

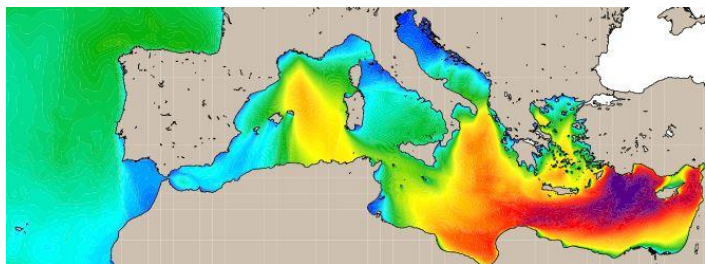
The recent upgrade of the CMEMS MEDWAVES system: description and evolution

Michalis Ravdas, Anna Zacharioudaki, Dimitra Denaxa and Gerasimos Korres

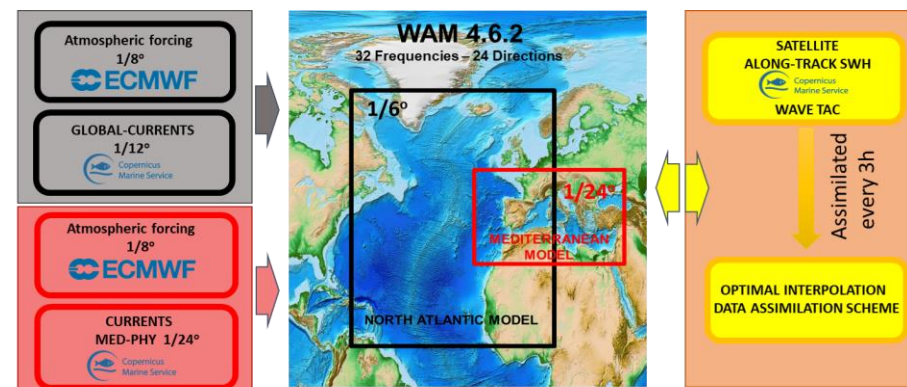
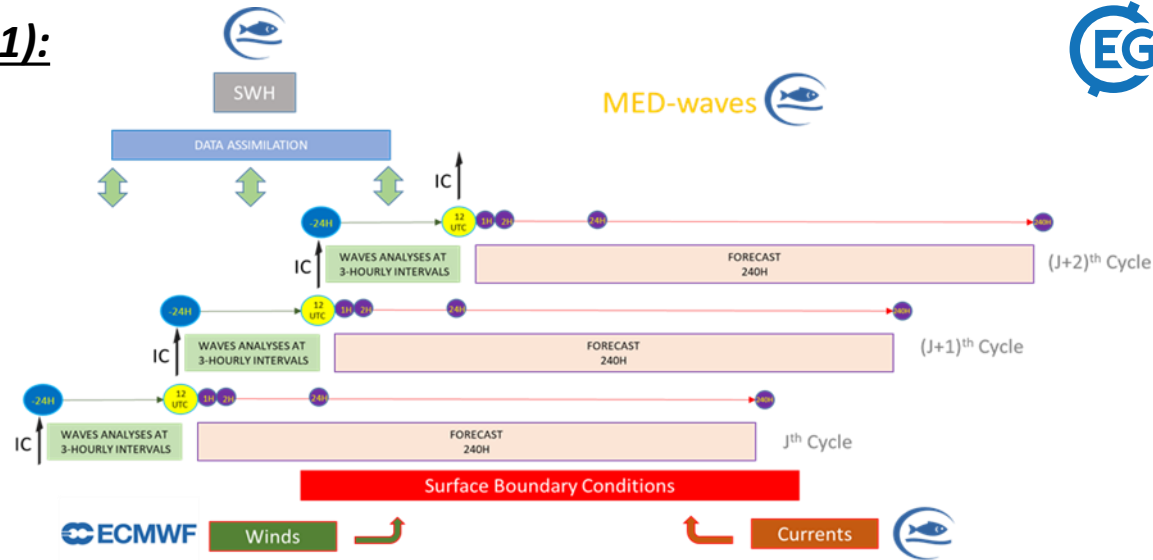
Hellenic Centre for Marine Research (HCMR), Athens, Greece



MEDSEA_ANALYSIS_FORECAST_WAV_006_017



- ✓ Covering the Mediterranean Sea (18.125° W 36.2917° E ; 30.1875° N 45.9792° N)
- ✓ Nested sequence of two computational grids (coarse and fine)
- ✓ Composed by wave parameters at 1/24° horizontal resolution (approx. 4.6km)
- ✓ Forced with ECMWF 10m-above-sea-surface winds
- ✓ Upgraded model version WAM 4.6.2
- ✓ Providing Mediterranean wave analysis and 10 days Mediterranean wave forecasts updated once a day (00 UTC)
- ✓ Coupled with daily surface currents from Med-PHY
- ✓ Assimilating all available along-track satellite SWH observations by CMEMS (optimal interpolation)



MED-WAVES NRT 2020Q1

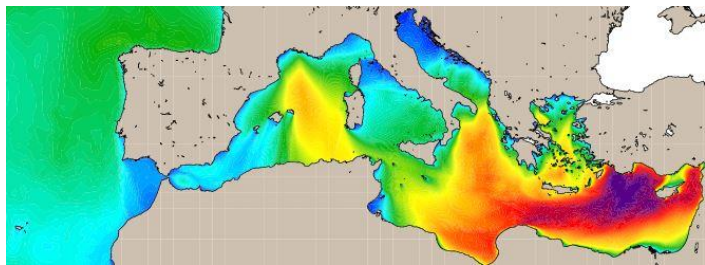
Analysis & 10-days Forecast Products : 2D Instantaneous hourly for

- | | |
|---|--|
| <ul style="list-style-type: none"> ➤ spectral significant wave height (Hm0), ➤ spectral moments (0,2) wave period (Tm02), ➤ spectral moments (-1,0) wave period (Tm-10), ➤ wave period at spectral peak/peak period (Tp), ➤ mean wave direction from (Mdir), ➤ wave principal direction at spectral peak, ➤ stokes drift U, ➤ stokes drift V, | <ul style="list-style-type: none"> ➤ spectral significant wind wave height, ➤ spectral moments (0,1) wind wave period, ➤ mean wind wave direction from, ➤ spectral significant primary swell wave height, ➤ spectral moments (0,1) primary swell wave period, ➤ mean primary swell wave direction from, ➤ spectral significant secondary swell wave height, ➤ spectral moments (0,1) secondary swell wave period, ➤ mean secondary swell wave direction from. |
|---|--|

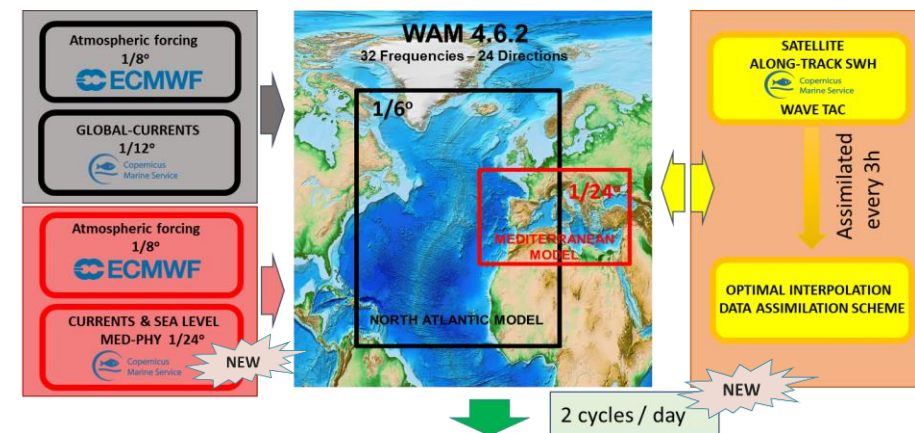
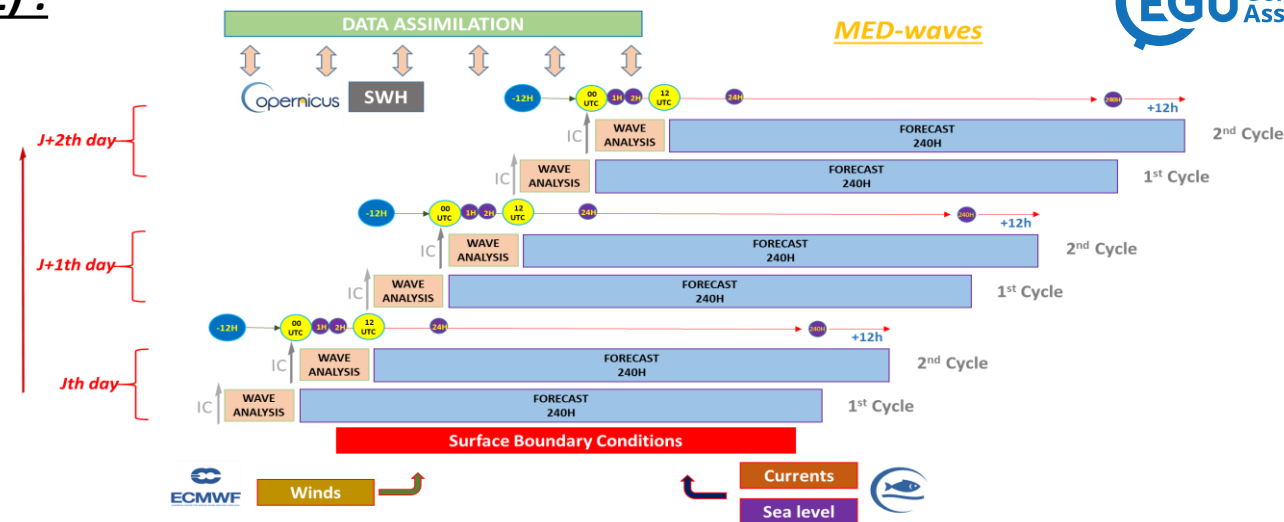
Cal/Val module
In-situ and Satellite observations

➤ Output of wave spectra over the whole domain (1-h analysis, 3-h forecasts) available at medmfc.hcmr.gr

MEDSEA_ANALYSISFORECAST_WAV_006_017



- ✓ Accounts for Atlantic swell through a nested sequence of two computational grids (coarse and fine)
- ✓ Off-line coupled with **hourly** surface currents and **sea level** from Med-PHY
- ✓ Uses the latest state-of-the-art WAM model version
- ✓ Assimilates all available along-track satellite SWH observations by CMEMS – currently 7 missions
- ✓ Includes **2 forecast cycles** (00 UTC, 12 UTC); providing Mediterranean wave analysis and 10 days Mediterranean wave forecasts updated **twice a day**
- ✓ Provides wave parameters at $1/24^\circ$ horizontal resolution (approx. 4.6km) from the Mediterranean model (18.125° W 36.2917° E ; 30.1875° N 45.9792° N)



MED-WAVES
NRT 2021Q2

Analysis & 10-days Forecast Products : 2D Instantaneous hourly for

- | | |
|---|---|
| <ul style="list-style-type: none"> ➤ spectral significant wave height (Hm0), ➤ spectral moments (0,2) wave period (Tm02), ➤ spectral moments (-1,0) wave period (Tm-10), ➤ wave period at spectral peak/peak period (Tp), ➤ mean wave direction from (Mdir), ➤ wave principal direction at spectral peak, ➤ stokes drift U, ➤ stokes drift V, | <ul style="list-style-type: none"> ➤ spectral significant wind wave height, ➤ spectral moments (0,1) wind wave period, ➤ mean wind wave direction from, ➤ spectral significant primary swell wave height, ➤ spectral moments (0,1) primary swell wave period, ➤ mean primary swell wave direction from, ➤ spectral significant secondary swell wave height, ➤ spectral moments (0,1) secondary swell wave period, ➤ mean secondary swell wave direction from. |
|---|---|

Cal/Val module
In-situ and Satellite
observations



➤ Output of **wave spectra** over the whole domain (1-h analysis, 3-h forecasts) available at medmfc.hcmr.gr

Upgrades of the upcoming Med-waves system (Q2/2021) compared to the previous version (Q1/2020):

- ✓ **One-way coupling with hourly currents** and sea level from the new version (Q2/2021) of the Med-MFC Physical component's product *MEDSEA_ANALYSISFORECAST_PHY_006_013*.
- ✓ **Addition of a 2nd forecast cycle:** The wave prediction system will run two cycles per day, starting at 00:00 UTC and 12:00 UTC. Each cycle is scheduled to simulate 252 hours: 12 hours in the past (wave analysis) blending through data assimilation model results with available SWH satellite observations available from CMEMS WAVE TAC and 240 hours into the future (10-days wave forecasts).
- ✓ **Inclusion of additional SWH along track satellite observations** (CFOSAT & HAIYANG-2B) in the Data Assimilation system.

Med-waves NRT system - Evaluation

Full Med metrics (Jul 2019 – Jul 2020)

Model analysis vs. in-situ observations

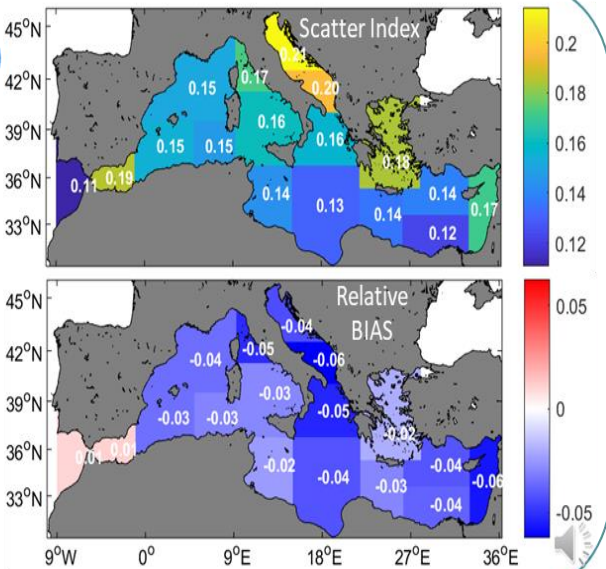
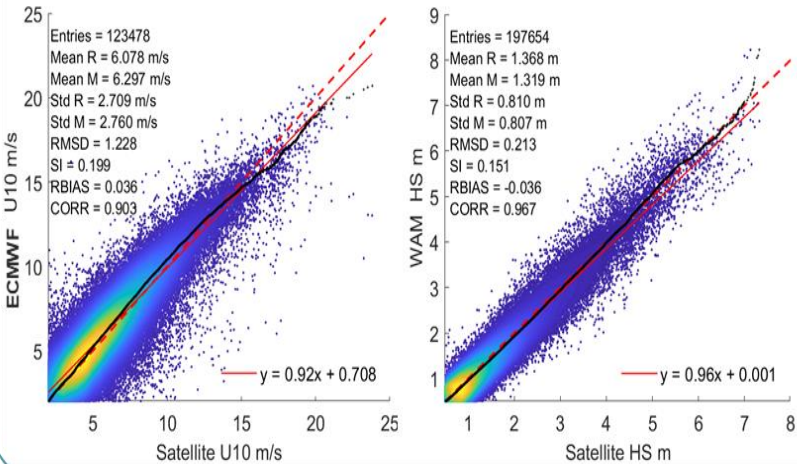
Model first-guess vs. satellite observations

		Q1/2020		Q2/2021		Units
		BIAS	RMSD	BIAS	RMSD	
Model analysis vs. in-situ observations	SWH	0.007	0.209	0.014	0.209	m
	MWP	-0.398	0.648	-0.377	0.631	s
Model first-guess vs. satellite observations	SWH	-0.057	0.220	-0.049	0.213	m



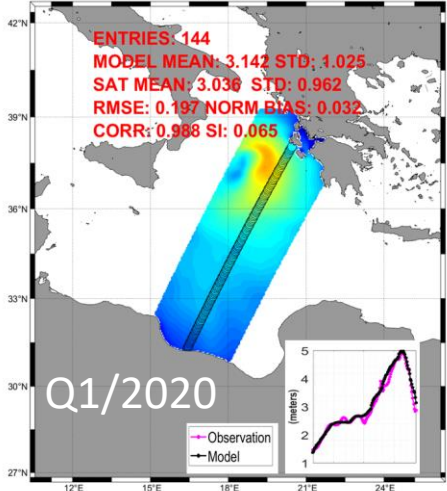
Q2/2021 was found to better approximate high waves (SWH > 4-5 m) in all comparisons.

Q2/2021: Full Med and regional metrics (Jul 2019 – Jul 2020)

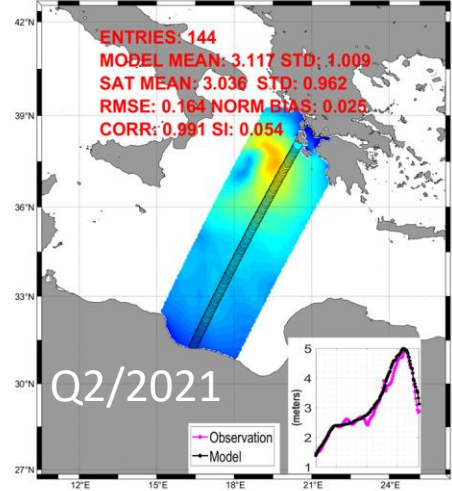


Medicane Ianos (September 2020)

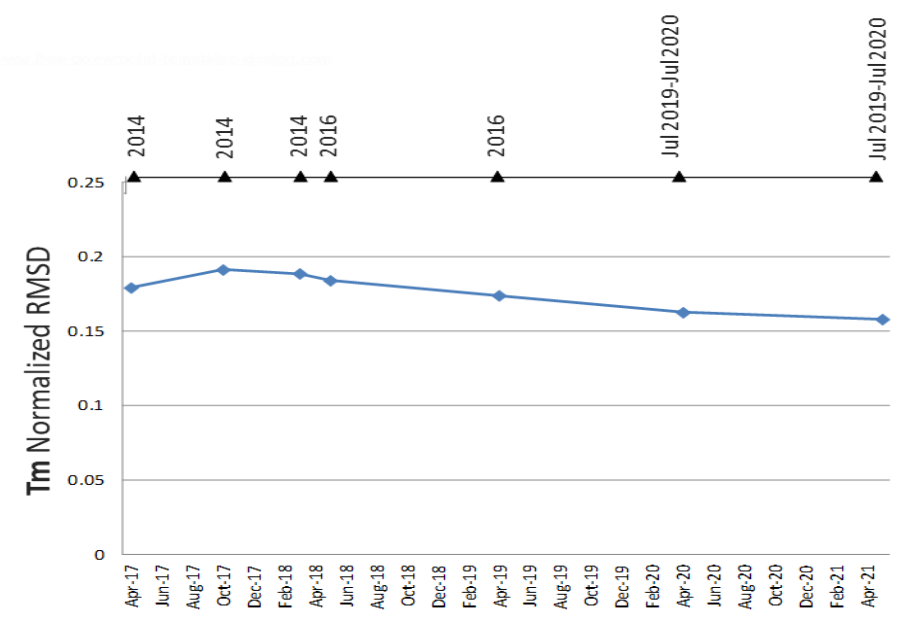
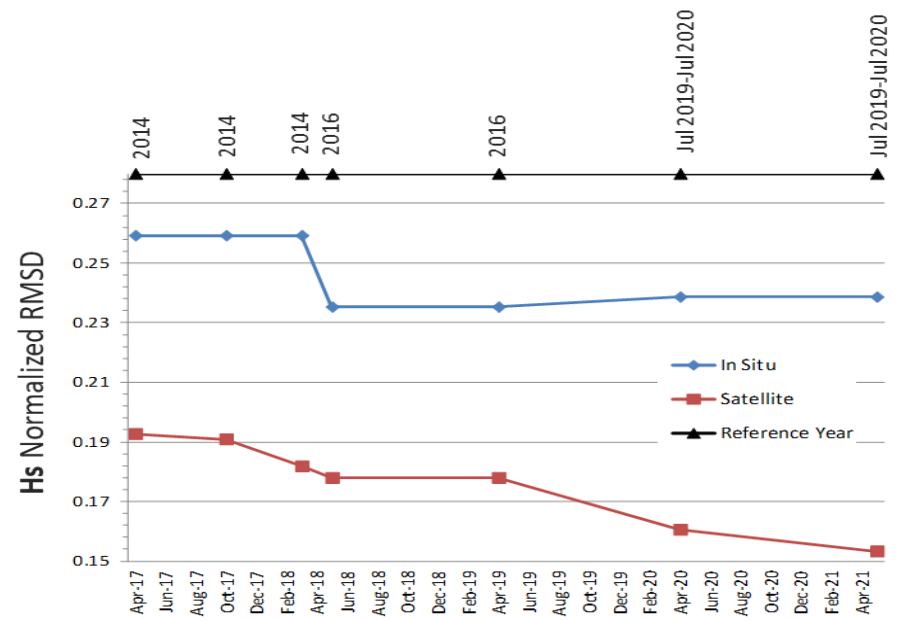
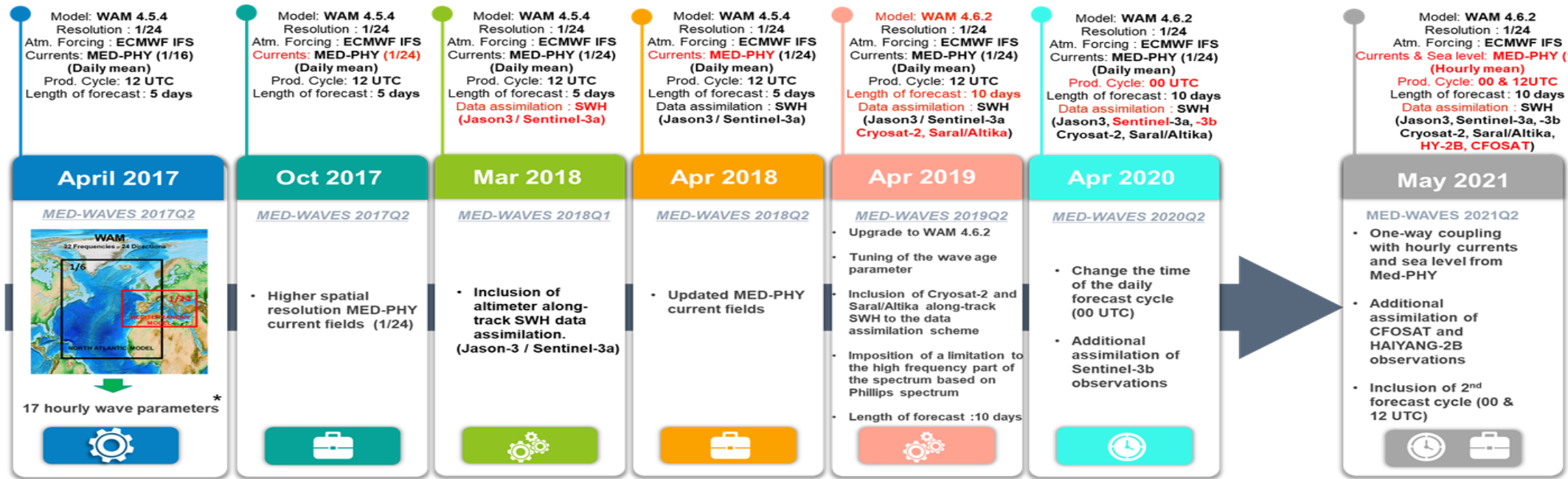
September 17, 2020 11:47 jason3



September 17, 2020 11:47 jason3

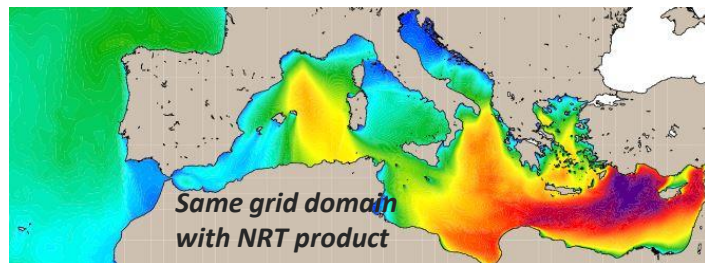


Med-waves NRT system Evolution

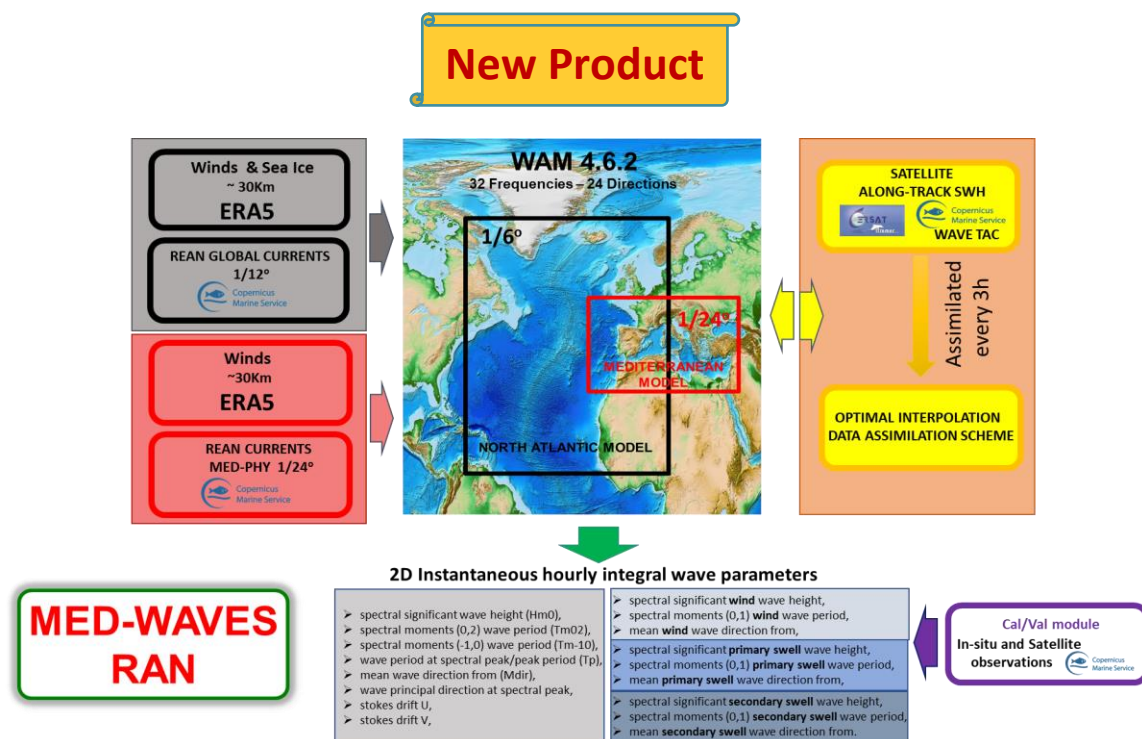


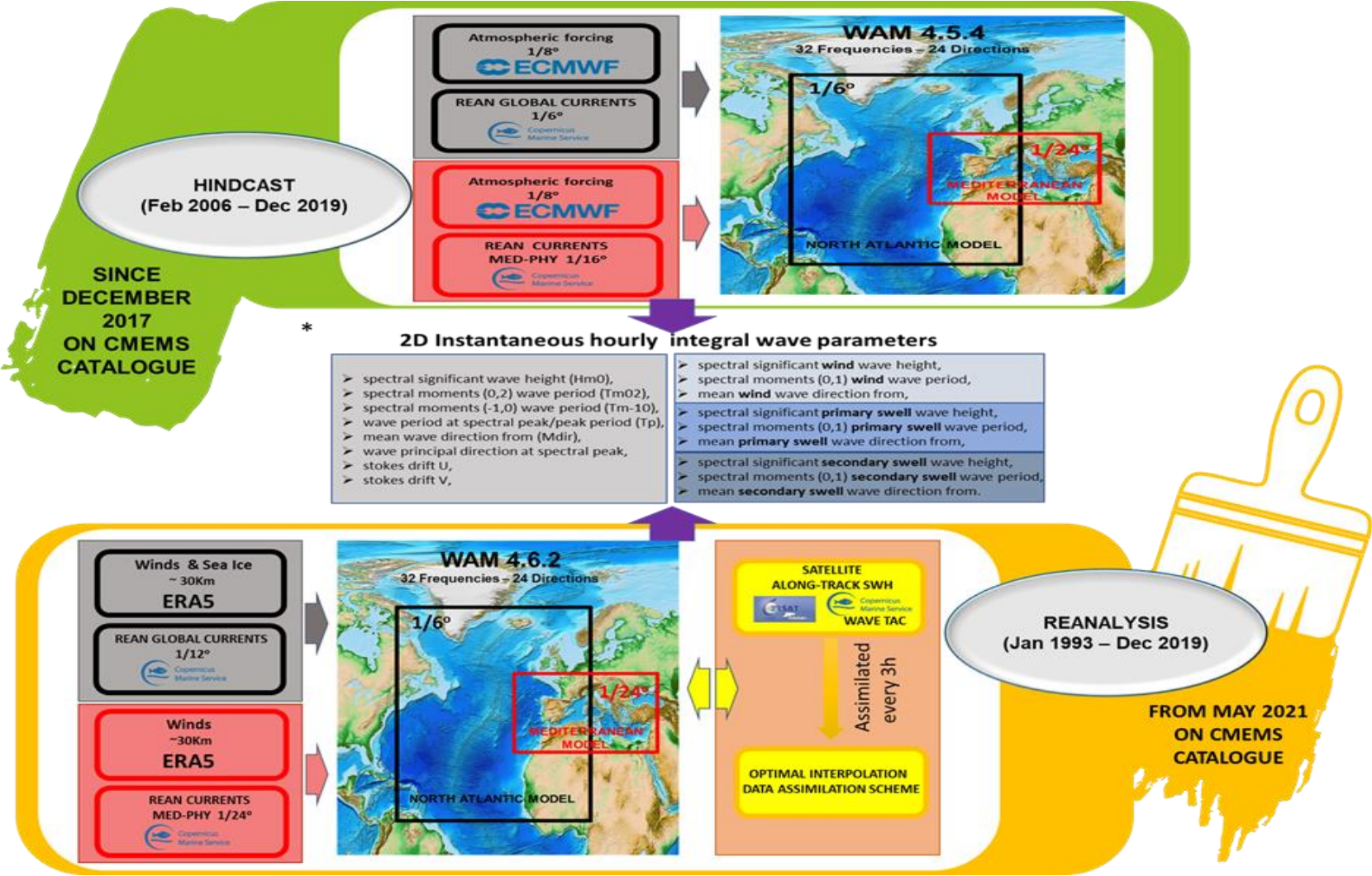
Qualification metrics obtained from the comparison of model output with reference observations, over a period of 1 year, across system versions (EIS release date)

MEDSEA_MULTIYEAR_WAV_006_012



- ✓ Reanalysis time series covering the period Jan 1993 – Dec 2019
- ✓ Covering the Mediterranean Sea (18.125° W 36.2917° E ; 30.1875° N 45.9792° N)
- ✓ Nested sequence of two computational grids (coarse and fine)
- ✓ Composed by wave parameters at 1/24° horizontal resolution (approx. 4.6km)
- ✓ Upgraded model version WAM 4.6.2
- ✓ Assimilating all available along-track satellite SWH observations by CMEMS and CERSAT (optimal interpolation)
- ✓ Forced with ECMWF ERA5 Reanalysis surface winds
- ✓ To be updated twice a year (6-months extensions); plus monthly interim production reaching one month before present





Full Med metrics (1993– 2018)

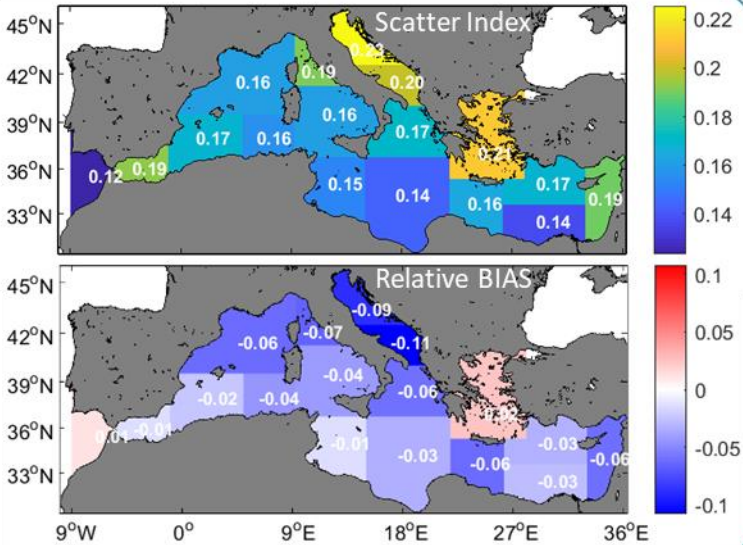
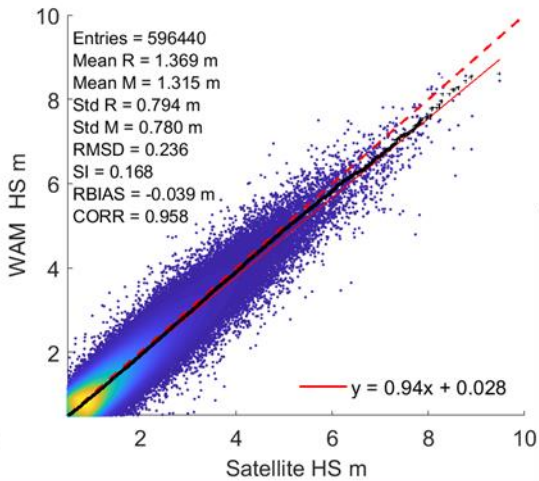
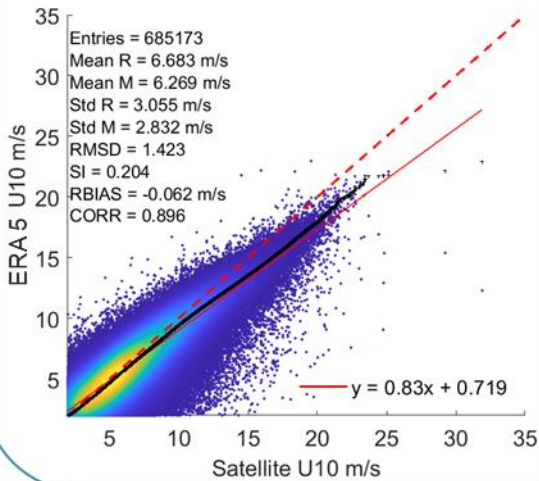
Mean annual values ± standard deviation

Model analysis vs. in-situ observations

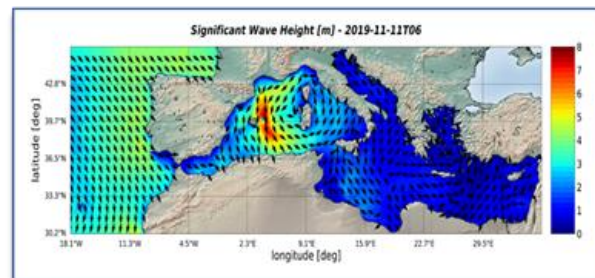
Model first-guess vs. satellite observations

	Q2/2021		Units
	BIAS	RMSD	
SWH	-0.056 ± 0.022	0.227 ± 0.012	m
MWP	-0.338 ± 0.078	0.656 ± 0.066	s
SWH	-0.052 ± 0.011	0.236 ± 0.01	m

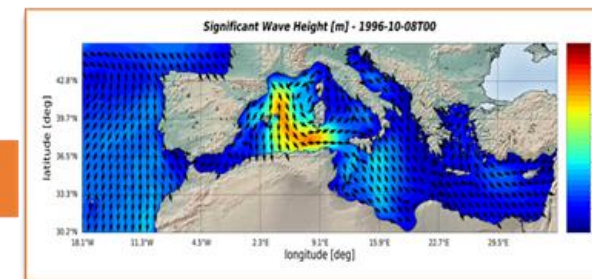
Full Med and regional metrics (1993-2018)



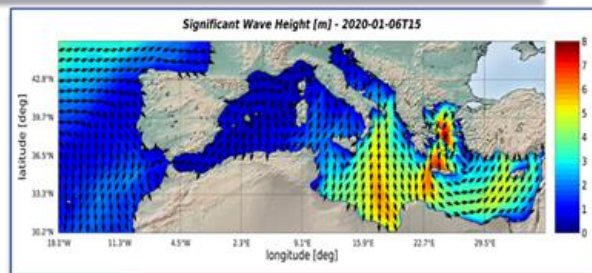
SNAPSHOTS OF MED-WAVES NRT & MULTIYEAR SYSTEM



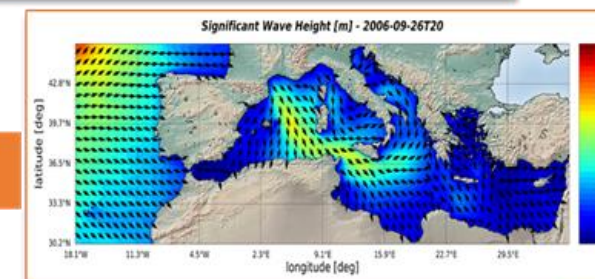
11 Nov 2019
Storm
"Trudy"



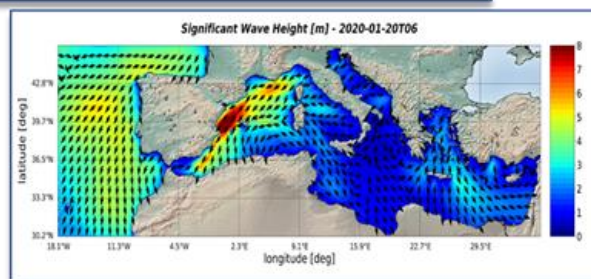
08 Oct 1996
Storm
"Cornelia"



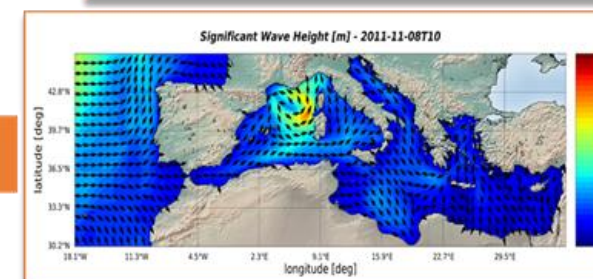
06 Jan 2020
Storm
"Hephaestion"



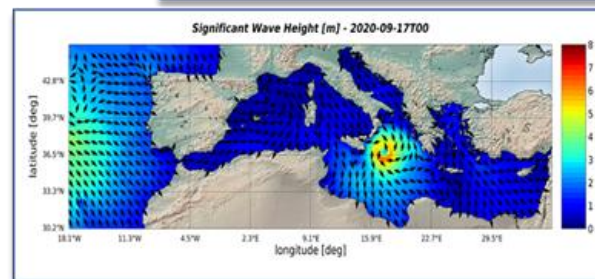
26 Sep 2006
Medicane
"Querida"



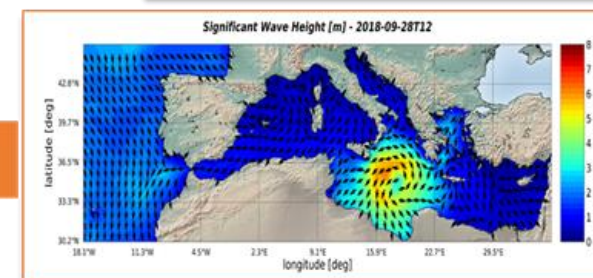
20 Jan 2020
Storm
"Gloria"



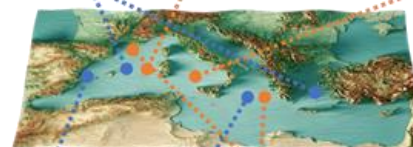
08 Nov 2011
Storm
"Rolf"



17 Sep 2020
Medicane
"Ianos"



28 Oct 2018
Medicane
"Zorbas"

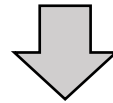


- Nesting with the CMEMS Global wave forecasting system
- Continuous upgrade of the Med-waves system (ingestion of new satellite products including wave spectra, ECMWF winds with higher temporal and spatial resolution, upgraded WAM model versions)
- Deal with wave forecast uncertainty: setup and operate a wave ensemble forecasting system for the Mediterranean Sea
- Use directional wave spectrum and theoretical statistical models for wave extremes to accurately infer the expected shape and probability of the largest waves
- Continues upgrade of the Med-waves validation (validation of wave direction, validation of wave spectra)

https://resources.marine.copernicus.eu/?option=com_csw&view=details&product_id=MEDSEA_ANALYSIS_FORECAST_WAV_006_017

https://resources.marine.copernicus.eu/?option=com_csw&view=details&product_id=MEDSEA_HINDCAST_WAV_006_012

From 4 May 2021



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https://resources.marine.copernicus.eu/?option=com_csw&view=details&product_id=MEDSEA_MULTIYEAR_WAV_006_012

