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Spring phenology in Siberia in 1982-2004 :observations by remote sensing, modelling and impact on the terrestrial carbon budget.

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Phenology is both an indicator of climate changes and an important factor in the terrestrial carbon budget. In particular in boreal regions, climate warming may result in longer growing season, and in an increase of carbon uptake.

In this paper, remote sensing observations are used to assess the trend of greening date variations in Siberia since the early 1980's, and to calibrate a phenological model based on temperature. This phenological model is Integrated in a Dynamic Vegetation Model and used to assess the effect of phenological changes induced by temperature on the Net Primary Productivity.

NOAA-NDVI based phenological studies have revealed a lengthening of the growing season in the 1982-1999 period in the northern latitudes. However, other studies have shown that this observed lengthening could be an artifact of the sensitivity of NDVI to snow. In this paper, we have developed a method to determine the date of onset of vegetation greening which removes the uncertainty due to snow. The method is based on the near and middle infrared bands of the SPOT VEGETATION sensor (1998 onwards). Comparison with in situ phenological records (5 sites, up to 5 year long) shows better agreement than the results obtained with standards NDVI methods. Error ranges between 6.5 days and 9.5 days RMS.

In order to have a meaningful long record, we have developed a method to measure the date of leaf appearance from the 1982-2001 NOAA Pathfinder with no distur-

bance from snow. For this, we have calibrated NOAA NDVI thresholds corresponding to the leaf appearance date, using SPOT VEGETATION and Pathfinder NDVI overlap. These thresholds were used to retrieve the leaf appearance dates from the whole Pathfinder record. The comparison with the in situ records (7 sites, up to 20 year long) gives an error of 9 days RMS. The temporal and spatial variations are successfully retrieved.

The resulting phenological dataset over Siberia at the 0.1˚ resolution from 1982 to 2004 has been used for trend analysis. The greening up has tended to occur earlier in the last twenty three years, especially in a large zone located from the Baikal lake to the Ob river, and in the North East part of Siberia, where in average it tends to occur earlier by up to ten days per decade.

In order to quantify the influence of temperature changes on phenology, the 1998-2002 phenology record over Siberia has been used to calibrate a degree day model to predict the date of onset and applied in the 1982-2002 period. The agreement between the modelled dates with the in situ dates and with the remote sensing dates confirms that spring phenology is driven by late winter and early spring warming. The phenology model was then included in the Sheffield Dynamic Vegetation Model, to test the sensitivity of SDVGM predicted NPP to temperature.