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Evolution of snow and ice thickness in Lake Orajärvi, northern Finland

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Finnish Meteorological Institute

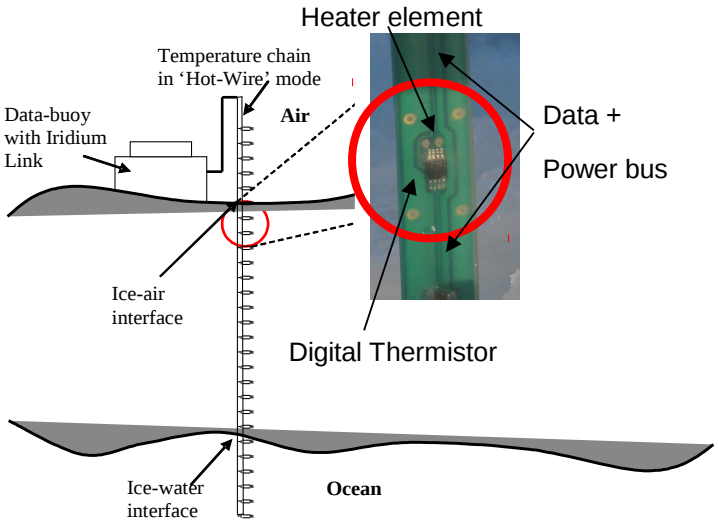
We aim to carry out sustainable snow and ice observations in lake Orajärvi, in the vicinity of the Arctic Research Centre of FMI, Sodankylä monitoring facilities in northern Finland. The objectives of this ongoing research are as follows:

- - to investigate snow and ice mass balance and temperature regimes.
- - to improve snow and ice thermodynamic model HIGHTSI.
- - to validate results of numerical weather prediction model (e.g. HIRLAM) .
- - to test a prototype snow and ice mass balance buoy in a lake environment.

- Observations
- Modelling

Ice mass balance buoys

- İnvented by SAMS (Scottish Association for Marine Science)
- Continuous measurements at one location
- Monitor high resolution temperature profile (sensor interval: 2cm)



Schematic of the temperature chain used to measure the ice-air and ice-water interface.(by Jeremy Wilkinson)

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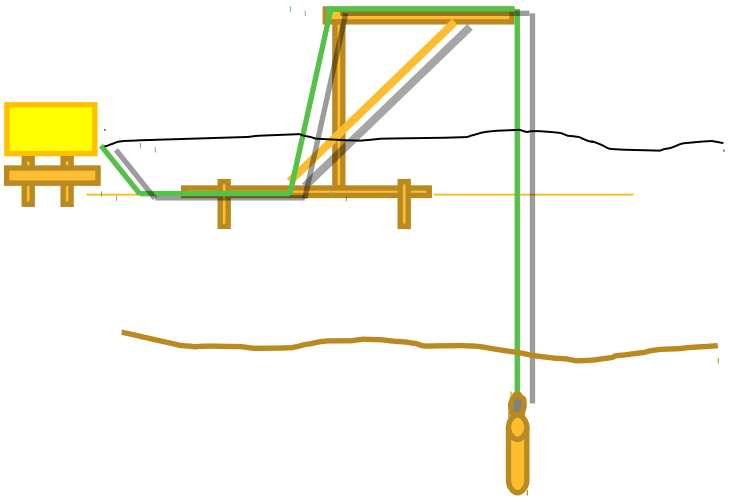

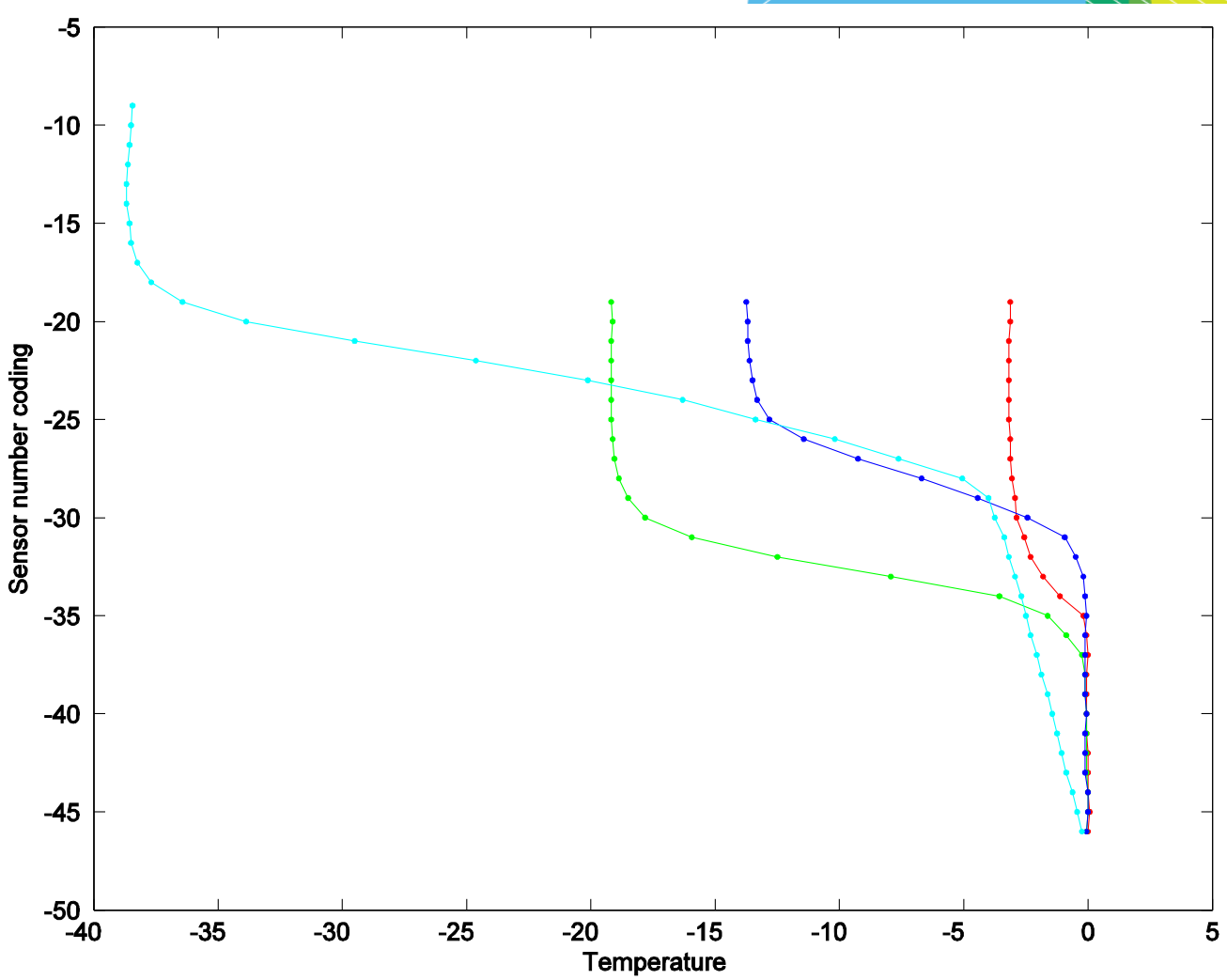
Sensor number coding
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-15
-20
-25
-30
-35
-40
-45
-50
-40
-35
-30
-25
-20
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-10
-5
0
5
Temperature

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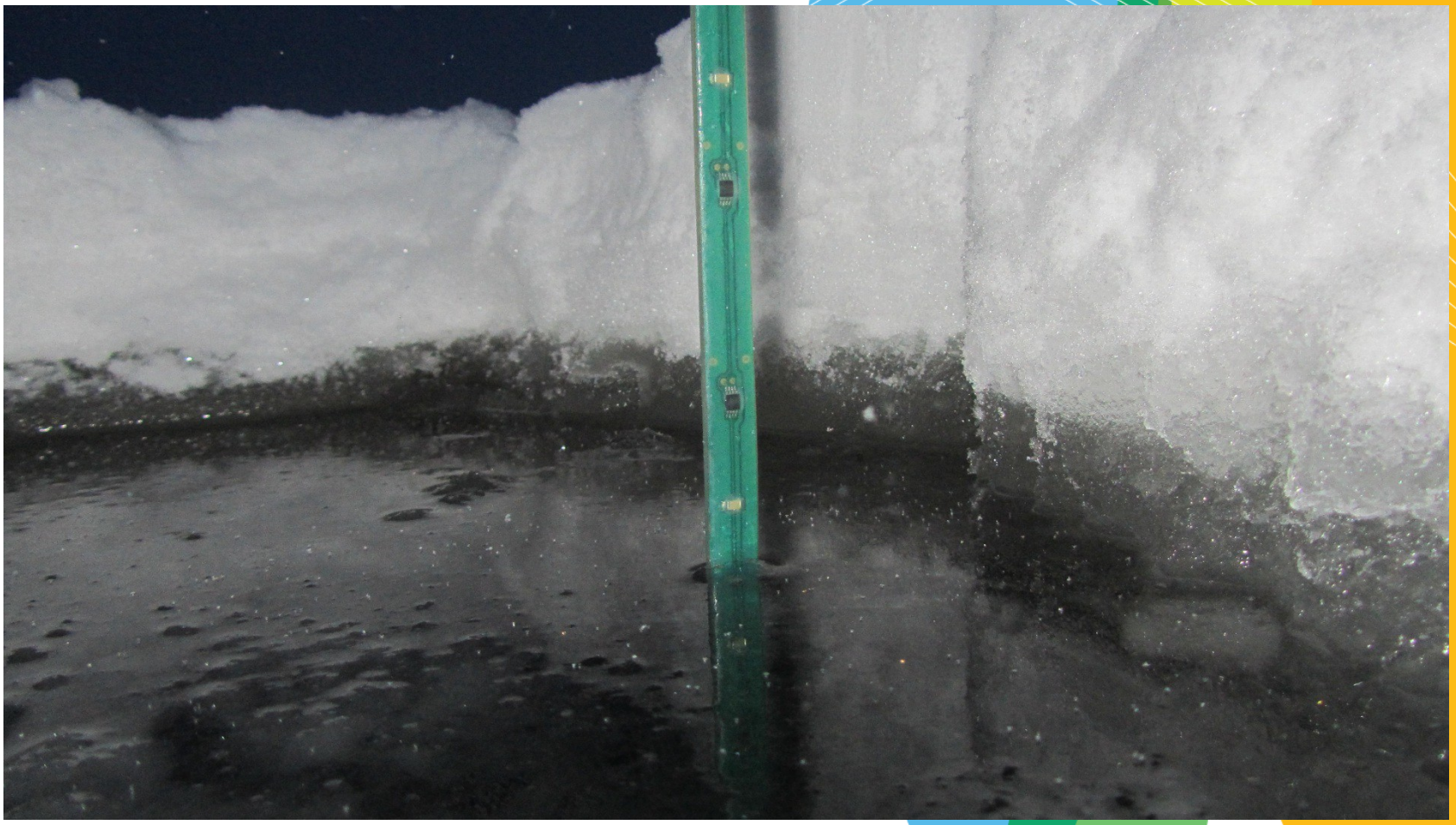

28 May - 1 June

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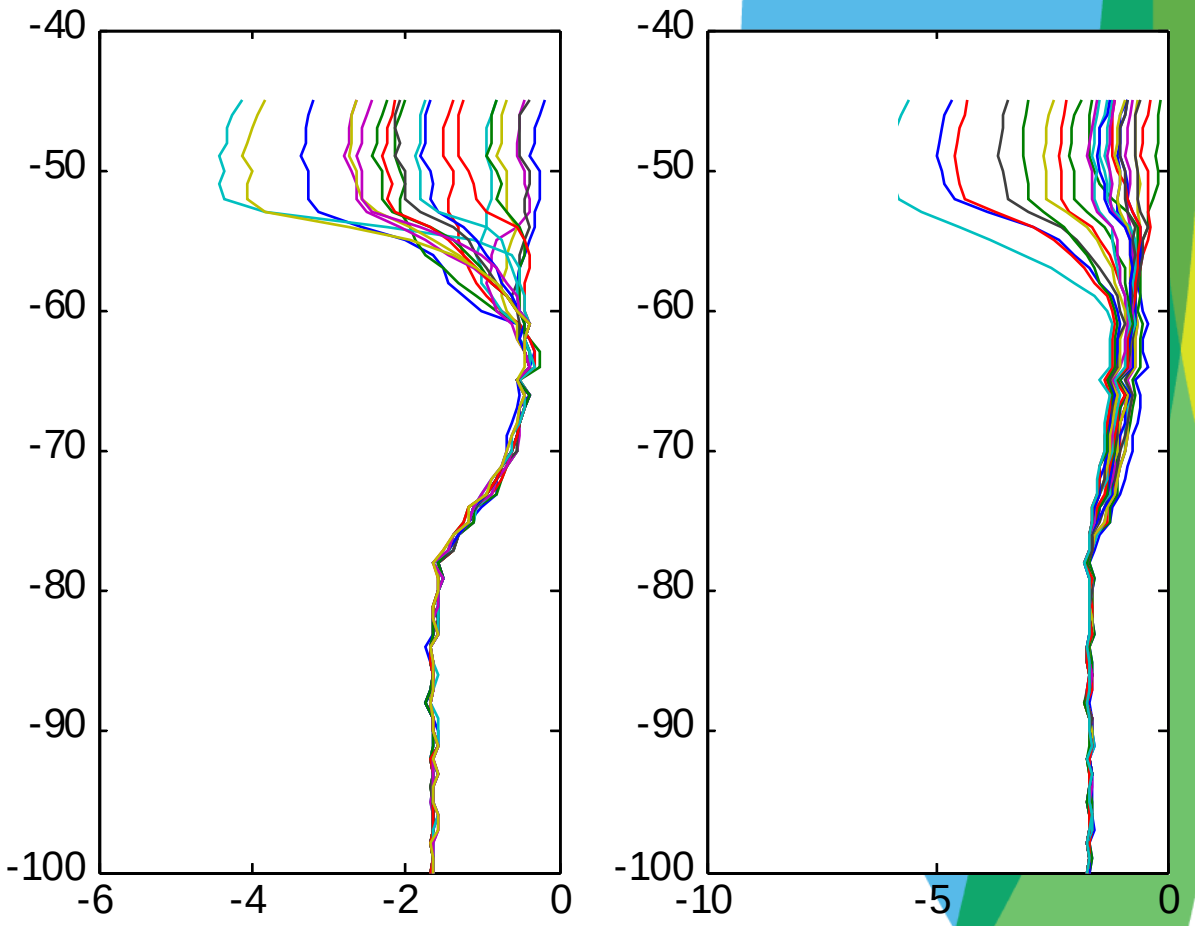
http://martech.sams.ac.uk/fmi/



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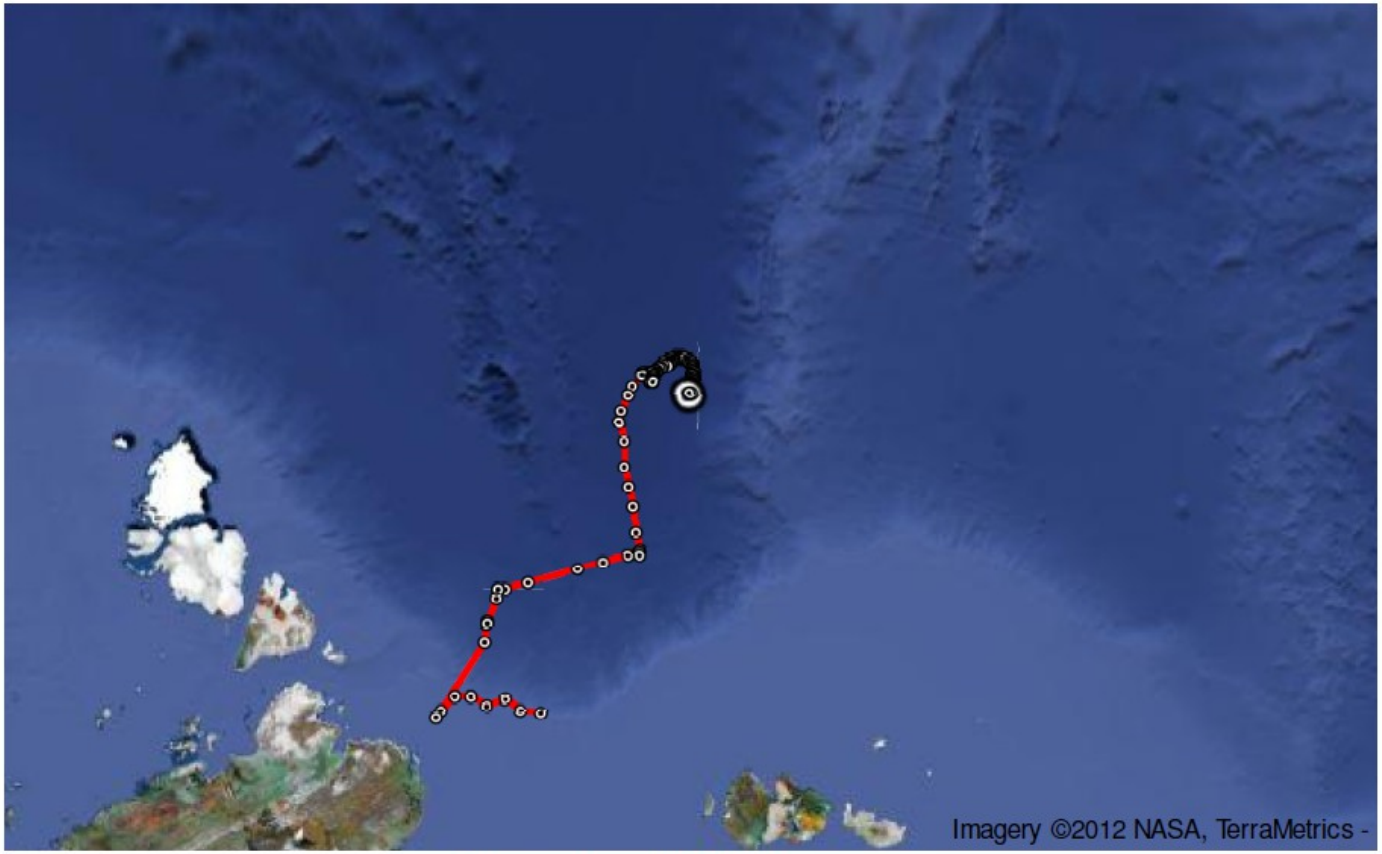
FMI 4 MAP



Map updated **04:47 hours ago**

Sea Ice Extent Composite courtesy of Polar View.

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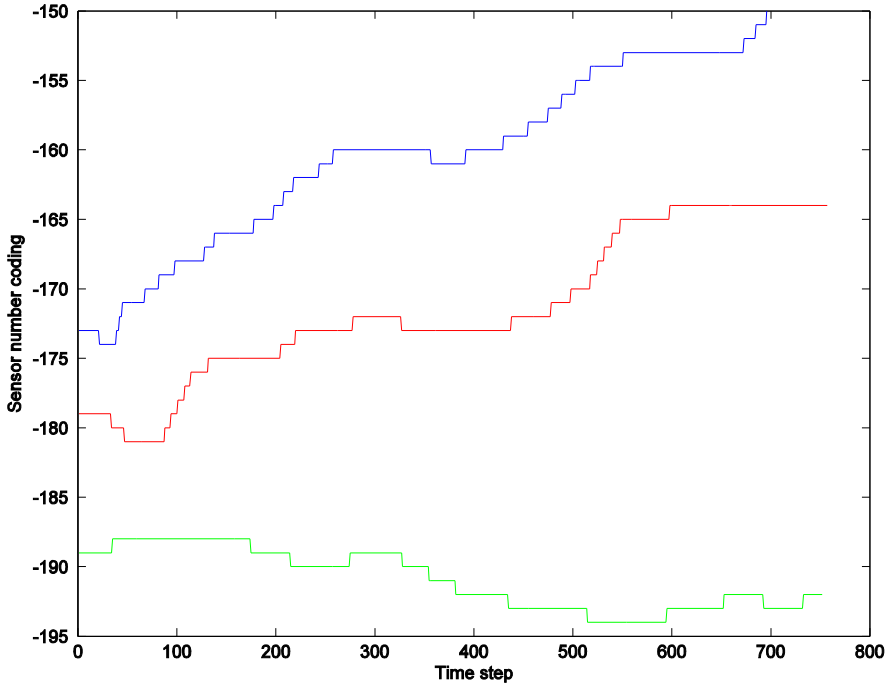
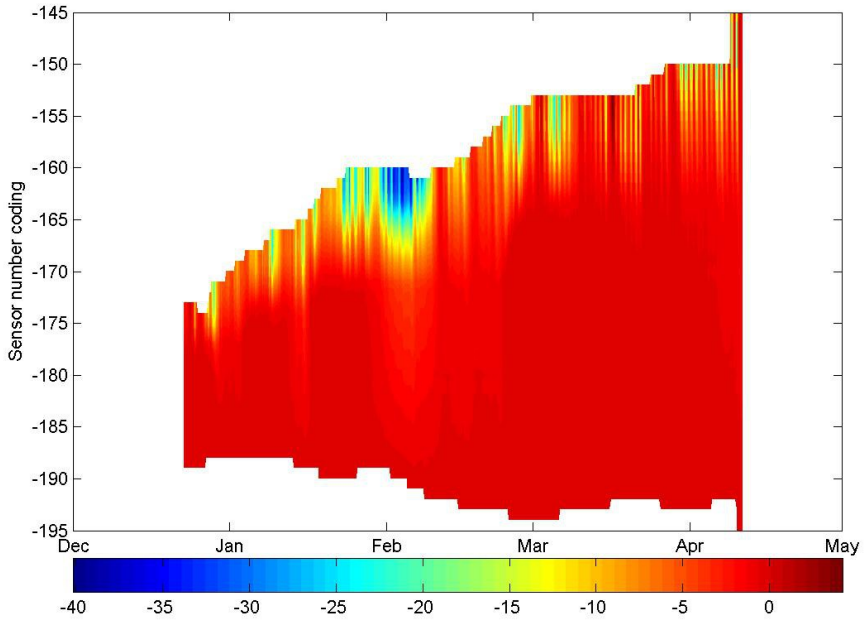
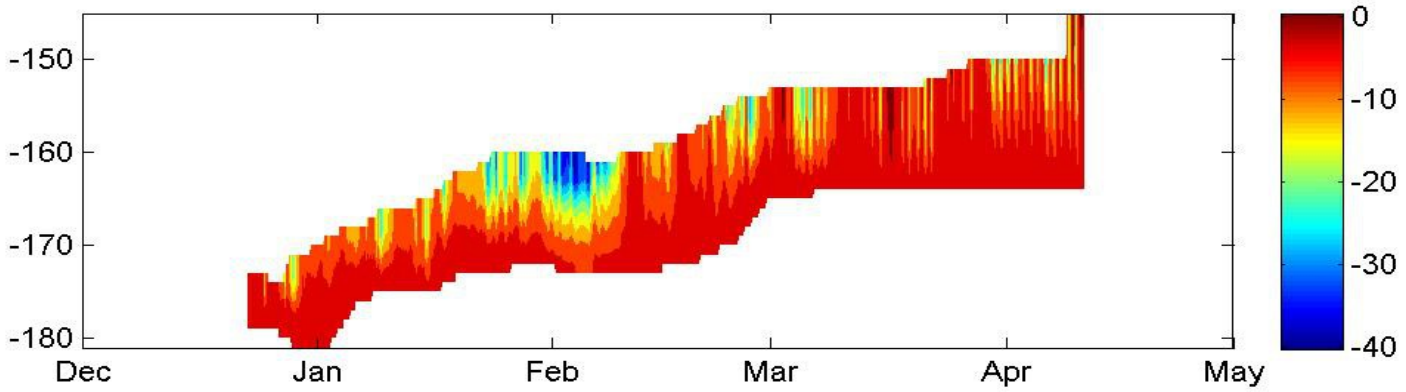
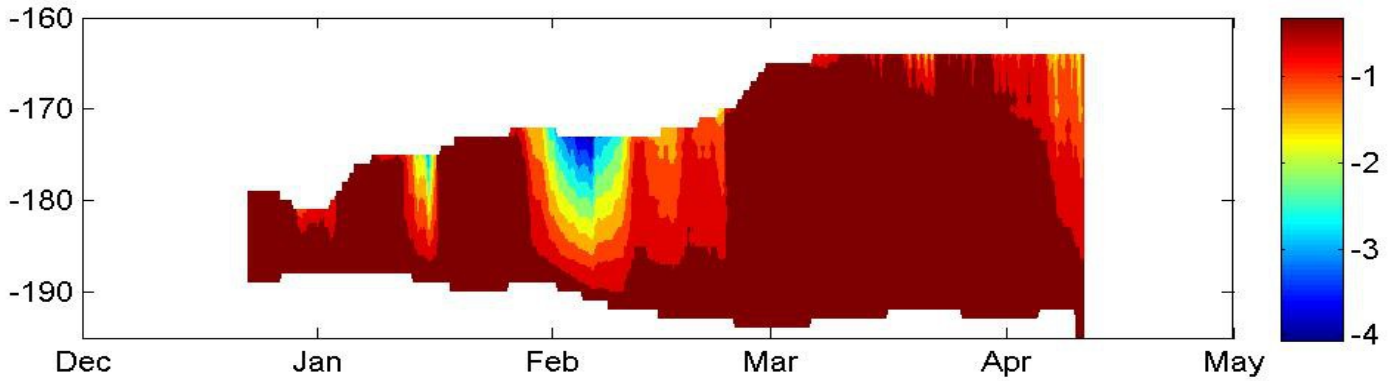
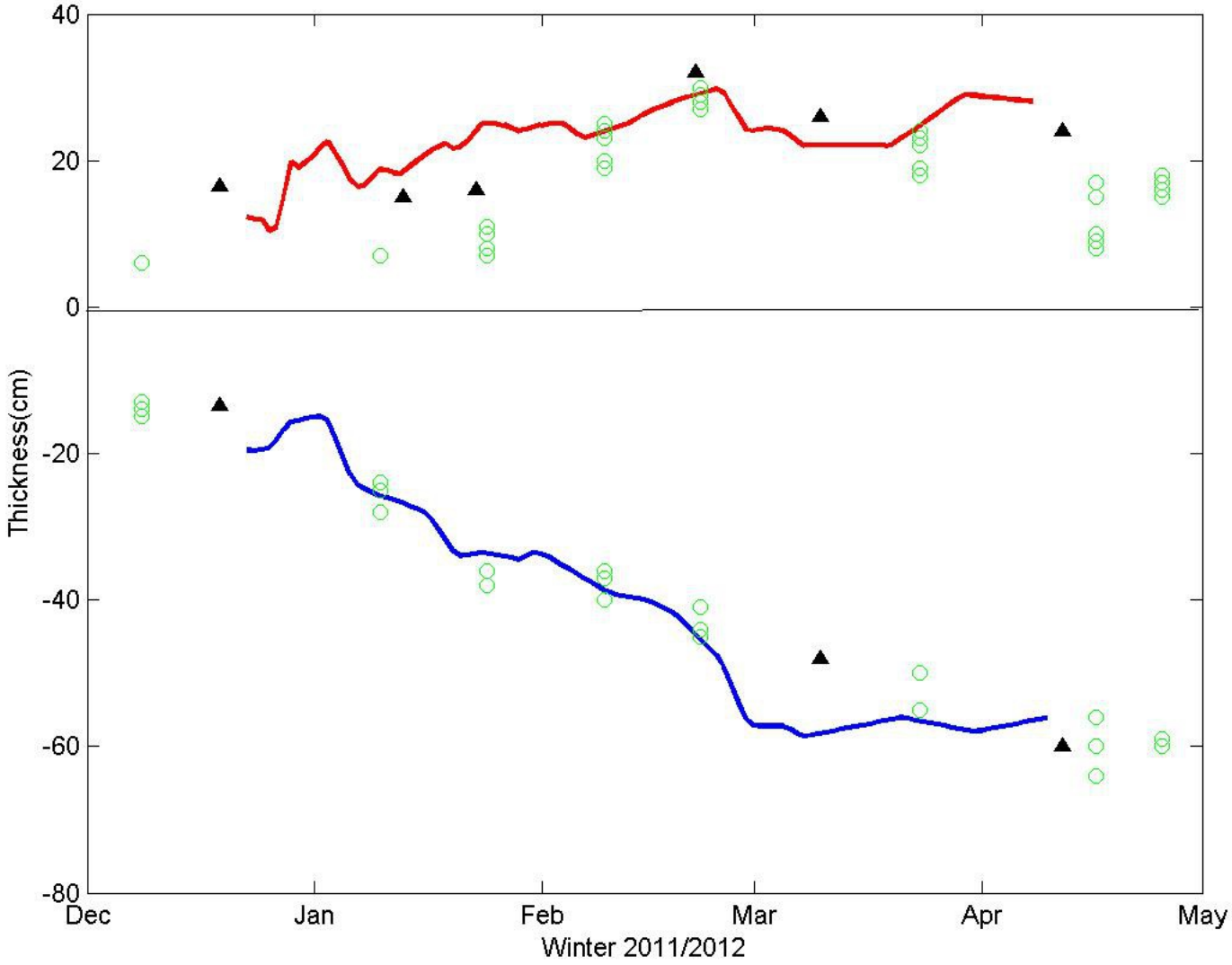
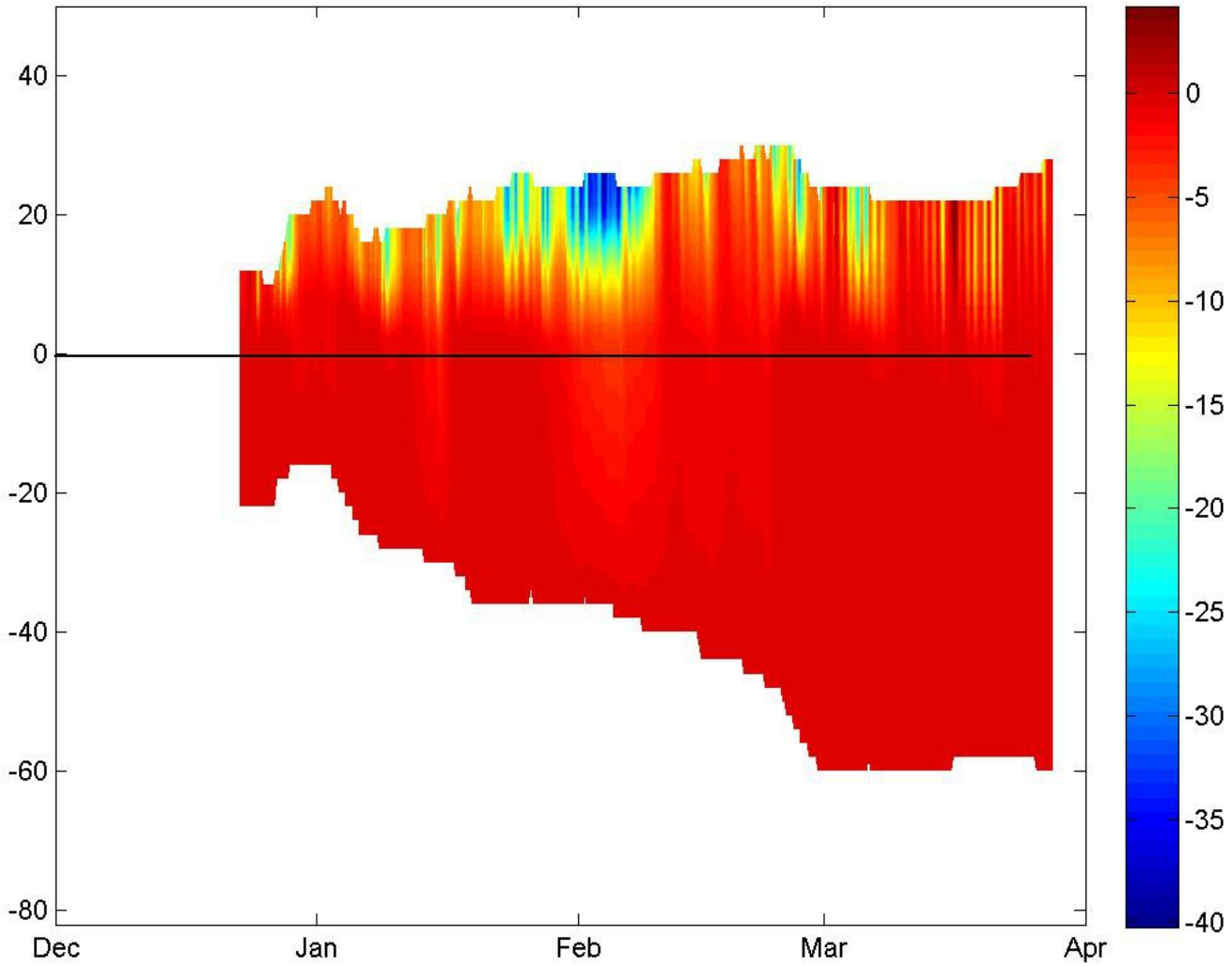





-150
-160
-170
-180
Dec
Jan
Feb
Mar
Apr
May
0
-10
-20
-30
-40


-160
-170
-180
-190
Dec
Jan
Feb
Mar
Apr
May
-1
-2
-3
-4


40
20
0
-20
-40
-60
-80
Thickness(cm)
Dec
Jan
Feb
Mar
Apr
May
Winter 2011/2012


40
20
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-40
-60
-80
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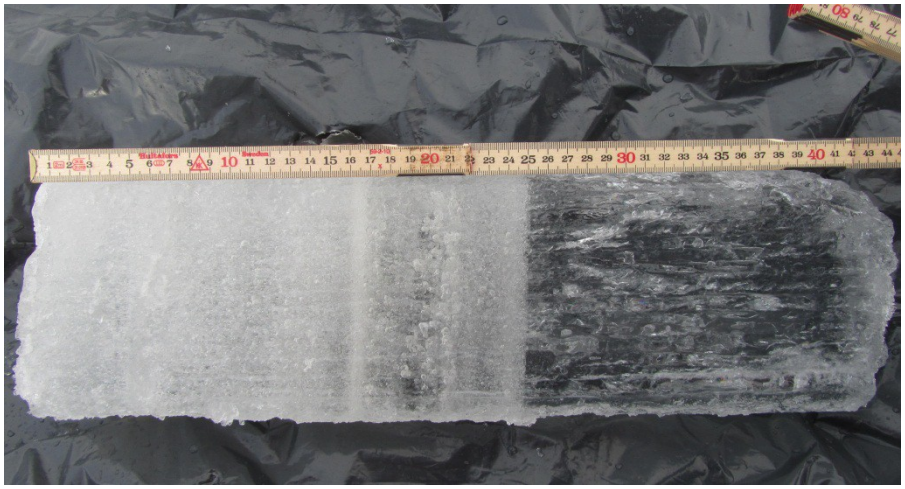
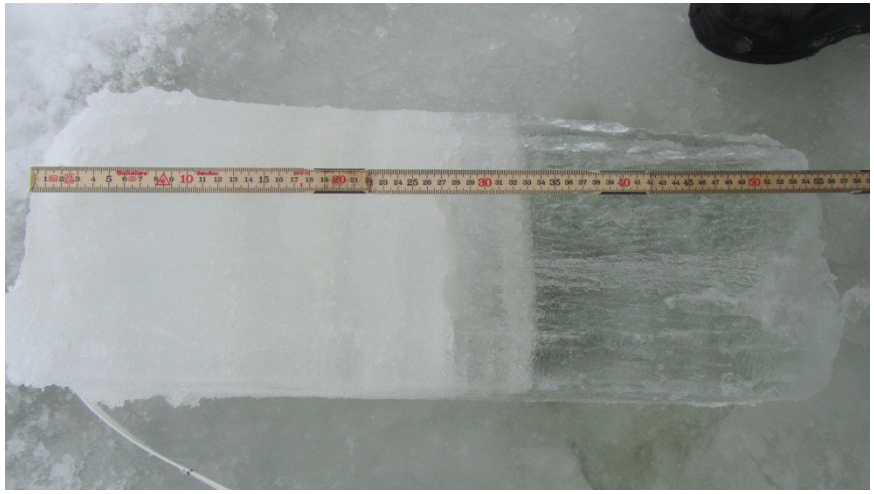
-40

11,3,2012



12,4,2012



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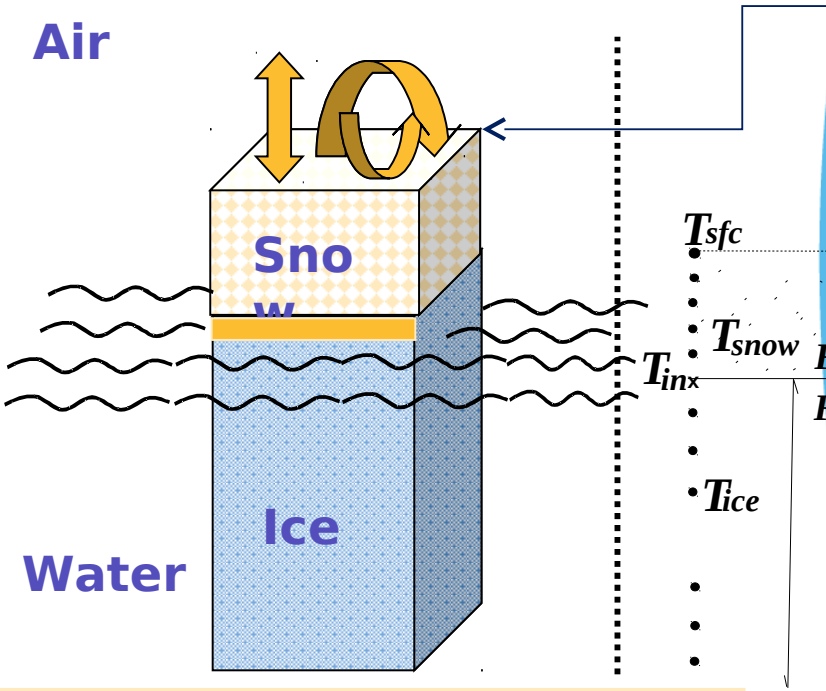
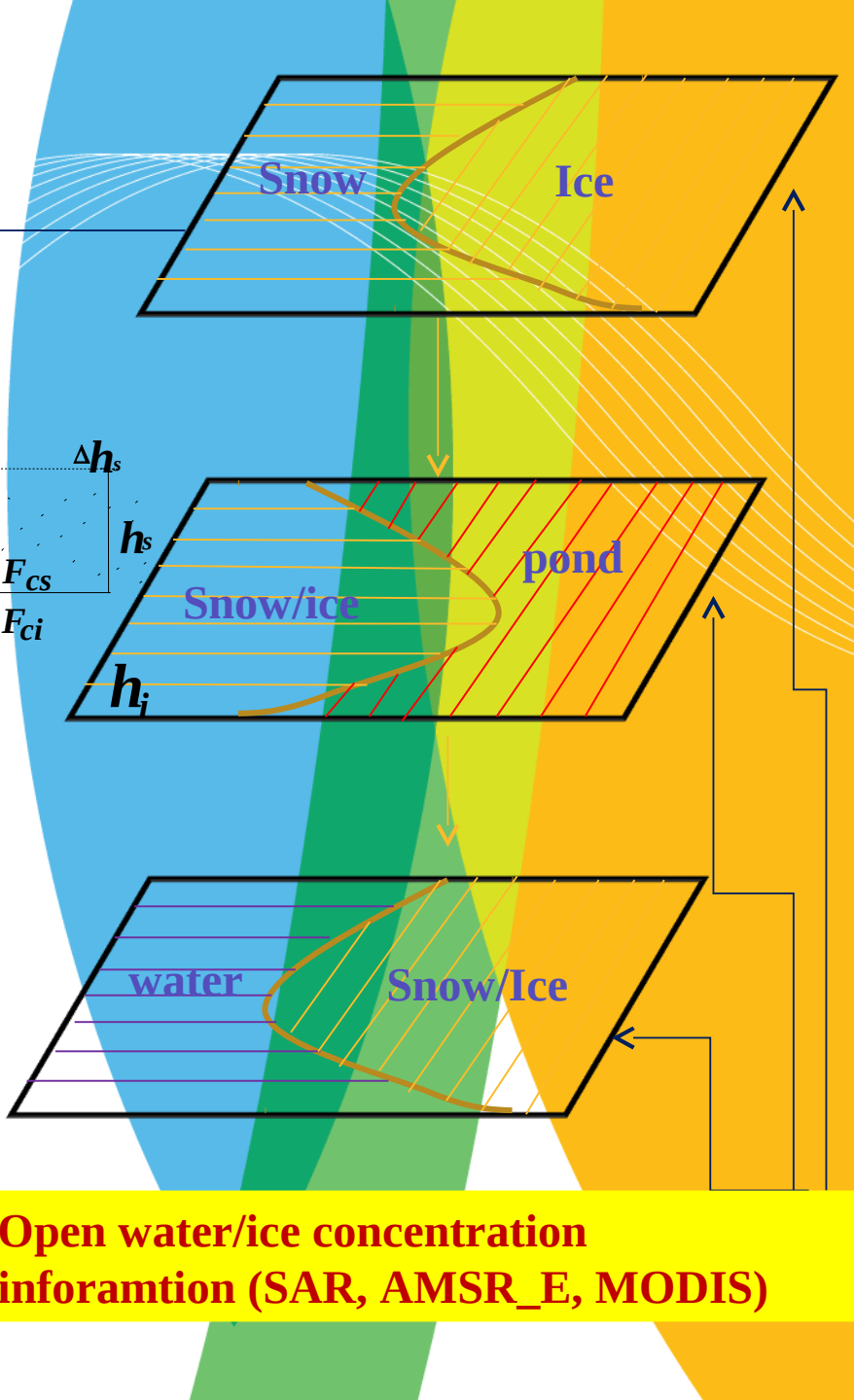




HIGHTSI: One dimensional snow/ice thermodynamic model considered in a horizontal unit area

External forcing: NWP models (HIRLAM/ECMWF)
Result: Snow and ice thickness; surface temperature

Open water/ice concentration inforamtion (SAR, AMSR_E, MODIS)

Doronin (1971)

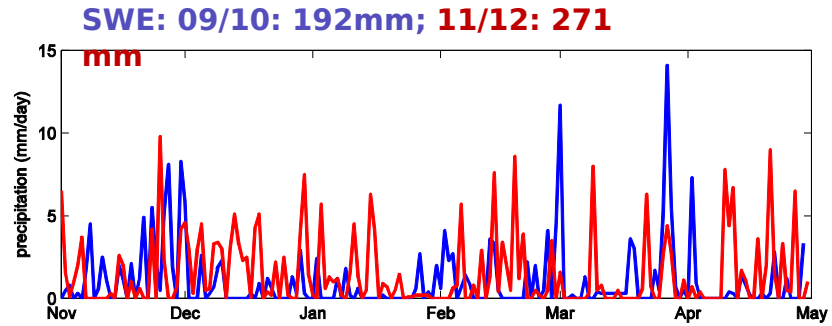
$hs = 0$ for $hi < 5$ cm

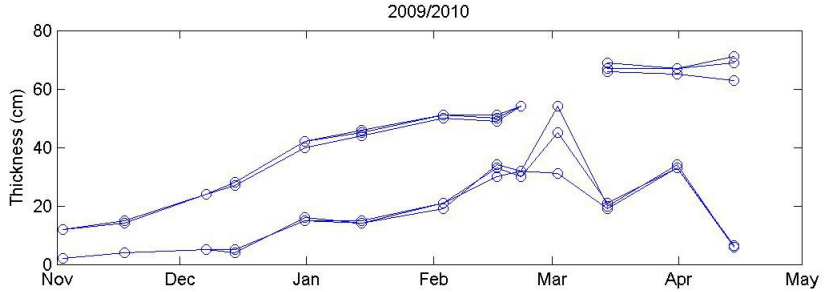
$hs = 0.05hi$ for $5\text{ cm} \leq hi \leq 20$ cm

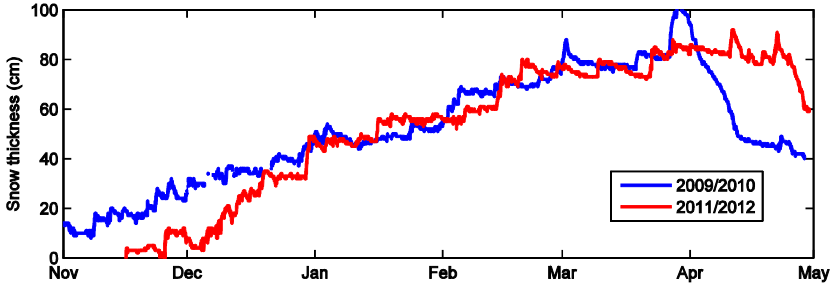
$hs = 0.1hi$ for $hi > 20$ cm

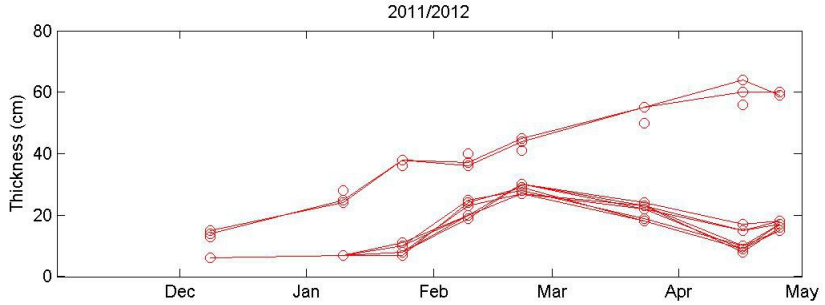
Model experiments										
				Coastal ice stations						
		Snow thickness parameterization	V	I	S	Vi	D	M	U
I	S1	No snow		x	x	x	x	x	x
	S2	$h_s = 0$, if $h_i < 0.05$; $h_s = 0.05h_i$, if $0.05 \leq h_i \leq 0.2$; $h_s = 0.09h_i$, if $h_i \geq 0.2$ (Mäkynen and others this issue)		x	x	x	x	x	x
	S3	$h_{s\_input}(t) = P_{snow} / \rho_{s0}$; Snow precipitation = Snow accumulation; snow heat conductivity k_s is from Strum and others,(1997)		x	x	x	x	x	x
	S4	$h_{s\_input}(t) = P_{snow} / \rho_{s0}$; $h_{s\_input}(t) = 0.2 \cdot (Prec / \rho_{s0})$, if $h_i < 0.3$; $h_{s\_input}(t) = 0.9 \cdot (P_{snow} / \rho_{s0})$, if $h_i \geq 0.3$; k_s : Sturm and others(1997)		x	x	x	x	x	x
	S5	same as case4, but apply effective snow heat conductivity (k_{seff}) according to Semmler and others (2012)		x	x	x	x	x	x
II	S6	$h_{s\_input}(t) = P_{snow}(Land\_ob) / \rho_{s0}$, k_{seff}	x				x		
	S7	$h_{s\_input}(t) = 0.4 \times h_s(Land\_ob)$, k_{seff}	x				x		

Cheng et al, Annals of Glaciology, 2012

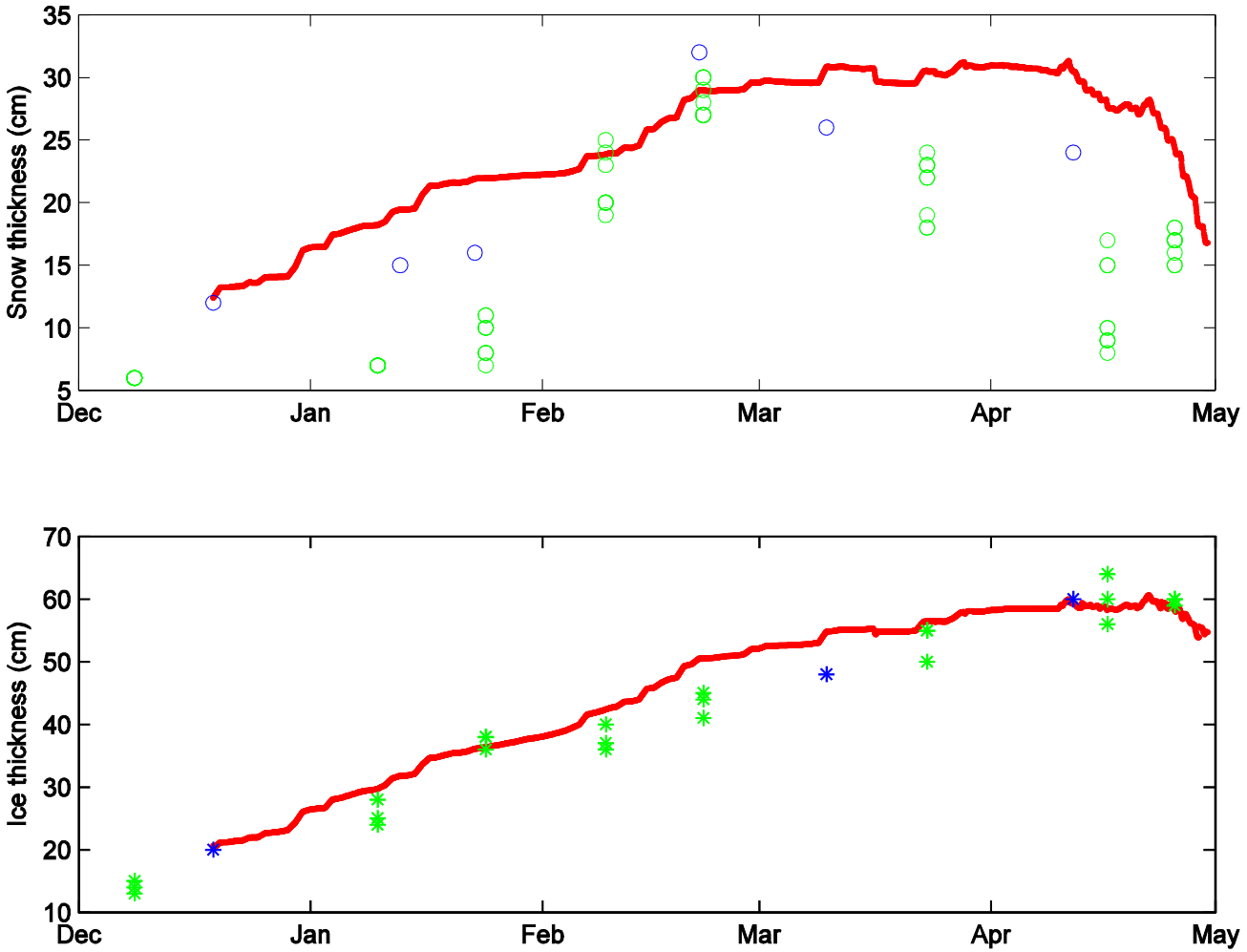




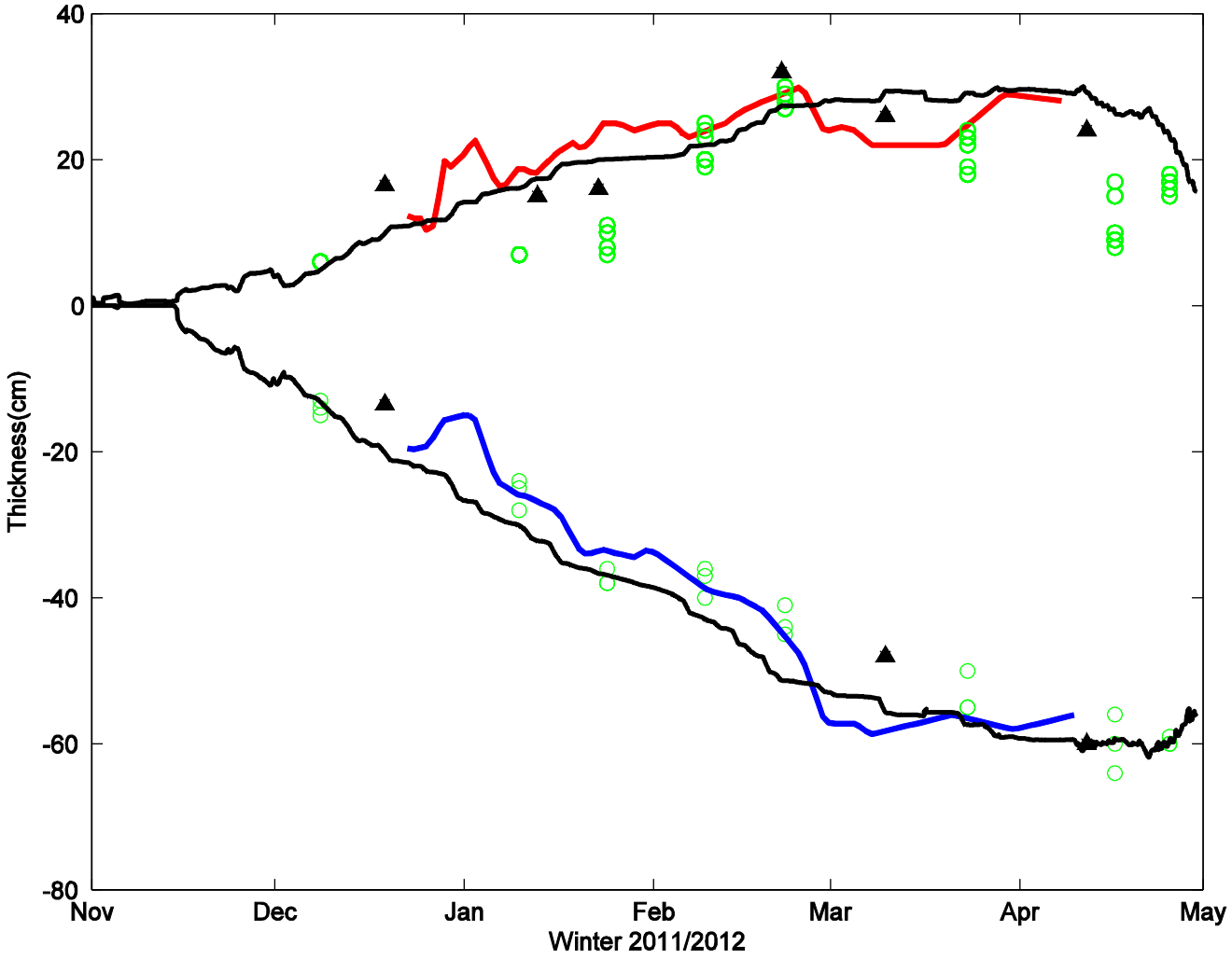


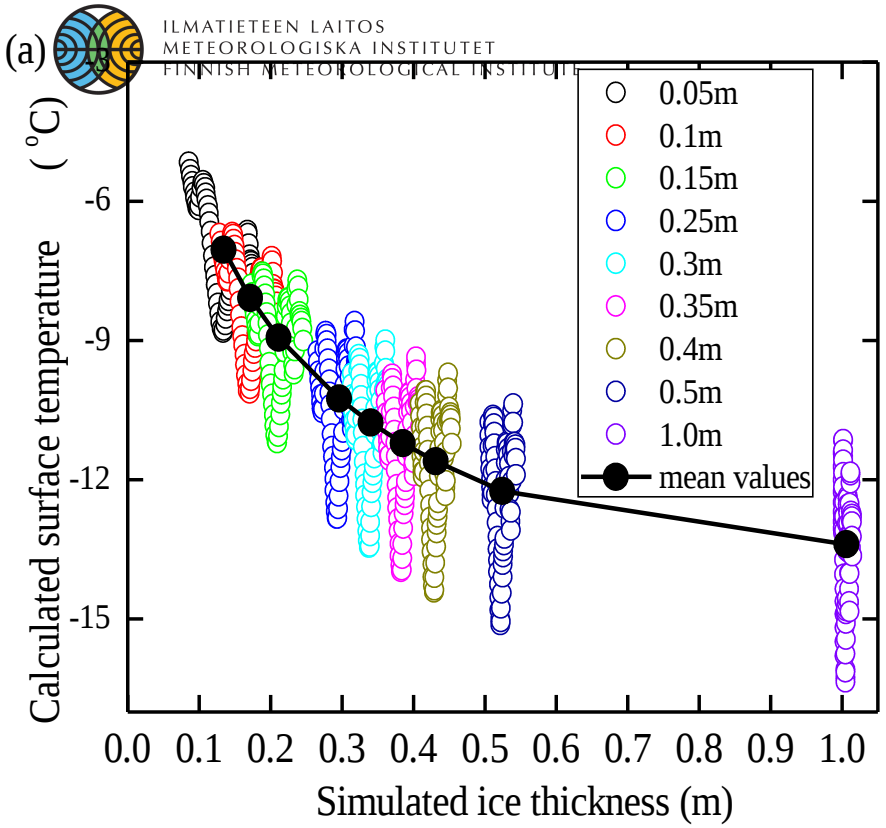


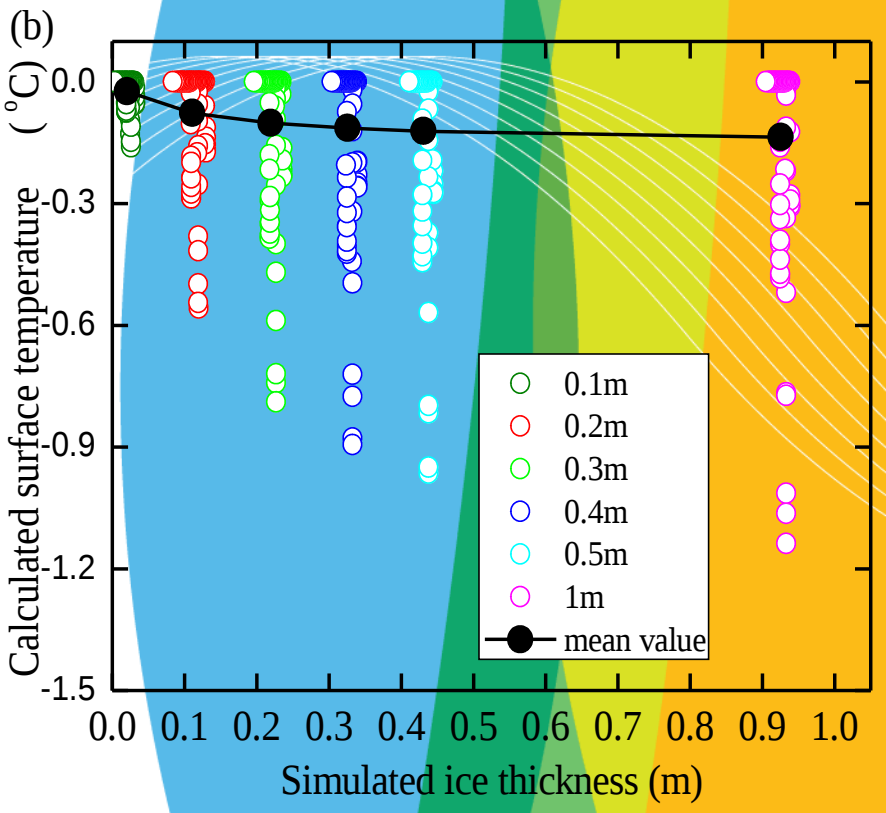
The daily precipitation and accumulated thickness on land, and snow and ice thicknesses measured on Lake Orajärvi for winters 2009/2010 and 2011/2012.



HIGHTSI modelled snow and ice thickness for winter 2011/2012. The external forcing was *in situ* observations. The green circles and blue dots mark *in situ* observations made in two different locations on Lake Orajärvi.


40
20
0
-20
-40
-60
-80
Thickness(cm)
Nov
Dec
Jan
Feb
Mar
Apr
May
Winter 2011/2012





Surface temperature versus different ice thickness category:

(a) a cold period between 3 Jan 0:00 - 5 Jan 23:00 (b) a warm period between 8 April 0:00 - 11 April 13:00 (*Yang et al, 2012, Tellus*)

Surface temperature response strongly for thin ice category (<0.5m) in cold condition

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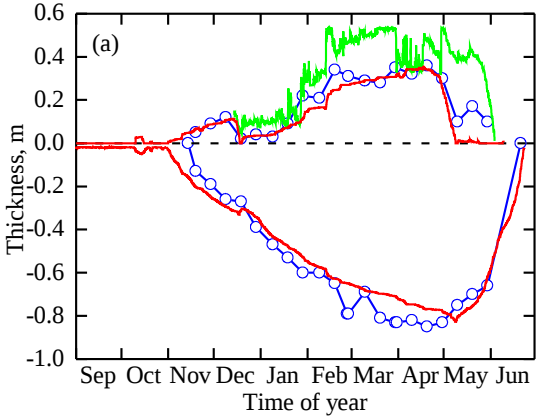
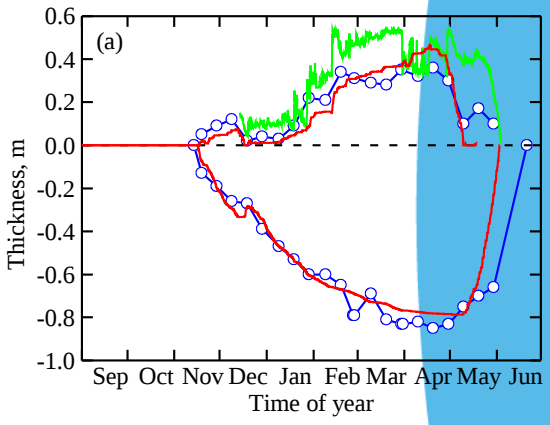
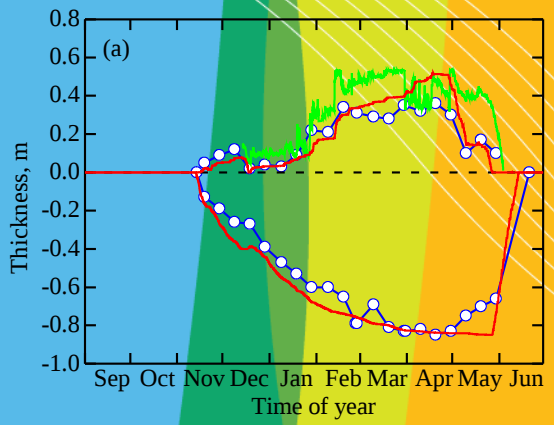
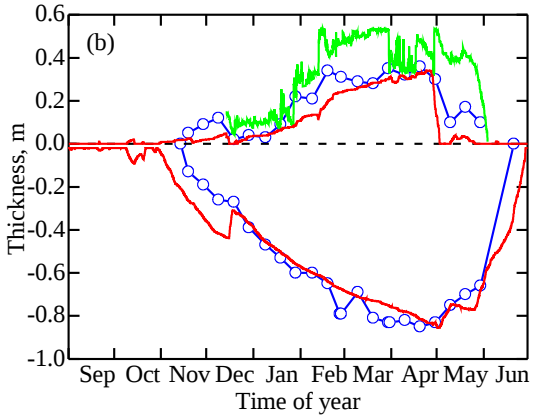
Local forcing



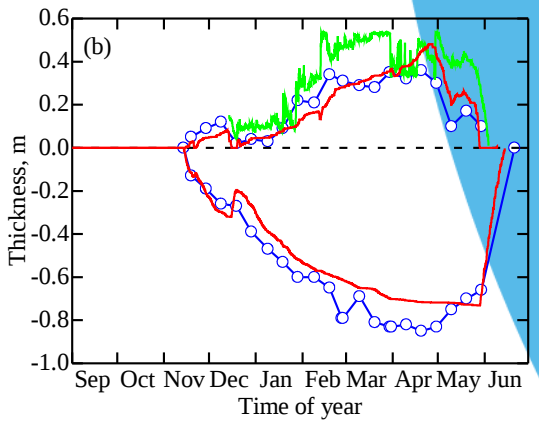




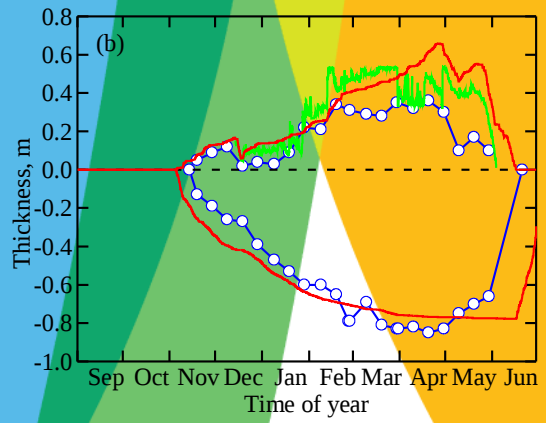
HIGHTSI Flake



SURFEX_Flake

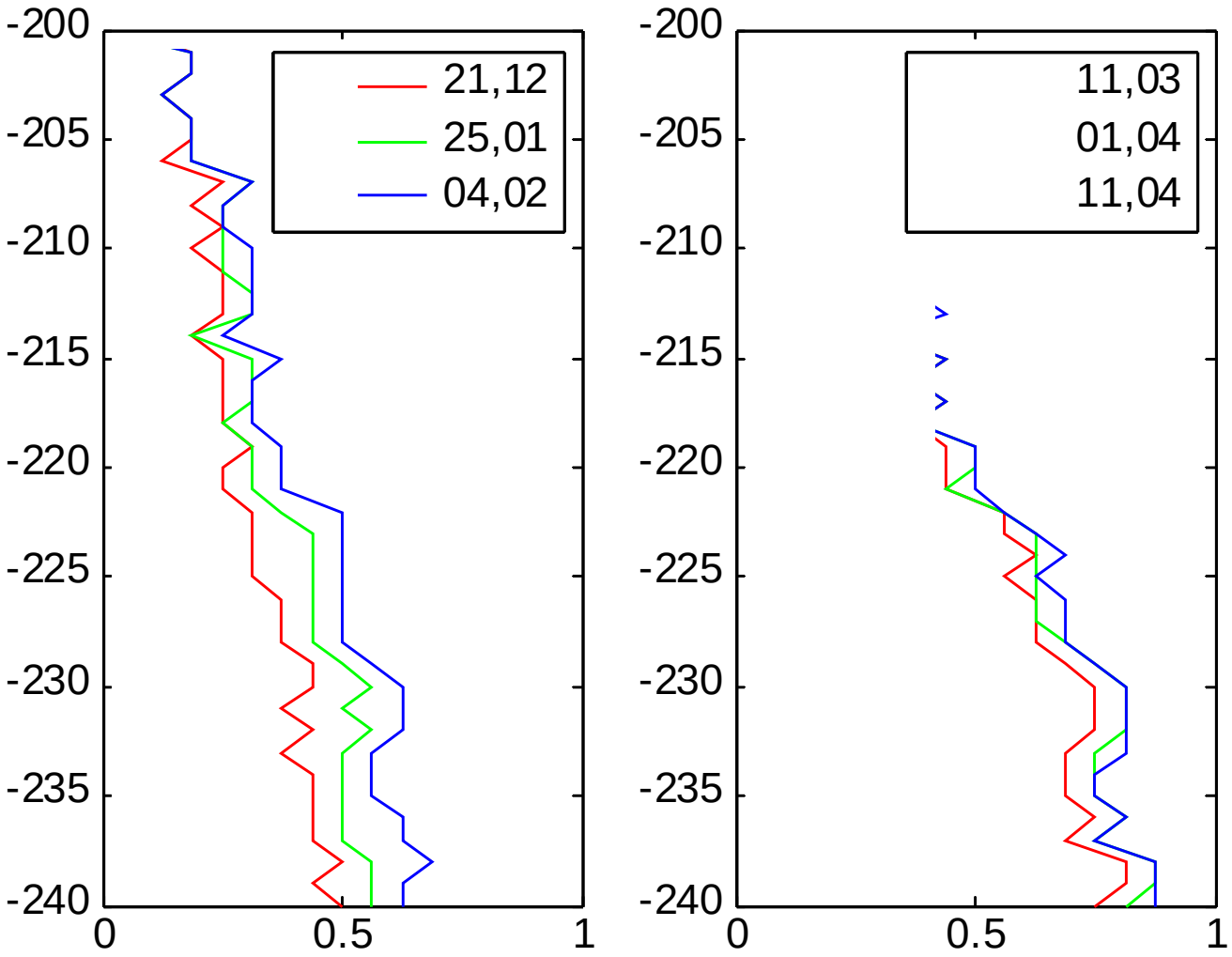


Stand-alone



Hirlam (forecasts) forcing

Yang et al, 2012, BER under revision


-200
-205
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-215
-220
-225
-230
-235
-240
0
0.5
1
21,12
25,01
04,02
11,03
01,04
11,04

The following work has been carried and will be carried out:

- snow and ice measurements on Lake Orajärvi in winters 2009/2010, 2010/2011 and 2011/2012.

-The prototype ice mass balance buoys deployed in winters 2009/2010 and 2011/2012.

- The HIRLAM operational forecasts compared with *in situ* measurements for 2009/2010.

- HIGHTSI simulation for winter 2009/2010 applying *in situ* observations and HIRLAM forecasts as external forcing.

- HIGHTSI simulation for winter 2011/2012 applying in situ observations as external forcing.

-Continue field measurement; HIGHTSI modeling with HIRLAM 2011/2012 data

-HIGHTSI now casting modelling

-HIGHTSI + ECMWF ensemble data