

# Issues in statistical downscaling modeling. Application for Romanian climate.

**Aristita Busuioc**

National Meteorological Administration, Bucharest, Romania

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Oslo, 3-4 October 2005 29**

# Main issues in statistical downscaling modeling

- Choice of methods/predictors
- Evaluating of statistical downscaling technique
- Extremes
- Expression of uncertainty

# Choice of methods and predictors

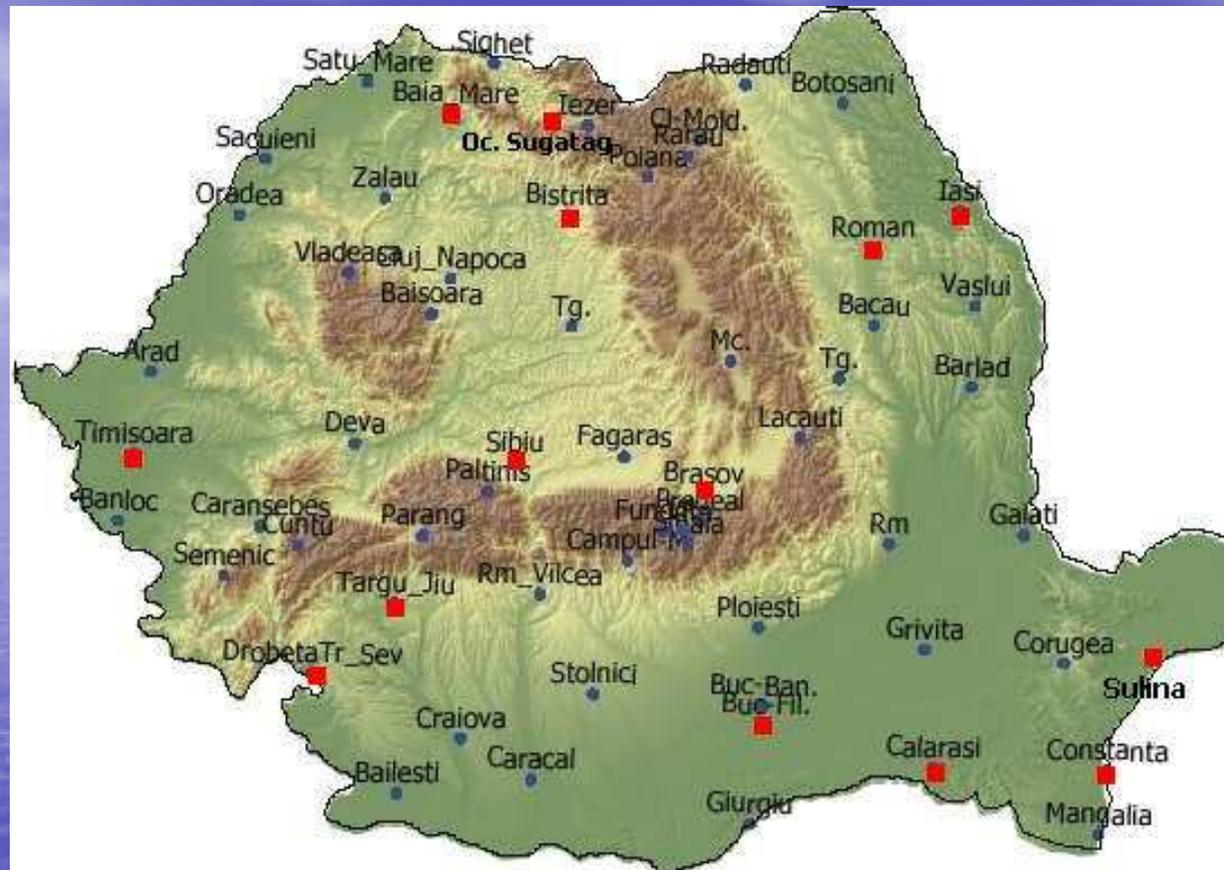
## Methods:

**Regression based on CCA** (Busuioc et al., 1999, 2001, 2005)

- monthly/seasonal mean temperature ;
- seasonal precipitation;
- seasonal frequency of extreme precipitation;

**Conditional stochastic model** (Busuioc and von Storch, 2003);

- daily precipitation time series, focusing on extreme events



Stations used in this presentation (1961-2000), in red-  
stations with longer time series-1901-2000)

## ● Predictors:

- Sea level pressure (SLP);
- Geopotential height (500 hPa);
- Specific Humidity (SH);
- Grid point temperature at European scale;
- Geopotential thickness (1000-500 hPa);

## Summary:

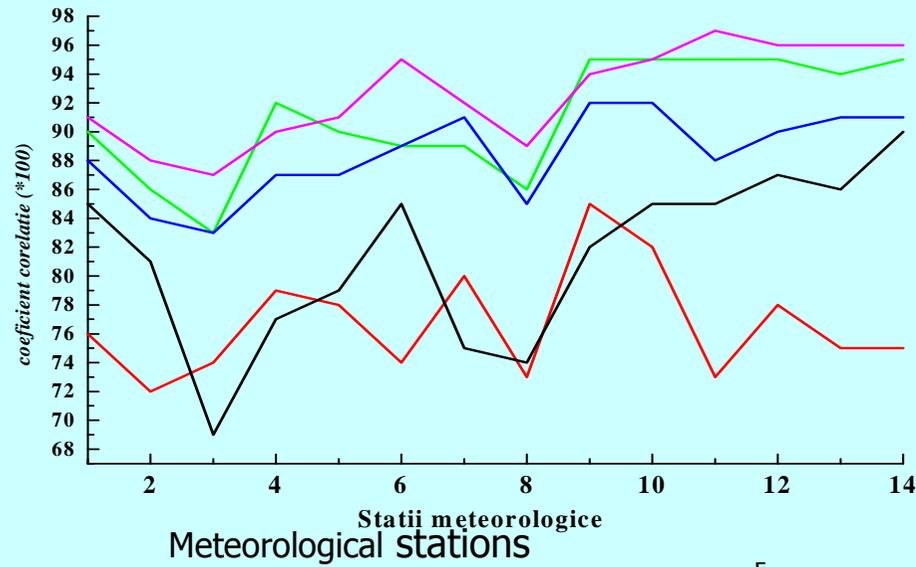
### Precipitation:

- SLP alone is generally the best predictor, the highest skill for winter and autumn; the skill is dependent on the SLP size, length of validation/calibration interval but some spatial features are constant **Busuioc et al., 1999; Busuioc et al., 2005);**
- The inclusion of SH as a further predictor in the SDM only adds improvements to the model skill for some stations but the explained variance is low **(Busuioc et al., 2005);** H500 does not improve the SLP skill **(Busuioc, 2001);**

### Temperature:

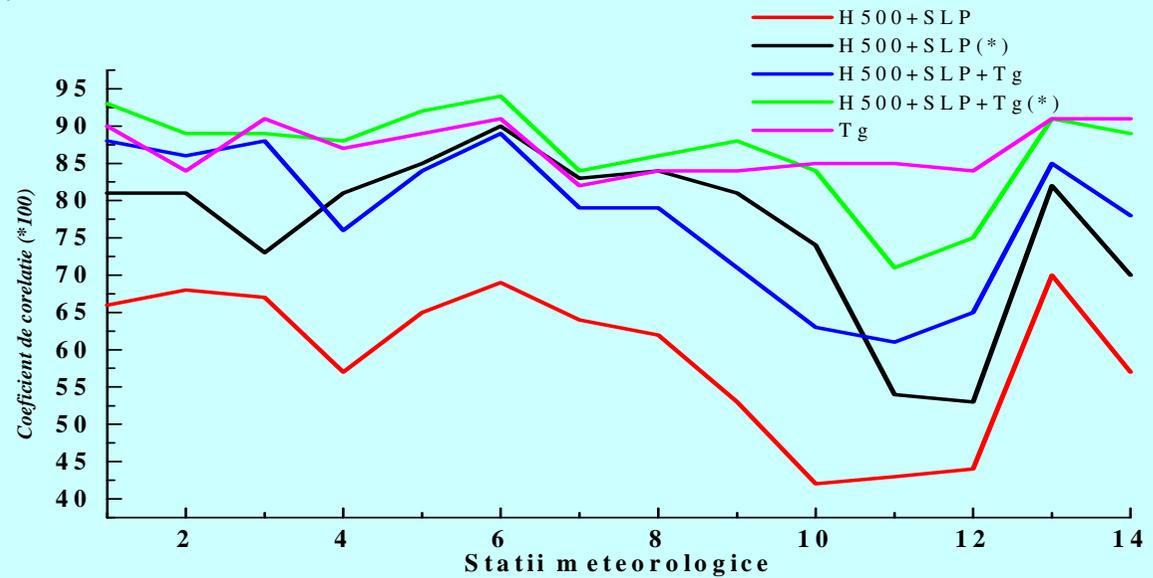
- The combined vector of large-scale (SLP, H500, Tg) and combined vector of local-scale temperature and precipitation gave a sensibly higher skill than any single predictor; similar skill is obtained by using Tg alone as predictor **(Busuioc, 2001);**
- For the July mean temperature the thickness 1000-500 hPa is a better predictor than SLP while for the January the SLP is better.

winter



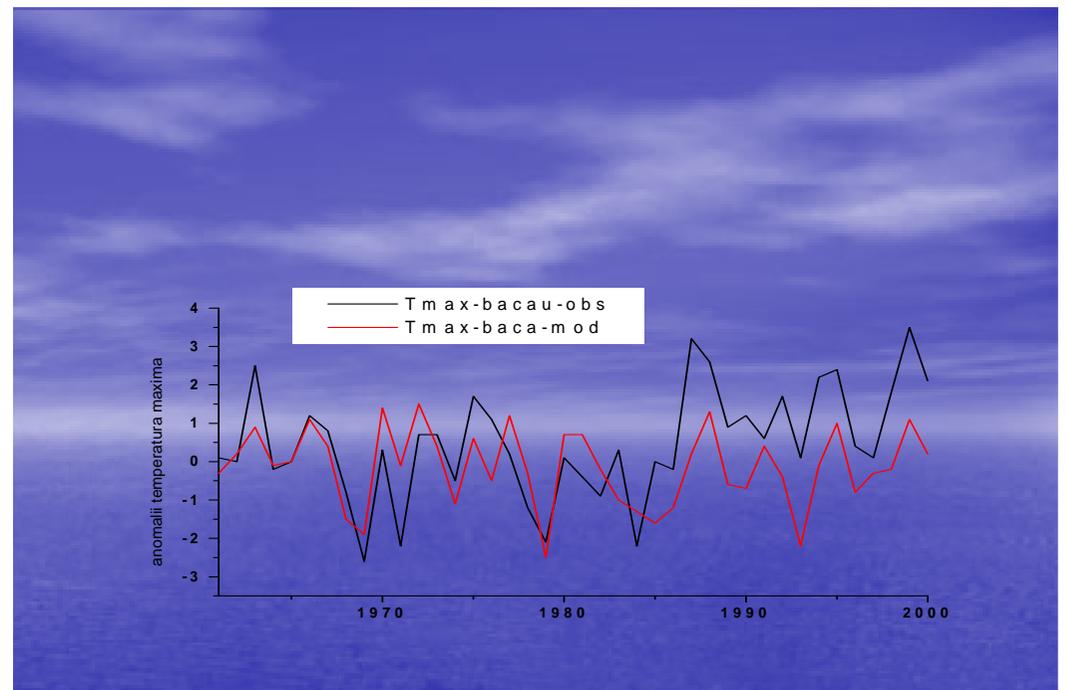
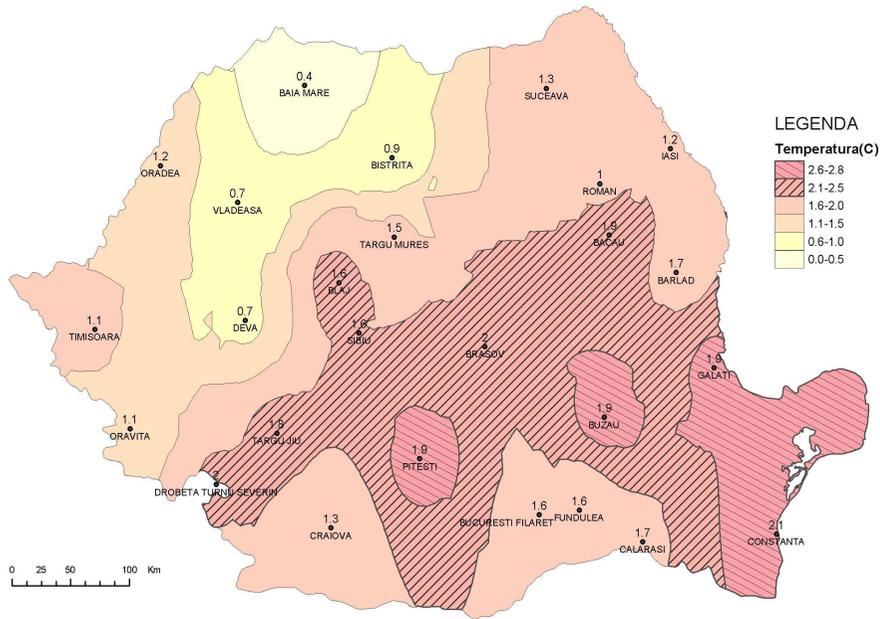
**Skil of the CCA model for the seasonal temperature for various predictors,  
\*-combination with precipitation as predictand**

Calibration:1975-2000,  
1951-1974:validation

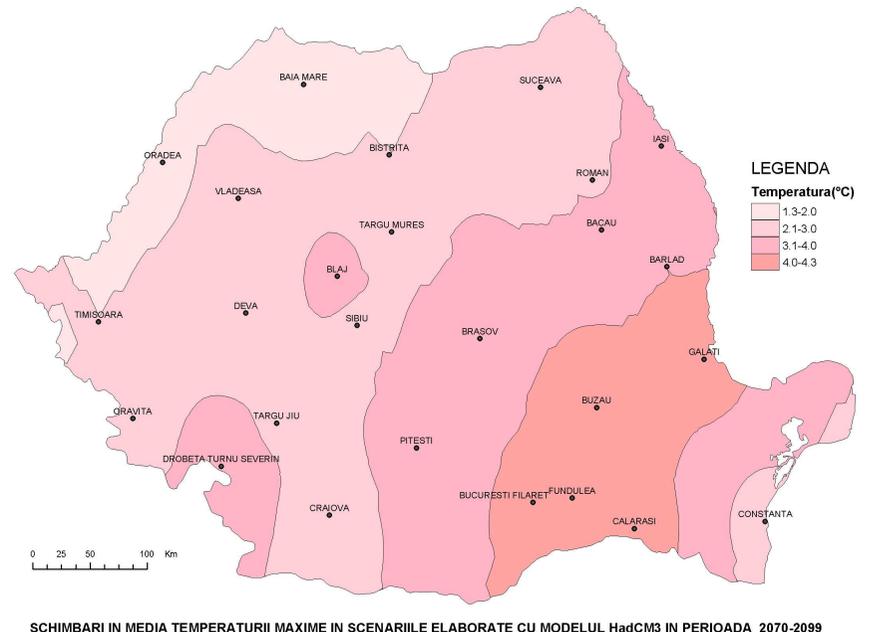


summer

(Busuioc, 2001)



## Trends of July mean maximum temperature 1961-2000

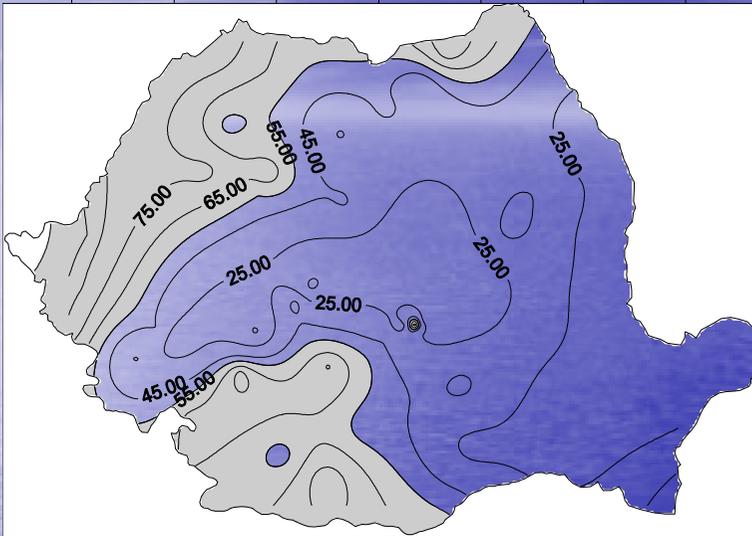


SCHIMBARI IN MEDIA TEMPERATURII MAXIME IN SCENARIILE ELABORATE CU MODELUL HadCM3 IN PERIOADA 2070-2099

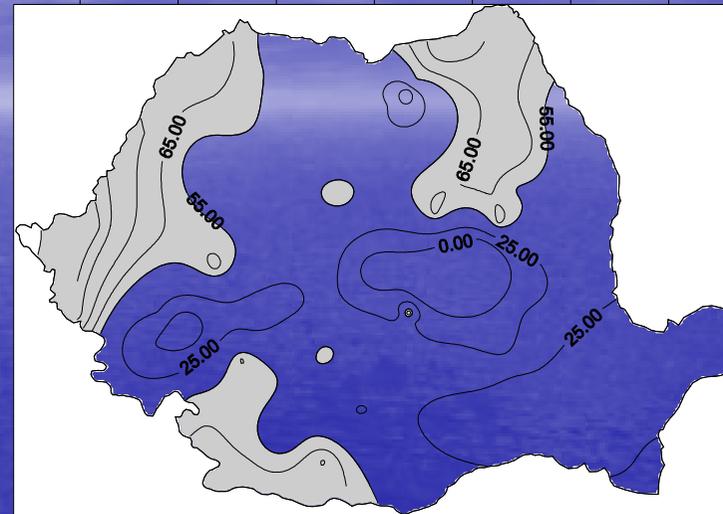
## Downscaling for Tmax; 2070-2099, SLP predictor, HadCM3-A2

Skill of the statistical downscaling model (correlation coefficient) for various predictors over the independent data set 1991-2000, calibration:1961-1990  
(Busuioc et al. 2005)

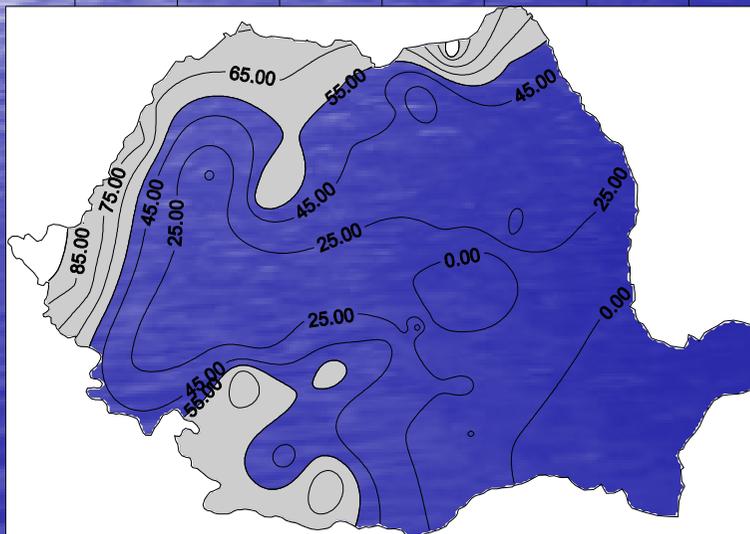
**SLP**



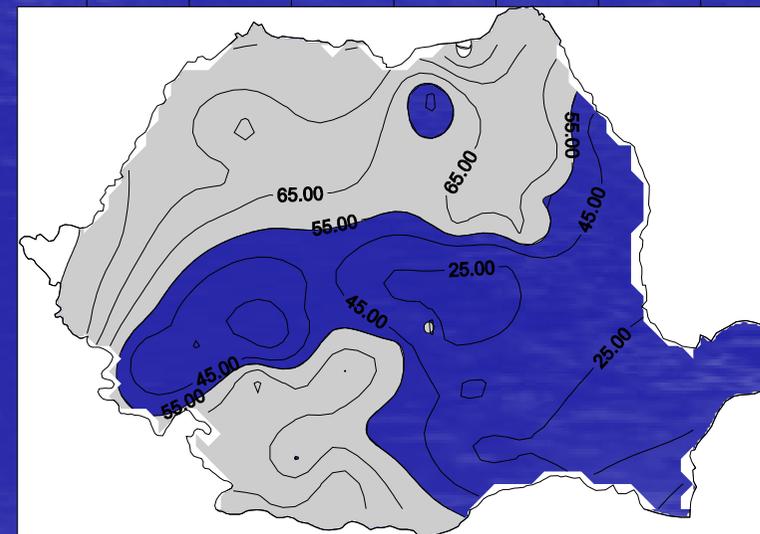
**SH**



**SLP+SH**

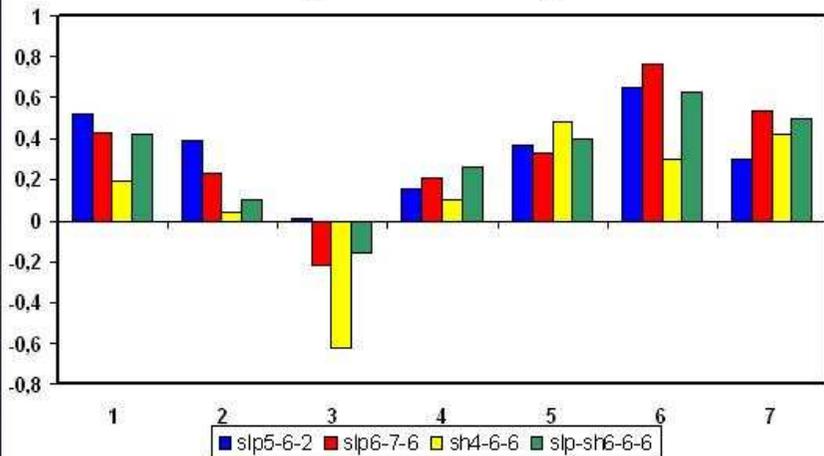


**OPTIMUM**

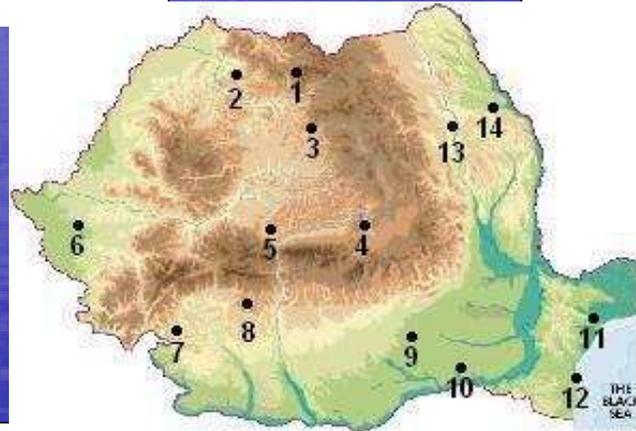
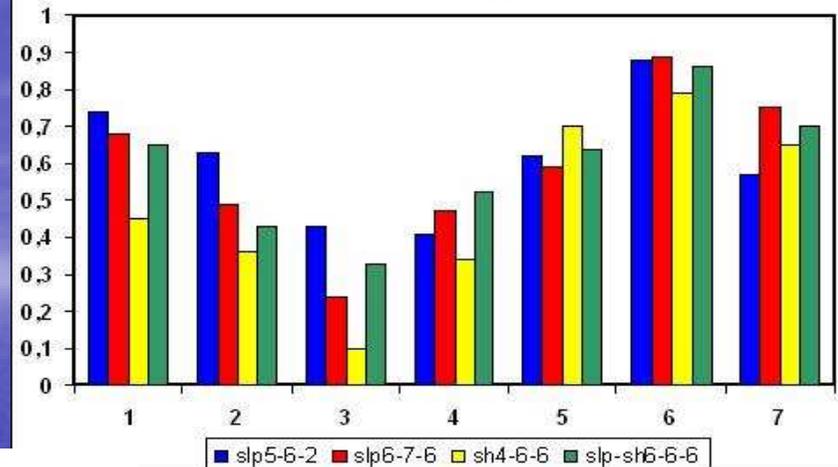


# Performance of the statistical downscaling model for various predictors

## Explained variance (I)

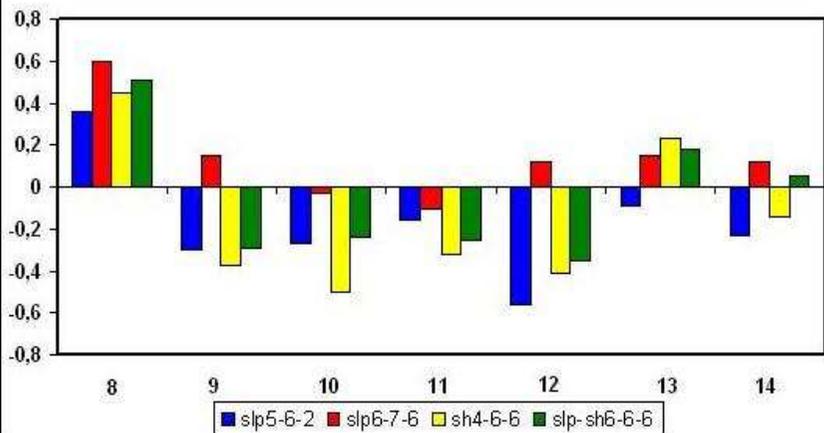


## Correlation coefficient

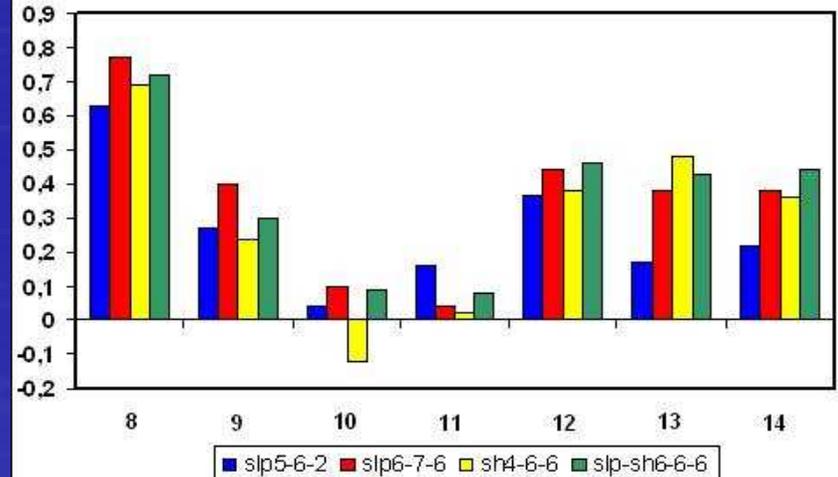


**Validation interval:  
1951-1960+1991-2000**

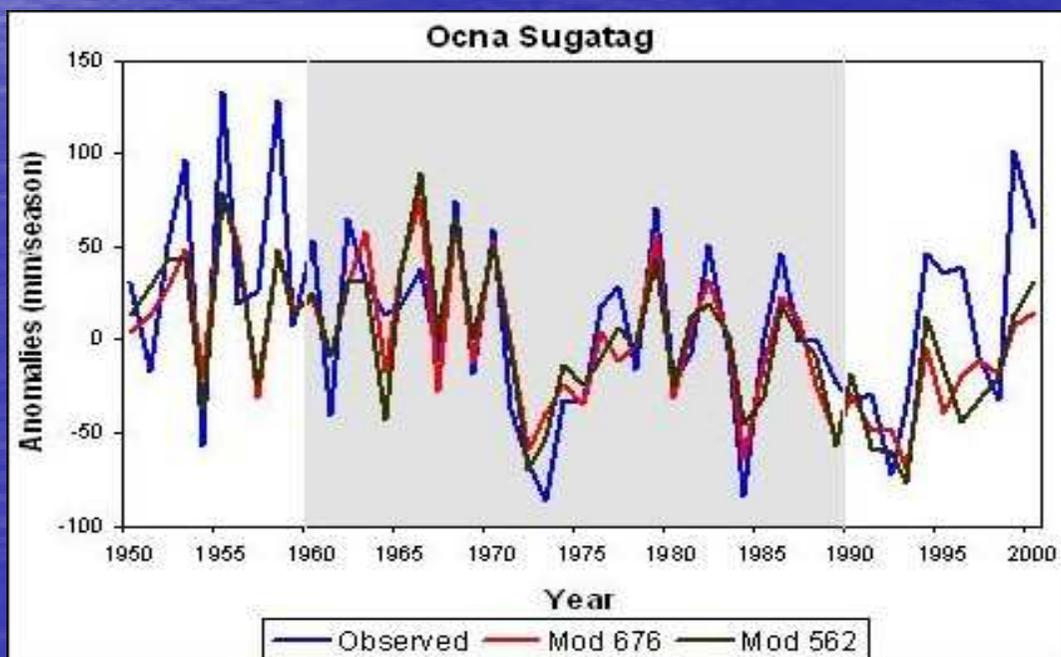
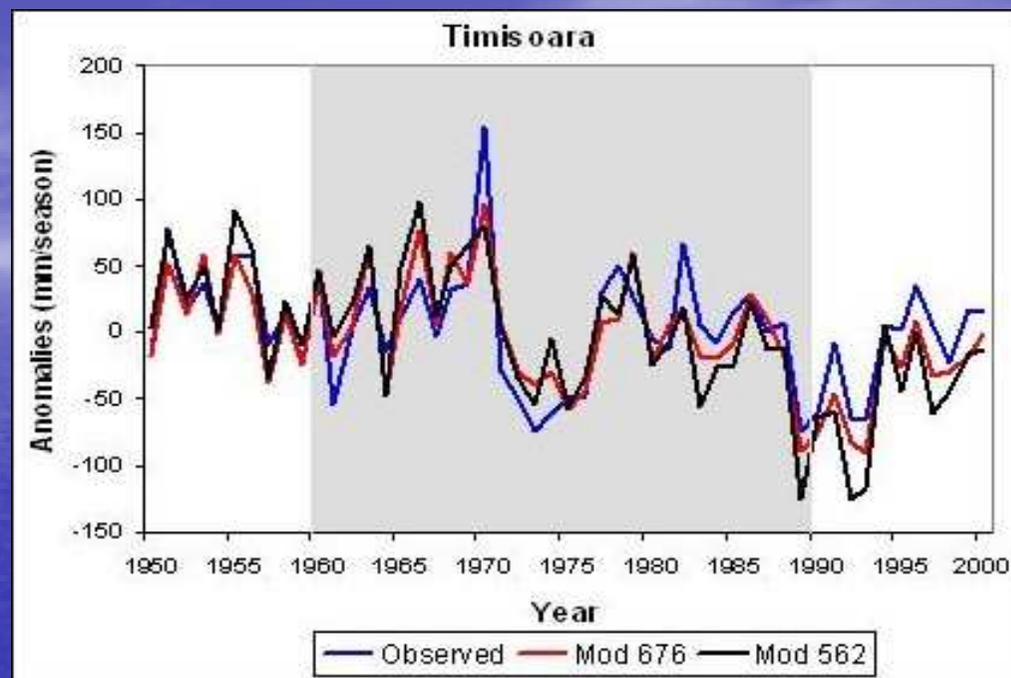
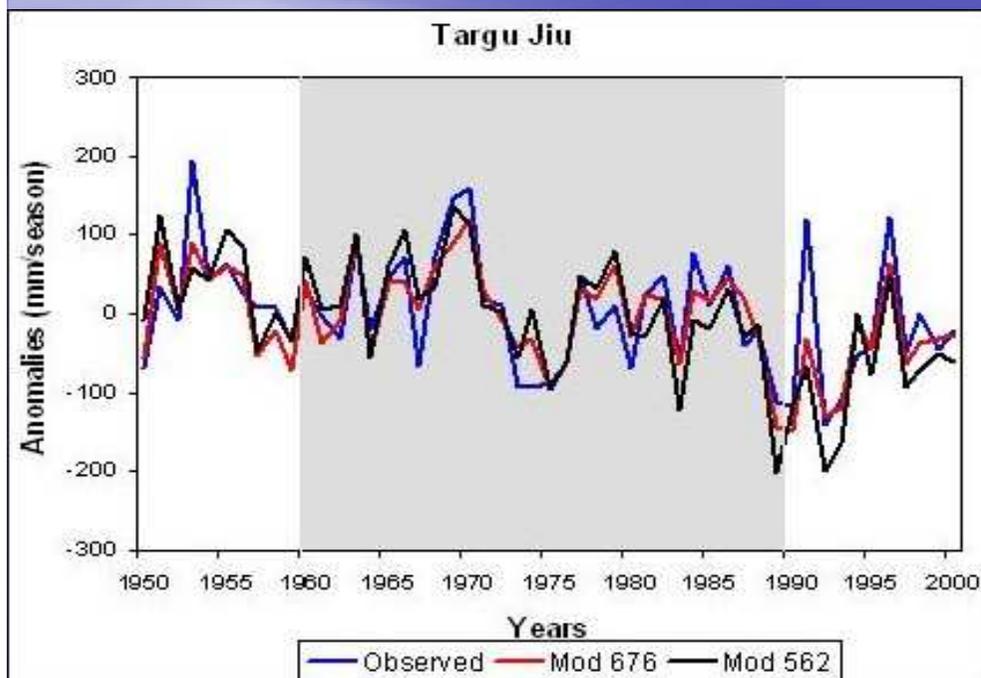
## Explained variance (II)



## Correlation coefficient



## Observed and reconstructed precipitation anomalies: shaded area-calibration interval



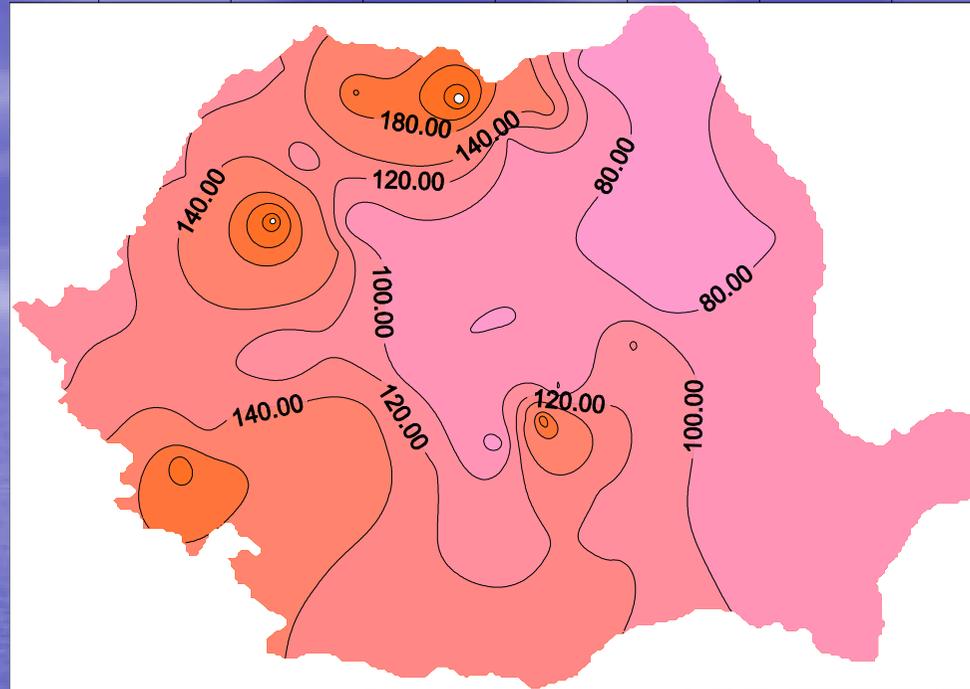
## Evaluating of statistical downscaling technique

- - **two independent intervals: validation and calibration** (Busuioc et al., 1999, 2001, 2005; Trigo and Palutikof, 2001, Hansen Bauer et al., 2003) **Vs.** **cross-validation** (e.g. Bartman et al., 2003; Huth, 2002);
- **Stationarity** of the SDM is only weakly assessed through cross-validation;
- - **A convergence of the climate change signals** across GCMs, RCMs (reasonably reproducing the local climate variability and local/regional-large scale relationship used in SDM) and SDMs is a better measure (e.g. Busuioc et al., 1999, 2001, 2005, Hewitson and Crane, 2005).
- **Measure of the SDM performance:**
  - -explained variance;
  - -correlation coefficient ;
  - -reproduction of trend;

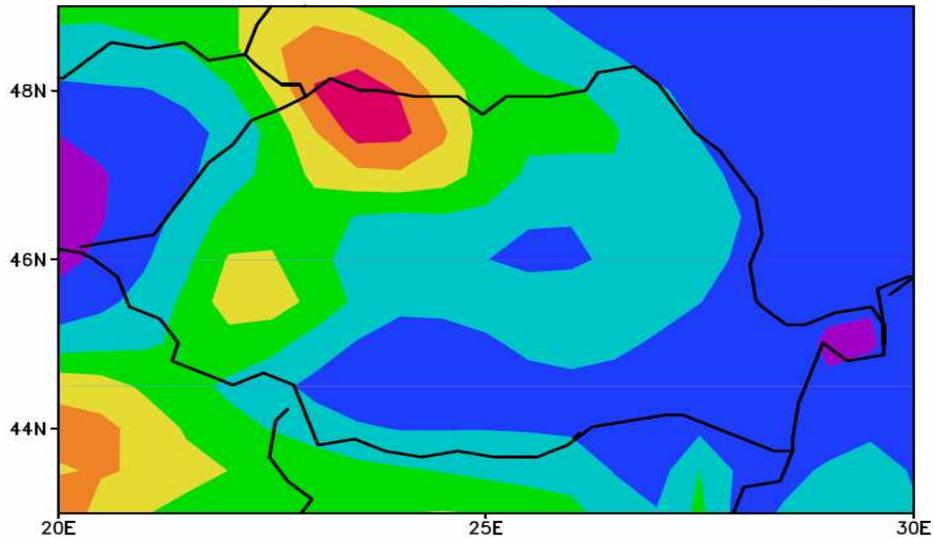
- Comparison between RCMs, GCMs and SDMs (Busuioc et al., 2005)
- HadCM3 (Pope et al., 2000)
- RegCM (Giorgi et al, 2004)
- SDM based on CCA

- current climate (1961-1990)
- A2, B2 scenarios (2070-2100)

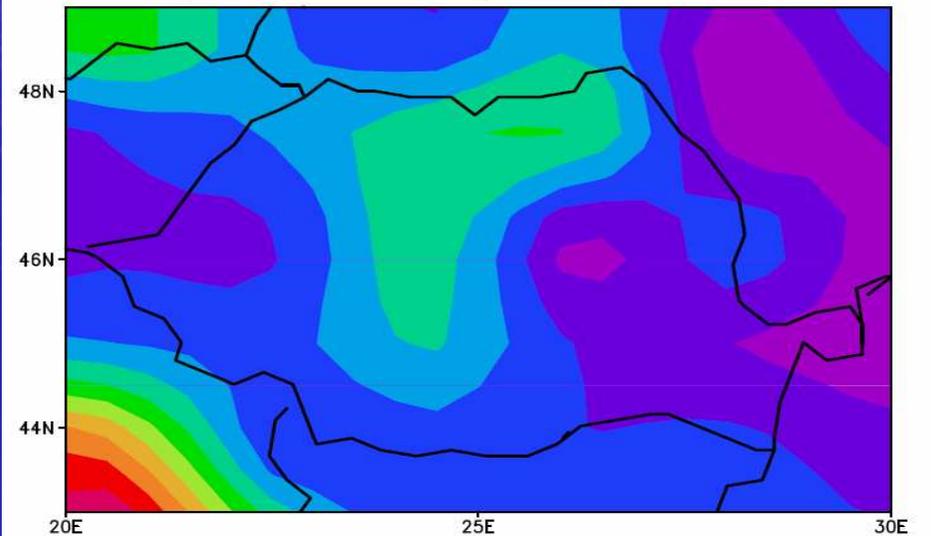
# Winter precipitation - long term mean



Winter precipitation—long term mean RegCM



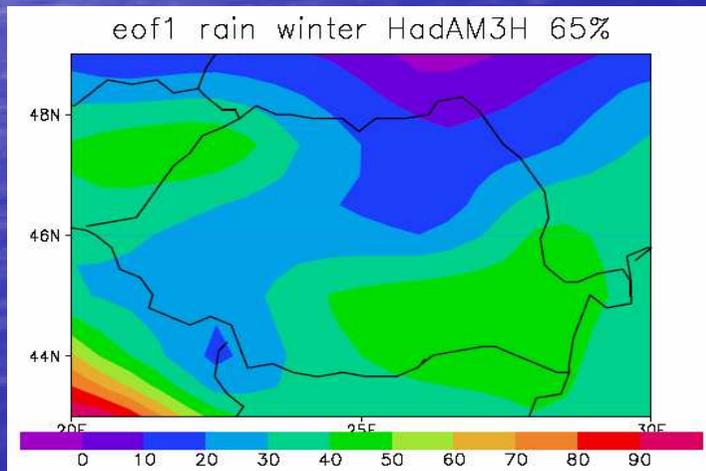
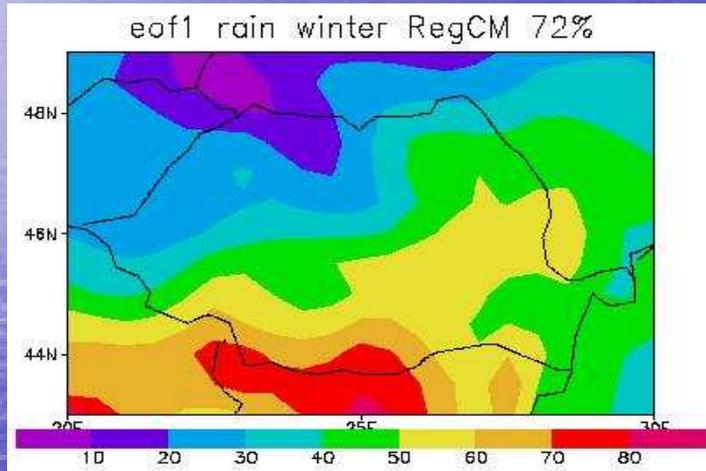
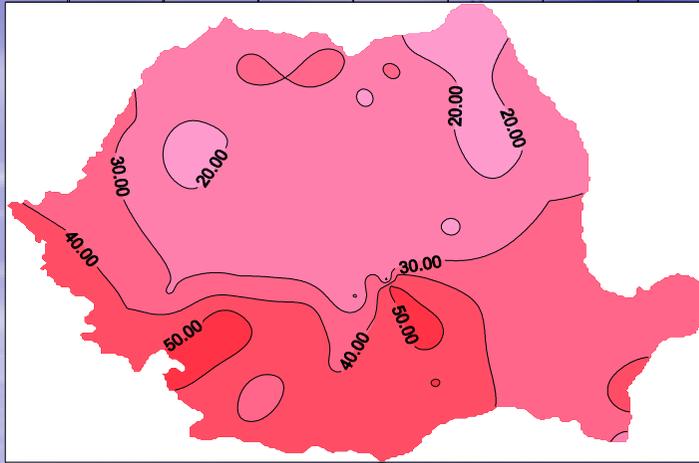
Winter precipitation—long term mean HadAM3M



# EOF PATTERNS PRECIPITATION

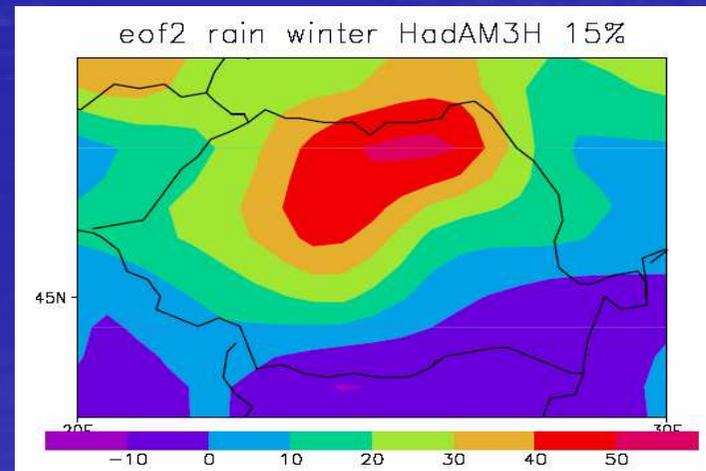
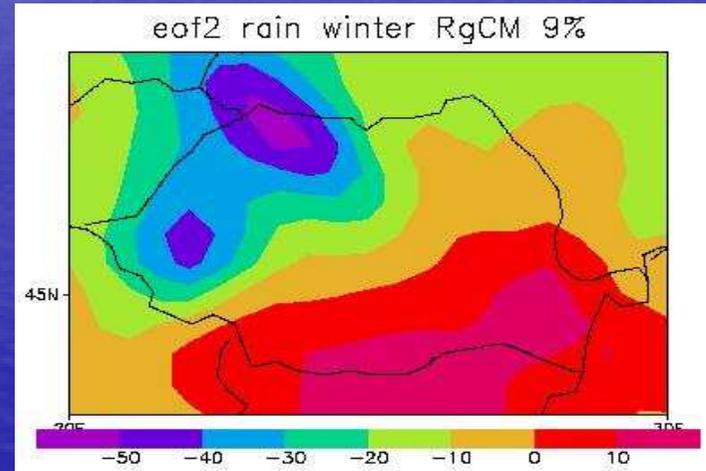
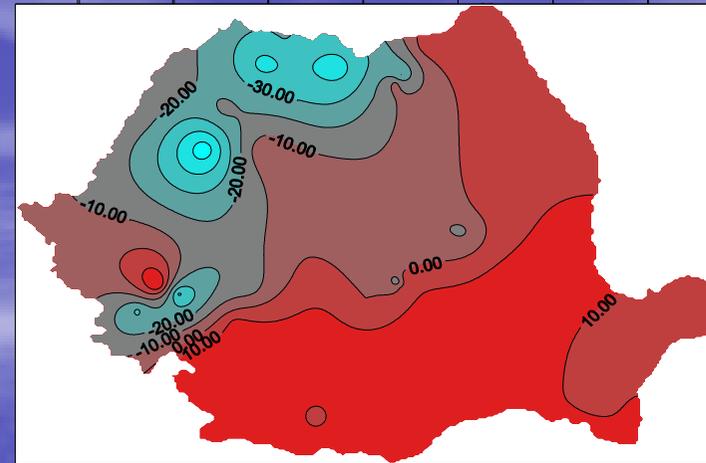
EOF 1

50%



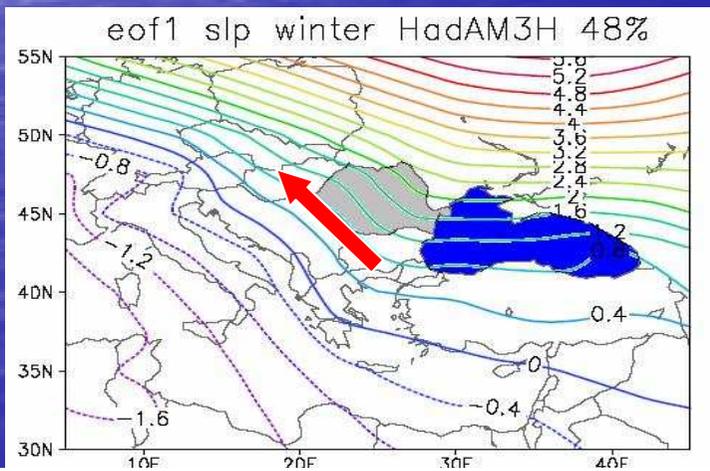
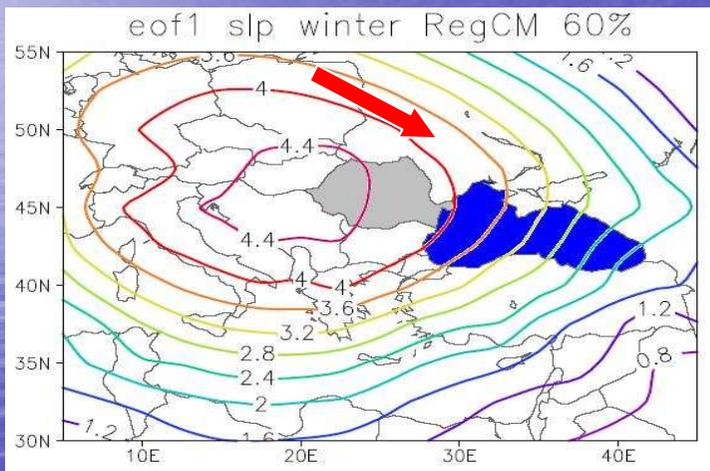
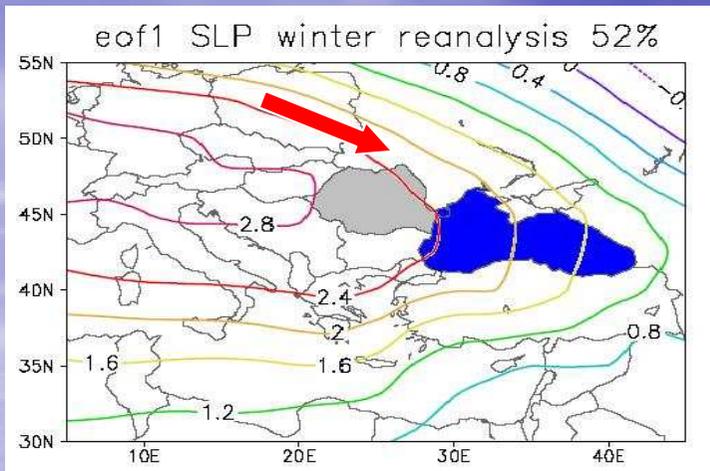
EOF 2

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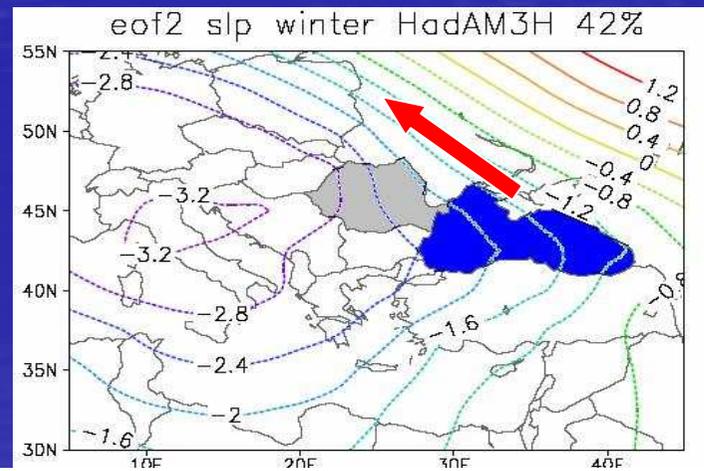
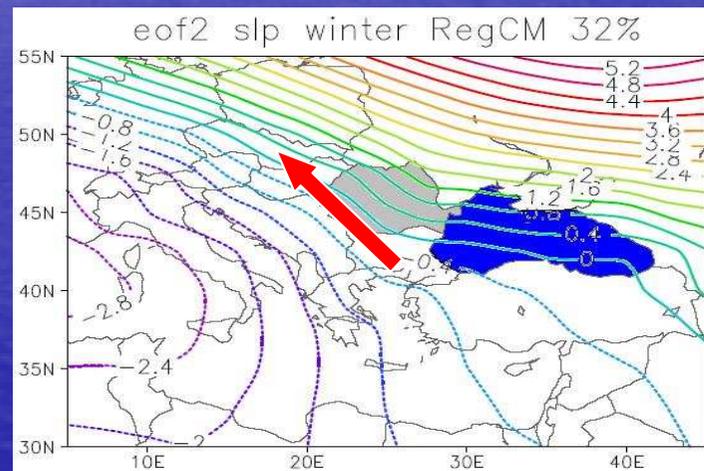
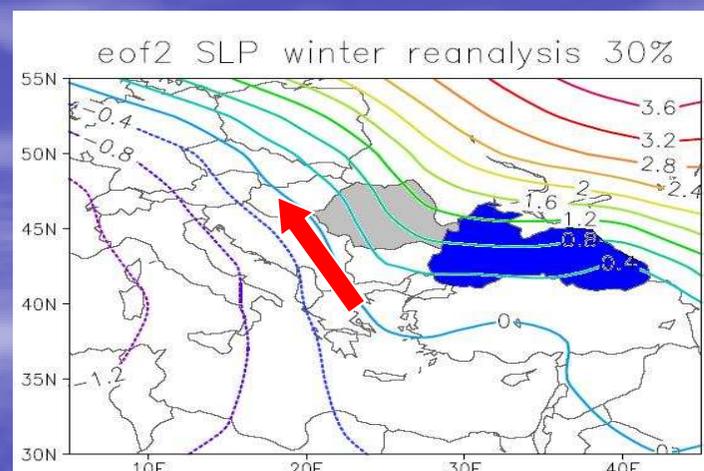


# EOF PATTERNS SEA LEVEL PRESSURE

## EOF 1



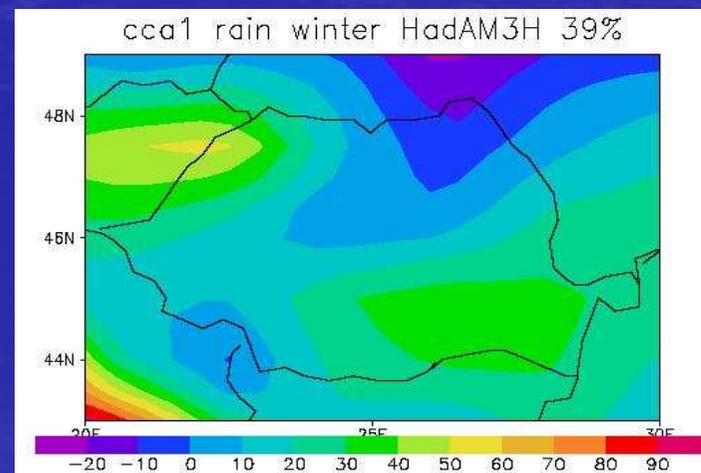
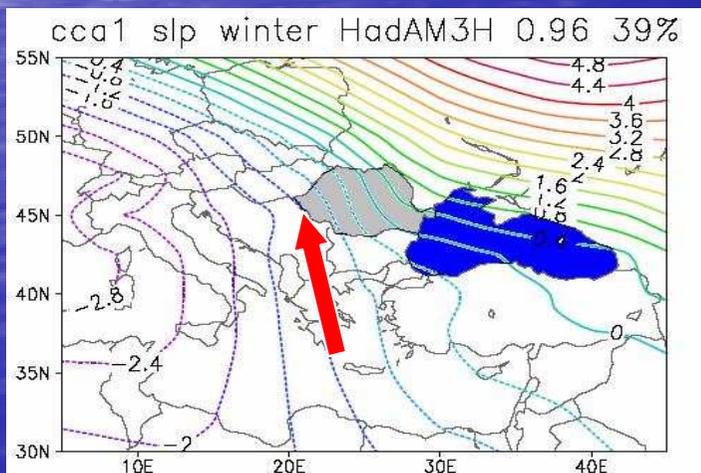
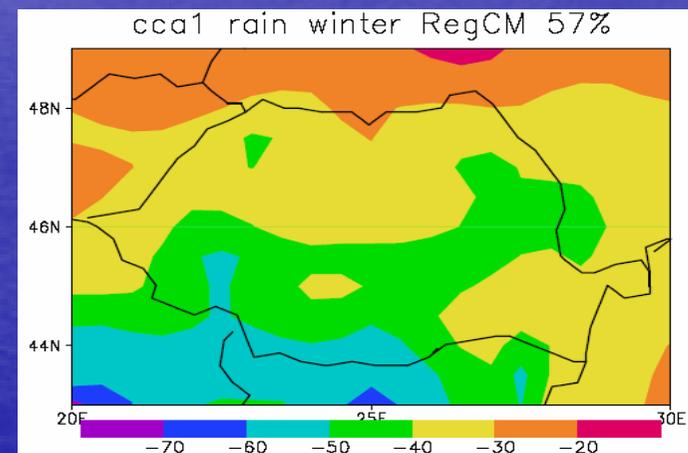
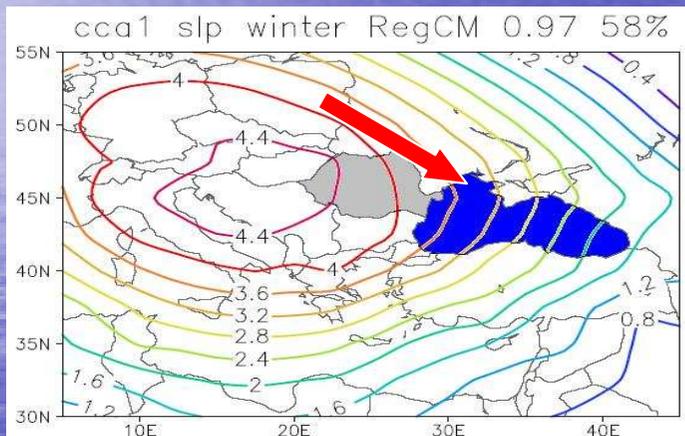
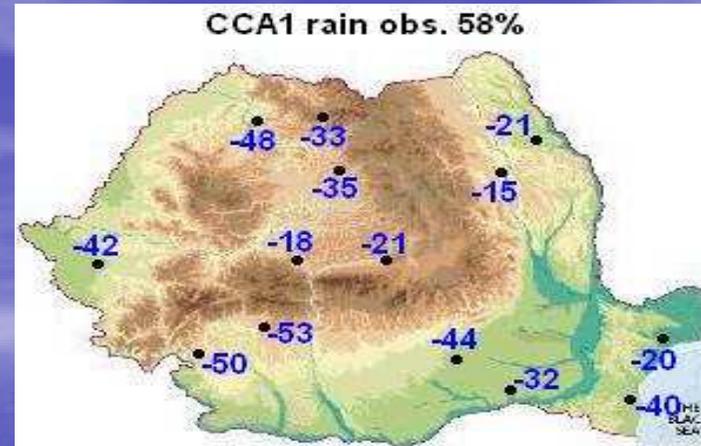
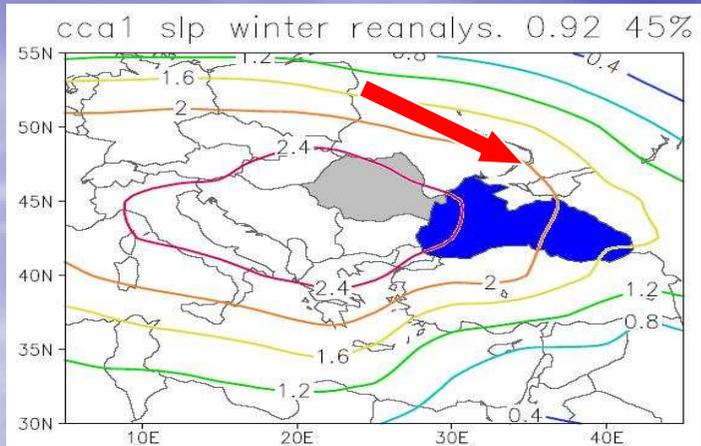
## EOF 2



# SLP

# CCA1 PATTERNS

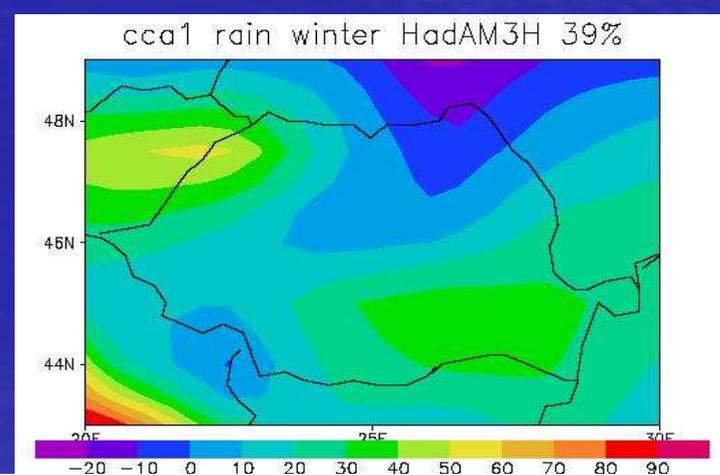
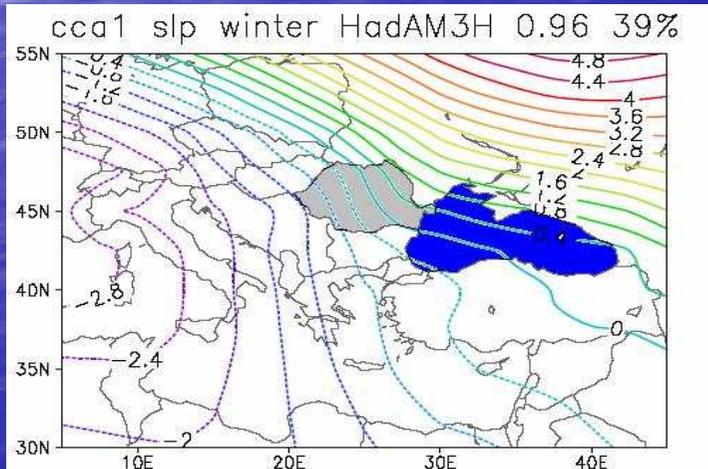
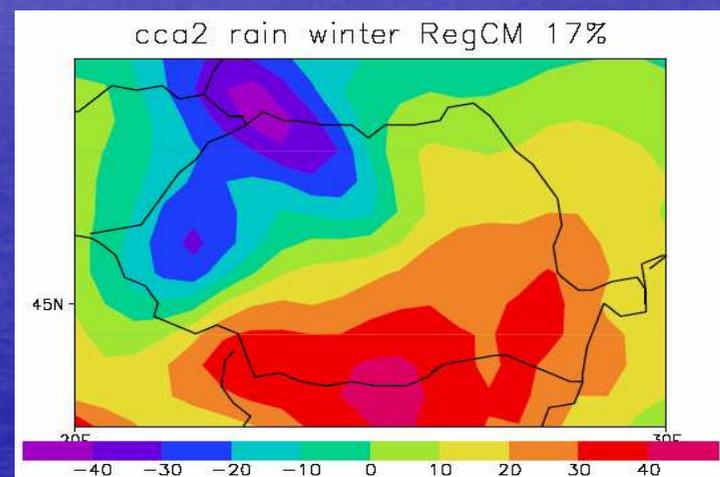
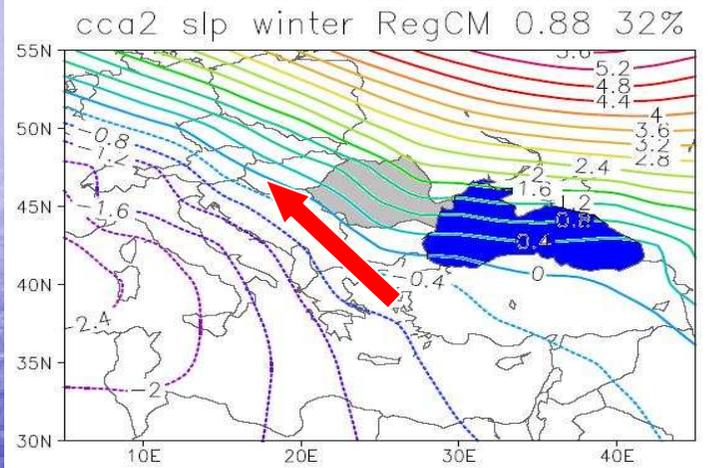
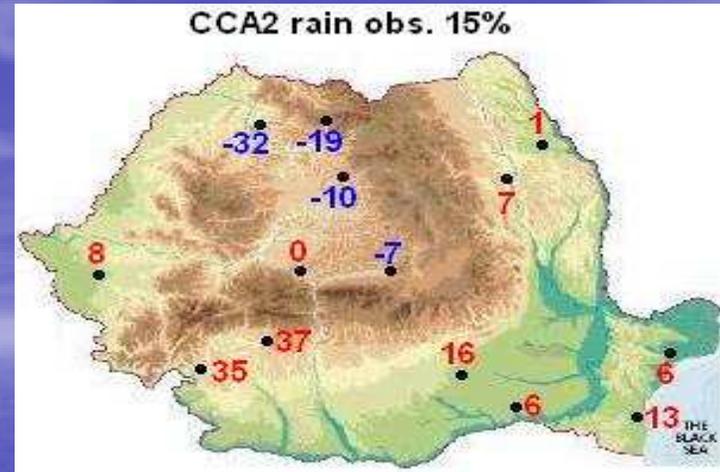
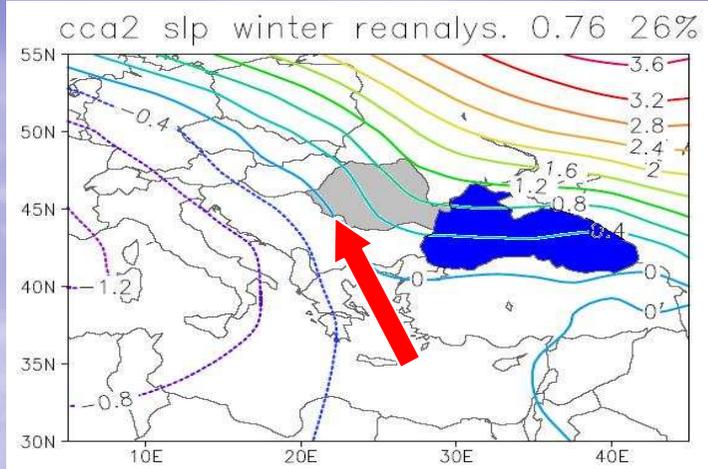
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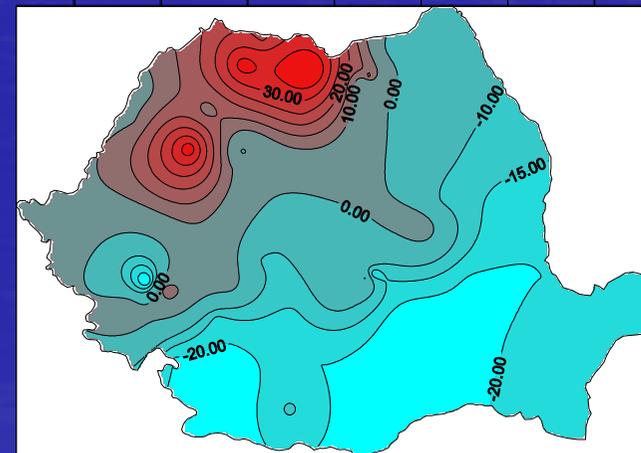
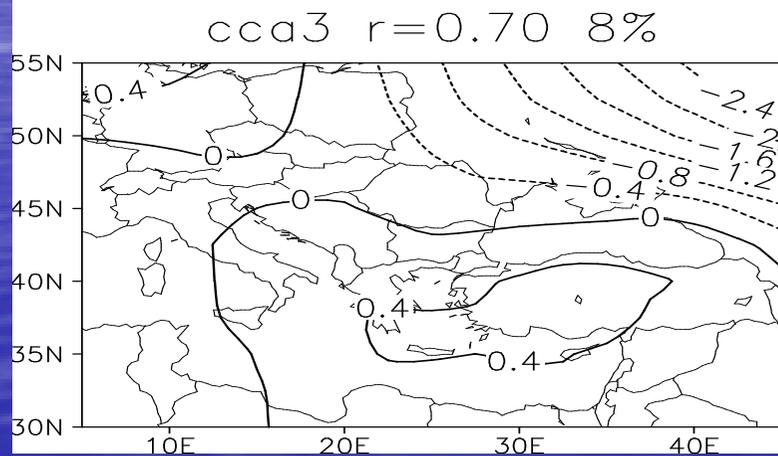
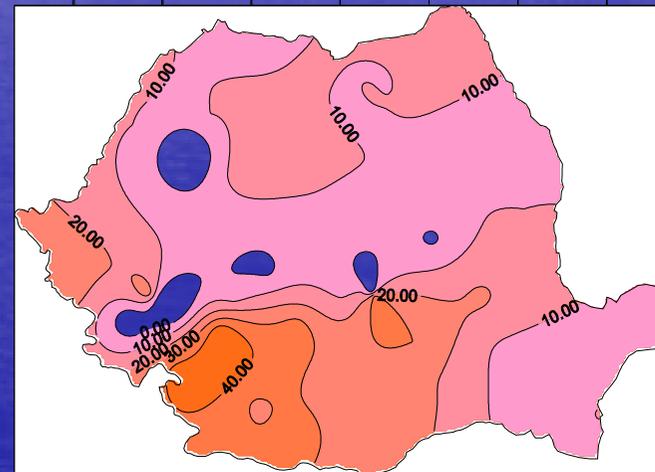
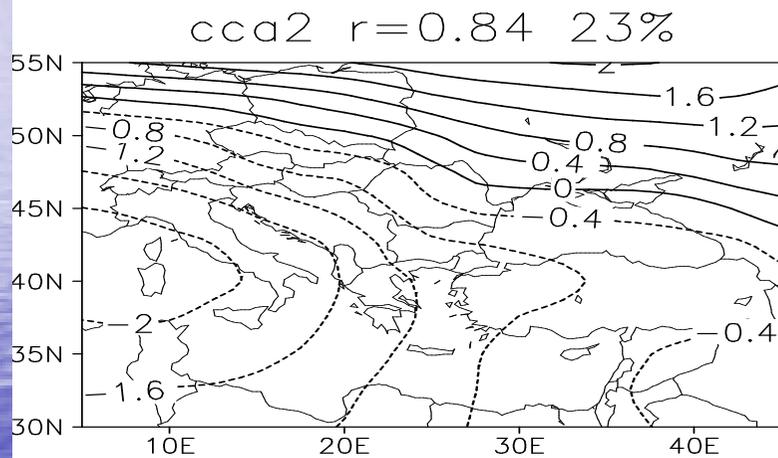
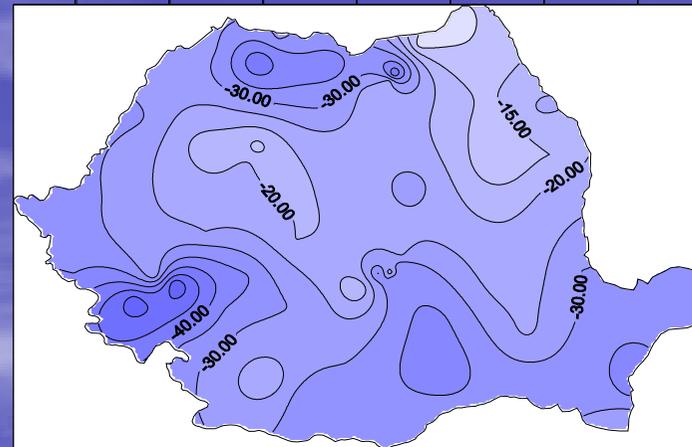
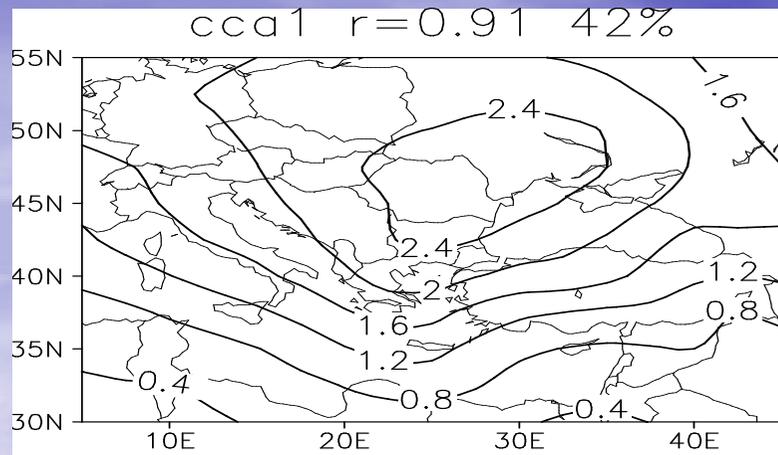


# SLP

# CCA2 PATTERNS

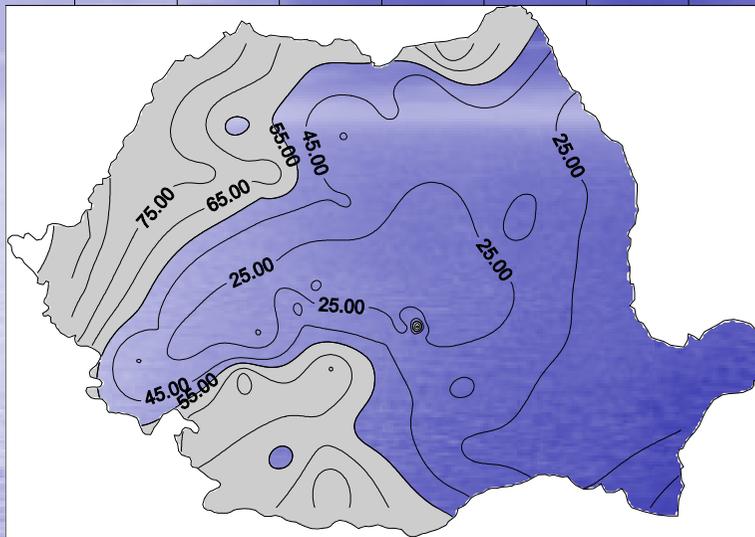
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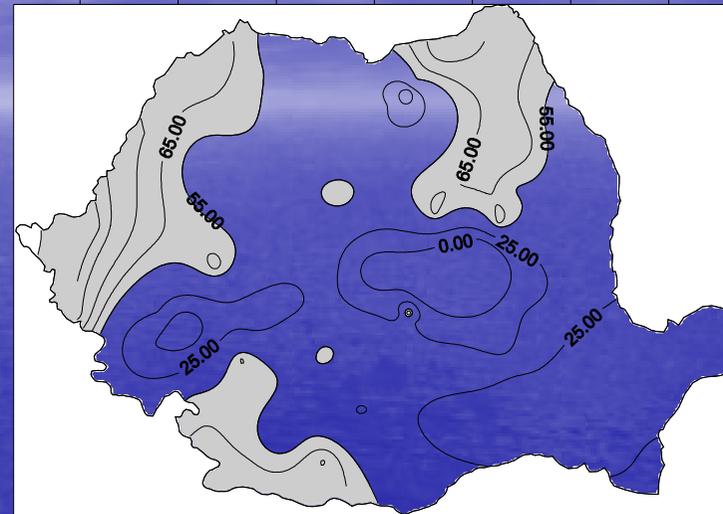


Skill of the statistical downscaling model (correlation coefficient) for various predictors over the independent data set 1991-2000

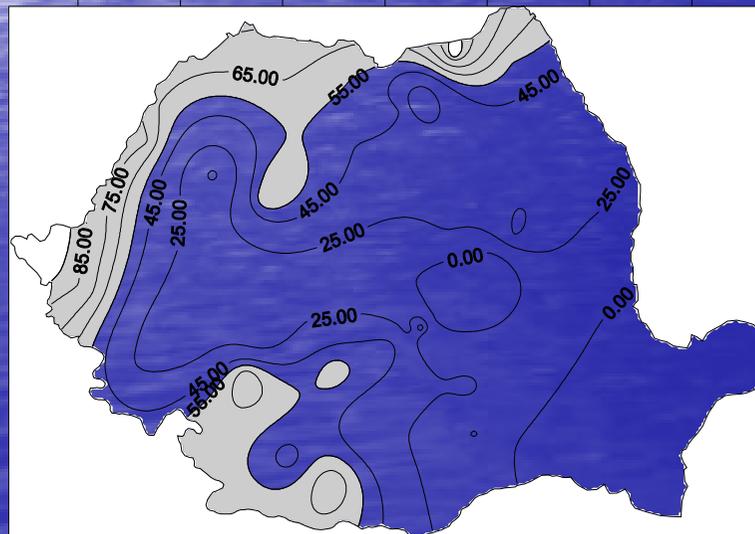
**SLP**



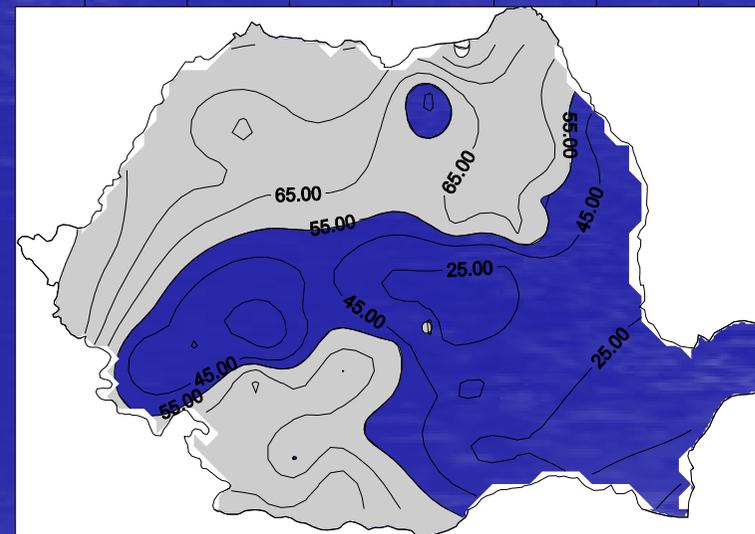
**SH**

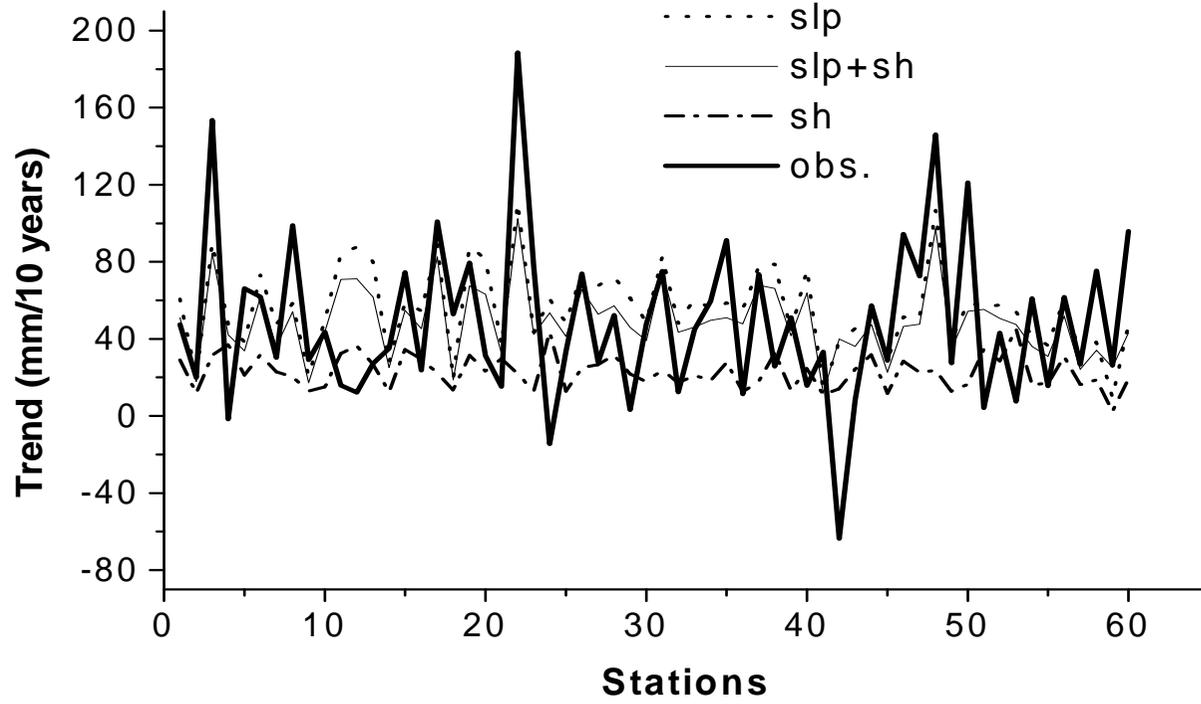


**SLP+SH**



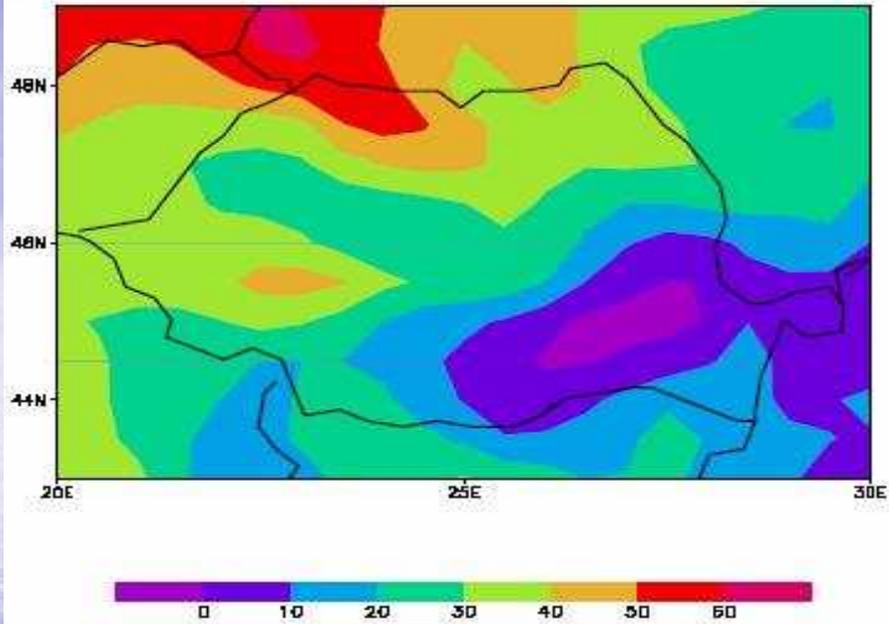
**OPTIMUM**



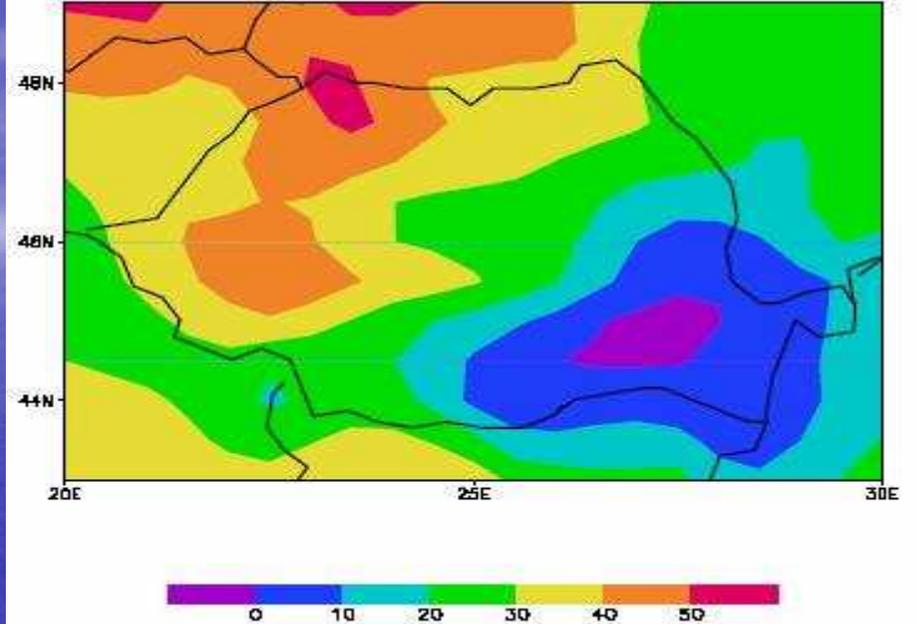


# Climate change scenarios for Romanian precipitation (2071-2100) based on RegCM and HadAM3H outputs

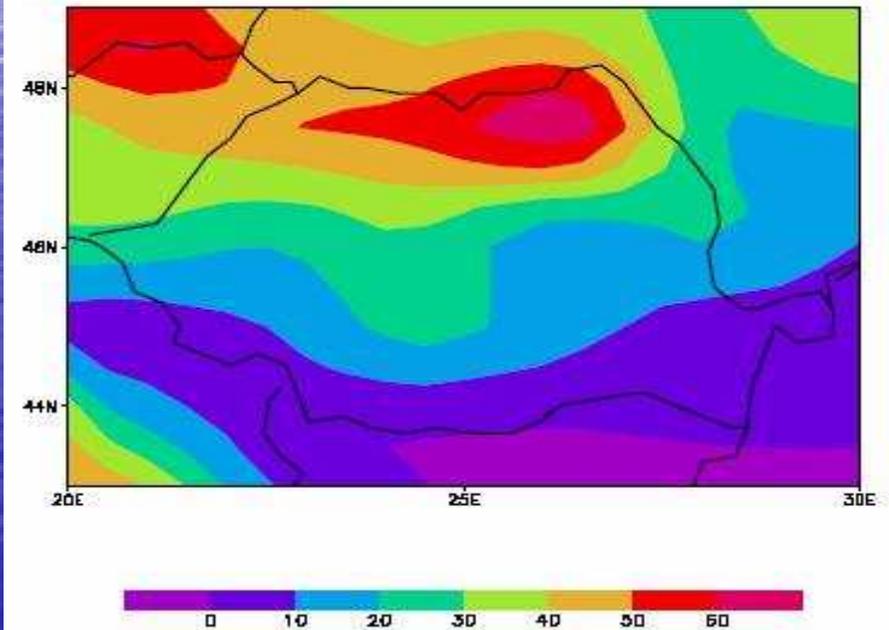
winter precip. changes A2 scenario RegCM 2070-2100



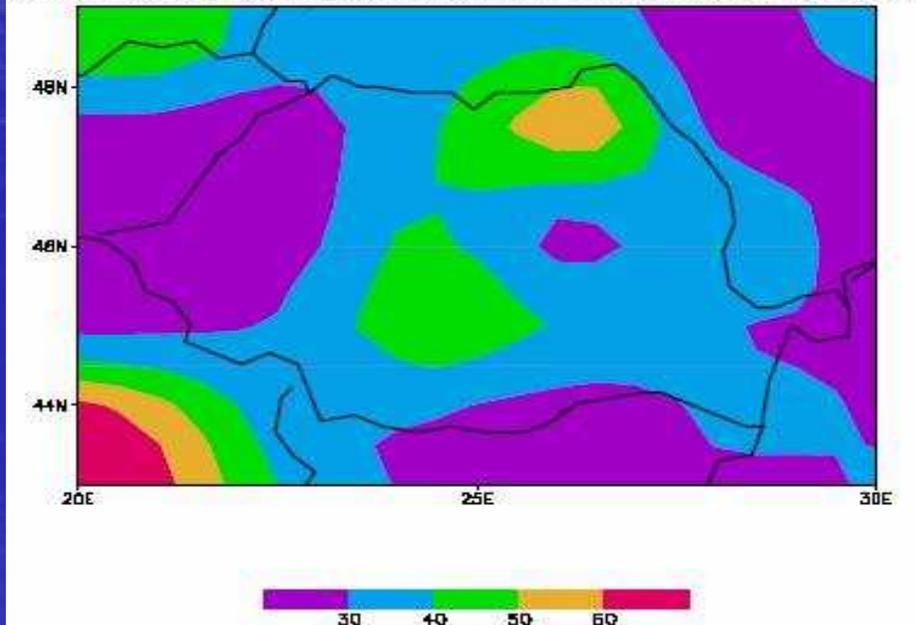
winter precip. changes B2 scenario RegCM 2070-2100



winter precip. changes A2 scenario HadAM3H 2070-2100

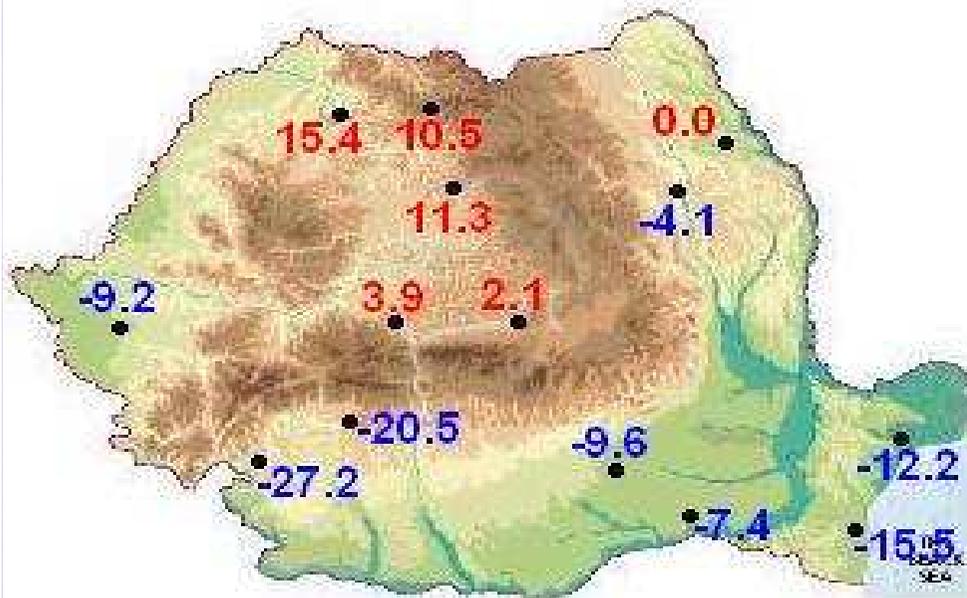


winter precip. changes B2 scenario HadAM3H 2070-2100

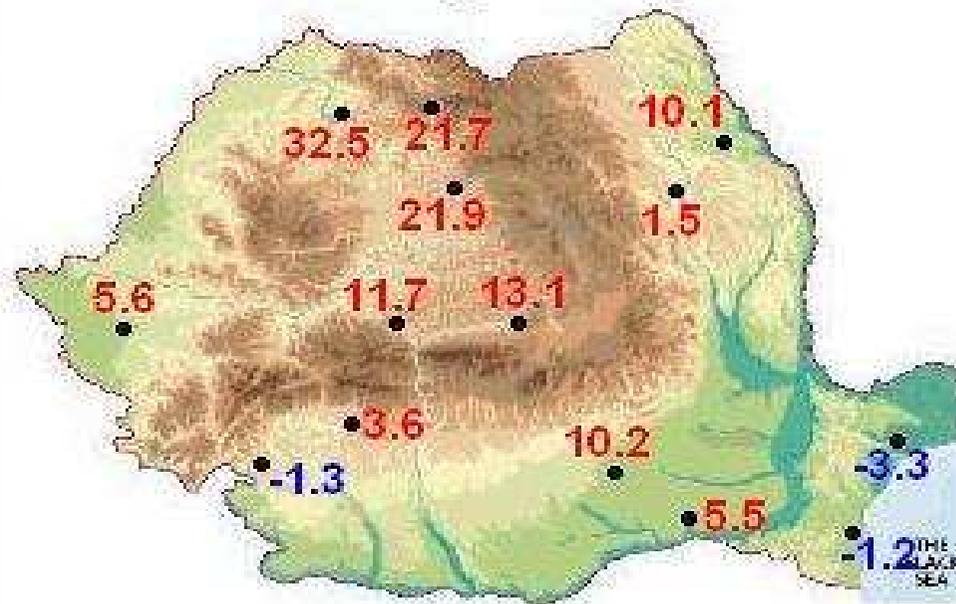


# Downscaled climate change scenarios using optimum model for each station

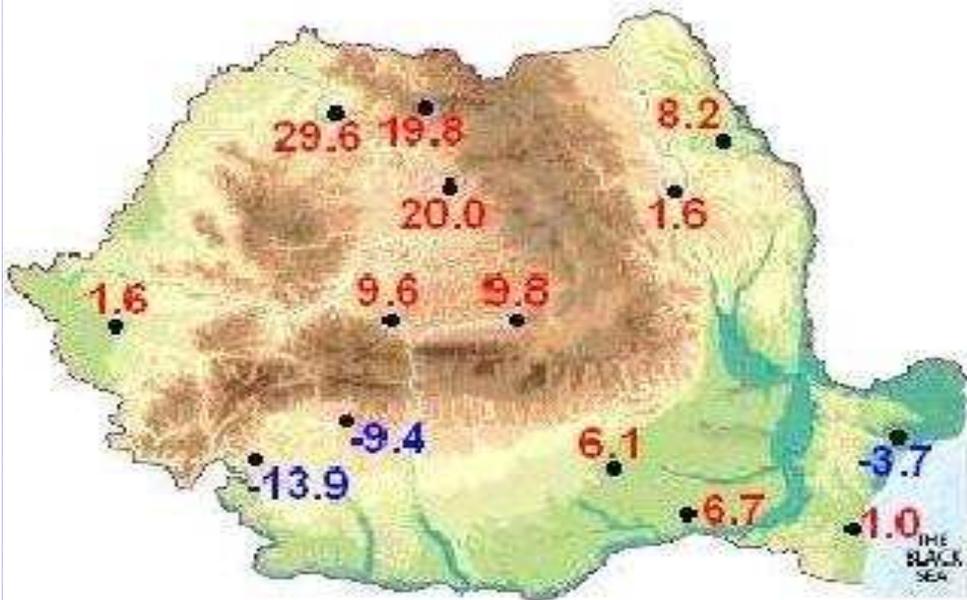
## Downscaling A2 - RegCM



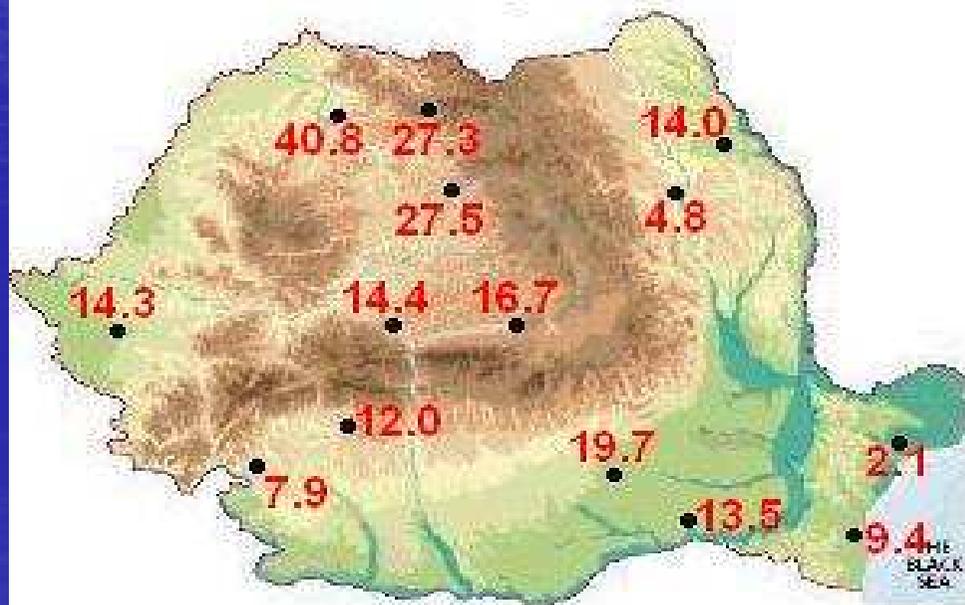
## Downscaling B2 - RegCM



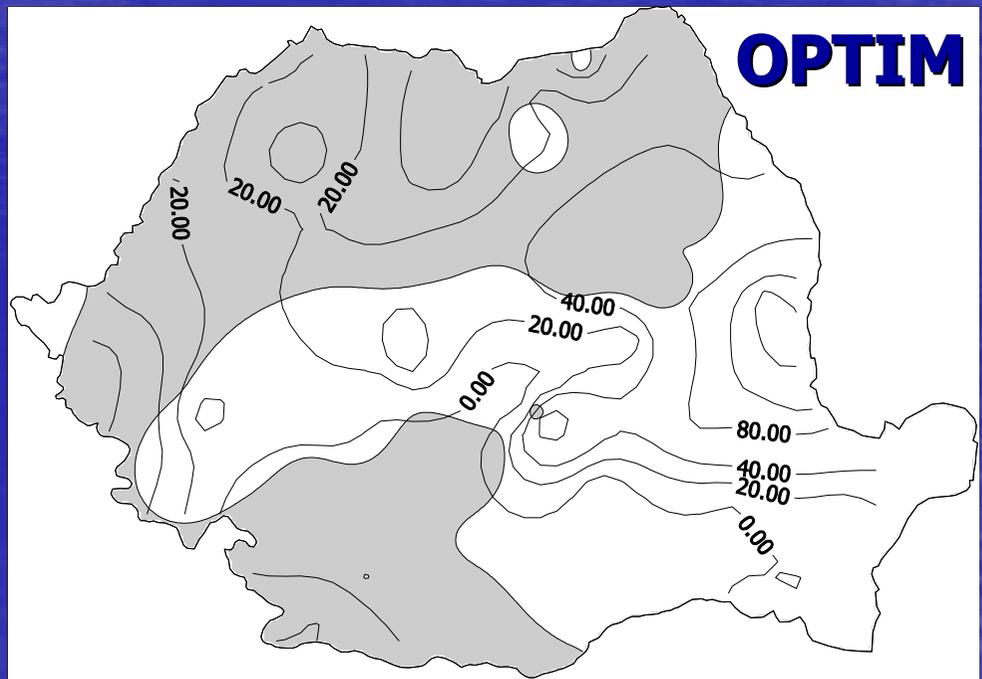
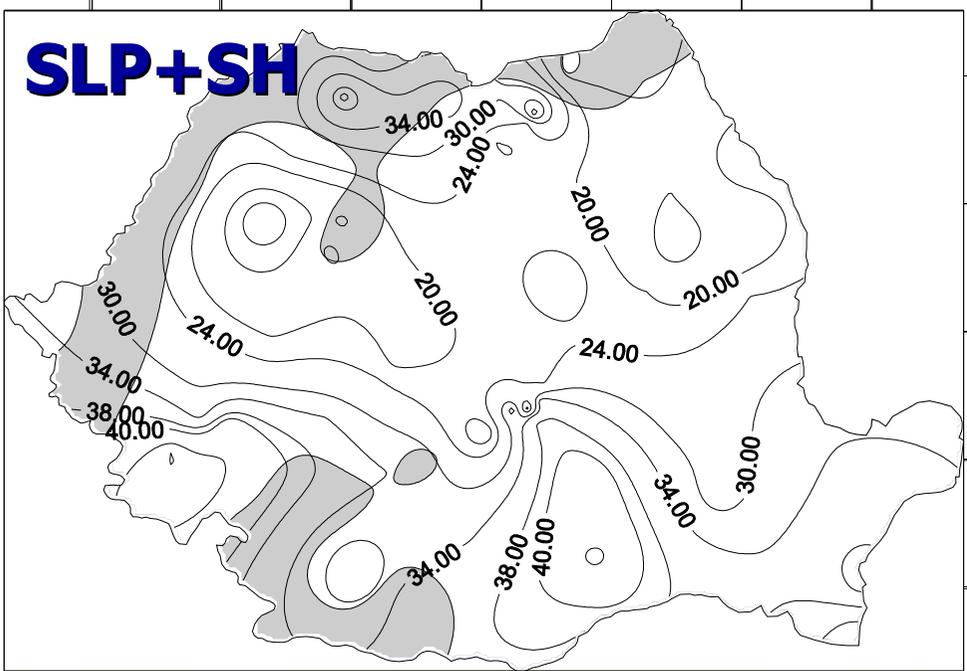
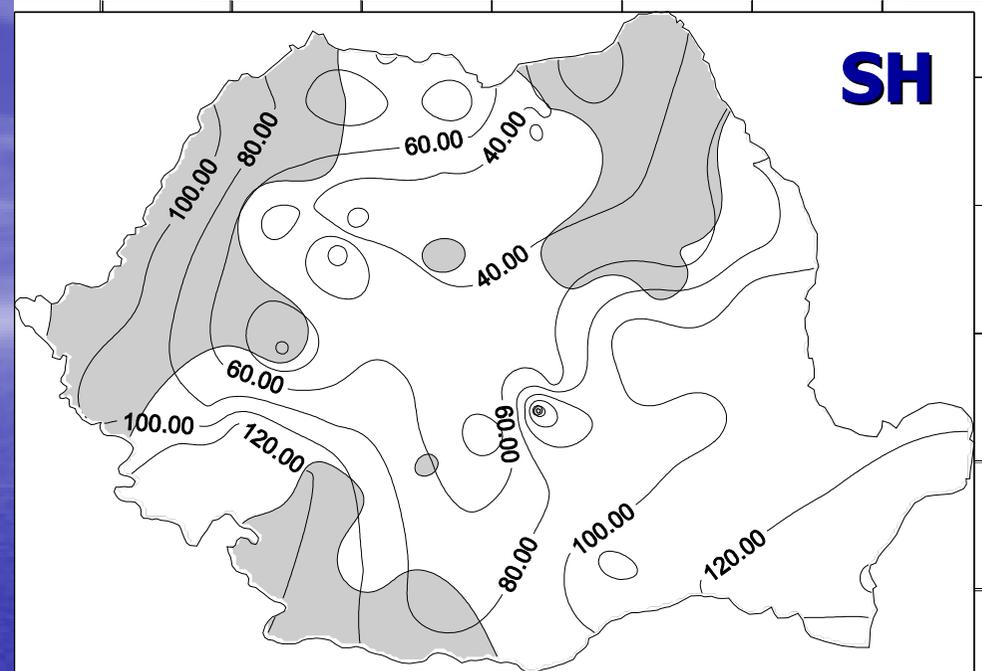
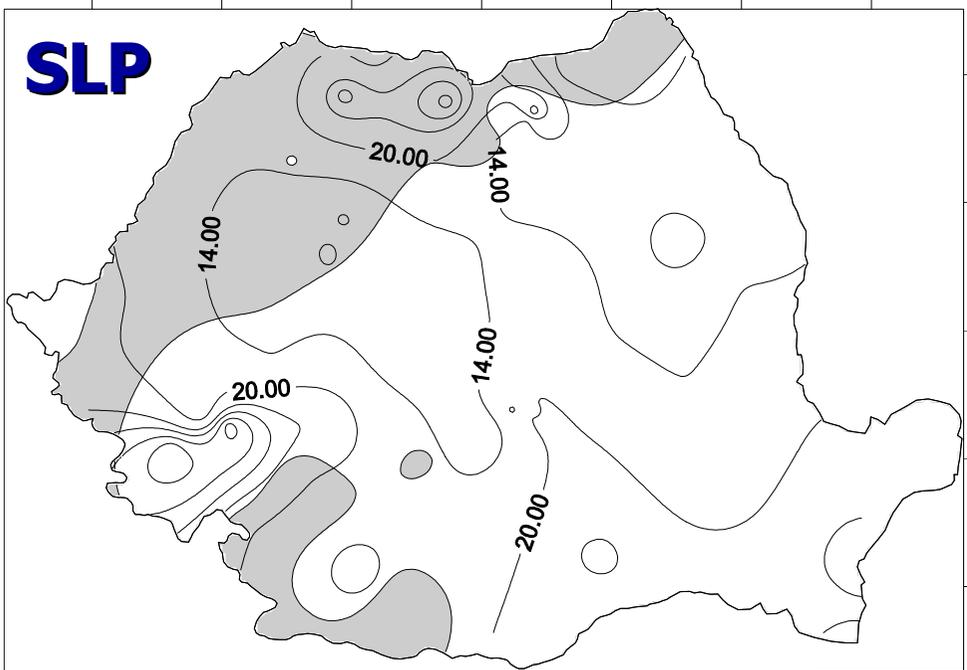
## Downscaling A2 - Had



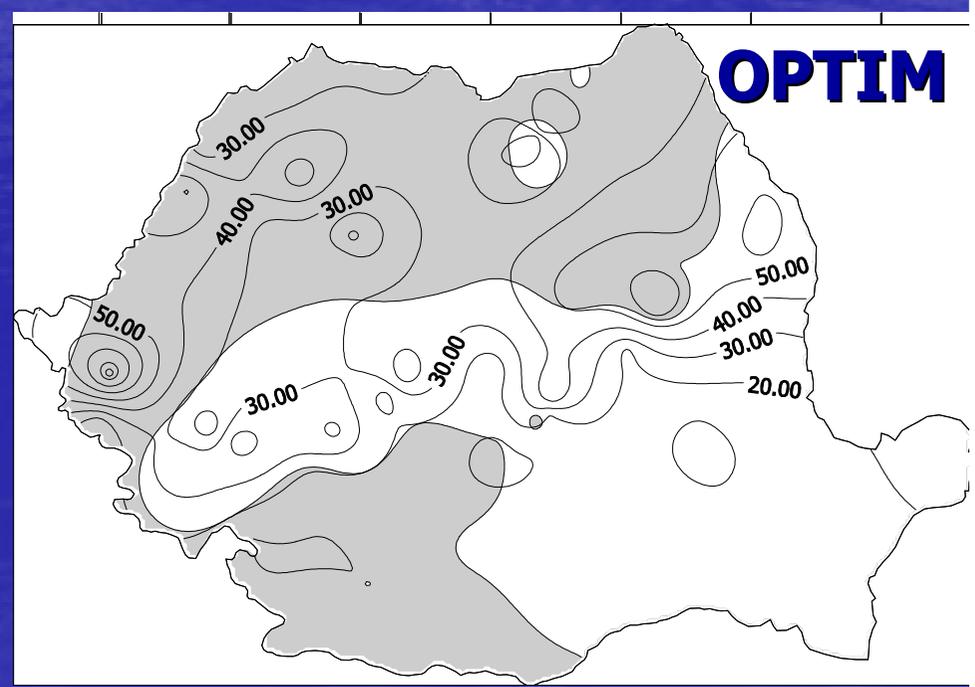
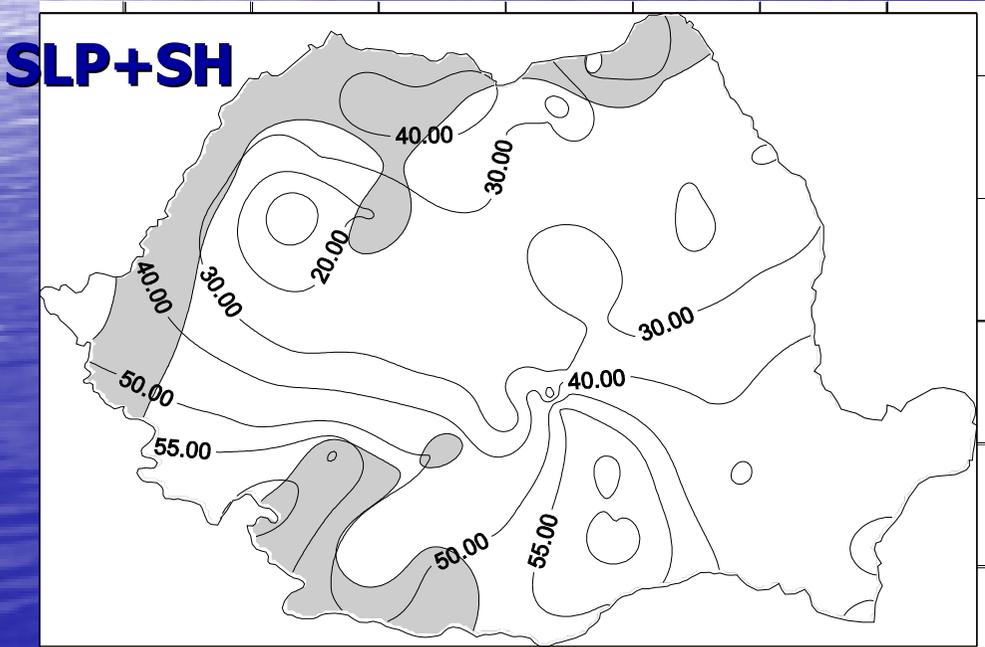
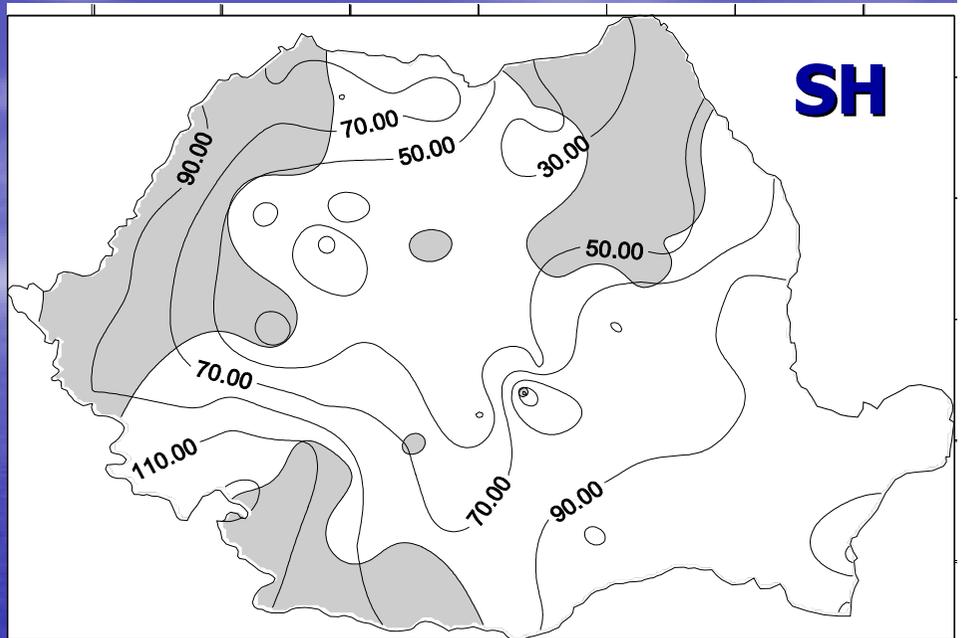
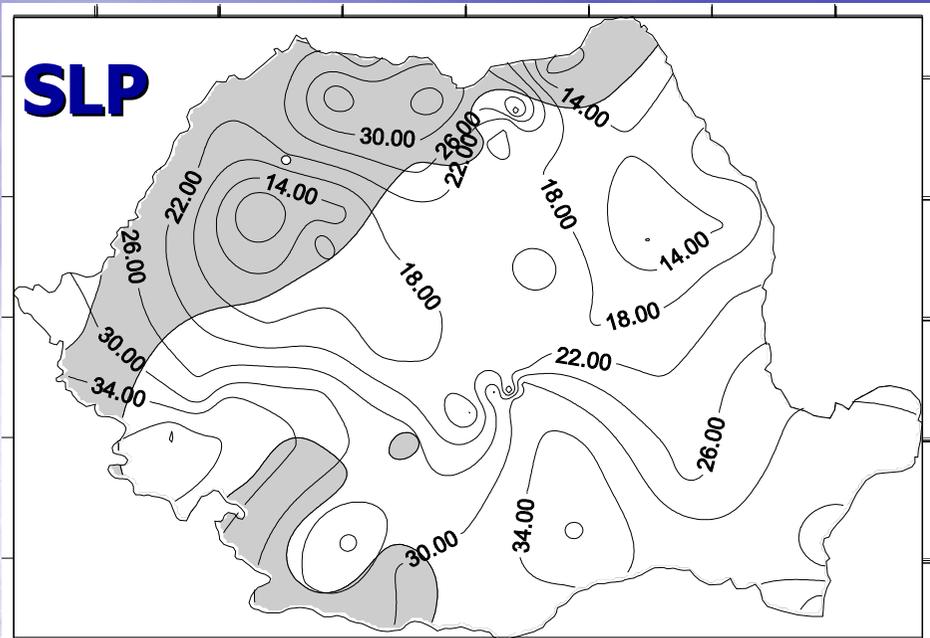
## Downscaling B2 - Had



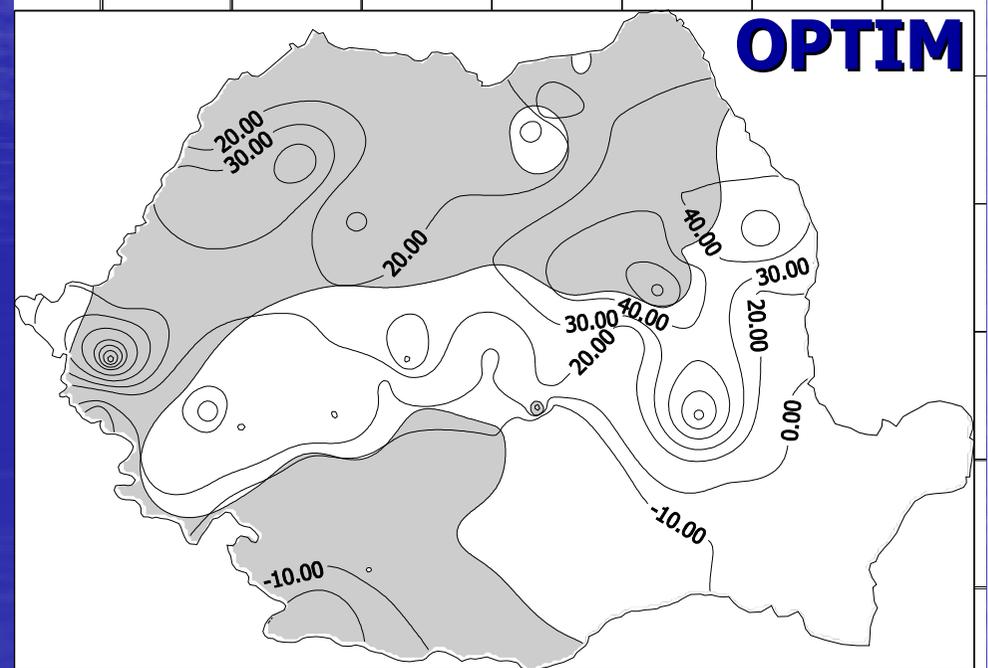
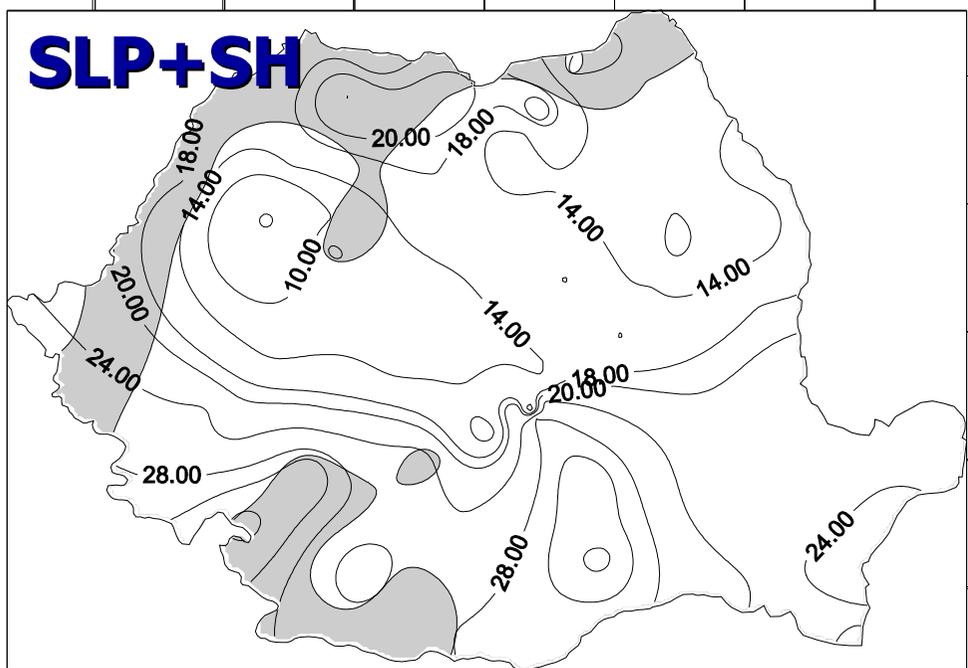
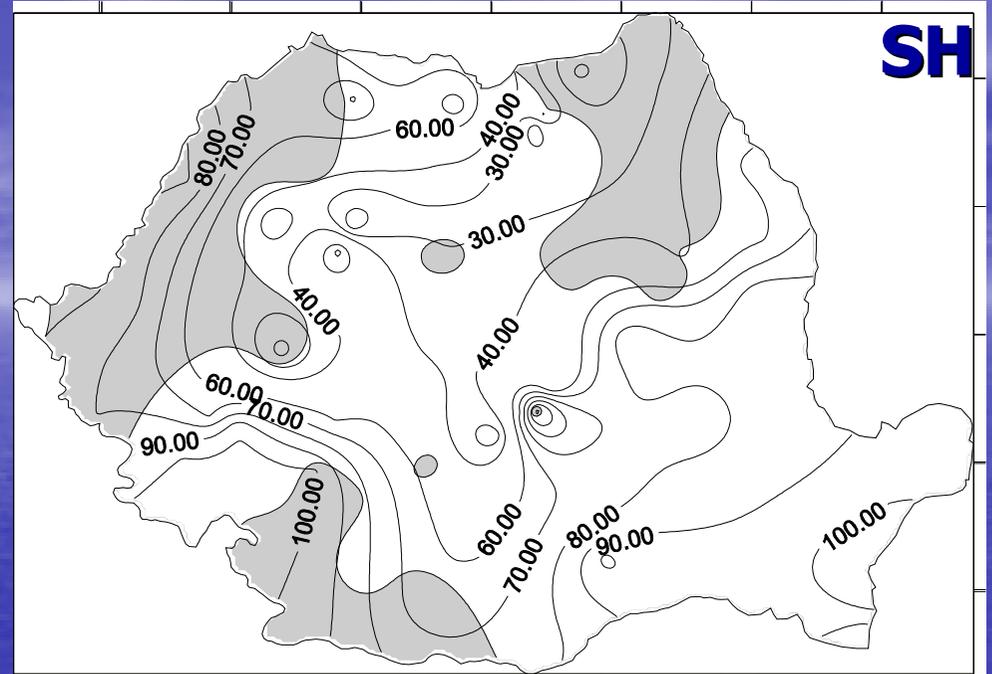
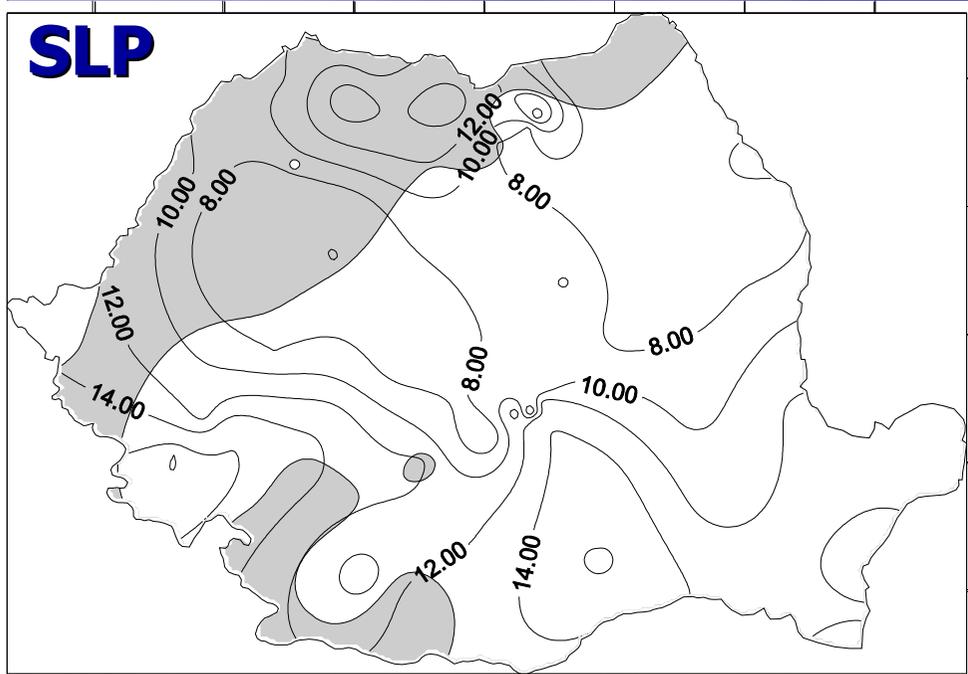
# Changes in winter Romanian precipitation under HadAM3H - A2 scenarios



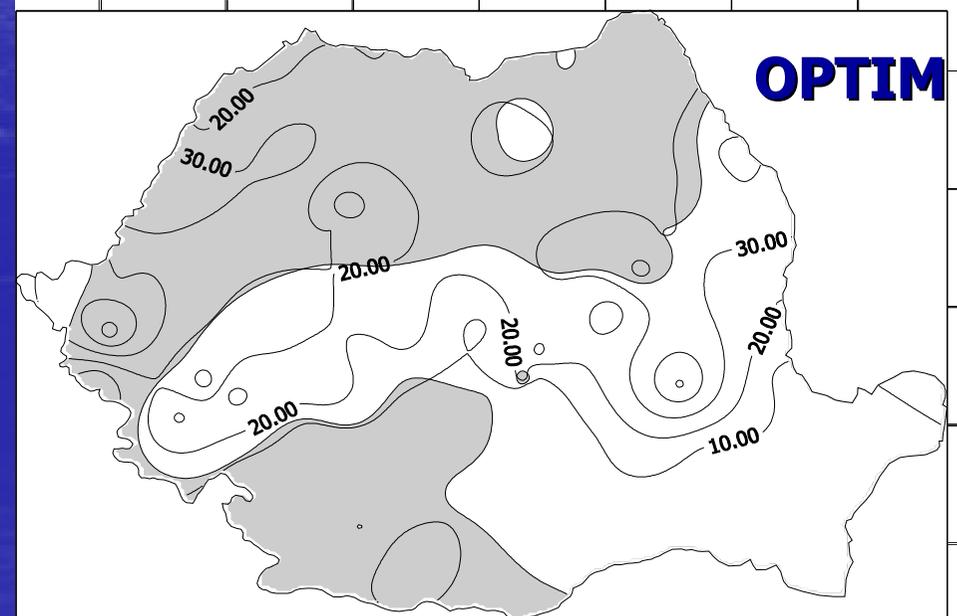
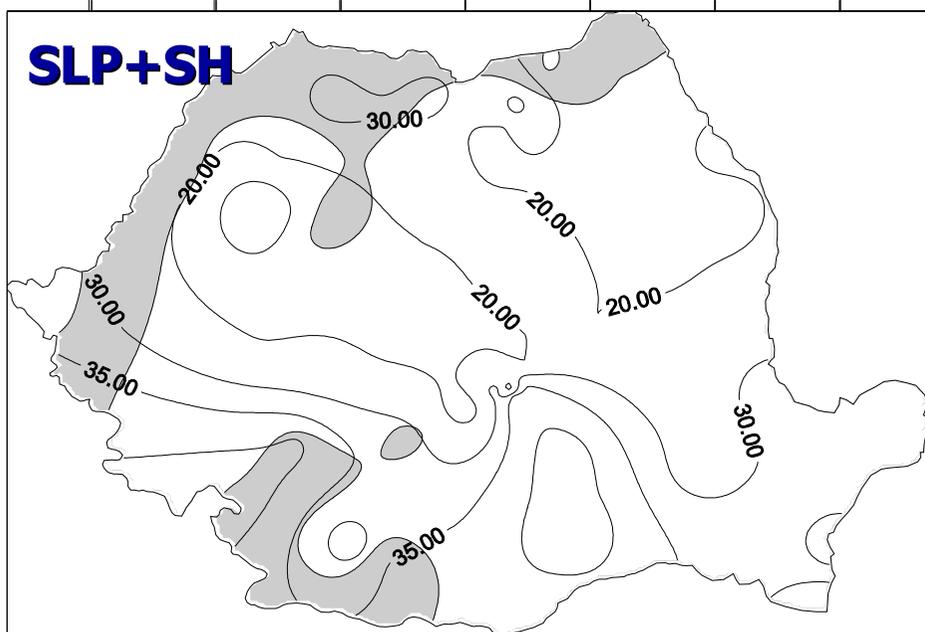
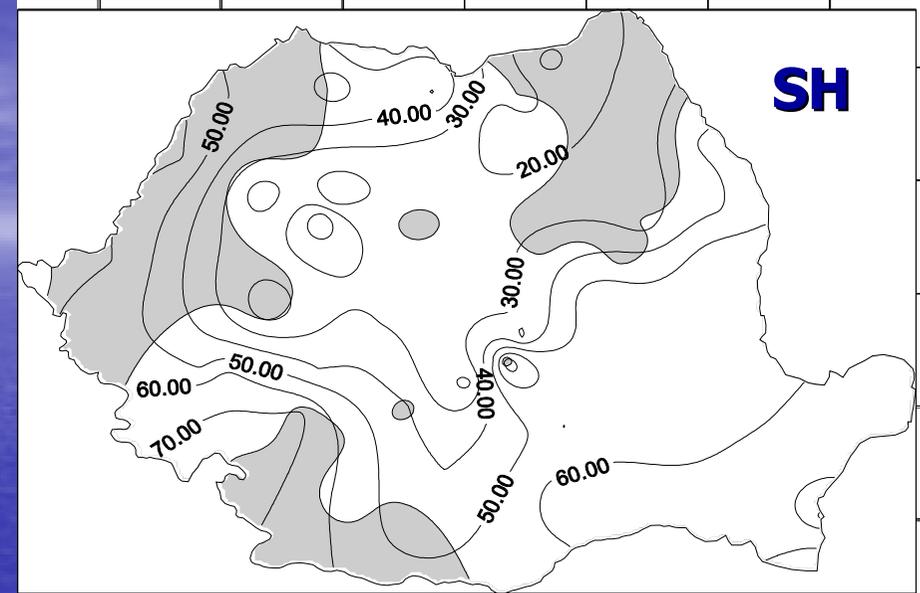
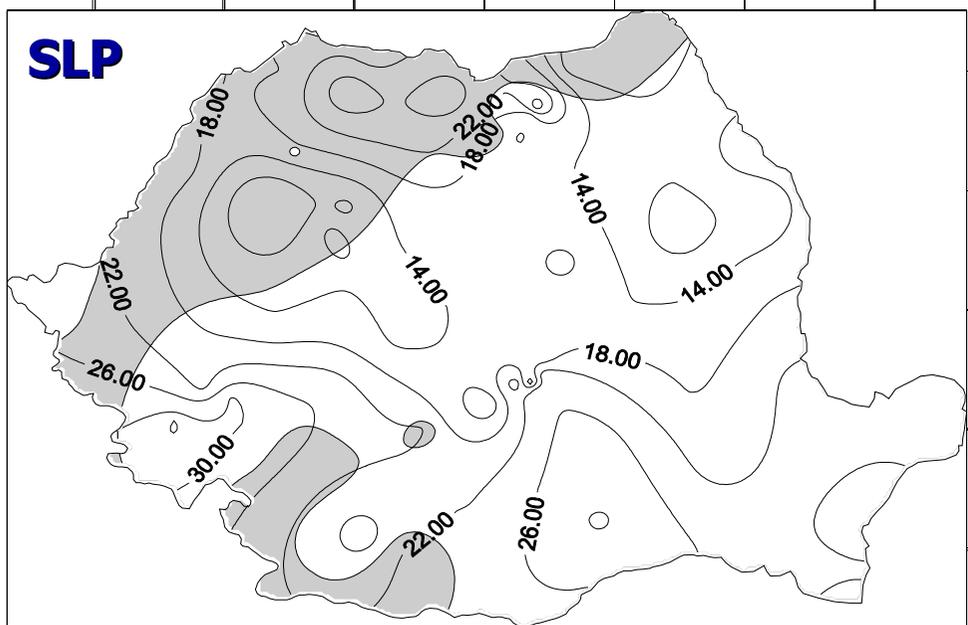
# Changes in winter Romanian precipitation under HadAM3H - B2 scenarios



# Changes in winter Romanian precipitation under RegCM - A2 scenarios



# Changes in winter Romanian precipitation under RegCM - B2 scenarios



# Conclusions

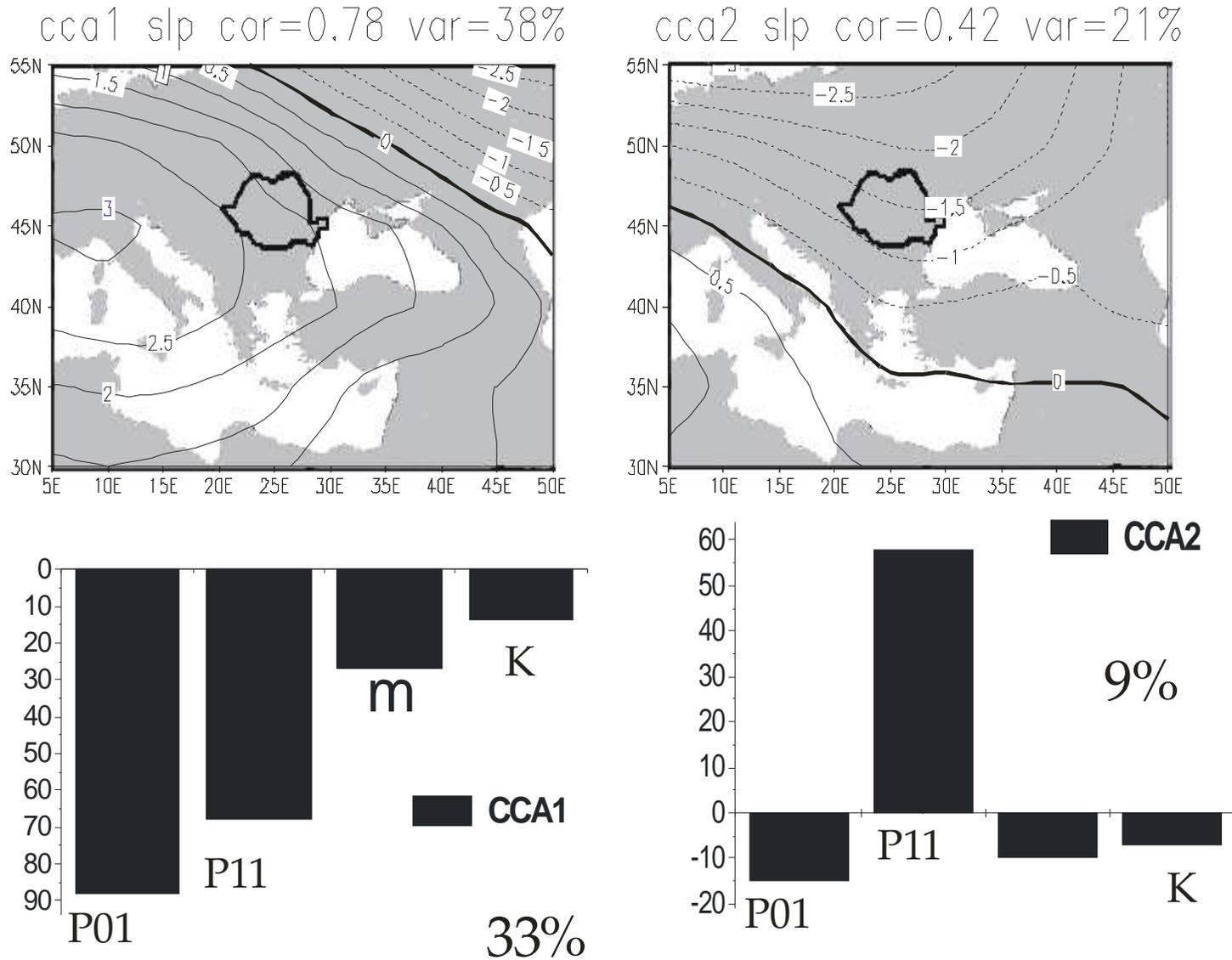
- Statistical downscaling model is more skilful for the southwestern and northwestern part; SLP is the best predictor and inclusion of SH only adds improvements at some northeastern stations;
- RegCM is more skilful than HadAM3H in the simulation of Romanian precipitation variability and its connection with large-scale circulation;
- Both models overestimate winter precipitation in eastern part of Romania may be due to the overestimation of some large-scale circulation patterns; SH is underestimated by both models (especially HadAM3H) in southern part of Romania;
- RegCM and HadAM3H scenarios (A2 and B2) show increase of precipitation over the 2070-2100 period higher in NW and NE, respectively; there are no significant differences between the climate signal amplitude for the two scenarios;
- Similar signal is obtained through the statistical downscaling model when the OPTIMUM technique is applied, but the amplitude is lower, especially A2.
- The uncertainty of results is higher for the southeastern-eastern regions; we are more confident in the results for the northwestern and southwestern regions.

- **EXTREMES**

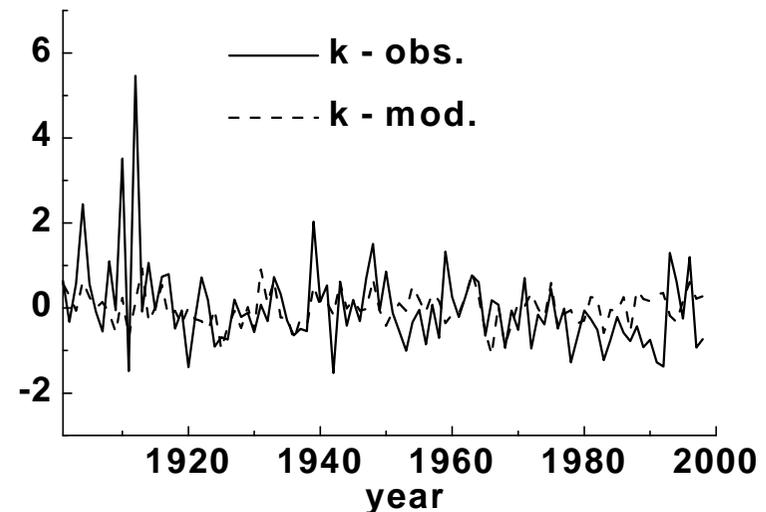
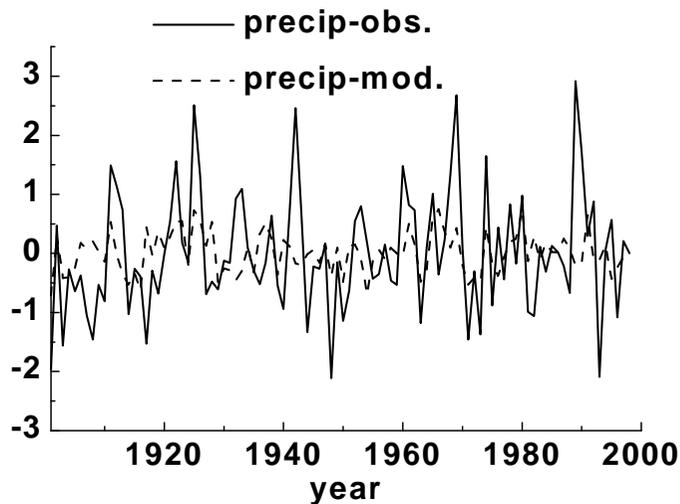
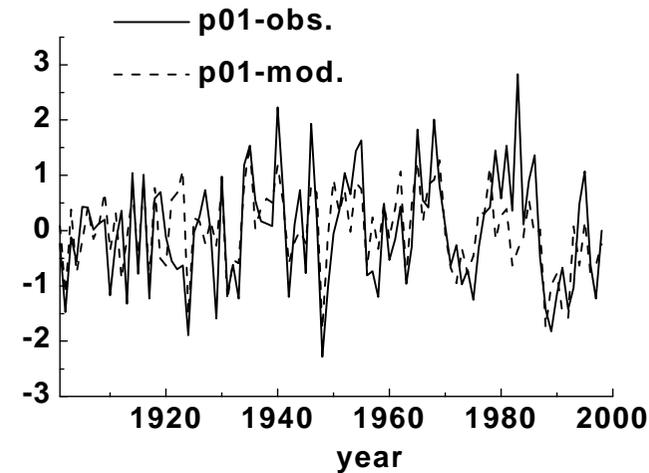
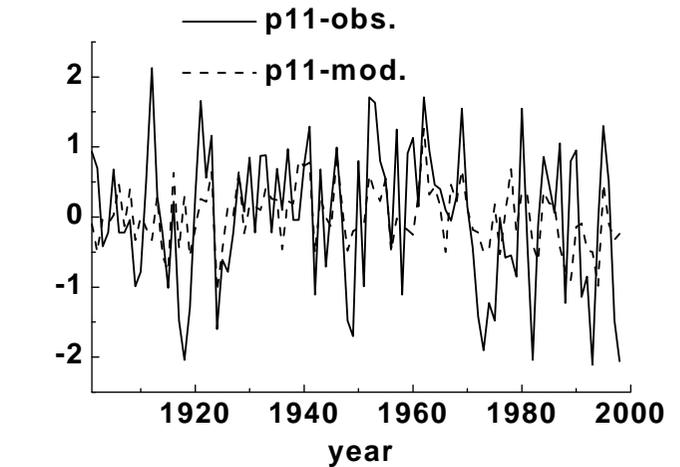
- Conditional stochastic model (Busuioc et al., 2003)

- is a combination between a first-order Markov chain and a statistical downscaling model based on CCA

Fig.2. Patterns of the first two CCA pairs of winter mean SLP and winter parameters of precipitation distribution derived from the interval 1950-1990



Winter standardized anomalies of the precipitation distribution parameters for 1901-1999 derived from observations (solid line) and indirectly from the European-scale SLP anomalies using the downscaling model (dashed line fitted to the 1901-1949 data)



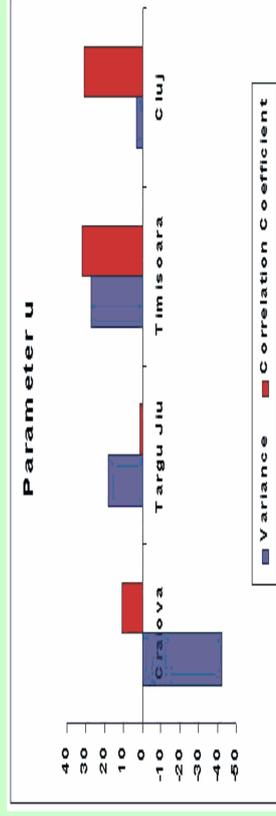
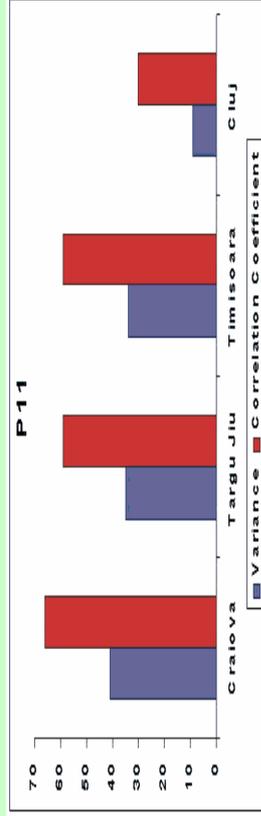
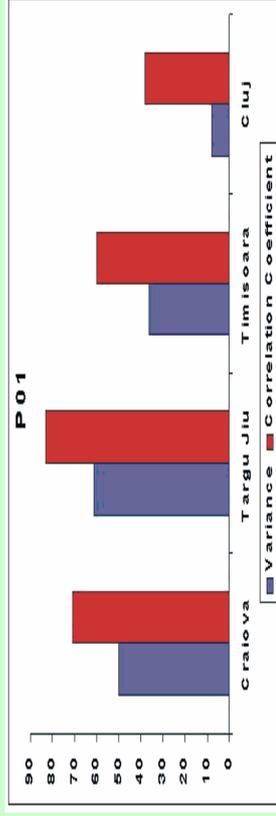
The performance of the stochastic models was determined in terms of how well the model reproduces the following statistical features of the observed precipitation time series:

- Appearance/nonappearance of precipitation quantified by: mean and expected maximum duration of wet and dry intervals.
- Daily mean and standard deviation of precipitation for wet days, expected maximum daily precipitation amount and frequency distributions of daily precipitation.
- Changes (linear trend) in the seasonal precipitation amount induced. The significance of the linear trend is estimated by the Mann-Kendall statistic (Sneyers 1975).
- Interannual variability of seasonal precipitation amount quantified by the standard deviation.
- These statistical features were computed for the 2 subintervals (1901-1949, 1950-1999).
- An ensemble of 1000 simulations was generated for each model, and the statistical parameters listed above were expressed as ensemble means with their 90% confidence intervals computed with a bootstrapping procedure.

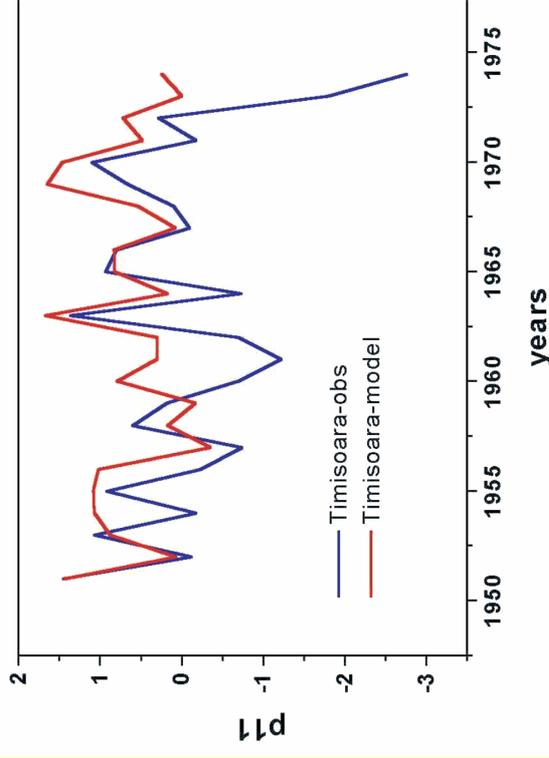
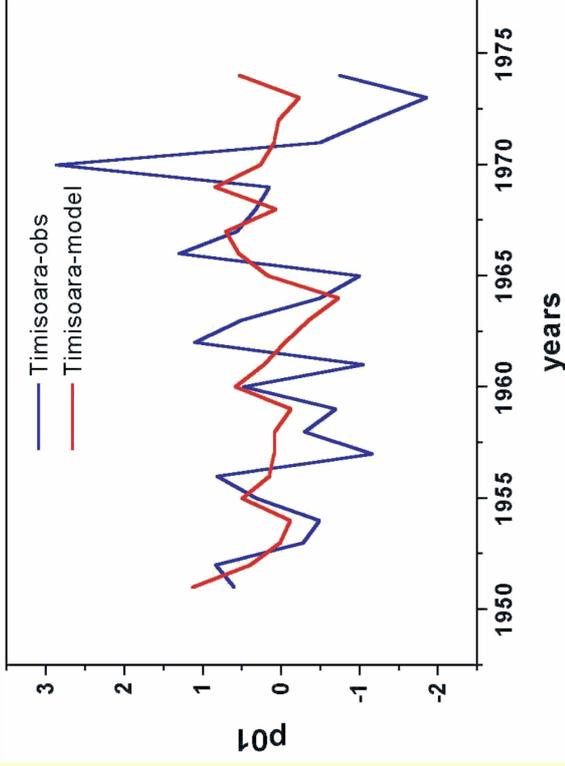
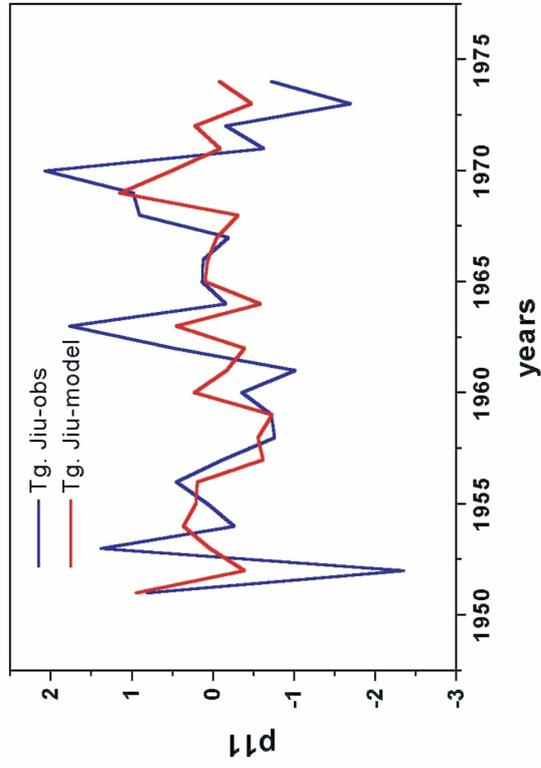
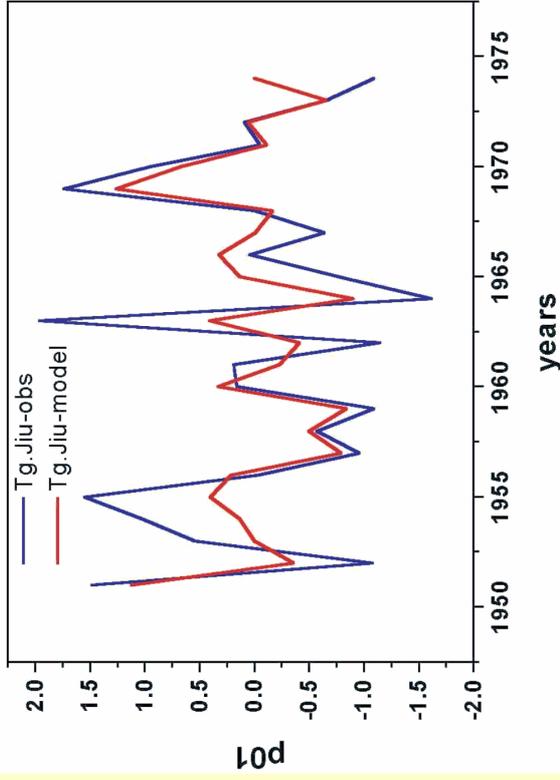
## Conclusions

The CCA model is skilful for the transition probabilities and for stations placed in the southwestern region; The lowest skill was obtained for the Cluj station.

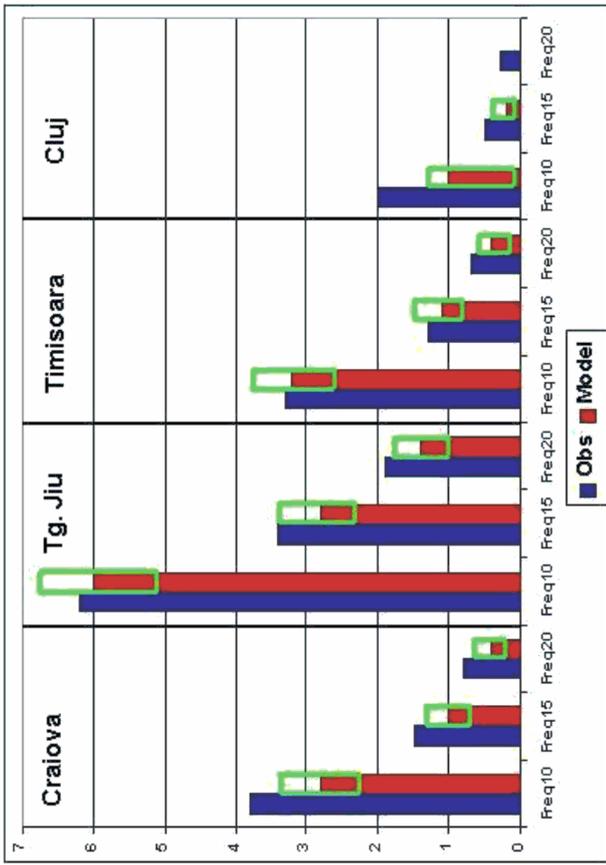
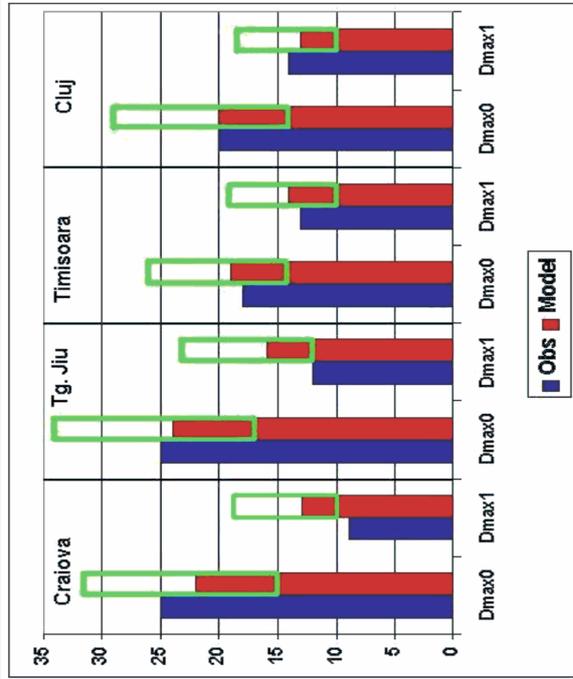
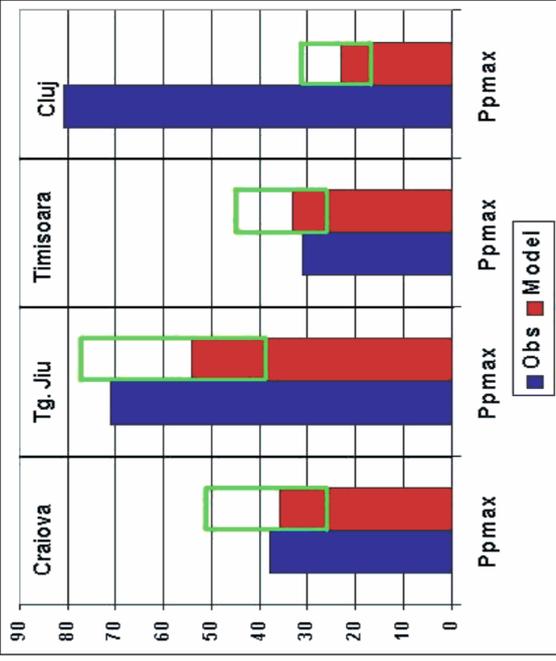
The extreme precipitation indices are generally well reproduced by the conditional stochastic model, except for the frequency of extreme precipitation (Craiova and Cluj stations- all thresholds- underestimated), maximum daily precipitation (Cluj station);



Accuracy of the CCA model expressed as explained variance (blue bar) and correlation coefficient (red bar) for estimation of the transition probabilities and gamma distribution parameter  $u$  (mean precipitation for wet days)

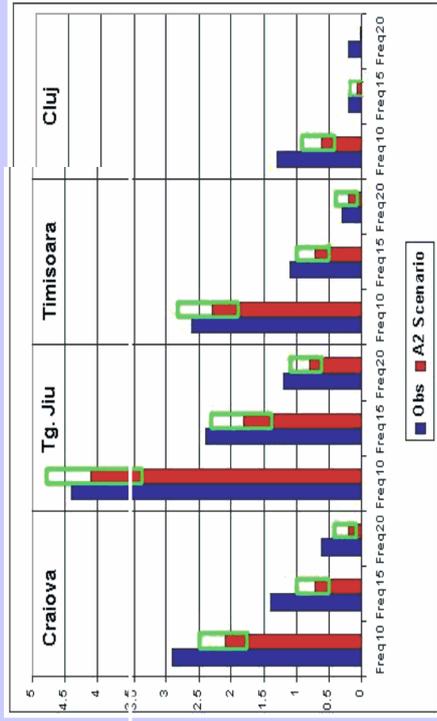
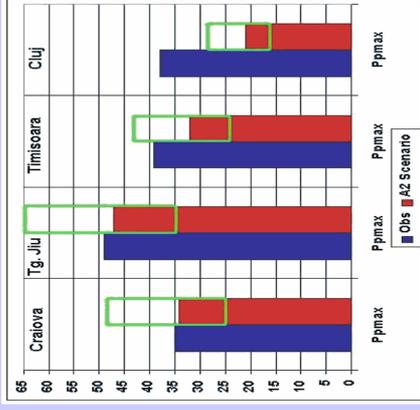
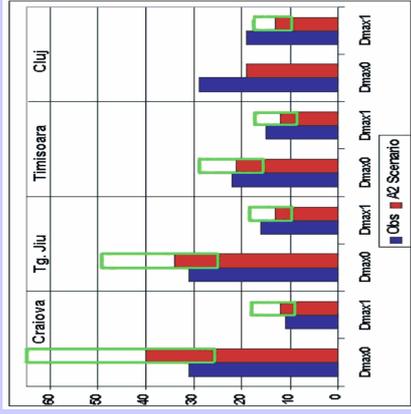


**Standardized anomalies of the transition probabilities derived from observations ( blue line) and derived indirectly from the observed SLP anomalies using the CCA model (red line) over the independent interval 1951-1974**



Extreme precipitation indices derived directly from observations and indirectly from the conditional stochastic model over the independent interval 1951-1974 with model fitted over the 1975-1999 interval. The values are computed as ensemble means for 1000 runs. 90% confidence intervals are marked.

Changes in the extreme precipitation indices over the period 2070-2099 compared to observed period 1974-1999 derived through conditional stochastic model applied to the outputs of the HadCM3 the model ( IPCC A2-scenarios).



Under the HadCM3-A2 scenario, significant changes are expected in the frequency of daily extreme precipitation (decrease) at all stations, maximum duration of dry intervals (increase for southwestern stations and decrease for central one), maximum duration of wet interval (decrease, except for Craiova station), maximum daily precipitation (decrease, except for Craiova station)

Some uncertainties of the estimated changes are due to the low skill of the CCA model in estimation of the gamma distribution parameters; other approaches are needed in the future.

# References

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