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HELMHOLTZ CENTRE FOR ENVIRONMENTAL RESEARCH – UFZ

Hydrogeological modelling and its application to IWRM concepts

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0 Outline

- Introduction: groundwater management ↔ IWRM
- Groundwater modelling: Pipiripau watershed
- Work in progress & conclusion

1 Introduction

Feature	*Groundwater resources and aquifers*	*Surface water resources and reservoirs*
Hydrological characteristics		
Storage	Very large	Small to moderate
Resource areas	Relatively unrestricted	Restricted to water bodies
Flow velocities	Very low	Moderate to high
Residence time	Decades/centuries	Mainly weeks/months
Drought vulnerability	Generally low	Generally high
Evaporation losses	Low & localised	High for reservoirs
Resource evaluation	High costs & uncertainty	Lower cost & less uncertain
Abstraction impacts	Delayed & dispersed	Immediate
Natural quality	Generally high	Variable
Pollution vulnerability	Variable natural protection	Largely unprotected
Pollution persistent	Often extrem	Mainly transitory

1 Introduction

Main objectives

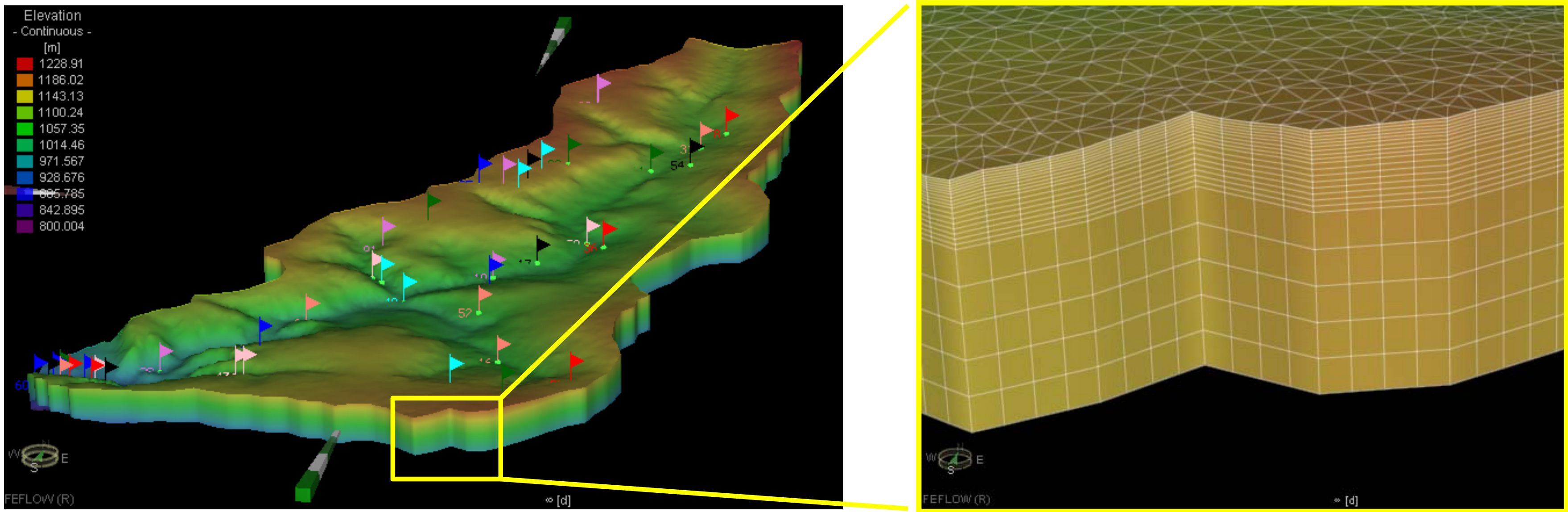
- To realise the importance of aquifer characterisation in groundwater resources management
- Understand key properties of aquifers for improving the groundwater management
- Understand main hydro-geological systems and groundwater dynamics, and their implications in terms of groundwater development

2 Pipiripau watershed

Regional objectives

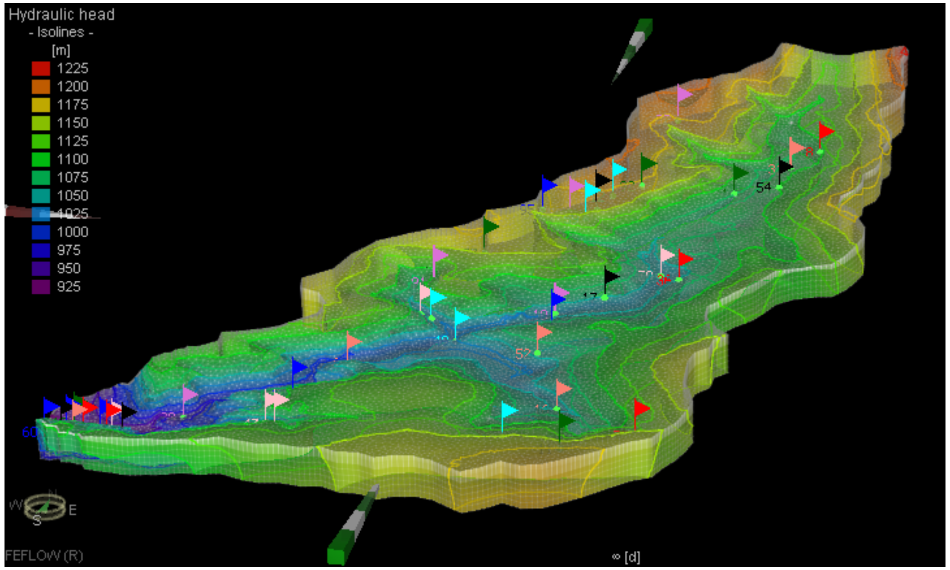
- Available hydrogeological data – representative?
  - Hydrogeological structural data
  - Hydraulic conductivities
- Estimation of groundwater flow velocities
- Estimation of groundwater recharge
- Mean groundwater age?

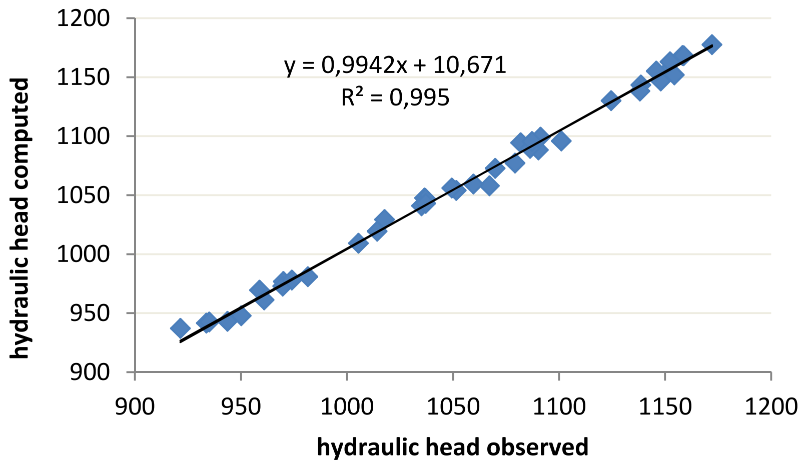
2 Hydrogeological data integration



- **Structural setup**
  - Conceptual model includes several soil & aquifer units
  - Lithological information of about 60 boreholes
  - Finite element model contains numerous model layers

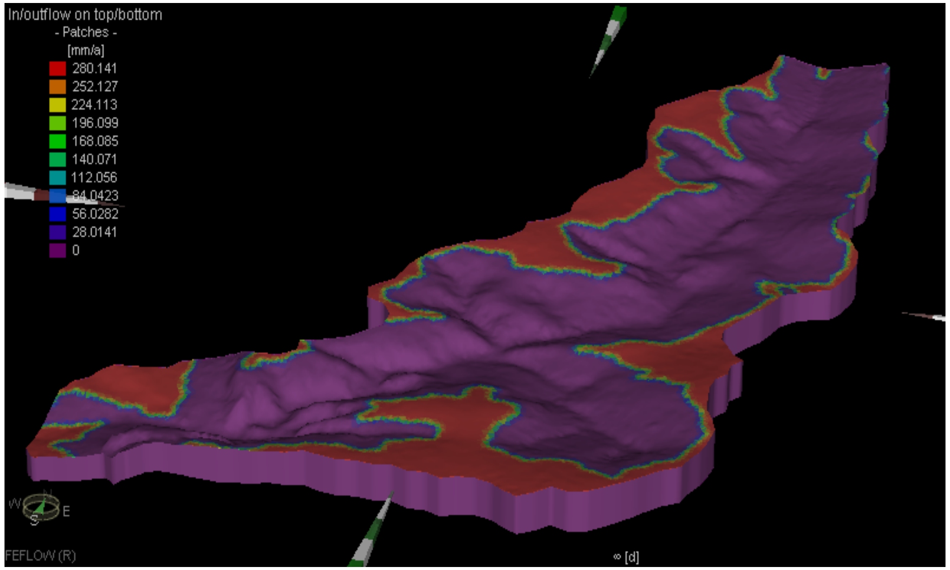
2 Calibration of hydraulic conductivity





Hydraulic systems	Kf-values [m/s]	Kf_x-values$_{model}$ [m/s]	Kf_y-values$_{model}$ [m/s]	Kf_z-values$_{model}$ [m/s]	Kf-values$_{model}$ [m/s]
Porous Units					
P1	**1.68E-6**	1.68E-6	1.68E-6	1.68E-6	**1.68E-6**
P4	**3.11E-7**	3.11E-7	3.11E-7	3.11E-7	**3.11E-7**
Saprolite	**1.68E-6 to 3.11E-7**	3.98E-6	4.03E-6	5.90E-7	**2.87e-6**
Fractured Units					
A	**2.06E-6**	1.07E-7	9.80E-8	1.30E-8	**7.27E-8**
R3/Q3	**8.43E-7**	3.10E-7	3.32E-7	3.80E-8	**2.27E-7**
R4	**1.26E-6**	7.90E-8	4.70E-8	7.00E-9	**4.43E-8**

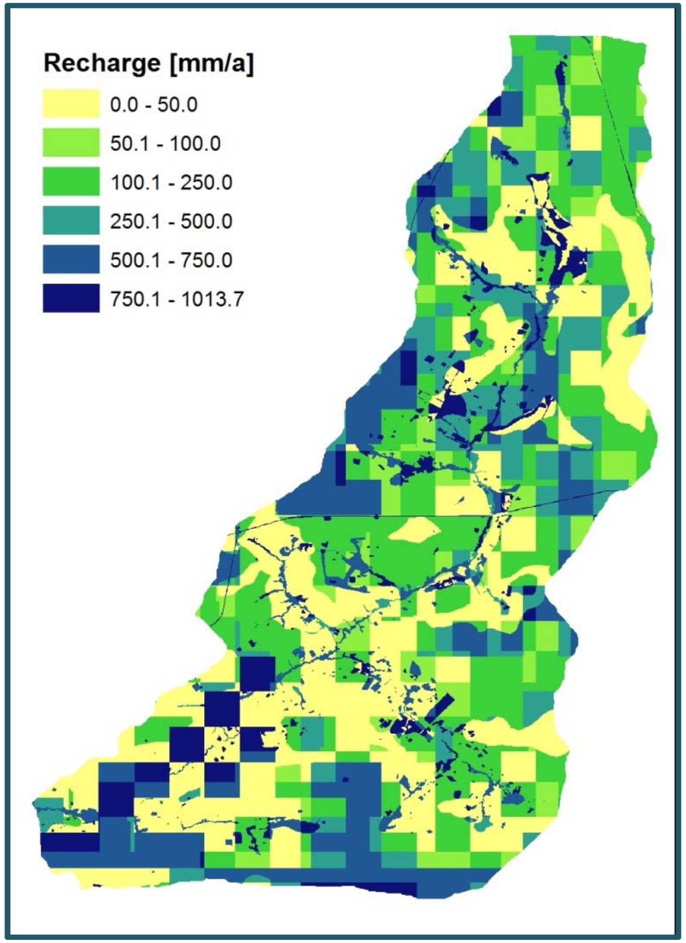
2 Hydraulic system characteristics



- **Groundwater recharge**
  - Coimbra (1987): 12%
  - Carmelo (2002): 34%
  - **Stollberg (2013): 17-19%**

- **Groundwater flow velocity [m/a]**
  - Soil unit: 0.017 (min) – 11.073 (max); **4.633** (mean)
  - Saprolite unit: 0.003 (min) – 12.279 (max); **4.623** (mean)
  - Bedrock unit: 0.001 (min) – 1.249 (max); **0.027** (mean)

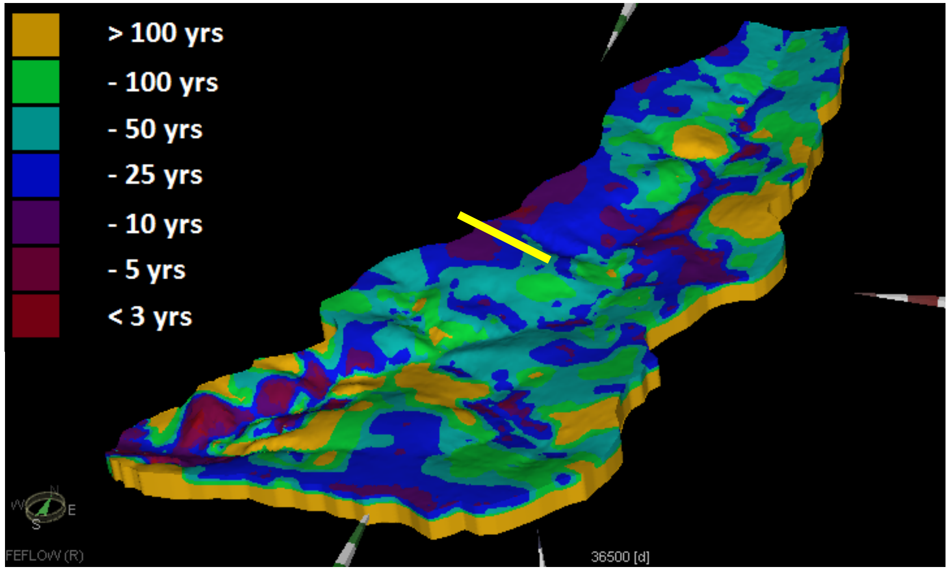
2 Analytical groundwater recharge model



- **Recharge estimation**
  - Schroeder & Wyrwich (1990), Meßer (1997)
  - Modified & implemented
- **Considered input data**
  - Tropic soils & land-use
  - Relative relief
  - Depth to groundwater
  - regionalized precipitation
  - Evapotranspiration (MODIS)

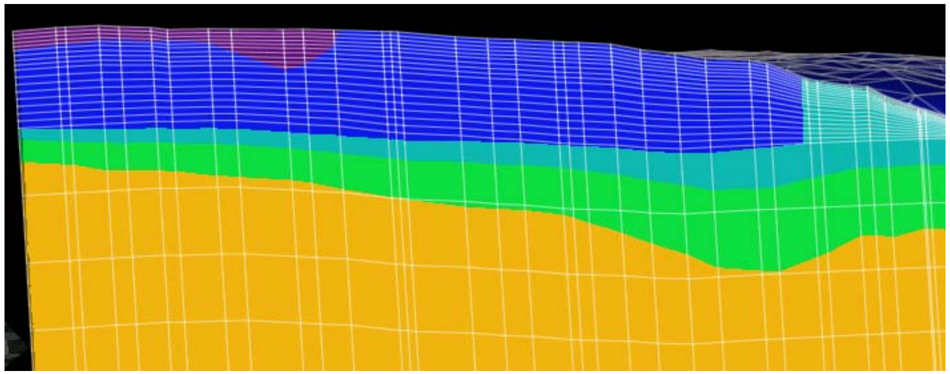
(Run-off: Tropic soils & land-use, Relative relief, Depth to groundwater)

2 Mean groundwater age estimation



Mean age simulation

- Based on conventional steady-state solute transport modeling
- Mass concentration used as tracer for mean age



Retrieved information

- Mean age → travel time
- Age of extracted water → vulnerability mapping

3 Work in progress

Final phase

- Transient model calibration
  - Seasonal groundwater level fluctuations
  - Baseflow estimation
  - Climatic scenarios

- Integrative model coupling of FE-model & SWAT
  - Effects of land-use optimization onto groundwater resources

4 Conclusion

- Understand key properties of aquifers for improving the groundwater management
  - 3-D hydrogeological structures
  - Hydraulic conductivities & groundwater flow velocities
- Understand main hydro-geological systems and groundwater dynamics…
  - Groundwater recharge estimation → analytical model
- To realise the importance of aquifer characterisation in groundwater resources management
  - Mean groundwater age → vulnerability assessment

5 Acknowledgement

- Brazilian partners for support
- BMBF for funding