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Interactive comment on "Is groundwater sufficient to support sustainable irrigation agriculture in a reclaimed wetland region?" *by* Z. Pang et al.

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General comments: Pang et al. present a manuscript describing their study which employs isotopic tracers to examine the prospects for sustainable groundwater usage in agriculture in an area of reclaimed wetland in northeast China.

Overall, the methods adopted here are not particularly novel (many other studies have been published using similar tracers), but the study is potentially of international significance, given the importance of groundwater sustainability in agriculture in northern China - a region of globally significant agriculture facing a major water crisis. The sampling and analytical campaign is well-designed and the data-sets are of good quality. The paper is generally well written (although there are sections that need some improvement), and the figures clear and informative.

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However, there are deficiencies which I believe need to be addressed prior to publication. In particular, more rigour is needed in the processing and interpretation of the isotopic tracer data. Limitations of the methods used to arrive at estimates of groundwater age and categorisation of water into 'modern' and 'pre-modern' need to be acknowledged and discussed in much more detail. The links between groundwater and surface water also need to be more clearly demonstrated with reference to the data and figures (such as maps and spatially referenced comparisons between surface water and groundwater levels). The discussion is also too brief and lacks depth and detail at this stage. The link between groundwater age and recharge mechanism, and groundwater sustainability is not explained clearly enough. Are the authors proposing that low recharge rates and a lack of tritium indicate 'pre-modern' water in the confined aquifer, and thus that there is a limit to the sustainable extraction rate from this system? If so, this should be carefully explained and the potential for 'capture' of water from other areas (and release of water from aquitards) explored. There may be water quality implications for high rates of groundwater extraction also, as documented in Currell et al. Journal of Hydrology 385 pp 216-225. With regard to the unconfined aquifer, it appears that there is active recharge, on the basis of high nitrate and tritium concentrations observed in shallow groundwater. Is this attributed to recharge through irrigation return leakage, rainfall recharge, surface water leakage, or some combination of the three? Is groundwater quality a limiting factor for the utilisation of the unconfined aquifer groundwater (e.g. because of the high nitrate concentrations)? These issues should all be clearly explained with reference to the data and more detailed discussion of the trends observed in different parts of the study area. I think some further figures such as maps showing the distribution of tritium and perhaps nitrate in the aquifers will be illustrative of the areas where recharge is actively occurring.

If these issues (and the specific comments below) can be addressed, along with some required technical corrections, I believe the paper may be suitable for publication.

Specific comments: The editor has noted that the authors need to provide background

on the purpose of each analysis and more detail about the stable isotope evaporation model and tritium decay model. These areas have been addressed to some degree. However, I question how robust the use of the Ottawa tritium in precipitation record is for the study area, given there have been only 4 samples collected at the local IAEA station for comparison. The 'latitude effect' is not clearly explained; do you mean that because the two stations are at similar latitude we can infer the tritium records are expected to be approximately the same? Some explanation and one or more references for this assumption is needed here. It should also be made clear that the age estimation using tritium is only a semi-quantitative tool (as the 3H-He method is not adopted).

Abstract The abstract needs some more reference to the data and more context. e.g. Is groundwater quality the limiting factor for groundwater utilisation from the unconfined aquifer? If so, then what particular aspects of water quality are important? What is the link between groundwater age and recharge mechanism, and sustainability of groundwater usage? For example, groundwater extraction from the confined aquifers will induce flow and leakage from other areas, is the quality of the induced flow a potential limiting factor (as in other areas in China)?

Introduction The introduction and background information are concise and generally informative.

Methods Further information is needed on the sample collection methods for groundwater and surface water. Are the groundwater samples from production wells, or monitoring wells? What is the range of sample depths and screened intervals? For surface water, were the samples 'grab samples'? If so, at what time of year were they taken? This may impact whether the samples represent recent runoff, snow melt and/or water impacted by evaporative enrichment.

The LMWL should be calculated using a weighted regression method, as described in Hughes and Crawford, Journal of Hydrology 464-465 pp 344-351 (2012), rather than simple linear regression.

Results The relationship between lithology and ion composition (e.g. Ca) should be discussed and examined in more detail. Are carbonate minerals in the soil and/or aquifer the likely source of Ca? Is fertiliser a potential source also? A plot of the Ca vs 13C isotopes would be helpful in this context. You may also consider including and discussing the full dataset on water major ion chemistry, and discuss TDS distribution in the aquifers.

Plotting tritium and carbon-14 data vs sample depth would be useful, and also plotting tritium concentrations on a map. This would allow better assessment of where spatially the recent and 'pre-modern' water samples are distributed with respect to current agricultural irrigation areas, and it will help to better identify areas of 'active recharge' as distinct from those not receiving such recharge.

Discussion The writing in the discussion needs some further improvement; technical corrections are suggested below but these are not exhaustive.

-When discussing 'vertical infiltration' as a recharge mechanism (e.g. p. 10) you should distinguish between recharge due to rainfall infiltration and/or irrigation return-flow, and recharge from surface water bodies such as rivers. -The use of the tritium/radiocarbon plot to estimate initial activities of 14C has some merit, however it should be conducted more rigorously, explained in more detail, and used with some caution. Are you using a linear extrapolation between 'modern' and tritium free water in the various samples to arrive at the initial pMC of approximately 80? What about the influence of mixing between 'young' water and older water (which should produce a straight line relationship, as opposed to a decay-based curve)? Decay and mixing will produce different patterns in 3H and 14C and this needs to be carefully analysed. For further detail refer to Cartwright et al, Journal of Hydrology 380 pp. 203-221 (2010), particularly Figure 8. The use of this method does not discount the need to assess other potential sources of DIC and influences on initial 14C activities. A plot of the 13C vs 14C data is needed, as is some further analysis of the ion chemistry (e.g. Ca vs 13C) to shore up this area. -As indicated above, the link between groundwater age, recharge and ground-

water sustainability is not explained clearly enough. You need to put more work into defining (on your maps) where groundwater is influenced by direct vertical recharge, river recharge and lateral recharge, and discuss the water quality implications of these different mechanisms. Where in particular do you think the extraction rates for groundwater are likely to be much greater than recharge? What is the likely response of the aquifer(s) to extraction and is there any water level data to show what is happening currently? What are the likely water quality implications of extraction from different aquifers and depths (see previous comments)? -Overall the discussion is too brief, and further discussion of limitations of your isotopic data, and alternative explanations need to be explored and discounted.

Technical corrections: p2 Line 10 'Recharge and regime', do you mean 'recharge and groundwater flow patterns'? Lines 11 & 12: Grammar is poor. Do you mean 'with ages over 50y is recharged by lateral flow..as evidenced by depleted heavy isotopes'? Which isotopes (I assume 18O and 2H)? Line 27: Citation (Assessment, 2005) is incorrect. A suggested citation format is given in the front matter of this report. P4. Line 22: Suggest using ML rather than mega-L P5. Line 2: 'hydrogeology' should be 'hydrogeological' P6. Line 19-20: Can remove the statement 'our current efforts...tracers'. It is better to clearly outline your study aims and scope in the introduction section

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