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Alpine Forest Fire Warning System

Evaluation of fire potential in the climatic scenario: an Alpine area perspective

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ALP FFIRS Project

ALPine Forest FIRe Warning System

An INTERREG Alpine Space project.

Funded by the European Regional Development fund of the Alpine Space Program, reference number 15-2-3-IT

Work Package 4: Operational Warning System Implementation

Work Package 5: Climate change impacts

Work Package 6: Procedures & Training

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Outlook

- Introduction
- Dynamical downscaling: COSMO-CLM model
- Statistical downscaling: Multimodel SuperEnsemble application on RCMs in the Alpine Area
- Fire Weather Index evaluation
- Confrontation with observed fires and projection to the scenario
- Conclusion

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Introduction

The Alps: an “hot spot” for the climate change (observed and projected)

Climate change impact evaluation on wildfire potential in the whole Alpine area.

The Canadian Fire Weather Index has skill in the Alps on weather station, can be used also in a “coarse” climatic contest?

Long-term series of observed fires has to be used to validate the results.

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Introduction

Climate Models: a comparison of two techniques.

A single model run by the COSMO-CLM model.
Advantages: more coeherence between the parameters.
Disadvantage: RCMs show big biases vs obs. in the Alps

Multimodel SuperEnsemble and SuperEnsemble Dressing: a very careful downscaling technique to obtain better parameter fields in a complex orography region like the alpine area. Disadvantage: fields are not coeherent each with the other.

Non-parametric statistics are used to project the fire potential in the scenario.

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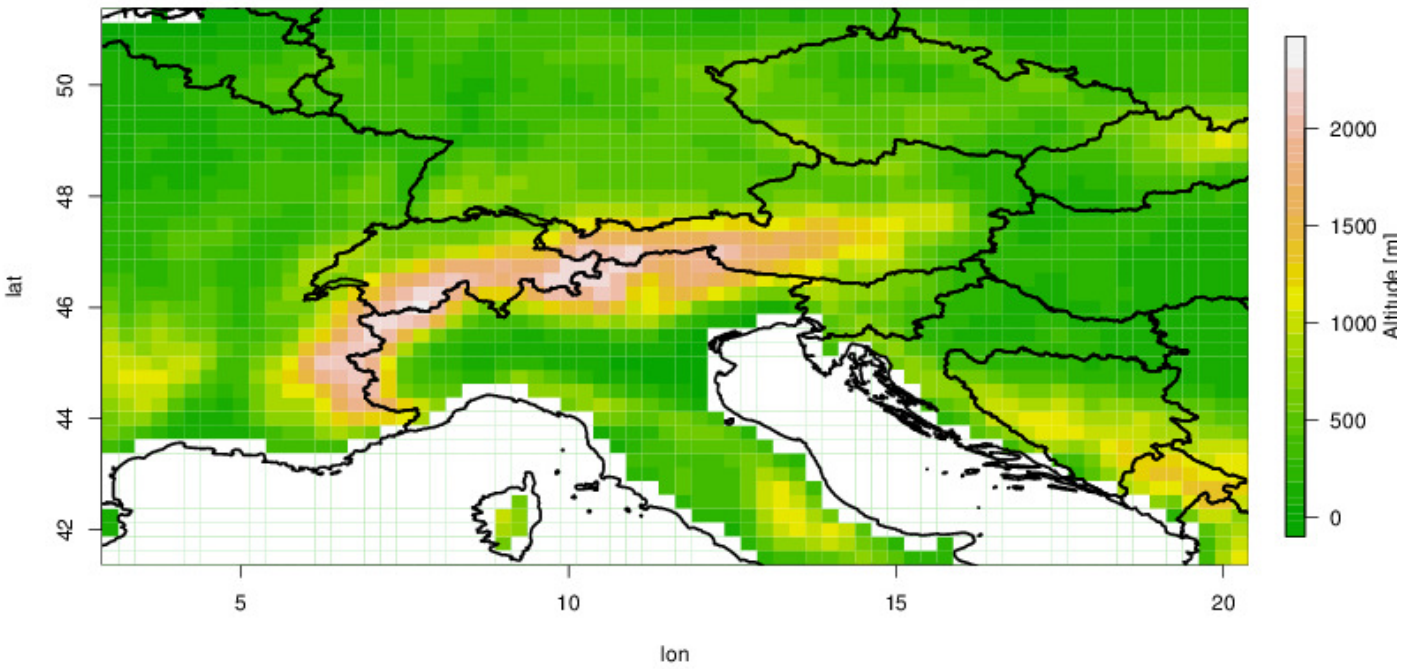
DOMAIN: Greater Alpine Area



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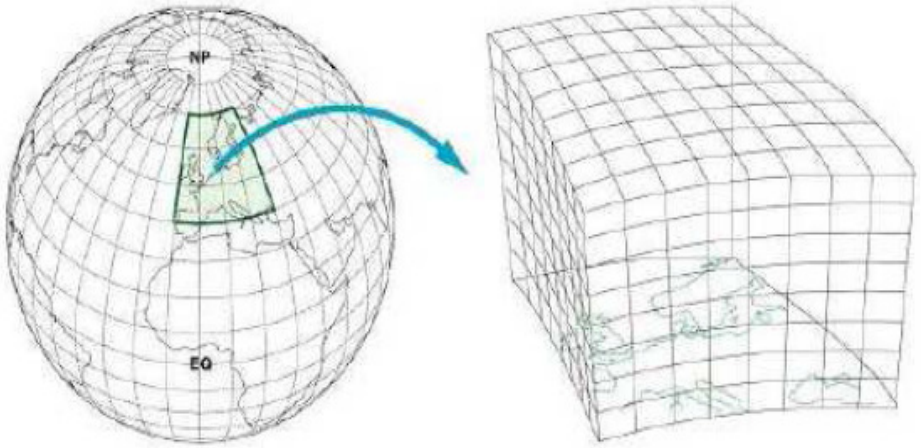
COSMO model

- Nesting of a high resolution regional climate model (COSMO-CLM) in coupled atmosphere-ocean global circulation model ECHAM5/MPIOM
- Boundary conditions of RCM are taken from GCM (data exchange every 6h)
- GCM gives large scale trend, RCM refines simulation in complex terrain



GCM
Δx = 200 km

RCM
Δx = 18 km

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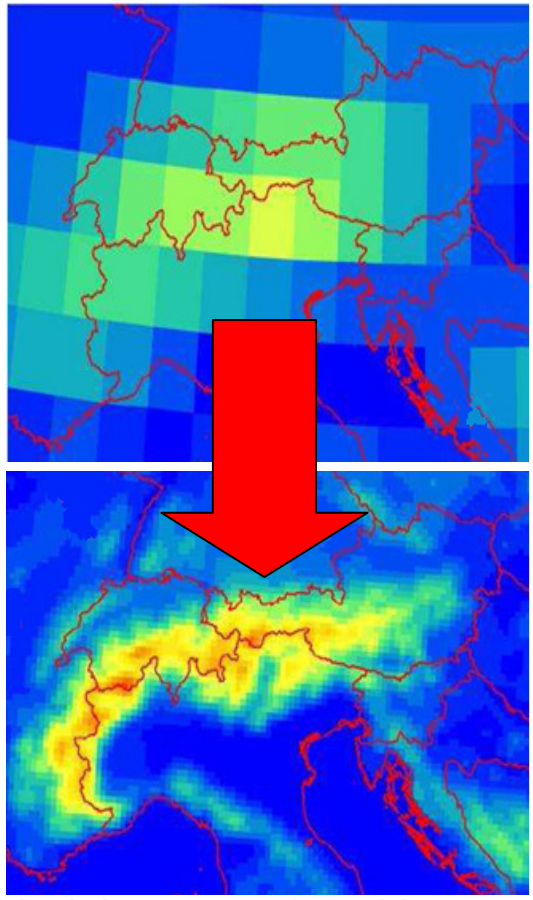
- IPCC scenario A1B
- RCM simulations covering the Greater Alpine Region (GAR) from 1986 – 2050 (5year spin-up)
- Temporal resolution of output between 1h (prec, wind) and 3h (other parameters)
- Reducing of model BIAS by comparing two periods within one model run
- Control period (1991 – 2010)
- Scenario period (2031 – 2050)



Model topography with 200 km and 18 km resolution

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Multimodel for RCMs downscaling

Reanalysis on ECMWF ERA-40 (1961-2000) and A1B scenario runs (1961-2100) of the following RCMs (daily data):

- **HIRHAM5 – DMI (GCM: Arpege)**
- **REGCM3 – ICTP (GCM: ECHAM5)**
- **HadRM3Q0 - Hadley Center (GCM: HadCM3Q0)**
- **RM4.5 – CNRM (GCM: Arpege)**
- **CLM - ETH Zurich (GCM: HadCM3Q0)**
- **RACMO2 – KNMI (GCM: ECHAM5)**
- **REMO - Max Plank Institute (GCM: ECHAM5)**

Observations: E-OBS dataset from the (resolution: 25 km)
Source: ENSEMBLES project

- **Model data are interpolated to the grid via bi-linear interpolation**

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Multimodel Techniques

Poor Man Ensemble

$$S = \frac{1}{N}\sum_{i=1}^{N} F_i$$

Un-biased Multimodel Ensemble

$$S = \overline{O} + \frac{1}{N}\sum_{i=1}^{N}\left(F_i - \overline{F_i}\right)$$

Multimodel SuperEnsemble

$$S = \overline{O} + \sum_{i=1}^{N} a_i\left(F_i - \overline{F_i}\right)$$

Probabilistic Multimodel SuperEnsemble Dressing

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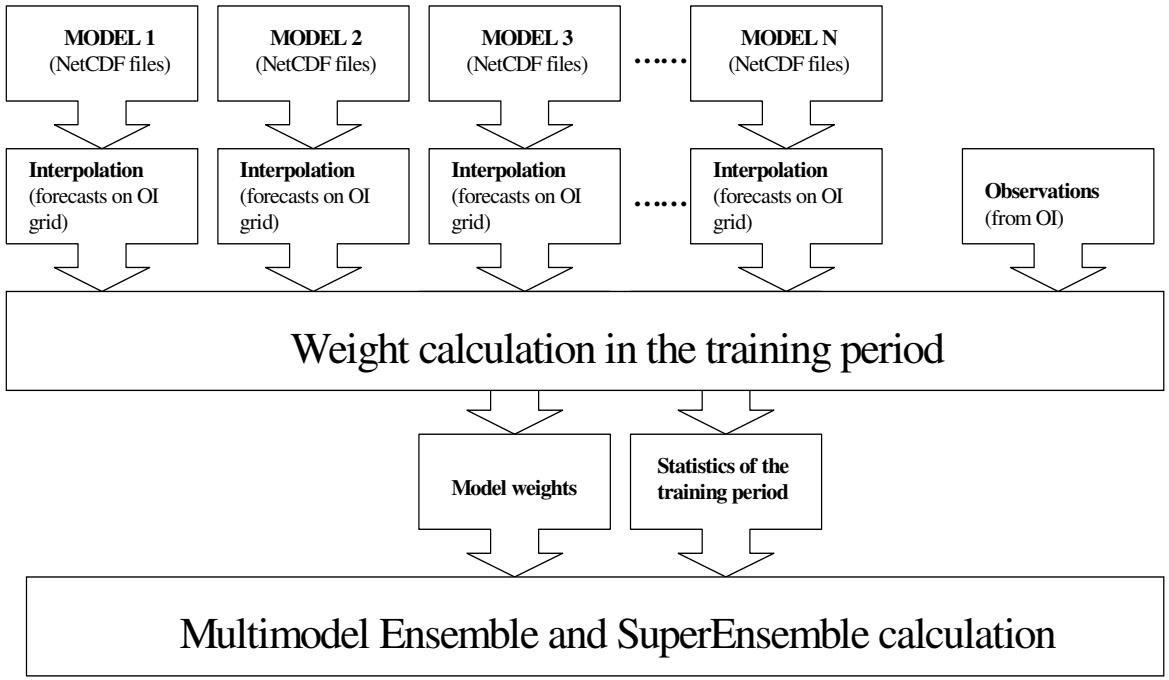
Standard Multimodel SuperEnsemble



Weights are calculated with a Gauss-Jordan minimisation

Krishnamurti T.N. et al., "Improved weather and seasonal climate forecasts from Multimodel SuperEnsemble", Science 285, 1548-1550, 1999
Cane D., Milelli M., "Weather forecasts obtained with a Multimodel SuperEnsemble Technique in a complex orography region", Meteorologische Zeitschrift, Vol. 15, No. 2, 207-214, 2006

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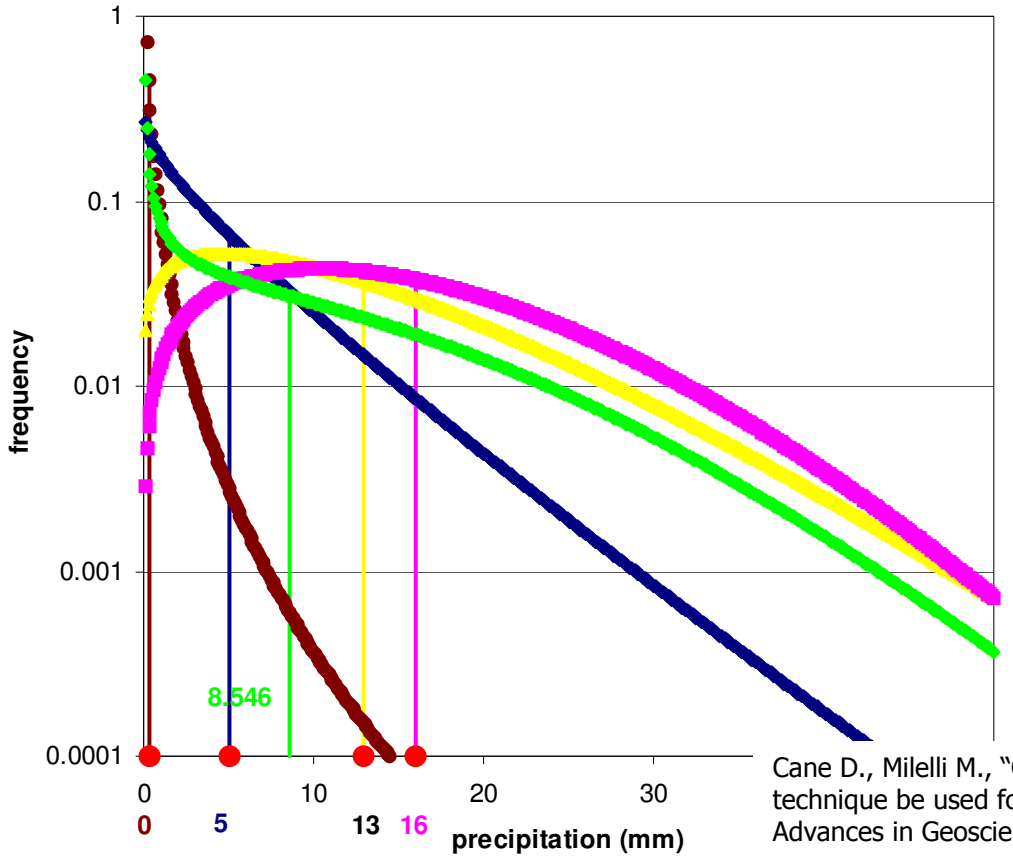
Multimodel SuperEnsemble dressing



We associate to each model's QPF the empirical Probability Density Function (PDF)

We calculate the (weighted) mean PDF.

Cane D., Milelli M., "Can a Multimodel SuperEnsemble technique be used for precipitation forecasts?", Advances in Geoscience, 25, 17-22, 2010

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Multimodel calculation

Weights: inverse of the continuous ranked probability score (CRPS), normalized to the sum of inverses of the CRPSs of the models

$$CRPS = \int_{-\infty}^{\infty} (P_f(x) - P_o(x))^2 dx$$

NOTE: the CRPSs are calculated on the Reanalysis and not on the scenario (for calculation a correspondence between forecast and observation is needed day by day)

For any day of the scenario a given precipitation value is extracted randomly from the PDF.

TO DO: use of a correlated (auto-regressive) random number distribution instead of a "white noise" random number

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Climate scenario FWI calculation

HIGH RESOLUTION DATA IN PIEMONTE

OBS:

- **Temperature: Optimal Interpolation**
- **Precipitation: Optimal Interpolation**
- **Rel. humidity: Poor Man Ensemble RCMs reanalyses**
- **Wind speed: Poor Man Ensemble RCMs reanalyses**

+ # recorded forest fires in Piedmont 1957-2009

Scenario/reanalysis:

- **Temperature: tmax (MM standard)**
- **Precipitation: MM probabilistic**
- **Rel. humidity: Poor Man Ensemble RCMs reanalyses/scenarios**
- **Wind speed: Poor Man Ensemble RCMs reanalyses /scenarios**

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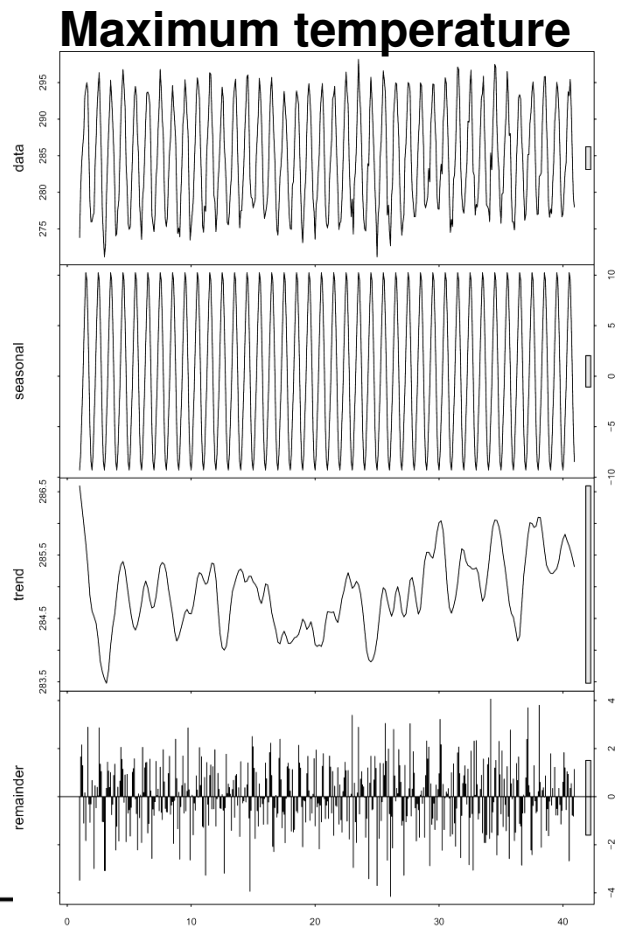
Seasonal Decomposition

An example of the signal decomposition according to the Seasonal Decomposition of Time Series by LOESS (Cleveland et al., 1990).

Data are calculated daily, but statistics are performed on a monthly basis.



Training period 1961-1980, forecast period 1981-2000

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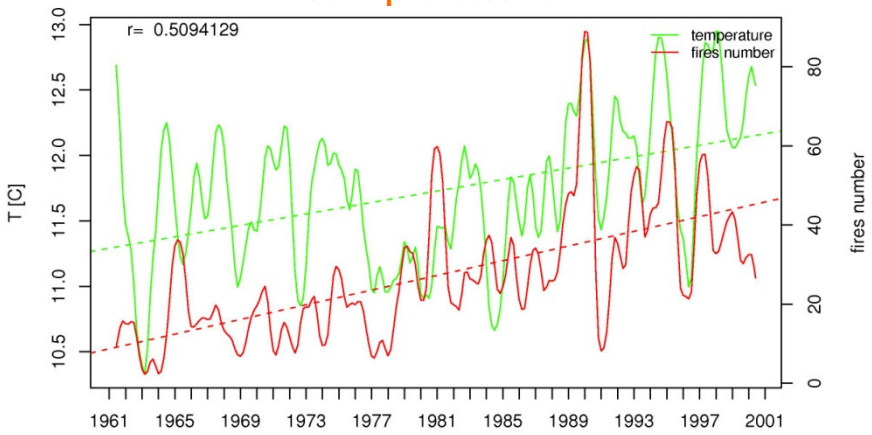
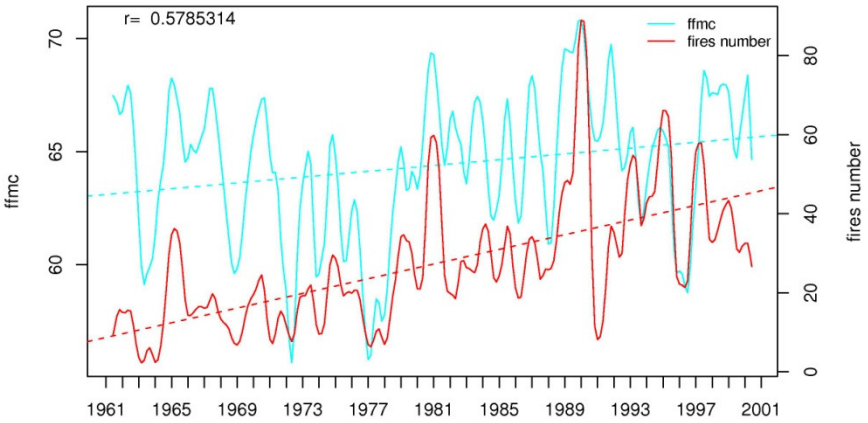
temperature



ffmc



Obs 1961-2000: trends

>90% of Piedmont Region forest fires have an anthropogenic cause, but the fire potential is strongly linked to the climate.

Cane D., Barbarino S., Renier L. A., and Ronchi C., “Detailed downscaling trough Ensemble techniques of the Regional Climate Models for a Fire Weather Indices projection in the Alpine region”, Proceedings of the International Conference on Fire Behaviour and Risk (Alghero, Italy, October 2011) , *submitted*

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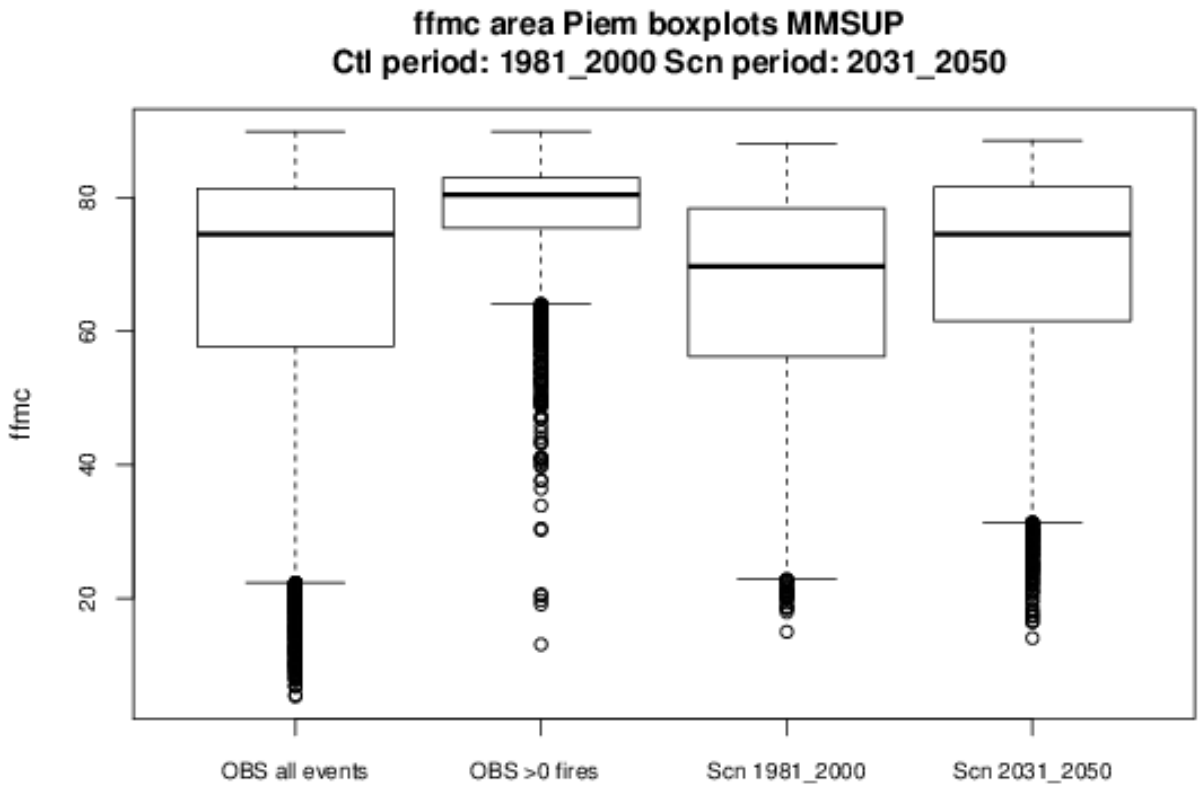
BUT: the scenario data do not have a correspondence with the real days… we have to work in terms of distributions!



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Climate scenario FWI calculation

LOWER RESOLUTION DATA: THE GREATER ALPINE AREA

OBS:
- **Temperature: from E-OBS**
- **Precipitation: from E-OBS**
- **Rel. humidity: Poor Man Ensemble RCMs reanalyses**
- **Wind speed: Poor Man Ensemble RCMs reanalyses**

+ # recorded forest fires NOT AVAILABLE

Scenario/reanalysis:
- **Temperature: tmax (MM standard) / t12 (COSMO model)**
- **Precipitation: daily values (MM probabilistic)**
- **Rel. humidity: daily average (Poor Man Ensemble) / h12 (COSMO model)**
- **Wind speed: daily average (Poor Man Ensemble) / w12 (COSMO model)**

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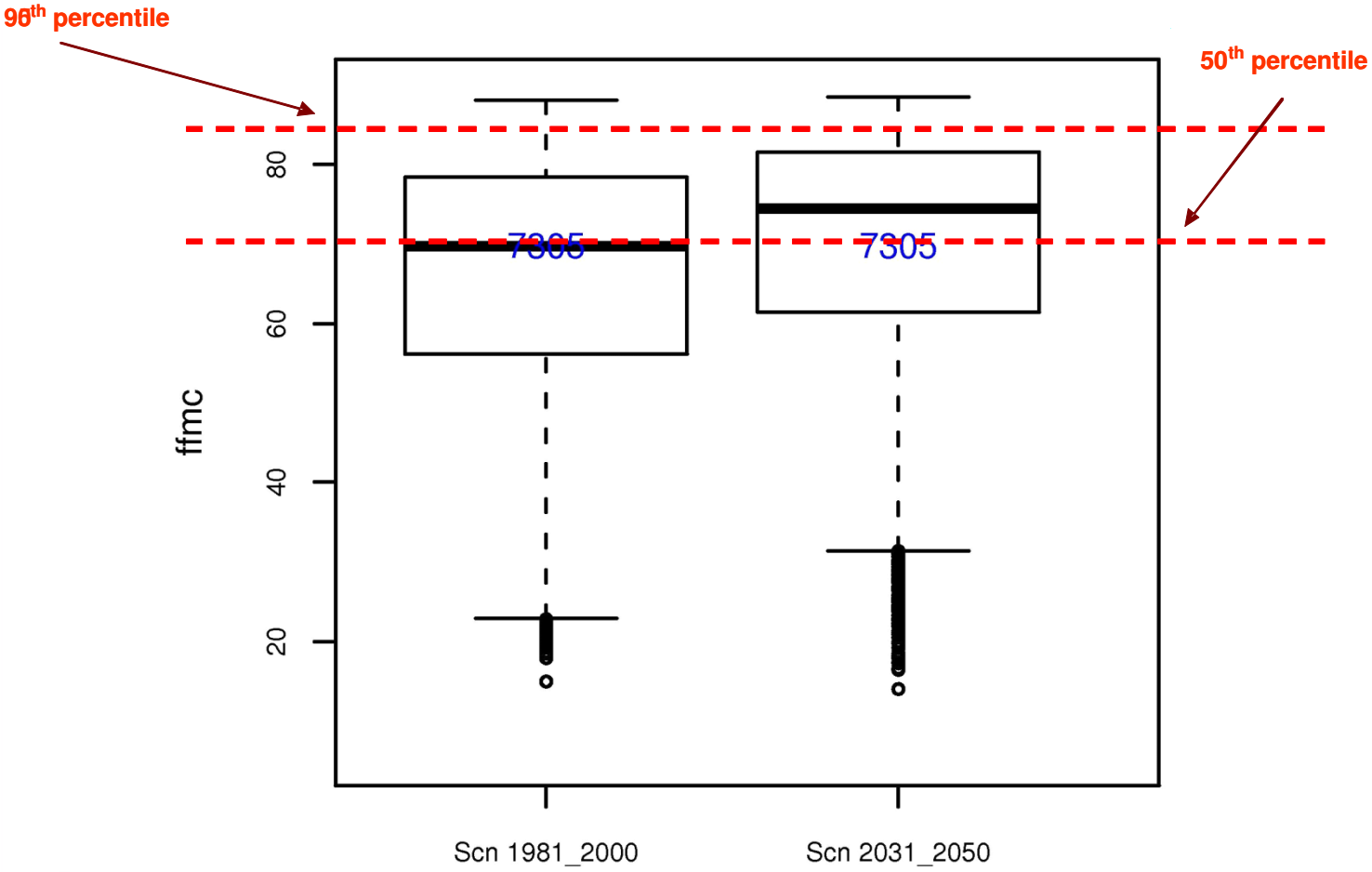

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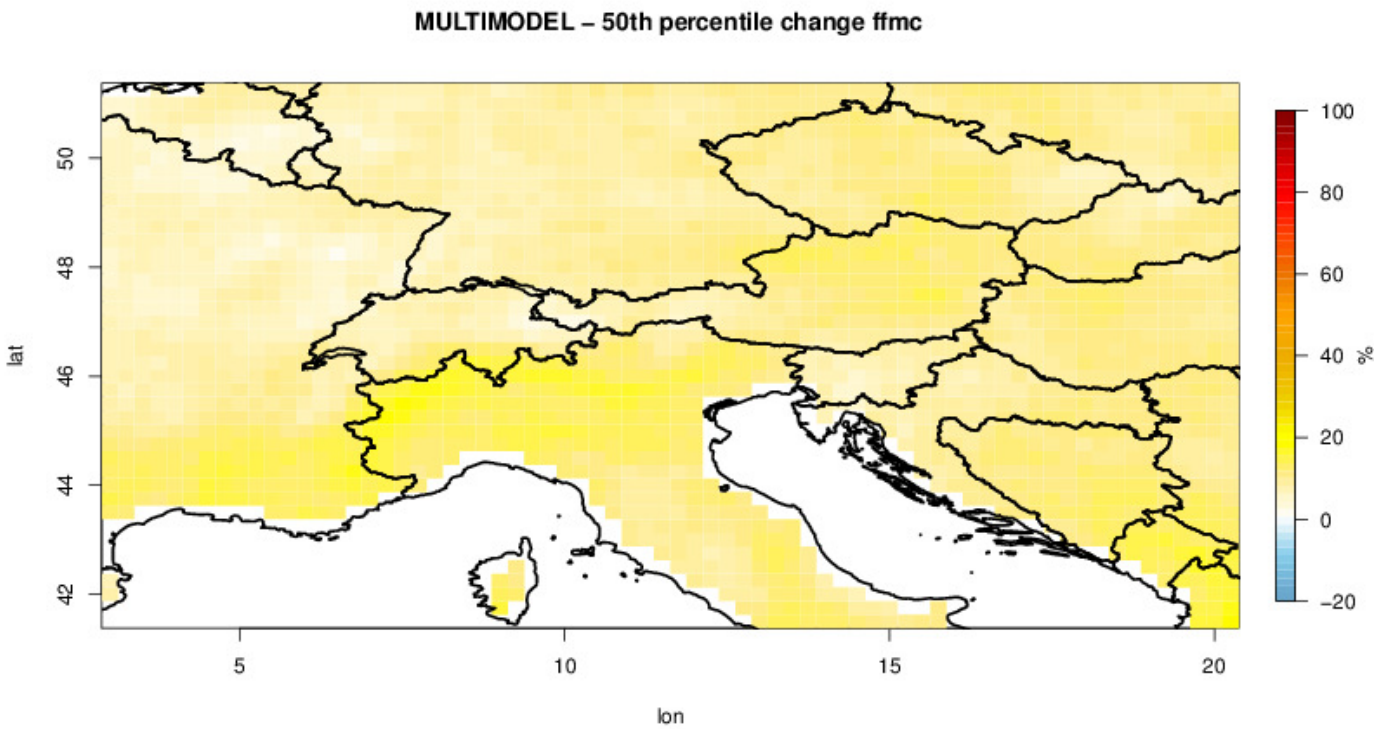

Percentage change of occurrence of the present condition thresholds for the median of the FFMC distribution in the Greater Alpine Area in the period 2031-2050 vs period 1991-2010 – Multimodel

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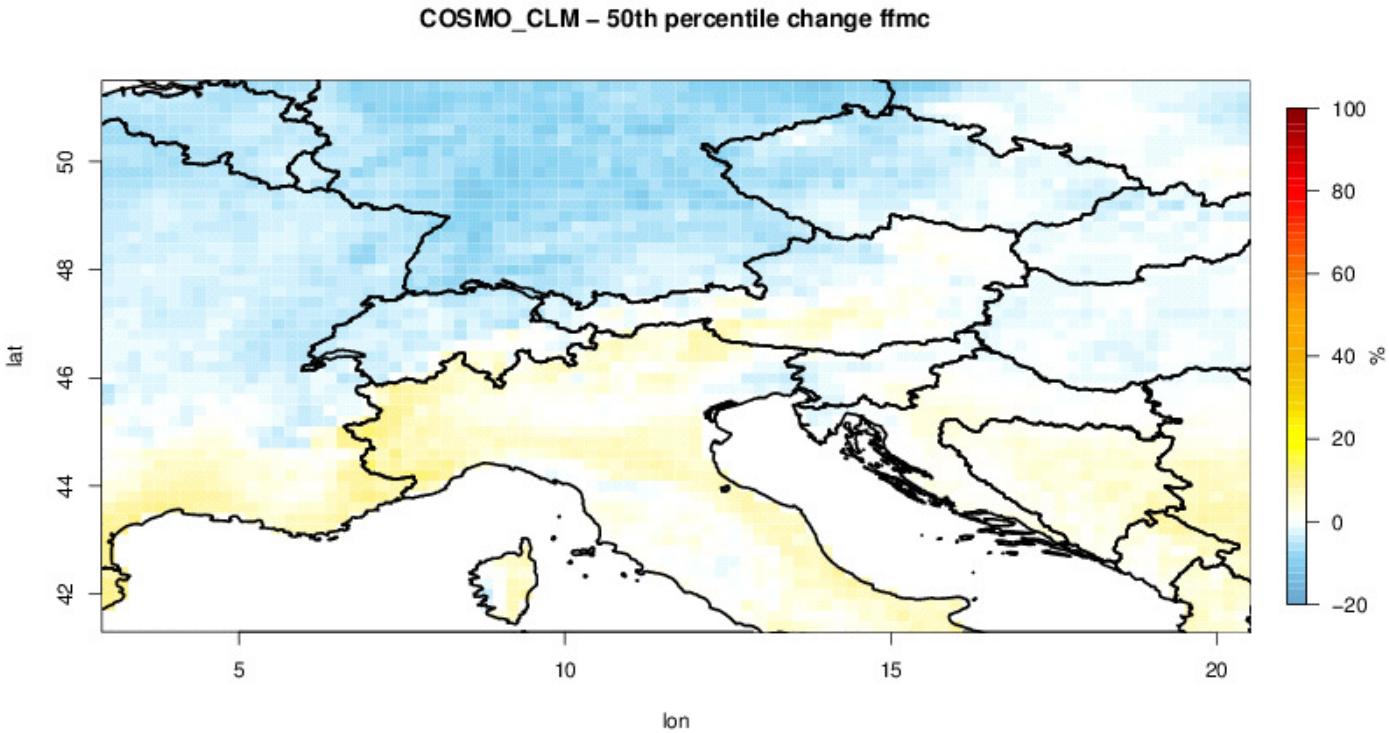

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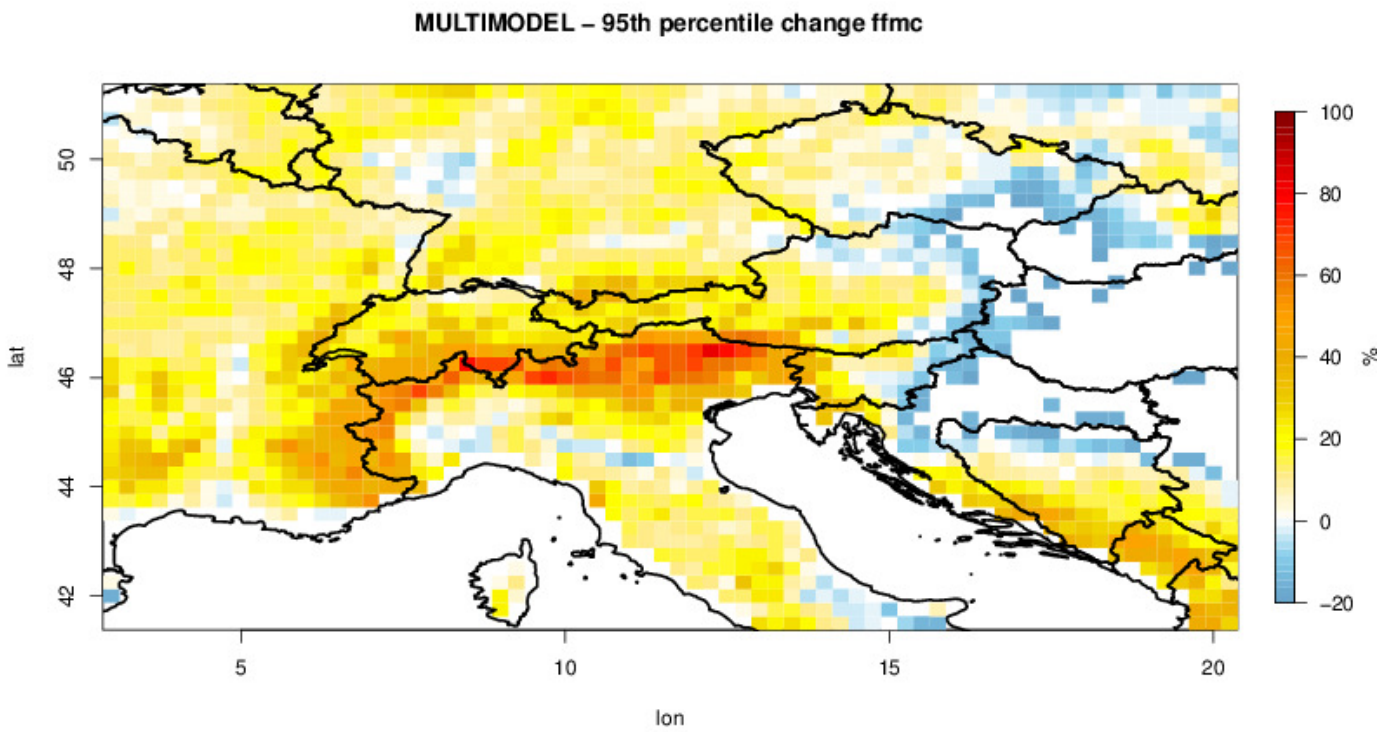

Percentage change of occurrence of the present condition thresholds for the 95th percentile of the FFMC distribution in the Greater Alpine Area in the period 2031-2050 vs period 1991-2010 – Multimodel

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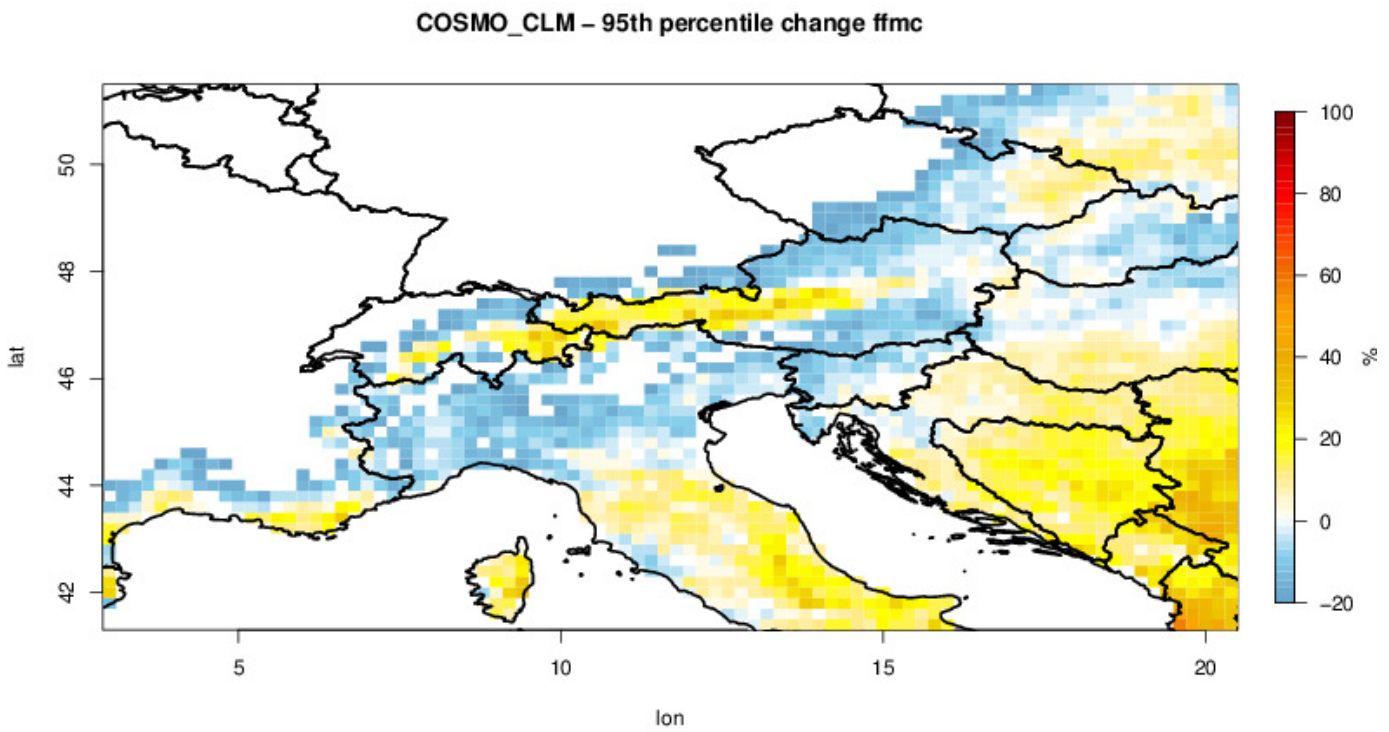

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