Shirshov Institute of Oceanology
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Understanding discrepancies in global ocean surface wave climate based on ERA5, MERRA2, ERA-I and CFSR hindcasts

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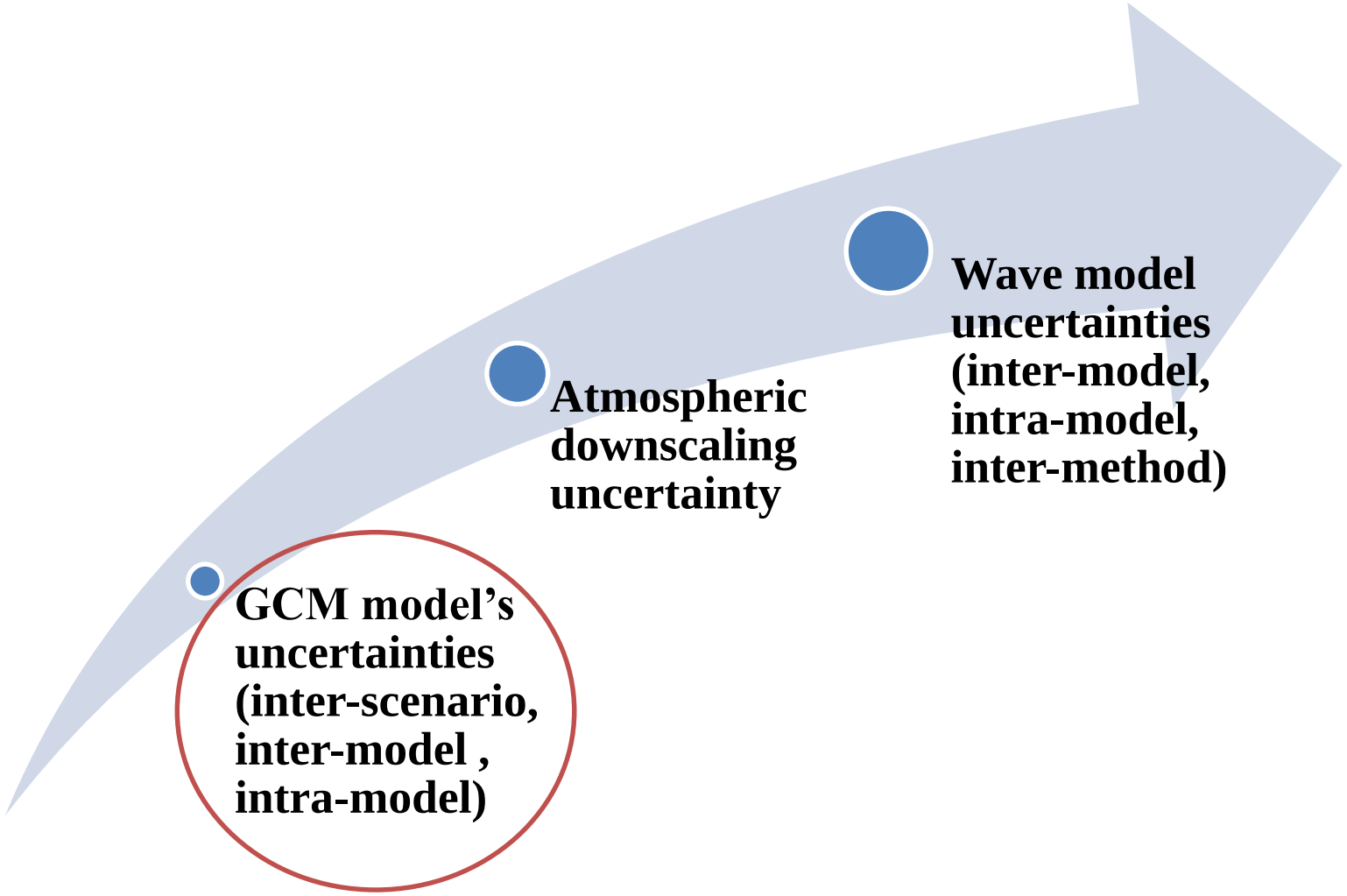
Discrepancies-?



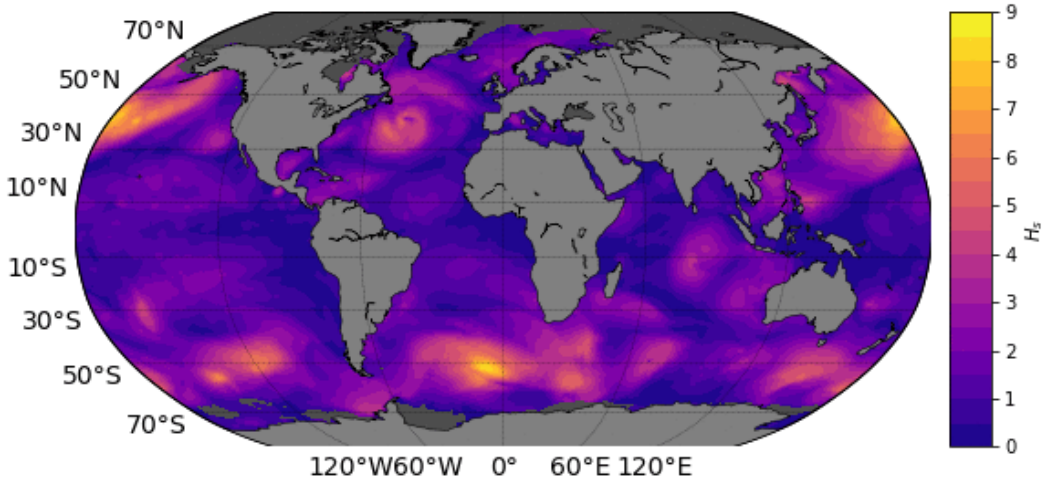
(COWCLIP nomenclature, Morim et.al, 2018)

Goals

1. To perform 4 hindcats based on modern reanalyses
2. To validate wind speeds and wave heights from hindcasts against satellite data
3. To analyze discrepancies between different hindcasts
4. To estimate global trends in wind speeds and wave heights from reanalyses and hindcasts

Methods

We performed 4 long-term (1980-2017) wind wave hindcasts based on ERA5, CFSR, MERRA2, ERA-Interim atmospheric reanalyses and analysed discrepancies between them.



WAVEWATCH III – third generation spectral wave model:

- ST4 physics package
- Spectral resolution: 25 frequencies, 24 directions
- DIA for non-linear wave interactions

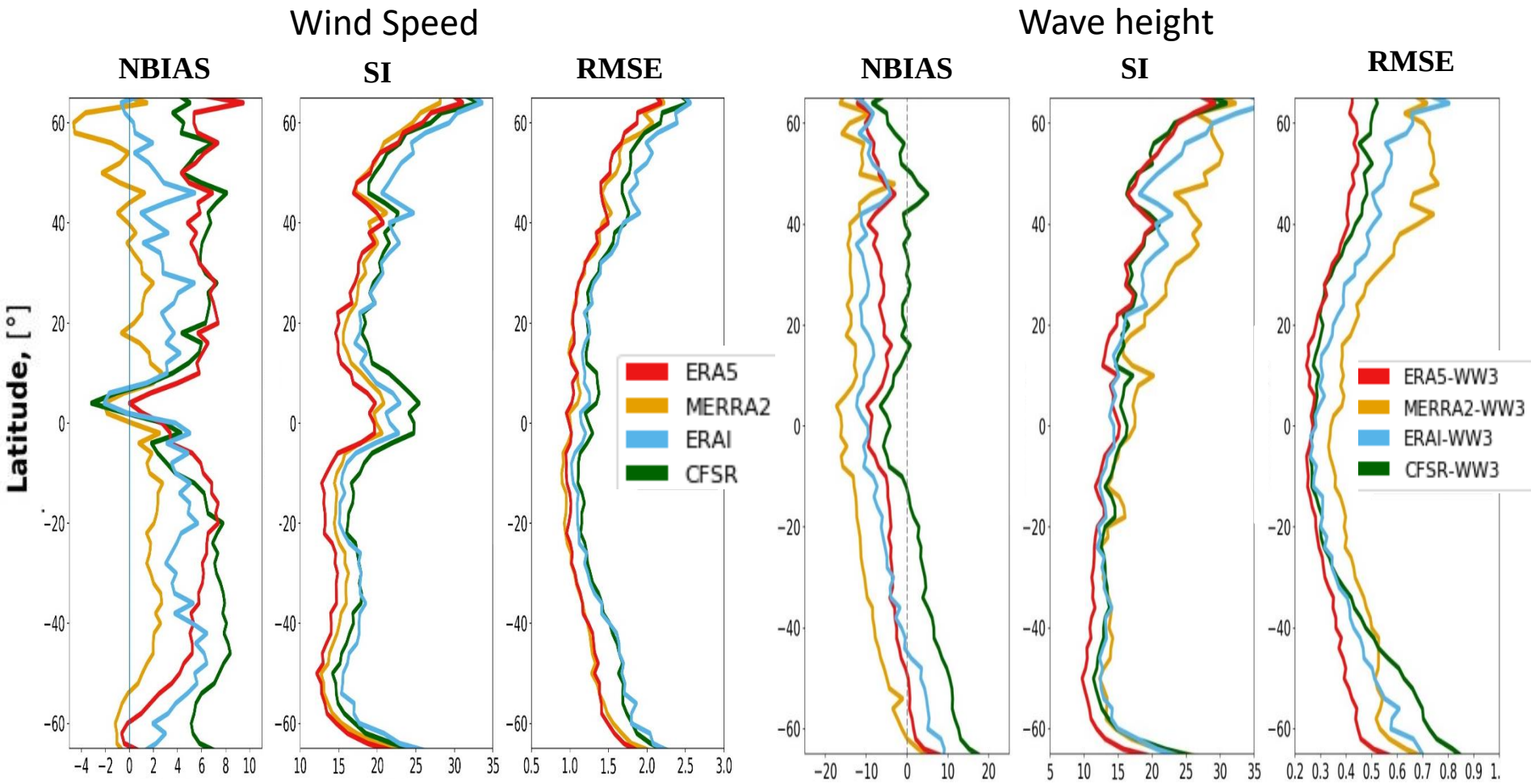
Boundary conditions: 10-m winds and sea ice concentrations (6-hourly)	Spatial resolution (lat x lon)
ERA5 (ECMWF)	0.25° × 0.25°
ERA-Interim (ECMWF)	0.7° × 0.7°
NCEP CFSR (v2)	0.312° × 0.312°
MERRA2 (NASA)	0.5° × 0.625°

Validation of hindcasts against altimeter data (Jason1)

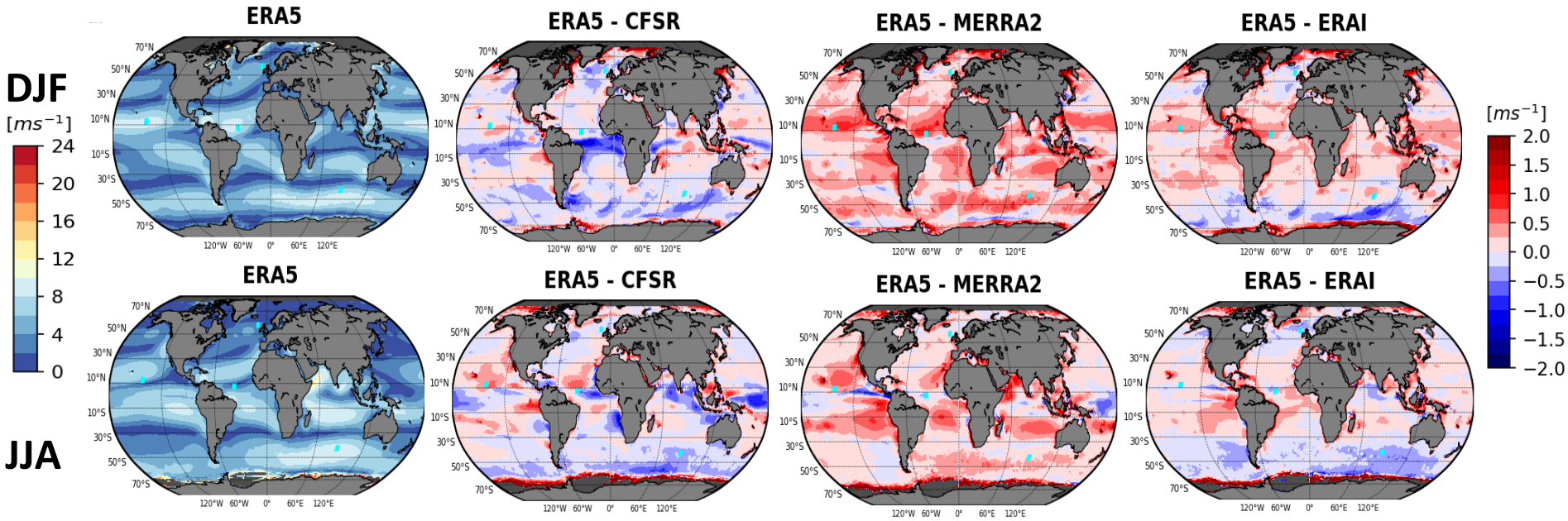
$$NBIAS = \left[\left(\bar{h} - \bar{m} \right) / \sqrt{\frac{1}{n} \sum_{i=1}^{n} \left(m_i \right)^2} \right] \times 100$$

$$SI = \frac{1}{\bar{h}} \sqrt{\frac{1}{n} \sum_{i=1}^{n} \left[\left(h_i - \bar{h} \right) - \left(m_i - \bar{m} \right) \right]^2} \times 100$$

$$RMSE = \sqrt{\frac{1}{n} \sum_{i=1}^{n} \left(h_i - m_i \right)^2}$$

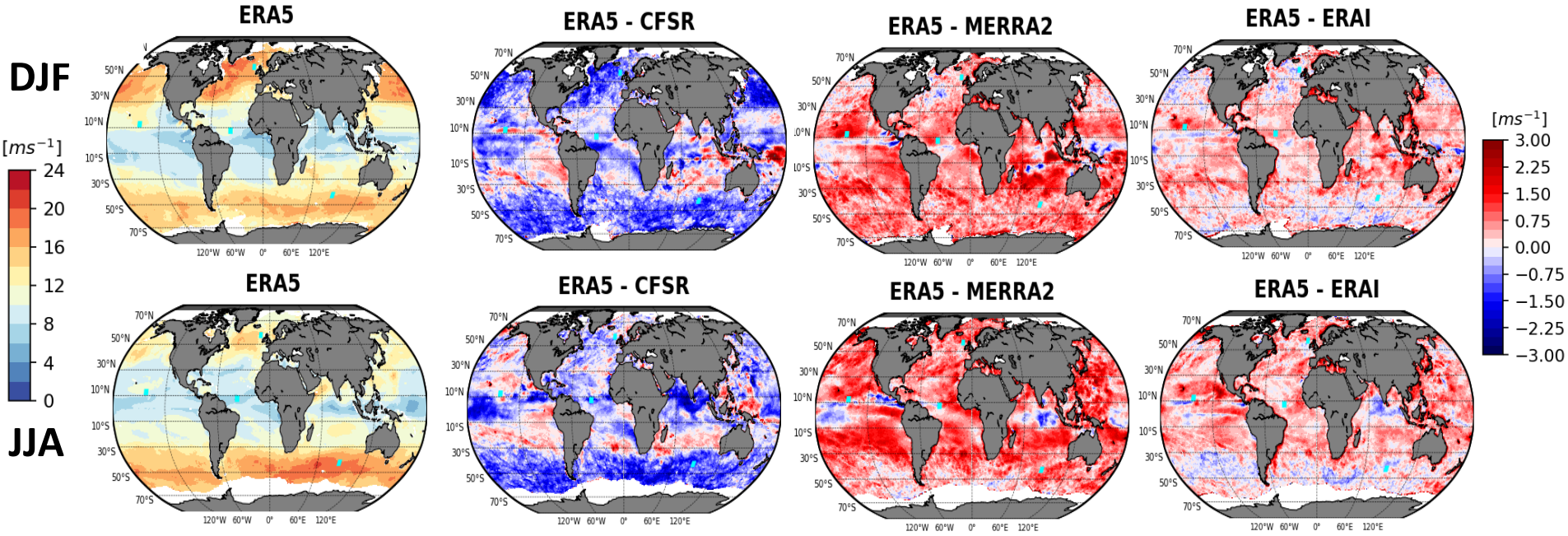


Climatology of wind speed in 1980-2017



- ERA5 < CFSR in the equatorial region
- ERA5 > MERRA2 in the tropical regions
- ERA5 and ERA-Interim give the closest mean wind speeds

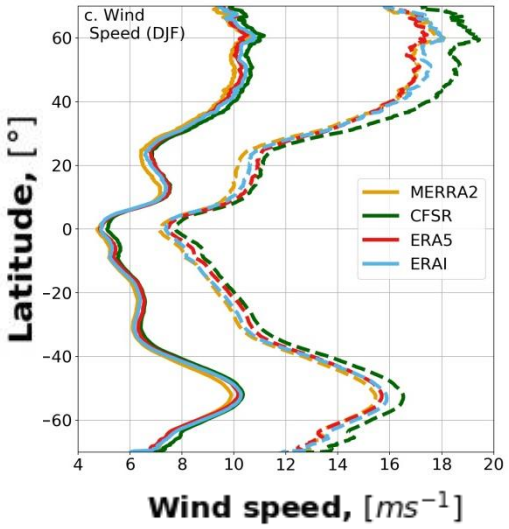
Extreme wind speeds in 1980-2017

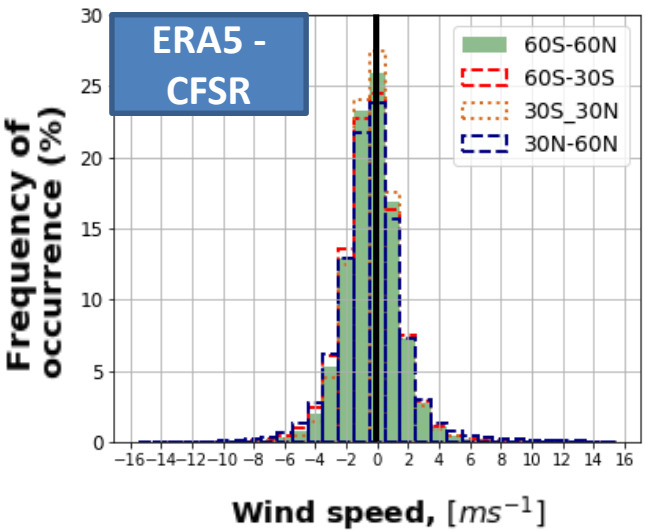


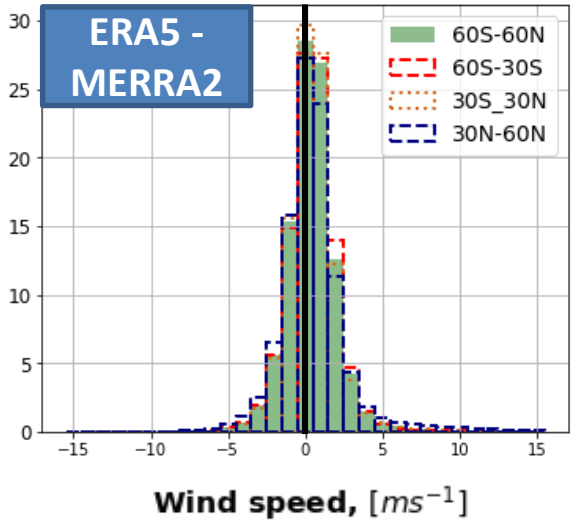
- ERA5 < CFSR both in the equatorial region and in **the mid-latitudes**
- ERA5 > MERRA2 overall
- ERA5 the closest to ERA-i

Wind speed: zonal mean and error histograms

DJF

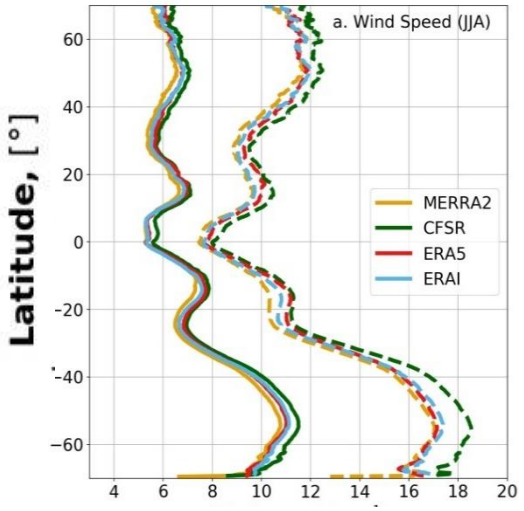


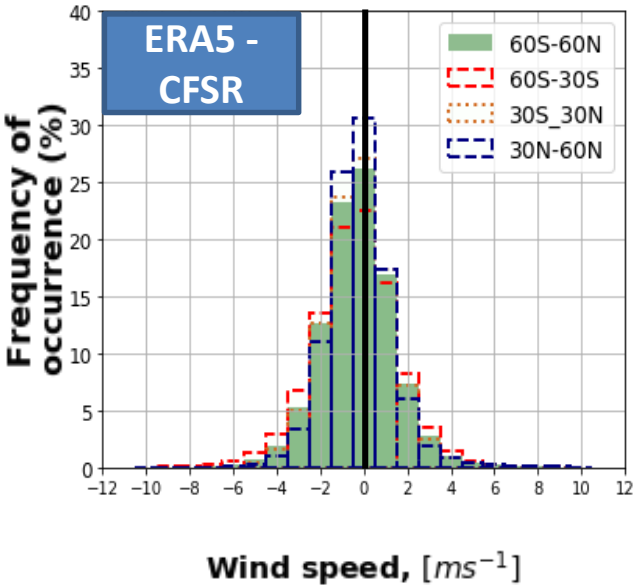


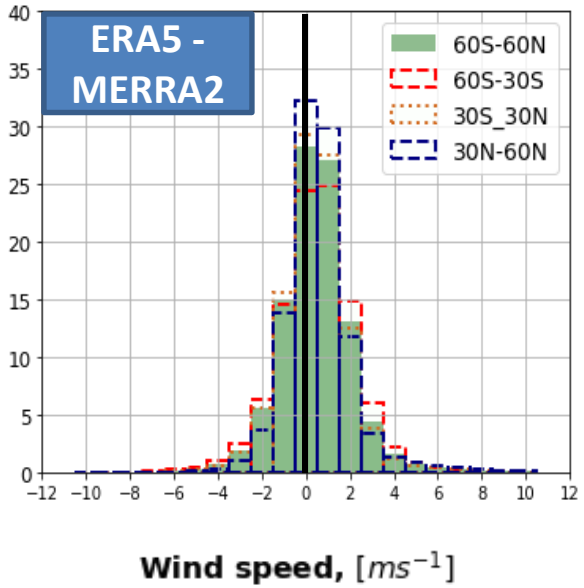


Wind speed: zonal mean and error histograms

JJA

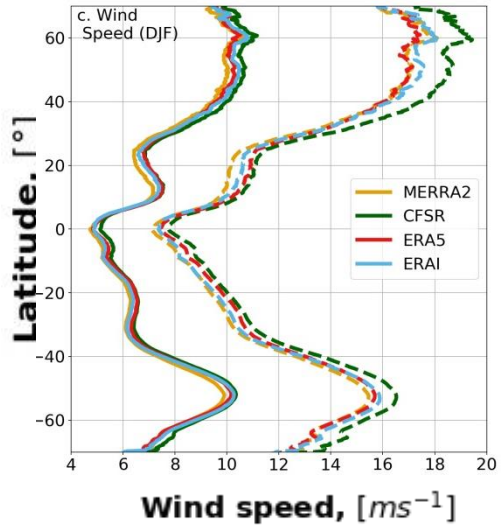


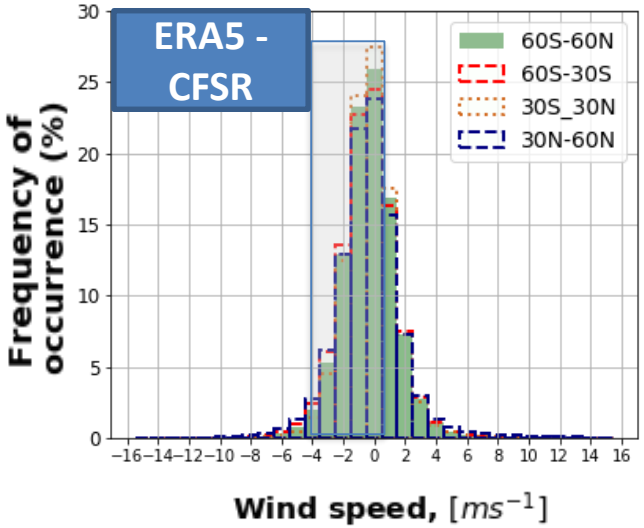


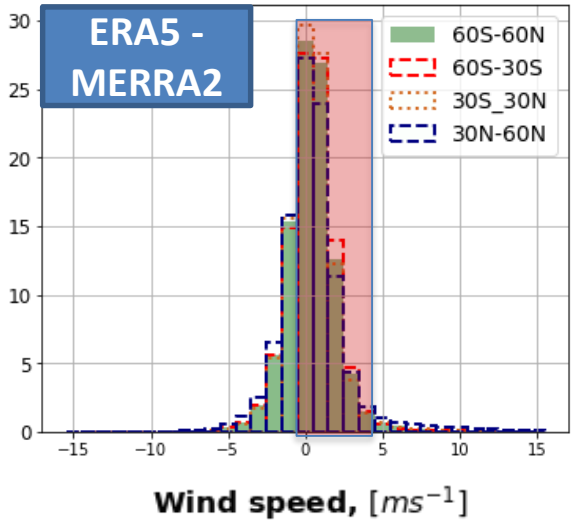


Wind speed: zonal mean and error histograms

DJF







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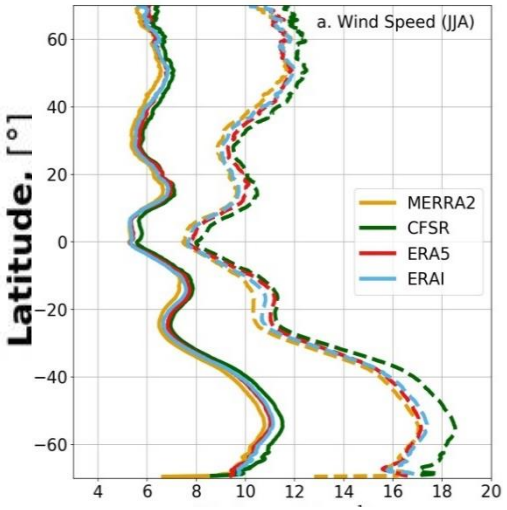
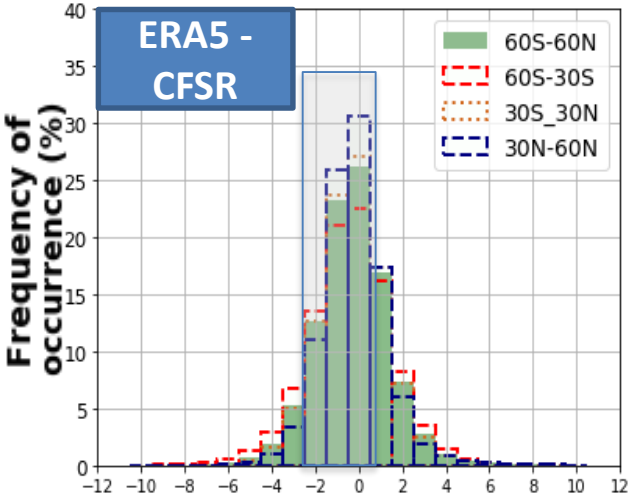
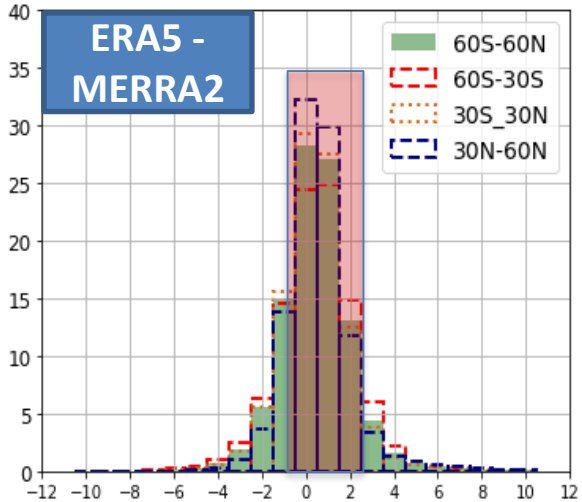
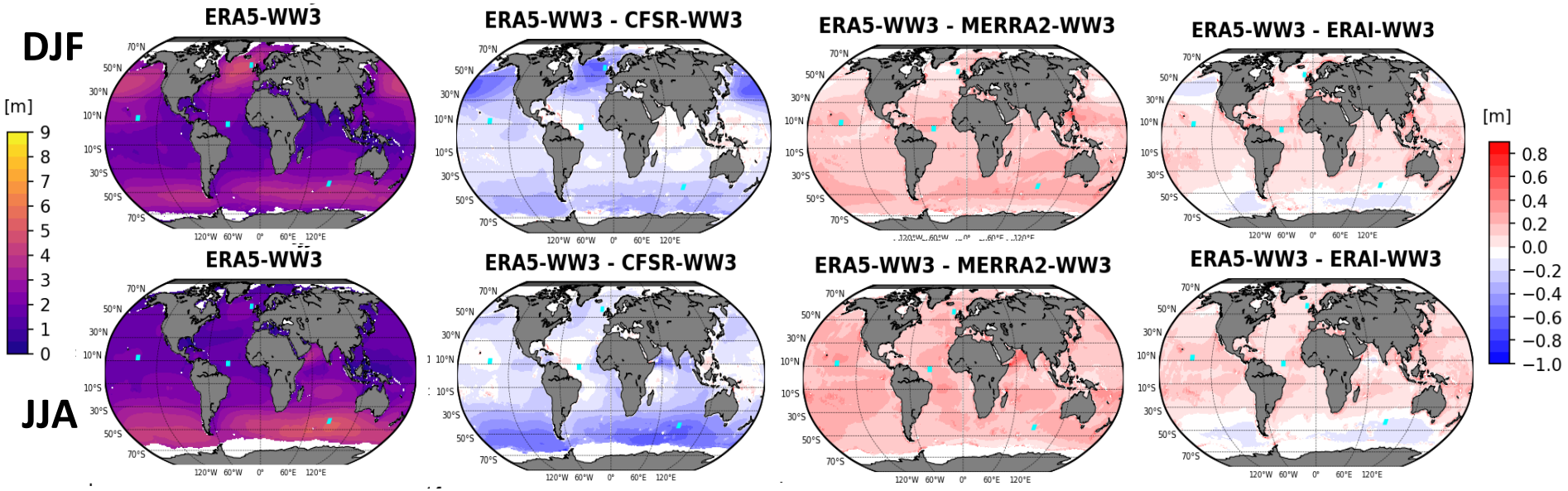




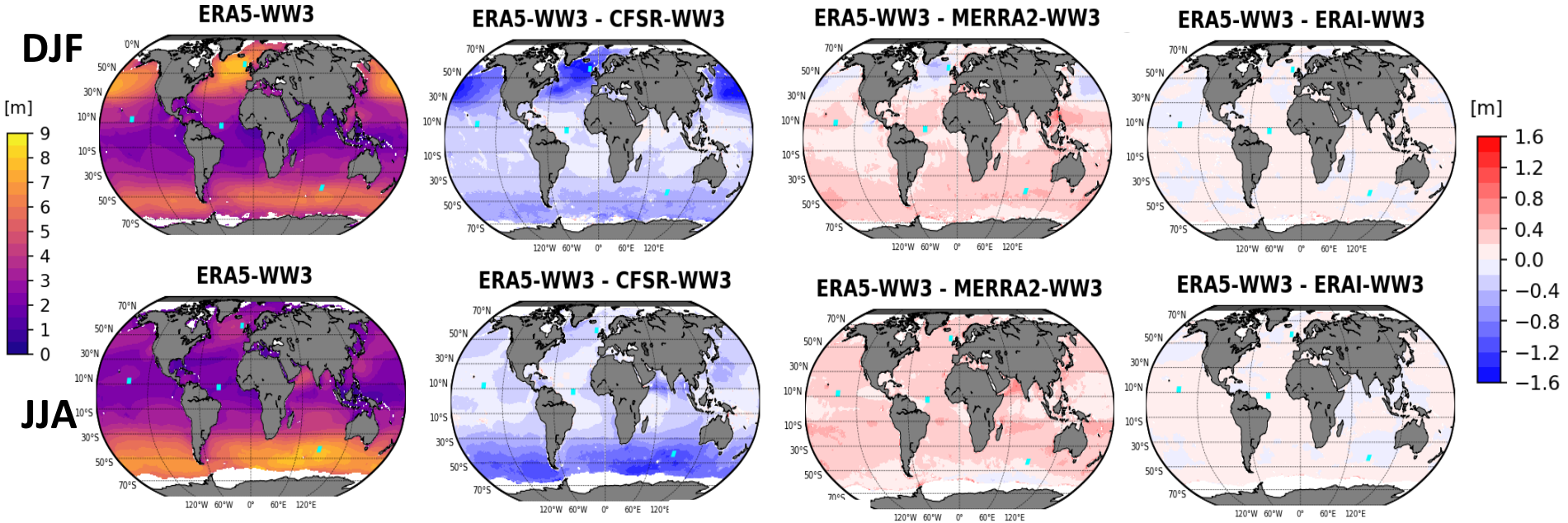


Climatology of wave height in 1980-2017



- ERA5-WW3 < CFSR-WW3 in winter of the correspondent hemisphere
- ERA5-WW3 > MERRA2-WW3 overall
- ERA5-WW3 < ERAi-WW3 in the SH mid-latitudes

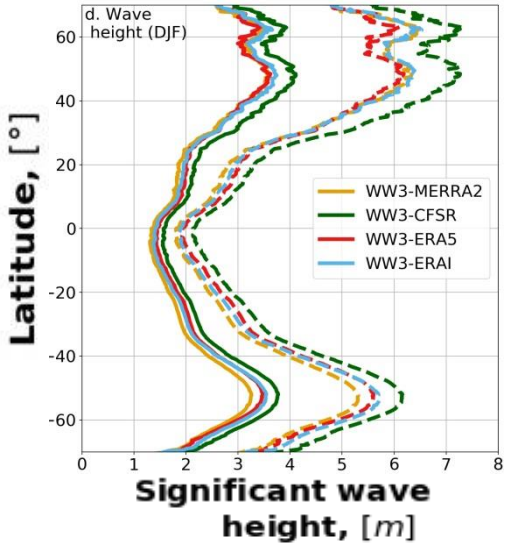
Extreme wave height in 1980-2017

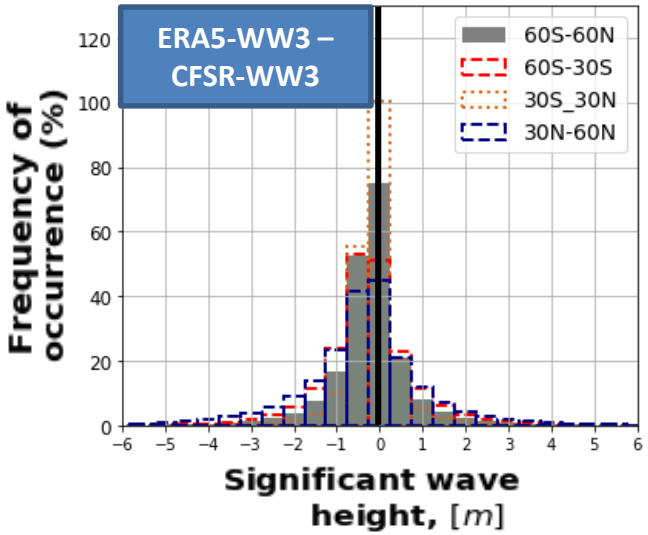


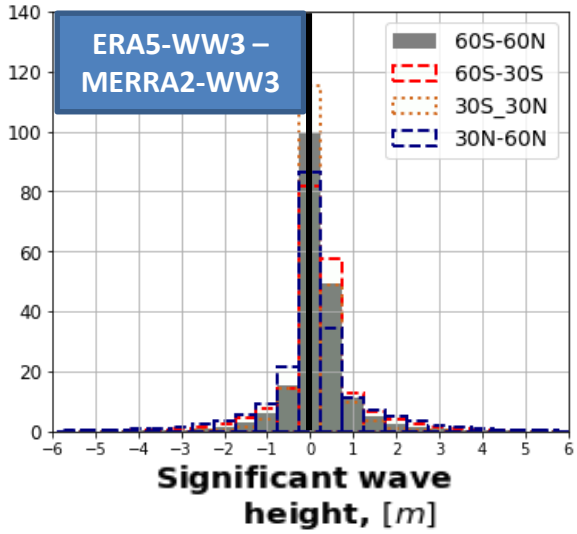
- ERA5-WW3 < CFSR-WW3
- ERA5 > MERRA2 overall, except **the mid-latitudes of NH in DJF**
- ERA5-WW3 the **closest** to ERAi-WW3

Wave height: zonal mean and error histograms

DJF

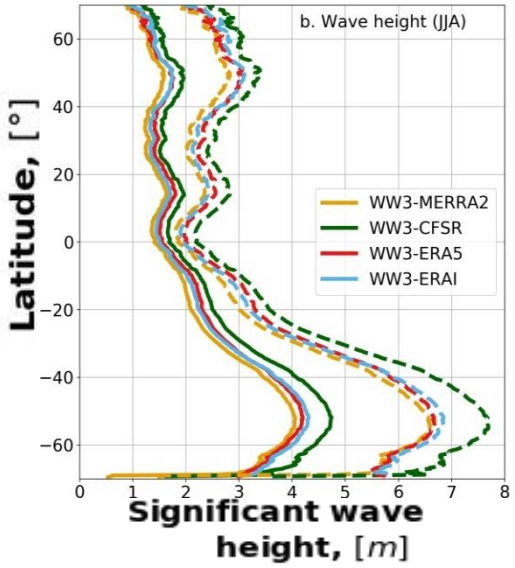


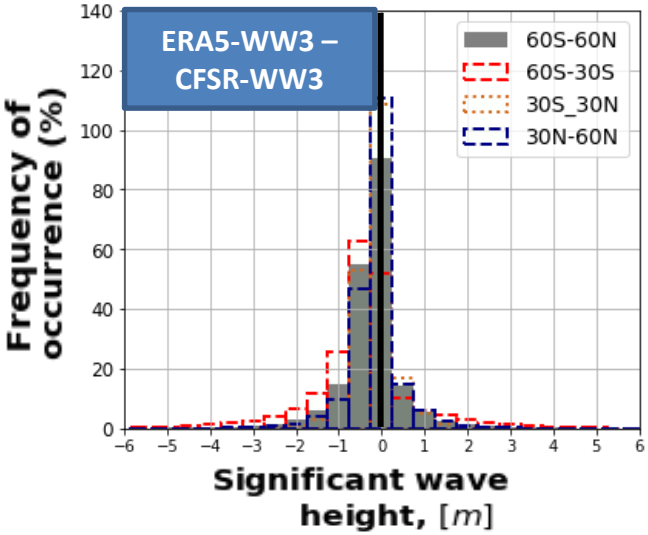


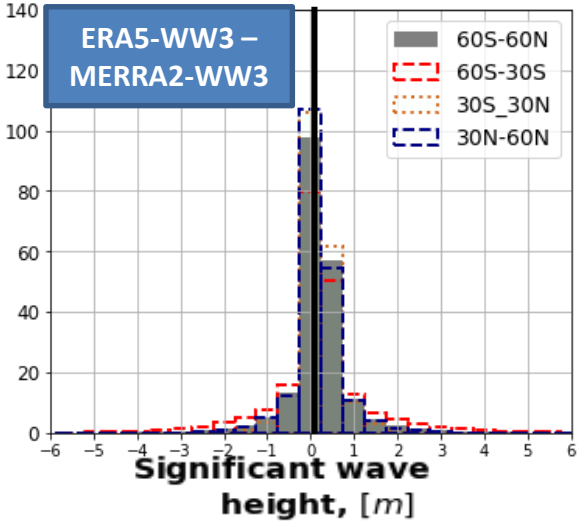


Wave height: zonal mean and error histograms

JJA

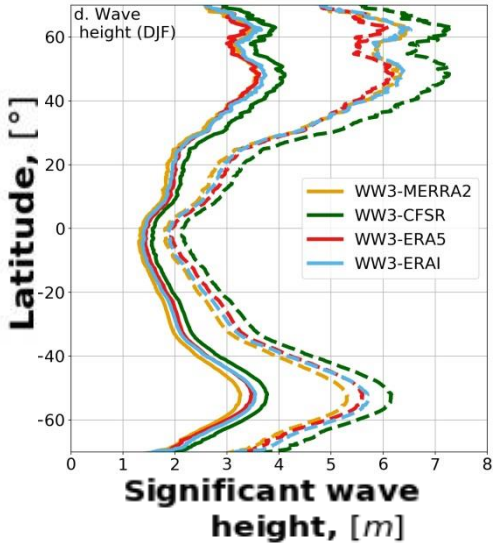


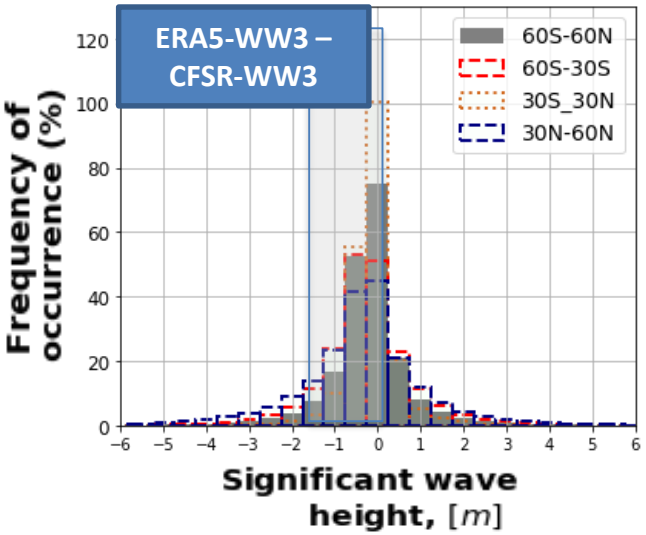


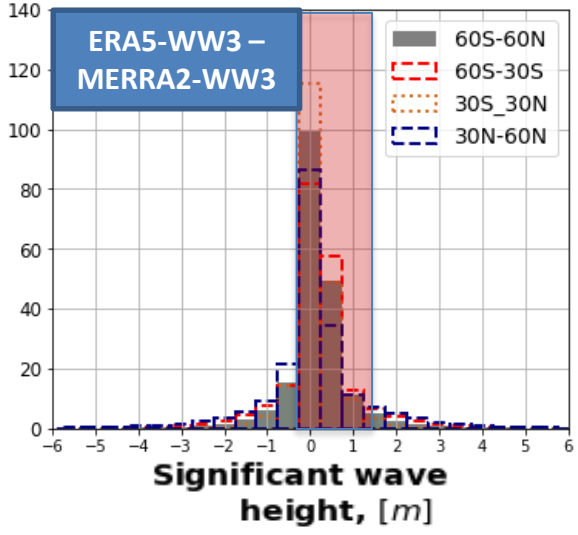


Wave height: zonal mean and error histograms

DJF







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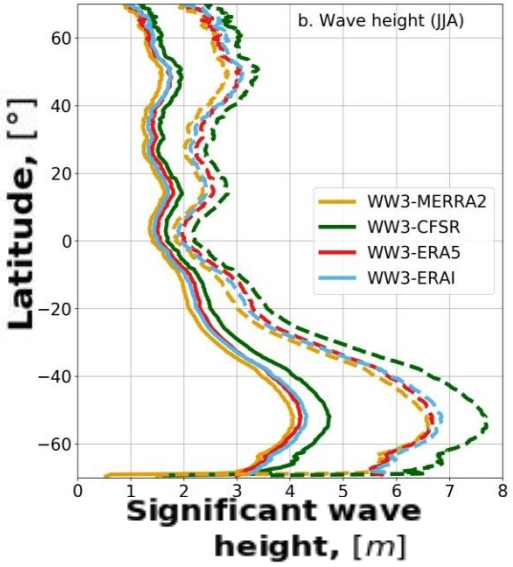
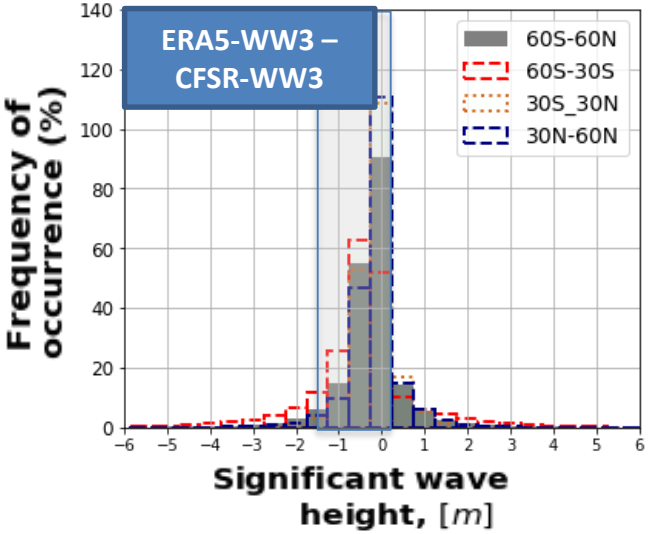
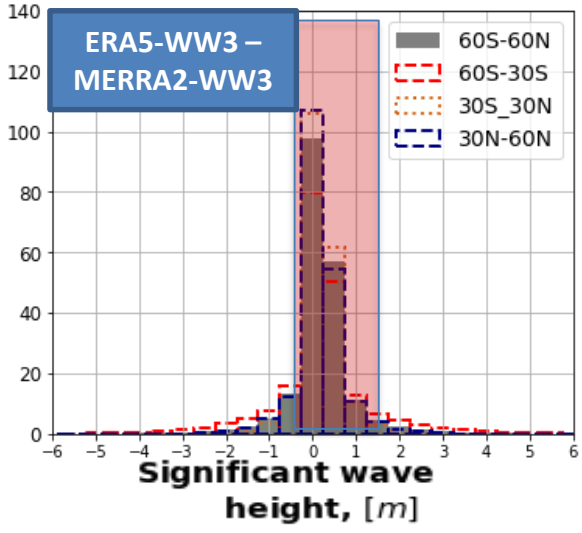
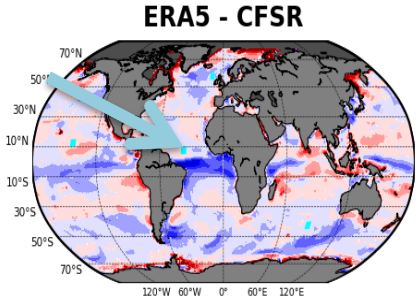
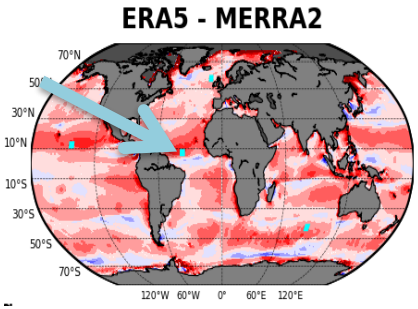


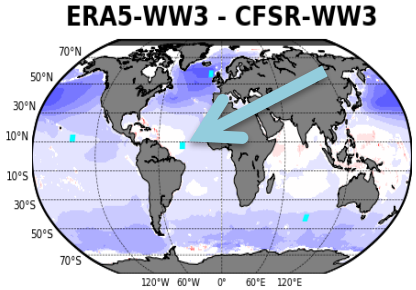


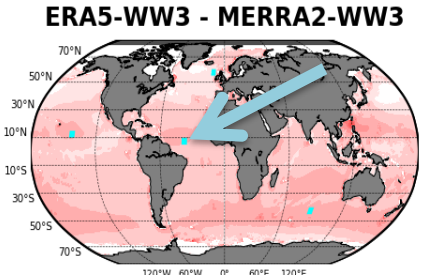


Regional analysis



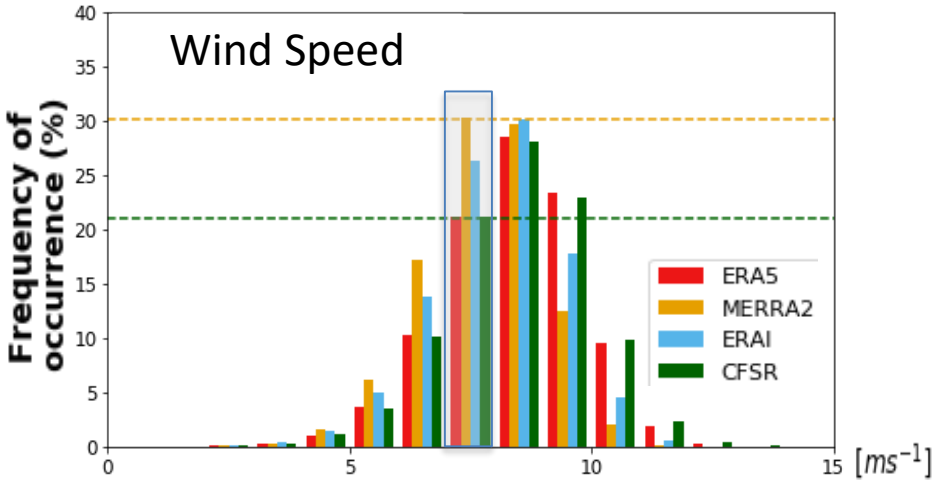


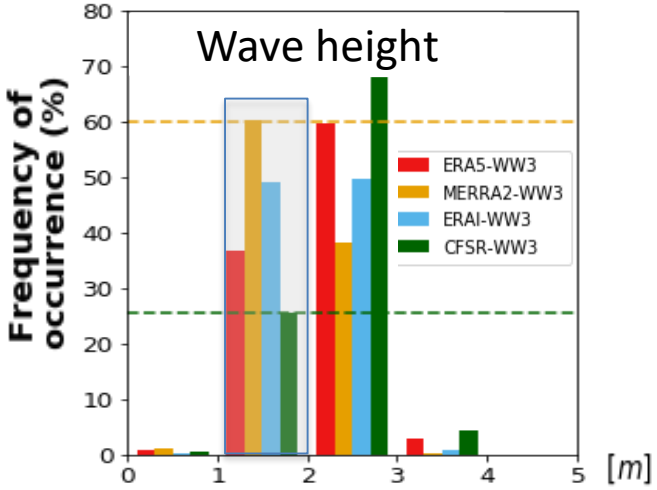


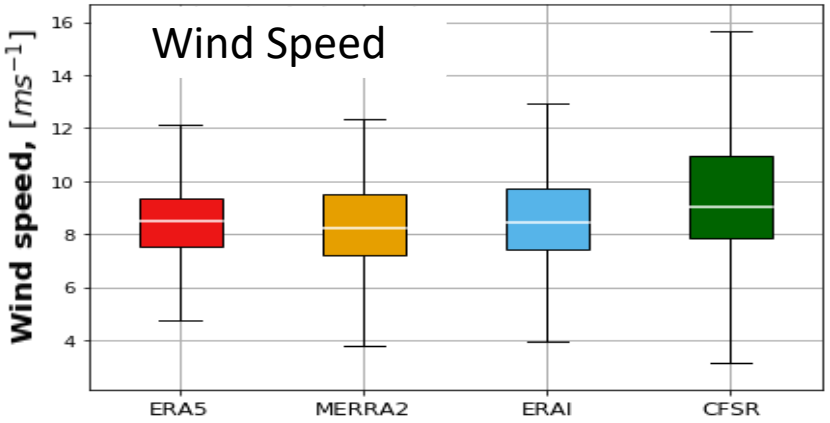


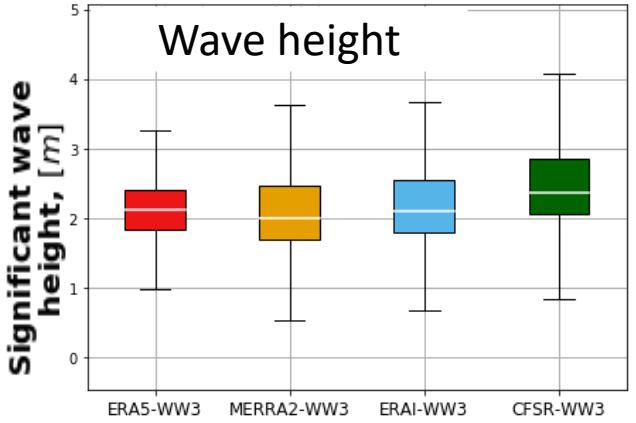
Central Atlantic Ocean (CAO)

Histograms and box diagrams in Central Atlantic in DJF

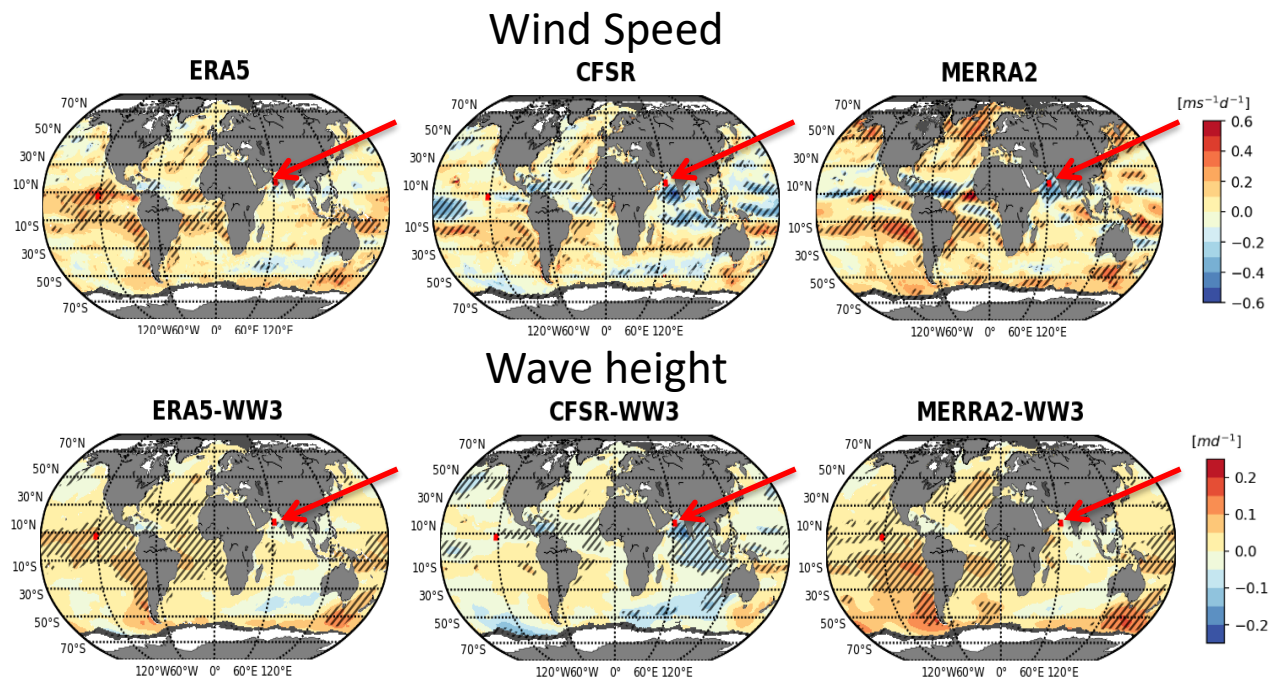


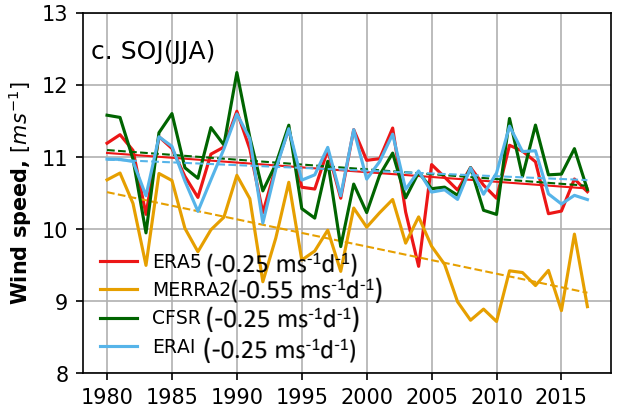


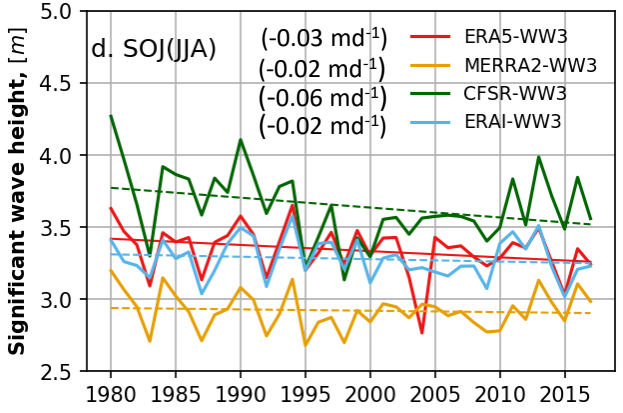




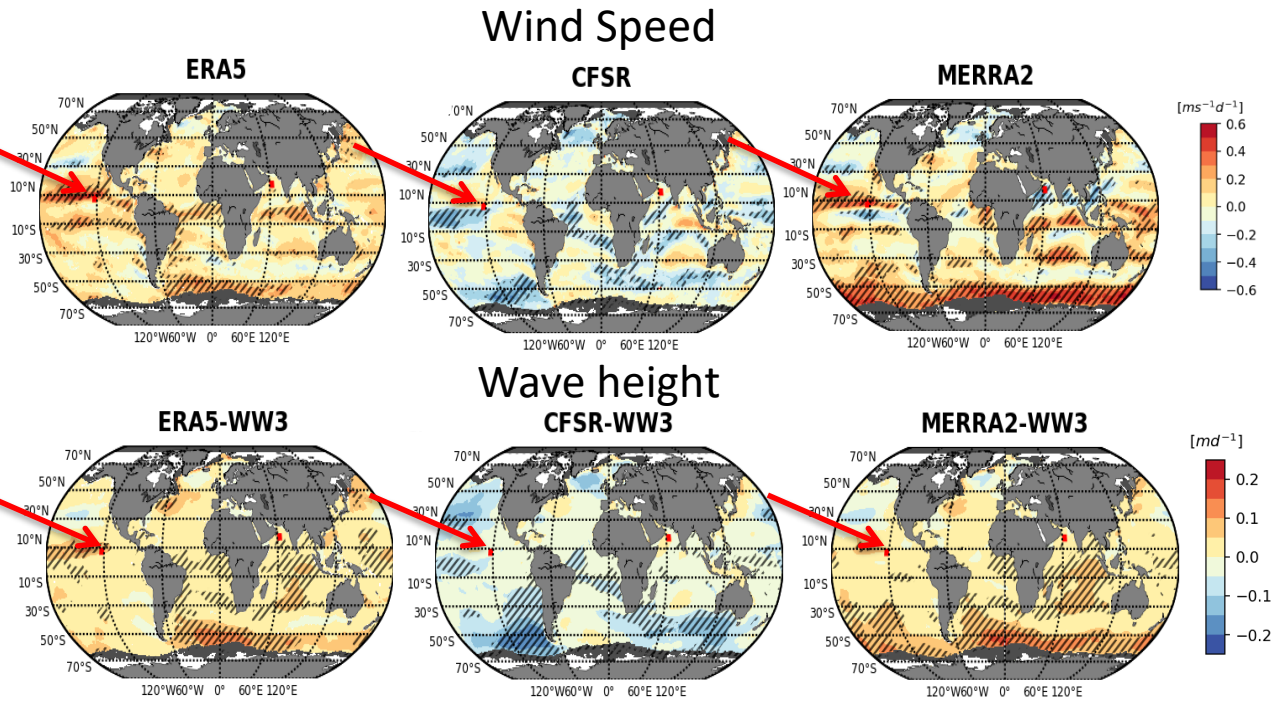
Trends in mean wind speed and wave height in 1980-2017 (JJA)

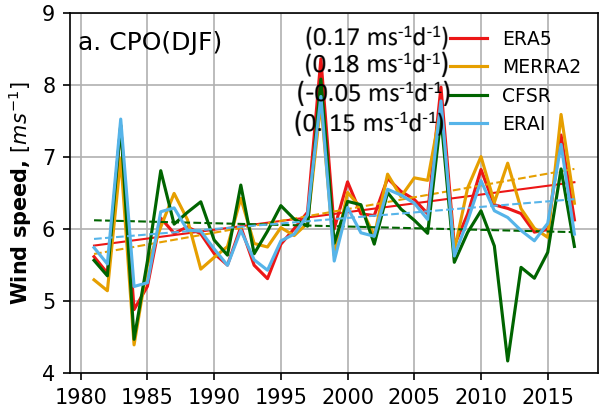


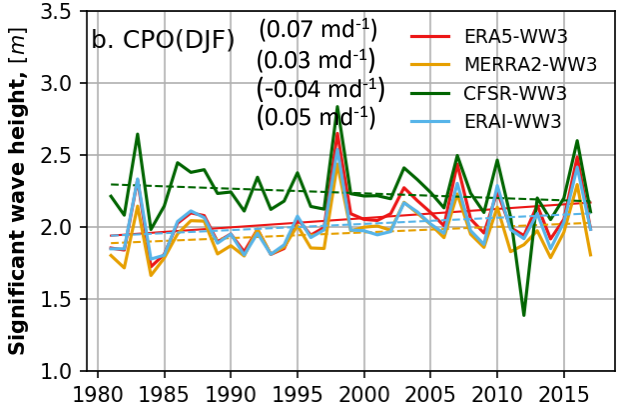




Trends in mean wind speed and wave height in 1980-2017 (DJF)







Conclusions

- **Four global long-term wind wave hindcasts have been created**
  (MERRA2 was used for the first time)

- The largest discrepancies in **wind speeds in the tropical regions** and in **wave heights in the extratropical areas**
  (MERRA2 < ERA5 < CFSR)

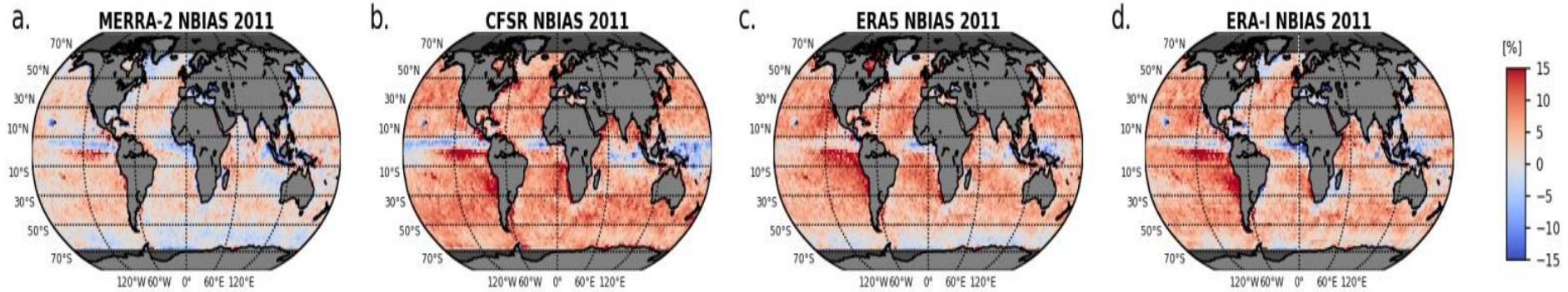
- **Positive trends** in wind speed in North Atlantic and equatorial Pacific, Indian Oceans. **Negative trends** in Caribbean and Arabian Seas and Bay of Bengal.

- **Trends in waves are consistent with winds, only with larger spatial coverage**

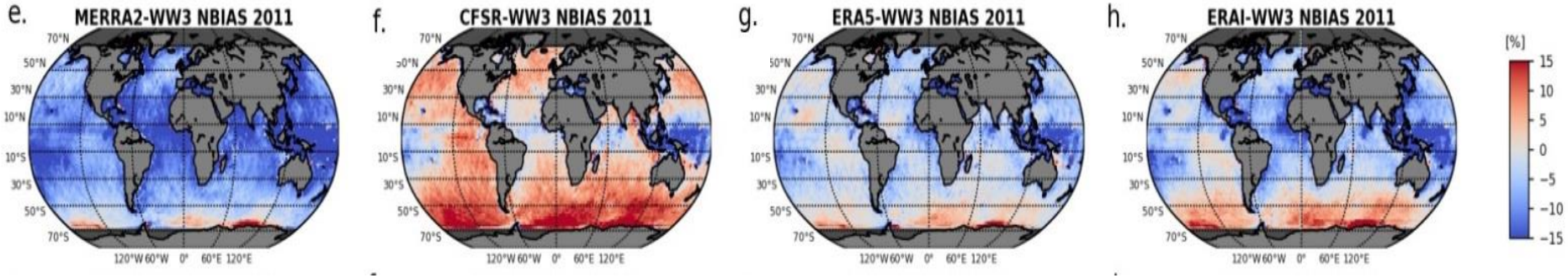
Normalized bias between reanalyses/hindcasts against altimeter (Jason1)

$$NBIAS = \left[\left(\bar{h} - \bar{m} \right) / \sqrt{\frac{1}{n} \sum_{i=1}^{n} \left(m_i \right)^2} \right] \times 100$$

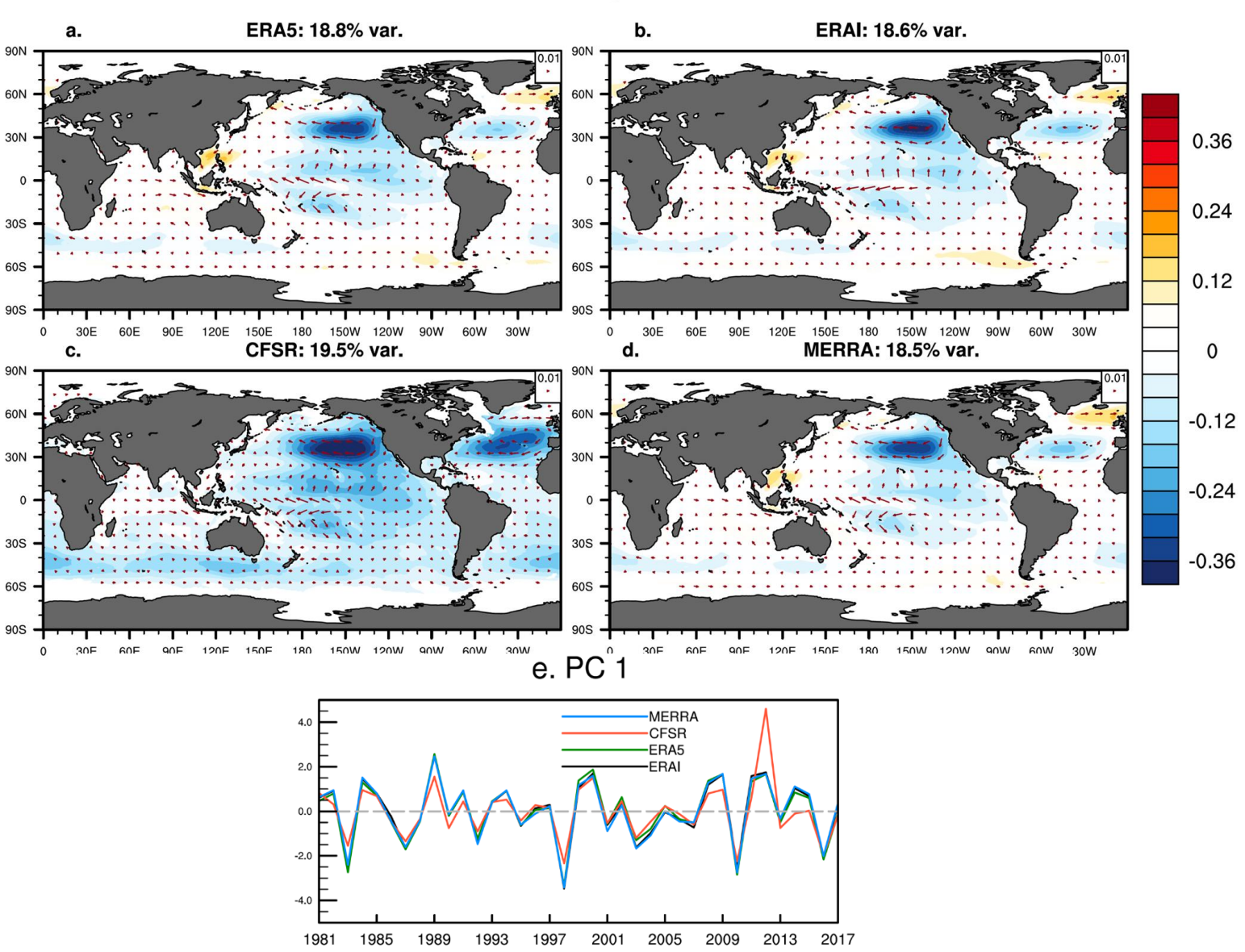
10-m winds according to reanalyses

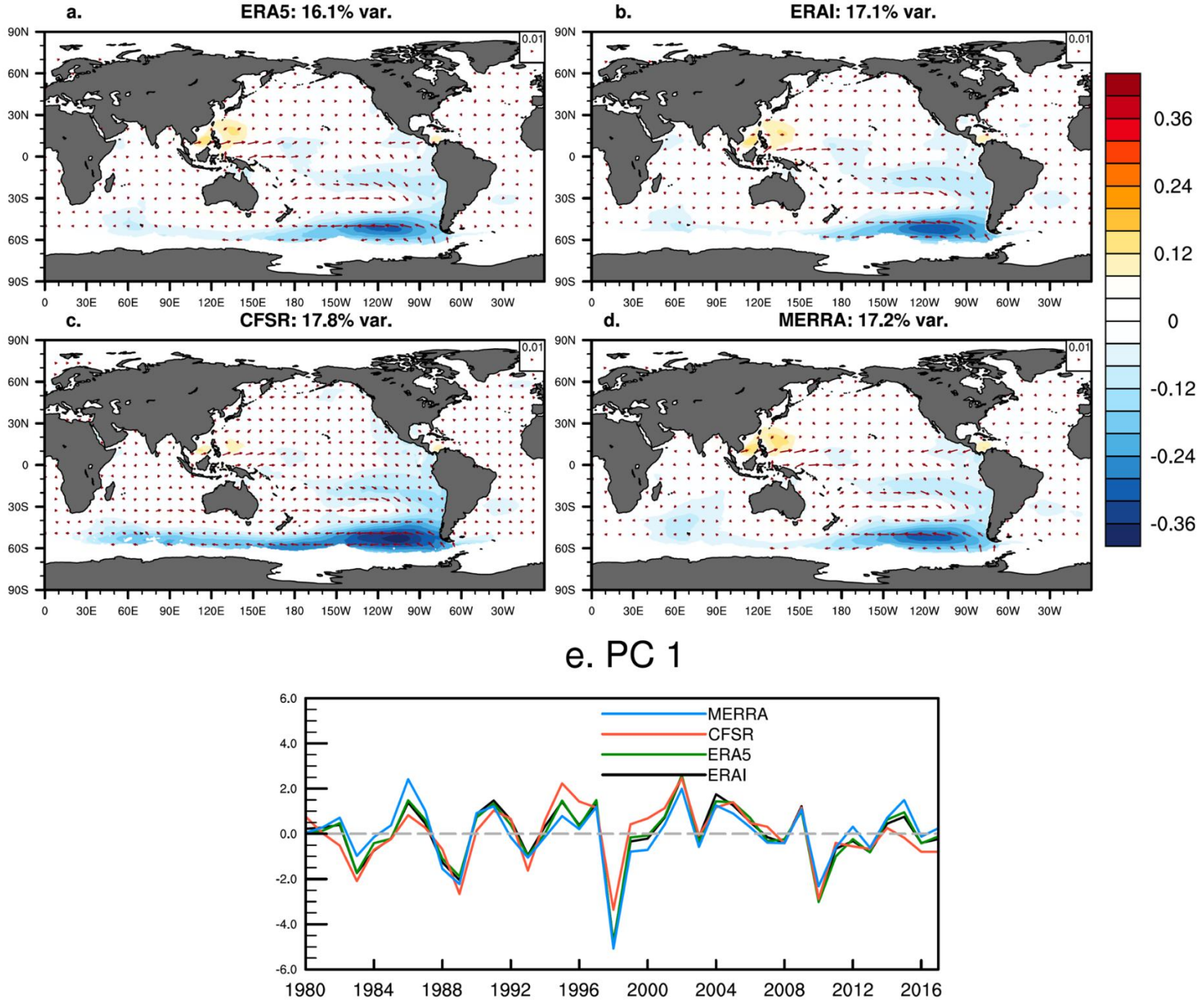


Wave heights according to hindcasts



Connection between the wave field variability and wind field




EOF 1
a.
ERA5: 16.1% var.
b.
ERAI: 17.1% var.
c.
CFSR: 17.8% var.
d.
MERRA: 17.2% var.
0.01
90N
60N
30N
0
30S
60S
90S
0
30E
60E
90E
120E
150E
180
150W
120W
90W
60W
30W
0.36
0.24
0.12
0
-0.12
-0.24
-0.36
e. PC 1
MERRA
CFSR
ERA5
ERAI
6.0
4.0
2.0
0.0
-2.0
-4.0
-6.0
1980
1984
1988
1992
1996
2000
2004
2008
2012
2016