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Surface temperature model errors in off-line ice simulations under SBL conditions

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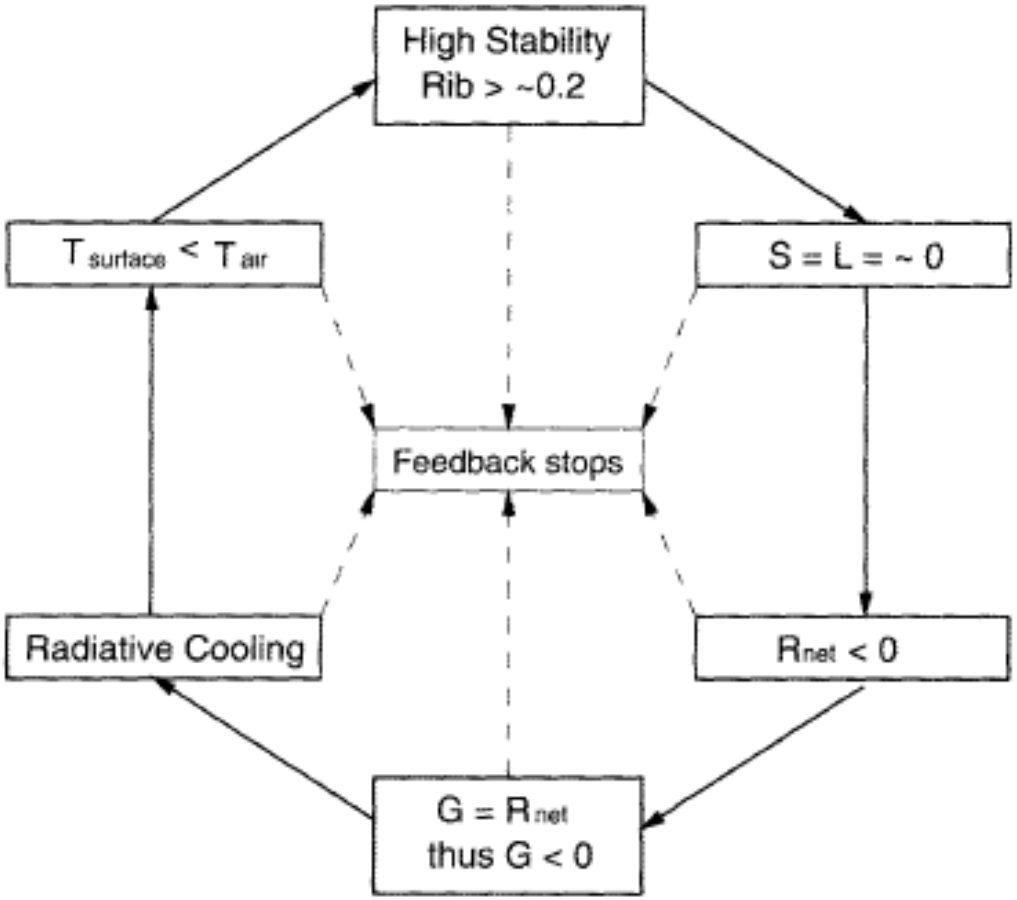
Introduction

Scheme of decoupling



Role of each model block?

Slater, A., Schlosser C., Desborough C., Pitman, A., Henderson-Sellers, A. and co-authors. 2001. The Representation of Snow Land-Surface Schemes: Results from PILPS 2(d). *J. Hydrometeorol.* **2**, 7-25

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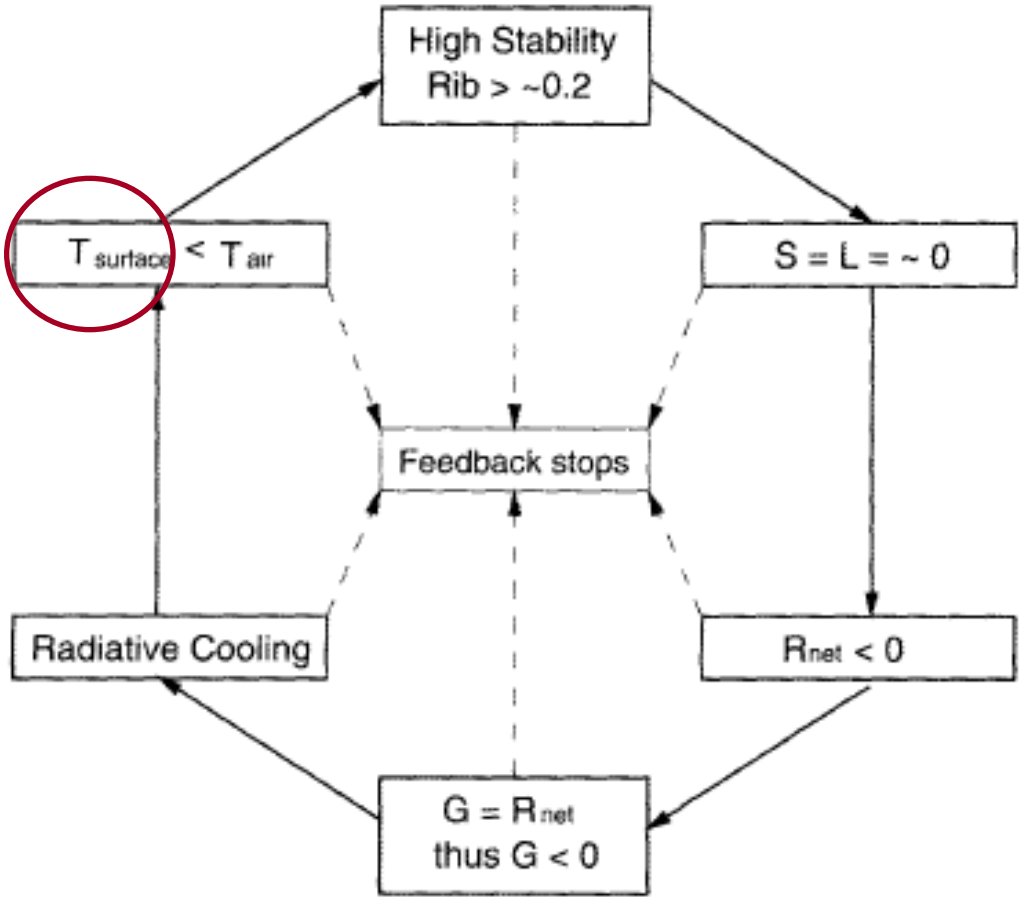

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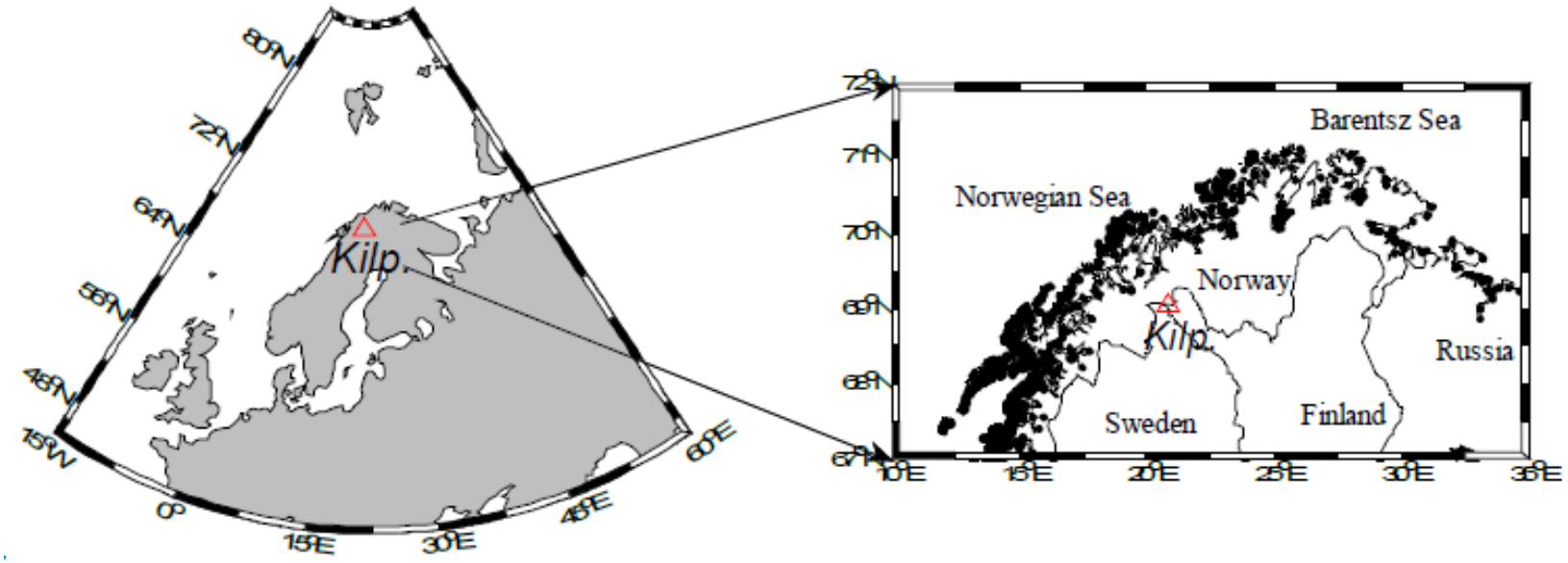
Introduction

Main objective:

Lake ice model intercomparison and verification against observations over Lake Kilpisjärvi

"By-product": analysis of surface temperature errors.

Observational campaign



Observational campaign

Winter 2007-2008

Ice and snow thicknesses : Kilpisjärvi Biological Station (KBS):
every 10 m along a 100 m section in the near-shore zone, averaged; 10-day intervals

Surface radiative temperature: automatic ice station *Lotus* (a floating raft) with an infrared thermosensor (THI-303N, Tasco Ltd., Japan S/N: T508019);
the accuracy is 0.3° *C*;
every twenty minutes and averaged to one-hour intervals.

SYNOP measurements: Enontekiö Kilpisjärvi Kyläkeskus station

Numerical Ice Models (offline mode)

HIGHTSI (Launiainen and Cheng 1998; Cheng *et al.* 2003, 2008)

solves numerically the heat conductivity equation in snow and ice;

implicit numerical solution for the surface heat balance equation (iterations to predict the surface temperature);

vertical resolution: stretched grid, 10 layers in snow and 20 layers in ice;

snow packing, etc.;

turbulent and radiative fluxes from the atmosphere are parameterised.

Atmospheric forcing: HIRLAM, local measurements

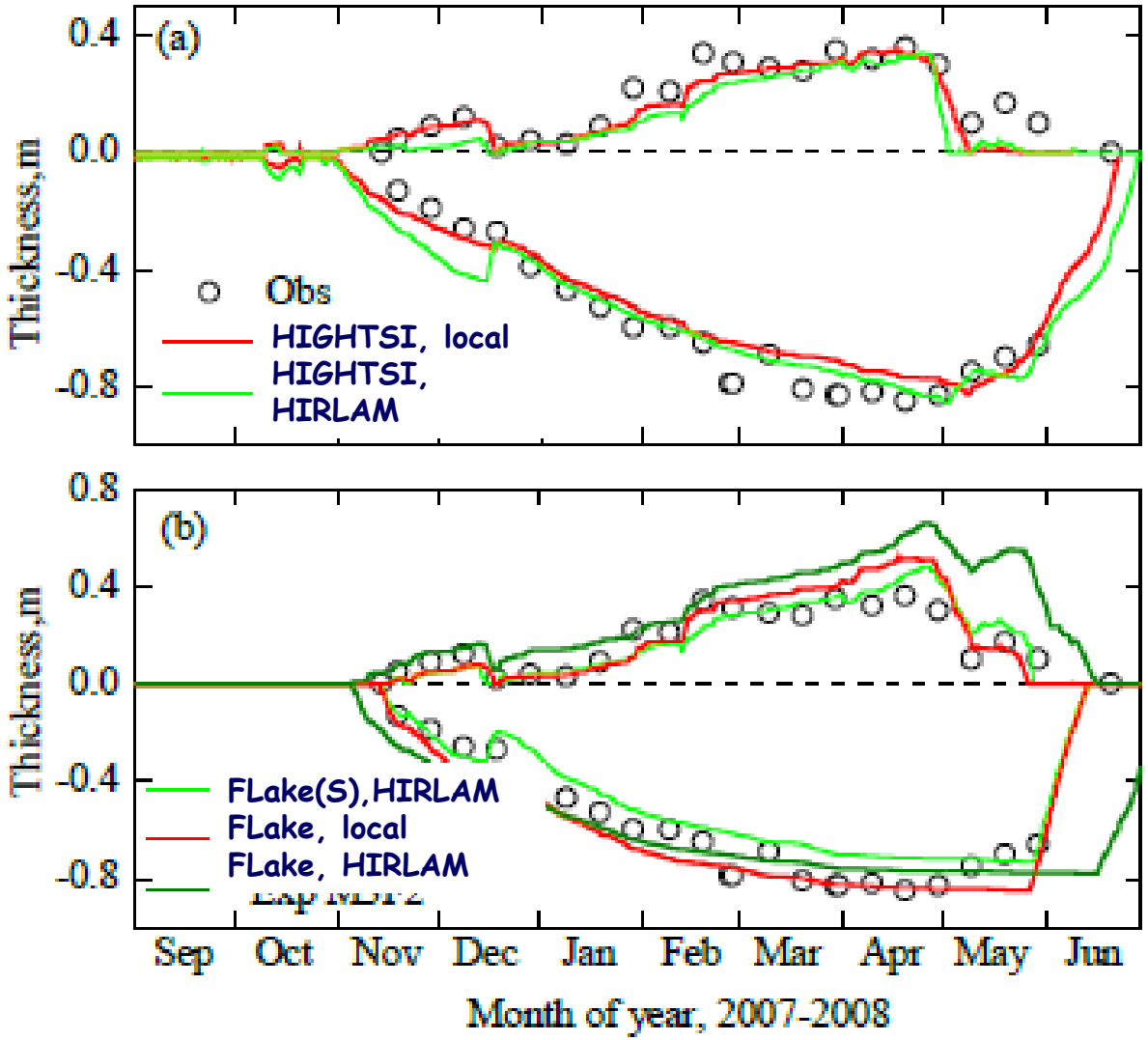
Numerical Ice Models (offline mode)

FLake (Mironov 2008; Mironov *et al.* 2010)

lake model with ice and snow blocks
self-similarity concept with parametric representation of temperature profiles: linear profiles in ice and snow;
explicit numerical solution;
turbulent and radiative fluxes from the atmosphere are parameterised (for radiative – from HIGHTSI)

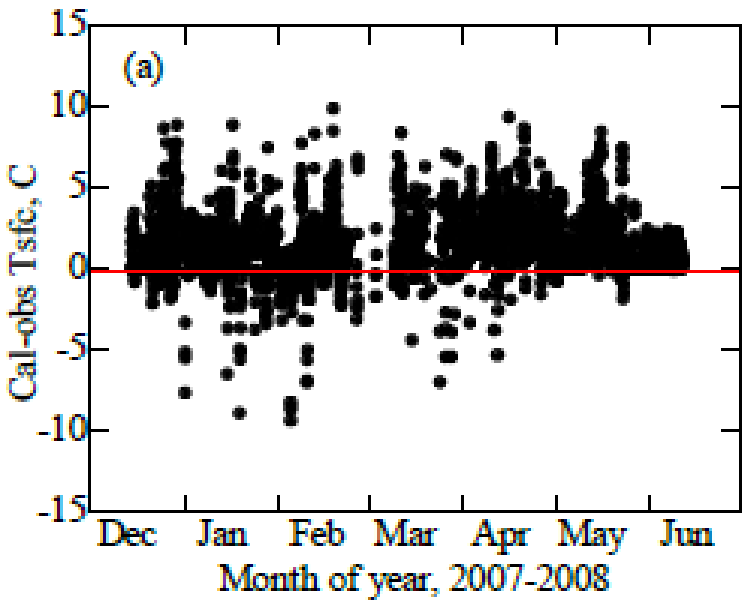
Atmospheric forcing: local measurements

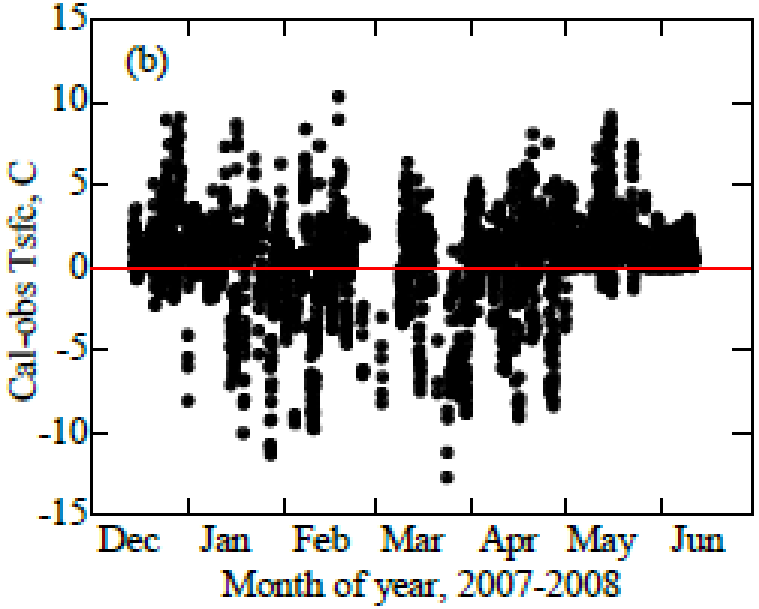
Results: ice and snow



Results: surface temperature.

Expectation: HIGHTSI should reproduce it much better than FLake. But ...



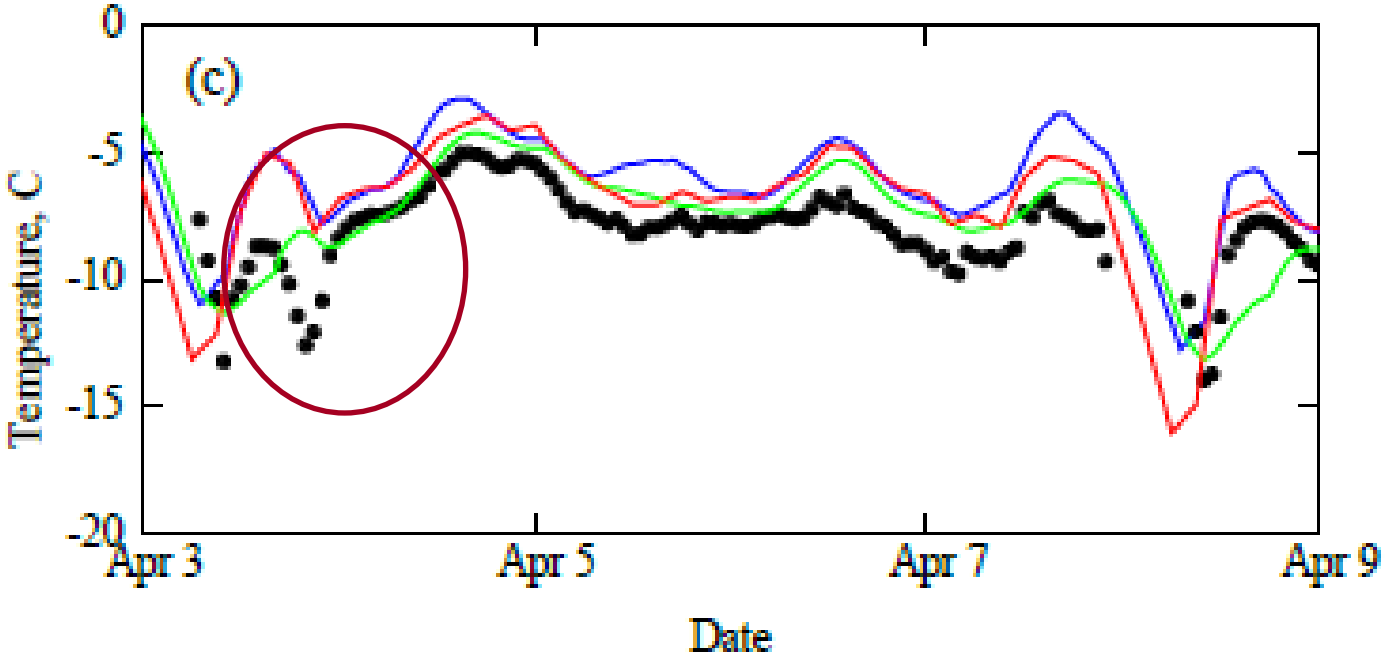


HIGHTSI: bias 1.3
RMSE 1.9

FLake: bias 0.3
RMSE 2.2

Results: surface temperature.

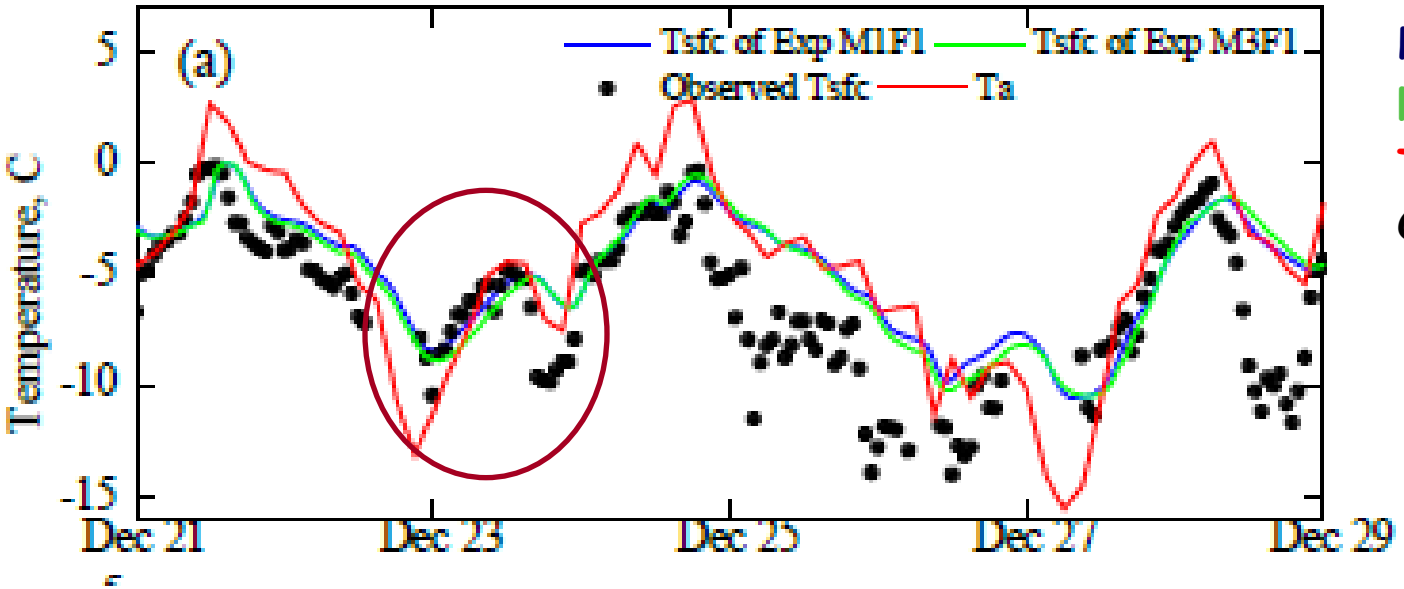
Case I: Rapid cooling, slow warming
HIGHTSI and FLake can't reproduce cooling (too slow) but reproduce warming
Tmin is too warm, Tmax is reproduces well



HIGHTSI
FLake
T air
Obs

Results: surface temperature.

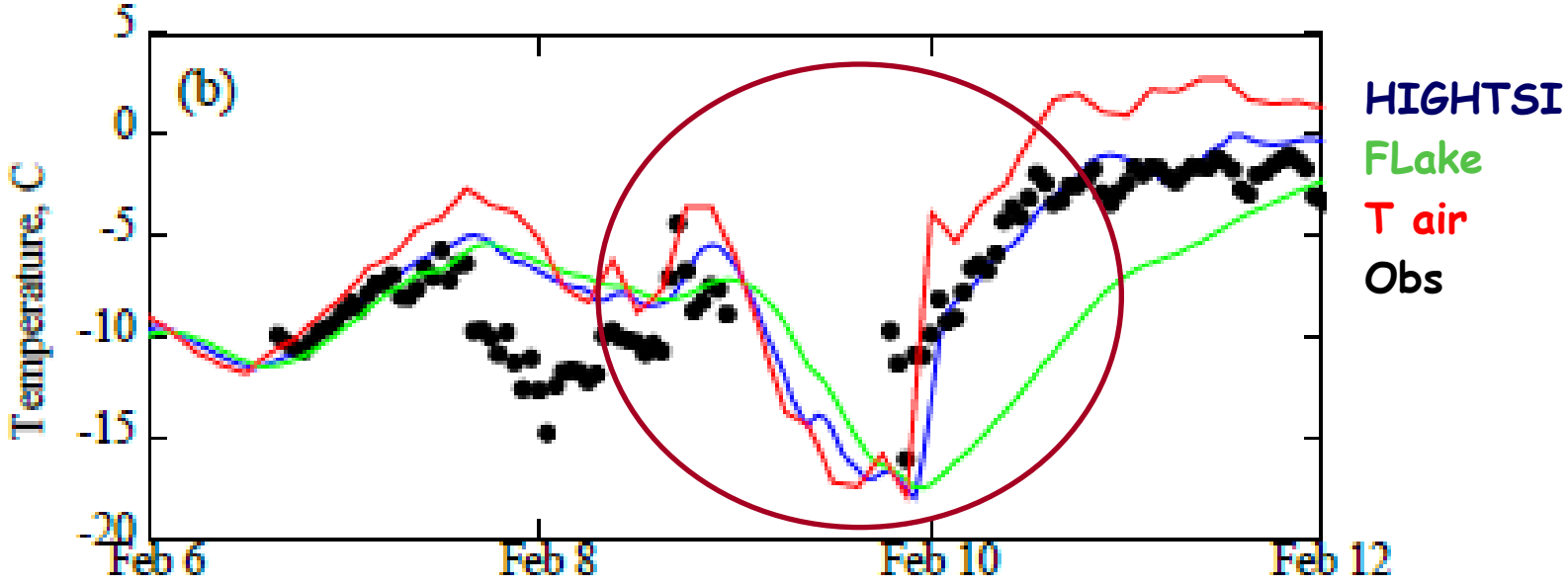
Case II: Rapid cooling, rapid warming
HIGHTSI and FLake can't reproduce both (too slow)
Tmin is too warm, Tmax is too cold



HIGHTSI
FLake
T air
Obs

Results: surface temperature.

Case III: Rapid cooling, quite fast warming
HIGHTSI and FLake can't reproduce cooling (too slow)
HIGHTSI can reproduce warming, FLake not
Tmin is too warm, Tmax is too cold



Conclusions

From 3 types of situations:
mainly warm bias for HIGHTSI, both warm and cold bias for FLake;
warm bias is higher in HIGHTSI, but RMSE is higher in FLake;

Both models have too much thermal inertia: they can reproduce slow oscillations but can't reproduce fast oscillations

Errors are not only in amplitude, but also in phase.

Reasons: numerical? forcing? More experiments needed!