Table S1. Variables used in the experiments. 'C' denotes current-month variables, 'all A' represents all antecedent months, while 1M represents one-month antecedent variables, with similar notation for other antecedent months.

	DD	SWI	MaxT	DTR	Lightning	CROP	POPD	HERB	SHRUB	TREE	AGB	VOD	FAPAR	LAI	SIF
ALL	C & all A	C	C	C	C	C	C	C	C	C	C	C & all A	C & all A	C & all A	C & all A
TOP15	C, 1M, 3M		C			C	C					C, 1M, 3M	C, 1M	1M, 3M	C, 9M
CURR	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C
15VEG_FAPAR	C, 1M, 3M, 6M, 9M		C			C	C	C			C		C, 1M, 3M, 6M, 9M		
15VEG_LAI	C, 1M, 3M, 6M, 9M		C			C	C	C			C			C, 1M, 3M, 6M, 9M	
15VEG_SIF	C, 1M, 3M, 6M, 9M		C			C	C	C			C				C, 1M, 3M, 6M, 9M
15VEG_VOD	C, 1M, 3M, 6M, 9M		C			C	C	C			C	C, 1M, 3M, 6M, 9M			
CURRDD_FAPAR	C	C	C	C	C	C		C	C	C	C		C, 1M, 3M, 6M, 9M		
CURRDD_LAI	C	C	C	C	C	C		C	C	C	C			C, 1M, 3M, 6M, 9M	
CURRDD_SIF	C	C	C	C	C	C		C	C	C	C				C, 1M, 3M, 6M, 9M
CURRDD_VOD	C	C	C	C	C	C		C	C	C	C	C, 1M, 3M, 6M, 9M			
BEST15	C, 1M, 3M, 6M, 9M		C			C	C	C			C	9M	C, 1M	3M	6M

Table S2. Ranked importance of variables in the RF experiments according to the composite importance measure introduced in Sect. 2.4.

	ALL	TOP15	CURR	15VEG_FAPAR	15VEG_LAI	15VEG_SIF	15VEG_VOD	CURRDD_FAPAR	CURRDD_LAI	CURRDD_SIF	CURRDD_VOD	BEST15
1	DD	FAPAR	DD	FAPAR	LAI	SIF	DD	FAPAR	LAI	SIF	VOD	FAPAR
2	FAPAR	DD	MaxT	DD	DD	DD	VOD 1M	FAPAR 1M	DD	DD	VOD 1M	DD
3	MaxT	MaxT	TREE	FAPAR 1M	LAI 1M	MaxT	VOD 3M	DD	LAI 1M	MaxT	VOD 3M	FAPAR 1M
4	VOD 3M	VOD 3M	SWI	FAPAR 3M	LAI 3M	SIF 6M	VOD	FAPAR 3M	LAI 3M	SIF 3M	DD	LAI 3M
5	LAI 1M	LAI 1M	VOD	MaxT	MaxT	CROP	MaxT	MaxT	MaxT	CROP	MaxT	MaxT
6	DD 1M	SIF 9M	LAI	HERB	HERB	DD 3M	VOD 9M	FAPAR 6M	LAI 6M	TREE	VOD 9M	CROP
7	DD 3M	SIF	FAPAR	DD 3M	CROP	DD 1M	DD 9M	HERB	HERB	SIF 6M	AGB	VOD 9M
8	SIF	VOD	HERB	DD 1M	DD 1M	SIF 9M	DD 3M	CROP	CROP	SIF 9M	DTR	DD 9M
9	LAI 3M	CROP	SIF	FAPAR 6M	LAI 6M	POPD	CROP	FAPAR 9M	LAI 9M	SIF 1M	CROP	POPD
10	VOD 1M	DD 1M	DTR	CROP	DD 3M	AGB	DD 6M	Lightning	SHRUB	Lightning	VOD 6M	DD 1M
11	VOD	LAI 3M	SHRUB	POPD	DD 9M	SIF 3M	HERB	SHRUB	DTR	SWI	HERB	SIF 6M
12	FAPAR 1M	POPD	AGB	DD 9M	POPD	DD 6M	DD 1M	DTR	Lightning	DTR	Lightning	HERB
13	CROP	DD 3M	CROP	DD 6M	LAI 9M	SIF 1M	AGB	SWI	SWI	SHRUB	SWI	DD 6M
14	SIF 9M	FAPAR 1M	Lightning	FAPAR 9M	DD 6M	DD 9M	POPD	AGB	AGB	HERB	SHRUB	DD 3M
15	POPD	VOD 1M	POPD	AGB	AGB	HERB	VOD 6M	TREE	TREE	AGB	TREE	AGB
16	VOD 9M											
17	DD 9M											
18	AGB											
19	DD 6M											
20	HERB											
21	SHRUB											
22	SWI											
23	DTR											
24	FAPAR 3M											
25	LAI											
26	Lightning											
27	SIF 6M											
28	FAPAR 6M											
29	VOD 6M											
30	SIF 3M											
31	LAI 6M											
32	SIF 1M											
33	FAPAR 9M											
34	LAI 9M											
35	VOD Δ12M											
36	TREE											
37	LAI Δ12M											
38	FAPAR Δ12M											
39	SIF Δ24M											
40	SIF Δ12M											
41	LAI Δ18M											
42	FAPAR Δ18M											
43	VOD Δ18M											
44	SIF Δ18M											
45	FAPAR Δ24M											
46	VOD Δ24M											
47	DD Δ24M											
48	LAI Δ24M											
49	DD Δ18M											
50	DD Δ12M											

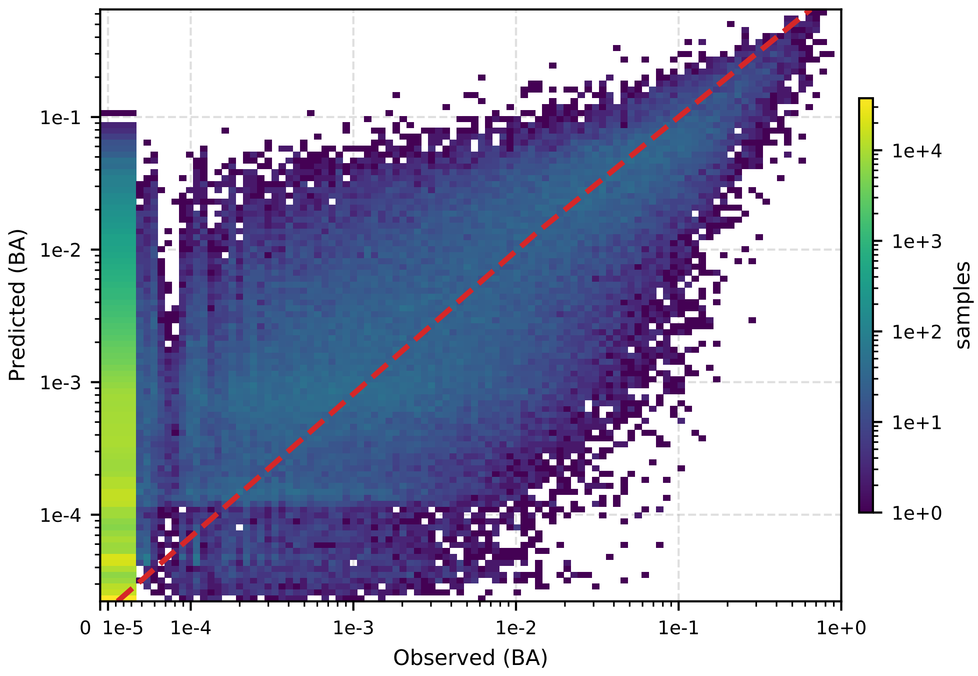

Figure S1. Out-of-sample BA predictions by the ALL model and corresponding observations.

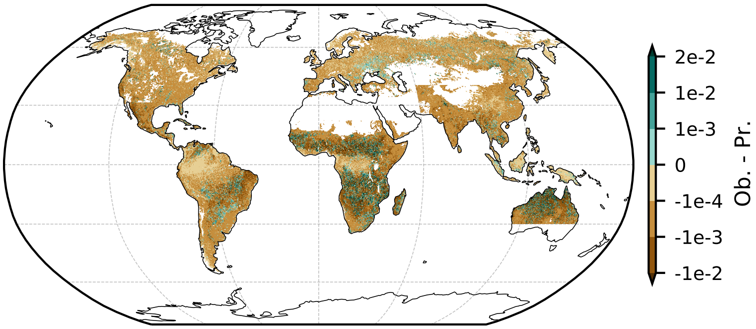

Figure S2. Mean difference between the out-of-sample observed (Ob.) and predicted (Pr.; by the ALL model) BA.

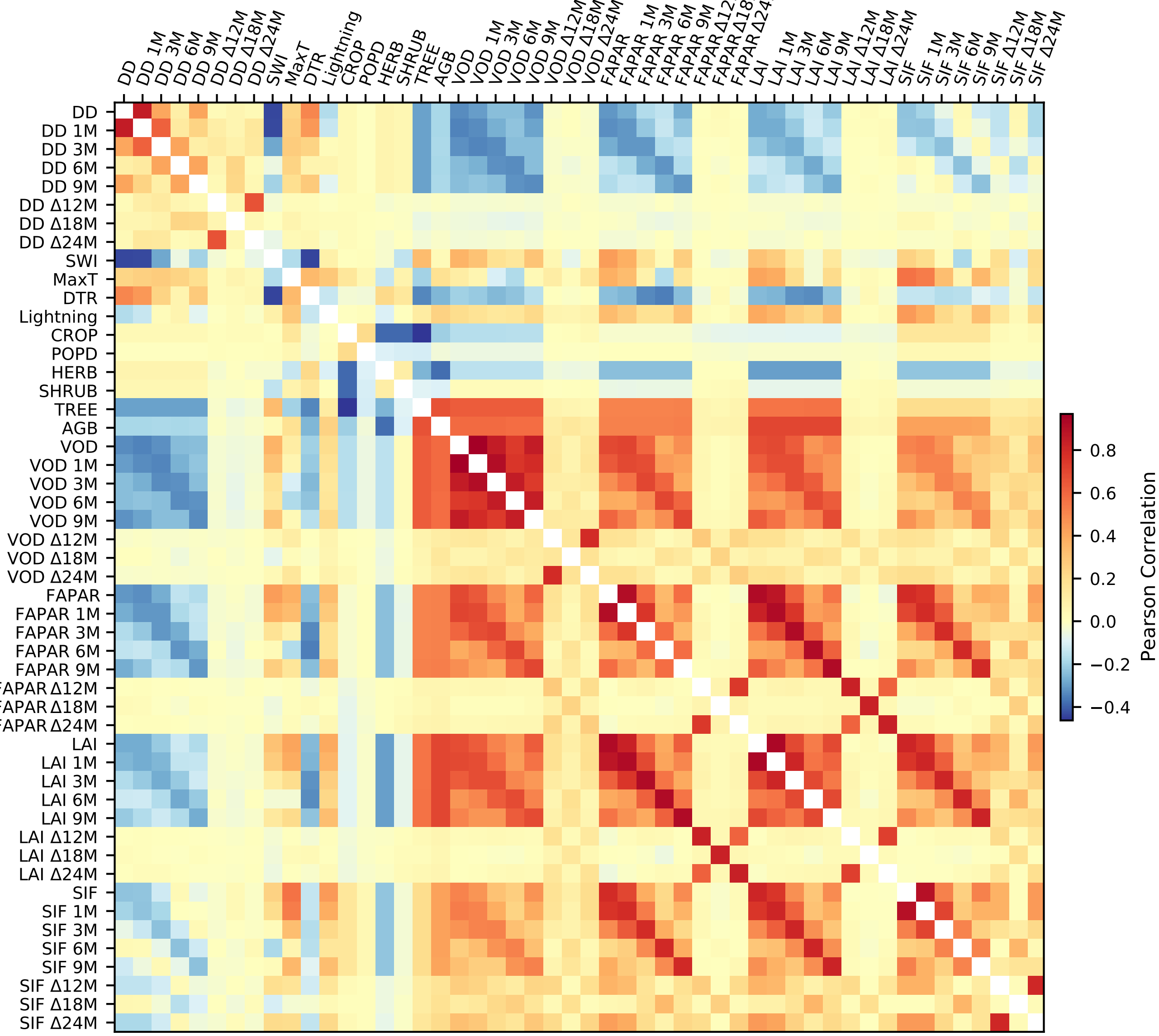

Figure S3. Pearson correlations between all variables used in the analysis. Especially large positive correlations exist between variable pairs separated by multiples of 12 months and between FAPAR, LAI, and SIF. The largest negative correlations are found between SWI and Dry Days (instantaneous, 12 month, 24 month), SWI and DTR, and pftCrop and TreeAll.

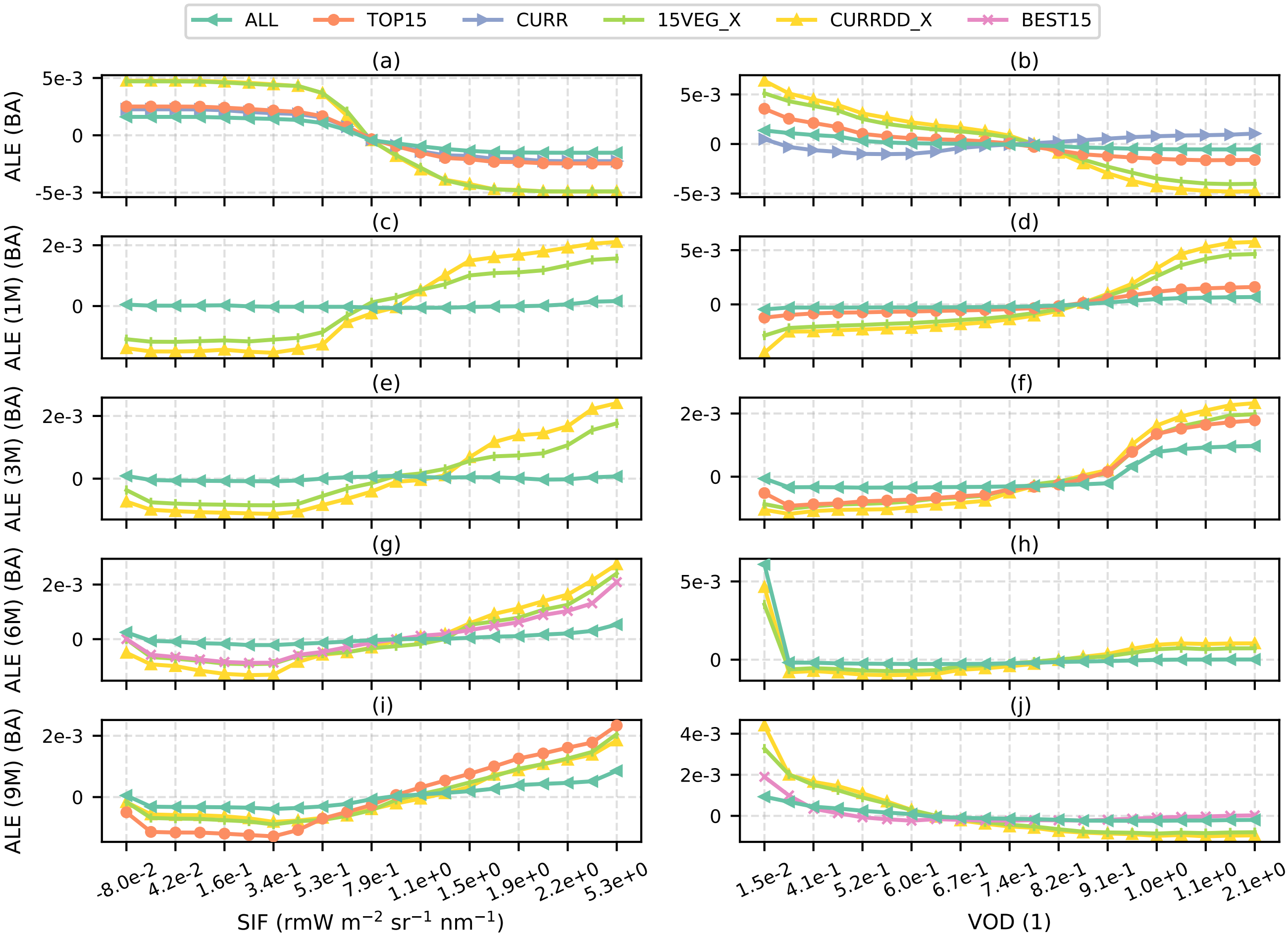

Figure S4. First-order LAI ALEs for different lags (< 1 yr) from all relevant modelling experiments for the relationships between BA and SIF (left hand columns) and VOD (right hand columns). Evenly spaced quantiles were used in the construction of the plots. Labels were calculated using the averaged quantiles of all the datasets used.

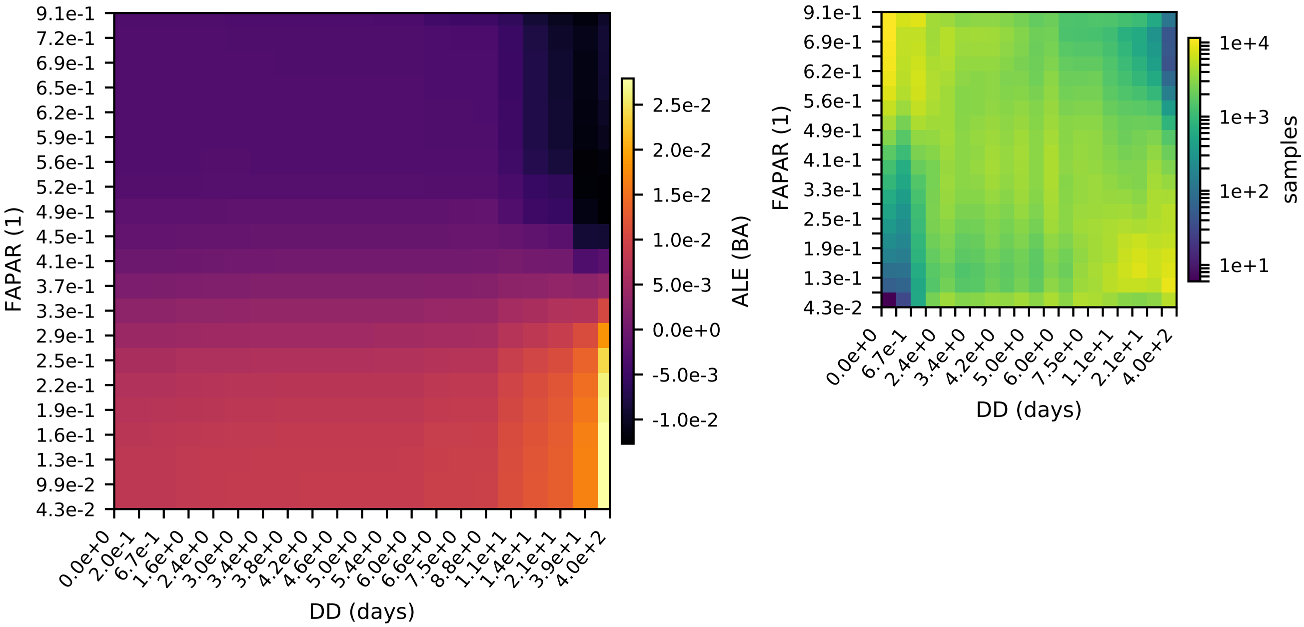

Figure S5. Second-order ALE plot showing the combined zeroth order (mean), first order, and second order modelled effects of DD and FAPAR on BA from the 15VEG_FAPAR model, taking into account all other variables. Grey boxes indicate missing data. The diagonal structure of the sample count matrix demonstrates the anticorrelation between these variables. Evenly spaced quantiles are used in the construction and labelling of the plots.

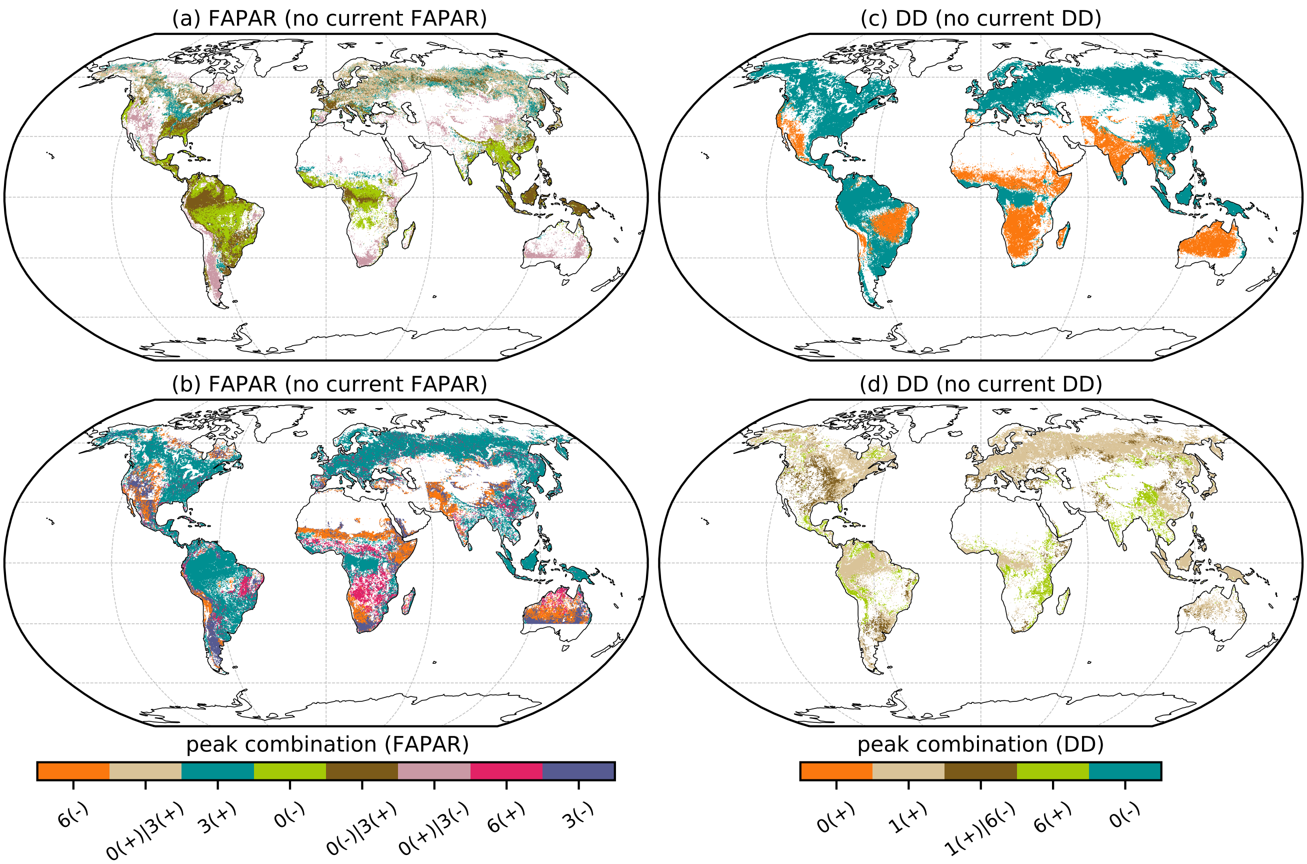

Figure S6. Spatial distribution of individual peak combinations for SHAP values as in Fig. 7. The sign of the maximum effect on BA at a certain antecedent month is indicated in parentheses after each month. The peak combinations are shown here such that their ordering has no significance (e.g. $0(+)|3(+)$ equals $3(+)|0(+)$). Dominant antecedent periods are apparent from Fig. 7. Most clearly, the general limitation of BA by instantaneous DD in tropical and boreal regions is seen in (c), combined with the positive effect of instantaneous DD on burning in the remaining regions. The limitation of BA by instantaneous DD shown in (c) generally agrees with the enhancement of BA by three-month antecedent FAPAR shown in (b), as well as the enhancement by one-month antecedent DD in (d).

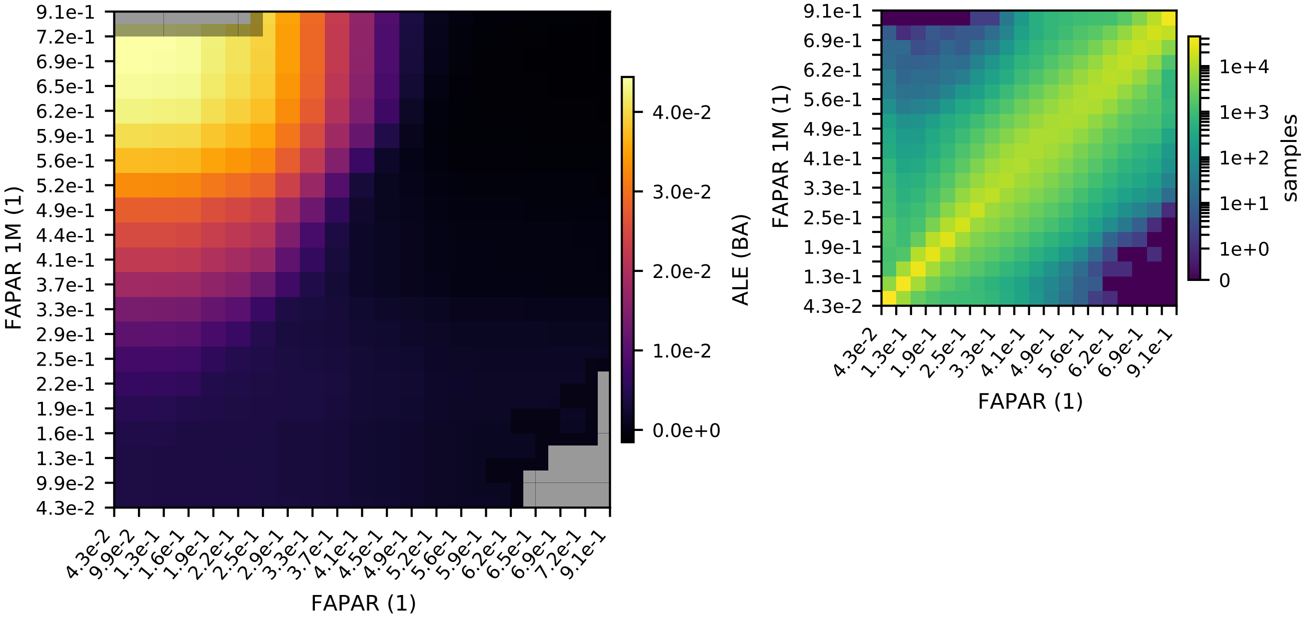

Figure S7. Second-order ALE plot showing the combined zeroth order (mean), first order, and second order modelled effects of FAPAR and FAPAR 1M on BA from the 15VEG_FAPAR model, taking into account all other variables. Grey boxes indicate missing data. The diagonal structure of the sample count matrix demonstrates the correlation between these variables. Evenly spaced quantiles are used in the construction and labelling of the plots.