General comments

The authors present a smart method for deducing degree-day factors from in situ snow depth and satellite snow cover area data. This topic is relevant for HESS: hydrological model parameters, and as a consequence snow melt/accumulation model parameters, are always difficult to estimate, especially when data are scarce.

The paper is very well written, both regarding the English and the scientific aspects, apart from minor flaws. Methods are well presented and are adapted to the study, and conclusions are well supported by the results.

Reply: Thank you very much for your positive comments.

I however have a major methodological concern. The authors do perform a split-sample test to the results of the hydrological model, which allows identifying the transferability in time of the model parameters and an independent evaluation. Unfortunately, this test is not performed for the DDFs estimation from MODIS. It should in my opinion be done. Snow conditions are evolving from a year to another, which has an impact on the DDFs values. It is difficult to assume the reason why this test has not been performed: maybe the authors judged that the 10 snow data availability is not enough for such a test (but apparently it was enough for splitting the discharge data). However, I would appreciate that the authors present the results of the transferability in time of the DDFs estimated values as a preliminary step of the presented results.

Reply: Thanks for the suggestions. In the original manuscript, we have already divided the whole study period into two sub-periods (i.e., 2001 to 2005 and 2006 to 2010) for the testing and validating of the estimated DDF_S (please find the sentence as "Both the estimations of snow density and DDFs are carried out in a calculation period, 2001–2005." on line 11-12, page 9 in the original manuscript). We estimated the value of DDF_S in the calibration period (2001 to 2005) and validated the DDF_S set in the validation period (2006 to 2010). To evaluate the transferability in time of the estimated DDF_S, we have re-estimated the value of DDF_S in the validation period (2006 to 2010) in the revised manuscript. Correspondingly, we have added a section of the comparison between the two estimated DDF_S sets in the revised manuscript as follows:

4.2 Transferability in time of the estimated DDF_S

The data set used in this study has been divided into two sub-periods: calibration period from 1 January 2001 to 31 December 2005 and validation period from 1 January 2006 to 31

December 2010. The average annual precipitation is 1126 mm in the calibration period, and 1238 mm in the validation period. The mean daily temperature is 2.28℃ in the calibration period, and 2.59℃ mm in the validation period. Mean daily snow coverage from MODIS is approximately 10% in the calibration period, and about 12% in the validation period. Although the difference of the climate and snow cover conditions in the two periods is small, it can still play a role in the snowmelt processes. Therefore, we re-estimated the value of snow density and DDF_S using the climate data and MODIS snow data in the validation period and compared the new estimated DDF_S set with that estimated using data in the calibration period in Fig. 1. The comparison shows that the two estimated sets of DDF_S and snow density (SD) are slight different due to the different climate and snow cover conditions in the two sub-periods. However, the correlation coefficients between the two estimated DDF_S sets and that between the two SD sets are both high, i.e. 0.802 for the DDF_S and 0.720 for the SD (see Fig. 1), which indicates that both the two estimated DDF_S sets and two SD sets are consistent in the two periods. There is no significant bias for the estimated DDF_S and SD. This suggests the transferability in time of the estimated DDF_S in the whole study period. To further test its transferability in time, we applied DDF_S values estimated in one period for the simulation of basin discharge and snow cover in the other period. For example, we used the DDF_S set estimated by snow data in the calibration period (2001 to 2005) for the model simulation in the validation period (2006 to 2010). The simulations shown in Table 1, Fig. 6b, Fig. 8b, Fig.9b and Fig.11 for the validation period (2006 to 2010) indicate that the estimated DDF_S are transferrable in time with good accuracy.

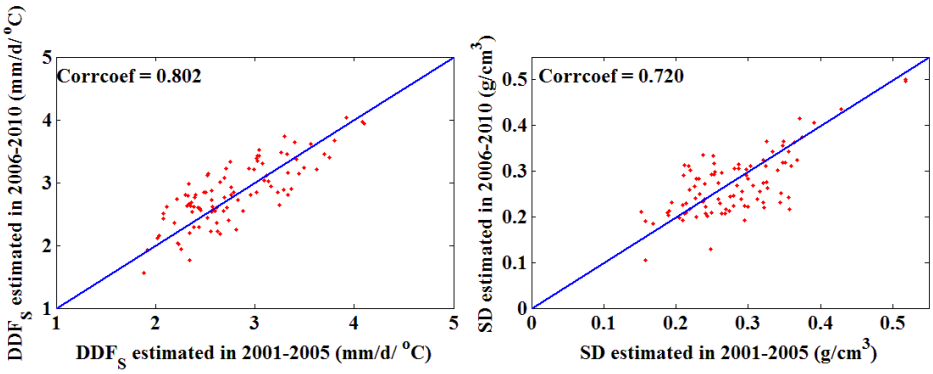

Figure 1. Comparison of the estimated degree-day factor for snowmelt (DDF_S) and snow density (SD) in two sub-periods. "Corrcoef" is the value of correlation coefficient between two estimated sets.

Minor comments:

1. **"degree-day" is sometimes written "degree day" in the manuscript. Please make a choice. The same thing is for "ground-based". I prefer using the hyphens.**

Reply: Done according to the suggestion.

2. **In the abstract the study area /basins should be briefly introduced.**

Reply: We have added a brief introduction of the study area in the abstract in the revised manuscript, i.e.,

"This method is applied to the Lienz catchment in East Tyrol, Austria, which covers an area of 1198 km^2. Its elevations range from 670 m a.s.l. to 3775 m a.s.l.. Approximate 70% of the basin is covered by snow in the early spring season."

3. **p. 3, l. 11-12: is "degree-day temperature" the correct name here? I would say it is a difference in temperature.**

Reply: We have corrected the "degree-day temperature" as "difference between daily temperature and the threshold value".

4. **p. 4, l. 12: "point-measured" is more correct**

Reply: Corrected.

5. **p. 4, l. 11-14: please rewrite this sentence to make clearer that the first cited study allowed the second one to do theirs. The used "and" does not reflect this dependence. The expression "the ratio of : : : and : : :" is present in several places. It is better to use "the ratio of : : : to : : :" or "the ratio between : : : and : : :".**

Reply: We have corrected the sentences in the revised manuscript as "Bormann et al. (2013, 2014) coupled the method developed by Sturm et al.(2010) to estimate snow density as the ratio between point measured SWE and snow depth data with the empirical relationship between DDF_S and snow density of Rango and Martinec(1995) to estimate daily variable DDF_S" on page 4, and some other presentation of "the ratio of :::and :::" in the manuscript have been revised as "the ratio between ::: and :::".

6. **p. 7, l. 9-12: I think that the ratio defined here is incorrect. The dimension of this ratio is equal to the inverse of the dimension of the degree-day factor.**

Reply: We have corrected these sentences as "Snow density is estimated from the days with snow accumulation as the ratio between measured precipitation and changes in snow volume. The degree-day factor is estimated from the days with ablation as the ratio between measured changes in snow water equivalent and the difference between daily temperature and the

threshold value."

7. **p. 7, l. 14: please remove the second occurrence of the word "model".**

Reply: We have removed this word, thanks.

8. **Section 2.1: since this section is a methodological one, there is no need to specify that the SCA data come from MODIS, and that the snow depth data are interpolated from pixel values. Knowing that spatially-distributed SCA and snow depths are used is enough here, the origin of data will be described later in the paper, in section 3.**

Reply: We have removed the related sentence in Section 2.1 and further introduced the data source in Section 3.

9. **p. 9, l. 25-26: how are rainfall and snowfall distributed for this window? Is it a linear interpolation? Please specify.**

Reply: Rainfall and snowfall in this temperature window were simply estimated as half of the total precipitation. We have added this sentence in Section 2.2.

10. **p. 10: What is "I"? The day index? Please specify.**

Reply: Yes, "I" is the day index, we have specified it in the revised manuscript.

11. **p. 10, l. 17: ": : : the number of sub-catchments that ARE covered: : :".**

Reply: We have corrected the sentence as "n is the number of sub-catchments that are covered with glacier".

12. **Equations 6 to 10 should be inserted in section 2.2 instead of 2.3.**

Reply: We have modified it in the revised manuscript.

13. **Section 3.2: please specify the version of the MODIS data as well as its origin. Does it come from the NSIDC? If yes, please respect the articles you have to make reference to. Please also add the time extent of availability of MODIS data.**

Reply: The MODIS snow cover data used in this study is the daily product, i.e. MOD10A1 and MYD10A1 (V005), (Hall et al., 2006a,b). It has been downloaded from the website of the National Snow and Ice Data Center (NSIDC, www.nsidc.org). The used data set consists of daily snow cover maps from 1 January 2001 to 31 December 2010. In response to this comment we have specified the version of MODIS dataset and added the following references:

Hall, D. K., V. V. Salomonson, and G. A. Riggs. 2006a. MODIS/Terra Snow Cover Daily L3 Global 500m Grid. Version 5. Boulder, Colorado USA: National Snow and Ice Data Center.

Hall, D. K., V. V. Salomonson, and G. A. Riggs. 2006b. MODIS/Aqua Snow Cover Daily L3 Global 500m Grid. Version 5. Boulder, Colorado USA: National Snow and Ice Data Center.

14. **Section 3.3: a description of the differences of climate and snow conditions between the two periods could help to better understand later in the paper the results over these two periods.**

Reply: We have added a new Section in the revised manuscript (Sect. 4.2, see the second reply in this document) in which we added a description of the climate and snow conditions in the two periods: "The data set used in this study has been divided into two sub-periods: 1 January 2001 to 31 December 2005 and 1 January 2006 to 31 December 2010. The average annual precipitation is 1126 mm in the first period, and 1238 mm in the second period. The mean daily temperature is 2.28℃ in the first period, and 2.59℃ mm in the second period. Mean daily snow coverage from MODIS is approximately 10% in the first period, and about 12% in the second period".

15. **p.12, l. 5: we don't know at this point on which period the DDFs values have been estimated. Please specify. As I said earlier, the article would benefit from testing and validating the method over two sub-periods.**

Reply: In the original manuscript, we estimated the value of DDF_S in the calibration period (2001 to 2005) and validated the DDF_S set in the validation period (2006 to 2010). Please find the sentence as "Both the estimations of snow density and DDFs are carried out for the period 2001–2005." in line 11-12, page 9 in the original manuscript. In response to this comment, we have re-estimated the value of DDFs in the validation period (2006 to 2010) in the revised manuscript. Comparison between the values of the two estimated DDF_S sets shown in Fig. 1 (see the second reply) demonstrates the transferability in time of the estimated DDF_S. For the simulation of discharge and snow cover in the validation period (2006 to 2010), we used the DDF_S estimated by snow data in the calibration period (2001 to 2005), not the corresponding DDF_S set estimated by snow data in 2006 to 2010. This is to further test the transferability in time of the estimated DDF_S. The sound simulation for the validation period by the DDF_S values estimated in the calibration period points to the reliability of the estimated DDF_S values.

16. **Section 4.2: I am quite surprised about the better results on the validation period than on the calibration period that we often observe in the results. Please comment.**

Reply: The sound results in both the validation period and calibration period suggest that the calibrated parameters are reasonable. The better results in validation period than those in the calibration period may be attributed to the uncertainty in the calibrated parameter values. Given the slightly different climate conditions in the two periods, the calibrated parameter set may produce better results in the validation period, but this could be random. To evaluate the performance of the calibration process is not the core of this paper, but can be an issue of further studies.

17. **p. 17, l. 11: why did you use RMSE here, instead of the other metrics (NSE: : :) used for evaluating discharges earlier?**

Reply: The RMSE is a linear function of NSE. The metric used in Fig.7 is to evaluate the simulation of the snowmelt partition by using different DDFs choices. We did not focus on the accuracy of each simulation but on the relative performance through inter-comparison. To the authors' understanding, no matter which metrics are used here, the inter-comparison results should be similar.

18. **Figures 10 and 11: on these figures, SWE from the two modelling choices and SCA from MODIS are presented. However, p. 19, l. 17-19, the authors say: "Correspondingly, the simulated snow covered areas using calibrated DDFs are higher than those observed from MODIS (see Figs. 10 and 11 on 10 June 2003 and 27 May 2008)". I don't know what allows the authors to state that. On these figures, different things are presented and cannot directly be compared. There is no simulated snow covered areas. I assume that the authors speak about the green and purple surfaces to differentiate covered and non-covered areas. I am a bit skeptical about this choice since a SWE of 18 mm was defined earlier. I would urge the authors to be cautious in this sentence and the end of this paragraph with what they say, and maybe also to modify the figures following my comments.**

Reply: We have replaced the concept of "snow cover areas" in this discussion with the concept of "sub-catchments are covered with snow". The sub-catchments are covered with snow refers to purple surfaces in Figs. 10 and 11. The threshold value of snow water equivalent (SWE) as 18 mm is just used in Figs.8 and 9, but is not used in Figs 10 and 11. The intensity of the purple color in Figs 10 and 11 depends on the value of snow cover area (SCA) from MODIS or simulated SWE values. The green surface in these two Figures refers to areas where SCA value from MODIS or the simulated SWE value is zero, i.e. non-snow covered areas. We have used "sub-catchments are covered with snow" instead of "snow cover areas" to present the purple surface in Figs 10 and 11 in the revised manuscript. Thanks.

19. **p. 20, l. 26 to p. 21, l. 2: please pay attention to the fact that on snowmelt driven basins (or any basin with high discharge seasonality) high NSE values are easier to be reached.**

Reply: We have pointed this out in the revised manuscript: "Considering that high NSE values are relatively easier to be reached in snowmelt affected basins, the performance of the stepwise calibration method should be evaluated in further studies. The core of this paper is on evaluating the performance of the estimated DDFs in hydrological modeling, so we used a stepwise calibration method to identify the DDFs in the model separately, reducing its interdependence with other model parameters of the traditional calibration method".

20. **Globally the figures are good, but I am afraid that some of them would not appear clearly in the final version of the paper. The legend fonts are too small for Figure 2. Figures 4 to 7 are difficult to read, please try to find a way to ease the distinction between the different curves.**

Reply: We have improved these Figures in the revised manuscript. Thanks.