From informal inter-comparison to the Lead Centre for Wave Forecast Verification (LC-WFV)

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Informal inter-comparison

- Comparisons of ocean wave forecast data from different models were first informally established in 1995 by scientists working on wave models.
- The comparisons were based on a monthly exchange of model analysis and forecast data at the locations of in-situ observations of wave and wind available via the Global Telecommunication System (GTS) from moored buoys and fixed platforms.
- The GTS data were gathered, and quality controlled by Jean Bidlot and collated with the model data. The time series were then shared with the other participants.
- The idea was to provide a validation of operational wave forecasts in slightly behind real time (within 1 to 2 months).

Intercomparison of the Performance of Operational Ocean Wave Forecasting Systems with Buoy Data

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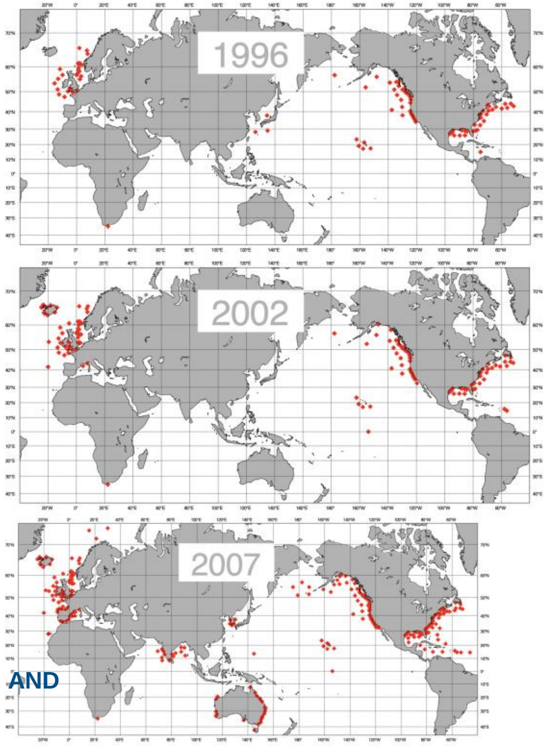
(Manuscript received 7 March 2001, in final form 22 October 2001)



Locations of in-situ significant wave height observations

Informal inter-comparison

- The Expert Team on Wind Waves and Storm Surges of the Joint Technical Commission for Oceanography and Marine Meteorology (JCOMM) noted the value of the exchange during its meeting in Halifax, Canada, in June 2003 and endorsed the expansion of the scheme to include other wave forecasting systems.

- Monthly summary reports were manually uploaded onto the JCOMM web site on a best effort basis.

- A few scientific papers were published using the data.

Inter-comparison of operational wave forecasting systems.

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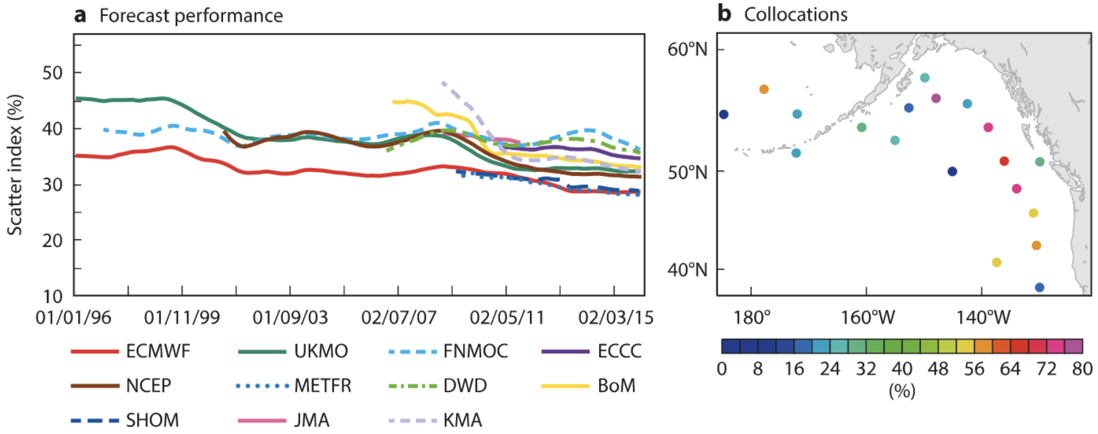
Nadao Kohno,
Japan Meteorological Agency, Japan.
Sanwook Park,
Korea Meteorological Administration, Republic of Korea.
Marta Gomez,
Puertos del Estado, Spain.

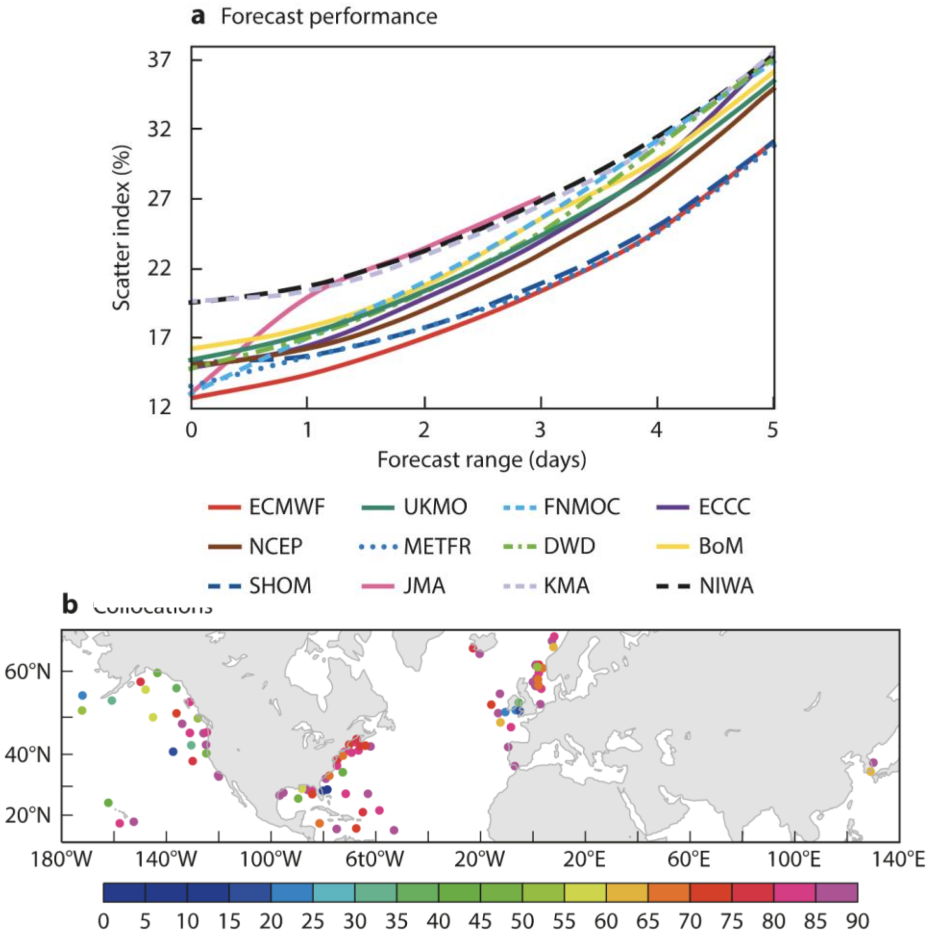
Bidlot et al.. 2007

Informal inter-comparison

- A review of 21 years of wave verification results shows clear improvements in the quality of wave forecasting.
- The comparison project has benefitted all participants and should continue to do so.



Forecast performance of different centres for forecasts initialised at 00 UTC and 12 UTC showing (a) the long-term evolution of 5-year running mean scatter index values for day-5 significant wave height forecasts when compared to buoy observations over the North- East Pacific.



(Forecast performance of different centres for forecasts initialised at 0 and 12 UTC between September 2015 and August 2016. Top: the scatter index (%) for significant wave height when compared to observations for different forecast ranges and bottom the buoy positions and the number of observation-model collocations used relative to the maximum number of possible collocations over this one-year period.

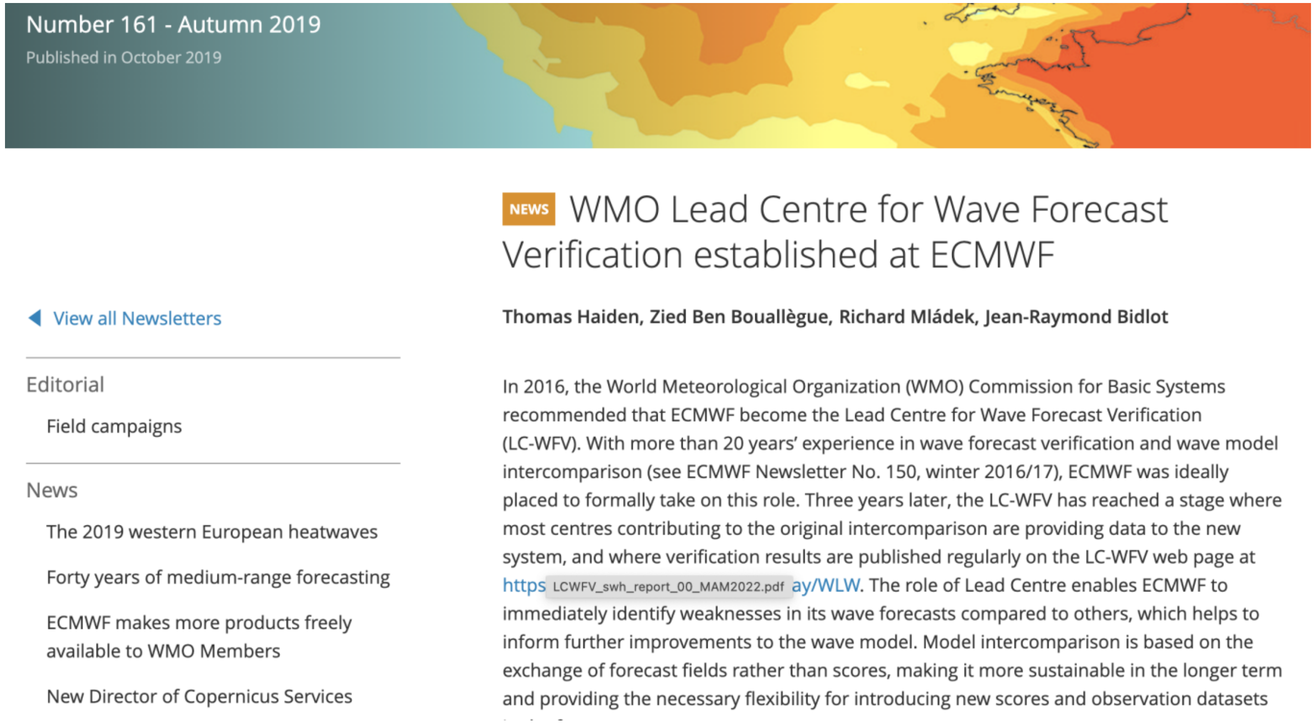
https://www.ecmwf.int/en/newsletter/150/meteorology/twenty-one-years-wave-forecast-verification

From Informal inter-comparison to LC-WFV

- **However**, the informal character of the exchange prevents a rapid adaptation to new data and needed a more reliable exchange of model data.

- For these reasons, the World Meteorological Organization (WMO) established in 2016 a Lead Centre for Wave Forecast Verification (LC-WFV) with clearly defined interfaces between the participants and the Lead Centre.

- ECMWF expressed its interest in becoming the designated Lead Centre and allocated extra resources to that end.



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New Director of Copernicus Services

NEWS WMO Lead Centre for Wave Forecast Verification established at ECMWF

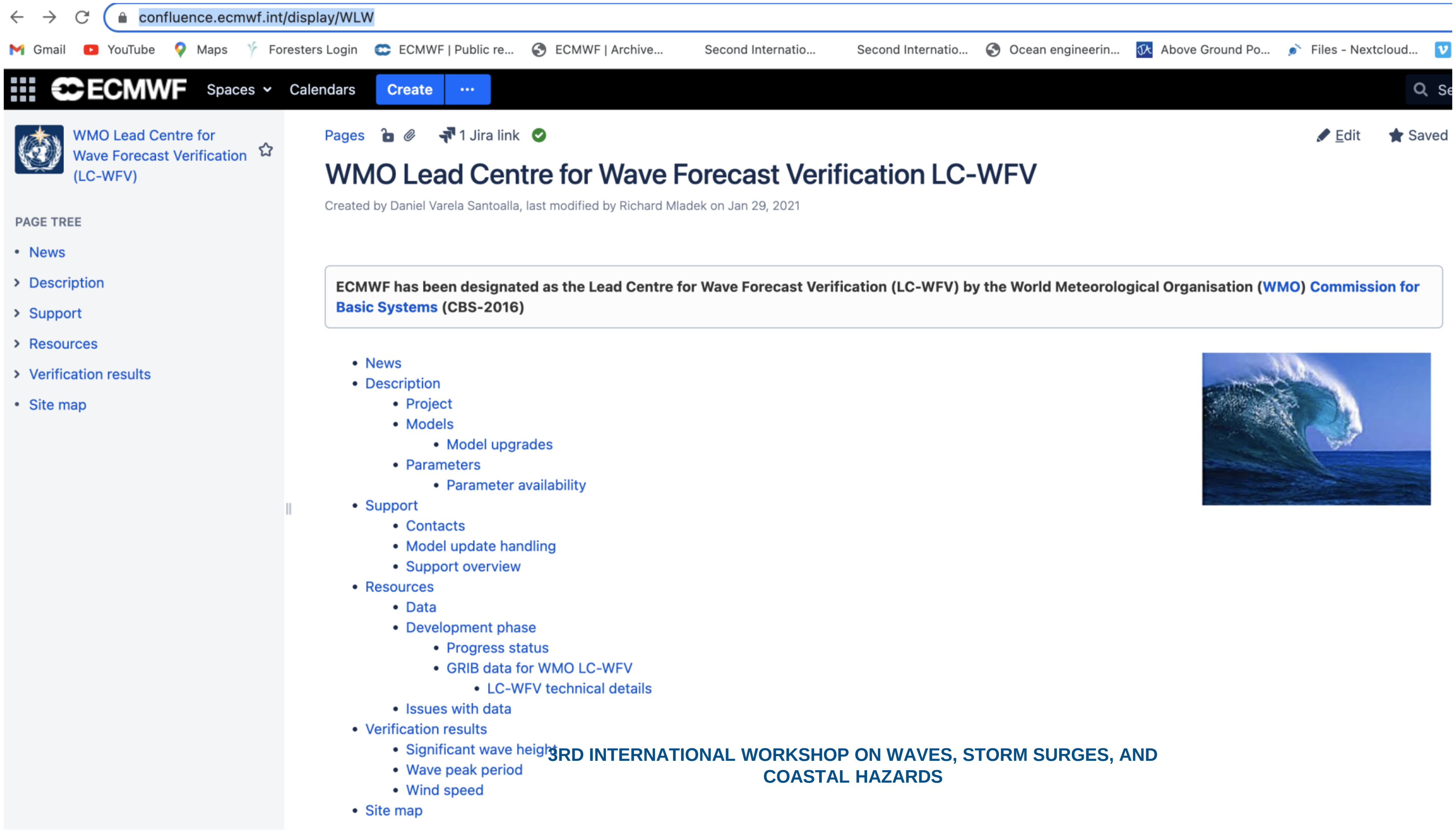
Thomas Haiden, Zied Ben Bouallègue, Richard Mládek, Jean-Raymond Bidlot

In 2016, the World Meteorological Organization (WMO) Commission for Basic Systems recommended that ECMWF become the Lead Centre for Wave Forecast Verification (LC-WFV). With more than 20 years' experience in wave forecast verification and wave model intercomparison (see ECMWF Newsletter No. 150, winter 2016/17), ECMWF was ideally placed to formally take on this role. Three years later, the LC-WFV has reached a stage where most centres contributing to the original intercomparison are providing data to the new system, and where verification results are published regularly on the LC-WFV web page at https LCWFV_swh_report_00_MAM2022.pdf ay/WLW. The role of Lead Centre enables ECMWF to immediately identify weaknesses in its wave forecasts compared to others, which helps to inform further improvements to the wave model. Model intercomparison is based on the exchange of forecast fields rather than scores, making it more sustainable in the longer term and providing the necessary flexibility for introducing new scores and observation datasets

https://www.ecmwf.int/en/newsletter/161/news/wmo-lead-centre-wave-forecast-verification-established-ecmwf

Lead Centre for Wave Forecast Verification (LC-WFV)

ECMWF started working on the LC-WFV in 2017, with dedicated web pages documenting progress, gathering of data in earnest from 2018 onwards.



LC-WFV project

- Providing the facility for participating Centres producing global or ocean basin scale wave forecasts to **automatically** deposit their **gridded** forecast fields in specified format (grib2) and **archive** them.
- **Monitoring** the received forecast fields and consult with participating Centre if data are missing or suspect.
- **Collecting** annually from the participating centres **information** on any changes to their wave forecast systems.

General requirements

- **Domain and resolution**
  - The fields have to be provided on a regular latitude-longitude grid at the resolution that is best matching the native resolution of the direct model output.
- **Parameters**
  - following set of parameters was agreed:
    - Atmospheric forcing:
      - 10 metre U wind component [m/s]
      - 10 metre V wind component [m/s]
    - Wave Fields:
      - Significant height of combined wind waves and swell [m]
      - Peak wave period [s]
      - Mean zero-crossing wave period [s]
      - Mean wave direction [degree true]
- **Forecast-observation matching**
  - The matching between forecast and observation will be based on a nearest grid point approach.
  - No match-up will be performed if any of the surrounding grid points are missing in order to minimise land contamination effects.
- **Data format**
  - The data shall be encoded in GRIB format (edition 2) using WMO compliant templates. ECMWF can assist in the conversion into GRIB edition 2.
  - Encoding details
    - Refer to the page LC-WFV technical details for complete specification of the required input data.
- **Data exchange**
  - Refer to the page LC-WFV technical details for expected test and future production work flow.

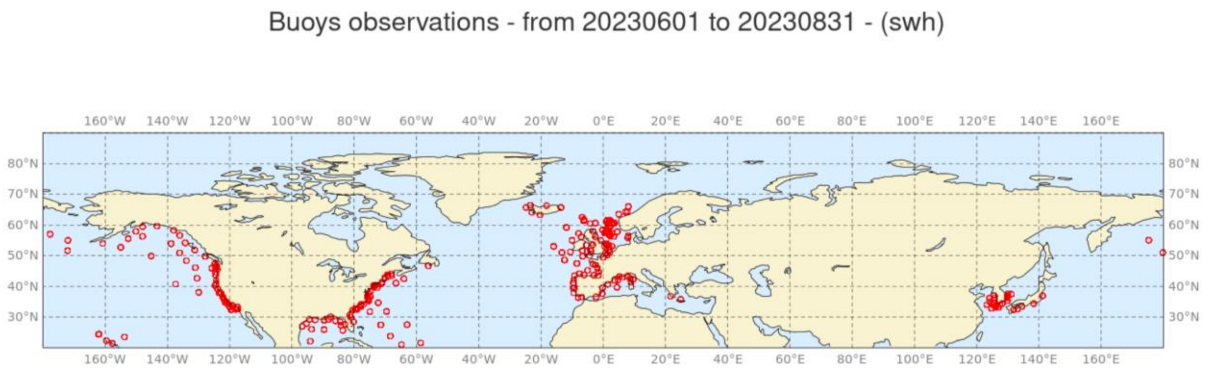
Example of data issue:

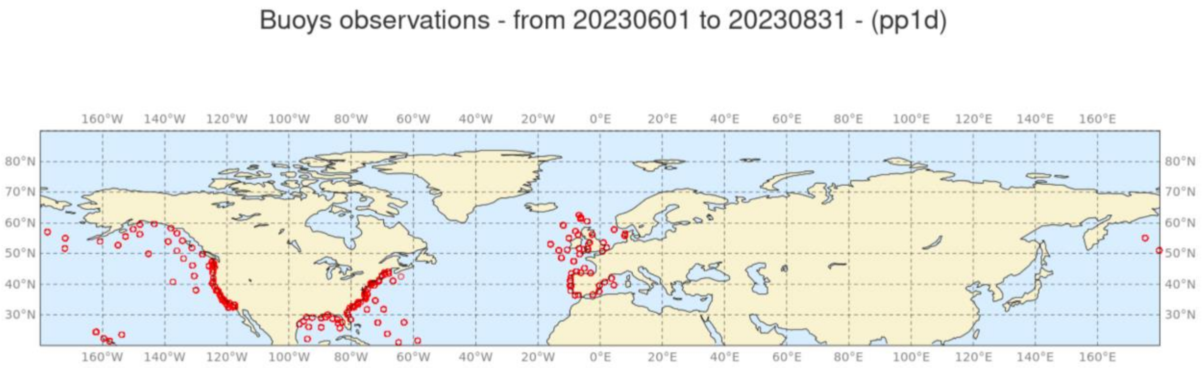
Key	Summary	T	Created	Updated	Due	Assignee	Reporter	P	Status	Resolution
SD-69229	Missing 0/12Z, 20221007 runs from BoM (ammc) for LC-WFV		Oct 11, 2022	Oct 13, 2022		Richard Mladek	Richard Mladek		WAITING FOR CUSTOMER	Unresolved
SD-69046	Missing runs from NZMS (nzkl) for LC-WFV		Oct 07, 2022	Oct 12, 2022		Richard Mladek	Anastasios Mavroudis		CLOSED	Won't Fix
SD-69042	Missing runs from METNO (enmi) for LC-WFV		Oct 07, 2022	Oct 12, 2022		Richard Mladek	Anastasios Mavroudis		CLOSED	Fixed
SD-68803	Bad peak period data in Australian wave model (BoM, ammc) for LC-WFV		Oct 03, 2022	Oct 12, 2022		Richard Mladek	Richard Mladek		WAITING FOR 2ND LINE	Unresolved
SD-68785	Missing runs from PdE (lemm) for LC-WFV		Oct 03, 2022	Oct 11, 2022		Richard Mladek	Richard Mladek		WAITING FOR 2ND LINE	Unresolved
SD-68508	Incomplete 0Z, 20220923 run from NZMS (nzkl) for LC-WFV		Sep 27, 2022	Oct 07, 2022		Richard Mladek	Anastasios Mavroudis		CLOSED	Fixed

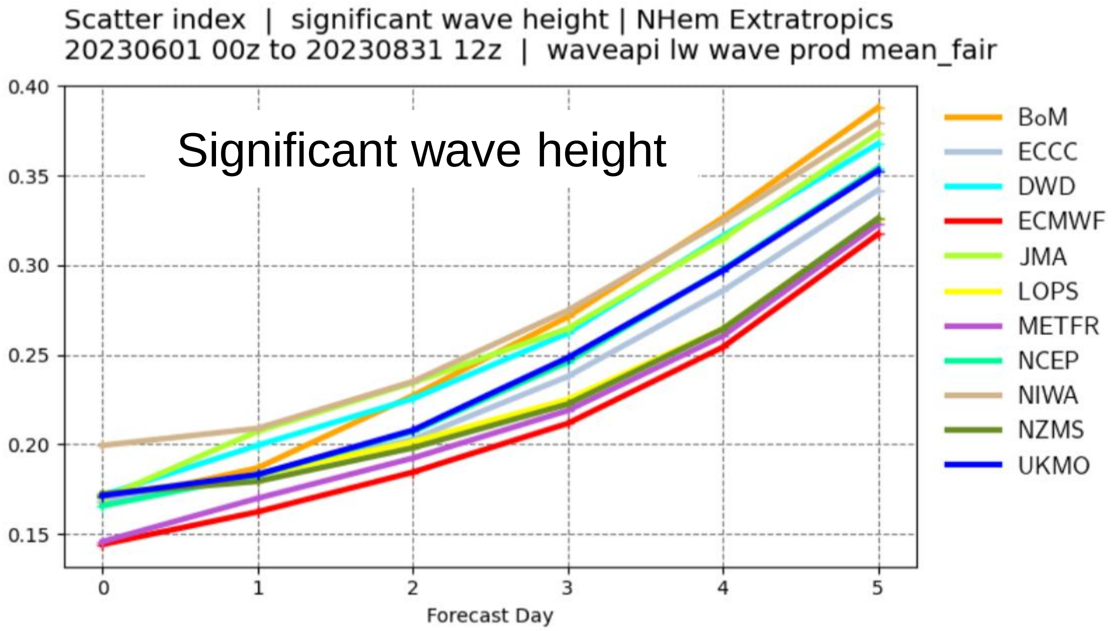
LC-WFV project

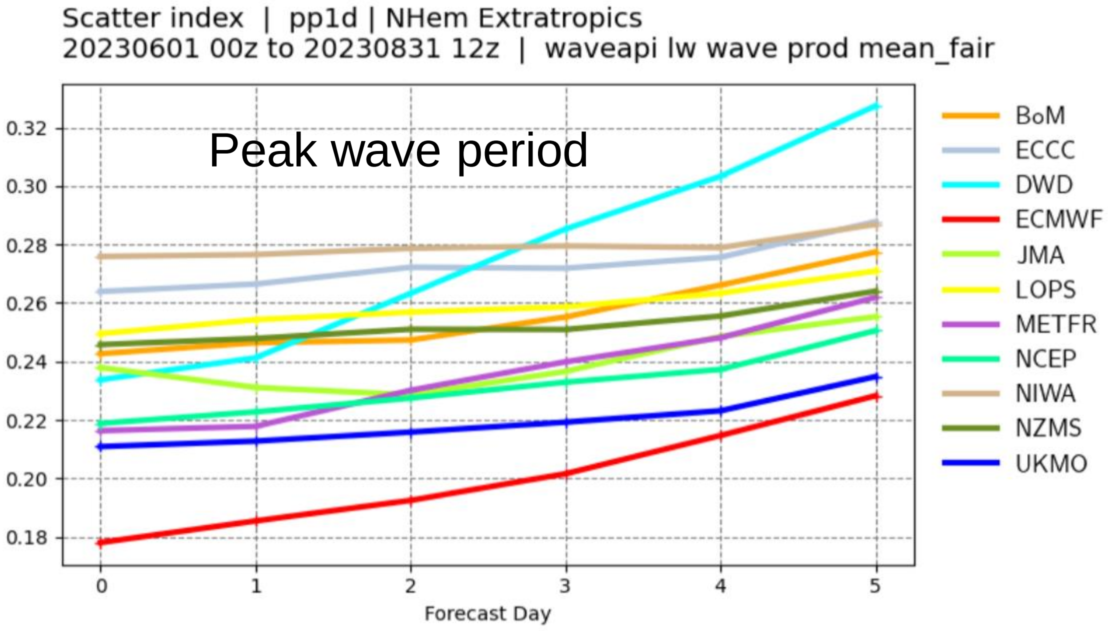
- Gathering and quality control of in-situ wave and wind observations as received by ECMWF.
- Maintaining an archive of the verification statistics to allow the generation and display of trends in performance.
- Providing ftp access to the observations and the model match-ups used to perform the standard verification.
- Providing on the website:
  1. Up-to-date graphical displays of verification results from participating Centres based on evaluation of the received forecast fields.
  2. Relevant documentation including access to the standard procedures required to perform the verification, and links to the websites of participating Centres.
  3. Contact details to encourage feedback from participating Centres on the usefulness of the verification information.

Wave forecast – N.Hem Extratropics



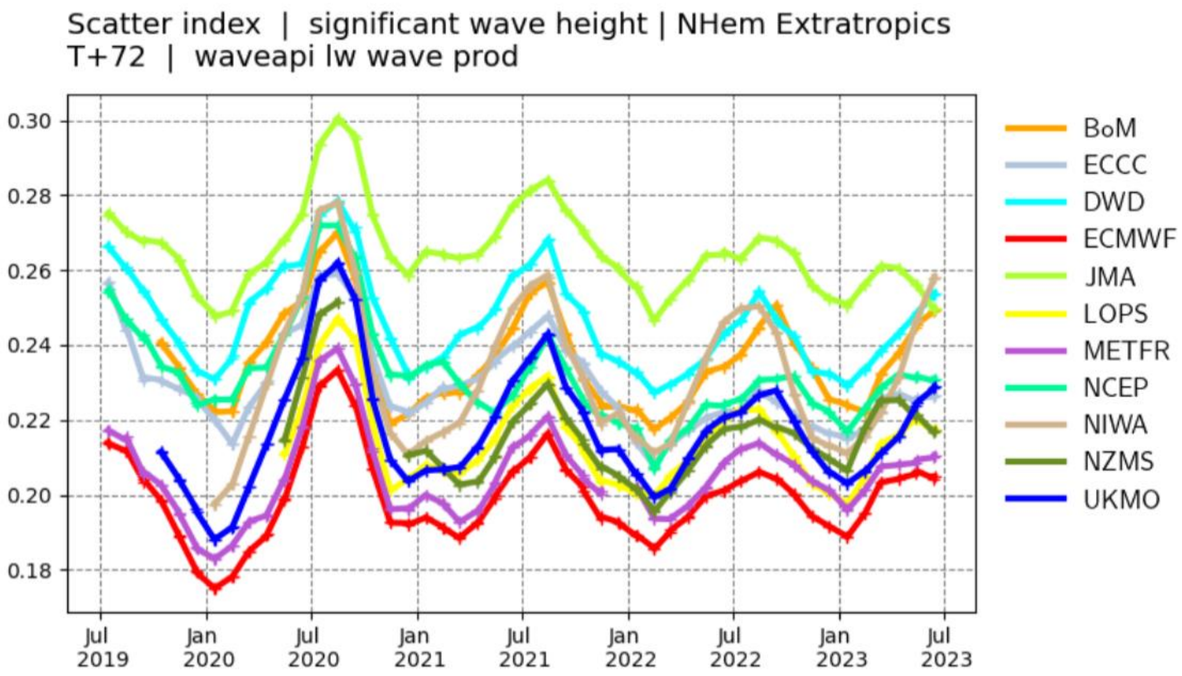




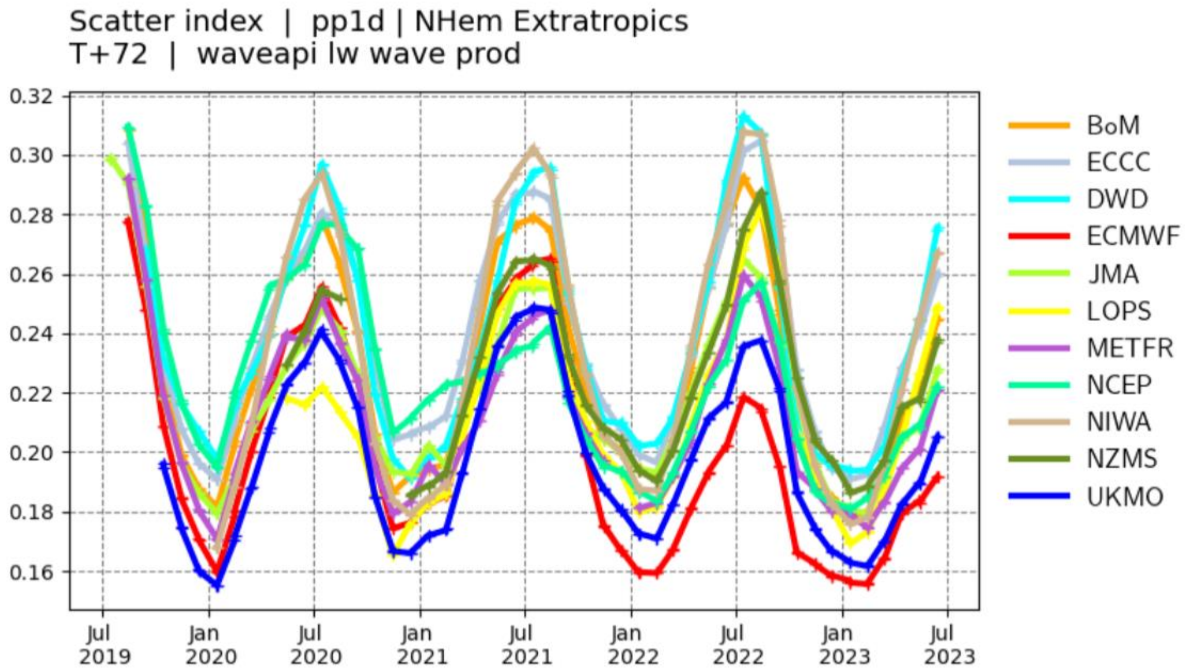


Scatter index: normalized standard deviation of error

Wave forecast – N.Hem Extratropics



Significant wave height

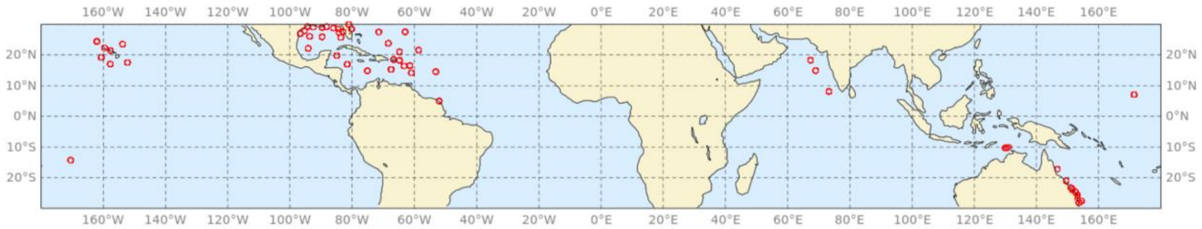


Peak period

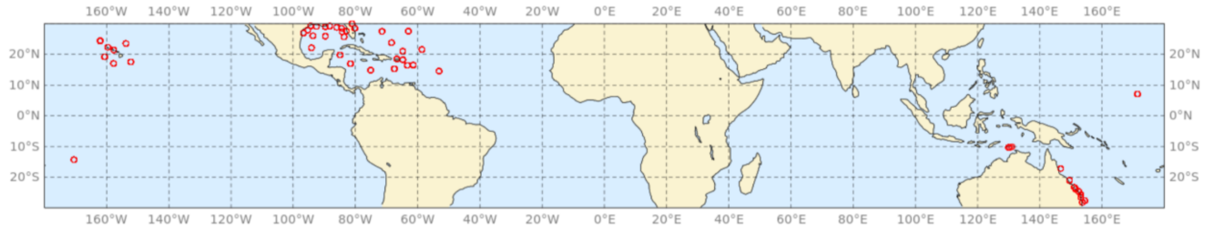
Scatter index: normalized standard deviation of error

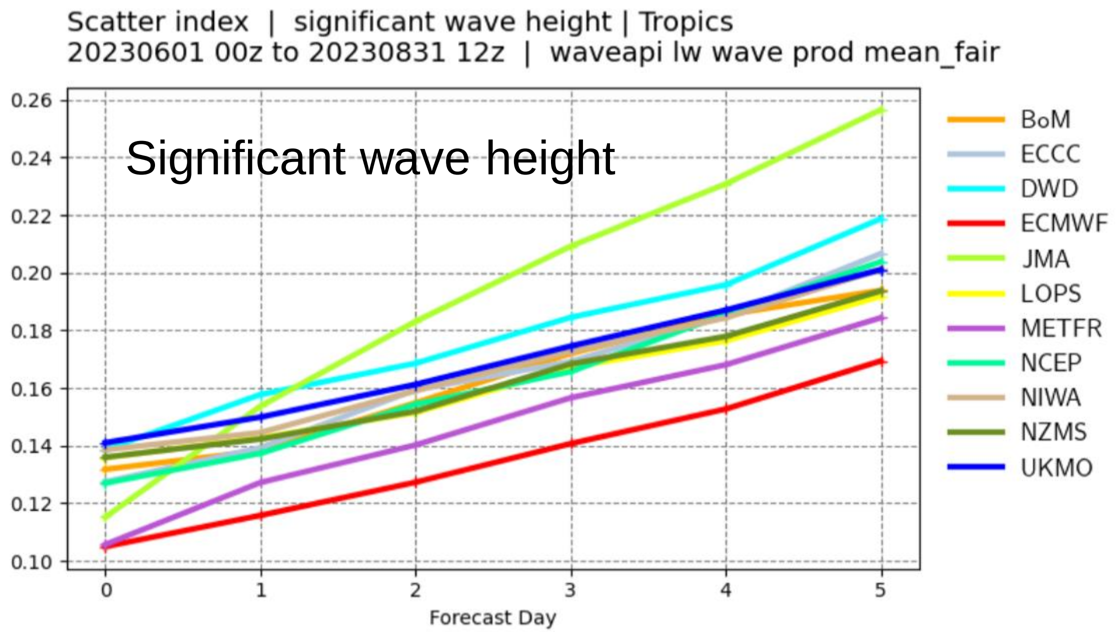
Wave forecast – Tropics

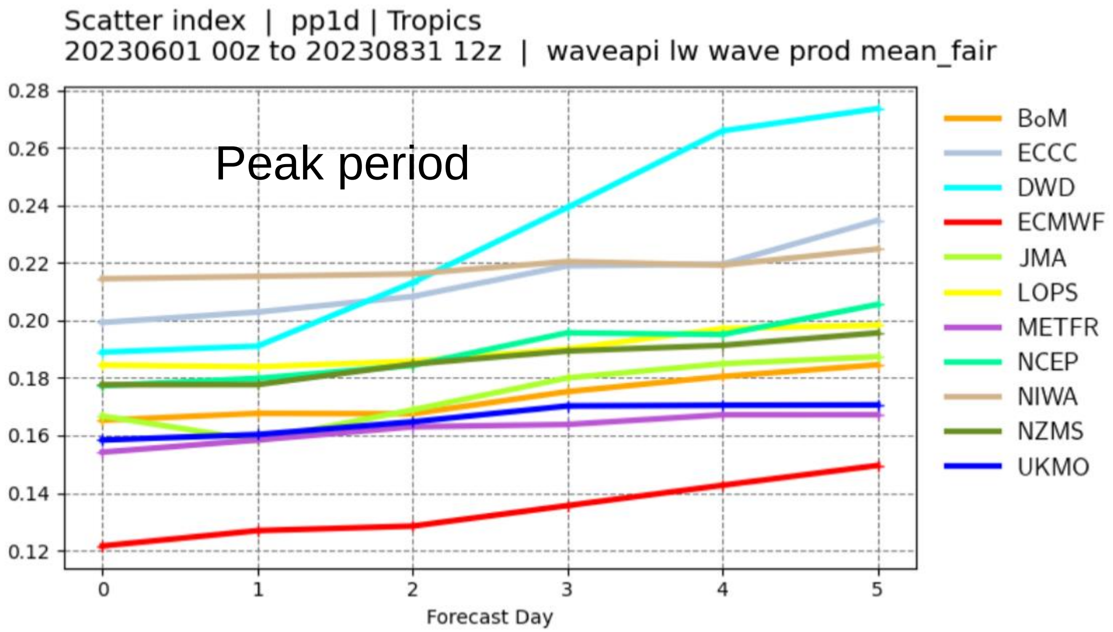
Buoys observations - from 20230601 to 20230831 - (swh)



Buoys observations - from 20230601 to 20230831 - (pp1d)

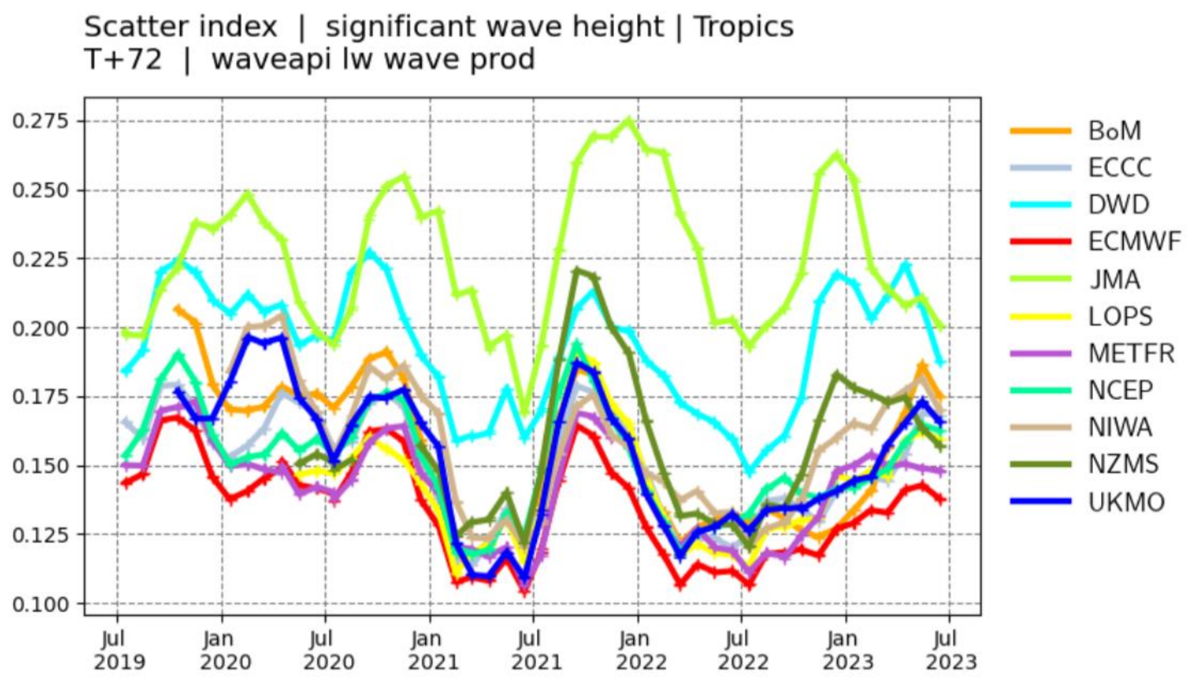




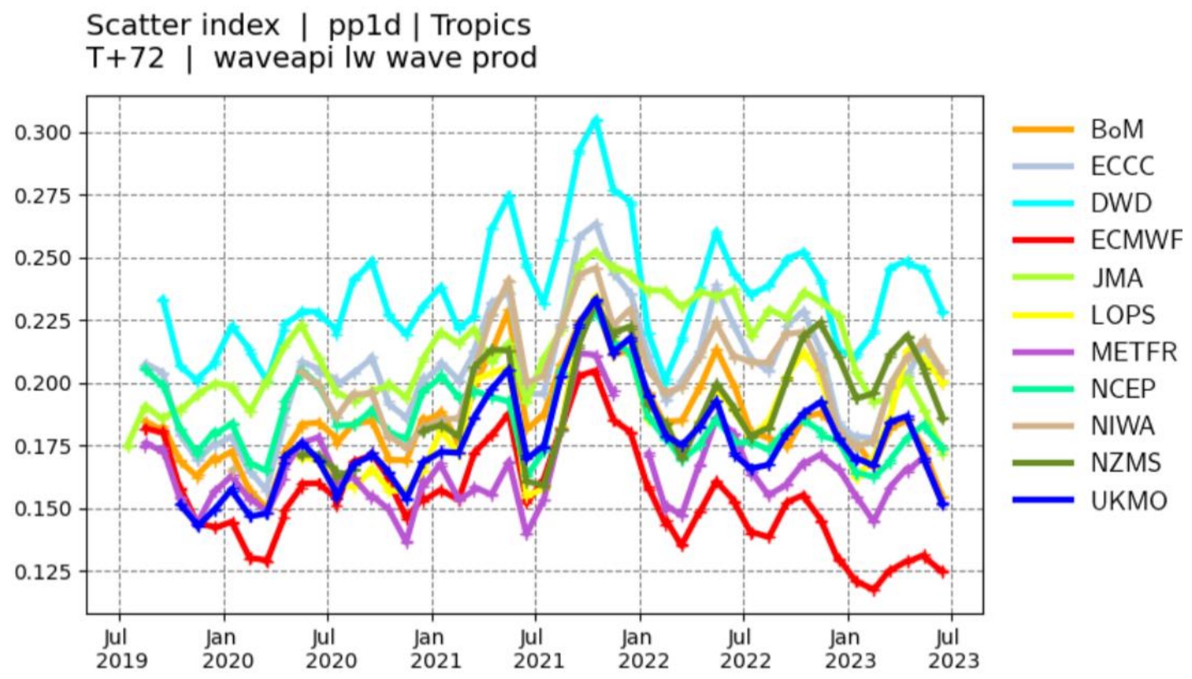


Scatter index: normalized standard deviation of error

Wave forecast – Tropics



Significant wave height



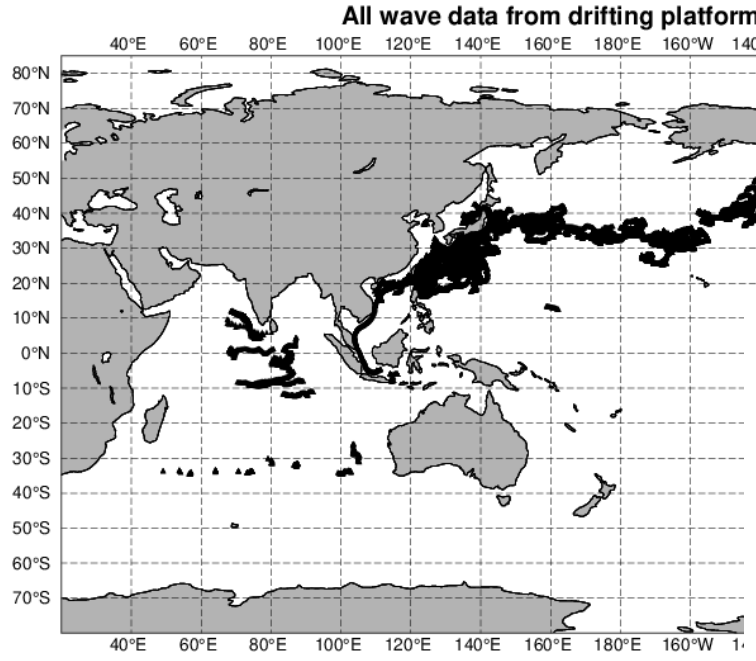
Peak period

Scatter index: normalized standard deviation of error

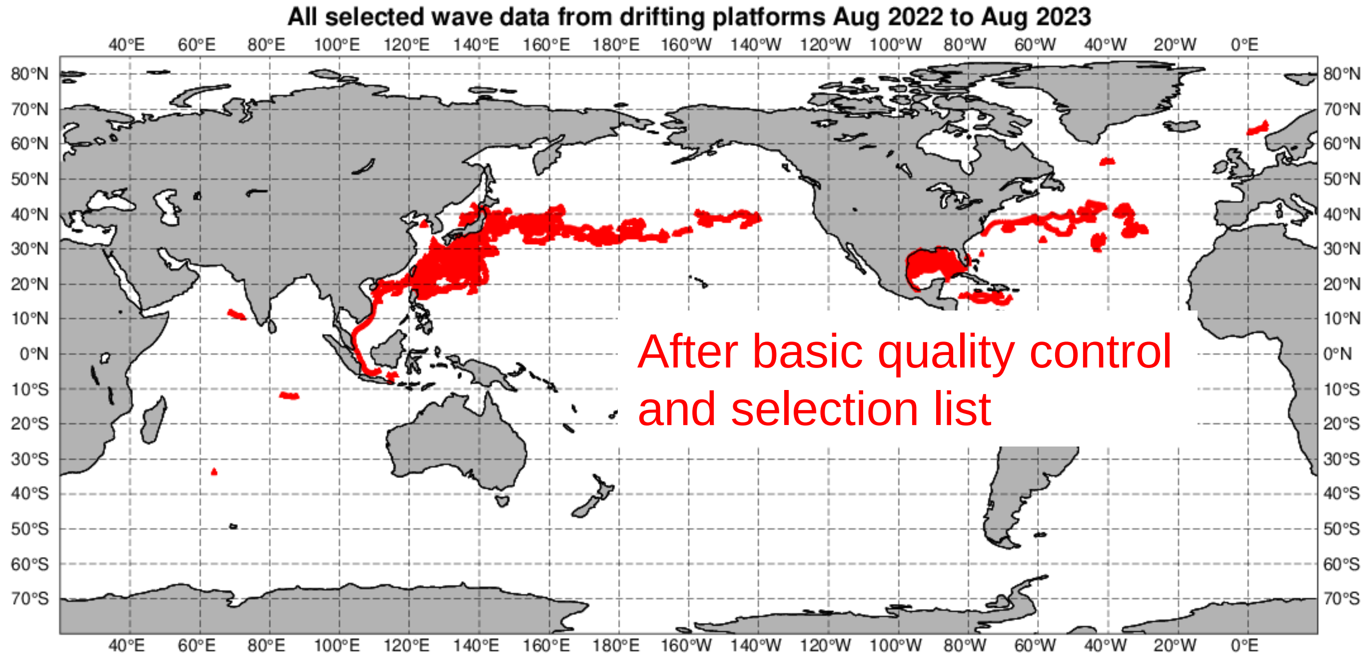
LC-WFV project: further developments

- Gather feedback from participants on usefulness of the project.
- Extend comparison to other data sets:
  - Convince wave data providers to make their data more easily available (GTS and/or CMEM in-situ TAC).
  - Wave observations from drifting buoys.
  - Satellite observations?
  - Model fields comparison?

LC-WFV project: drifting buoys data received at ECMWF



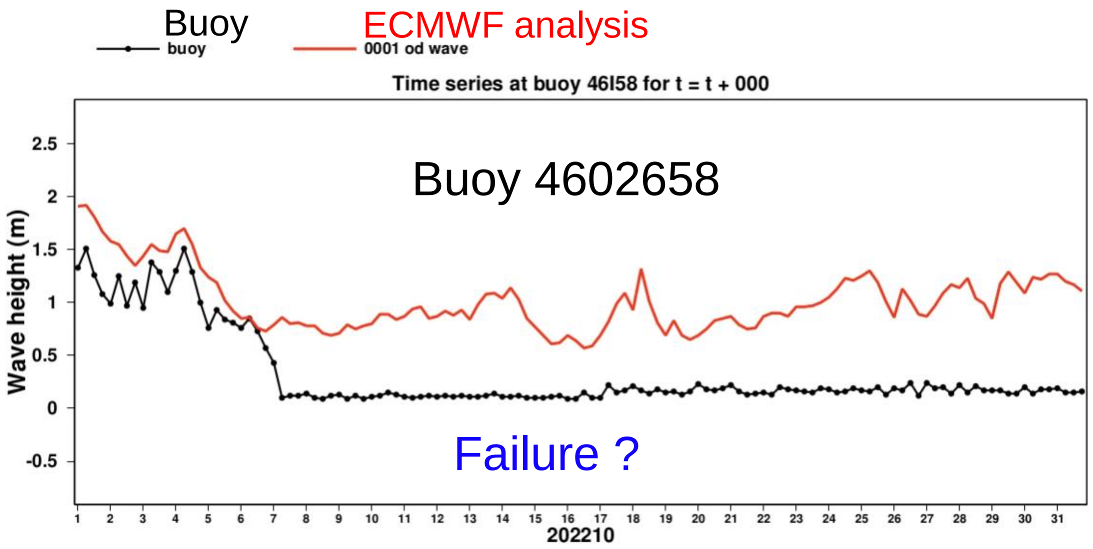
First look at the data potential for validation

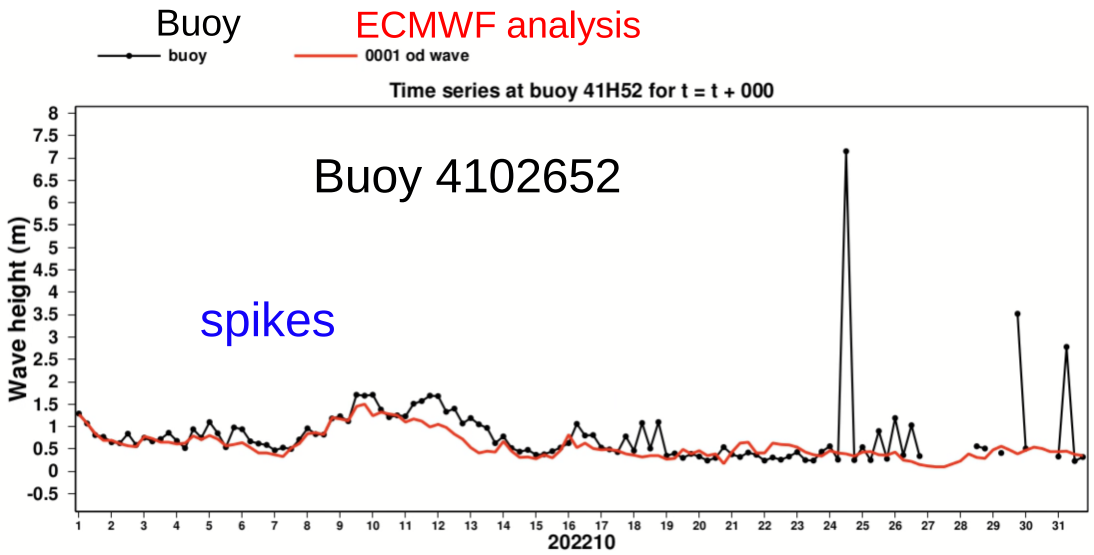


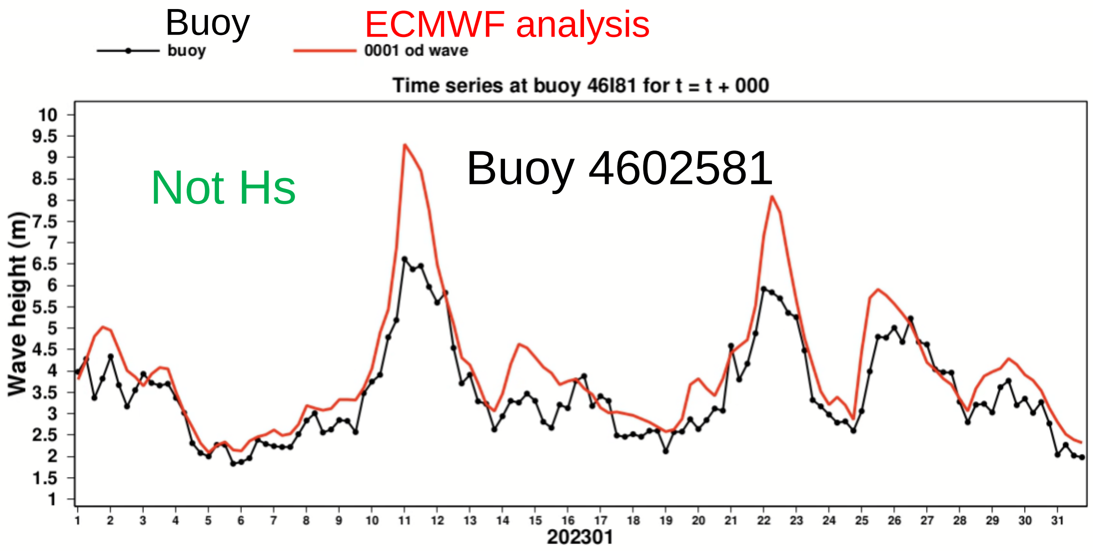
After basic quality control and selection list

August 2022 to August 2023

LC-WFV project: drifting buoys data received at ECMWF





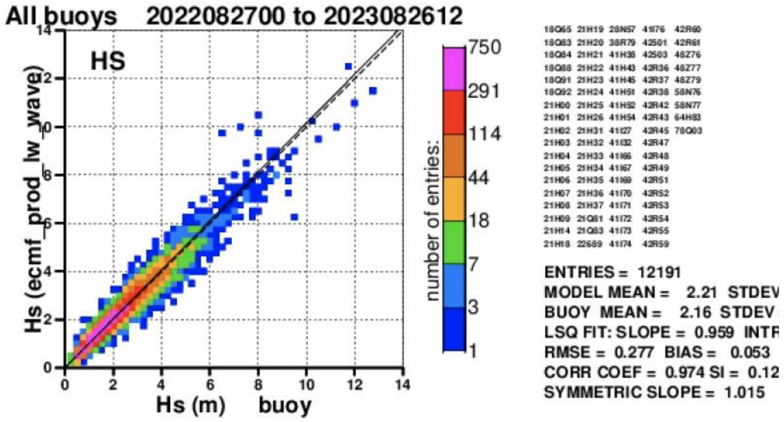


Quality control is needed !

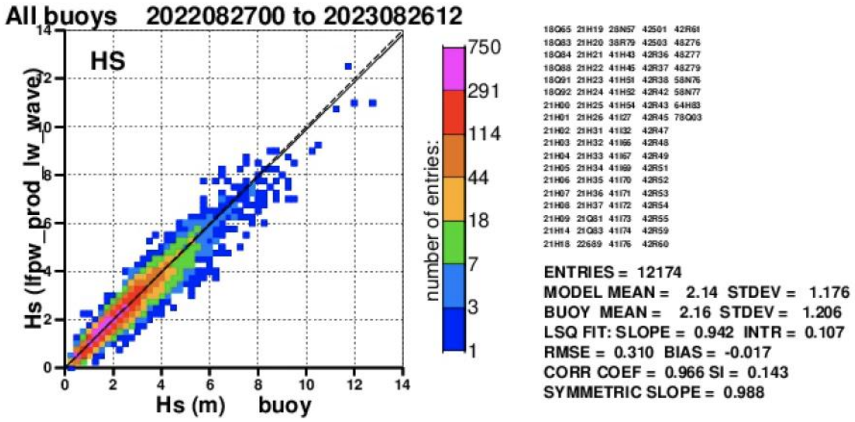
Manual selection !

LC-WFV project: drifting buoys data received at ECMWF

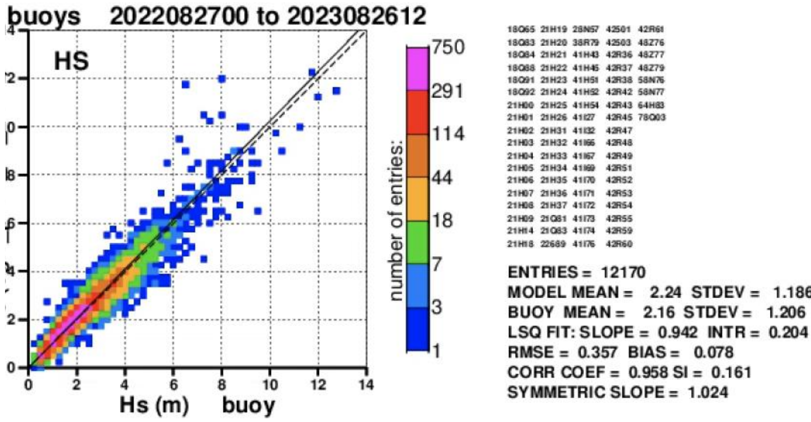
2022-08-27 to 2023-08-26, forecast step 24 hours



Comparison of fc step 0 ecmf wave heights with buoy data.

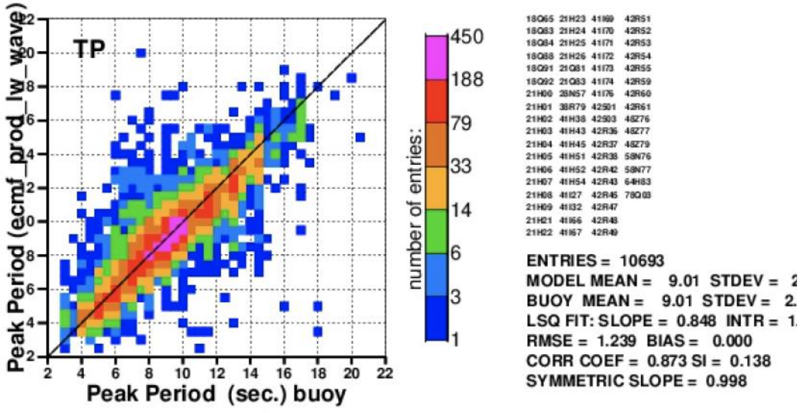


Comparison of fc step 24 lfpw wave heights with buoy data.

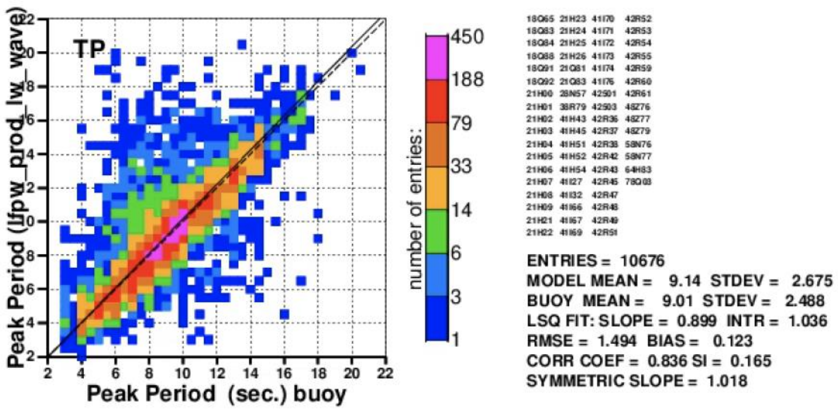


Comparison of fc step 24 egrr wave heights with buoy data.

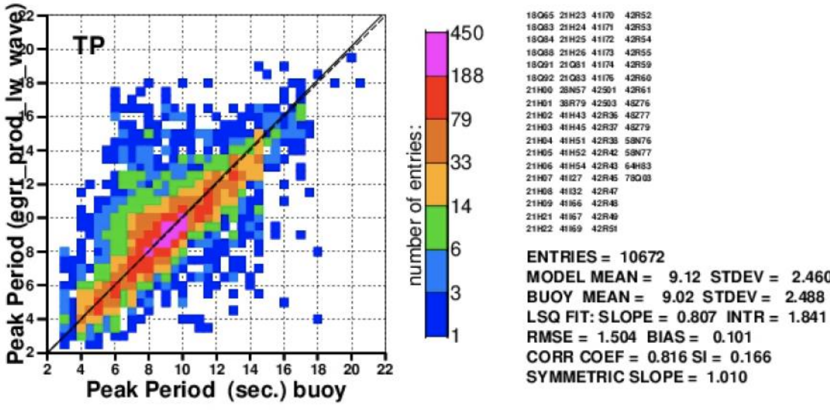
ECMWF **METFR** **UKMO**



Comparison of fc step 0 ecmf peak periods with buoy data.



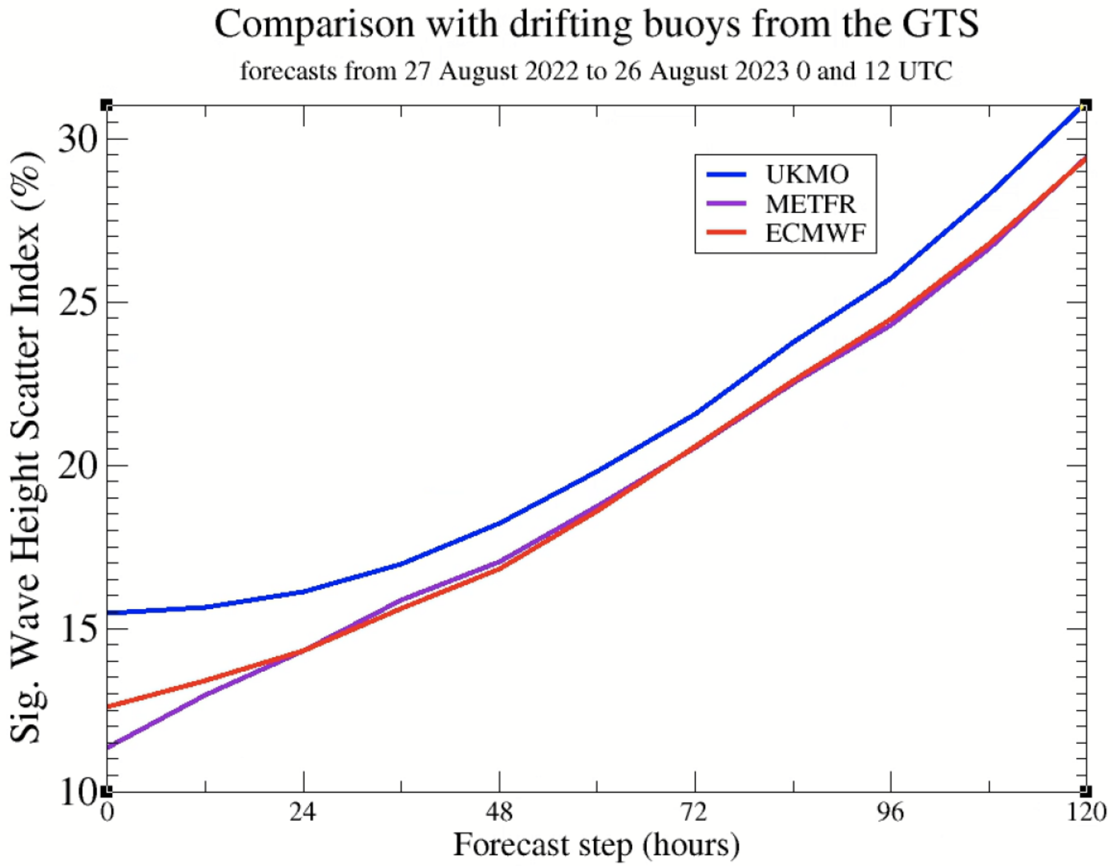
Comparison of fc step 24 lfpw peak periods with buoy data.

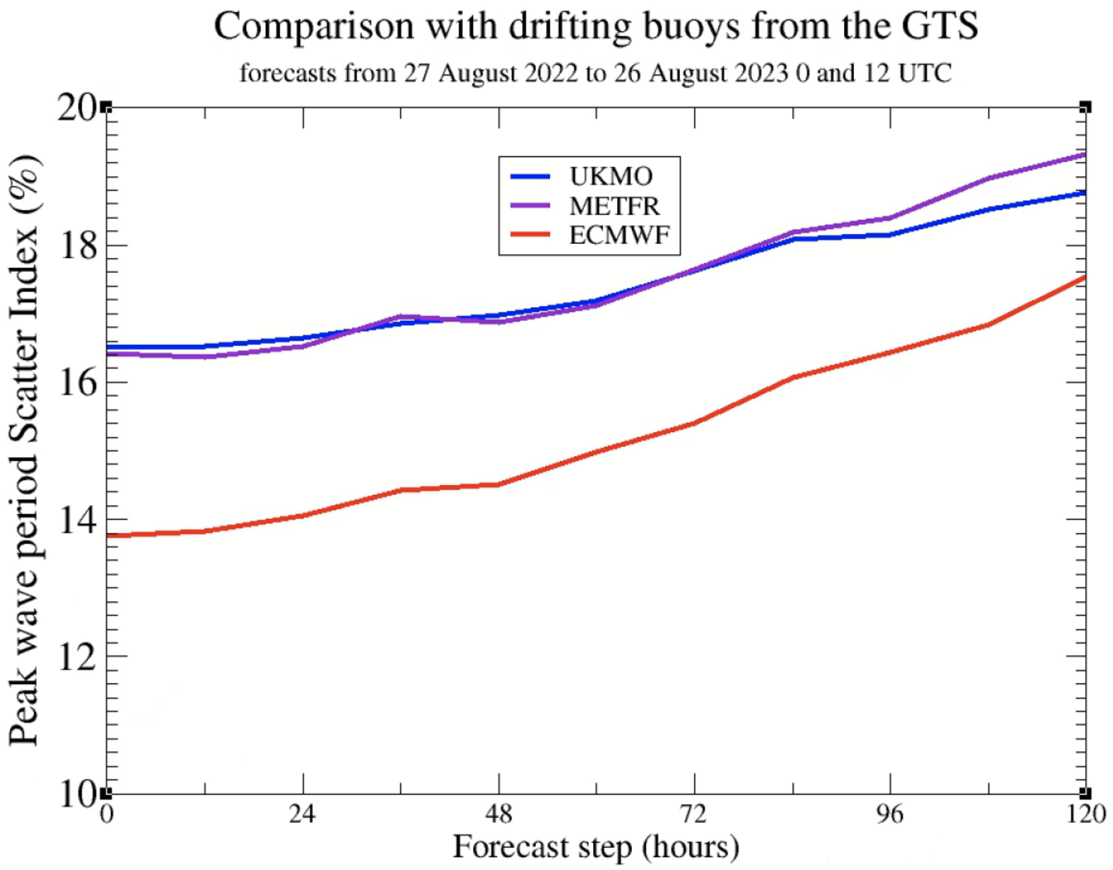


Comparison of fc step 24 egrr peak periods with buoy data.

LC-WFV project: drifting buoys data received at ECMWF

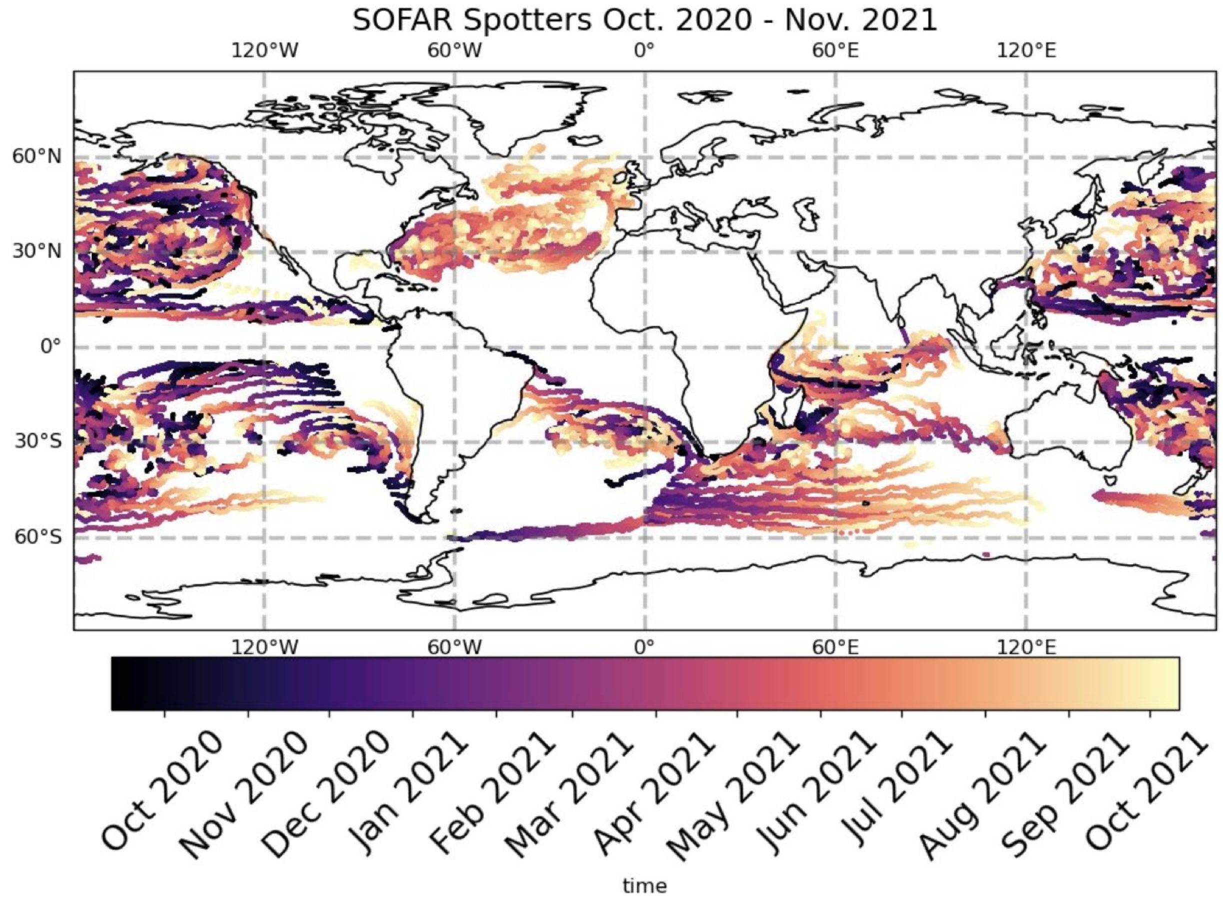
2022-08-27 to 2023-08-26, forecast step 24 hours





LC-WFV project: there are other sources of drifting buoys data

e.g.



SOFAR spotters for Remote Sensing applications

LOPS, IFREMER, France

Cc Alexis Mouche

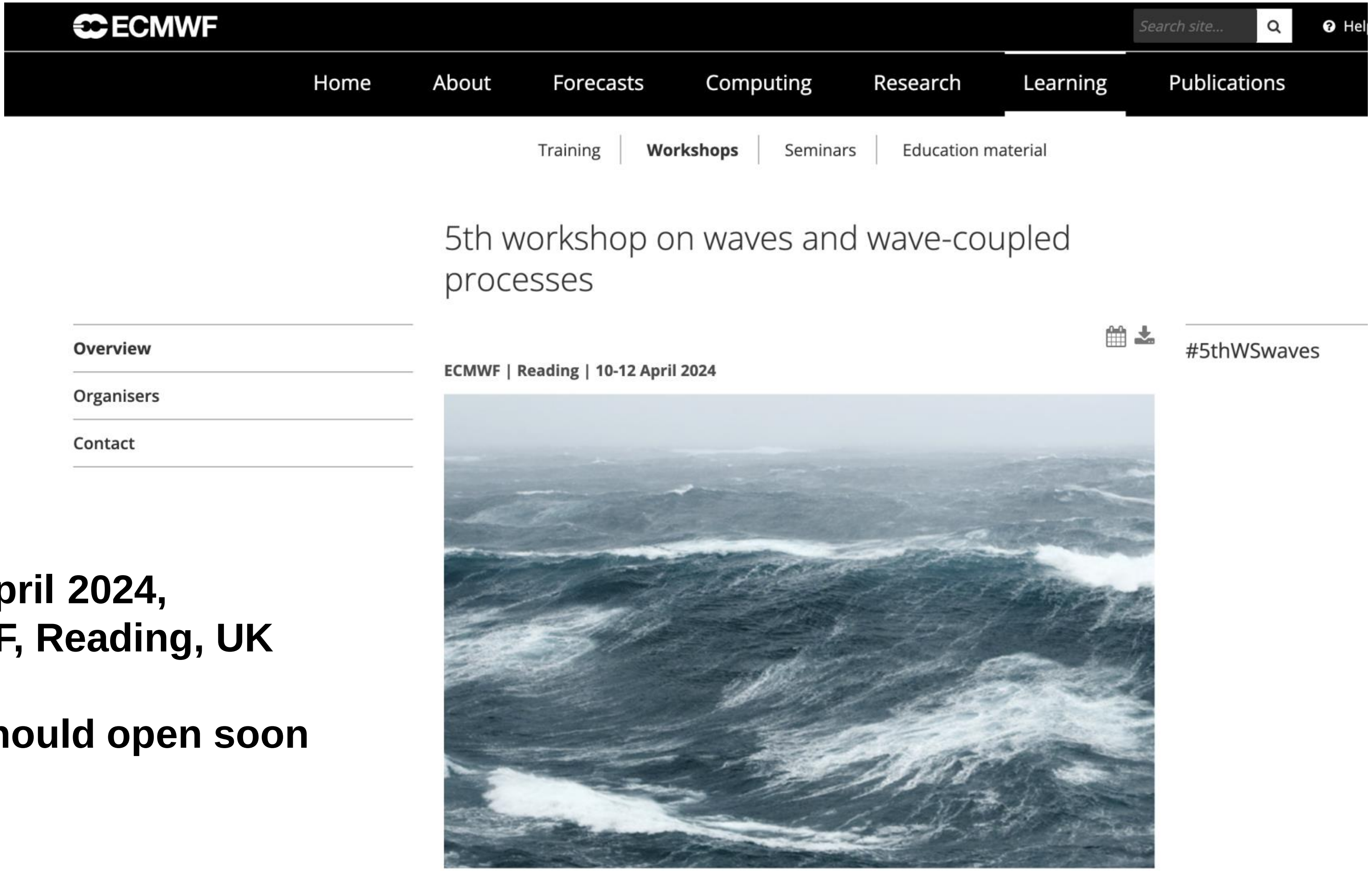
To be investigated,
But …

Conclusions

- For the past 28 years, ECMWF has led a verification of global wave and wind forecasts.
- From an informal beginning, the project has transitioned into the WMO Lead Centre for Wave Forecast Validation.
- This transition was absolute necessary to insure the future of the project.

- Having gathered all model fields, it is now possible to look at the feasibility to extend to other data type/source.
- Sadly, there are still too many wave observations that are not automatically made available in near real time to be easily incorporated in the system.
- Also, there is still a strong need for quality control of the data.

Announcement



When: 10-12 April 2024,
Where: ECMWF, Reading, UK

Registration should open soon

https://events.ecmwf.int/event/364/

References

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LC-WFV results page:

https://confluence.ecmwf.int/display/WLW/Verification+results