


Handling of lakes in NWP and surface data assimilation

introduction for the discussion

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contents:

- coupling of lake model with climate model
  * lake model FLake
  * climate model RCA
  * results

- conclusions: ideas for NWP and DA

- project: SMHI and RSHU + DWD
  "Lakes and regional climate"
  support: SI
- purpose: couple climate model RCA of Rossby Center (SMHI) and lake model FLake
- Lake model acts as a PARAMETERISATION of lakes in atmospheric model

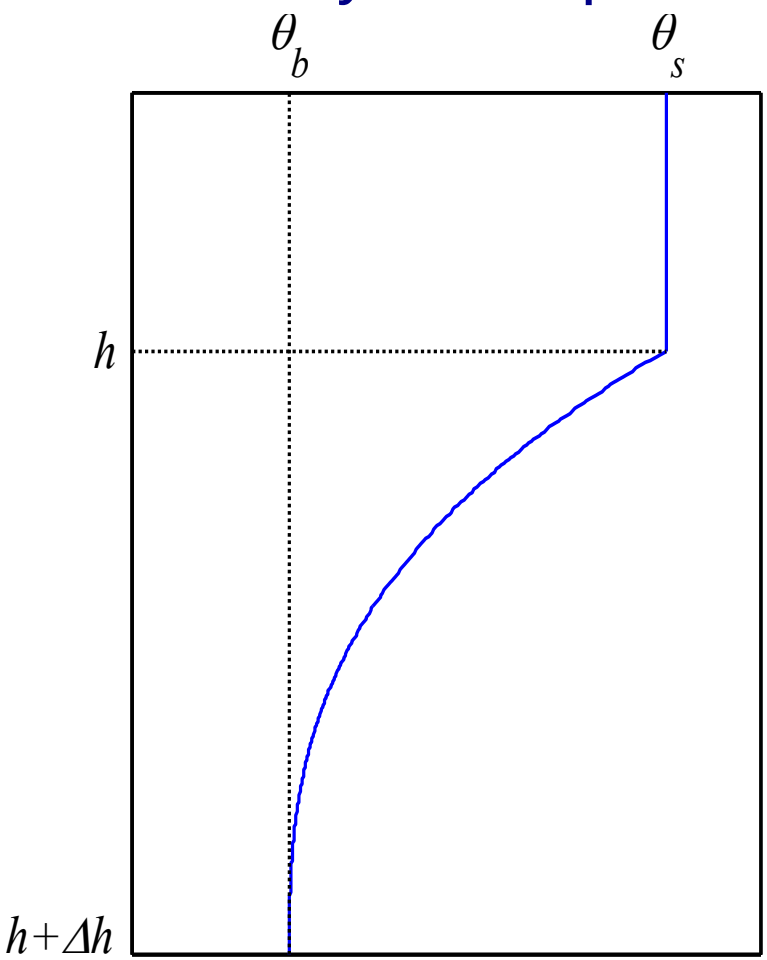
To act as a PARAMETERISATION lake model should be:

- computationally cheap
- incorporate most of essential physics
- do not need tuning for the specific lake
- need minimum of specific lake parameters

Lake model FLake

developed by D. Mironov

FLake: lake model based on two-layer parametric representation of the temperature profile and self-simularity concept



$\theta_s(t)$ – mixed layer temperature

$h(t)$ – mixed layer depth

$\theta_b(t)$, –bottom temperature

$D=h+\Delta h$.

to represent temperature profile shape-function and shape-factor are used

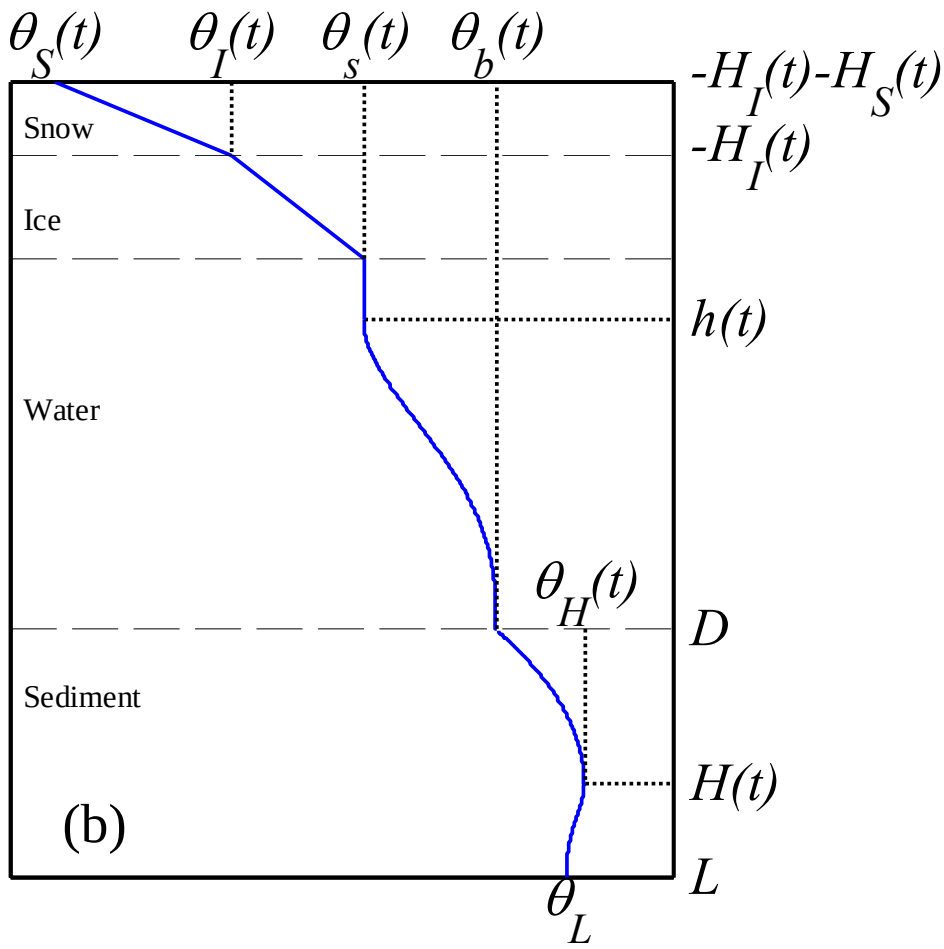
$$\theta = \begin{cases} \theta_s, & 0 \le z \le h \\ \theta_s - (\theta_s - \theta_b)\Phi_\theta(\xi), & h \le z \le D \end{cases}$$

$$\xi = \frac{z - h}{D - h}$$

$$\Phi_\theta = \frac{\theta_s - \theta}{\theta_s - \theta_b}$$ is approximated by polinom ξ

$$C_\theta = \int_0^1 \Phi_\theta(\xi)\, d\xi$$

temperature profile for lake covered with ice and snow:



basic equations:

- for mean temperature

$$\frac{\partial \theta}{\partial t} = \frac{1}{\rho_w c_w}\left[Q_s \cdot I_s - Q_b - I(D)\right]$$

- for bottom temperature

$$\frac{1}{2}(D) - h^2 \frac{d\theta_s}{dt} - \frac{d}{dt}\left[C_\theta (D) - h^2 (\theta_s - \theta_b)\right] =$$

$$\frac{1}{\rho_w c_w}\left[C_Q (D) - h (Q_h - Q_b) \cdot (D) - h I(h) = \int_h^D I(z)\,dz\right]$$

- for mixed layer temperature

$$h \frac{d\theta_s}{dt} = \frac{1}{\rho_w c_w}\left[Q_s \cdot I_s - Q_h - I(h)\right]$$

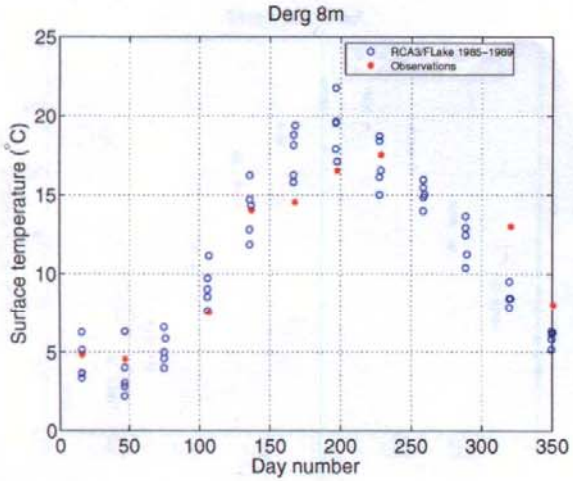
model blocks:

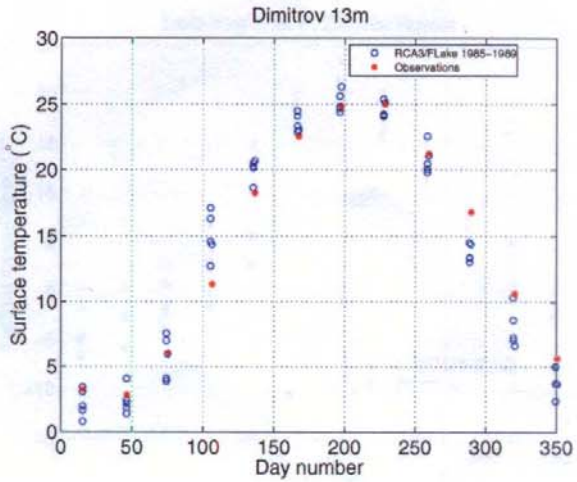
- prediction of mixed layer depth
  - convection
  - neutral and stable stratification
- short-wave radiation transfer
- ice and snow
- bottom sediments

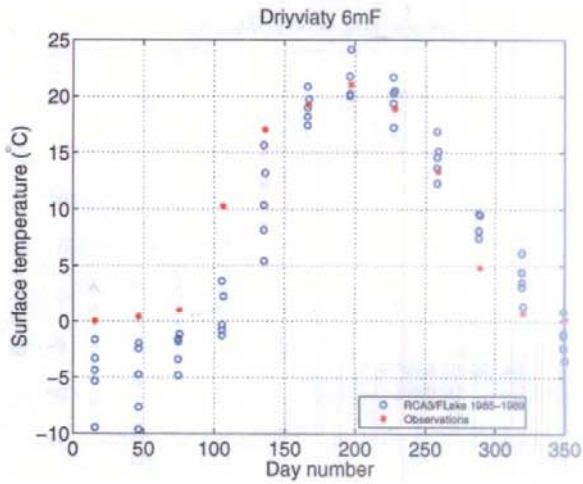
individual lake parameter: depth
real depth data for Sweden, d=10m for European lakes, depth for Ladoga=40m

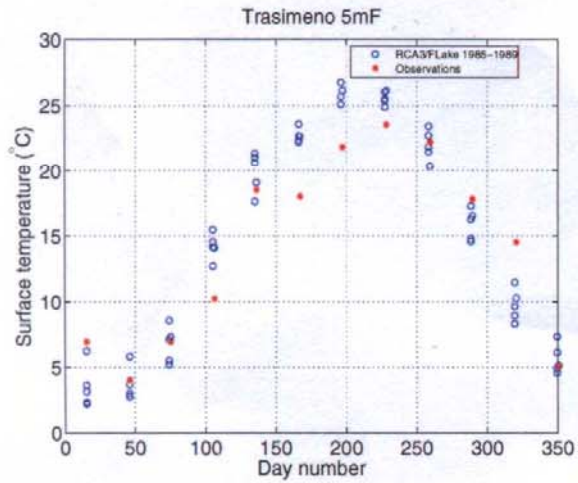
included into RCA like parameterization,
every time step, CALL from surf. scheme

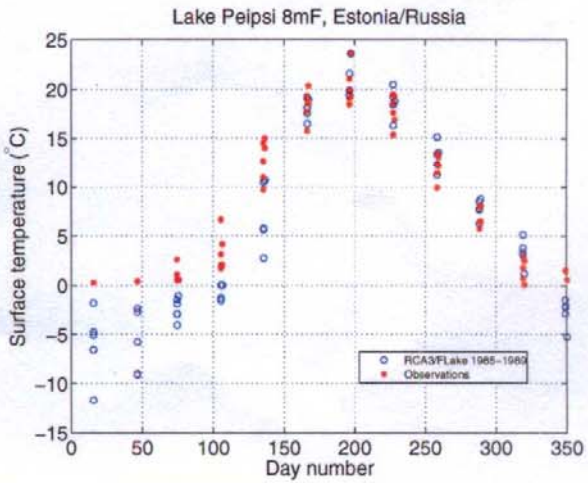
experiments and verification: for individual lakes

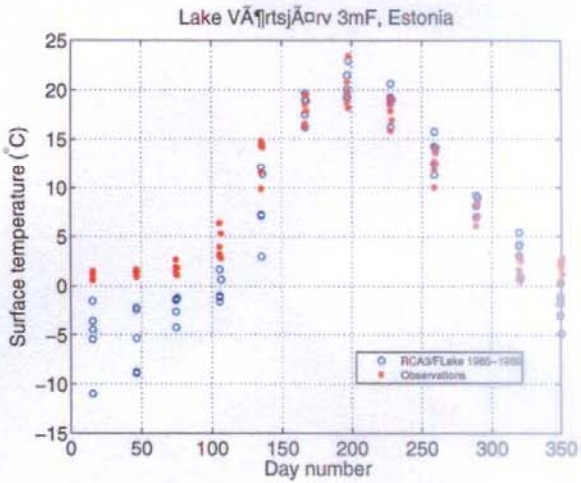




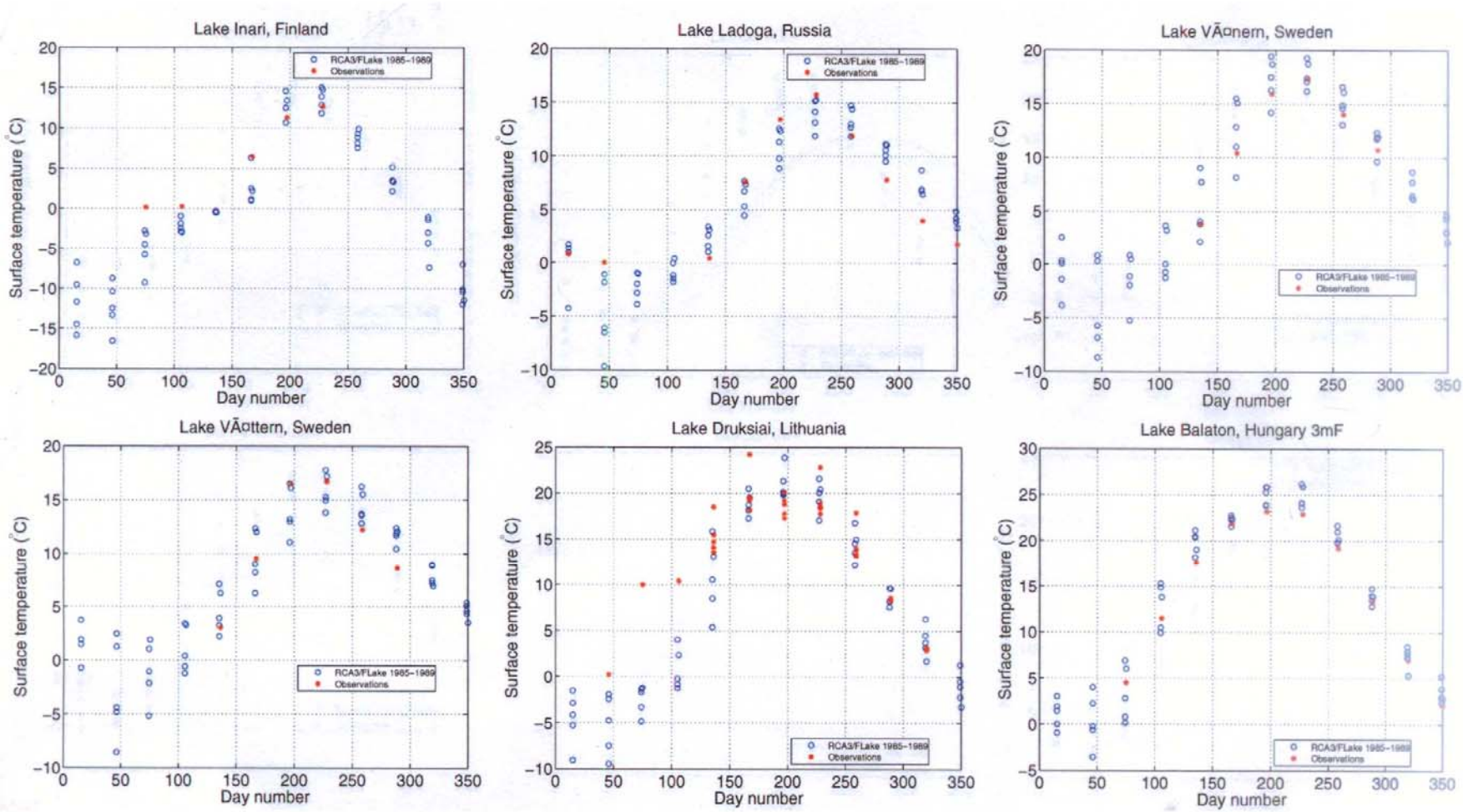








experiments and verification: for individual lakes



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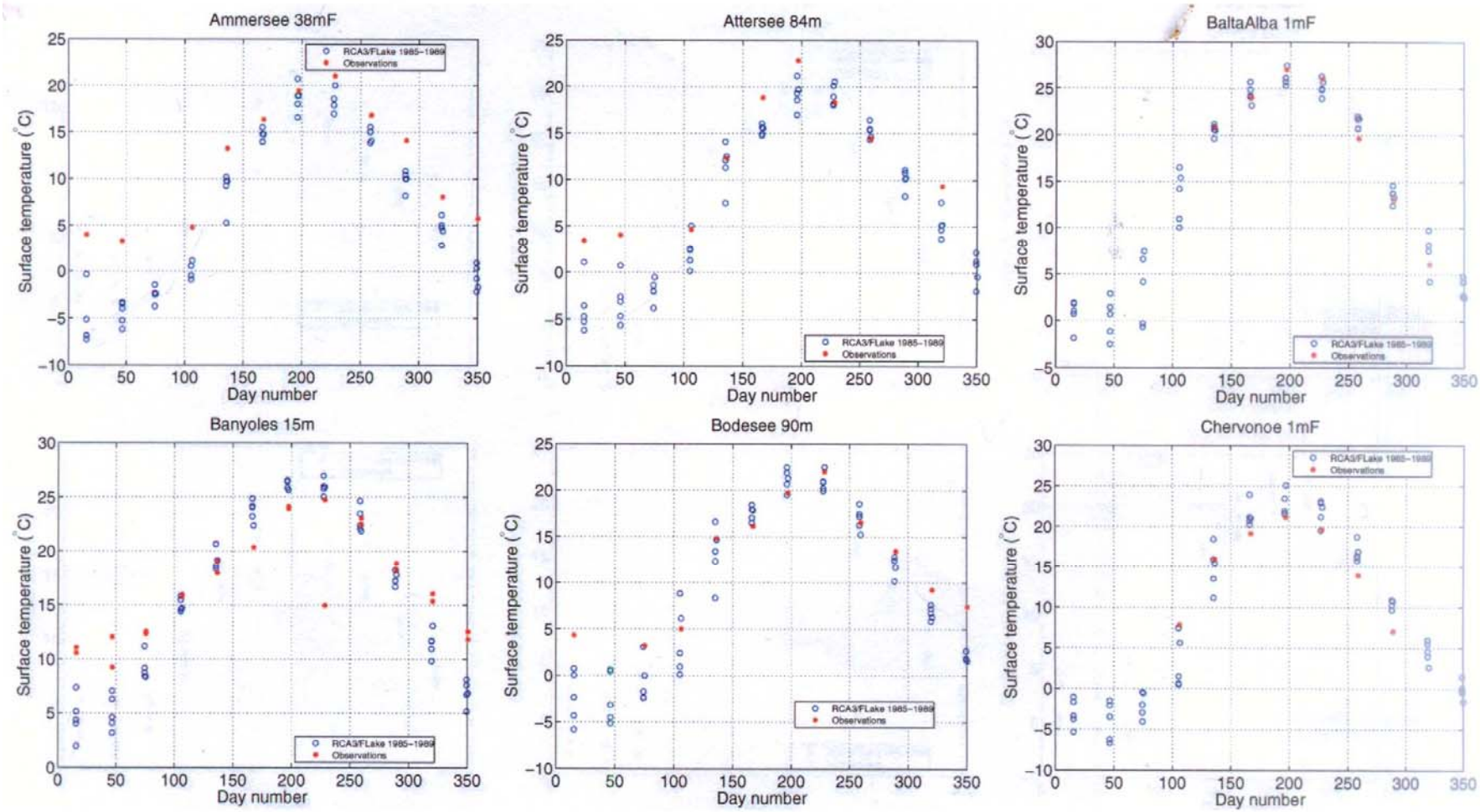

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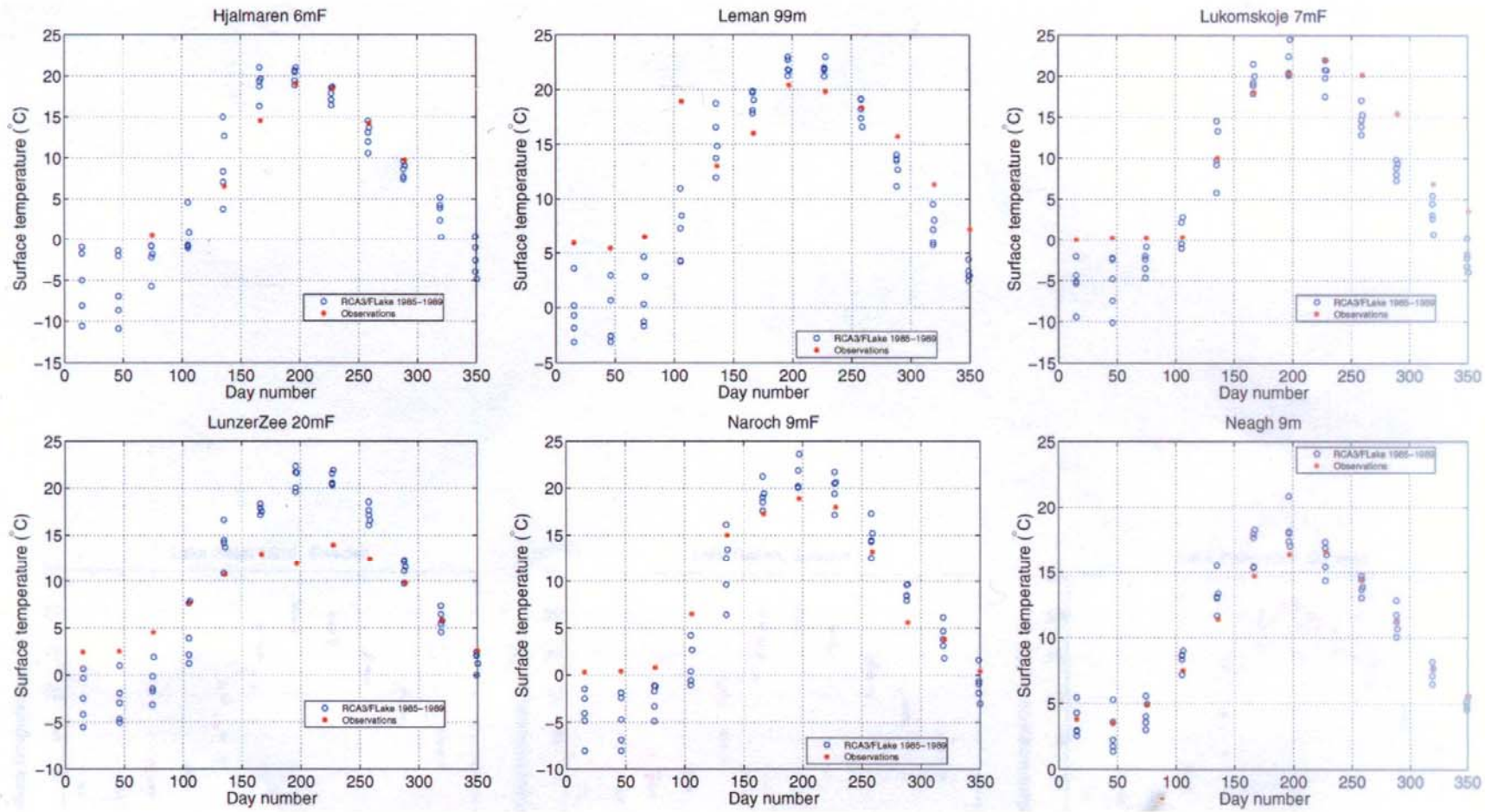

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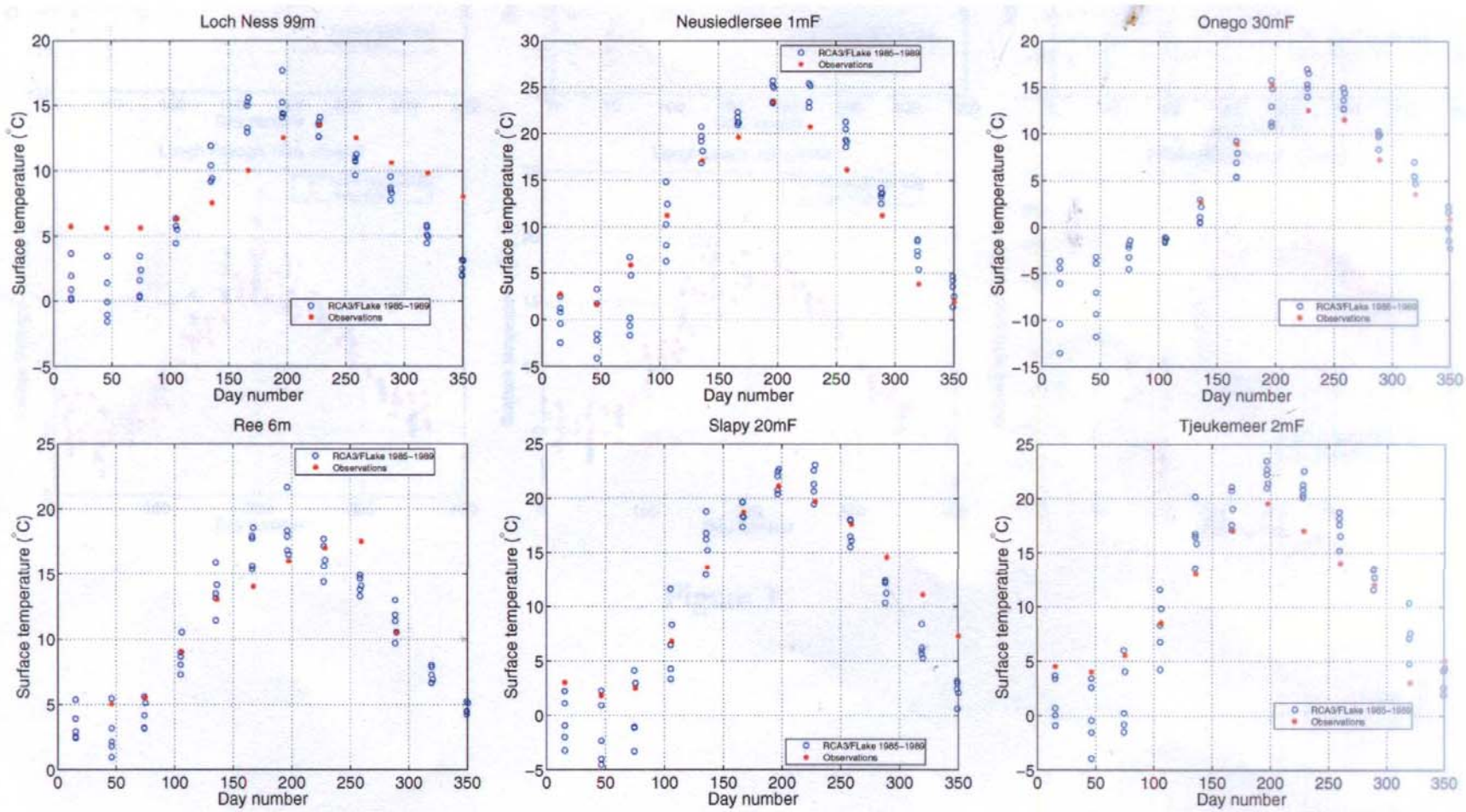

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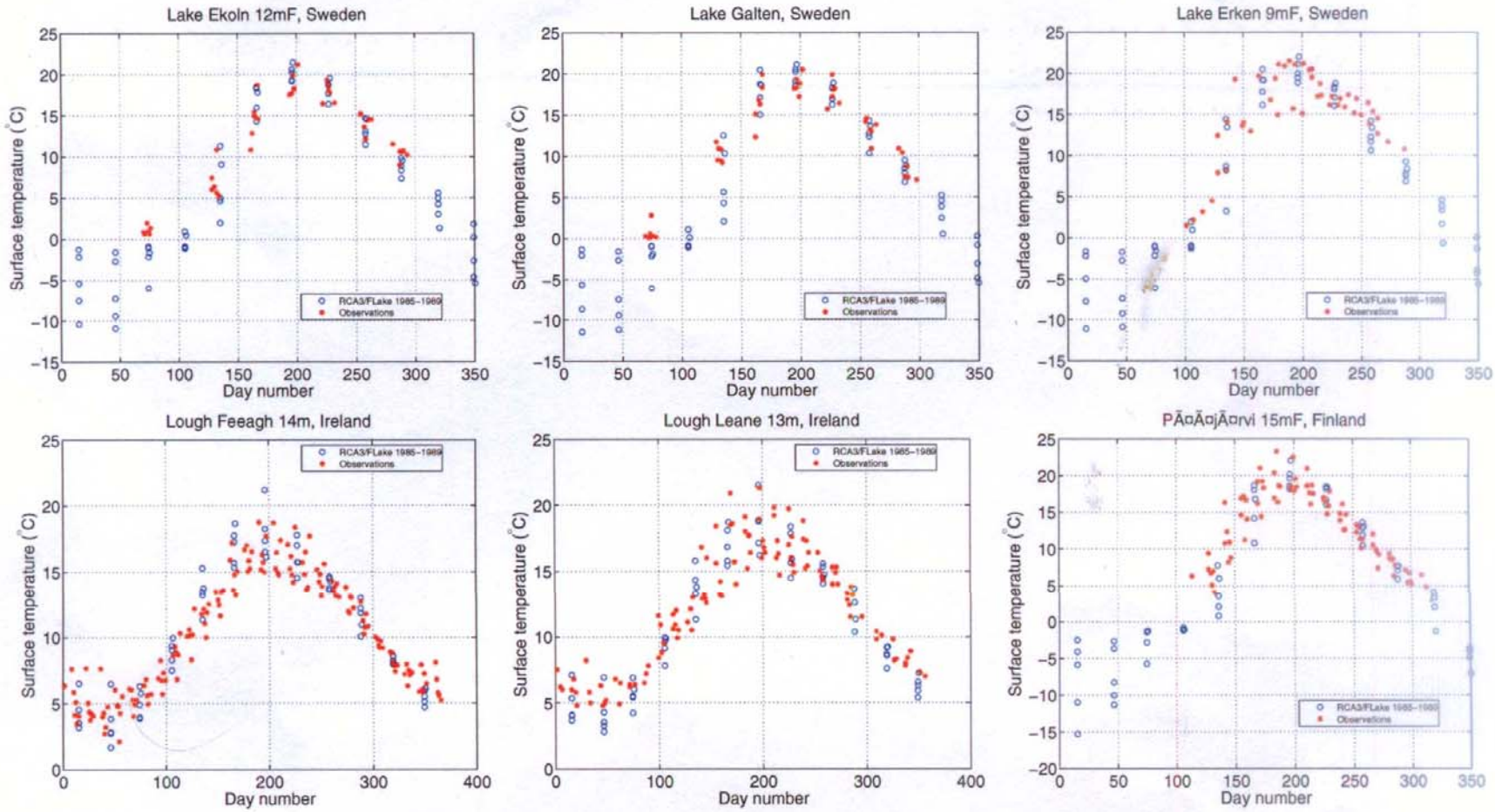
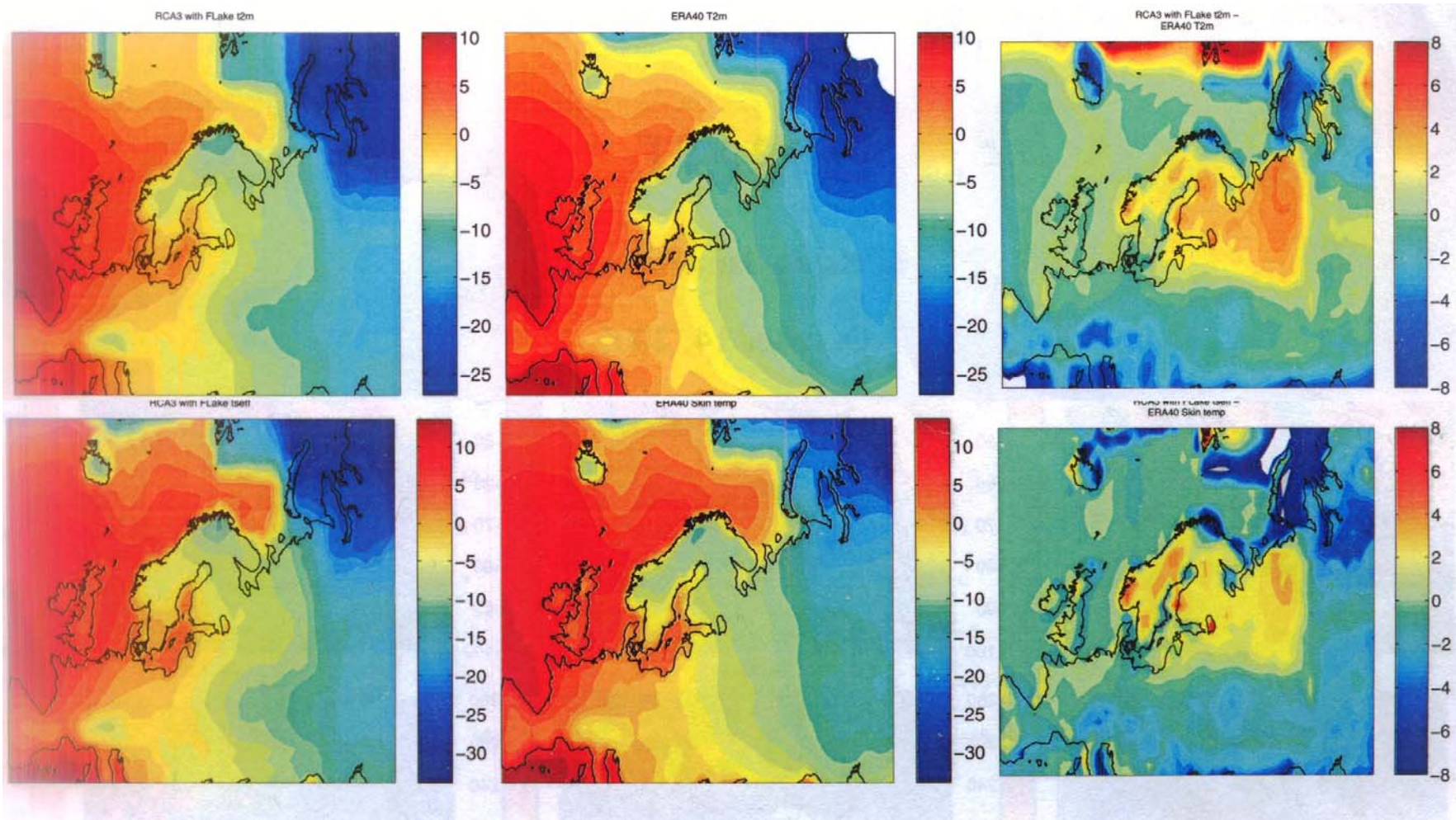


Figure 3:

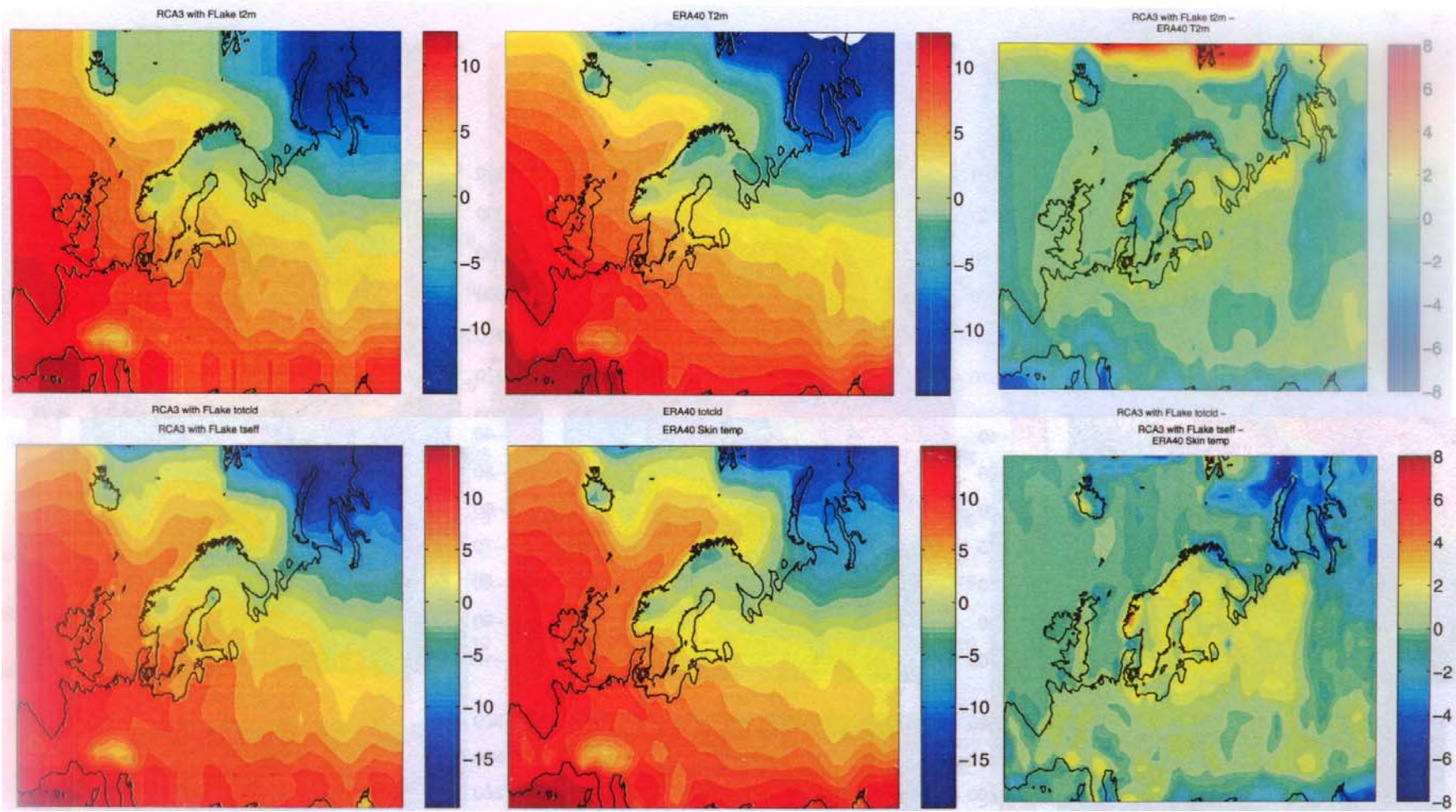
experiments and verification: ERA data

winter



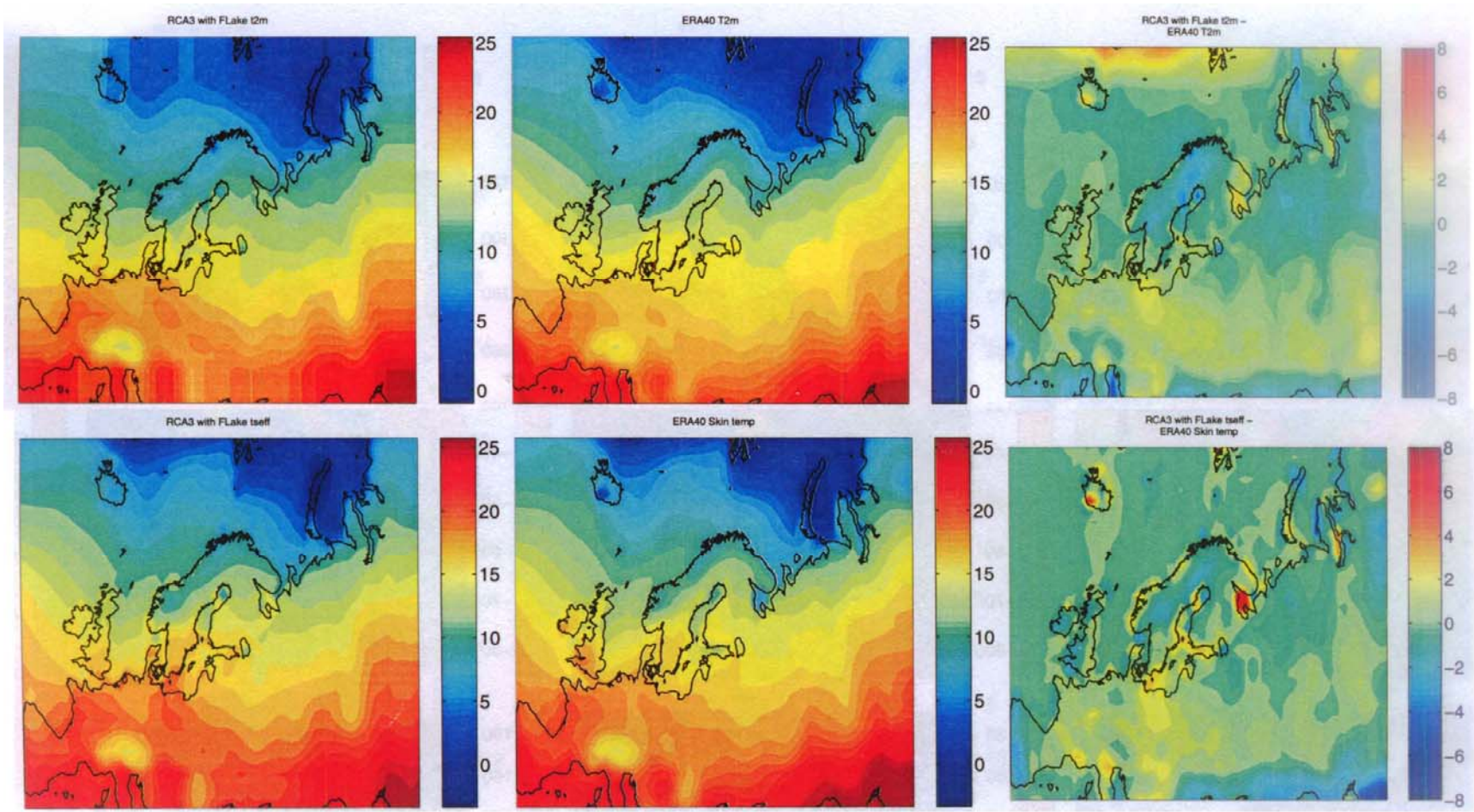
experiments and verification: ERA data

spring



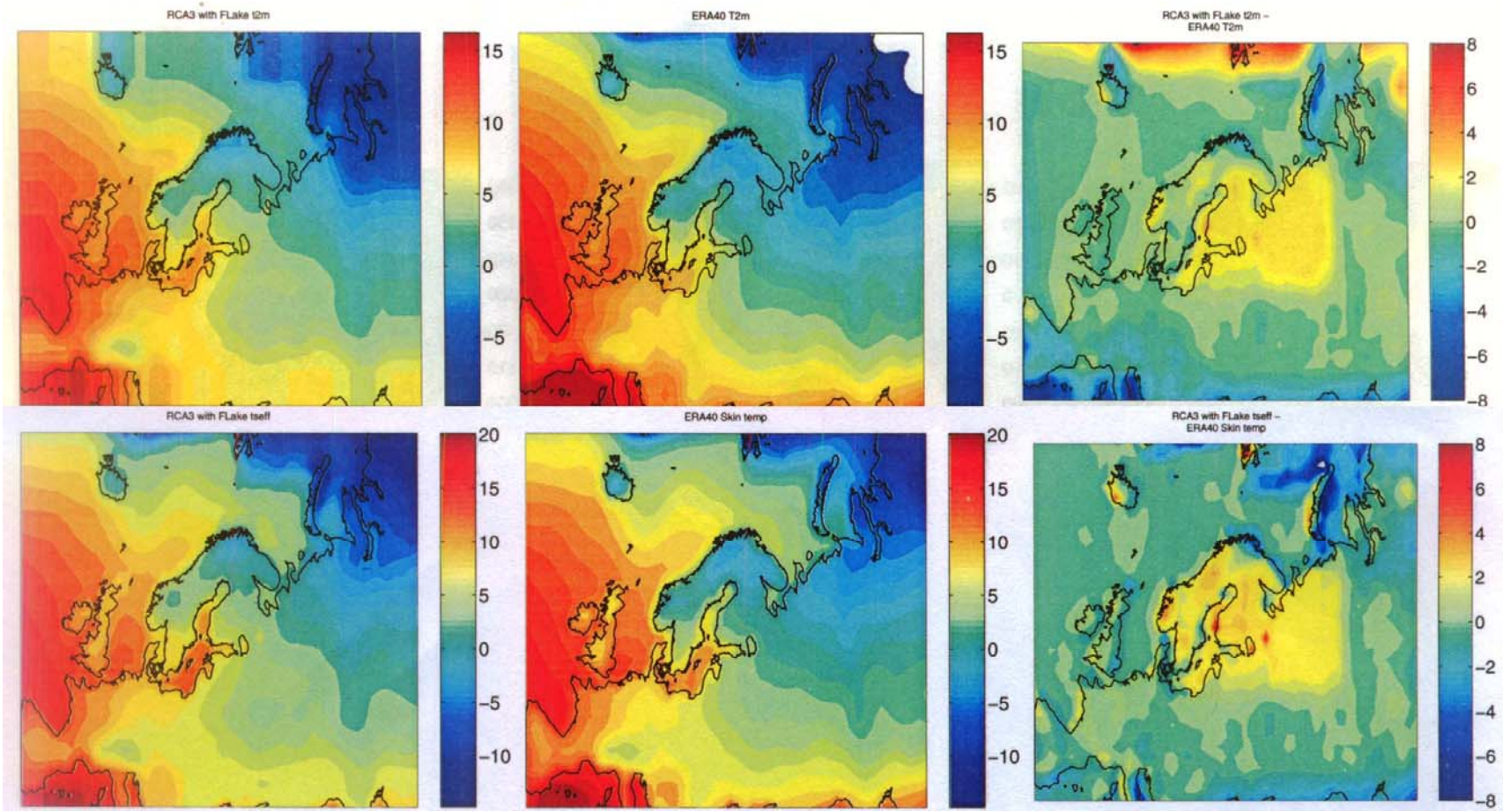
experiments and verification: ERA data

summer



experiments and verification: ERA data

autumn



conclusions: ideas for NWP and DA

- lake model FLake could be included into NWP model as a parameterization
- main benefit: background fields of surface temperature for DA, most important when appearing and disappearing of ice
- problems:
  lake depth < lake depth database (almost ready)

Acknowledgements:

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Thank you for attention!