Dear reviewer,

We would like to thank you for thoroughly reviewing our manuscript entitled: "SPHY v2.0: Spatial Processes in Hydrology". After reading your comments we have made substantial revisions to the manuscript, and replied to all your comments. We think the manuscript has considerably improved. Please find our reply to each comment in *italic* font below.

Major comments

1)
SPHY is certainly not the "first" hydrological model developed for the large scale (to my knowledge, there are plethora applications of LISFLOOD, VIC, SWAT, SWIM, HYPE, mHM etc.) and even used for similar applications as those presented in the article for almost a decade (Lindström et al., 2010; Samaniego et al., 2010). Apart from reference to those models and articles, I believe that it would be very insightful to present the pros and cons (for instance, in a table) of SPHYv2 in comparison to other hydrological models for the large scale. Why would a modeller work with SPHY and not with another model structure? It is also important to state the model structural improvements in comparison to the model's 1st version; hence highlighting the novelty of the new version.

We agree with the reviewer that SPHY is not the first hydrological model developed for the large scale. This was also one of the main issues as stated by the other reviewer. As suggested by the reviewer we have therefore inserted a table showing the pros and cons of many well-known hydrological models, including the SPHY model. Based on this table it is clear that all these models have their pros and cons in terms of i) the number and detail of hydrological processes that are integrated, ii) their field and iii) scale of application, and iv) the way they are implemented. SPHY has been developed with the explicit aim to simulate terrestrial hydrology under various physiographical and hydro-climatic conditions by integrating key components from existing and well-tested models: HydroS (Droogers and Immerzeel, 2010), SWAT (Neitsch et al., 2009), PCR-GLOBWB (van Beek and Bierkens, 2008; Bierkens and van Beek, 2009; Wada et al., 2010; Sperna Weiland et al., 2010), SWAP (van Dam et al., 1997) and HimSim (Immerzeel et al., 2011). Based on Tab. 2 it is clear that SPHY i) integrates most hydrologic processes, including glacier processes, ii) has the flexibility to study a wide range of applications, including climate and land use change impacts, irrigation planning, and droughts, iii) can be used for catchment- and river basin scale applications as well as farm- and country-level applications, and has a flexible spatial resolution, and iv) can easily be implemented.

The following text and table were inserted to i) acknowledge historic hydrologic model developments, and ii) show the pros and cons of the SPHY model compared to other well-known hydrological models:

"Over the past decades the land surface and hydrologic communities have made substantial progress in understanding the spatial presentation of fluxes of water and energy (Abbott et al., 1986; Wigmosta et al., 1994; VanderKwaak and Loague, 2001; Rigon et al., 2006). Their efforts have led to the development of well-known hydrological models, such as e.g. VIC (Liang et al., 1994, 1996), SWAT (Neitsch et al., 2009), TOPKAPI-ETH (Finger et al., 2011; Ragettli and Pellicciotti, 2012; Ragettli et al., 2013, 2014), LISFLOOD (Van Der Knijff et al., 2010), SWIM (Krysanova et al., 2015, 2000, 1998), HYPE (Lindström et al., 2010), mHM (Samaniego et al., 2010), PCR-GLOBWB (van Beek and Bierkens, 2008; Bierkens and van Beek, 2009; Wada et al., 2010; SpernaWeiland et al., 2010), MIKE-SHE (Refshaard and Storm, 1995; Oogathoo et al., 2008; Deb and Shukla, 2011) and GEOtop (Rigon et al., 2006; Endrizzi et al., 2013, 2011), amongst others. The number of existing hydrological models is probably in the tens of thousands (Droogers and Bouma, 2014). Some existing model- overviews cover a substantial amount of models: IRRISOFT (Irrisoft, 2014): 114, USGS (USGS, 2014): 110, EPA (EPA, 2014): 211, USACE (HEC, 2014): 18.

All these hydrological models are different with respect to i) the number and detail of hydrological processes that are integrated, ii) their field and iii) scale of application, and iv) the way they are implemented. Whereas for example the SWIM (Krysanova et al., 2015, 2000, 1998) and the HYPE model (Lindström et al., 2010) both include all major hydrological processes, they are typically developed for large-scale (large river basins to continental) applications and therefore contain less detail as fully distributed models such as e.g. GEOtop (Rigon et al., 2006; Endrizzi et al., 2013, 2011) and TOPKAPI-ETH (Finger et al., 2011; Ragettli and Pellicciotti, 2012; Ragettli et al., 2013, 2014) that typically focus on the catchment and river basin scale. Models like e.g. MIKE-SHE (Refshaard and Storm, 1995; Oogathoo et al., 2008; Deb and Shukla, 2011) and LISFLOOD (Van Der Knijff et al., 2010) have the advantage of being flexible in terms of the spatial and temporal resolution, but their disadvantages are that they do not include glacier processes and that they are not open-source and therefore not available to the larger community.

It is clear that all these models have their pros and cons in terms of i) processes integrated, ii) field of application, iii) scale of application, and iv) implementation. Table 2 shows the pros and cons of some well-known hydrological models, including the Spatial Processes in HYdrology (SPHY) model. Over the last couple of years we have developed the SPHY model, and improved its usefulness by applying the model in various research projects. SPHY has been developed with the explicit aim to simulate terrestrial hydrology under various physiographical and hydro-climatic conditions by integrating key components from existing and well-tested models: HydroS (Droogers and Immerzeel, 2010), SWAT (Neitsch et al., 2009), PCR-GLOBWB (van Beek and Bierkens, 2008; Bierkens and van Beek, 2009; Wada et al., 2010; Sperna Weiland et al., 2010), SWAP (van Dam et al., 1997) and HimSim (Immerzeel et al., 2011). Based on Tab. 2 it is clear that SPHY i) integrates most hydrologic processes, including glacier processes, ii) has the flexibility to study a wide range of applications, including climate and land use change impacts, irrigation planning, and droughts, iii) can be used for catchment- and river basin scale applications as well as farm- and country-level applications, and has a flexible spatial resolution, and iv) can easily be implemented. Implementation of SPHY is relatively easy because it i) is open-source, ii) in- and output maps can directly be used in GIS, iii) is setup modular in order to switch on/off relevant/irrelevant processes and thus decreases model run-time and data requirements, iv) needs only daily precipitation and temperature data as climate forcing, v) can be forced with remote sensing data, and vi) uses a configuration file that allows the user to change model parameters and choose the model output that needs to be reported.

The objective of this publication is to introduce and present the SPHY model, its development background, and demonstrate some typical applications. The model executable and source code are in the public domain (open access) and can be obtained from our website free of charge (www.sphy.nl)."

Table 2. Pros (+) and cons (-) of some well-known hydrological models, including the SPHY model. A categorization is made between i) processes that are integrated, ii) field of application, iii) scale of application, and iv) implementation.

	SPHY	TOPKAPI-ETH	SWAT	VIC	LIS-FLOOD	SWIM	HYPE	mHM	MIKE-SHE	PCRGLOB-WB	GEO-top
Processes integrated											
Rainfall-runoff	+	+	+	+	+	+	+	+	+	+	+
Evapotranspiration	+	+	+	+	+	+	+	+	+	+	+
Dynamic vegetation growth	+	-	+	+	+	+	+	NA	+	+	-
Unsaturated zone	+	+	+	+	+	+	+	+	+	+	+
Groundwater	+	-	+	+	+	+	+	+	+	+	+
Glaciers	+	+	-	-	-	+	+	-	-	-	+
Snow	+	+	+	+	+	+	+	+	+	+	+
Routing	+	+	+	+	+	+	+	+	+	+	+
Lakes incorporated in routing scheme	+	-	+	+	+	+	+	NA	+	+	-
Reservoir management	-	-	+	-	-	+	+	NA	-	+	-
Field of application											
Climate change impacts	+	+	+	+	+	+	+	+	+	+	+
Land use change impacts	+	+	+	+	+	+	+	+	+	+	+
Irrigation planning	+	-	+	+	-	+	+	-	+	-	+
Floods	-	-	-	-	*3	-	-	-	+	+	+
Droughts	+	+	+	+	+	+	+	+	+	+	+
Water supply and demand	-	-	+	-	-	-	-	NA	-	-	-
Scale of application											
Catchment-scale	+	+	+	+	-	-	-	-	+	-	+
River basin scale	+	+	+	+	+	+	+	+	+	-	-
Mesoscale river basins	+	-	+	+	+	+	+	+	+	+	-
Global-scale	-	-	-	+	-	-	+	-	-	+	-
Farm-level	+	-	-	-	-	-	-	-	-	-	-
Country-level	+	-	-	-	-	-	-	-	-	-	-
Fully distributed	+	+	-	+	+	-	-	+	+	+	+
Sub-grid variability	+	-	-	+	-	-	-	+	-	+	+
Felxible spatial resolution	+	+	-	+	+	-	-	+	+	+	+
Hourly resolution	-	+	+	-	+	-	-	+	+	-	+
Sub-daily resolution	-	-	-	+	+	-	-	NA	+	-	-
Daily resolution	+	+	+	+	+	+	+	NA	+	+	-
Implementation											
Open-source	+	-	+	+	-	-	+	-	-	-	+
Forcing with remote sensing	+	+	-	+	+	-	-	NA	-	-	+
GIS compatibility	+	+	+	-	+	+	-	+	+	+	+
Modular setup	+	-	-	+	+	+	+	+	+	-	-
Computational efficient	+	+	+	-	+	+	+	+	-	+	+
Climate forcing requirements	+	+	-	*2	-	-	+	+	-	-	-
Flexible output reporing options	+	+	-	+	+	+	+	NA	+	-	+
Graphical user-interface in GIS	*1	-	+	-	-	+	-	-	+	-	-

*1 Currently in development.
*2 More climate variables are required if model is run in energy balance mode.
*3 Only if run in combination with LISFLOOD-FP.
NA Information not available.

The reviewer also wonders about the structural improvements between SPHY v2.0 and SPHY v1.0. To be honest, there has never been an official (published) version 1.0 of SPHY, because before SPHY 2.0 was developed, there were 3 separate models focusing on i) soil moisture simulations, ii) rain-fall runoff modelling, and iii) cryosphere processes. For easiness and in order to have one model that can cover a wide range of applications, we have integrated these model structures into one model, and we gave it the name SPHY v2.0.

Minor comments

1)
Page 1688 Line 4: How would you define “best components”? I would suggest replacing with “important” or “dominant”

We agree that “best components” are not the correct words to be used here. Instead of using “important” or “dominant”, as suggested by the reviewer, we think “key components” is the best rephrasing here. Therefore, “best components” has been replaced with “key components”.

2)
Page 1688 Line 6: “… under various land use and climate conditions”. Is it only those? Why only mentioning land use and climate? To me a model should be applied in various physiographies and hydro -climatic conditions. Rephrase accordingly.

We agree with the reviewer that the model should be applicable for various physiographies and hydro-climatic conditions. Therefore, we have rephrased this sentence to:

“SPHY has been developed with the explicit aim to simulate terrestrial hydrology at flexible scales, under various physiographical and hydro-climatic conditions, by integrating key components from existing and well-tested models.”

3)
Page 1688 Line 9: Delete “Compared to other hydrological models, that typically focus on the simulation of streamflow only” to avoid misinterpretation. The statement is also not correct! Hydrological models at the large scale, they can describe many dominant hydrological processes including human alterations.

We agree that this sentence can cause some misinterpretation. This was also one of the major comments of the other reviewer, referring to the ‘negative’ tone used to introduce our model and how it compares to other models. Therefore, substantial parts of the introduction and the abstract have been rewritten (see also reply to major comment 1)), removing sentences with a ‘negative’ tone. Please see the revised manuscript (mainly in the abstract and introduction sections) for these corrections.

4)
Page 1688 Line 12: “remote sensing data”. Why limiting this to remote sensing data? I suggest replace this with “forcing meteorological data”

We agree with the reviewer that besides remote sensing data, also forcing with meteorological data is important. However, we do not agree that ‘remote sensing data’ in this case should be replaced with ‘forcing meteorological data’, because besides meteorological data, remote sensing can also retrieve data like e.g. snow cover, NDVI, etc., which are not meteorological forcings. One of the strengths of SPHY is for example that it can be forced with a time-series of NDVI images in order to calculate crop coefficients and canopy storage dynamically.

To mention the fact that meteorological forcing data requirements in SPHY are small (only precipitation and temperature), we inserted the sentence below in the revised version of the manuscript:

“Implementation of SPHY is relatively easy because it i) is open-source, ii) in- and output maps can directly be used in GIS, iii) is setup modular in order to switch on/off irrelevant processes and thus decreases model run-time and data requirements, iv) needs only daily precipitation and temperature data as climate forcing, v) can be forced with remote sensing data, and vi) uses a configuration file

that allows the user to change model parameters and choose the model output that needs to be reported."

5)
Page 1689 Line 9: You can cite the paper by Pechlivanidis et al. (2011)

This citation has been included as suggested.

6)
Page 1689 Line 14: I suggest rephrasing as "… provide hydrologic information on high temporal…"

This has been rephrased as suggested by the reviewer

7)
Page 1689 Line 15: What do you mean with "and for difficult to observe sub-processes"?

With 'difficult to observed sub-processes' we refer to hydrological processes that are very difficult to measure on the large spatial scale that hydrological models are often applied on. To make this clearer, this sentence has been rephrased to:

"The strength of hydrological models is that they can provide output on high temporal and spatial resolutions, and for hydrological processes that are difficult to observe on the large scale that they are generally applied on."

8)
Page 1689 Line 18-19: "Such scenarios are often referred to as projections." I do not agree with this statement. There is a distinction between scenarios and projections. For instance a climate projection is based on an emission scenario. Would you call a scenario of T+2oC as projection? I suggest deleting this sentence to avoid misunderstandings.

This sentence has been deleted to avoid misunderstandings.

9)
Page 1689 Line 23-24 and Page 1690 Line 1-2: The statement is clearly a personal opinion and not clarified by a reference. In my opinion though, the HBV model is generally considered as a benchmark (Ceola et al., 2014). To avoid biases towards personal opinions, I suggest deleting those sentences.

As suggested by the reviewer these sentences have been deleted.

10)
Page 1690 Line 12-14: What about irrigation?

We agree that irrigation is important as well. As stated before, the Introduction section has been substantially revised. The text from:

"Traditionally, hydrologists…….." (page 1690 line 3)

up till:

"……free of charge (www.sphy.nl)." (page 1691 line 2)

has almost completely been removed. Since irrigation planning is important, it is included as one of the 'pros' of the SPHY model in the table as shown under major comment 1).

11)
Page 1690 Line 15 -18: This is very specific and should be further discussed. Models should be flexible to incorporate any kind of information, i.e. a reservoir operation scheme, demands for irrigation, levels in the lakes etc.

The reviewer here refers to the importance of models being flexible enough to incorporate any kind of information, e.g. reservoir operational rules, irrigation demand, etc. Because a substantial part of the introduction section has been rewritten (see response to major comment 1), the sentences the reviewer is referring to have been deleted in the revised manuscript, and are therefore less relevant to discuss here.

However, regarding model flexibility we can say that SPHY i) integrates the dominant hydrological processes, ii) has the flexibility to study a wide range of applications, and iii) and scale of applications.

- *i.* *SPHY is flexible enough to include lakes in the routing scheme, using measured lake levels from remote sensing, to calculate the lake outflow according to a Q(h)-relation (see also section 2.8.2 of the manuscript). Additionally, SPHY has the flexibility to be forced with a time-series of NDVI (obtained from remote sensing) to calculate growth stages dynamically. Reservoir operational rules are not implemented yet, but this is foreseen for future versions of the SPHY model.*
- *ii.* *Irrigation scheduling is one of the many applications that SPHY is suitable for: SPHY can be used to evaluate the evapotranspiration deficit spatially. This can be used by farmers to optimize their irrigation scheduling. For details we refer to the case study in Section 3.1.*
- *iii.* *SPHY does not only focus on catchment- or river basin scale applications. As already stated in ii), SPHY can be applied on a very small scale (e.g. farm-level). This allows incorporating high-detail information, such as applied amount of irrigation water.*

Regarding model flexibility we refer to Table 2, the text as shown below, and Section 3.1 in the revised manuscript:

"Based on Tab. 2 it is clear that SPHY i) integrates most hydrologic processes, including glacier processes, ii) has the flexibility to study a wide range of applications, including climate and land use change impacts, irrigation planning, and droughts, iii) can be used for catchment- and river basin scale applications as well as farm- and country-level applications, and has a flexible spatial resolution, and iv) can easily be implemented."

12)
Page 1690 Line 19-24: What about parameterisation? I would have interpreted that "model setup" includes parameterisation, however here you only mention switching on/off processes.

Besides switching on/off processes, model parameterization is indeed part of the model setup, and can easily be done in the model's configuration file. Within the configuration file, the model parameters are clearly organized within sections that are related to the different hydrological processes. We have inserted the text as shown below to inform the reader about the ease of parameterization, using the configuration file. Additionally, we have included Table A1 with the SPHY model parameters, as was suggested by the other reviewer.

"Implementation of SPHY is relatively easy because it i) is open-source, ii) in- and output maps can directly be used in GIS, iii) is setup modular in order to switch on/off irrelevant processes and thus

decreases model run-time and data requirements, iv) needs only daily precipitation and temperature data as climate forcing, v) can be forced with remote sensing data, and vi) uses a configuration file that allows the user to change model parameters and choose the model output that needs to be reported."

Table A1. Overview of SPHY model parameters. The last column indicates if this parameter is easy (+++), moderate (++), or difficult (+) to observe.

Acronym	Description	Units	Observable
Kc	Crop coefficient	-	++
Kc_{max}	Maximum crop coefficient	-	++
Kc_{min}	Minimum crop coefficient	-	++
$NDVI_{max}$	Maximum NDVI	-	+++
$NDVI_{min}$	Minimum NDVI	-	+++
$FPAR_{max}$	Maximum Fraction of Absorbed Photosynthetically Active Radiation	-	++
$FPAR_{min}$	Minimum Fraction of Absorbed Photosynthetically Active Radiation	-	++
T_{crit}	Temperature threshold for precipitation to fall as snow	$^{\circ}C$	+
DDF_s	Degree Day Factor for snow	$mm\ ^{\circ}C^{-1}d^{-1}$	+
SSC	Water storage capacity of snowpack	$mm\ mm^{-1}$	+
$GlacF$	Glacier fraction of grid-cell	-	+++
DDF_{CI}	Degree Day Factor for debris free glaciers	$mm\ ^{\circ}C^{-1}d^{-1}$	+
DDF_{DC}	Degree Day Factor for debris covered glaciers	$mm\ ^{\circ}C^{-1}d^{-1}$	+
F_{CI}	Fraction of GlacF that is debris free	-	+++
F_{DC}	Fraction of GlacF that is covered with debris	-	+++
$GlacROF$	Fraction of glacier melt that becomes glacier runoff	-	+
$SW_{1,sat}$	Saturated soil water content of first soil layer	mm	+++
$SW_{1,fc}$	Field capacity of first soil layer	mm	+++
$SW_{1,pF3}$	Wilting point of first soil layer	mm	+++
$SW_{1,pF4.2}$	Permanent wilting point of first soil layer	mm	+++
$K_{sat,1}$	Saturated hydraulic conductivity of first soil layer	$mm\ d^{-1}$	+++
$SW_{2,sat}$	Saturated soil water content of second soil layer	mm	+++
$SW_{2,fc}$	Field capacity of second soil layer	mm	+++
$K_{sat,2}$	Saturated hydraulic conductivity of second soil layer	$mm\ d^{-1}$	+++
$SW_{3,sat}$	Saturated soil water content of groundwater layer	mm	+
slp	Slope of grid-cell	$m\ m^{-1}$	+++
δ_{gw}	Groundwater recharge delay time	d	+
α_{gw}	Baseflow recession coefficient	d^{-1}	++
BF_{tresh}	Threshold for baseflow to occur	mm	+
kx	Flow recession coefficient	-	+

13)
Page 1691 Line 4: Maybe use 'Background' instead of 'Introduction'

This has been corrected as suggested by the reviewer.

14)
Page 1691 Line 5: "best component". See my previous comment.

The paragraph starting with:

"The SPHY model...... (Page 1691 line 5)

Till:

"....and climate conditions (Page 1691 line 10)

has been rephrased and moved and to the Introduction section of the revised manuscript. 'Best components' has been replaced by 'key components'. Please see the revised text as shown below:

"SPHY has been developed with the explicit aim to simulate terrestrial hydrology under various physiographical and hydro-climatic conditions by integrating key components from existing and well-tested models: HydroS (Droogers and Immerzeel, 2010), SWAT (Neitsch et al., 2009), PCR-GLOBWB (van Beek and Bierkens, 2008; Bierkens and van Beek, 2009; Wada et al., 2010; Sperna Weiland et al., 2010), SWAP (van Dam et al., 1997) and HimSim (Immerzeel et al., 2011)."

15)
Page 1691 Line 9: You discuss about land use but what about soil and topography?

This comment is more or less equal to minor comment nr. 2, where the reviewer stated: To me a model should be applied in various physiographies and hydro-climatic conditions.

Besides land use, the model should indeed be applicable under various soil and topographical conditions as well. In our opinion the word 'physiographies' refers to a wide range of land use, soil, and topographical conditions. As already explained under comment 2, this sentence has been corrected to:

"SPHY has been developed with the explicit aim to simulate terrestrial hydrology at flexible scales, under various physiographical and hydro-climatic conditions, by integrating key components from existing and well-tested models."

16)
Page 1692 Line 19: "… scheme is used; depending on the…"

This has been corrected as suggested by the reviewer.

17)
Page 1693 Line 2-5: I believe that calibration/evaluation should be discussed in a separate subsection.

We agree with the reviewer that more information regarding model calibration/evaluation should be included in the manuscript. Instead of doing this in a separate subsection, we have discussed the calibration/evaluation as part of one of the case-study applications (snow and glacier-fed river basins), in which MODIS snow cover images have been used to calibrate the simulation of snow cover by the model, before proceeding with calibrating for observed discharge.

On page 1693 after "……and/or snow coverage." (line 5) we have inserted the following sentence:

"Section 3.2 contains an example application in which the SPHY model has been calibrated using MODIS snow cover images."

In Section 3.2 we have inserted the following text and figures:

"For basins with snow melt being an important contributor to the flow, besides calibration to observed flow, the snow-related parameters in the SPHY model can also be calibrated to observed snow cover. For the Upper Indus basin the snow-related parameters degree-day factor for snow (DDF_s) and snow water storage capacity (SSC) were calibrated independently using MODIS snow cover imagery (Lutz et al., 2014a). The same MODIS dataset was used as in Immerzeel et al. (2009). From the beginning of 2000 until halfway 2008, the snow cover imagery was averaged for 46 different

periods of 8 days (5 days for the last period) to generate 46 different average snow cover maps. E.g. period 1 is the average snow cover for 1-8 January for 2000 until 2008, whereas period 2 is the average snow cover for 9-16 January for 2000 until 2008, etc. The SPHY model was run for 2000-2007 at a daily time step and for each 1x1 km grid cell the average snow cover was calculated for the same 46 periods as in the MODIS observed snow cover dataset. Subsequently, these simulated snow cover maps were resampled to 0.05° spatial resolution, which is the native resolution of the MODIS product. Figure 8 shows the basin-average observed and simulated fractional snow cover for the 46 periods during 2000-2008 and Figure 9 shows the same at the 0.05° grid cell level. As a final step, the baseflow recession coefficient (α_{gw}) and routing coefficient (kx) were calibrated to match the simulated streamflow with the observed streamflow."

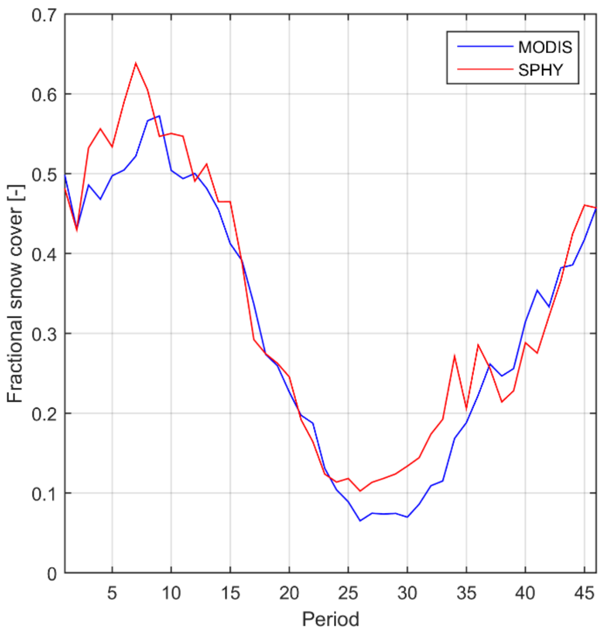

Figure 8: Observed and simulated average fractional snow cover in the upper Indus basin. The values represent the 9-year average for 46 (8-day) periods during 2000-2008.

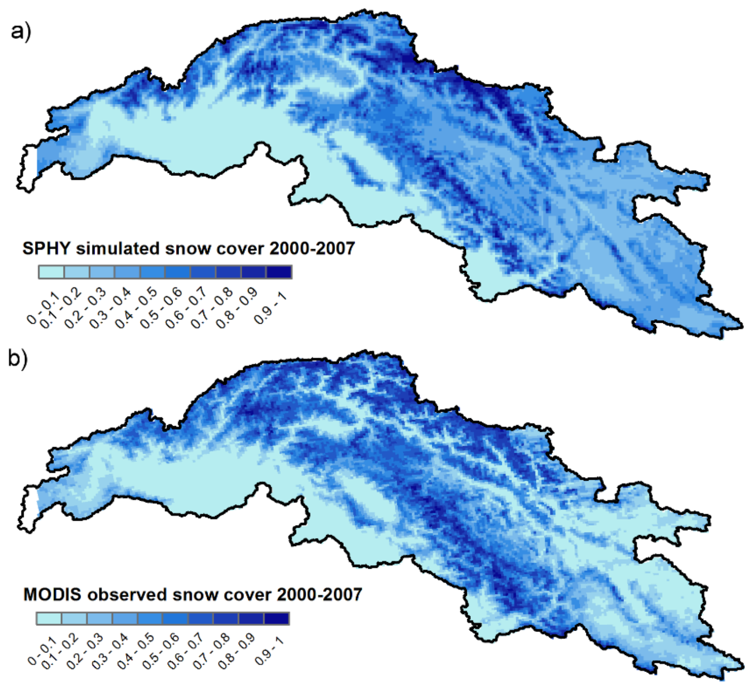

Figure 9: a) SPHY simulated snow cover 2000-2007 and b) MODIS observed snow cover 2000-2007.

18)
Page 1693 Line 6-8: There are many more variables that could be extracted from a model. However, you only do this for the most needed components. Page 1693 Line 7-8: I suggest "… maps of all the available hydrological processes, i.e. actual evapotranspiration…"

We agree that only a few variables (actual evapotranspiration, runoff generation, and groundwater recharge) that could be extracted from the model are mentioned here. SPHY can indeed report maps of all the available hydrological processes. As suggested by the reviewer we have therefore modified this sentence to:

"Spatial output can be presented as maps of all the available hydrological processes, i.e. actual evapotranspiration, runoff generation (separated by its components), and groundwater recharge."

19)
Page 1693 Line 10: I suggest "… base, but can also be aggregated at monthly or annual time periods."

This has been corrected as suggested by the reviewer.

20)
Page 1693 Line 11: Instead of "location" do you mean "cell"?

We indeed mean "cell" instead of "location". This has been corrected as suggested.

21)
Page 1693 Line 12: The "under current and future conditions" is not necessary information. I suggest deleting.

We agree that this information is not required and have therefore deleted this part.

22)
Page 1693 Line 12: What about inflows, water level in lakes/reservoir, water demands, snow water equivalent etc.?

First of all we like to emphasize that SPHY is not a water allocation, supply, or demand model, such as for example the WEAP model is. This is also clearly stated in the new table (Table 2) that shows the pros and cons of the SPHY model amongst other models. Therefore, water demands can only be evaluated based on the evapotranspiration deficit, as shown for the Romanian case study (e.g. Fig 4). Inflows are not reported explicitly, but can be reported if the user defines a streamflow station at these inflow cells. Water levels and snow water equivalent not reported, but are only calculated as a background process. The option to report these variables may be useful to be implemented in the next version of the SPHY model.

23)
Page 1693 Line 19-22: This is not stated well. There is a difference between 'interested in simulating only' and 'dominant processes occur'. Despite the interest on certain processes if the remaining is important they should be switched on.

This comment was also made by the other reviewer (comment nr.5). We agree with the reviewer that despite the interest in certain processes, they should be switched on if they are important for the area of interest. In other words: the processes included (switched on) in the modelling framework are dependent on the catchment properties. It is therefore required that the user knows which *characteristics and processes are relevant for their area of interest. If this is known, then the irrelevant processes (modules) can be turned off.*

To make this clear to the reader we have inserted the text as shown below after page 1693 line 23:

"It should be noted, however, that the hydrologic model structure should be specific to the catchment's characteristics (Pomeroy et al., 2007; Clark et al., 2008; Niu et al., 2011; Essery et al., 2013; Clark et al., 2015a, b). It is therefore essential that the user knows which catchment characteristics and processes should be included in their modeling framework."

24)
Page 1693 Line 28: Delete since the message is given in the previous sentence.

This has been deleted as suggested by the reviewer.

25)
Page 1694 Line 3: It should be "… available: (i)…"

This has been corrected as suggested by the reviewer.

26)
Page 1694 Line 9-20: This is unnecessary repetition of facts or methods which are well known. I would personally stick to the major limitation to provide data for the highly demanded energy based methods. Hence the need for simplistic algorithms based on temperate only.

We agree with the reviewer that this is an unnecessary repetition of facts. We have therefore rephrased and condensed this text to the text as shown below:

"Despite the good physical underlying theory of the Penman-Monteith equation (Allen et al., 1998) to calculate the reference evapotranspiration (ETr), its major limitation is the high data demand for energy based methods. This brought Hargreaves and Samini (1985) to derive the modified Hargreaves equation that is based on temperature only. For this reason, this equation has also been implemented in the SPHY model, according to:"

27)
Page 1694 Line 12: "standard method".

This comment is not relevant anymore because it has been rephrased (see previous comment).

28)
Page 1695 Line 18: "… or use a time-series of crop coefficients as model input." Isn't that related to the dynamic module?

The user has the option to i) use the dynamic vegetation module, or ii) not to use the dynamic vegetation module. If the user opts to use the dynamic vegetation module, then the crop coefficient is calculated dynamically using a time-series of NDVI (see section 2.4). If the user opts not to use the dynamic vegetation module, then there are two options:

1. *Provide a single constant crop coefficient for the entire simulation period.*
2. *Provide a time-series with crop coefficients.*

Option 2 can be obtained from literature (e.g. Allen et al., 1998) or the FAO (e.g. http://www.fao.org/nr/water/cropinfo_wheat.html).

We think that this was well explained in the manuscript. However, we modified this section slightly according to the text below:

"If the dynamic vegetation module in SPHY is not used, then the user can opt to i) use a single constant Kc throughout the entire simulation period or ii) use a pre-defined time-series of crop coefficients as model input. Plausible values for Kc can be obtained from literature (Allen et al. 1998; FAO, 2013)."

29)
Page 1695 Line 20: Delete sentence "and therefore… simulation period."

This has been deleted as suggested by the reviewer.

30)
Page 1696 Line 3-6: Such an approach can only be used when NDVI data are available. In the case of assessment under future conditions, how do you calculate Kc dynamically?

This is a very good point. For the assessment of future conditions it is impossible to use remotely sensed NDVI imagery to calculate the Kc dynamically. The $NDVI_{max}$ *and* $NDVI_{min}$ *are crop specific, and are independent of future conditions. However, the actual measured NDVI is dependent on many factors, including e.g. water availability, nitrogen, temperature, etc. Since these factors are unknown for future conditions, equation 3 is less suitable to be used for the dynamic calculation of Kc for future conditions. Therefore, two options may be considered:*

1. *Use a pre-defined time-series of Kc, instead of the dynamic vegetation module*
2. *Assume a pre-defined time-series of NDVI: depending on the expected climate conditions in the future, one can assess if the expected climate will be above or below average. Based on this, the user can choose a comparable historical climatological period (in terms of wetness, dryness, temperature), and retrieve a time-series of NDVI imagery from this comparable period to be used to force the model.*

31)
Page 1698 Line 22: Delete "easily".

This has been deleted as suggested by the reviewer.

32)
Page 1705 Line 21-22: What type of parameters? What are they related to?

According to Bartholemeus et al. (2008), the minimum gas filled porosity of soil ($ø_{gas\_min}$*) is the porosity of the soil at which oxygen stress starts to occur. They showed that* $ø_{gas\_min}$ *is especially sensitive to soil temperature, root dry weight, and plant respiration characteristics. These properties can only be determined accurately if the focus is on a very small scale. To make this clearer in the manuscript, we have modified this sentence into:*

"The calculation of evapotranspiration reduction due to water excess (oxygen stress) is quite complex and requires a substantial amount of plant and soil properties (e.g. soil temperature, root dry weight, plant respiration, and minimum gas filled soil porosity (Bartholomeus et al., (2008)) that are generally not available for the spatial scale that SPHY is applied on."

33)
Page 1719: Reference to Fig. 7 seems to be missing.

This reference was indeed missing. Based on the comments of reviewer 1, Fig. 7 has been replaced by another figure, showing snow storage simulations throughout the melting season. We included the reference to this new figure.

34)
Page 1725 Line 5: "applicable, (iv) can easily be …, and (v) can be applied…"

Since the Conclusion section has been substantially revised, this sentence does not exist anymore.

35)
Page 1743: In Figure 4, it is difficult to distinguish the two lines. Give a different colour and line style (to even be distinguishable in grey scale).

We modified the line colors to red and blue, which are very good distinguishable in grey scale.

36)
Page 1744: Same as in Figure 4.

We modified the line colors to red and blue, which are very good distinguishable in grey scale.

37)
Page 1747: Same as in Figure 4.

We modified the line colors to red and blue, which are very good distinguishable in grey scale.