The Cryosphere Discuss., 8, C2724–C2730, 2014
www.the-cryosphere-discuss.net/8/C2724/2014/

The Cryosphere
Discussions
Open Access

Interactive comment on "Factors controlling Slope Environmental Lapse Rate (SELR) of temperature in the monsoon and cold-arid glacio-hydrological regimes of the Himalaya" *by* R. J. Thayyen and A. P. Dimri

Anonymous Referee #3

Received and published: 22 December 2014

General comments and recommendation:

This paper aims at evaluating the Slope Environmental Lapse Rate (SELR) of temperature along the higher Himalayan mountain slopes. Using local observations in Garhwal Himalaya (a monsoon regime region) and in Ladakh Himalaya (a cold-arid region), the authors evaluate the SELR in these two regions, and point out its strong dependence on moisture rates. This last result is obvious, and does not consist in a strong discovery. However, estimating realistic SERL is highly challenging, and these new estimations will be very useful for the different communities that regularly need SELR, in particular

for hydrological and glaciological applications. This new interesting study shows that it is inappropriate to use standard SELR for glacio-hydrological applications, in particular in the Himalayan catchments. This paper is scientifically well constructed and well presented. It is fully in he scope of the journal TC, and shows significant results that will be of interest for climate sciences, glaciology and hydrology. However, we point out on he following 4 major points that need to be addressed before publication in TC (Section 1). Section 2 of this review shows minors points that should be taken into account in a final version.

Section 1: major recommendations:

1/ We know very few information about the observational data used in this study. This paper cannot be published without more details on how are measured precipitation, temperature and moisture. The author should also detail the uncertainties associated with these observations. Does observations come from a specific Indian network? Or is this observational data collected specifically for this study? In addition, you should explain the possible uncertainties associated with this data, in particular those related to the difficulty to measure snowfall with rain gauges. Please refer to previous papers dealing with observational and modelling approaches showing that precipitation is potentially under-estimated in high altitude areas (e.g. Palazzi et al., 2013, Dimri et al. 2013). Ménégoz et al. (2013) estimated that that more than half of the total annual precipitation occurs as snowfall on average over a region located higher than 2500 m. a.s.l. at the border between Nepal and India. Shrestha et al. (2012) strongly corrected local measurements of precipitation considering snow depth and snow albedo measurements.

2/ Observational data is not sampled during the same periods for the two different regions. It would have been better to use observations sampled at the same time for the two regions. If such observations are not available, the authors should investigate how the climate inter-annual variability may have affected their comparisons between the SELR observed in the two regions?

3/ How is applicable such model in other hydrological catchments? What can we think about using it for Himalayan regions located at higher altitudes? This new calibrated model is certainly strongly dependent on the local atmospheric circulation. I am not sure that it can be used directly used in other Himalayan basins. The authors should explain more in detail the limits of the application of such a model in other regions. In addition, the authors should detail their calibration methodology to allow the use of their method by author scientists in other catchments of the Himalaya. Similarly, they should have to provide all the needed parameters and constants to the reader.

4/ The authors are using too few references to other studies estimating lapse rates over other mountains range. They should look for other studies based both in observational data and modelling approaches to check if similar findings have been found in other places, or to get a clearer idea of the specificity of the Himalayan region. As an example, Minder et al. (2010) and Feld et al. (2013) estimated lapse rates in other mountains. Regarding other modelling studies, the authors should consider both in the introduction and in the conclusion the limits of the application of a simplified model in comparison to full regional climate models. In addition, the authors should quote other studies based on the developments of o large number of automatic weather stations (e.g. Whiteman et al., 2014)

Section 2: minor points:

* Introduction, P5647, L. 14: Âń Glacier change in the region is found to be comparable with other mountain glacier systems of the world (Zemp et al., 2009) Âż: Himalayan glaciers respond on a very different way to climate variations depending on their location along the mountain range (Kääb et al., 2012), so please modify this too vague statement.

* P 5646, L17: focred

* L.7, P 5649 : glacio-hydrolgical

* P5650: Please, could you quickly describe the different sections of the paper at the end of the introduction?

* P5650, L10: “Among the three dominant glacio-hydrologic regimes of the Himalaya, present study focus on the wet monsoon regime of the Garhwal Himalaya and the cold-arid region of Ladakh (Fig. 1). The wet system studies are carried out in the Dingad catchment of Garhwal Himalaya.” Please indicate the exact location of Garhwal, Ladakh and Dingad region on Fig. 1.

* P 5651: In Section “methodology”, Could you add more details concerning the description of the meteorological stations used for this study? (See major comment 1)

* P5651, L2: Please detail where do come from the observations showed in Fig. 3. (Major comment 1)

* P5651: Methodology: Could you discuss the uncertainties induced by the fact that observational data is not sampled during the same periods for the two different regions? (See major comment 2).

* P5652, L25: Why Section-1M has been computed with the lower and upper stations (2540 and 3763ma.s.l.) whereas Section-1A has been computed with the lower and intermediate stations (3500 and 4700ma.s.l.)?

* P5654: Section 4.2: Precipitation : If rain gauges do not catch snowfall, it is tricky to discuss the vertical gradient of precipitation. What do you think about the quality of snowfall measurements that you used? You find that precipitation is not varying with the altitude in the Dingad catchment, what do you think of the uncertainty related to this finding?

* P5655: L13: “Hence we strongly believe that this phenomenon is a characteristic of Himalayan catchments.” Do you think such phenomenon cannot be observed over other mountain ranges?

* P5658, L15: Please, could you explain in details how was constructed the theoretical

SALR curves in Fig.6? You should indicate both in the text and in the caption if you used the equation (2). In addition, could you indicate the full description of vertical axis of this graph? It would be also relevant to show a similar graph for DALR for a better comprehension of your analysis. Some references to SALR and DALR, based on both theoretical and experimental approaches should be added in the manuscript.

* P5660, L10: Please, could you explain where do come from these humidity observational data sets? It could be introduced in Section 3 for example.

* P5661: Modelling Section: Please detail which data has been used to make the graphs 8 and 9. We suppose local temperature observations have been used, but did you also use pressure data? You should also indicate which values were used for all parameters and constants.

* P5665, L10: The modelled values seem to have a low standard deviation compared to observations. Is it due to the monthly time-step application of the model? Which results would have got with daily time-step?

* Conclusion: P5666, L24: “Manifestations of atmospheric pressure–moisture variability driven by the orographic lifting lead to greater saturation at the higher altitude regions; resulting into comparatively lower SELR’s in the higher Himalaya than the lower sections”. Is this remark valid for higher altitude areas of the Himalayan Mountains? If all the moisture is condensate/evaporated at intermediate altitude, could high altitude areas be characteristic of arid regions?

* Please consider in your introduction previous studies based on both observational and modelling approaches that have been performed in other mountain range to estimate lapse rates (see major recommendation 1).

* References: please check the references.

* Figure 2: Please increase the size of the text on the maps that is difficult to read.

* Figure 6: This Figure is not clear. Please, could you add more information concerning

the vertical axis information?

* Figure 8: Please add the horizontal time axis indicating the months for more clarity.

* Figures 4-6-7-9: Please increase the size of the axes captions.

References (that could be added to the manuscript):

Dimri. A. P. and Niyogi, D.: Regional climate model application at subgrid scale on Indian winter monsoon over the western Himalayas, Int. J. of Climatol., 33, 2185–2205, 2013.

Feld, S. I., N. C. Cristea, and J. D. Lundquist, Representing atmospheric moisture content along mountain slopes: Examination using distributed sensors in the Sierra Nevada, California, Water Resour. Res., 49, 4424–4441, doi:10.1002/wrcr.20318, 2013.

Ménégoz, M., Gallée, H., and Jacobi, H. W.: Precipitation and snow cover in the Himalaya: from reanalysis to regional climate simulations, Hydrol. Earth Syst. Sci., 17, 3921-3936, doi:10.5194/hess-17-3921-2013, 2013.

Minder, J. R., P. W. Mote, and J. D. Lundquist, Surface temperature lapse rates over complex terrain: Lessons from the Cascade Mountains, J. Geophys. Res., 115, D14122, doi:10.1029/2009JD013493, 2010.

Palazzi, E., J. von Hardenberg, and A. Provenzale, Precipitation in the Hindu-Kush Karakoram Himalaya: Observations and future scenarios, J. Geophys. Res. Atmos., 118, 85–100, doi: 10.1029/2012JD018697, 2013.

Shrestha, M., Wang, L., Koike, T., Xue, Y., and Hirabayashi, Y.: Modeling the spatial distribution of snow cover in the Dudhkoshi Region of the Nepal Himalayas, J. Hydrometeorol., 13, 204–222, doi:10.1175/JHM-D-10-05027.1, 2012.

Whiteman, C. D., and S. W. Hoch, 2014: Pseudo-vertical temperature profiles in a broad valley from lines of temperature sensors on the sidewalls. J. Appl. Meteor.

Climatol., 53 (11), 2430-2437.

Interactive comment on The Cryosphere Discuss., 8, 5645, 2014.