Project information

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validation physical biogeochemical models
Project title
ECOAN WP3-OA8: Validation and comparison of coupled physical-biogeochemical models
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2016
Project leader
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Geographical localization of the research project in decimal degrees (max 5 per project, ex. 70,662°N and 23,707°E)
Arctic region
Participants

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Flagship
Ocean Acidification
Funding Source

Framsenter Flagship

Summary of Results

Validation datasets

During 2016 we updated the validation data set by replacing the CARINA dataset with the latest compilation from the CDIAC website, GLODAPv2[1], by adding recent data from cruises reported to the Miljødirektoratet[2], and by adding Russian data from cruises in the Kara Sea[3].

The pCO2 data from high latitude time series (IRM, IS) were unfortunately excluded from the GLODAPv2 product, thus preventing recalculation of pH etc. at these points. The GLODAPv2 product was therefore merged (without duplication) with the complete datasets from (IRM, IS) that were also reported separately to CDIAC. Only data with WOCE flag = 0 (calculated), 2 (good), or 6 (average of replicates) were accepted, and all rejected or missing data are set to NaN. We do NOT use the GLODAPv2 values for water depth as these are "not research quality"[1]. Instead, water depth was estimated at all Latitudes/Longitudes using high-resolution bathymetry products (IBCAO and ETOPOv2), and where appropriate correcting to the maximum sampled depth (calculated from maximum sampled pressure using a standard function). A few negative reported values for nutrients were set to zero. We then recalculated the carbonate system (pH etc.) using CO2SYS.m[4] with constants reported as suitable for low temperatures and salinities[5-7]. Missing silicate and phosphate data, needed by CO2SYS.m, were filled by kernel smoothing over latitude/longitude in month/depth level bins (this gives a slight improvement over using zero or a mean value). Measured values of pH in the GLODAPv2 dataset were then compared with recalculated values from CO2SYS.m for different choices of equilibrium constants. The Millero (2010) coefficients[5] gave best overall agreement with the measured pH values. However, the calculation from DIC-alkalinity using CO2SYS.m gave biased values relative to measurements at low salinities (< 30 psu) irrespective of the choice of coefficients. We conclude that model-data comparisons based on pH values calculated from DIC-alkalinity should be avoided in water of salinity < 30 psu. For the validation dataset, pH etc. was recalculated from (DIC-alkalinity) or (pCO2-alkalinity) wherever this was possible. Where not possible, any existing (measured) pH value in the original GLODAPv2 data set was directly included in the final dataset. Calculated values were preferred in this way because the model estimates are necessarily derived from DIC-alkalinity using CO2SYS.m.

SINMOD validation results

A major finding is that while SINMOD achieves reasonable correlations with all biogeochemical variables measured on the Nordic Seas, Barents Sea, and East Greenland Shelf (see 2015 report, Fig. 1), the model is unable to reproduce the low pH values (2 (SINMOD assumes that DIC = alkalinity for riverine inputs, so aqueous CO_2 input is implicitly small).

Comparisons with the Russian data for the Kara Sea also suggested significant biases (see Fig. 1). The very large pH bias in fresh/shallow water (S < 7 psu, depth < 50 m) could be due to a faulty riverine end-member assumption in SINMOD for the Ob and Yenisey rivers in particular. However, there is still significant bias (SINMOD pH roughly 0.15 units higher) even in deep and salty water (S > 30 psu, depth > 50 m). This cannot be explained by faulty end members, and suggests either a regional bias in the model hindcast or a measurement bias in the Russian data. This is will be investigated further by comparing measurements by NIVA, using the DIC-alkalinity approach, with Russian data from the same samples derived from electrode measurements and converted from NBS to total scale using standard formulae.

We also performed time series analysis for the derived variables (pH, Ω, pCO_2) at the Irminger Sea (IRM), Icelandic Sea (IS), and Ocean Weather Station M (OWSM) stations. This essentially confirmed the analysis of the directly measured parameters (Figs. 4 and 5 in the 2015 report): shallow depths at IRM and IS stations showed strong decreasing trends in observed pH (0.002-0.003 units/yr) and increasing trends in observed pCO_2 (1.5 – 3 uatm/yr). SINMOD successfully reproduced these trends except for the trends below 300 m at the IS station; here it the model trends had the wrong sign, likely due to inadequate spin-up time and/or choice of initial conditions.

NORWECOM.E2E validation results

The validation data set has been uploaded to IMR and software has been prepared for a comparison between model and observations. The available NORWECOM.E2E simulations using realistic forcing from the ROMS model ends in 2007, but a new hindcast forced with the NEMO ocean model for the period 2005-2015 is planned to be performed first half of 2017. To be able to do the validation on a consistent and up to date hindcast, further work on this task has been postponed to this new simulation is available.

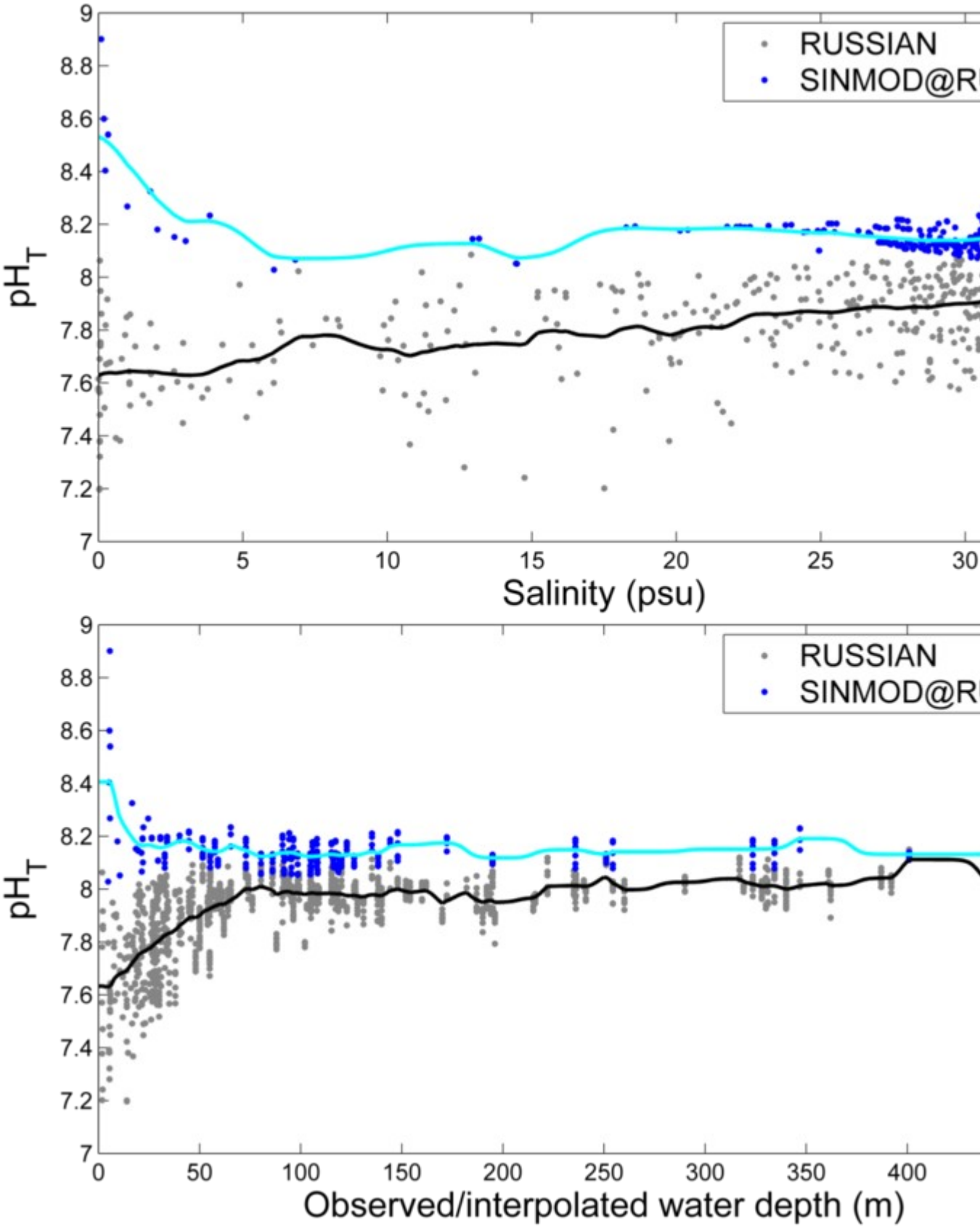

Figure 1. Comparison of Russian pH data (converted to total scale using CO2SYS.m) with total scale pH values derived from SINMOD output colocated to the sampled positions and dates. Upper plot shows values plotted against measured salinity (for the data) or modelled salinity (for the model output) (this has the effect of removing any bias due to bias in the model salinity). The lower plot shows pH values plotted against the measured water depth, filled with interpolations of

IBCAO bathymetry product where missing, for both data and model output.

References

[1]Olsen, A., Key, R. M., van Heuven, S., Lauvset, S. K., Velo, A., Lin, X., Schirnick, C., Kozyr, A., Tanhua, T., Hoppema, M., Jutterström, S., Steinfeldt, R., Jeansson, E., Ishii, M., Pérez, F. F., and Suzuki, T.: The Global Ocean Data Analysis Project version 2 (GLODAPv2) – an internally consistent data product for the world ocean, Earth Syst. Sci. Data, 8, 297-323, doi:10.5194/essd-8-297-2016, 2016.

[2]Chierici, M., I. Skjelvan., R. Bellerby., M. Norli., L. Lunde Fonnes., H. Hodal Lødemel., K.Y. Børsheim., S. K. Lauvset., T. Johannessen.,K. Sørensen., E. Yakushev. 2015. Overvåking av havforsuring i norske farvann, Rapport, Miljødirektoratet, M-354|2015.

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[5]Millero, F.J. 2010. Marine and Freshwater Research 61(2) 139-142.

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[7]Uppstrøm, L.R., 1974. Deep Sea Research I, 21(2) 161-162.

For the Management

The project is progressing as planned and is on track to meet all milestones and deliverables.

Published Results/Planned Publications

SINMOD and NORWECOM validation results are planned to be published together with the projections (see OA9) during 2017.

A publication of SINMOD results for the bottom of the water column (benthic) is also foreseen for 2017.

Communicated Results

SINMOD and NORWECOM results have been communicated to the ECOAN group during the annual workshop in October.

Interdisciplinary Cooperation

This project has demanded the close collaboration of modellers with observationalists and database managers.

Could results from the project be subject for any commercial utilization

No

Conclusions

The project is on track and producing important insights into sources of error and bias in model predictions of ocean acidification.