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Hydrology and Earth System Sciences
Discussions

Interactive comment on "Near–surface air temperature and snow skin temperature comparison from CREST-SAFE station data with MODIS land surface temperature data" *by* C. L. Pérez Díaz et al.

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Reply to Reviewer #2:

First of all, we want to thank you very much for all your suggestions. These helped improve the manuscript considerably.

We appreciated the revisions and have addressed each of the comments.

The manuscript was completely rewritten. Additional information was added to more

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Interactive Discussion

Discussion Paper

than one section.

NOTE: All changes to the manuscript are highlighted in yellow.

General comments:

The paper 'near-surface air temperature and snow skin temperature comparisons from CREST-SAVE station data with MODIS land surface temperature data' submitted by C.L. Perez-Diaz et al. is generally well written. However, the structure of the paper and how the content is presented is confusing. The paper investigates the relationship between satellite-retrieved temperature and air temperature / skin temperature over snow, but its main message and findings remain unclear. The limited representativeness of the in-situ measurements and the consequences this has for the findings is not sufficiently discussed or accounted for, even though this is of utmost importance for correctly interpreting the results (see attached screenshot of a wider area around Caribou station). The data, instruments and methods also need to be described in more detail. Given the relatively small data set, the conclusions drawn about the relationship between skin temperature, cloudiness, wind speed and air temperature (figs 6 and 7) appear to be speculative. A major revision and resubmission of the paper is recommended.

Reply to General Comments:

The objective of the paper was to validate in situ T-air and T-skin with MODIS LST using the data recorded from a meteorological station (CREST-SAFE) located in a cold climate suitable for snow studies. The findings presented are of interest because most MODIS LST validation studies have been done over snowless barren surfaces. Furthermore, CREST-SAFE presents a distinct advantage over other synoptic stations because it has the instrumentation to observe T-skin directly. This allowed for the direct comparison between in situ T-skin and MODIS LST. Additionally, meteorological parameters such as wind speed and cloudiness were incorporated in the study to explain the physical changes the snowpack undergoes through the winter, and how these

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make T-air and T-skin diverge. Typically, barren surfaces share a similar temperature to T-air. This allows for some researchers to validate remotely-sensed LST with T-air, in lack of surface radiance emission measurements to derive in situ LST. However, as it was shown in this study, T-skin (which is to be considered the "soil" surface by the MODIS signal when present) is not similar to T-air.

We realize that CREST-SAFE's specific conditions might not apply elsewhere. However, the fact that CREST-SAFE does provide continuous T-skin and T-air data does help provide insight on the T-skin – T-air interaction throughout the snow season to evaluate whether the assumption that T-air and T-soil remains true for snow-covered regions was correct. Additionally, since wind speed is recorded in an automated manner at CREST-SAFE and cloudiness is recorded continuously at the NWS offices next to the site, a multiple linear regression analysis was used to find if there is a relationship between T-diff (dependent variable), cloudiness (independent variable), and wind speed (independent variable) to better understand the T-air and T-skin interaction. The results indicated that T-diff is affected inversely by both independent variables.

Lastly, and perhaps more importantly, the statement the paper wanted to make was that it is not accurate to validate MODIS LST using in situ T-air in snow-covered regions by assuming that T-skin will be similar to T-air because that is not the case due to snow heterogeneity, cloudiness, wind speed, and T-air itself. In addition to the already known commonality of pixel resolution and land cover type. It would be ideal if more synoptic stations around the world collected continuous T-skin observations and made them public. This study could then be expanded and perhaps a way to derive T-skin from MODIS LST could be developed. Specific comments:

The 'Abstract' reads more like a part of the introduction and should be rewritten.

Thank you. The Abstract was rewritten.

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Lines 9-11: it is stated that in-situ measurements often cannot provide measurements that are representative for wide areas. However, a broad range of medium to coarse spatial resolution LST products have been successfully validated using temperature-based validation, e.g. MODIS, ASTER, AATSR, and SEVIRI. Please refer to the corresponding literature and try to specify the conditions for sufficiently representative in-situ measurements w.r.t. your location / application.

Yes, the location of CREST-SAFE in Caribou, ME (a rural county in Northeastern USA) is representative of snow-covered areas in high latitude regions since the MODIS inversion cell is closely centered to the station and does not extend to forested areas. Instead, is a mixture of grassland, bare land, and some residential homes.

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line 3: need

Corrected.

line 4: consider rewording 'for proper scrutiny'

This was reworded.

line 5: researchers often use near surface air temperature over snow as proxy

Thank you. This was modified in the paper.

lines 6-7: please reformulate.

This two lines, and most of the manuscript, were reworded.

Line 12: (Zhou et al. 2013). In contrast, only few researchers...

Corrected.

lines 14-17: difficult to read and understand: please reformulate this sentence.

The sentence was reformulated.

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Line 27: introduce LT ('local 'time' ?)

The acronym was introduced.

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lines 4-15: please give the source of the data and acknowledge and reference the data providers. Also provide the name of the LST retrieval algorithm, briefly state its qualities and state the expected accuracy, in particular w.r.t. your application (land cover types).

The sources and data providers were acknowledged. The LST algorithm was discussed in the revised version.

Line 17: please name and refer to the experimenters who performed the CREST-SAFE measurements.

The names of the experimenters were added.

Lines 19-20: what is the relevance of the microwave observations in the context of the paper?

There is no relevance. This was removed.

Page 7670

line 4: please provide more details about the Apogee radiometer (instrument type, spectral range, FOV, mounting height, cover type within observed surface area).

All instruments at CREST-SAFE were now discussed in detail in the revised version.

Line 7: do you mean 'accuracy of 0.2C ' or is this the 'digitisation interval' of the instrument (compare with achievable accuracy of the instrument)?

That is the achievable accuracy of the instrument.

Line 21: behaviour, the hourly values (Sect. 4.3.) indicate otherwise.

Corrected.

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Line23: The time series shows that

Corrected.

line 24: was the colder

Corrected.

line 25: ruled out that the

Corrected.

page 7671

line 1: temperature was colder

Corrected.

line 2: but this is not observed in the daily averages.

Corrected.

Line 6: is negligible, so that the radiative cooling of the ground, which results in lower

Corrected.

line 7: between air minus

Corrected.

Page 7672

Lines 13-24: is air temperature also closer to satellite-retrieved LST if the land is covered by snow? The referenced articles appear to relate to snow–free surfaces only.

Near-surface air temperature is not closer to RS LST when snow is present. The presence of snow affects both T-air and T-skin. A reference was added in which it is demonstrated how MODIS LST deviates from in situ LST when the soil surface is covered by snow.

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Line 21-22: LST is the radiative temperature of the land cover. Therefore, the statement that 'the temperature of the vegetation canopy is usually closer to air temperature than to the land surface temperature, does not make any sense, since over completely forested areas LST is derived exclusively over vegetation and, hence is also close to air temperature. The larger differences observed in this studies stem from the fact that the in-situ LST is not representative for the satellite LST.

Naturally, the temperature of the canopies of tall trees in a forested region will be closer to T-air. That was the statement that was tried to be made. The large differences are also due to snow heterogeneity and its radiative properties when compared to barren surfaces.

Page 7673

Lines 5 and 12: clear-sky (rather than non-clouded)

Corrected.

Page 7675

Line 29: drawn by repeating this study

Corrected.

Figure 3: in my opinion the scatter observed in figure 3 may be due to cloud-contamination with a broad range of cloud heights, i.e. different cloud temperatures. Furthermore, LST is usually only retrieved for clear-sky situations. The authors should explain the effect of cloudiness on the measurements, which should mainly be observed for average air temperatures (as long as LST are limited to clear-sky situations).

All RS LSTs were filtered and only those under clear-sky conditions were used in this study. However, the effects of cloudiness and wind speed on T-diff were explained using a multiple regression analysis in Section 3.1.

Figures 4 and 5: the two figures appear to mainly demonstrate the lack of representa-

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tiveness of the in-situ LST. Please comment.

Mean Absolute Differences and Biases between RS LST and in situ temperatures were now added to explain the differences and similarities between them. Results showed acceptable accuracy for the MODIS LST retrieval algorithm and that the MODIS LST is indeed representative of in situ T-skin is at CREST-SAFE when looking at Biases, which are the common measurement used for RS LST validation using the temperature based method.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 12, 7665, 2015.