Ekaterina Kurzeneva

Assimilation of lake observations in NWP: methods, plans, ideas.

Lake data assimilation seminar, 19 April 2011
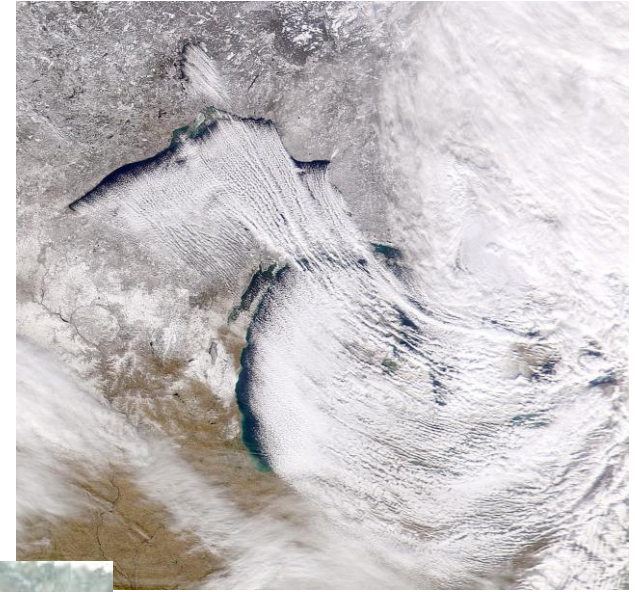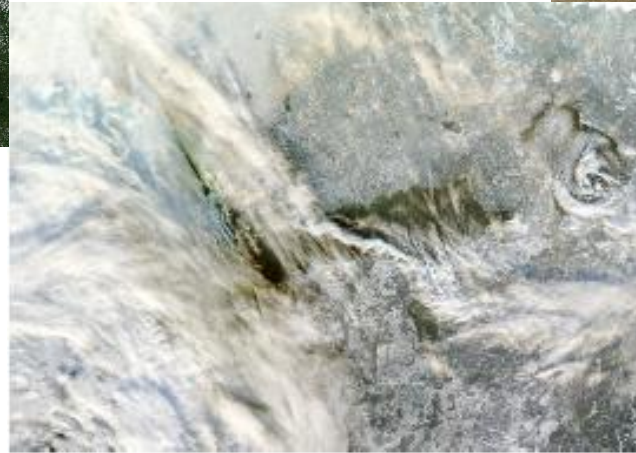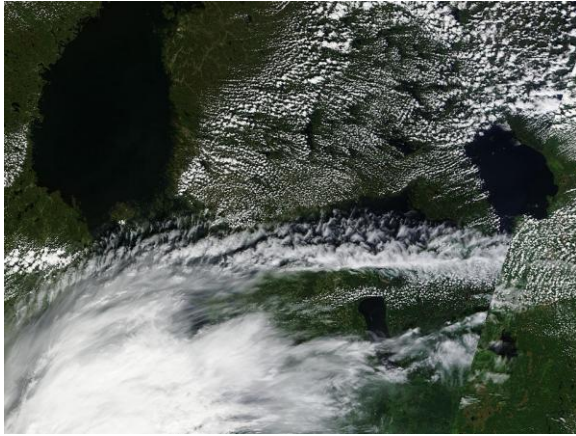
Finnish Meteorological Institute

Contents

- Introduction: why lakes are important for NWP? what is specific for NWP?

- Assimilation of lake information: variables, methods

- What do we have now …

- To be improved, to be developed …

Introduction

Why lakes are important for NWP?

- lakes affect surface fluxes
- ice covered/ ice free surface – different physics
- in some regions lakes may cover the significant part of the territory
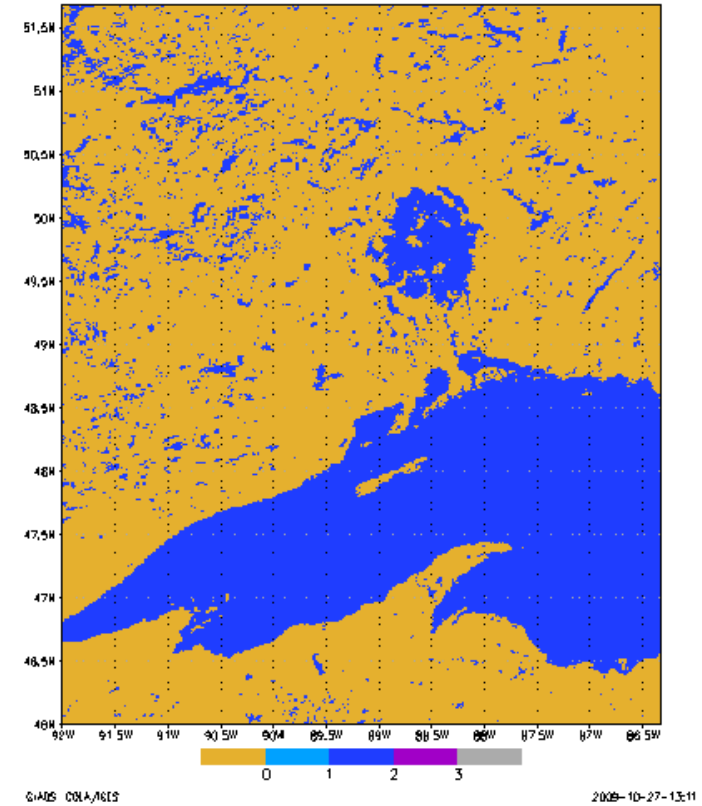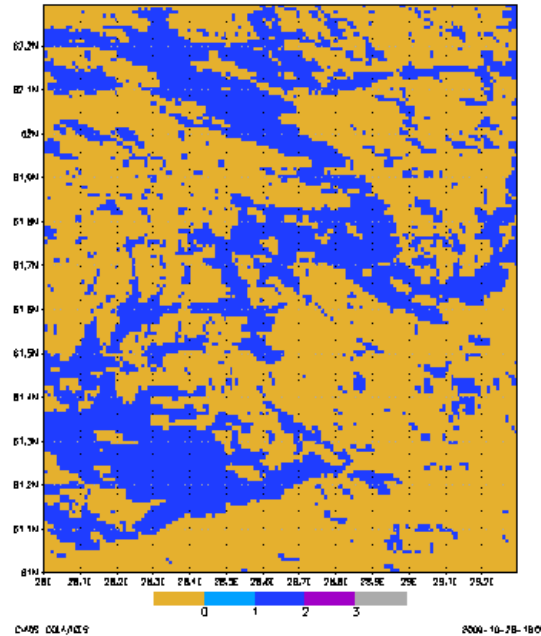- lakes influence regional climate and local weather conditions

Introduction
What is specific for NWP?

We are between hydrology, oceanography and meteorology!

- In contrast to hydrology: **all** lakes are needed! But the accuracy is less important to have at least something reasonable

- In contrast to oceanography: water variables are discontinuous

Introduction

What is specific for NWP?

- Maps, grids
- Lakes may be presented in NWP model as follows:
- parameterized - lake model is coupled with NWP model (but not yet operational! HIRLAM + FLake)
- LST is constant during the forecast time (hours ~ days)
- to initialize the lake model we or to keep LST constant need data for large territories (even the globe) with all lakes included!
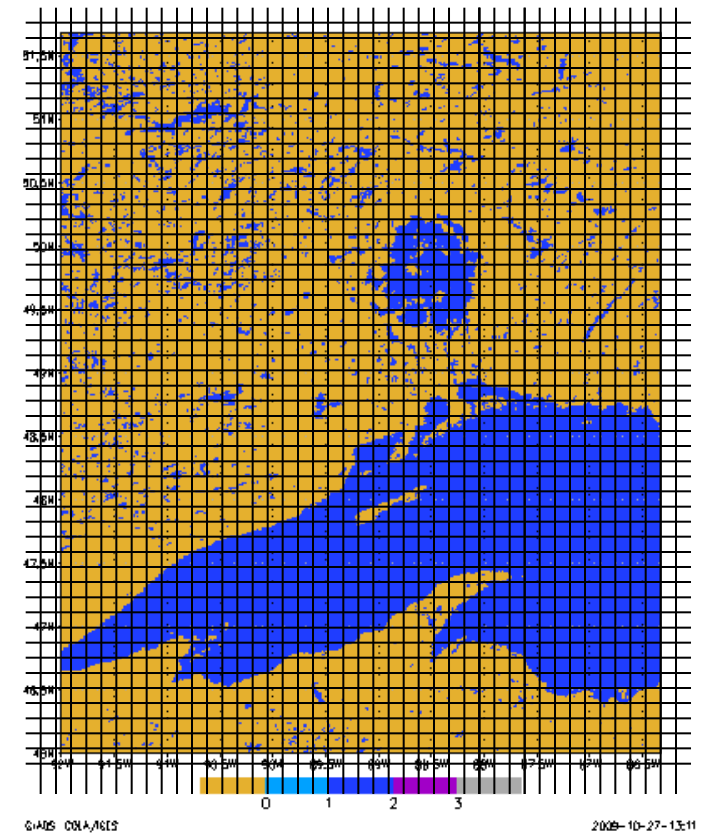
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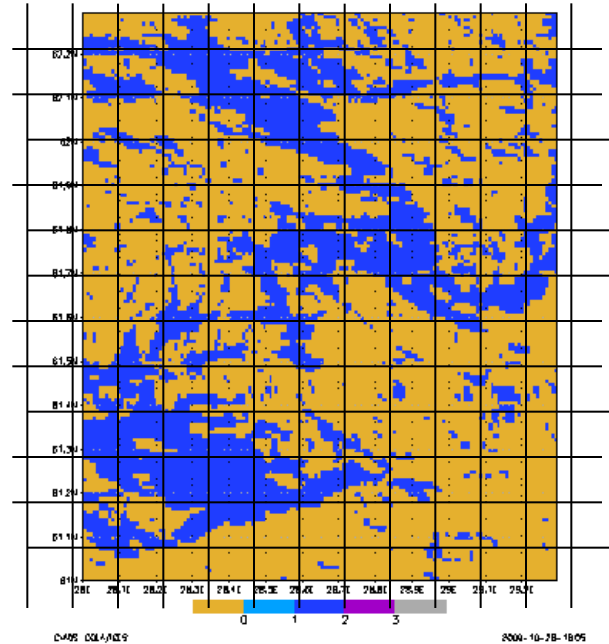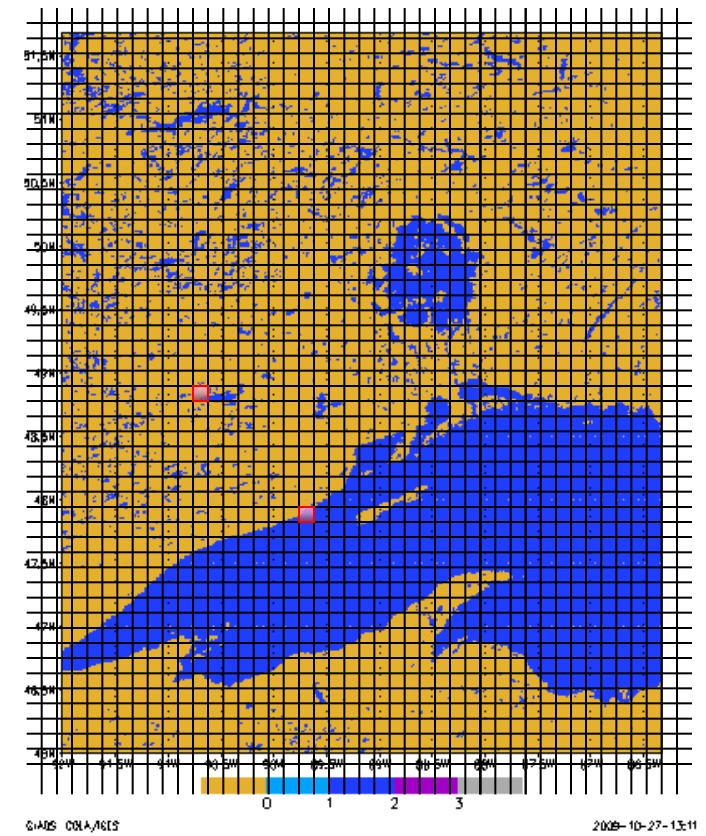
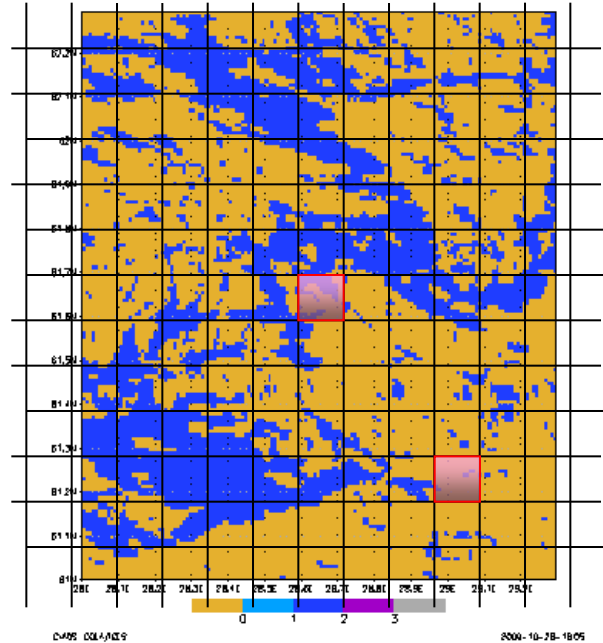# Introduction

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Assimilation of lake information: methods, variables

Variables:

- Temperature
  - LST!
  - discontinuous in space, continuous in time. Correlation between LST of neighboring lakes?

- Ice cover
  - very important!
  - but discontinuous both in space and in time!
  - ice/no ice, ice depth, ice fraction (?), snow on ice (?)

- For operational use all the information should be in real time or in near real time; processed automatically

Assimilation of lake information: methods, variables

Methods of DA for atmosphere and ocean:

- Statistical interpolation and filtration - optimal interpolation (OI), variational methods, Kalman filtering (EKF)

- Use auxiliary (background) information: **previous model run.**

- Variables should be continuous and smooth

No yet methods for a coupled system lake/atmosphere! Use oceanographic methods. But lake variables from the atmospheric point of view are discontinuous!

What do we have now …
for HIRLAM

EXP: ECMWF, +00H, SST and Ice cov.
initial: 00Z12FEB2011 valid: 00Z12FEB2011
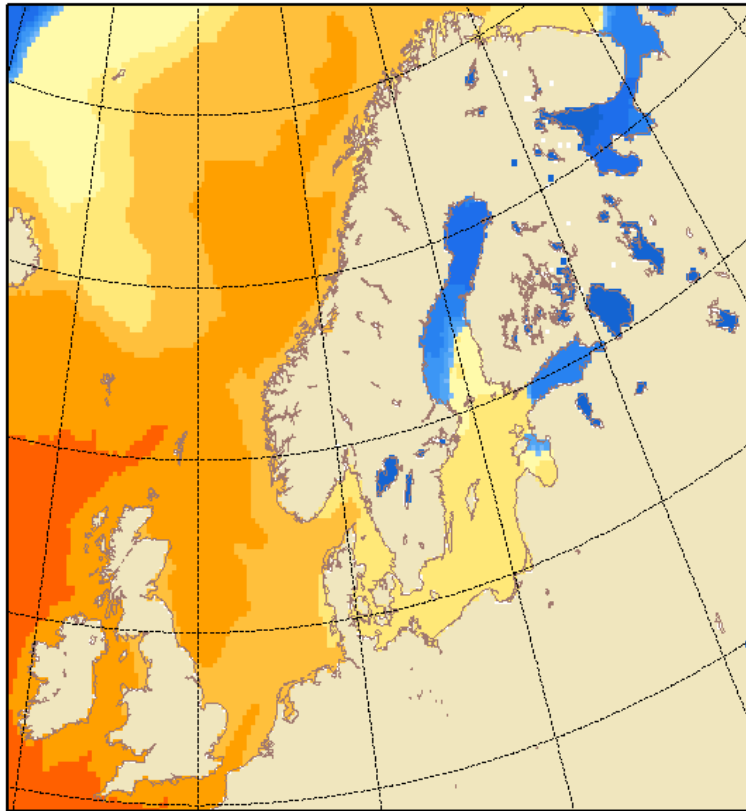
Pseudo-observations of LST are produced by NCEP/ECMWF everywhere but in reality:
▪ from observed LST only over the North American Great Lakes
▪from time-lagged near-surface observations elsewhere

Pseudo-observations over the Finnish and some neighbouring lakes from climate values (based on the long-term climatology of freezing and breakup dates)

Pseudo-observations from ocean climate values, when nothing else is available

OI to spread information in horisontal (from oceanography)
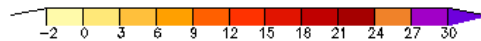
What do we have now ...
for HIRLAM

Coming observations ...

Järven pintalämpötila, 04 411 Pielinen
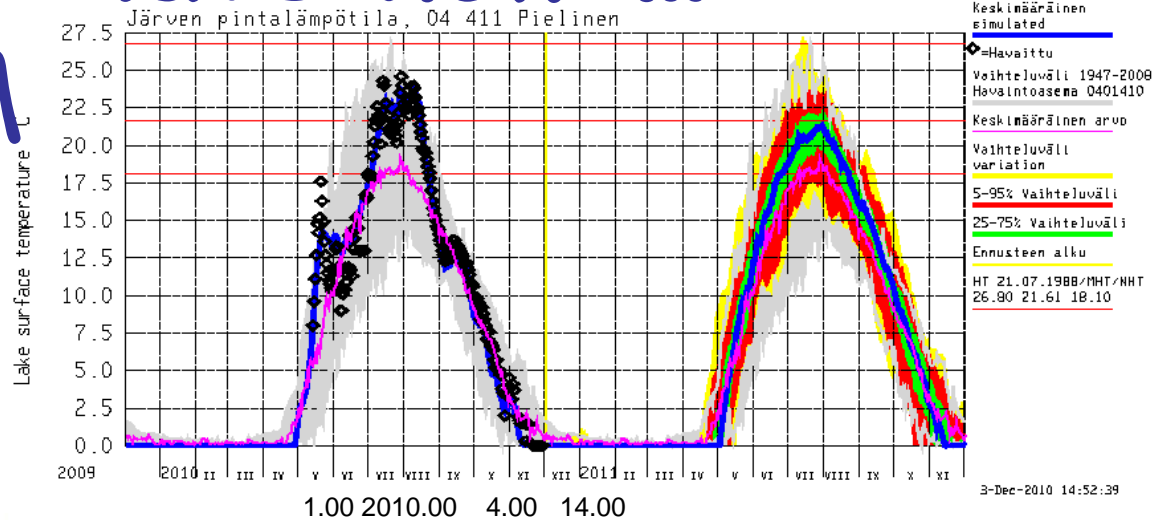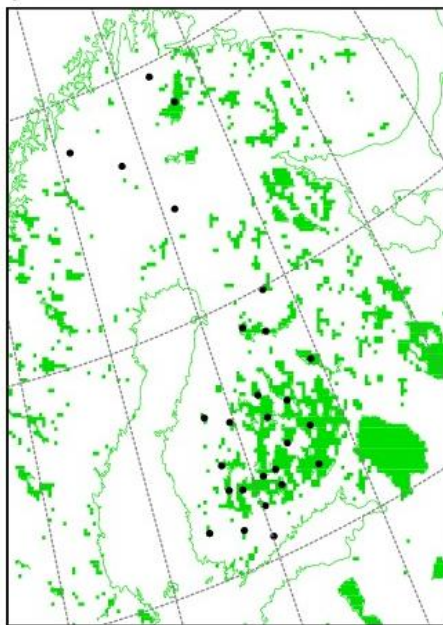
```
                         1.00 2010.00    4.00   14.00
        4.00  -2.20  63.27  29.61  Pielinen   - frozen lake flag set
        4.00  -2.20  62.76  27.78  Kallavesi  - frozen lake flag set
        4.00   4.40  62.11  28.39  Haukivesi  - SYKE statistical fit
        4.00   3.86  61.34  28.12  Saimaa     - SYKE statistical fit
        4.00  -2.20  62.86  24.79  Paajarvi1  - frozen lake flag set
        4.00  -2.20  63.11  26.53  Nilakka    - frozen lake flag set
        4.00  -2.20  62.63  26.60  Konnevesi  - frozen lake flag set
        4.00   5.57  61.63  26.14  Jaasjarvi  - SYKE statistical fit
        4.00   5.32  61.61  25.48  Paijanne   - SYKE statistical fit
        4.00   6.05  62.14  23.76  Vaskivesi- - SYKE statistical fit
        4.00   6.10  60.79  23.86  Kuivajarvi - SYKE statistical fit
        4.00   4.94  61.63  23.75  Nasijarvi  - SYKE statistical fit
        4.00  -2.20  63.15  23.67  Lappajarvi - frozen lake flag set
        4.00  -2.20  64.45  26.97  Oulujarvi  - frozen lake flag set
        4.00  -2.20  68.38  23.60  Ounasjarvi - frozen lake flag set
        4.00  -2.20  67.17  25.71  Unari      - frozen lake flag set
        4.00  -2.20  69.01  20.82  Kilpisjarv - frozen lake flag set
        4.00  -2.20  69.75  27.01  Kevojarvi  - frozen lake flag set
        4.00  -2.20  69.08  27.92  Inarijarvi - frozen lake flag set
```

**Lake surface temperature *in-situ* observations over 27 lakes in Finland, backed up by the Finnish Enviroment Institute (SYKE) lake model
http://wwwi2.ymparisto.fi/i2/kooste/jarvilampo_p.html**

In future ...

Coming observations ...

Over the Baltic Sea and
the Swedish lakes Vänern and Vettern,
water temperature observations
based on the operational ice map
by the Finnish Meteorological Institute

Possibly satellite-based temperatures/ice cover
over Lake Ladoga (Onega ...)

http://www.itameriportaali.fi/en/itamerinyt/en_GB/jaatilanne/
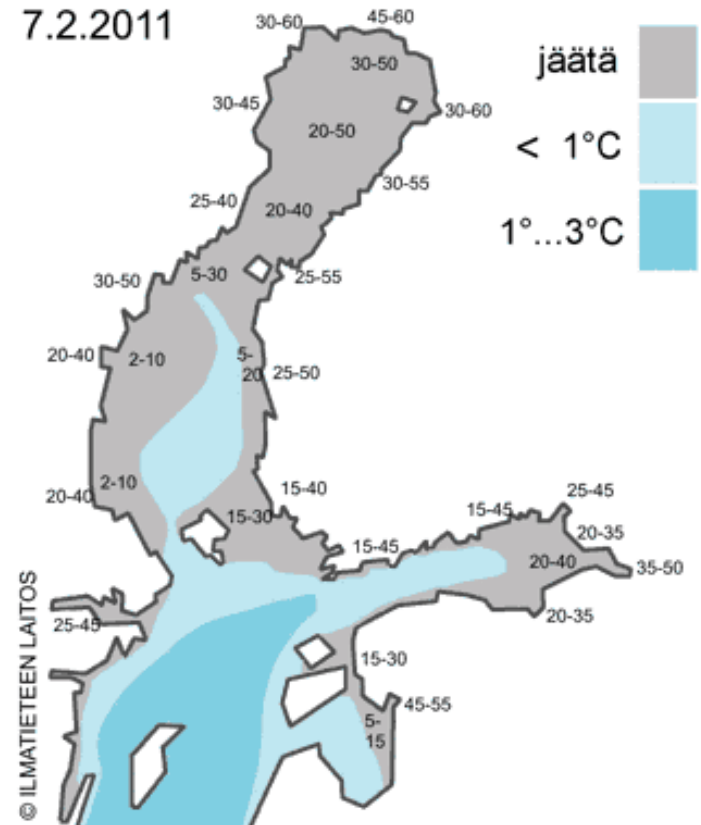
In future …

Observations

- Remote sensing
  – MODIS
  - coming ESA products - North Hydrology, probably
  gridded data for the region
  with 1 km resolution

  - other?

Ideas for DA of LST

For coupled system lake/atmosphere we need:

- To spread information in horizontal - to transfer information into gridded form (in contrast to data for individual lake)

    - OI?
  To adapt for discontinuous fields – to introduce into structure functions **the dependency on lake depth**

- To spread information in vertical (inside FLake)
  – EKF?
  Slow variables
  B-matrix modeling is difficult
  Nonlinearity sometimes may be strong

Ideas for DA of LST

To spread information in vertical (inside FLake)

State vector

$$\mathbf{x} = \begin{bmatrix} \overline{\theta} \\ \theta_b \\ h \\ C_\theta \end{bmatrix}$$

Obs vector

$$\mathbf{y} = \left| \theta_s \right|$$

Obs operator

$$\theta_s = \left(1 - C_\theta \left(1 - \frac{h}{D} \right) \right)^{-1} \left(\overline{\theta} - \left(1 - \frac{h}{D} \right) \theta_b \right)$$

Plan for discussion, work, cooperation ...

Operational ?

- in situ! - local
- MODIS? How it is organized?
- other?

Plan for discussion, work, cooperation …

Research!
- in situ!
- MODIS!
  - obs statistics – how to obtain?
  - quality control
  - lake mask
  - cloud mask
  - use composites or not?
  - how to aggregate data (if needed)?
  - structure functions for OI
- other?

Plan for discussion, work, cooperation ...

MODIS –related tasks

- 2 products with LakeST: LST, SST. Different quality? Interested in both – also for Gulf of Finland and Bothnian bay?
- Validation of both products against in-situ, intercomparison
- Derive obs. statistics, day/night, skin temperature problem
- 100 individual lakes from MODIS to HIRLAM
- Derive structure functions for OI
- other?