# Low flow estimation at ungauged sites


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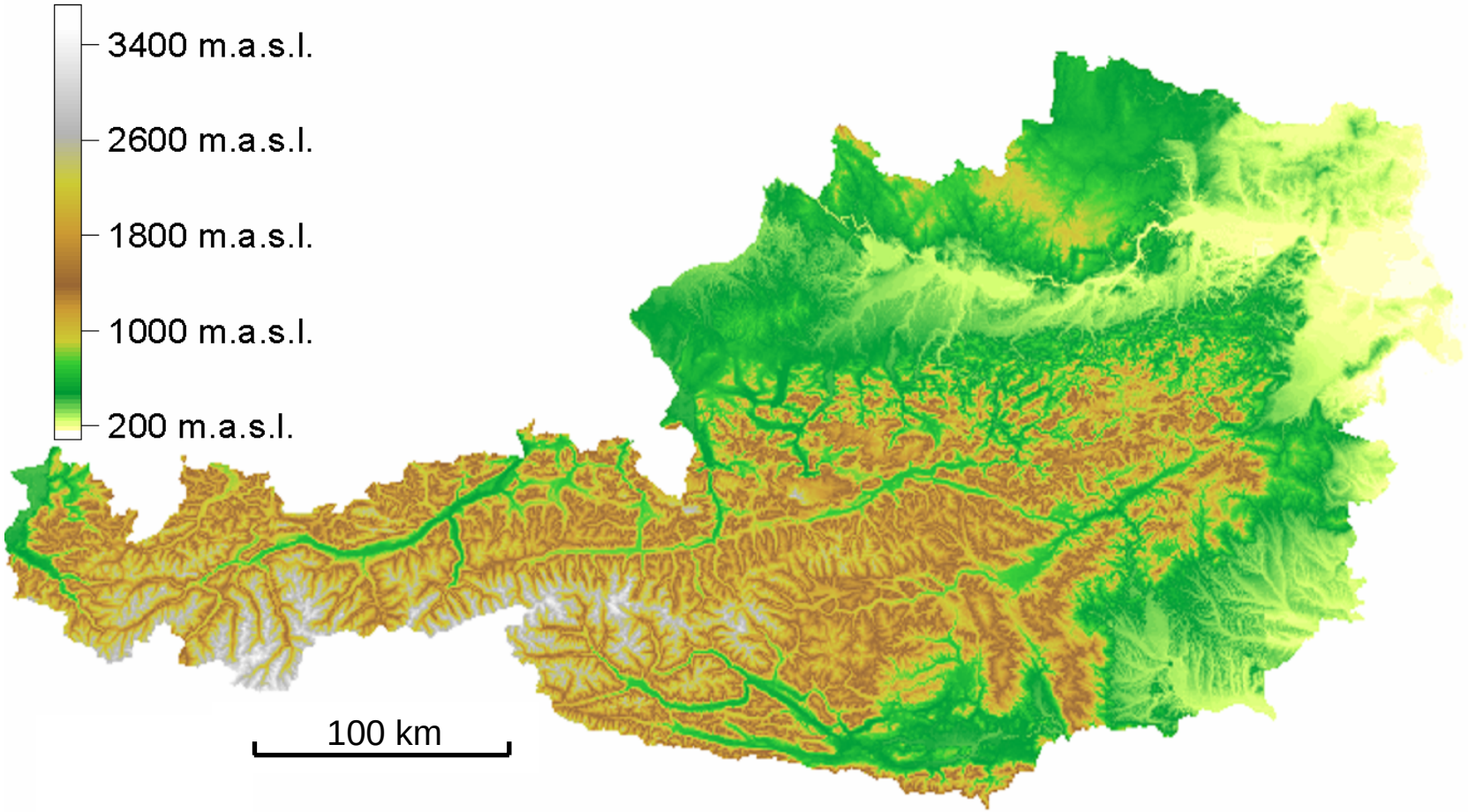
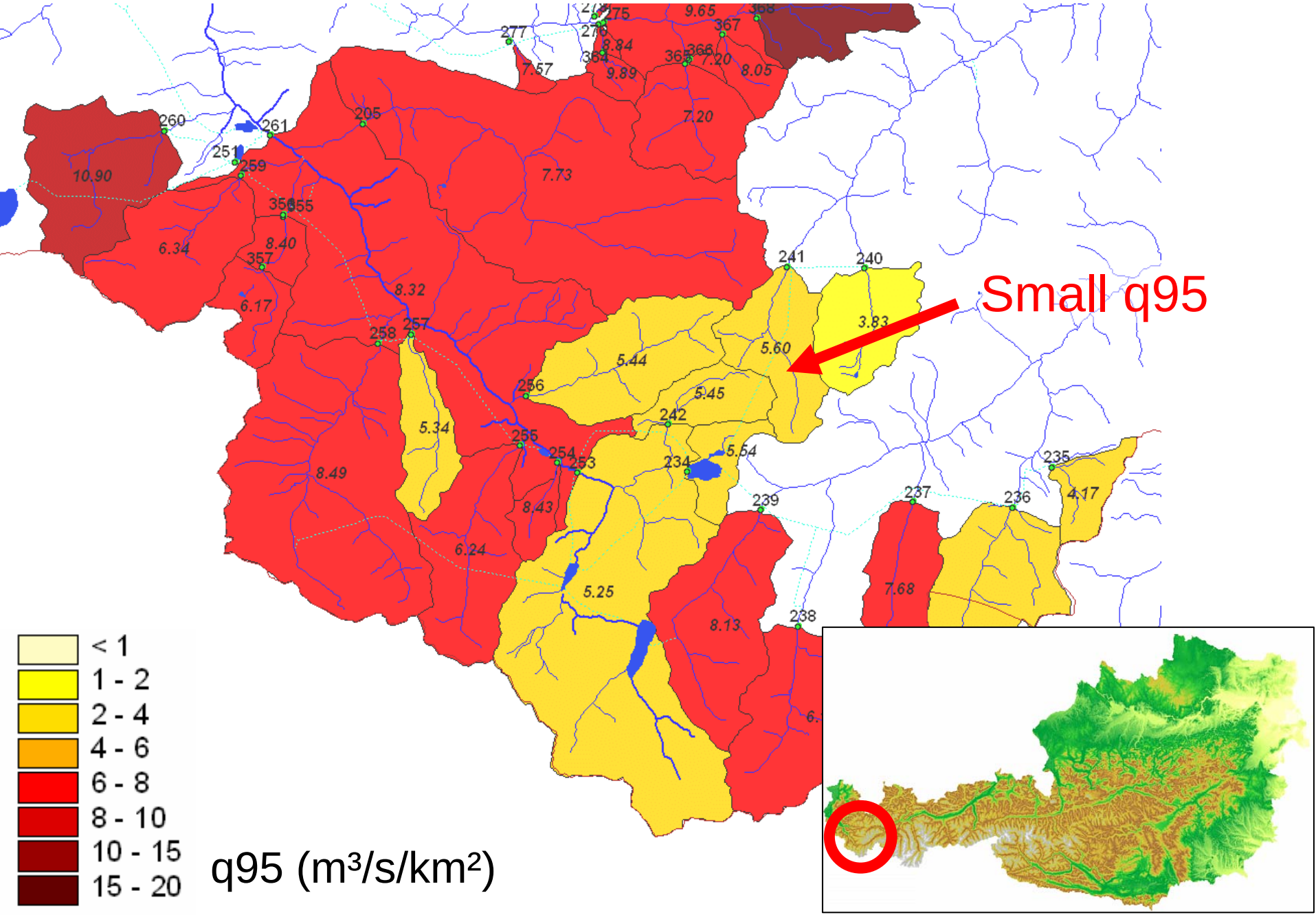
# Low flow processes

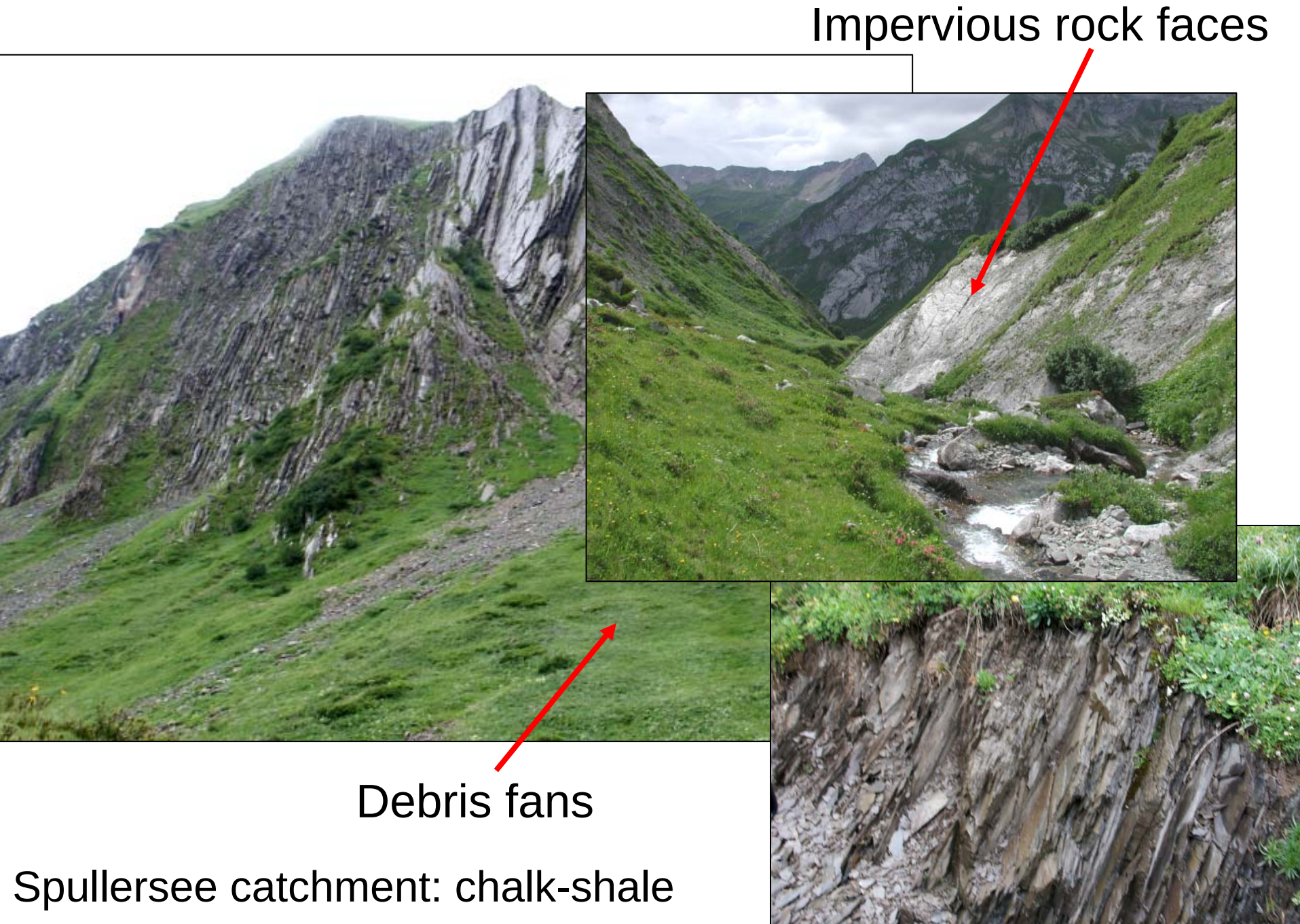



**Examples: q95 (m³/s/km²)**

= daily discharge exceeded 95% of time

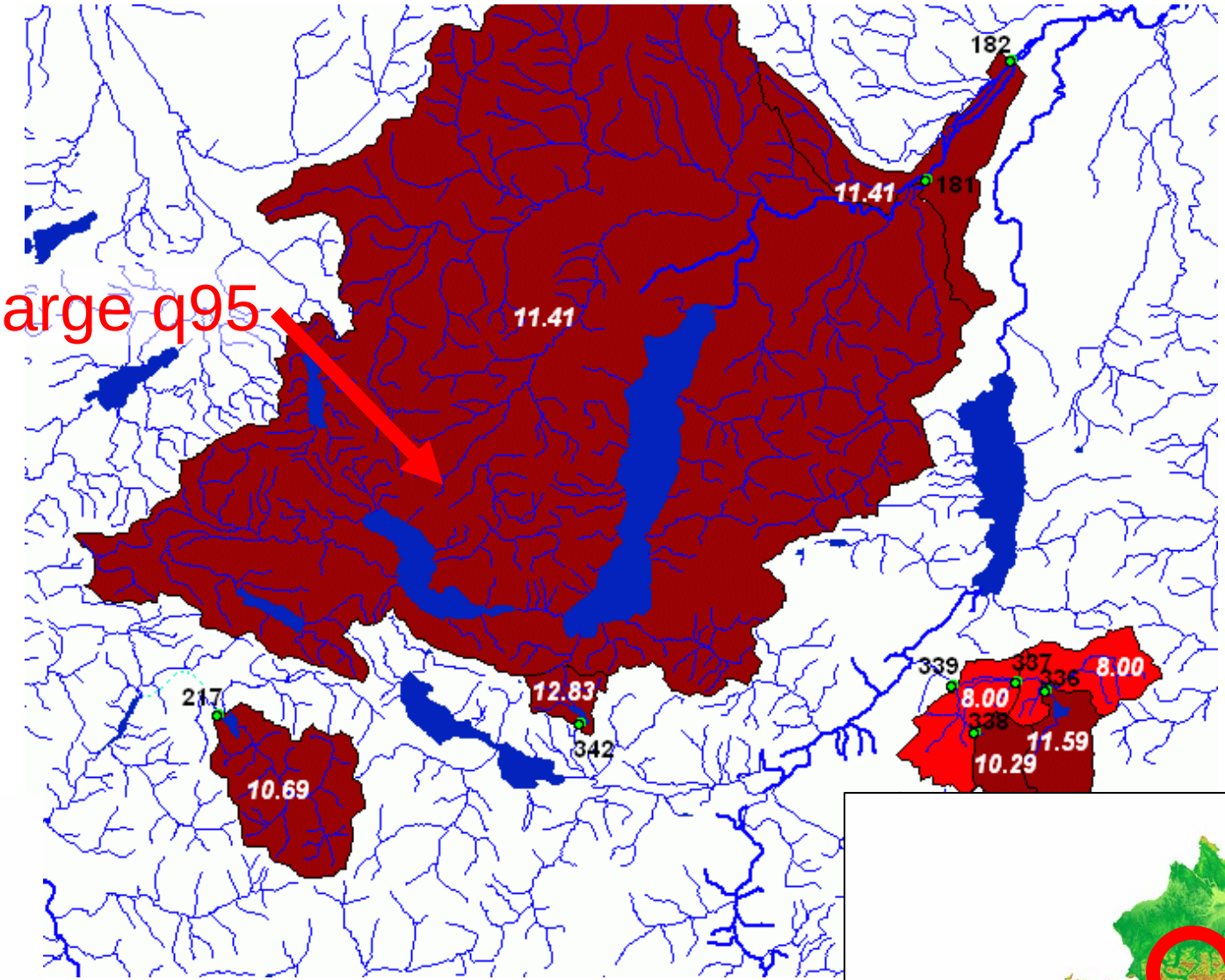
# High altitudes → Small low flows





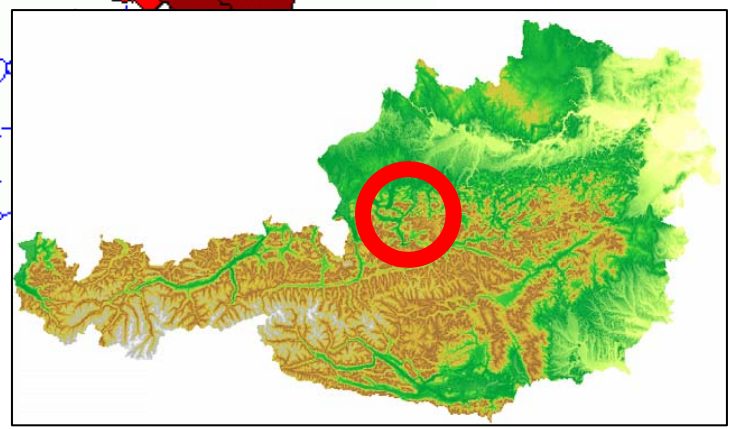

Spullersee catchment: chalk-shale

# High precipitation, lakes → Large low flows

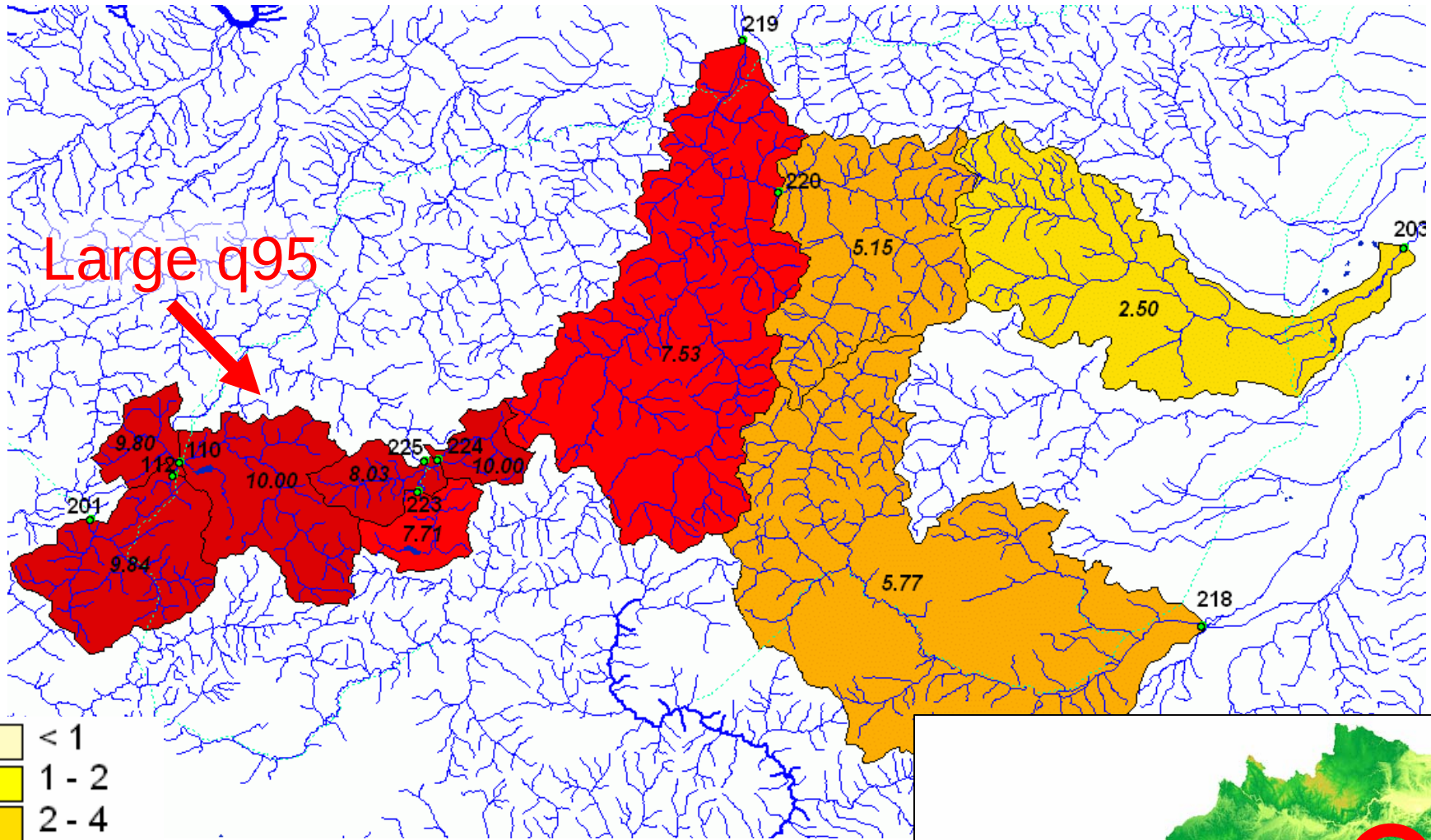



< 1
1 - 2
2 - 4
4 - 6
6 - 8
8 - 10
10 - 15
15 - 20

q95 ($m^3/s/km^2$)



# High precipitation → Large low flows

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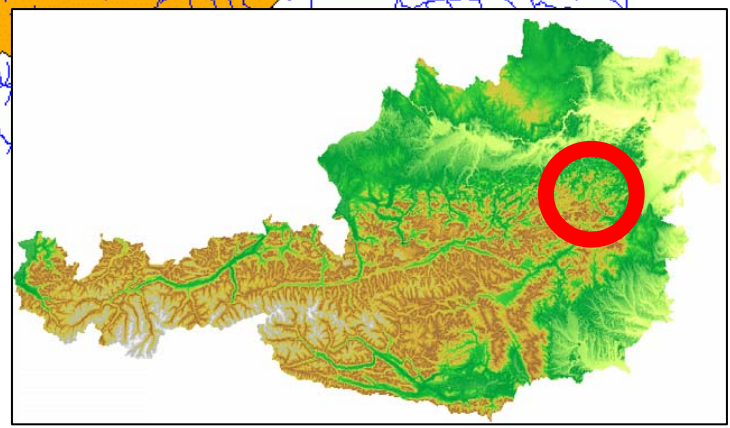
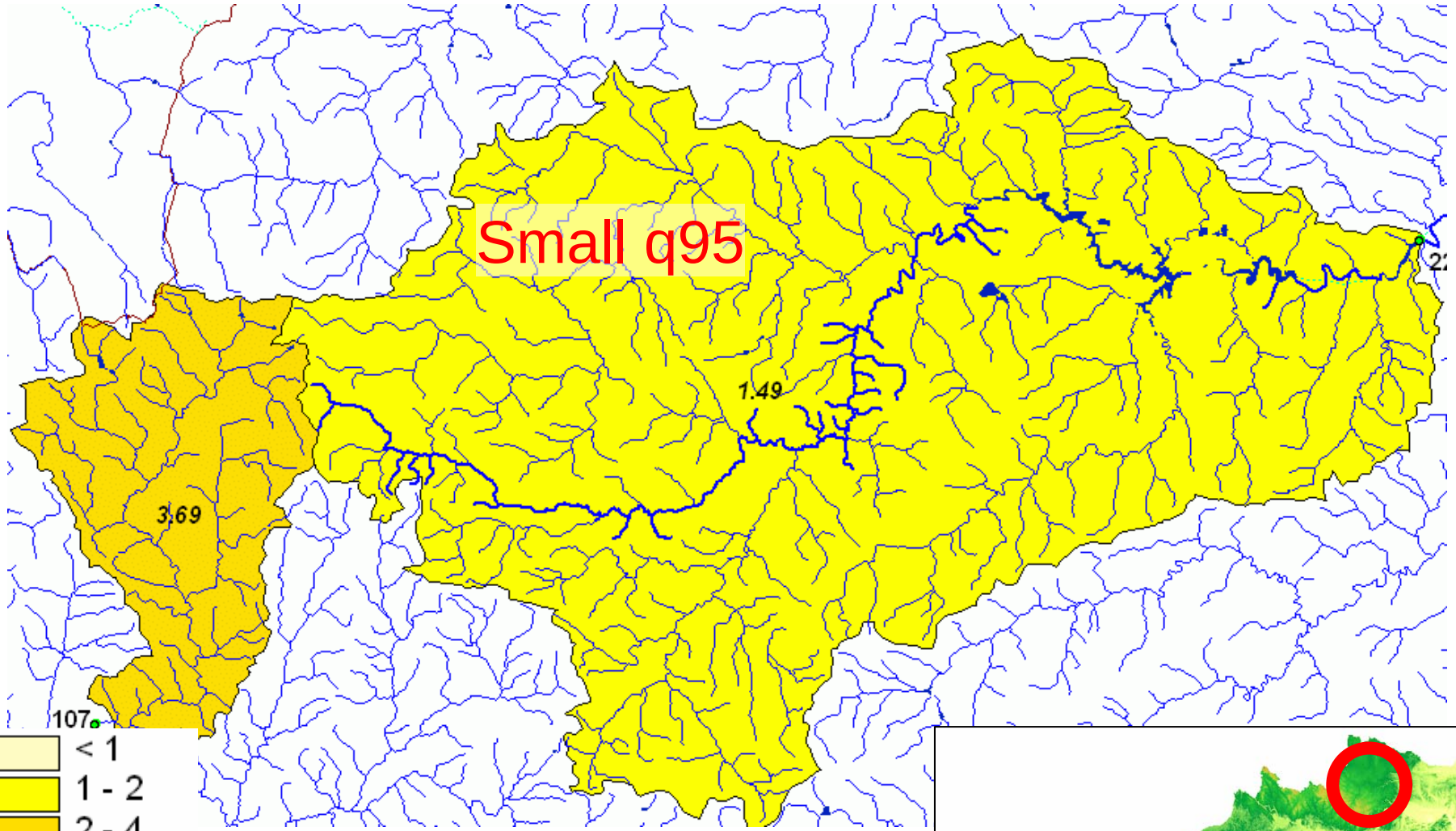
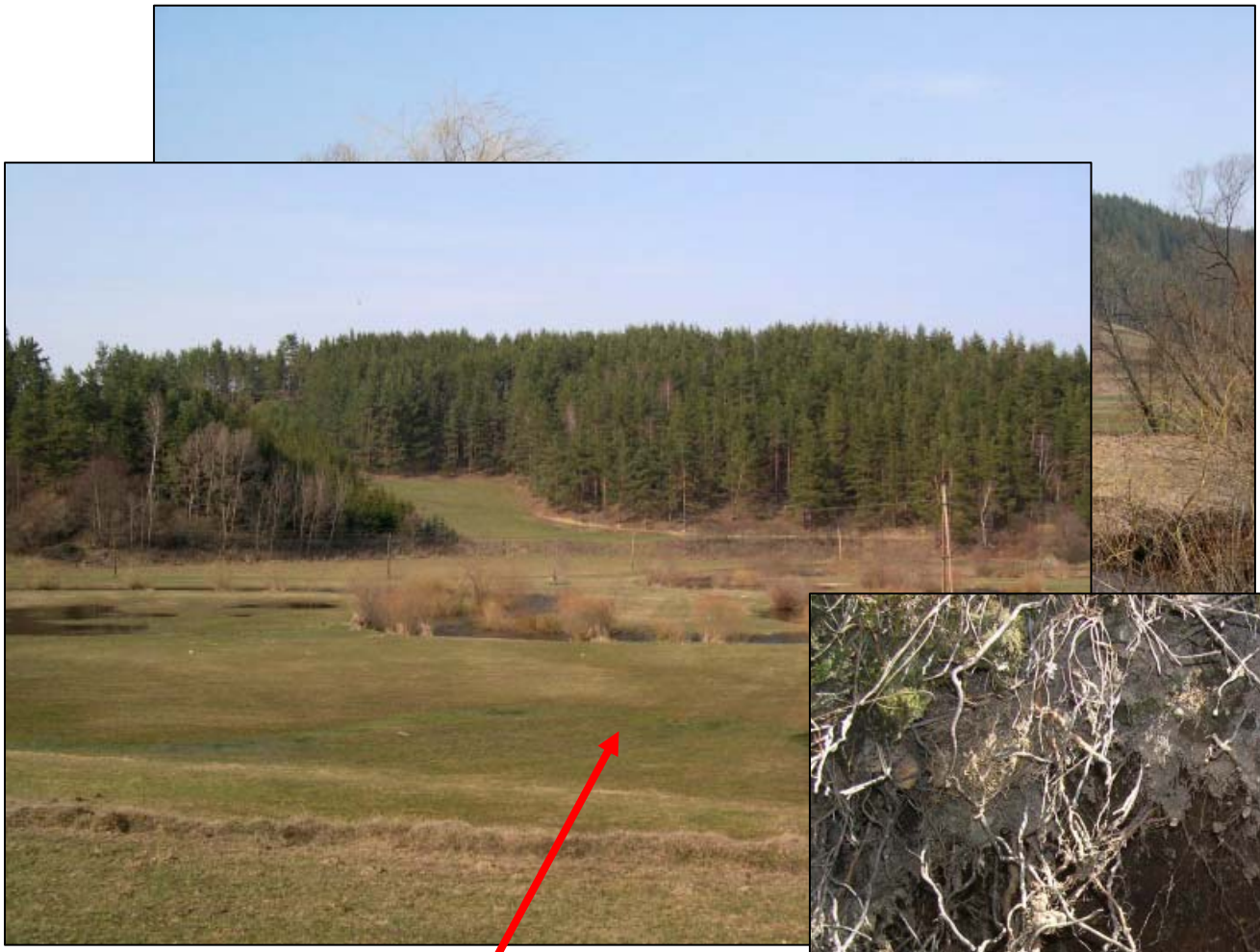
q95 ($m^3/s/km^2$)



# Permeable soils → Small low flows





Permeable soils

Saturation areas

Kamp catchment:
granite, gneiss

# Representing low flow processes at ungauged sites

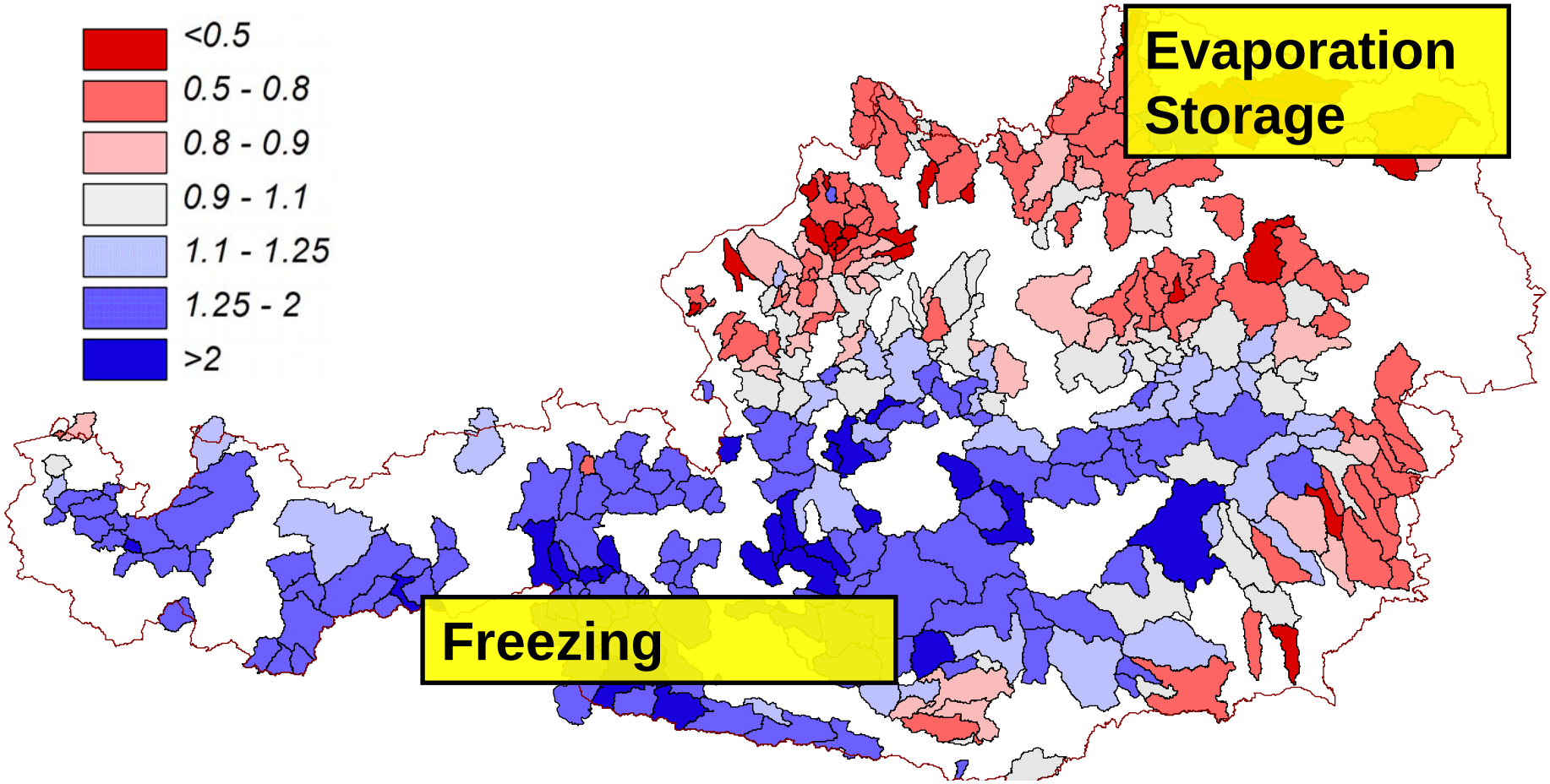
- Usually more than one process control important

  - Climate (precipitation, evaporation, snow processes)
  - Catchment (groundwater, soils)
  - Anthropogenic effects

- Single processes: Catchment attributes
- Combined processes: Seasonality
- Local effects: expert judgement/field survey

# Seasonality

To tag combined processes



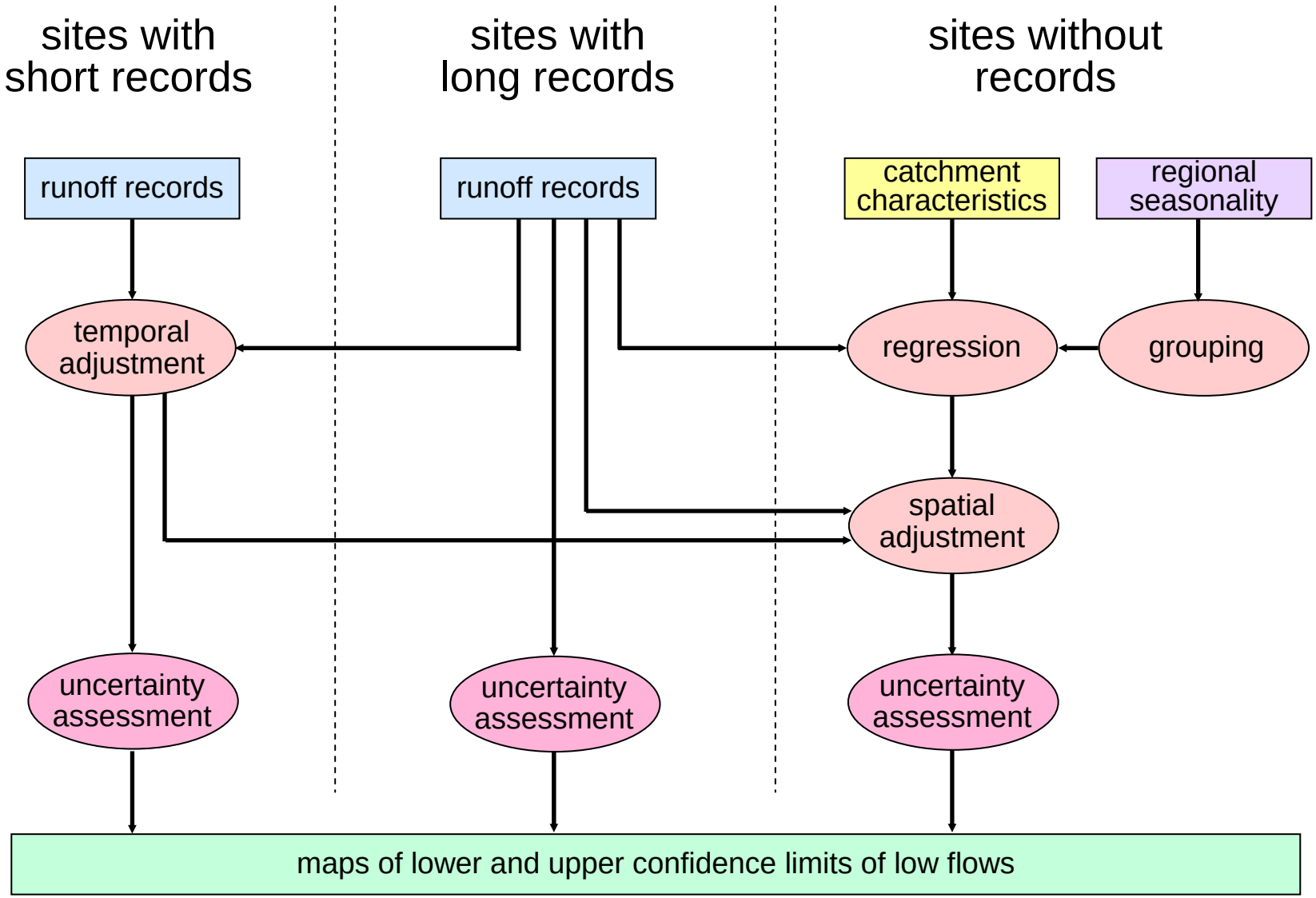

Ratio of Q95 summer and winter low flow

# Low flow estimation procedures

**Ideally …**

- Account for all relevant processes
  → catchment attributes; seasonality
- Use most accurate methods
  → comparison of methods by crossvalidation
- Exploit available data in best possible way
  → short and long runoff records
- Allow for local expert judgement
  → uncertainty bounds

# Estimation strategy

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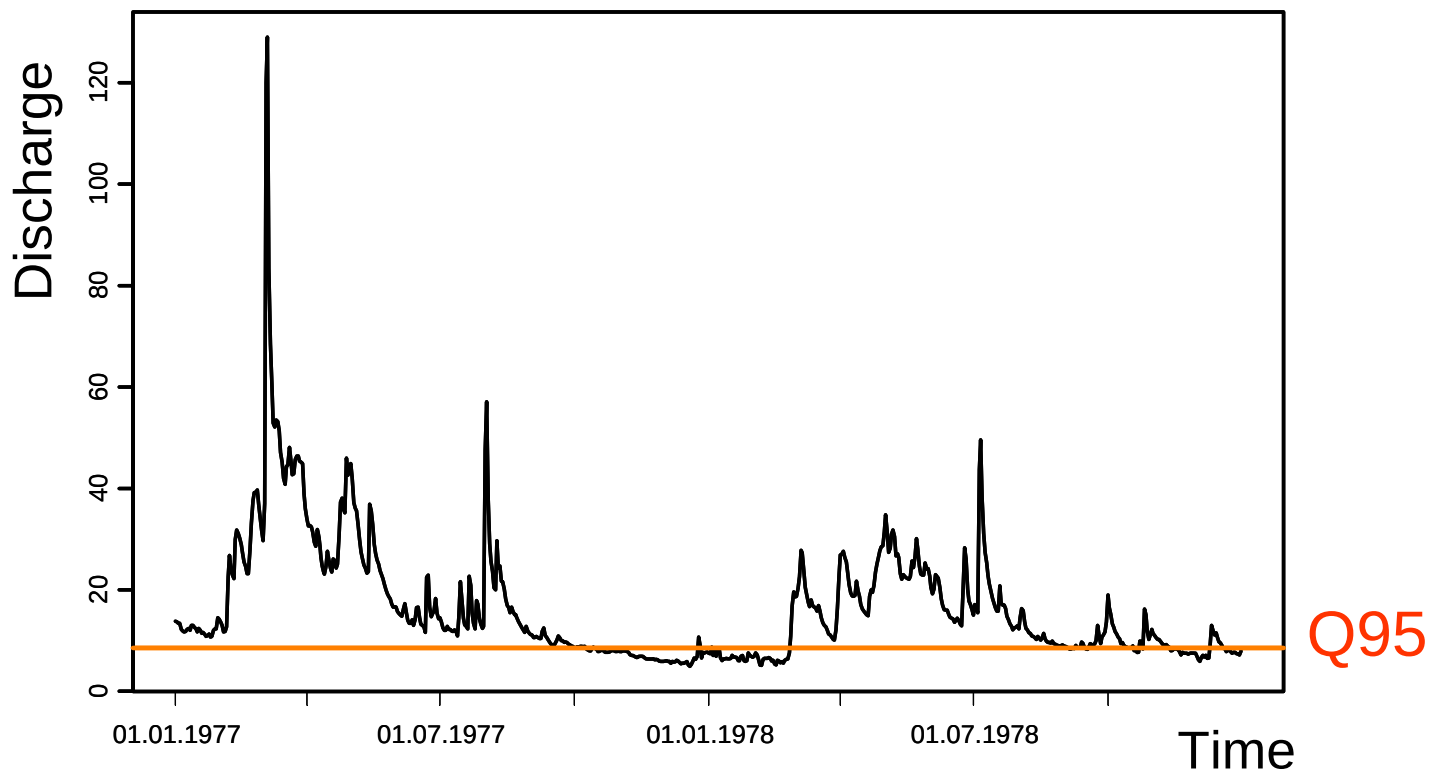
# Sites with long records

- Q95 from flow duration curve
- Straightforward but potential data problems



# Sites with short records

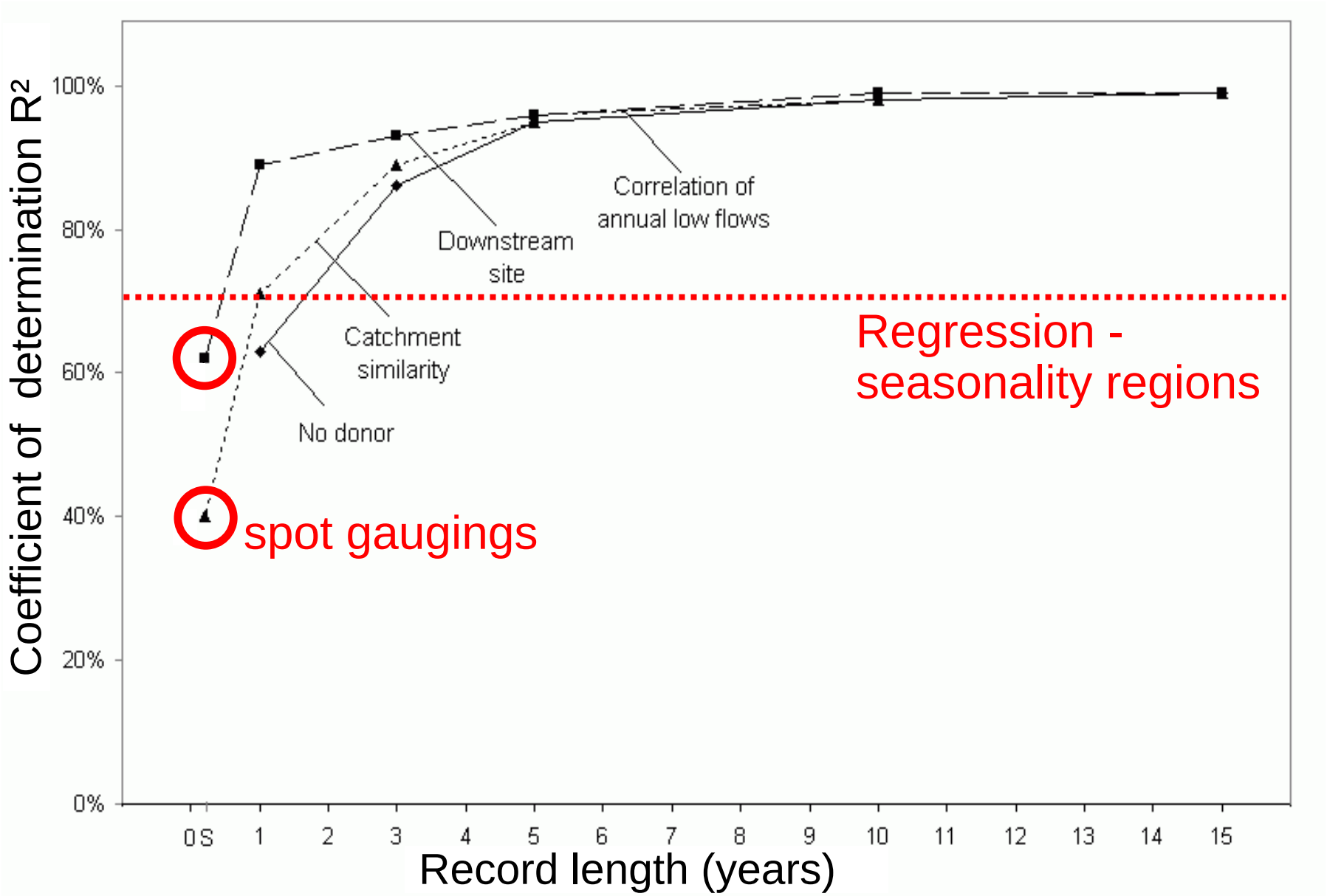
- Need to correct for
  climate fluctuations ↔ data window
  (i.e. temporal adjustment)
- What method for climate correction?

→ Comparison of four methods

- Pretending records are short
- Cross-validation

Laaha & Blöschl (2005) *J. Hydrol.*

# Performance of climate corrections



# Performance of climate corrections

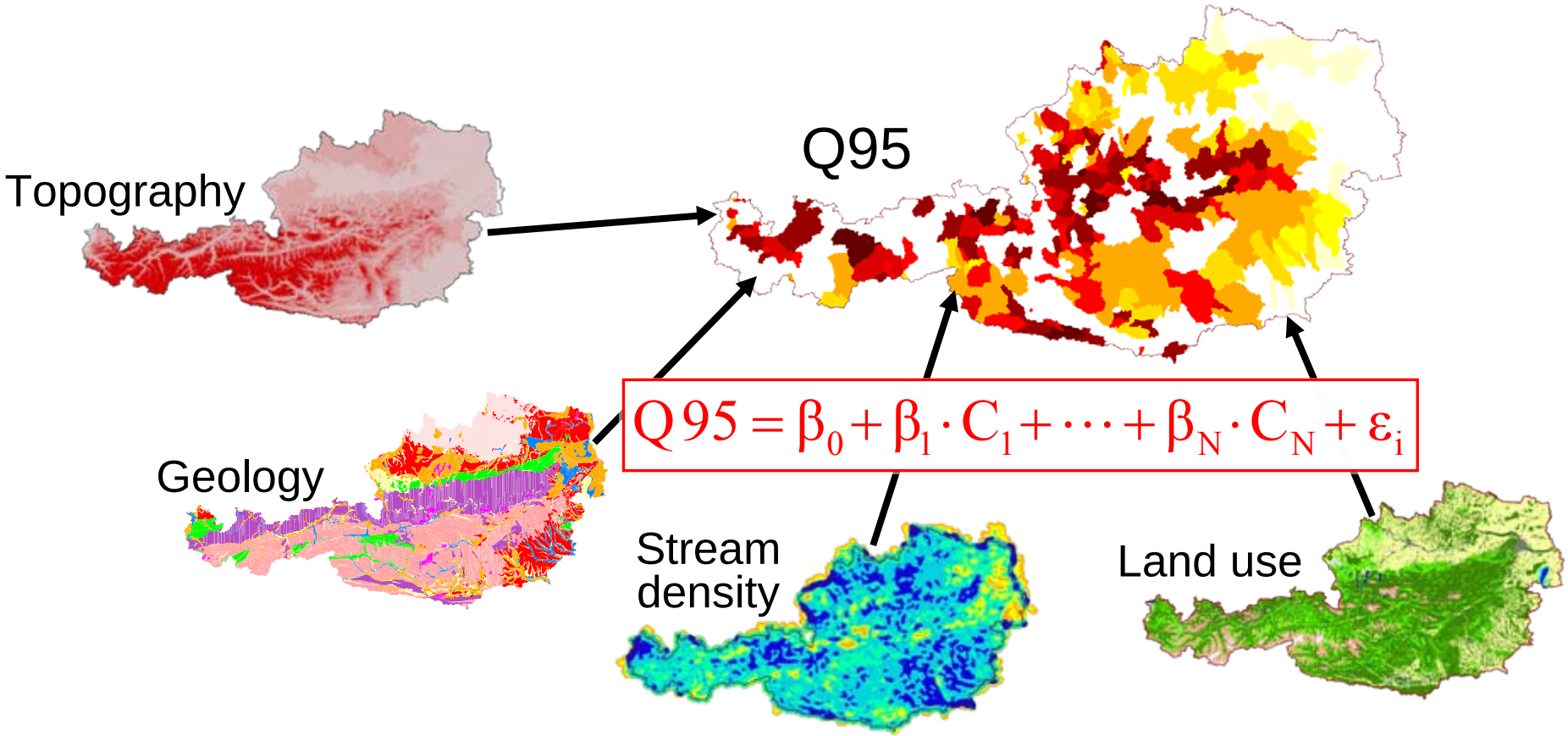
- Downstream-site method performs best
- One year of runoff data - better than regionalisation
- Spot gaugings - poorer than regionalisation

# Sites without records

- Regression between Q95 and catchment characteristics
- What catchment characteristics?
  → stepwise regression
- Collinearity → stepwise regression

- Separate regressions in homogeneous regions
  (catchment grouping)
- What catchment grouping?
  → Comparison of four methods

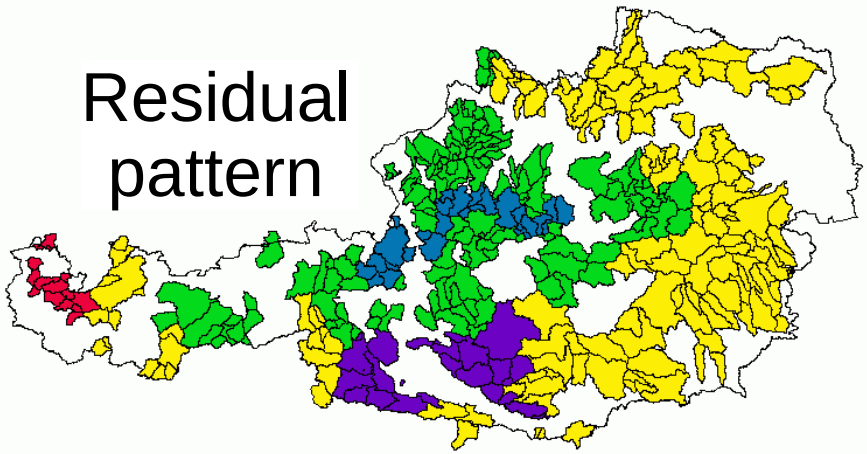
# Regional regression between Q95 and catchment characteristics *C*



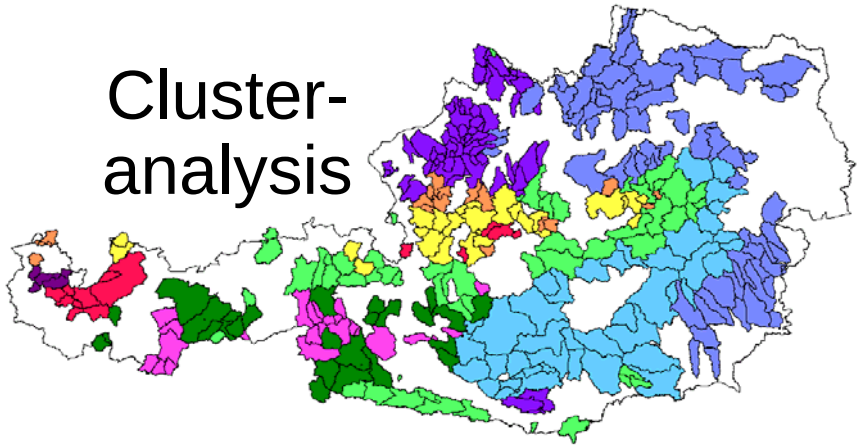
# What catchment grouping?

## Groupings

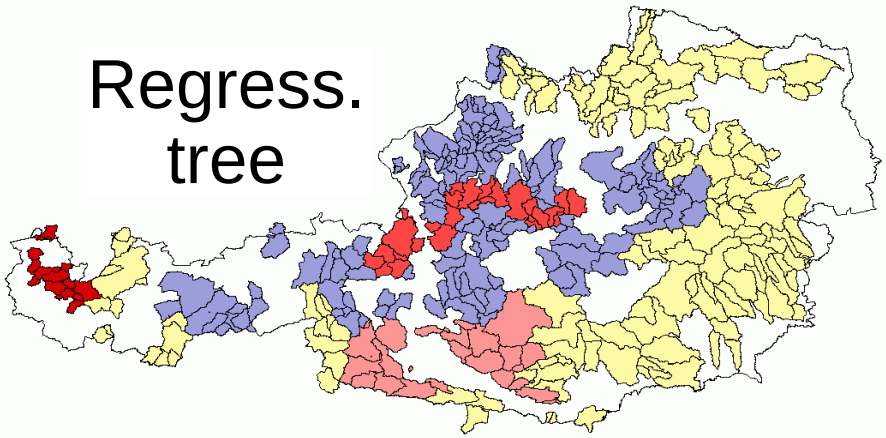
Residual pattern



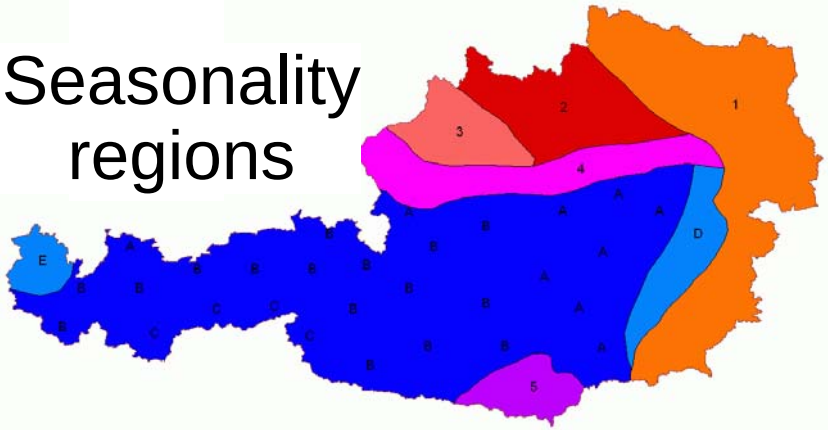
Cluster-analysis



Regress. tree



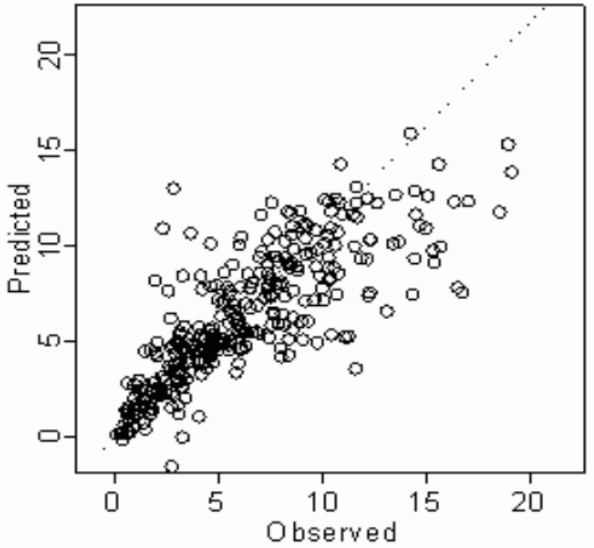
Seasonality regions

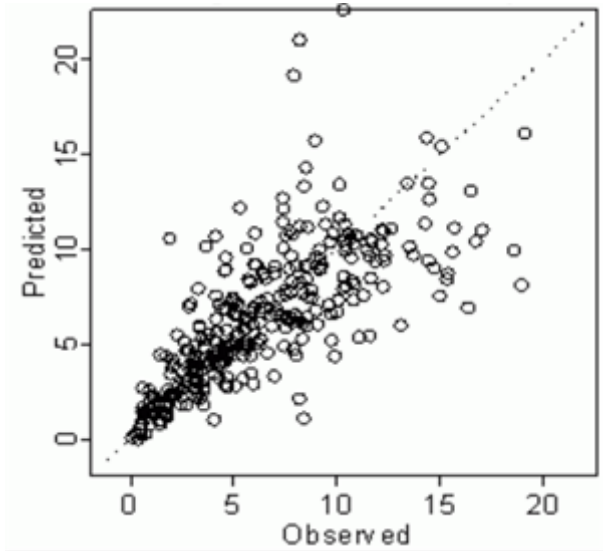


# What catchment grouping?

## Cross-validation of q95 (l/s/km²)

Residual pattern

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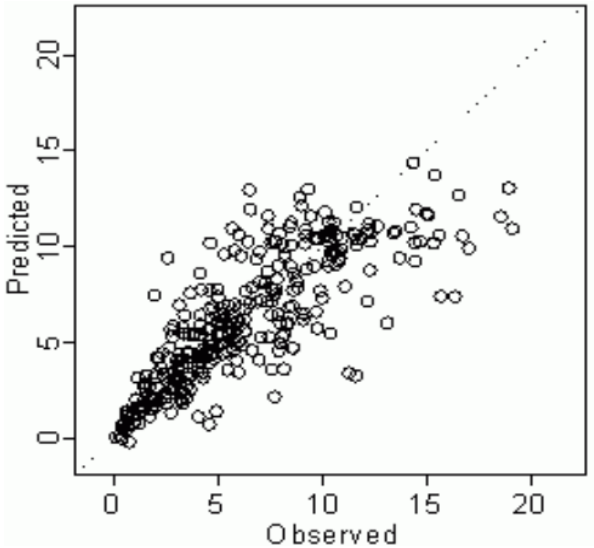
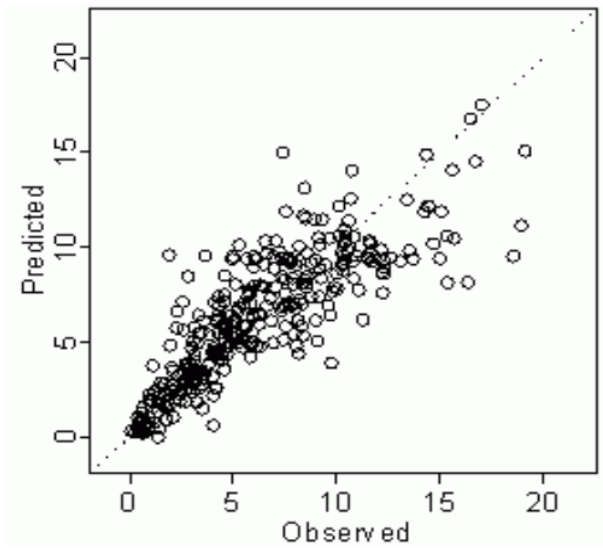



Seasonality regions

# What catchment grouping?

Cross-validation of q95

| **Classification** | $R^2_{cv}$ |
|---|---|
| No grouping | 57% |
| Residual patterns | 63% |
| Cluster analysis | 59% |
| Regression tree | 64% |
| Seasonality regions | 70% |

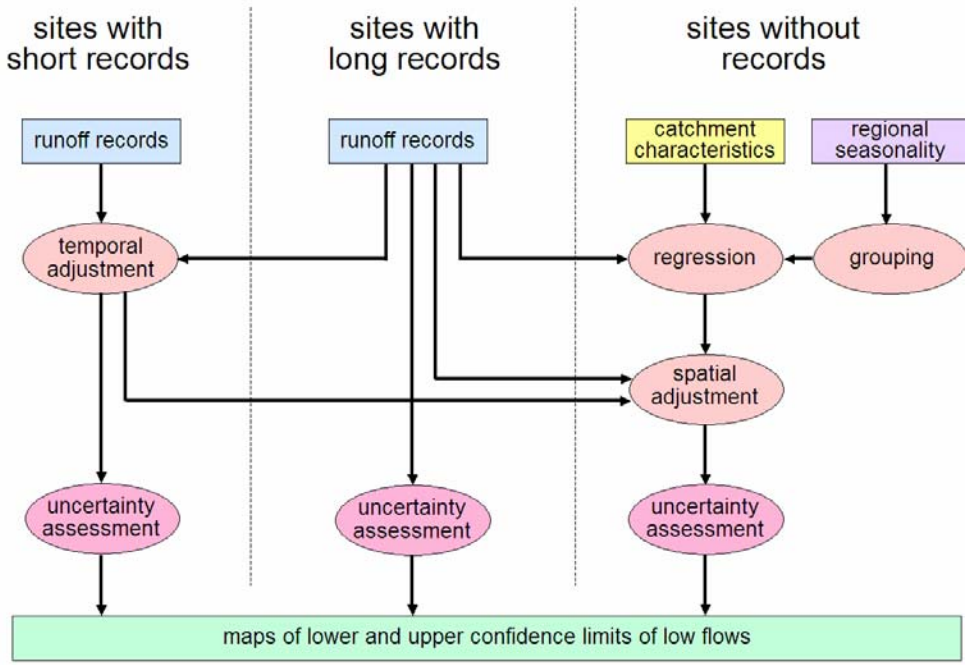
→ Seasonality regions perform best

Laaha & Blöschl (2006) *J. Hydrol.*

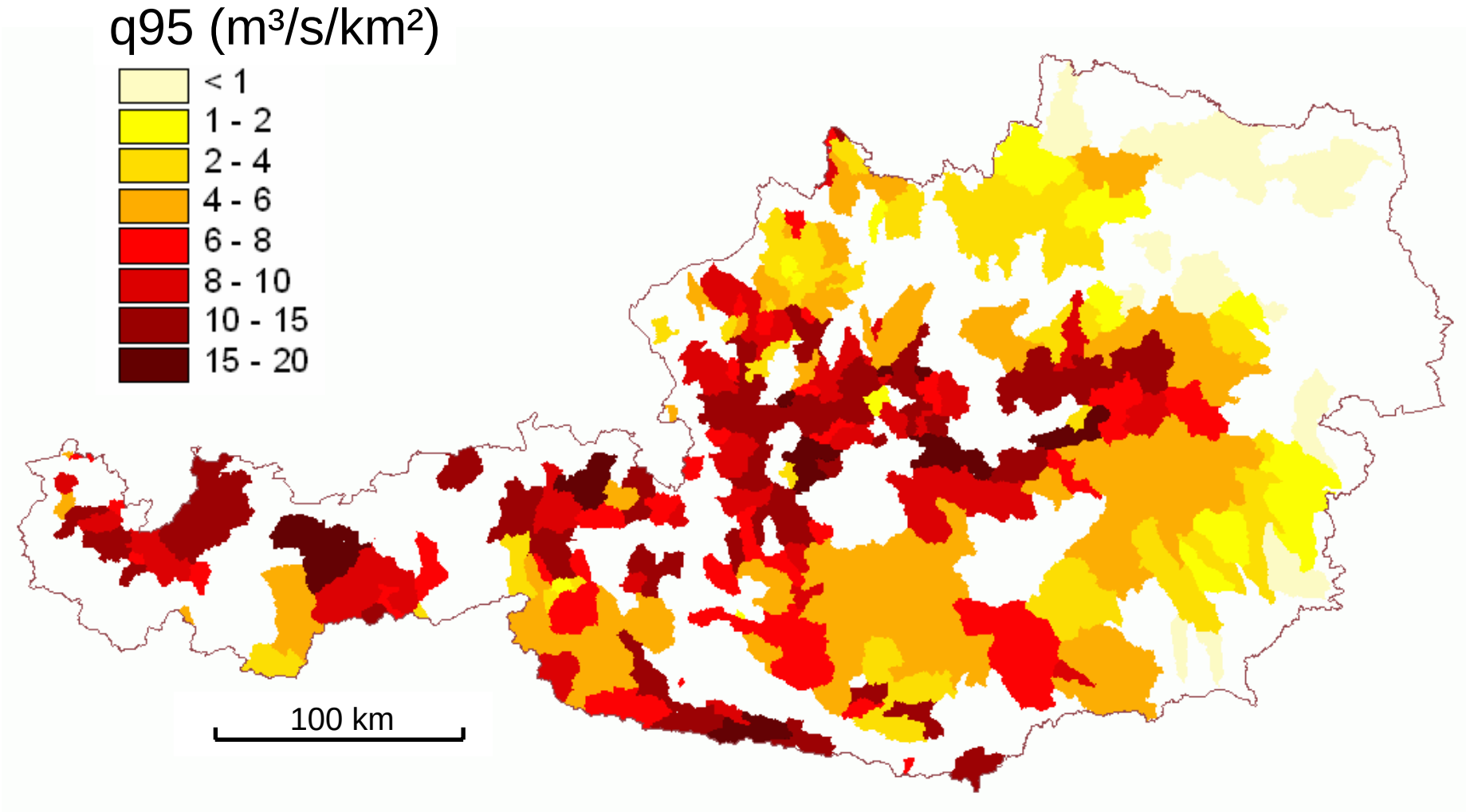
# Putting it all together

- Long records (325 catchments, 20 yrs)
- Short records (192 catchments, 5-19 yrs)
- No records (21000 catchments)

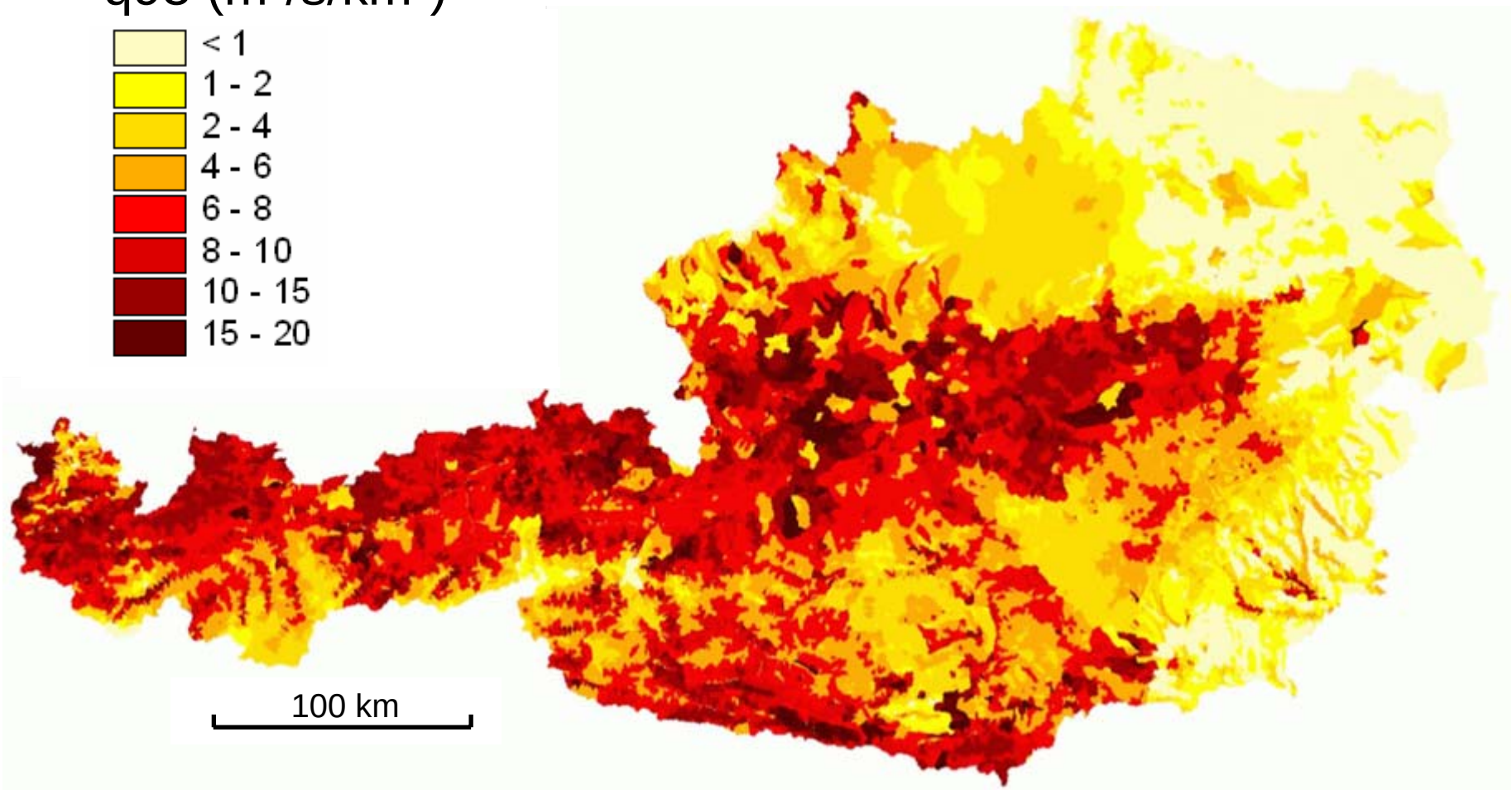
- Records with little anthropogenic effects
- Spatial adjustment



# Observed low flows q95



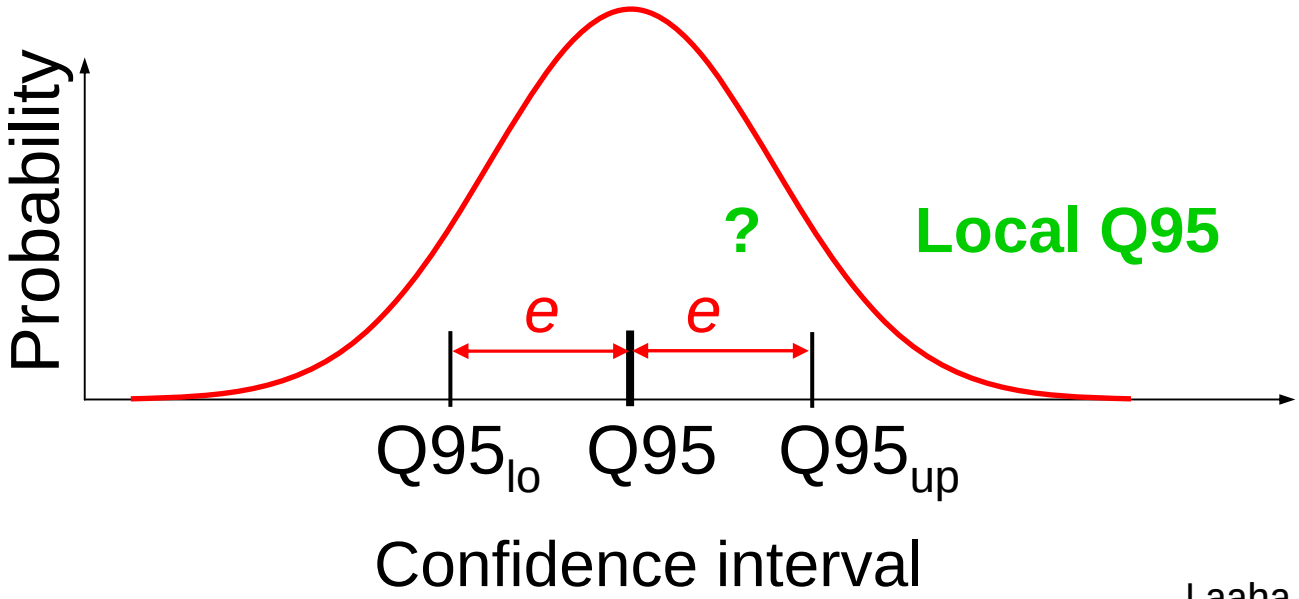
# Estimated low flows q95



# Uncertainty Assessment

- Regression model represents **regional trend**
- **Local effects** from expert judgement/field survey

- Data and model uncertainty:
- Error propagation to combine error sources
- *e* = f(record length, data errors, regression error)

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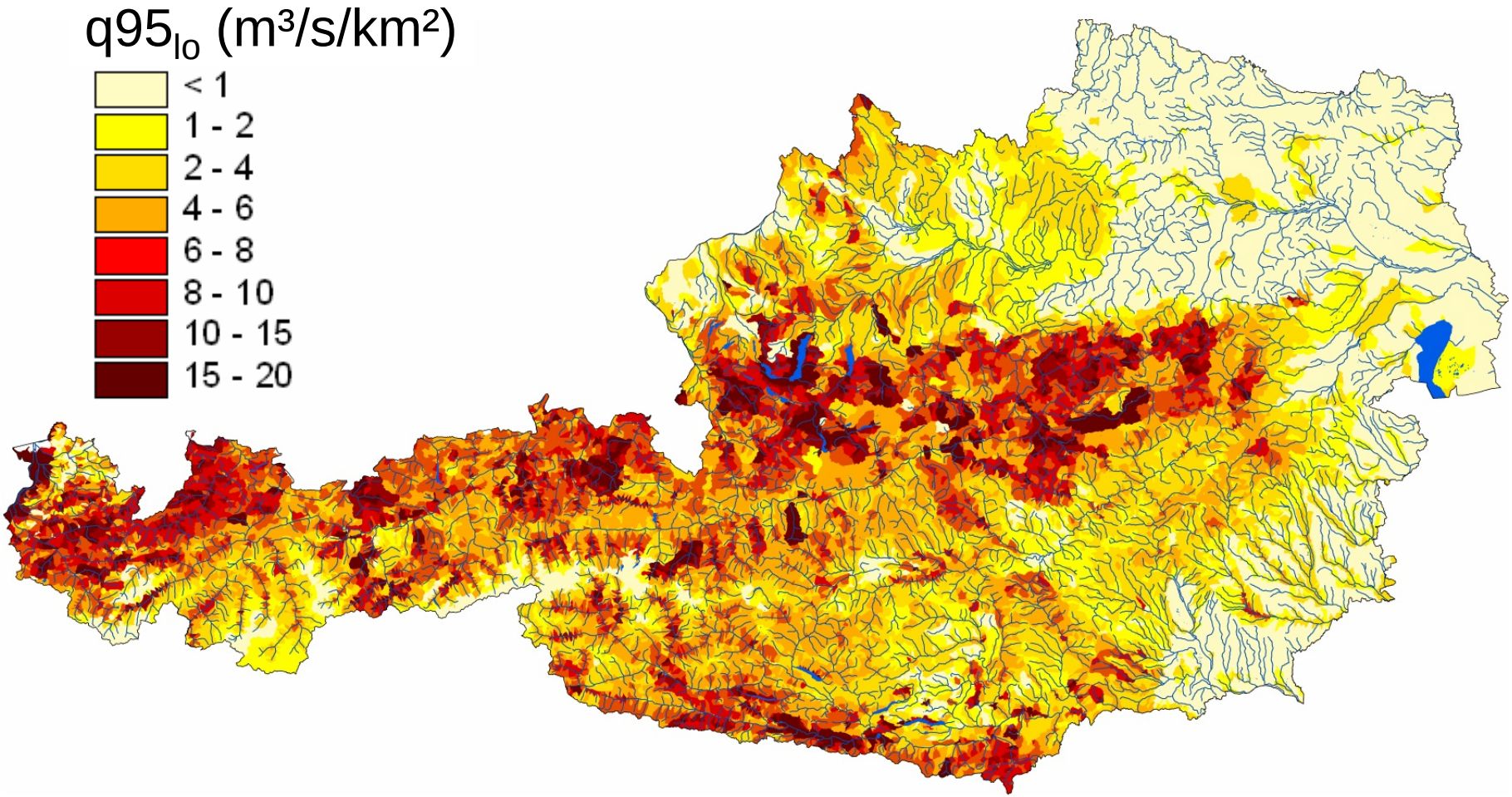
# Lower Confidence limit

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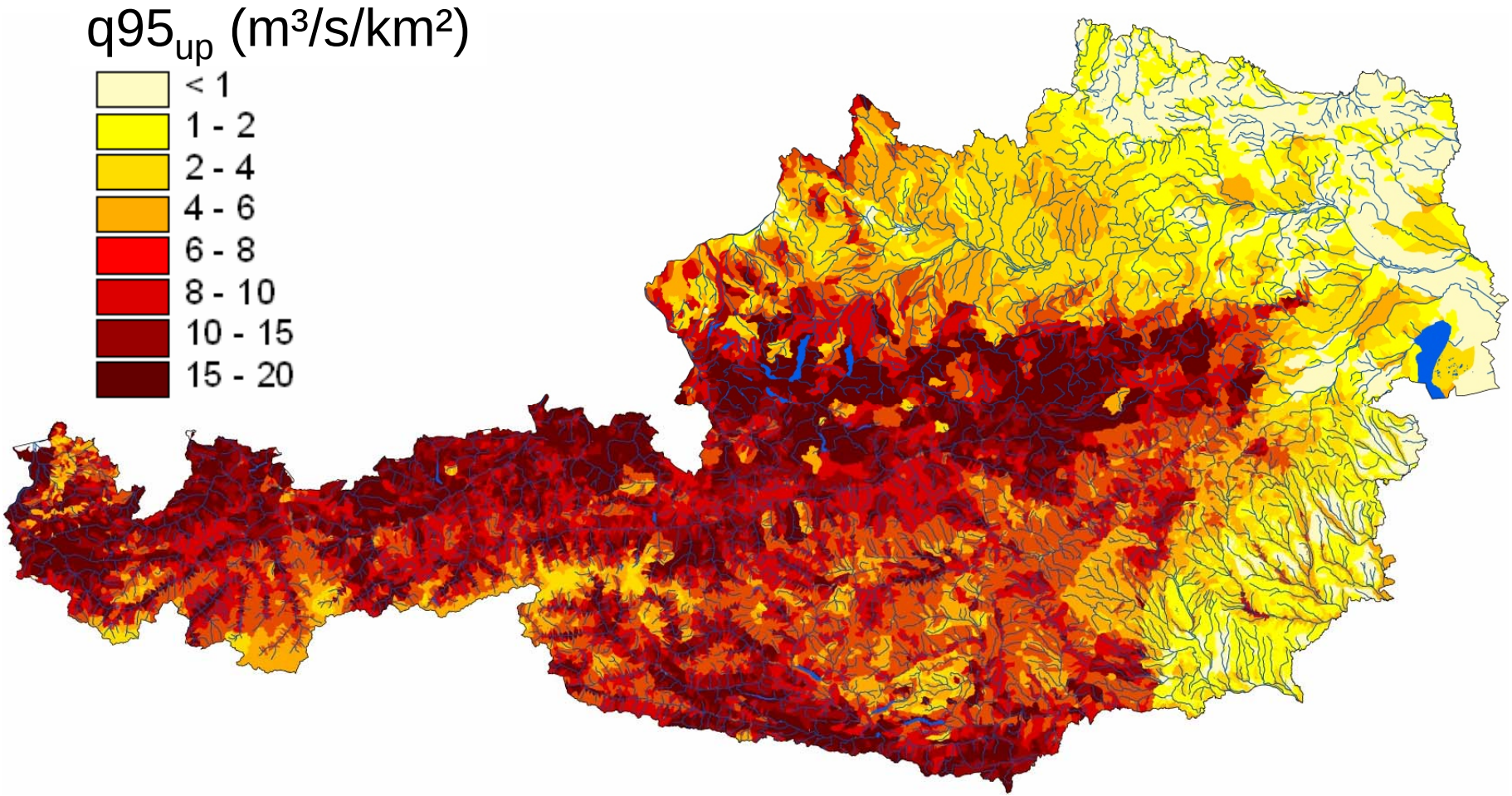
# Upper Confidence limit

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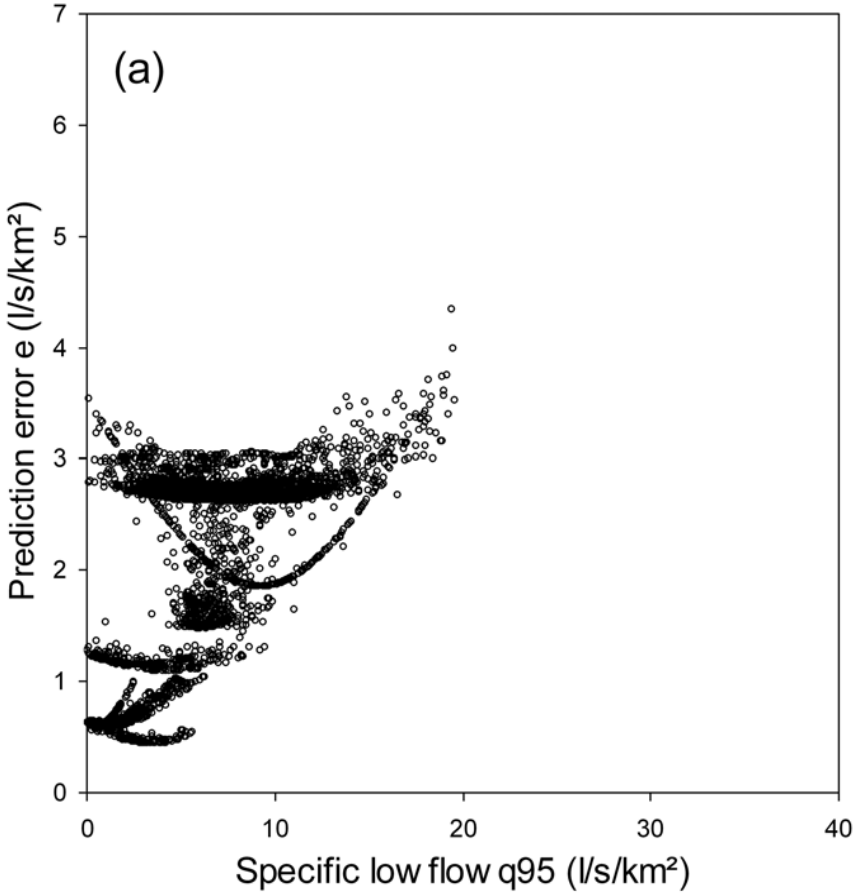
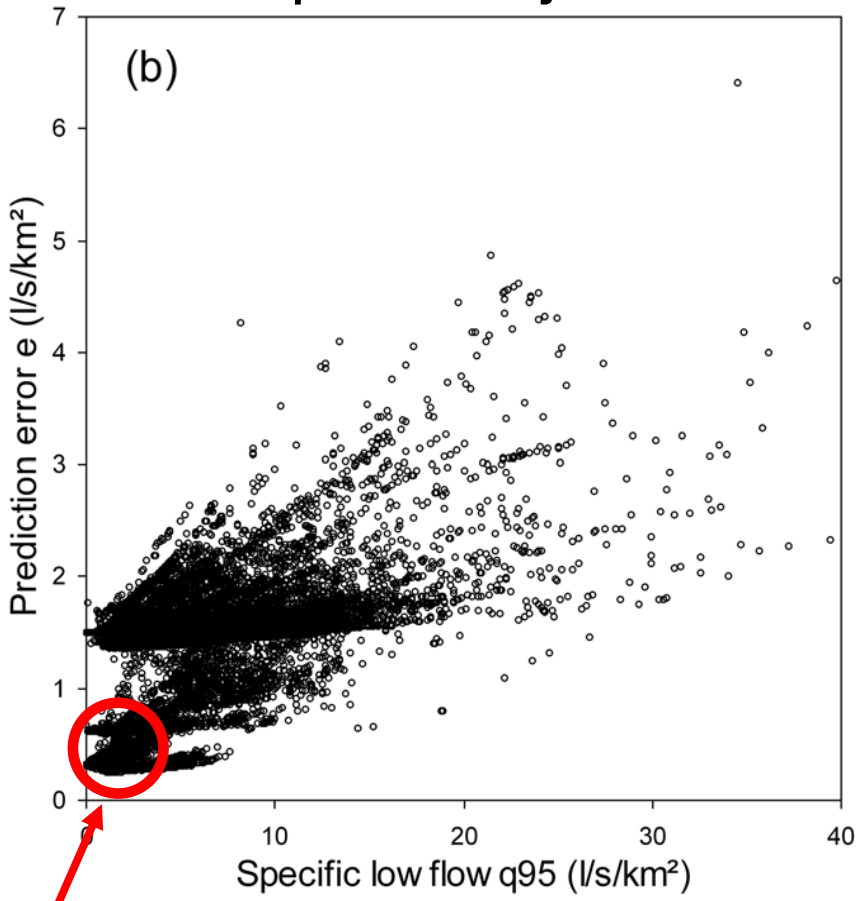
# Estimation errors

without spatial adjustment

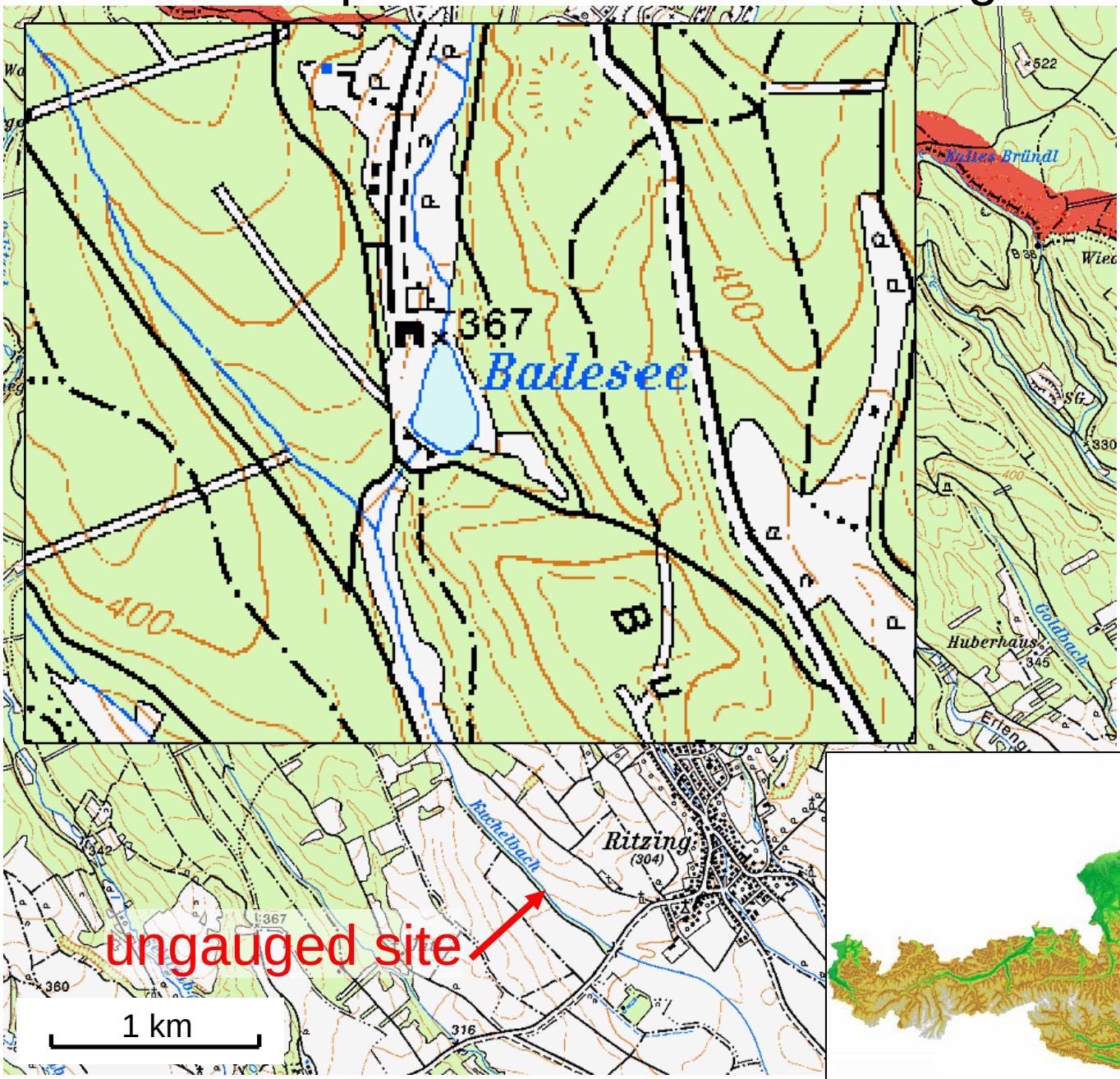



with spatial adjustment




Kuchelbach

# Example: Kuchelbach at Ritzing



# Example: Kuchelbach at Ritzing

Catchment area: 10 km²

**Regional** estimate (from regression)´:

$Q95_{lo}$ = 0.35 l/s
Q95 = 4.3 l/s
$Q95_{up}$ = 8.7 l/s

} uncertainty

**Local process**: evaporation from small lake

→ reduce Q95 from regional estimate: **3 l/s**

Prior estimate of hydrographic service: 5 l/s

Other local processes: abstractions, transfers, …

# Conclusions

- Tag processes
  → catchment attributes and seasonality
- Use most accurate methods
  → comparison of methods by crossvalidation
- Exploit available data in best possible way
  → short and long runoff records
- Uncertainty estimation
  → error propagation
- Account for local effects (natural and anthropogenic)
  → combine expert judgement & uncertainty bounds

# IAHS Initiative on

# **P**redictions in **U**ngauged **B**asins (PUB)

Theme of Third biennium: Taking stock & looking ahead

→ **Benchmark report**

Encourage you to get involved in working groups and benchmark report: see http://www.pub.iwmi.org

Contact: bloeschl@hydro.tuwien.ac.at