Sea ice mass balance in the Arctic Ocean

Bin Cheng[1], Yurii Batrak[2]

[1] Finnish Meteorological Institute ,Finland
[2] Norwegian Meteorological Institute, Norway

Objectives

- Further improvement of the HARMONIE-AROME. sea ice component SICE by
  - Introducing sea ice mass balance at ice bottom
  - Taking into account parameterization of
    - Snow properties
    - Sea ice thermal properties
- Validation of updated HARMONIE-AROME (SICE) performance by
  - Modelling for cold season (SIMBA/FMI02 drift)
    - Compare with the model run using constant ice thickness
    - Compare with process HIGHTSI model result
  - Modelling for melting season (Tara ice drift)
    - HIGHTSI run
    - HARMONIE-AROME (SICE) run

HARMONIE-AROME (SICE) experiments

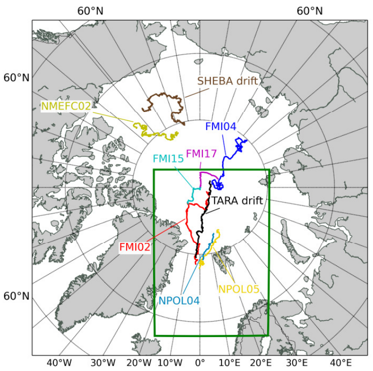
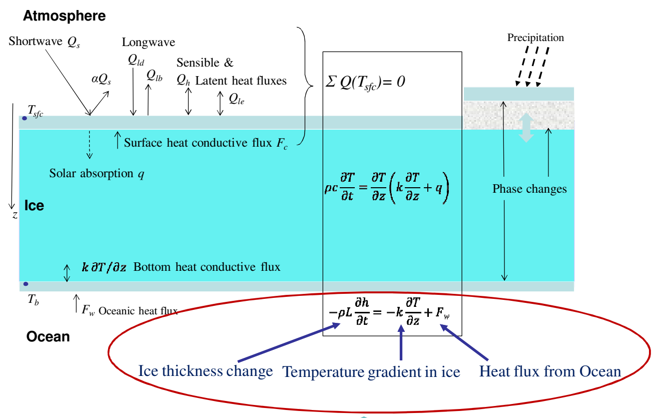


Figure 1. HARMONIE-AROME polar domain (green frame) for this study.
Modelling period:
FMI02: 22.09.2012 - 31.05.2013.
TARA: 01.04. 2007 - 31.10.2007.
The buoy drift trajectory:
FMI02 ---- red
TARA ---- black
Several other ice mass buoy (IMB) drifting trajectories are shown in the Figure. The IMB (FMI02,Tara, NPOL04, NPOL05) moved along the Transpolar Drift Stream (TDS).

Snow and ice thermodynamic processes



Introduced into SICE to calculate ice bottom mass balance

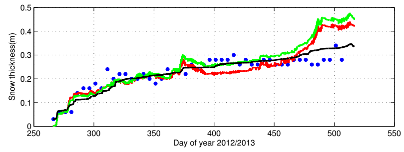
HIGHTSI vs SICE

Model	HIGHTSI	SICE
Num. snow layers (Ns)	>3	3
Num. ice layers (Ni)	>3	3 < Ni < 99
Snow thickness	evolution	
Ice thickness	evolution	fixed/evolution
Oceanic heat flux	prescribed	
Snow compaction	Function of density	Yes
snow refreezing	Yes	No
Enabled to SURFEX	No	Yes

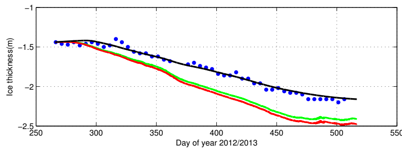
Acknowledgement:
This study is part of HIRLAM_C program. HIGHTSI modelling and SIMBA data analyses was partly supported by the Academy of Finland (259537) and National Natural Science Foundation of China (41428603); FMI02 was deployed during AMORA project(193592) funded by the Research Council of Norway.

Modelling results

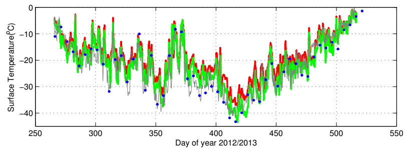
FMI02 case: Ice drift along TDS during autumn/winter/spring season



Snow thickness during FMI02 drift period. The blue-dots are SIMBA observations; HARMONIE-AROME run without (red) and with (green) ice bottom mass balance. The black line is HIGHTSI result.



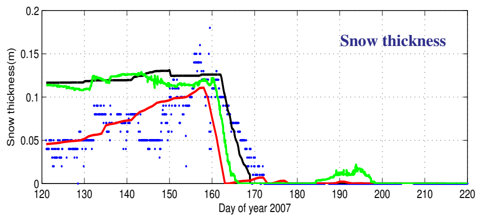
Ice thickness during FMI02 drift period. The blue-dots are SIMBA observations; HARMONIE-AROME runs applying (Fw=1W/m2, red) and (Fw =2W/m2, green) at ice bottom. The black line is HIGHTSI result.

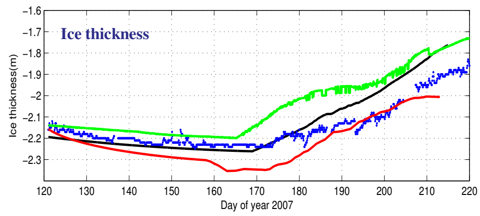


The surface temperature of FMI02. The blue dots are SIMBA observations. HARMONIE-AROME run without (red) and with (green) ice bottom mass balance. The black line is HIGHTSI result

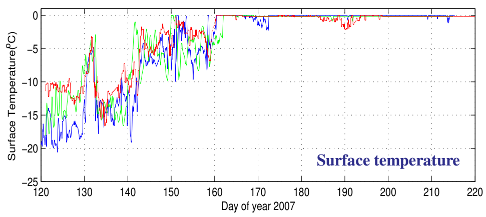
The HARMONIE-AROME overestimated ice mass balance, possibly due to effect of thermal properties of sea ice and maybe too small oceanic heat flux at ice bottom. The HARMONIE-AROME calculated surface temperature has improved with ice mass balance taken into account in SICE.

TARA case: Ice drift along TDS during spring/summer/autumn season





HARMONIE-AROME offline, i.e. standalone SURFEX experiment (SICE) forced by HIRLAM results as ABL external forcing (red). Snow melting is faster.
Coupled HARMONIE-AROME (SICE) experiment (green). The experiment was configured in a similar way as for FIM02 case, i.e. same domain, same spatial resolution and time step. Run started form snow-free ice surface with ice temperature equal to 271.3K. Heat flux from ocean to ice was set to 2W/m^2.
HIGHTSI results (black); Ice mass balance buoy measurements (blue dots).



Surface temperature during Tara drift period. Blue line was the observation; green line was result of HIGHTSI model; The red line was the result of HARMONIE-AROME coupled experiment taken ice mass balance into consideration

Conclusions

- SICE was enabled to HARMONIE-AROME; Currently SICE applied ice mass balance calculation in simulations; SICE modelled reasonable snow thickness after snow properties updated; HARMONIE-AROME yields improved surface temperature calculations when SICE was enabled to HARMONIE-AROME with ice mass balance consideration at ice bottom.
- FMI02 case: Snow and ice properties of SICE can still be improved.
- TARA case: HARMONIE-AROME (SICE) produce comparable surface temperature and timing of onset ice melting compared with HIGHTSI model.

References

Cheng, B., Zhang, Z., Vihma, T., Johansson, M., Bian, L., Li, Z. and Wu, H. 2008, Model experiments on snow and ice thermodynamics in the Arctic Ocean with CHINARE 2003 data, J. Geophys. Res., 113, C09020, doi:10.1029/2007JC004654.
Launiainen, J. and B. Cheng. 1998. Modelling of ice thermodynamics in natural water bodies. Cold Reg. Sci. Technol., 27(3), 153-178.