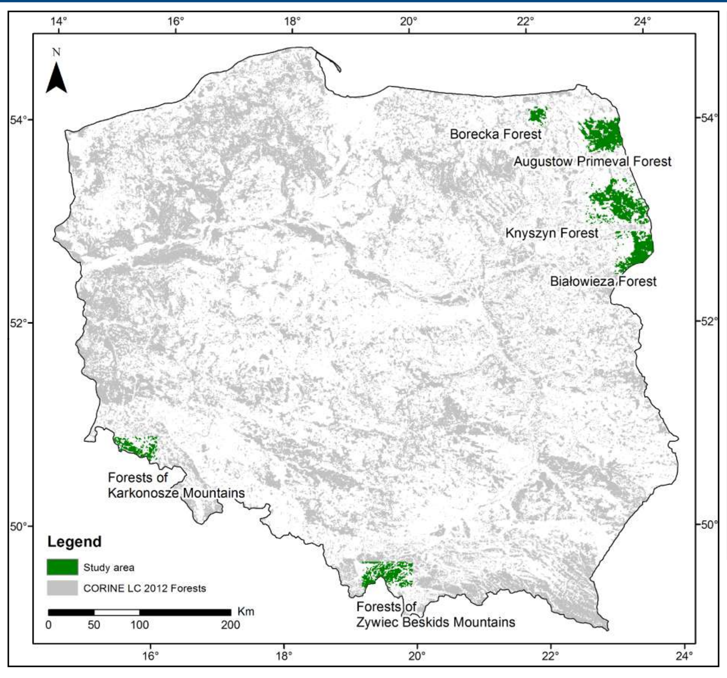
FOREST PHENOLOGY AND ITS RESPONSES TO METEOROLOGICAL OBSERVATIONS IN POLAND USING MULTITEMPORAL SPOT VGT AND PROBA-V DATA

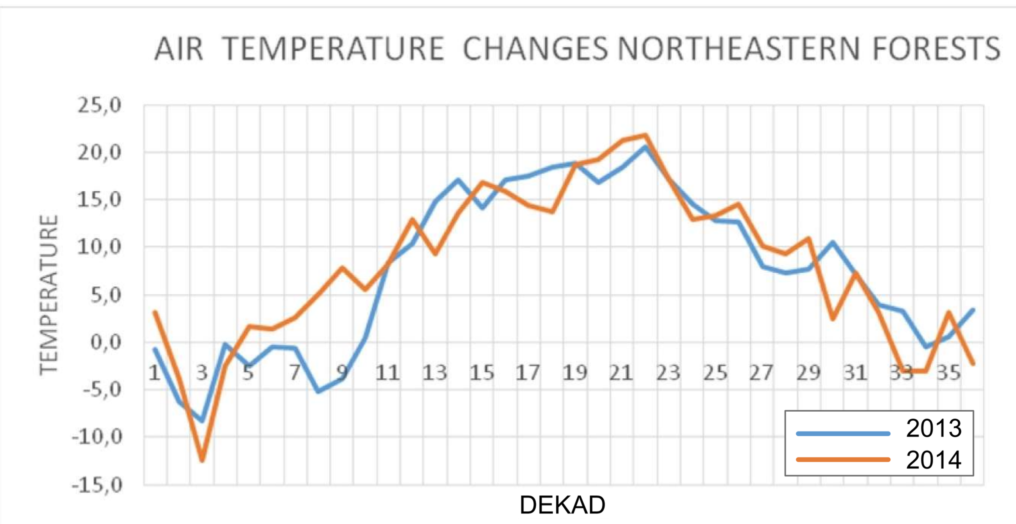
Maciej Bartold*, Zbigniew Bochenek, Katarzyna Dabrowska-Zielinska****

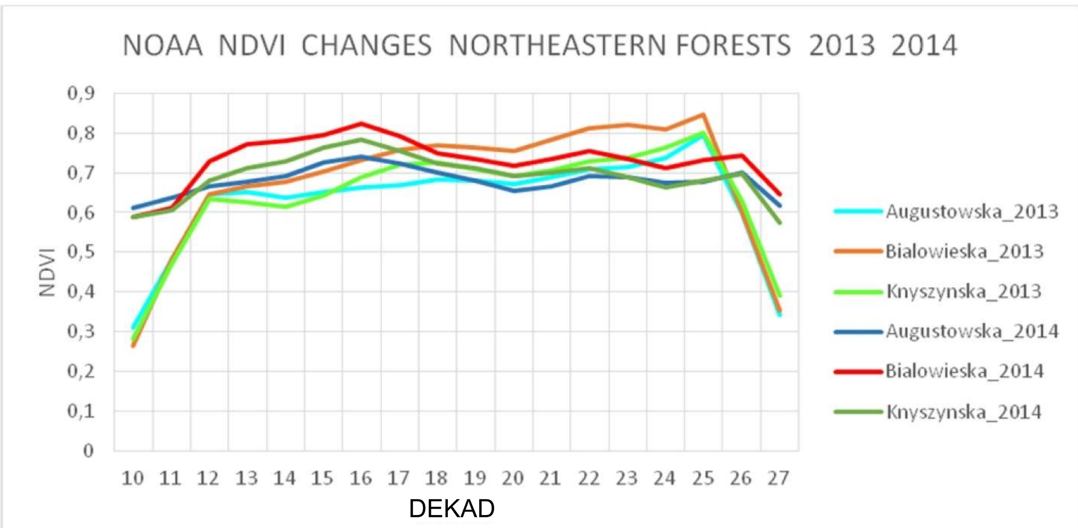
* Faculty of Geography and Regional Studies, University of Warsaw
**Remote Sensing Centre, Institute of Geodesy and Cartography, Warsaw
www.igik.edu.pl, maciej.bartold@igik.edu.pl

BACKGROUND AND MOTIVATION

Recent studies on applicability of low resolution 1 km x 1 km NOAA AVHRR obs. in 2013-2014 for record of environmental & climatic conditions in six forest study areas in Poland revealed that both aspects of forest variability can be monitored with the use of vegetation index derived from EO images. NDVI for northeastern forests, which are under the influence of a continental climate with the impact of polar air masses correlates well with temperatures existing at the wintertime in March e.g. Borecka F. at r=0.86, Bialowieza F. at 0.63. NDVI of forests of Karkonosze Mountains, which are under the influence of maritime climate with the tropical air masses also correlates well, at r=0.67. The results indicate further and complex research to find impact of unfavourable conditions on growing season taking into account variability of species and all broad-leaved forests in Poland.



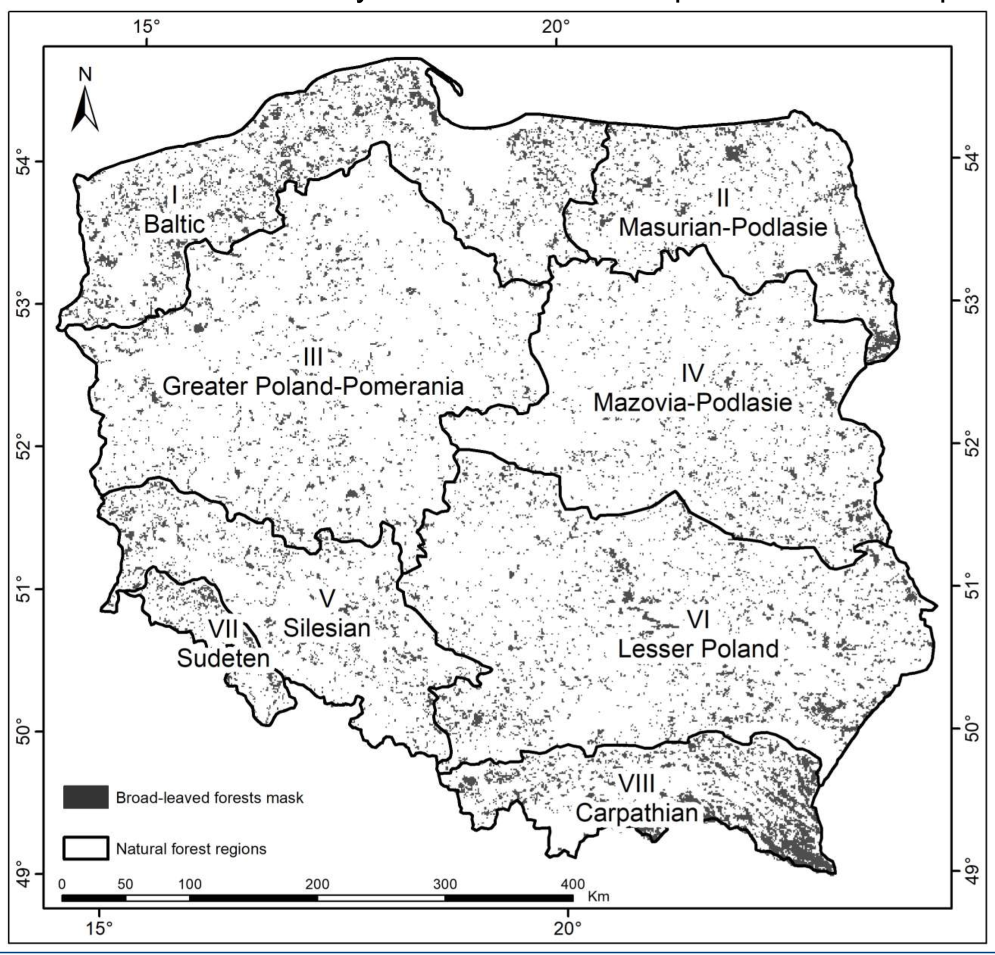




Much lower air temperatures at the start of vegetation season stopped development of vegetation, which was expressed by much lower NDVI. Higher temperatures in 2013 from dekads 13 till 18, accompanied by high precipitation rates in dekads 15 and 16, caused that at dekad 18 NDVI in 2013 and 2014 was similar. The similarity is kept until mid-September, when in 2013 strong decrease of NDVI index is observed, caused most probably by high precipitation rates, which increased moisture amount in leaves/needles, thus decreasing NDVI levels.

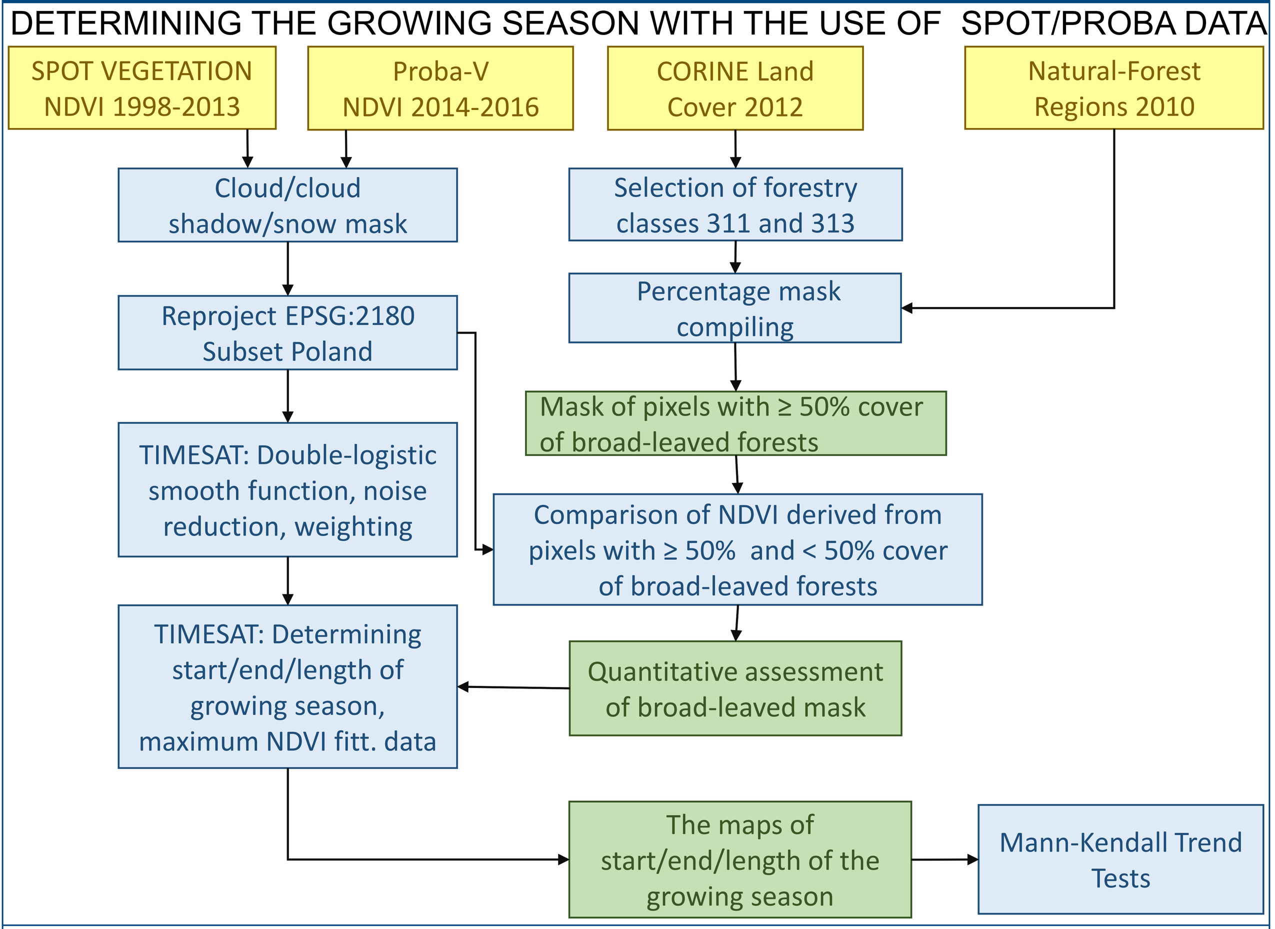
OBJECTIVE

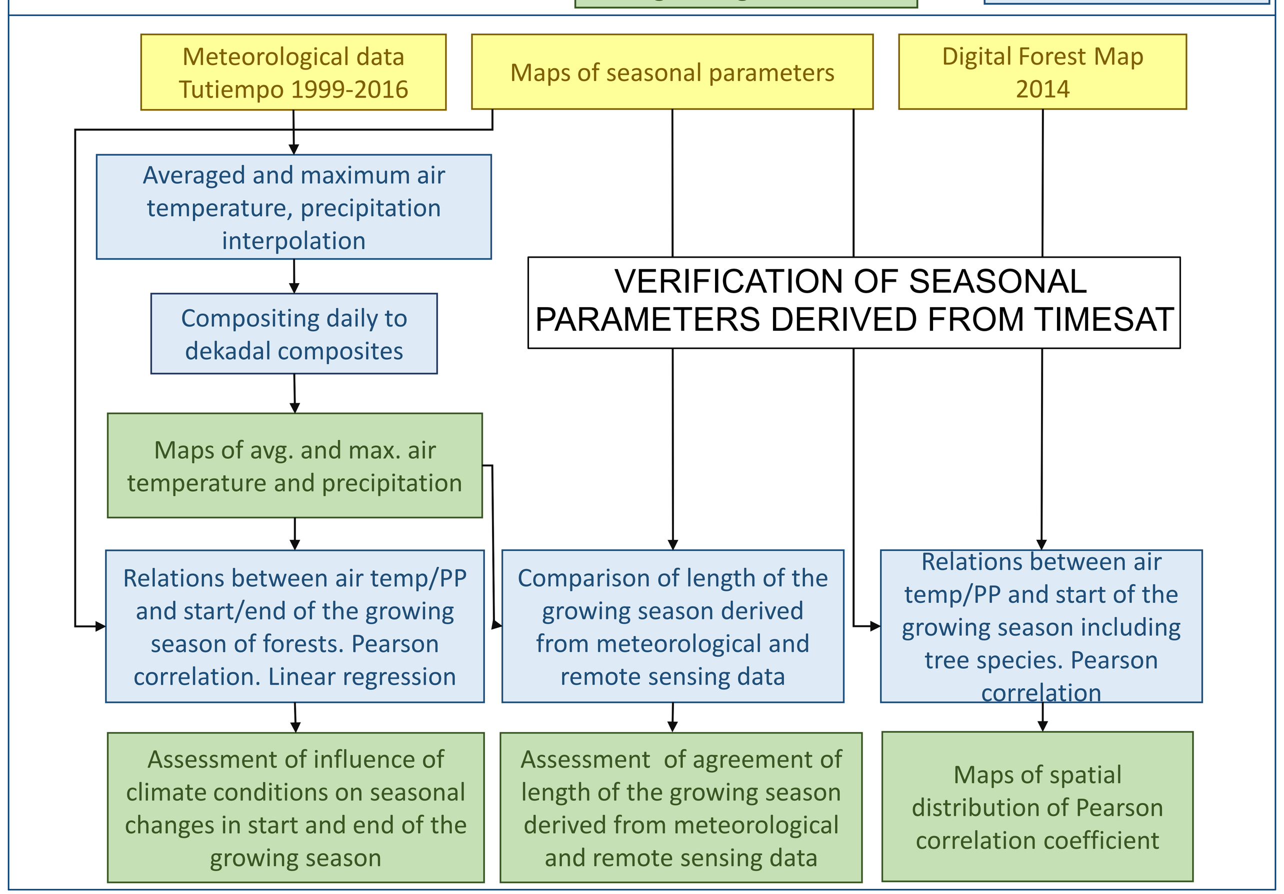
The work presented here aims at investigating phenological changes using satellite-based vegetation indices in broad-leaved forests over eight Natural Forest Regions in Poland. In this study the time-series of the Normalized Difference Vegetation Index (NDVI) comprising SPOT VGT & Proba-V (latest collection C1) images from 1999 to 2016 were applied. The seasonal parameters such as onset of the growing season, end of the season, length of the season, maximum NDVI observed during the growing season were determined using a threshold-based method. Next meteorological observations derived from Tutiempo Database were extracted in order to analyze the relationship with forest phenology.



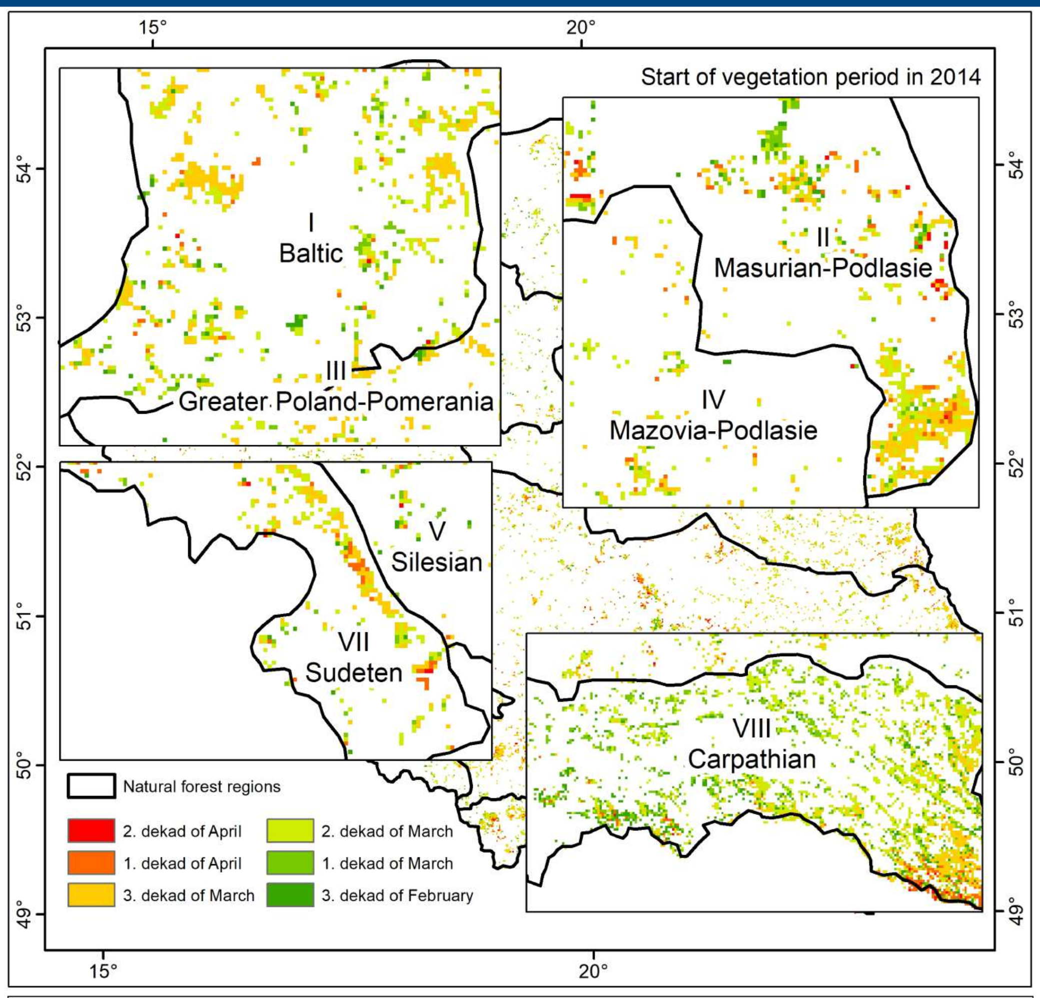
METHODS

DETERMINING THE GROWING SEASON WITH THE USE OF SPOT/PROBA DATA





RESULTS



The map presented on the left reveals the spatial differentiation of the start of the growing season of forests in 2014, ranging 40-50 days at national scale. It is strictly related to tree species, which response differently to climatic conditions. Carpathian region is characterized by beech as dominant species which responses to favourable conditions earlier than the forests in Masurian-Podlasie or Sudeten.

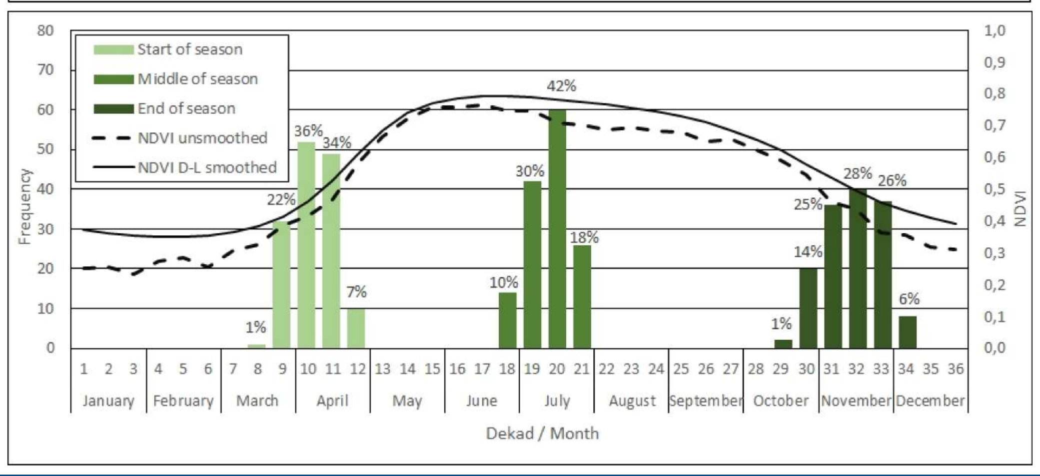
Three scenarios of the impact of max.air temp. and PP were analyzed; regarding meteorolog. observations in period January-March, March and the last dekad in March.

The results indicate moderate correlations with Max. Air Temp. observed in wintertime. Generally there were no signific.correlations with precipitation noted.

r(START OF SEASON, MAX OF AIR TEMP.)	JANUARY-MARCH	MARCH	MARCH 3DEKAD	r(START OF SEASON, PRECIPITATION)	JANUARY-MARCH	MARCH	MARCH 3DEKAD
Baltic	-0,54	-0,54	-0,54	Baltic	-0,10	-0,09	-0,06
Masurian-Podlasie	-0,61	-0,60	-0,62	Masurian-Podlasie	-0,24	-0,16	-0,11
Greater Poland-Pomerania	-0,29	-0,30	-0,38	Greater Poland-Pomerania	0,05	-0,12	-0,46
Mazovia-Podlasie	-0,31	-0,35	-0,37	Mazovia-Podlasie	-0,19	-0,16	-0,22
Silesian	0,03	-0,01	-0,09	Silesian	-0,44	-0,52	-0,45
Lesser Poland	-0,46	-0,49	-0,43	Lesser Poland	-0,04	0,11	-0,01
Sudeten	-0,42	-0,45	-0,45	Sudeten	-0,04	-0,10	-0,25
Carpathian	-0,70	-0,69	-0,50	Carpathian	0,04	0,21	0,05

r(ENF OD SEASON, MAX OF AIR TEMP.)	AUGUST-OCTOBER	OCTOBER	OCTOBER 3DEKAD	r(END OF SEASON, PRECIPITATION)	AUGUST-OCTOBER	OCTOBER	OCTOBER 3DEKAD
Baltic	-0,46	0,26	0,02	Baltic	0,30	0,15	0,01
Masurian-Podlasie	-0,63	0,39	0,15	Masurian-Podlasie	0,40	0,03	-0,10
Greater Poland-Pomerania	-0,52	0,24	0,17	Greater Poland-Pomerania	0,04	-0,06	-0,03
Mazovia-Podlasie	-0,55	0,10	0,06	Mazovia-Podlasie	0,29	0,16	0,03
Silesian	-0,46	-0,08	0,01	Silesian	-0,02	0,12	0,07
Lesser Poland	-0,39	0,22	0,17	Lesser Poland	0,03	0,05	-0,10
Sudeten	-0,12	0,09	-0,11	Sudeten	-0,21	0,13	0,10
Carpathian	-0,04	0,43	0,13	Carpathian	-0,33	-0,21	-0,13

Strength of the relationship
0,0≤|r|≤0,2 – very weak
0,2<|r|≤0,4 - weak
0,4<|r|≤0,7 - moderate
0,7<|r|≤0,9 – strong
0,9<|r|≤1,0 – very strong

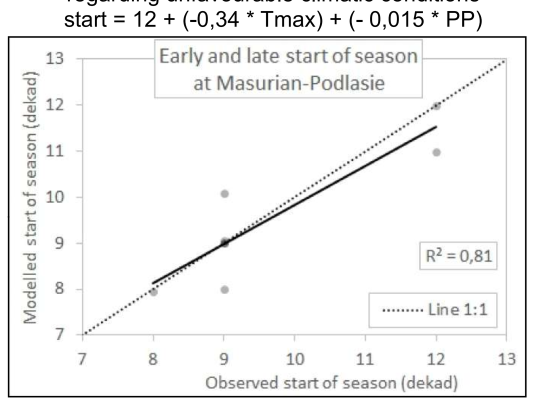


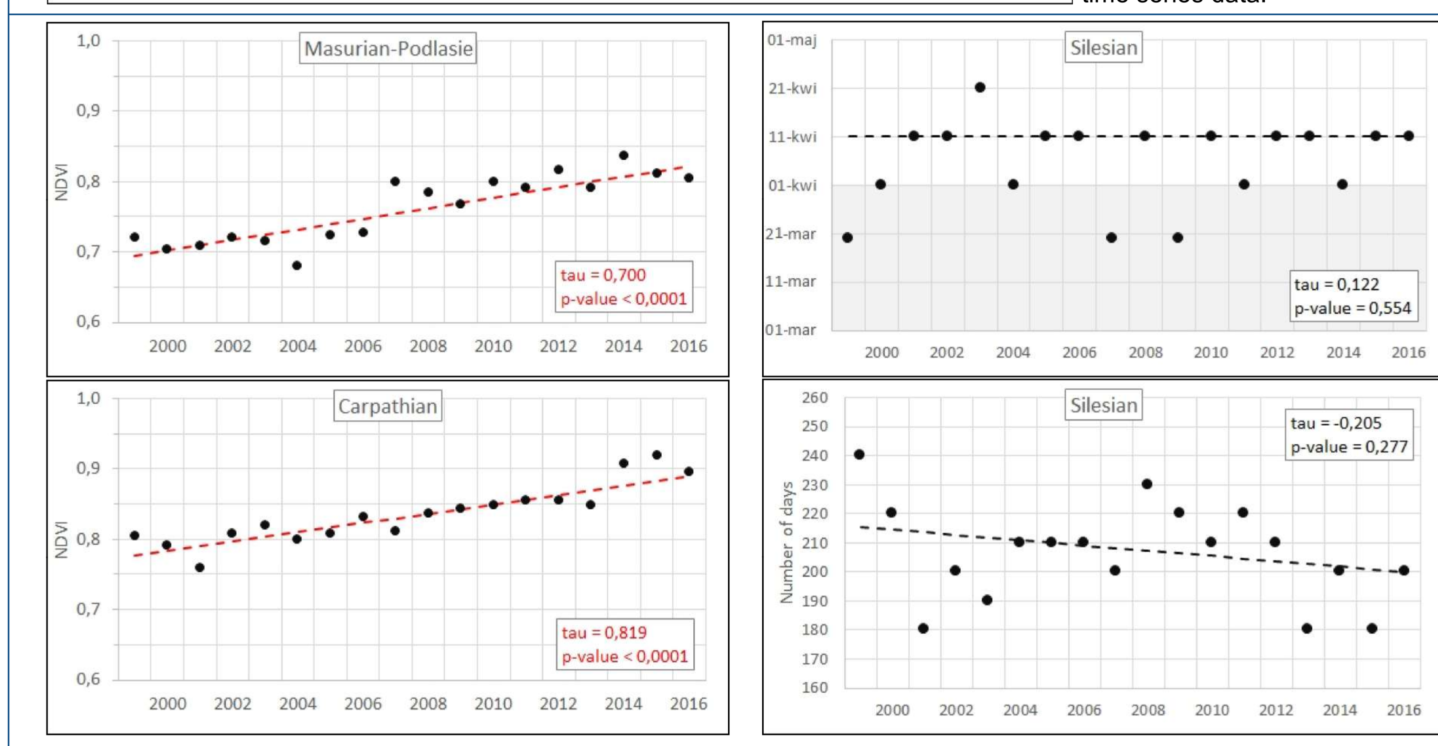
In order to confirm early and late (before 10 and after 11 dekad) starts of the growing season of the forests in Masurian-Podlasie region observed in eight years we correlated to air temperature in March. The results shows the impact of unfavourable air temp. conditions on shifts of the start of the growing season; R2=0.81.

Histogram of frequency of start/middle/end of season determined from SPOT-VGT and Proba-V time series data.

Year	Start of season [dekad]	Av. Air Tmax in March [°C]	Sum PP in March [mm/m2]
1999	10	7,37	25,05
2000	10	5,40	55,39
2001	11	4,80	44,34
2002	**9**	**8,17**	**47,27**
2003	10	5,34	12,16
2004	10	5,62	38,84
2005	10	1,66	38,71
2006	**12**	**1,48**	**9,10**
2007	**8**	**10,21**	**21,69**
2008	10	6,16	55,35
2009	**9**	**4,04**	**56,21**
2010	10	5,84	29,56
2011	**9**	**5,47**	**13,43**
2012	**9**	**7,17**	**16,13**
2013	**12**	**0,20**	**18,16**
2014	**9**	**9,66**	**38,32**
2015	10	9,01	42,10
2016	11	6,08	35,39

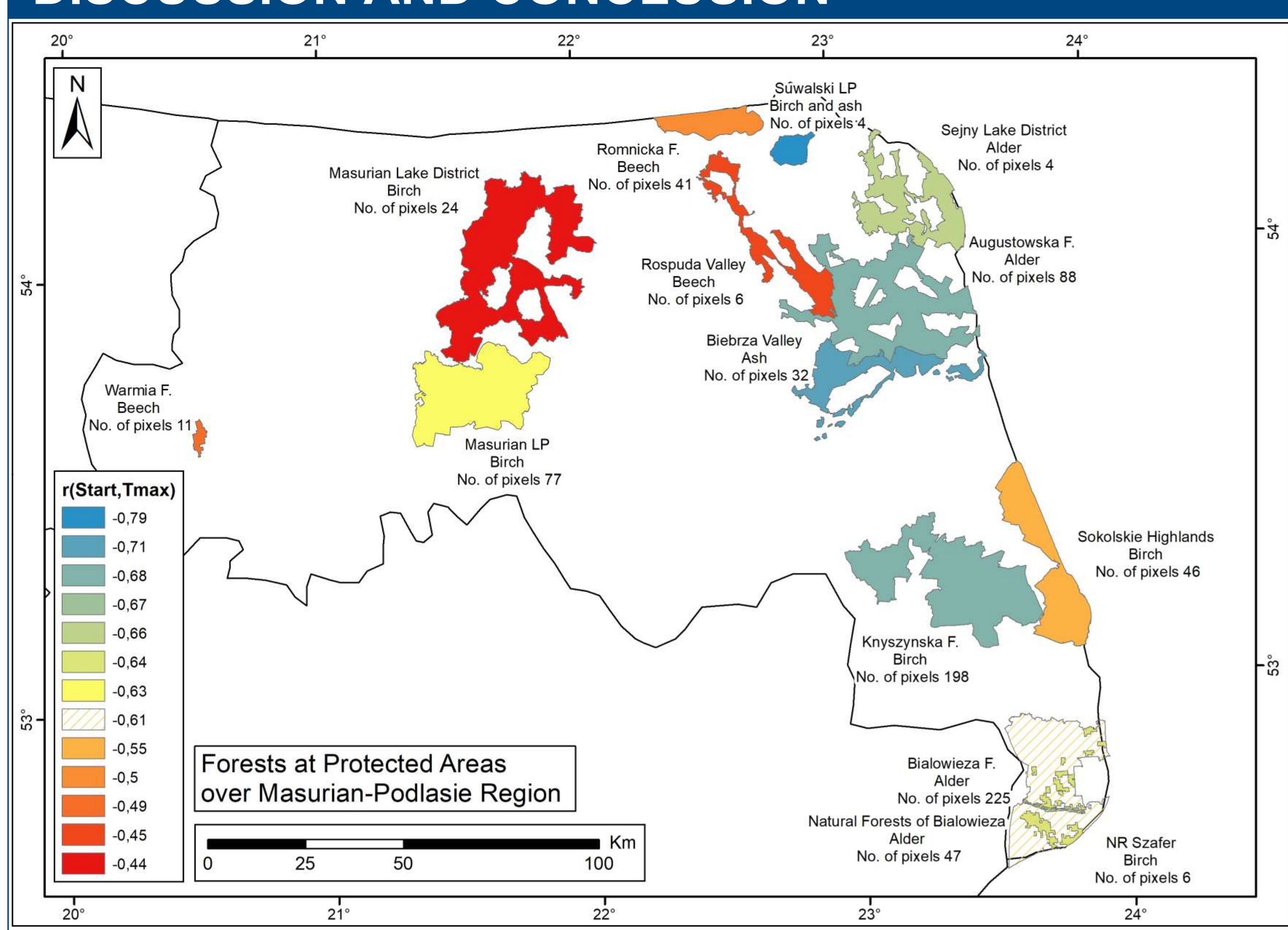
Model for the start of the growing season regarding unfavourable climatic conditions
start = 12 + (-0,34 * Tmax) + (- 0,015 * PP)





Mann-Kendall trend test were applied to detect trends in seasonal parameters start, end and length of the growing season. Maximum NDVI derived from fitted remote sensing data was observed during determined season in order to identify trend as well. The results highlighted red indicate statistically significant trend of maximum ndvi in 1999-2016 over forests in Masurian-Podlasie with the strength of the relationship tau=0,700, p-value < 0,0001 and Carpathian with tau=0,819, p-value < 0,0001.The statistically significic. trends of max.NDVI were noted over forests in all eight Natural-forest regions. The results indicate development of canopy of broad-leaved trees at Natural-forest regions, excluding man-made disturbances at the analyzed scale. On the contrary there were no statistically significant trends noted of the start, end and length of the growing season in each of eight Nature-forest regions. On the left start and length of the growing season in Silesian is shown.

DISCUSSION AND CONCLUSION



On the left: Map presents the spatial differentiation of Pearson correlation coefficient between start of growing season and maximum air temperature in March in forest protected areas in northeastern Poland. Tree species such as alder (Alnus serrulata), silver birch (Betula pendula) begin greening phases in early spring. Remote sensing methods proved the start of their growing season correlates well with climatic conditions at r = -0.60 ÷ -0.80. On the contrary the areas with beech as dominant species which starts greening phase 20-30 days later relative to early spring trees, characterize low correlation with climatic conditions at r = -0.50.

The results indicate further research on applying high-resolution satellite data (combination of Landsat & Sentinel-2), with spatially detailed information for analyzing the impact of climate on environmental aspects at local scale, taking into account the habitat conditions, the moisture and the surface temperature.

ACKNOWLEDGEMENTS

The research work has been conducted within the Polish-Norwegian Research Programme, Norway Grants financed by the National Centre for Research and Development, as part of the WICLAP project "Ecosystem stress from the combined effects of winter climate change and air pollution - how do the impacts differ between biomes?"

eea grants norway grants The National Centre for Research and Development WICLAP Polish-Norwegian Project