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35-year 1979-2013 (1979–2000 for now) high resolution North Atlantic wind wave hindcast (pilot results)

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2nd JCOMM Scientific and Technical Symposium on Storm Surges

Outline

- High-resolution spectral wave model **WAVEWATCH III** (WW3) in conjunction with non-hydrostatic mesoscale NWP system **WRF** (Weather Research and Forecasting)
- Validation against buoys and VOS
- 22-year time period **from 1979 to 2000** *(the period 2001-2013 is still to come)*
- Output : **basic characteristics of wind waves**, including extreme waves
- Results of the analysis include characteristics of interannual variability of mean and extreme waves

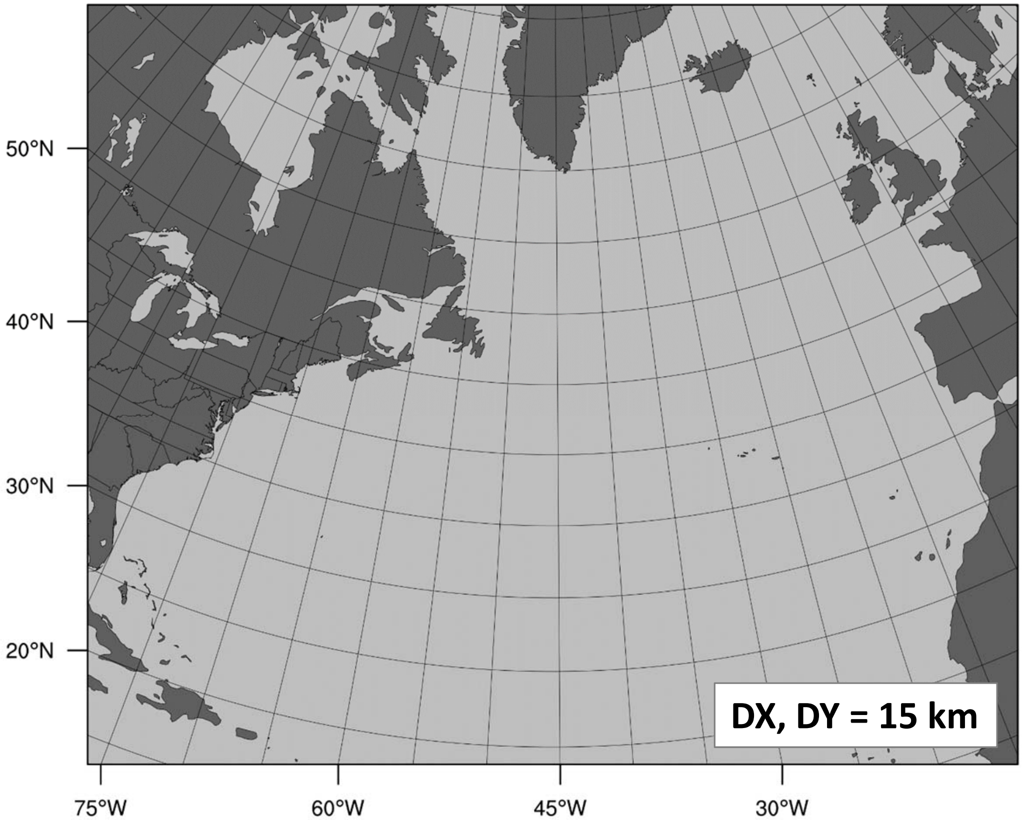
Contents:

1. WRF configuration
2. WW3 configuration
3. Mean waves analysis (reanalysis ERA-Interim vs WW3-WRF hindcast)
4. Extreme waves analysis (reanalysis ERA-Interim vs WW3-WRF hindcast)
5. Conclusions

WRF configuration

Domain

490 x 400 points



Parametrizations

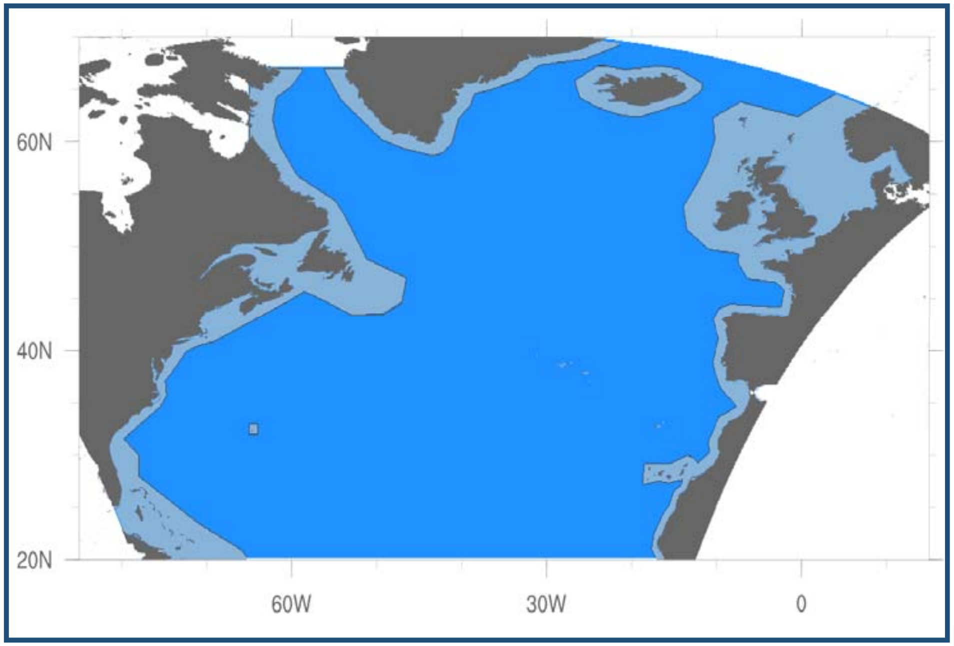
Microphysics	WRF Single-Moment 3-class scheme (WSM3)
Convection	Advanced Kain-Fritsch scheme
Radiation	CAM scheme
Surface	Noah Land Surface Model
PBL	**BouLac PBL**
Surface layer	**Eta similarity**

Initial conditions

ERA-Interim reanalysis of the global atmosphere covers the period since 1979 with resolution 0.7° (T255) and 60 levels in vertical.

WRF is run at 6-hr resolution with time-varying SST from the ERA-Interim reanalysis (2 times daily)

WAVEWATCH III configuration



WW3 version 4.18

- multi-grid set-up with regular spherical grids **(20-70° N, 85° W-15° E)**
- horizontal resolution of **0,25° (global grid)** and **0,1 ° (regional grid)**
- spectral resolution with **40 frequencies** and **36 directions**
- parametrization scheme of input and dissipation **BYDRZ** (Babanin, Young, Donelan, Rogers, Zieger) includes swell dissipation
- Non-linear interactions: **DIA**

- Initial conditions:

10 m winds from WRF at 15 km resolution

Computer resources

MiniCluster **CRAY CX1**
4 nodes (**48** cores in total)
Memory : **8 Gb / core**.
Peak performance **0,6 TFLOPS**.

Data preparation

- *Preparing data for WRF hindcast*
- *Regridding WRF output wind on WW3 grid*
- *Sensitivity tests*
- *Data analysis*

Modelling

Running model experiments. Both WRF and WW3 were running yearly on 256 CPU cores.

"LOMONOSOV“ (MSU)
Nodes: **1065** nodes
Cores: **52 168**
Memory: **2 Gb / core**
Peak performance: **1700 TFLOPS**

Real performance:
1 year of WRF (256 cores): **24 hr**
1 year of WW3 (256 cores): **35 hr**

"MVS-100K “ (JSCC RAS)
Nodes: **1275** nodes
Cores: **10572**
Memory: **1 Gb / core**
Peak performance: **227,9 TFLOPS**

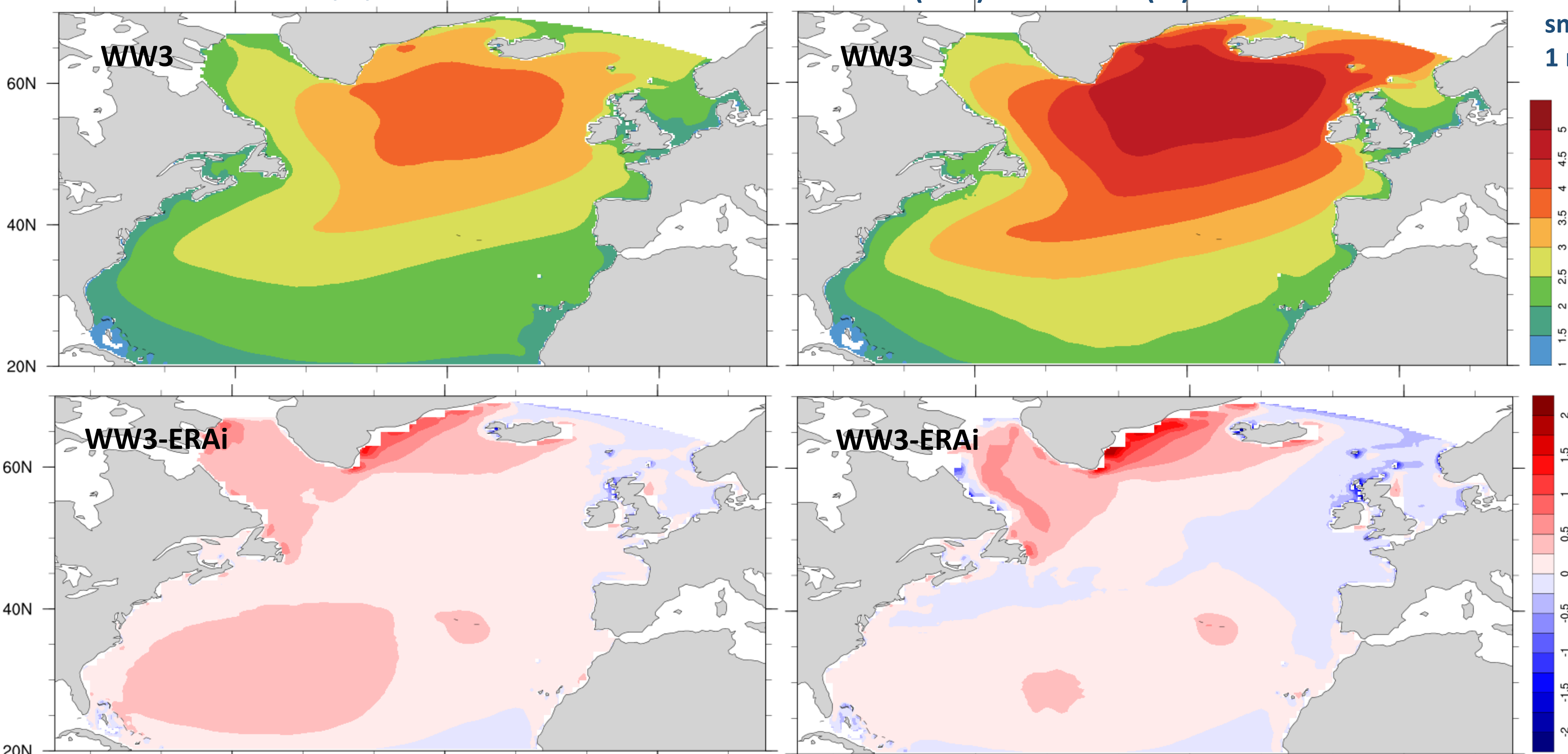
Real performance:
1 year of WRF (256 cores): **42 hr**
1 year of WW3 (256 cores): **54 hr**

Climatic means (1979-2010) significant wave height (SWH)

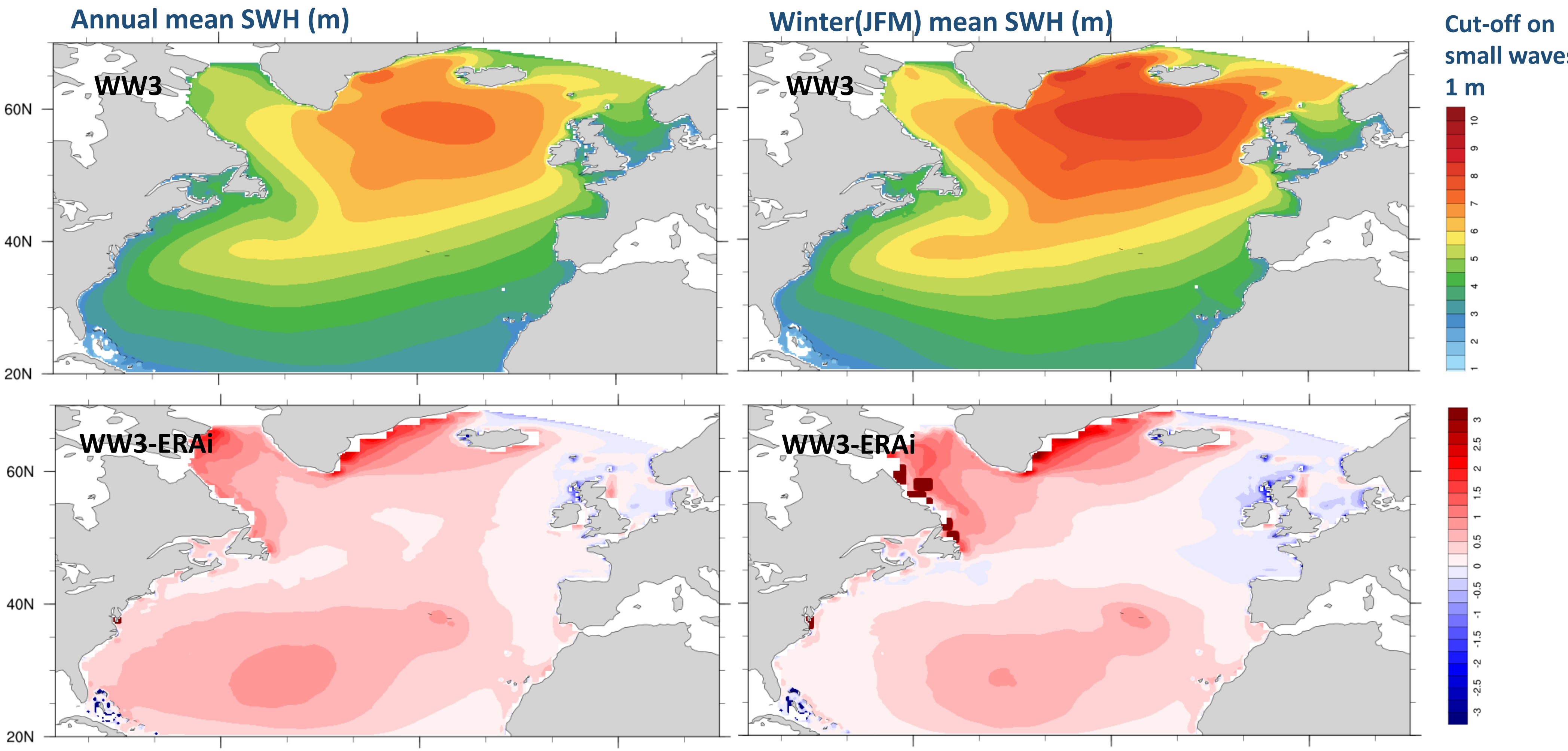
Annual mean SWH (m)

Winter(JFM) mean SWH (m)

Cut-off on small waves 1 m

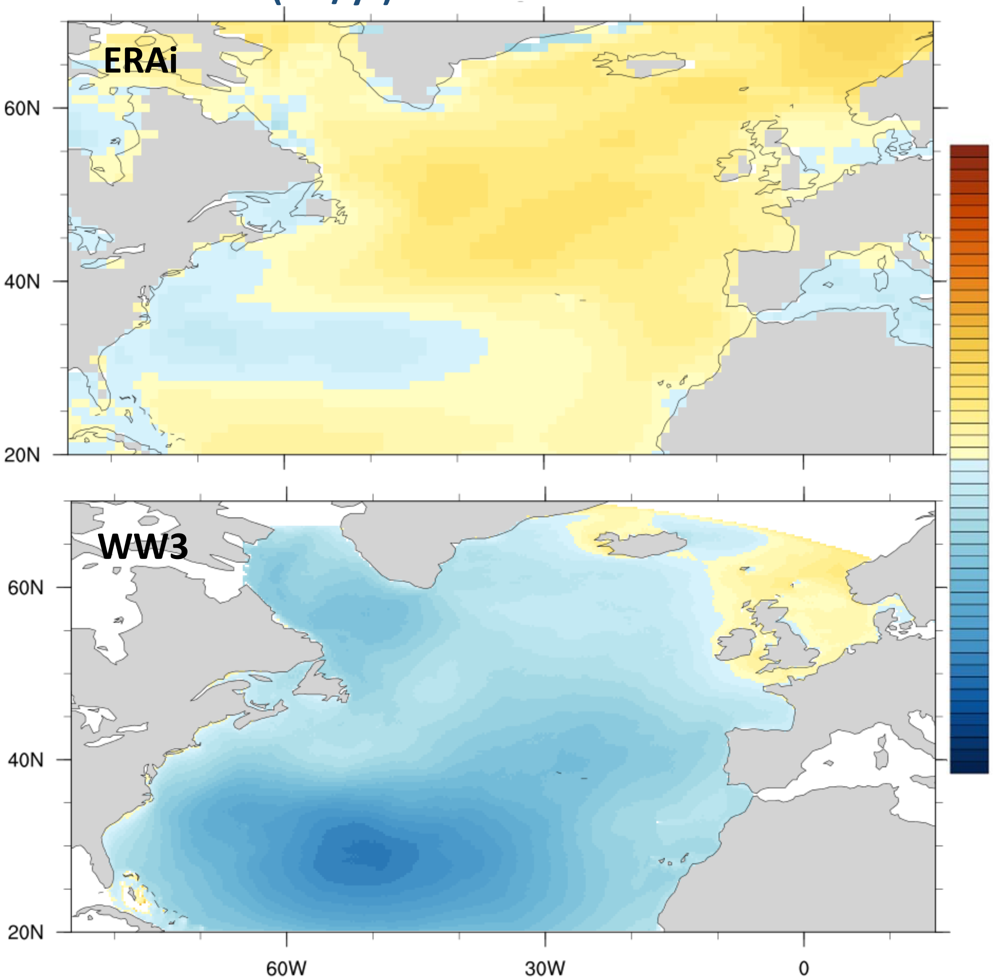


Climatic means (1979-2010) 95th percentile significant wave height (SWH)

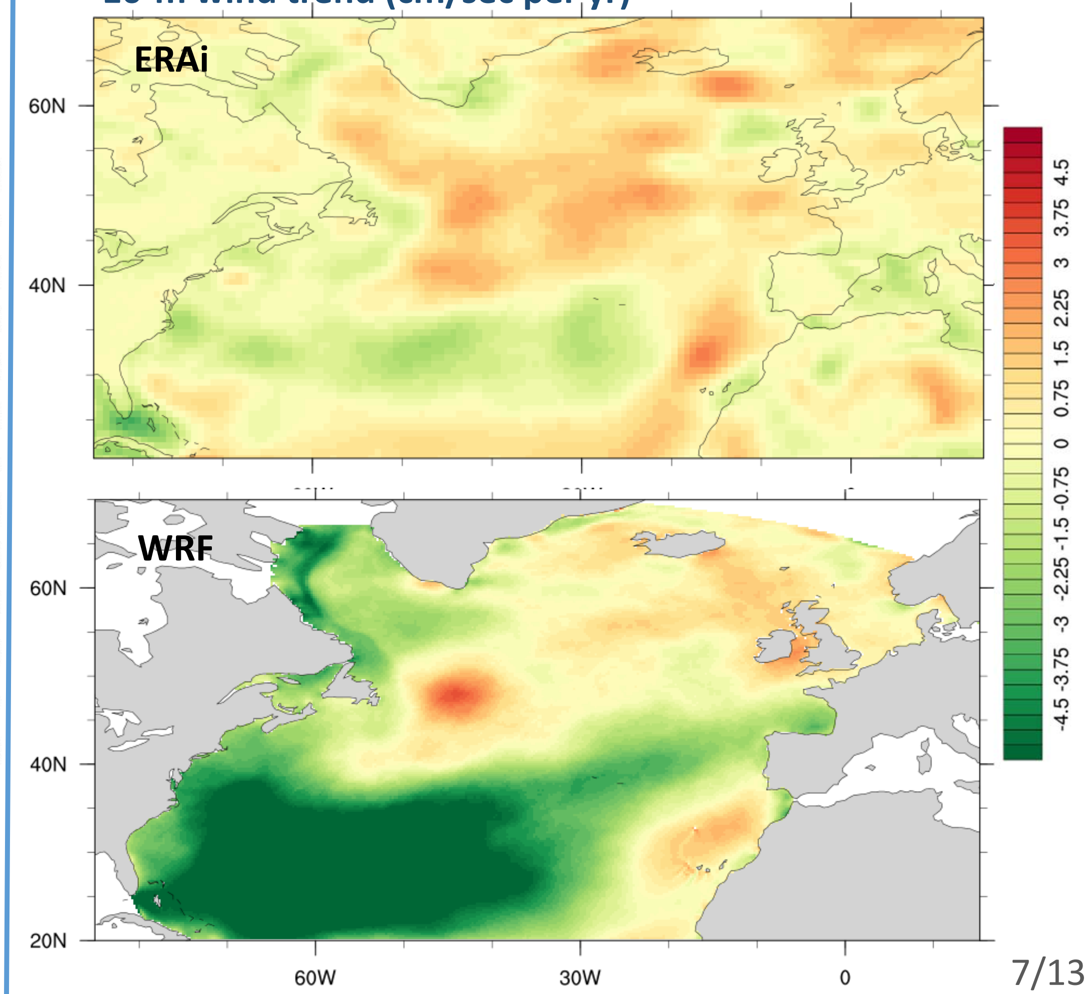


Annual trends in mean SWH and 10-m wind (ERAi vs WW3)

SWH trend (cm/yr)

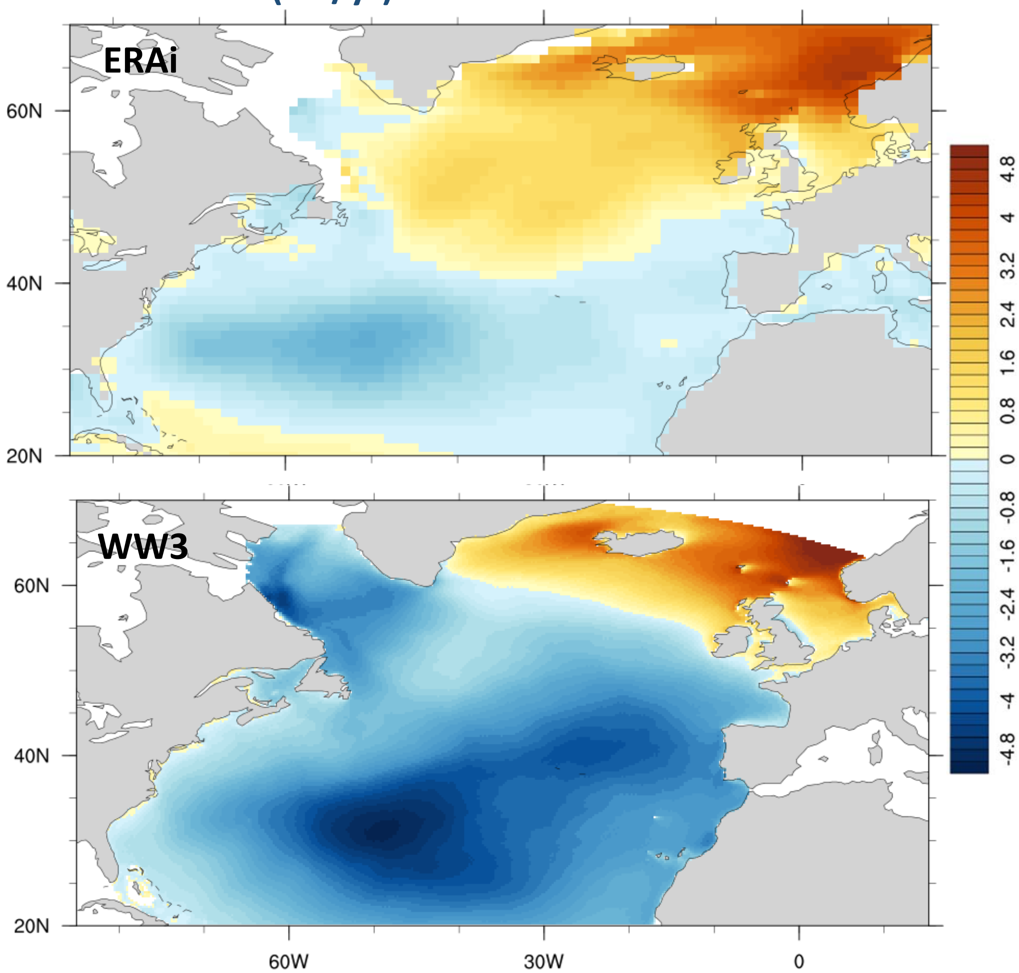


10-m wind trend (cm/sec per yr)

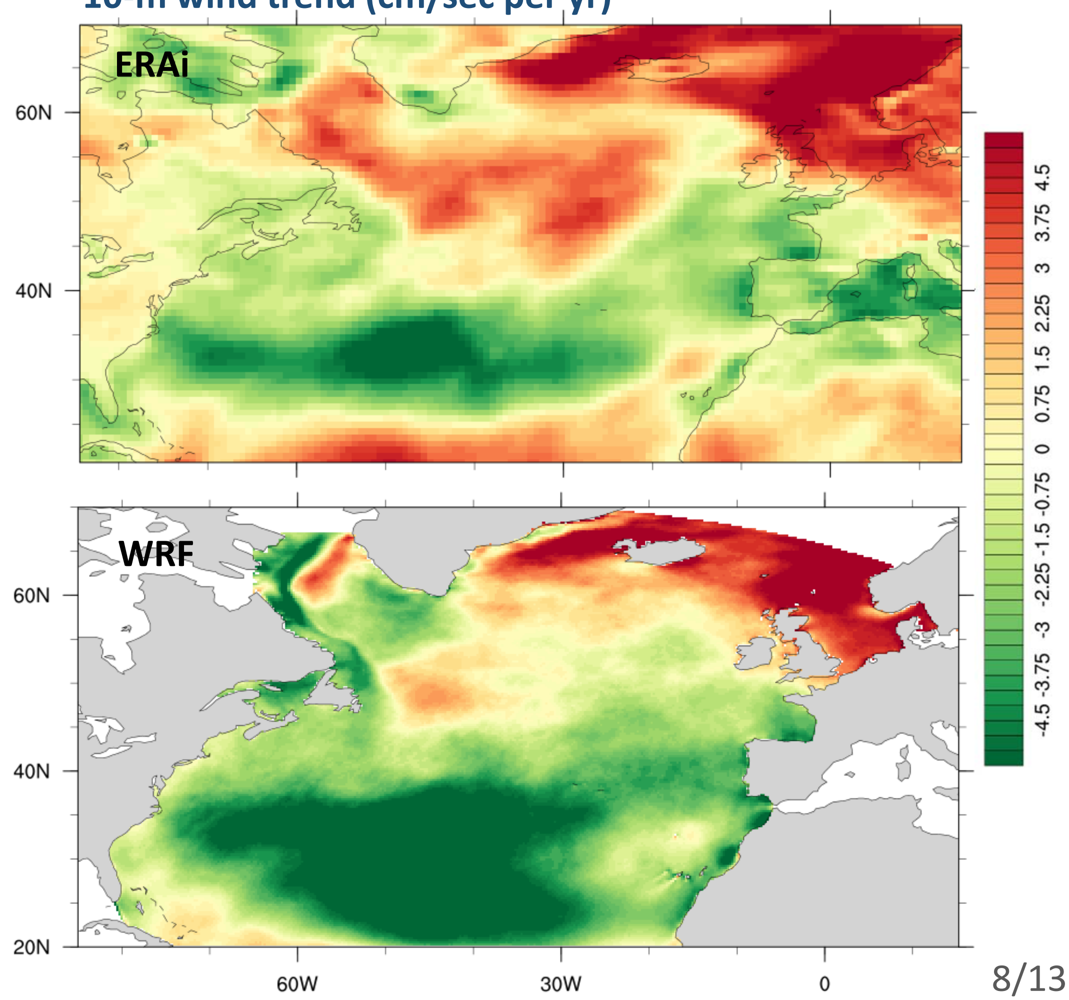


Annual winter trends in SWH and 10-m wind (ERAi vs WW3)

SWH trend (cm/yr)

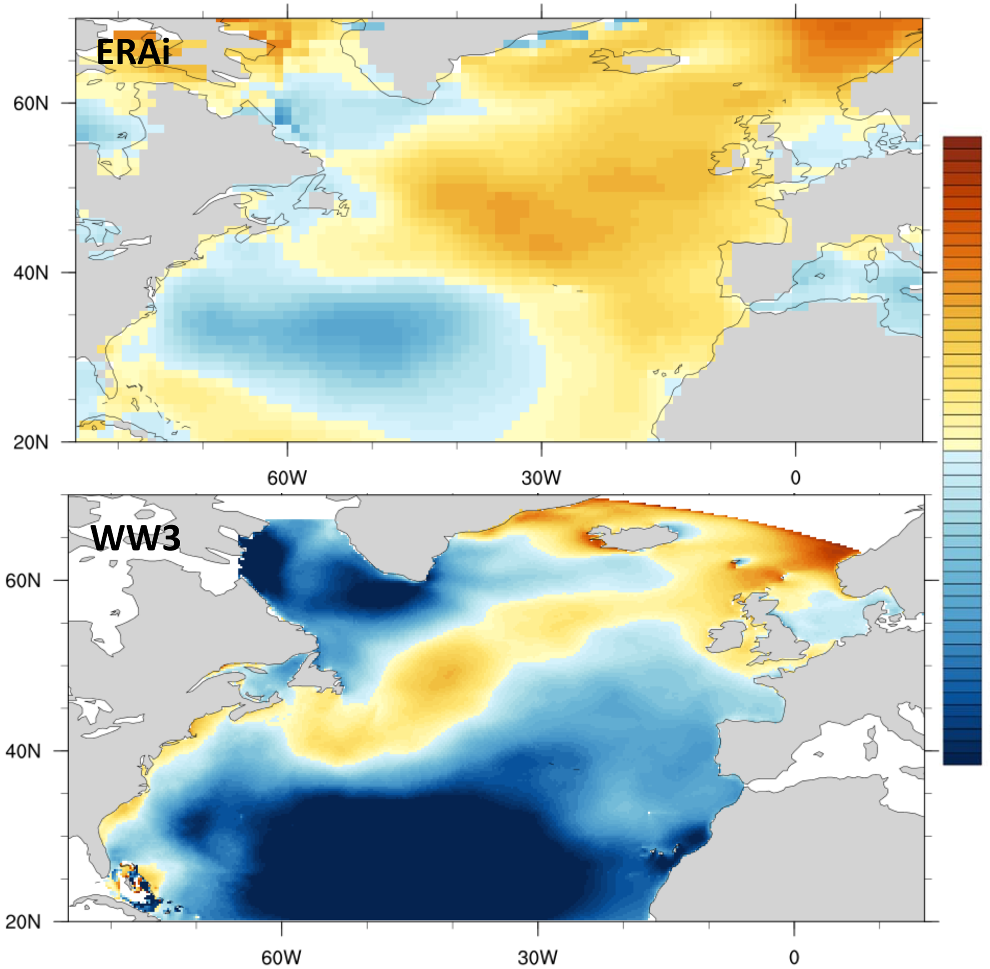


10-m wind trend (cm/sec per yr)

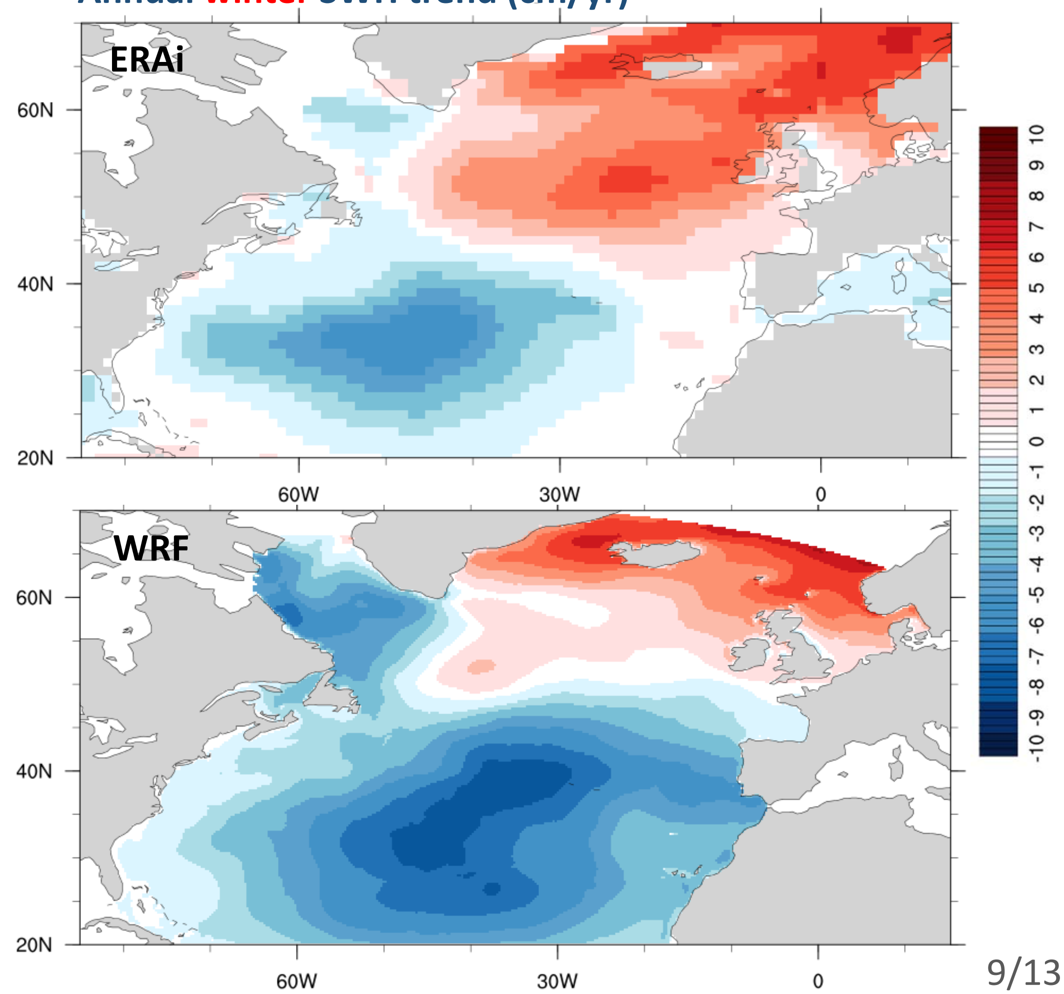


Annual trends in 95th percentile SWH (ERAi vs WW3)

Annual SWH trend (cm/yr)



Annual winter SWH trend (cm/yr)



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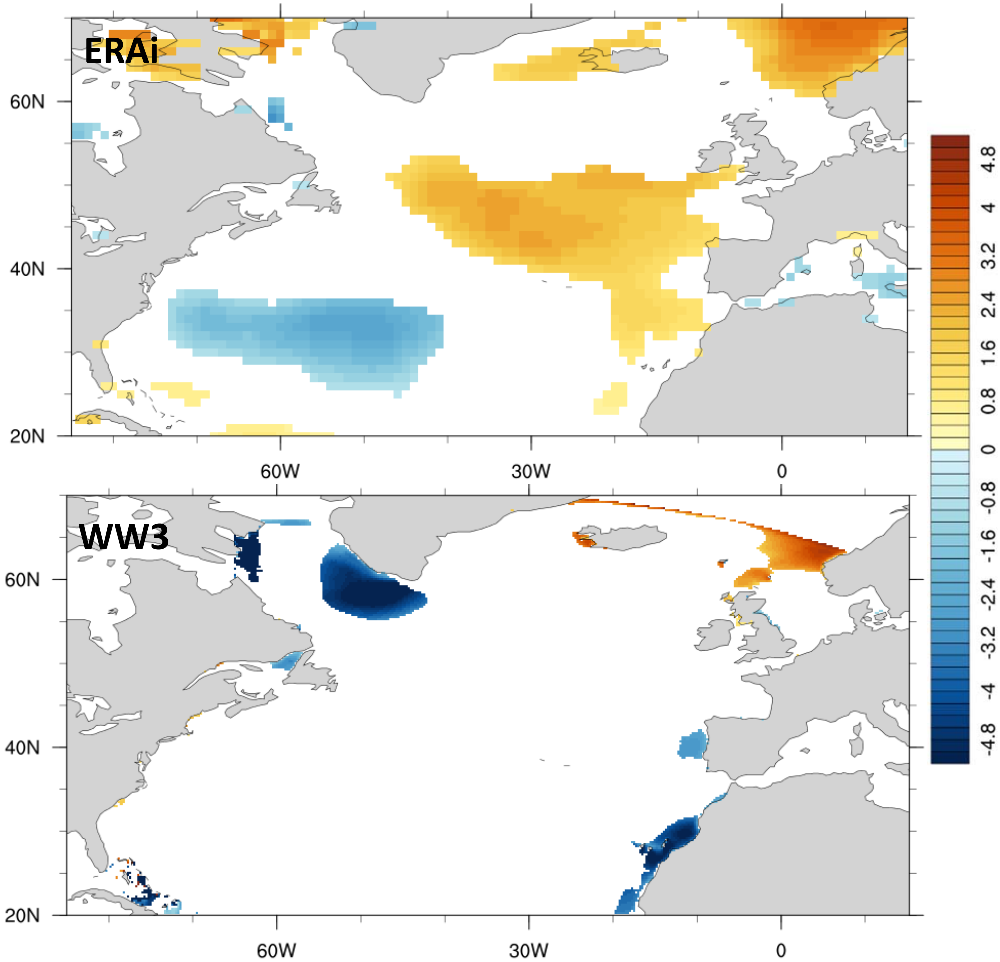
Annual SWH trend (cm/yr)



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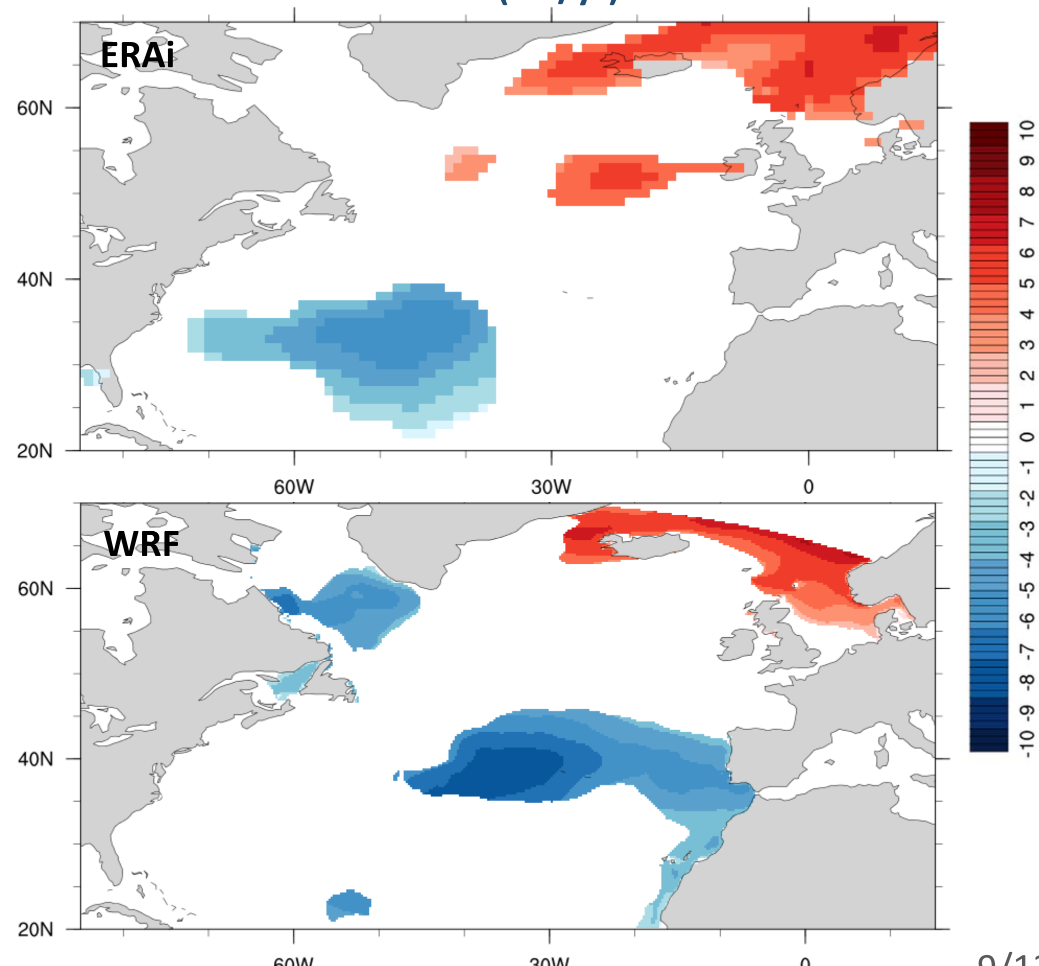
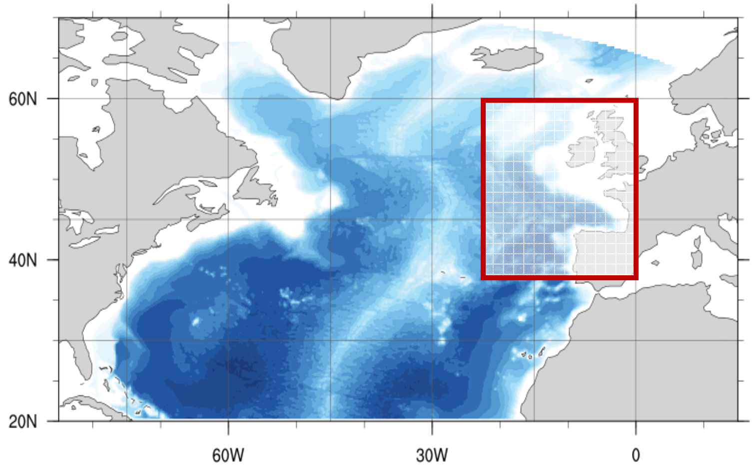
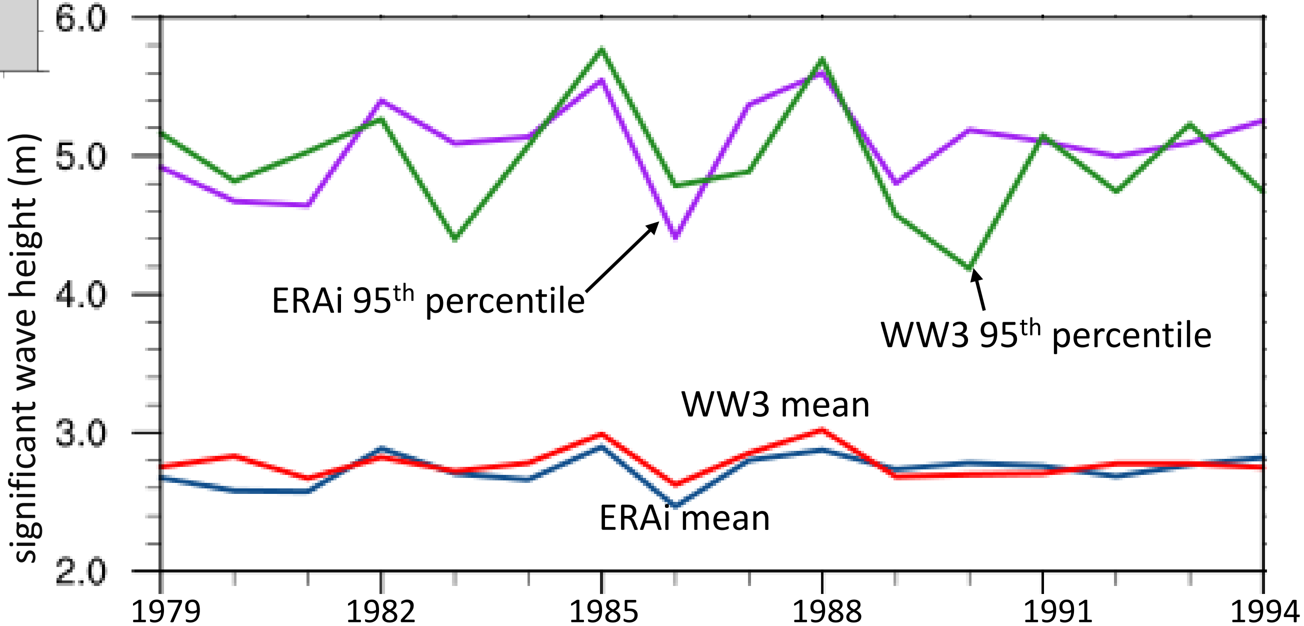
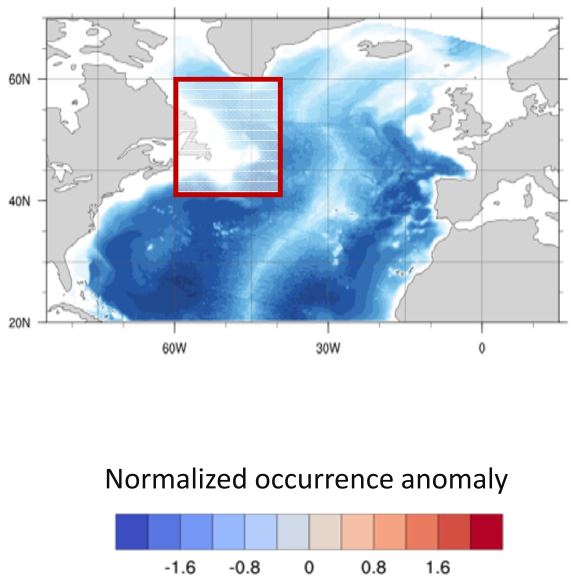


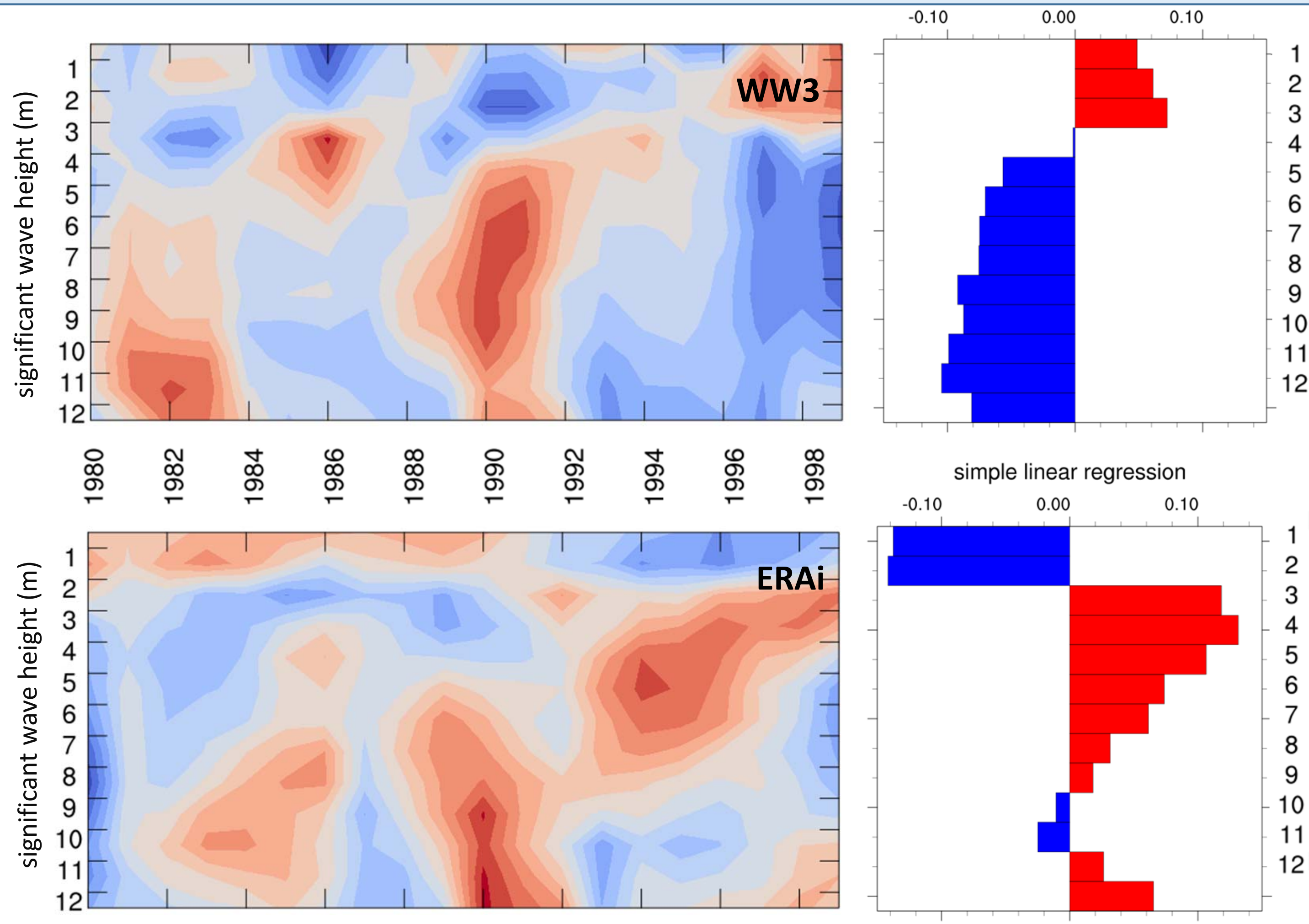
Regional interannual variability of mean SWH and 95th percentile





Regional temporal evolution of anomalies in SWH (ERAi vs WW3)





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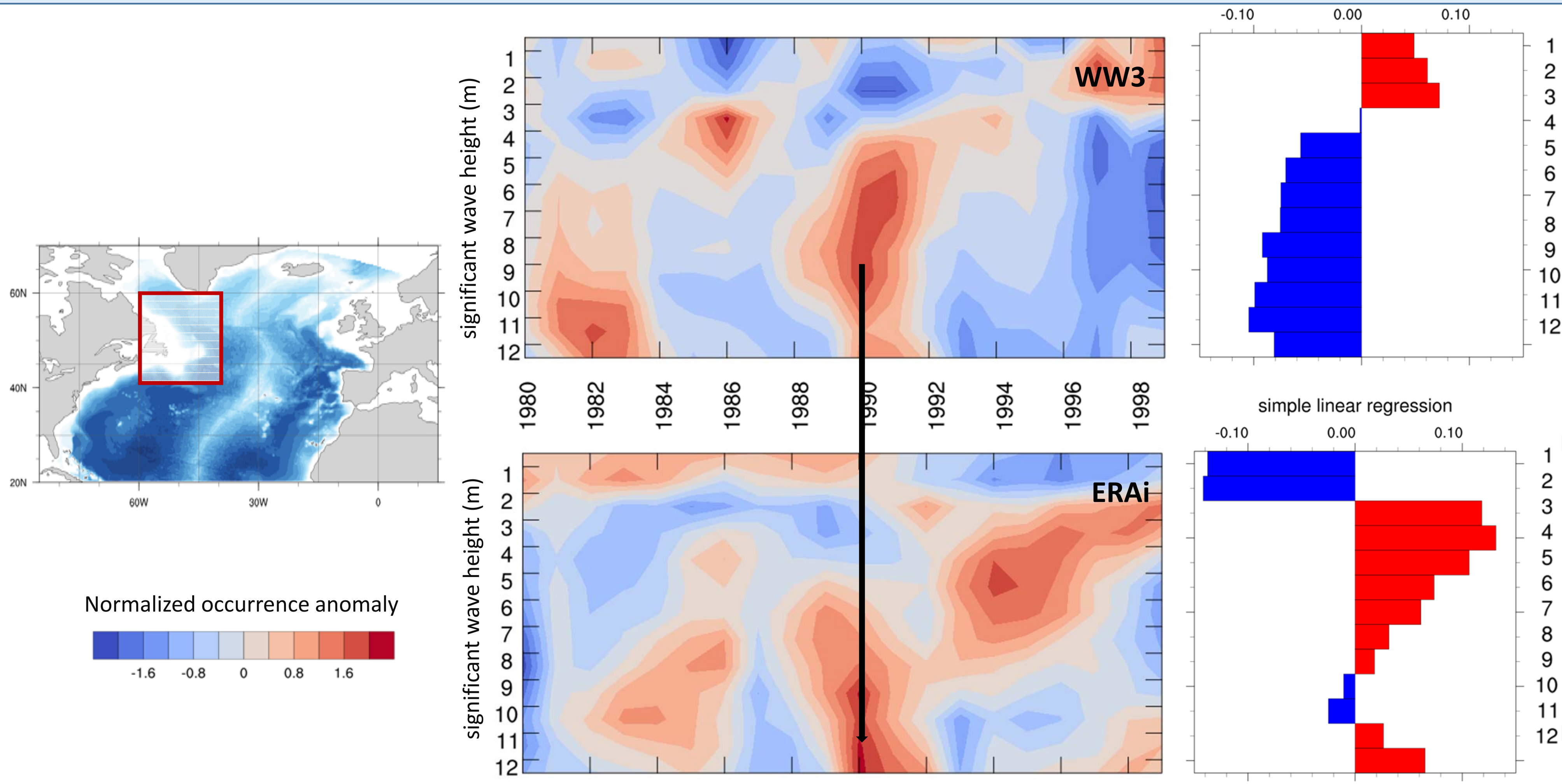

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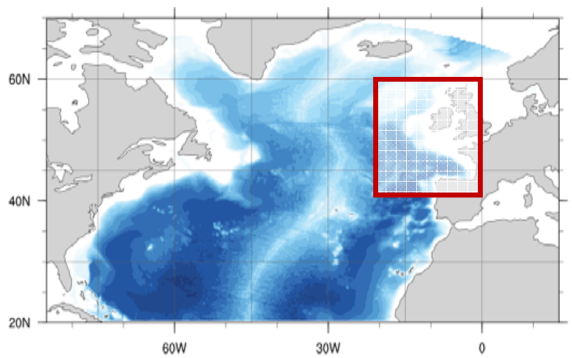

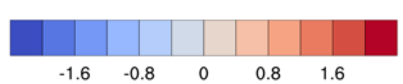

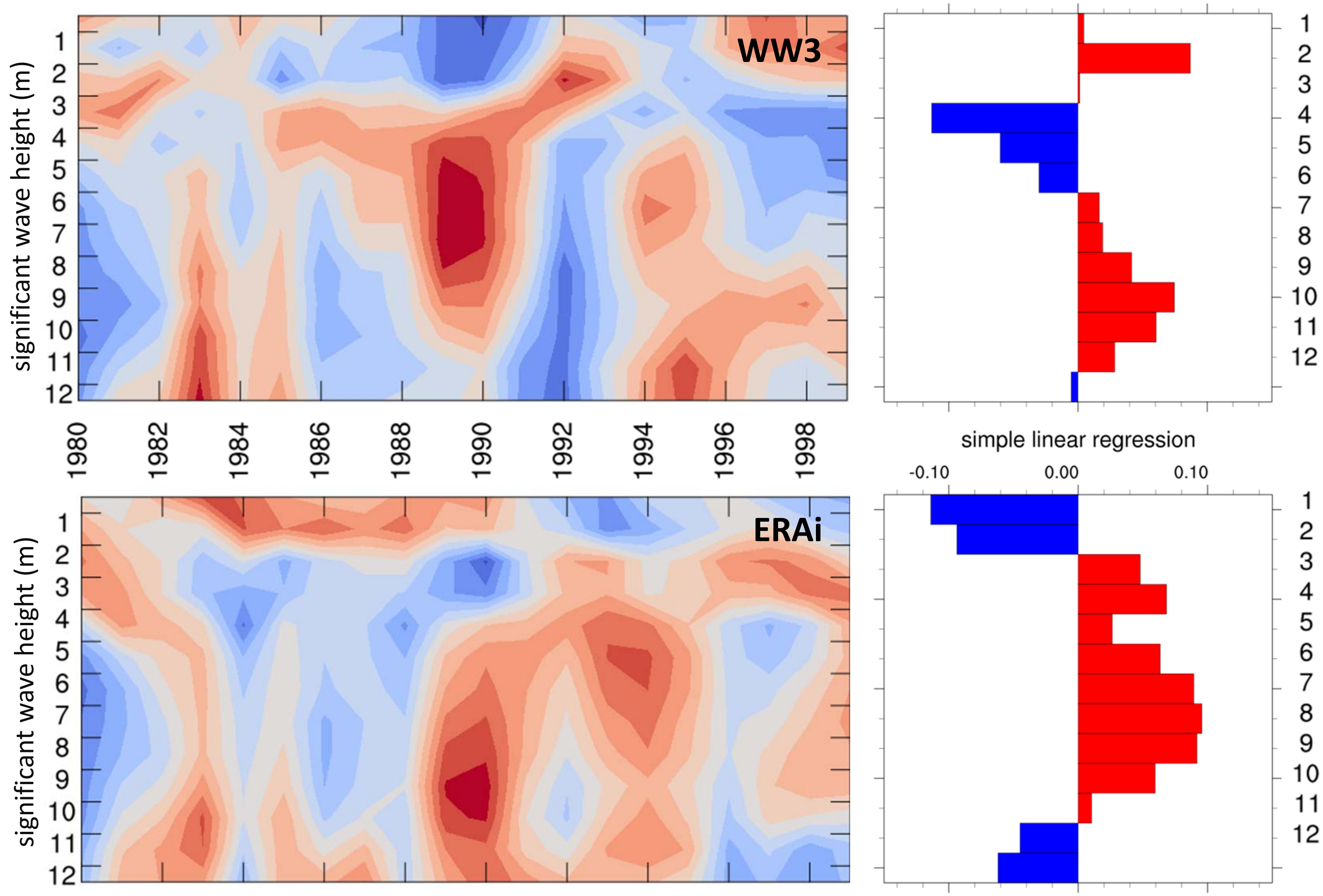

Conclusions

- Long-term high resolution wind wave hindcast over the North Atlantic for period from 1979 to 2000 has been performed
- Pilot analysis of variability reveals serious inconsistencies with ERAi:
  - The output reveals positive significant trends(5 cm/yr) in the mean SWH in the northeastern Atlantic (consistently with ERAi). A little consistency between WW3 and ERAi has been found in long-term variability in the subtropics
  - Positive significant trends(3 cm/yr) in 95th percentile of SWH for the northeastern Atlantic and negative trends (-5 cm/yr) in the central Atlantic subtropics –*winters only*
  - Growing occurrence of high waves (1989 - 1991) for both eastern and western North Atlantic midlatitudes
- Analysis of potential reasons (both technical and physical) for the observed inconsistencies is on the way