surface resistance and roughness length. At this time, not all of this data was available at one site. A set of data was generated which could be considered typical of the area.

The average midday values of temperature, humidity and available energy over 17 days in the summer were measured over the Vine site at Tomelloso (Oliver and Sene, 1992). These were used as typical midday values for the area.

TABLE 1

	r_{smin}	r_s	q
Run 1		70	1
Run 2	40		1
Run 3		70	4
Run 4		156	1
Run 5	75		1

Table 1 shows the values of r_{smin} and r_s (irrigated) and q, the ratio of the roughness length for the irrigated and dry areas. Runs were made with a constant roughness (0.1 m) and with differing roughness lengths for the irrigated and non-irrigated areas (0.2 m and 0.05 m).

The surface resistances of the irrigated and non-irrigated areas were calculated by Bastiaanssen et al (1994) from remotely sensed data. Typical non-irrigated values are 1000 s m^{-1}, and typical irrigated values are between 70 and 150 s m^{-1}. Therefore two runs were made with these upper and lower limits. In addition two runs were made with a responsive r_s (see below).

<u>Humidity deficit control on r_s</u>

An additional numerical experiment was carried out with a surface resistance responsive to humidity deficit. The usual form of this response can be described with the following (Jarvis, 1976).

$$r_s = r_{smin} \exp(C\,\delta q)$$

where r_{smin} is the minimum surface resistance, a constant for each vegetation type, and C is also a constant which can depend on the vegetation type.

The value of C found by Huntingford et al (1994) in bushes in the Sahel was about 50 kg kg^{-1}. While this value cannot be considered correct for irrigated corn and barley, it can at least be considered to be of the right order of magnitude. Therefore, in the absence of any other data, this value of 50 kg kg^{-1} for C is used.

<u>Results</u>

Figure 1 shows the values of the latent heat fluxes across the model domain for runs 1, 2 and 3 and Figure 2 shows them for runs 4 and 5. From these figures it can be seen that runs 1, 3 and 4 have an enhancement of the evaporation at the windward edge of the irrigated patch, as expected. However, the responsive vegetation, runs 2 and 5, almost cancels out this edge effect.

Table 2 shows the values of the area average evaporation for the five runs. There is little difference in average evaporation between the runs with similar surface resistance values (1 and 3 and 4 and 5). However, the evaporation is sensitive to the change in roughness (cf. runs 1 and 3) and to the change in surface resistance (cf runs 1 and 4).

Effective parameters.

Several methods of averaging surface resistances have been proposed (see eg Blyth et al, 1993). The simplest is to take the average;

$$r_s^e = \frac{1}{n}\sum r_{si} \tag{1}$$

or to take a parallel average (e.g. Noilhan and Lacarrere, 1993)

$$r_s^e = \frac{n}{\sum \frac{1}{r_{si}}} \tag{2}$$

or to take an average of these two estimates;

$$r_s^e = \frac{1}{2}\left(\sum r_{si} + 1/\sum \frac{1}{r_{si}}\right) \tag{3}$$

TABLE 1 Latent heat flux, modelled and estimated from above equations.

	Modelled	Eqn 1	Eqn 2	Eqn 3
Run 1	216	128 (-40%)	282 (+30%)	177 (-18%)
Run 2	214	145 (-32%)	238 (+11%)	180 (-16%)
Run 3	226	134 (-41%)	281 (+24%)	182 (-19%)
Run 4	193	123 (-36%)	205 (+6%)	154 (-20%)
Run 5	192	122 (-36%)	204 (+6%)	153 (-20%)

Conclusions.

The 2D modelling has shown that edge effects are small at the Barrax site for typical midday conditions and therefore a 'tile' model (where fluxes are calculated for different fluxes separately and an weighted area average of the fluxes made) can be used. However effective parameters are more generally used in numerical models and errors can arise in the calculation of these due to the non-linearity of the SVAT equations. A comparison of the various proposed methods of calculating the effective surface resistance shows that the average given by Equation 3 always estimates the area average evaporation to within 20%.

The operation of the 2D model needs to be tested with the extensive EFEDA data base, as this becomes available, and this will be the next step in this project. Other surface combinations should also be tested, although the irrigated/non-irrigated example investigated here is probably the most extreme encountered in this region (another possible extreme example are the lakes which occur near to the EFEDA region). A second activity within this project, the testing of the IH/UKMO MITRE SVAT model awaits the availability of the surface flux archive.

References

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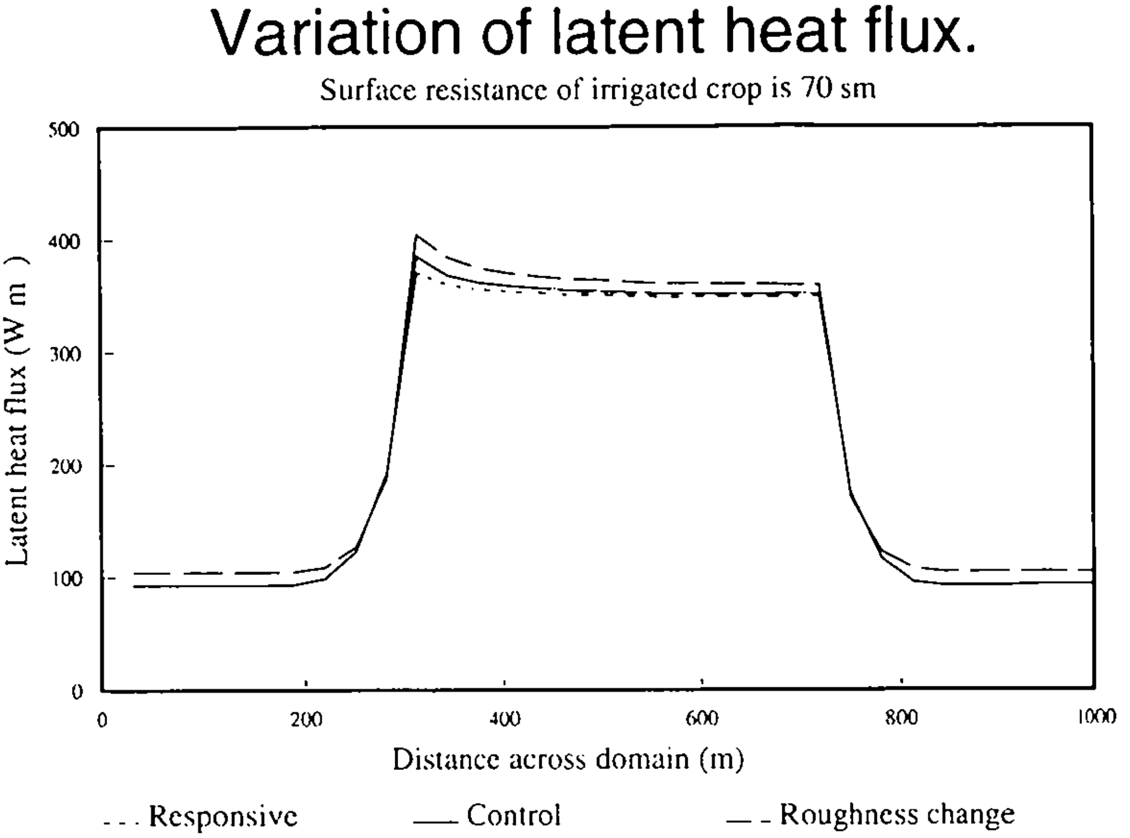
Figure 1



Variation of latent heat flux.
Surface resistance of irrigated crop is 70 sm
Latent heat flux (W m)
500
400
300
200
100
0
0
200
400
600
800
1000
Distance across domain (m)
... Responsive
— Control
— - Roughness change

Figure 2

Variation of latent heat flux.

Surface resistance of irrigated crop is 156 sm