Coupled regional Earth system Modelling in the Baltic Sea region

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Abstract

1. Introduction (**Matthias, Markus, all,** max. 3-4 pages)

- historical outline on coupling, importance for mid to high latitude regions
- elaborate basic differences between coupled models and standalone models (Matthias, Markus)
- short survey on coupling techniques (Christian, Matthias)

2. Current state of knowledge

2.1 land surface-atmosphere coupling (**Paul,**Wilhelm max 4-5 pages)

- Main processes involved in land-atmosphere coupling in the Baltic Sea region
  - Biogeophysical effects
  - Biogeochemical effects
- Model representations of main processes in models applied to Baltic Sea region
  - Dynamic global vegetation models, e.g. LPJ-GUESS
  - Land surface schemes with static vegetation, e.g. SURFEX
  - RCMs with dynamic land surface properties, e.g. RCA-GUESS
- Model applications to study land-atmosphere coupling in the Baltic Sea region
  - SURFEX applications, RCA & RCA-GUESS studies,

Kommentiert [1]: Le Moigne, P. 2012. Surfex Scientific Documentation. Technical Report. Météo-France.

2.2 ocean-atmosphere coupling (**Ha, Matthias, Christian,** max. 5 pages**)**

- Development of different AORCMs for the Baltic Sea and the North Sea regions since last two decades (e.g., Gustafsson et al., 1998; Hagedorn et al., 2000; Meier and Döscher, 2002; Döscher et al., 2002; Schrum et al., 2003; Lehmann et al., 2004; Dieterich et al., 2013; Tian et al., 2013; Ho-Hagemann et al., 2015, 2017; Van Pham et al., 2014; Wang et al., 2015; Gröger et al., 2015; Dieterich et al. 2019)
- Coupling impact on cyclones in Europe have been investigated in some studies for hurricanes in the Mediterranean Sea (see Akhtar et al., 2014 and references therein). For the North Sea and Baltic Sea, to our knowledge by far, almost no study on this topic have been done. The main reason is that ocean models in the available coupled models for the North Sea and Baltic Sea often have a relatively small domain. They often cover the Baltic Sea and the North Sea only and the North Atlantic was not taken into account in these coupled models. The COSTRICE

coupled system developed by Ho-Hagemann et al. (2015, 2017) extended the ocean domain to the North Atlantic which allow them to analyse the impact of air-sea coupling on the heavy rainfall affected by the 'Vb' cyclones. However, the air-sea coupling impact on the storm track and intensity have not been investigated.

- Here we investigate the air-sea coupling impact on mid-latitude cyclones in a new AORCM coupled system GCOAST AHOI which were conducted to simulate the storm Christian happened in late October 2013 in northern Europe. We will evaluate simulated mean sea level pressure, wind speed, surface temperature, 2-m air temperature, 2-m relative humidity, precipitation, sensible and latent heat fluxes of the stand-alone atmospheric model CCLM and the coupled model GCOAST AHOI against ERA5 reanalysis data and available observation with a focus on extreme wind speed.
- The influence of European marginal seas on Vb cyclones has been investigated by Akhtar et al., 2019 using a suite of RCMs that included the Mediterranean and the North Sea and Baltic Sea.
- With the same coupled RCM Primo et al., under review looked at extreme events in Europe and found that temperatures are better represented in the coupled model compared to the uncoupled one.

2.3 ocean-wave-atmosphere coupling (**Anna Rutgersson, Lichuan Wu** max 4-5 pages)

-Some theoretical background concerning how and why the waves have an impact on the atmosphere as well as the ocean (impacts of wave-breaking, wave age and slope, Langmuir circulation and other aspects).

- The coupling impacts on different aspects of the coupled system for the Baltic and North Sea areas, this includes:

1) resolution/numerical effects

2) storm simulations

3) climate simulations

4) mesoscale features

2.4 hydrological coupling (**Stefan Hagemann**, C. Dieterich, max 4-5 pages)
Hydrological coupling = Closing the water cycle

a) Background on coupling and simulated discharge within ESMs
   - Importance focuses on Baltic Sea region
   - Frequently used in global ESMs, less frequently used in RESMs. Here, mostly by using rather coarse resolution discharge models (--> b)
b) Coupling to coarse resolution discharge models
   - Coupled model examples and applications
c) Coupling to high resolution discharge models
   - Mostly limited by computational effort, so that they are either used only for short time periods or on relatively small domains. → Examples
   - First developments for applications on large domains and climate time scales

Kommentiert [2]: Stefan: Note that I already have some basic text that comprises a short summary of what I plan to extend in some more detail to write an initial draft of the subsection. But this is in my office and as I am sick at home since yesterday I couldn't include it, here.

3. Uncertainties and gaps (all, 2-3 pages**)**

- **Future projections of land-atmosphere coupling: how to initialize the land surface state?**
- **How do we produce detailed land use scenarios at appropriate resolutions for detailed studies of the Baltic Sea areas?**
- **How do we close some of the current missing links between modelled subsystems, e.g. land-ocean/freshwater, land-atmosphere BVOC & aerosols/precursors from wildfire?**

3. Conclusions and key messages (max 1 page)

References

Mathis, M., Elizalde, A., Mikolajewicz, U., (2017). Which complexity of regional climate system models is essential for downscaling anthropogenic climate change in the Northwest European Shelf? Climate Dynamics, doi:10.1007/s00382-017-3761-3

keyswords: article clearly shows that ocean only simulations are sticked too strongly to the driving atmosphere, importance of model domain
M. Mathis, A. Elizalde, U. Mikolajewicz, (2019),The future regime of Atlantic nutrient supply to the Northwest European Shelf, Journal of Marine Systems, 189, 98-115, DOI:10.1016/j.jmarsys.2018.10.002.-

Alari V., J. Staneva, O. Breivik, JR Bidlot, K. Mogensen and P. Janssen (2016): Response of water temperature to surface wave effects in the Baltic Sea: simulations with the coupled NEMO-WAM model. Ocean Dynamics, Vol. 66, Issue 8, pp 917-930. doi.org/10.1007/s10236-016-0963-x

Staneva, J., K. Wahle, H. Günther and E. Stanev (2016): Coupling of wave and circulation models in coastal-ocean predicting systems: a case study for the German Bight. Ocean Science, 12, 797–806. doi.org/10.5194/os-12-797-2016

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Wahle, K., J. Staneva, W. Koch, L. Fenoglio-Marc, H.T.M. Ho-Hagemann and E.V. Stanev (2017): An atmosphere-wave regional coupled model: improving predictions of wave heights and surface winds in the Southern North Sea. Ocean Sci., 13, 289–301, 2017. http://dx.doi.org/10.5194/os-13-289-2017

Primo, C., Kelemen, F. D., Feldmann, H., Ahrens, B.: A regional atmosphere-ocean climate system model (CCLMv5.0clm7-NEMOv3.3-NEMOv3.6) over Europe including three marginal seas: on its stability and performance, Geoscientific Model Development Discussions, 2019, 1-33, 10.5194/gmd-2019-73, 2019

Akhtar, Naveed, Krug, Amelie, Brauch, Jennifer, Arsouze, Thomas, Dieterich, Christian, Ahrens, Bodo: European Marginal Seas in a regional atmosphere-ocean coupled model and their impact on Vb-cyclones and associated precipitation, Clim Dynam, 2019, 1-33, 10.1007/s00382-019-04906-x, 2019