

Supporting Information for "Everything hits at once - how remote rainfall matters for the prediction of the Canadian heat 2021"

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Contents of this file

This file contains supplementary methods and the supplementary figures S1, S2, S3, S4 and S5.

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Supplementary methods

The relevance of West Pacific heavy precipitation for the process chain leading to the highly amplified upper-level ridge and for the predictability of the event is further underlined using tailored relaxation experiments. Following the approach of Magnusson (2017), the forecast model is nudged towards the analysis in a pre-defined regional box during the model integration, leading to a perfect forecast within the box and reduced forecast errors downstream. Such experiments, comprising 22 ensemble members plus control forecast each, are initialized on 19, 20 and 21 June 00 UTC, with the nudging constrained to the region 100° – 160° E, 15° – 45° N. For comparison, additional nudging experiments with a box shifted further upstream (60° – 100° E, 0° – 60° N) were performed.

In the manuscript, the relevance of the rising air airstreams is put into climatological context. The following describes the data sets used for the climatological comparisons. Precipitation anomalies computed from daily precipitation sums retrieved from the Global Precipitation Measurement (GPM IMERG) data set (Huffman et al., 2019) are used to investigate the role of anomalous precipitation over the West Pacific. Data were remapped from their original $0.1^{\circ} \times 0.1^{\circ}$ resolution to a coarser resolution of $1.0^{\circ} \times 1.0^{\circ}$. June 2021 precipitation anomalies are computed relative to the June climatology defined over a reduced reference period from 2000 to 2021. To compare the WCB activity prior to the heat wave to the climatological WCB frequency, we calculate 15 to 29 June WCB anomalies with respect to the June climatology from 1979 to 2020. This climatological analysis is based on WCB probabilities computed from ERA5 using ELIAS2.0 (Quinting Grams,

2022a; Quinting et al., 2022; Quinting Grams, 2022b). We also calculate percentiles of tropopause height based on 3-h ERA5 data for the period 1979–2020.

Supplementary figures S1, S2, S3, S4 and S5.

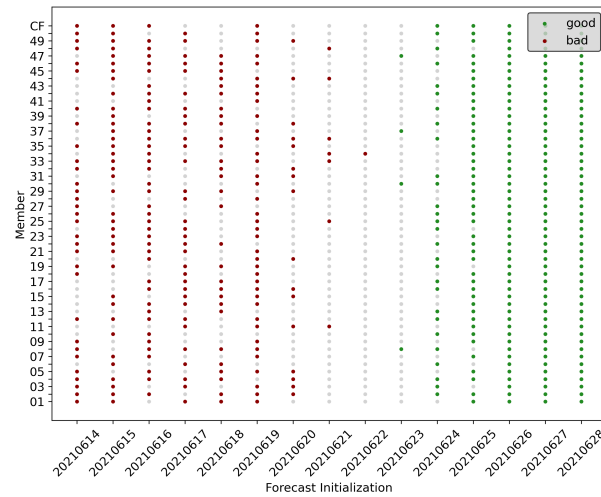


Figure S1. Initialization dates of 'good' (green) and 'bad' (red) forecasts of the medium-range ECMWF ensemble initialised daily at 00 UTC between 14 and 29 June 2021. Both categories comprise 230 forecasts. - Grey dots show neutral forecasts that are neither classified as 'good' nor 'bad' (see Methods for a detailed description of the forecast classification).

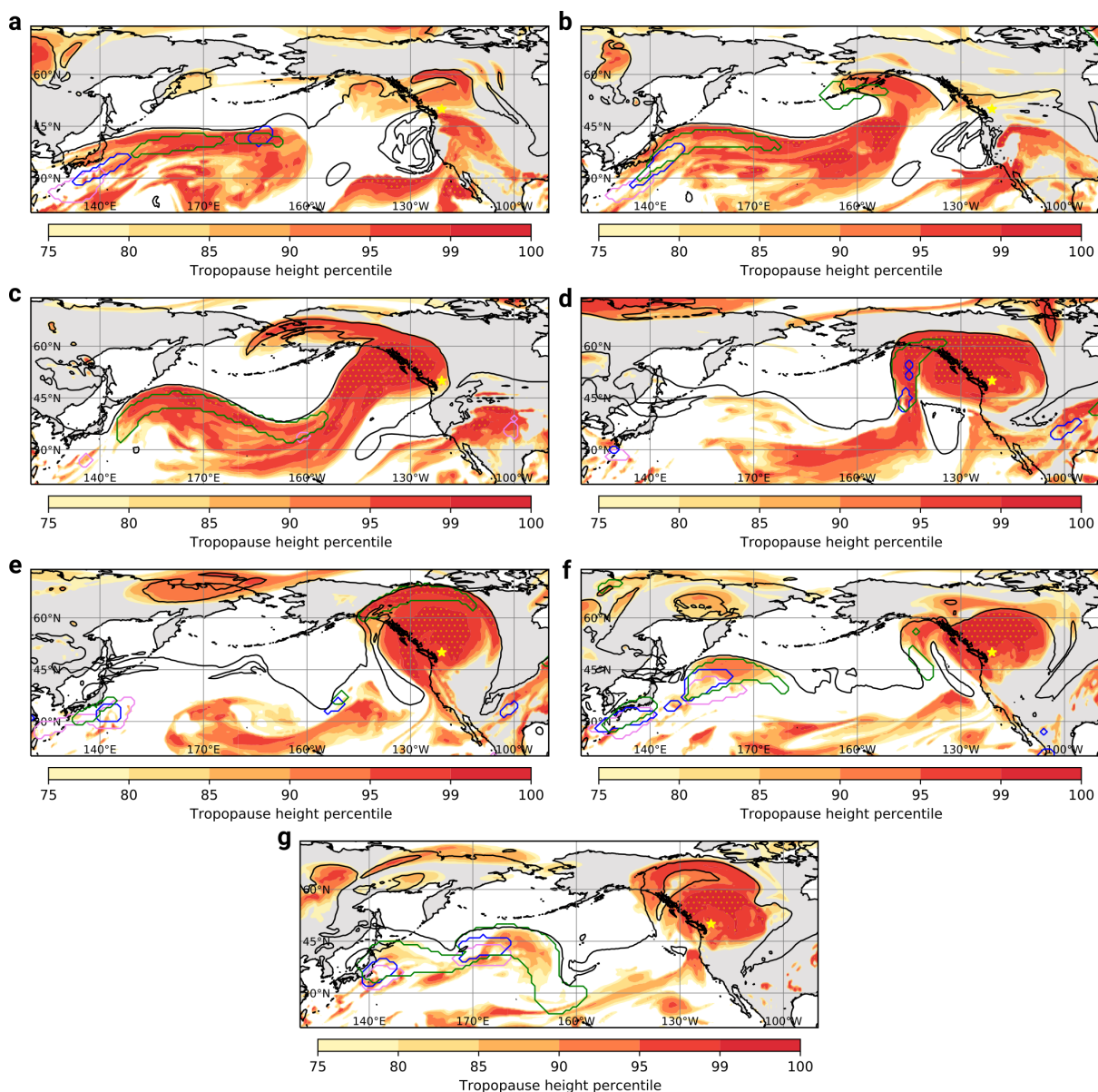


Figure S2. WCB inflow (violet), ascent (blue) and outflow (green contours) and percentiles of tropopause height from ERA5 (shading) for a 22 June 06 UTC, b 23 June 06 UTC, c 24 June 06 UTC, d 26 June 06 UTC, e 27 June 06 UTC, f 28 June 06 UTC, g 29 June 00 UTC. Orange hatching highlights regions where the tropopause height (i.e. potential temperature on 2 PVU surface) exceeds the 99th percentile).

August 26, 2022, 6:06am

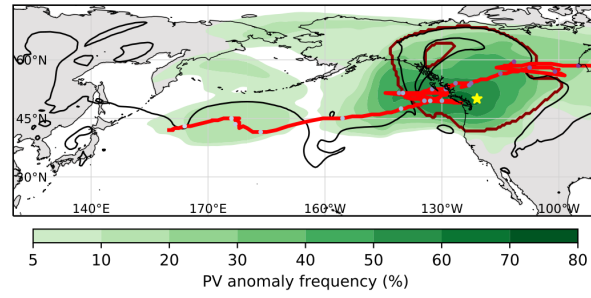


Figure S3. Frequency density of negative upper-level PV anomaly (shading) and the track of its centre of mass (red line) between 13 June and 04 July. The blue dots mark the position every 24 h at 00 UTC and become darker during the time evolution. The upper-level negative PV-anomaly object on 29 2021 00 UTC is outlined in dark red, and the black contour shows the 2 PVU line on 335 K.

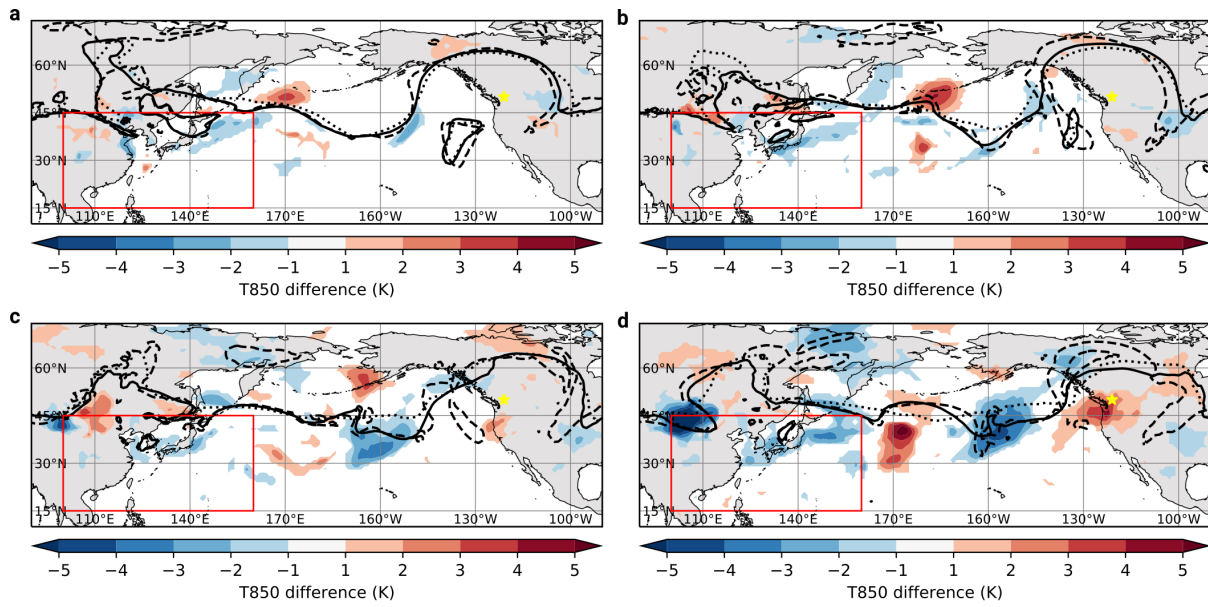


Figure S4. Ensemble-mean temperature differences at 850 hPa between the relaxation and control experiments initialised on 21 June 2021 (shading) and 2 PVU line on 335 K of the relaxation experiment (solid), the control experiment (dotted) and the analysis (dashed), valid on a 26 June 00 UTC, b 27 June 00 UTC, c 28 June 00 UTC, d 29 June 00 UTC. The relaxation domain is depicted by the red box.

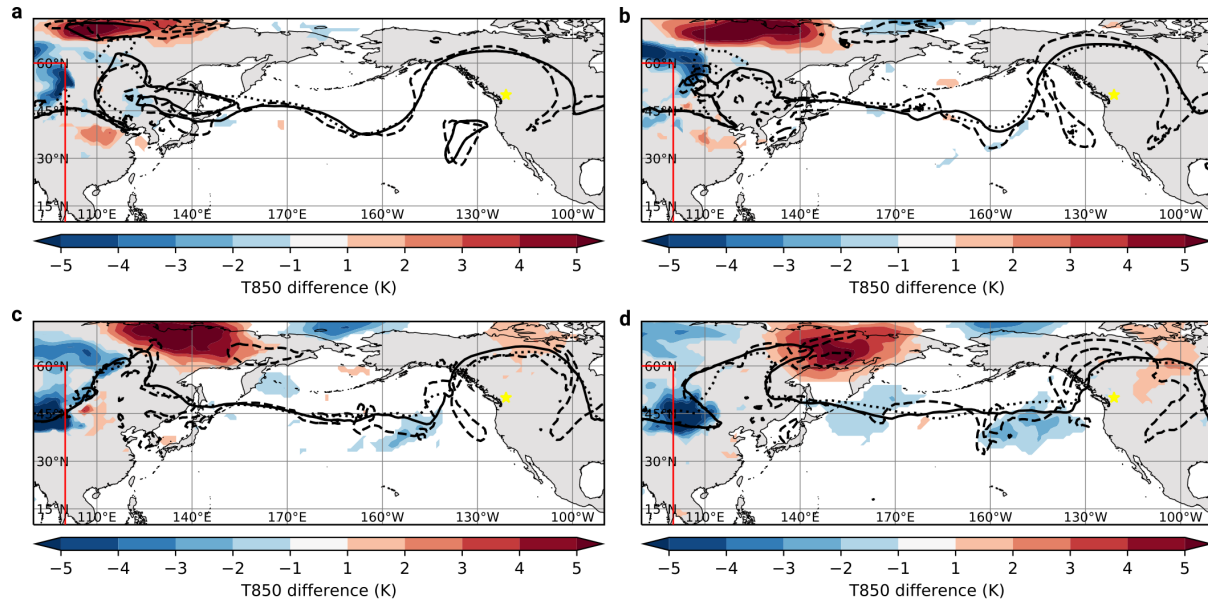


Figure S5. As Figure S4, but for the experiment with the relaxation domain from 60° - 100° E, 0° - 60° N. Note that only the north-western edge of the domain is depicted in the Figure.