SUPPLEMENT

Equations for the predictions:

The first two prediction methods are simple delta change techniques (Lenderink et al. 2007),

$$F_{\mathrm{pred}\ Full,i,j} = C_{\mathrm{full},i}\left[1 + R_{full,j}\right] \quad (1)$$

$$F_{\mathrm{pred}\ \ Filt,i,j} = C_{\mathrm{full},i}\left[1 + R_{filt,j}\right]. \quad (2)$$

The first prediction uses the change information derived from member *j*, and "adds" this change to the control climate state of *i* (which is assumed to be known) to predict its future state. The second prediction applies the same method, but only uses the large-scale pattern of change.

In order to assess the potential gain in prediction skill by better knowledge of the present-day climatology, we evaluate the following two predictions:

$$F_{\mathrm{pred\ Full\ Cmean},i,j} = C_{\mathrm{full},m}\left[1 + R_{full,j}\right] + O_i \quad (3)$$

$$F_{\mathrm{pred\ \ Filt\ Cmean},i,j} = C_{\mathrm{full},m}\left[1 + R_{filt,j}\right] + O_i \quad (4)$$

where the "*m*" denotes the 16-member ensemble mean, and O_i is a zero-term to indicate that this prediction is the same for all members *i*.

In the next approach we assume Perfect knowledge of the Large-Scale change (PLS). In that case the two predictions become:

$$F_{\mathrm{pred\ Full\ PLS},i,j} = C_{\mathrm{full},i}\left[1 + R_{filt,i} + R_{fine,j}\right] \quad (5)$$

$$F_{\mathrm{pred\ Filt\ PLS},i,j} = C_{\mathrm{full},i}\left[1 + R_{filt,i}\right] + O_j \quad (6)$$

with O_j similar to O_i: that is, the same for all *j*.
Finally, we note that the first prediction in Eq. 1 can be written differently:

$$F_{\mathrm{pred}\ Full,i,j} = C_{\mathrm{full},i}\left[1 + R_{full,j}\right] = F_{full,j}\,\frac{C_{\mathrm{full},i}}{C_{\mathrm{full},j}}$$

Given that in our approach, the model is assumed to be perfect and therefore $F_{full,j}$ can be considered as the best estimate of $F_{full,i}$ assuming that we cannot predict internal variability, we also considered the following direct prediction

$$F_{\mathrm{pred}\ Direct,i,j} = F_{\mathrm{full},j} + O_i \quad (7)$$

The skill of a prediction is measured by two different indices, the spatial correlation between predicted $F_{pred,i,j}$ and actual future climate state F_i, and a mean absolute error which is defined by:

$$E_{i,j} = \left\langle \left| \frac{F_{pred,i,j}}{F_i} - 1 \right| \right\rangle \qquad \text{for precipitation (in fraction), and}$$

$$E_{i,j} = \left\langle \left| F_{pred,i,j} - F_i \right| \right\rangle \qquad \text{for temperature (in degrees),}$$

where |..| is the absolute value and <..> the spatial mean over the analysis domain.

Forced response and natural variability

Spatial patterns

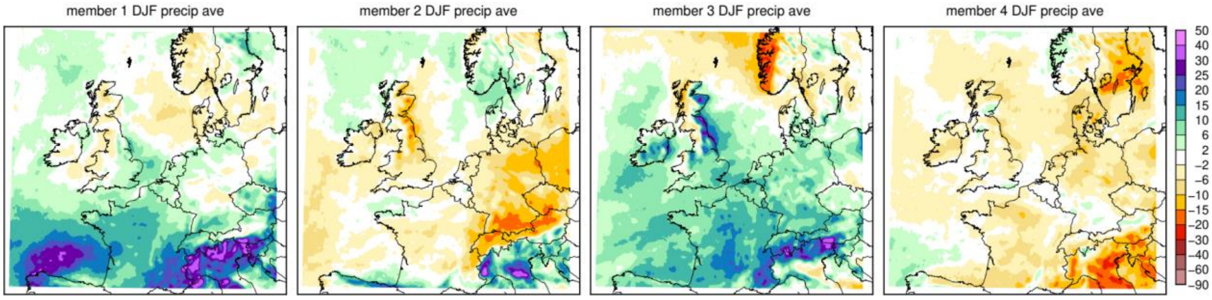

Figure 1. Deviation from the forced response in mean winter precipitaiton in the first 4 ensemble members

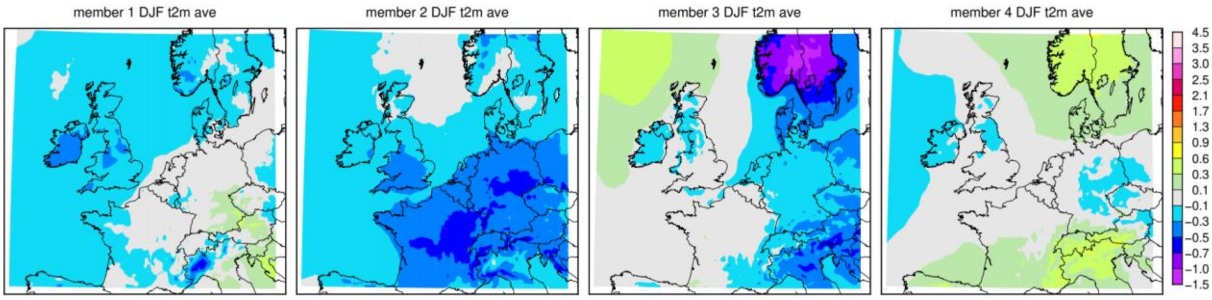

Figure 2. Same as previous figure but now for temperature

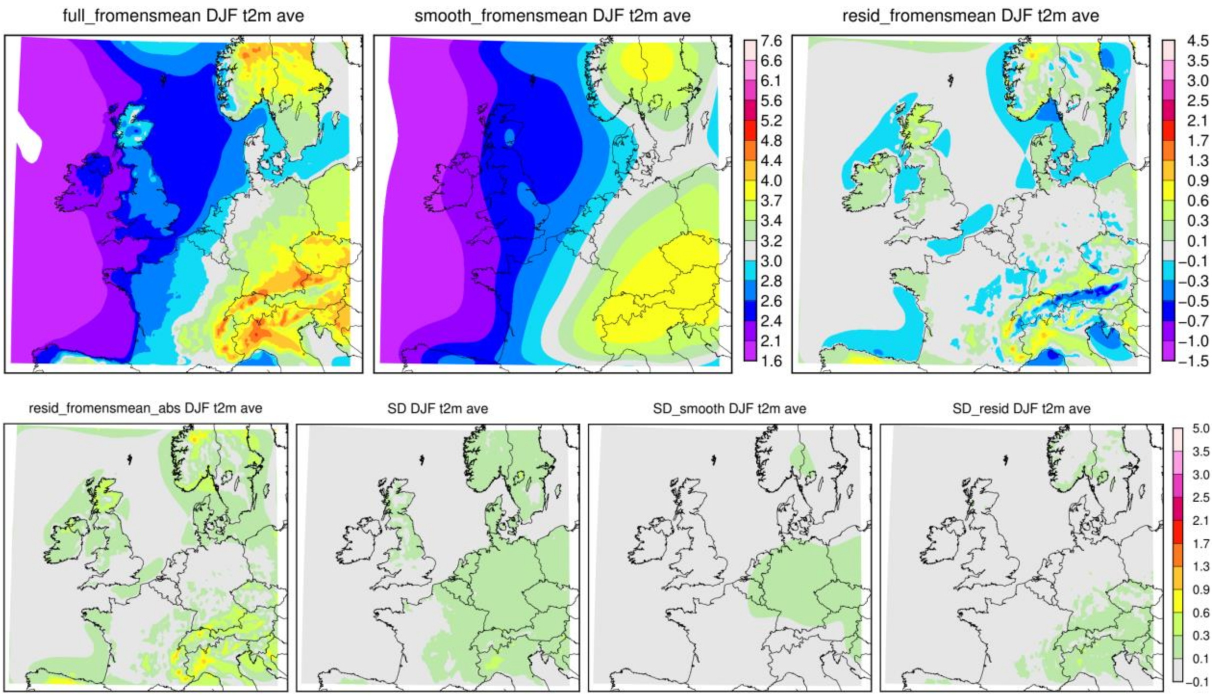

Figure 3. Same as Figure 3 from main text, but now for temperature showing the results of the PGW ensemble.

Predictions.

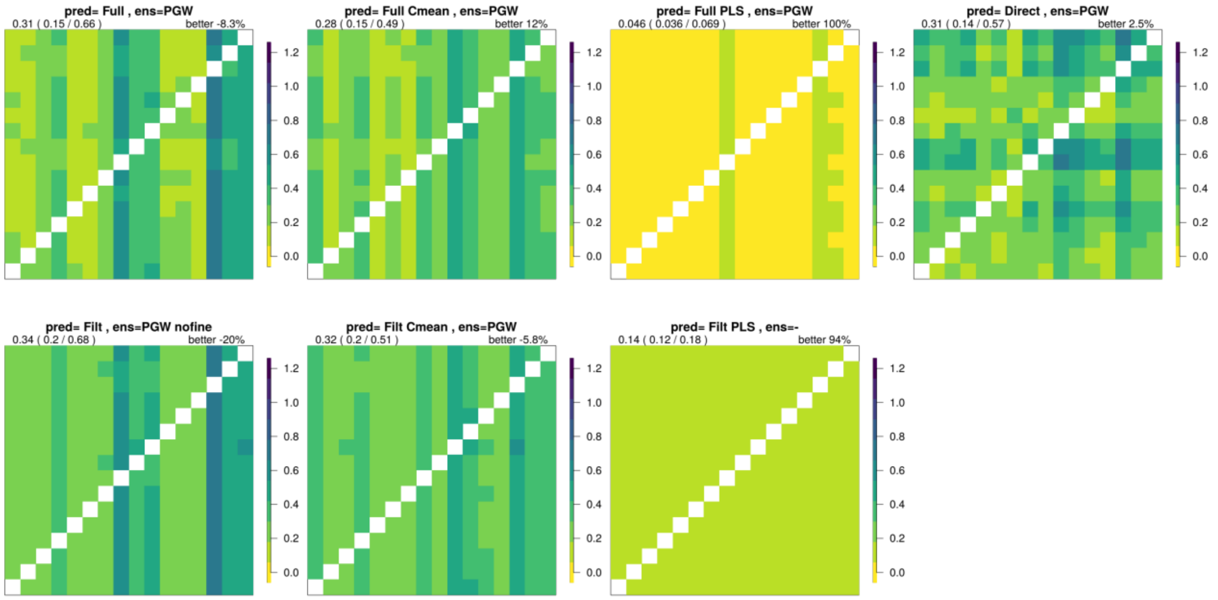

Figure 4. Temperature prediction using PGW

Prediction matrix

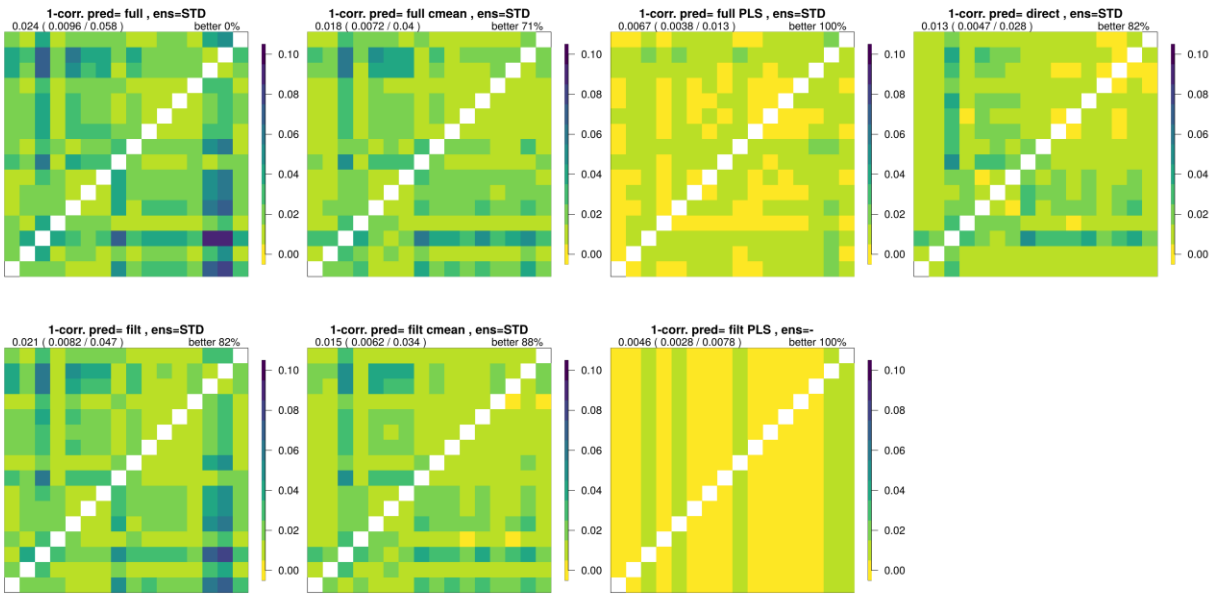

Figure 5. Correlation (numbers are 1 – correlation, so 0 would be perfect correlation) between predicted mean winter precipitation and actual climate state using the standard ensemble

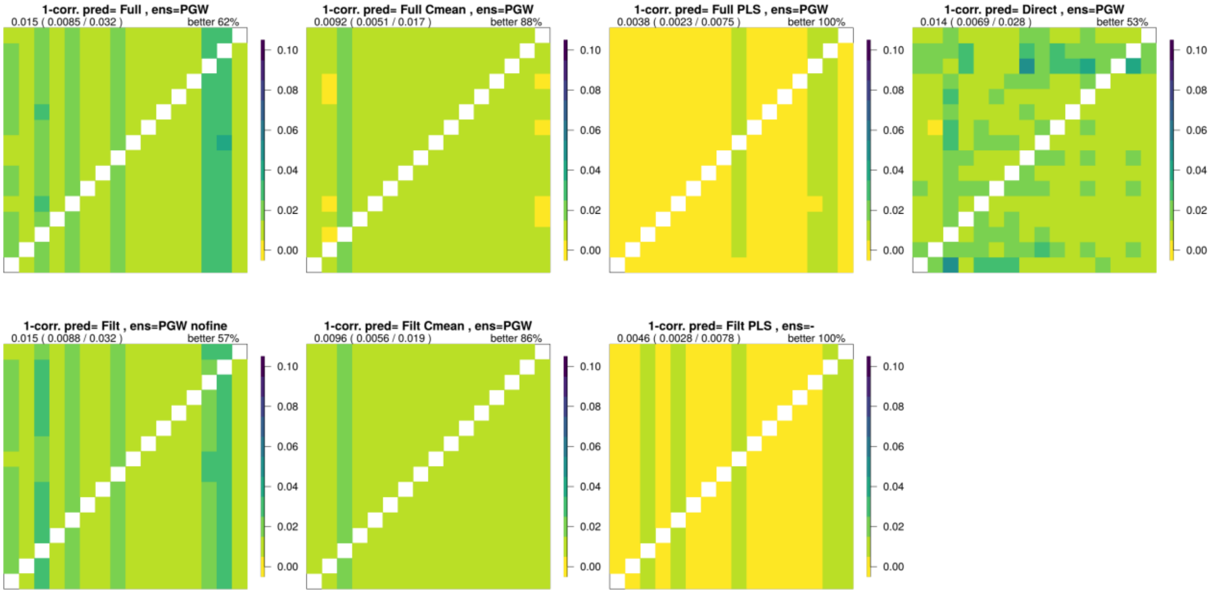

Figure 6. Same as previous figure, but now using the PGW ensemble

Statistics

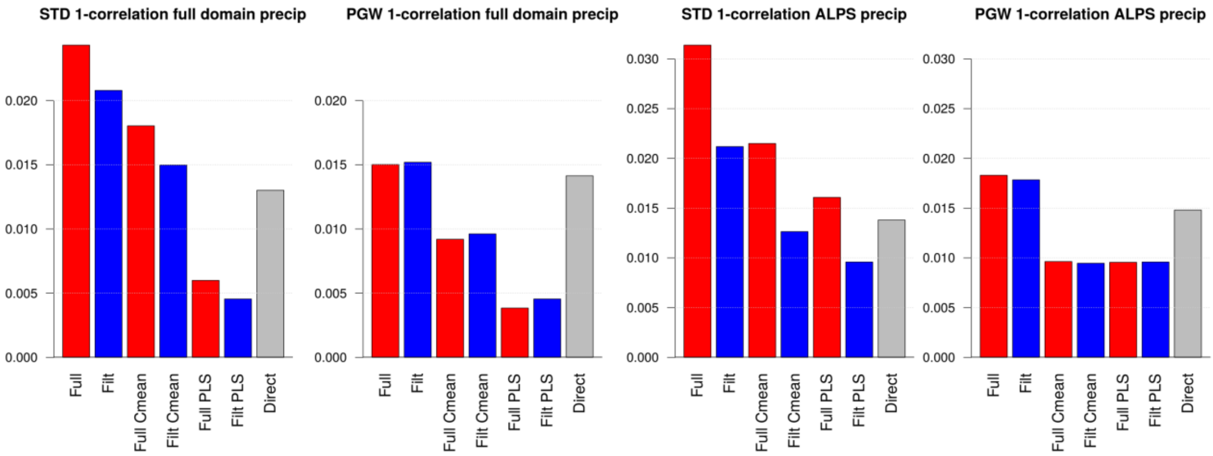

Figure 7. Correlation measure precipitation predictions

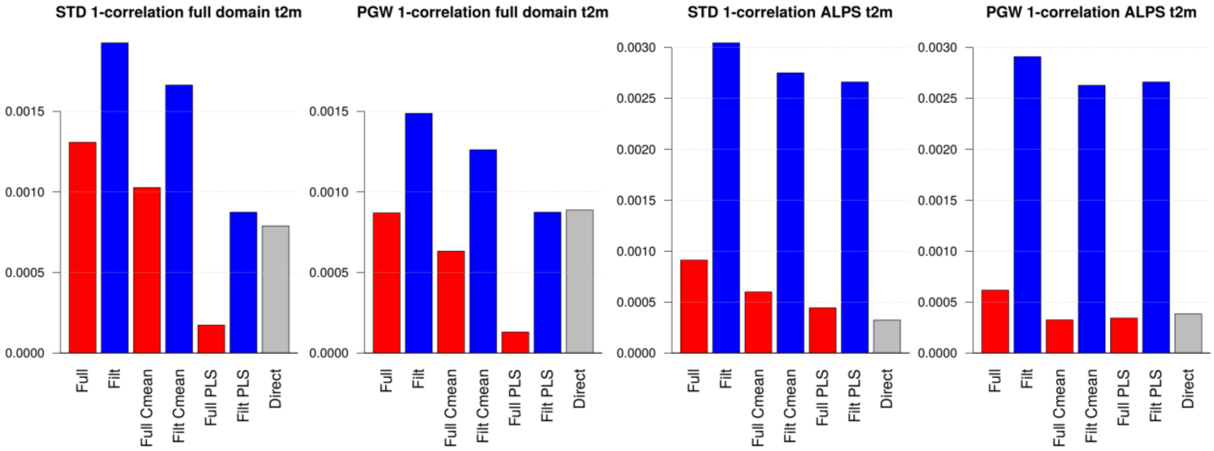

Figure 8. Correlation measure temperature predictions.

Comparison internal variability in standard and PGW ensemble

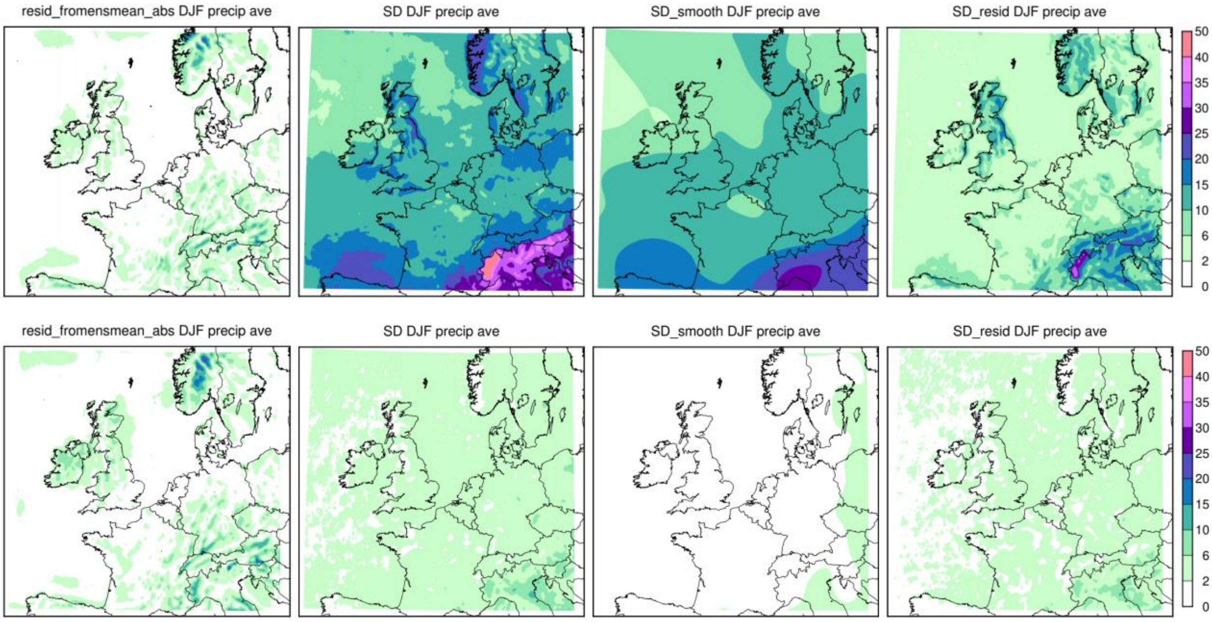

Figure 9. Comparing absolute values of the fine-scale forced response in standard (top) and PGW (bottom) ensemble, in comparison with internal variability at different scales (2nd panel, all, 3rd panel only large-scale, 4th panel, fine-scale). Results are relative changes in mean winter precipitation.

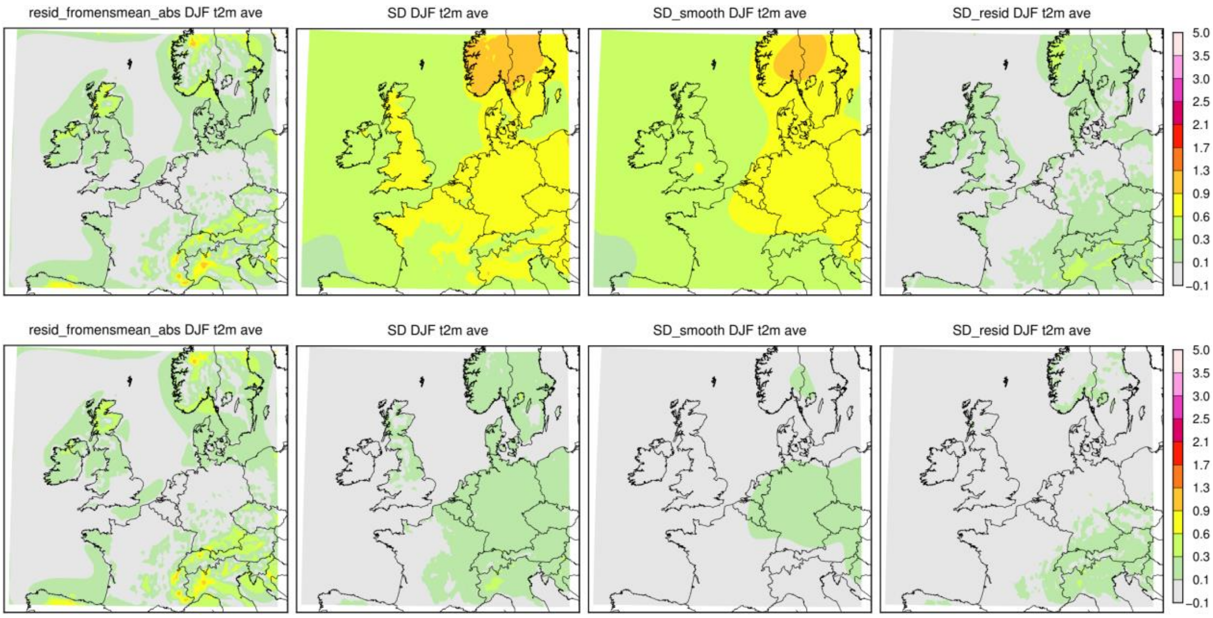

Figure 10. Same as previous figure, but now mean winter temperature change.

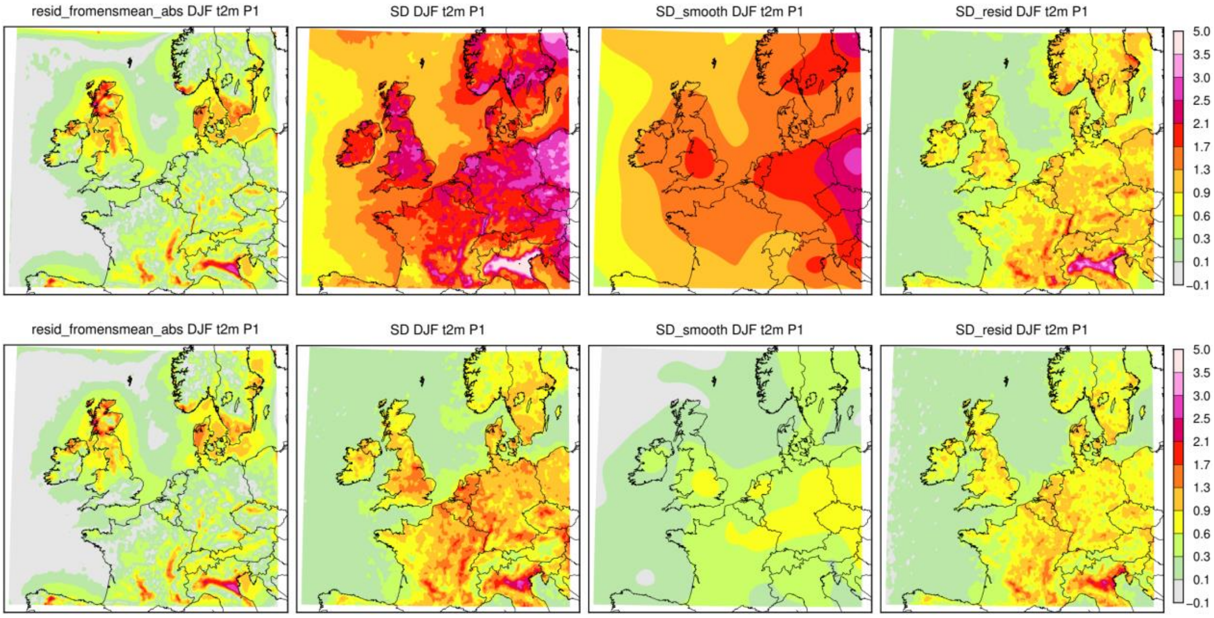

Figure 11. Same as previous figure, but now cold days in winter (1st percentile from daily temperature).