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Climate of the Past Discussions

Interactive comment on "Heterogeneous response of Siberian tree-ring and stable isotope proxies to the largest Common Era volcanic eruptions" *by* Olga V. Churakova et al.

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We are thankful to Referee 2 for the advices to improve the manuscript and considered them as follows: Referee 2: The title needs a change since the chosen six volcanic events do not represent the largest volcanic eruptions, as stated in lines 179-180.

Answer: We modified the title of our manuscript as follows: "Siberian tree-ring and stable isotope proxies as indicators of temperature and moisture changes after major stratospheric volcanic eruptions". The six volcanic events selected in this study are the largest eruptions over the past 1,500 years.

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Referee 2: The term Common Era seems to be inconsistent with the studied span 'the past 1500 years'.

Answer: We replaced to "the strongest eruptions of the past 1,500 years: CE.." (P. 4, L. 83).

Referee 2: Lines 72, 92, 119, 181 and Section 3.1 line: I am not sure about the wording 'Stratospheric volcanic eruptions'.

Answer: Not all volcanic eruptions can be classified as stratospheric. However, in our case, we considered only stratospheric volcanic eruptions; therefore, we highlighted this point in more detail in our manuscript.

Referee 2: Lines 99-101 and lines 470-472 seem to be contradictory. Please check it.

Answer: We clarified these sentences in lines 103-112 and removed the sentence that was in lines 470-472 in the original submission.

Referee 2: Lines 126-127 are not clear and need rephrasing.

Answer: To avoid confusion and misunderstanding we left this sentence away.

Referee 2: Fig. 1: five volcanic eruptions (vertical lines) are indicated but one eruption is missing.

Answer: We added a reference to the event in 540.

Referee 2: From the map, the two eruption sites (two black circles) are located in tropical areas. It would be more clear to point out in the text and abstract.

Answer: We included information about two eruption sites in the figure legend (P.8, line 165-166) and added as requested this info in the text and abstract (P. 3, line 52-53). More information about volcanic eruptions can be found in Table 1.

Referee 2: Line 184: the authors stated each studies segment is 'around $\pm$ 10 years', but Fig.2 caption says 'the specific periods 15 years before and after the eruptions'. It is confusing.

Answer: We corrected the text to 10 years (P. 17, Fig. 2, L. 339-341, legend).

Referee 2: Sections 2.6 and 2.7 can be combined together. Answer: Based on the reviewer's suggestion we combined both section 2.6 and section 2.7, and modified the subsection as following "2.6. Stable carbon (δ13C) and oxygen (δ18O) isotopes in tree-ring cellulose". (P. 13, L. 244).

Referee 2: Superposed Epoch Analysis (SEA) results need significance tests to enhance scientific rigor of the relevant descriptions (for example, section 3.1).

Answer: We applied unpaired t-test statistics to check significance between each proxy and each site and provided new (Fig. 3, P.18-19, L. 361-370).

Referee 2: Section 3.1 and section 3.2 should be swapped.

Answer: We disagree on this point, as, in our opinion, data should be presented first, followed by statistical relationships with climatic parameters. Therefore, we preferred to keep this order as it was originally.

Referee 2: Fig. 2: the gray line is not clear. It is suggested to change the line color to enhance visibility.

Answer: That's a relevant point. We have accordingly replaced grey color with pink, to enhance visibility, as suggested (P. 17, revised Fig.2).

Referee 2: For TRW and MXD, they are affected by both temperature and precipitation (see Fig. 3). It is difficult to separate temperature signals alone. However, the authors chose them as only temperature indicator.

Answer: Absolutely, it is difficult to separate temperature from precipitation signals in temperature-limited environments. We attempted to do so by presenting the most meaningful relations (Fig. 4, P. 20, L. 382-386) with precipitation. However, significant correlation with precipitation are clearly lacking during the summer for TRW and MXD, for example, for YAK.

Referee 2: Lag between volcanic events and response in tree rings is easy to understand for carbon isotope and ring width. But for oxygen and MXD, it is generally accepted that there is no legacy effect from previous year. The authors argued for findings of the heterogeneity with different volcanic eruptions each but a potential associated mechanism is missing, for example, climate response to 1815 Tambora eruptions.

Answer: The d18O chronology displays lag effects after volcanic events that might be due to permafrost availability and mixed source water (atmospheric precipitation and thawed permafrost water) recorded in tree-ring cellulose. This signal can be stored in melted permafrost water and captured back based on climate conditions (cooling, warming anomalies). Another reason could be that volcanic eruptions cause changes in tree physiology (e.g. damage to roots because they are not well supplied by fresh assimilates). This could affect not only growth and carbon isotopes in the following years, but also oxygen isotopes, because they also depend on root conditions and physiological properties (leaf water enrichment depends on transpiration rate and such signal is reflected partially in tree-ring cellulose). Since MXD represents late-summer climate conditions we can expect that the Tambora eruption, which took place only in April 1815 would not be visible in the 1815 ring. In a study by Esper et al. (2017) based on 20 Northern Hemispheric MXD chronologies, a strong and coherent post-volcano signal was seen, mainly in the year after the eruption. Esper, J., Büntgen, U., Hartl-Meier, C., Oppenheimer, C., Schneider, L.: Northern Hemisphere temperature anomalies during 1450s period of ambiguous volcanic forcing. Bull. Volcanology. 79, 41, 2017. An absence of widespread and intense cooling or reduction of precipitation over vast regions of Siberia over the past half millennia may result from the location and strength of the volcanic eruption, atmospheric transmissivity as well as from the modulation of radiative forcing effects by regional climate variability. Further studies are needed to understand the mechanisms and causes of these differences.

Referee 2: If available, additional evidence such as historical documents and long instrumental observations are much needed to strengthen the results.

Answer: There are no longer instrumental observations because our study sites are located in remote and hardly populated regions. Gridded CRU data is not representative back in time for our sites. We provided all available evidence for historical documents discussed in detail in papers by Myglan et al., 2008; Büntgen et al., 2016; Guillet et al., 2017.

Please also note the supplement to this comment:
https://www.clim-past-discuss.net/cp-2018-70/cp-2018-70-AC2-supplement.pdf

Interactive comment on Clim. Past Discuss., https://doi.org/10.5194/cp-2018-70, 2018.

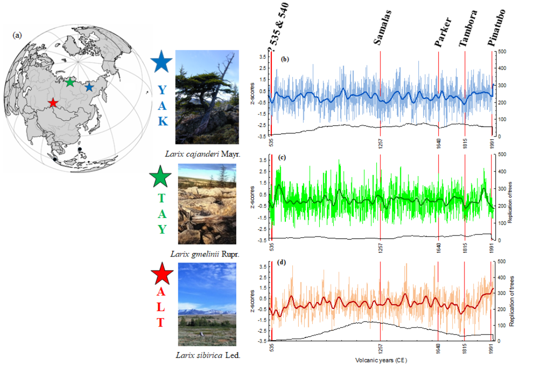

Fig. 1. Map with the locations of the study sites (stars) and volcanic eruptions from the tropics (black dots) considered in this study (a). Annual tree-ring width index (light lines) and smoothed by 51-year Hamming window (bold lines) chronologies from northeastern Yakutia (YAK - **blue**, b) (Hughes et al., 1999; Sidorova and Naurzbaev 2002; Sidorova 2003), eastern Taimyr (TAY - **green**, c) (Naurzbaev et al., 2002), and Russian Altai (ALT - **red**, d) (Myglan et al., 2009) were constructed based on larch trees (Photos: V. Myglan – ALT, M. M. Naurzbaev – YAK, TAY).

Fig. 1.

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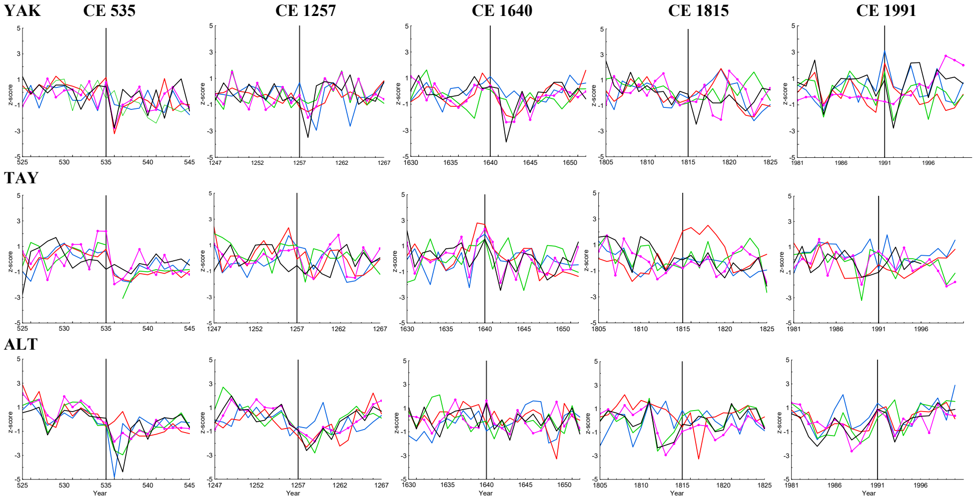

Fig. 2. Normalized (z-score) individual tree-ring index chronologies (TRWi, **pink**), maximum latewood density (MXD, **black**), cell wall thickness (CWT, **green**), $\delta^{13}C$ (**red**) and $\delta^{18}O$ (**blue**) in tree-ring cellulose chronologies from YAK, TAY and ALT for the specific periods 15 years before and after the eruptions CE 535, 1257, 1640, 1815 and 1991 are presented. Vertical lines showed year of the eruptions.

Fig. 2.

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Fig. 3.

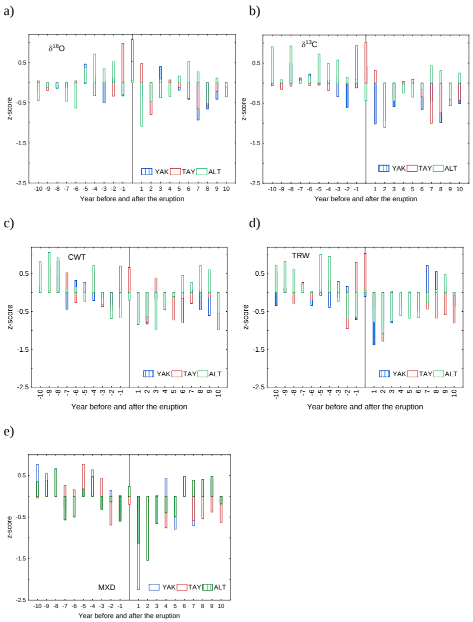

Fig. 3. Superposed epoch analysis of $\delta^{18}O$ (a), $\delta^{13}C$ (b), CWT (c), TRW (d) and MXD (e) chronologies for each study site and for the major volcanic eruptions in CE 535, 1257, 1641, 1815 and 1991.

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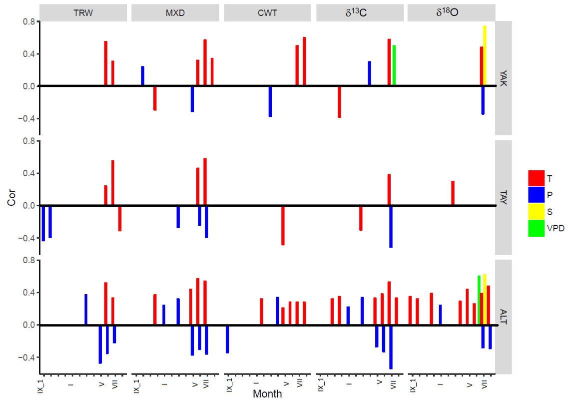

Fig. 4. Significant correlation coefficients between tree-ring parameters: TRW, MXD, CWT, $\delta^{13}C$ and $\delta^{18}O$ versus weather station data: temperature (T, red), precipitation (P, blue), vapor pressure deficit (VPD, green), and sunshine duration (S, yellow) from September of the previous year to August of the current year for three study sites were calculated. Table 2 lists stations used in the analysis.

Fig. 4.

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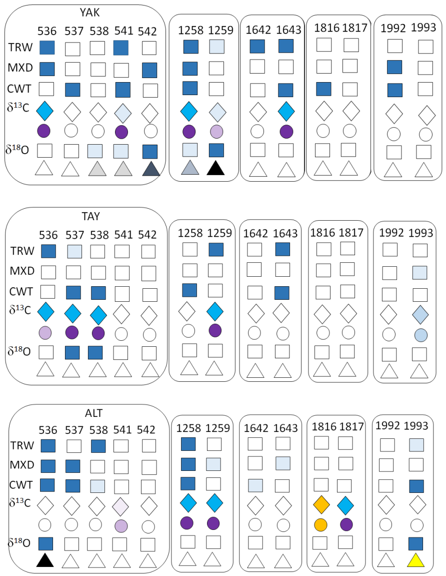

Fig. 5. Response of larch trees from Siberia to the CE volcanic eruptions (Table 1) with percentile of distribution considered as very extreme (< 5th, intensive color), extreme (>5th, <10th, light color) and non-extreme (>10th, white color). July temperature changes presented as a square from **heavy blue** (cold) to **light blue** (moderate). Summer vapor pressure deficit (VPD) variabilities are

Fig. 5.

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