The ERA-40 wind and wave data

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KNMI, De Bilt, Netherlands

- What is ERA-40?
- The quality of the ERA-40 waves
- The 100 year return wave height
- Statistical correction of wave heights
- The KNMI/ERA-40 Wave Atlas

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ERA-40 = ECMWF 40 year reanalysis

European Centre for Medium Range Weather Forecasts

40: length of reanalysis in years

reAnalysis: Data is used to start

Produces twice daily a 10-day weather forecast for the member states

....

How to Make a Weather Forecast?

forecast = initial value problem

or

know today's weather,
calculate tomorrow's one

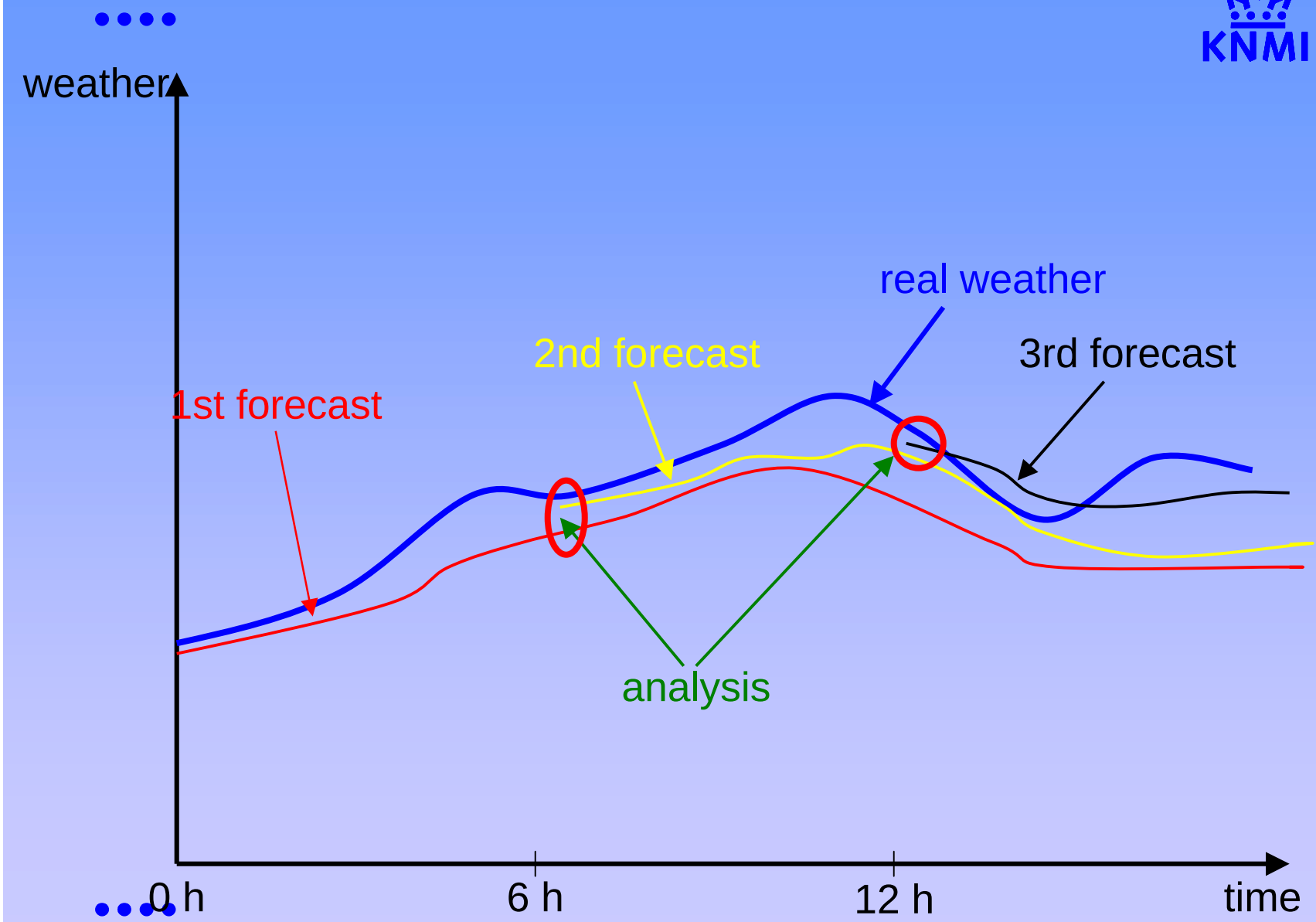
PROBLEM

you do not know today's weather

Solution

Analysis

= optimal combination of observations
and latest forecast (first guess)



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Result of analysis

Complete description of atmosphere
4 times a day

Drawback

Inhomogeneous over time due to model changes

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Reanalysis

Repeat analysis process for the past using a fixed, state-of-the-art analysis system.

Result

Long-term description of atmosphere free of *model* inhomogeneities.

Previous reanalyses

- NCEP/NCAR, 1949 – now
- ERA-15, 1979-1993

conducted around 1994.

New reanalyses

- ERA-40, 09/1957-08/2002 (45 years)

finished March 2003
http://data.ecmwf.int/data/d/era40

- plans in US and Japan

ECMWF Data Server

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ECMWF 40 Years

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- DEMETER
- ENACT
- ERA 15
- ERA 40

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See also...
- Data Services
- ECMWF Archive

Select date

Select a date range:

Start date: 1957-09-01

Select a list of month:

	Jan	Feb	Mar	Apr	May
1957					
1959	☐	☐	☐	☐	☐
1961	☐	☐	☐	☐	☐
1963	☐	☐	☐	☐	☐
1965	☐	☐	☐	☐	☐
1967	☐	☐	☐	☐	☐
1969	☐	☐	☐	☐	☐
1971	☐	☐	☐	☐	☐
1973	☐	☐	☐	☐	☐
1975	☐	☐	☐	☐	☐
1977	☐	☐	☐	☐	☐
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1987	☐	☐	☐	☐	☐
1989	☐	☐	☐	☐	☐
1991	☐	☐	☐	☐	☐
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1995	☐	☐	☐	☐	☐
1997	☐	☐	☐	☐	☐
1999	☐	☐	☐	☐	☐
2001	☐	☐	☐	☐	☐
	Jan	Feb	Mar	Apr	May

Select All or Clear

Select Time

☐ 00:00:00 ☐ 06:00:00

Select All or Clear

Select parameters

Pressure levels:

	1000	925
Geopotential	☐	☐
Temperature	☐	☐
U velocity	☐	☐
V velocity	☐	☐
Specific humidity	☐	☐
Vertical velocity	☐	☐

	1000	925	850	775	700	600	500	400	300	250	200	150	100	70	50	30	20	10	7	5	3	2	1
(relative)																							
Divergence	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Relative humidity	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Ozone mass mixing ratio	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Potential vorticity	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Select All or Clear

Surface:

- ☐ Boundary layer height
- ☐ East-West surface stress
- ☐ High cloud cover
- ☐ Ice surface temperature layer 3
- ☐ Ice surface temperature layer 1
- ☐ 2 metre temperature
- ☐ 10 metre V wind component
- ☐ Low cloud cover
- ☐ Mean wave direction **Wave dir**
- ☐ Medium cloud cover
- ☐ North-South surface stress
- ☐ Sea-ice cover
- ☐ Snow depth
- ☐ Snowfall (convective + stratiform)
- ☐ Soil temperature level 1
- ☐ Soil temperature level 3
- ☐ Stratiform precipitation (Large-scale precipitation)
- ☐ Surface net solar radiation, clear sky
- ☐ Surface sensible heat flux
- ☐ Surface solar radiation downwards
- ☐ Surface thermal radiation downwards
- ☐ Top net solar radiation, clear sky
- ☐ Top solar radiation
- ☐ Total cloud cover
- ☐ Total column water
- ☐ Volumetric soil water layer 3
- ☐ Volumetric soil water layer 1
- ☐ Convective precipitation
- ☐ Evaporation
- ☐ Ice surface temperature layer 4
- ☐ Ice surface temperature layer 2
- ☐ 2 metre dewpoint temperature
- ☐ 10 metre U wind component
- ☐ Latitudinal component of gravity wave stress
- ☐ Mean sea level pressure
- ☐ Mean wave period T_{mean}
- ☐ Meridional component of gravity wave stress
- ☐ Runoff
- ☐ Significant wave height H_s
- ☐ Snow evaporation
- ☐ Snowmelt
- ☐ Soil temperature level 4
- ☐ Soil temperature level 2
- ☐ Surface latent heat flux
- ☐ Surface net thermal radiation, clear sky
- ☐ Surface solar radiation
- ☐ Surface thermal radiation
- ☐ Temperature of snow layer
- ☐ Top net thermal radiation, clear sky
- ☐ Top thermal radiation
- ☐ Total column ozone
- ☐ Total column water vapour
- ☐ Volumetric soil water layer 4
- ☐ Volumetric soil water layer 2

Select All or Clear

Note:

In order to retrieve data from this server, please read our conditions of use.

13-11-2003

The ERA-40 system

- Operational ECMWF system (IFS)
- T_L159, 60 layers
- 3DVAR:
- COADS, GTS, satellites, hist. data,

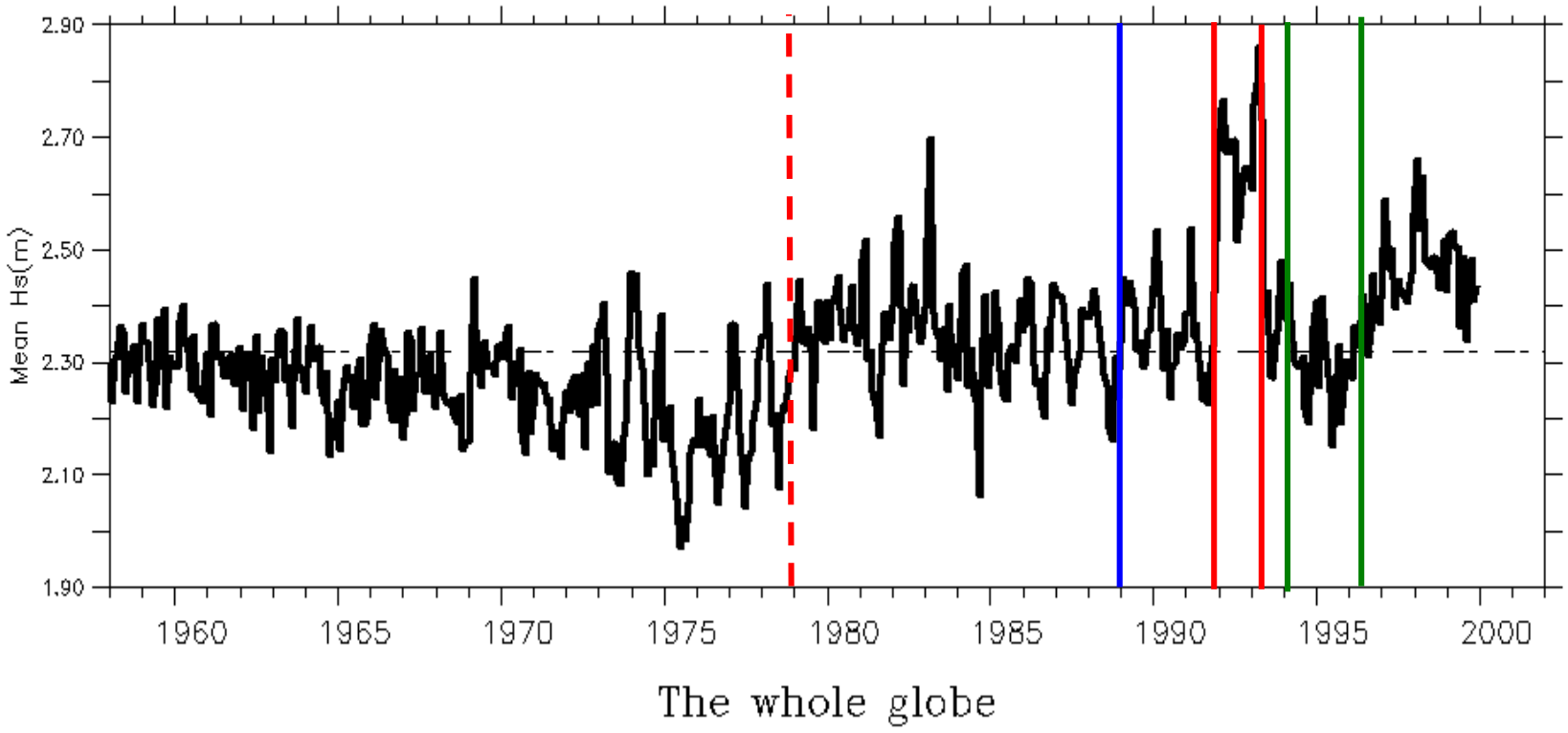
....

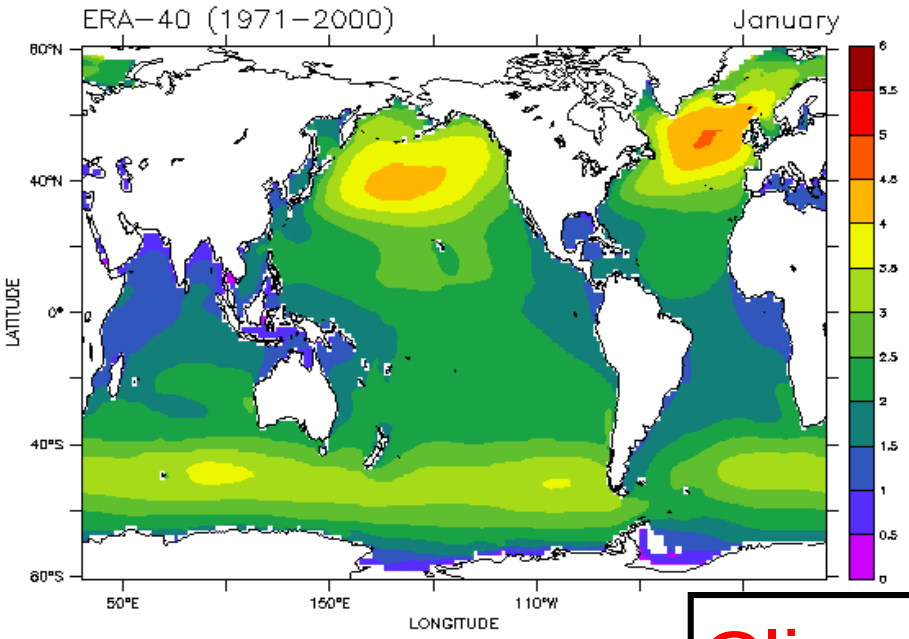
- interactive determination of Charnock Parameter (= sea surface roughness)
- coupled to WAM (1.5°)
- => Waves

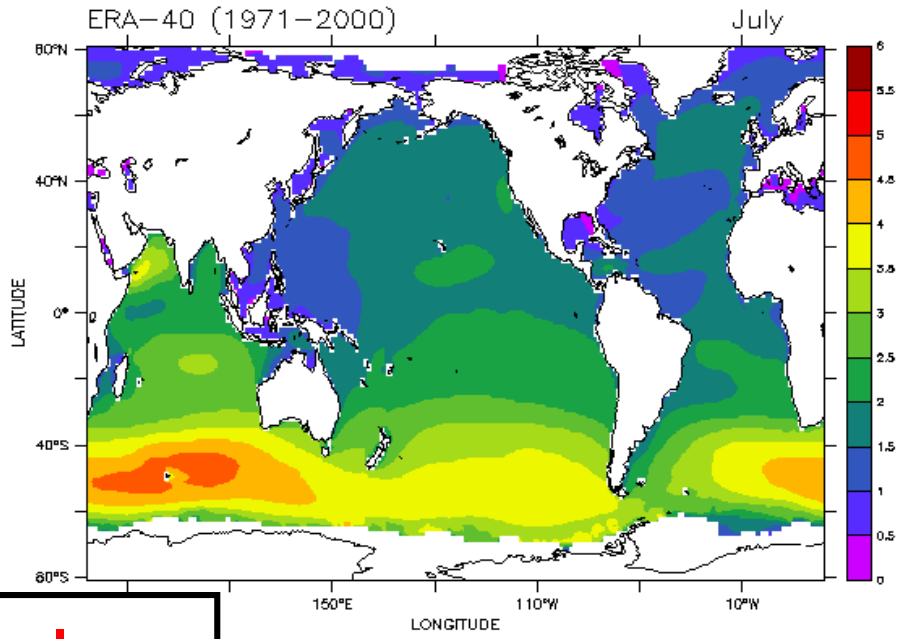
Possible inhomogeneities

- Assimilation of TOVS radiances in 1979
- Assimilation of SSM/I winds in 1989
- Assimilation of ERS-1 altimeter data
  - faulty: 12/1991-05/1993
  - none: 06/1993-12/1993
  - correct: 01/1994-05/1996
- assimilation of ERS-2 altimeter data since 06/1996

Global Mean Significant Wave Height



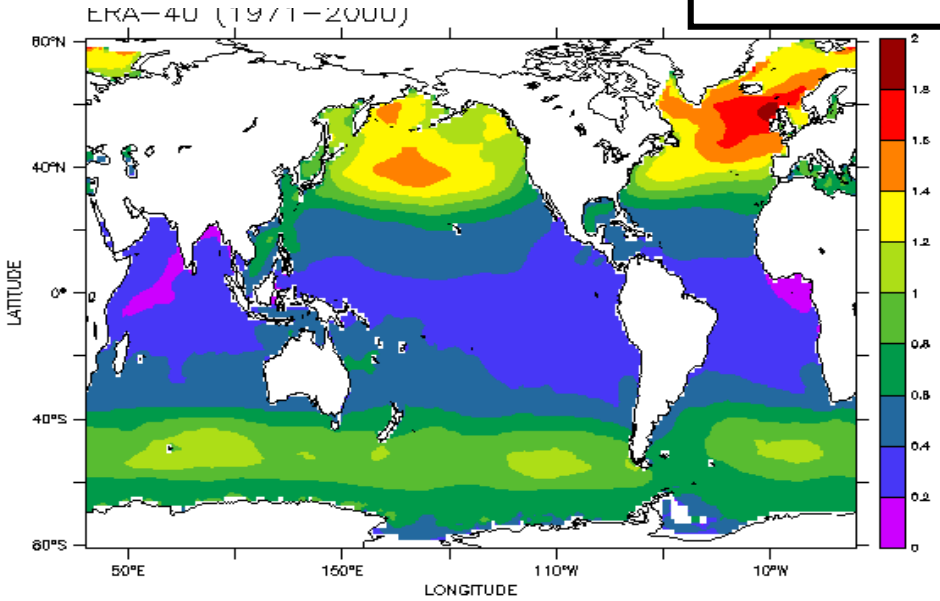




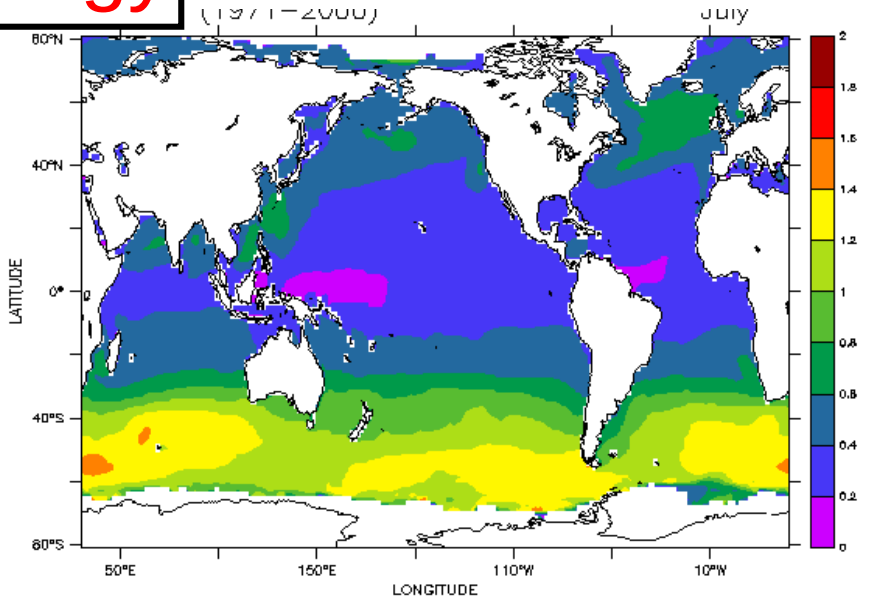
Significant wave height mean (m)

Climatology

Significant wave height mean (m)



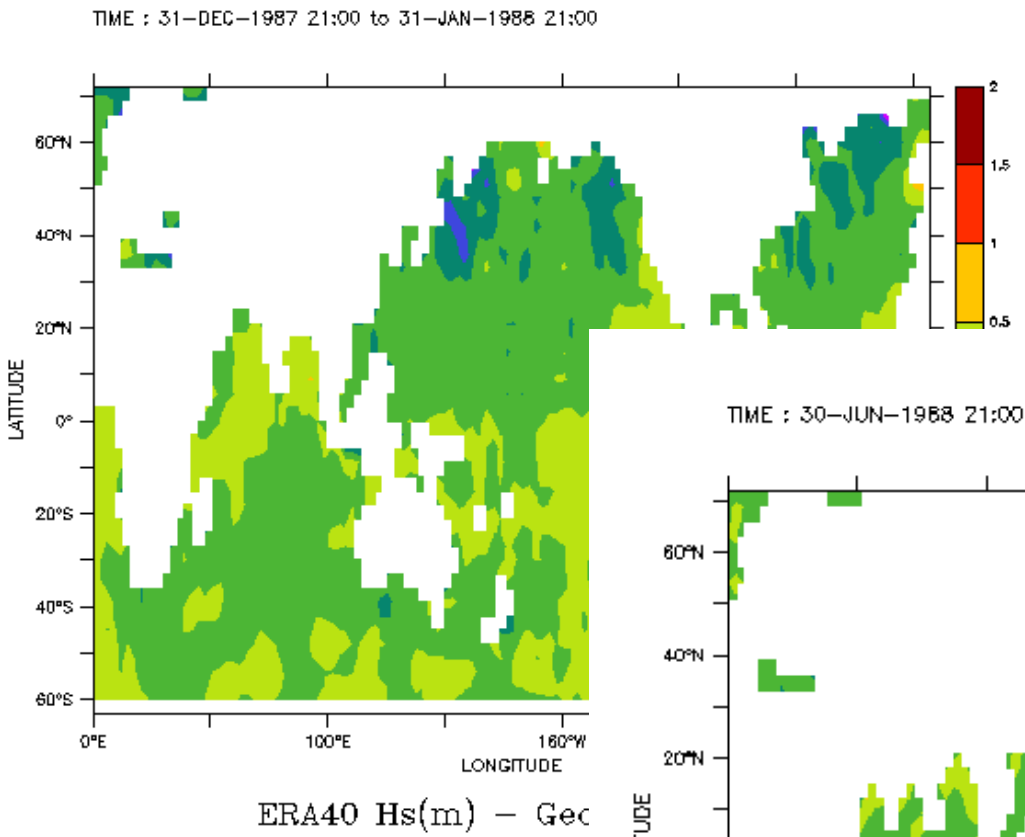
Significant wave height standard deviation (m)



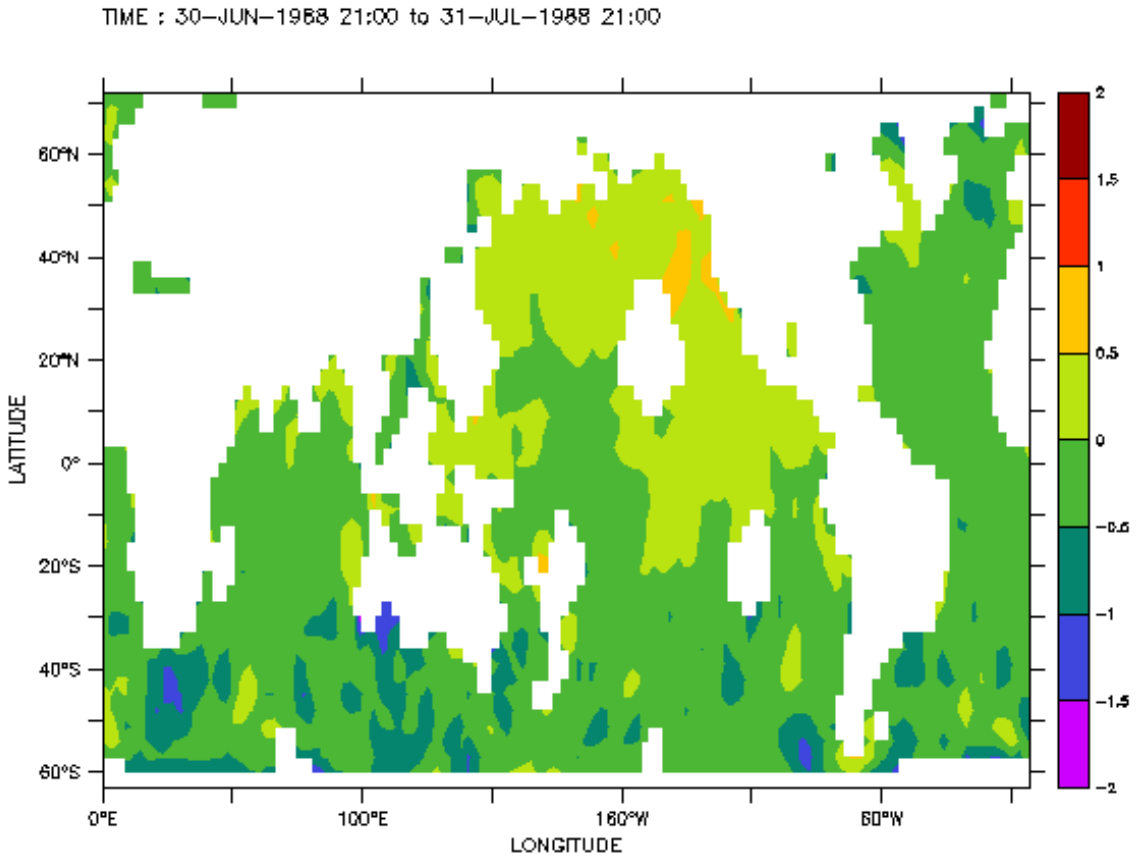
Significant wave height standard deviation (m)

Assessment of ERA-40 waves

- other modelling efforts
- buoys (since1978)
- altimeters (satellites)
  - Geosat (1987-1989)
  - ERS-1 (1991-1996)
  - ERS-2 (since 1996)
  - TOPEX/POSEIDON (since 1992)



ERA40 Hs(m) – Gec



ERA40 Hs(m) – Geosat Hs(m)

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Monthly Means

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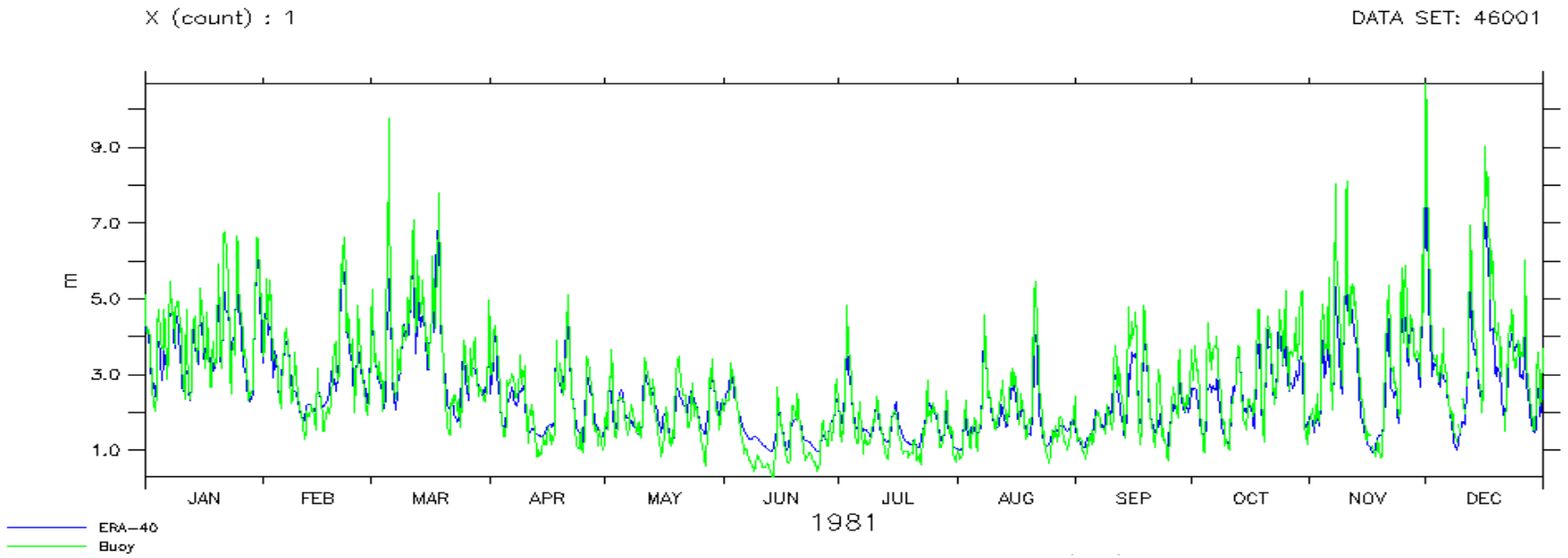
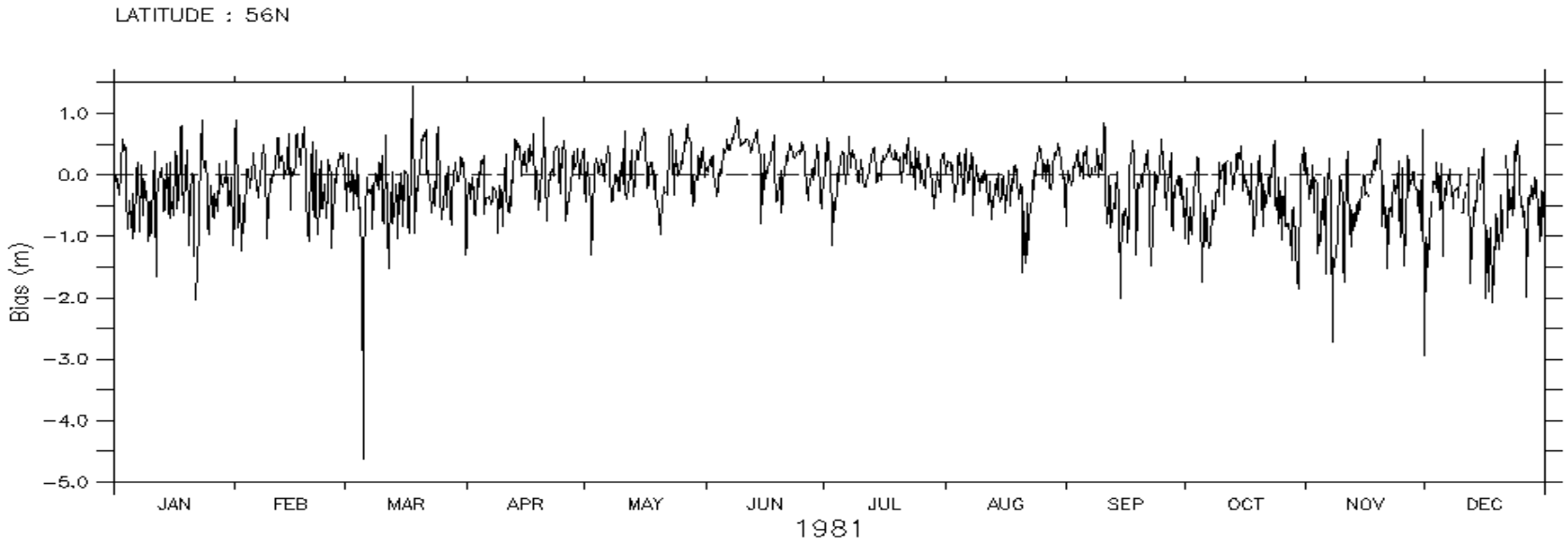
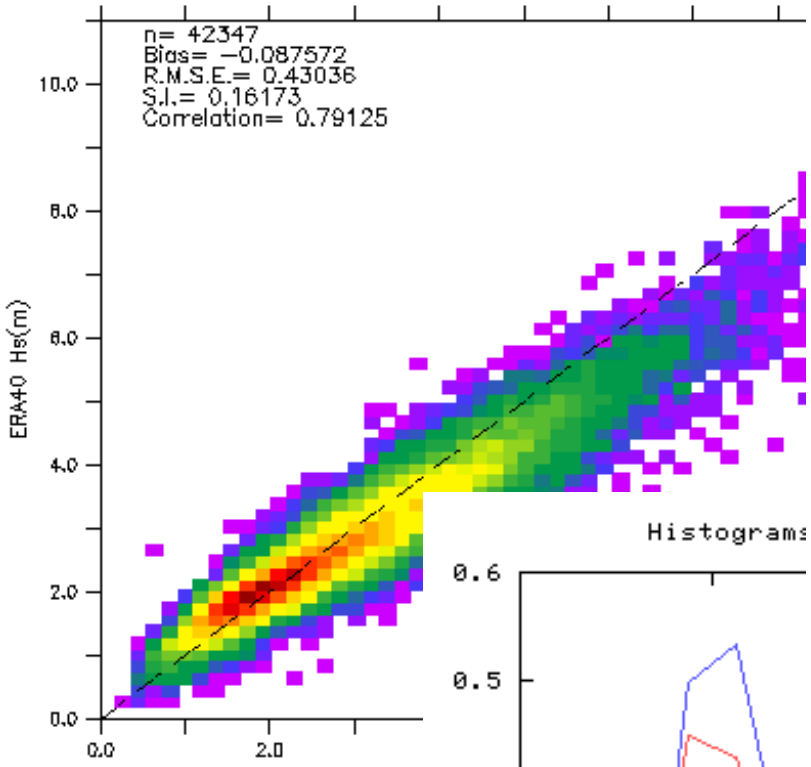
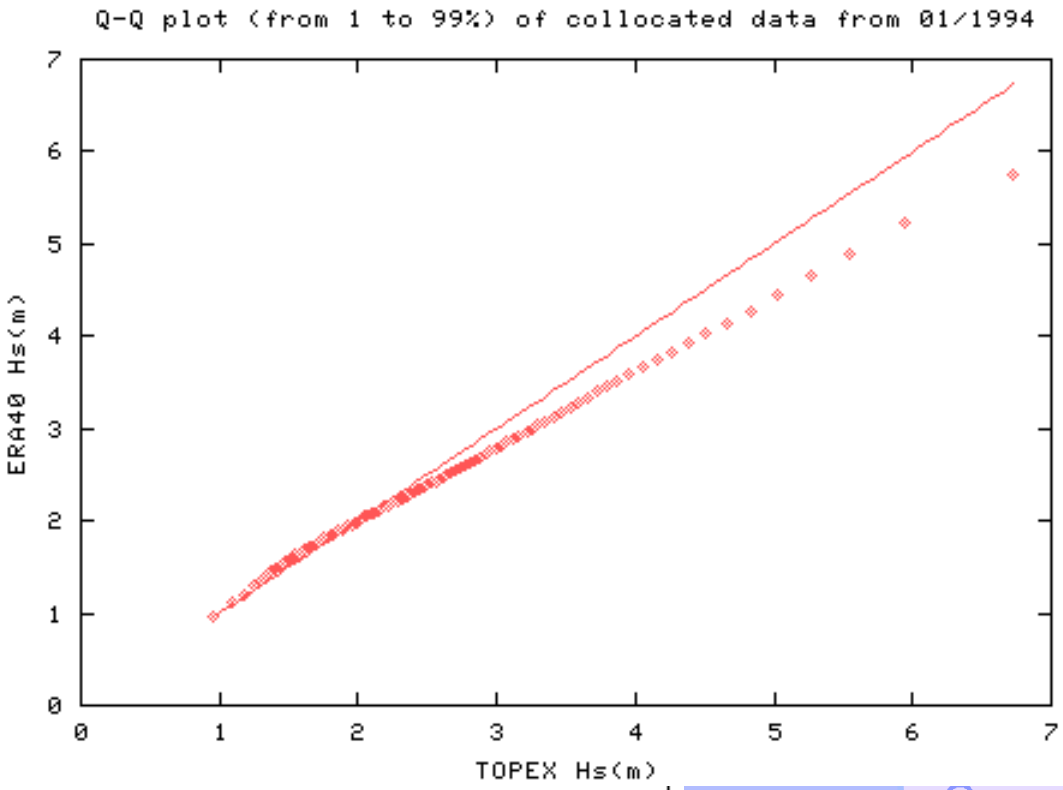
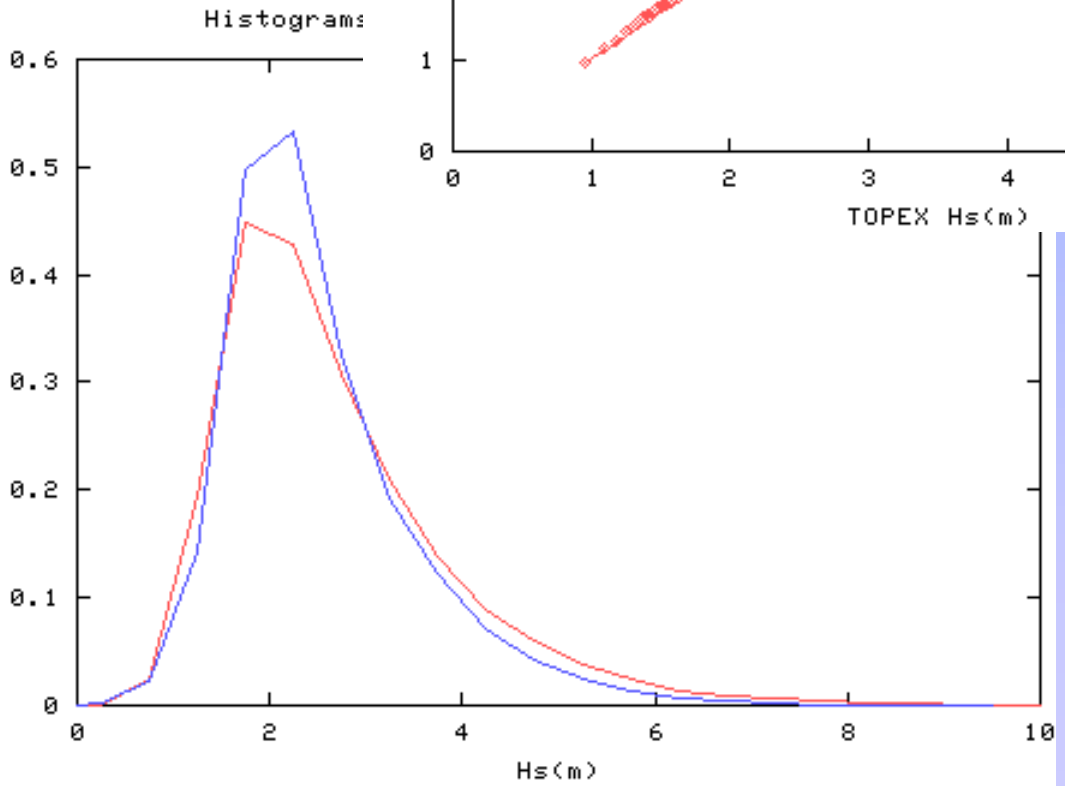




Significant Wave Height data at buoy 46001 location







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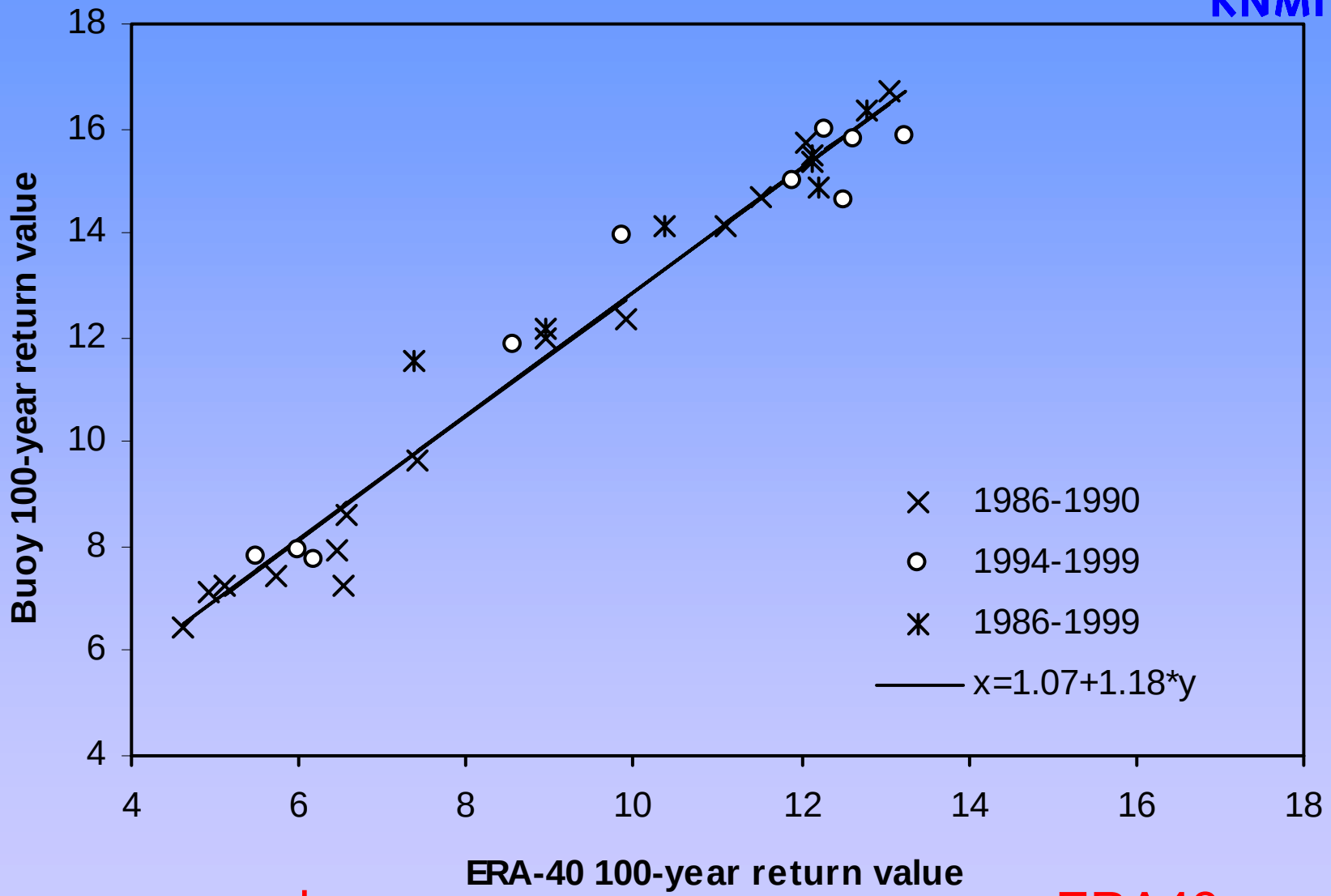
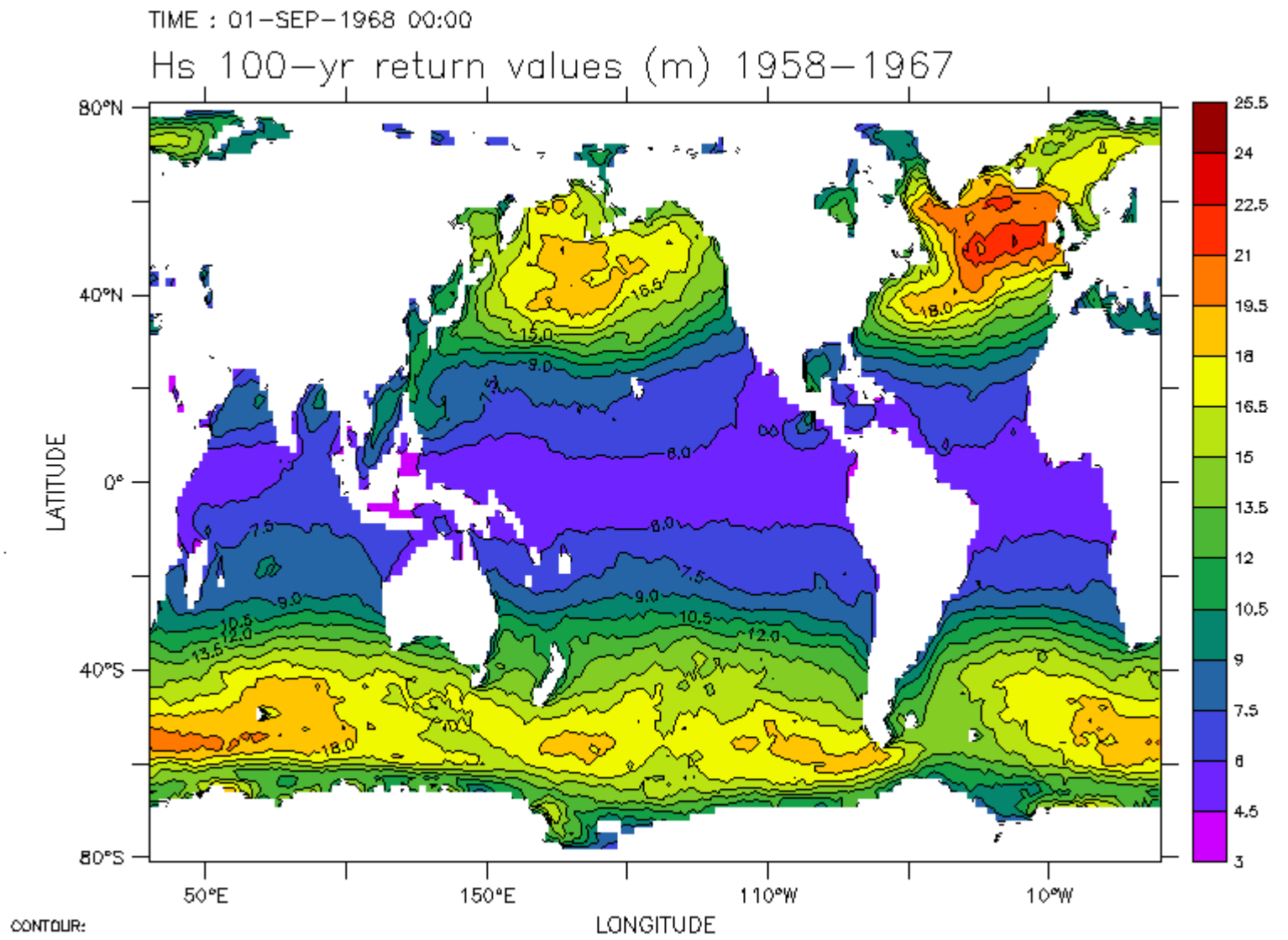
The “100 year return” wave height

- Peak-Over-Threshold (POT) method:
- $\{H_S: H_S > T\}$ – exponential PDF (or GPD)
- $T = H_S (Q_{93})$
- Estimate parameter(s) of PDF
- $\Rightarrow H_{100}$
- Both for ERA-40 and buoy

ERA-40 vs buoy data



$$H_{100}^{buoy} = 1.07 + 1.18\, H_{100}^{ERA40}$$



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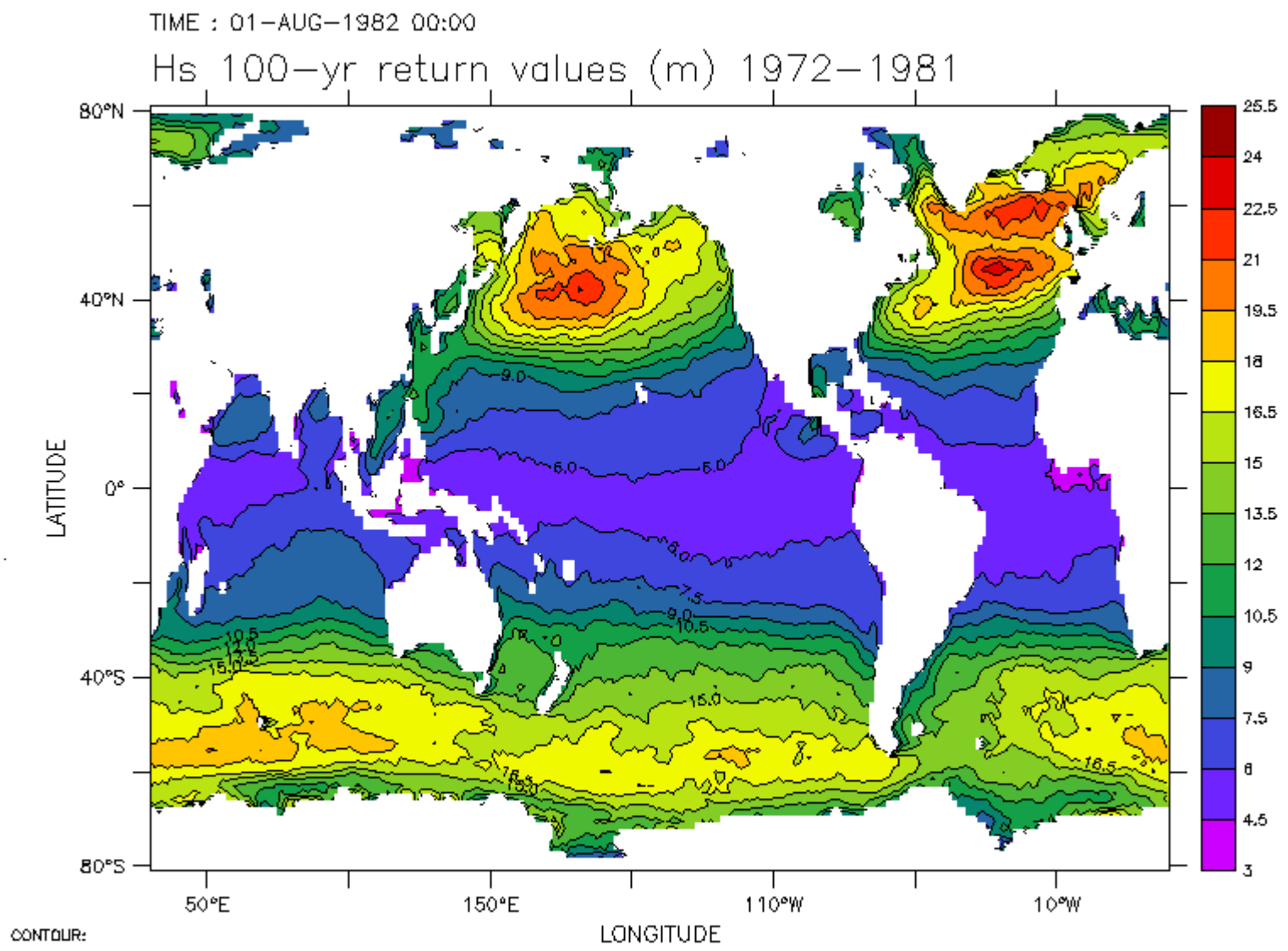

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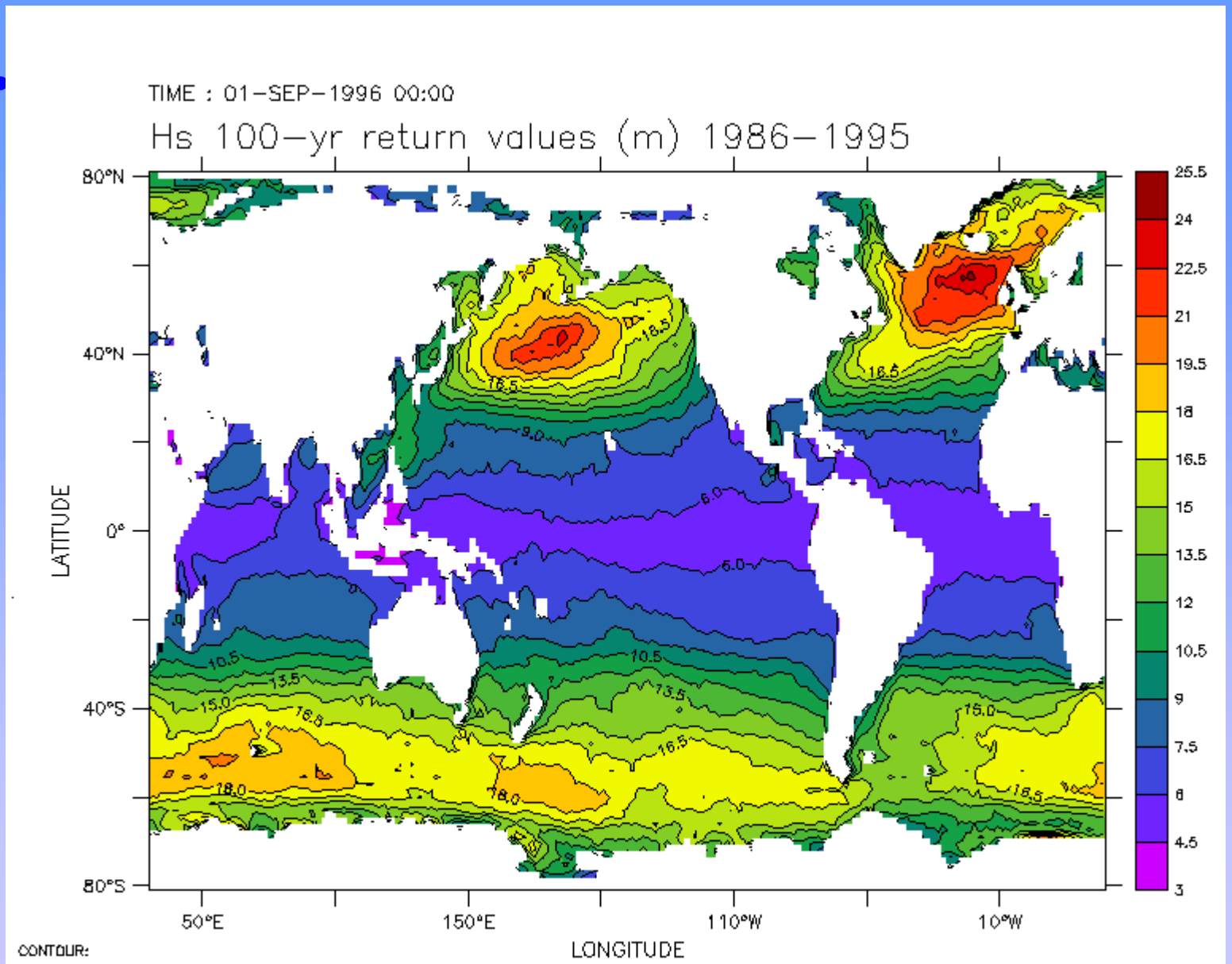

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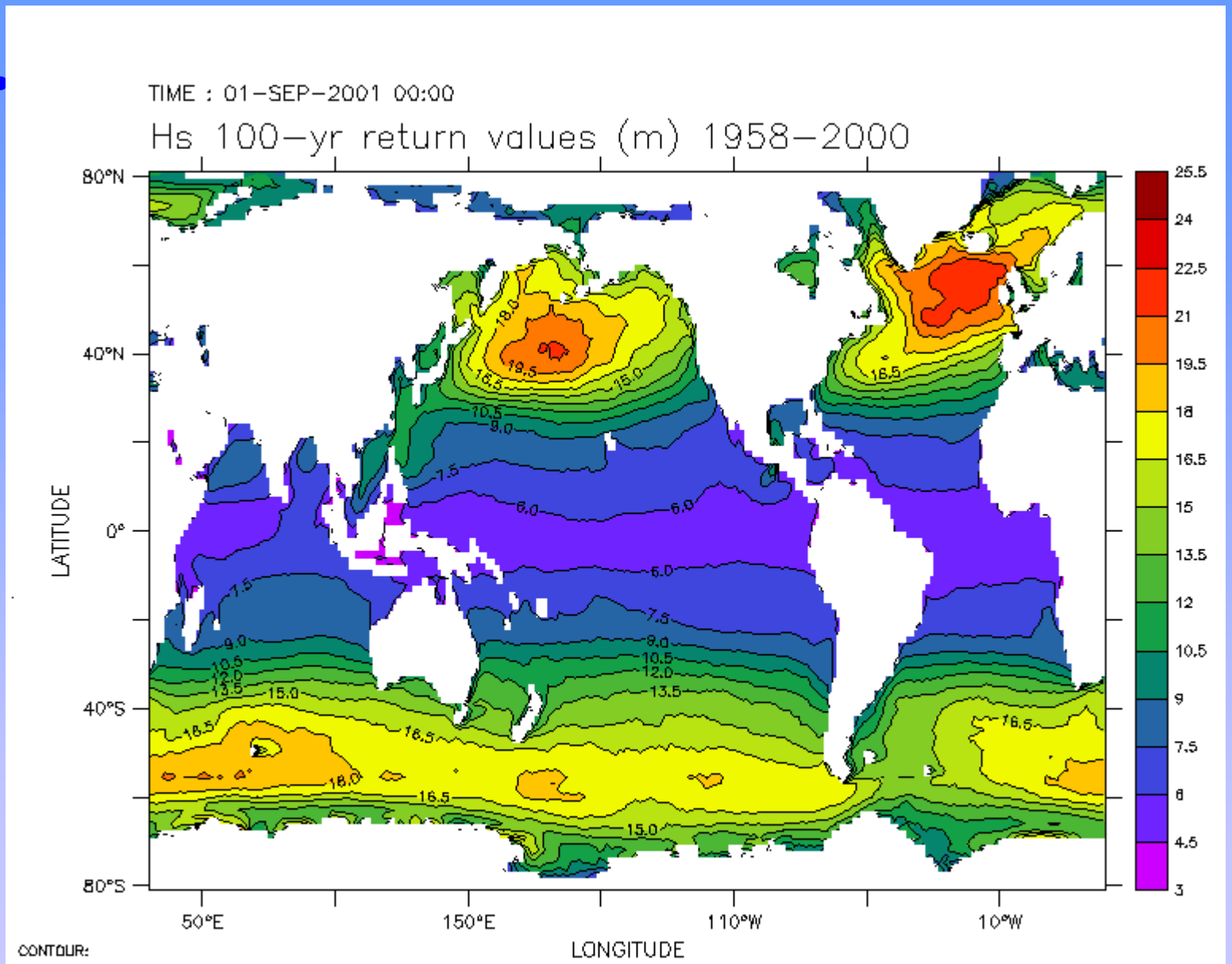

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Statistitical correction of wave heights

- bias = bias (H_s, swell, ...)
- => no simple parametric correction
- hope: bias similar in similar situations
- then:
- identify “similar” situations (“analogues”)
- learn from known biases (“learning data”)

....

Analogue

Last three H_s–values close together:

$$|H_s^1(t_0 - i\,\Delta t) - H_s^2(t_0 - i\,\Delta t)| < \varepsilon,\ i = 0, 1, 2$$

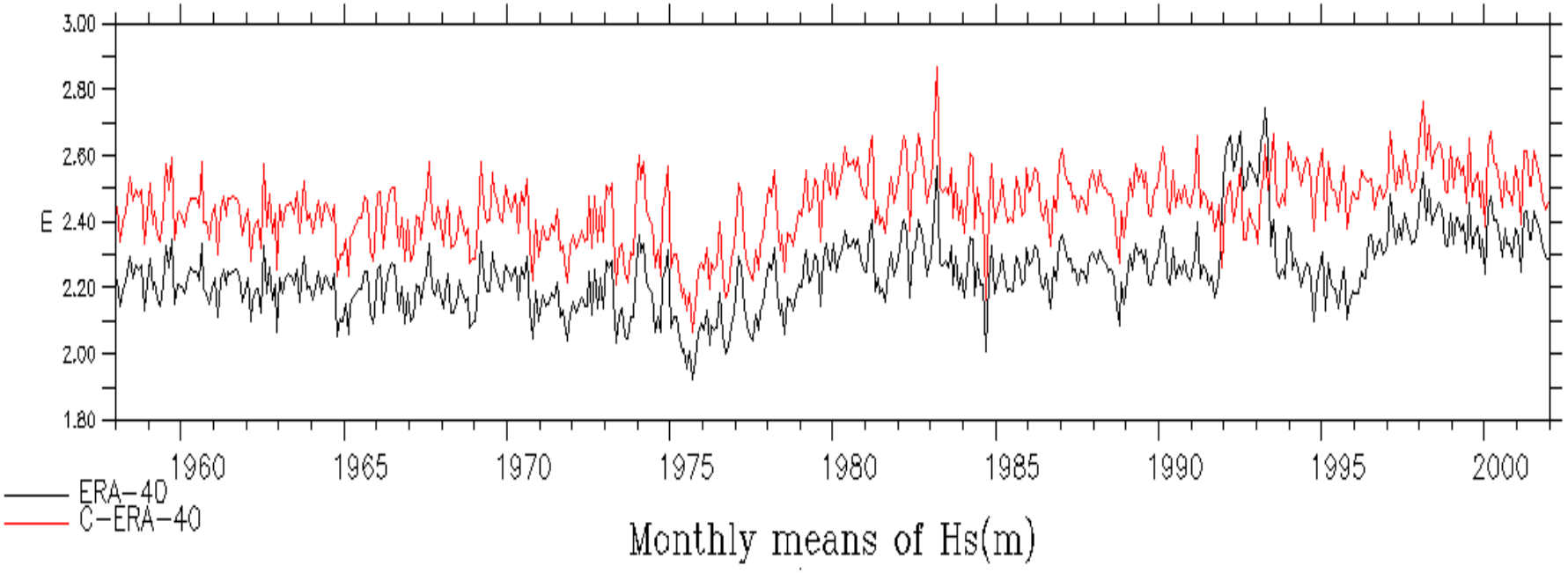
Or:

The development of the waves must be similar.

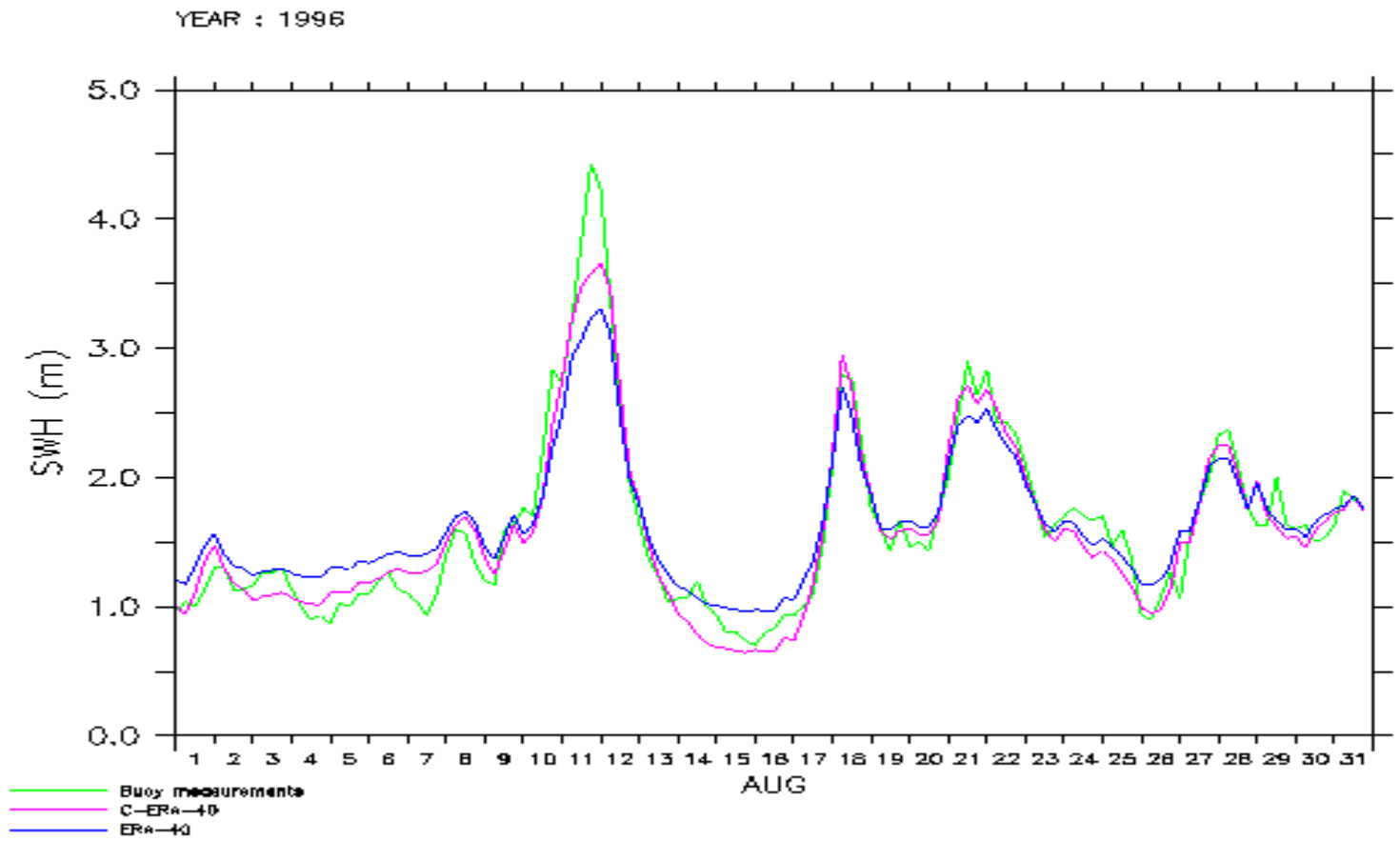
How to do it

- Divide ERA-40 into periods according to inhomogeneities
- “Truth” from TOPEX
- Build learning dataset for each period
- Identify analogues and correct data
- Calculate confidence intervals
- Validate (buoy, Geosat, ERS-2)

Global mean H_s



- wave height generally increased (bias ≈ 0)
- no more inhomogeneities



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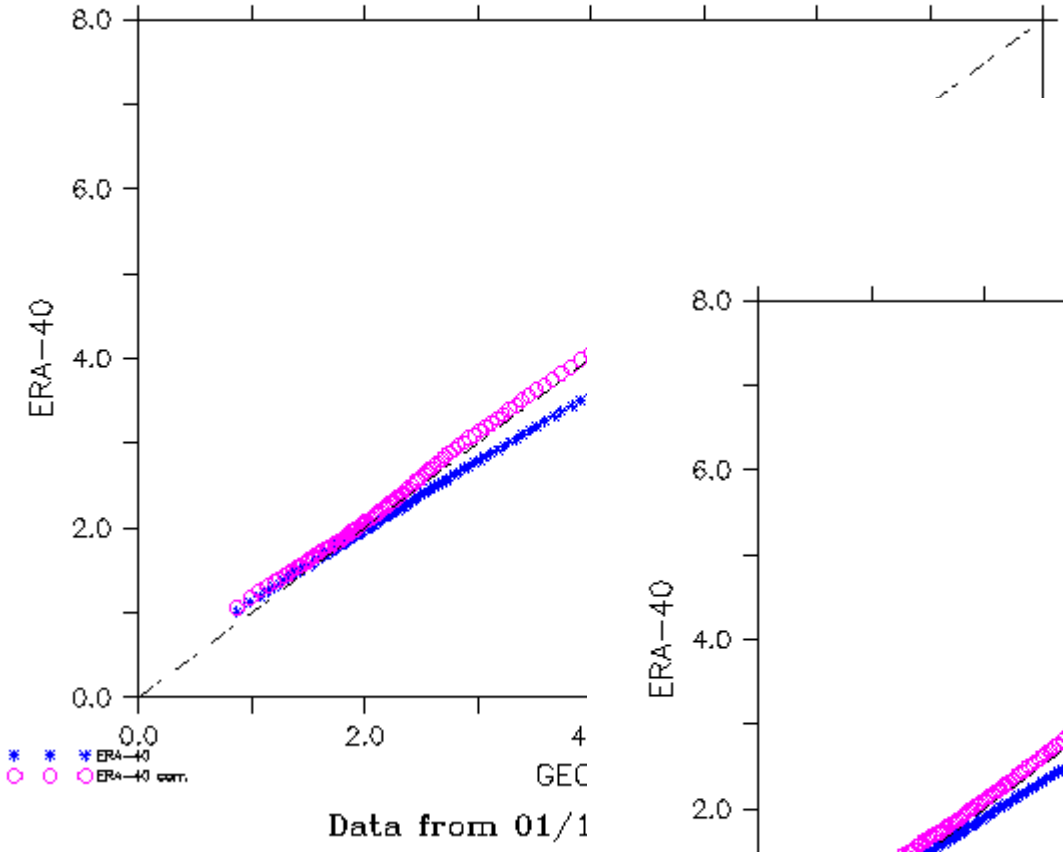
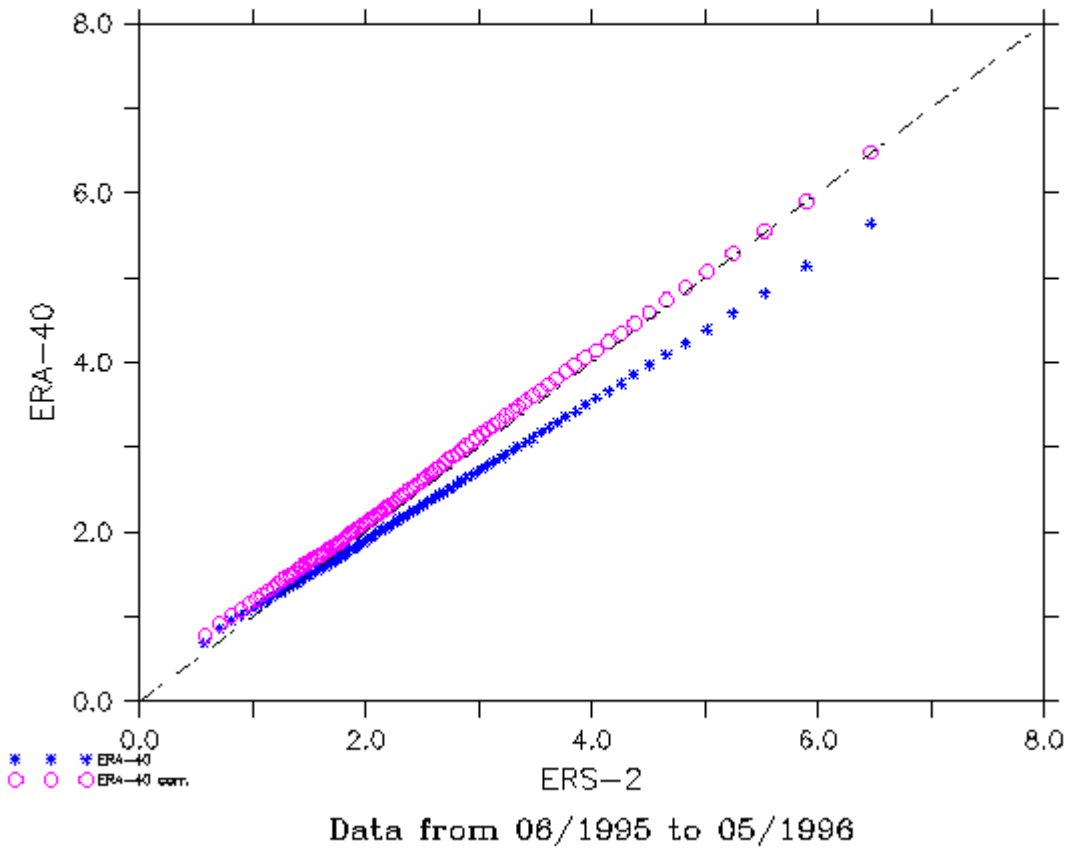

8.0
6.0
4.0
2.0
0.0
ERA-40
0.0
2.0
4
GEC
ERA-40
ERA-40 corr.
Data from 01/1


8.0
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ERA-40
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ERS-2
ERA-40
ERA-40 corr.
Data from 06/1995 to 05/1996

The KNMI/ERA-40 Wave Atlas

http://www.knmi.nl/onderzk/oceano/waves/era40/atlas.html

Click here for a no frames version of this page.

ATLAS
derived from 45-years of ECMWF reanalysis data

S. Caires, A. Sterl, G. Komen and V. Swail

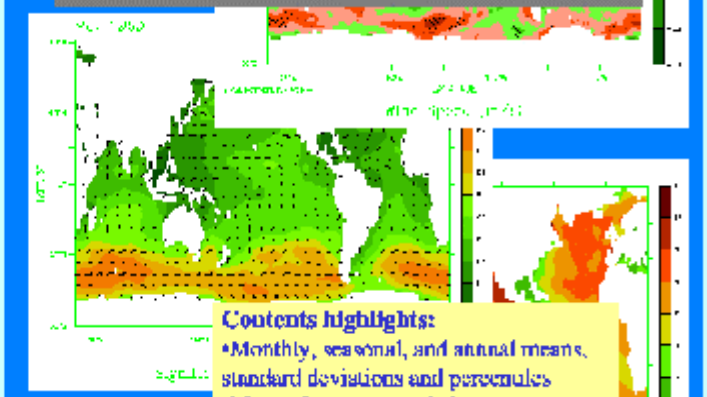
Thanks to European Centre for Medium Range Weather Forecasts for the raw ERA-40 data..

Table of contents

Global Wave Climatology Atlas
derived from 45-years of ECMWF reanalysis data

This web-based book describes wave climate and variability for use in

- Ocean engineering applications
- Detailed strategic planning of shipping routes
- Scientific areas such as climate research



Contents highlights:

- Monthly, seasonal, and annual means, standard deviations and percentiles
- Maps of extreme statistics
- Wave height, period and direction scatter tables
- Description of wind and wave climate variability

Developed by
S. Caires, G. Komen, A. Sterl and V. Swail

Bookmark:
http://www.knmi.nl/onderzk/oceano/waves/era40/atlas.html

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Summary

- Inhomogeneities due to changing data
- Good monthly means
- Low waves (slightly) too high
- High waves (much) too low
- Possibility of statistical correction
- Wave Atlas, freely accessible via http://www.knmi.nl/onderzk/oceano/waves/era40/atlas.html

The End !!