



Representing Lake Surface Dynamics in Earth System Reanalysis

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Background

Lakes modify the structure of the atmospheric boundary layer, and impact local climate (over 1°C difference in 2-metre temperature) and local weather (up to 10°C difference in 2-metre temperature). At the European Centre for Medium-Range Weather Forecasts (ECMWF), lake parametrization was introduced in 2015 by including the Fresh-water Lake model FLake in the Integrated Forecasting System (IFS).

The IFS model is used for global weather forecast production from medium to seasonal range, and for reanalysis (e.g. ERA5) generation. The current lake mask used in IFS is constant over time and represents permanent water over 34 years (1984-2018). It has been shown that monthly varying lake mask has a significant positive impact on regions with prolonged rain and dry seasons, especially in Malaysia, Indonesia and Papua New Guinea (see Kimpson et al., 2023).

Objectives

CERISE aims at improving C3S reanalyses and seasonal predictions. With global reanalyses now going back almost a century, it is important to appropriately describe changes to the land surface over time. Available observations show examples of lake variability in time, and this work is dedicated to generating (and evaluating) high-resolution monthly varying lake cover maps from 1925 to present, to be used as the boundary conditions of IFS model and beyond to benefit reanalysis and predictions.

Monthly varying lake cover maps

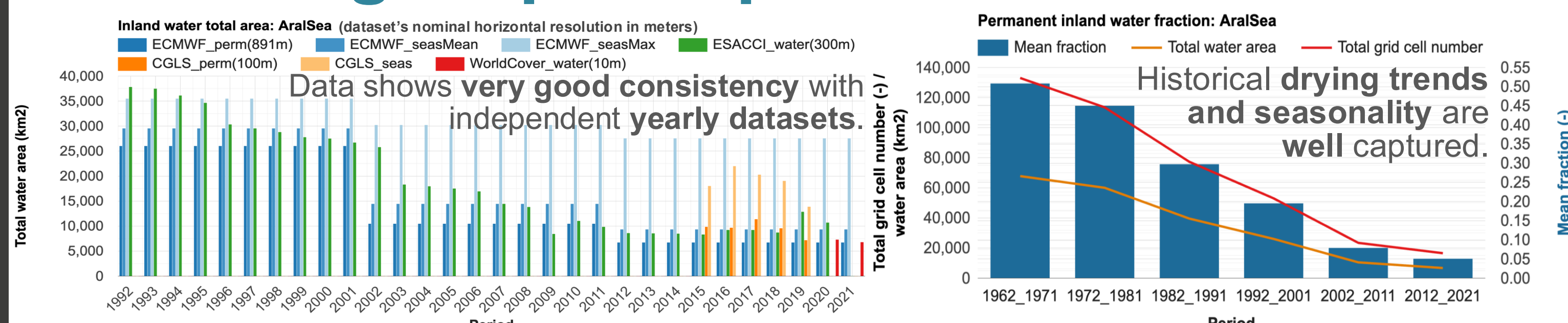
➤ Main data sources:

- ✓ 1984-2021 – Joint Research Centre Global Surface Water Explorer dataset (30 m);
- ✓ 1972-1983 – Landsat Global Land Survey dataset (60 m resolution);
- ✓ prior 1972 – historic maps (no available satellite data).

➤ Generated maps are grouped per 10-year period, each period has twelve monthly maps (i.e. permanent water + monthly delta) at 1 km resolution:

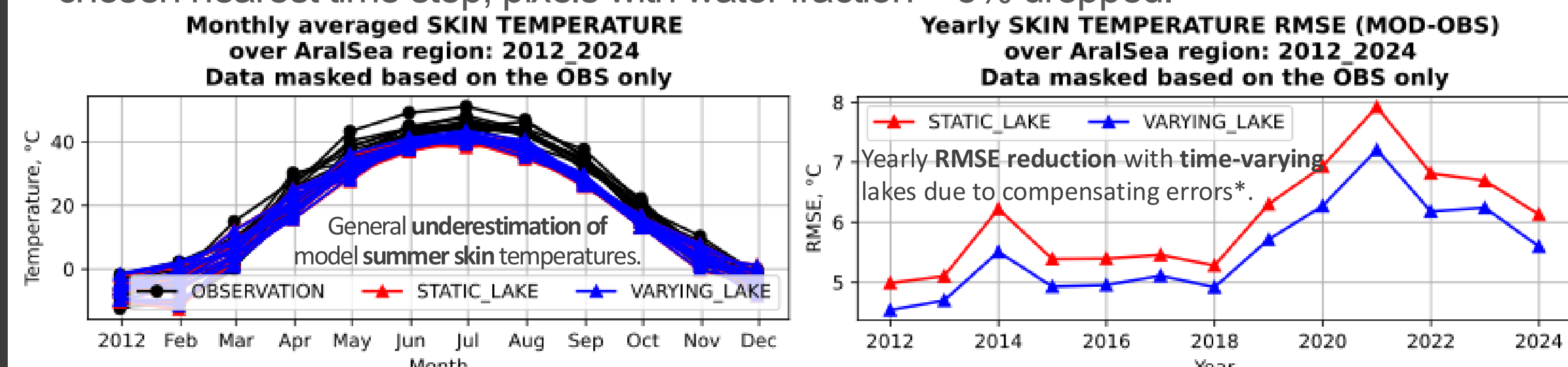
- ✓ 1992-2021 – lake surface dynamics is independent, based purely on JRC dataset;
- ✓ 1962-1991 – base line of 1992-2001 with regional corrections from other sources;
- ✓ 1925-1961 – maps are equal to 1962-1971 due to lack of additive information.

Resulting map comparison: Aral Sea

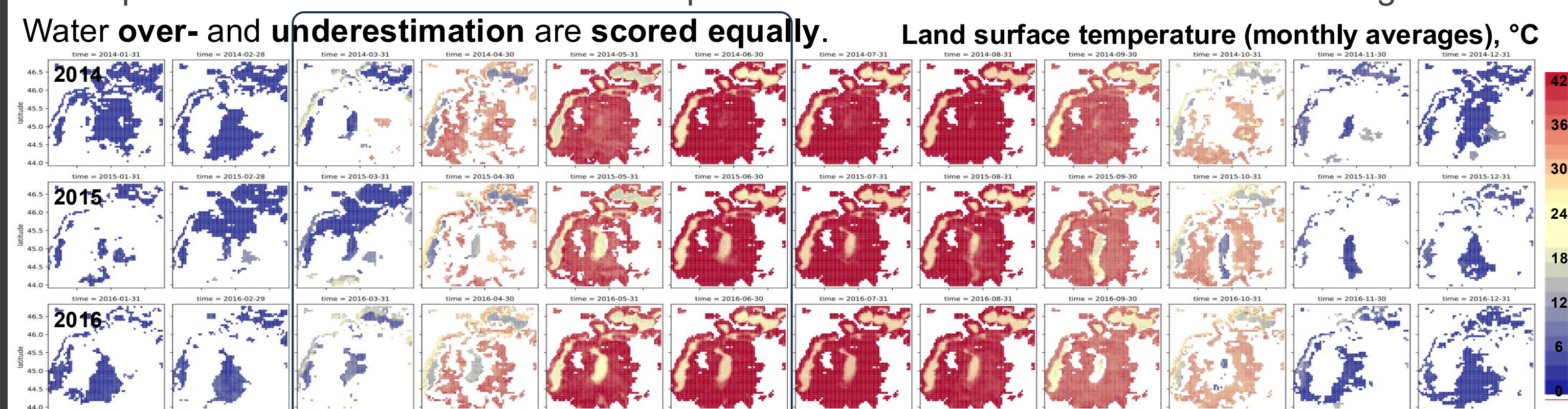


MODIS land surface temperature

Aral Sea IFS experiment results at ~9 km resolution are compared with MODIS Terra Day L3 (MOD21C1.061) satellite observations at ~10.30 am local time. Only best quality data used. Model data re-gridded to match observations (regular 0.05° grid), chosen nearest time step; pixels with water fraction < 3% dropped.



* Missing water in the time-varying lake cover in summer periods leads to warmer skin temperatures → closer to observed temperatures. This leads to better but misleading results. Water over- and underestimation are scored equally.



Acknowledgements

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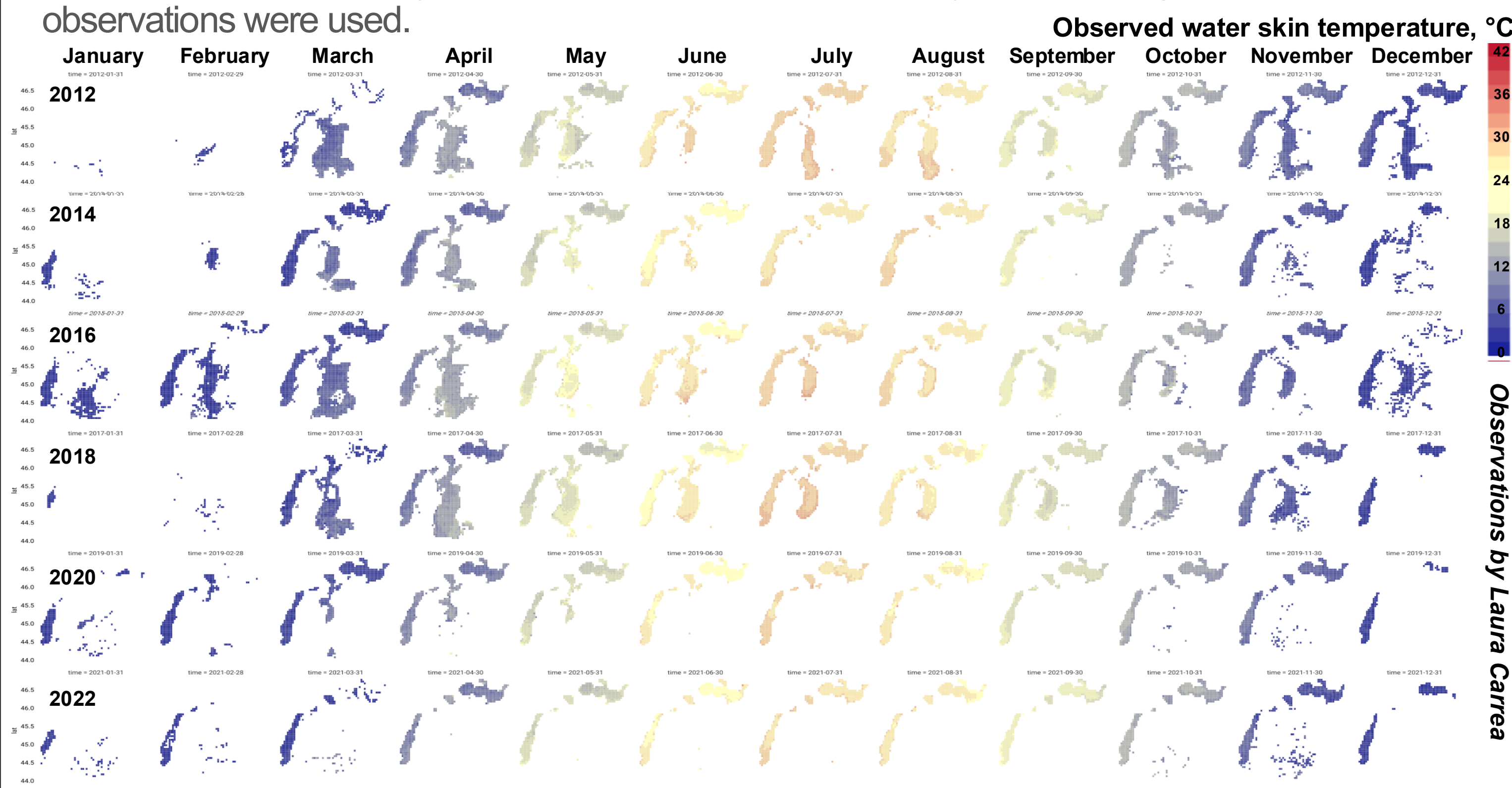


References

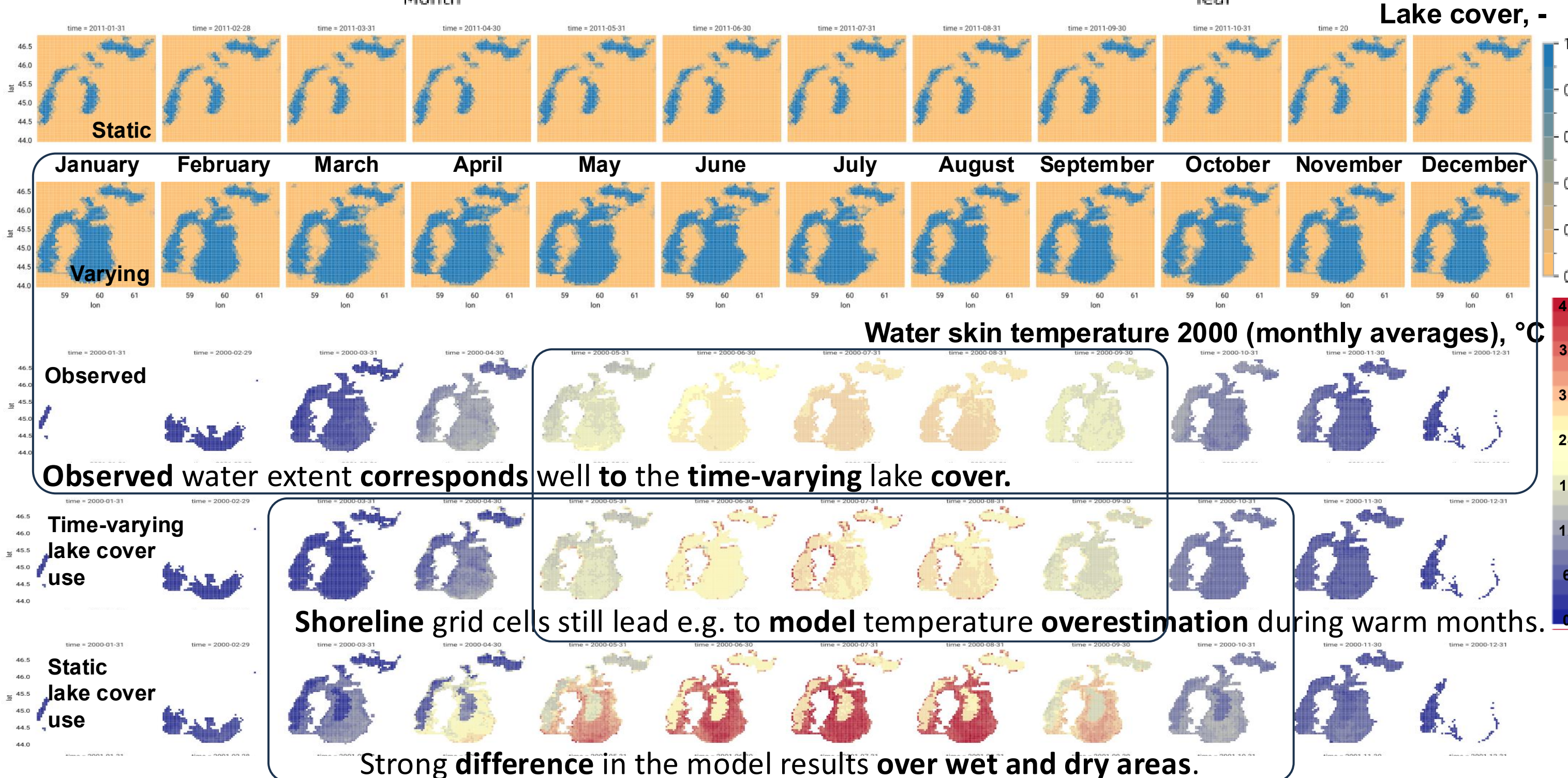
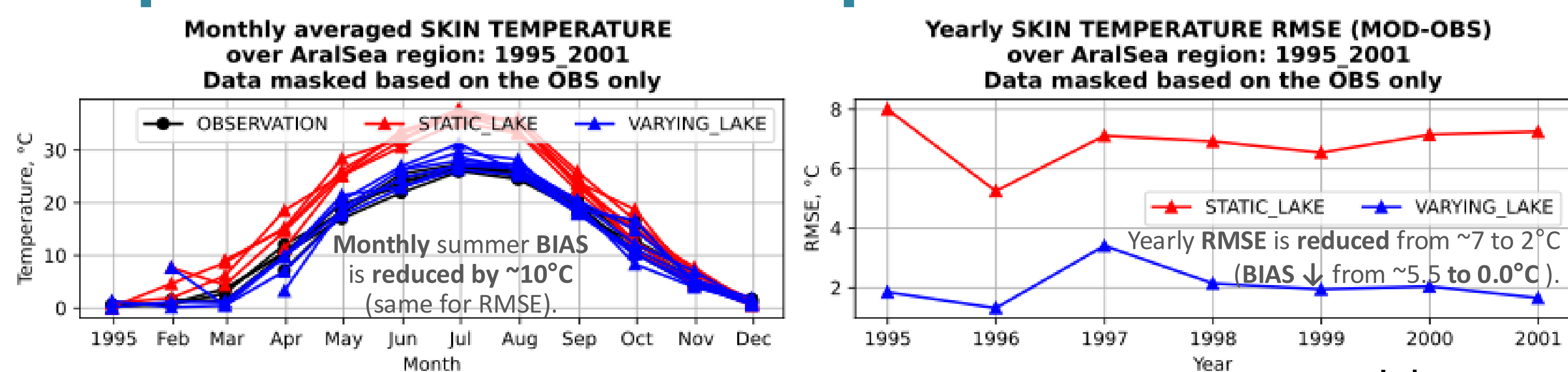
Kimpson, T., Choulga, M., Chantry, M., Balsamo, G., Boussetta, S., Dueben, P., and Palmer, T.: Deep learning for quality control of surface physiographic fields using satellite Earth observations, Hydrol. Earth Syst. Sci., 27, 4661–4685, <https://doi.org/10.5194/hess-27-4661-2023>, 2023.
Pekel, J.-F., Cottam, A., Gorelick, N., and Belward, A.: High-resolution mapping of global surface water and its long-term changes, Nature, 540, 418–422, <https://doi.org/10.1038/nature20584>, 2016.

CCI LAKES water surface temperature

Aral Sea IFS experiment results at ~9 km resolution are compared with ESA CCI LAKES / C3S multi-satellite high-fidelity surface water temperatures at ~10.30 am local time. Model data re-gridded to match observations (regular 0.05° grid), chosen nearest time step, used max of skin and lake mixed layer temperature to avoid ice. Only best quality skin temperature observations were used.

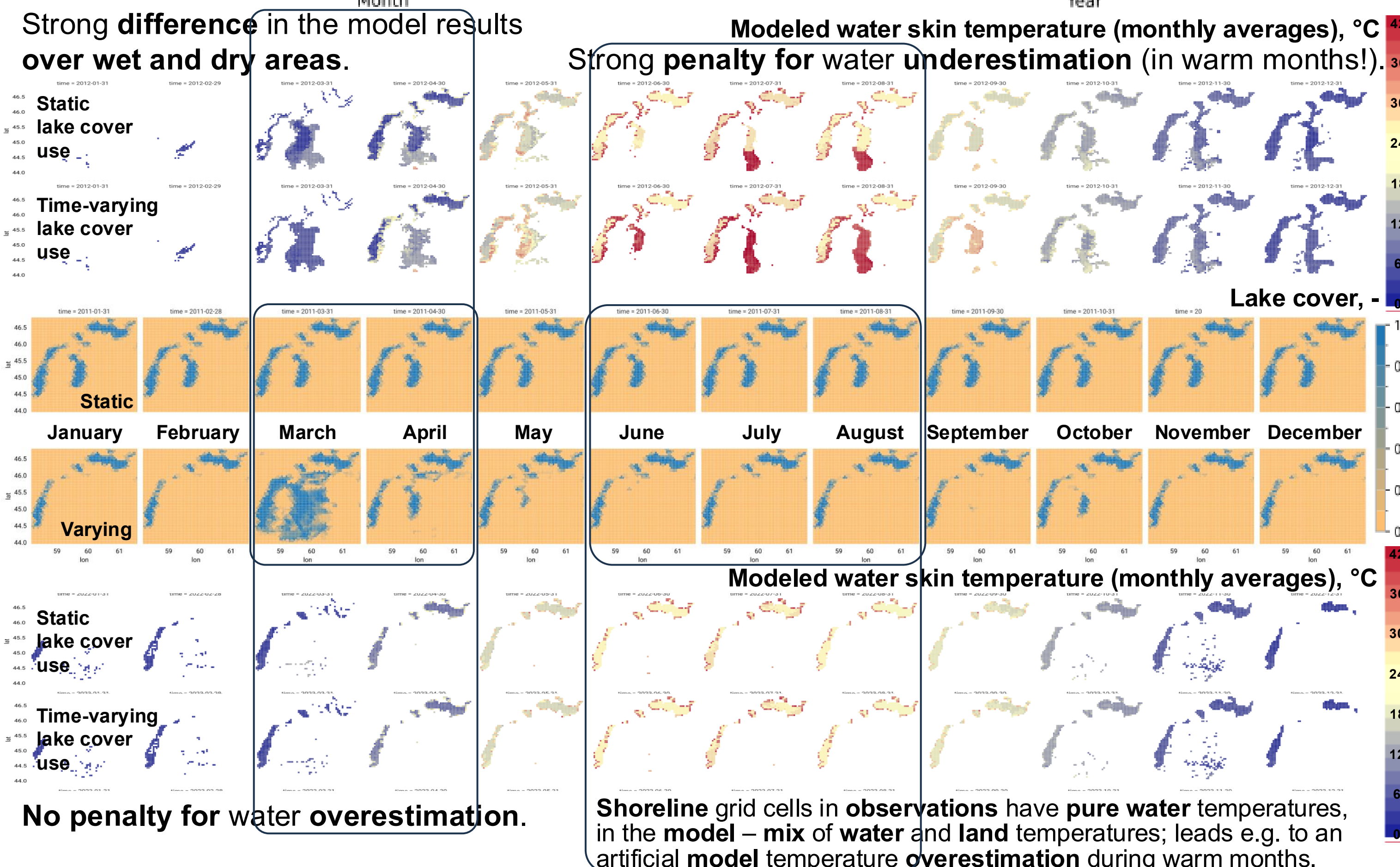
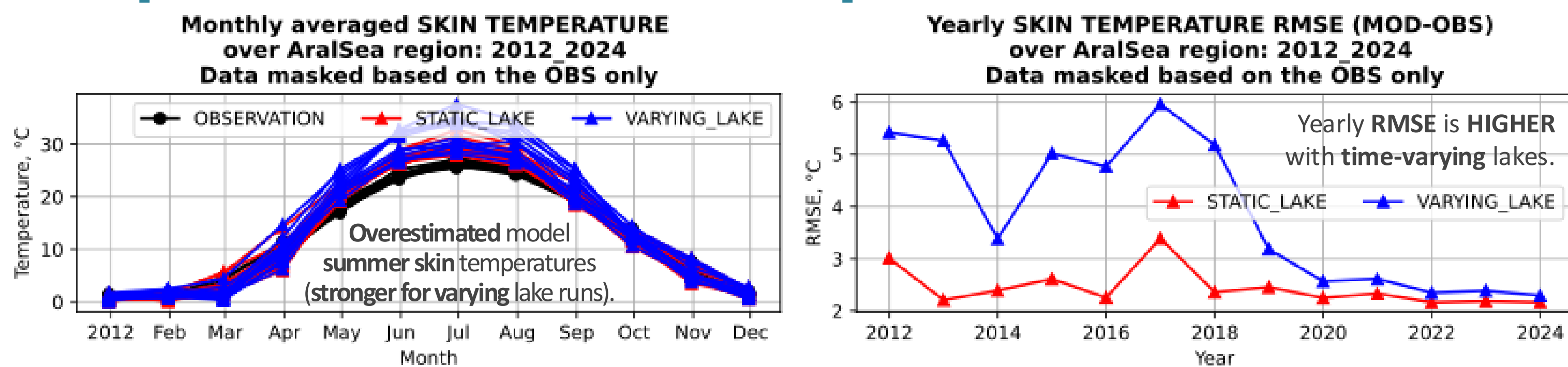


Impact on surface temperature: 1995-2001



High seasonality & low interannual variability processes can be well represented by simplified (i.e. decadal) monthly water extent climatology.

Impact on surface temperature: 2012-2024



High interannual variability processes can't be explained by simplified (i.e. decadal) monthly water extent climatology.