Wind Wave Periods and Steepness from VOS Data Over the Global Ocean

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OUTLINE:

- Visually observed waves from VOS: problems of the analysis of wave periods
- Global climatology of wave periods and steepness parameter
- Changes in wave lengths and periods: are they consistent with changes in wave height?
- Impact of wave periods on the extreme wave characteristics

Advance summary (meeting the requirements of Val):

- **Visually observed waves from VOS: problems of the analysis of wave periods**

  Accuracy is low compared to wave heights, corrections are required, their proper application is possible for 1970+ period

- **Changes in wave lengths and periods: are they consistent with changes in wave height?**

  They are qualitatively consistent, showing growing tendency in the NH oceans. However, sea steepness also grows up.

- **Impact of wave periods on the extreme waves**

  Steepness of extreme waves is higher than for the moderate and even high waves

Table F2-3

Conversion for SP Prior to 1968

Seconds	Code	Interval
5	2	5 seconds or less
7	3	6-7 seconds
9	4	8-9 seconds
11	5	10-11 seconds
13	6	12-13 seconds
15	7	14-15 seconds
17	8	16-17 seconds
19	9	18-19 seconds
21	0	20-21 seconds
22	1	over 21 seconds
0	-	calm or period not determined

Table F2-4

Conversion for SP Beginning 1 January 1968

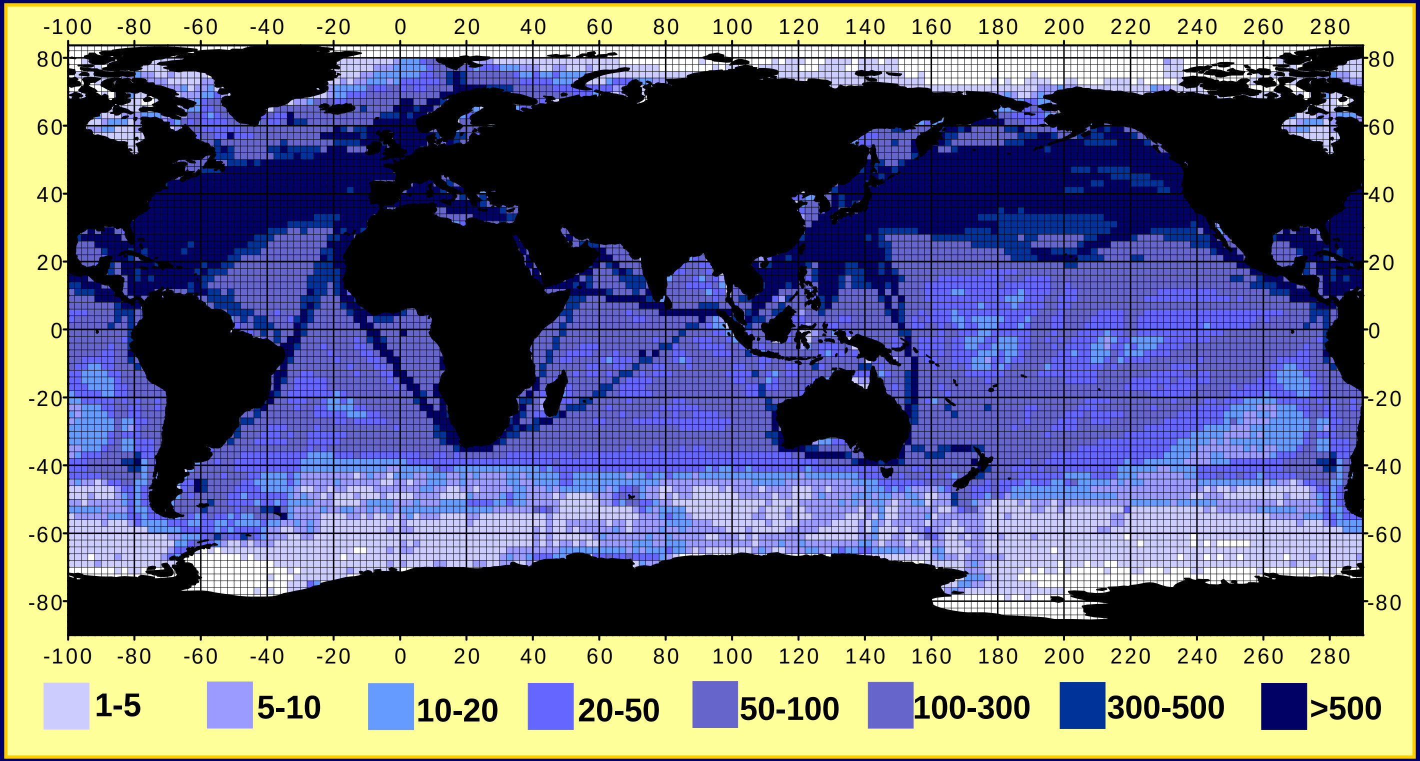
Seconds	Code	Interval
10	0	10 seconds
11	1	11 seconds
12	2	12 seconds
13	3	13 seconds
14	4	14 seconds or more
5	5	5 seconds or less
6	6	6 seconds
7	7	7 seconds
8	8	8 seconds
9	9	9 seconds
0	-	calm or period not determined

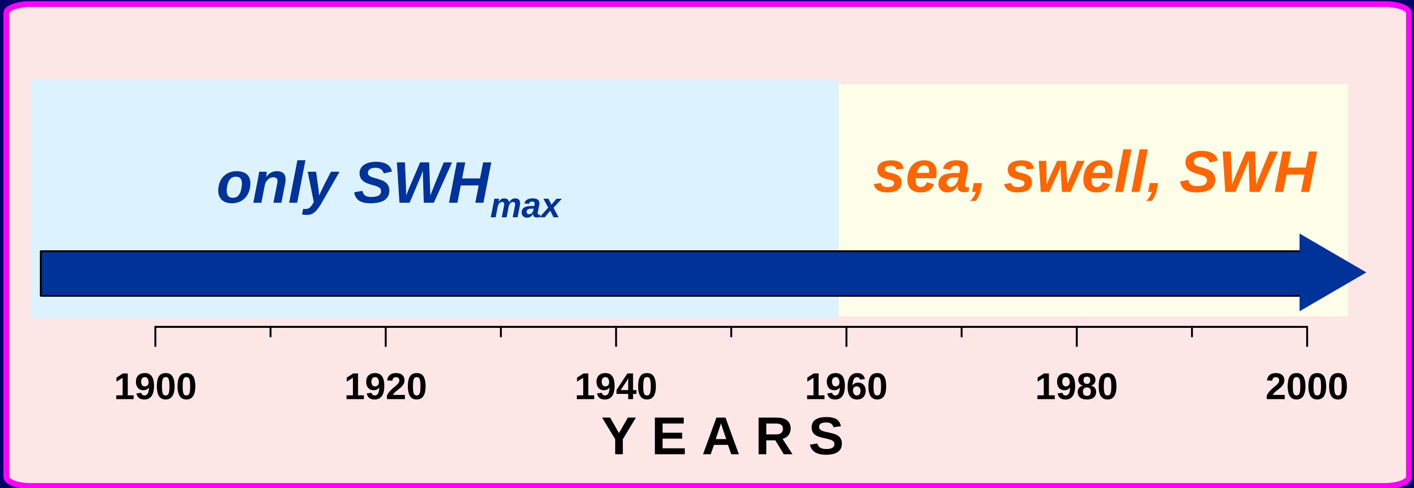
Visual wave observations: 1856-onwards

Sea and swell periods are given in codes with the code precision 1 second for sea period and 2 sec for swell period.

Important change of the WMO Manual on codes (1963) has happened in 1968 (Supplement P-67). This change affected swell periods. Incorrect conversion implies roughly doubling of swell periods.

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. 2003)

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

2. Significant wave height

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

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

4. 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

5. 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

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

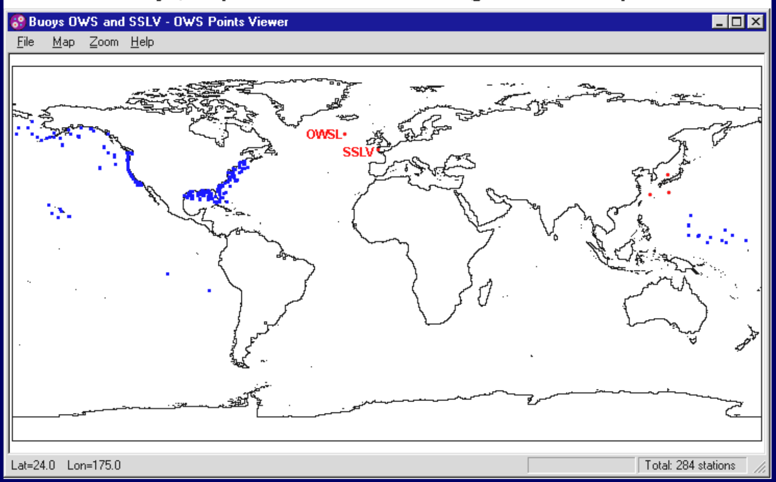
Use of the actual ship course and velocity

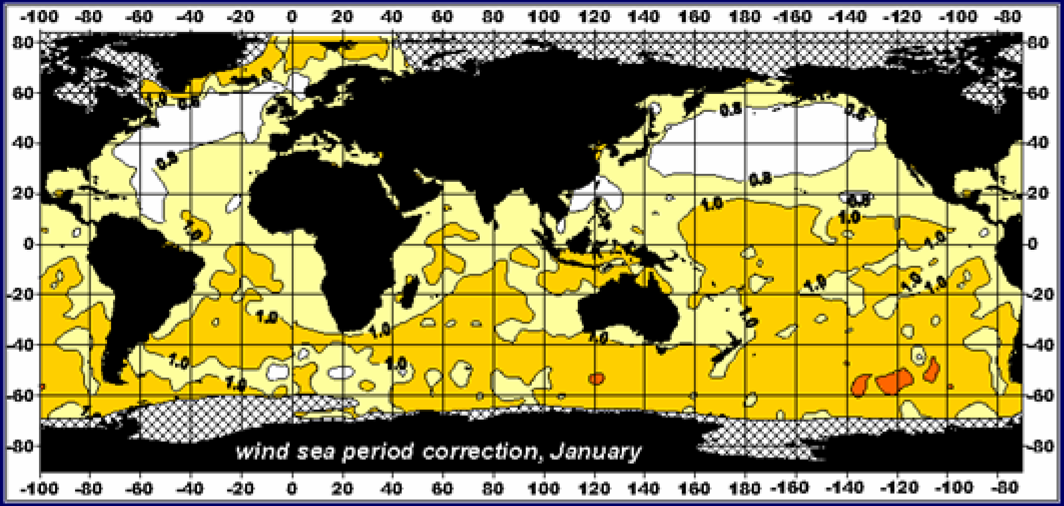
Correction of the systematic overestimatiuon of wave periods by VOS

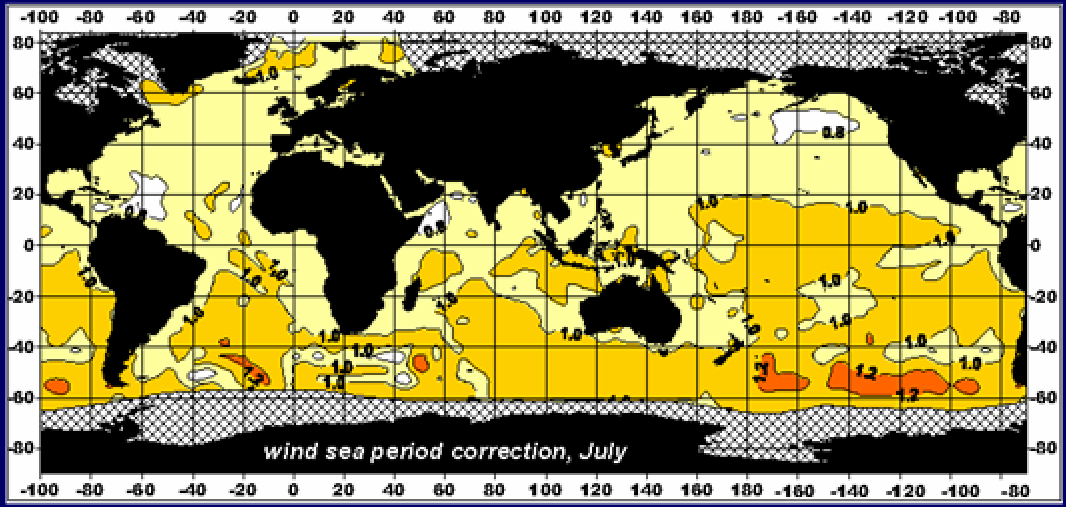
Gulev and Hasse (1998), Gulev et al. (2003) –

fitting of the 2D height-period distributions for sea and swell to the buoy data

Buoys, ship recoders at OWS and light vessels map



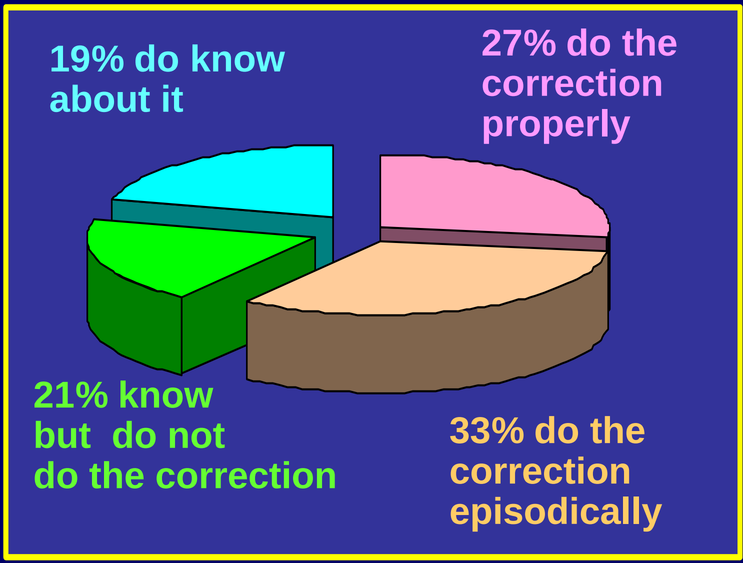




Corrections varies from 0.4 to 1.5 seconds with the largest values in the Southern Ocean

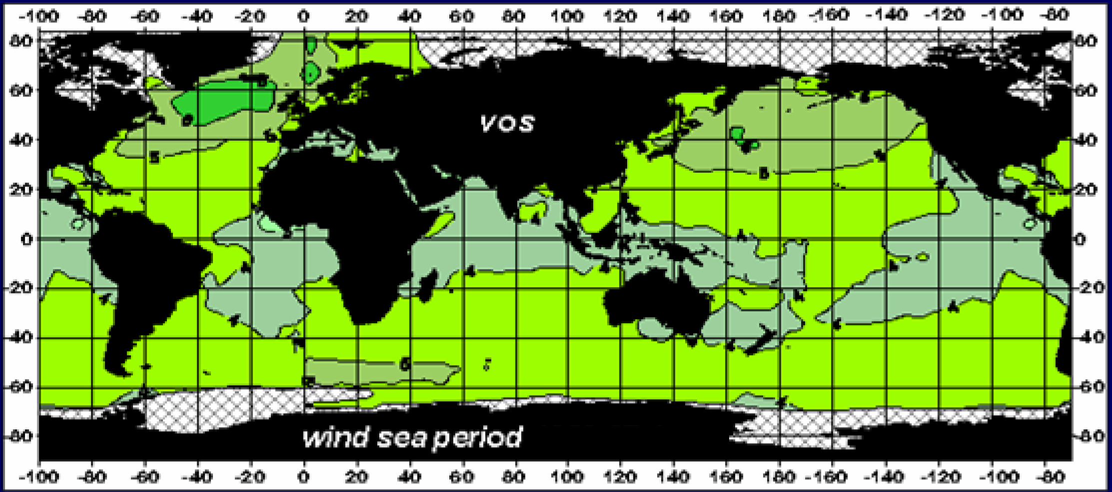
Evaluation of the true wave period

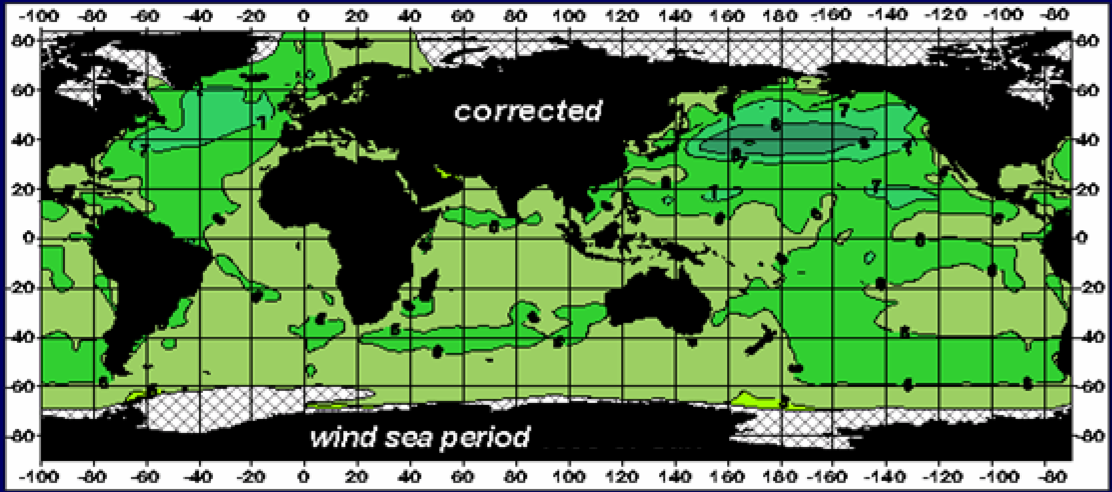
SHIPMET: true wind



True wave period

0% apply the correction

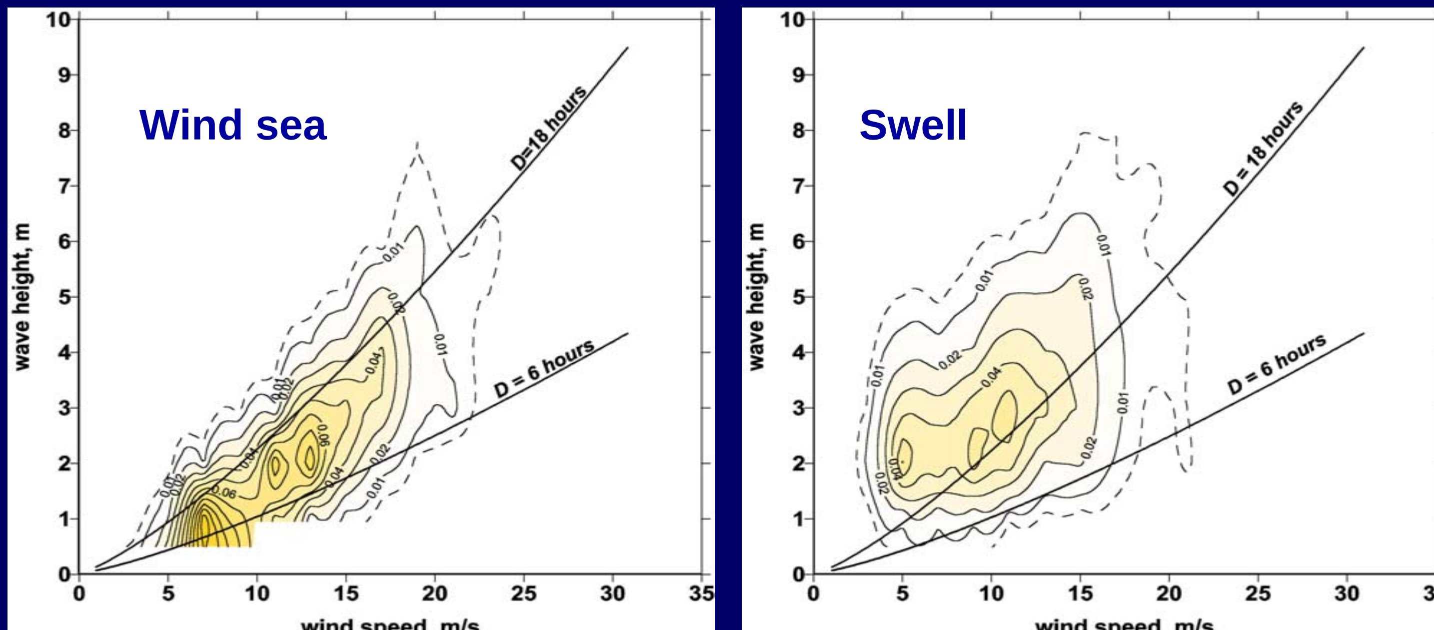




Sea and swell separation

1. Analysis of 2D wind-wave distributions with respect to the JONSWAP curves (Carter 1988) for wind durations of 6 to 24 hours:

elimination of 0.1 to 3% of reports



2. Wave age ($a = C_p/V_{ef,}$) analysis*:* waves reported as *"sea"* with a < 1.2 are attributed to sea, otherwise removed from the data set, waves reported as "swell" with a > 1.2 :are attributed to swell, otherwise removed

elimination of 0.05 to 1.5% of reports

Pre-processing: general scheme
for sea periods only

100%, 1948-2005

ICOADS AMMA decoding, matching AMMA and LMRF-6.0 reports to TDL-11 if available

83%, 1948-2005

Matching the selected reports to *WMO-47 “International list of selected, supplementary and auxiliary ships”* **by the ship call signs if available**

67%, 1970-2005

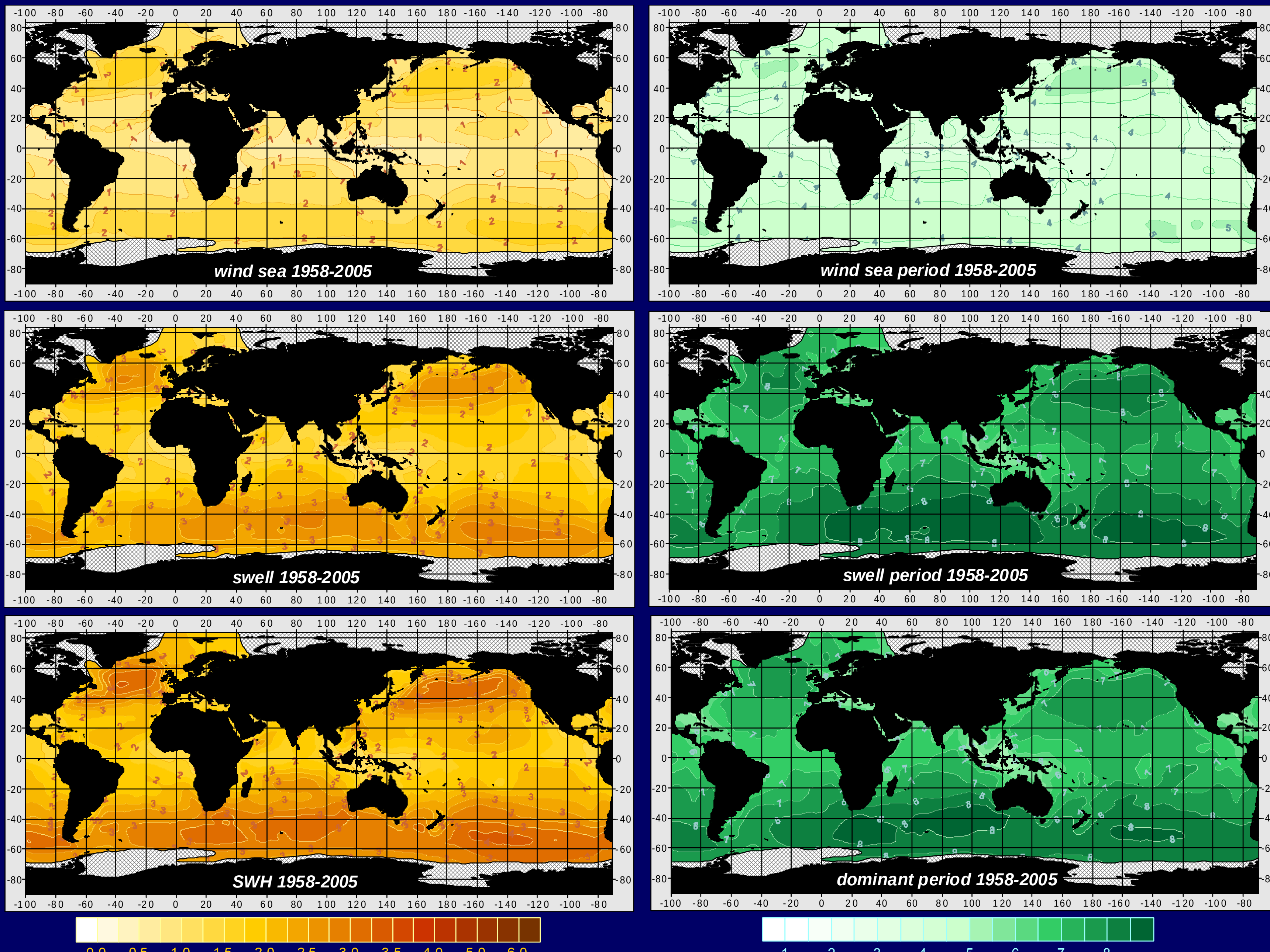
Checking for availability of ship course and speed

46%, 1970-2005

Monte-Carlo re-sampling to minimize sampling bias

39%, 1970-2005

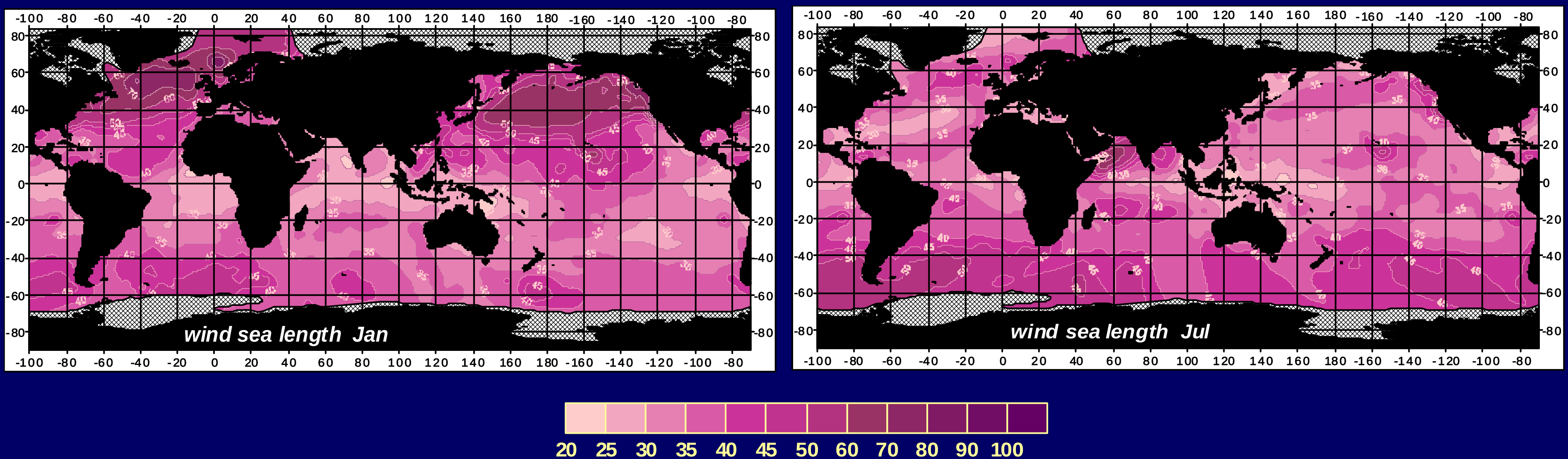
A global VOS wave climatology (1958-2005)

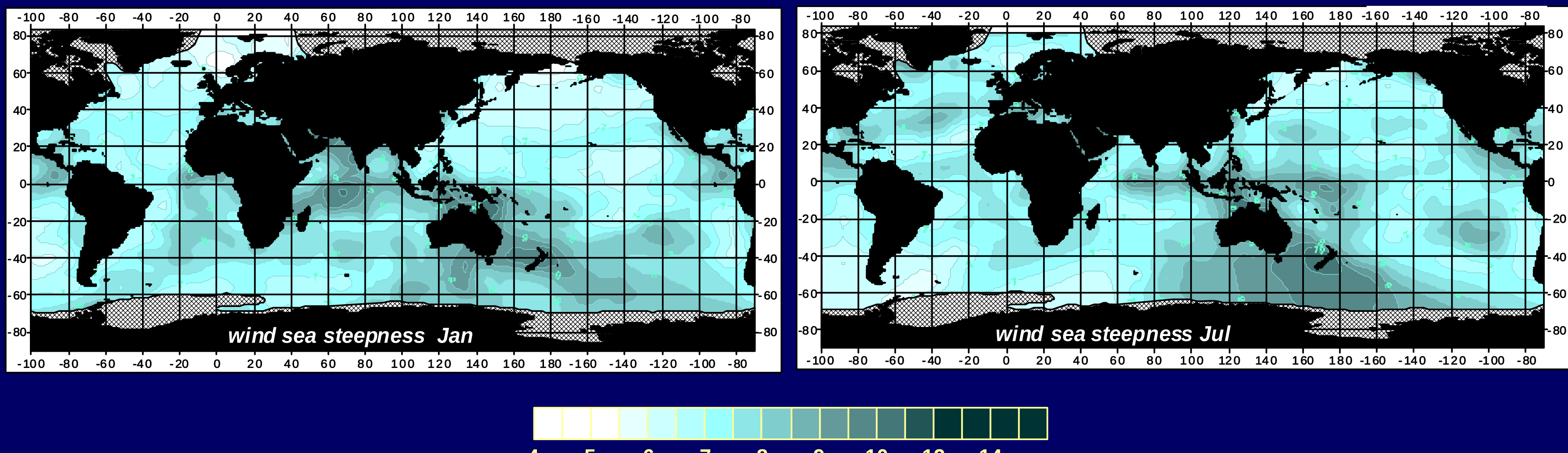


Gulev et al. 2003, JGR

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

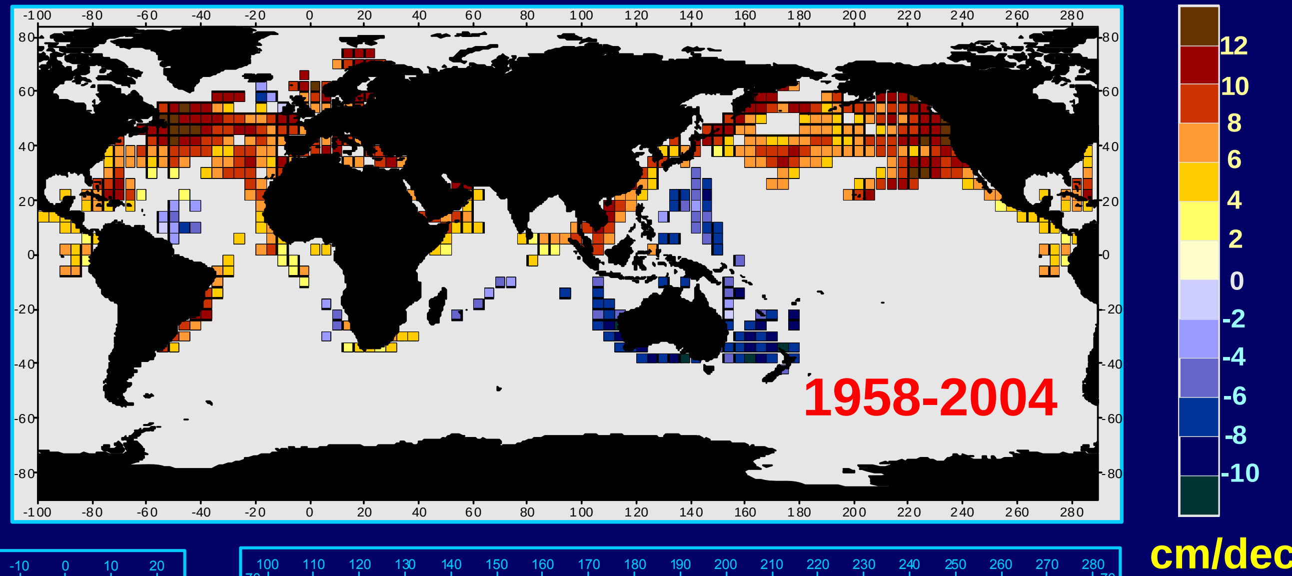
Global climatology of wave length and steepness

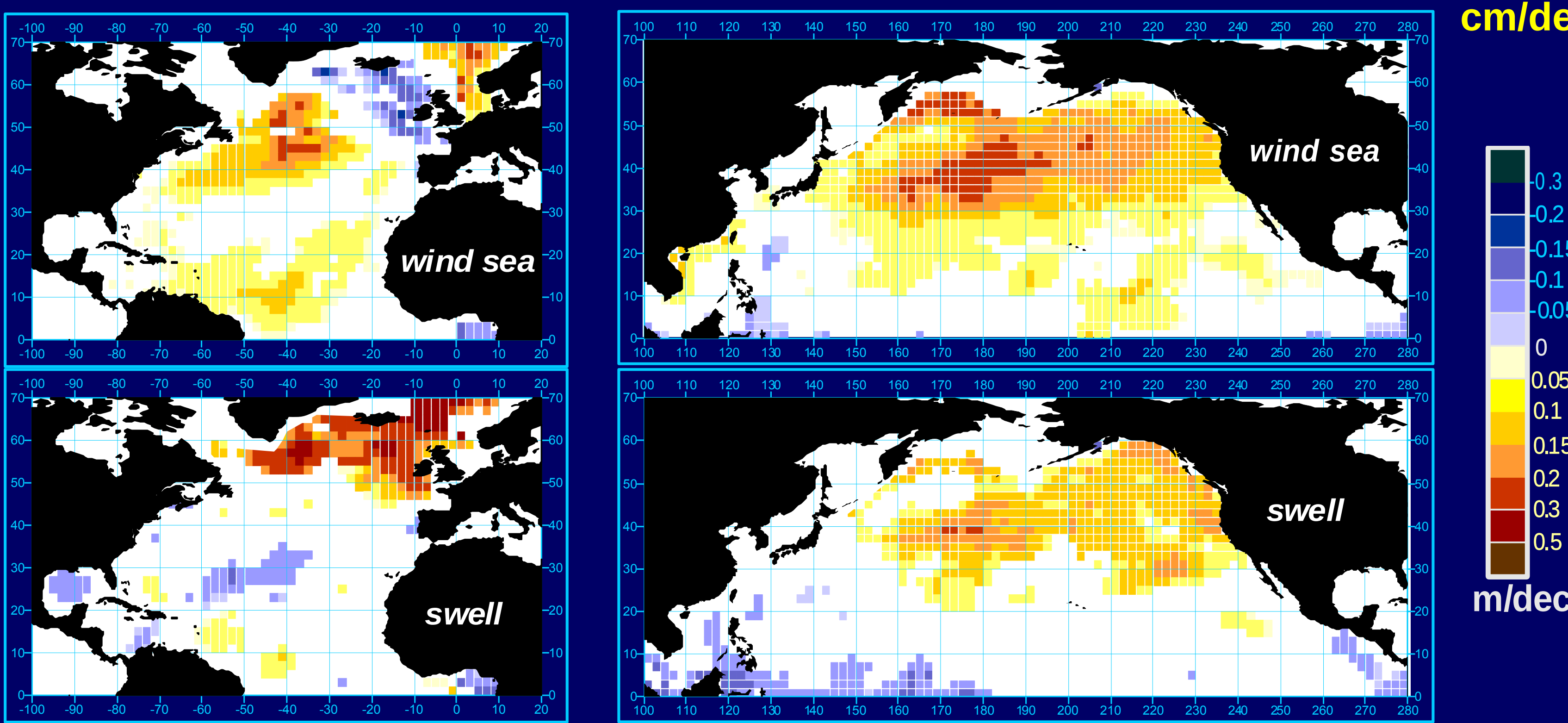




Linear trends

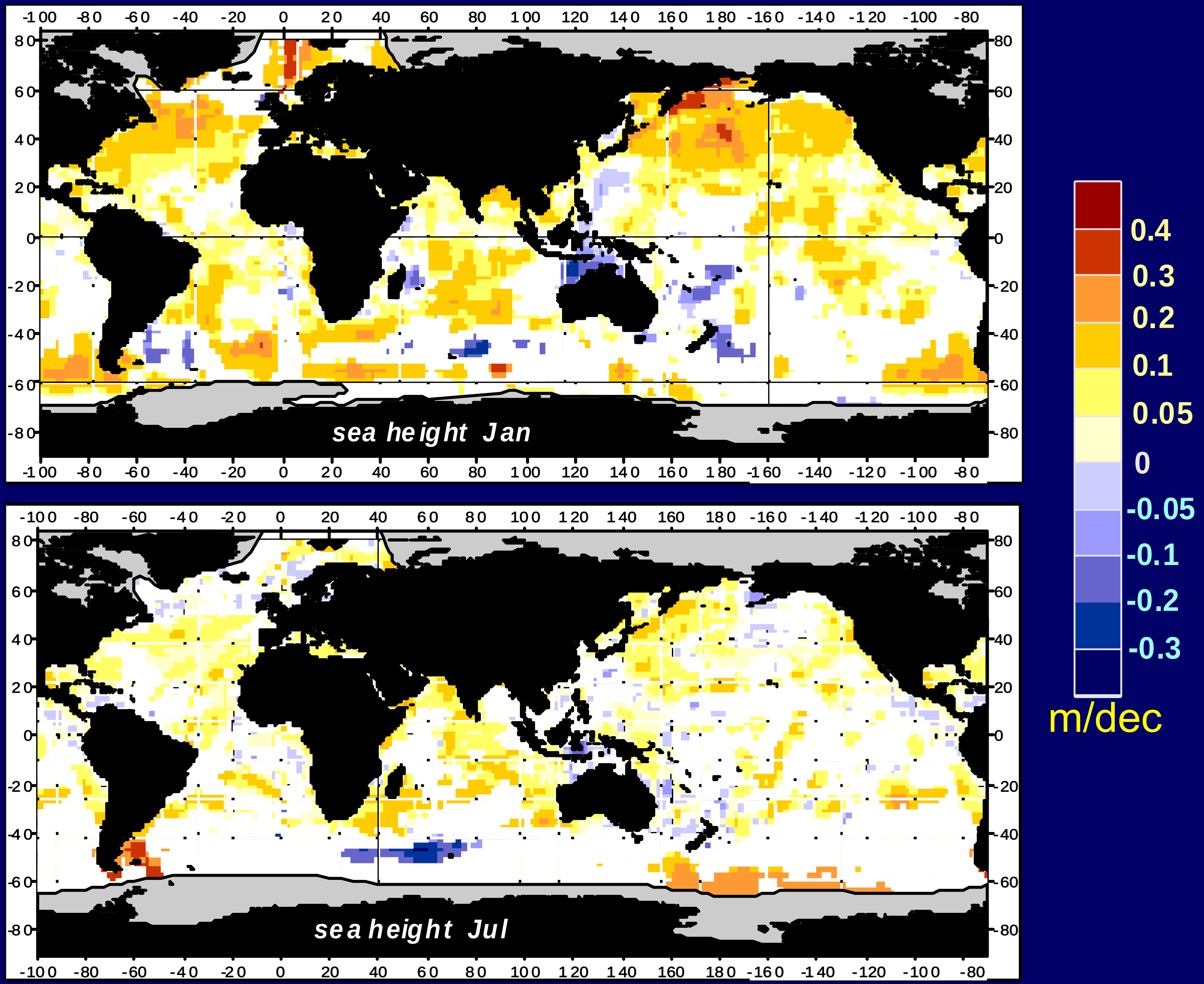
SWH, sea, swell: 1958-2004





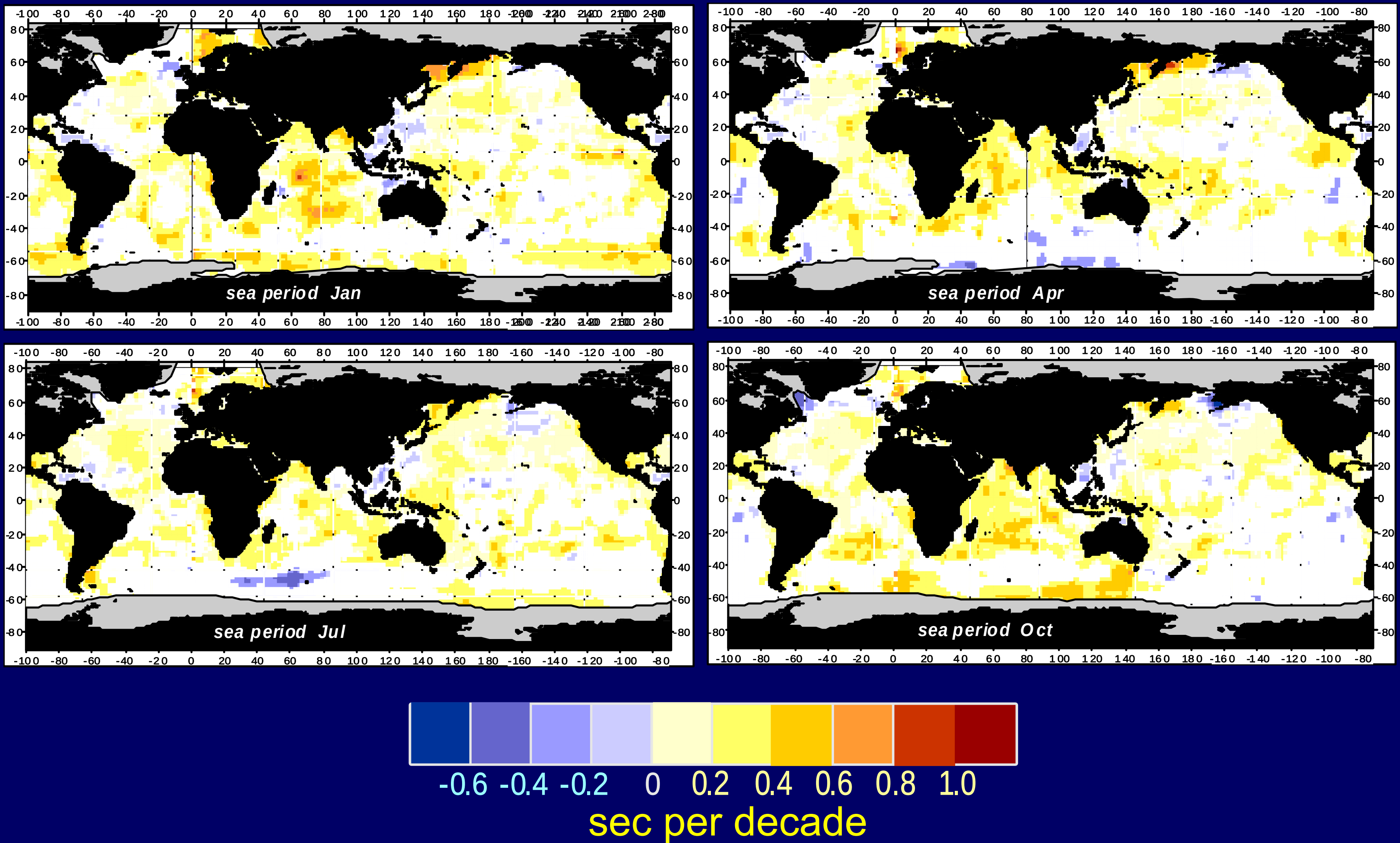
Gulev and Grigorieva 2004, GRL, 2006, J.Climate

Linear trends in sea height: 1970-2005



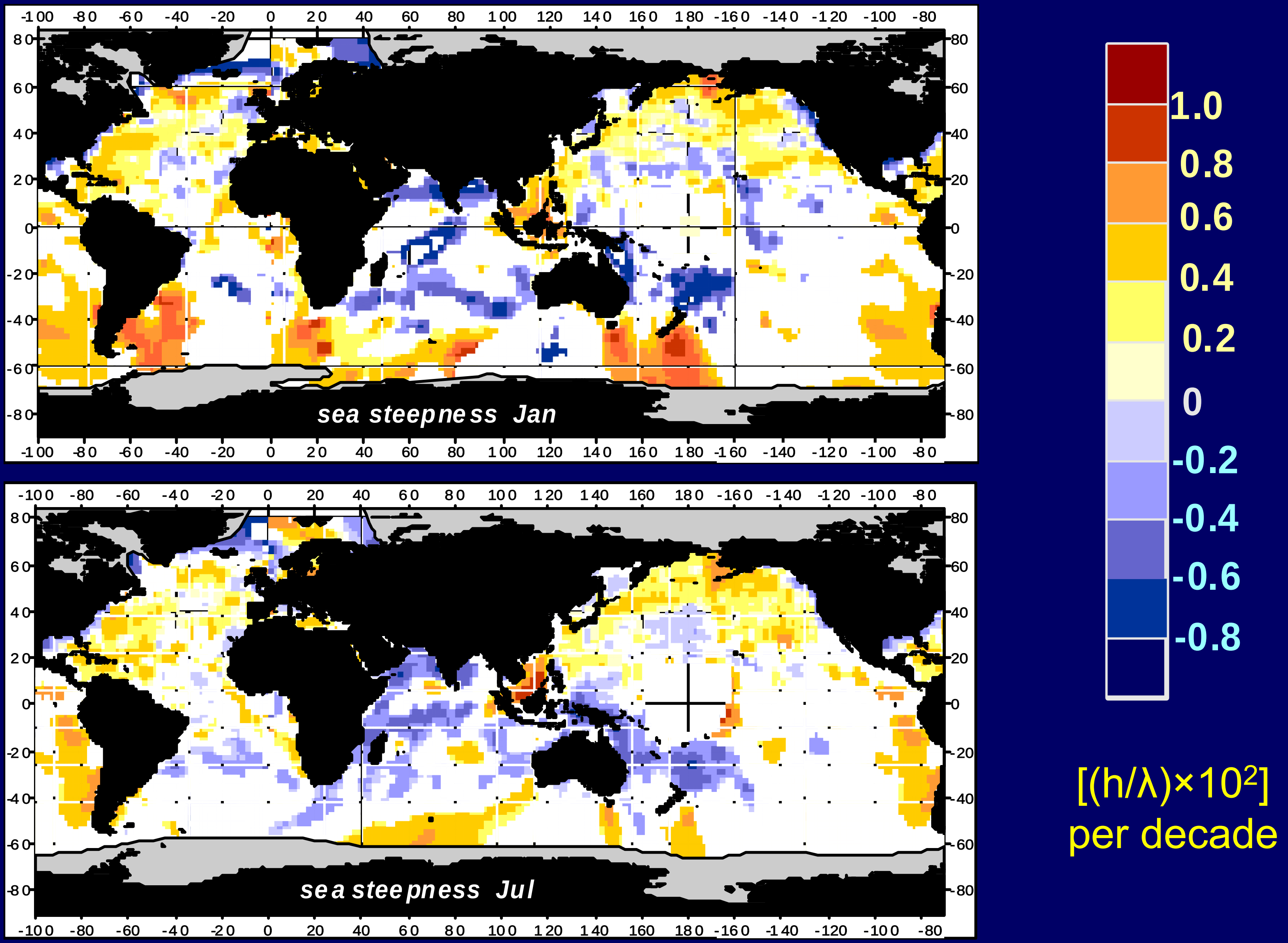
Whether these changes are co-ordinated with variability in wave period characteristics and if YES, HOW?

Linear trends in wind sea periods, 1970-2005

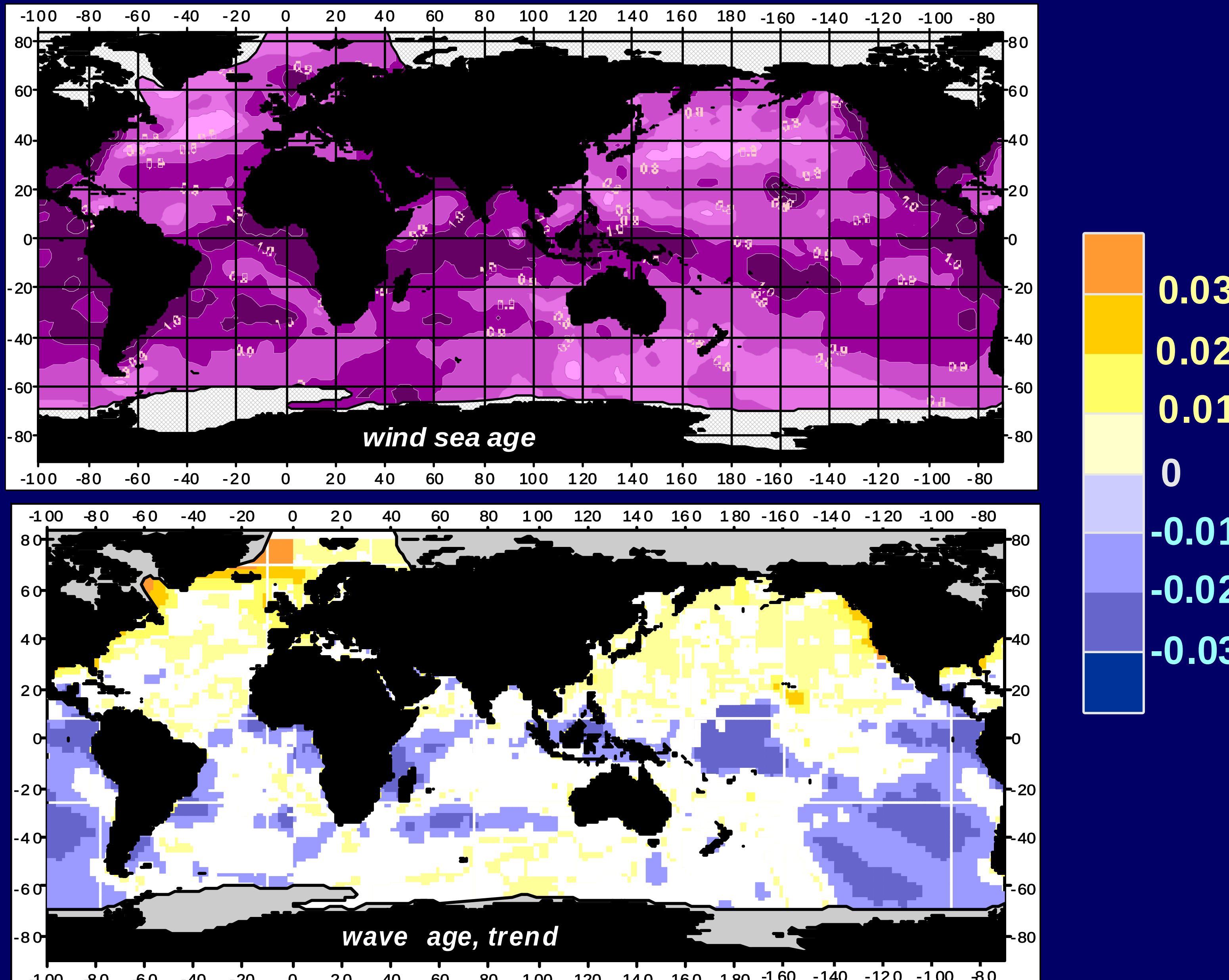


Student *t*-test + Hayashi reliability ratio

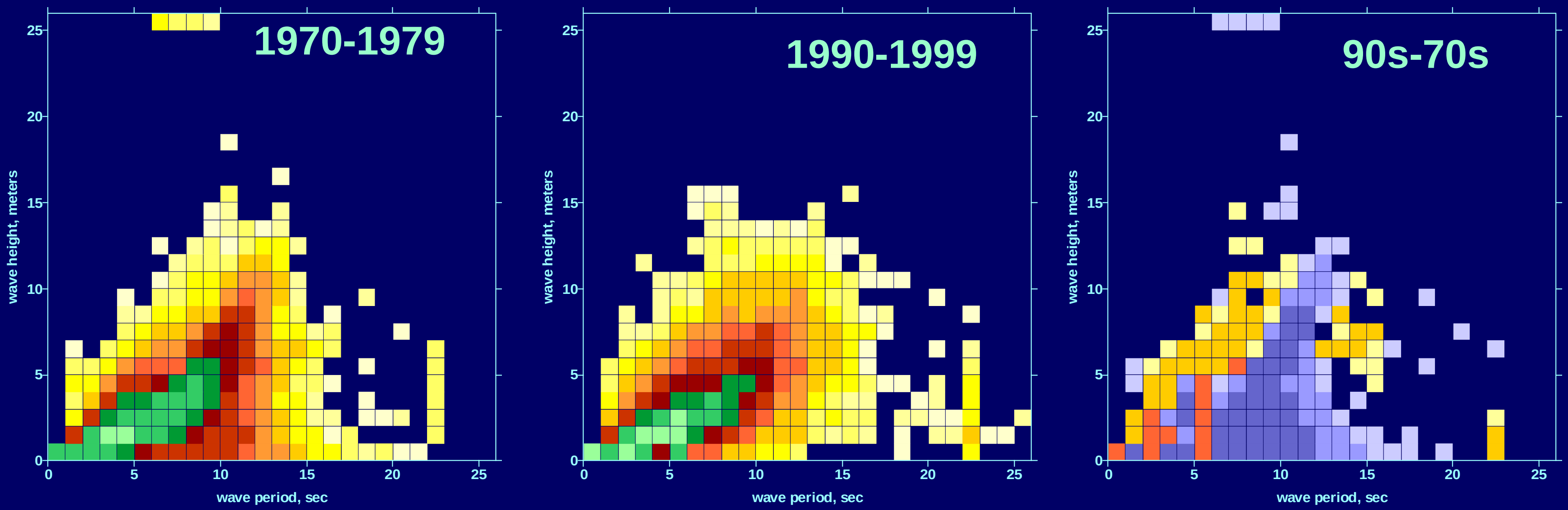
Linear trends in wind sea steepness, 1970-2005

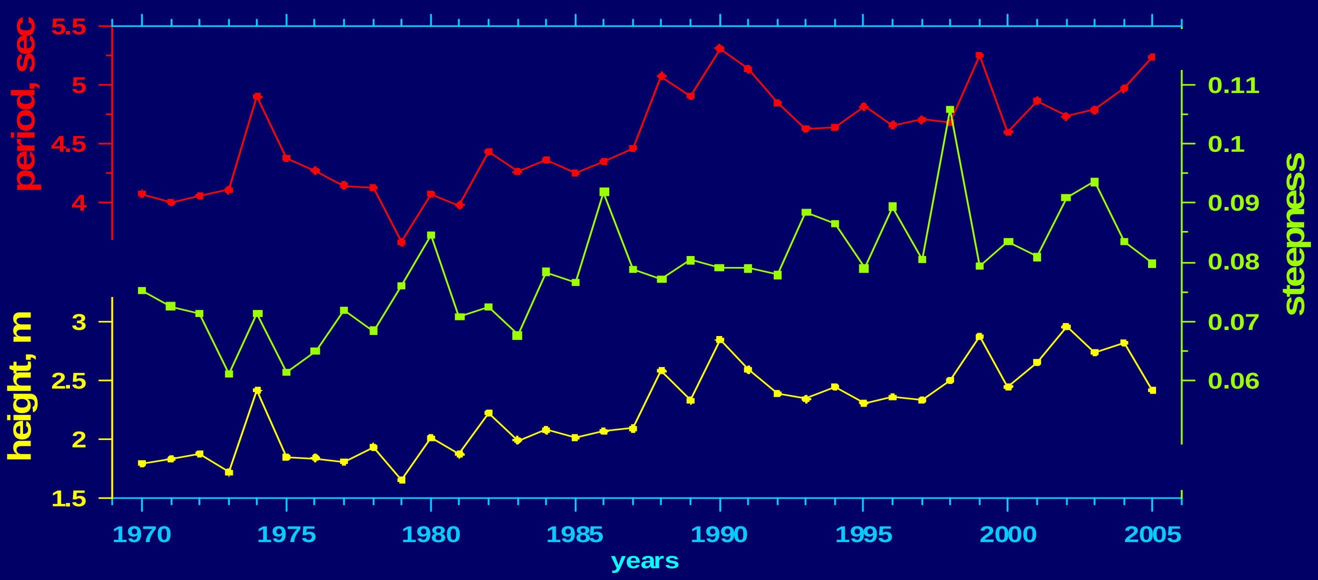


Linear trends in wind sea age, 1970-2005

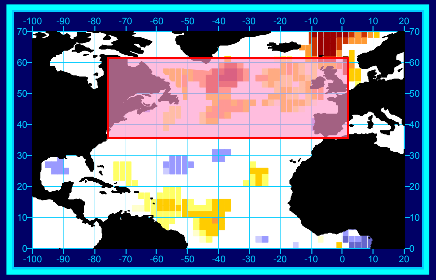


Changes in 2D height-period distributions

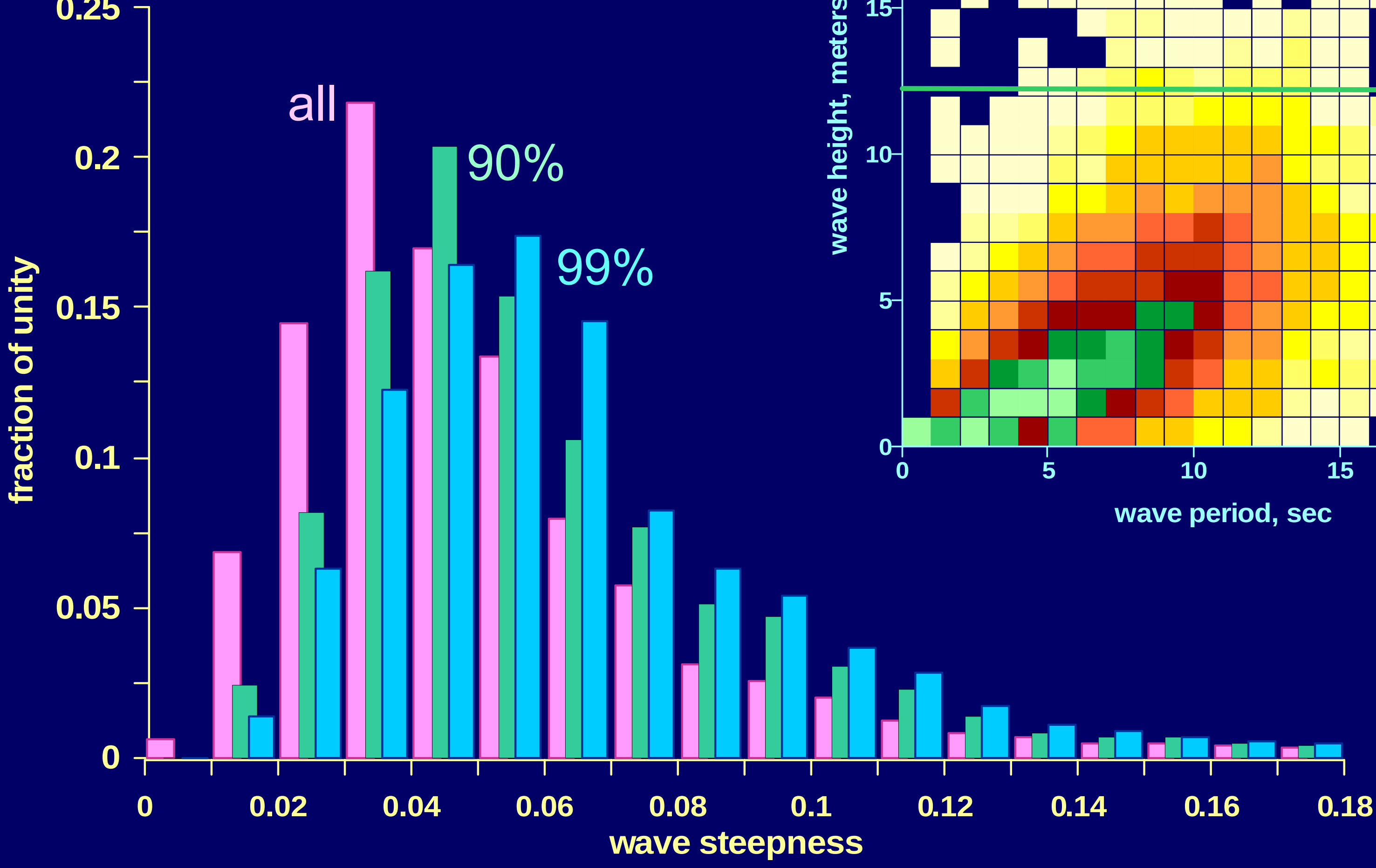


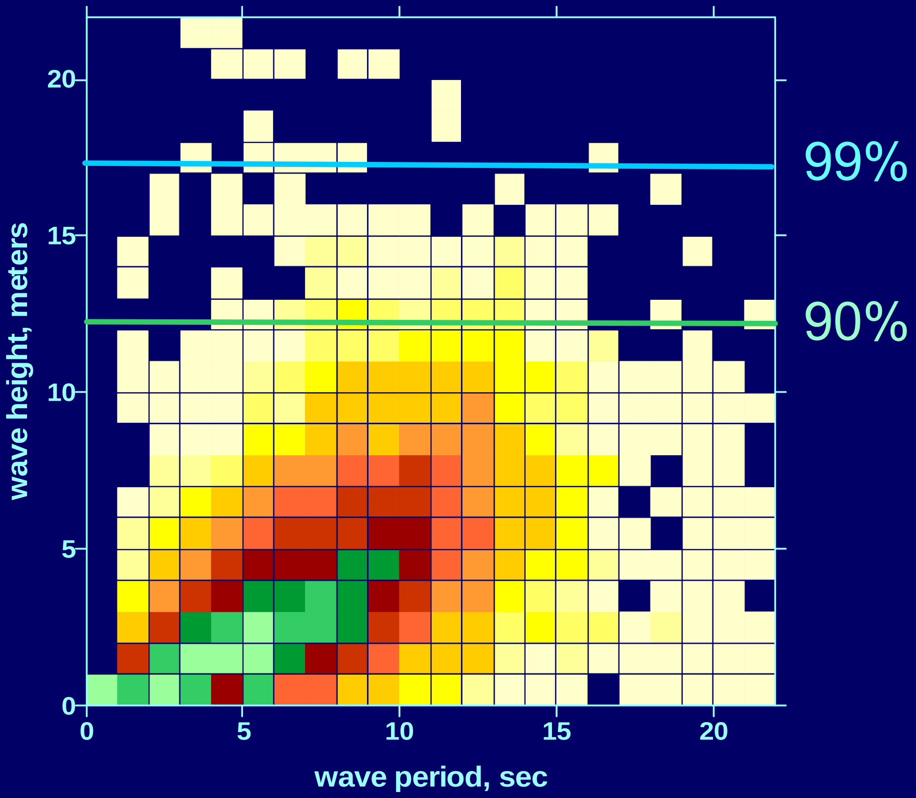


NA winter time series



Are the extreme waves more steep?

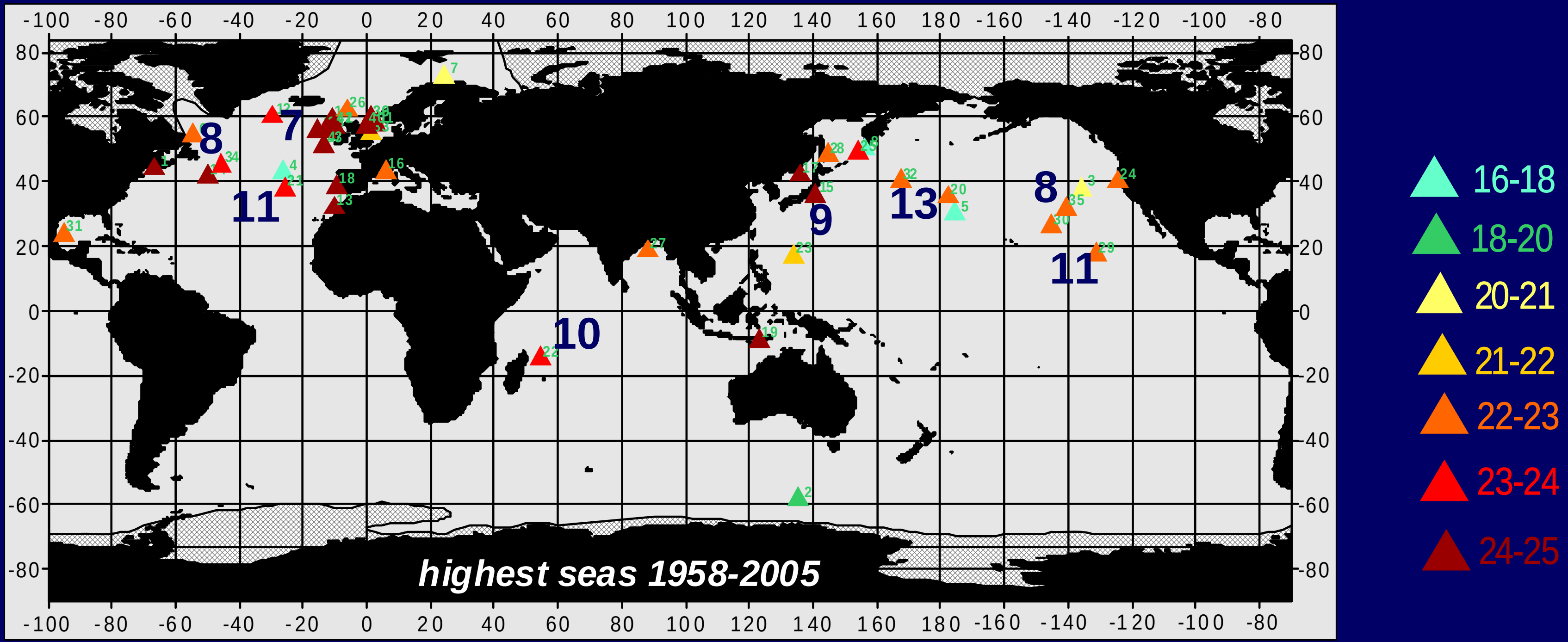




Conclusions:

- Wave periods from the visual VOS data are much more uncertain than the wave height estimates. An accurate pre-processing is possible exclusively for the period from 1970 onwards. A little can be done for the swell periods.
- Wave periods and lengths grow up (0.1 to 0.3 sec per dec) during 1970-2005. Spatial patterns are generally consistent with those for the trends in wind sea height.
- Changes in wind sea heights and periods, while consistent, result in positive trends in wave steepness with the largest increase of 0.006-0.008 per decade in the NH mid latitudes.
- Extreme seas are generally more steep compared to the moderate seas.

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