Discussion review of anonymous referee #1:

This manuscript documents the coupling of an unstructured-grid atmospheric model (ICON, configured as a limited-area model) with a structured-grid coastal ocean model (GETM). It clearly describes the technical route and the model simulations. The utilization of a community-based coupler (NUOPC/ESMF) is a good example for other people who have similar interests. I believe that this work fits within the scope of GMD and deserves publication. My major concern is about its scientific quality. While I think GMD appreciates technical work and interdisciplinarity, the current manuscript (as a model description paper) does not offer enough information that could be useful to the general readers. The major conclusion merely summarized what the authors have done: âĂIJThe demonstration example shows that there is now a coupled model available which allows the investigation of processes at the air-sea interface with high-resolved model simulations.âĂİ I do believe that the manuscript offers more than that, and it can be further improved. I have some questions and comments which might be helpful to the authors.

Many thanks to the reviewer for his motivating criticism.

1. *I find one useful aspect of this manuscript is to offer an example of coupling an unstructured-grid atmospheric model with a structured-grid ocean model, based on a community coupler (NUOPC/ESMF). It would be valuable to put the current work into a broader background. Is there any earlier study that has already explored along this line (including global and regional configuration)? If so, the authors should give a general overview; if not, the present work would be more unique and the authors should explicitly speak out.*

   Motivated by this comment, we rewrote the introduction and more clearly present the novelty of our work:

   "There is an ongoing effort to implement the new NUOPC layer into model systems and equip many popular models with a NUOPC interface under the umbrella of the Earth System Prediction Suite [35]. However, until now, there exists only a limited number of publications about its integration. The functioning of the NUOPC layer within the Regional Earth System Model was described by Turuncoglu [36]. Sun et al. [34] developed the regional integrated prediction system SKRIPS based on NUOPC, coupling the atmosphere model WRF and the nonhydrostatic ocean model MITgcm [21]. Only very recently, a coupled unstructured-grid model application consisting of the ocean model ADCIRC [19] and the wave model WAVEWATCH III [38] within the NUOPC-based NOAA Environmental Modeling System (NEMS; `https://www.emc.ncep.noaa.gov/emc/pages/infrastructure/nems.php`) was reported by Moghimi et al. [22].

   Despite the potential of the ESMF echange grid, its implementation and usage in a mediator component has not been published, yet."

2. *What is the major challenge of coupling an unstructured-grid atmospheric model with a structured-grid coastal ocean model? Or more general, any unstructured-grid model (atmosphere/ocean) with a structured-grid model.*

   In Section "3.4 Regridding", we now write:

"One major challenge for the coupling between the unstructured grid of ICON and the structured grid of GETM is the interpolation of data on scattered nodes. The irregularity of the unstructured grid complicates the selection of the stencil. The correct interpolation weights for a conservative interpolation require the determination of the intersections of the source and target grids, and the calculation of the resulting areas. The processing of distributed neighbor information in unstructured grids also requires performant data structures and algorithms. The ESMF exchange grid (`ESMF_XGrid`) and the associated interpolation weights stored in the `ESMF_RouteHandle` hide all these aspects from the user and provide an efficient and automatic conservative interpolation infrastructure."

3. *What is the unique aspect of using NUOPC for this particular work? In comparison with other community-based couplers such as OASIS. ItâĂŹs also useful to briefly review the existing coupled models based on NUOPC.*

   We now more clearly state the unique aspects of NUOPC in the introduction:

   "Key technical aspects of coupled model systems are the coordinated execution of and the data exchange between the individual models. Required infrastructure for time management, communication between different nodes and interpolation between different grids is provided by various coupling libraries, e.g. MCT, OASIS, ESMF. Coupling frameworks, like the Earth System Modeling Framework [ESMF; 12], provide an additional superstructure layer which offers a standardized execution of models as model components and data exchange in coupler components. On top of ESMF, the National Unified Operational Prediction Capability (NUOPC) layer [35] defines generic components which offer a unified and automated driving of coupled model systems. The generic components require only minimum specialization for the individual models, e.g. registration of routines for initialization and time step advance, definition of required import and possible export data. NUOPC automatically negotiates the data exchange between individual model components based on standard names and synonyms from a dictionary. All required information about the different model grids and their distribution across processors from the models are received during runtime. Therefore, models once equipped with a NUOPC-compliant interface can be plugged into any other coupled model system driven by NUOPC, without the need to adapt coupling specifications.

   NUOPC supports a seamless data exchange and interpolation between models operating on different grids via so called connectors. In addition, NUOPC offers mediator components to perform e.g. merging, time-averaging and interface flux calculations on a hub between several models. With ESMF/NUOPC, it is also possible to perform these calculations on automatically generated exchange grids. They have been introduced in Balaji et al. [1] as the union of two rectangular grids. ESMF extended this functionality to unstructured grids, with the final exchange grid obtained by a triangulation of the union. This triangulation is the basis for conservative interpolation. Moreover, the ESMF exchange grid considers the masking of the original grids, e.g. land/sea mask, such that fluxes can be calculated in a physically consistent way."

For the review of existing coupled models based on NUOPC please see our reply to major point #1 above.

4. *It would be useful to give more details on the construction of a coupled model within NUOPC, for instance, showing some prototype codes to allow people who have similar interests to learn from the authorsâĂŹ work (e.g., https://www.earthsystemcog.org/projects/nuopc/protocodes/). This would be mostly relevant to the value of this work. While I understand that ICON has a license restriction, it would be useful to present the interface of atmosphere/ocean and their positions in the NUOPC/ESMF layer, without freely releasing the actual code of each model component.*

   All details on the construction of the coupled model system in the ICON-GETM source code are now freely available from `https://gitlab.com/modellers-tropos/icongetm.git`. The *Code availability* section has been updated with new Zenodo dois for the used ICONGETM version (doi:10.5281/zenodo.4516568 - open access) and for the modified ICON code (doi:10.5281/zenodo.4432739 - restrictive access). In addition, Fig. 1 has been modified, where now all elements of the NUOPC coupling are interactively linked to the corresponding locations in the source code. Furthermore, we now added to Sec. 2.3:

   "The implementation of the NUOPC layer in ICONGETM was inspired by the prototype codes `AtmOcnMedPetListProto`, `AtmOcnTransferGridProto`, `CustomFieldDictionaryProto` and `AtmOcnFDSynoProto` as well as `AtmOcnConProto` from `https://earthsystemmodeling.org/nuopc/#prototype-applications`."

5. *The added value of two-way coupling for a high-resolution atmosphere/coastal ocean model is not clearly demonstrated. Such benefits should be explicitly stated in the conclusion to allow the readers better understand the importance of this work. Some of the figures are redundant, and some of them do not give enough information (see minor points). The authors need to better describe the gains of the coupled simulations for atmosphere and ocean, respectively.*

   The well-known added value of two-way coupling for high-resolution atmosphere-ocean models is now stated in the introduction and used to clearly motivate our work with focus on the technical implementation of the latest ESMF/NUOPC coupling technologies:

   "In numerous studies, the added value of two-way coupled atmosphere-ocean models has been demonstrated. Interactive model coupling is important for representing the mutual interactions and feedbacks between atmosphere and ocean dynamics [e.g., 6]. The sea surface temperature (SST) of the ocean determines moisture fluxes into the atmosphere and the stability of the atmospheric boundary layer [10]. The modulated surface wind in turn affects surface currents and mixing in the ocean, both altering SST patterns. This air-sea interaction is very dynamic and strongly sensitive to fronts and eddies [33, 29]. In the coastal ocean, fronts are further pronounced due to upwelling and river run-off. Therefore, especially high-resolution coastal applications, where sharp gradients and small-scale eddies are resolved, can benefit from two-way coupled atmosphere-ocean

models.
The atmosphere model COAMPS [13] and the regional ocean model ROMS [30] were coupled with the Model Coupling Toolkit [MCT; 15] for investigating an upwelling event with a 1 km high resolution [23]. In the following decade, numerous high resolution studies were performed with the two-way coupled model system COAMPS-NCOM, in which COAMPS was originally coupled via MCT with the coastal ocean model NCOM [2]. Pullen et al. [26, 24] demonstrated the improved skill of the two-way coupled model system during Bora events in the Adriatic Sea, simulated down to a resolution of 4 km in the atmosphere and 2 km in the ocean. With the same resolution and a coupling time step of 12 min, the model system has been applied to the Ligurian Sea and confirmed the importance of the interactive model coupling in the coastal zone [32]. The impact of coastal orography was investigated in a 2 km simulation of Madeira Island [25]. Another two-way coupled model system widely applied in high-resolution studies is COAWST [37]. The atmosphere model WRF [31], ROMS and the wave model SWAN [3] are coupled with MCT. COAWST has been applied for a realistic hindcast of a storm event over the Gulf of Lion and the Balearic Seas with a resolution of 3 km in the atmosphere and 1.8 km in the ocean [28]. In another application, a Bora event and the dense water formation in the Adriatic sea with 7 km resolution in the atmosphere and 1 km in the ocean was simulated [5]. Both studies investigated the effects of different coupling strategies and demonstrated the benefit of the fully coupled model system. Recently, the high-resolution regional coupled environmental prediction system UKC for the northwest European Shelf has been developed [17, 18]. On a 1.5 km high resolution, the atmosphere model MetUM [9, 4] was coupled with the ocean model NEMO [20] via OASIS3-MCT [8]. First results demonstrate reduced bias in SST fields [16] and impacts on cloud and fog formation over the North Sea [11, 10]."

We refer to the effects of the two-way coupling in Sec. 4.2, when we evaluate the results of our demonstration example for the successfully developed coupled model system.

However, an in-depth analysis of the high-resolution air-sea interactions during a specific event and focused on a local scale is out of the scope for our initial technical model description paper and planned as a follow-up study. Instead, the focus of our paper is the added value and potential of using the ESMF exchange grid in ICONGETM, which is now discussed in more detail in the Discussion section:

"ICONGETM supports the exchange of fluxes and state variables across the air-sea interface. The applied ESMF exchange grid guarantees a conservative flux exchange. The NUOPC-Mediator performs additional unit conversion and merging of precipitation fluxes, see Tab. 1. In ICONGETM v1.0, the air-sea fluxes are taken from the atmosphere model ICON. Their calculation in ICON is very complex and deeply nested in the model code. However, in later releases the air-sea fluxes should be calculated in the mediator, in terms of state variables received from atmosphere and ocean. Their calculation directly on the ESMF exchange grid also solves the problem of different land/sea masks [1] and ensures physical consistency in the sense that no fluxes calculated over land, i.e. not influenced by the sea surface temperature, are provided to the ocean. Without an ESMF exchange grid creep, nearest neighbor and other extrapolation methods might be required [see e.g. 14, 7, 36], especially if an atmosphere model with low spatial resolution is coupled. Fluxes provided by the mediator can be applied in the atmosphere and ocean over the same period until new fluxes are calculated in the next coupling time step. Besides this physical and energetic consistency, the flux calculation on the ESMF exchange grid in a central mediator component also offers the most straight-forward extension of the coupled system by models for e.g. waves and sea ice."

This is now also stated in the conclusion.

Regarding the redundancy of the figures please see our reply to minor point #5 below.

Minor points:

1. *Section 2.1, Line 60: when mentioning âĂIJthe usage of nonhydrostatic Euler equations on global domainsâĂİ, I think Gassmann and Herzog (2008) is an important work for ICON and should be cited among others.*

   Added reference.

2. *Lines 65-70: the description here is a little bit disorganized. It would be useful to say something like âĂIJThe atmospheric component of ICON can be configured to various models (e.g., LES, NWP, climate) by coupling a common dynamical core with different physics packages. The model used in this study is a configuration led by DWD, mainly used for high-resolution NWP applications. Some physics schemes largely inherit the COSMO model."*

   Added and adopted the suggested details to the description.

3. *Section 2.1: The YAC library, which is the coupler for ICON-ESM, is also mentioned here. Is it possible for YAC to do the work of this paper?*

   Sure, but the implementational effort would be high. According to the latest documentation from `https://dkrz-sw.gitlab-pages.dkrz.de/yac/`, YAC does not offer the same built-in functionality as NUOPC e.g. generic automated driving of coupled model systems and the features of the ESMF exchange grid.

4. *Line 205: pressure levels? It seems to me ICON is using a height-based vertical coordinate.*

   It is now clearly stated:

   "The vertical terrain-following hybrid grids consist of 90, 65 and 54 height-based vertical levels. The heights are pre-defined depending on the associated pressure in the US 1976 standard atmosphere, with the top boundary of the model domain depending on the numbers of levels [27, Fig. 3.5]."

5. *Figures 7 and 8, they are basically telling the same thing as 2-m air temperature is intimately connected with surface temperature.*

   Agreed, (sea) surface and 2 m air temperature are closely related. On the other hand, while the sea surface temperature in either case only represents a lower boundary condition for the atmospheric model, the $2\,m$ air temperature actually shows a response of the ICON model, which was important for us to show. This is also reflected for example by signatures of ocean eddies in SST as well as effect of land and uncoupled ocean surface on $2\,m$ air temperature.

6. *From Fig. 9, it is unclear that the two-way coupled model performs better than the uncoupled one. I understand that after 10 days, temperature is overall enhanced by the coupled model, but such a qualitative comparison is not enough for a scientific journal, especially when demonstrating an issue that is mostly relevant to the value of this work. I think the authors need some additional quantitative metrics to confirm the improvement (e.g., correlation coefficient, averaged temperature over a certain period).*

   A short statistical evaluation is now added to Sec. 4.2.1:

   "The average deviation from the modelled and measured temperature is about $1.6\,K$ / $1.5\,K$ and $1.9\,K$ / $2.0\,K$ for the two-way coupled and uncoupled simulations from 01 / 10 July 2012 onward, respectively. This is a significant improvement of about 15%/ 25%, respectively. However, the Pearson correlation coefficient is only slightly improved, i.e. 0.7158 / 0.7487 and 0.6996 / 0.7336 for the two-way coupled and uncoupled simulations from 01 / 10 July 2012, respectively. The more reduced average deviation and higher correlation of the two-way coupled simulations after 10 July 2012 is related to the spin up of the model, since GETM is initialized as hot start while ICON uses the IFS reanalysis data."

7. *Section 4.1.3, is there any guiding principle to obtain a good load balance in this coupled configuration. How do you draw the current conclusion about the number of cores for ICON and GETM.*

   The optimal load-balancing was estimated empirically in terms of minimum idle/waiting times for the single model components. The sentence in the text has been modified:

   "For the present setup a good concurrent load-balancing **with minimum idle/waiting times for the single model components was empirically** obtained with 864 processes for ICON and 384 processes for GETM."

Discussion review of anonymous referee #2:
This paper describes the implementation of the coupling between the atmospheric ICON model and the ocean GETM model using the ESMF/NUOPC coupling technology. It describes in particular the remapping between the unstructured atmosphere grid and the ocean structure grid, and vice-versa, using ESMF exchange grids available in ESMF regridding package. The impact of the two-way coupling is then analysed comparing in detail the results of two simulations of the central Baltic sea, one implementing two-way coupling and the other implementing only one-way coupling from the atmosphere to the ocean. It shows it particular that two-way coupling better represent the surface temperature as compared to the one-way coupling. The paper is clearly written and easy to follow, and explanations are well illustrated. It represents a nice description of a coupled application and would deserve publication in GMD, but only, I think, if the following major comment is addressed.

Many thanks to the Reviewer for his motivating critism.
Major comment:
In many places, you write that you implemented conservative interpolation between ICON and GETM, but from what I understood, I think this is not the case because of the non-matching sea-land masks in the two models. LetâĂŹs take Figure 5 but considering fluxes exchanged from the atmosphere to the ocean. One problem is how to calculate the flux, for example, for the lower left GETM cell. If one normalizes the flux calculation by the whole lower-left cell area (âĂIJdestareaâĂİ option in ESMF and SCRIP), then local conservation is ensured but non-physical values may result; if one normalizes by the intersected area (âĂIJfracareaâĂİ option in ESMF and SCRIP), then values will be physically sound but local conservation will not be ensured.

In ICONGETM, the interpolation is carried out via the ESMF exchange grid. This two-step procedure from the source to the exchange grid and further to the destination grid is a combination of the mentioned individual interpolation methods for a direct interpolation from a source to a destination grid. Therefore, interpolation via the ESMF exchange grid guarantees global conservation and physically reasonable interpolated quantities.

For example, in Figure 5, it is clear that fluxes coming from the atmosphere in âĂIJcase-2âĂİ regions would be lost as there is no corresponding ocean cell in GETM. The other problem is for the flux coming from case-2 atmosphere region; this part of the flux will not be transferred to any ocean cell and again local conservation will not be ensured.

A conservative interpolation ensures that e.g. the energy exchanged through a **common** area is conserved. For the data exchange between the atmosphere and ocean in ICONGETM, this is guaranteed by the implementation and use of the ESMF exchange grid. Of course, fluxes leaving the atmosphere not towards a common area with GETM are not further accounted in the atmosphere-ocean-system. A conservative atmosphere-ocean-system requires the surface area of the sea water fraction in an ICON cell being identical to the corresponding area in the exchange grid with GETM, see also next point.

The only way to set up a consistent atmosphere-ocean system and have a well-posed coupled problem, is to adopt the following best practice to defining coherent sea-land masks and sea fractions but it is applicable only if the atmosphere model can consider at least water and land sub surfaces. The original sea-land mask of the ocean model should be taken as is. For the atmosphere model, the fraction of *water in each cell should be defined by the conservative remapping of the ocean mask on the atmospheric grid. Therefore, the atmospheric coupling mask should be adapted associating a valid/active index to cells containing at least a fraction of sea. This method ensures that the total sea and land surfaces are the same in the ocean and atmosphere models, allowing global conservation of sea or land integrated quantities. Can you please comment on these important issues and clarify this in your manuscript?*

We absolutely agree with the reviewer. We double-checked the ICON code whether it is possible to implement this treatment, but modifications are far from trivial, at least for us, who are no developers of the ICON core. In the new Discussion section we now write: "Another feature missing in ICON is mixed land/ocean cells. However, for a fully coherent treatment of land/sea masks in the coupled system, ICON needs to consider the water fraction area of GETM from the exchange grid."

Minor comments:

- *p.1, l.20-21-22: I donâĂŹt understand why you give the example of the precipitation over sea, while you start by talking about precipitation over land. I would just remove the âĂIJe.g. by precipitation over seaâĂİ which is confusing, I think.*

  You are absolutely right. This sentence is now removed from the introduction.

  (After reorganizing the introduction, this part is now removed.)

- *p.2, l.43: for the OASIS reference, please use also: Craig A., Valcke S., Coquart L., 2017: Development and performance of a new version of the OASIS coupler, OASIS3-MCT_3.0, Geoscientific Model Development, 10, pp. 3297-3308, doi:10.5194/gmd-10-3297-2017*

  Added reference.

- *p.5, Table 1 captions: You write âĂIJIf graupel, ice and hail are activated in ICON, then the corresponding contributions to precipitation must also be considered.âĂİ but these are not explicit in Table 1 right? Maybe you should clarify this.*

  The sentence has been rephrased for clarification: "The corresponding contributions to precipitation from graupel, hail and ice are only considered for the coupling if they are activated in ICON."

  Graupel, ice and hail have been added to the table.

- *p.5, Table 1 captions: You write âĂIJThe humidity quantity is correctly identified by the name of the exchanged ESMF fieldâĂİ but I donâĂŹt understand what this means. More on this should be provided in the text?*

  It is now clearly written:

  "The **exchanged** humidity quantity **(dew point or relative humidity)** is correctly identified by the name attribute of the connected ESMF field".

- *p.5, Table 1 captions: You write âĂIJThe exchange of flux data (3rd block) or state variables (last block) offers the comparison of different coupling strategies within the same model environmentâĂİ but I donâĂŹt understand what this means. More on this should be provided in the text?*

Modified sentence:

"**The possibility to exchange either** flux data (3rd block) **or** state variables (last block) offers the comparison of different coupling strategies within the same model environment."

- *p.5, Table 1 captions: The last block is never exchanged as nothing appears in the last column? If so, why does it appear in the Table?*

  Because in Tab. 1 all quantities are listed that can be exchanged with the developed model system, not only the ones considered in the demonstration example.

- *p.13, l.239-240: Can you provide more precise numbers on the load balance obtained with 864 processes for ICON and 384 processes for GETM?*

  The optimal load-balancing was estimated empirically in terms of minimum idle/waiting times for the single model components. A systematic analysis was not conducted, because it would be applicable only for this specific setup anyway.

- *p.14, l.251: can you describe and locate the âĂIJupwelling regionsâĂİ more precisely?*

  The text was expanded accordingly:

  âĂIJIn July 2012, the simulated SST ranged around 289 K, with values below 282 K in the upwelling areas south of the coast of mainland Sweden and the islands of Öland and Gotland.âĂIJ

- *p.13, l.254: It could be relevant to mention Figure 9 when you write about the RV Meteor.*

  Added figure reference to text.

- *p.13, l.255: It would be helpful to locate the island of Gotland on one figure.*

  The white frames in Figs. 2 and 9 are showing the island of Gotland.

- *p.13, l.256-258: You state that âĂIJthe values from the two-way coupled ICONGETM run are in the same range as the measurements and the temporal development also agrees much better with the observationsâĂIJ. I agree this is obviously the case after 10 days but not so obvious for the first days; can you better quantify the improvement, maybe by providing a correlation coefficient.*

  A short statistical evaluation is now added to Sec. 4.2.1:

  "The average deviation from the modelled and measured temperature is about 1.6 K / 1.5 K and 1.9 K / 2.0 K for the two-way coupled and uncoupled simulations from 01 / 10 July 2012 onward, respectively. This is a significant improvement of about 15%/ 25%, respectively. However, the Pearson correlation coefficient is only slightly improved, i.e. 0.7158 / 0.7487 and 0.6996 / 0.7336 for the two-way coupled and uncoupled simulations from 01 / 10 July 2012, respectively. The more reduced average deviation and higher correlation of the two-way coupled simulations after 10 July 2012 is related to the spin up of the model, since GETM is initialized as hot start while ICON uses the IFS reanalysis data."

- *p. 15, Figure 9: Which area is more precisely concerned, when you write âĂIJEastern Gotland BasinâĂİ? Could you give the latitudes and longitudes of the region and maybe show it on one of the figures?*

  The ship track is now presented on the right panel of Fig. 9.

- *p.15, l.269: Can you locate more precisely the âĂIJarea east of ÖlandâĂİ?*

  Added reference to marker in Fig. 8.

- *p.16, l. 274: can you give a definition of âĂIJcentralâĂİ and âĂIJupperâĂİ part of the boundary layer in meters so to refer to Fig. 12?*

  It is now clearly written: "... in the central to upper part of the boundary layer, between 900 m and 2400 m in the left panel of Fig. 12. Due to reduced evaporation, it is less in the lowermost part, below 500 m in the left panel of Fig. 12."

- *p.16, l.277: you write âĂIJto the strengthening of the local land-sea circulation (cf. Fig. 11)âĂİ. I donâĂŹt clearly see this, can you describe this in more details?*

  The description has been reworded:

  "In addition, there is less momentum mixed downwards (not shown), which is a likely explanation for the locally reduced wind velocity in the upwelling regions at SwedenâĂŹs mainland coast and the Öland and Gotland islands, shown by negative differences in the central panel of Fig. 11. In the coupled case, the temperature gradient between land and sea is increased in the area of the upwelling, cf. Fig. 8, with almost the same land temperatures but significantly lower SSTs, which locally increases the onshore wind component and thus weakens the overall more easterly wind in Fig. 11."

- *p.17, l.295: You could refer to Figure 15 C and D.*

  Done as suggested.

- *p.18, l.305: What does âĂIJcannot be switched off by minor changesâĂİ mean?*

  We now write:

  "In ICONGETM v1.0, the air-sea fluxes are taken from the atmosphere model ICON. Their calculation in ICON is very complex and deeply nested in the model code."

  Therefore, the flux calculation cannot easily be moved to the mediator.

- *p.18, l. 310-312: These sentences describe what should be implemented ideally. You should replace âĂIJcanâĂİ by âĂIJcouldâĂİ (l.310) and âĂIJis doneâĂİ by âĂIJshould be doneâĂİ (l.312)*

  The whole part of the discussion on flux exchange via a mediator has been modified.

Other comments:

- *p.1, l.4: replace âĂIJThe work achieved the development ...âĂİ by âĂIJWe present here the development ...âĂİ*

  Modified sentence.

- *p.1, l.19: add âĂIJbutâĂİ before âĂIJlaterâĂİ*

  After reorganizing the introduction, this part is now removed.

- *p.1, l.20-21: Start the sentence with âĂIJHowever, for most ...âĂİ and remove it on line 21.*

  After reorganizing the introduction, this part is now removed.

- *p.2, l.31: Replace âĂIJshowâĂİ by âĂIJhaveâĂİ*

  After reorganizing the introduction, this part is now removed.

- *p.2, l.34-35-36: These sentences use âĂIJThe latterâĂİ and âĂIJTheyâĂİ and âĂIJthemâĂİ; I suppose these designate the âĂIJcoastally trapped wavesâĂİ but it could be made more explicit for clarity.*

  After reorganizing the introduction, this part is now removed.

- *p.4, Figure 1 captions: replace âĂIJby arrowsâĂİ with âĂIJby horizontal arrowsâĂİ?*

  No, all arrows repesent generic NUOPC operations.

- *p.4, l.95: consider rewriting the last part of the sentence as âĂIJ... and only individual specification routines need to be implemented for the model and coupler components.âĂİ*

  Rephrased sentence.

- *p.16, l.284: you talk about the surface heat flux, but these are not shown in any figure right? If so, you should add âĂIJ(not shown)âĂİ.*

  Added "not shown".

Bibliography

[1] V. Balaji et al. "The Exchange Grid: A mechanism for data exchange between Earth System components on independent grids". In: *Parallel Computational Fluid Dynamics 2005*. Elsevier, 2006, pp. 179–186. DOI: 10.1016/B978-044452206-1/50021-5.

[2] Charlie N. Barron et al. "Formulation, implementation and examination of vertical coordinate choices in the Global Navy Coastal Ocean Model (NCOM)". In: *Ocean Modelling* 11.3-4 (2006), pp. 347–375. ISSN: 14635003. DOI: 10.1016/j.ocemod.2005.01.004.

[3] N. Booij, R. C. Ris, and L. H. Holthuijsen. "A third-generation wave model for coastal regions: 1. Model description and validation". In: *Journal of Geophysical Research: Oceans* 104.C4 (1999), pp. 7649–7666. ISSN: 01480227. DOI: 10.1029/98JC02622.

[4] Andrew Brown et al. "Unified Modeling and Prediction of Weather and Climate: A 25-Year Journey". In: *Bulletin of the American Meteorological Society* 93.12 (2012), pp. 1865–1877. ISSN: 1520-0477. DOI: 10.1175/BAMS-D-12-00018.1.

[5] Sandro Carniel et al. "Scratching beneath the surface while coupling atmosphere, ocean and waves: Analysis of a dense water formation event". In: *Ocean Modelling* 101 (2016), pp. 101–112. ISSN: 14635003. DOI: 10.1016/j.ocemod.2016.03.007.

[6] Dudley B. Chelton and Shang-Ping Xie. "Coupled Ocean-Atmosphere Interaction at Oceanic Mesoscales". In: *Oceanography* 23.4 (2010), pp. 52–69. ISSN: 10428275. DOI: 10.5670/oceanog.2010.05.

[7] Sue Chen et al. "Effect of Two-Way AirâĂŞSea Coupling in High and Low Wind Speed Regimes". In: *Monthly Weather Review* 138.9 (2010), pp. 3579–3602. ISSN: 1520-0493. DOI: 10.1175/2009MWR3119.1.

[8] Anthony Craig, Sophie Valcke, and Laure Coquart. "Development and performance of a new version of the OASIS coupler, OASIS3-MCT_3.0". In: *Geoscientific Model Development* 10.9 (2017), pp. 3297–3308. ISSN: 1991-9603. DOI: 10.5194/gmd-10-3297-2017.

[9] Michael J.P. Cullen. "The unified forecast/climate model". In: *Meteorological Magazine* 122 (1993), pp. 81–94.

[10] Joachim Fallmann et al. "Impact of highâĂŘresolution oceanâĂŞatmosphere coupling on fog formation over the North Sea". In: *Quarterly Journal of the Royal Meteorological Society* 145.720 (2019), pp. 1180–1201. ISSN: 0035-9009. DOI: 10.1002/qj.3488.

[11] Joachim Fallmann et al. "Impact of sea surface temperature on stratiform cloud formation over the North Sea". In: *Geophysical Research Letters* 44.9 (2017), pp. 4296–4303. ISSN: 00948276. DOI: 10.1002/2017GL073105.

[12] Chris Hill et al. "The architecture of the earth system modeling framework". In: *Computing in Science & Engineering* 6.1 (2004), pp. 18–28. ISSN: 1521-9615. DOI: 10.1109/MCISE.2004.1255817.

[13] Richard M. Hodur. "The Naval Research Laboratory's Coupled Ocean/Atmosphere Mesoscale Prediction System (COAMPS)". In: *Monthly Weather Review* 125.7 (1997), pp. 1414–1430. ISSN: 0027-0644. DOI: 10.1175/1520-0493(1997)125<1414:TNRLSC>2.0.CO;2.

[14] A. Birol Kara, Alan J. Wallcraft, and Harley E. Hurlburt. "A Correction for Land Contamination of Atmospheric Variables near LandâĂŞSea Boundaries*". In: *Journal of Physical Oceanography* 37.4 (2007), pp. 803–818. ISSN: 1520-0485. DOI: 10.1175/JPO2984.1.

[15] Jay Larson, Robert Jacob, and Everest Ong. "The Model Coupling Toolkit: A New Fortran90 Toolkit for Building Multiphysics Parallel Coupled Models". In: *The International Journal of High Performance Computing Applications* 19.3 (2005), pp. 277–292. ISSN: 1094-3420. DOI: 10.1177/1094342005056115.

[16] Huw W. Lewis et al. "Evaluating the impact of atmospheric forcing and airâĂŞsea coupling on near-coastal regional ocean prediction". In: *Ocean Science* 15.3 (2019), pp. 761–778. ISSN: 1812-0792. DOI: 10.5194/os-15-761-2019.

[17] Huw W. Lewis et al. "The UKC2 regional coupled environmental prediction system". In: *Geoscientific Model Development* 11.1 (2018), pp. 1–42. ISSN: 1991-9603. DOI: 10.5194/gmd-11-1-2018.

[18] Huw W. Lewis et al. "The UKC3 regional coupled environmental prediction system". In: *Geoscientific Model Development* 12.6 (2019), pp. 2357–2400. ISSN: 1991-9603. DOI: 10.5194/gmd-12-2357-2019.

[19] R. A. Luettich, Jr., J. J. Westerink, and Norman W. Scheffner. *ADCIRC: An Advanced Three-Dimensional Circulation Model for Shelves, Coasts, and Estuaries. Report 1. Theory and Methodology of ADCIRC-2DDI and ADCIRC-3DL.* Tech. rep. Vicksburg, MS: Coastal Engineering Research Center, 1992.

[20] Gurvan Madec et al. *NEMO ocean engine (Version v3.6-patch).* Tech. rep. Pôle De Modélisation De L'institut Pierre-simon Laplace (IPSL), 2017. DOI: 10.5281/ZENODO.3248739.

[21] John Marshall et al. "A finite-volume, incompressible Navier Stokes model for studies of the ocean on parallel computers". In: *Journal of Geophysical Research: Oceans* 102.C3 (1997), pp. 5753–5766. ISSN: 01480227. DOI: 10.1029/96JC02775.

[22] Saeed Moghimi et al. "Development of an ESMF Based Flexible Coupling Application of ADCIRC and WAVEWATCH III for High Fidelity Coastal Inundation Studies". In: *Journal of Marine Science and Engineering* 8.5 (2020), p. 308. ISSN: 2077-1312. DOI: 10.3390/jmse8050308.

[23] Natalie Perlin et al. "Numerical Simulation of AirâĂŞSea Coupling during Coastal Upwelling". In: *Journal of Physical Oceanography* 37.8 (2007), pp. 2081–2093. ISSN: 1520-0485. DOI: 10.1175/JPO3104.1.

[24] Julie Pullen et al. "Bora event variability and the role of air-sea feedback". In: *Journal of Geophysical Research* 112.C3 (2007), C03S18. ISSN: 0148-0227. DOI: 10.1029/2006JC003726.

[25] Julie Pullen et al. "Modeling the airâĂŘsea feedback system of Madeira Island". In: *Journal of Advances in Modeling Earth Systems* 9.3 (2017), pp. 1641–1664. ISSN: 1942-2466. DOI: 10.1002/2016MS000861.

[26] Julie Pullen, James D. Doyle, and Richard P. Signell. "Two-Way AirâĂŞSea Coupling: A Study of the Adriatic". In: *Monthly Weather Review* 134.5 (2006), pp. 1465–1483. ISSN: 1520-0493. DOI: 10.1175/MWR3137.1.

[27] Daniel Reinert et al. *Database Reference Manual for ICON and ICON-EPS*. Tech. rep. Offenbach: DWD, 2020. DOI: 10.5676/DWD_pub/nwv/icon_1.2.12.

[28] Lionel Renault et al. "Coupled atmosphere-ocean-wave simulations of a storm event over the Gulf of Lion and Balearic Sea". In: *Journal of Geophysical Research: Oceans* 117.C9 (2012), n/a–n/a. ISSN: 01480227. DOI: 10.1029/2012JC007924.

[29] Mingming Shao et al. "The Variability of Winds and Fluxes Observed Near Submesoscale Fronts". In: *Journal of Geophysical Research: Oceans* 124.11 (2019), pp. 7756–7780. ISSN: 2169-9275. DOI: 10.1029/2019JC015236.

[30] Alexander F. Shchepetkin and James C. McWilliams. "The regional oceanic modeling system (ROMS): a split-explicit, free-surface, topography-following-coordinate oceanic model". In: *Ocean Modelling* 9.4 (2005), pp. 347–404. ISSN: 14635003. DOI: 10.1016/j.ocemod.2004.08.002.

[31] William C. Skamarock et al. *A Description of the Advanced Research WRF Version 2*. Tech. rep. UCAR, 2005. DOI: 10.5065/D6DZ069T.

[32] R. J. Small et al. "AirâĂŞSea Interaction in the Ligurian Sea: Assessment of a Coupled OceanâĂŞAtmosphere Model Using In Situ Data from LASIE07". In: *Monthly Weather Review* 139.6 (2011), pp. 1785–1808. ISSN: 0027-0644. DOI: 10.1175/2010MWR3431.1.

[33] R. J. Small et al. "AirâĂŞsea interaction over ocean fronts and eddies". In: *Dynamics of Atmospheres and Oceans* 45.3-4 (2008), pp. 274–319. ISSN: 03770265. DOI: 10.1016/j.dynatmoce.2008.01.001.

[34] Rui Sun et al. "SKRIPS v1.0: a regional coupled oceanâĂŞatmosphere modeling framework (MITgcmâĂŞWRF) using ESMF/NUOPC, description and preliminary results for the Red Sea". In: *Geoscientific Model Development* 12.10 (2019), pp. 4221–4244. ISSN: 1991-9603. DOI: 10.5194/gmd-12-4221-2019.

[35] Gerhard Theurich et al. "The earth system prediction suite: Toward a coordinated U.S. modeling capability". In: *Bulletin of the American Meteorological Society* 97.7 (2016), pp. 1229–1247. ISSN: 00030007. DOI: 10.1175/BAMS-D-14-00164.1.

[36] Ufuk Utku Turuncoglu. "Toward modular in situ visualization in Earth system models: the regional modeling system RegESM 1.1". In: *Geoscientific Model Development* 12.1 (2019), pp. 233–259. ISSN: 1991-9603. DOI: 10.5194/gmd-12-233-2019.

[37] John C. Warner et al. "Development of a Coupled OceanâĂŞAtmosphereâĂŞWaveâĂŞSediment Transport (COAWST) Modeling System". In: *Ocean Modelling* 35.3 (2010), pp. 230–244. ISSN: 14635003. DOI: 10.1016/j.ocemod.2010.07.010.

[38] The WAVEWATCH III Development Group WW3DG. *User Manual and System Documentation of WAVEWATCH III version 6.07.* Tech. rep. Tech. Note 33. NOAA/NWS/NCEP/MMAB, 2019.