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Tuning of *FLake* lake model using observational lake surface water temperature data for lakes worldwide

Introduction…..

Lake surface water temperatures (LSWTs) of 247 globally distributed large lakes were recently derived from Along-Track Scanning Radiometers (ATSR) for the period 1991 to 2010. Lake location and size are shown in figure 1.

The mean LSWT climatology derived from these data have previously been shown to quantify on a global scale the responses of large lakes' surface temperatures to the annual cycle of forcing by solar radiation and to air temperature extremes.

Current research utilizes observed LSWT time series (1991 to 2010) data for lakes with a mean annual freezing cycle to tune *FLake* lake model for optimal LSWT prediction. Initial trial work on 21 lakes indicate that an optimum combination of variations of 3 *FLake* model parameter values improve *FLake* LSWT prediction capabilities for the modelled lakes.

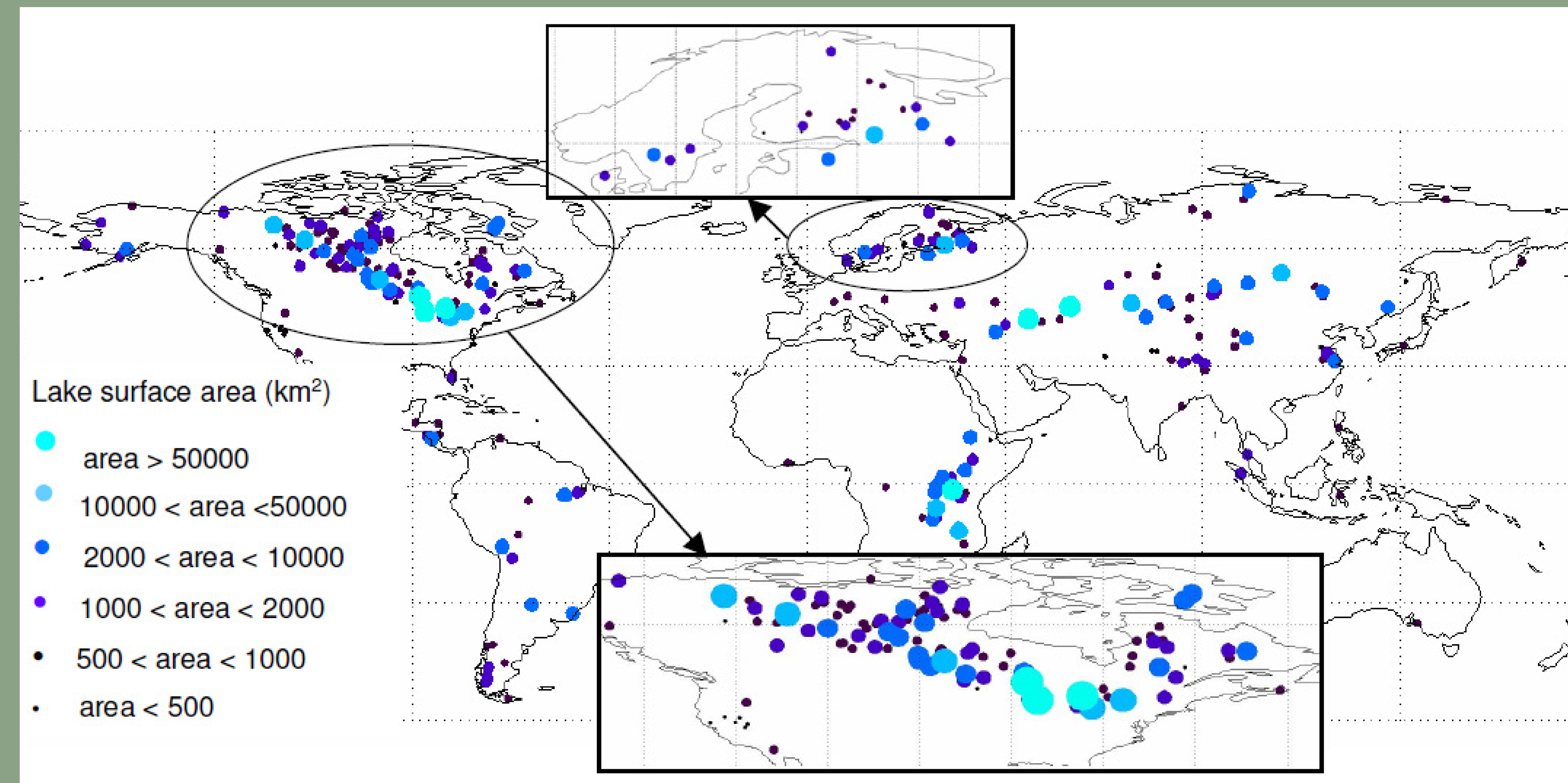

Figure 1 Location and lake size of lakes with available climatology and time series data (n=247). Data products freely available; http://www.geos.ed.ac.uk/arclake/data.html

Observed vs modelled LSWT; Tuning *FLake* model

FLake is a freshwater lake model capable of predicting the vertical temperature structure and mixing conditions in lakes. LSWTs of 21 Eurasian and North American lakes with mean depths (Z_D) ranging from 4 -138m and light extinction coefficient (ĸ) ranging from 0.06-5.31 were modelled using *FLake* and compared with observed LSWTs. Results showed that *FLake* almost consistently over-estimates the maximum LSWT and underestimates the lake ice cover period (later ice-on and earlier ice-off), figure 2a.

Tuning the model using an optimum combination of only 3 *FLake* lake model parameter values can substantially improve the LSWT output i.e., lengthen the ice cover period and reduce maximum LSWT for these 21 lakes. A typical example is shown in figure 2b. Table 1 outlines the 3 *FLake* model parameter and their values.

Model parameter	Parameter value			Effect on LSWT
Snow and ice albedo (α)	Parameter value code	Snow & white ice	melting snow & blue ice	higher α yields later ice–off dates
	α1	0.60	0.10	α1 = default *FLake* α setting
	α2	0.80	0.60	
	α3	0.60	0.40	
	α4	0.80	0.30	
Mean lake depth (Z_D)	Z_D1	lake specific Z_D,		lower Z_D yields earlier ice–on dates
	Z_D2	Z_D*0.75		
	Z_D3	Z_D*0.50		
Light extinction coefficient (κ)	κ1	lake specific κ,		lower κ reduces the maximum LSWT
	κ2	κ*0.5		
	κ3	κ (two wavelengths bands)		

Table 1 *FLake* tuning parameters, values and their general effect on LSWT. Initial model conditions (before tuning) marked with a blue background

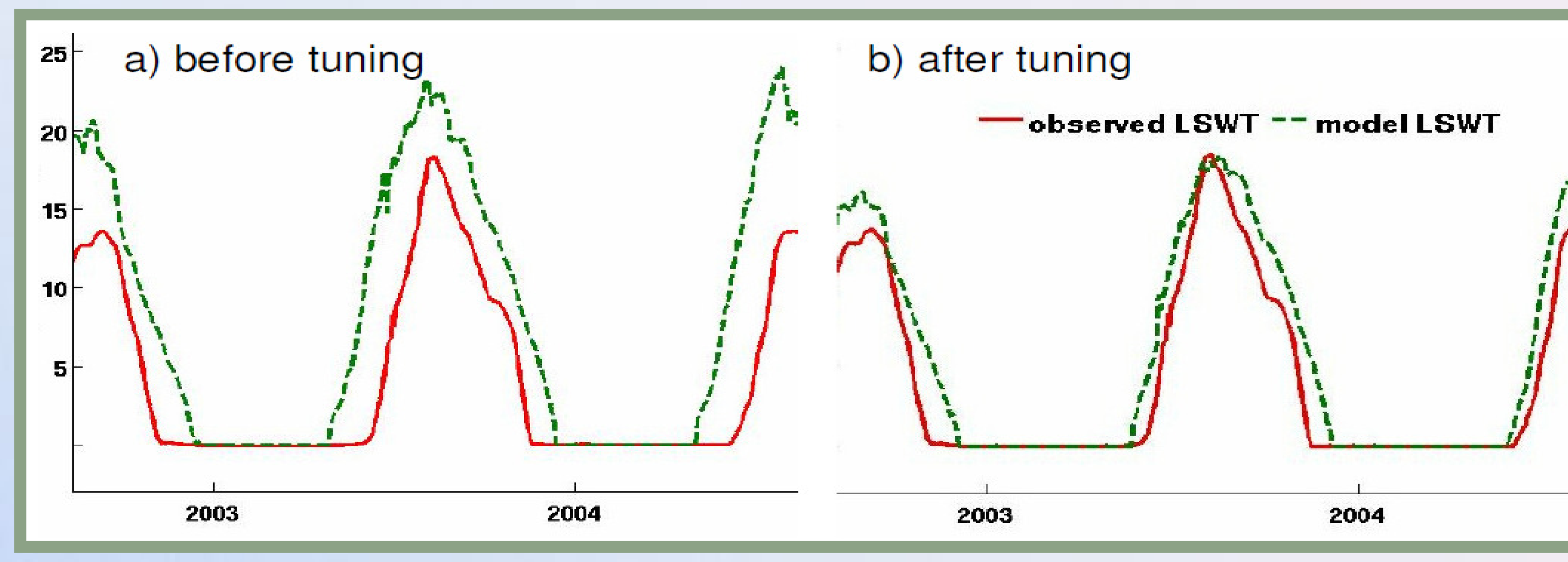

Figure 2 Time series section of observed vs *FLake* lake model data for Lake Athabsaca;
a) before model tuning (using default albedo *α1* and lake specific mean depth (*Z_D1)* and light extinction coefficient (*ĸ1*) b) after tuning

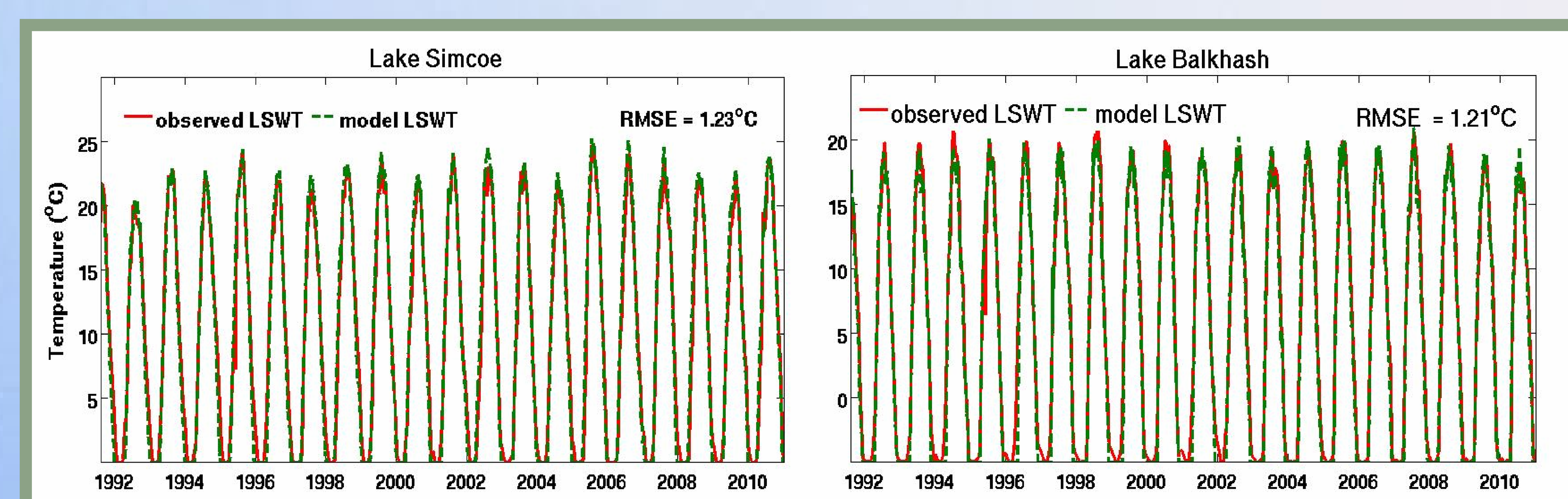

Figure 3 An example of observed vs *FLake* lake model (tuned) time series data; a) Lake Simcoe, Canada b) Lake Balkhash, Russia

Trial outcome

1) RMSE and average daily difference; model vs observed data

	average RMSE	average daily difference (absolute)
Before tuning	2.59	2.67
After tuning	1.74	1.36

2) Optimal LSWT combinations
include the highest values for snow and ice albedo (α2) for all 21 lakes
include two wavelength bands for light extinction coefficient (ĸ3) for 15 of the 21 lakes

Further work

Repeat trial work using albedo values centred about *α2* and a three wavelength band for *ĸ*.
Apply same approach to all observed lakes with lake mean seasonal ice cover (n= ~150).

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