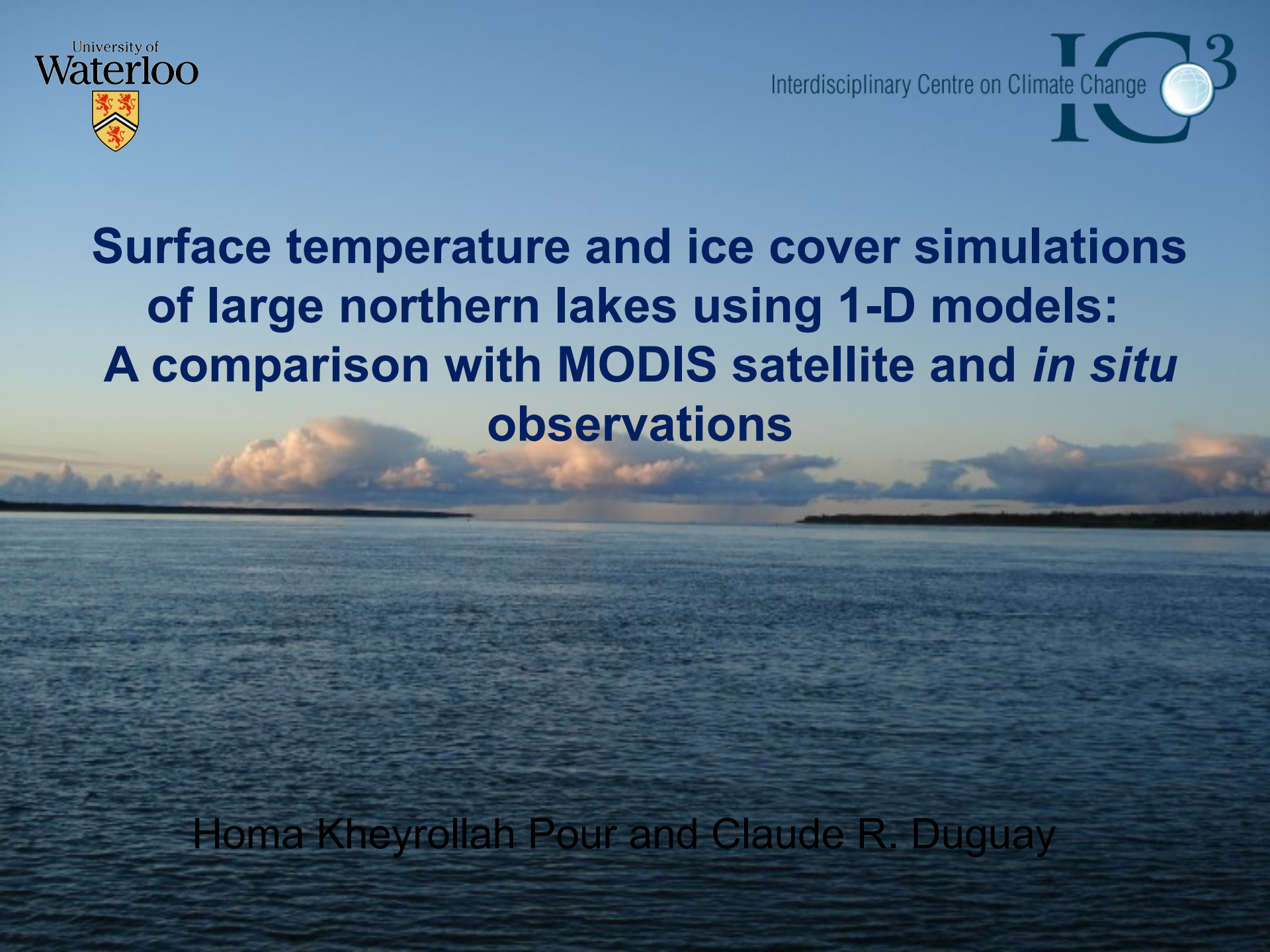


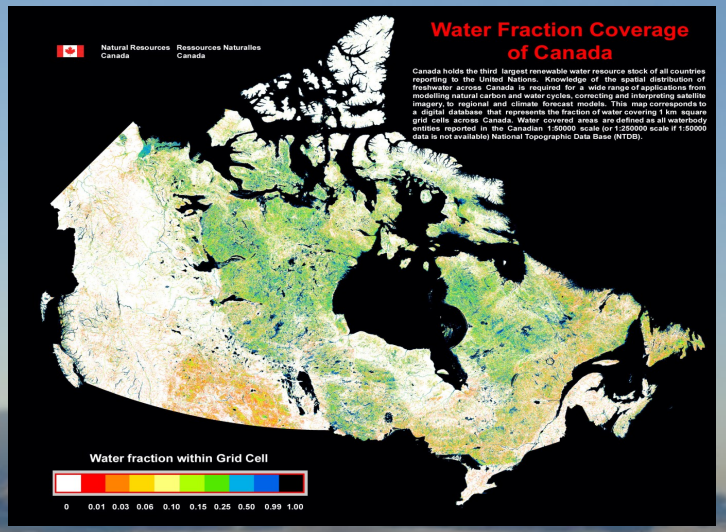
University of Waterloo

Interdisciplinary Centre on Climate Change

Surface temperature and ice cover simulations of large northern lakes using 1-D models: A comparison with MODIS satellite and *in situ* observations

Homa Kheyrollah Pour and Claude R. Duguay

Lakes in Canada



- 9% of Canada's landmass is covered by lakes (~ 2 million lakes).
- Lakes influence the regional heat, moisture content and circulation of the atmosphere.
- Ice cover and lake temperature have important effects on regional weather and climate in the vicinity of the lakes.
- A good representation of lake ice/temperature-climate interactions is necessary for improved weather forecasting and climate modelling.

Research objectives

- Asses the performance of the FLake and CLIMo models for simulating surface temperature and ice cover on two large, deep, lakes in northern Canada.

  - Compare simulated lake surface temperature (LST), ice thickness, and freeze up/break up dates obtained with the two 1-D lake models to MODIS LST data and *in situ* ice observations.

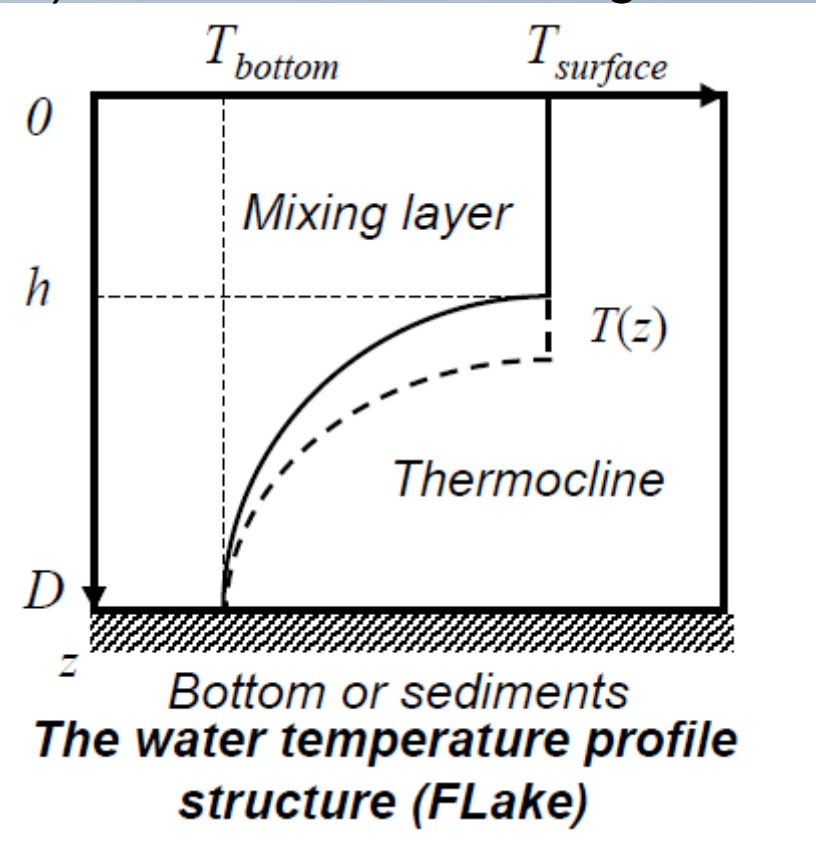
  - Identify the uncertainties and limitations of the numerical models and the MODIS satellite data products.

FLake

A 1D lake model developed for Numerical Weather Prediction (NWP) and climate modeling.

Inputs

- Air temperature (°C)
- Relative humidity (mb)
- Wind speed (m/s)
- Cloud cover (tenths)
- Solar radiation(w/m2)

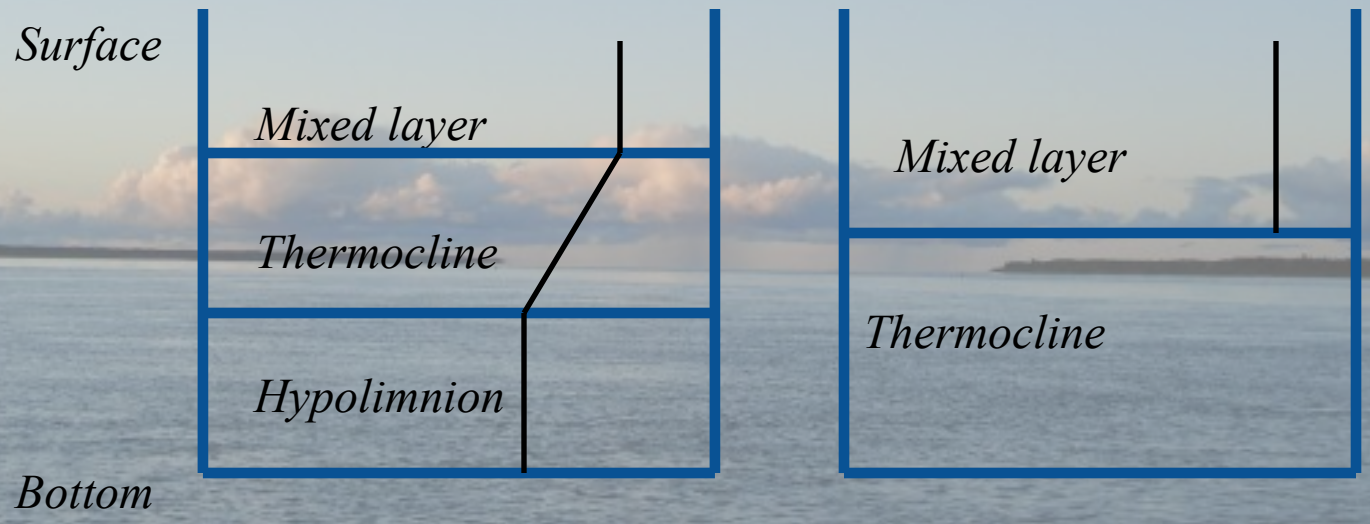


The water temperature profile structure (FLake)

Martynov *et al.*, 2008

Application limit

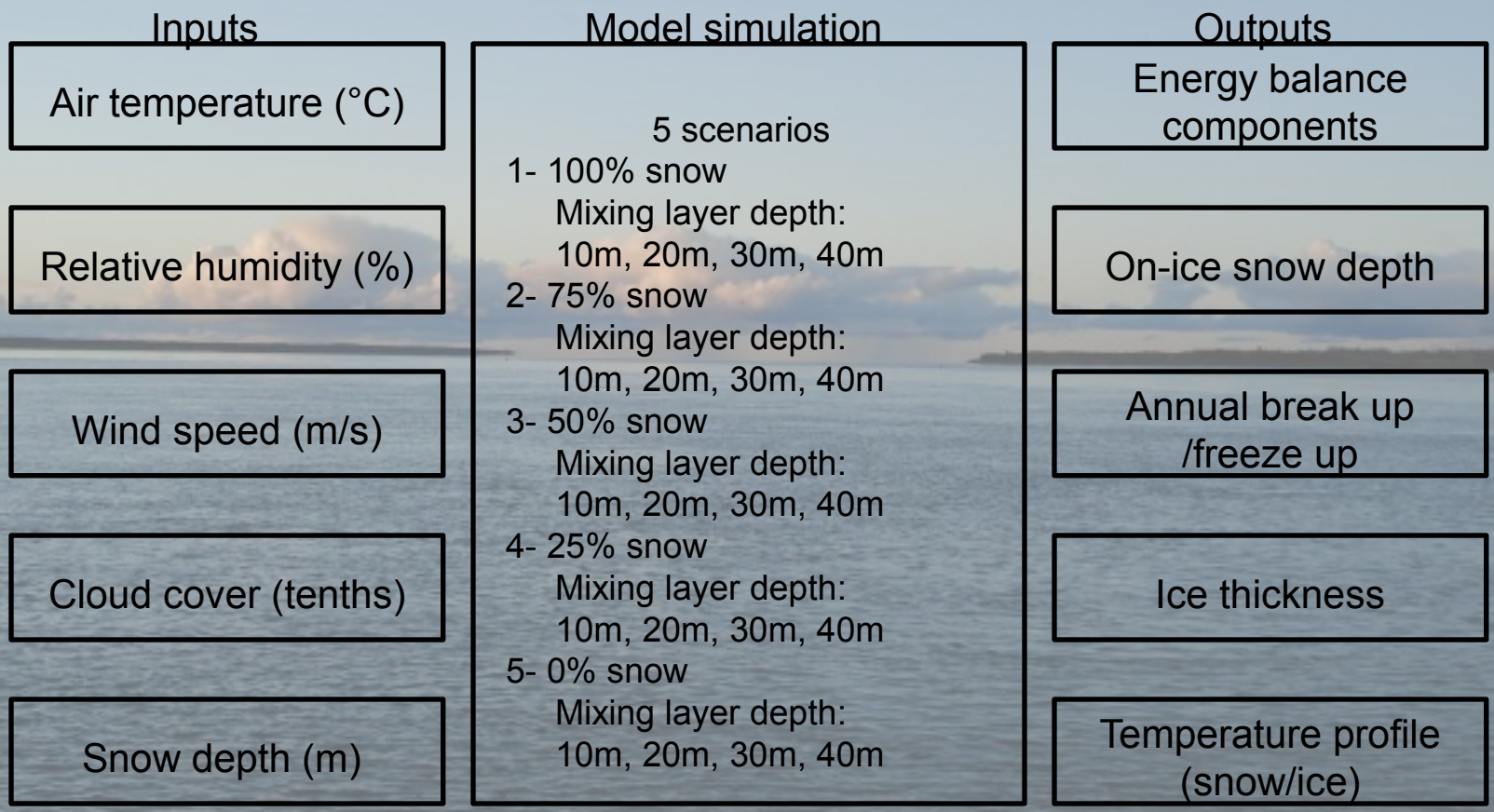
- Previous lake studies have shown good performance of 1D lake models in small and shallow lakes.



- "virtual bottom", usually at 40 to 60 meters, is used in simulations, instead of the real lake depth.

CLIMo

Canadian **L**ake **I**ce **Mo**del (CLIMo) (Duguay *et al.*, 2003)



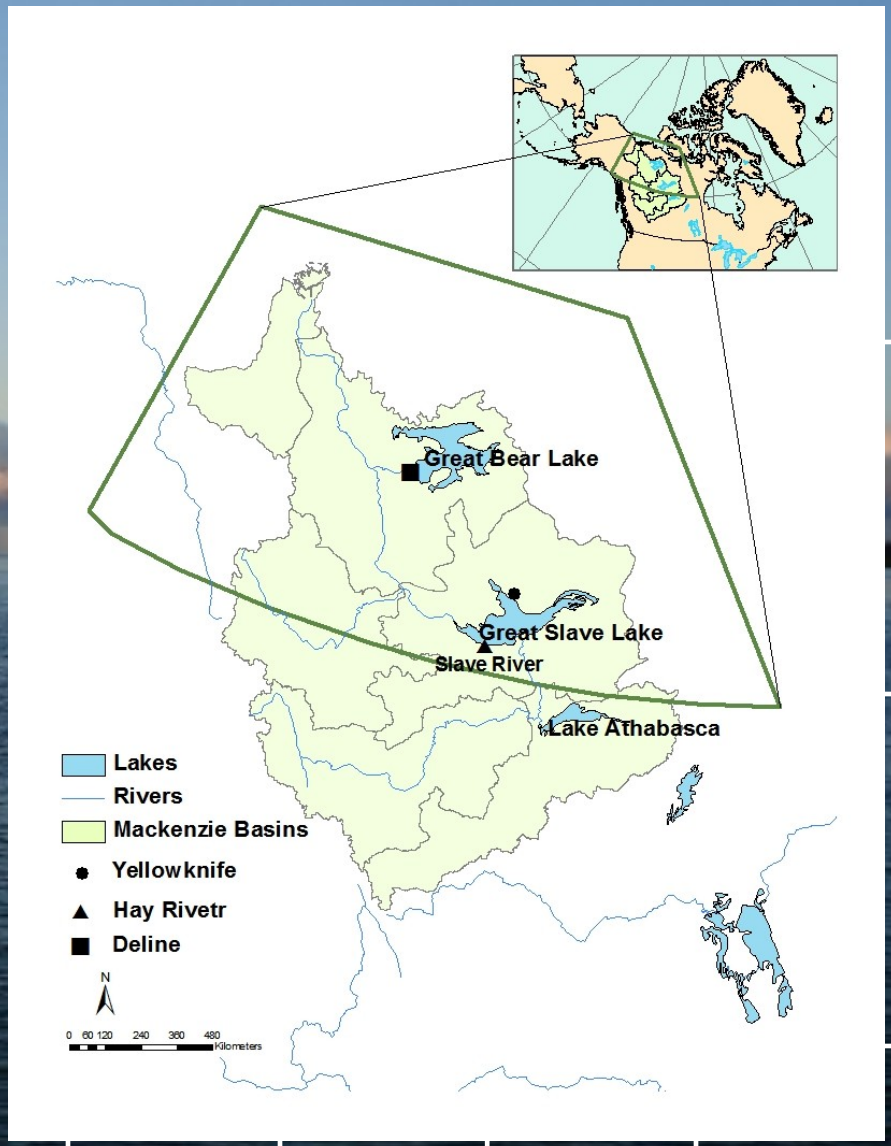
Study Area

Great **S**lave **L**ake (GSL)

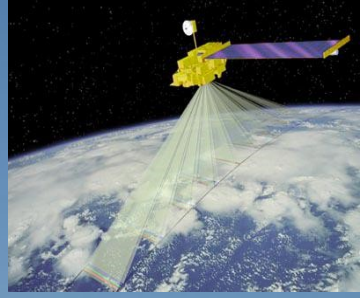
- Surface area : 27,200 km2
- Volume : 1580 km3
- Maximum depth : 614 m
- Mean depth : 41 m
- Lat., Lon. : 61.6 °N, 114.0°W

Great **B**ear **L**ake (GBL)

- Surface area : 31,153 km2
- Volume : 2240 km3
- Maximum depth : 413 m
- Mean depth : 72 m
- Lat., Lon. : 65.8 °N, 120.8°W



Moderate Resolution **I**maging **S**pectroradiometer

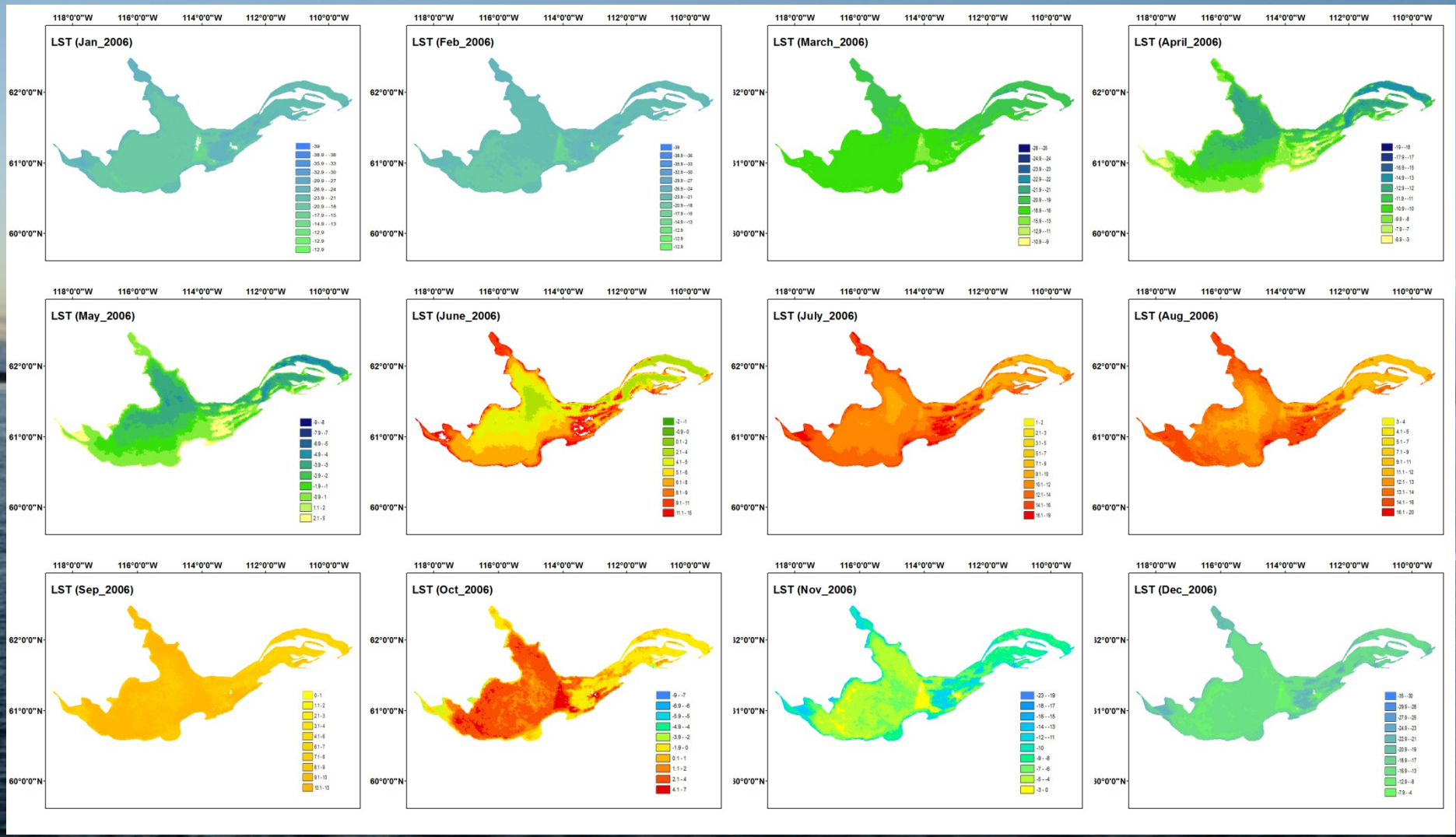


- Daily MODIS Terra and Aqua products (Level 3, 1 km2 resolution, Version 5) day and night time.

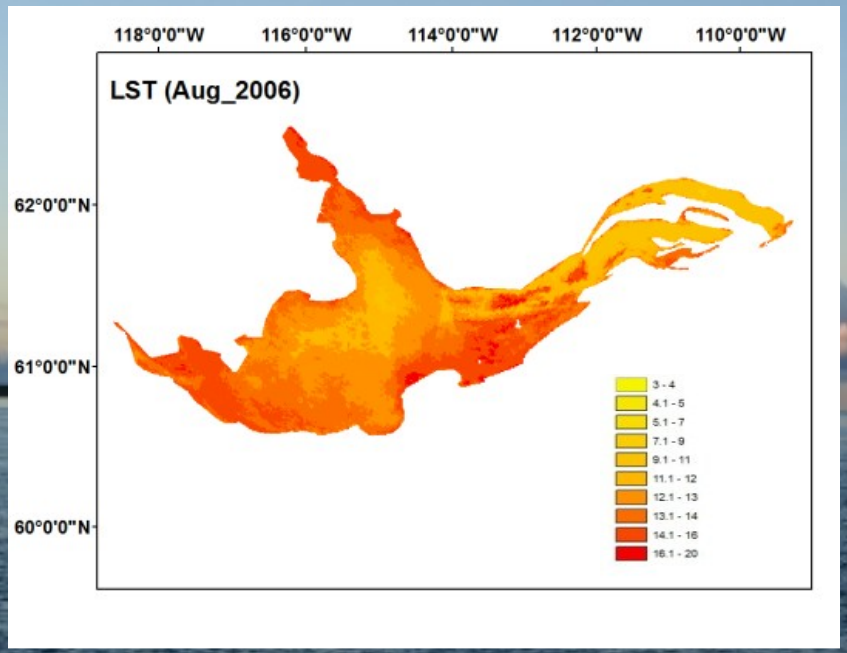
- Data processed using a program written in Matlab to average Terra, Aqua, day, and night LST products.

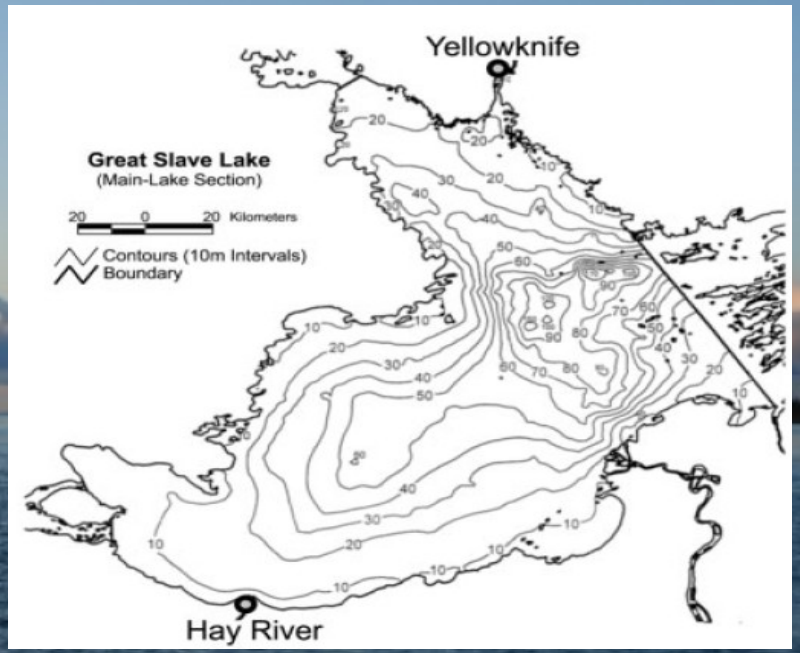
- Pixels extracted over lakes at different depths using ENVI software (different locations over lakes with different mixed layer depths).

Spatial & Temporal LST Variations (MODIS, 2006)



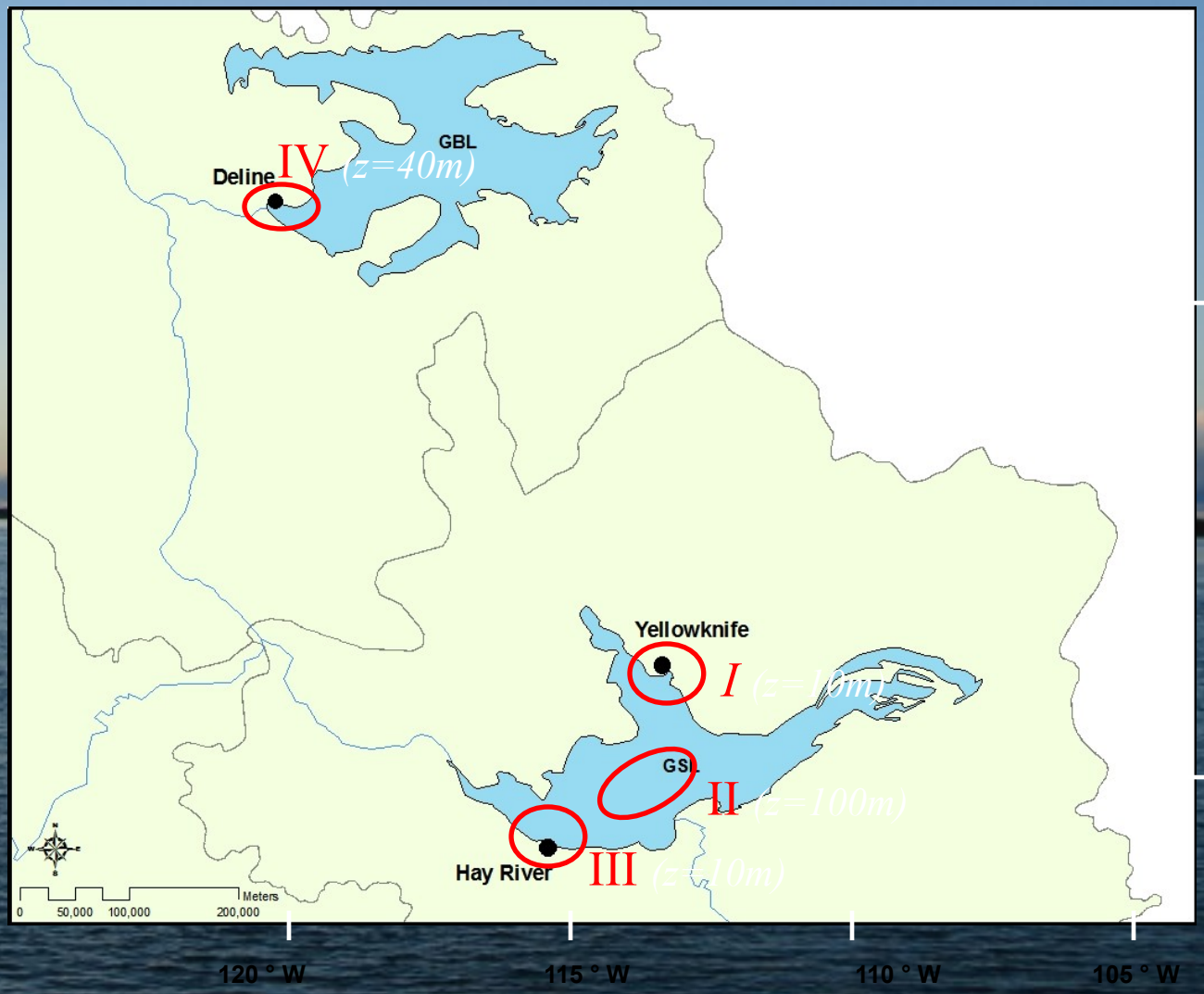
Spatial & Temporal LST Variations in 2006
MODIS





Ménard *et al.*, 2002

Study Sites


GBL
Deline
IV (z=40m)
Yellowknife
I (z=10m)
GSL
II (z=100m)
Hay River
III (z=10m)
Meters
0
50,000
100,000
200,000
66 ° N
62 ° N
120 ° W
115 ° W
110 ° W
105 ° W

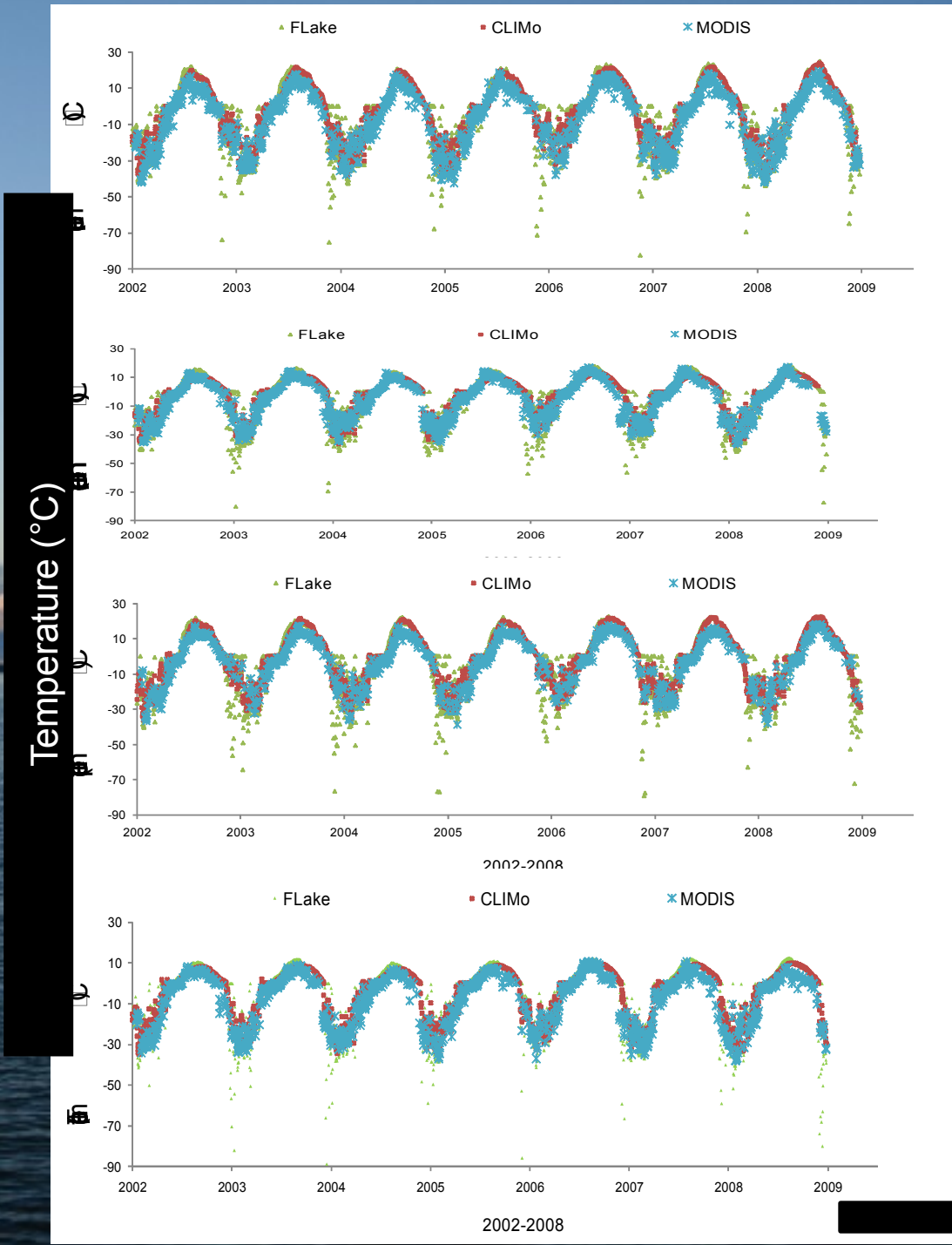
Results

GSL-Back Bay

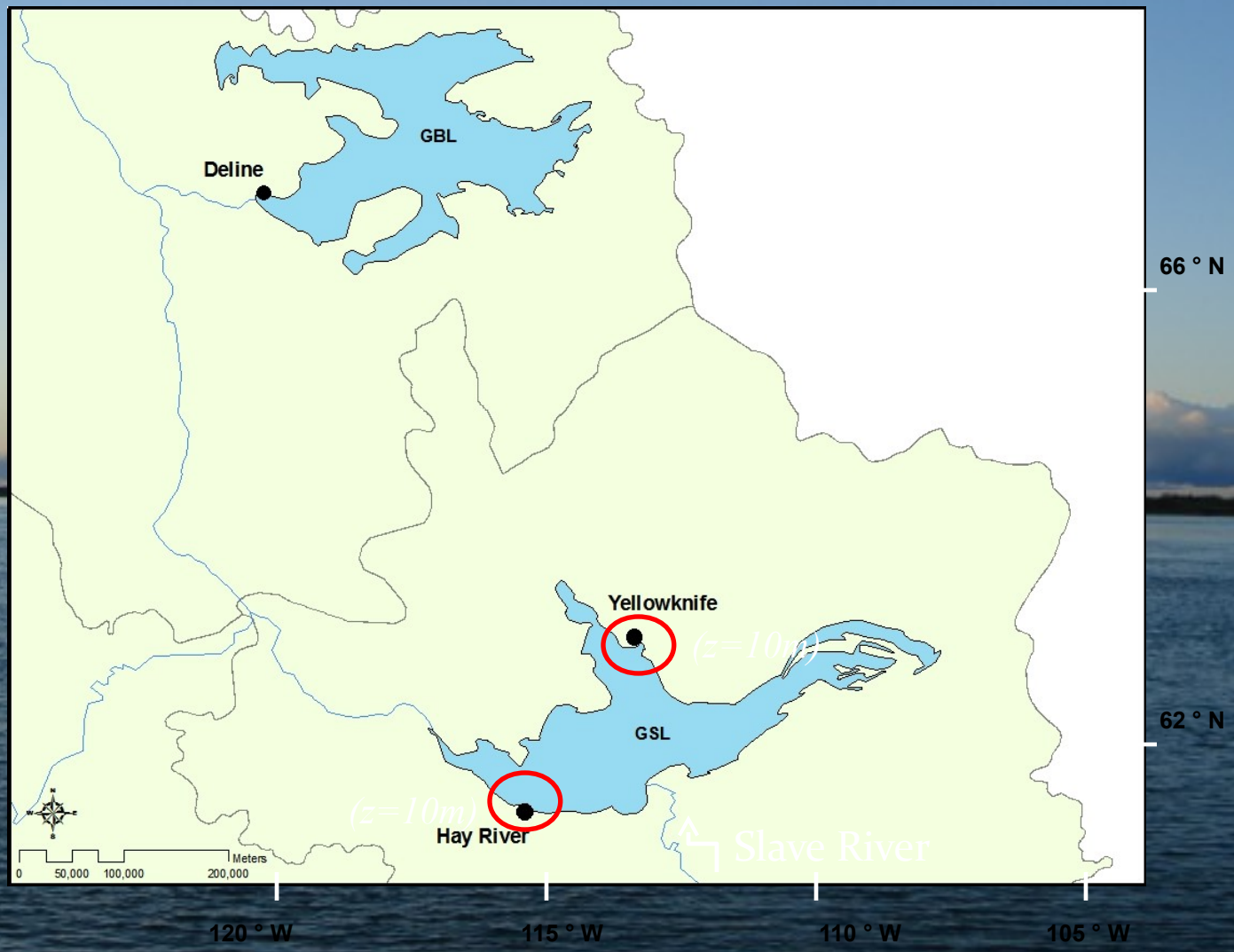
GSL-Main Basin

GSL-Hay River

GBL-Deline



Study Sites - GSL

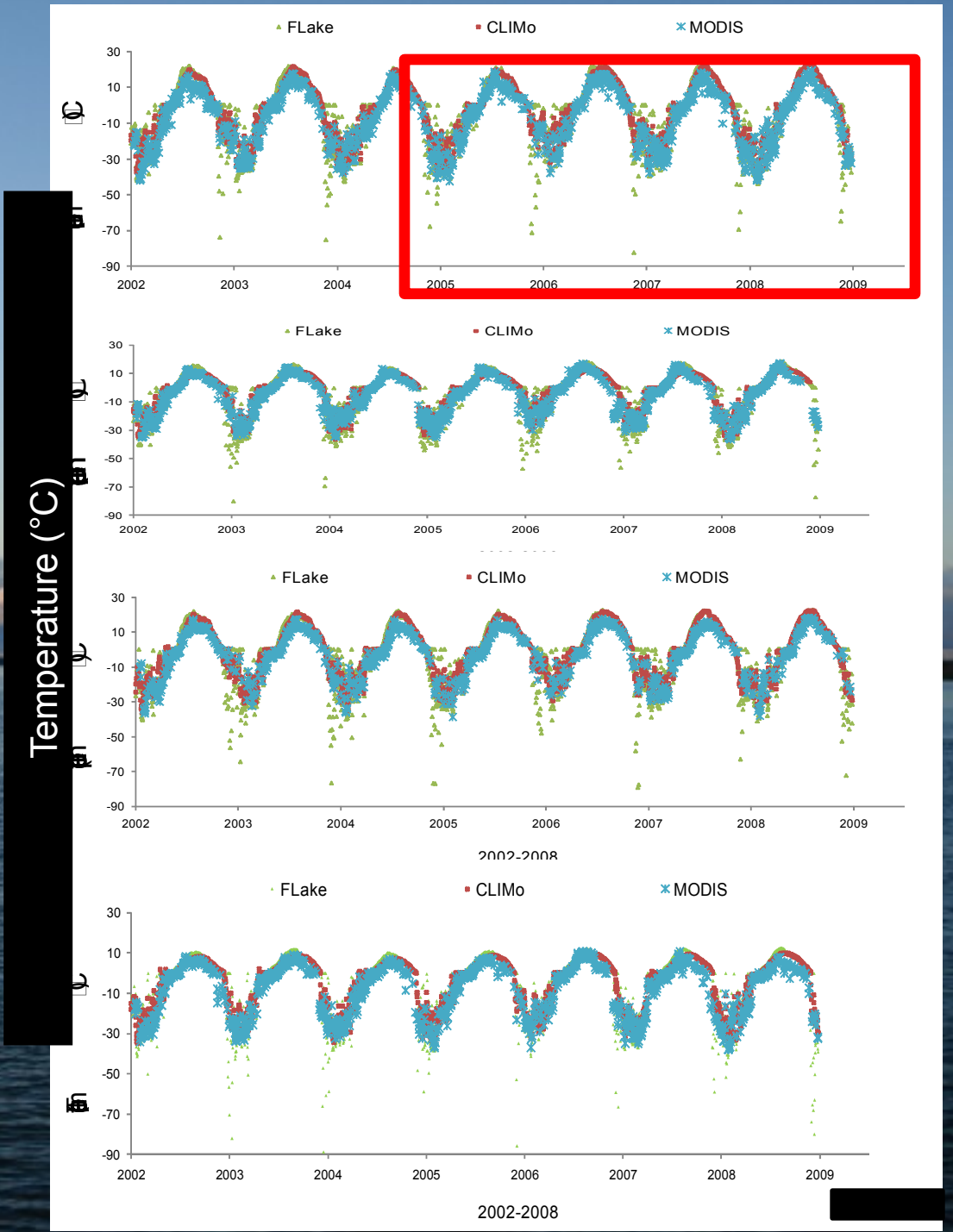


GSL-Back Bay

GSL-Main Basin

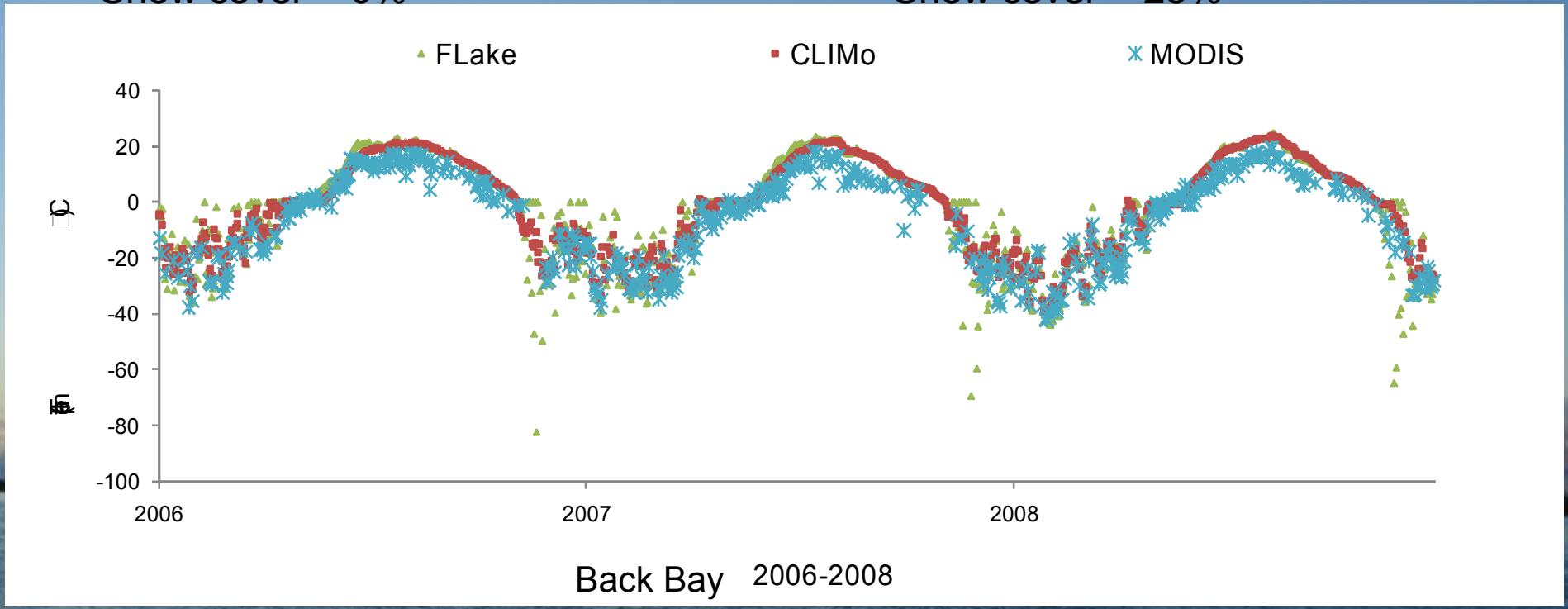
GSL-Hay River

GBL-Deline

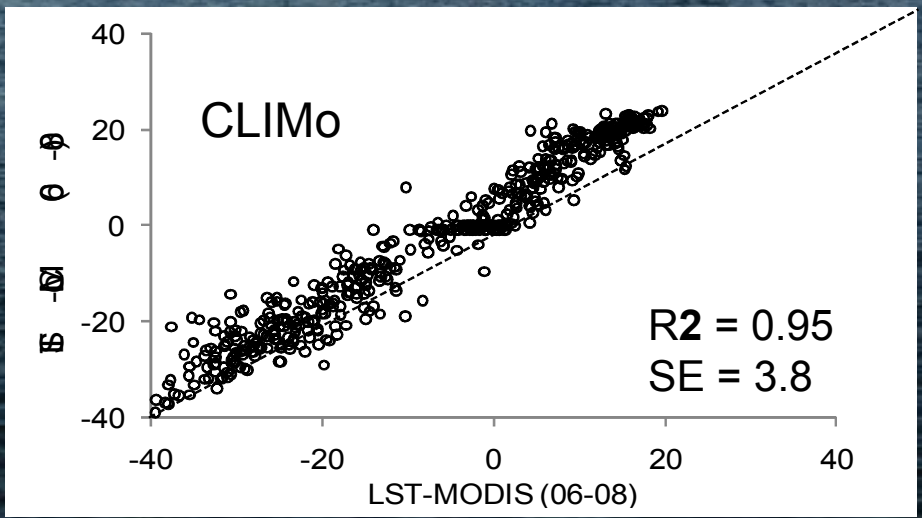


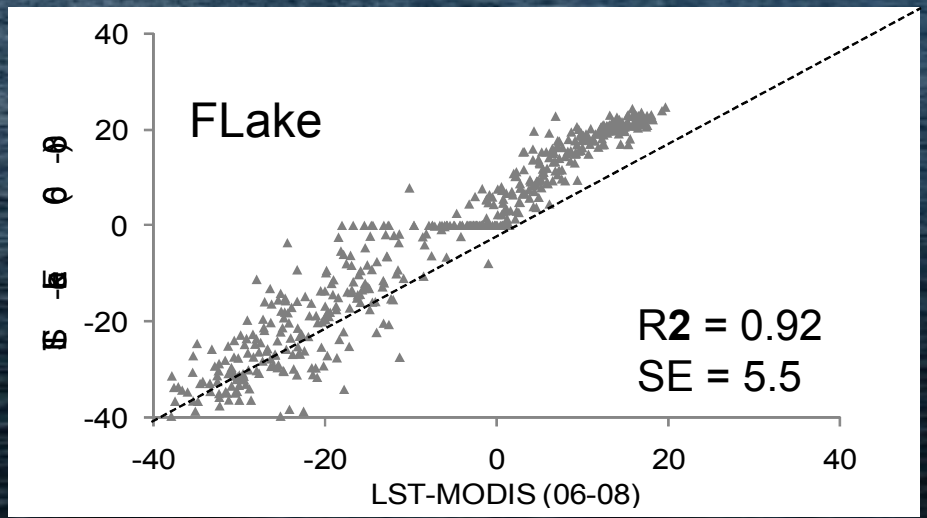
FLake:
Fixed mixed layer depth = 10m
Snow cover = 0%

CLIMo:
Initial mixed layer depth = 10m
Snow cover = 25%



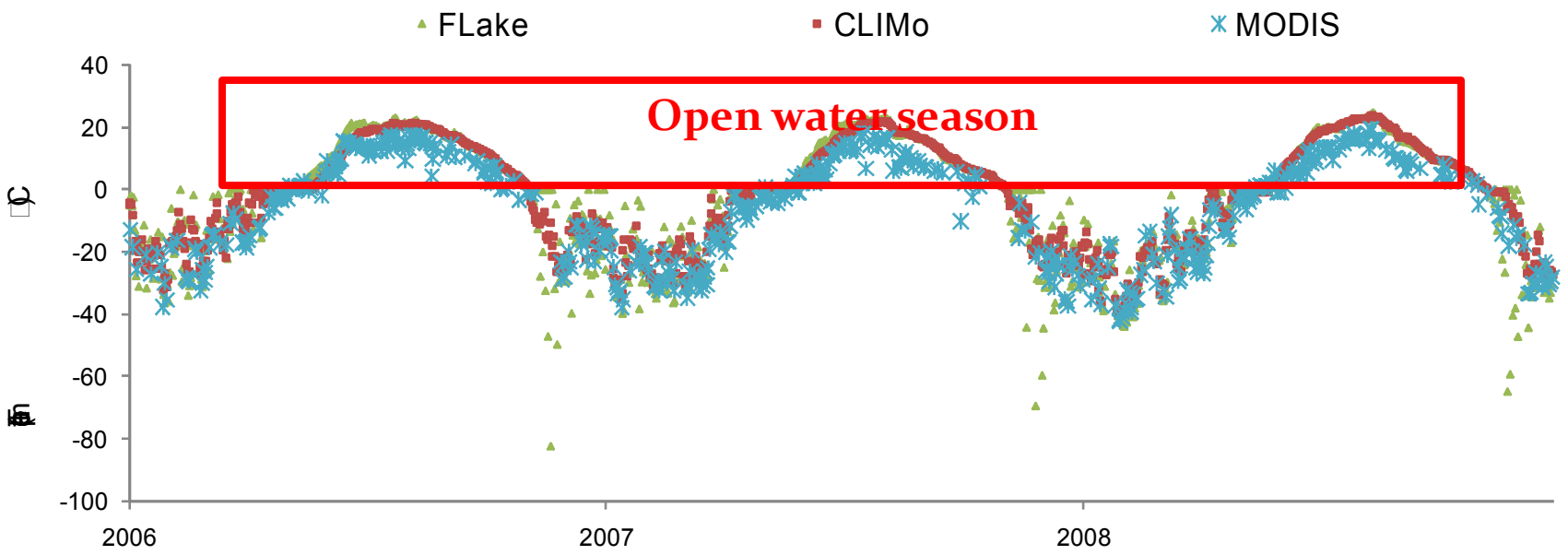
Back Bay 2006-2008





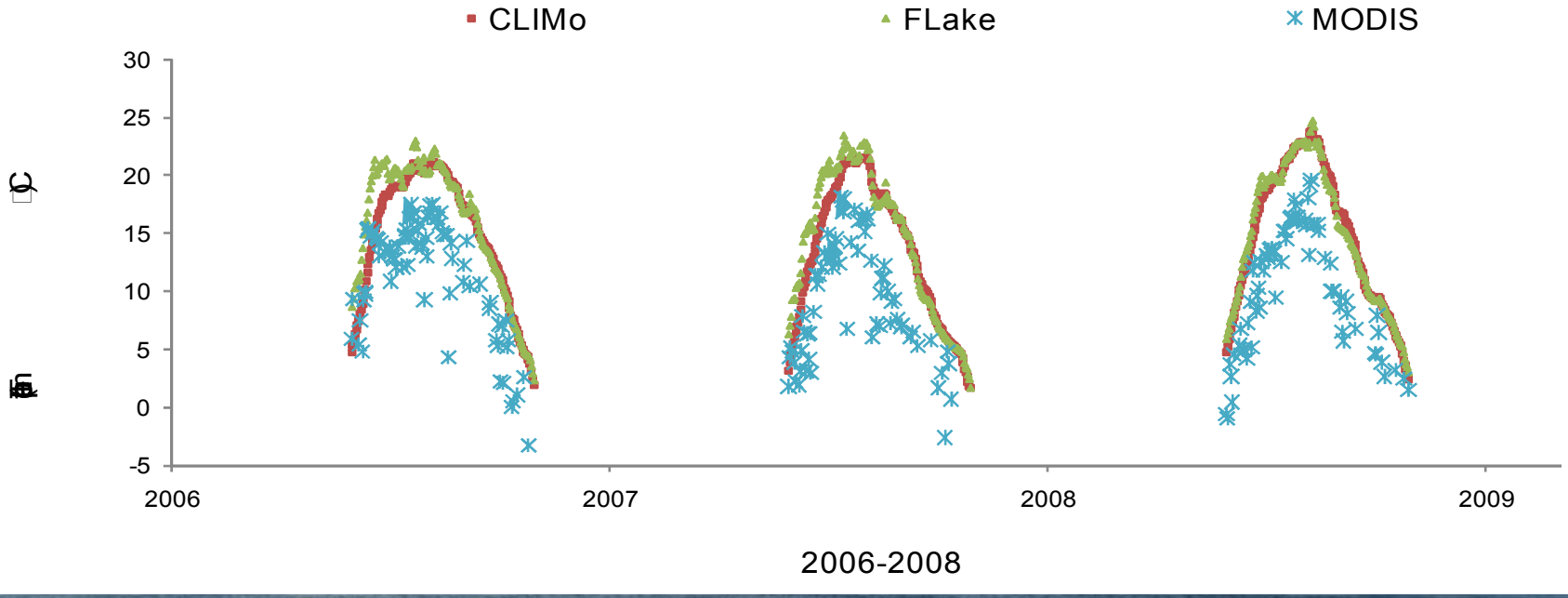
FLake:
Mixed layer depth = 10m
Snow cover = 0%

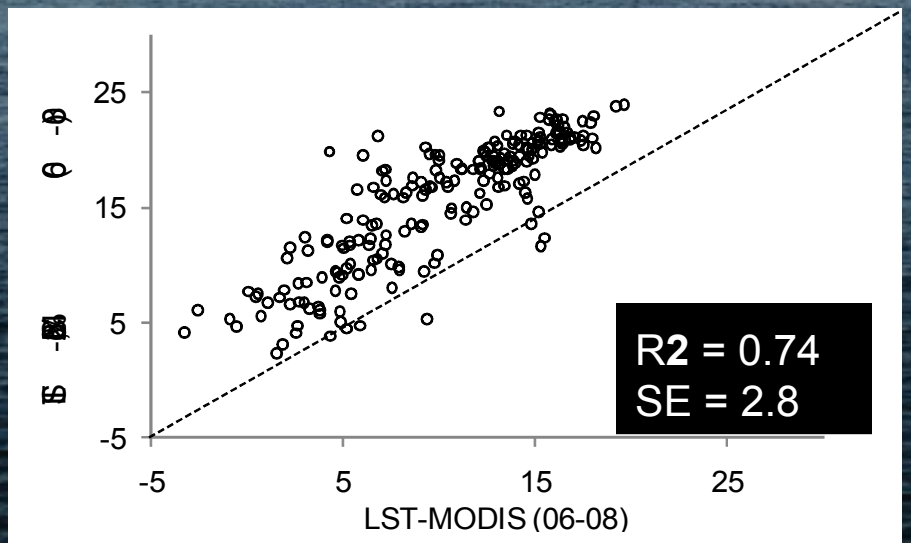
CLIMo:
Mixed layer depth = 10m
Snow cover = 25%

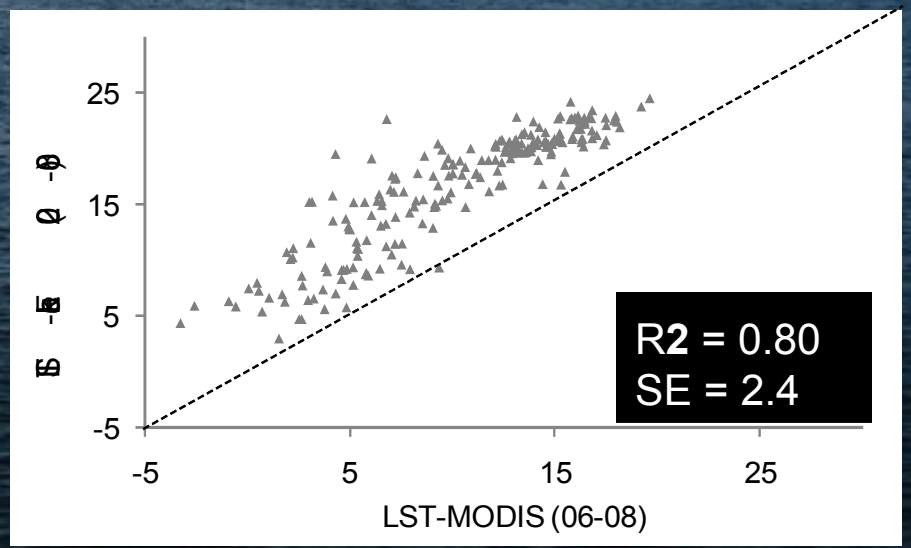


Back Bay 2006-2008

Open Water Season

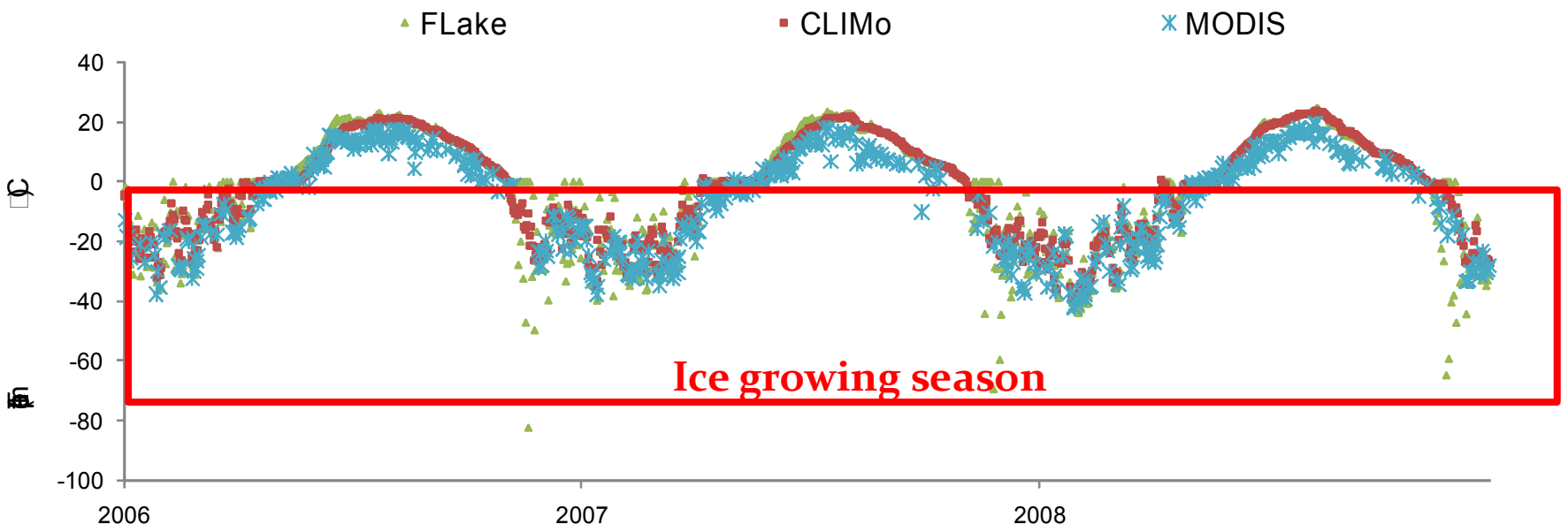






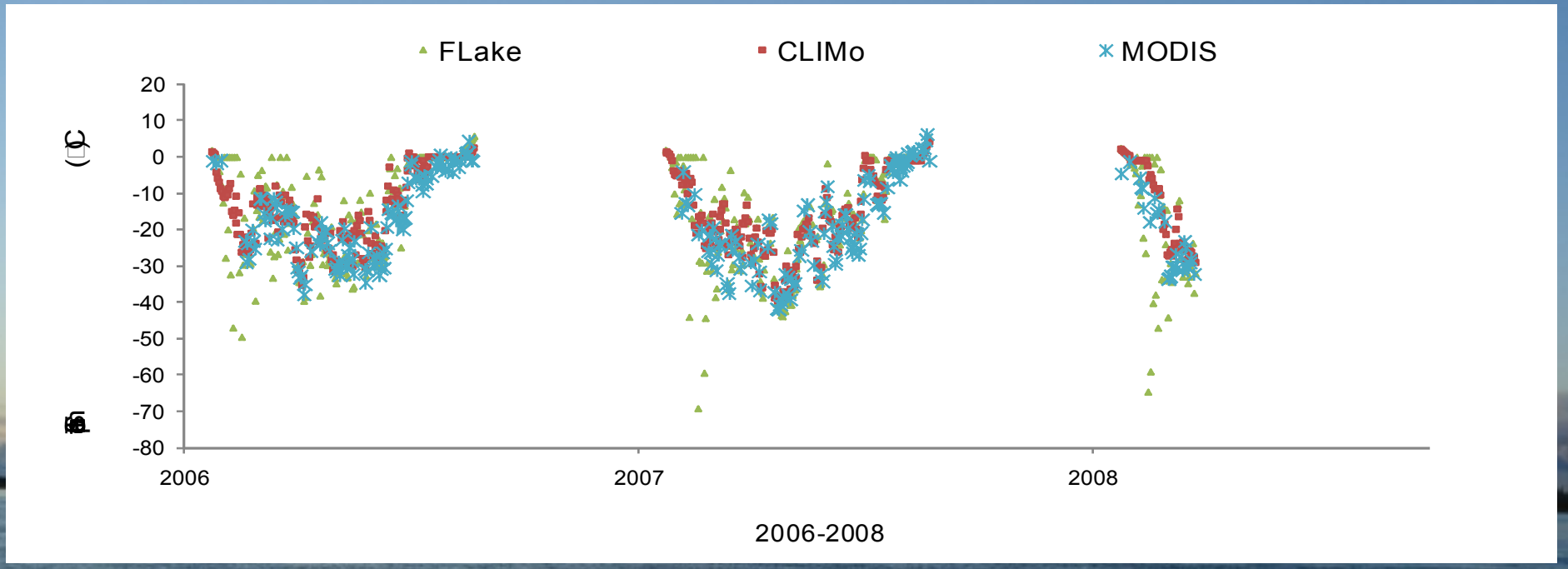
FLake:
Mixed layer depth = 10m
Snow cover = 0%

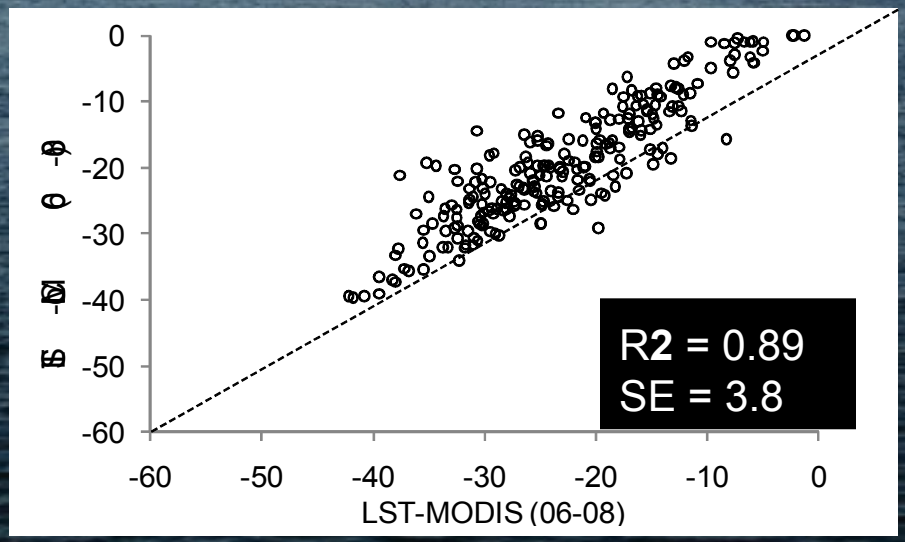
CLIMo:
Mixed layer depth = 10m
Snow cover = 25%

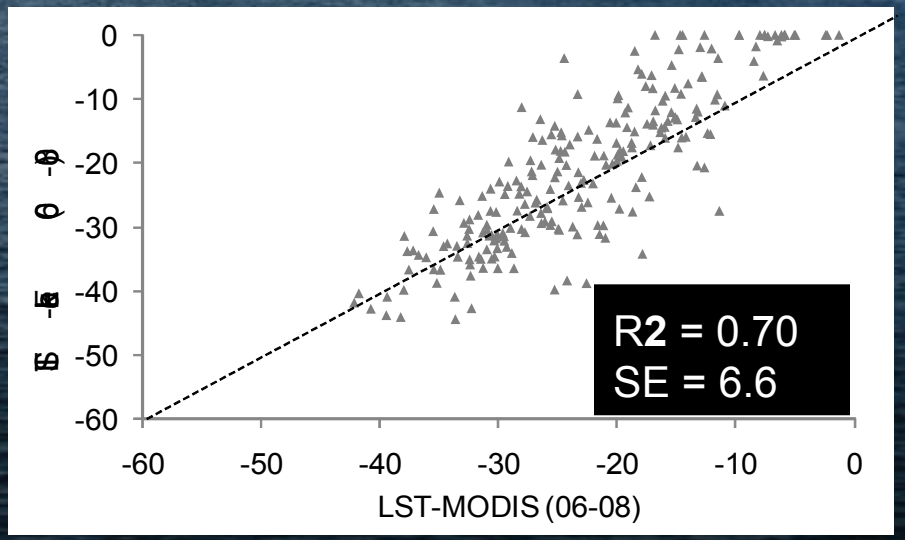


Back Bay 2006-2008

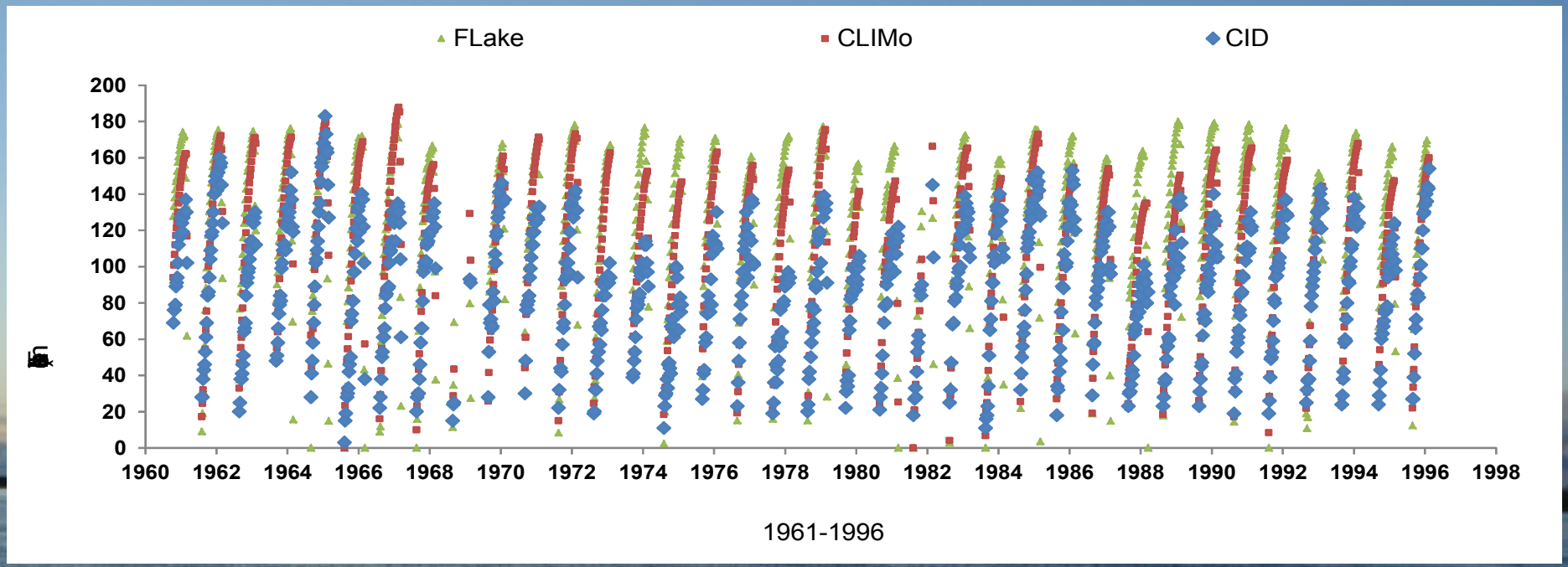
Ice Growth Season

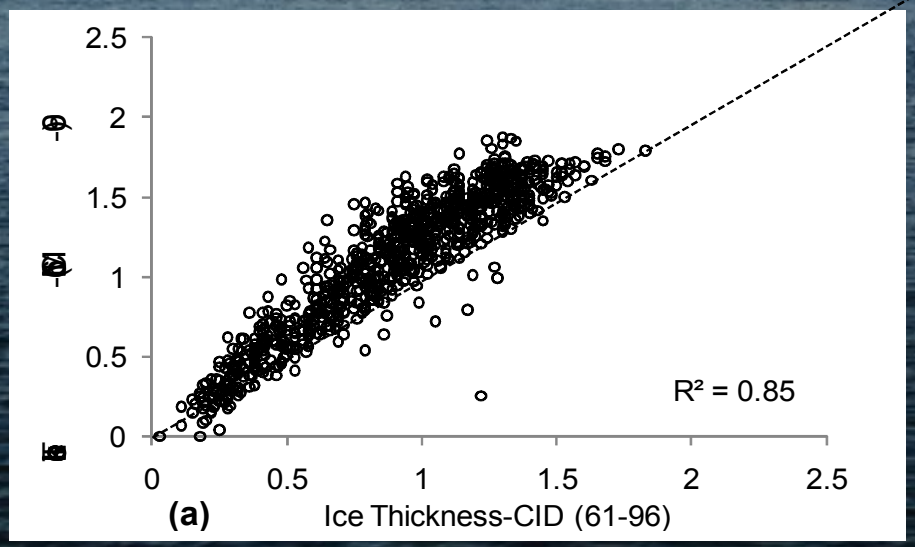


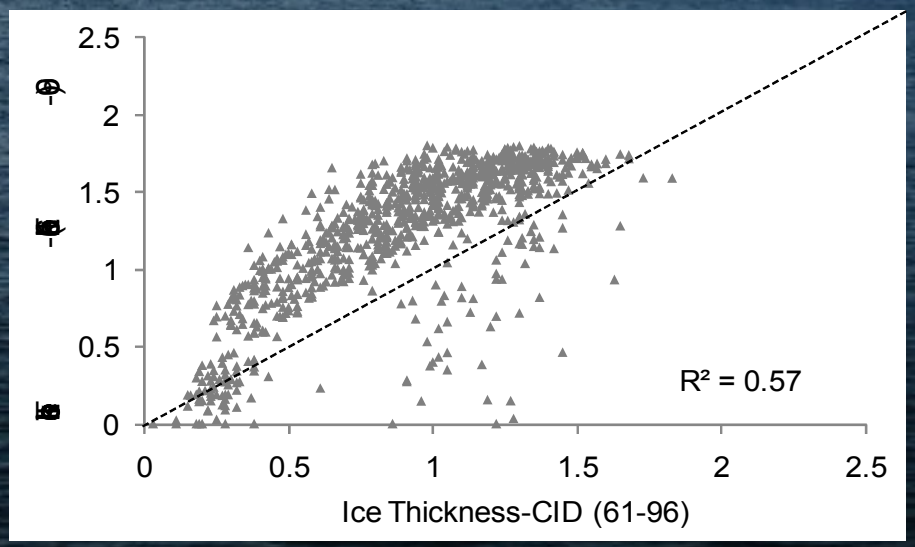




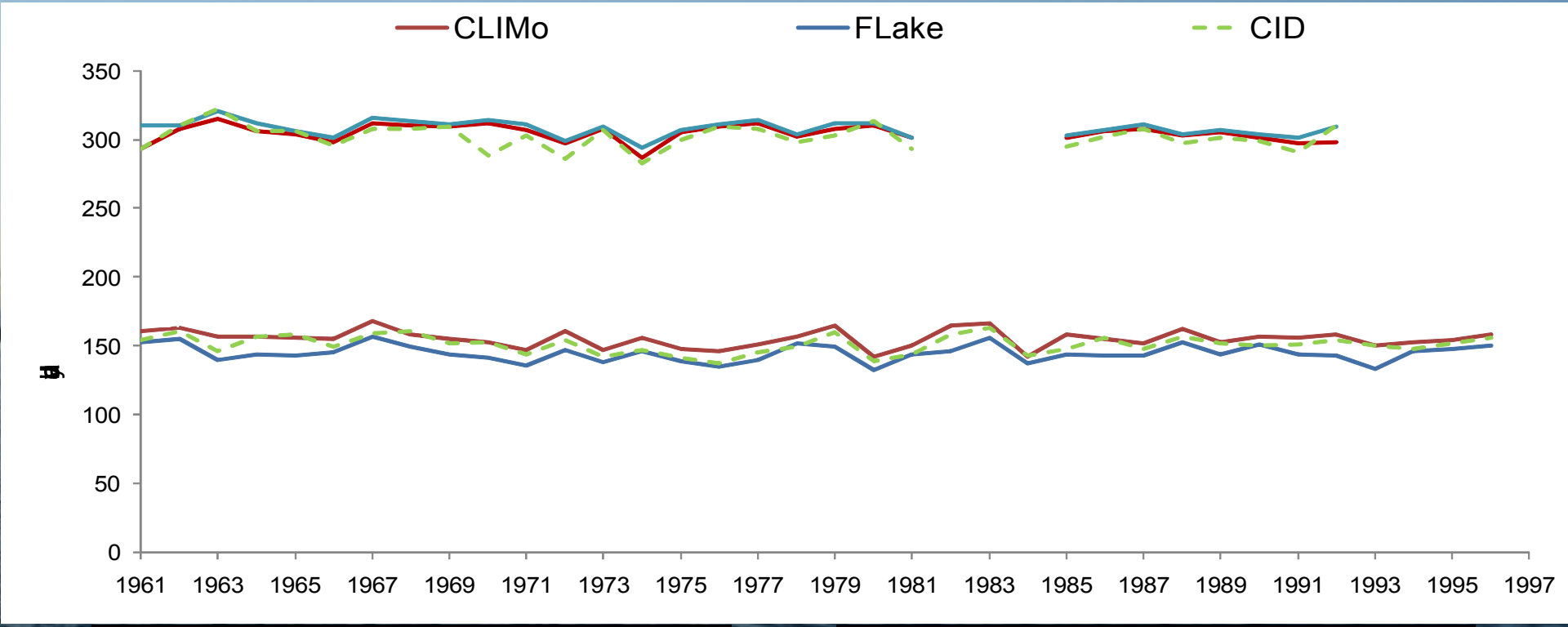
Ice Thickness







Freeze up/Break up



Freeze up	CLIMO	FLake
Ia	0.99	0.99
MBE (days)	2	5

Break up	CLIMO	FLake
Ia	0.83	0.71
MBE (days)	4	-6

Conclusion

- CLIMo demonstrated a generally better performance than the FLake model in the case of GSL and GBL.
- CLIMo matched better MODIS data during the ice growing season and FLake was better for open water season in all simulations conducted.
- The accumulation of snow on ice can influence the growth and thaw rates of the ice cover.
- MODIS was useful for evaluating the models and is a promising data source for assimilation into numerical weather forecasting models.


THANKS