enabling delta life

Deltares

TurboSWAN: AI-driven wave forecasts

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Rijkswaterstaat CIP Project

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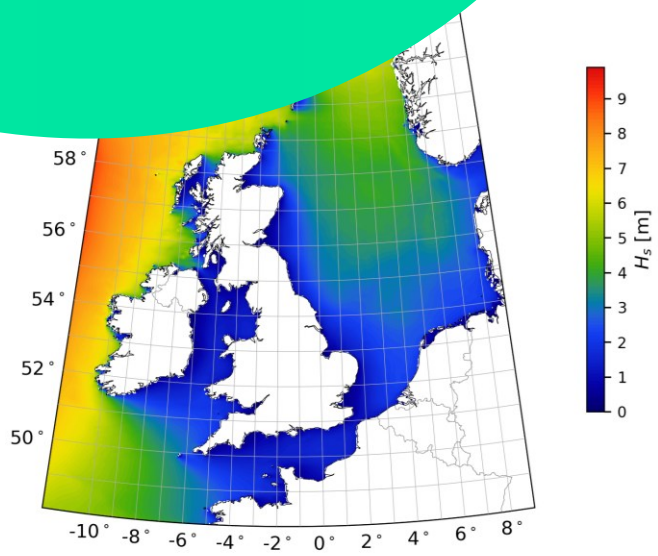
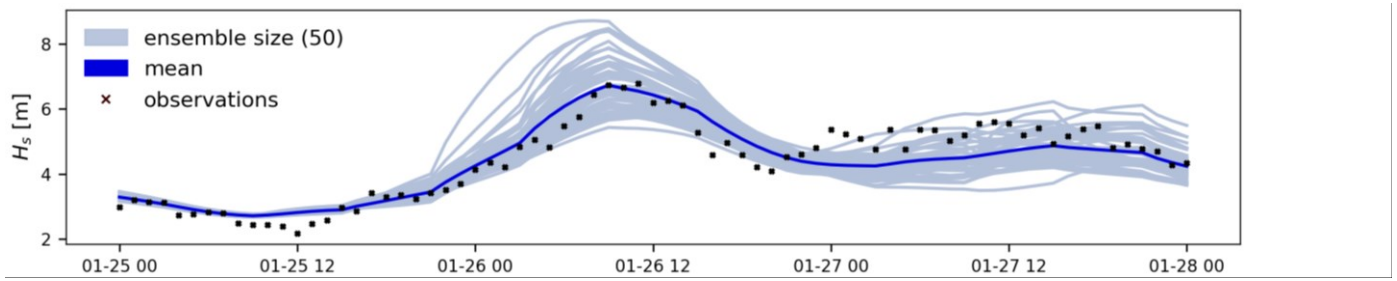
User question

North Sea wave forecasts for:

- Safe navigation
- Flood safety



How reliable are the wave forecasts?

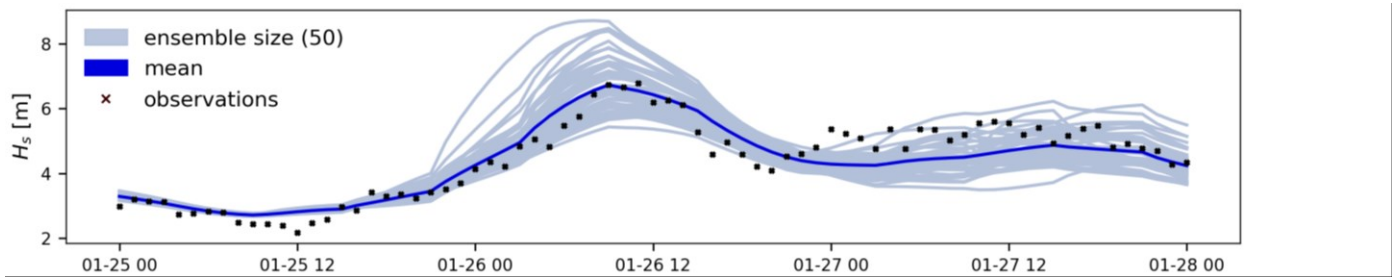


→ **Wish for confidence intervals**
→ **Based on wind ensembles**

Aim

- Provide confidence intervals to the operational wave forecasts, enabling sound and save decisions for navigation and flood warning

Example ensemble forecast wave height



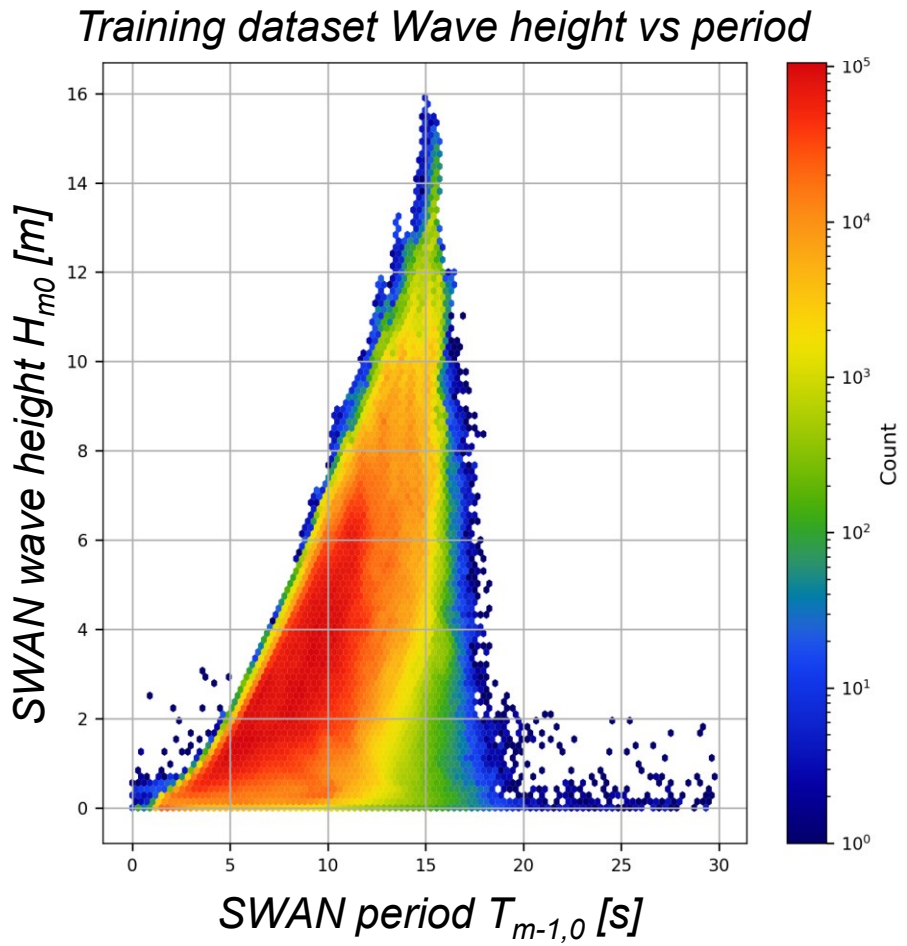
SWAN is computationally intensive → 50 wind ECMWF wind ensembles require ~ 50 hr

As an alternative, train a surrogate model, based on SWAN results: **TurboSWAN**

Setting up TurboSWAN

SWAN results

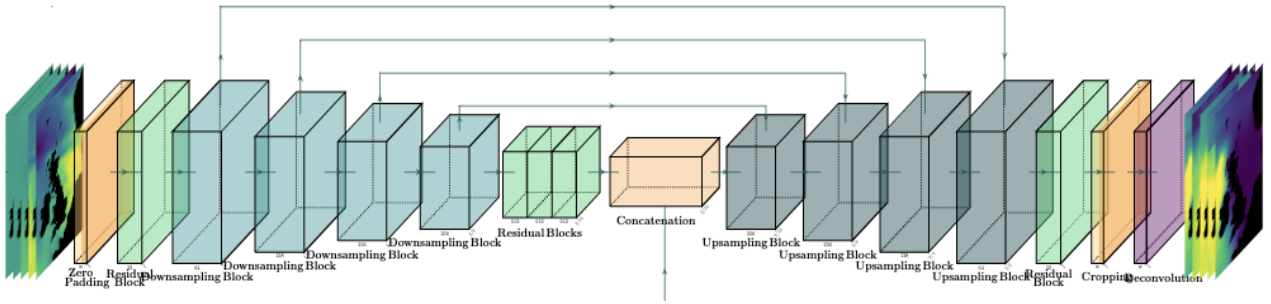
- The SWAN results considered as ‘truth’
- Training-, and validation data based on 20 months of SWAN ensemble runs:
  50 ensembles members, every 6 hr.
- ‘mild’ conditions and storm events



Setting up TurboSWAN

- Training based on SWAN results
- Convolutional neural network pattern recognition

Convolutional neural network

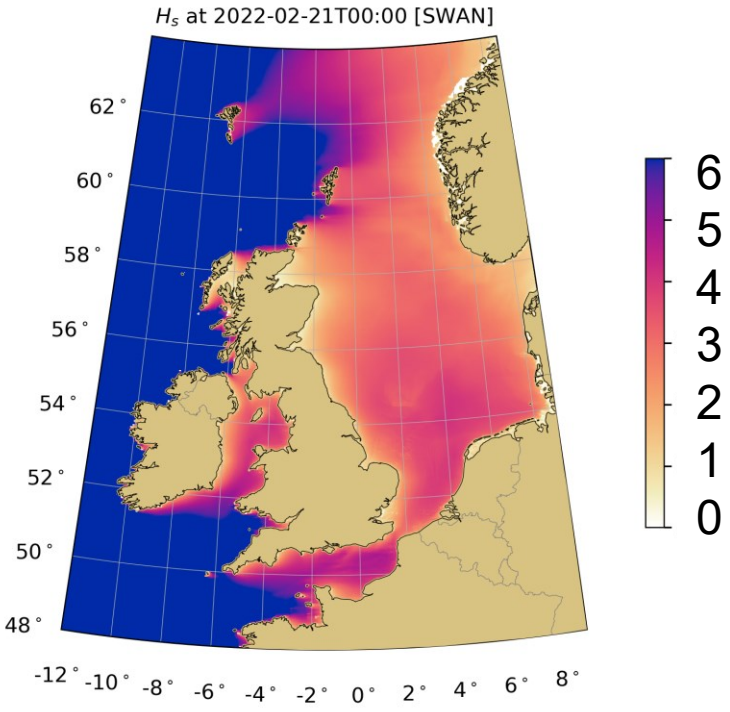


- Input variables: spatial fields of wind, water depth, currents; 0 h and -6 h
- Wave boundary conditions as input: wave height, swell, period, direction
- Output variables: wave height, swell, period, direction on the entire domain
- ‘loss function’ based on mean square error (MSE)
- Snellius Super computer / GPU

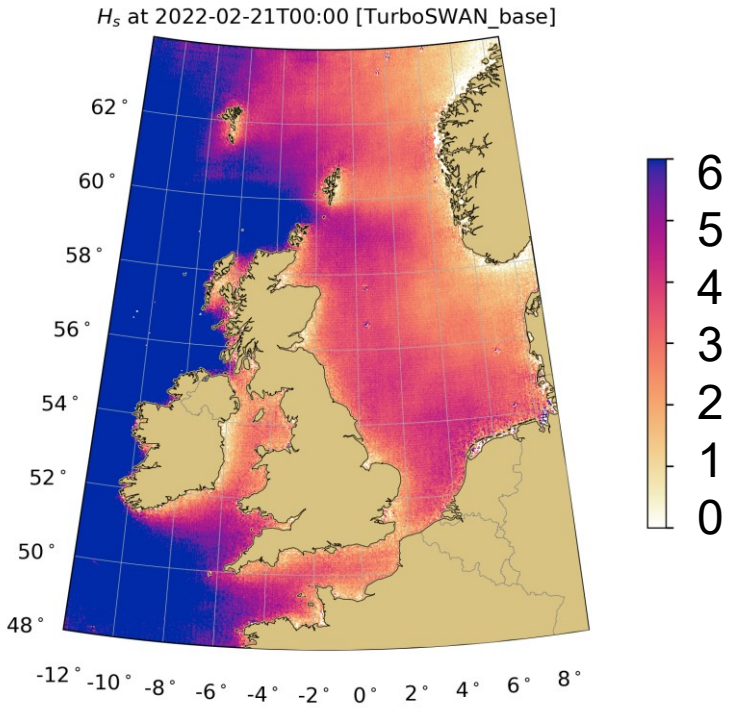
Results – work in progress

Random example 21 Feb 2022 00:00 from validation dataset

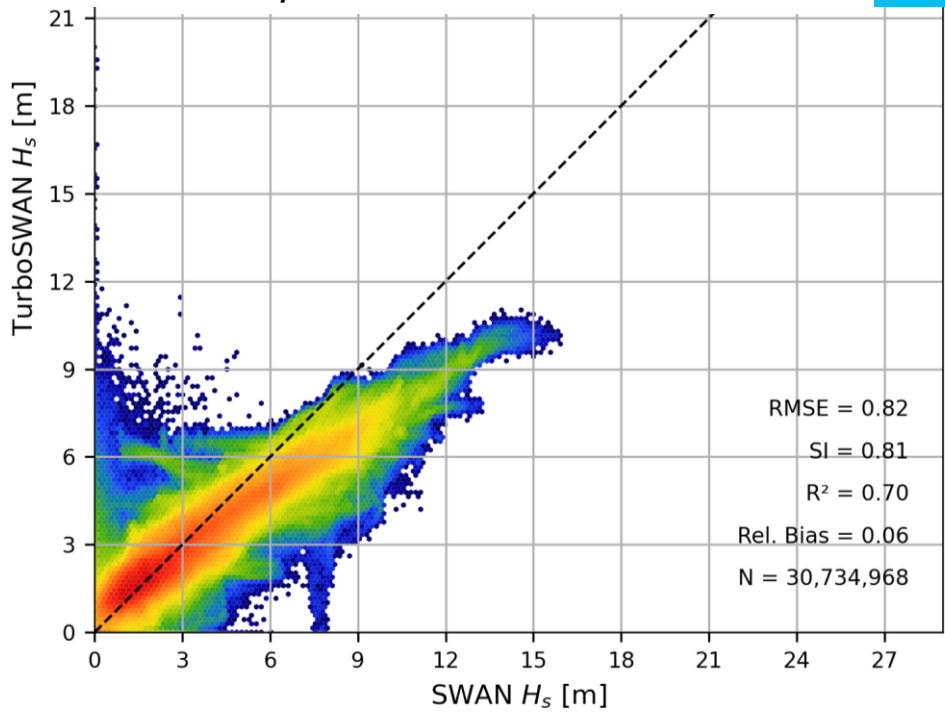
SWAN Wave height H_{m0} [m]



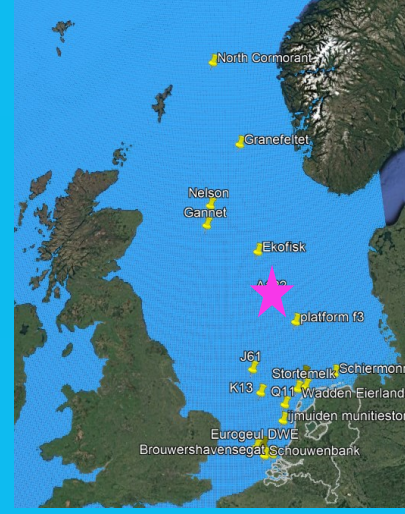
TurboSWAN Wave height H_{m0} [m]

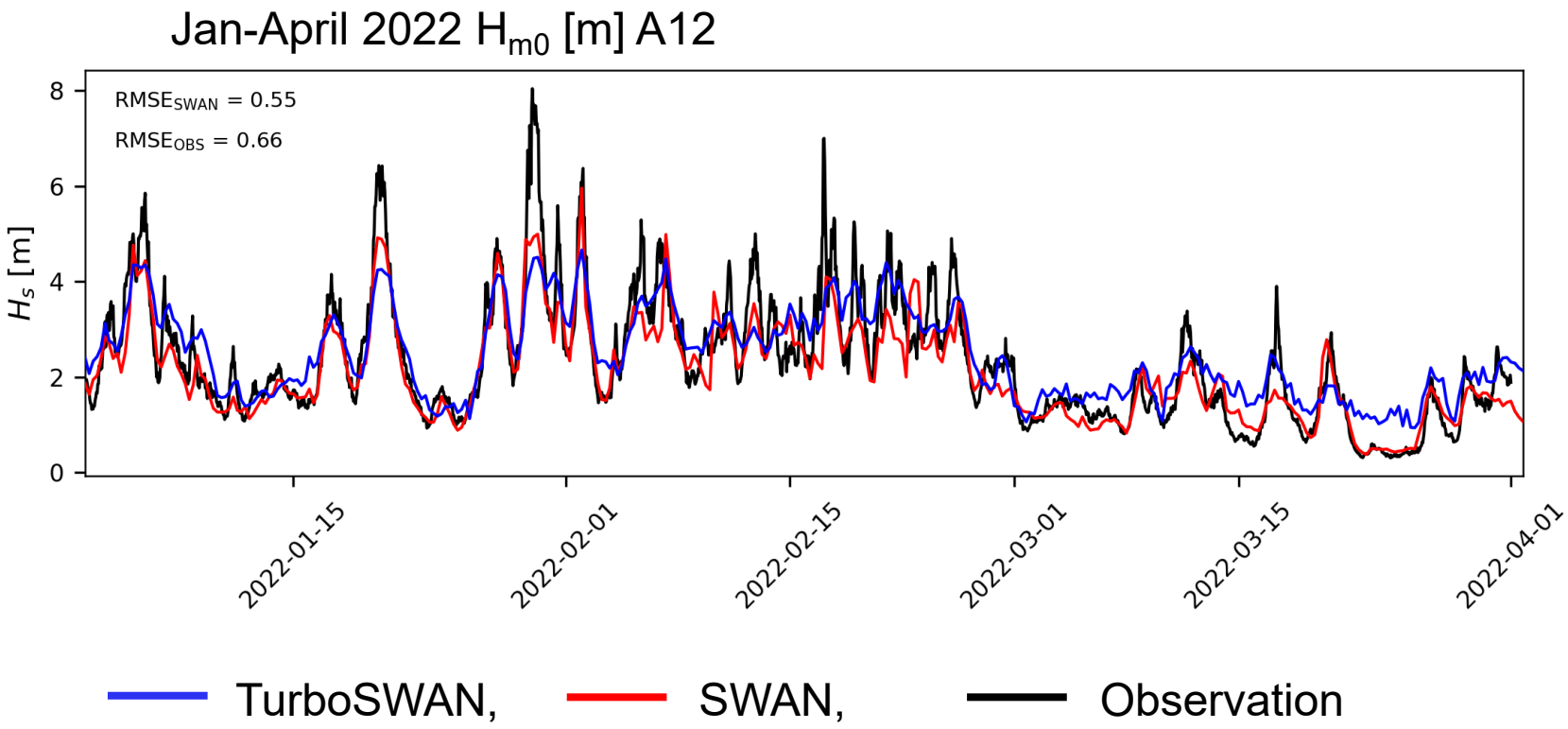


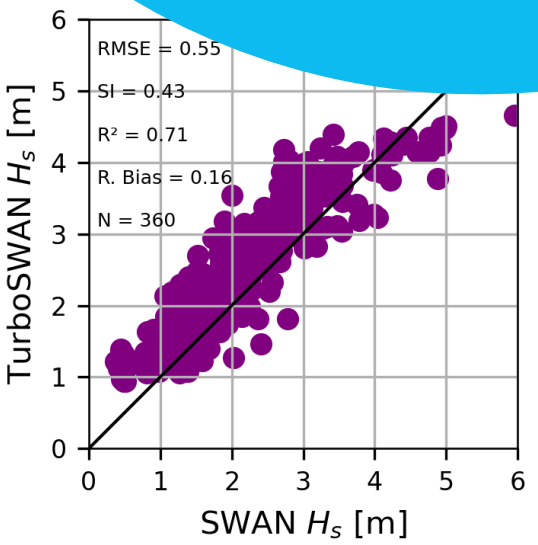
Scatterplot TurboSWAN vs SWAN



Results – work in progress







Challenges & lessons learned

- Funding: Rijkswaterstaat's Corporate Innovation Program (CIP) offered a great opportunity.
- Expectation management. Balance between practical application vs realistic time path. Low TRL, not directly the perfect model. RWS interested in AI developments
- Interesting co-operation between AI experts and wave specialists. Both are needed for a good AI model.
- Generating training data is relatively easy since we do the SWAN model runs ourselves.
- Large data storage and computation capacity needed. We use Snellius (SURF-Sara). Challenging to estimate required storage and number of computational nodes in advance.