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Potential use of seasonal forecasts for operational planning of north European forest management

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ABSTRACT

Weather and climate conditions can have large impacts on the outcome of forest management operations: Suboptimal conditions can increase the amount of driving damage to forest ground caused by the heavy machines used for harvesting, forwarding and soil scarification. Planting of tree seedlings is commonly practised after clear cutting, and drought in summer or soil frost uplifting in autumn reduces the likelihood of successful plant establishment. Weather and climate also influence the risk of forest fires and the occurrence and development of pest and pathogens, and thereby the timing suitable for surveillance and countermeasures.

In this study, the potential use of seasonal forecasts to support the operational planning of forest management in northern Europe was assessed. The analysis was based on temperature and precipitation data from WFDEI System 4 with 15 ensemble members representing seasonal hindcasts (retrospective predictions) for the period of 1981–2010. The data was used directly and as input to a soil model from which monthly indices of frozen soil and plant water stress were calculated. Relatively low skills were found for most months, and in particular for longer lead times. Highest skill was found for bias corrected temperature of January to March, with one month lead time. The skill was higher for the soil model indices, in particular those related to soil frost, as they are influenced by cumulative processes and the initial model conditions contribute to the skill. Probabilistic forecasts on frozen soil can thus be valuable for planning of which areas to harvest, taking the risk of driving damage to forest soils and forest roads into account.

1. Introduction

The boreal and nemoral forests of northern Europe, dominated by evergreen conifers and summer green broadleaved tree species, are highly influenced by management for timber, fibre and biofuel. Coniferous tree species are generally favored over deciduous tree species in the production forests, and monocultures with clear-cutting and planting of tree seedlings tend to be dominant in the boreal forest zone whereas continuous cover forest management is more common in the nemoral zone.

Weather and climate and the associated extreme events influence tree growth and vitality (Eriksson et al., 2016; Seidl et al., 2011). The weather conditions before, during and after a forest management operation, such as harvesting and planting, can have a large impact on the outcome, mainly by affecting the state of the soil (Fig. 1). For example, heavy precipitation and unfrozen ground during harvest increase the amount of soil compaction and deep wheel tracks caused by the heavy machines used for harvesting, forwarding and soil scarification (Cambi et al., 2015). The weather conditions after planting can have a large influence on the establishment rates of the seedlings, and drought in late spring and soil frost uplifting in late autumn can both be fatal (Hallsby, 2013). Warm and dry weather conditions increase the risk of forest fires and influence the occurrence and development of pest and pathogens (Seidl et al., 2011), and may open up opportunities for insect pest outbreaks and establishment of invasive species that requires timely implementation of eradication measures (Diez et al., 2012).

Climate model projections are of high relevance for long term planning of forest management, such as selection of tree species at regeneration and proactive management strategies aiming at reducing future risks (Jönsson et al., 2015). Seasonal forecasts that bridge the gap between short-term weather forecasts and long-term climate projections are being used across a range of sectors to predict if the coming season will be wetter, drier, warmer or colder than normal (Weisheimer and Palmer, 2014). They have been used successfully within the agricultural sector for several kinds of crops and in different part of the world (Hansen et al., 2006; Williams and Falloon, 2015), and may therefore also be of relevance when it comes to planning the timing of a wide range of forest management actions. However, seasonal forecasts

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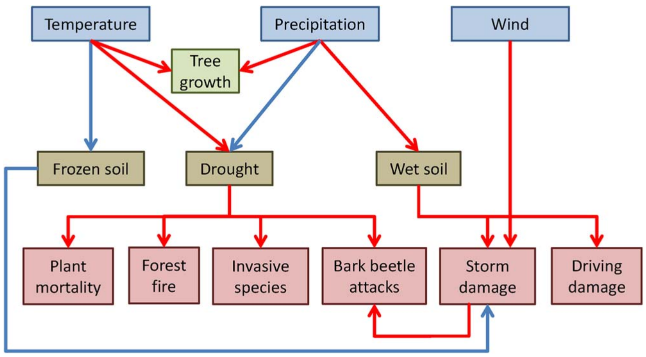

Fig. 1. Concept map showing the links between temperature and precipitation and forestry related risks through the state of the soil, for which seasonal forecast could provide useful support for operational planning of management and countermeasures. Blue arrows indicate negative feedback and red arrows positive feedback.

have so far not been tried within the forestry sector, according to a stakeholder survey on user's needs of seasonal forecasts carried out by the EU-FP7 project EUPORIAS (Dessai and Soares, 2015). That is, whereas seasonal forecasts of yield are common within the agricultural sector (Williams and Falloon, 2015), such predictions are less useful within the forestry sector as the rotation period of a forest stand is multi-decadal rather than annual. In northern Europe the rotation period length is 50–150 years, depending on climate conditions and management decisions, and climate change projections are better suited for assessments of the long-term forest stand productivity (Jönsson et al., 2015).

On the other hand, European forest companies commonly use weather forecasts for weekly planning of management action, e.g. fire indices are used for warning, to increase surveillance and stop management operations that can initiate fire. The risk of fire and drought are both influenced by the combined effect of temperature and precipitation. Studies using data from ECMWF System 4 have shown that the risk of fire can be predicted months in advance in Indonesia (Spessa et al., 2015), but in the Mediterranean region such forecasts are associated with lack of skill (Marcos et al., 2015). This is due to that the prediction model captures aspects of the climate system that are influenced by ENSO and ENSO teleconnections (Kim et al., 2012), and thus perform better in regions highly influenced by El Niño and La Niña events. However, the skill of specific impact indices commonly differ from the seasonal forecast skill (Falloon et al., 2013). The aim of this study was therefore to assess the potential to use seasonal forecasts as well as tailored impact indices to support the operational planning of forest management in northern Europe. A soil model was applied to calculate indicators of frozen soil and water deficit to assess the potential to use forecasts of the soil state to support planning of harvest operations and planting of tree seedlings. Our hypothesis was that the skill of tailored impact indices will outperform the skill of climate indices. The analysis was based on data from one of the leading providers, ECMWF System 4 (Molteni et al., 2011), and included both uncorrected and bias corrected seasonal forecasts for comparison.

2. Material and methods

This study focus on the seasonal predictability of temperature and precipitation and their potential use for operational planning of management actions and handling of associated risks. North-eastern Europe was chosen as study area (latitude 50.25–69.75°N, longitude 3.75–29.25°E).

2.1. Seasonal forecasts

This study was based on daily temperature, precipitation and global radiation data with a 0.5° spatial resolution from the seasonal forecast system ECMWF SYSTEM4 (Molteni et al., 2011), with the study area covering 753 grid cells over land (Fig. 2). The data set consists of 15 ensemble members with monthly hindcasts, i.e. retrospective forecasts, for the period 1981–2010 dissected at a monthly time scale covering up to seven months. Raw data, originally downloaded from www.ecmwf.

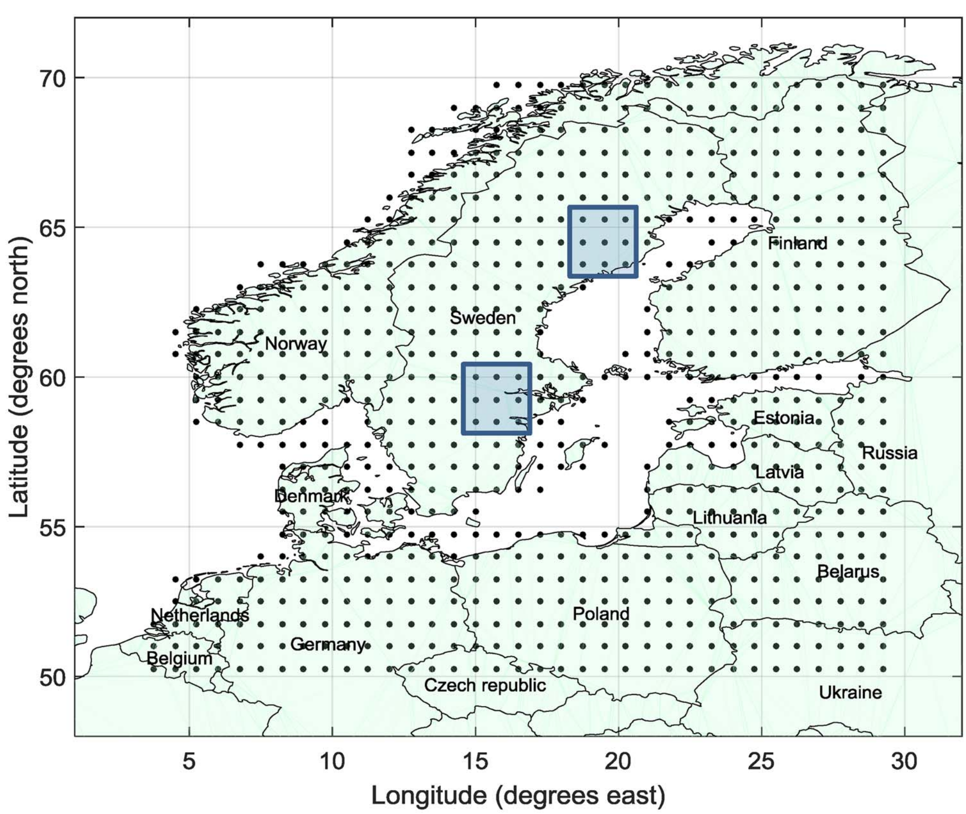

Fig. 2. Map over the study area. The dots indicates the centre of the grid cells included in the analysis. The boxes show two clusters of 3 × 3 grid cells, one in south-eastern and one-north eastern Sweden, included in the ROC analysis.