Estimation of climate variability of wind wave extremes from the VOS data: using model hindcasts for validation

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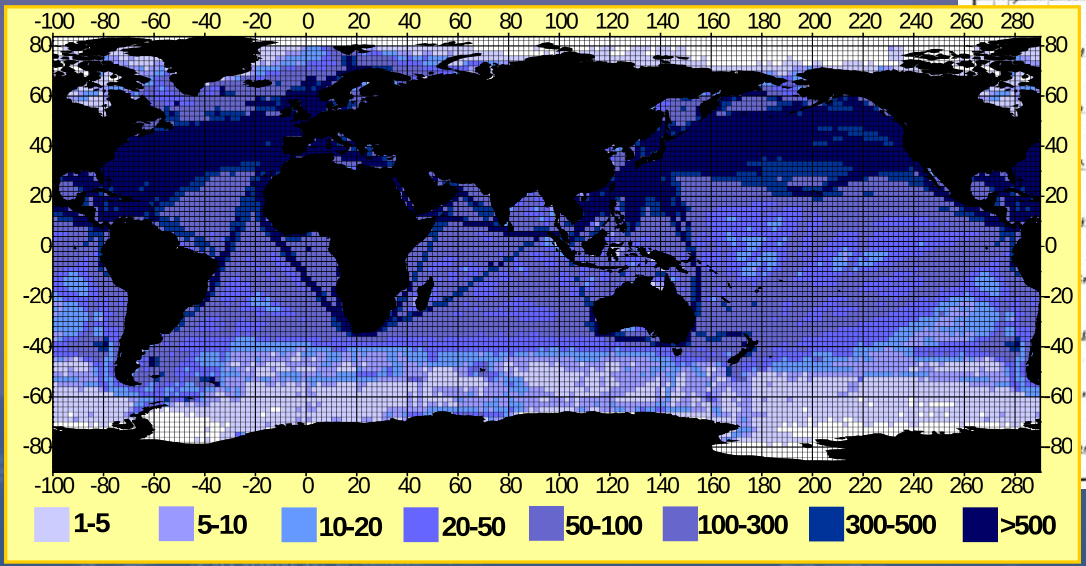
- Visual wind wave data from VOS: the longest homogeneous records of marine storminess
- Derivation of extreme waves from VOS: IVD (importance of removing of massively reported 24.5 (16) meter waves
- EVD: Sub-sampling of WAM to derive parameter estimators for censored samples
- Using homogenized wave time series: changes in extreme wave height: Pacific vs Atlantic

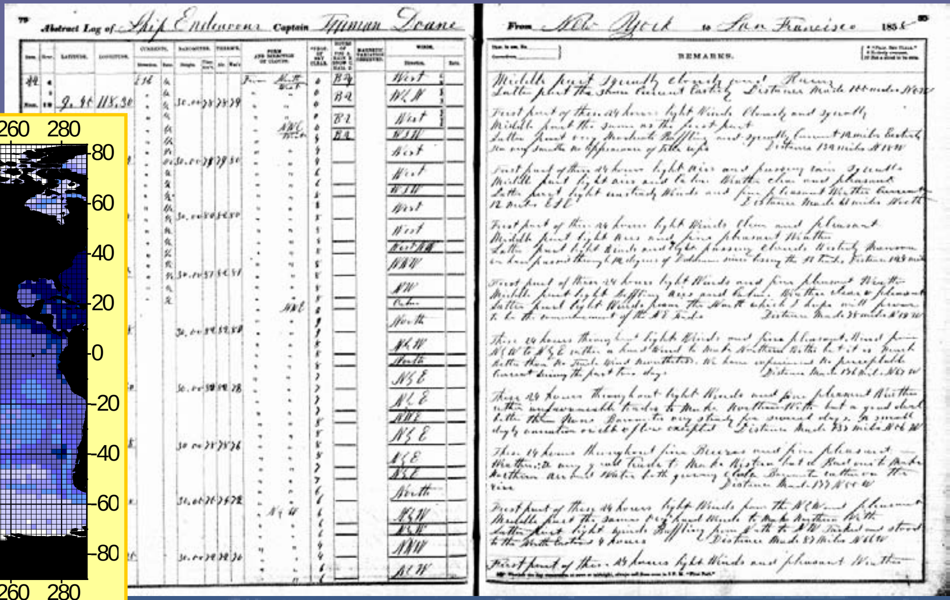
Conclusions:

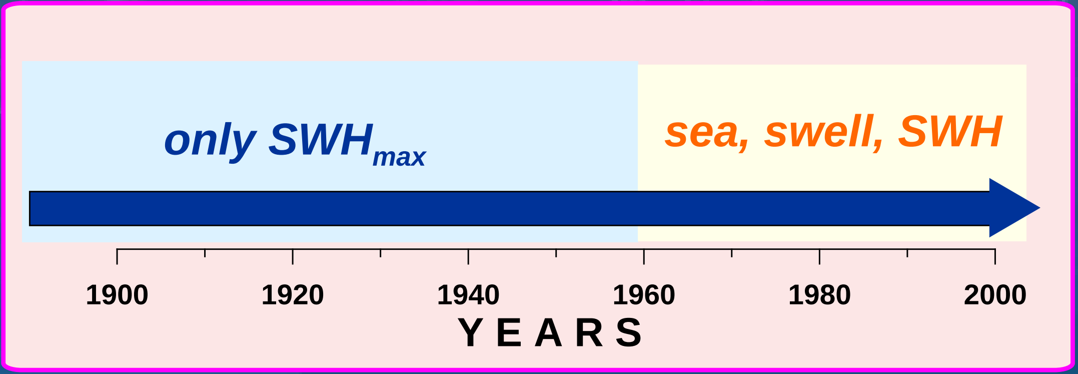
- Estimation of extreme waves from VOS can be influenced by the profound contribution of highest possible waves (need for accurate decoding)
- IVD and VOS: underestimation of extreme waves by about 25%
- EVD: Model hindcasts give a good prospect for merging the advances of VOS data and regular sampling in model waves – technique for estimation of EVD parameters from censored samples
- EVD give maxima 100-yr return value of SWH of 24-27 m in the Atlantic and 22-24 m in the Pacific (likely a bit high)
- Extreme waves revealed by VOS data show quite evident decadal variability. Decadal changes in the extreme SWH and wind sea are not correlated in the Atlantic and are closely correlated in the Pacific

Visual wave observations: 1856 - onwards

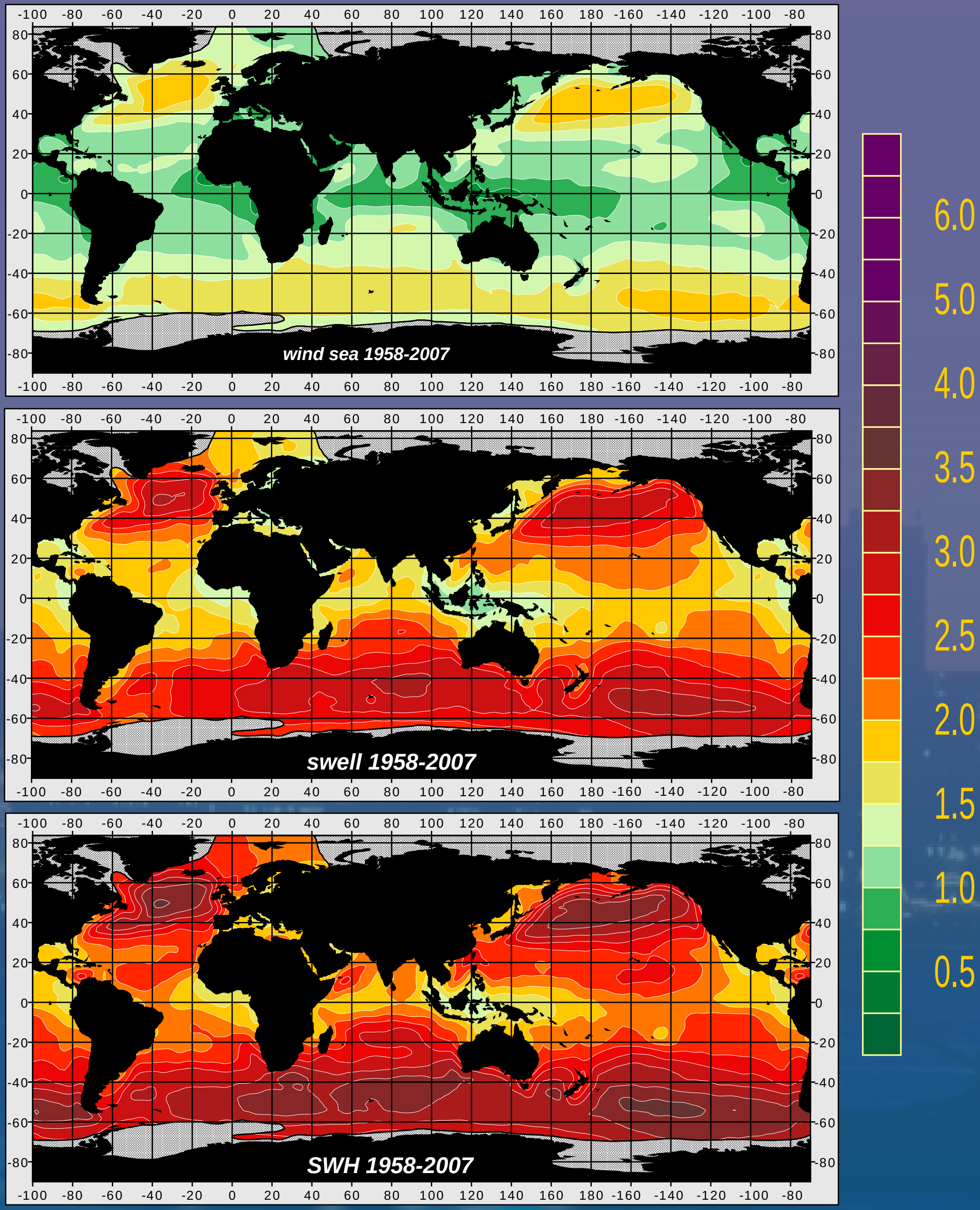
2 streams of data:
(1856-1958) and (1958-2005)







- Observational practice has never been changed
- Coding systems have been changed several times, while documented
- Assimilated in ICOADS



1958-2007 climatology:

- small waves
- separation sea/swell
- SWH
- true wave direction
- day/night estimates

Estimation of wave extremes from VOS

1. **Taking a maximum:**

problem of the code figures *9 (12 m or 16 m)* (before 1963) and *49* (24.5 meters) after 1963:

(i) the maximum is prescribed, (ii) it is finite, (iii) it is too frequently observed (up to 0.15% of all reports)

Coding systems:

1904 (Hydrographic Office No. 1190), 1906, and 1908 (US Weather Bureau "Circular M, 2nd edition") - descriptive

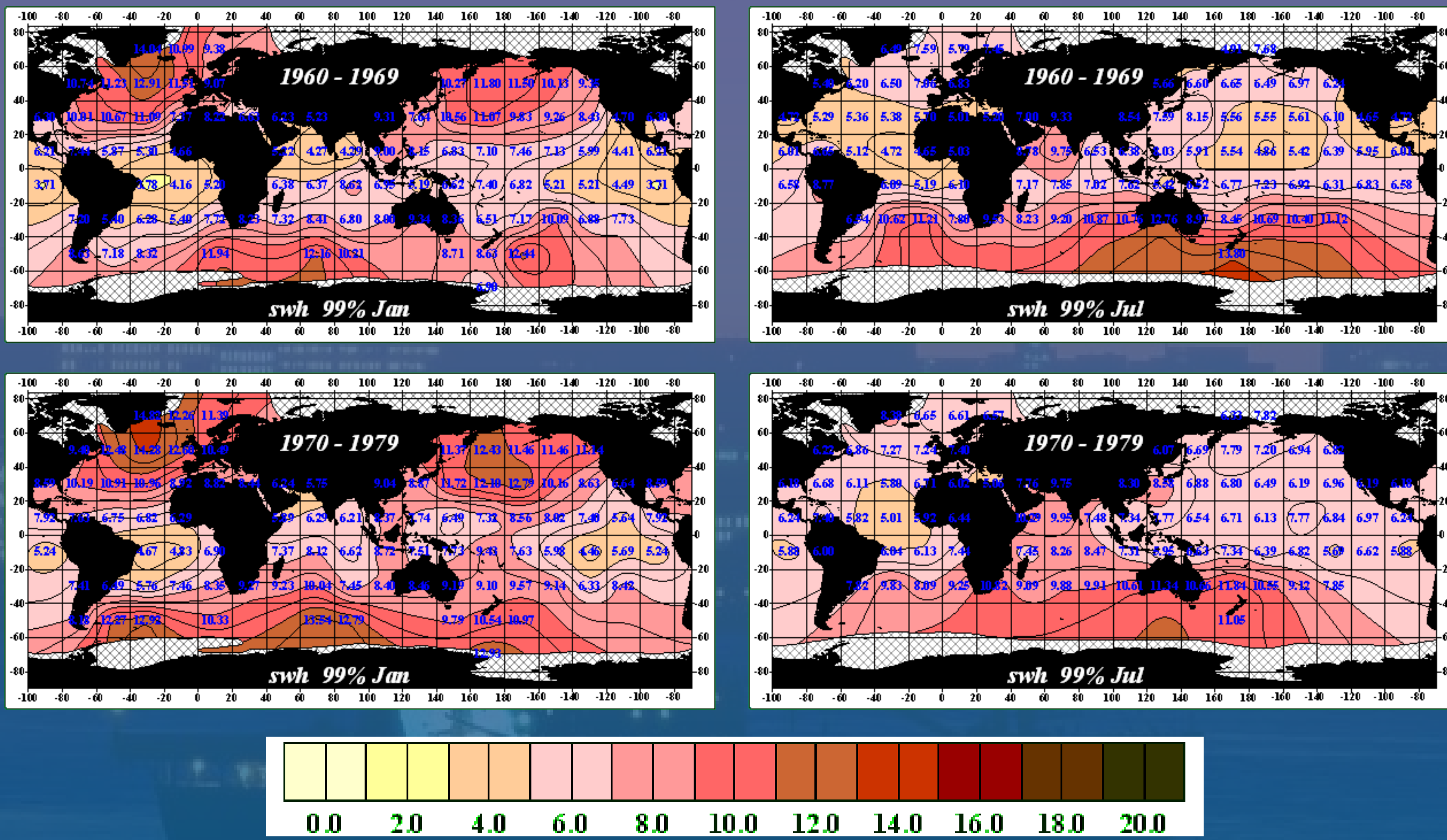
The Original Reference Manual of 1917 - 0-9 scale in feets

1925 US instructions (Circular M, 4th edition): a 0-9 scale is used

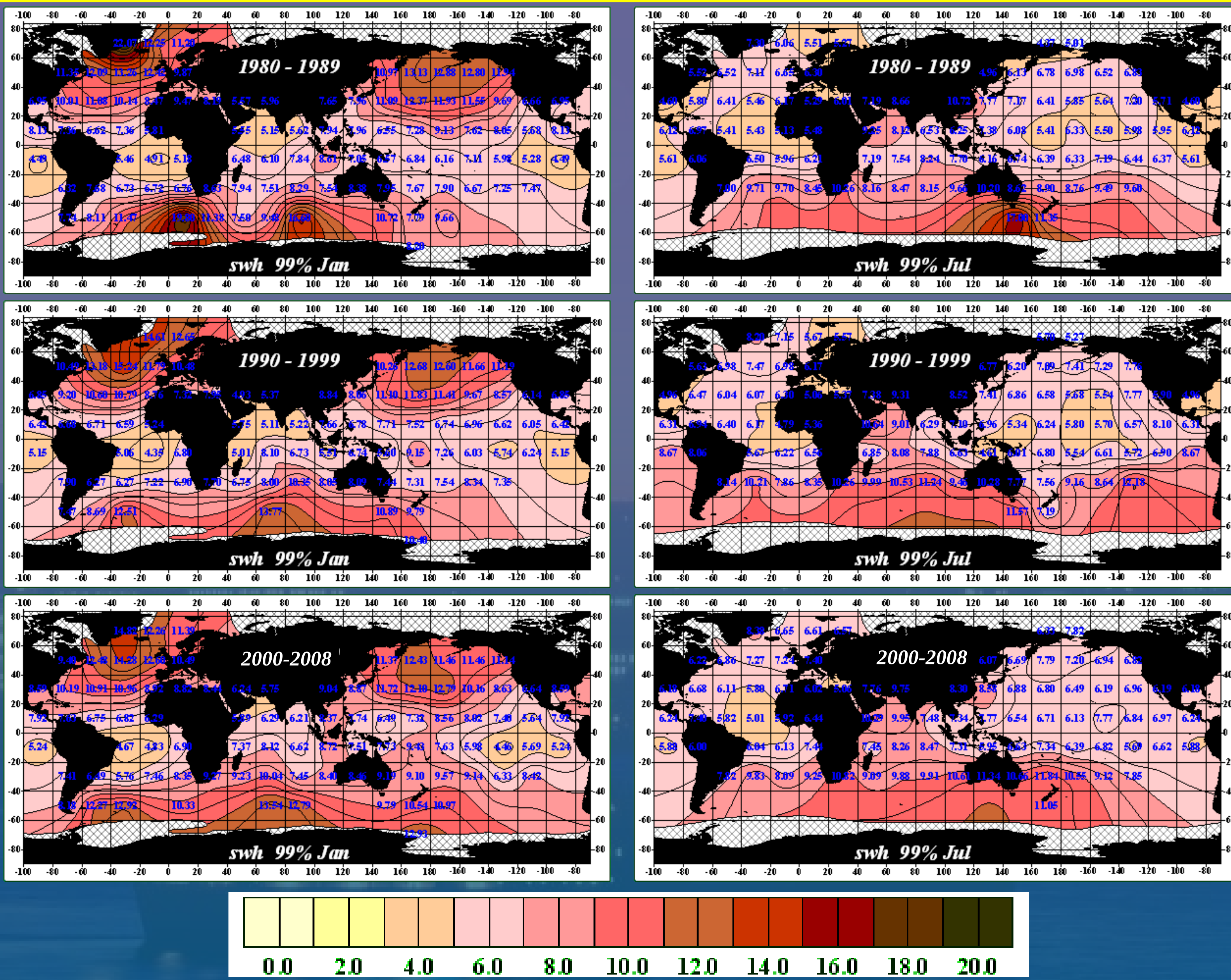
1963 WMO Manual on codes: 1-49 (0.5 meter increments)

Estimation of wave extremes from VOS

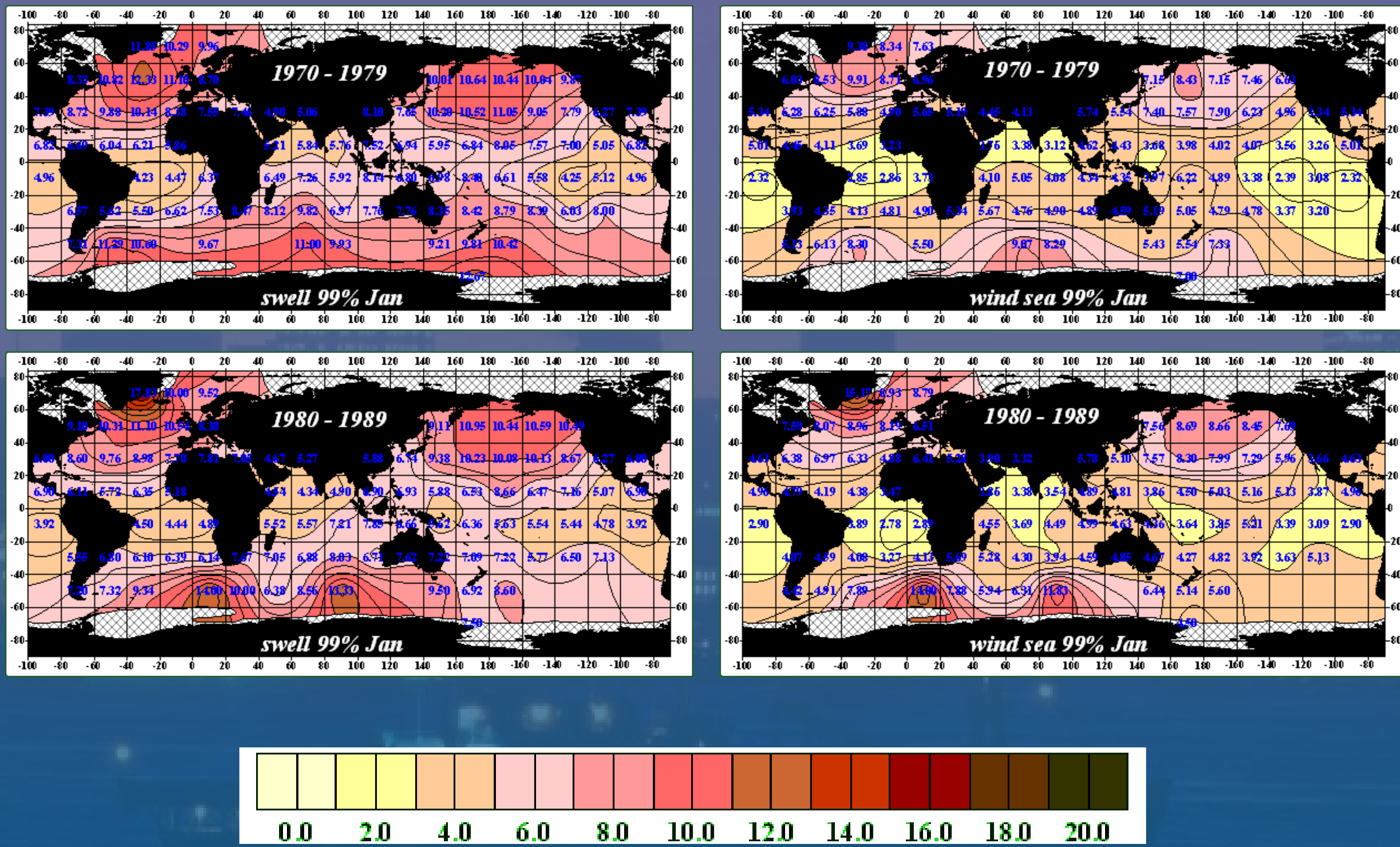
2. Excluding all code figures “49” and apply initial value distribution method



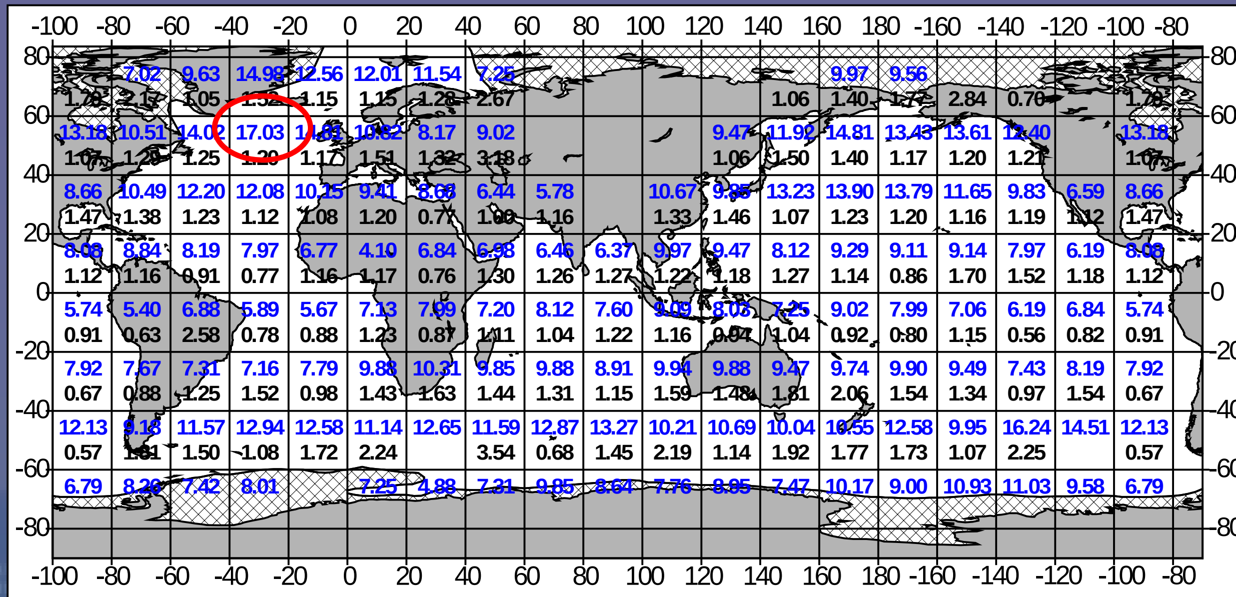
Estimation of wave extremes from VOS: IVDM



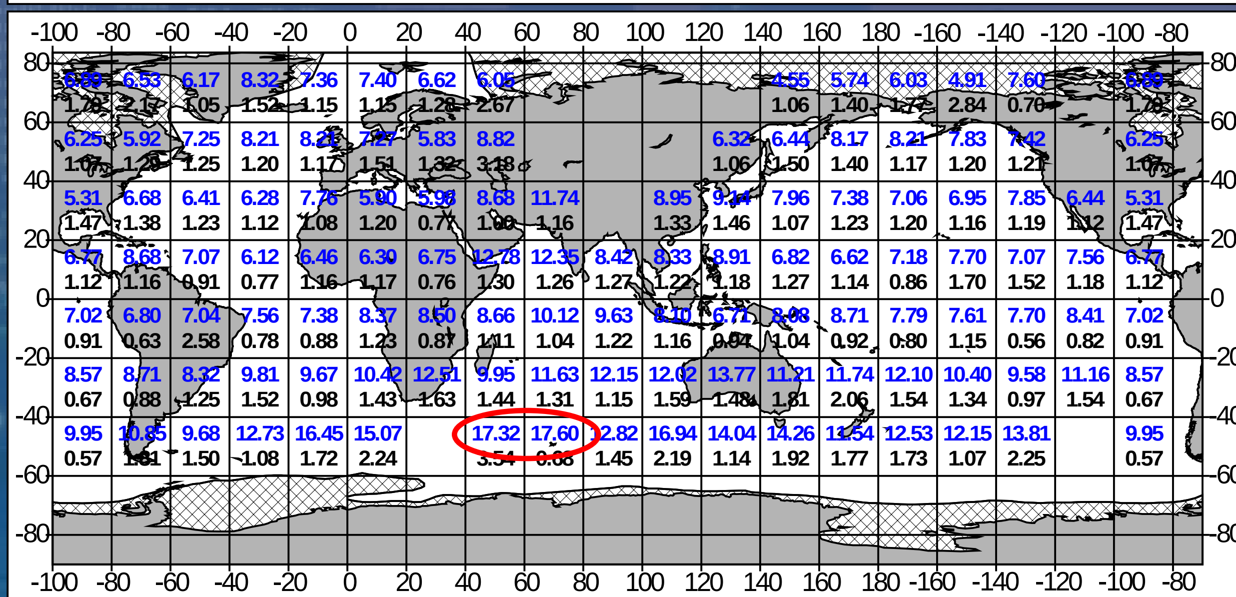
Estimation of wave extremes from VOS: IVD – sea and swell extremes



VOS 100-yr returns: IVDM



Winter



Summer

VOS data and POT: problems of application

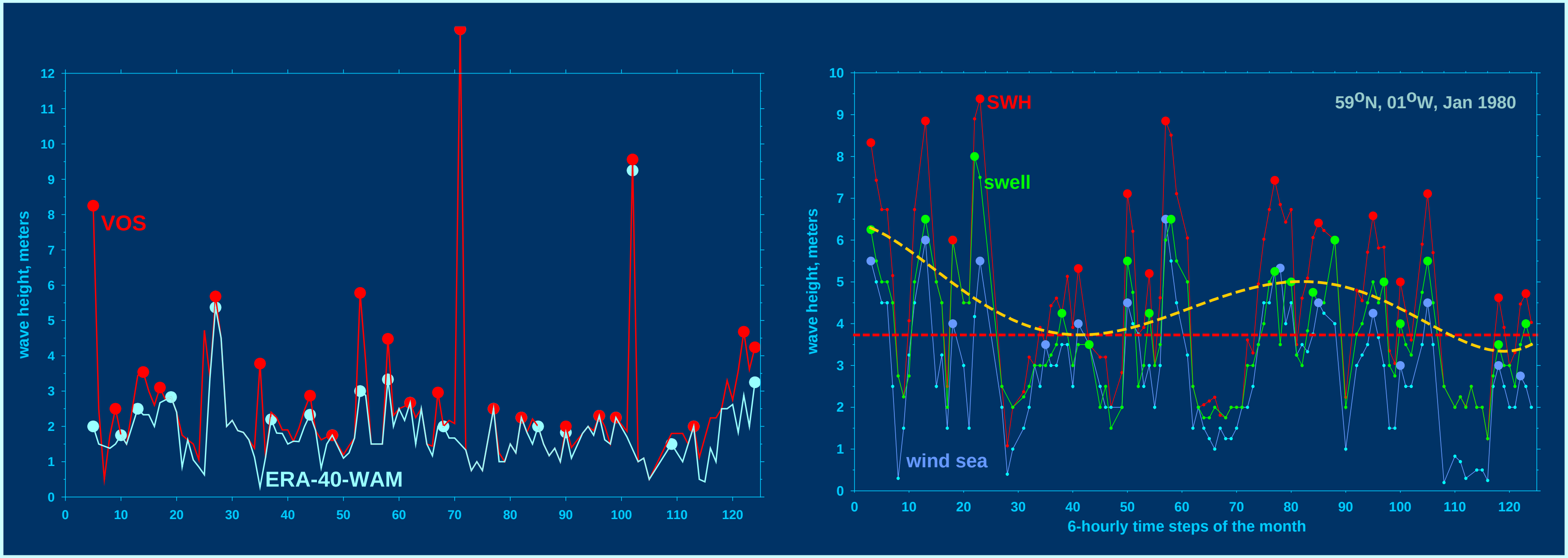
VOS data may not necessarily report the highest exceedances =>

but the distribution of any exceedance = probability of the largest

VOS data are influenced by sampling uncertainty =>

Undersampling results potentially in underestimation of extremes

- Use WAM hindcast (1958-2002) to simulate VOS sampling density
- Estimate EVD from the original and sub-sampled WAM
- Build up the transfer function for EVD based on full sample
- Define threshold using storm durations estimates and moving 40-day period
- different EVDs are fitted to the storm peak values (medians of them if several reports are available for 2-degree cell)



EVD: $$P(x) = -(\alpha \cdot \beta) \cdot \exp(\beta x) \cdot \exp\left[-\alpha \cdot \exp(\beta x)\right], \quad \alpha > 0, \beta < 0$$

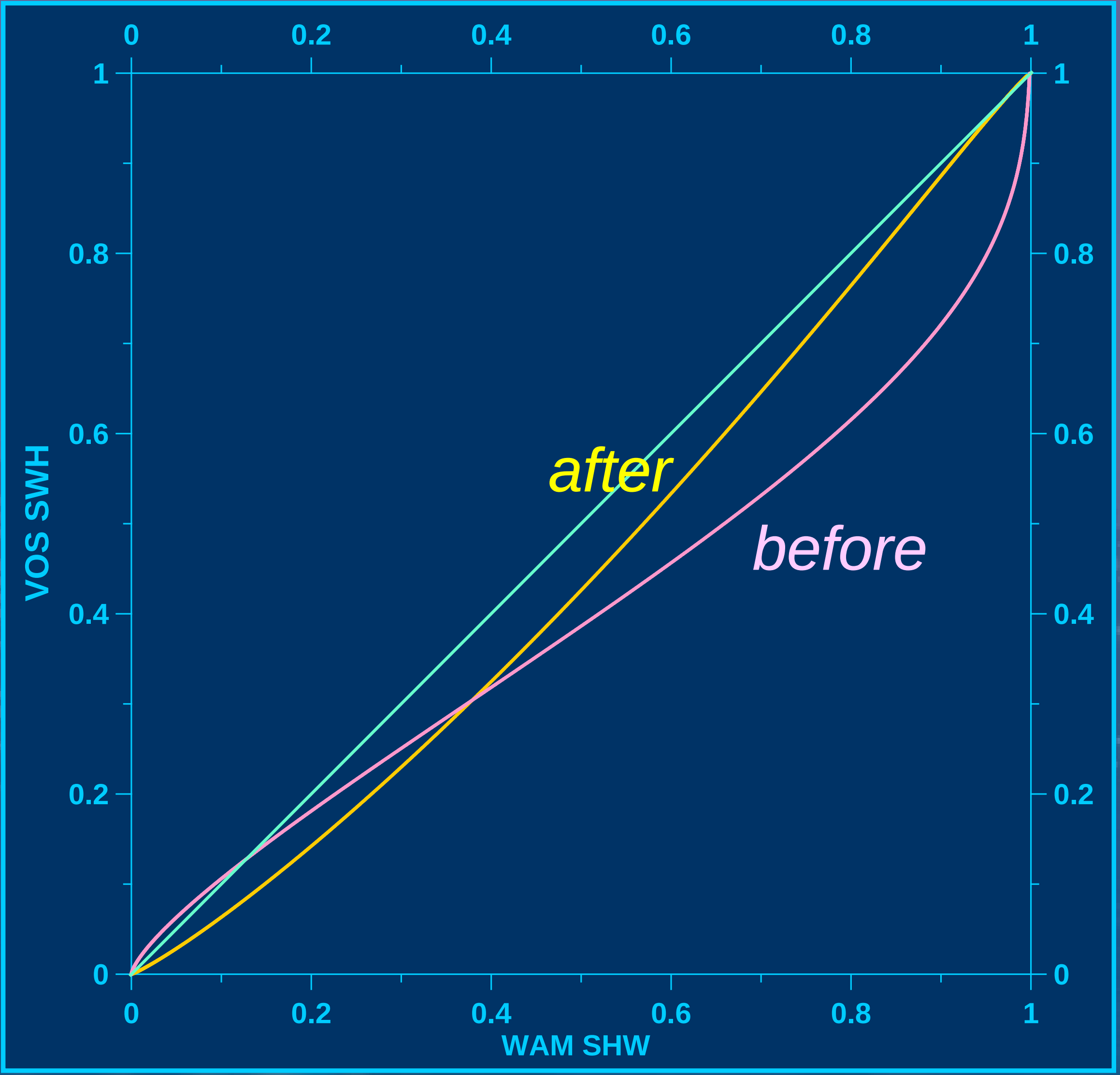
$$\frac{n}{\beta} + \sum_{i=1}^{n} x_i - n \Big/ \sum_{i=1}^{n} e^{\beta x_i} \cdot \sum_{i=1}^{n} x_i e^{\beta x_i} = 0; \quad \alpha = n \Big/ \sum_{i=1}^{n} e^{\beta x_i}$$

full sample

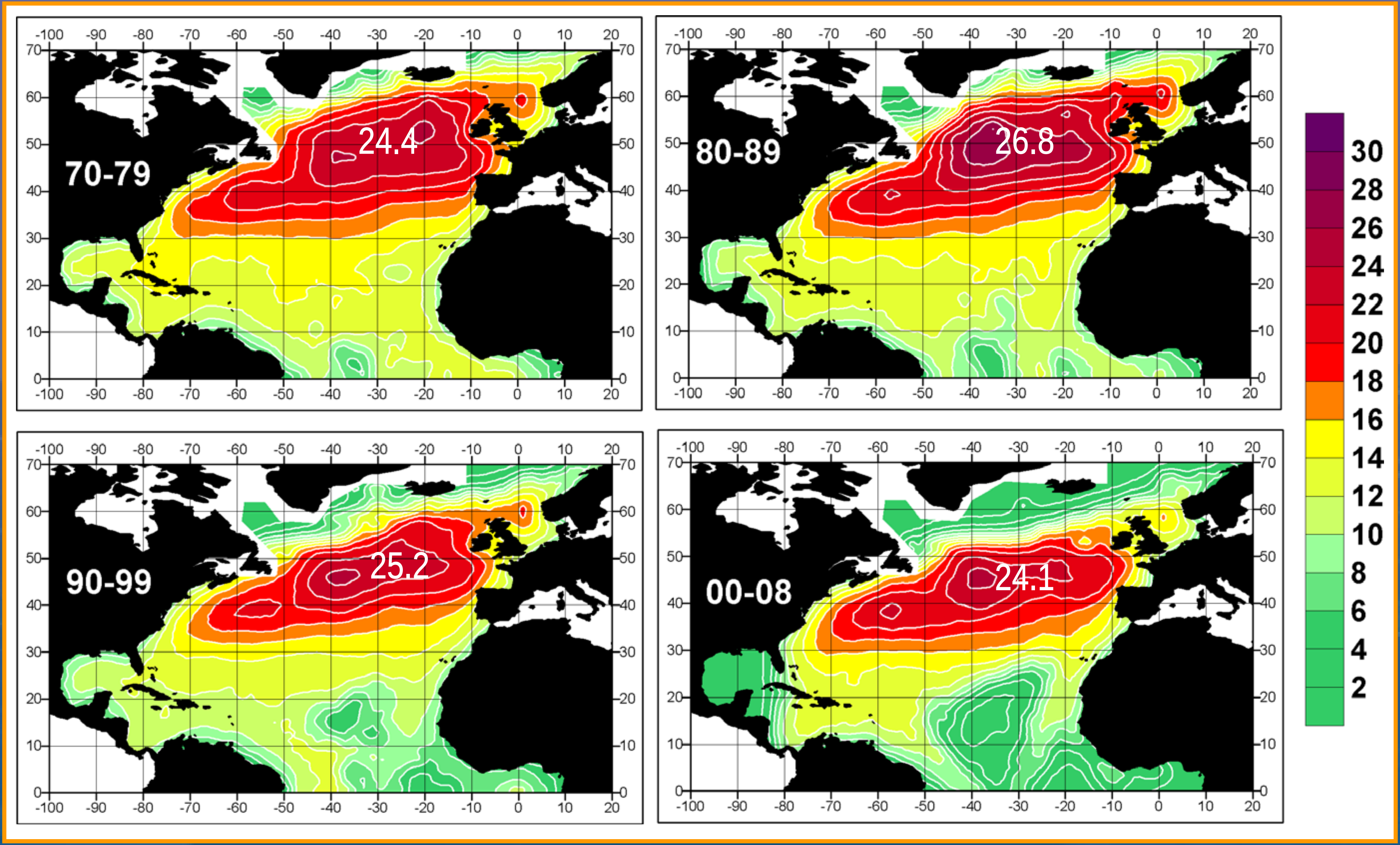
$$\frac{n}{\alpha} = n_1 + \sum_{i=n_1+1}^{n} \exp(-\beta x_i), \quad -\frac{n}{\beta} - \frac{n_1}{\beta}(C + \ln \alpha) + \sum_{i=1}^{n} x_i = \frac{2}{\alpha^2 \beta}\left(\frac{3}{2} - C - \ln \alpha\right) + \sum_{i=n_1+1}^{n} x_i \exp(-\beta x_i)$$

censored sample

VOS vs WAM hindcast: how the inconsistencies were improved by courtesy of the adaptation of EVD to the censored sample



100-year return SWH for different decades



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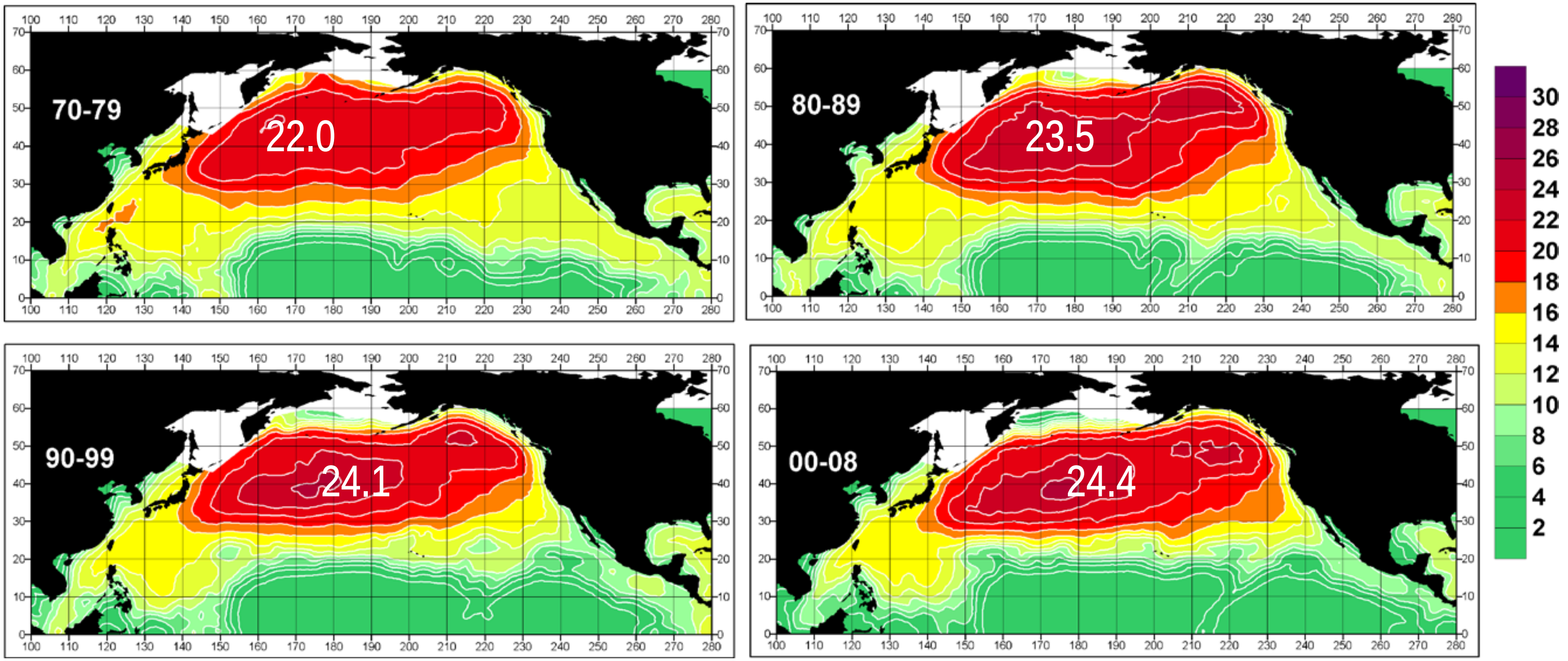
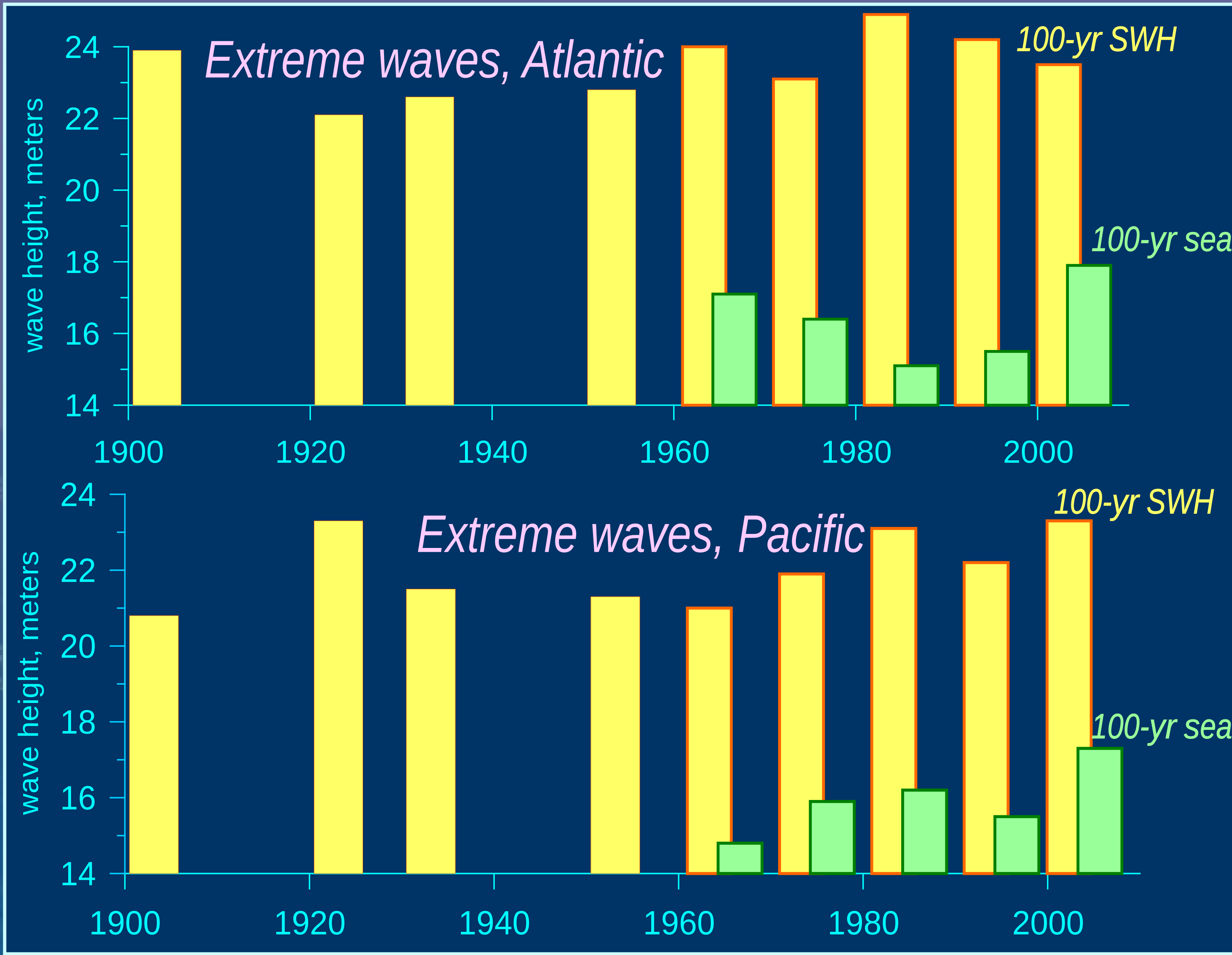
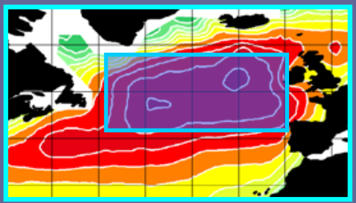
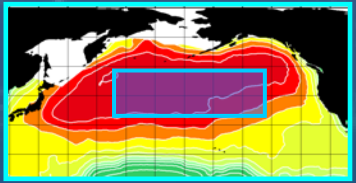


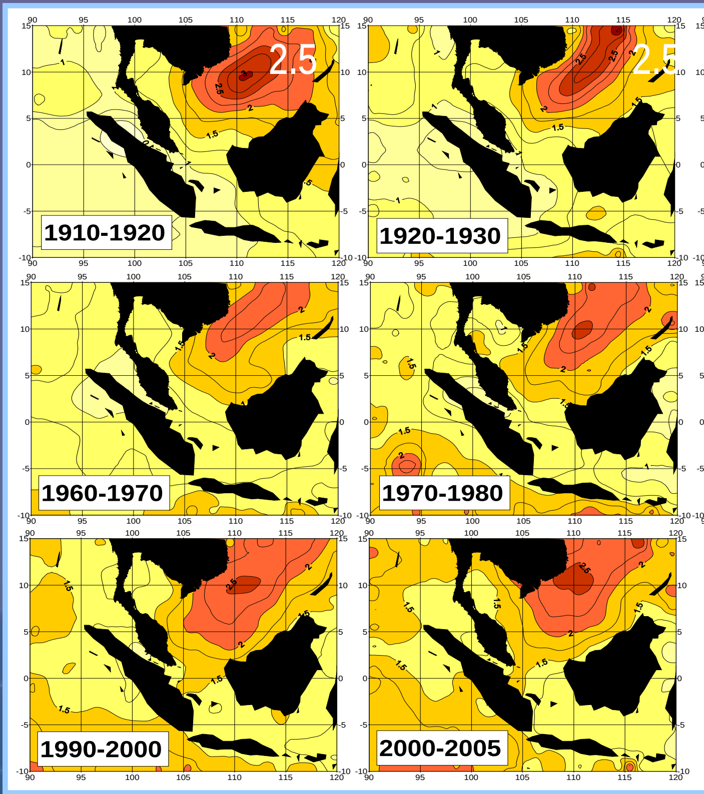
Decadal changes in 100-yr return values of SWH. averaged over NA and NP mid latitudes

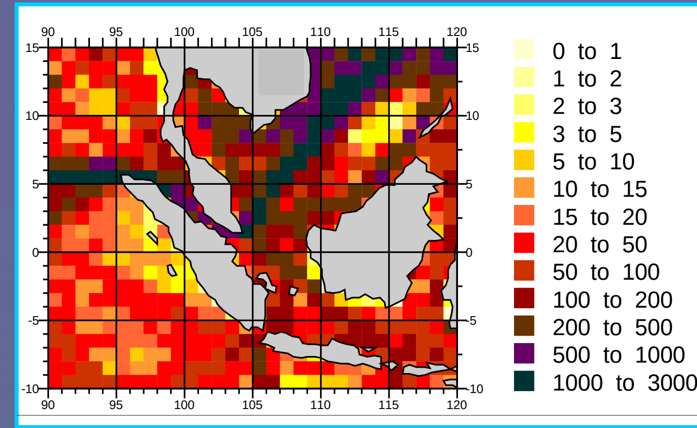




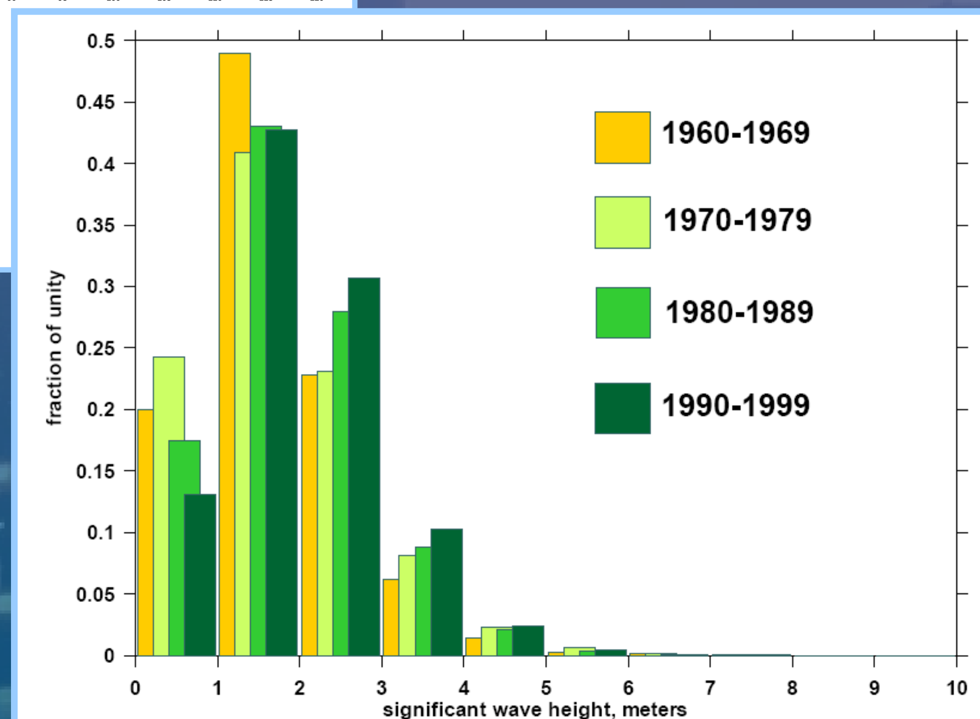


Best sampled ship route in the world: 1910-2005

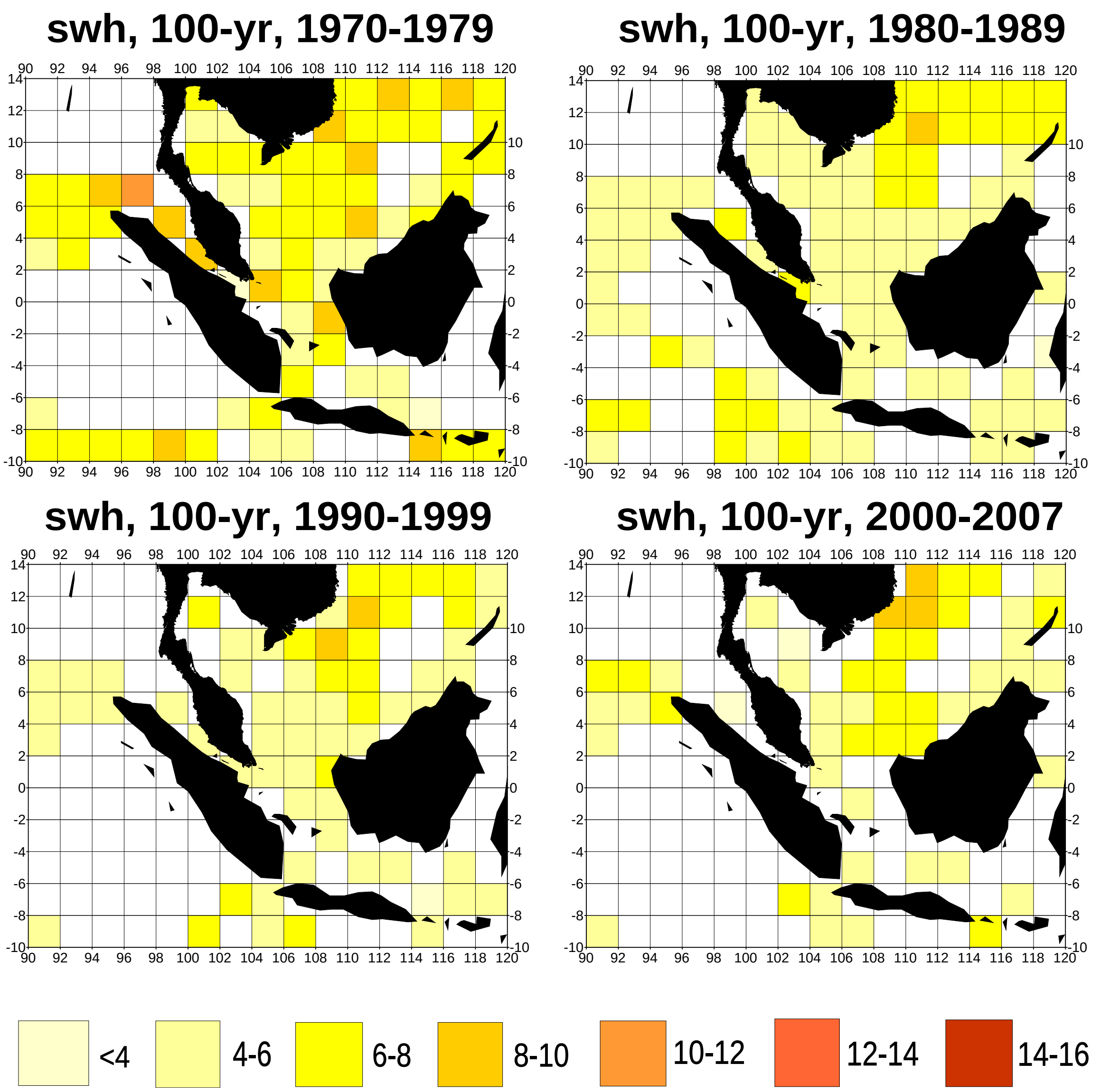




Interdecadal changes in probability distributions of SWH



Extreme SWH for 1970-2007



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