Intercomparison of stand-alone and two-way nested models for CMEMS downstream service

Vilnis Frishfelds (1,2), Jens Murawski (1) and Jun She (1)
(1) Danish Meteorological Institute
(2) Institute of Numerical Modelling, University of Latvia

INTRODUCTION

The Limfjord is the largest Danish fjord system but not covered by CMEMS. It is very important for oyster farming, transport and as an ecosystem. In frame of FORCOAST project, an operational service is elaborated based on CMEMS boundary condition.

Considered setups:

- Nested setup [1] of Limfjord with 4 domains: North sea - Baltic sea, Wadden sea, Danish straits and Limfjord, see Figure at right.
- Stand-alone setup has only Limfjord domain with the same resolution.

Advantages and disadvantages of nested or stand-alone setups:

- Nested models usually have better performance [2].
- Nested setup simulates salinity inflows well.
- Stand-alone setup requires much less computational resources, can be tuned more effectively, less limits for increasing the resolution.
- Stand-alone setup is influenced by changes in CMEMS operational products at North West Shelf and Baltic sea.

Main tuning steps of stand-alone setup:
In order to mimick inflows at western and eastern boundaries, sea level is enhanced by:

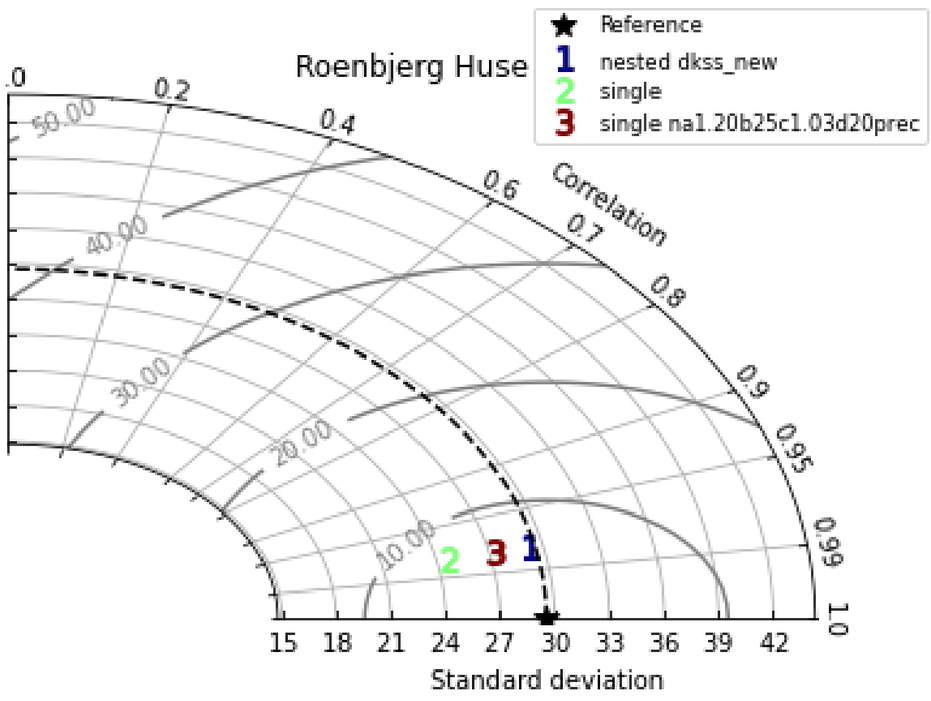
- Western boundary: z_{new}=1.20*z+25 (cm)
- Eastern boundary: z_{new}=1.03*z+20 (cm)

in current operational setup.

Boundary salinities are increased:
+ 1 [PSU] at west and + 3 [PSU] at east

Sea level at western part boundary is applied 15 minutes sooner.

62 % of E-hype values are used as river run-off in Limfjord area.



Taylor diagram of sea level in Rønbjerg Huse in period of 2017.07.01-2020.03.01. 1 is nested setup, 2 – stand-alone untuned setup, 3 – tuned stand-alone setup.

As can be seen from Taylor diagram, multiplicative factor > 1 improves the variability of sea level and RMSD.

Additive factor of boundary sea level enables to improve the narrow straits in eastern part.

RESULTS

Sea level:
Performance is comparable in both nested and stand-alone setups.

In western stand-alone setup has even a slight advantage.

Nested setup has an advantage in middle part of Limfjord because of better inflows through narrows of Oddesund and Sallingsund.

Stand-alone setup has better sea level performance in eastern stations except Hals.

Stand-alone setup handles better situations with low sea level.

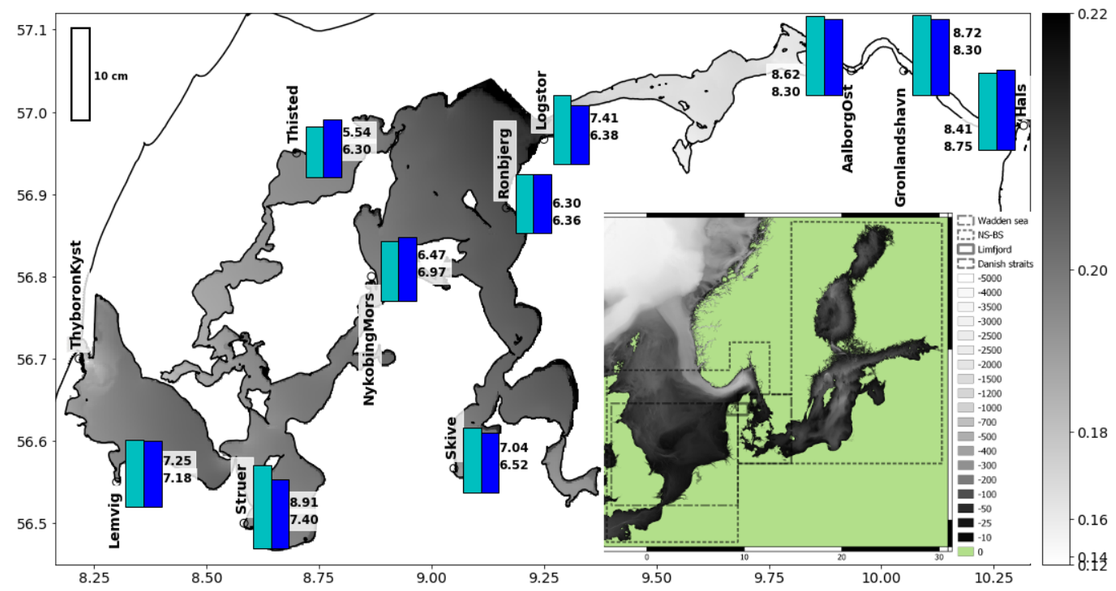
Precipitation-evaporation slightly improves sea level performance in middle part of Limfjord. It also improves seasonal variability of salinity.

Salinity:
Stand-alone setup results in worse performance in middle part of Limfjord due to insufficient inflows through Oddesund and Sallingsund.

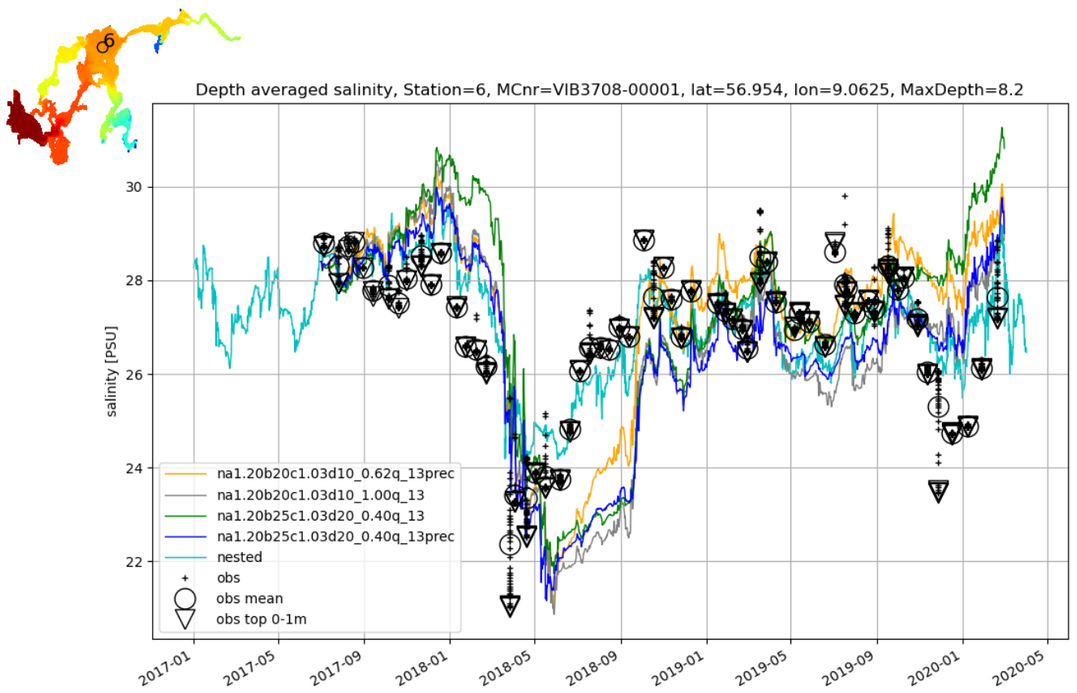
Temperature:
Both stand-alone and nested setups provide rather good temperature forecasts with bias and central RMSD of less than 1 degree for the 3 year period.
Good thermodynamics is a key factor for applications like Oyster farming in Limfjord.

FORCOAST OPERATIONAL SERVICE

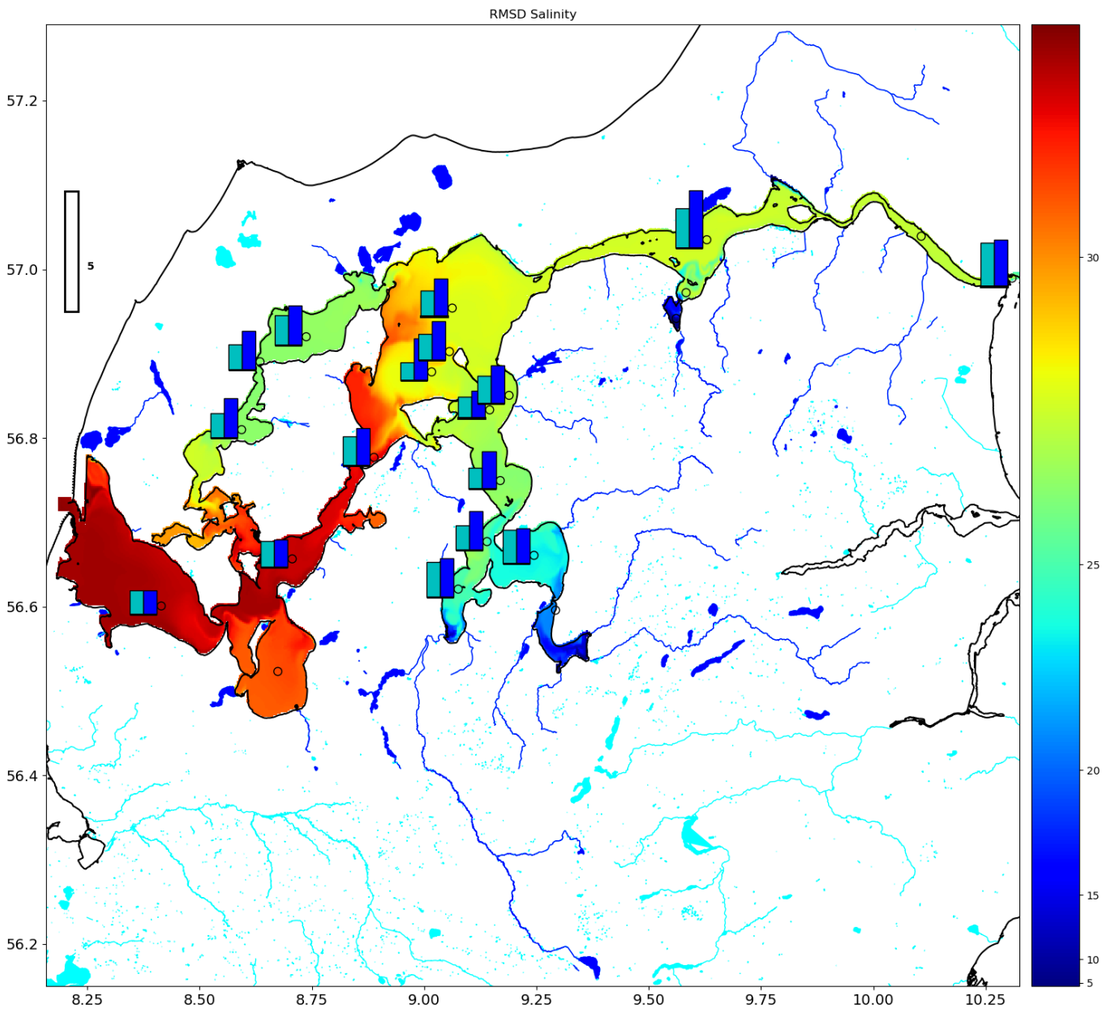
Basing on the results of optimisation, a stand-alone operational setup is elaborated based on CMEMS boundary conditions. That provides 5 day forecast twice per day.



Centralized Root-Mean-Square-Error of DMI's 2-way nested model (light blue, upper number) and tuned stand-alone model (dark blue, lower number). Units are given in centimeter. Period 2017.07.01-2020.03.01. The shading shows the modelled 5 year mean sea-level. Restricted water transport through narrows at Oddesund (near Struer) and Agersund (near Løgstør) leads to a higher mean sea level in the western part of the fjord. Lower-right: Domains of the nested setup: North sea - Baltic sea (3nm), Wadden sea (1nm), Danish straits (0.5nm) and Limfjord (185m).



Development of depth averaged salinity in middle of Limfjord, Løgstør Bredning. Circles represent average observed salinity in profile from ODA database, triangles – observed salinity in top 1 m layer; "+" - all salinity observations in given profile; light grey line - nested setup; other lines – different tuning in stand-alone setup. Yellow curve is selected as best fit.



RMSD of depth averaged salinity [PSU] in period 2017.07.01-2020.03.01 as compared to ODA observation profiles Nested model (light blue, upper number) and tuned stand-alone model (dark blue, lower number). Main rivers and lakes of Limfjord catchment are shown as blue. Colormap shows distribution of depth averaged salinity in August 6, 2017.

REFERENCES

[1] Murawski, J., She, J., Mohn, C., Frishfelds, V. and Nielsen, J.W. (2021). Ocean Circulation Model Applications for the estuary-coastal-open sea continuum. *Front. Mar. Sci.*, https://www.frontiersin.org/articles/10.3389/fmars.2021.657720/abstract
[2] Frishfelds, V., Sennikovs, J., Bethers, U., Murawski, J. and Timuhins, A. (2021) Modelling transit flow through port gates and connecting channel in Baltic Sea -Liepaja Port -Liepaja lake system Baltic sea -Liepaja Port, *Front. Mar. Sci.,* *https://www.frontiersin.org/articles/10.3389/fmars.2021.657721/full*