

# Biophysical impacts of land use changes on the local and regional climate

## Results and lessons learnt from the CORDEX Flagship Pilot Study LUCAS

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### Our objective:

We want to quantify biophysical impacts of human land surface modifications on the regional climate and answer the question: What error do we make if we ignore land use changes?

### What is LUCAS?

Land Use and Climate Across Scales (LUCAS) is a coordinated effort to integrate land use changes into multi-model regional climate change simulations for Europe and North America (LUCAS-NA).

### Our approach:

- (1) Extreme land use change experiments
- (2) Realistic past and SSP-based future land use changes in regional climate change projections
- (3) Pilot studies on convection permitting (CP) scales

### Biophysical impacts of extreme land use changes

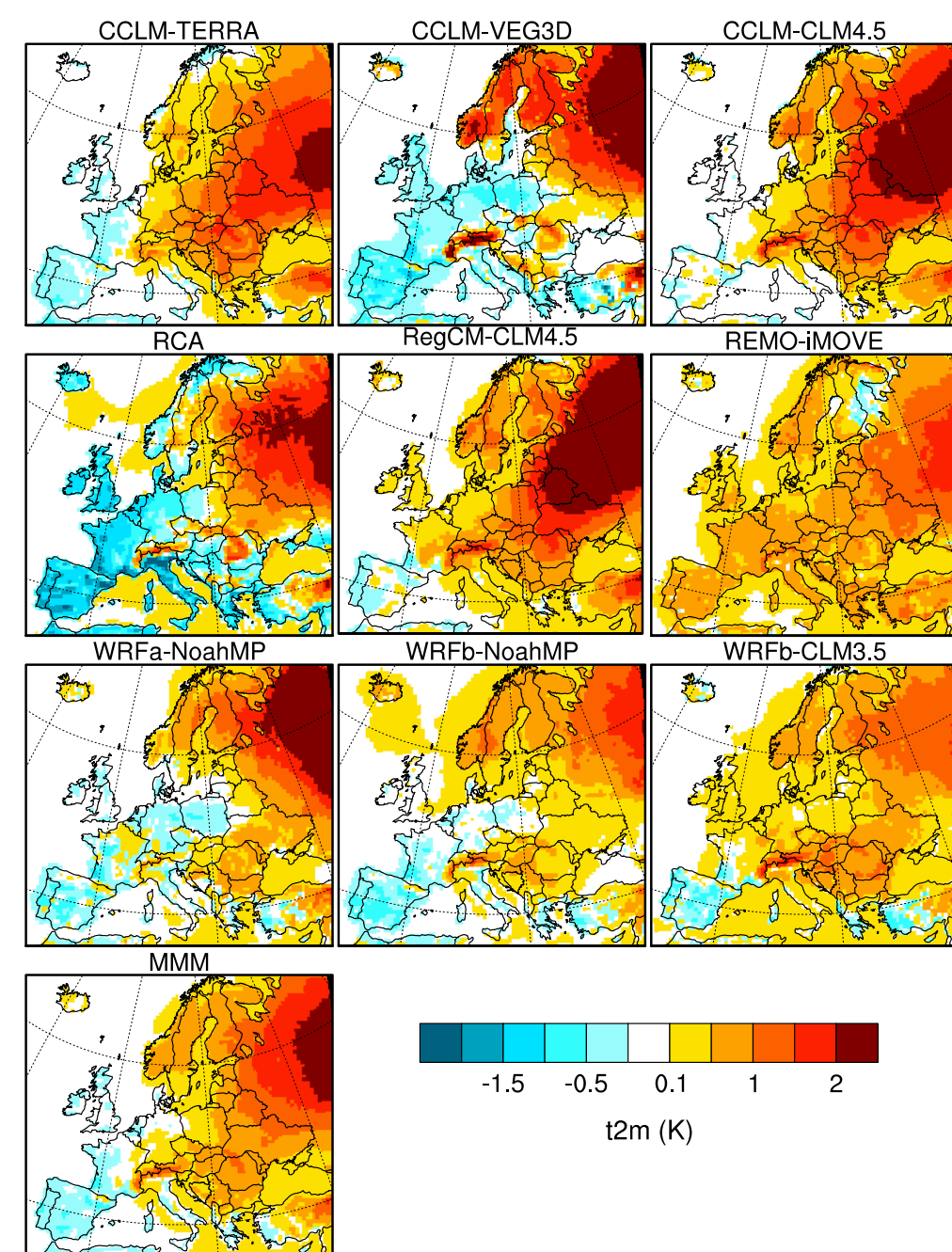


Fig. 1: Near-surface temperature (2m) difference between FOREST and GRASS for winter (Dec, Jan, Feb) 1986-2015, of individual models and multi-model mean (MMM). Source: Davin et al. 2020.

### Impacts of continental scale re-/afforestation with maximised forest cover (FOREST) vs. forest cover replaced by grass (GRASS) in reanalyses-driven RCM simulations:

- In many parts of Europe, models agree in winter warming with regional increases up to +2 K (Fig.1), which can be attributed to consistently simulated land surface albedo change.
- There is a strong disagreement among models in summer temperature responses which range between -2 K and +2 K (Fig.2), which can be largely attributed to differences in the partitioning of sensible and latent heat fluxes.
- Further RCM intercomparison studies show robust biophysical impacts of forestation on soil-vegetation-atmosphere interactions, and local to regional climate in Europe (e.g. Breil et al., 2020, Sofiadis et al., 2022; Daloz et al., 2022; Mooney et al., 2022, Wohland et al., in prep.).
- LUCAS-NA simulations reveal strong inter-continental similarities (Asselin et al., 2022).

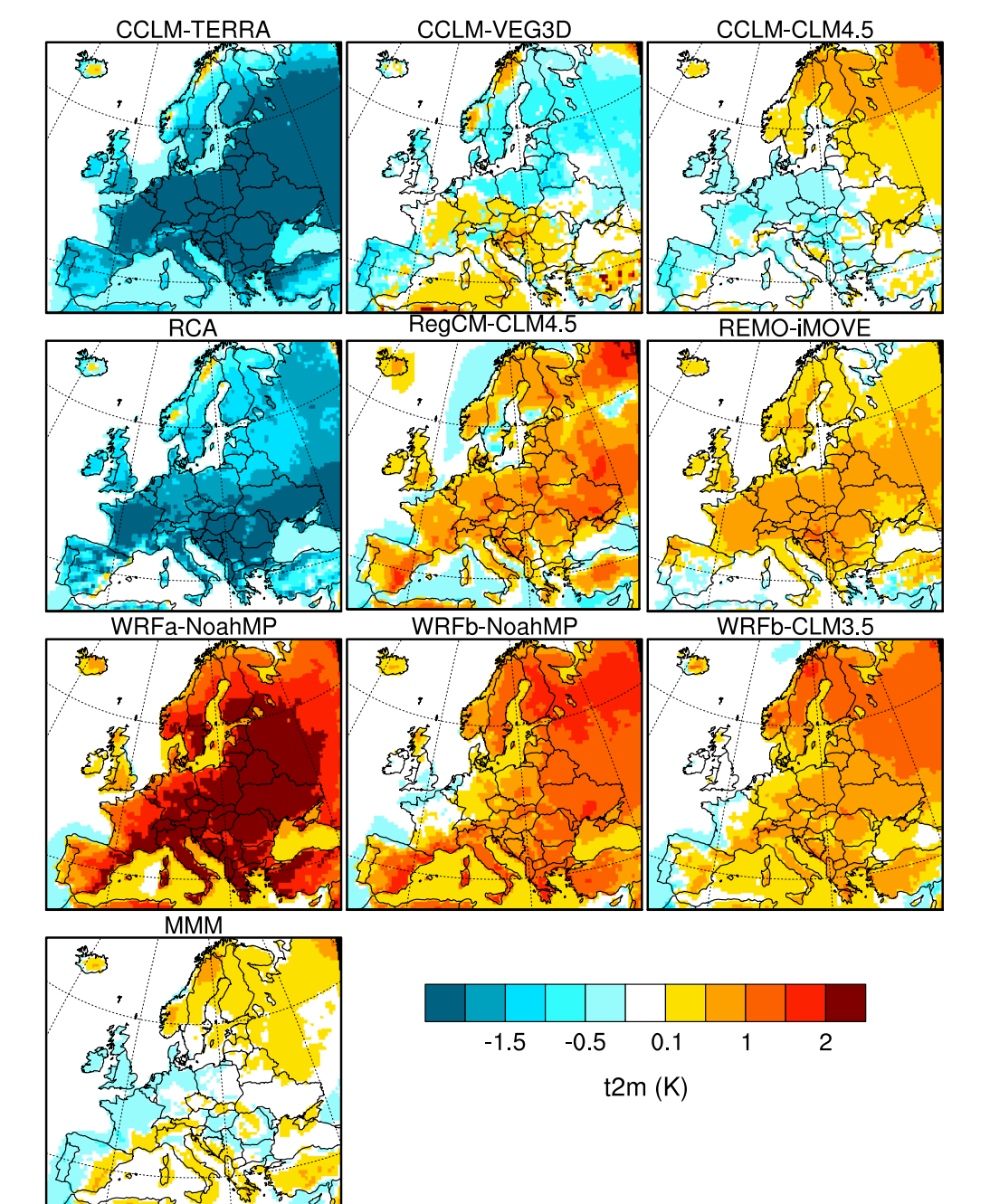


Fig. 2: Near-surface temperature (2m) difference between FOREST and GRASS for summer (Jun, Jul, Aug) 1986-2015, of individual models and multi-model mean (MMM). Source: Davin et al. 2020.

### First coordinated multi-model regional climate change projections including transient land use changes

#### LUCAS phase 2 experiment protocol available:

- Transient RCM simulations 1950-2015 / 2015-2100 over EURO-CORDEX domain on 0.11°
- Driven by GCM CMIP6 simulations for SSP126 and optionally further SSPs
- With annually varying land use from LUCAS LUC V1.1 (Hoffmann et al. 2023, Fig.3)
- Corresponding reference simulation with static land cover map for the year 2015
- Guidelines for the implementation of the LUCAS LUC PFT maps consistently into RCMs

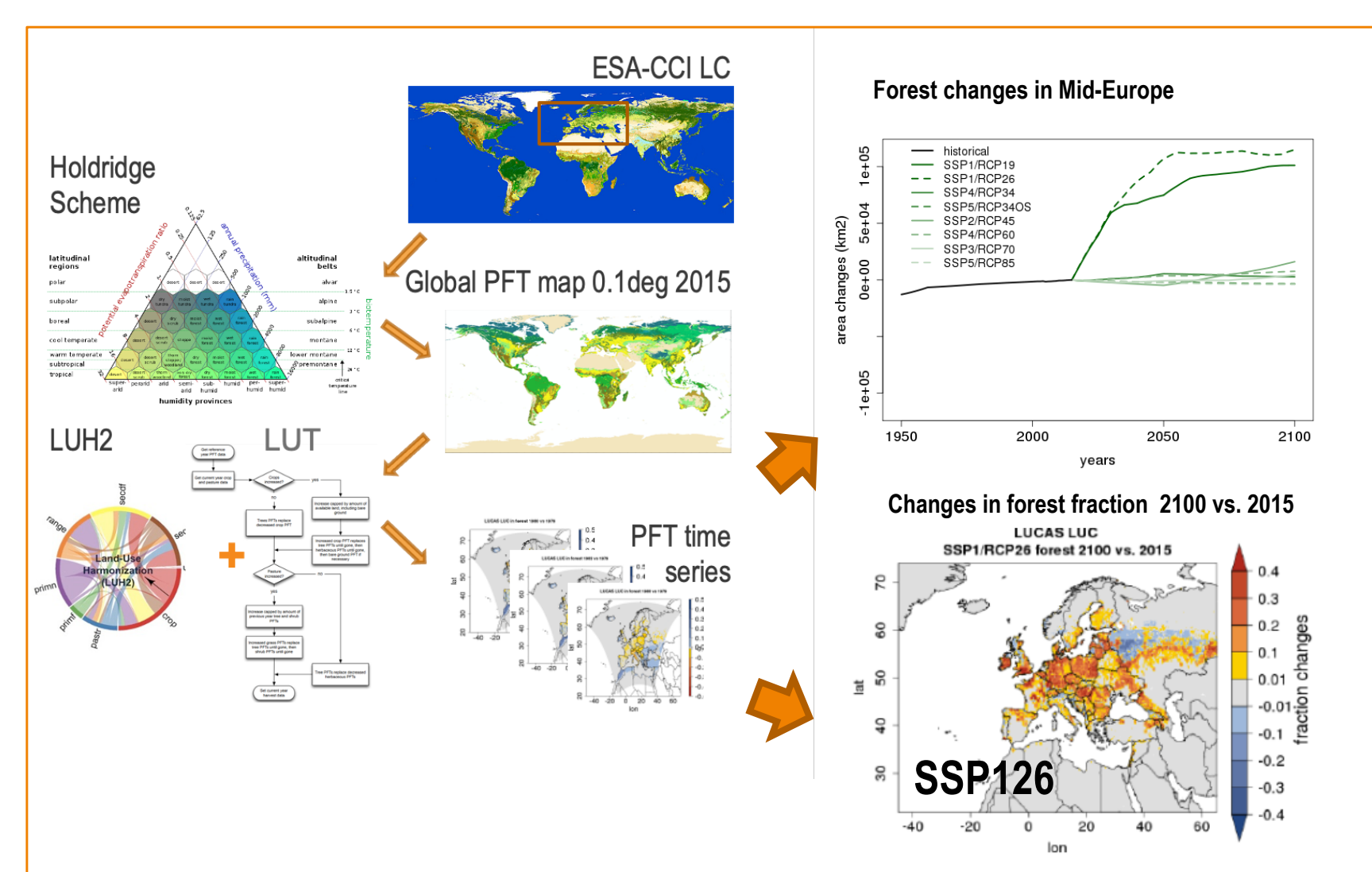


Fig. 3: From remotely sensed land cover to Plant Functional Types (PFT): LANDMATE PFT map 2015 on 0.018° and 0.1° for EURO-CORDEX domain (Reinhart et al., 2022), and LUCAS LUC annual PFT maps on 0.1° for EURO-CORDEX domain for past period 1950-2015 and multiple SSPs 2016-2100, based on LUH2 land use transitions (Hoffmann et al., 2023). Datasets published at WDCC/DKRZ: <https://www.wdc-climate.de/lu/project/acronym=LANDMATE>

#### Where we are:

- All RCMs use the same land use land cover distribution: successful translation of LUCAS LUC PFTs into RCM specific land surface types.
- RCM test experiments driven by ERA5 conducted.
- To be considered: subgrid-scale land use dynamics are represented differently in RCMs with land use 'tile approach' and in those with 'majority approach'.
- LUCAS phase 2 simulations have been started.
- First SSP-based RCM simulations with LUCAS LUC PFT maps for time slices by Asselin et al. (in prep.).

#### What next?

- Create the first multi-RCM ensemble of regional climate change projections including transient land use changes
- CPRCM studies in pilot regions as currently prepared for irrigation experiments
- Provide the new database for impact studies and climate services

#### What did we learn? Some key points:

- We see robust biophysical impacts of land use changes on the regional climate in Europe and North America, but also contradictory responses among models.
- There are still fundamental uncertainties related to the representation of land processes in RCMs, which highlights the need for improved land parameterisation schemes.
- LUCAS provides a framework to incorporate land use changes consistently into coordinated downscaling experiments which can be transferred to other CORDEX regions.

#### Interested?

- Would you like to join? Would you like to apply the LUCAS framework to your CORDEX region? You are welcome to contact us: [diana.rechid@hereon.de](mailto:diana.rechid@hereon.de)
- Have a look at our LUCAS website and publication list:



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