'High-resolution monitoring of catchment nutrient response to the end of the 2011-12 drought in England, captured by the demonstration test catchments' by Outram FN, Lloyd C, Jonczyk J, Benskin CMcWH, Grant F, Dorling SR, Steele CJ, Freer J, Haygarth PM, Hiscock KM, Johnes PJ, Lovett AL.

A Summary of the Manuscript's Content

The manuscript describes the monitoring of three streams in England during April 2012. The three streams are the Wylye, Blackwater Drain and the Morland and these drain catchments that contrast in terms of location, climate, soil type, geology and land cover. The data presented describe the changes in the flow and streamwater nitrate, ammonium, total phosphorus and total reactive phosphorus concentrations during a major storm event coming at the end of a major drought. The chemical data were collected using instrumentation deployed on the stream bank and therefore issues with sample degradation were avoided. The measurements were made every 30 minutes and are part of a much larger dataset being collected as part of the Demonstration Test Catchment programme. The streamwater concentrations were set in the context of data collected over one hydrological year by plotting the flows and concentrations on flow-duration and concentration-duration plots. The results of a storm event hysteresis analysis were used to explore transport pathways and sources of inorganic nitrogen and total and total reactive phosphorus during the storm event, and the analysis was also used to indicate whether the diffuse nutrient sources were source or transport limited. It was concluded that source limitation did not occur in these agricultural systems when the frontal system passed in April 2012.

Evaluation

The article presents important datasets and provides interesting and useful insights into the hydrochemical dynamics during a storm. The subject of the paper is of definite interest to the readers of HESS and a broad international audience, and these new data add to our understanding of catchment hydrochemical functioning. Before the paper can be accepted, I feel there are a number of major issues that need to be addressed by the authors regarding the work, and therefore this review focuses on points of clarification, rather than an in-depth discussion of the results.

General Points

1. The title reflects the contents, though it seems unnecessary to include 'demonstration test catchments' at the end. If this is to be kept, then capital letters should be used: 'Demonstration Test Catchments'.
2. The abstract alone is sufficiently informative, even when read in isolation, however there is an (over)emphasis on describing the supporting research programme which is perhaps unnecessary and makes the abstract too long. The same issue occurs in the introduction.
3. One of my main concerns is that I do not feel the overall aim of the paper is made clear. What do the authors hope to gain by studying the effects of the same frontal system moving over the three catchments that could not be done by looking at all the extreme events in the data collected since 2011? If it is because of the highly unusual nature of the April 2012 event (coming at the end of prolonged drought), then the analysis needs to account for the different antecedent conditions, reported on page 15128, line 20 to page 15219, line 18. There appears to be an assumption that all three systems are at a similar baseline at the onset of the rainfall event on the 25 March 2012, but I am not convinced by this. For the Wensum, higher rainfall values were reported for March, 2012 than at the other two study sites. The authors note 'The Wensum DTC, by contrast, was already exhibiting relatively high flows before the first event (5.9% exceedance), due to heavy rainfall at the end of March and continued wet conditions in April 2012.' (page 15129, lines 10-12). The different baseline conditions need to be accounted for in the analysis and these differences make comparison difficult and must have an effect on the interpretation of the nutrient transport behavior in the dry-to-wet transition.

4. As only one event is described in detail, it is difficult to know if the behavior reported in each of these systems is typical, or not. The flow-duration and concentration-duration curves show that the flow and chemical response was extreme within the year, however there is no sense of what the flow and streamwater concentration dynamics are like in general. Given the variation of chemical response expected and the extent of the dataset with measurements made since 2011, it appears a major limitation not to have explored the full dataset to comment on the range of storm responses to provide a comparison with this extreme event (see specific comment 9).

5. I am not sure why the authors have modelled the rainfall event when they have tipping bucket gauges in each catchment. The data from the gauges do not appear to have been used other than in Figure 2.

6. The catchment descriptions are too brief. There is no overview of how the hydrology or hydrochemistry compares across the three study sites. This is important given the paper is about comparing the flow and chemistry response to a single storm event across the three different sites. Without a discussion of the normal hydrological regime of the individual catchments it is difficult to distinguish differences in storm response between the catchments. Much is made of the importance of fertiliser applications controlling the concentration changes, but there is only a limited description of the land use and no data on fertiliser application rates within the catchments. There is no detail on point sources; the work seems to focus on diffuse sources only. Does effluent, either from sewage treatment works or septic tanks, influence the observed chemical dynamics? The cause of the nitrate rich baseflow in the Hampshire Avon is not really discussed. Is the resuspension of bed material important for explaining the phosphorus dynamics?

7. There seems to be some confusion as to whether the Blackwater, a tributary of the Wensum, is the study site or the Wensum itself. This is important because the geology seems to be quite different in the Blackwater from the rest of the Wensum. The references to the 'Wensum DTC', 'Eden DTC' and 'Hampshire-Avon DTC' rather than the name of the study site causes confusion because it is unclear if the authors are referring to the larger catchments of the Wensum, Eden and Hampshire-Avon or the smaller study areas where the sub-daily measurements have been made.

8. I would recommend that a section is included on the quality assurance of the sub-daily data. How robust are these data compared to laboratory based analyses. Were corrections made for temperature effects or drift?

9. The storm event responses are described in great detail but I'm not sure if all this detail is relevant. Could the paper be made shorter and more focused by reducing the level of detail in the results section and drawing out the salient points, and then placing the results in the context of other storm events measured since 2011? This would be very interesting.

10. Given the focus of the paper is a comparison of the response across the three sites, it might be better to cut down the description of the individual storm responses and focus more on this comparison. In addition, I'm unsure what new has been learnt about storm event responses in these catchments, or how the findings fit into the context of the broader literature (e.g. Ferrant et al., 2012; Melland et al., 2012, Mellander et al, 2012a, b and the list of references given the paper). Please can the authors put the results into context? It would be excellent to see if these results confirm or contrast with other studies.

11. I feel the conclusions require further consideration as I do not believe that all the potential nutrient sources have been fully evaluated in the interpretation of the results. For example, there is little consideration of effluent from sewage sources or septic tanks, or of inputs of groundwater enriched by nitrate in the Chalk dominated catchments.

12. Table 3 is not necessary. Loads are presented in this table, but loads are not considered in the aims, discussion or conclusions.

13. Figure 8. The results for total phosphorus in the Hampshire-Avon look odd in that the maximum concentration appears to be exactly 1 mg P l^{-1} and the measurements seem to remain constant at this concentration even though the flow decreases from approximately 1.7 to 0.7 m^3s^{-1}. Is this a data transcription error or is it suggesting exhaustion of supply (see specific comment 22)?

Specific Points

1. 15214, 23-28. Is the reference to the examples from Australia and Ireland relevant? The details regarding the Demonstration Test Catchments add to the length and it is unclear why these are needed in the context of this article.

2. 15215, 3. 'Numerous authors' is rather vague. Please could you be more specific?

3. 15215, 19. Did all three catchments experience drought stress and then flood conditions? What were the hydrological conditions in all three catchments prior to, and after, the storm?

4. 15217, 27. What does 'ARW' stand for? Please could you define acronyms on first use?

5. 15128, 4. Please don't use colloquial terms such as 'nudging towards'. What is meant here – bias correction?

6. 15128, 12. What is the definition of 'winter 2011-12'? Is this December 2011 to February 2012? I thought that March 2012 was also dry in some catchments. Please could you clarify the period that you are considering?

7. 15128, 20 to 15219, 18. These lines suggest that there were differences between the antecedent conditions in the three study sites. How did this affect the results? Does it really matter that you have captured the same weather front as this will manifest itself in different ways in the different catchments. The key is measuring the transition from very dry to wet conditions in a short space of time, but what will this tell us that other analyses of storm event responses haven't done already? Please could the authors explain?

8. 15219, 23-26. Could the high nitrate concentrations in the Wensum be due to the transport of groundwater, enriched with nitrate, from Chalk?

9. 15130, 15-29. Again I would suggest that nitrate enriched groundwater is an important source of nitrate in the Hampshire-Avon and Wensum, which are both predominantly Chalk catchments.

10. 15131. Be careful with precision here. Can you really quote runoff to 0.01 mm per hour?

11. 15134, 4. Change 'NRL' and 'NFL' to 'N_{RL}' and 'N_{FL}'.

12. 15134, 6. What is meant be 'more hysteretic'? Do you mean a greater difference between the concentrations on the rising and falling limbs of the hydrograph?

13. 15135, 3. Are the dilutions caused by relatively clean water entering the system and diluting effluent inputs? The authors acknowledge that sewage will affect the ammonium concentrations, but why is sewage not important for nitrate and phosphorus?

14. 15135, 4. Are the increased concentrations caused by the flushing of mineral N from the upper soil layers, or is it the input of groundwater enriched with nitrate?

15. 15141, 1-13. Was the pre-storm period drier than 1997, or wetter?

16. 15142, 7-10. How can you be sure that you are separating the effects of transport- and source-limitation? Please could a note be added to the methods section? Would it be useful to refer to the paper by Evans and Tranter (1998)?

17. 15143, 7-8. A hydrological year is not very long in terms of capturing a good representation of the full range of hydrological conditions. If you look at the series of storms in one hydrological year you will gain a better understanding of the dynamics, though you won't capture the full range of conditions.
18. 15144. 25-27. I would suggest that to understand sub-hourly data you need long-term, low frequency data to determine the context of the sub-daily dynamics.
19. 15145, 16. What is the evidence for transport limitation?
20. 15145, 17. Wensum – is it drainage, or groundwater nitrate?
21. 15145, 26. No nutrient exhaustion, but TP in the Hampshire Avon maxed out at 1 mg P l^{-1}, does this indicate that there might be some exhaustion of supply?
22. Table 1. The geology is described, but not the soils. Is the elevation the mid-point of the catchment? Please could the elevation be specified as a range?
23. Figure 1. The catchment areas of the Eden, Wensum and Hampshire-Avon are shown on the map, but these are different from the study areas, which are much smaller.
24. Figure 4. It would be better to present the flow-duration and concentration-duration plots on a normalized scale, so that the extremes can be seen more clearly?

References

Evans, C. D. and Tranter, M. D. 1998. Causes of concentration/discharge hysteresis and its potential as a tool for analysis of episode hydrochemistry, Water Resour. Res., 34, 129–137, doi:10.1029/97WR01881, 1998

Ferrant, S., Laplanche, C., Durbe, G., Probst, A., Dugast, P., Durand, P., Sanchez-Perez, J .M., and Probst, J. L. 2012. Continuous measurement of nitrate concentration in a highly event responsive agricultural catchment in south-west of France: is the gain of information useful?, Hydrol. Process., doi:10.1002/hyp.9324.

Melland, A. R., Mellander, P.-E., Murphy, P. N. C., Wall, D. P., Mechan, S., Shine, O., Shortle, G., and Jordan, P. 2012. Stream water quality in intensive cereal cropping catchments with regulated nutrient management, Environ. Sci. Policy, doi.10.1016/j.envsci.2012.06.006.

Mellander, P.-E., Jordan, P., Wall, D. P., Melland, A. R., Meehan, R., Kelly, C., and Shortle, G. 2012a. Delivery and impact bypass in a karst aquifer with high phosphorus source and pathway potential, Water Res., 46, 2225–2236.

Mellander, P.-E., Melland, A. R., Jordan, P.,Wall, D. P., Murphy, P., and Shortle, G. 2012b. Quantifying phosphorus and nitrogen transfer pathways in agricultural catchments using high time resolution data, Environ. Sci. Policy, doi:10.1016/j.envsci.2012.06.004.