Project: **1338**

Project title: **CliNSBaS – Climate change impacts and adaptation in the North Sea – Baltic Sea region**

Principal investigator: **Tim Kruschke**

Report period: **2022-11-01 to 2023-10-31**

As described in the proposal, CliNSBaS consists of three subprojects. The progress of each one is described below.

In the first three quarters of 2023 a substantial amount of the granted computing resources expired. This is because we started from scratch on DKRZ facilities, partly also based on tools completely new to us. The result was a substantial delay in actual scientific work due to technical efforts setting up the working environment. Additionally, the tools in use (NEMO4.2.0/Xios as well as the CRAI-package) performed much better than expected a priori. These experiences will be factored into our resource request for the year 2024, ensuring more accurate resource allocation in the future.

CRAI - BSH SST analysis 3.0

The kick-off for this part of the project was in February 2023. The goal is to train a convolutional neural network (CNN) developed at DKRZ (https://github.com/FREVA-CLINT/climatereconstructionAI) with sea-surface temperatures (SST) from model data so that in the end the trained model can fill gappy observational data from satellites and ships retrospectively and operationally.

As a first test case, we trained the CNN with 35 years of daily SSTs from a historical climate model simulation for the North Sea region using the default parameters for the CNN training. We constructed the training masks from 33 years of satellite data over the North Sea. The grid resolution for the input and output data was chosen to be similar to the current operational BSH SST analysis: 0.5° x 0.25°, approx. 20 km, resulting in a 56 x 44 grid for this test case. This set-up gave us encouraging results already. We then added another data set to the training: 15 years of SST data from the BSH operational model; and we started experimenting with varying the parameters for training the CNN, e.g. number of encoding layers, number of filters, and number of iterations.

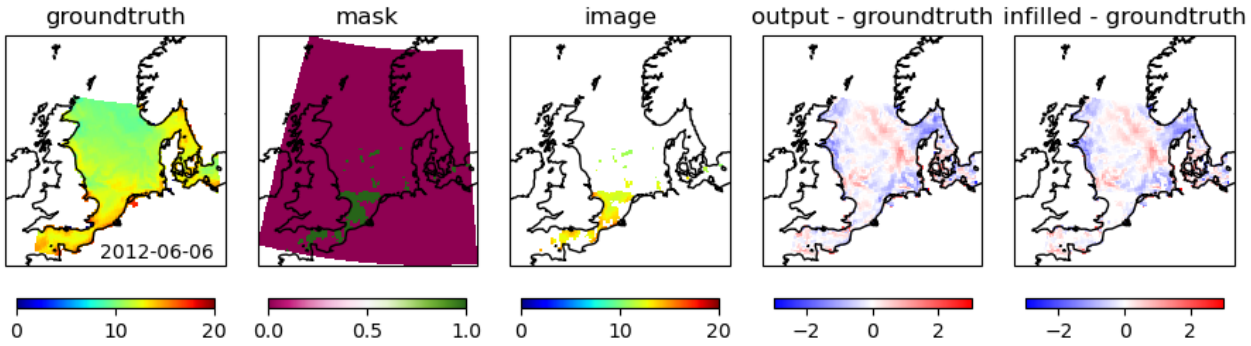

Fig. 1 Example of a model SST-field (left) that was masked (center) according to a real cloud field taken from satellite data (2nd from left) presented to the afore-trained CRAI-CNN and the difference between the CNN-output (3rd and 4th from left) and the groundtruth

Fig. 1 provides an illustrative example of the performance of the approach for the current status of the development. Systematic validation is performed based on independent test data (not shown). Given that the approach is now technically working with our data and first results look promising, current work and planned efforts for 2024 involve 1) further increasing the training data pool (more climate model simulations, reanalysis data etc.), 2) further increase the grid resolution, and 3) testing the Short-Term-Memory (LSTM) module to better handle days with (almost) no satellite data.

Development of next generation DAS-Basisdienst regional climate model

In March, the initiative to advance the development of the BSH stand-alone regional climate model for the DAS-Basisdienst, with a primary focus on enhancing wetting-and-drying capabilities and

achieving higher resolutions, started by setting up the Nemo4.2/Xios model environment at DKRZ. Following technical test runs exploring reproducibility and performance, a 5-year hindcast run with new initialization fields for temperature and salinity as well as multiple new boundary conditions (FES2014 tidal constraints, runoff data from the “Bundesanstalt für Gewässerkunde”, atmospheric forcing from ECMWF’s ERA5 and salinity and temperature boundary conditions from ORAS5) was conducted.

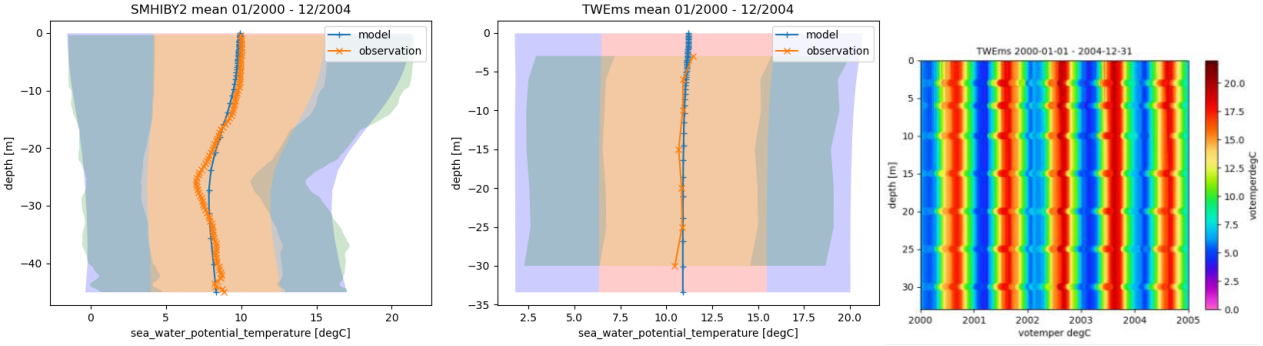

Fig. 2 Temperature validation at stations SMHIBY2 and TWEms

Exemplarily the mean temperature profile validation against observations is displayed at two stations (SMHIBY2: 14.10° lon, 54.17° lat; TWEms: 6.35° lon, 54.17° lat) in Fig. 2. Additionally, for the Weser-Ems station, a Hovmöller plot is utilized to visualize the temporal evolution of temperature profiles.

Test runs were undertaken to enhance the numerical stability of the wetting-and-drying scheme. This improvement involved the adjustment of bathymetric data and the tapering function. Subsequently, a one-year run with a coarse resolution of 2 nautical miles was conducted, incorporating an active wetting-and-drying scheme across the entire computational domain. The resulting dry-time ratio is visually presented in Fig. 3 for the section of the domain, which is relevant for the DAS-Basisdienst.

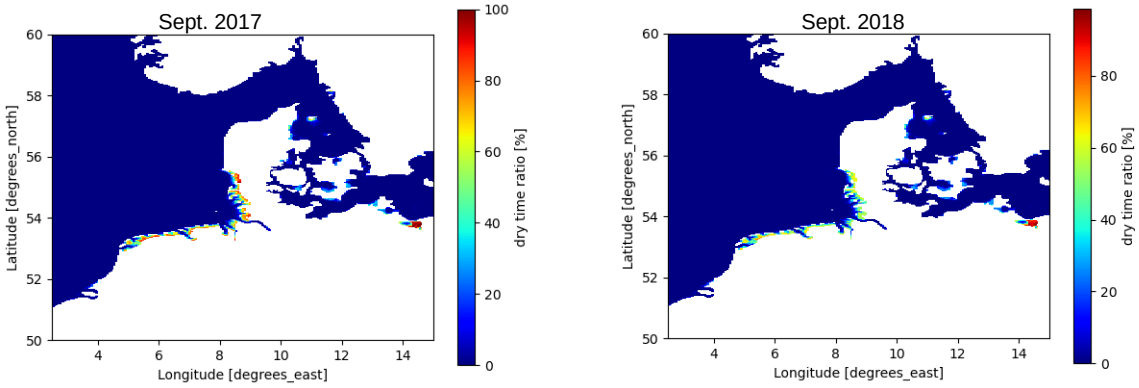

Fig. 3 Dry time ratio for 1-year Nemo4.2 run with wetting-and-drying.

A 30-year hindcast run and runs featuring higher resolutions specifically within the German Bight are planned in Oct-Dec 2023.

Conference Contributions:

- Ehlers, B.-M., Meyer, J., Düsterhöft-Wriggers, W., Maurer, V., and Janssen, F.: NEMO v4.2 in regional climate modelling - towards climate projections for the German coasts, EGU General Assembly 2023, Vienna, Austria, 24–28 Apr 2023, EGU23-7307, https://doi.org/10.5194/egusphere-egu23-7307, 2023.
- Düsterhöft-Wriggers, W., Meyer, J., Ehlers, B.-M., and Janssen, F.: Towards high resolution climate projections for the German coasts with NEMOv4.2, IWMO 2023, Hamburg, Germany, 27-30 June 2023.
- V. Maurer, J. Meyer, B.-M. Ehlers, F. Janssen, W. Düsterhöft-Wriggers, H. Hagemann, B. Früh, Calibration of the new regional ocean-atmosphere model based on ICON and NEMO for the EURO-CORDEX domain, CLM-Community Assembly 2023, Leuven, Belgium, 18-22 Sept 2023.
- V. Maurer, J. Meyer, B.-M. Ehlers, F. Janssen, W. Düsterhöft-Wriggers, H. Hagemann, B. Früh, Calibration of the new regional ocean-atmosphere model based on ICON and NEMO for the EURO-CORDEX domain, ICRC-CORDEX 2023, Trieste, Italy, 25-29 Sept 2023.