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Approach of Characterizing Changes in the Sectors Subjected to Climate Change. Characteristics of Climate Indicators for Forestry Sector of Latvia

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ABSTRACT: We present the approach of using an ensemble of the downscaled numerical climate projections to characterize quantitatively the climate change impact on a particular sector – forestry. The methodology demonstrates the potential impact of climate change using the quantitative assessment of the specific indicators of the sector in future.
In the presented analysis – the set of indicators characterizing the forestry sector in Latvia includes the phenologic indicators like average dates of the latest spring frosts, the number of drought periods per main vegetation period, the number of days below the reference temperature between the main vegetation periods, the total precipitation during the vegetation period and others. Methodology is favorable because it gives information about potential future indicator values as well as about its uncertainties. It can be generalized for characterization of necessary adaptation to climate change in other climate sensitive sectors of the economy.

Keywords: ENSEMBLES, Down-scaled numerical climate projections, Indicators, Forestry

1 INTRODUCTION

Adaptation to climate change and mitigation to climate change had become important science and policy issues all over the world. Experimental evidences of the climate change influence on phenological phases in Latvia have been obtained (Kalvāne et. al. 2009). Successive European climate research projects – PRUDENCE (Christensen and Christensen, 2007), ENSEMBLES (ENSEMBLES members, 2009)) and the most recent World Climate Research project - Coordinated Regional Climate Downscaling Experiment (CORDEX) aims to provide future climate projections – time series of meteorological variables. Limiting the uncertainty of long-term climate change predictions is essential for providing a reliable data source for resource management and planning. Bias correction and downscaling methods have been widely discussed to apply the available results on the local scale (Abatzoglou and Brown 2012). At the same time, another issue – how to express the results of a Regional Climate Model (RCM) in a way that is understandable and meaningful for a wider community (forestry, agriculture, public health, etc.) – must be addressed.

The aim of the study is to develop the methodology that gives quantitative assessment of climate change induced impact on climate sensitive sectors. Since forestry is one of the most important economic sectors in Latvia and long-term planning is essential in the sector, it has been chosen as a pilot sector for the study.

2 METHODOLOGY

2.1 *Selection of characteristic indicators*

We propose to focus on quantitative indicators that can be directly derived from meteorological observations in the study. Indicators obtainable from widely measured parameters that are also among the model parameters of the global and regional climate models – temperature, precipitation, humidity and wind speed have been selected. Quantitative assessment of its future range is possible using available future climate projections – numerical outputs of the regional climate model runs.

Climatic vegetation period characterization including precipitation/drought characteristics and detailed study of the negative degree day period that is important for the rest of vegetation after the active growth period are focused. In more detail we split the indicators into the following subgroups:

1. Length and beginning date of the main vegetation period (MVP) using several critical reference temperatures T_{ref}.
2. Number of days meeting particular temperature conditions (in a year and/or MVP).
3. Length of periods meeting particular climatic conditions (in / before / after) meeting another climatic conditions.
4. Dates of last spring and first autumn events (for example frost events).
5. Sum of active or growth or negative temperatures (in different periods defined before).
6. Number of drought periods and its length statistics in MVP.
7. Total precipitation in MVP.
8. Continentality and fire risk describing indexes.

Example of the results of some of the indicator subgroups and its change in near and far future are given in section 3.

2.2 *Selected data set*

One hour resolution data series of hourly average, minimal and maximal temperature, precipitation, for the set of ENSEMBLES project model runs were acquired as a database for the future indicator assessment. Time periods 1961-1990, 2021-2050 and 2071-2100 have been selected. The number of model runs differed from 15 to 21 - depending on data availability for the parameter (temperature, precipitation) and time scale (2021-2050 or 2071-2100).

Each of the original ENSEMBLES model result data series in 55 locations of Latvia has been bias corrected using histogram modification algorithm. Histogram correction approach is described in more detail by Seņņikovs and Bethers 2009 and Cepīte-Frišfelde et. al. 2012. Histogram correction function had been obtained in moving time window for every day of the year using histograms built from meteorological observations (including previous five and the next five days of the year in time period 1961-1990). In those of 55 stations where no observations of the certain parameter have been done, histogram correction functions had been interpolated to obtain bias corrected time series of the parameter. Histogram correction functions had been assumed the same for 1961-1990, 2021-2050 and 2071-2100 year periods.

2.3 *Representation of the results*

55 locations in Latvia (corresponding to the meteorologic observation station sites) are selected in the study. Indicator values are calculated for each of the 55 locations for each year and each bias corrected ENSEBLES model output. Calculation is repeated for each of three selected periods – control period, near and far future 30-year long periods. Climatical (30-year) averages of the indicator are calculated. The results are represented using: 1) maps that are based on distribution of indicator and it changes values in 55 locations using interpolation; 2) tables of indicator and its changes values in 7 locations (each of it correspond to one of 7 agro-climatic regions of Latvia, see Table 1). When interpreting the results of the study only indicator distribution in teritorry of Latvia can be analized because the study do not include calculation of indicator values outside Latvia. Indicator value changes between near future/far future and control period have been obtained for each model run in the selected ensemble of models. Three percentiles – 17% (low climate change projection), 50% (mean climate change projection) and 83% (significant climate change projection) are used to illustrate the uncertainty of projected indicator changes.

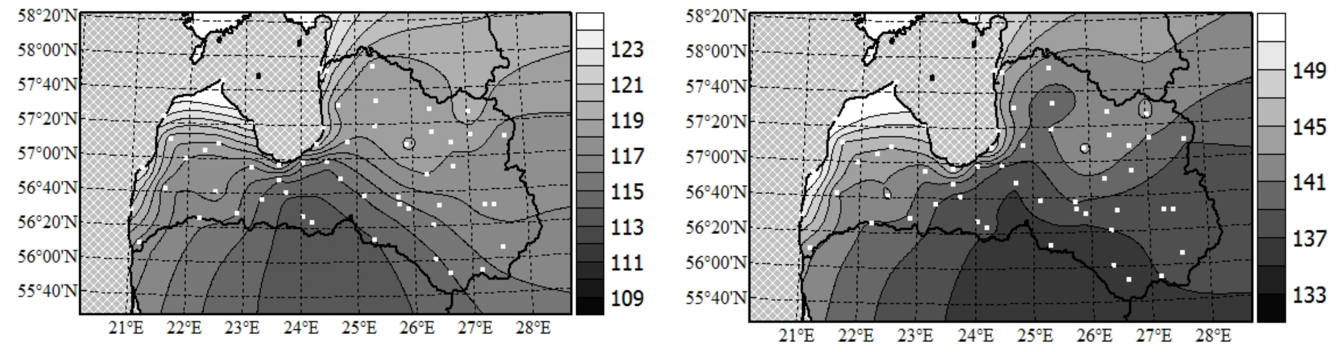
Table 1. Agro-climatic regions of Latvia and station chosen to represent it in the study

Agro-climatic region	Station name	Longitude	Latitude
Coastal Lowland of Latvia	Pāvilosta	21.189	56.888
Kurzeme Highland	Stende	22.530	57.138
Middle-Latvian Lowland	Bauska	24.216	56.388
Northern-Latvian Lowland	Rūjiena	25.329	57.888
Vidzeme Highland	Zosēni	25.916	57.121
Lubāna Lowland	Zīlāni	25.916	56.505
Latgale Highland	Daugavpils	26.617	55.867

3 RESULTS

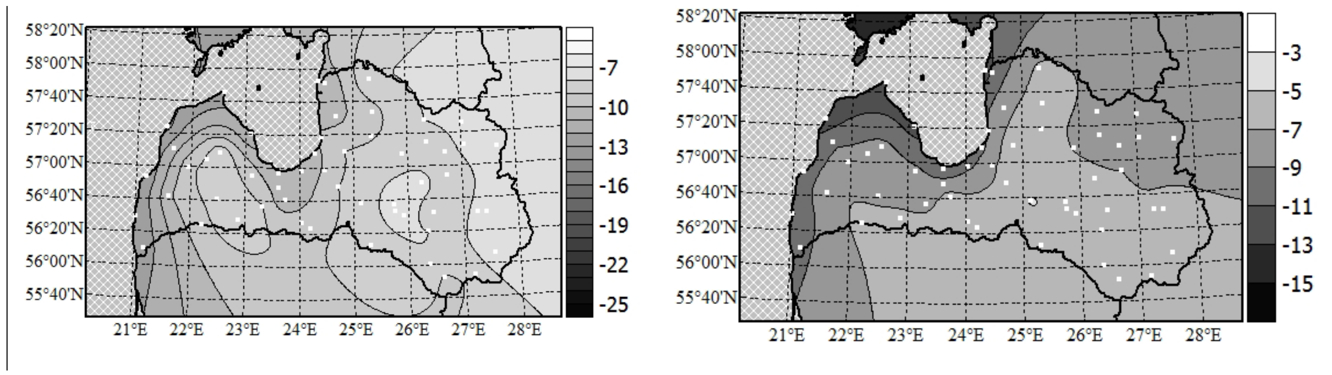
3.1 *Main vegetation period characteristics*

The earliest beginning of the main vegetation period is in Southern, Southern-Eastern part of Latvia, Fig.1. The latest MVP is near the Baltic Sea and the Gulf of Riga as well as in the Northern part of Latvia. Two weeks is the characteristic diversity of indicator values in Latvia. The starting date of the MVP is earlier in territory of Latvia, Fig.2. The most important changes are projected near the Coastal zone of the Baltic Sea and the Gulf of Riga.



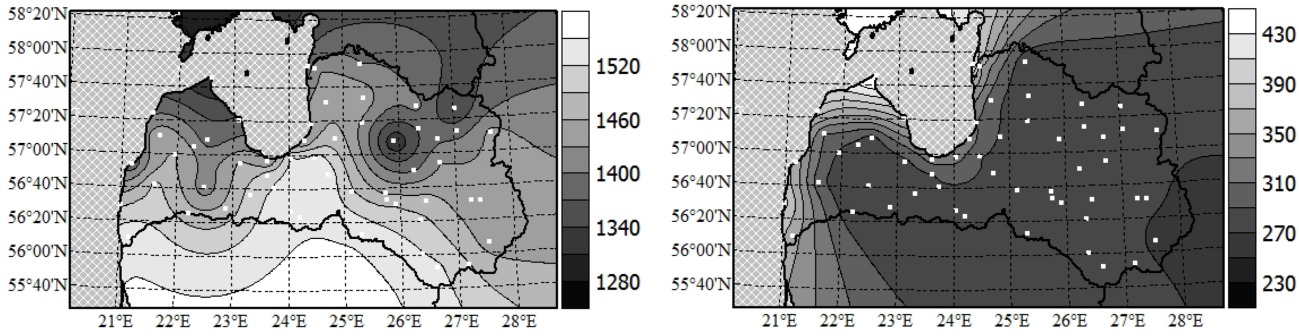
(a) *(b)*

Figure 1. The starting date (days from the beginning of the year) of the main vegetation period (MVP) in 1961-1990, Tref=5 °C (a), Tref=10 °C (b).



(a) *(b)*

Figure 2 .The change of MVP starting date (days from the beginning of the year) in near future (2021-2050) according to mean climate change projections: Tref=5 °C (a), Tref=10 °C (b).



(a) *(b)*

Figure 3. The sum of daily temperature rise above 5 °C in the MVP in 1961-1990 (a), changes (°C) according to mean climate change projections (b).

The sum of daily average temperature rise above 5 °C in the MVP is the highest in Southern-Latvia, Fig.3. The indicator is the smallest in Northern-Western part of Latvia and in Vidzeme Highland. Indicator values increases in near future. The highest rise (300 – 400 °C) is projected in the Coastal Lowland of Latvia, 250 – 300 °C are characteristic increase in other regions of Latvia.

3.2 *Precipitation and drought periods characteristics*

Analysis shows that Pāvilosta (Coastal Lowland of Latvia) is the location with the highest number of drought periods in MVP, Table 2. The least number of drought periods in the control period is in Zosēni (Vidzeme Highland). Slight increase of the indicator value is expected in all agro-climatic regions of Latvia according to mean and significant climate change projections in near and far future.

Pāvilosta and Bauska are locations with the lowest sum of precipitation in MVP in the control period, Table 3. Near and far future climate change projections show that there is expected the increase of the total sum of precipitation in the MVP in all analyzed locations. At the same time it gives evidence that Pāvilosta might become a region with the highest amount of the precipitation sum in the MVP in the future. Table 2 and Table 3 analyzed together gives evidence of more intense precipitation between the drought periods in the future in comparison with the control period situation.

Table 2. Average number of periods longer than 5 days with precipitation < 0.1 mm/day in the MVP (Tref=5°C). Its changes in near and far future in 7 locations in Latvia (representing different agro-climatic regions according to Table 1).

Period	Percentile	Location						
		Pāvilosta	Stende	Bauska	Rūjiena	Zosēni	Zīlāni	Daugavpils
Control (1961-1990)	50%	5.2	4.3	4.6	4.1	3.6	4.2	4.2
Near future (2021-2050)	17%	-0.5	-0.6	-0.2	-0.2	-0.3	-0.4	-0.1
	50%	0.2	0.1	0.2	0.2	0.2	0.2	0.3
	83%	0.8	0.9	1.0	0.7	0.7	0.8	0.9
Far future	17%	0.2	-0.3	0.0	0.2	0.1	-0.1	0.0
	50%	1.3	0.8	1.3	1.1	1.1	1.1	1.4
	83%	2.4	2.1	2.3	1.8	1.7	2.1	2.2

Table 3. Total sum of precipitation (mm) in the MVP (T_{ref}=10°C). Its changes (mm) in near and far future in 7 locations in Latvia (representing different agro-climatic regions according to Table 1).

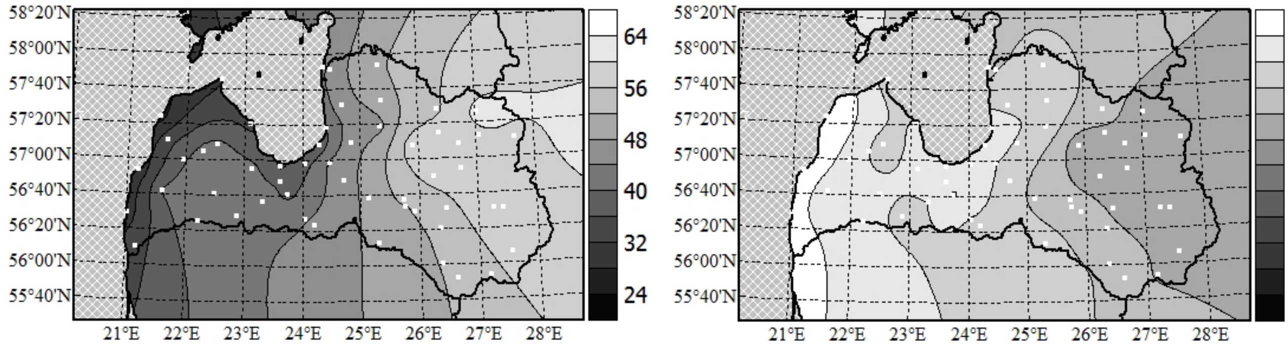
Period	Percentile	Location						
		Pāvilosta	Stende	Bauska	Rūjiena	Zosēni	Zīlāni	Daugavpils
Control (1961-1990)	50%	289	296	286	312	306	300	312
Near future (2021-2050)	17%	67	59	50	46	50	47	35
	50%	121	81	69	81	73	77	67
	83%	150	113	93	107	100	102	101
Far future	17%	91	79	45	78	73	54	29
	50%	162	107	84	116	87	99	86
	83%	234	169	149	169	136	135	150

3.3 *Characterization of the frosts and winter season*

Analysis shows that there is eastern-western gradient for the distribution of the indicator – days with daily mean temperature below -5 °C in the control period in Latvia. The values of the indicator are smaller in Coastal Lowland (below 30 days on the Baltic Sea shore) and increases in inland direction (above 60 days in Eastern-Western part of Latvia), Fig.4a. Diversity of indicator values are going to decrease in near future according to mean climate change projections, Fig. 4b. The largest decrease of the indicator value is found in Eastern part of Latvia, smaller decrease is shown near the Baltic Sea shore. Nevertheless, characteristic number of days with mean temperature below -5 °C is twice as low in near future near the Baltic shore as it is in the control period. The indicator might be of high interest because low temperatures in winters are related to reduction of the number of insects that can be harmful to forest vegetation during MVP.

The day of the last spring frost in MPV in 7 representative locations in Latvia is shown in Table 4. The latest spring frosts in the control period occur in Zosēni in Vidzeme Highland in 24th of May. Two weeks difference of the indicator values among 7 locations is acquired. Low, mean and significant climate change projections show that the value of the indicator increases in the future. The diversity of the indicator values is slightly decreasing according to mean climate change scenarios. The latest spring frost in MVP is 9 to 17 days earlier than in the control period. The largest changes are shown in Coastal Lowland in Pāvilosta, the smallest – in Middle-Latvia Lowland (Bauska). Characteristic uncertainty between 17% and 83% percentile is two weeks and the highest uncertainty is found in Pāvilosta (22 days in near future period and 35 days in far future period).

Table 5 illustrate the sum of daily temperature rise above 5 °C from the beginning of the year until the last spring frost in MVP. The highest value of the indicator is in Zosēni (Vidzeme Highland) where accumulation of 168 °C above 5 °C occur until the last spring frost in the end of May. The least significant accumulation of 72 °C above 5 °C occurs in Pāvilosta near the Baltic Sea shore where the last spring frost is only one week earlier than in Zosēni. Analysis shows that all 3 representative percentiles project the decrease of the indicator values in Vidzeme, Kurzeme and Latgale Higlands in near future. Situation is different in Lowlands where decrease of the indicator values are projected according to mean and significant climate change scenarios and no changes or even slight increase is projected according to low climate change scenarios (17%).



(a) *(b)*

Figure 4. The average number of days with daily mean temperature below -5 °C between two MVP in 1961-1990 (a), changes in near future according to mean climate change projections (b).

Table 4. The day of the last spring frost in MVP (from beginning of the year), T_{ref}=5°C. Its changes (days) in near and far future in 7 locations in Latvia (representing different agro-climatic regions according to Table 1).

Period	Percentile	Location						
		Pāvilosta	Stende	Bauska	Rūjiena	Zosēni	Zīlāni	Daugavpils
Control (1961-1990)	50%	139	144	131	137	146	133	136
Near future (2021-2050)	17%	-4	-6	-4	-7	-7	-6	-7
	50%	-17	-13	-9	-12	-14	-10	-12
	83%	-26	-22	-15	-17	-22	-17	-16
Far future (2071-2100)	17%	-21	-24	-16	-19	-18	-16	-17
	50%	-46	-32	-21	-23	-27	-24	-23
	83%	-56	-36	-28	-28	-32	-30	-20

Table 5. The sum of daily temperature rise above 5 °C from the beginning of the year until the last spring frost in MVP, T_{ref}=5°C. Its changes (°C) in near and far future in 7 locations in Latvia (representing different agro-climatic regions according to Table 1).

Period	Percentile	Location						
		Pāvilosta	Stende	Bauska	Rūjiena	Zosēni	Zīlāni	Daugavpils
Control (1961-1990)	50%	72	156	110	118	168	119	144
Near future (2021-2050)	17%	16	-14	13	0	-18	11	-5
	50%	-6	-34	-10	-25	-43	-22	-26
	83%	-23	-59	-33	-37	-64	-50	-50
Far future (2071-2100)	17%	23	-14	12	1	-15	6	16
	50%	11	-44	-11	-23	-43	-20	-36
	83%	-27	-73	-28	-39	-69	-43	-57

4 CONCLUSIONS

Presented approach gives quantitative characteristics of climatic change of indicator spatial distribution. Since indicators are calculated for every year of each model run of the ensemble, the uncertainty that is characterized using the difference between 17^{th} and 83th percentile is known for each indicator.

According to ENSEMBLES model results the starting date of the MVP is earlier in near future than in the control period. The number of drought periods is going to increase in Vidzeme, Latgale, Kurzeme

Highlands of Latvia at the same time the total sum of precipitation in MVP is going to increase as well. It means that more intense precipitation between drought periods is expected.

Analysis of multiple indicators allows better understanding characteristic features of different regions of Latvia – both in the control and future periods. For example – Vidzeme Highland is the region with one of the earliest beginnings of MVP and the largest amount of precipitation at the same time it accumulates the lowest temperature rise above 5 °C in Latvia as well as the latest spring frosts and the largest number of drought periods occurs there. It makes it less favourable for agricultural production of multiple species than other regions of Latvia having later MVP and less precipitation.

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REFERENCES

Abatzoglou, J. T., Brown, T. J. (2012). A comparison of statistical downscaling methods suited for wildfire applications, International Journal of Climatology, Vol. 32, pp. 772-780.

Cepīte-Frišfelde, D., Bethers, U. Sennikovs, J., Timuhins, A. (2012). Penalty function for identification of regions with similar climatic conditions. Climate Change in Latvia and Adaptation to It. University of Latvia Press, pp. 8-16.

Christensen J.H., Christensen O.B. (2007). A summary of the PRUDENCE model projections of changes in European climate by the end of this century. Climatic Change, Vol. 81, pp. 7–30.

ENSEMBLES members, (2009). Climate change and its impacts at seasonal, decadal and centennial timescales. Summary of research and results from the ENSEMBLES Project 164 pages.

Kalvāne, G., Romanovskaja, D., Briede, A., Bakšiene, E. (2009). Influence of climate change on phenological phases in Latvia and Lithuania. Climate Research, Vol. 39, pp. 209-219.

Sennikovs, J., Bethers, U. (2009). Statistical downscaling method of regional climate model results for hydrological modelling. 18th World IMACS / MODSIM Congress, Cairns, Australia.