Extreme wind waves from the VOS data and their changes over the last 50 years

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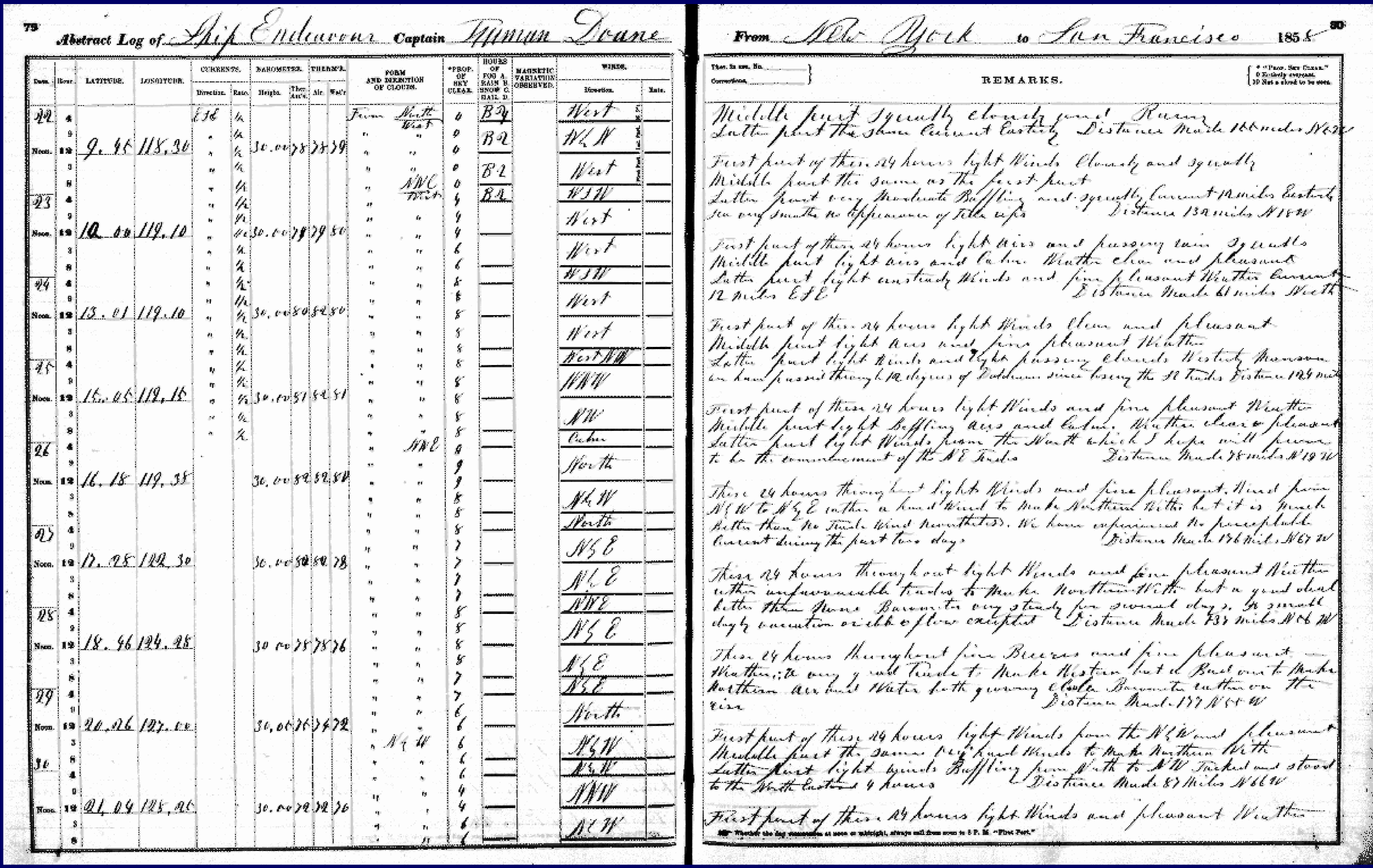
OUTLINE:

- Global climatology of visually observed waves: 1958-2005
- Mean wave characteristics: trends and mechanisms of interannual variations
- Can the extreme waves be properly estimated from the VOS data and where?
- Did extreme waves change during the last 50 years?

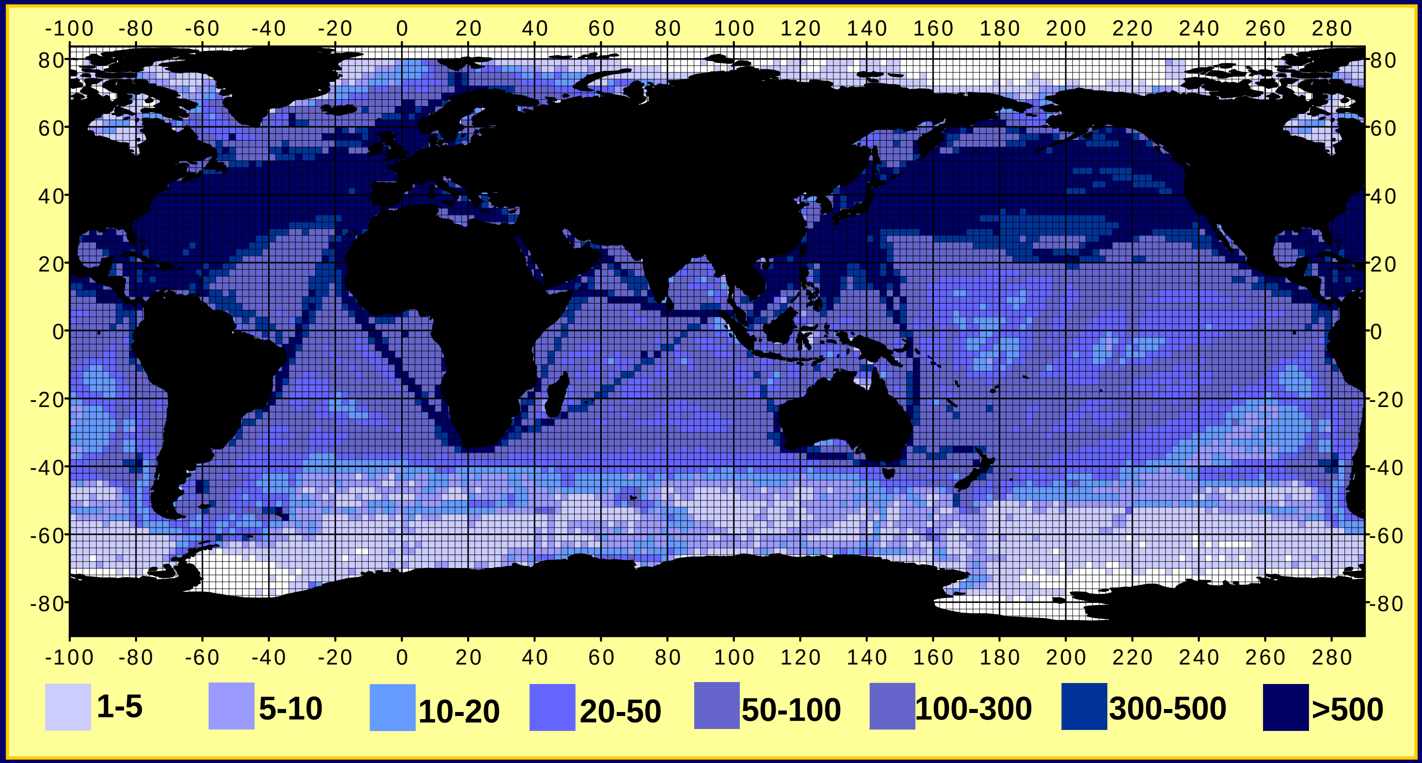
Visual wave observations: 1856 - onwards

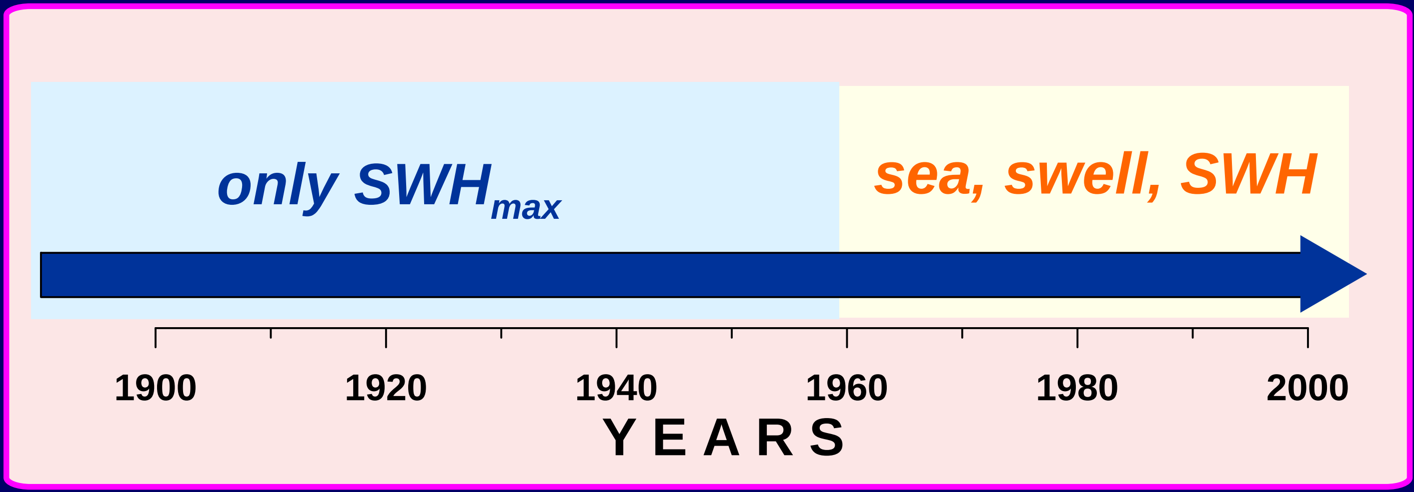


Visual wave observations:

- Observational practice has never been changed
- Coding systems have been changed several times, while documented
    - 1904 (Hydrographic Office No. 1190), 1906, and 1908 (US Weather Bureau "Circular M, 2nd edition") - descriptive
    - The Original Reference Manual of 1917 - 0-9 scale in feets
    - 1925 US instructions (Circular M, 4th edition): a 0-9 scale is used
    - 1963 WMO Manual on codes: 1-49 (0.5 meter increments)
- Assimilated in ICOADS

Visual VOS (ICOADS archive): 2 streams (1856-1958) and (1958-2005)





Wave data pre-processing and corrections

(Gulev et al. 2003, JGR, 2004, GRL)

1. Correction of small wave heights: code figure "01" problem (Gulev et al. 2002)

$$hs = 0.5 - exp(-0.658V)$$

2. Separation of sea and swell in visual estimates (Carter 1988, Gulev and Hasse 1999)

2D wind-wave distributions with the JONSWAP curves for duration of 6 to 18 hours

3. Significant wave height

$$SWH = \begin{cases} (h_w^2 + h_s^2)^{1/2}, & [dir_{sea}, dir_{swell}] \in 30^\circ\, sector \\ max[h_w, h_s], & [dir_{sea}, dir_{swell}] \notin 30^\circ\, sector \end{cases}$$

4. Correction of the wave periods and computation of the dominant period (Gulev and Hasse 1998)

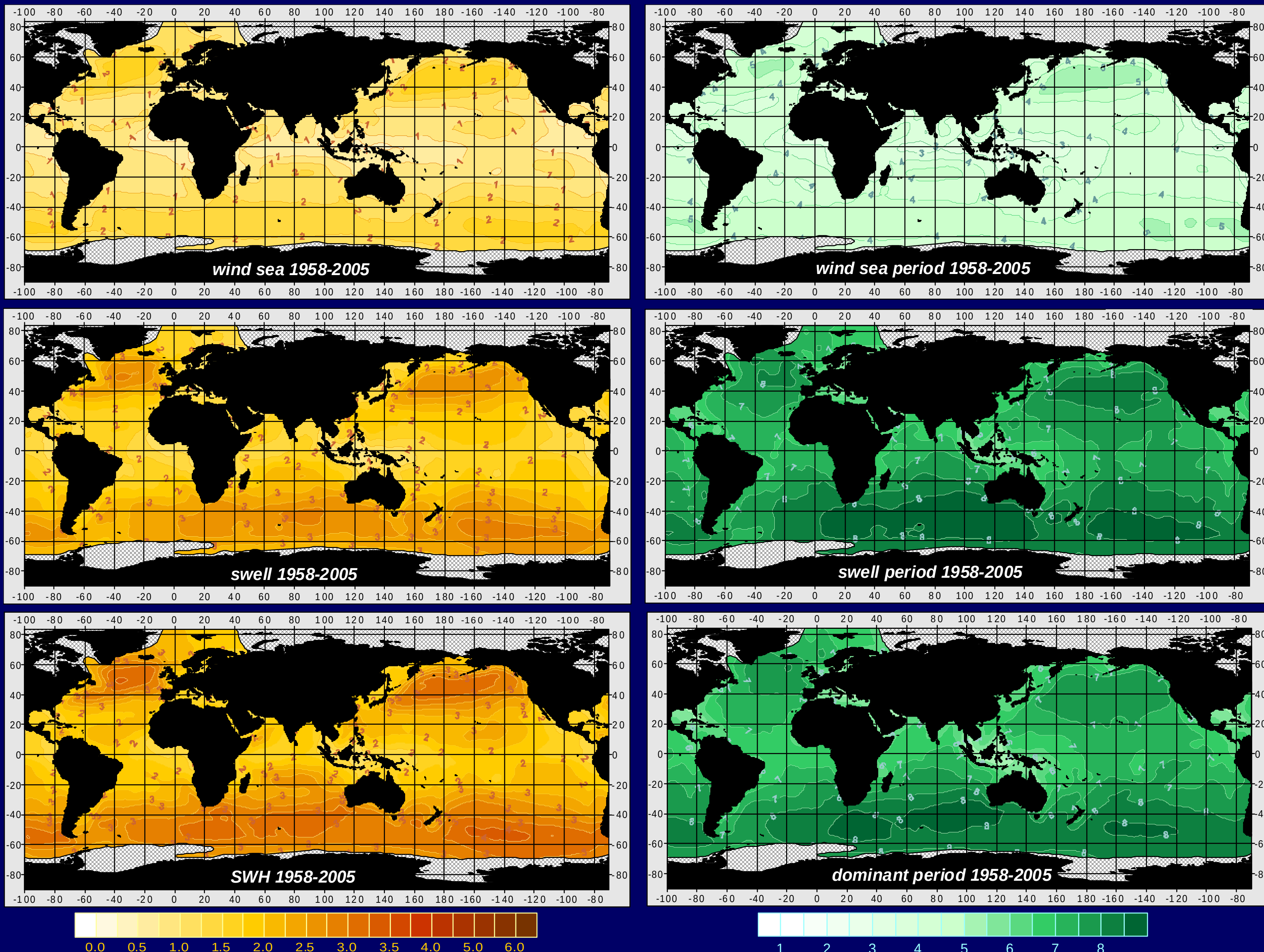
Fitting of the 2D wave-period distributions for sea and swell

5. Uncertainty of the evaluation of the true wave direction and period from the relative direction (Grigorieva and Gulev 2004)

Use of the actual ship course and velocity

6. Day-time minus night-time biases (Grigorieva and Gulev 2004)

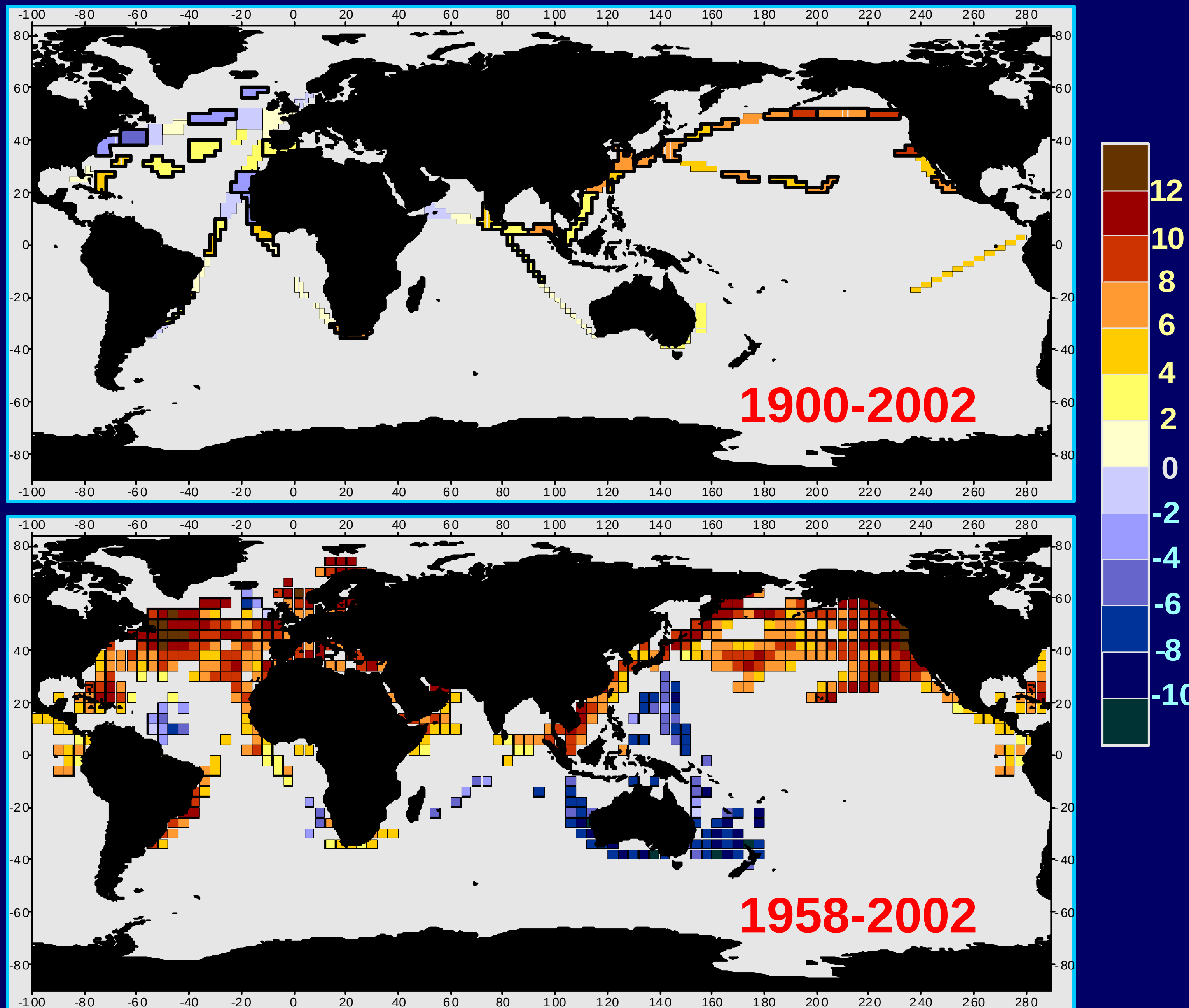
A global VOS wave climatology (1958-2005)



Gulev et al. 2003, JGR

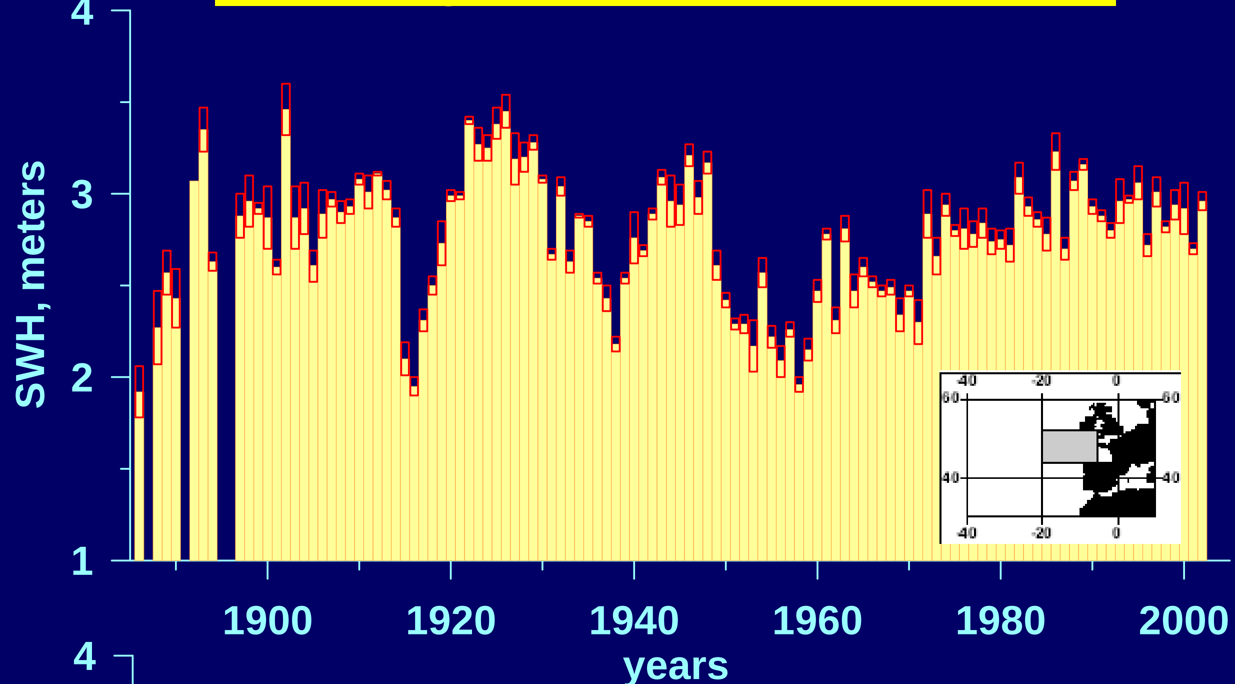
http://www.sail.msk.ru/atlas/index.htm

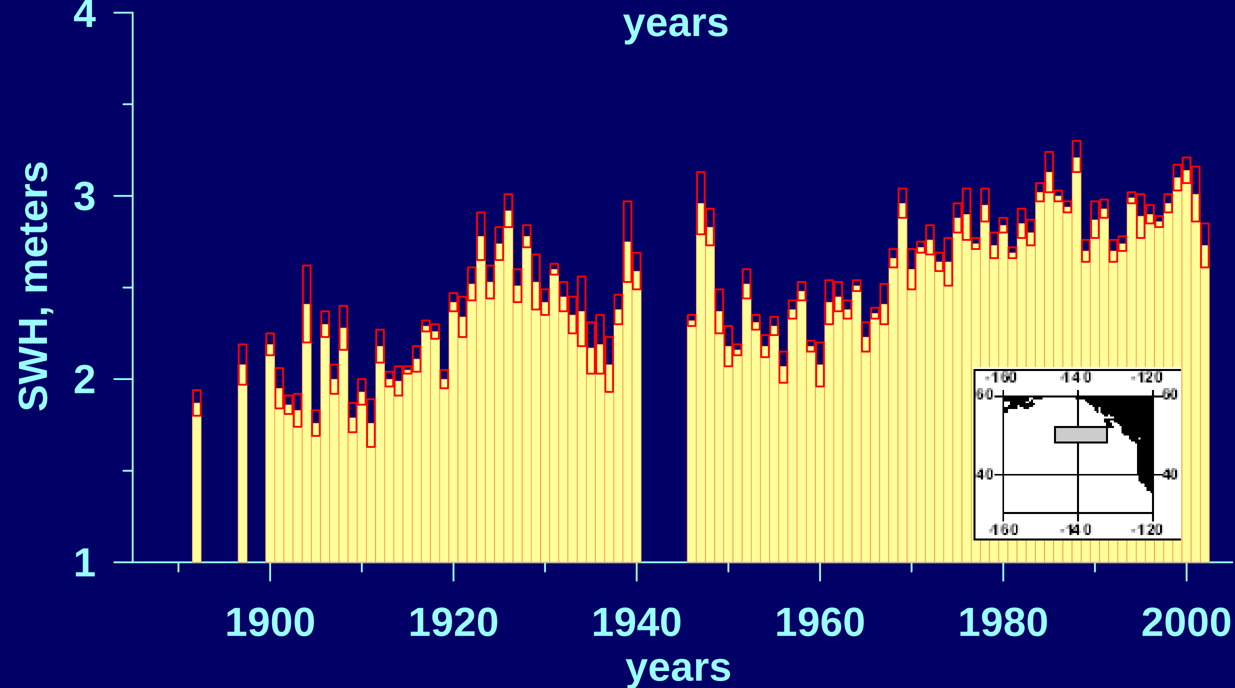
Linear trends in SWH (cm/decade)



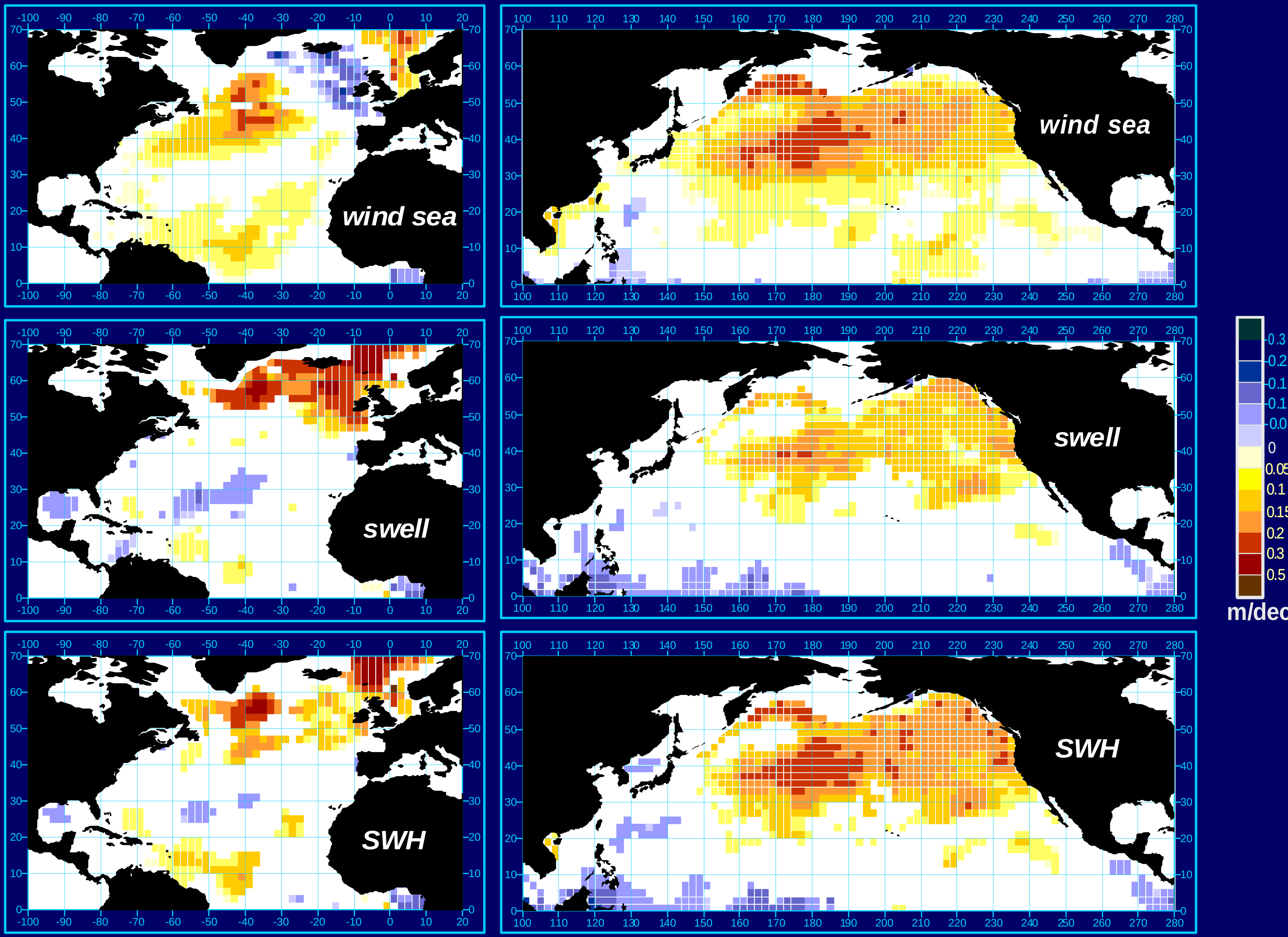
Gulev and Grigorieva 2004, GRL

Homogenized time series



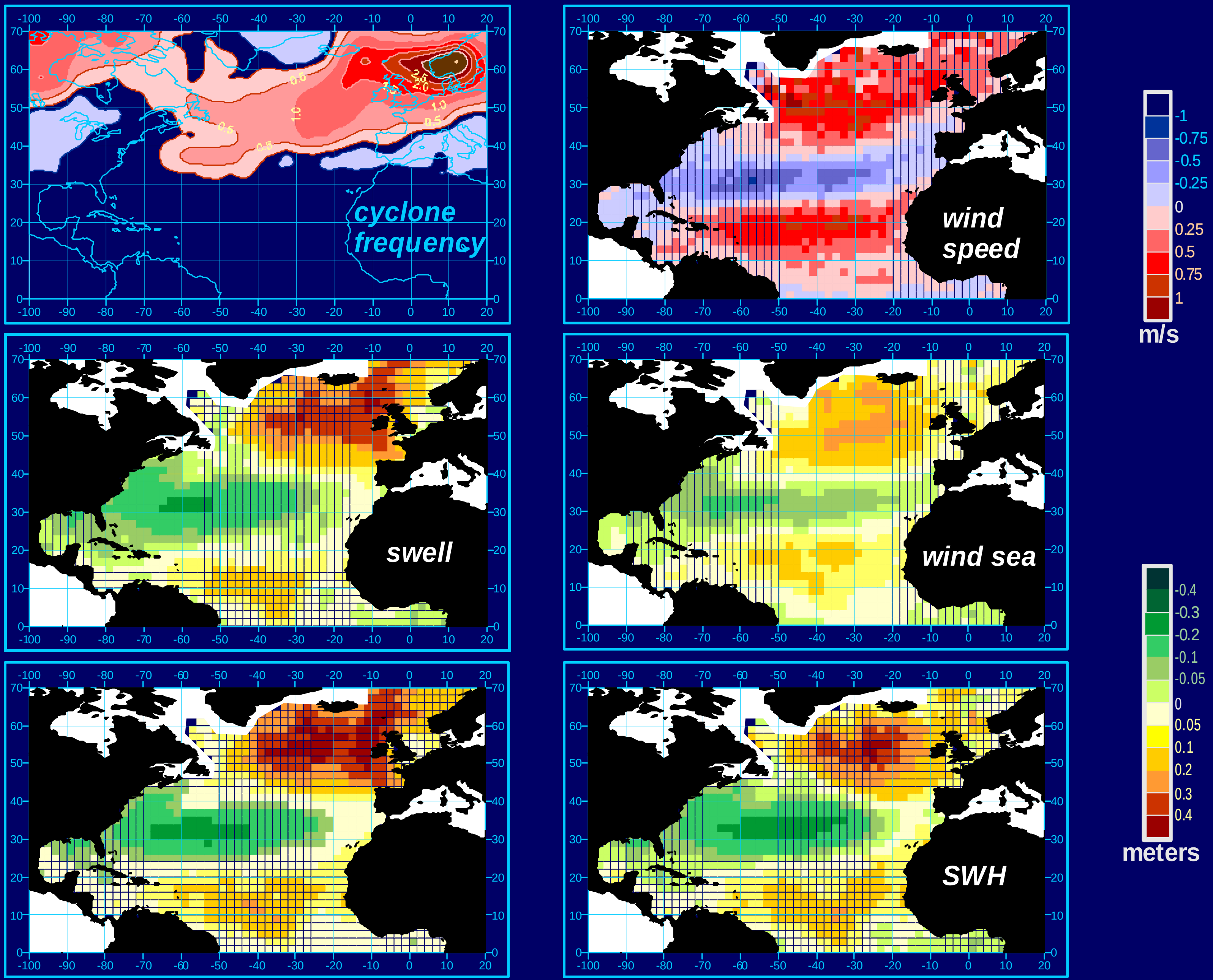


Linear trends in sea, swell, SWH: 1958-2003



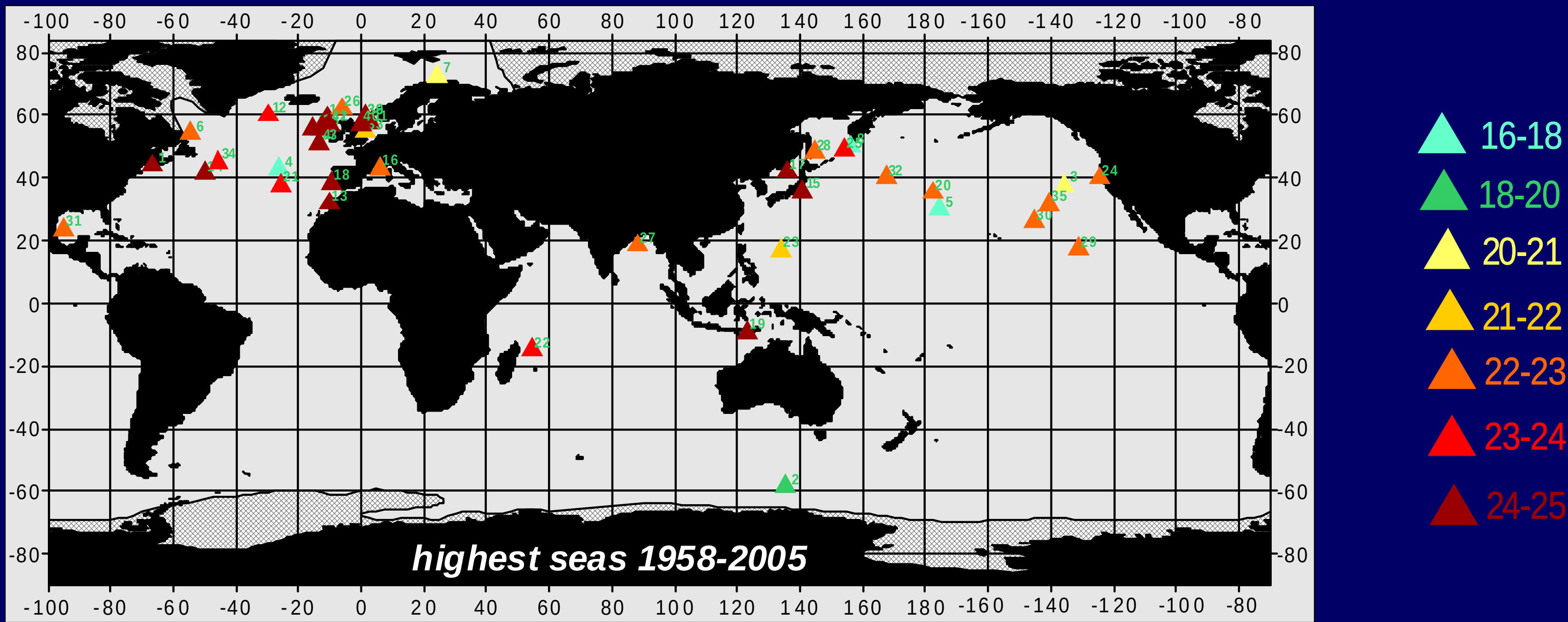
Gulev and Grigorieva. 2006, J. Climate

Mechanisms: CCA – wind speed and cyclone frequency



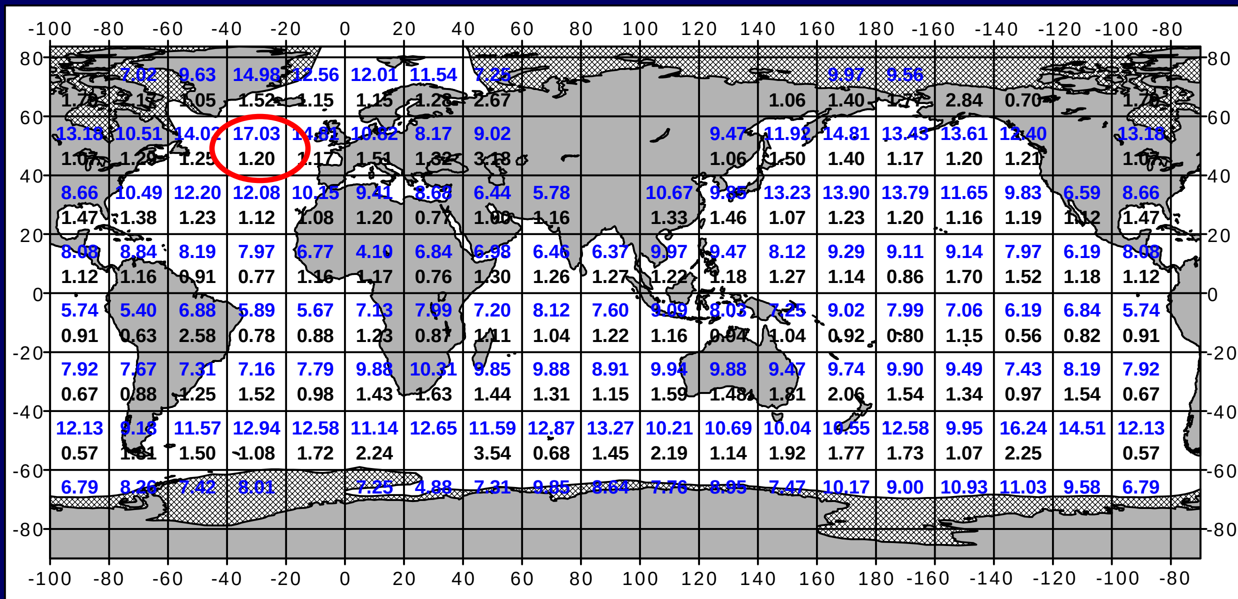
Gulev and Grigorieva. 2006, J. Climate

Highest observed seas by VOS (43 cases)

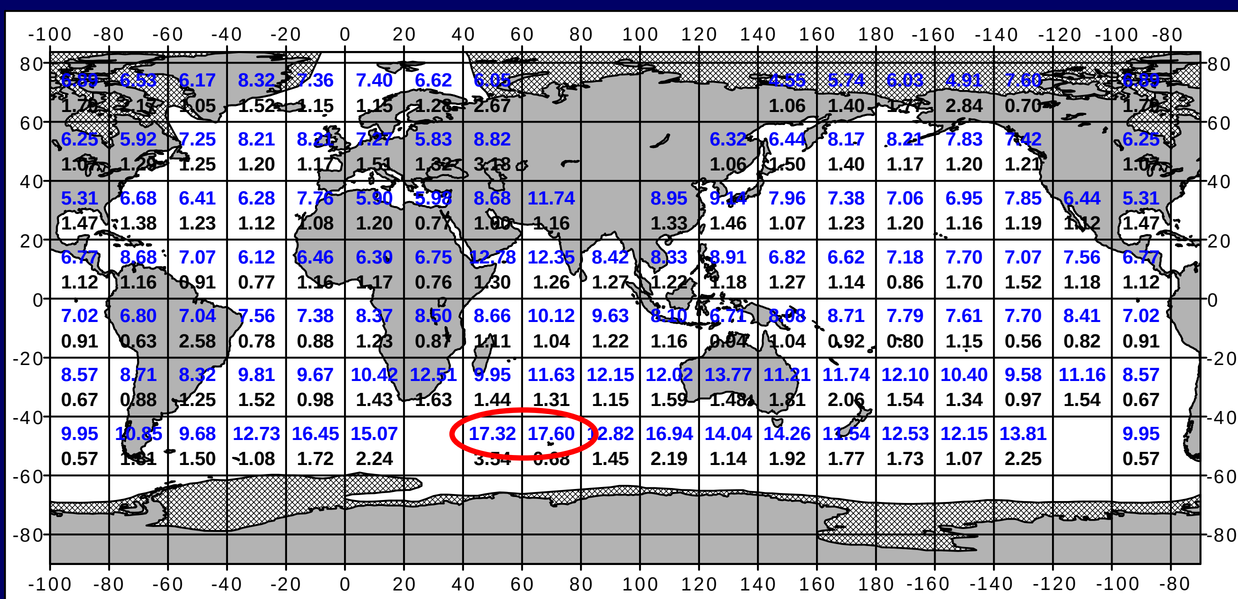


1	1960	09 Dec
2	1962	28 Jun
3	1962	02 Dec
4	1963	02 Feb
5	1966	21 Dec
6	1966	06 Dec
7	1966	26 Dec
8	1967	16 Jan
9	1968	05 Feb
10	1969	04 Dec
11	1970	08 Dec
12	1970	22 Feb
13	1970	05 Dec
14	1973	22 Nov
15	1973	09 Dec
16	1974	14 Dec
17	1975	10 Dec
18	1977	22 Jan
19	1978	08 Jan
20	1978	05 Dec
21	1980	10 Jan
22	1981	09 Sep
23	1982	20 Dec
24	1983	03 Dec
25	1983	16 Dec
26	1985	18 Jan
27	1985	11 Dec
28	1985	10 Feb
29	1988	01 Dec
30	1989	20 Nov
31	1989	30 Sep
32	1990	06 Dec
33	1990	21 Dec
34	1991	26 Jan
35	1992	16 Feb
36	1992	06 Mar
37	1993	04 Dec
38	1996	06 Jan
39	1996	10 Dec
40	1998	29 Dec
41	1999	10 Feb
42	2000	13 Dec
43	2002	17 Dec

VOS 100-yr returns: IVDM



Winter 100-yr SWH return (best estimate from tails)



Summer 100-yr SWH return (best estimate from tails)

VOS data and POT: problems of application

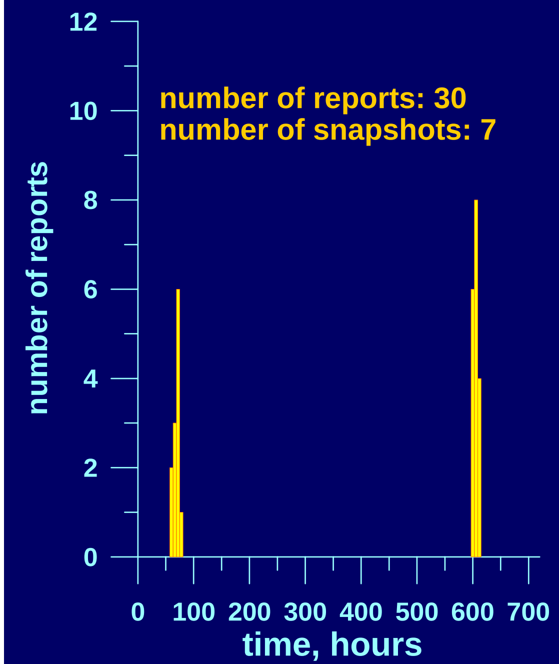
VOS data may not necessarily report the highest exceedances =>

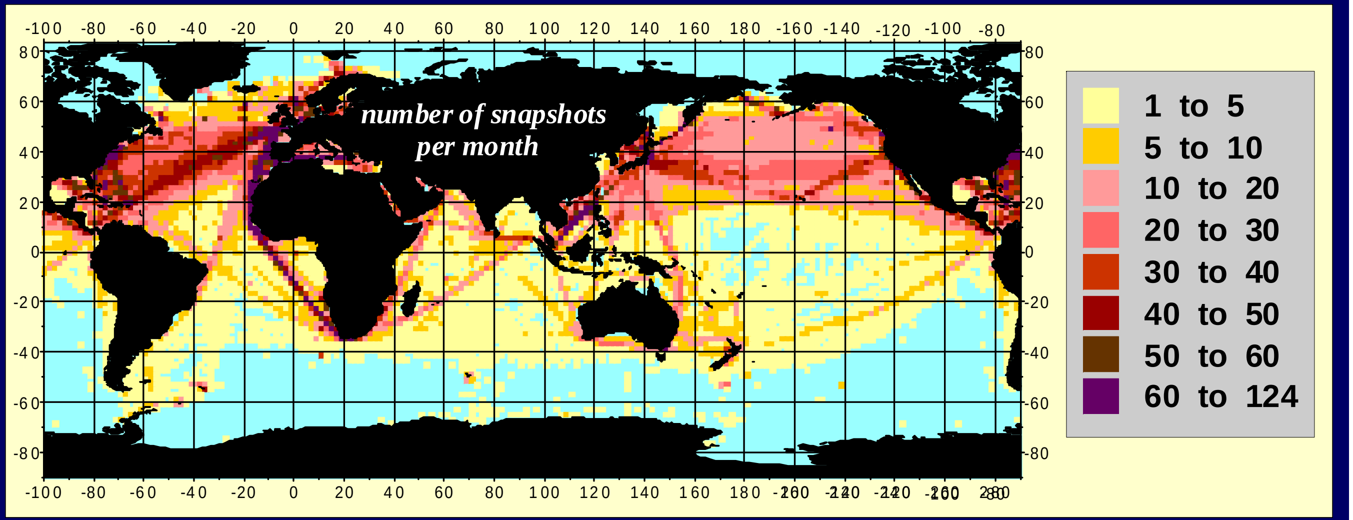
but the distribution of any exceedance = probability of the largest

VOS data are influenced by sampling uncertainty =>

Undersampling results potentially in underestimation of extremes

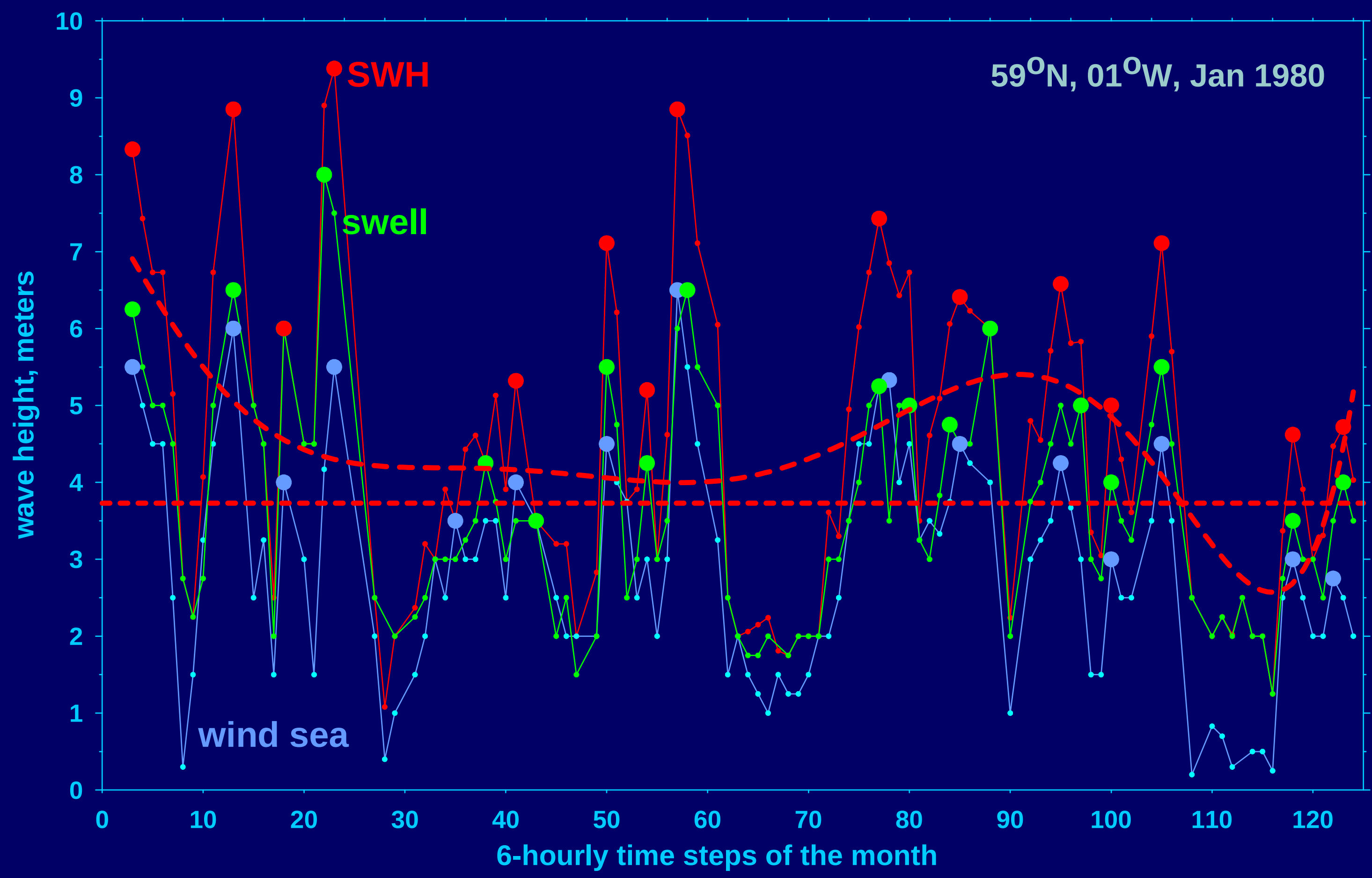
The number of 6-hourly snapshots in VOS data (WAM-like)



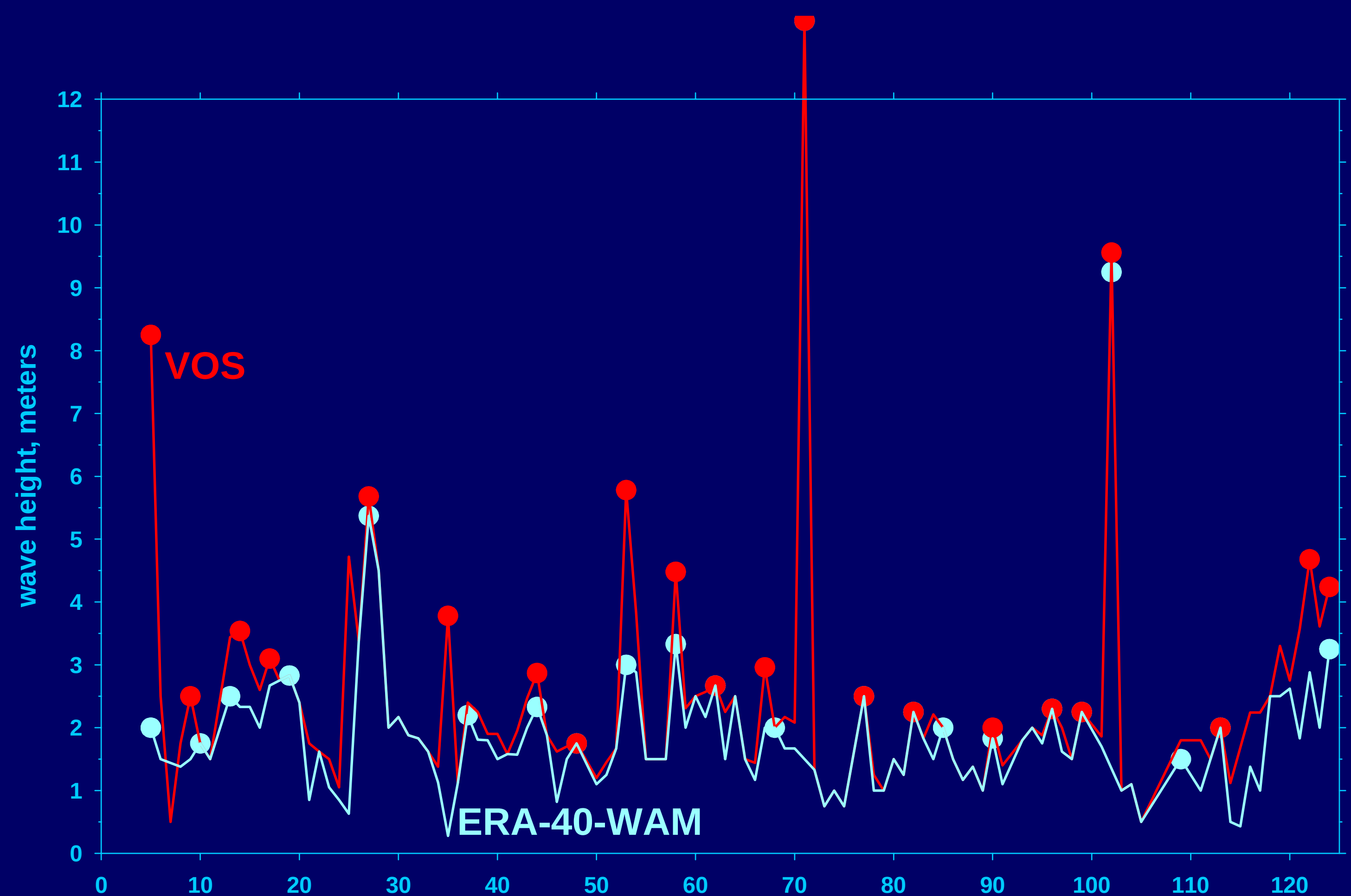


- For more than twelve 6-hourly snapshots per months only;
- Threshold is variable, set to 75% - 93% percentile;
- Storm duration is also variable and parameterized by Lanczos filter whose parameters are determined from the ERA-40-WAM storm durations for individual months;
- Medians of VOS data for each snapshot;
- EVD is fitted to the storm peak values.

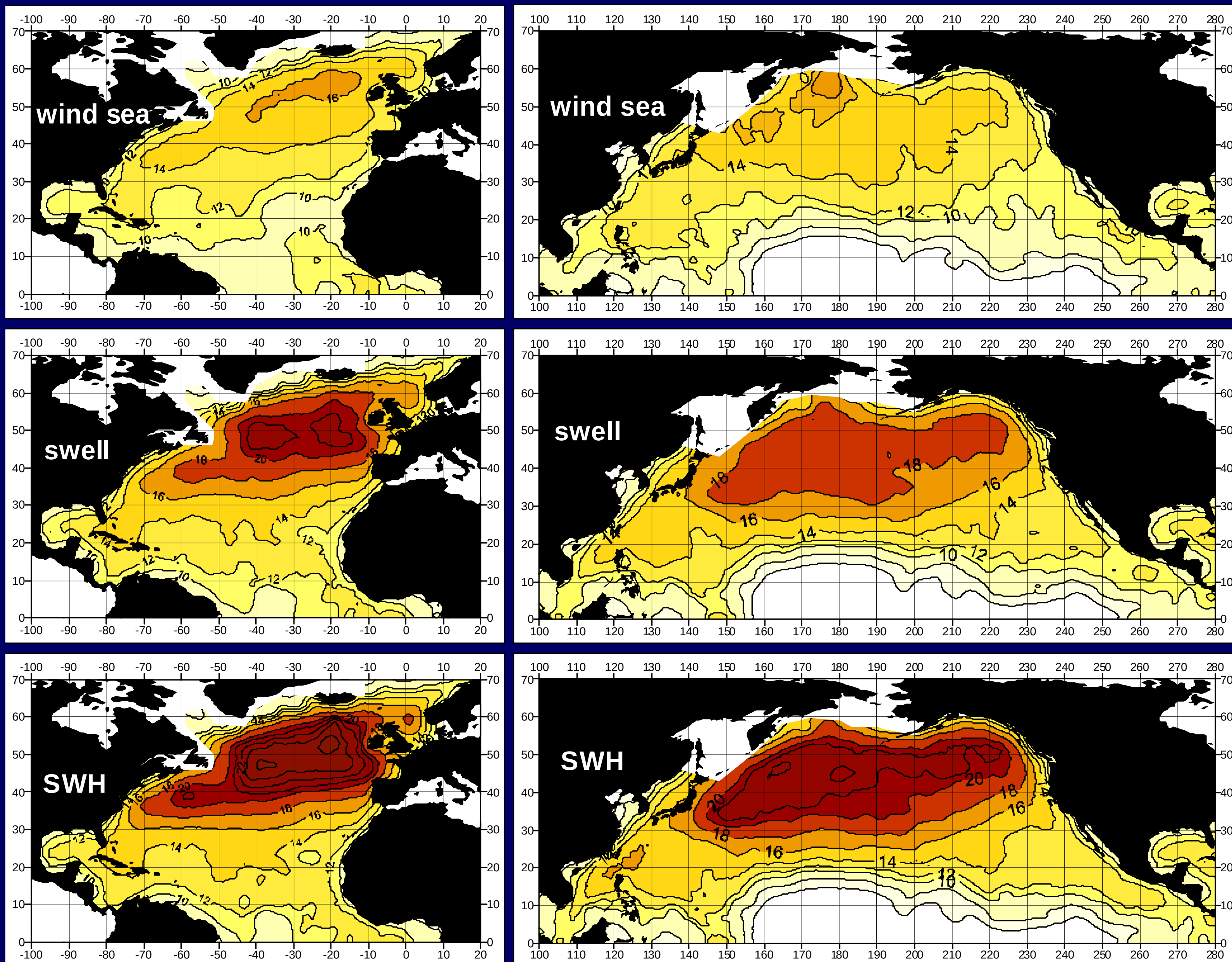
6-hourly median wave heights



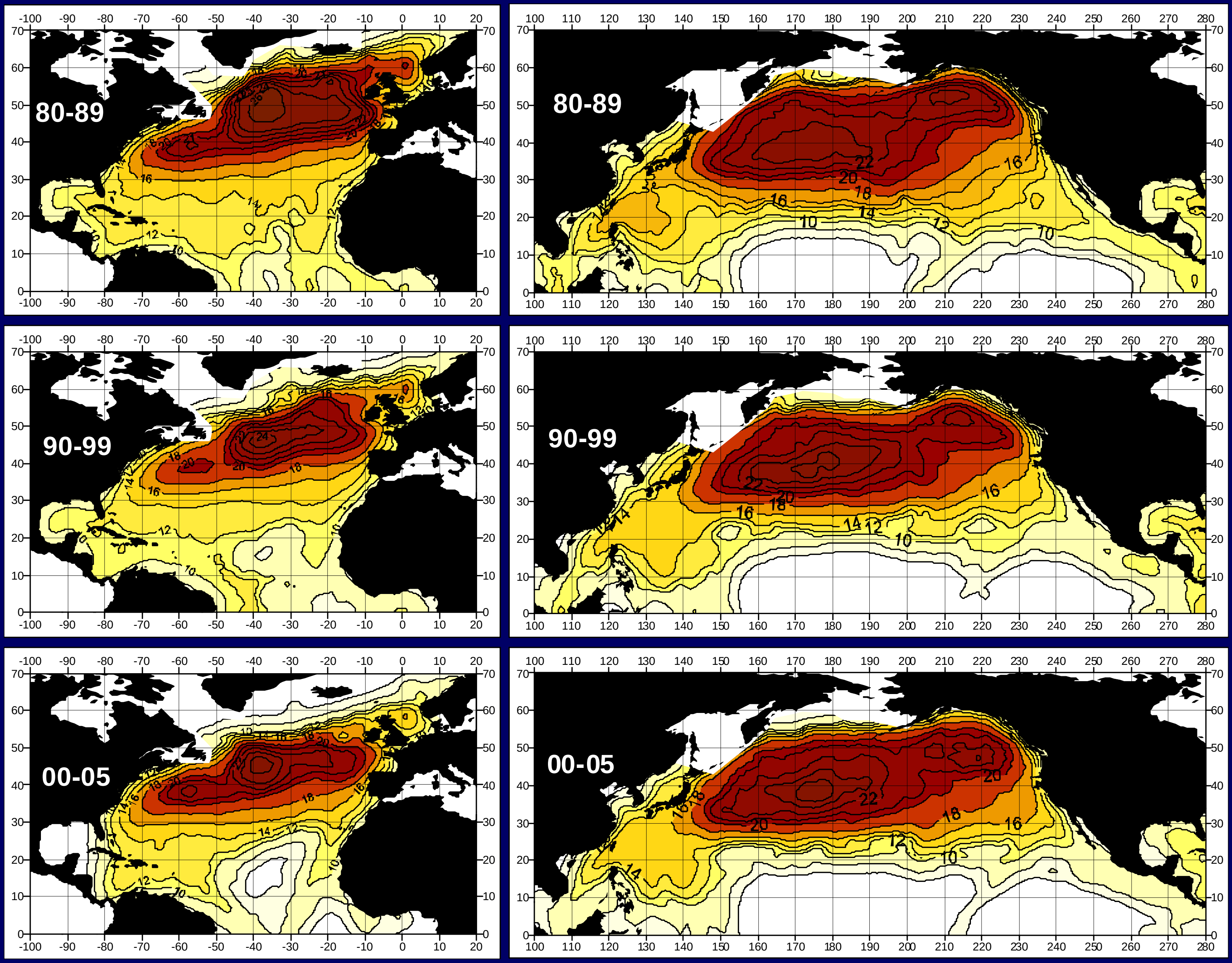
Comparison with ERA-40-WAM



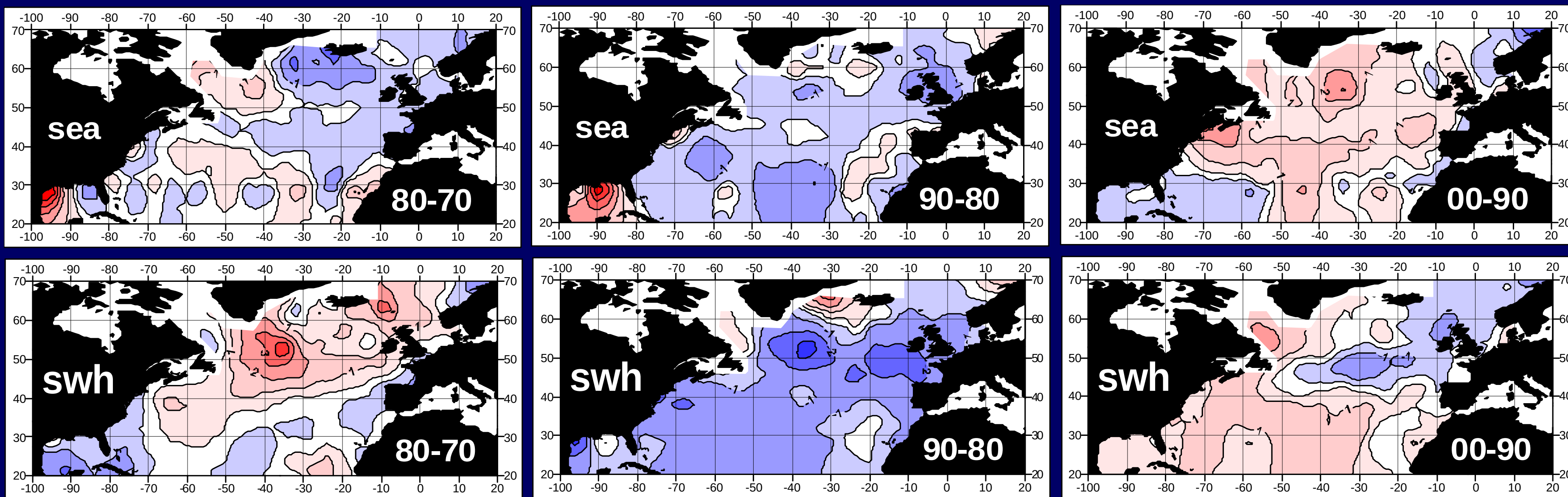
100-year return values: 1970-1979



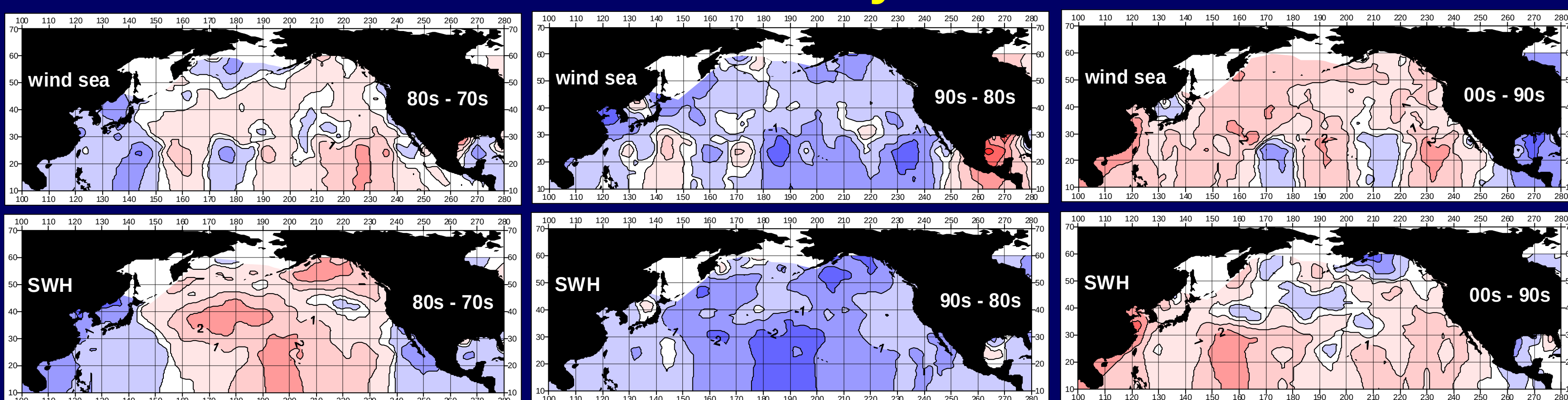
100-year return SWH for different decades

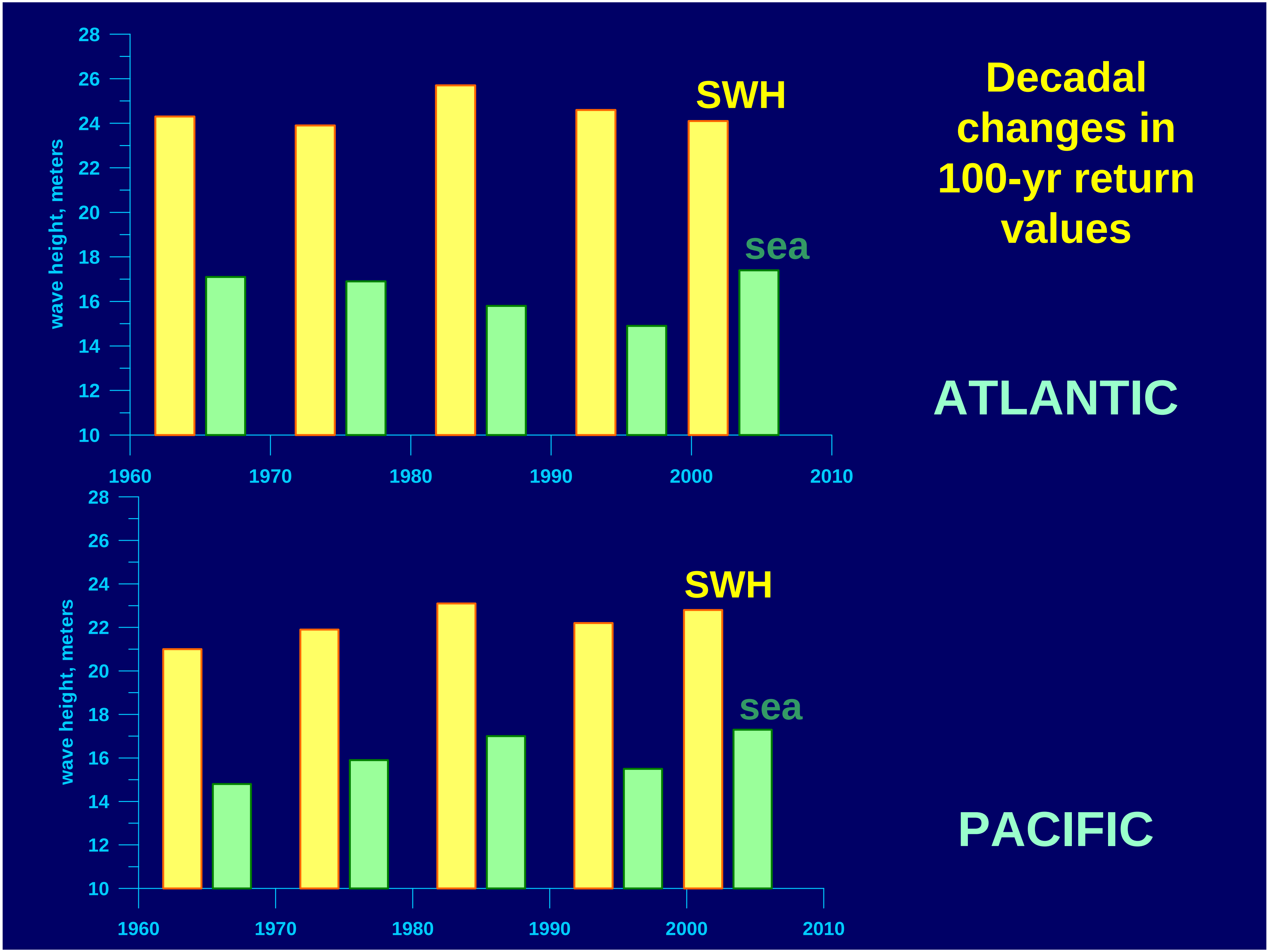


Interdecadal differences in 100-yr return values: Atlantic



Interdecadal differences in 100-yr return values: Pacific




Decadal changes in 100-yr return values
ATLANTIC
PACIFIC
SWH
sea
SWH
sea
wave height, meters
wave height, meters
28
26
24
22
20
18
16
14
12
10
1960
1970
1980
1990
2000
2010

Conclusions:

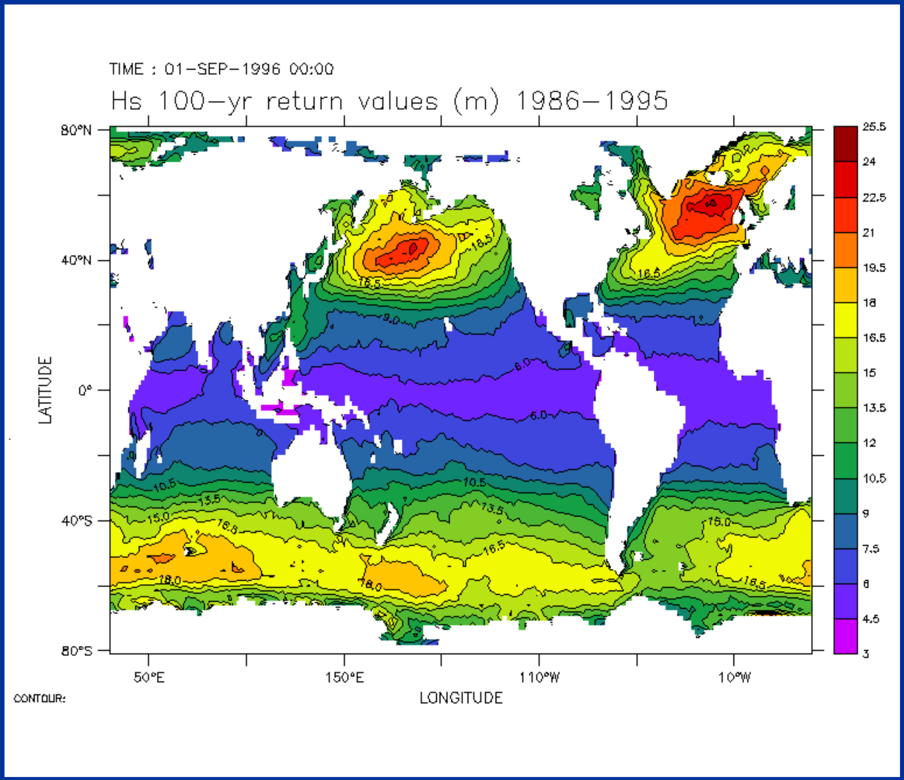
- Visual wave data, If properly pre-processed, represent an important source of information about wave climate.
- Mean wave climate: linear trends in the North Atlantic and North Pacific up to 1.2 m per century.
- Interannual variability in wind sea is driven by winds, while variations of swell are forced by cyclone frequency.

- Extreme wave statistics from VOS can only be accurately estimated for the Northern Hemisphere mid latitudes.
- The technique of the application of POT is still to be improved.

- Extreme waves revealed by VOS data show quite evident decadal variability. Decadal changes in the extreme SWH and wind sea are not correlated.

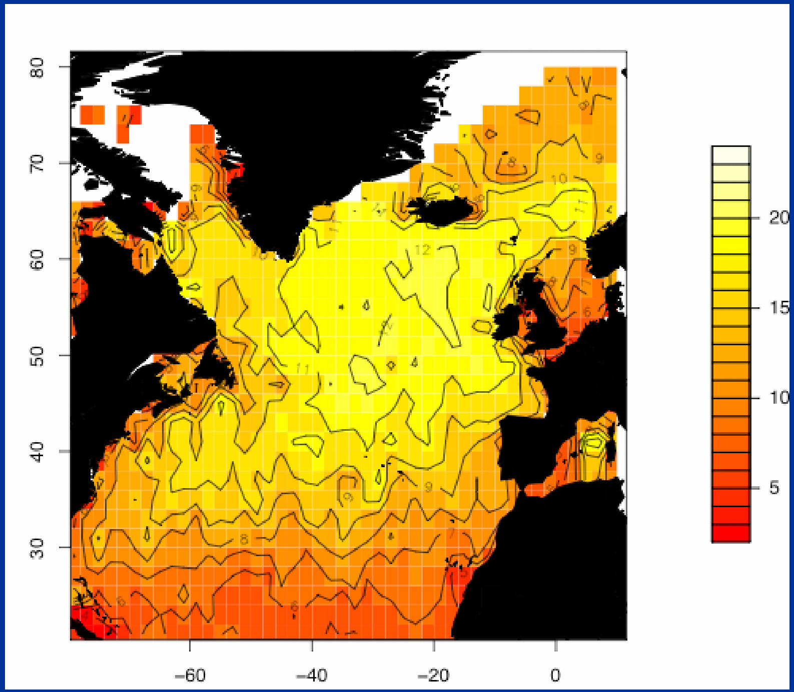
100-yr returns from WAM and altimetry: POT/GPD

ERA-40-WAM



Caires and Sterl 2004

TOPEX/POSEIDON altimeter



Challenor et al. 2004