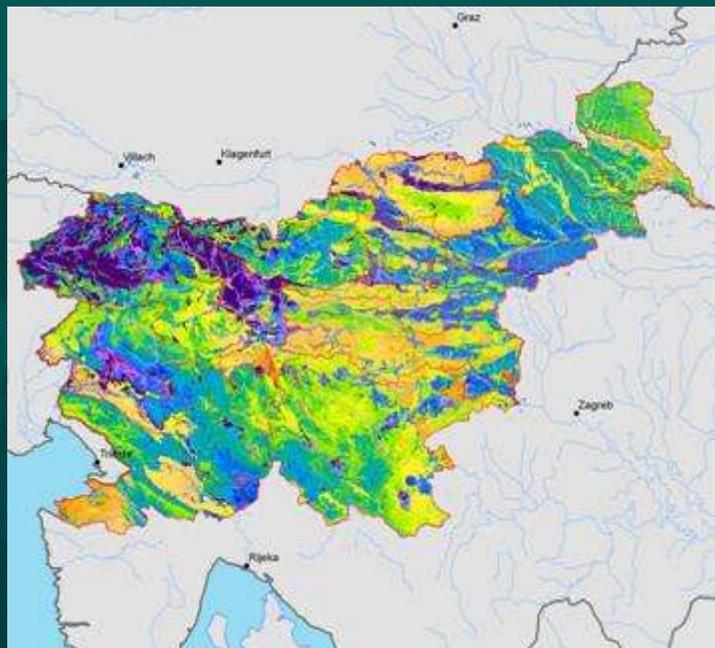




Modeling groundwater recharge in Slovenia for groundwater status assessments

Miso Andjelov



Background of the study

Input Data

Calculation of total runoff

Separation of groundwater recharge

Examples of GROWA used in Slovenia



Workshop on Groundwater modelling

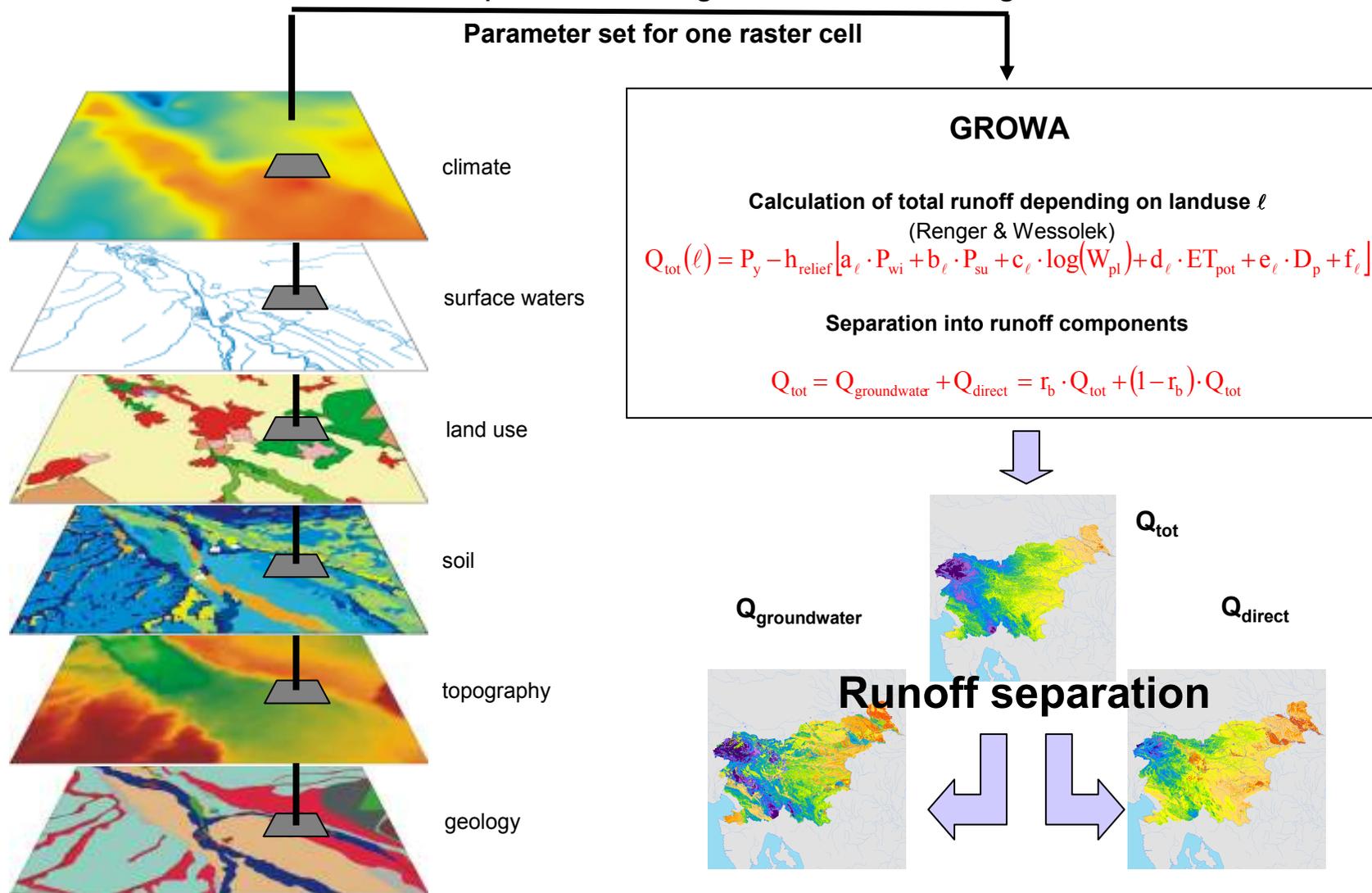
organised in co-operation with
the Environmental Agency of the Republic of Slovenia

Jan 2008

German-Slovenian co-operation project: Dec. 2008 – Dec. 2009



Water balance model GROWA (Kunkel & Wendland, 1998; 2002): Total runoff calculation and separation into groundwater recharge and direct runoff



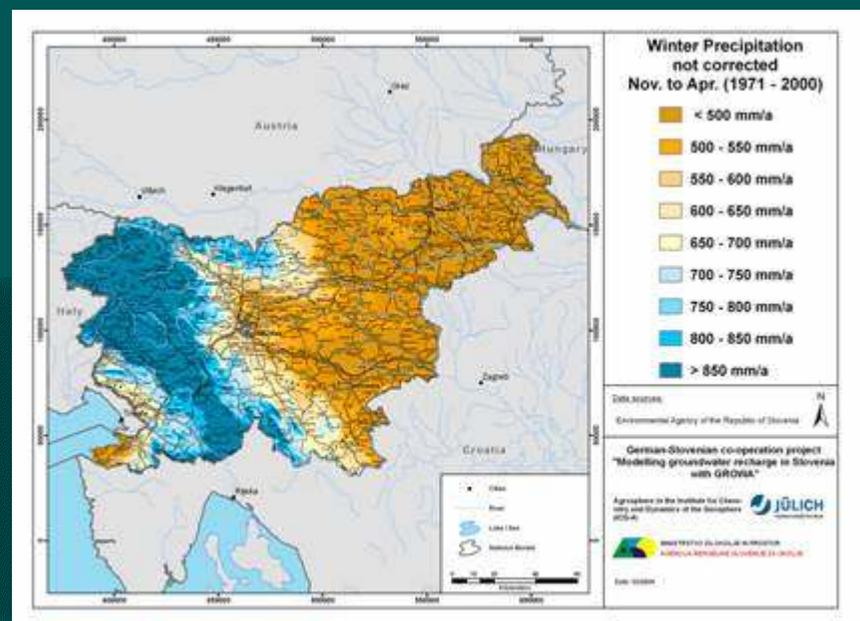
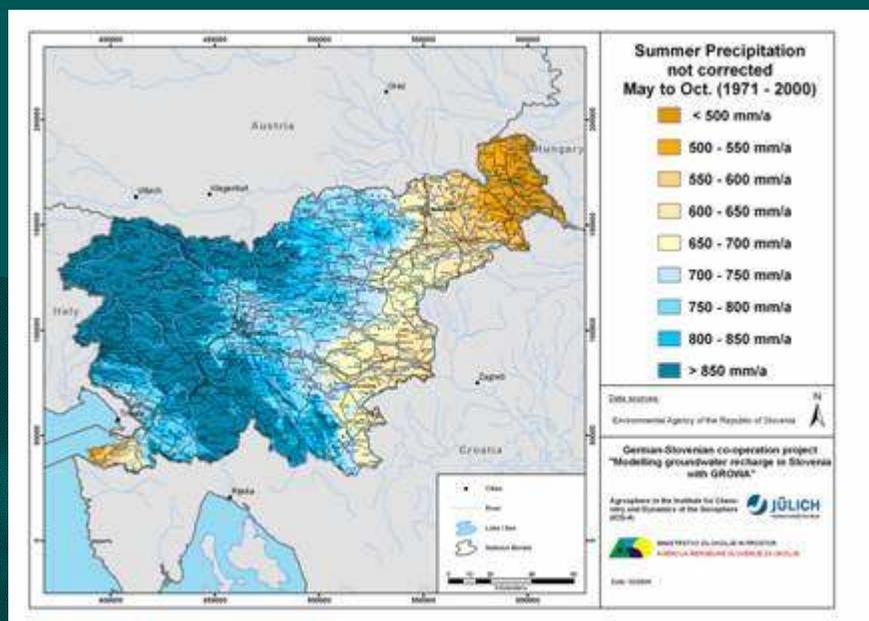


GROWA: Input data (Summary)

	Data base	Scale / spatial resolution	Data source
Climate data (1971-2000)	Precipitation (May - October) Precipitation (November -April) Potential Evapotranspiration	100 X 100 m ²	ARSO, Meteorology Office
Soil cover	Land use category	25 ha	CORINE data base
Soil data	Soil types Soil texture Effective field capacity for arable land	1:25.000	University of Ljubljana, Biotechnical Faculty Centre for Soil and Environmental Science
Soil data	Effective field capacity Influence of perching water Rooting depth	1:25.000	Derived based on pedo-transfer functions
Groundwater data	Depth to groundwater	1:25.000	ARSO, Hydrology and State of the Environment Office
Drainage	Artificially drained areas	1:25.000	Ministry of Agriculture, Forestry and Food
Relief	Digital elevation model	100 X 100 m ²	The Surveying and Mapping Authority of the Republic of Slovenia
Topography	Slope Exposure	100 X 100 m ²	Derived based on digital elevation model
Geology	Geological map Hydrogeological map	1:100.000 1:500.000	Geological Survey of Slovenia (GeoZS)
Surface water data	Catchment areas	1:25.000	ARSO, Hydrology and State of the Environment Office
	Daily runoff (1971 – 2000)		
Base maps	River network, political boundaries, towns etc.	1:25.000	The Surveying and Mapping Authority of the Republic of Slovenia



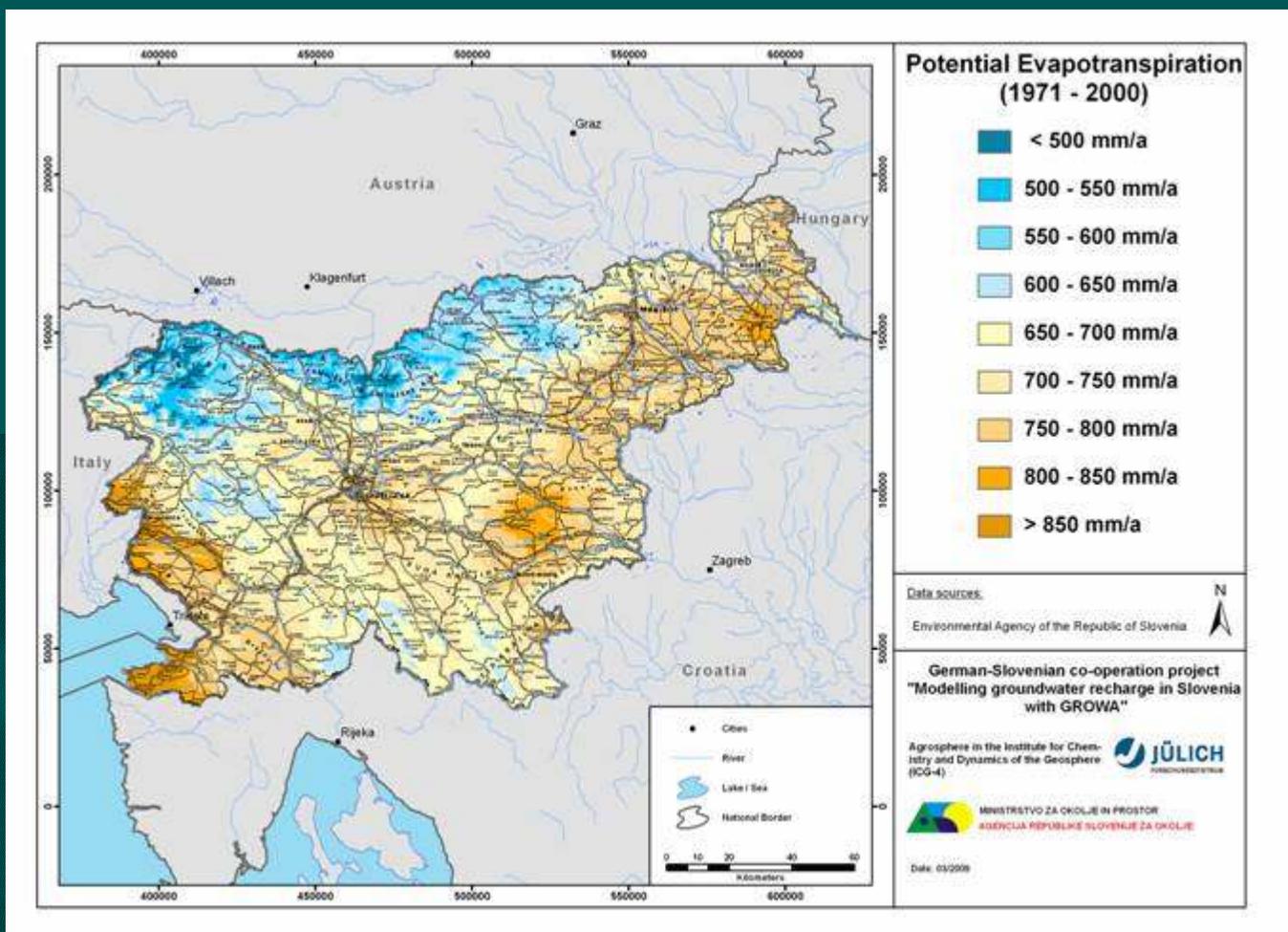
Input data for total runoff calculation: precipitation



Data Source:
ARSO, Meteorology Office



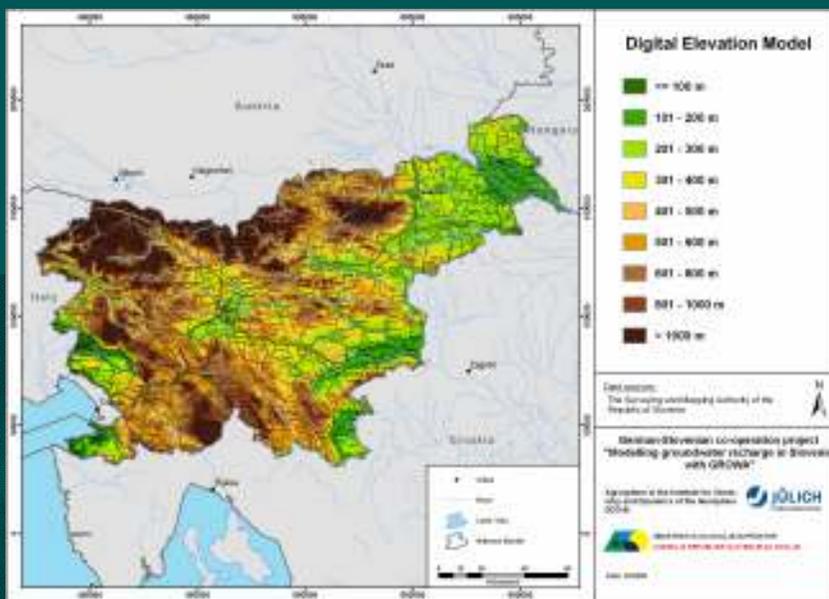
Input data for total runoff calculation: potential evapotranspiration



Data Source:
ARSO, Meteorology Office



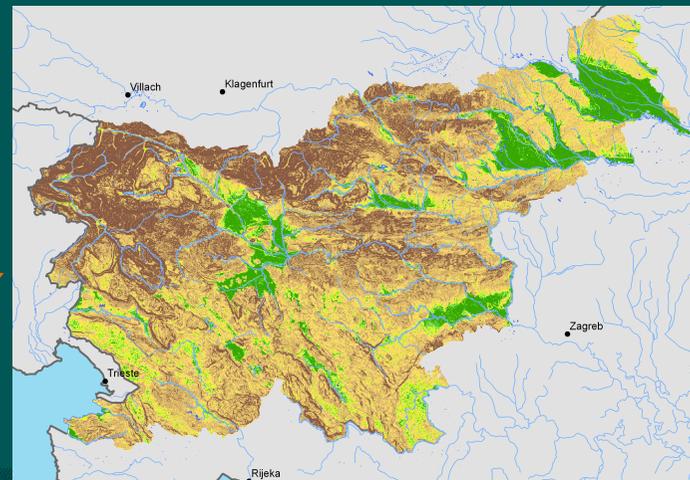
Input data for total runoff calculation: topography



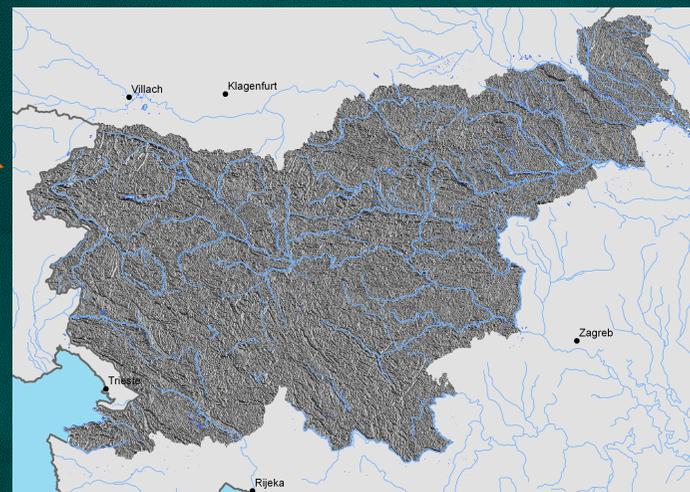
slope



Data Source:
DEM 100
(resolution 100m)



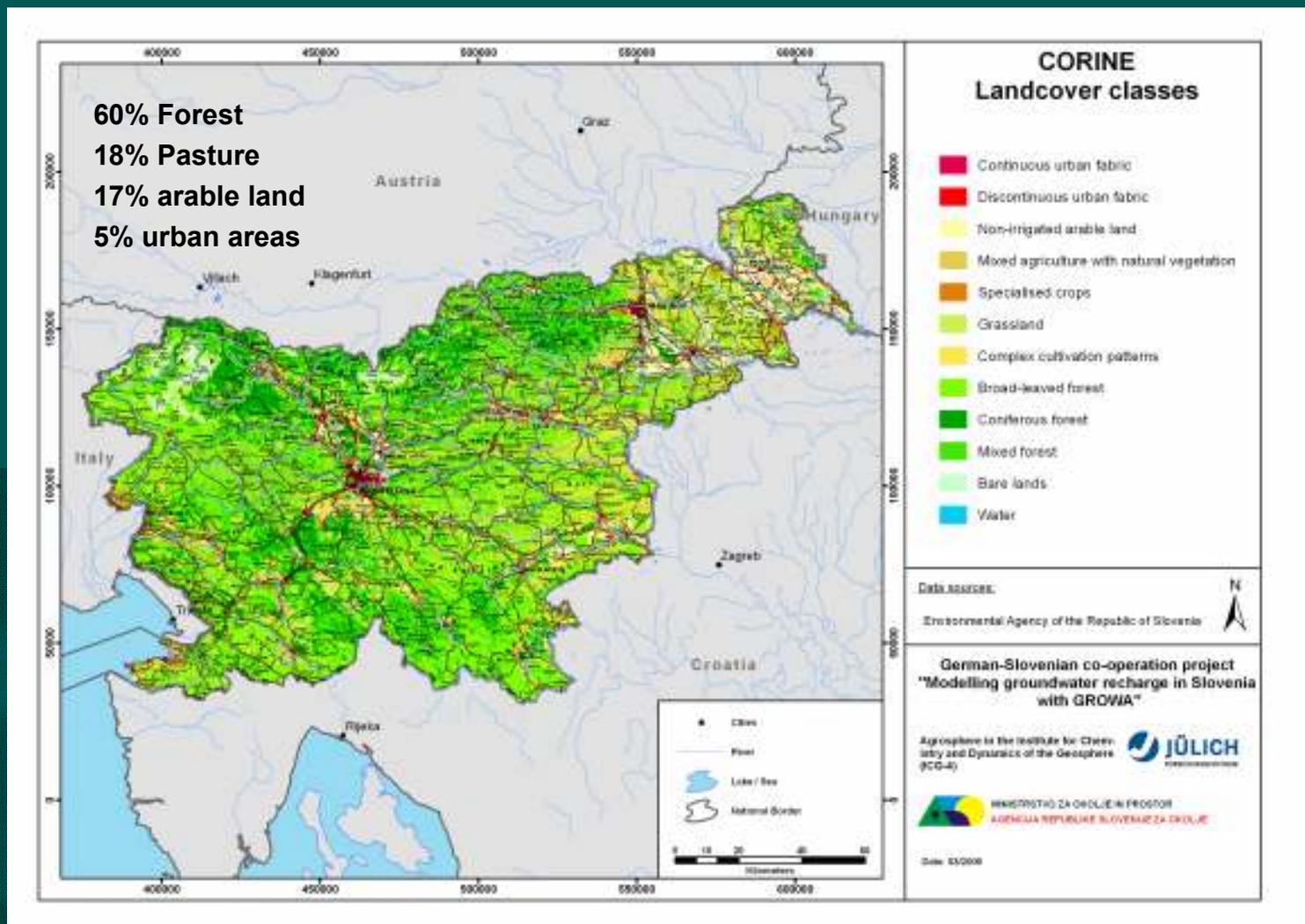
exposition



Data Source:
The Surveying and Mapping Authority of
the Republic of Slovenia



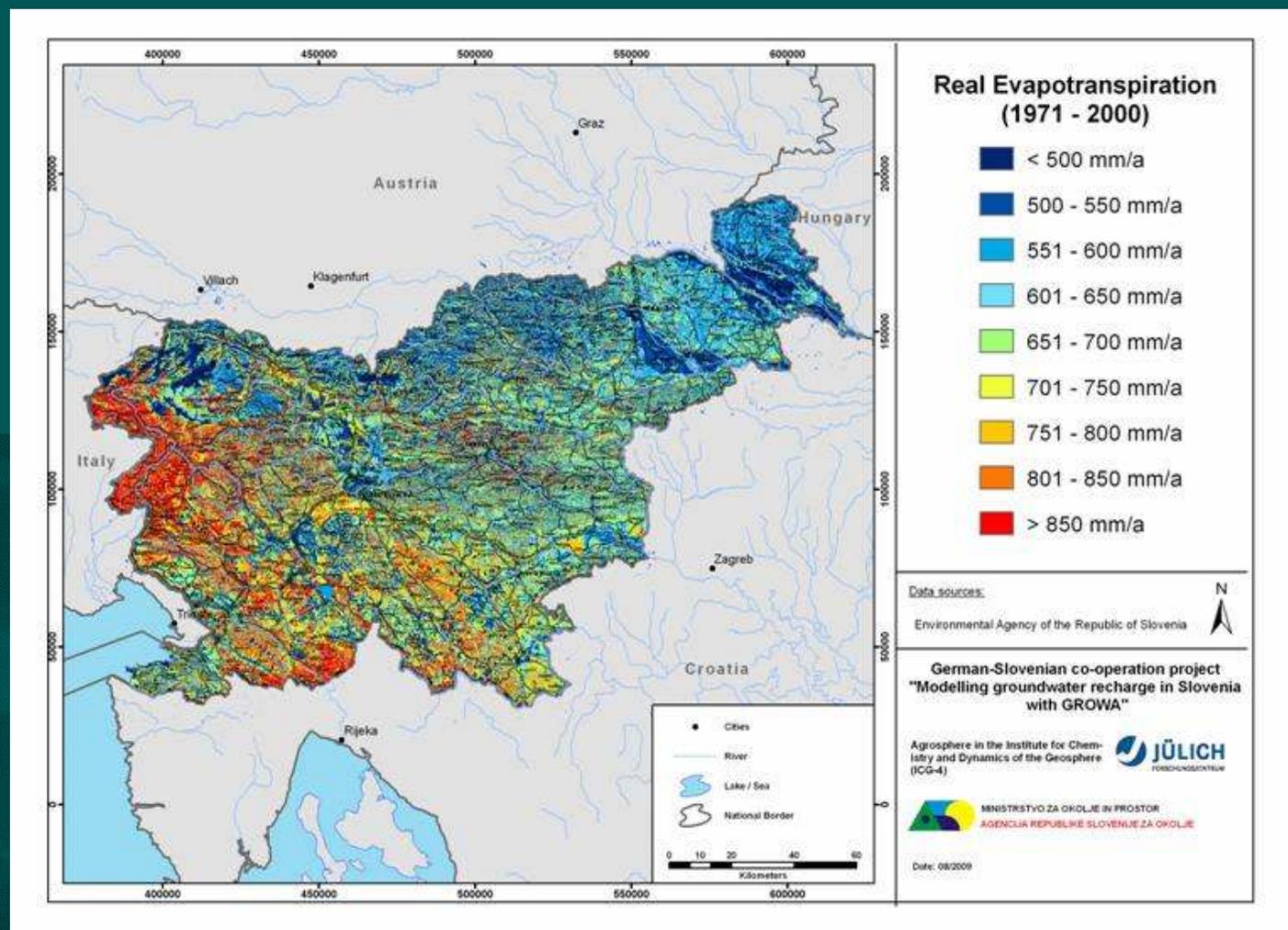
Input data for total runoff calculation: land cover



Data Source:
ARSO

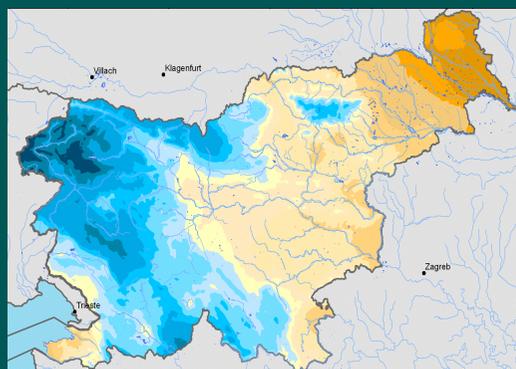


Calculated output parameter: actual evapotranspiration





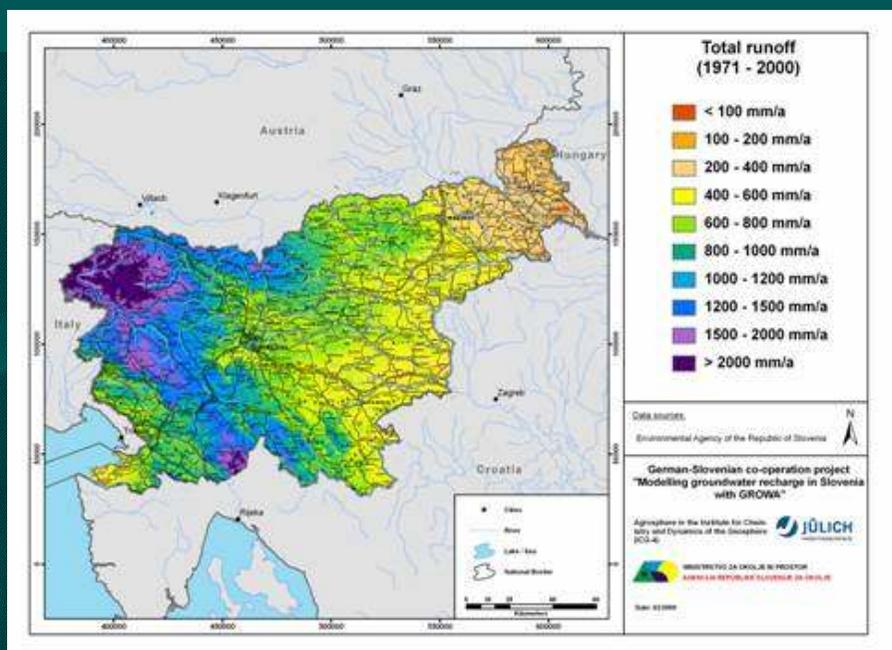
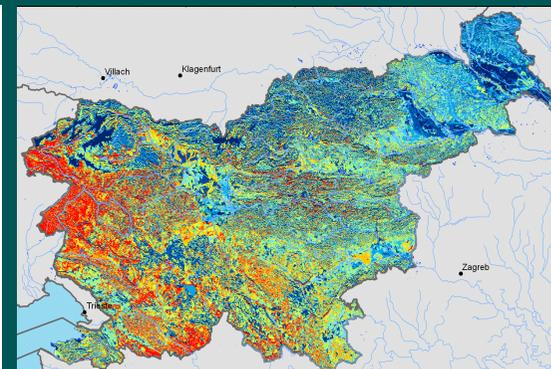
GROWA result: Total runoff



Annual Precipitation
(1971 - 2000)

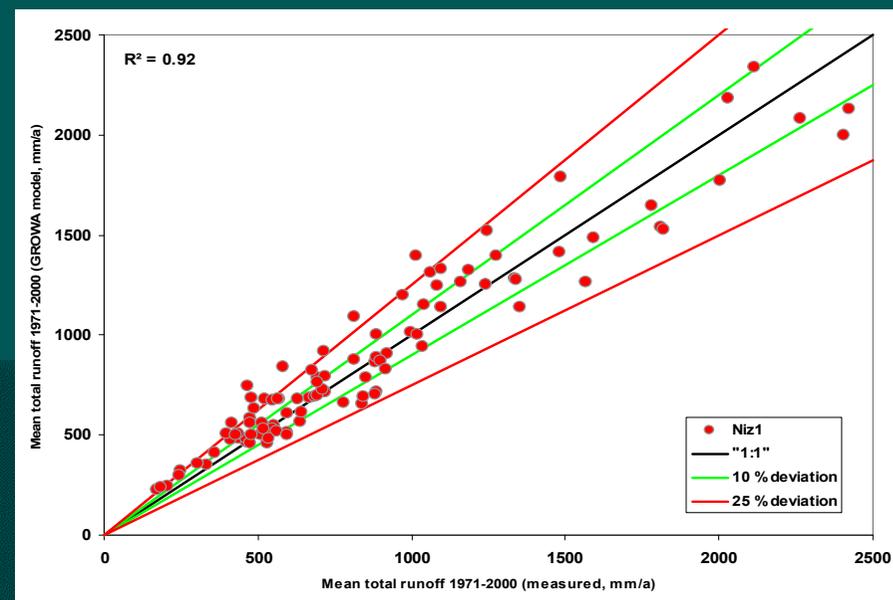
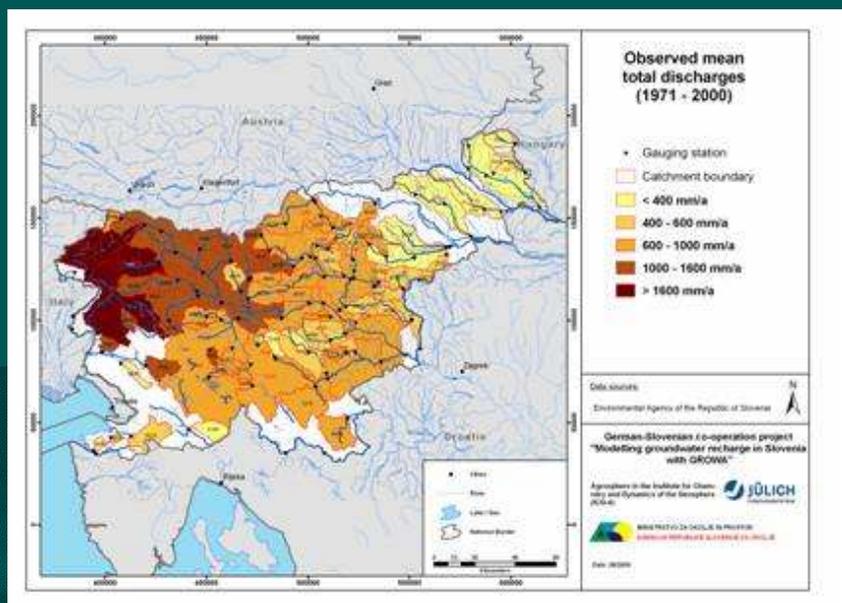


Real Evapotranspiration
(1971 - 2000)





GROWA – model validation in 97 sub-basins: Total runoff



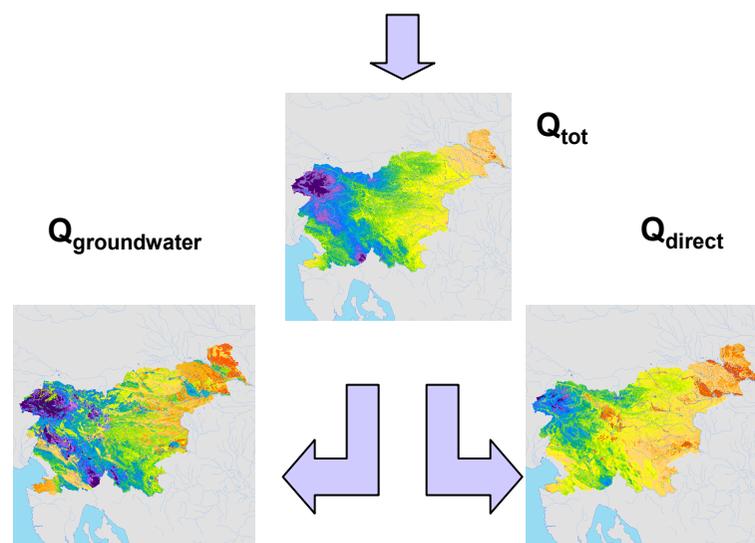
Data Source:
ARSO, Hydrology and State of the Environment Office



Total runoff separation in to groundwater recharge and direct runoff

Separation into runoff components

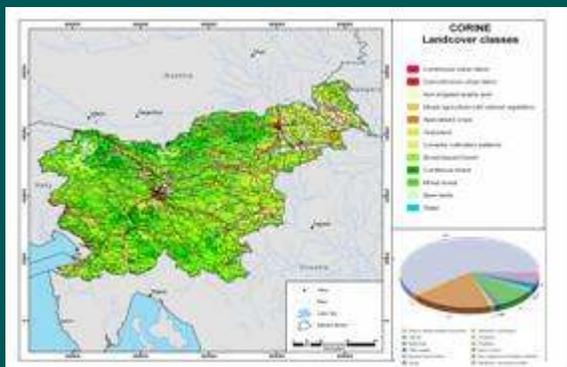
$$Q_{\text{tot}} = Q_{\text{groundwater}} + Q_{\text{direct}} = r_b \cdot Q_{\text{tot}} + (1 - r_b) \cdot Q_{\text{tot}}$$



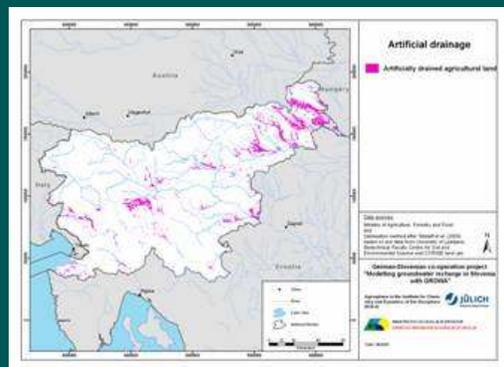


Input data for groundwater recharge separation

Land use



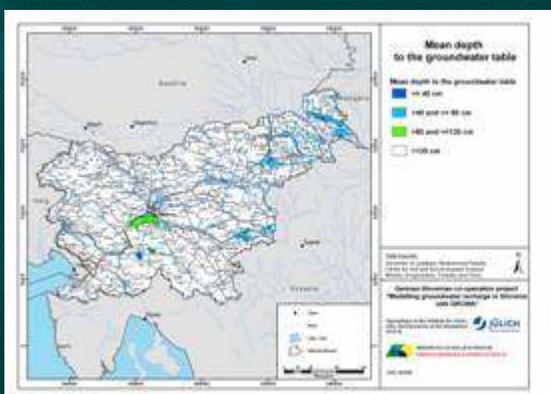
Artificial drainage



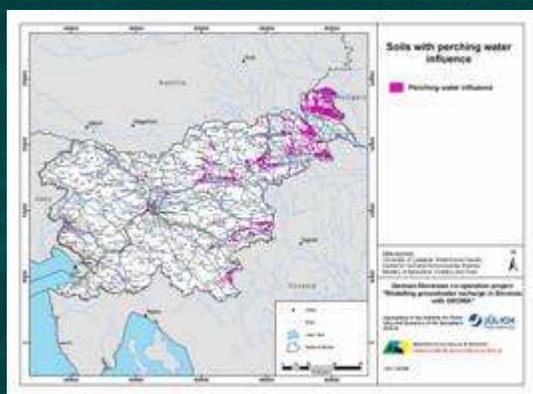
Hard rock units



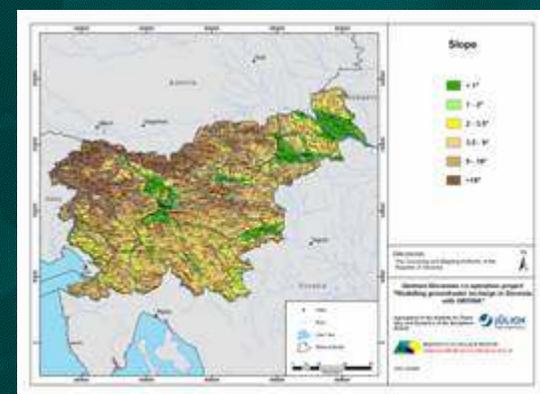
Gw influence on soil



Perching water

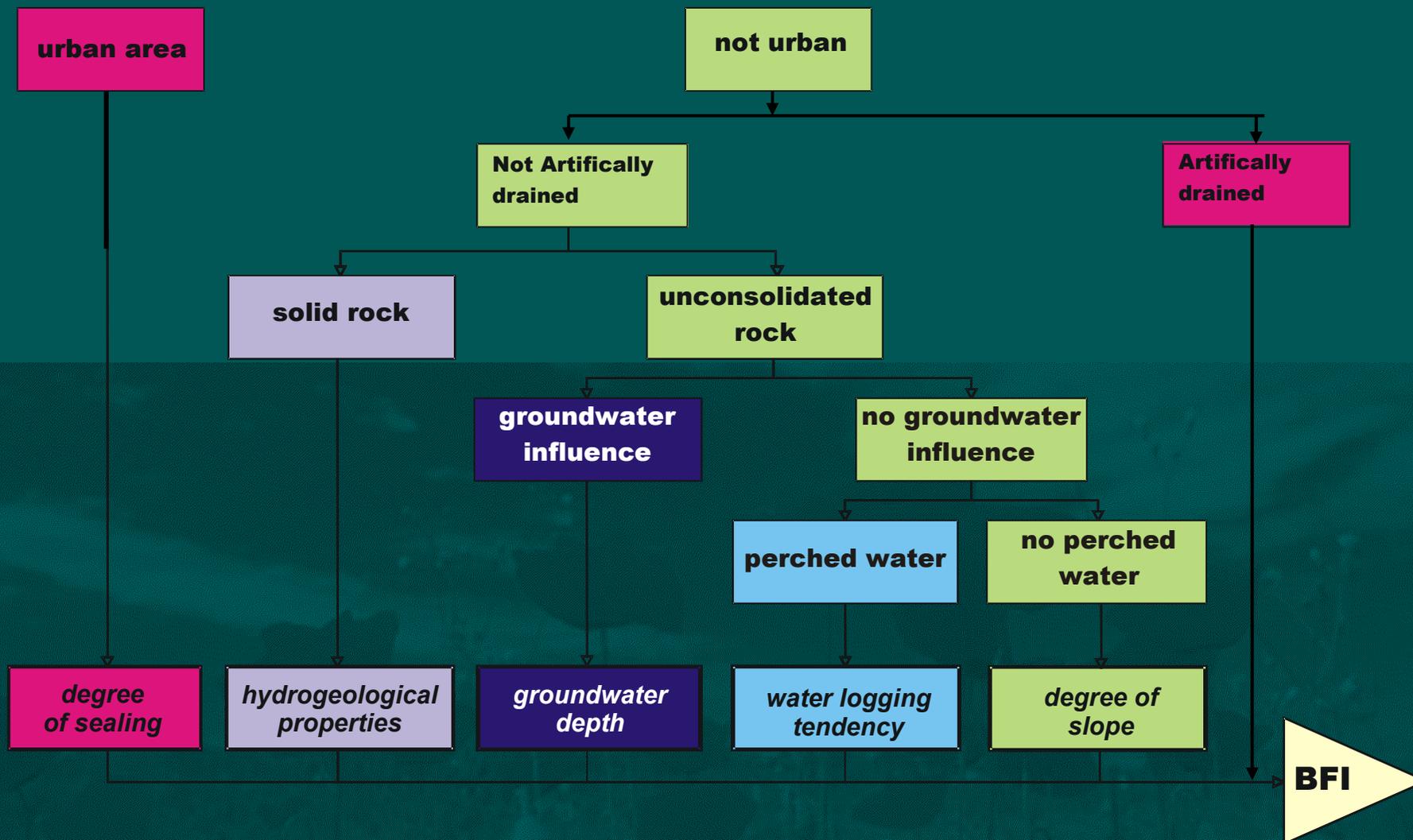


Slope



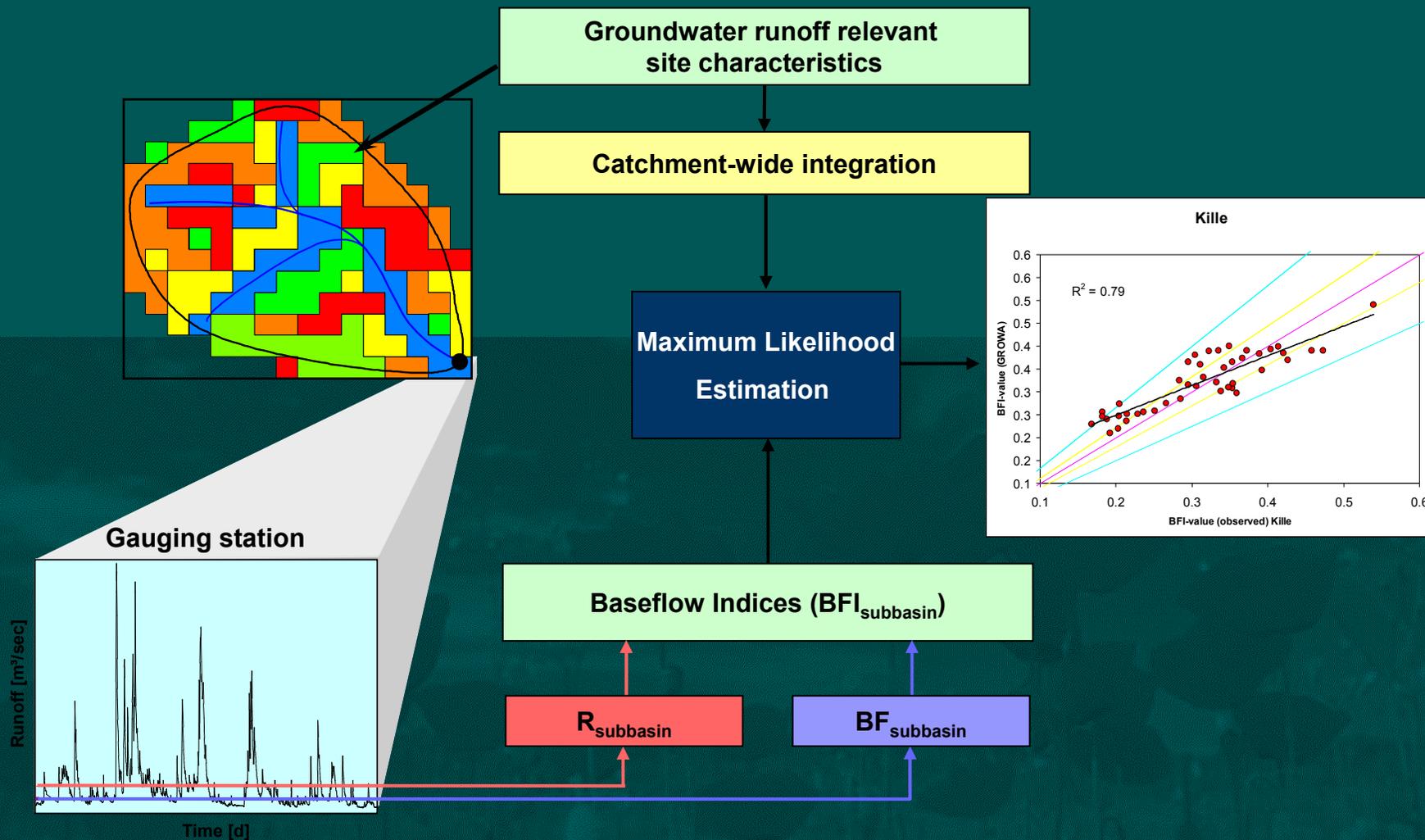


Determination of groundwater runoff relevant site characteristics



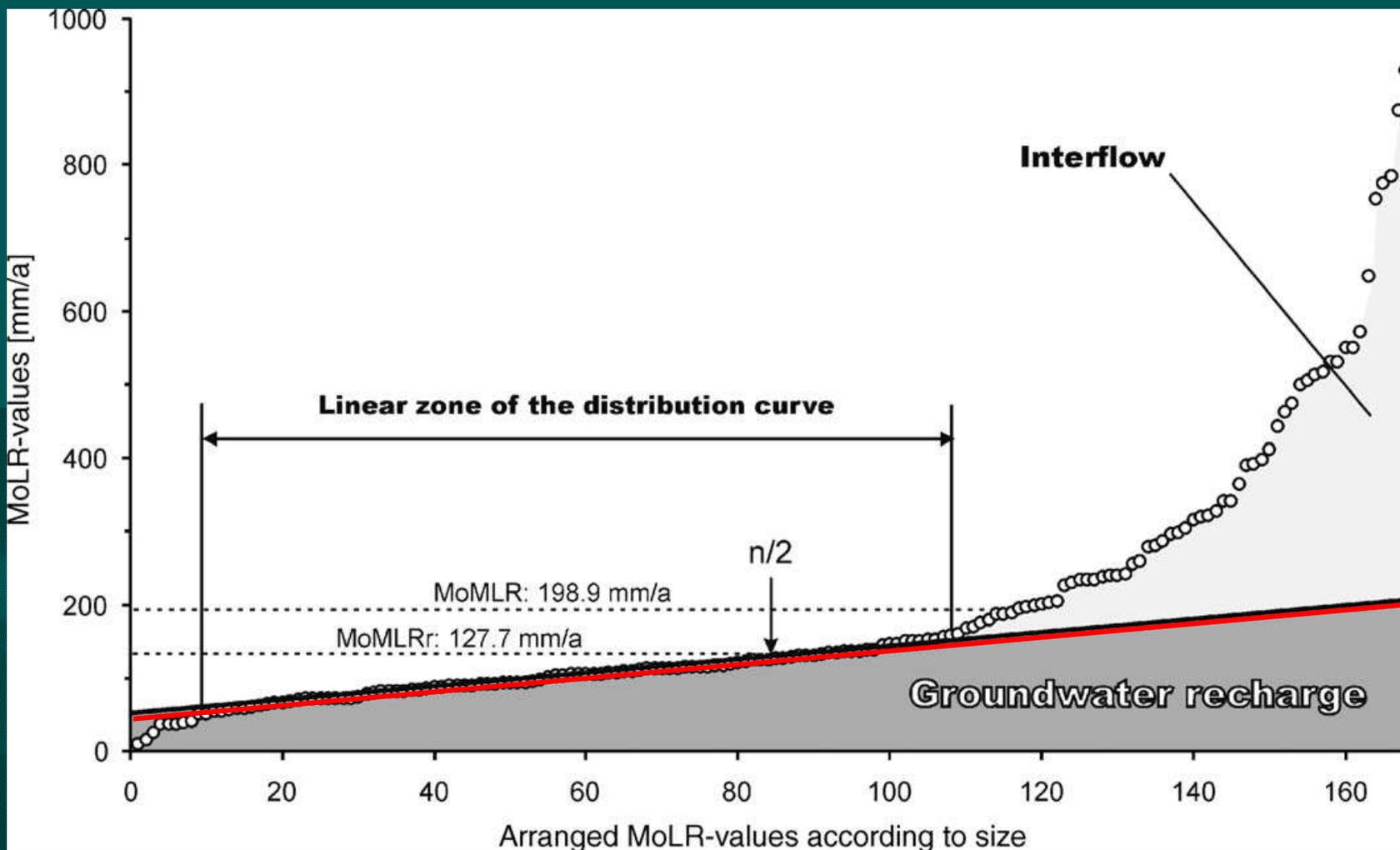


BFI calibration procedure (44 sub catchment areas)





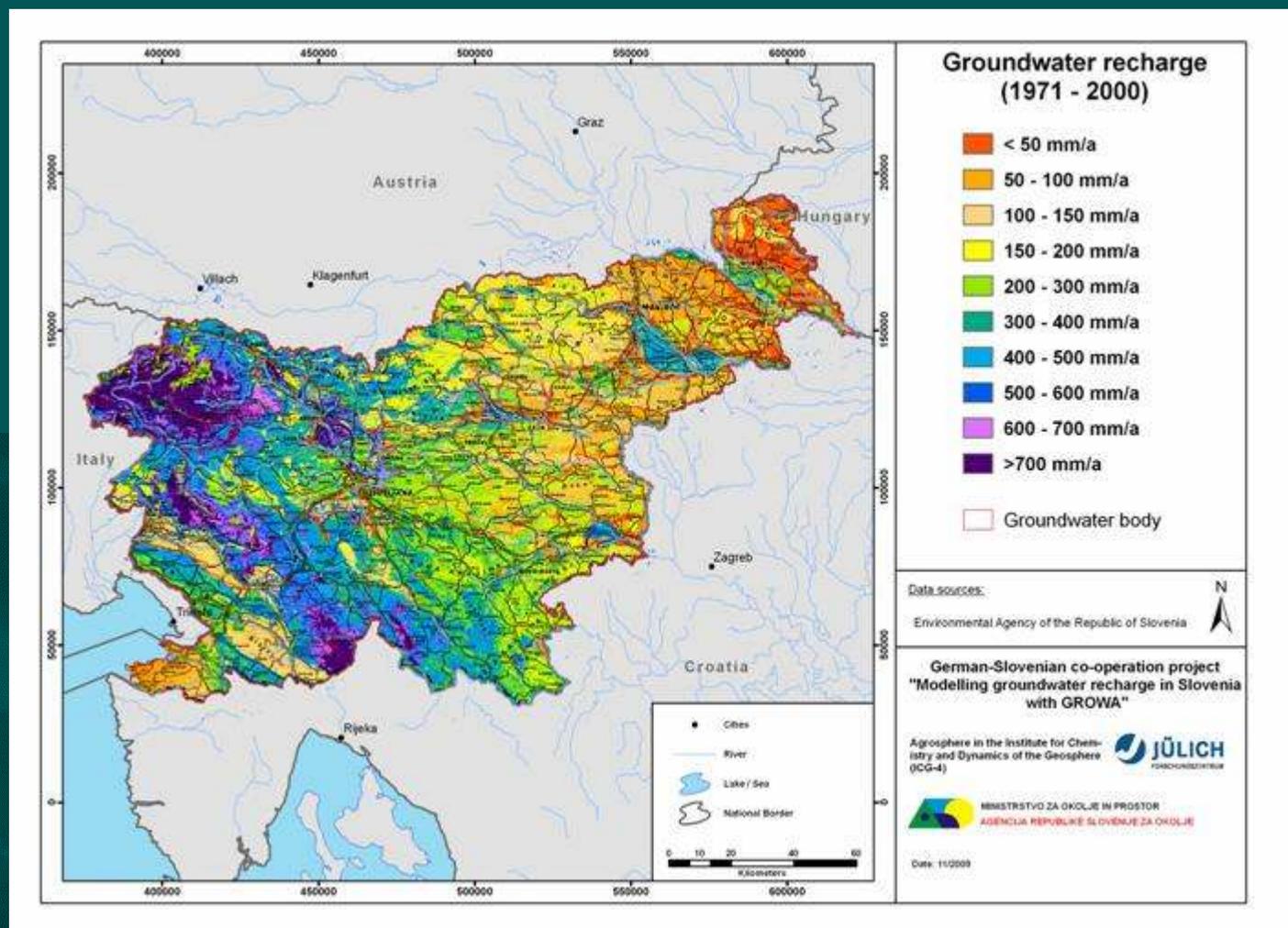
Baseflow derivation by Kille method



Impact of hydrological season can be considered

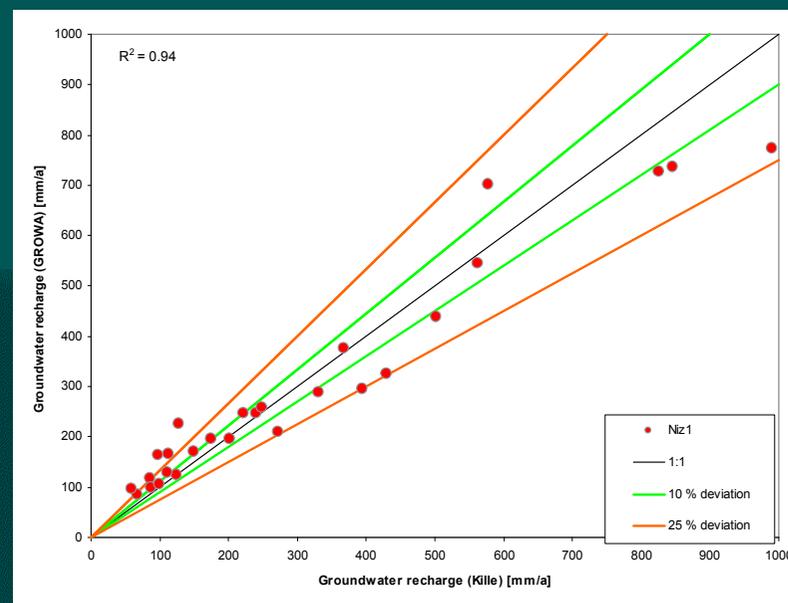
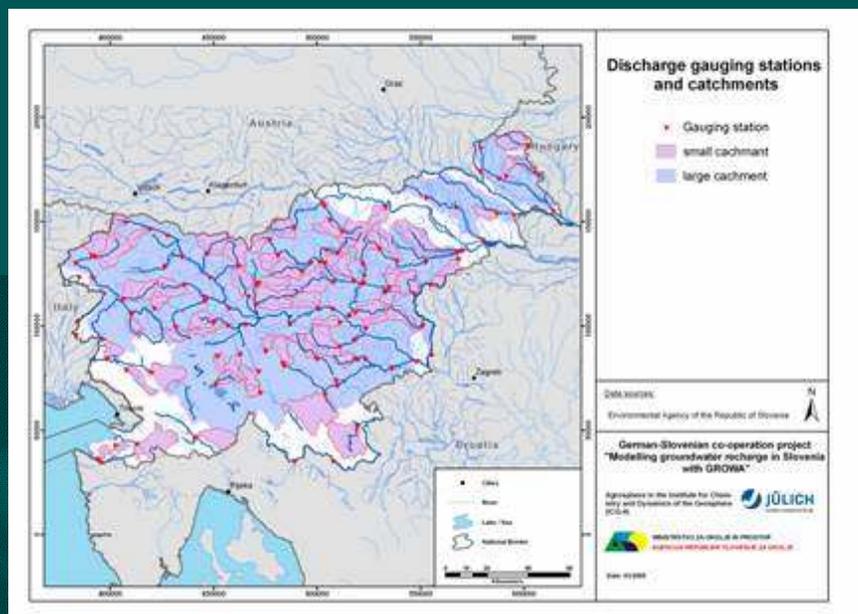


Groundwater recharge level for Slovenia





Validation of groundwater recharge (27 sub catchment areas)





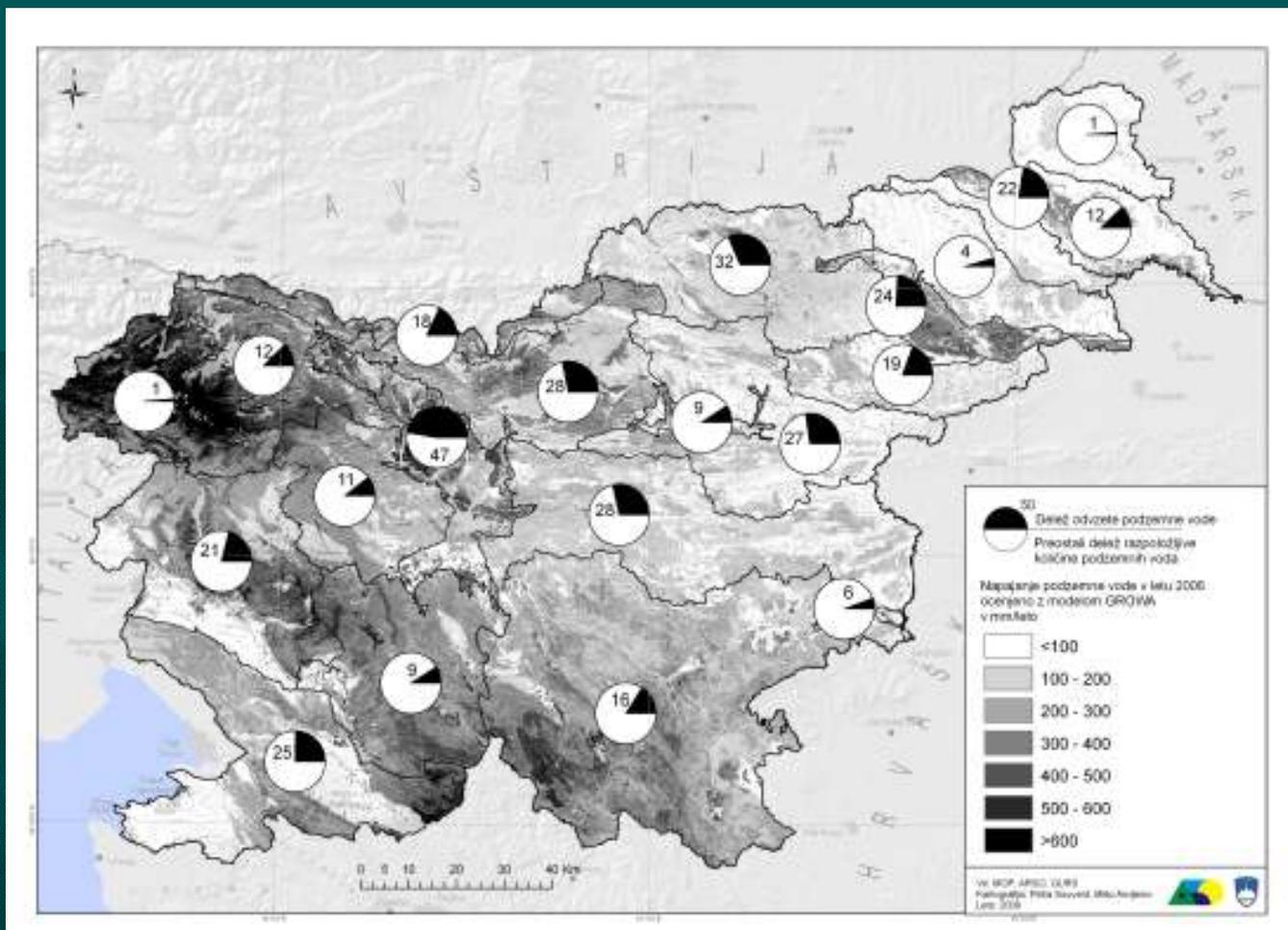
Applications of GROWA in Slovenia (11/2009)

- POS Parliament report
- WISE-EEA report:
re-calculation for single years..... 2006-2008
- Report concerning EU-WFD
- Ongoing: SE-European project on water scarcity.....
CC-Water



1. Example of use GROWA

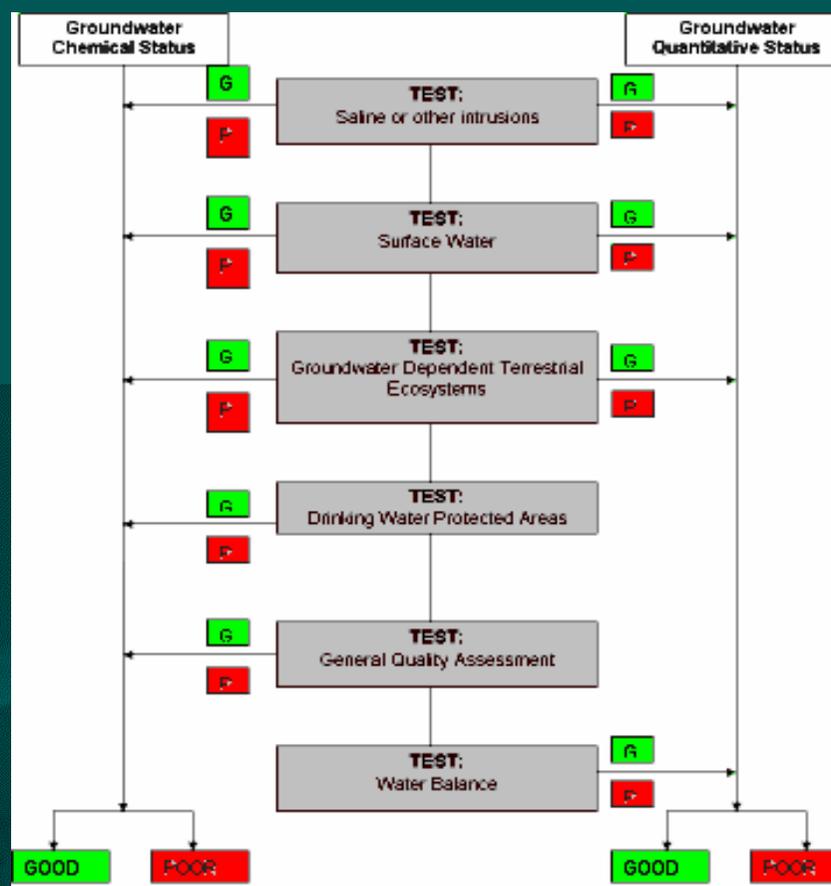
Report to Parliament on the state of the environment in Slovenia (POS)





2. Example of use GROWA

WFD reporting – Water balance test





3. Example of use GROWA



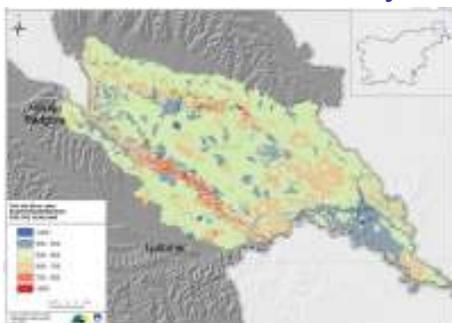


4. Example of use GROWA

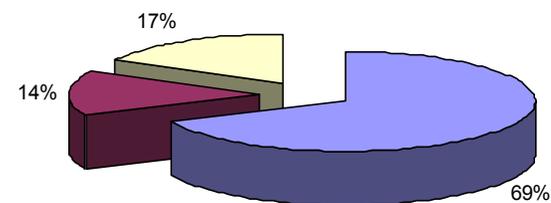
Groundwater Water balance



Evapotranspiration: 300 Mm³/year

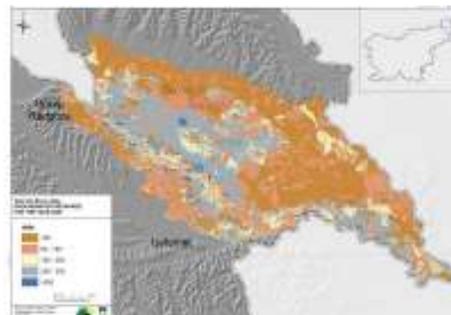


Year 2006



- Evapotranspiration
- direct runoff (surface runoff + interflow)
- groundwater recharge

Groundwater recharge: 76 Mm³/year



Direct runoff: 63 Mm³/year



Precipitation: 439 Mm³/year



**Thank you for
your attention**