Agriculture and climate change

Use of climate model results

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Global Climate Models (GCMs) and Regional Climate models (RCMs)

- Mathematical models with included physics of the Earths system components, which affect climate, and information about estimated future progress of anthropogenic impact.

- GCMs: large-scale physical processes of the atmosphere-ocean-land system, coarse-grid resolution, obtained results do not have spatial scale fine enough for impact assessment studies.

$\Rightarrow$ statistical and dynamical downscaling

- RCMs forced with IPCC/SRES scenarios.

- Bias of the results of the climate simulations must be reduced to minimum in presentation of the results:

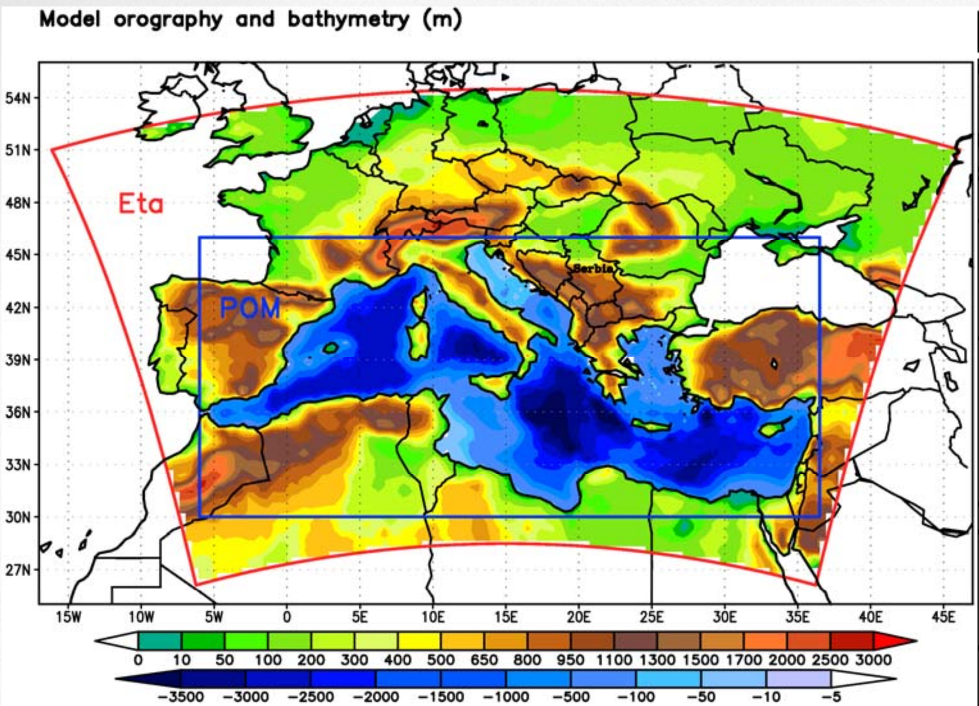
1. Delta approach (model output average 30y for future period - model output average 30y for base period),
2. Statistical bias correction.

- “Summer drying problem” in climate model simulations => necessary bias correction!

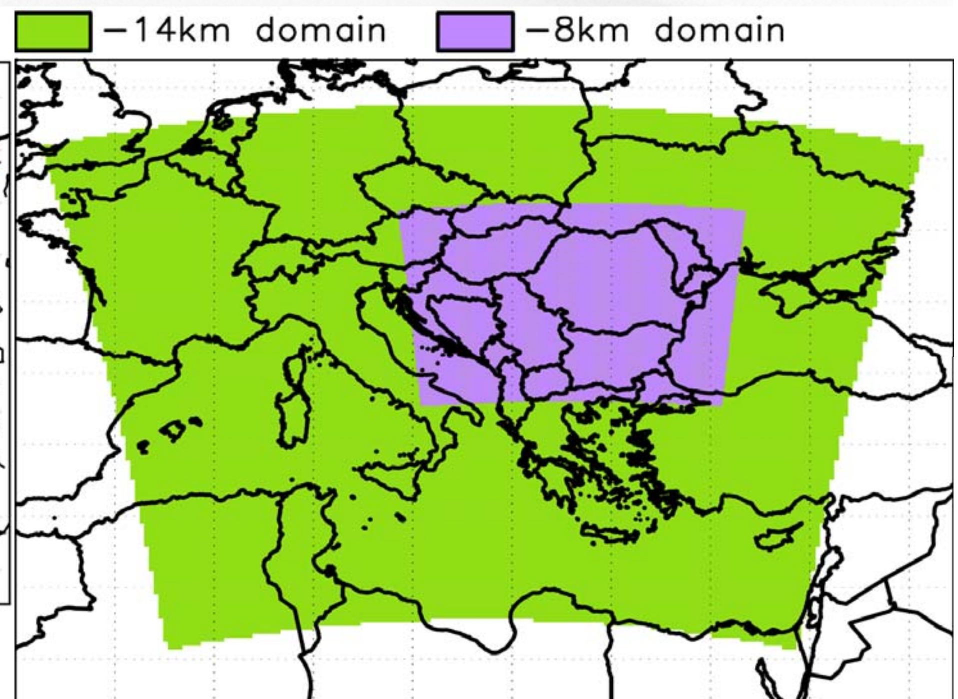
RHMSS/SEEVCCC RCM – climate simulations

- EBU-POM/SXG: base period 1961-1990, 2001-2030 (A1B scenario), 2071-2100 (A1B, A2; IPCC 2007).
- EBU-POM/ECHAM5 base period 1951-2000, 2001-2100 (A1B, A2).
- NMMB/CMCC: base period 1971-2004, 2005-2100 (RCP8.5, IPCC 2013).

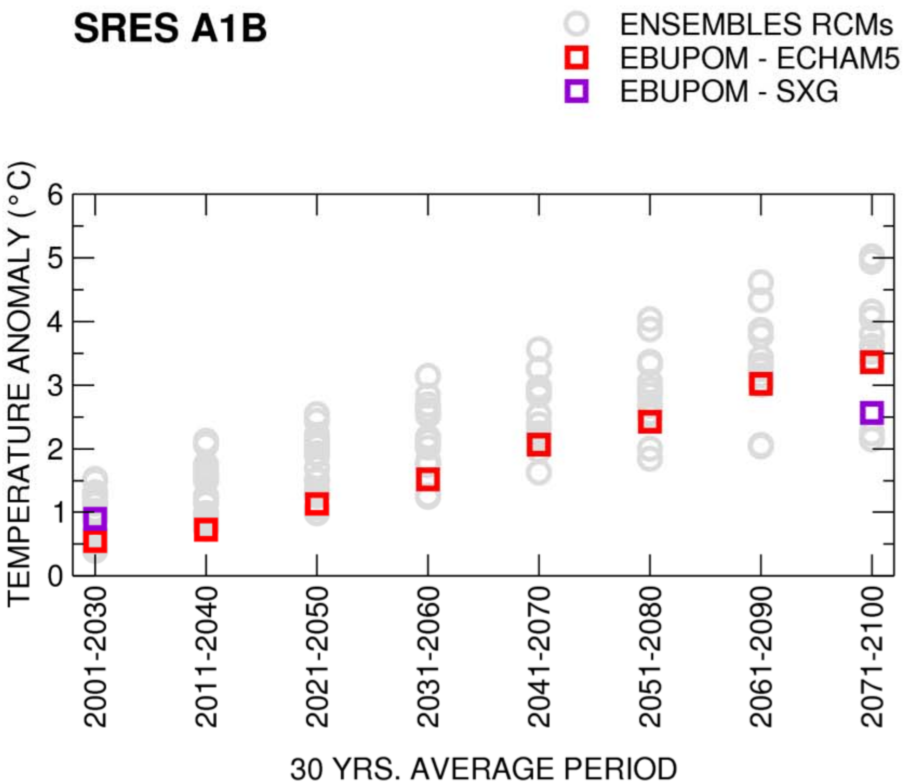
<u>EBU-POM domain</u>
EBU resolution 0.25deg,
POM resolution 0.20deg.



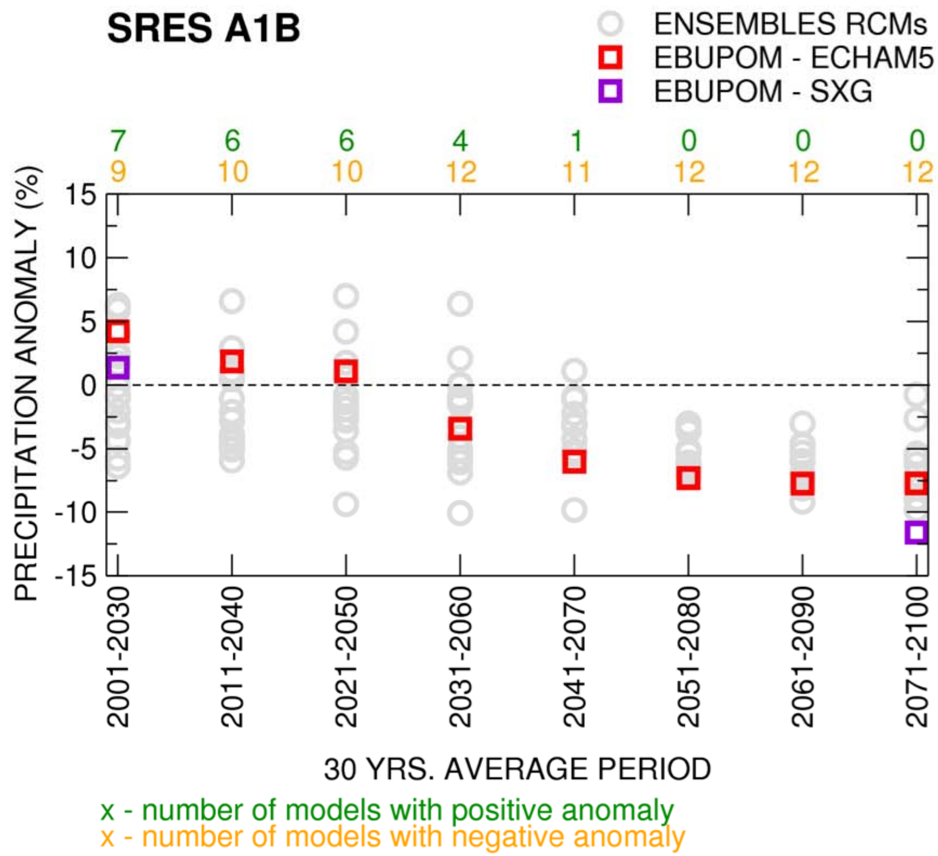
<u>NMMB domain</u>
green – low resolution (14km);
purple – high resolution (8km)



EBU-POM vs. 16 ENSEMBLES regional climate simulations:
analysis of the annual temperature and precipitation change for Serbia



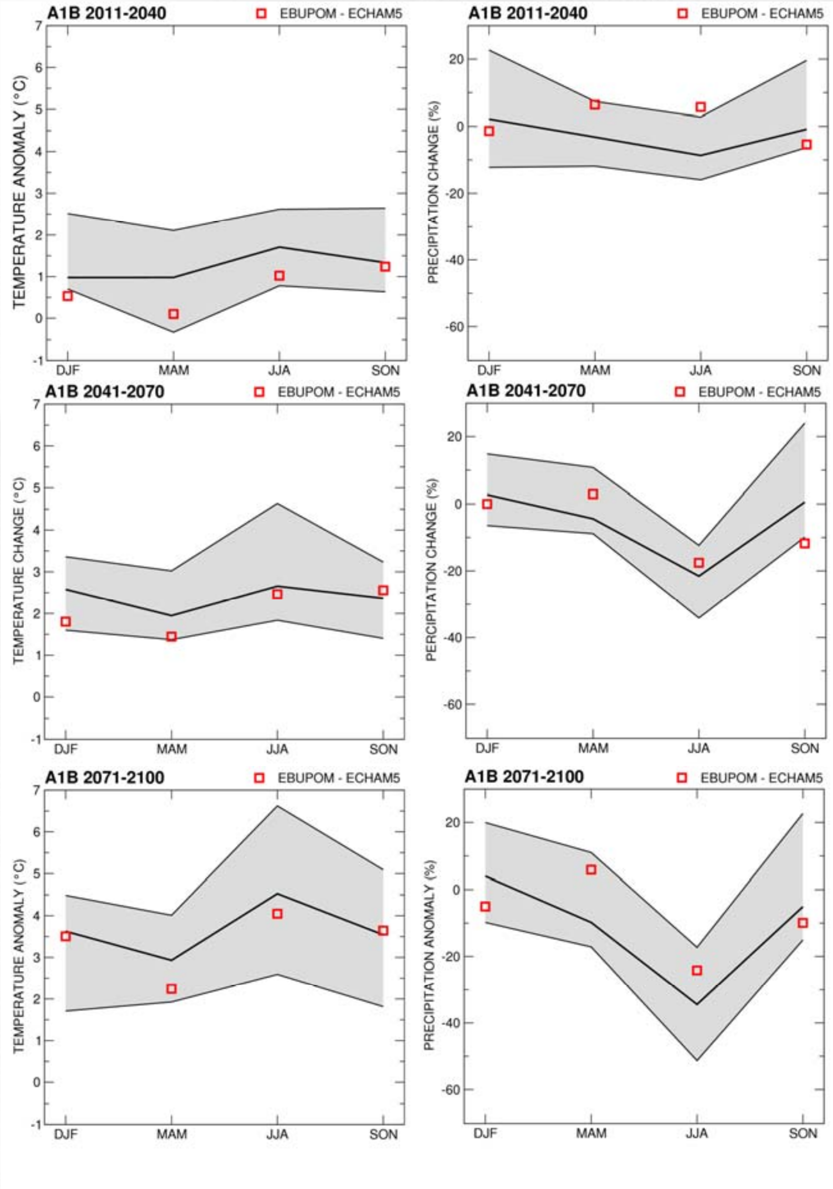
Anomalies of the mean annual temperature over the territory of Serbia comparing to the 1961-1990.



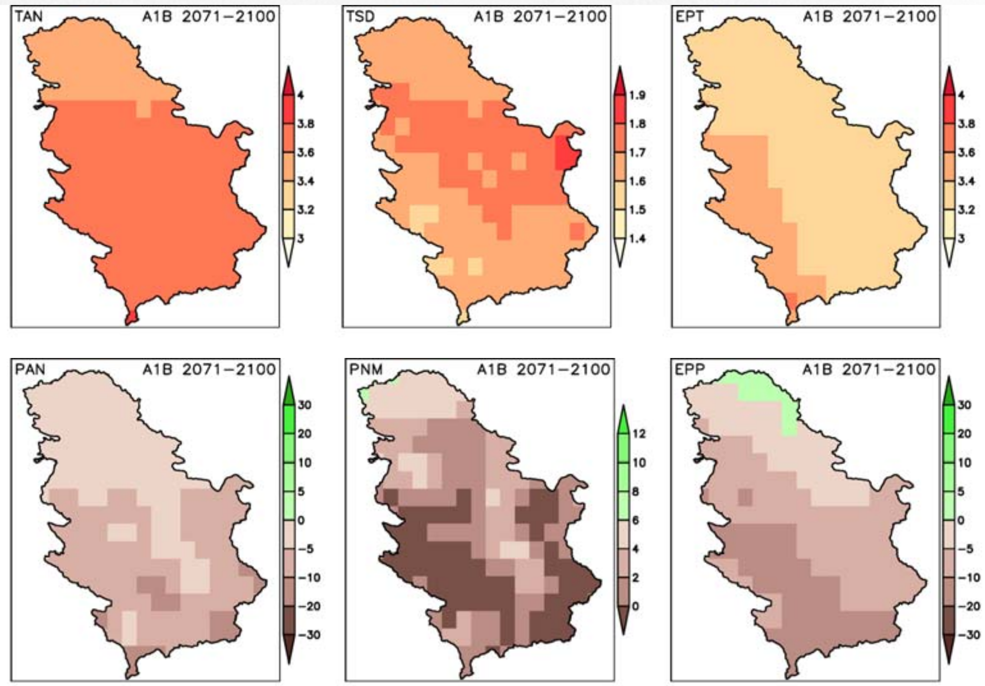
Anomalies of the accumulated annual precipitation over the territory of Serbia comparing to the 1961-1990.

EBU-POM/ECHAM5 & 16 ENSEMBLES regional climate simulations:

seasonal temp. and prec. change for Serbia; spatial analysis of temp. and prec. change



TAN= average mean annual temp. anomaly – ENSEMBLES;
STD=deviation of the ensemble members from the average value with 95% confidence;
EPT=EBU-POM mean annual temperature anomaly.



PAN= average acc. annual prec. anomaly (%)– ENSEMBLES;
PNM=number of ENSEMBLE members with positive prec. anomaly;
EPP=EBU-POM mean acc. annual prec. anomaly.

Main conclusions obtained from EMSEMBLES RCMs and EBU-POM/ECHAM5 results, forced with A1B IPCC/SRES, for 21st century

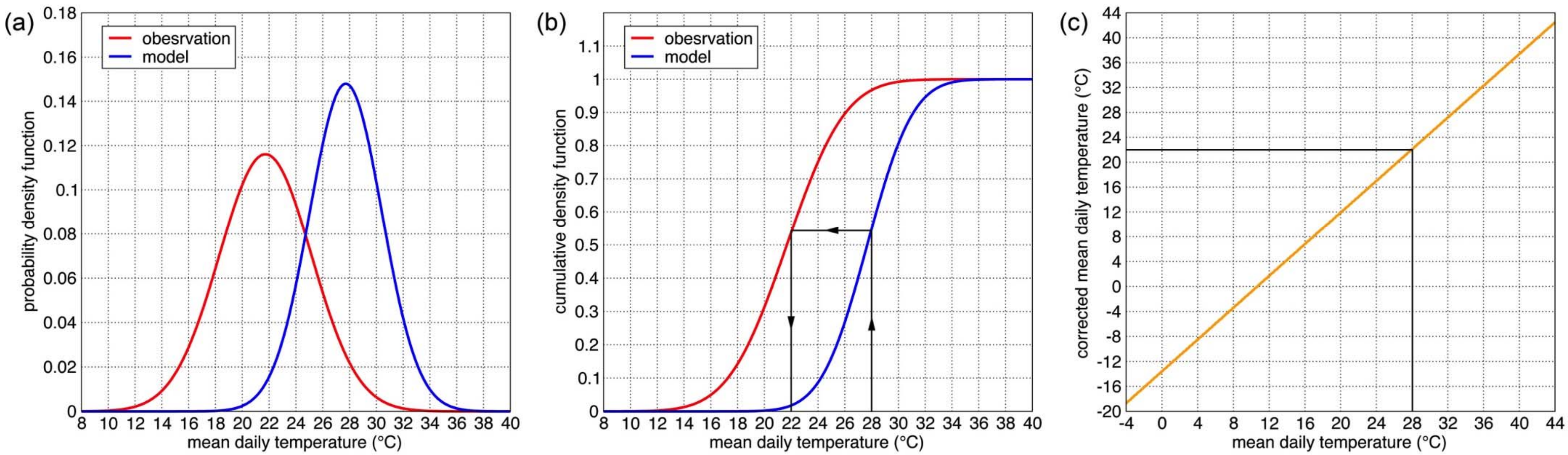
	2011-2040	2041-2070	2071-2100
average ensemble mean annual temperature anomaly	1.4C	2.6C	3.6C
second sigma of ensemble members' mean ann. temp. anom.	0.8C	1.1C	1.7C
EBU-POM mean annual temperature anomaly	0.7C	2.1C	3.4C
average ensemble mean annual accumulated precipitation anomaly	-1.6%	-3.4%	-6.6%
number of ensemble members with positive precipitation anomaly	6	1	0
EBU-POM mean annual accumulated precipitation anomaly	1.9	-5.5%	-7.3%

- Increase in temperature projected with all RCMs;
- Temperature anomaly increasing from over 1.0°C to over 3.0°C during 21st century in all seasons;
- Largest increase in temperature expected during summer with most probable value of 4.5°C by the end of the century;
- Annual accumulated precipitation over the territory of Serbia decrease is certain event during the second half of the century;
- Most severe precipitation change is expected during summer, summer precipitation decrease is certain event, and most probably over 30 % by the end of the century;
- North parts of Serbia are under lesser impact of climate change then central and southern parts;
- Higher altitudes will have largest and certain deficit in precipitation by the end of the century;
- EBU-POM results are inside the spread of ENSEMBLES RCMs data, but mainly gave less dramatic changes than most of the ENSEMBLES RCMs.

Statistical bias correction

- Daily model data for temperature (average, maximum, minimum) and precipitation:
  temperature (Gaussian distribution, monthly correction functions, bin 0.1C),
  precipitation (Gamma distribution with special consideration of dry days; monthly c.f, bin 0.1mmm).

- Necessary if daily data are needed for calculations of indices, as input for impact models, etc.
  (if calculation is not linearly dependable of the average 30y model output values).

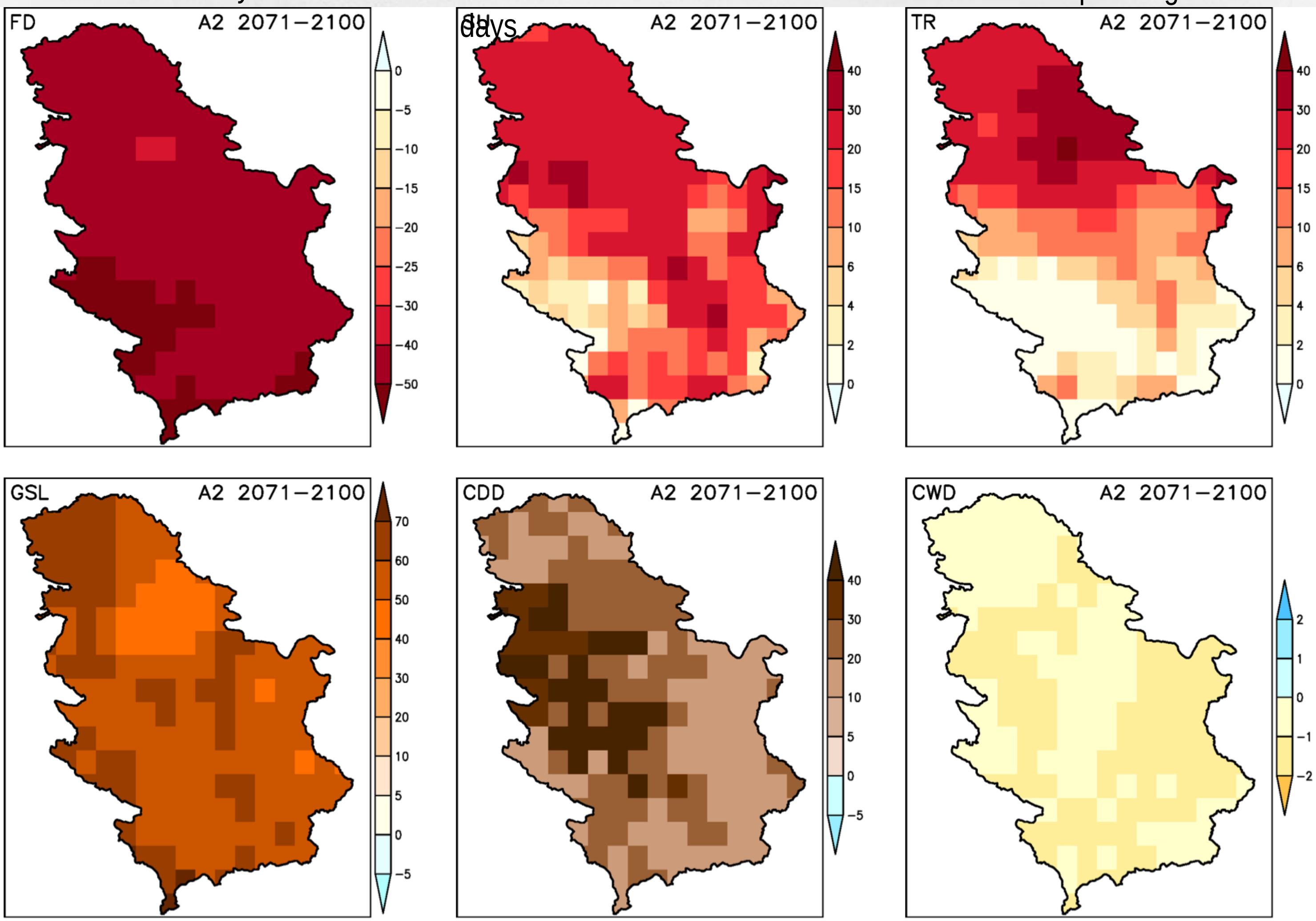


Extreme example: July temperature in SDP region for 1961-1990: EBU-POM and observed data.

⇒ Result: bias free daily values of the climate model simulations for use in impact studies.

Example: of bias corrected EBU-POM/ECHAM5 A2 IPCC/SRES applied for indices calculation

number of frost days | number of summer days | number of tropical nights



growing season length | consecutive dry days | consecutive wet days

Results are average values for 2071-2100 (A2) compared to 1961-1990.

Main conclusions from EBU-POM/ECHAM5 A1B and A2 IPCC/SRES compared to 1961-1990

Temperature change for 2011-2040; 2041-2070; 2071-2100:

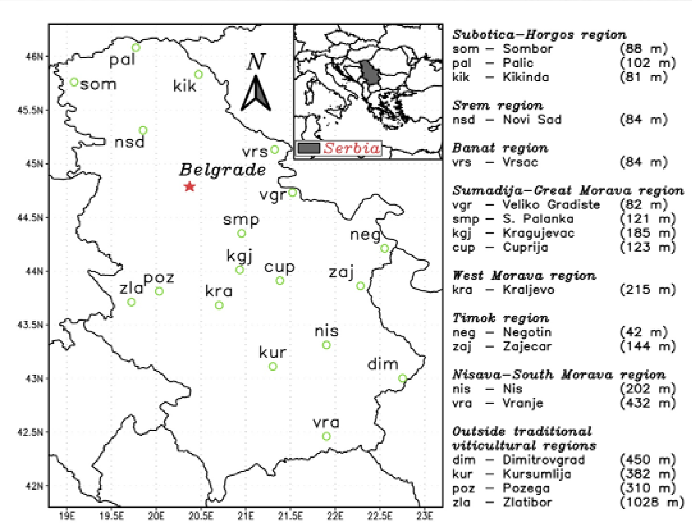
- A1B and A2 scenario show increase in air temperature over the whole territory of Serbia;
- spring season has the smallest projected change of temperature, most extreme changes are expected for the summer and fall seasons;
- during the periods 2011-2040 and 2041-2070 increase in temperature is more pronounced under A1B scenario than A2;
- at the end of the century (2071-2100) change of A2 temperature is overcoming A1B values;
- FD, SU, TR, GSL: show somewhat larger change toward warmer climate under A1B scenario, while at the end of the century results obtained under A2 scenario reach and overcome values gained from simulations with A1B scenario;
- Both scenarios in general project decrease of FD, increase of SU and TR, and significant expansion of GSL.

Precipitation change for 2011-2040; 2041-2070; 2071-2100:

- increase in precipitation during the period 2011-2040;
- decreasing trend toward negative values of precipitation change over the whole Serbia by the end of the century;
- during the summer season drying is most pronounced, and for the spring season in general is projected increase of precipitation or insignificant change;
- less precipitation is projected with A1B scenario than A2 during the first two periods (2011-2070)
- at the end of the century results obtained under A2 show drier climate than with A1B;
- dry period (CDD) is prolonging with time, in general more extremely according to A1B scenario during the first two periods, and at the end of the century results from A2 scenario simulations exceed A1B;
- CWD has negative trend but not significant. Largest changes are under 2 days.

http://haos.ff.bg.ac.rs/climatedb-srb/

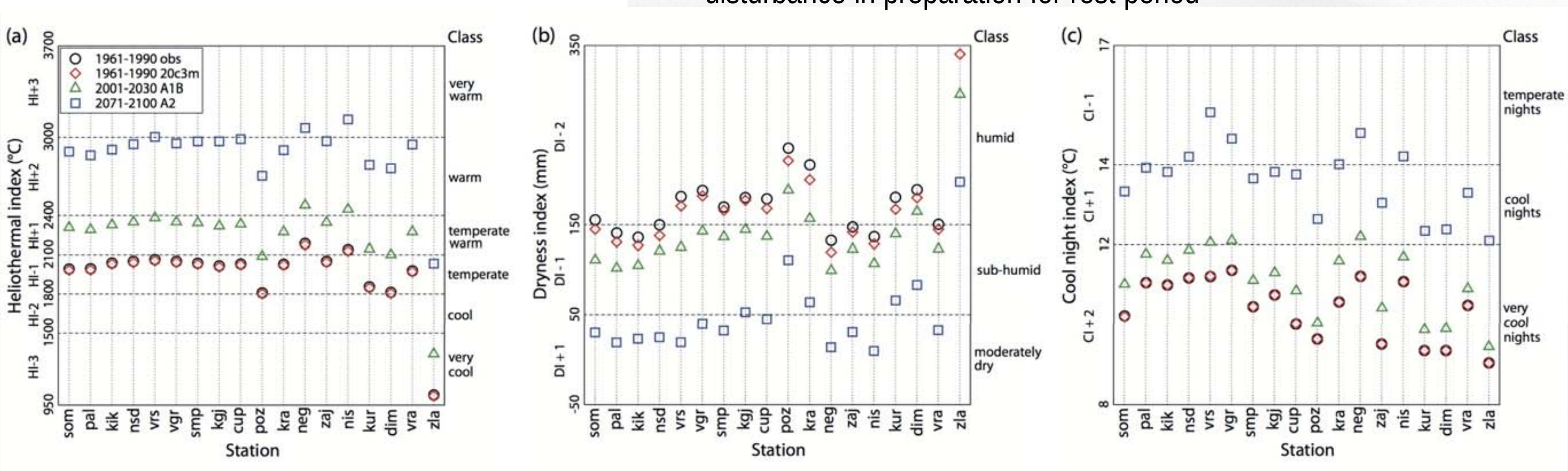
Other special studies: impact of climate change on viticulture in Serbia



Serbian viticulture regions; base period 1961-1990;
use of bias corrected EBU-POM/SXG data for 21st century.

<u>General conclusions:</u>

- warming and drying of Serbian vineyards
- appropriate climate conditions for vine growing shift to higher altitudes (~1000m altitude)
- higher risk of spring frost,
- extended growing season
- early ripening, possible double ripening,
- higher concentration of sugar due to extended dry periods during growing season
- disturbance in preparation for rest period



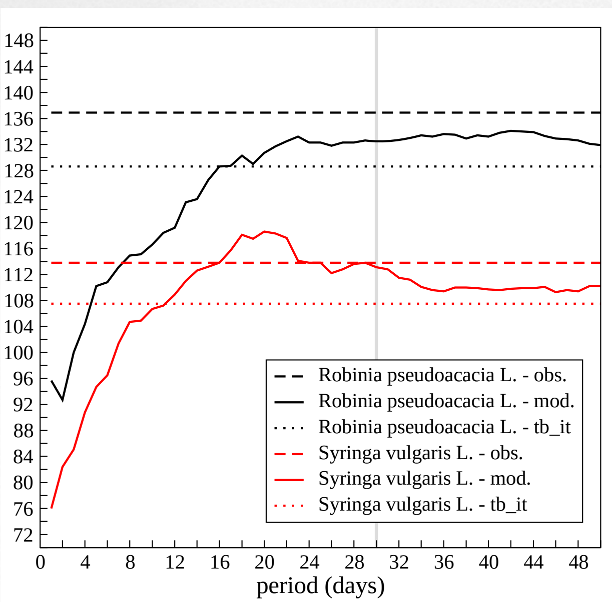
Ruml M., Vukovic A., Vujadinovic M., Djurdjevic V., Rankovic-Vasic Z., Atanackovic Z., Sivcev B., Markovic N., Matijasevic S., Petrovic N., 2012, ”On the use of regional climate models: Implications of climate change for viticulture in Serbia”, *Agricultural and Forest Meteorology*, 158, 53-62

Other special studies: impact of climate change on Woody taxa flowering

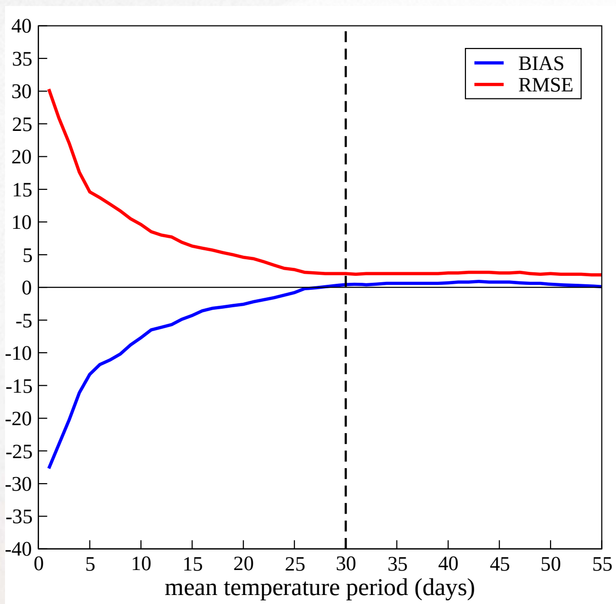
- Observed flowering for ~100 woody taxa (2007-2012); Belgrade region (Stojicic, 2014: Influence of the environmental factors on Woody taxa flowering from Magnoliophyta group in Belgrade, PhD thesis, Faculty of Forestry, University of Belgrade)

  ⇒ Taxa show early flowering in 2007-2012 compared to the historical data from RHMSS and data collected in the different literature
- Observed data for 2007-2012 used for creating a connection between temperature and flowering: threshold for mean 30days temperature before flowering for each taxon, when exceeded flowering occurs;
- Model for flowering verified applying it on historical data of flowering 1961-1990;
- Model applied on climate projections EBU-POM/SXG to calculate flowering date;
- Bias corrected data needed.

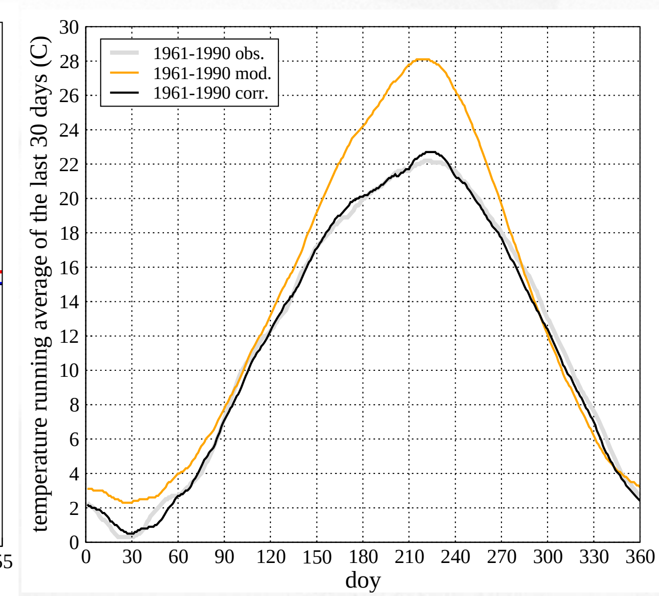
Testing the flowering model on 1961-1990.

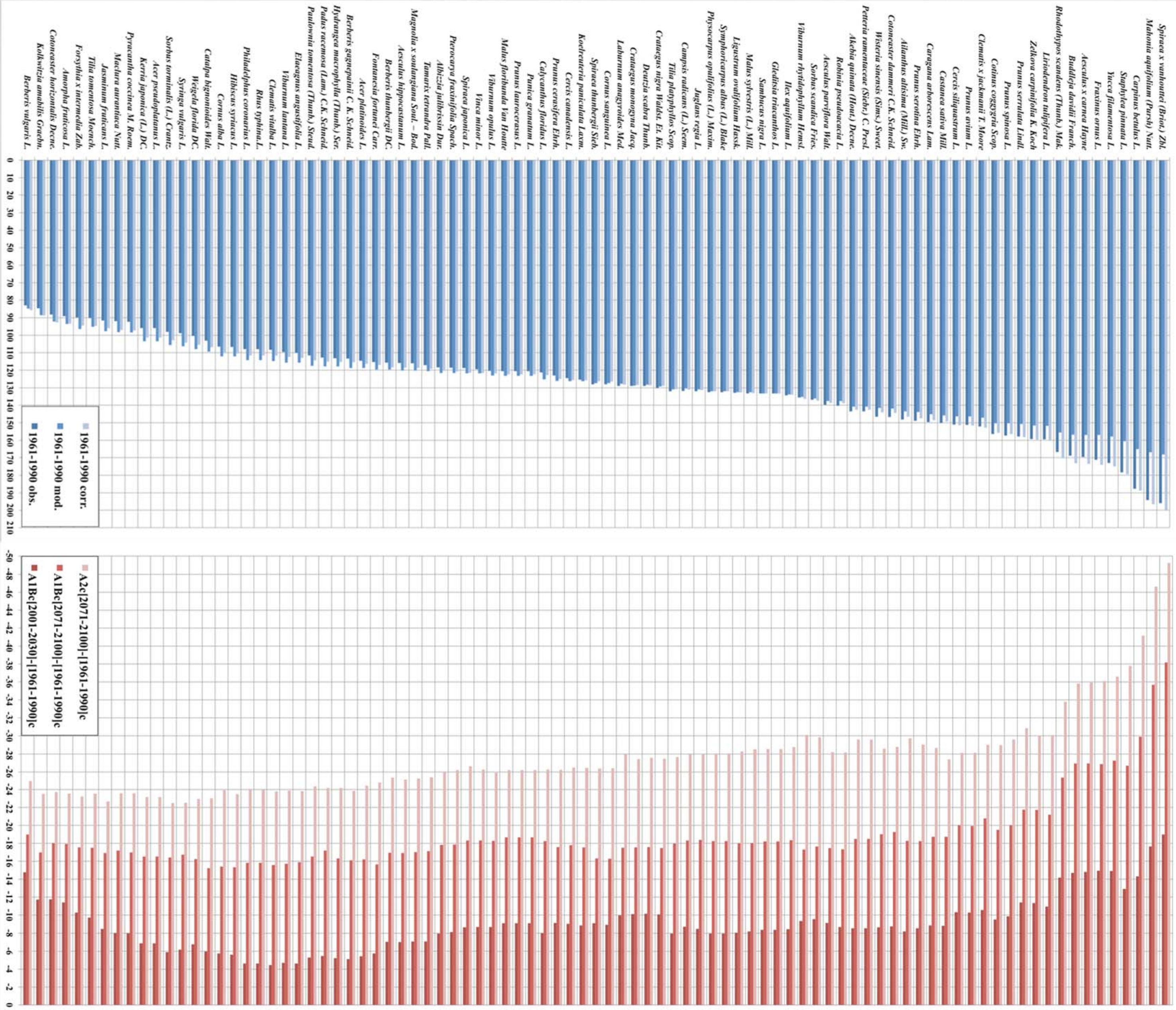


Model verification: BIAS & RMSE.



30days running average; showing importance of bias correction.





Belgrade region;
~100 Woody taxa
base period: 1961-1990

Flowering depends on 30days mean temperature before flowering.

General conclusions:

- Shift in flowering
  - 2001-2030: 10-30 days
  - 2071-2100: 20-45 days

Selected conclusions

- Higher temperatures, less precipitation – dryer and warmer climate projected for Serbian territory;
- Higher frequency of extreme temperatures, longer periods without precipitation – draught;
- Less precipitation but more days with precipitation > 10mm – extreme precipitation events, hail;
- In general higher frequency of extreme events;
- Increase in crop damage (sunburns, hail damage, late frost damage, disturbed dormant period, new crop diseases, etc.);
- Latest research on CC impact on agriculture, vulnerability and risk assessments, adaptation measures in agriculture can be found in:

  Second National Communication of the Republic of Serbia, 2014: Report 6 and 8 – under development

  Ruml et al. 2014: Response of grapevine phenology to recent temperature change and variability in the wine-producing area of Sremski Karlovci, Serbia, under revision.

  Mihailovic et al. 2014: Impact of observed and projected shifts of Köppen climate zones on the crops yield change in Serbia under the SRES-A1B and SRES-A2, under revision.

  etc…..

<u>Climate is changing, unknown weather in upcoming seasons:</u>

⇒ Early warning system needed to prepare for extreme weather conditions

⇒ Need for developing full system: seasonal, monthly, medium and short range forecast

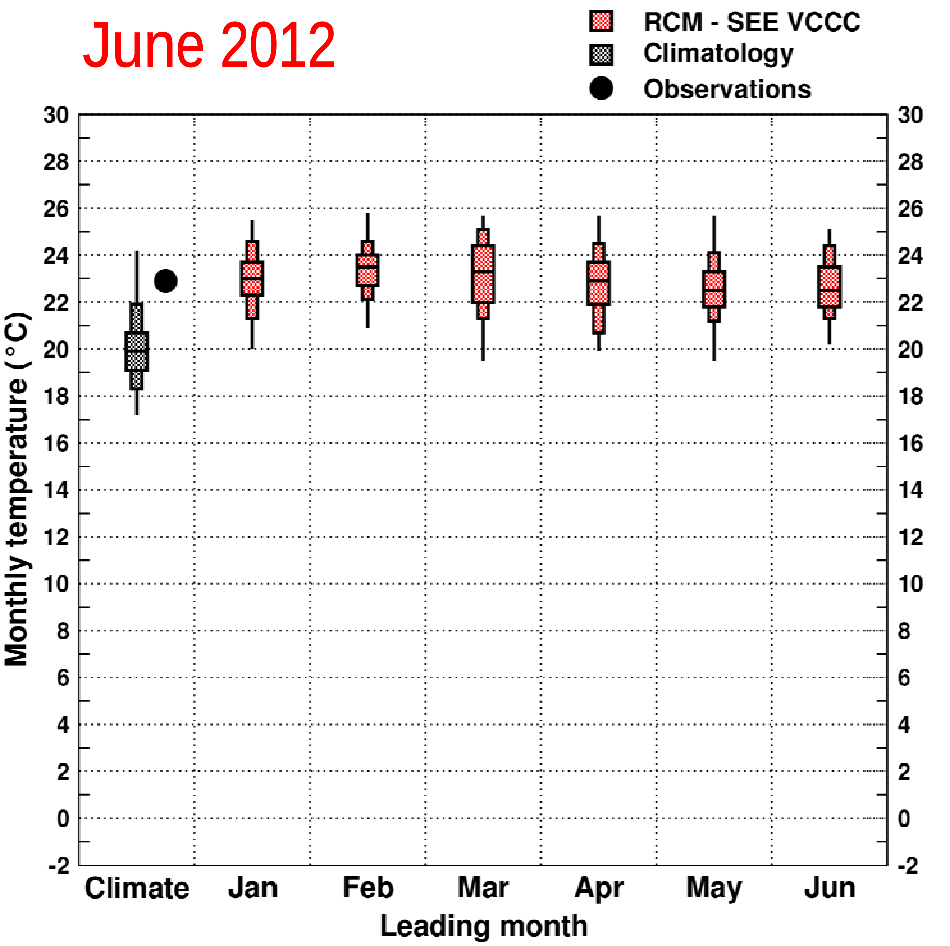
Mean monthly temperature forecast during the heat wave

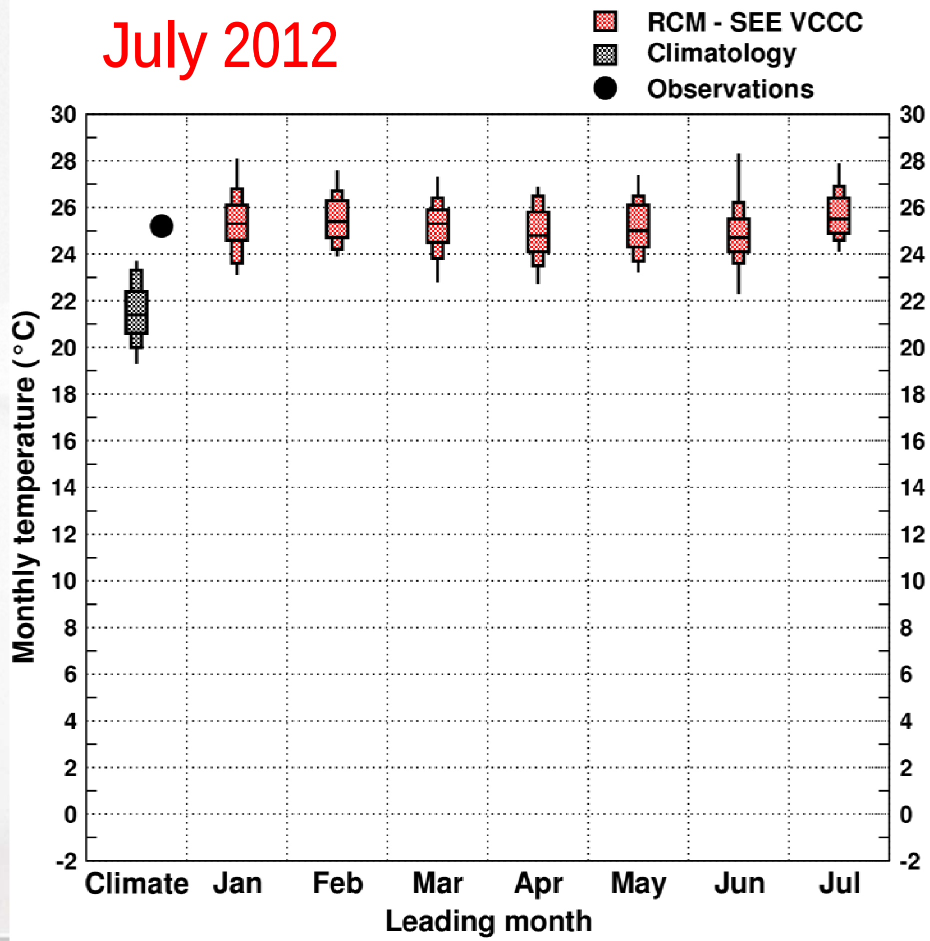
Leading months: January – September 2012

Climatology: 1961-2010

Observations: Rimski Sancevi, Vojvodina, Serbia, 2012

Percentiles: (min),10, 25, 50, 75, 90, (max)





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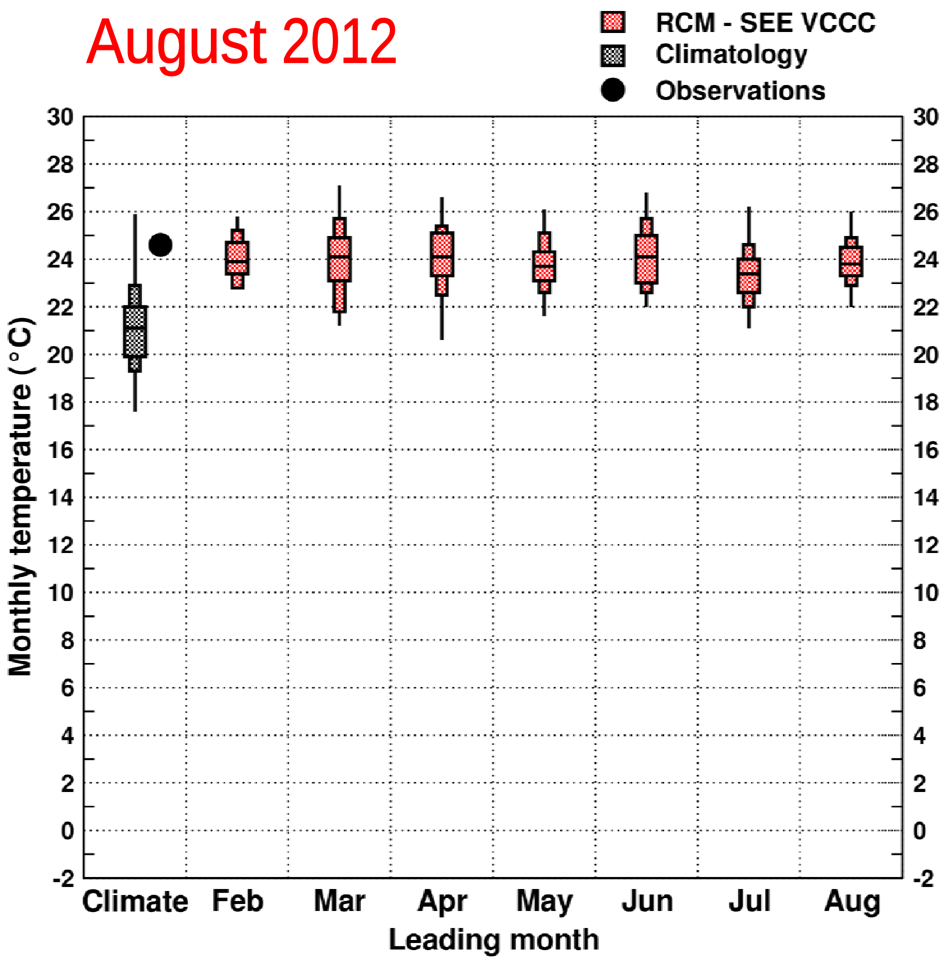
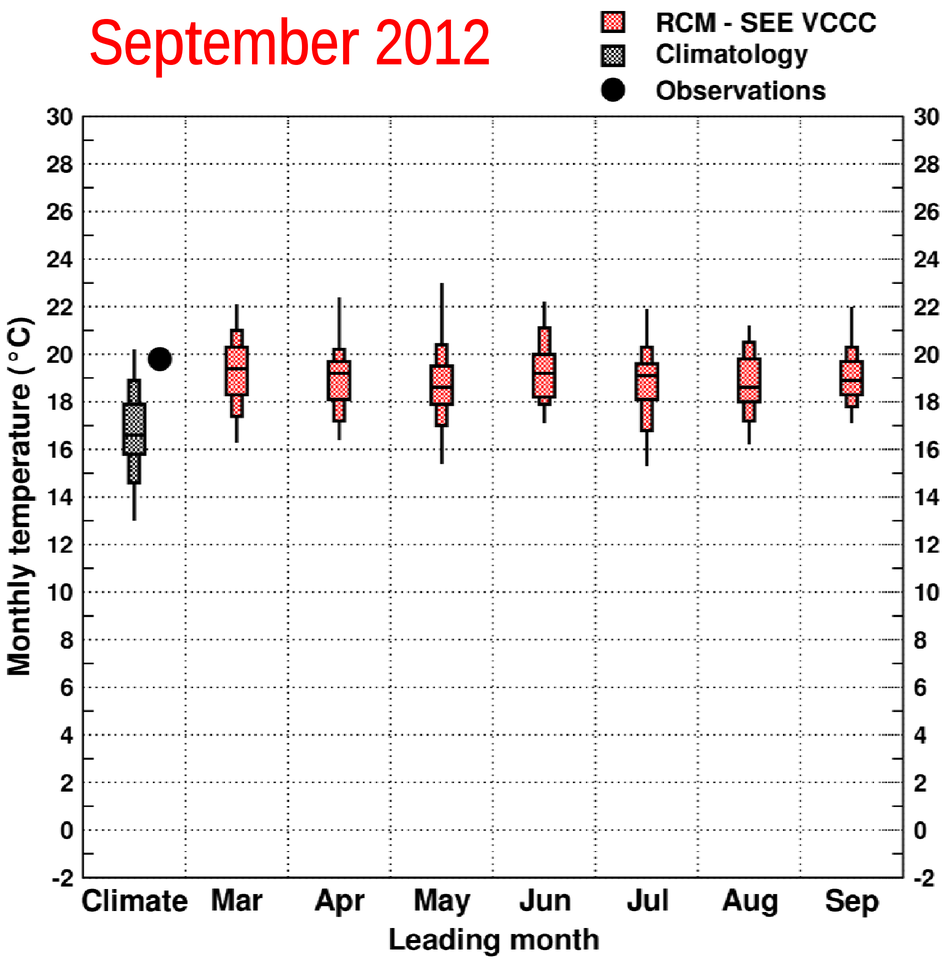




Start/end of the growing season period – year 2012

6 consecutive days with T>10C during Jan-Jun – start

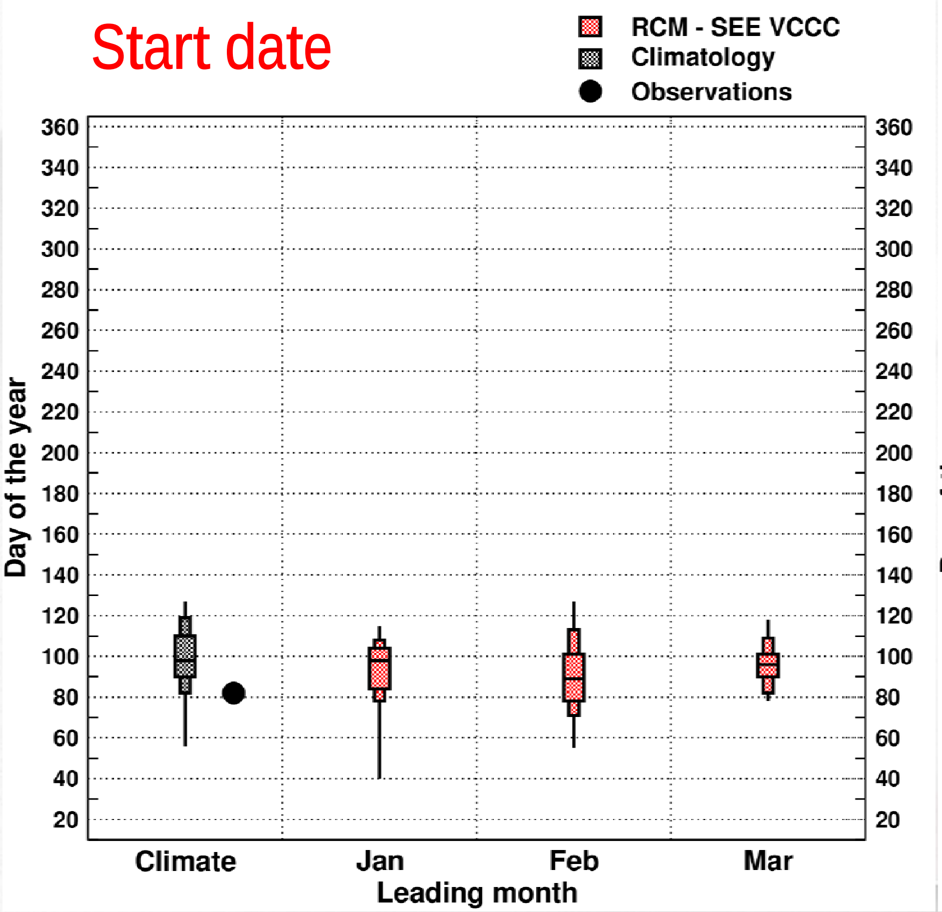
6 consecutive days with T<10C during Jul-Dec – end

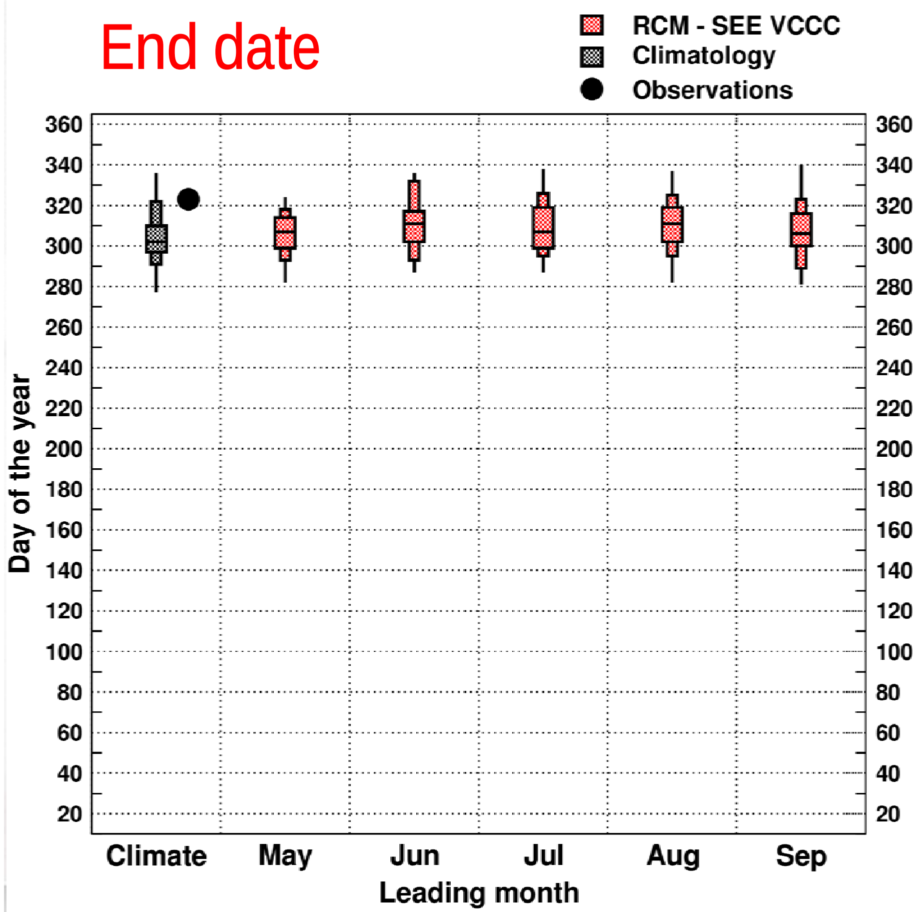
Leading months: January – September 2012

Climatology: 1961-2010

Observations: Rimski Sancevi, Vojvodina, Serbia, 2012

Percentiles: (min), 10, 25, 50, 75, 90, (max)





Grapevine ripening date for GDD 2800/3500 – year 2012

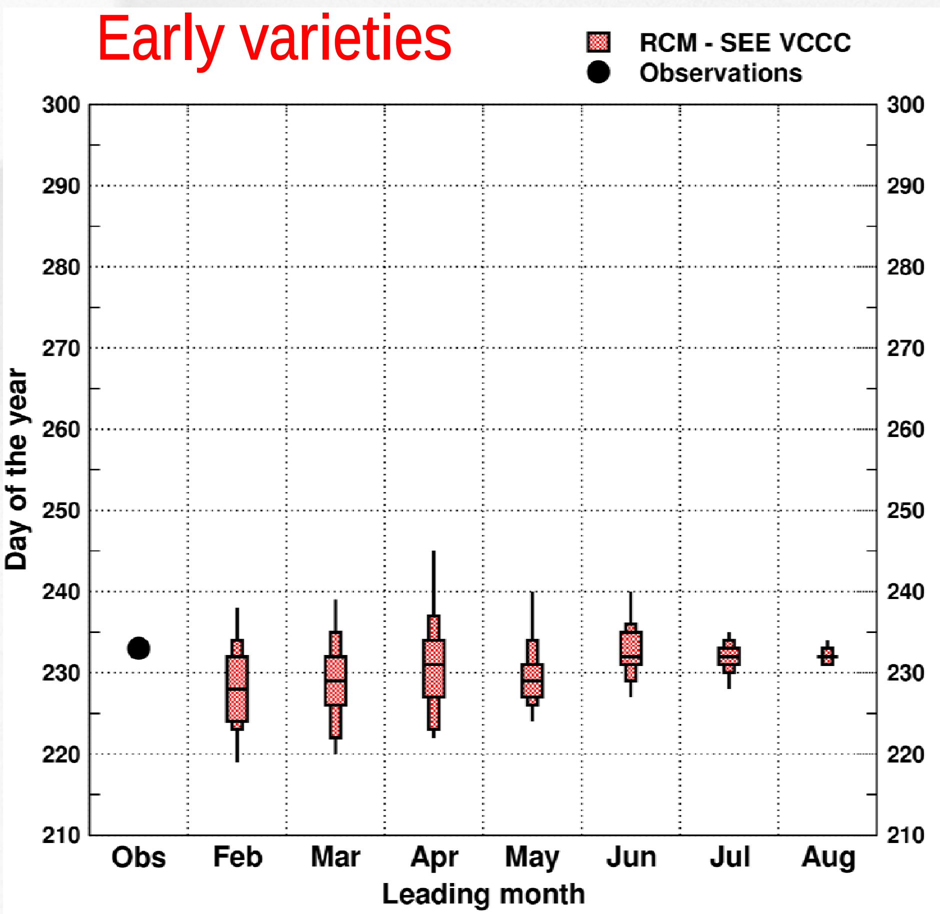
Start of the growing season fixed on 1.april, GDD=sum(T), if T>10C

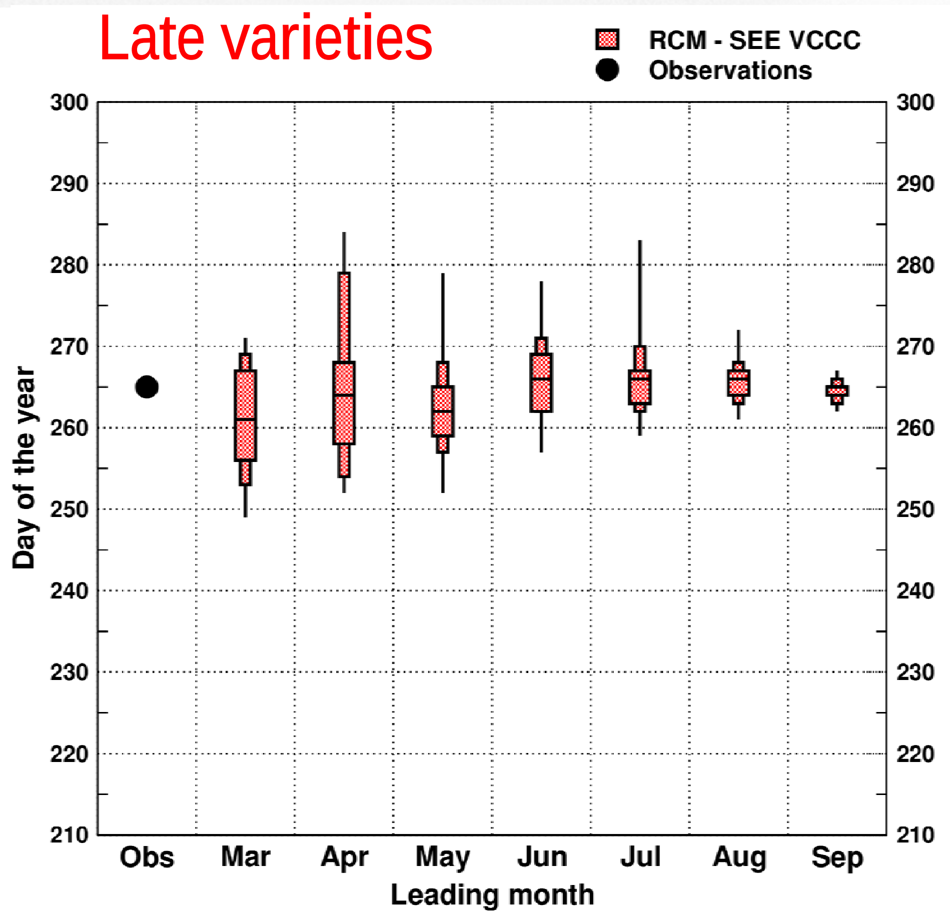
Ripening date = first day when GDD reached 2800/3500 heat units

Leading months: January – September 2012

Observations: Rimski Sancevi, Vojvodina, Serbia, 2012

Percentiles: (min),10, 25, 50, 75, 90, (max)





Adaptation

- Problems in vulnerability and risk assessment:
  availability of the data and observations for evaluation of the so far impact of CC in agriculture;
  knowledge about relation of the climate and different plant varieties development;
  use of verified and reliable methods in application of climate projections.
- Share of the collected knowledge to all: from decision makers, general public, to small farmers
- Collaboration with different sectors of economics
- Analysis of climate change impacts according to the need of users
- Preparation of data in the form understandable for others
- Examples of the initial implementation of the adaptation measures: increased investments in anti-hail net covers, development of the irrigation system, optimization of irrigation, optimal use of fertilizers, plant protection, change in crop selection, etc.
  (in the latest project for the Viticulture zoning in Serbia are added varieties appropriate for changed climate, and boundary for allowed altitude for grape growing shifted to higher altitudes).