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How have past fire disturbances contributed to the current carbon balance of boreal ecosystems?

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1. Compare simulated tree cover with multiple observation data sets

To address the uncertainties in observation data when examining the simulated tree cover and fractional coverages of different forest groups (broadleaf, evergreen needleleaf and deciduous needleleaf), we expand the validataion data sets to include further another three land cover maps: the ESA CCI land cover v1.1 for year 2010 (European Space Agency Climate Change Initiative; Bontemps et al., 2013, http://maps.elie.ucl.ac.be/CCI/viewer/index.php), GLC2000 (JRC, 2003), and ISLSCP II vegetation continuous field for 1992–1993 (DeFries and Hansen, 2009). The first two land-cover products (hereafter ESA and GLC) were converted from their original classifications (22 categories based on the FAO Land Cover Classification System) into PFT maps, using the cross-walking method of Poulter et al. (2011). The third product (hereafter VCF) provides the fractional cover of bare ground, herbaceous vegetation and forest (further split into evergreen or deciduous, and broadleaf or needleleaf), and was merged with climate zones of the Köppen–Geiger classification system to resolve to PFT classes, based on Poulter et al. (2011). These methods are consistent with the method used for MODIS land cover data set as in the main text section 2.4. For more details on how these land cover data sets are converted into plant functional type (PFT) maps, please refer to Zhu et al. (2015).

In total, four data sets (ESA, GLC, VCF and MODIS) are included when comparing simulated results with observation data. The minimum and maximum values are extracted from the four observation data sets, the extents of model underestimation (when ORCHIDEE value is lower than the minimum of observations) or overestimation (when ORCHIDEE value is higher than the maximum of observations) are calculated. When ORCHIEE value is within the range of the minimum and maximum of observations, we consider the model result as acceptable. Note here uncertainties in each individual observation data set are not considered. The comparisons and model errors for tree cover, broadleaf forest, evergreen needleaf and deciduous needleaf are shown respectively in Figure S1, Figure S2, Figure S3 and Figure S4.

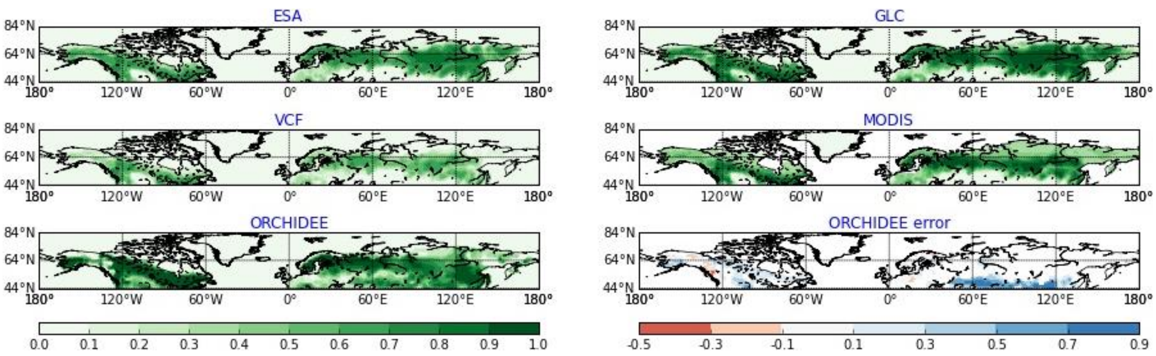

Figure S1 **Foliage projective tree cover** (in fraction of ground area) by observation data sets of ESA, GLC, VCF and MODIS and as simulated by ORCHIDEE. When simulated value is outside the range of (minimum, maximum) of the observation data sets, model error (show as "ORCHIDEE error") is calculated as the difference between the simulated value and the minimum or maximum of the observation data sets. Otherwise the simulated result is considered as acceptable.

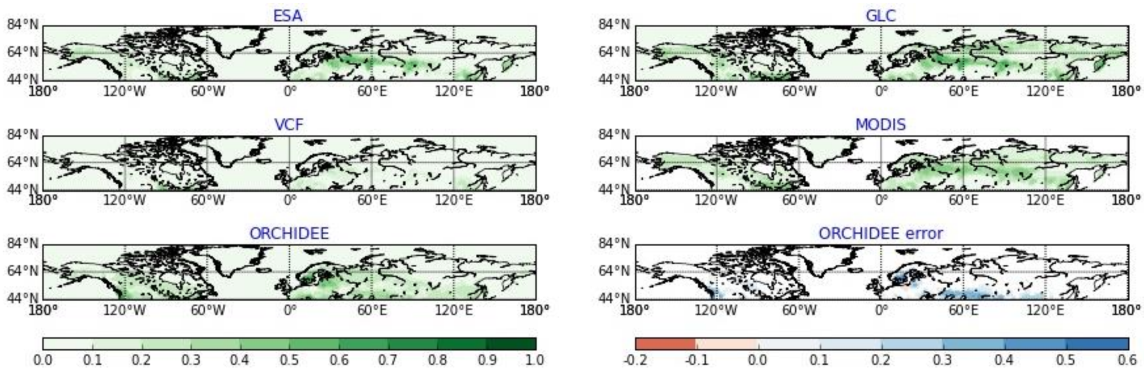

Figure S2 **Foliage projective cover of broadleaf forest** (in fraction of ground area) by observation data sets of ESA, GLC, VCF and MODIS and as simulated by ORCHIDEE. When simulated value is outside the range of (minimum, maximum) of the observation data sets, model error (show as "ORCHIDEE error") is calculated as the difference between the simulated value and the minimum or maximum of the observation data sets. Otherwise the simulated result is considered as acceptable.

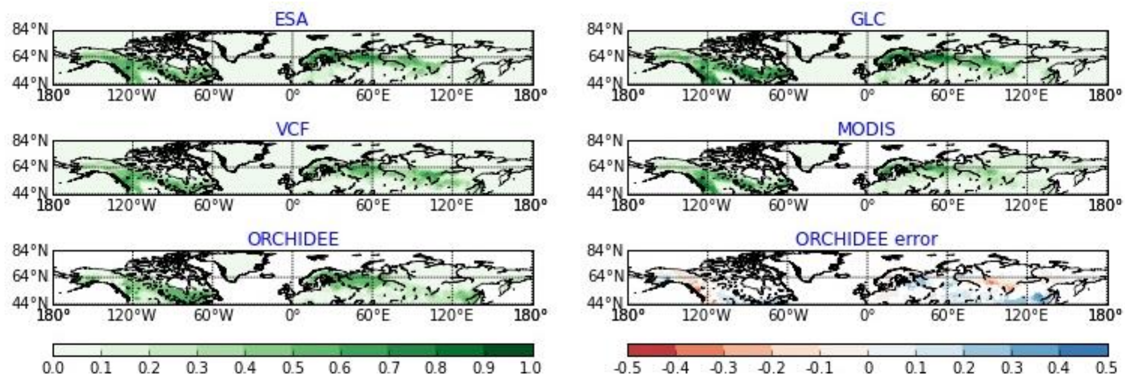

Figure S3 **Foliage projective cover of evergreen needleleaf forest** (in fraction of ground area) by observation data sets of ESA, GLC, VCF and MODIS and as simulated by ORCHIDEE. When simulated value is outside the range of (minimum, maximum) of the observation data sets, model error (show as "ORCHIDEE error") is calculated as the difference between the simulated value and the minimum or maximum of the observation data sets. Otherwise the simulated result is considered as acceptable.

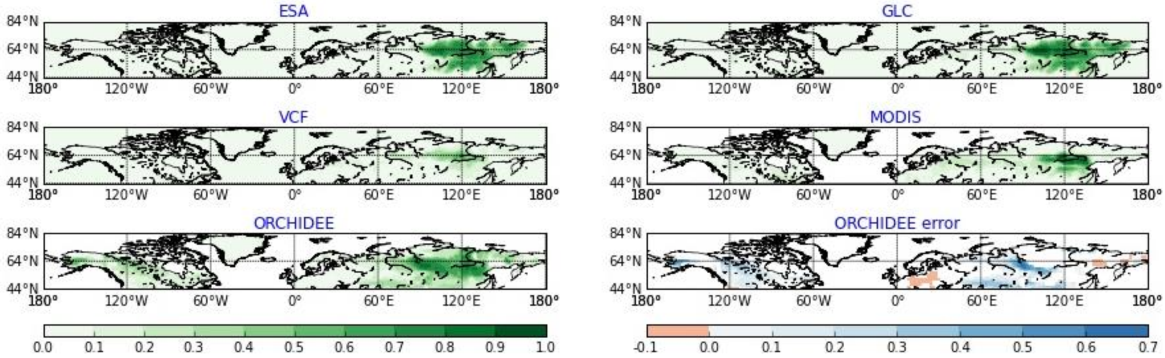

Figure S4 **Foliage projective cover of deciduous needleleaf forest** (in fraction of ground area) by observation data sets of ESA, GLC, VCF and MODIS and as simulated by ORCHIDEE. When simulated value is outside the range of (minimum, maximum) of the observation data sets, model error (show as "ORCHIDEE error") is calculated as the difference between the simulated value and the minimum or maximum of the observation data sets. Otherwise the simulated result is considered as acceptable.

2. Decadal fire legacy carbon sink contributions in relation with burned area and groups of fire return intervals

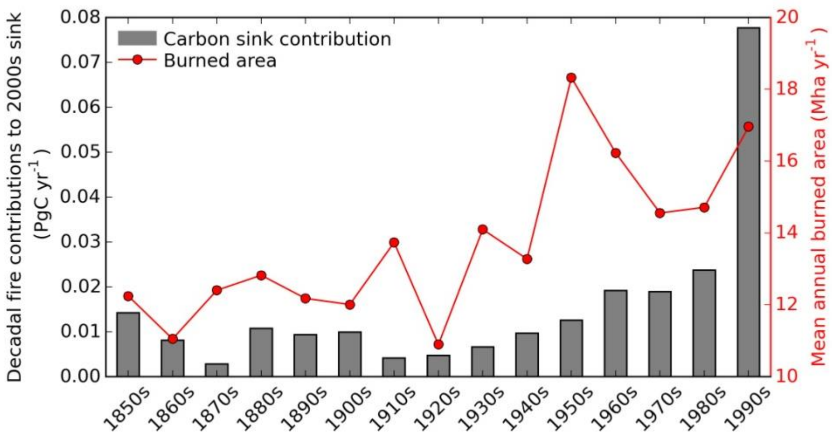

Figure S5 Decadal fire legacy carbon sink contributions to the 2000s-decadal carbon balance (gray bar, left vertical axis) and mean annual burned area for each decade (red line, right vertical axis).

Table S1 Fire sink contribution magnitudes (PgC yr^{-1}), mean annual burned areas (BA, Mha yr^{-1}), land areas (Mkm^2 yr^{-1}) for different fire groups in terms of fire return interval (years). The respective fractions of each fire group in terms of the total amount are also shown in the table (indicated as Sink fraction, BA fraction, Land area fraction). The last column indicates the sink density in terms of burned area (Pg C Mha^{-1}). All values show the average of each decade ranging from 1850s to 1990s. For more details on grouping by model grid cells by fire return intervals, see the 3rd paragraph of section 3.3 in the main texts.

Fire groups	**Sink (PgC yr^{-1})**	**BA (Mha yr^{-1})**	**Land area (Mkm^2)**	**Sink fraction (-)**	**BA fraction (-)**	**Land area fraction (-)**	**Sink per BA (PgC Mha^{-1})**
>500 yr	0.02	0.97	35.9	0.11	0.07	0.84	0.025
200-500 yr	0.03	0.88	2.8	0.14	0.06	0.06	0.037
100-200 yr	0.04	1.02	1.4	0.16	0.08	0.03	0.037
50-100 yr	0.03	1.42	1.0	0.12	0.10	0.02	0.019
10-50 yr	0.10	7.81	1.7	0.43	0.58	0.04	0.013
2-10 yr	0.01	1.42	0.1	0.05	0.11	0.00	0.008
Total	0.23	13.51	42.9	1.00	1.00	1.00	0.017

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