Representing seasonal water in ECMWF ECLand system

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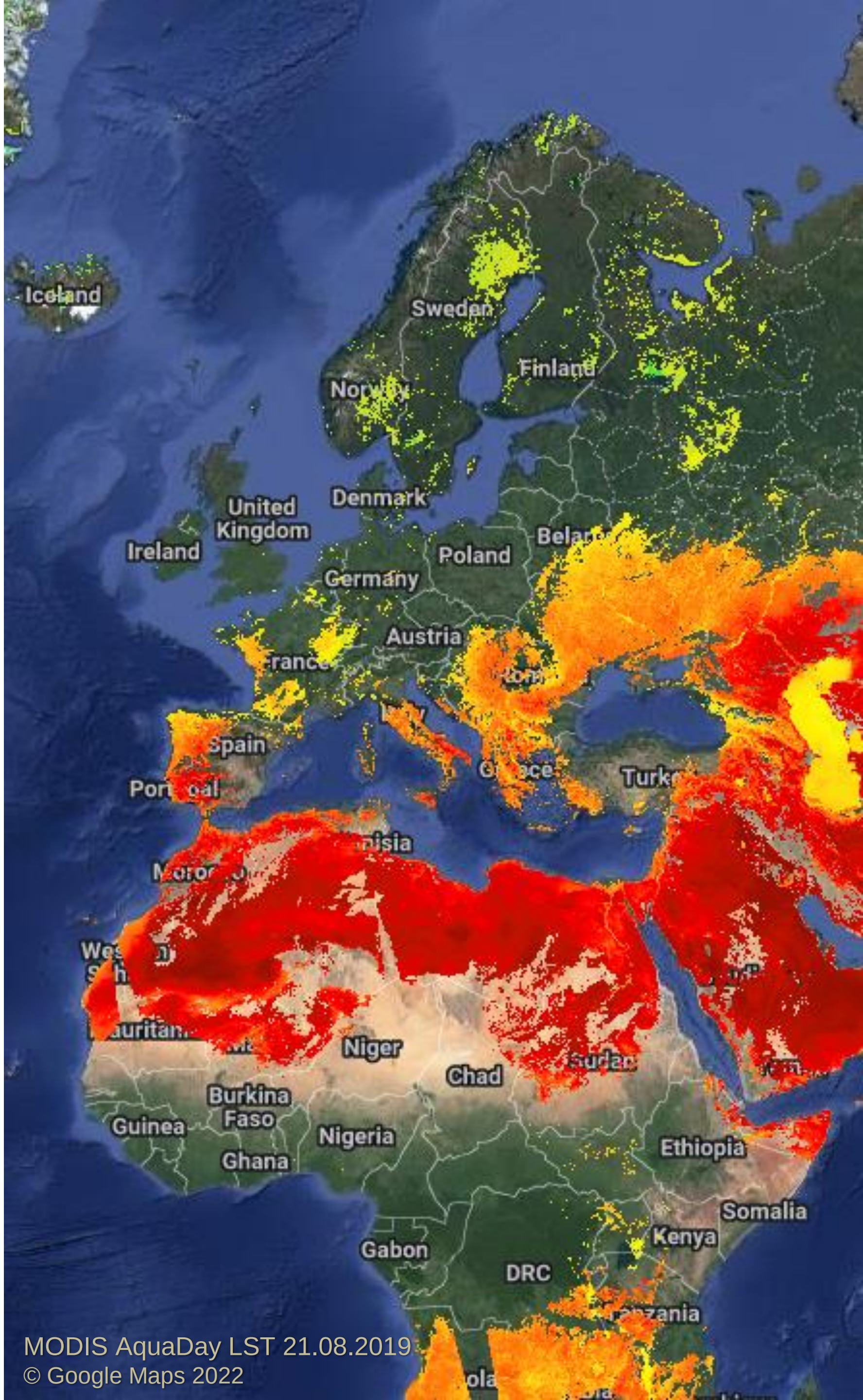
CoCO2 Prototype system for a Copernicus CO_2 service



MODIS AquaDay LST 21.08.2019
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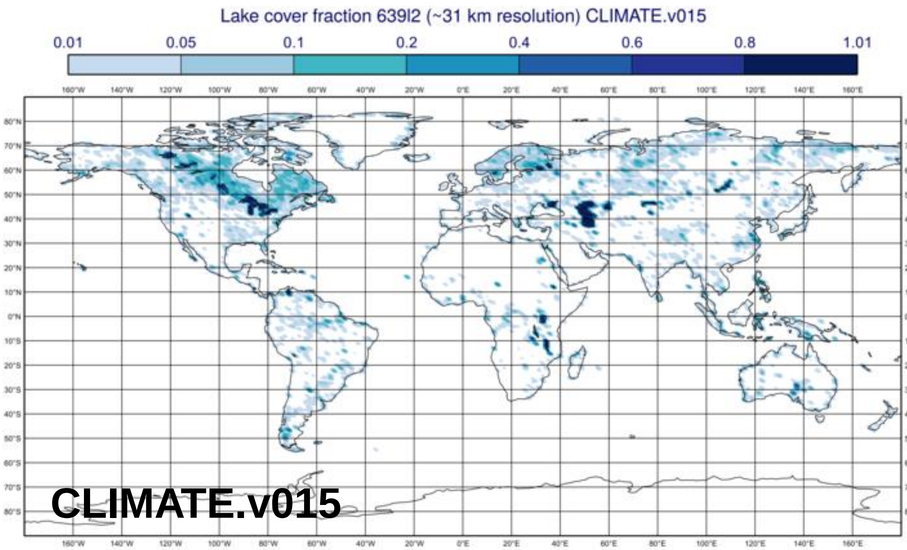
Background

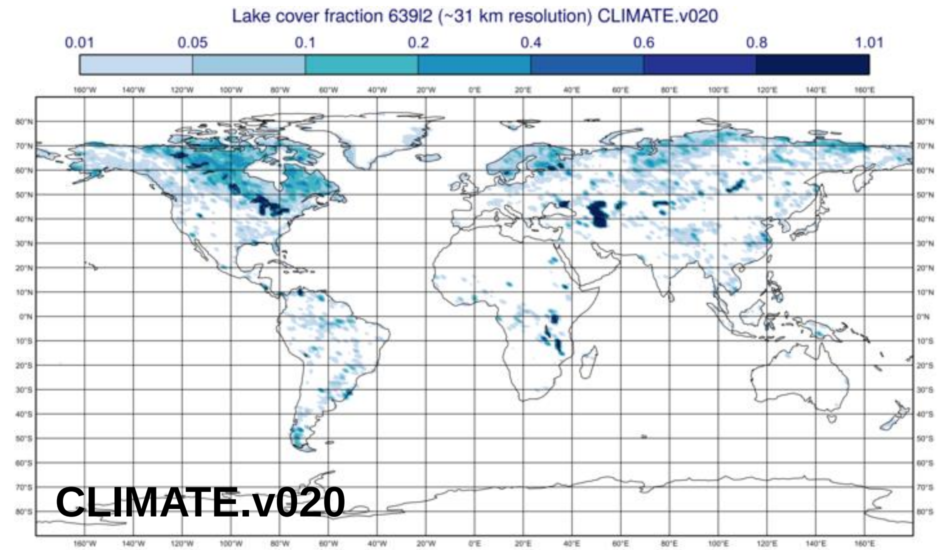
- Globally **lakes** occupy about **3.7 % of the land** surface (Borre, 2014; Verpoorter et al., 2014), and are **distributed** very **unevenly**.
- **Surface heat**, **moisture** and **momentum fluxes depend** not only on atmospheric conditions but also on the properties of the land surface, which **in lake-rich areas** are largely determined by **inland water bodies**.
- By seasonal variations in water level and volume **lakes** are **classified**:
  - **Perennial** - has water throughout the year, no extreme fluctuations in level.
  - **Intermittent** - short-lived lake that fills with water and dries up (disappears) seasonally.

Objectives

- Create an **up-to-date monthly water** distribution map suitable for NWP and global related applications (e.g. hydrology or carbon cycle) **based on high resolution**, **high quality** and **continuously** updated **data**.
- Develop an easy to use **automatic method to check** new **monthly water** distribution added value, i.e. prior coding new maps in the NWP model.

Lake cover (fractional) – *what we want to test*

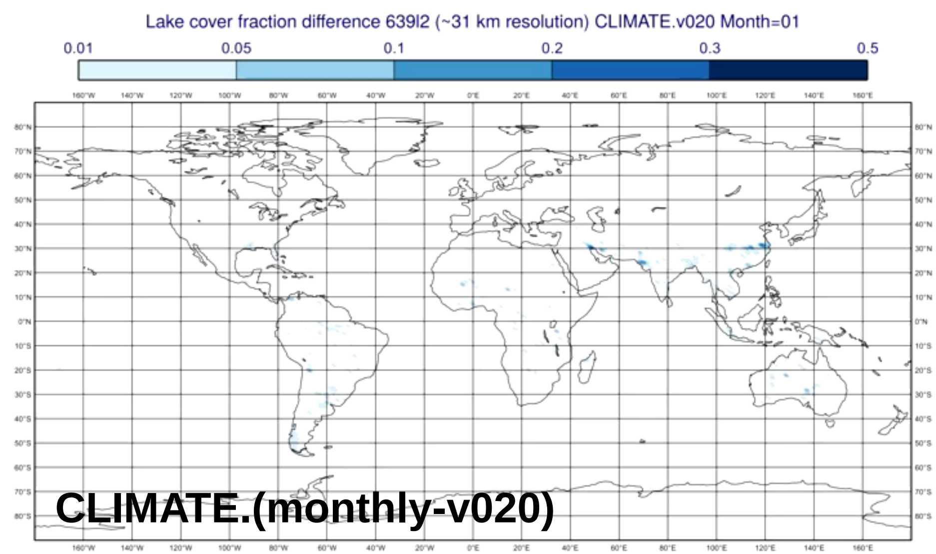




CLIMATE.v015 **(water)** main source **GlobCover 2009** ecosystem map (nominal **resolution 300 m**, 2009); corrected over **Iceland** and **polar regions**.

CLIMATE.v020 **(permanent water)** main source **JRC Global Surface Water Mapping Layer v1.2** water transition map (nominal **resolution 30 m**, 1984-2018); corrected over **glacier regions**.

CLIMATE.v020+monthly **(permanent + seasonal water)** main source in addition **JRC Monthly Water History v1.3** monthly maps (nominal **resolution 30 m**, 2010-2020); **fraction ≥ permanent** water.



Surface temperature – *against what we want to test*

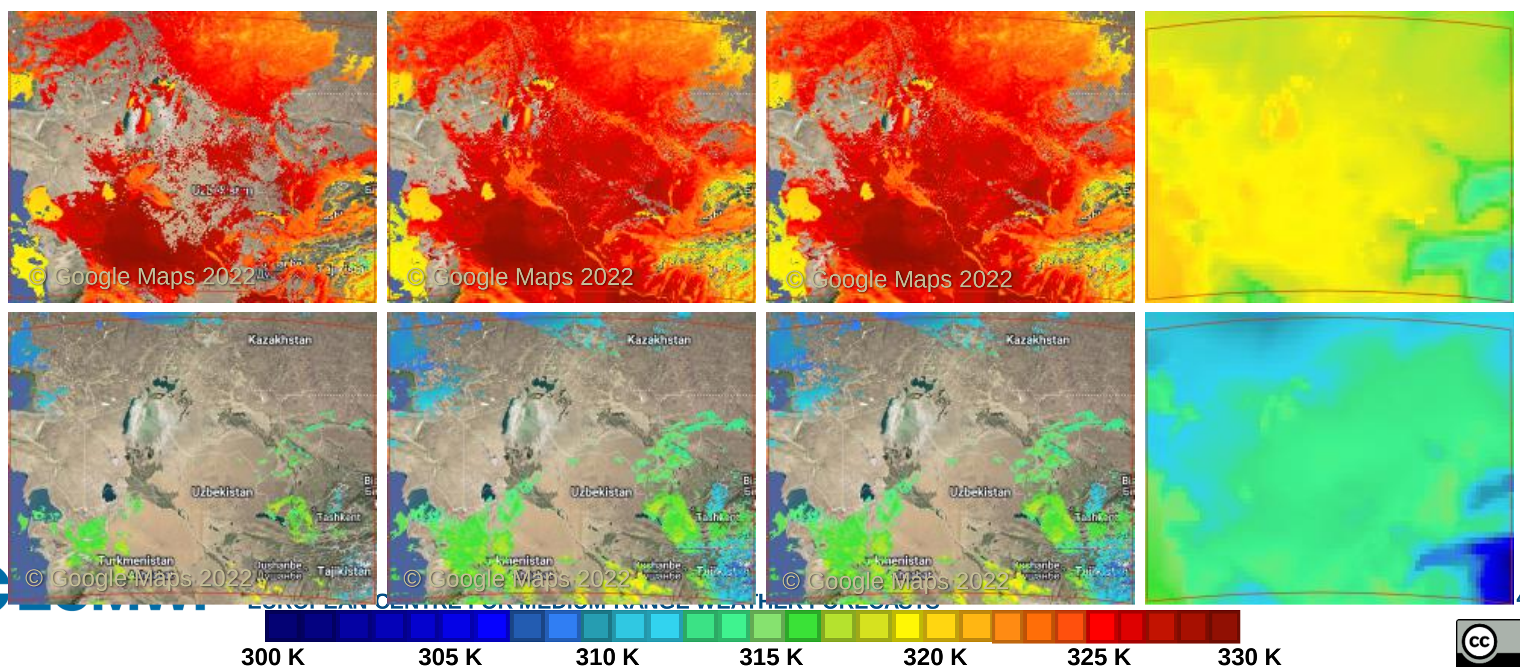
***ERA5** reanalysis skin temperature*: hourly, resolution ~31 km, reduced gaussian grid.

LST – Land Surface Temperature observed corresponds to the modelled skin temperature.

***MODIS** MYD11A1.061 AquaDay LST*: daily at ~1.30 pm local time, horizontal resolution ~1 km, MODIS sinusoidal projection grid (SR-ORG:6974, projection uses a spherical projection ellipsoid but a WGS84 datum ellipsoid);

- Averaged all quality data to ~4 km resolution if ≥8 grid-cells have values, re-gridded to a regular latitude/longitude grid (EPSG:4326).

***Matching** MODIS and ERA5 data*: MODIS values matched to the ERA5 ~1.30 pm local solar time nearest grid-cell (max radius 50 km), and then all available values are averaged to ERA5 resolution and grid.



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Global machine learning model – *how we want to test*

Training input:

- year 2016 (validation set 2017);
- horizontal resolution ~31 km, reduced gaussian grid (639_l2);
- pre-processed ERA5 and MODIS skin temperatures;
- surface static fields:
  a) **Climate.v015**
  b) **Climate.v015 + differences v020-v015** for lake related fields (land sea mask, lake cover, lake mean depth, high/low vegetation cover, glacier cover, geopotential, and sub-grid orography (standard deviation, anisotropy, orientation, slope, etc.))
  c) **Climate.v015 + differences v020-v015** for lake related fields
  + 12 **monthly water** maps with seasonal water **+ salt lake cover** (only major lakes)

Regression technique:

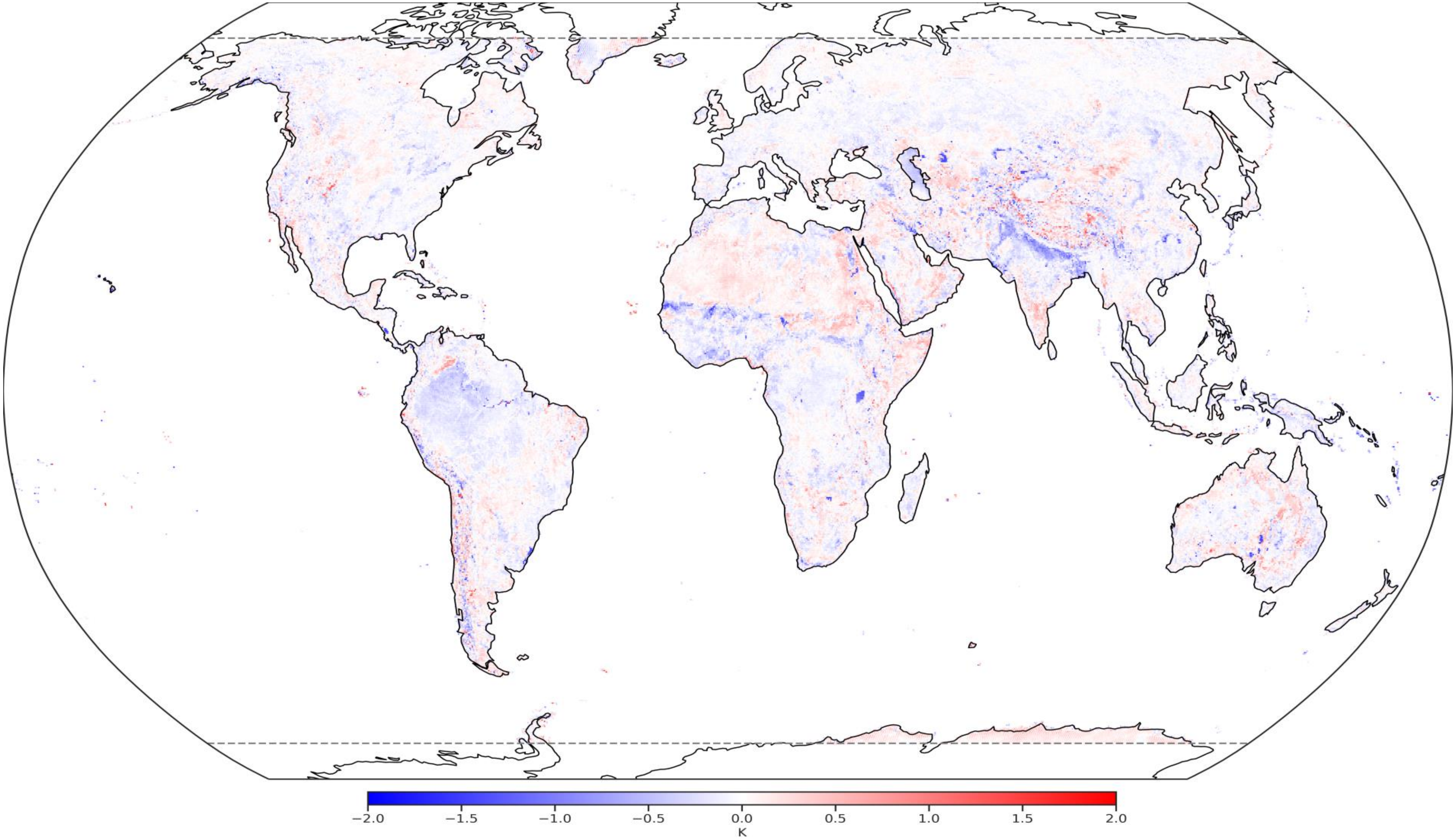
- fully connected neural network (1700 degrees of freedom);
- point wise approach.

Forecast output:

- year 2019;
- land skin temperature.

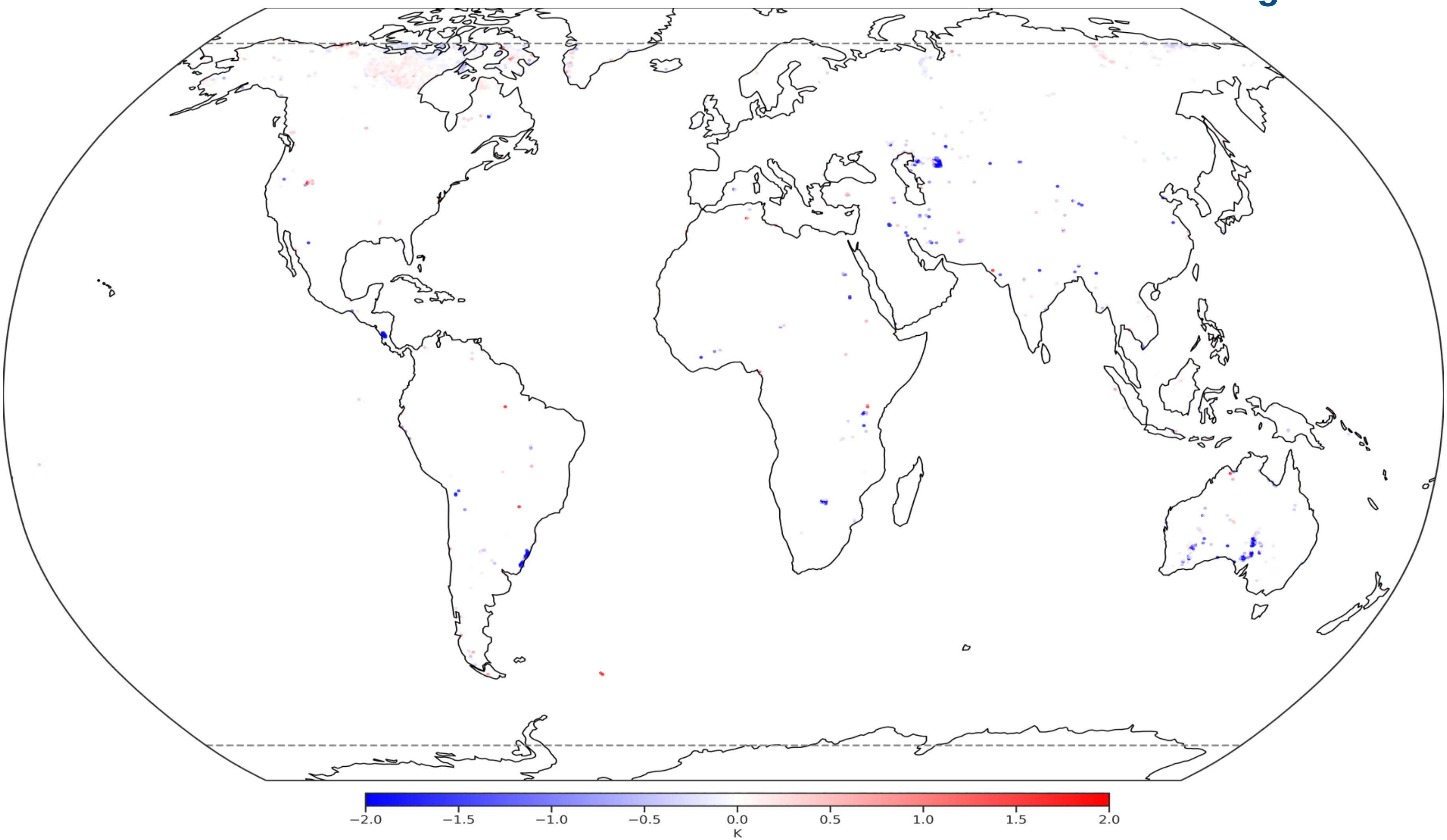
Results: skin temperature forecast 2019 MAE.v020-MAE.v015

no filter



Results: skin temperature forecast 2019
MAE.v020-MAE.v015

filter
lake cover changes ≥0.1



Results: MAE.v020-MAE.v015

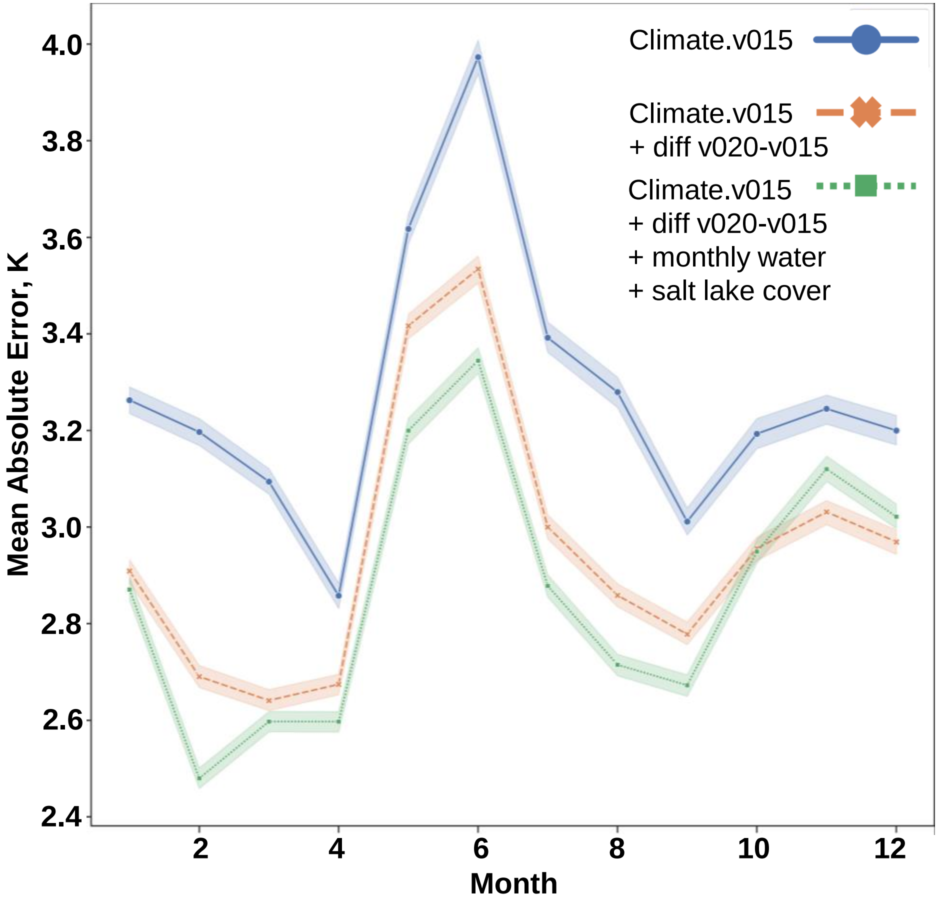
filter
lake cover changes ≥0.1

Table shows only **significant changes** between **skin temperature predictions** for the year 2019 based on **Climate.v015** and **Climate.v015 + diff v020-v015** with **grid-cells grouped** according the surface static fields changes.

Surface static field value changed ≥ ±10%						**Number of grid-cells**	**Average difference**	**Note** *lsm/cl* land/lake cover; *cvh/cvl* high/low vegetation cover; *dl* lake mean depth; *s10* glacier cover
cl			dl	lsm		1512	**-0.34**	Main benefit from upgrading cl
			dl		s10	834	**-0.15**	Mainly benefit from updating (reducing) glacier fraction
						9119	**-0.05**	Mainly benefit from using MODE depth aggregation instead of MEAN
			dl			135005	**-0.02**	Mainly benefit from updating ocean bathymetry and lake mean depths
cl		cvl	dl			8	**0.49**	Mixture of cvl and **bare ground** became cl and bare ground → in reality should be a mixture of cvl and cl
	cvh	cvl	dl			18	**3.91**	All cvh and cvl became **bare ground** → in reality should be mostly cvh
	cvh		dl			13	**7.59**	All cvh became **bare ground** → in reality should be mostly cvh

Results: MAE.v020-MAE.v015

filter
lake cover changes ≥0.1



Surface fields	Mean Absolute Error, K	Standard Deviation, K
Climate.v015	3.27	3.23
Climate.v015 + diff v020-v015	2.95	2.64
Climate.v015 + diff v020-v015 + monthly water + salt lake cover	2.87	2.58

Model type: fully connected neural network
Training period: 2016 (validation period 2017)
Forecast period: 2019
Variable: skin temperature

With the increase of lake temporal distribution (from permanent to monthly):

- **freshwater and saline lake** behaviour **mismatch** becomes more **prominent** → for better performance saline lakes should be treated separately;
- **observations** over high latitudes (north **from 60 °N**) become even more **relevant** in cold season (**September-December**), especially for **ice start/break-up** dates → for better performance cloud independent data should be used.

Conclusions

- **New** monthly climatological water distribution **maps** are **generated** based on **30 meter** resolution data from Global Surface Water Explorer (**GSWE**).
- An **automatic chain** based on fully connected neural network model is **developed to check** an **impact** of monthly water distribution.
- To correctly **assess** the **impact** of monthly water distribution
  - during **warm period** (March-August) **one-two year** observational **data** is needed,
  - during **cold season** (September-December) especially north from 60 °N (ice start/break-up!) **several year data** is required due to clouds (i.e. missing data).
- **Comparison** shows that **more** detailed knowledge of **surface heterogeneity** (e.g. up-to-date permanent/seasonal water distribution, fresh/salt water distribution, etc.) can give **mean absolute error reduction** of skin temperature **globally ~1 K** in summer.
- Take home message – **seasonally varying inland water can substantially impact near surface weather**.

Future work

- **Higher resolution** data (i.e. ERA5-Land, Sentinel-2 data) will be used **to assess** the **impact** of monthly water distribution in the model.
- ECMWF **IFS** model **adaptation to** use 12 **monthly lake cover** maps.
- Performing **high-resolution** (~9 km) numerical **experiments with** ECMWF **IFS** model **to access** the **impact of** 12 monthly lake cover use and **dynamical inundation** on the atmospheric forecast.

Thank you for your attention!