ASSESSMENT OF ECLAND'S (ECMWF) REVISED LAND COVER: IMPACT ON NEAR-SURFACE TEMPERATURE FORECASTS

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INTRODUCTION

Land-atmosphere interactions play an important role in climate variability, however the detailed description on the evolution of these processes still requires further improvements from numerical weather prediction (NWP) models. One of the most crucial near-surface variables within the earth's climate system is air temperature, where its variation not only affects (directly) energy, water, and carbon flux exchanges that occur above the surface, but also (indirectly) plant growth through soil water. In the context of biogenic fluxes modelling, recent progress towards vegetation classification and land cover use in the Integrated Forecasting System (IFS), the global model from the European Centre for Medium-range Weather Forecasts (ECMWF), has been performed in the framework of the Copernicus Prototype System for CO_2 Monitoring - CoCO2 project.

This work highlights developments made towards the IFS land surface model (ECLand, Boussetta et al. 2021[1]) through an evaluation of the revised land cover and Leaf Area Index (LAI), focusing on the impact that these changes have over the meteorology and near-surface temperature forecasts. In this context, IFS online simulations are evaluated against ECLand default configuration and Global Historical Climatology Network (GHCN) observations for the spring and summer periods of 2019.

[1]S. Boussetta *et al.*, "Ecland: The ecmwf land surface modelling system," *Atmosphere (Basel).*, 12, 6, pp.1–38, 2021, 10.3390/atmos12060723

DATA AND METHODS

GHCN observations

GHCN daily air temperature extremes (maximum and minimum values) from the NOAA online repository[2] are used to evaluate ECLand's 2-metre air temperature (T2M) daily forecasts. A total of 14625 stations are considered for analysis after pre-processing (**Figure 1**).

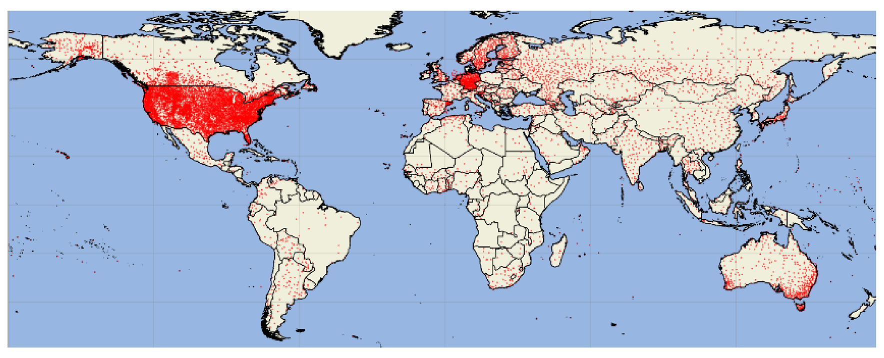

Figure 1 – GHCN ground stations (red dots) analysed for the evaluation of ECLand's air temperature forecasts.

ECLand simulations

Daily forecasts from two model configurations are considered: i) a control simulation (CTR0) with ECLand's default setup (used as reference); and ii) a revised land cover and LAI climatology simulation (CCI0). The simulations comprise a set of medium-range weather forecasts with a 5-day lead time initialized at 00UTC on all days of 2019. Atmospheric initial conditions are established according to ECMWF-ERA5 reanalysis, while land initial conditions are established with respective surface simulations, i.e. CTR0 with ECLand's default land conditions and CCI0 with the new land cover and LAI climatology conditions.

Data screening and NWP metrics

To evaluate ECLand forecasts against GHCN observations, data screening was performed, including: i) stations with more than 80 % of available data; ii) a minimum 10 days of valid data; iii) a maximum altitude difference of 100 m between station and model altitudes; and iv) land areas corresponding to a minimum fraction of 0.9 within each pixel. Standard NWP metrics are used over seasonal mean values (computed by averaging corresponding daily values within each season) independently for each station, considering the nearest model grid-cell. Metrics are then spatially aggregated to each model grid-cell to partially homogenize stations density.

[2] https://www.ncei.noaa.gov/products/land-based-station/global-historical-climatology-network-daily

ANALYSIS AND DISCUSSIONS

Meteorological impact

Normalized root mean square error (nRMSE) differences between CCI0 and CTR0 forecasts of T2M, 2-metre dewpoint temperature (TD2M), and mean sea level pressure (MSL), show (**Figure 2**) CCI0 improved and deteriorated regions (blue and red contours, respectively) for the spring (top panel) and summer (bottom panel) periods of 2019.

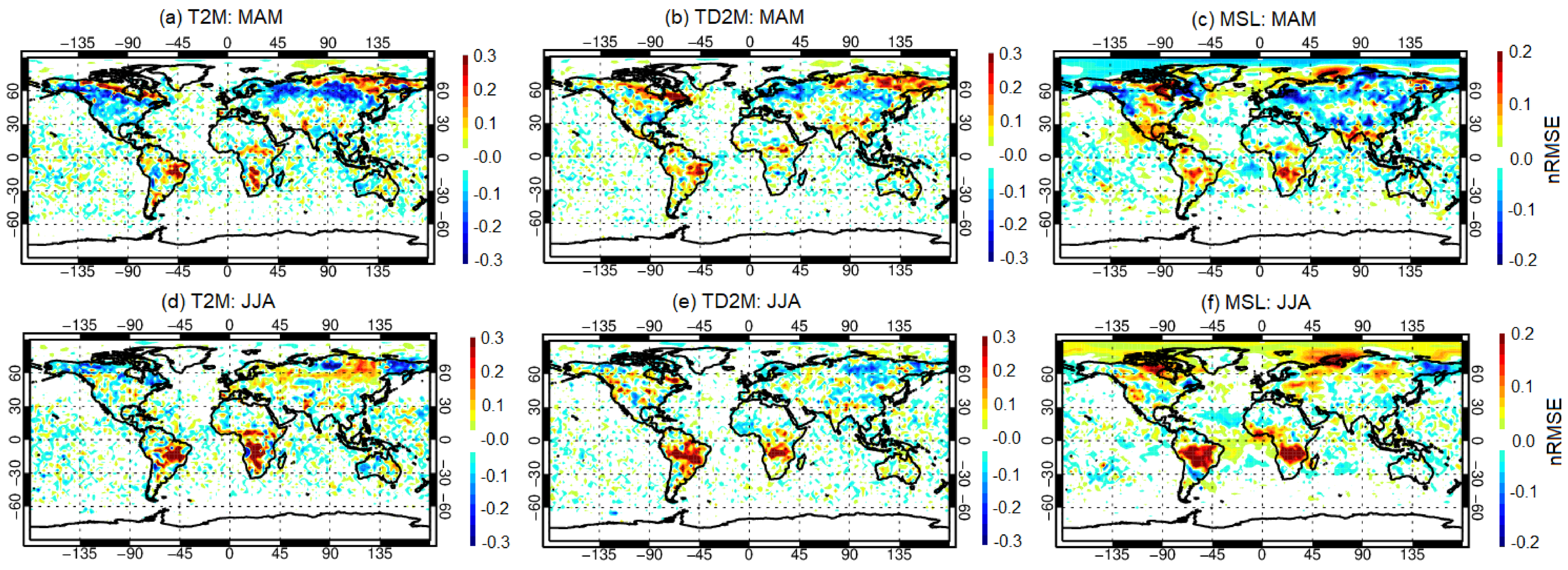

Figure 2 – ECLand's 2 days-ahead forecasts of 2-metre air and dewpoint temperatures (T2M, TD2M), and mean sea level pressure (MSL), for spring (MAM) and summer (JJA) of 2019. Normalised difference in root mean square error (nRMSE) between revised land cover and control simulation.

When forecasting different surface fields, CCI0 improvements generally occur in the northern hemisphere (NH), particularly during spring over USA, Eastern Europe, and Russia, for T2M, TD2M, and MSL. While CCI0 error reductions of 10-30 % are found over these regions, higher errors with CCI0 are also obtained at higher latitudes (NH) and in the tropical regions (Eastern Brazil, central-south Africa) with increases around 30 %.

During the summer period, the tropical regions are generally characterized by a significant increase of the error, depicting a forecast deterioration in CCI0 with error increases over 30 %.

These results identify a consistent seasonal and geospatial signal with a positive impact of CCI0 in the NH during spring, while a negative impact is found in the tropical region, particularly during summer. The latter is likely related to changes of high to low vegetation cover in such regions, as well as the associated impact on surface roughness for momentum and heat.

Near-surface temperature impact

When compared with daily maximum and minimum temperatures from GHCN observations (TMAX and TMIN, respectively), forecasts from the ECLand's revised land cover and LAI show a stronger impact for TMAX (**Figure 3**) than TMIN (**Figure 4**).

TMAX bias differences between CCI0 and CTR0 (**Figure 3, left panels**) generally show positive changes (CCI0 warmer) with values around 1.00 K in USA, Eastern Europe, and Russia, particularly in spring. The corresponding CCI0 improvements (blue contours) are further noticed by the absolute bias changes (**Figure 3**, **right panels**), while higher deviations (red contours) are found mostly in Eastern USA and central-south Africa. Moreover, the constant presence of a warm/cold bias anomaly in the USA region indicates that further model developments are required.

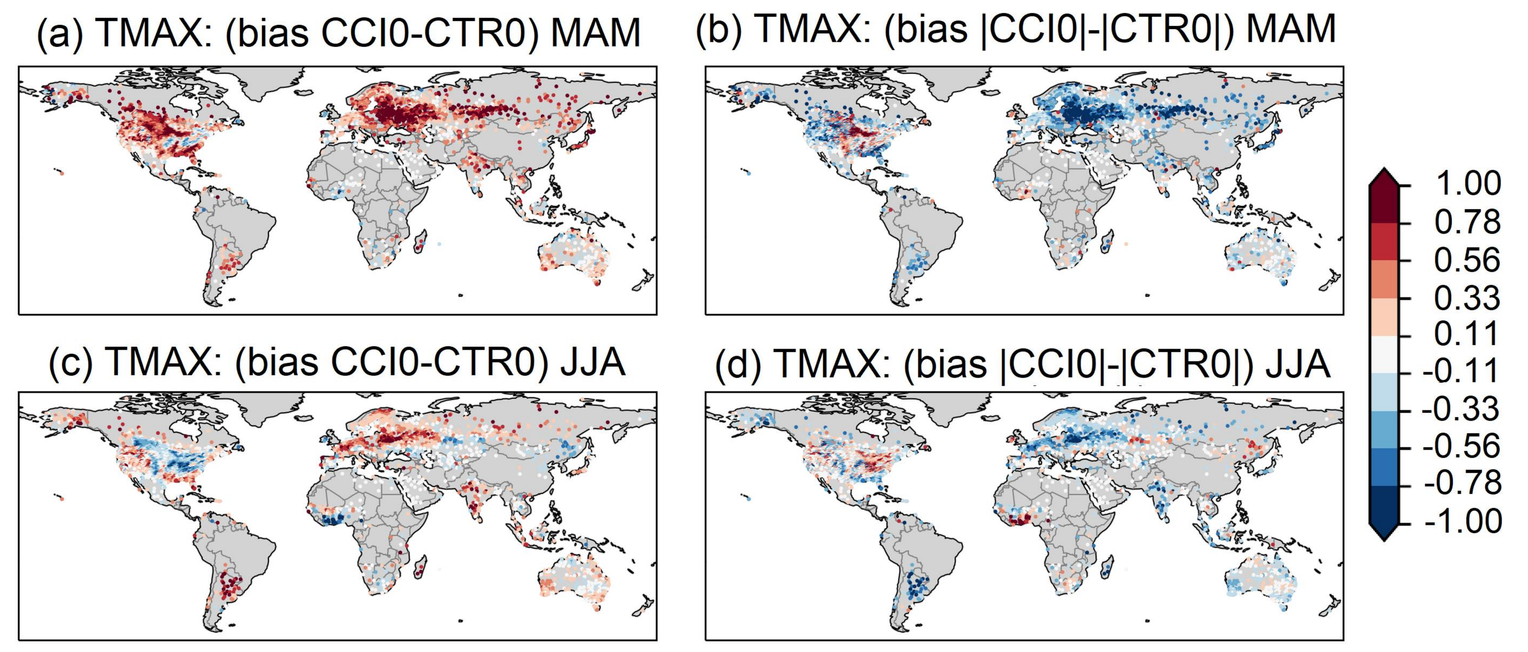

Figure 3 – Daily maximum air temperatures (TMAX) for spring (MAM) and summer (JJA) of 2019. Bias (in K) between ECLand's 2 days-ahead forecasts with revised land cover (CCI0), control simulation (CTR0), and GHCN observations. Mean bias differences (left panels) and absolute bias changes (right panels).

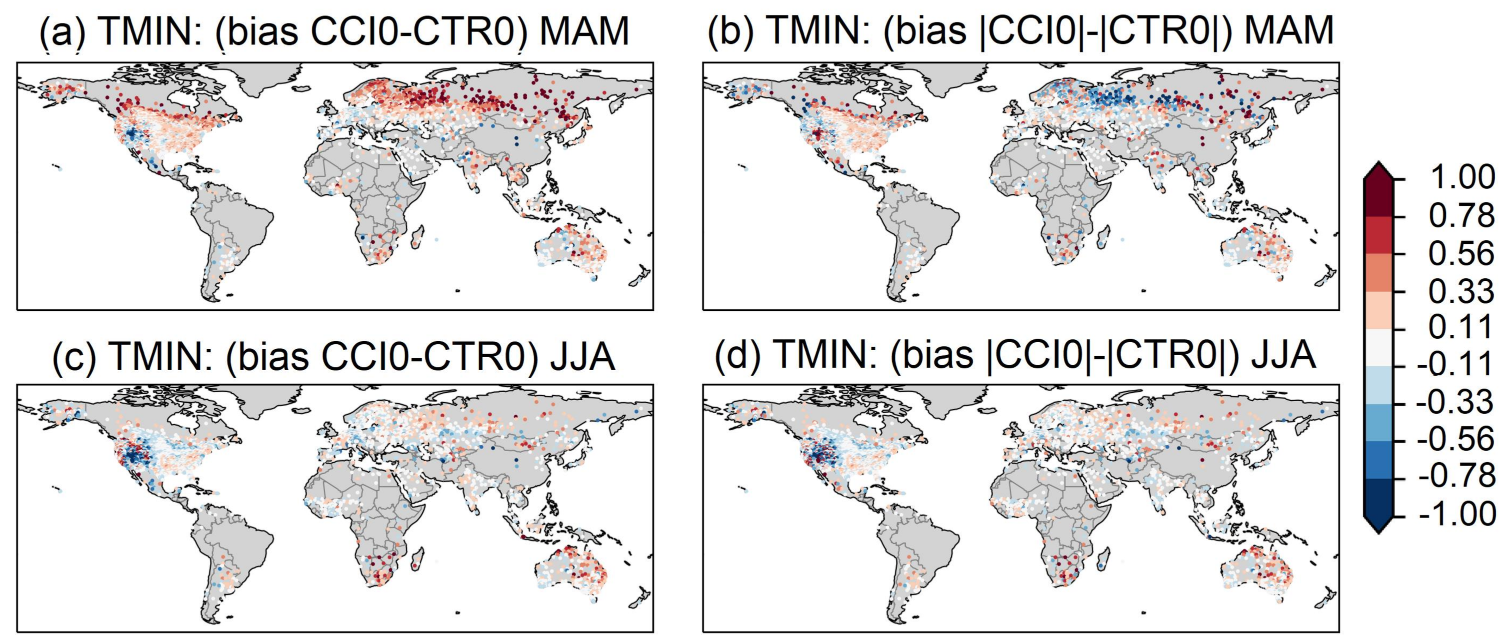

Figure 4 – Daily minimum air temperatures (TMAX) for spring (MAM) and summer (JJA) of 2019. Bias (in K) between ECLand's 2 days-ahead forecasts with revised land cover (CCI0), control simulation (CTR0), and GHCN observations. Mean bias differences (left panels) and absolute bias changes (right panels).

CONCLUSIONS

- ECLand's revised land cover shows improvements, particularly during spring in the NH, while systematic errors are generally found in the tropics, being amplified during the summer period (**Figure 2**).
- The increase of temperature found in the model generally results from changes in surface roughness lengths and vegetation cover, leading to a positive (negative) impact where there is pre-existing cold bias (warm bias).
- Further developments in ECLand for the next operational IFS cycle include:
    - Model tunning and revision towards the handling of roughness lengths disaggregation for the tiles and post-processing of T2M;

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