



Magical kingdom of ECMWF

True story told by Land Team

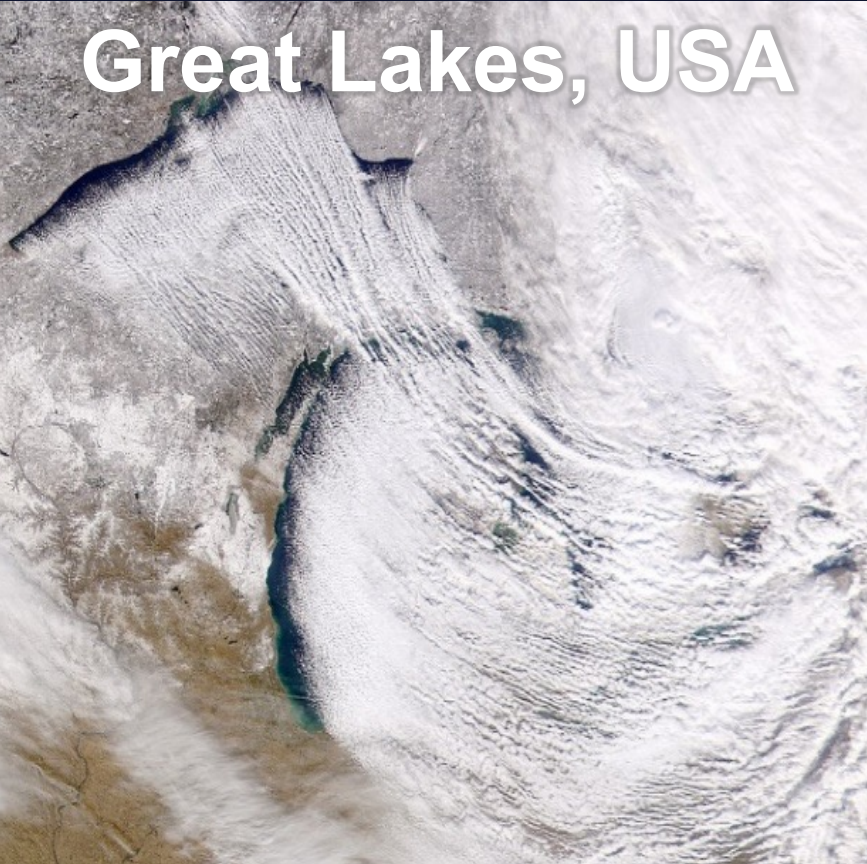
Life is better with lakes*

... they can be found all around the Globe

* Here, term “**lakes**” is used in the broad sense of **any inland water body** which lateral movement of water is neglected (i.e. lakes, reservoirs, rivers and coastal waters), although a clear separation is often complex and varies in time.

Once upon a time in a **magical kingdom of ECMWF** people were predicting weather all over the world. They were working hard every day to be one step closer to their **common goal – to provide world-leading weather predictions and monitoring of the Earth system to its member states, which helps save lives and protect infrastructure**. Kingdom of ECMWF was representing different surfaces – oceans, forests, fields, and empty lands, but not **lakes** (NB! globally lakes occupy about 3.7% of the land surface).

Lakes influence local weather climate: *During freezing/melting* - different surface energy balance.



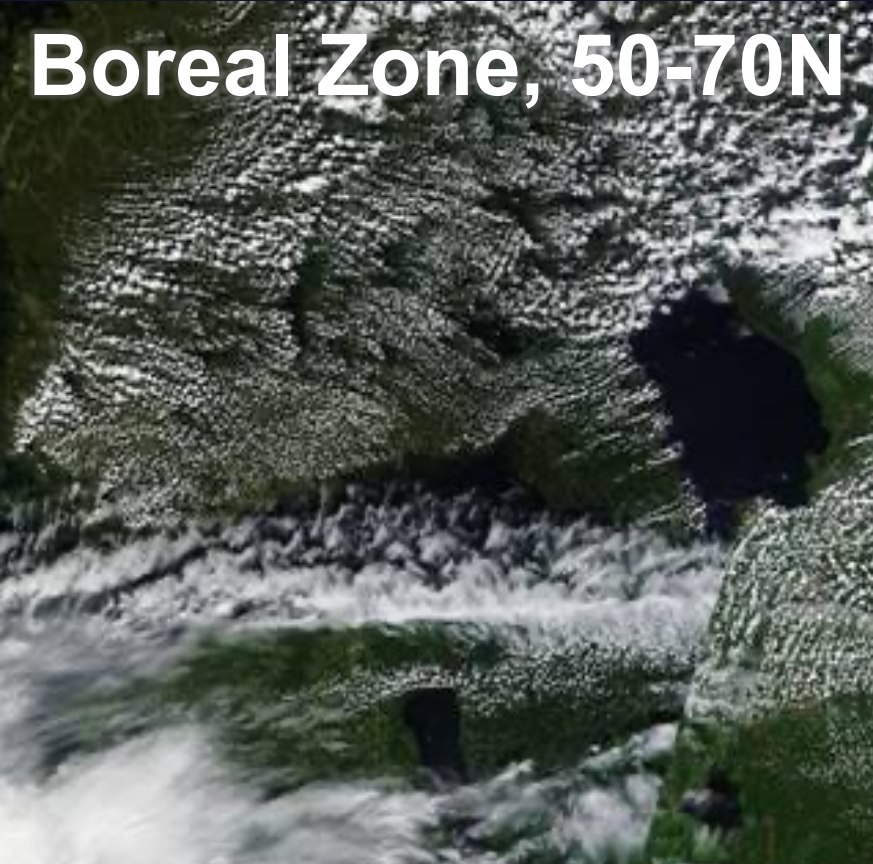
Great Lakes, USA

Can intensify winter snowstorms



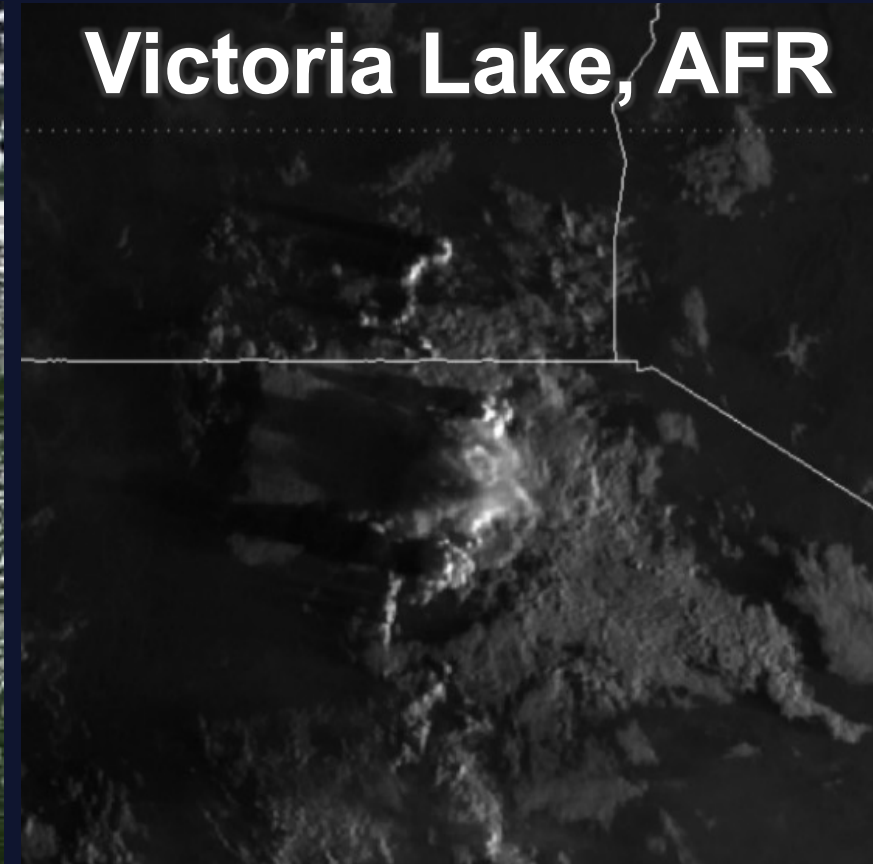
Ladoga Lake, RUS

Can generate low clouds & increase T2m up to 10 °C in neighboring country



Boreal Zone, 50-70N

Usually cause a decrease of summer precipitation



Victoria Lake, AFR

Generates night convection with intensive thunderstorms – death of 1000s fisherman every year!



Small shallow thermokarst lakes

Small shallow type of lake is the most common (~77 % of the lakes globally), emit carbon dioxide CO₂ and methane CH₄ through the lake's surface, and influence green house gas budget!



Methane degassing

In **2006** a brave LakeMan arrived to the kingdom of ECMWF. He started by looking into different parts of the model code and soon realized that **lakes** are still only **treated indirectly** – their **surface temperature** is prescribed as a **lagged 2m temperature** by a **month**, or as a **sea surface temperature climatology**.

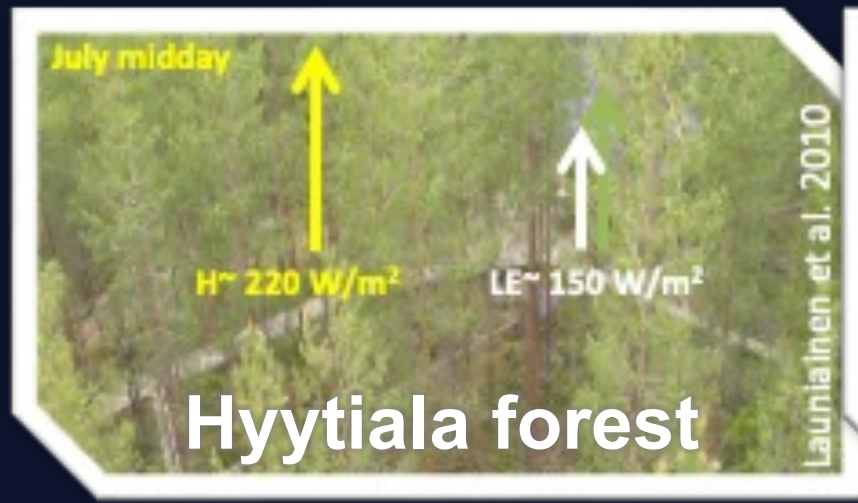


Lake Man

In **2008** a brave LakeMan traveled over the horizon to Zelenogorsk, Russia where he met other LakePeople from all around the world. They were very friendly, and shared a lot of passion, knowledge and lake observational data.



1st Workshop "Parameterization of Lakes in Numerical Weather Prediction and Climate Modelling"



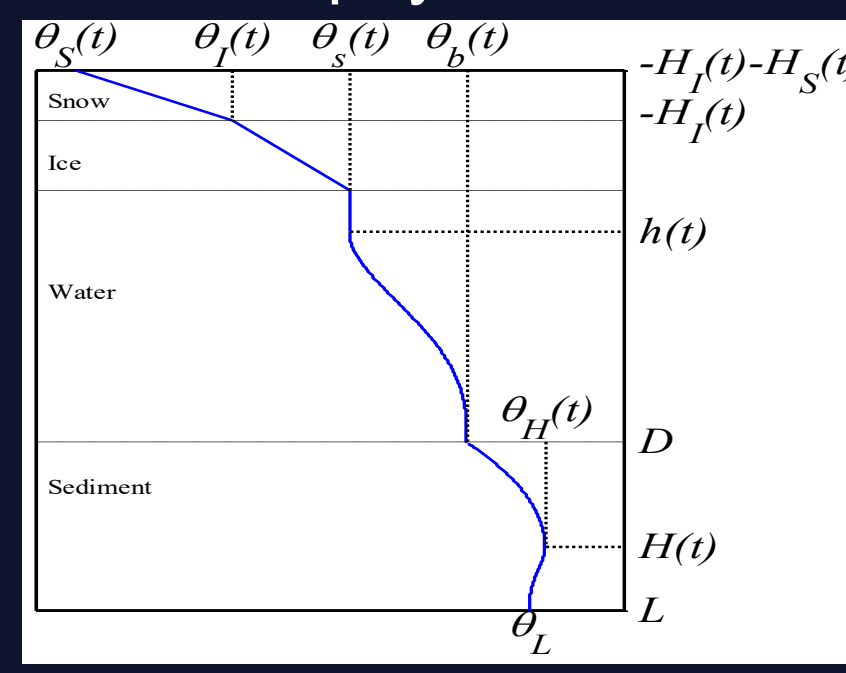
Hyytiala forest



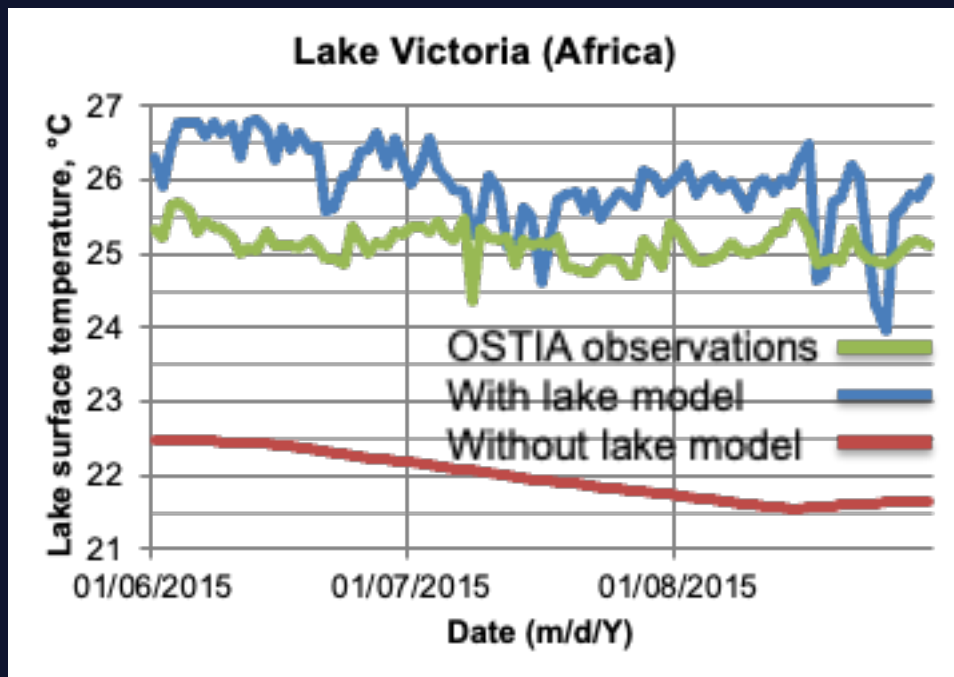
Valkea-Kotinen Lake

In situ data, stations are ~80km apart, big difference in sensible heat flux!

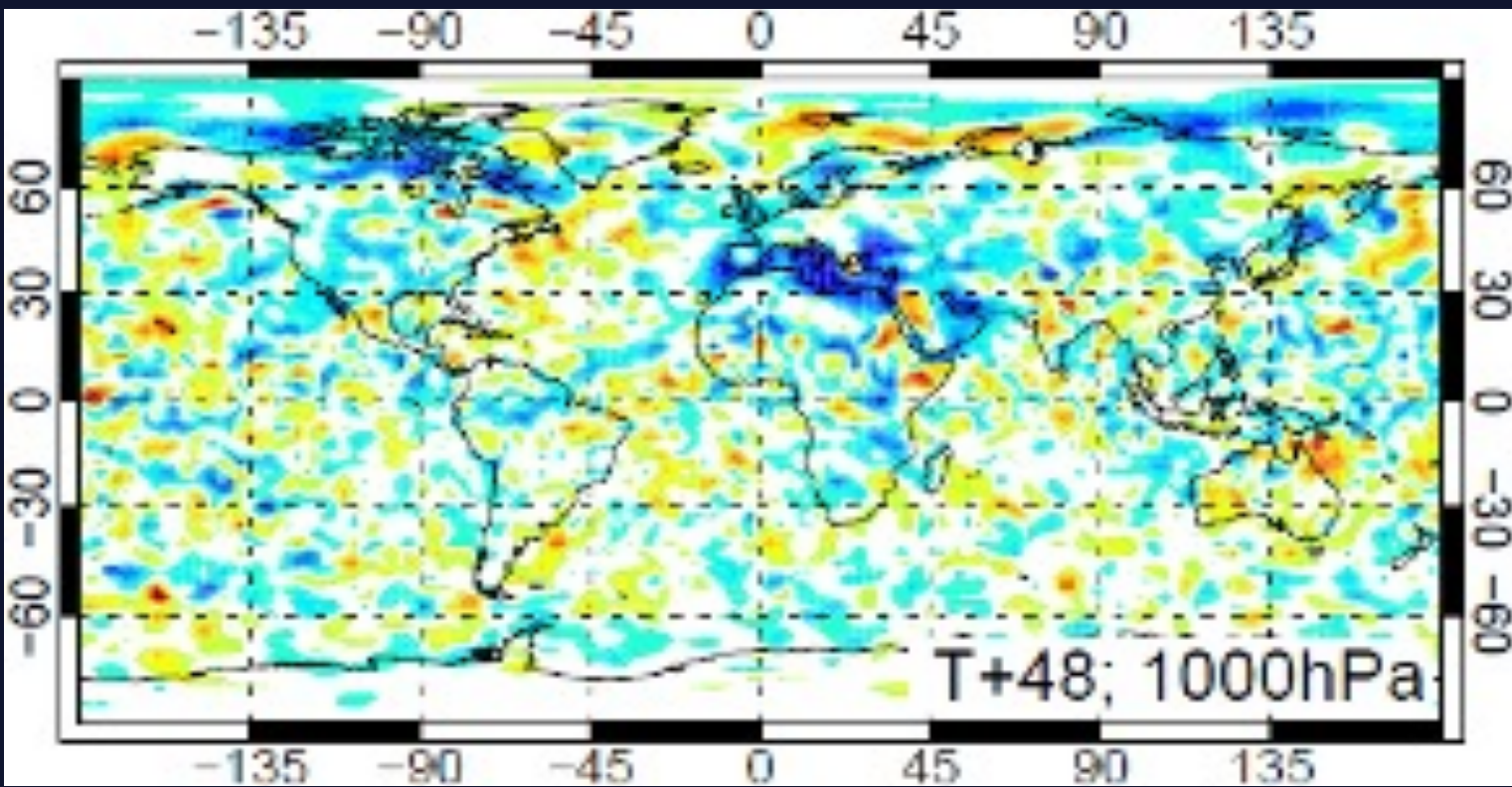
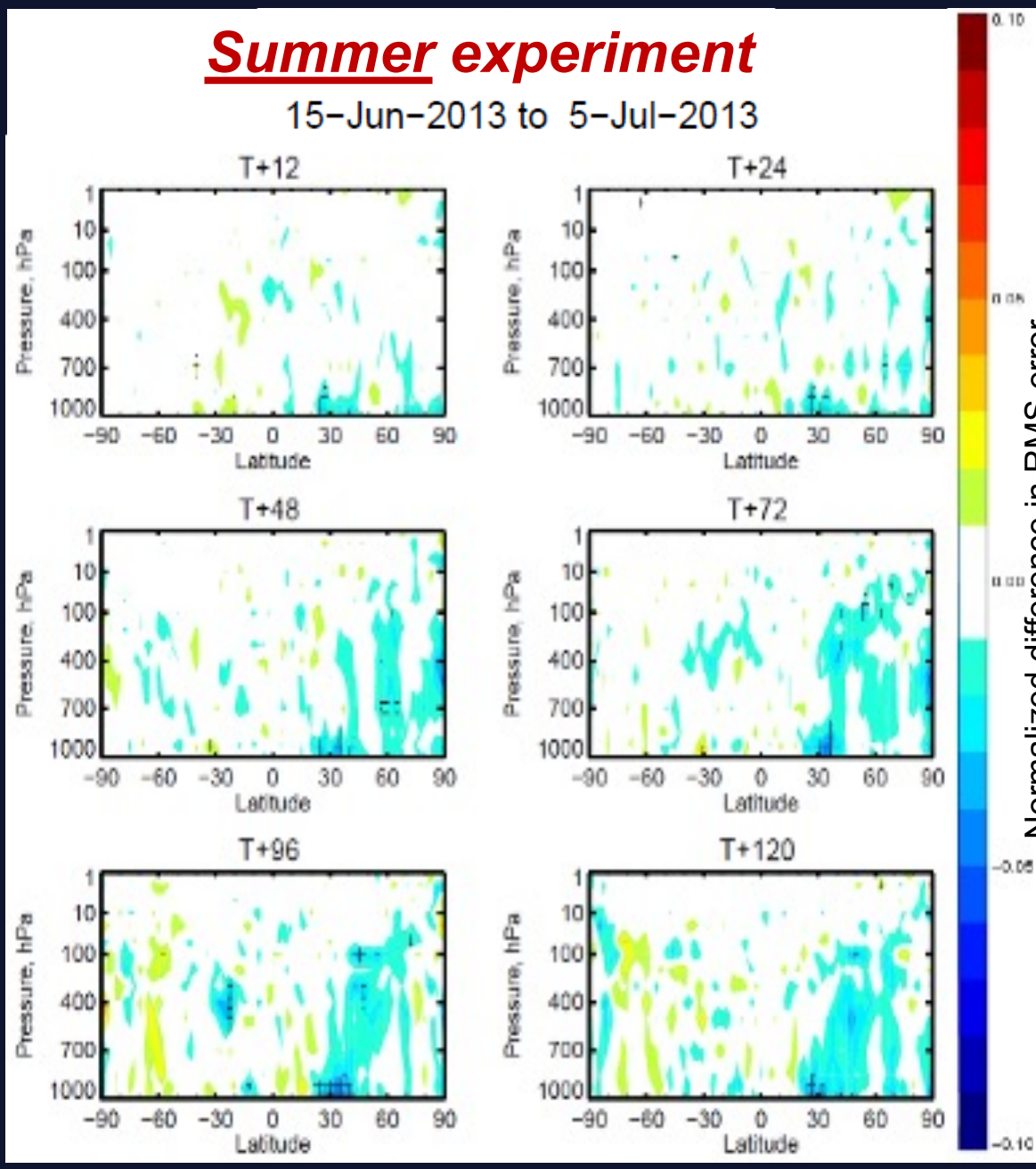
Fresh-water Lake model **FLake** – one-dimensional **computationally efficient shallow-water** model that incorporates most of the essential physics.



In **2015** a brave LakeMan together with LakePeople **operationally** introduced **lakes** into kingdom of ECMWF model surface scheme **ecLand** by including **FLake** model. FLake runs over every grid cell with **no bottom sediments** and **no snow accumulation**, has **fractional ice**, and stores **6 prognostic variables**.

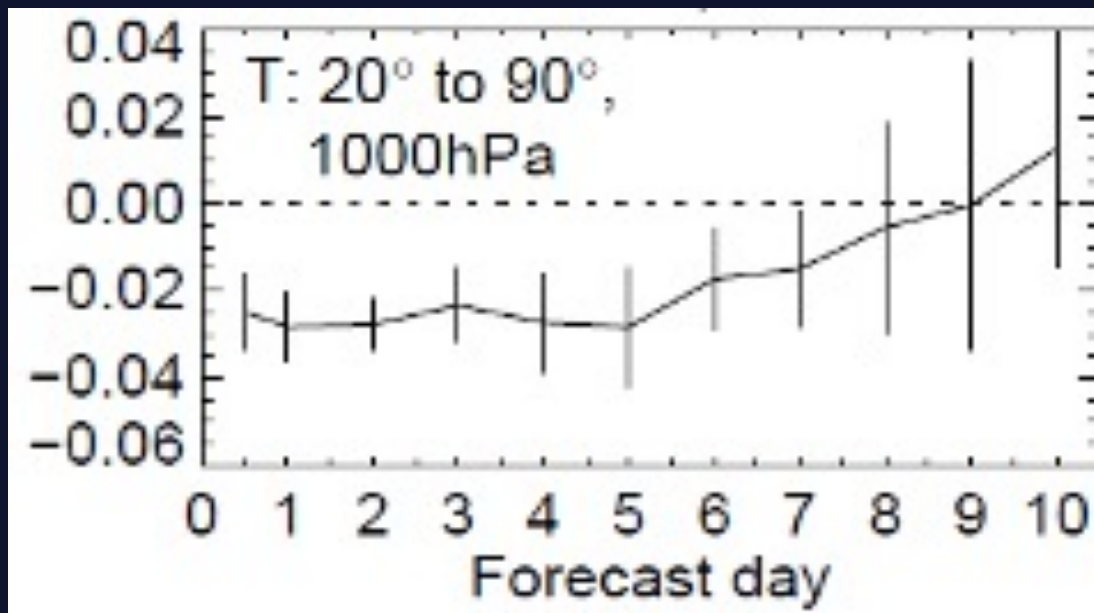


- reduced lake temperature bias for big and deep lakes (e.g. Lake Victoria, Great Bear, Titicaca);
- generally, more realistic temperature diurnal variability.



Analysis experiment show:

- propagation of the positive impact (blue colours) on T2m to higher model levels up to day 5! during summer;
- reduction of mean model temperature error over Northern hemisphere in summer.

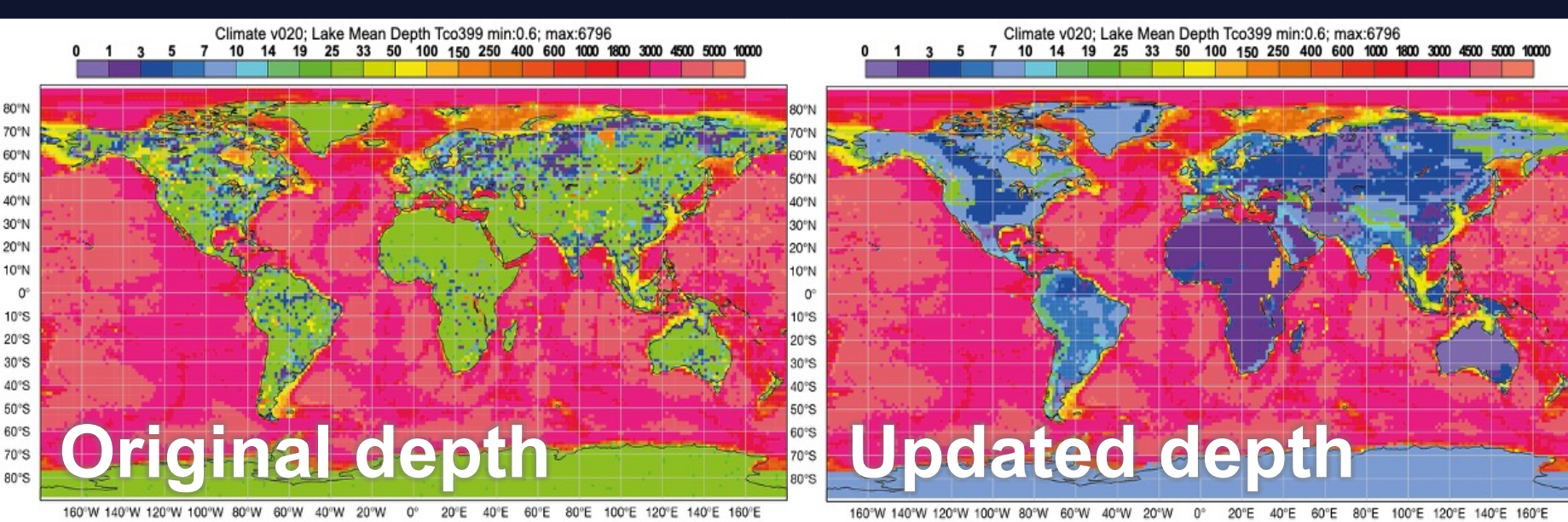


- near lakes T2m forecast is improved;
- during summer there is 2-3% of relative improvement in 1000 hPa temperature RMSE, with significance of up to 7 days;
- during winter RMSE impact is also positive and around 1%.

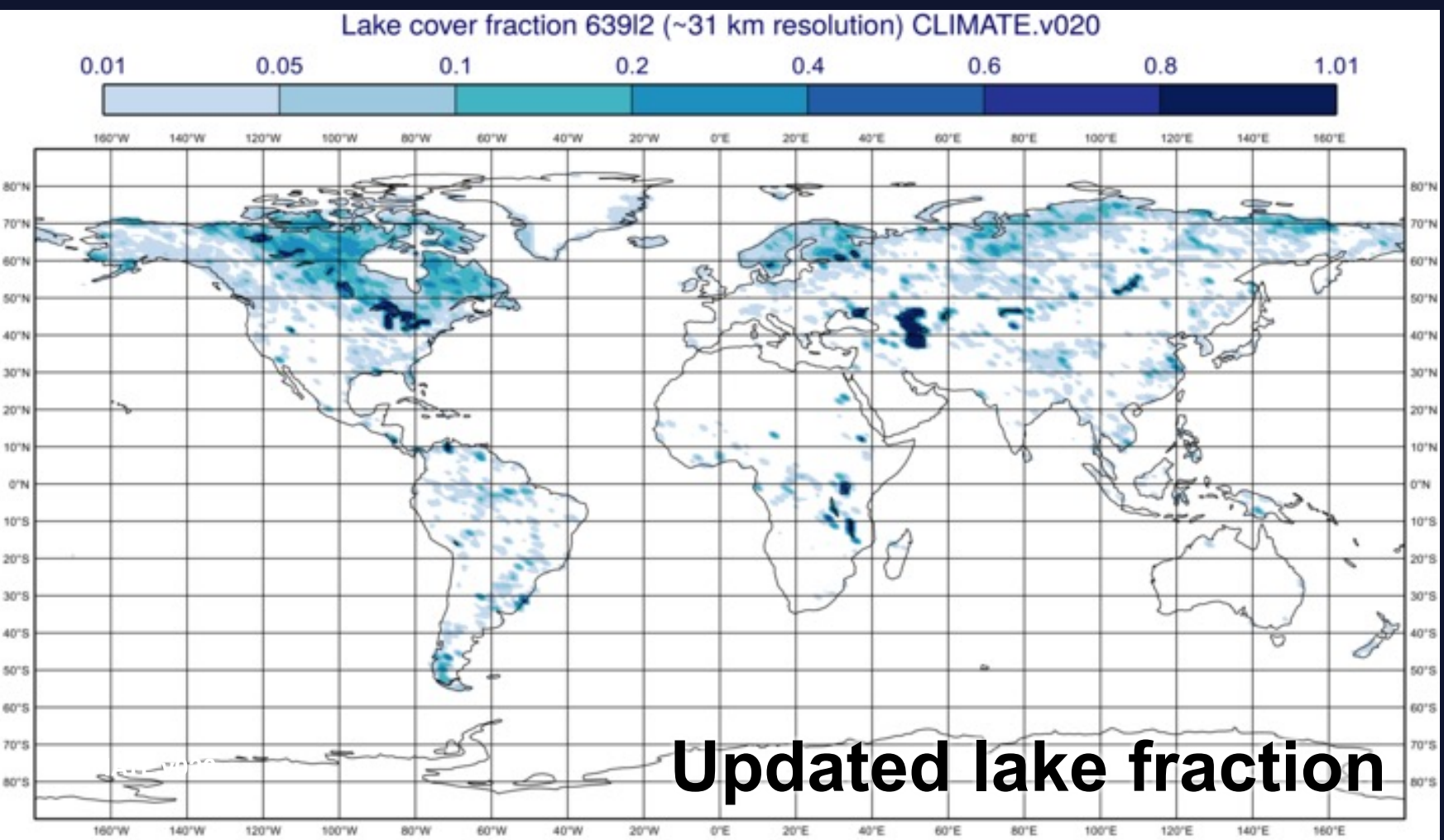
In **2017** a passionate LakeLady moved to the kingdom of ECMWF. She knew that lake parametrization needs external fields: **fractional lake cover** and lake **depth** (preferably bathymetry; accurate and up-to-date, **global & continuous**).



Lake Lady



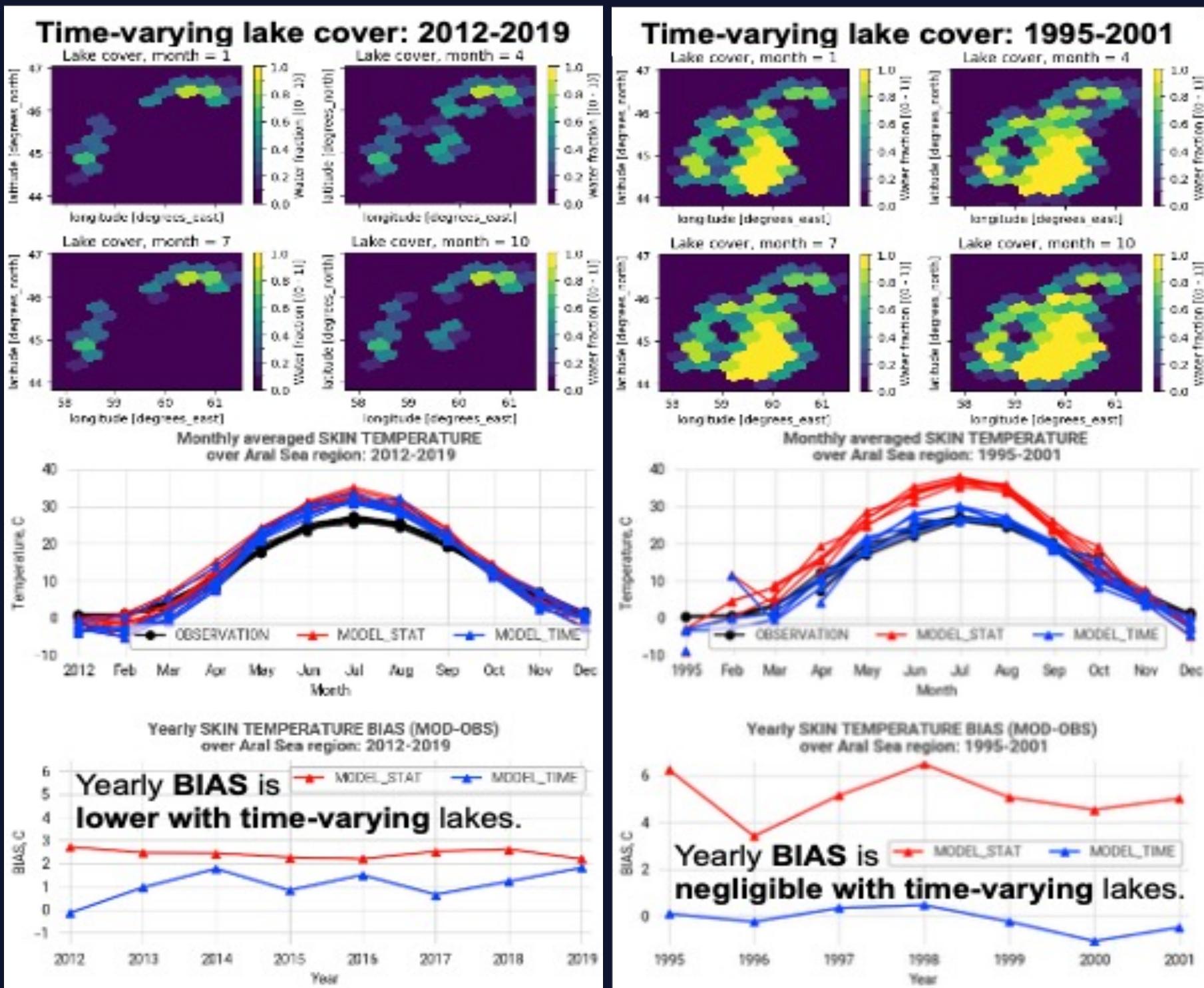
Default lake depth 25m (green, left) updated with indirect depth estimates based on lake geological origin. Blue-ish colors refer to 5-10m which much better represent reality. Tskin annual cycle amplitude changes for 1K when 1-7m deep lake depth changes by 1m (16-40m deep lake depth changes by 3m).



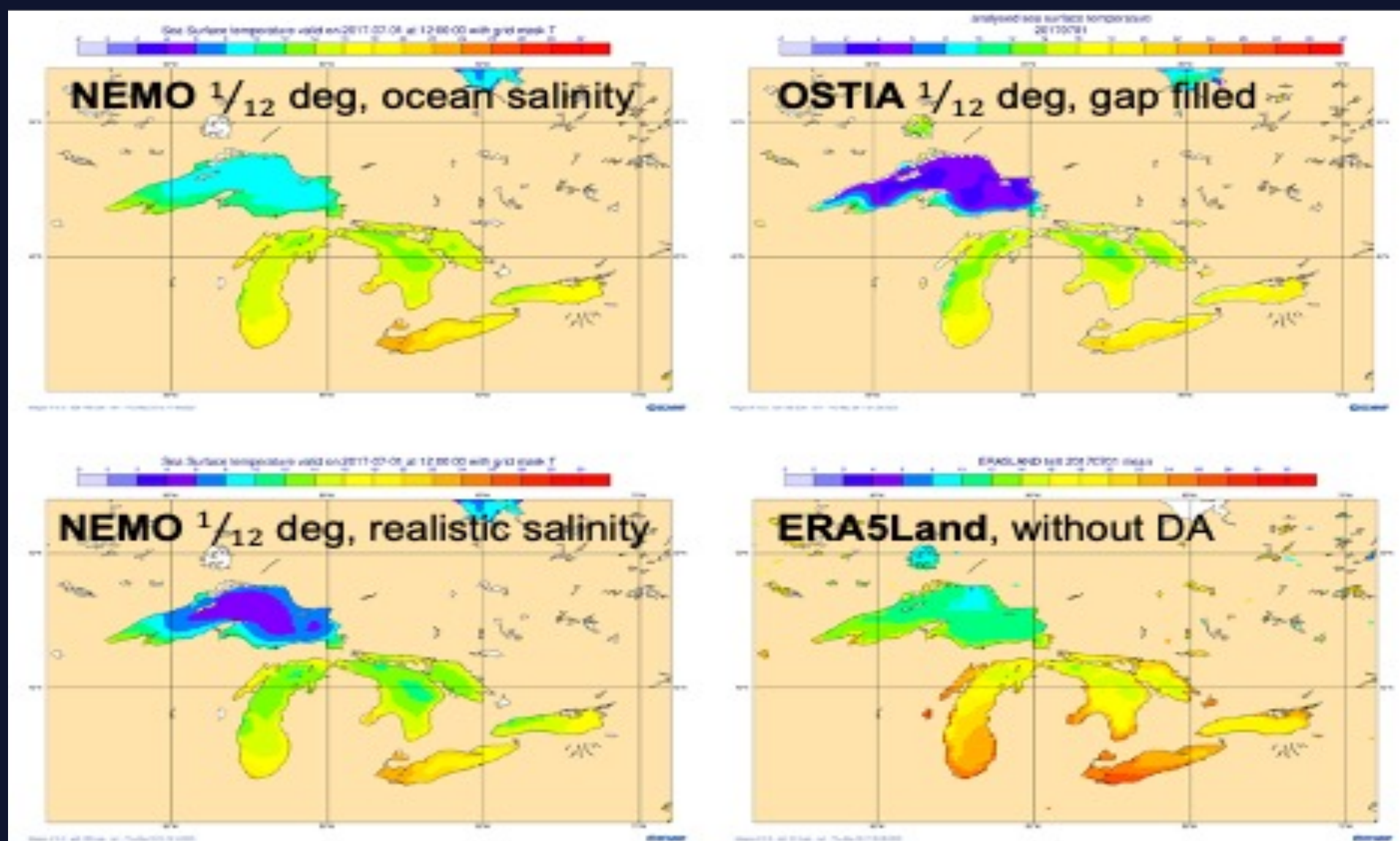
Updated lake fraction

In **2024** she generated **time-varying lake covers & updated ecLand** to use them – reduced yearly Tskin overestimation for all epochs (in 1995-2001 over erroneously not water-covered areas yearly **BIAS reduced by 10 °C!** over Aral Sea region). It will be used in ERA6Land reanalysis.

And now she needs to adapt lake depth for time-varying lakes...



Ocean Guy



In **2025** an OceanGuy with Viking blood tried to take away some **big lakes** from LakeLady and model them with **NEMO** ocean model. OceanGuy was friendly and only wanted to help - his **first results** proved that including **3D dynamics in big lakes** significantly **reduces** summer temperature **overestimation**, and **can improve ice** duration dates.



Wave Jedi

In **2024**, Wave Jedi was the first to use updated lake depth outside lake parameterization. He used it for **wave forecasts** over lakes – step towards fully consistent coupled model.

In **2025** Seasonal Oracle updated calculation of temperature change with depth parameter – reduction of large lake summer temperature overestimation.



Seasonal Oracle