Quantifying the summer temperature response to extreme deforestation in Europe

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Introduction

Anthropogenic land cover changes affect regional and global climate through biophysical variations of the surface energy budget mediated by albedo, evapotranspiration and roughness [1].

The net effect on local climate is a balance of these mechanisms. The existing model-based studies on land cover changes are contrasting, especially at mid-latitudes, finding significant spatial heterogeneities [2].

Method

We use the Weather Research and Forecasting Model (WRF) v3.8.1, coupled with Community Land Model (CLM) v3.5. The atmospheric model is run at a resolution of 0.44° over the period 1986-2015.

To evaluate the impact of deforestation we contrast a maximally forested Europe (FOREST) and a completely deforested Europe (GRASS).

Our analysis is based on the components of the surface energy budget: $Qs(1-a) + Q_{LD} = Q_{LU} + Q_H + Q_E + Q_G$ where **a** : albedo

Q_{SD} : Incoming Shortwave radiation
Q_{LD} : Incoming longwave radiation
Q_{LU} Outgoing longwave radiation
Q_H Sensible heat
Q_E Latent heat
Q_G Residual term (soil heat flux to deeper layers)

All fluxes are in units (W/m^2)

$$Qa = Qs(1-a) + Q_{LD}$$

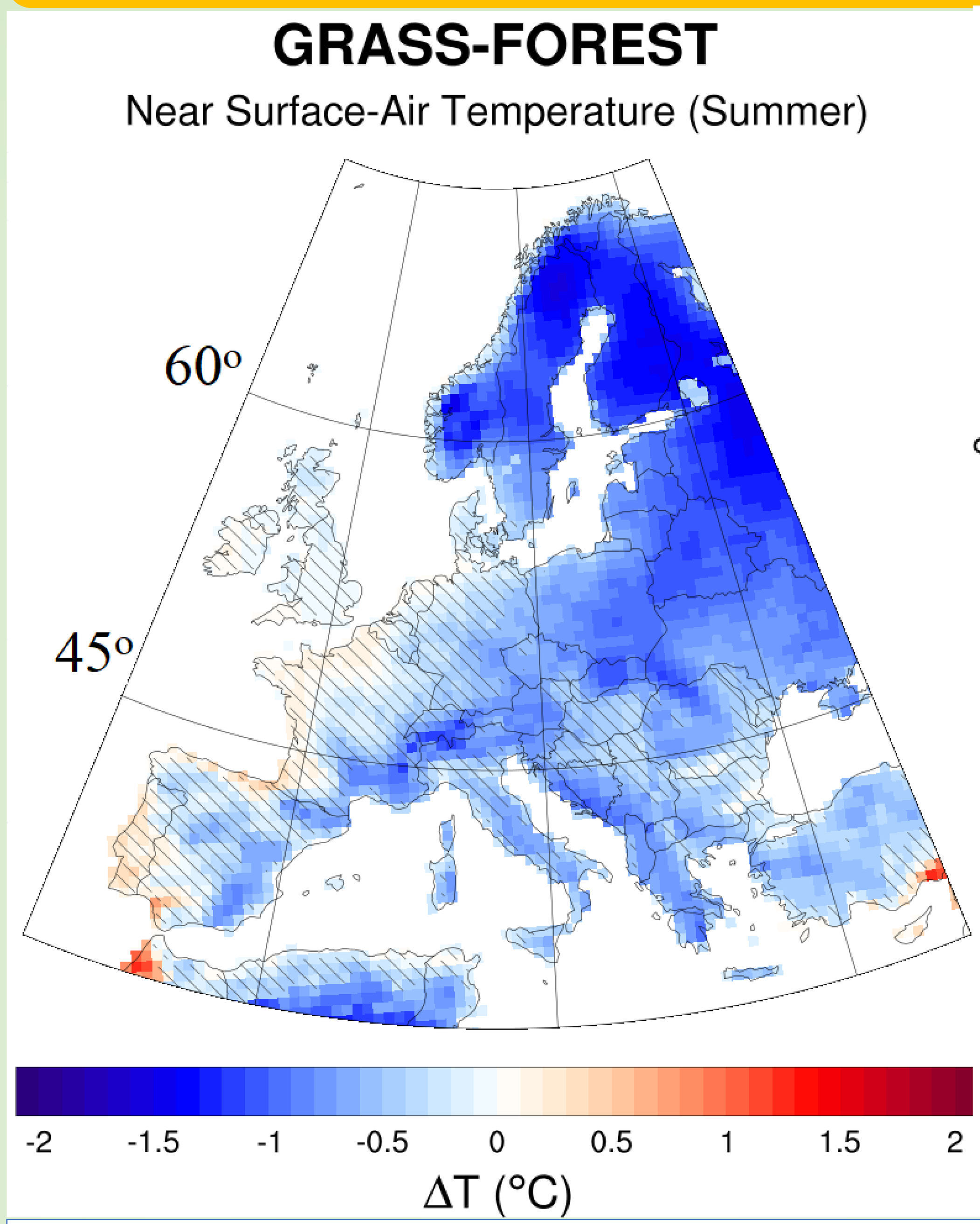

Figure 1: Mean summer temperature response to deforestation. The differences refer to GRASS-FOREST experiment. The black lines show the grids that not passed t-test at 0.05 level

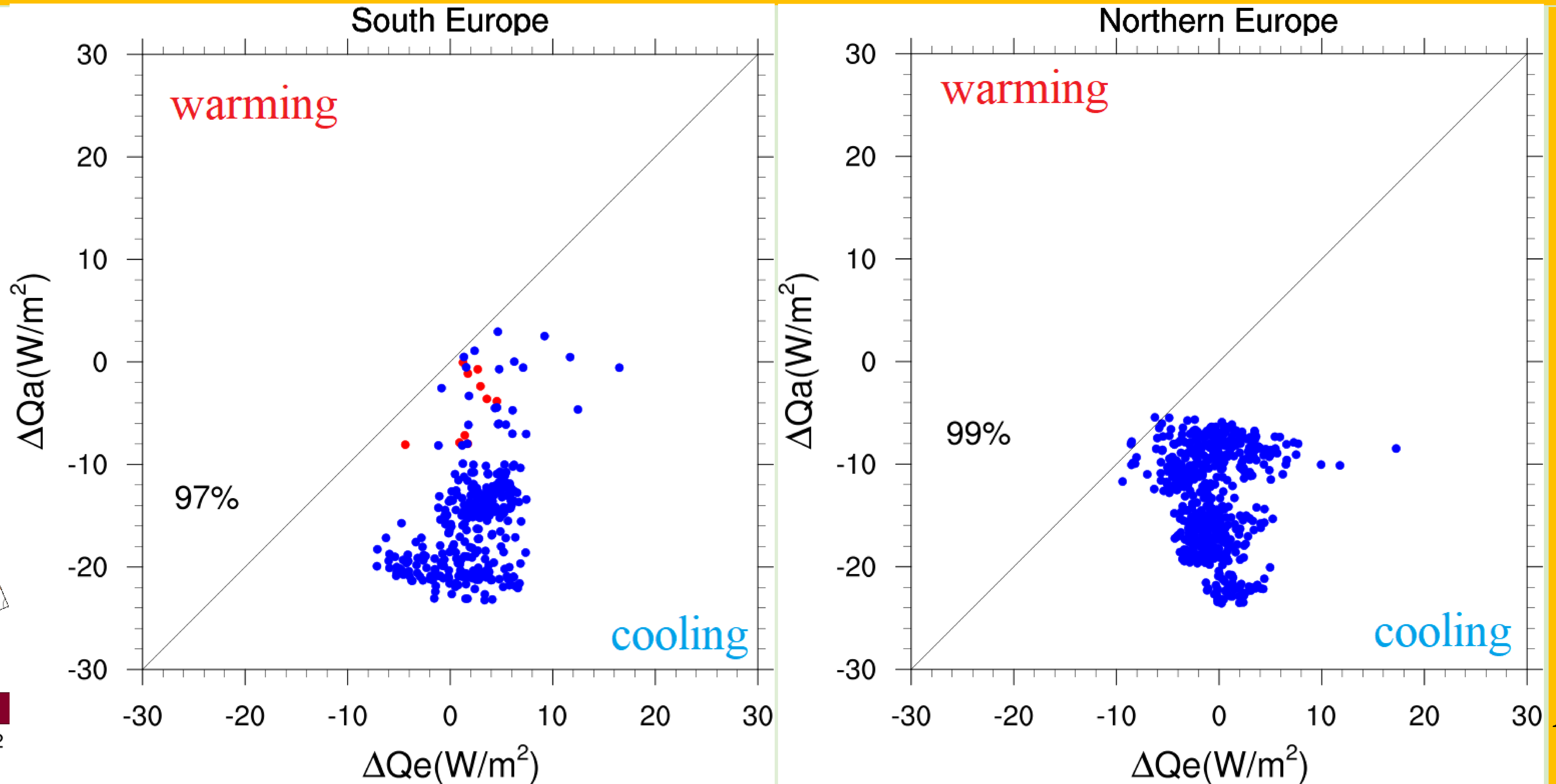

Figure 2: Changes in ET(Qe), absorbed radiation(ΔQa), and their relationship with temperature change(ΔT) over Southern(30°-45°) and Northern Europe(45°-75°). The upper left area represents ET warming exceeding albedo cooling; the lower-right area represents albedo cooling exceeding ET warming. Blue(red) are the actual grid points where temperature decreased (increased). Number denotes the percentage of deforested points whose sign of ΔT can be explained by the relative importance of ΔQa and ΔQe.

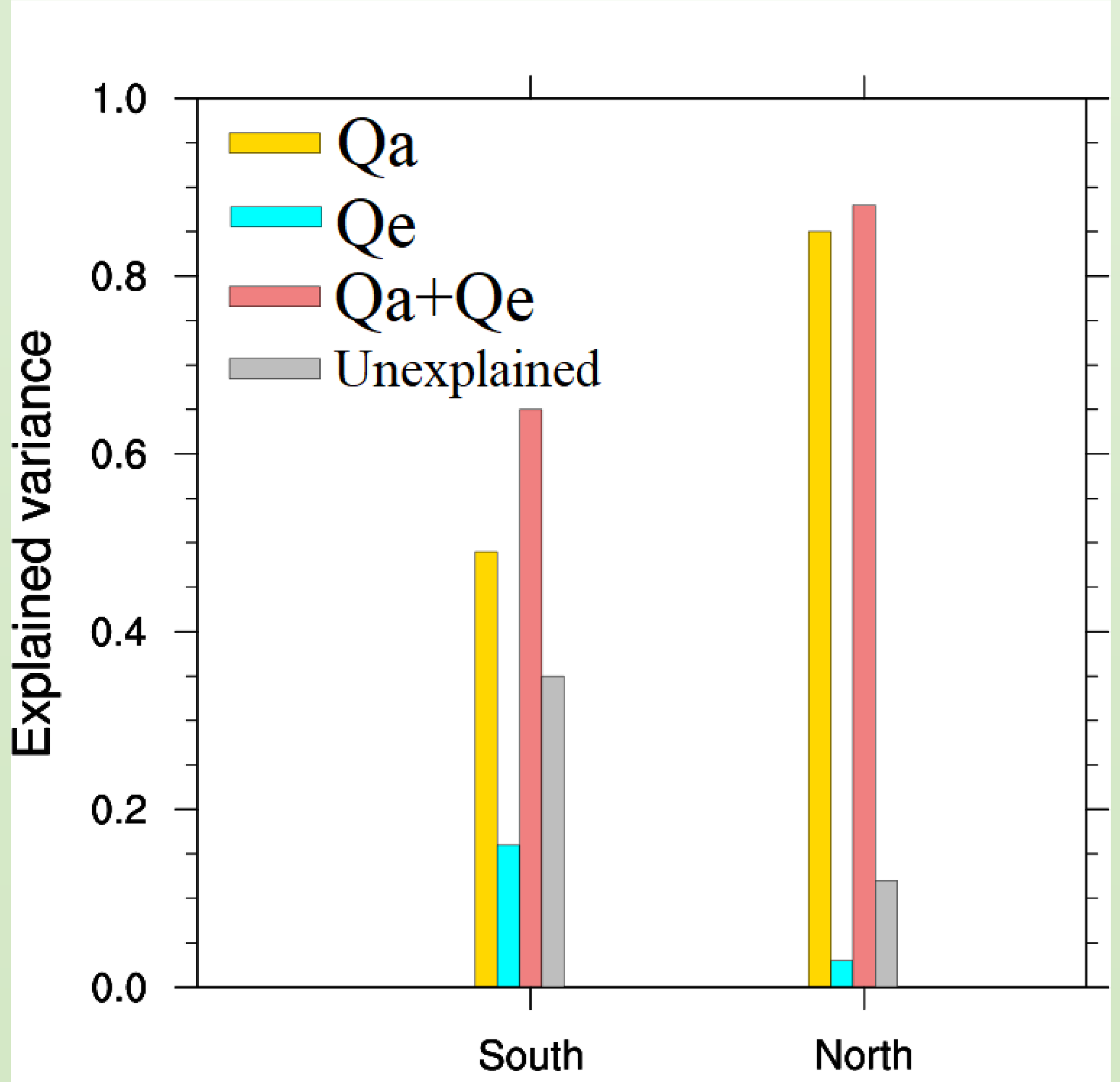

Figure 3: The relative contribution of albedo (Qa) and evapotranspiration (Qe) changes on corresponding temperature changes (ΔT) over Northern and Southern Europe.

Discussion

- Deforestation causes a decrease in mean summer temperature in almost all European regions.
- The sign of temperature change(ΔT) can be approximated by a simple ratio Qe/Qa. A ratio larger than 1 suggests that ΔQe warming exceeds ΔQa cooling and temperature is likely to increase, and vice versa.
- According to a multivariate analysis applied, ΔQa and ΔQe largely explain the corresponding temperature decrease in the northern and southern regions. However, the non-linear term (probably roughness effect) is not negligible in Southern Europe, that is, summer temperature decrease is not only determined by these two factors.

Acknowledgements
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References

[1] Davin E. 2010: Climatic Impact of Global-Scale Deforestation: Radiative versus Non-radiative Processes, *Journal of Climate*, p.97-112

[2] Yan Li 2016: The role of spatial scale and background climate in the latitudal temperature response to deforestation, *Earth System Dynamics*, p.167-181