A synergistic impact of climate change on forest trees growth and forest pests dynamics

The use of high resolution climate change scenario

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Background

- Climate change is generally agreed to have a profound impact on forest structure and dynamics
- Direct impacts (e.g. through changes in trees physiological processes) and indirect (e.g. by alteration of forest disturbance regime), such as:
  - reduced forest productivity in the Mediterranean and continental Europe
  - Improved productivity in the Northern Europe
  - the risk of forest fires will rise in the southern regions
  - Increased mortality is expected at the limits trees biogeographical distribution
- Unknown non-linear and threshold-type responses hinder the prediction of CC impacts and development of a proper measures – *(e.g. IGBP in 2003 convened a WG Development of Earth System Models to Predict Nonlinear Responses/Switches)*
- Specific responses of individual forest components

Presentation's structure

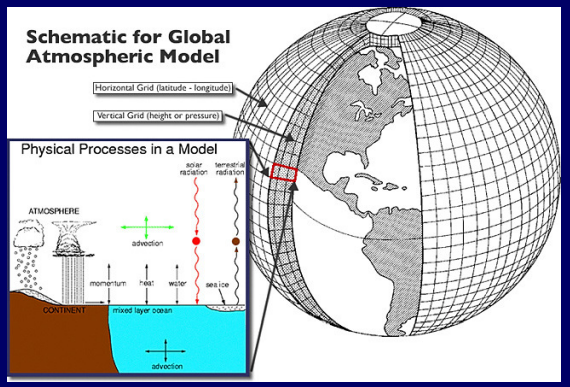
- Introduction of the recent high resolutions climate change scenario for CEE, CECILIA project
- Climate change impacts on spruce growth
  - Environmental envelope modeling
  - Tree growth simulator modeling
- Climate change impact on spruce bark beetle
- A synthesis (?)

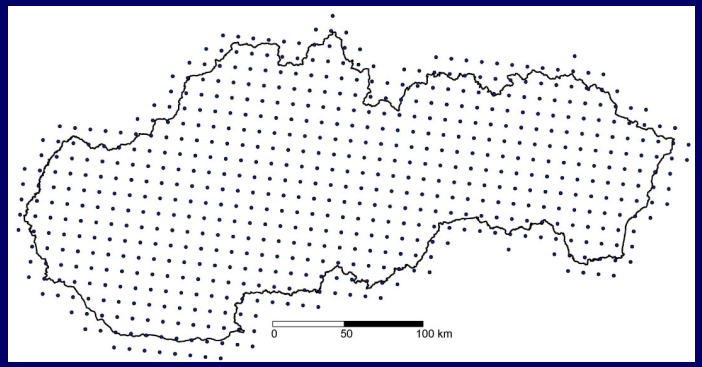
From GCMs to RCMs

Cimatic model is a computer model, describing the atmosphere and ocean for the entire Earth, or for a fraction of it.

Global Circulation/Climatic Models (GCM, e.g Arpege)

Regional Circulation/Climatic Models (RCM, e.g Aladin, RegCM)



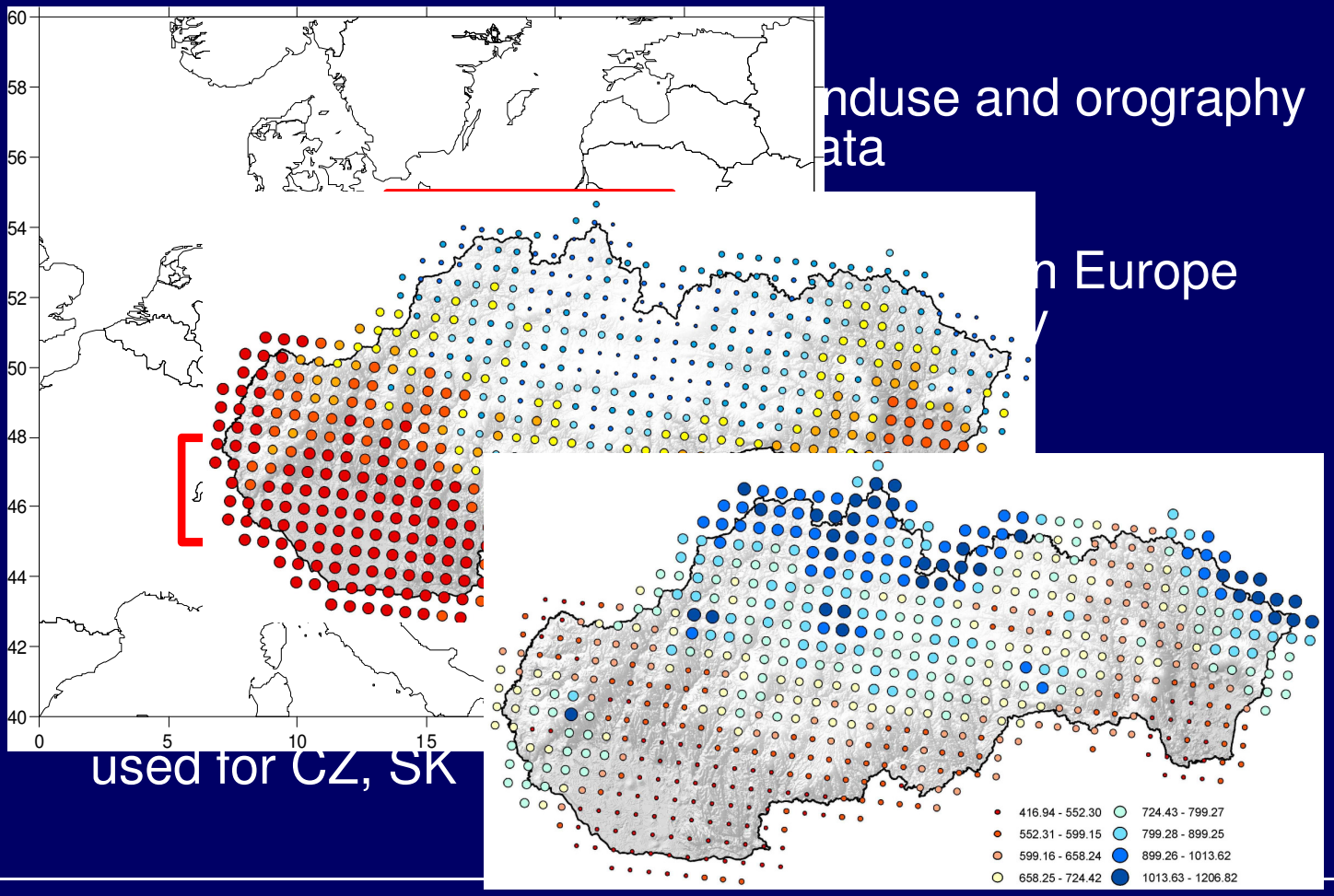


From GCM to RCM – dynamic and statistical downscaling

Two diametrically different ways to reach the same

Crucial for impact studies

High resolution climate change scenario data for CEE



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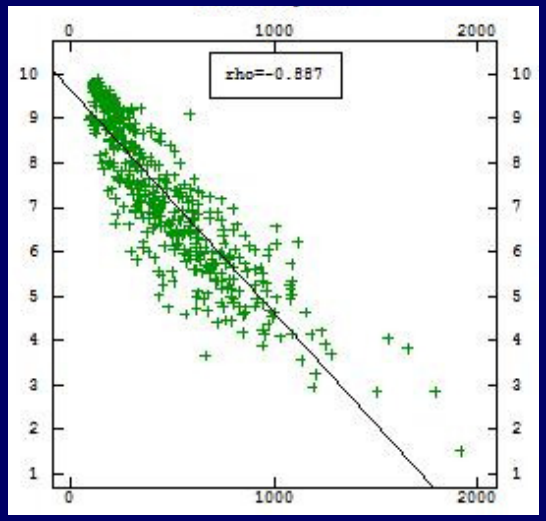
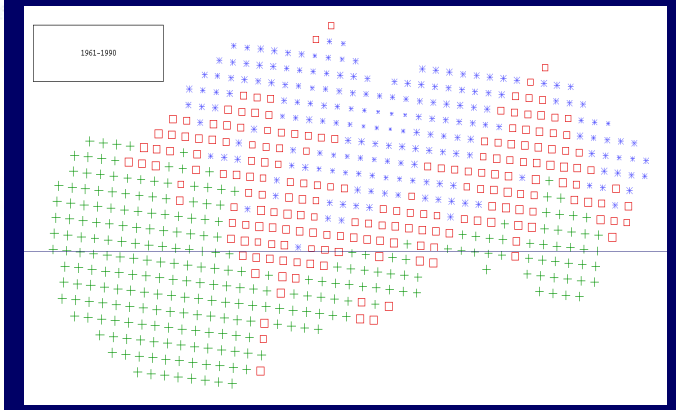
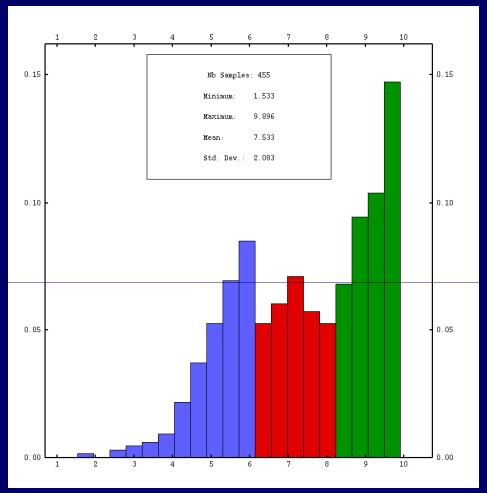
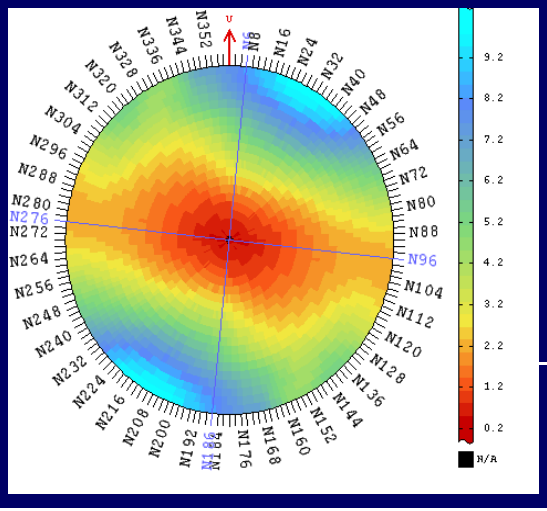
used for CZ, SK

Data analysis 1





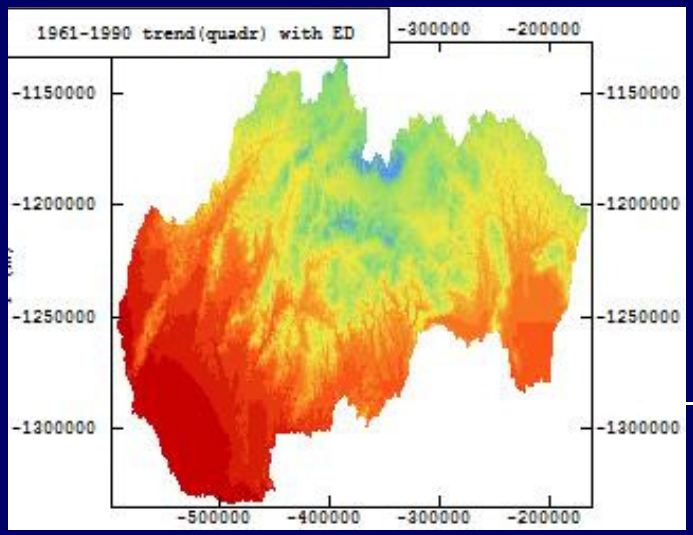


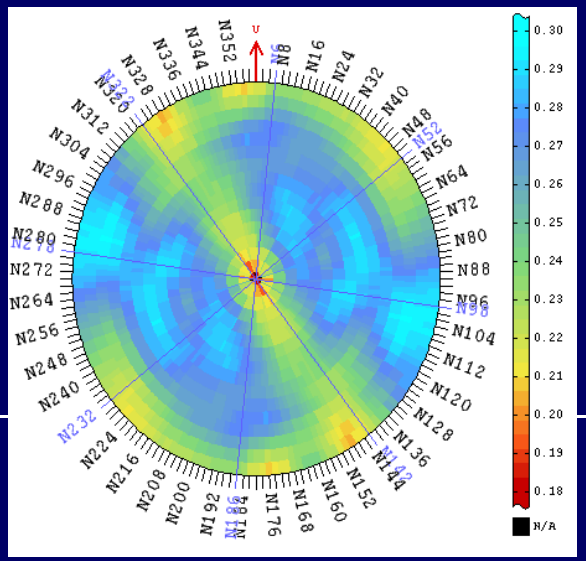


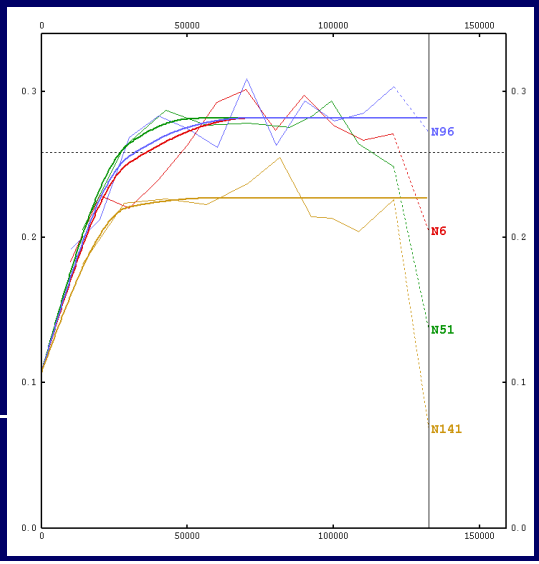
- Non stationary data with strong N-S drift
- Correlated with elevation

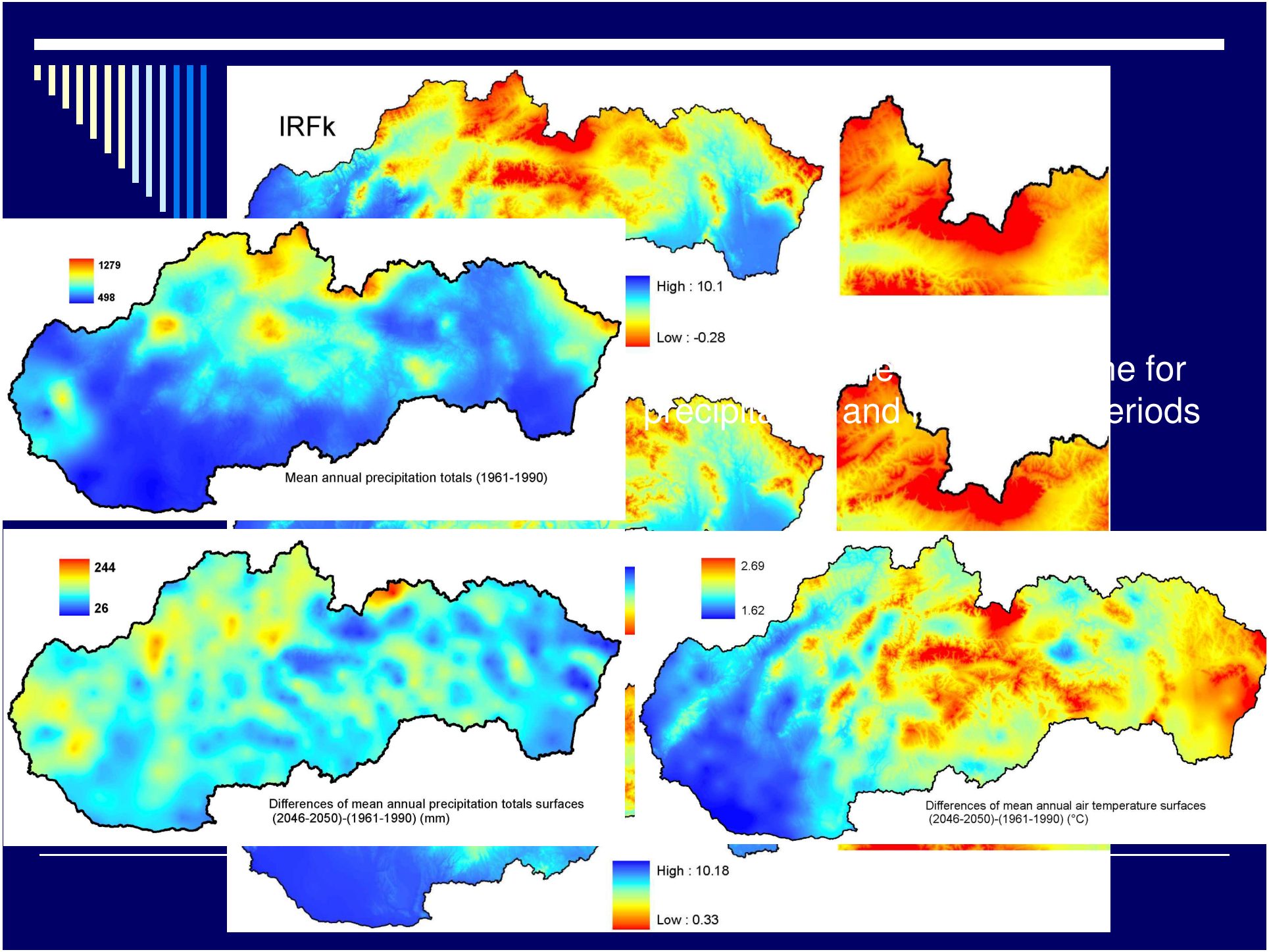
Data analysis 2

- Kriging of residuals by means of
  - Ordinary kriging with final addition of the extracted global trend
  - Universal kriging
  - Kriging in the realm of IRFk (intrinsic random functions of order *k*)
- Crossvalidation



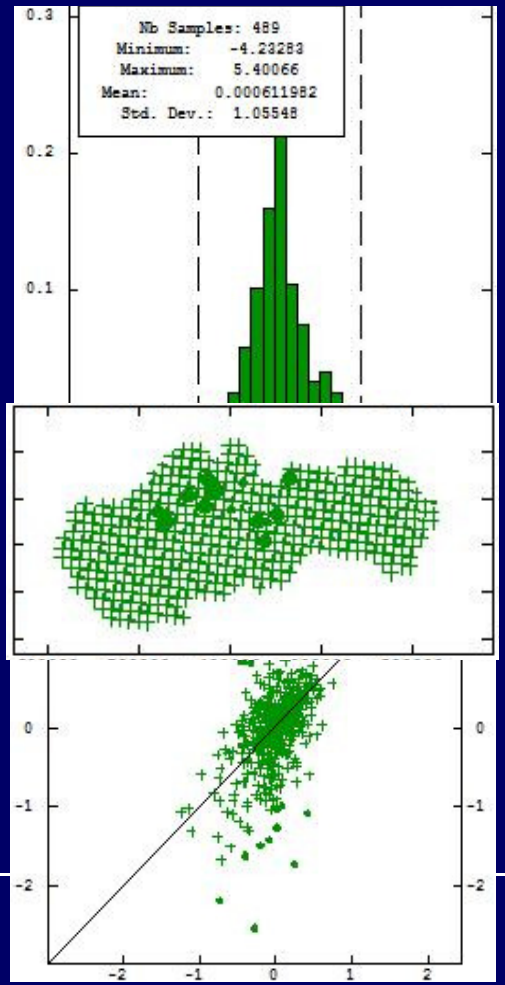




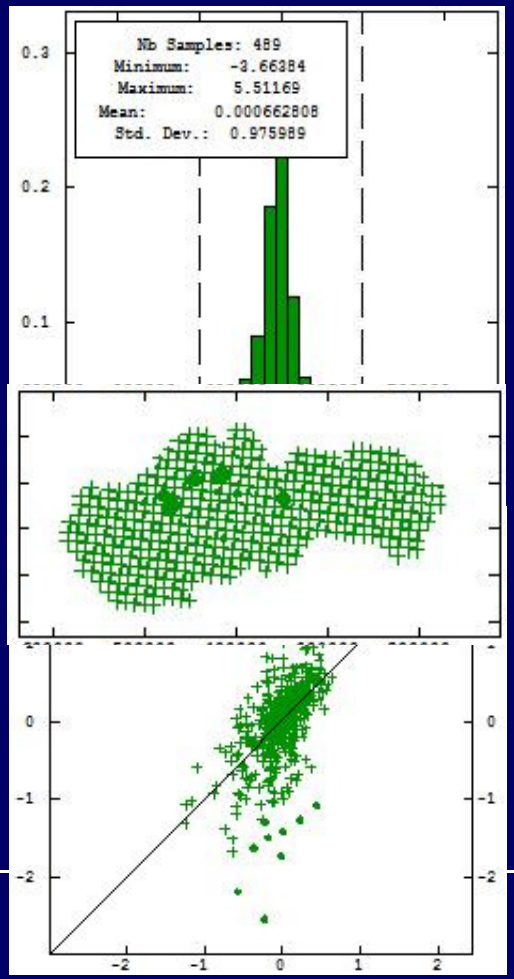

IRFk
1279
498
Mean annual precipitation totals (1961-1990)
High : 10.1
Low : -0.28
244
26
Differences of mean annual precipitation totals surfaces
(2046-2050)-(1961-1990) (mm)
2.69
1.62
Differences of mean annual air temperature surfaces
(2046-2050)-(1961-1990) (°C)
High : 10.18
Low : 0.33

Data analysis 3

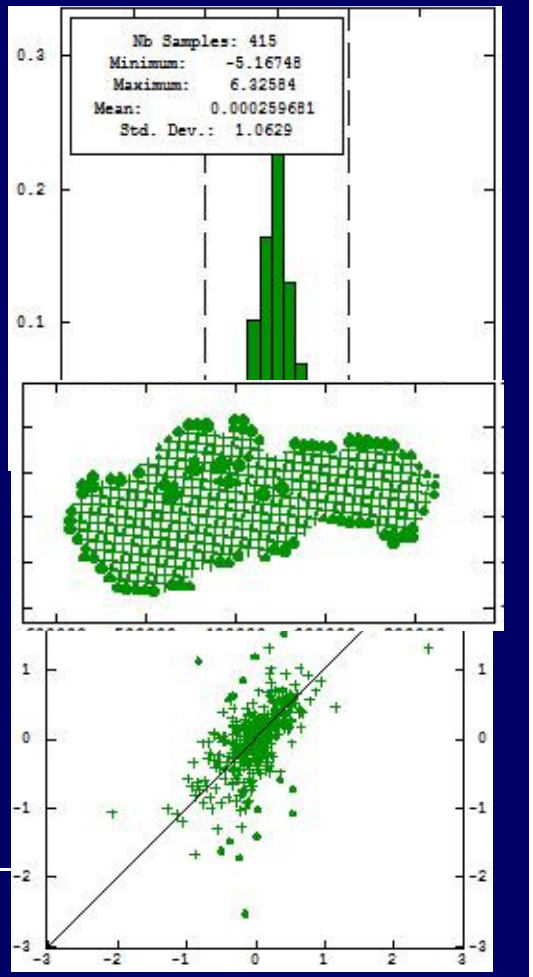
Residuals kriging



Universal kriging



IRF*k*



CC impacts on trees growth

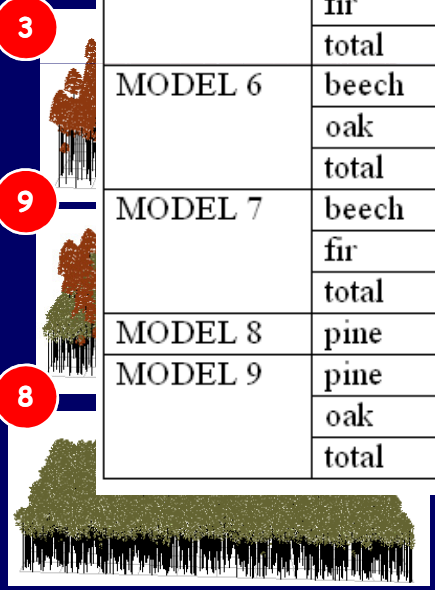
- By individual tree (stand)
  - Based on Sibyla tree growth simulator
  - Number of model forest stands produced
  - Various management regimes applied
  - Run under reference climate and climate change scenario
  - Focus on production and mortality
- By region
  - Tree growth index evaluated at a number of forest monitoring plots
  - Response functions to climatic gradient designed
  - Thermic and xeric limits modeled independently
  - Climate change scenario applied

Zvolenská pahorkatina
500 m. a.s.l.
BK 100

Liptovské Tatry
1300 m. a.s.l.
SM 100

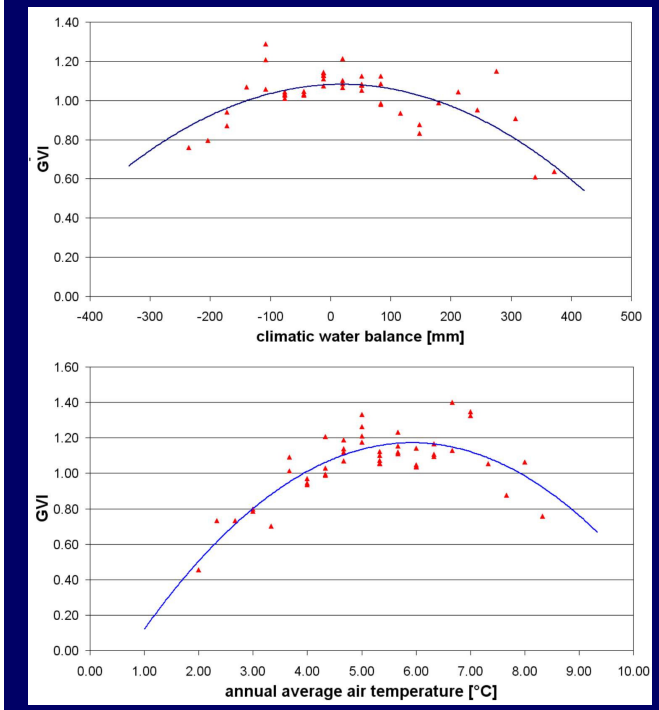
Table 2. Total volume production (TVP) at the end of the prognosis

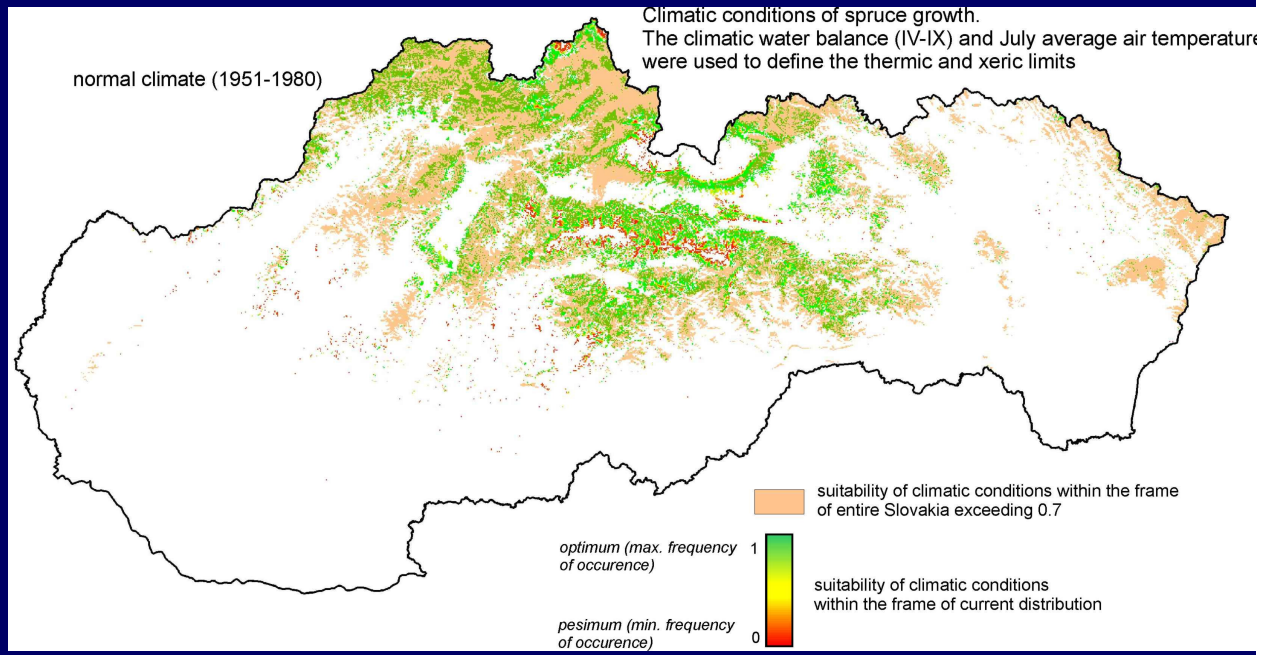
stand model		TVP ($m^3.ha^{-1}$)		difference $m^3.ha^{-1}$ (%)	statistical significant
	tree species	climate change	reference climate		
MODEL 1	spruce	1157	1488	-331 (-22%)	yes
MODEL 2	beech	942	1131	-189 (-17%)	yes
MODEL 3	oak	729	813	-84 (-10%)	yes
MODEL 4	spruce (mountain)	902	842	+60 (+7%)	yes
MODEL 5	spruce	468	490	-22 (-4%)	yes
	beech	445	470	-25 (-5%)	no
	fir	194	283	-89 (-31%)	yes
	total	1107	1243	-136 (-11%)	yes
MODEL 6	beech	693	866	-173 (-20%)	yes
	oak	185	186	-1 (-1%)	no
	total	878	1052	-174 (-17%)	yes
MODEL 7	beech	790	855	-65 (-8%)	yes
	fir	341	394	-53 (-13%)	yes
	total	1131	1249	-118 (-9%)	yes
MODEL 8	pine	712	967	-255 (-26%)	yes
MODEL 9	pine	164	190	-26 (-14%)	yes
	oak	478	592	-114 (-19%)	yes
	total	642	782	-140 (-18%)	yes

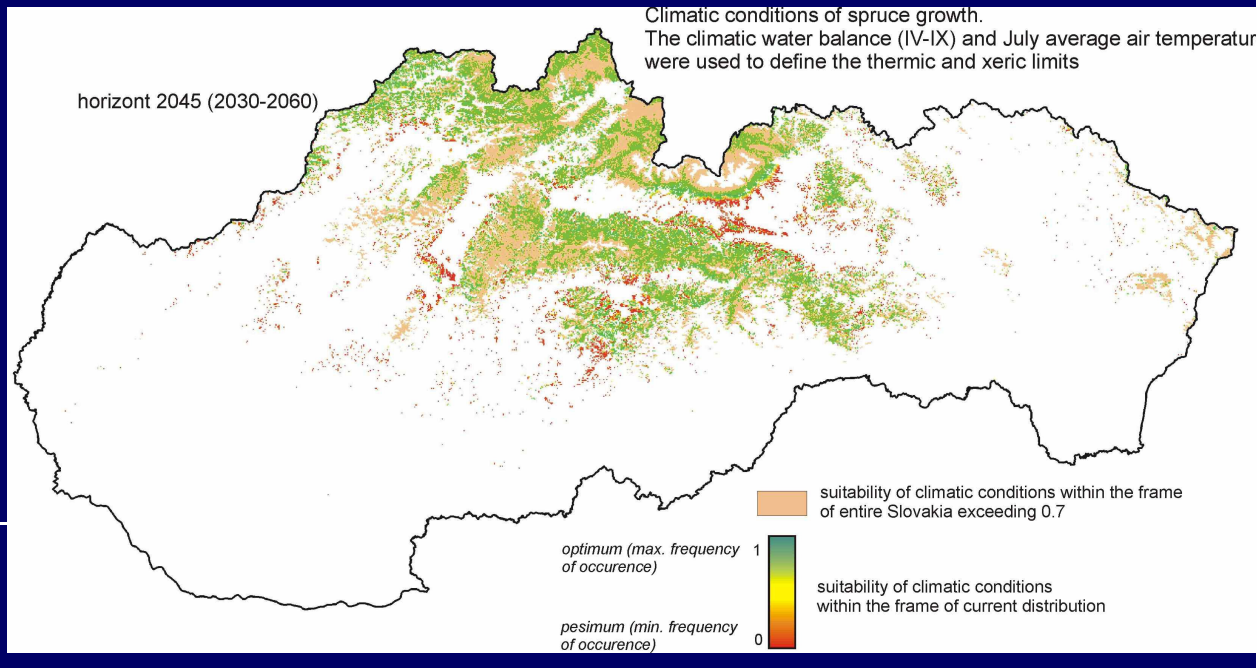


200 m. a.s.l.
BO 100

1-2nd VFS


GVI
climatic water balance [mm]
GVI
annual average air temperature [°C]


Climatic conditions of spruce growth.
The climatic water balance (IV-IX) and July average air temperature
were used to define the thermic and xeric limits
normal climate (1951-1980)
suitability of climatic conditions within the frame
of entire Slovakia exceeding 0.7
optimum (max. frequency
of occurence)
1
suitability of climatic conditions
within the frame of current distribution
pesimum (min. frequency
of occurence)
0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of entire Slovakia exceeding 0.7
optimum (max. frequency
of occurence)
1
suitability of climatic conditions
within the frame of current distribution
pesimum (min. frequency
of occurence)
0

CC impact on spruce bark beetle

Point ID	Altitude (m a.s.l.)	D-days 61-90	Gens. 61-90	D-days 35-50	Gens. 35-50	1st gen. egg 61-90	1st gen 61-90
Brdy 1	850	532.5	0.95	**630**	1.13	XX	XX
Brdy 2	375	931.1	**1.67**	**1180**	2.12	14.5.	20.6
Brdy 3	550	789.5	**1.41**	**950**	1.71	22.5	28.6
Brdy 4	700	719.3	**1.29**	**933**	1.68	27.5.	4.7
Šumava 1	1350	0	0.00	**102**	0.18	XX	XX
Šumava 2	1200	293.1	0.52	**502**	0.90	XX	XX
Šumava 3	1050	338.3	0.60	**550**	0.99	XX	XX
Šumava 4	900	465.0	0.83	**720**	1.29	XX	XX
Šumava 5	750	639.2	**1.14**	**800**	1.44	29.5.	7.7

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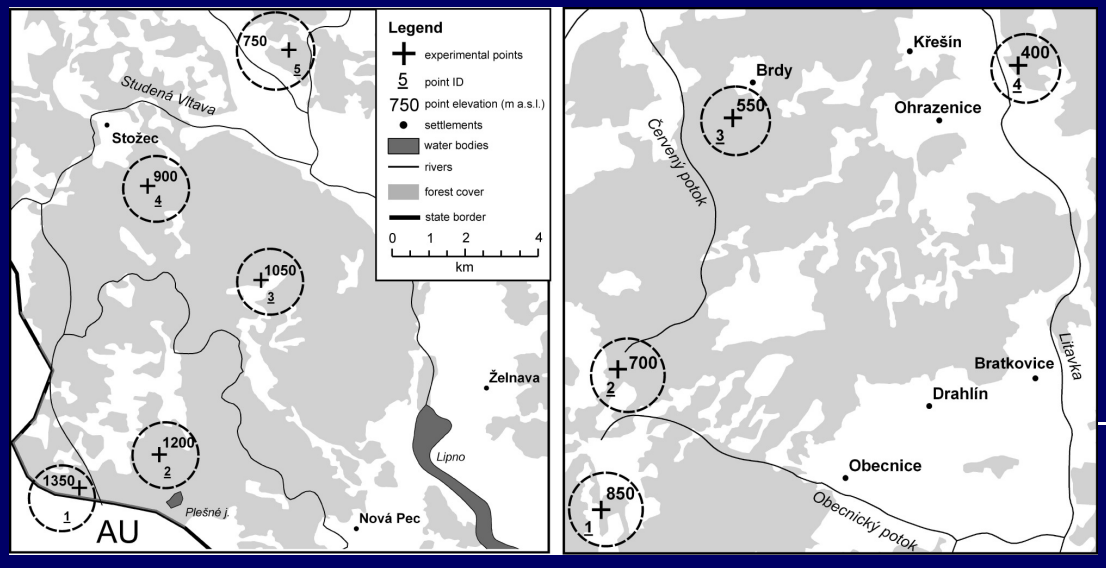
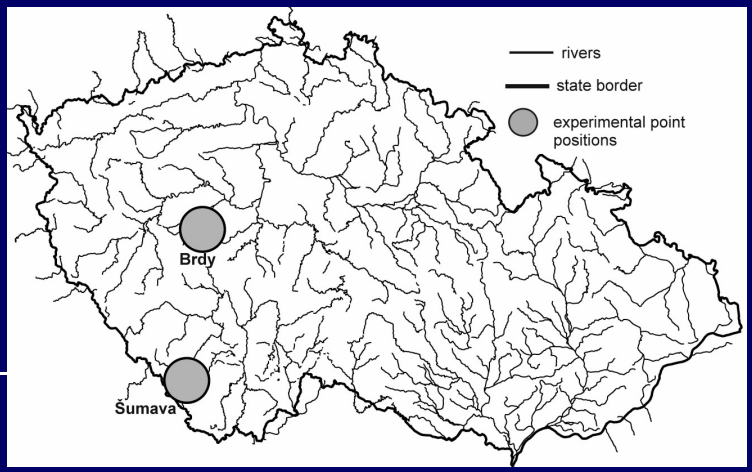
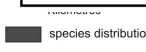


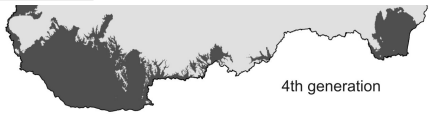


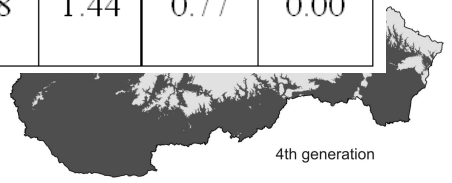
CC impact on spruce bark beetle

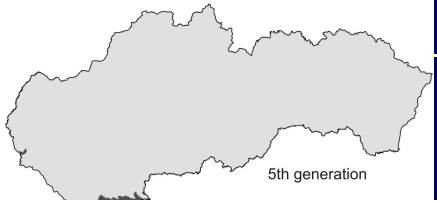
2015 2045 2075

Time scale /Generation	1st generation		2nd generation		3rd generation		4th generation		5th generation	
Variant	1	2	1	2	1	2	1	2	1	2
1951-1980 (+0 °C)	98.72	97.59	90.07	52.92	51.54	1.01	0.00	0.00	0.00	0.00
2015 (+1.249 °C)	100.00	98.57	95.74	78.42	68.78	7.43	20.88	0.00	0.00	0.00
2045 (+2.034 °C)	100.00	100.00	97.29	88.01	78.04	20.48	35.61	0.12	0.00	0.00
2075 (+3.316 °C)	100.00	100.00	98.64	96.77	89.76	51.95	54.68	1.44	0.77	0.00



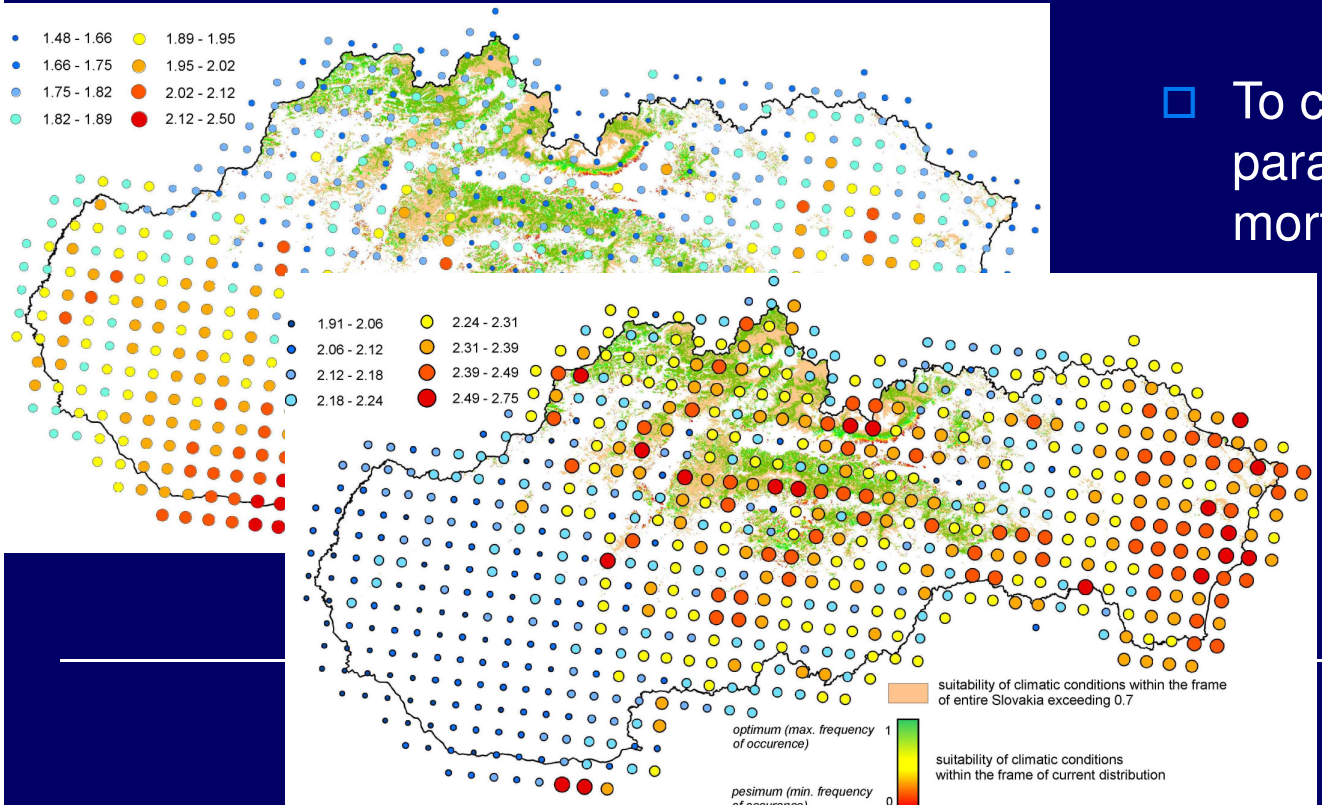






How it may look together (just idea now)

- To identify the regions and forest stands were the impacts on trees growth and increase of bark beetle activity will be the most pronounced in selected future time horizons



- To consider also other parameter, such as trees mortality in the future

- To put it together in complex CC forest vulnerability model

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