Current status of lake modelling and initialisation at ECMWF

G Balsamo, A Manrique Suñen, E Dutra, D. Mironov, P. Miranda, V Stepanenko, P Viterbo, A Nordbo, R Salgado, I Mammarella, A Beljaars, H Hersbach and P de Rosnay

Current status: SST and Sea Ice analysis

(Hersbach, ECMWF Res. Memo, 1125, 2011)

Products used in operations at ECMWF:

May 2001 – September 2008:

- **NCEP** product at 0.5x0.5 degrees from NCEP
  Based on Infra-red (AVHRR) In situ (Ships, Buoys)
  Used at ECMWF for Oceans, Caspian Sea, Great Lakes
  Information at: http://polar.ncep.noaa.gov/sst/oper/Welcome.html

Since October 2008:

- **OSTIA** product at 0.05x0.05 degrees from The UK MetOffice.
  Based on Infra-red (AVHRR, AATSR, SEVIRI), microwave (AMSR-E, TMI), In situ (Ships, drifting and moored buoys)
  Used at ECMWF for Oceans, Caspian Sea
- **NCEP**
  Used at ECMWF for the Great Lakes (2008) + Caspian & Azov (2011)

Informations at: http://ghrsst-pp.metoffice.com/pages/latest_analysis/ostia.html

Current status: SST and Sea Ice analysis

Deterministic Forecast:

SST and sea ice persited anomaly SST (climato + ERA-I trend)
Based on imported products re-sampled to the reduced Gaussian grid.

SST and Sea Ice analysis conducted for grid points with water fraction larger than 0.5. Smaller water fractions not resolved.

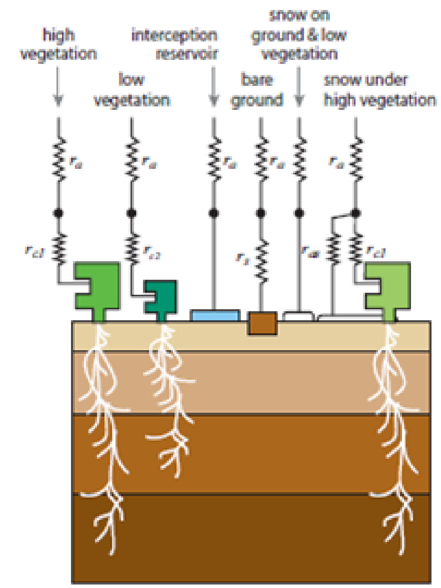
Over Land, lake SST analysed using:

- Great Lakes: NCEP SST and sea ice
- Black Sea: OSTIA SST and Sea Ice
- Caspian and Azov: NCEP sea ice and OSTIA SST
- Other lakes: Climatological SST: SSTLake (t) = T2m (t-1)

Lake modelling Developments at ECMWF

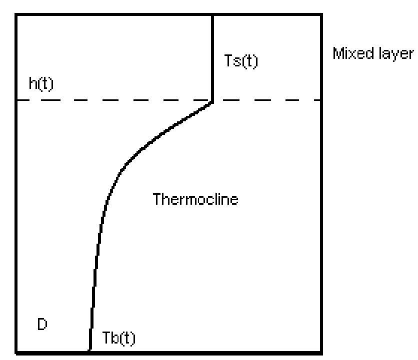
- HTESSEL (Hydrology Tiled ECMWF Scheme for Surface Exchanges over Land):

  8 Tiles: Low vegetation, high vegetation, snow on low vegetation or bare ground, high vegetation with snow beneath, bare ground, interception, ocean (Open water, ice water)



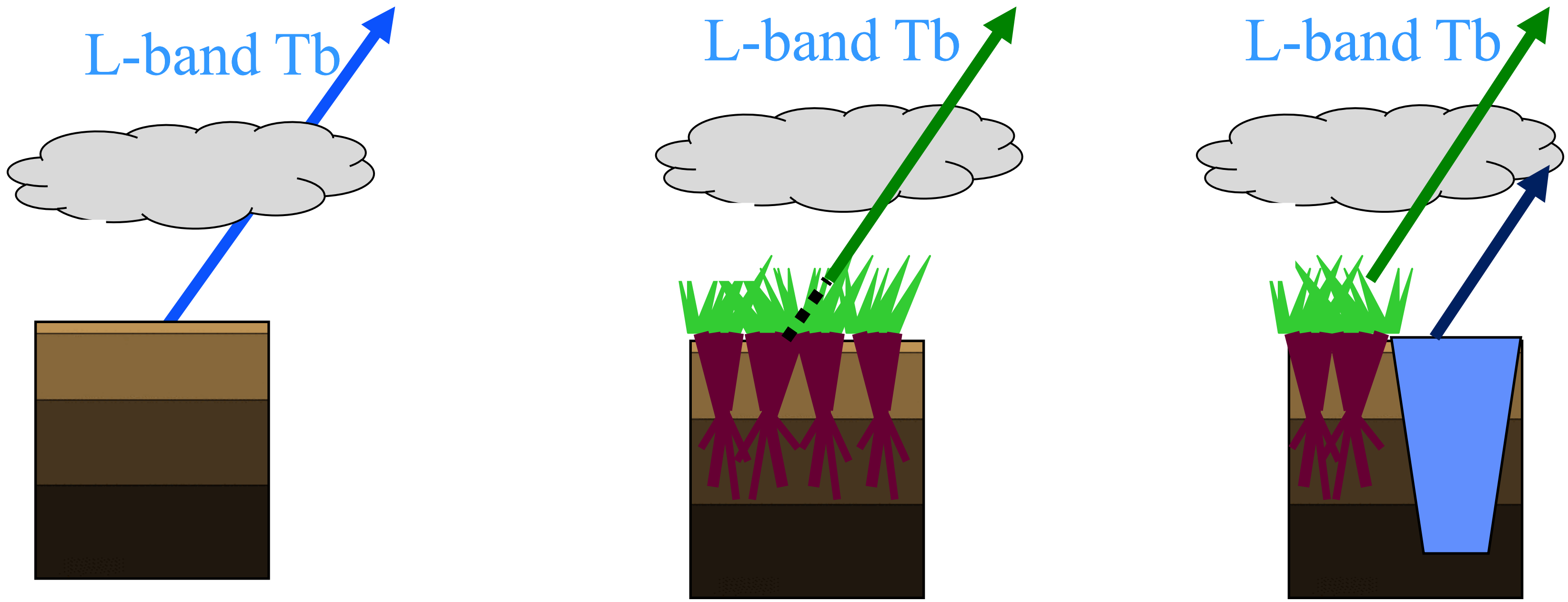
- LAKEHTESSEL (Adds a new tile for inland lakes)

  Includes FLake lake model, (Mironov, 2008) based on self similarity of the temperature profile, with prognostic variables: mixed layer depth and temperature, ice depth and temperature, shape factor, bottom temperature



ECMWF

Microwave Remotely sensing from space: Relevance of open-water in forward modelling



Soil moisture modifies soil dielectric constant→ emissivity ε

$$T_{b\_soil} = \varepsilon T_s$$

Vegetation attenuates soil emission + emits its own TB

T_b influenced by vegetation layer [f(LAI)]

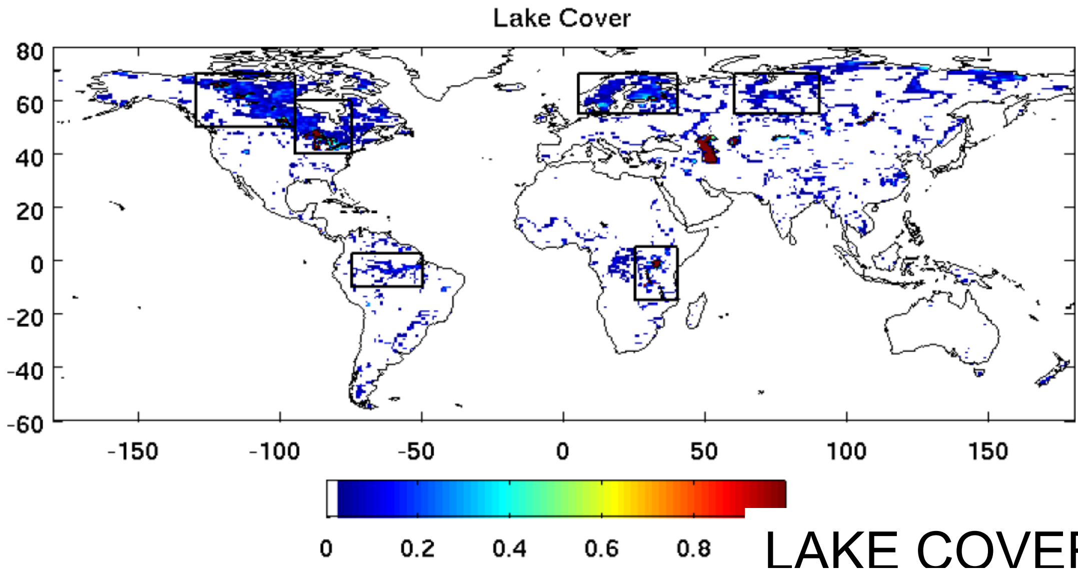
Lakes create a strong cold signal, masking the signal of soil

T_b varying with lake temperature [f (T_skin)]

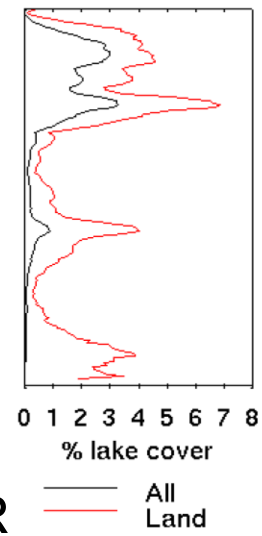
	Sounding soil depth	Frequency	Wavelength	Atmospheric absorption
L-band Tb	**~5 cm**	1.4 GHz	21 cm	**Negligible**
C-band Tb	~1cm	6.9 GHz	5 cm	Low (except rainy area)

Lake modelling Developments at ECMWF

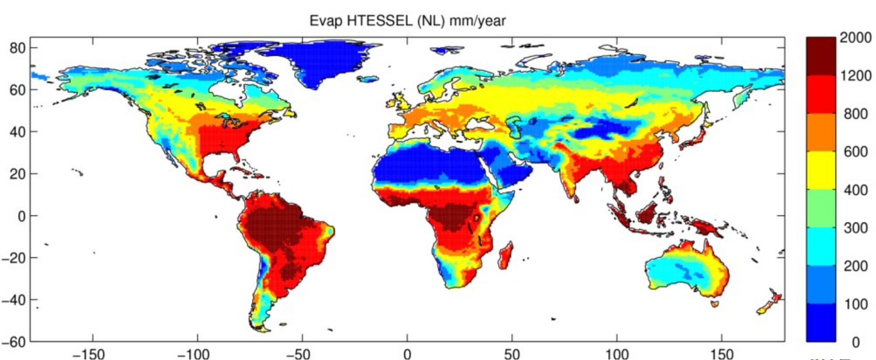
Dutra et al. (2010), Balsamo et al (2010), *Boreal Env. Res., and TM608/609*

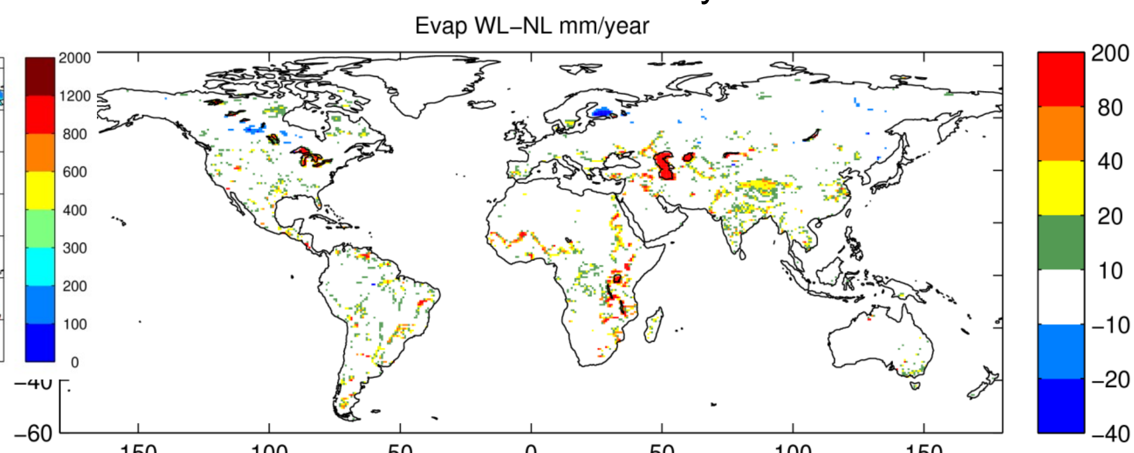


LAKE COVER



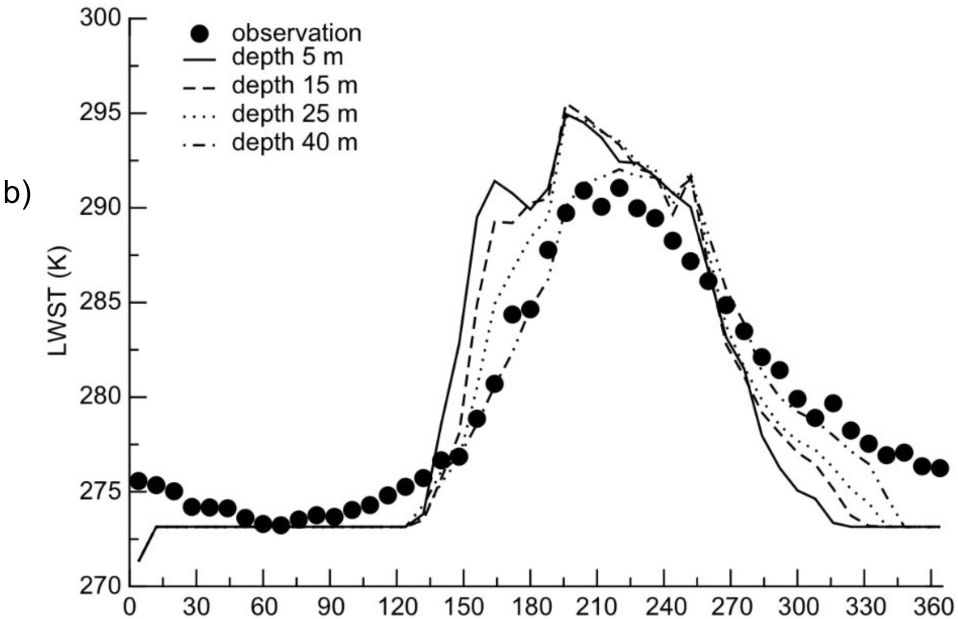
- The lake cover datasets quality is important to account for lakes.
- Currently GLCC
- Planned ESA GlobCover (but no lake flag, can use ECOCLIMAP2?)
- Evaporation is generally enhanced over grid-point with lakes but the biggest change is on sensible and latent heat fluxes diurnal cycles.





ERA-Interim forced runs of the FLAKE model are used to evaluated FLAKE in offline experiments showing a sensitivity in the land evaporation (lakes generally increase the annual mean, with a delayed seasonal cycle w.r.t. land surface points)

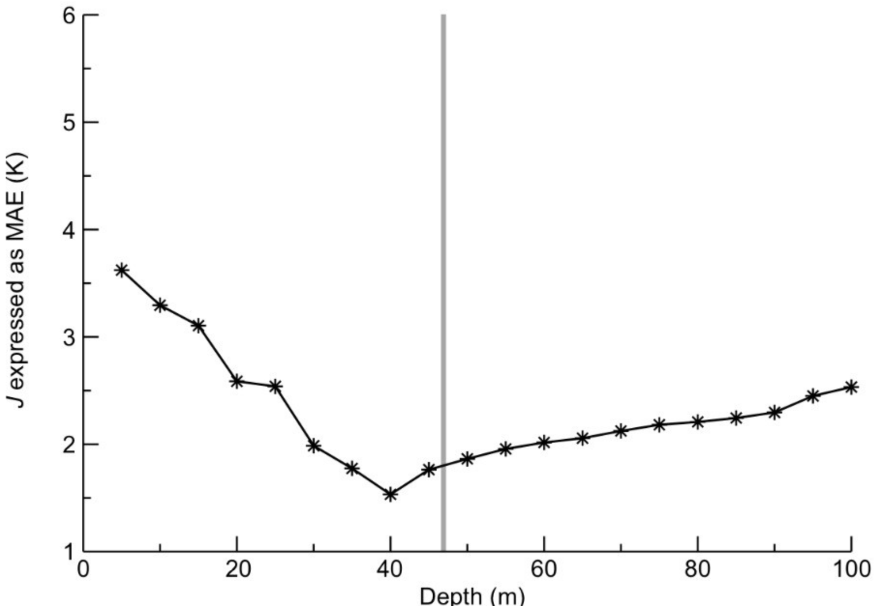
Lake depth: a crucial parameter



Example from lake Ladoga annual cycle simulated by FLake (with different lake depths) and compared with satellite-based observations.

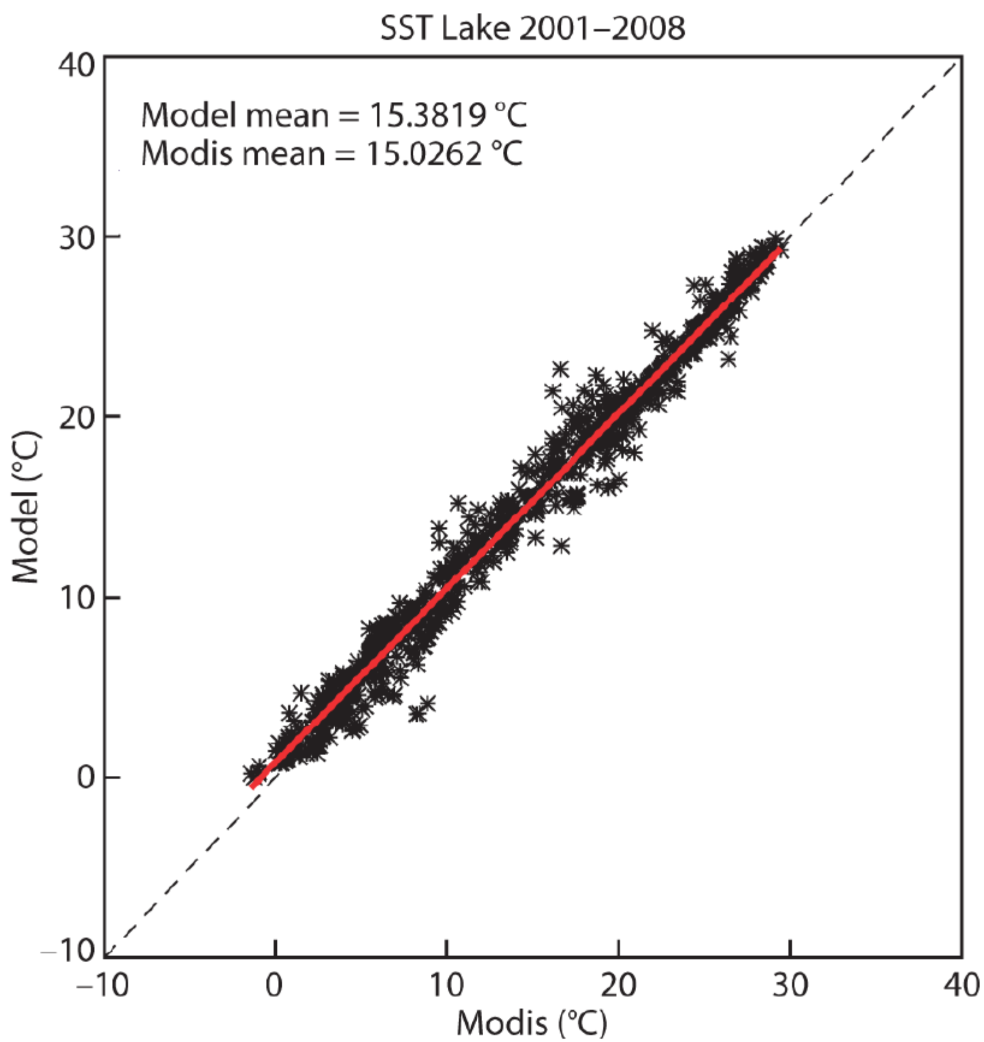
The mean lake depth inversion for Ladoga agrees with in-situ estimates **(Balsamo et al. 2010)**

- Simulation of lake temperature annual cycle strongly depends on lake-depth
- The observed lake depth (grey line) seems to minimize errors (evaluated with MODIS lake surface temperature data)



FLake model in the IFS: global verification

Balsamo et al. (2012, TELLUS-A) and TM 648



- FLAKE Lake surface temperature is verified against the MODIS LST product (from GSFC/NASA)
- Good correlation

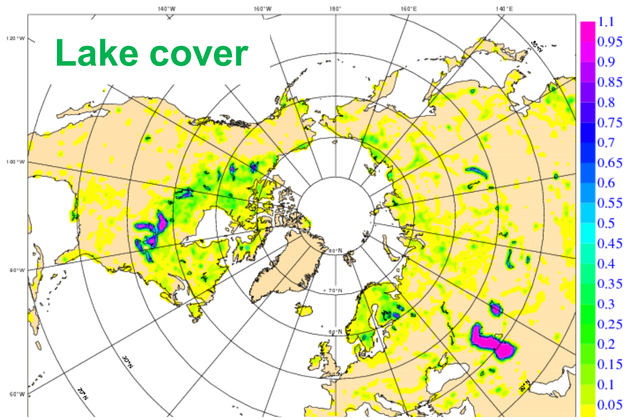
  R=0.98
- Small bias

  BIAS (Mod-Obs) < 0.3 K

ECMWF

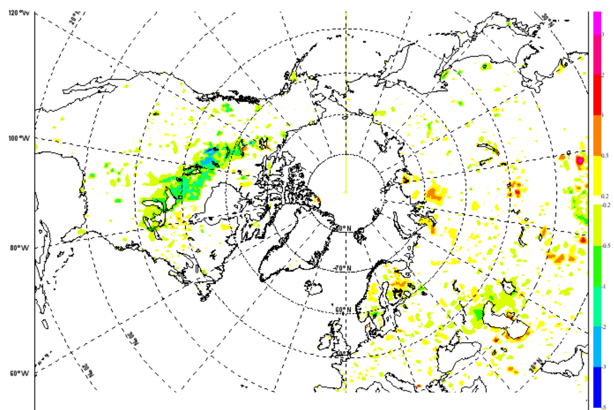
FLake model in the IFS: Forecast impact

Balsamo et al. (2012, TELLUS-A) and ECMWF TM 648



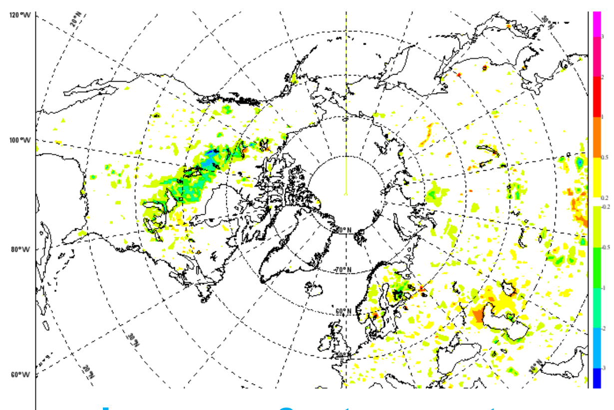
- Forecasts sensitivity and impact is shown to produce a spring-cooling on lake areas with benefit on the temperatures forecasts (day) at 2m.

Forecast sensitivity



Cooling 2m temperature
Warming 2m temperature

Forecast impact

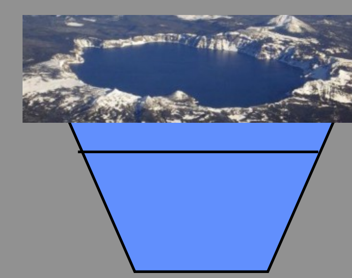


Improves 2m temperature
Degrades 2m temperature

- FLake

Mironov et al (2010),
Dutra et al. (2010),
Balsamo et al. (2010)
Balsamo et al. (2011)

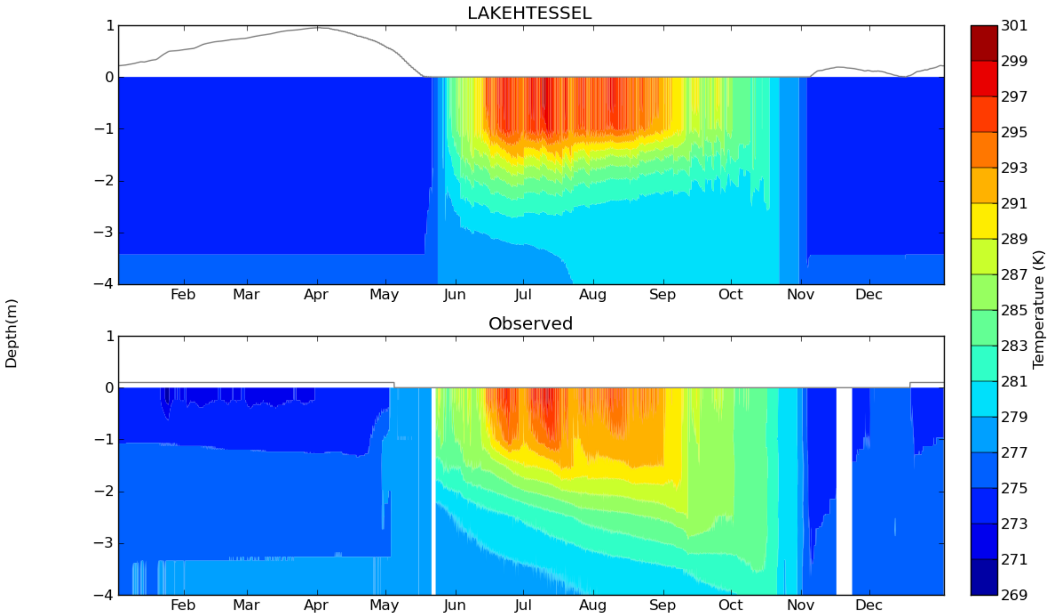
Extra tile (9) to account for sub-grid lakes



ERA-Interim forced runs of the FLAKE model are used to generate a lake model climatology which serves as IC in forecasts experiments (Here it is shown spring sensitivity and error impact on temperature when activating the lake model).

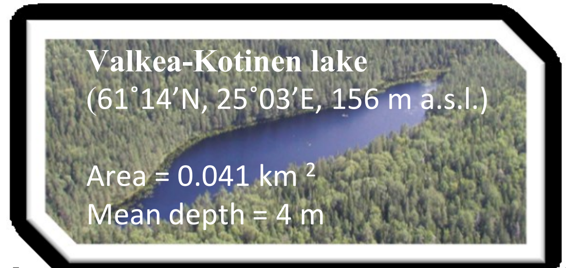
ECMWF

FLake model compared to lake observations



2006

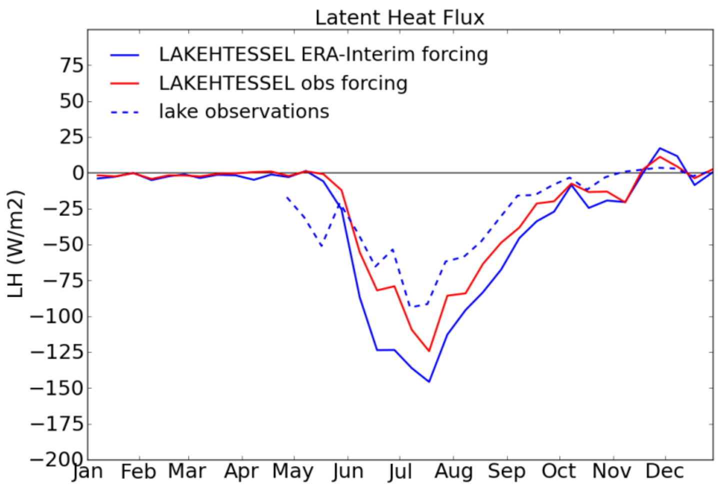
Comparison of FLake (Mironov et al. 2010) model output as provided by the LAKEHTESSEL model version, in an offline experiment for an instrumented lake site:

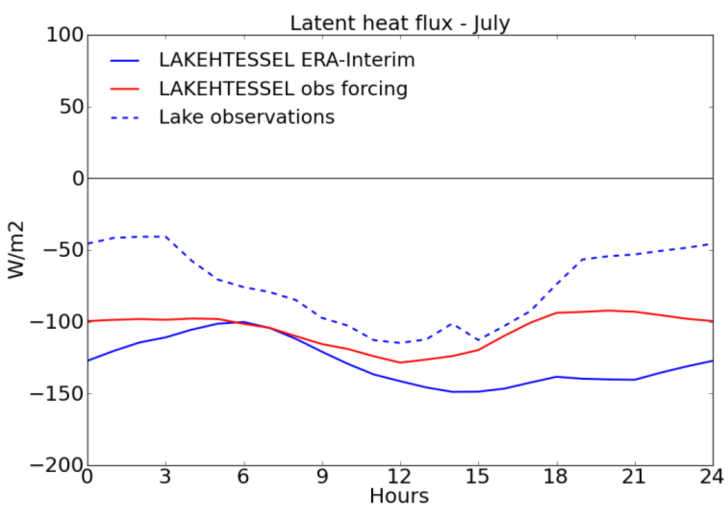


Andrea Manrique Sunen et al (2012)

- Surface temperature very well reproduced → relevant for NWP
- Deepening of the mixed layer from July to August underestimated
- Model's ice-covered period overestimated (first/definite ice formation 48/5 days early, melting 14 days late). Due to not representing snow insulating effect in LAKEHTESSEL.
- Winter: bottom layer 2˚C too cold. Due to bottom sediments not in LAKEHTESSEL (negligible for deeper lakes).

Use of observed forcing vs ERA-Interim for the lake site



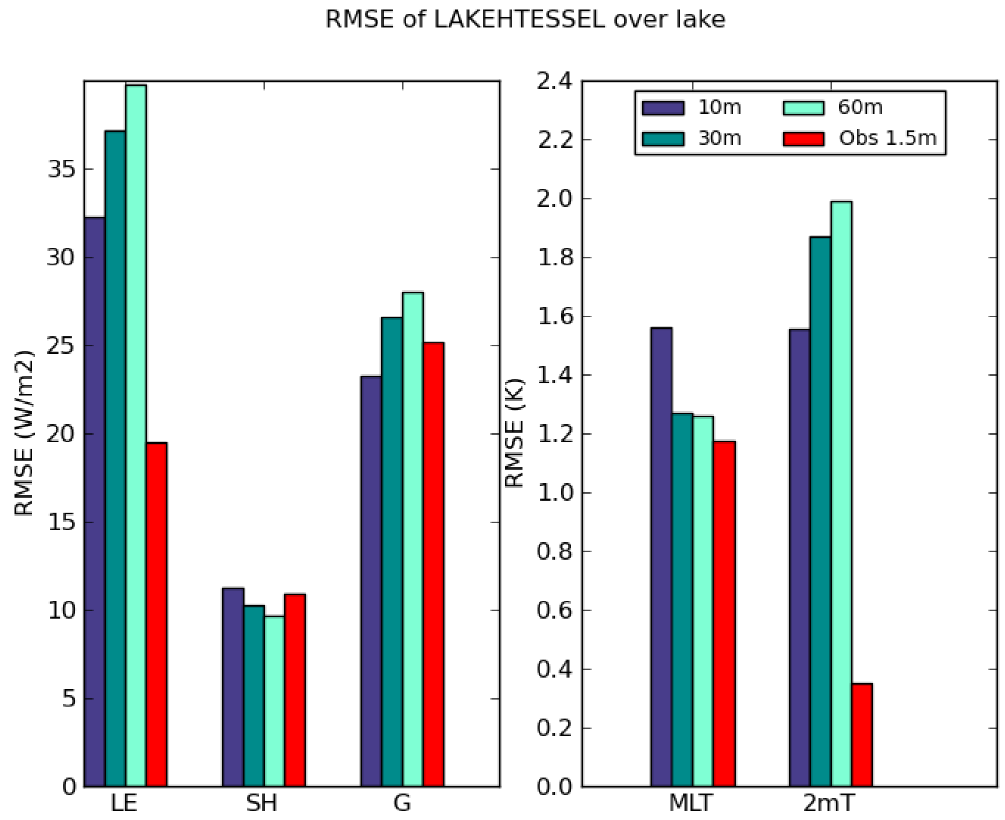


Seasonal cycle:
The use of observed forcing reduces the RMSE in evaporation from 32 W m^{-2} to 19 W m^{-2}

Diurnal cycle for July:
The evaporation is reduced, but errors remain at night. The model's transfer coefficients might not be appropriate for a calm situation

Manrique Suñen, EGU 2012

Forcing height influence on the offline runs: Energy fluxes



The increase in forcing height enhances the already overestimated evaporation.
The error in latent heat increases by 7 W m^{-2}

Conclusions and perspectives

- Constant SST and Sea Ice in the deterministic forecast, for lake fraction larger than 0.5: based on NCEP, OSTIA and temperature climatology
- Simulating lakes in the IFS: potential of improving near-surface weather forecasting of temperatures as demonstrated in Balsamo et al. (2012).
- The validity and usefulness of the atmospheric blending height hypothesis for NWP applications in presence of lakes is verified in a dedicated study by Manrique Suñen et al. (2012, submitted).
- Characterizing inland water-bodies with their water-temperature has consequences for the radiative transfer and can improve the microwave forward operator (e.g. CMEM) in data assimilation activities.
- The System-4 seasonal forecast (Molteni et al. 2011) already benefits from a FLAKE-derived lake climatology.
- A lake depth dataset is being developed within SRNWP (following Kourzeneva 2011) to support more accurate lakes simulations (collaboration with ECMWF).
- Implementation in CY39 is envisaged (technical “plumbing” and links with OSTIA lake-surface temperature and lake-ice need further studies).