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Response to Comment on "Trend Reversal of Nitrate in Danish Groundwater—A Reflection of Agricultural Practices and Nitrogen Surpluses since 1950"

We wish to thank Dr. T. B. Spruill for his comments on our paper "Trend reversal of nitrate in Danish groundwater—A reflection of agricultural practices and nitrogen surpluses since 1950".

1. Context of Interpretation of Results Shown in Table 1. As shown in Figure 5, the distribution curves of the estimated trends in the three recharge age groups are similar in shape and the youngest groups are shifted leftward. Furthermore, they resemble the curves obtained for three normal distributions with equal standard deviations and unequal means. Thus, Figure 5 supports the underlying assumption of the random coefficient model (PROC MIXED) we used to compare the group mean trends between the three groups. As these assumptions for the random coefficient model seem to be fulfilled, we believe that our analysis has more statistical power than Chi-square tests comparing positive/negative trends, since dichotomizing the trends will induce some degree of (unbiased) misclassification because of sampling errors on the estimated trends. We have not reported the estimated group mean trends, but as can be seen from Figure 5, the overall trend in the youngest group is negative, close to zero in the middle aged group and slightly positive in the oldest group.

2. Methodology and Decreasing Trends Presented in Figure 3. Figure 3 is based on data from the groundwater sampling points in oxic groundwater shown in Figure 2. These oxic groundwater sampling points have been determined by our Danish national monitoring program, and samples are collected at least once per year for main chemical components like nitrate. The nitrate-time-series varies from 8 to 20 years for each groundwater monitoring point. However, the groundwater recharge age was determined at the groundwater monitoring points typically only once in the period from 1997 to 2006, using the CFC method.

The Danish groundwater monitoring program is designed to be representative for different agro-hydro-geo-chemical conditions in Denmark, and the groundwater monitoring points are affected by different types of (1) agricultural land uses, (2) geological settings, (3) hydrological conditions, for example, groundwater recharge rates, (4) depths, and (5) redox conditions as described in the paper. So the program is not directly designed to yield an equal distribution of groundwater recharge years, and groundwater recharge year may therefore be seen as an independently measured variable.

In Figure 3, we are using "groundwater recharge year (CFC-year)" as an independent variable and not "sampling year". This choice allows us to combine nitrate concentrations in groundwater and nitrogen surpluses in agriculture. This explains the unequal distribution of data from year to year.

We decided to use a simple moving-average to show the overall tendency. However, a LOWESS-smooth-curve shows the same tendency and resembles the moving-average-curve.

Instead of using an empirically based splitting of the time (CFC-year) into two halves, we have preferred to estimate this change point with a confidence interval (PROC MCMC). We acknowledge that these methods do rely on assumptions of normal distributions, but we have made probability plots of the residuals and the fits are, to the best of our knowledge, acceptable. Furthermore, the analysis is based on a very large number of observations and the overall analysis should hence be quite robust.

3. Conclusion. We appreciate the comments made by Dr. T.B. Spruill, which have allowed us to further substantiate our points and conclusions as stated above. We, therefore, also regret to inform you that we do not share his criticism of our paper, but firmly believe that our conclusions rest on solid arguments and valid data.

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