

Supplementary Material

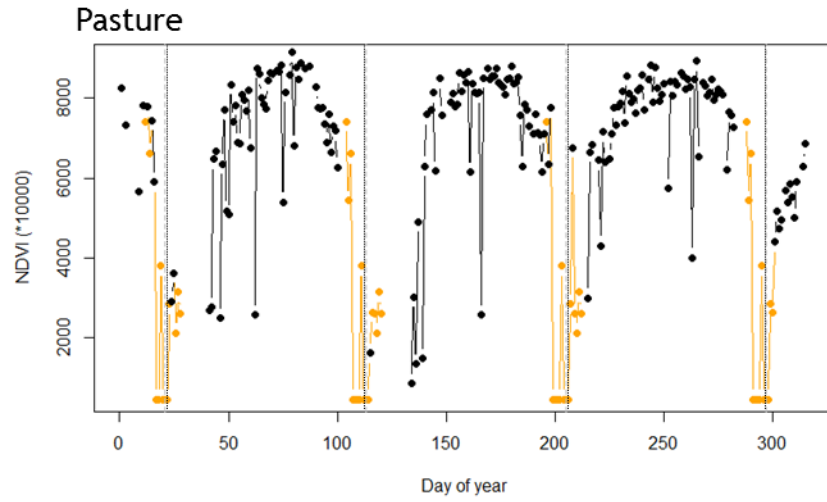


Figure S1: Illustration of the used NDVI time series winter gap filling approach for a pasture area. The black dots indicate the original NDVI values, which display long gaps in the winter month. The orange dots represent the gap fill values taken from values of the same date from neighboring years on a pixel-wise basis.

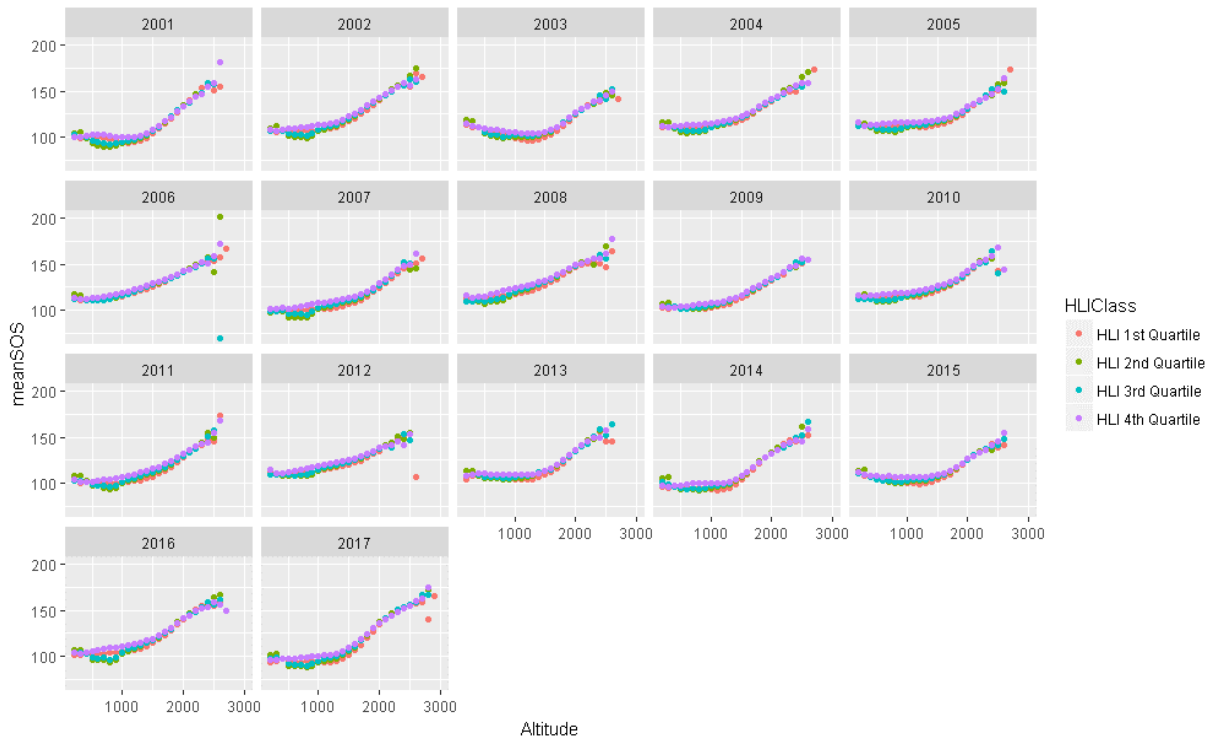


Figure S2: Yearly mean SOS of the years 2000 – 2017 for four HLI value ranges representing the quartiles of the data set.

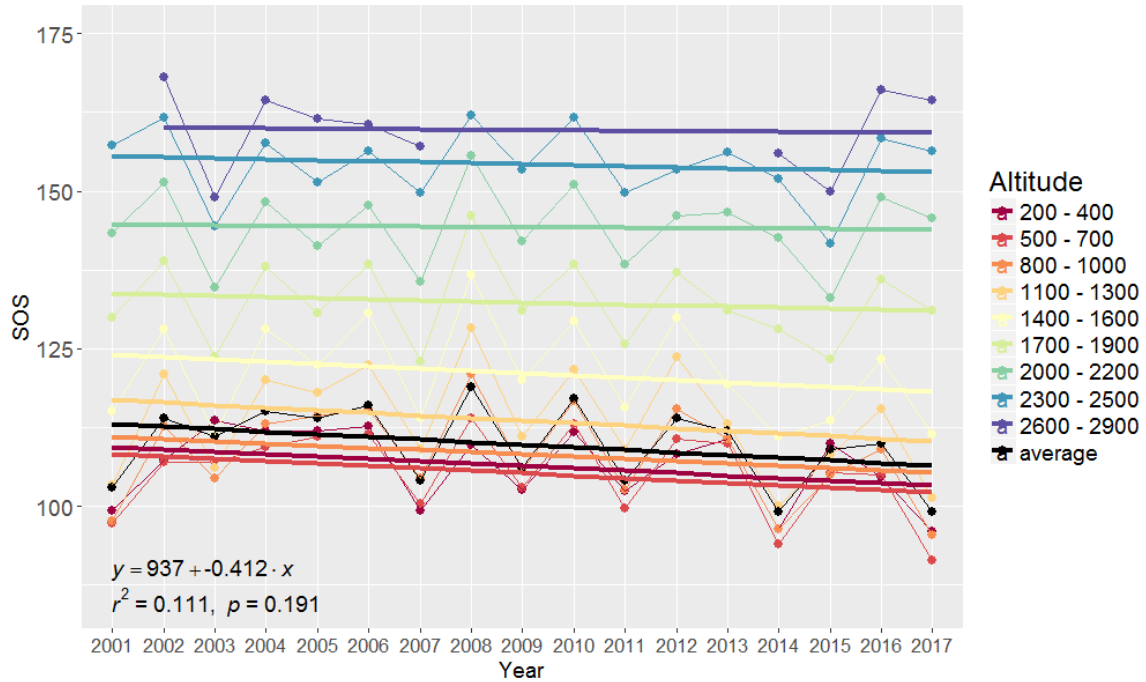


Figure S3: Median SOS over the Alps for the years 2001 – 2017 for different altitudes and the respective trend lines. The formula, correlation coefficient and accuracy level are indicated for the median SOS averaged over all altitudes.

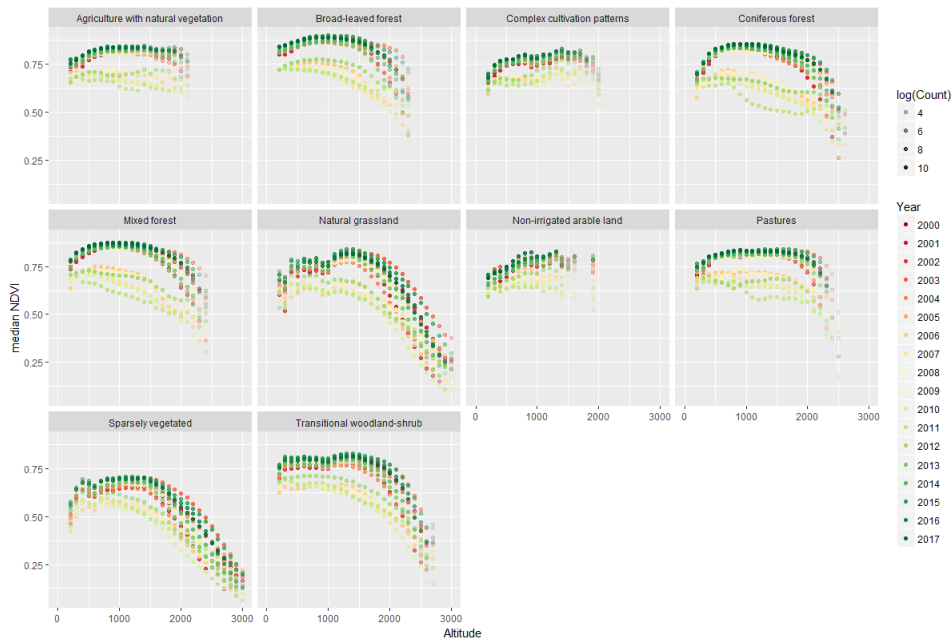


Figure S4: Yearly alpine-wide median NDVI of the years 2000 – 2017 for the ten analyzed CORINE land cover. The amount on data available per class, year and altitude range is indicated by the transparency level.

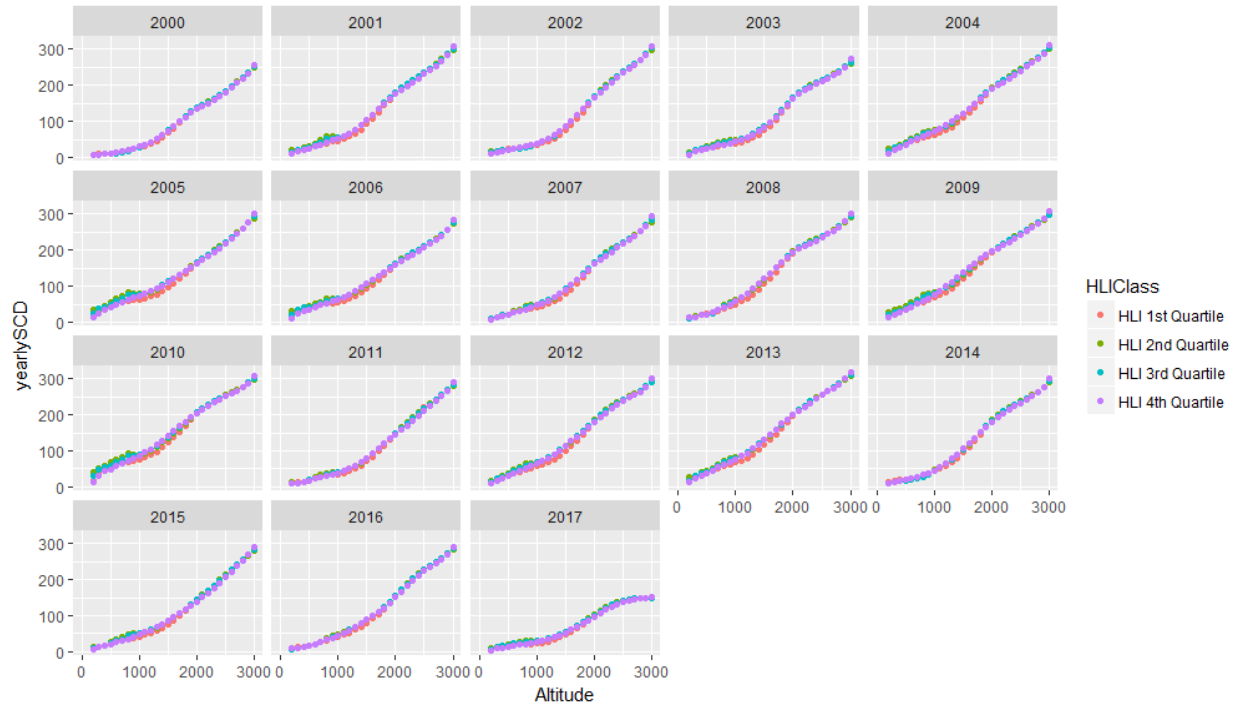
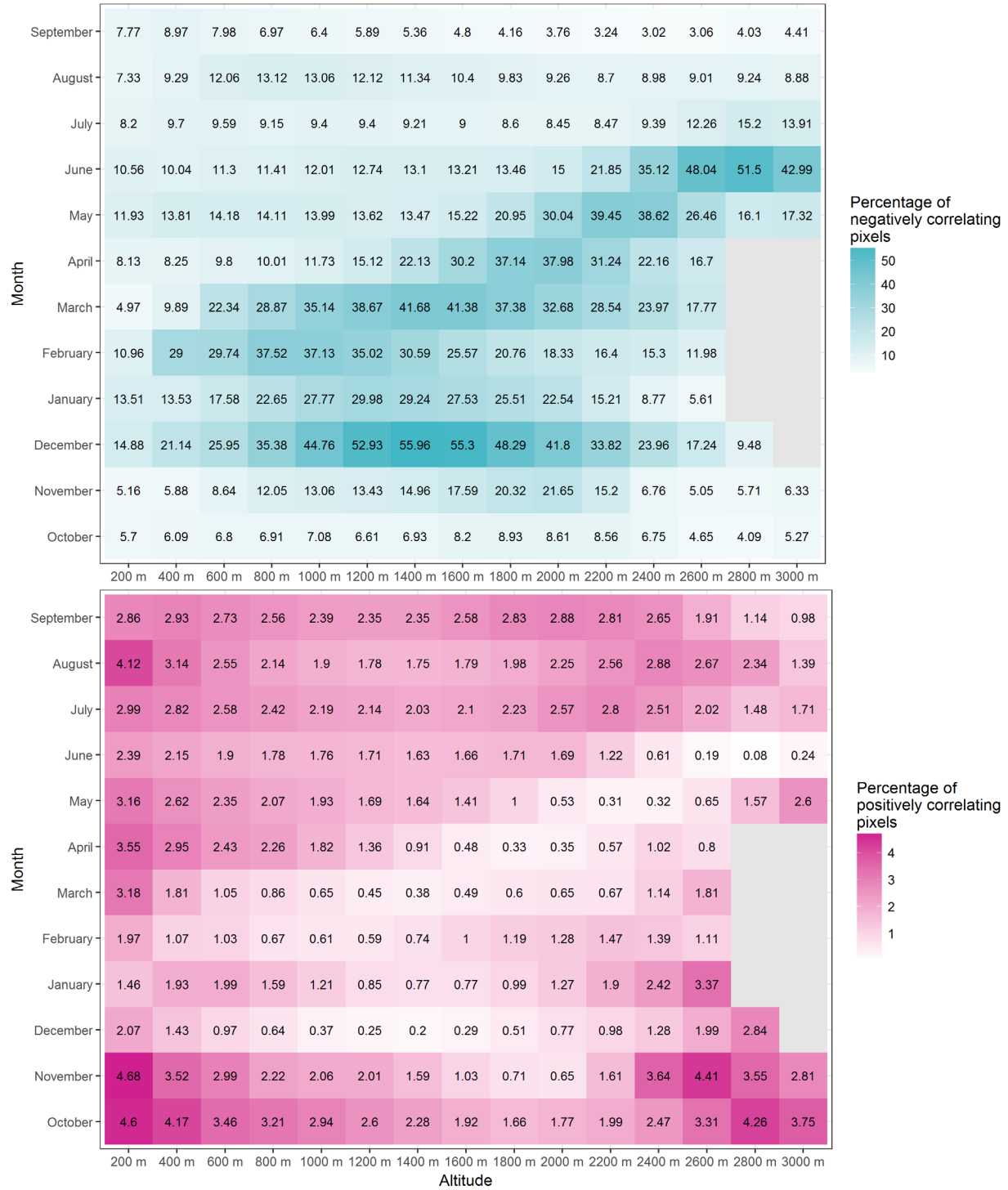


Figure S5: Yearly SCD of the years 2000 – 2017 for four HLI value ranges representing the quartiles of the data set.



.Figure S6: Percentage of all negatively (top) and positively (bottom) correlated pixels between SCD and mean NDVI of the respective same month over the hydrological year (1 October - 30 September).

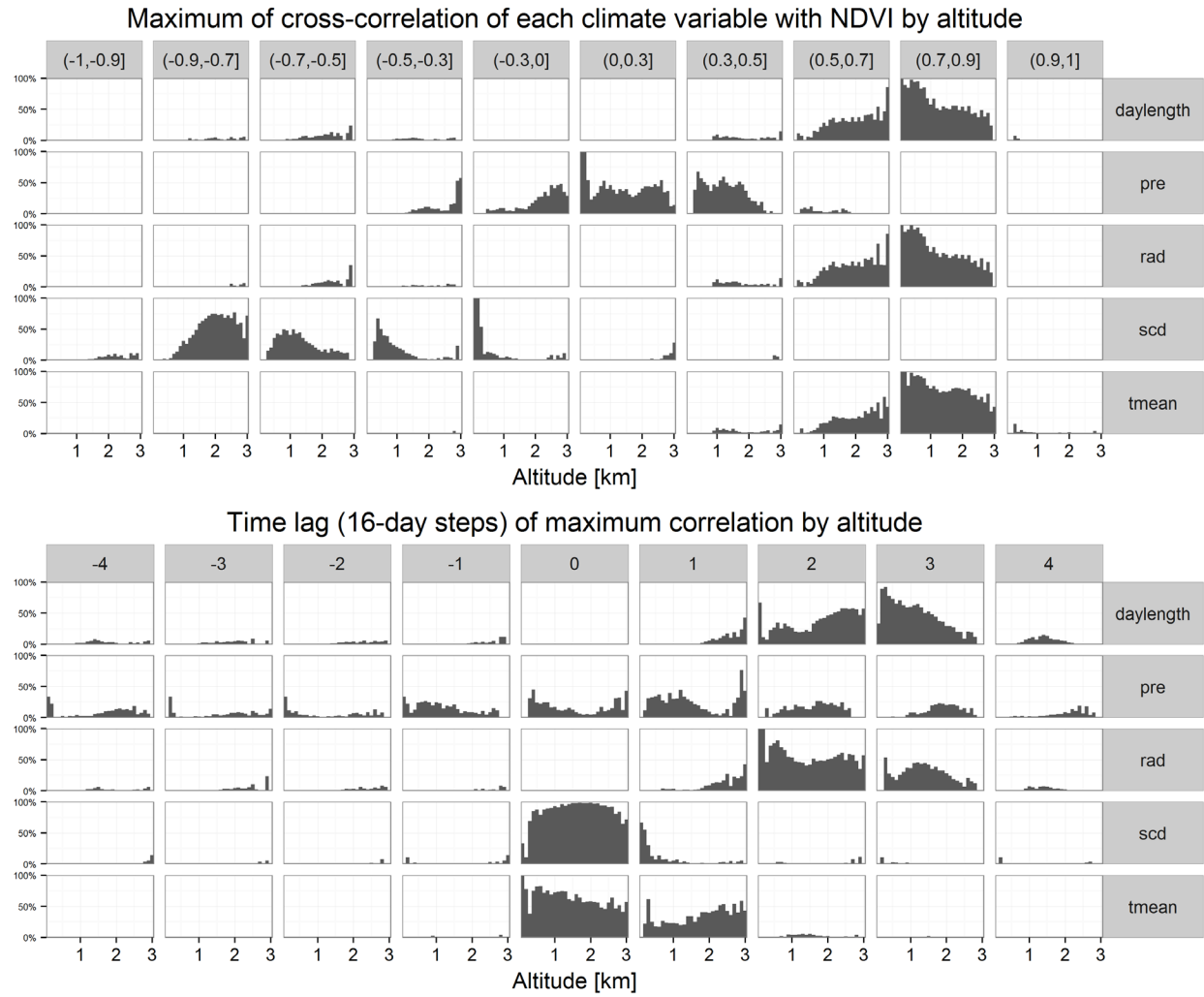


Figure S7: Results from cross-correlating 16-day values of NDVI with climate variables for all 2km by 2km grid cells in South Tyrol during 2003-2012. For each 100m altitude bin, percentages of the maximum correlation and corresponding time lag are shown. Abbreviations: pre (precipitation), rad (radiation), scd (snow cover duration), and tmean (mean temperature).

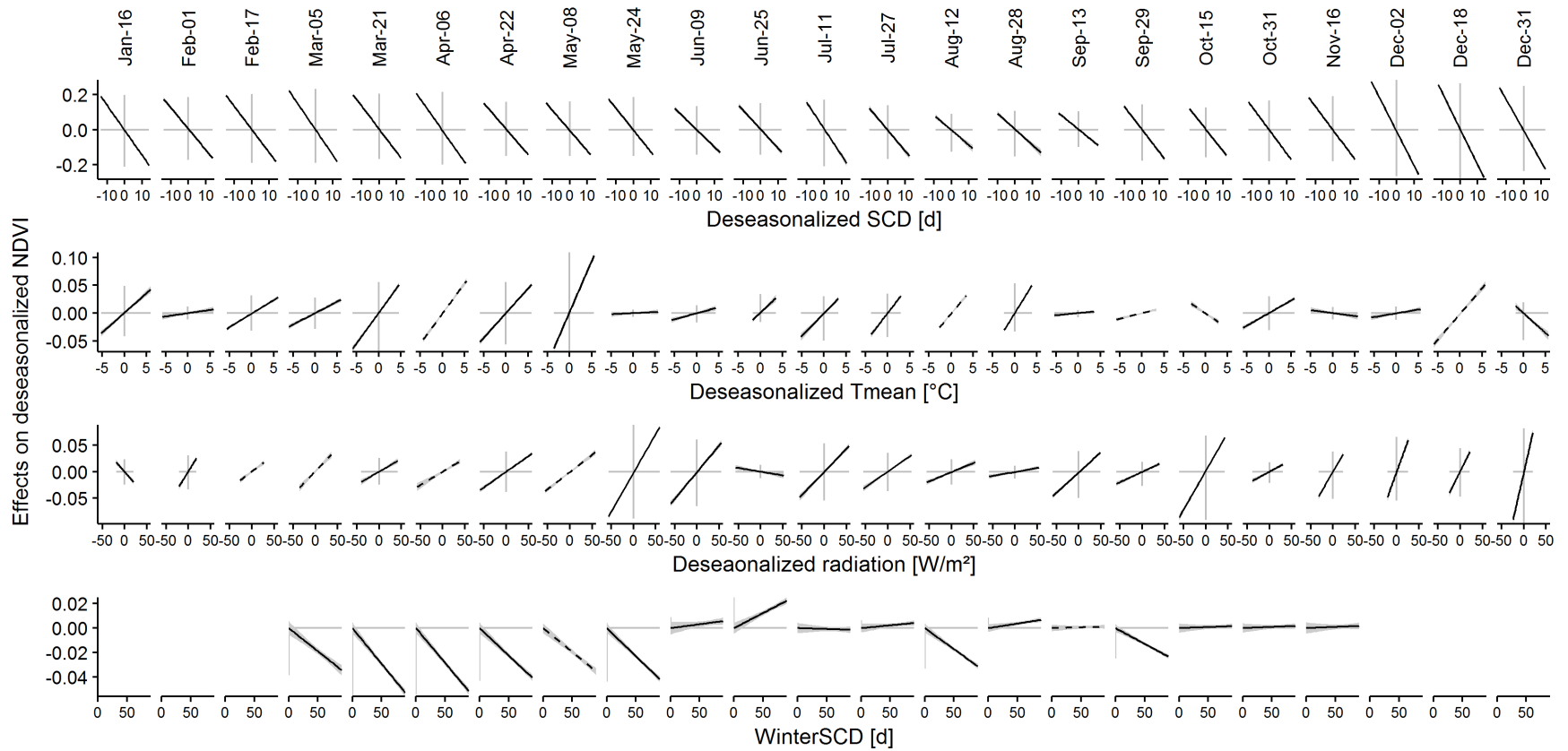


Figure S8: Influence of climate variability on NDVI (normalized difference vegetation index). Shown are effects of deseasonalized climate variables on deseasonalized NDVI, holding other variables constant. Grey area denotes 95% confidence intervals. Dashed lines denote insignificant variables (adjusted $p > 0.05$). Empty panel for WinterSCD means variable was not included in model. SCD stands for snow cover duration.

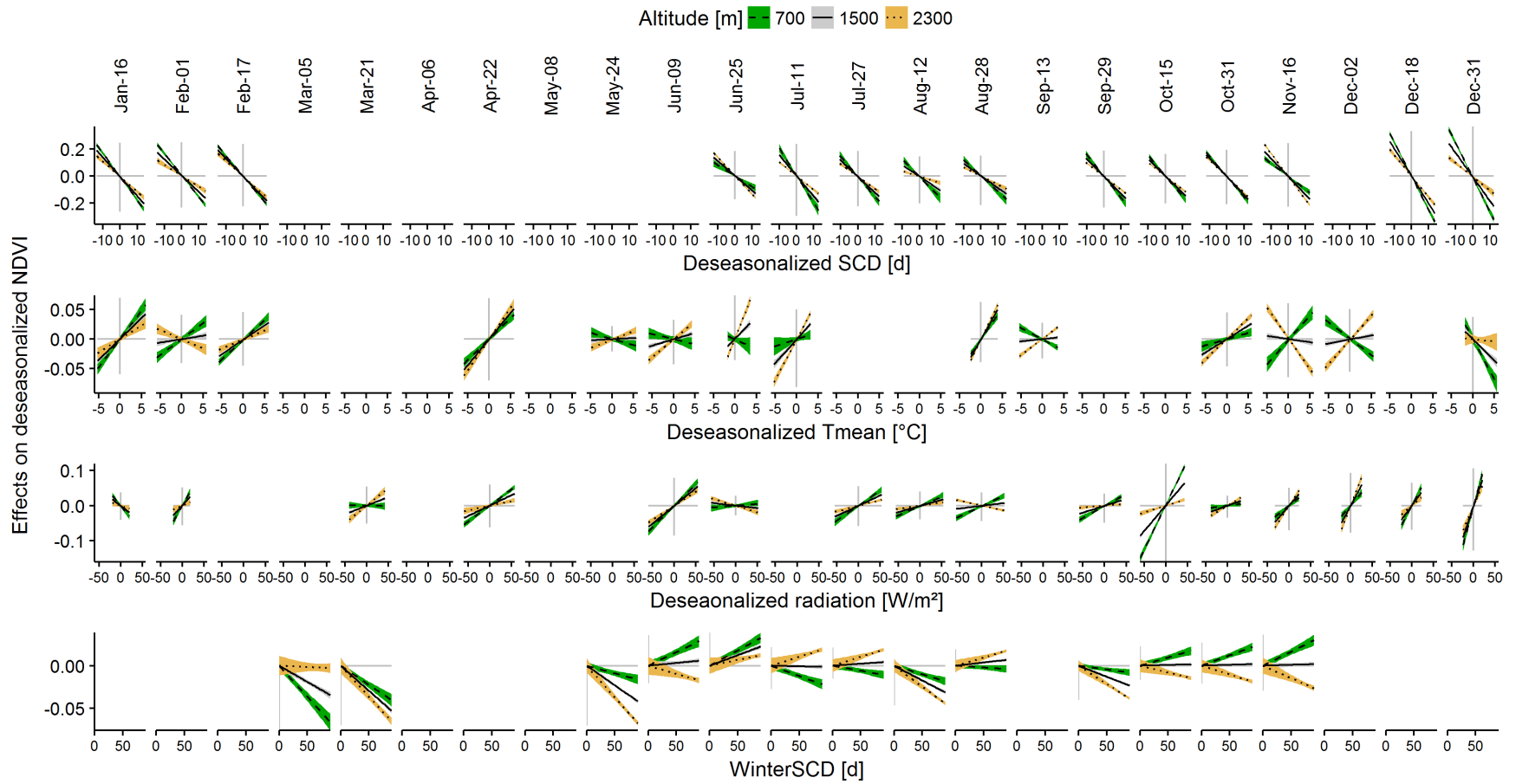


Figure S9: Influence of climate variability on NDVI (normalized difference vegetation index) at different altitude classes. Shown are effects of deseasonalized climate variables on deseasonalized NDVI, holding other variables constant. Grey area denotes 95% confidence intervals. Dashed lines denote insignificant variables (adjusted $p > 0.05$). Empty panel for WinterSCD means variable was not included in model. SCD stands for snow cover duration.

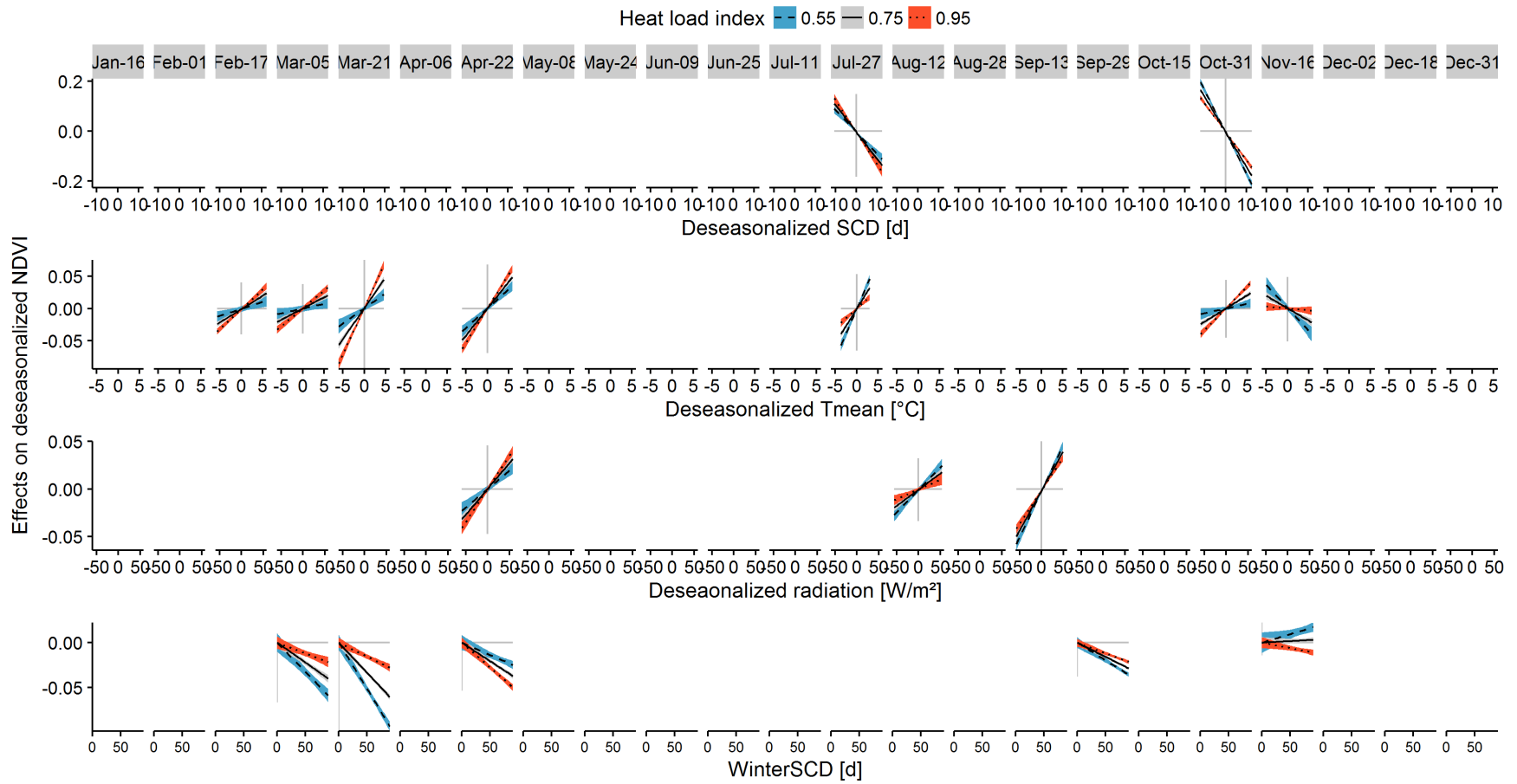


Figure S10: Influence of climate variability on NDVI (normalized difference vegetation index) at different HLI classes. Shown are effects of deseasonalized climate variables on deseasonalized NDVI, holding other variables constant. Grey area denotes 95% confidence intervals. Dashed lines denote insignificant variables (adjusted $p > 0.05$). Empty panel for WinterSCD means variable was not included in model. SCD stands for snow cover duration.

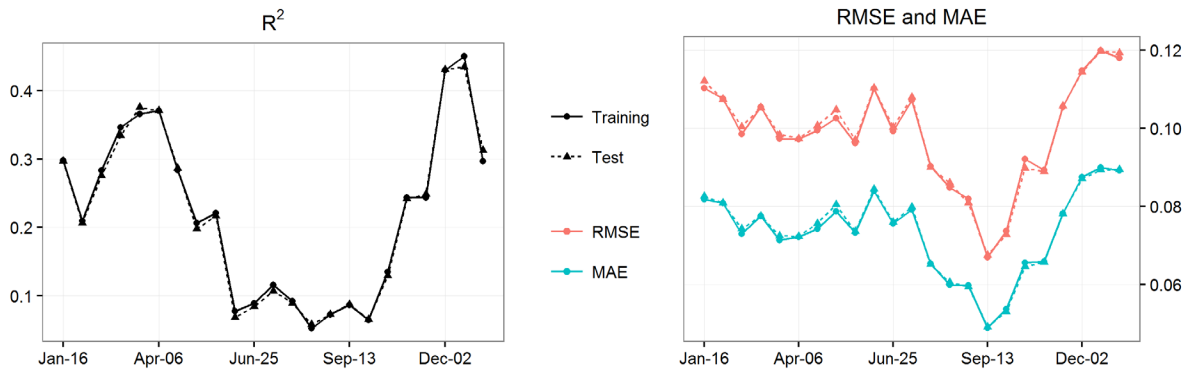


Figure S11: Model metrics of regressing deseasonalized NDVI on deseasonalized climate variables interacted with altitude and HLI (heat load index). Shown are R², RMSE (root mean square error), and MAE (mean absolute error) for the training and test data, which comprise each 50% or randomly selected pixels for each date (16-day group).