Evaluation of the model structure and parameterisation of the FOOT-CRS tool

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Introduction

In the EU-project FOOTPRINT (www.eu-footprint.org) three pesticide risk assessment and management tools were developed, for use by three distinct end-user communities at three different spatial scales. FOOT-CRS (**C**atchment and **R**egional **S**cale) is a GIS-based tool for pesticide risk assessment and management at the catchment scale. It is to be used by 'water quality' managers, i.e. regional/local authorities, water agencies, and water companies. The emphasis in FOOT-CRS is on i) identifying the areas most contributing to the contamination of water resources by pesticides, and ii) defining and/or optimising action plans at the scale of the catchment.

Model overview

FOOT-CRS has been programmed as a toolbar in ArcGIS 9.3. For the calculation of pesticide inputs into surface waters via surface runoff and erosion, a routing to the surface water network is performed on a grid basis, and the pesticide load reduction during transport in overland flow by reinfiltration or redeposition is explicitly calculated. Subsequently, the fractions of pesticide surface runoff loss and pesticide erosion loss from a cell that finally reach the sw network are computed for each cell. This information is crucial for determining critical source areas and the sites where the establishment of additional mitigation measures will be most effective. FOOT-CRS produces several types of output:
i. maps and spatial cumulative distribution functions (CDFs) of pesticide leaching concentrations (PECgw)
ii. maps and spatial CDFs of pesticide losses from fields and pesticide inputs into the surface water network
iii. temporal CDFs of Predicted Environmental Concentrations in surface water (PECsw) at the catchment outlet (i.e. for one point in space), for different pesticide input pathways. These CDFs can e.g. be used to determine the return period of a given peak exposure concentration.

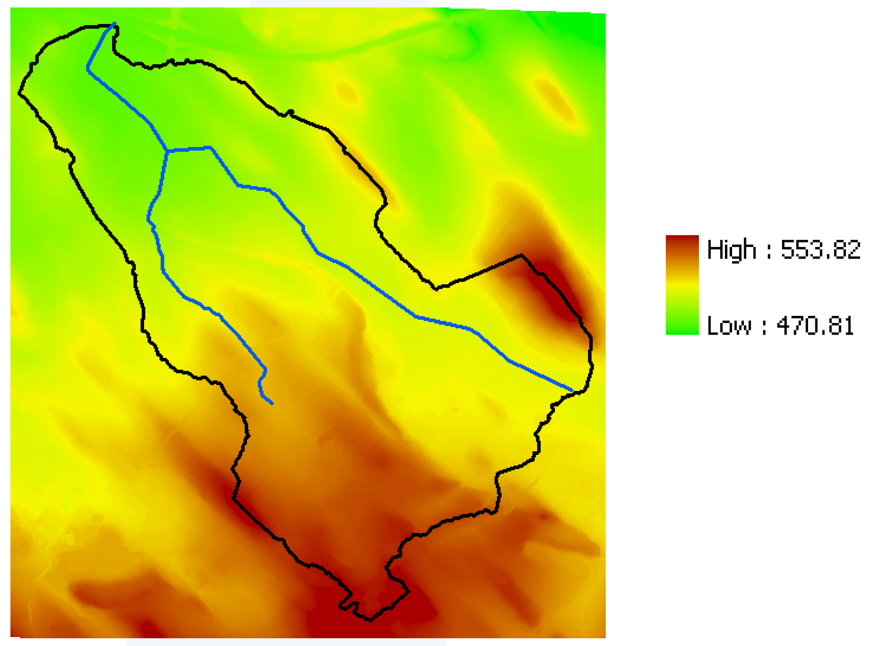

Fig. 1: Digital Elevation Model (2 m * 2 m)

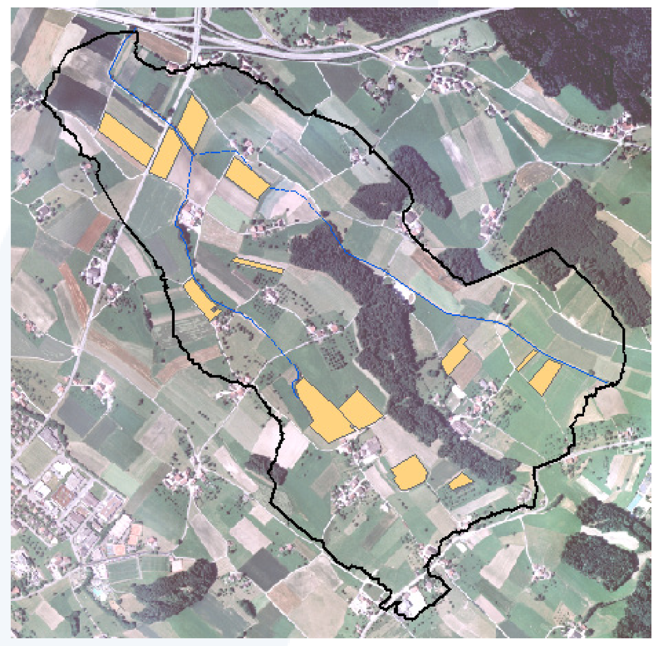

Fig. 2: Rohr catchment with treated maize fields

Stepwise evaluation of FOOT-CRS

A stepwise evaluation of the FOOT-CRS tool against experimental data from the Rohr catchment (2.1 km^2) on the Swiss plateau has been carried out. In the first evaluation step (cf. poster at the EGU 2010), the output of a standard FOOT-CRS simulation (with a 20-year FOOTPRINT weather time series for the appropriate climate zone) was compared statistically with measured data obtained by the EAWAG during a controlled application experiment in 2000 (840 g ha^{-1} atrazine on fodder maize on 8 May; cf. Leu et al., 2004, Environ. Sci. Technol. 38, 3827-3834), to check the plausibility of the FOOT-CRS results and the representativeness of the FOOTPRINT weather series for the Rohr catchment.
The second evaluation step now involves a non-standard FOOT-CRS simulation, using new underlying modelling databases. These contain the results of new MACRO and PRZM simulations with the original weather time series observed during the experiment and have a daily resolution (as opposed to monthly maxima in the standard FOOT-CRS). Consequently, the modified FOOT-CRS produces daily time series of PECsw at the catchment outlet. Thus, a direct comparison of simulated and measured concentration and flux time series can be performed, allowing an evaluation of the FOOT-CRS model structure and parameterization.

Results and Discussion

Atrazine inputs into the sw network matched well with measured loads at the catchment outlet (Fig. 4). However, in the model atrazine inputs into the stream occurred only 10 days after application and not immediately as observed. According to FOOT-CRS, the pesticide input pathways lateral subsurface flow and drainage were more important than surface runoff.
Peak discharges were underestimated by FOOT-CRS (by a factor of 2 for the main peak on 31/05/2000; Fig. 3). This may be explained by a possible underestimation of the area proportion of the catchment exhibiting lateral subsurface flow or being artificially drained (based on the classification of local soils into FOOTPRINT soil types, 33 % of the catchment area were artificially drained, 18 % exhibited lateral subsurface flow, and 49 % had only vertical water movement in the soil).
Baseflow was strongly overestimated (Fig. 3). This is due to inaccuracies in the input values for mean monthly runoff (the dataset used, the UNH-GRDC Composite Runoff Fields, has only a very low spatial resolution).
Simulated peak atrazine concentrations in surface water, calculated as the ratio of atrazine input to water flux (Fig. 5), were overestimated as a result of the too low peak discharge. However, the direct PECsw output of FOOT-CRS (calculated as atrazine input / water flux * the Gustafson factor GF to account for geomorphological dispersion), seriously overestimated atrazine concentrations in surface water (not shown). GF was calculated as 19.56 and thus yielded much too high concentrations. It needs to be investigated whether the calculation method of GF implemented in FOOT-CRS needs to be revised or the assumptions of the Gustafson method are not met for the Rohr catchment (e.g. due to its small size).

Measured vs. modelled time series

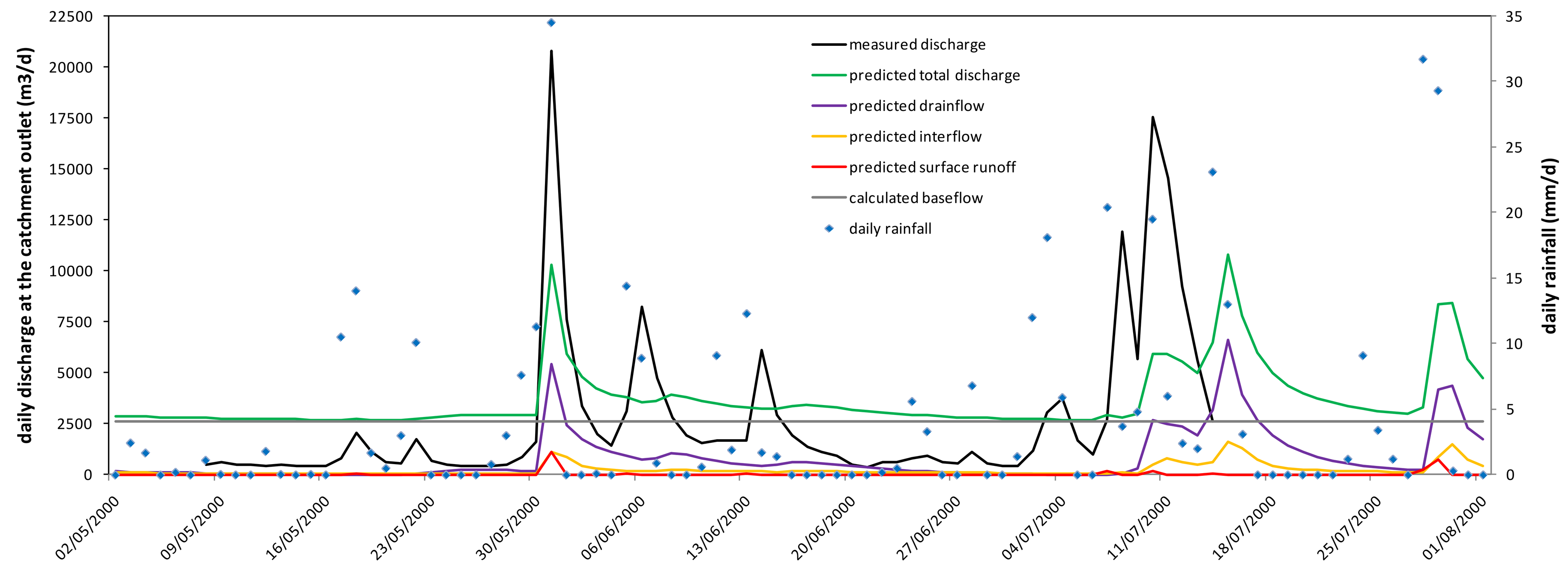

Fig. 3: Observed stream discharge, predicted total stream discharge and predicted individual discharge components at the catchment outlet (m3/d), plus daily rainfall (mm/d) recorded on-site during the experimental period (02/05/2000 – 01/08/2000).

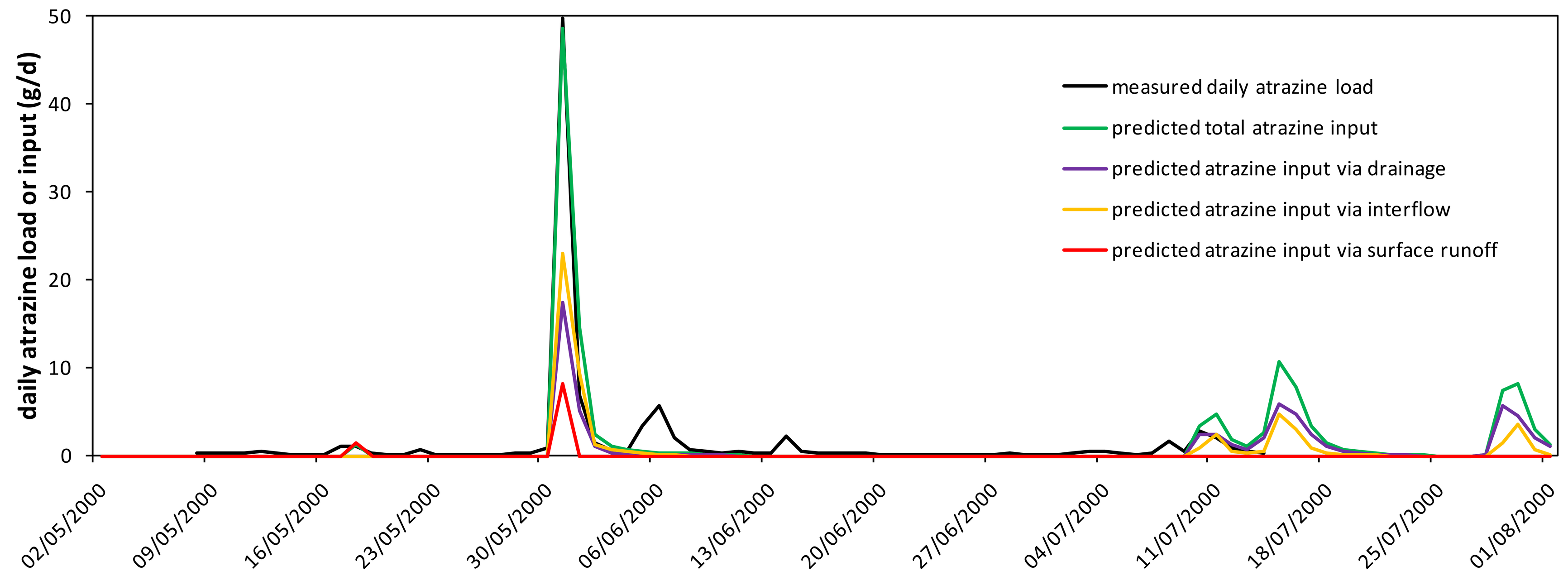

Fig. 4: Observed daily atrazine loads at the catchment outlet (08/05/2000 – 14/07/2000) and predicted inputs into the surface water network (g/d). Predicted pesticide erosion inputs were always zero.

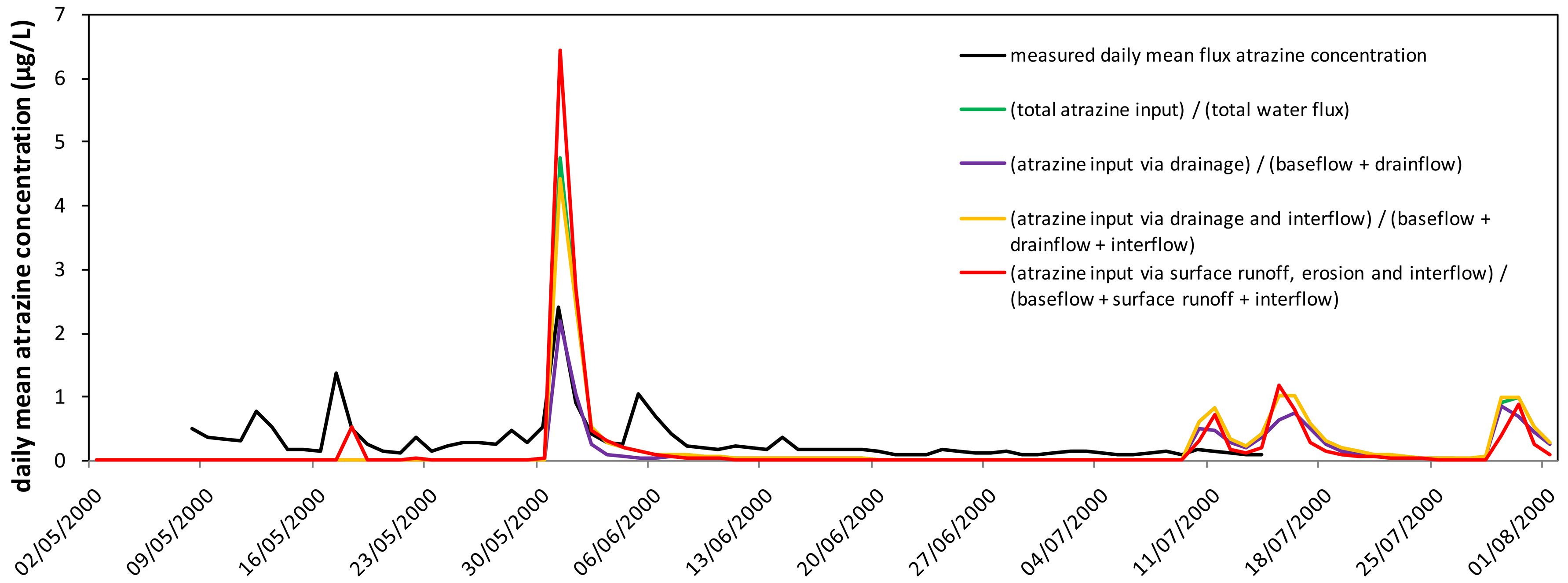

Fig. 5: Observed and predicted daily mean atrazine concentrations (µg/L) at the catchment outlet.

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