DIFFERENT SOURCES OF ERRRORS AND UNCERTAINTIES IN THE VISUAL WAVE ESTIMATES

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Background:

- Reliable information about the ocean wind waves is very important for many scientific and practical needs
- VOS wave data still have the longest continuity and provide separate estimates of the wind sea and swell parameters
- A general concern about the low accuracy of the VOS visual wave data results primarily from a poor knowledge of the actual errors and uncertainties inherent in the VOS wave observations

Objective:

To quantify the major errors and uncertainties of the visual wave data by validating a global wind wave climatology

Outline

Visual VOS wave data: developments of a global 40-yr climatology

- Computation of significant wave height
- Sea and swell separation
- Correction of small waves and periods

Estimation of the errors in visually observed waves

- Random observational errors
- Day-night biases
- The impact of evaluation of true wave direction/period
- Sampling errors and fair weather bias

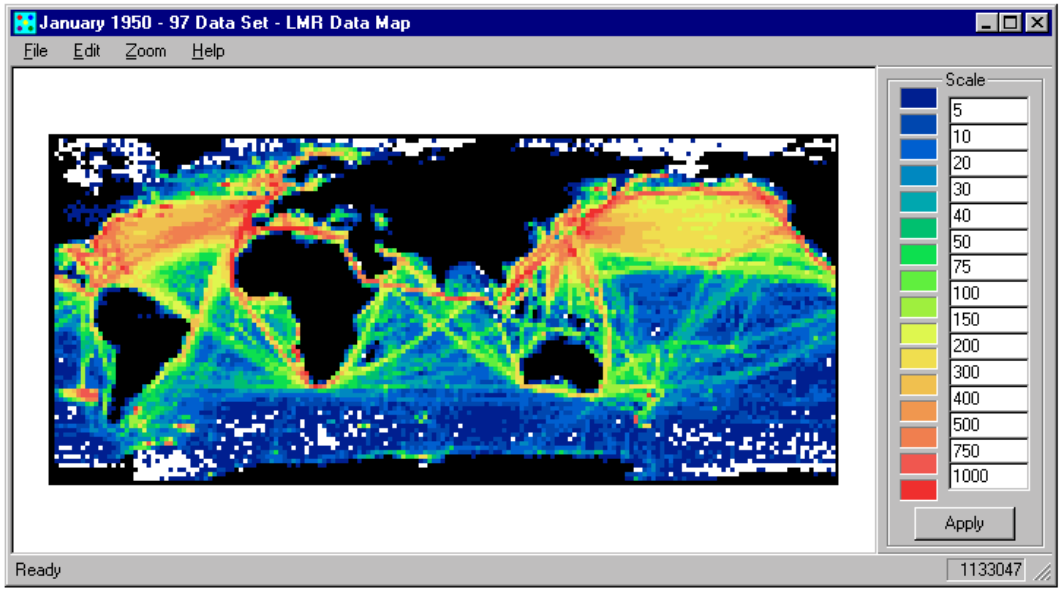
Conclusions

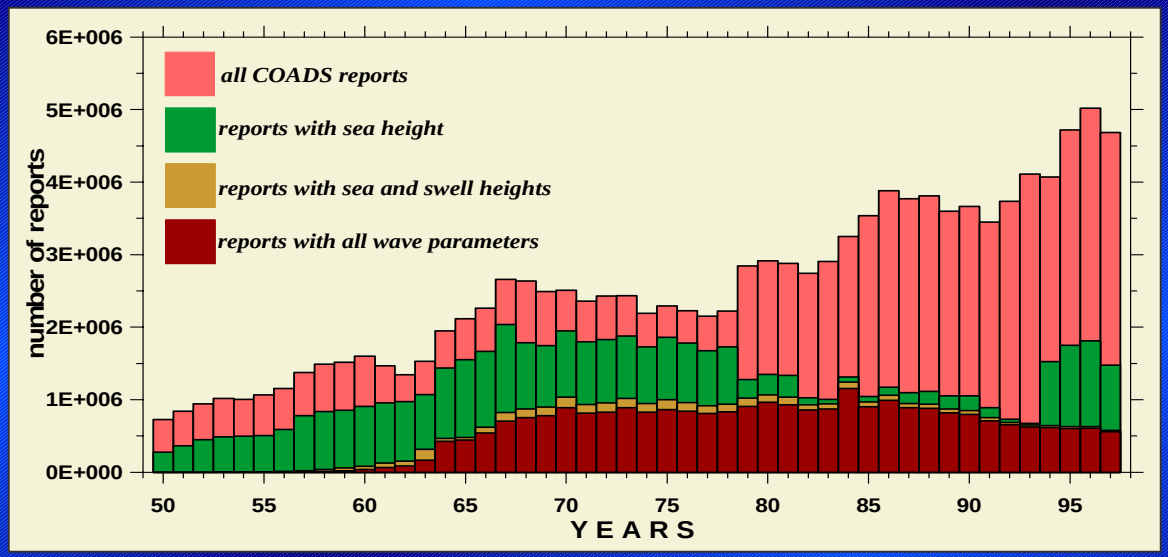
Visual wind wave data 1958-1997 (1850-1997)

Global 2-degree climatology of ocean waves [Gulev et al. 2003] is based on the COADS Releases 1a and 1b (1950-1997) visually observed heights, periods and directions of wind sea and swell.

Spatial distribution of the number of observations: significant spatial inhomogeneity of sampling density.

Long Marine Reports sampling frequency in space

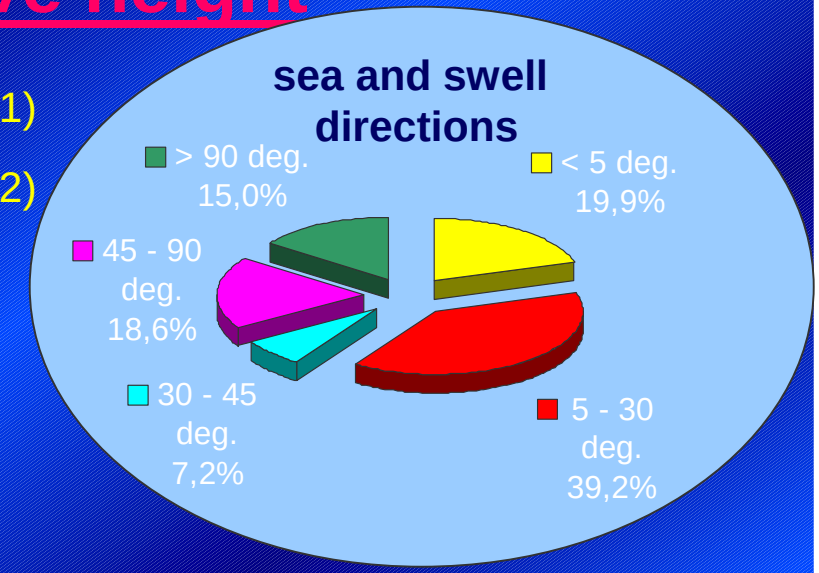


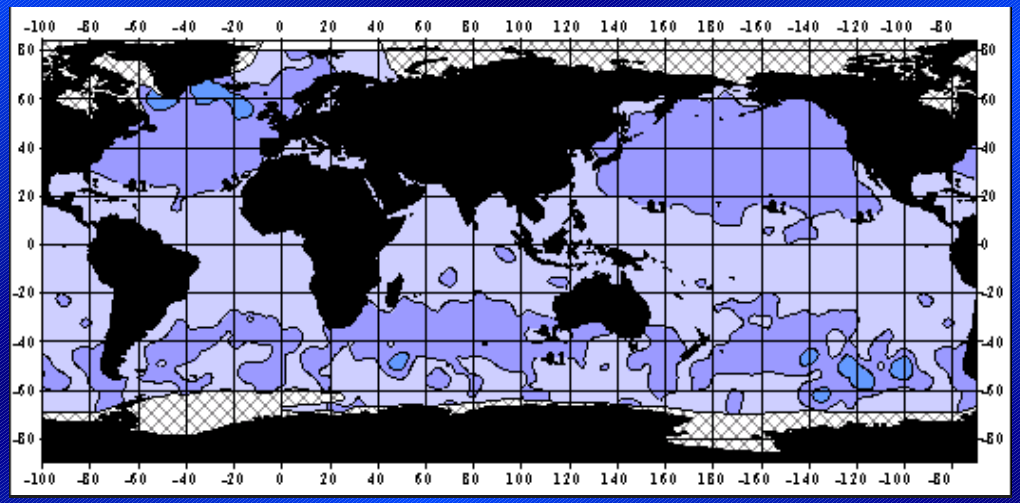


The percentage of wave reports varies from 30 to 80%, that implies about the same level of uncertainty as for the other basic meteorological variables and fluxes.

Computation of significant wave height

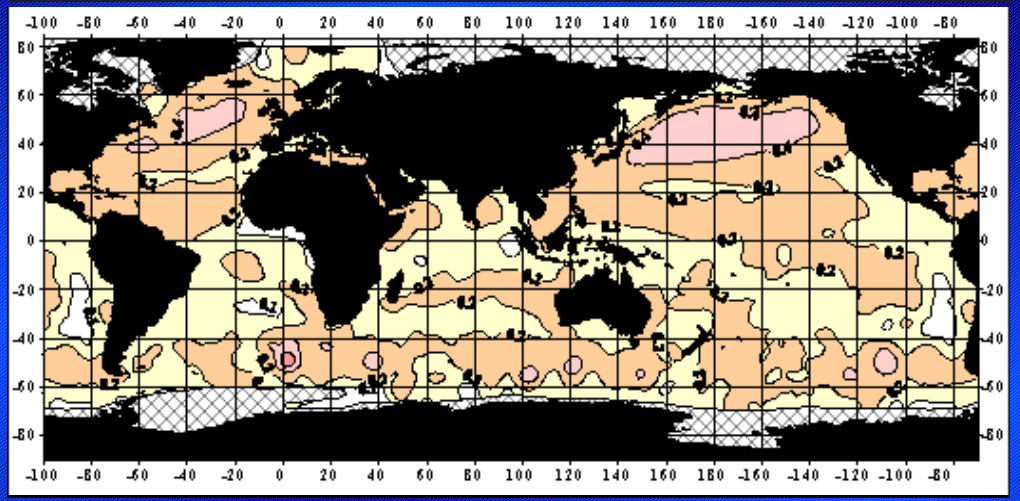
$$SWH = \begin{cases} (h_w^2 + h_s^2)^{1/2}, & [dir_{sea}, dir_{swell}] \in 30^\circ sector \\ max[h_w, h_s], & [dir_{sea}, dir_{swell}] \notin 30^\circ sector \end{cases} \begin{matrix} (1) \\ (2) \end{matrix}$$





Our estimate minus (1)

Negative differences <0.3 m



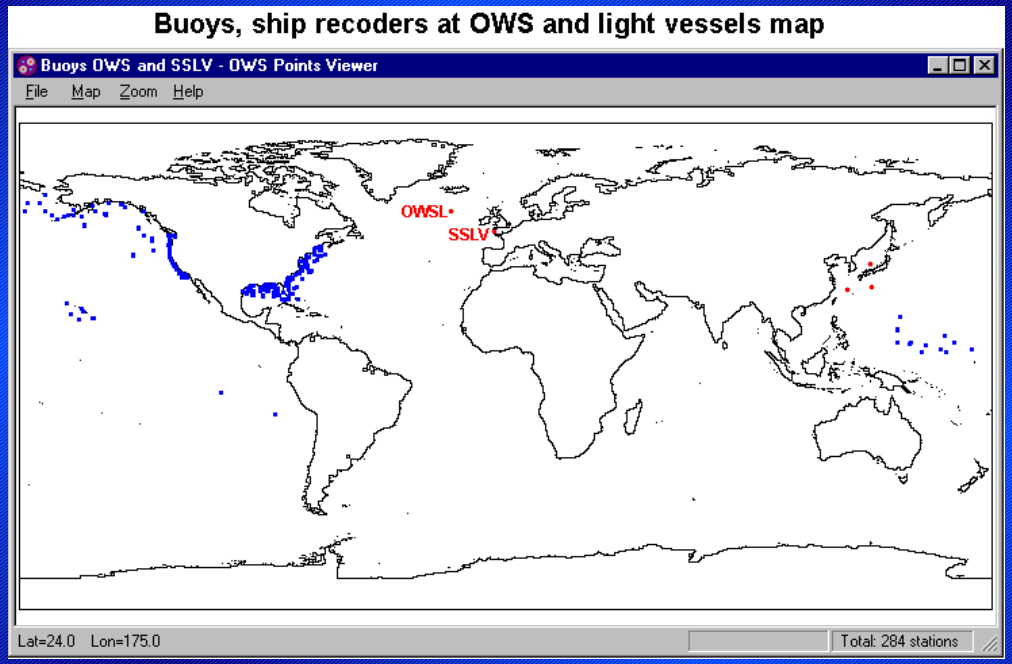
Our estimate minus (2)

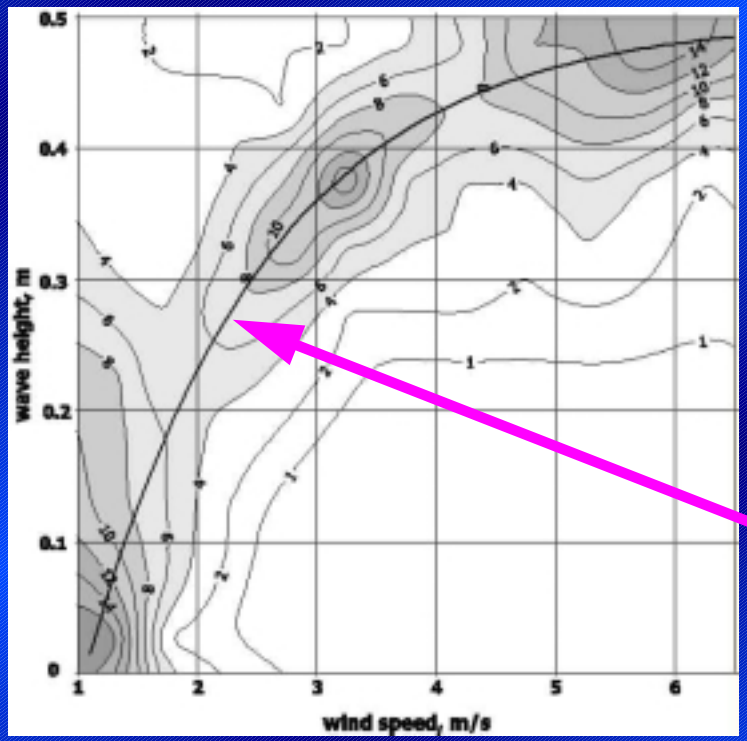
Positive deviations 0.2-0.45

Correction of small waves

(code figure “01” problem)

Analysis of 2D PDFs of small wind waves and winds in the vicinity of NDBC buoys





For the wind speeds from 1.2 to 6 m/s

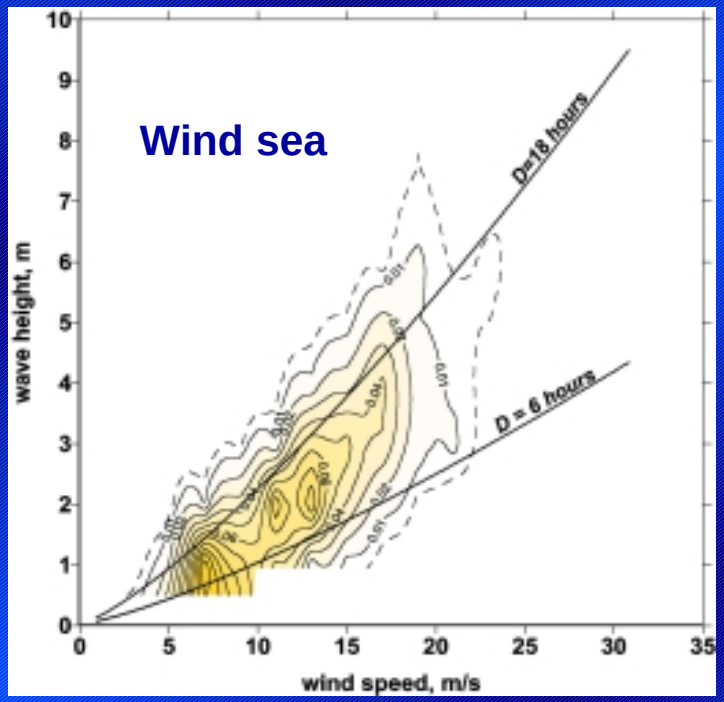
$$hs = 0.5 - \exp(-0.658V)$$

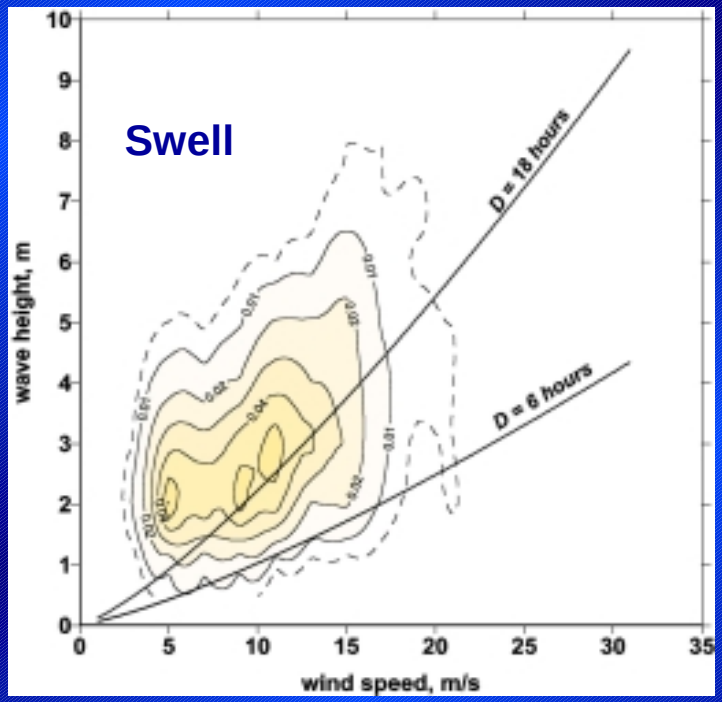
Sea and swell separation

1st step:

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



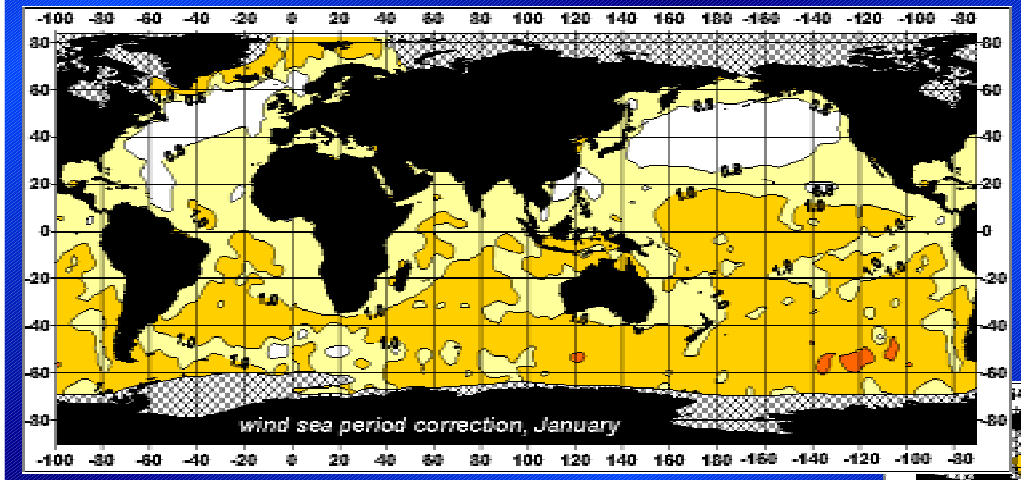


2nd step:

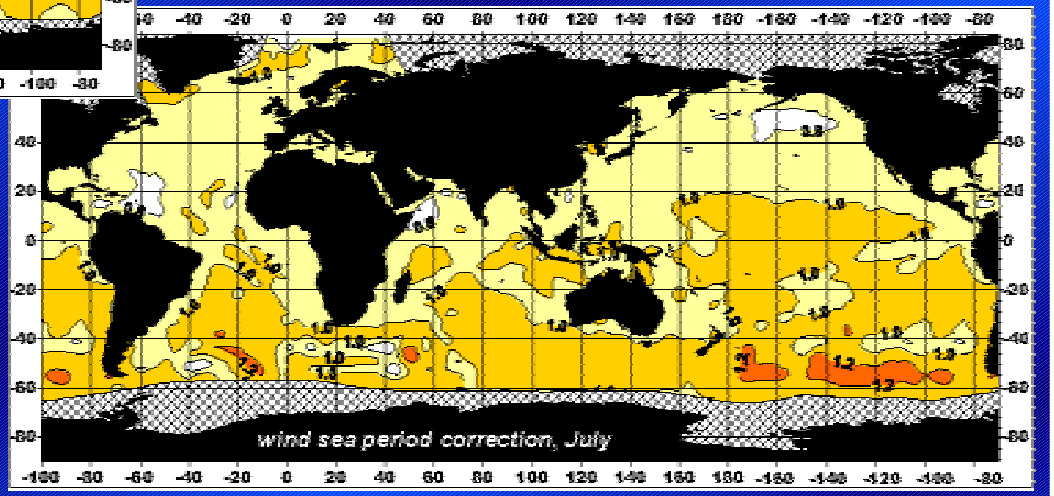
Analysis of wave age $a = C_p / V_{ef,}$ where $C_p = (g/2\pi)p_w$ is the deep water phase speed: waves with $a < 1.2$ are attributed to sea, otherwise to swell:

elimination of 0.05 to 1.5% of reports

Correction of the wave periods and computation of the dominant period



Formulation of Gulev and Hasse (1998), based on the fitting of the 2D wave-period distributions for sea and swell

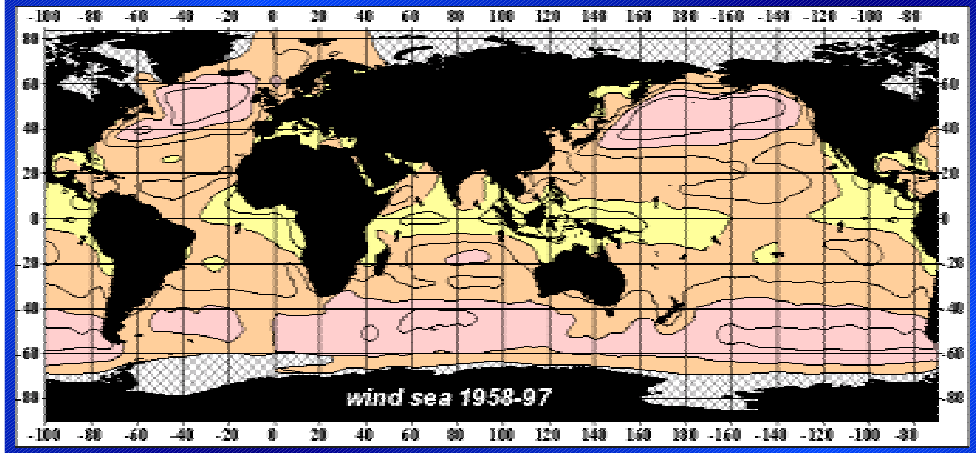


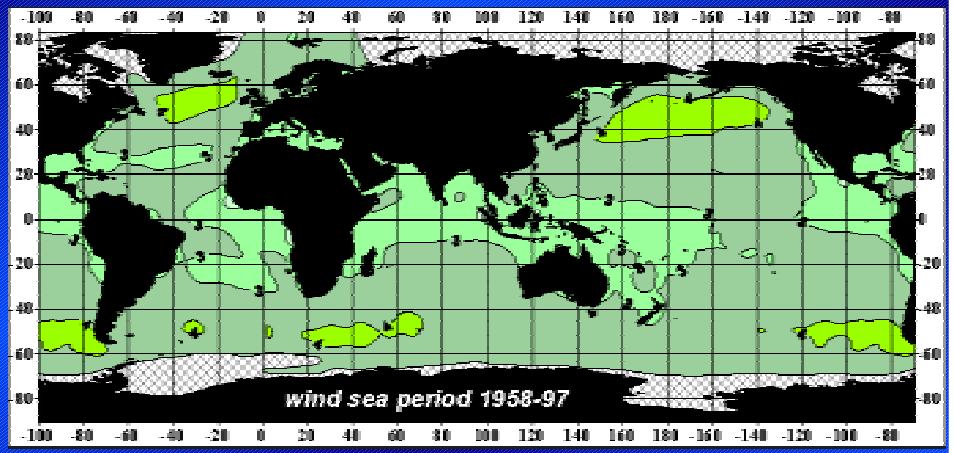
Corrections varies from 0.4 to 1.5 seconds with the largest values observed in the Southern Ocean

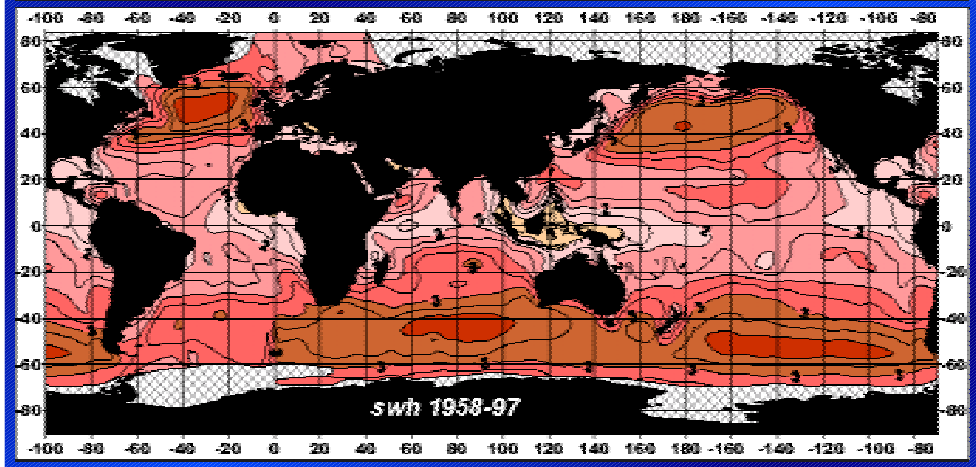
Dominant period is estimated as the period reported with the largest of sea and swell components

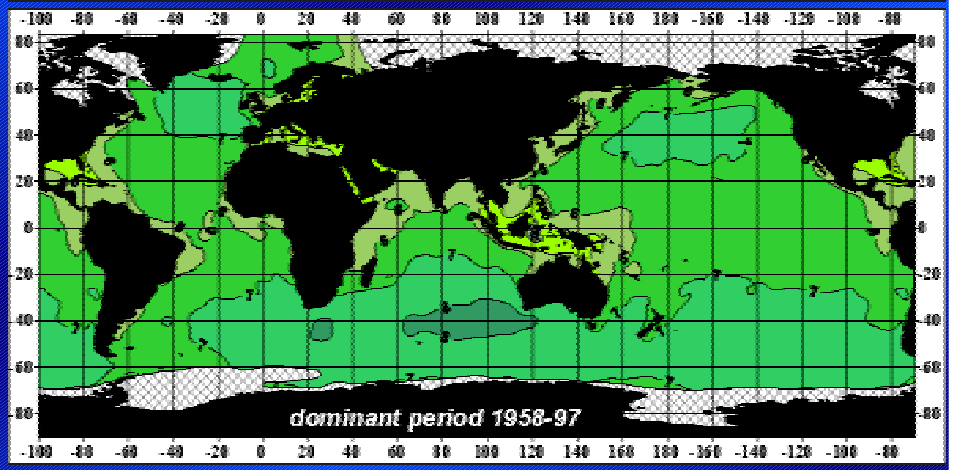
A global VOS waves climatology (1958-1997):

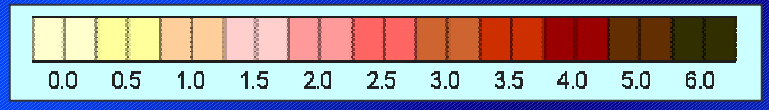
http://www.sail.msk.ru/atlas/index.htm

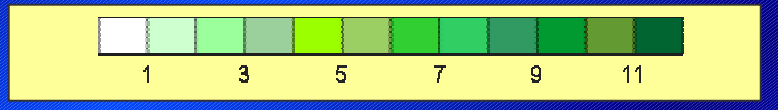






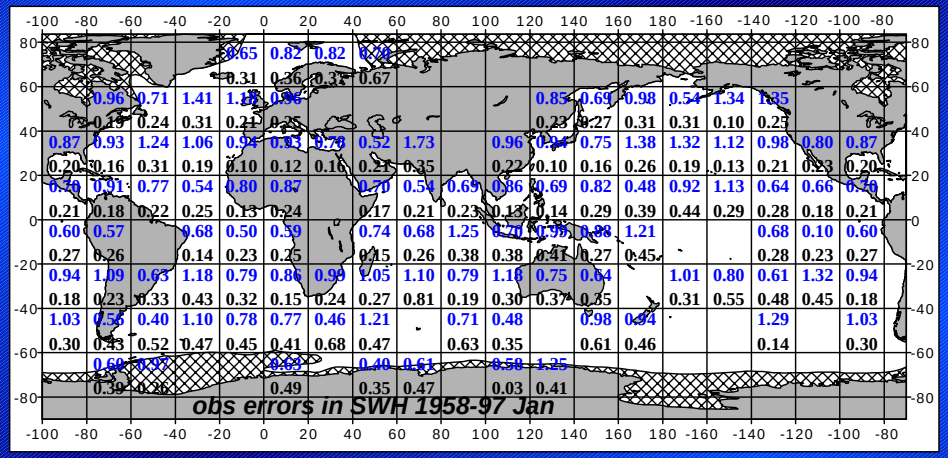


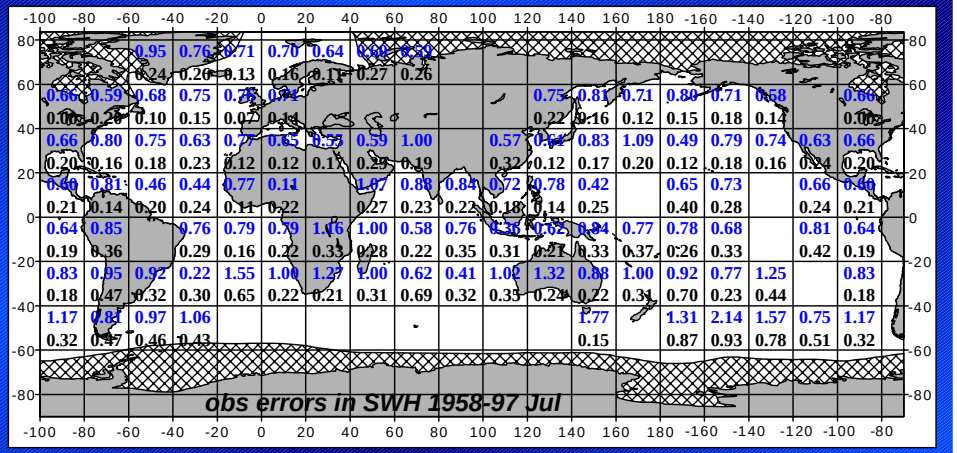


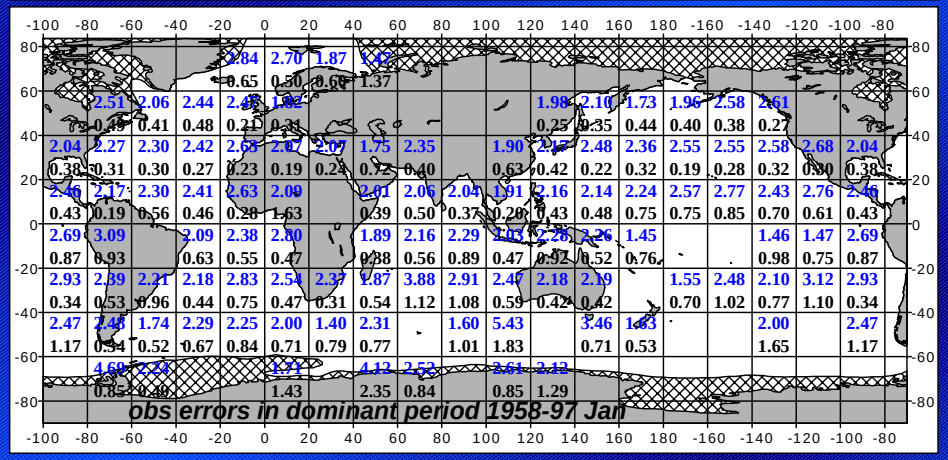


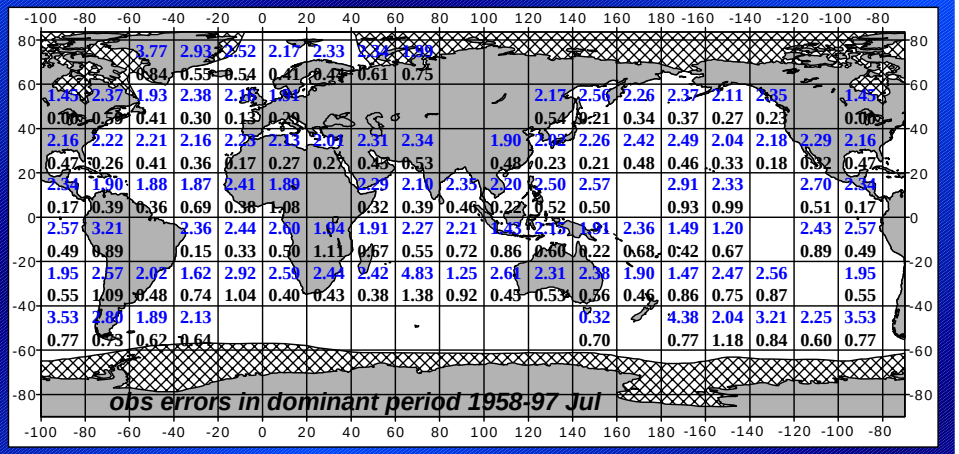
Climatological distributions of basic wave variables represent quite reliable picture, especially in the Northern Hemisphere, characterized by high and homogeneous sampling. In the Southern Hemisphere, some climatological wave parameters are biased due to inadequate sampling.

Estimation of the random observational errors



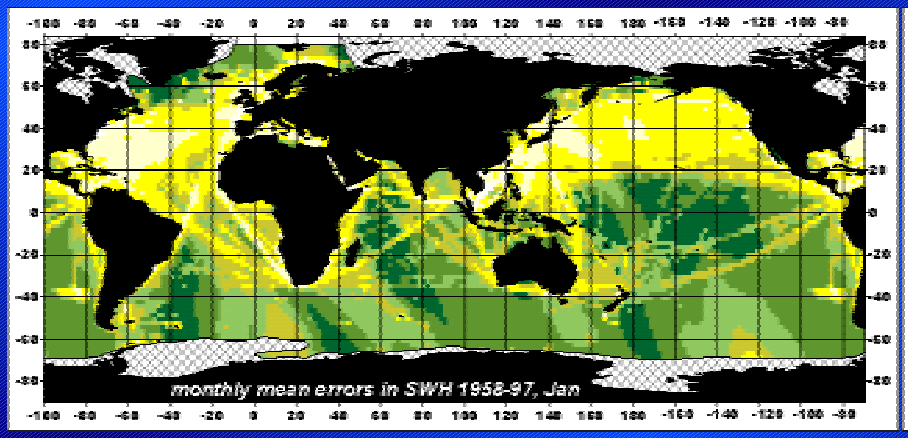


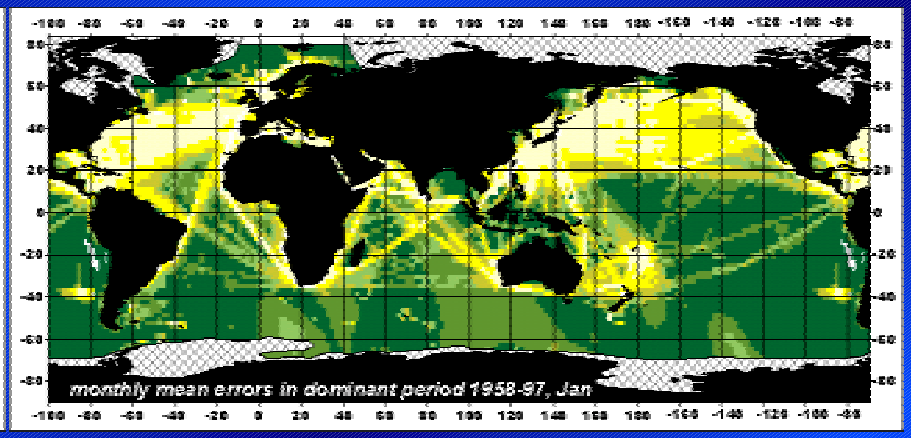


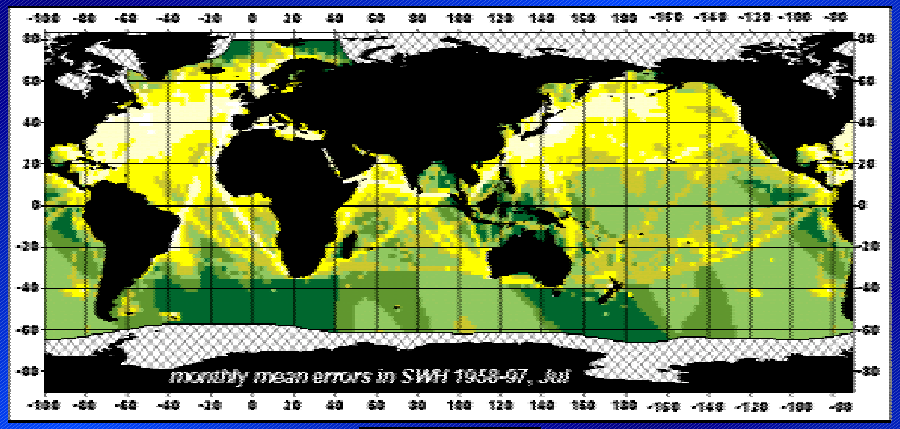


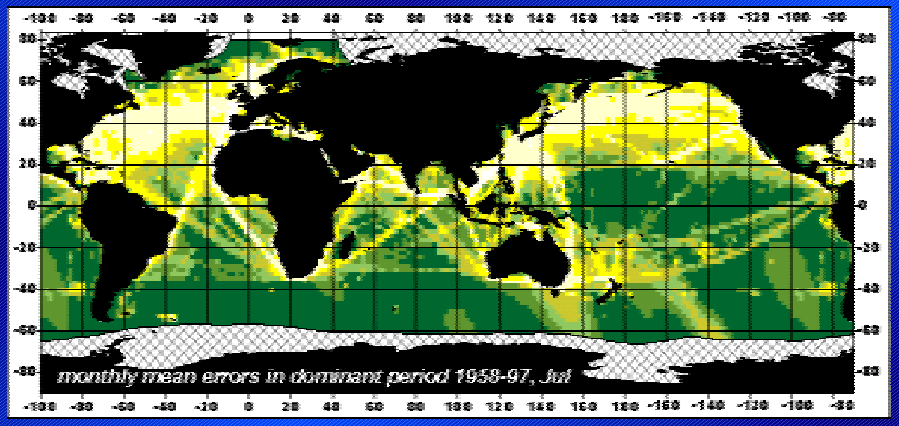
Random observational errors (upper numbers) and uncertainties in random observational errors (lower numbers) (m) in SWH and dominant periods in January and July.
For the blank boxes errors were not estimated because of an insufficient numbers of pairs.

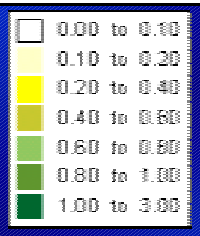
Estimation of the random observational errors in monthly means

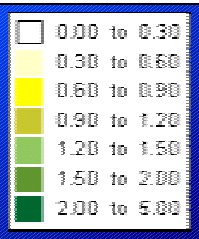




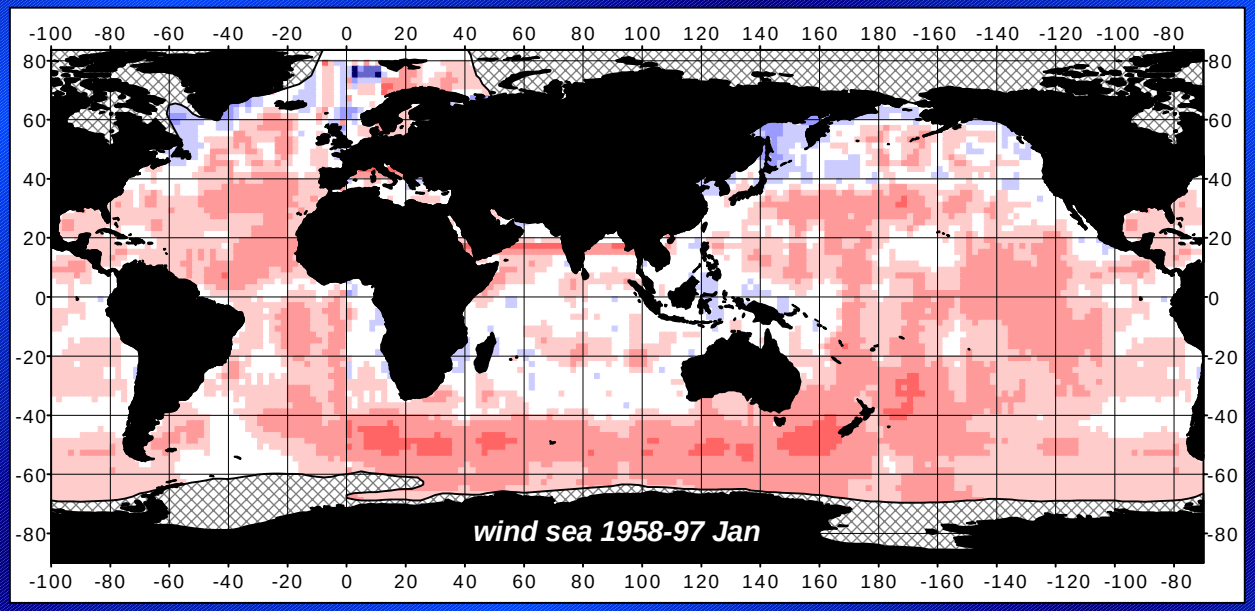


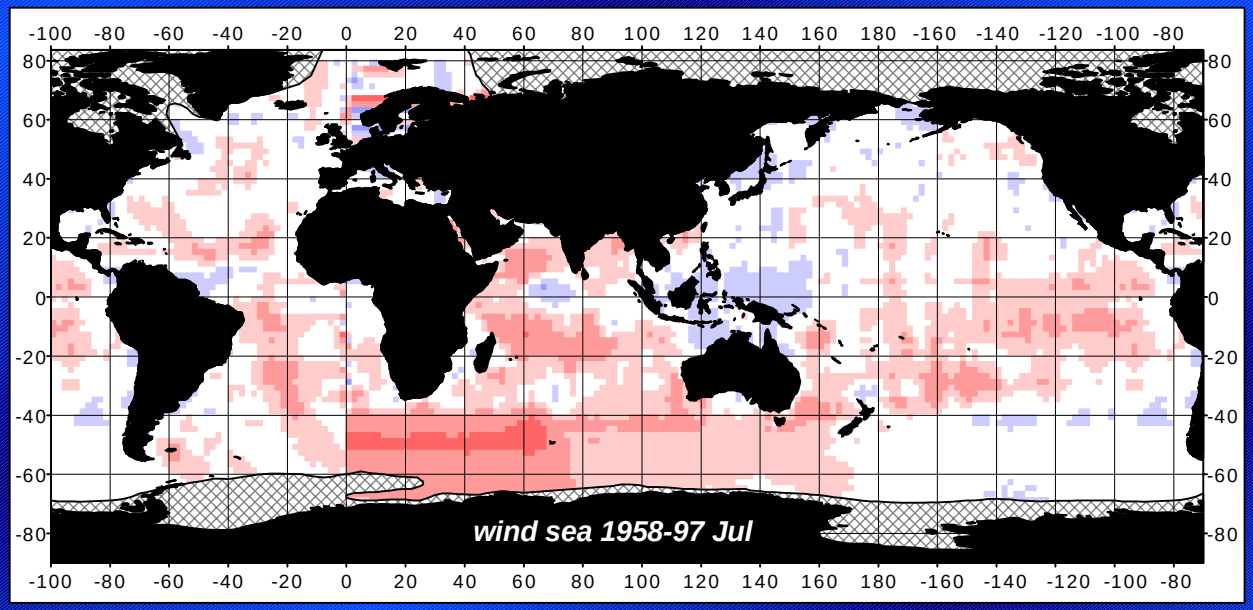






Day minus night differences

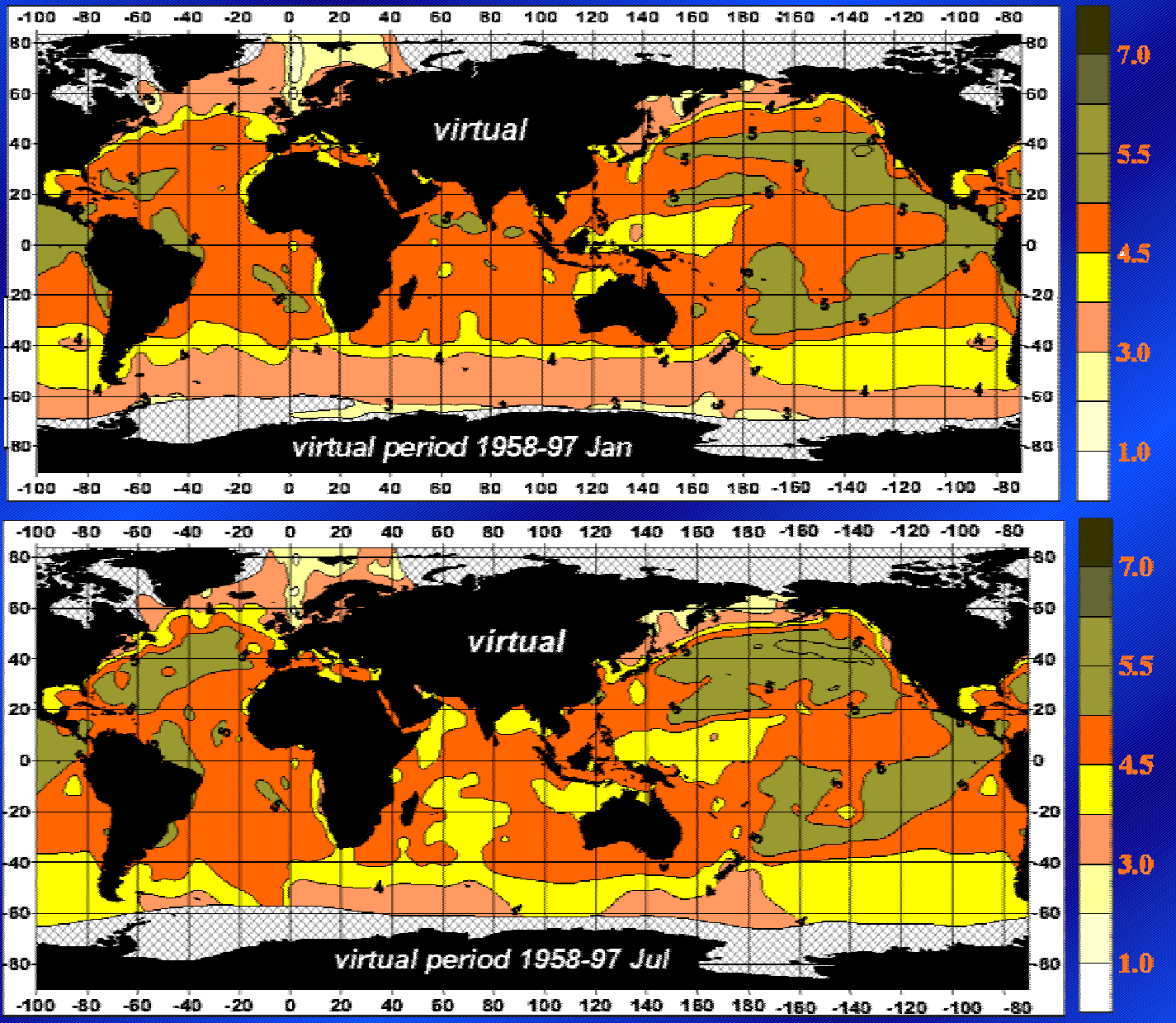




-0.40 to -0.30
-0.30 to -0.20
-0.20 to -0.10
-0.10 to -0.05
-0.05 to 0.05
0.05 to 0.10
0.10 to 0.20
0.20 to 0.50

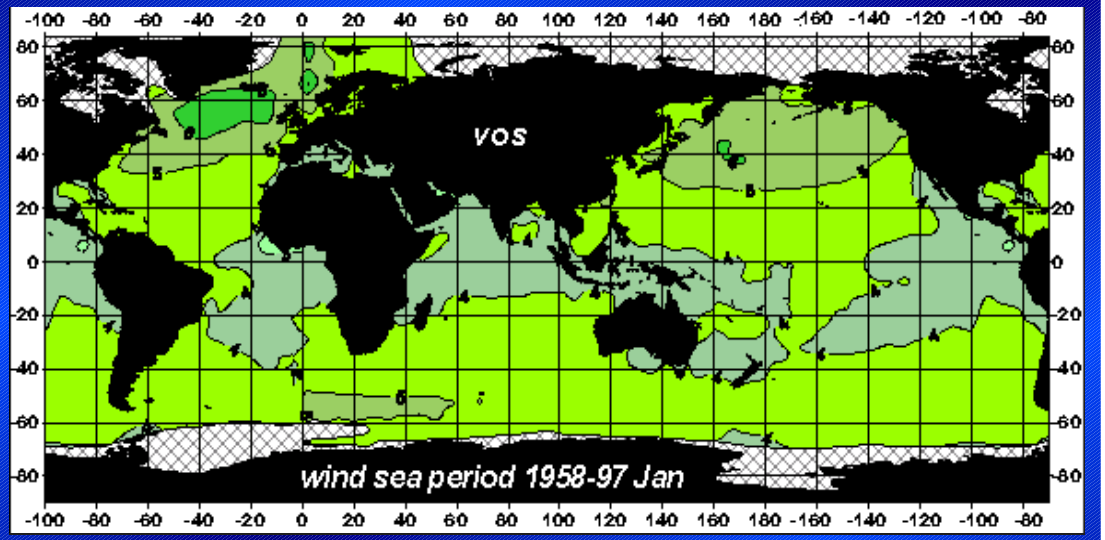
The effect of the evaluation of the true period/direction:

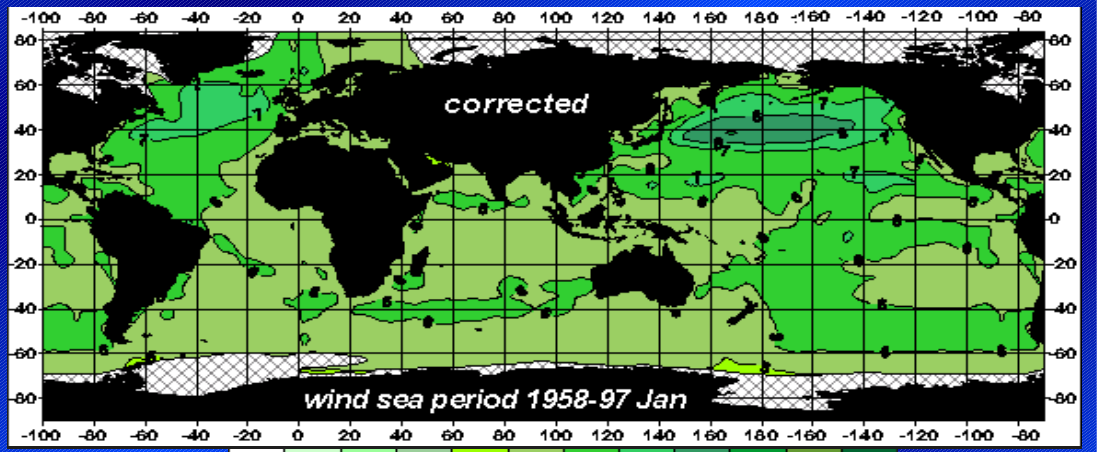
The largest possible uncertainty, estimated from the ship courses and velocities (virtual periods)



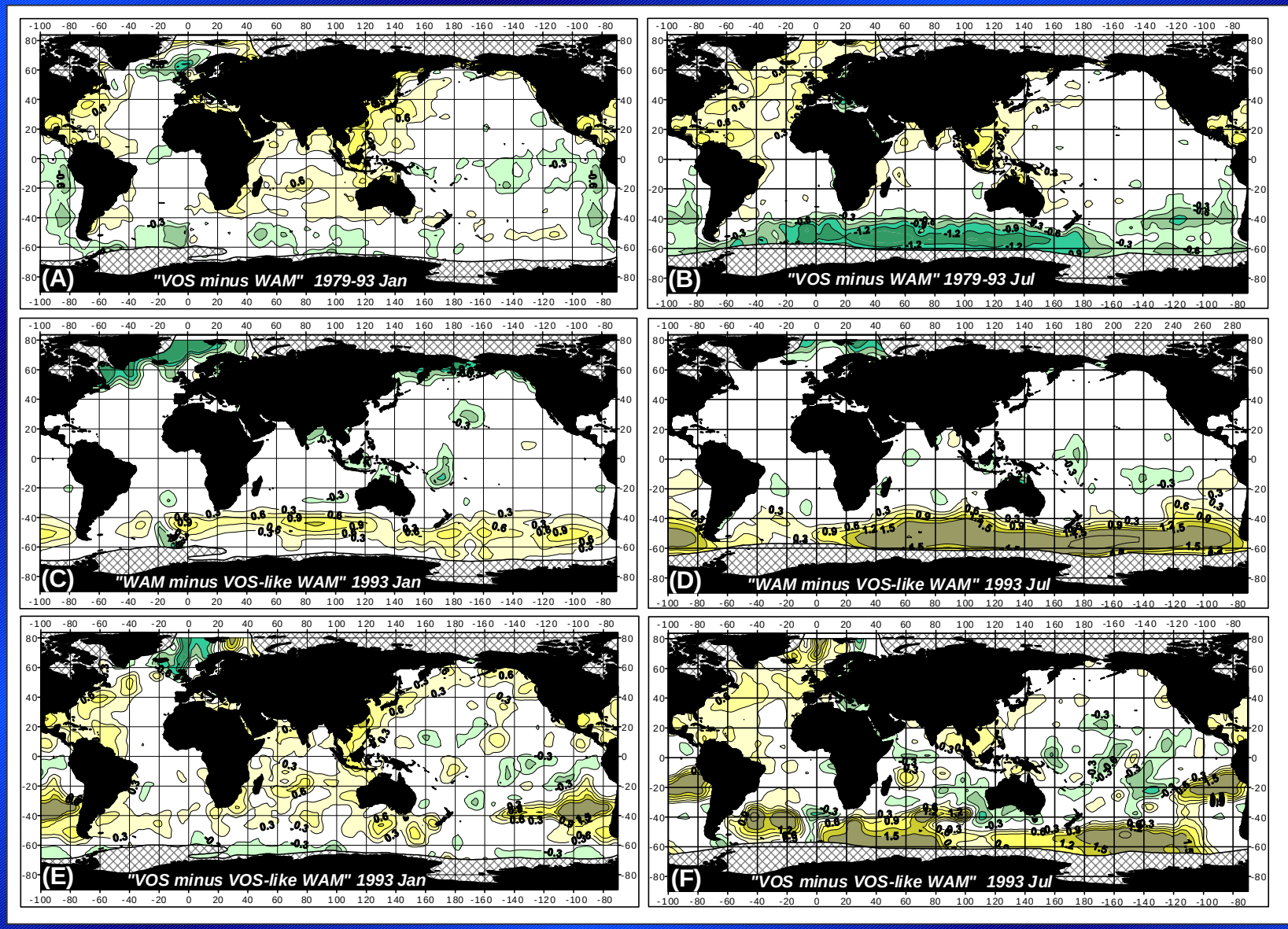
Evaluation of the true wave period

SHIPMET questionnaire:

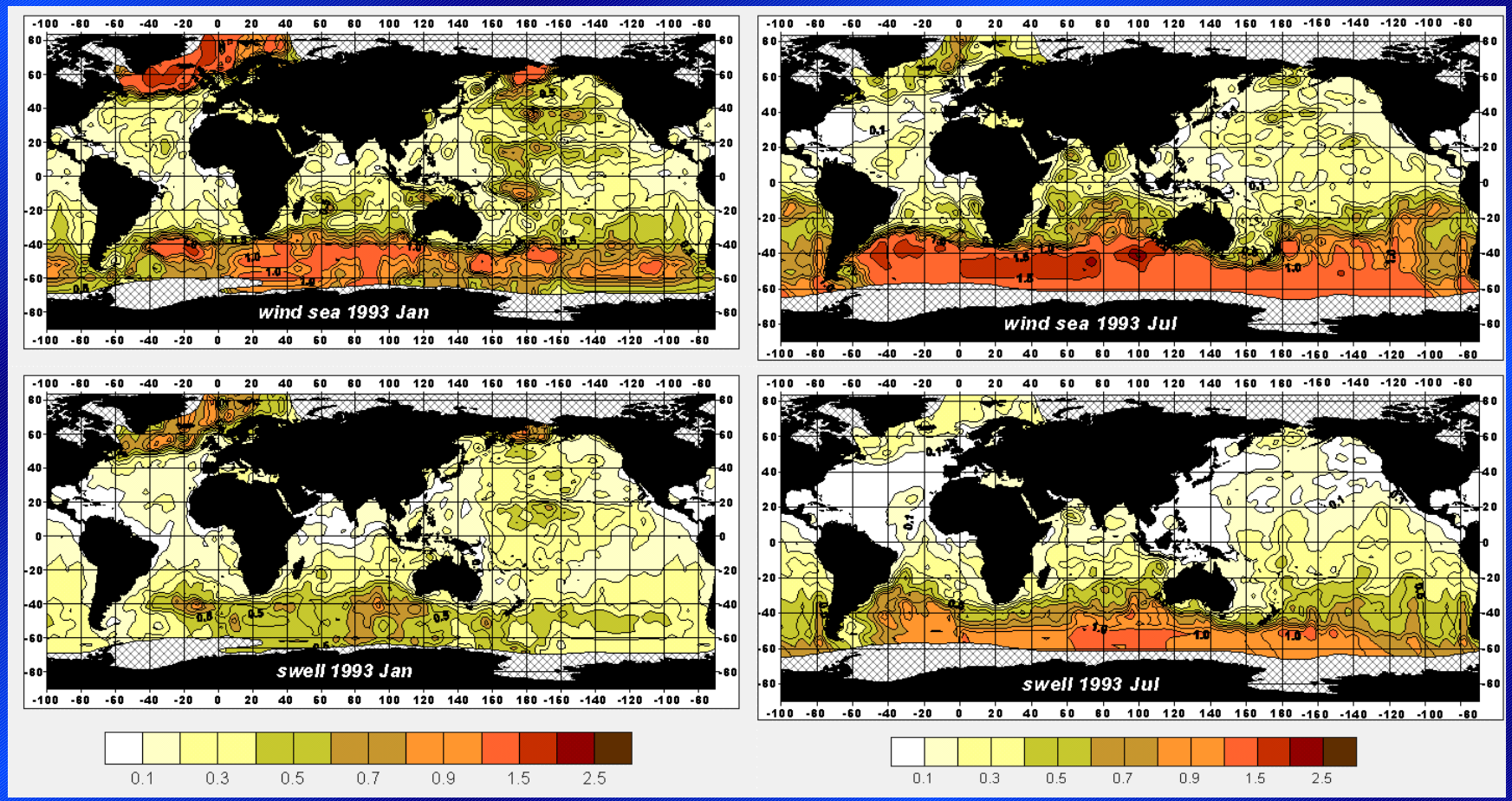




Sampling errors: simulation of the VOS sampling in the WAM hindcast: total errors



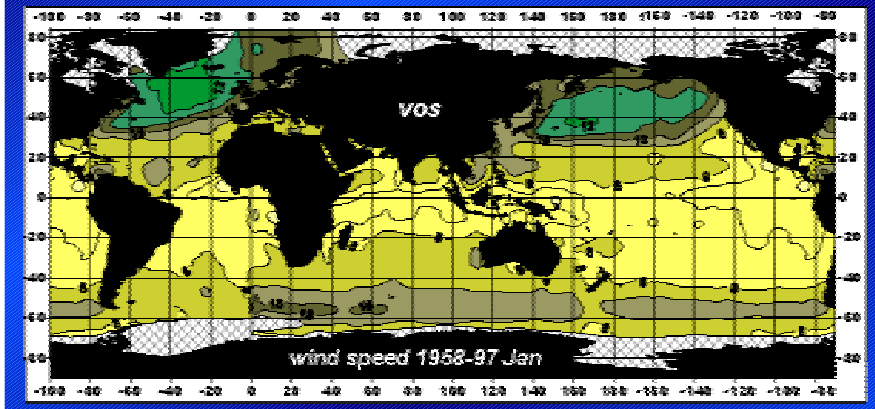
Sampling errors: simulation of the VOS sampling in the WAM hindcast: random errors

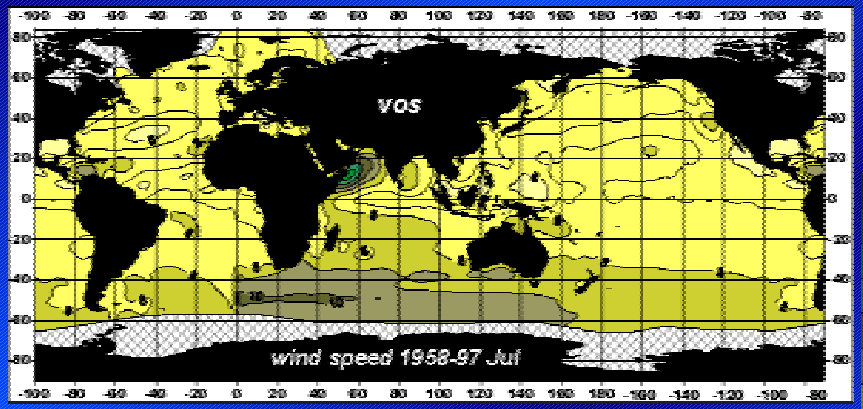


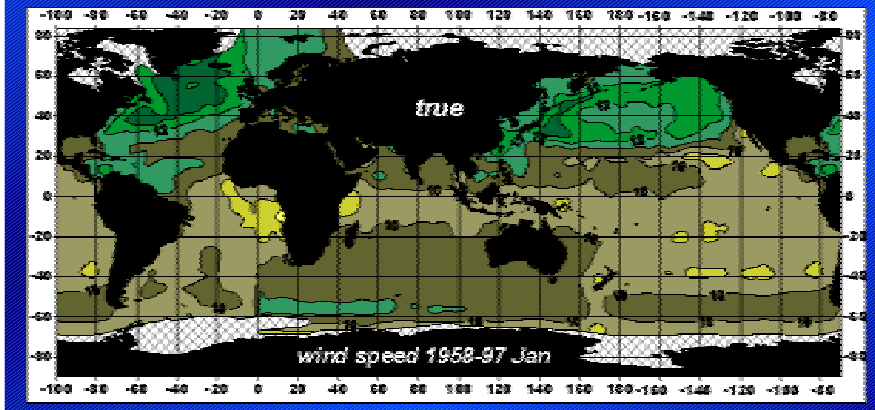
Conclusions:

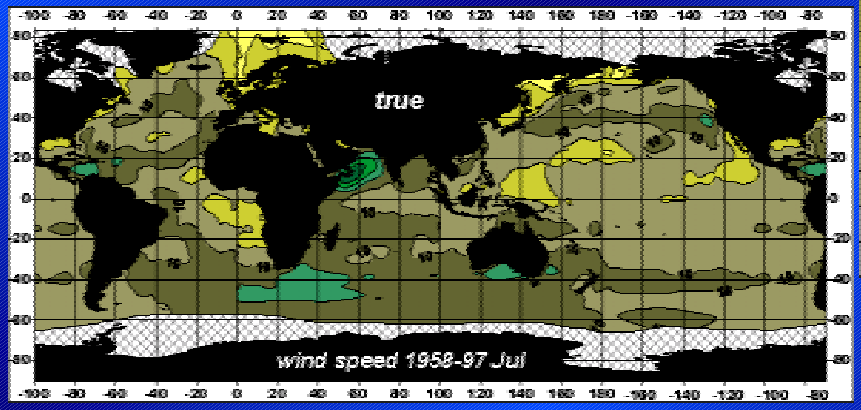
- *Global climatology of wind waves based on visual wave data provide reliable information about basic wave characteristics over the period from 1958 to 1997.*
- *Random observational errors are approximately in the same relation to the mean values as for the other basic meteorological variables.*
- *Omitting of the evaluation of the true wave period/direction implies primarily negative wave period uncertainties ranging within 2.5 sec.*
- *Sampling uncertainties are the highest among the other errors in the Southern Ocean.*

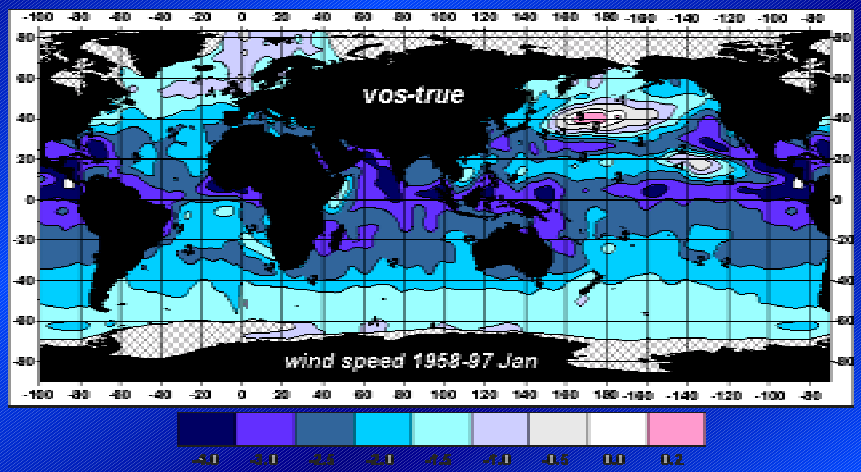
Evaluation of the true wind direction

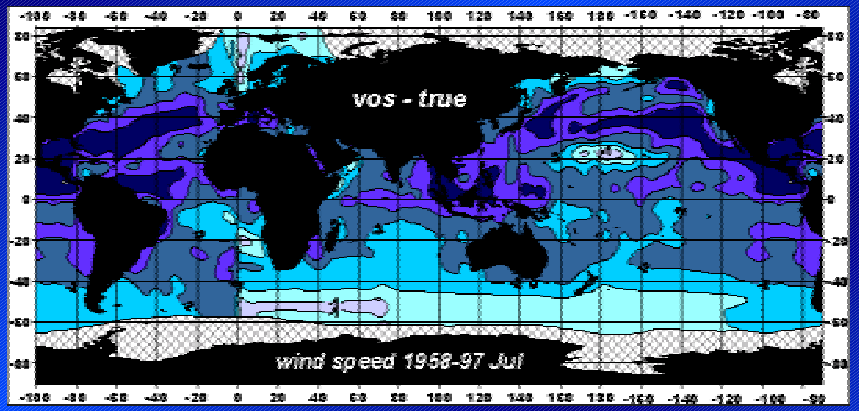




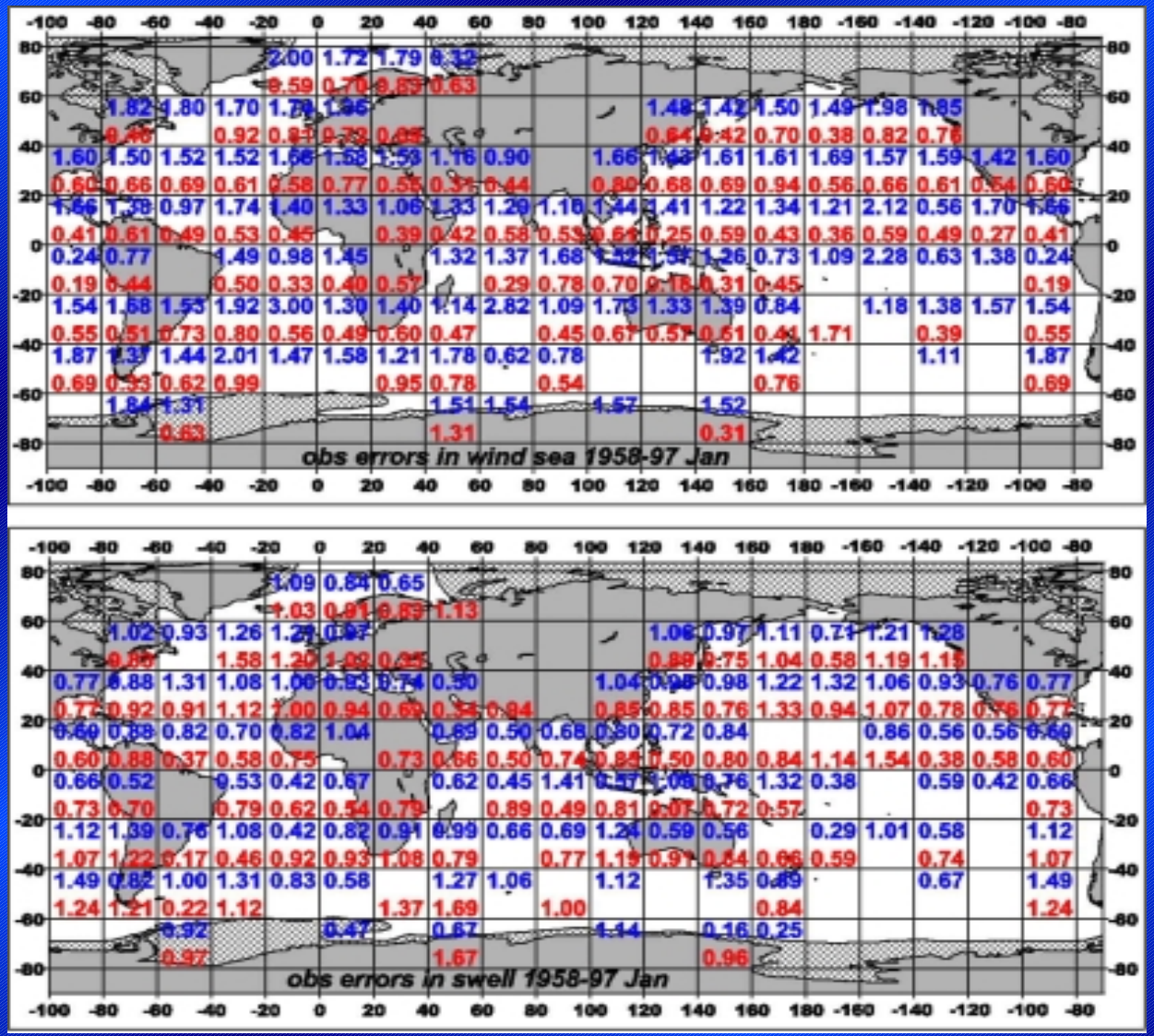








Random observational errors for day-time and night-time observations



Observational errors during night time may be even higher than during day time, because the observers do not strictly follow the guidelines during the night time