

SWAN-Kuststrook for operational forecasts

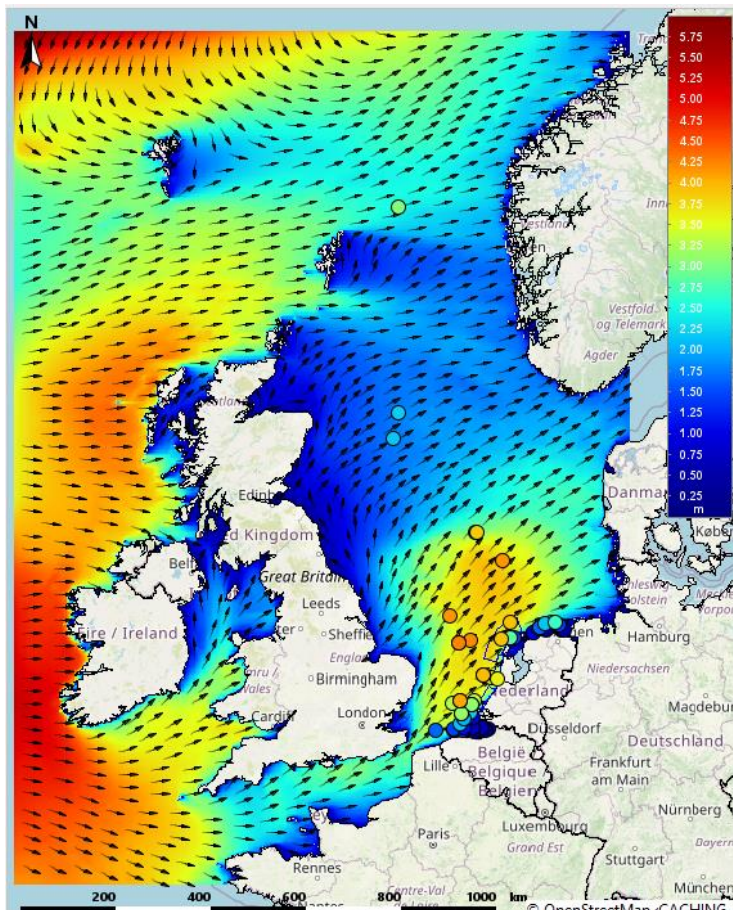
17th Int. Waves Workshop Notre Dame

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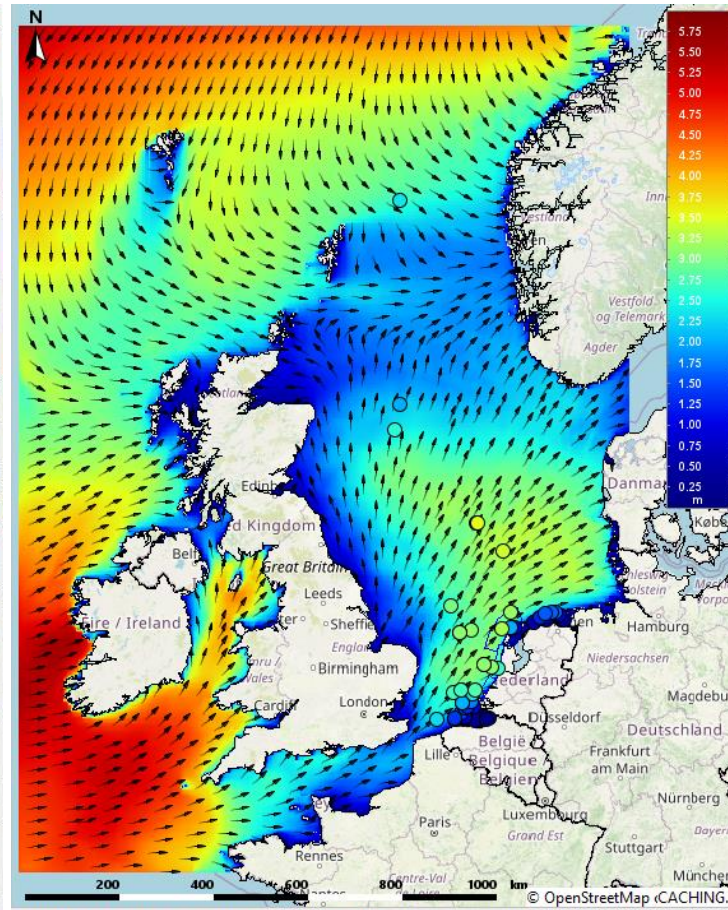
Sep, 2023



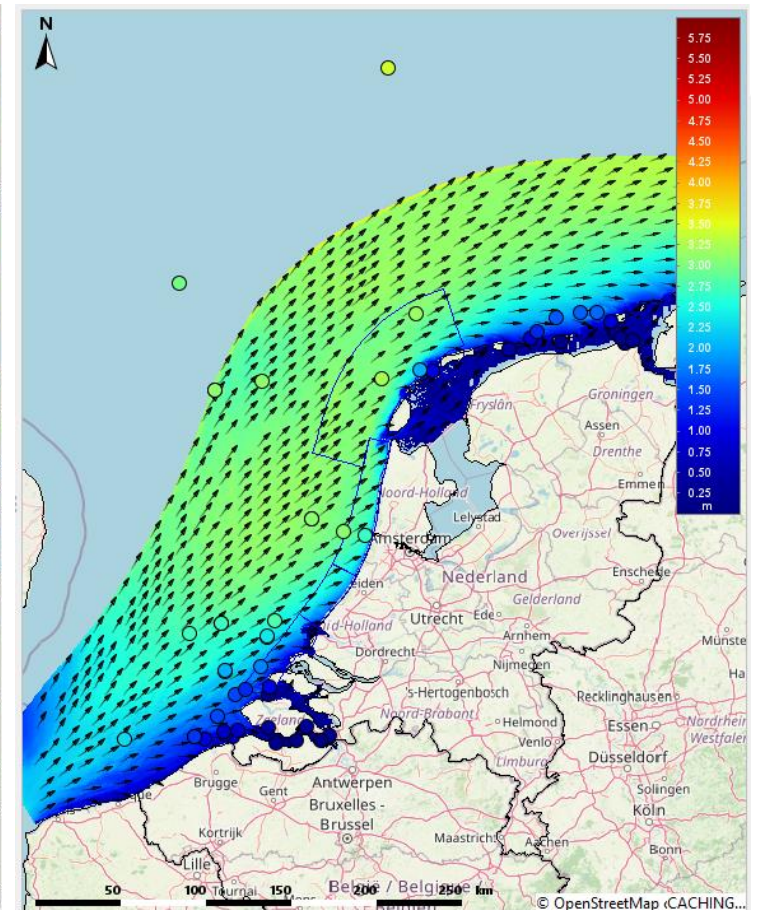
Operational wave forecasts: SWAN-NS & SWAN-KS



Sep 19, 2pm



Sep 20, 4am



Sep 20, 4am

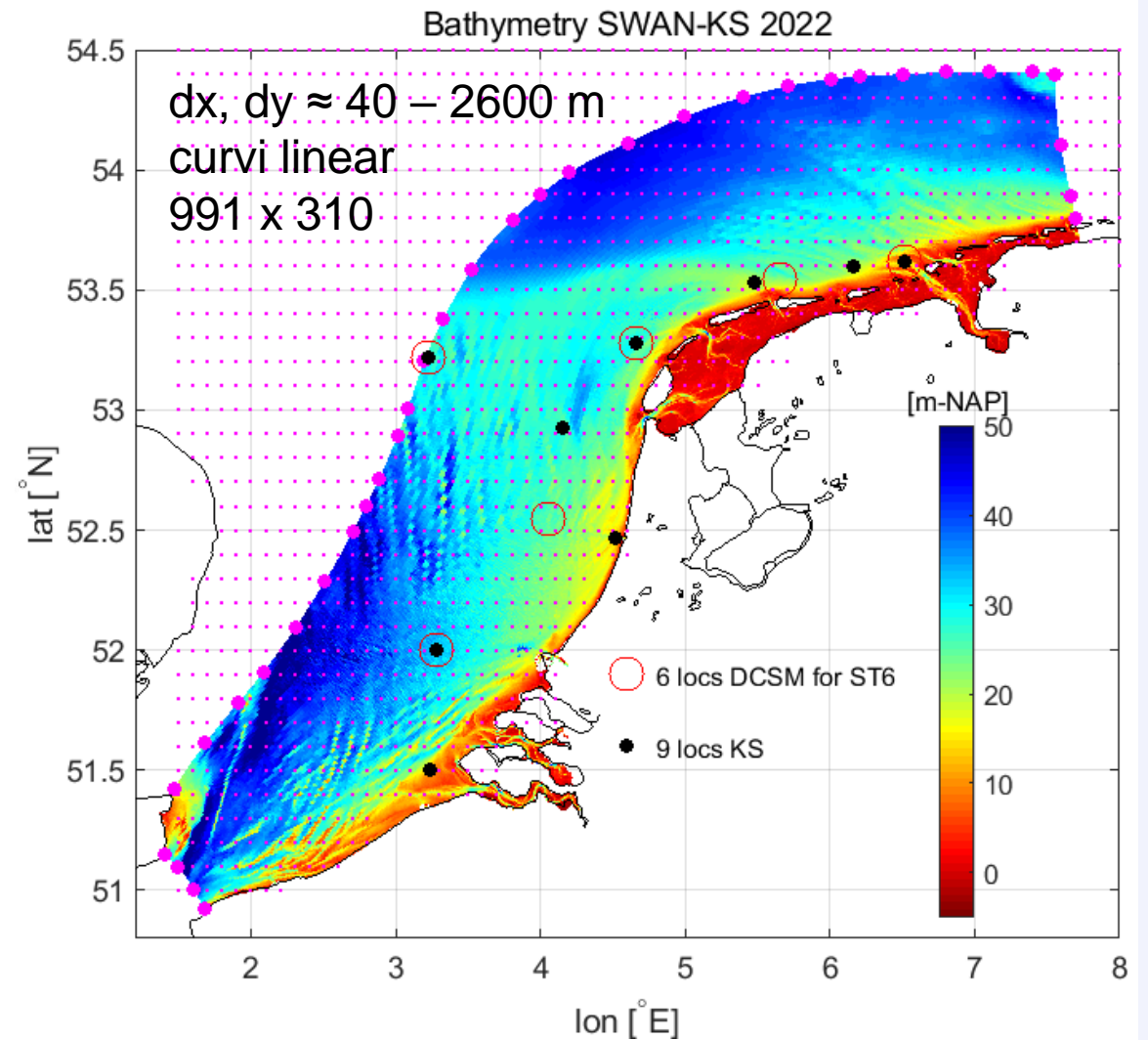
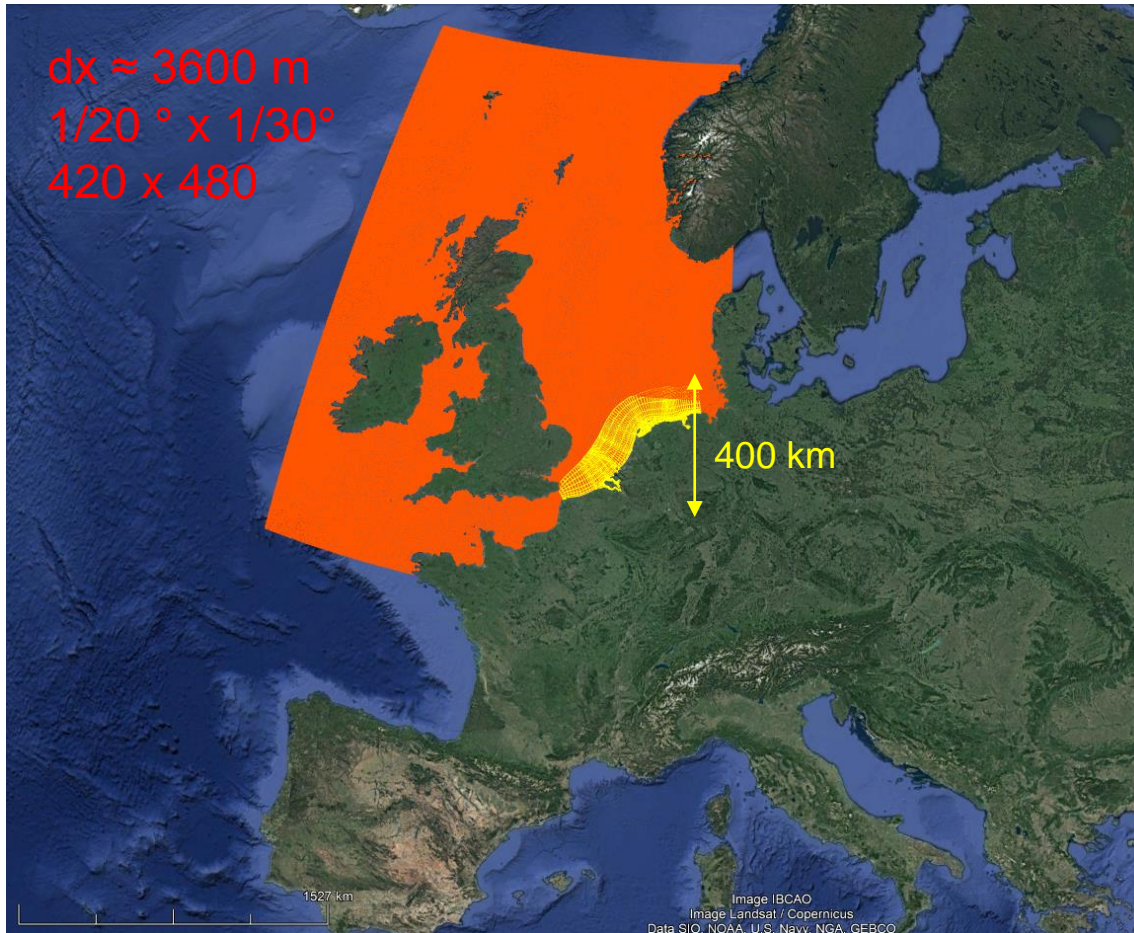
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Rijkswaterstaat provides operational forecasts of [water levels](#) and [waves](#) at the North Sea, mainly for flood forecasts and safe navigation.

1. SWAN-Kuststrook set up
2. Model settings, ST6
3. Results
4. Correction based on data driven model
5. Conclusions

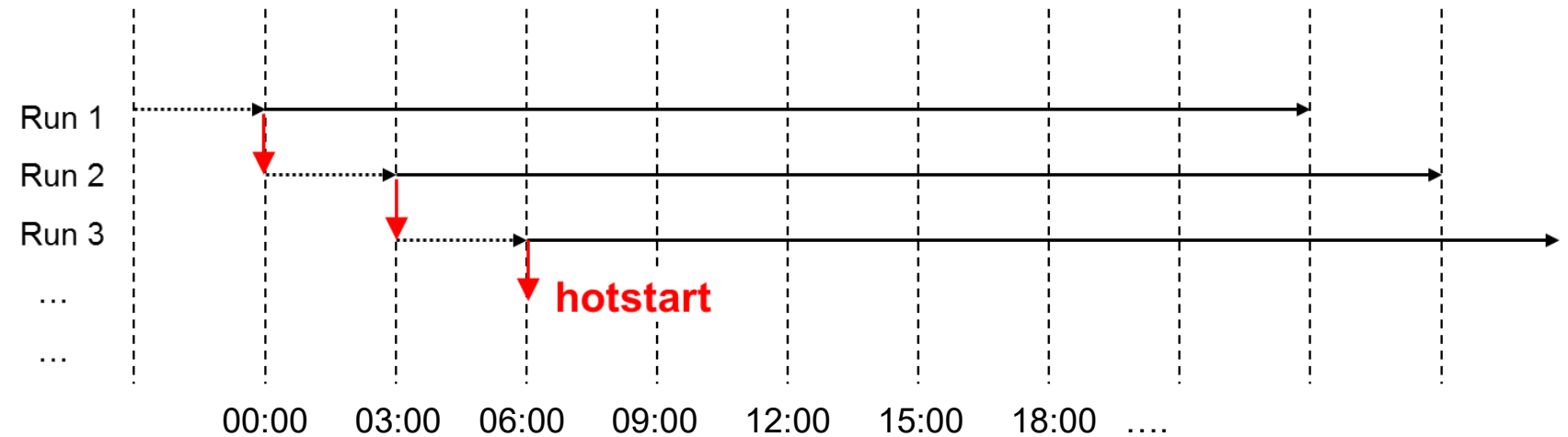


SWAN-Kuststrook domain



Every 3 hours a new SWAN run starts

- 3 hr hindcast + 48 hr forecast
- Time step: 1 uur
- Wave boundary conditions: 2d spectra HRES-WAM by ECMWF 0:00 6:00 12:00 18:00... dt = 3hr
- Wind: Harmonie 0:00 3:00 6:00 9:00... dt = 1hr
- Water levels and currents from D-Flow FM 0:00 3:00 6:00 9:00... dt = 1hr



ST6 (wind input, whitecapping, swell dissipation)

ST6 Whitecapping (RBW, 2012)

Waves do not break unless the spectral density at a frequency exceeds a threshold, calculated from the spectral saturation spectrum.

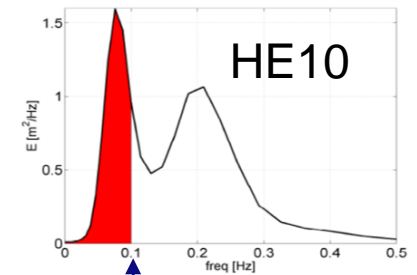
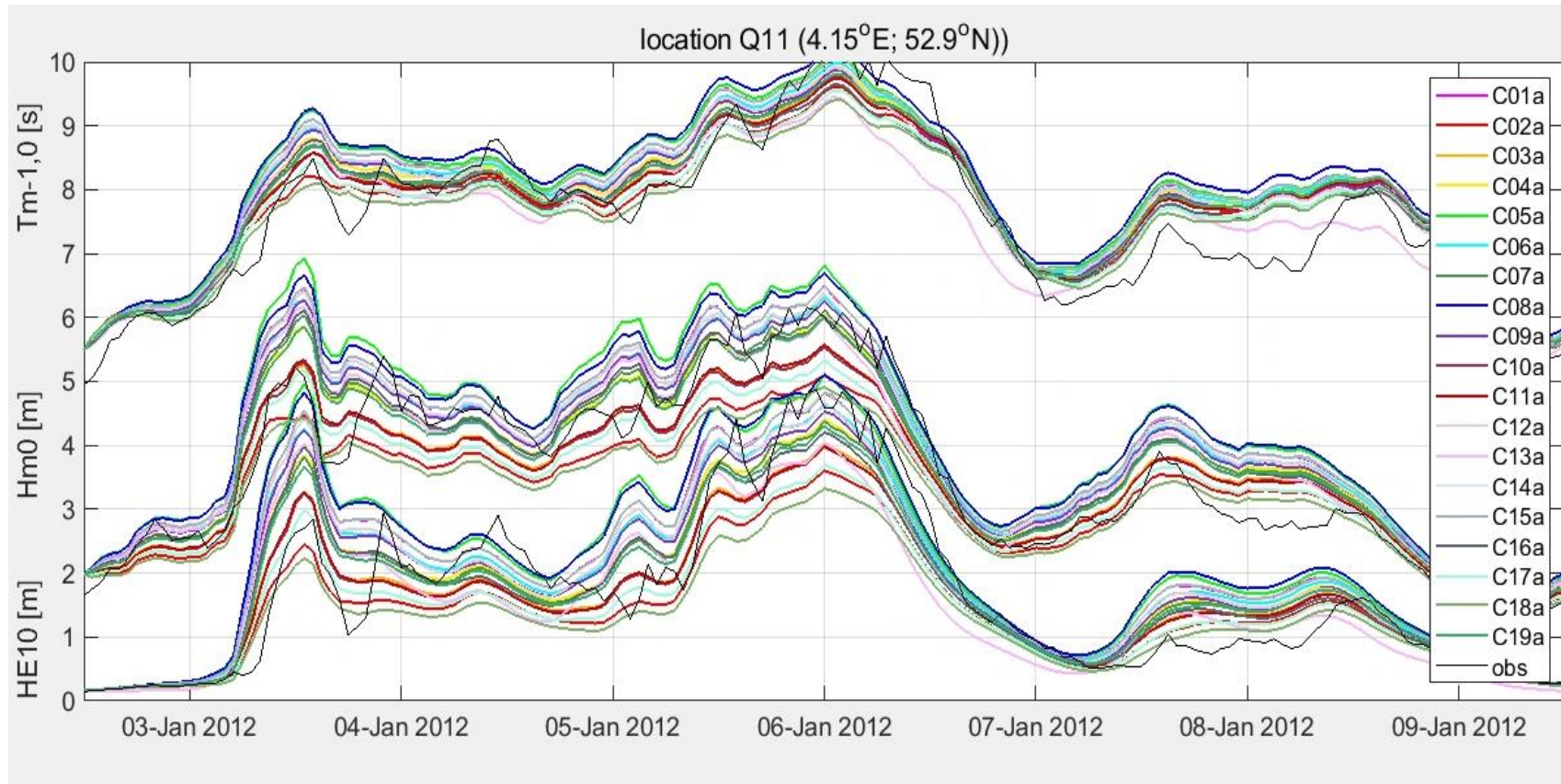
Whitecapping is composed of two components:

- T1: inherent breaking term for that specific frequency.
- T2: induced breaking of short waves due to modulation of longer waves.

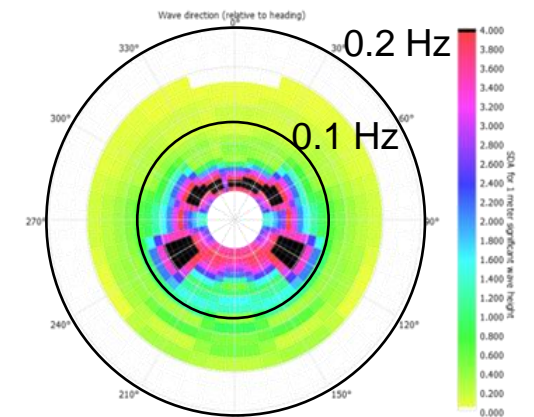
non-breaking swell dissipation term (C_{dsv})

	a_1	a_2	wind scaling	friction	C_{dsv}
	[*10 ⁻⁶]	[*10 ⁻⁵]		[m ² s ⁻³]	
C01a	2.8	3.5	32	0.038	1.2
C02a	2.8	35.0	32	0.038	1.2
C03a	2.8	17.5	32	0.038	1.2
C04a	5.6	7.0	32	0.038	1.2
C05a	2.8	1.8	32	0.038	1.2
C06a	5.6	3.5	32	0.038	1.2
C07a	14.0	1.8	32	0.038	1.2
C08a	2.8	3.5	33	0.038	1.2
C09a	2.8	3.5	31	0.038	1.2
C10a	5.6	17.5	32	0.038	1.2
C11a	11.2	14.0	32	0.038	1.2
C12a	2.8	3.5	32	0.045	1.2
C13a	2.8	3.5	32	0.067	1.2
C14a	2.8	3.5	32	0.038	2.4
C15a	2.8	3.5	32	0.038	12.0
C16a	2.8	3.5	30	0.038	1.2
C17a	5.6	17.5	31	0.038	1.2
C18a	2.8	35.0	31	0.038	1.2
C19a	14.0	3.5	32	0.038	1.2

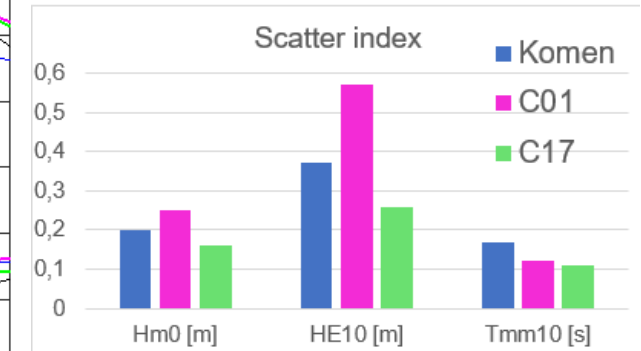
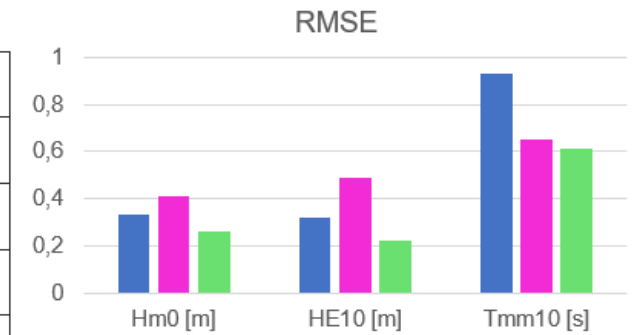
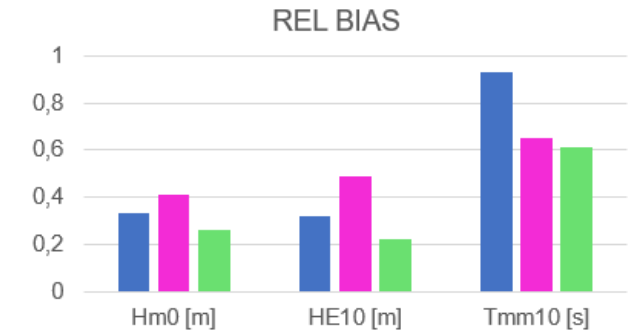
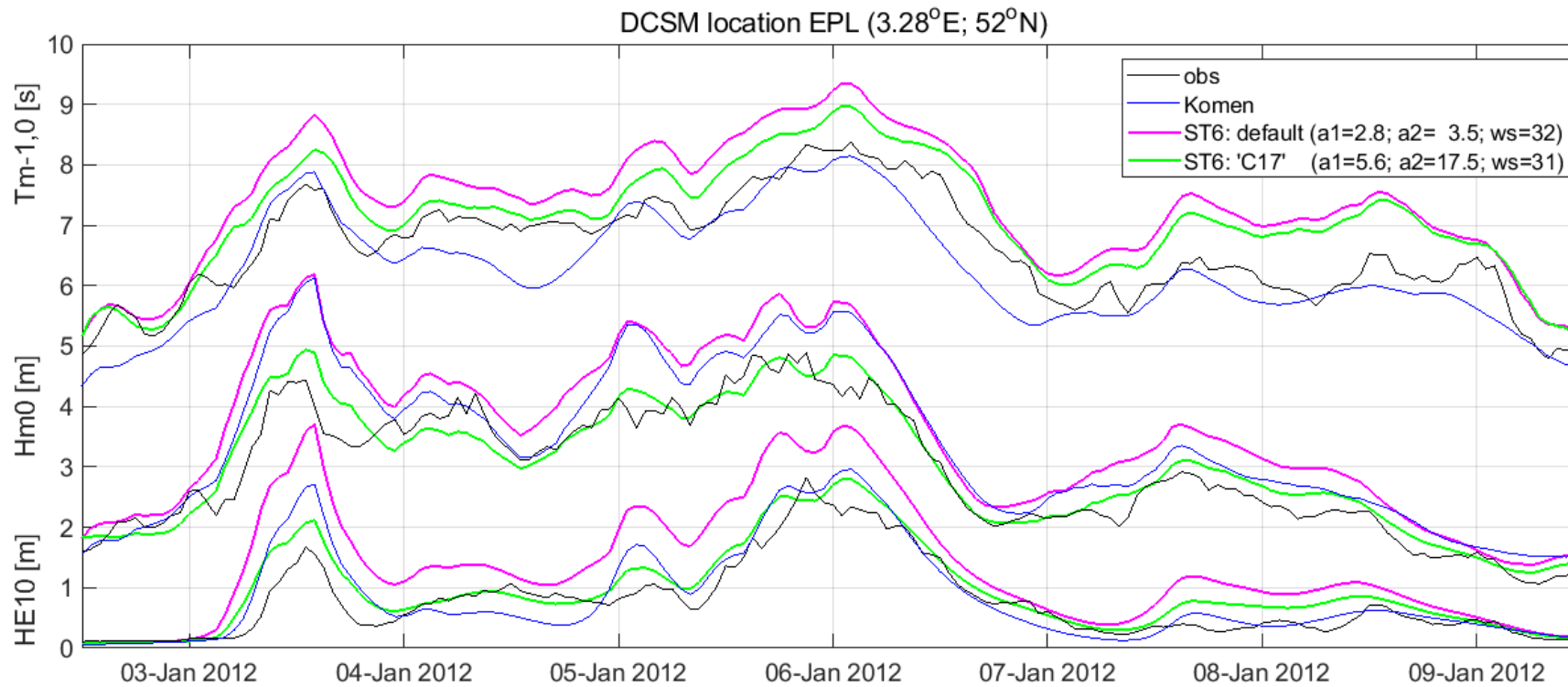
Calibration ST6



0.1 Hz



Calibration ST6

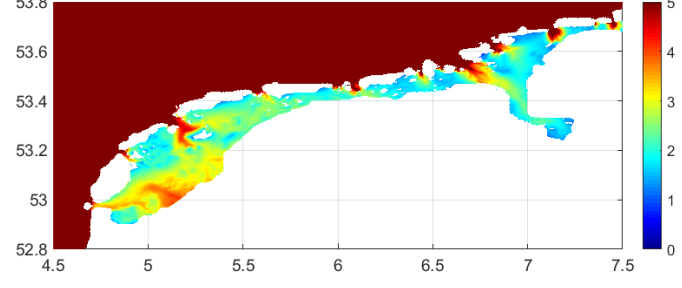
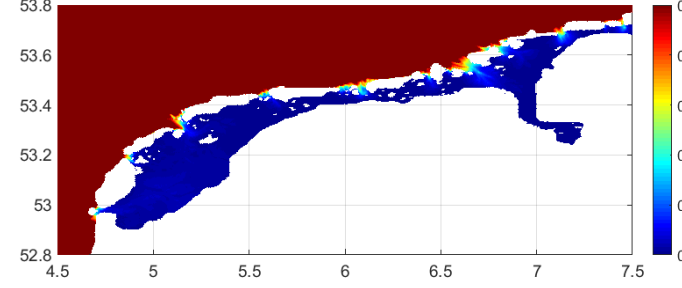
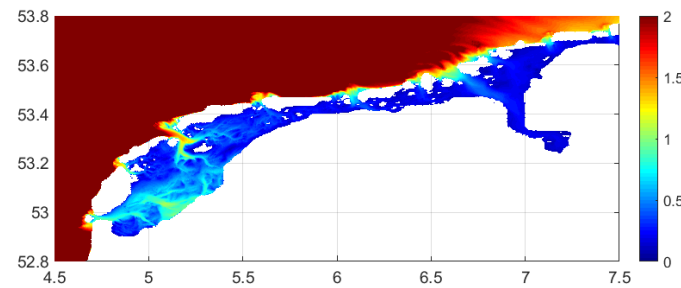
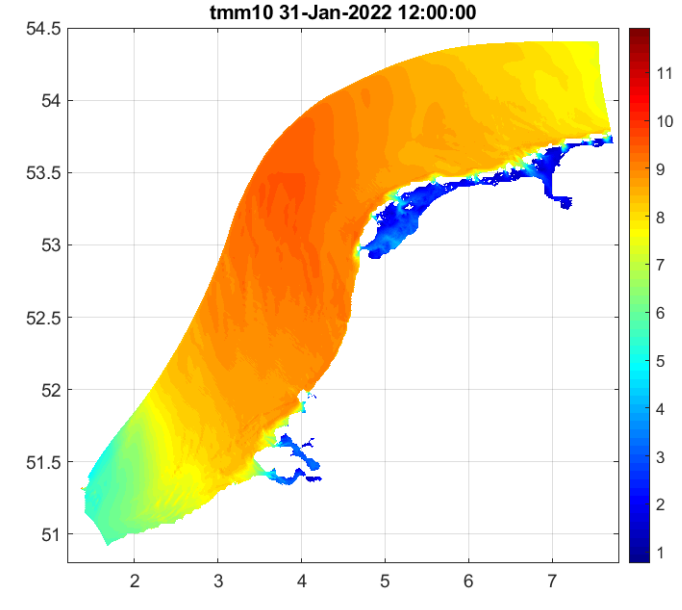
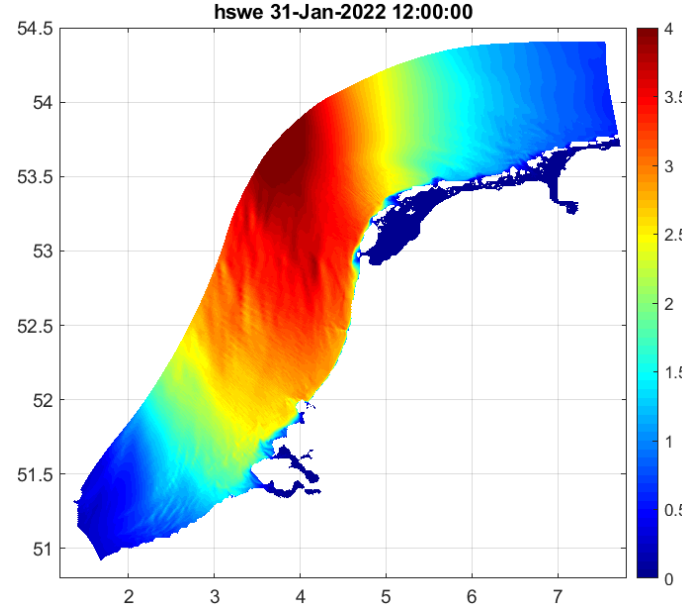
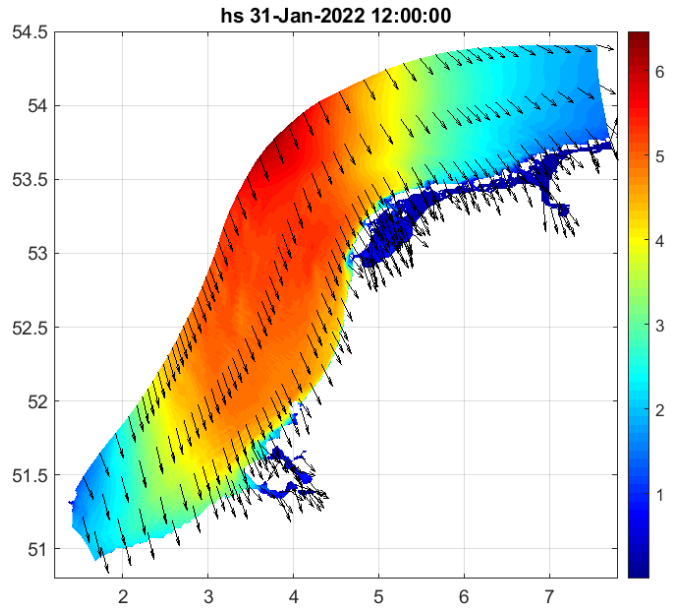


6 months 2011/2012; 6 locations SWAN-DCSM

H_{m0}

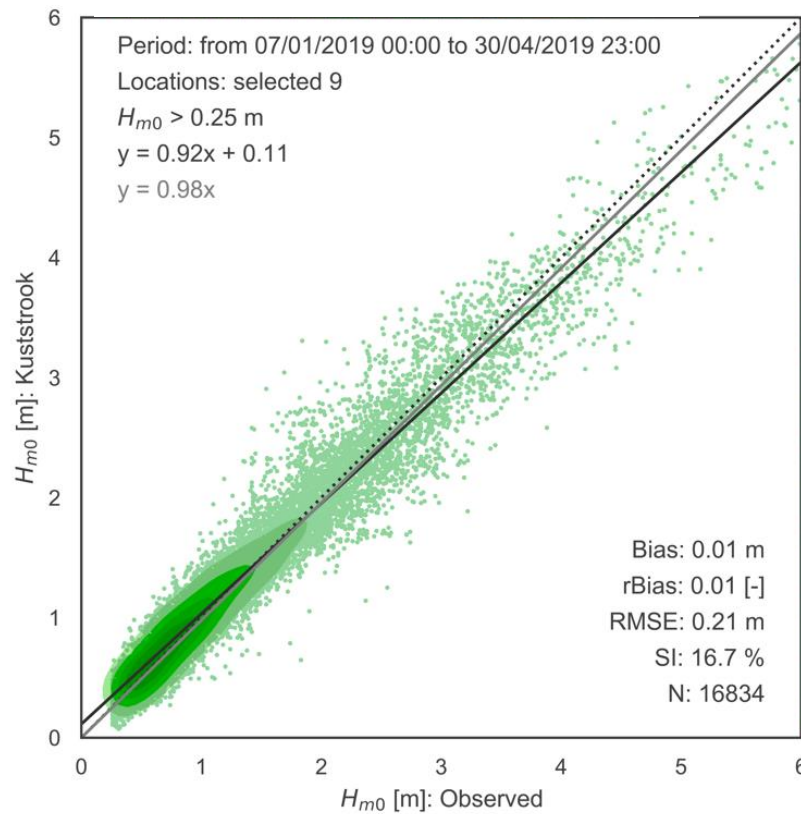
H_{E10}

$T_{m-1,0}$

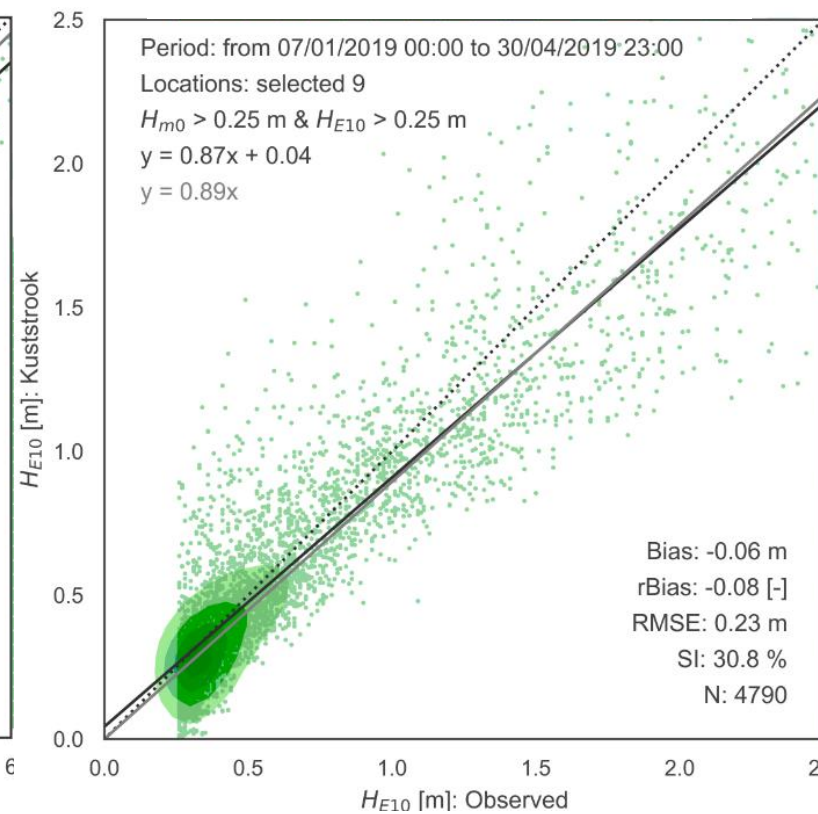


Scatterplots SWAN-KS Jan-Apr 2019; 9 locations

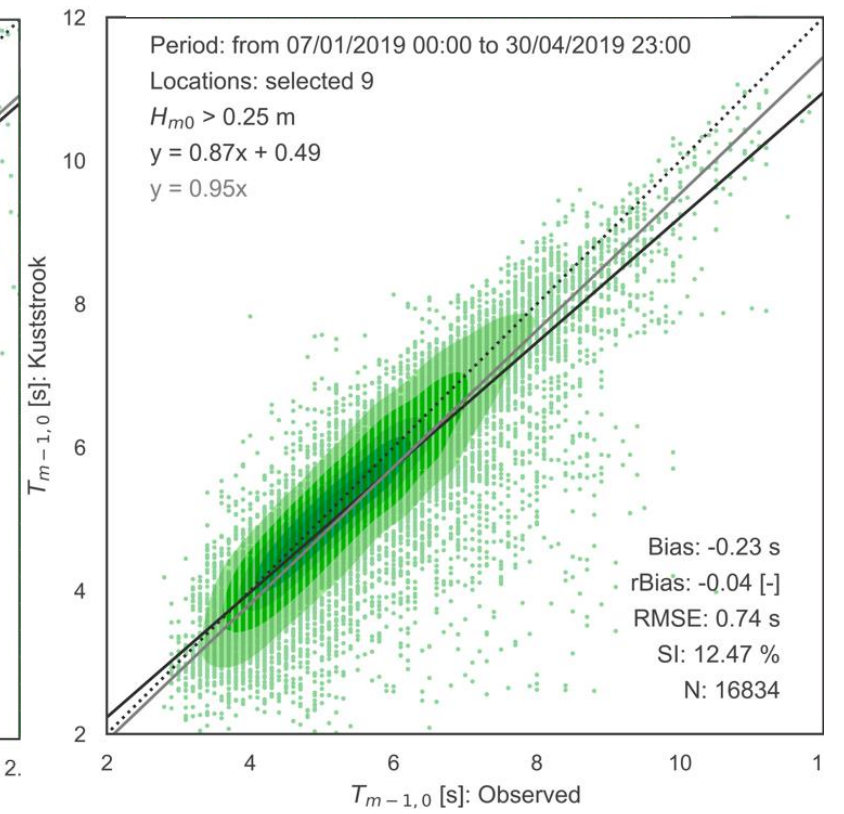
Hm0



HE10

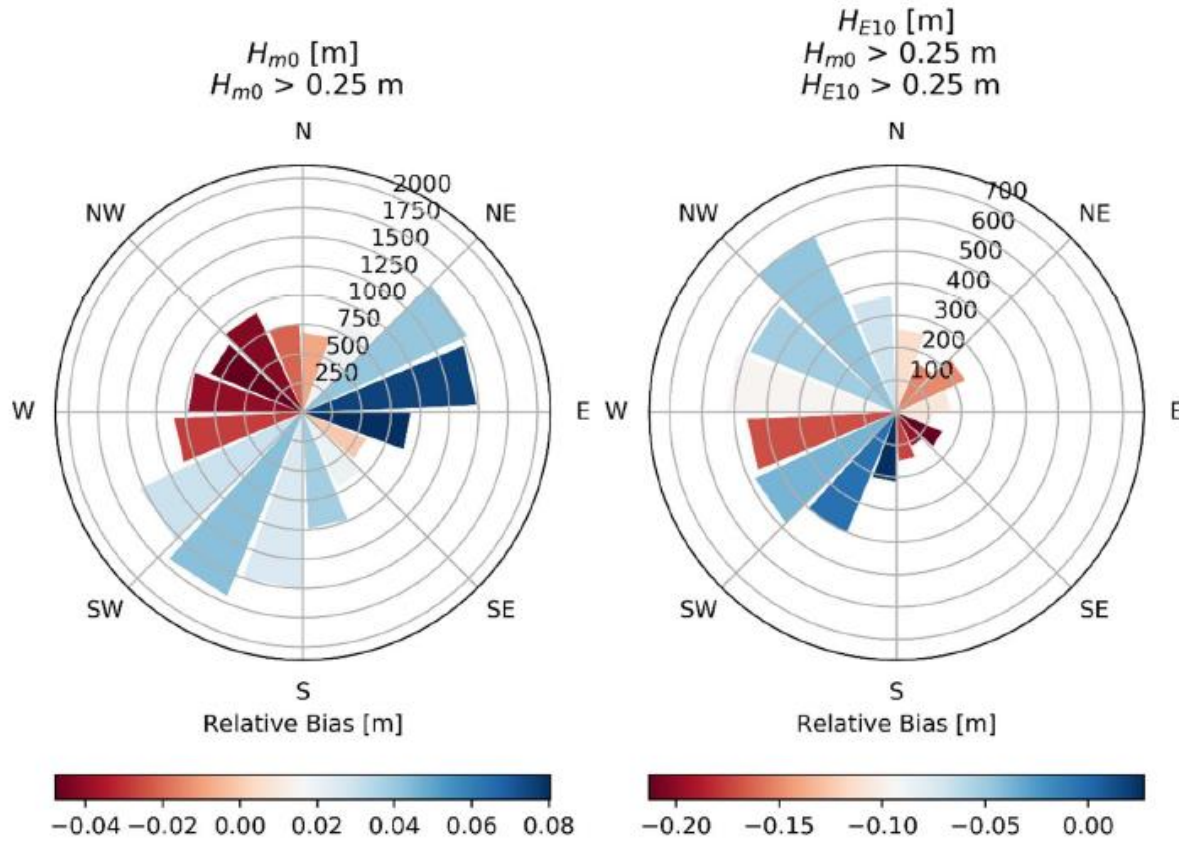


Tm-1,0

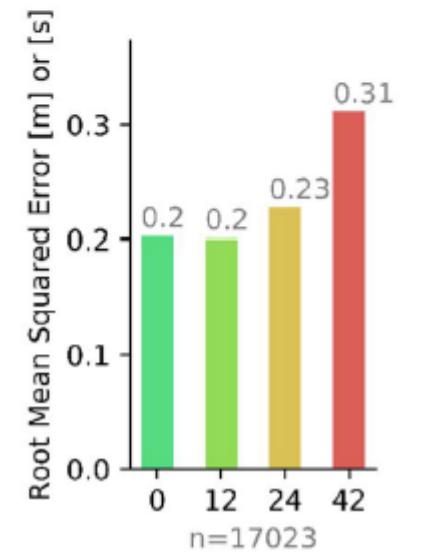
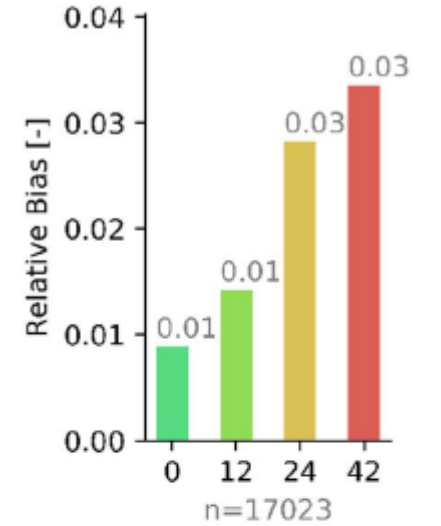


Relative bias Hm0 and HE10 per wave dir...

Period: from 07/01/2019 00:00 to 30/04/2019 23:00, Locations: selected 9



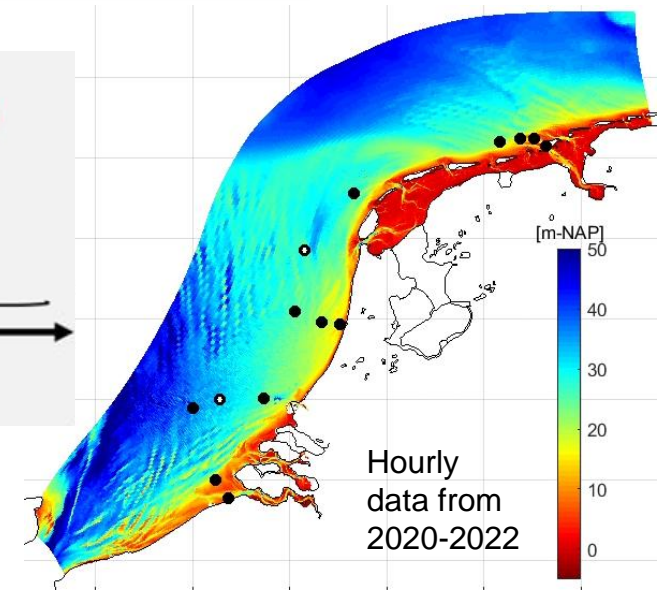
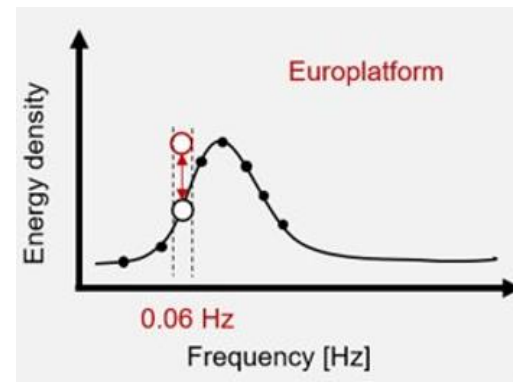
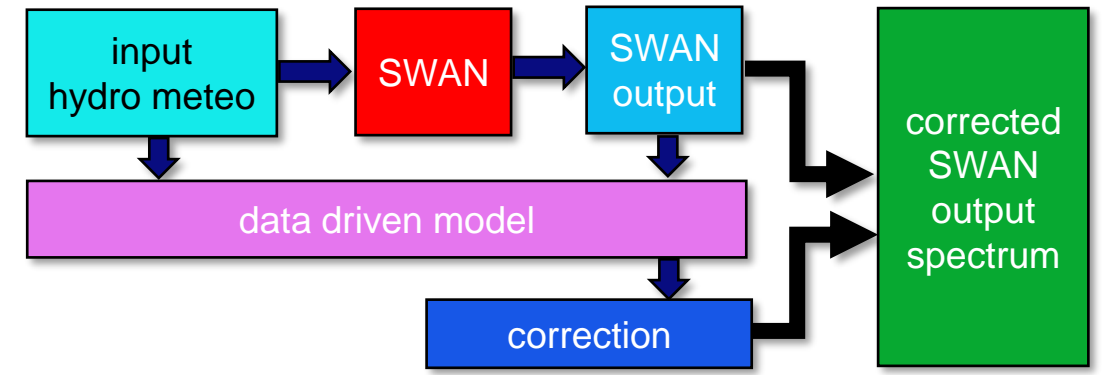
... and lead time



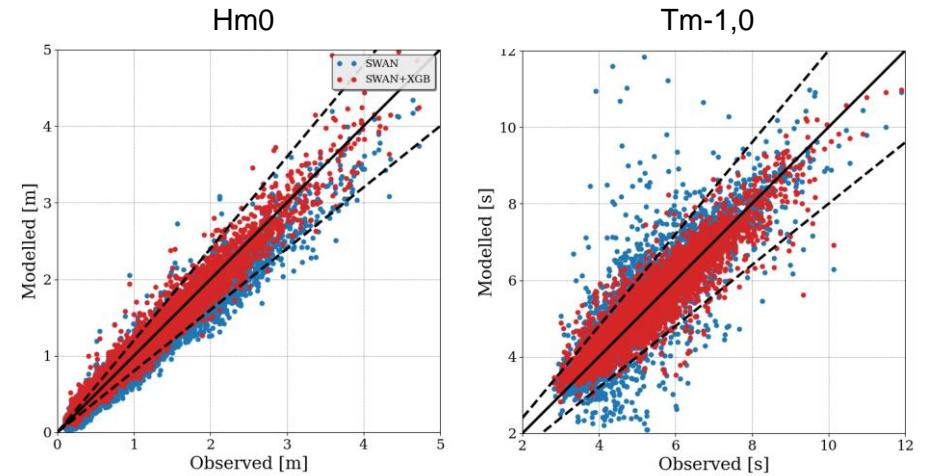
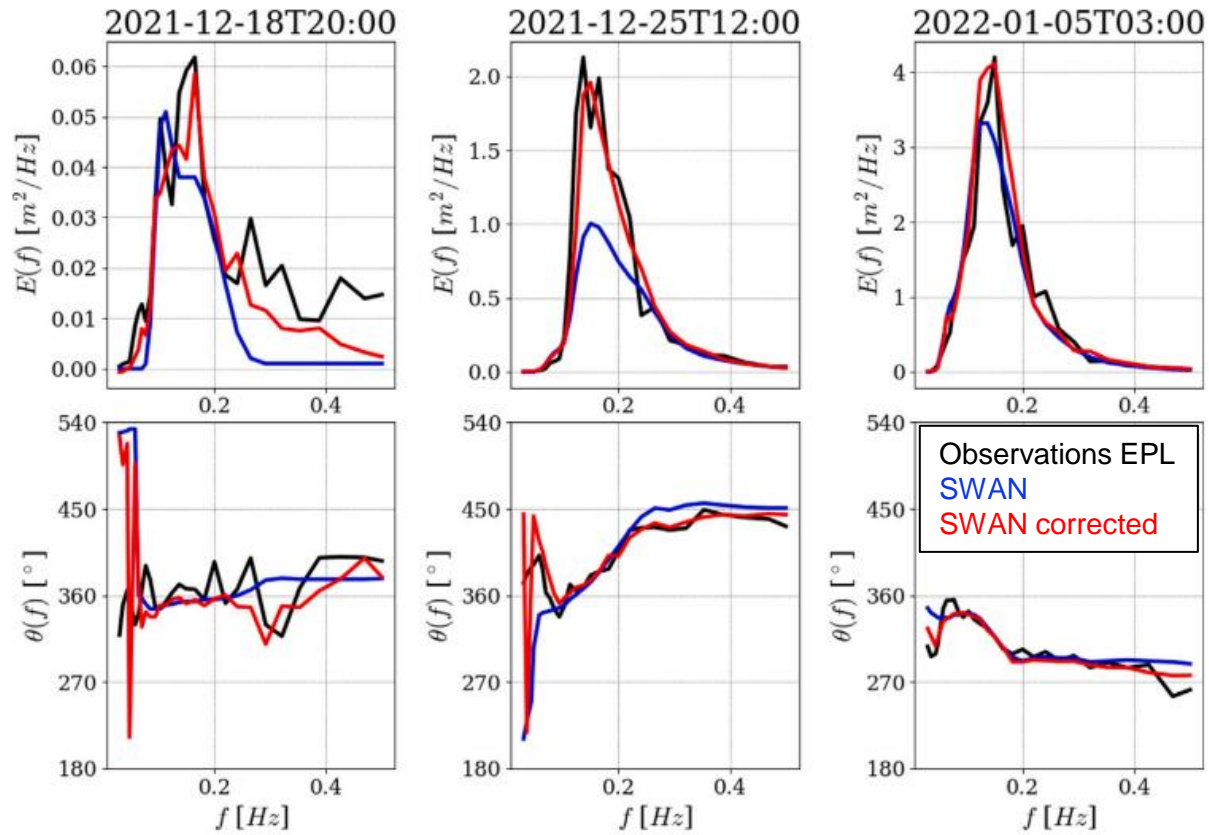
Correct the SWAN-results based on data driven model

- Wind velocity as used in SWAN
- Wind direction as used in SWAN
- Water level as used in SWAN
- Significant wave height predicted by SWAN
- Spectral wave period predicted by SWAN
- Deep water wave steepness predicted by SWAN
- Wave direction predicted by SWAN
- Energy density in frequency bin predicted by SWAN
- Main wave direction in frequency bin predicted by SWAN
- Difference between wave and wind direction predicted by SWAN

$$\Delta E(f) = \frac{E_{obs}(f) - E(f)}{E_{SWAN, total}} \quad ; \quad \Delta \theta(f) = \frac{\theta_{obs}(f) - \theta(f)}{360}$$



SWAN results after correction



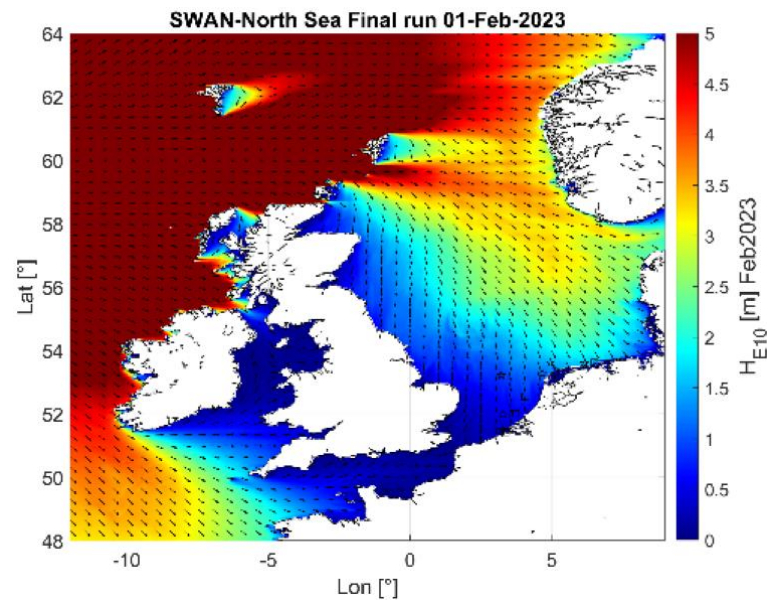
RMSE	SWAN	SWAN corrected	Improvement
H _{m0} [m]	0.21	0.14	-33% ↓
H _{E10} [m]	0.08	0.06	-25% ↓
T _{m-1,0} [s]	0.67	0.41	-39% ↓

Conclusions

- SWAN-Kuststrook runs operationally to provide wave forecasts for the coming 2 days.
- Models forcings are HARMONIE wind, DFLOW-FM water levels and currents, and WAM-HRES wave boundary conditions.
- ST6 improves the results. Wave period increases. Wave height (and HE10) is more sensitive to settings.
- SWAN-Kuststrook has a relative bias of 1% in Hm0, -8% in HE10 and -4% in Tm-1,0. The scatter is large: 17% and 31%. For wave period it is 12%.
- By means of machine learning (XG Boost) we adjust the computed spectra, based on years of trainingsdata (SWAN results and observations)

Future plans

- Boundary conditions (WAM-HRES or SWAN-DCSM)



- Shallow water physics: triads and breaking (see next presentation)

Questions, discussion



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- www.deltares.nl

