

# Downscaling daily precipitation

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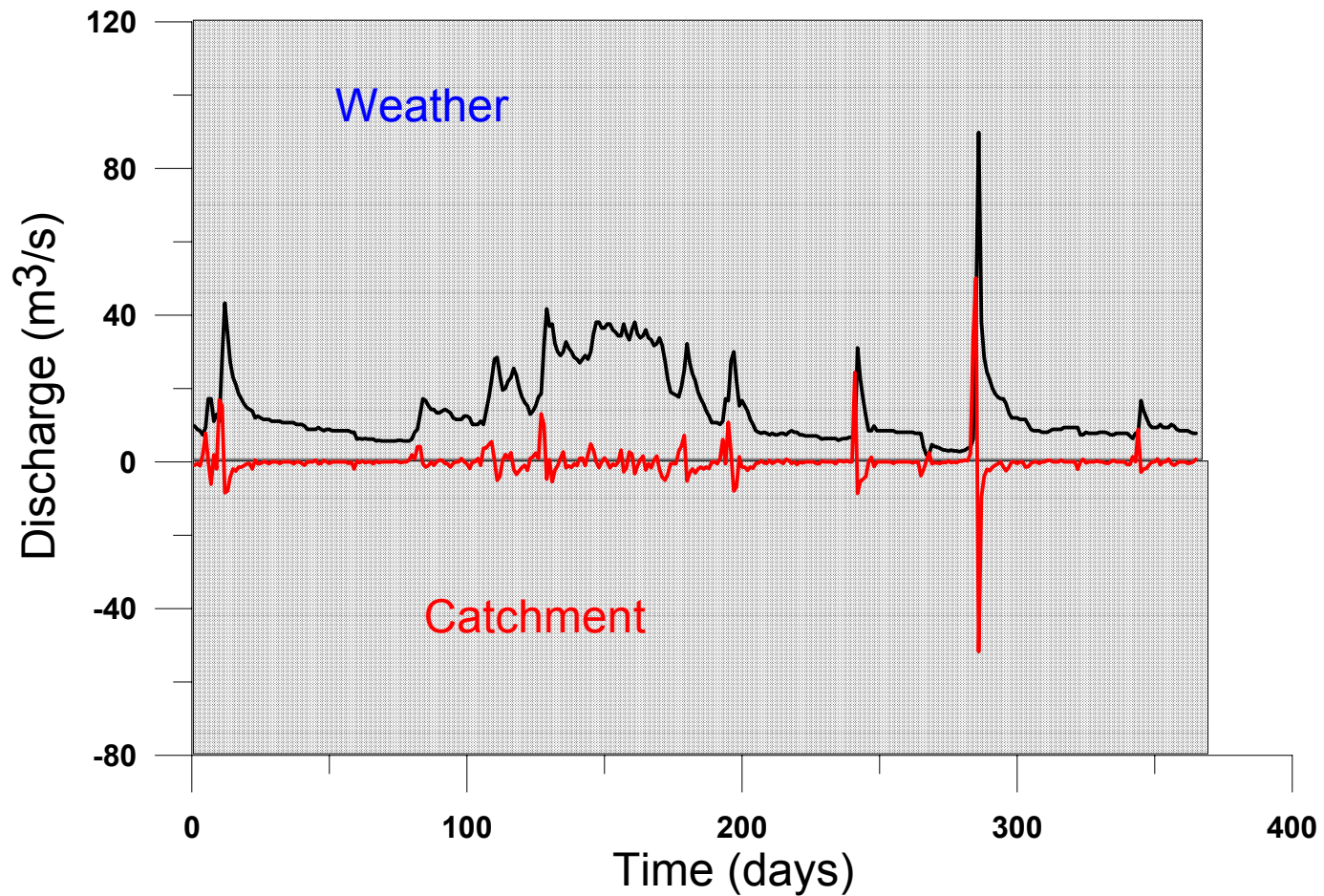
# Model: Mixed discrete continuous

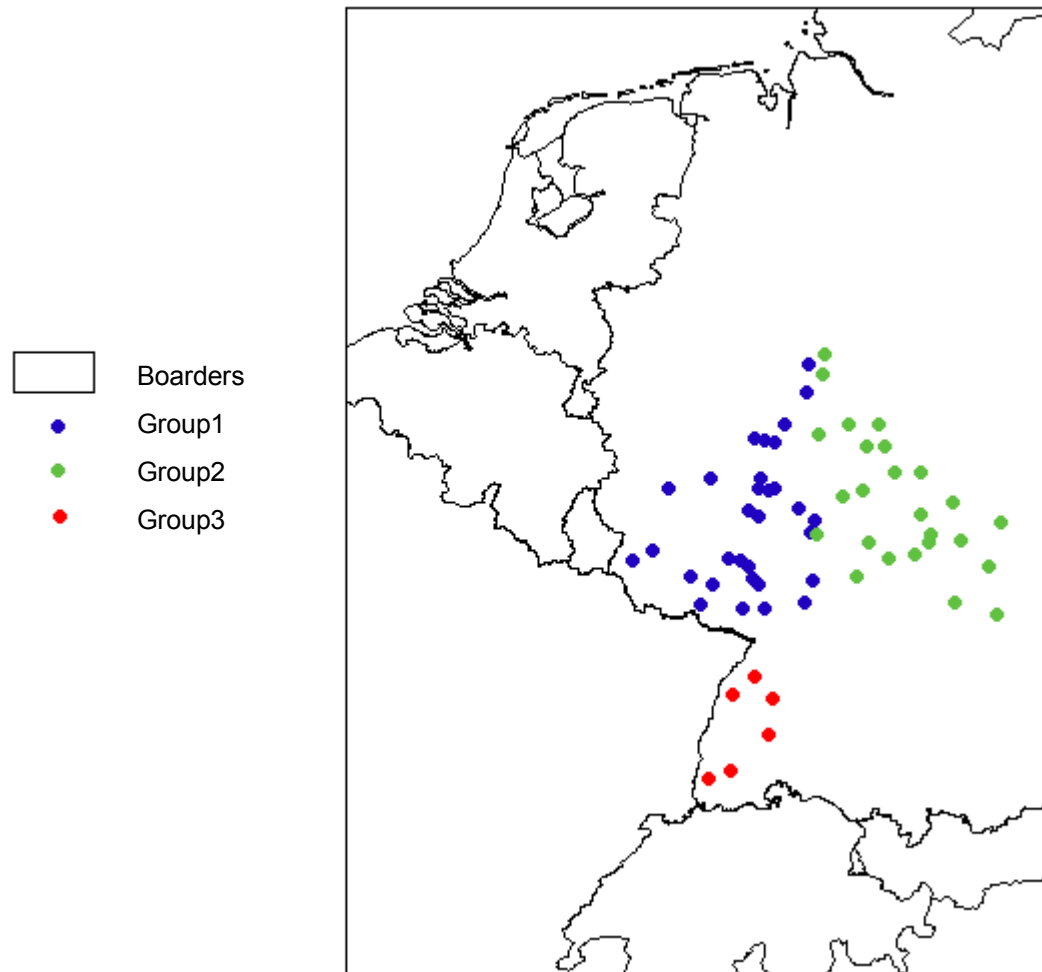
- Downscaling:
  - Regression type approaches
  - Classification
- Circulation patterns as classes
- Within each class continuous variables
  - Probability of rainfall
  - Rainfall amount on wet days
  - Spatial correlation

# CP definitions

- Fuzzy rule based classification (location of anomalies)
- Using SLP or 700 hPa
- Optimizing an objective function:
  - Precipitation (extremes)
  - Temperature
  - Discharge based – areal extremes

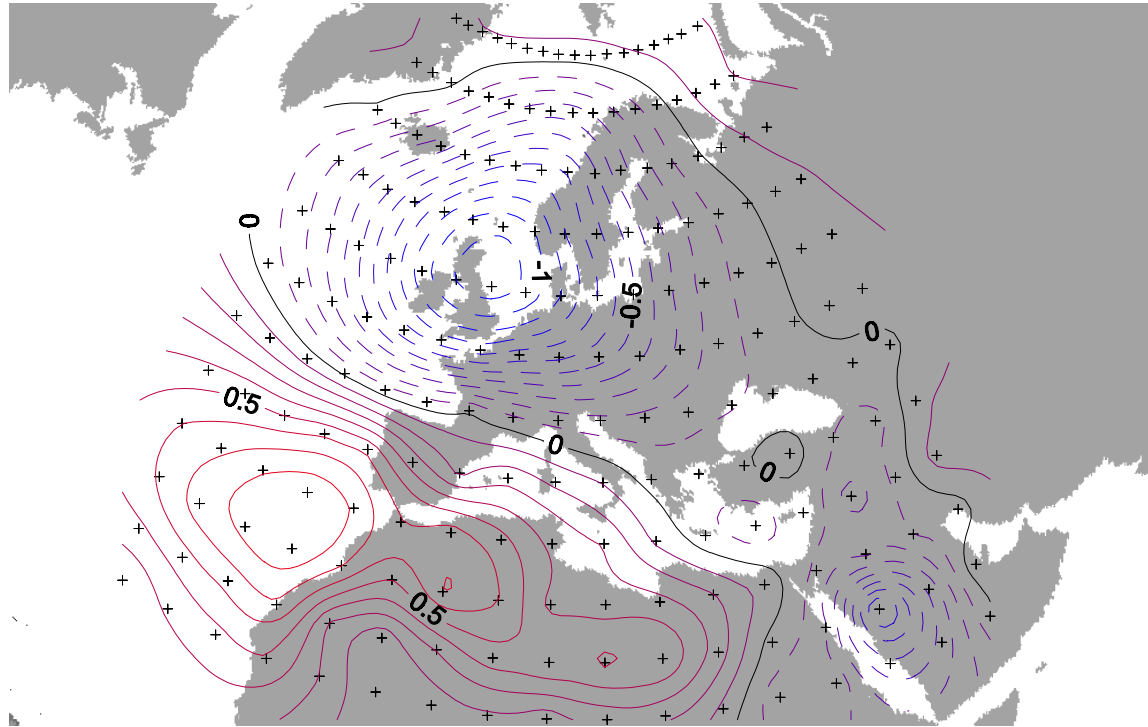
# Principle of CP definition



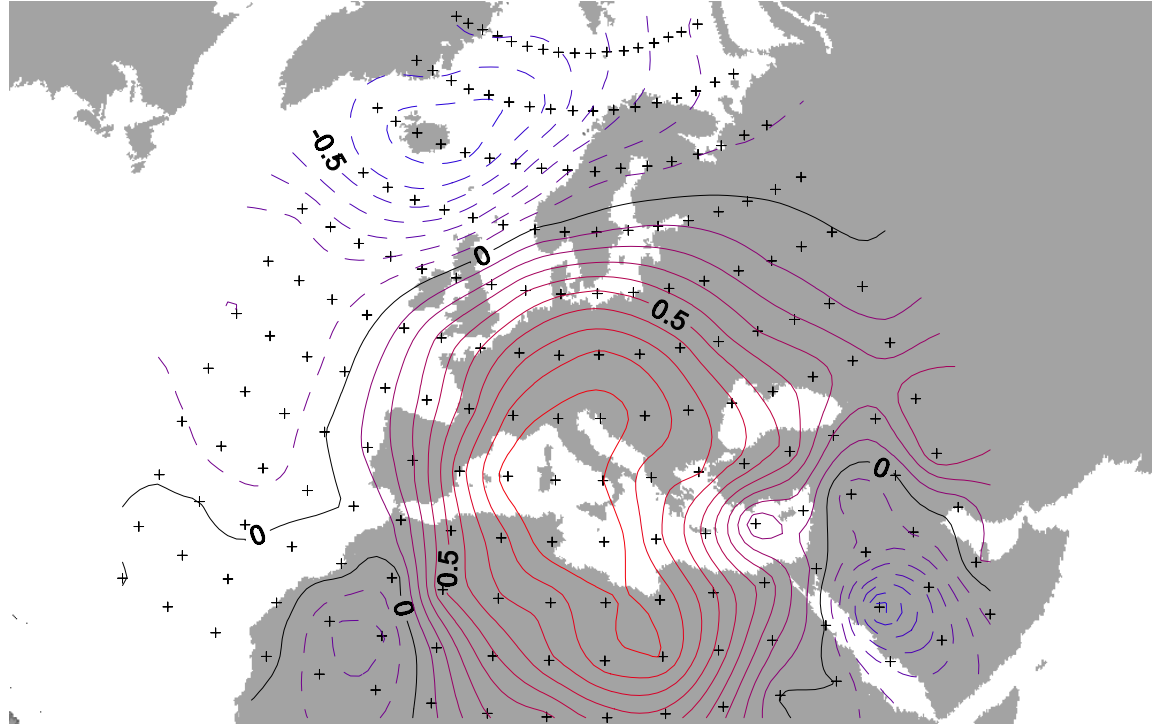


**Fig. 2: Distribution of selected precipitation stations in the German Rhine catchment area**

## CP 2



# CP 7



# Precipitation

## Upper Neckar - Winter

	Frequency (%)	Mean Precip.	Relative >P90
<b>CP02</b>	<b>14.0</b>	<b>36.8 %</b>	<b>34.0 %</b>
<b>CP07</b>	<b>10.7</b>	<b>3.5 %</b>	<b>2.4 %</b>
<b>CP09</b>	<b>8.7</b>	<b>20.9 %</b>	<b>23.7 %</b>
<b>CP11</b>	<b>7.6</b>	<b>13.1 %</b>	<b>15.8%</b>



# Additional variables

Continuous component

- Moisture flux
- Windspeed (W-E)

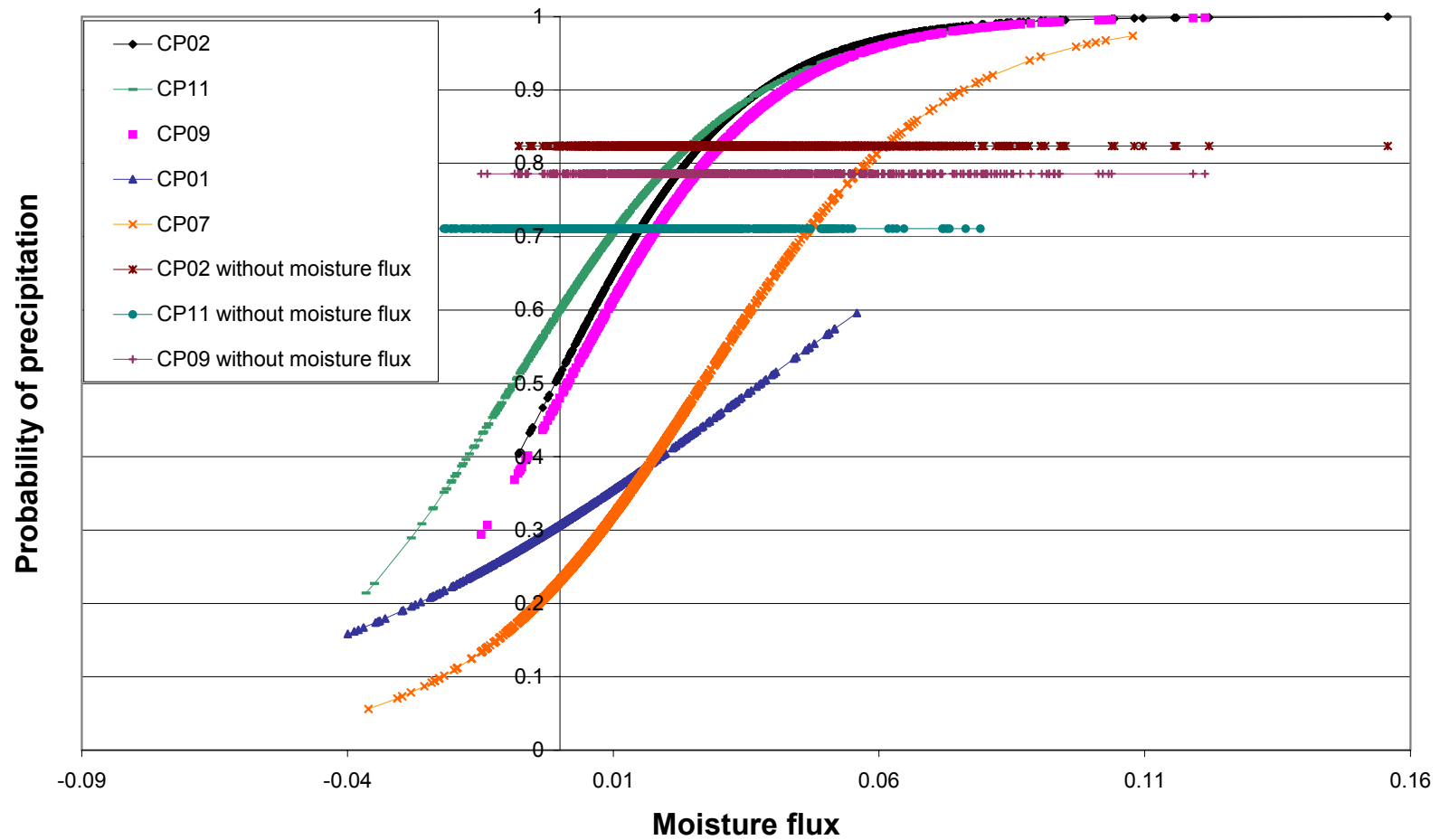
850 hPa, 700 hPa and 500 hPa

# Results – correlations

(for stations in different groups)

	Total MF			Zonal MF		
	G1	G2	G3	G1	G2	G3
500 hPa	0.330	0.295	0.357	0.348	0.308	0.378
700 hPa	0.372	0.335	0.405	0.400	0.355	0.430
850 hPa	0.357	0.311	0.377	0.378	0.329	0.429

# MF + CP



Probability of precipitation at station 75103 conditioned to wet and dry CPs

# Combination (linear)

- MF only (regression)
- CP only (classification)
- MF + annual cycle
- MF + CP + annual cycle (conditional regression)

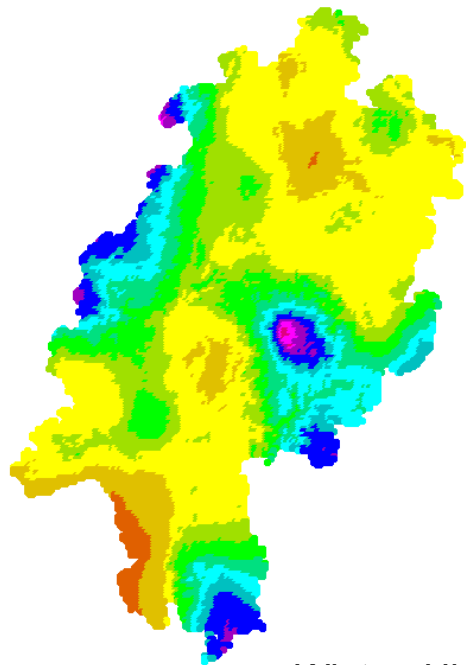
Calibration and validation period

MF      MF + AC      MF+CP      MF+CP+AC

Aver.	0.338	0.358	0.421	0.456
Max.	0.481	0.510	0.559	0.587
Min.	0.225	0.232	0.310	0.346
STD	0.051	0.057	0.058	0.059

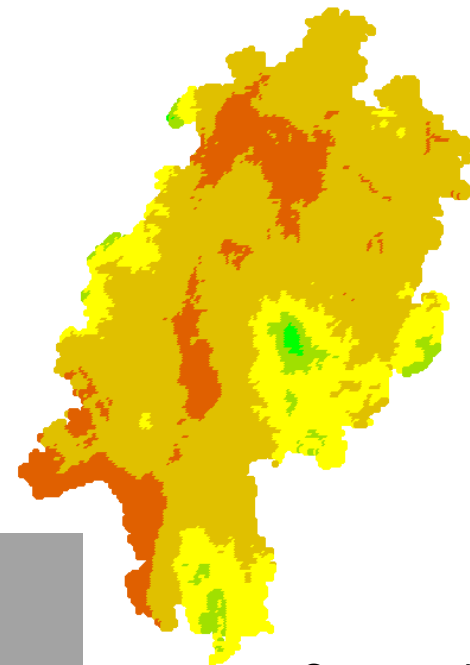
Validation

0.388	0.410	0.460	0.466
0.537	0.595	0.596	0.639
0.262	0.260	0.341	0.319
0.051	0.062	0.061	0.070



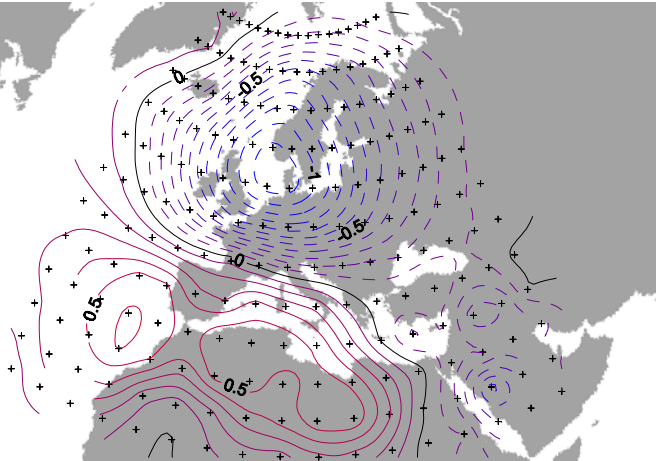
- 14.2 - 17.8
- 17.8 - 21.4
- 21.4 - 25
- 25 - 28.6
- 28.6 - 32.2
- 32.2 - 35.7
- 35.7 - 39.2
- 39.2 - 42.6
- 42.6 - 46.1
- 46.1 - 49.6
- 49.6 - 53.1
- 53.1 - 56.6
- 56.6 - 60
- 60 - 63.5
- 63.5 - 67
- 67 - 70.5
- 70.5 - 74
- 74 - 77.5
- 77.5 - 80.9
- 80.9 - 84.4
- 84.4 - 87.9
- 87.9 - 91.4
- 91.4 - 94.9
- 94.9 - 98.3
- 98.3 - 101.8
- 101.8 - 105.3
- 105.3 - 108.8
- 108.8 - 112.3
- 112.3 - 115.8
- 115.8 - 119.2
- 119.2 - 122.7
- 122.7 - 126.2
- 126.2 - 129.7
- 129.7 - 133.2
- 133.2 - 136.6
- 136.6 - 140.1

Winter\_High MF

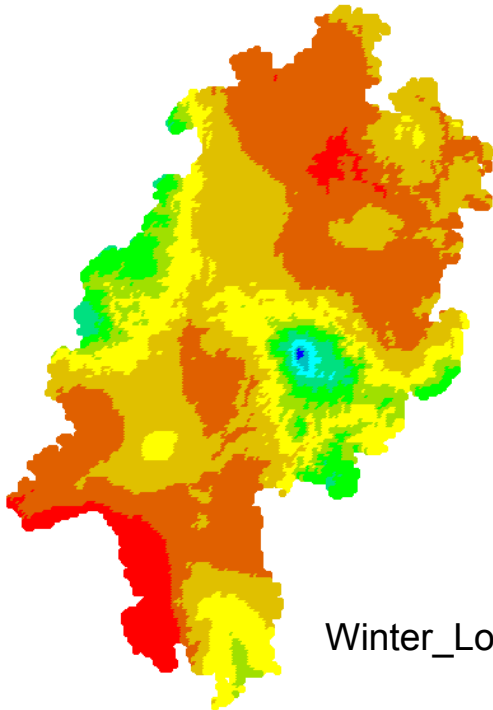


- 14.2 - 17.8
- 17.8 - 21.4
- 21.4 - 25
- 25 - 28.6
- 28.6 - 32.2
- 32.2 - 35.7
- 35.7 - 39.2
- 39.2 - 42.6
- 42.6 - 46.1
- 46.1 - 49.6
- 49.6 - 53.1
- 53.1 - 56.6
- 56.6 - 60
- 60 - 63.5
- 63.5 - 67
- 67 - 70.5
- 70.5 - 74
- 74 - 77.5
- 77.5 - 80.9
- 80.9 - 84.4
- 84.4 - 87.9
- 87.9 - 91.4
- 91.4 - 94.9
- 94.9 - 98.3
- 98.3 - 101.8
- 101.8 - 105.3
- 105.3 - 108.8
- 108.8 - 112.3
- 112.3 - 115.8
- 115.8 - 119.2
- 119.2 - 122.7
- 122.7 - 126.2
- 126.2 - 129.7
- 129.7 - 133.2
- 133.2 - 136.6
- 136.6 - 140.1

Summer\_High MF

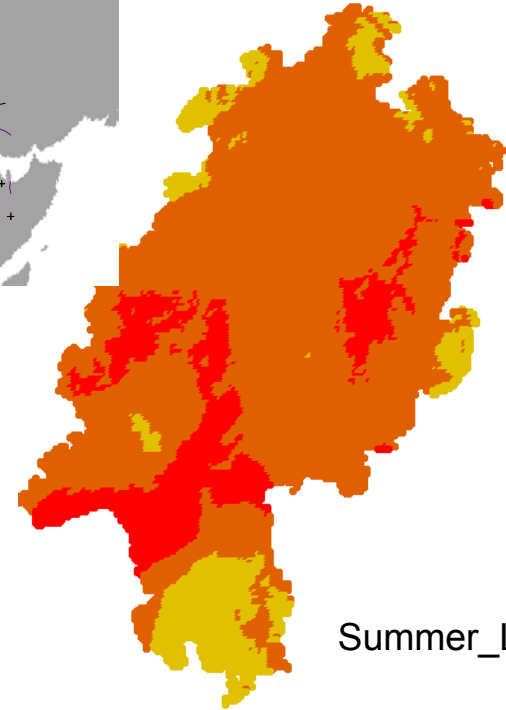


CP 11



- 14.2 - 17.8
- 17.8 - 21.4
- 21.4 - 25
- 25 - 28.6
- 28.6 - 32.2
- 32.2 - 35.7
- 35.7 - 39.2
- 39.2 - 42.6
- 42.6 - 46.1
- 46.1 - 49.6
- 49.6 - 53.1
- 53.1 - 56.6
- 56.6 - 60
- 60 - 63.5
- 63.5 - 67
- 67 - 70.5
- 70.5 - 74
- 74 - 77.5
- 77.5 - 80.9
- 80.9 - 84.4
- 84.4 - 87.9
- 87.9 - 91.4
- 91.4 - 94.9
- 94.9 - 98.3
- 98.3 - 101.8
- 101.8 - 105.3
- 105.3 - 108.8
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- 112.3 - 115.8
- 115.8 - 119.2
- 119.2 - 122.7
- 122.7 - 126.2
- 126.2 - 129.7
- 129.7 - 133.2
- 133.2 - 136.6
- 136.6 - 140.1

Winter\_Low MF



- 14.2 - 17.8
- 17.8 - 21.4
- 21.4 - 25
- 25 - 28.6
- 28.6 - 32.2
- 32.2 - 35.7
- 35.7 - 39.2
- 39.2 - 42.6
- 42.6 - 46.1
- 46.1 - 49.6
- 49.6 - 53.1
- 53.1 - 56.6
- 56.6 - 60
- 60 - 63.5
- 63.5 - 67
- 67 - 70.5
- 70.5 - 74
- 74 - 77.5
- 77.5 - 80.9
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- 112.3 - 115.8
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- 119.2 - 122.7
- 122.7 - 126.2
- 126.2 - 129.7
- 129.7 - 133.2
- 133.2 - 136.6
- 136.6 - 140.1

Summer\_Low MF

# Precipitation Model

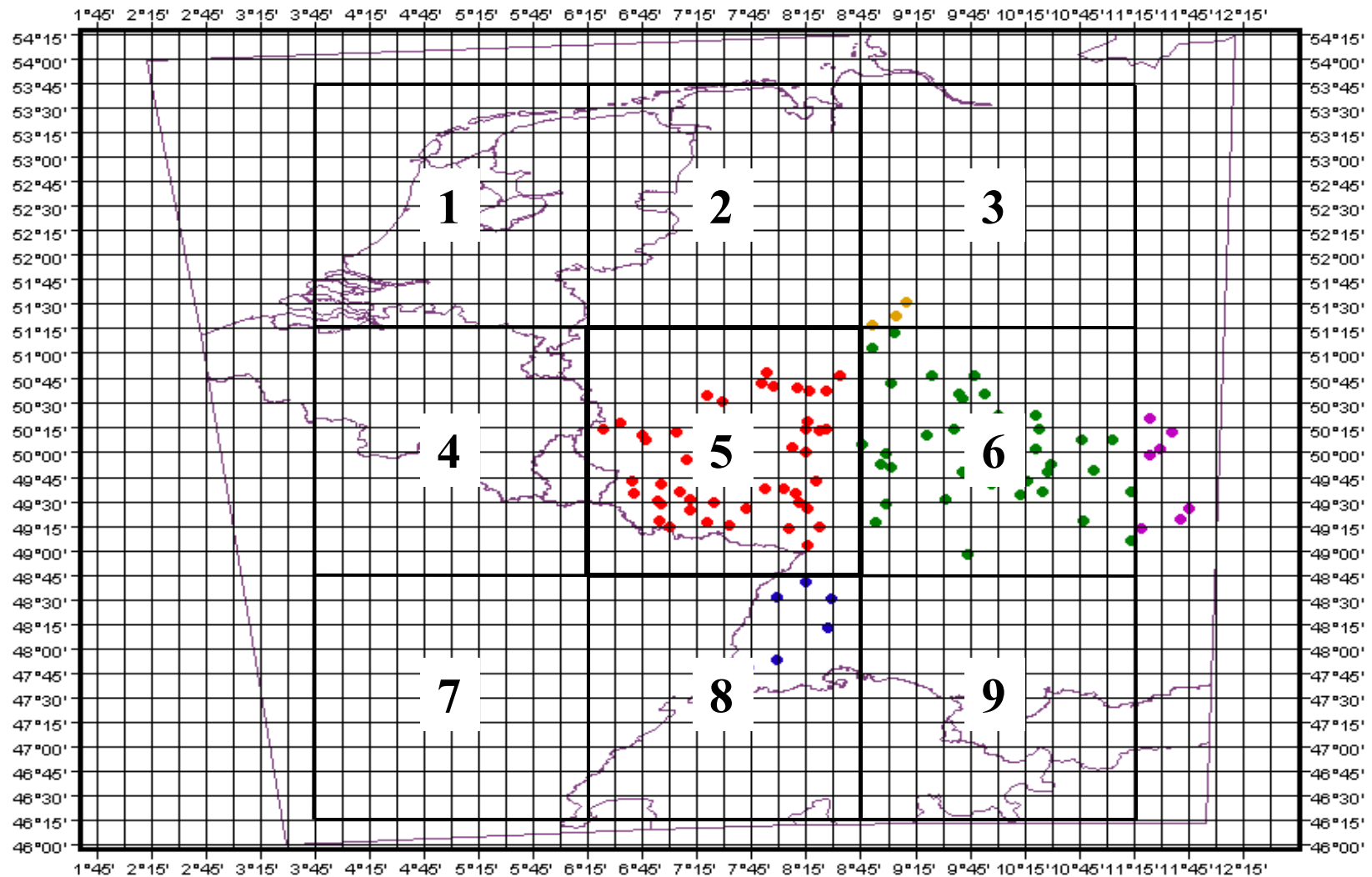
- Conditioned transformed multivariate normal model (power transformation)
- Parameter estimation – Maximum likelihood
- Validation for extreme indices

# Summary

- Non linearity in downscaling → classification
- Proportionality to be considered
- Mixture models



# Location of the stations

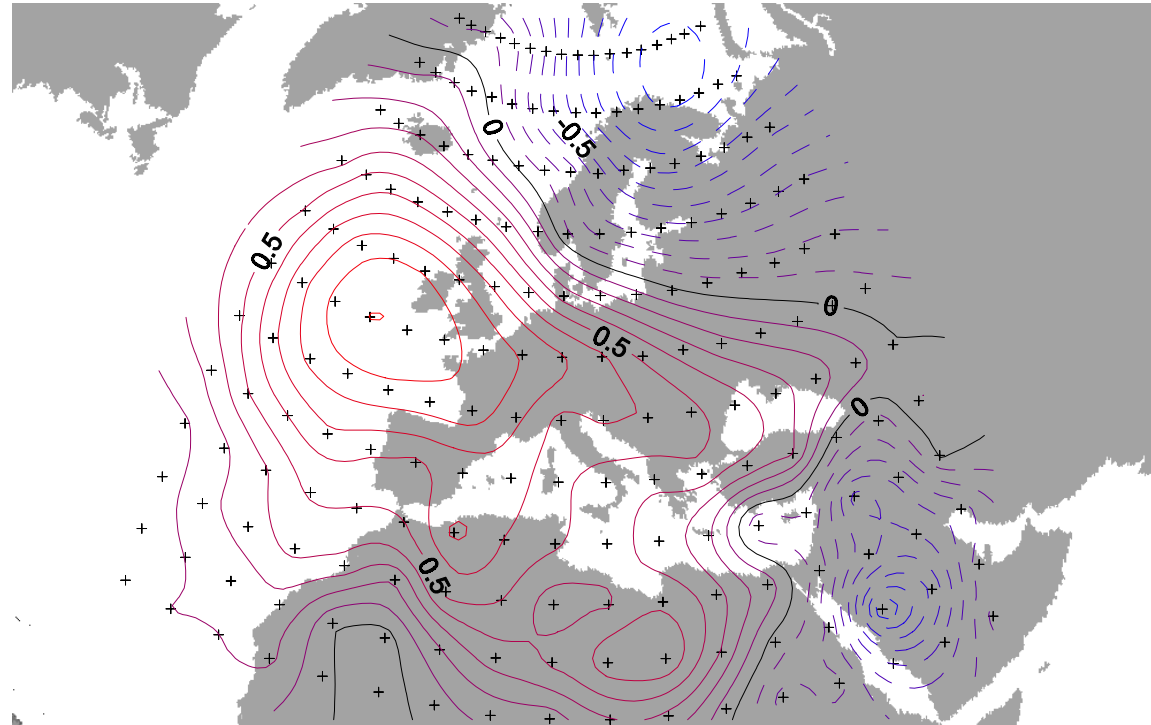


# Precipitation

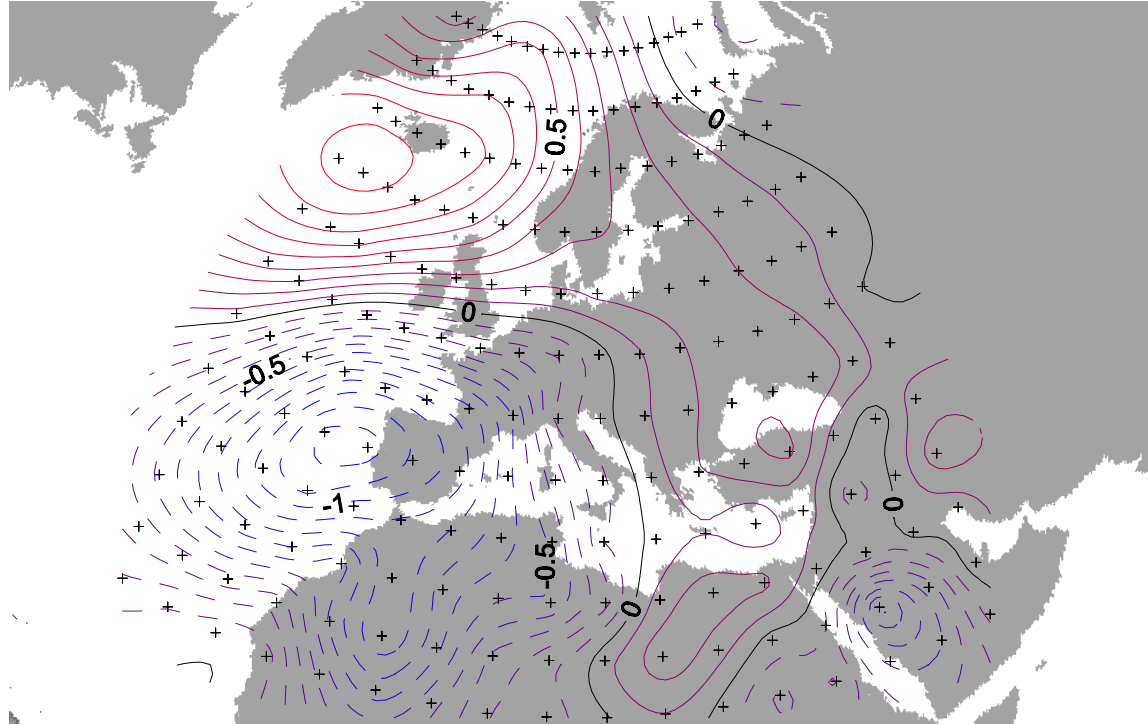
## Upper Neckar - Summer

	Frequency (%)	Mean Precip.	Relative >P90
<b>CP02</b>	<b>11.4</b>	<b>16.6 %</b>	<b>14.8 %</b>
<b>CP07</b>	<b>15.2</b>	<b>8.0 %</b>	<b>8.3 %</b>
<b>CP09</b>	<b>6.7</b>	<b>9.9 %</b>	<b>11.3 %</b>
<b>CP11</b>	<b>7.9</b>	<b>15.7 %</b>	<b>18.3%</b>

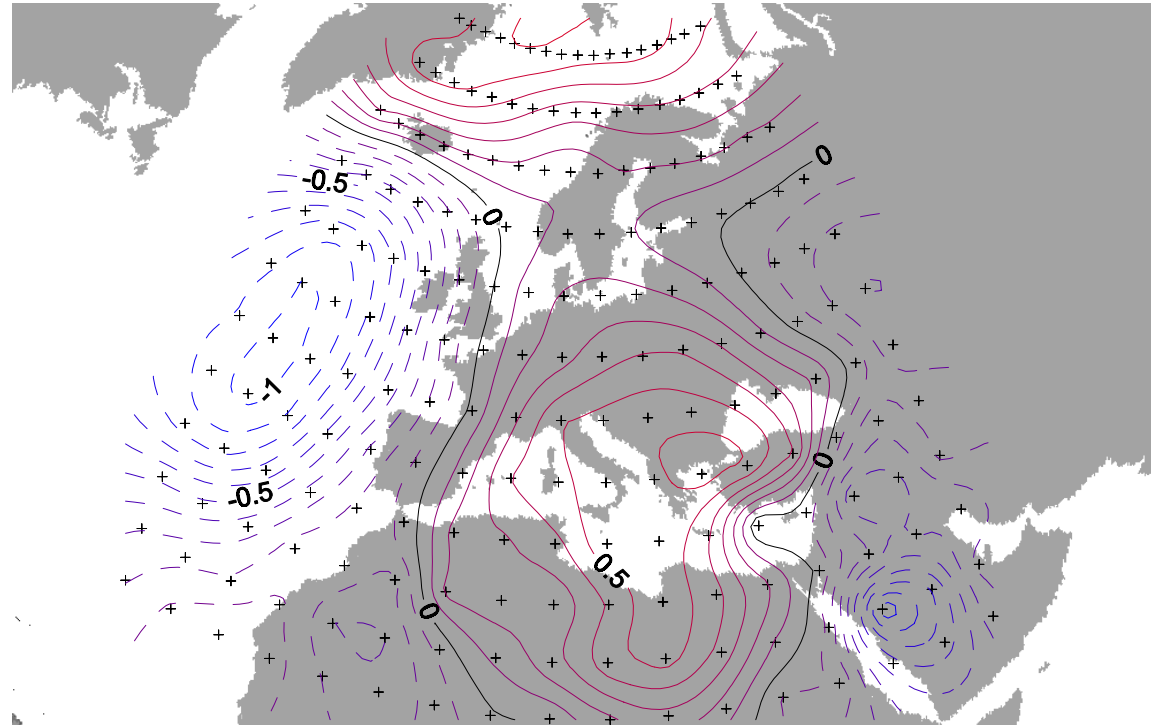
# CP 3



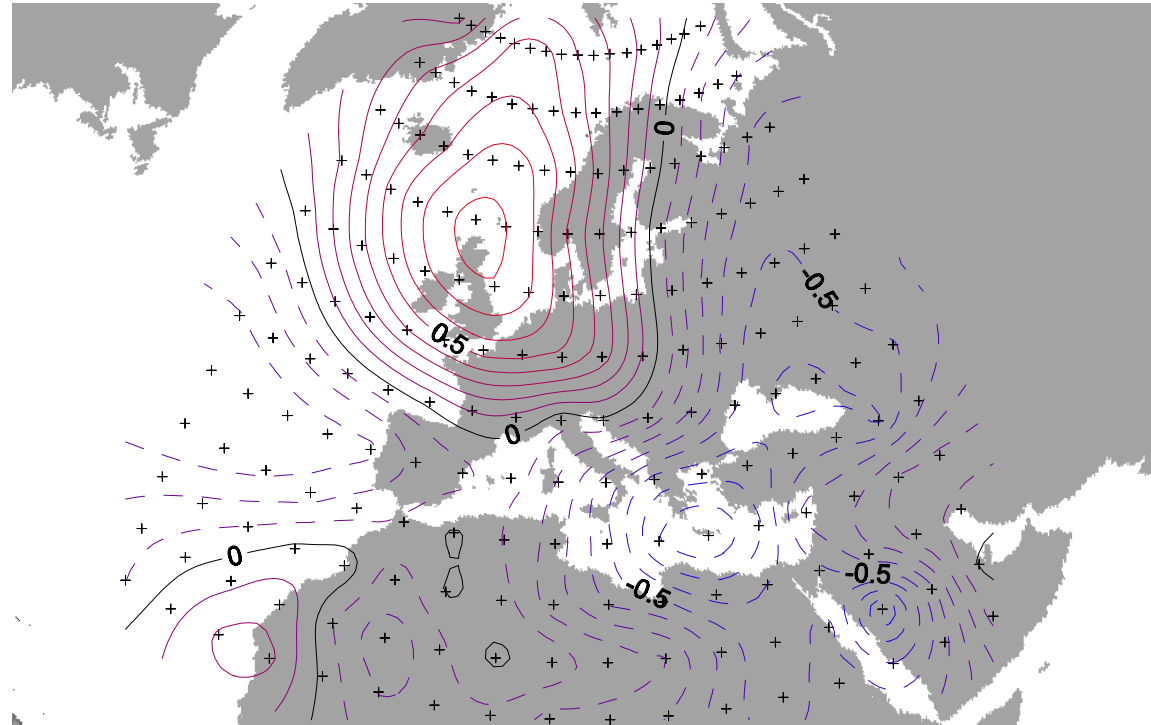
# CP 4



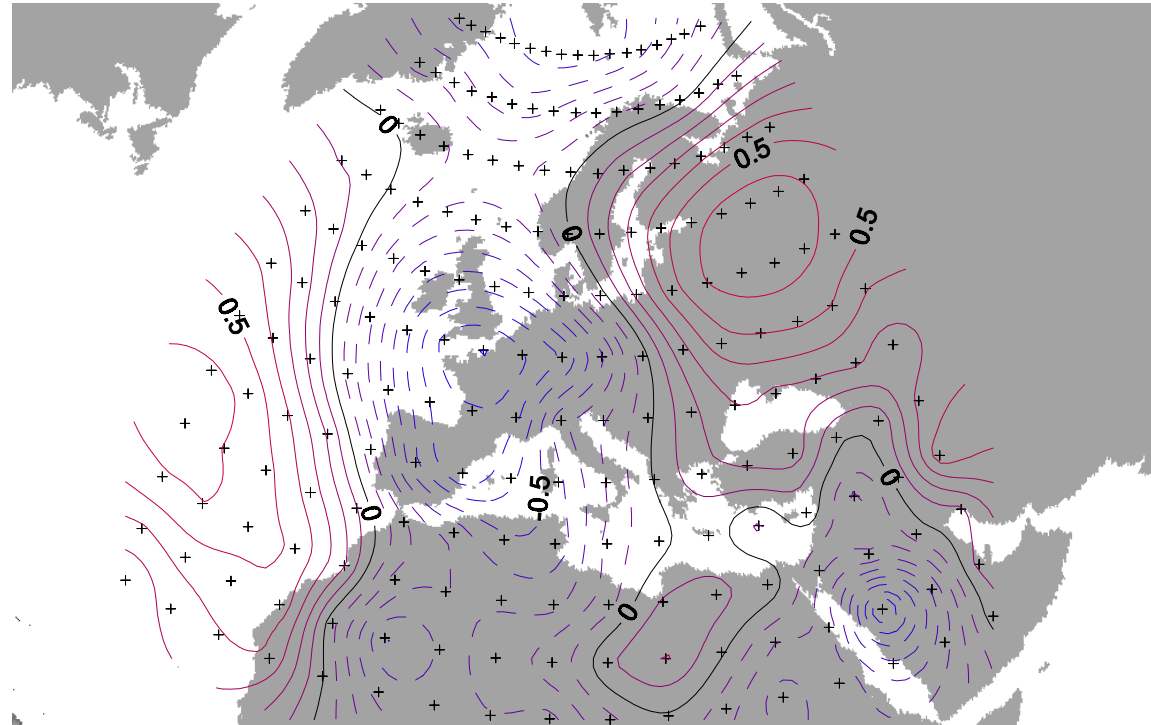
# CP 5



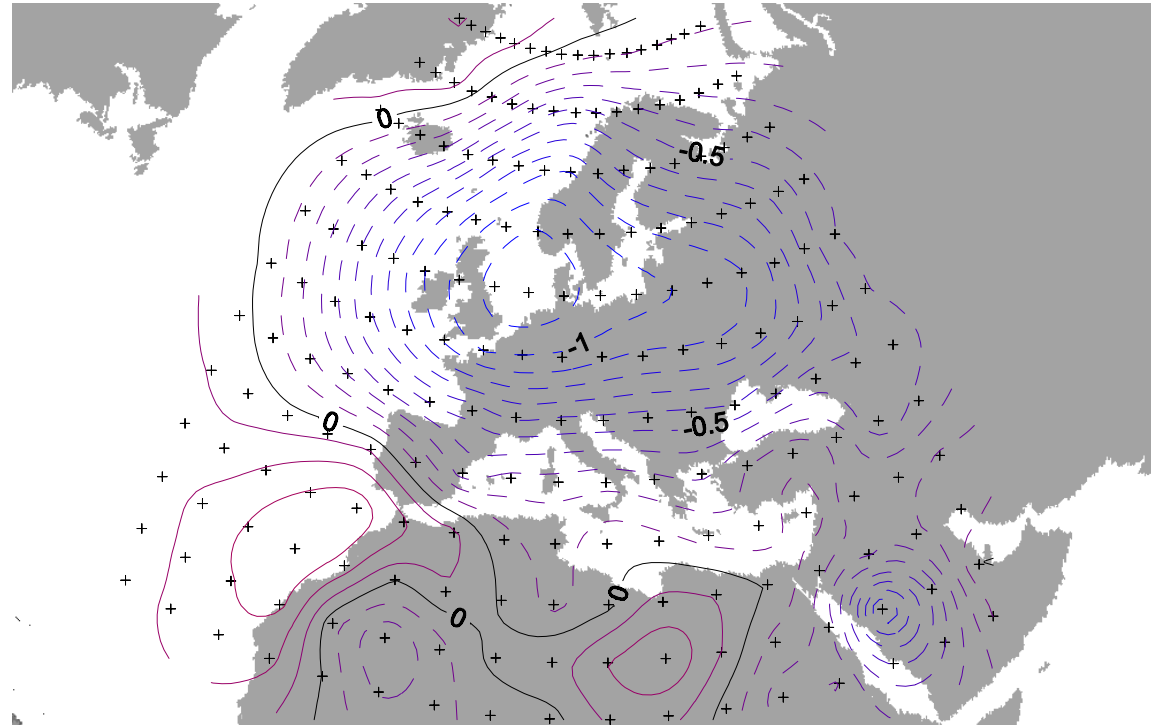
# CP 6



# CP 8

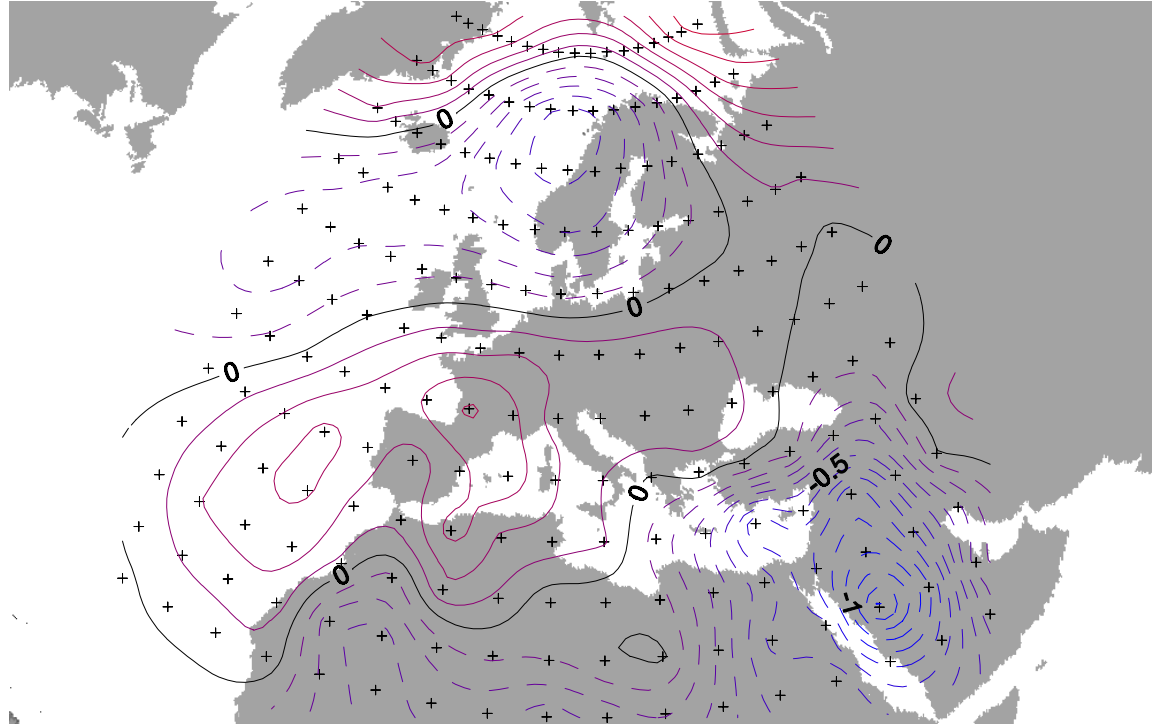


# CP 9

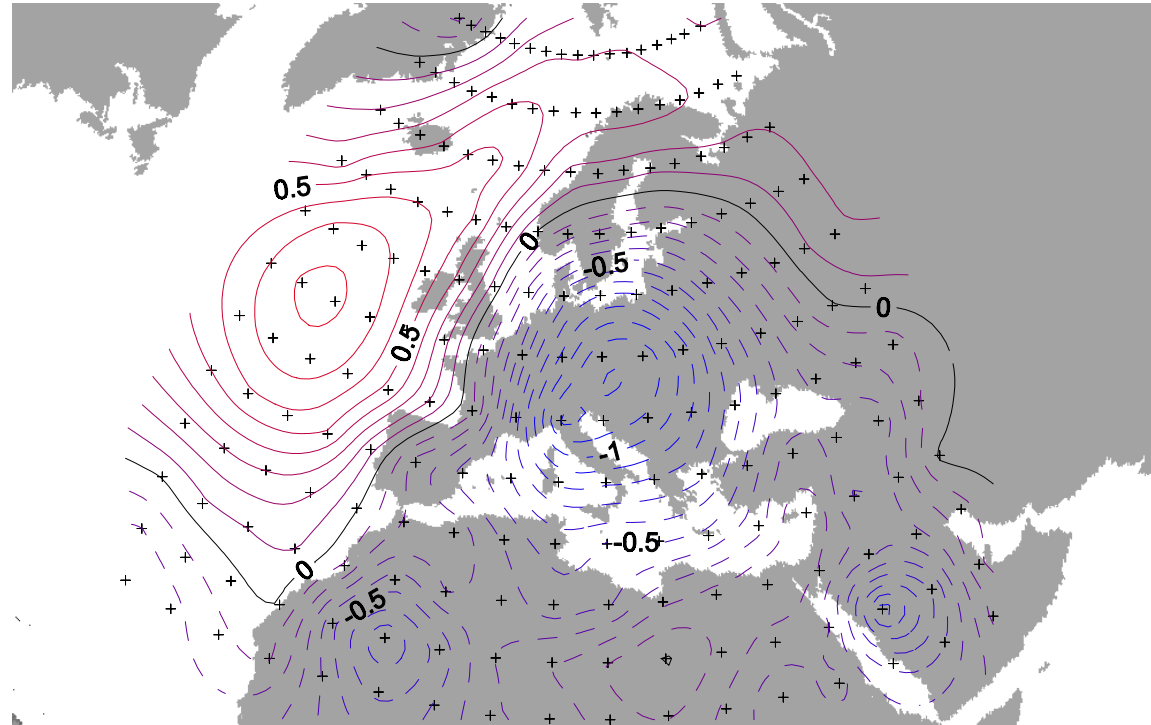




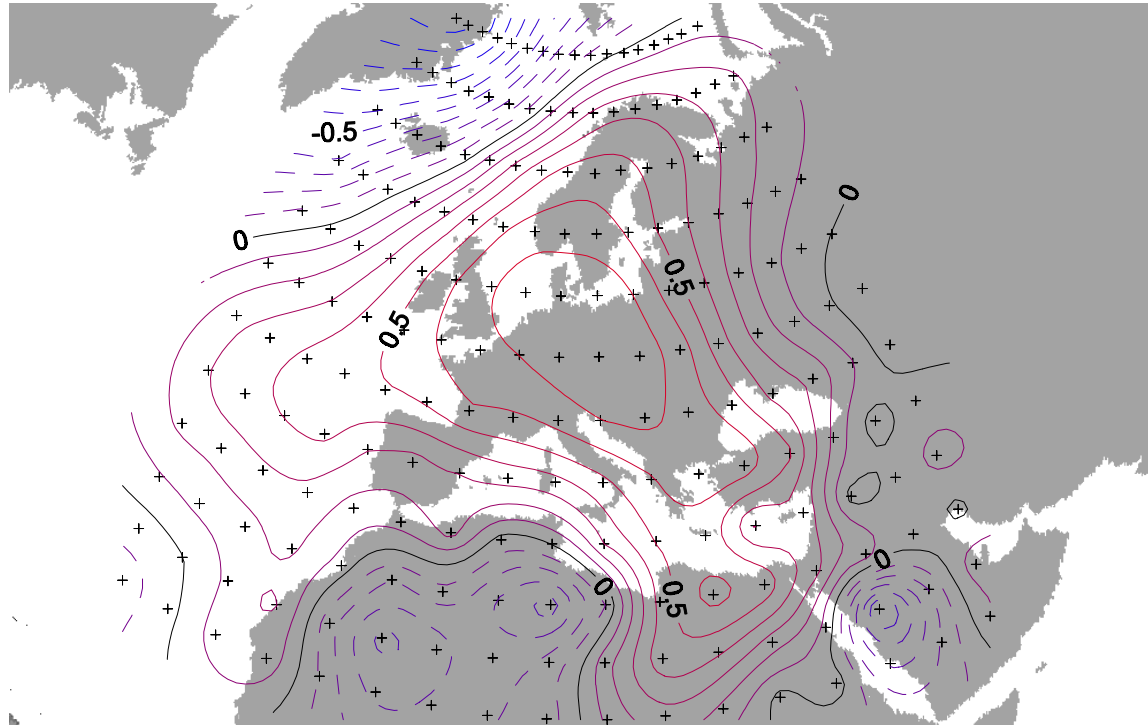
# CP 10



# CP 11



# CP 12



# Moisture flux

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## ■ Definition of Moisture flux

**Relative humidity:** the ratio of the actual vapor pressure to the saturation vapor pressure at the air temperature

**Specific humidity:** moisture content of air, is the ratio of the mass of water vapor in a sample to the total mass of the air

# Moisture flux

## Current Result

### Critical CPs:

CP09

CP08

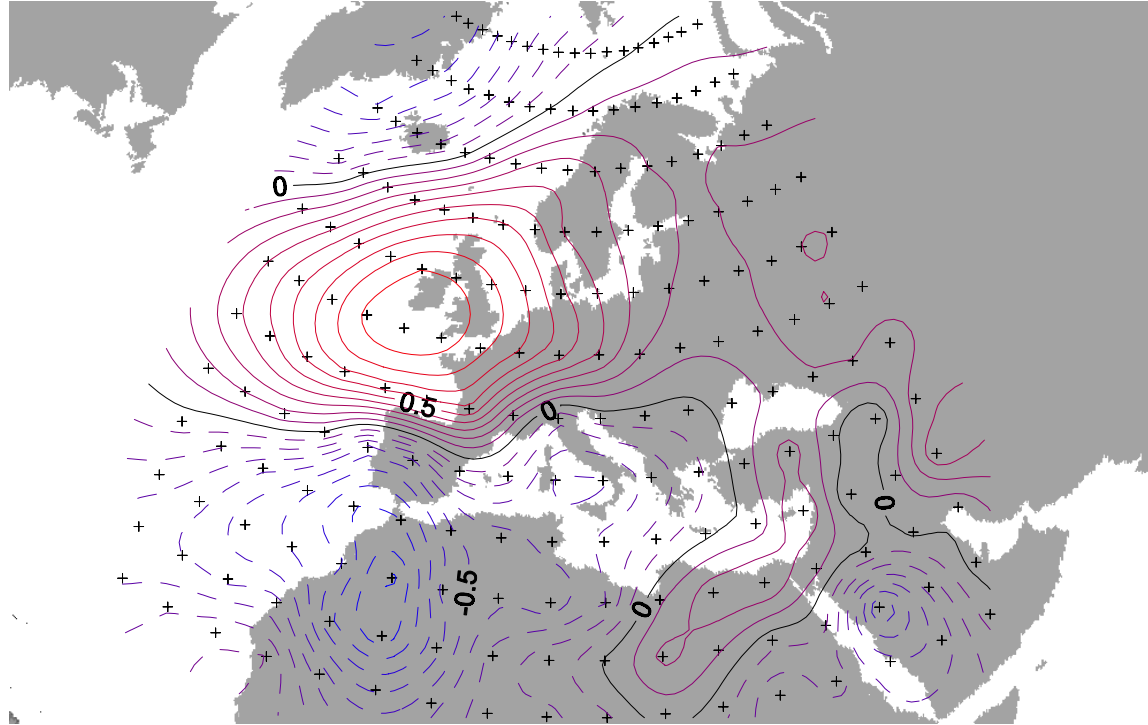
CP02

CP04

	Group1	Group2	Group3
All Days	0.400	0.355	0.430
CP01	0.155	0.172	0.188
<b>CP02</b>	<b>0.389</b>	<b>0.370</b>	<b>0.458</b>
CP03	0.281	0.290	0.377
<b>CP04</b>	<b>0.353</b>	<b>0.365</b>	<b>0.438</b>
CP05	0.373	0.312	0.382
CP06	0.171	0.170	0.219
CP07	0.290	0.273	0.323
<b>CP08</b>	<b>0.399</b>	<b>0.361</b>	<b>0.421</b>
<b>CP09</b>	<b>0.440</b>	<b>0.401</b>	<b>0.455</b>
CP10	0.256	0.261	0.383
CP11	0.149	0.099	0.227
CP12	0.265	0.259	0.316

Tab.2 The correlation coefficient of 3 Groups at 700 hPa conditioned to CPs

# CP 1



# Moisture flux

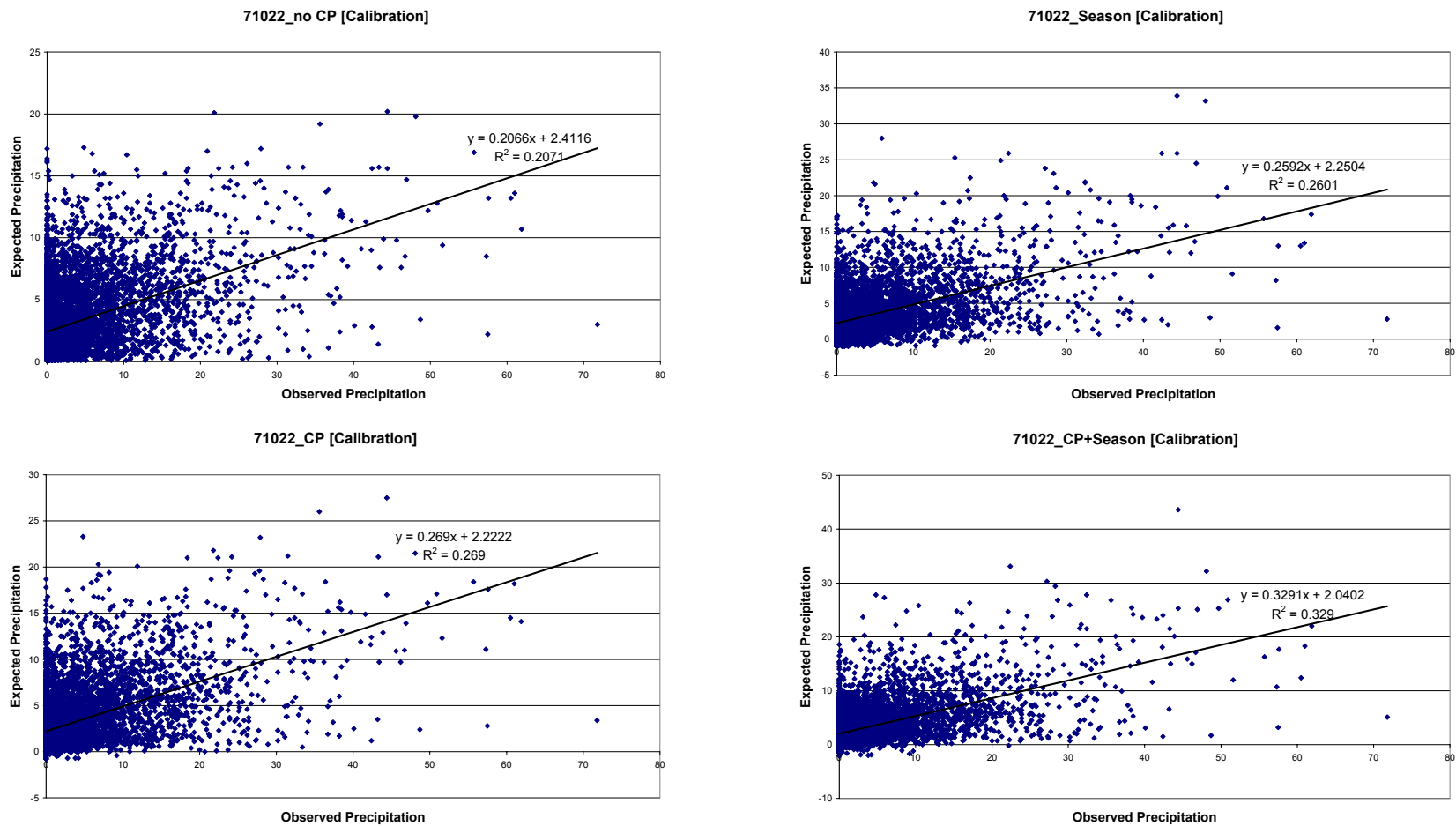


Fig.2 Comparison between observed and expected precipitation amount during Calibration period [1958-1978,1994-2001] for station 71022 conditioned to different cases

# Moisture flux

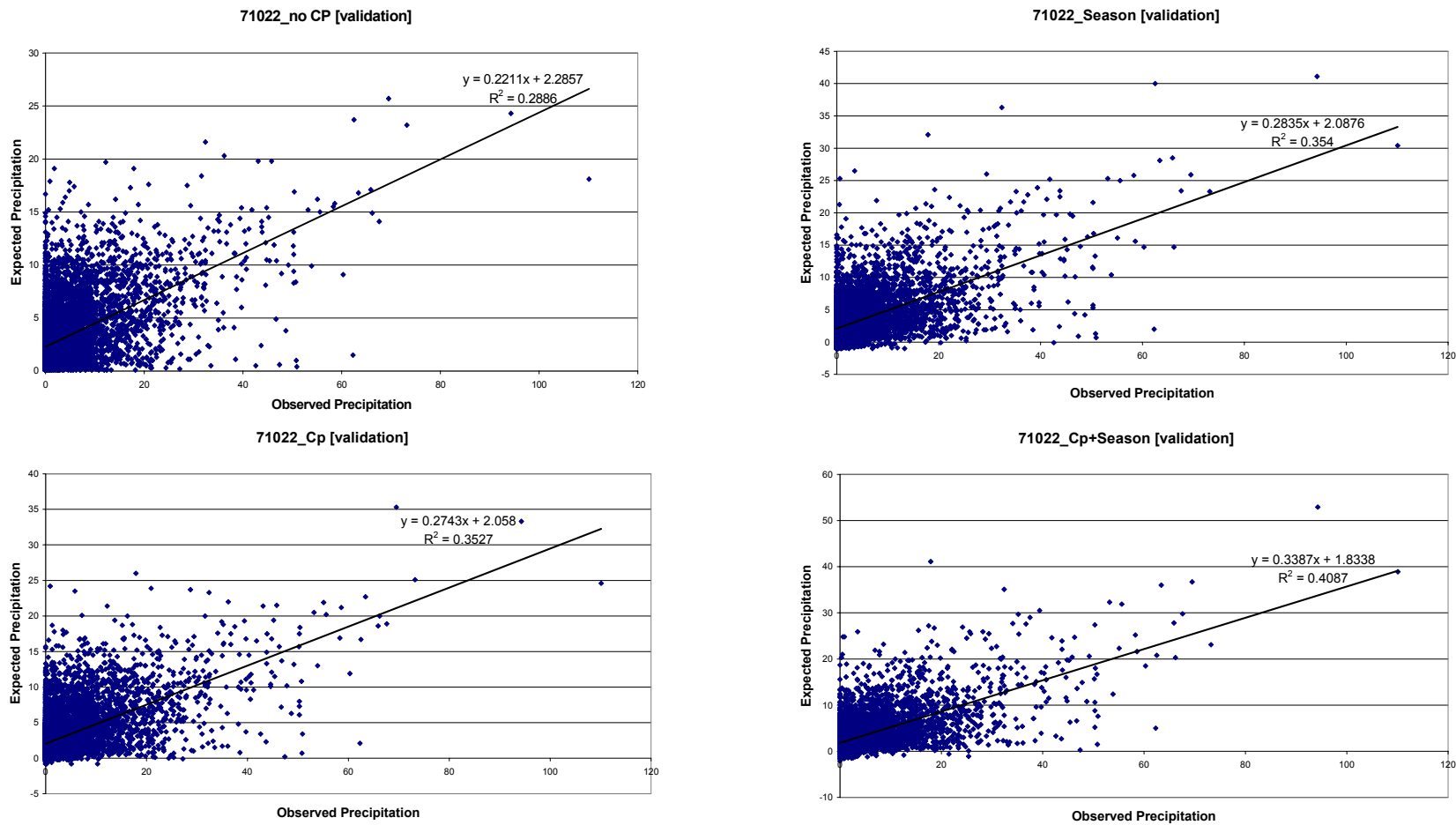


Fig.3 Comparison between observed and expected precipitation amount during validation period [1979-1993] for station 71022 conditioned to different cases



# Moisture flux

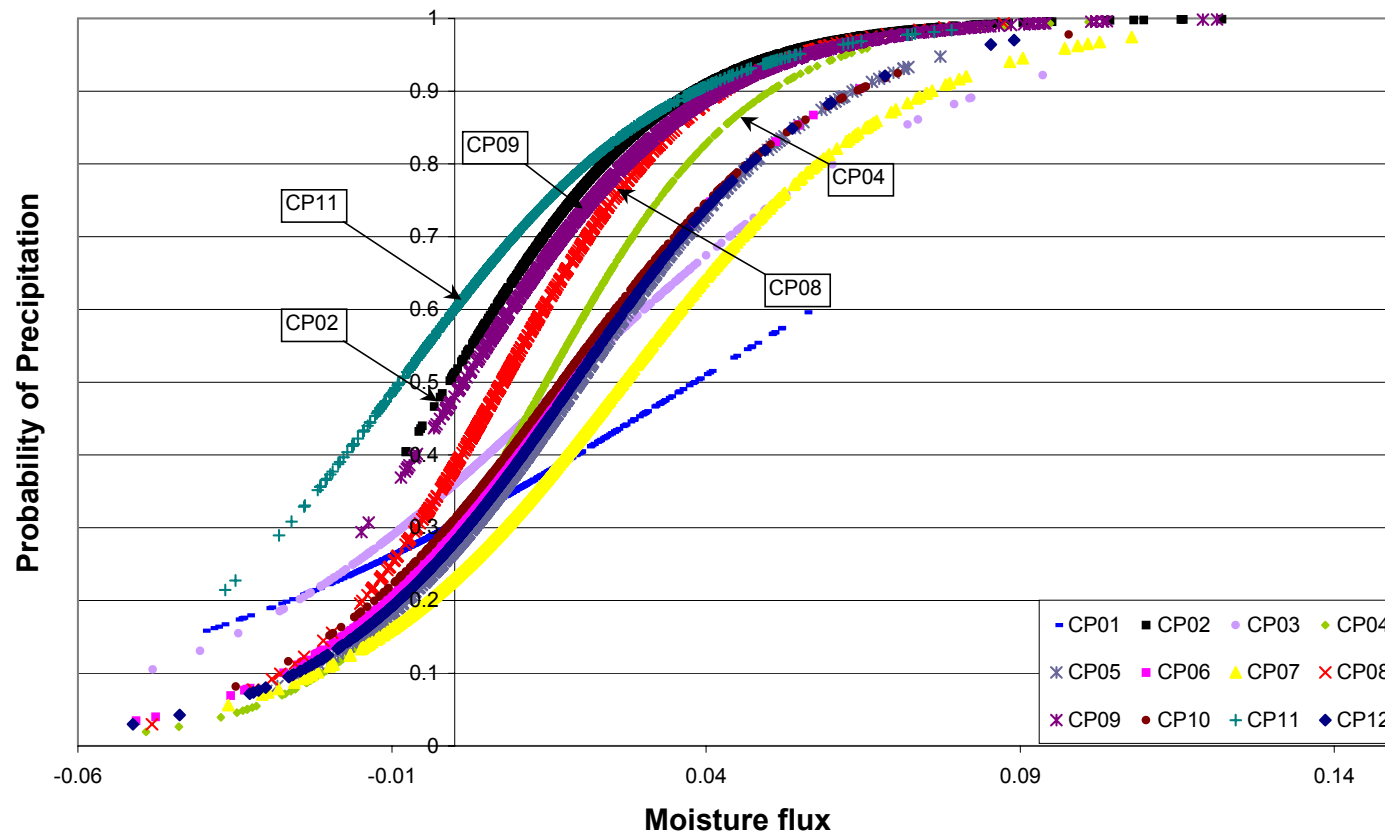


Fig.4 Probability of precipitation at station 75103 conditioned to CPs