

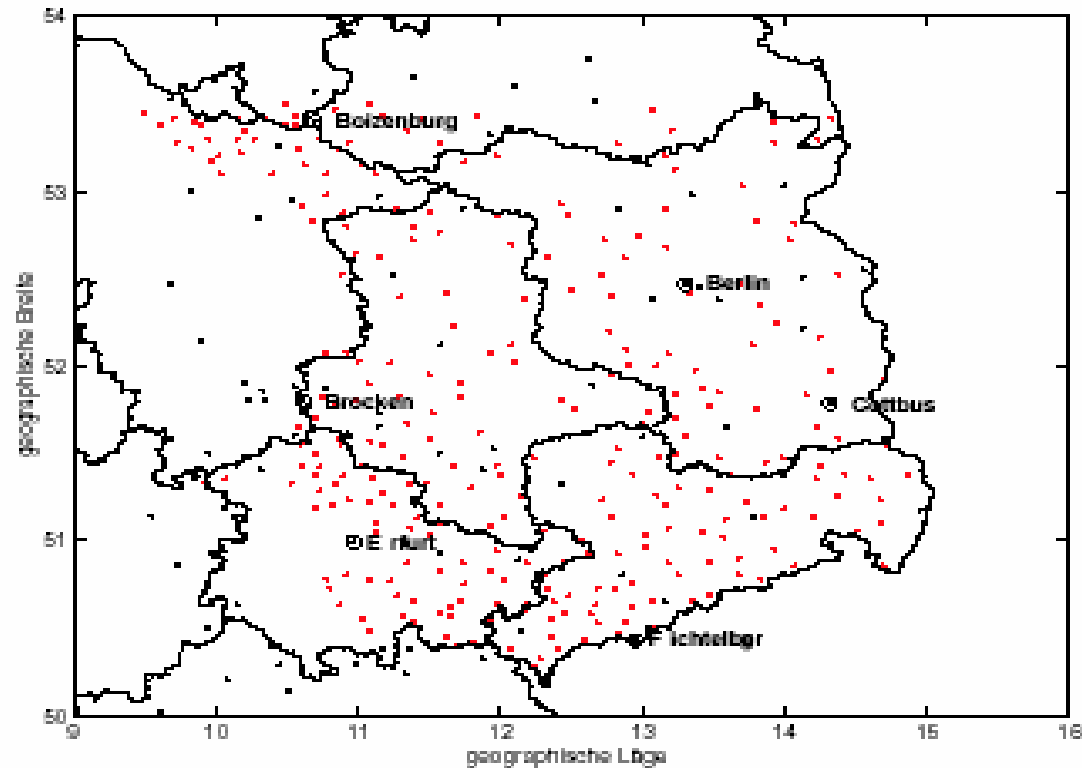
Estimation of temperature, precipitation und evaporation with Neuro-Fuzzy method



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June 2003

Goal of project

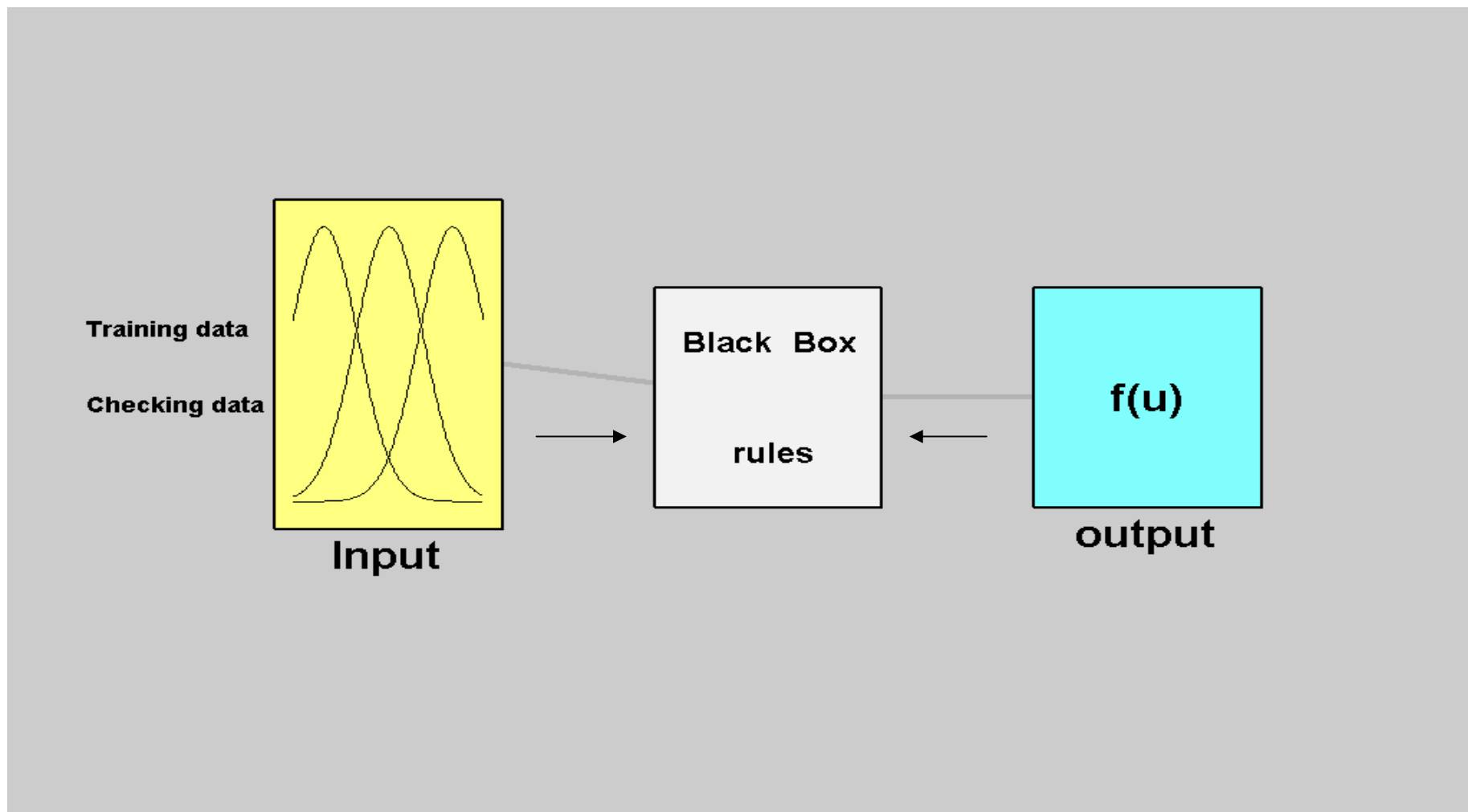
- n **Estimation of climate parameters in Elbe catchment area (2000-2055)**



85 Stations

- What is Neuro-Fuzzy
- Input/Output data
- Training and checking data
- Selecting the best Input parameters
- Modeling
- Estimation of Temperature and precipitation
- Estimation of Evaporation

Fuzzy Inference System (FIS)



Input/output GCM and climate observation

GCM:

- ECHAM4/OPYC3
- ECHAM/REMO

Observation:

- Daily temperature and precipitation from 85 stations in Elbe catchment area

Input/output GCM and climate observation

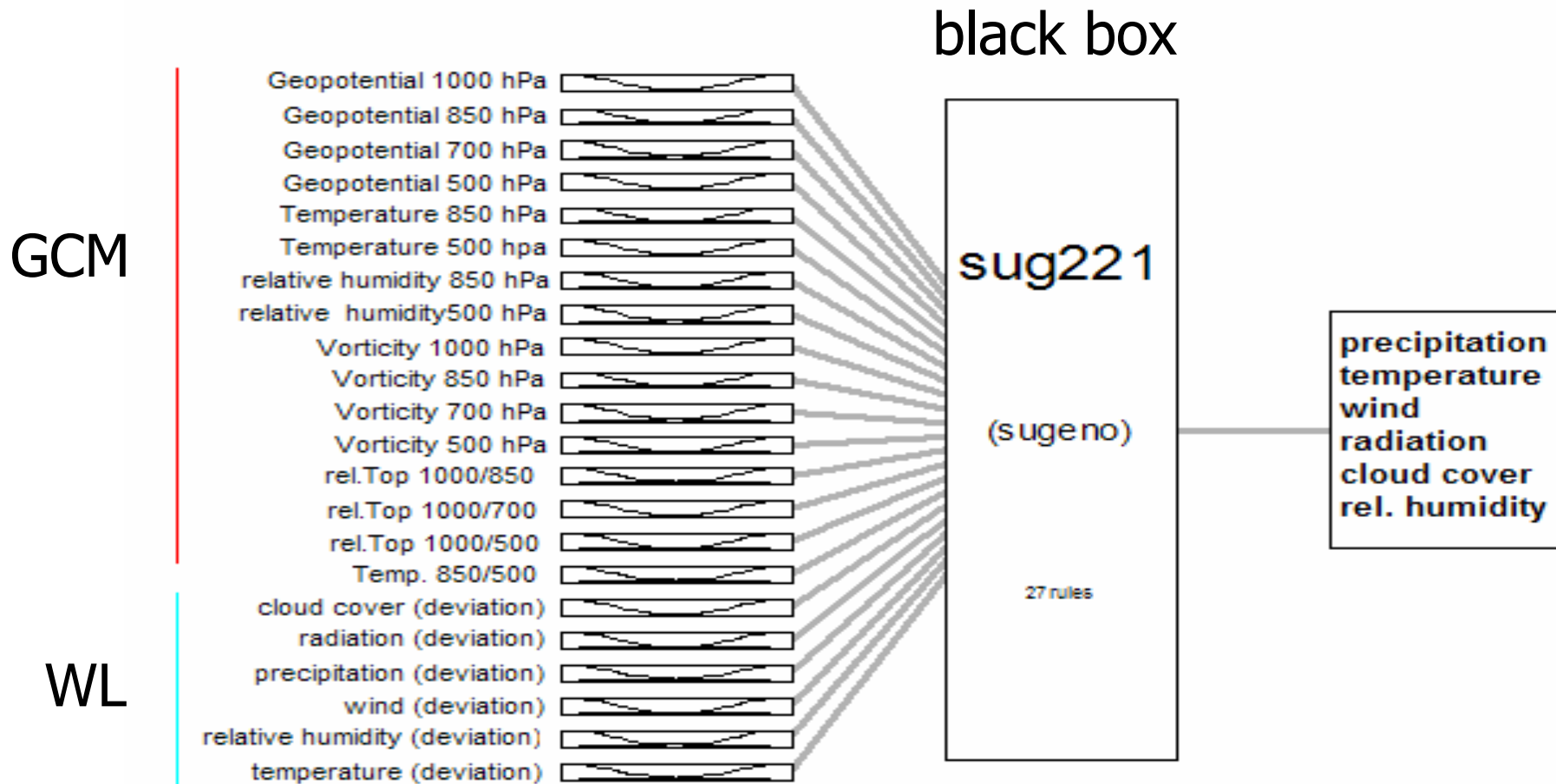
GCM:

- ECHAM4/OPYC3 300 km
- ECHAM/REMO 50 km

Observation:

- Daily temperature and precipitation from 85 stations in Elbe catchment area

Input/output - Fuzzy



Training und checking data

Training data	1980,1981,1982,1984,1986, 1988,1989,1991,1993,1994, 1995,1996,1997,1998
Checking data	1983,1985,1987,1990,1992

Selecting Input 1

Selecting input 1 ...

ANFIS model 1: GP10 --> trn=3.4388, chk=2.7317
ANFIS model 2: GP85 --> trn=3.4388, chk=2.7350
ANFIS model 3: GP70 --> trn=3.4391, chk=2.7341
ANFIS model 4: GP50 --> trn=3.4391, chk=2.7343
ANFIS model 5: TP85 --> trn=3.4391, chk=2.7390
ANFIS model 6: TP50 --> trn=3.4390, chk=2.7309
ANFIS model 7: RH85 --> trn=3.4391, chk=2.7311
ANFIS model 8: RH50 --> trn=3.4392, chk=2.7314
ANFIS model 9: VR10 --> trn=3.4389, chk=2.7362
ANFIS model 10: VR85 --> trn=3.4391, chk=2.7316
ANFIS model 11: VR70 --> trn=3.4381, chk=2.7375
ANFIS model 12: VR50 --> trn=3.4378, chk=2.7385
ANFIS model 13: RT18 --> trn=3.4390, chk=2.7389
ANFIS model 14: RT17 --> trn=3.4391, chk=2.7392
ANFIS model 15: RT15 --> trn=3.4391, chk=2.7366
ANFIS model 16: TD85 --> trn=3.4382, chk=2.7300
ANFIS model 17: BEDE --> trn=3.4369, chk=2.7339
ANFIS model 18: GLOB --> trn=3.4367, chk=2.7324
ANFIS model 19: NIED --> trn=3.4371, chk=2.7260
ANFIS model 20: WIND --> trn=3.4388, chk=2.7285
ANFIS model 21: RELF --> trn=3.4369, chk=2.7324
ANFIS model 22: TEMP --> trn=3.4390, chk=2.7317

Currently selected inputs: GLOB

Selecting Input 2

- Selecting input 2 ...
- ANFIS model 23: GLOB GP10 --> trn=3.4345, chk=2.7320
- ANFIS model 24: GLOB GP85 --> trn=3.4344, chk=2.7418
- ANFIS model 25: GLOB GP70 --> trn=3.4329, chk=2.7477
- ANFIS model 26: GLOB GP50 --> trn=3.4334, chk=2.7492
- ANFIS model 27: GLOB TP85 --> trn=3.4313, chk=2.7482
- ANFIS model 28: GLOB TP50 --> trn=3.4337, chk=2.7473
- ANFIS model 29: GLOB RH85 --> trn=3.4322, chk=2.7288
- ANFIS model 30: GLOB RH50 --> trn=3.4317, chk=2.7319
- ANFIS model 31: GLOB VR10 --> trn=3.4332, chk=2.7351
- ANFIS model 32: GLOB VR85 --> trn=3.4326, chk=2.7384
- ANFIS model 33: GLOB VR70 --> trn=3.4332, chk=2.7453
- ANFIS model 34: GLOB VR50 --> trn=3.4337, chk=2.7397
- ANFIS model 35: GLOB RT18 --> trn=3.4328, chk=2.7517
- ANFIS model 36: GLOB RT17 --> trn=3.4318, chk=2.7519
- ANFIS model 37: GLOB RT15 --> trn=3.4327, chk=2.7490
- ANFIS model 38: GLOB TD85 --> trn=3.4322, chk=2.7293
- ANFIS model 39: GLOB BEDE --> trn=3.4344, chk=2.7510
- ANFIS model 40: GLOB NIED --> trn=3.4332, chk=2.7350
- ANFIS model 41: GLOB WIND --> trn=3.4336, chk=2.7408
- ANFIS model 42: GLOB RELF --> trn=3.4311, chk=2.7204
- ANFIS model 43: GLOB TEMP --> trn=3.4333, chk=2.7488
- Currently selected inputs: GLOB RELF

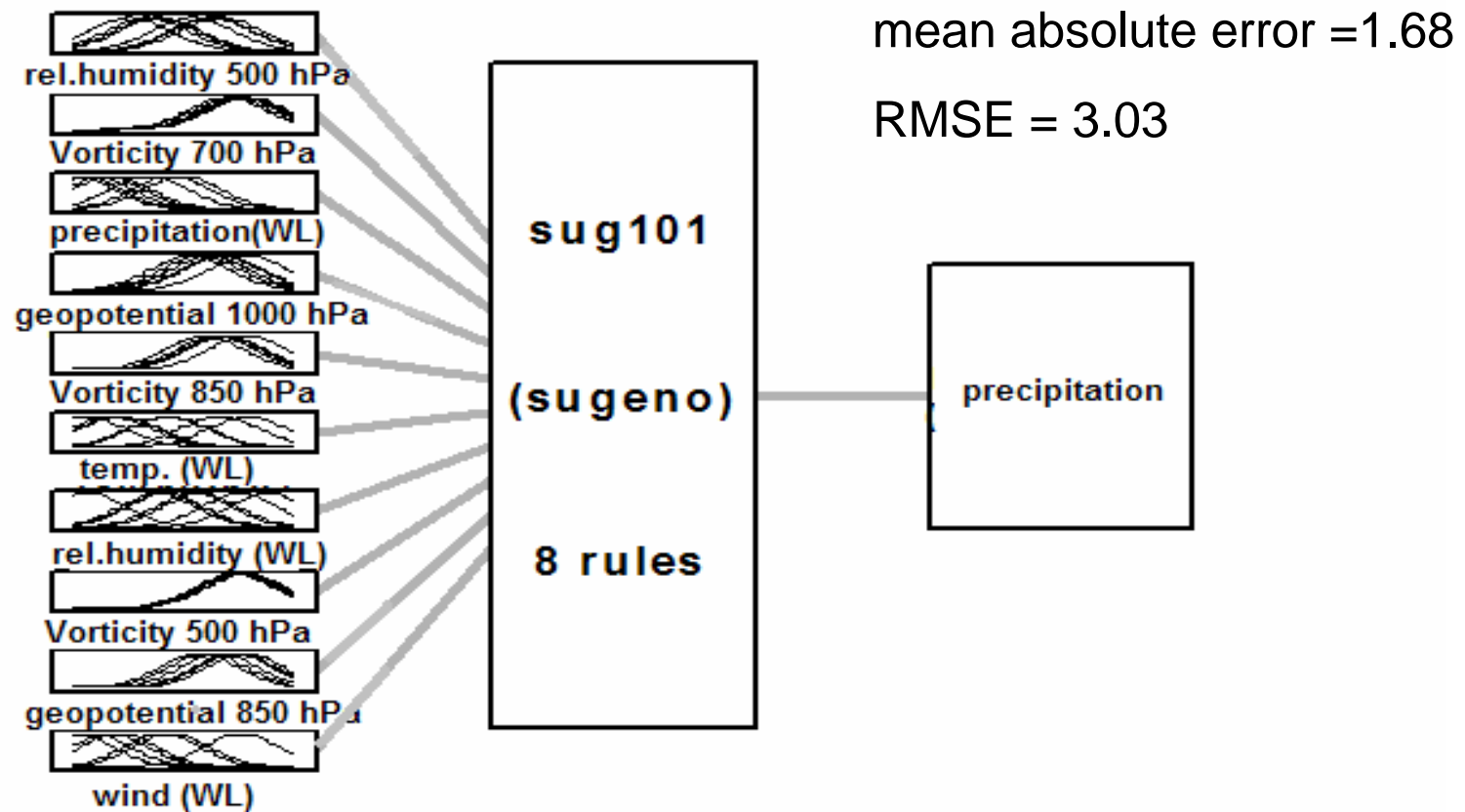
Selecting Input 3

- Selecting input 3 ...
- ANFIS model 44: GLOB RELF GP10 --> trn=3.4248, chk=2.7706
- ANFIS model 45: GLOB RELF GP85 --> trn=3.4251, chk=2.7731
- ANFIS model 46: GLOB RELF GP70 --> trn=3.4212, chk=2.7723
- ANFIS model 47: GLOB RELF GP50 --> trn=3.4210, chk=2.7706
- ANFIS model 48: GLOB RELF TP85 --> trn=3.4195, chk=2.7737
- ANFIS model 49: GLOB RELF TP50 --> trn=3.4232, chk=2.7683
- ANFIS model 50: GLOB RELF RH85 --> trn=3.4191, chk=2.7598
- ANFIS model 51: GLOB RELF RH50 --> trn=3.4221, chk=2.7616
- ANFIS model 52: GLOB RELF VR10 --> trn=3.4220, chk=2.7636
- ANFIS model 53: GLOB RELF VR85 --> trn=3.4236, chk=2.7672
- ANFIS model 54: GLOB RELF VR70 --> trn=3.4248, chk=2.7825
- ANFIS model 55: GLOB RELF VR50 --> trn=3.4248, chk=2.7613
- ANFIS model 56: GLOB RELF RT18 --> trn=3.4213, chk=2.7788
- ANFIS model 57: GLOB RELF RT17 --> trn=3.4206, chk=2.7763
- ANFIS model 58: GLOB RELF RT15 --> trn=3.4213, chk=2.7712
- ANFIS model 59: GLOB RELF TD85 --> trn=3.4239, chk=2.7635
- ANFIS model 60: GLOB RELF BEDE --> trn=3.4243, chk=2.7832
- ANFIS model 61: GLOB RELF NIED --> trn=3.4209, chk=2.7702
- ANFIS model 62: GLOB RELF WIND --> trn=3.4252, chk=2.7784
- ANFIS model 63: GLOB RELF TEMP --> trn=3.4251, chk=2.7776
- Currently selected inputs: RH85 GLOB RELF

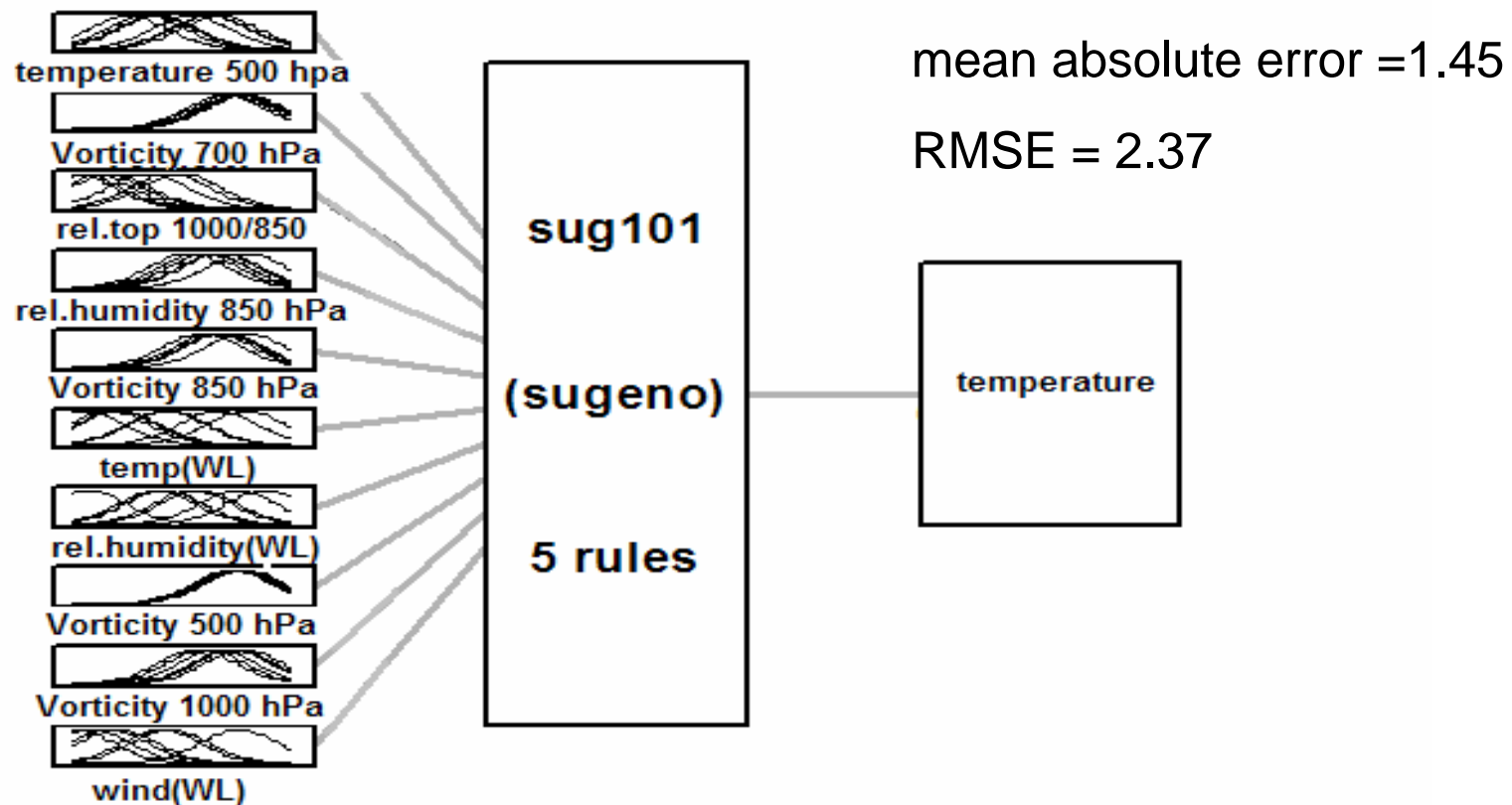
Selecting Input 4

- Selecting input 4 ...
- ANFIS model 64: RH85 GLOB RELF GP10 --> trn=3.3936, chk=2.8270
- ANFIS model 65: RH85 GLOB RELF GP85 --> trn=3.3960, chk=2.8077
- ANFIS model 66: RH85 GLOB RELF GP70 --> trn=3.3942, chk=2.7955
- ANFIS model 67: RH85 GLOB RELF GP50 --> trn=3.3901, chk=2.8054
- ANFIS model 68: RH85 GLOB RELF TP85 --> trn=3.3925, chk=2.8127
- ANFIS model 69: RH85 GLOB RELF TP50 --> trn=3.3983, chk=2.7964
- ANFIS model 70: RH85 GLOB RELF RH50 --> trn=3.3966, chk=2.7529
- ANFIS model 71: RH85 GLOB RELF VR10 --> trn=3.3948, chk=2.7817
- ANFIS model 72: RH85 GLOB RELF VR85 --> trn=3.3995, chk=2.7764
- ANFIS model 73: RH85 GLOB RELF VR70 --> trn=3.3927, chk=2.8425
- ANFIS model 74: RH85 GLOB RELF VR50 --> trn=3.3958, chk=2.7780
- ANFIS model 75: RH85 GLOB RELF RT18 --> trn=3.3950, chk=2.8075
- ANFIS model 76: RH85 GLOB RELF RT17 --> trn=3.3932, chk=2.8140
- ANFIS model 77: RH85 GLOB RELF RT15 --> trn=3.3938, chk=2.8018
- ANFIS model 78: RH85 GLOB RELF TD85 --> trn=3.3930, chk=2.8089
- ANFIS model 79: RH85 GLOB RELF BEDE --> trn=3.3981, chk=2.8469
- ANFIS model 80: RH85 GLOB RELF NIED --> trn=3.3952, chk=2.7907
- ANFIS model 81: RH85 GLOB RELF WIND --> trn=3.3998, chk=2.8244
- ANFIS model 82: RH85 GLOB RELF TEMP --> trn=3.4019, chk=2.8326
- Currently selected inputs: GP50 RH85 GLOB RELF

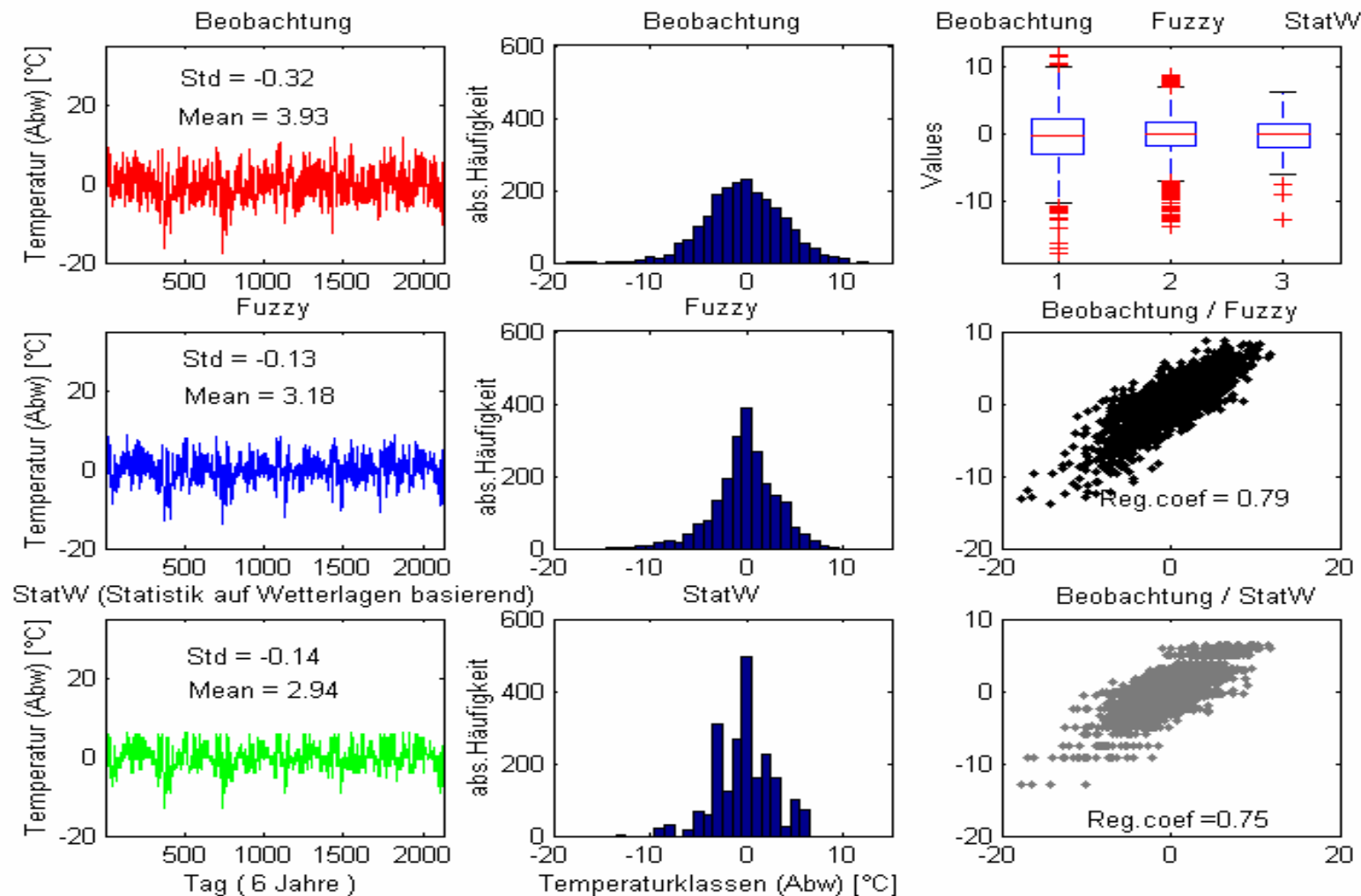
Precipitation-Fuzzy model



Temperature-Fuzzy model



Estimation of temperature for Station Berlin



Estimation for the period 2000-2055

- generate 100 variations

Weekly constant:

for precipitation: $W = Z * (\text{std}/2)$

for temperature: $W = Z * (\text{std}/8)$

Z... Gaussian random number ($- 5 \leq Z \leq + 5$)

std... standard deviation

monthly constant:

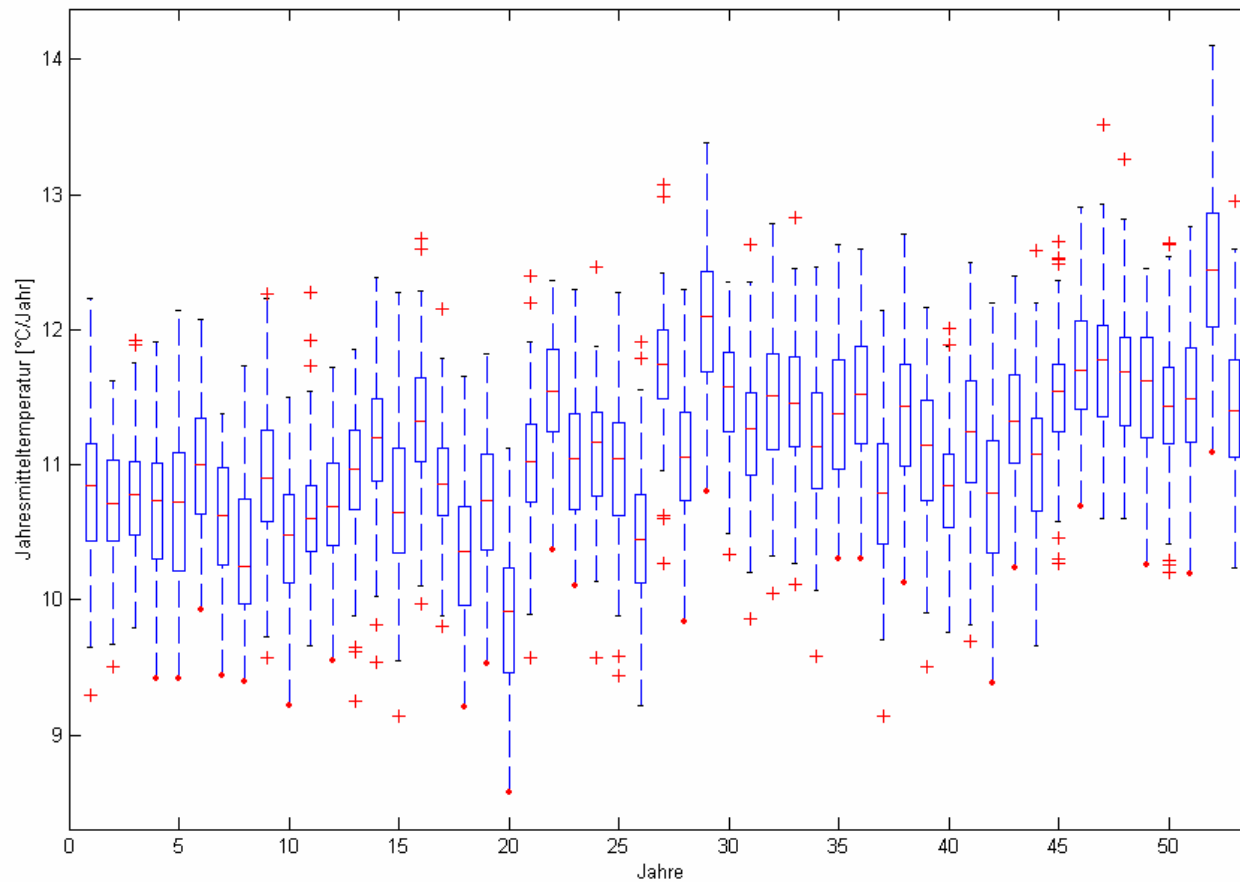
for precipitation/temperature: $M = Z * (\text{std}/30)$

yearly constant:

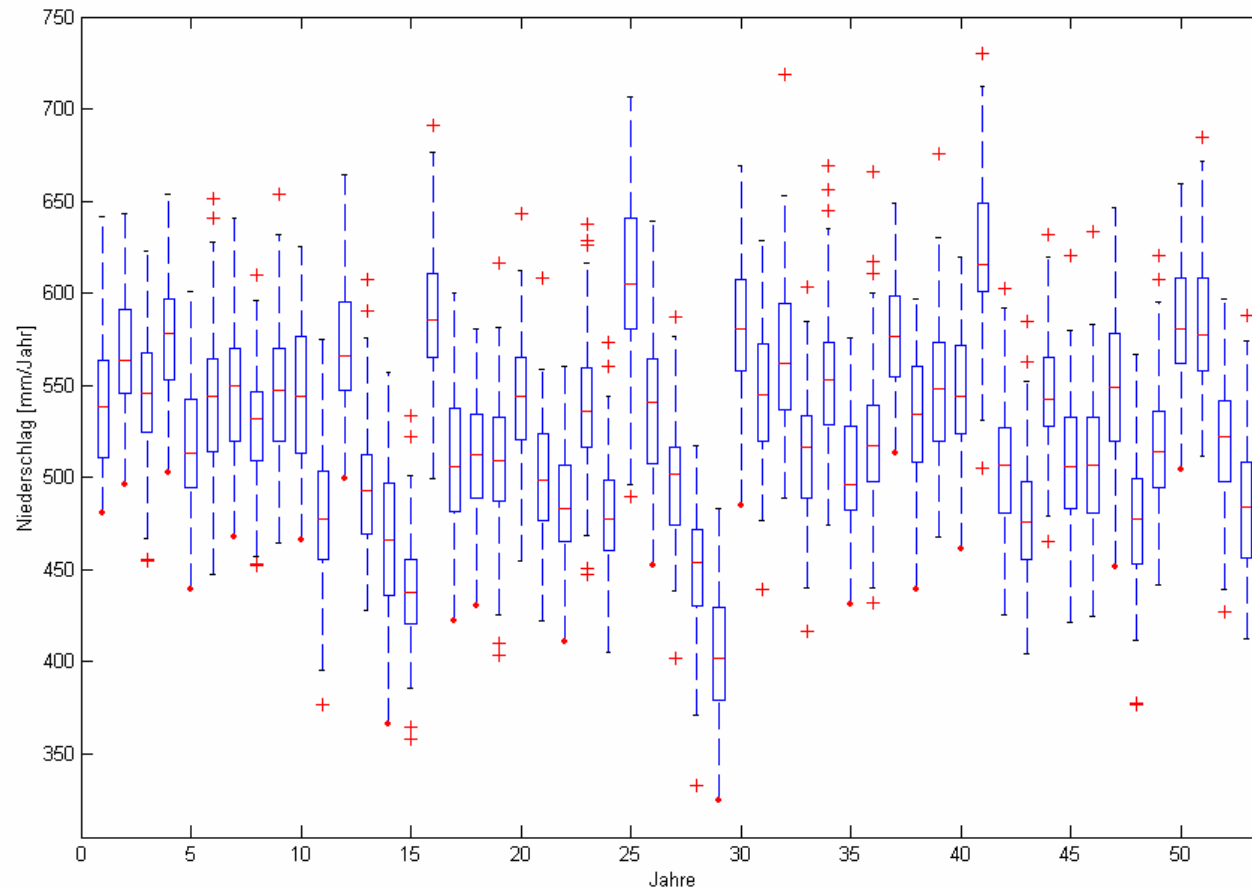
for precipitation: $J = Z * (30/360)$

for temperature: $J = Z * 0.5$

100 variations (temperature)

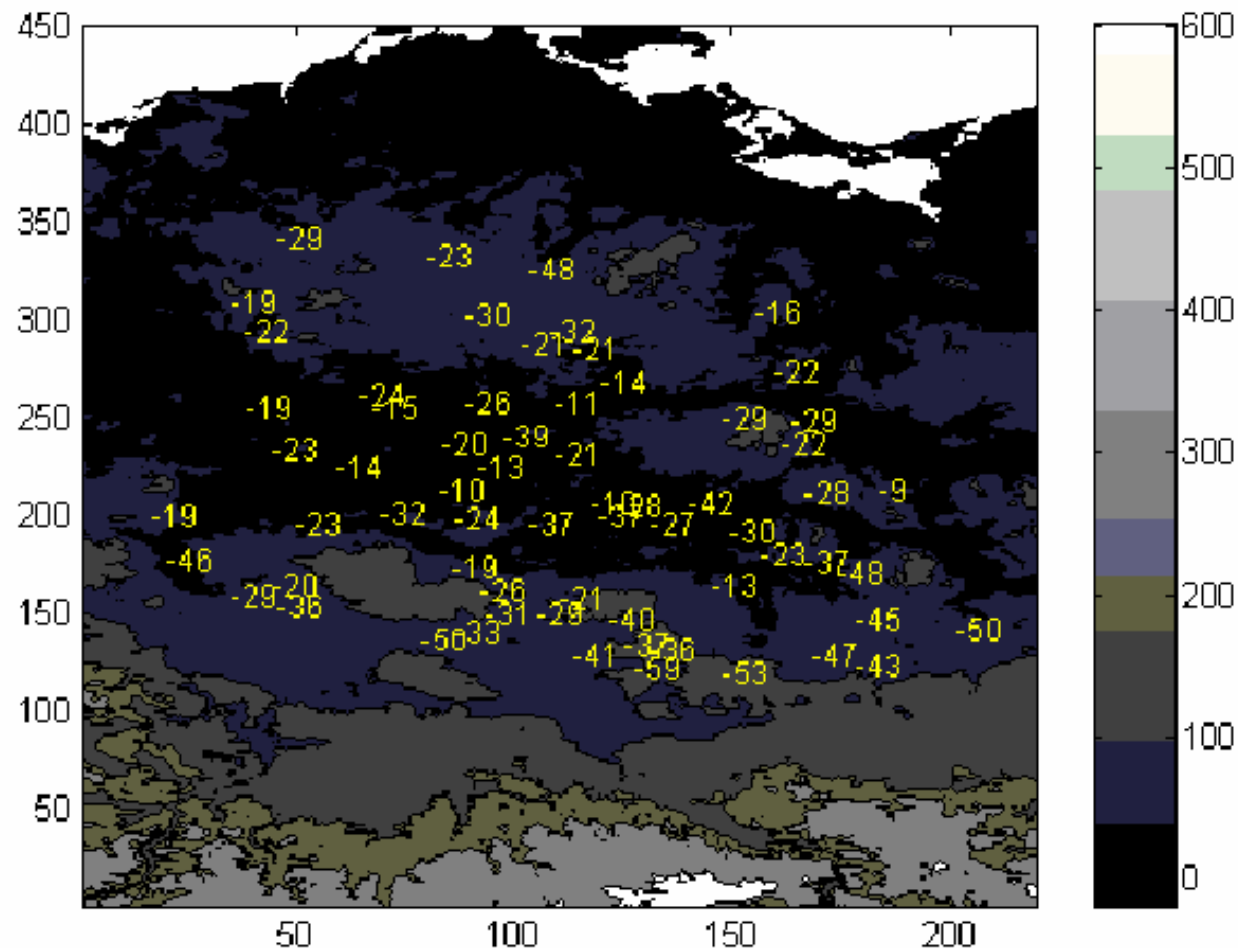


100 variations (precipitation)



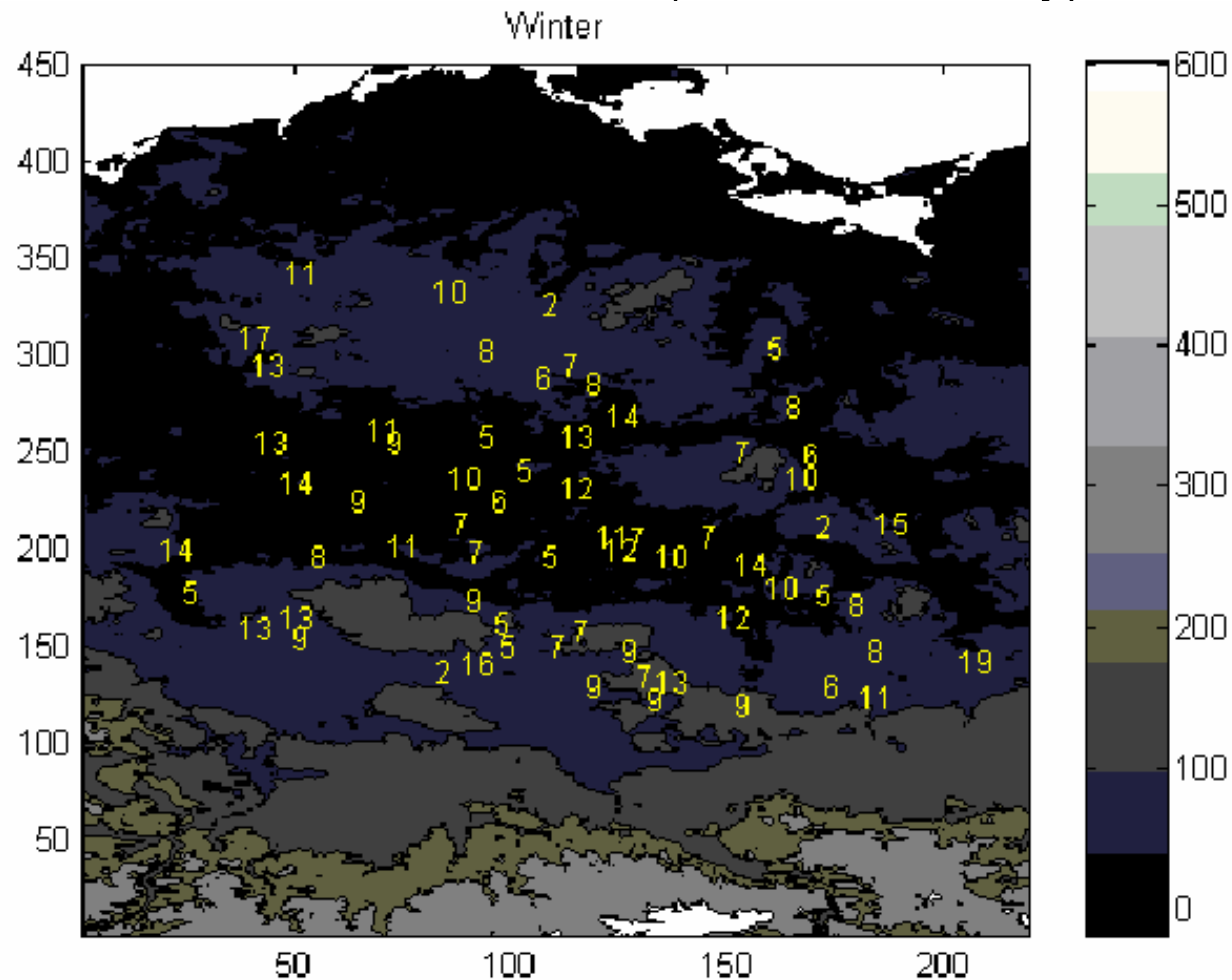
Linear trend of annual precipitation

2001-2055 (ECHAM+Fuzzy)



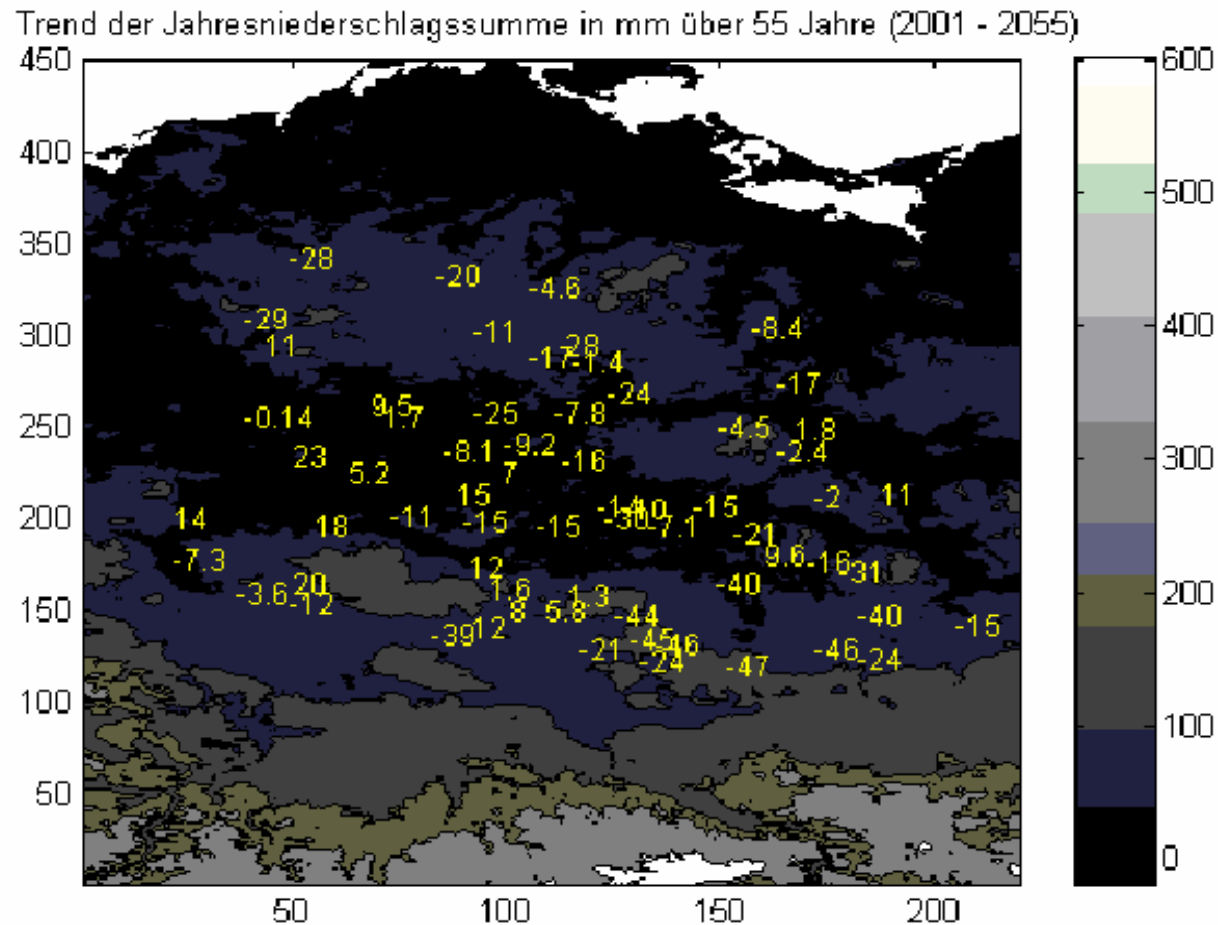
Linear trend of winter precipitation

2001-2055 (ECHAM+Fuzzy)



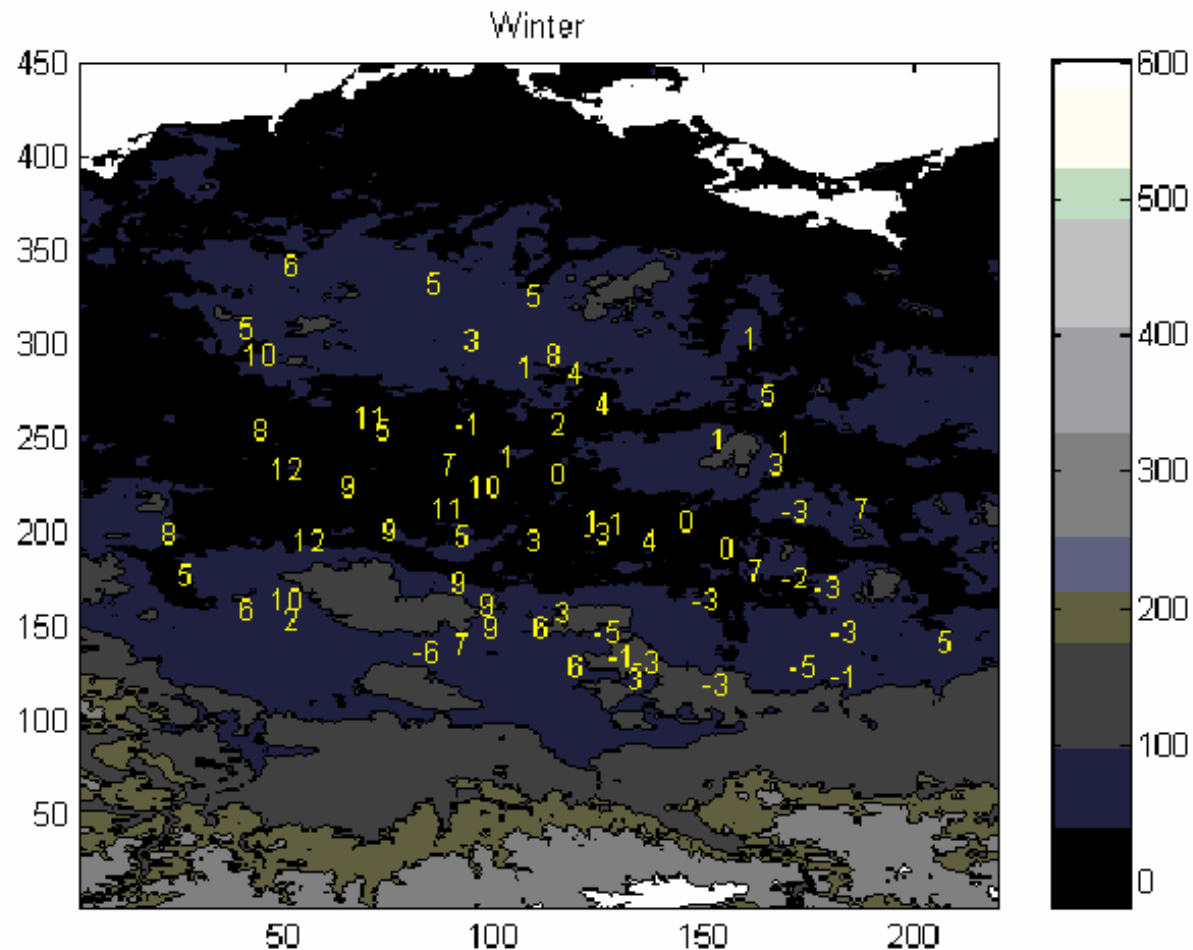
Linear trend of annual precipitation

2001-2055 (REMO+Fuzzy)



Linear trend of winter precipitation

2001-2055 (REMO+Fuzzy)



Results

Fuzzy model based on	ECHAM				REMO			
Season	W	S	S	A	W	S	S	A
Temperature	+	+	+	+	+	+	+	+
Precipitation	+	-	-	-	+	-	+	-
Evaporation	-	-	+	+	-	-	-	+