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Uncertainties in the mesoscale modelling of water and nitrogen fluxes

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Water and nutrient fluxes have to be modelled in order to implement the EU Water Framework Directive. The models are needed to determine the probability of nutrients entering the groundwater and surface water.

The snag is that the error rate of model findings is usually unknown. A distinction needs to be drawn between uncertainties about the way processes are modelled internally and uncertainties caused by inaccurate model parametrisation. Here, the latter are dealt with in connection with a study of water and nitrogen fluxes in the 1980s and 1990s in the catchment area of the middle Mulde (2700 km², Hirt 2003). The study is part of the project "Ecological research in the riverine landscape of the River Elbe, No: 0339586", funded by the German Ministry of Education and Research.

The following water and nitrogen models were employed successively:

1. ABIMO, to determine the *total runoff* (Glugla & Fürtig 1997);
2. The *separation of the runoff components* into direct and groundwater runoff after Röder (in BASTIAN & SCHREIBER, 1994) and drainage runoff using a method to determine proportions of drainage area (Behrendt et al. 1999);
3. Linking nitrogen fluxes to the runoff components using a modified method developed by Feldwisch & Frede (1998).

The following calculations of nitrogen losses were carried out while varying the input data:

Calculation 1: Changing the effective field capacity

The effective field capacity was derived using an alternative method based on medium-scale agricultural site mapping (Mittelmaßstäbige Landwirtschaftliche Standortkartierung, MMK) (Hirt 2003). The values were derived for each layer from substrate figures using Method A, and for each horizon of the respective soil type using Method B. The average deviation of the results of both methods is 15%.

Result: Changing the method of derivation the effective field capacity increases N losses by 5% (Figure 1, AC1).

Calculation 2: Changing the amount of precipitation:

The mean annual precipitation was reduced and increased by 7% in line with the error calculated by Kunkel & Wendland (1998).

Result: The changes in the annual precipitation caused a nearly 10% decrease and a 9% increase in the N losses. This alteration of the results is one third higher than the change in the parameter precipitation (Figure 1, AC 2 and 3).

Calculation 3: Changing the nitrogen balance:

Of all the components used to calculate the N balance, the most difficult one to determine is N deposition. Previous investigations (Gauger et al. 2000) take into account both wet and dry deposition. Using the ^{15}N isotope dilution method (integral total nitrogen method) allows to measure total atmospheric nitrogen deposition in the soil-plant system for the first time (Weigel et al. 2001). The results were on average 30 kg/ha*a higher than previous deposition measurements. As regional differentiation is not yet possible, the figures reported by Gauger et al. (2000) were all increased by 30 kg/ha*a. This raised the N balances in the 1980s by 32% and in the 1990s by 71%.

Result: The losses rose considerably – by 41% for 1986-1989 and 105% for 1997 1999. The higher increase in the 1990s loss can be attributed to the lower N balance in that decade and the higher influence of the additional 30 kg/ha*a, as well as to the calculation of the denitrification, which increases subproportional with increasing N balance. The rise in the total nitrogen losses in both decades is superproportional to the increase of the parameter values. Nitrogen losses are therefore highly sensitive to the input parameter *nitrogen balance* (Figure 1, AC 4 and 5).

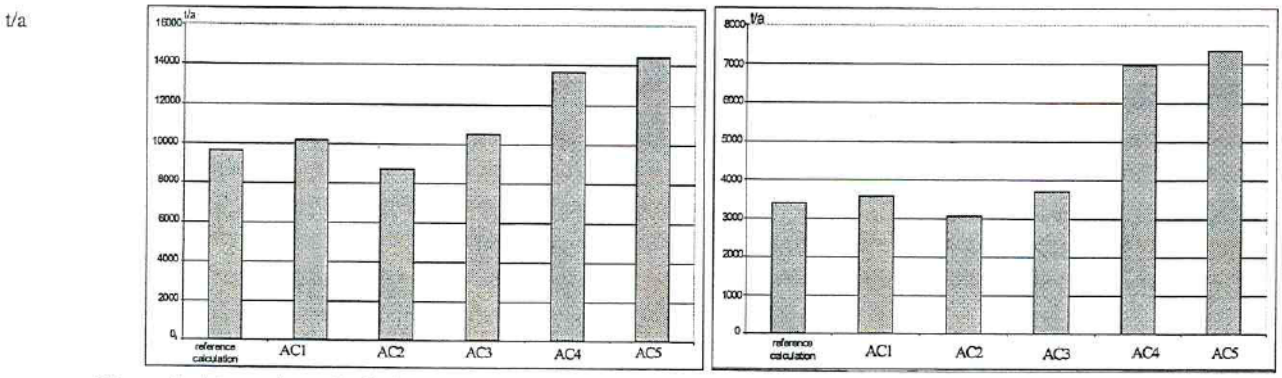

Figure 1: Alternative calculations (AC) to determine the width of fluctuation of the N losses from the soil zone in 1986–89 (left) and 1997–99 (right) (AC 1: Derivation of FK using method B; AC 2: precipitation –7%; AC 3: precipitation +7%; AC 4: N balance increased by 30 kg/ha*a and derivation of FK using method A; AC 5: N balance increased by 30 kg/ha*a and derivation of FK using method B).

Summary: Nitrogen losses have a different sensibility to the input parameters *effective field capacity, precipitation* and *nitrogen balance*. Altering *effective field capacity* leads to subproportional changes in N-losses, while changes in *precipitation* and *nitrogen balance* affected N-losses superproportionally. Especially the calculation of the *nitrogen balance* and its input parameter *atmospheric nitrogen deposition* is very uncertain, because it is on one hand very influential for the results and on the other hand can still not be accurately determined. Thus its quantification provides the highest uncertainty in comparison to other model parameters

Due to the uncertain quantification and the strong effect on nitrogen loss modelling *atmospheric nitrogen deposition* is still burdened with high uncertainties. N-deposition monitoring devices need to be installed in different natural regions and in the presence of different crops so that regional input parameters can be accurately determined.

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