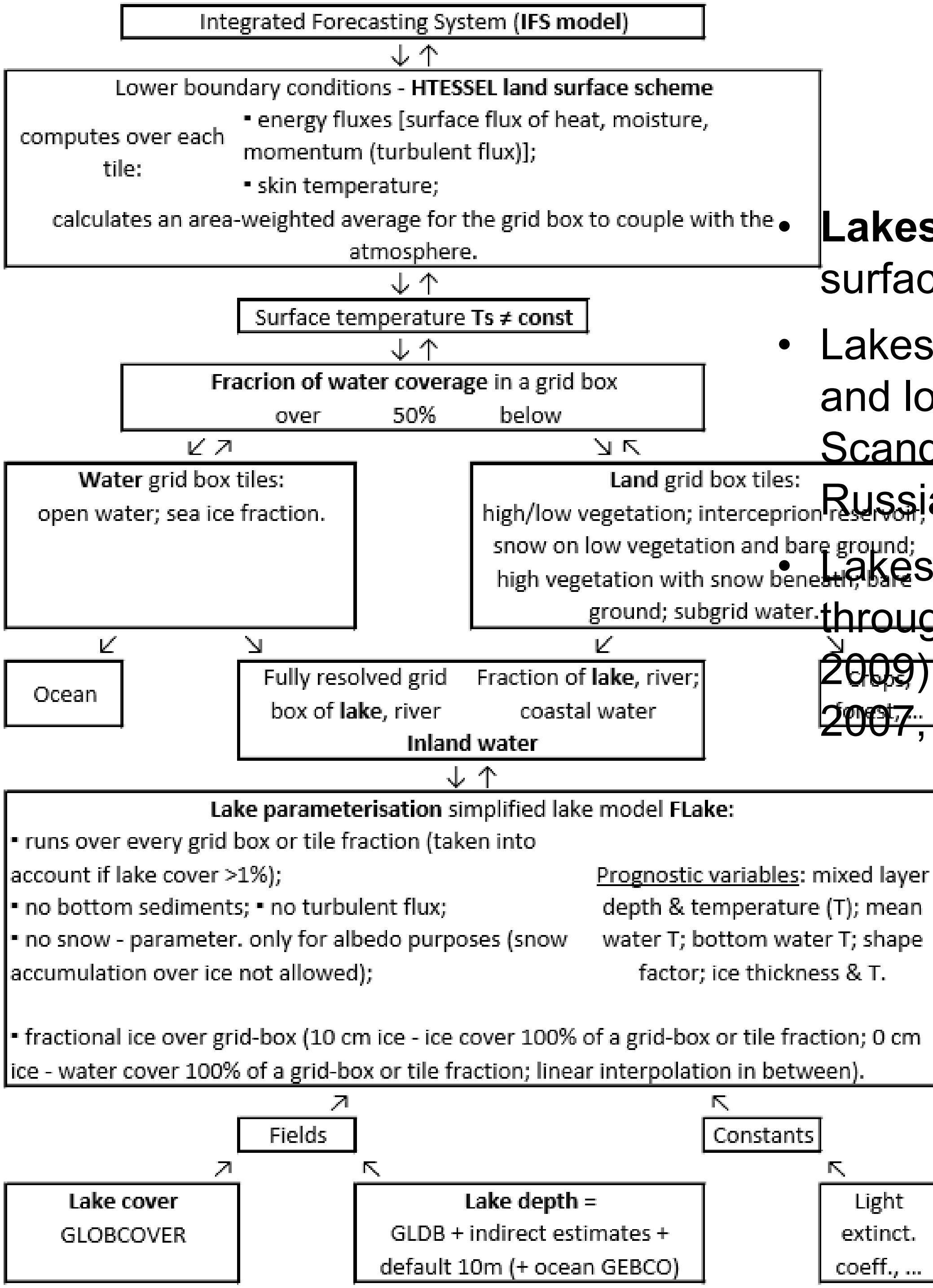
LAKE CLIMATOLOGICAL FIELDS UPGRADE

Thanks to:
Gianpaolo Balsamo,
Ekaterina Kurzeneva,
Souhail Boussetta,
Kristian Mogensen,
Jean Bidlot, …

Margarita Choulga, PhD

ECMWF, Research Department
margarita.choulga@ecmwf.int

BACKGROUND

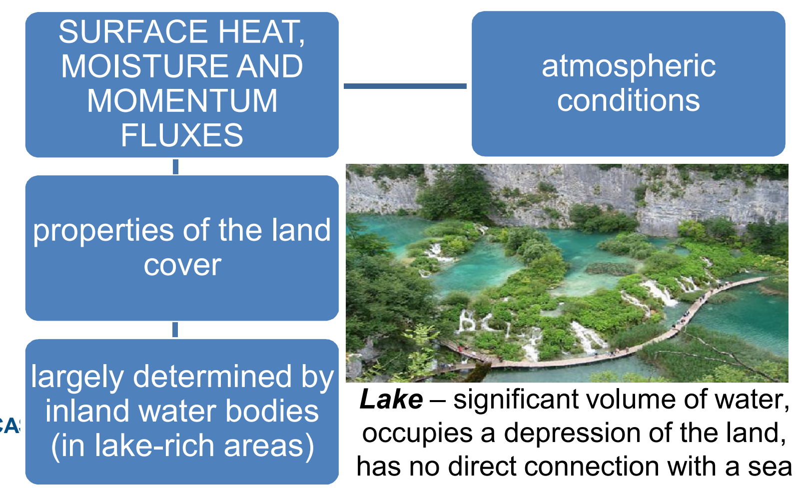


- **Lakes occupy about 1.8%** of the land surface, and are distributed very unevenly.
- Lakes **influence local weather** conditions and local climate. Especially in Canada, Scandinavian peninsula, Finland, northern Russia including Siberia, etc.
- Lakes can **influence global climate** through carbon cycle in lakes (Tranvik et al. 2009) and thermokarst lakes (Walter et al. 2007, Stepanenko et al. 2011).

Parametrization of lakes in NWP and climate models **needs**:

1) lake location (**lake cover**);
2) lake morphological parameters – the most important **LAKE DEPTH** (used by all lake models!).

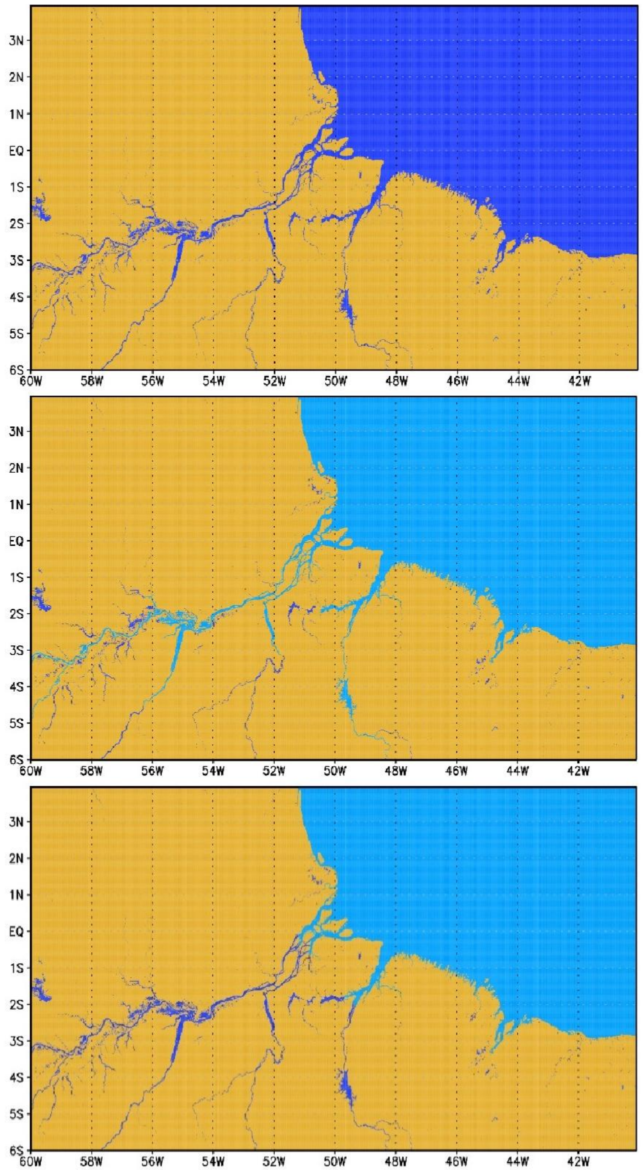
For the atmospheric modelling **global coverage** of data is essential!



Lake – significant volume of water, occupies a depression of the land, has no direct connection with a sea

OCEAN LAND INLAND WATER

LAND SEA MASK and LAKE COVER



GLOBCOVER (2010, nominal resolution ~300 m) – WATER class
(no separation between ocean and inland water bodies [rivers, lakes, etc.]):

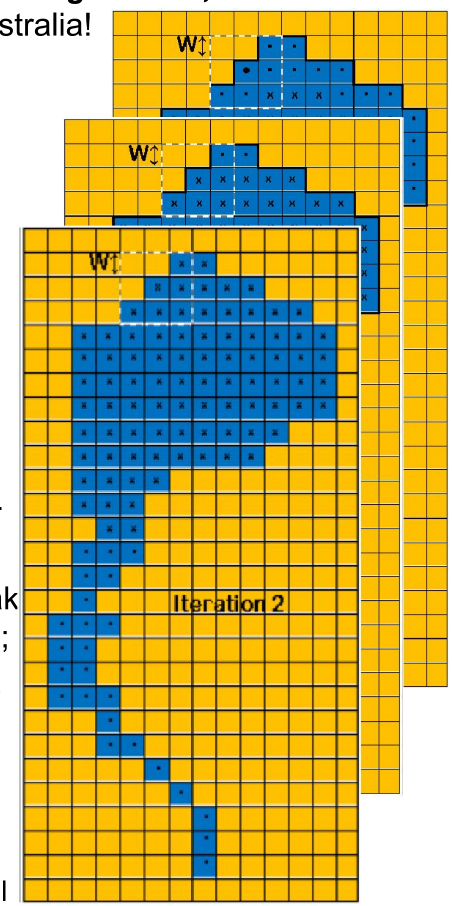
- ***separate ocean from closed inland water (lakes, rivers not connected to the ocean);***
- ***stop ocean from penetrating deep into land through rivers;***
- too much inland water in Aral Sea region and Australia!

Water class division:

1) flooding algorithm (more accurate) to separate ocean from inland water [remaining problem – ocean penetrates too deep into land];

2) newly developed an automatic pixel-by-pixel algorithm separates rivers (lagoon type lakes) and oceans (Kurzeneva E.) –

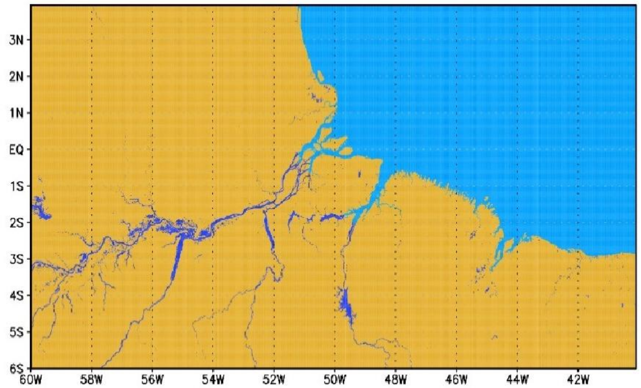
Iteration 0 – for each lake pixel check the window of **W** pixels around; if there are only lak pixels, mark pixel in question with [**x**], else [●];
Iteration 1 – for each lake pixel with [●] check the same window; if there is at least one [**x**], mark pixel in question with [••];
then change [••] to [**x**] and repeat *Iteration 1*.
Number of iterations **L** is chosen according to the data type and resolution.



[**x**] – true lake pixel
[●] – inland water pixel (not lake)

OCEAN | LAND | INLAND WATER

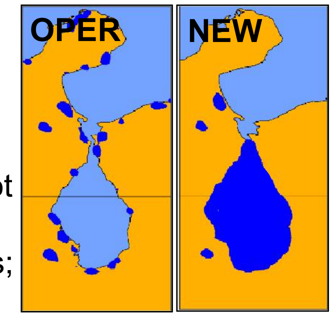
LAND SEA MASK and LAKE COVER – EXTRA!



GLOBCOVER (2010, nominal resolution ~300 m) – WATER class
(no separation between ocean and inland water bodies [rivers, lakes, etc.]):

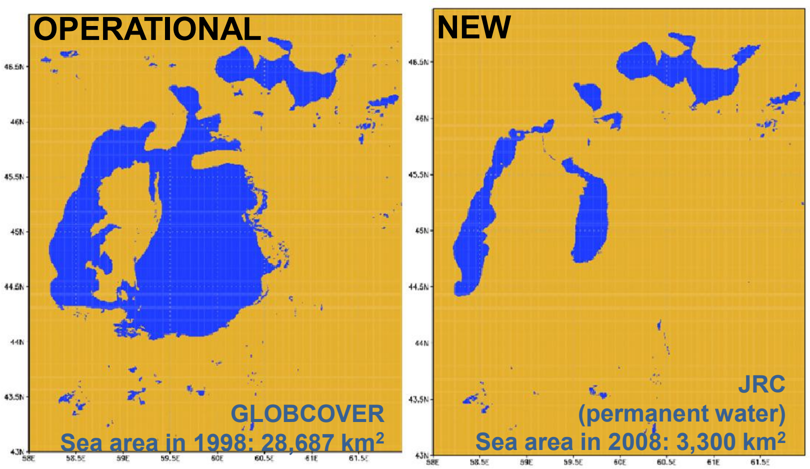
- separate ocean from closed inland water (lakes, rivers not connected to the ocean);
- stop ocean from penetrating deep into land through rivers;
- ***too much inland water in Aral Sea region and Australia!***

MARACAIBO
(25° S, 130° E)



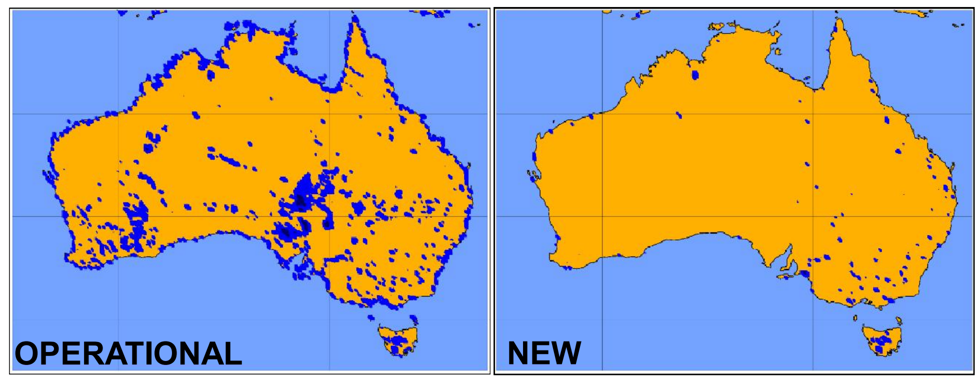
3) manual intervention for lagoon type lakes strongly minimised;

ARAL SEA
(45° N, 60° E)

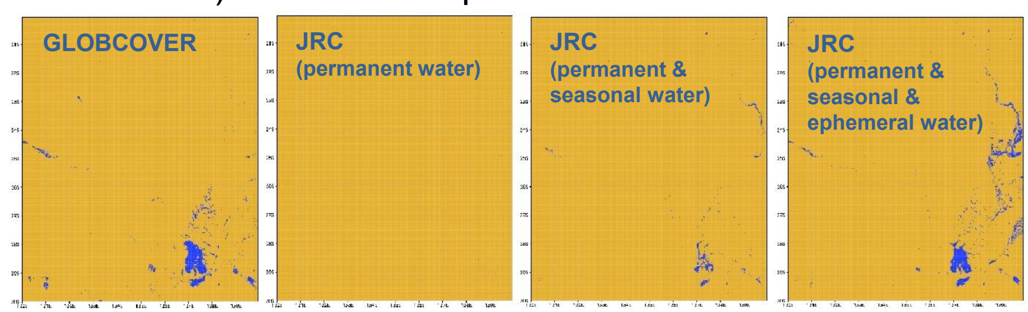


4) minimization of Aral sea;

AUSTRALIA
(25° S, 130° E)

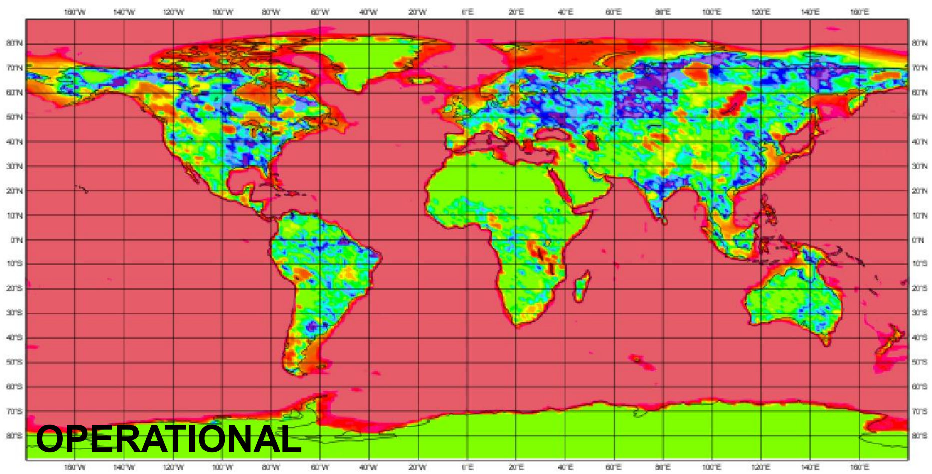


5) Australian ephemeral lake removal.



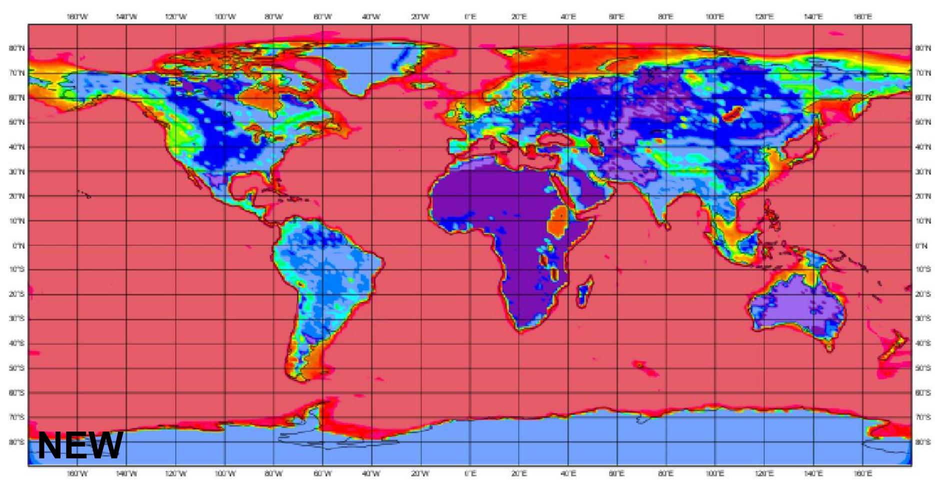
LAKE DEPTH FILE UPGRADE

Essential qualities:
- **global** coverage (data over land & ocean);
- **realistic** depths.



Lake depth:
- **GLDBv1** (2009, in-situ ~13’000)
- bathymetry – **ETOPO2** [~4 km] (Great lakes, Azov sea, Caspian sea)
- default = **25 m**

Ocean: **ETOPO2** (2006, ~4 km)

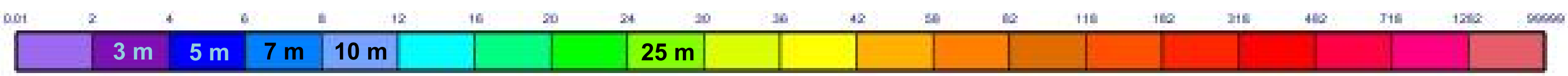


Lake depth:
- **GLDBv3** (2015, in-situ ~14’500)
- **indirect estimates** derived from geological origin of lakes
- bathymetry – **ETOPO1** [~2 km] + **digitized navigation maps** [~1 km] (for 36 large lakes)
- default = **10 m**

Ocean: **GEBCO** (2014, ~1 km) updated with national databases, recent in-situ measurements

MAIN ADVANTAGES:
LATEST UPDATES, REALISM,
HIGH-RESOLUTION GLOBAL COVERAGE,
NO MISSING DATA

Aggregation to a coarser **resolution** (from 1 km) with modified **MODE** algorithm (not AVERAGE).



VERIFICATION AGAINST IN-SITU OBSERVATIONS

Surface off-line experiments (**no feedback** of the **surface into** the **atmosphere**) with **IFS** model (CY43R3), horizontal **resolution ~25 km** (Tco399), ERA5 forcing, **01.06.2016-30.06.2017** (with 5 years of spin up).

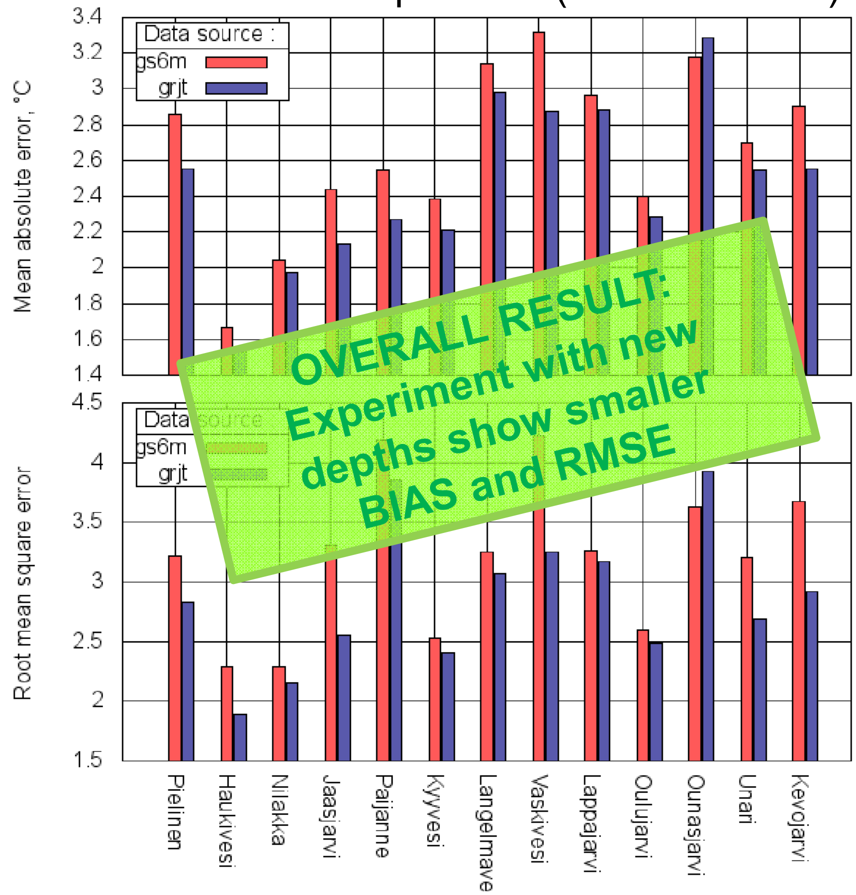
Finnish Environment Institute (SUKE):
- **regular in-situ** measurements;
- **once a day** (8.00 local time);
- 20 cm below the water surface, close to lake shore;
- represent daily minimum;
- only during the ice-free season.

Depth	Experiment name
oper	gs6m
new	grjt

For depth influence analysis SYKE observation timing & locations were used.

Lake name	Area, km^2	In-situ depth, m	Oper depth, m	New depth, m
Pielinen	870.8	10.1	3.9	9.0
Haukivesi	560.4	9.1	2.2	7.0
Nilakka	168.3	4.9	17.0	9.3
Jaasjarvi	81.1	4.6	16.1	8.3
Paijanne	1070.0	14.1	29.6	14.0
Kyyvesi	129.9	4.4	1.0	5.5
Langelmave	133.0	6.8	15.0	7.0
Vaskivesi	46.2	7.0	11.3	7.0
Lappajarvi	145.5	6.9	2.3	7.0
Oulujarvi	928.1	7.0	1.8	7.0
Ounasjarvi	6.9	6.6	3.0	7.0
Unari	29.1	7.0	1.0	7.0
Kevojarvi	1.0	7.0	14.0	7.0

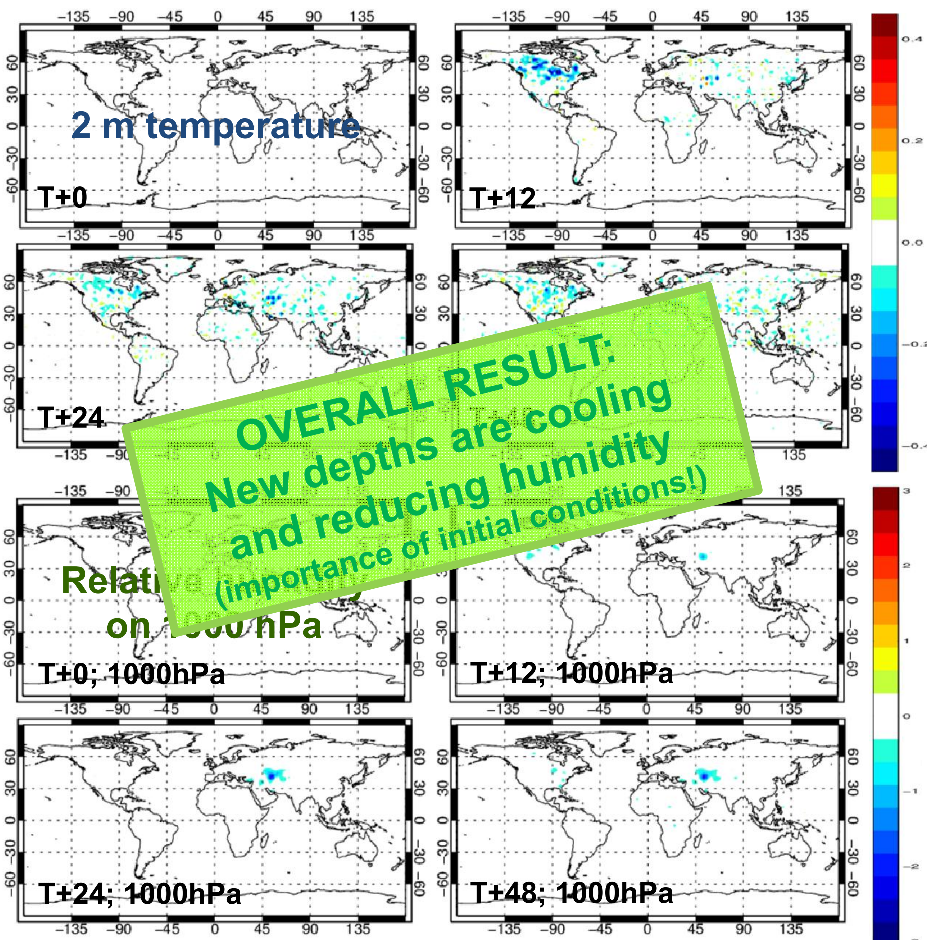
Lake surface water temperature (IN-SITU - EXP):



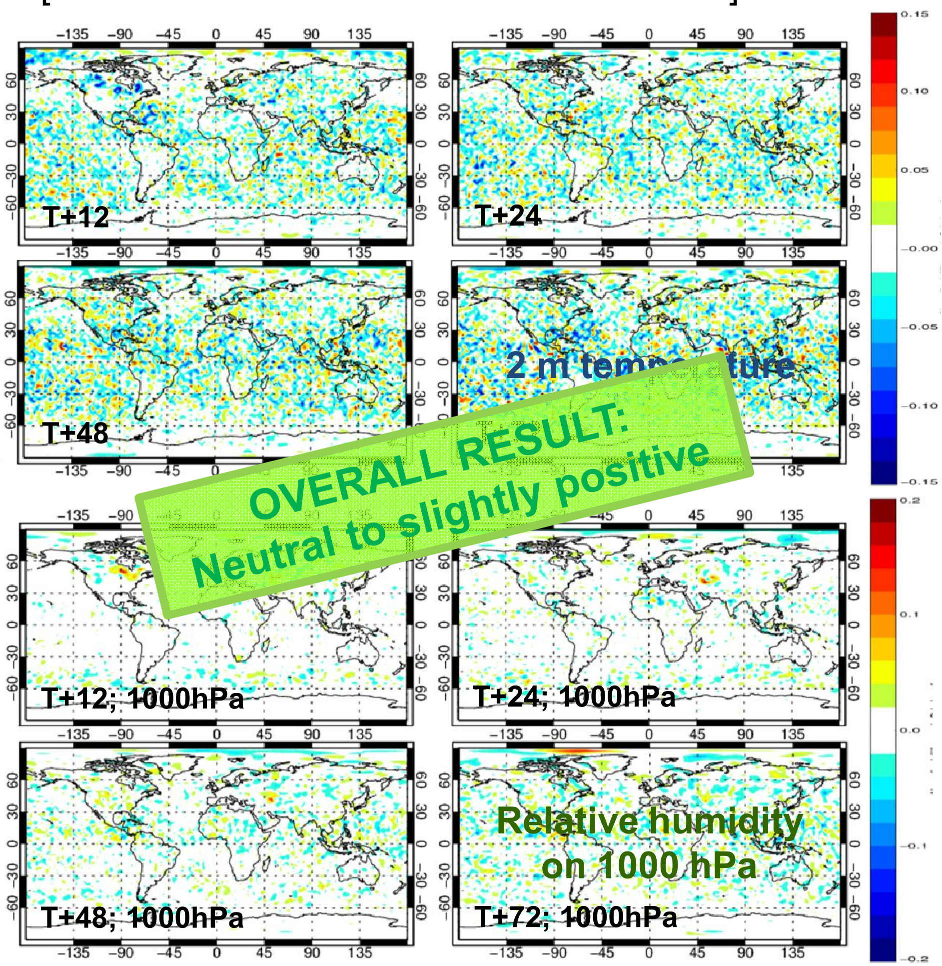
VERIFICATION AGAINST OPERATIONAL ANALYSIS

Forecast experiments, **no surface off-line** (no spin up of lake variables), with **IFS** (CY43R3) model, horizontal **resolution ~25 km** (Tco399), operational analysis, **summer** (JJA) **2016** with **different depths**.

Analysing ***forecast difference*** (EXP_{new}-CTL_{oper}) [difference in time-mean field, %] for:



Analysing ***change in error*** (EXP_{new}-CTL_{oper}) [normalized difference in Std. dev. of error] for:



CONCLUSIONS AND FUTURE PLANS

Land sea mask and **lake cover** upgrades:

- ✓ no deep penetration of ocean into land through rivers (using newly developed an automatic pixel-by-pixel algorithm);
- ✓ manual intervention for lagoon type lakes strongly minimised;
- ✓ Aral sea area was updated (using JRC 30 m resolution dataset);
- ✓ Australian inland water distribution was updated (using JRC 30 m resolution dataset + opinion from local meteorological weather service).

Forecast sensitivity experiments have to be done and analysed in modified areas!

Lake depth high-resolution global coverage file with latest available information was created.

More forecast sensitivity experiments have to be done!

STILL TO DO:

- ❑ **investigation of the Light Extinction Coefficient** (second the most important parameter for lake parameterization) impact to the forecast – ongoing job;
- ❑ **collaboration with JRC** to produce **monthly climatology maps of lake cover** (+ forecast sensitivity to lake cover adaptation);
- ❑ adjust **lake mean depth** values **according to precipitation-evaporation** budget.

To achieve these goals lake surface high resolution maps (30 [JRC database] and 300 m, 1 km [**Copernicus Waterbody** dataset]) will be used.

ALWAYS ONGOING:

- ➢ GLDB adaptation to **higher resolution** land cover map (GLOBCOVER) – in progress;
- ➢ GLDB **update with mean depth** data for individual lakes;
- ➢ adding **bathymetry data** for large lakes;
- ➢ adding data for **reservoirs** and **salt lakes**.