Measurement and modelling of ammonia flux between the atmosphere and aquatic ecosystems in Hungary

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Introduction

- Results of the previous investigations
- Introduction of the applied methods: measurement, modelling
- Results
- Summary, conclusions

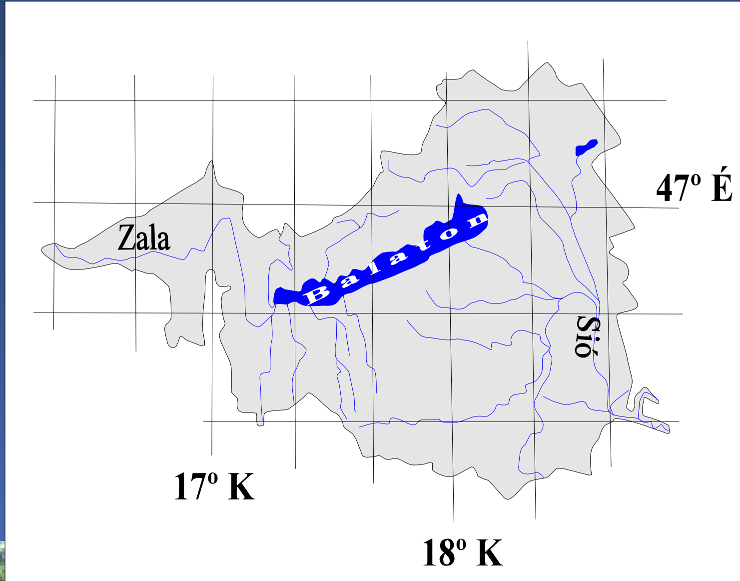
Results of previous investigations

- Ammonia compensation point model
- Max. emission 0,131 $\mu g\ m^{-2}s^{-1}$
- Max. deposition 0,087 $\mu g\ m^{-2}s^{-1}$
- Only summer measurements
- CO_2 concentration 350 ppm
- pH of the water 8,1

Horváth, L. (1982): On the vertical flux of gaseous ammonia above water and soil surfaces. In: *Deposition of Atmospheric Pollutants*. (Ed: D. Reidel) Dordrecht, 17-22.

Acquatic ecosystem

- Lake Balaton
- Largest lake in CE (600 km^2), average depth 3 m
- Eutrophication problems (‘70s)
- One of the main source of nutrients (N): atmospheric dry and wet deposition
- Aim: determine the magnitude of atmospheric NH_3-exchange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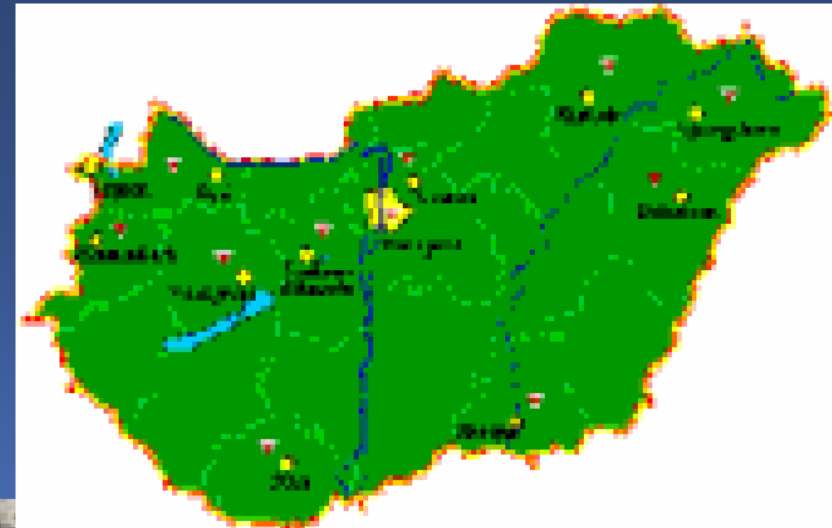
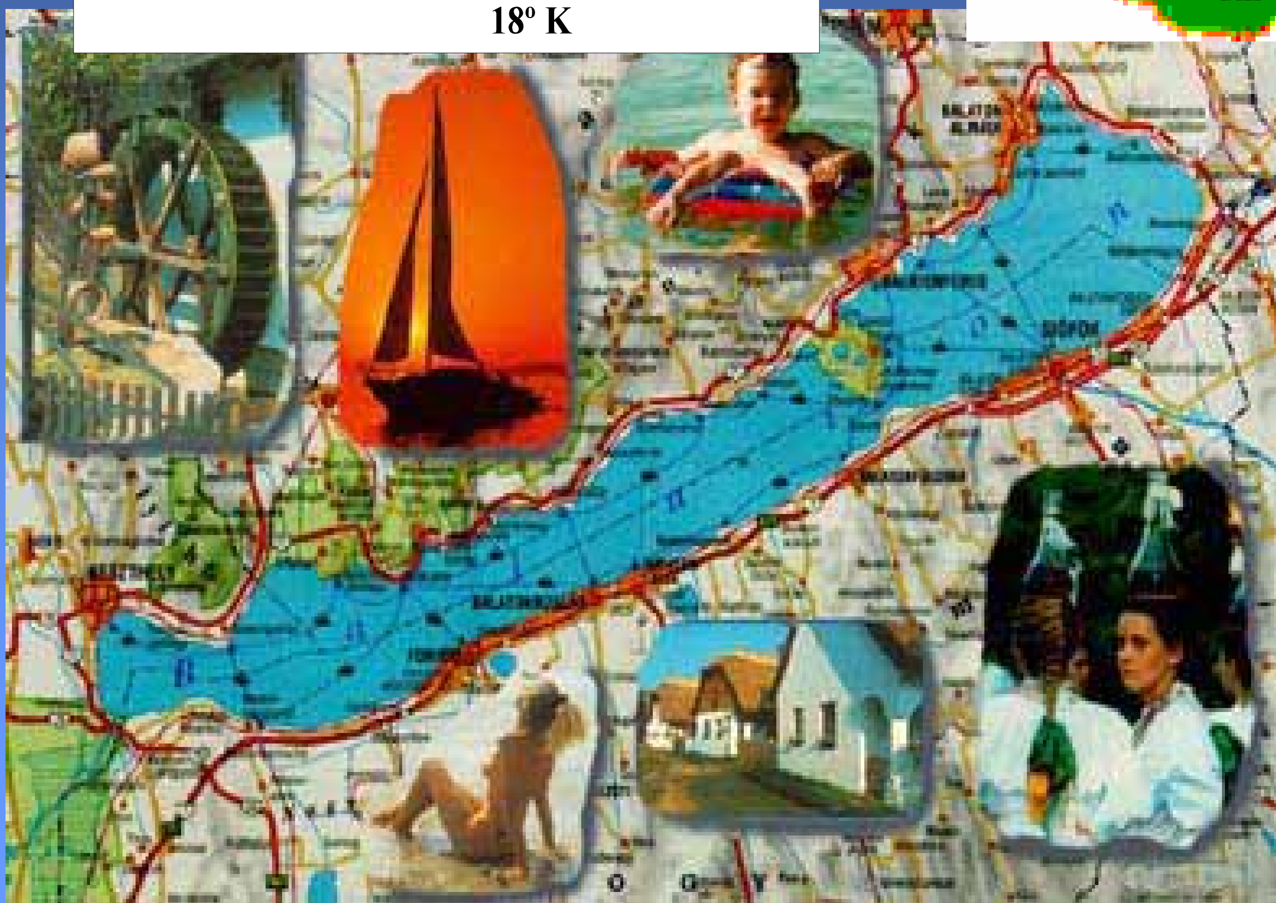




Atmospheric input

- Wet deposition of NO_3^- and NH_4^+
- Dry deposition of particle NO_3^- and NH_4^+
- Net flux of NH_3 (bi-directional)
- Dry deposition of NO, NO_2 and HNO_3
- Possible emission of N_2O (and N_2)

Measurements: March 2002- February 2003

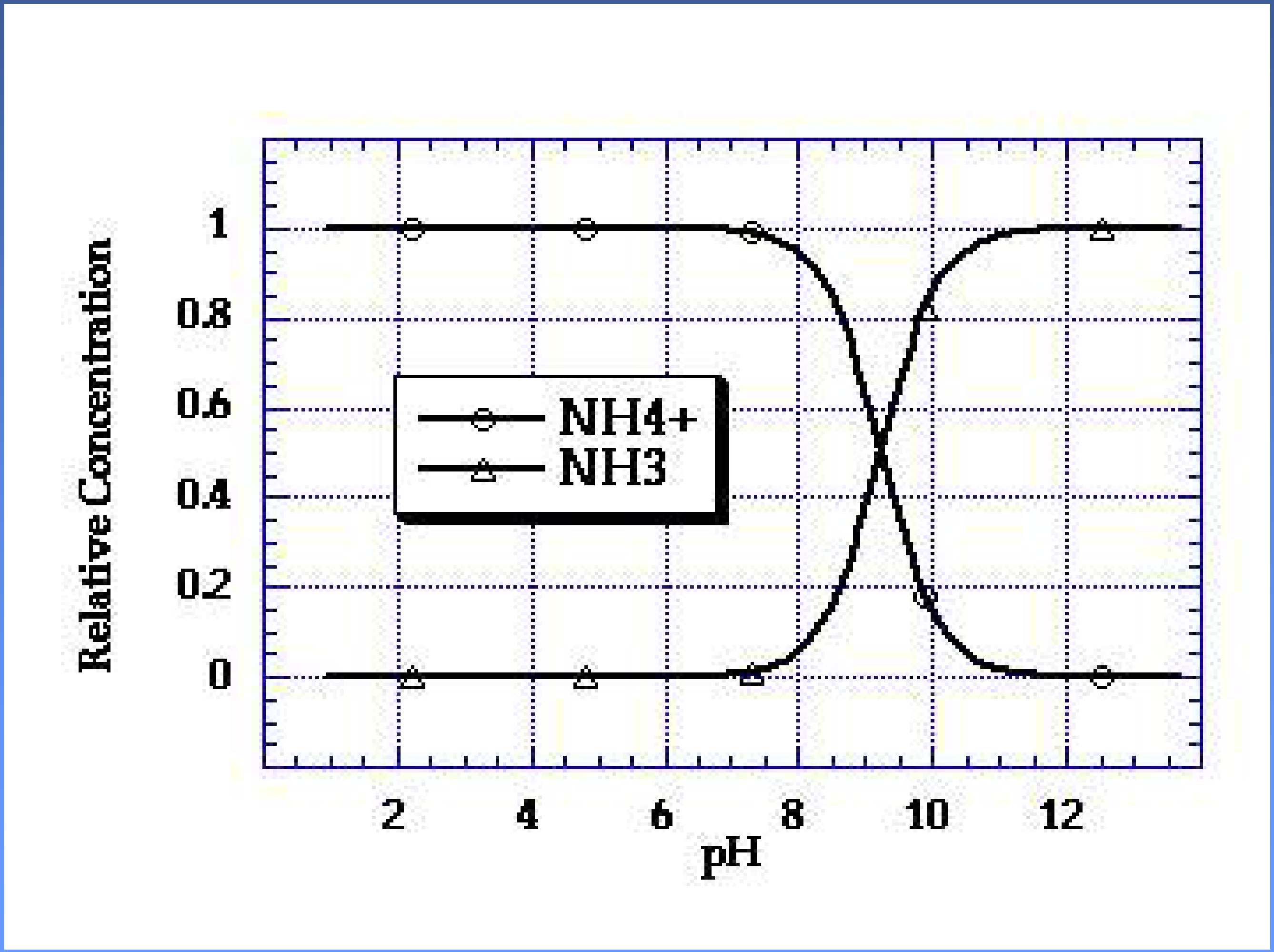
Sampling site near the lake

Sampling site near the lake

Net flux of ammonia

Mean pH of the water is 8.5:

both **NH_4^+ and NH_3** exist, bi-directional flux



Ammonia exchange model 1.

- Flux:

$$F = -\left[C(z_{ref}) - C(z_0)\right]\left(\frac{1}{R_a + R_b}\right)$$

- where $C(z_{ref})$: concentration measured at the reference height,
- $C(z_0)$ the compensation point concentration at z_0

Direction of flux is determined by the difference of $C(z_{ref})$ and $C(z_0)$

Concentration measurements $C(z_{ref})$ (at 12.3 m)

Modelling the resistances and heat fluxes with the measurements

Ammonia exchange model 2.

- Compensation point C (z_0):

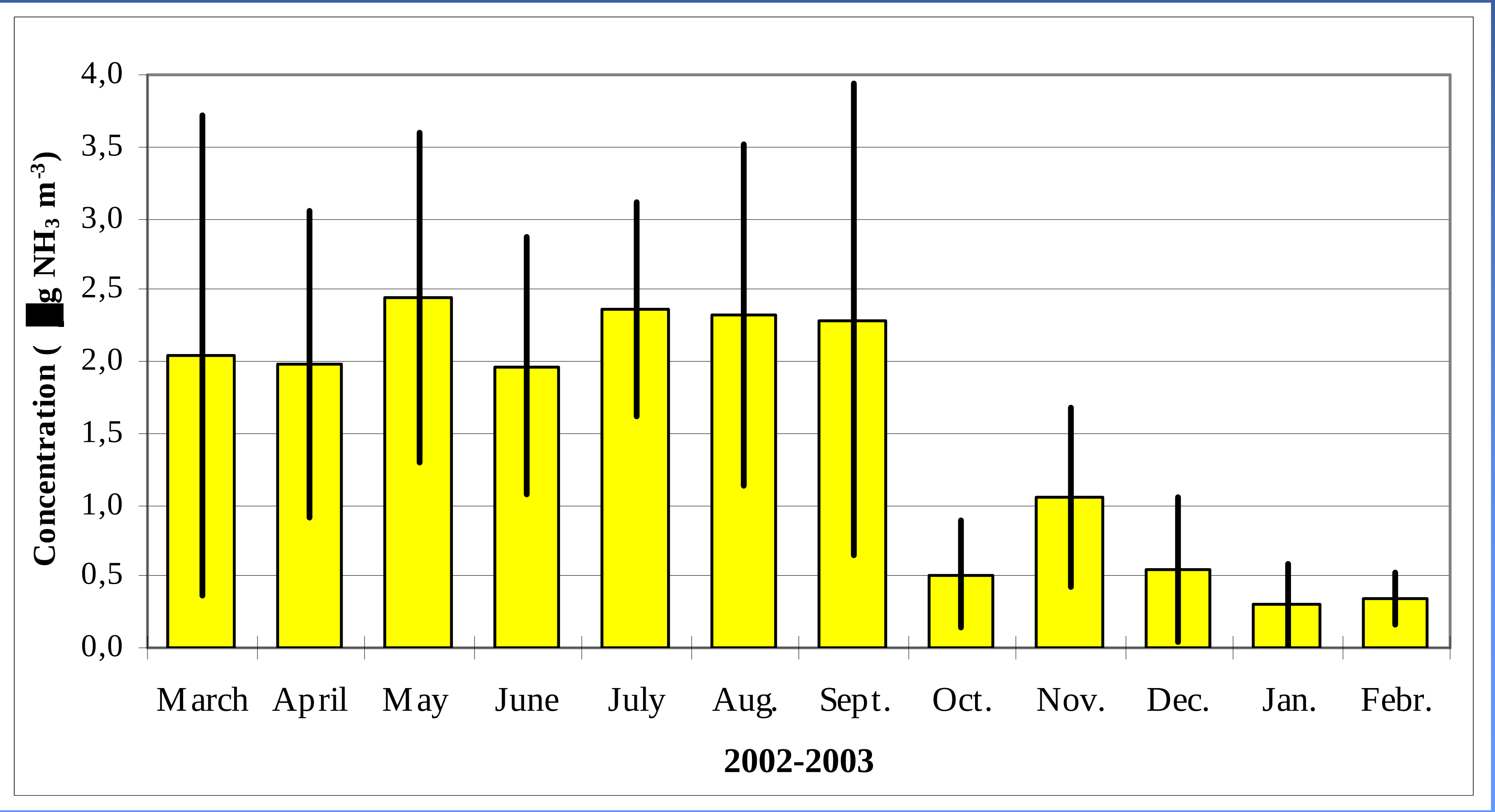
(CO_2 present increases the volatilisation of ammonia, Lau and Charlson, 1977: Atmos Envir 11, 1133-1147)

$$C(z_0) = \frac{C_w \left(H_1 H_2 [CO_2] Q + 1\right)}{H_1 H_2 P [CO_2] + \left(H^+\right) \frac{K}{K_w} H_1 + H_1}$$

P,Q: constant,
H_1, H_2: Henry-constant,
K: NH_3 hydrolysis constant,
K_w: ion-product of water,
CO_2: atmospheric concentration,
C_w: NH_3+NH_4^+ concentration in water,
H^+: H^+ ion concentration.

- Measurement of NH_3+NH_4^+ and pH in the lake water

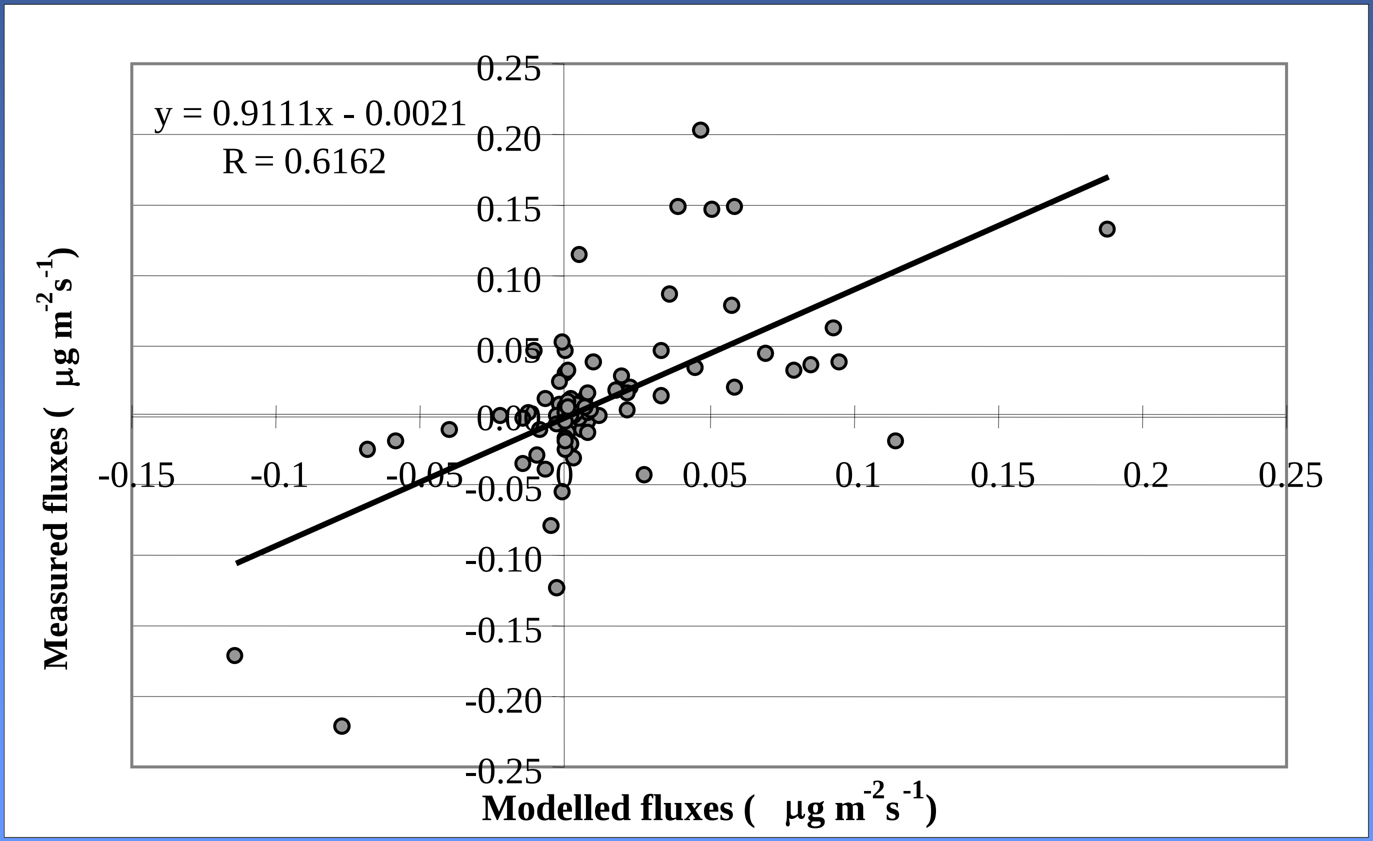
Monthly mean concentration and standard deviation of atmospheric ammonia concentration at Siófok station (near the lake)



Verification of the model

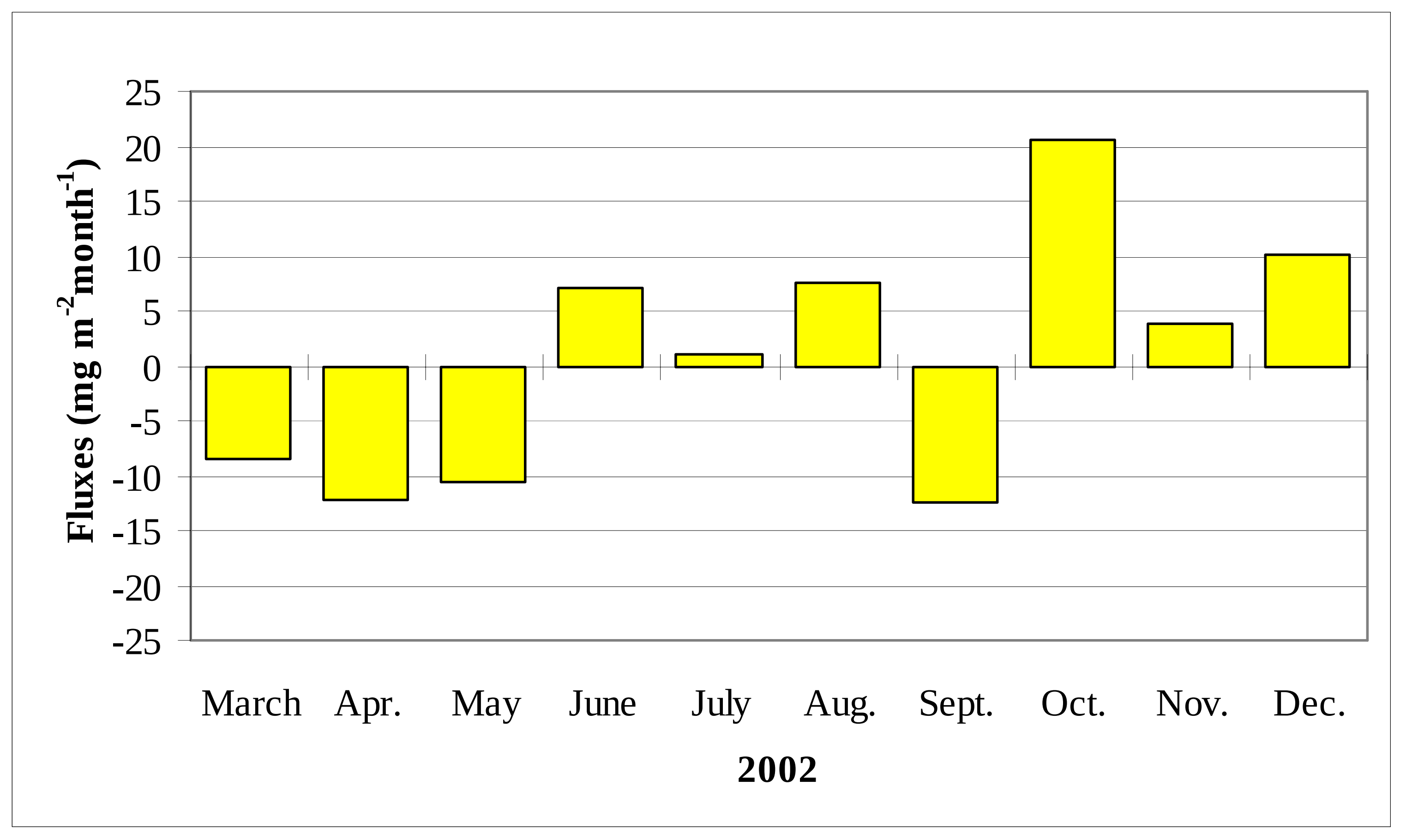
- Model verification with the gradient method during 2 expeditions
- Concentration measurements at 2 levels
- Flux: $$F = -K_H \frac{\Delta C}{\Delta z}$$
- K_H: turbulent diffusion coefficient
- $\Delta C / \Delta z$: concentration gradient

Comparison of the modelled and measured ammonia fluxes



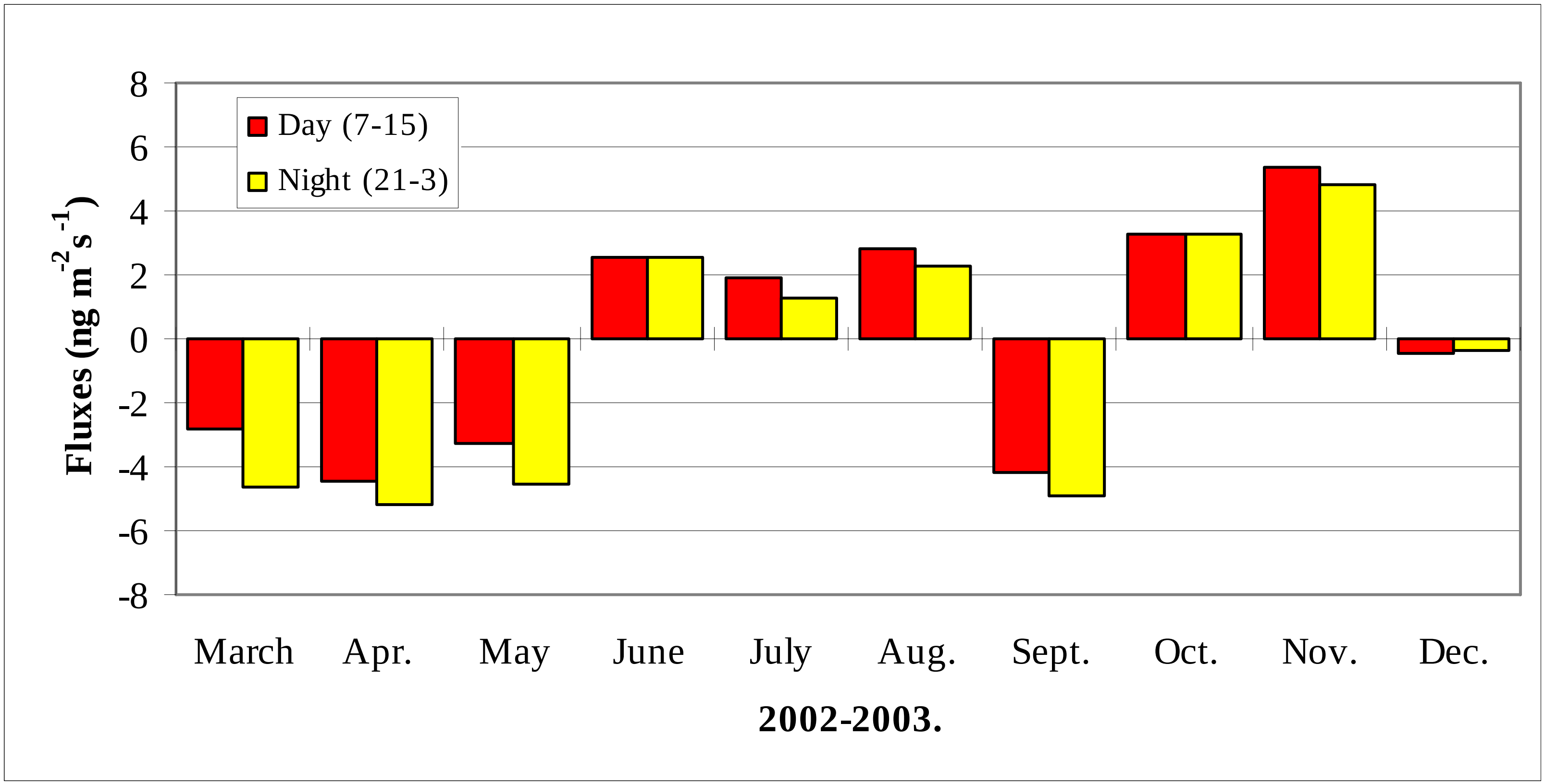
Monthly summarized ammonia fluxes

(lake was frozen up in January, February: no flux)



Day and night monthly averaged ammonia fluxes

(lake was frozen up in January, February: no flux)



Results

Name of the component	Wet deposition (mg N/m^2year)	Dry deposition (mg N/m^2year)	Sum (mg N/m^2year)
Nitrogen-monoxide (NO)	-	<1	-
Nitrogen-dioxide (NO_2)	-	25	25
Nitrate (NO_3^-)	811	7.7	818.7
Ammonium (NH_4^+)	112	11.2	123.2
Ammonia (NH_3)	-	-5.4	-5.4
Nitric acid (HNO_3)	-	31.6	31.6
Sum (N)	923	70.1	993.1

Conclusions

- Wet deposition is dominant (90%) in total atmospheric N-input (1 g N/m^2 yr)
- Ammonia emission is 5.4 mg N/m^2 year negligible
- Ammonia can play a buffering role (negative feedback when emission increases with the increase of N-load from other sources)
- Probably phosphorus is the limiting factor in the eutrophication

Future tasks

- Application for see-air exchange
- Net fluxes of other gases (mainly N_2, N_2O) for the total nitrogen balance