Trends in Stream Water Chemistry within the GEOMON Network, Czech Republic

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D. Fottova, J. Hruska, P. Kram,
F. Oulehle, M. Stepanova

and others…

Czech Republic

- ► central Europe
- ► 10.5 million inhabitants
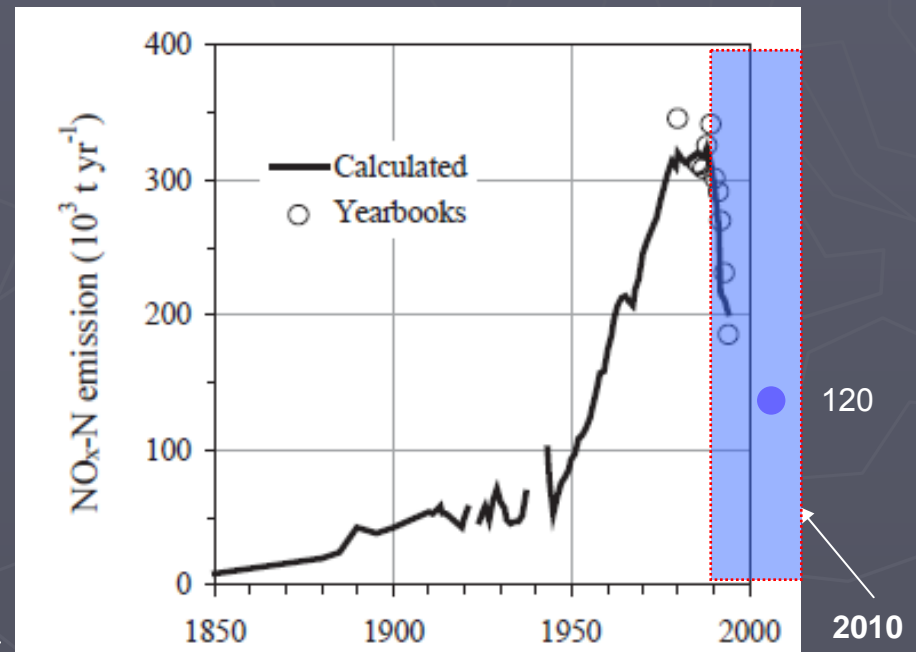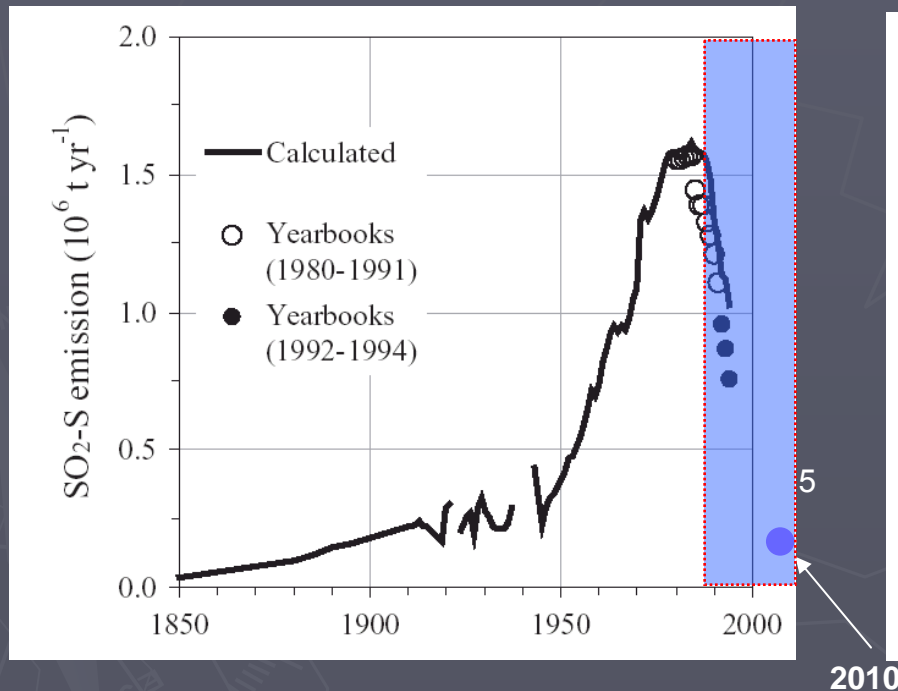- ► area 78 866 km^2

Maine
1.275 million inhabitants
area 86 542 km2

• power generation – mainly brown (soft) coal combustion

• currently combustion of coal 55% of energy generation in Czech Republic (33%nuc, 4%wat, 5%gas, 3.5%RR)

Czech Republic – Emission History

- power generation – mainly brown (soft) coal combustion
- current 55% of energy generation in Czech Republic (33%nuc, 4%wat, 5%gas, 3.5%RR)

- highest annual SO_x emissions 1.6 millions t
- highest annual NO_x emissions 320 thousands t

KOPÁČEK J, VESELÝ J
SULFUR AND NITROGEN EMISSIONS IN THE CZECH REPUBLIC AND SLOVAKIA FROM 1850 TILL 2000
Atmospheric Environment 39, 2005.
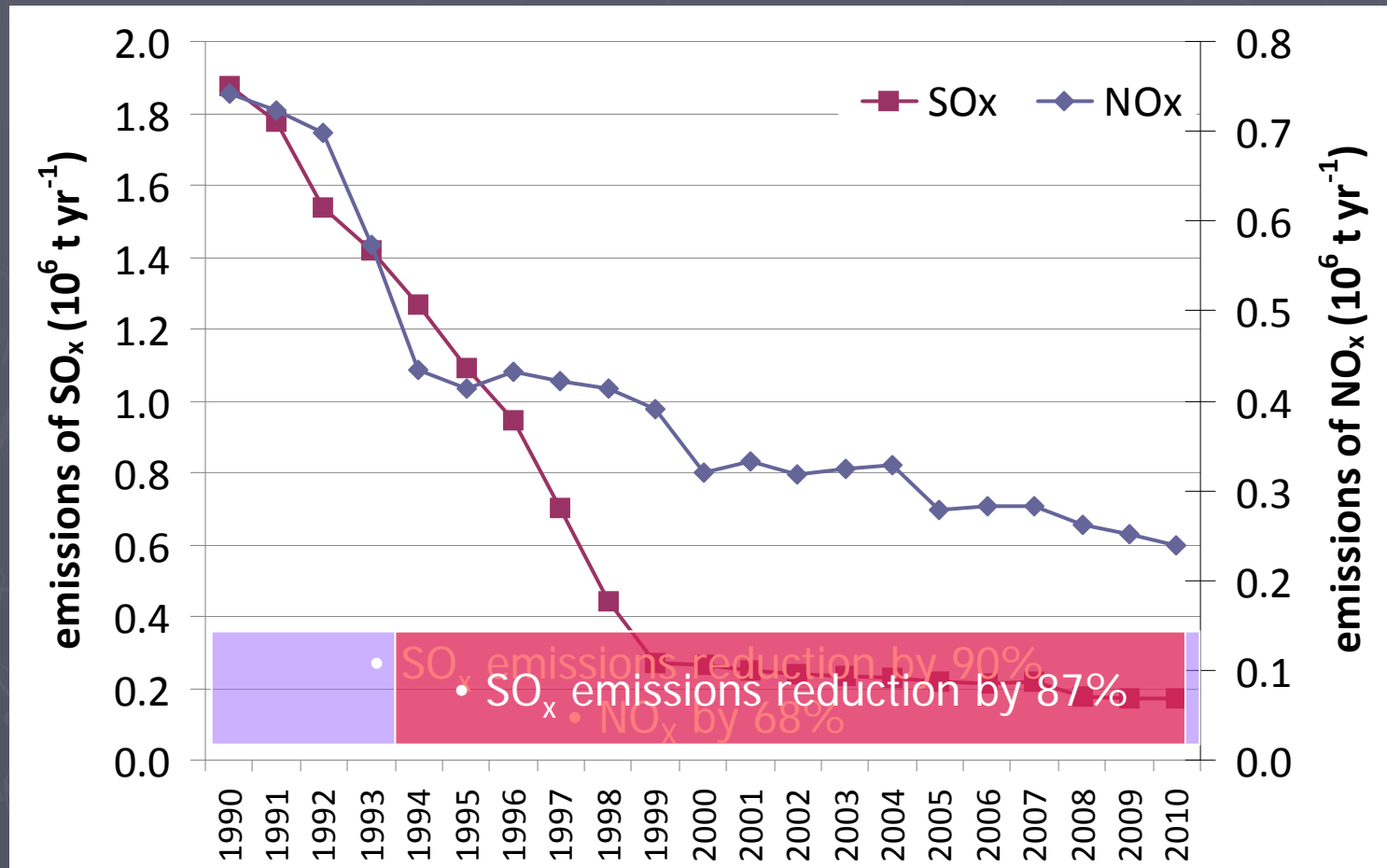
Emission History – EMEP data

- power generation – mainly brown (soft) coal combustion
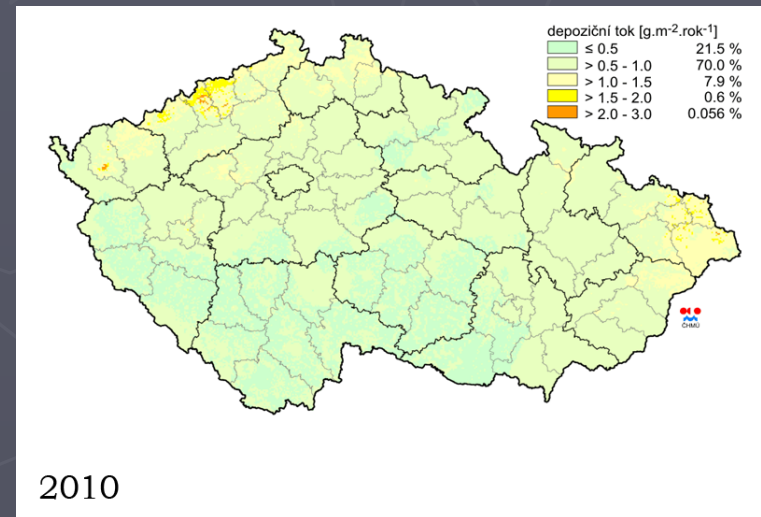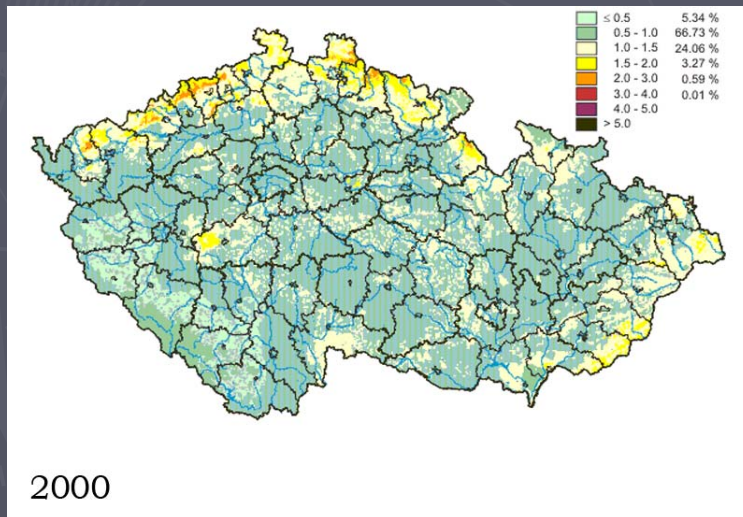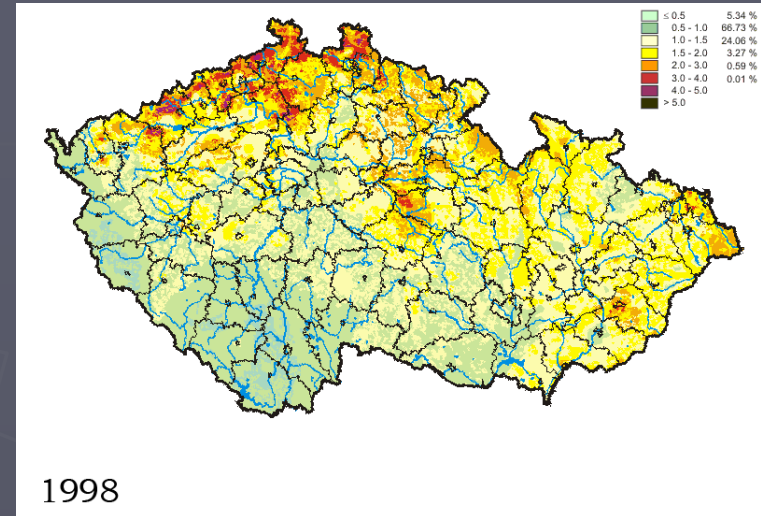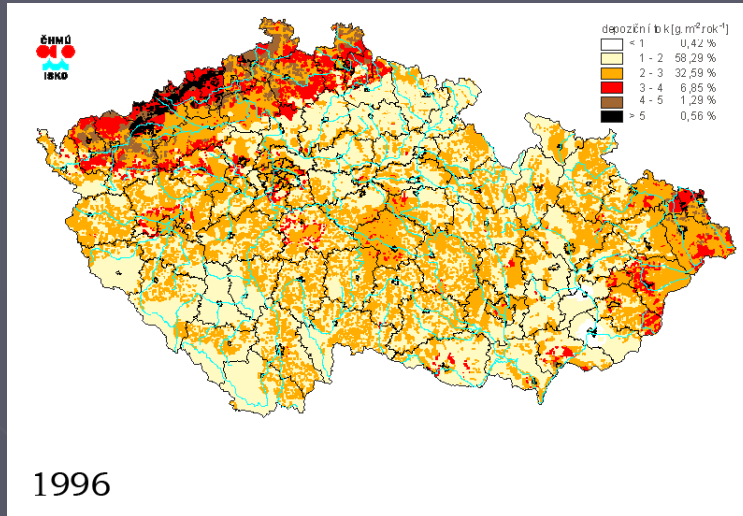- current 55% of energy generation in Czech Republic (33%nuc, 4%wat, 5%gas, 3.5%RR)

Spatial S total deposition changes

GEOMON monitoring network

- ► 13 catchments
- ► areas from 27 to 262 ha
- ► all catchments forested (33 to 100%)
- ► monthly sampling step

Altitude

JEZ UHL MOD LYS PLB UDI LES POM ANE SAL LIZ CER

- ► bulk precipitation
- ► throughfall
- ► stream water
- ► analyzed main anions and cations
- ► MK seasonal test, Sen slope estimator used for trend estimate
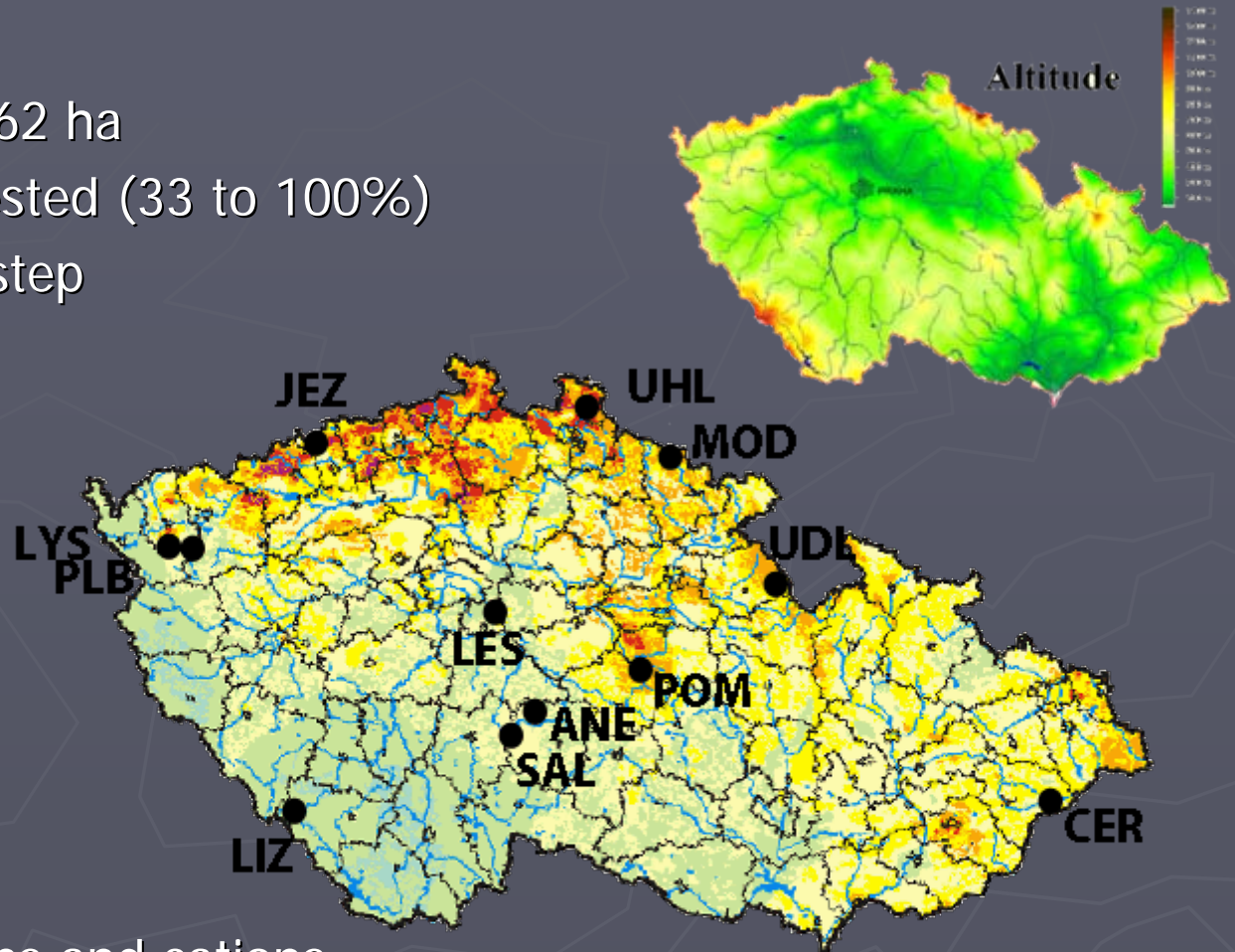
GEOMON – water budget
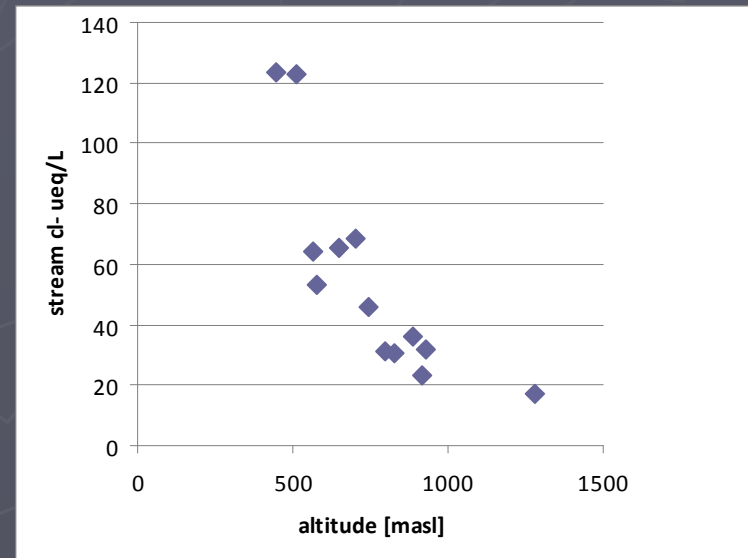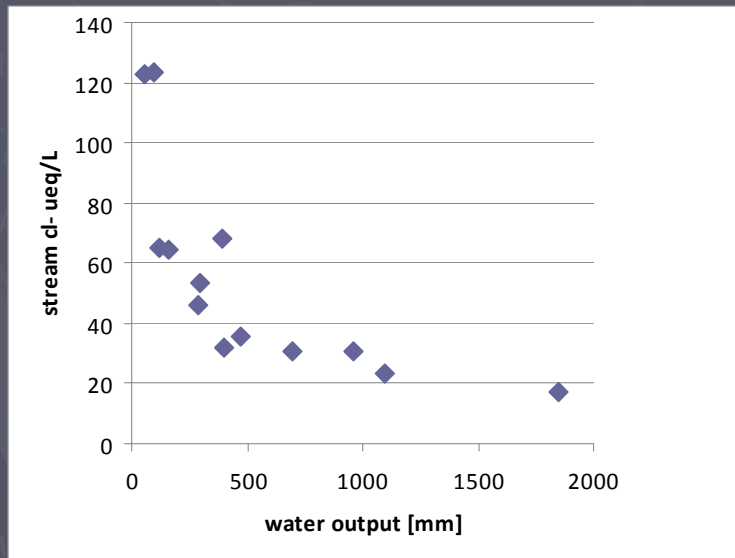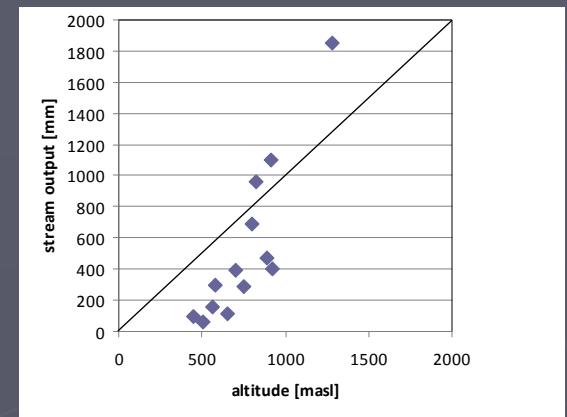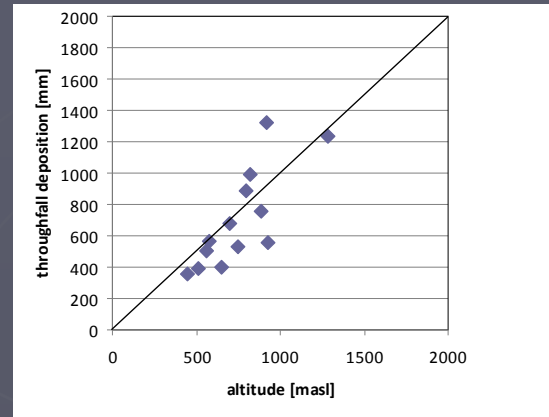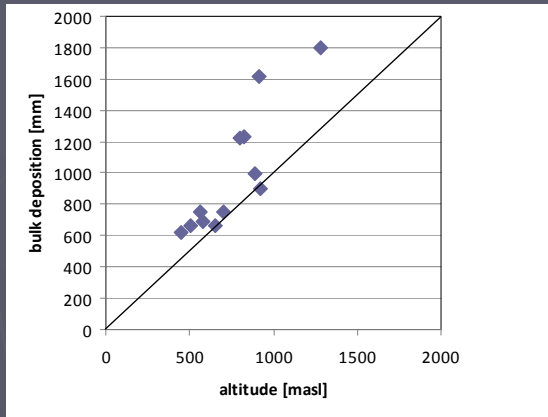
• average Cl- conc. in streams for period 1994-2010

Trends in Stream Water Chemistry

► why do we care?

► because of RECOVERY… how is it defined?

► possible indicators of RECOVERY:

SO_4^{2-}

NO_3^-

Al

ANC

pH

H^+

ANC = SAA-SBC

SAA = $SO_4^{2-}+NO_3^-+F^-+Cl^-$
SBC = $Na^++K^++Ca^{2+}+Mg^{2+}$
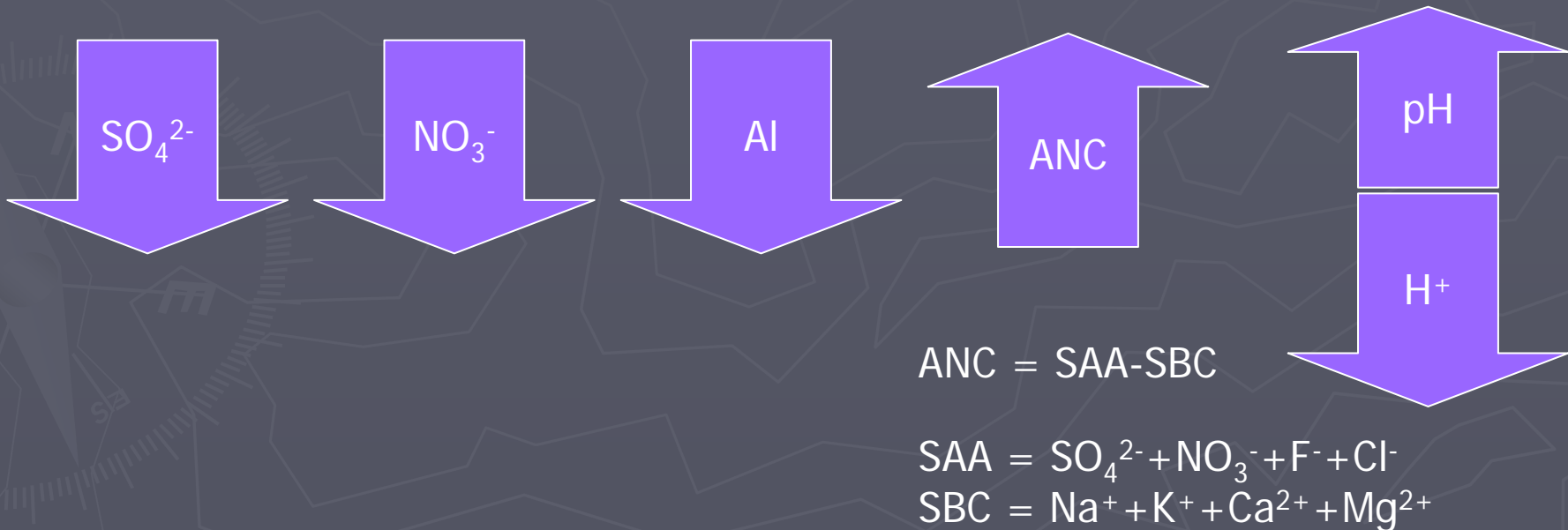
Sulfates

STREAM

ueq.L^{-1}.yr^{-1}	SO$_4^{2-}$ 1994-2010	
ANE	0.4	ns
CER	-7.8	***
JEZ	-31.6	***
LES	-41.7	**
LIZ	-2.1	ns
LKV	0.4	ns
LYS	-15.5	***
MOD	-1.9	***
PLB	-29.0	***
POM	-23.3	***
SAL	-1.2	ns
UDL	-3.7	***
UHL	-2.8	*
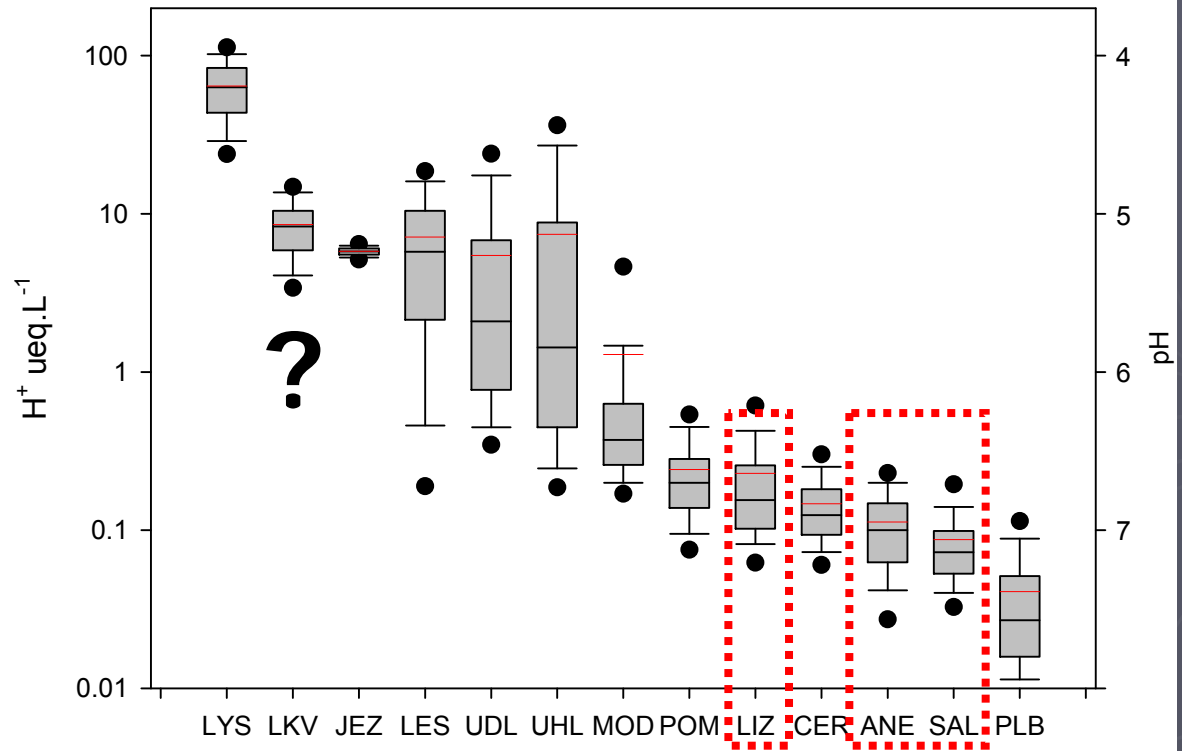
- significant decreasing trend of sulfate at acidic sites except LKV
- insignificant trends at well buffered catchments, with lower levels of sulfate deposition

Nitrates

STREAM

ueq.L^{-1}.yr^{-1}	NO$_3^-$ 1994-2010
ANE	-1.5 **
CER	-1.2 **
JEZ	-2.4 ***
LES	-1.3 *
LIZ	-1.5 **
LKV	-0.3 **
LYS	-0.3 **
MOD	-2.0 ***
PLB	0.7 ns
POM	-5.5 ***
SAL	-0.8 ns
UDL	-4.0 ***
UHL	-3.2 ***

OULEHLE F, MCDOWELL WH, AITKENHEAD-PETERSON JA, KRÁM P, HRUŠKA J, NAVRÁTIL T, BUZEK F, FOTTOVÁ D
LONG-TERM TRENDS IN STREAM NITRATE CONCENTRATIONS AND LOSSES ACROSS WATERSHEDS UNDERGOING
RECOVERY FROM ACIDIFICATION IN THE CZECH REPUBLIC.
Ecosystems 11, 2008.
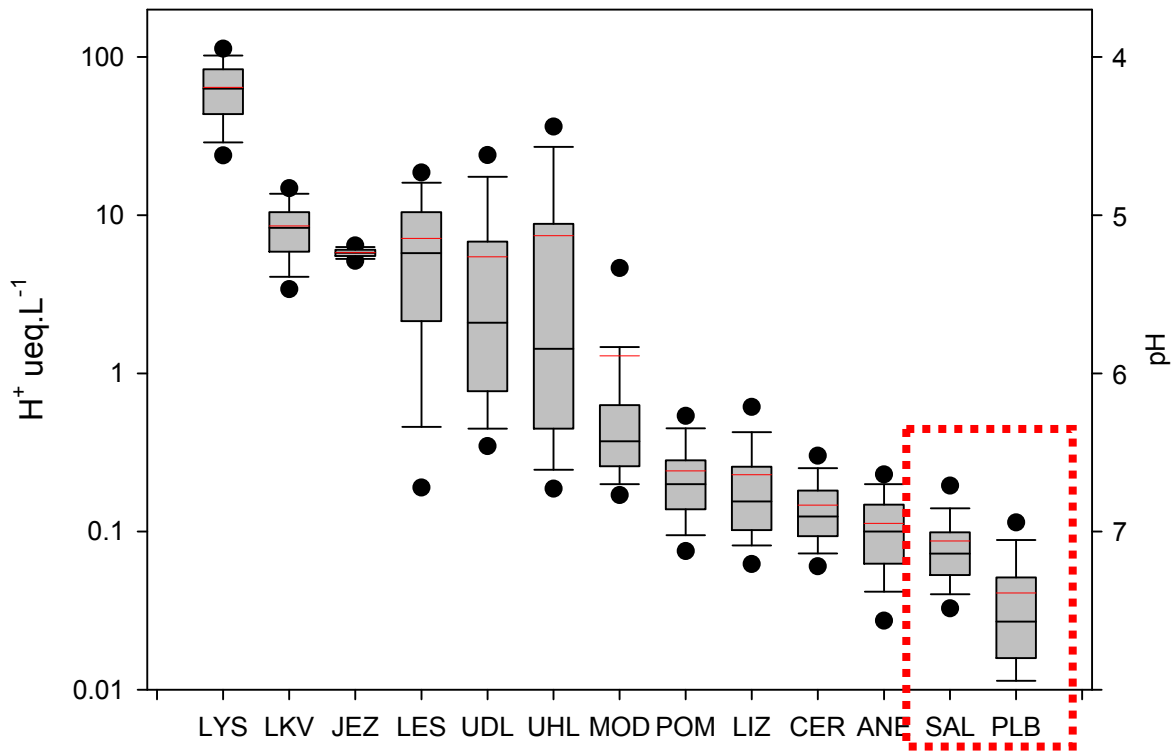
ANC, H$^+$ and Al-tot

STREAM

ueq.L^{-1}.yr^{-1}	ANC 1994-2010		H$^+$ 1994-2010		Al-tot 1994-2010	
ANE	5.8	ns	0.0	ns	-0.2	ns
CER	0.4	ns	0.0	ns	-0.1	ns
JEZ	0.6	ns	-0.1	*	-0.9	*
LES	-3.7	ns	-0.4	**	-2.4	**
LIZ	-0.8	ns	0.0	ns	0.0	ns
LKV	-4.8	ns	-0.2	ns	0.0	ns
LYS	7.2	***	-1.3	*	-1.9	**
MOD	2.6	***	0.0	ns	-0.4	*
PLB	15.1	ns	0.0	*	2.3	***
POM	3.8	ns	0.0	**	0.1	ns
SAL	-0.7	ns	0.0	ns	0.3	ns
UDL	5.0	**	-0.4	**	-1.2	**
UHL	5.6	**	-0.1	*	-1.0	*

• ANC decreased at mountainous catchments with poorly buffering bedrock

• decreases of H$^+$ concentrations were small and occurred mostly at sites with granite bedrock

• Al-tot concentrations decreased at sites with decrease of H$^+$

• well buffered site PLB with serpentinite bedrock was typical with increasing Al-tot concentration

KRAM P, HRUŠKA J, DRISCOLL CT, JOHNSON CE, OULEHLE F
LONG-TERM CHANGES IN ALUMINUM FRACTIONS OF DRAINAGE WATERS IN TWO FOREST CATCHMENTS WITH CONTRASTING LITHOLOGY
Journal of Inorganic Biochemistry 103, 2009.

Emission History – EMEP data

- period from 2001 to 2010
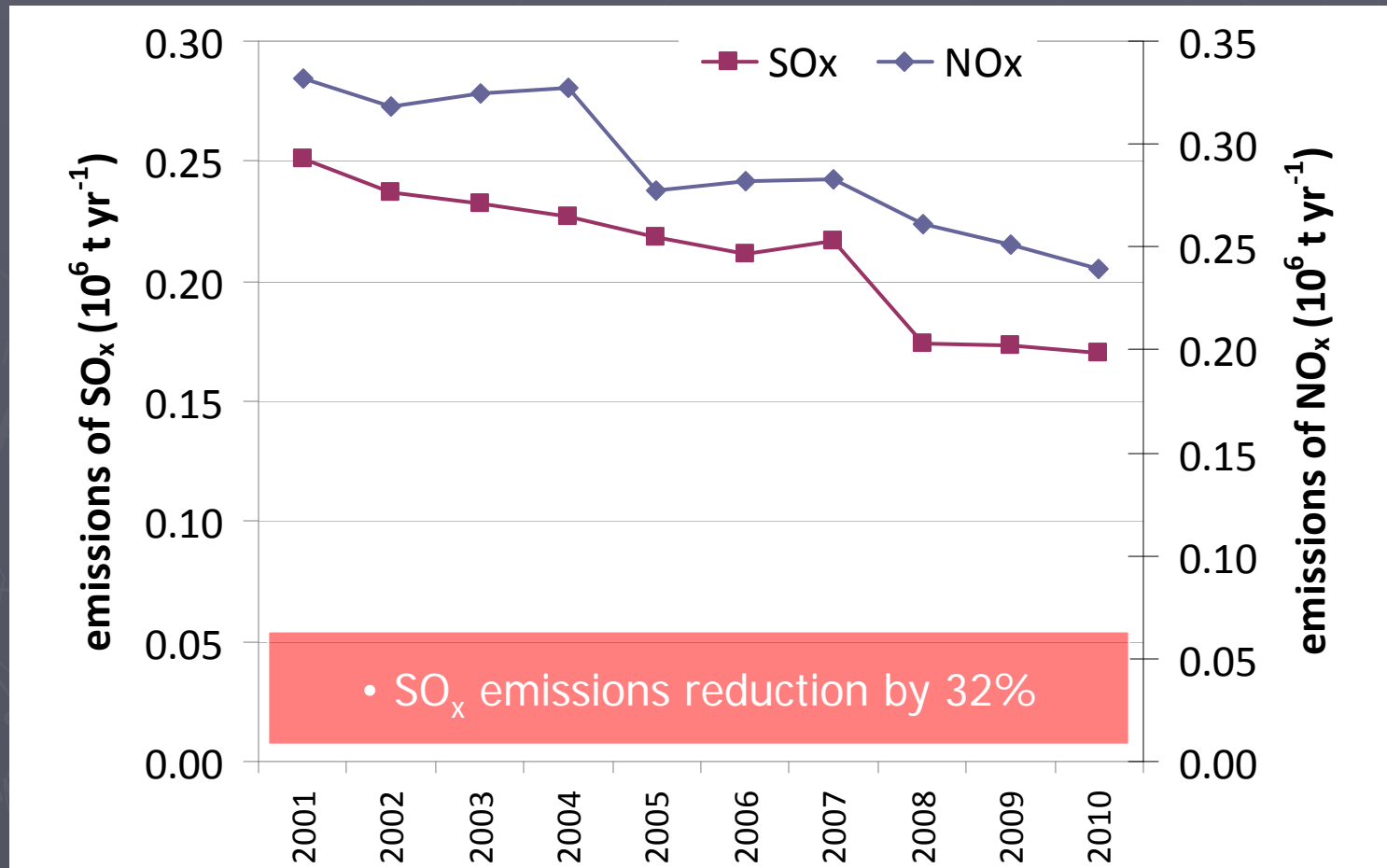
Trends in 21ˢᵗ century

ueq.L⁻¹.yr⁻¹	SO₄²⁻		BC		ANC		NO₃⁻		H⁺		Al-tot	
	1994-2010	2001-2010	1994-2010	2001-2010	1994-2010	2001-2010	1994-2010	2001-2010	1994-2010	2001-2010	1994-2010	2001-2010
ANE	0.4 ns	-40.4 ns	8.6 ns	-30.9 ns	5.8 ns	15.4 ns	-1.5 **	-0.1 ns	0.0 ns	0.0 *	-0.2 ns	-0.3 ns
CER	-7.8 ***	-7.2 *	-7.4 ***	-4.7 *	0.4 ns	-0.7 ns	-1.2 ***	-1.6 *	0.0 ns	0.0 ns	-0.1 ns	0.2 ns
JEZ	-31.6 ***	-27.8 **	-34.2 ***	-28.6 **	0.6 ns	3.9 ns	-2.4 ***	-2.5 *	-0.1 *	0.0 ns	-0.9 *	-0.5 ns
LES	-41.7 **	-63.4 *	-46.8 ***	-62.7 **	-3.7 ns	-1.6 ns	-1.3 *	-0.7 ns	-0.4 **	-1.0 *	-2.4 **	-4.0 ns
LIZ	-2.1 ns	-4.9 ns	-3.5 **	-5.9 *	-0.8 ns	-1.3 ns	-1.5 **	-1.0 ns	0.0 ns	0.0 ns	0.0 ns	0.4 ns
LKV	0.4 ns	-5.6 ns	-3.6 ns	-10.3 ns	-4.8 ns	-5.7 ns	-0.3 **	-0.2 *	-0.2 ns	-0.4 ns	0.0 ns	-0.4 ns
LYS	-15.5 ***	-8.2 ns	-8.7 **	-2.9 ns	7.2 ***	5.5 **	-0.3 **	0.0 ns	-1.3 *	-1.9 ns	-1.9 **	-2.1 ns
MOD	-1.9 ***	-2.2 **	-2.2 **	-1.1 ns	2.6 ***	4.8 **	-2.0 ***	-1.2 **	0.0 ns	0.0 ns	-0.4 *	-0.1 ns
PLB	-29.0 ***	-11.2 ns	-14.3 ns	-2.6 ns	15.1 ns	14.3 ns	0.7 ns	1.6 ns	0.0 *	0.0 ns	2.3 ***	0.7 ns
POM	-23.3 ***	-18.4 **	-25.2 ***	-16.1 **	3.8 ns	4.0 ns	-5.5 ***	-2.7 *	0.0 **	0.0 *	0.1 ns	0.4 ns
SAL	-1.2 ns	-3.3 ns	-3.8 *	-8.6 **	-0.7 ns	-3.8 ns	-0.8 ns	-1.8 **	0.0 ns	0.0 ns	0.3 ns	1.8 *
UDL	-3.7 ***	-5.8 **	-4.3 ***	-5.7 **	5.0 **	8.0 ns	-4.0 ***	-4.5 *	-0.4 **	-0.2 ns	-1.2 *	0.3 ns
UHL	-2.8 *	-4.6 ns	0.9 ns	-5.2 ns	5.6 **	1.4 ns	-3.2 ***	-2.7 *	-0.1 *	0.1 ns	-1.0 *	1.2 ns

Conclusions

► stream waters of GEOMON catchments are recovering

► SO4, NO3 concentrations decreased at most acidified catchments

► increases in ANC occurred only at acidified mountainous catchments

► H$^+$ and Al-tot decreased at some acidifed sites

► pace and significance of recovery in 21st century decreased

Thanks