SCERIN-6 Capacity Building Workshop on Earth System Observations
Zagreb, 11-14 June 2018

Social and Climatic Precursors of Land Cover Changes in Croatia

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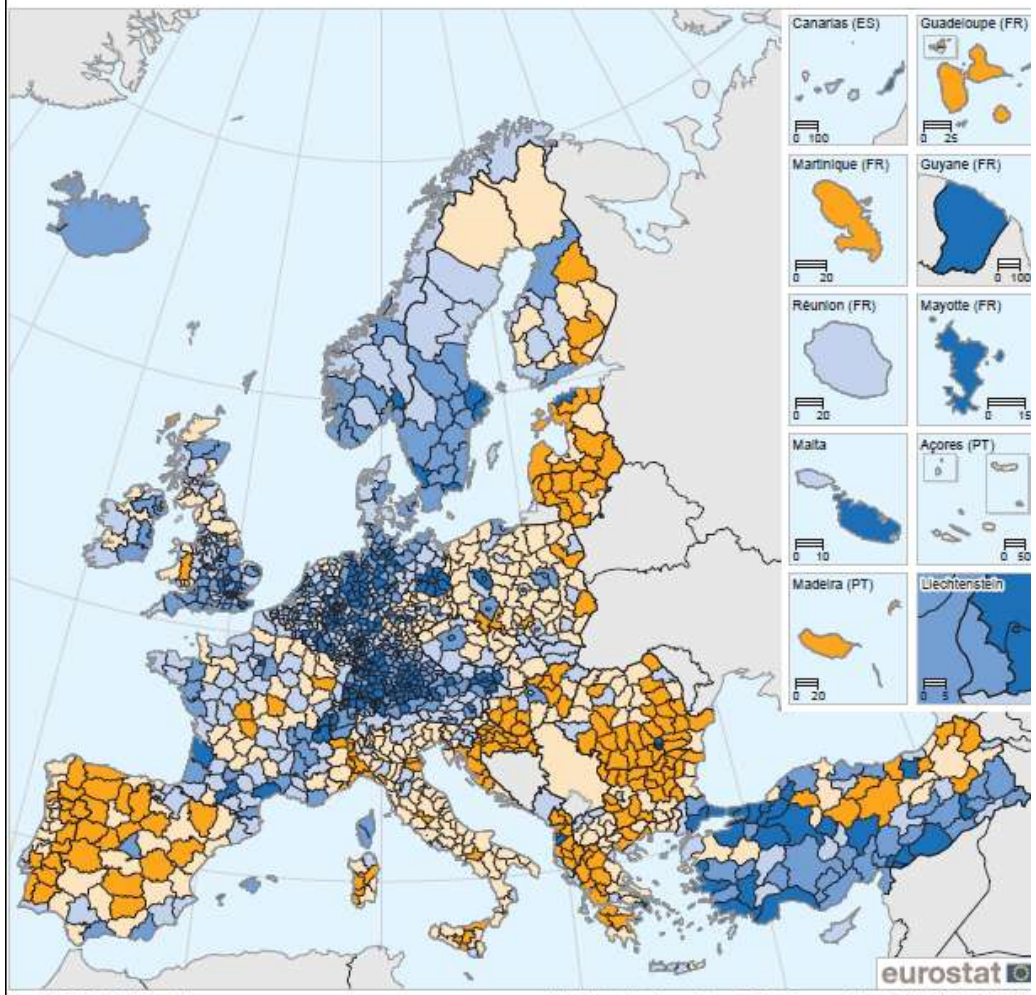
***This research is supported by Croatian Science Foundation, within the project Advanced Forest Ecosystem Assessment "AFORENSA"**

Crude rate of total population change, by NUTS 3 regions, 2015
(per 1 000 inhabitants)



(per 1 000 inhabitants)

EU-28 = 3.5

- < -6
- -6 – < 0
- 0 – < 6
- 6 – < 12
- >= 12
- Data not available

Cartography: Eurostat - GISCO, 07/2017

0 200 400 600 800 km

SOIL CARBON CONTENT - SOCIAL CHANGE INDICATOR IN CROATIA

LCLUC - Corine LC (1980, 1990, 2000, 2006) & SOIL CARBON CONTENT (2351 soil profiles)

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Estimation of soil organic carbon stocks and stock changes in Croatia (1980–2006) – use of national soil database and the Corine Land Cover

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Abstract

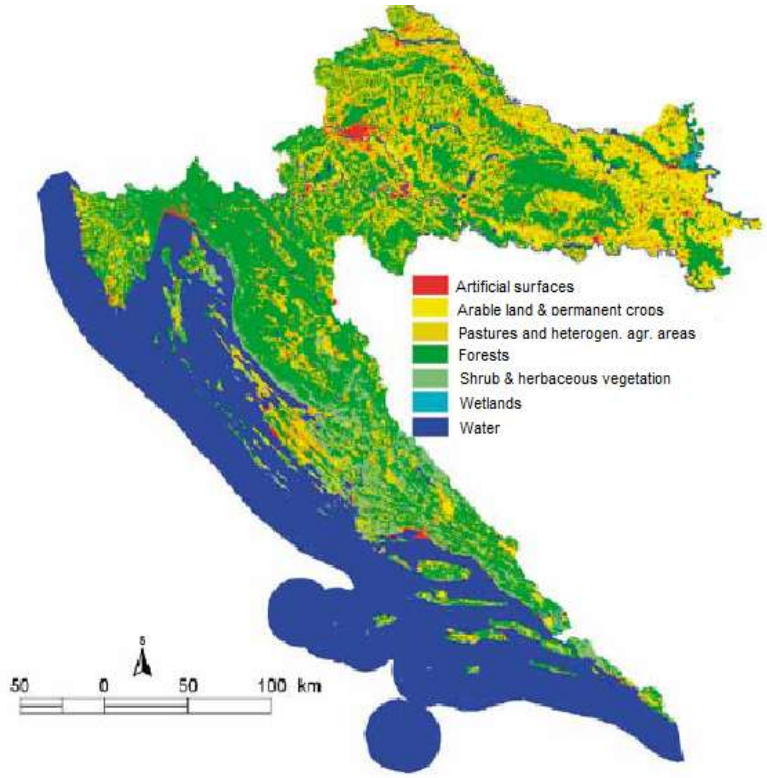
Background and Purpose: In this study, estimation of soil organic carbon (SOC) stocks for the LULUCF categories is provided together with assesment of spatial and temporal trend of soil carbon density (SCD) for the 1980–2006 period in Croatia.

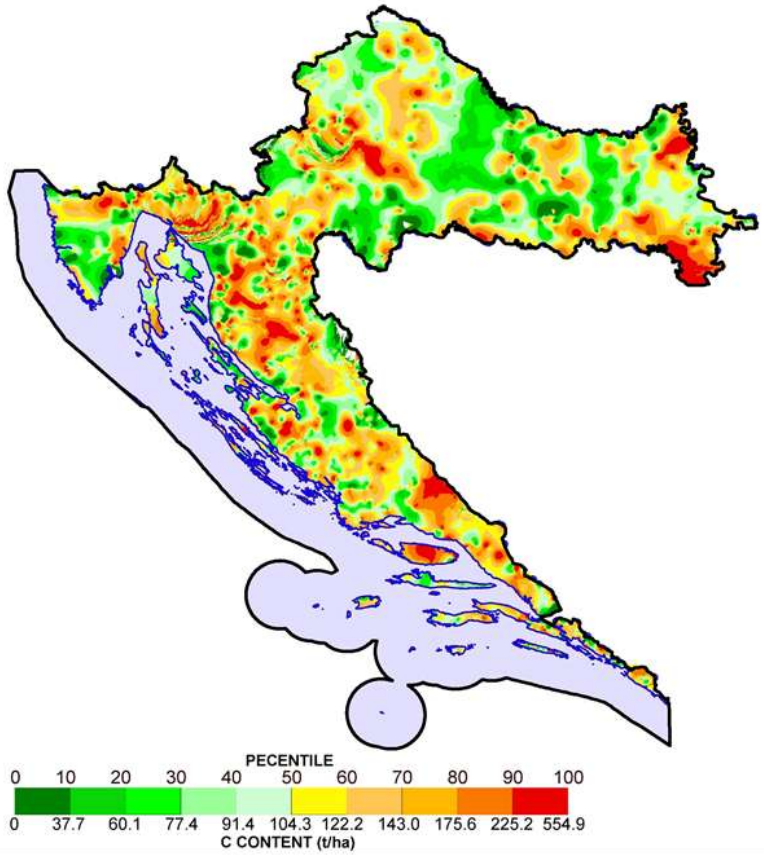
Materials and Methods: Calculations of soil carbon stocks was based on data of soil organic carbon from the national (pedon) database of Croatian soils that consisted of 2351 soil profiles and Corine Land Cover inventories in 1980, 1990, 2000 and 2006.

Results and Conclusions: The total estimated soil organic carbon stock in Croatia for all CLC categories relevant for the LULUCF sector (93% of the total country area in 2006) is 618,77 Mt. Forests and areas with natural vegetation with 348,11 Mt contribute most of all categories, of which managed forests (broad-leaved, coniferous and mixed) contain 241,93 Mt and other natural vegetation classes 106,18 Mt. Estimated soil carbon stock in agricultural land is 270,46 Mt, of which 166,99 Mt contain classes of intensive agriculture (arable land, permanent crops and complex cultivation patterns). Total change in SC stock between 1980 and 2006 equals +1,91 Mt and is mostly due to changes in agricultural practices in rural

List of abbreviations:

IPCC	– Intergovernmental Panel on Climate Change
LULUCF	– Land use, land-use change and forestry
GHG	– greenhouse gas
GPG-LULUCF	– The Good Practice Guidance for Land Use, Land-Use Change and Forestry
SSURGO	– Soil Survey Geographic database
STATSGO	– State Soil Geographic database
NCSS	– National Cooperative Soil Survey
SGDBE	– Soil Geographical Database of Europe
AFSS	– Austrian Forest Soil Survey
HWSD	– Harmonized World Soil Database
SOC	– soil organic carbon
SCD	– soil carbon density
OPK-RH	– Basic soil map of Republic of Croatia
CLC	– Corine Land Cover
GAMs	– Generalized Additive Models
mgcv library	– Mixed GAM Computation Vehicle with GCV/AIC/REML smoothness estimation and GAMs by REML/PQL

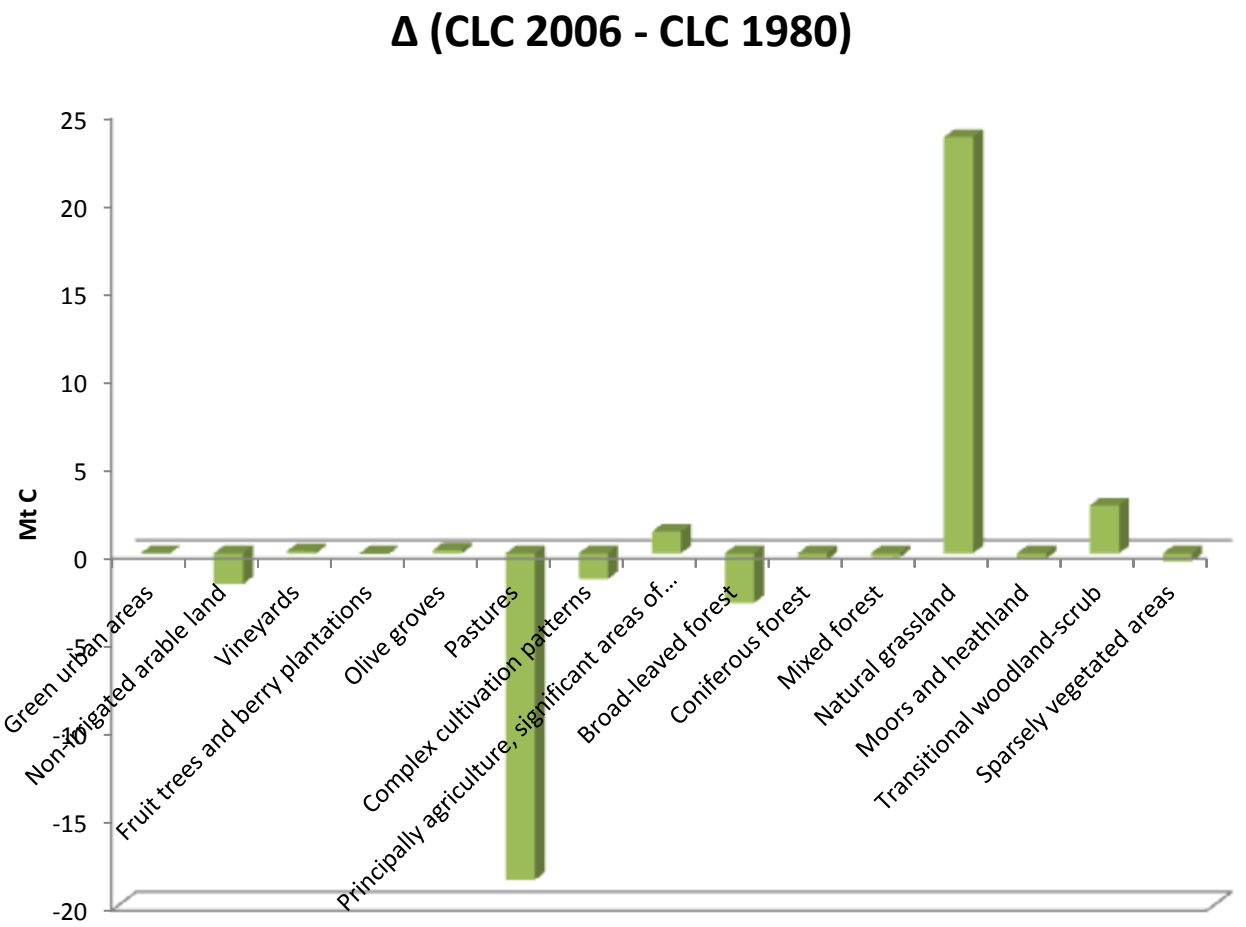




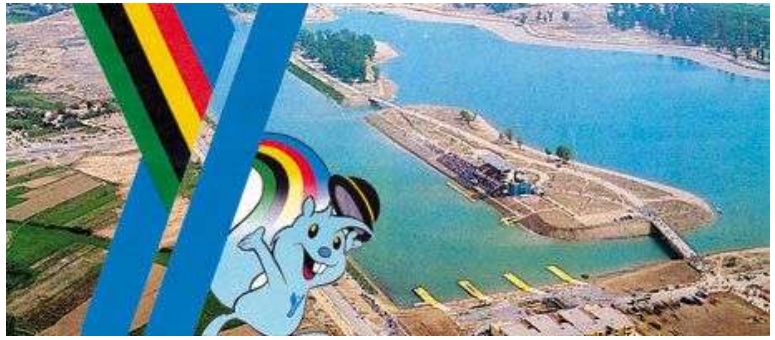
CLC level 3	N	Mean	CLC 1980	CLC 1990	CLC 2000	CLC 2006	CLC 1980	CLC 1990	CLC 2000	CLC 2006	Δ (CLC 2006 - CLC 1980)
		(T C/ha)	(ha)				(Mt C)				(Mt C)
Green urban areas	29	**115,18**	1812	1812	1782	1724	0,21	0,21	0,21	0,20	-0,01
Non-irrigated arable land	629	**114,29**	385633	378430	368974	370262	44,07	43,25	42,17	42,32	-1,76
Vineyards	137	**135,3**	28200	28193	28925	29055	3,82	3,81	3,91	3,93	0,12
Fruit trees and berry plantations	40	**163,92**	9760	9410	9548	9574	1,60	1,54	1,57	1,57	-0,03
Olive groves	15	**121,62**	18759	18705	20223	20197	2,28	2,27	2,46	2,46	0,17
Pastures	97	**104,96**	475815	477566	307296	298950	49,94	50,13	32,25	31,38	-18,56
Complex cultivation patterns	21	**114,2**	1034844	1026779	1017238	1022051	118,18	117,26	116,17	116,72	-1,46
Principally agriculture, significant areas of natural vegetation	10	**137,52**	515282	510822	523509	524202	70,86	70,25	71,99	72,09	1,23
Broad-leaved forest	723	**117,08**	1706194	1695356	1695495	1682078	199,76	198,49	198,51	196,94	-2,82
Coniferous forest	103	**126,53**	105473	102496	105702	102528	13,35	12,97	13,37	12,97	-0,37
Mixed forest	142	**117,88**	273533	275465	272522	271624	32,24	32,47	32,12	32,02	-0,23
Natural grassland	259	**134,74**	77147	77103	252102	252781	10,39	10,39	33,97	34,06	23,66
Moors and heathland	8	**121,95**	6892	6916	4114	4421	0,84	0,84	0,50	0,54	-0,30
Transitional woodland-scrub	94	**110,47**	567840	591160	579824	592532	62,73	65,31	64,05	65,46	2,73
Sparsely vegetated areas	7	**100,69**	65329	63989	61061	60807	6,58	6,44	6,15	6,12	-0,46
Total of above CLC categories			**5272513**	**5264202**	**5248315**	**5242786**	**616,86**	**615,64**	**619,41**	**618,77**	**1,91**
Total country land area acording to CLC			5657456	5657984	5658451	5658465					
Percentage of Country			93	93	93	93					

	CLC 1980	CLC 1990	CLC 2000	CLC 2006
Pastures	475815	477566	307296	298950
Natural grassland	77147	77103	252102	252781

	CLC 1980-1990	CLC 1900-2000	CLC 2000-2006
	ha		
Pastures	1751	-170270	-8346
Natural grassland	-44	174999	679



1987 – World Student Games Zagreb

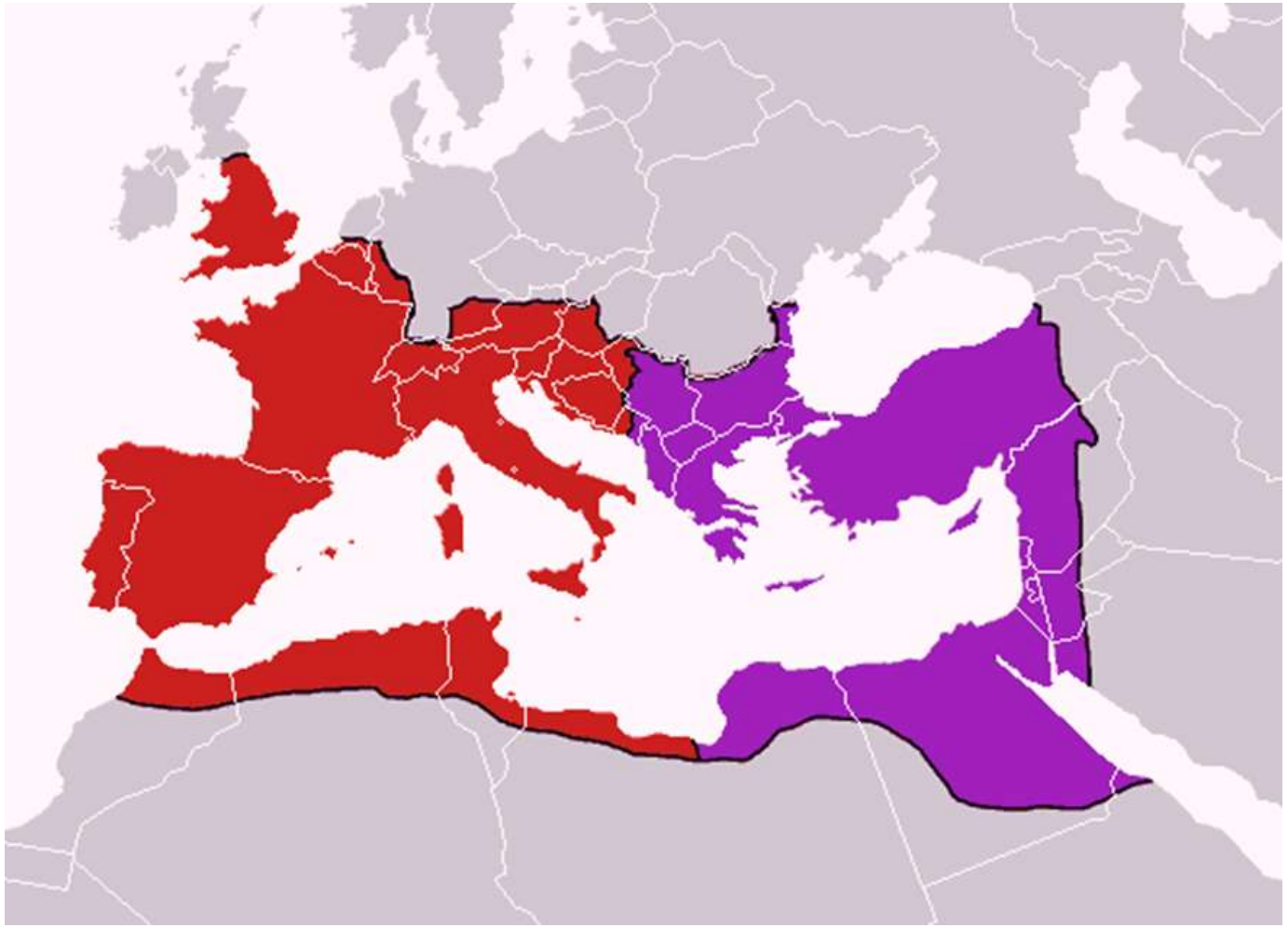


1990-1995 War period

2003 – 2005 Zagreb-Split „Dalmatina” road

What are the social precursors of LC change and disturbances in Croatia?

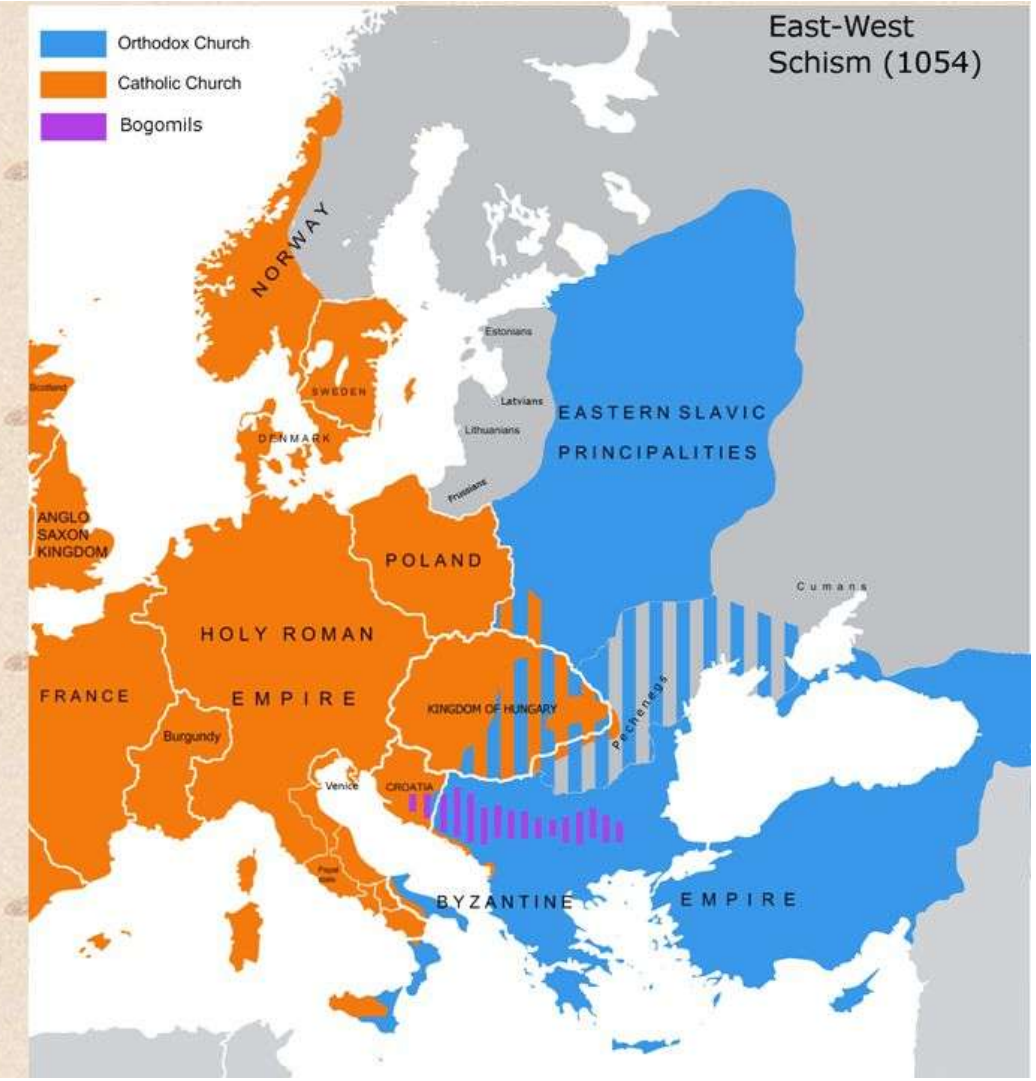
Partition of the Roman empare in 395, the death of Emperor Theodosius



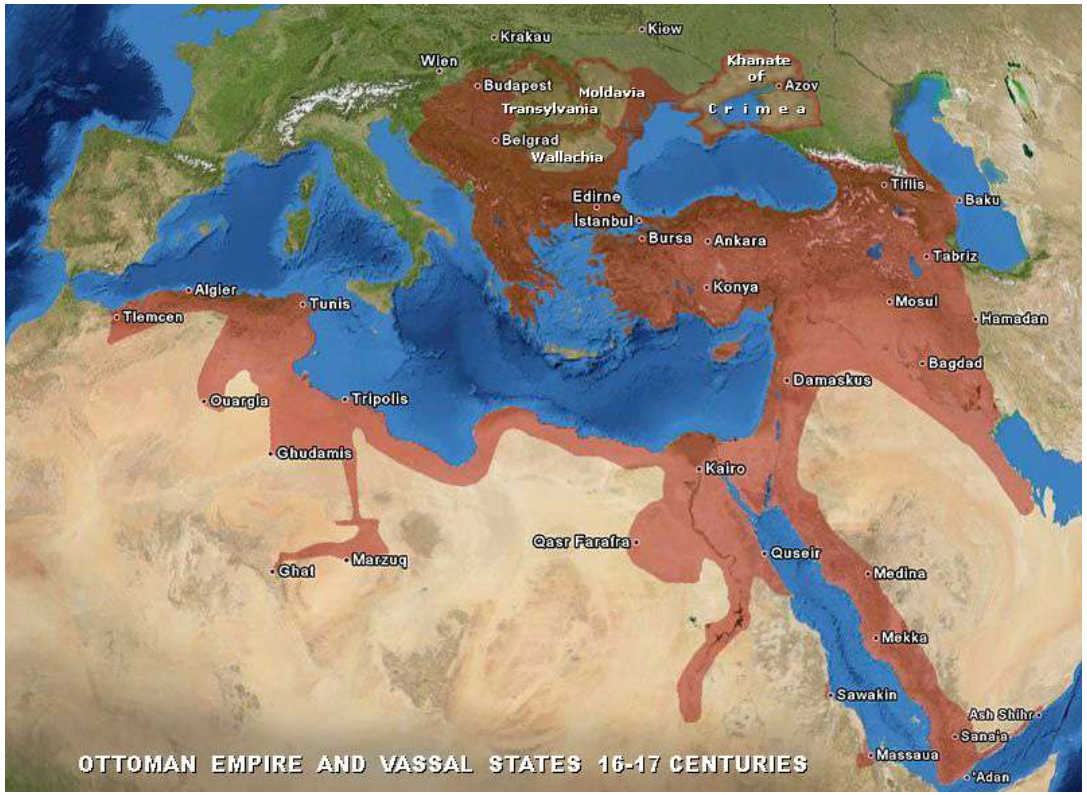
Split of the Christian church in 1054

Divisive Solution

- In 1054, Pope Leo IX of Rome and the Patriarch/Bishop of Constantinople decided to excommunicate each other.
- Excommunication a person is not allowed to receive sacraments and have no hope of entering heaven, according to Christian beliefs.

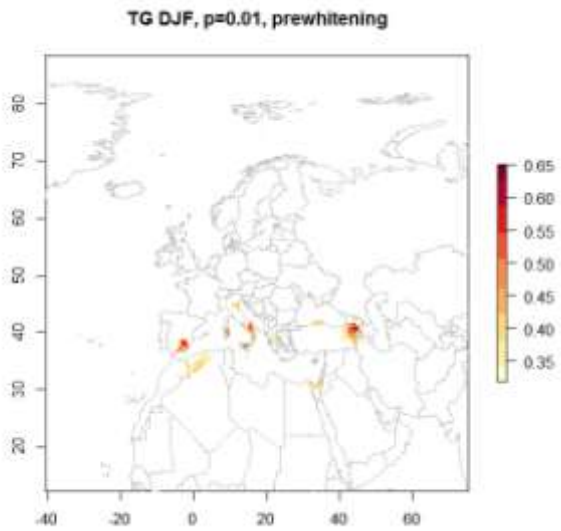


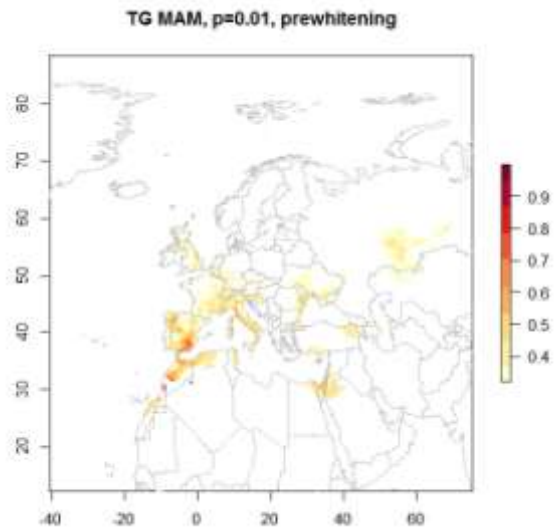
Otoman empire 1493 -1699 - "reliquiae reliquiarum"

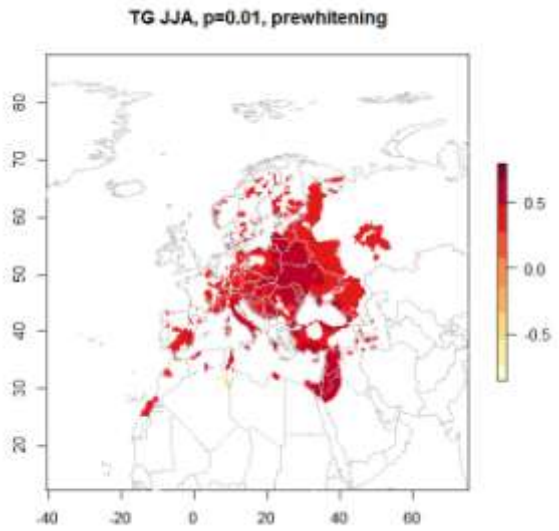


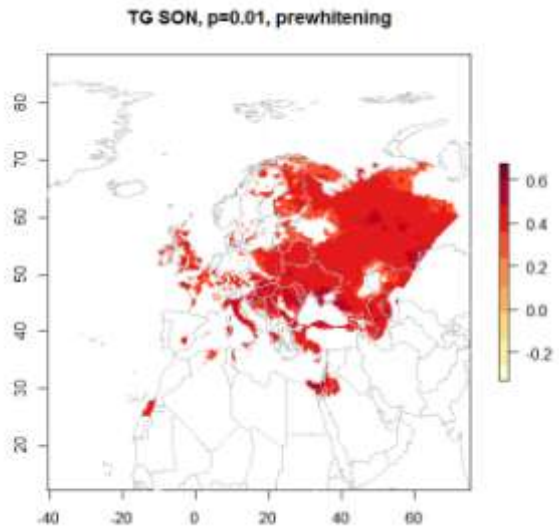
Climatic precursors of LC change

ECA&D E-Obs Seasonal climate trends 1982 – 2015

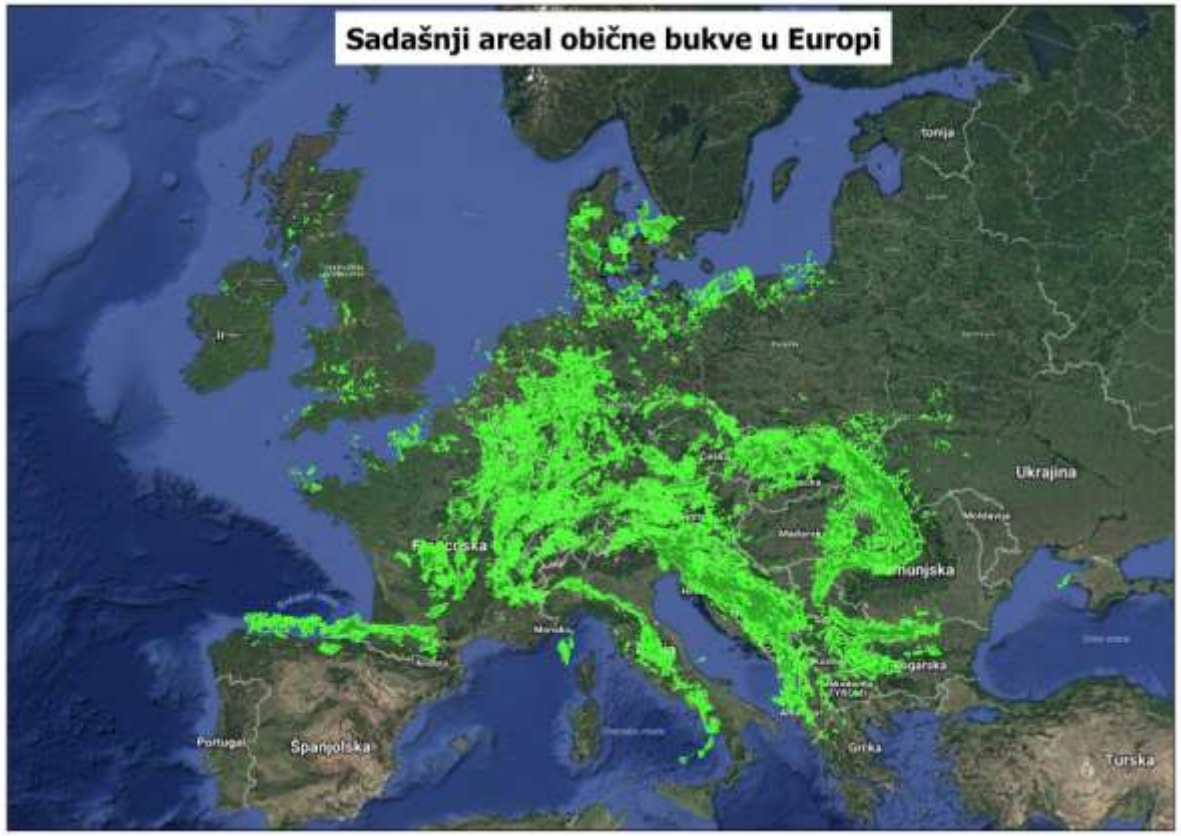


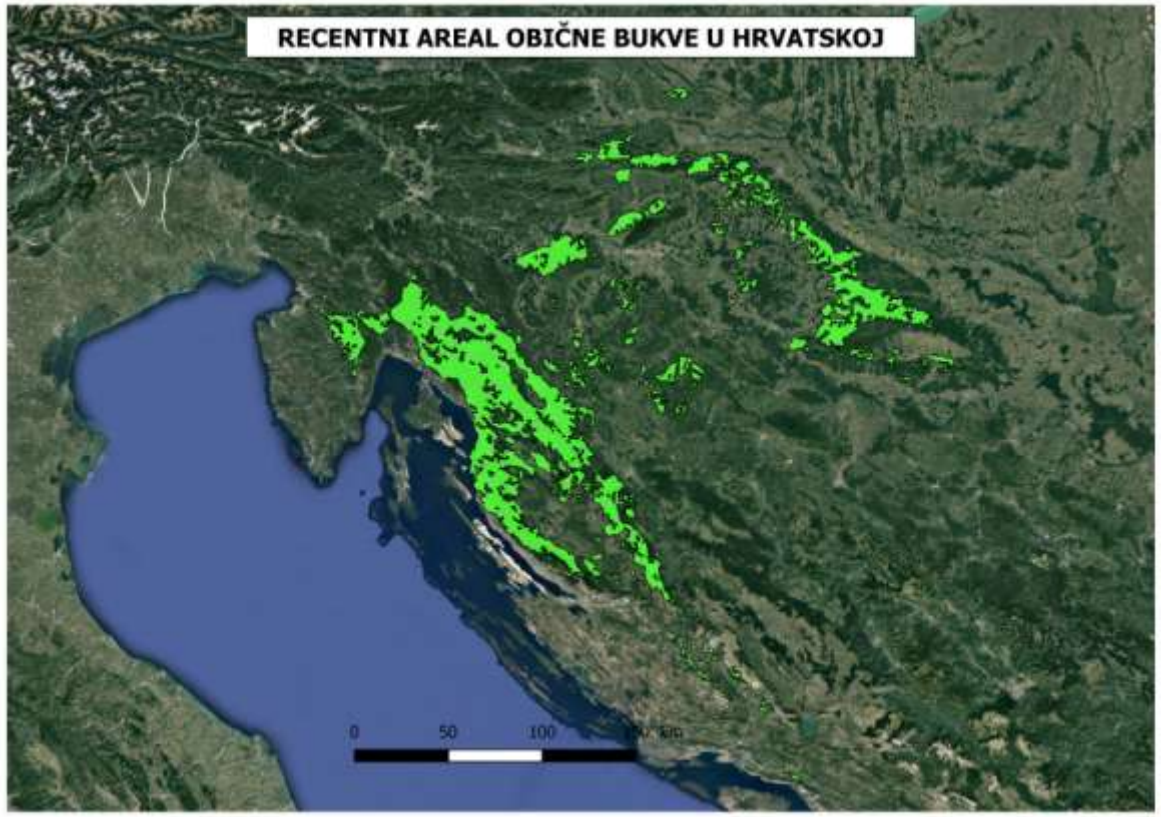




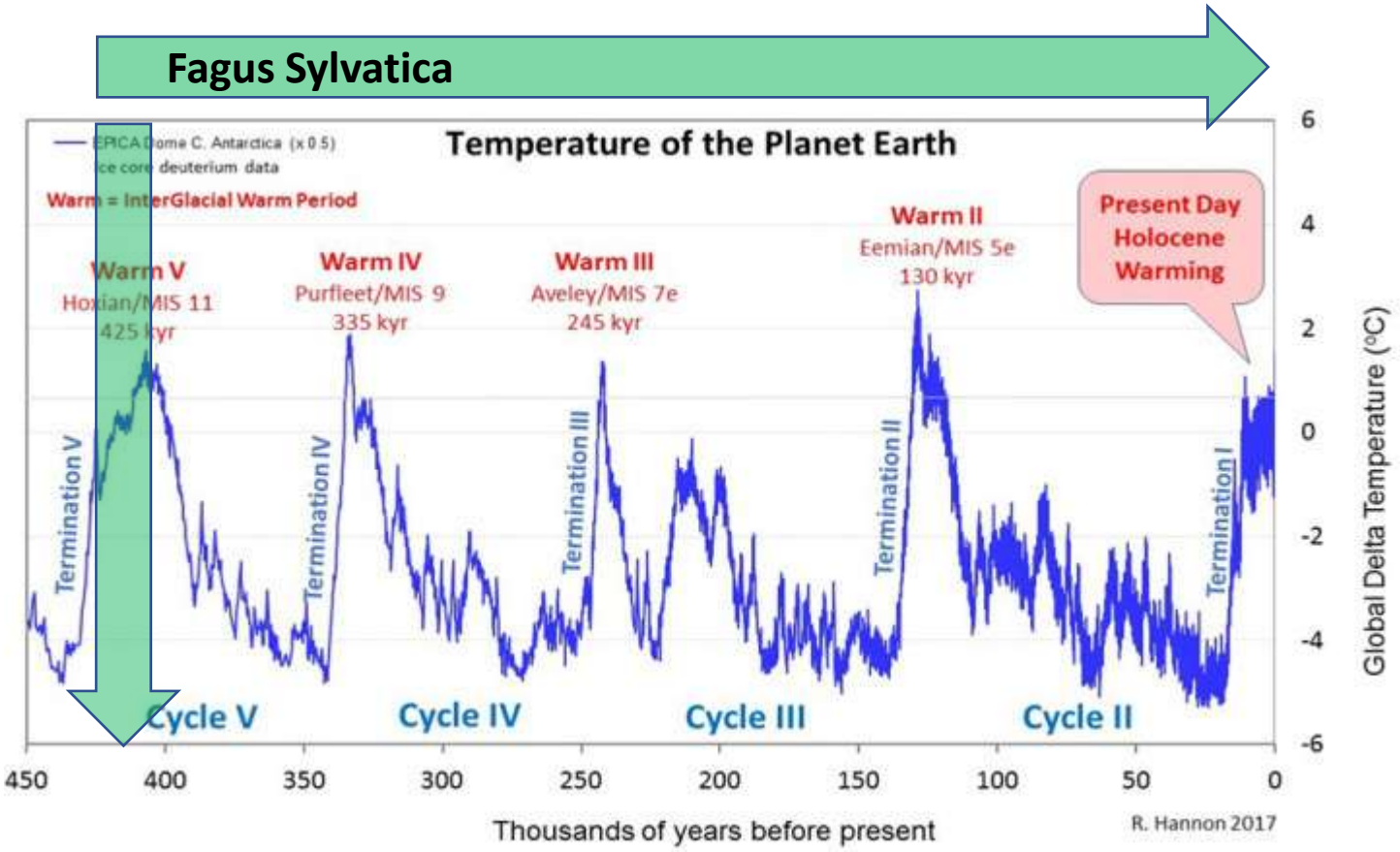


Long term climate change on the distribution of Common beech (Fagus sylvatica) in Europe and Croatia





- The oldest proof of the existence of common beech in Europe are samples of pollen aged over 400 000 years. (Magri et al. 2006)
- Since the beginning of its existence, the common beech has passed the exchange of four ice ages or hot interglacial periods



Four longest pollen diagrams of common Beech in Europe; France, Italy, Greece(Magri et al. 2006)

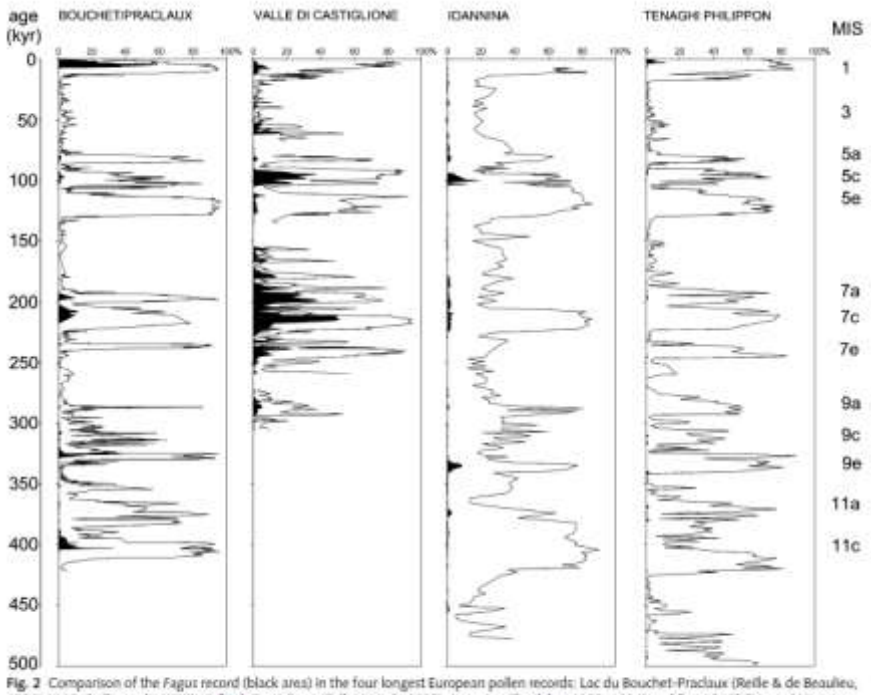
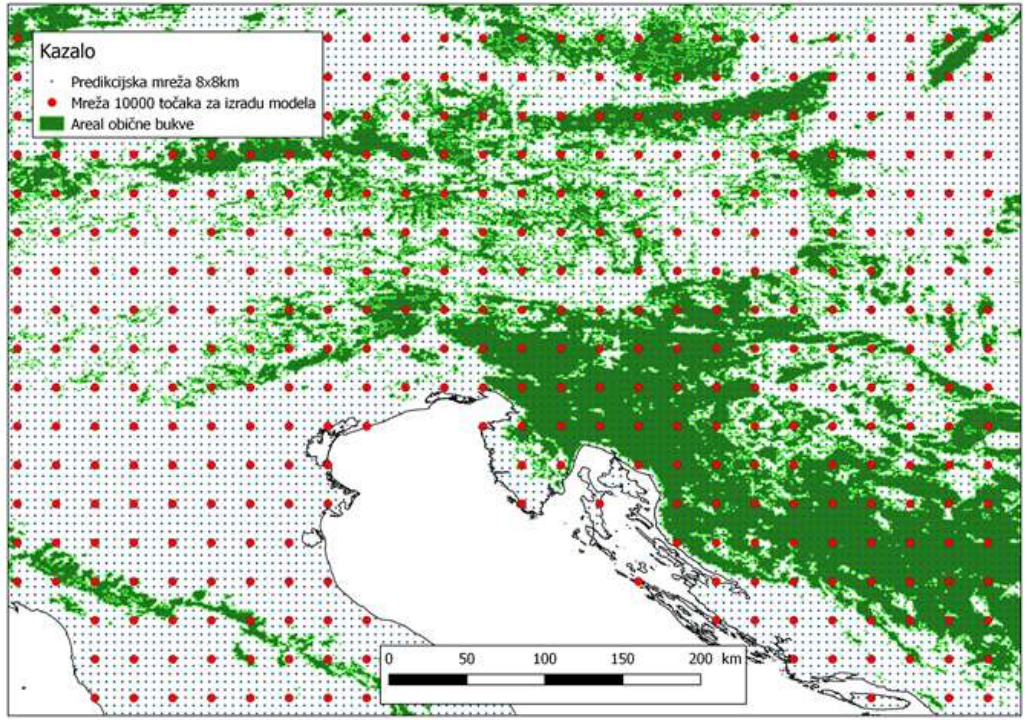
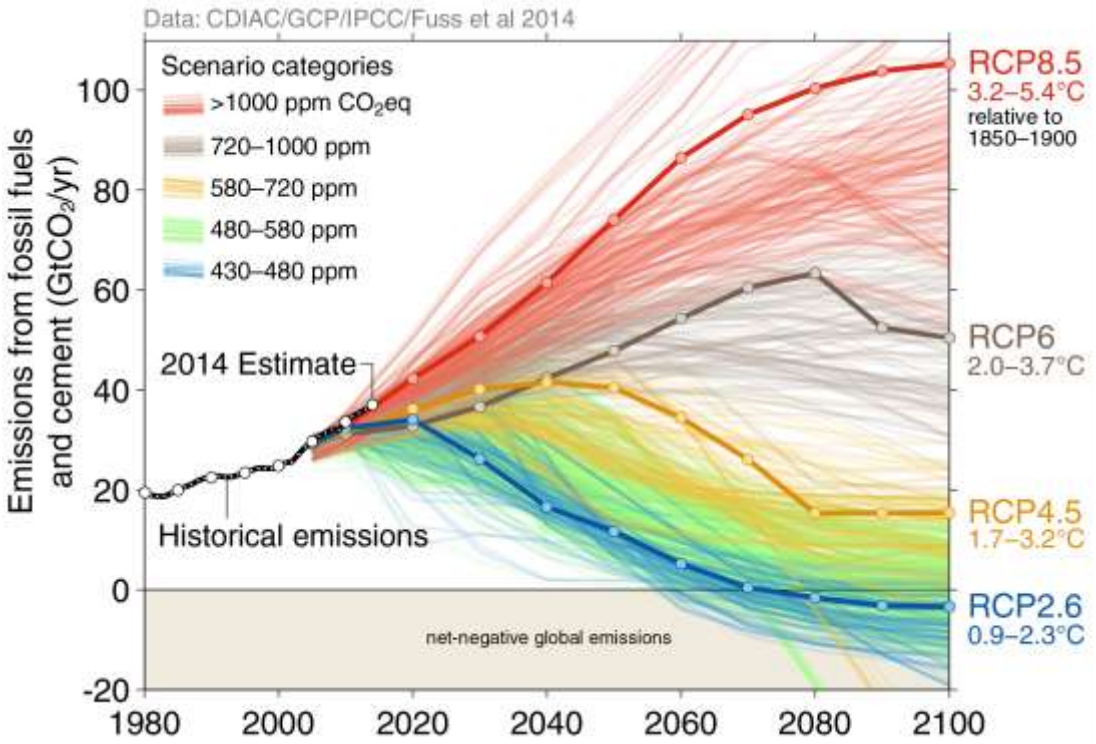


Fig. 2 Comparison of the *Fagus* record (black area) in the four longest European pollen records: Lac du Bouchet-Praclaux (Reille & de Beaulieu, 1990, 1995; Reille *et al.*, 1998); Valle di Castiglione (Follieri *et al.*, 1988), Ioannina (Tzedakis, 1993, 1994) and Tenaghi Philippon (Wijmstra, 1969; Wijmstra & Smit, 1976; Wijmstra & Groenhart, 1984). The solid line represents the percentages of arboreal pollen excluding *Pinus*. Chronology is according to Tzedakis *et al.* (1997).

Common beech climatic envelope model for Europe:

- **WorldClim Global Climate Data (CCSM4 Global Climate model)**
  - **Interglacial 120 000 BC, Ice age 22 000 BC, Holocene 6000 BC, 4 CC future scenarios 2050 i 2070 (*RCP 2.6, RCP 4.5, RCP 6, RCP 8.5*)**

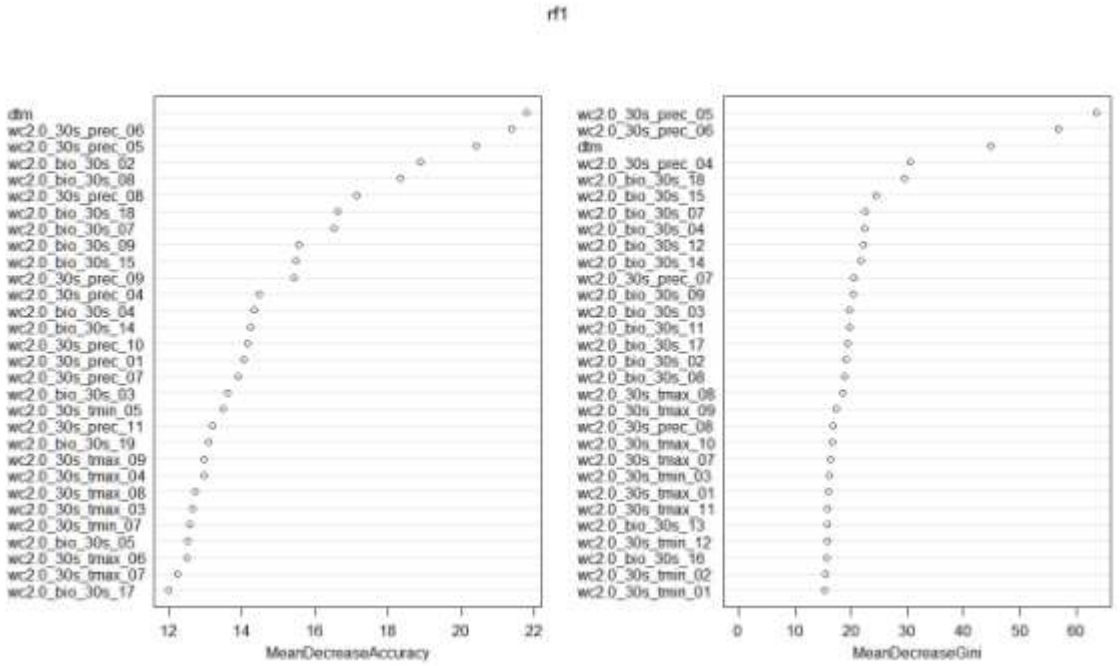




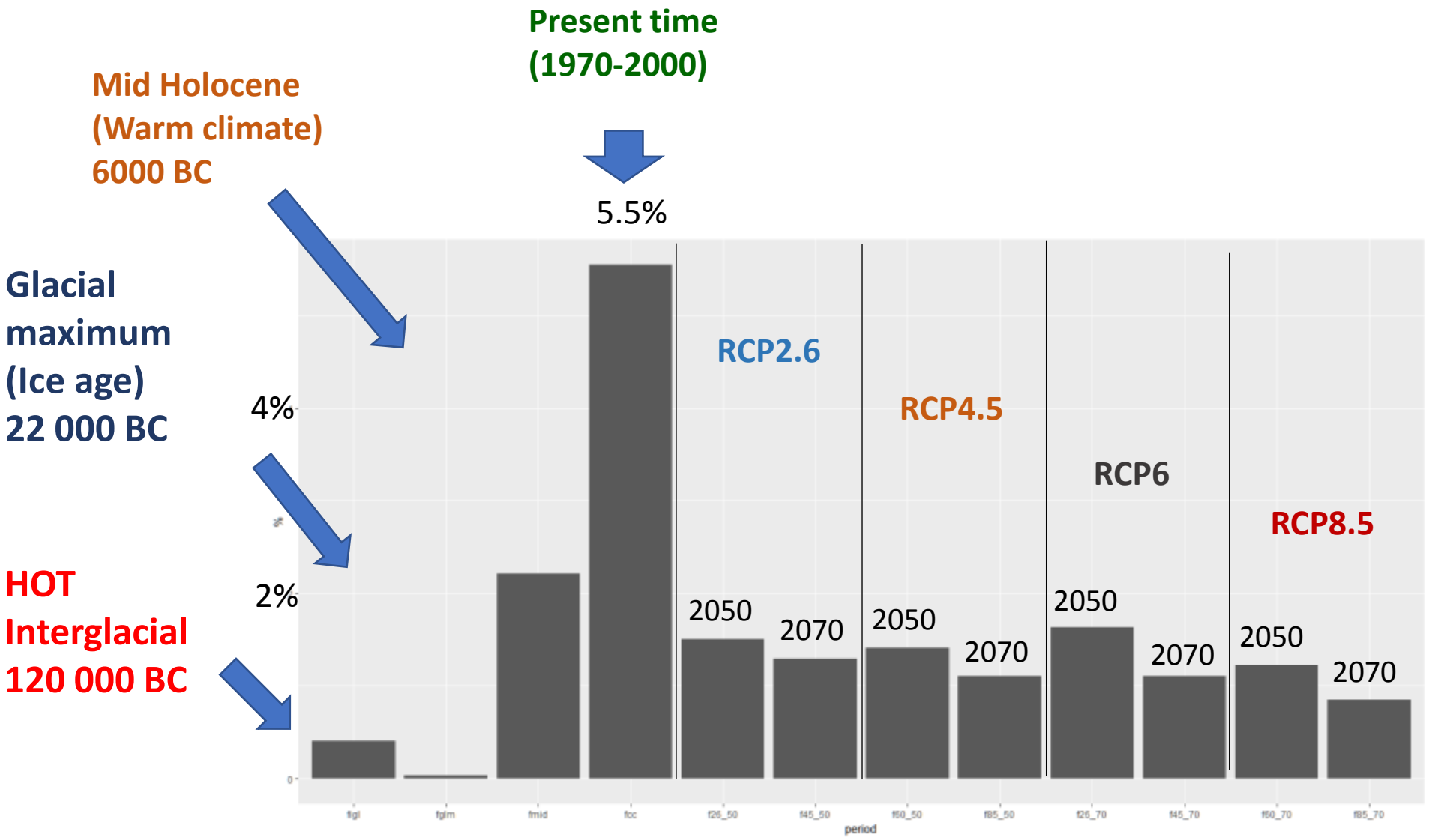
Statistical/machine learning model selection (Hastie et al. 2009)

- Random 10000 samples across Europe
- Training set 80% sample, test set 20%

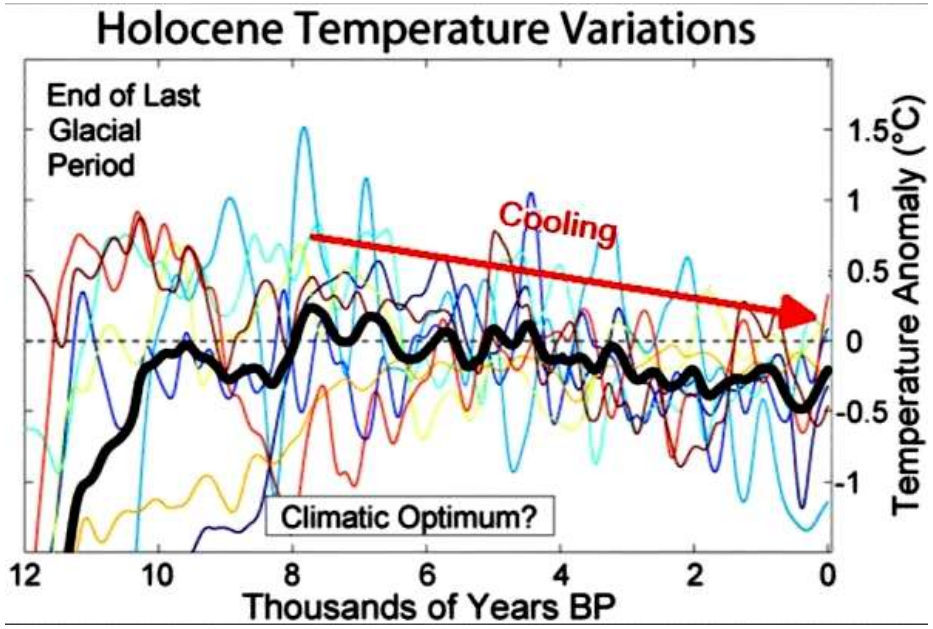
Type of algorithm	Accuracy
Logistic regression	0.05876393 (5,8%)
Linear Discriminant Analysis - LDA	0.9381652 (93.8%)
K Nearest Neighbours - KNN	0.9346173 (93.5%)
Regression Tree	0.9417131 (94.2%)
Bootstrap Aggregation	0.9493158 (94.9%)
Random Forest	**0.9513431 (95.1%)**
Boosting	0.9508363 (95.1%)
Support Vector Machines	0.9320831 (93.1%)

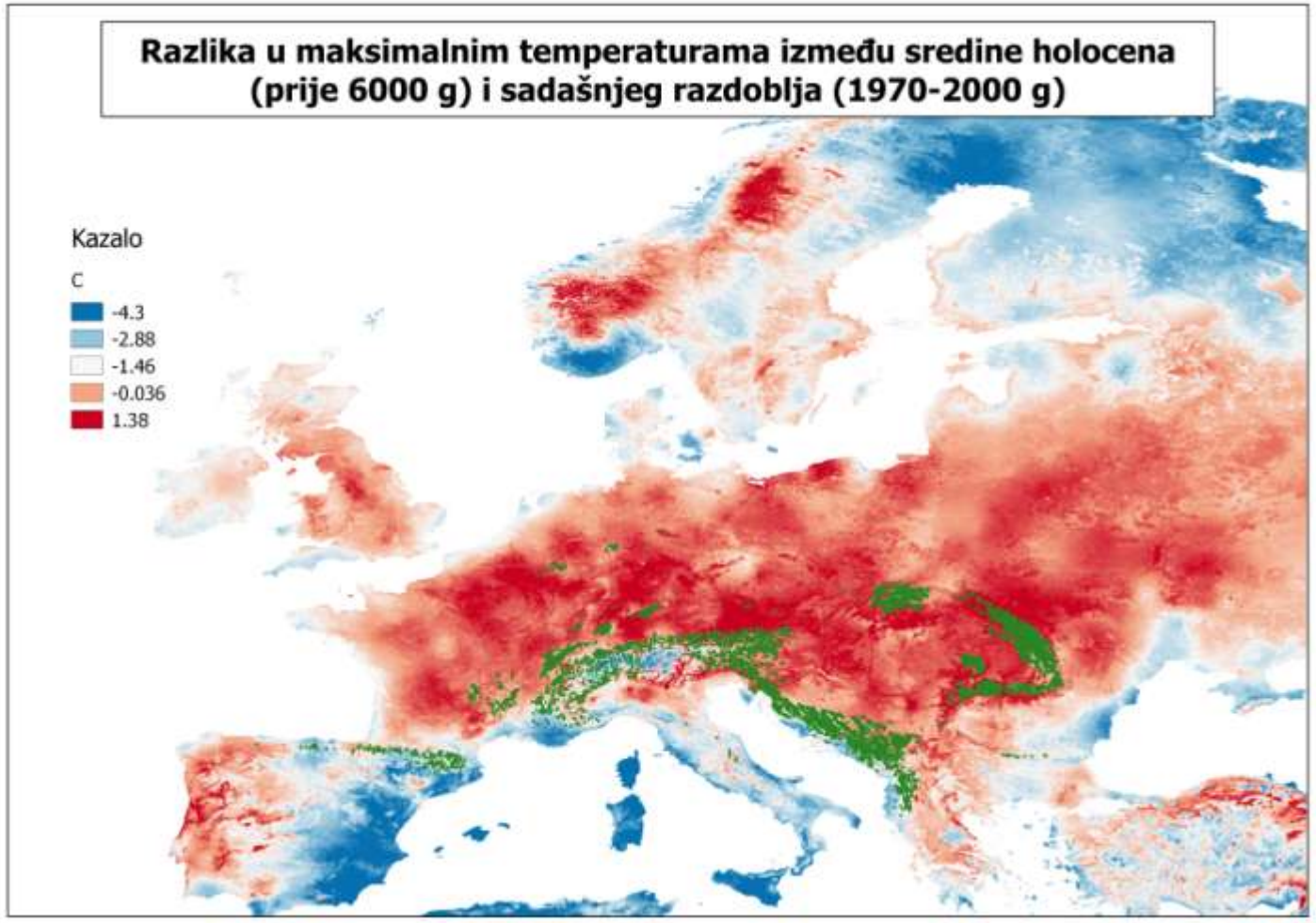


Change of the area of common beach in Europe (120000 BC – 2070)

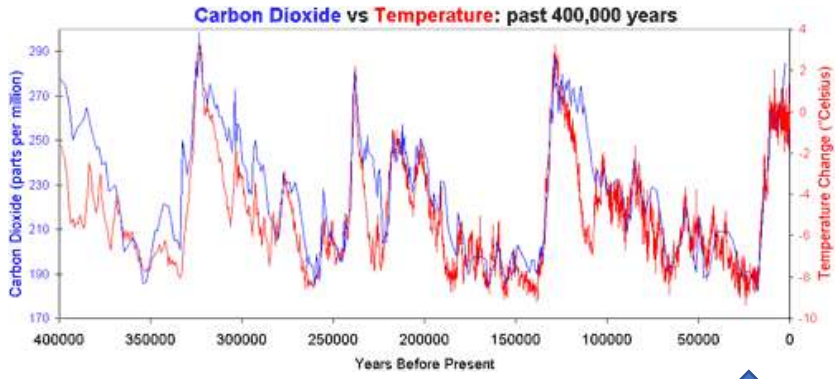


Reconstruction of the common beech distribution area during warm Holocene maxima (6000g BC)

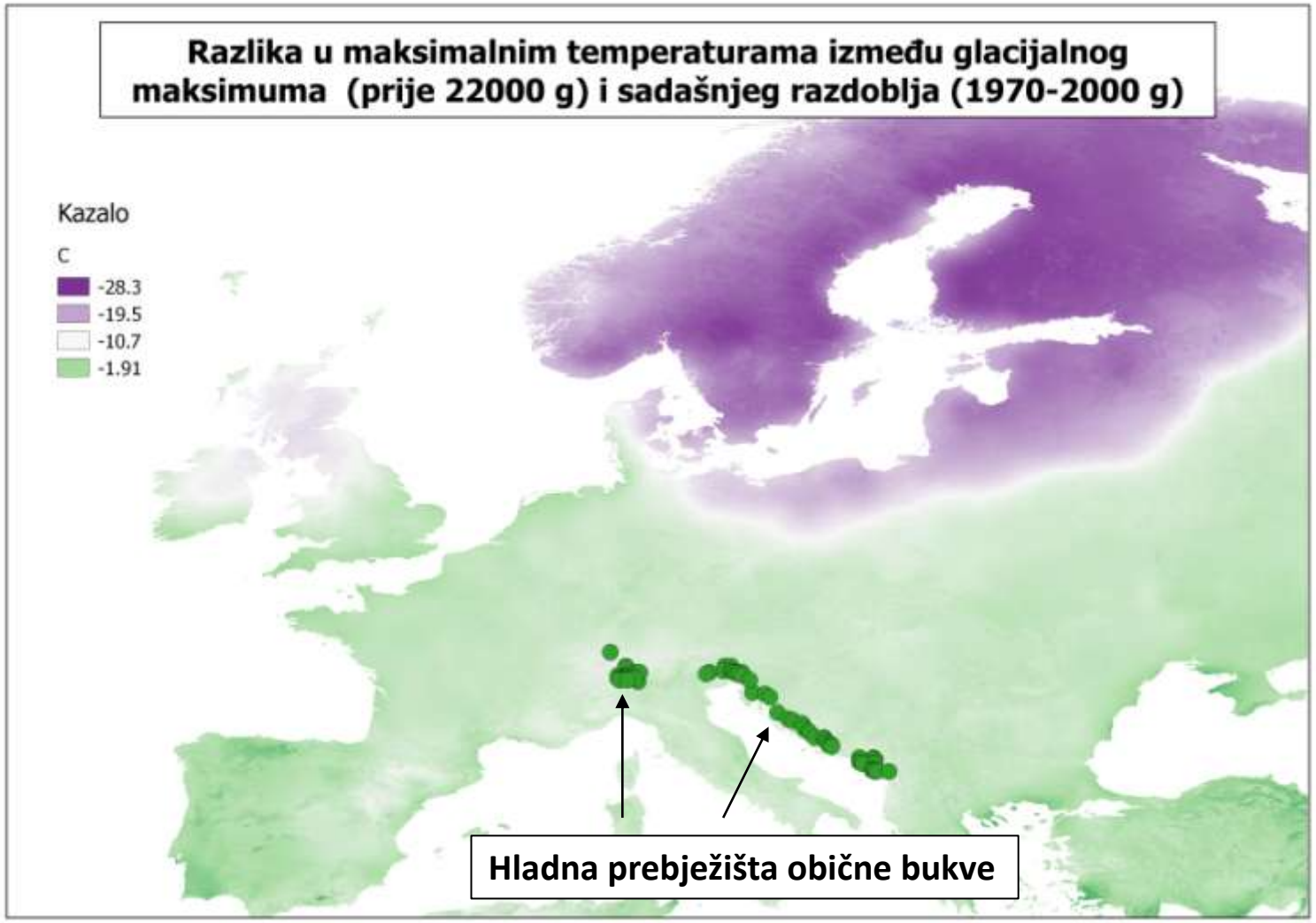


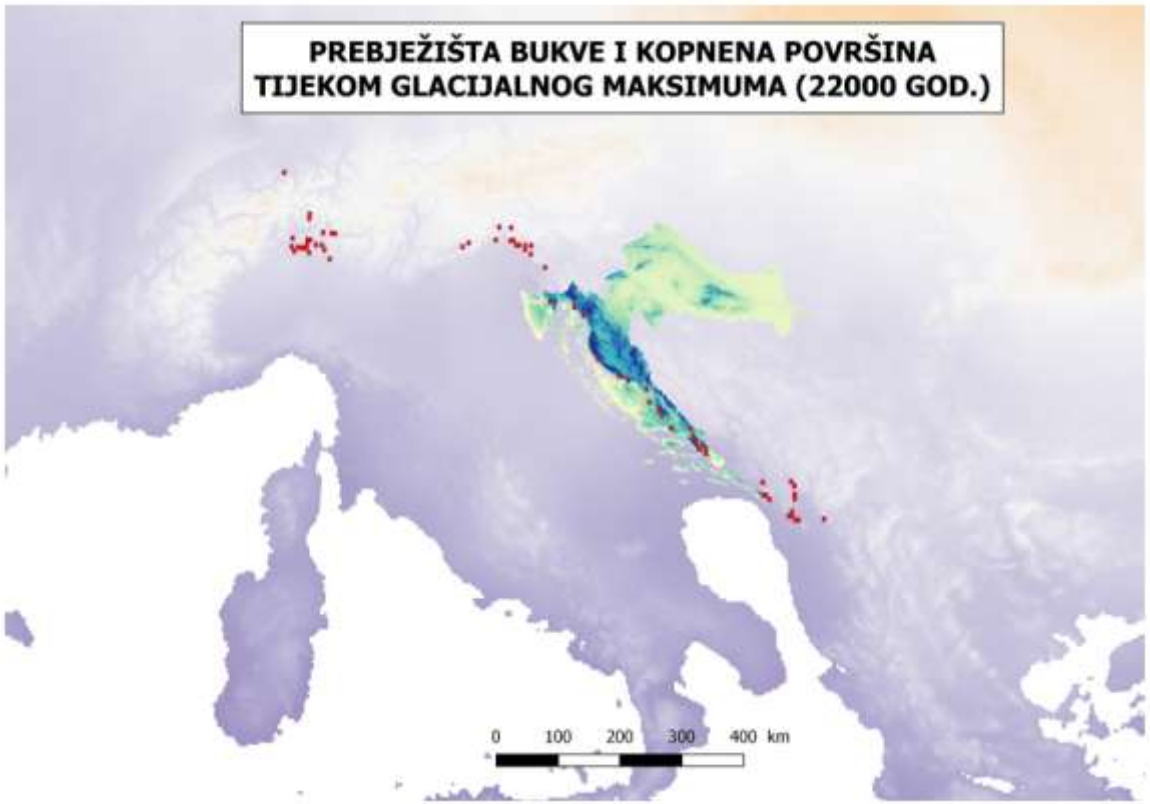


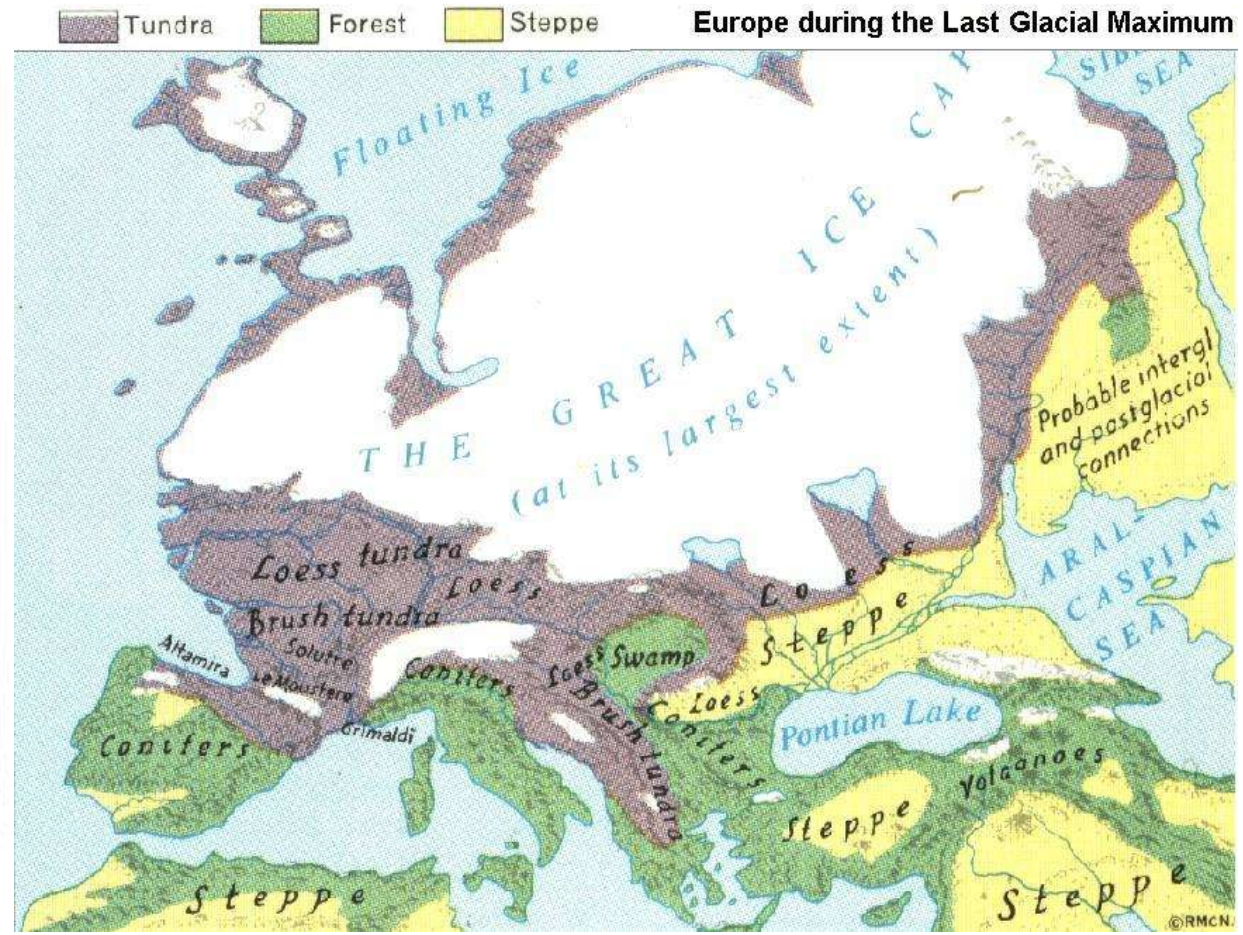
Reconstruction of the common beech distribution area during Glacial peak (22000 BC)- <u>a places of refuge during cold climate</u>!



Pr 22000g

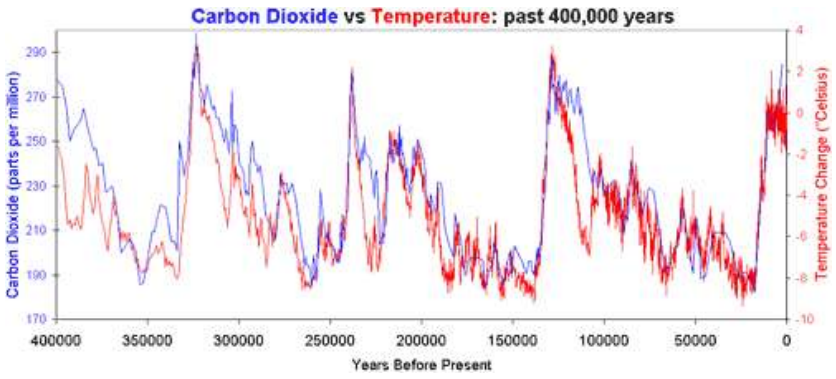


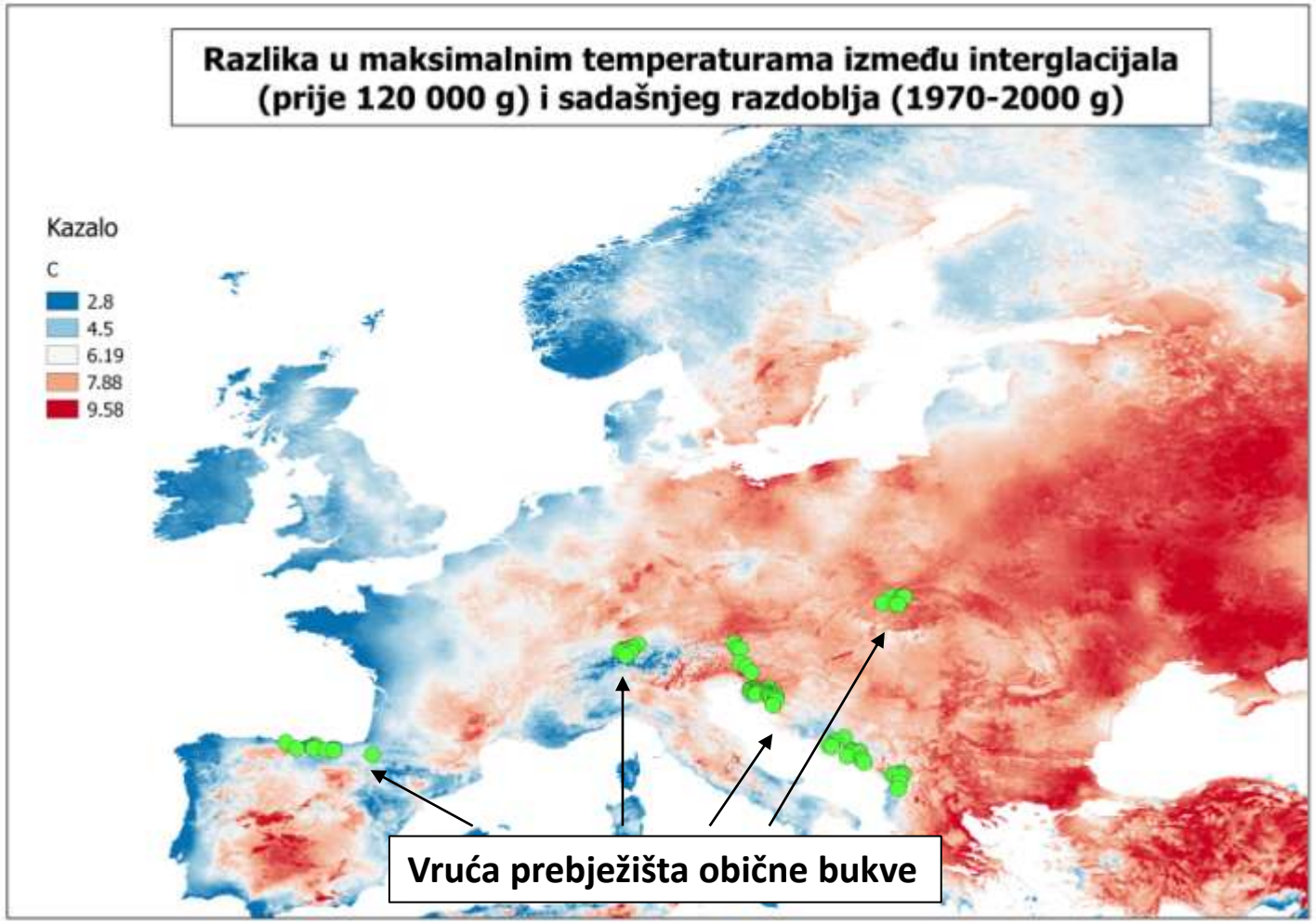

PREBJEŽIŠTA BUKVE I KOPNENA POVRŠINA
TIJEKOM GLACIJALNOG MAKSIMUMA (22000 GOD.)
0 100 200 300 400 km


Tundra
Forest
Steppe
Europe during the Last Glacial Maximum
Floating Ice
THE GREAT ICE CAP
(at its largest extent)
Probable interglacial and postglacial connections
Loess tundra
Loess
Brush tundra
Soliflucted
Altamira
Le Moustier
Grimaldi
Conifers
Loess Swamp
Brush tundra
Loess
Steppe
Conifers
Pontian Lake
Volcanoes
Steppe
Steppe
Steppe
ARAL SEA
CASPIAN SEA
©RMcN.

Reconstruction of the common beech distribution area during interglacial (22000 BC)- a places of refuge during hot climate!

120 000 BC





Validation of the model – Utvrđene lokacije prebježišta u velikoj mjeri se poklapaju s referentnim lokalitetima utvrđenim pomoću mikrofosilnih nalaza (polen analize) i genetskih markera (Magri et al. 2006)

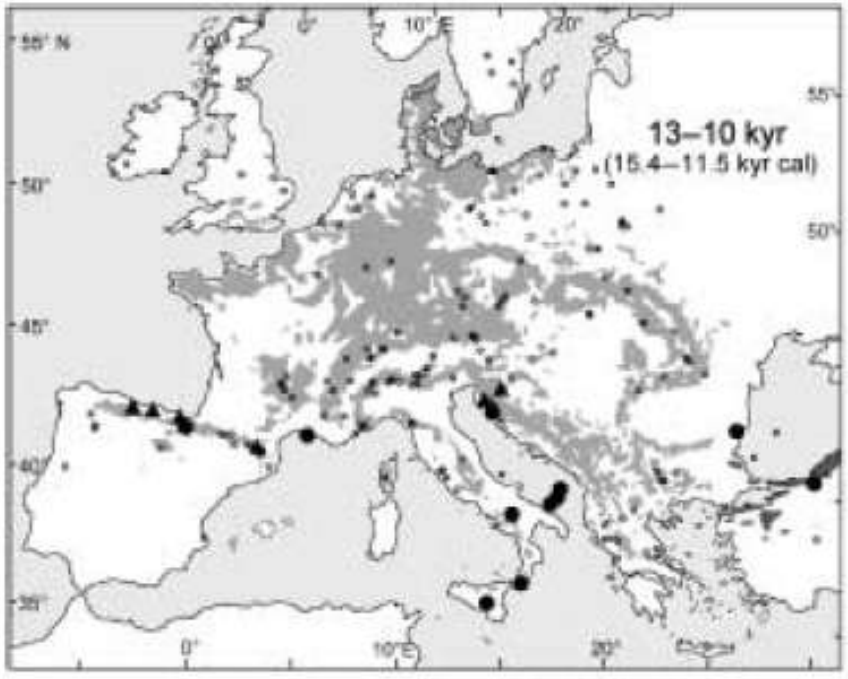
New Phytologist

Research

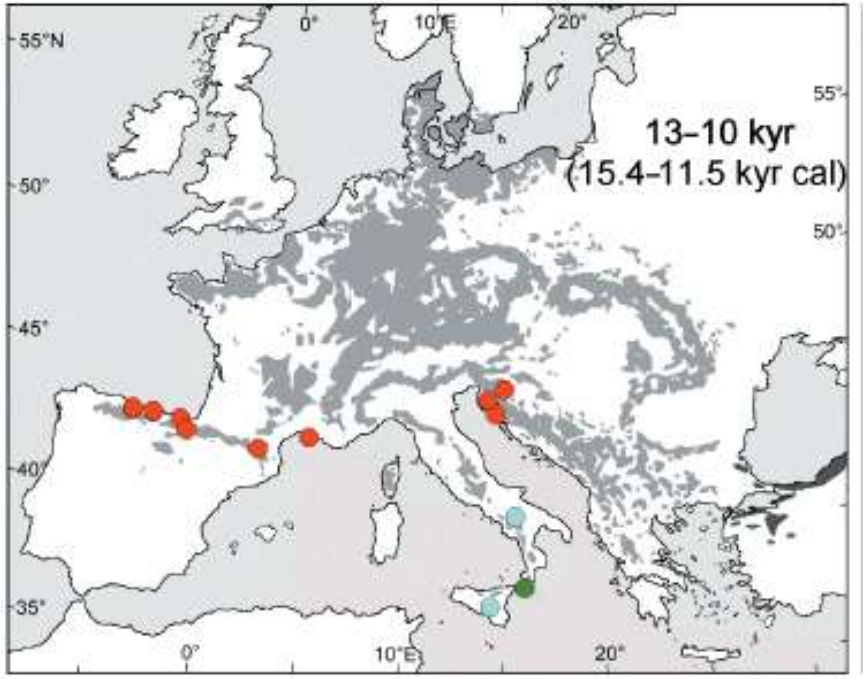
A new scenario for the Quaternary history of European beech populations: palaeobotanical evidence and genetic consequences

Donatella Magri[1], Giovanni G. Vendramin[2], Bernard Comps[3], Isabelle Dupanloup[4], Thomas Geburek[5], Dušan Gömöry[6], Małgorzata Latałowa[7], Thomas Litt[8], Ladislav Paule[6], Joan Maria Roure[9], Ioan Tantau[10], W. O. van der Knaap[11], Rémy J. Petit[12] and Jacques-Louis de Beaulieu[13]

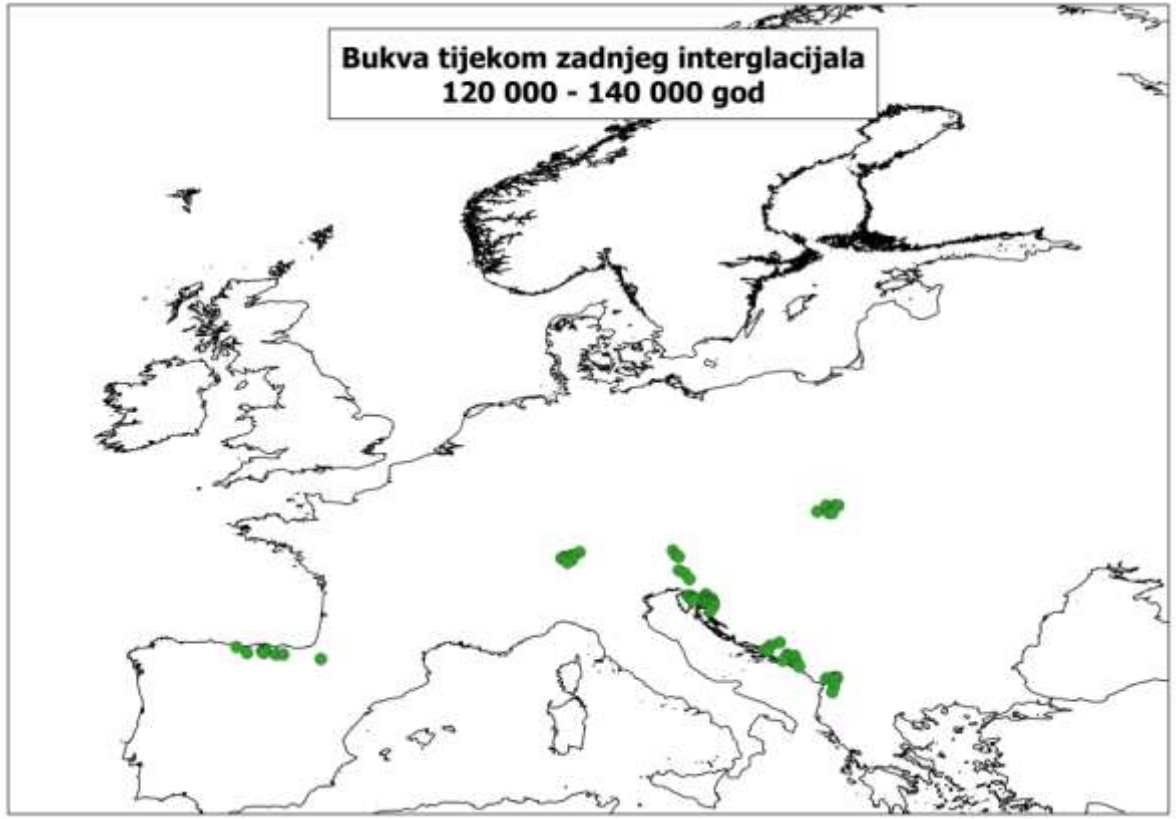
Utvrđena nalazišta obične bukve nakon glacijalnog razdoblja (pr 10000-13000g) pomoću polen analiza



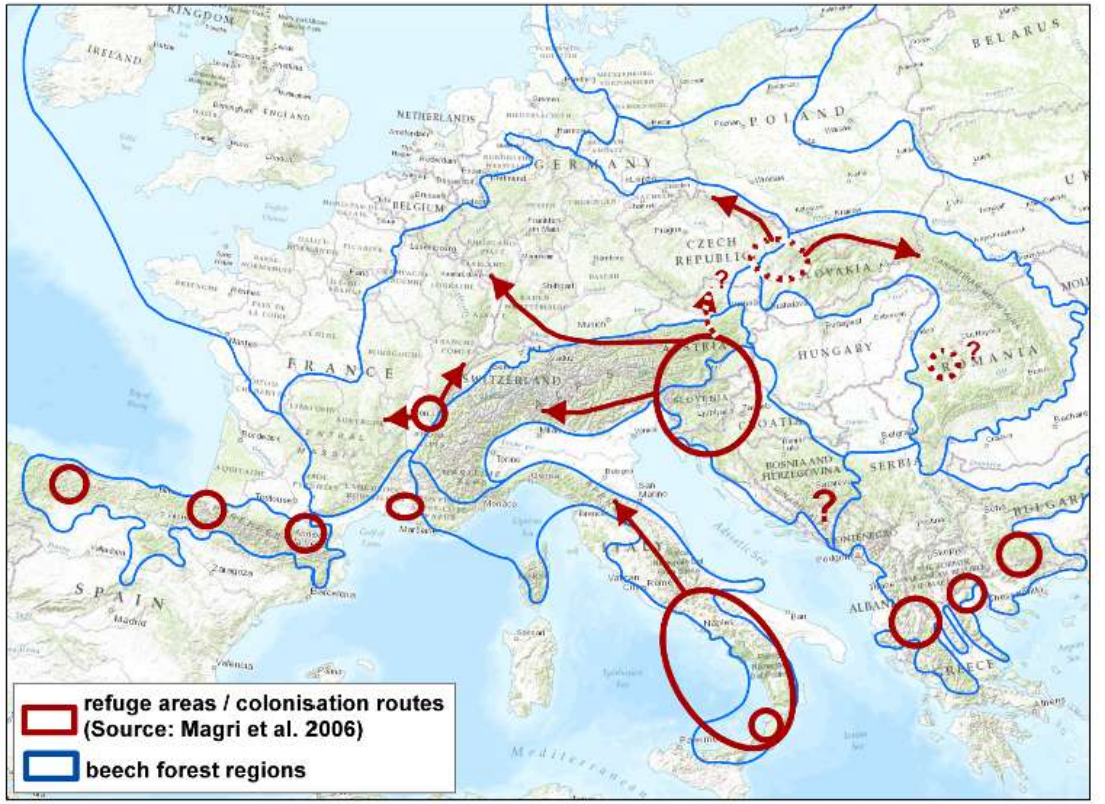
Utvrđena nalazišta obične bukve nakon glacijalnog razdoblja (pr 10000-13000g) pomoću genetskih markera



Interglacial refuges (120000g) by RF model

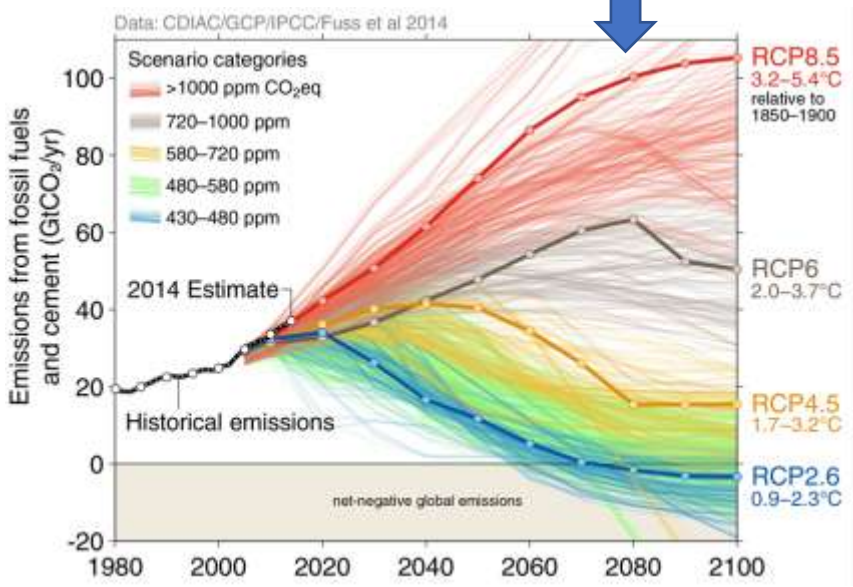


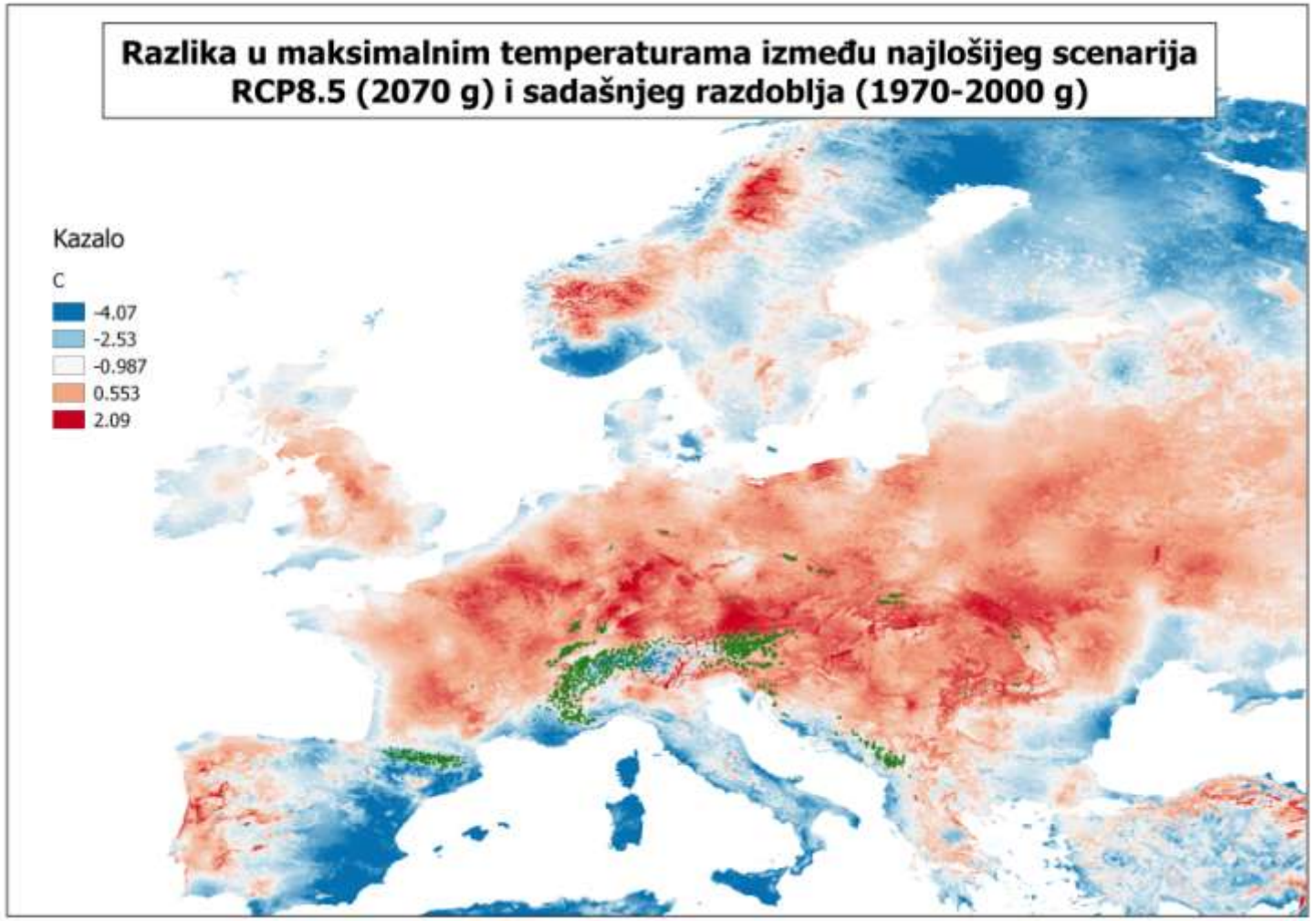
Colonization of beech in Europe after Glacial period (Huber 2017)



Reconstruction of the common beech distribution under the climate change scenario (RCP8.5) 2050. i 2070.

RCP8.5



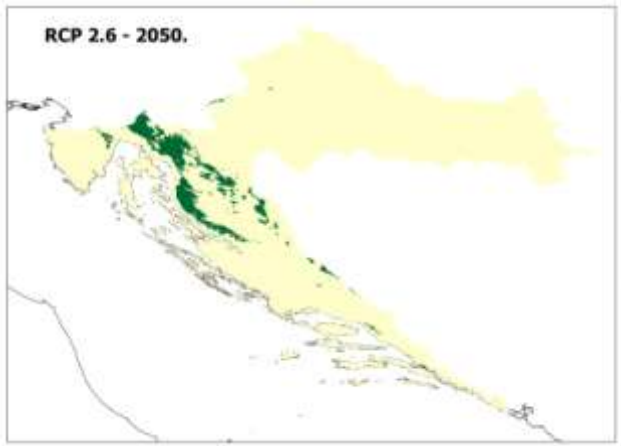


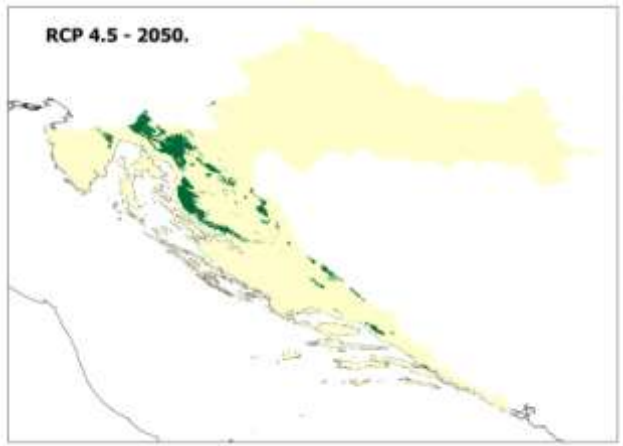
RCP2.6

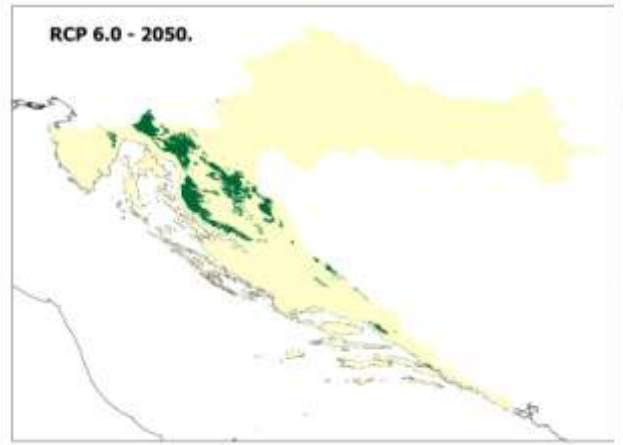
RCP4.5

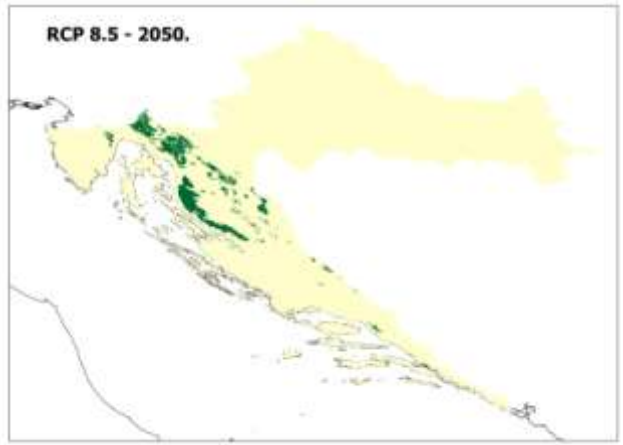
RCP6

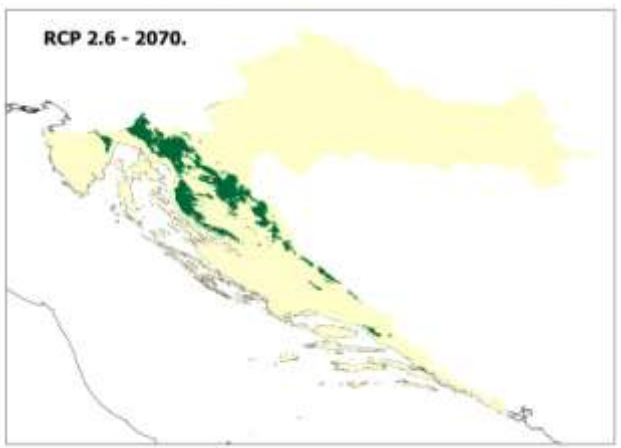
RCP8.5

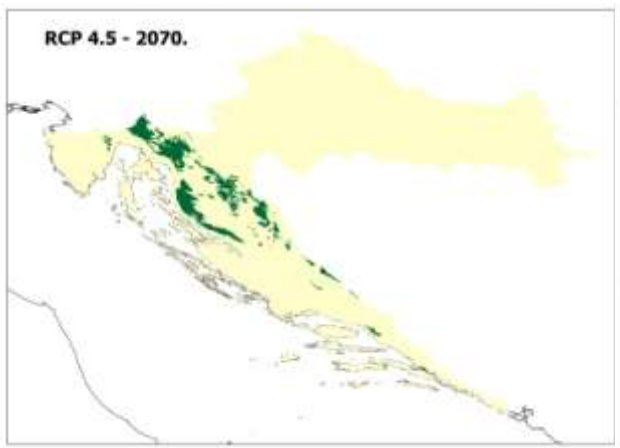


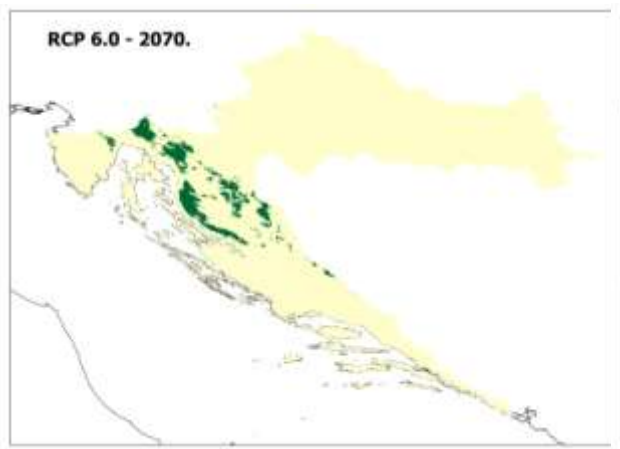


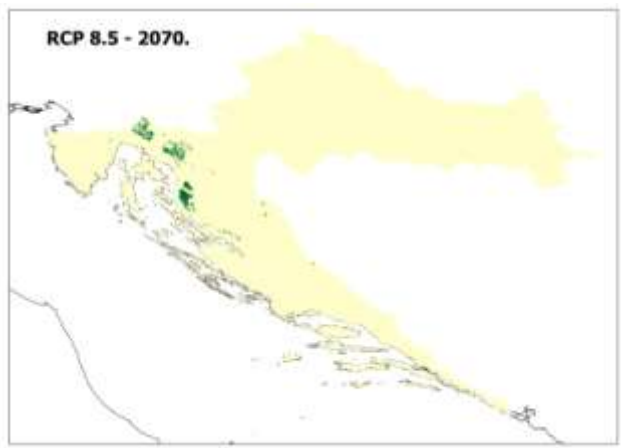








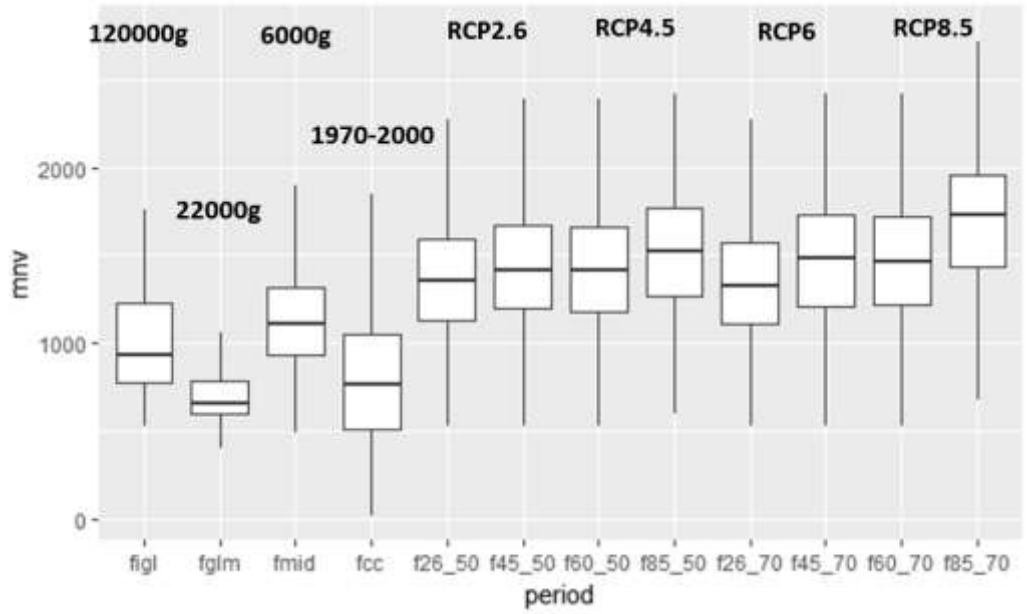


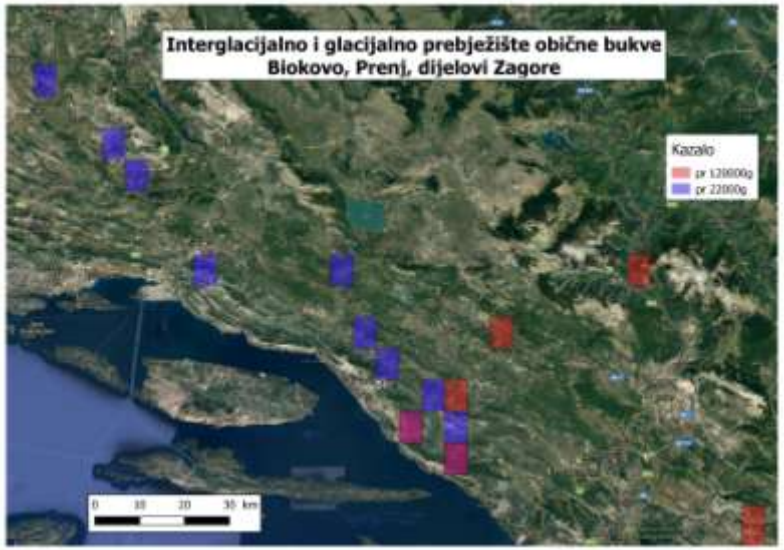


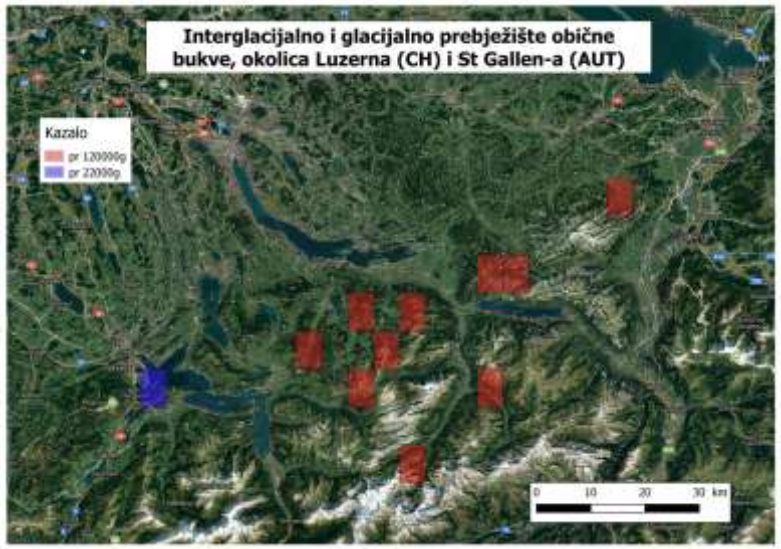
CLIMATIC VERTICAL MIGRATION OF THE COMMON BEECH IN REFUGE

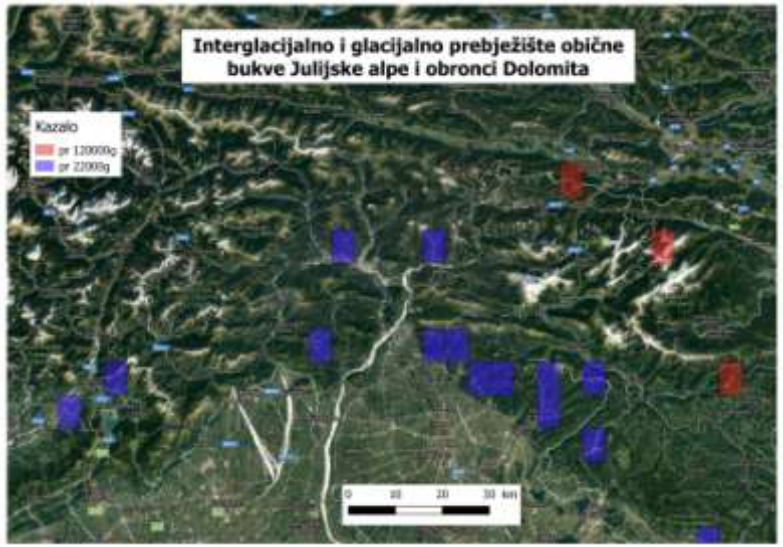
HOT CLIMATE

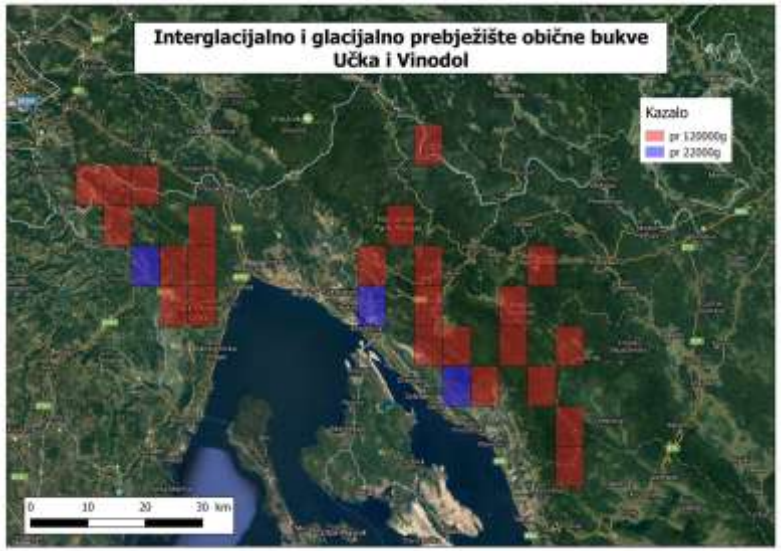
COLD CLIMATE











- Division of ecology & silviculture, Croatian Forest Research Institute
- Department of Geoinformatics, Faculty of Geodesy

2014 - HRZZ AFORENSA

Advanced Forest Ecosystem Services Assessment

2017 - HRZZ GEMINI

Geospatial monitoring of the green infrastructure

2017 – INTERREG CRO-HUN „Oak Protection”

2017 – HORIZON 2020 MySustainableForest

Earth Observation Services For Silvicultute

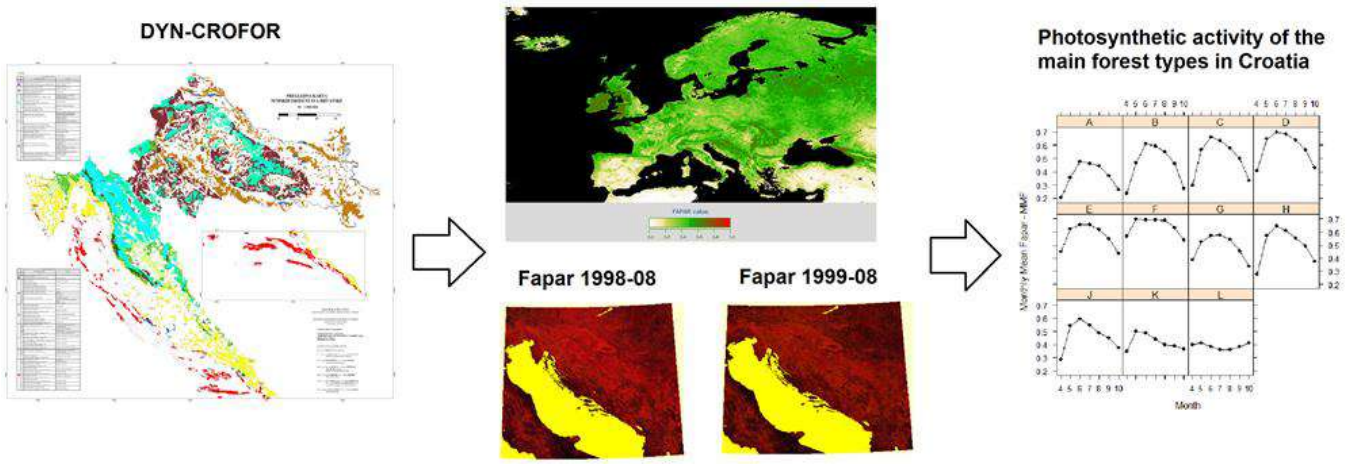
SCERIN-6 Capacity Building Workshop on Earth System Observations
Zagreb, 11-14 June 2018

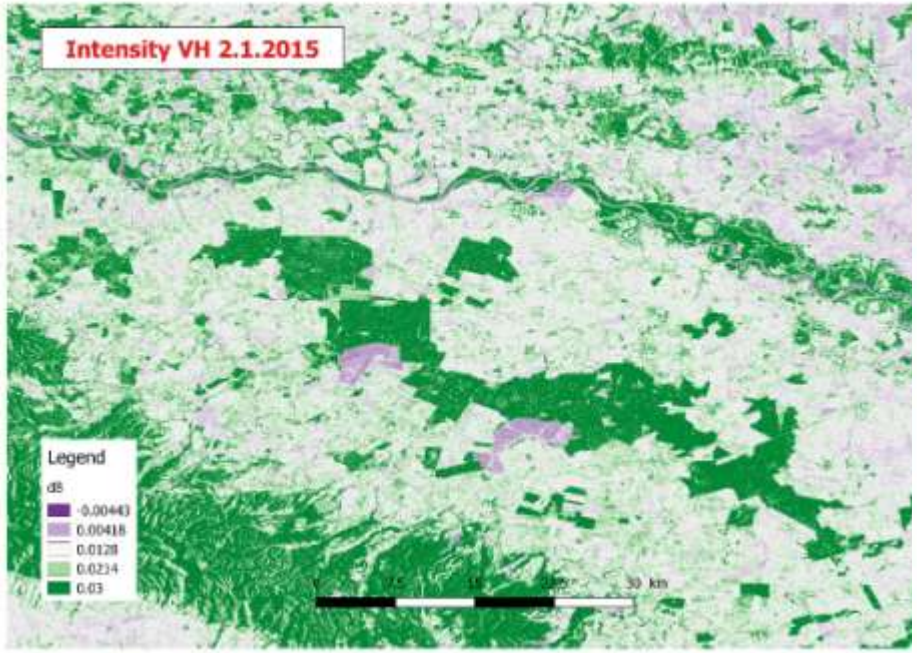
HRZZ AFORENSA - Advanced Forest Ecosystem Services Assessment
HRZZ Research Projects *(IP-11-2013)* *(Data science & Remote sensing project)*

Partners:

- Division of ecology & silviculture, Croatian Forest Research Institute
- Department of Geoinformatics, Faculty of Geodesy

The main objective of AFORENSA - how the forest ecosystems in Croatia responds to observed **extreme climatic variations**, and what are possible future expectations in respect to the progression of climate change and **disturbances of natural hydrologic cycle** with intensification of drought frequency and severity.




Intensity VH 2.1.2015
Legend
dB
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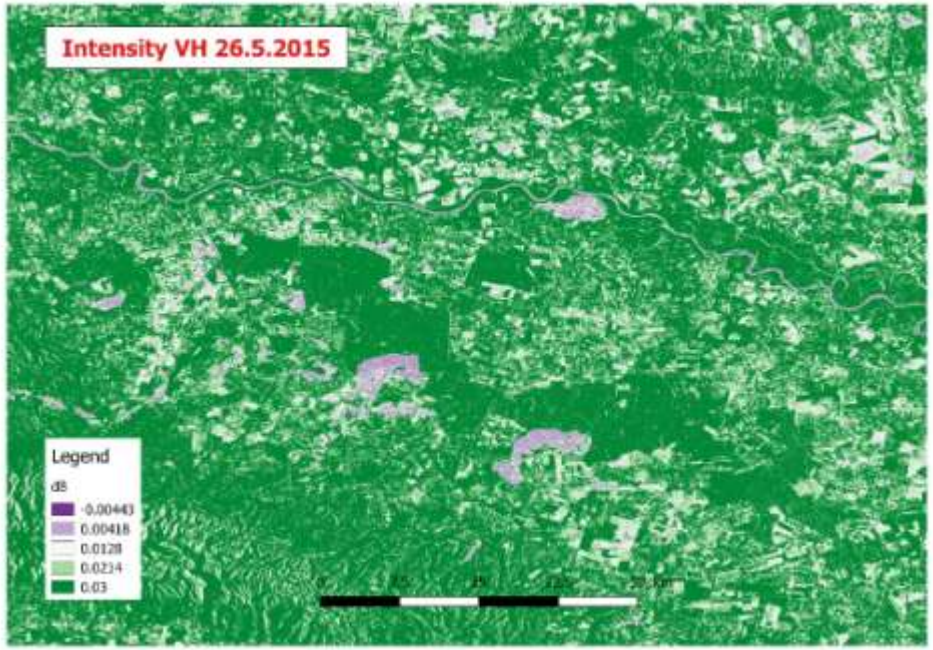
0.00418
0.0128
0.0214
0.03
0
7.5
15
22.5
30 km


Intensity VH 26.5.2015
Legend
dB
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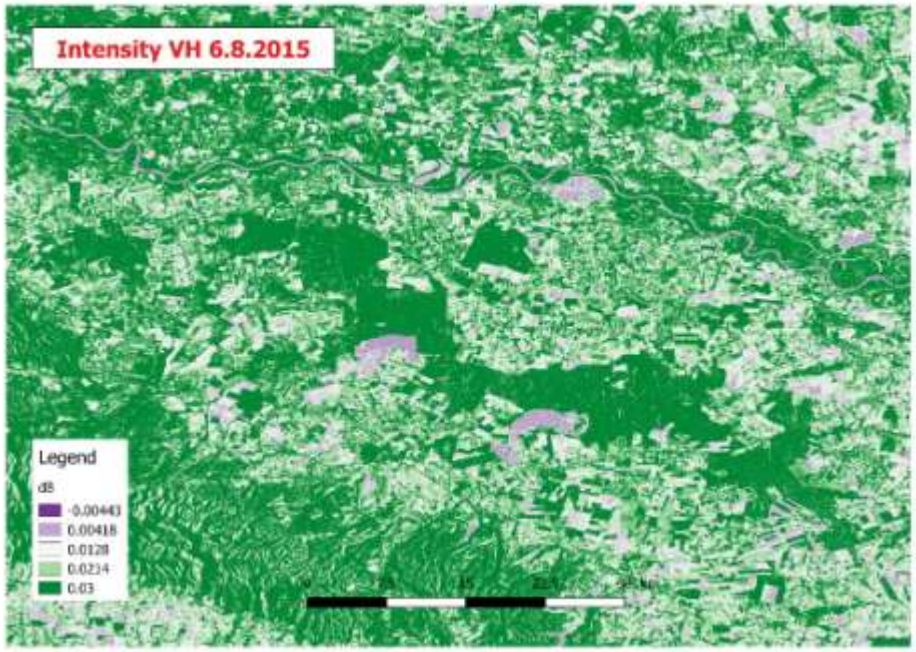
0.03


Intensity VH 6.8.2015
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dB
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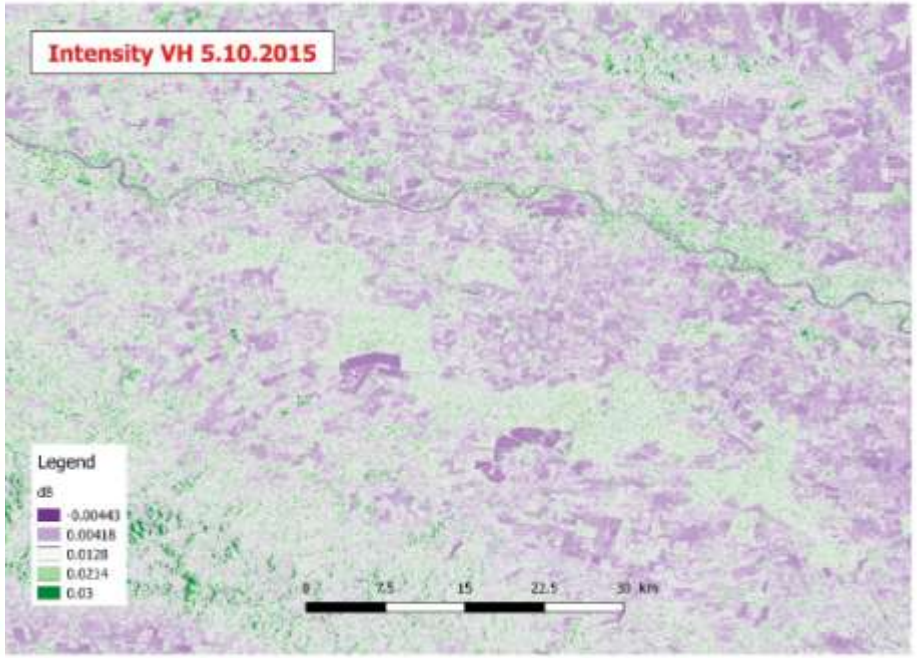
0.03


Intensity VH 5.10.2015
Legend
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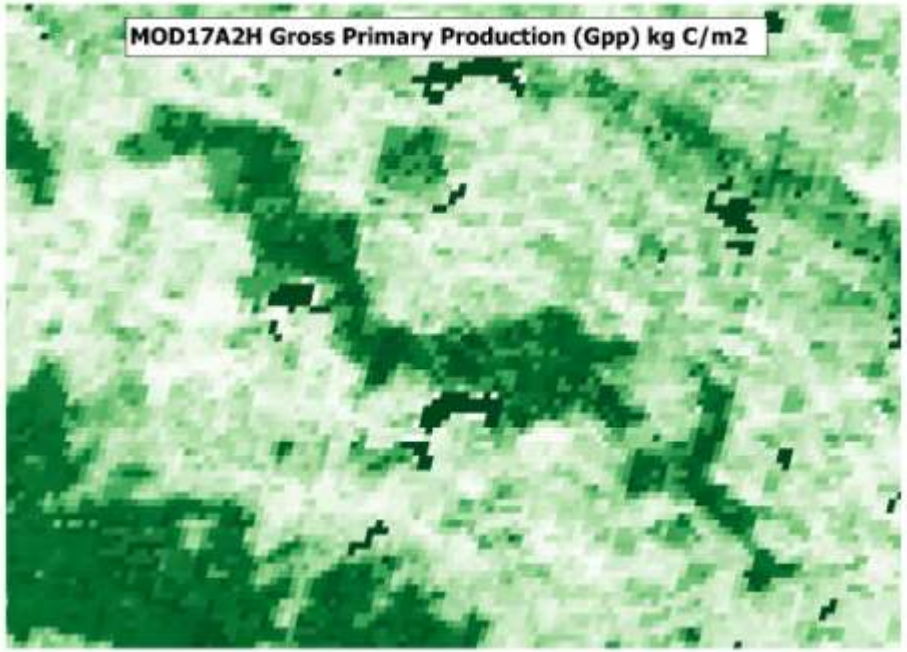
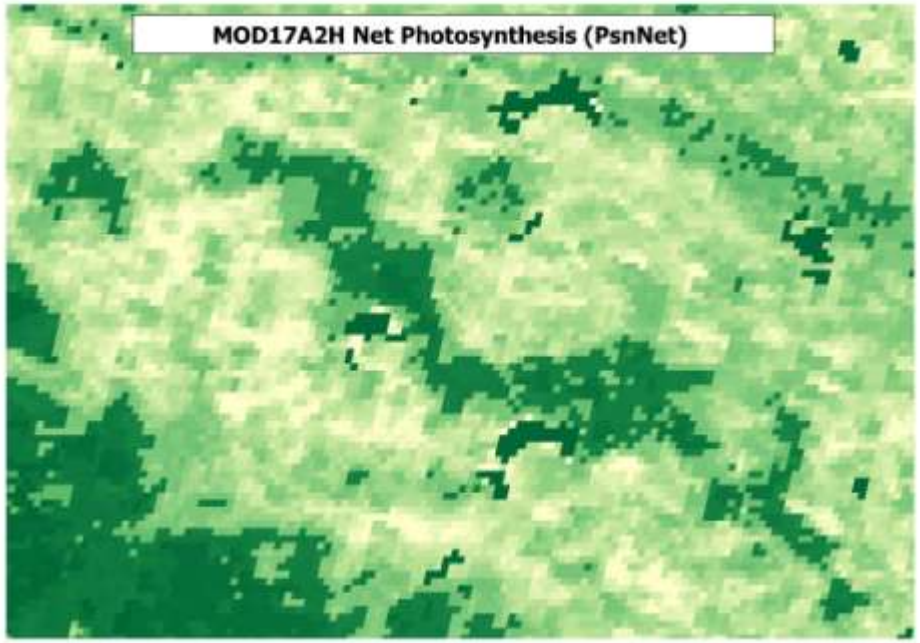
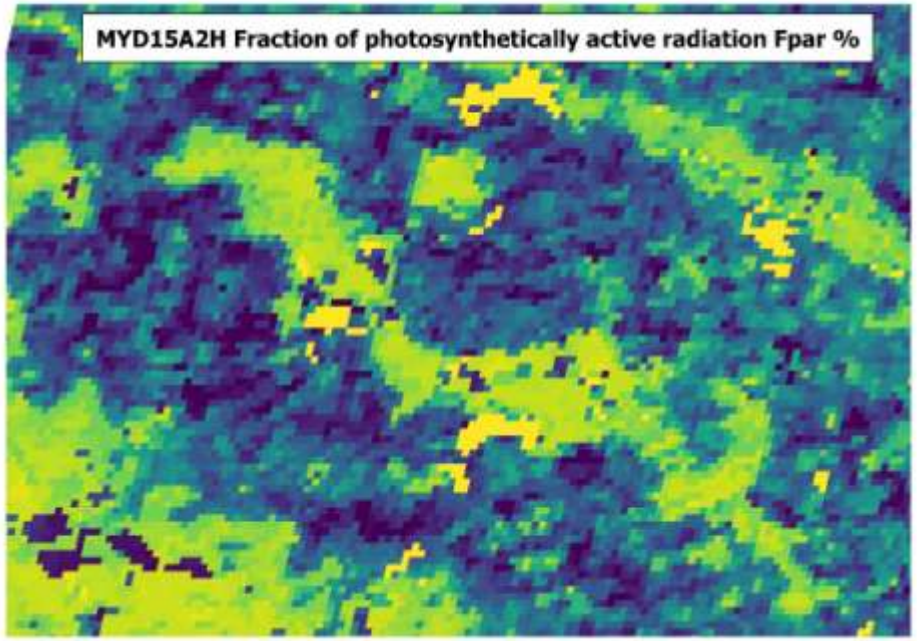
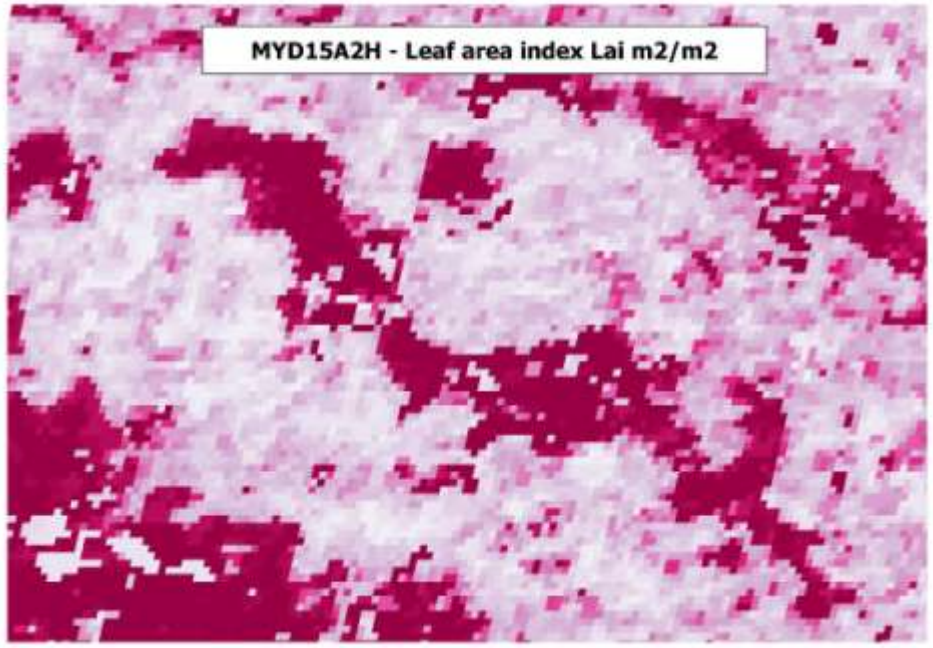
0.03
0
7.5
15
22.5
30 km

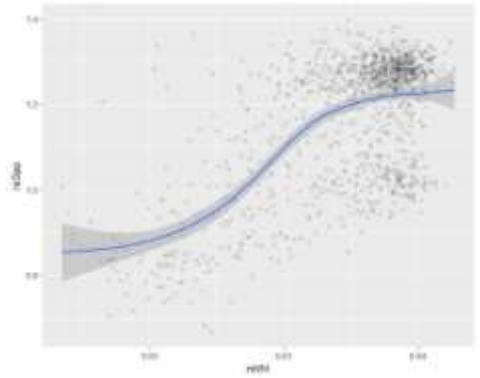

MOD17A2H Gross Primary Production (Gpp) kg C/m2


MOD17A2H Net Photosynthesis (PsnNet)

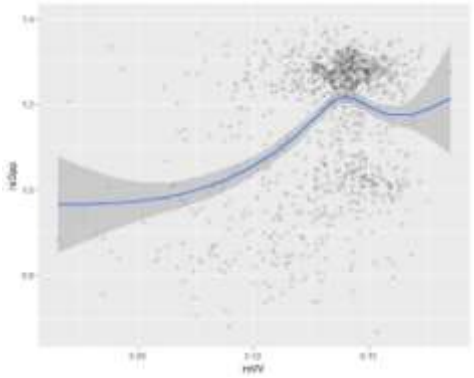

MYD15A2H Fraction of photosynthetically active radiation Fpar %


MYD15A2H - Leaf area index Lai m2/m2

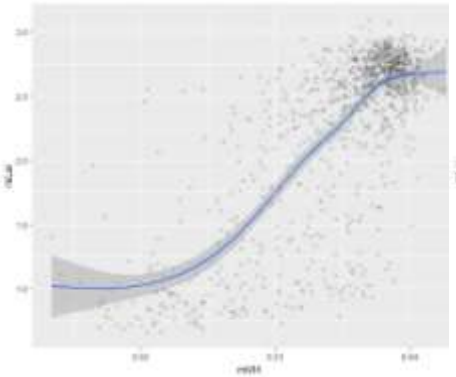
VH - Gpp



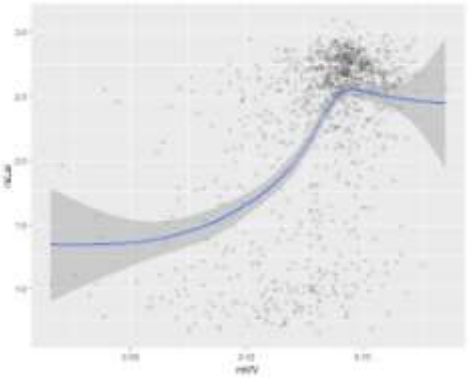
VV - Gpp



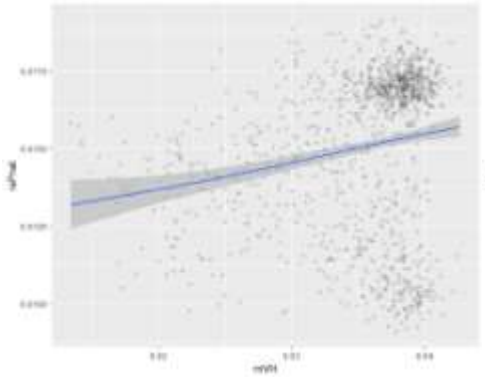
VH - Lai



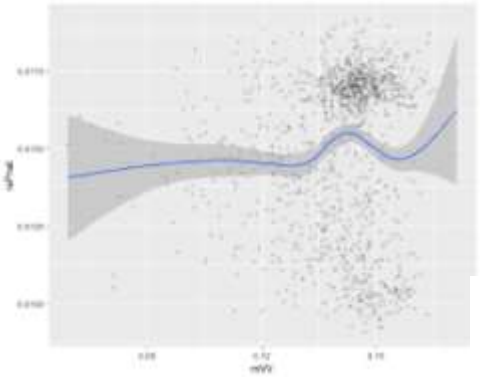
VV - Lai



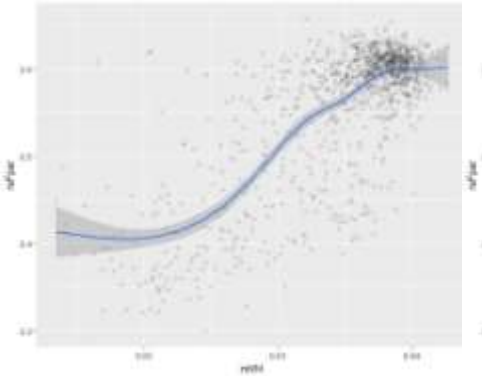
VH - PsNet



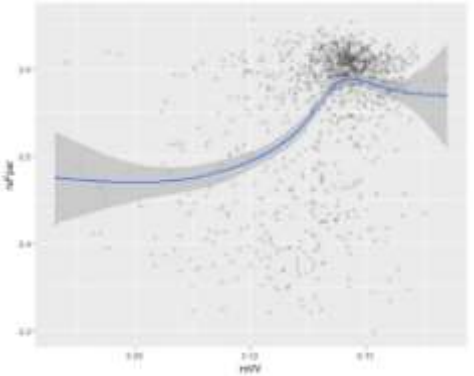
VV - PsNet



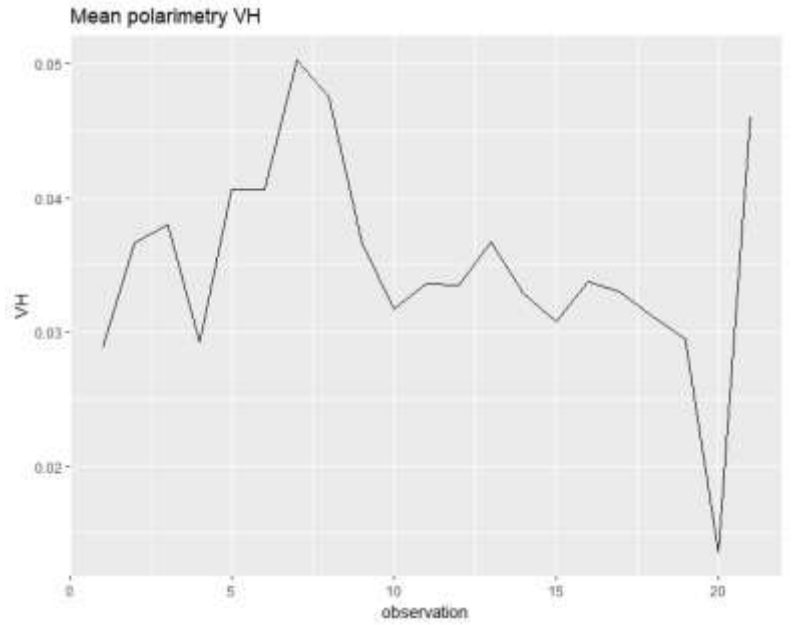
VH - Fpar

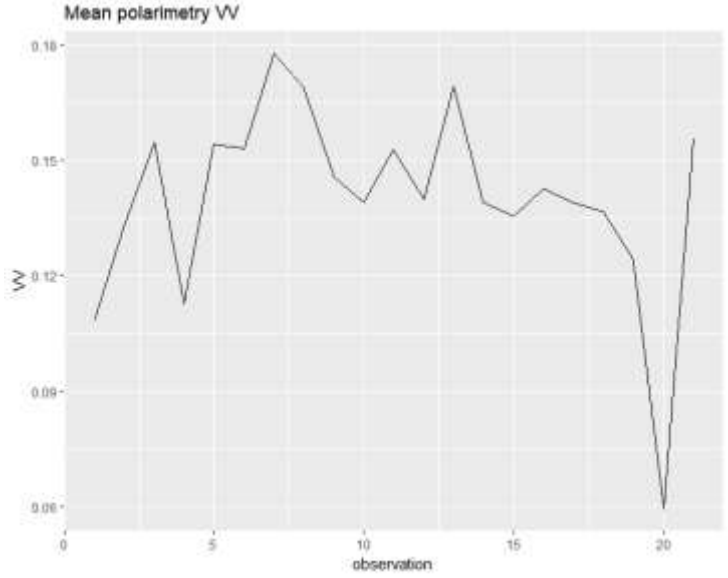


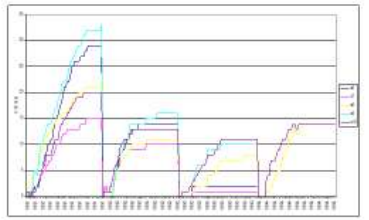
VV - Fpar

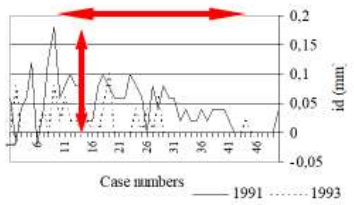


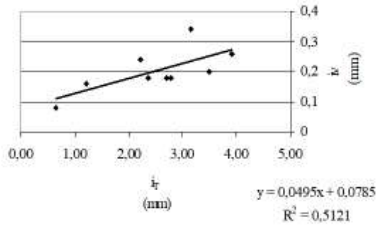
Real time BHD growth monitoring with SAR polarimetry?



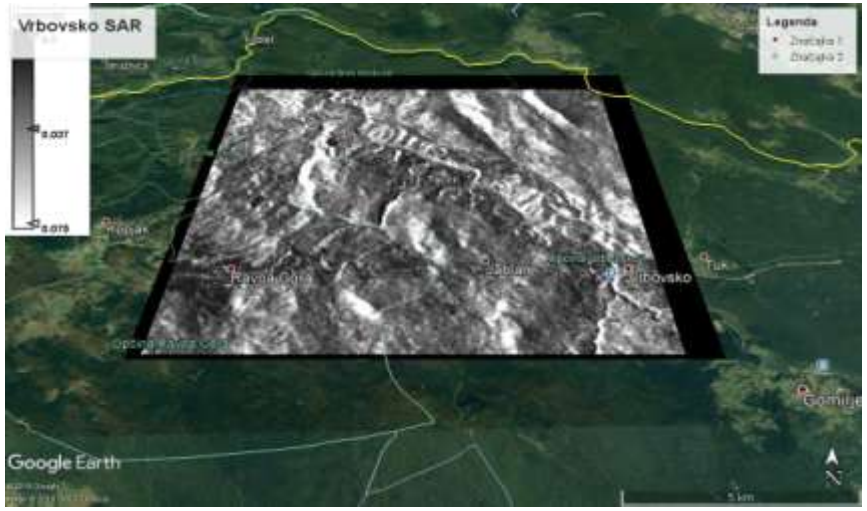






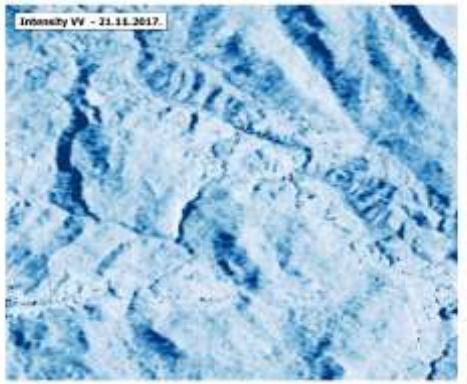


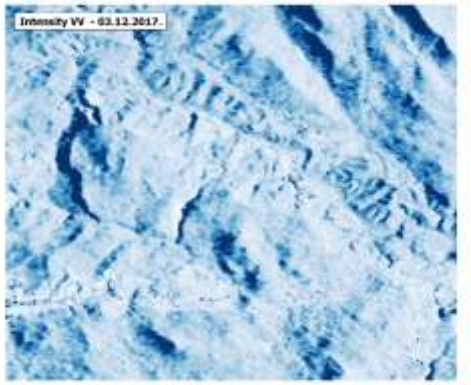
Rapid detection of forest disturbances by SAR (windthrow 11-12 December 2017) Vrbovsko, GJ Litorić




Intensity VH - 21.11.2017.

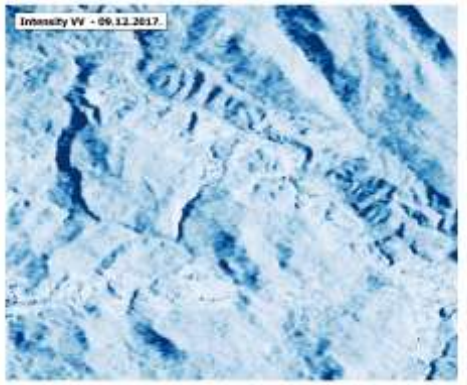

Intensity VH - 03.12.2017.

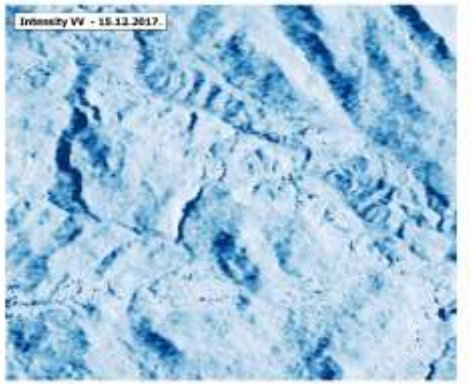

Intensity VV - 21.11.2017.


Intensity VV - 03.12.2017.


Intensity VH - 09.12.2017.

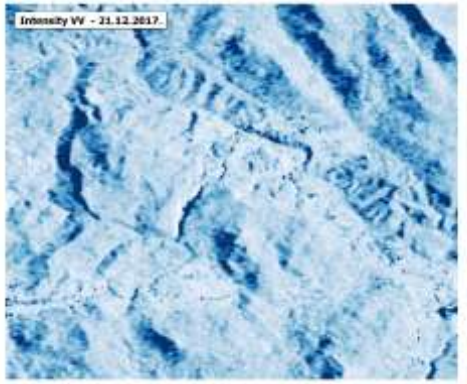

Intensity VH - 15.12.2017.

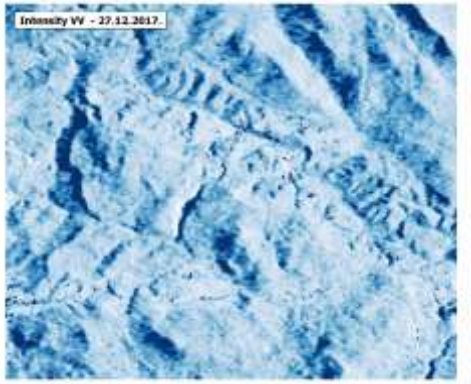

Intensity VV - 09.12.2017.

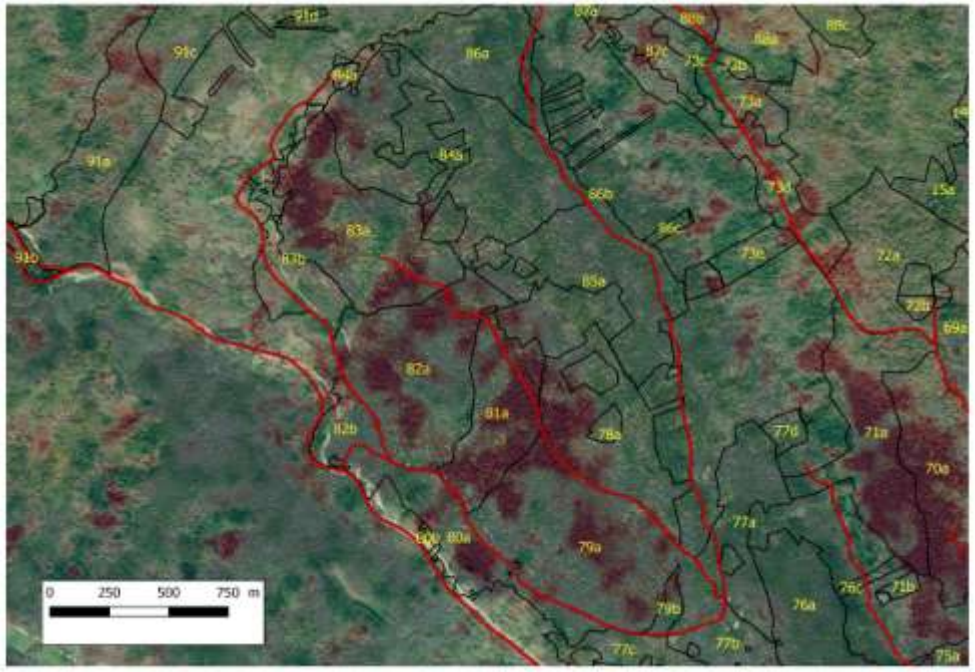

Intensity VV - 15.12.2017.


Intensity VH - 21.11.2017.


Intensity VH - 27.12.2017.


Intensity VV - 21.12.2017.


Intensity VV - 27.12.2017.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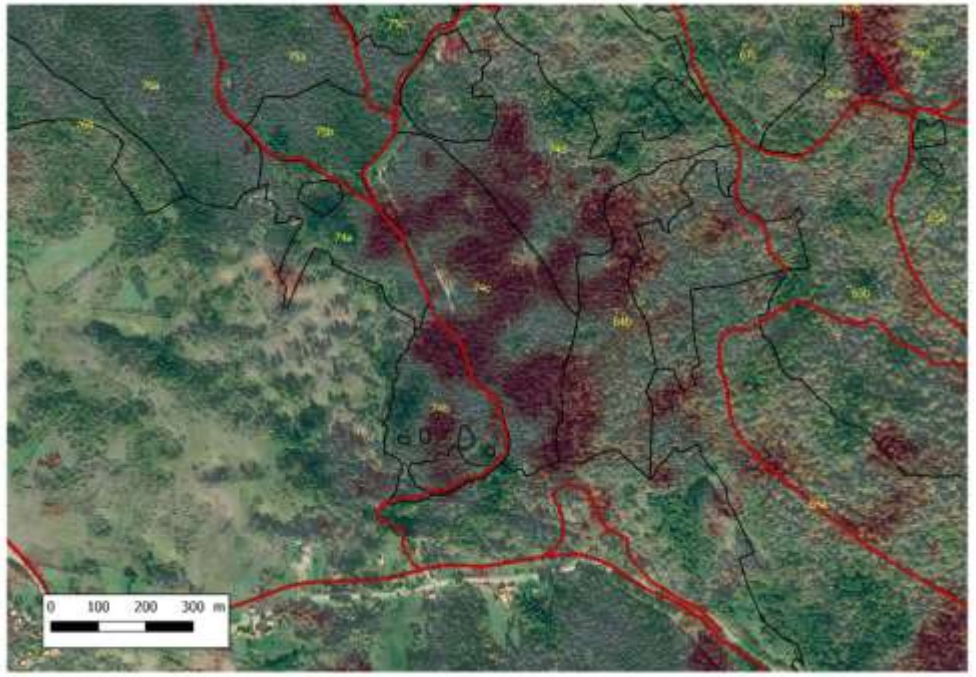
0 100 200 300 m