

## ***Interactive comment on “A Bayesian Approach to Infer Nitrogen Loading Rates from Crop and Landuse Types Surrounding Private Wells in the Central Valley, California” by Katherine M. Ransom et al.***

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We thank the reviewer for his or her comments on our work. We have attached a revised PDF incorporating our response to the comments. Please see specific responses below.

Anonymous Referee #1 Received and published: 20 March 2017

This study used nitrate measurements from many wells in the Central Valley, CA, to estimate nitrogen loading rate distributions for different crop and landuse types, using

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a Bayesian regression model. After reading the manuscript, I think the author should address the following major concerns. The author mentioned that they developed a novel Bayesian regression model, but since the whole manuscript lacks the introduction to previous statistical methods applied for N loading estimation and the reference of the application of Bayesian method related to the topic, it would be difficult for the reader to sense what the novelty is. The method section describes a lot about the site and data, leaving the statistical method vague and missing the implementation of the Bayesian method and the details (equations and descriptions) of the initial approximation and MCMC method for the posterior distributions. Overall, the manuscript is well-written except for a few results and conclusions not following the rigor of scientific standards (see specific comments). Moreover, some of the results (figures and tables) were not well organized or presented as pointed out in the specific comments below.

Specific comments:

The abstract is too general, and most of the contents seem to belong to the introduction section. Although the author claimed the development of the Bayesian regression model, the abstract did not emphasize the finding of this work using the model. And the focus of the work is clearly not the model development. Response: We agree that the abstract is too general and did not focus on the findings of the work. We have rewritten the abstract to focus more on the need for the study, the novel aspects, and include several sentences to mention specific findings.

P2L8, "Drinking water with nitrate concentrations above background levels of near 1 mg/L ..." What are the 'background levels'? They were not mentioned before. Response: We have inserted a reference for the background level of about 2 mg/L.

P2L19\_20, What is the source of these numbers? Any reference? Response: We have inserted the appropriate references here.

As the author mentioned they developed a novel Bayesian regression model, the introduction should describe the current research status of statistical methods used for

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the related topic, and whether the Bayesian method has been applied in this area. Otherwise, it is hard to tell what the scientific contribution is of this work. Response: Statistical methods have not been used, to our knowledge, to estimate nitrogen loading rates to groundwater. In the introduction we discuss how the previous work in this field is highly limited and mostly based on field studies. We have included some additional description in the Introduction section on the use of Bayesian statistical methods for estimating loading coefficients to surface water, and for nitrate source apportionment. In addition, we include text to point out that Bayesian methods have not been used previously to estimate nitrogen loading rates to groundwater. We have also included an additional section (new section 3.1) titled “Conceptual model” which explains in more detail nitrate transport modeling and the rationale behind the Bayesian method.

P3L17, ‘Spring 2011 depth to groundwater ...’ meaning in the Spring of 2011? Response: That is correct and we feel this description is adequate, we have left it as is.

P4L23\_24, how was the database filtered? why did you use median value, any reason for that? Response: We subset the database in the R statistical program to select only the more recent records (from between 2000-2015). Median value was used to prevent giving more weight to wells that had been sampled more than once by representing them, and the associated land use, with many samples (several wells had yearly or monthly sampling). We believe these methods to be well described in the paper and have left the description as is.

P4L26, ‘4.4268’, how to calculate this ‘mass ratio’? Response: It is the molar mass of nitrate divided by the molecular weight of nitrogen. This is a standard conversion and we therefore removed the reference to the conversion factor and just state that the values were converted.

P4L29, ‘ransom’ → random? Response: We have corrected this typo.

P5L10\_11, what are the soil properties that lead to the same behavior of pesticide and

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nitrate contamination? Or just simply because they are both hydrophilic? Response: We added clarifying text. Shallow water table, short residence time in the vadose zone, and low reactivity in the aquifer materials are key risk factors captured by the GWPA designation used here. Implicitly, but irrelevant to the choice here, it is indeed hydrophilic pesticides that would be the most likely to contaminate a well (as opposed to hydrophobic pesticides). P5L13, ‘raster’ → raster image file? Response: Yes, and we have changed the word “raster” here to “raster image file”.

P5L14, briefly introduce the data sources of CAML. Response: Text added.

P5L34, why is ‘2.4 km’? How to calculate? And why is ‘0.30’ m per year? Response: These are representative values for the Central Valley. Text was rearranged to further clarify and references are included.

P6L13, ‘occurring’ → occurring Response: We have corrected this typo.

P6L5\_17, has CVHM ever been fully tested for the research area? How accurate is this hydrologic model? Any reference? Response: CVHM is a well established groundwater model of the Central Valley. The reference (Faunt, 2009) includes calibration data and established the overall level of accuracy of the model.

P7L13, ‘reflect’ → reflects Response: We have corrected this typo.

P7L9\_16, what are the ‘location’ and ‘scale’ parameters? Student t-distribution has only one parameter, the degree of freedom. Present the equation for the distribution here. Response: We have used the form of the t-distribution containing the location and scale that is more common to modeling approaches. The standardized form of the t-distribution to which you refer, containing only the degrees of freedom parameter, can be converted to the form with the location and scale by the following equation:  $f(x;a,b) = (1/b)f((x-a)/b;0,1)$  Where  $f()$  is the standardized t-distribution,  $a$  is the location and  $b$  is the scale. This gives the equation found here: <https://www.mathworks.com/help/stats/t-location-scale-distribution.html?requestedDomain=www.mathworks.com>. We have in-

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cluded a reference to the JAGS user guide in the text, to refer the reader to the form of this probability distribution used in the study.

P8L5, '(1)' → Figure 1? Response: Yes, and we have corrected this typo.

P8L6, 'non-parametric Kruskal-Wallis test' should be described in the method section. Response: We have added the following two sentences to the Methods section under Well and Landuse data: The non-parametric Kruskal-Wallis statistical test was performed on the nitrate values for wells in each of the two groups (GWPS versus non-GWPA wells). The Kruskal-Wallis test is a ranked one-way analysis of variance which tests whether two groups of values should be considered independent or from the same distribution.

P8L25\_28, 'Pearson goodness-of-fit' and 'standardized Pearson goodness-of-fit' should also be described in the method section. Response: This is described at the very end of the Methods section under subsection Statistical methods.

P9L1\_4, this sentence is too long and unclear. Response: We have made this two sentences and edited for clarity.

P9L29, 'a' → as Response: This typo has been corrected.

P9L31, 'are greater than', why is that? If you wrote something, then discuss it accordingly. Or do not mention it. Response: In an effort to keep the results and discussion sections separate, this is discussed in discussion on page 13.

It should be better to put all comparisons with references in the discussion section, and no reference appears in the results section. Response: We agree and have moved the results paragraphs 6, 7, and 8 to the discussion section and edited for clarity.

P10L16, what is the meaning to put the parenthesis and the statement about alfalfa here? Response: We include this statement to describe why alfalfa does not need nitrogen applications and is expected to therefore have low nitrogen loading rates.

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P11L13, missing the punctuation in the parenthesis. Response: This typo has been corrected. P14L1, 'spatial correlation' does not appear in either results or discussion sections, how is it shown in the conclusion? Response: We agree here and have changed the phrase to "interactions".

Figures Fig. 1 was not referred throughout the entire manuscript. Response: This has been corrected above.

Figs. 2, 3, 5, 6, and 7 need the legends. Response: We have added legends to these figures.

Fig. 4, what are the x-axes? Response: We have edited this figure to include x-axis labels for each plot. Each plot has the same value for the x-axis: the proportion of well buffer area as the plotted land use.

Figs. 5 and 6, if data were not plotted in log scale, numbers in Tables 2 and 3 are repeated. Readers can receive the same information from the figures alone. Figs 5 and 6 can be combined as one. Figs 5, 6, and 7 are hard to read, suggest to change the style to bar plot, with landuse types on the x-axis and N loading on the y-axis. Response: We have reformatted Figure 5 to display the estimated probability densities, with each landuse group a separate plot. This has removed the need for a log scale. We see the data presented in Tables 2 and 3 as useful to the reader and therefore, we have combined Tables 2 and 3. We are unable to combine Figures 5 and 6 due to scaling issues (some direct measurements of nitrogen loading are much greater than our model estimates, and are therefore difficult to display nicely on one plot). We have therefore left Figure 5 and 6 separate, but for Figure 6 we have spread out the data a bit, included more tic marks on the x-axis, and included a legend. For Figure 7, we have also spaced the data out for ease of readability, added tic marks and labels, and included a legend.

Please also note the supplement to this comment:

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<https://www.hydrol-earth-syst-sci-discuss.net/hess-2017-39/hess-2017-39-AC1-supplement.pdf>

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Interactive comment on Hydrol. Earth Syst. Sci. Discuss., <https://doi.org/10.5194/hess-2017-39>, 2017.