Supporting Information for "A spatial assessment of current and future foliar Hg uptake fluxes across European forests"

Lena Wohlgemuth[1,2], Aryeh Feinberg[3], Allan Buras[4], Martin Jiskra[1]

[1]Department of Environmental Geosciences, University of Basel, Basel, Switzerland

[2]Thünen Institute of Forest Ecosystems, Eberswalde, Germany

[3]Institute for Data, Systems, and Society, MIT, Cambridge, USA

[4]TUM School of Life Sciences, Technical University of Munich, Munich, Germany

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Text S1.

Zhou & Obrist, (2021) give an estimate of median global foliage Hg assimilation by evergreen needleleaf forests of 61 Mg Hg year^{-1} and by deciduous broadleaf forests of 28 Mg Hg year^{-1} (Zhou & Obrist, 2021, Table 1). This estimate is based on global data on foliar Hg concentrations and net foliar biomass production. The global land area of evergreen needleleaf forests is given as 6.17 Mio km^2 and of deciduous broadleaf forests as 1.12 Mio km^2 (Zhou & Obrist, 2021). Converted to the land area of coniferous (1.0 Mio

km^2) and deciduous forests (0.73 Mio km^2) in Europe, we obtain a total Hg assimilation of 10.2 Mg Hg $year^{-1}$ for European coniferous forests and of 18.4 Mg Hg $year^{-1}$ for European deciduous forests.

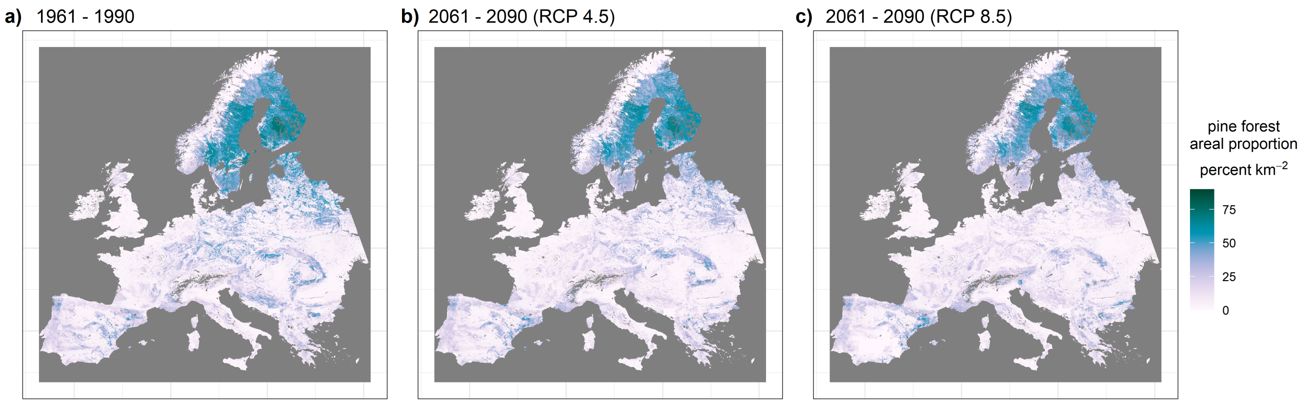

Figure S1. Simulated areal cover (percent km^{-2}) of pine forests in Europe (a) historically, (b) for the time period 2061 - 2090 under the climate change scenario RCP 4.5, and (c) RCP 8.5. Geographic distribution was derived from statistic mapping from Brus et al. 2012 and projected relative abundance probabilities under climate analogs from Buras et al. 2019 (see Sect. 2.1 for details).

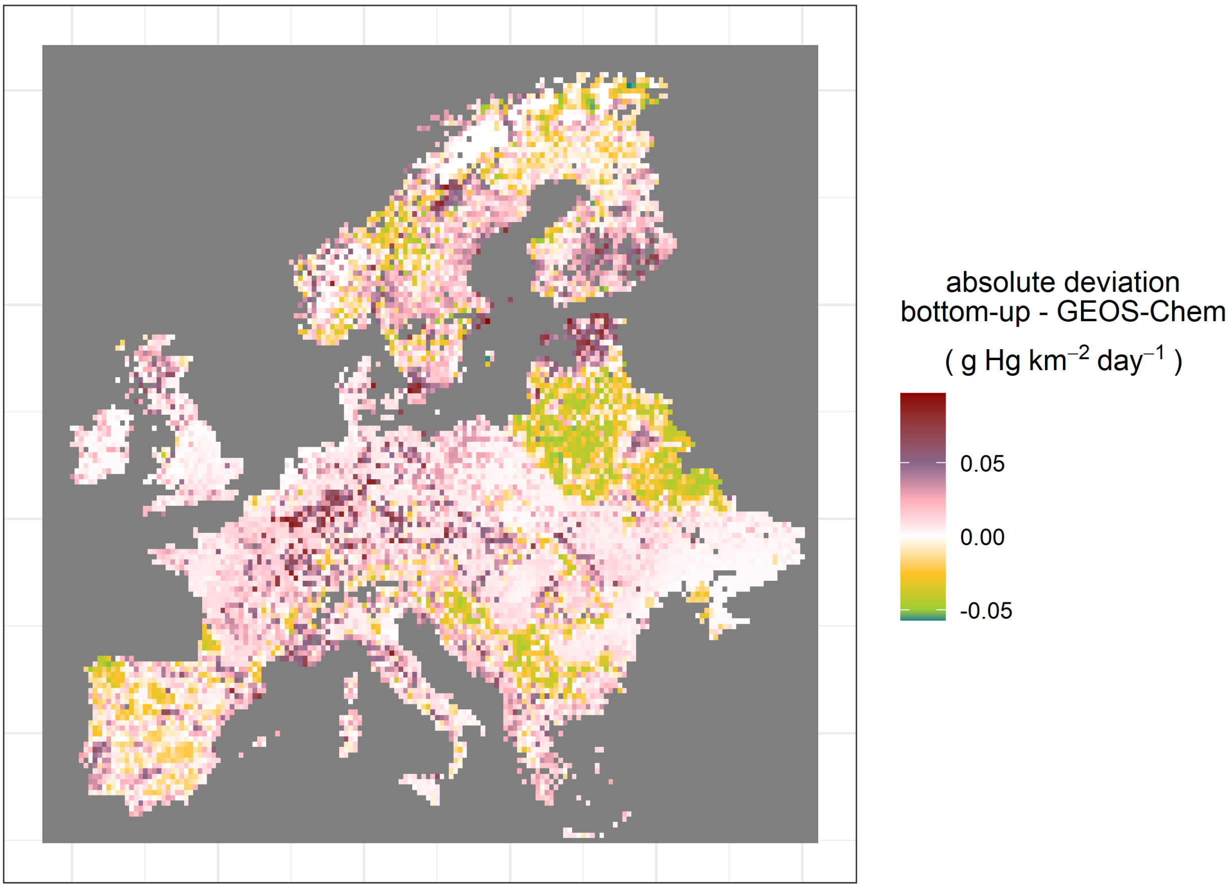

Figure S2. Absolute difference map of model outputs of forest foliar Hg uptake fluxes (g Hg km^{-2} day^{-1}) from the bottom-up model - GEOS-Chem.

Table S1. Overview of LAI correction factor for tree height (cf_{height}) and Hg uptake rate correction factor for needle age class (cf_{age}) obtained from Wohlgemuth et al., (2020).

Tree species group	$\mathbf{cf}_{height}$	$\mathbf{cf}_{age}$
Abies alba	0.68	0.79
mix of all broadleaf values	0.63	-
Betula pendula	0.63	-
Carpinus betulus	0.63	-
mix of all conifer values	0.68	0.79
Fagus sylvatica	0.56	-
Fraxinus excelsior	0.63	-
Larix decidua	0.68	-
Pinus cembra; *Pinus mugo arborea*; *Pinus nigra* *Pinus nigra subsp. laricio*	0.68	0.86
Picea abies	0.68	0.79
Pinus pinaster	0.68	0.86
Pinus sylvestris	0.68	0.86
Pinus sylvestris	0.68	0.86
Pseudotsuga menziesii	0.68	0.86
Quercus cerris; *Quercus frainetto*; *Quercus ilex*; *Quercus pubescens*	0.7	-
Quercus robur; *Quercus petraea*	0.7	-

Table S2. Dataset on proportion of tree species per land area matched to dataset on foliar Hg uptake rates by tree species groups.

Matched and aggregated tree species groups	
Dataset on tree species proportion of land area (Brus et al., 2012)	**Dataset on foliar Hg up–take per tree species (Wohlgemuth et al., 2022)**
Abies spp	*Abies alba*
Alnus spp; Broadleaved misc; Castanea spp; Eucalyptus spp; Populus spp; Robinia Spp	mix of all broadleaf values
Betula spp	*Betula pendula*
Carpinus spp	*Carpinus betulus*
Conifers misc	mix of all conifer values
Fagus spp	*Fagus sylvatica*
Fraxinus spp	*Fraxinus excelsior*
Larix spp	*Larix decidua*
Picea spp	*Picea abies*
Pinus misc	*Pinus cembra*; *Pinus mugo arborea*; *Pinus nigra* *Pinus nigra subsp. laricio*
Pinus pinaster	*Pinus pinaster*
Pinus sylvestris	*Pinus sylvestris*
Pseudotsuga menziesii	*Pseudotsuga menziesii*
Quercus misc	*Quercus cerris*; *Quercus frainetto*; *Quercus ilex*; *Quercus pubescens*
Quercus robur & Quercus petraea	*Quercus robur*; *Quercus petraea*

Table S3. Overview of all combinations of Global Climate Models (GCMs) – Regional Climate Models (RCMs) and ensemble members used for downloading simulated data of 2m air temperature and 2m relative humidity from the Copernicus Climate Data Store in the framework of the Coordinated Regional Climate Downscaling Experiment (CORDEX) for the two climate scenarios of Representative Concentration Pathways (RCPs) 4.5 and 8.5. RCM data on a high regional resolution (here: European domain; 0.11° x 0.11°) depend on output from GCMs for lateral and lower boundary conditions. Temporal resolution of downloaded data was 3 hours and time period was 2068-2082.

Climate scenario	GCM	RCM	ensemble member
	CNRM-CERFACS-CM5	KNMI-RACMO22E	r1i1p1
	ICHEC-EC-EARTH	DMI-HIRHAM5	r3i1p1
	ICHEC-EC-EARTH	GERICS-REMO2015	r12i1p1
	ICHEC-EC-EARTH	KNMI-RACMO22E	r1i1p1
	ICHEC-EC-EARTH	SMHI-RC4A	r12i1p1
	IPSL-CM5A-MR	SMHI-RC4A	r1i1p1
RCP 4.5	MOHC-HadGEM2-ES	GERICS-REMO2015	r1i1p1
	MOHC-HadGEM2-ES	KNMI-RACMO22E	r1i1p1
	MOHC-HadGEM2-ES	SMHI-RC4A	r1i1p1
	MPI-M-MPI-ESM-LR	SMHI-RC4A	r1i1p1
	NCC-NorESM1-M	DMI-HIRHAM5	r1i1p1
	NCC-NorESM1-M	GERICS-REMO2015	r1i1p1
	NCC-NorESM1-M	SMHI-RC4A	r1i1p1
	CCCma-CanESM2	CLMcom-CLM-CCLM4-8-17	r1i1p1
	CNRM-CERFACS-CM5	CLMcom-ETH-COSMO-crCLIM	r1i1p1
	CNRM-CERFACS-CM5	GERICS-REMO2015	r1i1p1
	ICHEC-EC-EARTH	CLMcom-ETH-COSMO-crCLIM	r12i1p1
	ICHEC-EC-EARTH	KNMI-RACMO22E	r12i1p1
	ICHEC-EC-EARTH	SMHI-RCA4	r12i1p1
RCP 8.5	IPSL-CM5A-MR	DMI-HIRHAM5	r1i1p1
	MIROC-MIROC5	CLMcom-CLM-CCLM4-8-17	r1i1p1
	MOHC-HadGEM2-ES	SMHI-RCA4	r1i1p1
	MPI-M-MPI-ESM-LR	DMI-HIRHAM5	r1i1p1
	NCC-NorESM1-M	CLMcom-ETH-COSMO-crCLIM	r1i1p1
	NCC-NorESM1-M	GERICS-REMO2015	r1i1p1
	NCC-NorESM1-M	KNMI-RACMO22E	r1i1p1

Table S4. Overview of relative uncertainty values for different parameters per forest tree species group propagated by error propagation principle for every spatial tile of the forest foliar Hg uptake flux map (Fig. 1).

Tree species group[a]	relative uncertainty (ru)						
	LMA[b]	DMA[c]	LAI[d]	Forest area[e]	cf_{age} [f]	pine[g]	**total**[h]
Abies spp	0.36	0.1	0.44	0.40	0.03	-	0.70
Betula spp	0.61				-	-	0.86
Broadleaved mixed	0.82				-	-	1.02
Carpinus spp	0.18				-	-	0.63
Fagus spp	0.47				-	-	0.77
Fraxinus spp	0.54				-	-	0.81
Larix spp	0.76				-	-	0.97
Picea spp	0.75				0.03	-	0.96
Pine	0.72				0.06	0.014	0.94
Pseudotsuga menziesii	0.69				0.06	-	0.92
Quercus misc	0.28				-	-	0.67
Quercus robur & Quercus petraea	0.52				-	-	0.80

a See Table S2 for an overview of tree species aggregated into tree species groups. For the group of mixed conifer species (Table S2), we calculated an average uncertainty value from total uncertainty values of coniferous needle tree species groups, which equals 0.90.

b Leaf mass per area (LMA) values per tree species group were obtained from Forrester et al., 2017. The relative uncertainty of LMA per tree species group was calculated including the range of all LMA values within each respective tree species group: (maximum LMA - minimum LMA)/(average LMA).

c Foliar Hg values were obtained from a dataset of Hg concentrations in foliage samples of the ICP Forests biomonitoring network and the Austrian Bio-Indicator Grid measured using a direct mercury analyzer (DMA) (see Sect. **??** and Wohlgemuth et al., 2022). A DMA measurement sequence of foliar Hg concentrations was accepted when primary liquid reference standards did not deviate by more than ± 10% from target value.

d Relative root mean square deviation (RMSD) of the leaf area index (LAI) product from PROBA-V from LAI ground observations evaluated by Fuster et al. (2020).

e The uncertainty of the proportion of tree species per forest land area (spatial resolution: 1 km^2) was not evaluated by Brus et al., 2012 and depends on the heterogenous availability of national forest inventories in Europe. From the overall accuracy given in Brus et al., 2012, we estimated a relative uncertainty value of 0.4 per tree species and km^2.

f Uncertainty of the correction factor (cf_{age}) for upscaling Hg uptake rates of needles of different age classes to whole coniferous evergreen trees (see Wohlgemuth et al., 2020).

g Relative RMSD of the linear regression slope of the average daily pine needle Hg uptake rate vs. time proportion of VPD > 1.2 kPa (see Wohlgemuth et al., 2022).

h Total species uncertainty = $\sqrt{ru^2_{LMA} + ru^2_{DMA} + ru^2_{LAI} + ru^2_{for.area} + ru^2_{cfage} + ru^2_{pine}}$