Author response to the Referee Comments by Anonymous Reviewer 2 on the manuscript:

Conservation of heat and mass in P-SKRIPS version 1: the coupled atmosphere-ice-ocean model of The Ross Sea

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submitted to Geoscientific Model Developments (https://doi.org/10.5194/egusphere-2022-1135)

We thank the Reviewer for all the time and effort put into the review of our manuscript and are pleased with their positive and constructive comments. Please find the response to each of the comments below. The reviewer's comments are displayed in **bold text**, replies are shown in normal text, text from the original manuscript is shown in blue, and proposed changes to the manuscript are shown in red.

This is my first review of the manuscript entitled "Conservation of heat and mass in P-SKRIPS version 1: the coupled atmosphere-ice-ocean model of the Ross Sea". The authors first introduce the importance of regional climate modelling in Antarctica. They introduce various existing setups and explain the challenges related to energy conservation in these setups. Then, they present their setup, which they call P-SKRIPS, which is based on the SKRIPS model, with a focus on the Ross and a particular attention to the conservation of energy. They describe how their implementation improves the consistency and conservation of heat and mass fluxes between the climate (PWARF) and the ocean (MITgcm) components of the coupled system. They compare the SKRIPS and the P-SKRIPS over two months (one in winter, one in summer) and describe the impact of the improved flux conservation on the evolution of these fluxes.

The manuscript is generally well-written and pleasant to follow. The implementation and the setup are well-described and well-motivated. It is a significant contribution to the development of polar regional climate modelling and I would therefore recommend this manuscript for publication in GMD after my comments, generally minor, have been addressed.

1 Specific comments:

The abstract is short and to the point (congratulations!). However, I find that the expression "shows the advantages" is overstating the results of the manuscripts. This is at least a bit misleading, as I was expecting a more in-depth discussion of the scientific implication of heat conservation in the setup. I would suggest using "impacts" or "implications".

We thank you for this remark and appreciate your appraisal of our abstaract. We will change the text accordingly.

P-SKRIPS v.1 shows the advantages of conserving heat flux over the Terra Nova Bay and Ross Sea polynyas in August 2016, eliminating the mismatch between total flux calculation in PWRF and MITgcm up to 922 W m^{-2}.

P-SKRIPS v.1 shows the implications of conserving heat flux over the Terra Nova Bay and Ross Sea polynyas in August 2016, eliminating the mismatch between total flux calculation in PWRF and MITgcm up to 922 W m^{-2}.

L57: It looks like there is an outdated Table reference in the manuscript file.

We thank you for highlighting this. This is an error as no table is planned to be inserted here, we will remove the reference to the table.

L69: "This is critical to avoid..." The introduction presents a good motivation for the study and is generally very well referenced, except maybe for this sentence (that is actually quite key to the focus of the study). I would recommend developing a bit on the importance of heat conservation. For instance, it is better when everything is conserved, but depending on the question that one tries to answer, this is not always critical. Can the authors show examples (ideally with references) where it is absolutely critical?

We agree that 'critical' might have been an overstatement. We propose to add some references and to soften the statement to:

This is critical to avoid model drift and inconsistencies between the two model components over long term simulations.

This is necessary when modelling long-term air-ocean fluxes and interactions, in order to avoid model drift and inconsistencies between the two model components. For example, the amount of heat transferred form the atmosphere into the ocean or sea ice can have an impact on upwelling (Morrison et al. 2015; Skinner et al. 2020) and sea ice extent (Cerovecki 2022), as well as impacting the atmospheric boundary layer processes (e.g. Alam and Curry 1995).

L116: "as is ordinary the case". This sentence is a bit confusing, ordinary for who? Do the authors mean a standard preprocessing described in WRF manual for instance? Do the authors have a reference for this?

We agree that this is not clear. The WRF manual indicates a series of standard steps to manipulate the original input files so that they can be ingested by the WRF program. WRF users are probably familiar with this, but we will include more details in the manuscript.

The preprocessing of the input files was conducted as is ordinarily the case,

The preprocessing of the WRF input files followed the standard procedure (ungrib.exe - metgrid.exe - real.exe, Wang et al. (2019)),

Figure 3: In the caption, I think there is a mistake with the references to the a,b,c,d panels (SKRIPS and P-SKRIPS are inverted).

Yes, thank you for pointing this out. This will be corrected.

L168: "The coupling ... ice sheet." I am sorry but I do not understand the end of this sentence.

The two models simulate different parts of the ocean-sea ice, snow and atmosphere components: the oceanic realm is in the ocean model, and the atmosphere is dealt with by the atmosphere model. Sea ice is composed of the ice floating on the ocean, and the snow layer on top of this block. The sea ice block changes and movement are dealt with in the ocean model, while the atmosphere model is responsible for the changes in snow cover (accumulation, compaction etc...) so the exchange interface between the two models is between the surface of the sea ice block and the snowpack that lays on top of it. Over the ice sheet, there is no ocean but there is a snowpack/firn, overlying pure ice. Typically an ice sheet model would take care of the ice dynamics (not present in this configuration) and the atmosphere model deals with snowpack changes (meltwater runoff for instance). In P-SKRIPS, this runoff is then exiting into the ocean. We agree that the ice sheet part (last part of the sentence) is confusing and probably not needed. We propose to rephrase as follows:

The coupling interface between models is defined as air-ocean over open ocean, between the sea ice and the snow on top of it, and below the snowpack on top of the ice sheet

The coupling interface between the atmosphere and ocean models is defined as (1) air-ocean over open ocean, (2) between the sea ice (changes and advection of sea ice simulated by the ocean model) and the snow layer on top of it (accumulation and compaction are dealt with by the atmosphere model).

L169: This paragraph seems to repeat some statements made in the previous paragraphs, statements that are repeated L208. This repetition, instead of clarifying things, makes them a bit more confusing in my opinion. Was this paragraph intended to be a short summary of the subsection? If yes, I would recommend either shortening it to maximum of 2 short sentences or removing it. (Same for L208–>214.)

We thank the reviewer for this remark. This is indeed repetitions that can be removed. We propose to keep the first paragraph, and remove the subsequent ones.

L217: I cannot find the introduction of the “exf” package before in the text. I would recommend giving a bit of context to the reader of what this package is.

Thank you, the exf package refers to the external forcing package in MITgcm and its decription can be found in the docmuentation: "The external forcing package, in conjunction with the calendar package (cal), enables the handling of real-time (or “model-time”) forcing fields of differing temporal forcing patterns. It comprises climatological restoring and relaxation. Bulk formulae are implemented to convert atmospheric fields to surface fluxes. An interpolation routine provides on-the-fly interpolation of forcing fields an arbitrary grid onto the model grid." We have added the full name "external forcing package (exf package)" the first time we mention it in the manuscript.

The import of surface fluxes in the external forcing package (exf package) is prohibited when using the sea ice package in a standard version of MITgcm

L218: “In the coupled setup”: The manuscript mostly focuses on coupled setups. Which one is referred to here?

We refer to our way of defining the model domains, that was set up to not to have to regrid or interpolate and have corresponding grids and the same ocean-land mask in the two models. This is the case, regardless of whether we use SKRIPS or

P-SKRIPS.

In the coupled set up, the sea ice mask is coordinated between PWRF and MITgcm, so the fluxes can be directly used in the sea ice packages, without any mask mismatch.

We have set up the two models with the same grid and the same ice-ocean mask between PWRF and MITgcm, so the fluxes can be directly used in the sea ice packages, without any mask mismatch.

L218: Not sure of what the authors mean with "coordinated"

As mentioned in the previous comment, we have 'coordinated' our efforts in setting up the models so that both have exactely the same grid, and the same ice-ocean mask. We will rephrase in the new version of the manuscript:

In the coupled set up, the sea ice mask is coordinated between PWRF and MITgcm, so the fluxes can be directly used in the sea ice packages, without any mask mismatch.

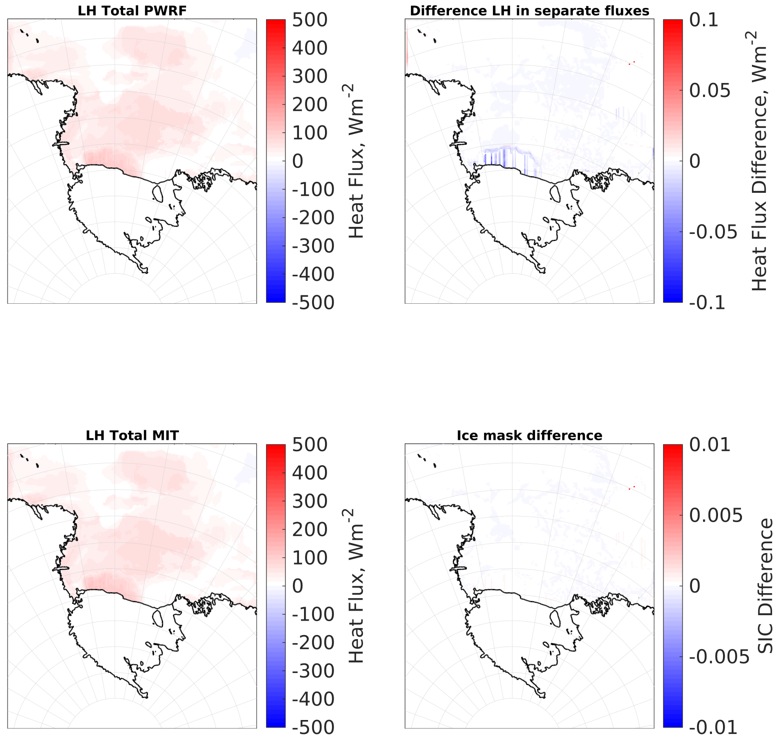
We have set up the two models with the same grid and the same ice-ocean mask between PWRF and MITgcm, so the fluxes can be directly used in the sea ice packages, without any mask mismatch.

Figure 6: The colorbar saturates a lot for the differences, so it is hard to believe there are only "subtle differences in the order of $10^{-3}W.m^{-2}$". There are weird also patterns (vertical lines north of the ice shelf) that are not well explained. Do the authors have an explanation for them?

The stripes are present over areas of low sea ice concentration (below 0.1 sea ice cover) and only in the first 10 days of the simulation. We attribute these to the spinup adjustment of the two models to the mismatch in the input data for sea ice cover and sea surface temperature: coming from ERA-5 for PWRF and from BSOSE for MITgcm. We have updated the figure caption to include the full range of the differences and include the figure with updated range for information below. We decided to keep the original figure in the text because we focus on the heterogeneity caused by the sea ice mask difference, which is close to $10^{-3}W.m^{-2}$.

(a) Latent Heat (LH) flux: total heat flux in PWRF using the capture of the Separate fluxes, (b) latent heat in MITgcm, (c) differences between (a) and (b) and (d) ice concentration mask difference between the two timesteps. See Section 3.1.2 for more details.

(a) Latent Heat (LH) flux: total heat flux in PWRF using the capture of the Separate fluxes, (b) latent heat in MITgcm, (c) differences between (a) and (b); (d) ice concentration mask difference between the two timesteps. The full range of differences for (c) is -0.08 to 0.02 $W.m^{-2}$. See Section 2.5 for more details.



[h]

L241: 104–>10^4 I suppose?

Correct. We will change this.

the scaling multiplication by X_{ICE}, which is 104

the scaling multiplication by X_{ICE}, which is $\sim 10^4$

Table S1 is very unclear. Please add context to its caption. Why is there a "Total" row, and why is it empty?

We agree that the caption is not clear. The table is meant to indicate the definition of each flux component, in each model (positive upward or downward). The TOTAL column is indeed not needed. We will update the Table accordingly.

"At midday… (Figure S4)". I do not understand the link between this comment on the flux evolution and the rest of the paragraph that discusses discrepancies in MITgcm fluxes between the two setups. I do not see larger discrepancies associated with these peaks.

We agree and propose to remove the sentence.

Figure S4 could belong to the main manuscript in my opinion. The same for Table 2. Just a suggestion.

We thank you for this suggestion, but we prefer to have them in the supplements.

Table 1. Import of heat and mass fluxes versus calculations in the two experiments

		MITgcm exf	MITgcm seaice	PWRF
HEAT	latent heat	↓	↑	↑
	sensible heat	↓	↑	↑
	short wave net	↑	↓	↓
	long wave net	↑	↑	↓
	TOTAL	↑	↑	-
MASS	evaporation	↑	-	↑
	precipitation	↓	-	↓
	sea ice runoff	↓	-	↓
	land runoff	↓	-	↓
	TOTAL			

Table 2. Sign definition of each flux, in each model component. ↓ indicates defined positive downward, ↑ indicates defined positive upward.

		MITgcm exf	MITgcm seaice	PWRF
HEAT	latent heat	↓	↑	↑
	sensible heat	↓	↑	↑
	short wave net	↑	↓	↓
	long wave net	↑	↑	↓
MASS	evaporation	↑	-	↑
	precipitation	↓	-	↓
	sea ice runoff	↓	-	↓
	land runoff	↓	-	↓

I find Figure 8 and S4 not very readable. I get why the authors want to show both the evolution of the fluxes and the differences between MITgcm and PWRF but doing both on the same figures means these differences are hard to see. I would really recommend plotting the differences on a different figure. At the very least, the authors could play with the width of the different lines, or add markers, to make it easier to distinguish what is what.

We thank you for this suggestion, we will add two new figures showing the differences and refer to them in the text, as appropriate. In addition, we will add two supplementary tables indicating the mean value for each of these timeseries and the differences.

Figure 8 displays the January 2016 time series for each of the integrated fluxes presented in Figure 6 and Figure 7. We integrate all flux components over the ocean (we ignore land), and present the fluxes at the atmosphere-ocean or snow-sea ice interface, following Figure 6 (through the coupling interface). The PWRF - P-SKRIPS, and MITgcm - P-SKRIPS curves

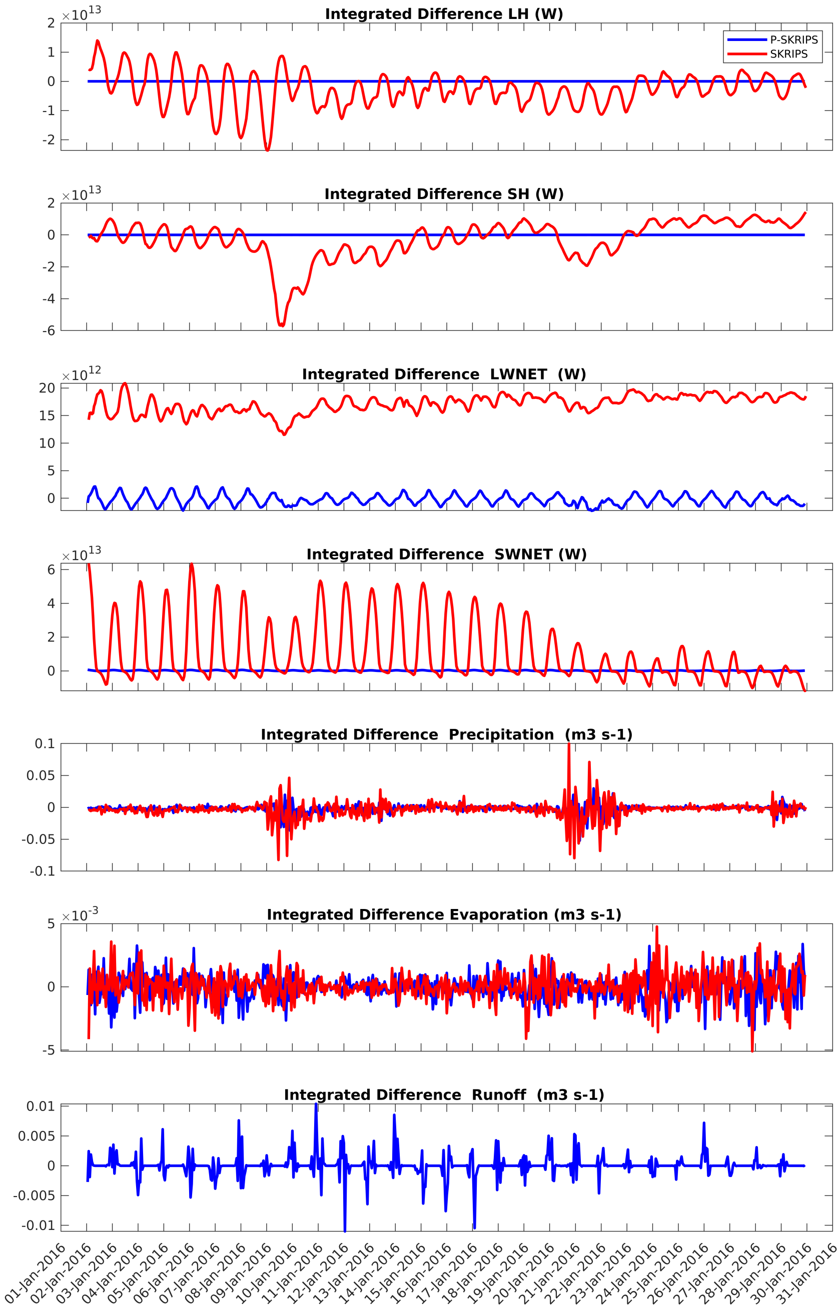


Figure 1. Differences of the integrated flux time series through the coupling interface for the January 2016 experiment. P-SKRIPS case is displayed in blue, SKRIPS case is in red. Heat fluxes are defined positive upwards, the evaporation is defined positive upwards, the precipitation and runoff are defined positive downwards. For more details see Section 3.3. For the August experiment results, see Figure S5.

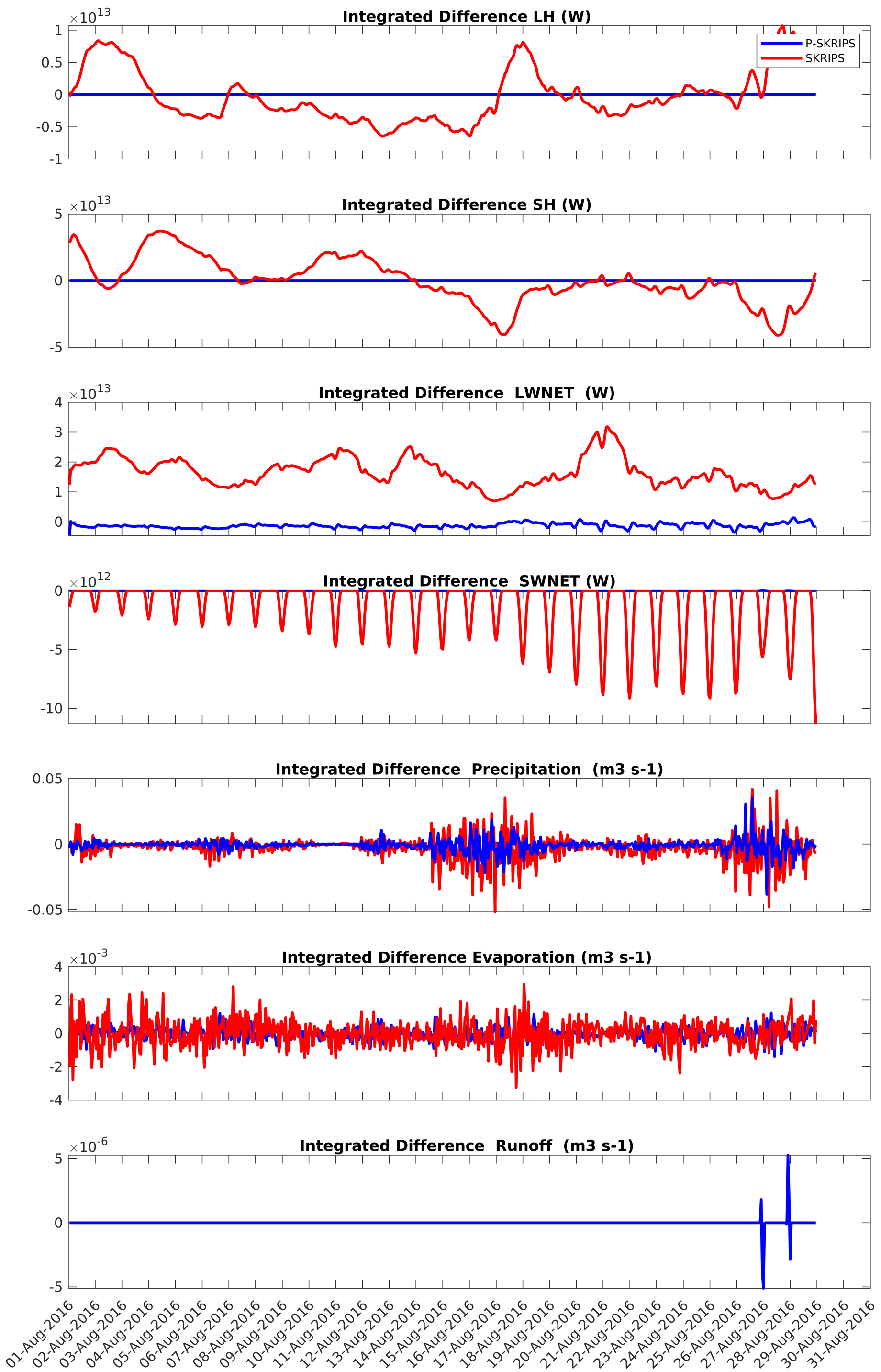


Figure 2. Same as Figure 9, but for August 2016 experiments.

overlap perfectly for each of the variables; they are identical. There are small differences in the PWRF flux variables between the P-SKRIPS and the SKRIPS cases, expressed either as larger minima (in the case of short wave fluxes) or as divergence over time. This is because the simulations show different responses to the conservation of fluxes versus parallel calculation. In summer, the incoming shortwave radiation is at its maximum in the middle of the day and the differences in albedo parameterization between PWRF and MITgcm account for the variations in the magnitude of the shortwave peak.

The largest discrepancies in heat fluxes are between the MITgcm results from the direct import method used in P-SKRIPS case and the independent calculation used in the SKRIPS case. In summer, differences in the shortwave net calculations between PWRF and MITgcm in the SKRIPS case dominate the heat flux inconsistencies (on average, an order of magnitude larger than the turbulent heat fluxes differences, Table S2). In August, when the sun is low on the horizon, the sensible heat and longwave radiation fluxes show the largest differences between PWRF and MITgcm (Figure S4).

The ocean receives a larger amount of latent heat in the SKRIPS simulation with an almost constant bias of 1.1013 W. The differences in sensible heat flux into the ocean varies over time between the two models. Larger discrepancies are associated with precipitation events (6th-8th of August, 12th of August, 14th-19th of August, and 26th-31th of August, with 29th excepted), leading to a loss of heat from the ocean for the SKRIPS simulation, while the P-SKRIPS simulation indicates a gain for the ocean. The longwave net radiation in the SKRIPS case is always slightly underestimated, as compared to the P-SKRIPS, although both curves show very similar variations over time.

Despite the fact that precipitation is directly imported from PWRF to MITgcm (also in the SKRIPS case), the amount of precipitation sent by PWRF to MITgcm is overestimated. This is because in the SKRIPS case the total precipitation is made out of the sum of the time step non-convective precipitation (RAINNCV) and non-convective snow and ice (SNOWNCV). However, the latter is defined as a component of the non-convective precipitation, which encompasses all species (rain, graupel and snow and ice) and, therefore, is accounted for twice in the precipitation term. It is likely that over the course of the winter season, additional accumulation of snow over the sea ice affect the heat transfer through that layer, and in spring it will lead to increased freshwater flux into the surface of the ocean. In the P-SKRIPS, the components are added individually and the time step non convective precipitation term is ignored.

As evaporation is directly imported from PWRF to MITgcm in both cases, no difference exists between the two simulations. In the last week of the simulation, the fluxes in the two experiments diverge more and more, due to the (now correct) balancing of the fluxes.

Finally, the runoff over sea ice is an additional modification in the P-SKRIPS that does not exist in the SKRIPS case. Therefore, only the PWRF and MITgcm balanced outputs are present, and match perfectly.

Figure 8 displays the January 2016 time series for each of the integrated fluxes presented in Figure 6 and Figure 7. We integrate all flux components over the ocean (we ignore land), and present the fluxes at the atmosphere-ocean or snow-sea ice interface, following Figure 6 (through the coupling interface). The PWRF - P-SKRIPS, and MITgcm - P-SKRIPS curves overlap closely for each of the variables. We have significantly reduced the differences between PWRF and MITgcm fluxes in the original SKRIPS set up and in our P-SKRIPS model (Figure 9 for the January case and Figure S5 for the August case). There are small differences in the PWRF flux variables between the P-SKRIPS and the SKRIPS cases, expressed either as larger minima (in the case of short wave fluxes) or as divergence over time. This is because the simulations show different responses to the conservation of fluxes versus parallel calculation. In summer, the incoming shortwave radiation is at its maximum in the middle of the day and the differences in albedo parameterization between PWRF and MITgcm account for the variations in the magnitude of the shortwave peak.

The largest discrepancies in heat fluxes are between the MITgcm results from the direct import method used in P-SKRIPS case and the independent calculation used in the SKRIPS case (see also Figure 9). In summer, differences in the shortwave net calculations between PWRF and MITgcm in the SKRIPS case dominate the heat flux inconsistencies (on average, an order of magnitude larger than the turbulent heat fluxes differences, Table S2). In August, when the sun is low on the horizon, the sensible heat and longwave radiation fluxes show the largest differences between PWRF and MITgcm (Figure S4).

The ocean receives a larger amount of latent heat in the SKRIPS simulation with an almost constant bias of 1.1013 W. The differences in sensible heat flux into the ocean varies over time between the two models. Larger discrepancies are associated with precipitation events (6th-8th of August, 12th of August, 14th-19th of August, and 26th-31th of August, with 29th excepted), leading to a loss of heat from the ocean for the SKRIPS simulation, while the P-SKRIPS simulation indicates a gain for the ocean. The longwave net radiation in the SKRIPS case is always slightly underestimated, as compared to the P-SKRIPS, although both curves show very similar variations over time.

Despite the fact that precipitation is directly imported from PWRF to MITgcm (also in the SKRIPS case), the amount of precipitation sent by PWRF to MITgcm is overestimated. This is because in the SKRIPS case the total precipitation is made out of the sum of the time step non-convective precipitation (RAINNCV) and non-convective snow and ice (SNOWNCV). However, the latter is defined as a component of the non-convective precipitation, which encompasses all species (rain, graupel and snow and ice) and, therefore, is accounted for twice in the precipitation term. It is likely that over the course of the winter season, additional accumulation of snow over the sea ice affect the heat transfer through that layer, and in spring it will lead to increased freshwater flux into the surface of the ocean. In the P-SKRIPS, the components are added individually and the time step non convective precipitation term is ignored.

As evaporation is directly imported from PWRF to MITgcm in both cases, no large difference exists between the two simulations. In the last week of the simulation, the fluxes in the two experiments diverge more and more, due to the (now correct) balancing of the fluxes.

Finally, the runoff over sea ice is an additional modification in the P-SKRIPS that does not exist in the SKRIPS case. Therefore, only the PWRF and MITgcm balanced outputs are present, and match almost perfectly (See Table S3 and S4 for more information).

L310–>318: This paragraph seems quite important (at least to me), but I find it quite confusing. I would strongly recommend rephrasing it. The differences between the two setups are particularly significant for this term, so it is worth clarifying what the implications are.

We thank you for this comment, in line with Reviewer 1 comment. We propose to clarify as follows:

Table 3. Statistics presenting the mean value for the different variables in Figures 8 and S4 in January for both the SKRIPS and the P-SKRIPS simulations, as well as the mean values for the differences between the PWRF and the MITgcm variables for each of these simulations. The variables are integrated over the whole simulation and through the entire domain.

simulation JAN	LH [W]	SH [W]	LWNET [W]	SWNET [W]	Prec. $[m^3s^{-1}]$	Evap. $[m^3s^{-1}]$	Runoff $m^3s^{-1}]$
SKRIPS	$2.69e^{13}$	$1.68e^{13}$	$8.87e^{13}$	$-3.93e^{14}$	$7.74e^4$	$1.03e^4$	PWRF $1.09e^4$
P-SKRIPS	$2.44e^{13}$	$1.20e^{13}$	$9.19e^{13}$	$-3.92e^{14}$	$3.69e^4$	$9.38e^3$	MITgcm $1.13e^4$
SKRIPS difference	$-2.74e^{12}$	$-2.89e^{12}$	$1.71e^{13}$	$1.e^{13}$	-0.0036	$5.33e^{-5}$	diff $7.18e^{-5}$
P-SKRIPS difference	$7.87e^7$	$2.38e^8$	-2.64^{11}	$1.44e^{11}$	-0.0019	$-3.40e^{-5}$	

Table 4. Statistics presenting the mean value for the different variables in Figures 8 and S4 in August for both the SKRIPS and the P-SKRIPS simulations, as well as the mean values for the differences between the PWRF and the MITgcm variables for each of these simulations. The variables are integrated over the whole simulation and through the entire domain.

simulation AUG	LH [W]	SH [W]	LWNET [W]	SWNET [W]	Prec. $[m^3s^{-1}]$	Evap. $[m^3s^{-1}]$	Runoff $m^3s^{-1}]$
SKRIPS	$2.06e^{13}$	$-5.83e^{12}$	$1.24e^{14}$	$-9.19e^{12}$	$7.02e^4$	$8.46e^3$	PWRF 0.99
P-SKRIPS	$7.42e^{12}$	$-1.69e^{13}$	$1.14e^{14}$	$-8.21e^{12}$	$3.27e^4$	$3.34e^3$	MITgcm 0.99
SKRIPS difference	$-1.77e^{11}$	$-8.24e^{10}$	$1.64e^{13}$	$-1.14e^{12}$	-0.0029	$-1.1e^{-5}$	diff $-4.15e^{-9}$
P-SKRIPS difference	$5.85e^7$	$1.46e^8$	$-1.29e^{12}$	$6.24e^8$	$-9.71e^{-4}$	$6.84e^{-6}$	

However, the latter is defined as a component of the non-convective precipitation, which encompasses all species (rain, graupel and snow and ice) and, therefore, is accounted for twice in the snowfall term. In the P-SKRIPS, the components are added individually and the time step non convective precipitation term is ignored.

However, the latter is defined as a component of the non-convective precipitation, which encompasses all species (rain, graupel and snow and ice) and, therefore, is accounted for twice in the precipitation term. It is likely that over the course of the winter season, additional accumulation of snow over the sea ice affect the heat transfer through that layer, and in spring it will lead to increased freshwater flux into the surface of the ocean. In the P-SKRIPS, the components are added individually and the time step non convective precipitation term is ignored.

L377: A bit in line with my first comment, it is likely that these differences in heat fluxes will affect these processes. However, it has not been proven in the manuscript and I would therefore recommend rephrasing a bit. For instance, use "likely" instead of "directly".

We agree that this is a limitation in our technical paper. We will explore more of the fluxes in a subsequent "scientific" paper. We will therefore rephrase:

The non-conservation of up to 922 W m^{-2} is directly affecting the heat content of the atmosphere and deep convection of the ocean.

The non-conservation of up to 922 W m^{-2} is likely affecting the heat content of the atmosphere and deep convection of the ocean.

L380: This sentence sounds like an overstatement. What are the metrics used by the authors to make such a claim? Depending on the question that is asked, another model may be more suitable and have a much better representation of the processes of interest. It is a nice paper overall, do not upset readers that would only read the conclusion!

We thank the reviewer for this fair comment. We will change our conclusive sentence according to comments from both reviewers.

The presented coupled model setup constitutes, to our knowledge, the most accurate representation of ocean/atmosphere/sea ice interactions for polar climates and is thus recommended for climate modelling in any Arctic and Antarctic region.

The presented coupled model setup constitutes, to our knowledge, the most physically consistent representation of ocean/atmosphere/sea ice interactions for polar climates and is thus recommended for climate modelling in any Arctic and Antarctic region.

I wish the authors good luck with the revisions!

Thank you :)

comment from the authors: Note that as noted in the existing Discussion comment, part of the code is not in open access. We have provided all of the files that are under open access licences to the repositories: https://doi.org/10.5281/zenodo.7739063 and https://doi.org/10.5281/zenodo.7739059. Unfortunately, the PWRF model (https://doi.org/10.1029/2012J018139) files are not publicly available for publishing and the decision is beyond our control. However, the files can be obtained on the PWRF website upon request https://polarmet.osu.edu/PWRF/ . We are also able to provide files to the reviewers for the purpose of reviewing this manuscript through the editor if needed. The data availability statement has been updated accordingly.

The developments and files required to set up and run the model presented in this paper are available at https://github.com/alena-malyarenko/P-SKRIPS and on Zenodo https://doi.org/10.5281/zenodo.7297744. The coupled model builds on the Scripps-Kaust model described in Cerovecki et al. (2022) and Sun et al. (2019). The base code can be find at https://github.com/iurnus/scripps_kaust_model/. ERA5 Reanalysis (0.25 Degree Latitude-Longitude Grid), generated by European Centre for Medium-Range Weather Forecasts are available at https://cds.climate.copernicus.eu/cdsapp#!/dataset/reanalysis-era5-pressure-levels and https://cds.climate.copernicus.eu/cdsapp#!/dataset/reanalysis-era5-single-levels. BSOSE data is availbe at http://sose.ucsd.edu/. The Bedmap2 data can be downloaded from https://www.bas.ac.uk/project/bedmap-2/.

Our model code for the Ross Sea case is based on PolarWRF and MITgcm. The P-SKRIPS model code is an updated version of SKRIPS (https://doi.org/10.5281/zenodo.7336070) and can be found in the two directories due to size limits (https://doi.org/10.5281/zenodo.7739063 and https://doi.org/10.5281/zenodo.7739059). The detailed instructions for converting WRF to PWRF (https://doi.org/10.1029/2012J018139) can be found within PSKRIPS-main folder. The short description of steps for PWRF is as follows: find PSKRIPS/Models/WRF_4.1.3 within the repository; obtain PWRF-4.1.3 modifications by email and merge the code locally; add P-SKRIPS modifications to PWRF; compile.

ERA5 Reanalysis (0.25 Degree Latitude-Longitude Grid), generated by European Centre for Medium-Range Weather Forecasts are available at https://cds.climate.copernicus.eu/cdsapp#!/dataset/reanalysis-era5-pressure-levels and https://cds.climate.copernicus.eu/cdsapp#!/dataset/reanalysis-era5-single-levels. BSOSE data is availabe at http://sose.ucsd.edu/. The Bedmap 2 data can be downloaded from https://www.bas.ac.uk/project/bedmap-2/.

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