Comment on hess-2021-639

Anonymous Referee #2

Referee comment on "Impact of distributed meteorological forcing on snow dynamic and induced water fluxes over a mid-elevation alpine micro-scale catchment" by Aniket Gupta et al., Hydrol. Earth Syst. Sci. Discuss., https://doi.org/10.5194/hess-2021-639-RC2, 2022

General comments

The aim of this paper was to explore the impact of using spatially distributed meteorological forcing (precipitation, solar radiation and wind) on the simulated water and energy balances, such as simulated snow cover dynamics, evapotranspiration, runoff, etc. on a small (15 ha) mid elevation French catchment. The coupled hydrology-land surface model, ParFlow-CLM with a hyper-resolution of 10 m was used in this study. It was found that accounting for spatially distributed precipitation had the largest influence on the catchment's hydrological behaviour. The study demonstrated the importance of accounting for the influence of the terrain when hydrologically modelling a mid-elevation catchment.

This is an interesting paper, the presented methods and conclusions of the study could be useful for the hydrologic modelling community.

A few comments addressing methodological and organizational issues, as well as minor technical corrections are listed below.

Specific comments

Currently, only results of the model calibration is presented. It would be good, if the model could be tested on a different, independent time period. It would be also interesting to see if the results/conclusions remain the same for an independent time period.

I am not entirely sure for which field measurements the model was calibrated? Actual evapotranspiration was overestimated for each scenario. If there are observed latent heat flux time series available, would it be possible to change some e.g. model parameters in order to more realistically simulate actual evapotranspiration? It is interesting to see that certain modelling states became e.g. more patchy, or that by accounting for spatially distributed precipitation some of the simulated model fluxes and state variables changed – but how can the authors decide if the modelling results are realistic or better compared to model setup where meteorological forcing is not distributed?

Furthermore, it would be good if the simulation efficiency of the model in terms of simulating snow cover (Figure 10) could be quantitatively assessed, not only visually comparing the simulation results with (only) four Sentinel-2 images – how good are the snow cover simulations during the rest of the year?

It would be also very good if the authors could formulate the take home messages of the paper in a very clear way, trying to be specific. Instead of writing "that impacts the hydrology" in the Abstract, the authors could be clear which processes are actually influenced? This applies not only to the abstract, but also to the results and conclusion sections.

The study lacks a Discussion section – Lines 394-400 probably try to put the study into the context of existing literature, but only two studies are mentioned. Generally, it would be good to add a separate, very clear Discussion section to the manuscript. Here, the authors could also elaborate on the question, whether their findings are general/could be generalized (different catchments, different climates, etc.)?

I found it hard to follow the different simulation setups through the manuscript. There is a list in Lines 227-234, but when the Results are presented it would be very helpful for a reader to sometimes explain in detail the differences between the simulations, to remind the reader what the abbreviations refer to, etc.

On a similar note, it is hard to understand the figures, and generally the sequence and subsections of the Results. There are a lot of very similar figures and the differences can be often visually not noticed. Often there is jumping between figures, between the beginning and end of the results, e.g. Line 265 already mentions figure 9; Line 300, etc. The Results section could be potentially reorganized or the section names could be changed, i.e. the Results section starts with describing non-distributed and distributed forcing simulations – which probably refers to different simulation setups. But then it continues with sections such as water budget and snow dynamics – I am not sure how these subsections are logically linked.

I think the study might benefit from a very thorough English language editing, some formulations and sentences are unclear (e.g. storage instead of stock?, shortwave radiation instead of writing simply shortwave?, etc.). Please find below, under technical corrections a few suggestions.

Technical corrections

-Generally: it might be good to use either present or past tense when presenting the methods, results, etc. – but not to mix the two.

-Introduction (and also later in the manuscript): generally, it might be better to split very long sentences into more, shorter ones. This might make it easier for the reader to understand and follow the paper.

-Title: dynamics? Instead of dynamic? Is the word "induced" necessary in the title?

-Line 3: These impact (or influence)

-Line 9: 3D simulations of what? Please add. Please be specific.

-Line 13: induces

-Line 14: please consider to rephrase, "Distributed forcing induces a snowpack" – what does this actually mean? Which forcing? Is "induce" the right word here?

-Line 15: what does "good agreement" mean? Please revise, please add some quantitative information.

-Lune 15: what does a "smoother hydrological response" mean? This sentence is unclear. Please consider to rewrite this sentence.

-Line 16: but how can the authors decide if the "patchiness" is more realistic for distributed meteorological forcing compared to non-distributed one? Again, this should be quantitatively proved.

-Line 16: Among

-Line 17: "impacts the hydrology" – please revise, please be specific, what exactly is influenced and how? And how do the authors know that these results are realistic?

-Line 17: please add: most important in terms of what?

-Line 19: please add: what does "it" mean? Please also revise the sentence, what does "small differential melting effect" mean? What does "small" mean? How small? This should be quantitatively expressed.

-Line 20: please remove "participate to". Please replace "accelerate" with "accelerates"

-Line 21: patchiness in what? Please add. How do the authors know if more patchiness is more realistic/is what in reality happens in the catchment?

-Line 28: spatial differences in melting

-Line 30: please be specific. Change the hydrology in which sense? Please revise.

-Line 35: please revise the first sentence. What does this sentence mean?

-Line 40: what does "proper soil moisture" mean? Please revise this sentence.

-Line 40: sloppy? Do the authors mean sloping?

-Lines 41-42: I do not understand this sentence: precipitation, etc. can simulate the spatial variability in hydrological fluxes? Please revise.

-Line 43: please replace "coverage" with "cover" (also in the whole manuscript).

-Line 43: what does limit mean? Please revise this sentence. What does "differential melting" mean? Please revise.

-Line 45: please revise "differential snow melting".

-Line 45: what does "variable saturation" mean? Please revise.

-Line 47: "snowy catchment"?

-Lines 52-53: Shortwave? Do the authors mean shortwave radiation? Please revise this in the whole manuscript.

-Line 54: please explain here what directional effects mean.

-Line 56: "meteorological distributions"? Please revise.

-Line 60: please add what physical processes are meant here. Please be specific.

-Lines 61-62: the meaning of these sentences is not clear, please revise.

-Line 64: "meteorological parameters"? Please revise.

-Line 65: catchments

-Line 64: please replace "catch" with simulate or reproduce.

-Line 71: on the water balance (or budget)

-Line 72: spatially distributing precipitation

-Line 77: based on the manuscript I am a bit confused: the model was not validated; and it is also unclear for which observations the model was calibrated.

-Line 79: what does individual or combined mean here? Can the authors please provide some explanation?

-Lines 79-80: these goals are not clear, please explain or revise/rephrase.

-Line 83: details

-Line 83: "meteorological distribution"? Please revise.

-Line 83: The fourth

-Line 91: please add: 5 to 6 months per year

-Line 91: This sentence is unclear. What is "C4"? What does this sentence mean? Please revise.

-Figure 1: caption: please remove second "for" from fourth line. Snow coefficients and wind direction mask: how were these derived? Can the authors either explain in the caption or refer to the main text where it is explained? Otherwise it is very hard to understand the figure.

-Line 98: Please consider to revise, e.g. The study area is located in a mid-latitude…

-Line 99: on 11 November

-Line 105: "are well phased" – what does this mean? They are in phase? Please revise this sentence.

-Line 107: what does "also" mean? What other purpose did the observations serve?

-Line 108: input time series?

-Line 111: wind speed

-Line 115: Please revise the first sentence. In 2017 an OTT Pluvio rain gauge was installed at the weather station?

-Line 117: what does "reduced to a 30 min time step" mean? Averaged? Please revise.

-Line 124: what does "solve the surface and subsurface flow" mean? Please revise.

-Line 125: transfers of what? Please add.

-Line 128: make

-Lines 128-129: "grid which eases boundary conditions prescription mesh refinements" I am not entirely sure what the authors mean here.

-Line 130: kinematic

-Line 130: "any saturated cell flows" please revise.

-Line 135: Common Land Model

-Line 140: snow layer thickness? Or snow depth?

-Line 142: "snow fraction is used to account for the surface uncovered by snow" I am not entirely sure what the authors mean here.

-Line 143: please explain how this reduction was exactly done.

-Line 144: cover

-Line 145: temperature

-Line 148: Further information on…

-Line 155: please explain how these factors were derived/where they come from.

-Line 162: please explain how this upscaling was done.

-Line 167: It must be noted

-Lines 169-170: I am not sure what exactly this means: "rain has not been distributed according to an altitudinal gradient". Does this mean that precipitation in terms of rain was not distributed over the catchment, but only snow?

-Line 172, 174, 194, 201, 233: shortwave radiation

-Eq. 3 and 4: cosi?

-Line 183: was

-Line 201: air pressure?

-Line 203: please explain how, or provide a reference.

-Line 209: which satellite images, and how was this done exactly? Please explain.

-Line 213: allows

-Line 219: what does "key profile" mean? Where exactly? Or how were these locations selected? How many locations? Please be specific, so that the results are reproducible.

-Line 222: what does "meteorological distribution" mean? Please revise.

-Figure 3: is it maybe possible to please replace the colour name "salmon" with e.g. pink or light red? In third line: please remove "from" and replace it with e.g. in terms of

-Line 223: what does "outputted" mean? Was the simulation time step one hour? Or just the results were written out for every hour? Please explain.

-Line 225: what does "stock difference" mean? Please revise.

-Line 226: please remove "to"

-Line 226: the 10th year

-Line 228: spatial distribution of only (similarly in the next lines)

-Line 235: mean

-Lines 238-239: Please revise this sentence.

-Line 240: please explain why.

-Line 240, 241: "-2" should be in the exponent.

-Line 247: serve

-Line 247: "catching the slope, curvature and aspect effect in spatial distribution" – Please revise.

-Line 249: variation between what? Please add. Please explain how the authors obtained these numbers.

-Line 253: accumulation of what? Please add.

-Line 258: what is a "subsurface stock"? Storage? Of what?

-Figure 4.a.: legend missing. c: shortwave radiation? c, d: over the watershed (instead of along)

-Line 262: variability of what? Please add.

-Line 264: what is a "subsurface stock"? Storage? Of what? Please revise.

-Line 265: please avoid referring to figures which are somewhere else/come much later in the results. Figure 9 is not yet explained. This would be very confusing for a reader.

-Line 266-267: this sentence is grammatically incorrect, please revise.

-Line 269: cover (also later).

-Line 271: in the extraction

-Line 273: "subsurface stock increment" What does this mean? Please revise.

-Line 273: when ET is smaller?

-Line 274: this sentence is unclear. Please revise.

-Line 276: difference between what and what? Please add.

-Line 277: were prescribed. Please use consistently either present or past tense when showing the results, please avoid mixing.

-Figure 5: legend: storage and not stock, please revise.

-Line 280: several years? Please explain.

-Line 281: orientation of what? Please add.

-Line 284: fluxes of what? Please add.

-Line 291: are they the same or not? Please revise.

-Line 291: distribution of what? Which scale? Please add.

-Paragraph starting in Line 293: this seems to be the very same paragraph as the one before (just being incomplete).

-Line 299: seem

-Line 302: produces spatial variability in snow melt

-Line 303: please remove comma

-Line 305: larger than

-Line 305: "-1" should be in the exponent

-Line 308: what does "marked on" mean? Please revise.

-Line 310: please explain.

-Line 310: than the two latter

-Line 308: It must be noted

-Line 311: is there any difference or is there no difference? Please revise this sentence.

-Line 314: please explain in methods how the footprint area was exactly estimated.

-Figure 7 caption: "Evapotranspiration simulation masked with wind direction mask for 17 days" Please explain this in detail in methods.

-Figure 7: ET is overestimated by each simulation. Why is that? Would it be possible to e.g. adjust model parameters?

-Line 319: saffron curve – orange curve?

-Line 321: "d-b" – does this mean b, c and d? Please revise.

-Line 321: "The cause is that the average shortwave after the distribution is less than the shortwave without distribution" I am not sure what the authors mean here. Please revise this sentence.

-Line 324: overestimate

-Table 1: "Stock"? Storage? Of what, where?

-Line 326: "To the first order"? Please revise.

-Line 327: Shortwave radiation

-Line 329: what does "correspond much better" mean? Please quantify this.

-Line 330: water balance?

-Line 337, 339, 342: stock?

-Line 341: "ET drawdown subsurface stock" – Please revise.

-Line 344: dynamics

-Line 351: "return to its snow value" – Please revise

-Line 354-355: please remove - figure caption should describe what is on a plot, in main text just please refer to a figure.

-Line 356, 361: cover

-Line 357: accumulation of what? Please add.

-Line 358: which other ones? Please be specific.

-Figure: there seems to be two red lines on the figure, please choose a different colour for e.g. Pix-PM albedo. A: right blue axis title for precipitation is missing. Please add dimension to each axis title - If dimensionless then simply "(-)".

-Lines 371-373: this belongs to the methods section.

-Table 2: belongs to the methods.

-Line 378: "The 2D-AD simulation has less green pixels" Please revise, and add physical explanation.

-Line 383: "The 25th of May is located when snow partially cover the catchment during the melting period." Please revise this sentence, the meaning is unclear.

-Line 383: represents

-Line 388: what does "slightly" mean? Please revise, please be specific. How late exactly?

-Line 391: what does "play" mean? Please rewrite this sentence.

-Line 394: Overall

-Line 396, 405: cover

-Line 397: catchments

-Please add a Discussion section to the manuscript.

-Line 417: spatially distributed snow melt?

-Line 409: "snow-stays"? – days with snow cover?

-Line 409: "These longer snow-stays lead to a significant impact on the hydrological cycle from increased water storage to evapotranspiration regime" – please revise this sentence.

-Line 411: "because it favours the appearance of no-snow patches in the melting season" Please revise.

-Line 411: Shortwave radiation

-Line 412: "differential melting"? Please revise.

-Line 414: reduced

-Lines 417-418: please revise this sentence.

-Line 421: dynamics

-Line 421: "has to be accounted accordingly for hydrological processes" – do the authors here mean accounting for the terrain? Please revise.