Royal Netherlands
Meteorological Institute
Ministry of Infrastructure and the Environment

Prediction of lake ice in the Netherlands using FLake

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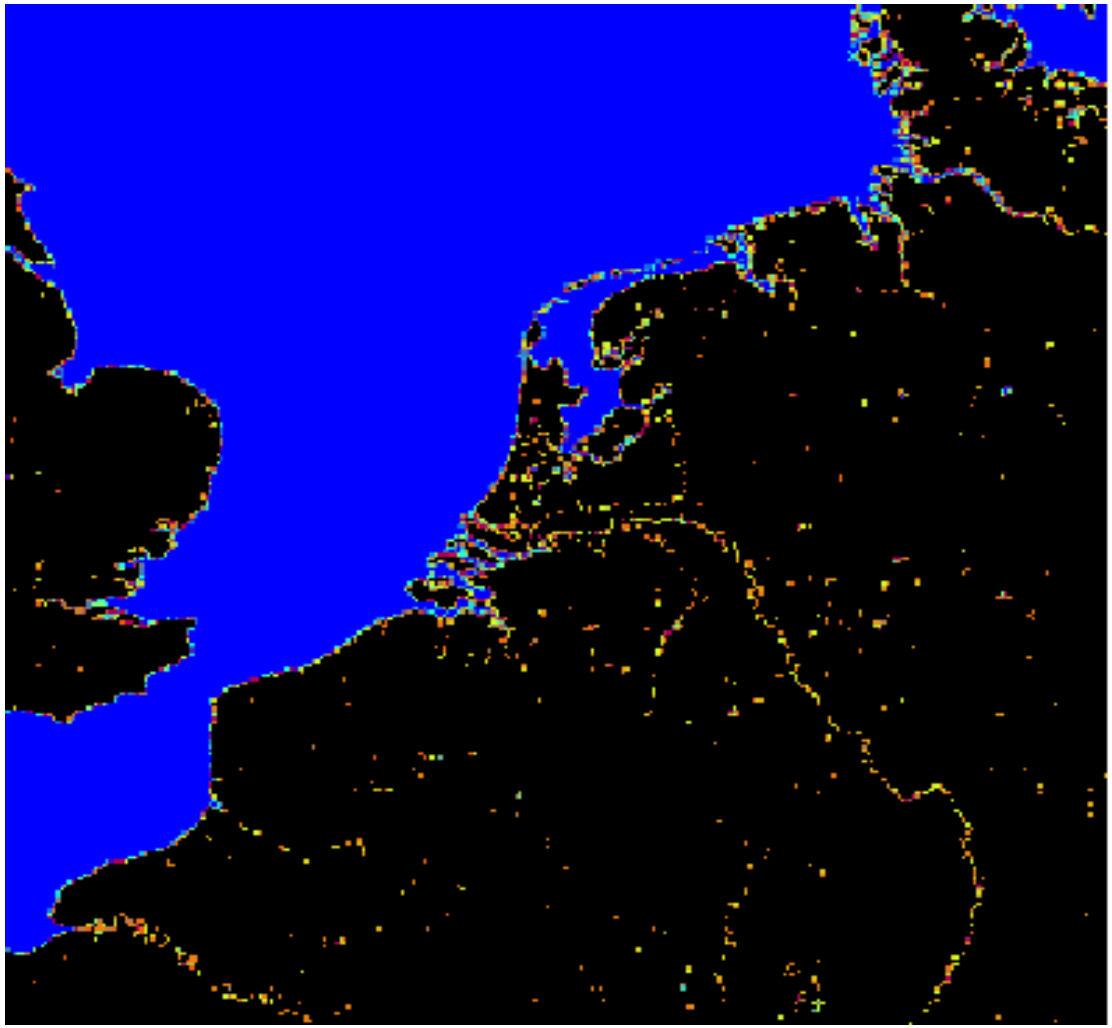
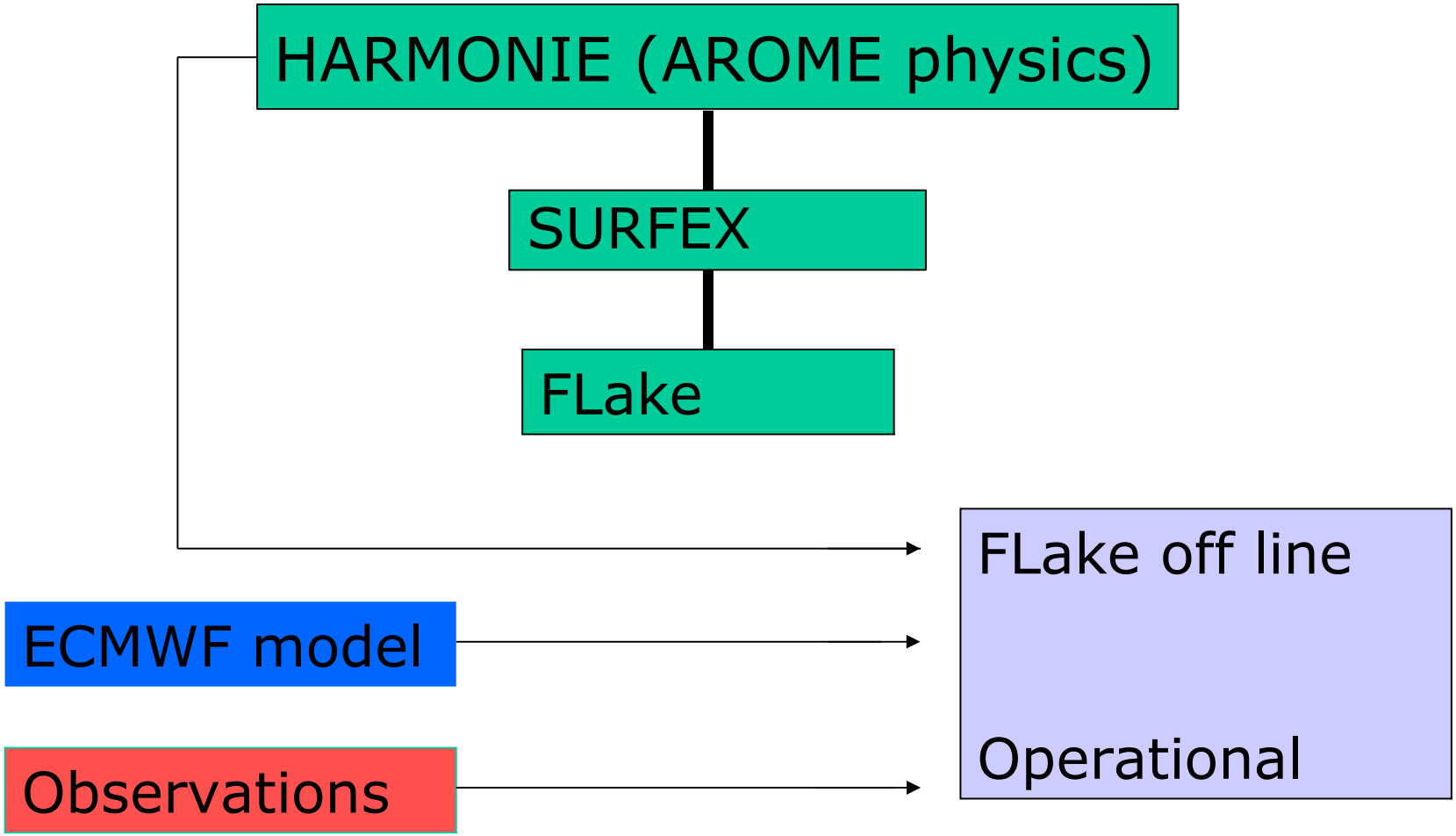
Motivation

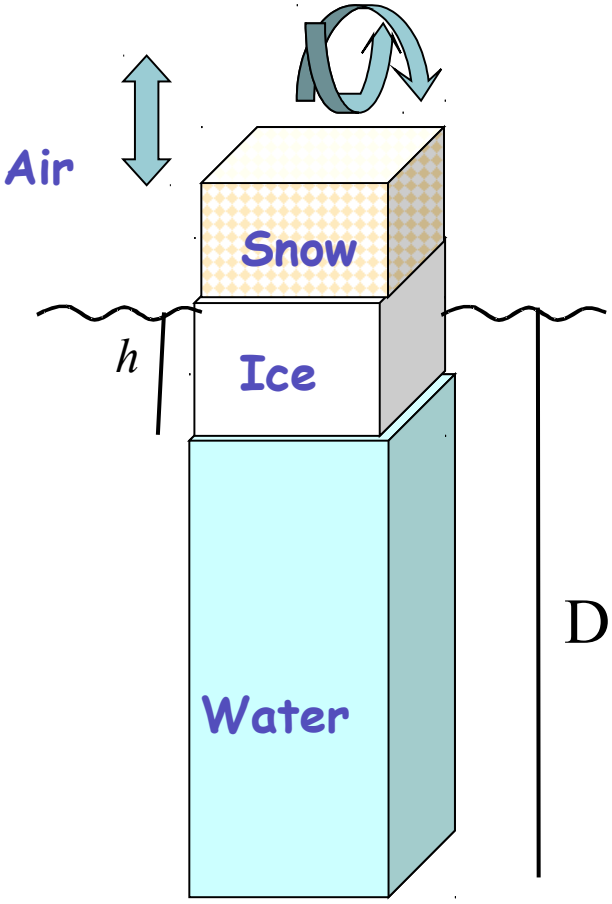
- Interest by ice skaters for frozen waterways in the Netherlands
- Interest by transport sector for navigable waterways
- Need for interactive tool for ice prediction

HARMONIE: land/sea mask + inland waters




HARMONIE (AROME physics)
SURFEX
FLake
FLake off line
ECMWF model
Operational
Observations

De Bruin and Wessels: One dimensional ice model (JAM 1987)



Input :

dtg

10m wind

2m temp

2m dewpoint

Cloud cover

WW-code

Snow

- Surface energy
  - Radiative fluxes (Qs, Ql, absorbed solar radiation)
  - Turbulent fluxes (sensible and latent heat fluxes, momentum flux)
- Snow
  - Thermal and Optical properties of snow
- Ice
  - Thermal regimes (temperature profiles)

Empirical formula's for longwave - and net radiation

rdlong=(0.76*0.004*ta)*ppb*(ta+273.15)**4+(2.25*nn+5.25*nh)

rdnet=(1.0-albedo)*rdglob-emiss*(ppb*(tn+273.0)**4.0-rdlong)

ta=air temperature [C]

tn=wet or ice bulb temperature [C]

ppb= Stephan Boltzmann constant [W/m2/K4]

nn= total cloud cover [octa]

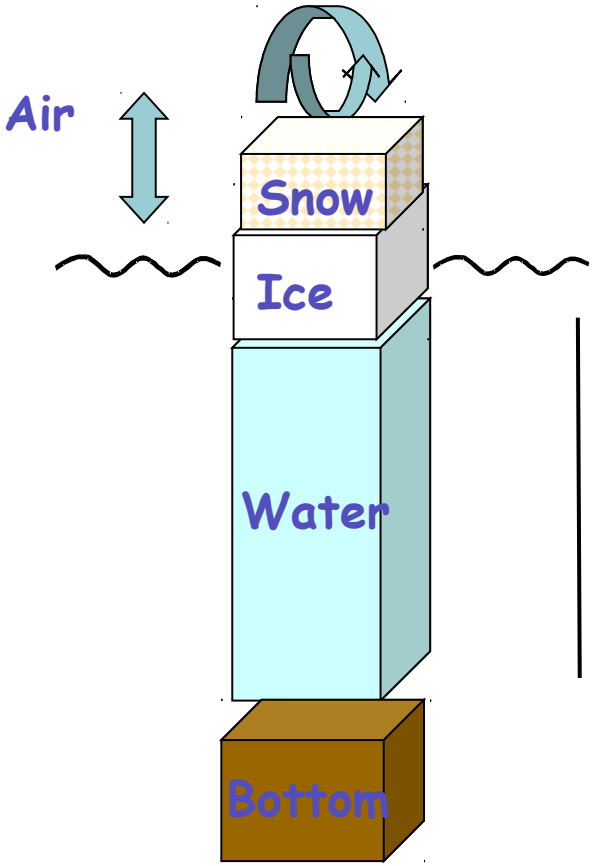
nh=low cloud cover [octa]

rdglob=global radiation [W/m2]

emiss=emissivity [0.9 or 0.95]

Flake: Lake parameterization D. Mironov et al. (Boreal Env. Res. 2010)

Snow on ice: Semmler et al. (Tellus 2011)



Input :

dtg

10m wind

2m temp

q2m

SWrad

LWrad

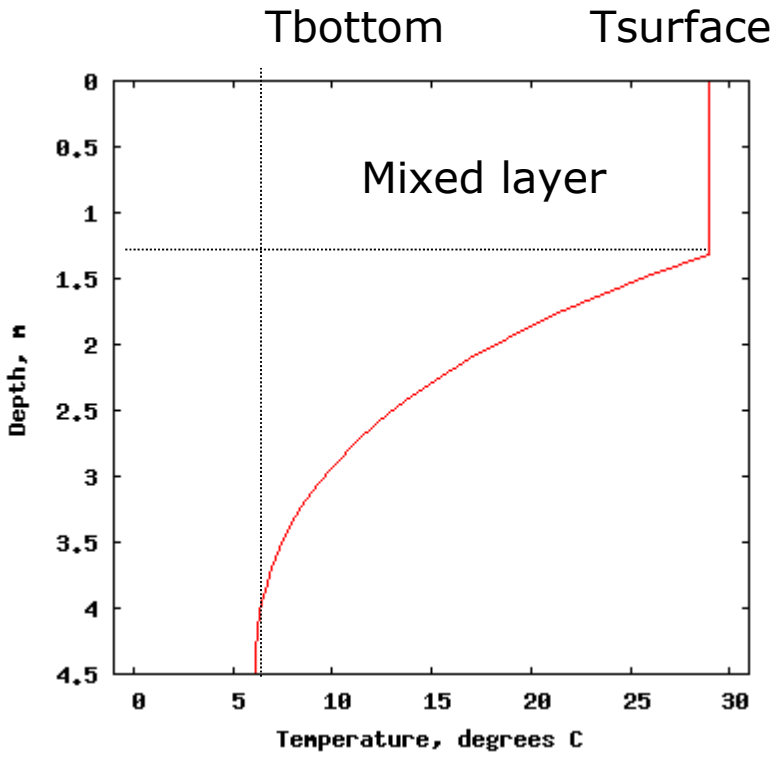
Snow

Pressure

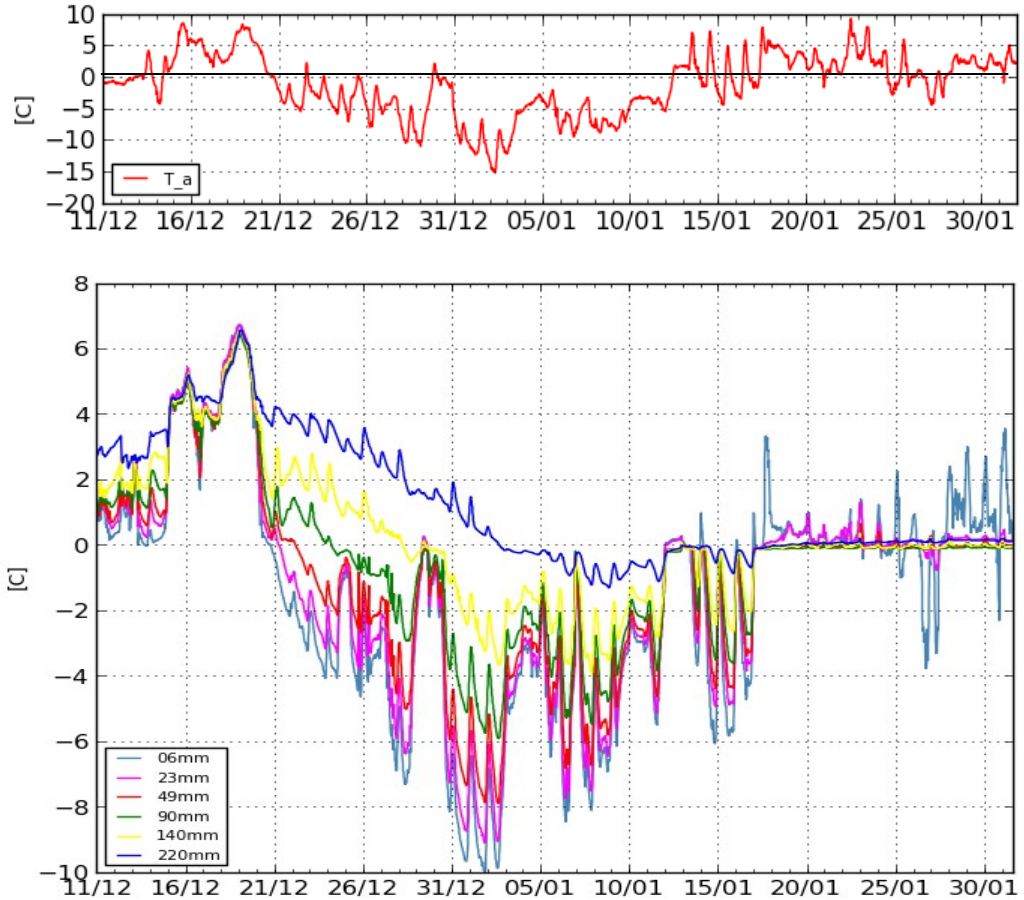
- Surface
  - absorbed solar radiation
  - Turbulent fluxes (sensible and latent heat fluxes, momentum flux)
- Snow
  - Thermal and Optical properties of snow
- Ice
  - Thermal regimes (temperature profiles)
- Bottom
  - Heat flux to bottom vice versa
  - Temperature in bottom layer

From Bin Cheng

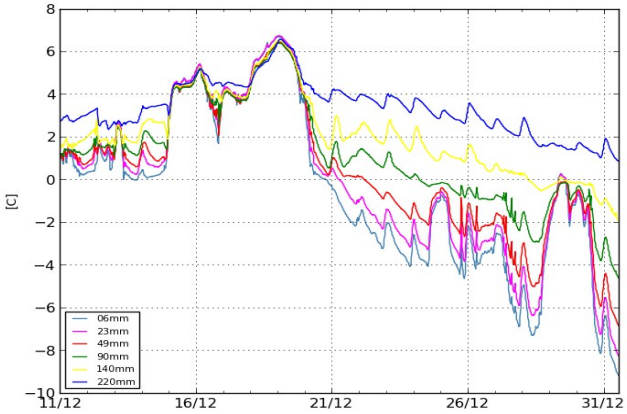
FLake – Freshwater Lake model: a bulk lake model for parameterization of lakes in NWP and climate modeling



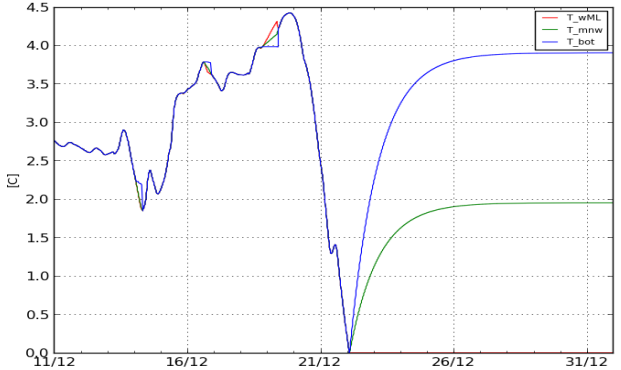
Water temperature measurements during the winter of 1996-1997 at Cabauw (Heusinkveld, Bosveld)



Water temperatures



Observations



Flake temperatures

T_mnw=column

T_wML=mixed layer

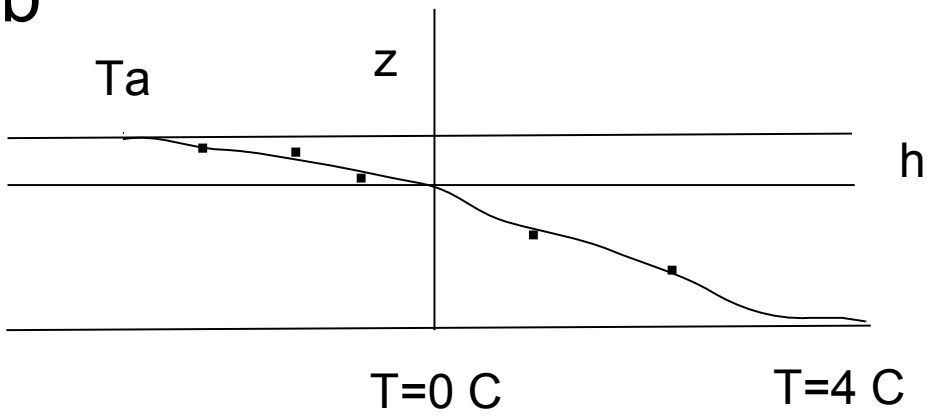
T_bot=bottom

Water temp --> pseudo ice thickness

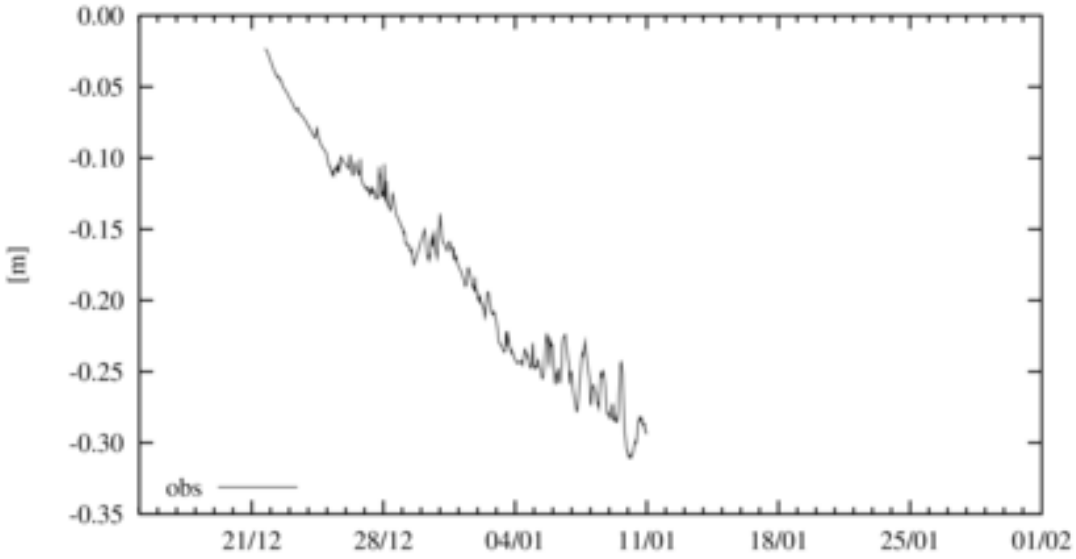
Example:

mm			T Celsius			
6			-2.24			
23			-2.13			
49			-1.24			
90			0.25			
140			0.23			
226			3.86			

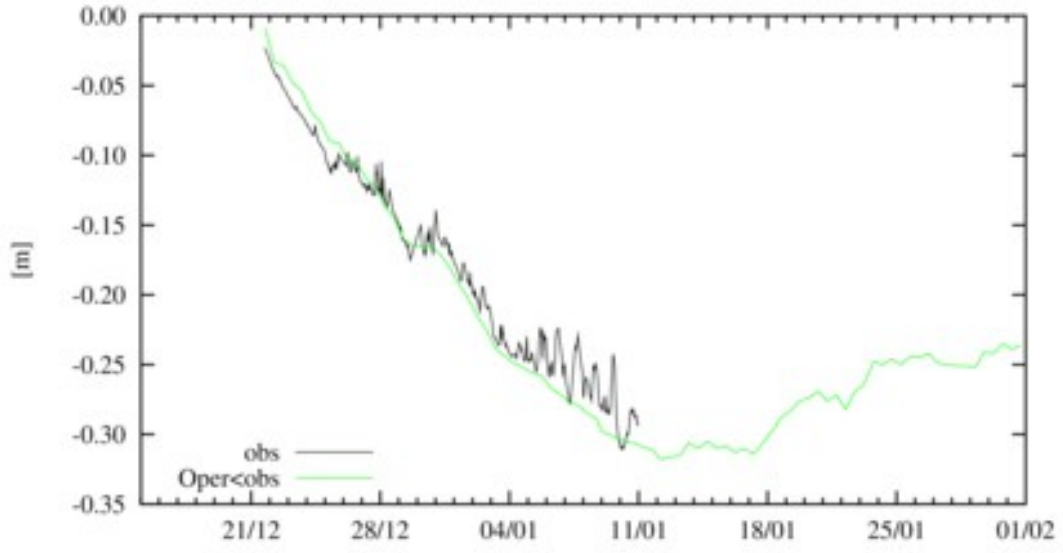
$z=aT+b$



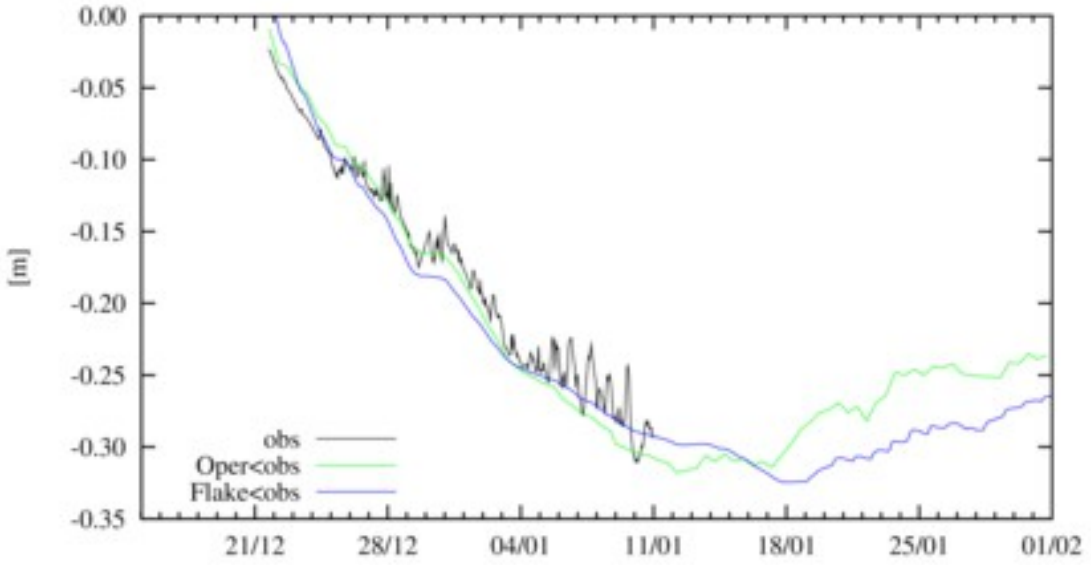
pseudo ice thickness



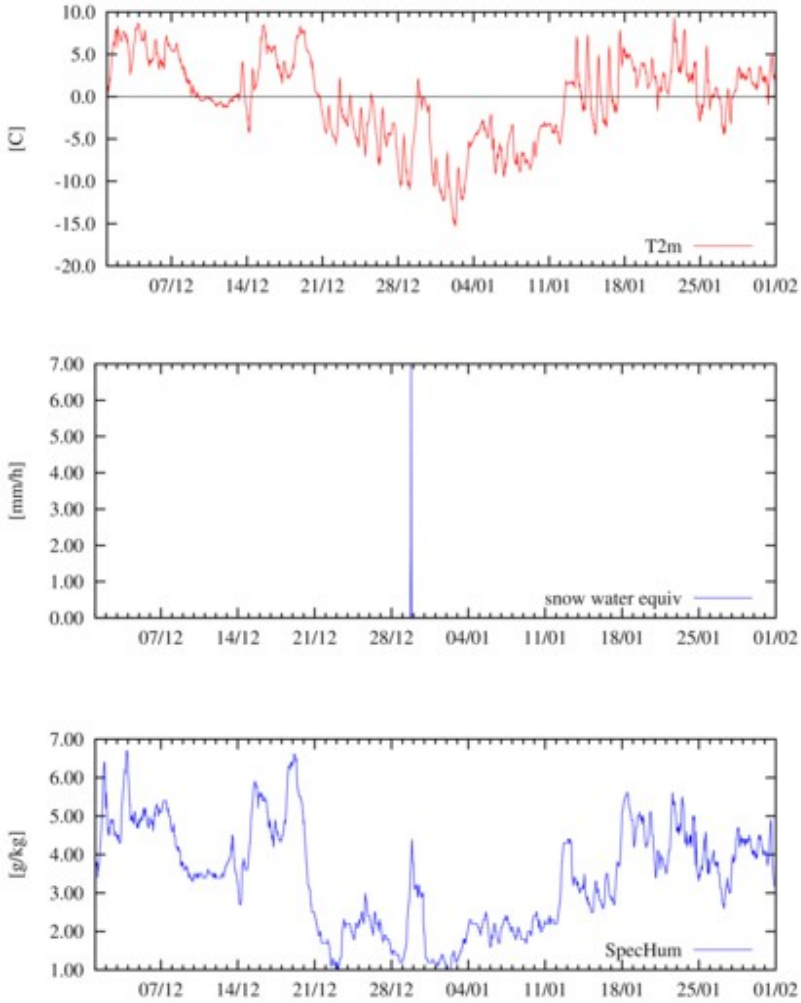
Operational ice prediction model (Wessels) driven by observations at Cabauw, winter 1996/1997



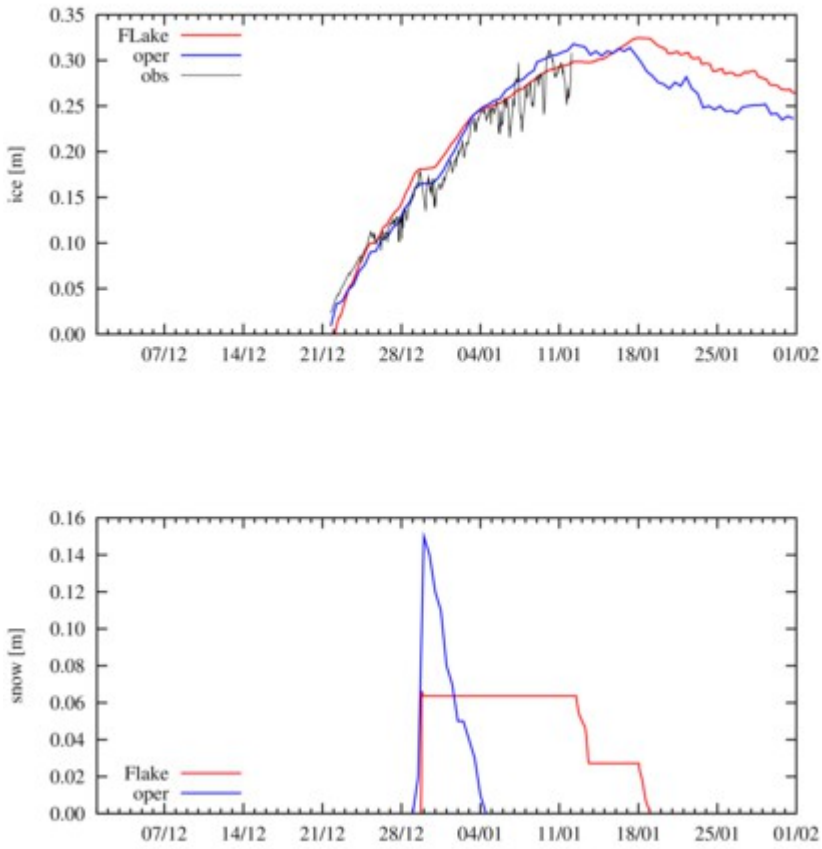
FLake driven by observations (30 min) at Cabauw, winter 1996/1997



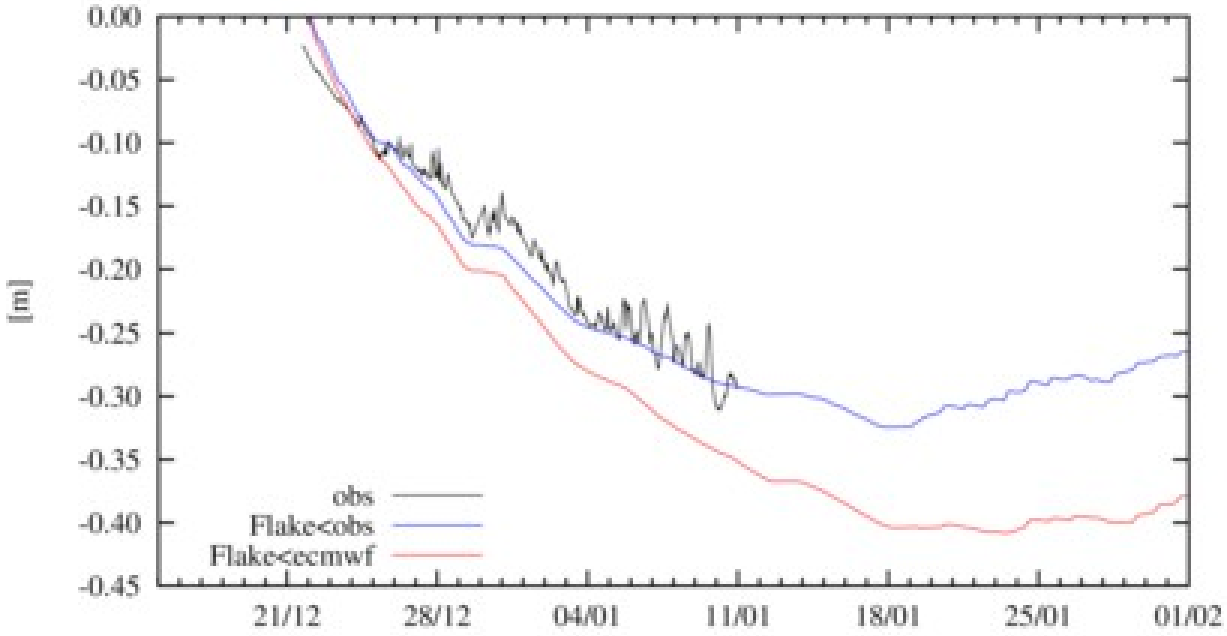
Cabauw, observations



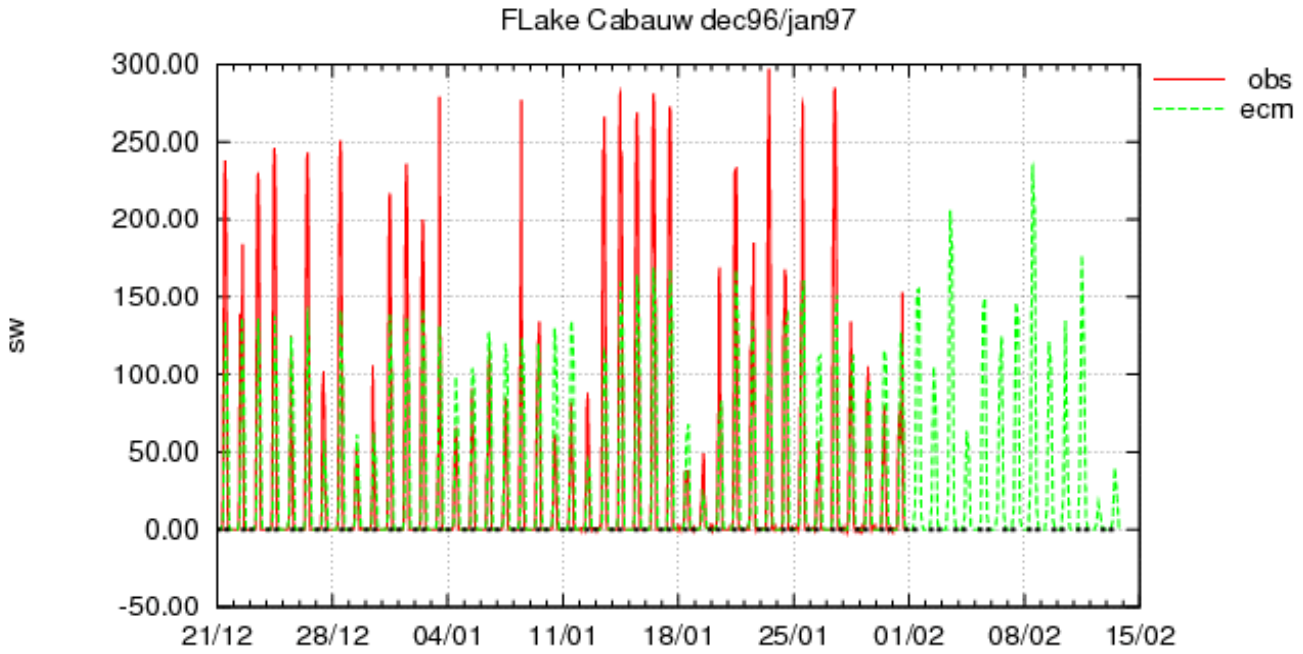
Ice and snow



FLake driven by ECMWF data every 3h +24h

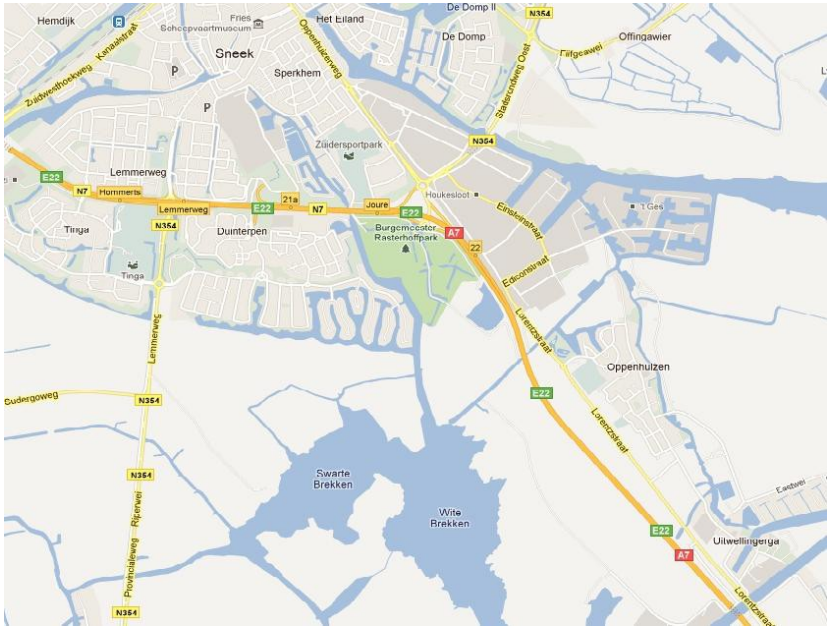


short wave radiation



Martin Stam and Rudolf van Westrhenen: Collection of observed ice thickness via internet

dataset winter 2010/2012

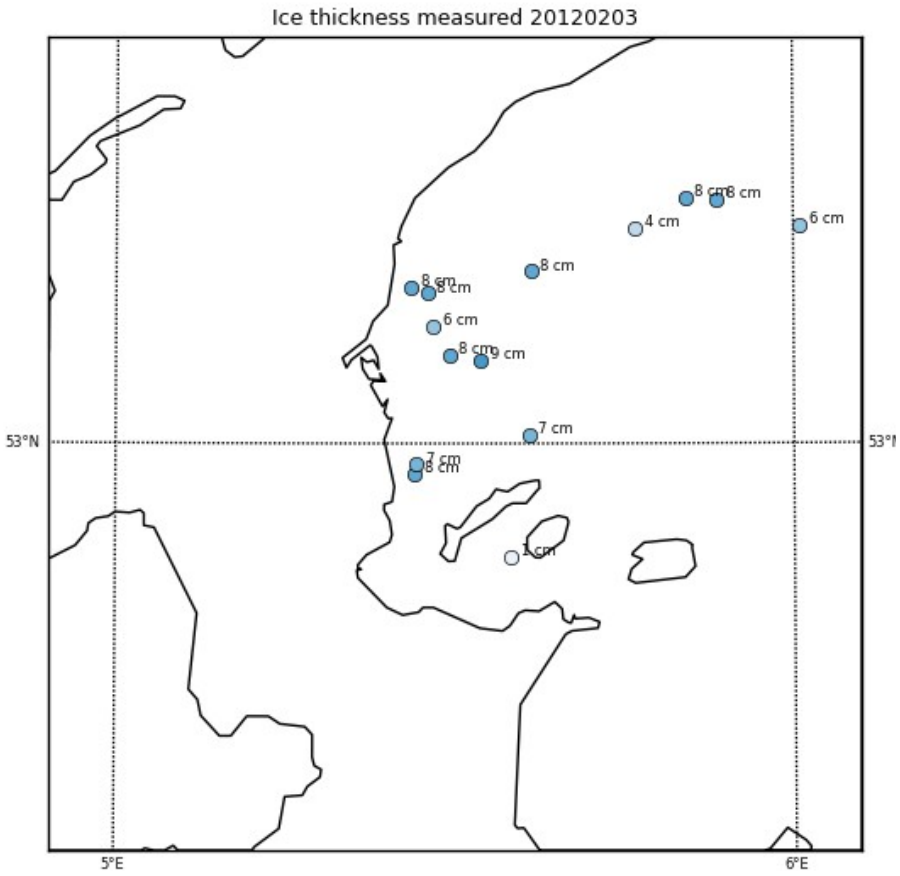


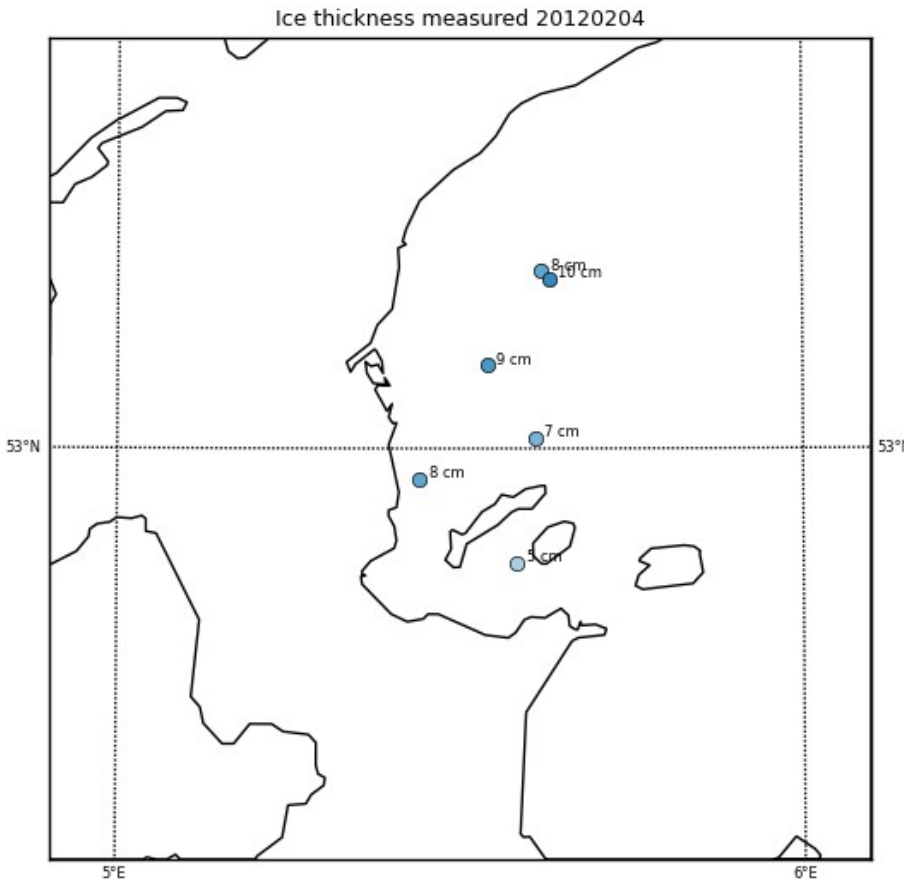
IJsdikte meting

locatie:	53.023584,5.691166	
sneeuwhoogte:	0	centimeter
ijsdikte:	26	centimeter
waterdiepte:	1,5	meter

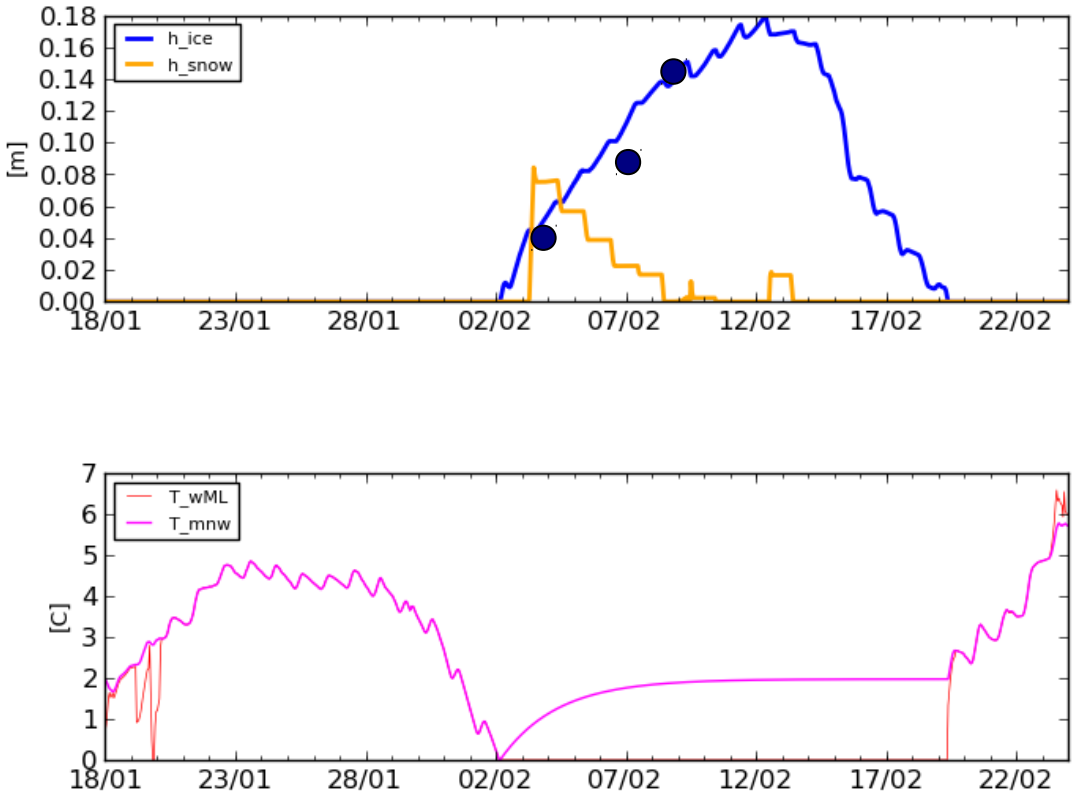
cancel

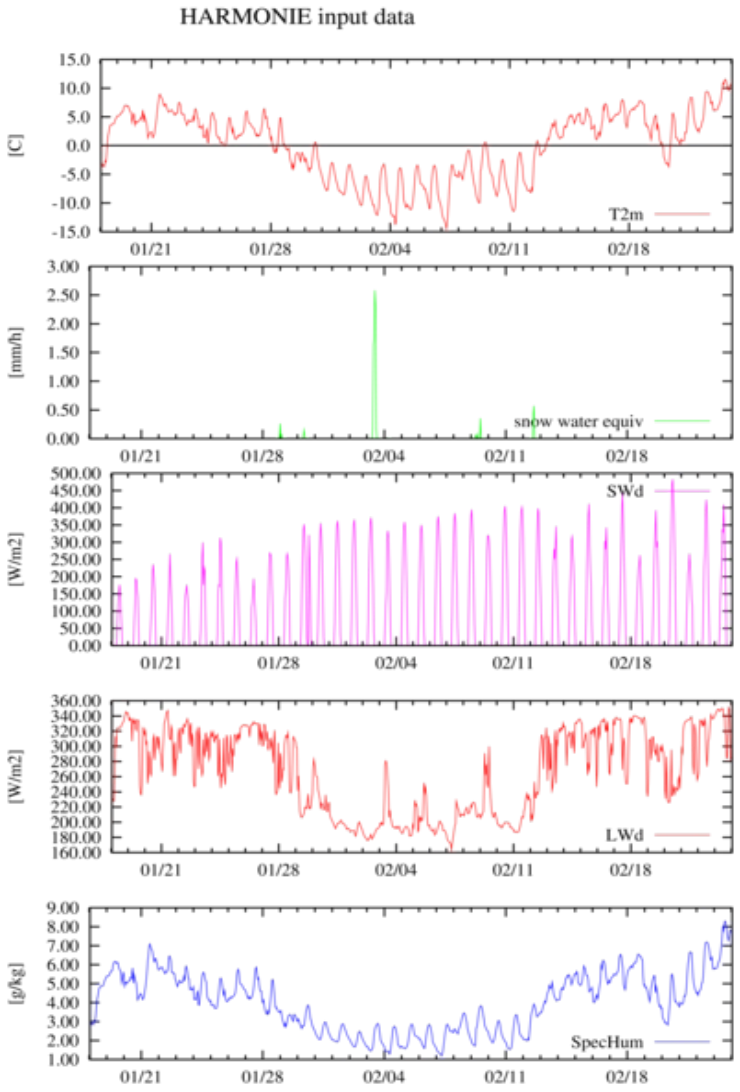
versturen

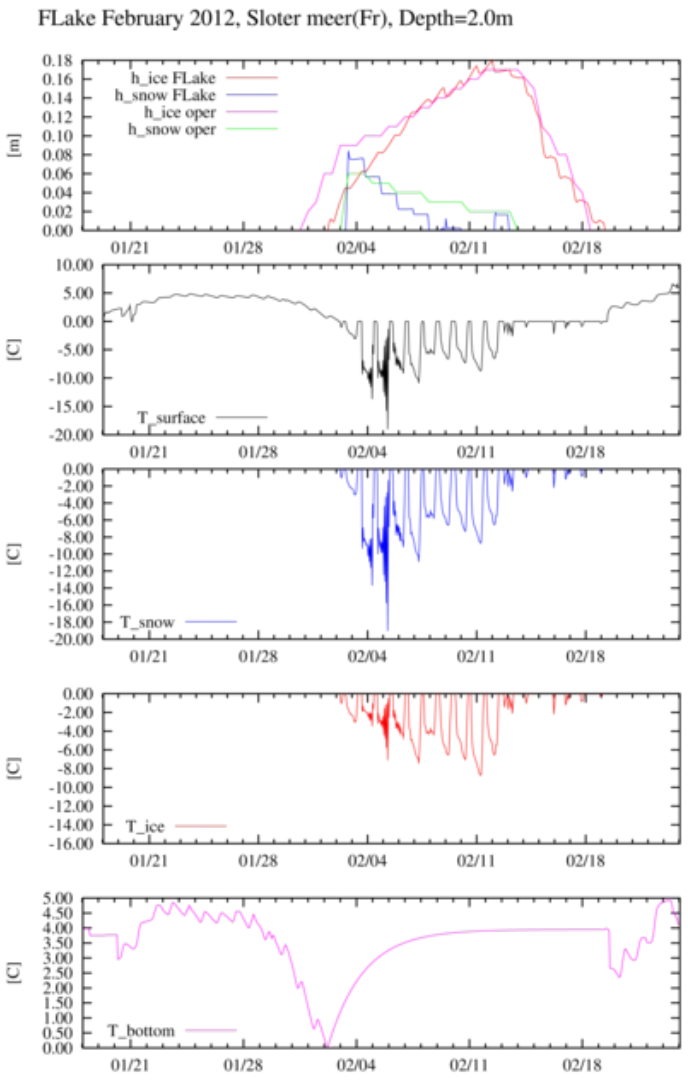

Ice thickness measured 20120203
8 cm
8 cm
4 cm
6 cm
8 cm
8 cm
8 cm
6 cm
8 cm
9 cm
7 cm
7 cm
8 cm
1 cm
53°N
5°E
6°E


Ice thickness measured 20120204
8 cm
10 cm
9 cm
7 cm
8 cm
5 cm
53°N
5°E
6°E

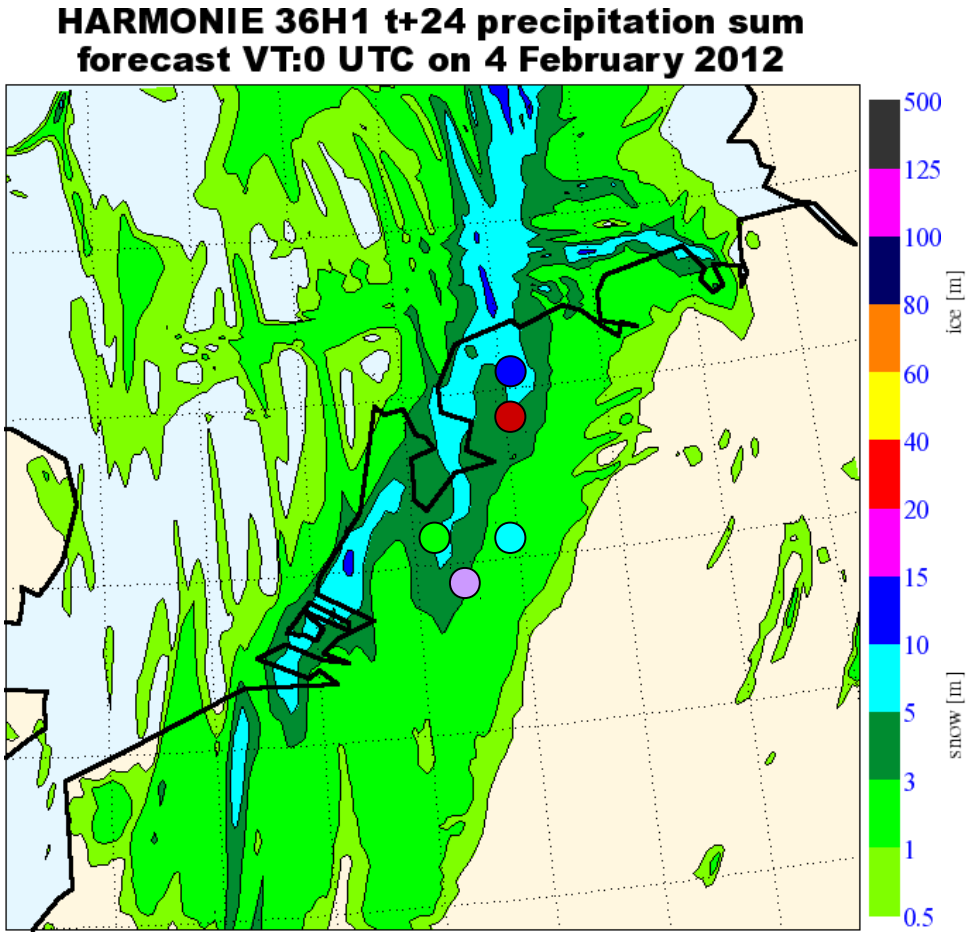
Ice episode winter 2012, Slotermeer, d=2 m

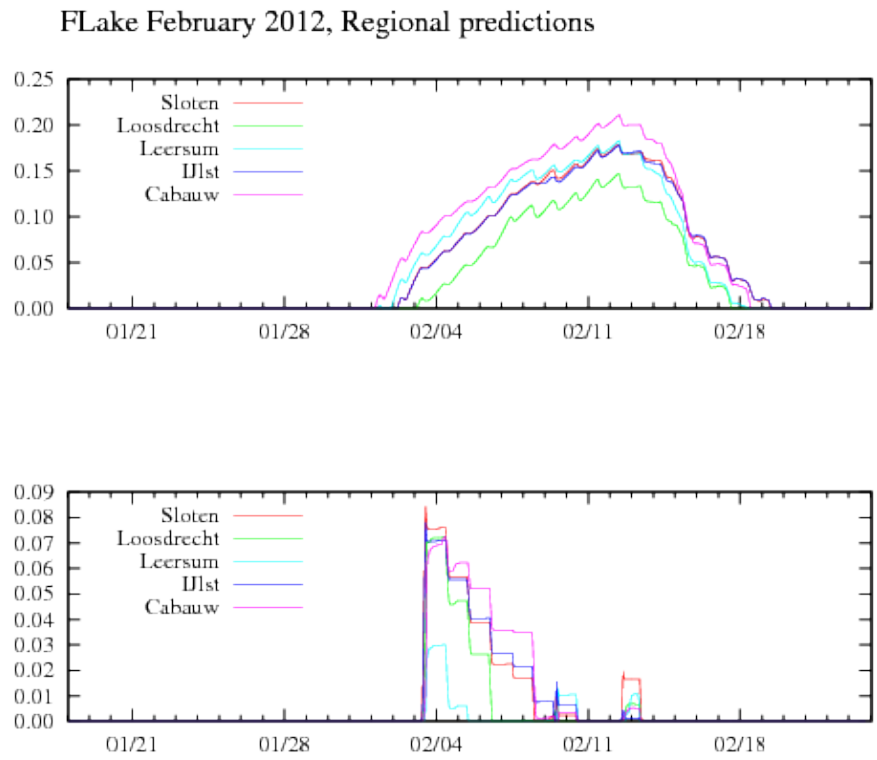




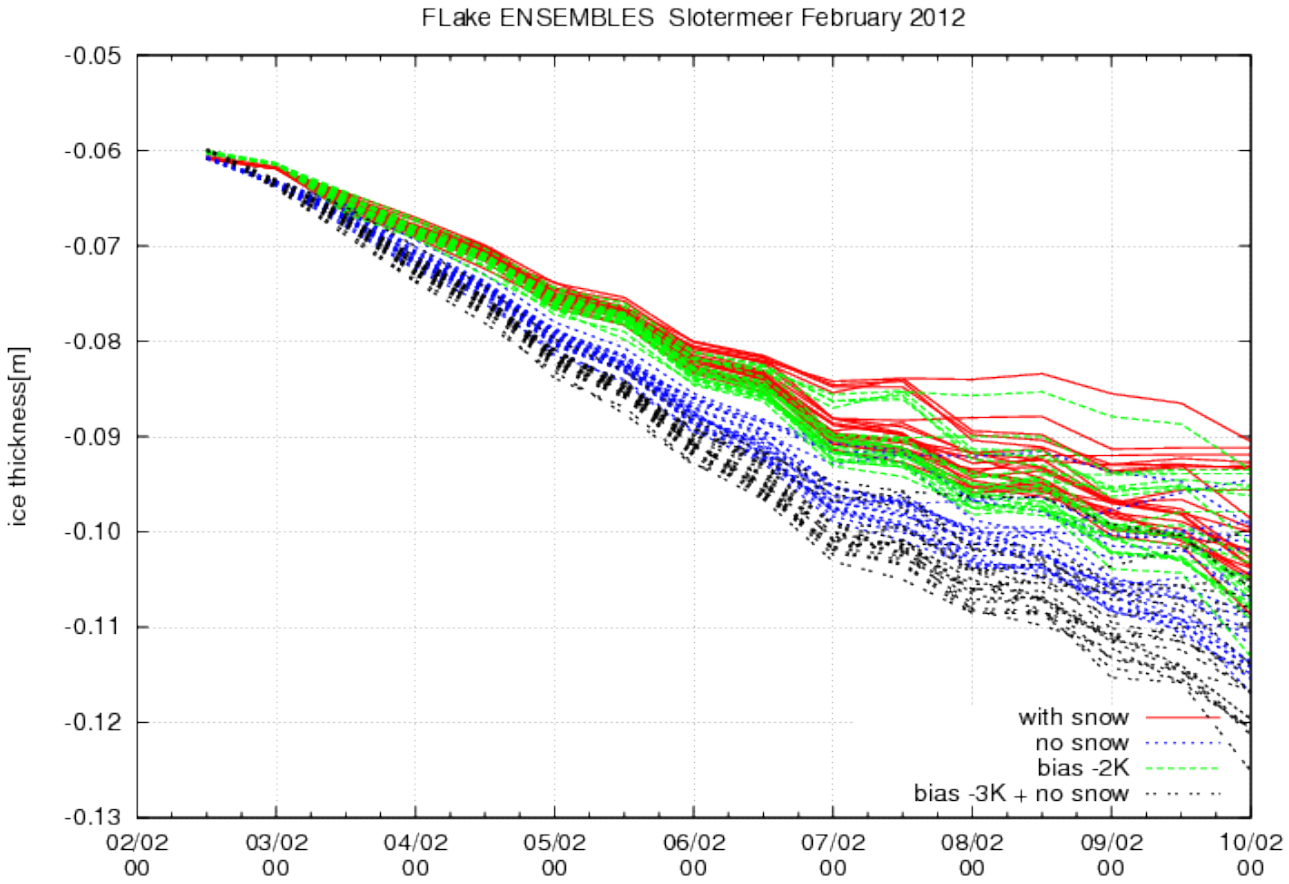


Lake workshop sept 2012

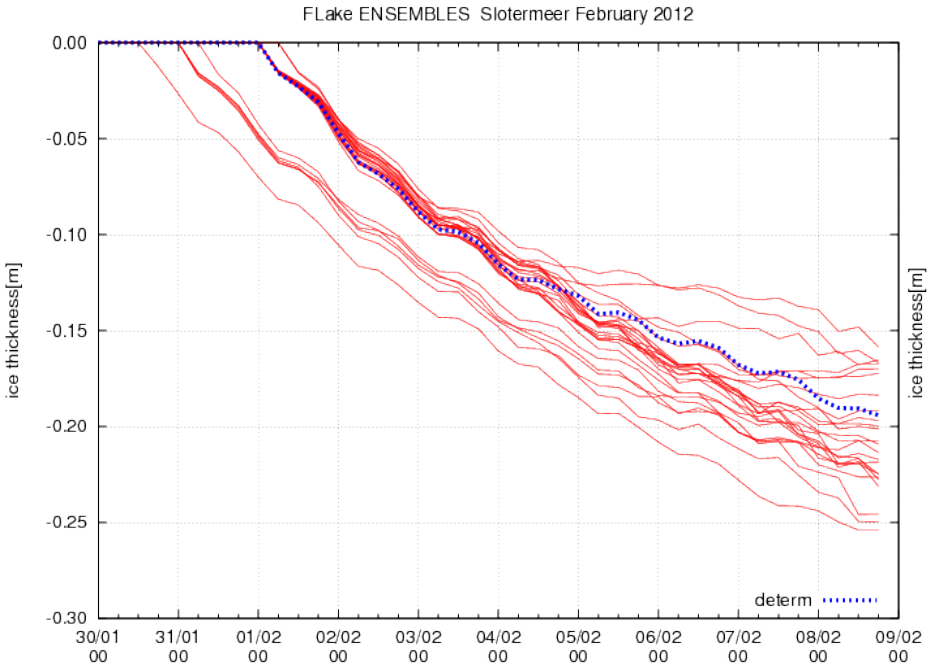

HARMONIE 36H1 t+24 precipitation sum
forecast VT:0 UTC on 4 February 2012
500
125
100
80
60
40
20
15
10
5
3
1
0.5

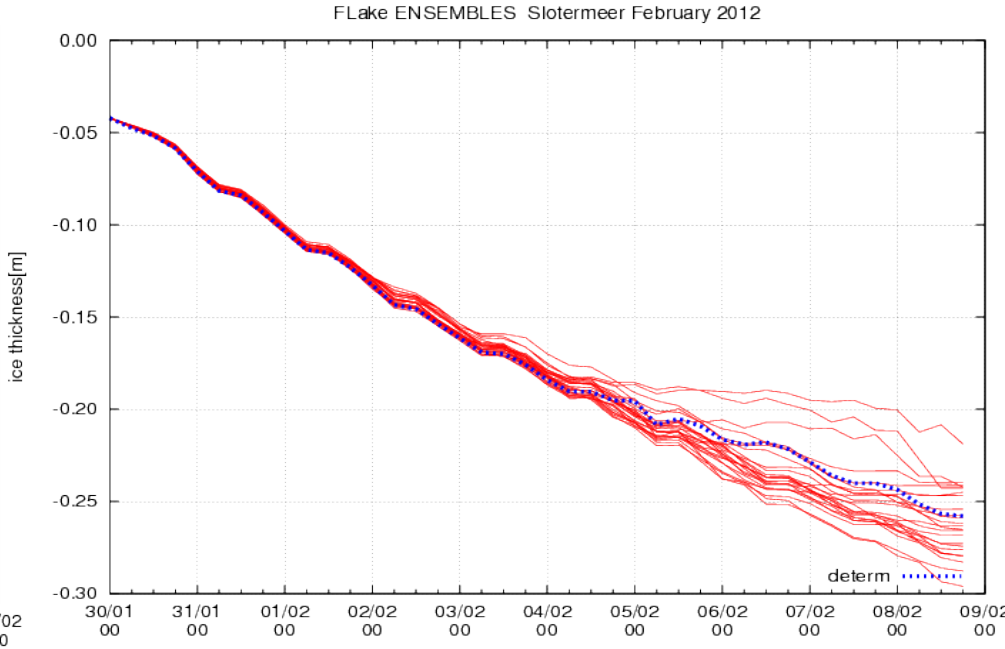

FLake February 2012, Regional predictions
ice [m]
0.25
0.20
0.15
0.10
0.05
0.00
Sloten
Loosdrecht
Leersum
IJlst
Cabauw
01/21
01/28
02/04
02/11
02/18
snow [m]
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
Sloten
Loosdrecht
Leersum
IJlst
Cabauw
01/21
01/28
02/04
02/11
02/18

Ensembles, ECMWF



Sensitivity for initial values





Conclusions

- Flake is useful for predicting ice and snow thicknesses, although it slightly overpredicts ice thicknesses.
- Flake is competitive with operational ice prediction model
- Flake's performance with snow on ice is improved
- Flake off line is an useful tool
- Regional predictions are possible using HARMONIE data
- Uncertainty in icegrowth is well captured using EPS data

Plans

- Further implementation of FLake in HARMONIE
- Comparison of Flake and Operational ice model
- Apply Dutch measurements of ice thickness for validation of lake ice models
- Observations of ice thickness are still sparse, but …

More observations are coming up
Ground penetrating Radar applied for measuring ICE thickness

Grontmij, De Bilt,

Dick Broekhuizen

Water frozen in two frost periods with cracks inside the ice.