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Danube Transnational Programme
DanubeSediment

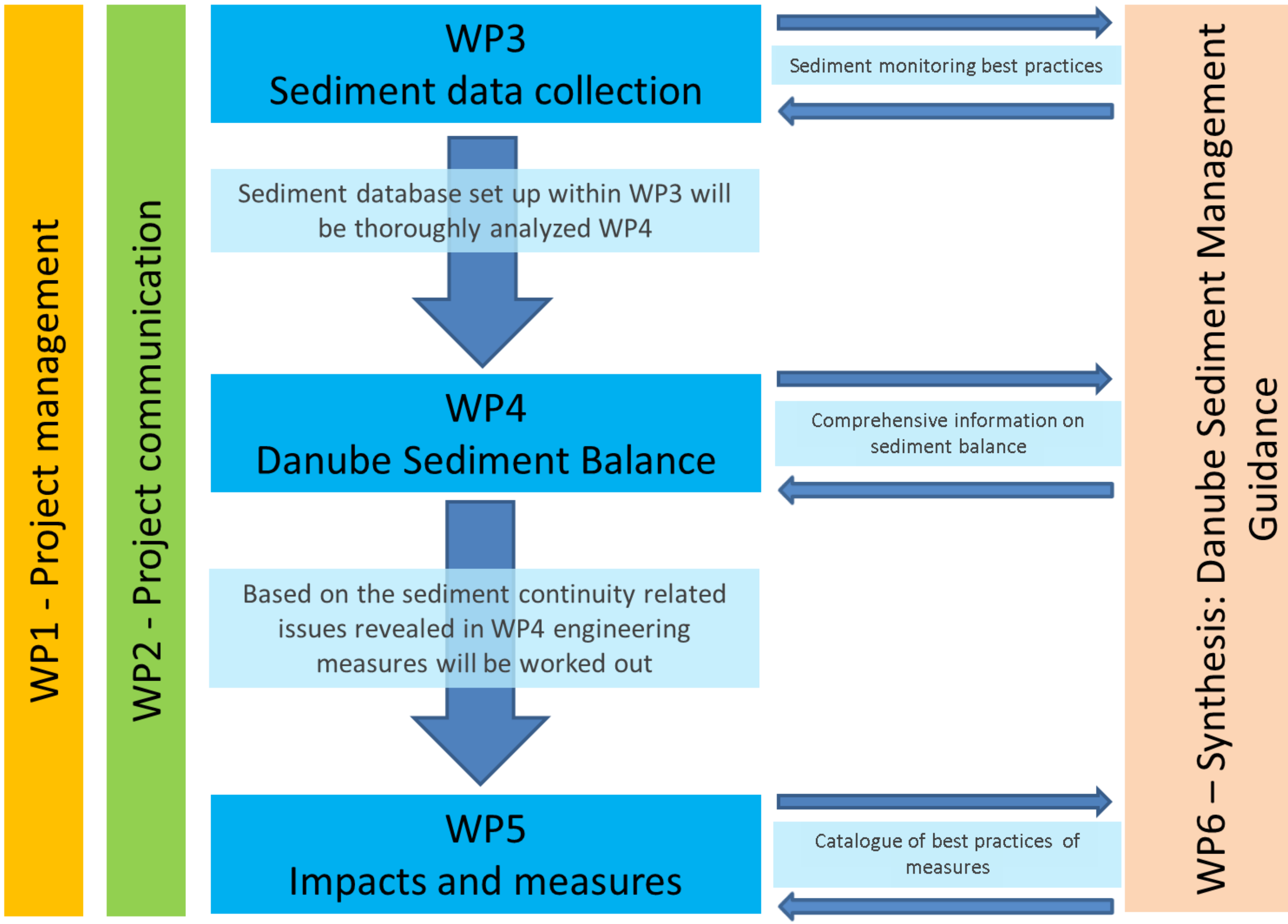
Sediment sampling in large rivers
DanubeSediment project

Introduction of applied sediment monitoring methods along the Danube

Barbara Kéri and Sándor Baranya, BME

Vienna, 10.04.2019

Project methodology



WP3: Sediment Data Collection

Objectives

- Reveal all available sediment data for the Danube and the major selected tributaries at the confluence
- Permanent interaction with the data owner stakeholders (water directorates, private companies, Project Partners)
- Limited sediment transport monitoring at short reaches with significant data gaps
- Comparative analysis and intercalibration of different sediment monitoring techniques
- Recommendations for the good practices of sediment monitoring techniques
- Training of sediment experts on an international workshop

Transport modes of sediments in rivers

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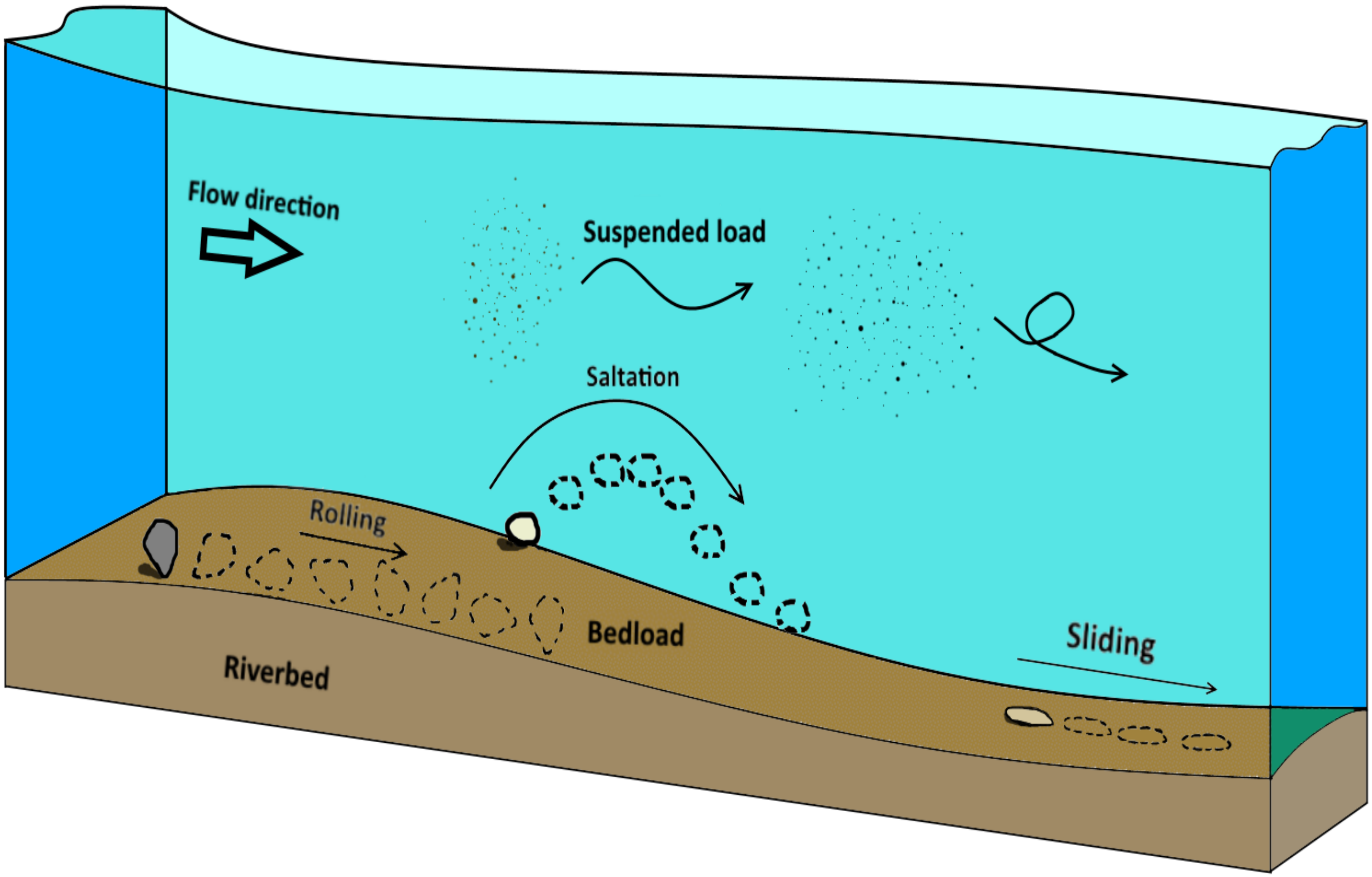

Sediment monitoring system along the Danube and at the most important tributaries

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Collection of metadata

- Web based questionnaire

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DanubeSediment: Sediment monitoring spreadsheet

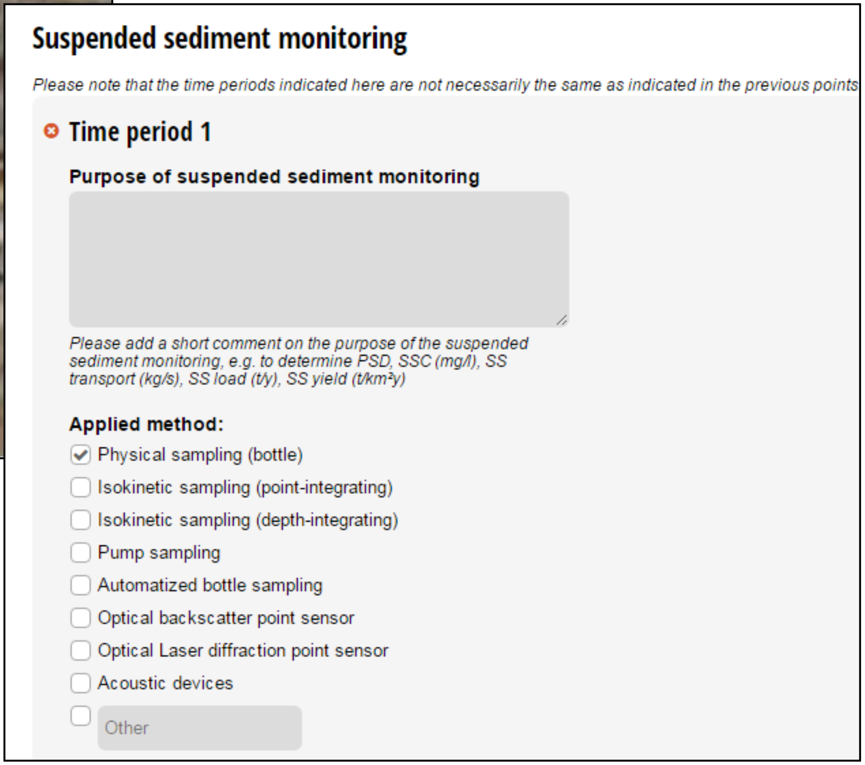
This spreadsheet provides relevant information about the sediment monitoring methods applied by the Danube countries in the Danube River and at the most significant tributaries (at the stations closest to the confluence). One questionnaire is to be filled in for each monitoring station.

Name of user:

Organization:

email address:

1. Basic information of the monitoring station



Suspended sediment monitoring

Please note that the time periods indicated here are not necessarily the same as indicated in the previous points

Time period 1

Purpose of suspended sediment monitoring

Please add a short comment on the purpose of the suspended sediment monitoring, e.g. to determine PSD, SSC (mg/l), SS transport (kg/s), SS load (t/y), SS yield (t/km²y)

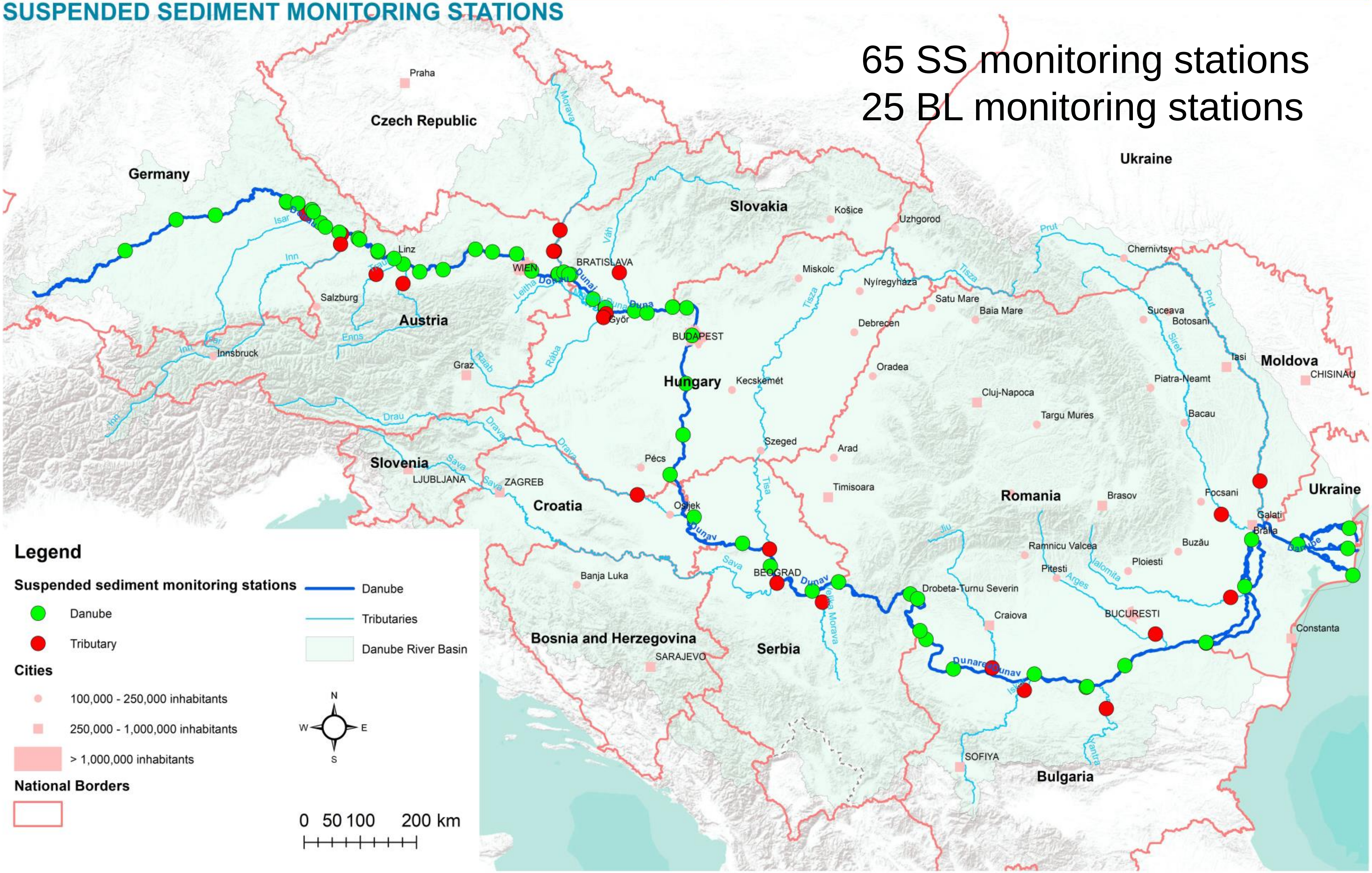
Applied method:

- [x] Physical sampling (bottle)
- [ ] Isokinetic sampling (point-integrating)
- [ ] Isokinetic sampling (depth-integrating)
- [ ] Pump sampling
- [ ] Automatized bottle sampling
- [ ] Optical backscatter point sensor
- [ ] Optical Laser diffraction point sensor
- [ ] Acoustic devices
- [ ] Other

Suspended sediment monitoring stations along the Danube and at the most important tributaries (closest to the confluence)

Map 1

65 SS monitoring stations
25 BL monitoring stations



http://www.interreg-danube.eu/approved-projects/danubesediment

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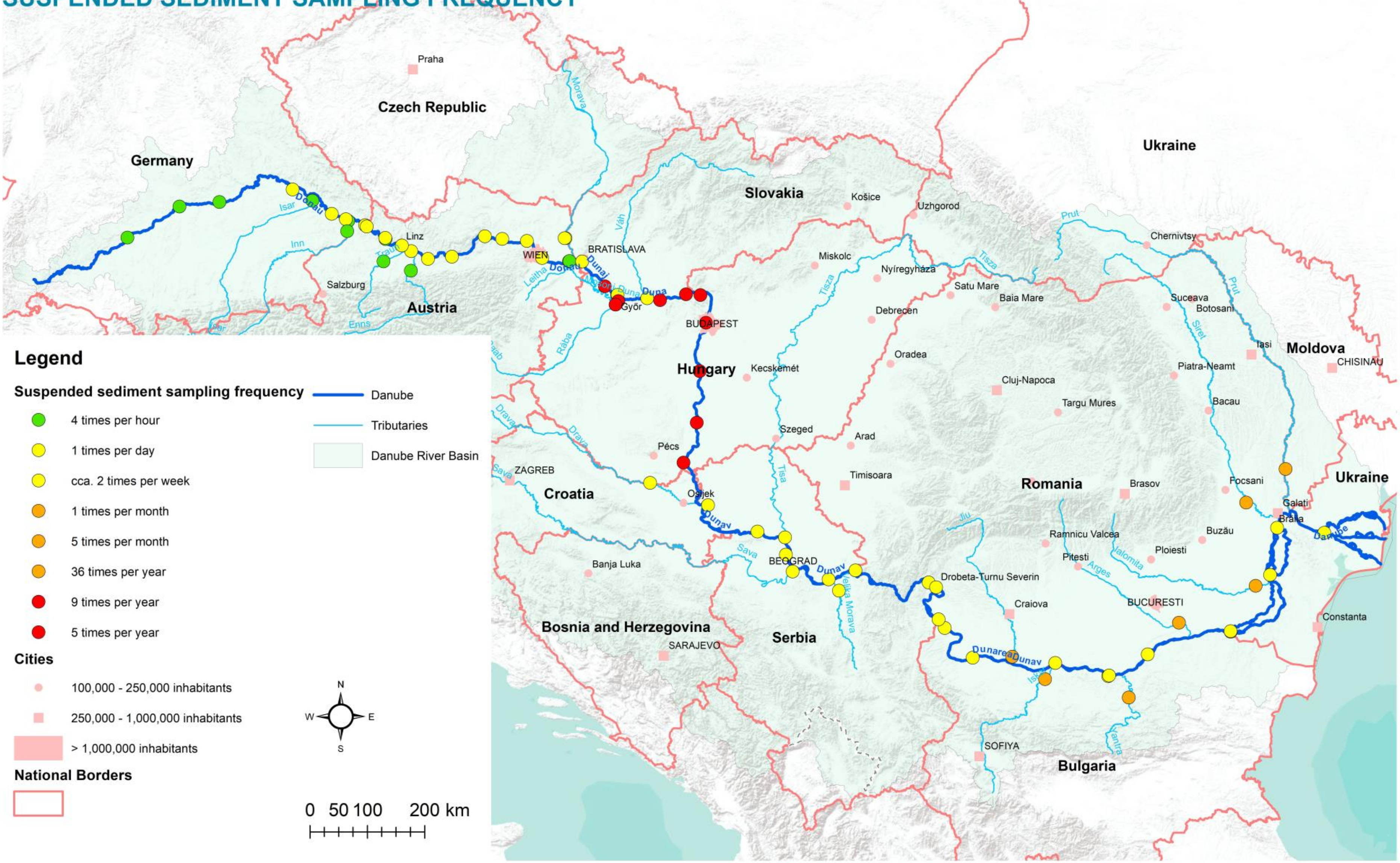
Suspended sediment monitoring stations along the Danube and at the most important tributaries (closest to the confluence)

Map 4

SUSPENDED SEDIMENT SAMPLING FREQUENCY



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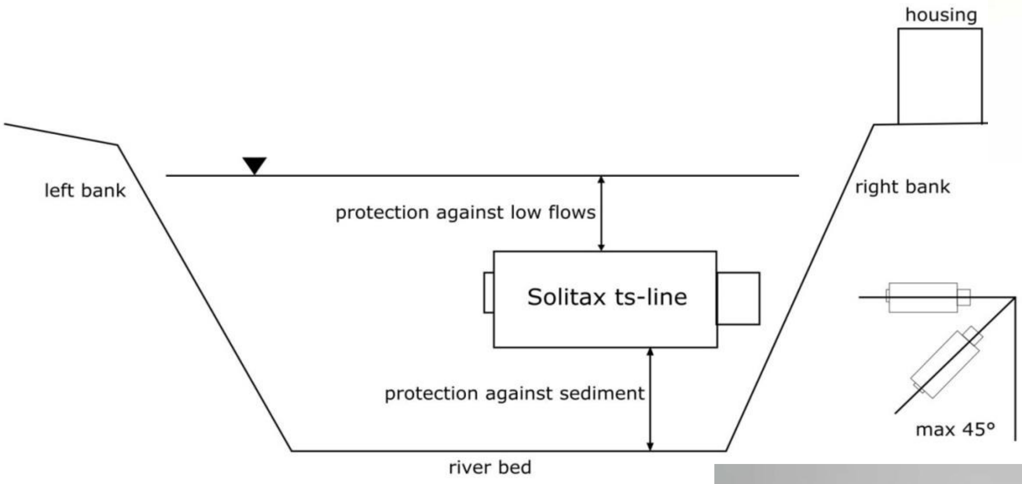
Suspended sediment monitoring in Germany

- Responsible institute: Bavarian Environment Agency (LfU), Bavarian Hydrological Service (GKD), Federal Waterways and Shipping Administration (WSV)
- Automatized monitoring using Optical Backscatter Sensors (OBS), physical sampling (bottle)
- Sampling frequency: 15 min
- Nr. of stations: 9 (2 trib.)

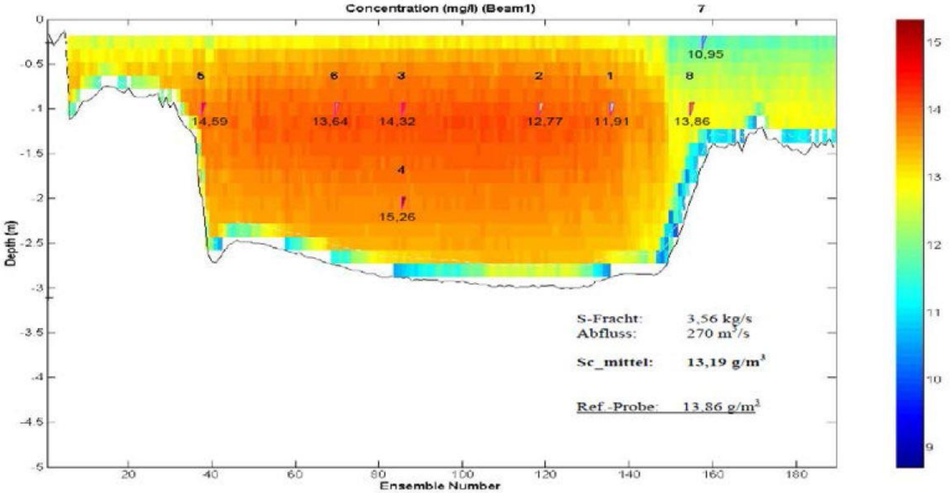


Solitax ts-line

Suspended sediment monitoring in Germany

- Calibration of OBS – point sampling at the sensor

- Multipoint sampling and
- Acoustic profiling:
  - StreamPro ADCP + ViSea
- SSC analysis method: filtering



Suspended sediment monitoring in Austria

- Responsible institute: ViaDonau, Verbund Hydro Power
- Automatized monitoring using Optical Backscatter Sensors (OBS), pump sampling, automatized bottle sampling
- Sampling frequency: 15 min
- Nr. of stations: 11 (4 trib.)

Suspended sediment monitoring in Austria

- Estimation of sediment load (Habersack et al., 2013):

Turbidity

↓

Concentration close to the sensor

↓

Mean concentration

↓

Suspended sediment transport

↓

Suspended sediment load

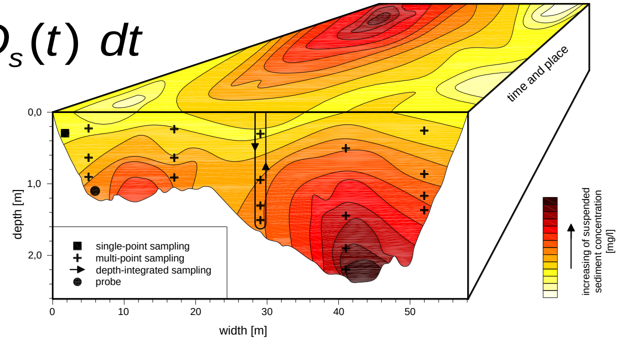
Probe characteristic $s_k = a\ s_s$

Probe factor $k_s = s_k / s_s$

Cross-sectional characteristic $s_m = a\ s_k$

Discharge $Q_s = s_m\ Q$

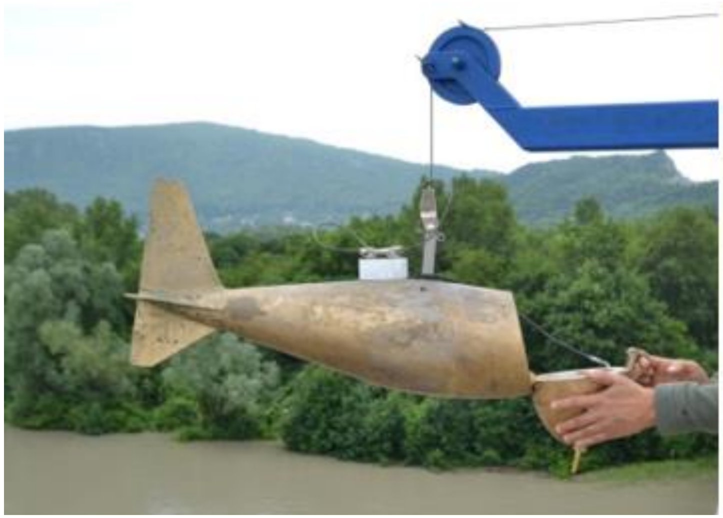
Time $V_s = \int_{t_1}^{t_2} Q_s(t)\ dt$



Suspended sediments vary in space and time

Suspended sediment monitoring in Austria

- Cross-sectional calibration – multipoint sampling



Suspended sediment monitoring in Austria

- Laboratory analysis of water samples
- SSC → vacuum filtration (0.45 µm filter), drying (2 hours on 105° C), weighing
- PSD → sieving instrument and sedimentation instrument

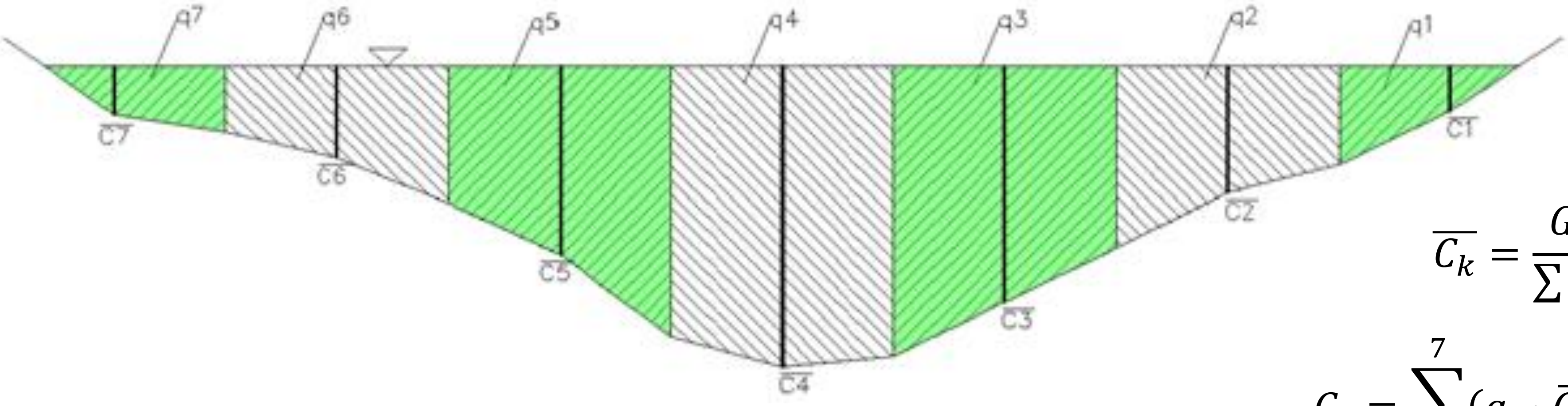
Suspended sediment monitoring in Slovakia

- Responsible institute: SHMU, VUVH
- Typical frequency: 3 to 20 times/week
- Depth-integrated sampling at representative verticals
- Nr. of stations: 5 (1 trib.)

- SSC → filtration of 0.2 l (0.45 µm filter), drying (24 hours on 105° C), weighing

Suspended sediment monitoring in Hungary

- Expeditionary multipoint measurements
- Typical frequency: 5 times/year
- 7 verticals, 10 points/vertical, 1 liter/point using pump
- 10x1 liter samples are integrated → sedimentation → extraction of 9 liters → remaining 1 liter is analysed → drying, weighing
- PSD → sedimentation instrument
- Nr. of stations: 7 (1 trib.)



$$\overline{C_k} = \frac{G_s}{\sum q_i}$$

$$G_s = \sum_{i=1}^{7} (q_i \cdot \overline{C_i})$$

Suspended sediment monitoring in Hungary

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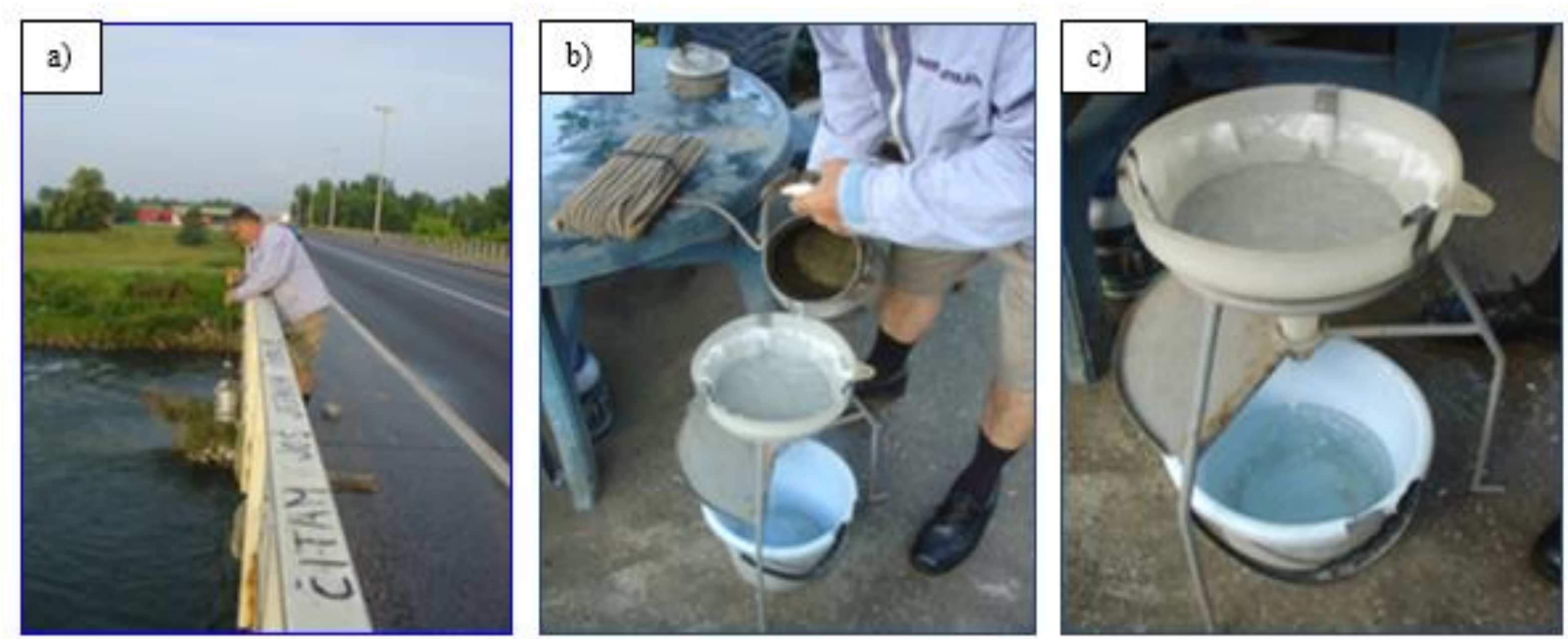
- Pump sampler

- Estimation of SSL using sediment rating curves and actual discharge

Suspended sediment monitoring in Croatia

- Daily physical sampling in one point at the water surface using bucket sampler→ filtration (0.45 μm filter) → filters to laboratory, drying (on 105° C), weighing
- Multipoint measurements 6 times/year with pump
- Nr. of stations: 1 trib.

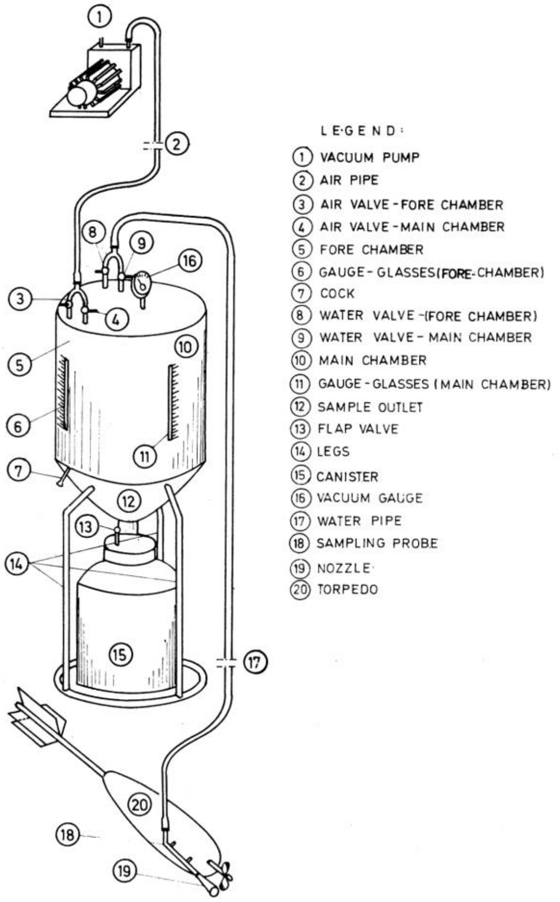


Suspended sediment monitoring in Serbia

- Daily physical sampling in one point at the water surface using bucket sampler (10 liters) → filtration (0.45 μm filter) → filters to laboratory, drying (on 105° C), weighing
- Multipoint measurements 1-3 times/year with vacuum bathometer in 7-10 verticals, 5 points/vertical, ~40 liter sample/point
- Estimation of SSL → Correlation between surface concentration and mean concentration along the cross-section
- Sedimentation of samples for days → 1-1.5 liter of concentrated sample is extracted → repeated settling for a day → 0.1 liter of concentrated sample is extracted → drying, weighing
- Nr. of stations: 7 (3 trib.)

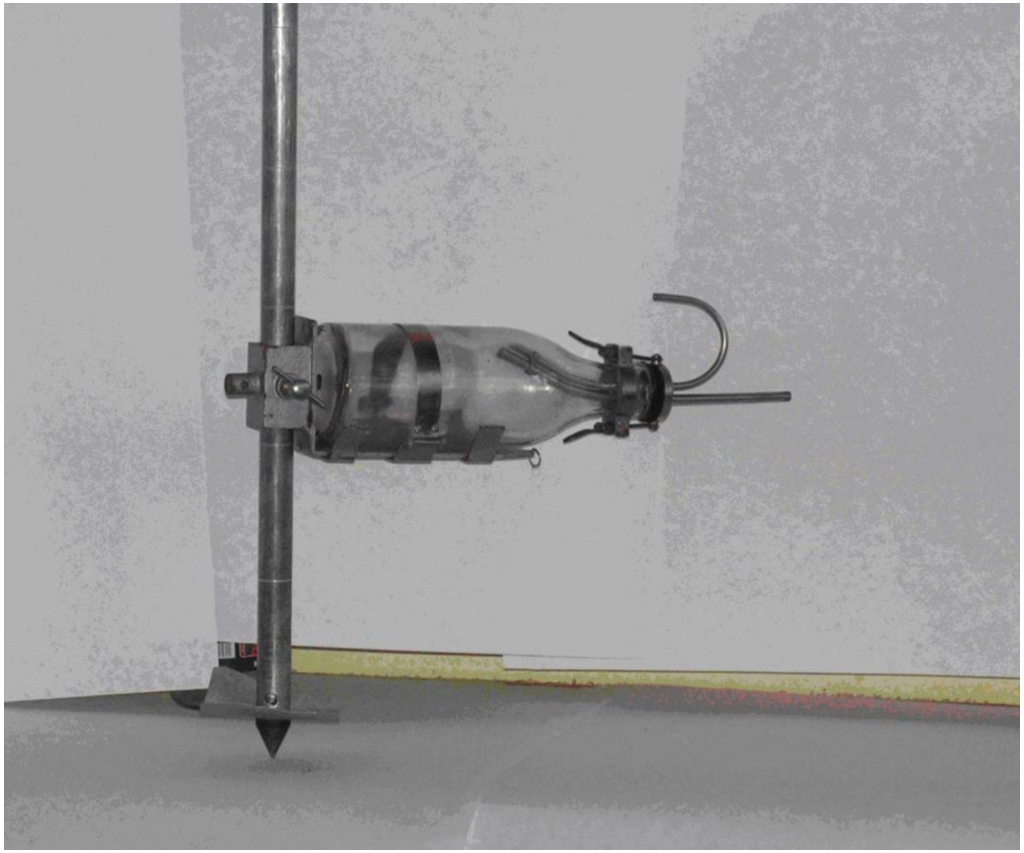
Suspended sediment monitoring in Serbia

- Daily physical sampling
- Multipoint measurements 4-6 times/year with bathometer in 5-9 verticals
- Correction of point samples with cross-section calibration
  → daily sediment discharge



Suspended sediment monitoring in Bulgaria

- Daily physical sampling with bottle sampler at the river bank
- Mean concentration in the cross-section is assumed to be the measured one at the river bank
  $\rightarrow$ daily sediment discharge
- Nr. of stations: 6 (2 trib.)



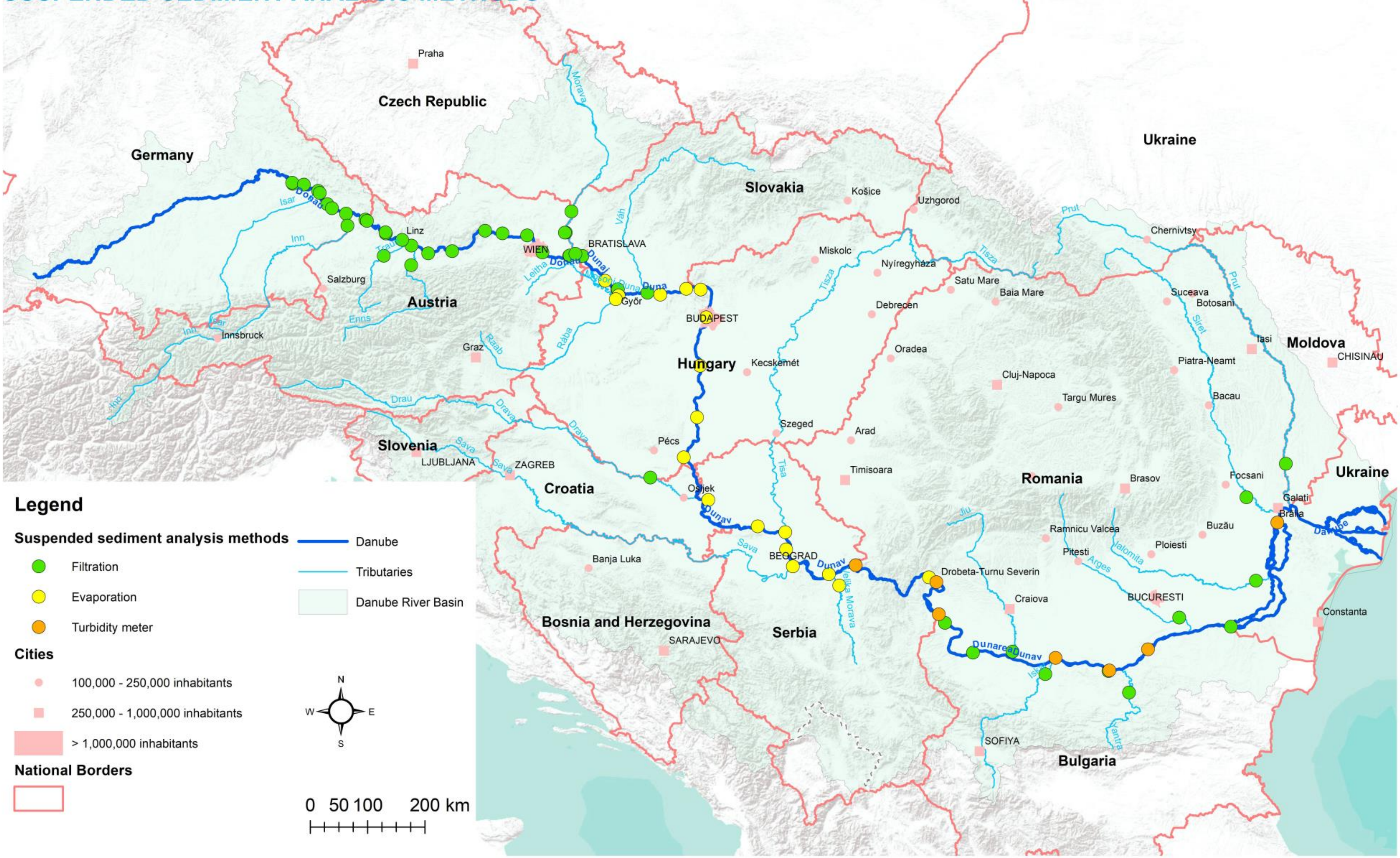
Suspended sediment monitoring in Romania

- Daily physical sampling with bottle sampler at the river bank
- Multipoint measurements 4-6 times/year with bathometer in 5-9 verticals
- SSC is determined using a portable turbidity sensor
- Nr. of stations: 19 (5 trib.)

Suspended sediment monitoring stations along the Danube and at the most important tributaries (closest to the confluence)

Map 3

SUSPENDED SEDIMENT ANALYSIS METHODS



http://www.interreg-danube.eu/approved-projects/danubesediment

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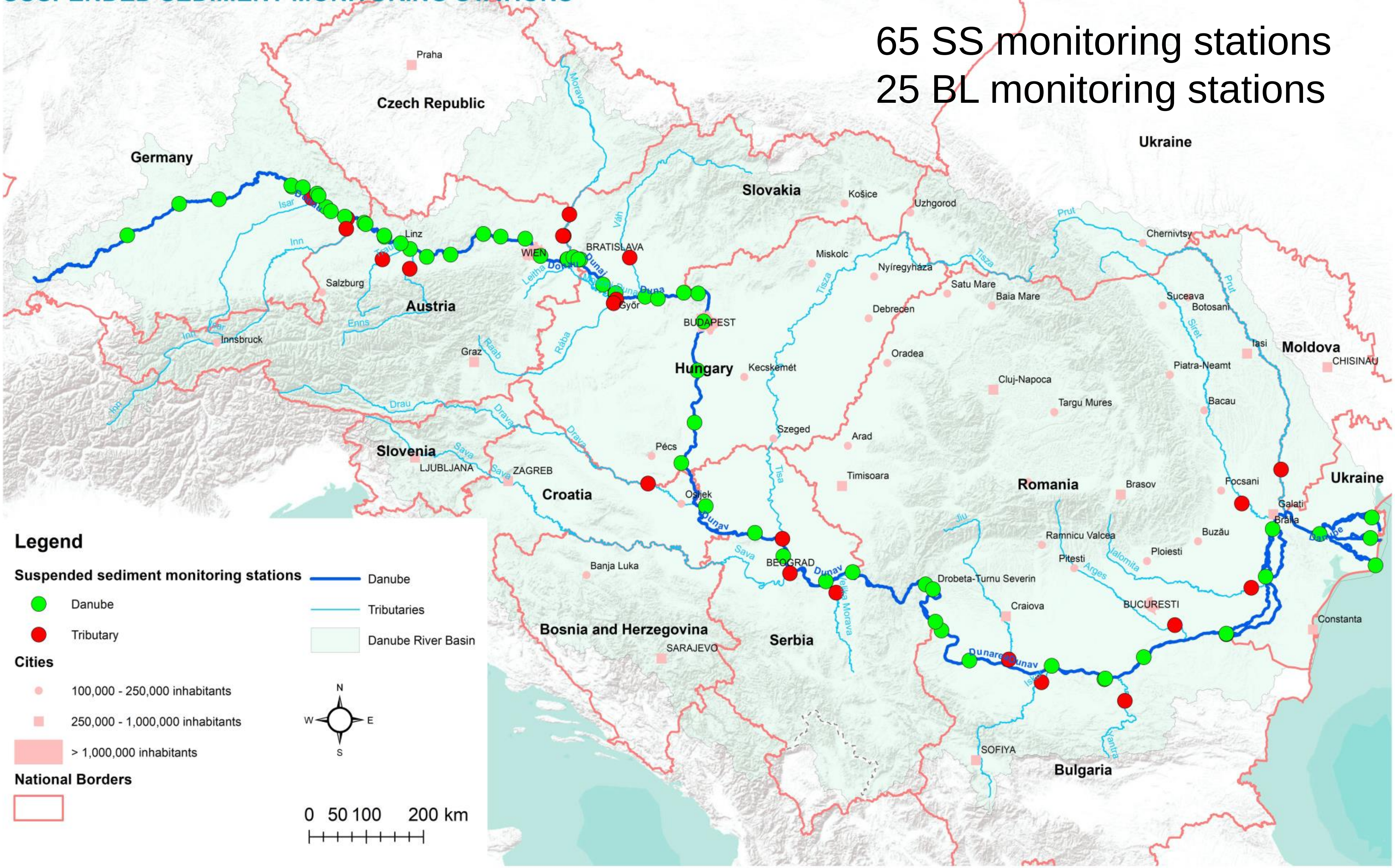
Suspended sediment monitoring stations along the Danube and at the most important tributaries (closest to the confluence)

Map 1

SUSPENDED SEDIMENT MONITORING STATIONS



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Bedload monitoring stations along the Danube and at the most important tributaries (closest to the confluence)

BEDLOAD MONITORING STATIONS

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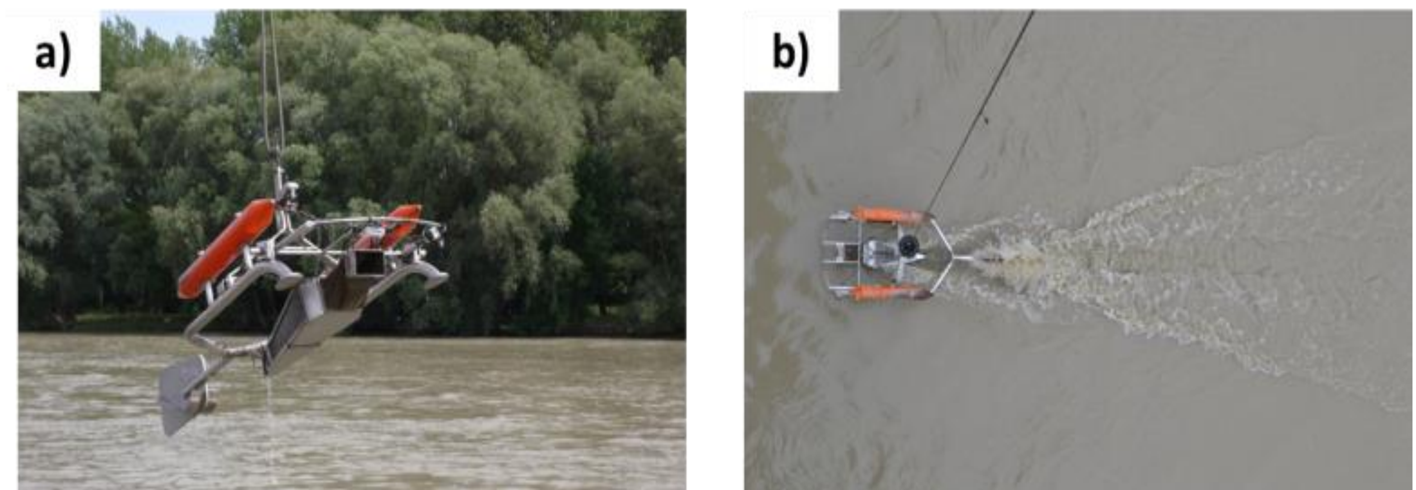
Bedload monitoring

- Germany: expeditionary monitoring campaigns at 9 sites
  - BfG sampler
  - Sampling from ship
  - Rating curves
- Austria (1 station):
  - BfG sampler (monitoring at Bad-Deutsch Altenburg)
  - Mesh size: 1 mm
  - Sampling from bridge or from ship
  - 8-15 verticals, 3x5 minute long samplings
  - 3 times/year
  - Drying, sieving



Bedload monitoring

- Slovakia (2+1 stations):
  - intensive measurement campaigns in 1997-1998 and 2002-2003
  - Swiss-type sampler, 5-6 verticals
  - 2-5 min long samplings
  - Drying, sieving of the samples
  - Rating curves have been set up

Bedload monitoring

- Hungary (1 station):
  - continuous monitoring since 1998 at Vámosszabadi (Medvedov)
  - 4-6 times/year using the modified Károlyi-sampler at 7 verticals
  - 15 min long samplings
  - Drying, sieving of samples

Bedload monitoring

- Romania (11 stations):
  - 4-6 times/year at 11 monitoring stations, 5-9 verticals
  - ~10 min long samplings
  - Drying, sieving (0.063-50 mm)

Longitudinal variation of long-term (1986-2016) mean annual suspended sediment load along the Danube River

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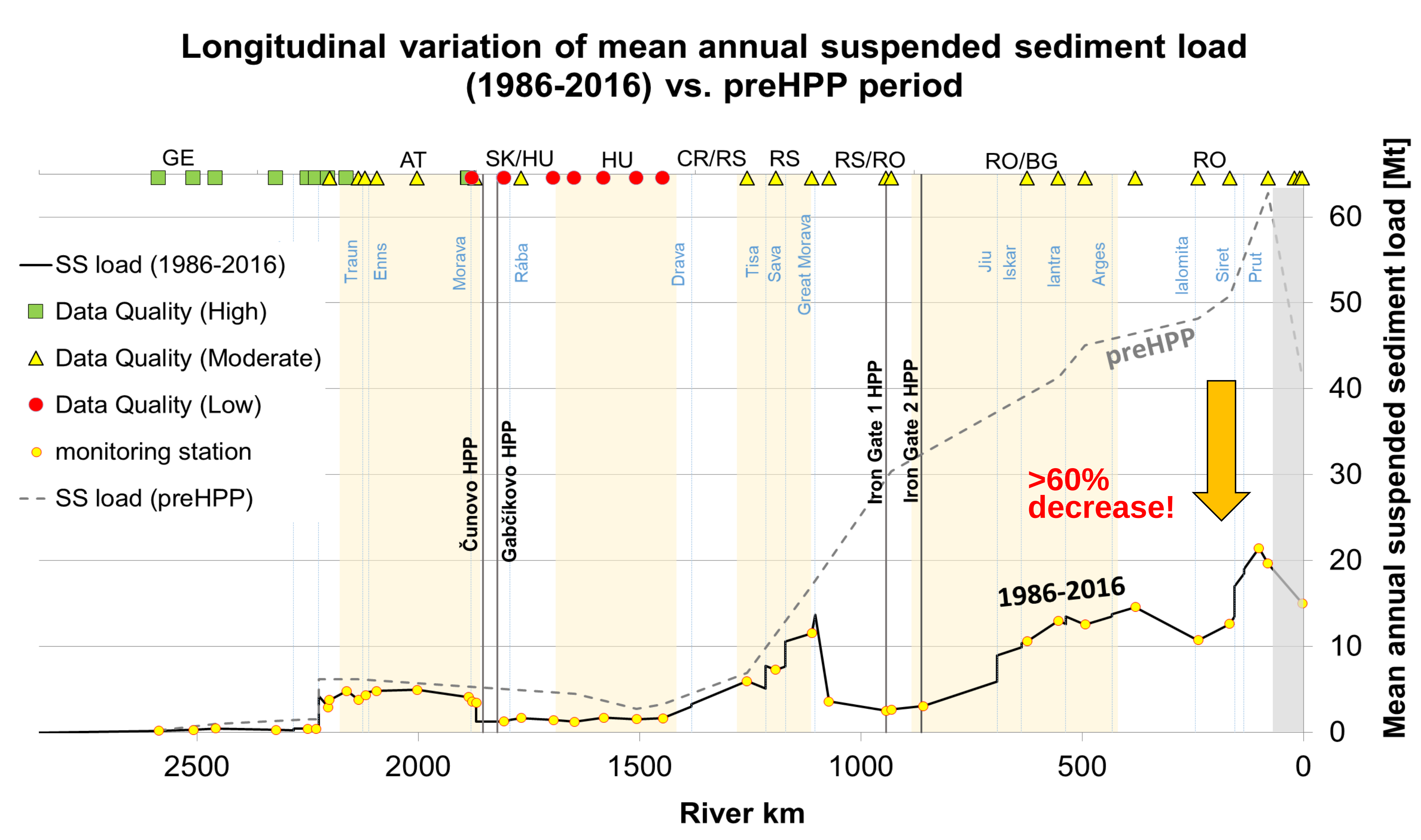

Thank you for your attention!

- Barbara Kéri
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- +36 30 275 2655

WP3: Sediment Data Collection

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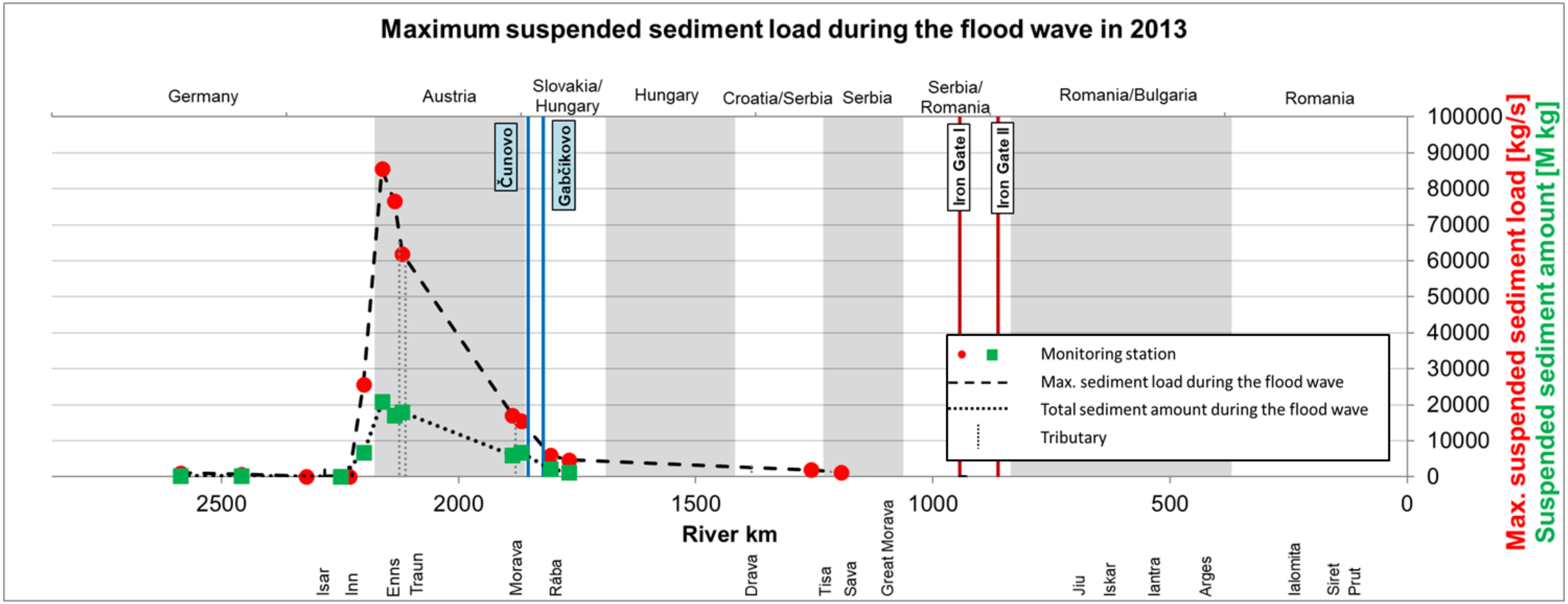
Activity 3.3 – Assessment of sediment data

Influence of floods on SS transport



- 20M tons mobilized in AT (mean annual around 5Mt)

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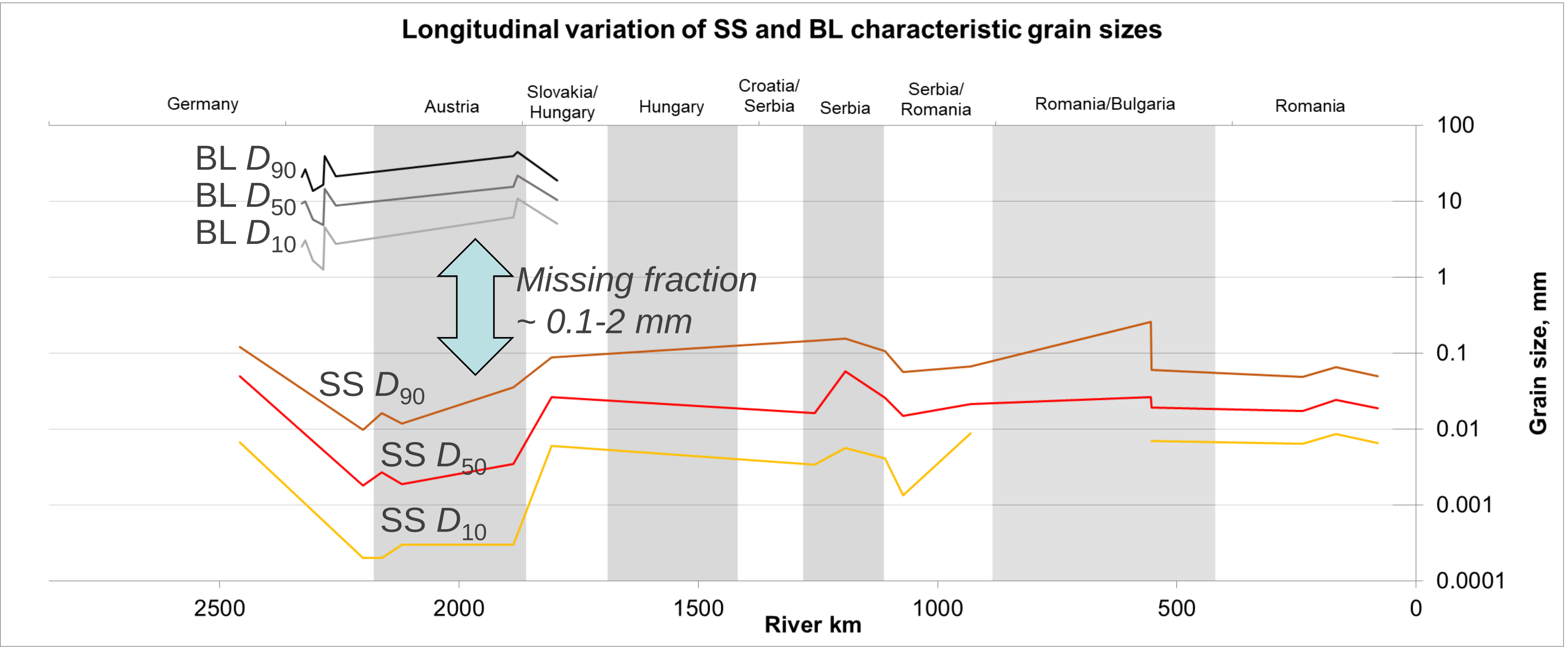
Activity 3.3 – Assessment of sediment data

Longitudinal variation of characteristic sediment grain sizes



WP3: Sediment Data Collection

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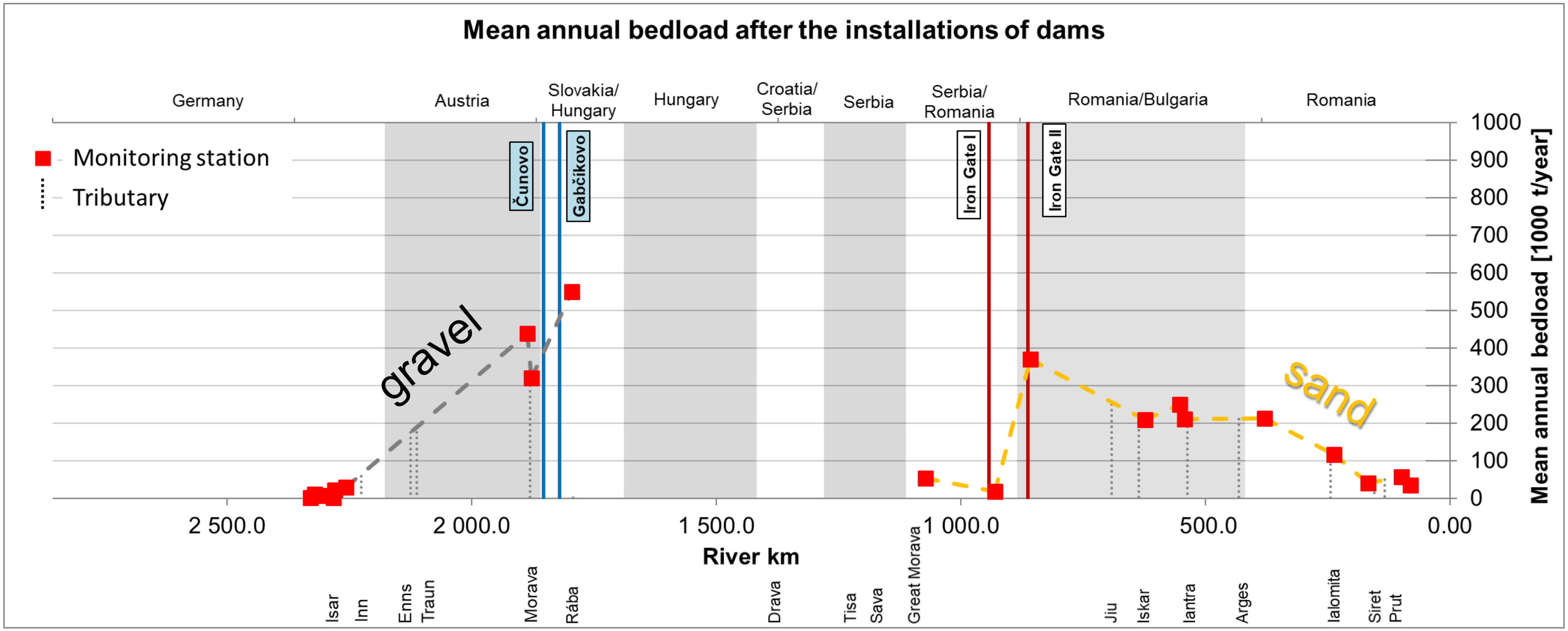
Activity 3.3 – Assessment of sediment data

Bedload transport



WP3: Sediment Data Collection

Activity 3.2 – Comparative analysis

Good practices in SS monitoring

Methodology

Turbidity

↓

Concentration close to the sensor

↓

Mean concentration

↓

Suspended sediment load

↓

Annual Suspended sediment load

← Probe characteristic $s_k = a\ s_s$

Probe factor $k_s = s_k / s_s$

Sensor calibration

← Cross-sectional characteristic

$s_m = a\ s_k$

Cross-sectional calibration

← Load $Q_s = s_m\ Q$

← Time $V_s = \int_{t_1}^{t_2} Q_s(t)\ dt$

WP3: Sediment Data Collection

Activity 3.2 – Comparative analysis

Good practices in SS monitoring

Sensor calibration

Turbidity

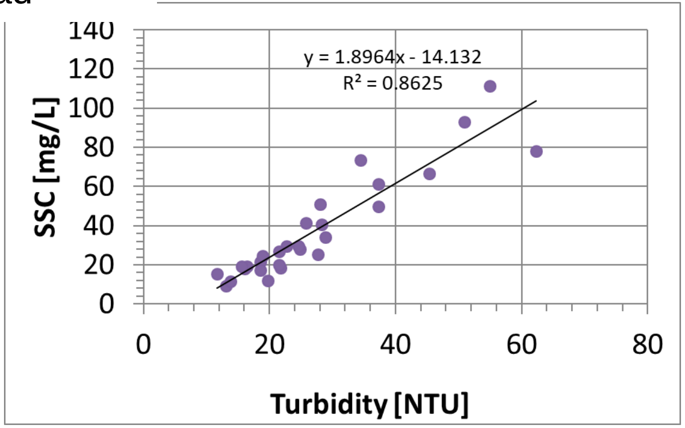
Concentration close to the sensor

Mean concentration

Suspended sediment load

Annual Suspended sediment load

Load



WP3: Sediment Data Collection

Activity 3.2 – Comparative analysis

Good practices in SS monitoring

Cross-sectional calibration (isokinetic sampling!)

Turbidity

↓

Concentration close to the sensor

↓

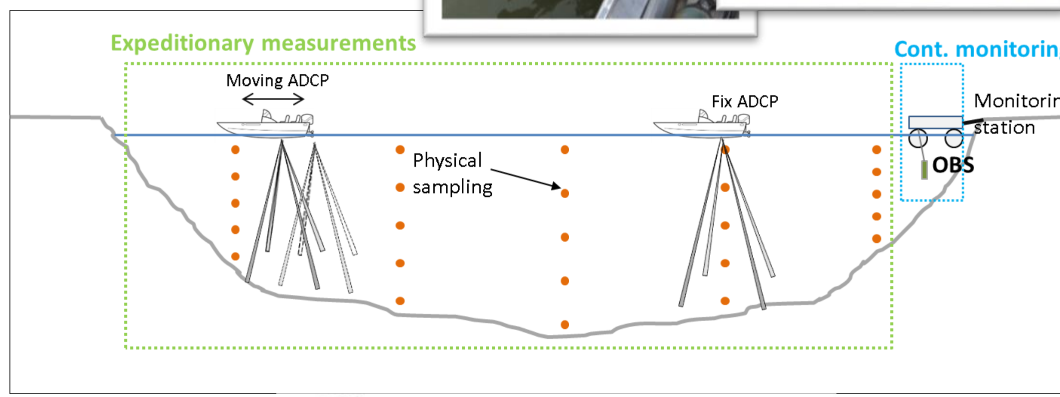
Mean concentration

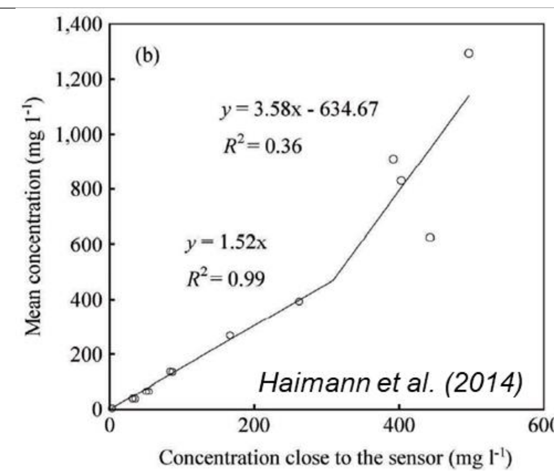
↓

Suspended sediment load

↓

Annual Suspended sediment load





Haimann et al. (2014)

WP3: Sediment Data Collection

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Activity 3.2 – Comparative analysis

Good practices in SS monitoring

Temporal variation of SS load

Turbidity

↓

Concentration close to the sensor

↓

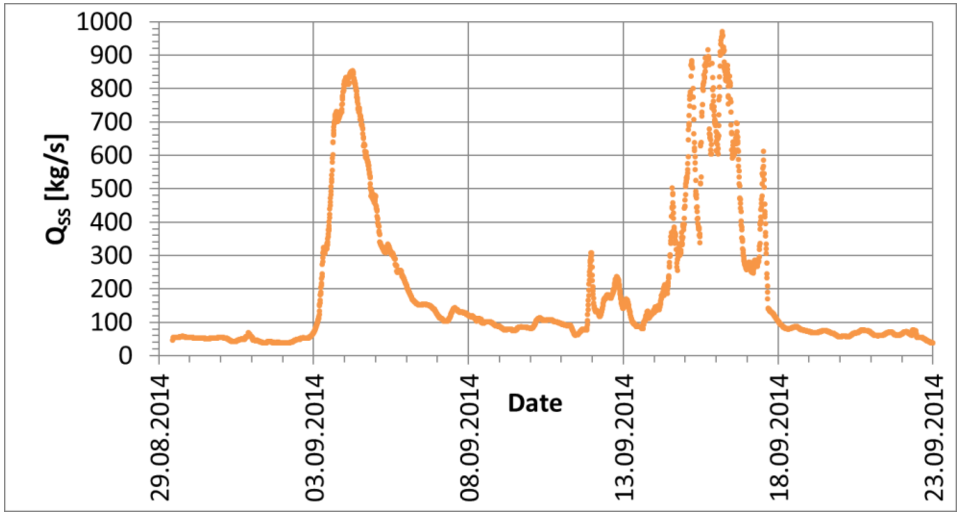
Mean concentration

↓

Suspended sediment load

↓

Annual Suspended sediment load



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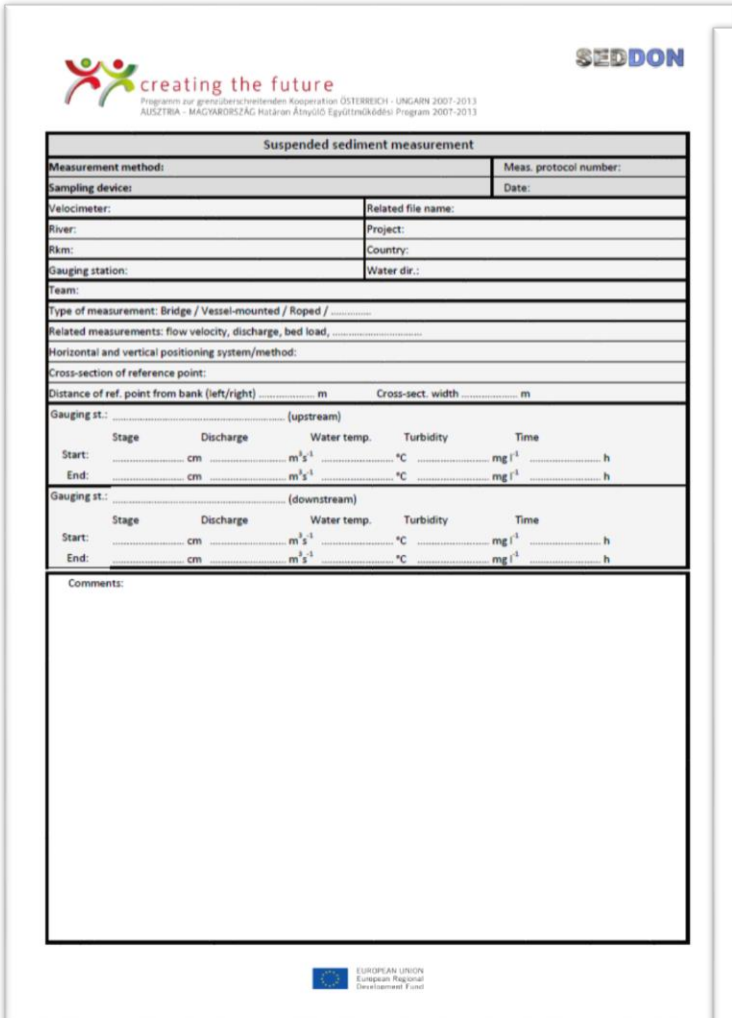
Activity 3.2 – Comparative analysis

Good practices in SS monitoring

Protocols



creating the future
Programm zur grenzüberschreitenden Kooperation ÖSTERREICH - UNGARN 2007-2013
AUSZTRIA - MAGYARORSZÁG Határon Átnyúló Együttműködési Program 2007-2013

SEDDON

Suspended sediment measurement

Measurement method:	Meas. protocol number:
Sampling device:	Date:
Velocimeter:	Related file name:
River:	Project:
Rkm:	Country:
Gauging station:	Water dir.:

Team:

Type of measurement: Bridge / Vessel-mounted / Roped / ....

Related measurements: flow velocity, discharge, bed load, ...

Horizontal and vertical positioning system/method:

Cross-section of reference point:

Distance of ref. point from bank (left/right) .... m Cross-sect. width .... m

Gauging st.: .... (upstream)

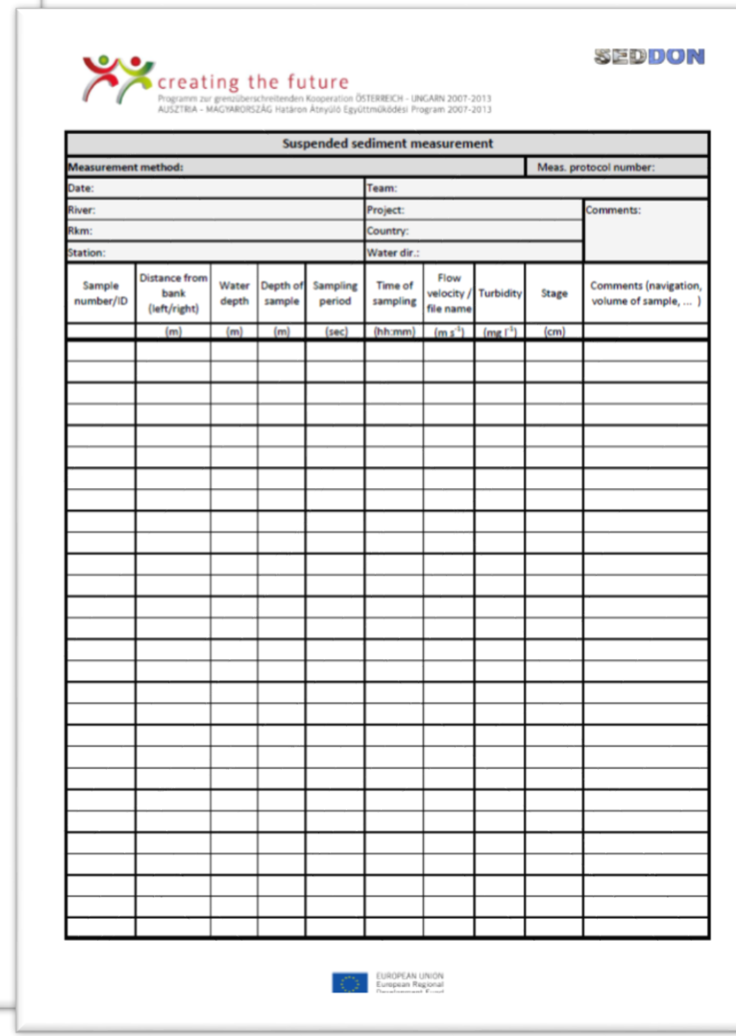
	Stage	Discharge	Water temp.	Turbidity	Time
Start:	.... cm	.... m^3s^{-1}	.... °C	.... $mg\ l^{-1}$	.... h
End:	.... cm	.... m^3s^{-1}	.... °C	.... $mg\ l^{-1}$	.... h

Gauging st.: .... (downstream)

	Stage	Discharge	Water temp.	Turbidity	Time
Start:	.... cm	.... m^3s^{-1}	.... °C	.... $mg\ l^{-1}$	.... h
End:	.... cm	.... m^3s^{-1}	.... °C	.... $mg\ l^{-1}$	.... h

Comments:

EUROPEAN UNION
European Regional Development Fund



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SEDDON

Suspended sediment measurement

Measurement method:		Meas. protocol number:
Date:	Team:	
River:	Project:	Comments:
Rkm:	Country:	
Station:	Water dir.:	

Sample number/ID	Distance from bank (left/right)	Water depth	Depth of sample	Sampling period	Time of sampling	Flow velocity / file name	Turbidity	Stage	Comments (navigation, volume of sample, ...)
	(m)	(m)	(m)	(sec)	(hh:mm)	$(m\ s^{-1})$	$(mg\ l^{-1})$	(cm)	

EUROPEAN UNION
European Regional

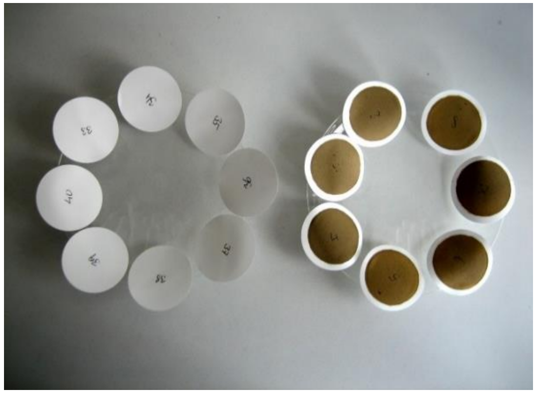
WP3: Sediment Data Collection

Activity 3.2 – Comparative analysis

Good practices in SS monitoring

Laboratory analysis after BMLFUW (2008, 2017)

- Main steps:
  - Drying of membrane filter (of 0.45 µm pores) at 105° C until constant weight, after the drying the filter is placed in a desiccator, to let the filter cool down
  - Mass of the plate and filter is measured (m_a)
  - Membrane filter is placed into the filtering device.
  - Sample is poured into the filtering device and its volume is measured precisely (V_p).
  - After filtering, the membrane filter is dried at 105° C until constant weight, after the drying the filter is placed in a desiccator, to let the filter cool down
  - Plate and membrane filter is weighted again (m_b).
  - Dry matter content is: $m_T=m_b-m_a$ [mg].
  - SSC = m_T/V_p [mg/l].



BMLFUW (ed.) (2008): Schwebstoffe im Fließgewässer – Leitfaden zur Erfassung des Schwebstofftransportes. Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft, Austria, Vienna.

WP3: Sediment Data Collection

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Activity 3.2 – Comparative analysis

Good practices in BL monitoring

Methodology

Sample weight and sampling time

Calibration coefficient
Sampler width

Transport rate for each sample

Average samples
of one vertical

Transport rate for a vertical

Integrate over the
active width

Cross-sectional bedload transport

Integrate over time:
Bed load – discharge relation
(rating curve)
And Discharge

Bedload yield