

Biogeophysical impacts of re/afforestation in Europe: First results from the LUCAS Regional Climate Model intercomparison

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LUCAS FPS

- Flagship Pilot Study endorsed by the CORDEX consortium
- **Aim:** include Land Use Change (LUC) forcing in Regional Climate Models (RCM) and understand its impact at the regional scale
- ~20 participating institutions with ~13 RCMs

Coordination:

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LUCAS Science Questions

- How sensitive are RCMs to LUC and how does this sensitivity varies across a range of models?
- How large is the contribution of LUC to past and future climate trends?
- What is the role of spatial resolution when quantifying LUC-induced impacts?
- Which land use choices are most influential at the regional scale?
- ...and many more

LUCAS strategy

- **Phase 1: Idealized experiments**
 - Europe, 50km resolution
 - “GRASS” and “FOREST” experiments
- **Phase 2: Realistic experiments**
 - Continental scale, ~25 km resolution
 - Historical LUC forcing and future LUC SSP forcing?
- **Phase 3: High resolution experiments**
 - Sub-continental scale, <5km resolution
 - Pilot domains identified in FPS on Convective phenomena?

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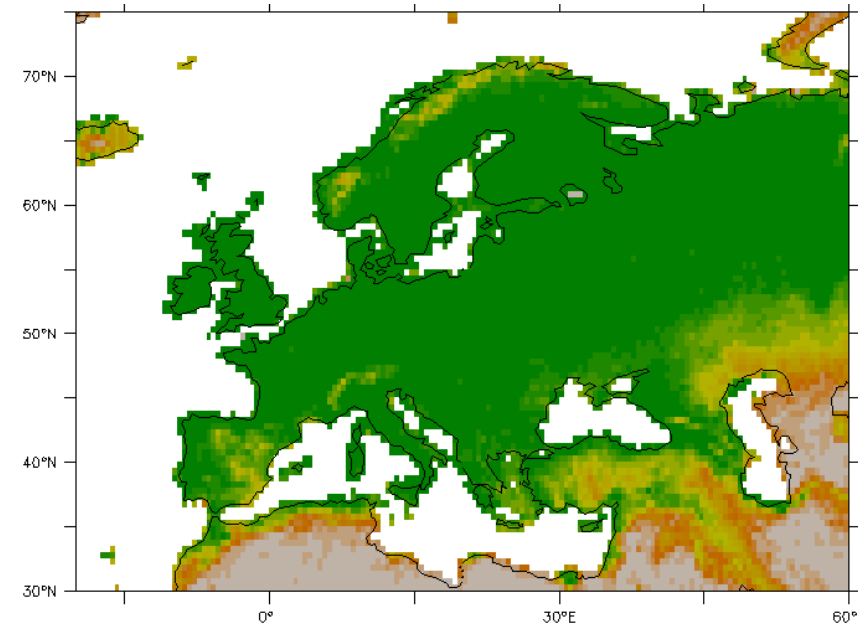
Phase 1

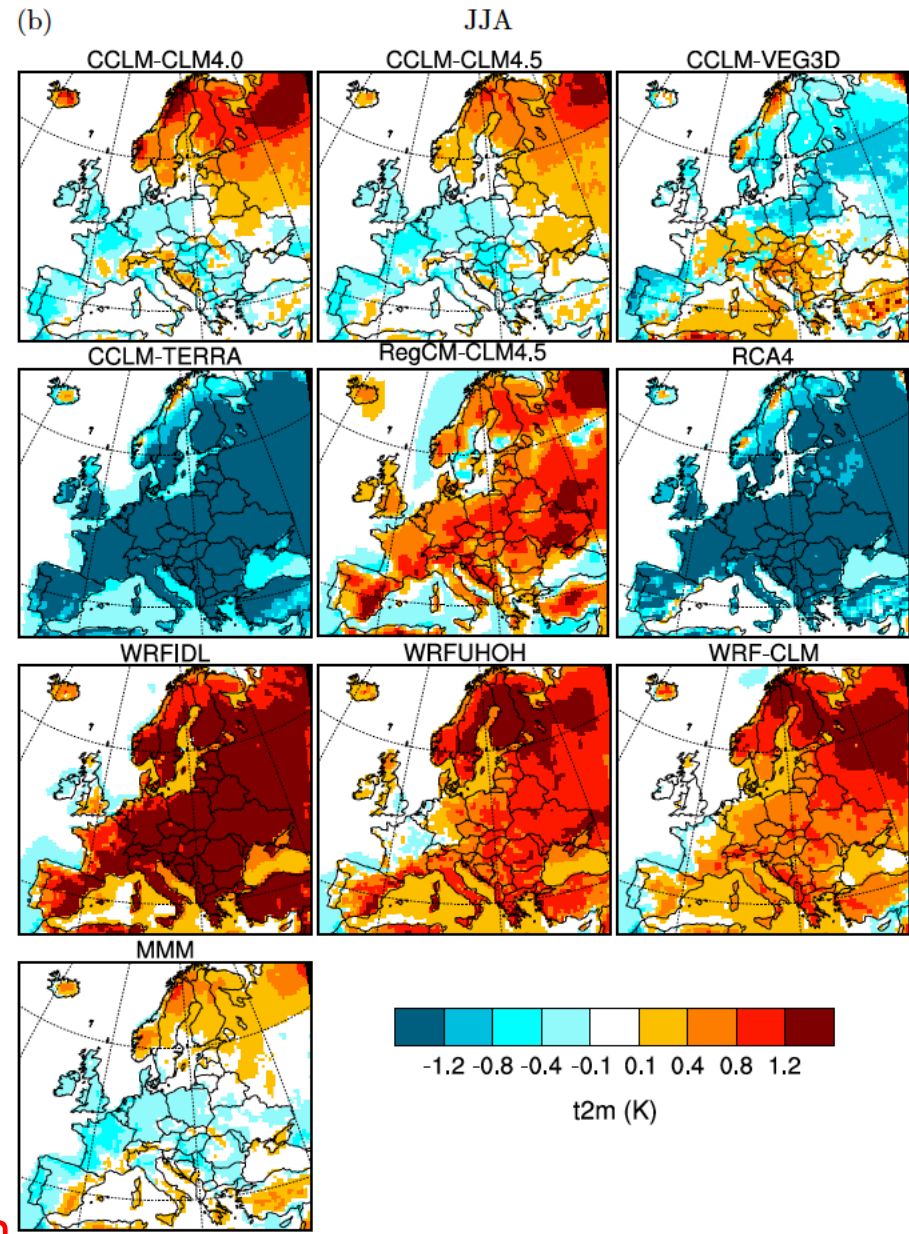
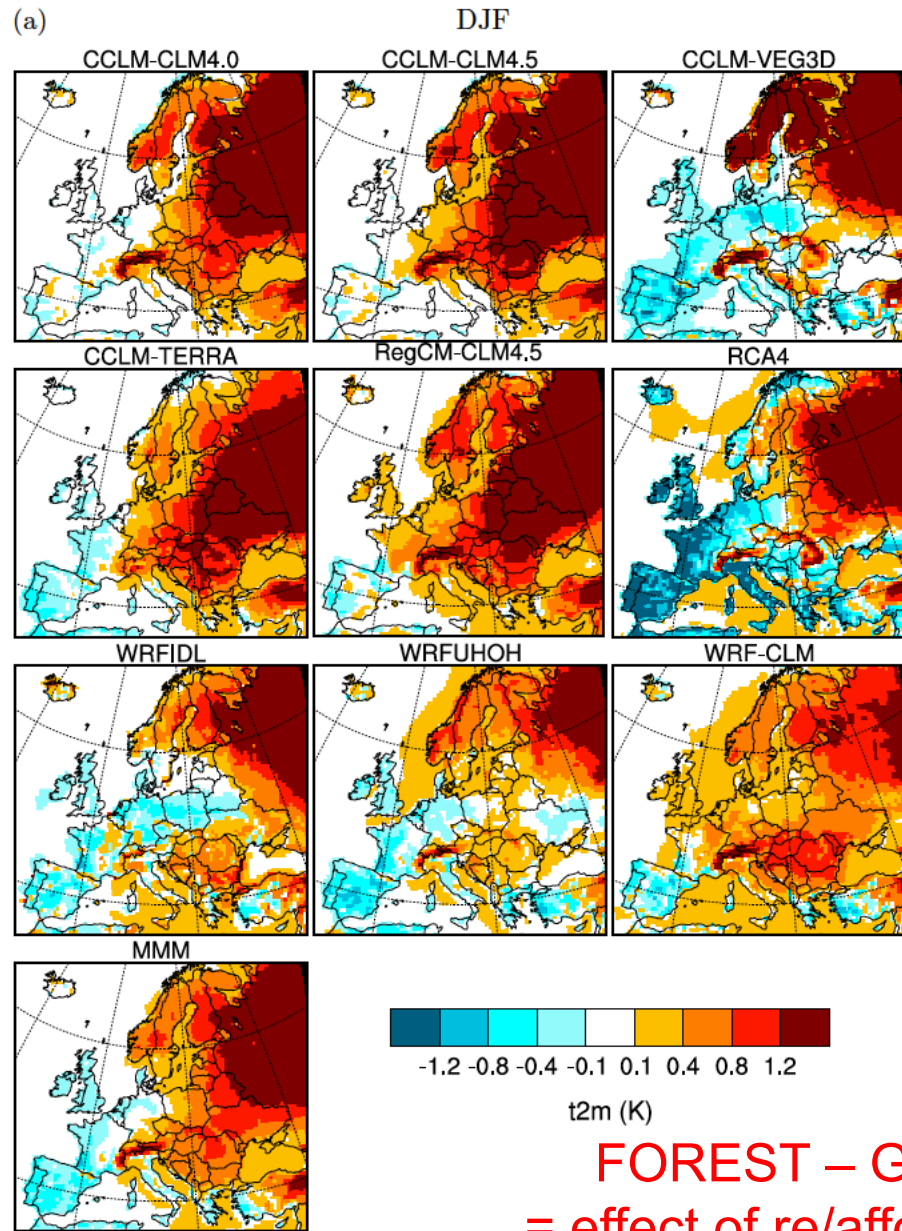
Experiment name	Tier	Description	LUC forcing	Global forcing	Domain	Resolution	Time period
"FOREST" (maximised forest cover)	1	Reanalysis-driven run with maximized forest cover (according to potential vegetation)	Static map of potential vegetation (break down forest types)	ERA-Interim	EURO-CORDEX	0.44°	1986-2015 (analysis period) <i>individual model spin up e.g. 1979-1985</i>
GRASS (no forest, only grasses)	1	Reanalysis-driven run without forest (maximum deforestation scenario)	Grassland only static map (break down C3/C4 grasses)	ERA-Interim	EURO-CORDEX	0.44°	1986-2015 (analysis period) <i>model spin up</i>

Vegetation maps

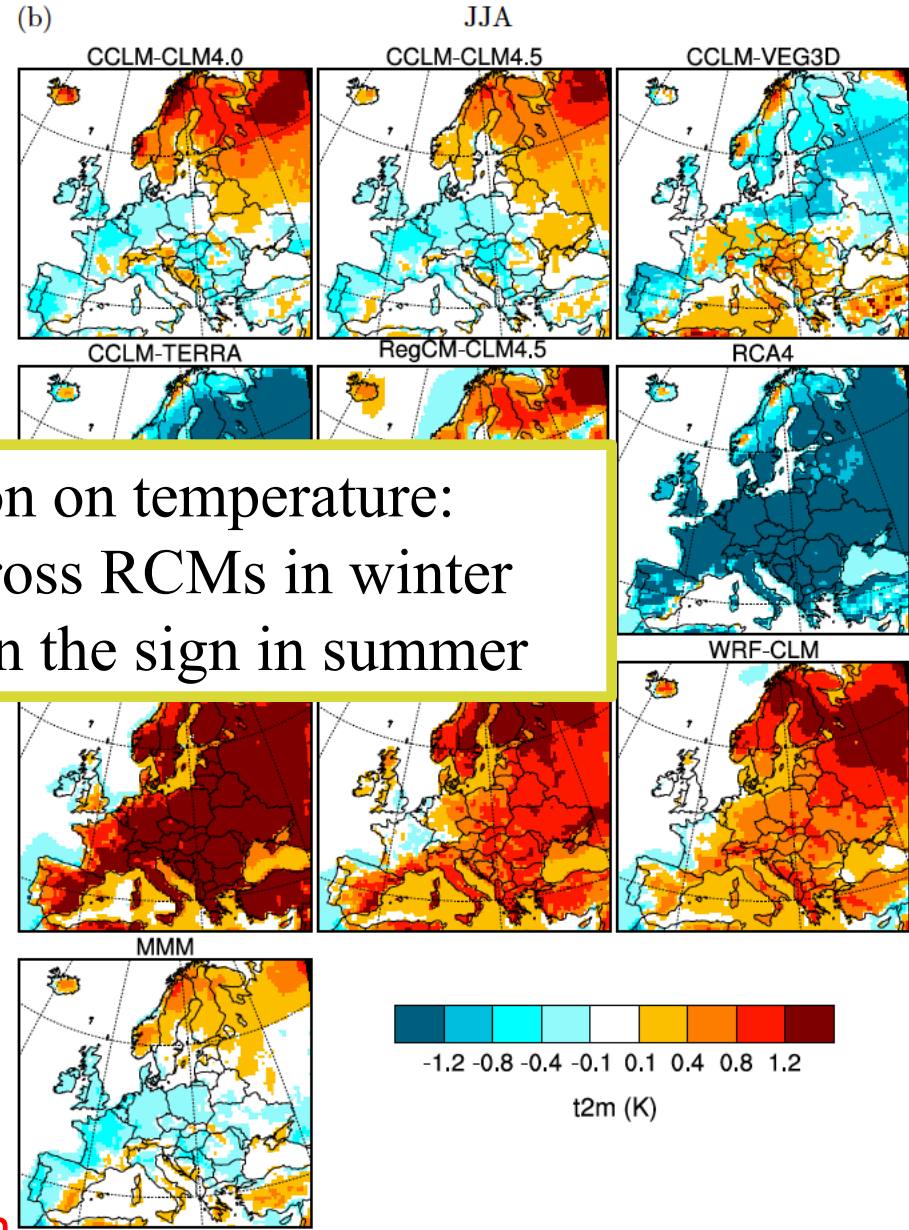
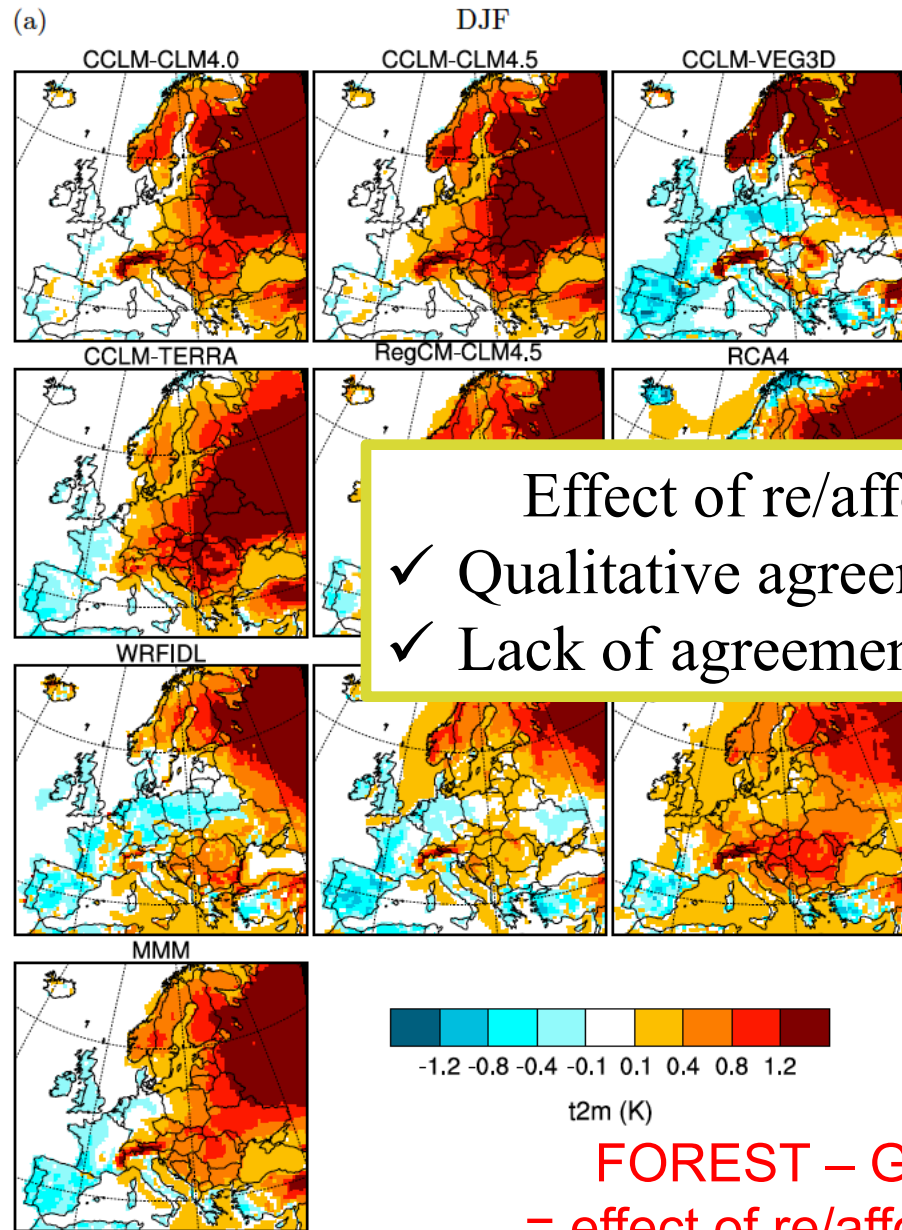
- Start with MODIS-based land cover map at 0.5 degree resolution (Lawrence and Chase, 2007)
- Rescale forest PFTs so that they occupy the non-bare soil area in all grid cells, i.e. forest PFTs+bare soil = 100%
- Conserve ratio between different forest PFTs. If no trees are present in a given grid cell that has less than 100% bare soil, take the zonal mean forest composition as a representative value before scaling it.
- The “**FOREST**” map represents a theoretical maximum of forest coverage if trees were allowed to occupy all of the land area, excluding warm and cold deserts where they cannot realistically grow
- In the “**GRASS**” map all forest PFTs are replaced by grassland (C3/C4 ratio conserved)

Forest cover



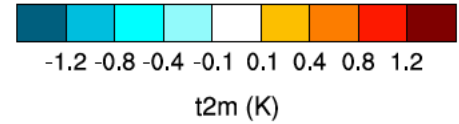
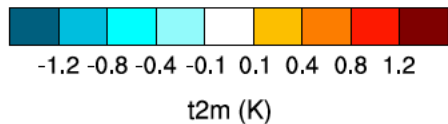


FOREST – GRASS
= effect of re/afforestation



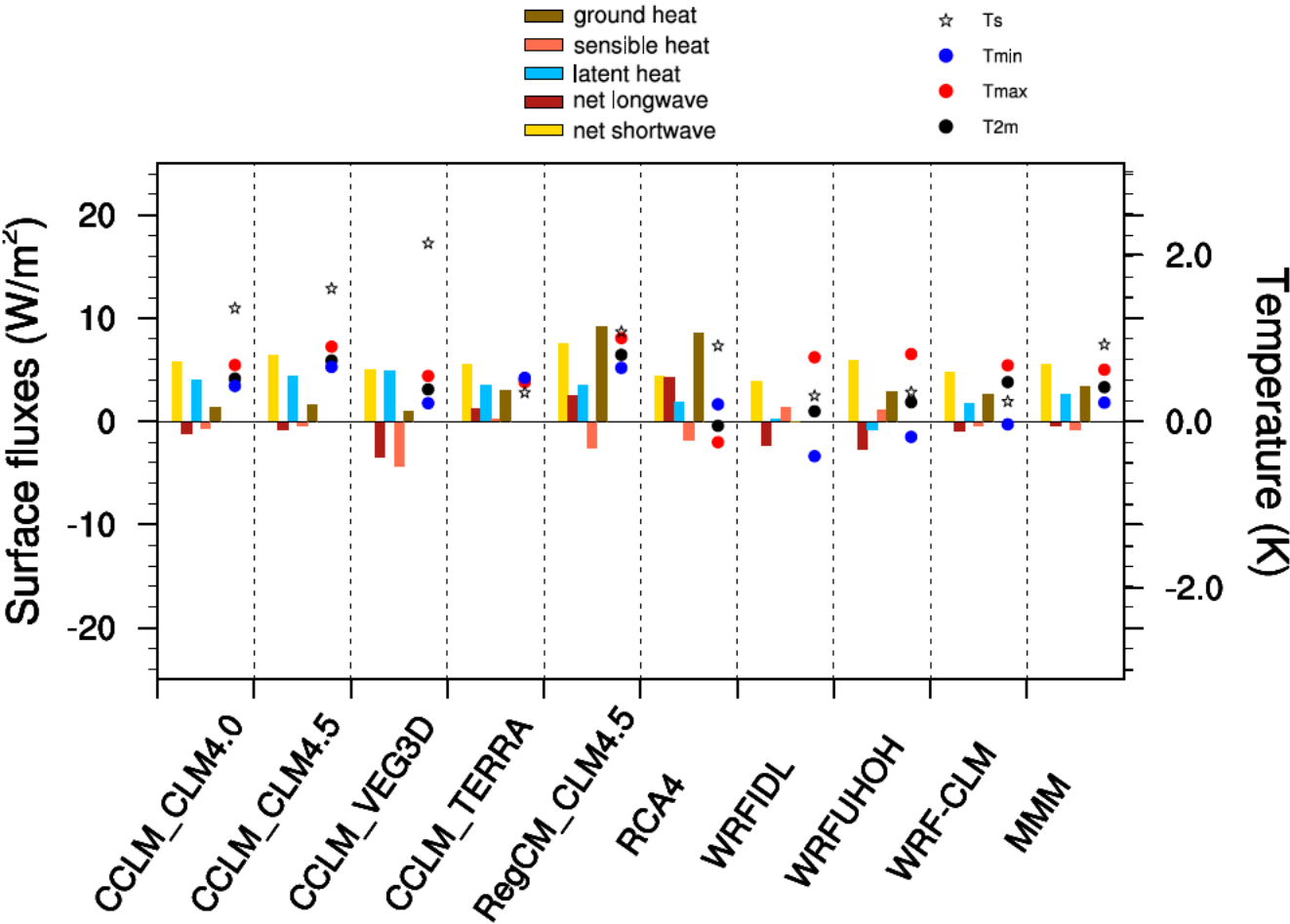
Effect of re/afforestation on temperature:

- ✓ Qualitative agreement across RCMs in winter
- ✓ Lack of agreement even in the sign in summer



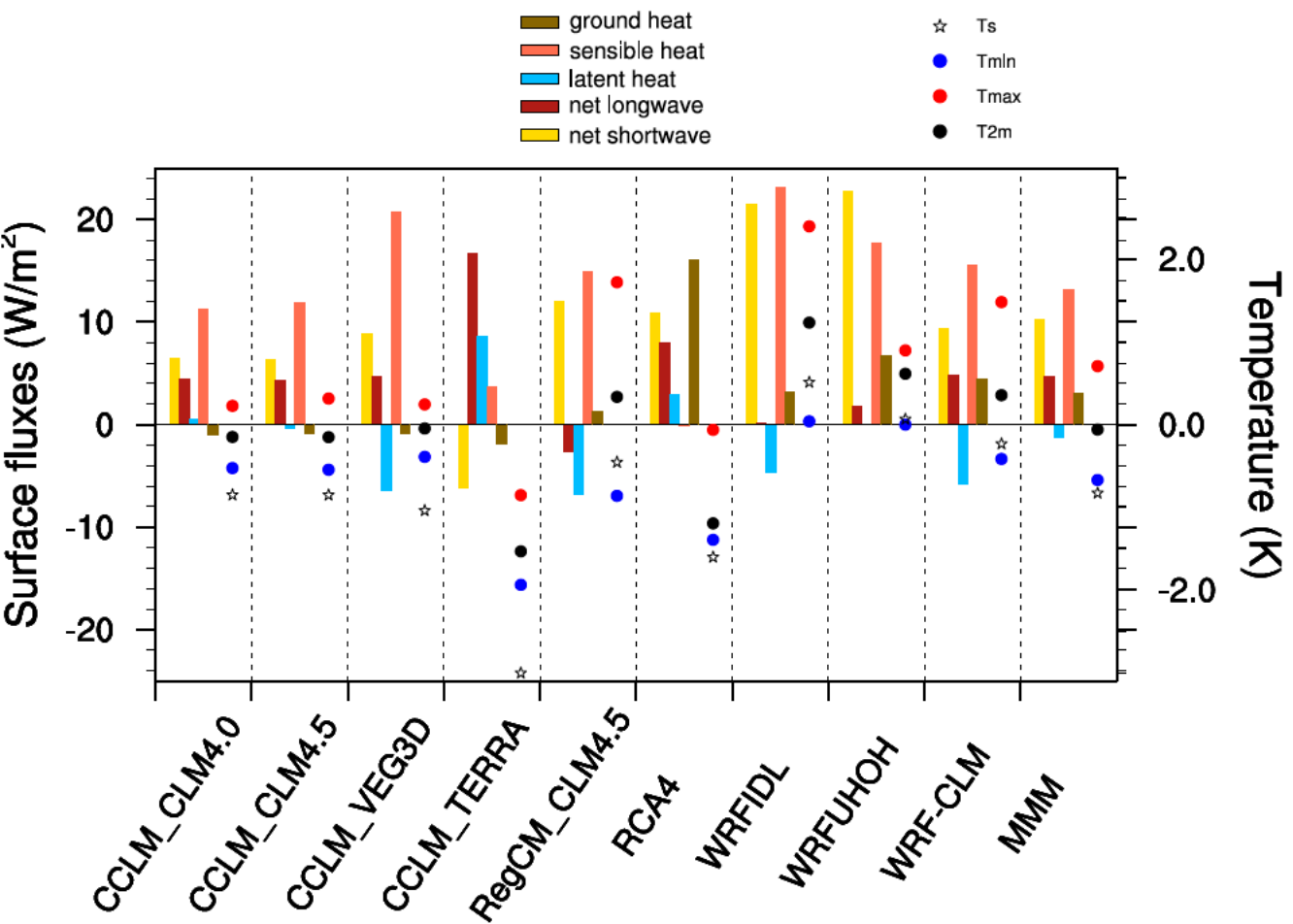
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(a) DJF (Northern Europe)



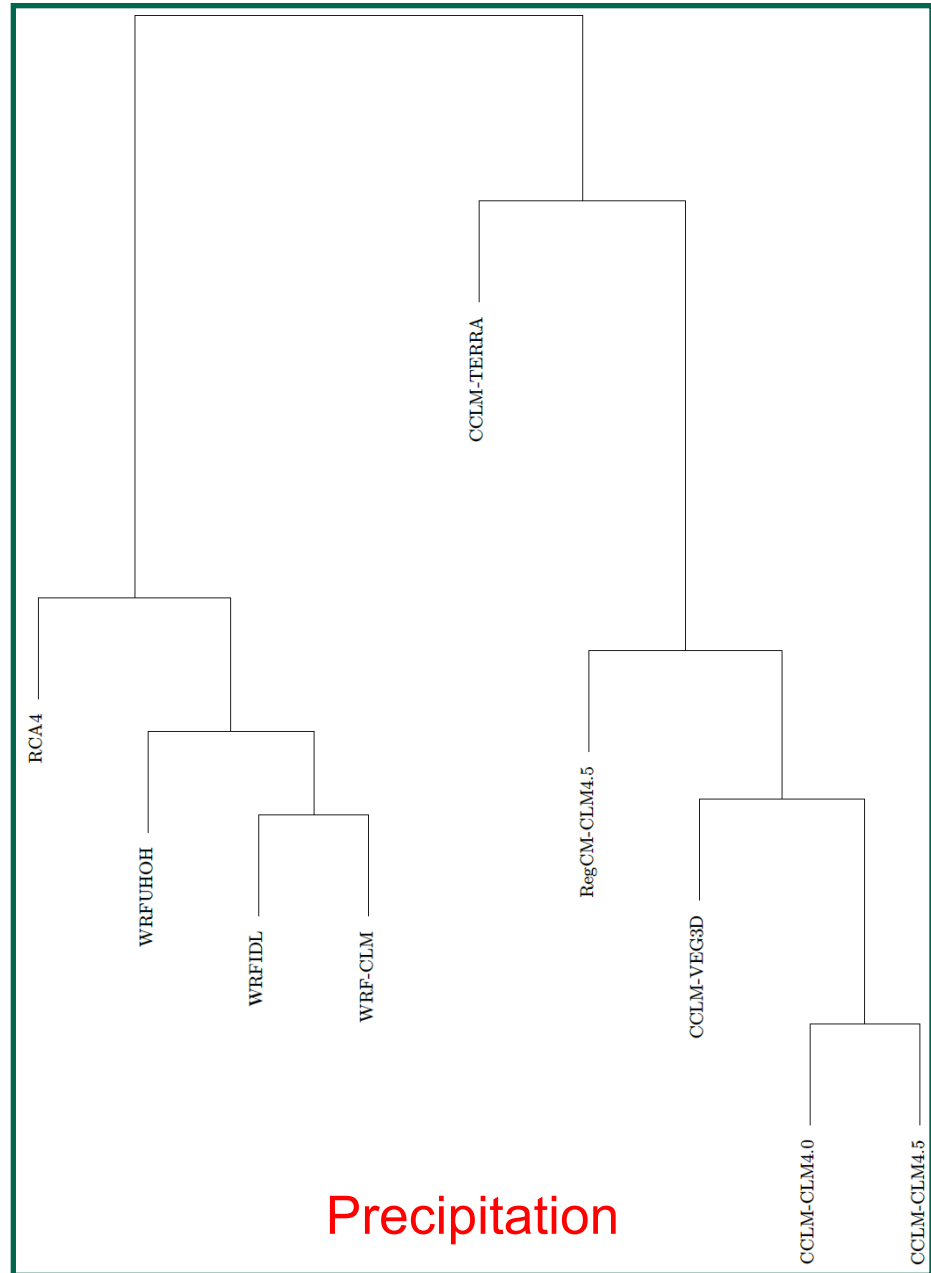
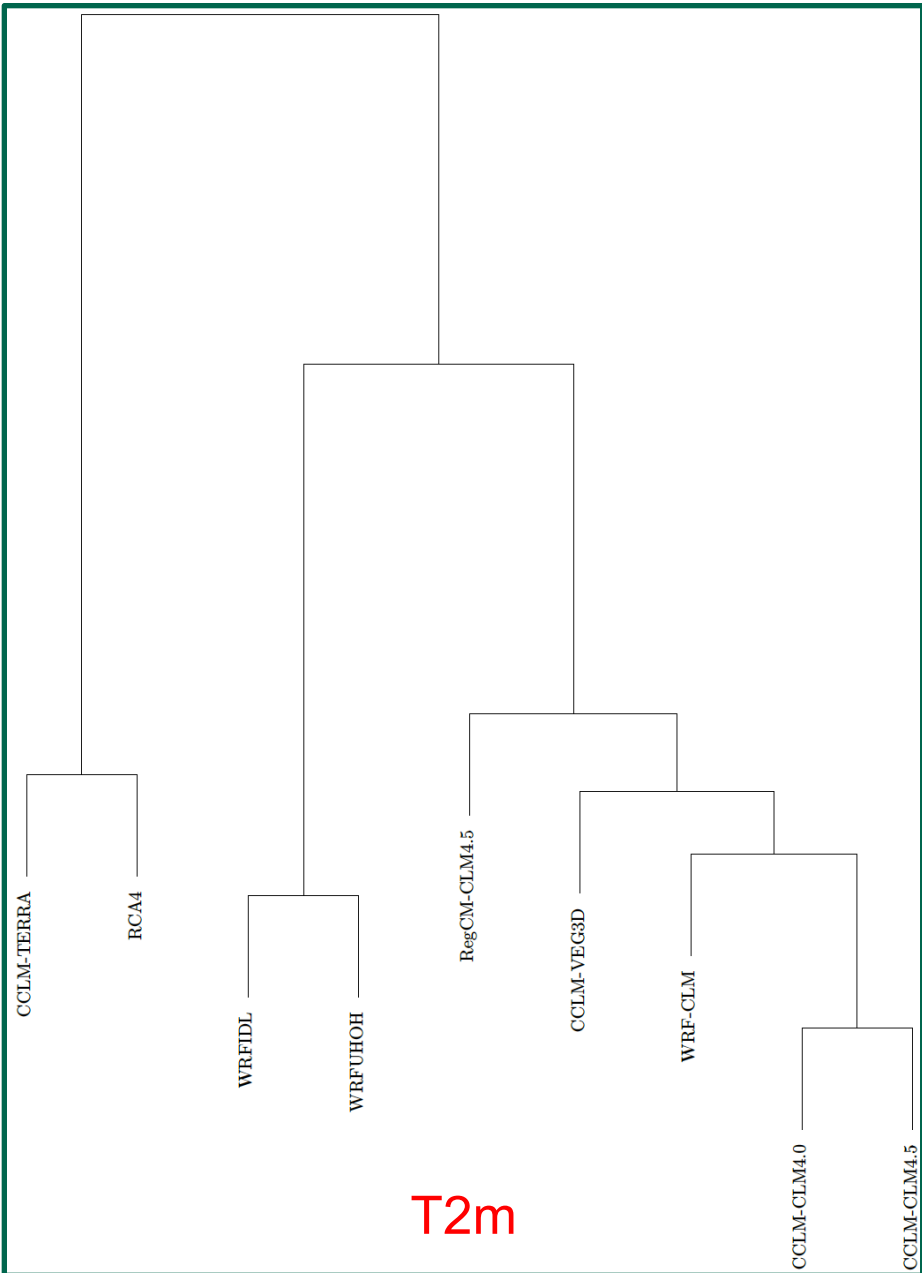
✓ Winter response is dominated by the radiative effect of forest (albedo decrease) which is consistent across RCMs

(c) JJA (Southern Europe)

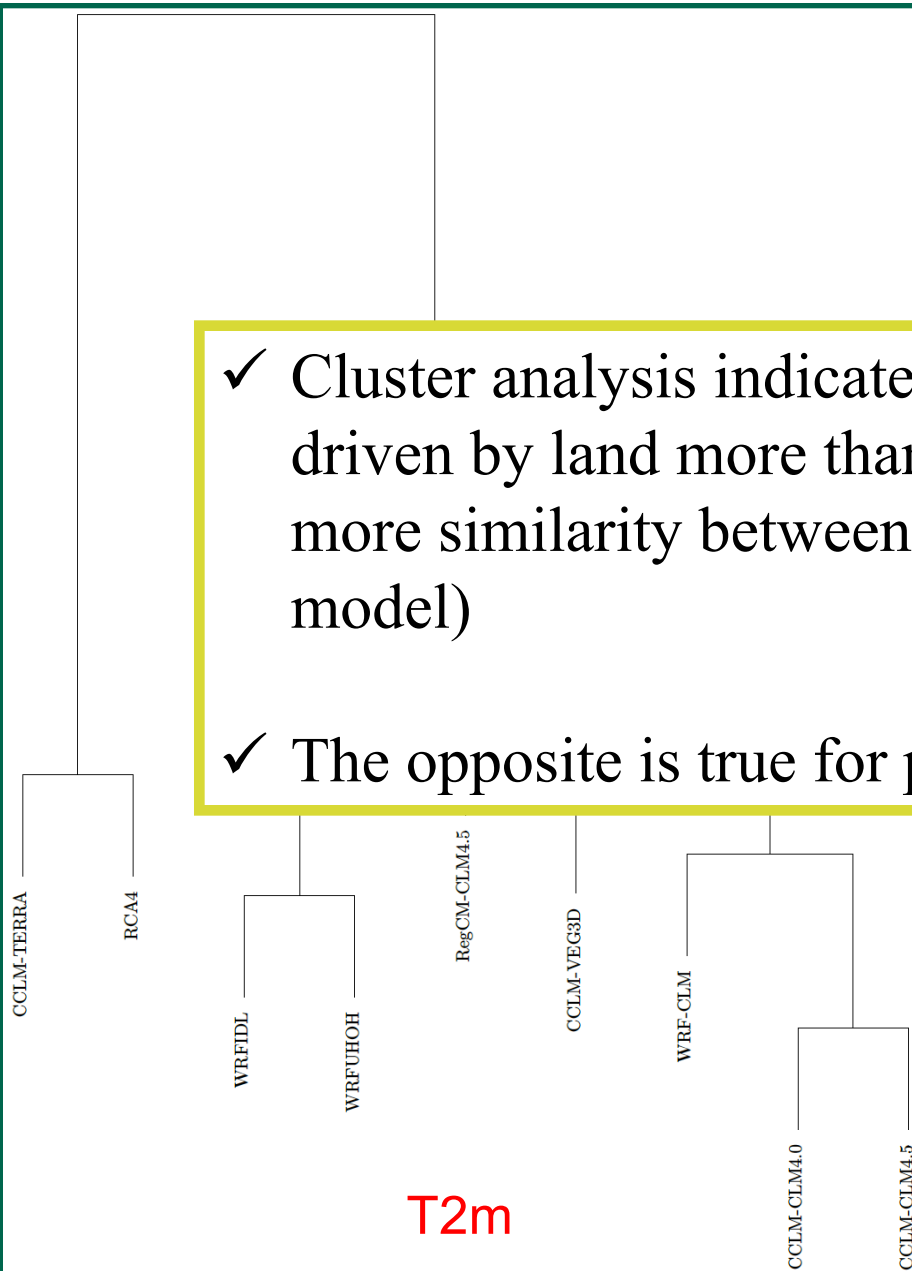


✓ Disagreement in summer is linked with discrepancies in ET response

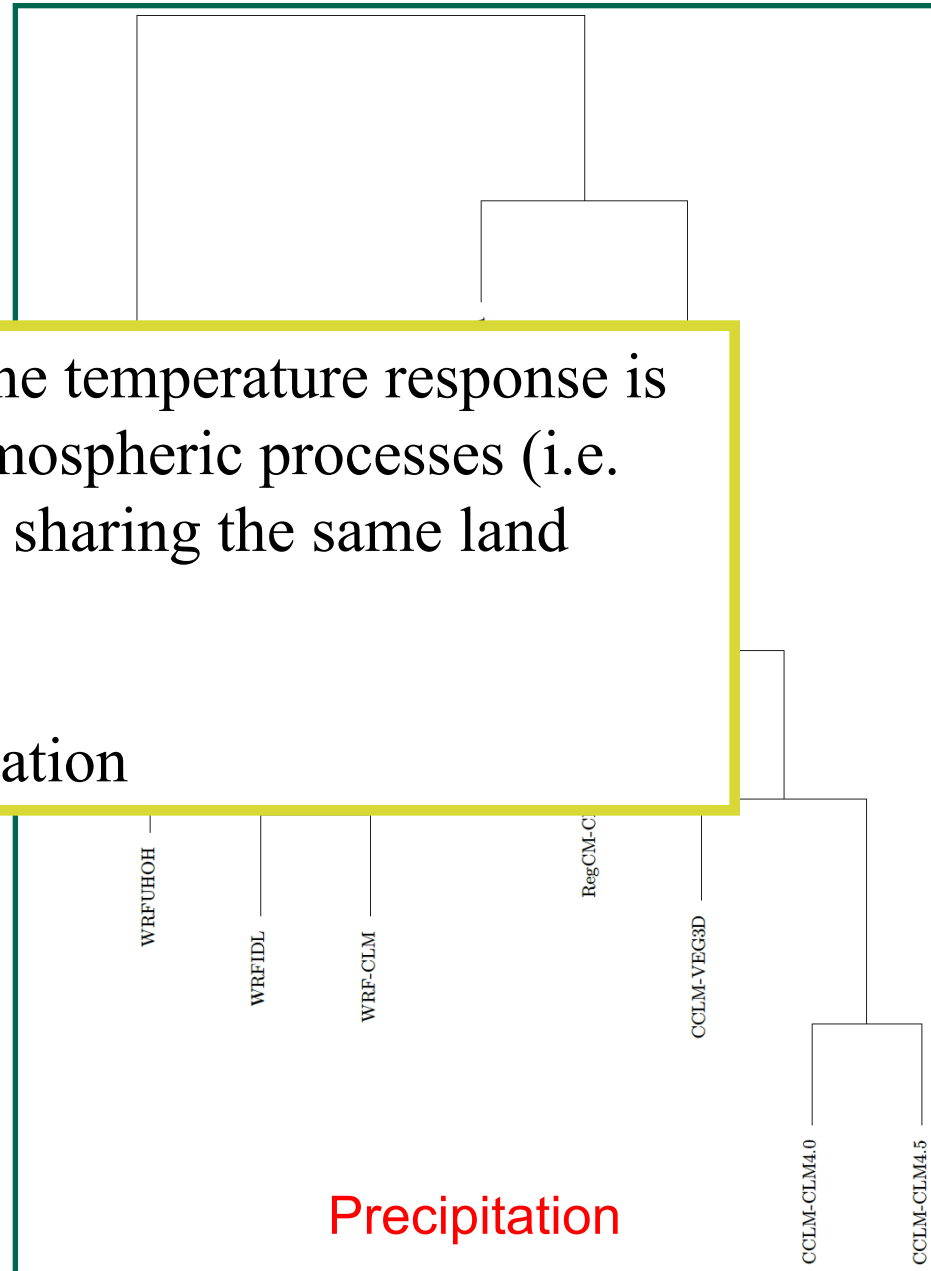
✓ Decrease in Tmin and increase in Tmax for all RCMs except RCA and CCLM-TERRA



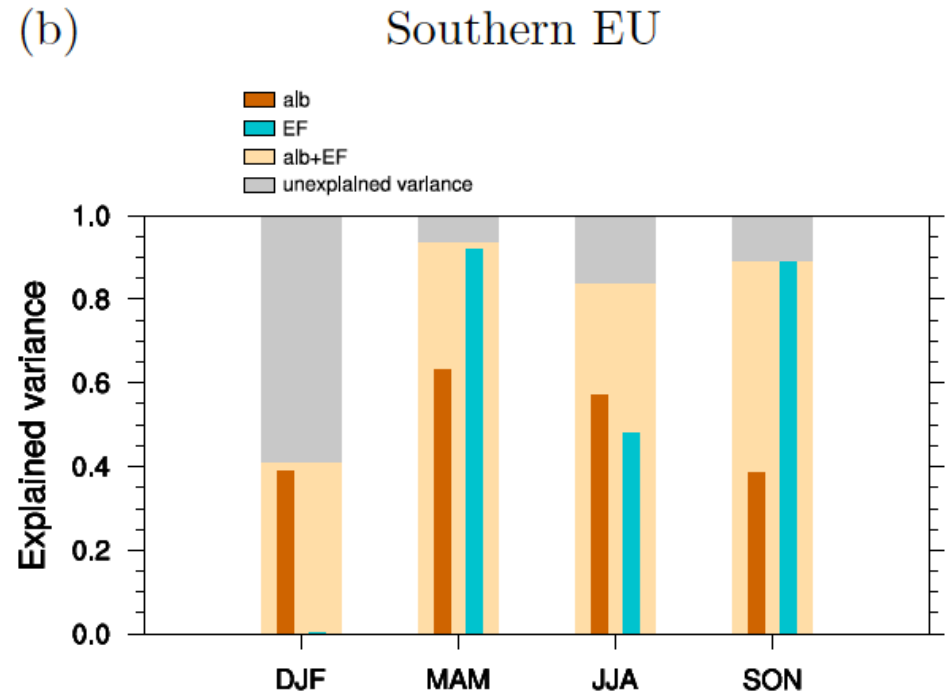
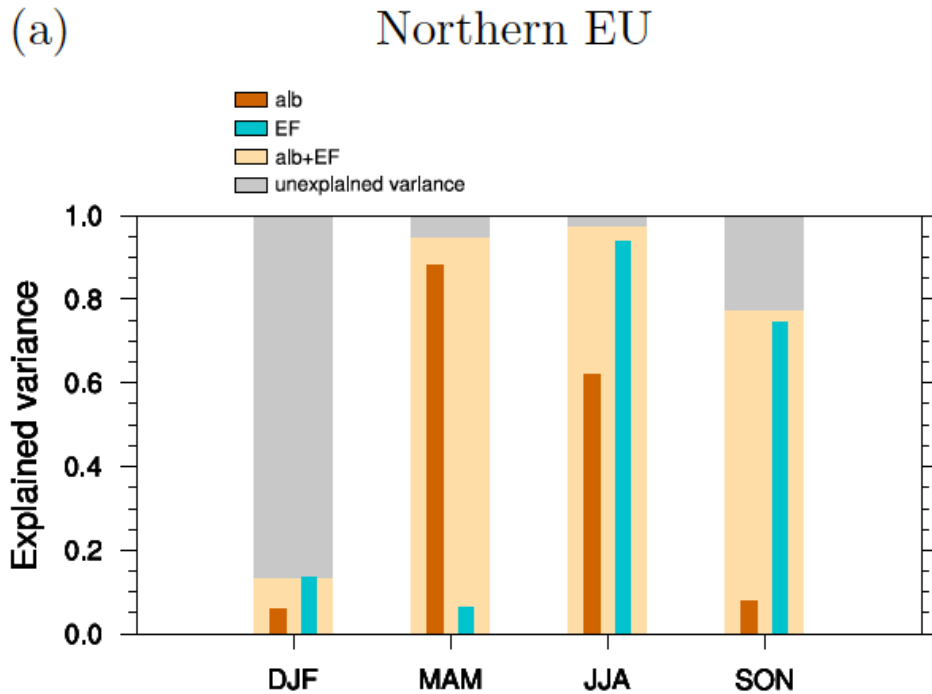
- ✓ Cluster analysis indicates that the temperature response is driven by land more than by atmospheric processes (i.e. more similarity between RCMs sharing the same land model)
- ✓ The opposite is true for precipitation



T2m



Precipitation



- ✓ Multi-linear regression analysis indicates that inter-model differences (in the response to re/afforestation) can be attributed partly to albedo in winter and to evaporative fraction in summer
- ✓ But depends strongly on region and season
- ✓ Atmospheric feedbacks play a larger role in winter

Conclusions and outlook

- These results show how important but also how challenging (e.g. large uncertainties) it is to include LUC as a standard forcing in RCM simulations
- Open questions: what is causing the spread in ET response?; discrepancy between T2m and skin temperature...
- Future analysis of Phase 1 experiments: diurnal cycle, extremes, coupling strength, relation between model biases/sensitivities, observational constraints, and more...
- Design of Phase 2/3 will be discussed at the upcoming LUCAS workshop