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

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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)
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5. Conclusions
Domain: 490 x 400 points

**Parametrizations**

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**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)
• 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 mean SWH (m) vs Winter (JFM) mean SWH (m)

Cut-off on small waves 1 m
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 95\textsuperscript{th} percentile SWH (ERAi vs WW3)

**Annual SWH trend (cm/yr)**

- **ERAi**
  - Maps showing the annual SWH trend in different regions.

- **WW3**
  - Maps showing the annual SWH trend in different regions.

**Annual winter SWH trend (cm/yr)**

- **ERAi**
  - Maps showing the annual winter SWH trend in different regions.

- **WRF**
  - Maps showing the annual winter SWH trend in different regions.
Annual trends in 95th percentile SWH (ERAi vs WW3)

Annual SWH trend (cm/yr)

Annual winter SWH trend (cm/yr)
Regional interannual variability of mean SWH and 95\textsuperscript{th} percentile
Regional temporal evolution of anomalies in SWH (ERAi vs WW3)
Regional temporal evolution of anomalies in SWH (ERAi vs WW3)
Regional temporal evolution of anomalies in SWH (ERAi vs WW3)
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