FLake model at global scale: off-line settings and evaluation of the impacts when coupled to the global circulation model CNRM-CM5

Outline

1. General context
2. SURFEX off-line calibration
3. CNRM-CM on-line evaluation

P. Le Moigne, J. Colin, B. Decharme

General context

➲ **Improvement of lake parameterization in MF models**

Due to the increase of horizontal resolution in models
Need to improve the diurnal cycle over lake areas
A step forward to data assimilation

➲ **SURFEX implementation of FLake model**

Salgado and Le Moigne, 2010

➲ **Field Campaigns validations**

THAUMEX, South-France : Le Moigne et al., 2013

➲ **CNRM-CM implementation**

Improve lake representation in global climate model
A component of the next IPCC exercise with CNRM-CM

SURFEX off-line calibration

off-line simulations:

- Driven by ERA-Interim atmospheric reanalyses 1979-2010
- Compared to Arc-Lake products (ESA project, ATSR1,2 radiometers) :

Surface temperature and ice cover 1991-2010, 200 lakes with area>500km2

- Settings of lake depth, light extinction coefficient, ice albedo, skin temperature model

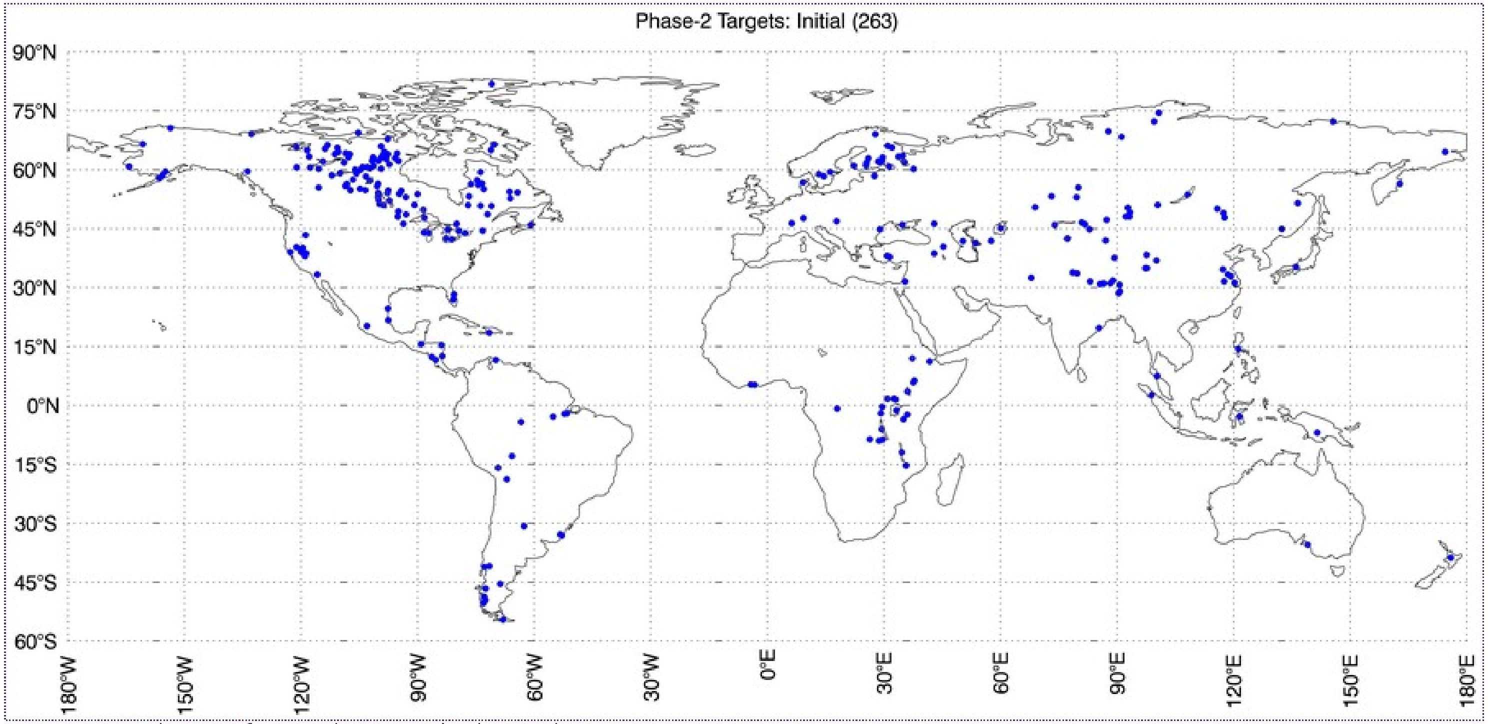


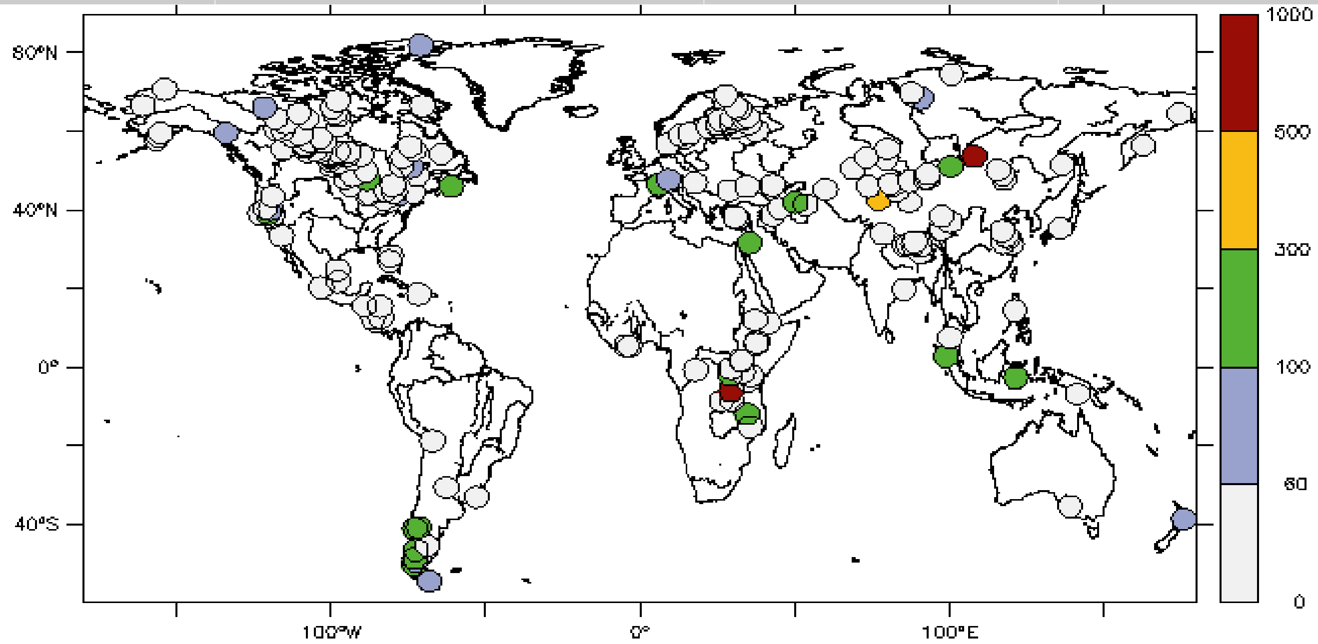
Figure 1. Target locations for v1 and v2 ARC-Lake data products

ANCE

SURFEX off-line settings

Experiment Name	Max Lake Depth [m]	Albedo of Ice	Light Extinction Coefficient [m^{-1}]	Skin Temperature
XPR	Unlimited	0,6	3,0	On
XPD	60	0,6	3,0	On
XPA	60	0,4	3,0	On
XPE	60	0,4	0,5	On
XPF	60	0,4	0,5	Off

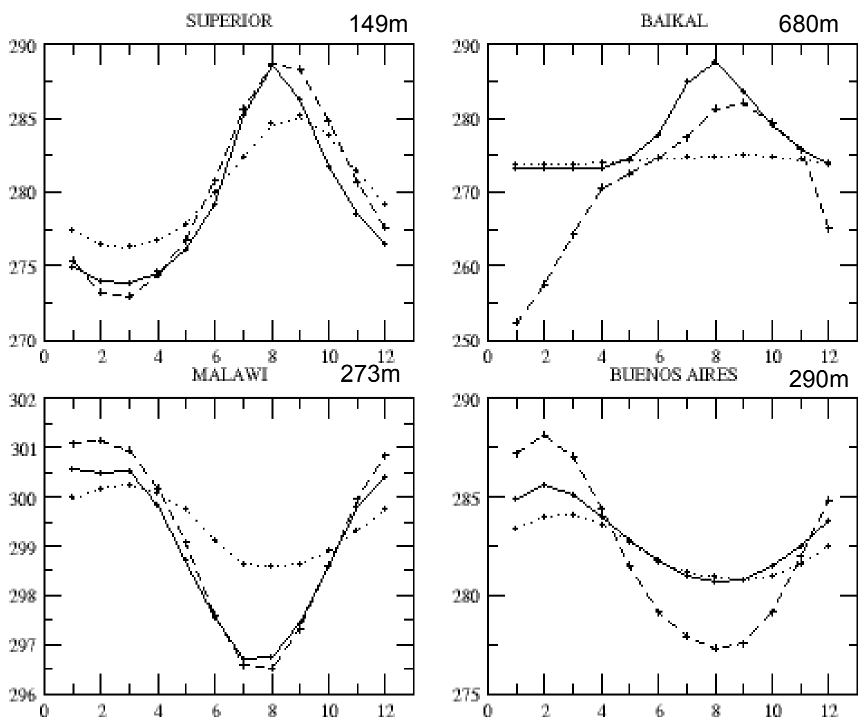
➲ Lake depth limitation to 60m (Perroud et al., 2009 ; Masson et al., 2013)



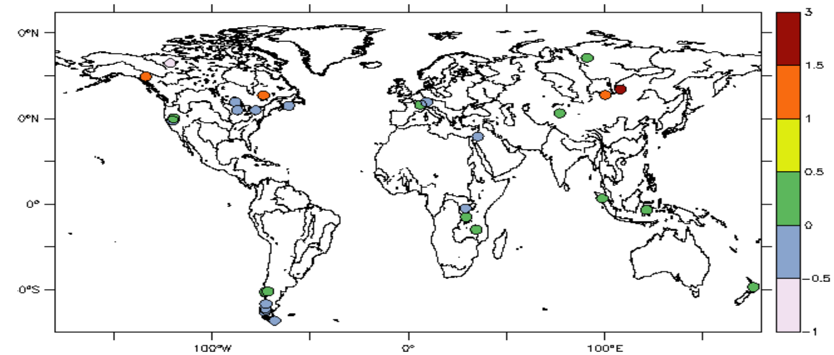
RANCE

Lake depth limitation

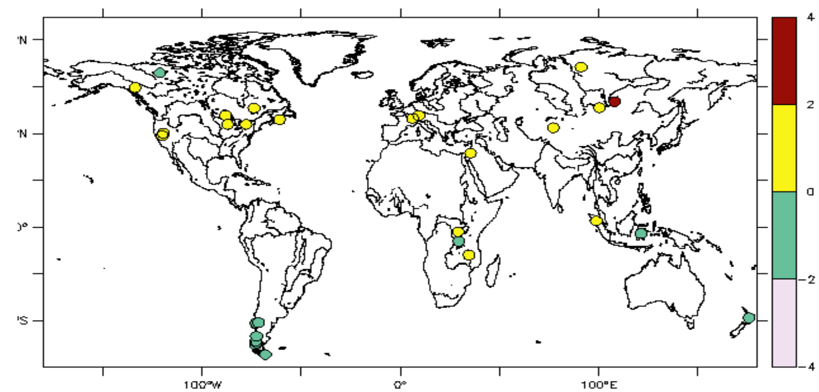
Surface temperature annual cycles



BIAS : XPR - XPD

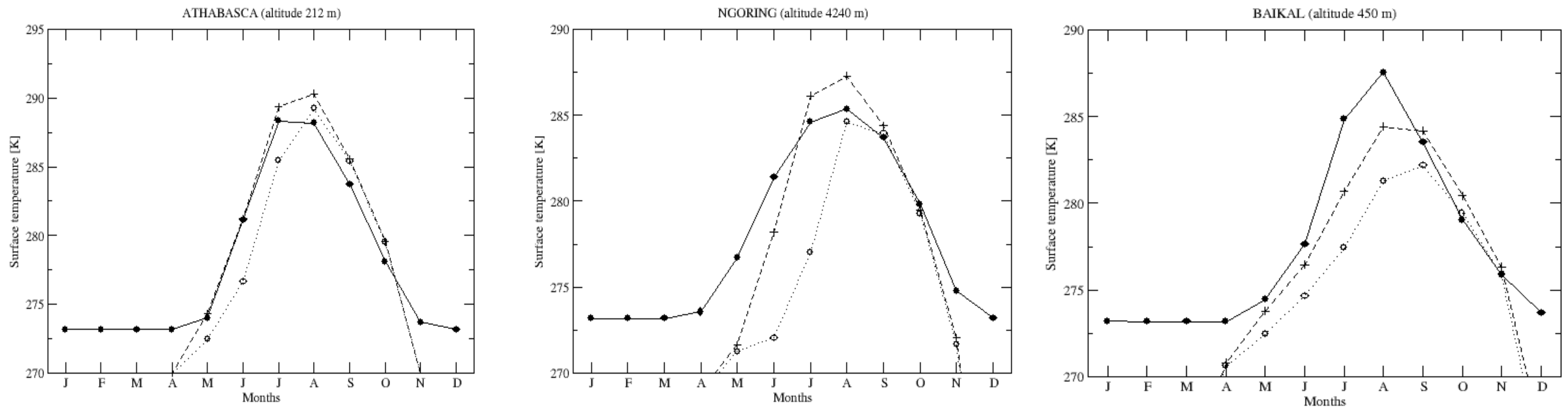


RMSE : XPR - XPD

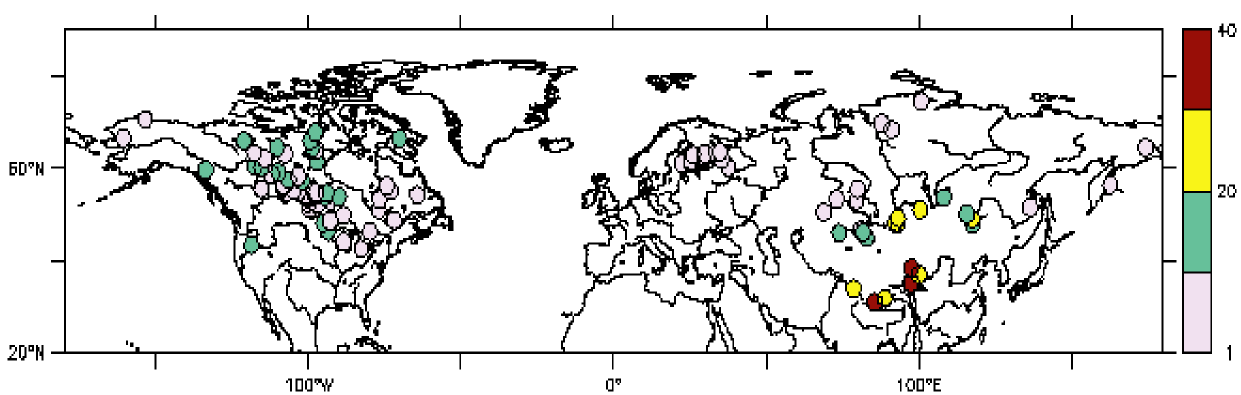


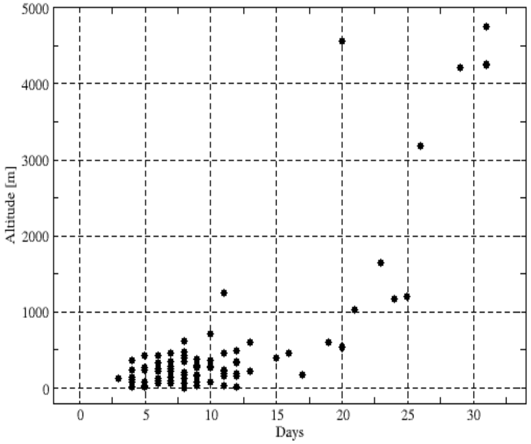
Ice albedo decrease

Surface temperature annual cycles



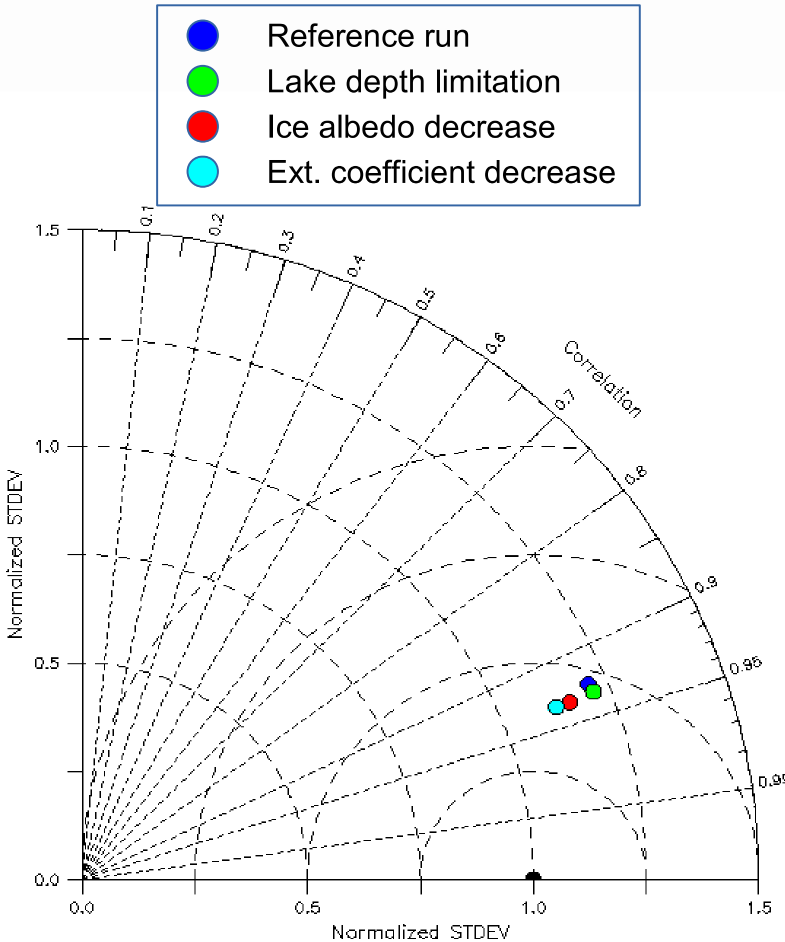
Reduction of spring thaw delay





Extinction coefficient decrease and skin temperature effect

SWD = 1000 W/m² alb = 0.06
k = 3.0 m^{-1} QW = 47 W/m²
k = 0.5 m^{-1} QW = 570 W/m²



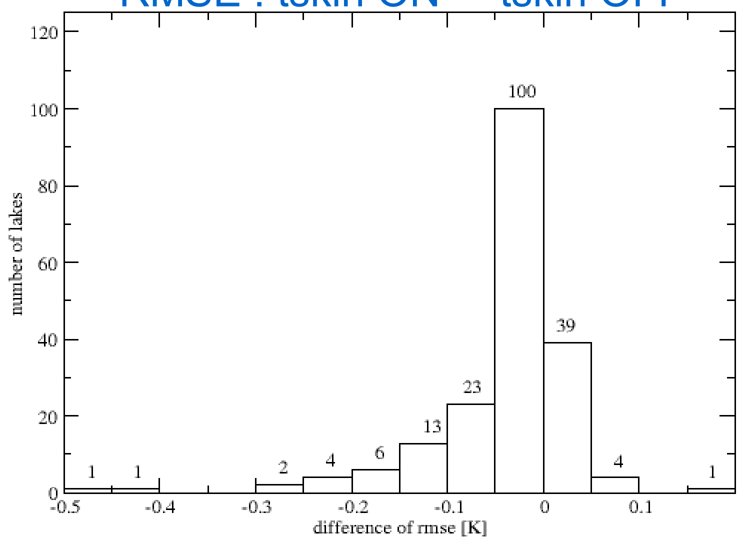
1D heat transfer

$$\rho_w c_w \frac{dT}{dt} = \lambda_w \nabla T + Q$$

skin temperature equation

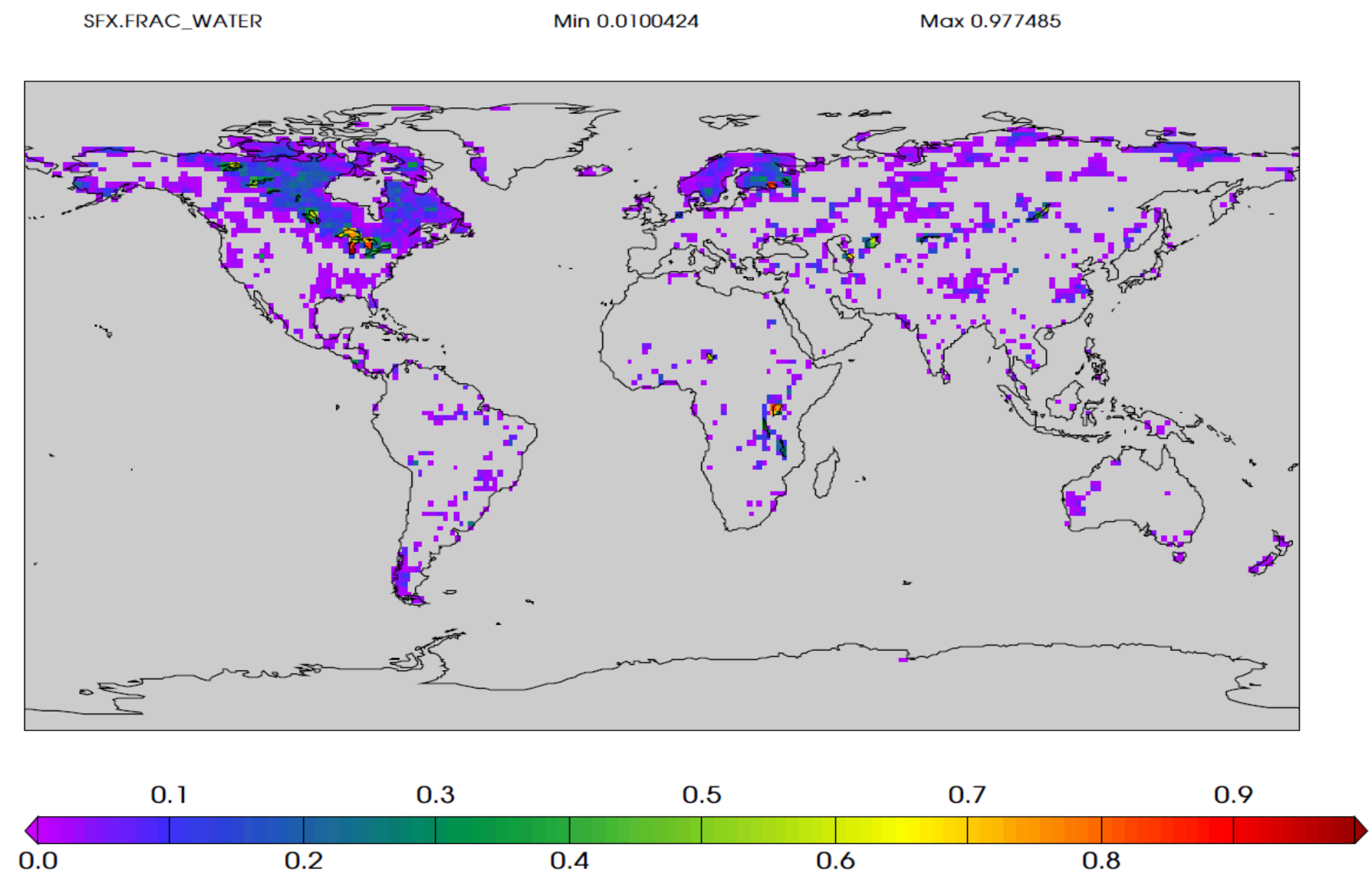
$$\overline{T}(0) = \overline{T}(-h) + \frac{h}{\lambda_w}\left(L^* + S^* - (QH + QE)\right) - \frac{1-\alpha_w}{k\lambda_w} I_0 \left(1 - e^{-kh}\right)$$

RMSE : tskin ON – tskin OFF

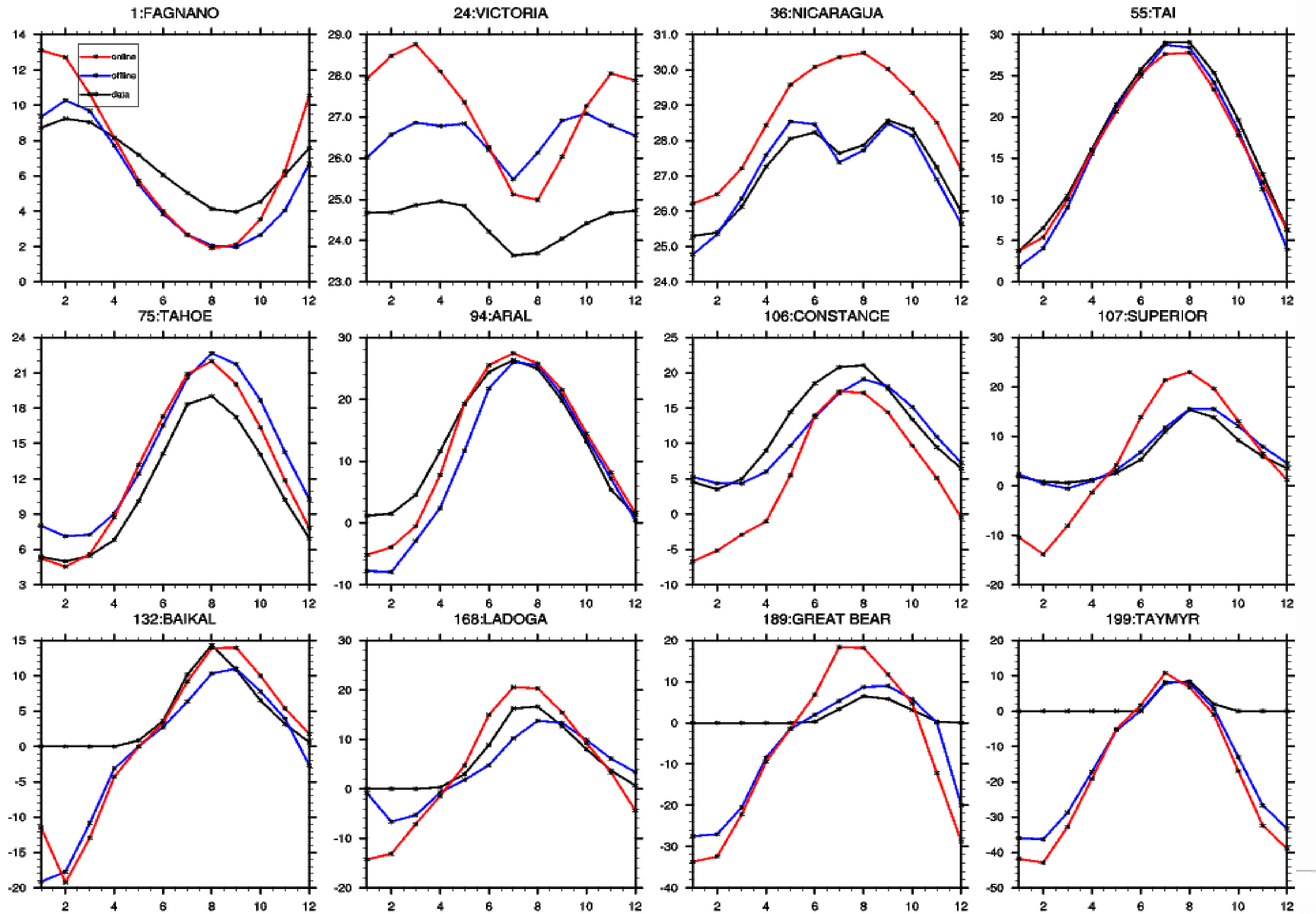


CNRM-CM on-line evaluation

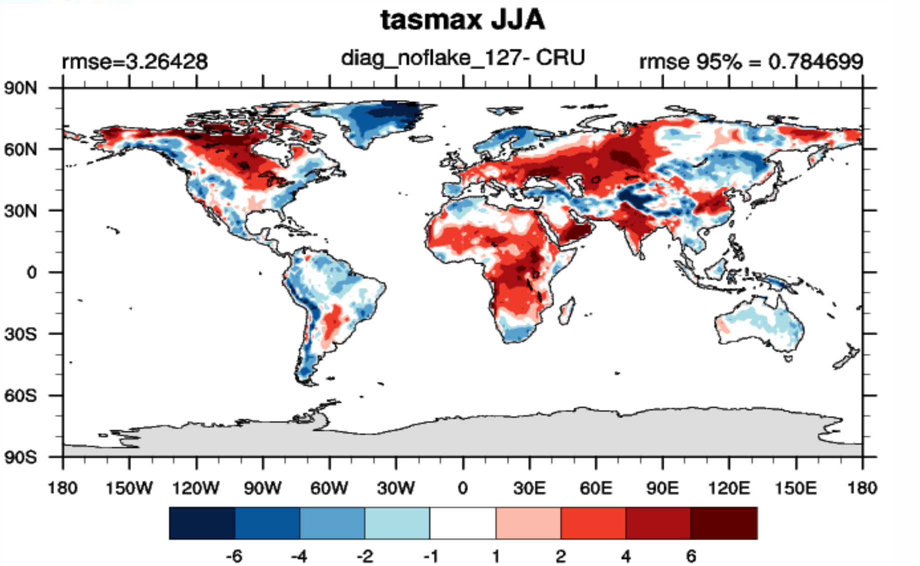
- Adapt model to large scale (budget closure, separation lakes/rivers)
- 2 model configurations : lakes treated by FLake or replaced by land
- 1971-2010 – T127 : 1.5° at equateur

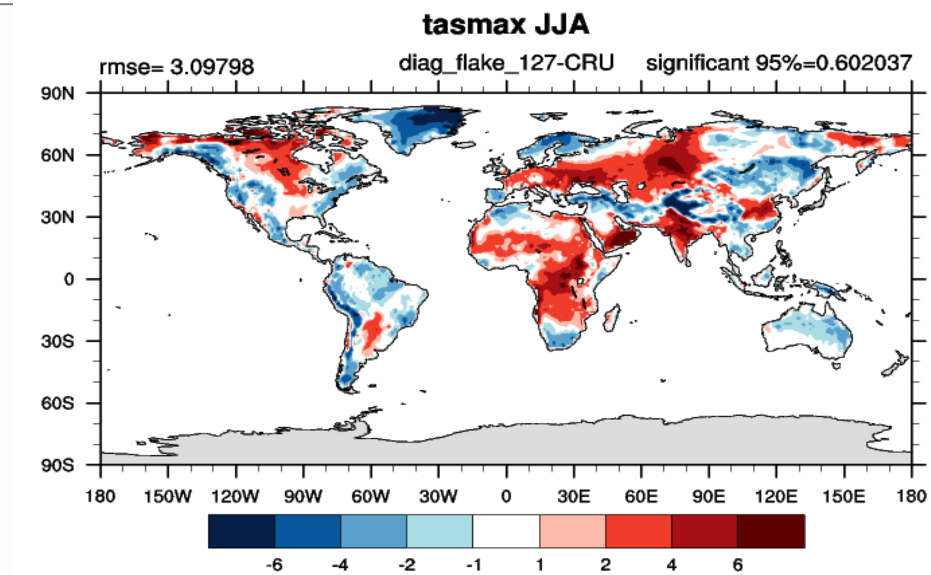


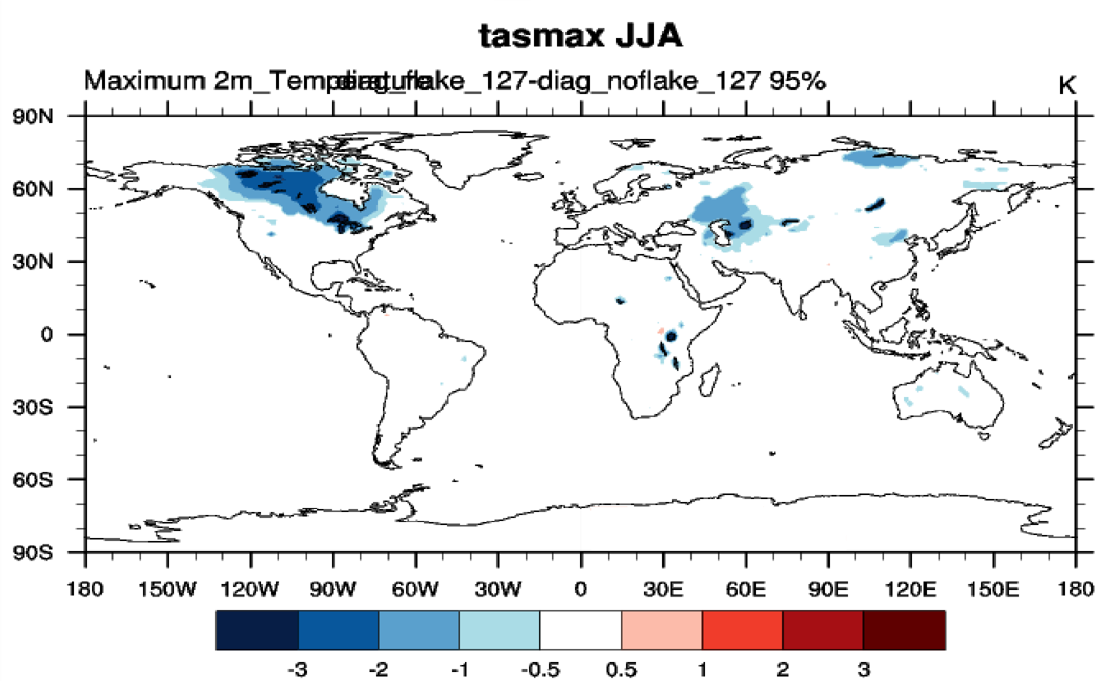
off-line vs on-line comparison



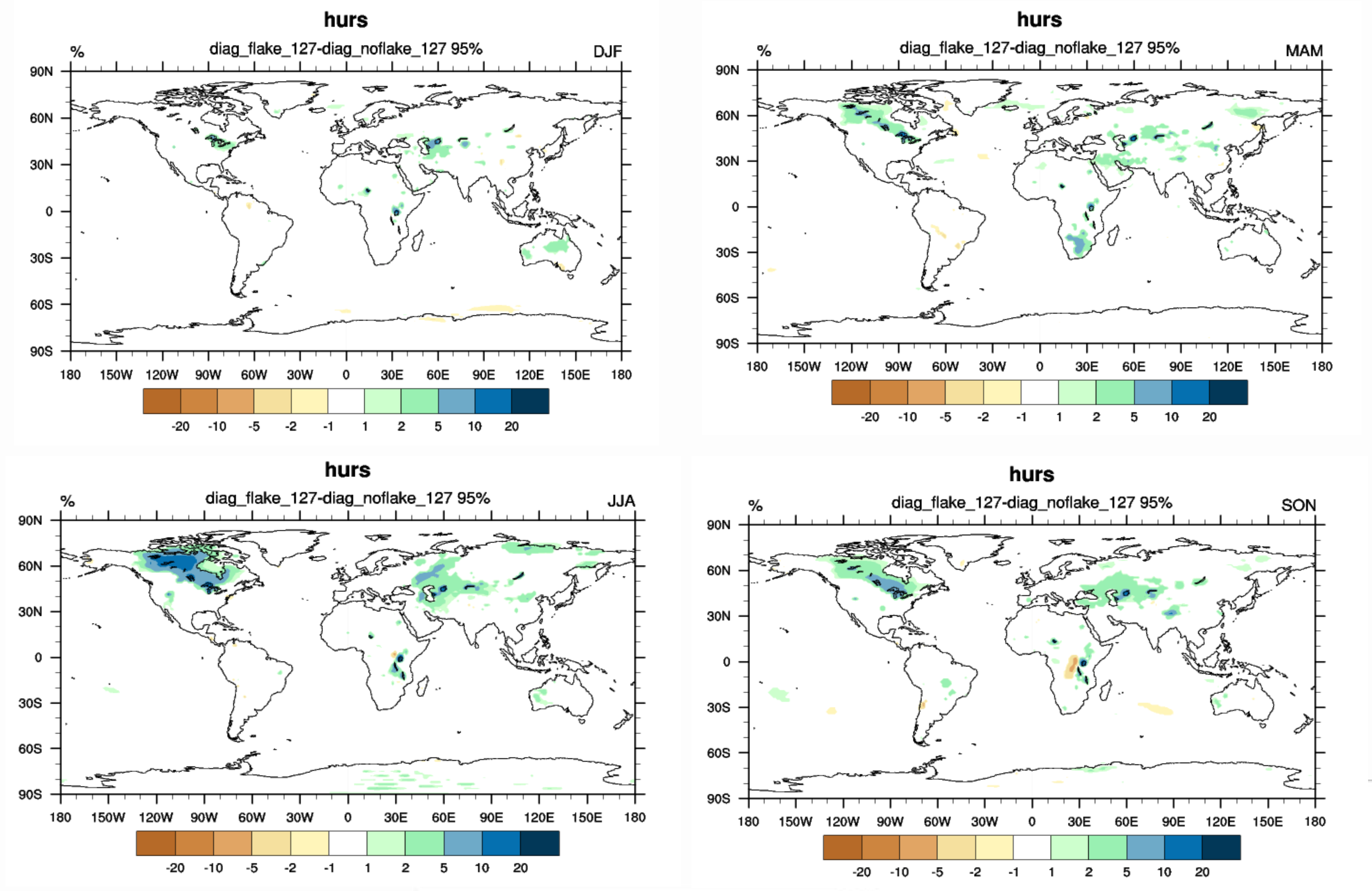
Summertime cooling effect of lakes : JJA maximum T2M







Moistening effect of lakes : seasonal RH2M



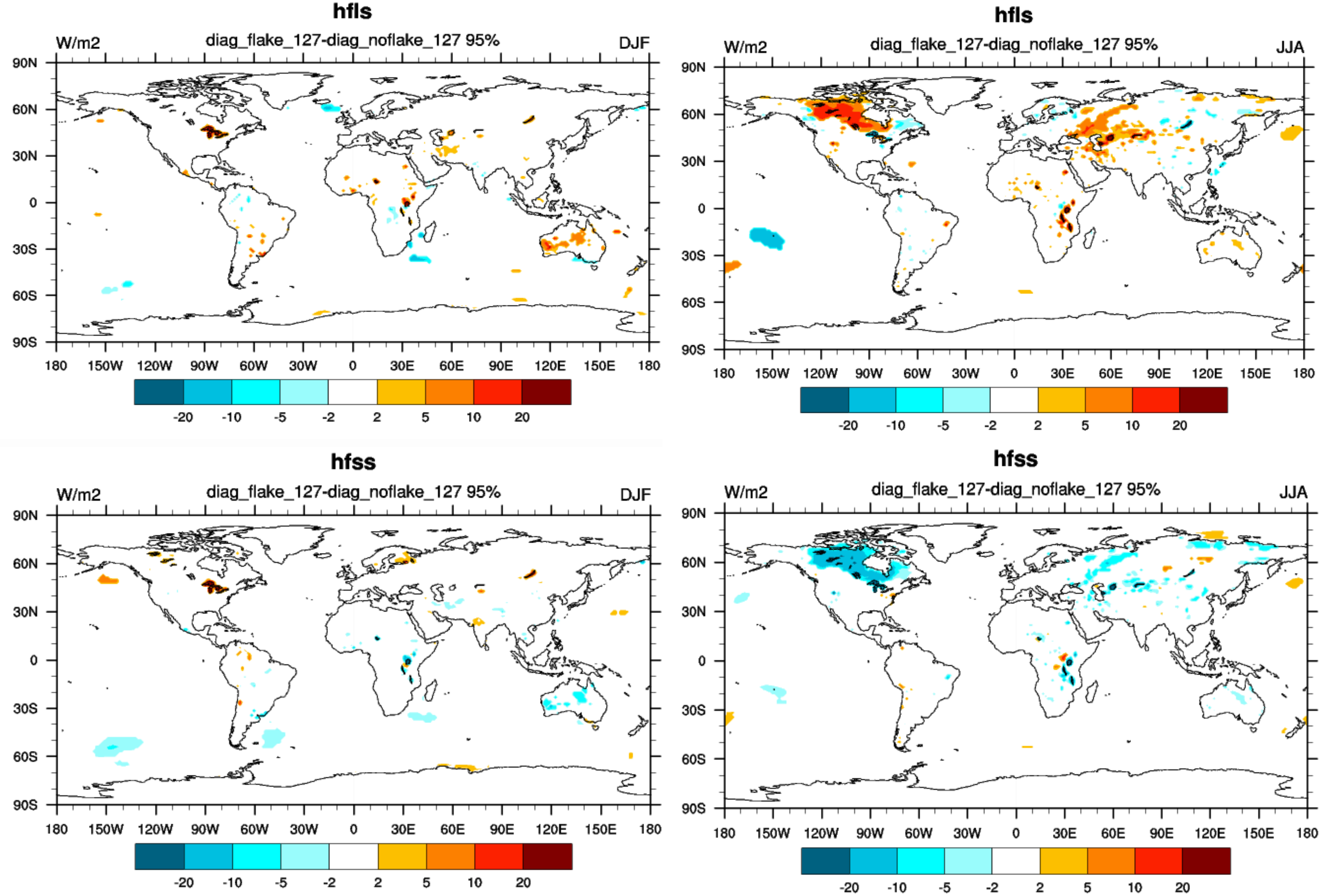
Impact on surface fluxes QH & QE

winter - DJF

summer - JJA

QE

QH



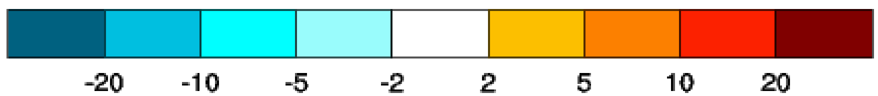
Impact on Great Lakes JJA radiative budget

Δ(SWD) +10 W/m2

less clouds

Δ(SWU) -15 W/m2

albedo effect



Δ(LWD) -5 W/m2

less clouds

Δ(LWU) -10 W/m2

temperature effect

Summary

Model settings

- The limitation of depth to 60m for FLake is mandatory
- The too long ice cover duration was improved by limiting the albedo of ice to 0.4
- The setting of the light extinction coefficient to 0.5 (clear water) improved significantly surface temperature annual cycle
- Using a skin temperature module improved slightly the results

Global evaluation

- FLake was coupled to CNRM-CM model
- High cooling effect of ~3K particularly during summertime
- Associated to a moistening effect : +10 % in JJA and +5% in MAM and SON
- More QE in JJA : +15W/m² due to a moister air
- Less QH in JJA : -15W/m² due to thermal effects (inertia)
- Weak impact on precipitation, surface pressure
- Over Great Lakes region,
  - DJF evaporation bigger : lakes not frozen compared to ground covered by snow
  - Wind speed impact localized : bigger all the time due to roughness effects
  - Relatively high impact on radiative budget components

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Thanks for your attention !