Improved lake climatology for use in NWP

Yurii Batrak

Ekaterina Kurzeneva

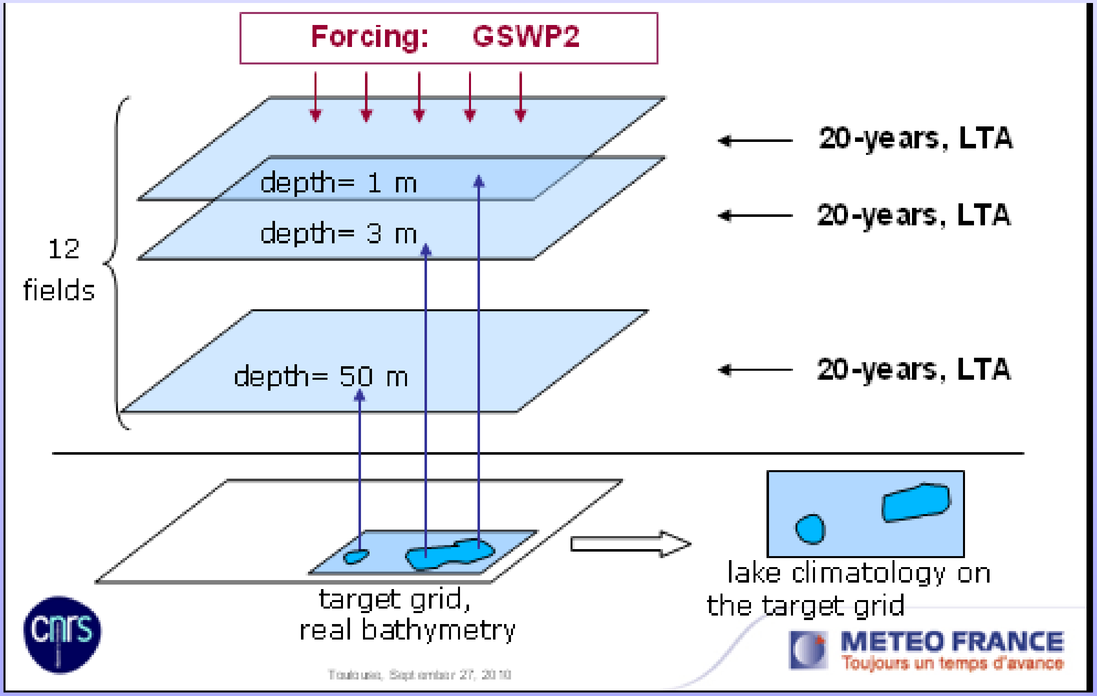
18-20.09, Lake2012

Contents

- Background
- Experiments with climate system:
  - forcing data
  - albedo of ice
  - numerical schemes
  - snow block
- Improved system CliLake2
- Conclusions and overall comments

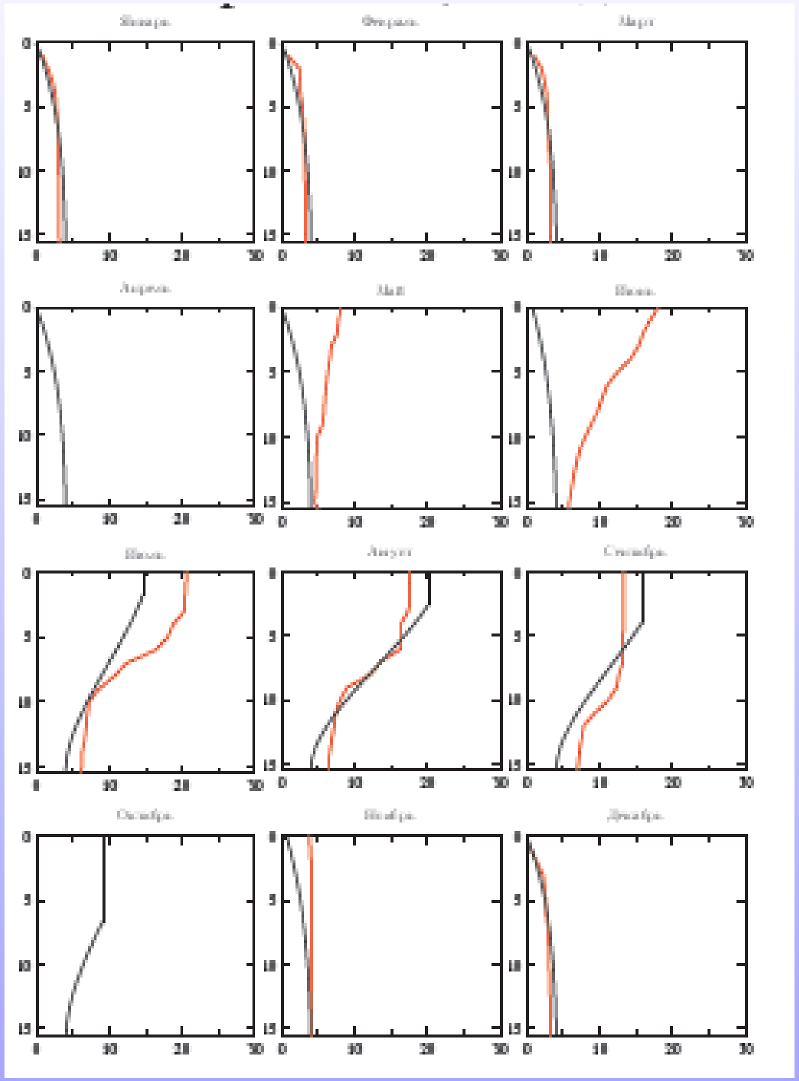
Background

- Gridded lake climatology is needed for the Cold Start of operational NWP model coupled with a lake model
- CliLake1: model lake climatology from off-line runs of FLake
- 20 year runs
- globally, res. of 1^0
- 12 different depths
- Annual cycle with res. of 10 days



Background

- CliLake1 was verified against in-situ data for 208 lakes (ILEC, Ryanzhin 1990)
- Significant errors in spring:
- Too late ice break-off
- Errors in surface temperature reached 15^{0}C



Lake Amisk, Canada

Objectives of the study

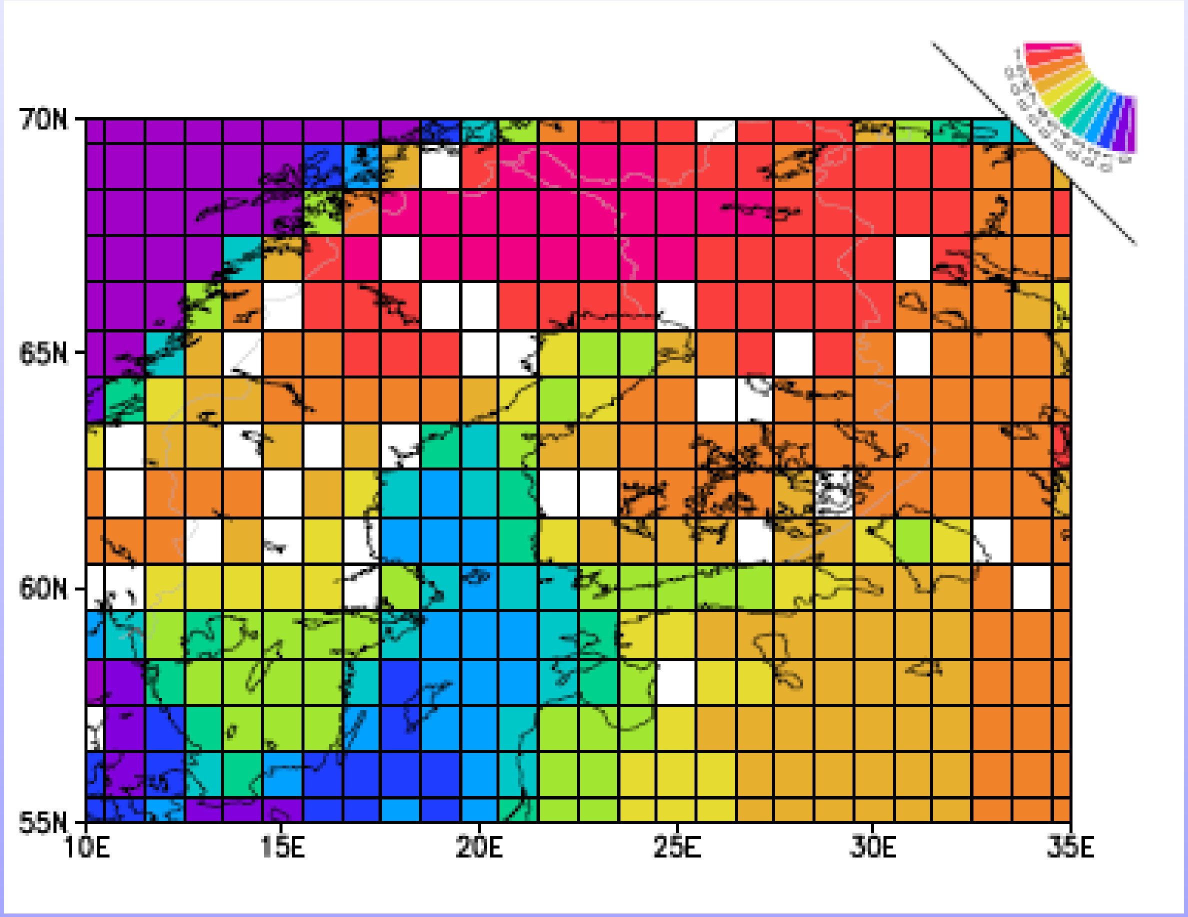
- To find sources of model errors in spring
- To build the improved system CliLake2
- To verify new model lake climatology

Experiments with the model system

- Forcing data
- Albedo of ice
- Numerical schemes
- Temperature on levels in atmosphere
- Snow block

Pseudoperiodical solution

Nov. 2005 – Nov. 2006



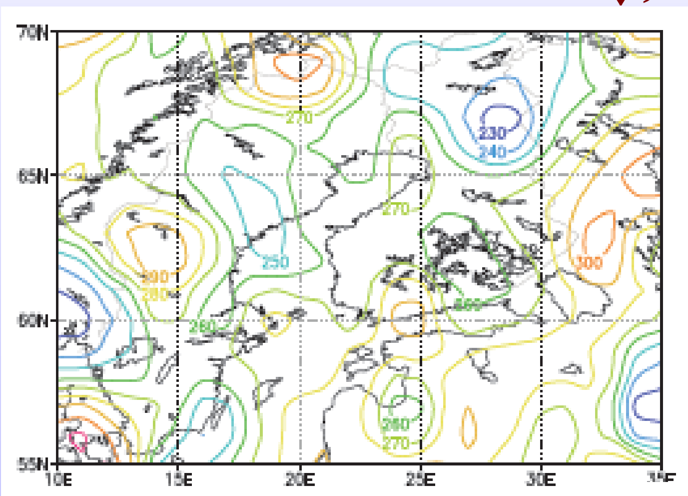
18-20.09,
Lake2012

Experiments with different forcing data

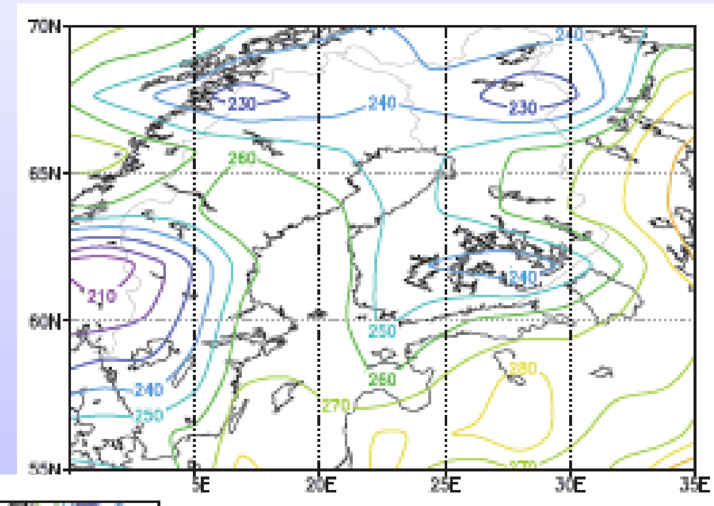
- GMFD LSM — Global Meteorological Forcing Dataset for Land Surface Modelling, Princeton University (Sheffield et al., 2006), 1^0
- NCEP/NCAR Reanalysis, Gaussian grid T62
- GDAS – operational analysis of GFS, 1^0 (LW↓ obtained from screen level temperature and total cloudiness)

Experiments with in different forcing data

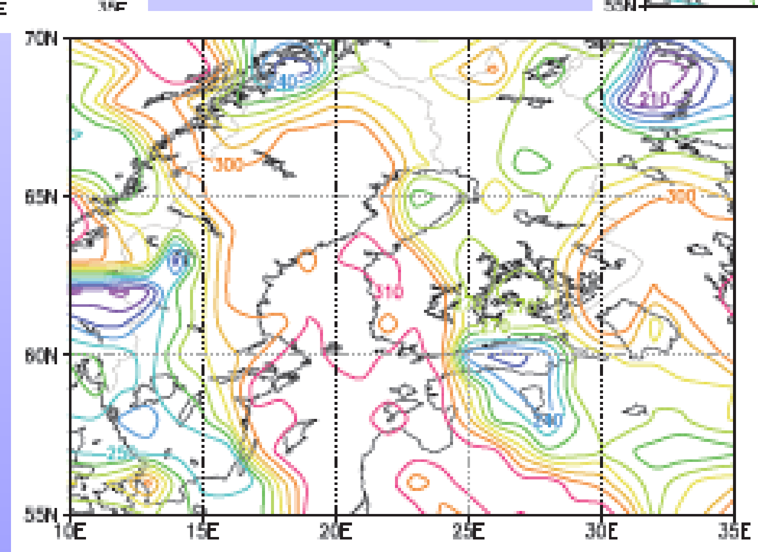
LW↓, 00 GMT 15.04.2006



GMFD LSM



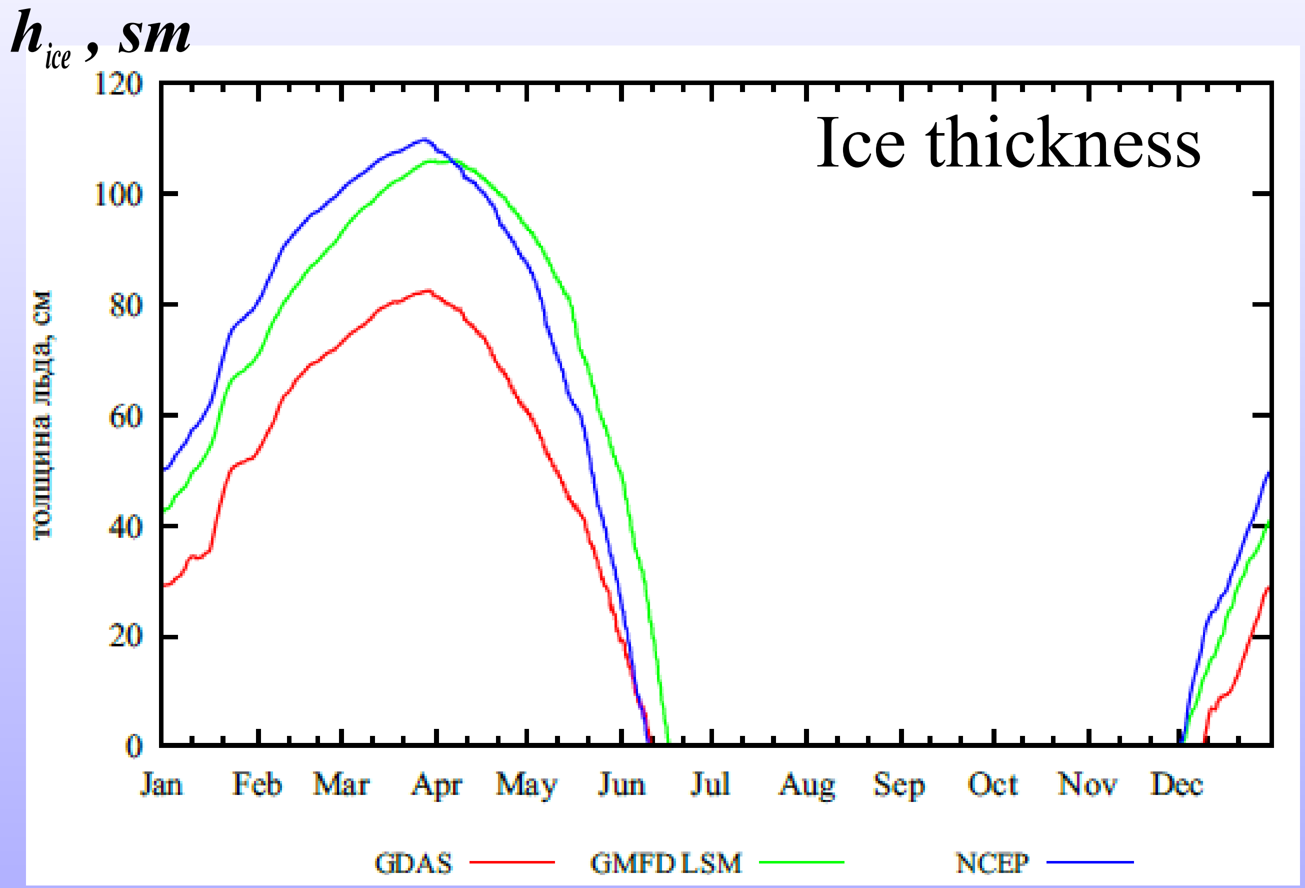
NCEP



GDAS

18-20.09,
Lake2012

Experiments with in different forcing data



30^0 LON, 60^0 LAT, d=10 m

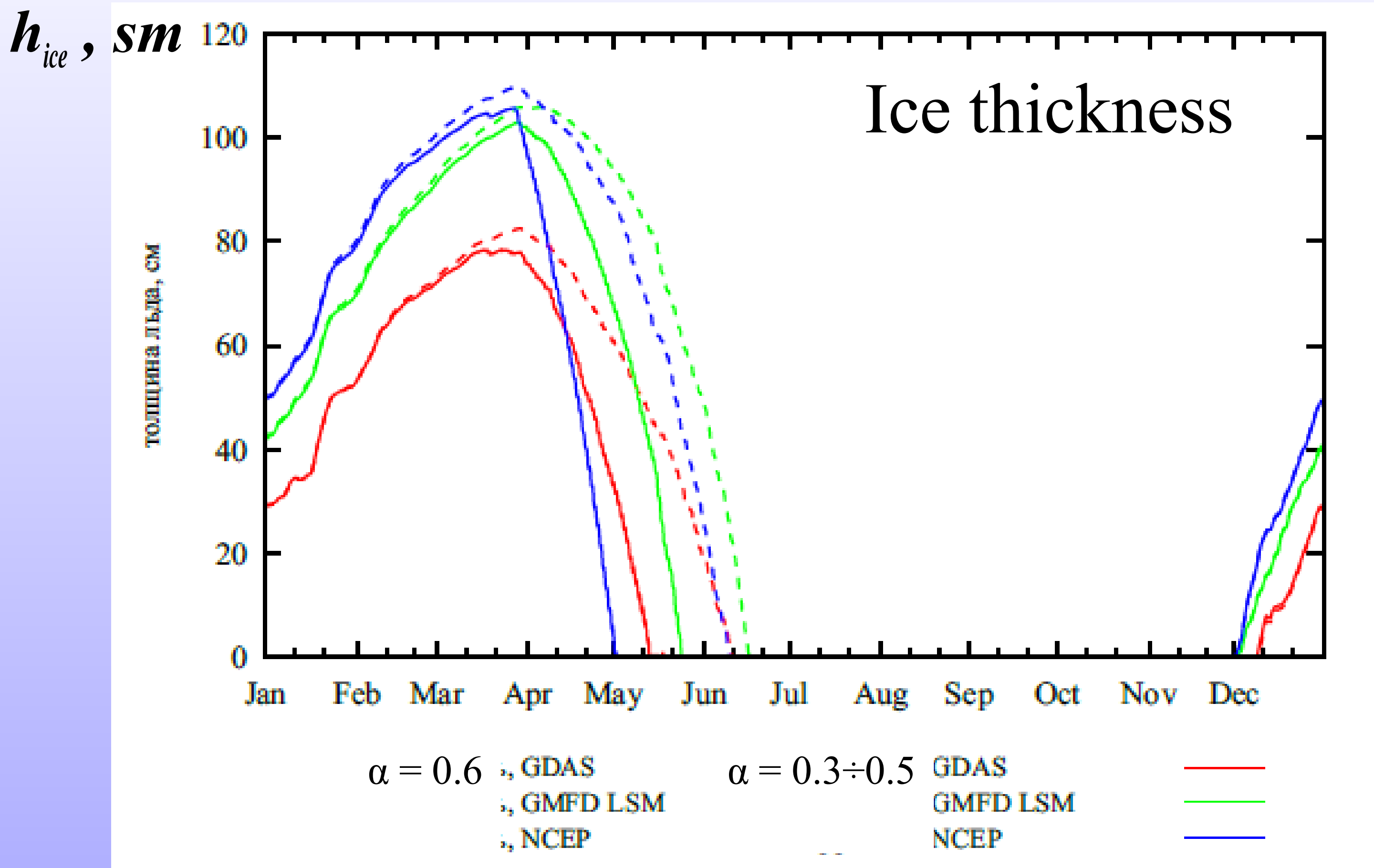
Experiments with in different albedo of ice

- $\alpha = 0.6$
- Parameterization after Mironov-Ritter:

  $\alpha = \alpha(T_{sfc})$

  $\alpha = 0.3 \div 0.5$

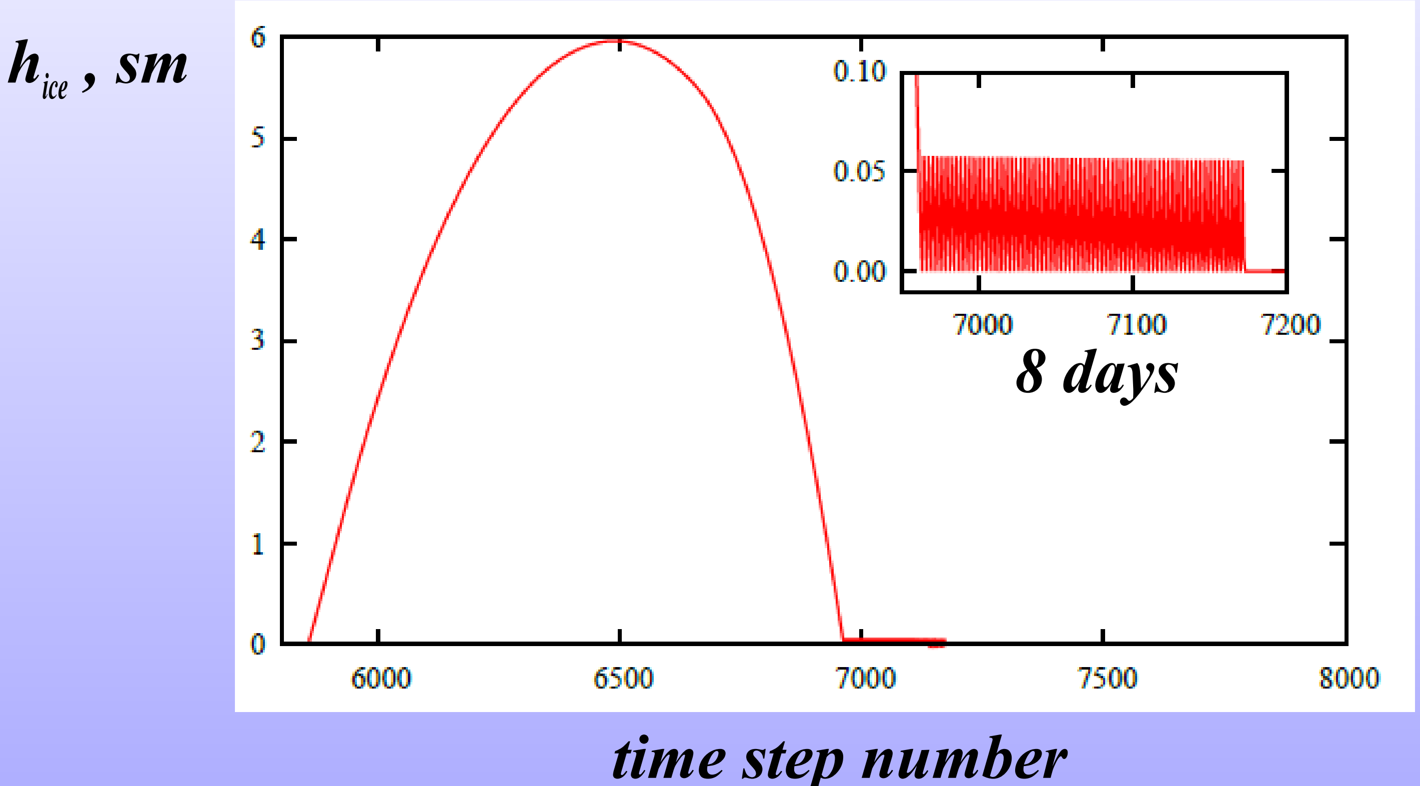
Experiments with in different albedo of ice



30⁰ LON, 60⁰ LAT, d=10 m

Experiments with in different numerical schemes

Numerical instability in quasi-equilibrium ice model



5^0 LON, 50^0 LAT, d=7 m, Δt = 1 hour

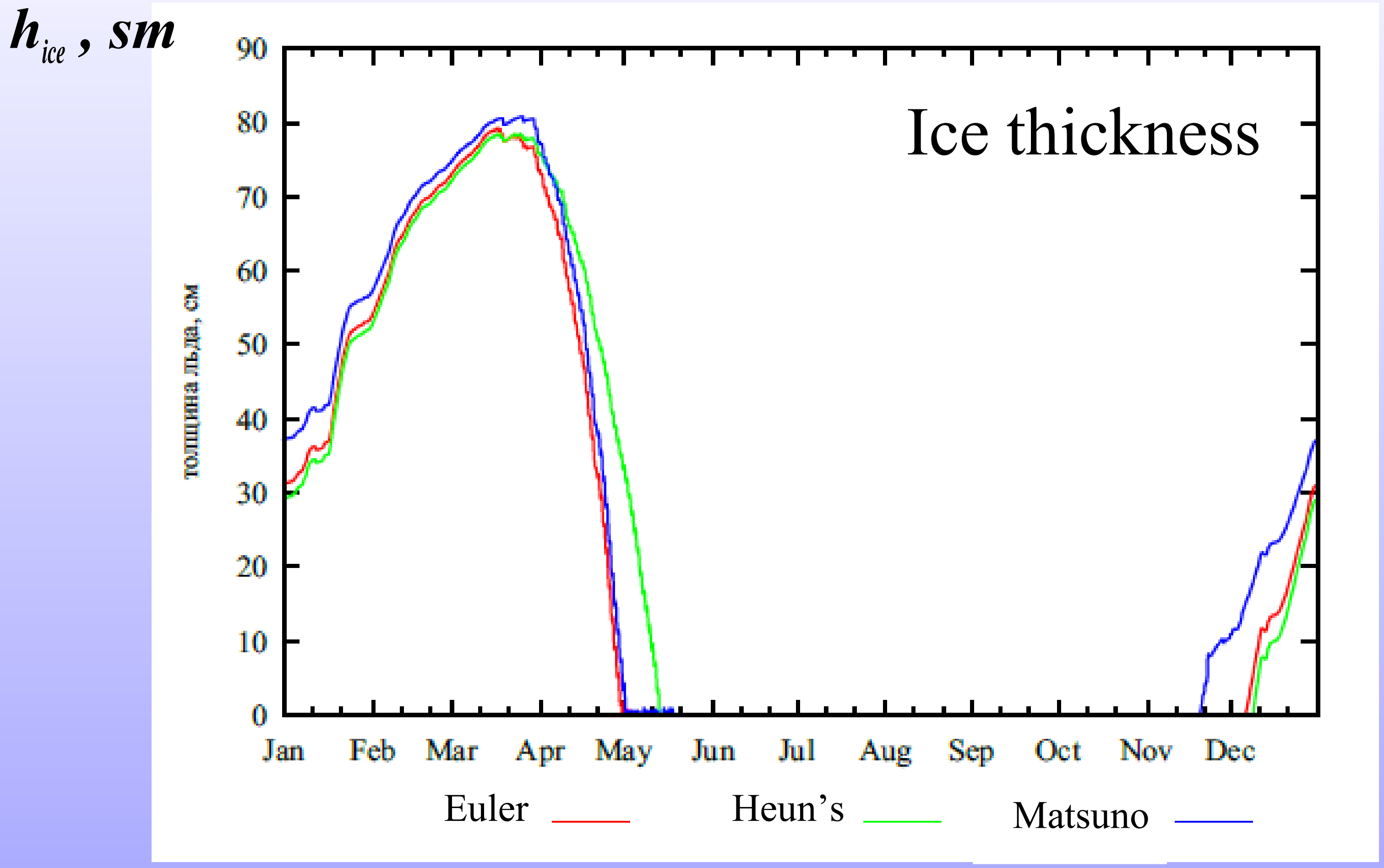
Experiments with in different numerical schemes

- Euler scheme with different time steps
- Predictor-corrector schemes:
  - Matsuno
  - Heun's
- Runge-Kutta scheme
- Linearization of equations of quasi-equilibrium ice model

Linearization – can't suppress instability

Predictor-corrector schemes and Runge-Kutta sceme – for the whole model

Experiments with in different albedo of ice

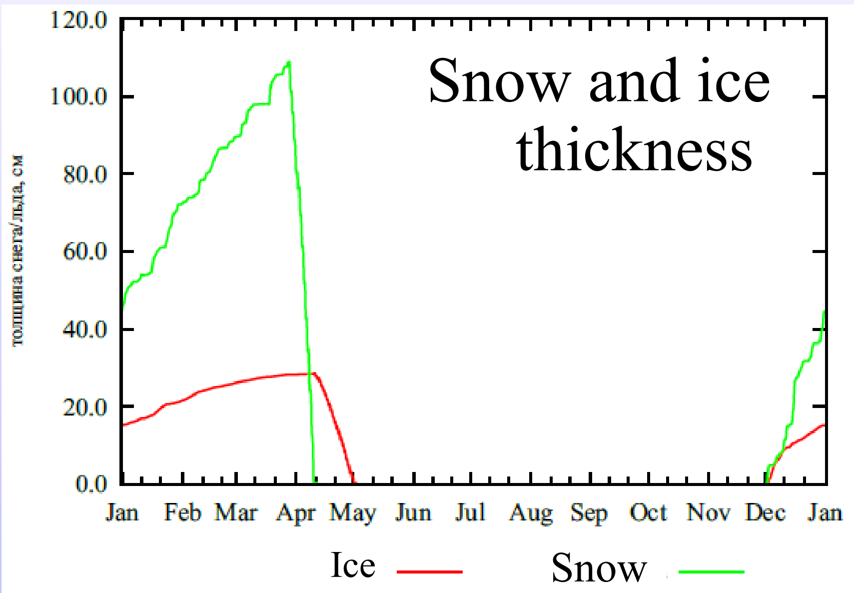


30^0 LON, 60^0 LAT, d=10 m,
Δt = 1 hour, GMDF LSM

Experiments with snow block

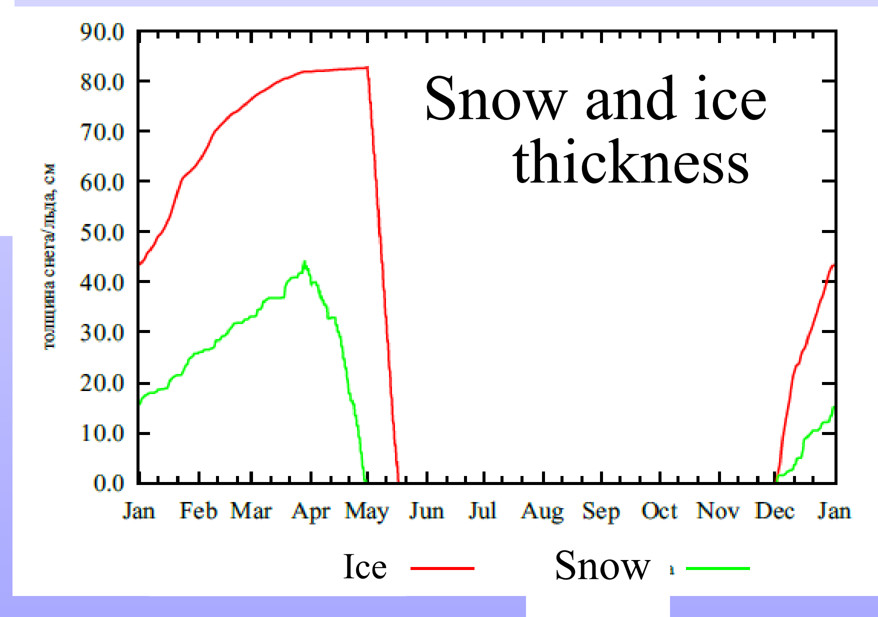
h, sm

original



Modifications by Semmler et al., 2011

h, sm



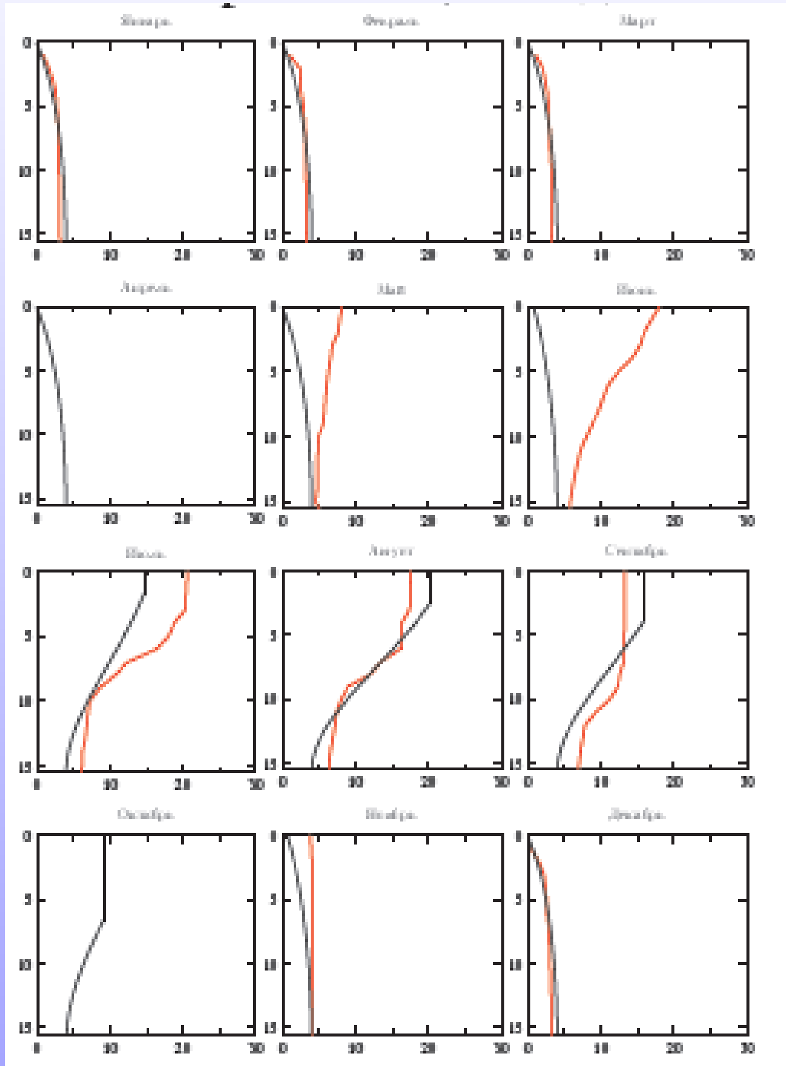
30^0 LON, 60^0 LAT, d=10 m, NCEP

Improved system CliLake2

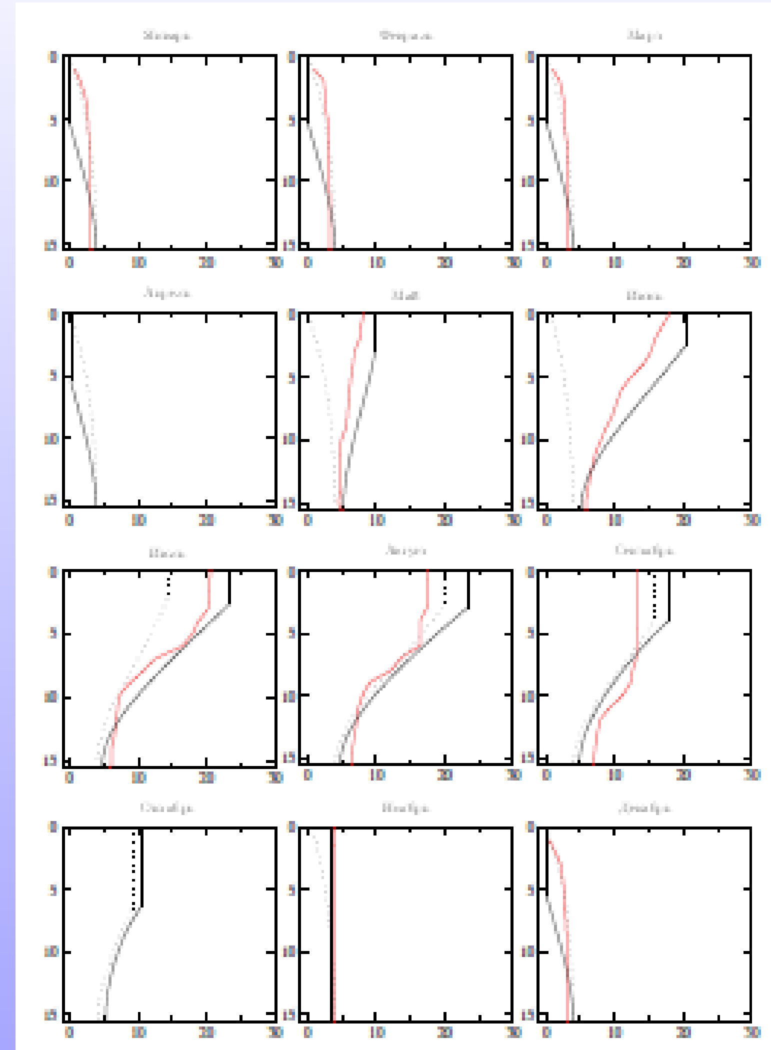
- NCEP/NCAR Reanalysis for the atmospheric forcing, Gaussian grind T62
- Temperature, specific humidity and wind speed from the lowest model level, $\sigma = 0.995$
- Parameterization of ice albedo after Mironov-Ritter
- Euler scheme with $\Delta t = 20$ min
- Snow block with modifications after Semmler et al., 2011

Improved system CliLake2

CliLake1



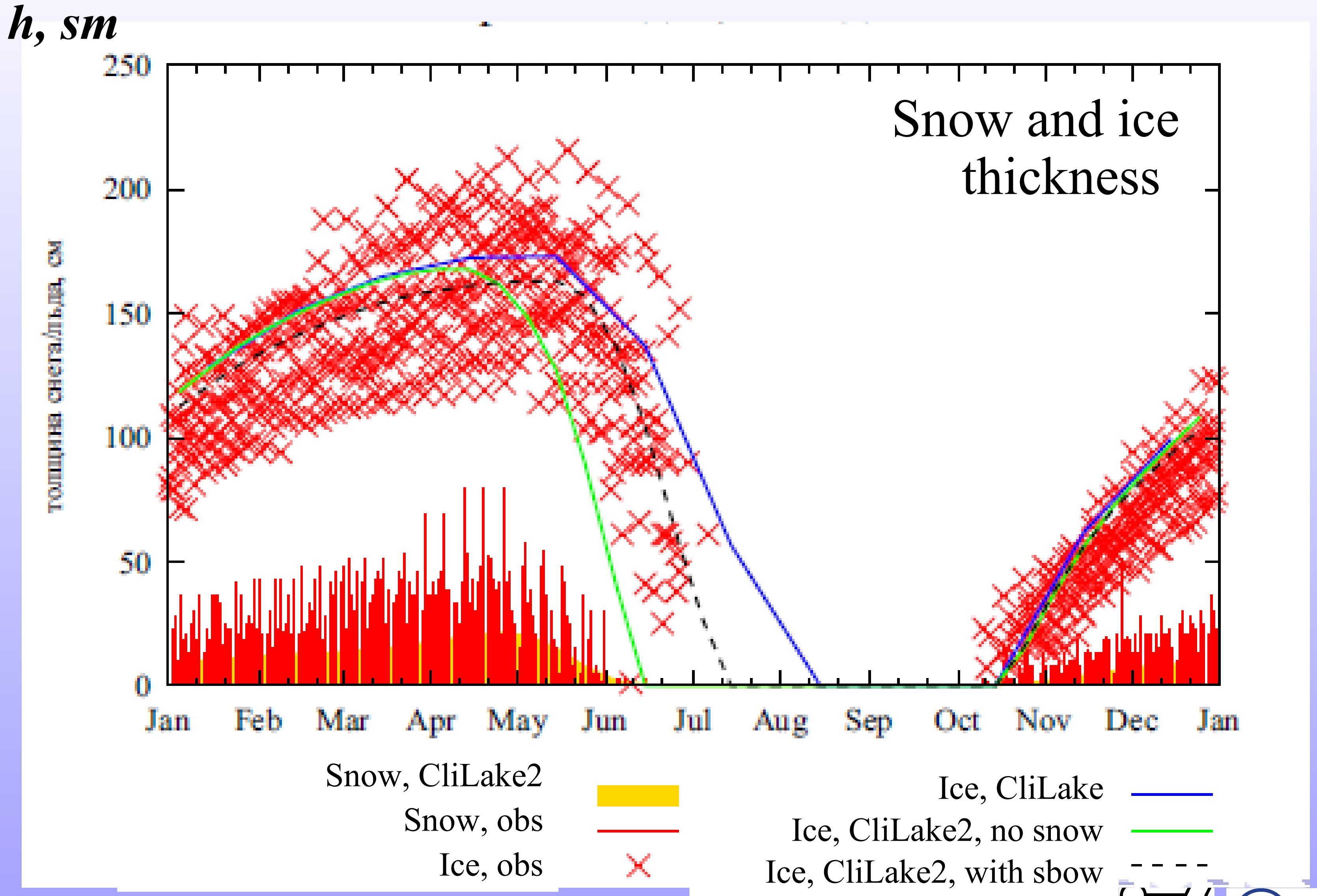
CliLake2



Lake Amisk, Canada
temperature profiles

18-20.09, Lake2012

Improved system CliLake2



Lake Ennady, Canada

Conclusions

- Spring problem in CliLake1 was due to: errors in forcing data, lack of albedo parameterisation, using of Heun's numerical scheme
- Improved system CliLake2 was developed and verified against in-situ measurements
- CliLake2 includes snow block

… overall comments

- Forcing data differ very much, modeling results are very sensitive to forcing:
  for ice depth – tens of sm
  for ice break-off - weeks
- Ice break-up date is very sensitive to different changes in the modeling system
  ice albedo – months!
  numerical scheme
- Numerical instability may appear in the thin ice model!
  use small time steps, less than 30 min