Possible Contribution to "Atmospheric Circulation Classification and Regional Downscaling" by the MPI für Meteorologie

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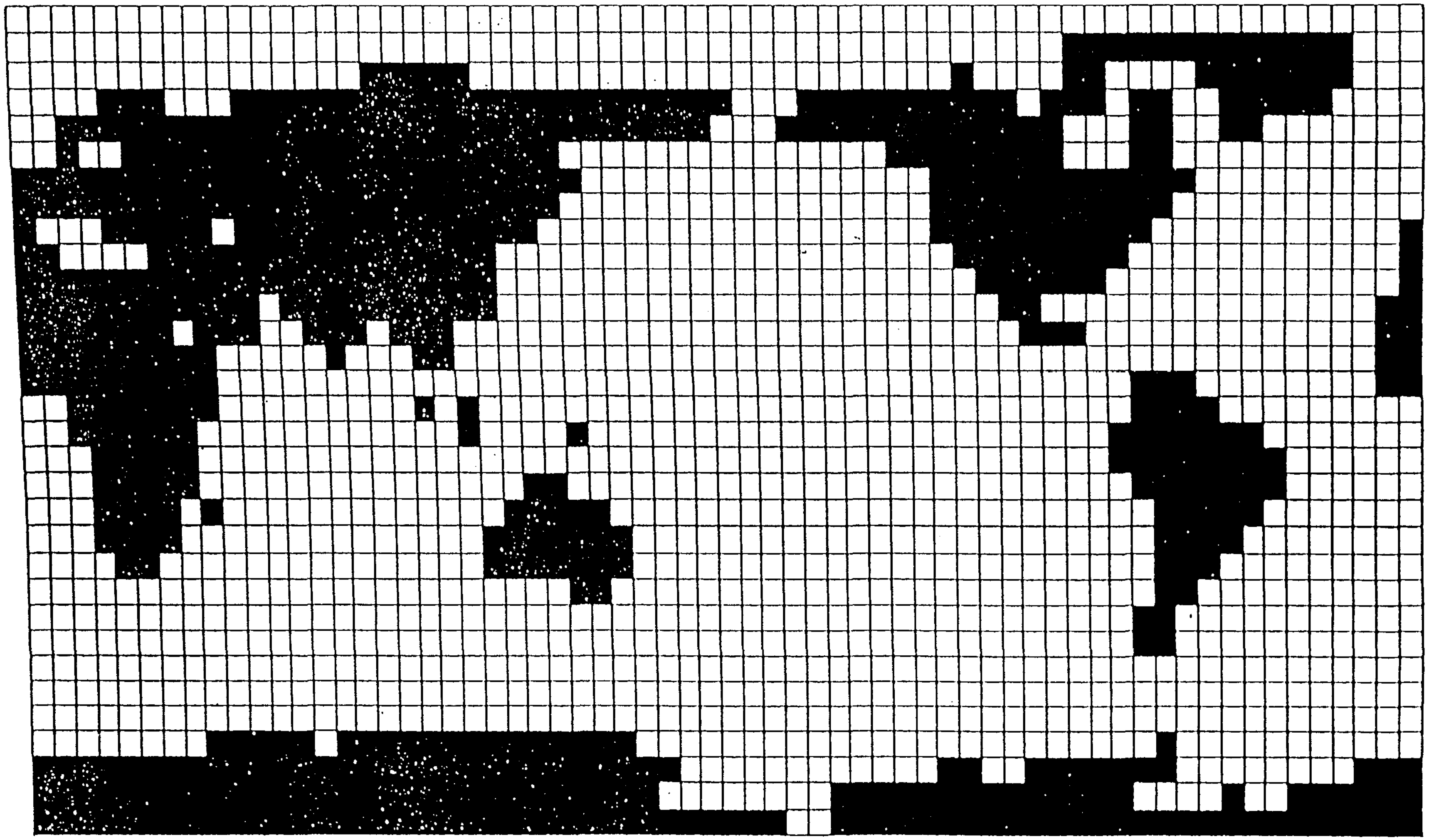
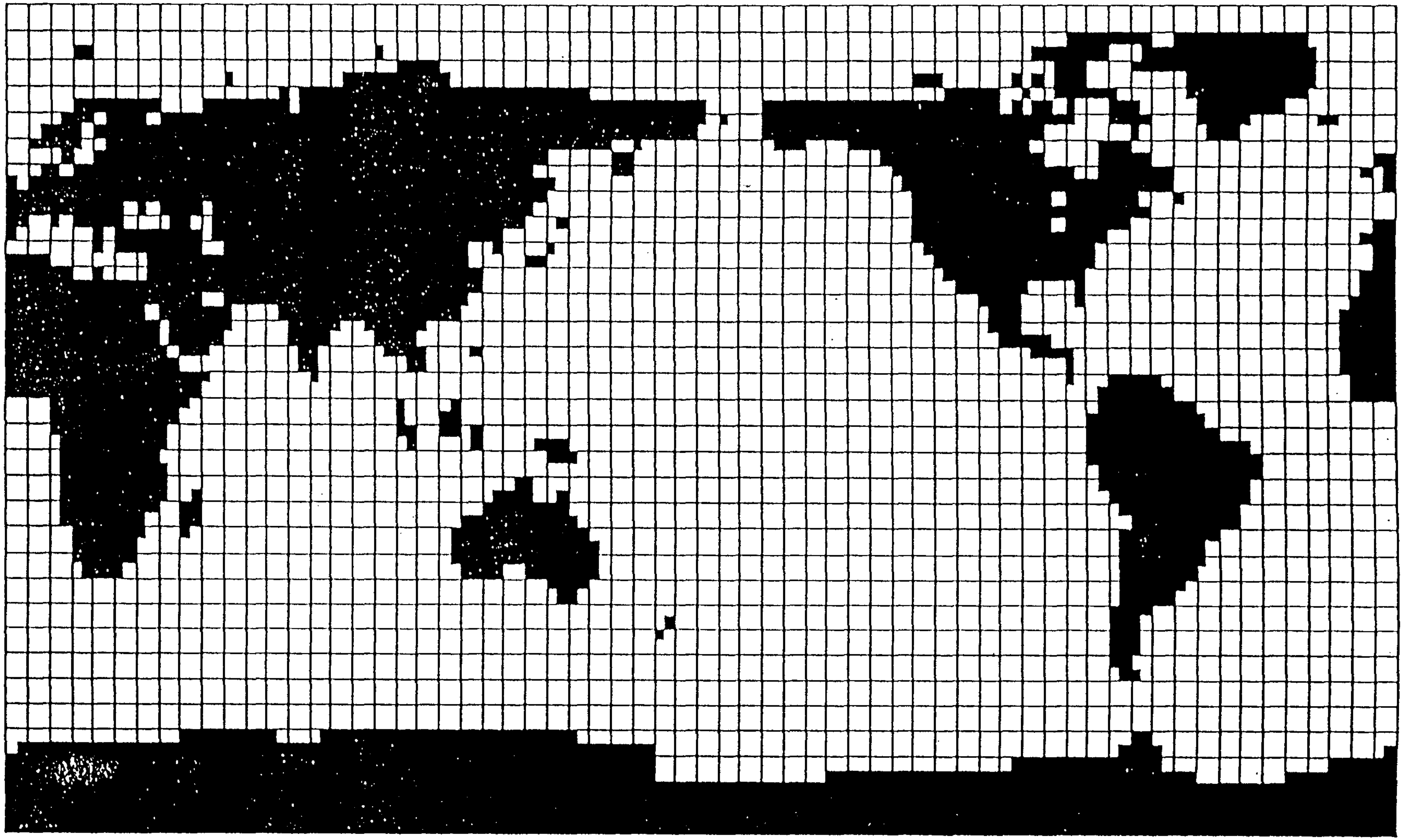
Objectives

- **Confirmation of GCMs** run under "control" conditions, such as
  - ECHAM T42 (30 years)
  - ECHAM T106 (5-10 years)
  - HIRHAM (5-10 years)
- **Assessment of "natural" variability** simulated in the 1000 year run with the T21 ECHAM1/LSG climate model.
- **Investigation of the potential of downscaling procedures** concerning the transfer of information
  - from the "planetary-scale" to the "weather-type" scale (needed for T21-type ultralong runs), and
  - from "weather-type" scale to the local scale (needed for impact applications).

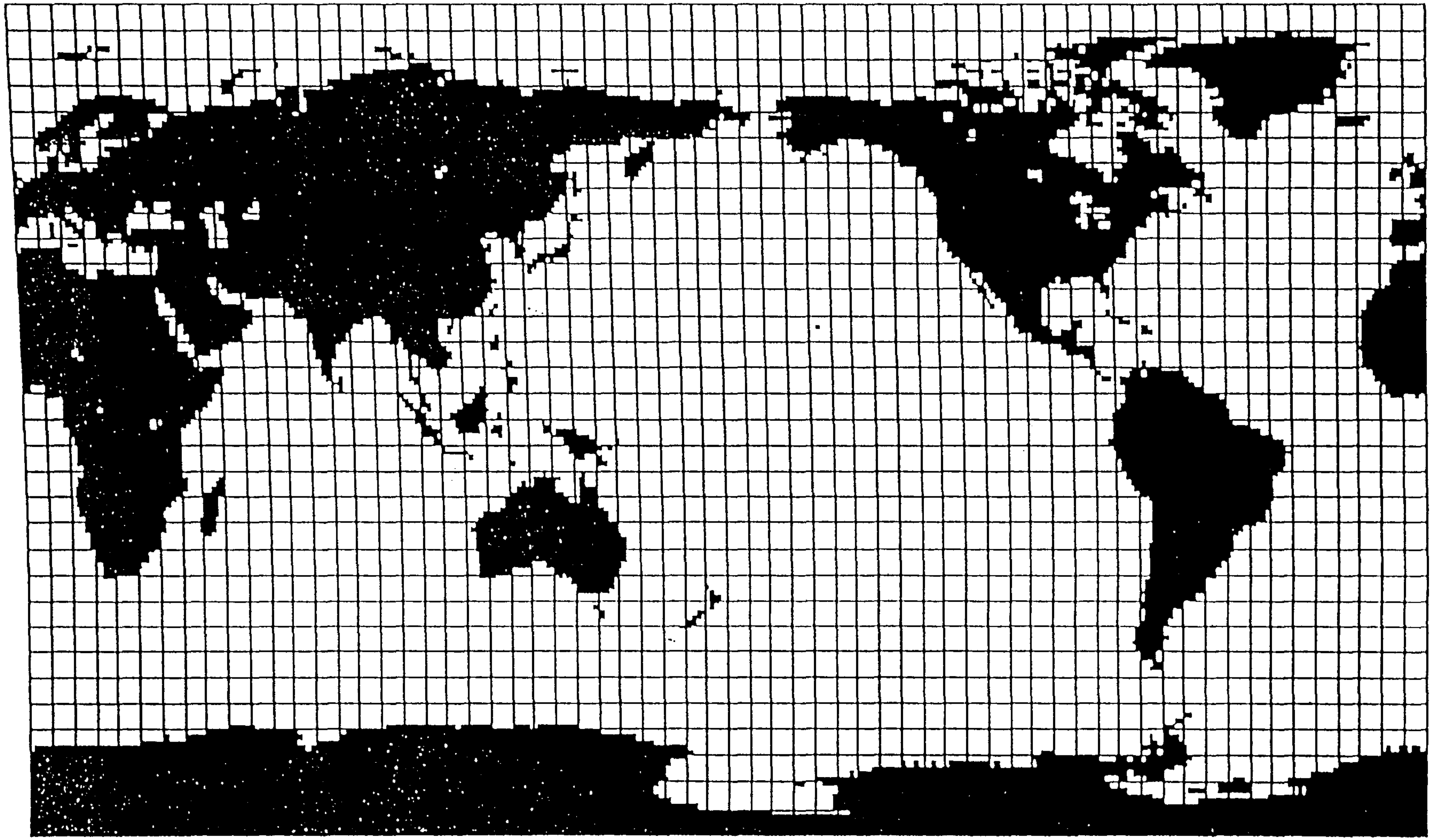
  in the climate change context. The general strategy would be
  - to derive statistical downscaling procedures from observational data, and
  - to examine the output of models of different power in specifying regional details.
  - Those statistical relationships, which are reproduced by the models, will then be checked if they are reproduced by the same model in a "2035"-time-slice experiment .



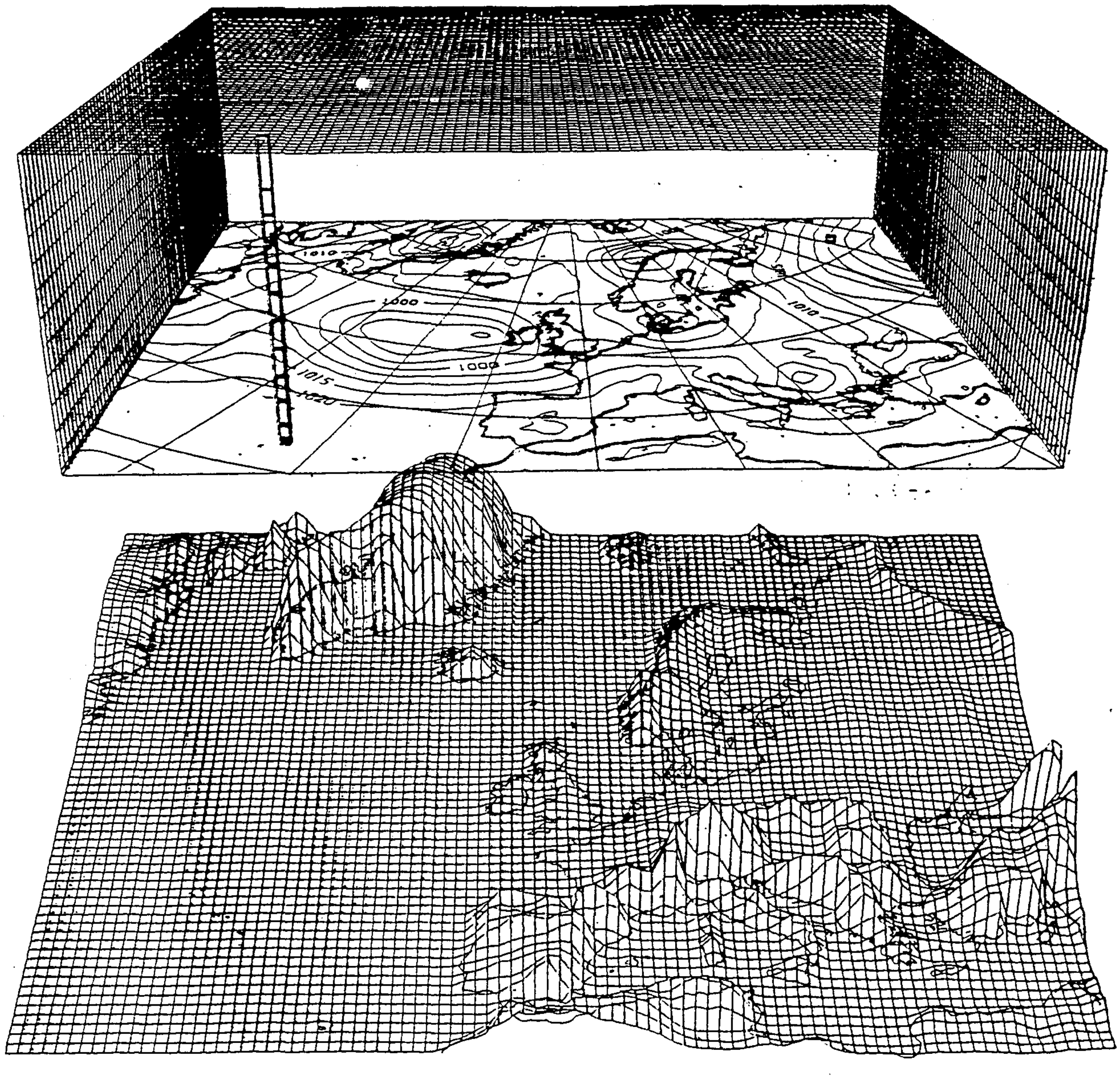
Land-sea mask for T21 model truncation



Land-sea mask for T42 model truncation



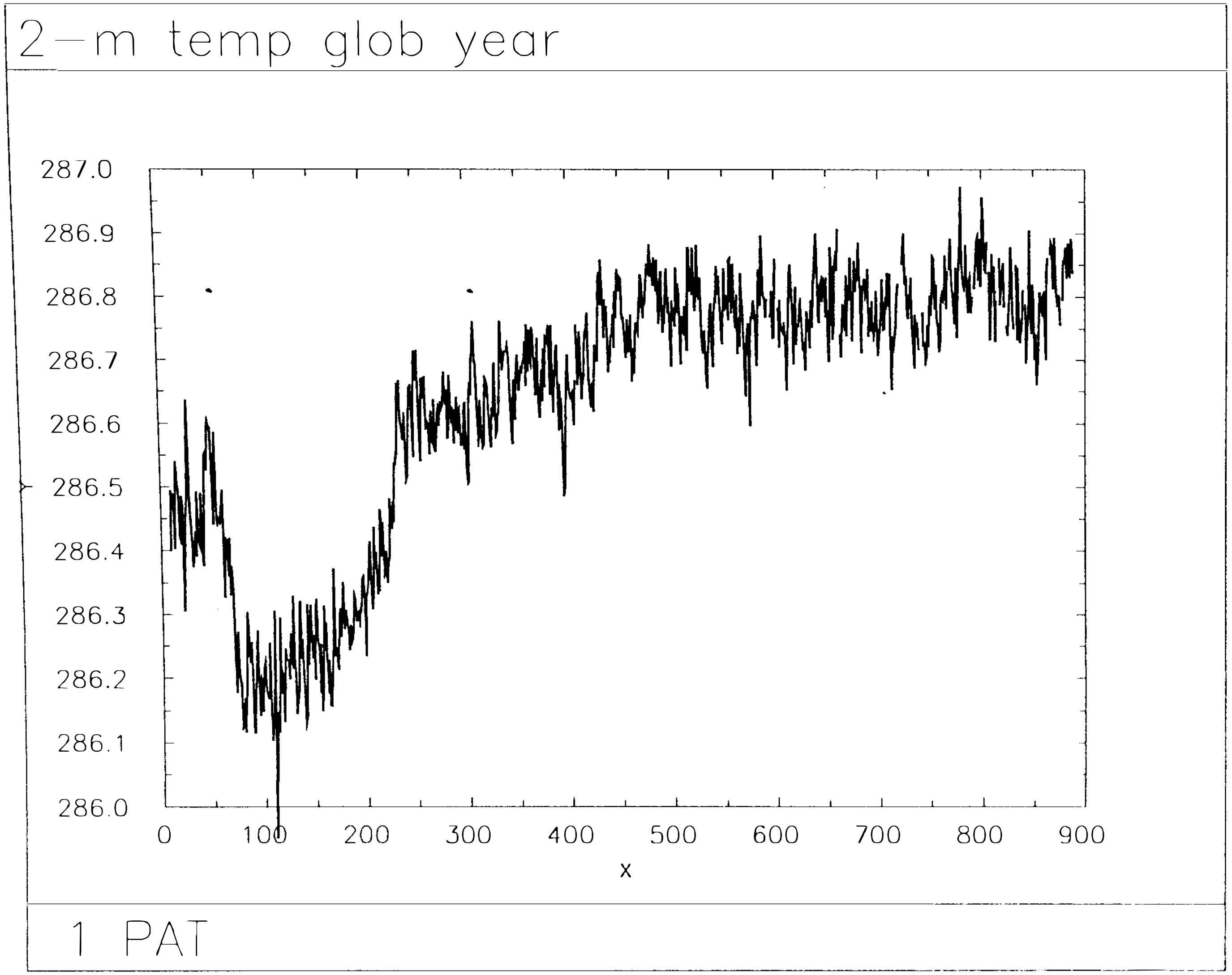
Land-sea mask for T106 model truncation



LIMITED AREA MODEL

Horizontal grid length

0.7 deg.


2-m temp glob year
287.0
286.9
286.8
286.7
286.6
286.5
286.4
286.3
286.2
286.1
286.0
0
100
200
300
400
500
600
700
800
900
x
1 PAT

The Joint Structure of Weather Generators

- The basic assumption is that we may adopt a model for rainfall $\vec{R}$ of the form
$$\vec{R} = f(\vec{L}) + noise \tag{1}$$
where $\vec{L}$ represents the large-scale circulation (or state of the troposphere) and f is a deterministic function.

- When using the model (1) in the downscaling / climate change context, we may disregard the noise or not. The noise may be specified by invoking a random number generator or by sampling from the ensemble of observed states.

- In general the topography given by f is unknown, but we may try to approximate it by utilizing our empirical knowledge. Several approaches are possible.

Approximation of the topography of f

- **Classification:** The full phase space (represented by $\vec{L}$) is split up into a finite number of areas, say $A_1 \ldots A_n$. For each area we specify an expected rainfall $\vec{R}_1^* \ldots \vec{R}_n^*$ and a (Gaussian) noise term with zero mean and covariance matrices $\Sigma_1 \ldots \Sigma_n$. Then

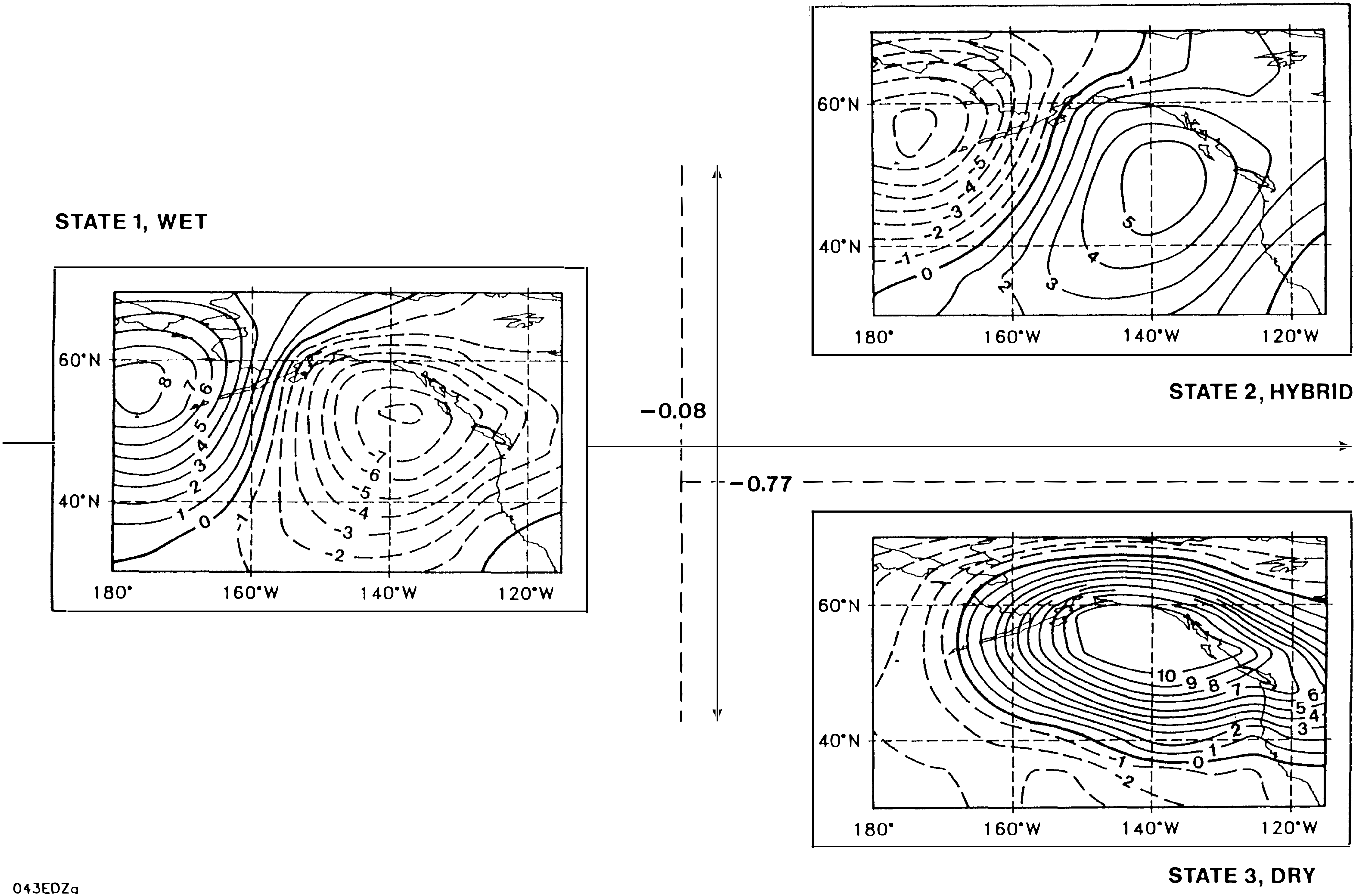
$$\vec{R} = \vec{R}_k^* + \vec{\eta}$$

if $\vec{L} \in A_k$ and $\vec{\eta} \sim \mathcal{N}(0, \Sigma_k)$

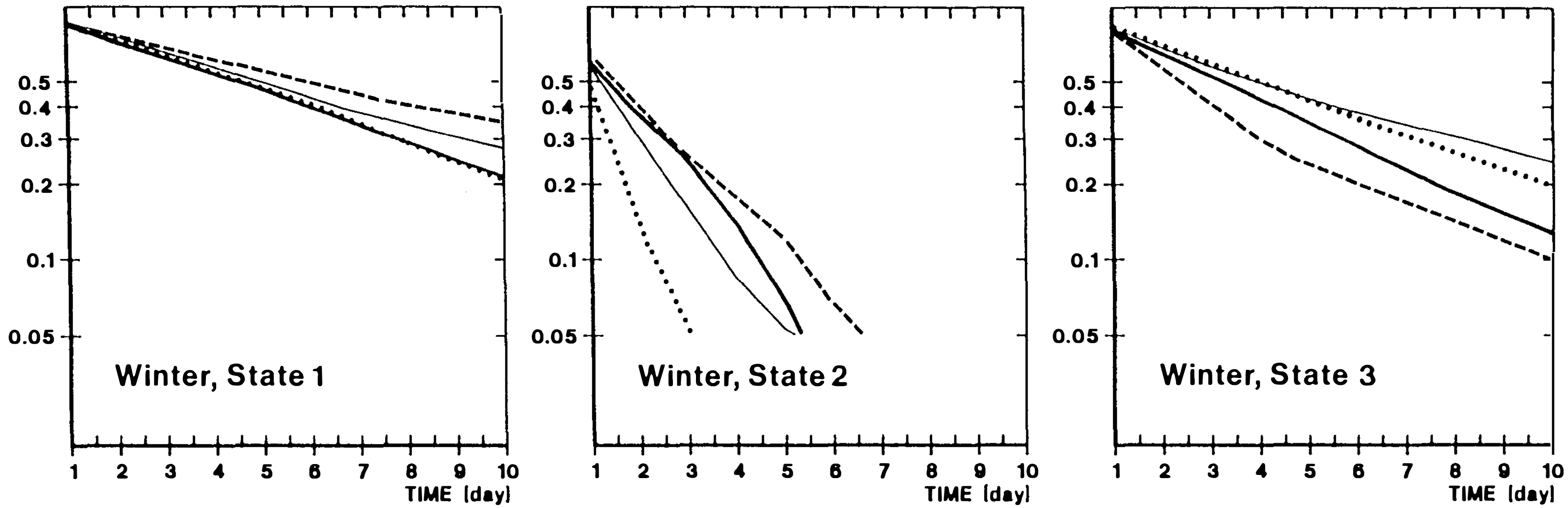
  - In the CART approach, an automatic classification algorithm zones the full phase space so that the $\vec{R}$ values are statistically homogeneous within each zone A_k (Hughes et al., 1993; Zorita et al., 1993).
  - In the Grosswetterlagen approach synoptic classifications of the daily weather, prepared operationally by weather servies, are utilized. That is, A_k is the set of all circulations belonging to grosswetterlage k.
    Note that the definition of the grosswetterlagen is <u>independent</u> of $\vec{R}$. (Bárdossy and Plate, 1992)

For time means, the frequency H_k of $\vec{L}(t) \in A_k$ is determined and the mean precipitation is specified as

$$\overline{\vec{R}} = \sum_k H_k \times \vec{R}_k^*$$

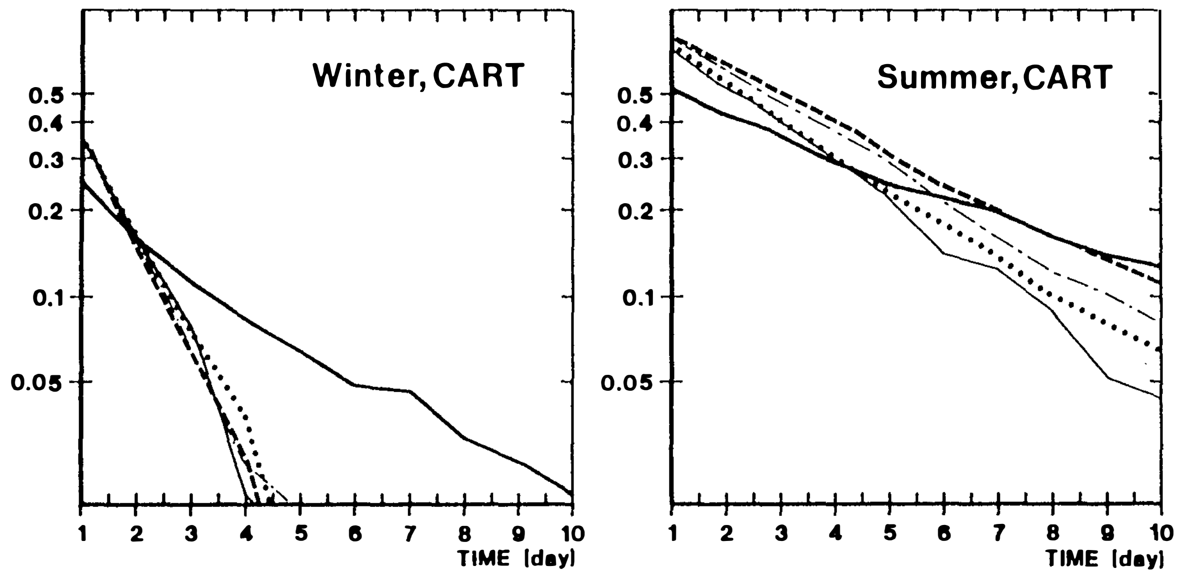

STATE 1, WET
STATE 2, HYBRID
STATE 3, DRY
−0.08
−0.77
60°N
40°N
180°
160°W
140°W
120°W

043EDZa



0.5
0.4
0.3
0.2
0.1
0.05
Winter, State 1
Winter, State 2
Winter, State 3
1 2 3 4 5 6 7 8 9 10
TIME (day)

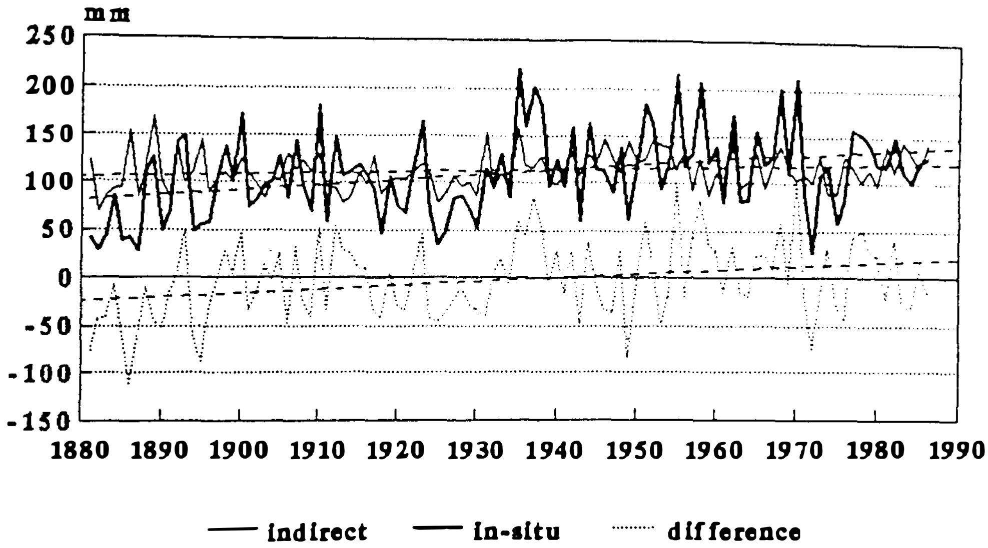
033EDZc



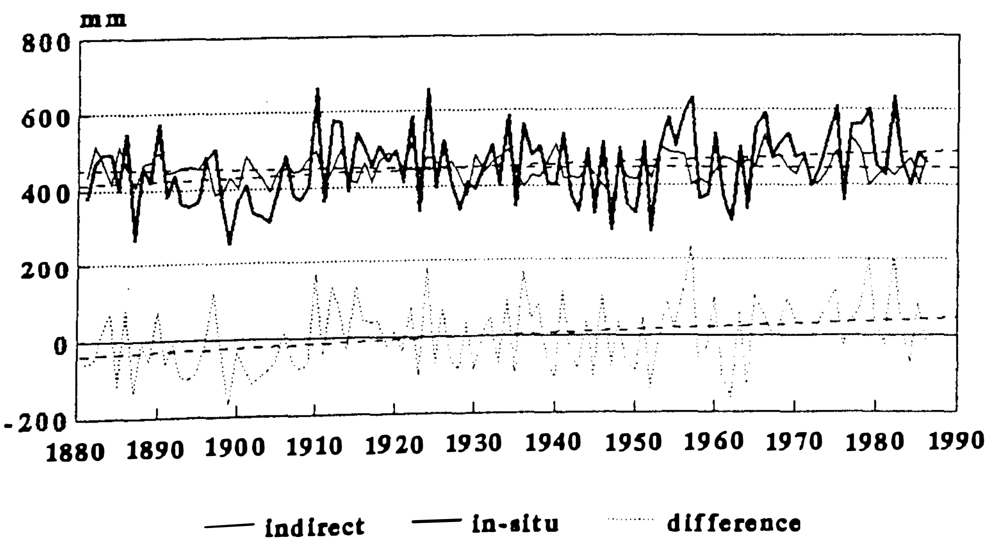
Winter, CART
0.5
0.4
0.3
0.2
0.1
0.05
1 2 3 4 5 6 7 8 9 10
TIME [day]
Summer, CART
0.5
0.4
0.3
0.2
0.1
0.05
1 2 3 4 5 6 7 8 9 10
TIME [day]

033EDZc

Precipitation at Hohenp.bg. in JF
Estimation with Statistic of Grosswetterlagen 1901-40

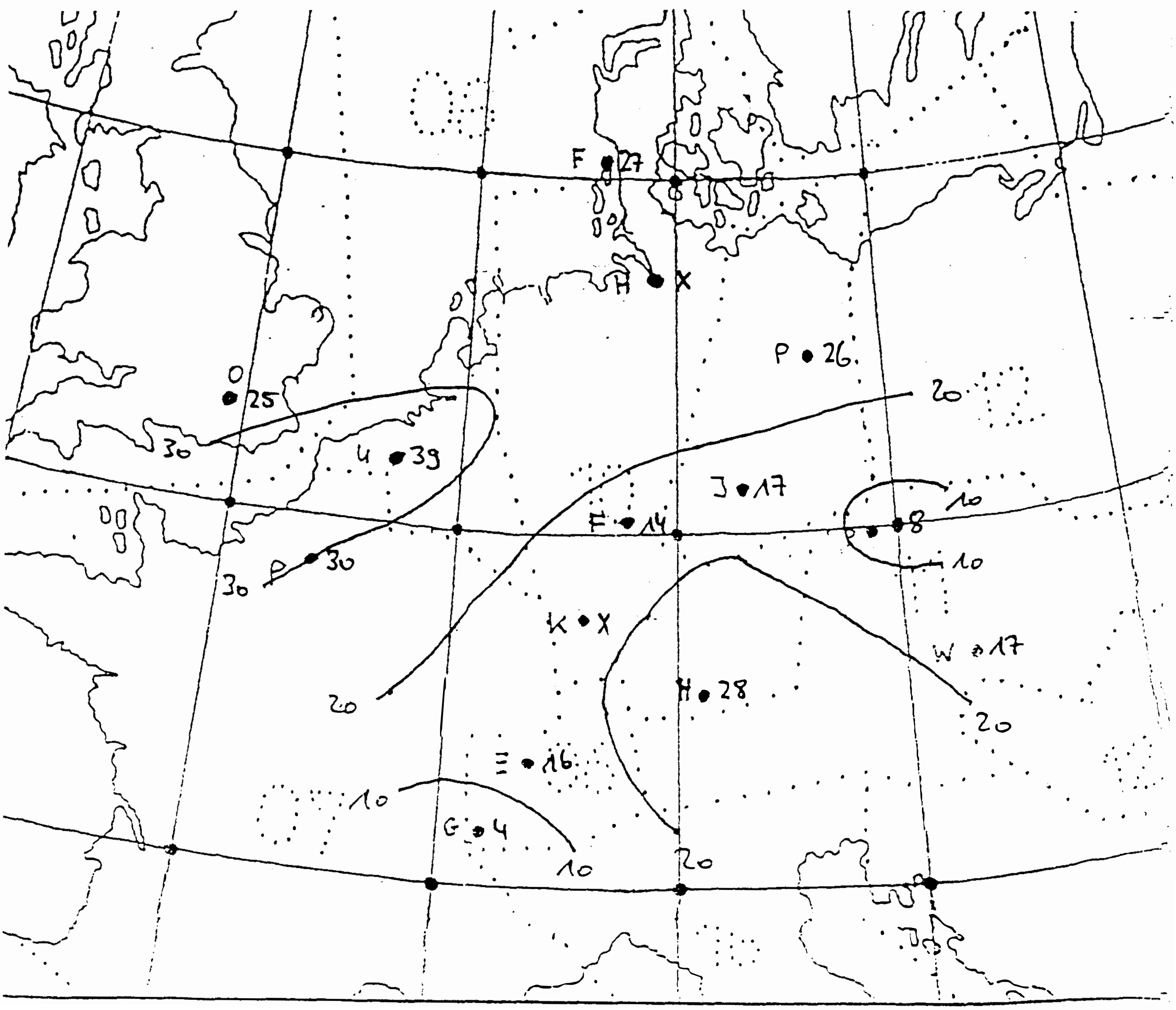


Precipitation at Hohenp.bg. in JJA
Estimation with Statistic of Grosswetterlagen 1901-40



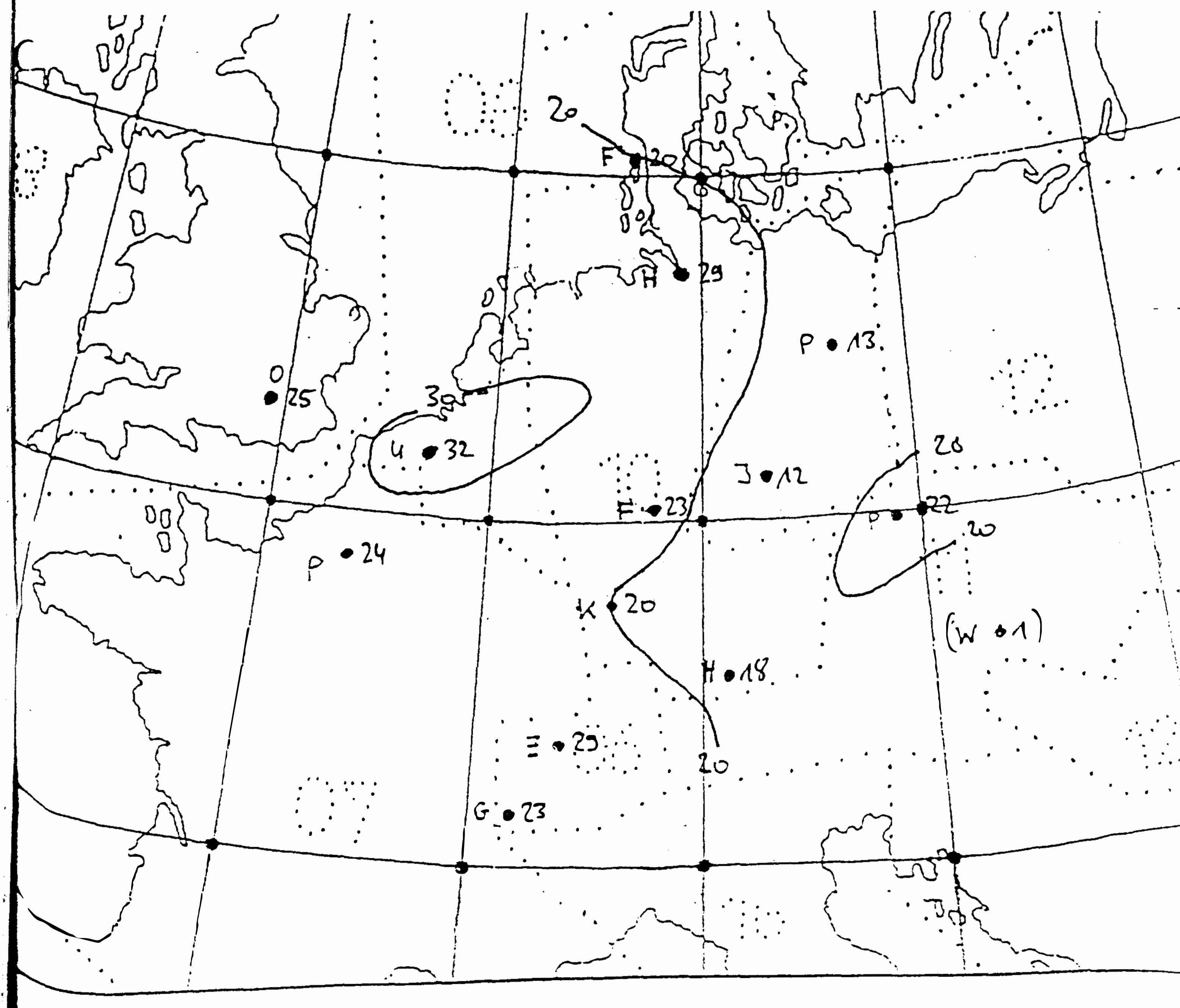
~~by~~ from PC Werner (PIK)
(pers. communication)

klärte Varianzen (%) zwischen simulierter u. beobachteter
itreihe, Tagesminimum der Lufttemperatur, 1901 - 80, Sommer (JJA)

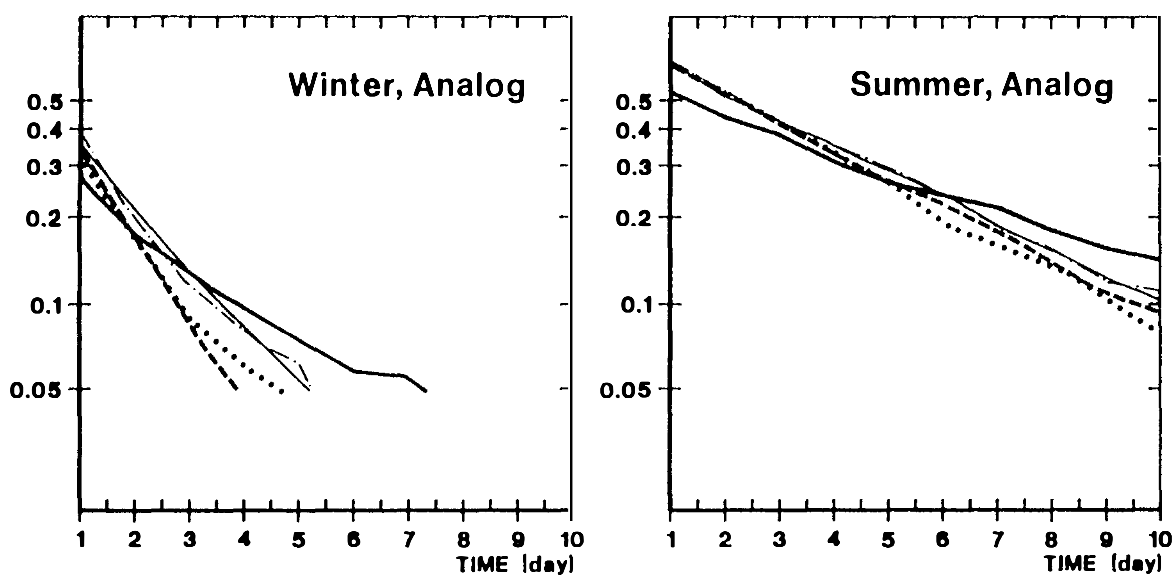


PC Werner, 1993
(PIK)

Erklärte Varianzen (%) zwischen simulierter und beobachteter Zeitreihe, Tagessumme des Niederschlags, 1901–80, Sommer (JJA)



PC Werner, 1993
(PIK)


Winter, Analog
Summer, Analog
0.5
0.4
0.3
0.2
0.1
0.05
1 2 3 4 5 6 7 8 9 10
TIME (day)

033EDZc

Approximation of the topography of f

- **The analogue approach:** for any given state $\vec{L}$ we search for the closest *observed* $\vec{L}(t)$ and specify

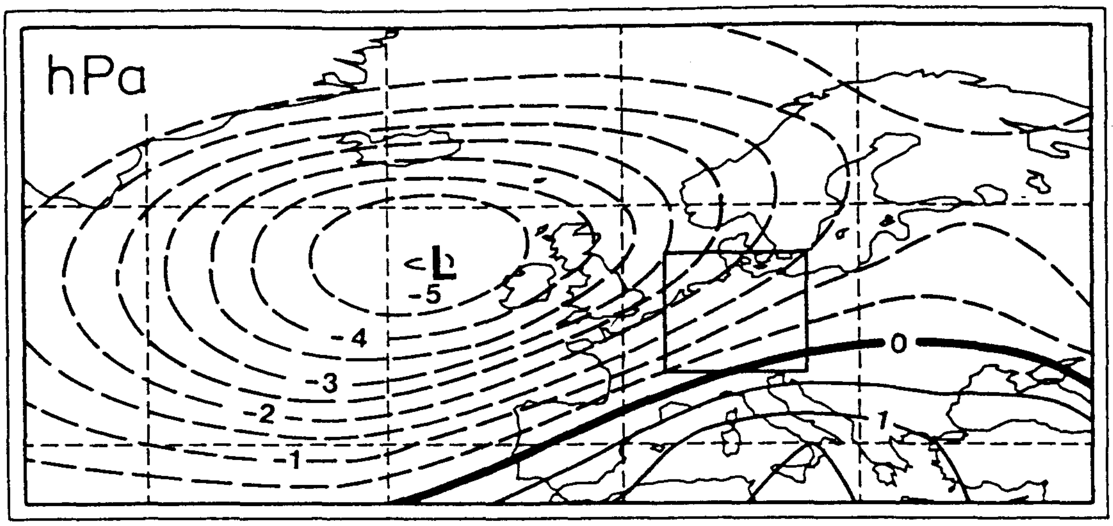
$$f(\vec{L}) = \vec{R}(t)$$

  which is the rainfall observed together with $\vec{L}(t)$ at time t. (See Zorita et al., 1993)
  Geometrically we may think of approximating the f-topography by constant surfaces of variable shape and size.

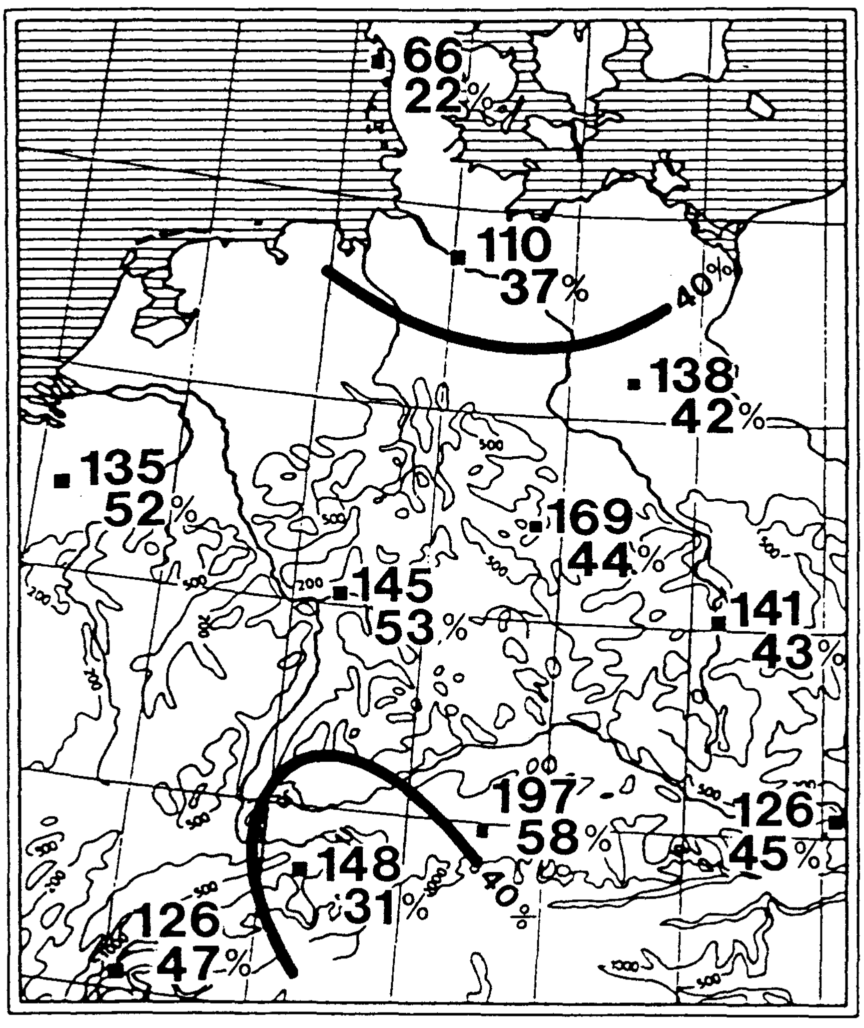
- **Regression techniques** create linear approximations of the topography. CCA belongs into this category (von Storch et. al., 1993). One might think of combining this approach with the classification technique by fitting different approximations for different areas A_k.

- **Interpolation techniques** - such as kriging (first experiments done by Gyalistras). This approach is closely related to the analogue technique with the following difference: In the analog technique the f-surface is approximated by piecewise constant values whereas in the kriging the approximation is done with piecewise linear (or other) functions.

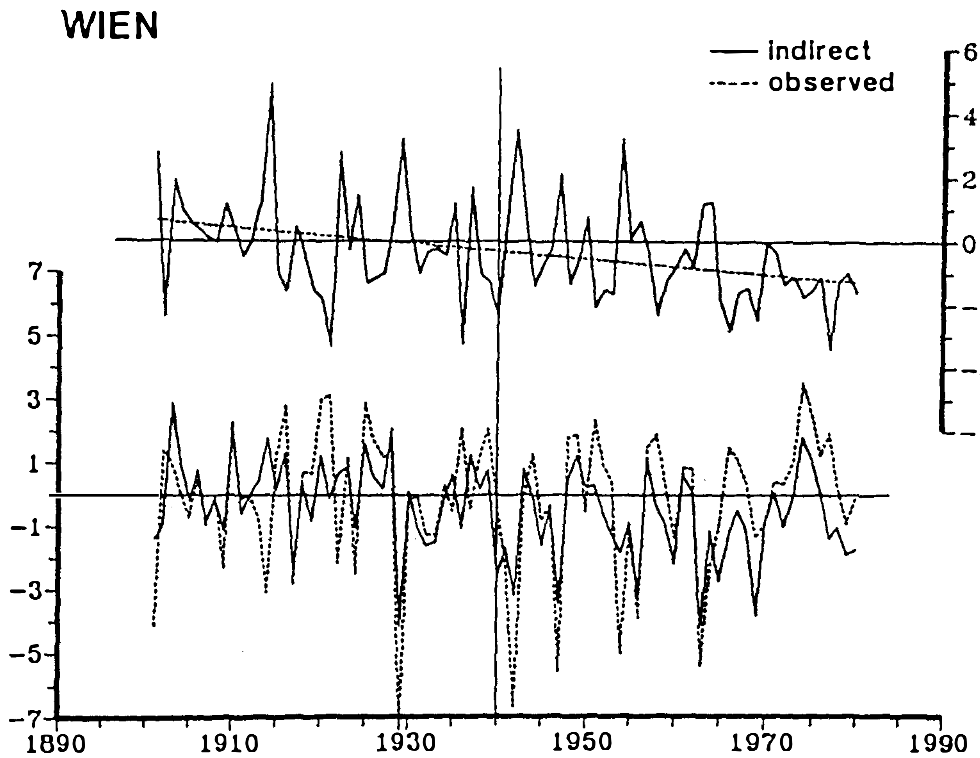
- **Neural Networks.** (First experiments done by Zorita.)


hPa
L
-5
-4
-3
-2
-1
0
1

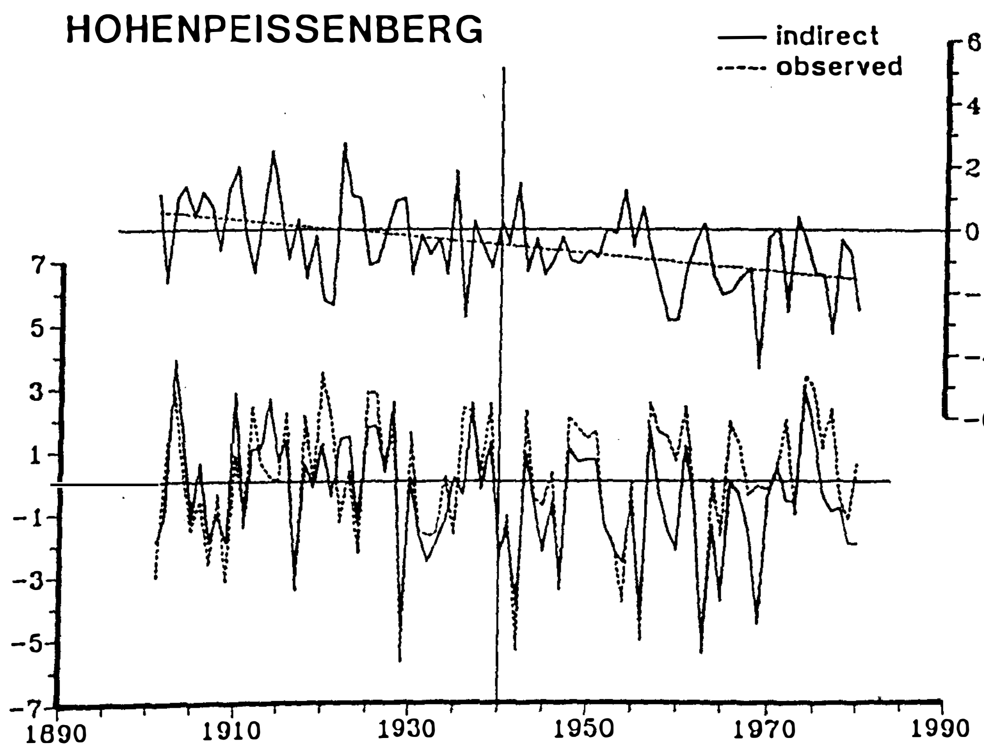
JF


66
22%
110
37%
40%
138
42%
135
52%
169
44%
145
53%
141
43%
197
58%
126
45%
148
31%
40%
126
47%

10^{-2} K



WIEN
indirect
observed



HOHENPEISSENBERG
indirect
observed

032HVS