We thank both reviewers and Yan Li for their time and effort and their helpful and constructive comments. The original comments of the reviewers and Yan Li are in color. Our reply is in black.

1. First, let me say that, in general, I like this analysis and think that it's important. The authors have done a good job incorporating many quality dataset to address a complex problem, and the spatial nature of the analysis is a major strength. However, I have a major problem in that the presentation of the study design and methods are incomplete, such that I cannot determine whether the study design is sound. I am left fully confused by what was actually done. I therefore cannot determine whether the analysis is actually fine, but the methodology simply needs to be explained better, or rather the study design is flawed or could be improved. I will be more specific below. The fundamental problem is that, despite an emphasis on the spatial nature of this analysis, it is not at all indicated where the land use transitions you include actually happen, or even how much land area is converted. Figures 3 and 4 indicate results are "wall to wall", where every pixel has experienced a radiative forcing. This implies that all pixels were assigned a land use transition, which seams very unreasonable. You considered five land use transitions; which pixels received each transition? Figures 3 and 4 (and 5??) are presented for a particular transition (Intensively Used Open Land (<1000 m) and Extensively Used Open Land (>1000) to Closed Forest), so was the analysis done five times where all pixels received the same transition? Where are the figures for the other transitions? Is this supposed to represent a maximum afforestation case, where all open land is converted to forest? Is that climatologically reasonable? Could forests grow in all of these pixels? Right now your relevant study design text spans about five lines (P10129, lines 6-11). Please expand this and include new figures and tables that illustrate the location and amount of area where particular land use transitions occurred, and text that addresses whether these transitions are supposed to represent reality (between 1985 and 1997) or a hypothetical case? I cannot imagine it is the former, since every pixel seems to have been altered (and experienced a radiative forcing).

Since most of the questions and concerns of reviewer 2 are related to the methodology concerning the transitions between land use/land cover classes and the study design, we will first address these issues in general and then answer the individual questions more specifically.

The methodology of the assessment of land use/land cover transitions are based on aerial photograph based surveys of land use/land cover for Switzerland in the years 1985 and 1997 and has been described in more detail in Rutherford et al. (2008). We realize and acknowledge that the description of this method has been kept very short in this manuscript and that it can be difficult to understand the methodology without additional information about these data. Also we acknowledge that it may have been confusing that we used these data slightly differently for the analysis of (1) spatial pattern in Radiative Forcing in a temperate mountainous region and (2) what the inclusion of albedo change implies for the greenhouse gas inventory in Switzerland between 1985 and 1997 (calculating the total amount of albedo forcing and CO_2 forcing of the forest expansion between 1985 and 1997).

In the revised version of the discussion paper we will explain the methodology of land use/land cover assessment more clearly and we will in particular separate more clearly between the two different analysis/results for (1) spatial pattern in Radiative Forcing and (2) and Radiative Forcing of forest expansion in Switzerland between 1985 and 1997.

We added the following paragraph to the introduction:

"Our study design is twofold: First, we use the spatially explicit datasets to show the pattern of RF assuming that each location in Switzerland is facing a transition from agriculturally used open land to forest. This is not related to any particular or realistic scenario, however, the spatial pattern of RF can be of high interest for any land-use policies steering forest cover change towards desired futures. In Switzerland agricultural subsidies directly influence farmers decisions on whether to keep managing or abandon their land. The latter will usually result in forest expansion. Second, we include the type and location of 5 different land use transitions to calculate RF in Switzerland between 1985 and 1997. In summary we estimate i) to which extent albedo RF offsets CO_2 RF in different parts of temperate mountainous regions, ii) how each input parameter influences RF, and iii) what the inclusion of albedo change implies for the greenhouse gas inventory in Switzerland."

For further changes see point 2 and 3.

2. The fundamental problem is that, despite an emphasis on the spatial nature of this analysis, it is not at all indicated where the land use transitions you include actually happen, or even how much land area is converted.

Unfortunately, the figure A1 and the table A4 are at the very end of this discussion paper and thus not very visible. Figure A1 shows where most transitions occur. We had to use a kernel density function (showing densities of land-use transitions) because it is difficult to visualize single pixels in a 3000 x 2000 grid. Table A4 shows forest expansion for every biogeographical region. We will refer to this figure and this table more clearly in the text. In addition we added more information to Table 4.

We added:

"… At lower elevations, transitions from Intensively Used Open Land to Forest are frequent, while in higher elevations transitions from Extensively Used Open Land to Forest are most likely (**Error! Reference source not found.**). …"

Table 4 (modified version): Area affected by each type of transition between 1985 and 1997. Numbers behind each biogeographical region 1-3 indicate the elevation (1 = below 600m, 2 = 600 – 1200m, 3 = above 1200m).

Biogeo-graphical region	Intensively Used Open Land to Closed Forest [ha]	Extensively Used Open Land to Closed Forest [ha]	Intensively Used Open Land to Open Forest [ha]	Extensively Used Open Land to Open Forest [ha]	Open Forest to Closed Forest [ha]	Forest expansion (sum of all transitions) [ha]
Jura 1	116	31	98	35	106	386
Jura 2	113	238	73	330	522	1276
Jura 3	1	46	1	155	490	693
Plateau 1	613	87	379	52	264	1395
Plateau 2	232	60	110	44	85	531
Plateau 3	NA	NA	NA	NA	1	1
Northern Prealps 1	109	21	78	13	53	274
Northern Prealps 2	321	497	295	401	959	2473
Northern Prealps 3	34	955	77	1180	2476	4722
Alps 1	4	4	6	11	29	54
Alps 2	93	101	267	154	679	1294
Alps 3	102	739	291	1700	3687	6519

Southern Prealps 1	61	25	145	22	196	449
Southern Prealps 2	76	77	170	135	731	1189
Southern Prealps 3	23	274	71	604	1541	2513

We added:

"… Forest expansion mainly took place in elevations above 1200 m in the Prealps and the Central Alps (Figure 1). …"

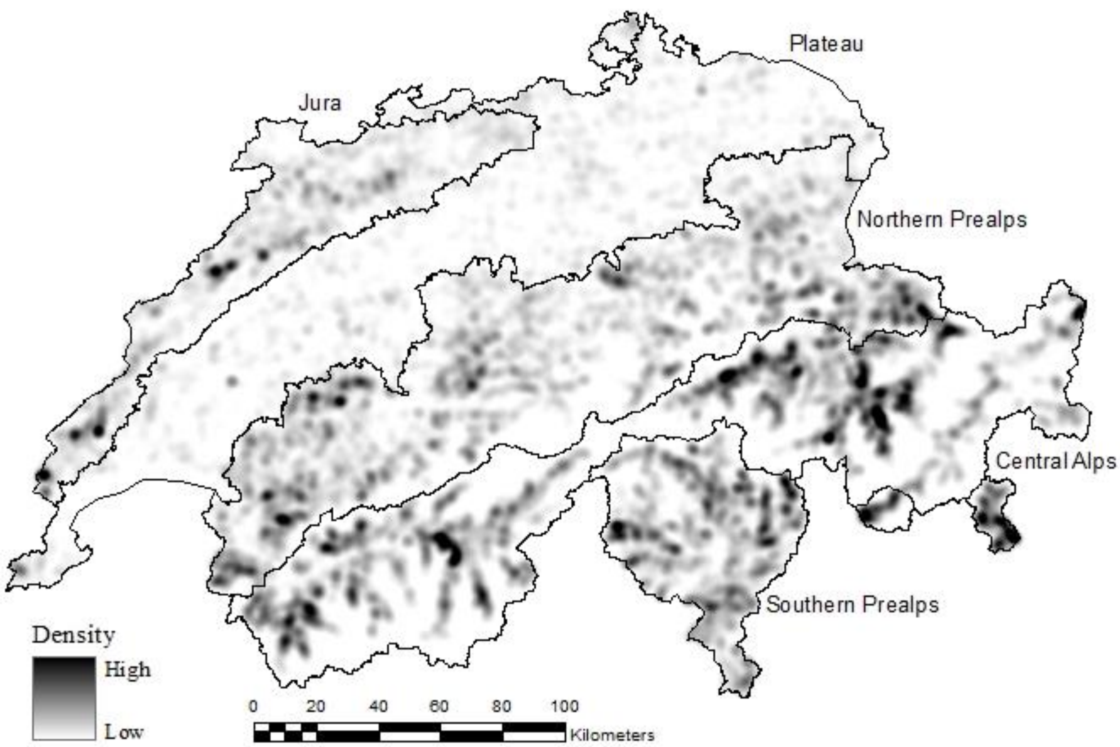

Figure 1: Spatial pattern of forest expansion. The pattern illustrates the density of forest expansion in Switzerland. The density was calculated including the area of all five transitions we used for calculating RF (see chapter "Swiss forest expansion between 1985 and 1997") and a kernel-density function in ArcGis 10.1 (ESRI).

3. Right now your relevant study design text spans about five lines (P10129, lines 6-11). Please expand this and include new figures and tables that illustrate the location and amount of area where particular land use transitions occurred, and text that addresses whether these transitions are supposed to represent reality (between 1985 and 1997) or a hypothetical case?

We put chapter 2.6. (Spatial variability of RF and RF of Swiss forest expansion) right after the description of the study area. Now chapter 2.6. and 2.2. (we renamed chapter 2.2 from “Land use/Land cover (LULC)” to “Swiss forest expansion between 1985 and 1997”) are close together. Both together are a description of the study design. We included some changes. The two chapters are now:

“Spatial variability of RF and RF of Swiss forest expansion

We calculated the net RF and the offset of CO2 RF through albedo RF (ΔRFCO2/ΔRFalbedo) to show the pattern of RF in Switzerland and to calculate RF of Swiss forest-cover expansion between 1985 and 1997. To illustrate the pattern of RF in Switzerland we calculated a value of RF for every location in Switzerland, excluding non-vegetated land, water, settlement and areas that lie above the tree line (**Error! Reference source not found.**). These are hypothetical values, because we calculated RF for the change from open land to forest for all vegetated areas, and not only for the ones where forest expansion was actually observed. At lower elevations, transitions from Intensively Used Open Land to forest are frequent, while in higher elevations transitions are usually from Extensively Used Open Land to Forest (**Error! Reference source not found.**). We considered this by separating our estimation of the hypothetical RF in transitions from Intensively Used Open Land to forest below 1000 m and transitions from Extensively Used Open Land to Forest above 1000 m. The results of the spatial pattern of RF are shown in maps of the study area (**Error! Reference source not found.** c,d).
To obtain results for RF of forest-cover expansion between 1985 and 1997 in Switzerland we calculated net Radiative Forcing as the sum of RF for all pixels where forests expanded. This meant including information on the type of forest expansion and on the location of forest expansion:

$$\Delta RF_{ges} = \frac{\sum_{x=1}^{n} RF_{x,T}}{A_E} \quad (1)$$

, where ΔRFges is the net Radiative Forcing (net RF), n the number of pixels where forests expanded and RF the Radiative Forcing, which depends on the location x and the type of transition T. The sum over RF is devided by the the earth’s surface AE to convert local RF into a global average RF.

Swiss forest expansion between 1985 and 1997

We use aerial photographs processed by Swiss Statistics at a spatial resolution of 100 m to derive changes in land use/land cover (LULC). These aerial photographs are from the Swiss Federal Office of Topography and are fully available for the two inventory periods 1979-85 and 1992-97 (Humbel et al., 2010). We reclassified the data of the different inventory periods into five aggregated classes (Rutherford et al., 2008). While 18 classes were aggregated into four classes: Closed Forest, Open Forest, Extensively and Intensively Used Open Land (**Error! Reference source not found.**), the remaining 56 were classified as Other, and consisted mainly of settlements, water and non-vegetated land (**Error! Reference source not found.**). The aggregation of the original land-use classes is a simplification. It was not possible to derive reliable data on albedo and carbon stocks for each LULC class. The aggregation of the original land-use classes results in a sufficiently large sample of reliable albedo values and carbon stocks in each of the five biogeographical regions and three elevational strata for five relevant and well established land-use classes.

To calculate RF of land use change between 1985 and 1997, we included five transitions: 1. Intensively Used Open Land -> Closed Forest, 2. Extensively Used Open Land -> Closed Forest, 3. Intensively Used Open Land -> Open Forest, 4. Extensively Used Open Land -> Open Forest and 5. Open Forest -> Closed Forest. We focused on transitions where forest cover and carbon stocks increase, because these transitions highly exceeded transitions with forest decrease in Switzerland. In fact, the Swiss law strongly protects forests so that there have been only few changes from forest to agriculturally used land during the last 30 years (Bloetzer, 2004, Rutherford et al., 2008)."

4. Also, crucially, what is the impact of aggregating 19 land classes into five? The authors need to include figures to clarify the impact of these simplifications in their analysis. Again, how much area is affected?

We added a table to the discussion paper that shows how we aggregated the LULC classes and how much area is affected.

It was not possible to derive reliable data on albedo and carbon stocks for each LULC class (18 classes are related to forest cover change). Aggregating the land-use classes meant that it was not possible anymore to differentiate between Radiative Forcings of very particular transitions (e.g. from "Stony Alpine Pasture" to "Slender Forest"). However, it was possible to define average albedos and carbon stocks of the aggregated land-use classes in every biogeographical region and three elevational strata. The broad definitions of closed forest, open forest, intensively and extensively used open land are given in Table 5. These definitions refer to well established land-use classes and are very useful to reflect the most relevant categories in terms of land-use change and radiative forcing.

Table 5: Aggregation of land use classes from Swiss Arealstatistik (ASCH85, ASCH97 and ASCH04) adapted from (Rutherford et al., 2008).

Aggregated class	Area [ha]	Classes from Swiss land use statistics	Area [ha]	Broad definition
Closed Forest	1121544	Afforestation*, 52 Forest dieback*, 54 Normal forest, 50 Slender Forest, 51 Bushes, 57 Groves and hedges, 58	3349 14851 962312 44711 60514 35807	Vegetation height >3m, cover density >60%, composed of tree species
Open Forest	150101	On non-agriculturally used land, 56 On agriculturally used land, 55 Groups of trees on agriculturally used land, 59 Groups of trees on non-agriculturally used land, 60	52825 24108 38157 35011	Vegetation height >3m, cover density 20-60%, composed of tree species
Extensively Use Open Land	767842	Pasture in the vicinity of settlements, 43 Alpine meadows, 45 Sheep alps, 49 Favourable to pasturing, 46 Stony alpine pasture, 48 Grass and herb vegetation, 65	87303 32316 51124 368691 46024 182384	Used for grazing, use not year-round, not machine-accessible
Intensively Used Open Land	837128	Arable land, 41 Natural meadows, 42	547754 289374	Year-round use, in the vicinity of settlements, Mown
Other		1-40, 44, 47, 61-64, 66-72		

Numbers in column 2 represent the official ASCH classes of the nomenclature 2004 (Humbel et al., 2010). The aggregation in **Error! Reference source not found.** was adapted to the new nomenclature.

*Afforestation and *Forest dieback are LULC classes and not transitions or processes.

5. The abstract will also need to be revised so that it is very clear how the land use transitions were assigned. I think the paper would be greatly improved if it was organized to address a very clear and specific statement of the research objective.

We added the following paragraphs to the abstract:

"Our study design is twofold: First, we show the spatial pattern of RF assuming that each location in Switzerland is facing a transition from open land to forest. Second, we include the type and location of 5 different land use transitions to calculate RF in Switzerland between 1985 and 1997.We are able to show where we expect low climatic benefits of forest expansion in an alpine region and if albedo RF could be relevant for the greenhouse gas inventory in Switzerland."

"The objective of this study was to improve our understanding of the forest potential for climate mitigation by quantifying both carbon sequestration and albedo change on appropriately high resolution in Switzerland"

6. Major comment:

Assuming constant upward transmissivity in the radiative forcing calculation is a major simplification. I would think the upward transmissivity would vary a lot over the elevation gradient in this region. I appreciate that you have quantified the error associated with 30% variance in this variable, but why not make an effort to include some real spatial information here? I suspect this will exacerbate the elevational effects you are seeing. I think you could use some archived high-resolution climate model data to develop a climatology of upward transmissivity in the region and use that.

This is a very important point. The absorption will indeed vary if there is an elevation gradient (differences in cloud cover etc.). We agree that a spatially explicit quantification would most likely increase the elevational effect (as we have also stated in the discussion paper P 10143 L 6 – L 9). In high elevations the "upward transmissivity" will usually be higher and the "upward absorption" will be lower. That means that the value of 0.23 will be lower in high elevations. A lower value for the atmospheric absorption (see equation (6)) will cause a higher Radiative Forcing in high elevations.

The simple approach of using a constant value for the absorption (or the upward transmissivity) has been compared to a more complex radiative transfer model by Bright and Kvalevag (2013). They have shown that the simple model performed well in comparison to the more complex model. Their result shows a root mean square error of 7.2 % and a correlation of 0.93 between the forcings calculated by the simple and the complex model. This is in line with our sensitivity analysis, where we assumed a high variation (30%) in atmospheric absorption. However, in the sensitivity analysis we simplified matters, because we assumed an independently varying atmospheric absorption. As we discussed, it will probably be linked to the variation in global radiation.

Assuming constant albedo differences and constant global radiation, equation (6) simplifies to I * Δα * (1 – a). We use the following values:

1. Δα = 0.15, I = 176 W/m2 and absorption a=0.23 (high elevation scenario); RF = 20.3 W/m2
2. Δα = 0.15, I = 176 W/m2 and absorption a=0.16 (high elevation scenario); RF = 22.2 W/m2
3. Δα = 0.05, I = 120 W/m2 and absorption a=0.23 (low elevation scenario); RF = 4.6 W/m2
4. Δα = 0.05, I = 120 W/m2 and absorption a=0.3 (low elevation scenario); RF = 4.2 W/m2

This is a very simplified example. However, it illustrates that Radiative Forcing changes are small, even though we used rather unrealistic high and low values for the atmospheric absorption (+/- 30%). If we use the Fu/Liou online Radiative Transfer Model and calculate values of atmospheric absorption in low elevation (high cloud cover fraction) and high elevation (low cloud cover fraction), we get values of absorption of 0.25 and 0.19. Although the way we derive the absorption values from the Fu/Liou model is a simplification, these values probably give a more realistic range of the absorption than the values 0.3 and 0.16. (Simplifications in the way we calculated the absorption: We used the output of the Fu/Liou model together with a radiation model (Donohoe and Battisti, 2011) (assuming isotropic solar fluxes) to calculate atmospheric absorption. The "isotropic assumption" is probably not exactly true and we calculate the absorption without including multiple reflections.)

We thank you for your suggestion "to use some archived high-resolution climate model data to develop a climatology of upward transmissivity in the region and use that". This could be an option. However, using data of a regional climate model for developing a climatology of upward transmissivity will also include assumptions and simplifications. To our knowledge this has not been done yet (for regional models on a higher resolution).

We acknowledge that a spatially explicit estimation would reduce uncertainty in our study. We extended our discussion on this point in the manuscript. However, a spatially explicit estimation will not affect our major results and findings.

Adapted paragraph in the discussion:

"The average parameter for atmospheric absorption "0.23" could be replaced by a spatially explicit estimate. Including a spatially explicit parameter for atmospheric absorption would probably increase the elevation gradient of RF, because atmospheric absorption should be higher in low elevations than in high elevations. According to our sensitivity analysis and Bright and Kvalevag (2013) improving data on atmospheric absorption will have a relatively small influence on the results."

7. Minor comments:

p. 10126, line 21: change "biogeophysical (mainly albedo) and biogeophysical" to "biogeophysical (mainly albedo) and biogeochemical"?

We changed it to biogeochemical.

8. Figure 3 captions are scrambled

We corrected the captions.

9. Equation 6, need to clarify whether the RF is at top of atmosphere (TOA) or at the surface. It should be at the top of atmosphere.

We clarified that the RF is top of the atmosphere.

10. Also need to clarify whether the incoming global radiation data are for the surface, or TOA. It needs to be at the surface, so that the incoming beam is already attenuated by clouds, aerosols etc. This helps reduce the error associated with assuming a constant upwelling transmissivity over the whole domain (although I hope you will address that problem separately).

We clarified that global radiation is the surface shortwave irradiance.

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