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Mapping the reduction in gross primary productivity in subarctic birch forests due to insect outbreaks

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PAR modelled GPP

The Misterlich light response curve (Eq. S1; Falge et al. 2001) was fitted to daytime NEE from the growing season of 2009.

$$NEE = -(F_{csat} + R_d)\left[1 - e^{\frac{-\alpha Q}{F_{csat}+R_d}}\right] + R_d \qquad (S1)$$

where F_{csat} (µmol CO_2 m^{-2} s^{-1}) is net photosynthesis at light saturation level, R_d (µmol CO_2 m^{-2} s^{-1}) is daytime ecosystem respiration, α (µmol CO_2 m^{-2} s^{-1}/µmol photons m^{-2} s^{-1}) is quantum efficiency and Q (µmol photons m^{-2} s^{-1}) is PAR. Since the aim was to check how light available for photosynthesis influenced GPP for all years, one arbitrary chosen year was sufficient to get comparable results. Parameters of the fit were: F_{csat} = 5.052, R_d = 1.933, α = 0.02219. The GPP model was based on a modified Misterlich light response function (Eq. S2) and GPP was computed according to Eq. S3.

$$GPP = R_d - NEE \qquad (S2)$$

$$GPP = (F_{csat} + R_d)\left[1 - e^{\frac{-\alpha Q}{F_{csat}+R_d}}\right] \qquad (S3)$$

References

Falge, E., et al.: Gap filling strategies for defensible annual sums of net ecosystem exchange, Agric. For. Meteorol., 107, 43–69, 10.1016/S0168-1923(00)00225-2, 2001.

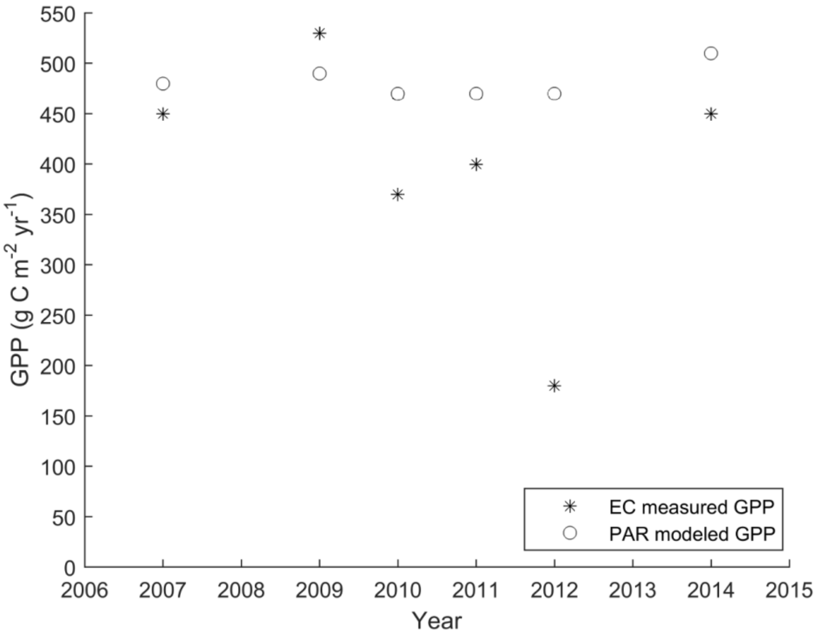

Figure S1. PAR modelled and EC measured GPP for the years 2007, 2009, 2010, 2011, 2012 and 2014.

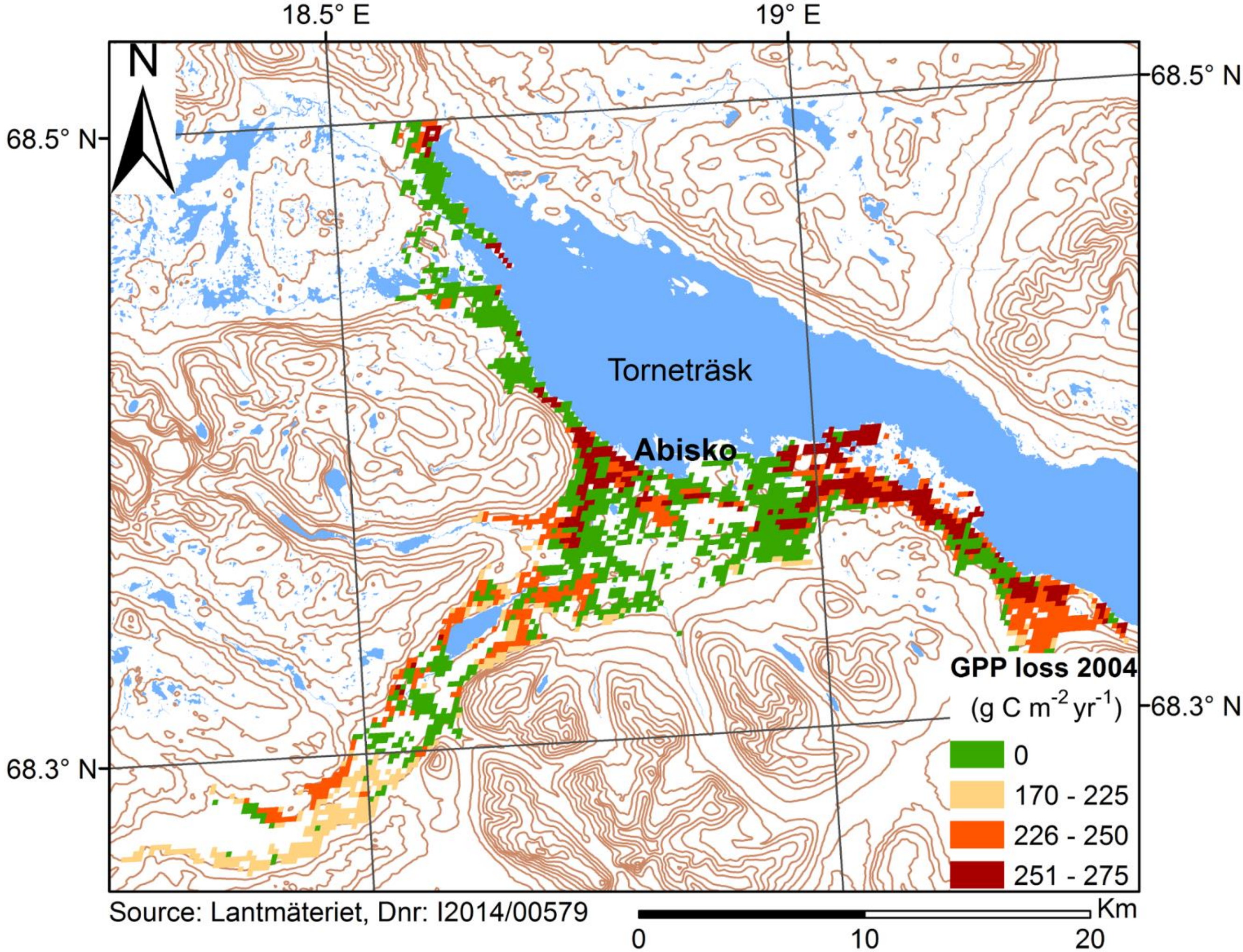

Figure S2. Reduction in annual GPP (g C m^{-2} yr^{-1}) due to the outbreak of autumnal moth and winter moth in 2004 computed with a LUE model also for defoliation (Method 2). One standard deviation of the GPP losses is estimated to 35% of the given values. Areas with only the background map have a canopy cover less than 50% or are outside the study area shown in Fig. 1. The reference system is SWEREF99 TM and latitude and longitude are in WGS84. Source of background map: Lantmäteriet (Dnr: I2014/00579).

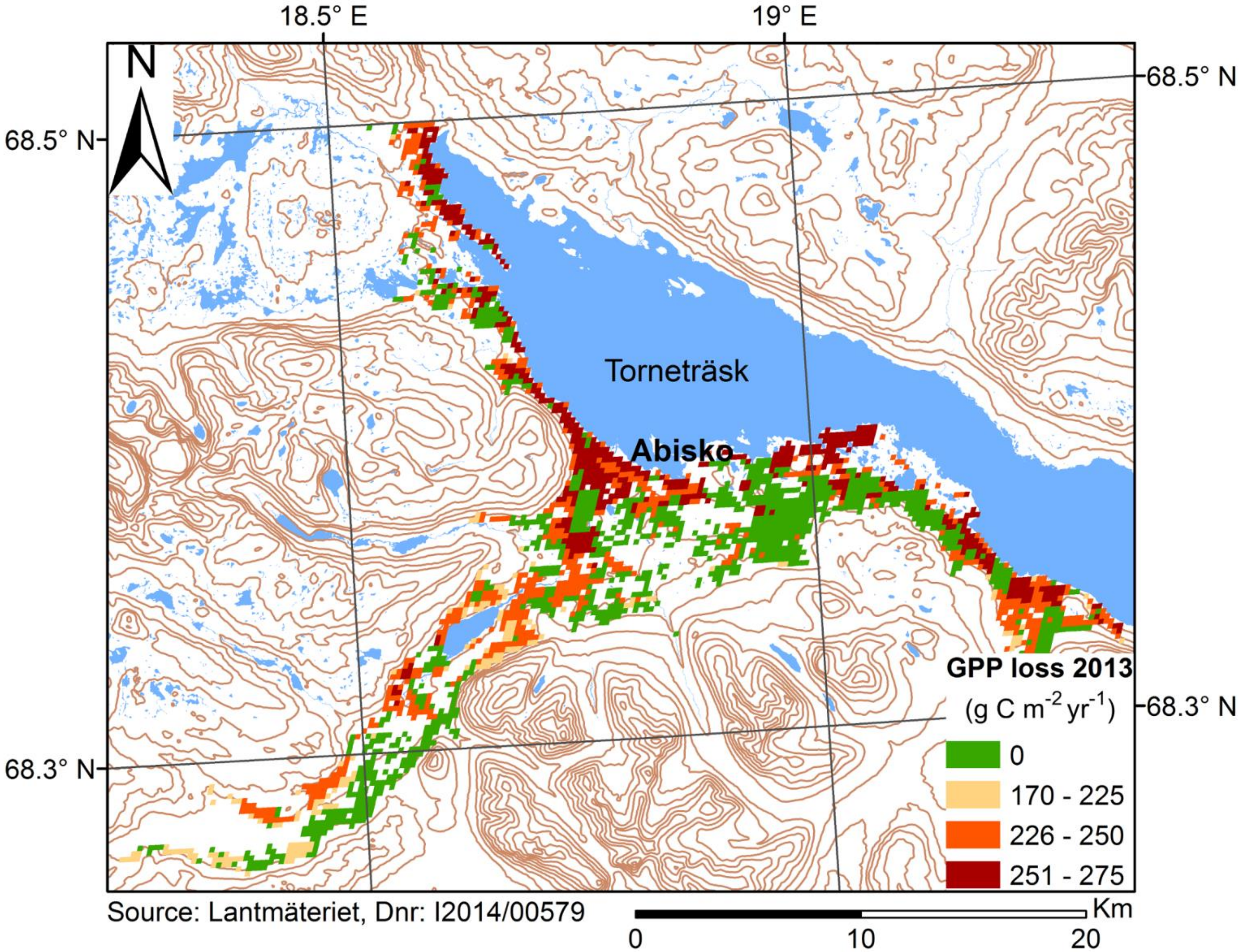

Figure S3. Reduction in annual GPP (g C m^{-2} yr^{-1}) due to the outbreak of autumnal moth and winter moth in 2013 computed with a LUE model also for defoliation (Method 2). One standard deviation of the GPP losses is estimated to 35% of the given values. Areas with only the background map have a canopy cover less than 50% or are outside the study area shown in Fig. 1. The reference system is SWEREF99 TM and latitude and longitude are in WGS84. Source of background map: Lantmäteriet (Dnr: I2014/00579).

Table S1. Variables used in the developed method with descriptions.

Variable	Description
ε_{max}	Maximum light use efficiency for undisturbed birch forest
$\varepsilon_{max, def}$	Maximum light use efficiency for defoliated birch forest
f_{8day}	Reduction factor that reduces ε_{max} depending in temperature
$fAPAR_{8day}$	fAPAR for a MODIS 8-day period
GDD_{thres}	Threshold set to control when temperature no longer influences ε_{max}
GPP_{lue}	GPP estimated with the LUE model
GPP_{EC}	GPP derived from the EC-data
$NDVI_{DL}$	NDVI smoothed with double logistic functions in TIMESAT
P_{frost}	Reduction factor the influence f_{8day} depending on frost events
PAR_{8day}	Mean daily PAR over an MODIS 8-day period
S_{GDD}	Reduction factor that influence f_{8day} depending on P_{frost} and GDD
T_{mean8}	Mean temperature for a MODIS 8-day period
T_{min8}	Min temp for a MODIS 8-day period
T_{thres}	Factor controlling how T_{mean8} influences f_{8day} in the 2nd part of the season