

Interfaces forest – water resources: Examples of existing projects and model cases for possible projects

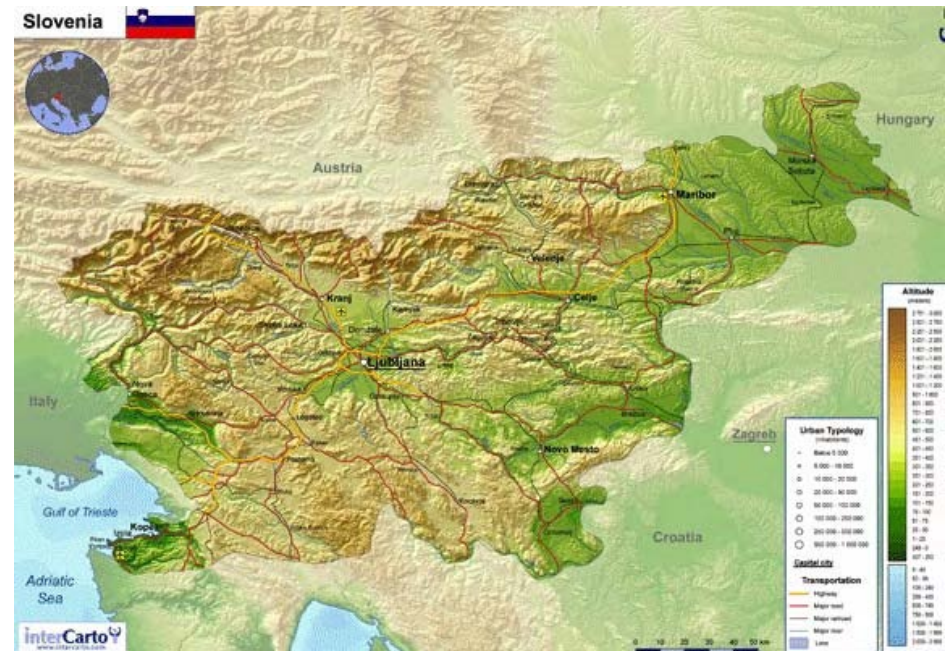
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¹ Slovenian Environment Agency (ARSO) , Slovenia

² Forschungszentrum Jülich, Agrosphere Institute (IBG-3), Germany

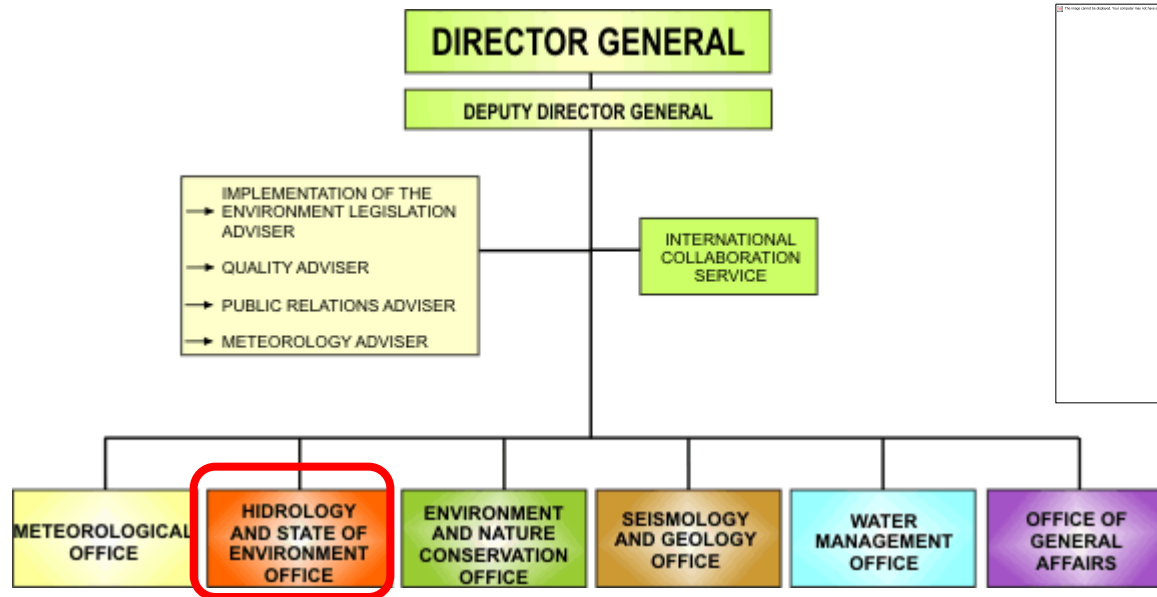
Outline of presentation

- Introduction to ARSO and FZJ
- EU Water framework directive
- Assessing total available water and groundwater recharge
- Application to Slovenia
- Assessing water quality
- Climate change
- Roadmap to start projects in SE Europe
- Relevant EU FP7 research topics



Slovenian Environment Agency (ARSO)

- Preserving natural resources, biodiversity and sustainable development
- Observing, analysing and forecasting natural phenomena and processes in the environment
- Reducing impact of natural hazards
- Ensuring legal protection and professional assistance to participants in environmental encroachment procedures
- Guiding change of national and personal values system in relation to the environment as well as influencing the value criteria for environmental encroachments
- Ensuring high-quality environmental data for all target groups
- Raising the awareness of people and institutions about the environment and environmental issues



Research Center Jülich

Institute for Bio and Geosciences

Agrosphere (IBG-3): scientific challenges

- Improved understanding of biogeochemical processes in terrestrial systems (agro-ecosystems, soil-groundwater systems)
- Functional analysis of soils, sediments and aquifer systems
- Development and implementation of technologies for monitoring and characterization of terrestrial systems
- Modelling terrestrial systems

Understanding

Catchment (macroscale)



Region



Field



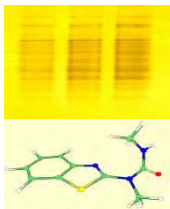
Lysimeter



Soil column



Molecule

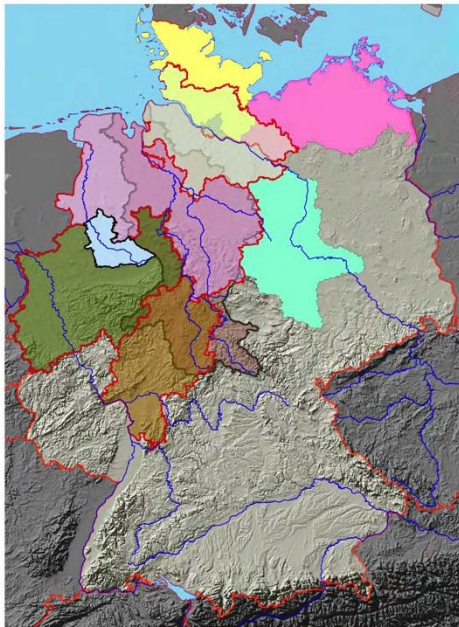


Management

Research group: Modelling and management of catchment areas

- Development of models for balancing and forecasting water and material fluxes in river basins
- Derivation of regional adapted strategies for a sustainable protection and management of water resources
- High portion of applied research projects (e.g. EU, ministries, Federal agencies) and co-operations

Regional foci (2012)



Germany:

- 7 Federal Environmental Agencies
 - 2 Federal Ministries
 - 1 River Basin Commission
- water balance, nutrients, climate change

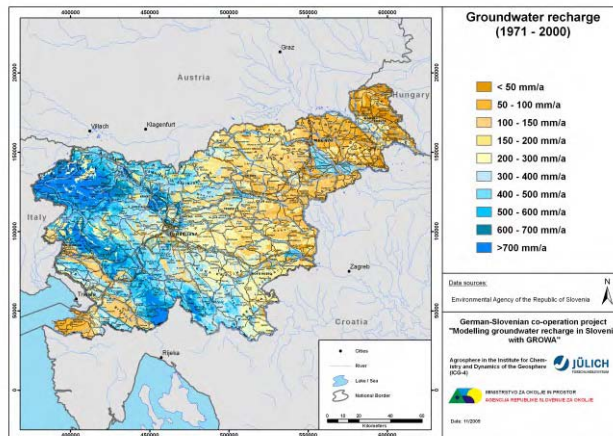
Turkey:

- EU – CLIMB: Climate change
- HGF – TUBITAK: Nutrients



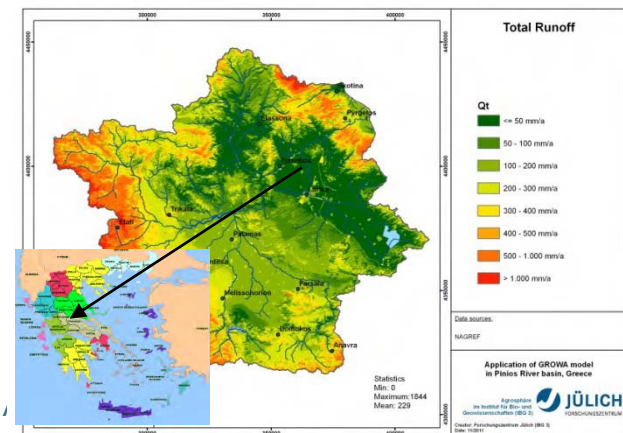
Slovenia:

TTB T/Z1015.03.08: Water balance, nitrate



Greece:

IKYDA – DAAD: 50834253: Water balance, nitrate



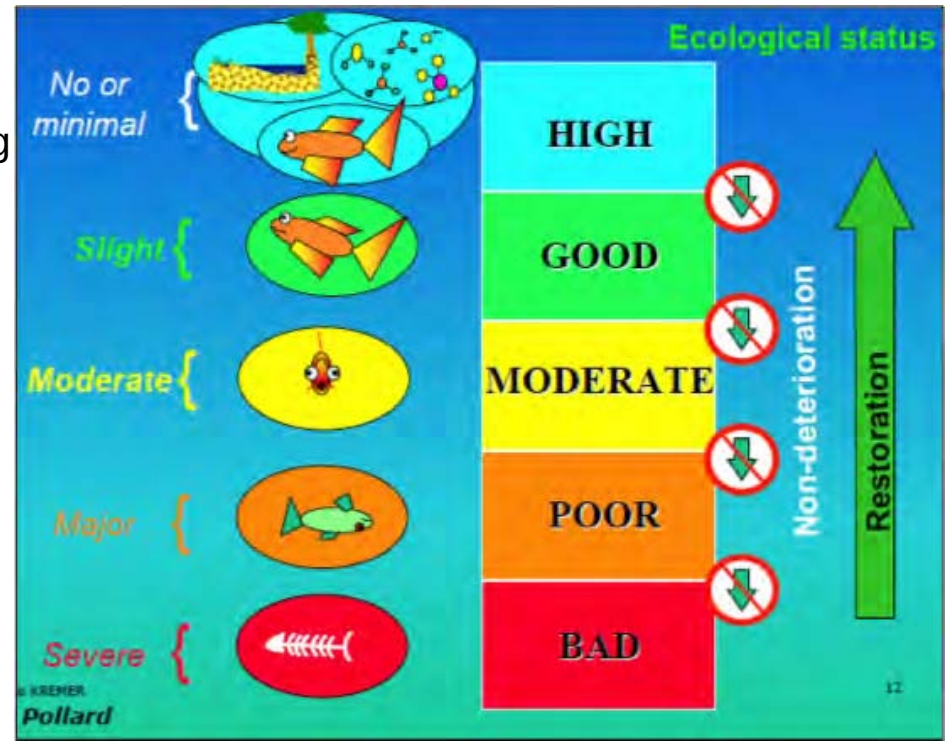
EU – Water framework directive (EU - WFD)

- Sustainable use and effective protection of water resources
- Integrative approach:
 - Groundwater,
 - Surface waters,
 - Coastal waters
- **Management according to river basins**
- National and international cooperation during implementation
- Including stakeholders:
 - Pressure groups,
 - Public services,
 - Governmental institutions,
 - Industrial associations,
 - Public
- **Target: Good quantitative and qualitative status” until 2015**



WFD: Status of water bodies

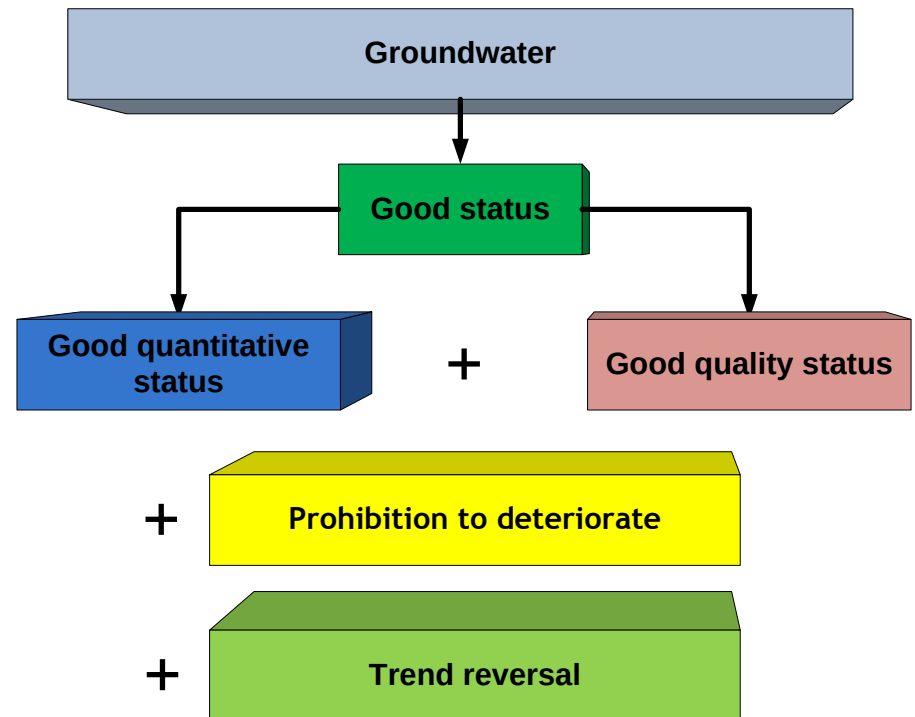
- **“High ecological status”:**
little or no effects of human activity compared to undisturbed conditions
Maintain “high status” of waters where it exists
- Prevent any deterioration in the existing status of waters and
- **“Good ecological status”:**
slight changes caused by human activity compared to undisturbed conditions”.
Achieve at least “good status” in all waters by 2015.
- Manage water bodies in a way that protects ecosystems and habitats.
- “Good status” for groundwater to be achieved for
 - Quality
 - Quantity



Groundwater directive (GWD): Environmental objectives

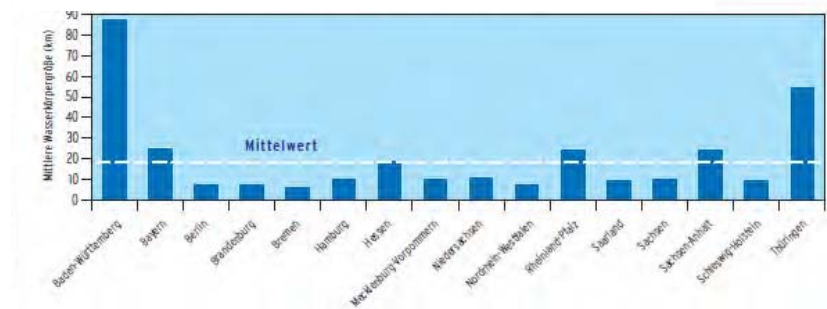
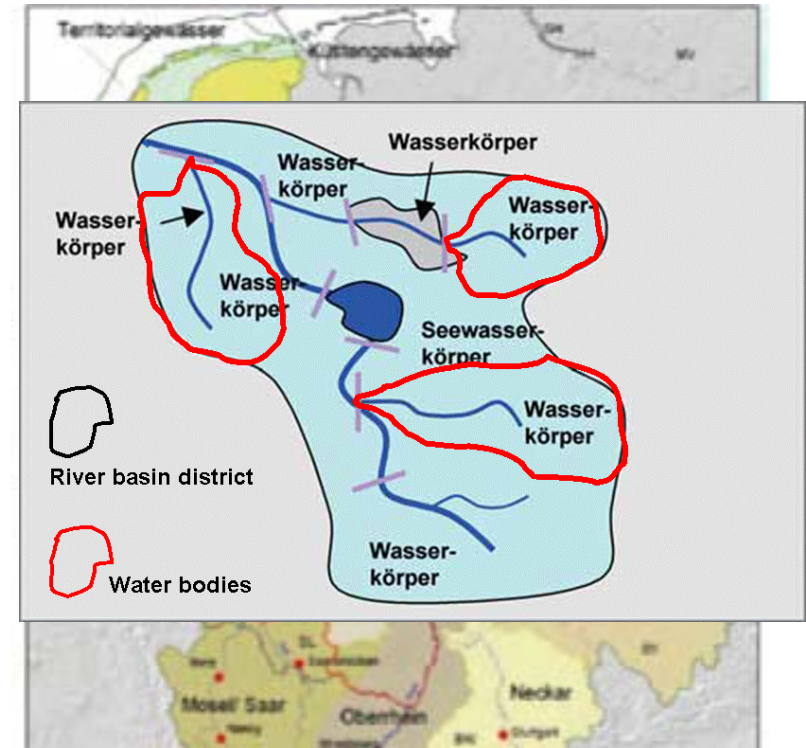
“Good Status” for groundwater bodies:

- Quantity (balance between natural recharge and abstraction)
- Quality (compliance with numerical quality standards; no upward trends; no saline or other intrusions)
 - EU-wide Quality Standards for Nitrate and Pesticides
 - Threshold Values for parameters at risk
- Prevention of inputs of hazardous substances
- Limitation of inputs of non-hazardous substance
- Trend reversal in case of significant and steadily rising trends



Initial river basin analysis / status review (2004)

- Entire river basins or river basin districts too big and too heterogeneous for:
 - Compilation of pollution load
 - Monitoring or
 - Derivation of protection measures
- Subdivision according to „water bodies“ („uniform entities inside catchment areas“)
- Represent the real level of implementation of EU-WFD
- First tasks in the implementation process was the identification of „water bodies“ and their allocation to a certain river basin district.
- Germany: 9870 water bodies
 - 9000 rivers
 - 800 lakes
 - 70 coastal areas
- Average water body size in Germany: ca. 10 km² - > 80 km², i.e. rather heterogeneous



Status of water bodies in the EU

EEA, 2008

failing good status:

- Ecological status (point source pollutants)
- hydromorphology

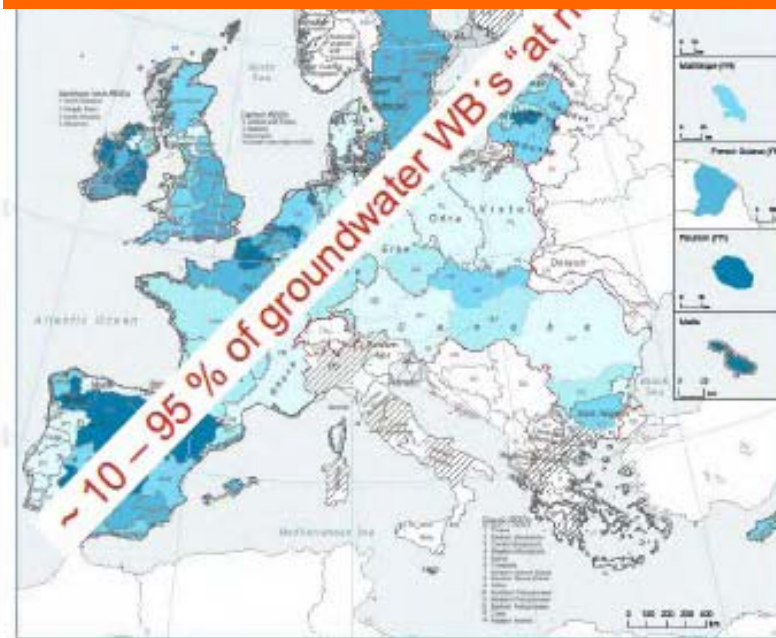


Notes:
1) The risk assessment for many water bodies in most Member States has not been conclusive due to lack of data. Percentages of water bodies not assessed due to insufficient data range from 0 to 66 % with an average of 33%. For the 23 countries providing data.
2) Denmark: No risk assessment results provided for the Weysser.
3) Poland: Current and long-term risk assessment results provided.
4) Poland: Data only submitted for the Gdansk and Vistula RDBs.
5) Sweden: No data submitted for risk assessment carried out at regional rather than water body level.

Surface Water Bodies Not At Risk

failing good status:

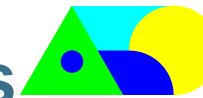
- diffuse inputs into groundwater from agriculture



Notes:
1) The risk assessment for many water bodies in most Member States has not been conclusive due to lack of data. Percentages of water bodies not assessed due to insufficient data range from 0 to 66 % with an average of 33%. For the 23 countries providing data.
2) Denmark: Current and long-term risk assessment results provided.
3) Poland: Data only submitted for the Gdansk and Vistula RDBs.

Groundwater Bodies Not At Risk

From Status reviews to programs of measures (nach V. Mohaupt, UBA)



2004/5

2006

2008/2009

Further data requirements

unclear

Risk assessment on the level of water bodies:
Will EU-WFD targets fail?

Probably no

Probably yes

Set up of Monitoring Programs

Dec. 2006

Results of monitoring

In case targets are failed

Program of measures

Management plans for river basins

December 2009

Identification of „heavily modified“ water bodies

River basin management plans to be developed and implemented for every river basin

- A complete analysis of river basin characteristics including
 - a review of pressures and human impacts on water status.
 - Identification of heavily modified and artificial waters.
- An economic analysis of water use (cost recovery)
- A register of:
 - protected areas
 - waters used for the abstraction of drinking water
 - Existing monitoring networks and monitoring results
- A summarization of the elaborated programs of measures
- River basin management plan can be completed by
 - Detailed programs of measures for sub-basins
 - Certain regional relevant aspects of water management



Major European Rivers and their Drainage Basins
(Vogt et al. 2007. EUR 22920 EN)

EU-WFD implementation timetable



Year	Timetable for Implementing the Water Framework Directive
2000	WFD comes into force
2001	Common Implementation Strategy published
2003	Transposition into national legislation Designation of river basin districts and competent authorities
2004	For each river basin: - Analysis of the natural characteristics, pressures and human impacts - Economic analysis of water use - Register of areas needing special protection
2006	Operational water monitoring programmes
2008	Public consultation on proposed river basin management plans
2009	River basin management plans with programmes of measures finalised
2009-15	Implementation of programmes of measures
2010	Water pricing policies in place to promote sustainable use of water
2015	Achievement of good status for all surface waters and ground waters

How may forests contribute to water related topics?

1. Water availability and sustainable water use
2. Water quality
 - Atmospheric deposition of nutrients in forests
 - Leaching of nutrients from forests into the soil and groundwater
 - Forests as „dilution areas“ for diffuse inputs from agriculture
3. Climate change related topics
 - How may forests contribute to the evolution of water quality and quantity
4. Problems occur if forests are missing:
 - Flood prevention
 - Soil erosion protection

Water balance and land use

- Water balance is determined by the hydrological cycle
- Total available water is given by the difference of precipitation and evapotranspiration

Total runoff

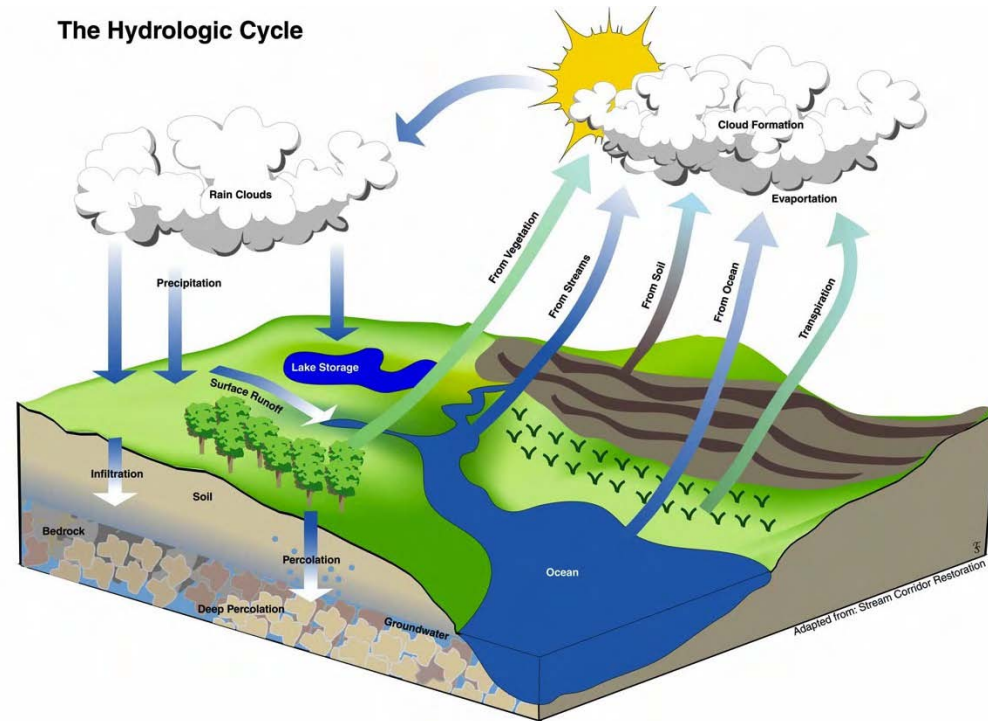
- Evapotranspiration (ET) is determined amongst others by land cover:

- Low ET

- Paved areas
- Arable land
- Pasture
- Leafed forest
- Coniferous forest

- High ET

- Changes in land cover always influence the total available water



Influence of forest type on groundwater recharge

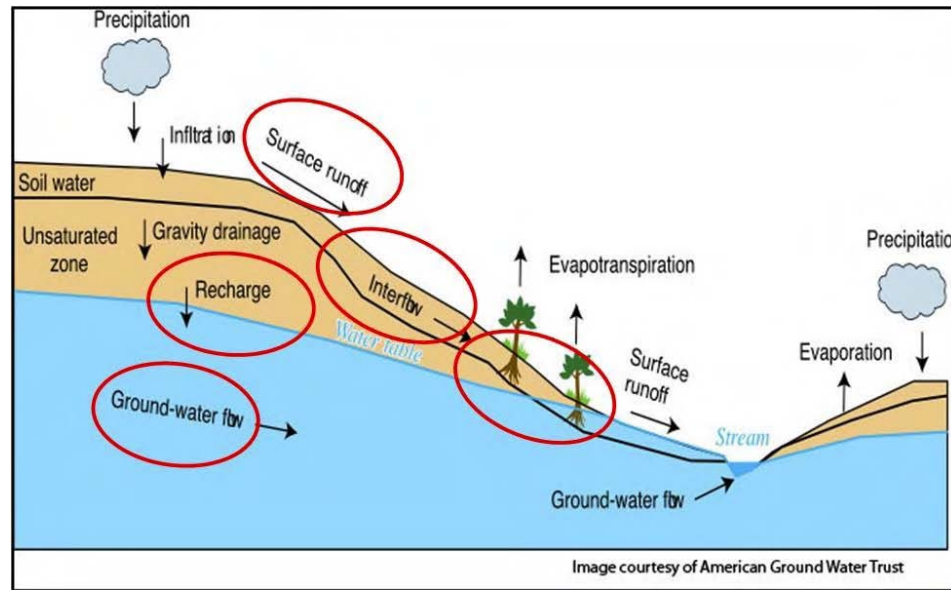
Coniferous forests

- High evapotranspiration throughout the year
- Rough bark prevents water downflow
- Reduced or missing groundwater recharge

Leafed forests

- Enhanced groundwater recharge in winter due to missing leaves
- Smooth bark optimizes water downflow
- Optimized groundwater recharge



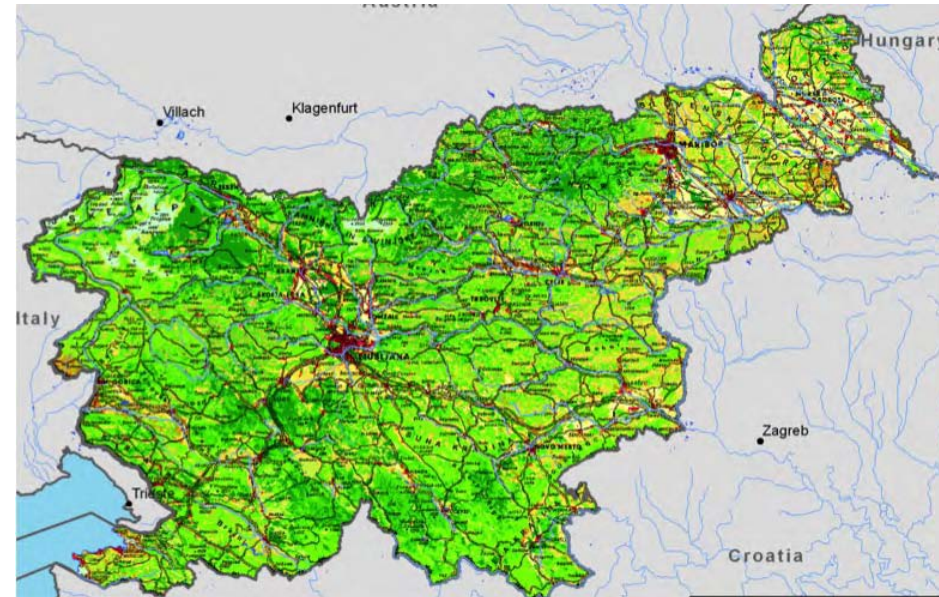


- **Direct runoff** indicates all runoff components which reach surface waters shortly after a rainfall event. It consists of:
 - **Surface runoff**: reaches surface water without having passed through the soil column.
 - **Natural interflow**: infiltrated vertically into the soil until it has reached an impermeable layer.
 - **Drainage runoff**: all runoff fractions which reach surface waters via artificial drainage systems (ditches and drainages)
- **Groundwater recharge** designates the volume of water which percolates through the unsaturated zone and reaches the aquifer.
- For longer time periods there is a balance between the groundwater recharge and the related groundwater runoff.

- Water resources planning in Slovenia was based on an overview about total runoff (Bat & Frantar, 2008), which was e.g. used for the dimensioning of power plants.
- Groundwater status assessment according to EU-WFD was carried out on the level of 21 groundwater bodies only (Official Gazette of Republic of Slovenia 65/2003, 63/2005; Andjelov et al., 2005, 2006).
- Area-differentiated information about groundwater recharge rates were not available

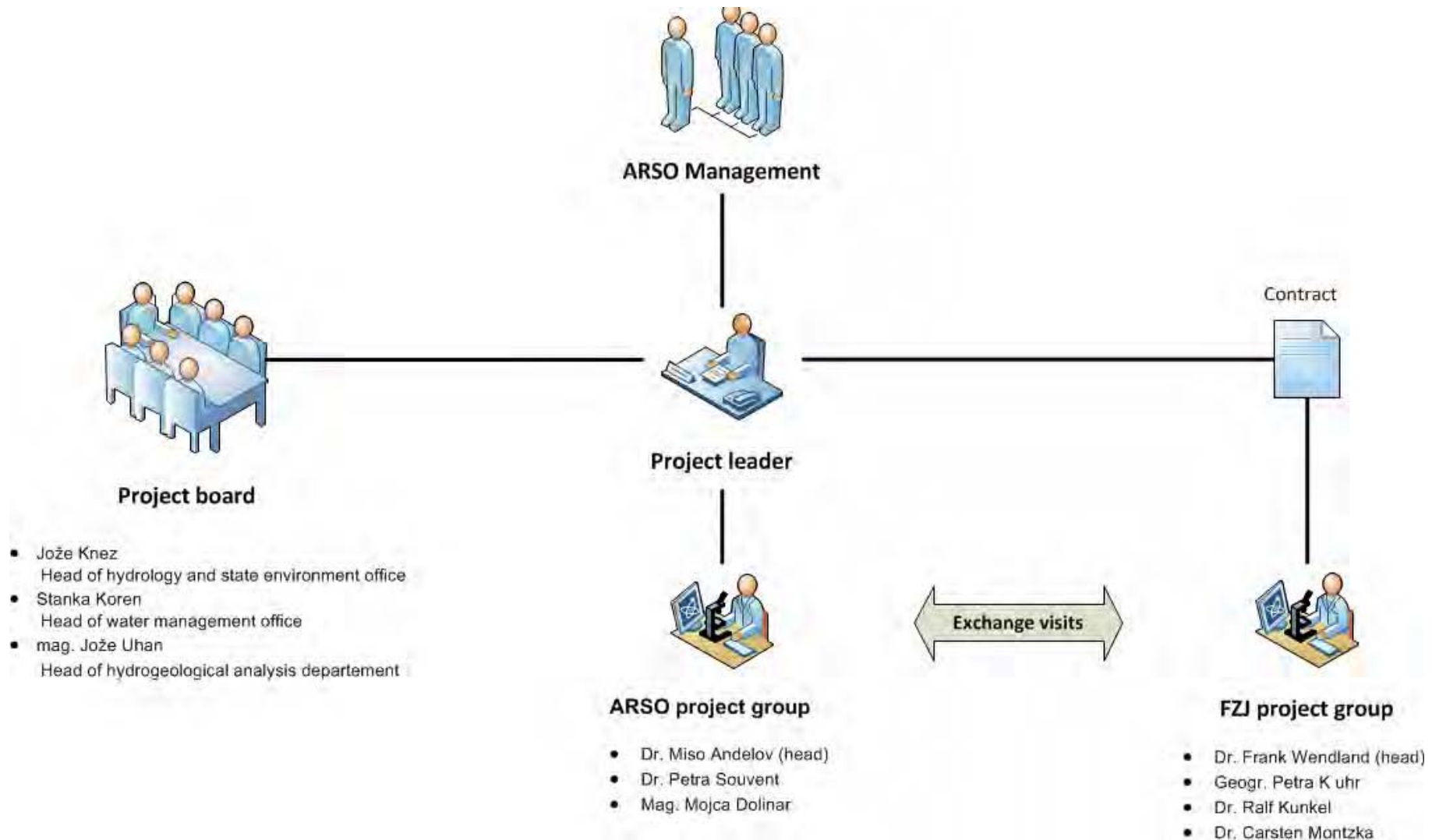
Modelling water availability and groundwater recharge in Slovenia: Constraints

- Survey about water balance as prerequisite for harmonized regional water resources management
 - Based on existing digital availability data sets
 - Comparability of model results (same model approach)
 - **!!! No patchwork of local studies!!!** (different models, different periods and different data bases)
- Evaluation of the area-differentiated (distributed) mean runoff components including long-term groundwater recharge
- Availability digital of model results (GIS) for further application (e.g. use in regional water boards)



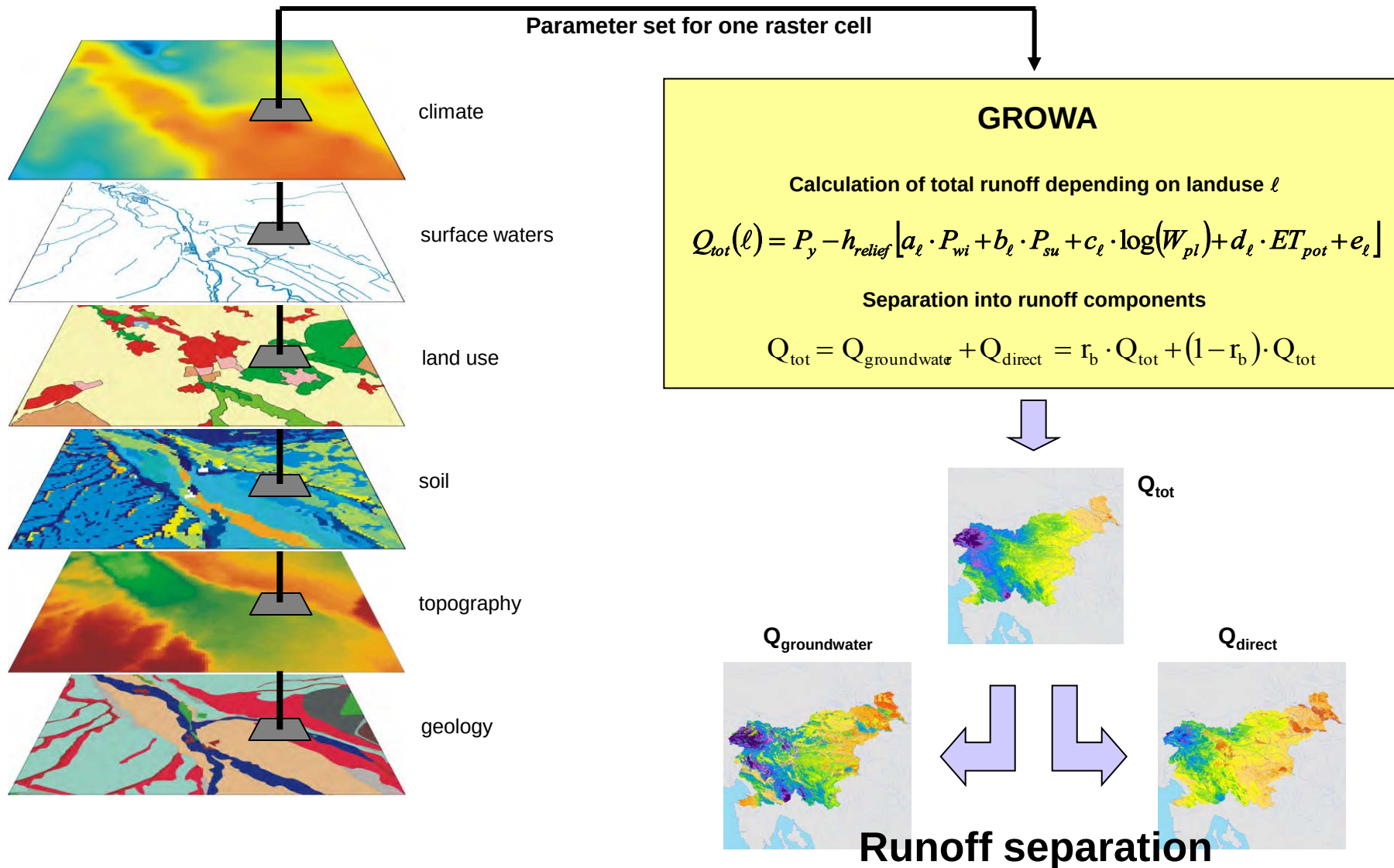
Land cover in Slovenia (CORINE 2010)

Project organisation



GROWA model

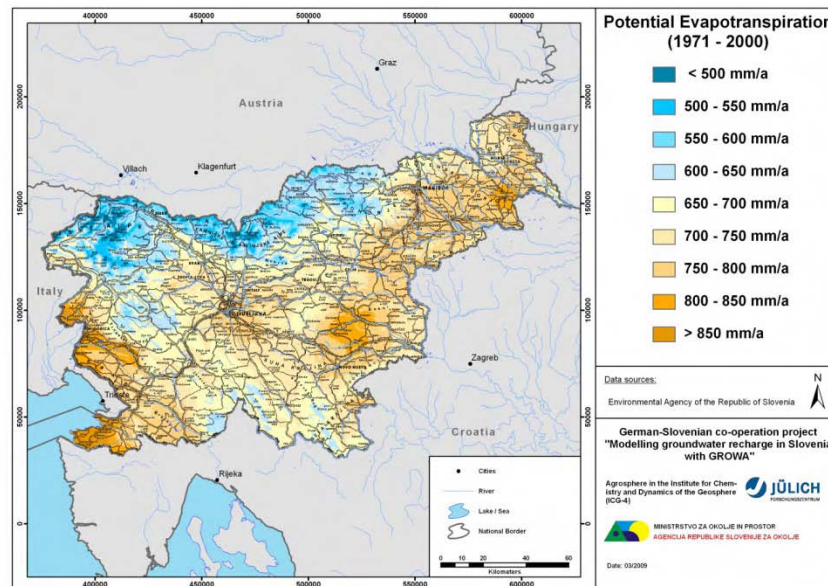
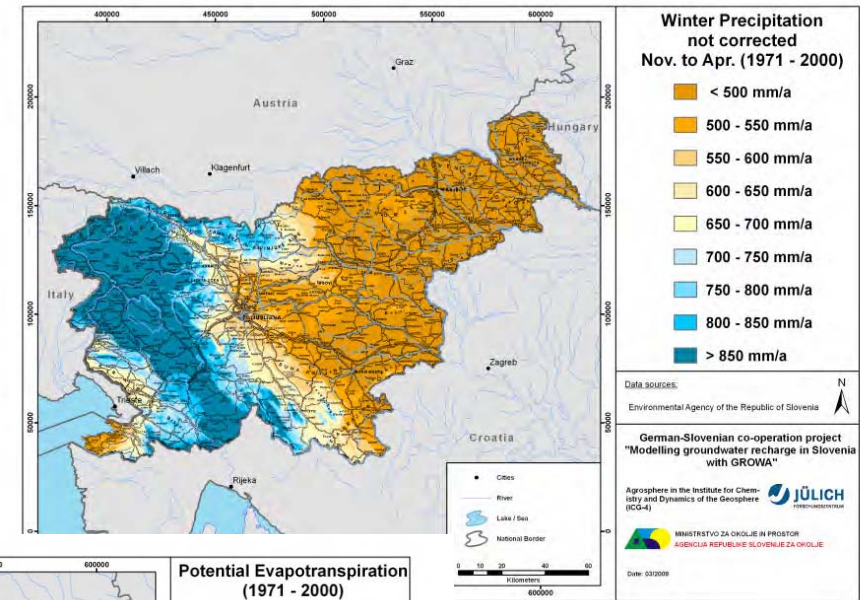
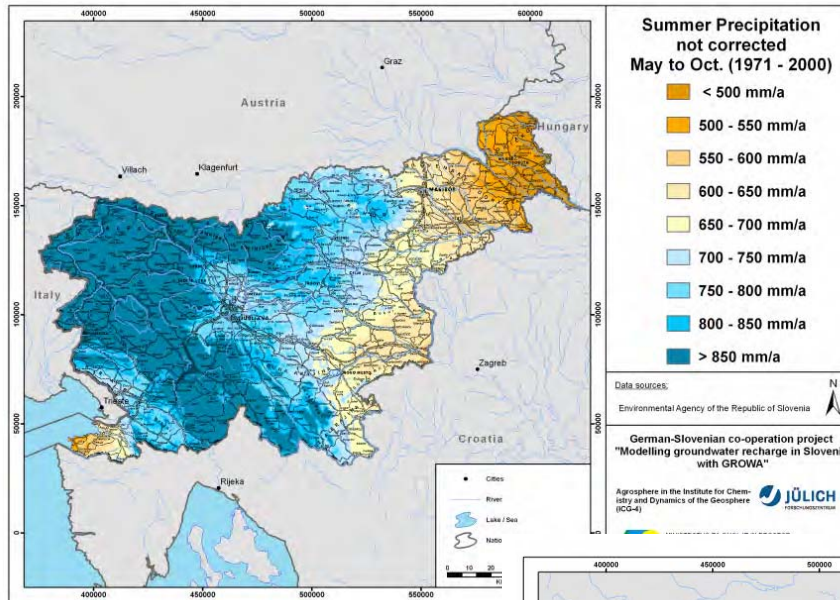
(Kunkel & Wendland, 1998; 2002)



GROWA: Input data (Summary)

	Data base	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 lend	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 pseudo-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 and potential evapotranspiration



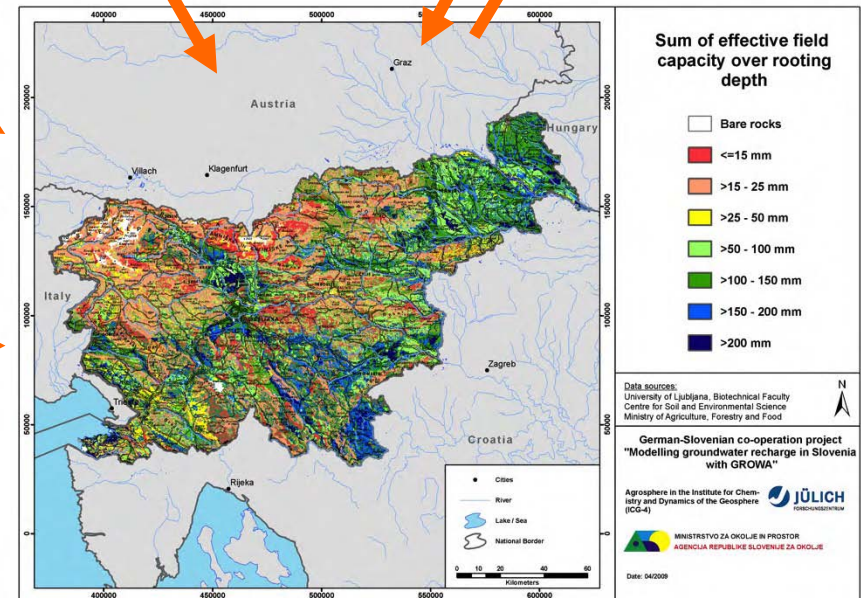
Data Source:
ARSO, Meteorology Office

General soil type map 1:25000

CORINE land cover

al Faculty, CPVO
onmental Science

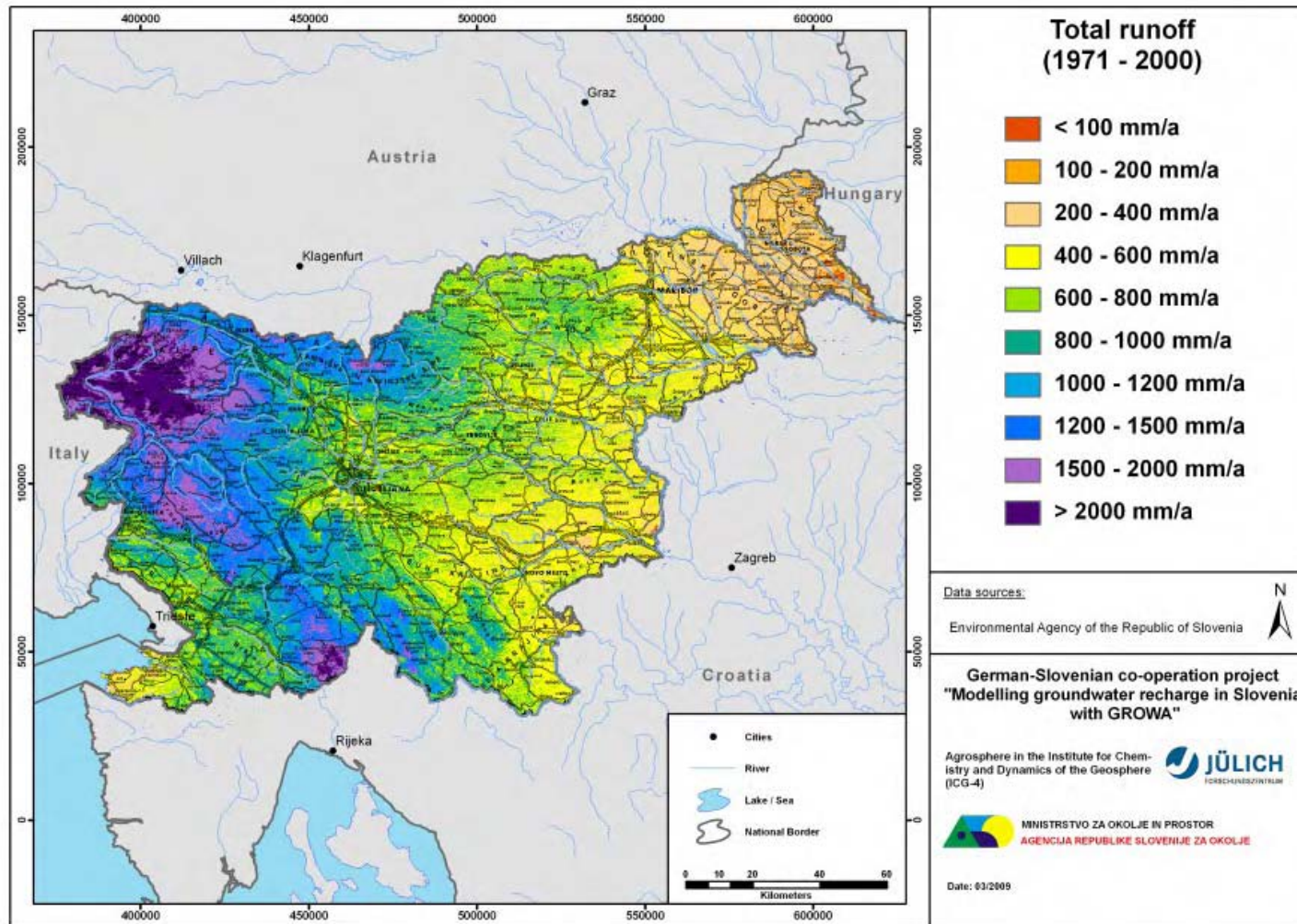
Verification of
pedotransfer functions



Institut für Bio- und Geowissenschaften - Agrosphäre (IBG-3)

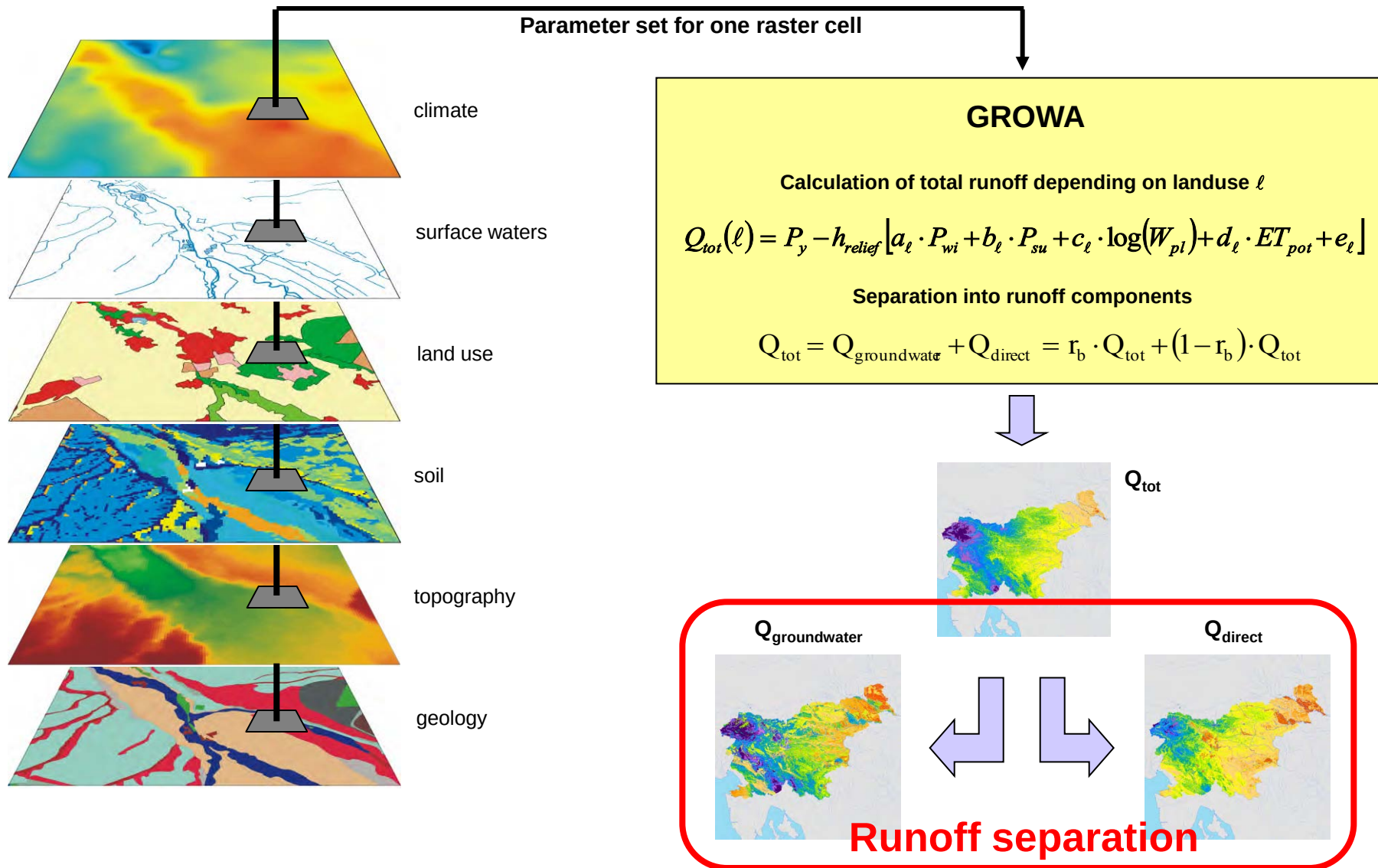
GROWA model result

Total runoff



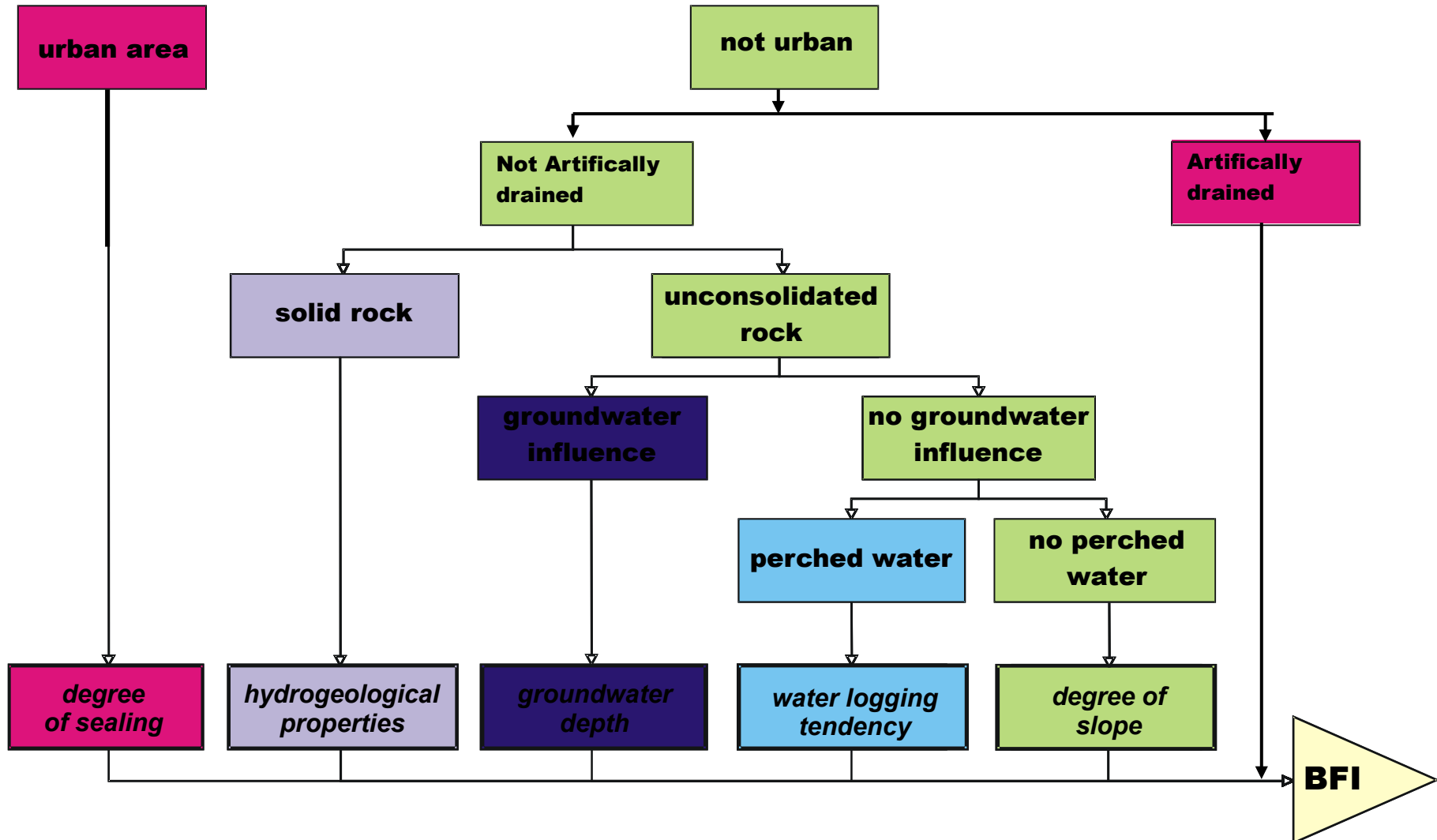
GROWA model

(Kunkel & Wendland, 1998; 2002)



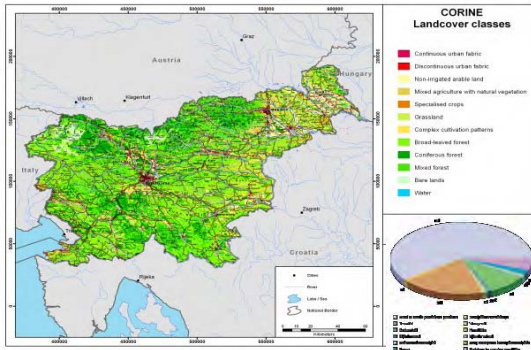
Determination of groundwater runoff

Relevant site characteristics

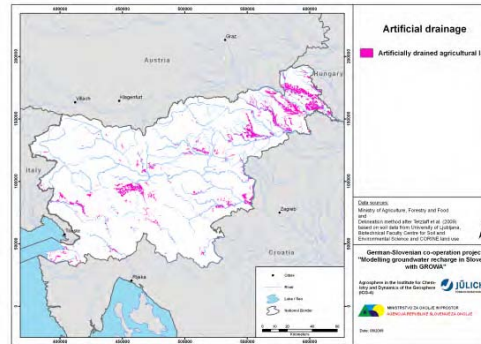


Input data for groundwater recharge separation

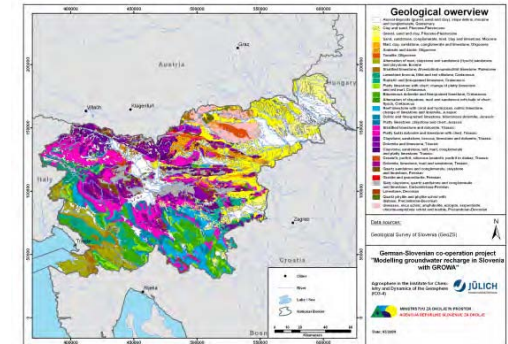
Land use



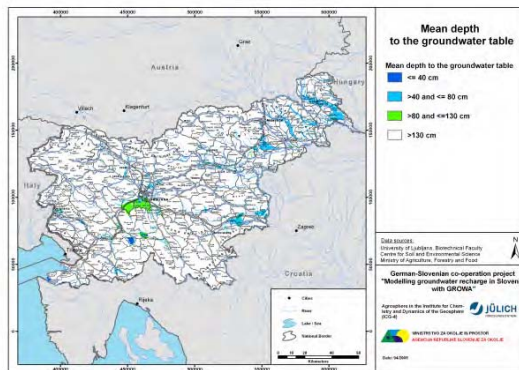
Artificial drainage



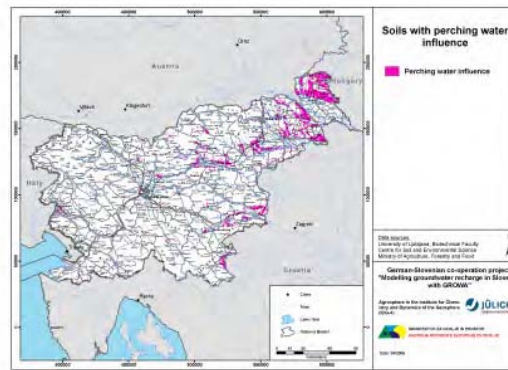
Hard rock units



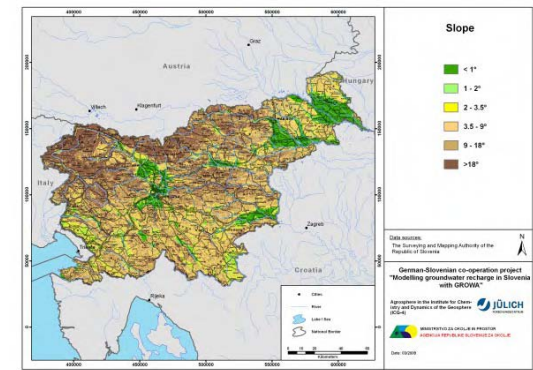
Gw influence on soil



Perching water



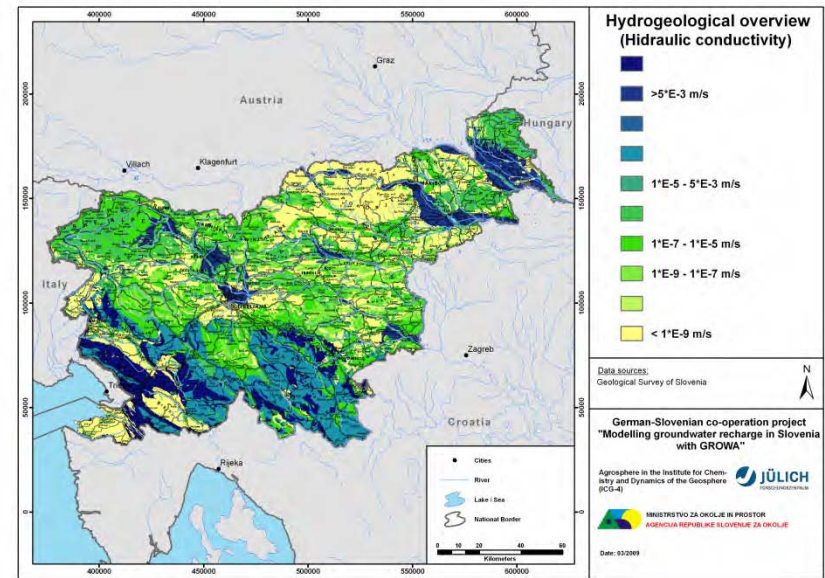
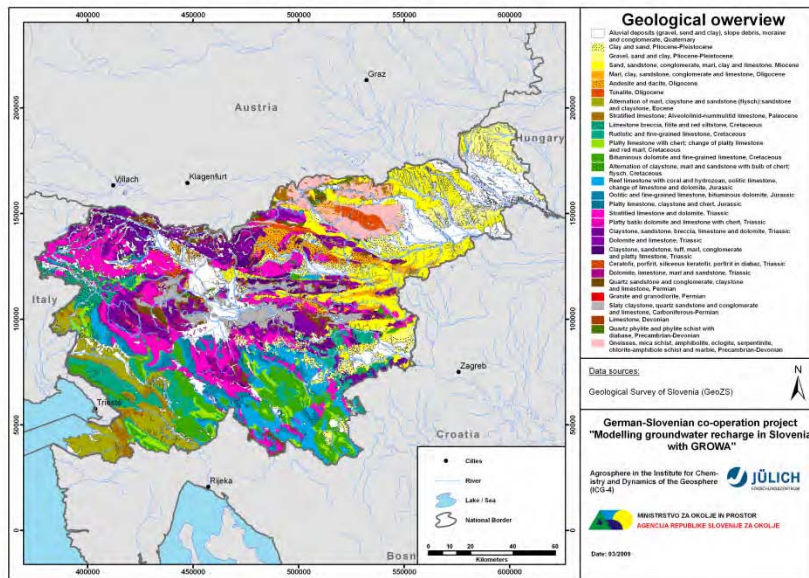
Slope



Input data for groundwater recharge separation

Hydrogeological properties

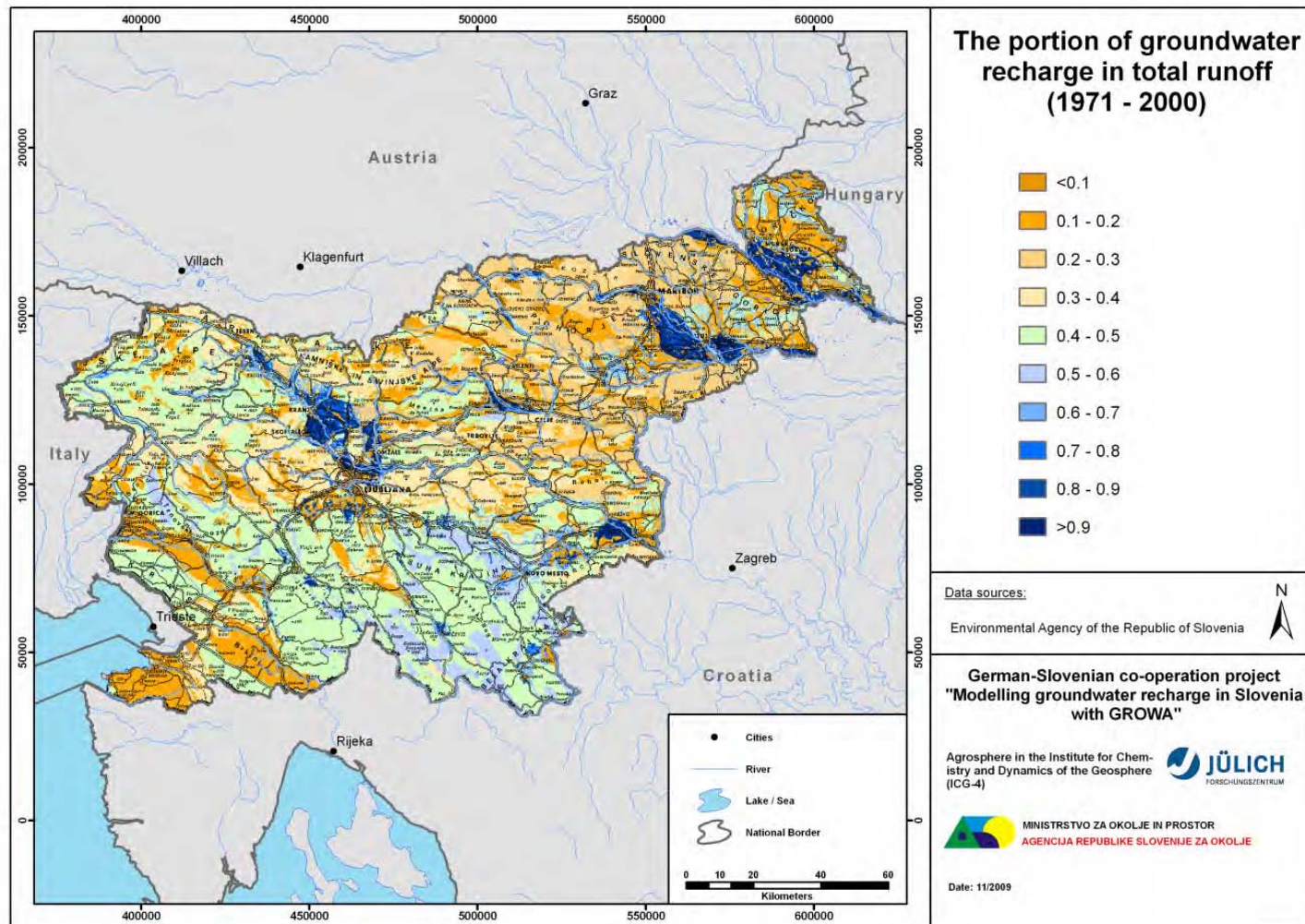
Data Source: Geological Survey of Slovenia (GeoZS)



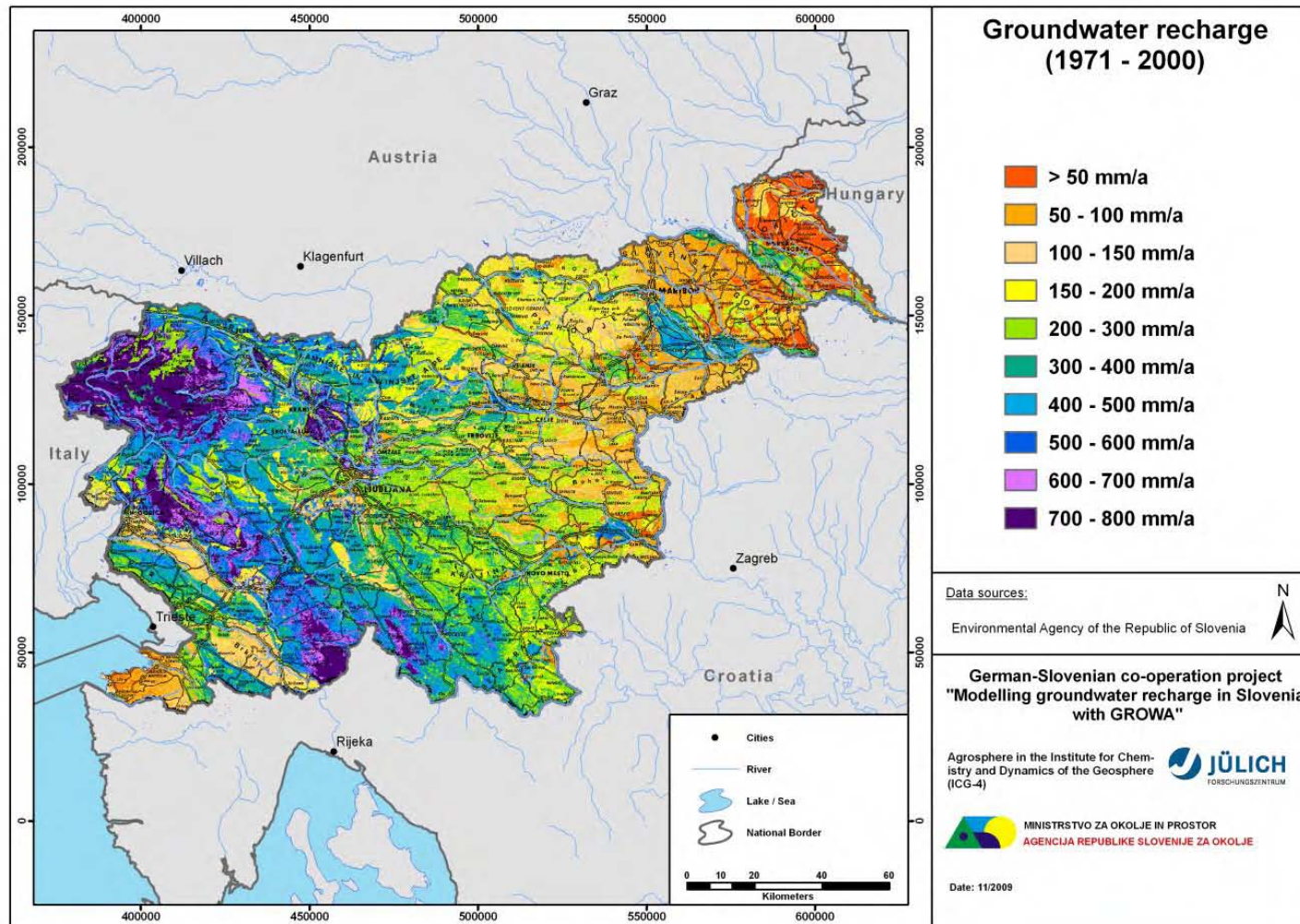
Examples for BFI values:

- Karst: 0.4-0.54;
- Sandstones: 0.15 – 0.35
- Quarternary: 0.7 – 0.9

Distributed values of BFI



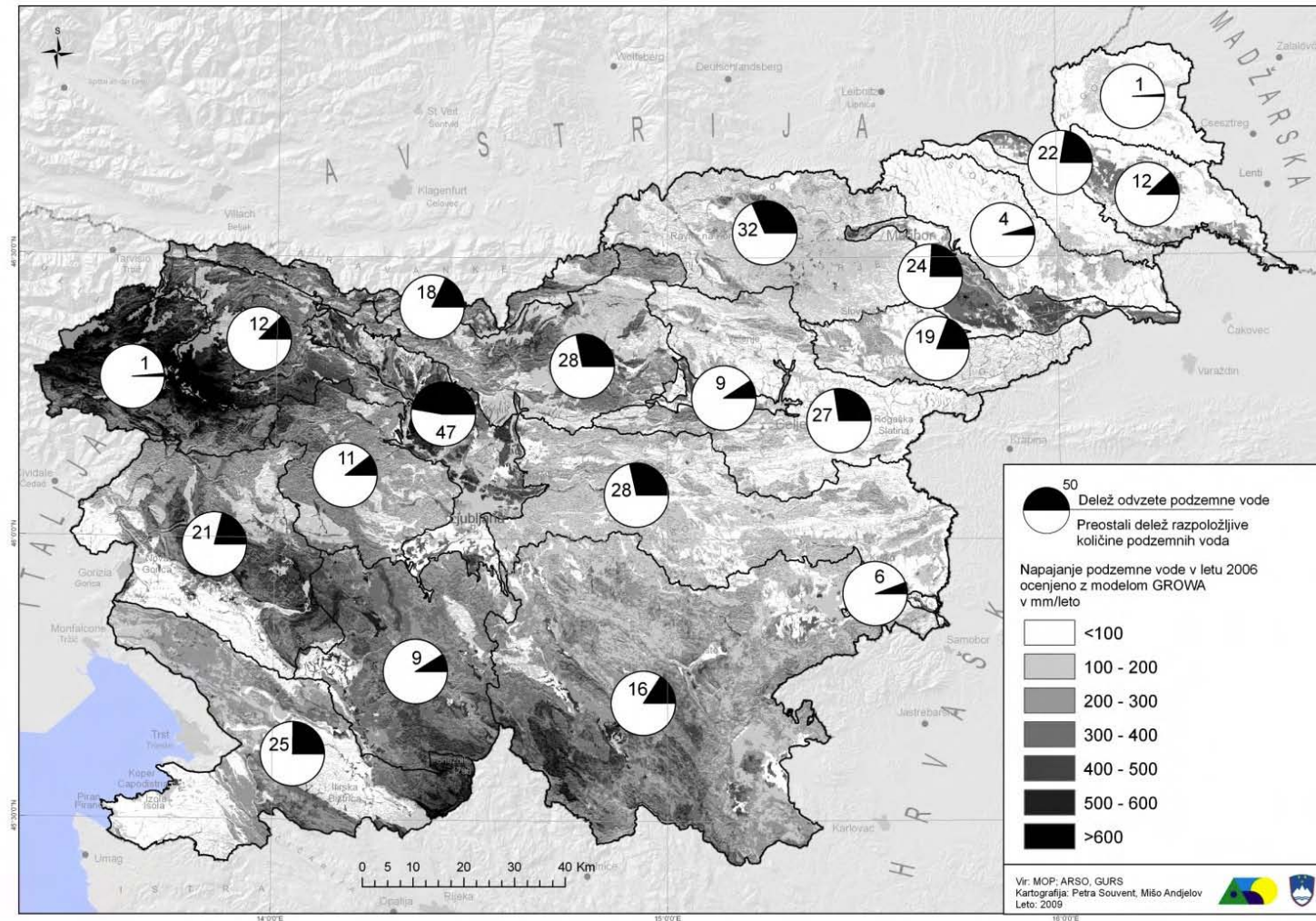
GROWA result: Groundwater recharge for Slovenia



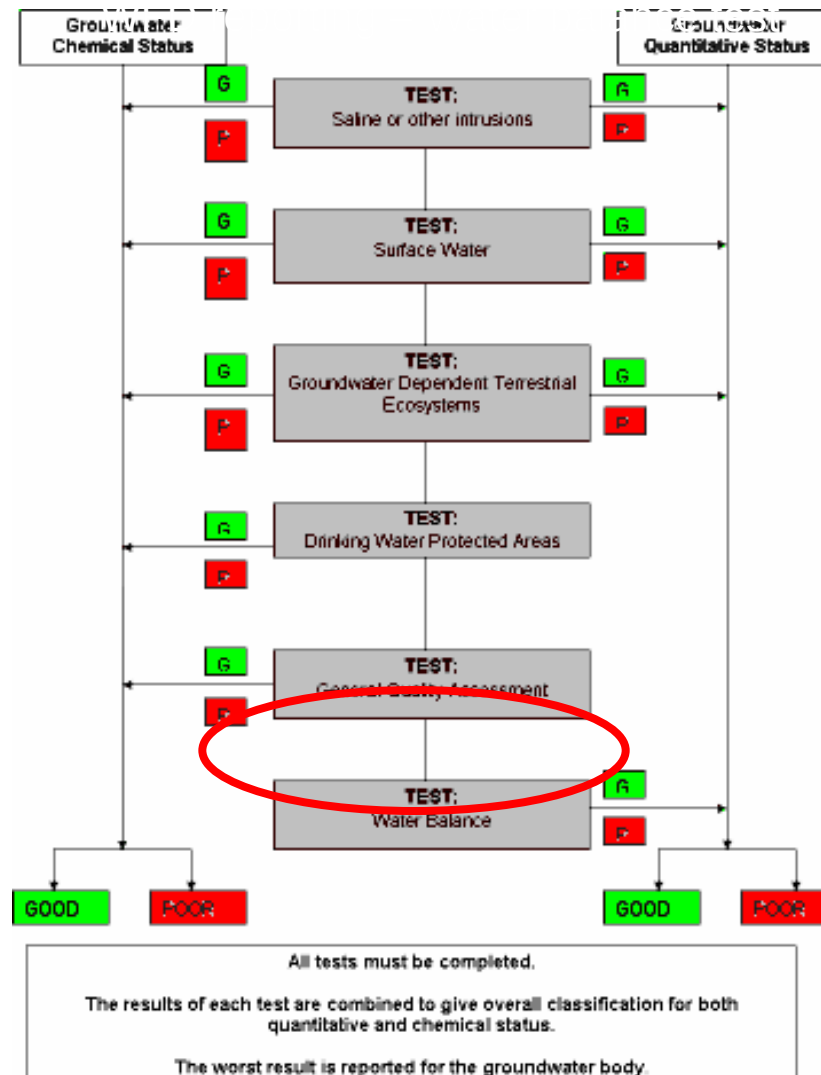
Examples for the application of GROWA results to Slovenia

- WFD reporting – Water balance test
- Slovenian contribution to EEA WISE-report
- Granting of permits to abstract groundwater on regional level
- Report to the Parliament on the state of the environment in Slovenia (POS)
- Slovenian contribution to EU – project SOUTH EAST EUROPE on water scarcity..... (CC-Water)
- Assessment of yearly water balance in National Park „Julian Alps“
-

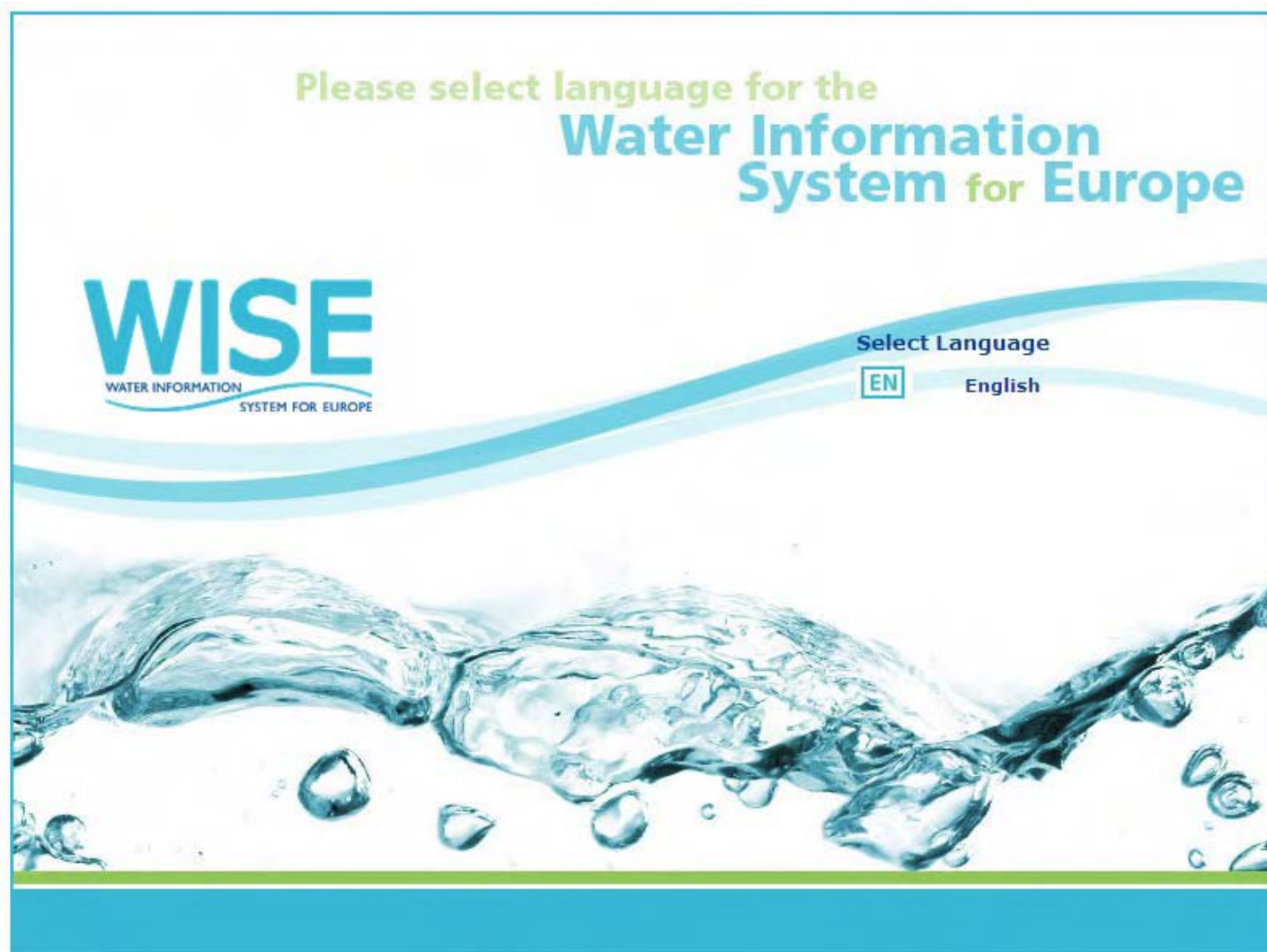
Report to the Parliament on the state of the environment in Slovenia (POS)



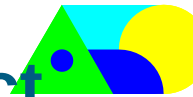
WFD reporting – Water balance test



Slovenian contribution to EEA report



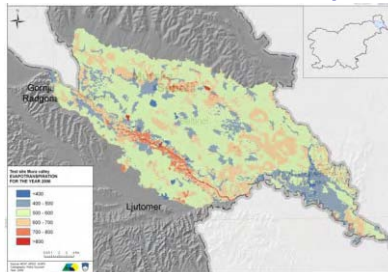
Slovenian contribution to EU-project SOUTH EAST EUROPE on water scarcity



Groundwater Water balance

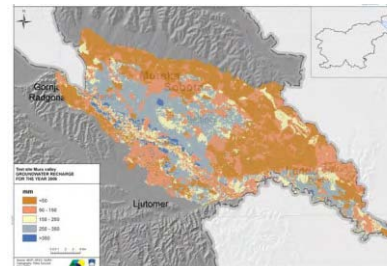


Evapotranspiration: 300 Mm³/year

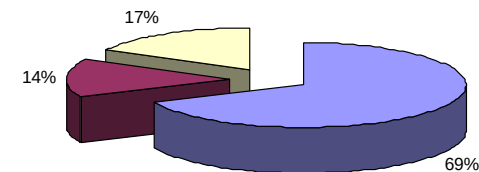
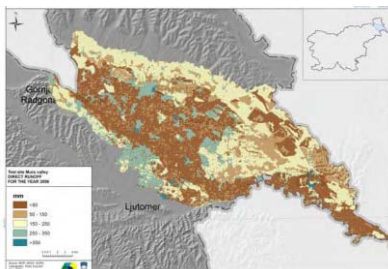


Year 2006

Groundwater recharge: 76 Mm³/year



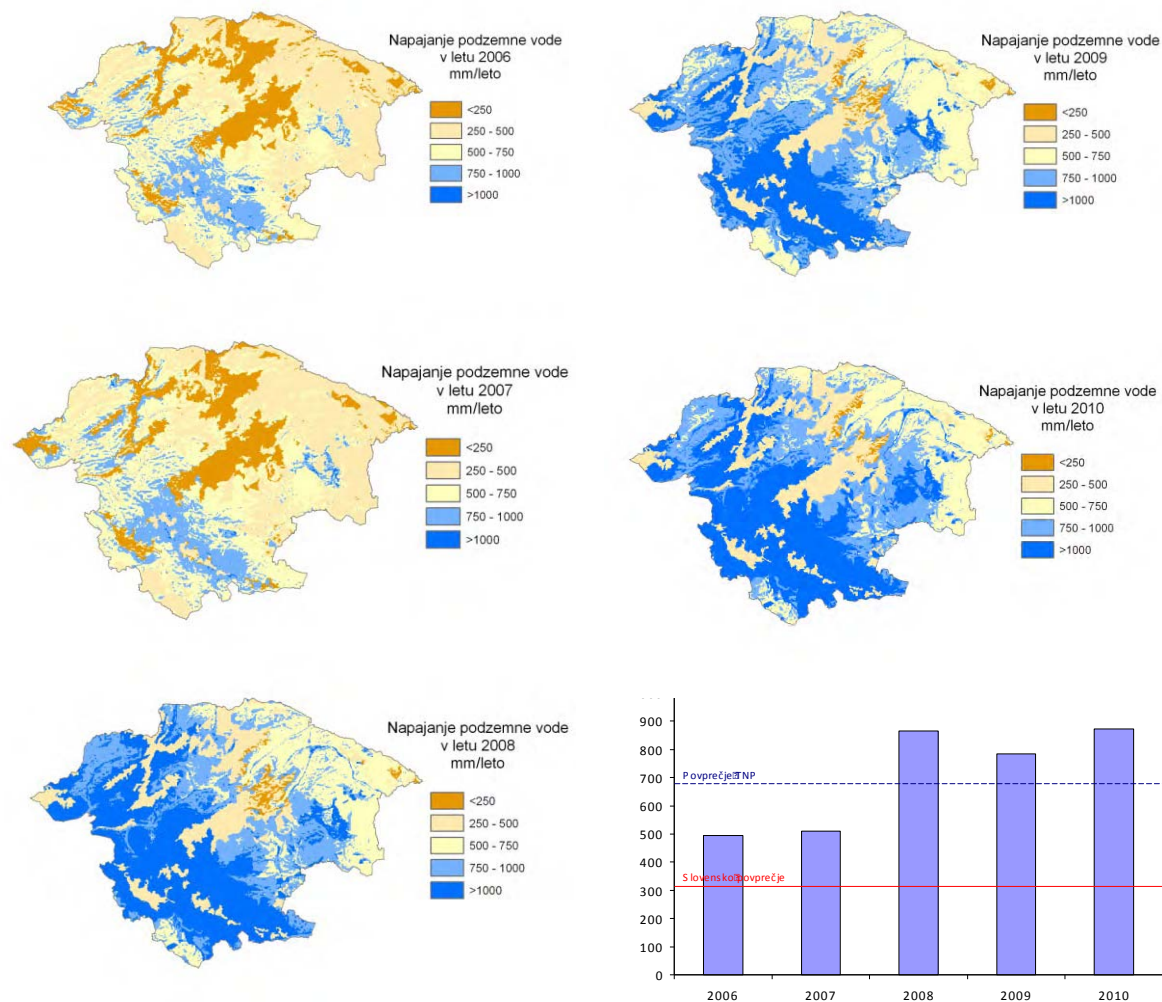
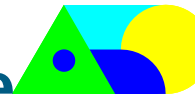
Direct runoff: 63 Mm³/year



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

Precipitation: 439 Mm³/year

Assessment of yearly water balance in National Park „Julian Alps“ (Forestral area)



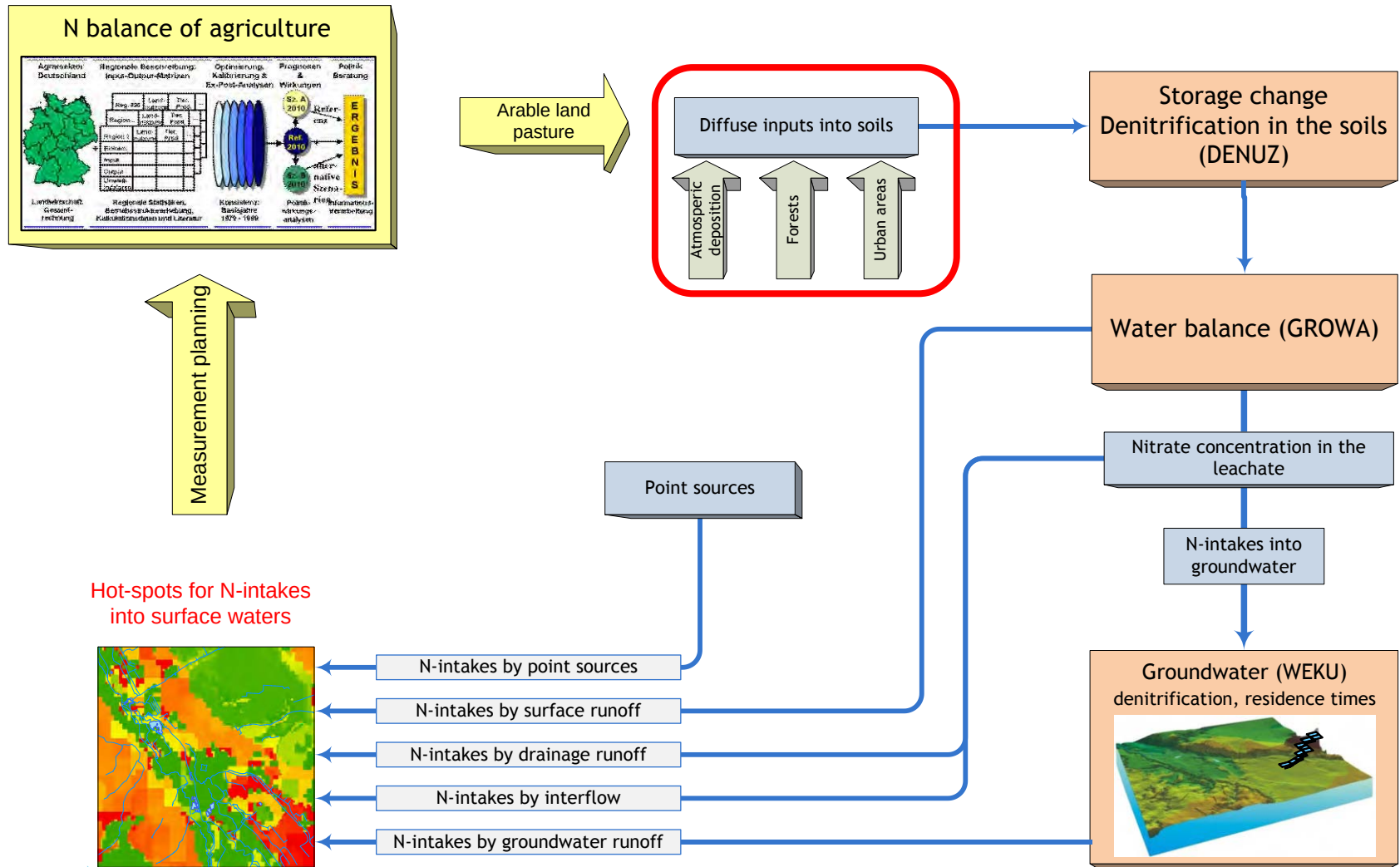
**Forestral
national long-
term water
reservoir**

**Sala-river
(upper
catchment)**

How may forests contribute to water related topics?

1. Water availability and sustainable water use
2. Water quality
 - Atmospheric deposition of nutrients in forests
 - Leaching of nutrients from forests into the soil and groundwater
 - Forests as „dilution areas“ for diffuse inputs from agriculture
3. Climate change related topics
 - Contribution of forests to the evolution of water quality and quantity
4. Additional topics, e.g.:
 - Flood prevention
 - Soil erosion protection

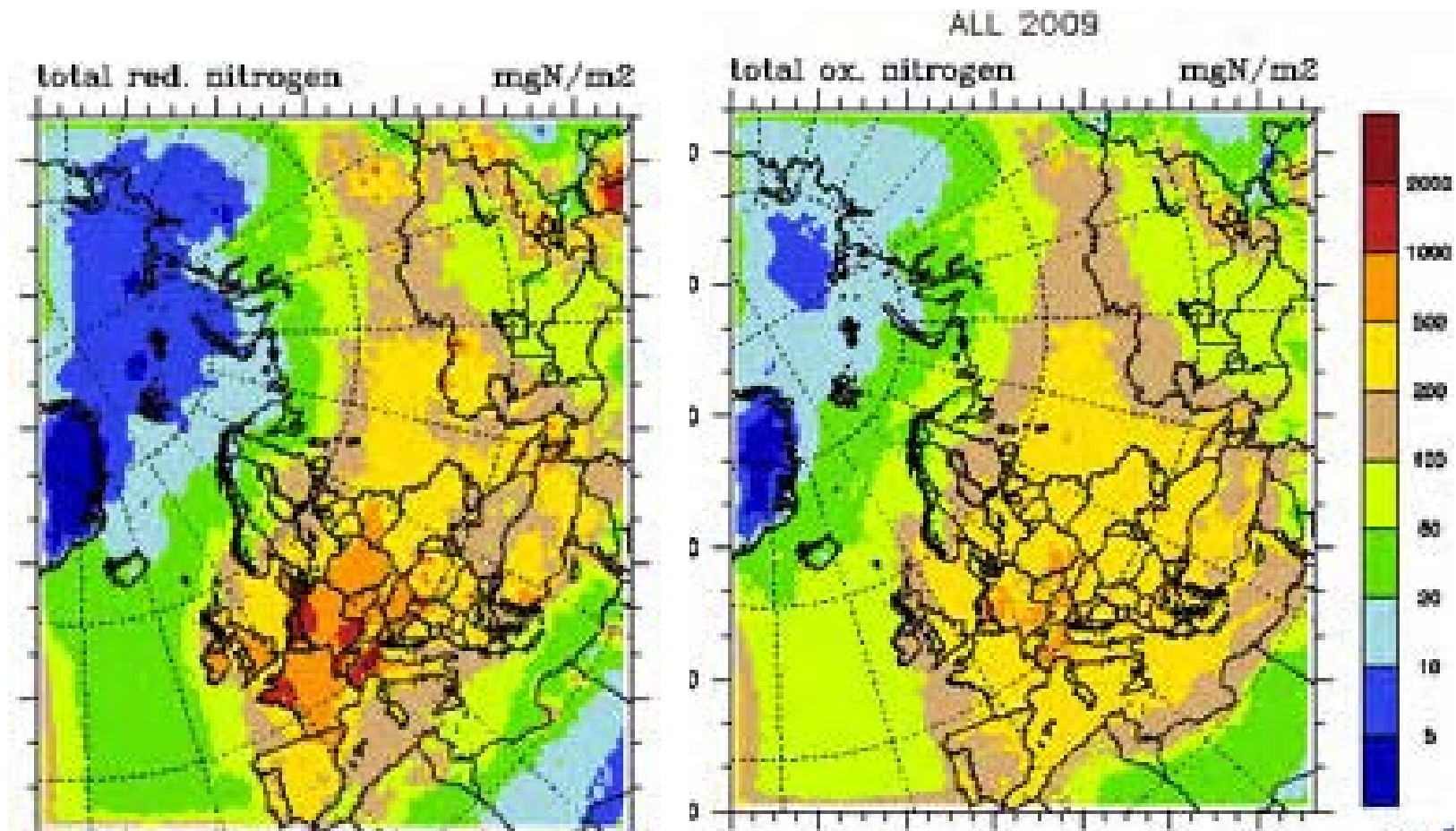
Coupled model system for nitrate flux modelling



Nutrient management questions related to forests

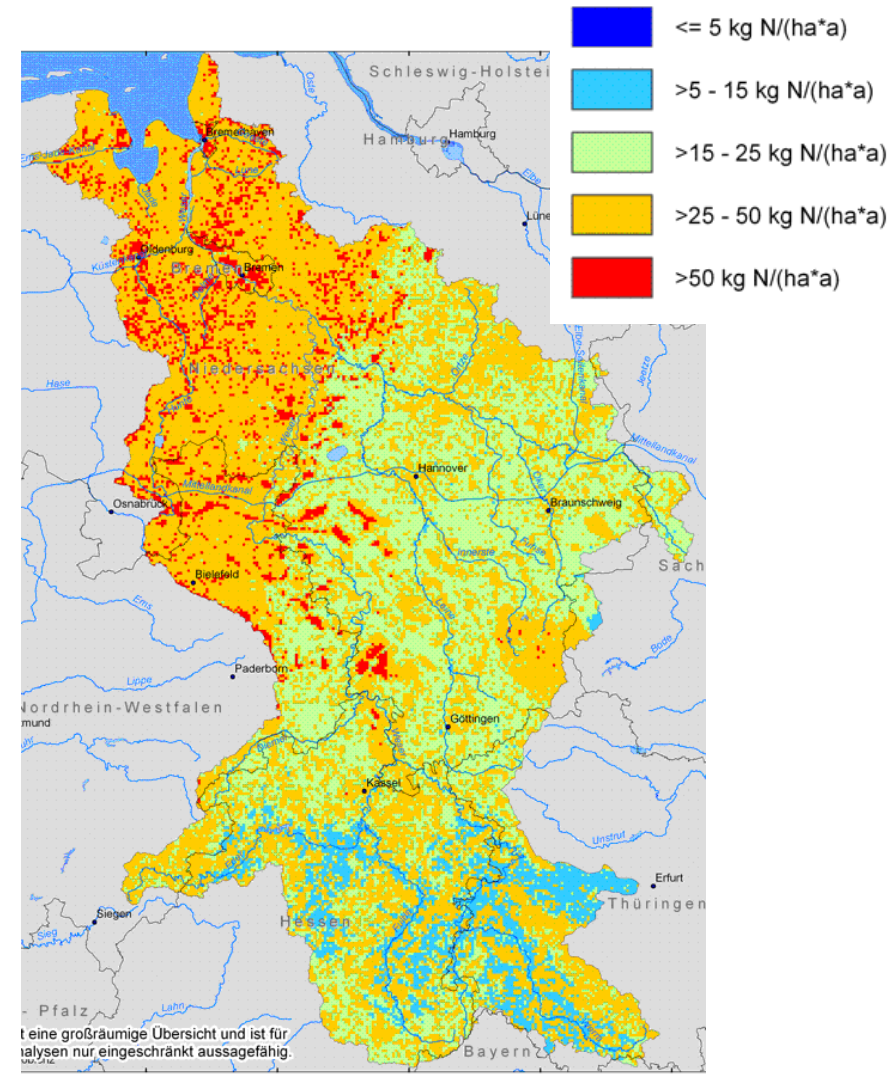
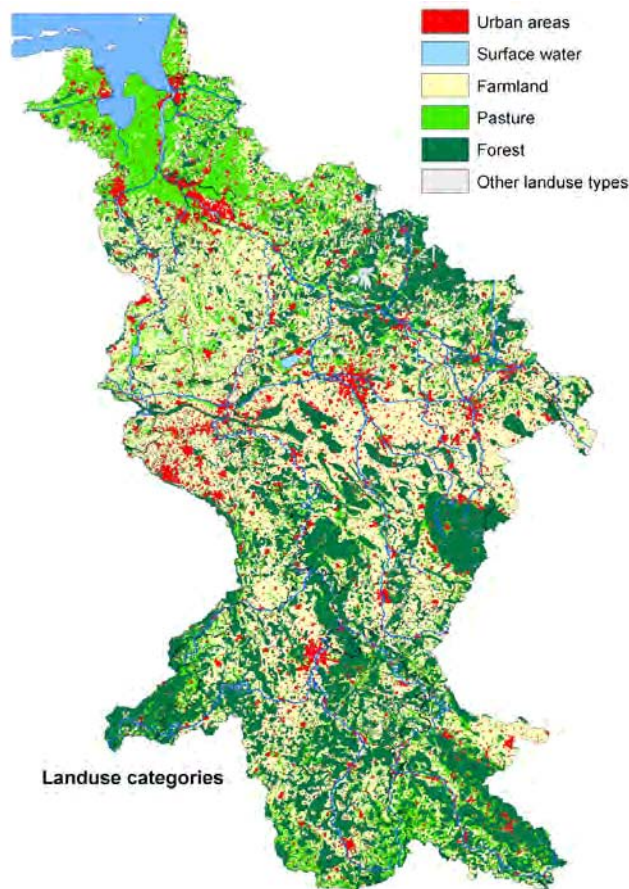
- What are the N-inputs from atmospheric deposition into forests?
- To what extend are these nutrients stored/used by vegetation?
 - Tree growth
 - N-removals by tree harvesting
 - Litter fall
 - „Retention“ of nutrients by forests (critical loads)
- To which extend are nutrients released into the soils, the groundwater and into surface waters and through which pathways?
- To which extend can forests act as dilution areas to achieve better water quality e.g. with respect to the consideration of groundwater bodies
- Can forest related land use management measures contribute to an improvement of water quality?

E-Meps results for atmospheric N-deposition in Europe



Total N-inputs in the Balkan region 5-20 kg N/(ha a)

Atmospheric N-deposition (according to Gauger, example Weser basin)

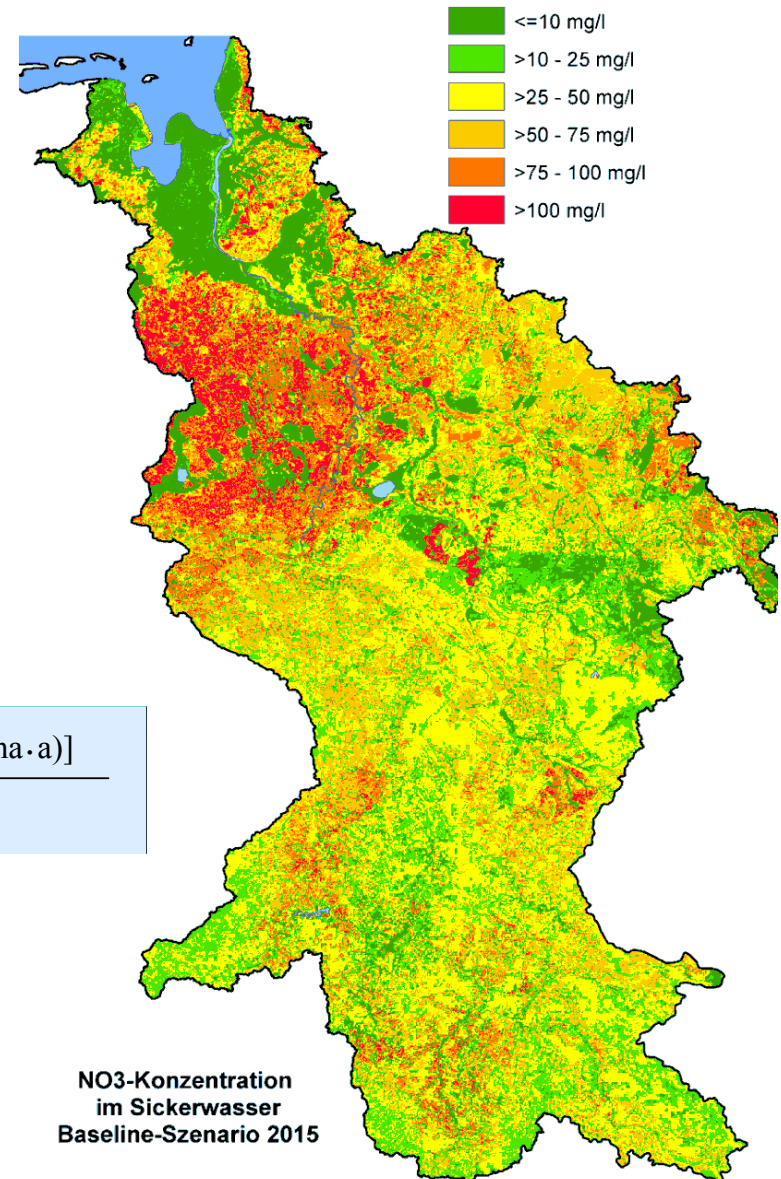


Potential nitrate concentration in the leachate

- EU groundwater daughter directive: 50 mg/L nitrate in groundwater
- Practical environmental target with respect to modelling: 50 mg/L nitrate in recharged groundwater

$$C_{NO_3}[mg/L] = 443 \cdot \frac{(N \text{ surplus} - \text{denitrification in soil}) [kg N/(ha \cdot a)]}{\text{Infiltration rate [mm/a]}}$$

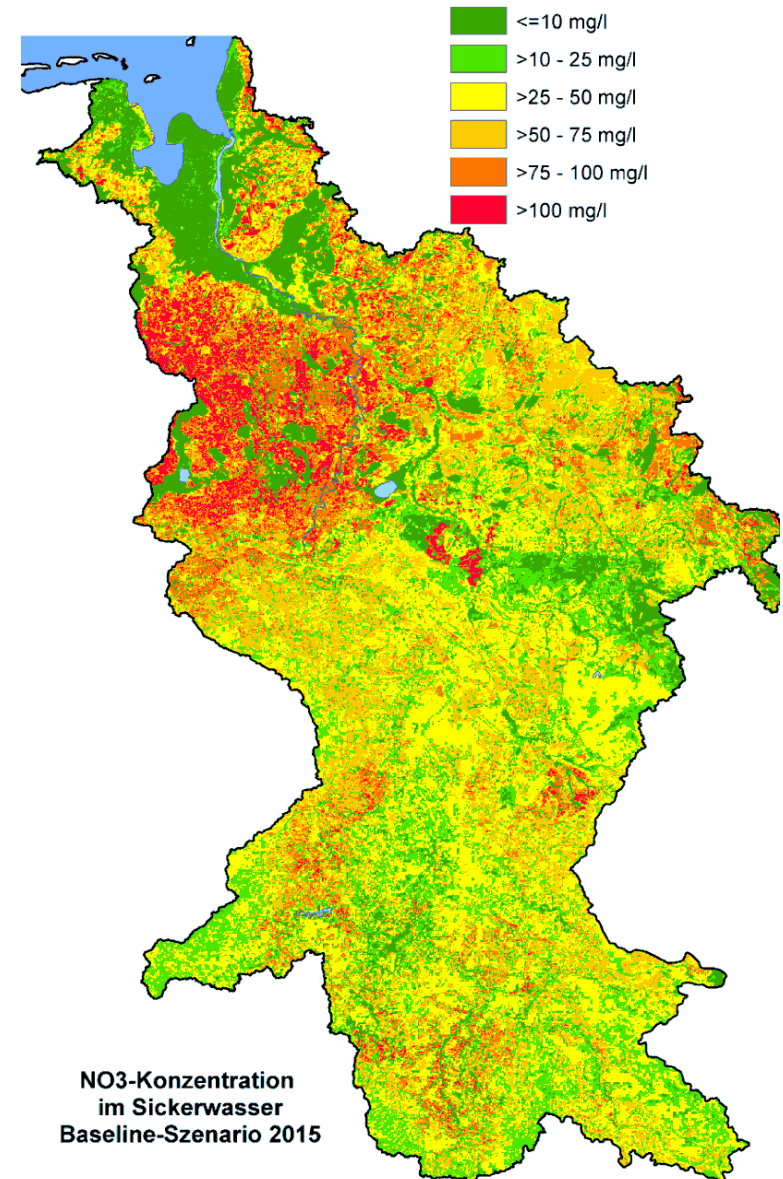
- All areas with nitrate concentrations above 50 mg/L may show groundwater quality problems in the future



Assessing necessary nutrient reduction



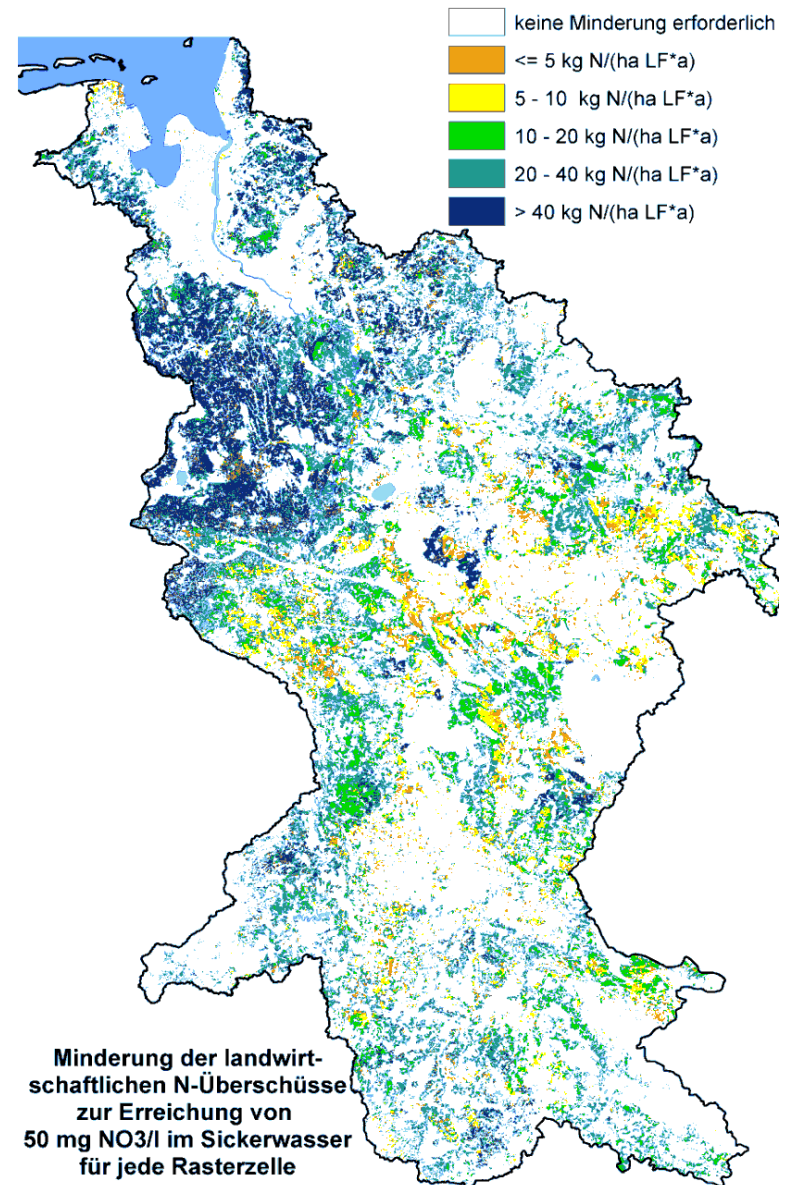
- Important questions:
 - Which N-surplus can be allowed to guarantee achievement of target for groundwater (50 mg/l)?
 - What amount of nitrate reduction in agriculture is required?
- Inverse (backward) model runs:
 - Apart from N-surplus all input parameters remain unchanged
- Adjusting N-surpluses until 50 mg NO₃/L are achieved



Assessing necessary nutrient reduction for the individual grids

➤ Option 1:
environmental target of 50
NO₃/l in the leachate is related
to every raster cell
(100 x 100 m)

- Result:
- Very high reduction needs for agricultural intensively used areas
 - Partially high reduction needs also in agricultural extensively used areas



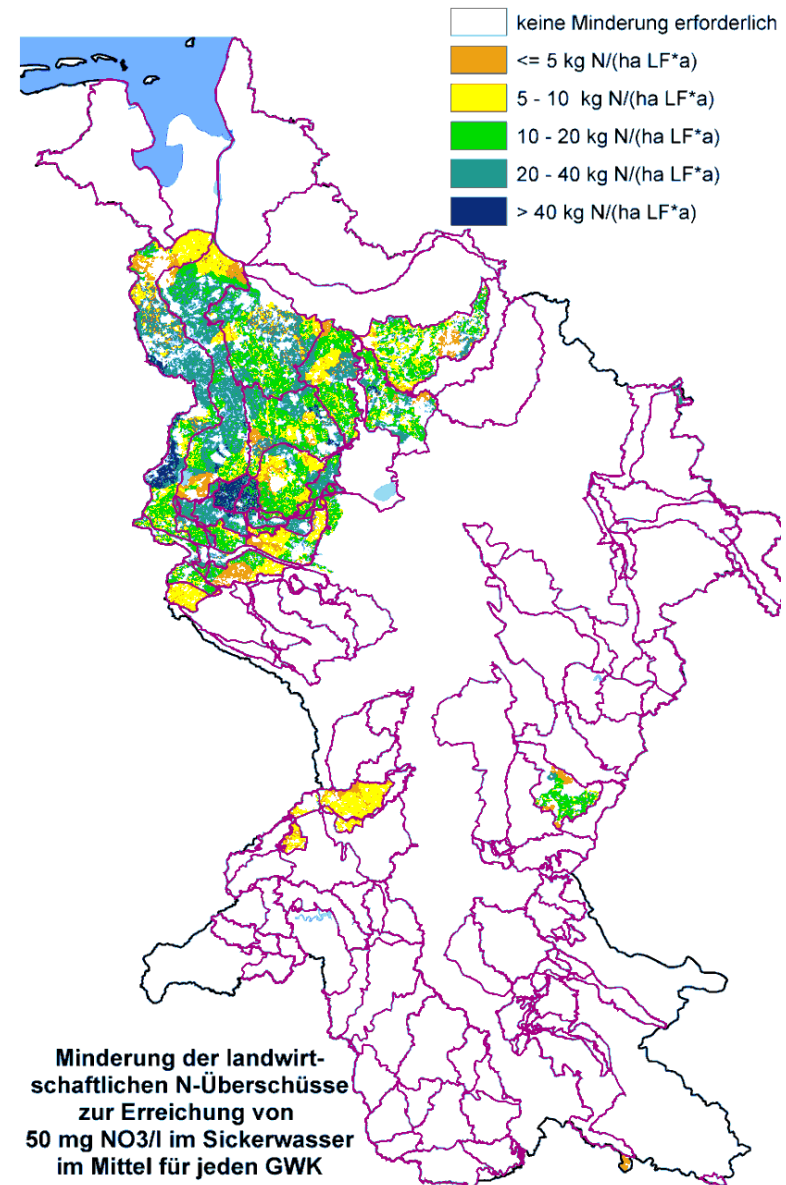
Assessing nutrient reduction

➤ Option 2:

Relating environmental target
to whole groundwater bodies

Result:

- Reduced reduction needs
- Affects mainly groundwater bodies at risk
- Forests acts as dilution areas reducing the average nutrient inputs into water bodies



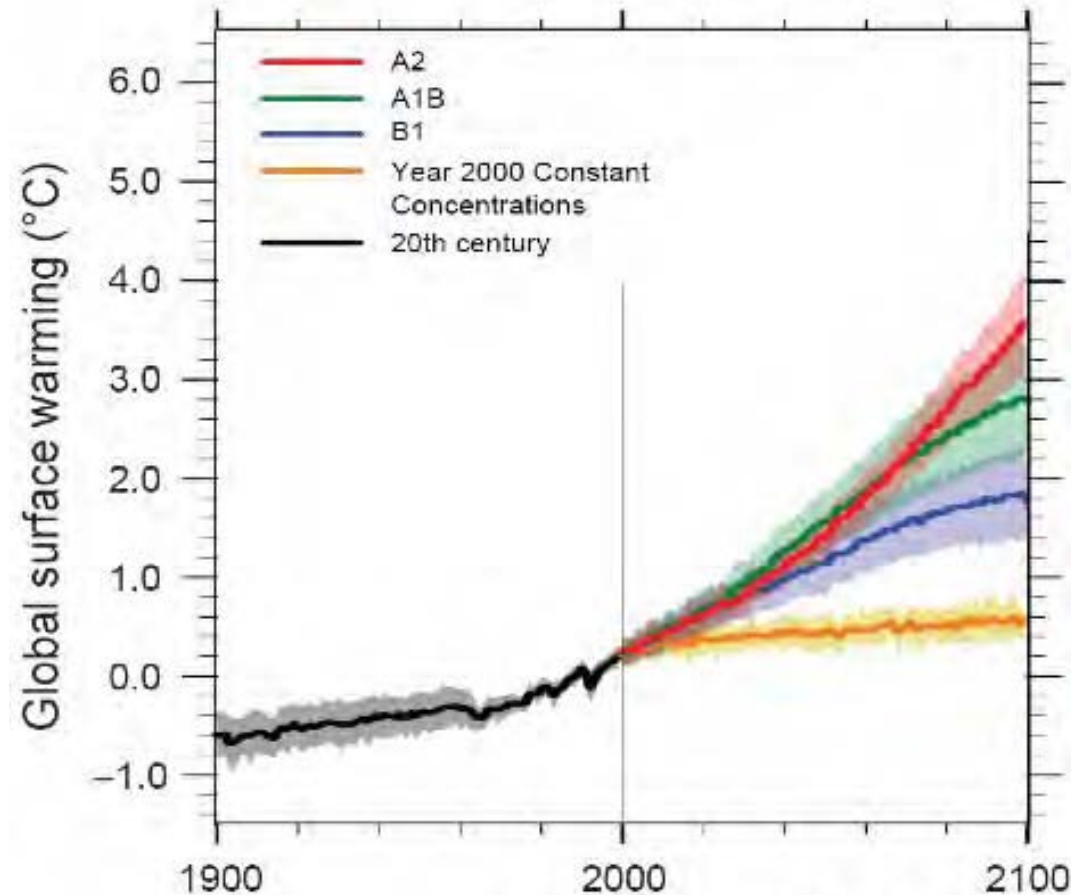
How may forests contribute to water related topics?

1. Water availability and sustainable water use
2. Water quality
 - Atmospheric deposition of nutrients in forests
 - Leaching of nutrients from forests into the soil and groundwater
 - Forests as „dilution areas“ for diffuse inputs from agriculture
3. Climate change related topics
 - Contribution of forests to the evolution of water quality and quantity
4. Additional topics, e.g.:
 - Flood prevention
 - Soil erosion prevention

IPCC emission (SRES) scenarios as a basis for climate predictions



- A1: very fast economical growth and rapid implementation of new and efficient technologies.
- A2: heterogeneous world, characterized by autarchy and conservation of local identities
- B1: global solutions for an economical, social and ecological sustainability.
- B2: local solutions for an economical, social and ecological sustainability.



Quelle: IPCC Fourth Assessment Report, Climate Change

Projections of climate change: precipitation changes until 2100

Climate change effects:

Less precipitation and higher temperature



- Less precipitation and higher temperatures lead to
 - Higher potential evapotranspiration
 - Less total runoff
 - Maybe less groundwater recharge
- Induced changes in tree species
- Induced changes in land cover

- **Assessment of water balance essential to trackle the potential effects of changed climatical conditions**



Available data bases for water balance modelling in SE Europe

- Landcover (CORINE)
- Soil (FAO map)
- Geology
- Topography (NASA SRTM data)
- Weak point: Climate
- Providing these data allows a consistent assessment of region water balance



How to start modelling activities on water and forestry

➤ Definition of modelling area

Common „regional groundwater body Dinaric Alps“ (Sava + Drin basins)

➤ Inventory of existing

- Regional map data (soil, topography, geology, land cover)
- Climate monitoring data
- Surface water monitoring data
- Ground water monitoring data (for quality assessment)

➤ Water balance modelling using pragmatical approaches

➤ Identification of gaps and improvement

➤ Application to more specific questions



Forthcoming EU FP7 research topics with relevance to water - forestry



- **ENV.2013.6.1-4 Land cover and land-use change and climate change mitigation**
Design, assessment and implementation of European and international policies related to land use changes and climate change mitigation through more accurate models and methodologies
- **ENV.2013.6.2-2 Toxicants, environmental pollutants and land and water resources management**
Development of environmental and especially water policies with respect to emerging pollutants and pollutant mixtures through improved knowledge and tools.
- **ENV.2013.WATER INNO&DEMO-2 Ensuring the integration of water and innovation demonstration projects and support to trans-national networks of procurers**
Promoting a continuous dialogue and exchange of good practices between all actors involved, improve communication and transfer of knowledge, and, finally, to identify gaps in matching demand and supply innovation measures.

Possible project topics

- **Water quantity assessment on a regional base**
 - Water balance
 - Groundwater recharge
- **Water quality issues**
 - Pollution prevention
 - Water supply and irrigation
- **Climate change adaptation strategies**
- **Protection issues**
 - Flood prevention
 - Fire protection
 - Soil erosion and segmentation protection
- **Biodiversity**
- **Homogenisation issues**
 - Monitoring
 - Area differentiated data
- **Policies**
 - Illegal logging
 - Protection zones
 - Crisis management
- **Capacity building**
 - Demonstration of participatory approaches
 - Methods on how to enhance capacity building

..... (your suggestions!)

Important: the project topics should be „regional“ and „international“, i.e. cover larger areas in several countries