Parametrisation challenge: Lake Titicaca

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Outline

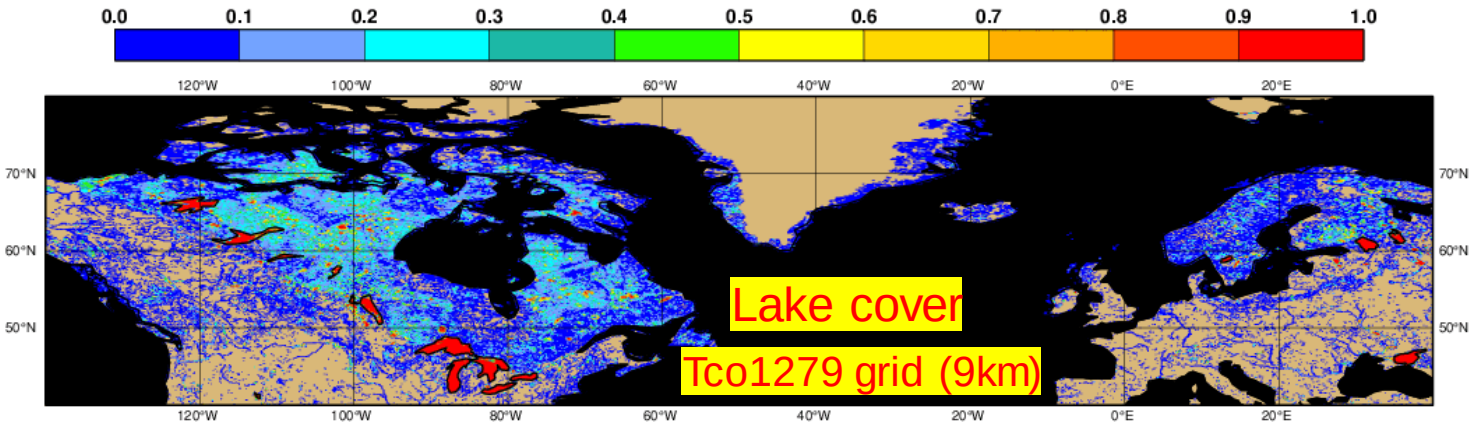
- Introduction: Global wave model simulation at 1.4 km with resolved lakes included.

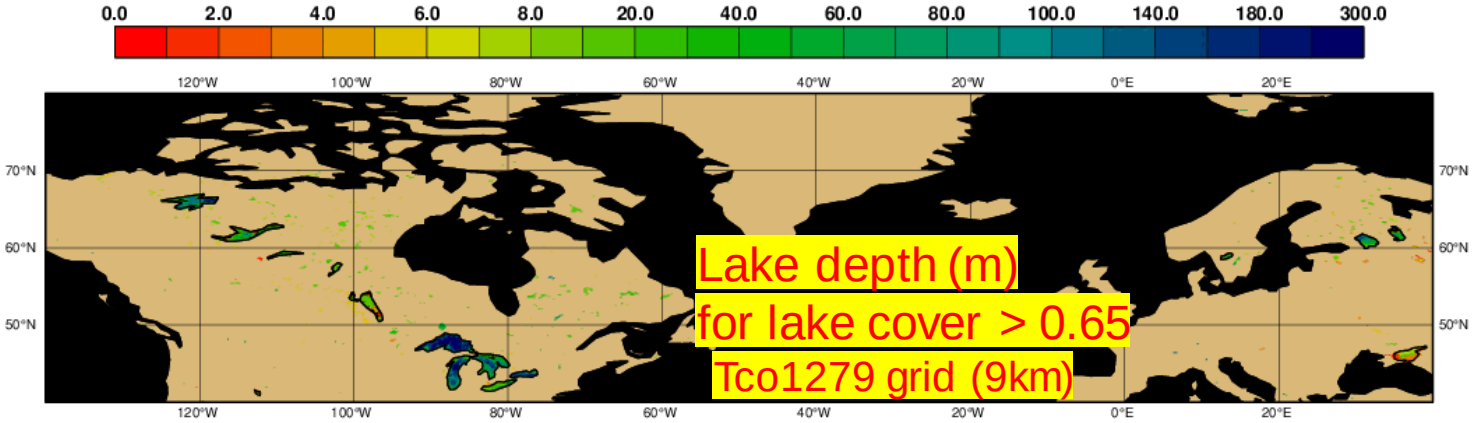
- Modelling waves on lake Titicaca (first results).

Isla de la Luna and Cordillera Real, Lake Titicaca, Bolivia (looking south-east along the axis of the lake)

Introduction

- ECMWF atmospheric model has a simple lake model (Flake) to represent water bodies over land.
- Flake needs information on the fraction of the grid box covered by water bodies (**lake cover**) and the corresponding water depth (**lake depth**).
- These are part of the climate fields that are regularly updated as part of ECMWF model upgrade.
- So,
- Could we use the lake cover and lake depth information to run the wave model (ecWAM) over lakes?





ecWAM stand alone on Tco7999 grid on oceans and lakes:

- With my Team leader departure to WMO, I joked that I could run the wave model on Lake Geneva.
- Well,
- With the next model update (CY49R1), ecWAM will be using the same grid as the atmosphere.
- Therefore, it is easy to blend the bathymetry information with the lake information from the climate fields.
- Lake depth for lakes with **cover > 65%** were blended with the existing model bathymetry.
- Using the triangular–cubic–octahedral Tco7999 grid with a grid spacing of the order of **1.4 km.**
- A total of 182,533,607 water points are used with 36 frequencies and 48 directions for the spectrum.
- Ran 4 days on ECMWF Atos HPC with NPES=2048 and THREAD=16.
- with 6 hourly operational analysis forcing.
- 4-day simulation in slightly less than 1 hour.
- **NB**: not coupled yet.

ecWAM stand alone on Tco7999 on lakes: first results

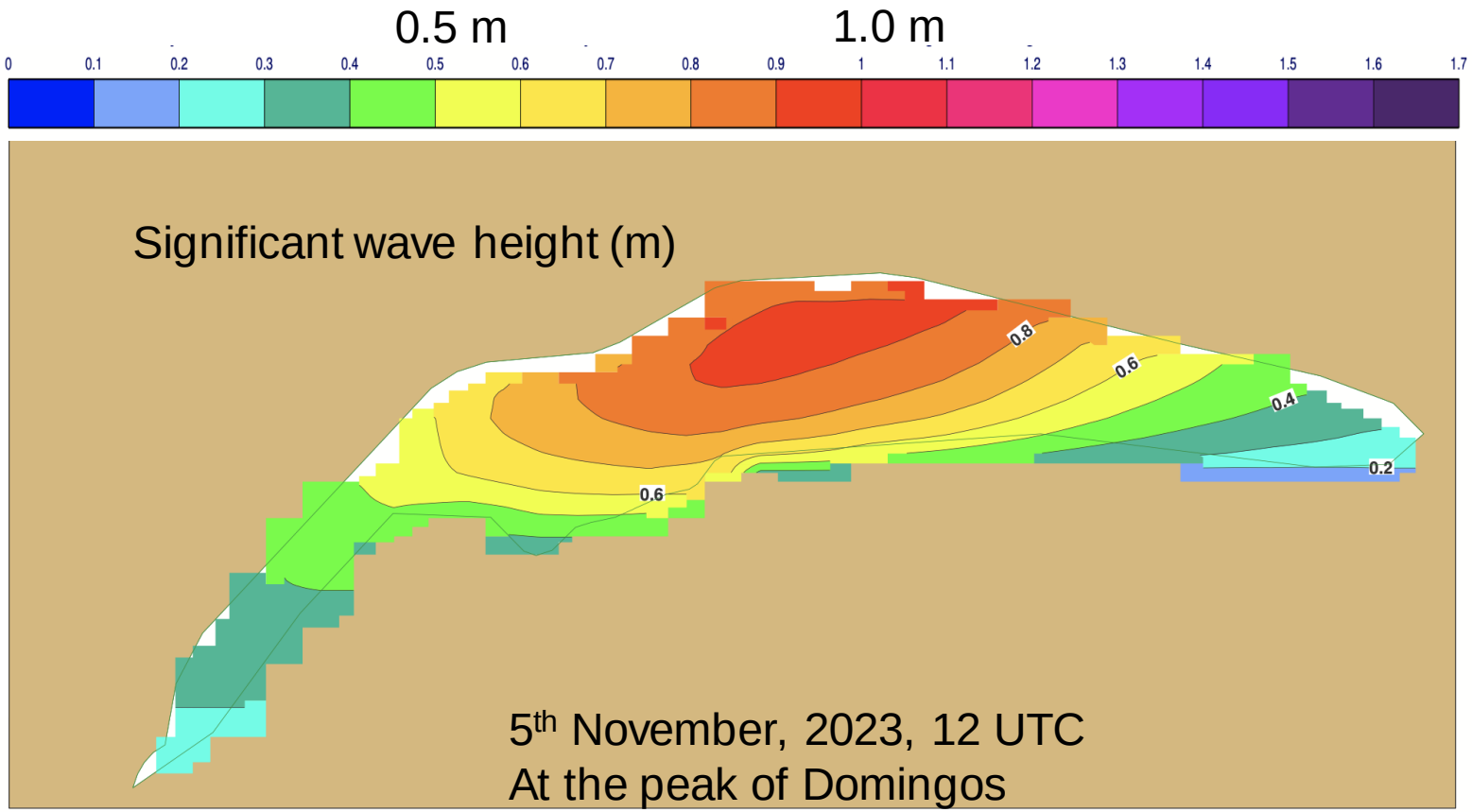
- Voila:

PLUIE ET VENTS VIOLENTS

Actualisé 5. novembre 2023, 16:12

Chute d'arbres, bateau coulé, la tempête Domingos a secoué la Suisse romande

Après avoir traversé la France, la tempête Domingos a décoiffé notre pays. De nombreux bateaux ont dû interrompre leur service.



https://www.lematin.ch/story/suisse-la-tempete-domingos-met-a-quai-la-cgn-734402605380

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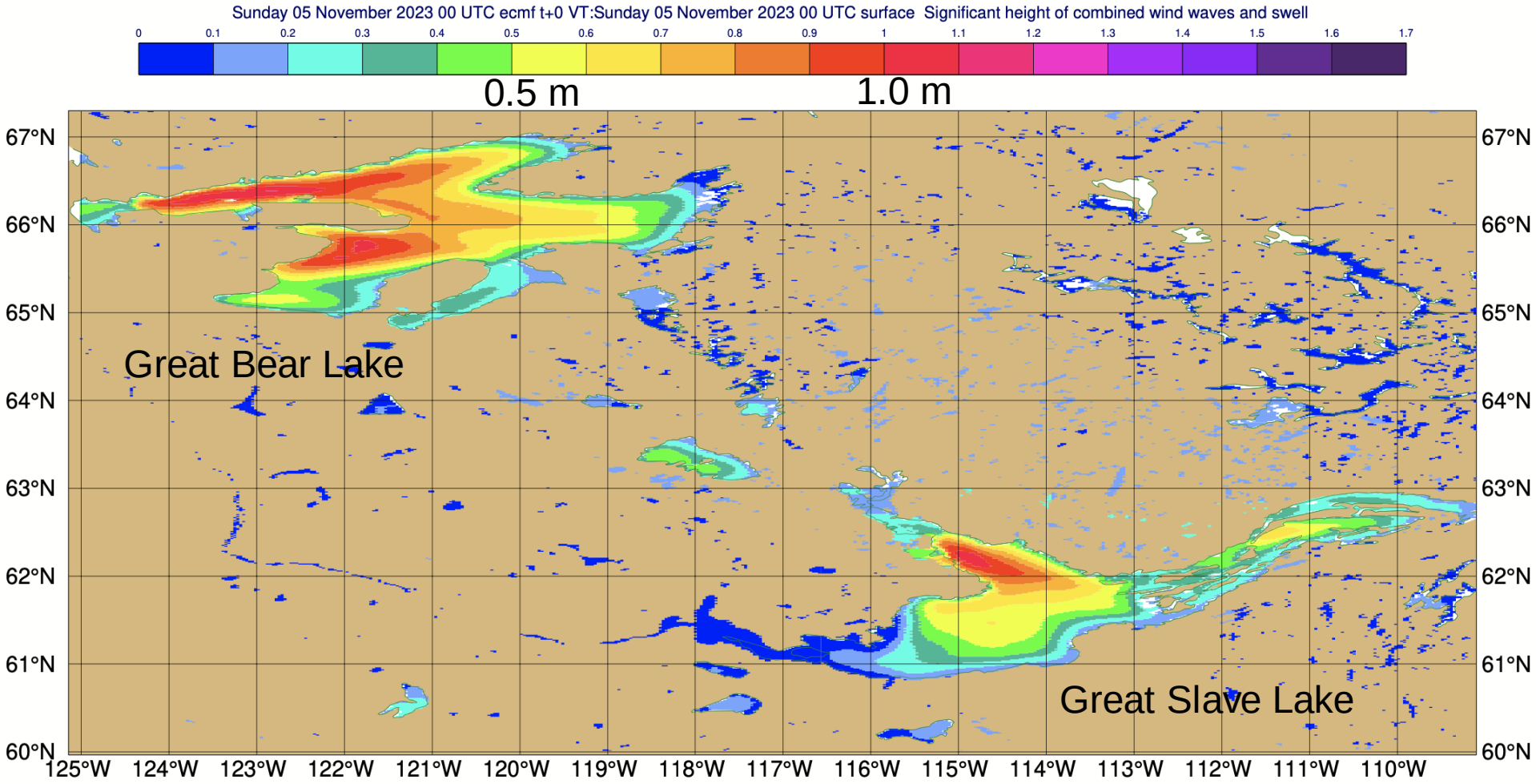
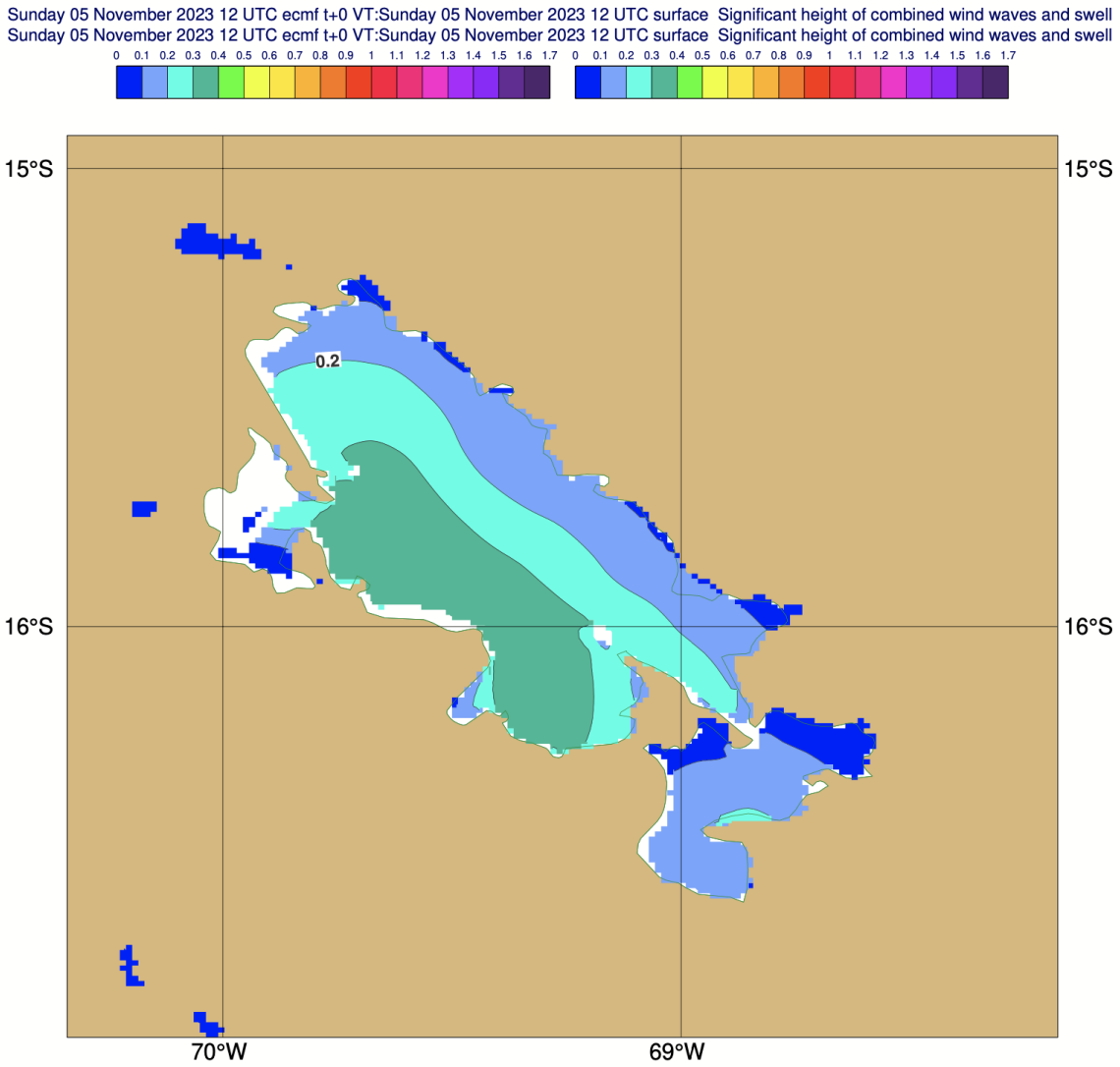
ecWAM stand alone on Tco7999 on lakes: first results



ECMWF

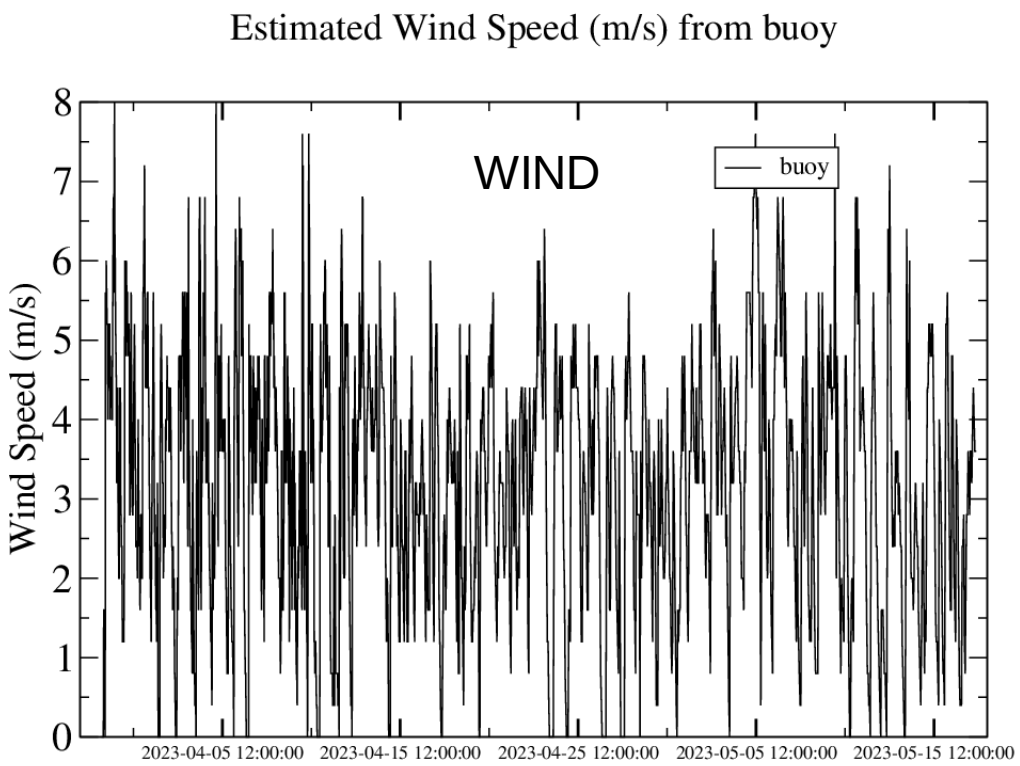
ecWAM stand alone on Tco7999 on lake Titicaca : first results

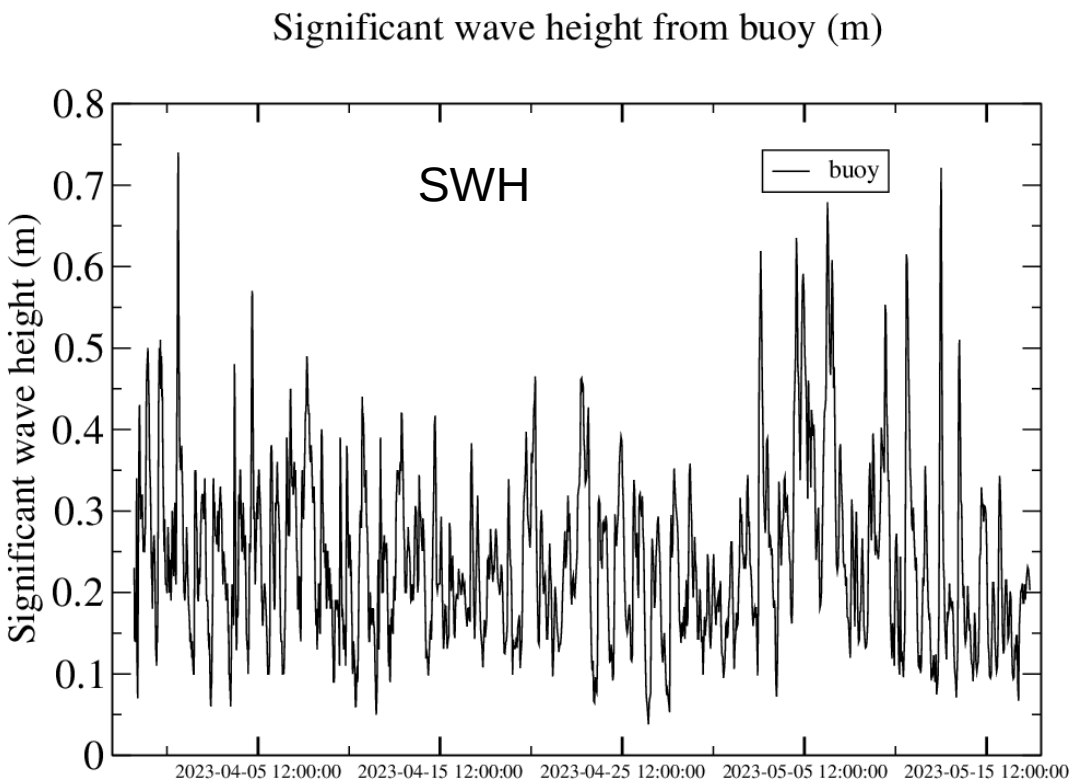


NB: still with sea level air density

Wave observations from lake Titicaca

Following Alex Babanin efforts, colleagues in Bolivia have managed to deploy a moored Spotter buoy for a short period (29 March to 17 May 2023) just north of Isla de la Luna:





Data were kindly provided by Eduardo Palenque and Edson Anghelo Garcia Foronda via Joey Voermans at University of Melbourne
Wind data were derived from an experimental algorithm using the buoy spectra.

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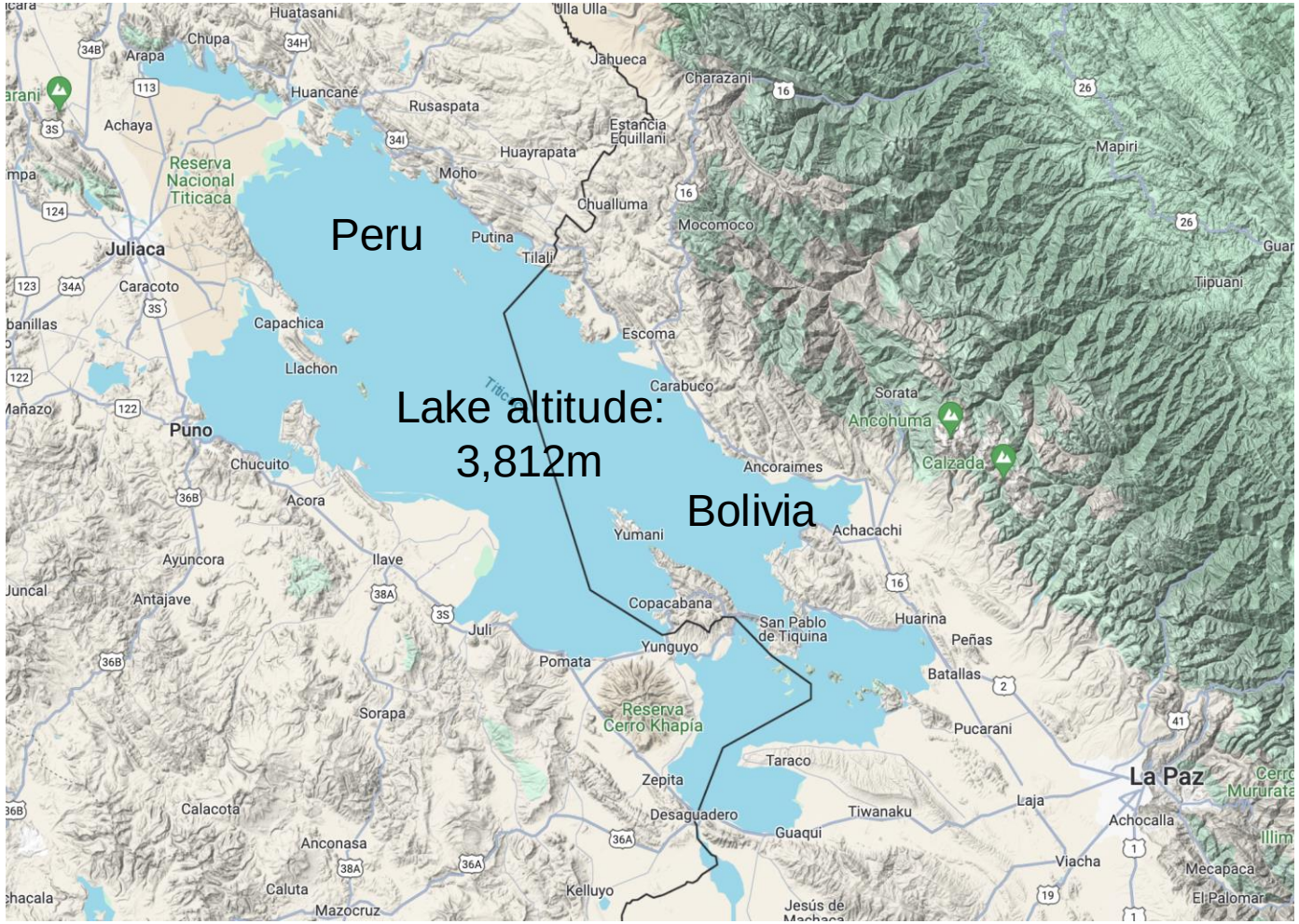
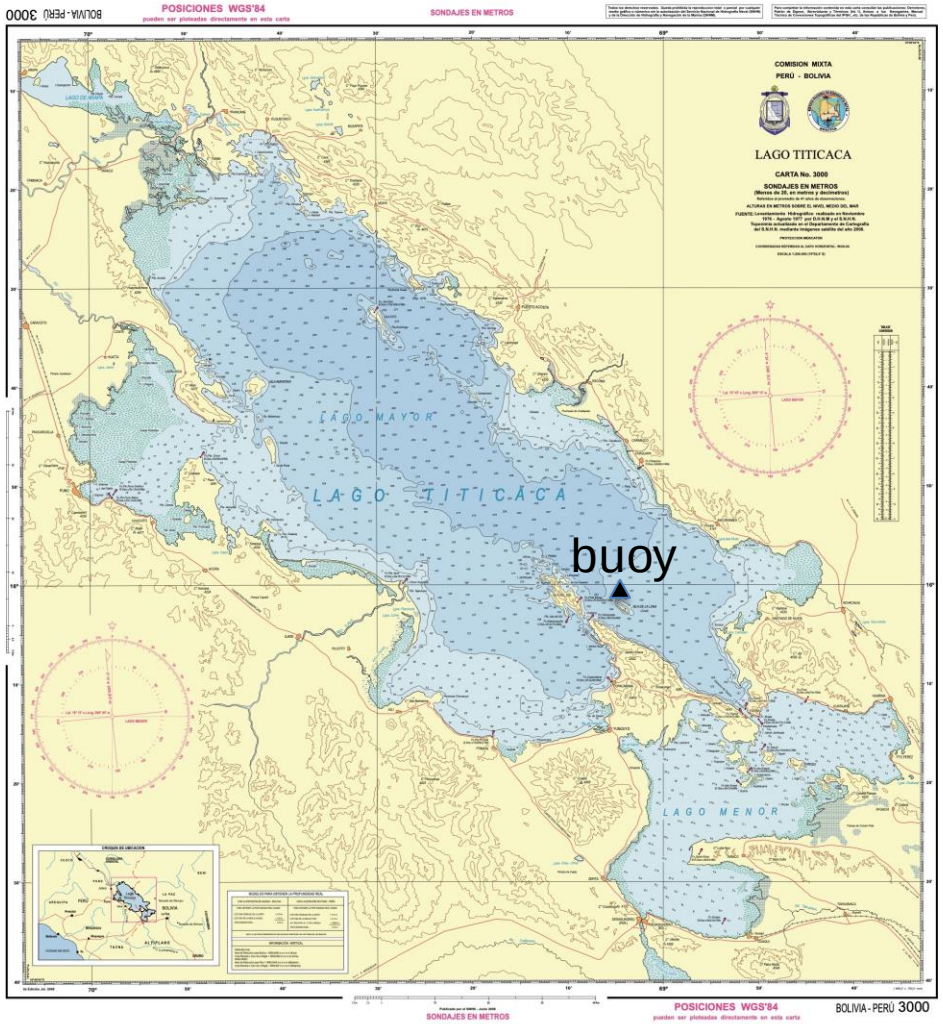
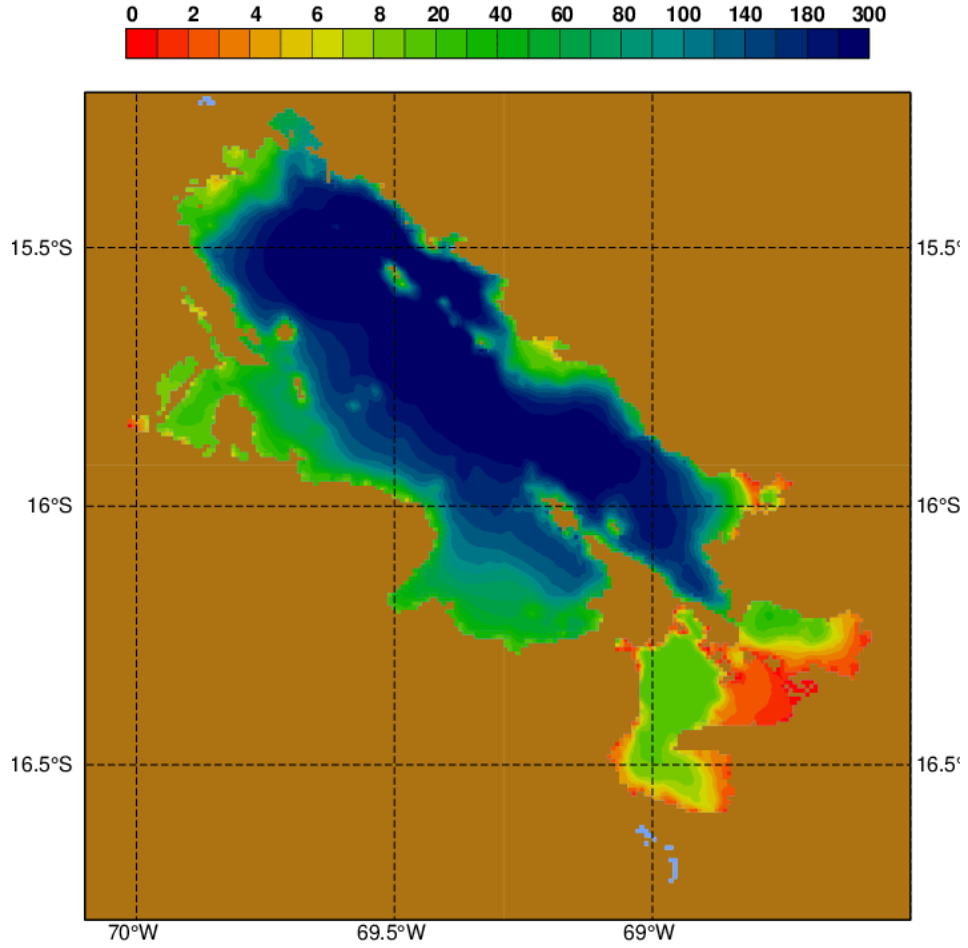
Lake Titicaca

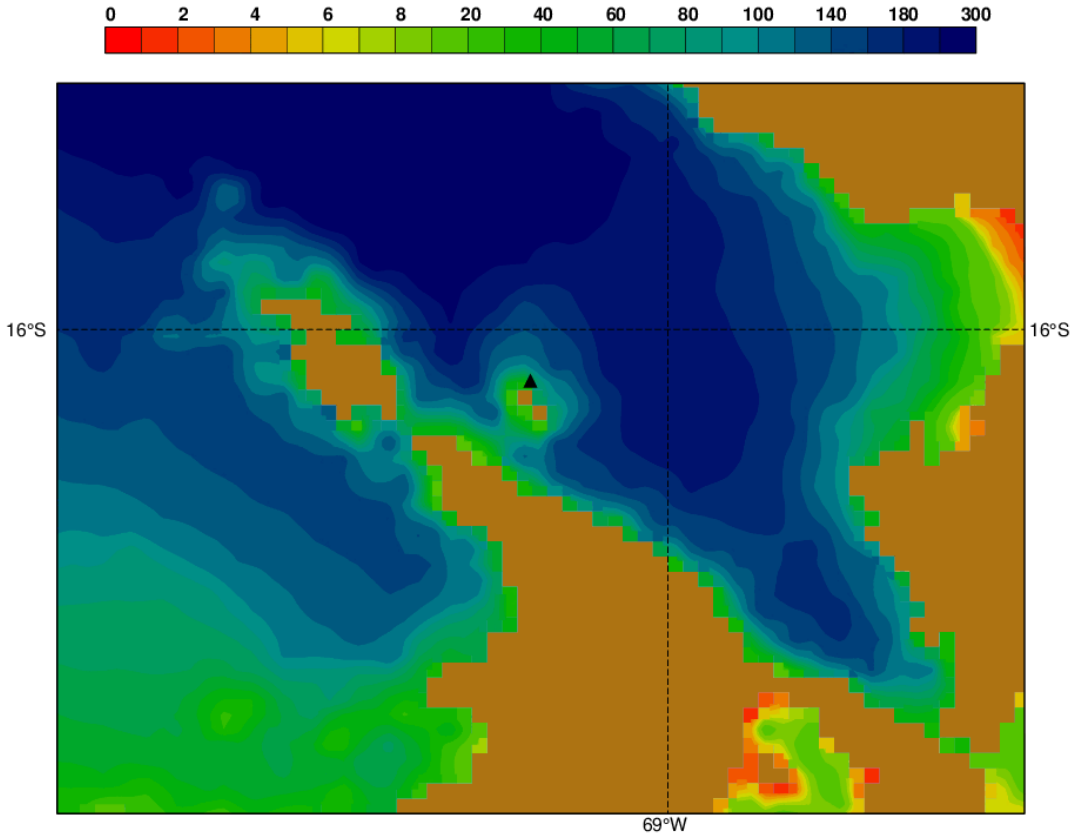




Reconstructed lake depth on a 0.08° x 0.08° grid

Using the lake cover data and the bathymetric data, we have restructured the lake depth map:





Bathymetric data kindly provided by Francois Duquesne: Duquesne et al. 2021: https://doi.org/10.1016/j.ecolmodel.2020.109418

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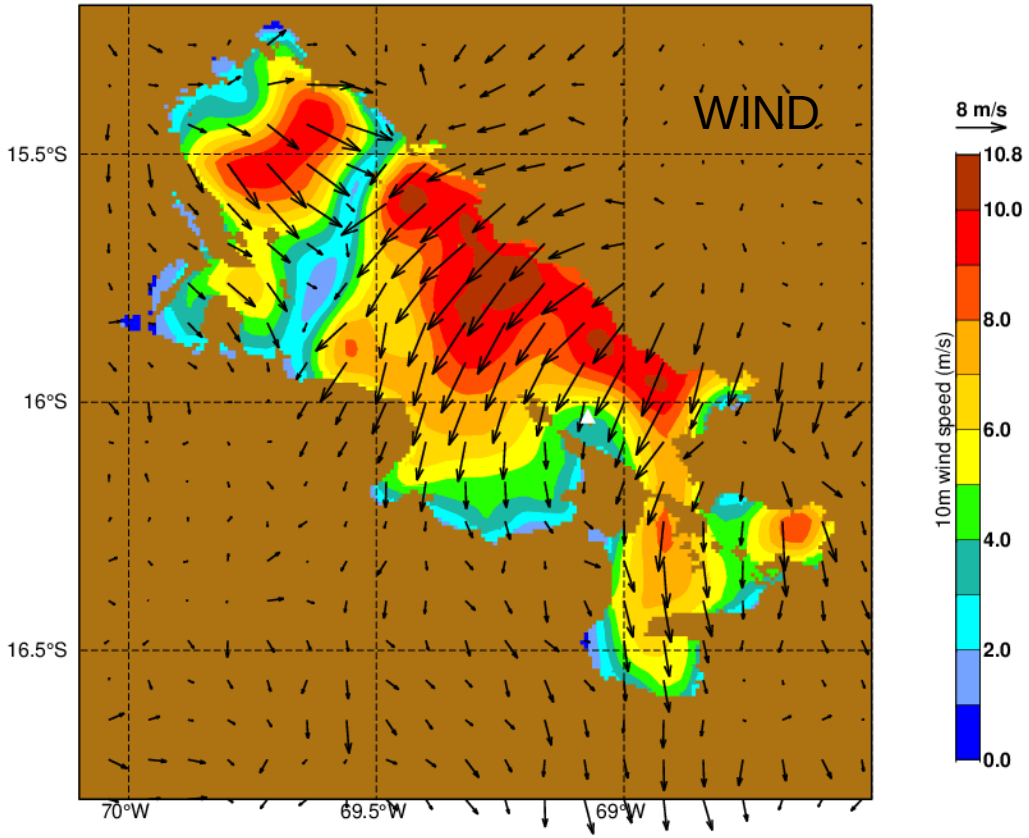
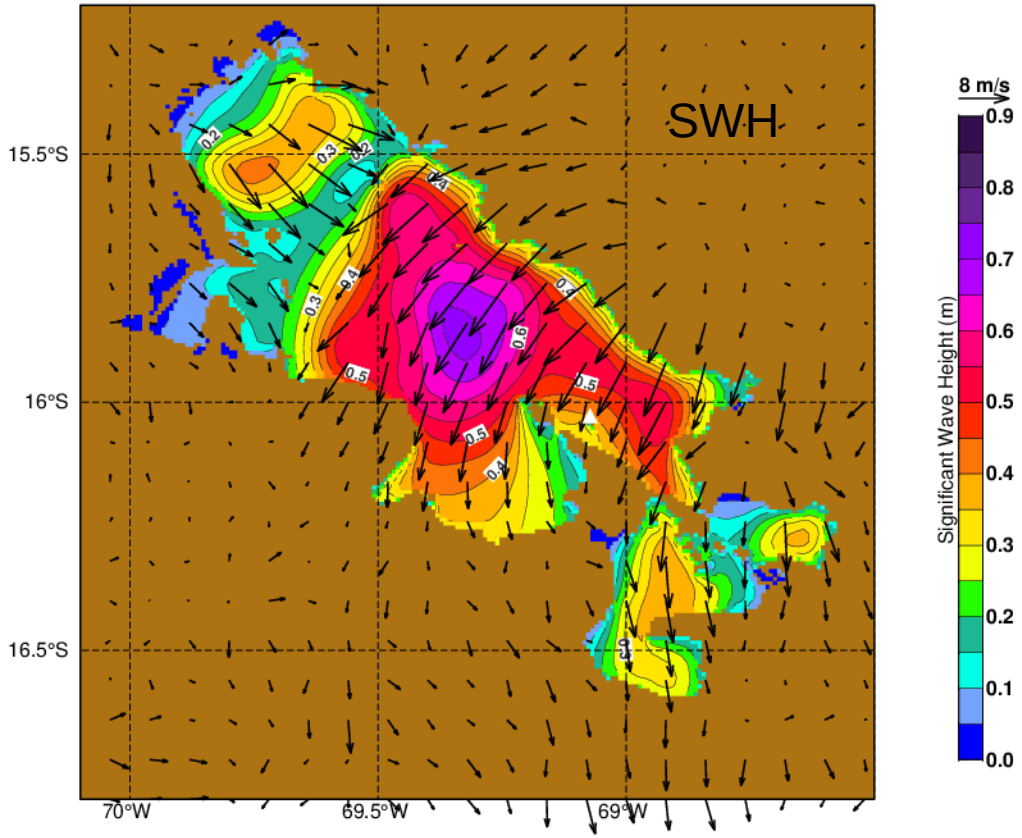
ecWAM stand alone simulation for lake Titicaca only:

- 0.008° x 0.008° (~ 1km) grid, 36 frequencies, first frequency 0.06 Hz, 48 directions.
- 45 s time steps.
- ecWAM CY49R1 (physics Ardhuin et al. 2010 + Janssen and Bidlot 2023).
- Air density changed from 1.225 kg/m^3 to 0.785 kg/m^3.
- Wind forcing:
  - ERA5 cannot be used as too low resolution.
  - Operational analysis is only available every 6 hours (need hourly forcing).
  - Use short range forecasts from 0 and 12 UTC (steps 3 to 14 hours) at operational resolution Tco1279 (9 km) and DestinE resolution Tco2559 (4.4 km) based on the latest CY49R1 with resolved lakes.
  - ...

Wind and waves

2023-05-05 0 UTC





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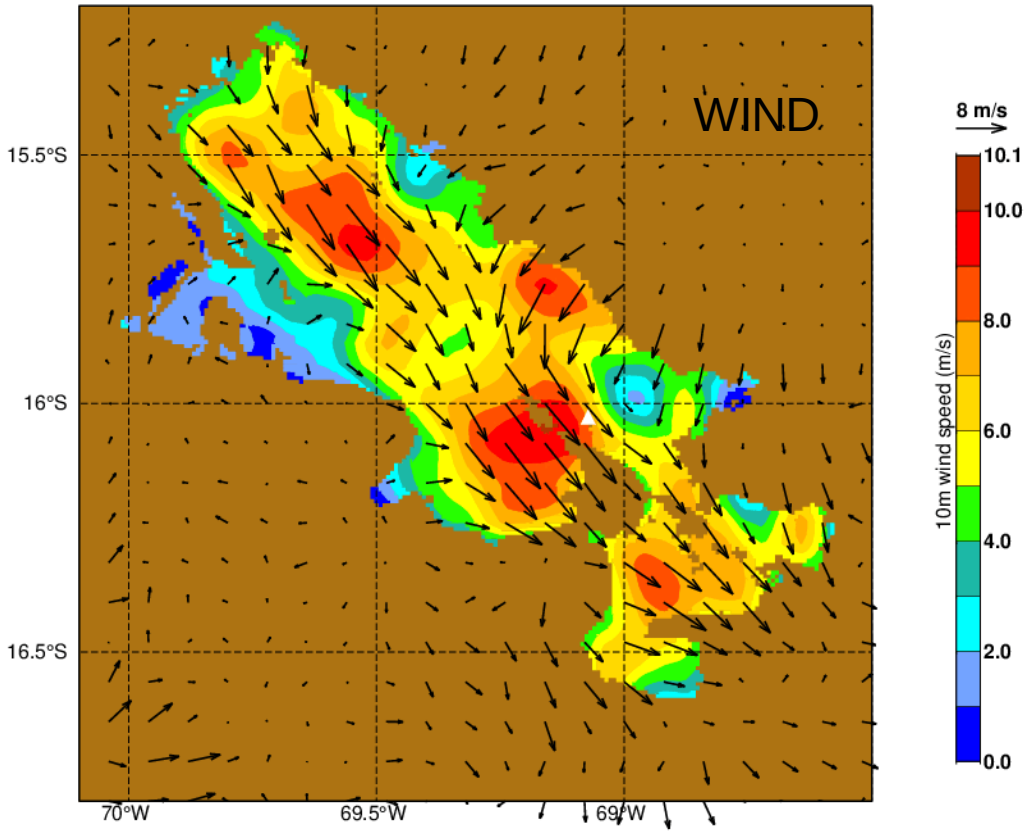
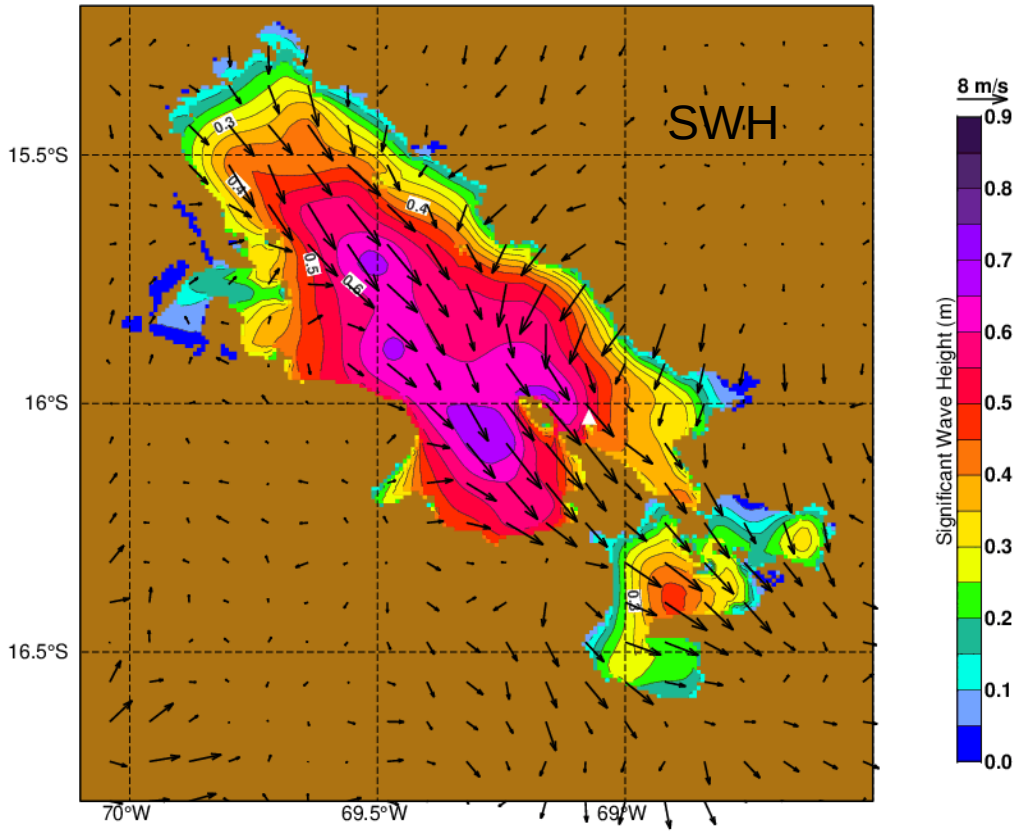
Wind and waves

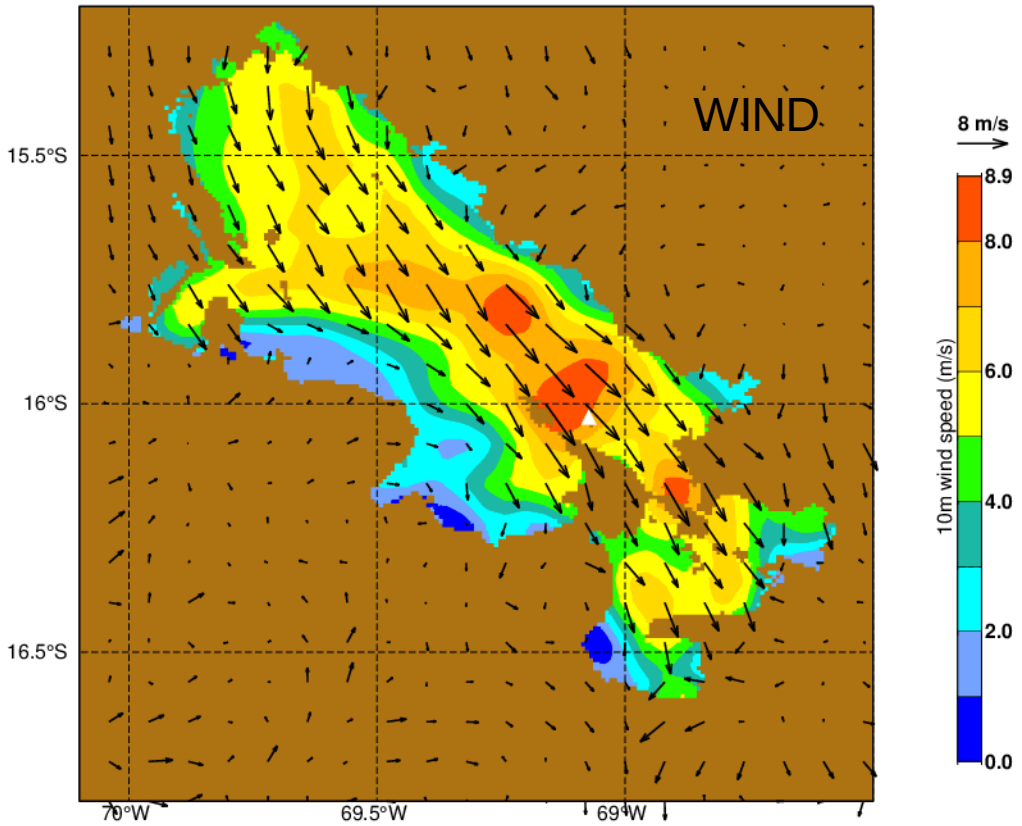
2023-05-05 6 UTC

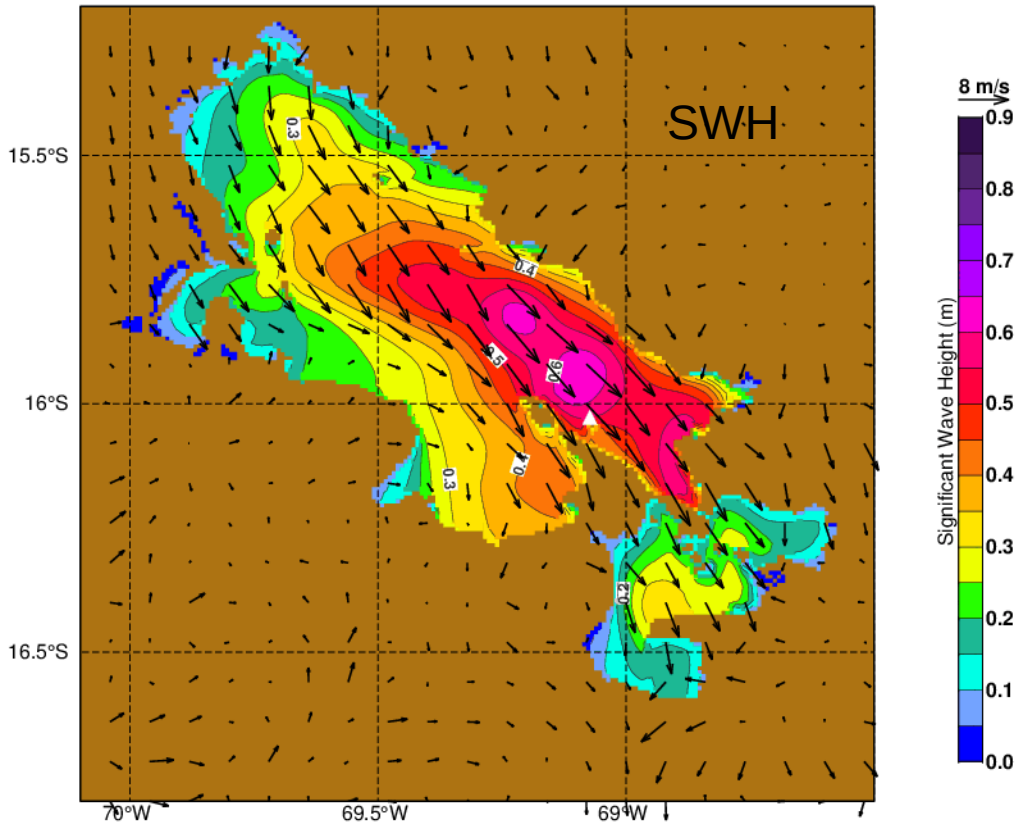




Wind and waves

2023-05-05 12 UTC





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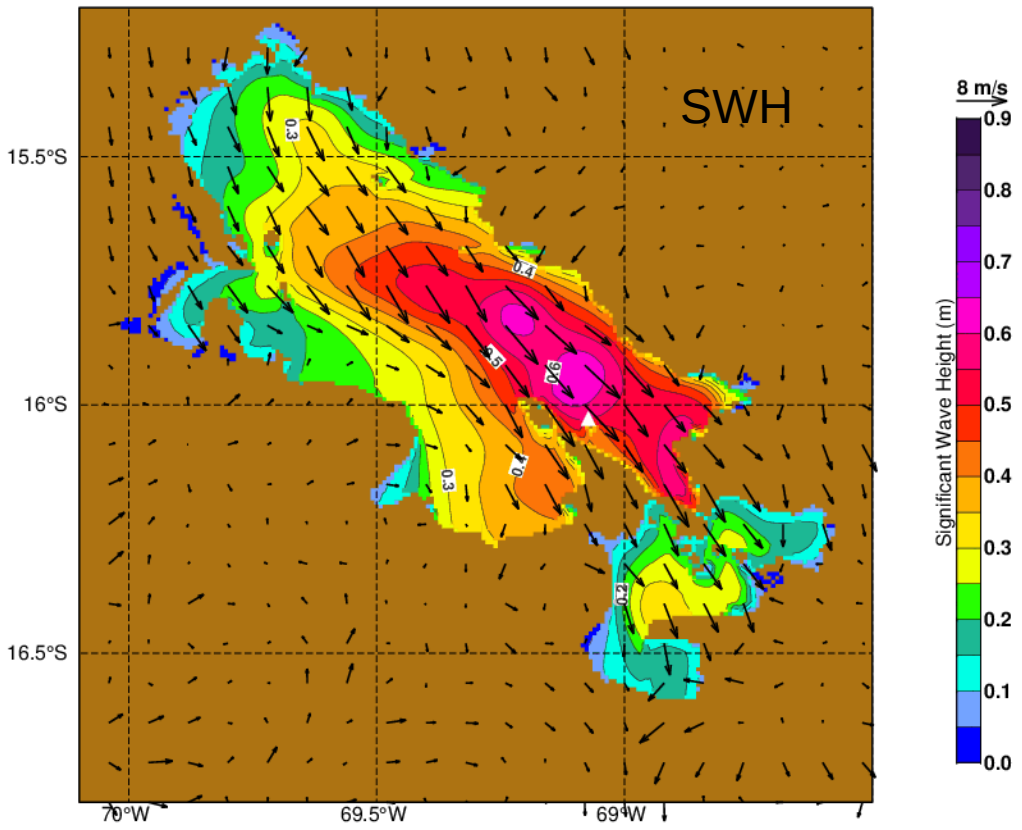
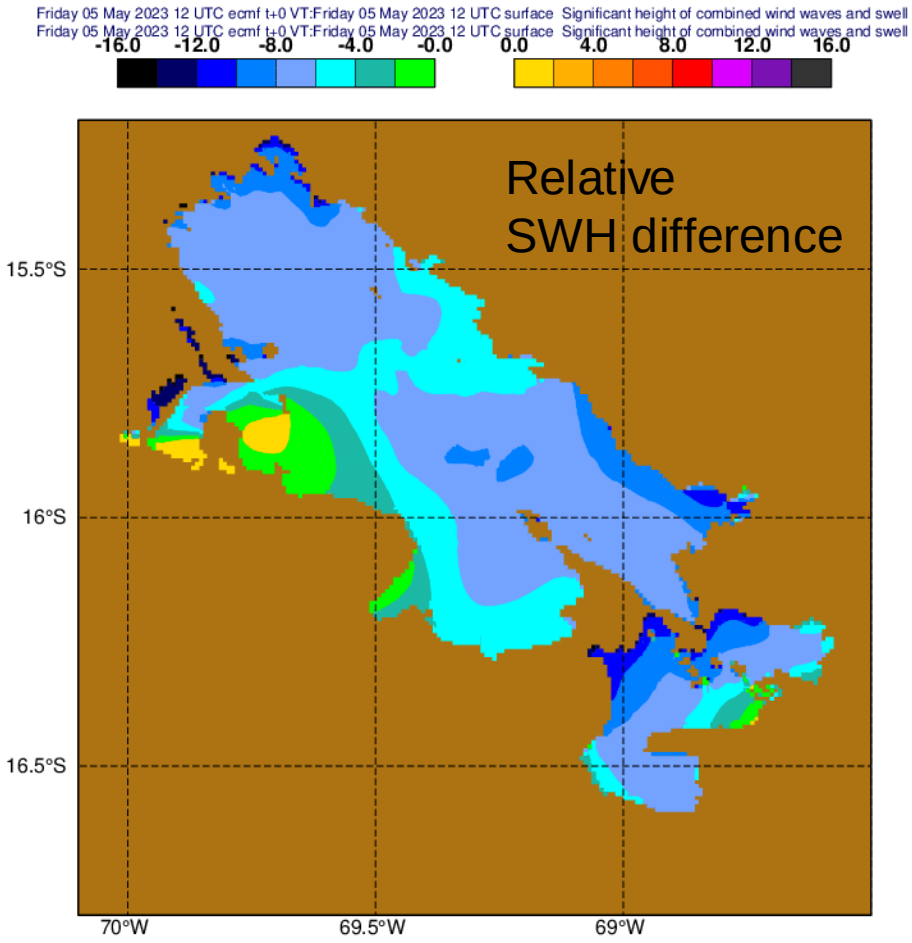
Impact of air density change on waves

2023-05-05 12 UTC



Significant Wave Height



Relative change in Significant Wave Height
(air density 0.785 kg/m^3 - 1.225 kg/m^3)

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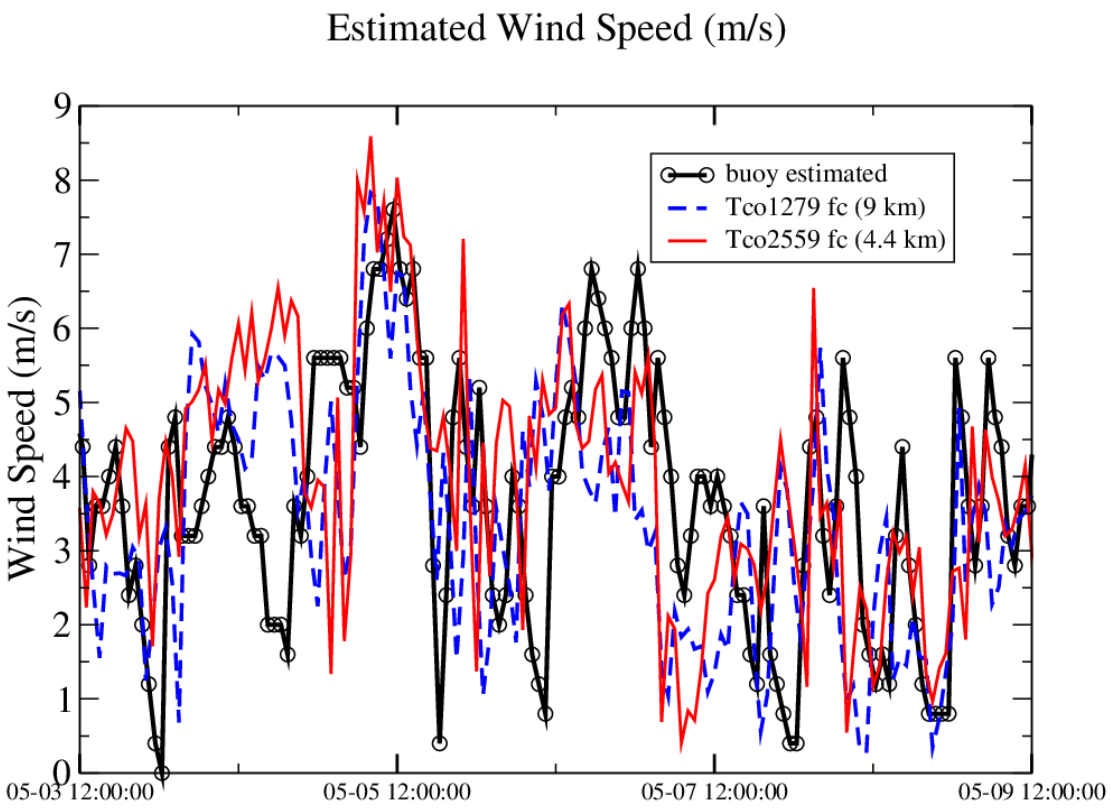
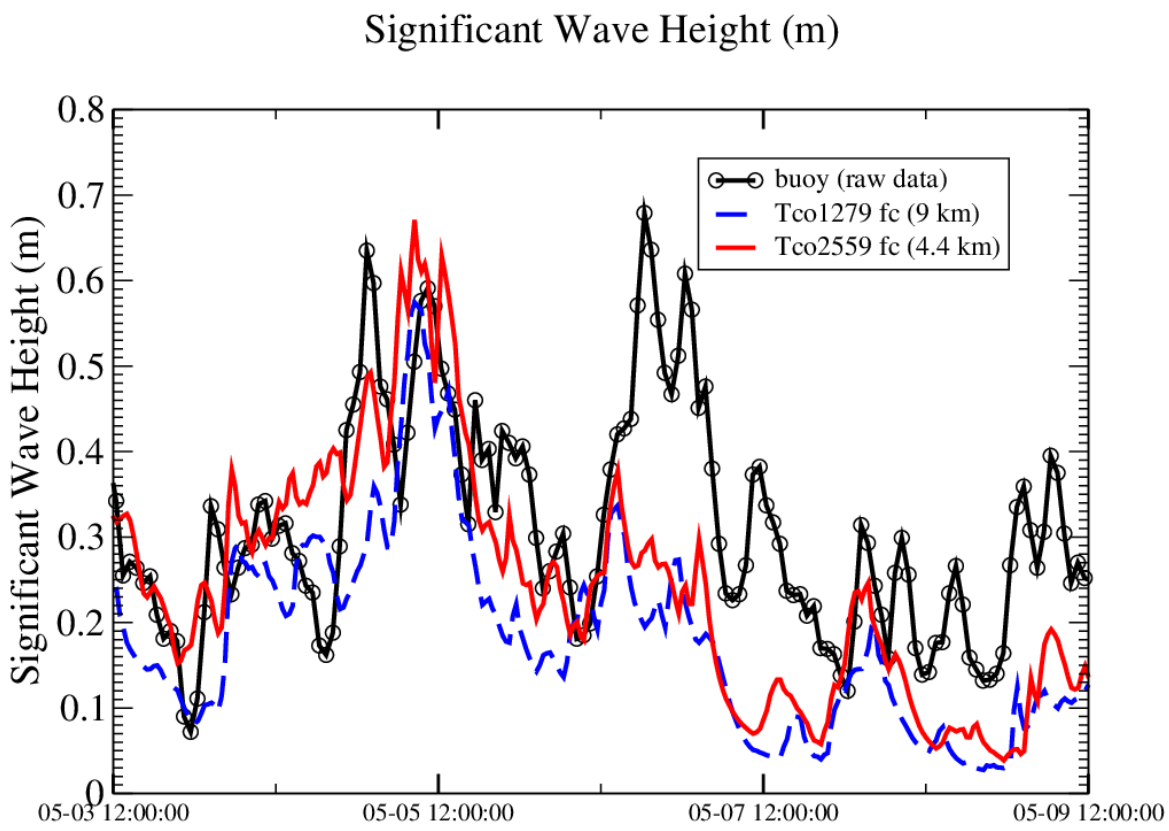
Preliminary comparison to buoy observations

WIND

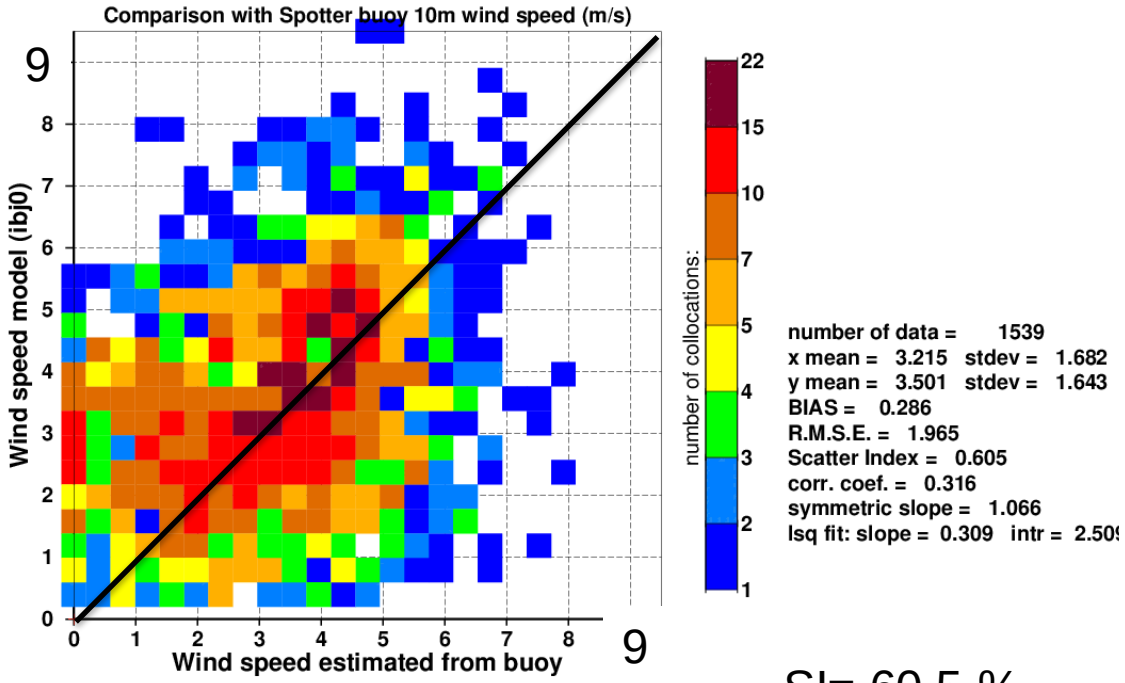


SWH



Preliminary comparison to buoy observations

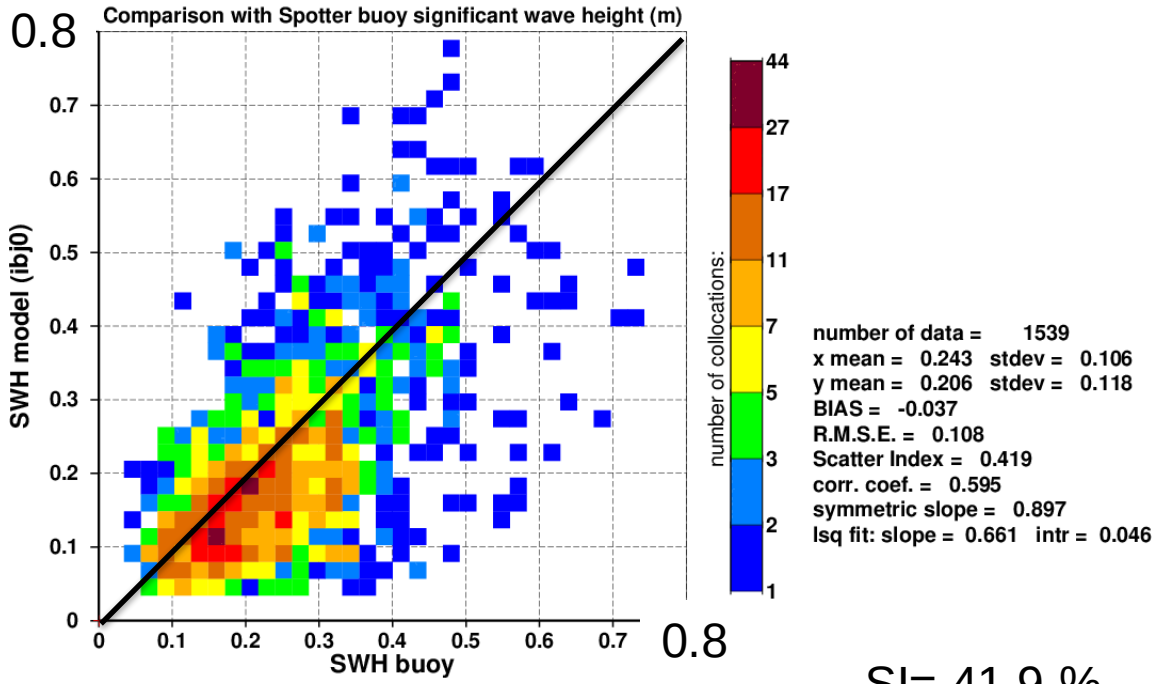
WIND



Data from 29 March to 17 May 2023
Tco2559 short forecasts winds (steps 3 to 14 by 1 hour)

SI= 60.5 %

SWH

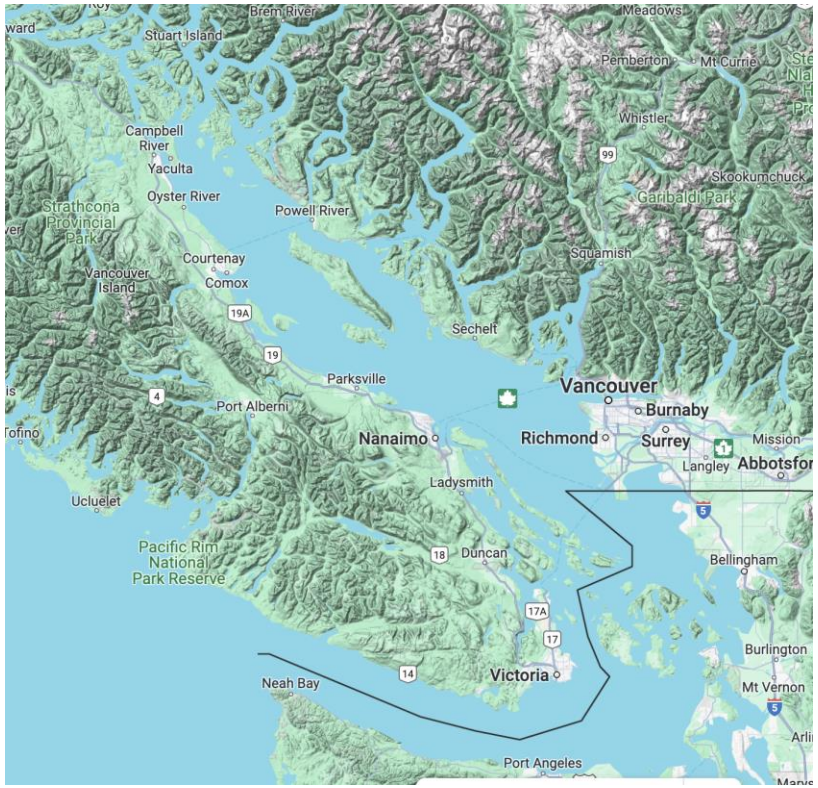


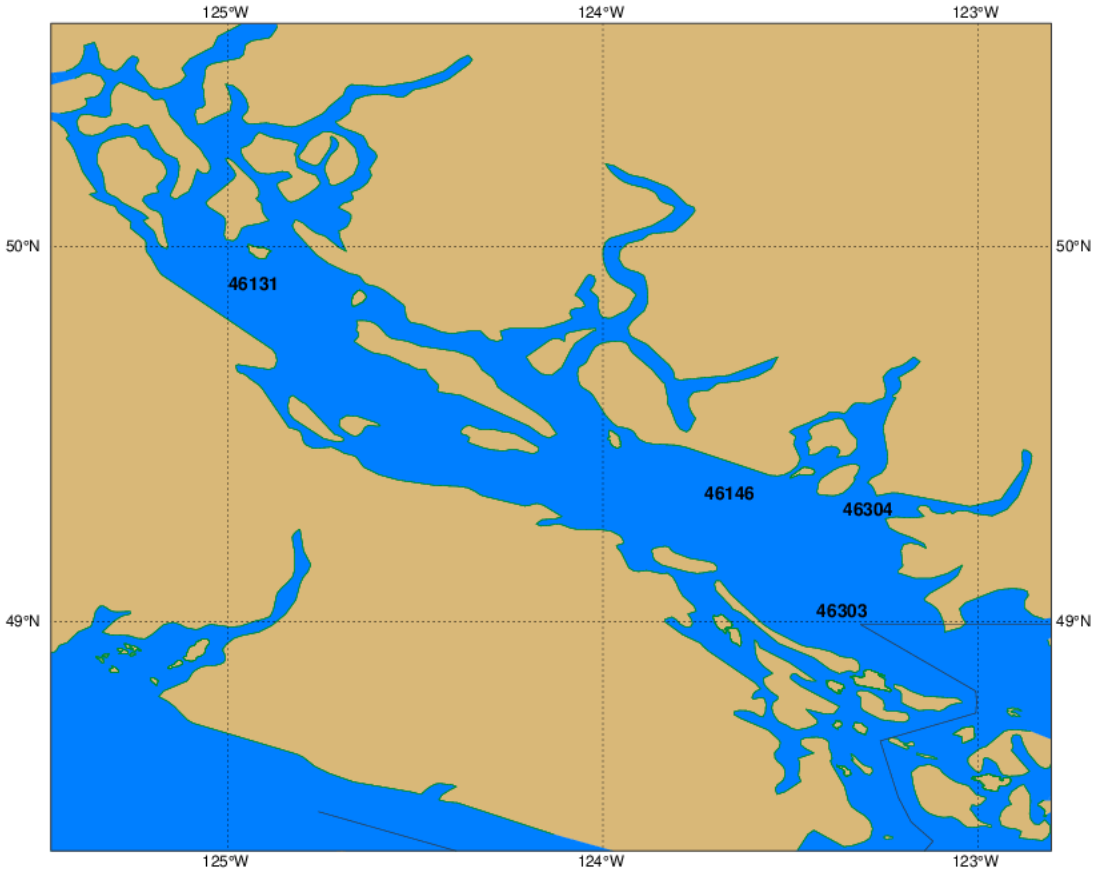
Data from 29 March to 17 May 2023
Model hindcast forced by Tco2559 short forecasts winds

SI= 41.9 %

Challenge: similar conditions at sea level?

Strait of Georgia, western Canada

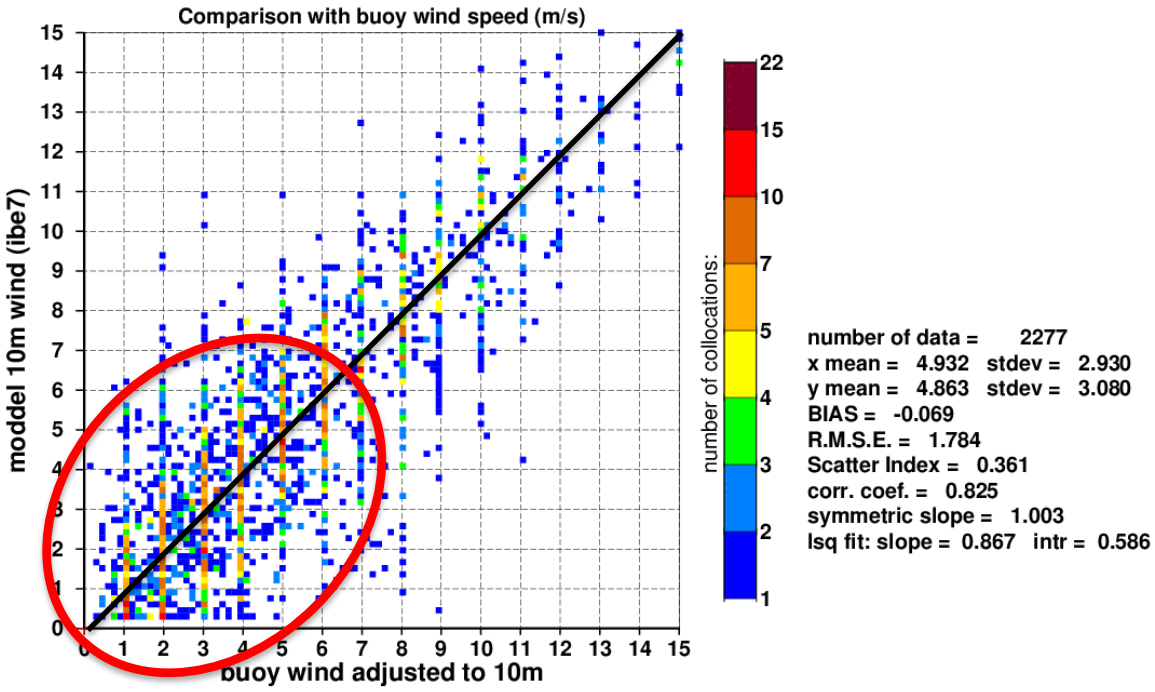




Strait of Georgia

Same period as for Lake Titicaca simulation,
Winds from Tco2559 short range forecasts.
0.01° x 0.01°

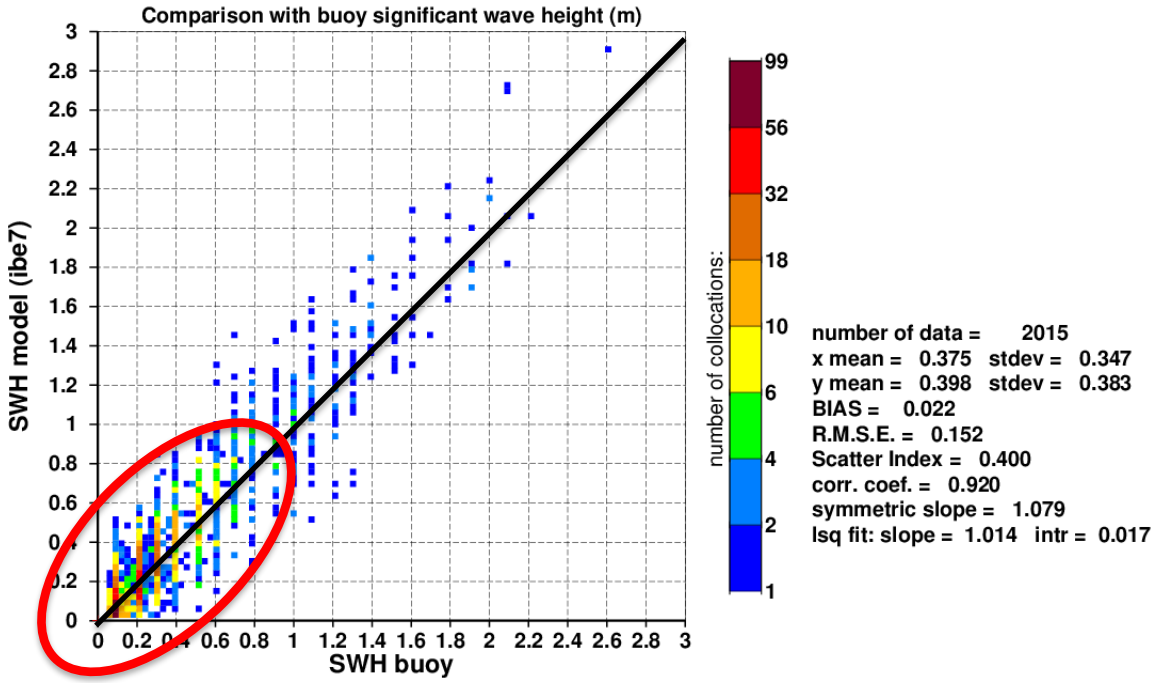
WIND



Data from 29 March to 17 May 2023
Tco2559 short forecasts winds (step 3 to 14 by 1 hour)

SI= 36.1 %

SWH



Data from 29 March to 17 May 2023
Model hindcast forced by Tco2559 short forecasts winds

SI= 40.0 %

Similar large scatter for low winds conditions !

Conclusions

- Global wave model simulation at 1.4 km with resolved lakes included can be run with ecWAM.

- Modelling waves on lake Titicaca is an ongoing challenge.
- Forcing wind fields might be an issue (more work needed).
- So far, there is no clear sign that the wave model parameterization would not work.
- Need more data…