# Downscaling of GLOBAL Climate Change Estimates to REGIONAL scales:

## An Application to Iberian Rainfall in Wintertime

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# Spatial Scales
## in Climate Change Research

SCALES IN GCMs

o the MINIMUM spatial scale
  M ▪ distance between two grid points.
  Typically › 500 km

o the SKILLFUL spatial scale
  S ▪ 3 to 4 times the minimum scale
  Typically › 1500 km

GCMs yield reasonable results on the scales ›S,
questionable results on scales ‹ S and › M
no results on scales ‹ M

SCALE REQUESTED BY CONSUMERS

o the REGIONAL scale R
  Typically ‹ 200 km or less

## Problem

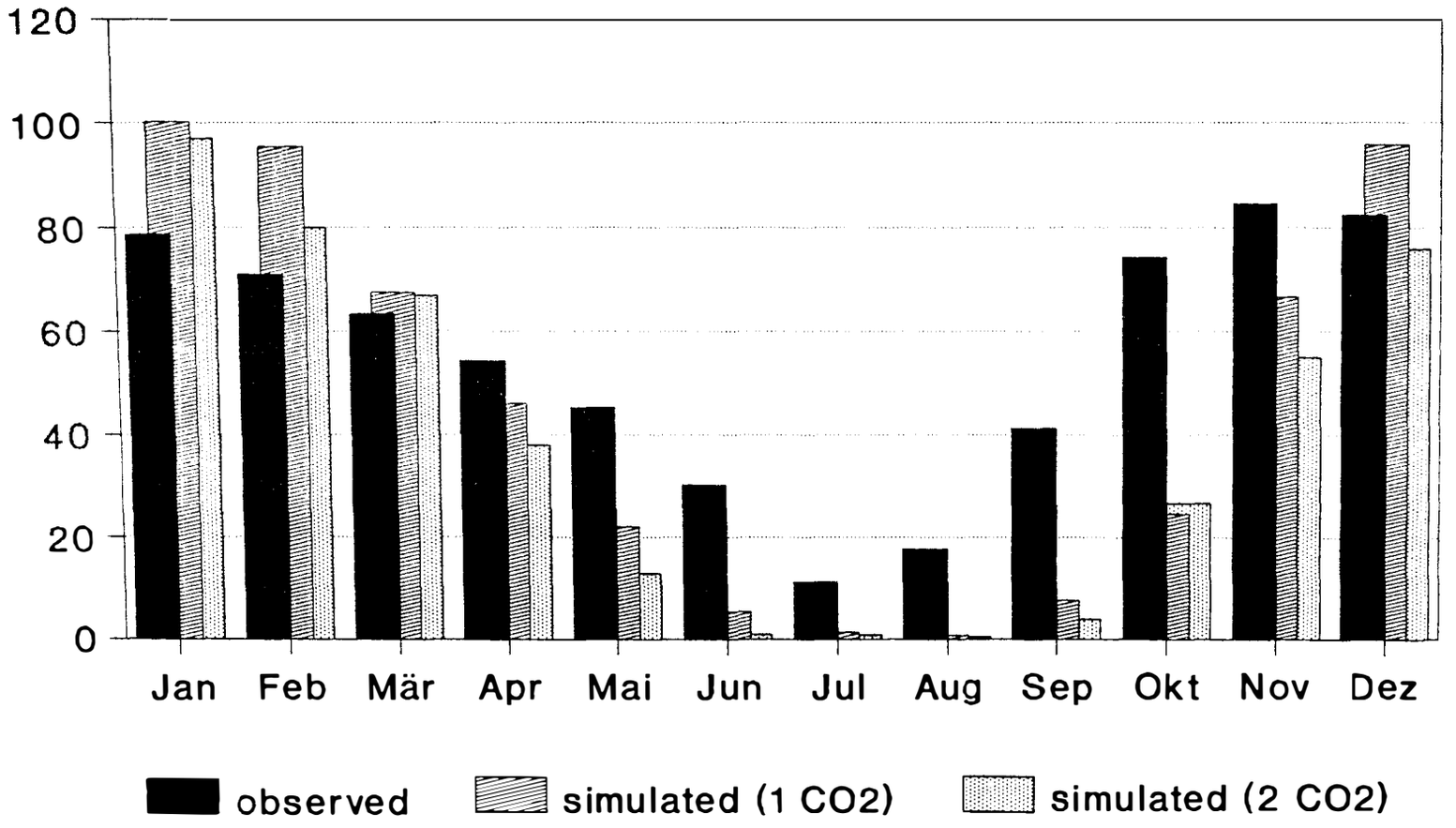
Regional scale < skillful scale

## Strategy

Interpret S-scale GCM output on the R-scale
by means of
- regional dynamical models
- statistical models

# Seasonal mean rainfall on the Iberian Pensinula in winter (DJF)

# Iberian Rainfall
## Observed and Simulated



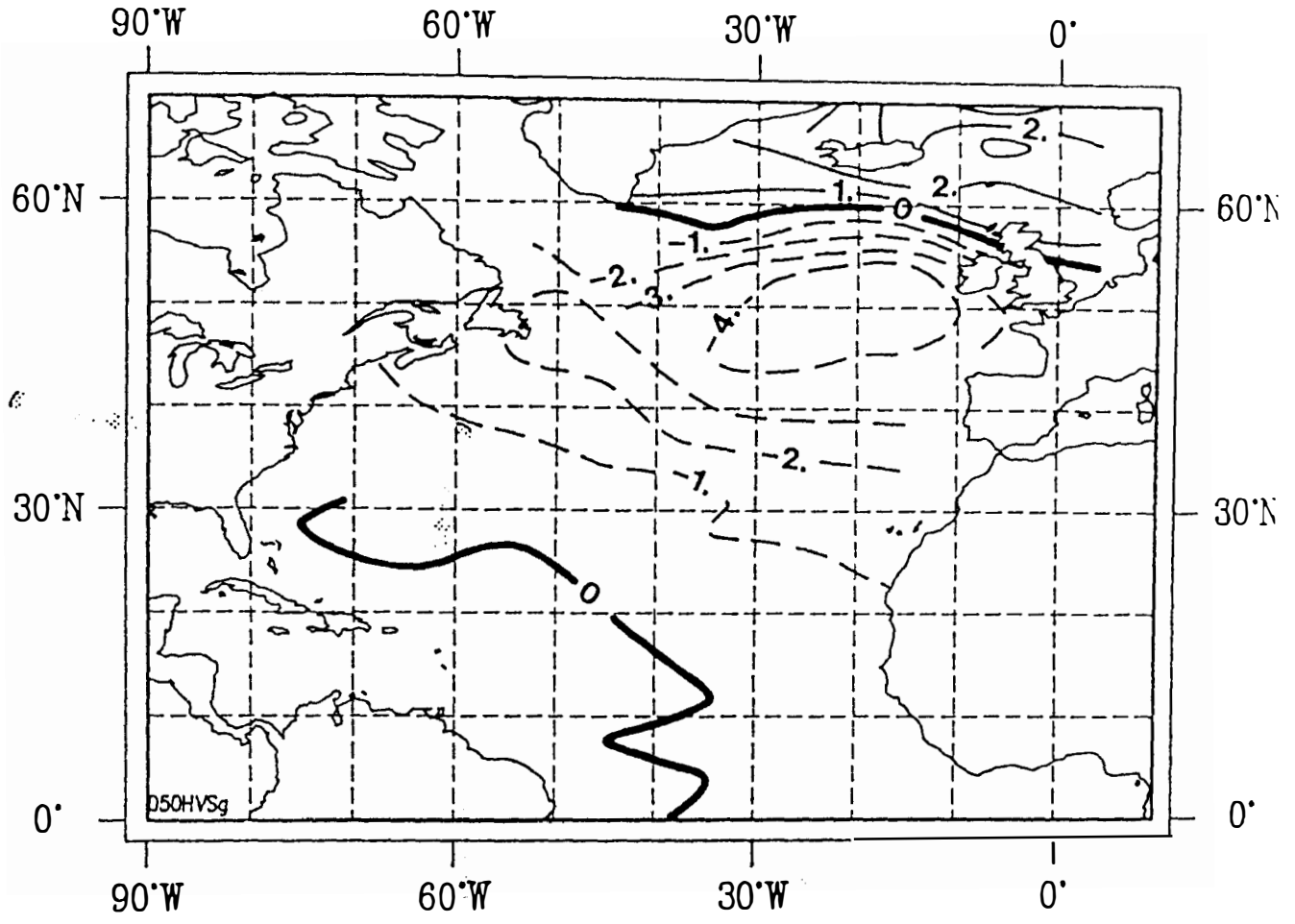
# The Statistical Model

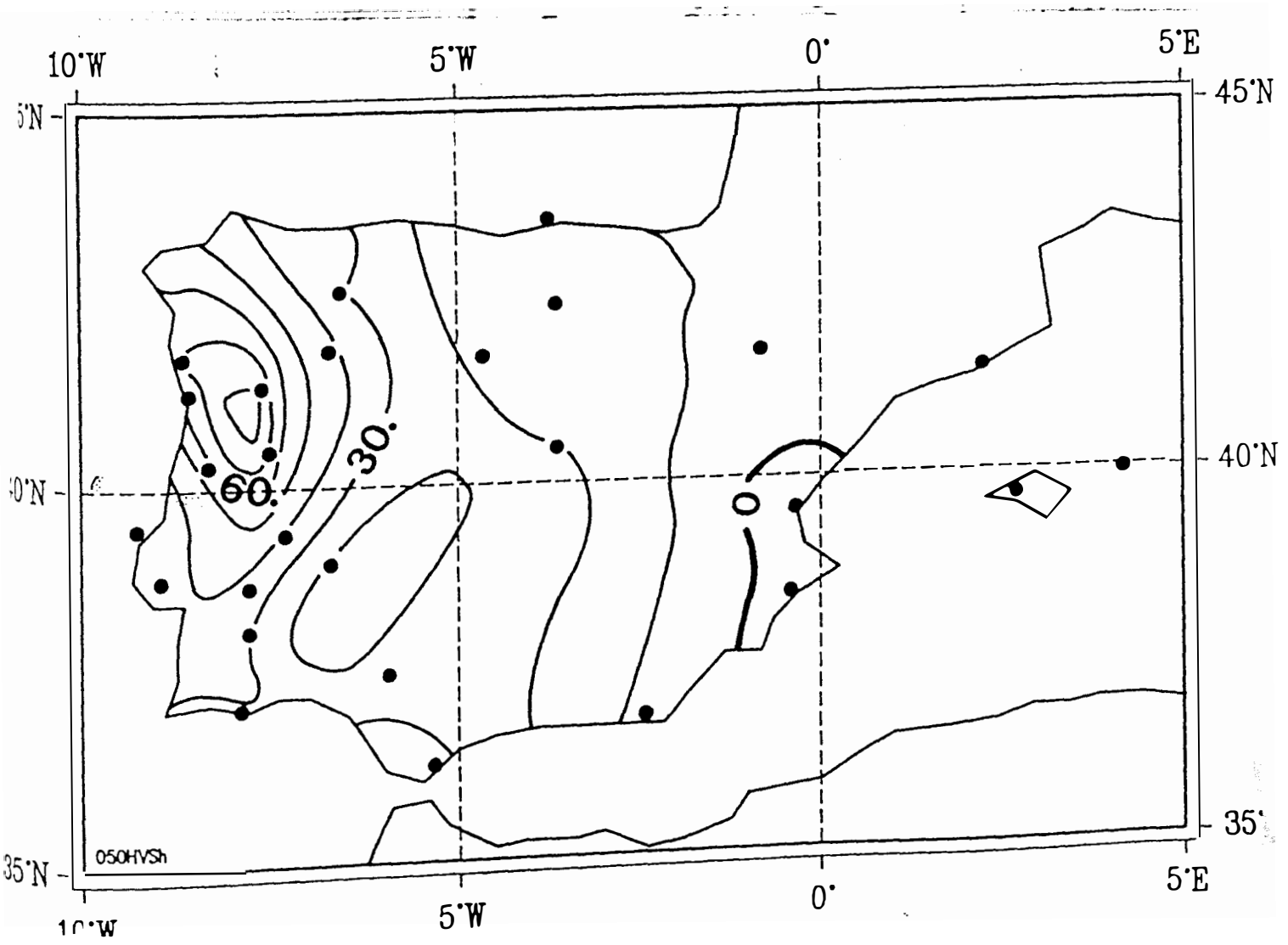
relates the GLOBAL scale
North Atlantic atmospheric circulation
to the REGIONAL scale
Iberian Peninsula Rainfall

by a pair of canonical correlation patterns which represent
- 40% of the seasonal SLP variance
- 65% of the seasonal rainfall variance
and share a correlation coefficient of 75%.

Data are
- COADS SLP, 1950-86
- WMSC station data, 1950-86
DJF only

*Ref: E. Zorita, V. Kharin and H. v. Storch, MPI Report 54*


90°W
60°W
30°W
0°
60°N
30°N
0°
2.
1.
0
2.
-1.
-2.
3.
4.
-2.
-1.
0
050HVSg


10°W
5°W
0°
5°E
45°N
40°N
35°N
60.
30.
0
050HVSh

# The Method

For each SLP field S(t) there is a coefficient z(t) so that

z(t) $R$(x) with $R$ = canonical rainfall pattern

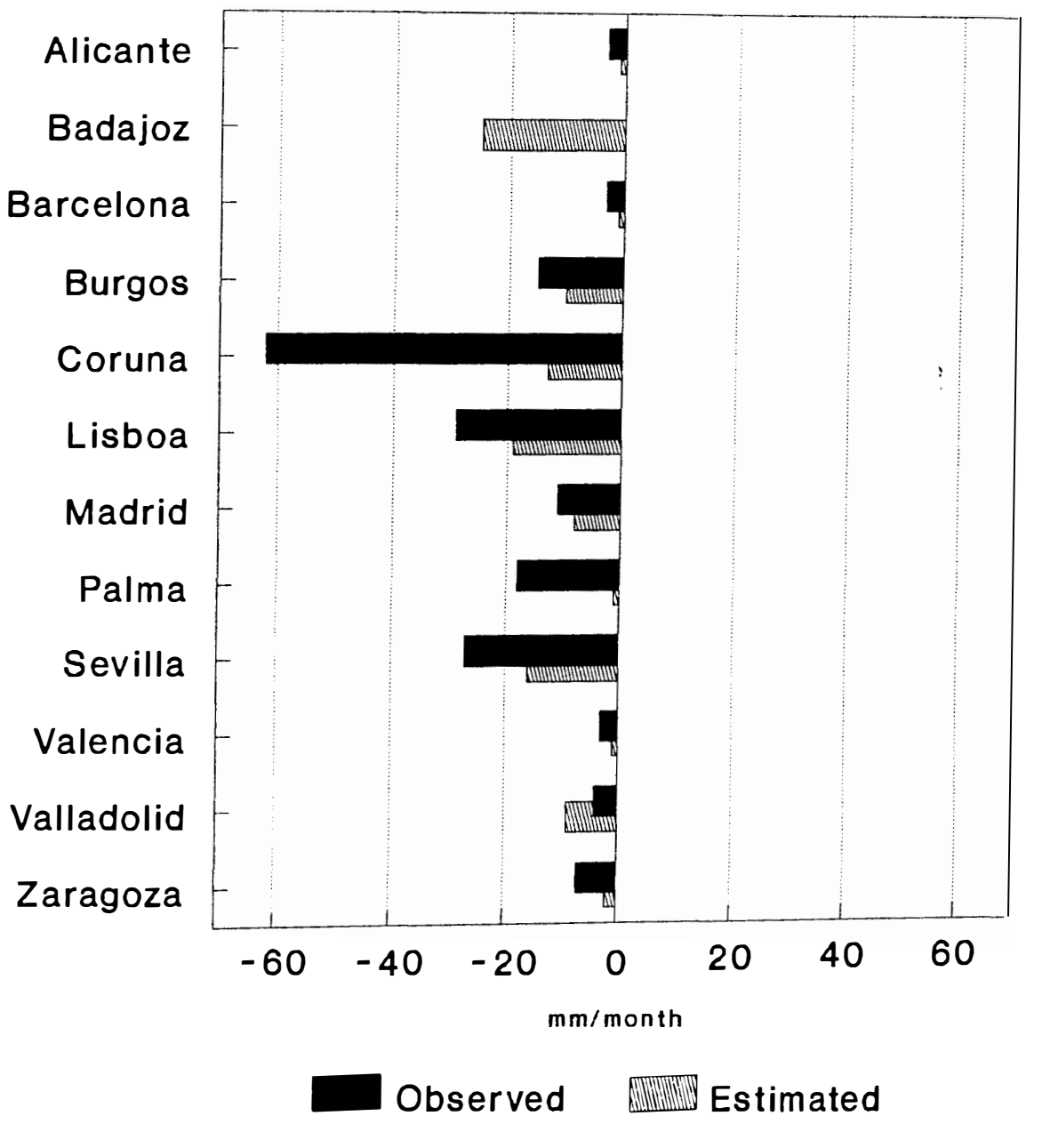
is explaining 65% of the seasonal mean Iberian rainfall.

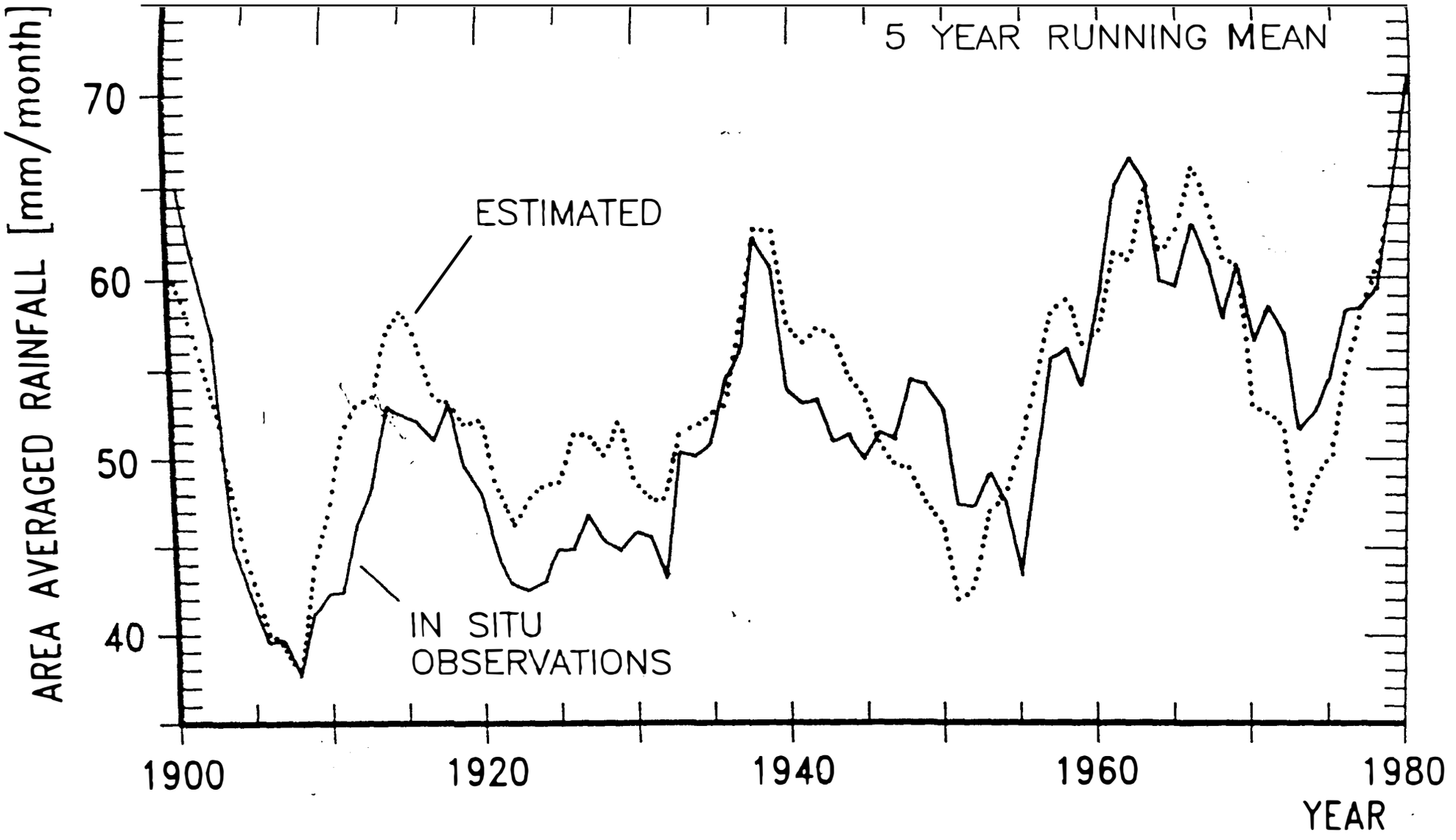
z(t)$R$(x) is called the dynamically consistent rainfall.

We test the concept by deriving z(t) from the SLP field for all DJF seasons from 1900 to 1980, and compare z(t)$R$(x) with the in-situ rainfall observations.

- local decadal differences 1904-13 vs. 1951-60
- area mean 1900-1980

# Decadal DJF rainfall differences 1904-13 vs. 1951-60




5 YEAR RUNNING MEAN
ESTIMATED
IN SITU
OBSERVATIONS
AREA AVERAGED RAINFALL [mm/month]
70
60
50
40
1900
1920
1940
1960
1980
YEAR

031HVS(b)

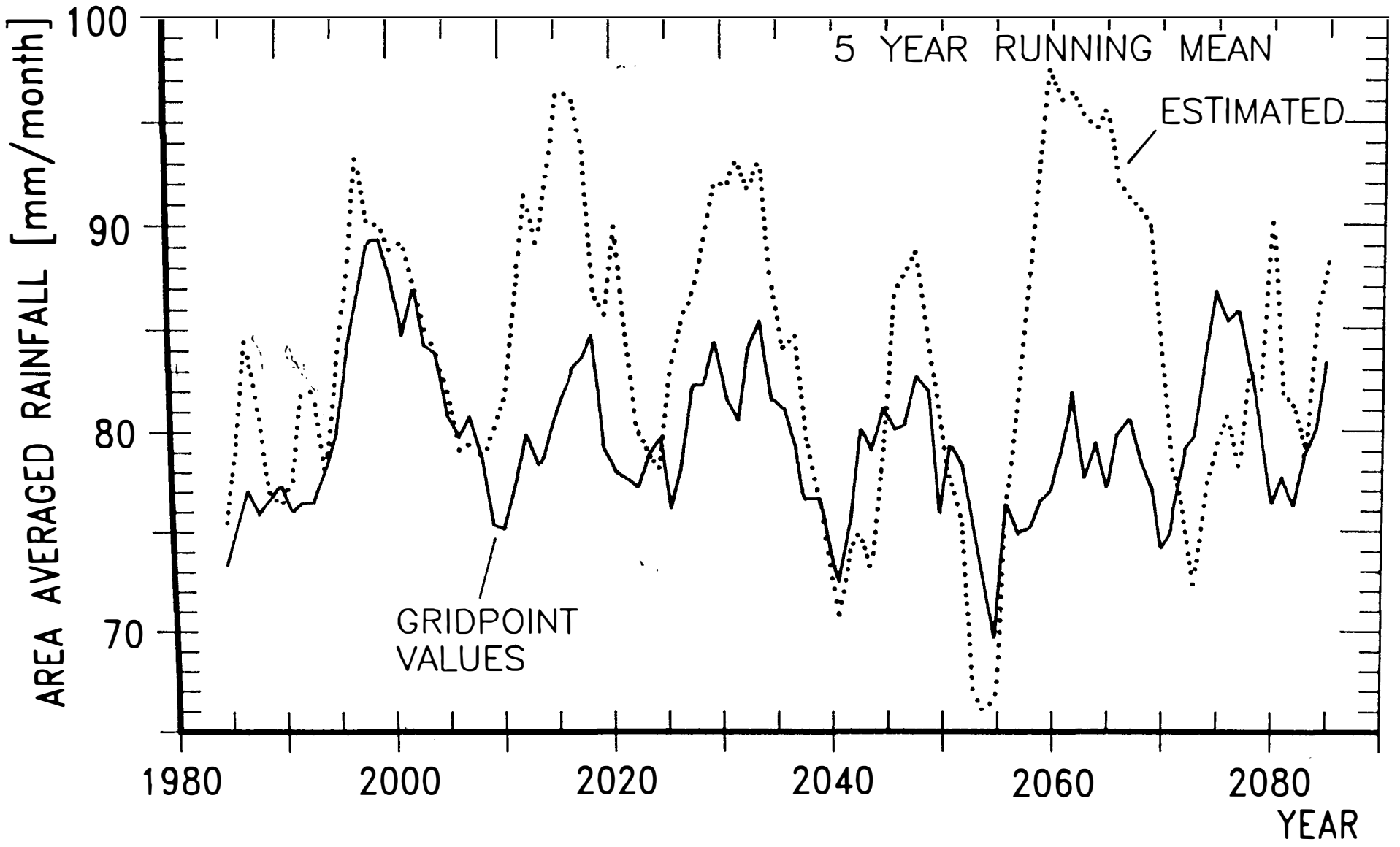
# Climate change experiment on the response to a transient increase of greenhouse gases

MPI coupled atmosphere-ocean GCM
- atmosphere: ECHAM1
- ocean: LSG

Greenhouse gas concentration: IPCC Scenario A
initial: 1985
exponentially growing by 1.3% per year

100 year integration

*Ref.: Cubasch et al., 1991, MPI Report*


5 YEAR RUNNING MEAN
ESTIMATED
GRIDPOINT
VALUES
AREA AVERAGED RAINFALL [mm/month]
100
90
80
70
1980
2000
2020
2040
2060
2080
YEAR

031HVS(a)

# Conclusions
# 1. Method

- Statistical models relating global (S-scale) anomalies and regional (R-scale) anomalies may be used to infer regional aspects of the expected climate change from GCM simulations
- On the long term, regional GCM will do a better job than statistical models, but then the R/S-scale problem is reoccurring on a smaller scale.
- The statistical approach is not limited to meteorological regional parameters. Also non-physical parameters from the biosphere or from the economy can be used.
- A severe limitation is that regional parameters often can not sufficiently stably be described in terms of S-scale parameters.

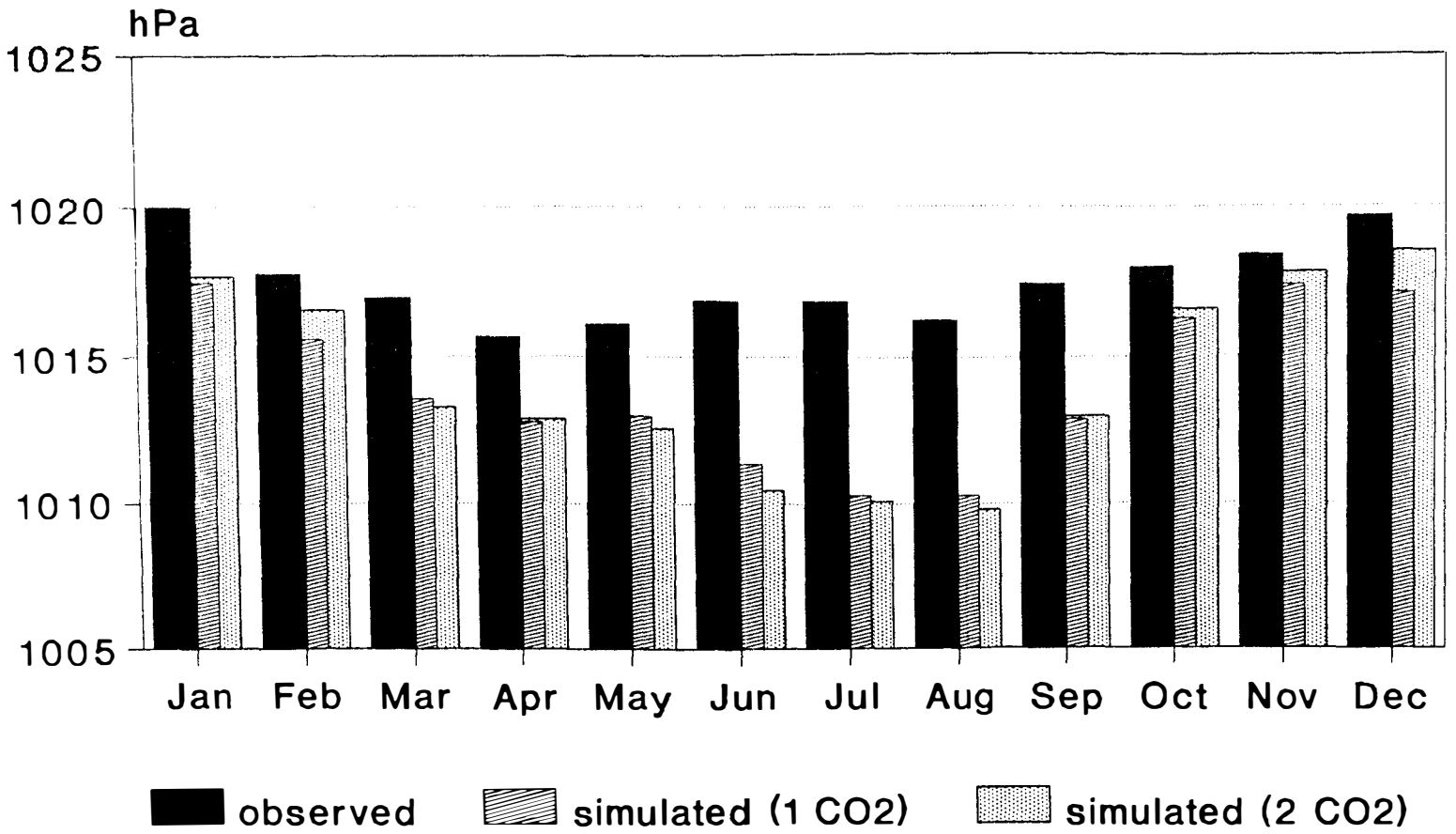
# Conclusions
# 2. Physical aspects

- There is a strong relationship between North Atlantic SLP and Iberian rainfall on the seasonal time scale in DJF. The physical mechanism is the increased or decreased transport of baroclinic disturbances with the mean flow.
- The Iberian rainfall has increased significantly since the beginning of this century, consistently in terms of local observations and North Atlantic SLP.
- The observations from 1900-80 indicate natural climate variations on the inter-decadal time scale with a standard deviation of up to 5 mm/month.

# Conclusions
# 3. Climate Change aspects

- The gridpoint value response to a increased greenhouse gas concentration is markedly different from the dynamically consistent rainfall response.
- In the IPCC scenario A, no significant rainfall changes are determined for teh Iberian Peninsula.
- The natural inter-decadal variations are larger in the dynamical consistent rainfall than in the gridpioint value rainfall.

# Iberian Sea Level Pressure
## Observed and Simulated



# Iberian Temperature
## Observed and Simulated