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Thermodynamic modelling of snow and ice for in-land water bodies

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- HIGHTSI model to be applied for lake ice
- Validation of HIRLAM forcing data for lake snow and ice modelling
- time evoluation of snow (Observation and Modelling)
- Application of Prototype ice mass balance buoy

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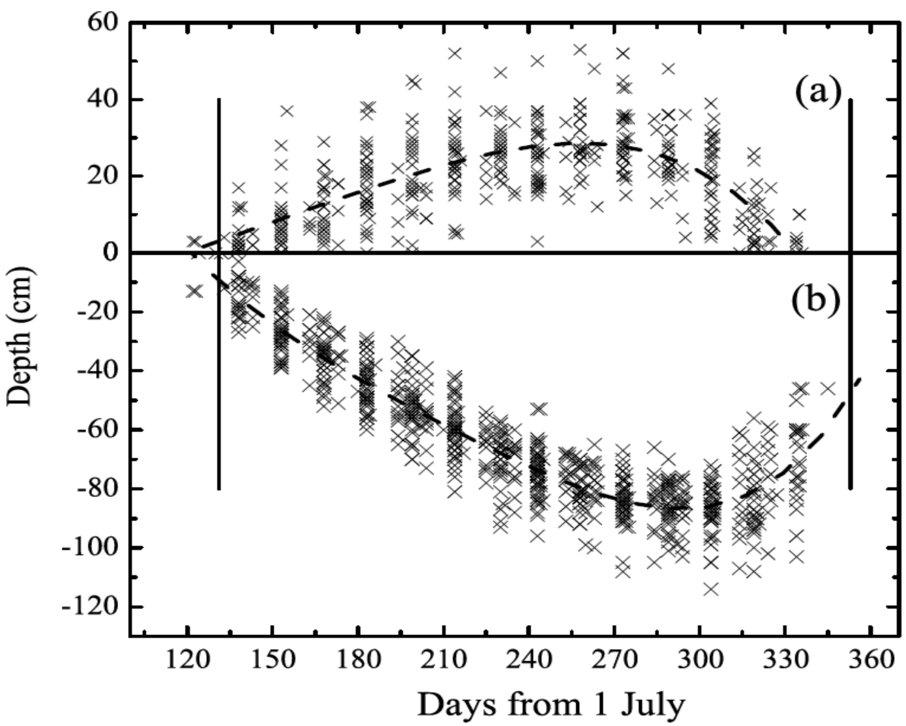
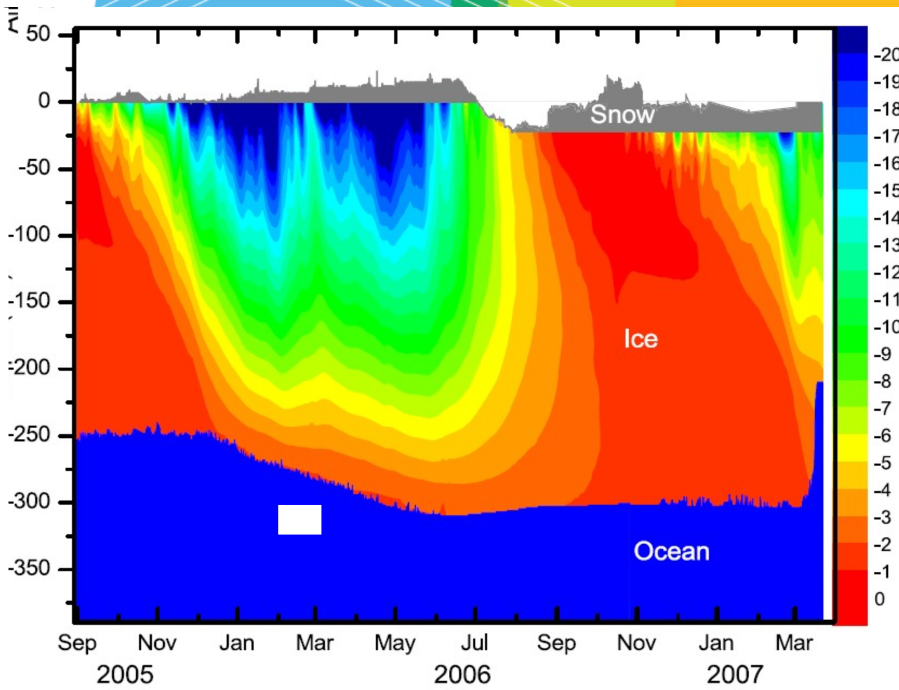


Ice thicknesses and snow depths from 1964 to 2008 (crossed marks), in a lake (Kilpisjärvi). The mean cures of snow depth and ice thickness (dashed line), and the average values of ice freeze-up date and ice breakup date (solid line) (Lei, et al, submitted)



Snow/ice thicknesses and ice temperature measured by an IMB buoy in the Arctic Ocean (Perovich et al, 2008) parameterizations of **Qs** **Ql** **Qh** **Qle** αs, αi, effect of cloud to Qs, Ql κi

parameterization of absorbed solar radiation in snow and ice

surface heat balance for snow and ice,
skin surface temperature is solved

simple parameterization of snow density

full heat conduction equation in snow

snow to ice transformation

continuation of heat flux between snow and ice interface

full heat conduction equation in ice

heat/mass balance at bottom

simple heat flux from water

(Launiainen and Cheng Cold Reg. Sci. Technol. 1998),
(Cheng, J. Glaciol. 2002)
(Vihma, et al, J. Geophys. Res. 2002)
(Cheng et al, Ann.Glaciol. 2006)
(Mäkynen, et al, IEEE Trans. Geosci. Remote Sens, 2007)
(Cheng et al J. Geophys. Res. 2008)

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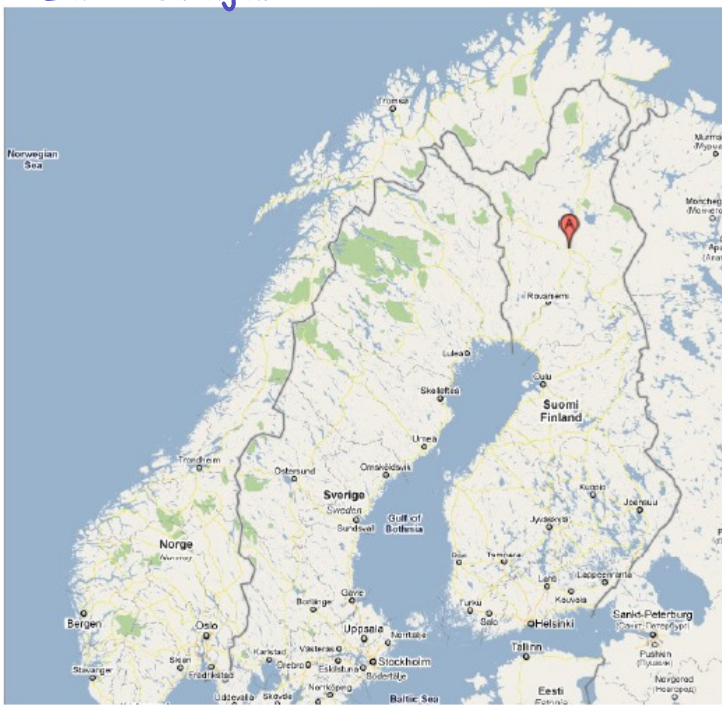
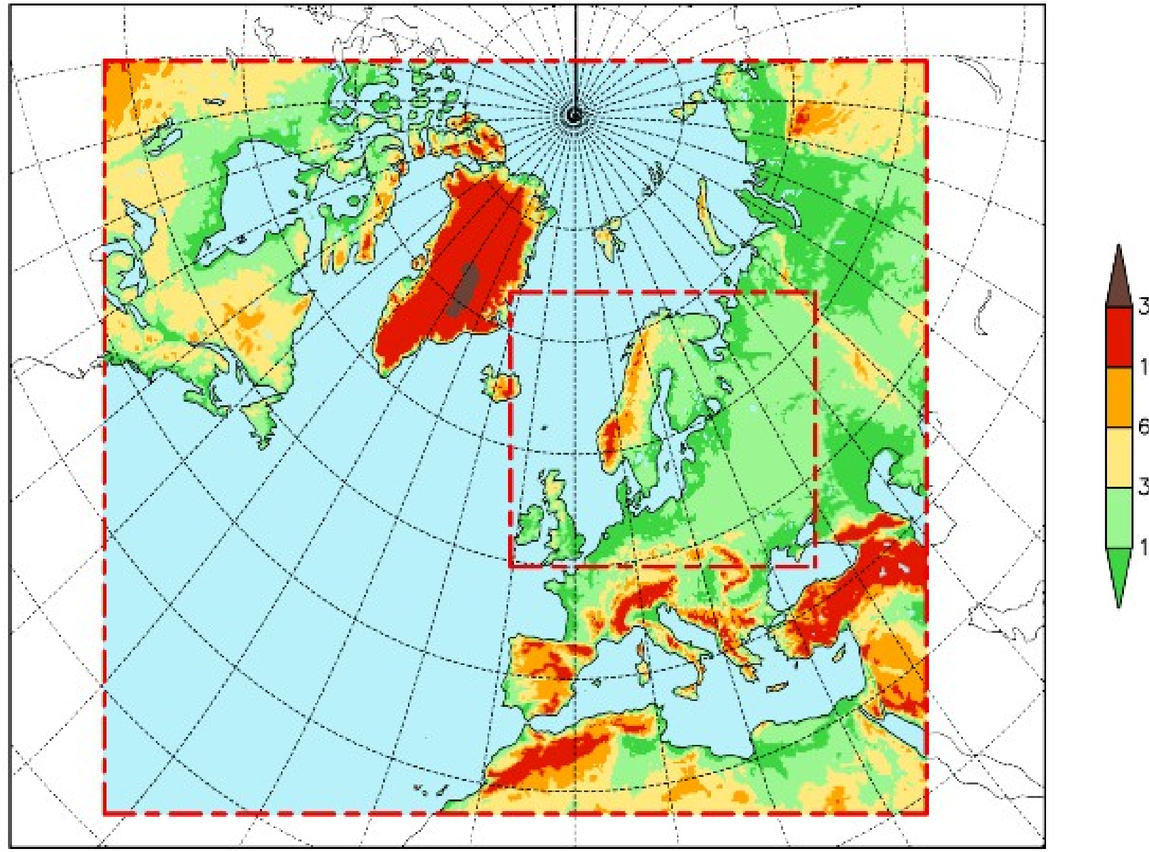
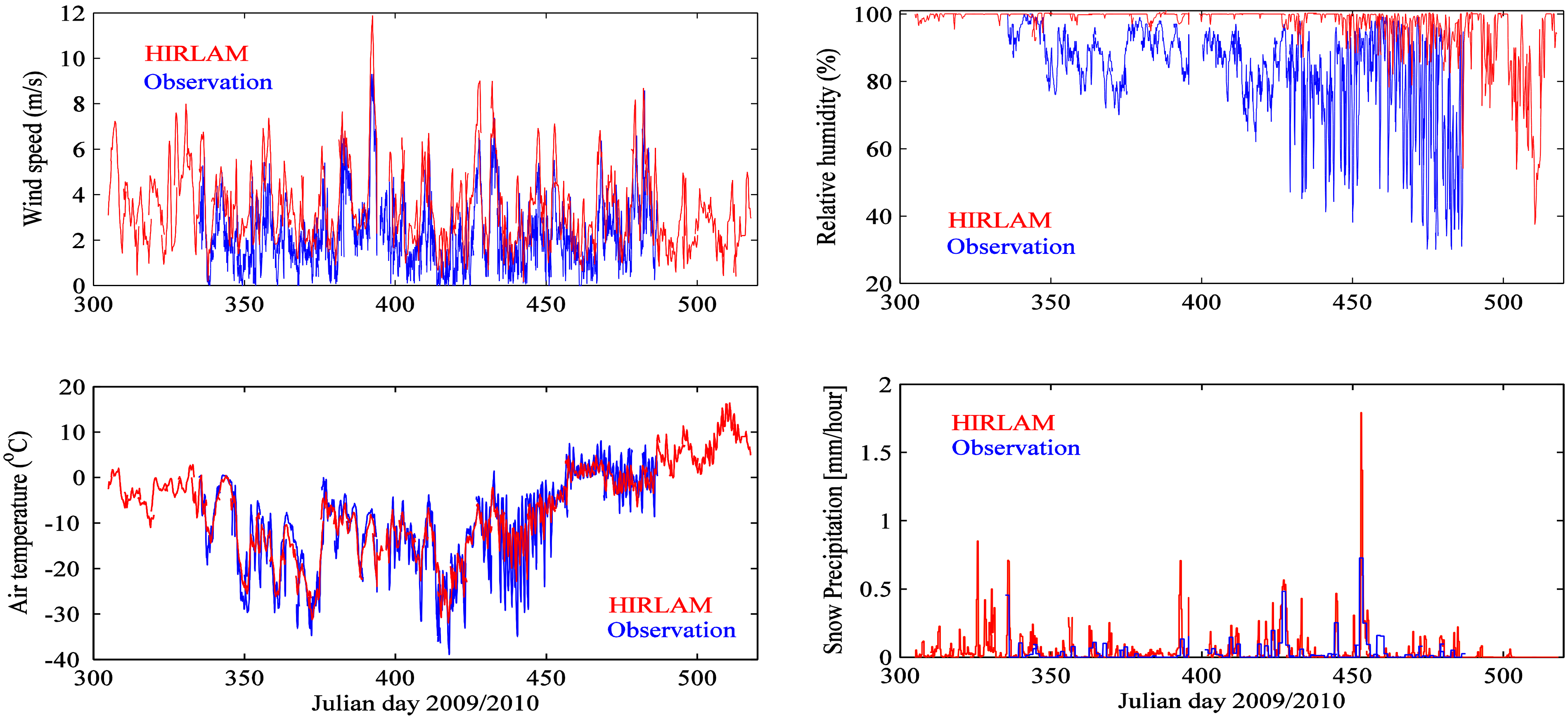
Lake Orajärvi

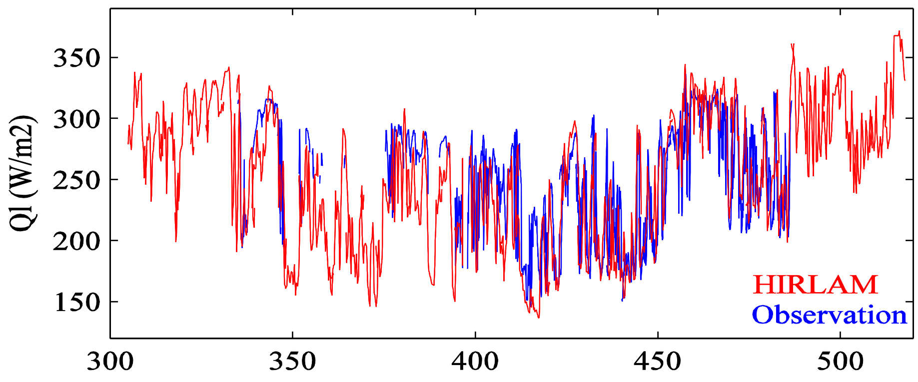


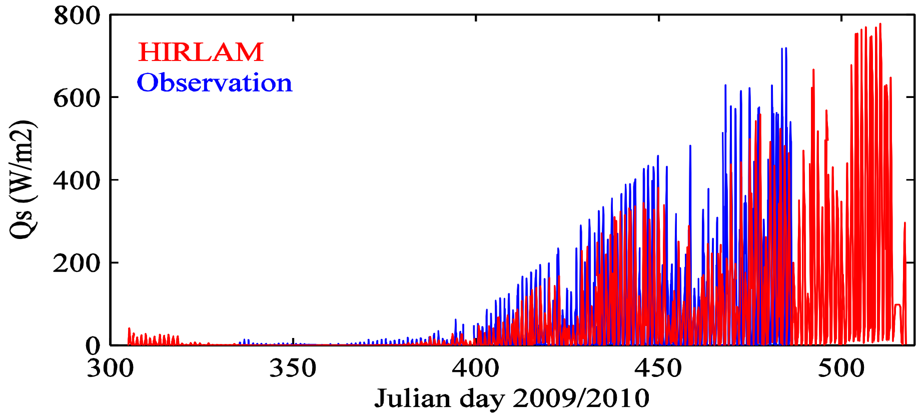
Google maps
Suomi | beta

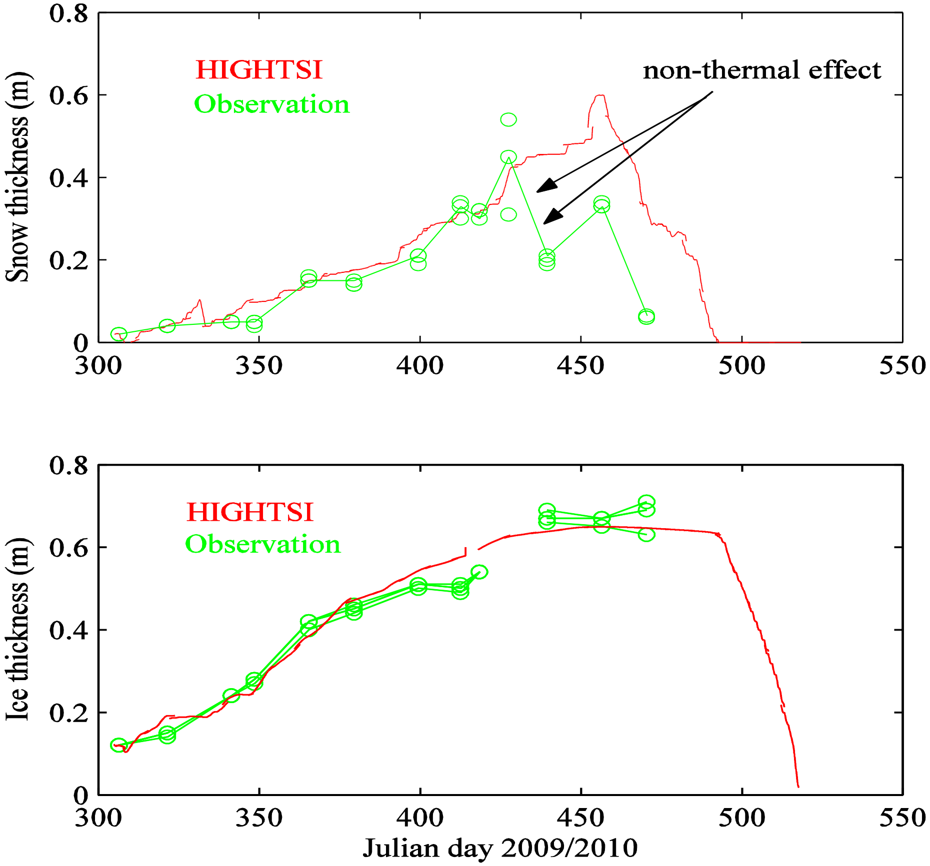
HIRLAM areas at FMI (dashed lines):
Inner area MBE, outer area RCR



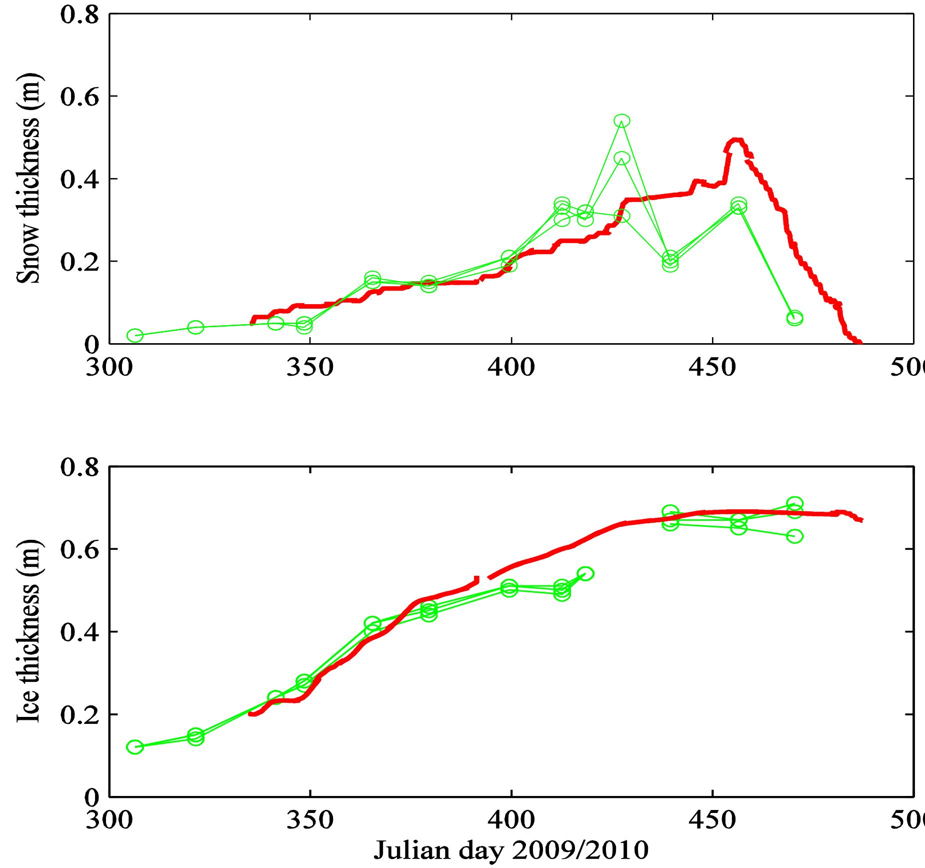

Wind speed (m/s)
HIRLAM
Observation
Relative humidity (%)
HIRLAM
Observation
Air temperature (^oC)
HIRLAM
Observation
Julian day 2009/2010
Snow Precipitation [mm/hour]
HIRLAM
Observation
Julian day 2009/2010


350
300
250
200
150
Ql (W/m2)
300
350
400
450
500
HIRLAM
Observation

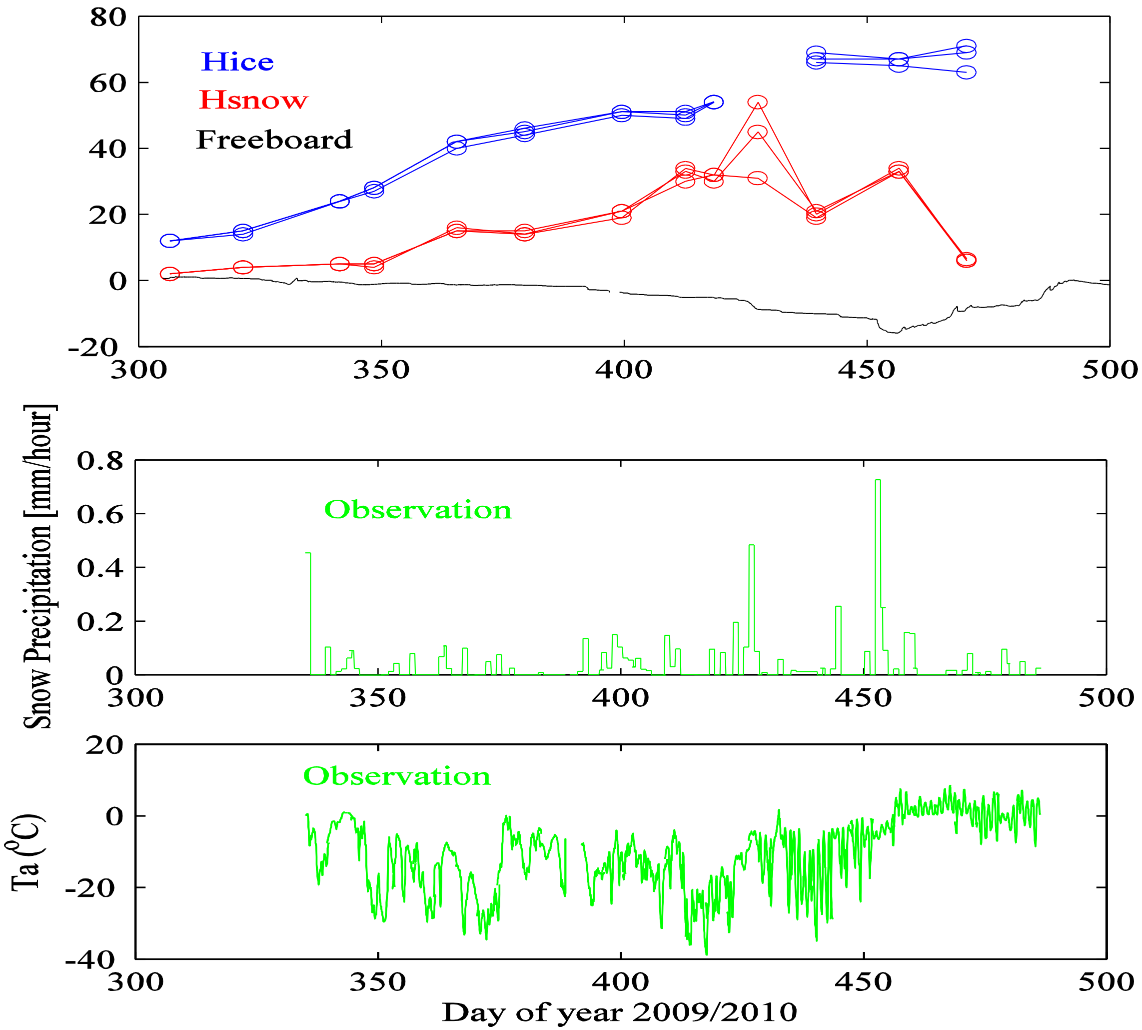

800
600
400
200
0
Qs (W/m2)
HIRLAM
Observation
300
350
400
450
500
Julian day 2009/2010

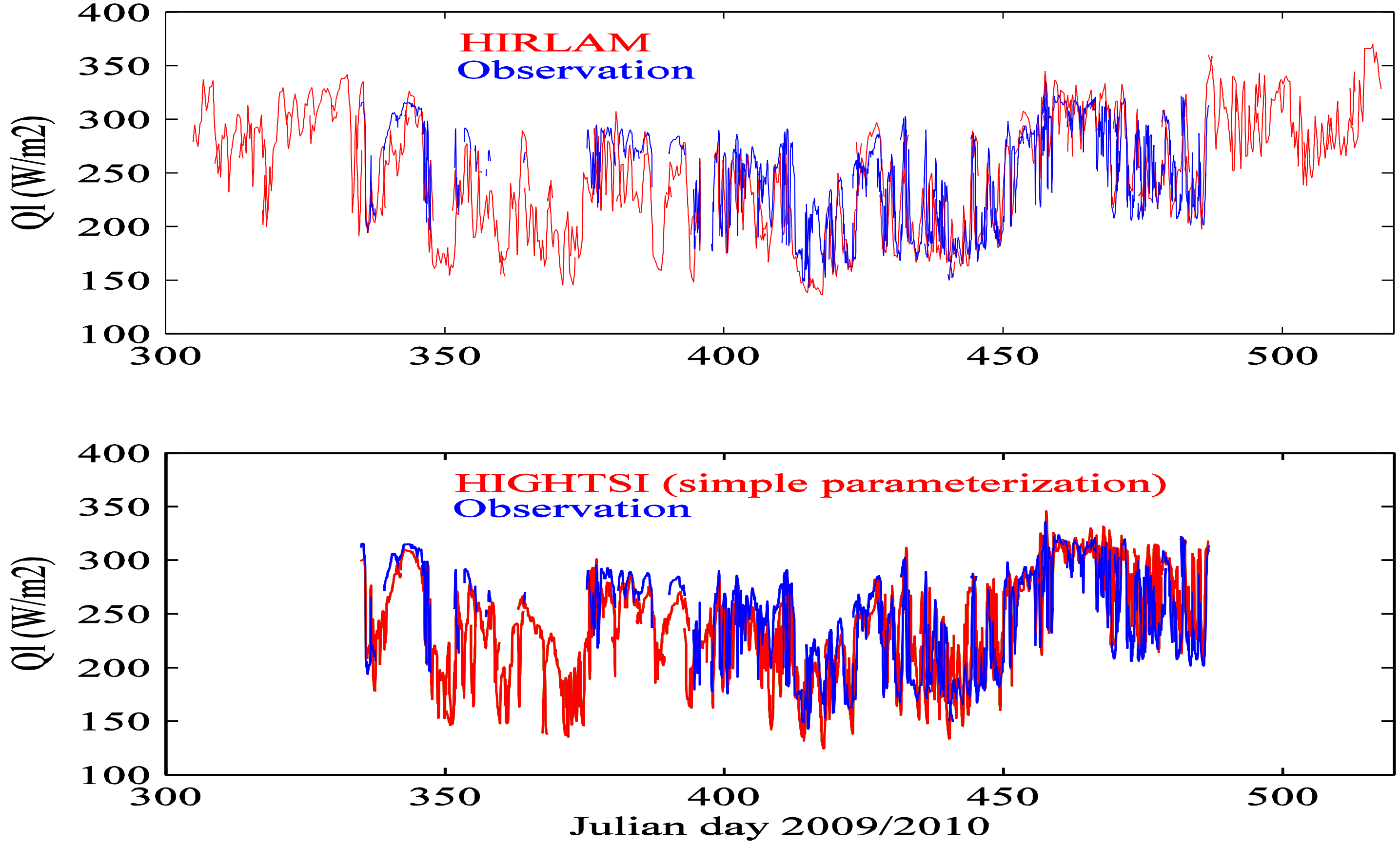


Model run with HIRLAM forcing



Model run with observation forcing


Hice
Hsnow
Freeboard
80
60
40
20
0
-20
300
350
400
450
500
Snow Precipitation [mm/hour]
Observation
0.8
0.6
0.4
0.2
0
Ta (°C)
Observation
20
0
-20
-40
Day of year 2009/2010


HIRLAM
Observation
HIGHTSI (simple parameterization)
Observation
Ql (W/m2)
Julian day 2009/2010
100
150
200
250
300
350
400
300
350
400
450
500

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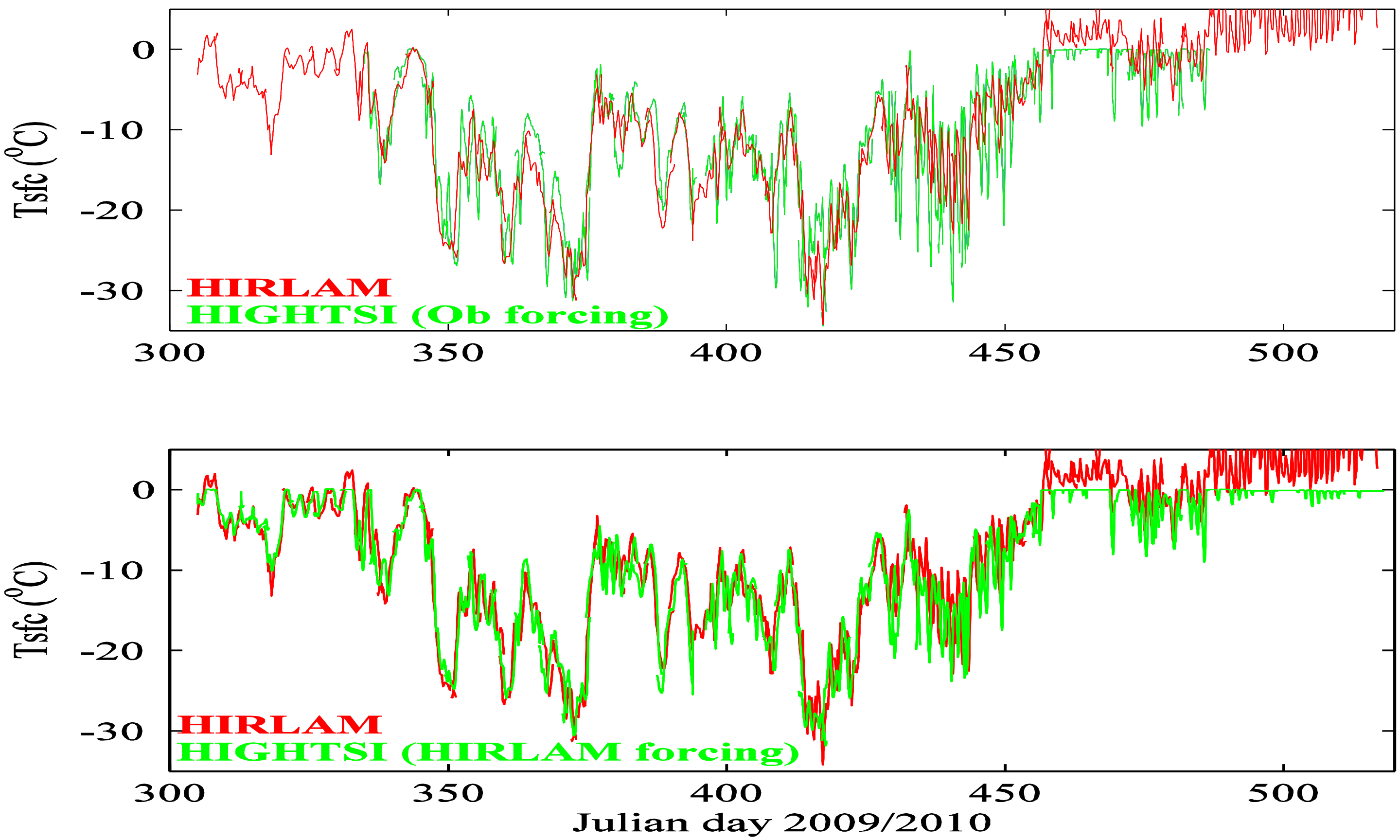

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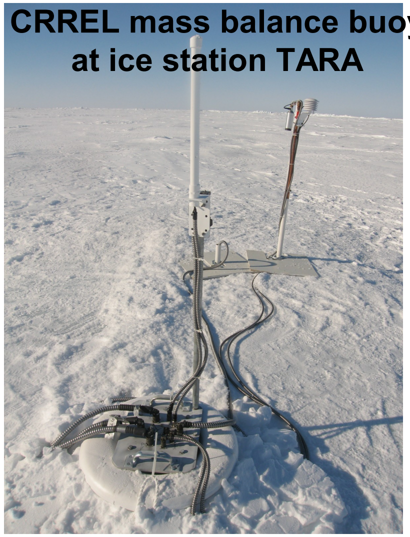
Ice mass balance buoys



- Continuous point measurements at one location
- Monitor ice thickness, snow thickness, as well as ocean, ice, snow and air temperature.
- Able to distinguish bottom melt from top melt.

invented by SAMS (Scottish association for Marine Science)

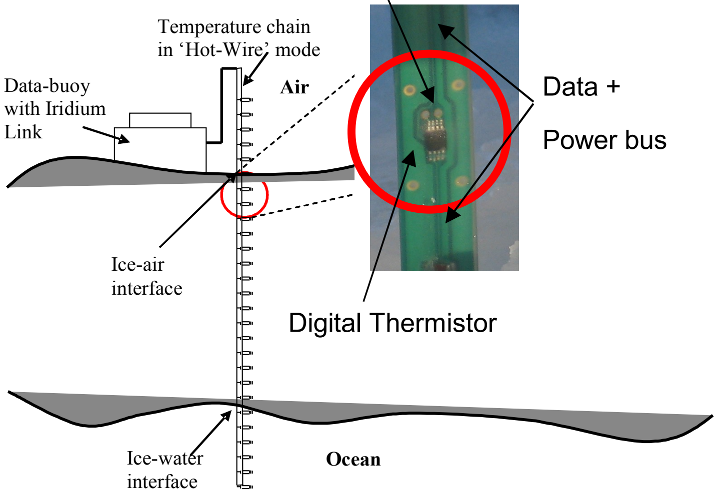


Figure 3: Schematic of the temperature chain used to measure the ice-air and ice-water interface.

16, December, 2009

3, February, 2010

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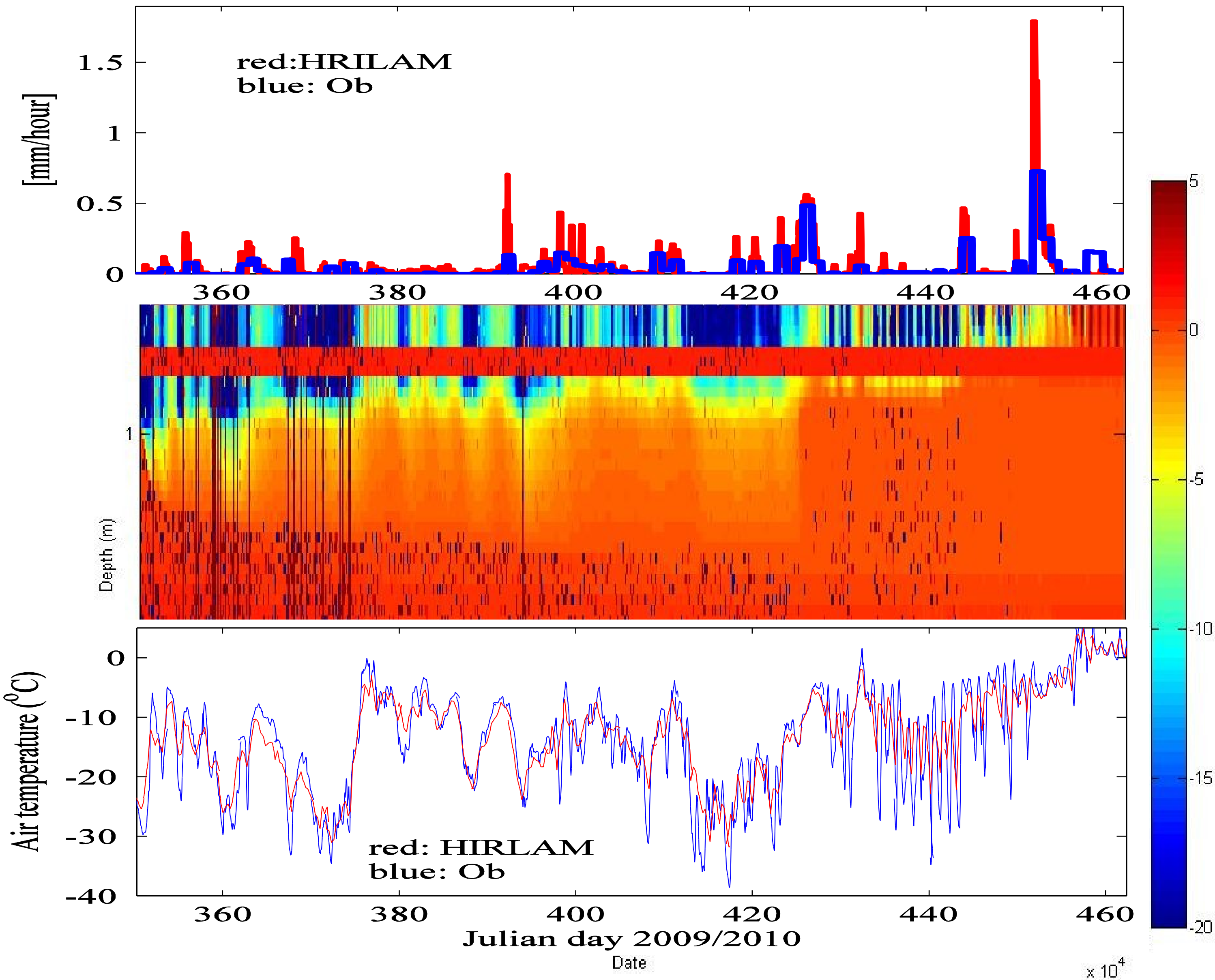
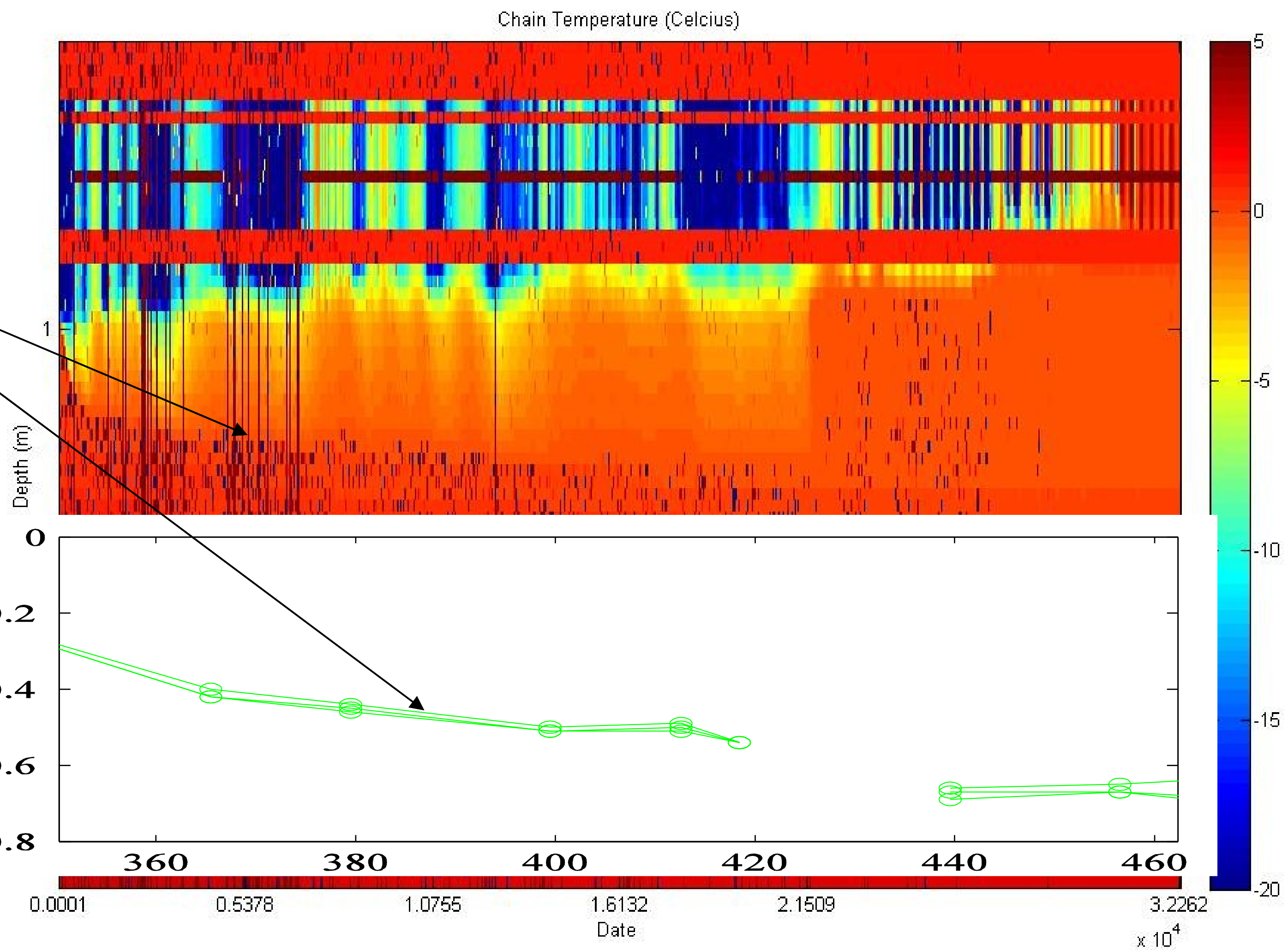


The ice bottom development



Conclusions

Snow and ice thicknesses for in land water bodies are modelled with a one-dimensional thermodynamic snow/ice model (HIGHTSI).

We pay attention to the time series of snow accumulation in a seasonal scale. The model forcing was based on in situ observations from weather stations and numerical weather predication (NWP) model (HIRLAM) results.

- HIGHTSI is capable for lake ice modelling
- HIRLAM results (e.g. Ta, Va) show less variability compared with observations
- The Ql produced by HIRLAM is quite good
- The snow precipitation produced by HIRLAM is applicable for HIGHTSI to simulate the snow time series for inland water body
- Parameterization of longwave radiation is critical for seasonal snow and ice modelling if no NWP results are available
- The precipitation, longwave radiation and melting process described in sea ice model are all important to reveal the snow time series against observations
- Prototype IMB gives encourage results. More sustainable field measurements are still needed in order to better understand the snow and ice in lake

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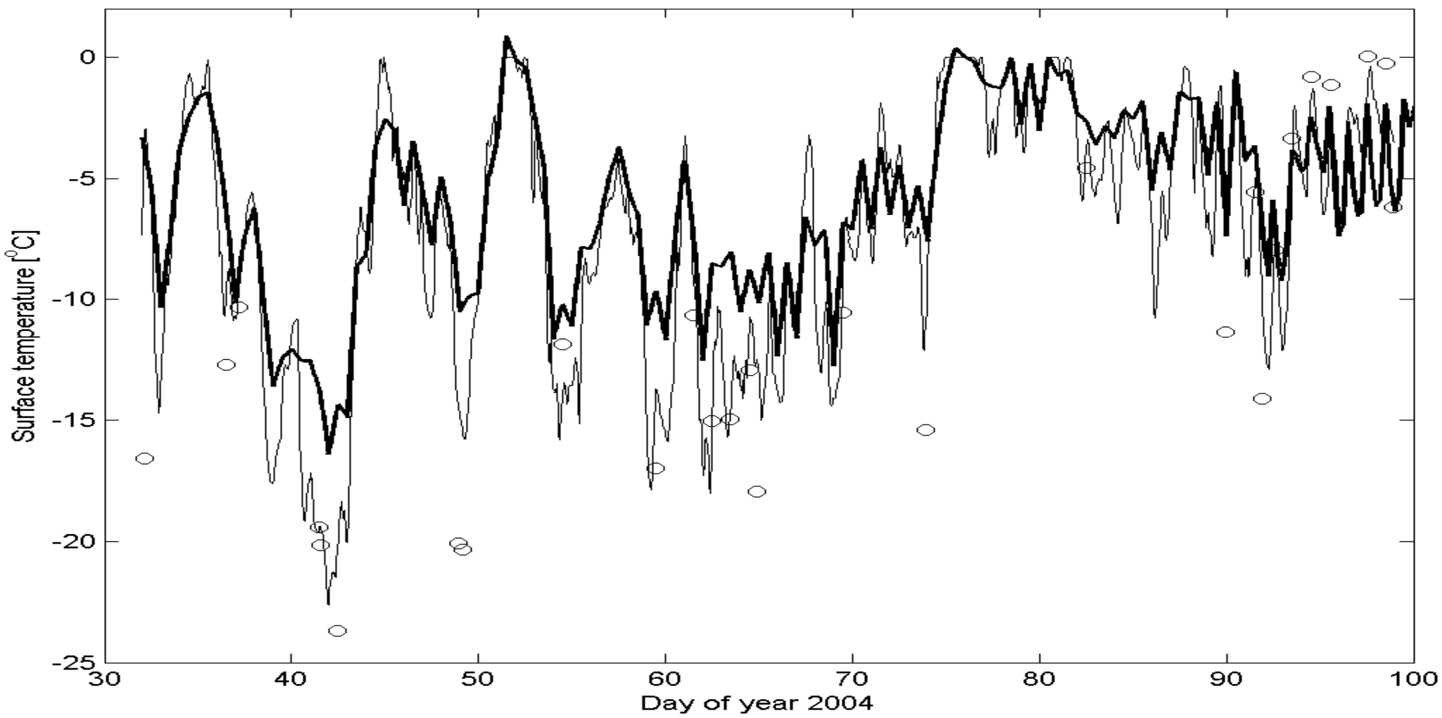
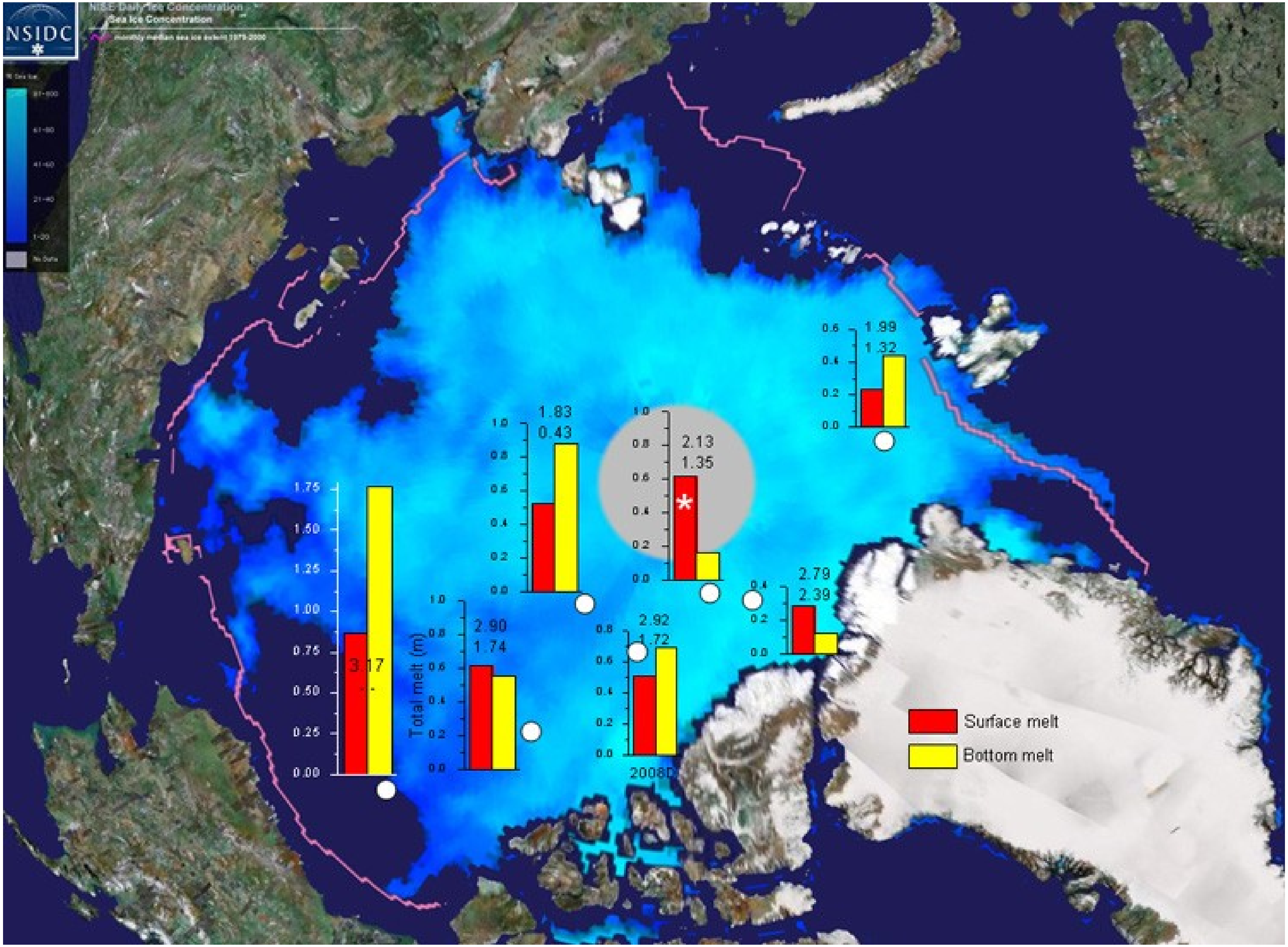


Time series of the snow surface temperature at the test site 2 based on MODIS (circles, only under clear-skies), calculated by HIGHTSI (thin line), and forecast of ECMWF (thick line).


NSIDC
1.83
0.43
2.13
1.35
1.99
1.32
2.79
2.39
2.90
1.74
2.92
1.72
Total melt (m)
2008D
Surface melt
Bottom melt