Global ocean wind waves from ICOADS during the last 130 years: reliability, extremes and climate variability

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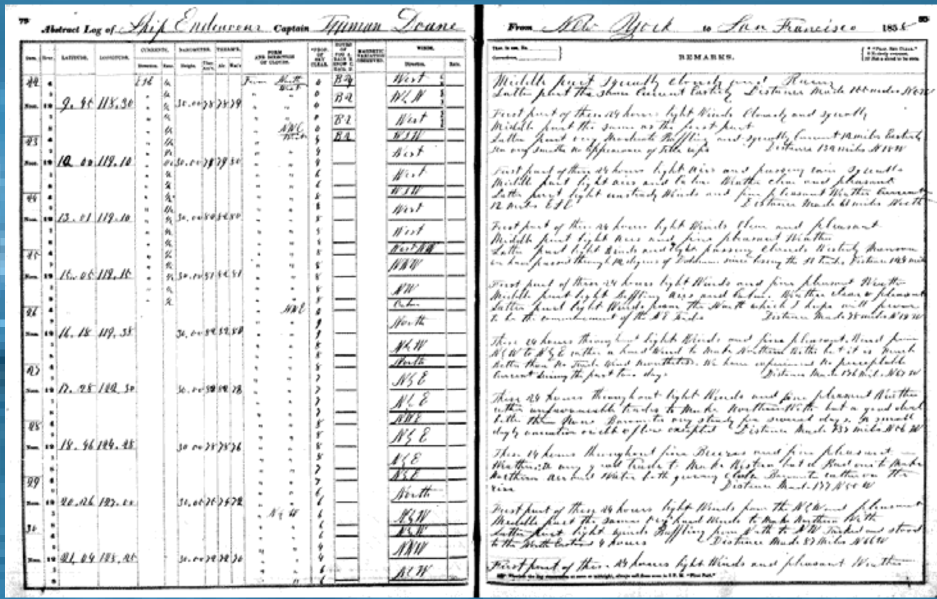
OUTLINE:

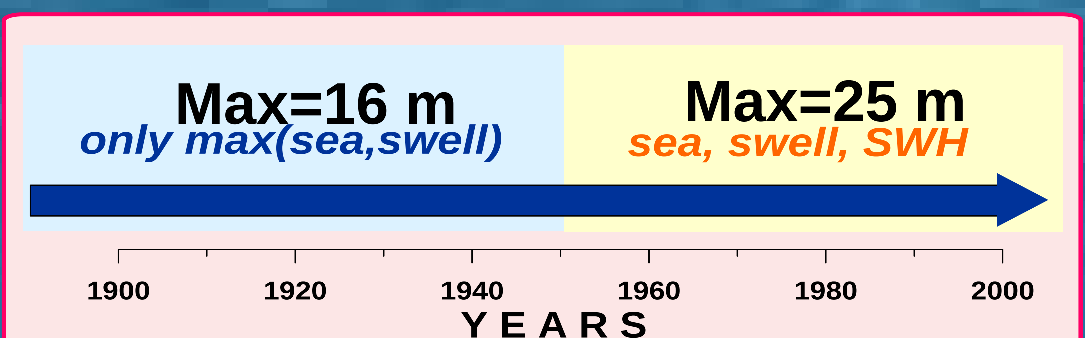
- ICOADS – based climatology of visually observed wind waves: 1870-1949 & 1950-2007
- Errors and uncertainties
- Centennial-scale changes
- Decadal variability
- Changes in wave statistics derived from VOS (Voluntary Observing Ship)
- Extreme wave tendencies

Visual wave observations: 1870 - onwards

2 streams of data:
(1870-1949) and (1950-2007)
> 2.000.000.000 telegrams

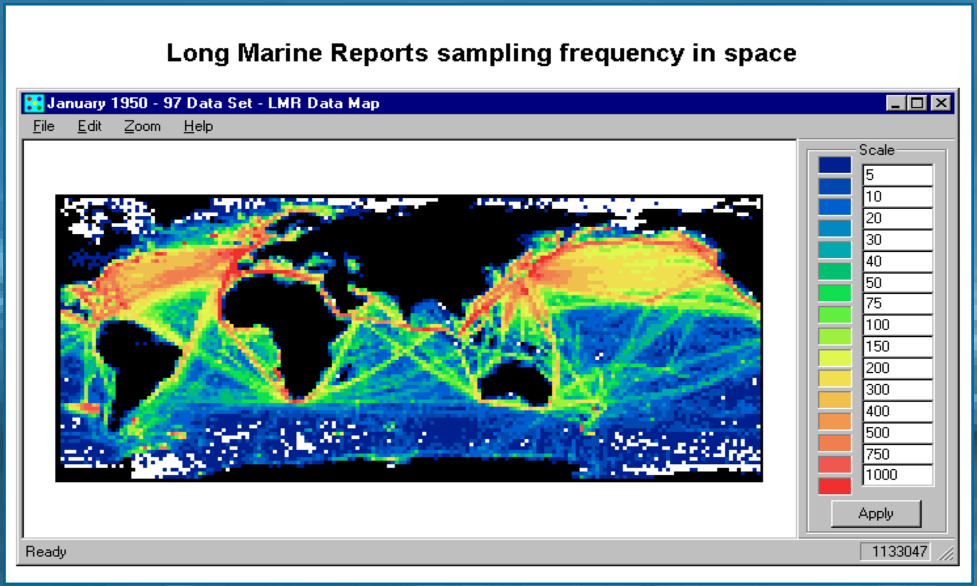
- wind sea height
- swell height
- wind sea period
- swell period
- wind sea direction
- swell direction
- wind direction
- wind speed
- SLP
- SST at cetera…


Abstract Log of Ship Endeavour Captain Truman Doane
From New York to San Francisco 185
REMARKS.



- Observational practice has never been changed
- Coding systems have been changed several times, while documented
- VOS is assimilated in the ICOADS

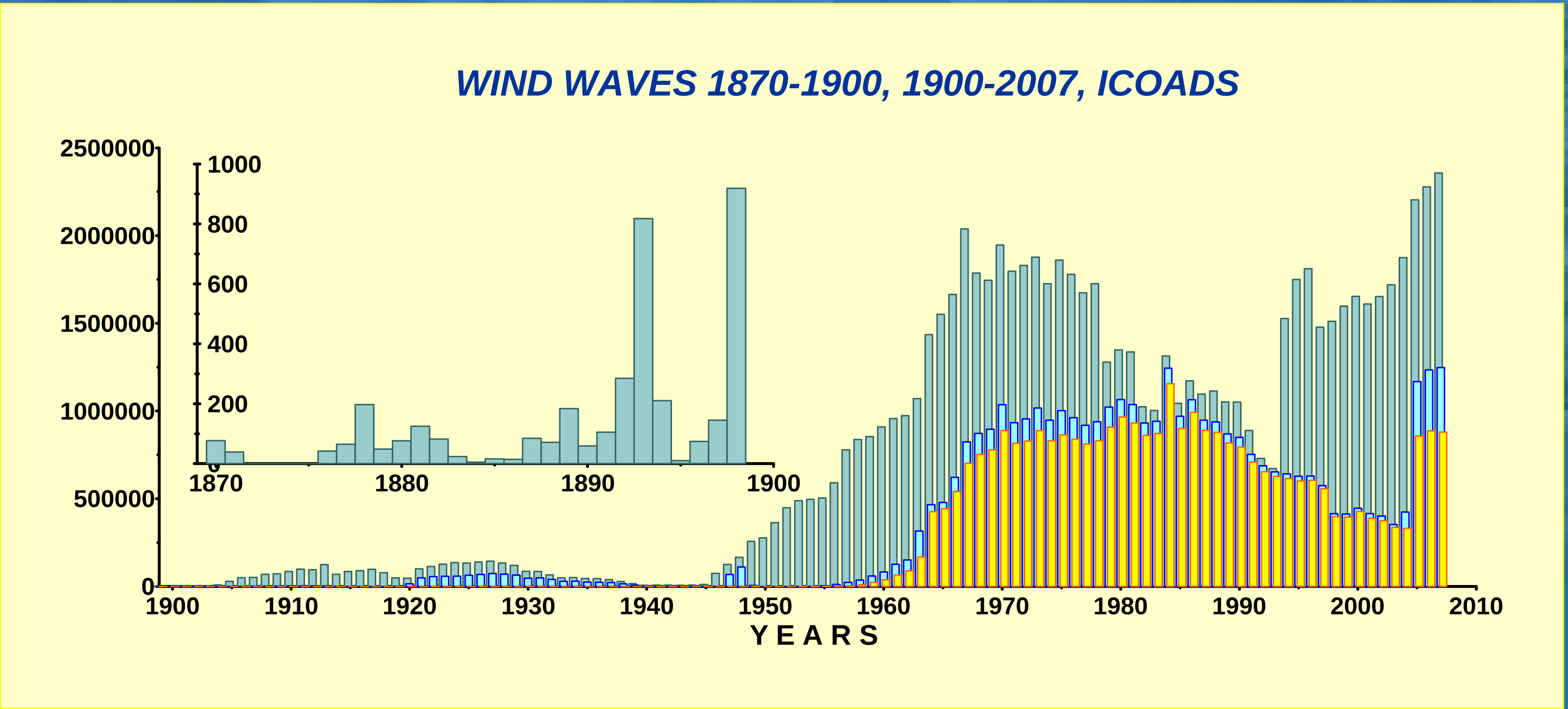
Visual wave observations: 1870 - onwards



increase in the total number of reports during the last decade

no actual increase in the number of reports containing all wave parameters

1970-1990 – best sampled period



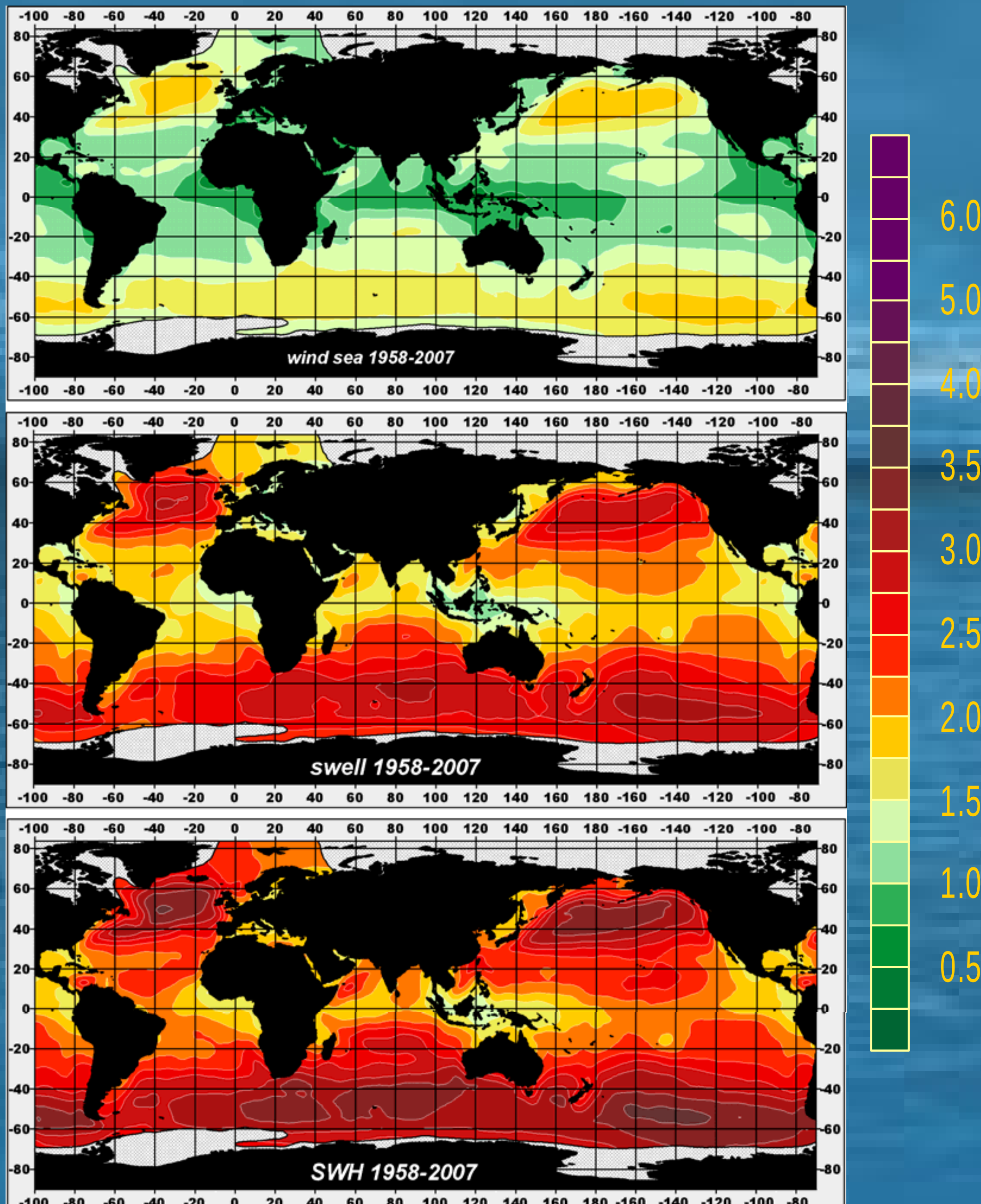
Data control and preprocessing

- Presence of all wave-related variables – elimination of up to 80% of reports
- Observational artifacts
  - unrealistic reporting date
  - reported zero periods for nonzero wave heights ~ 3%
- Computation of significant wave height
- Sea and swell separation – elimination of up to 10% of all reports
- Correction of small waves and periods ~ 5%
- Steepness control (elimination of waves with unrealistic steepness)

  Wind sea steepness > 0.2 – up to 30% !!! – problem of "1 s" period

  Swell steepness > 0.15 – up to 10%
- Wave age control

  $a = Cp / V_{ef}$, Cp = (g/2p)pw for all seas a > 1.2 – up to 3% of eliminated reports



Global Climatology of Wind Waves from VOS data:

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

- monthly
- 1958-2007 (updated)
- 2-degree resolution
- separate estimates of sea, swell, SWH
- original and analyzed data
- any region of your request
- random observational errors
- day-night biases
- sampling errors
- fair weather bias

Extreme waves from VOS: problem of estimation

IVD – Initial Value Distribution –

methodologically, most relevant for VOS data, use of the whole records, however results in underestimation of the extreme waves by about 25% - 20x20 degree resolution

POT – Peak Over Threshold –

requires regular sampling and explicit knowledge of the virtual storm duration - 2x2 degree resolution

Global Climatology of Extreme Waves

Wind sea
Swell
SWH

→

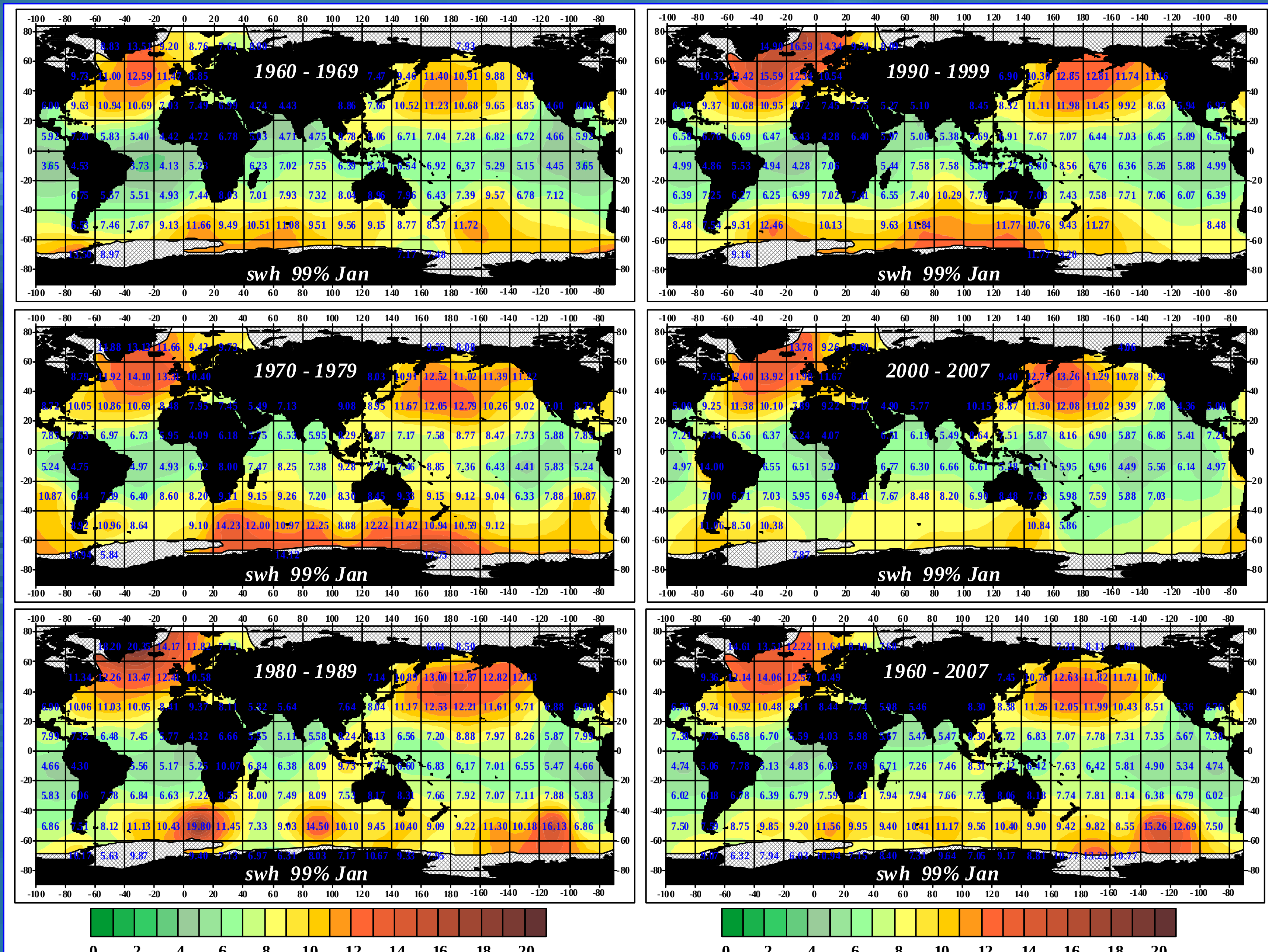
- 90th percentile
- 95th percentile
- 99th percentile
- 100 - yr return

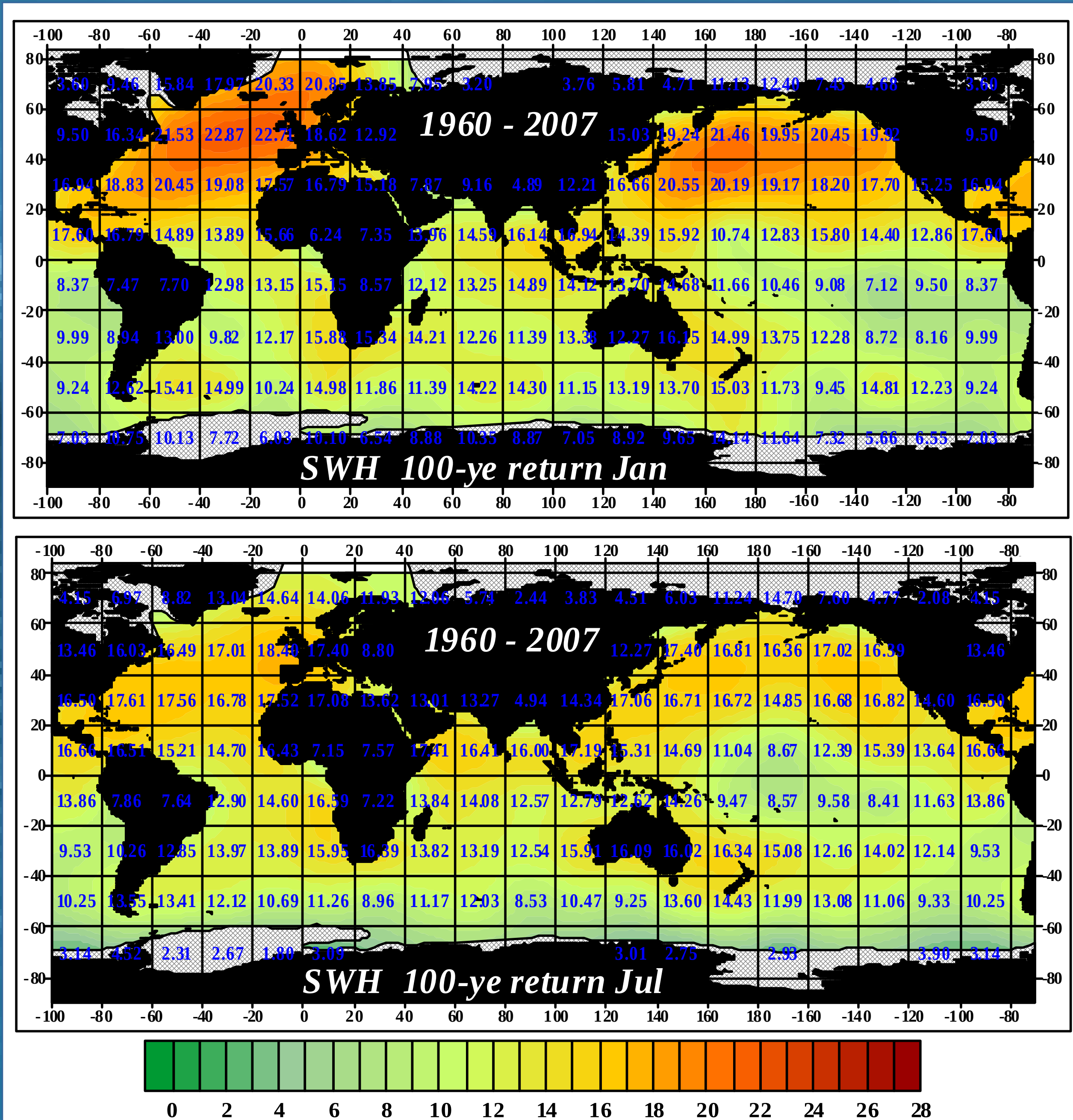
→

Centennial-scale changes
Interannual to decadal variability
Comparison with WAM

1900 – onwards: monthly

Global Climatology of Extreme Waves 1960-2007





100-yr returns 1960 – 2007

Wind sea

Jan: 16-17 m NA
14-15 m NP
Jul: 11-12 m NA
9-10 m NP
12-13 m SO

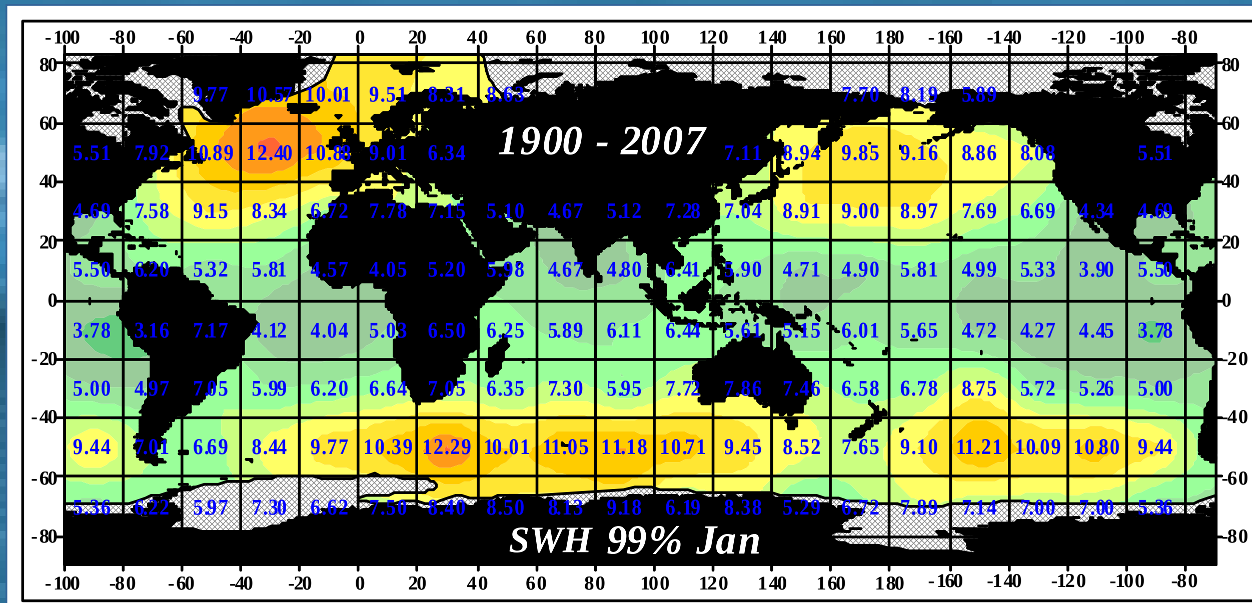
Swell

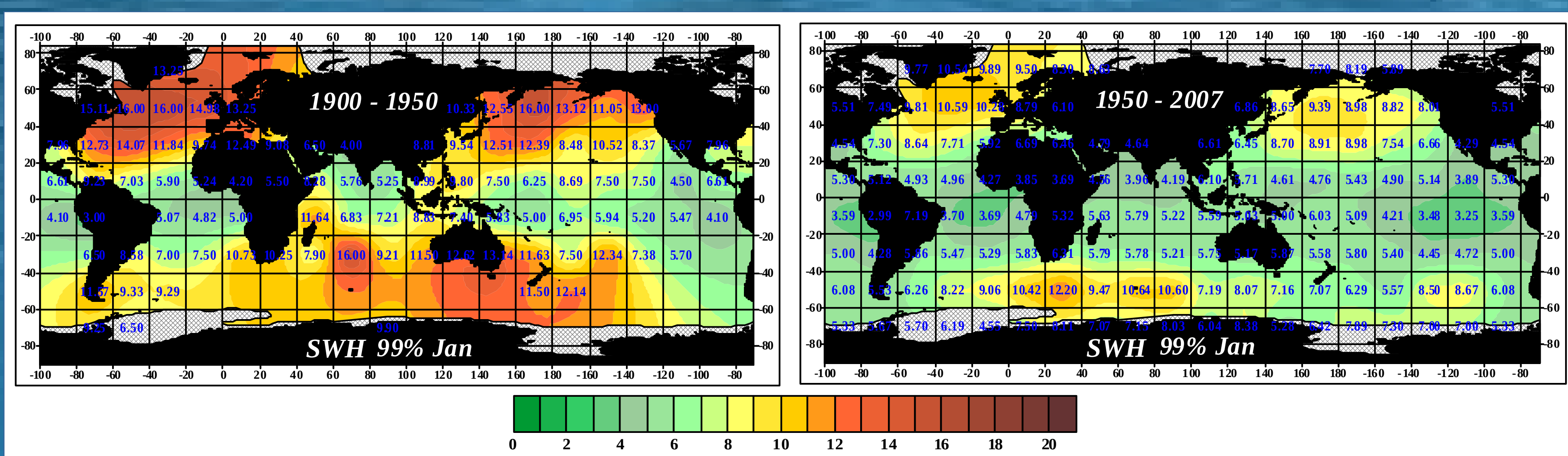
Jan: 17-18 m NA
16-17 m NP
Jul: 16-17 m NA
14-15 m NP
14-15 m SO

SWH

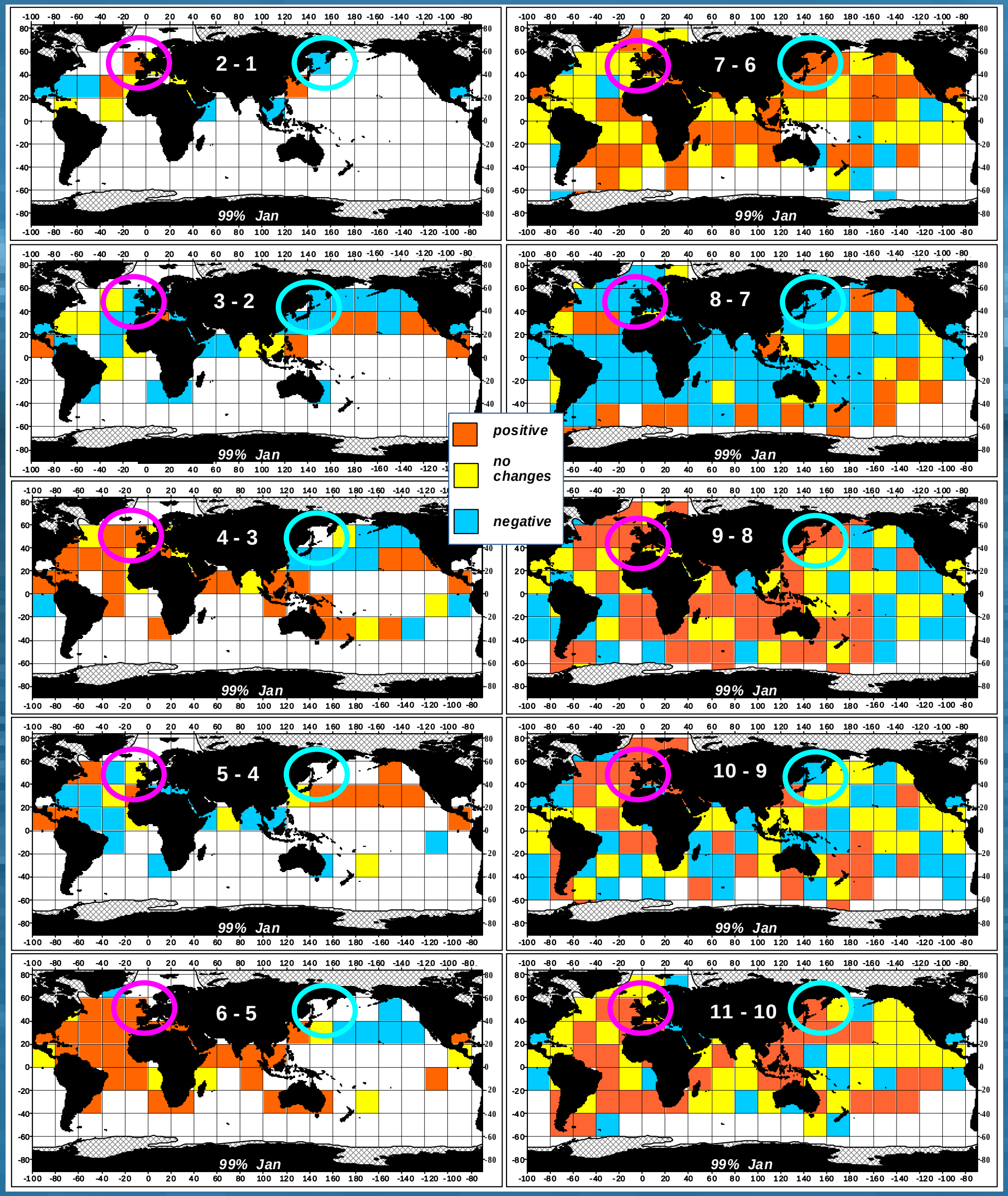
Jan: 22-23 m NA
20-21 m NP
Jul: 17-18 m NA
15-17 m NP
14-16 m SO

SWH extreme
1900 – 2007, 1900-1950, 1950-2007





Interdecadal variability in SWH extremes 1900-2007



90th , 95th , 99th percentiles

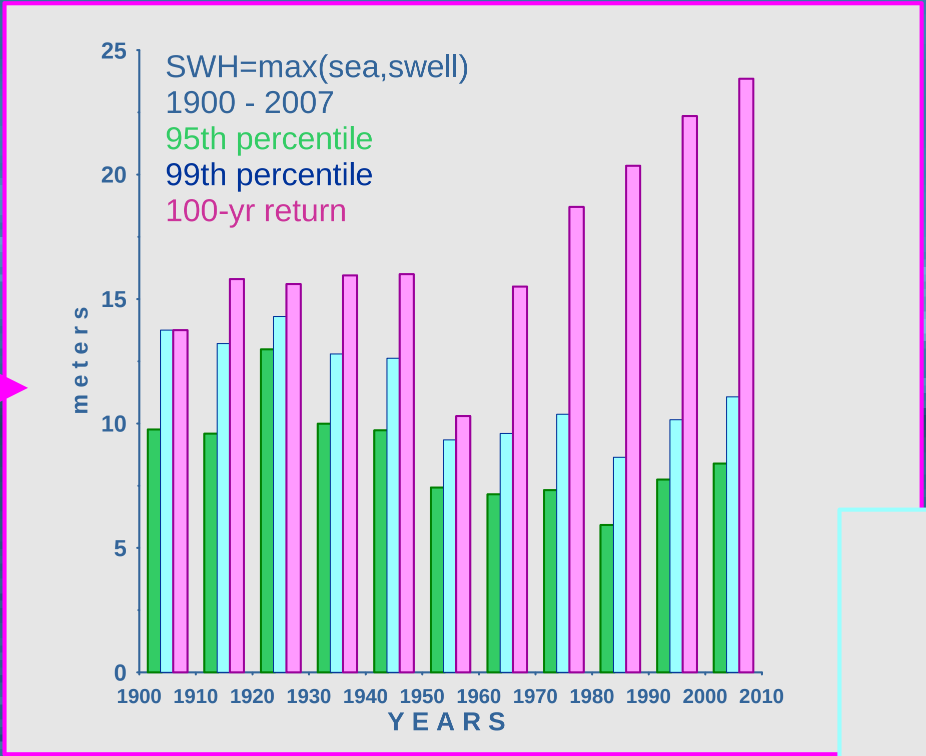
- 1970s > 1960s
- 1970s > 1980s
- weak positive change from decade to decade, especially in well sampled regions
- upward tendency in extreme waves during the last decade in the N-E Atlantic and N-W Pacific

100-yr returns

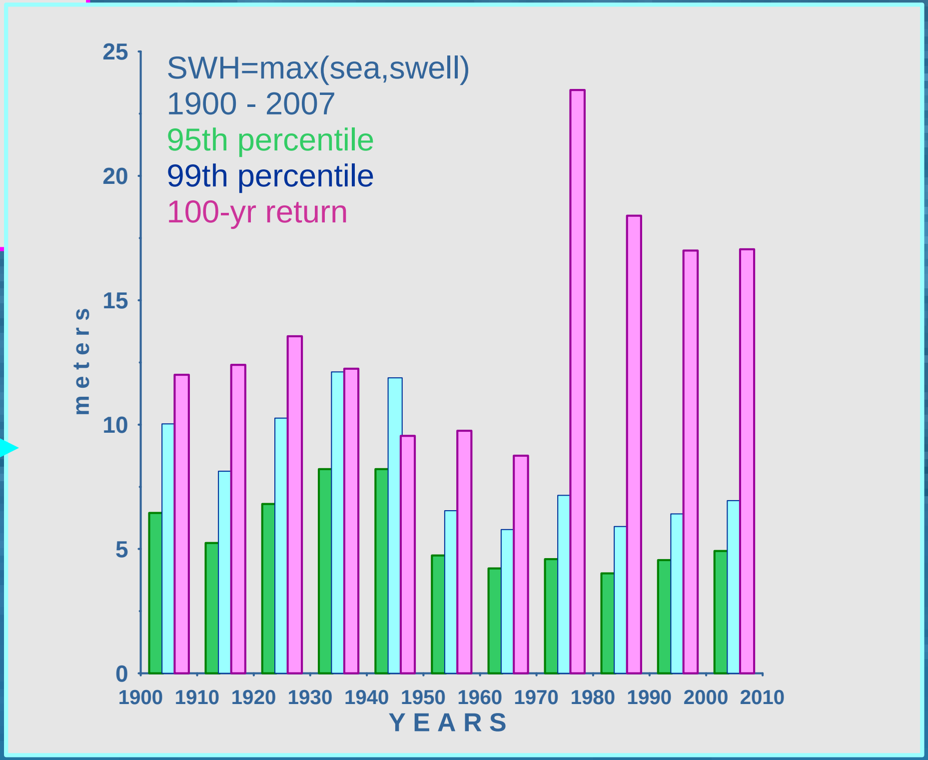
- 1910s > 1920s
- 1920s > 1930s
- 1970s > 1980s
- weak positive trend after 1980
- upward change during the last decade in the N-E Atlantic and N-E Pacific up to 15 cm/dec

Interdecadal variability in SWH extremes 1900-2007

NA



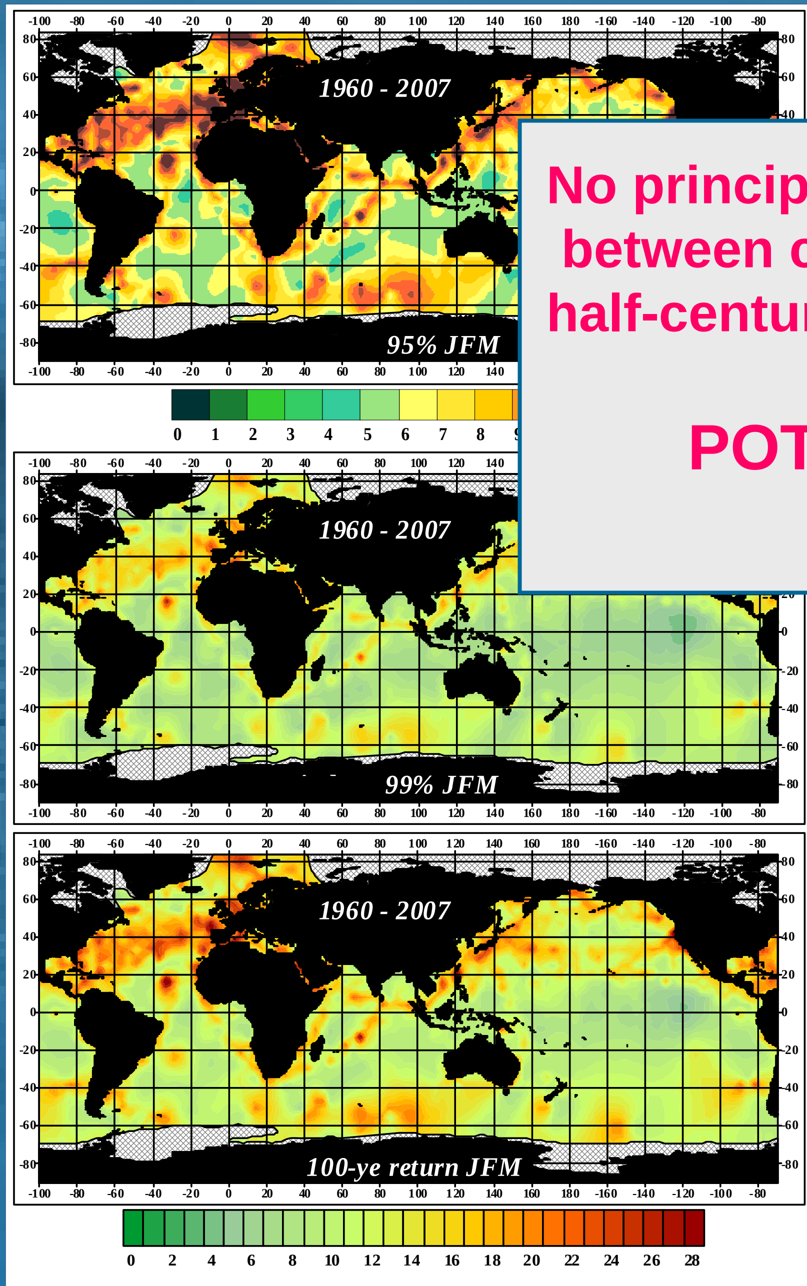
NP



POT methodology 1960-2007, 1900-2007

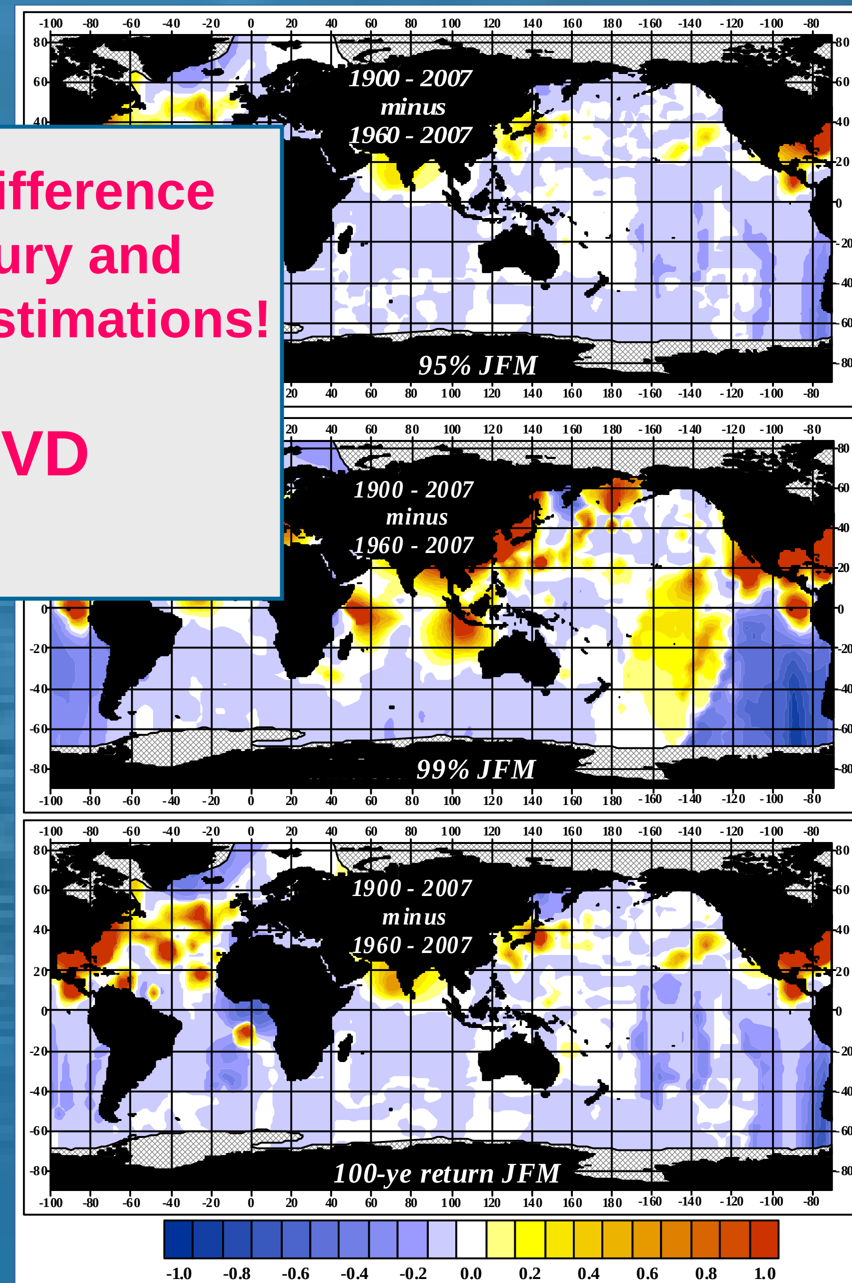
- All data (VOS reports) were converted to the virtual 6-hourly snapshots for 2x2 boxes for every season for all wave parameters (max time series length for e.g. JFM = 124+116+124 = 364). Gaps at fully unsampled time steps – up to 50%.
- Use of the 5-point moving filter for the detection of the storm peaks: equivalent to 12 hrs before and 12 hrs after the storm peak. Threshold for the detection of storm peaks was chosen as a median of time series
- Different types of EVDs were applied to approximate the distribution of peak values.
- Computation of the 90^{th}, 95^{th}, 99^{th} percentiles and 100-yr return values for all wave parameters.
- Similar procedure for 1900-2007 for SWH=max(sea,swell). Comparison of the estimates of extremes for different thresholds (50^{th}, 75^{th}, 90^{th} percentile)
- Comparison with estimates derived from WAM

POT extremes 1960-2007, 1900-2007 (SWH)

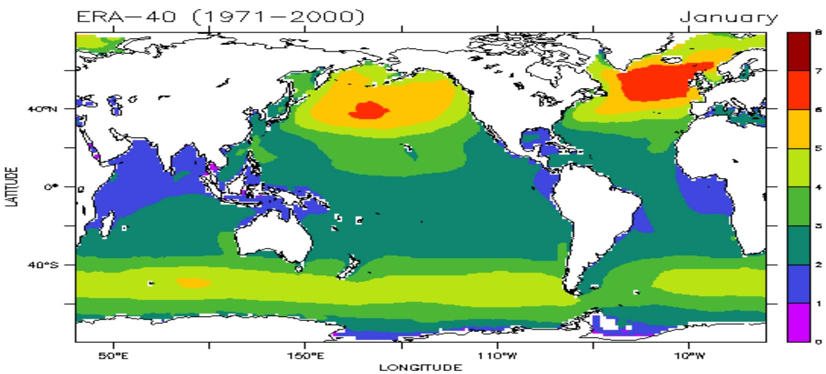


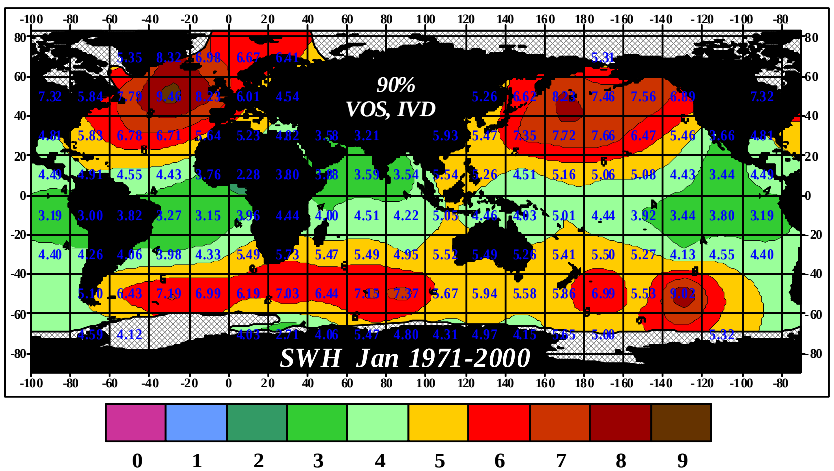
No principal difference between century and half-century estimations!

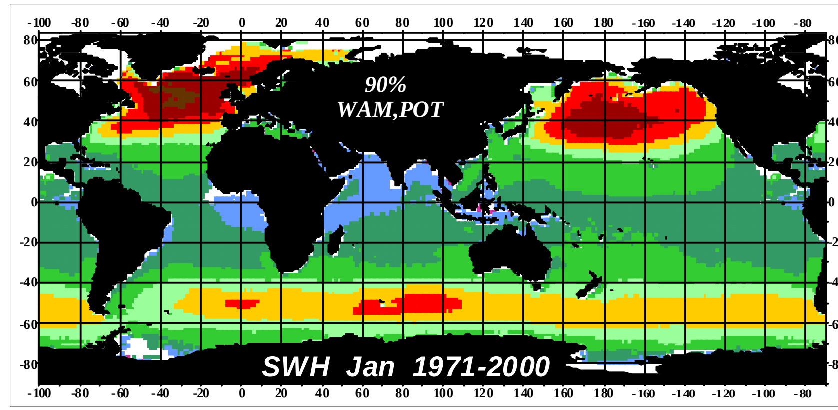
POT > IVD

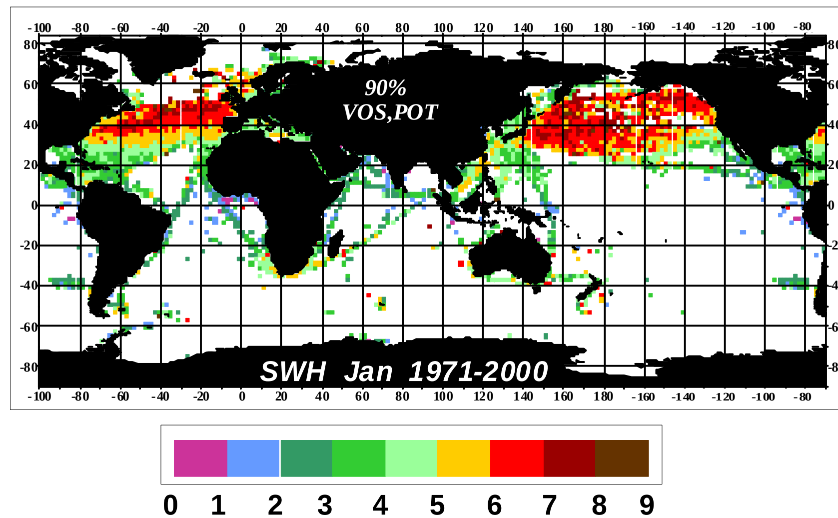


VOS and WAM compare



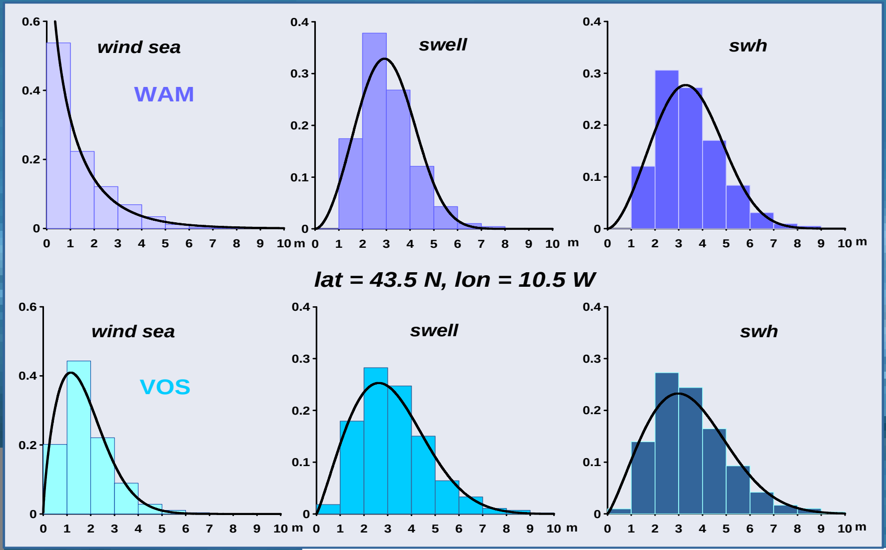






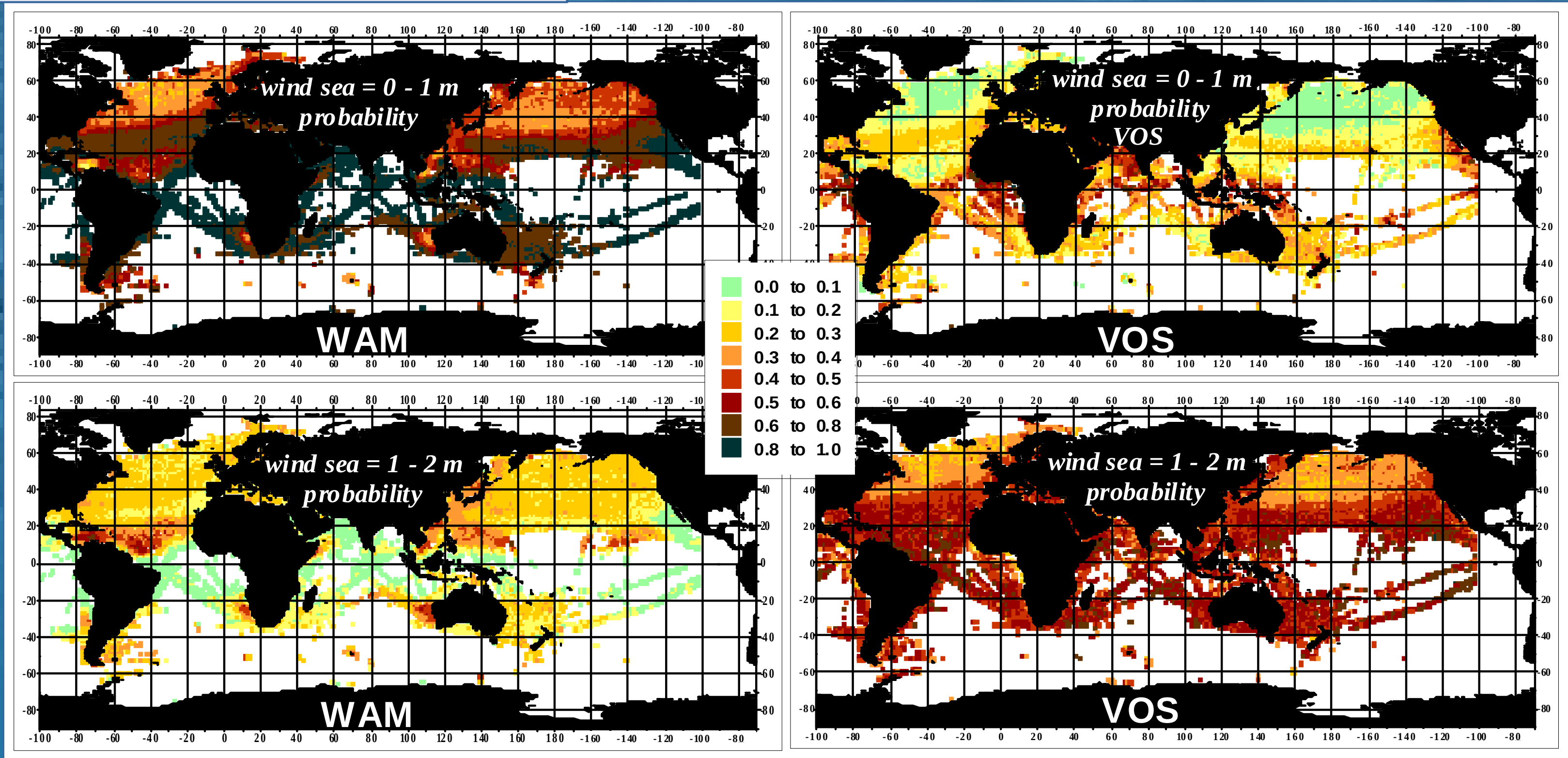
Derived extreme waves from VOS are larger than those from ERA-40-WAM hindcast

Possible reasons for VOS-WAM differences

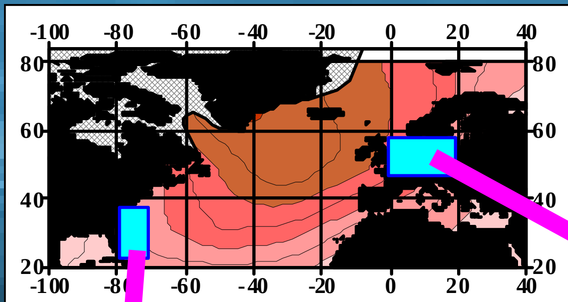


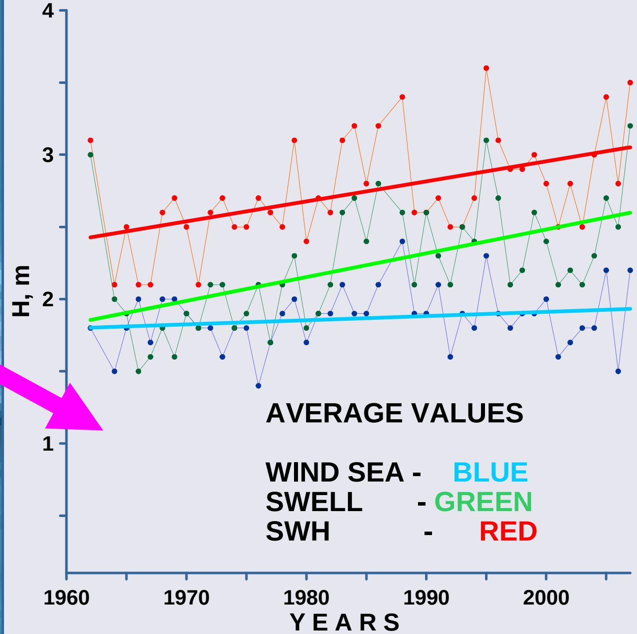
The major differences in the initial distributions of sea between WAM and VOS are identified over the Equator.

A better agreement is found for the swell distributions as well as for SWH



Regional climatologies (coastal areas)





JFM

IVD (ALL DATA) num = 25790

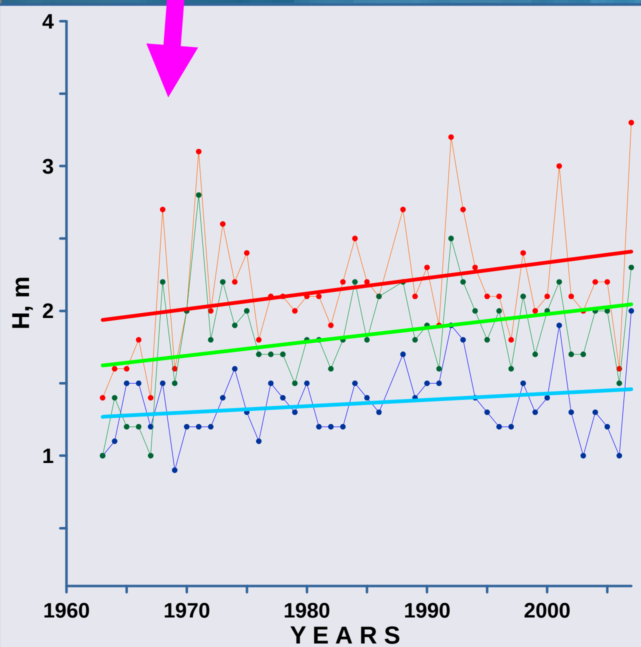
	P90%	P95%	P99%	100-ye
SEA	2.5	2.9	3.9	6.0
SWELL	3.4	4.1	5.4	8.2
SWH	4.1	4.8	6.4	9.4

POT (STORM PEAKS)

	num	P90%	P95%	P99%	100-ye
SEA	6800	3.9	4.6	6.0	10.2
SWELL	6606	5.0	5.9	7.9	14.5
SWH	6968	5.9	7.0	9.1	15.8

RAW

	P95%	P99%	100-ye
SEA	5.0	7.2	11.4
SWELL	5.9	8.6	15.3
SWH	7.4	10.4	16.5



JAS

IVD (ALL DATA) num = 57982

	P90%	P95%	P99%	100-ye
SEA	1.7	2.0	2.6	4.6
SWELL	2.5	3.0	3.9	7.0
SWH	2.9	3.5	4.5	7.9

POT (STORM PEAKS)

	num	P90%	P95%	P99%	100-ye
SEA	12266	2.8	3.2	4.2	7.2
SWELL	12869	3.9	4.7	6.2	11.1
SWH	13752	4.5	5.3	7.0	12.3

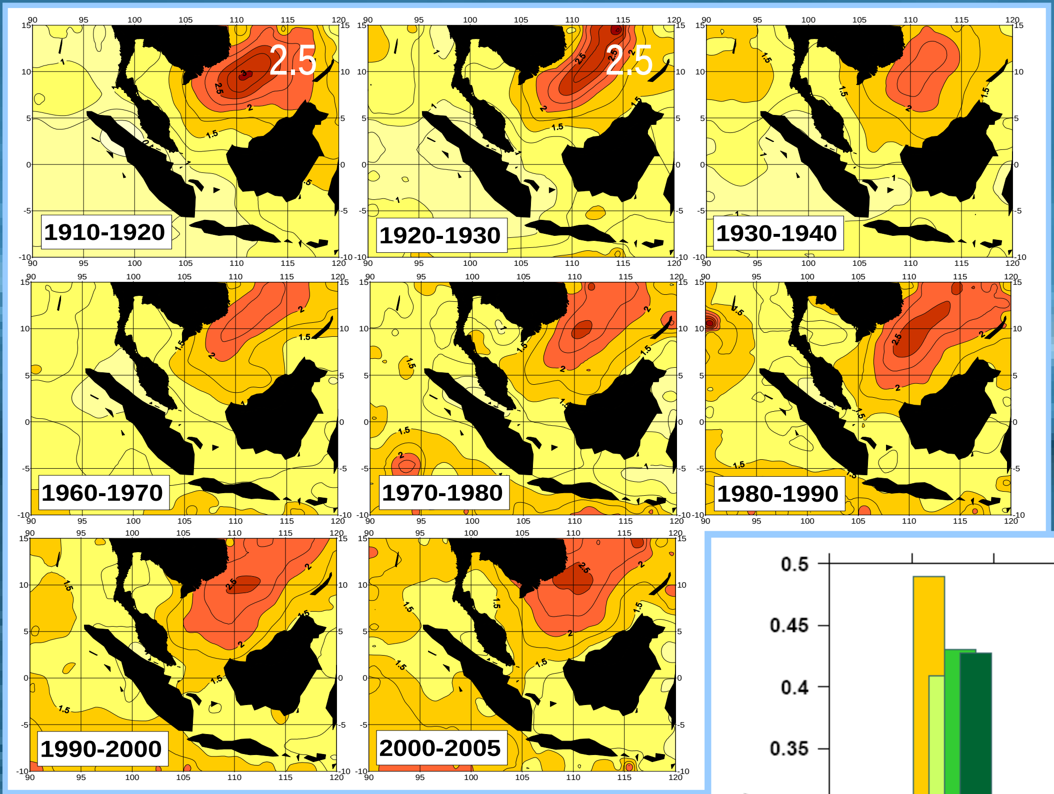
RAW

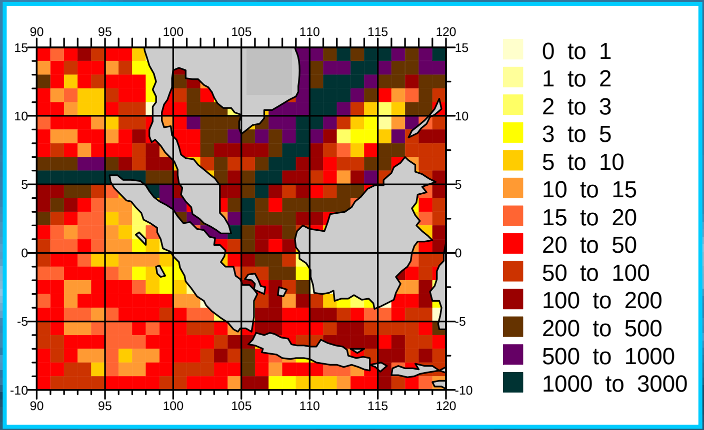
	P95%	P99%	100-ye
SEA	2.6	3.7	7.2
SWELL	3.6	5.3	11.7
SWH	4.2	6.0	12.1

Well sampled regions allow for comparisons of different methods of extreme wave estimation
POT, raw data-based, IVD

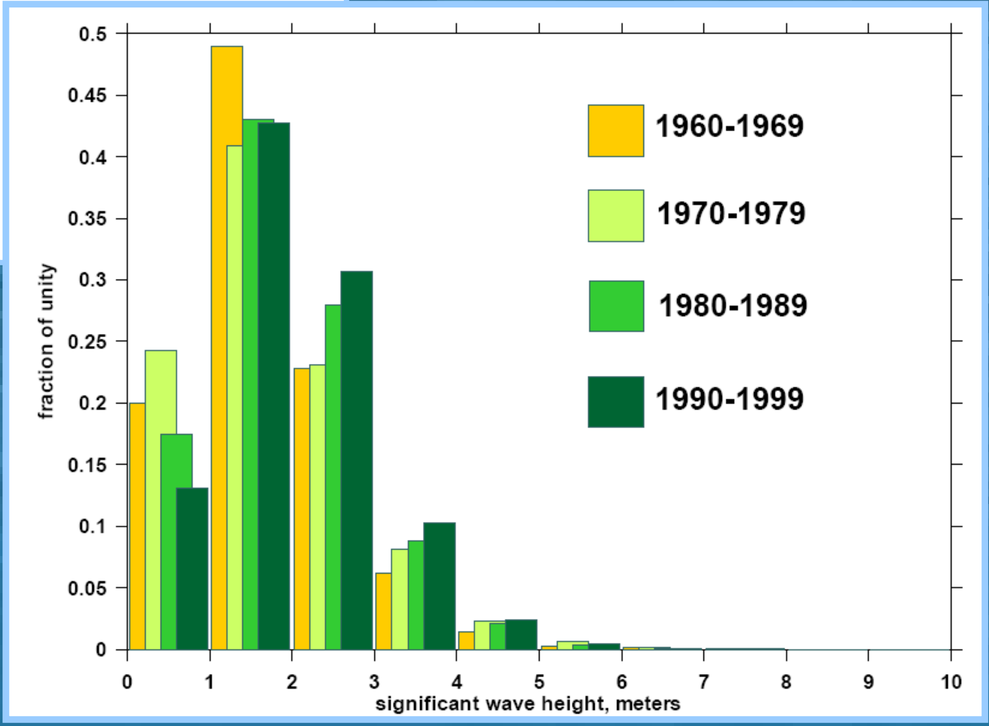
Weak positive trends in the wind sea, swell and SWH

Best sampled ship route in the world: 1910-2005

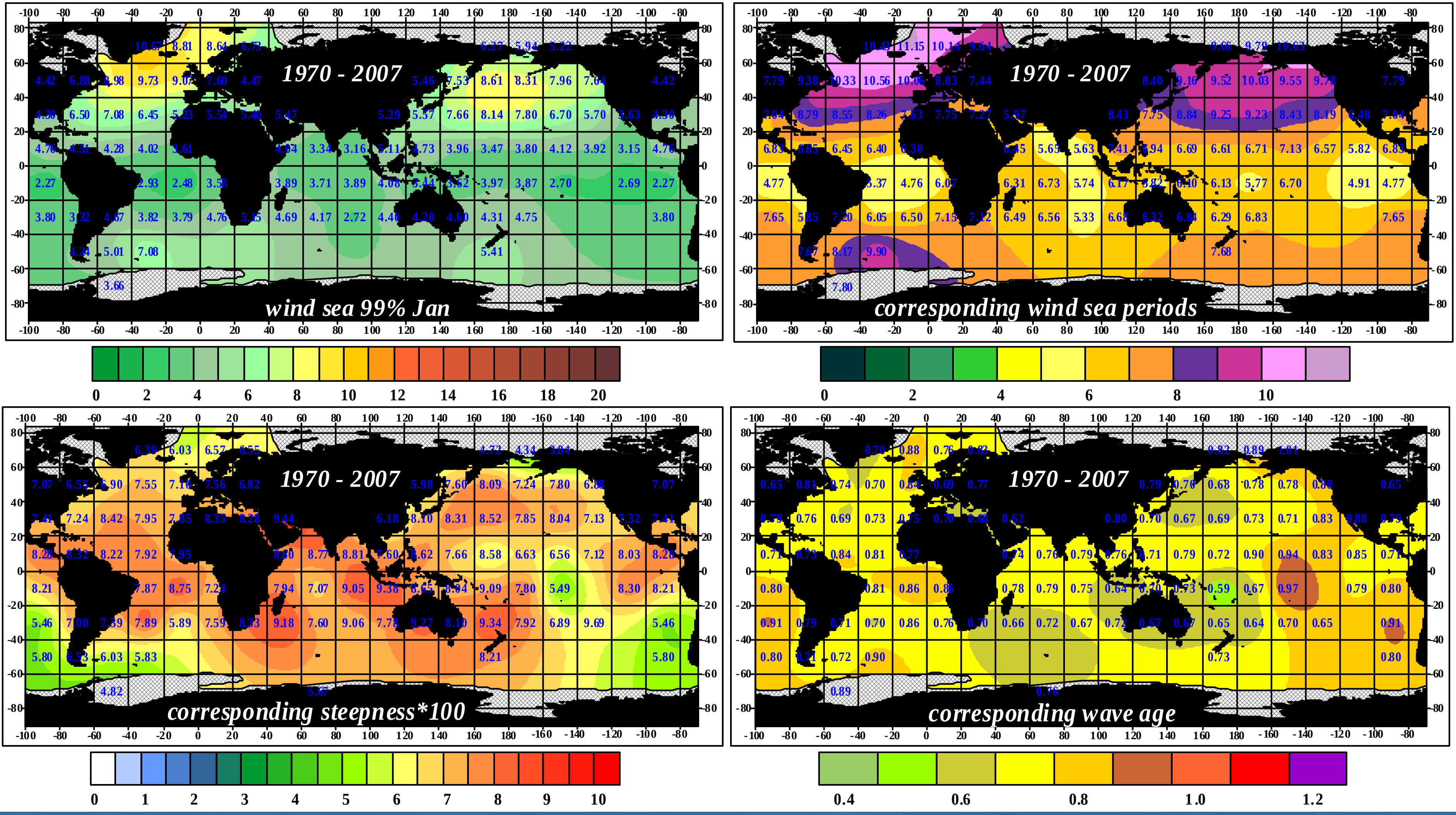




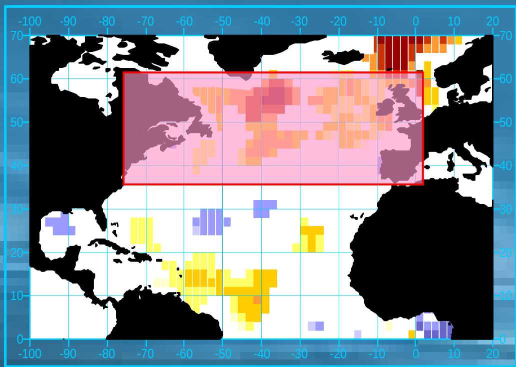
Interdecadal changes in probability distributions of SWH

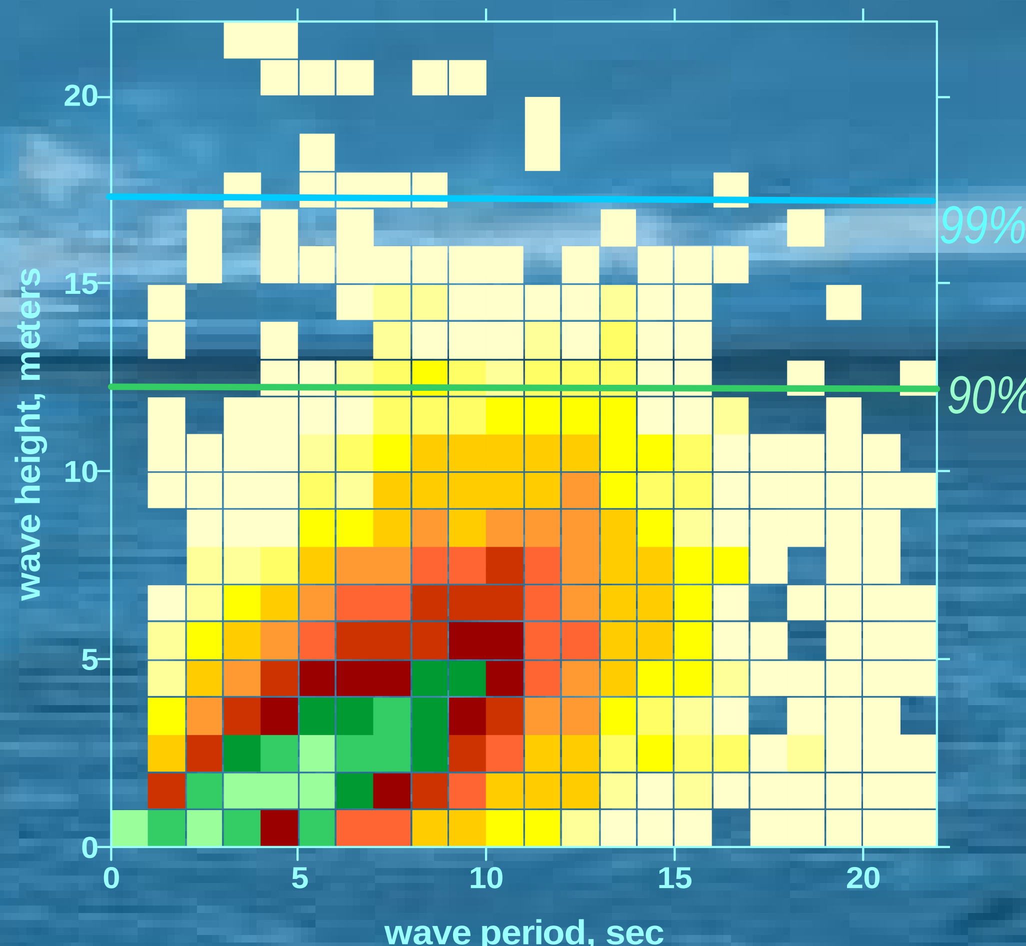


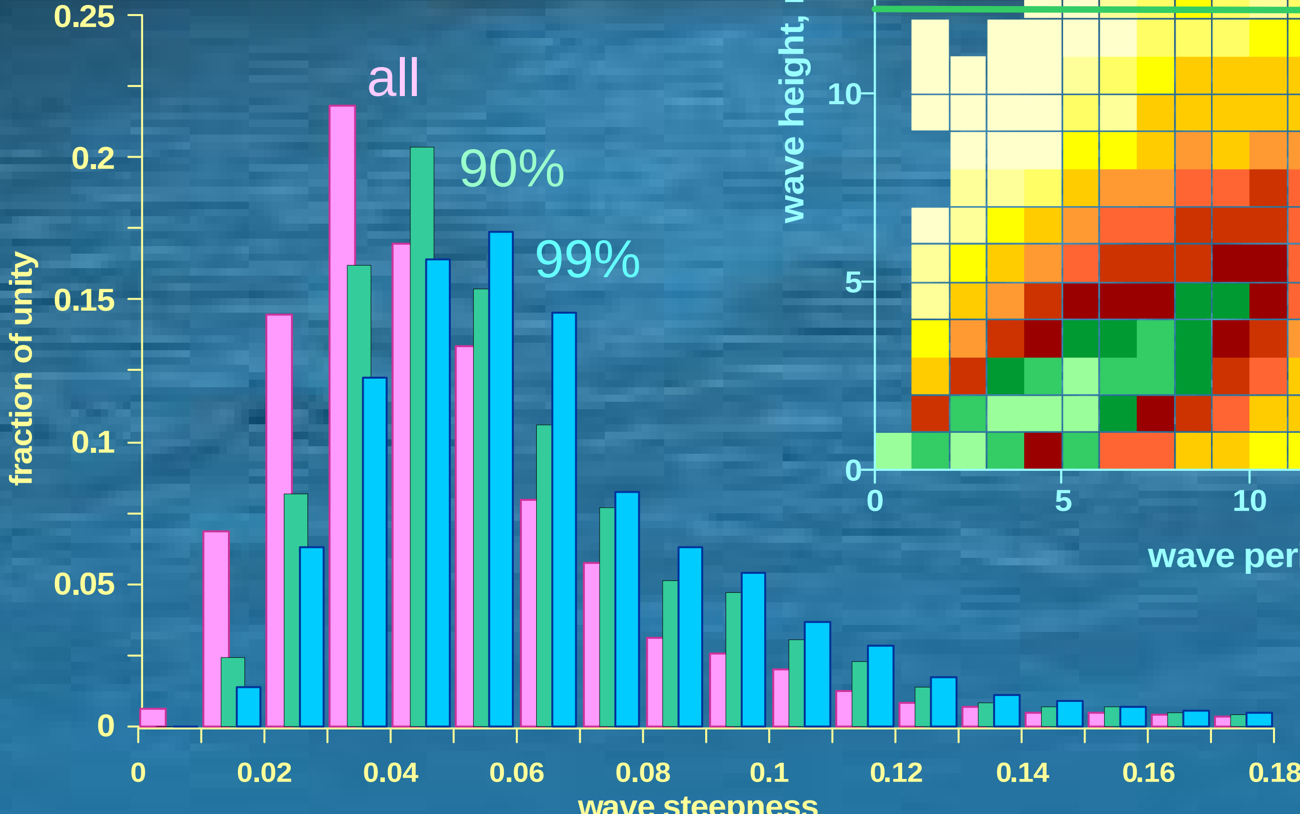
Wave geometry characteristics: 1970-2007



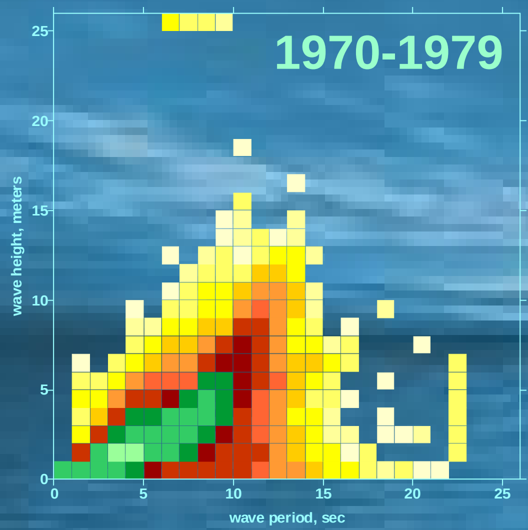
Are the extreme waves more steep?

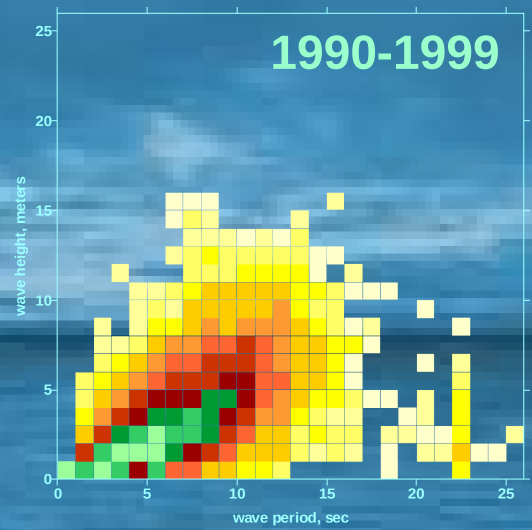


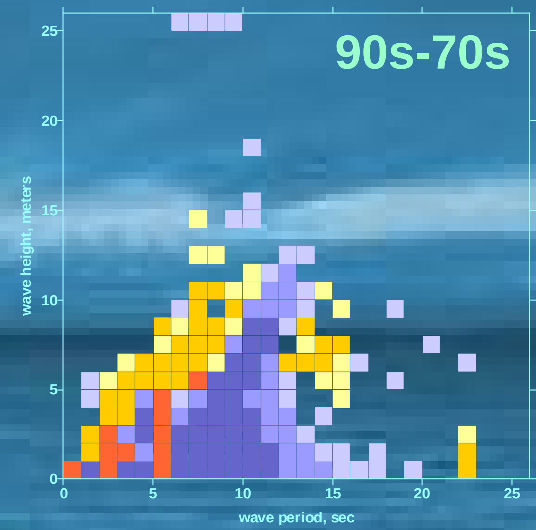


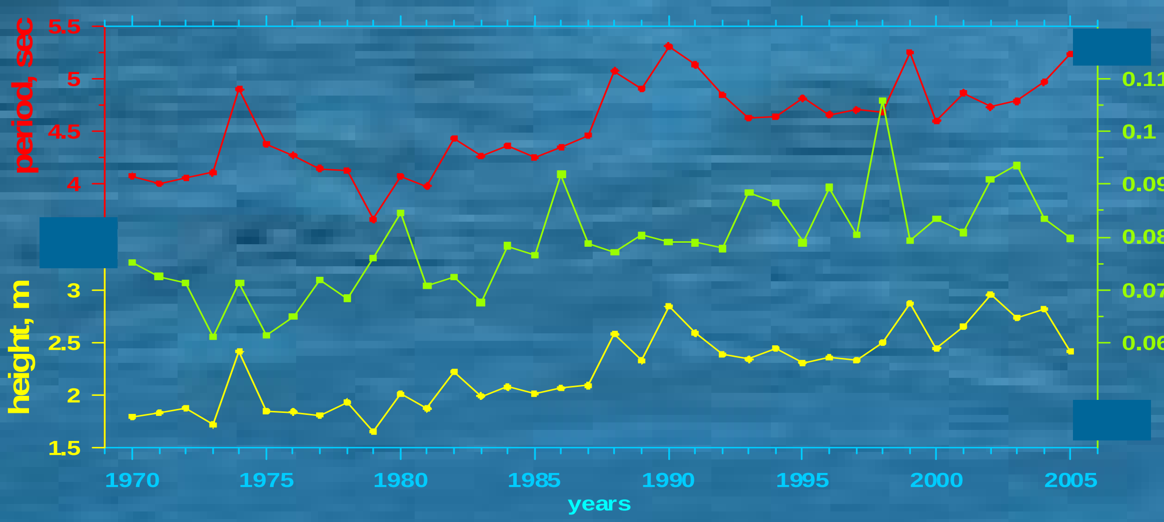


Changes in 2D height-period distributions

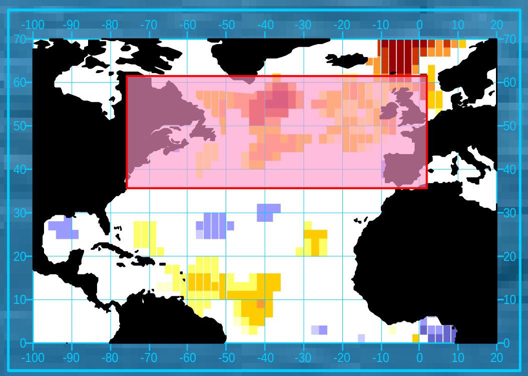








NA winter time series



Conclusions:

Visual wave observations from VOS provide good prospect for estimation of mean and extreme waves with both IVD and EVD approaches

Extreme wave heights computed using POT method are generally higher compared to those from IVD method. POT-based estimates from VOS are close to the estimates obtained from the model hindcasts.

Interdecadal variability in extreme waves (1900-2007) shows weak positive changes from decade to decade, especially in well sampled regions

We are waiting for the next updates of the ICOADS-data (2008+)


THANKS FOR YOUR
ATTENTION