Data Description

1. PROJECT

Title: Fragmentation and melting of the seasonal sea ice cover
Funding organisation: NERC industrial CASE studentship with the UK Met Office, reference NE/M009637/1.

2. DATASET

Title: Simulations of the Arctic sea ice comparing different approaches to modelling the floe size distribution and their respective impacts on the sea ice cover.

To produce this dataset a CPOM (Centre for Polar Observation and Modelling) version of the Los Alamos Sea Ice model v 5.1.2, hereafter referred to as CICE, is used (Hunke et al., 2015). This local version includes a prognostic mixed layer model (Petty et al., 2014) and additional parameterisations based on Schröder et al. (2019). Further details on the CICE model setup used here can be found within Bateson (2021).

The CICE setup used here also includes two alternative sea ice floe size distribution models. The first is a power-law derived approach, the WIPoFSD model (Waves-in-Ice module and Power law Floe Size Distribution model). Further details on the WIPoFSD model are available from Bateson et al. (2020). Simulations in chapter 4 and onwards use a modified version of the WIPoFSD model. Details of these modifications are available in section 4.3 of Bateson (2021). The second model used here has been adapted from the prognostic floe size-thickness distribution model presented in Roach et al. (2018, 2019). Full details of the version of the prognostic model used here are available in chapter 6 of Bateson (2021). A novel addition to the prognostic model used within simulations in chapter 7 and 8, a quasi-restoring brittle fracture scheme, is described in section 7.1.

This dataset is used within the thesis 'Fragmentation and melting of the seasonal sea ice cover' (Bateson, 2021) to investigate the impact of the sea ice floe size distribution on the evolution of the Arctic sea ice cover and to compare different approaches to modelling floe size. Results are presented to show how variable floe size changes the seasonal retreat of the Arctic sea ice cover via changes to lateral melt volume and momentum exchange between the sea ice, ocean, and atmosphere. Winter floe formation and growth processes are found to strongly influence FSD impacts on the seasonal retreat of the sea ice, and the need to include brittle fracture processes in floe size distribution models is also demonstrated. A high sensitivity is found to poorly constrained FSD parameters, highlighting the need for further observations of floe size.

A full description of the simulations and processing used to produce this dataset can be found within Bateson (2021). Note also that this dataset includes model output only. For further information on the floe size observations used to compared against model output in Chapters 6 and 7, please see Wang et al. (2020).

Publication Year: 2021
Creator: Adam Bateson
Organisation: University of Reading

3. TERMS OF USE
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4. CONTENTS

The dataset has been subdivided into folders corresponding to the relevant thesis chapter. For each chapter, the naming convention is first stated, then data variables are listed, and finally followed by any corresponding files.

<u>Grid Info</u>

Grid information relevant to all model output is described here.

Grid variables:

-1 TLAT, geographical latitude of grid cells
-2 TLON, geographical longitude of grid cells
-3 tarea, area of grid cells [m^2]

grid_info.nc

<u>Chapter 3</u>

Data for this chapter has already been published at Bateson (2019) to correspond with the research paper Bateson et al. (2020).

<u>Chapter 4</u>

File names are constructed using the following format:

cice_cpom_wipofsd_X, where X corresponds to the name of the simulation assigned in section 4.3.

Datasets:

Monthly means on a 1deg tripolar grid are provided between 2005 - 2016.

```
  -1  hi_m          grid cell mean ice thickness [m]
  -2  aice_m        ice area  (aggregate) [1]
  -3  meltt_m       top ice melt [cm/day]
  -4  meltb_m       basal ice melt [cm/day]
  -5  meltl_m       lateral ice melt [cm/day]
  -6  l_eff_m       effective floe size [m]
  -7  maxfloe_m     maximum floe size [m]
```

cice_cpom_wipofsd_leff-2.5.nc
cice_cpom_wipofsd_leff-3.5.nc
cice_cpom_wipofsd_lvar-2.5.nc
cice_cpom_wipofsd_lvar-3.5.nc

The following file is also included:

cice_cpom_init_1stJul05.nc

This file is the output of the spin-up between 1990 – 2004 with the reference setup and is used to initiate all simulations.

Chapter 5

File names are constructed using the following format:

cice_cpom_wipofsd_X, where X corresponds to the name of the simulation assigned in section 5.3.

Datasets:

Monthly means on a 1deg tripolar grid are provided between 1980 - 2016.

-1	hi_m	grid cell mean ice thickness [m]
-2	aice_m	ice area (aggregate) [1]
-3	meltt_m	top ice melt [cm/day]
-4	meltb_m	basal ice melt [cm/day]
-5	meltl_m	lateral ice melt [cm/day]
-6	l_eff_m	effective floe size [m]
-7	maxfloe_m	maximum floe size [m]

cice_cpom_wipofsd_fd-cf300.nc
cice_cpom_wipofsd_fd-leff.nc
cice_cpom_wipofsd_fd-lupkes.nc
cice_cpom_wipofsd_nofd.nc

Chapter 6

File names are constructed using the following format:

cice_cpom_prog_X, where X refers to either *16cat_nobf*, referring to the simulation described in section 6.6.1, *16cat_nobf_lowwld*, referring to the simulation with reduced floe welding described in section 6.6.3, or *16cat_nobf_nowb*, referring to the simulation with no wave break-up of floes described in section 6.6.3.

Datasets:

A. Monthly means on a 1deg tripolar grid are provided between 1980 - 2016.

-1	leff_m	effective floe size (diameter) [m]
-2	hi_m	grid cell mean ice thickness [m]
-3	aice_m	ice area (aggregate) [1]
-4	meltt_m	top ice melt [cm/day]
-5	meltb_m	basal ice melt [cm/day]
-6	meltl_m	lateral ice melt [cm/day]
-7	areal_fsd_m	areal floe size distribution, 16 subcategories [1]

cice_cpom_prog_16cat_nobf_lowwld.nc
cice_cpom_prog_16cat_nobf.nc
cice_cpom_prog_16cat_nobf_nowb.nc

B. Masks to define regions within model output to compare against floe size observations (see Fig. 6.6).

regionA-Chukchi.nc
regionB-CaFram.nc
regionC-Esiber.nc

Chapter 7

cice_cpom_wipofsd_X, where X corresponds to the name of the simulation as described in section 7.2, except for X = *16cat* where it refers to the simulation including brittle fracture described in section 7.1.3.

Datasets:

-1	leff_m	effective floe size (diameter) [m]
-2	hi_m	grid cell mean ice thickness [m]
-3	aice_m	ice area (aggregate) [1]
-4	meltt_m	top ice melt [cm/day]
-5	meltb_m	basal ice melt [cm/day]
-6	meltl_m	lateral ice melt [cm/day]
-7	areal_fsd_m	areal floe size distribution, 16 subcategories [1]

cice_cpom_prog_16cat.nc

-1	leff_m	effective floe size (diameter) [m]
-2	lexp_m	exponent of fitted power law [1]
-3	hi_m	grid cell mean ice thickness [m]
-4	aice_m	ice area (aggregate) [1]
-5	meltt_m	top ice melt [cm/day]
-6	meltb_m	basal ice melt [cm/day]
-7	meltl_m	lateral ice melt [cm/day]
-8	areal_fsd_m	areal floe size distribution, 12 subcategories [1]

cice_cpom_prog-stan.nc

-1	leff_m	effective floe size (diameter) [m]
-2	hi_m	grid cell mean ice thickness [m]
-3	aice_m	ice area (aggregate) [1]
-4	meltt_m	top ice melt [cm/day]
-5	meltb_m	basal ice melt [cm/day]
-6	meltl_m	lateral ice melt [cm/day]
-7	areal_fsd_m	areal floe size distribution, 12 subcategories [1]

cice_cpom_prog-fd300.nc
cice_cpom_prog-hiwld.nc
cice_cpom_prog-lowld.nc
cice_cpom_prog-morebf.nc
cice_cpom_prog-morewb.nc
cice_cpom_prog-ni0.nc
cice_cpom_prog-ni1.nc
cice_cpom_prog-nobf.nc
cice_cpom_prog-nolg.nc
cice_cpom_prog-nolm.nc
cice_cpom_prog-nowb.nc

-1	hi_m	grid cell mean ice thickness [m]
-2	aice_m	ice area (aggregate) [1]
-3	meltt_m	top ice melt [cm/day]
-4	meltb_m	basal ice melt [cm/day]
-5	meltl_m	lateral ice melt [cm/day]

cice_cpom_ref.nc

<u>Chapter 8</u>

File names are constructed using the following format:

cice_cpom_prog_X, where X corresponds to the name of the simulation as defined in either section 8.1.3 (hindcasts, except *WIPo-sg*), 8.4 (*WIPo-sg* only), or 8.5.1 (projections).

Datasets:

A. Monthly means on a 1deg tripolar grid are provided between 1980 - 2016.

-1	leff_m	effective floe size (diameter) [m]
-2	lexp_m	exponent of fitted power law [1]
-3	hi_m	grid cell mean ice thickness [m]
-4	aice_m	ice area (aggregate) [1]
-5	meltt_m	top ice melt [cm/day]
-6	meltb_m	basal ice melt [cm/day]
-7	meltl_m	lateral ice melt [cm/day]
-8	areal_fsd_m	areal floe size distribution, 12 subcategories [1]

cice_cpom_prog-best.nc

-1	hi_m	grid cell mean ice thickness [m]
-2	aice_m	ice area (aggregate) [1]
-3	meltt_m	top ice melt [cm/day]
-4	meltb_m	basal ice melt [cm/day]
-5	meltl_m	lateral ice melt [cm/day]
-6	l_eff_m	effective floe size [m]
-7	maxfloe_m	maximum floe size [m]

cice_cpom_WIPo-best.nc
cice_cpom_WIPo-sg.nc

-1	hi_m	grid cell mean ice thickness [m]
-2	aice_m	ice area (aggregate) [1]
-3	meltt_m	top ice melt [cm/day]
-4	meltb_m	basal ice melt [cm/day]
-5	meltl_m	lateral ice melt [cm/day]

cice_cpom_ref.nc

B. Monthly means on a 1deg tripolar grid are provided between 2017 - 2060.

-1	leff_m	effective floe size (diameter) [m]
-2	lexp_m	exponent of fitted power law [1]
-3	hi_m	grid cell mean ice thickness [m]
-4	aice_m	ice area (aggregate) [1]
-5	meltt_m	top ice melt [cm/day]
-6	meltb_m	basal ice melt [cm/day]
-7	meltl_m	lateral ice melt [cm/day]
-8	areal_fsd_m	areal floe size distribution, 12 subcategories [1]

cice_cpom_prog-proj.nc

-1	hi_m	grid cell mean ice thickness [m]
-2	aice_m	ice area (aggregate) [1]

```
  -3  meltt_m       top ice melt [cm/day]
  -4  meltb_m       basal ice melt [cm/day]
  -5  meltl_m       lateral ice melt [cm/day]
  -6  l_eff_m       effective floe size [m]
  -7  maxfloe_m     maximum floe size [m]
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cice_cpom_WIPo-proj.nc

```
  -1  hi_m          grid cell mean ice thickness [m]
  -2  aice_m        ice area  (aggregate) [1]
  -3  meltt_m       top ice melt [cm/day]
  -4  meltb_m       basal ice melt [cm/day]
  -5  meltl_m       lateral ice melt [cm/day]
```

cice_cpom_ref-proj.nc

C. Masks to define case study regions (see Fig. 8.9).

regionA-Esiber.nc
regionB-GLand.nc
regionC-Barents.nc
regionD-Beaufort.nc

5. REFERENCES

Bateson, A. W.: Fragmentation and melting of the seasonal sea ice cover, Ph.D. thesis, University of Reading, Reading, Berkshire, UK, 2021.
Bateson, A. W.: Simulations with the sea ice model CICE investigating the impact of sea ice floe size distribution on seasonal Arctic sea ice retreat, University of Reading [data set], doi:10.17864/1947.223, 2019.
Bateson, A. W., Feltham, D. L., Schröder, D., Hosekova, L., Ridley, J. K. and Aksenov, Y.: Impact of sea ice floe size distribution on seasonal fragmentation and melt of Arctic sea ice, Cryosphere, 14, 403–428, doi:10.5194/tc-14-403-2020, 2020.
Hunke, E. C., Lipscomb, W. H., Turner, A. K., Jeffery, N., and Elliott, S.: CICE: The Los Alamos Sea ice Model Documentation and Software User's Manual Version 5, Los Alamos National Laboratory, Los Alamos, New Mexico, USA, Tech. Rep. LA-CC-06-012, 115 pp., 2015.
Petty, A. A., Holland, P. R., and Feltham, D. L.: Sea ice and the ocean mixed layer over the Antarctic shelf seas, The Cryosphere, 8, 761–783, doi:10.5194/tc-8-761-2014, 2014.
Schröder, D., Feltham, D. L., Tsamados, M., Ridout, A., and Tilling, R.: New insight from CryoSat-2 sea ice thickness for sea ice modelling, The Cryosphere, 13, 125–139, ddoi:10.5194/tc-13-125-2019, 2019.
Wang, Y., Hwang, B., Basu, R., and Ren, J.: Regional differences in processes controlling Arctic sea ice floe size distribution in Chukchi Sea, East Siberian and Fram Strait during pre-ponding season , EGU General Assembly 2020, Online, 4–8 May 2020, EGU2020-5208, doi:10.5194/egusphere-egu2020-5208, 2020.