

# Improvement of objective analysis of lake surface state in HIRLAM using satellite observations

**WATERLOO**  
**ENVIRONMENT**

[environment.uwaterloo.ca](http://environment.uwaterloo.ca)

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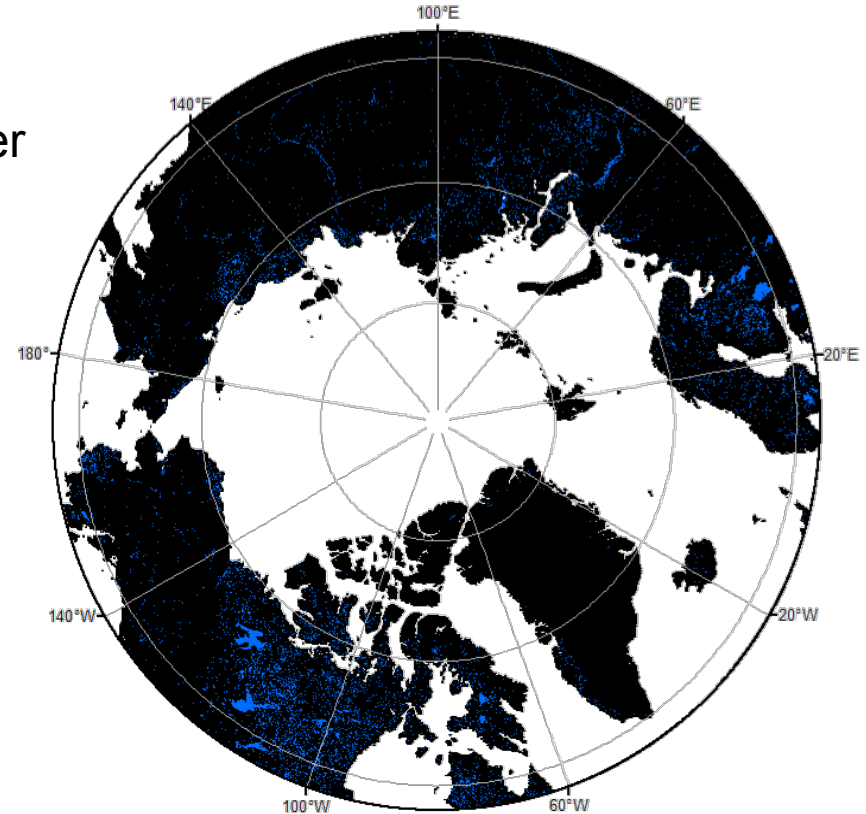
Finnish Meteorological Institute (FMI),  
Helsinki, Finland

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- **Context**
  - Lakes in regional weather and climate
  - Need for lake ice observations
- **Remote sensing of lake ice**
  - Evaluation of satellite LWST observations
  - MERIS ice fraction observations
- **Satellite LWST observations into HIRLAM analysis**
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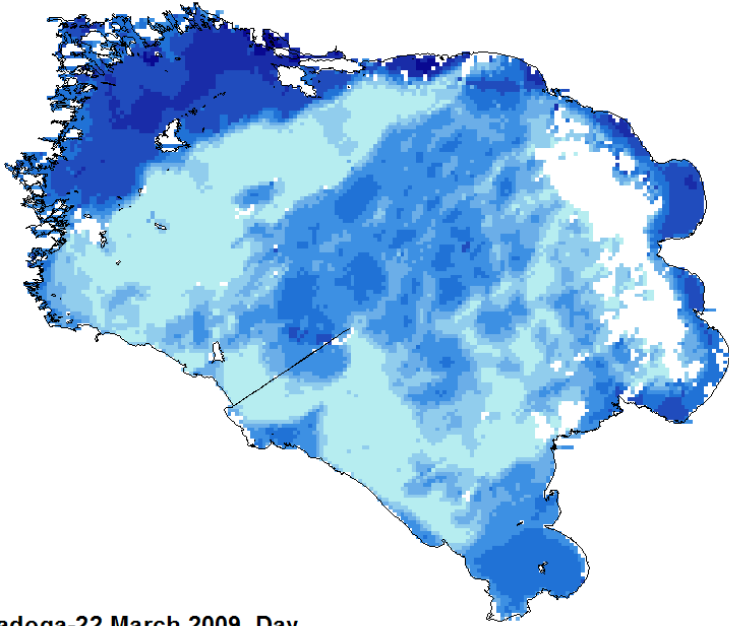
# Lakes in regional weather and climate

- Consideration of lake-atmosphere interactions is an important issue in climate modeling and numerical weather prediction (NWP).
- Lakes have an important role in the surface radiation balance, heat and water vapor exchanges with the atmosphere.
- The presence (or absence) of ice cover on lakes in winter has an effect on the surrounding climate.
- Earlier/later freeze-up and break-up results in ice cover duration change, and this strongly influences the radiation and energy balance.



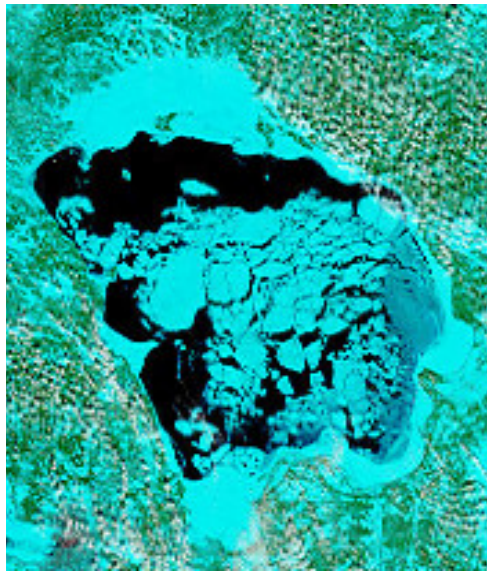
**A good representation of lake ice/temperature-atmosphere interactions is necessary to improve weather forecasting and climate modelling**

# Need for lake ice observations



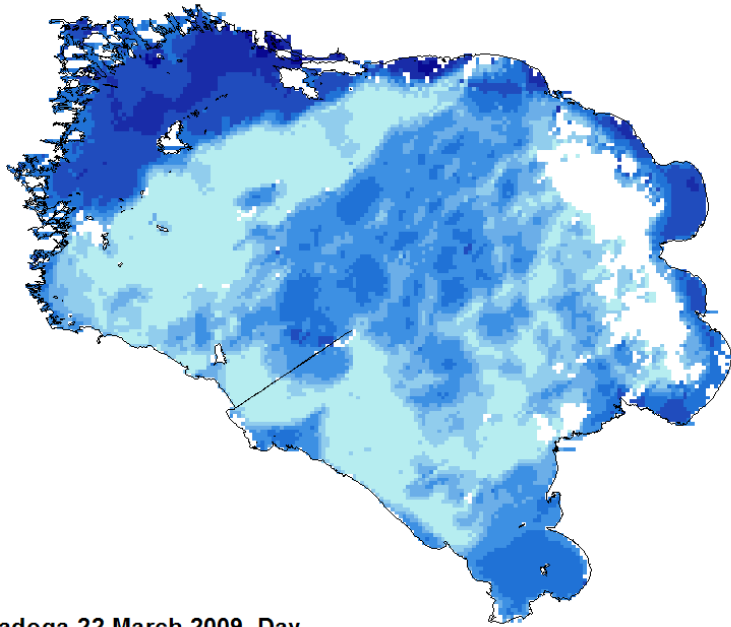
Ladoga-22 March 2009\_Day

- 263.049 - 264.58
- 264.58 - 266.72
- 266.72 - 267.97
- 267.97 - 268.94
- 268.94 - 269.79
- 269.79 - 270.76
- 270.76 - 271.81
- 271.814 - 273.35

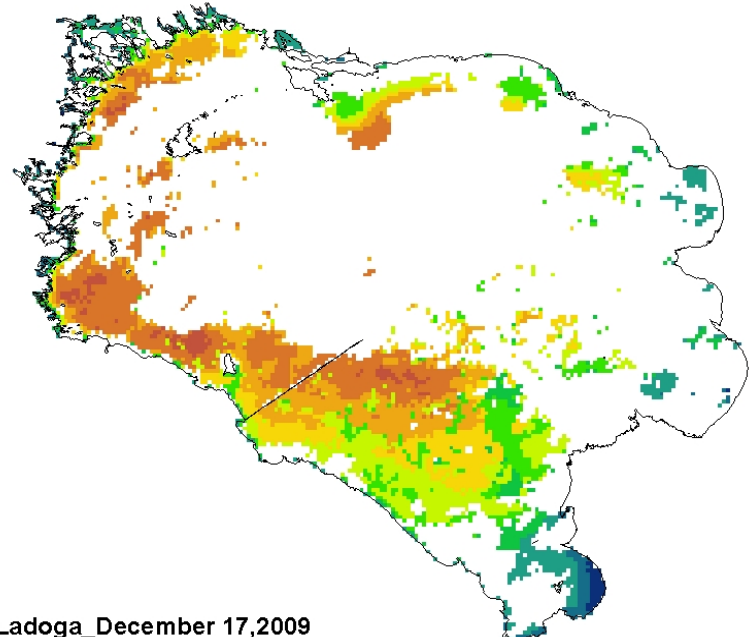
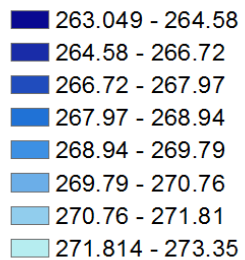


**Lake Ladoga**  
**22 March 2009**

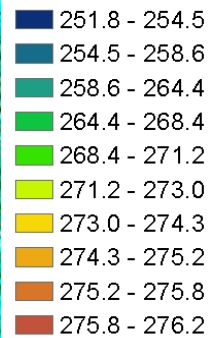
# Need for lake ice observations



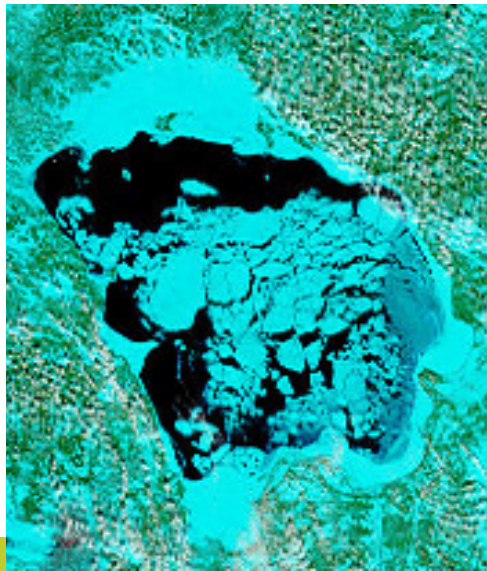
Ladoga-22 March 2009\_Day



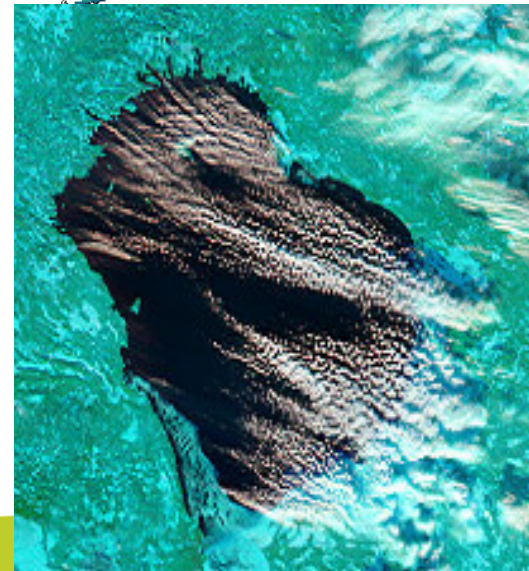
Ladoga\_December 17,2009



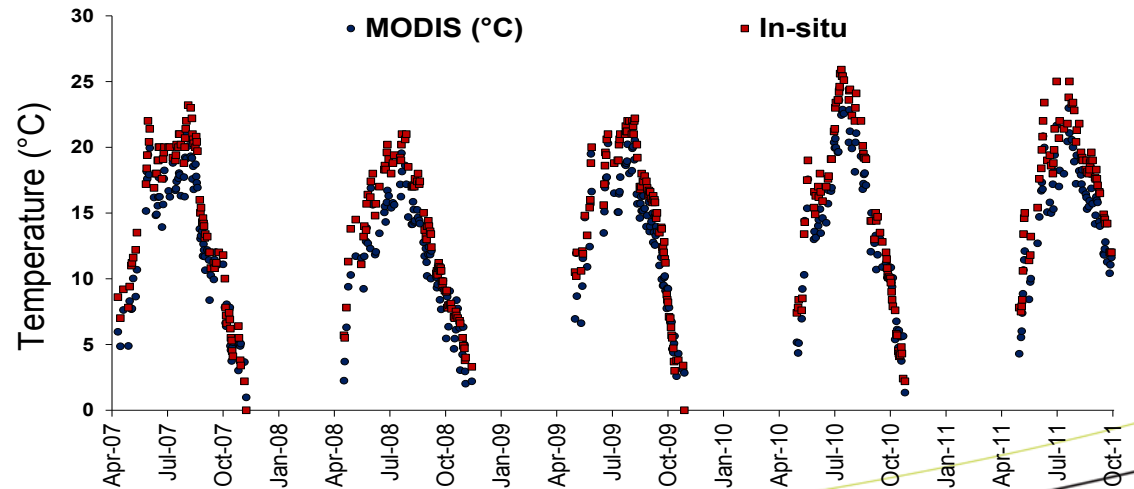
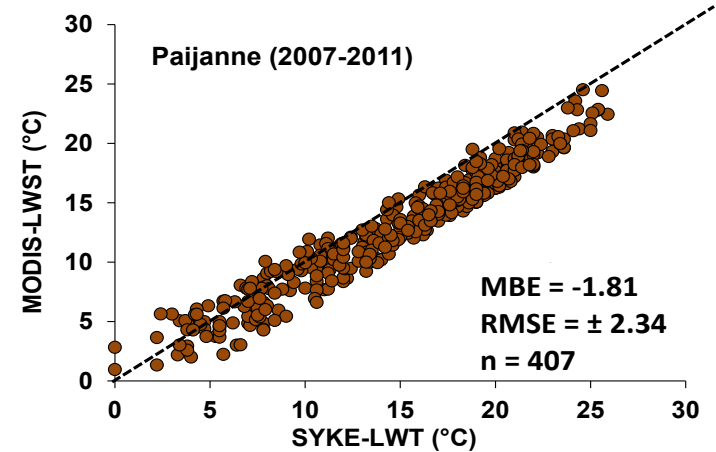
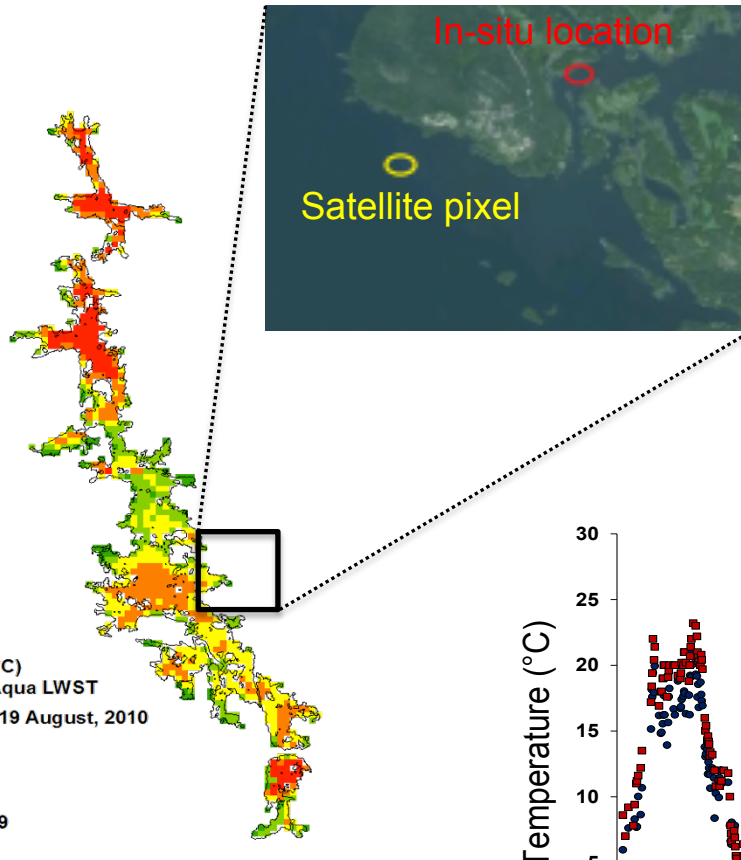
**Lake Ladoga  
22 March 2009**



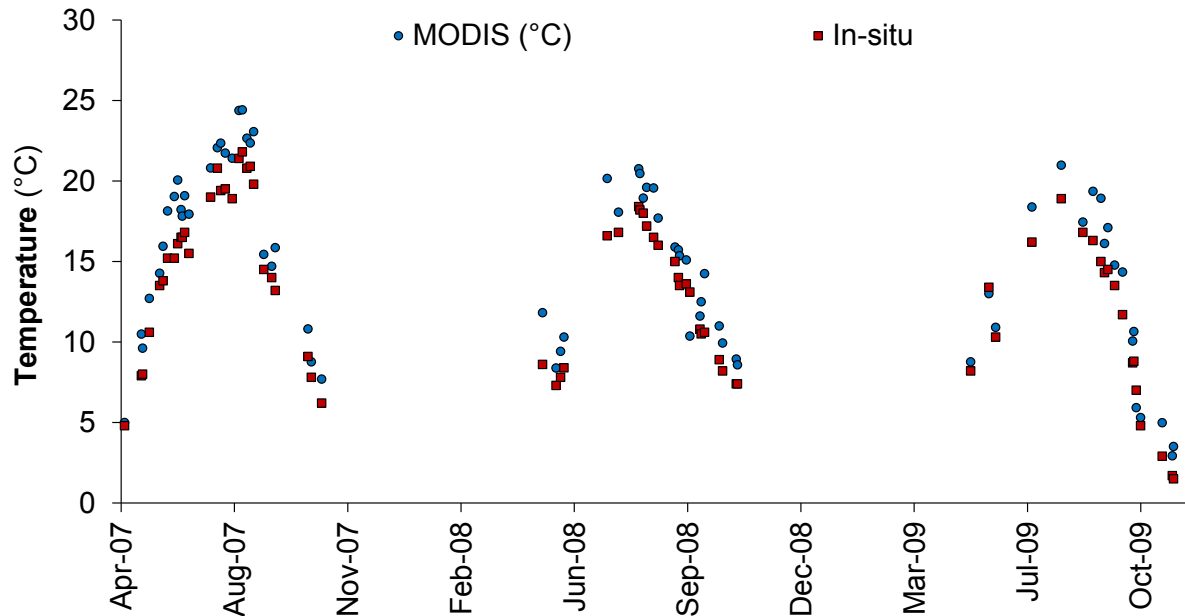
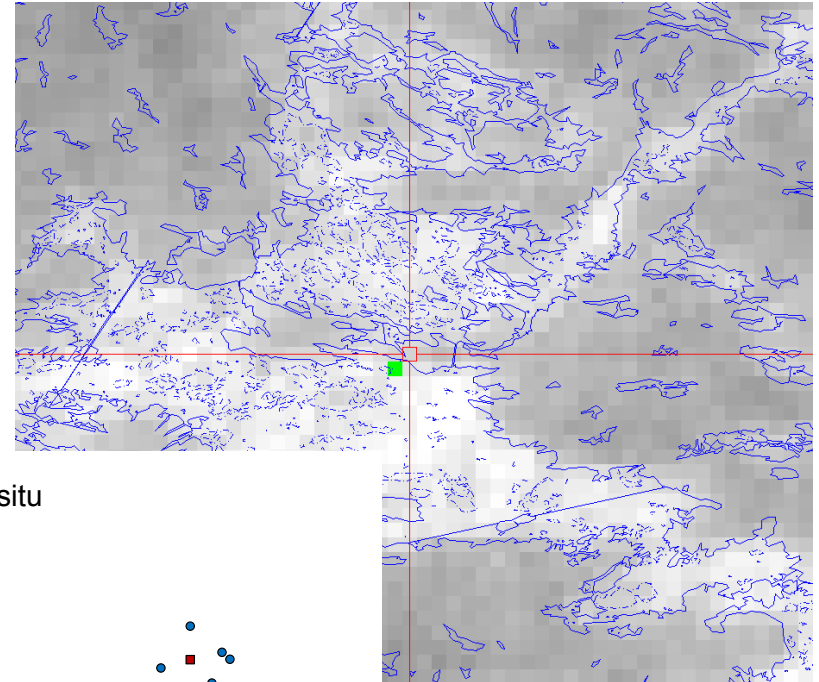
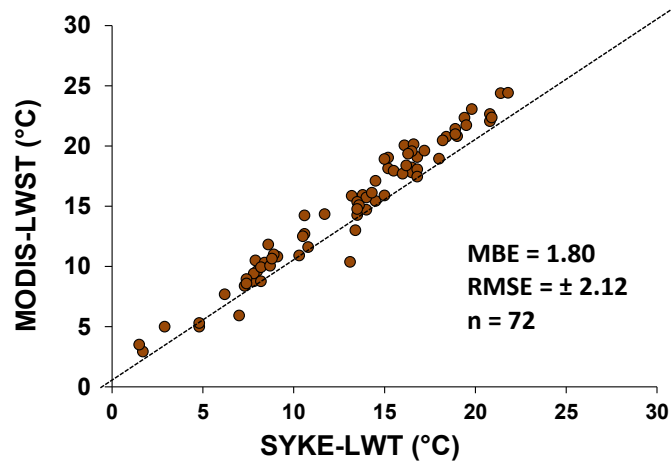
**Lake Ladoga  
17 December 2009**



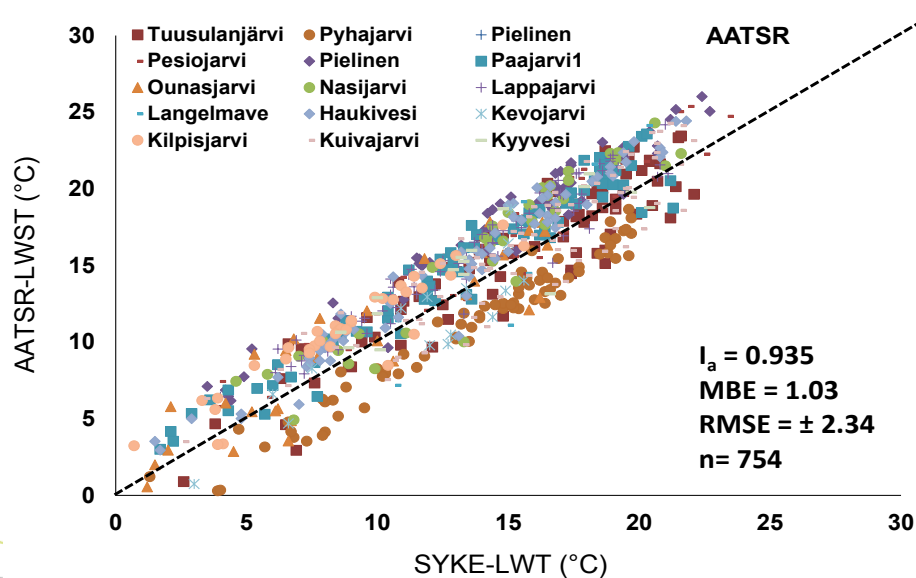
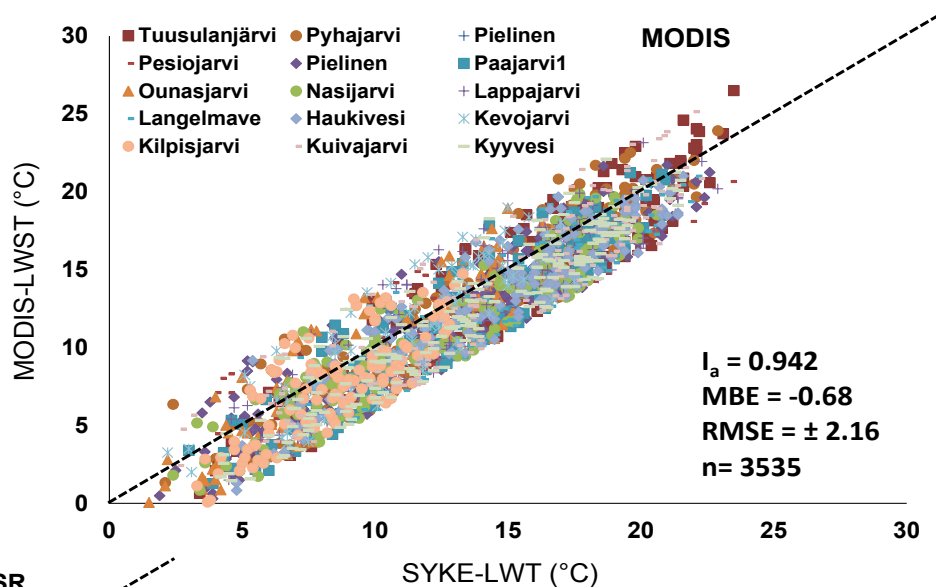
# Evaluation of MODIS LWST for Lake Päijänne



# Evaluation of AATSR LWST for Lake Haukivesi

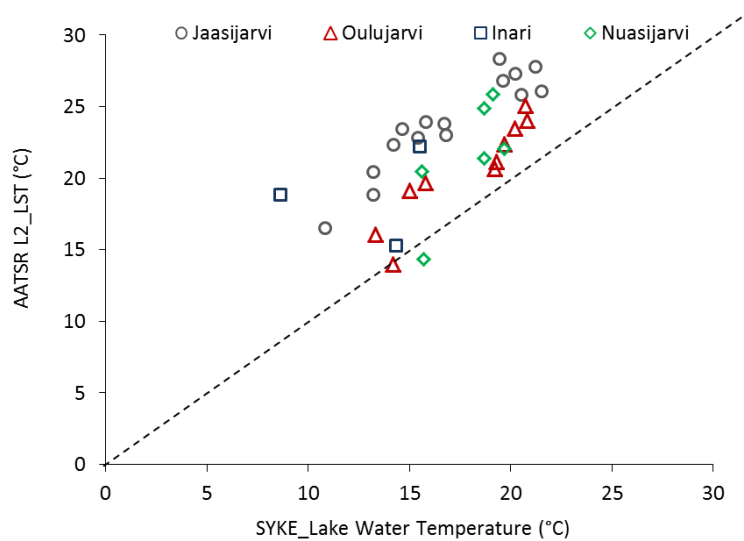
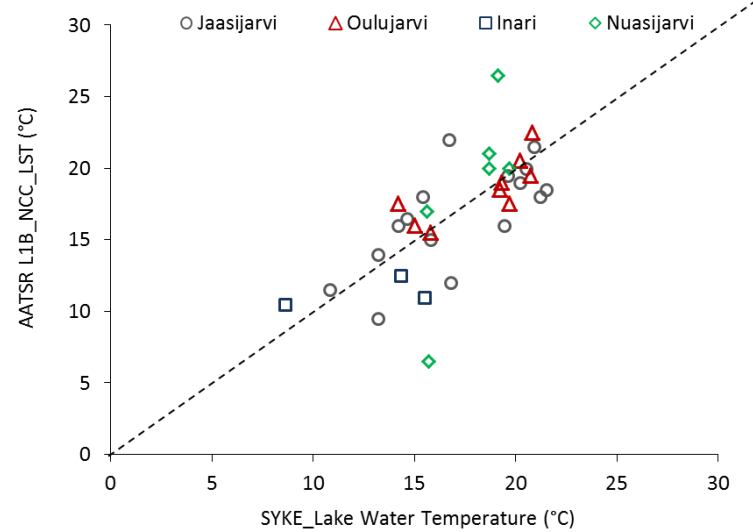
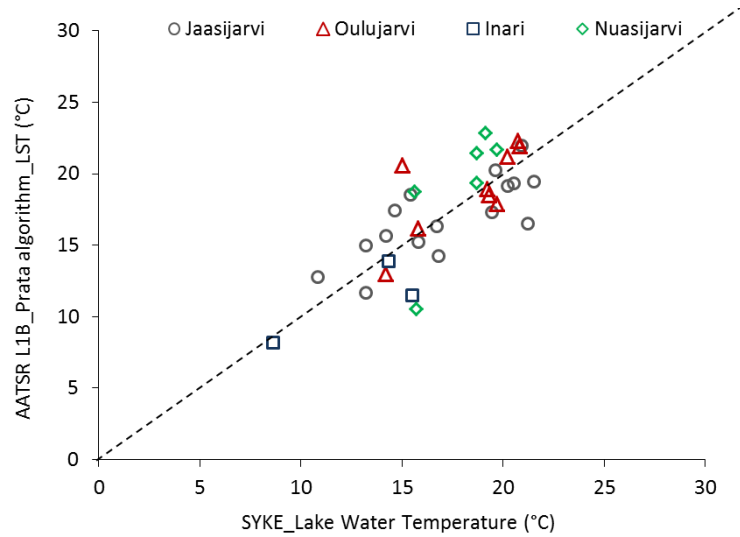


# Evaluation of MODIS/AATSR LWST on 15 Finnish lakes





# AATSR LWST algorithms



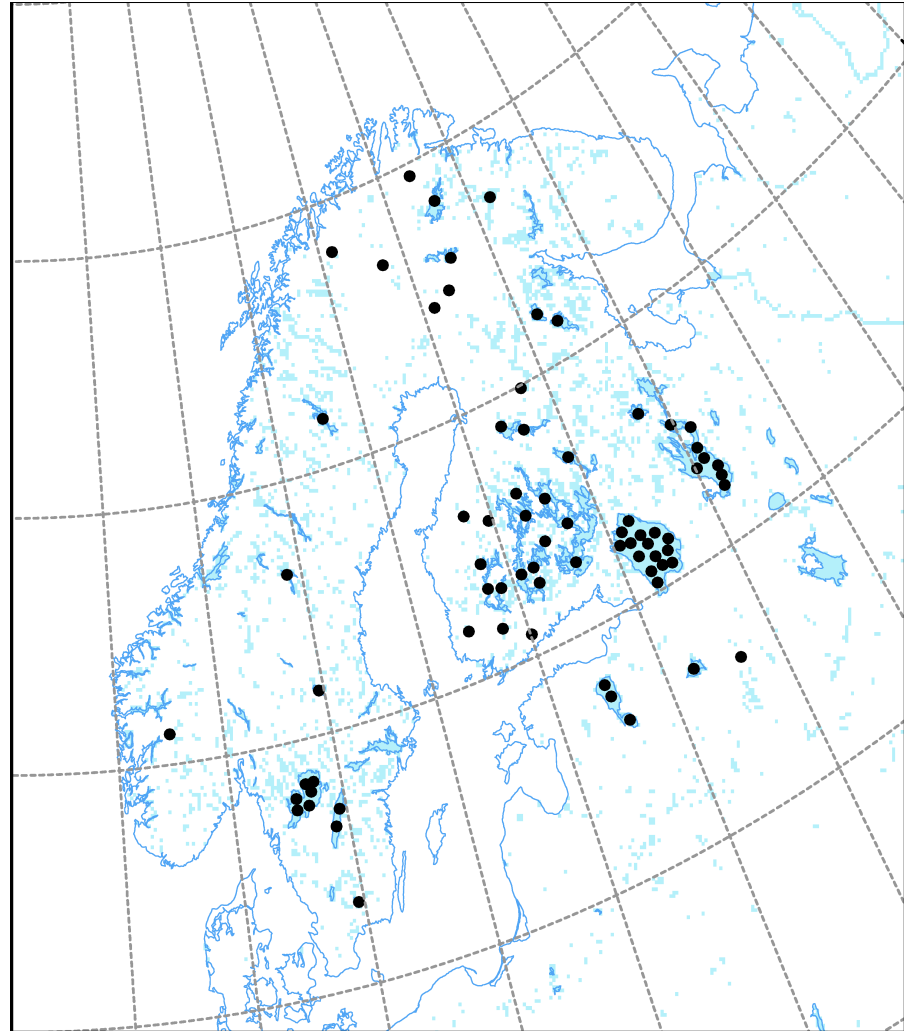
SYKE/AATSR_Prata	n	la	MBE	RMSE
Nuasijarvi	6	0.68	+1.18	±3.22
Oulujarvi	10	0.72	-0.76	±4.67
Jaasjarvi	16	0.87	-0.17	±2.11
Inari	3	0.84	-1.59	±2.33

SYKE/AATSR_NCC	n	la	MBE	RMSE
Nuasijarvi	6	0.55	+0.58	±4.97
Oulujarvi	10	0.44	-1.17	±4.46
Jaasjarvi	16	0.83	-0.44	±2.66
Inari	3	0.59	-1.47	±3.00

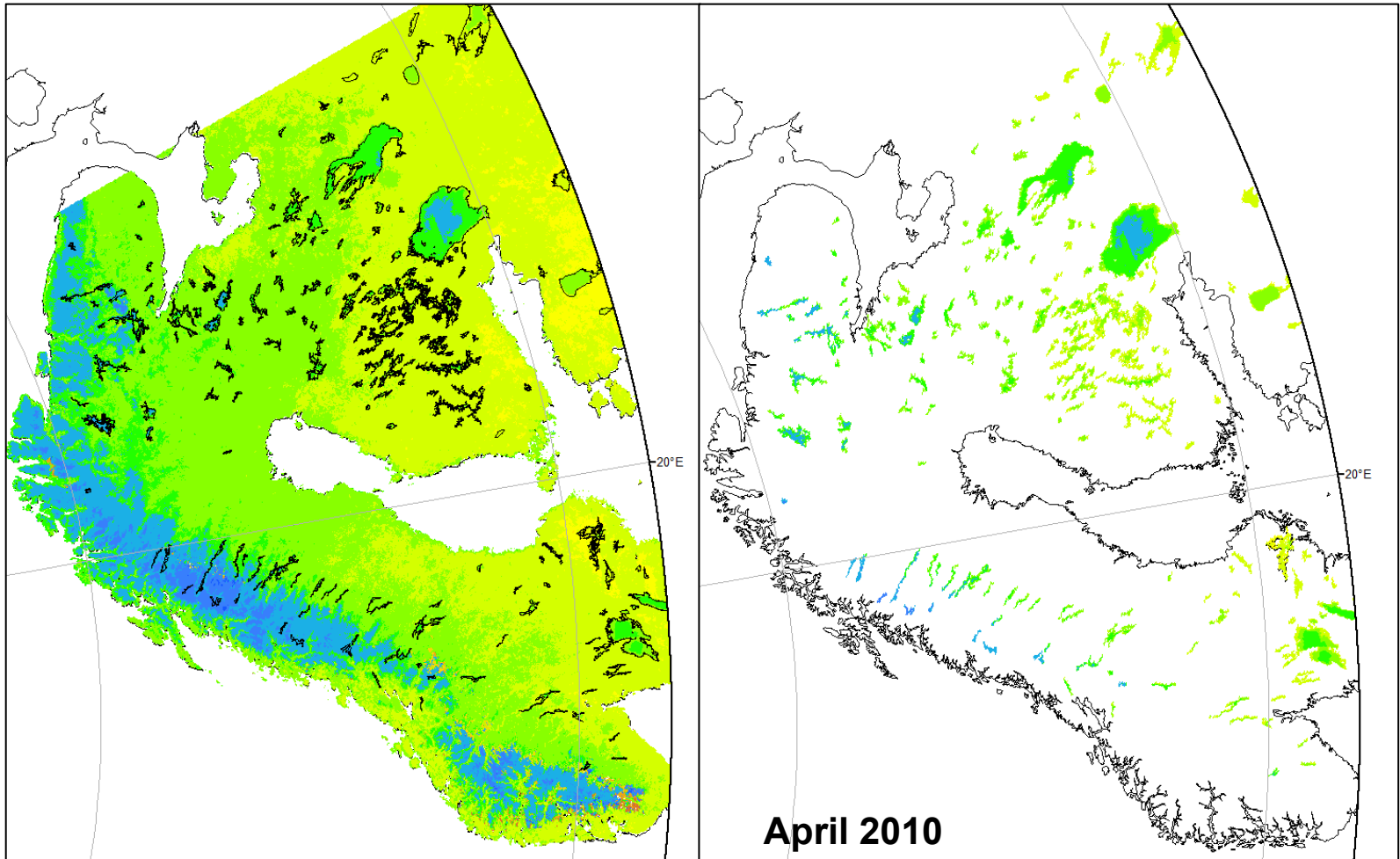
SYKE/AATSR_L2	n	la	MBE	RMSE
Nuasijarvi	6	0.52	+0.59	±4.51
Oulujarvi	10	0.80	+2.72	±3.04
Jaasjarvi	16	0.54	+7.11	±7.23
Inari	3	0.44	+6.02	±7.12

# Pre-defined pixels in HIRLAM domain

70 pixels over 41 lakes are chosen for picking remote sensing pixels to be used as observations in the HIRLAM optimal interpolation analysis and for comparison

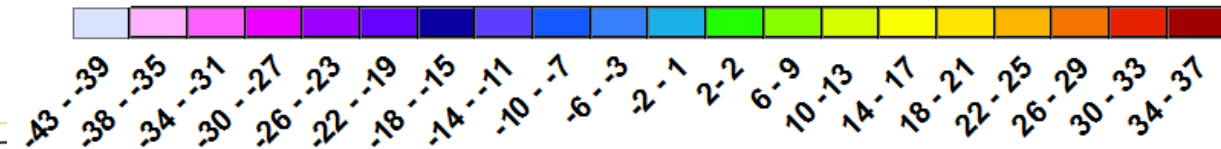


# MODIS Land/Lake surface temperature



**WATERLOO**  
**ENVIRONMENT**

Temperature (°C)



# MODIS/AATSR LWST & MERIS ice fraction

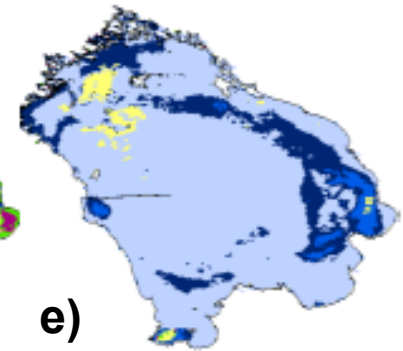
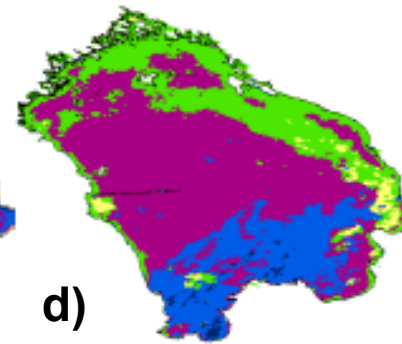
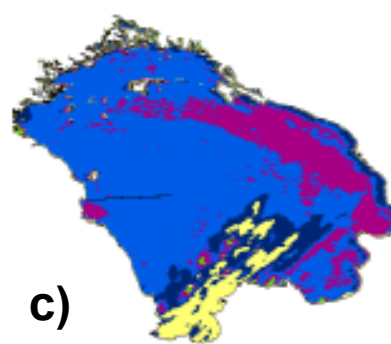
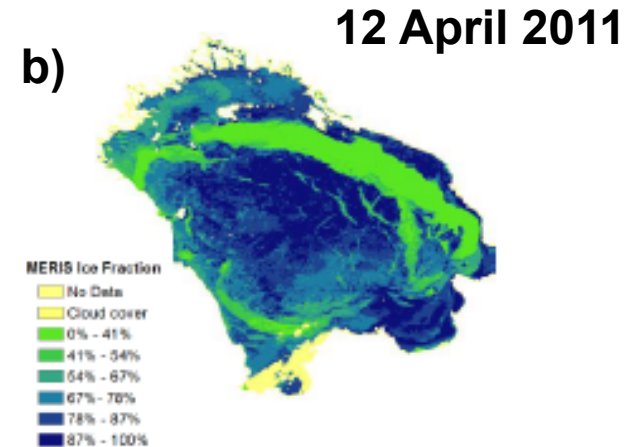
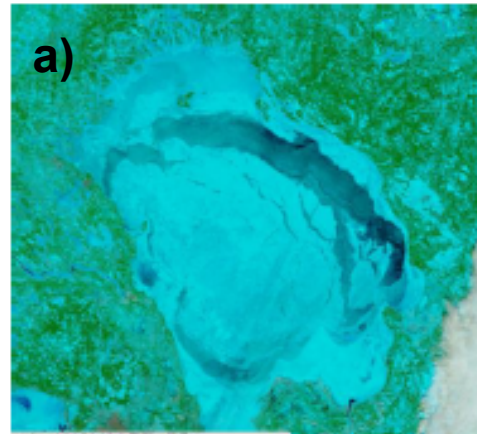
a) MODIS visible image

b) MERIS ice fraction

c) AATSR surface temperature (between 8-10 AM local time)

d) MODIS day time (between 10 AM -12 PM local time)

e) MODIS night time (between 10 PM - 3 AM local time)

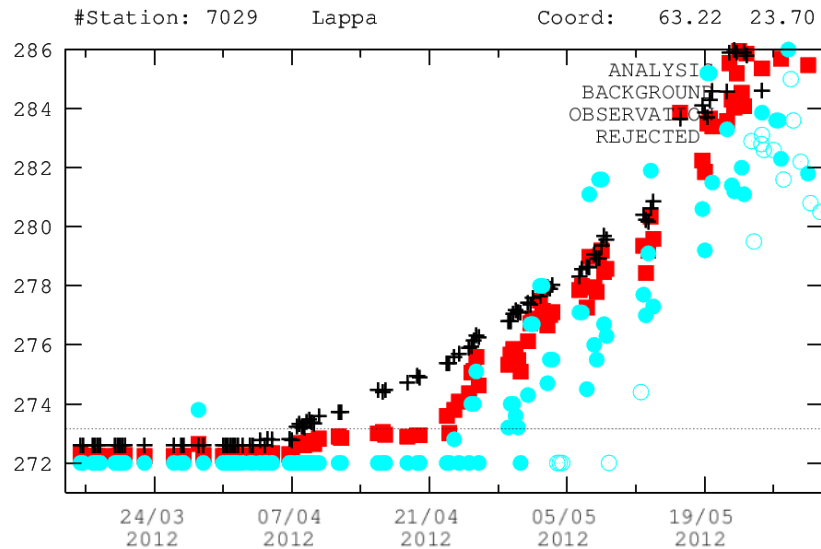


# HIRLAM experiments definition

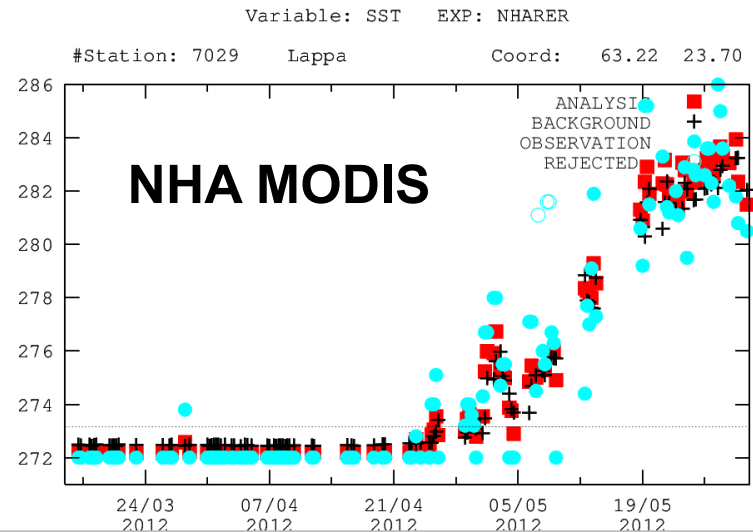
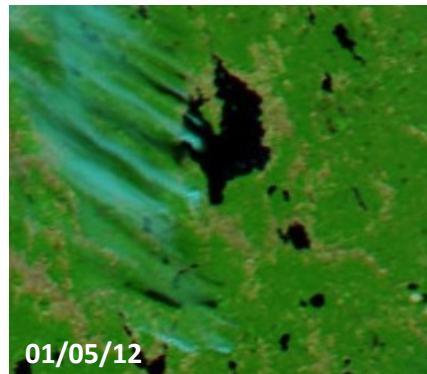
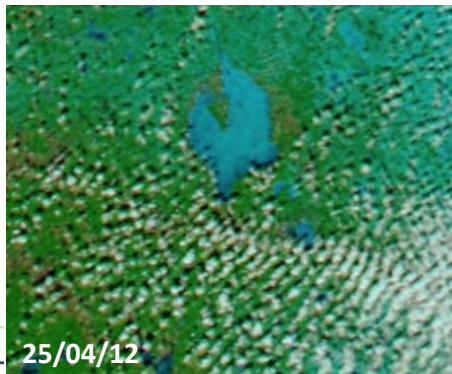
Time	Observations	Prognostic parameterizations	Forecast lead time	Notes
		FLake		
20101101 - 20120531	SYKE in Finland	( FLake for background)	27h	TRULAK
		FLake		
20101101 – 20120531	SYKE in Finland + 70 RS lakes	( FLake for background)	6h	NHFLAK
		none		
20120101 - 20120531	SYKE in Finland + 70 RS lakes	(previous analysis as background)	27h	NHALAK

# Results over Lake Lappa (15 March- 31 May 2011) - MODIS

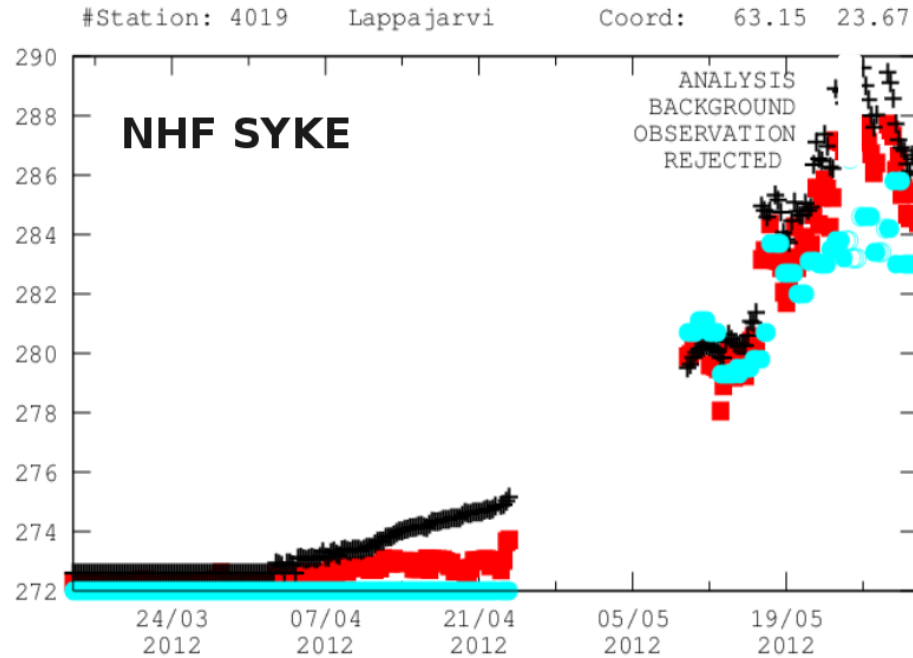
- +** Predicted LWST (Background)
- Analysis of LWST
- MODIS Observation
- Rejected MODIS Observation



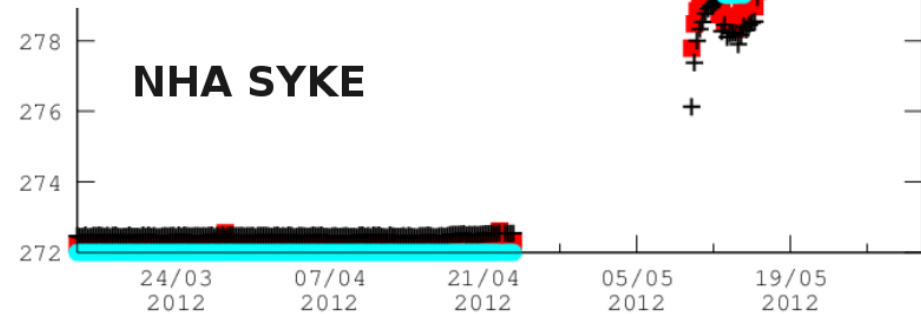
MODIS-Aqua visible images



# Results over Lake Lappa (15 March- 31 May 2011) - SYKE



- +** Predicted LWST (Background)
- Analysis of LWST
- SYKE Observation
- Rejected SYKE Observation



# Outlook and recommendations

- Apply satellite-based ice cover/ice fraction observation into the analysis of HIRLAM/HARMONIE
- Improve the horizontal interpolation and in-depth data assimilation methods within the NWP models (e.g. Extended Kalman Filter)
- Develop methods for thinning/screening/creation of super-observations for large lakes to reduce amount of input data when necessary
- Improve the method of the processing/cleaning/quality control of the primary measured data, specific for new remote sensing observations
- Develop methods to operationalize fully automatic usage of satellite observations of lake surface state
- **Recommendations?**