Review for

*Dynamics of Gap Winds in the Great Rift Valley, Ethiopia: Emphasis on StrongWinds at Lake Abaya*

by Weiss et al.

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## Synopsis:

The manuscripts present an interesting example of a gap wind in the Great Rift Valley, Ethopia, i.e., a region that attracted only little focus in atmospheric dynamics. Many dynamical mechanisms leading to the gap winds are discussed, e.g., the build-up of pressure differenence along the value due to differential temperature advection, hydraulic flow behaviour due to valley slopes and constrictions, impact of convective activity,... I think the processes are well described, the figures of high quality, and the text is well structured and written in a clear, concise way. The only concern that could be brought up is that the evolution of the gap winds is discussed in a rather descriptive/qualitative way, without quantifying the forcing mechanisms. Still, it is a coherent story that is told about an interesting weather feature in a rarely studied region. Therefore, I can recommend publication of the study in *Weather and Climate Dynamics* if the following (mostly) minor comments are adequately addressed. In addition to physical aspects, I also make a few suggestions about wording.

## Comments:

- L4: 'Therefore, two...' -> To this aim, two...'

- L15: 'were location dependent' -> 'depended on location'

- L17,18: 'The ERA5... Hence, ERA5 ... gap flows': I am not sure whether keep this more data-related aspect in this more mechanism-focused abstract.

- L20: 'produce water waves' -> 'induce surface waves on the lake'

- L29: 'The average depth of the lake is 8.6 m' -> It is interesting, although beyond the scope of this study, to think about how this rather shallow lake depth affects the waves that form on the surface. Possibly, the authors want to refer to one, two studies that address the modeling of surface waves on lakes, e.g.,

> *Seibt, Christian, Peeters, Frank, Graf, Michael, Sprenger, Michael, Hofmann, Hilmar, (2013), Modeling wind waves and wave exposure of nearshore zones in medium-sized lakes, Limnology and Oceanography, 58, doi: 10.4319/lo.2013.58.1.0023.*

*Graf, Michael, et al. "Evaluating the suitability of the SWAN/COSMO-2 modelsystem to simulate short-crested surface waves for a narrow lake with complex bathymetry." Meteorologische Zeitschrift 22.3 (2013): 257-272.*

The two studies illustrate how the ecology, but also archeological sites are affected by waves, in particular in the shallow shore region. I do not think that this wave-on-the-lake aspect is crucial for the study, but it is a nice point how strong winds can have indirect effects/impacts. If the introduction could be shortened, it would certainly be this relatively long paragraph (L27-50) about ecology and waves. However, as mentiond before, this is not mandatory from my side.

- L45: 'a bidirectional effect' -> 'two effects'

- L55,56: Avoid two consecutive sentences starting with similar 'connecting' words (Hence, Therefore)

- L52: 'Besides other large-scale drivers like ENSO...' -> How relevant is ENSO for *weather* in Ethopia? I am not sure that such a climate index is particularly relevant for this study. If yes, it could be discussed in somewhat greater detail

- L58: 'dual passage' -> 'biannual | twice-yearly passage'

- L69: In L49-50 it is written that the the waves coudl be the reason why Lake Abaya is less affected by invasive plants than, e.g., Lake Tana. In L45 it is argued that it is Lake Abaya's large size that allows many waves to evolve because of the large wind tech. On the other hand, Lake Tana is larger, offering a larger wind fetch. Wouln't one expect larger waves? Hence, is it more the wind speed that determines the wave acticvity than the wind fetch?

- L63: 'The adjustment of the wind field by local effects' -> What does this exactly mean? Could you be somewhat more specific!

- L66: 'shows strong differences to the synoptic flow' -> 'strongly deviates from the synoptic flow'

- L69: 'Lake Abaya is at least in some months connected to the large scale flow' -> Could you be a little more specific? What does 'connect' mean in this context?

- L73: 'on the lake water dynamics' -> 'on the lake's wave dynamics and internal mixing'

- L74: 'Therefore these winds...' -> 'It is the aim of this study to better understand these winds...'

- L76: 'the goal of' -> 'the more specific goal of'

- L79: 'The synoptic conditions prior to the two cases' -> Why *prior* to these events?

- L89: Remove 'that allowed for the local perspective'

- L92: 'horizontal resolution of 0.25 x 0.25' -> make clear that ERA5 is based on a spectral model and thus provide the spectral resolution, the grid spacing in latitude/longitude is 'only' an interpolation from spectral space

- L101: 'ERA5 model topography. ERA5 topography near...' -> 'ERA5 model topography, which near ...'

- L140: 'Lake Abaya, hence, the at the...' -> correct sentence structure!

- L141-143: 'led to an along pressure' -> more precisely, 'led to an along pressure gradient'

- L142: 'height Z at the 800 hPa surface. 800 hPa...' -> 'height Z at the 800 hPa surface, which...'

- L143: Here it is written that the pressure gradient *helped* to channel the air though the gap. The term 'helped' is somewhat too unspecific? Which other processes drive the air through the channel? To which degree does the pressure gradient contributes to the flow through the valley, and to which degree are other processes (which?) essential? I am quite convinced that the pressure gradient is indeed decisive, but the wording in the text could be more careful. In the same line of argument I wonder to which degree it is possible to understand the pressure gradient at 800 hPa by means of hydrostatic effects, i.e., due to the differences in the teperature?

- L155-157: Here, it is state that the large-scale flow is non-negligible, because it caused an inflow and hence forced channeling at both valley entrances. I am not sure whether I understand this point, and whether I see this inflow channeling in the figure. Possibly, my point is also related to the following question: Is the large-scale flow also associated with a pressure gradient that is perpendicular to the valley axis and thus contributes to the along-valley acceleration of the flow. In short, a more careful discussion/distinction of local effects and large-scale effects would be helpful.

- L162.163: The pressure difference...and their mixing' -> I had to read this sentence several times, and still I am not sure that I get it correctly. Please rephrase in clearer way. Possibly, a way to do so would be: 'Two points are selected at the valley entrance and exit, and the pressure difference between these two points is then take as a diagnostic for the gap winds in the GRV and their temporal evolution'.

- Figure 3 and the corresponding text are interesting measurements and model values that trigger some thoughts! First, at time 00-12 UTC 14 January Delta-Z-800hPa shows a clear pressure contrast, which then leads to a corresponding observed gap wind in the same time period. Hence, in this time slot Delta-Z-800hPa can be used as a reasonable diagnostic that quantifies the driving mechanism of the gap wind. However, then I also considered the time instance around 12 UTC 12 January. There, the diagnostic Delta-Z-800hPa is comparable in amplitude to the afore-mentioned time slot, but the observed wind in the valley is

completely different. Why is this? If my point is correct I wonder whether it is reasonable to assume that Delta-Z-800hPa can be taken as a metric for the gap-flow-driving mechanism? Possibly, I miss an essential point, or I misread the figure.

- Again to figure 3 and the corresponding text: It is first argued that the pressure contrast Delta-P-SFC cannot be used as a diagnostic for the gap-flow-driving mechanism. I fully agree, and it is also plausibly be argued why this field cannot be used. After having discussed that Delta-P-SFC cannot be used, the physically more reasonable Delta-Z-800hPa (at pass height) is introduced and discussed. The logic of the text structure assumes that the reader should expect that Delta-P-SFC should work as a diagnostic, but -- honestly -- it was clear to me from beginning that this won't work. Hence, the authors might start straightforward their discussion on the forcing mechanism with the much more plausible Delta-Z-800hPa.

- L173-174: 'The wind arrows... WRF simulation' -> Remove, no need to repeat this methodological aspect at this place.

- L174-175: 'Winds at Chamo ... at the pass' -> Describe in 1-2 sentences the differences in timing. Actually, this is done in the following sentence, but the 'Moreover' is a misleading connecting word between the two sentences.

- L188: correct 'tow' -> 'two'

- L194: It is stated that the temperature increase is consistent with the increase in pressure difference. I agree, but at the same time wonder what 'is consistent' exactly means. It this meant in a qualitative way, or is it assumed that the pressure contrast could be quantitatively be derived from the corresponding contrast in the temperature profiles, by applying the hydrostatic assumption?

- In Figure 5 and 6 the gap flow is from left to right, which is easy to 'read'. On the other hand, for the second case the flow in Figure 9 and 10 is from right to left. Of course, I see why the authors stick to this orientation. Personally, however, I would prefer an orientation of the vertical cross sections in a way that the flow also in Figure 9 and 10 goes from left to right. I think it would be easier to 'read'. However, I have no strong opinion on that, and only want the authors invite to re-think the orientation of the cross section in Figure 9 and 10.

- L196: 'a reduction of the flow depth...' -> How is the flow depth defined, how can it be inferred from the figures. Some more explanation would be helpful. It is, in the next sentence, also argued that this reduction indicates a transition to a supercritical state. I guess taht this is indeed the case, however, without quantitatively considering the Froude number the statement remains rather vague.

- Figure 10: 'Notice the reversed color scale compared to Fig. 6' -> That's OK, but if the orientation of the figures is reversed (flow from left to right, as mentioned before) this reversing of the color scale could be avoided.

- L334-335: Here it is argued that daytime convection may be a delaying mechanism, despite its role for differential heating. I think this specific role of convection is indeed a very interesting aspect. I would have appreciated a somewhat more detailed discussion how convection interacts/delays the gap flow. Actually, there are three effects discussed in the text that help to build up the temperature contrasts between the valley ends: (1) differential advection; (2) buildup (or not) of the CBL; and (3) the role of convection. Since this is a rather interesting aspect, a more careful discussion of the contributions and interactions would be nice.

- L343: 'the dynamic forcing was...' -> What is the dynamic forcing in this context? I guess it refers to the forcing due to the along-valley pressure gradient. However, due which degree is it reasonable to call this a dynamic forcer when the pressure contrast is driven by a temperature contrast? Possibly, I misunderstand the term 'dynamic forcing'?

- L343-344: ' Te thermal forcing.... on the smaller scale' -> I am not sure whether I fully understand the statement made here about larger- and smaller-scale effects. Please rephrase in clearer way.

- L363: Here, convective outflows are mentioned. Interesting! Is this the delaying effect that was earlier referred to?

- L368-378: Here a comparison between WRF and ERA5 is made. This is, in principle, interesting and also relevant, since it tells that and to which degree ERA5 can be used for meteorological studies in the target region. Hence , there is no doubt that this should be included in the study. I wonder, however, if section 6 with its focus on physical mechanisms is the right place to do so? Personally, I would shift this aspect to the end of the conclusions, where it can be combined with the last bullet point and make a bridge to the final statement of the manuscript about future studies. Note also the (more methodological, data-based) ERA5/WRF topic interrupts the discussion on physical aspects before from the physical aspects after (on hydraulic theory).

- L382-384: 'Applying reduced-gravity.... Weiss, 2021)' -> Am I correct in assuming that these shallow-water experiments were indeed performed in Weiss (2021). This is not completely clear in superficially reading the text.