

# WASA

## Waves And Storm climate in the North Atlantic and in the North Sea.

We are dealing with the

- RECONSTRUCTION of the storm- and wave climate in the North Atlantic and the North Sea in the 20th CENTURY
- CONSTRUCTION of FUTURE PERSPECTIVES of the WAST - climate in the 21st CENTURY

Two central questions are:

- Is the storm climate in the past 100 years consistent with the concept of intensifying or more frequently forming storms in the Northeast Atlantic?
- How was /might be the response of the wave field and the storm surge statistics to past /future changes in the storm climate and other atmospheric features?

# Strategy of WASA

1) "Creation" of relevant data.

- a) Collect homogeneous long time series of wind data (if available) and wind proxy-data (air-pressure, geostrophic wind, variance of high-frequency variability of sea level and ?)
- b) Run extended "hindcast" simulations with state-of-the-art wave models and high-quality and homogeneous atmospheric forcing over 10 - 30 years.  
Solve problem with the insufficient (?) determination of extreme events.  
Derive time series of wave statistics

2) Downscaling models

Relate the homogeneous time-series of wind-related data and of wave-statistics to homogeneous and long time series representative for the large-scale atmospheric climate (such as air-pressure or near surface temperature (well documented for the past 100 years and -partially- well simulated by climate models)) for the past 10-30 years (or so).

Strategy ...

- 3) Reconstruct WAST-climate of 20th century  
apply downscaling models: use large-scale  
state of the atmosphere to estimate WAST  
climate from 1900 onwards.
- 4) Estimate future WAST-climate for the  
21st century  
Evaluate output of climate change experiments  
with global models  
(in particular the MIPI experiments  
T21 scenario A + "early industrial" run,  
T42 and T106(?) time slice expe  
for "2035" and "2085")  
and apply downscaling procedures.

3. juni 84

**POLITIKEN**

## Tegn på klimaændringer

Miljøorganisationen Greenpeace har udsendt en rapport med beskrivelse af 500 ekstreme vejrhændelser – orkaner, rekordtrop raturer, tørke og lignende – fra de seneste tre år. De ekstreme begivenheder er taget til i antal i de senere år og tolkes af Greenpeace som de første tegn på klimaændringer som følge af drivhuseffekt. Rapporten 'Den tidsindstillede klimabombe', der i går blev overrakt til miljøminister Svend Auken (S), vil blive opdateret hver halve år. (Pol)

## Søvand til grundvand

De første forsøg med at danne nyt, rent grundvand ved at pumpe vand op af den plundrede Søvand til grundvand

# In this talk ...

I will present some new material concerning

- Detection of climate change in the observed near-surface temperature (Hegerl et al., 1994)
- Problems stemming from inhomogeneities (COADS vs. OWs) (Work presently done by Isenmer)
- Some results on storm statistics
- An example of a downscaling procedure which relates the wave period to the large-scale state of the atmosphere.
- Results from climate change experiments.

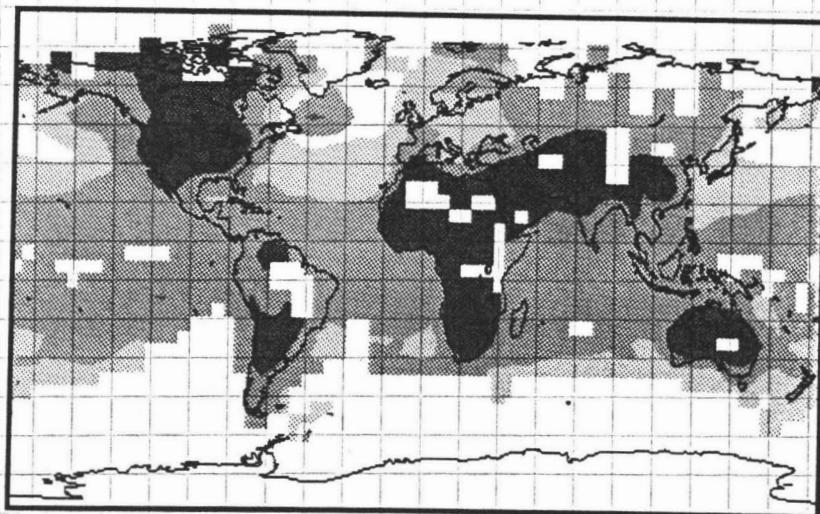
# Rezente Klimaänderungen - natürlich oder nicht?

- Die homogenisierten Analysen der bodennahen Temperatur deuten an einen Anstieg dieser Temperatur in den letzten 100 Jahren an.
- Das räumliche Muster dieses Temperaturanstieges wird auf das von Klimamodellen erwarteten Muster projiziert und so eine *Detection Variable* bestimmt.
- Der so bestimmte Wert der Detection Variable wird verglichen mit der Variabilität dieser Variable unter ausschliesslich natürlichen Umständen. Diese Variabilität wird abgeschätzt unter Zuhilfenahme von Resultaten von langen “Kontrollläufen” mit Klimamodellen.
- Falls diese Variabilitätsabschätzung richtig ist, sind die zuletzt beobachteten Trends in der bodennahen Temperatur nicht mit der Vorstellung einer rein natürlich bedingten Klimaschwankung konsistent.
- Ein Optimierung des erwarteten “Signal-to-Noise” Verhältnisses verstärkt das Resultat der Inkonsistenz von rezenter Erwärmung und natürlichen Klimaschwankungen.

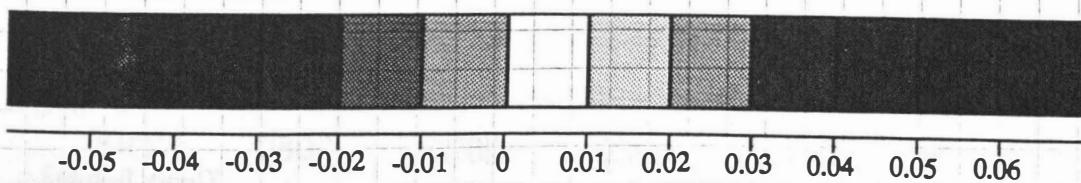
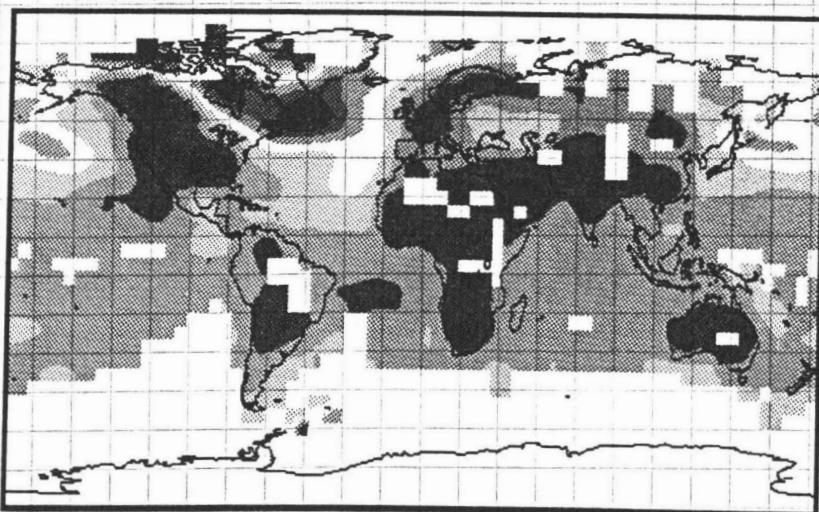
Eine Veröffentlichung von Hegerl et al. ist im Entwurf vorhanden.

**Optimal Rotation for full set of Variability data  
optimized in the space spanned by EOFs 1-4 of the  
Early Industrial global warming simulation**

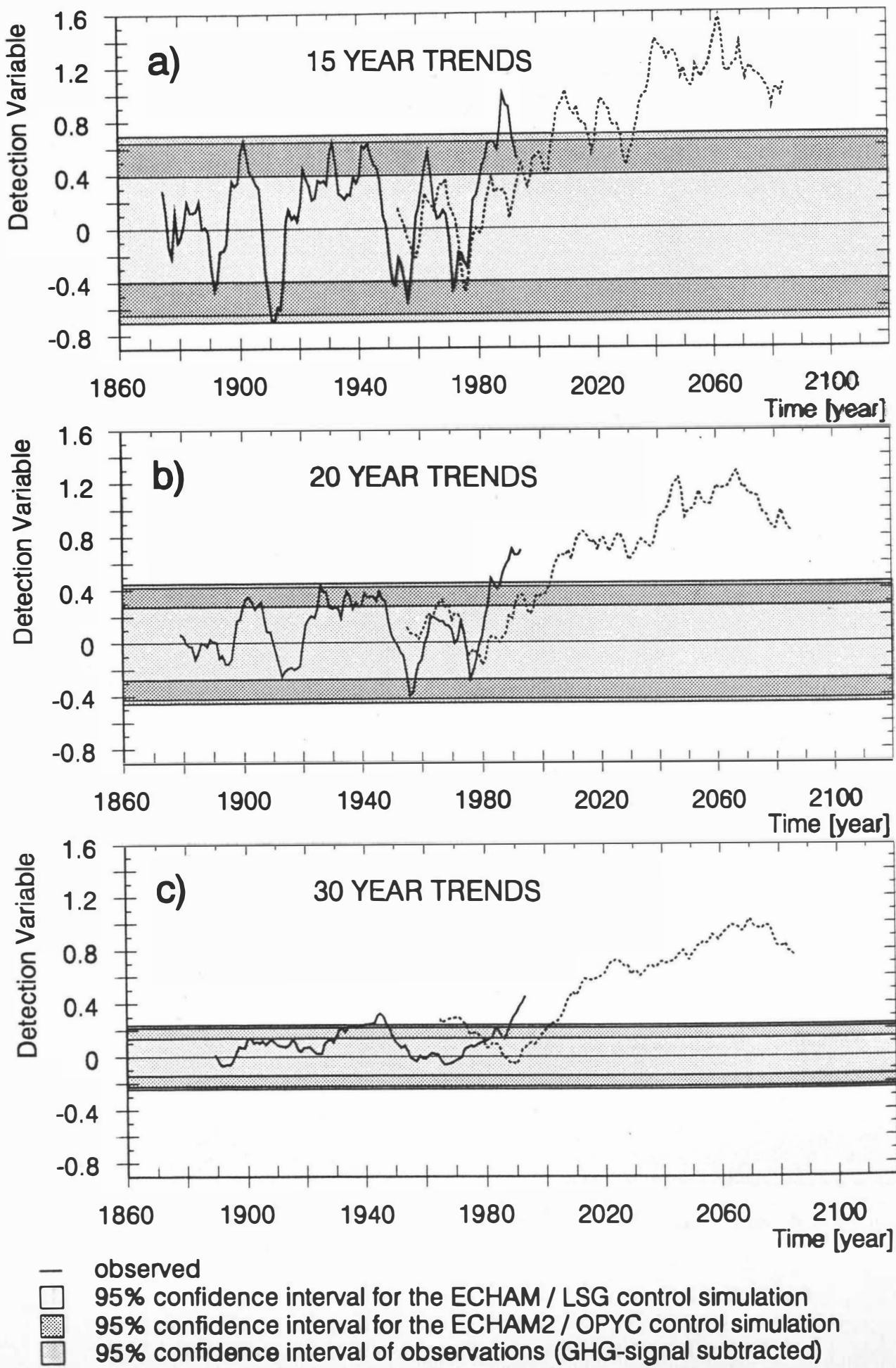
**guess-pattern  
fingerprint**



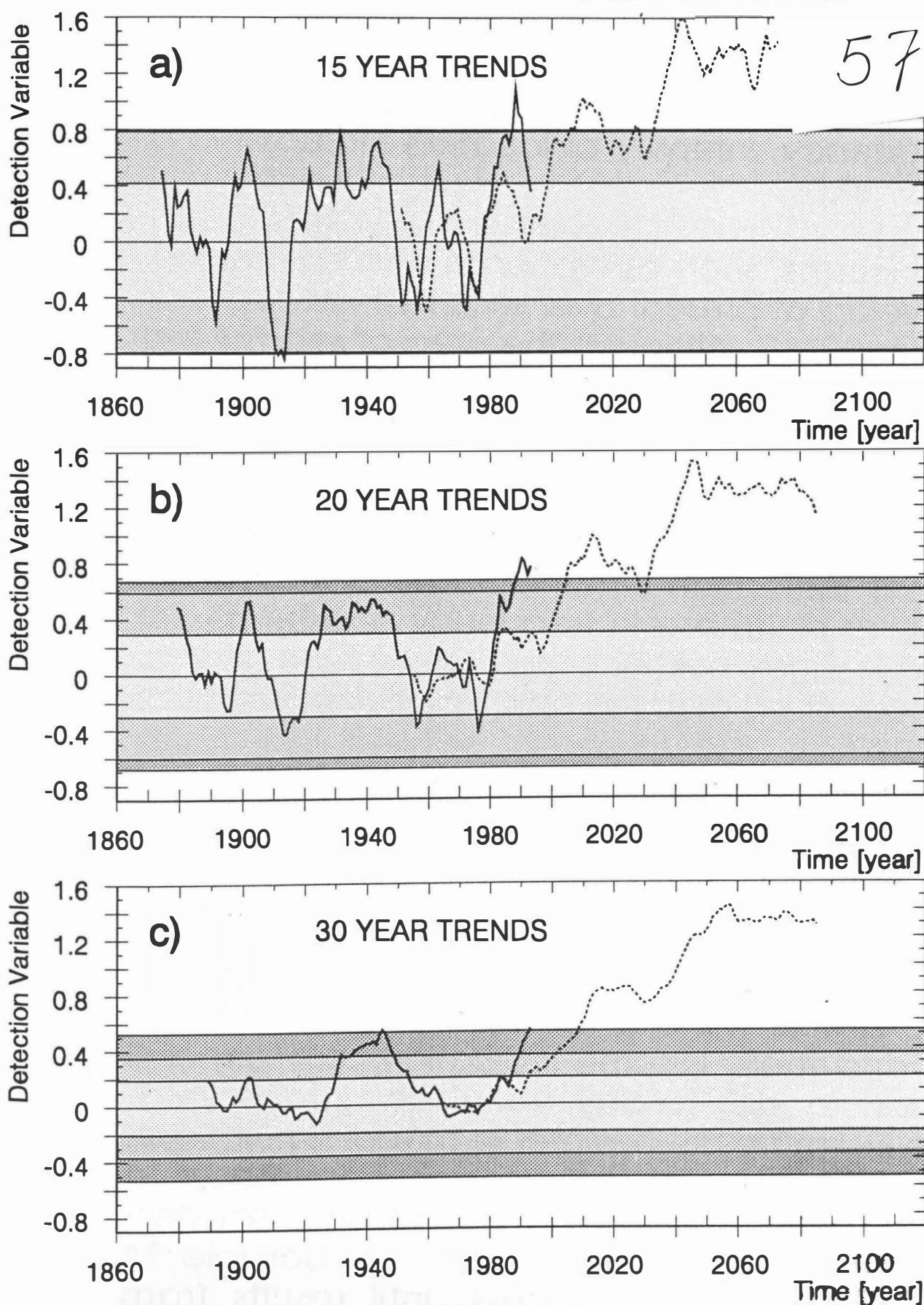
**optimally rotated  
fingerprint**



## SIGNIFICANCE OF THE OBSERVED PATTERN for the optimal fingerprint



## SIGNIFICANCE OF THE OBSERVED PATTERN



- observed
- 95% confidence interval for the ECHAM / LSG control simulation
- 95% confidence interval for the ECHAM2 / OPYC control simulation
- 95% confidence interval of observations (GHG-signal subtracted)

(PCC :

## Will Storms Increase in a Warmer World?

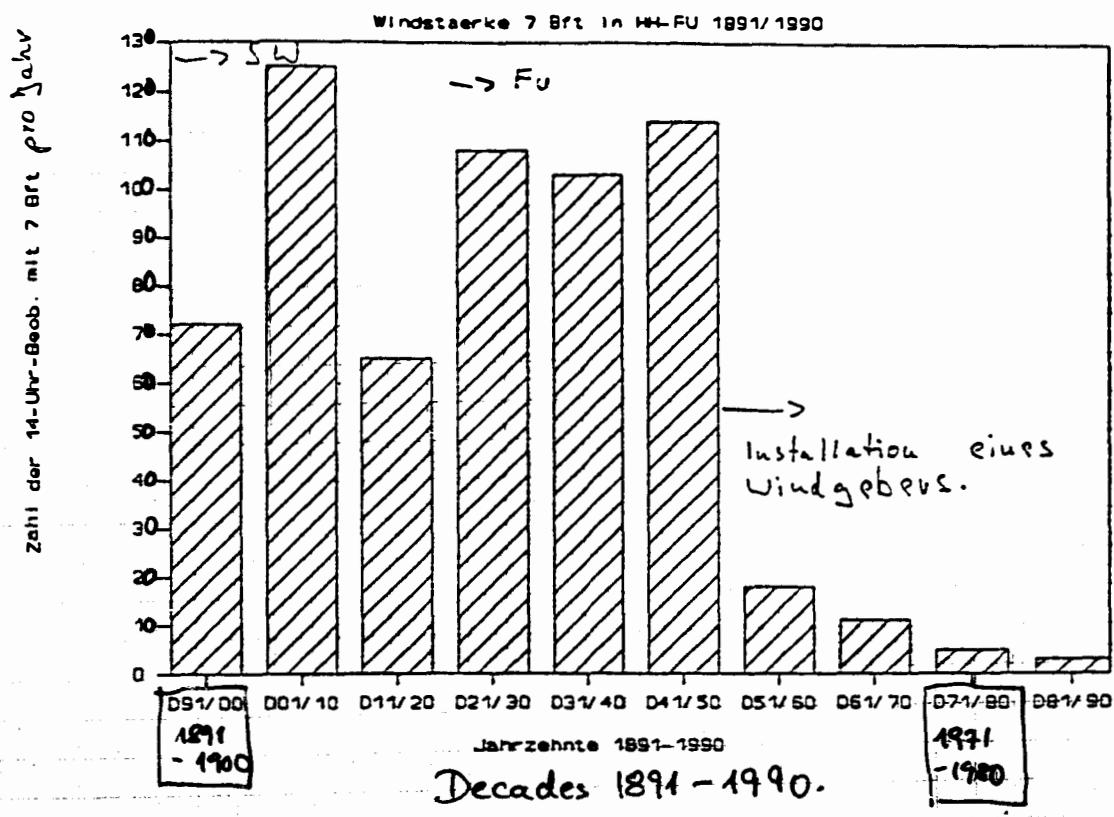
Storms can have a major impact on society. Will their frequency, intensity or location increase in a warmer world?

**Tropical storms**, such as typhoons and hurricanes, only develop at present over seas that are warmer than about 26°C. Although the area of sea having temperatures over this critical value will increase as the globe warms, the critical temperature itself may increase in a warmer world. Although the theoretical maximum intensity is expected to increase with temperature, climate models give no consistent indication whether tropical storms will increase or decrease in frequency or intensity with climate changes; neither is there any evidence that this has occurred over the past few decades.

**Mid-latitude storms**, such as those which track across the North Atlantic and North Pacific, are driven by the equator-to-pole temperature contrast. As this contrast will probably be weakened in a warmer world (at least in the northern hemisphere), it might be argued that mid-latitude storms will also weaken or change their tracks, and there is some indication of a general reduction in day-to-day variability in the mid-latitude storm tracks in winter in model simulations, though the pattern of changes vary from model to model. Present models do not resolve smaller-scale disturbances, so it will not be possible to assess changes in storminess until results from higher-resolution models become available in the next few years.

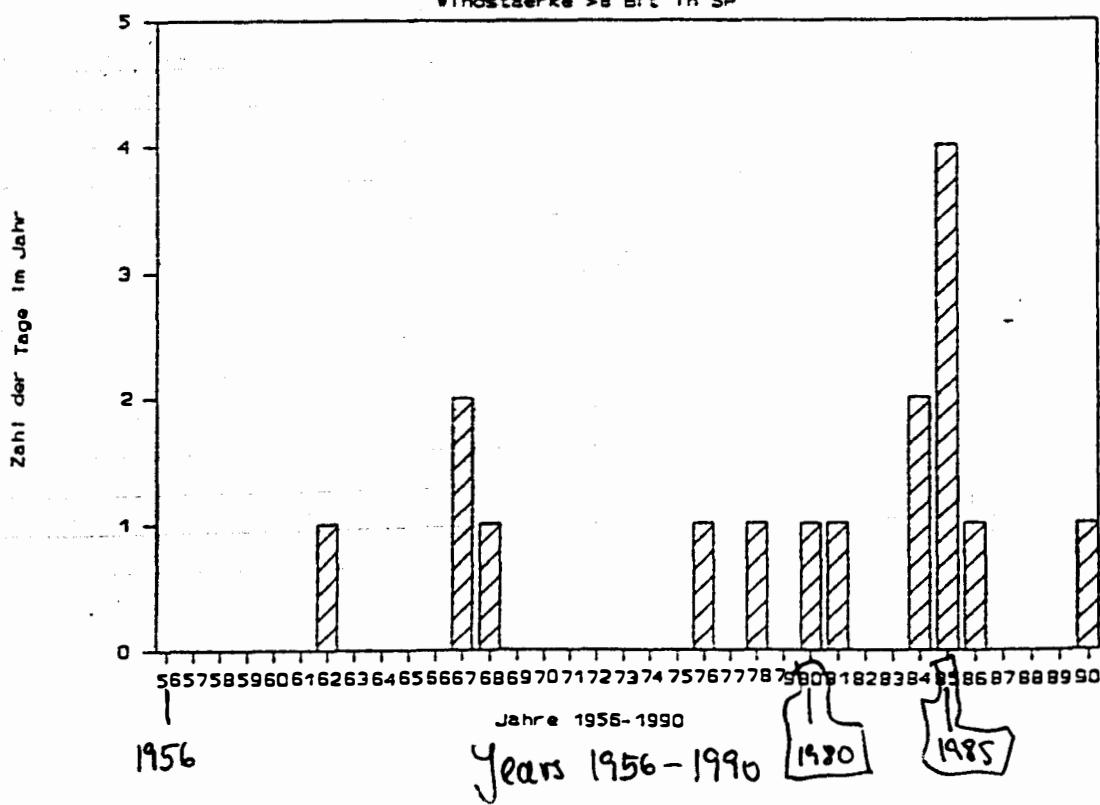
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### Mittlere Anzahl an Tagen mit



### Zahl der Tage mit

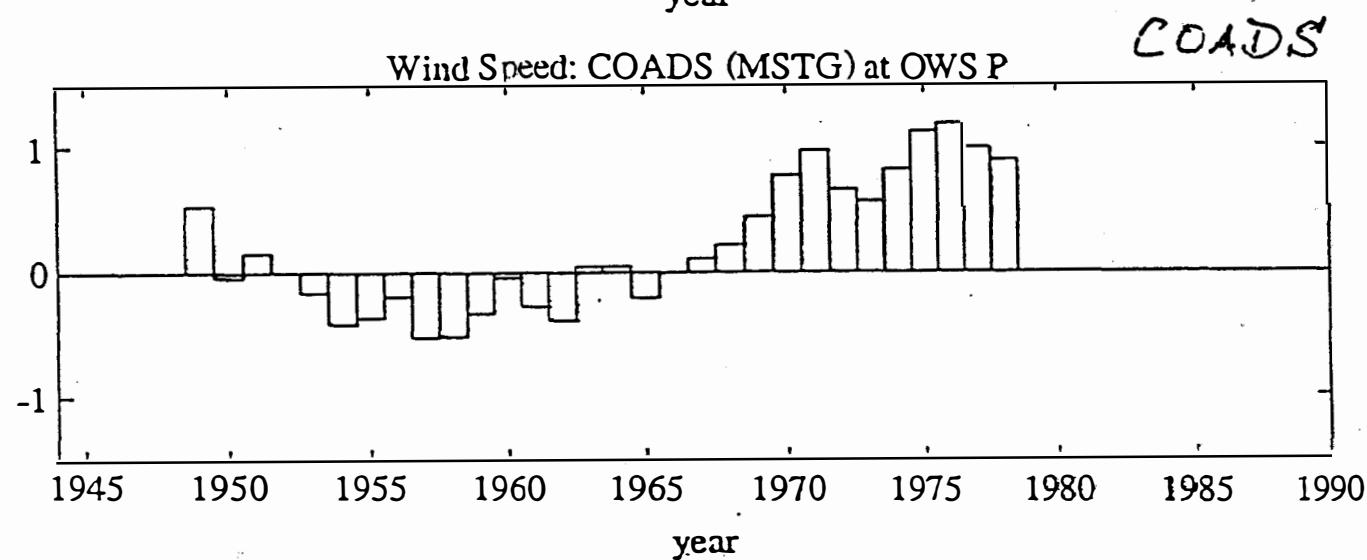
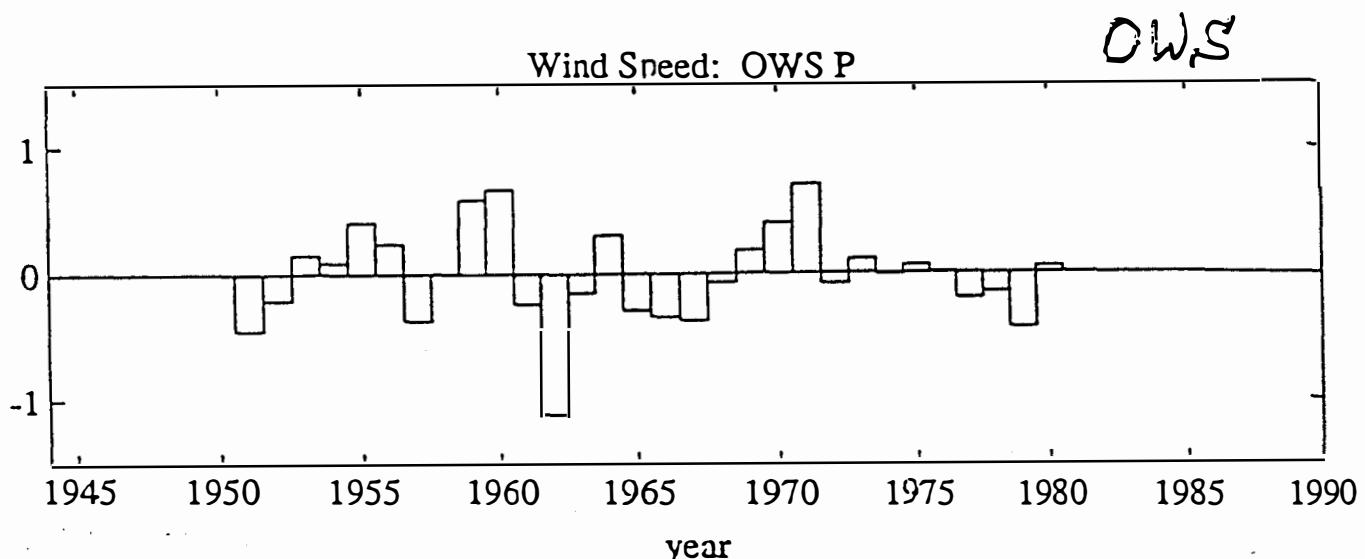
Windstaerke &gt; 8 Bft in SP



(Schmidt, SWA)

30

OWS P

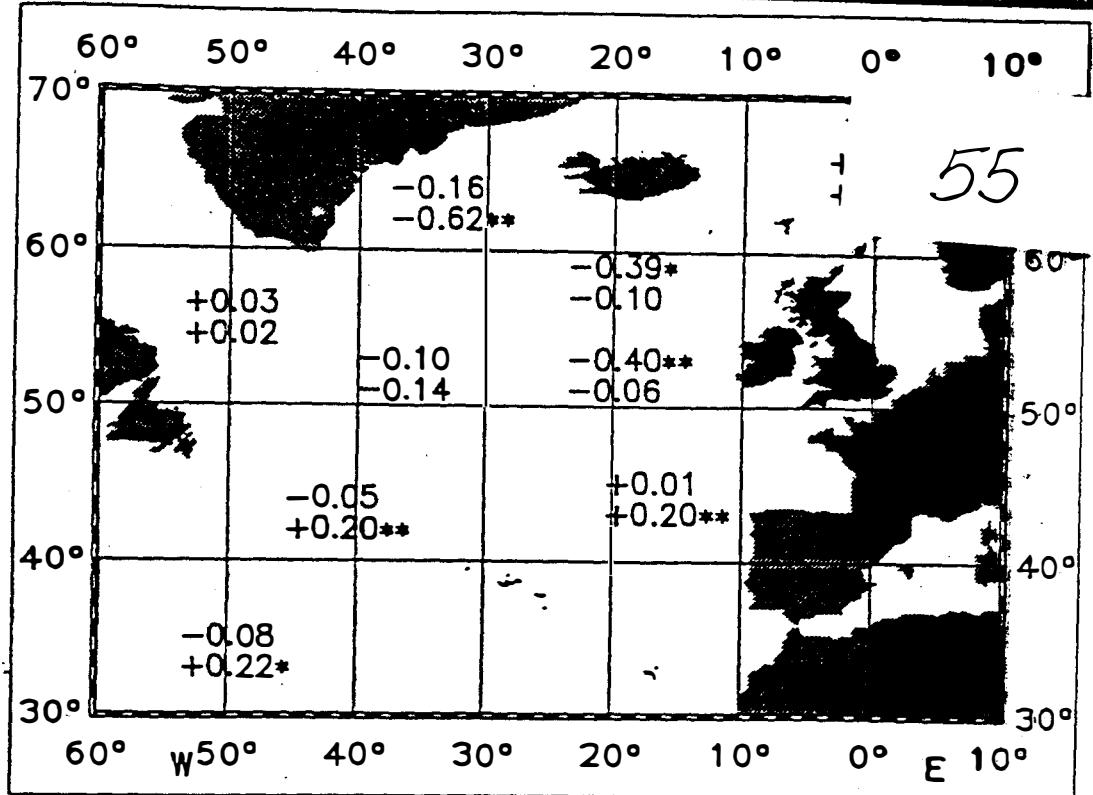


OWS :  $b = -0.02 \text{ ms}^{-1}/10y$        $R = -0.07$

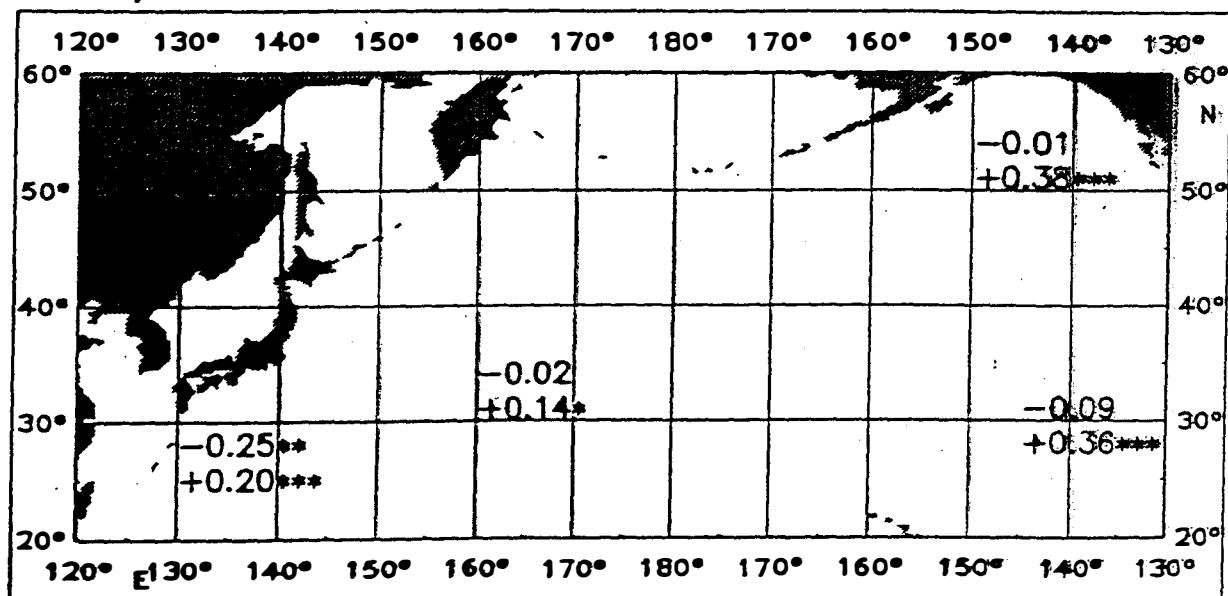
COADS :  $b = +0.52 \text{ ms}^{-1}/10y$        $R = +3.70$

$S_m = 0.59$ ,  $n = 358$

HJ | Semer



OWS/VOF Windtrend 1949-72



Isemer, 1994  
(unpublished)

Änderung der Häufigkeit bestimmter Windgeschwindigkeitsklassen

Stille  
sehr schwach mäßig stark

Bft. 0,1,2 3,4 schwach 5,6 7,8 > 9

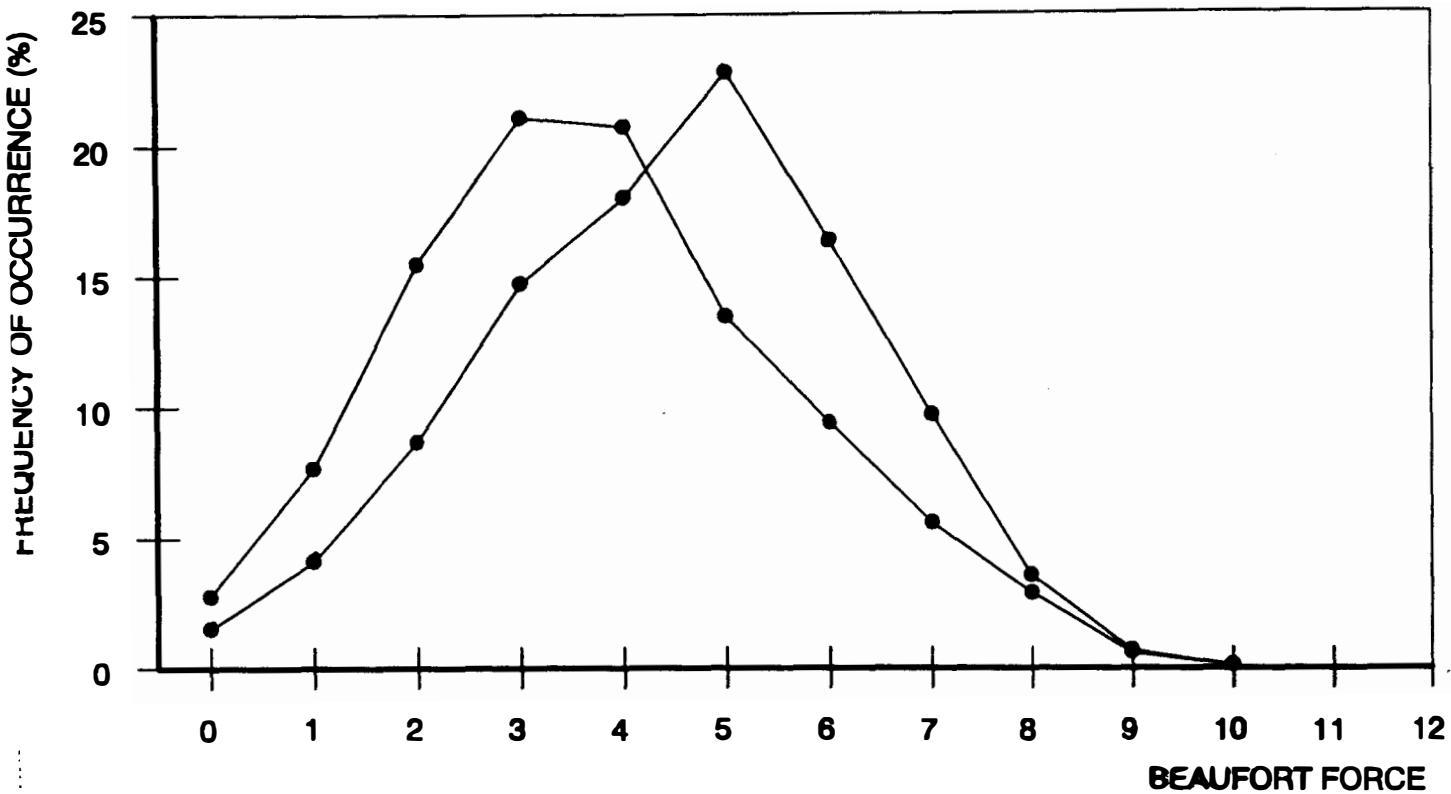
OWS/period	O	L	M	S	ST	$w_x$	$\alpha_x^2$
<b>M 1949-89</b>	---	(-)	++	+	(+)	++	--
<b>M 1949-75</b>	---	(-)	+	(+)	(+)	++	(-)
<b>A 1948-73</b>	-	+	++	(-)	---	(-)	---
<b>B 1949-72</b>	(+)	--	+	(+)	(-)	(+)	-
<b>C 1949-73</b>	+	(+)	(-)	(-)	(-)	(-)	-
<b>D 1950-72</b>	++	(-)	(-)	(-)	(+)	(-)	(+)
<b>E 1950-72</b>	(+)	(+)	(-)	(-)	(+)	(-)	(+)
<b>I 1950-74</b>	(-)	(-)	+++	---	-	-	(-)
<b>J 1950-74</b>	(-)	(+)	+++	---	-	--	-
<b>K 1950-74</b>	---	(+)	+++	-	(-)	(+)	---
<b>P 1950-80</b>	---	--	+++	+++	---	(-)	---
<b>N 1948-72</b>	(+)	(-)	(-)	++	+	(-)	++
<b>V 1956-71</b>	(-)	(+)	(-)	(+)	(+)	(+)	(-)
<b>T 1950-81</b>	(-)	+++	(-)	--	(-)	++	--
<b>M 1976-89</b>	---	(+)	(+)	(+)	(-)	(-)	--
<b>C 1976-89</b>	(+)	(-)	++	---	(-)	(-)	(-)
<b>L 1976-89</b>	-	(+)	+	(-)	(-)	(-)	---
<b>R 1977-85</b>	(-)	(+)	(+)	(+)	(-)	(+)	(+)

(seiner, 1994  
(unpublished)

## Summary

- Decrease of monthly variance of windspeed (1959-72) in the eastern and northwestern part of the North Atlantic.
  - Also detectable at three (of four) Atlantic OWSs after 1975.
  - Tendency for decrease of storm observations in the eastern and northwestern North Atlantic (both periods).
  - Decrease of low wind situations in the northern and eastern North Atlantic (both periods).
  - No evidence for a large scale increase both in mean wind speed and frequency of storm situations.
- 
- Increase in mean wave height is not distinctly supported by changes in wind climate, more evidence against than in favour of a real change in wave height.
  - The step-like increase in cyclone frequency cannot be supported or disproved because of too short OWS records.

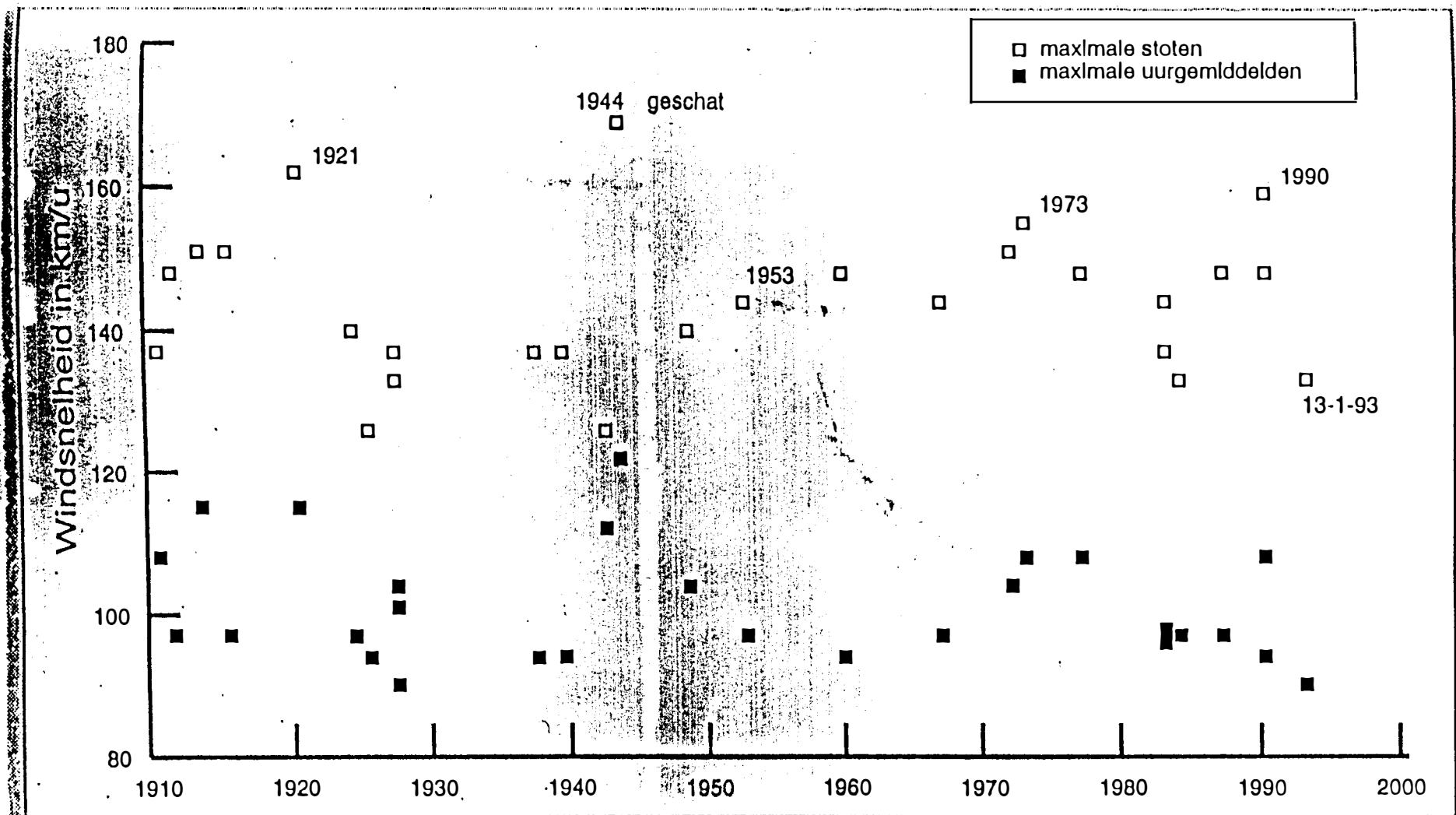
Isemer, 1994  
(unpublished)



Frequency distribution of Beaufort-force from ship reports of observations taken at the western entrance of the English Channel.

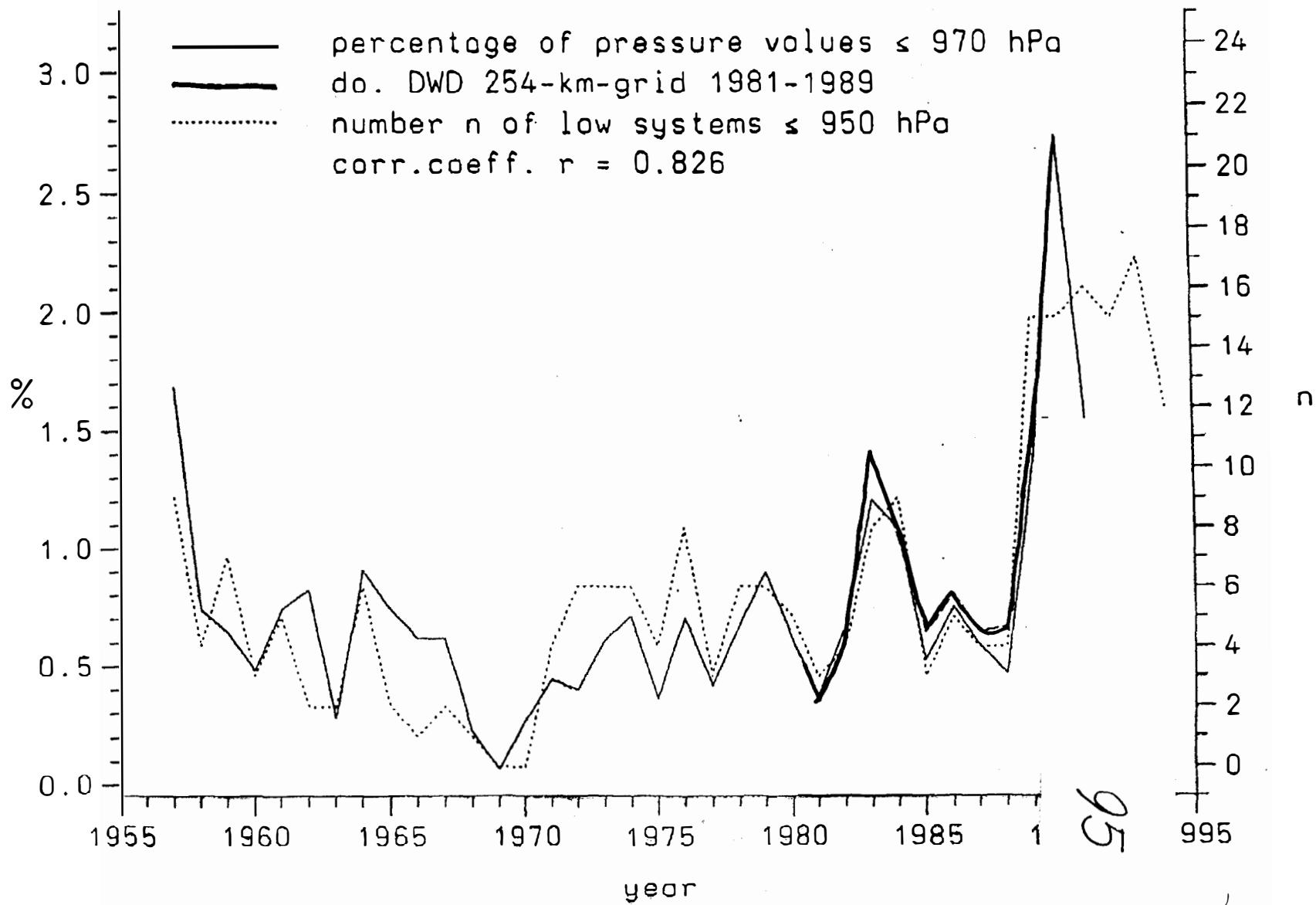
• Open circles: measured wind speed reported together with Beaufort estimates  
(981 observations since 1963).

Full dots: Beaufort estimates only reported (24 442 observations since 1949).



Figuur 8:  
Gemiddelde en maximale windsnelheid, gemeten bij zware stormen in het tijdvak  
1910-1993 (KNMI, 1993).

an H. von Storch  
mit schönen Gräßen von Olaf Sten und Andreas Heuse



## MODEL DESIGN

Identify regional climate parameter(s)  $R$ .



Find large-scale climate parameter  $L$  which

- controls  $R$  through  $R = \mathfrak{F}(L, \vec{\alpha})$  with parameters  $\vec{\alpha}$  to be specified.
- is well simulated by a climate model.



Use samples  $(R, L)$  from historical data to find  $\vec{\alpha}$  such that  $\|R - \mathfrak{F}(L, \vec{\alpha})\| = \min$



Validate choice of  $\vec{\alpha}$  with independent historical data.

PSA111

## MODEL APPLICATION

Get  $L$  from climate model output



Calculate  $R = \mathfrak{F}(L, \vec{\alpha})$



Use  $R$  as forcing function for impact model.

Example:

Wave height and period  
at Weathership H

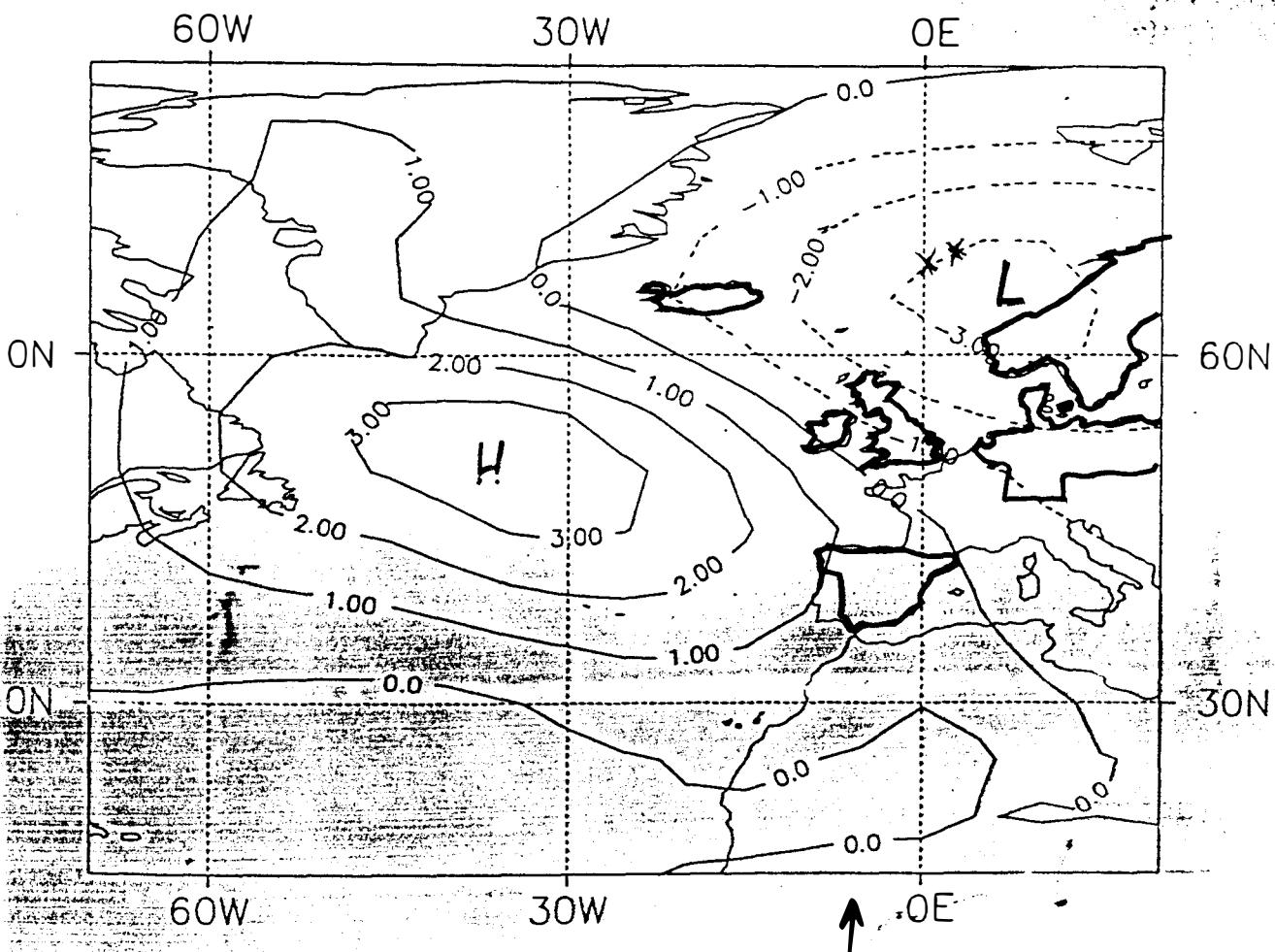
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$R$  = Seasonal distribution of daily  
wave height, or period,  
at Ocean Weathership H

$L$  = North Atlantic seasonal & mean  
distribution of air-pressure

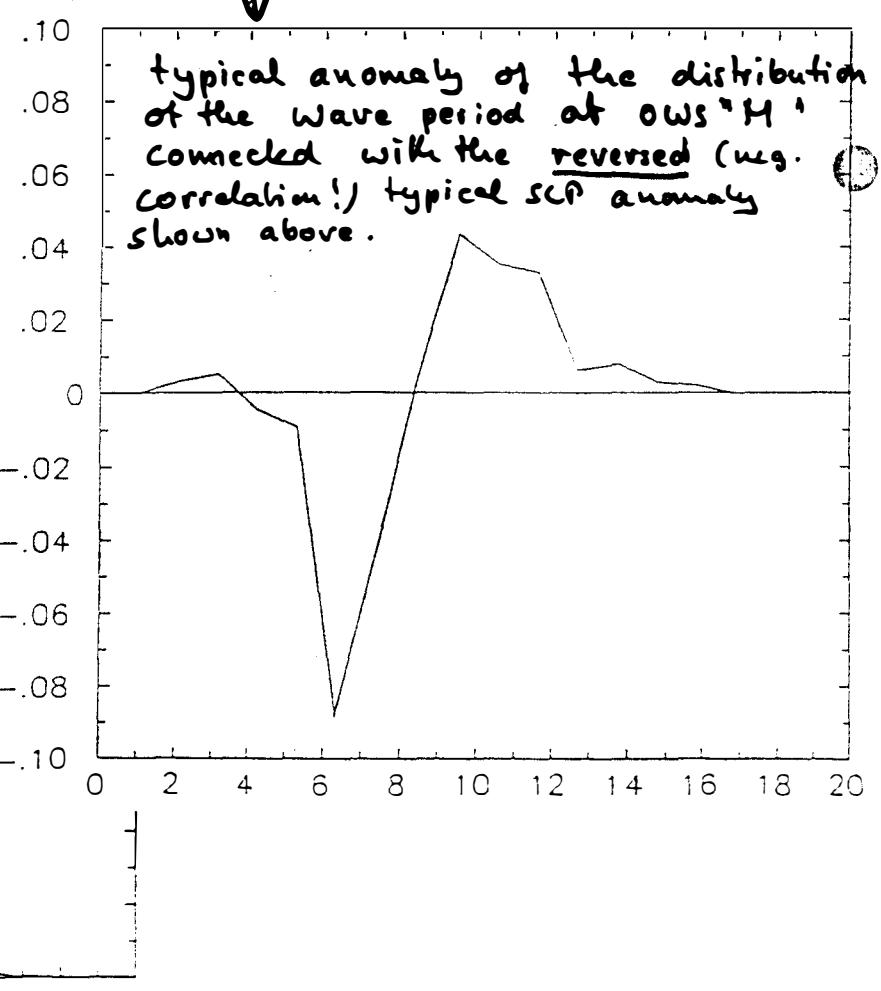
$F$  = CCA - model

typical anomalous pattern of air-pressure



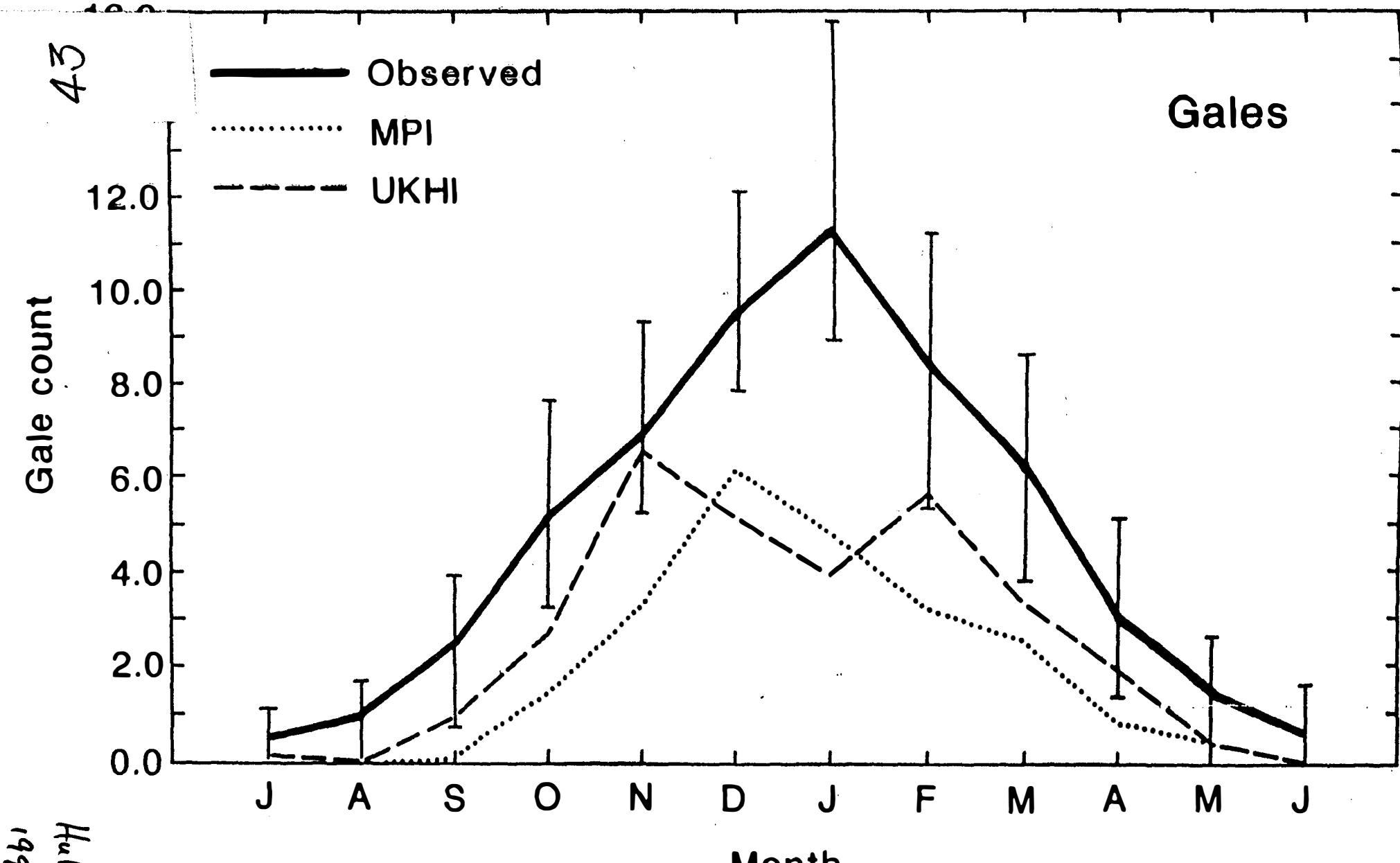
A cor:-0.65 , var: 0.2

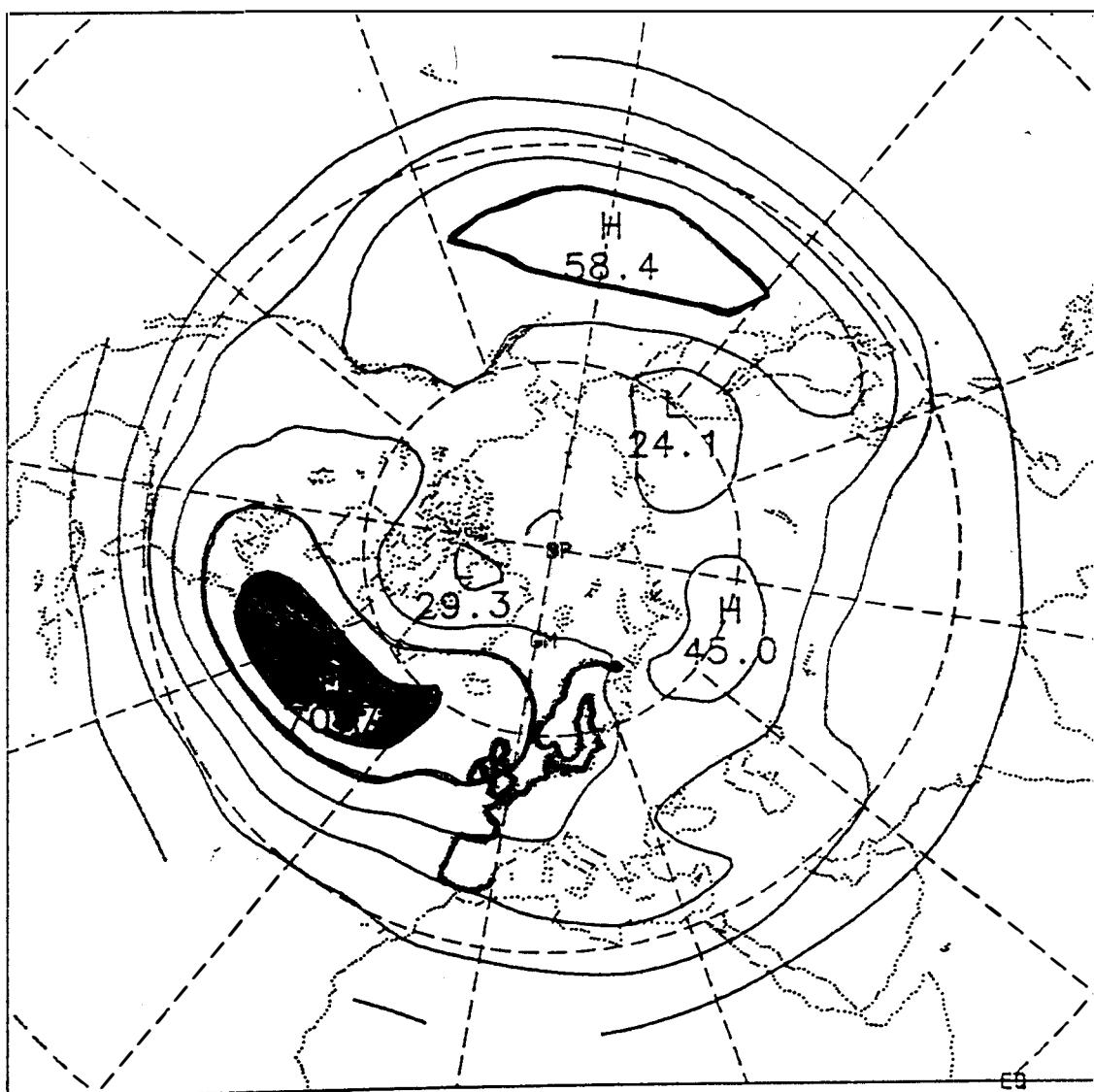
mean distribution of the  
wave period at ows "H"  
within a winter season



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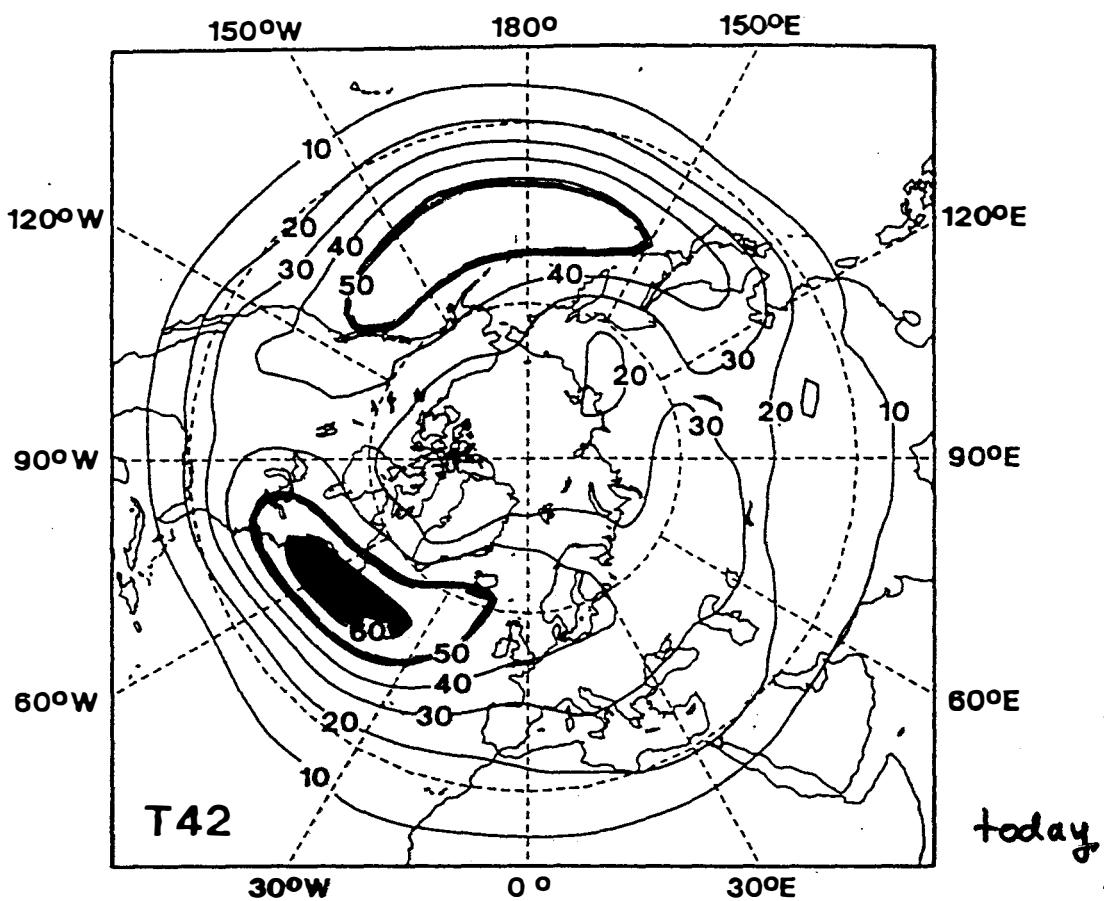
Gales

Hulme et al.  
1993

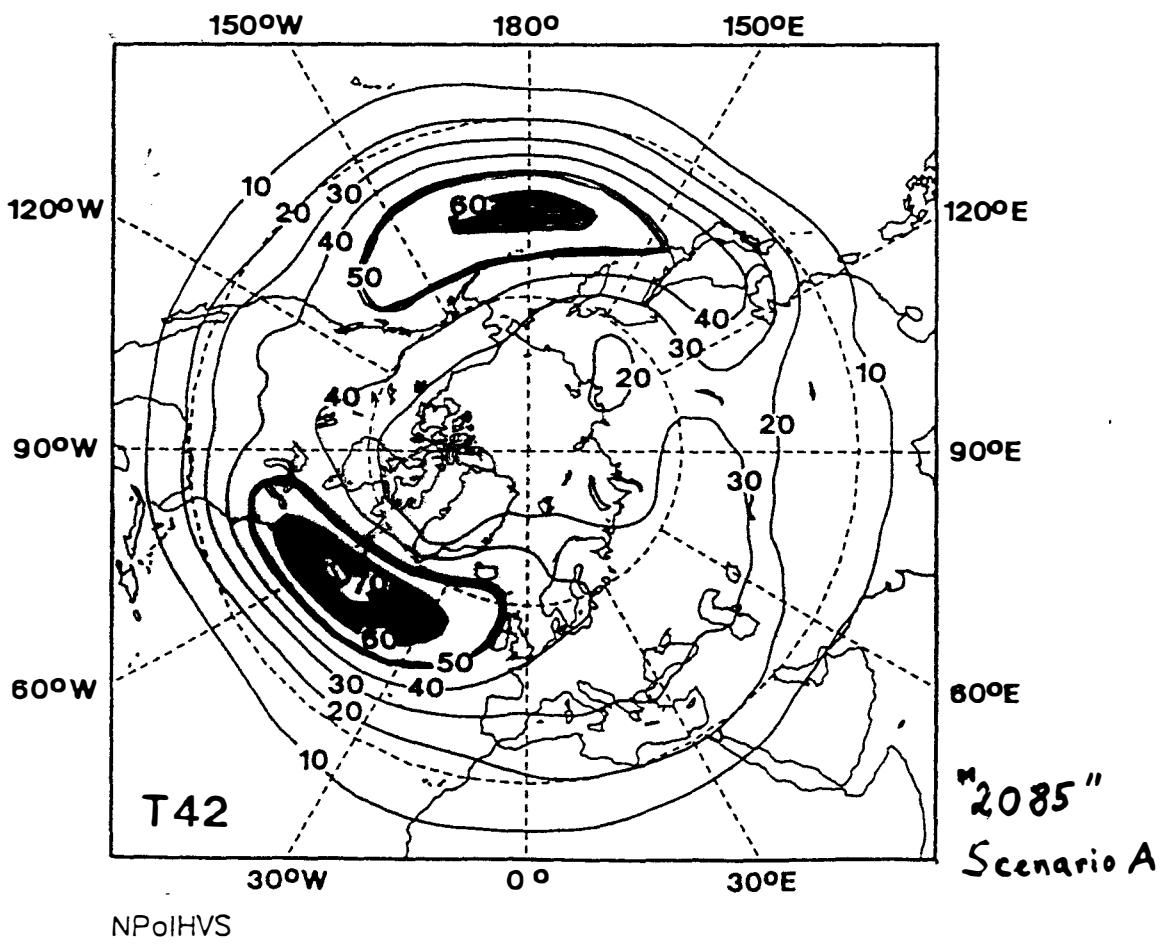


Observed high-pass filtered RMS  
of 500 hPa geopotential height  
(from METZ)

(2 - 8 days, winter)



GCM Scenarios (from Perlitz)



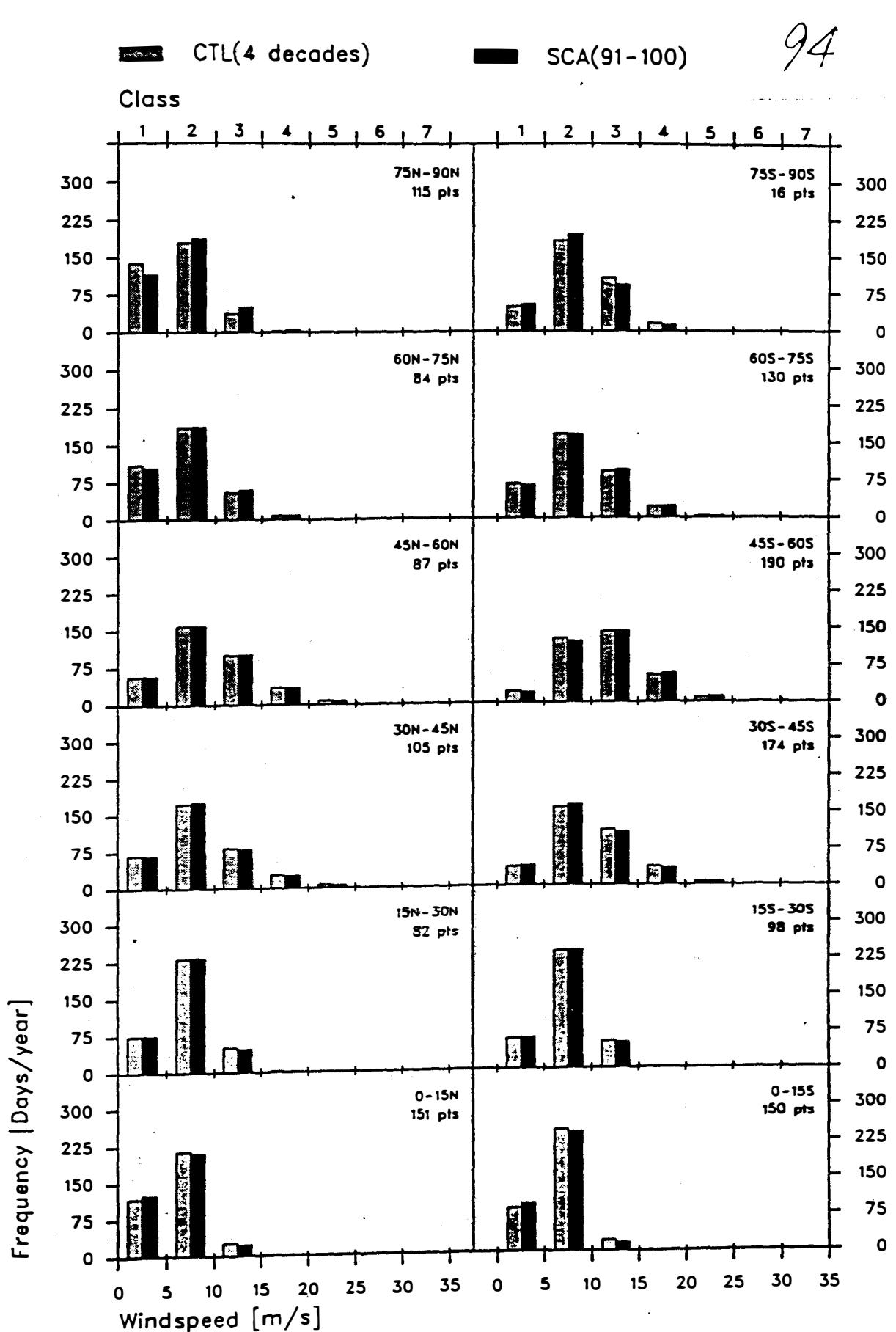


Figure 20: As Figure 18, but for ocean points.

# Status of WIST project 29

- Two workshops organized by Hov/DNME in Bergen (1992) and Reykjavik (1993) ... resulted in a tech note <sup>on short climate</sup> published by the TIPI (met favorable reactions from IPCC authors, but was turned down by BAMS).

- Present kick-off meeting to define detailed work program and to review state of present knowledge.

"External experts" Johnson (Iceland), Murphy (Ireland), Tichus (Poland), Bauer and Schmidt (Germany).

Other experts to be invited to future meetings: Cardone, Swail (USA), House and Isenmer (Germany) and ... ?

- Do we want to formulate an assessment for IPCC (and other purposes)?

- Next meeting in conjunction with Sixth International Conference on Statistical Climatology, Galway Ireland, June 19-23, 1995 (I am organizing a session on "downscaling". Conference proceedings with manuscripts ≤ 4 pages will be prepared)

There will also be sessions on  
"extreme value analysis" and  
"climate change detection".  
(agency offices)