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Hydrology and Earth System Sciences Discussions

Interactive comment on "The dynamics of cultivation and floods in arable lands of central Argentina" *by* E. F. Viglizzo et al.

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General comments

The paper presents some new, interesting and intriguing findings relating to long-term fluctuations in rainfall, groundwater levels and cultivation of crops in both the highland and lowland parts of a catchment in Argentina. It is appropriate for publication in the journal but will need some additional work before I believe it will be ready for publication. The methods are generally well explained and the literature that is cited is generally appropriate.

Analyses of long-term data sets like these are relatively rare but can often provide useful insights. The authors present two theoretically and logically defensible hypotheses as alternative explanations for the observed patterns. They initially present these as two opposing hypothesis but I agree with their comment that they are in fact both having an influence and may even be synergistic. The patterns in the highland part of the catchment appear to support their hypothesized interactions between multi-year rainfall cycles and the impacts of the changing area under cultivation, but the data for the lowlands do not. They have difficulty in explaining the causes for this anomalous behaviour and offer some not altogether satisfactory explanations. Their findings are surprising and at odds with expectations, but I think this may be due to unexplained patterns in the data and discuss these in my specific comments below.

Specific comments

The first problem I have with the analysis is this: although the patterns in the data seem to suggest that there are clear lags in the groundwater responses to the rainfall (see Fig 3), the authors barely mention them. For example, in the highland data there seems to be a lag of about a year between groundwater responses and rainfall (e.g. 1986, 1997). The groundwater responses also are smoothed relative to rainfall (which I would expect) but more so than I would expect (e.g. the smooth rise in groundwater levels from 1997-2001 despite marked rainfall cycles). The same is true of the lowland datasets. These lags need to be considered in deciding how to analyse the data. At the very least the authors should test correlations in the data using different lag periods to see if this resolves some of the strange patterns, especially in the lowlands.

The second problem I have is with anomalies in the data which also need explanation. For example groundwater levels in the lowlands fluctuate markedly from 1978-1987 despite a lack of similar variations in rainfall. There is also a drop from 1986-1987 despite an increase in rainfall. The lowland groundwater levels do not respond at all to variations in rainfall from 1998 onwards. This is despite a decrease in the cultivated area which should have increased groundwater levels if their hypothesis holds. There are obviously things happening in the catchment, and to groundwater levels, which

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are not the simple result of rainfall or changes in cultivation and the authors need to consider how to deal with them. For example, are these anomalies consistent over all the sub-catchments (boreholes) or confined to a few of them? Could any of them be due to groundwater abstraction?

The authors suggest that the flooding eventually recedes because the increasing extent of surface water bodies results in increased evaporation. This is plausible where there is a concurrent decline in the rainfall, but I would like to see some estimates of what the potential evaporation losses could be and whether they are sufficiently large to account for this. It is possible that PEt could be high given the seasonal rainfall, likely temperatures and high wind speeds but it would be useful to have some specific data.

The map the authors provide focuses only on the lowland section of the catchment which makes if difficult for those who do not know the area to form a mental picture of the whole catchment and how the section in Fig 1 relates to the rest topographically and hydrologically. For example where does the Quinto River flow to and does it have any tributaries in this area? Given the extremely flat nature of the lowlands and the “active” groundwater systems, how well defined is the catchment boundary in such flat terrain? How strongly does surface elevation determine subsurface flow patterns? Could any of the anomalies in the highland or lowland data (noted above) be due to subsurface flows between adjacent catchments?

It is not clear to me why the authors use administrative boundaries rather than hydrological or geohydrological boundaries to delineate subunits for analysis or simply treat each rainfall and groundwater level as a separate record (subdivided into highland and lowland as appropriate).

I think the authors perhaps make too much of the points made by Andreassian in his excellent 2004 review. There are other papers, most notably the ones by Bosch and Hewlett (1982 J Hydrol 55: 3-23, Zhang et al 2001 Water Resources Research 37: 701-708, Brown et al. 2005 J Hydrol ##: 1-34), which show much more consistent

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patterns and marked differences due to vegetation structure, root depths and evergreeness. Calder (1998 Tree Physiol. 18: 625-631) presents some hypotheses on limits to evaporation that support the authors arguments using some basic physical and physiological principles.

Technical corrections

Table 1 actually presents the linear regression statistics and not just the correlations and the caption should be corrected. The normal terminology for the linear regression is: y=ax+b where y = dependant, x = independent, a = coefficient and b = constant. It would also be more useful to have the correlation (r) which includes the sign of the relationshop (+ or -) rather than the coefficient of determination (R2), and whether the coefficient and constant were significantly different from zero.

Are the arrows in Fig 1 actual streams or groundwater flow directions? If the latter, are they based on surface elevation, aquifer elevation data or water table gradients?

The differences in slope above and below the 110-120 m contour could be shown more clearly by producing a slope class map at least for the portion of the area shown in Fig 2.

I presume that the units for groundwater are meters below ground level. If so, this should be stated on the axes in the Figures.

There are some places in the MS where it was difficult to follow what the authors were trying to say. There are some typographic errors. I think these should be dealt with once the major issues described above have been resolved.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 5, 2319, 2008.