IS-ENES3 Climate Impact Autumn School
Nov. – Dec. 2020

Examples of two (forestry and agriculture) impact studies

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Date: 11th November 2020

The IS-ENES3 project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 824084

Examples

Examples of two (forestry and agriculture) impact studies:

Forestry – basic one

- based on a simply forestry index
- one RCM model

Agriculture – a bit more complex

- introduction of a crop model
- RCM multi-model ensemble
- management “scenarios”

Forestry

Example: forestry index that connect three species and climate (environmental niche model).

Three species: Beech

Index: Ellenberg's climate quotient - EQ (mean temperature of the warmest month divided by annual precipitation, multiplied by 1000)

$$EQ = \left(\frac{T_{July}}{P_{annual}}\right) * 1000$$

Areas with **EQ < 30** are humid climate and are dominated by beech, whereas **EQ > 30** are dryer and warmer dominated by oak species. An EQ value of 30 is considered to be the maximum under which natural beech forests are expected to appear in Central Europe (Ellenberg, 1988).

Forestry

Data processing - steps:

1. Observations
   - Prepare observations (station observations or gridded/raster)
2. Climate model
   - Prepare raw model data (historical and projection)
   - Bias-adjustment of model data*

Calculations:

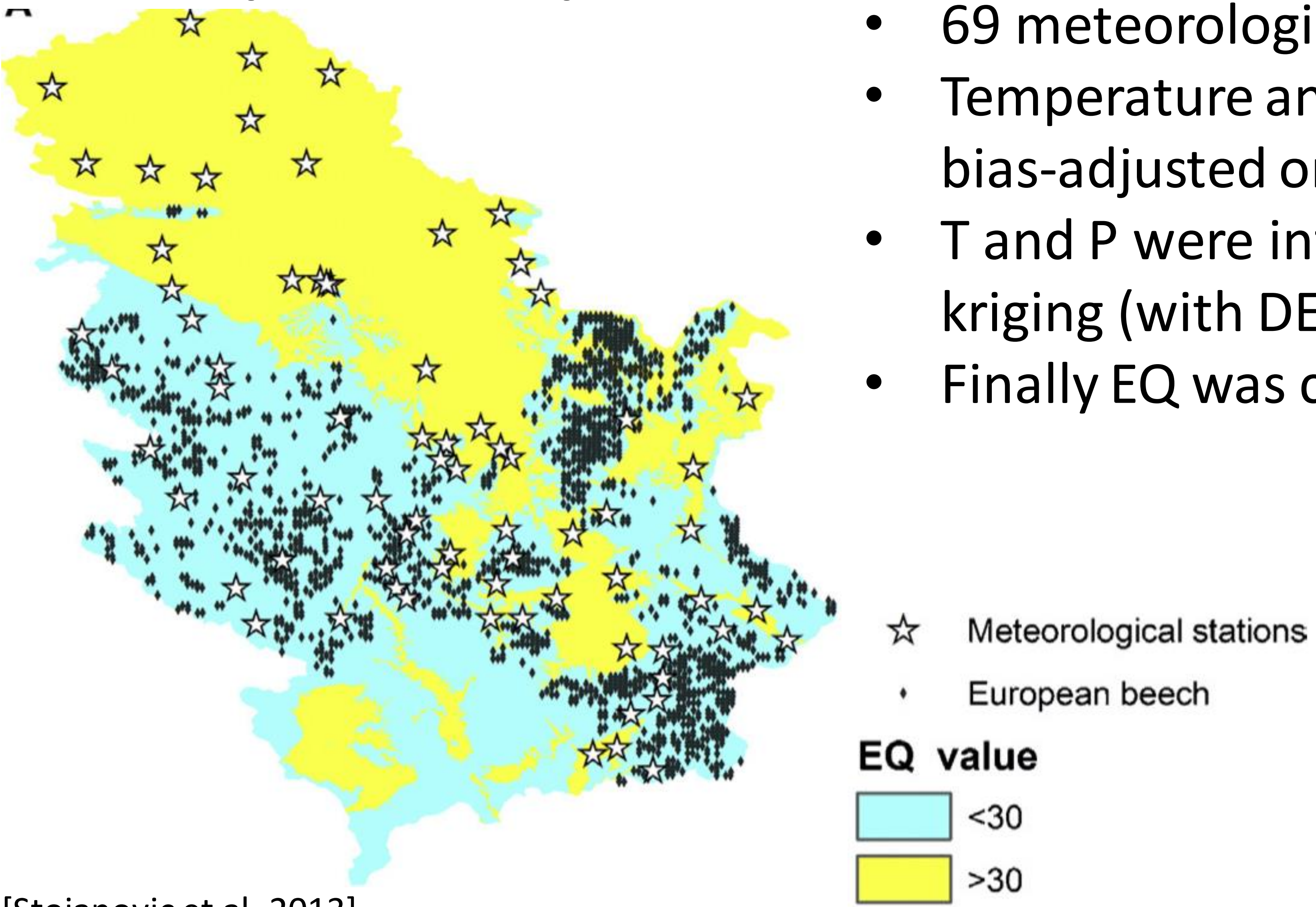
1. Calculate index from observations
2. Calculate index from historical run (same period as observed data) and projections (future), both bias-adjusted

Analysis:

1. Compare index calculated from observations vs. calculated from historical run
2. Compare future vs historical values

(*) Bias-adjustment steps are in extra-slides section

Historical / 1961-1990 /

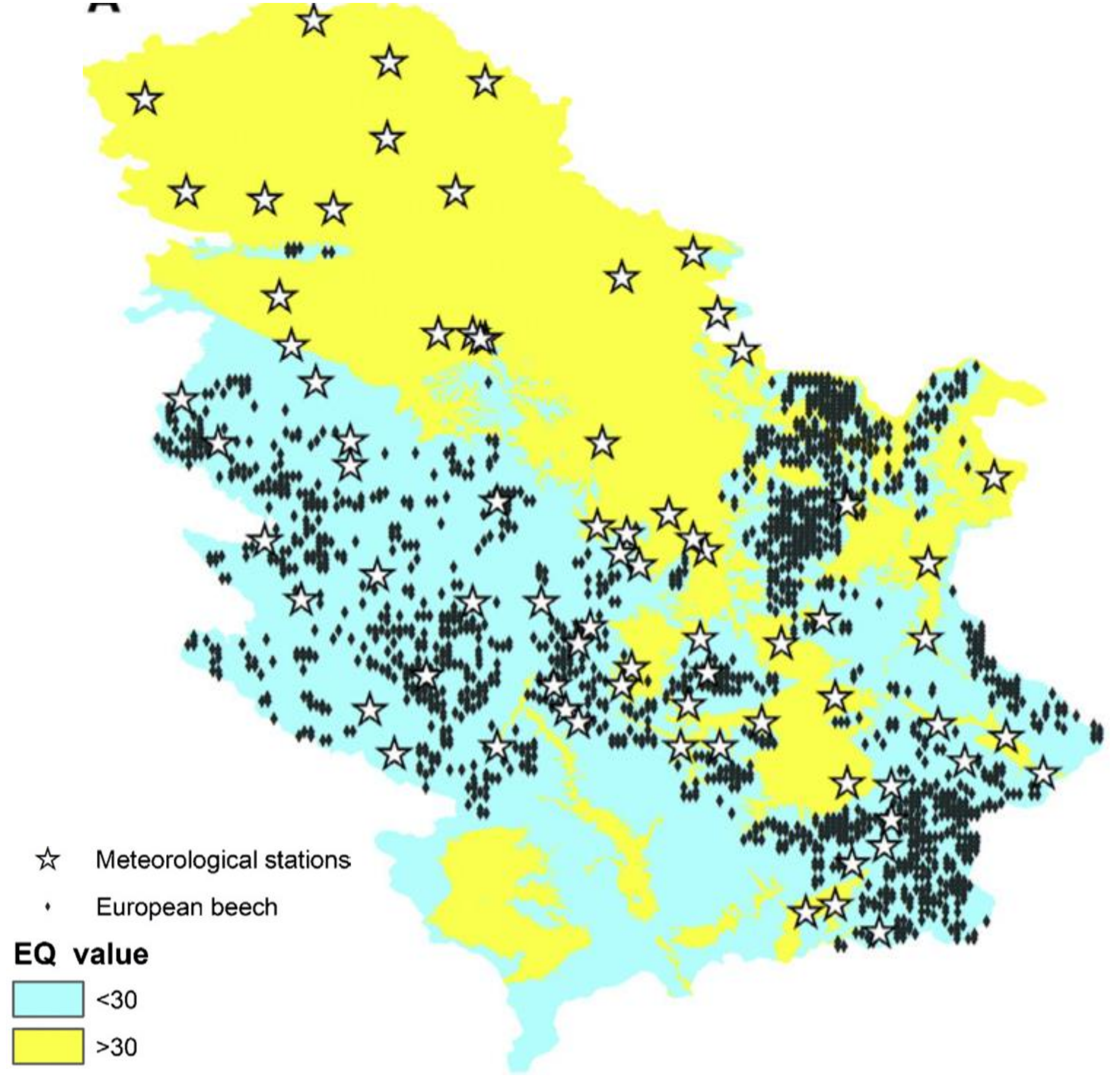


[Stojanovic et al, 2013]

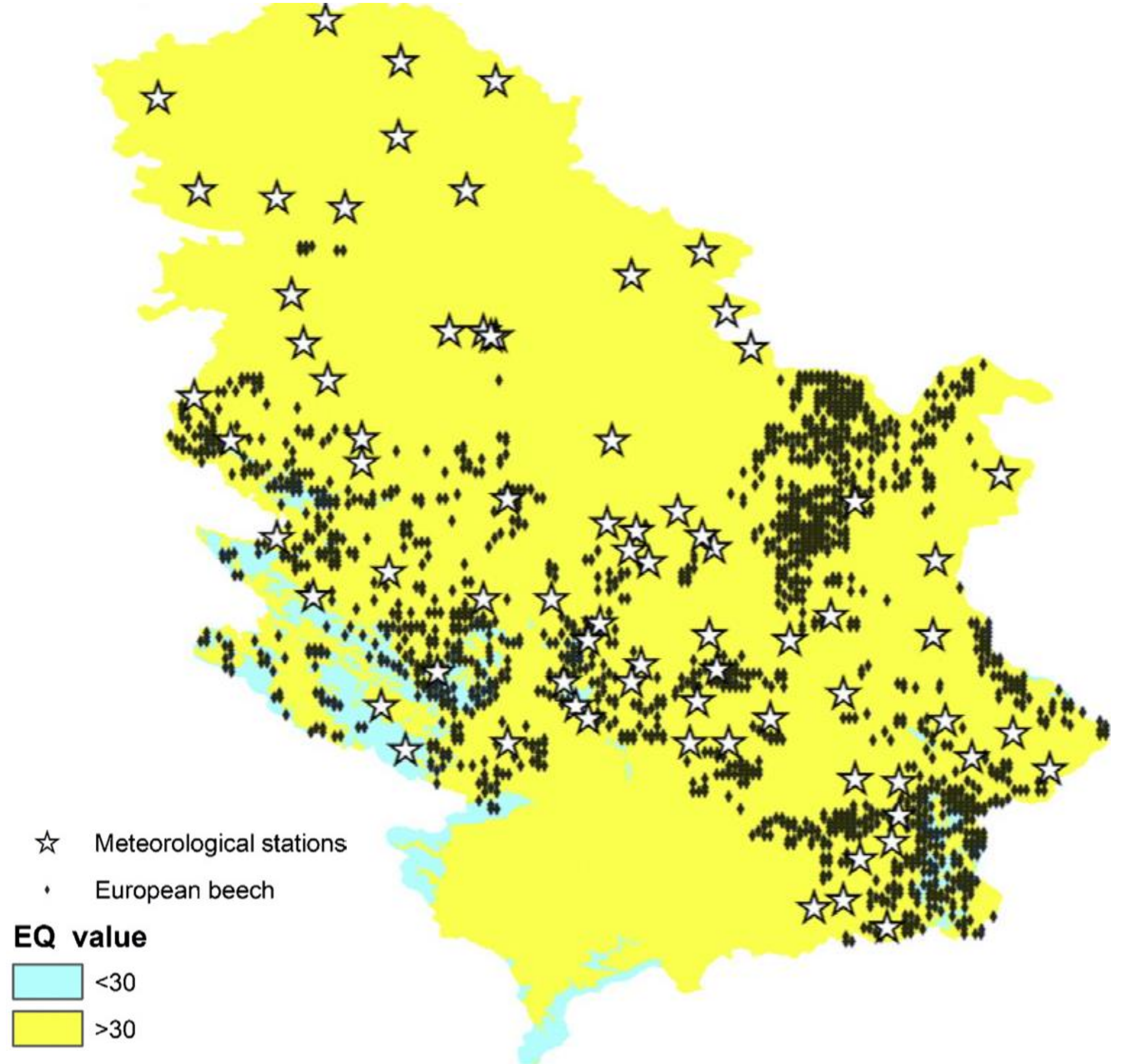
- 69 meteorological stations
- Temperature and precipitation were bias-adjusted on meteorological stations
- T and P were interpolated by universal kriging (with DEM model)
- Finally EQ was calculated for all cells.

Forestry

Historical / 1961-1990 /



Future A1B / 2071-2100 /*



[Stojanovic et al, 2013]

(*) Period 2011-2040 is in extra-slides section

Advantages

- Easy to implement even with large ensembles
- Easy to test system sensitivity to future climate change
- Not much additional uncertainty related to the impact model

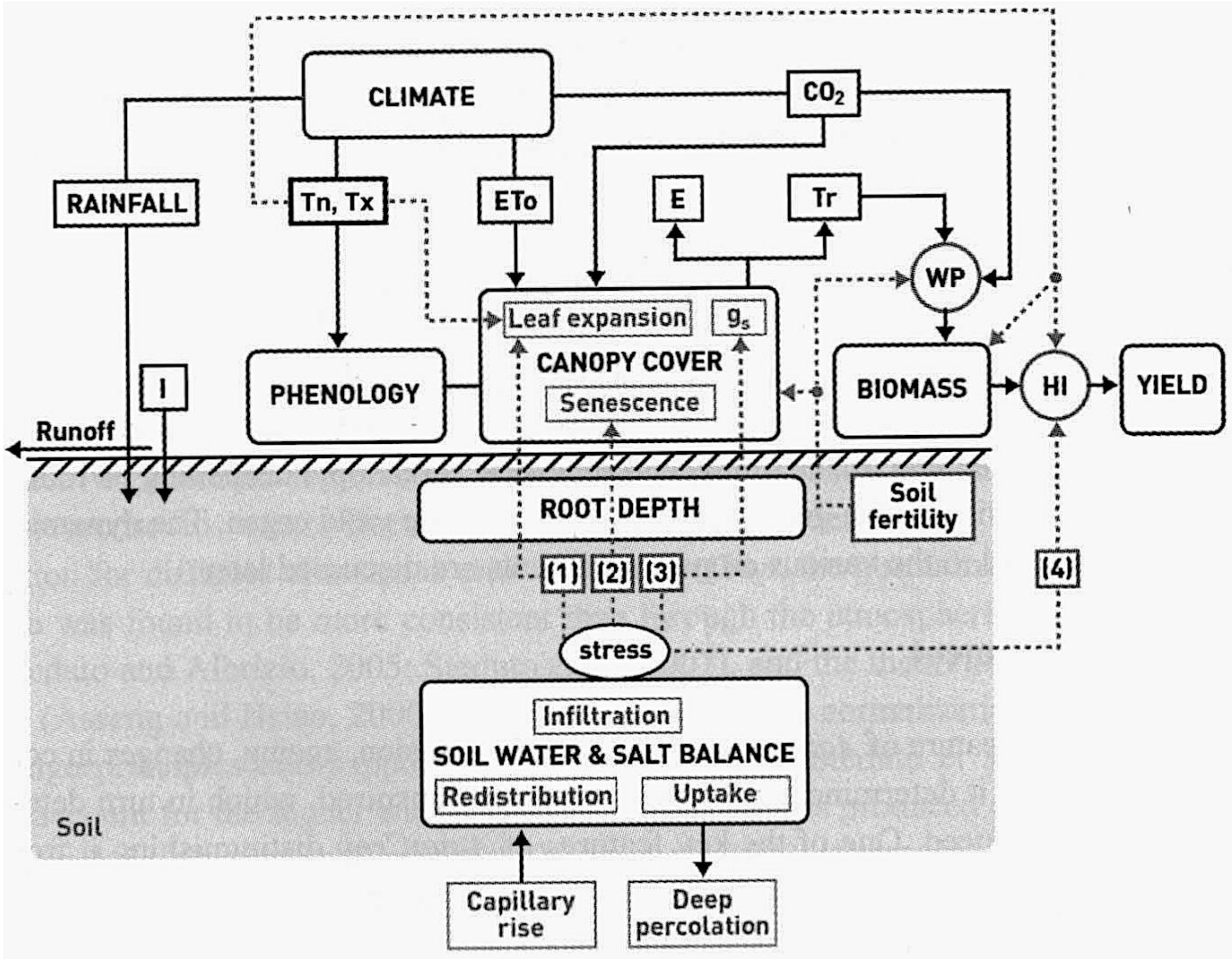
Disadvantages

- No feedbacks within the system
- Lack of “management/intervention” options
- No explicit information about other environmental components (e.g. soil properties)
- Maybe will not be valid in the future

Agriculture

Crop model - Crop models are a formal way to present quantitative knowledge about how a crop grows in interaction with its environment.

AquaCrop model simulates soil water balance and crop growth processes as a function of crop, soil, weather, and management input data, on a daily time step. In addition, AquaCrop simulates soil evaporation and crop transpiration explicitly as individual processes. The productive portion of water consumption (i.e. transpiration) is used to estimate biomass accumulated each day, using a crop-specific water productivity parameter that is normalized for reference evapotranspiration (Steduto et al., 2007), making the parameter applicable to a wide range of climates.



Agriculture

Data processing - steps:

1. Observations
   - Prepare observations
2. Climate model – multi-model ensemble data
   - Prepare raw model data (historical and projection) for each ensemble member (daily)
   - Bias-adjustment of model data*
3. Crop models often expect additional information, e.g. soil characteristics, management decisions (e.g. irrigation) etc. but also model calibration.

Calculations:

1. Run crop model using observation
2. For each ensemble member run crop model using data from historical and projections run [do not average model data and then run crop model with ”single realization” …]
3. Additional runs - different model setup, e.g. different management practice, or different genetics

Analysis:

1. Compare model results from “observations run” with “historical ensemble run”
2. Compare future vs historical values
3. Compare different model setup runs (e.g. different management decisions]

(*) Bias-adjustment steps are in extra-slides section

Maize example – conclusion form two research papers

Research paper 1 (without testing management options): without irrigation: "maize yield changes obtained for the period 2071–2100 … lie in the interval −52 to −22% " and … with irrigation: " … no change" …

Research paper 2 (with testing management options): **Irrigation norms** for achieving high and stable **yield of maize** will not change significantly, neither in the North nor in the South of the country, but only if **the sowing is done within optimum timeframes**. Any delays would pose the risk of corn entering into the stage of silking, pollination and formation of kernels – in the period of drought and high temperatures … Namely, such result is not an effect of large amounts of precipitation, but rather an increase in air temperature in spring, which will enable earlier sowing … by even 20 days at the end of the century. Warmer climate will also reduce the duration of all phenophases, which will ultimately result in shorter growing cycles. Favorable temperatures, together with precipitation, will lead to high yields (Table 5) on deep and fertile fields …

Agriculture

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Multi-model ensemble provide information about uncertainty

Table 5: Corn yields (t/ha) calculated using AquaCrop model, for 9 climate models and RCP8.5 scenario

Location		Rimski Šančevi				Valjevo				Kragujevac				Negotin				Leskovac			
Period		Min.	Max.	Med.	Change	Min.	Max.	Med.	Change	Min.	Max.	Med.	Change	Min.	Max.	Med.	Change	Min.	Max.	Med.	Change
1986-2005	average	11.2	11.7	11.5		11.7	12.1	11.9		11.6	12.1	11.8		9.9	10.7	10.6		11.4	12.2	11.7	
2016-2035	average	11	11.8	11.5	**-0.3**	11.4	12.3	11.9	**0.1**	11.5	12.3	11.8	**-0.3**	10.1	10.9	10.6	**-0.1**	11.4	12.4	11.7	**-0.3**
2046-2065	average	10.7	11.8	11.6	**-3.9**	11.6	12	11.8	**-0.6**	11.1	12	11.7	**-1.0**	10	10.9	10.7	**1.6**	11	11.9	11.7	**-0.7**
2080-2099	average	10.2	11.6	11.1	**-.3.5**	10.5	11.6	11.2	**-5.7**	10.6	11.6	11.2	**-5.5**	9.7	11	10.3	**-2.3**	10.6	11.3	11.1	**-5.6**

Note higher variability for the last period

Agriculture

Advantages

- With model that simulates the processes explicitly, you get more insight in what the changes in the future will be, feedbacks are included, and “management/intervention” options/scenarios are possible
- Different adaptation options can be tested
- Include explicit information about other environmental components (e.g. soil properties …)

Disadvantages

- More time and computational consuming
- Additional uncertainties (different sources: calibration, “management scenarios”, environmental conditions …)
- Generally cannot work with the "raw" climate model data (with biases), since they are calibrated with observational data (and often with point data!) and they do contain many non-lineair relations and thresholds
- Difficult to use a large ensemble of climate model data (often no time for this). Takes a lot of time to put the climate data in the right format and to bias-adjustment

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Thank you

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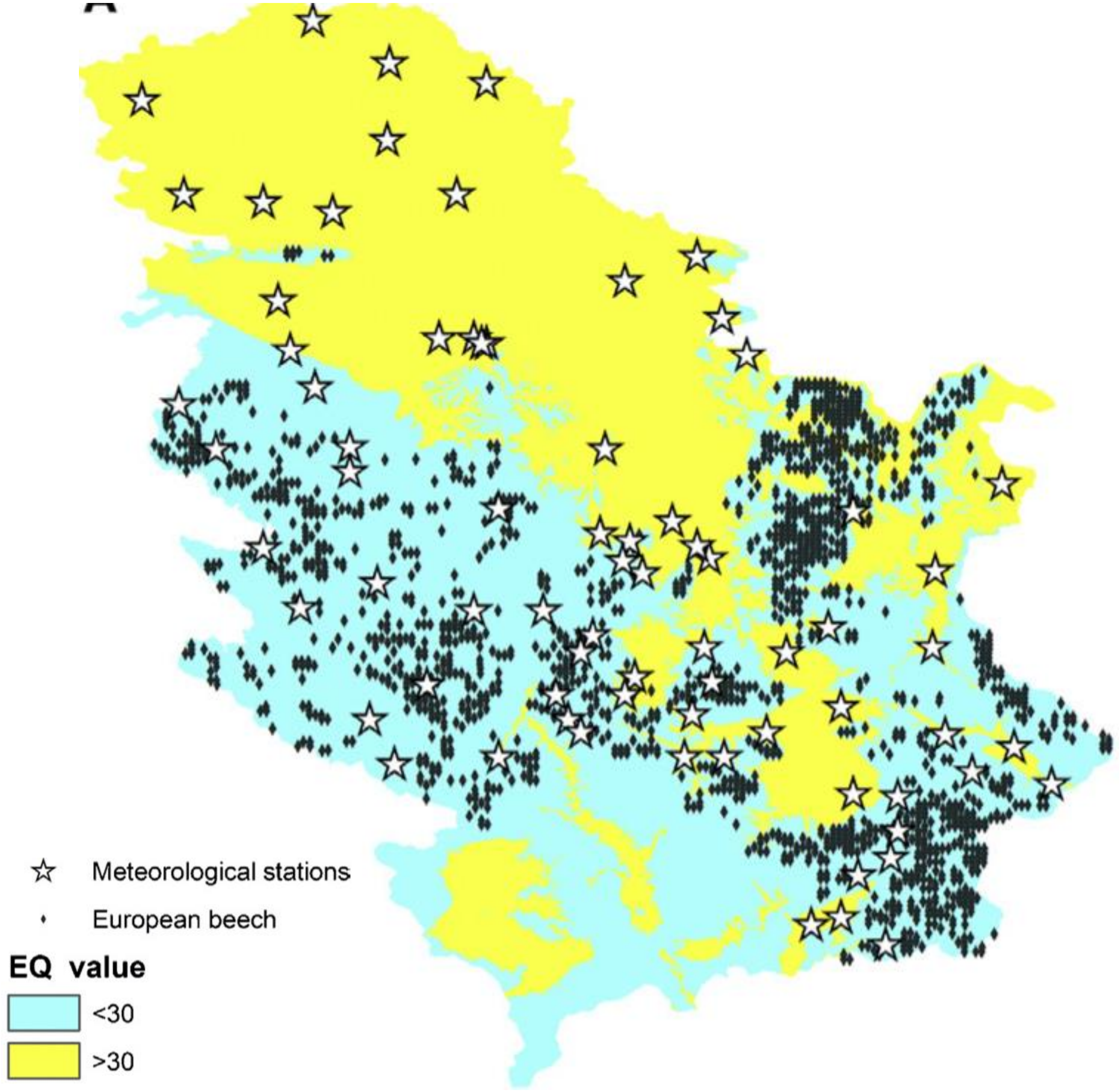
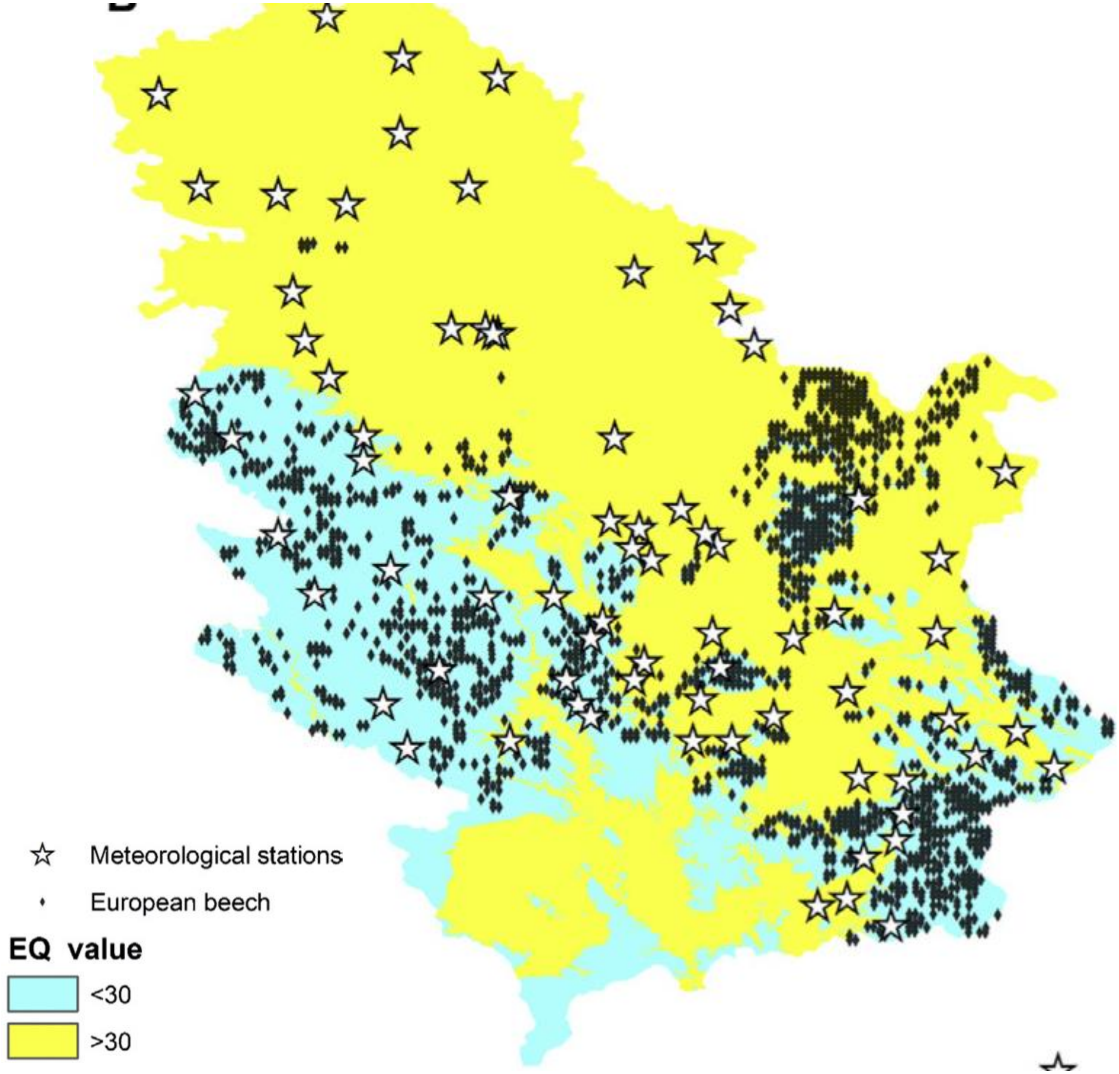
Extra slides

Forestry

Historical / 1961-1990 /



Future A1B / 2011-2040 /



[Stojanovic et al, 2013]

Bias-adjusment – one of the possibile approaches