Hydrol. Earth Syst. Sci. Discuss., 12, C4654–C4663, 2015
www.hydrol-earth-syst-sci-discuss.net/12/C4654/2015/

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.

C. L. Pérez Díaz et al.

carlos.p.diaz@gmail.com

Received and published: 5 November 2015

Reply to Reviewer #1:

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

than one section.

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

General comments

The paper is potentially interesting, but I find the content a bit weak. On the face of it, the paper is a straightforward evaluation of satellite data using ground-based (in situ) data. This is a reasonable thing to do, standard and worthwhile. However, I find the authors do not convey with sufficient force why their research is of interest. In particular, it does not come through clearly enough that, as I see it, this is a paper on the evaluation of satellite data. One reason for this is that I find the paper a bit disorganized, with the text not clear or not flowing in a number of places (see specific comments for examples).

I also would like the paper to have more details on the representativeness of the ground-based station at Caribou, and the motivation behind choosing just 8 days (and why these 8 days) for the study of the diurnal cycle. Finally, the figures need more details, in particular in the caption (see specific comments).

Once these issues have been addressed, as well as the specific comments below, the paper should be suitable for publication in HESS.

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 ex-

plain the physical changes the snowpack undergoes through the winter, and how these 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

P. 7666

L. 20-21: Why do you get this improved correlation?

The better correlation with T-air is mostly due to snowpack heterogeneity during its

melting phases. A warmer snowpack is known to have a wet snow layer at the surface, especially in the daytime. This changes the emissivity of the snow surface thus changing the TIR brightness temperature which is used for the MODIS LST.

L. 23: Do you need "To a lesser extent"?

Not to a lesser extent. The effects of vegetation are quite important when discussing RS LST retrievals. This is an important issue that was dealt with and discussed in the new revised version.

P. 7667

L. 3: Introduce acronyms when first used in the main manuscript.

Acronyms were introduced when first used in the main manuscript.

L. 16: Provide examples of the regions where in situ networks are sparse.

The examples were included in the revised paper. These regions include: Greenland, Northern Russia, regions of Central Asia, Canada, and Northern USA.

P. 7668

L. 1-2: Meteorological station networks also aid satellite data, e.g., evaluation, improved understanding.

Yes, this is true. This was corrected.

L. 3: Remind the reader of the "commonly known" needs for monitoring snow and ice temperatures.

Some of the more common needs for snow monitoring are spring floods and avalanche high temperature gradient tracking, hydrological modeling, snow microwave emission modeling.

L. 4: Lack of ground measurements at high latitudes?

Thank you, this was corrected.

L. 9: Which way?

Thank you, this sentence was rewritten.

L. 15-17: This statement is vague. Please rephrase.

Thank you, this sentence was rewritten.

L. 18-21: Provide a better link in the text discussing why you study the MODIS LST data.

Thank you. Additional references were added to the manuscript.

L. 19: Identify the seasons studied.

The months studied were January-April for 2013 and February-April for 2014.

L. 21: Mention what you will do in each section of the paper.

The introduction now includes what was done in each section.

P. 7669

L. 8: Why Caribou? Refer to CREST-SAFE.

Thank you. This was addressed.

L. 17: Indicate what is CREST-SAFE.

It is now indicated what CREST-SAFE is in the manuscript.

P. 7670

L. 14: Not clear to me the point about average daily cloudiness. Please rephrase.

Daily cloudiness was used to see whether there was a relationship between sky cover and the difference between near-surface air temperature minus snow surface temper-

ature. The revised version also includes wind speed in this analysis.

L. 24: Mention the winters considered (2013, 2014).

Thank you. This was corrected.

L. 25: Why this “cannot be ruled out”?

It cannot be ruled out because it is demonstrated in Section 3.3 that T-skin is eventually similar to T-air in the month of April due to warmer temperatures.

P. 7671

L. 5: What criterion is used to cluster the specific temperature ranges? Is there a bin over which this is done?

The revised version does not cluster air temperatures. It does include a multiple linear regression analysis that considers sky cover and wind speed as independent variables and T-diff as the dependent variable to look for the effect of predictors on the output variable (T-diff).

L. 6: Do you mean there is no radiative cooling?

Yes. This was corrected.

L. 9: Is the inverse relationship exact or approximate?

The inverse relationship is approximate.

L. 11: Identify the temperature difference.

The temperature difference is near-surface air temperature minus snow surface temperature.

L. 16: How does wind speed affect the temperature difference?

Wind speed “renews” the snow surface by adding a new layer to the top of the snowpack; this makes T-skin colder. Moreover, higher wind speeds reduce T-diff by making

T-skin resemble T-air.

L. 28: Identify which table (if any) shows this correlation. For the sentence "LST. . .", I suggest you do not start a sentence (here and elsewhere) with an acronym.

These correlation values are now in Tables 1 and 2. This sentenced was rewritten.

P. 7672

L. 13-24: This is a bit rambling. It is not clear to me what argument the authors are making.

The argument that was tried to be made was that if the MODIS pixel is mostly covered by forest canopy, naturally the RS LST will in fact be the temperature of the canopies and not the actual snow surface temperature. Hence, due to the height of the trees, the MODIS LST will resemble T-air.

P. 7673

L. 1: How are days selected?

The days were selected based on the coldest and warmest days of the season. Additionally, 4 days with average winter temperatures were selected.

L. 2: How were wind speed and cloud coverage taken into account to explain these disparities?

Sky cover and wind speed were used to check whether T-air and T-skin were similar or different whenever clouds were present or wind speed increased or decreased throughout a day.

L. 6: Feet per second is an unusual unit. I suggest you use metres per second. Did the temperatures peak all the time or most of the time, i.e., generally?

The units were changed to miles per hour. The temperatures peaked at 12 PM LT normally.

L. 9: Previously established where?

Previously established in Section 4.2.

L. 13-15: Explain further this understanding. How do you reach it?

We reached this understanding after looking at other days and comparing them with Figure 6a.

L. 15: Is the day shown in Fig. 6b representative?

Yes, the day in Fig. 6b is representative of a type of day that occurs at CREST-SAFE.

L. 22-24: This should be mentioned earlier.

Thank you. It is mentioned earlier in the manuscript now.

P. 7674

L. 1-3: Explain further why the same cannot be said for the cold winters of January and February.

T-air and T-skin are quite different from each other during January and February, before the snow starts undergoing through common melting phases due to rising air temperatures. Hence, MODIS LST will not resemble T-skin because it will affect the emissivity readings used by the MODIS LST algorithm used to derive LST.

L. 4: Are eight days enough for the diurnal cycle study?

The 8 days selected are representative of common days at CREST-SAFE and of different T-diff, sky cover, and wind speed conditions.

L. 13: Do you mean these changes slowly over time?

Yes. That was what was meant by the statement.

L. 18-20: You mention here validation, which seems to me what you are doing in the paper. Please make sure this is flagged clearly earlier in the paper.

This was flagged earlier in the paper.

P. 7675

L. 6: What do you mean by not being clustered?

This was removed since the sky cover analysis was completely modified.

L. 7: How does wind speed play a role?

See multiple regression analysis in Section 3.1.

L. 17: Is Caribou representative?

Yes, Caribou is representative of high latitude rural regions.

L. 22-23: Is the point that you want to discuss the use of MODIS LST for avalanche warnings? If so, please make clearer.

Yes, partially. This point was made clear now in the introduction.

P. 7676

L. 6: From where does this supplementary information come from?

These LST estimates would be derived and interpolated from actual LST readings.

L. 8-11: What would you expect to find from this study?

This study intends to demonstrate 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.

P. 7682

Fig. 2 caption: Indicate if the observing platform is Caribou. Provide details of the

information in the legend. Identify units and information in both y-axes.

The figure caption was modified as suggested.

P. 7683

Fig. 3 caption: Mention the units (I suggest you use degrees Kelvin instead of degrees Celsius) and the linear fit plotted.

The figure caption was modified as suggested.

P. 7684

Fig. 4 caption: Indicate if the observing platform is Caribou. Mention the linear fit plotted and the units of what is plotted. Do the same for Fig. 5.

The figure caption was modified as suggested.

P. 7686

Fig. 6 caption: I suggest you use Kelvin instead of Celsius. Mention the units, and describe the legend in the caption (do the same for Fig. 7).

The figure caption was modified as suggested. Temperatures were kept in Celsius because these are easier to understand universally.

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