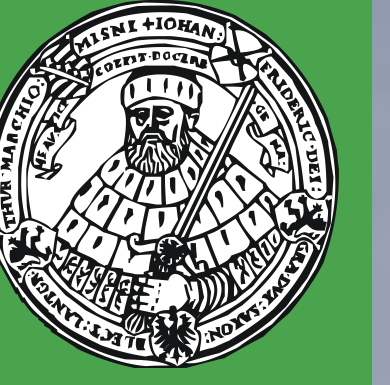


# Initial hydrological modelling to assess impacts of different land uses on process hydrology in a small-scale semi-arid catchment in the Western Cape Province, South Africa

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Introduction & Objectives

## INTRODUCTION

Numerous studies have shown that hydrological process dynamics are strongly influenced by the given land use practice. Since semi-arid regions suffer from water scarcity, an optimized land use practice is important for sustainable management of limited water resources in those areas.



In the Western Cape Province, South Africa, where land is intensively used for food production, various activities aim to study the quantitative and qualitative impact of land use options on local water resources. According to [1], hydrological models can be utilized to develop strategies towards sustainable management of water resources. In this study GIS tools were combined with hydrological modelling using the J2000 model ([1], [2]) to identify the impact of land use changes on basin hydrology and runoff dynamics within a small-scale ungauged catchment.

## OBJECTIVES

The main objective of the presented study was to develop a hydrological model to simulate and assess impacts of different land use types on basin hydrology.

To fulfill this task, the following technical and scientific goals have been identified:

- i) database creation with detailed information for the test catchment
- ii) delineation of Hydrological Response Units (HRUs) which are considered as being homogeneous process-related model entities [3] (where single plots were eventually used as the smallest entities) by extracting information about the spatial distribution of soils, geology and annually changing land use, as well as topographical parameters of the experimental plots
- iii) set up of various modifications of the J2000 hydrological model by using accurate multitemporal land use information
- iv) initial runoff modelling by taking the different land uses on the plots during the land use rotation cycle into account

Study Area

## STUDY AREA

### located within the Langgewens Experimental Farm:

- extracted watershed size: 17,6 ha → micro scale catchment (Fig. 1)
- average altitude: 177 m
- experimental plot size between 0,5 – 2,0 ha

### climate conditions:

- Mediterranean climate; hot dry summers and cool moist winters
- average annual rainfall: 398 mm [4]
- average annual temperature : 17.5°C

### land use management:

- crop rotation cycle; annually changing plot specific land use (Fig. 2)

### soils:

- mainly soils with a sandy loam to loam soil texture (e.g. Mispha and Glenrosa soils) which tend to become waterlogged → "ridge-and-furrowed" experimental plots [4]

### geology:

- precambrian Malmesbury Shale

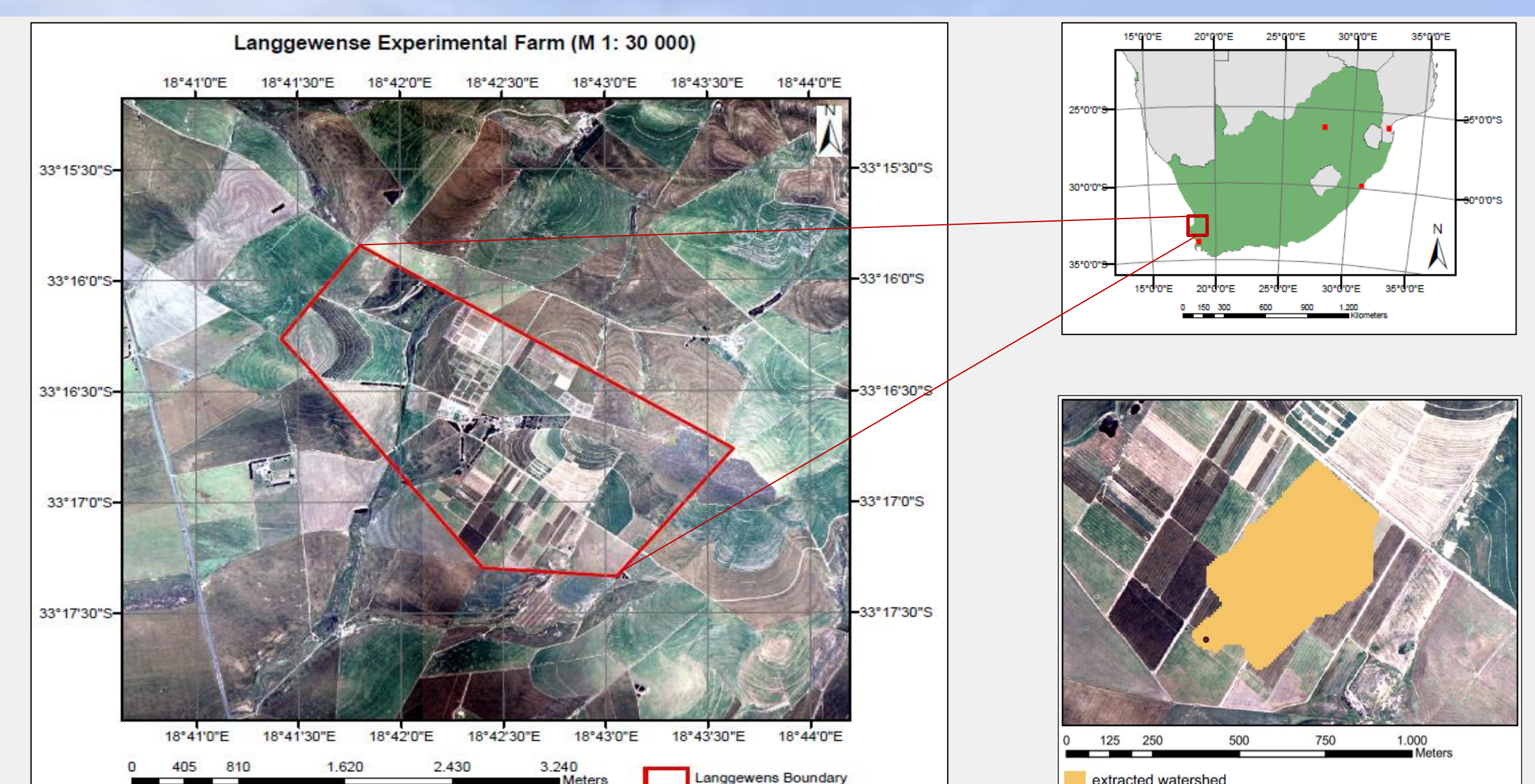


Fig. 1: Location of the Langgewens Experimental Farm and the extracted watershed

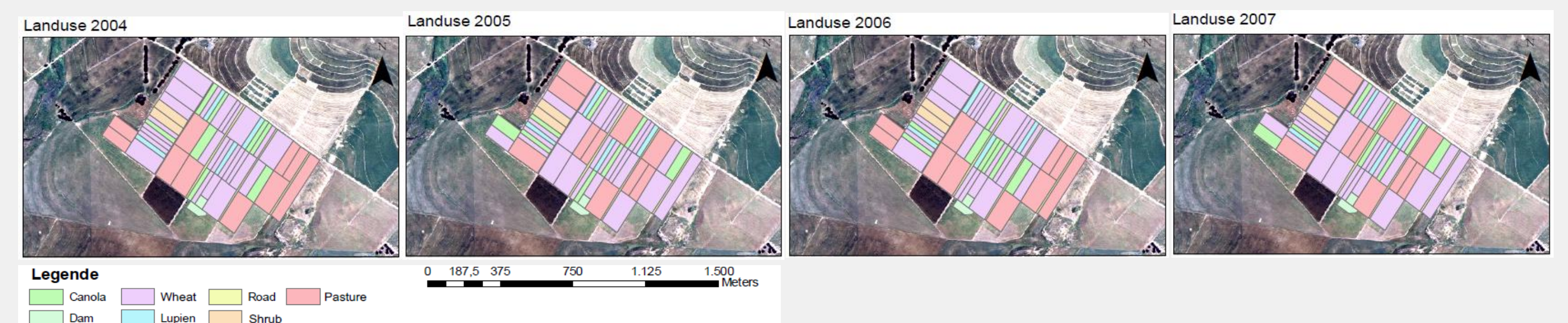


Fig. 2: Annual land use within the Langgewens Experimental Farm (2004 - 2007)

Data & Methods

## GIS DATA

- highly precise GPS field measurements and contour line information for digital elevation model (DEM) generation and watershed derivation
- different raster layers (spatial resolution = 7.6 m) containing plot specific information about soils, land use and geological conditions within the Langgewens Experimental Farm for precise HRU delineation
- accurate dam elevation measurements obtained by surveying a high number of measuring points (n=249)

## HYDRO-METEOROLOGICAL DATA

- daily values of climate data sets from four nearby stations (Fig. 3)
- time period: 01-01-2004 to 31-12-2007

	Station			
	Langgewens	De Hoek	Morreessburg	Landau
Absolute hum				
Precipitation				
Relative hum				
Sun hours				
Tmean				
Tmax				
Tmin				
Wind				



Fig. 3: climate data sets used for runoff modeling with the J2000 model (green = available data)

## METHODS

- i. raster layer creation for HRU delineation (soil, geology, land use)
- ii. subdivision of the catchment into HRUs following the physiogeographic delineation concept [3] applying overlay techniques of the different data layers (Fig. 4)
- iii. J2000 model parameter file creation
- iv. J2000 model set up for the whole crop rotation cycle and differently calculated stream networks
- v. J2000 - model initialization and first model runs

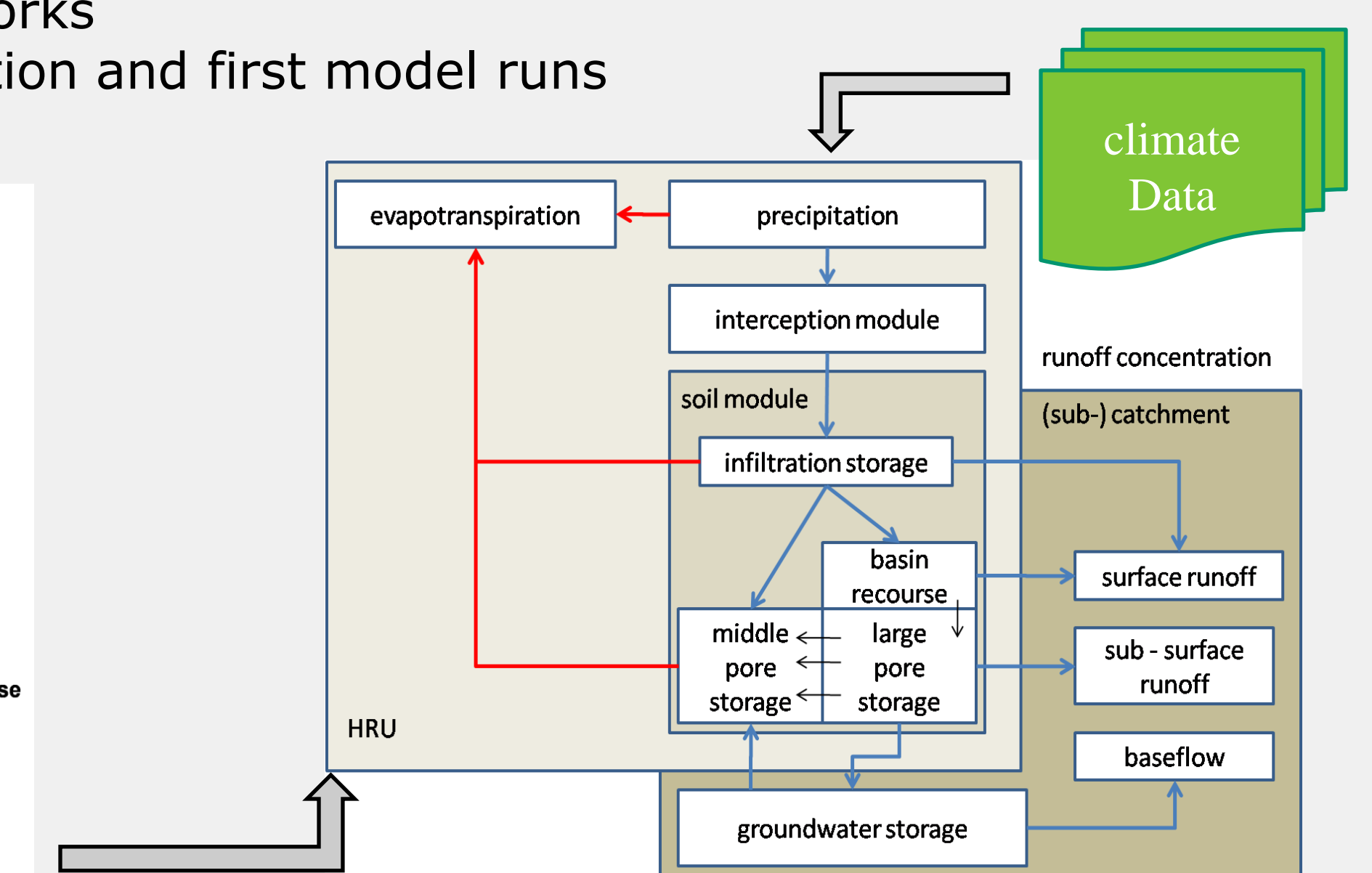
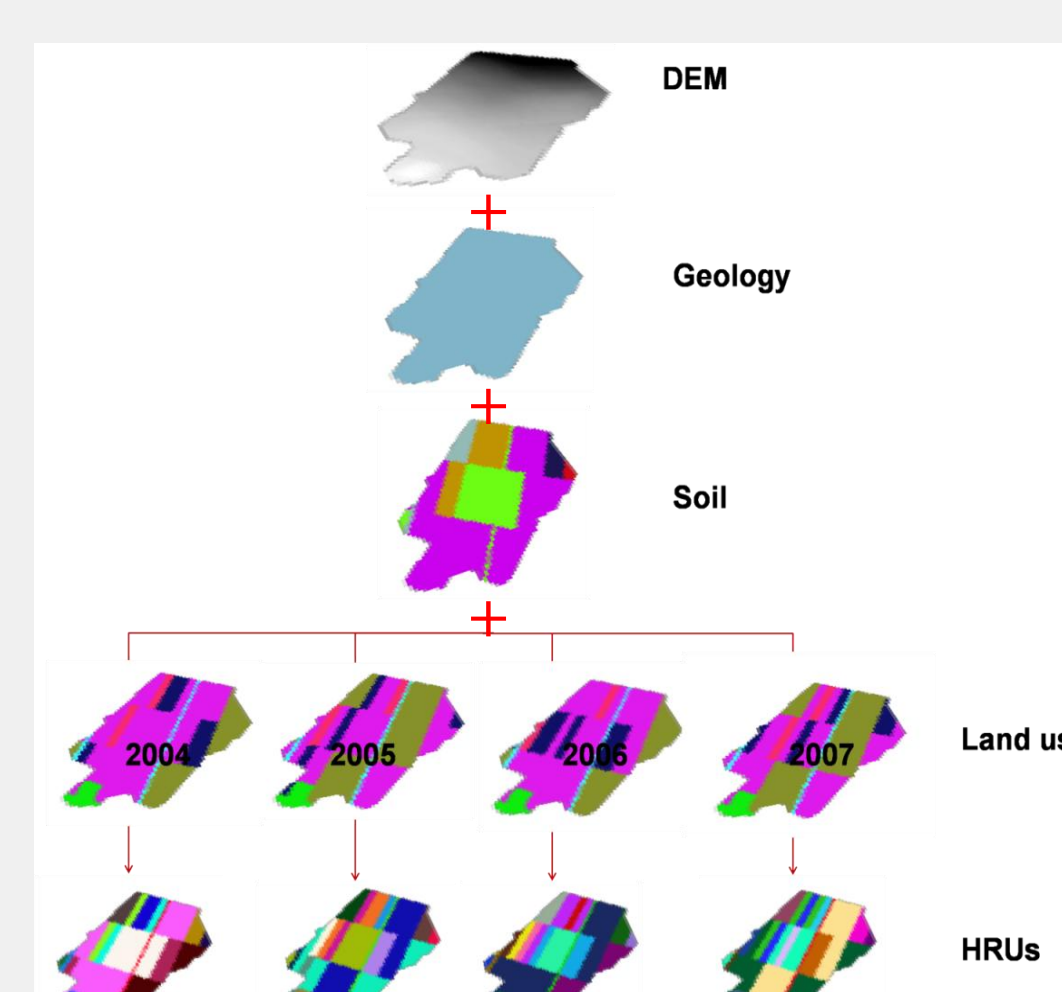


Fig. 4: HRU delineation process (left) and schematic concept of J2000 according to [2] (right)

First Results & Outlook

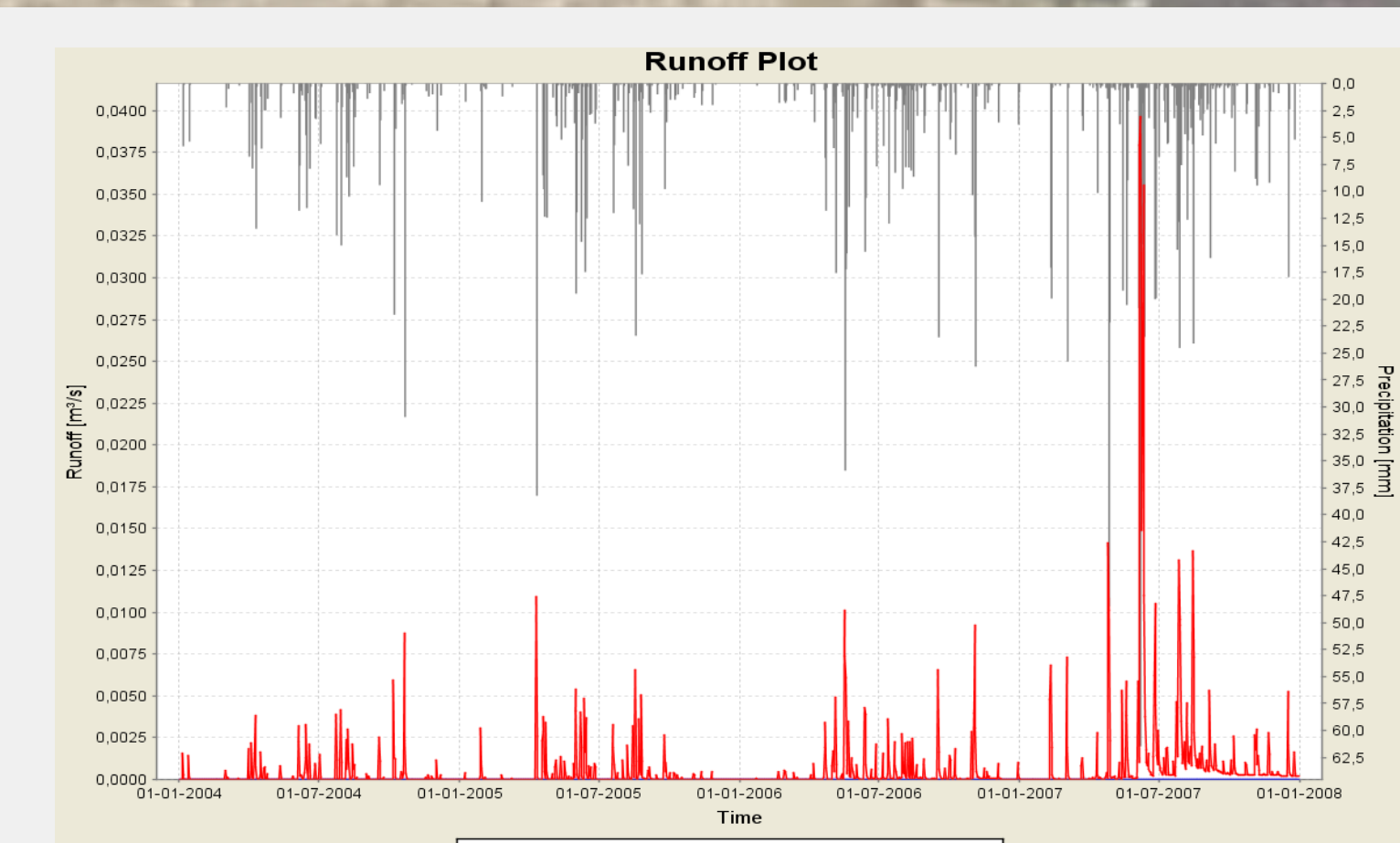


Fig. 5: modelled daily runoff over a 4 year time period at the Langgewens study site for land use conditions of 2004 (stream network pixel threshold = 50)

## FIRST RESULTS

- runoff dynamics could be simulated on an annual base, taking the different stream networks and the crop rotation cycle into account
- results of preliminary model runs show that J2000 is capable of representing the hydrological conditions within such a small-scale catchment (Fig. 5, Fig 6)

## OUTLOOK

- J2000 can be used for a detailed analysis of the individual hydrological components affected by land use change
- further expanding of the measurement infrastructure (e.g. soil moisture sensors, rain collectors, water sampling and runoff gauges)
- model calibration and validation using dam water levels
- transposing the model to other areas and catchments

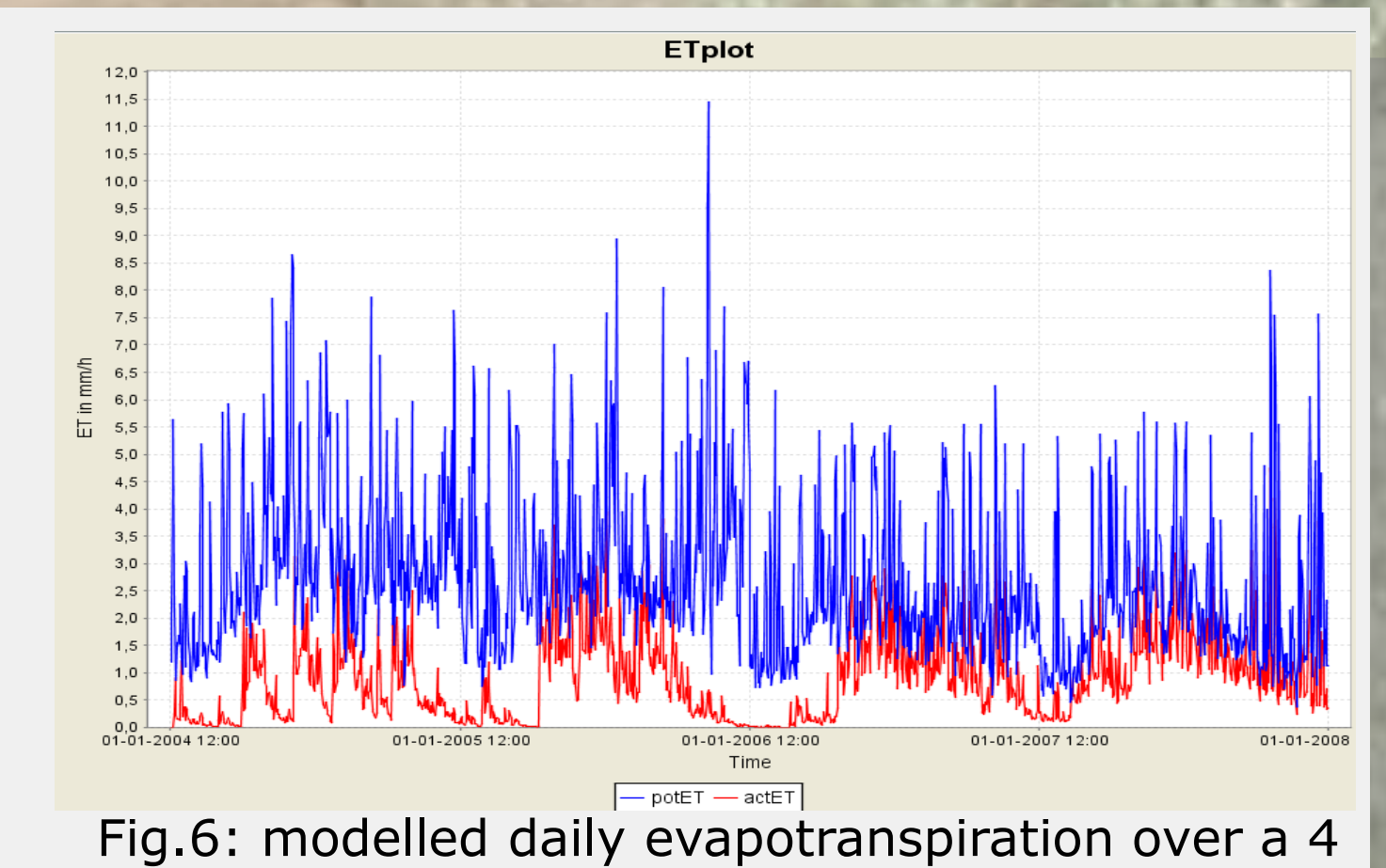


Fig.6: modelled daily evapotranspiration over a 4 year time period in the Langgewens study site for land use conditions 2004 (stream network threshold = 50)

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