Update of lake cover for NWP modelling

Margarita Choulga[1],

Souhail Boussetta[1],

Ekaterina Kourzeneva[2],

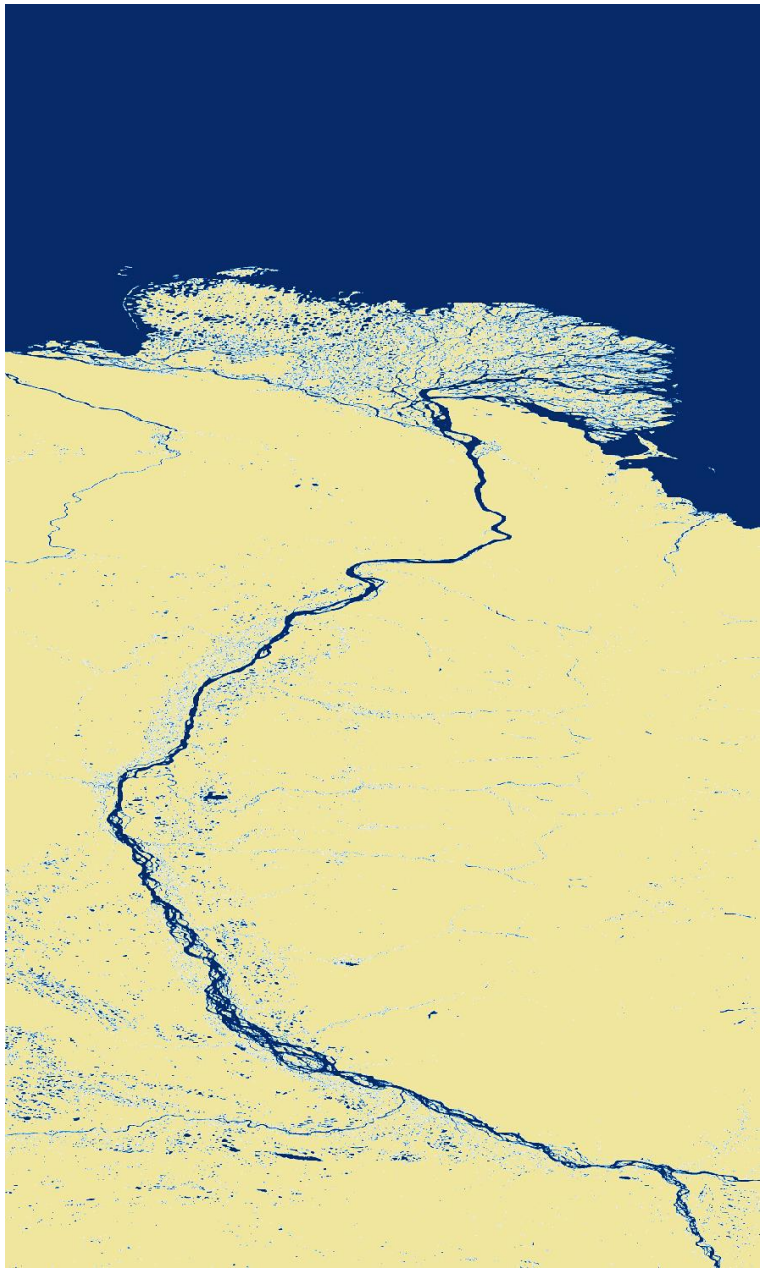
Gianpaolo Balsamo[1]

[1] ECMWF, Research Department, Reading, UK

[2] Finnish Meteorological institute, Helsinki, FI

Corresponding author:
margarita.choulga@ecmwf.int

Supported by **CO2 Human Emission (CHE)** and **Copernicus Emergency Management Service – Early Warning Systems – operational computational centre of EFAS (CEMS-Flood) projects**.
The CHE project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 776186.
The CEMS-Flood project has received funding from European Commission Copernicus Emergency Management Service (CEMS) Framework Contract No 198702 awarded to ECMWF.



Background

- Globally **lakes** occupy about **3.7 % of the land** surface (Borre, 2014; Verpoorter et al., 2014), and are **distributed** very **unevenly**.
- **Surface heat**, **moisture** and **momentum fluxes depend** not only on atmospheric conditions but also on the properties of the land surface, which **in lake-rich areas** are largely determined by **inland water bodies**.
- Lakes can **intensify** winter **snowstorms**, **increase precipitation** and surface **temperature**, **generate dangerous weather** phenomena such as night convection and intensive thunderstorms.

Objectives

- Create an **up-to-date water** distribution map suitable for NWP and global related applications **based on high resolution**, **high quality** and **continuously** updated **data**.
- Develop an **automatic method for prompt update** of water distribution map once new input data is available.

Current water distribution map @ ECMWF

- **Mainly** based on the **GlobCover 2009** global map (Bontemps et al, 2011; Arino et al., 2012): nominal **resolution** of **300 m**, Plate-Carree (WGS84 ellipsoid) projection, available **from 60° S to 85° N**, only **one "water" type** - does not distinguish between ocean (sea) and inland water bodies (lakes, rivers, etc.).
- **Corrected** over **Iceland** with the Digital map database of Iceland (**IS 50V**): conical Lambert projection (the reference is ISN93 or ISN2004).
- **Corrected** over **Australia**, **Aral Sea**, **Alqueva Reservoir** with Global Surface Water Explorer (**GSWE**) dataset the Water Transitions facet (Pekel et al., 2016): nominal resolution of 30 m, Albers Equal Area (WGS84 ellipsoid) projection.
- **Over polar regions** (south of 60° S) uses the high-resolution Radarsat Antarctic Mapping Project (RAMP) digital elevation model (DEM) Version 2 (RAMP2) data (Liu et al., 2015) for Antarctica: nominal resolution of 1 km, polar stereographic projection, only values 0= water and 1= land.
- In the **Arctic** (north of 85° N) **no land** is assumed.
- **Documentation**: *Choulga, M., Kourzeneva, E., Balsamo, G., Boussetta, S., Wedi, N.: Upgraded global mapping information for earth system modelling: an application to surface water depth at the ECMWF, HESS, 23, 10, 4051-4076, doi:10.5194/hess-23-4051-2019, 2019.*

New water distribution map @ ECMWF

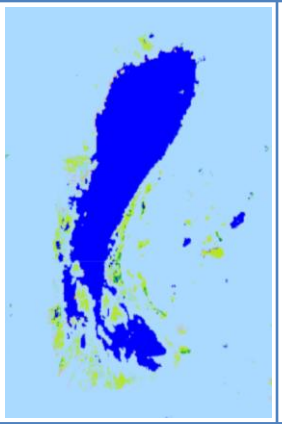
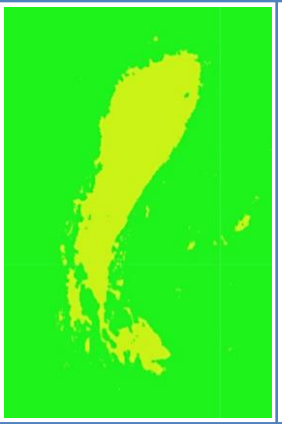
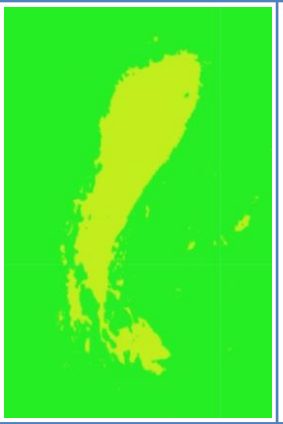
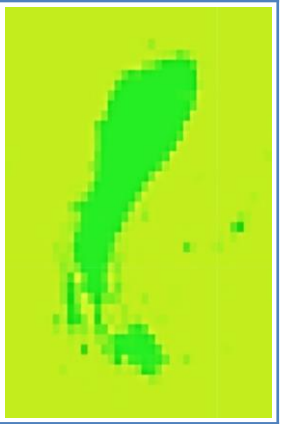
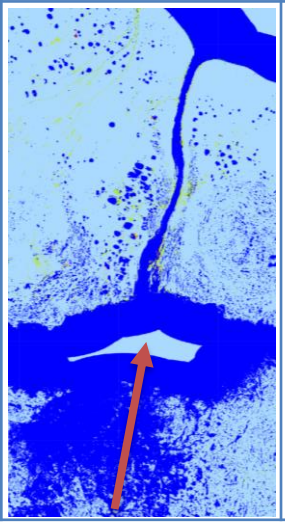
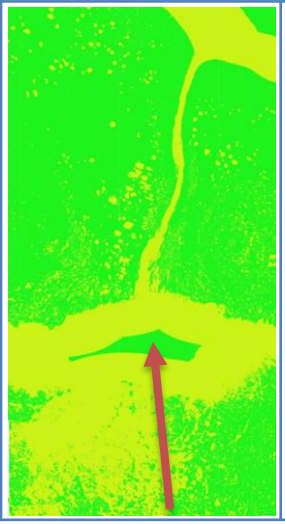
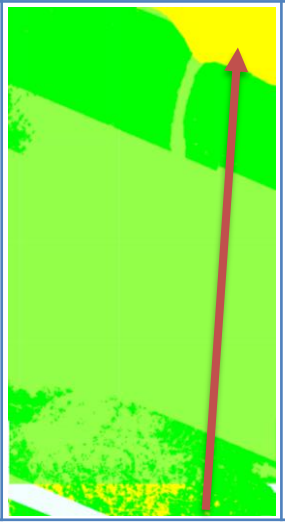
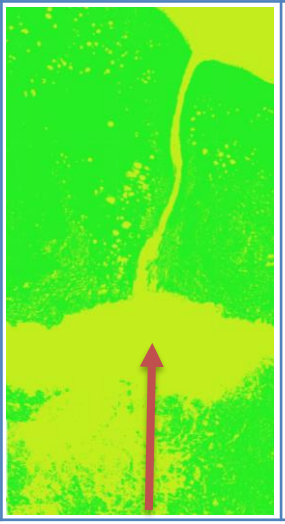
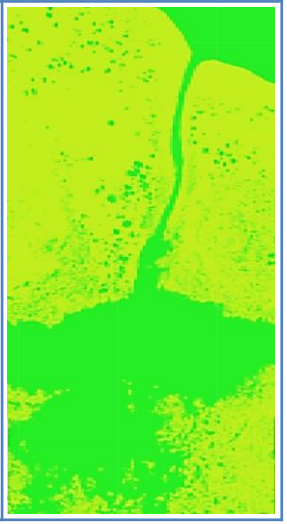
- **Mainly** based on the Global Surface Water Explorer (**GSWE**) dataset the **Water Transitions** facet (Pekel et al., 2016): nominal resolution of 30 m, Albers Equal Area (WGS84 ellipsoid) projection – distribution of **permanent water** over 35 year period (1984-2018).
  - + **High resolution**: 30 m horizontal resolution.
  - + **High quality**: < 1 % of false water detections, < 5 % of missed water surfaces.
  - – Areas where water has never been detected and areas of vast open water are masked: **missing value** over **land** and over big lakes/**ocean**.
- Uses **additional** datasets:
  - ÷ **ALOS DSM v2.2**: elevation datasets mask based on the global digital surface model (DSM) dataset of the World 3D Topographic Data, nominal resolution of 30 m.
  - ÷ **GSWE Metadata v1.1**: information on observations with values over land and no data over open ocean, i.e. number of valid and totally available observations in the study period.
- Generated at **Google Earth Engine** (earthengine.google.com) – **web-based** powerful code editor for **fast**, interactive algorithm development with **quick access** to high resolution data.

New algorithm for water distribution

Main steps of the future **fully automated** water distribution **algorithm**:

1. from GSWE Water Transitions 30 m resolution map **select** only **permanent water** pixels *(each pixel is fully covered with water)*
2. based on ALOS DSM 30 m resolution map create **mask** to ease **open ocean** recognition
3. based on GSWE Metadata 30 m resolution map create **mask** to fill **missed inland water** *(see Foxe Basin example from the next slide)*
4. **update** permanent **water** 30 m resolution map **considering** extra **masks**
5. **reduce resolution of** the updated permanent **water** map **to 1 km** *(significantly reduces output file size, each pixel represent fraction of water)*

New algorithm for water distribution: example

	Google **Satellite** Hybrid	GSWE: all **water**, 30 m light blue = NoData	[1]GSWE: **permanent water**, 30 m	[2]ALOS DSM: **mask**, 30 m yellow = ocean	[3]GSWE: water **detected** mask, 30 m	[5]**RESULT**: distribution of water, **1km**
Lake Neusiedl, Austria 47.843, 16.762						
Foxe Basin, Canada 66.572, -71.119						

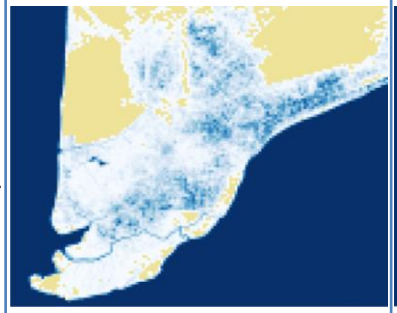
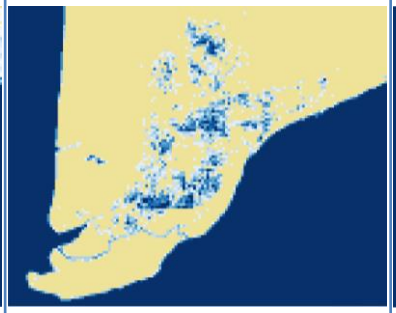
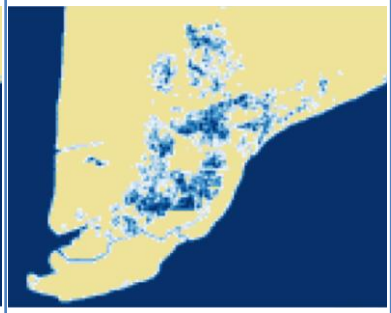
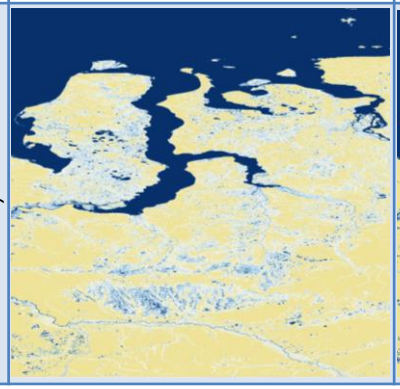
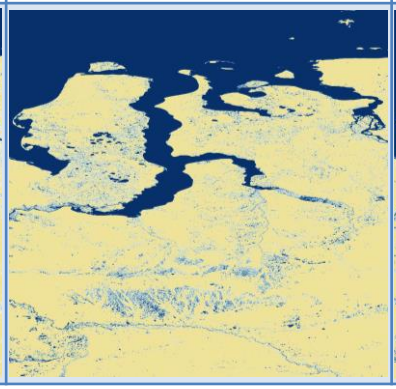
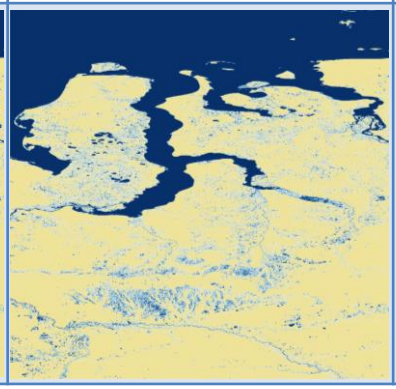
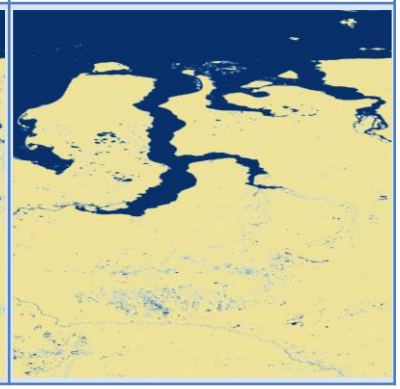
missed water **not permanent water** **ocean** **valid water observations**

New water distribution map comparison @ 1 km

Dataset	**New water distribution map**	ECOCLIMAP-SG	ESA-CCI	ECMWF (Globcover/GSWE)
Native resolution	30 m	300 m	300 m	1 km (300/30 m)
Base year	2018	2015	2015	2009 (2016)
Mean water fraction	**0.7696**	0.6781	0.6787	0.6666
Aral Sea 45.645, 59.636				

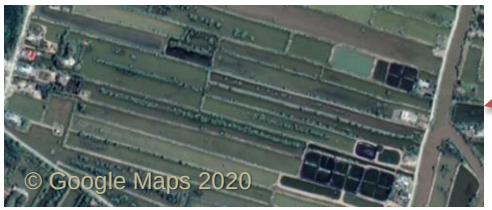
Difference in mean water fraction is due to the difference **over big water bodies**…

New water distribution map comparison @ 1 km

	New water distribution map	ECOCLIMAP-SG	ESA-CCI	ECMWF (Globcover/GSWE)
Rice fields, Vietnam 8.908, 105.097				
Gulf of Ob, Russia 68.785, 73.986				

Water fraction:
- 0 no water
- 0.0001
- 0.13
- 0.26
- 0.39
- 0.52
- 0.65
- 0.78
- 0.9
- 1 fully covered

… **and** due to the **difference in number of smaller** water **bodies** (e.g. rice fields and thermokarst lakes).



field width 20-30 m

lake diameter 1-2 km

Conclusions

- A **fully automatic method** for prompt update of **water distribution** map is **developed**.
- Method is **realised on Google Earth Platform** for **fast** computation, **easy access** of high resolution datasets and **easy share** of scripts and results *(enhances collaboration)*.
- **New** water distribution **map** is **generated** based on **30 meter** resolution data from Global Surface Water Explorer (**GSWE**).
- **Comparison** shows that new water distribution map has **highest water cover** among ECOCLIMAP, ESA-CCI, ECMWF (mainly Globcover) global ecosystem maps *(result consistent with the latest trend of emerging new water bodies due to permafrost thawing)*.

Future work

- **Lake cover map** with **30 meter** resolution is under **final check**.
- **Monthly water** distribution **and lake** cover maps **generation** in near future.
- High resolution numerical **experiments with** ECMWF **IFS** model **will be performed** to access impact on the atmospheric forecast.
- **Previous** study **on water** distribution and it's **impact** on the **forecast** are **documented** here:

Choulga, M., Kourzeneva, E., Balsamo, G., Boussetta, S., Wedi, N.: Upgraded global mapping information for earth system modelling: an application to surface water depth at the ECMWF, HESS, 23, 10, 4051-4076, doi:10.5194/hess-23-4051-2019, 2019.

Thank you for your attention!

This **presentation** reflects the **views only of the author**, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

Supported by **CO2 Human Emission (CHE)** and **Copernicus Emergency Management Service – Early Warning Systems – operational computational centre of EFAS (CEMS-Flood) projects**: The CHE project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 776186. The CEMS-Flood project has received funding from European Commission Copernicus Emergency Management Service (CEMS) Framework Contract No 198702 awarded to ECMWF.

Photo from https://champagneflight.com