

Simple water balance model using a Geographical Information System

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Topics of the presentation

- ★ Water balance model
- ★ The application to GIS
- ★ Calibration-verification
- ★ Conclusions

SIMPLE WATER BALANCE MODEL USING A GEOGRAPHICAL INFORMATION SYSTEM
26th General Assembly of the European Geophysical Society, Nice-France, 25-30 March 2001
Session: Water Resources Engineering, Hydrological Mapping (HSC11)
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Water balance model

Input variables:

- Precipitation, P
- Initial evapotranspiration, E_0
- Average monthly temperature, T_m
- Minimum mean daily temperature, T_{min}
- Maximum mean daily temperature, T_{max}

Output variables:

- Storage of soil moisture reservoir, S
- Storage of ground water reservoir, G
- Actual evapotranspiration, E_A
- Total runoff, Q

Model parameters:

- Percentage of imperviousness surface, α
- Storage capacity of soil moisture reservoir, K
- Retention coefficient of soil moisture, μ
- Retention coefficient of ground water, λ

The application to the ArcView-GIS

Calculation of rainfall surface from point values using kriging

Surface of potential evapotranspiration

Calibration and Verification of the Simple Model

Calibration

Verification

Conclusions

- A simple distributed water balance model was distributed in a GIS environment, which streamlines the hydrological process using a monthly time scale. The steps in hydro-meteorological and geographical data and the spatial distribution of rainfall, evapotranspiration and their storage in different ground states.
- The model, due to its distributed character and the GIS environment, allows the calculation of the spatial distribution of the output variables. Furthermore, the output variable evapotranspiration from the monthly scale along the stream, the comparison between the observed and computed values (used for calibration and verification), shows a very satisfactory performance of the model.
- Good management in ARC/INFO-GIS has undoubtedly despite the large number of output grid cells from 2000 grid cells covered for the application's needs.

Communication address

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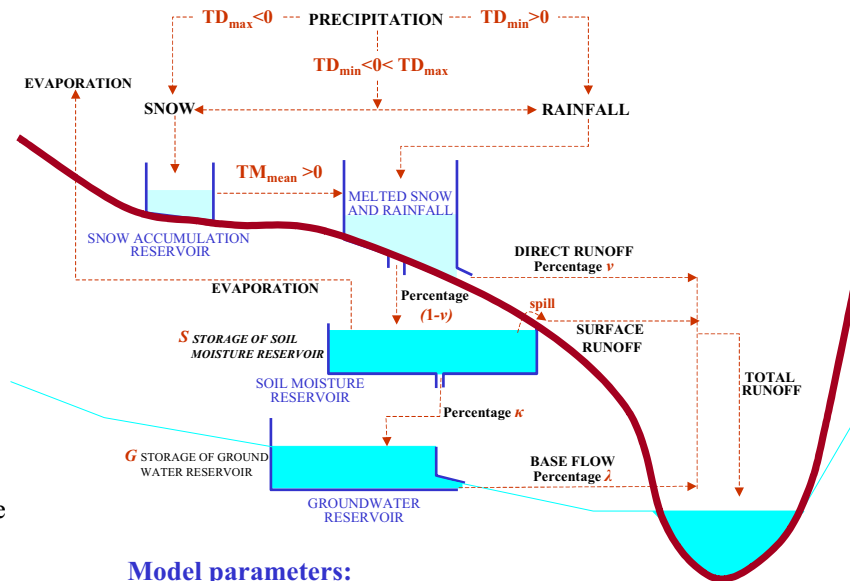
Water balance model

Input variables:

- ★ Precipitation, P
- ★ Potential evapotranspiration, E_p
- ★ Average monthly temperature, TM_{mean}
- ★ Minimum mean daily temperature, TD_{min}
- ★ Maximum mean daily temperature, TD_{max}

Output variables:

- ★ Storage of soil moisture reservoir, S
- ★ Storage of ground water reservoir, G
- ★ Actual evapotranspiration, RE
- ★ Total runoff, Q



Model parameters:

- ★ Percentage of imperviousness surface, v
- ★ Storage capacity of soil moisture reservoir, K
- ★ Recession coefficient of soil moisture, κ
- ★ Recession coefficient of ground water, λ

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The application to GIS

Model characteristics

Time step: monthly

Cell size: 2X2 km²

Data period:

October 1980-June 1988

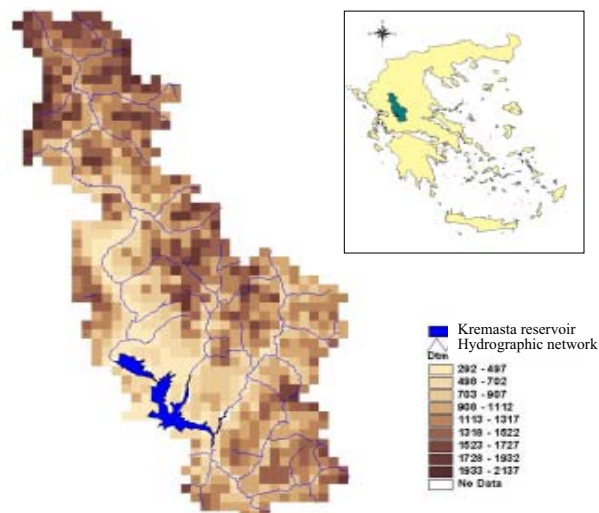
GIS: ArcView

Programming language:

Avenue

Study area

Acheloos water basin upstream of the Kremasta dam site (area 3424 km²), Western Greece



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The application to GIS (data used)

Geographical data

- Digital elevation model (DEM)
- Sites of the hydrometeorological stations
- Geology of the basin
- River network

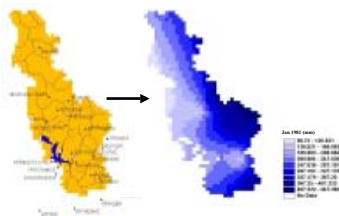
Hydrometeorological data

- Precipitation
- Temperature
- Relative humidity
- Wind speed
- Sunshine duration
- Discharge at the basin outlet

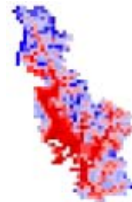
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The application to GIS Calculated surfaces

Precipitation
(from point values
using Kriging method)



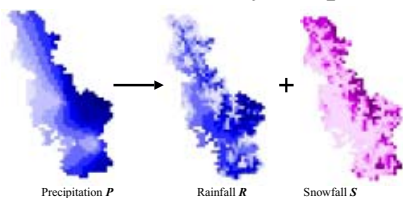
Temperature
(using points values, cell
altitude and temperature
gradient)



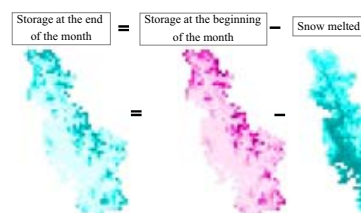
Potential evapotranspiration
(using points values cell
altitude and temperature)



Dissaggregation of precipitation
(to rainfall and snowfall using minimum
and maximum daily temperature)



Melted snow
(using temperature and storage)



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The application to GIS

Output variable's surfaces

Storage of soil moisture reservoir



Storage of ground water reservoir



Real evapotranspiration



Total runoff



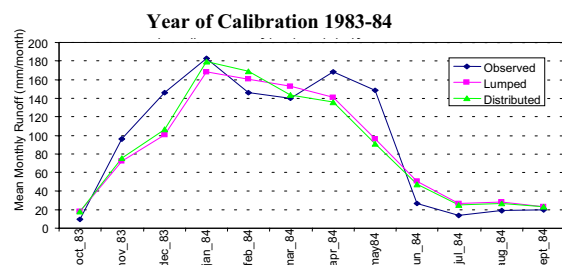
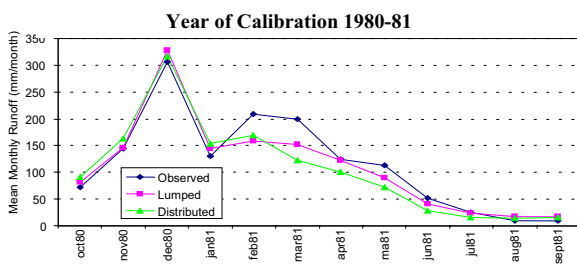
Accumulated runoff



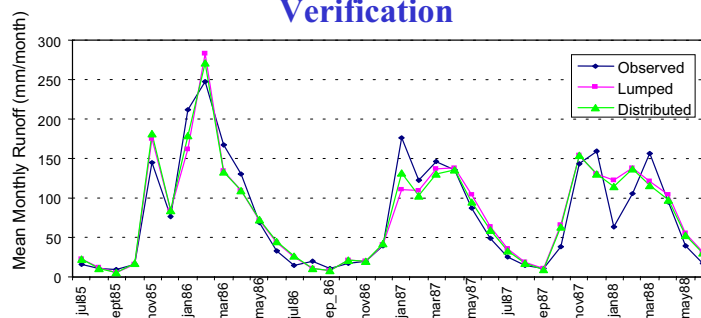
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Calibration and verification of the distributed model

Calibration



Verification



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Conclusions

- ★ A simple distributed water balance model was developed in a GIS environment, which simulates the hydrological processes using a monthly time step. The input is hydrometeorological and geographical data and the output is spatial data of runoff, evapotranspiration and water storage in different ground levels.
- ★ The model, due to its distributed character and the GIS environment, allows the calculation of the spatial distribution of the output variables. Furthermore, the output variables integration gives the monthly runoff along the rivers.
- ★ The model was calibrated using runoff values available at the basin outlet. The comparison between the observed and computed values (both for calibration and verification), shows a very satisfactory performance of the model.
- ★ Grid management in ARCVIEW-GIS was satisfactory despite the large number of created grids (more than 2000 grids were created for the application's needs).