

## ***Interactive comment on “Orbital changes, variation in solar activity and increased anthropogenic activities: controls on the Holocene flood frequency in the Lake Ledro area, Northern Italy” by B. Vannière et al.***

**G. Benito (Referee)**

benito@ccma.csic.es

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The article entitled “*Orbital changes, variation in solar activity and increased anthropogenic activities: controls on the Holocene flood frequency in the Lake Ledro area, Northern Italy*” is a study that combines classic sedimentological descriptions of lacustrine facies and geochemical data with an innovative method to count floods based on colourdataset processing of the sediment core images. Vannière et al. have presented an interesting Holocene flood record and provides a human and climate interpretation for it. In my opinion the strength of the manuscript relies on i) the high resolution flood

C2121

record and ii) the interesting method they have used to difference the lacustrinefacies, including endogenic and allochthonous sediments. However, I miss further explanations in the facies description and ask the authors to reconsider some climate interpretations. For this reason I think that the manuscript merits to be published in *Climate of the Past* although with major revisions addressing the comments listed below:

### **General comments:**

1. It is evident that the authors did not prepare the manuscript for submission carefully at all:

-There is neither line nor page numbering.

-Authors do not reference the figures adequately in the text. i.e Fig 2b cited in the text before 2a, Fig 8 before Fig 7

-References do not follow a similar format, and some of them are missing both in the text and in the reference list

-Figures are not numbered

Once corrected these edition mistakes, I would suggest the revision of the manuscript by an English native speaker. The English is readable but it could be improved considerably.

1. The background sediment faciesdescription is not entirely clear to me. Are the calcite and organic debris layers annually laminated? You do not state this in the text but in Wirth et al. (2012) –a workshop contribution mentioned in your reference list- they describe it as avarved record in the title. The authors hypothesize with the seasonality of the floods but, in my opinion, there is a big assumption in this. Seasonality of paleofloods is very difficult to know and it is only possible to confirm it with an understanding of the sedimentary record base on microscopic

C2122

inspection of thin sections and/or sediment traps in order to know the sediment dynamics during the annual cycle. The authors suggest that the calcite layers are deposited in spring during the increase in biological activity in the lake, is there any previous study about it? how do you know that there are not algae diatom blooms favouring calcite precipitation during autumn?. On top of that, you mention that the top clayish layer form the flood deposits are difficult to distinguish from the organic debris layer. Then, how can you say that flood layers are topped with the organic layer debris if you cannot difference them? If the authors do not provide more sedimentological information and additional description concerning to the lake sediment dynamics I would strongly suggest to delete the seasonality interpretation of the flood record in the manuscript and the climate implications (i.e., NAO as a forcing mechanism controlling storminess in the area)

2. This manuscript is a core based study from two long sediment cores retrieved in proximal and distal areas. I miss an additional figure showing both Holocene sequences (not just the gravity cores) and their correlation. This figure should also incorporate the 14C ages and lithological columns (and perhaps additional colour-based proxies discussed in the text). Perhaps a new figure 1b below the seismic profile..

As the figures are not numbered it is difficult to follow the paper. Where is figure 3b (threshold value with a Gaussian mixture model)??

1. You have presented a  $^{137}\text{Cs}$  chronology with a possible slump affecting the top-most sediments. I wonder, correcting the sediment duplicate, if you could compare flood deposits with the instrumental record or direct measurements in gauging stations from the rivers feeding the lake. If the sediment record has an annually lamination it could support the interpretation of the so-called flood deposits. I am aware that this is a difficult task because of the lake sediment dynamics

C2123

alterations due to the construction of the pumped-storage plant, but large floods should also be recovered during the XX<sup>th</sup> centuries besides anthropogenic disturbances.

2. I ask the authors to reconsider the climate interpretation of the paleoflood record based on the frequency of allochthonous detrital events. The authors link the increase in flood frequency during the Late Holocene with a decrease in a seasonal contrast of insolation, which started several centuries before the increase in flood frequency (in graph 8 it seems to be a delayed response of ca 500 years). Magny et al., 2012 already shown this control for the long term development of higher lake levees in Lake Ledro. Nevertheless, the authors do not provide either an explanation of the time delay nor climatic explanations for the increase in the storminess in relation to the orbital forcing at a millennial scale.

In the other hand, authors should first consider the human control on the flood frequency and not only on the amount of sediment delivery to the lake because of changes in land use and deforestation. They have found nice evidences of human occupation during the Bronze Age in the Lake Ledro shoreline coinciding with the increase in the flood deposits frequency. In my opinion, this would enhance the effectiveness of the lake system to record flood deposits under a strong anthropogenic influence in the lake catchment that would increase the sensitiveness of the lake to record smaller precipitation events hindering the climate signal.

#### **Specific comments:**

I include some specific comments, as the manuscript is not numbered, I will try to allocate them according to the page and line number and/or sections of the pdf I have received.

**Title:** I would delete orbital forcing from the title

C2124

*Abstract:* Modify according to the general comments suggested above. Make it shorter  
1pag; line 15: Late Holocene instead of last third of the Holocene

**Introduction:**

2pag; lines 21-28. Authors discuss that during the Holocene Thermal Maximum, southern European ecosystems experience great changes that contrasts with the Bronze period, that experience a social development. What do you want to say? Please, rewrite it.

2pag. Line 23: change Matthew et al., 2008 for Matthews and Dresser (2008).

2pag. Line 27: You cited a PAGES newsletter article (Canniere et al., 2010). It is a not index journal without a proper reviewing process. I suggest deleting this reference.

2pag. Line 31: delete "anthropogenic"

3 pag. Line 13: change "detritital" for "detrital"

**Material and methods:**

*Study site:*

I do not understand why the study site is in the material and methods section. In addition, I find the climate description of the study very poor. I would suggest to add an ombrotermic diagram of the area based on a close meteorological station and describe the hydrological cycles and the type of precipitation in the area. I think that the climate information explained in the discussion (pag 17, lines 10-19) should be added in the study site.

Pag4 lines 1-2 are you describing the littoral sediments? Specify it

Pag 4 lines 3-6. Please, describe the vegetation of the area as an altitudinal succession.

*Seismic survey and coring:*

C2125

Authors should add information about the length of the long cores. Also provide the labels of the gravity cores. If you use a standard UWITEC gravity corer you do not need to further describe the diameter of the PVC liners enlarging the manuscript unnecessarily.

*Geophysical logging.*

Is there any reason why you did not measure the magnetic susceptibility together with the bulk density using the GEOTEK multisensor core logger before splitting the sediment core?

*Geochemical analyses:*

Pag.5 lines 19. You introduce fig 2b before fig 2a

*Pollen analyses*

You have not included Stockmaar (1971) in the reference list

**Results:**

*Subchapter 3.1*

Pag 6.last line: I would include geochemistry in the heading 3.1 as you are describing the XRF data

In this section authors discuss about the seasonality of the floods and cite the Piànic-Sellere record, which is a well-understood paleolakevarved record, as discussed in the general comment 2, authors do not provide enough information about either concerning the nature of the background sediments nor about the annual sediment dynamic cycle in lake Ledro, please, add more information or consider deleting this information.

Authors define the dark brown facies (flood deposits) as graded facies, how is this grading?, finning upwards, coarsening upwards, both?. Please, add more information and not only refer as Simonneau et al., this volume as the description of floods deposits is

C2126

key in this study. Moreover, you comment several times about the grain-size pattern in both types of allochthonous facies but you do not provide quantitative data. If you have not performed direct grain-size measurements you should include in the text that they are based on visual observations.

Authors also discuss in this section about the correlation of flood layers in the proximal and distal cores (Table 2). I miss further explanations to explain the 20% lack of detrital layers in the distal deposits.

### *Subchapter 3.2*

Authors interpret the two  $^{137}\text{Cs}$  upper peaks as a slump deposit that duplicates the sequence. In Figure 2a you have related this mass movement with an earthquake in 2004 but you do not mention this in the text. You are discussing sedimentation rates after removing the allochthonous input to the lake. I would suggest to add percentages of the external sediment input to the lake in relation to the background sedimentation based on the age models shown in Fig 3

### *Subchapter 3.3*

I found the colour data processing methodology very interesting and innovative.

Pag 10.lines 15-17: Authors comment that flood signal does not depend either on the core location nor the counting methods based on the low amount of variability in the signals obtained from the two cores. However, the proximal core records a 20% more flood event deposits than the distal core, which suggest that core location is key to record the complete flood record.

Pag 10.Line 18. I would say, based on Figure 5, that the flood frequency increase at 4000 cal BP instead of 4500 cal BP

### *Subchapter 3.4*

Pag 11; line 15: I think “endogenic” is more adequate than “autochthonous” to define

C2127

the material deposited/precipitated biologically or biogeochemically within the lake.

Pag 11; line 15: “Before” instead of “after”

Pag 11; line 19: If you consider 1200-1400 cal BP should be 550-750 AD instead of 500-700 AD.

### **Discussion:**

#### *Subchapter 4.1:*

I miss a more exhaustive explanation dealing with the different factors that could affect the sediment delivery to the lake, both climatic and anthropogenic. It is clear that land uses changes lead to higher sedimentation rates by increasing the run-off due to deforestation, larger areas of bare soil, etc. Concerning the climate, it would be very interesting to discuss the sediment transport and remobilization in the catchment under different climate scenarios. Humid periods are supposed to increase the run-off in the watershed but, what happens during arid periods. Lake catchment should also be prone to soil weathering and erosion by splash, wetting-drying cycles, etc, ultimately leading to a higher sediment delivery to the lake (from source to sink) Are those thicker events corresponding to arid periods and lower lake levels? (at c. 6500-5500, 5000, 3500, 2500 cal BP). Addressing this issue would add additional value to the discussion. In addition, as suggested above, you could also add percentages of the allochthonous input to the lake during different phases, both human and climatic

#### *subchapters 4.3 and 4.4*

You cite figure 8 before figure 7

See general comment 5 and consider rewrite this chapter. The last sentence on section 4.4 concludes that orbitally driven climate changes is primarily driving the increase in the flood frequency. As you do not have either robust results that confirm this hypothesis nor a climate explanation for it, and because of the large expansion of human population during the Bronze Age I would consider anthropogenic activities the main

C2128

cause leading to a higher sensitiveness of the lake ecosystem to record flood deposits in relation to higher run-off and sediment availability in the catchment

*Subchapter 4.5*

Pag 17- lines 2-4. I would be careful with this linkage between solar irradiance and flood frequency. You are making this assumption based on a radiocarbon chronology with a non-negligible error and grouping flood records every 50 years, therefore, it is very risky to make this relationships without a high resolution record.

Pag 17- line 8. Hu et al., 2003 is not in the reference list...

Last paragraph. As discussed in general comment 2. You do not provide robust data and/or explanation to be able to discuss the seasonality of the flood deposits. On top of that you cite a study (Wirth et al., 2012) that is not published. Therefore, authors should provide further explanation and new data in the manuscript or the discussion of the seasonality of flood deposits, its climate implications and control mechanisms (i.e NAO) during the last millennium should be avoided.

**Conclusions:**

Conclusions should be modified according to the general and specific comments.

**References**

- There are some references cited as “(this volume)” that are not specified in the reference list whether they are accepted, in reviewing process, just submitted, etc
- References of the same author should be order chronologically
- The references Gobet et al. (2003) and Feng Sheng Hu et al (2003) are not cited in the text
- Hu et al (2003) and Stockmaar (1971) in the text but not in the reference list
- The references are not in the same format

C2129

-Wirth et al (2012) is a workshop contribution, due to the importance of this citation in the text, and considering that it has not been through a reviewing process I suggest deleting this reference from both, the text and the reference list

**Figures**

Fig. 1. Write in the figure caption what the blue and green lines represent

Fig. 2a. change “scans” for “sediment core images”. Add lithological columns for the sediment cores

Fig 3b not included

Fig. 5. I would add grey bands indicating the high flood frequency periods in the graphs showing the entire Holocene record. In the bottom graph spanning the last 1300 years I would include bands showing the main climate phases (DACP, MCA, LIA, XX<sup>th</sup> century)

Fig. 6. Write in the figure caption what the shaded bands means. Periods of high human impact in the catchment?

Fig 7. What do the grey bands represent?

**Tables**

Table 1: what are the numbers in brackets in the third column? Write it in the figure caption

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C2130