SATELLITE-OBSERVED PHENOLOGY OF BOREAL CONIFEROUS FORESTS

INTRODUCTION
Boreal forests are an important component of the global carbon budget as they store about one third of the global forest carbon stocks. As a consequence of climate change, temperature changes in boreal forests are predicted to be higher than in all other forest types and the timing of photosynthetic activity is likely to undergo changes. The length of the vegetation active period is thought to increase, leading to changes in the carbon uptake and release by vegetation and in the strength of the carbon feedback to the climate system (Richardson et al. 2013). For the monitoring of these changes and for validation and calibration of carbon balance models, remote sensing can provide valuable information over large areas. For ecosystem coniferous forests, current operational phenology products, e.g., MODIS Land Dynamic products, are biased as they track the greening and browning of forests.

OBJECTIVE
We investigate the usability of remote sensing observations as a proxy for the start and end of the vegetation active period in boreal coniferous forests in Finland. For this, we compare satellite data sets with the CO2 flux tower observations at three coniferous forest sites in Finland. Sites are located in the northern (Kenttärova and Sodankylä) and southern (Hyytiälä) boreal phytogeographical zones. The dominant tree species in the Kenttärova and Hyytiälä are Scots pine (Pinus sylvestris) and in the Sodankylä Norway spruce (Picea abies).

METHODS
We determined reference dates for the start and end of the vegetation active period from the continuous CO2 flux measurements and the eddy covariance method at three coniferous forest sites in Finland. Start and end dates were defined as the day on which the CO2 uptake exceeds, and accordingly falls below, the 5%, 10% and 15% level of the growing season maximum of the gross CO2 uptake (Böttcher et al. 2014). The same approach was used to define the sine of the vegetation period in MODIS data of the study period (Böttcher et al. 2014). The determination of the start and end dates of the vegetation active period was hindered by low sun elevation in autumn and long periods of cloud cover at the Hyytiälä site. Instead, soil freeze state from SMOS data appeared to be a reliable proxy for the start and end dates of the vegetation active period at the Hyytiälä site. Likewise, the quality of NDVI time-series was low at the end of autumn and NDVI threshold values were not applicable for the detection of the start and end dates of the vegetation active period at the Hyytiälä site.

RESULTS AND DISCUSSION
In contrast to FSC and soil freeze, sun-induced chlorophyll fluorescence is a direct proxy for photosynthetic activity. While its application for the detection of the start of season at northern boreal sites looks promising (Figure 1B, Walther et al. 2016), the day of partially frozen soil and end of season indicator based on the PI threshold 10% (Figure 2B). In contrast to FSC and soil freeze, sun-induced chlorophyll fluorescence is a direct proxy for photosynthetic activity. While its

CONCLUSIONS AND OUTLOOK
We studied the usability of various remote sensing indicators for the detection of the start and end of the vegetation active period in boreal coniferous forest in Finland. Snow cover decrease in spring was applied in the mapping of the start of the vegetation period with good accuracy. The publication of the operational phenology products, e.g., MODIS Land Dynamic products, is biased as they track the greening and browning of forests.