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Hydrology and Earth System Sciences Discussions

Interactive comment on "Inside the hydro-physics processes at the plunge point location: an analysis by satellite and in situ data" *by* A. T. Assireu et al.

A. T. Assireu et al.

enner@dsr.inpe.br

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Replies and justifications to the suggestions and criticisms of the reviewers.

Reviewer 1

We would like to thank Reviewer 1 for the important and constructive criticisms and suggestions made to our manuscript. The objective was reformulated and the main reviewers' questions were inserted, and as it now appear, are in a much better form

than it was previously.

We offer the following replies to the reviewers questions/doubts, using 'A' for our replies to the Reviewers' questions 'Q'.

Detailed comments

Q- According to the title of the paper, the reader is expected to be able to delve deeper into the physical processes at the plunge point of a buoyant flow entering a reservoir. However, after reading the abstract and the introduction, it seems clear that this is not the main topic of the paper. At the end of the introduction we read: "The purpose of this paper is to investigate both the potentiality and applicability of the use of thermal and visible satellite instruments to monitor the density difference between the water body and the inflowing water (plunge point location)". The idea seemed interesting to this referee although it is difficult to evaluate its novelty considering that the authors do not express clearly the state of the art of the topic, writing only the sentence: "There have been relatively few or absence of studies about the use of remote sensing to study the density currents in reservoirs". Reading further it appears that the "Results and Discussion" section is divided into: a) thermal structure, b) river effects in thermal structure and Kelvin-Helmholtz instability, and c) analysis of a plunging underflow. There is no in-depth study of the potential of the use of satellite data to locate the plunge point and only two examples are discussed. Finally in the conclusion (P1207L1-15) there are two conclusions related to satellite data and two to the hydrodynamics of the reservoir (not to the inflow). Accordingly, the paper would benefit a lot from a more focused approach responding to the real aim (or aims) of the work. A- The main objective was reformulated and now appears as: "Based on this, thermal and visible satellite instruments is combined to hydrologic data and satellite tracked drifters to monitor the density difference between the water body and the inflowing water (plunge point location)." - Related to state of the art of the topic: "…In contrast to the above, there have been relatively few or absence of studies about the use of remote sensing to study the plunge point location in reservoirs."

Q- More precisely, the second conclusion says (P1207L7-8): “For wet season the upward entrainment engendered by the Kelvin-Helmholtz instability was the main mixing mechanism in reservoir waters”. But in P1194L11.12 it is said that “the river flowing as underflow contributes to the thermal stability of the water column during the wet season” and in P1203L1-3 we read that an “analysis based on Wedderburn and Lake Number (not shown) indicated that the wind-driven upwelling/downwelling was unimportant during the wet season”. No definition or references for these numbers are given in the text . So, how can K-H dominate the mixing? It seems that the authors imagine the epilimnion moving due to the wind and the hypolimnion due to the underflow and that (P1205L8-9) “the Kelvin-Helmholtz may play a strong role in the thermocline displacement during the wet season”. Accordingly, they calculate a bulk Richardson number at the thermocline considering for the term (U1-U2) in the denominator the following (P1205L6-7): “estimates of U1 obtained from u* and U2 calculated from the inflow and measured by drifters”. In P1201L18-19 it is said “the friction velocity was calculated as where V is the surface wind speed”. The only sentence in the text about the value of the velocity of the flow is (P1204L6-7): “If moving with a propagation speed u $\sim$0.1 ms-1 (as estimated by model and confirmed by drifters)”. I suggest the authors read, for instance, Imberger, J. 1998, Flux paths in a stratified lake: A review in Physical Processes in Lakes and Oceans, American Geophysical Union , Washington, D.C.and rethink their analysis.

A- Insertions/corrections were made in order to solve these questions: “Wedderburn and Lake number The Wedderburn number, W=c2h/(L), was calculated as in Imberger and Patterson (1990). W is the ratio of the maximum baroclinic pressure force (before the upwind surfacing of the thermocline) and the surface wind force. Relevant internal gravity wave speed is c = . The dynamical balance defined by W was extended with the vertically integrated Lake Number (LN, Imberger and Patterson 1990; Stevens and Imberger 1996). This quantity is defined as LN =gSt(1-zt/H)/(Ao3/2(1-zg/H)), where zt is the height to the center of the metalimnion, zg is the height to the center of volume of the lake, A is the area, H is the depth of the lake, and St is the overall stability or

Schmidt stability parameter. This parameter represent the energy required to mix the entire water column against the potential energy due to its stratification and is given by St = , and zm is maximum depth of the lake. As Stevens and Imberger (1996) have shown, St can be considered an integral equivalent to W.”

“The thermal stratification in Manso Reservoir is moderate and is spread over a thick metalimnion in the first half of the analyzed period (February 02 – April 30) (Fig. 3 and Fig. 4). The metalimnion extends from 7-25 m, with temperatures ranging from 28-30 ïĆřC. During this period, wind speed was on average 2.3ïĆś0.5 ms-1 without any predominant direction. (deletar)During wet season-stratified period, the thick metalimnion and moderate stratification could make Manso Reservoir susceptible to partial upwelling (W > 2 or LN < 10), i.e., metalimnetic water reaching the surface. However, analysis based on Wedderburn and Lake Number (Fig. 4) indicated that the wind-driven upwelling/downwelling was unimportant during wet season. Some enhanced mixing events are visible during February 16-19, March 18-21, and May 06-09, when 28ïĆřC water was transported to the surface.

“Manso Reservoir experiences large seasonal and short time runoff variations. As result, the inflow variations present an intermittent pattern with large inflows at the summer-autumn months (Fig. 6a). This fact suggests that the inflow exerts controls on residence time for Manso Reservoir, as verified by Rueda et al. (2006) at the Sau Reservoir. The estimated power spectra at thermocline displacement and buoyancy flux due inflow show similar variability for frequency between 0.3 and 0.6 cpd (Fig. 6b). If the peaks in the range of 0.3-0.6 cpd were indicative of interchange between thermocline oscillation and buoyancy flux, they would be coherent but out of phase, (because the signal of inflow must be propagate 23 km downstream- from upstream until thermistor chain). If moving with a propagation speed u $\sim$ 0.1 ms-1 (as estimated by model and confirmed by drifters) and a distance of 23 km, one obtains the propagation time $\sim$ 2.5 days (because the signal of inflow must be propagate 23 km downstream – from upstream until thermistor chain). Coherence spectra (Fig. 6c) indicate that motions in the range of 0.3-0.6 cpd are coherent and are 120° out of phase (Fig. 6d). This result suggests that the inflow is an important mechanism driving thermocline displacement.

". In order to evaluate the typical vertical velocity shear, current measured by drifters in river-reservoir transition zone was analyzed. The mean difference between current to 6m and 2m were approximately 6.0 cms-1(Fig.9b). This difference (U1-U2) applied in the above inequality indicates that the Kelvin-Helmholtz may play a strong role in the thermocline displacement during the wet season. Alongshore components of the drifter velocity (Fig. 9a) shown the anisotropy in the mean kinetic energy.

Q- P1202L23-25: "Due to the weaker winds, the atmosphere's reservoir boundary layer is less turbulent, advection and diffusive contributions to sensible heat flux and evaporation are all small and the radiational heat input is concentrated in a shallower surface layer (Fig. 3)". I understand that "raditional heat" refers to the radiative fluxes. In this case, it is true that long-wave radiation affects only a thin layer at the surface but shortwave radiation always penetrates into the water column, although it could be absorbed rather quickly depending on the water characteristics, not on the non-turbulent state of the atmospheric boundary layer. In any case, Figure 3 is a contour plot of temperature profiles recorded with a thermistor chain, so it provides no direct information about the transfer of short-wave radiation in the water column. Figure 2.- Mean daily short-wave and long-wave data are presented but it will also be interesting to see the other components of the surface heat balance to support a convective regime as it is very inaccurately said in the text (P1202L14-19): "As latent and sensible flux terms are almost linearly dependent on wind and the short waves drops during the cold front passage, the net surface radiation becomes negative and reservoir loses (latent) heat to the atmosphere (not shown). Thus, the deepening of the surface mixing layer due to the stirring from the wind stress will be enhanced by downward convective mixing in dry seasons."

A- It is out of the scope of this work and was deleted. "The location of the thermistor chain and drifters deployment are indicated by position 8."

Q- Many stations have been indicated in Figure 1 (in fact more than those which are used in the text) but in Figure 3 it is said that the thermistor chain was "near the dam". Also it is not said at which stations data shown in Figures 8, 10 and 12 were recorded. The transect shown in Figure 7 should also be located in Figure 1. MAN40 station referred to in Figure 8 is neither indicated in Figure 1 nor, I believe, in the text. For what and where (see Figure 8) is the pH used in the text? A- This phrase was inserted in legend of Figure 1: "The location of the thermistor chain and drifters deployment are indicated by position 8." – pH profile was excluded. Q- Some of the data shown in Table 1 cannot be the same for every year but the year is not specified. Is it 2007?

A- A correction was made (Depth of turbine intakes 15m) and the table legend was modified: "Table 1: Mean general characteristics of the Manso Reservoir

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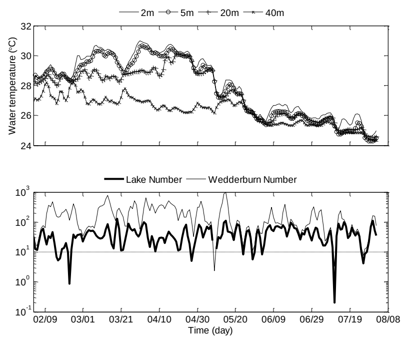

Figure 4: Time evolution of thermal structure (top panel) and Wedderburn and Lake numbers (bottom panel).at Station 13."

Fig. 1.

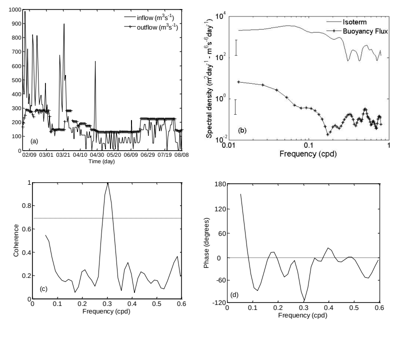

Figure 6: (a) Inflow and Outflow, (b) Power spectra of time evolution of thermocline displacements and buoyancy flux smoothed by three Hanning passes (the 95% confidence interval is indicated), (c) coherence (the 5% level for zero coherence is indicated) and (d) relative phase for thermocline and buoyancy flux.

Fig. 2.

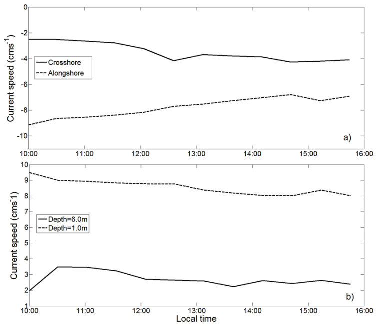

Figure 9: (a) Alongshore and cross-shore current velocity component, (b) speed to 1.0 and 6.0 m depth. "

Fig. 3.