Volcanic Impacts on Climate and Society in First Millennium BCE Babylonia

Session ITS2.13/AS4.29: Climatic, Environmental and Societal Impacts of Volcanic Activity

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Lion relief… main entrance of Babylon (at the Ishtar Gate), dated ca. 605-562 BCE (Yale University Art Gallery; photo: F. Ludlow)

Francis Ludlow [1]

Conor Kostick [1]

Rhonda McGovern [1]

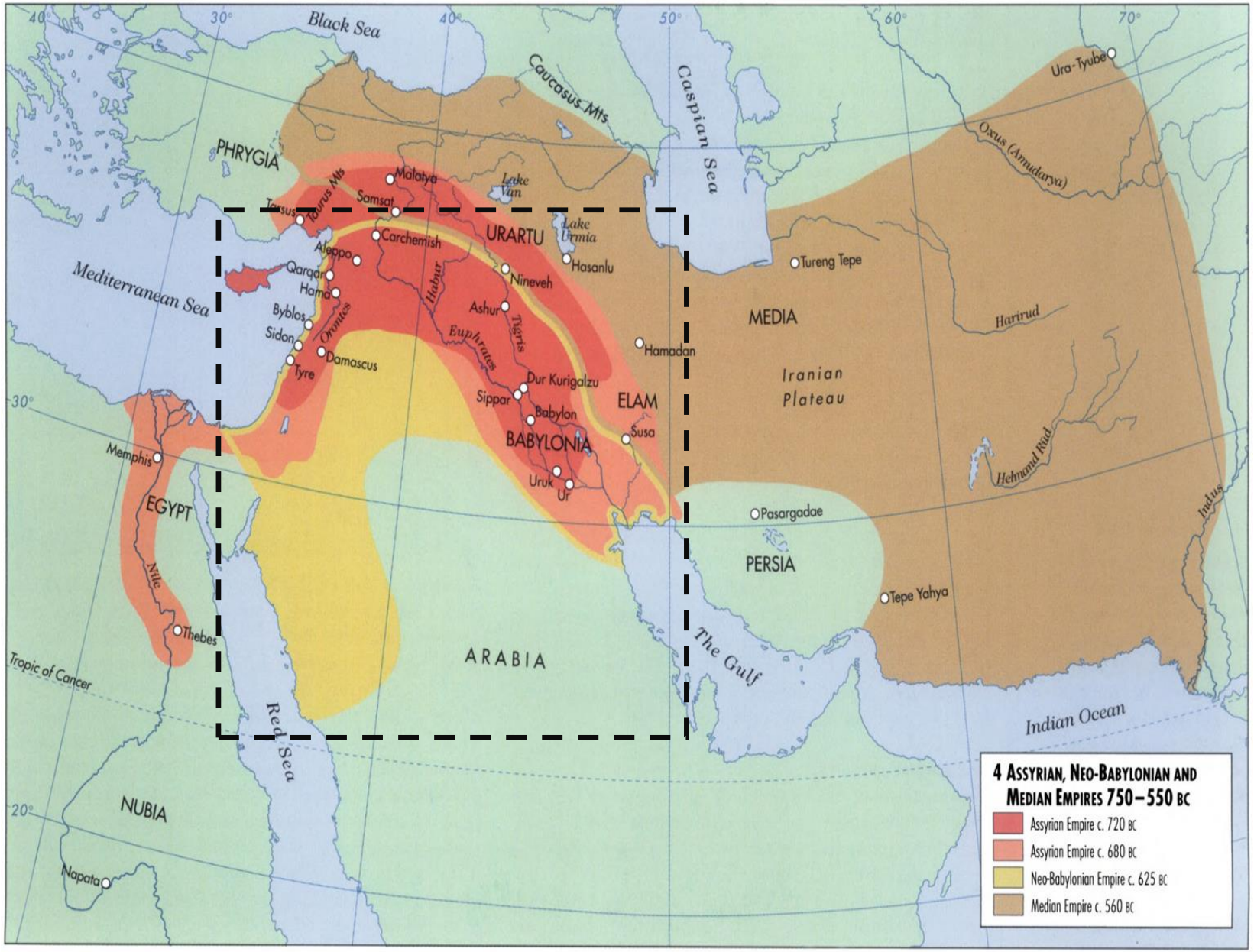
Al Matthews [1]

Michael Sigl [2]

Laura Farrelly [1]

1. Trinity Centre for Environmental Humanities, School of Histories & Humanities, Trinity College Dublin.
2. Climate and Environmental Physics, Physics Institute, and Oeschger Centre for Climate Change Research, University of Bern.

Study Region, Assyria & Babylonia, 8th to 1st Centuries BCE



Assyria, Neo-Babylonian & Median (Persian) Empires, 750-550 BCE. Map: O'Brien (2007)

The Cylinder of Persian King Cyrus the Great… 539 BC, *written to commemorate his conquest of Babylon, and found in the ruins of the city in 1879 (British Museum).*

250,000+ documents *survive for the Ancient Period from this reason, written in cuneiform script like the Cylinder.*

https://upload.wikimedia.org/wikipedia/commons/e/e5/Cyrus_Cylinder_front.jpg

Ancient Mesopotamian Climate History

Relevance to the explosive volcanism:

(1) Abundant written sources containing climatic and environmental data from the first millennium CE, in particular the “astronomical diaries”, that can help reveal climatic responses to explosive volcanism in this period and important historical region (“cradle of civilization”).

(2) Explosive volcanic eruptions, now increasingly known for this period thanks to ice-core-based reconstructions, can act as “tests” that reveal societal vulnerability and response to sudden hydroclimatic stressors.

Volcanic Impacts on Ancient Mesopotamian Hydroclimate

We provide here some highlights of how written evidence from this period can contribute understanding the environmental and hydroclimatic impacts of explosive volcanism.

Principal Sources: Astronomical Diaries, 652-60 BCE

Representative excerpts:

*"**Night of the 9th**, overcast, lightning, thunder, gusty west wind, rain… **Day of the 11th**, overcast, lightning, thunder, rain…"*

"There was much disease in the land."

"...famine in Babylonia, people sold their children for silver."

Above: Astronomical Diary from Babylon for 273 BCE. These diaries, kept as part of a multi-century recording programme aimed at predicting future events, detail a vast range of **weather conditions systematically observed at sub-daily resolution** (yet virtually ignored to date by scholars) and heights of the Euphrates at Babylon as well as food prices and major societal stresses. For above image, see: https://www.livius.org/pictures/a/tablets/astronomical-diary-mentioning-first-syrian-war/

https://en.wikipedia.org/wiki/Bishop%27s_Ring#/media/File:BishopRing18mei2010_18_sml.jpg

Pale sun due to volcanic particulates from Eyjafjallajökull eruption, Iceland; Photo in Leiden, 18 May 2010

ARTICLE

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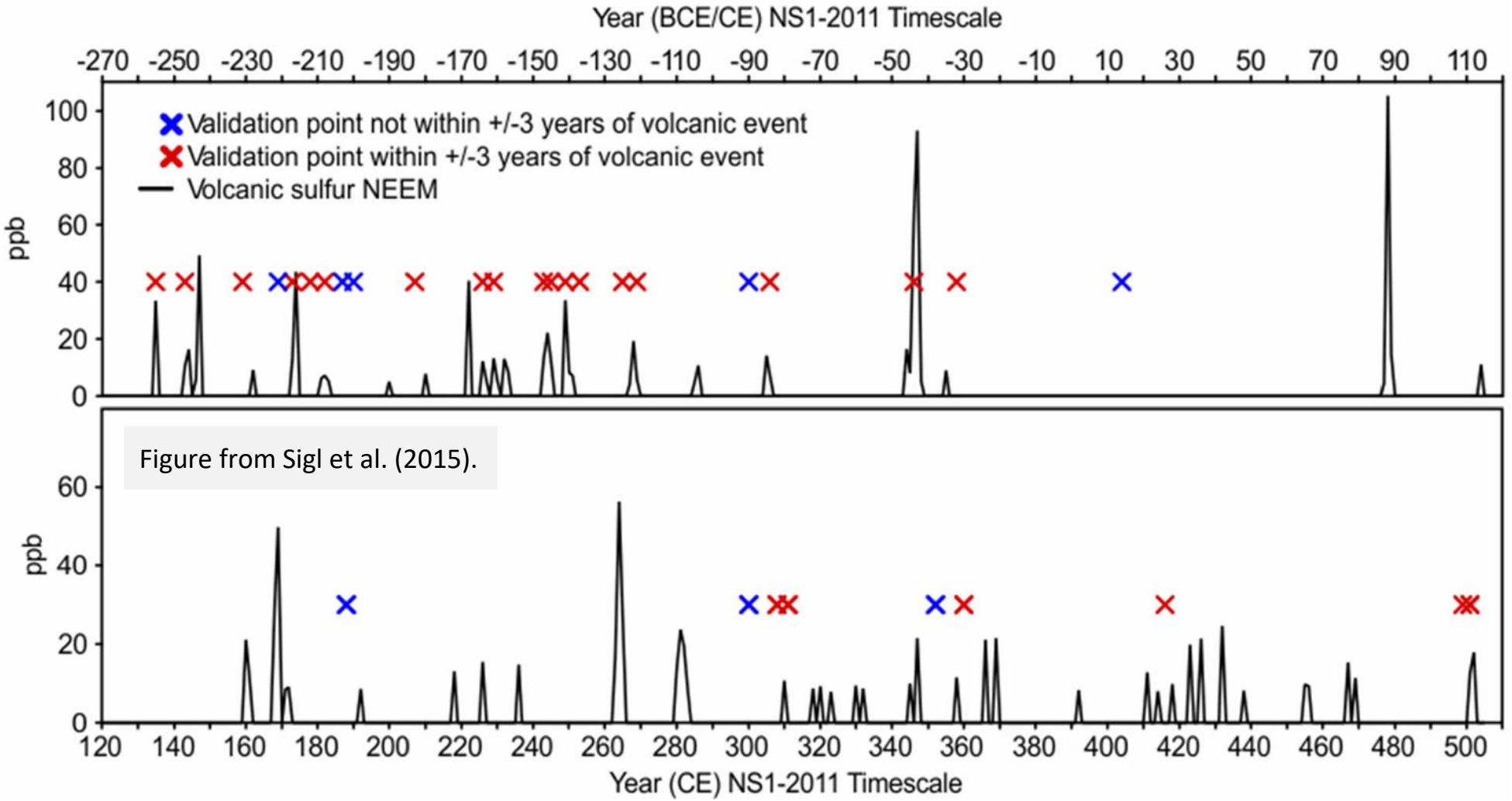
Timing and climate forcing of volcanic eruptions for the past 2,500 years

M. Sigl[1]†, M. Winstrup[2], J. R. McConnell[1], K. C. Welten[3], G. Plunkett[4], F. Ludlow[5], U. Büntgen[6,7,8], M. Caffee[9,10], N. Chellman[1], D. Dahl-Jensen[11], H. Fischer[7,12], S. Kipfstuhl[13], C. Kostick[14], O. J. Maselli[1], F. Mekhaldi[15], R. Mulvaney[16], R. Muscheler[15], D. R. Pasteris[1], J. R. Pilcher[4], M. Salzer[17], S. Schüpbach[7,12], J. P. Steffensen[11], B. M. Vinther[11] & T. E. Woodruff[9]

"The 24th, the north wind blew, the cold became severe… around noon, the ***disk of the sun looked like that of the moon…"*** Astronomical Diary, 173 BC.

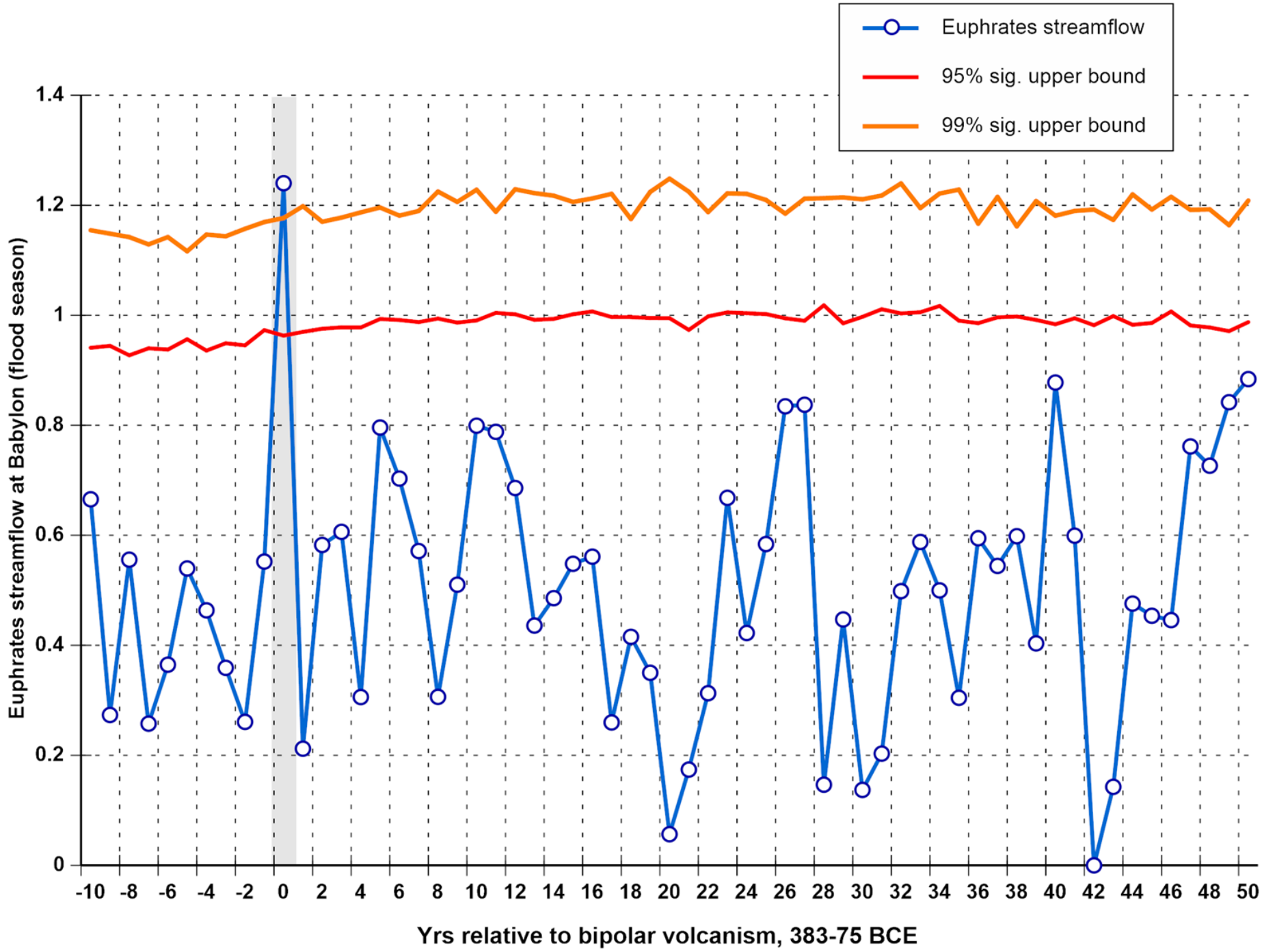
As well as recording wind direction, cloud cover, rainfall, dustfalls, thunder and lightning, and multiple qualitative temperature and precipitation indicators, the Diaries record instances of high atmospheric turbidity, in which sunlight was obscured or discoloured. The precise and accurate dates provided for such instances, which may plausibly relate to volcanic loading of the atmosphere with aerosols and other particulates, have been employed as chronological "validation points" for major revisions to ice-core-based volcanic event histories (i.e. Sigl et al., 2015, above right).



Potential dust-veil observations acting as chronological **"validation points"** - many previously unknown and drawn from the astronomical diaries for the period 255-61 BCE - are shown with Xs, and overlain on Greenland ice-core sulfate deposition peaks indicative of explosive volcanism.

The majority of such observations were found to occur closely in time with volcanic deposition on the revised ice-core timescale of Sigl et al. (2015).

Monte Carlo randomisations indicate that the probability of such a high level of correspondence occuring by chance alone is <1%, supporting the accuracy of the revised ice-core timescale.



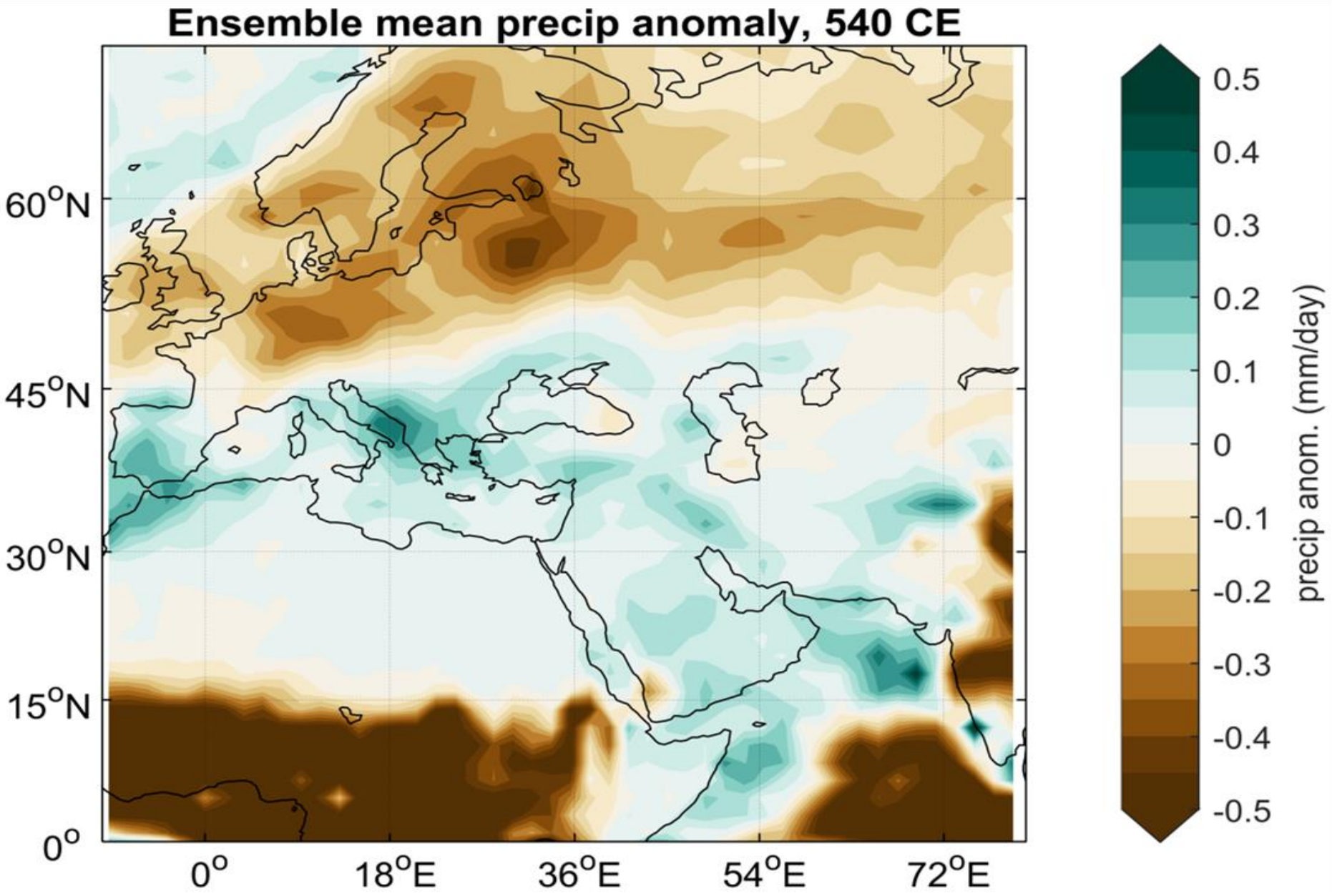
Superposed epoch analysis of **Euphrates spring-summer flood heights measured at Babylon**, plotted relative to the ice-core-based dates of 11 major tropical eruptions (Sigl et al., 2015), 383-75 BCE.

The flood heights in the inferred years of explosive eruptions are shown at Point 0 on the horizontal axis, and are clearly elevated relative to the average heights in the years before or following.

Spring-summer flood heights are strongly dependent upon melt of accumulated winter snowfall and subsequent spring precipitation in the Euphrates headwaters in the Armenian highlands (Turkey).

This result **suggests increased precipitation in these regions after explosive tropical eruptions**.

Heights in meters. Data courtesy Joost Huijs.



Simulated annual mean precipitation anomalies after the famous 540 CE tropical eruption, relative to a 1,000 year non-volcanic control run (Max Planck Institute Earth System Model), showing **anomalous wet weather in the Ancient Near East, and Babylonia**, and importantly in the Armenian highlands in which the Euphrates rises.

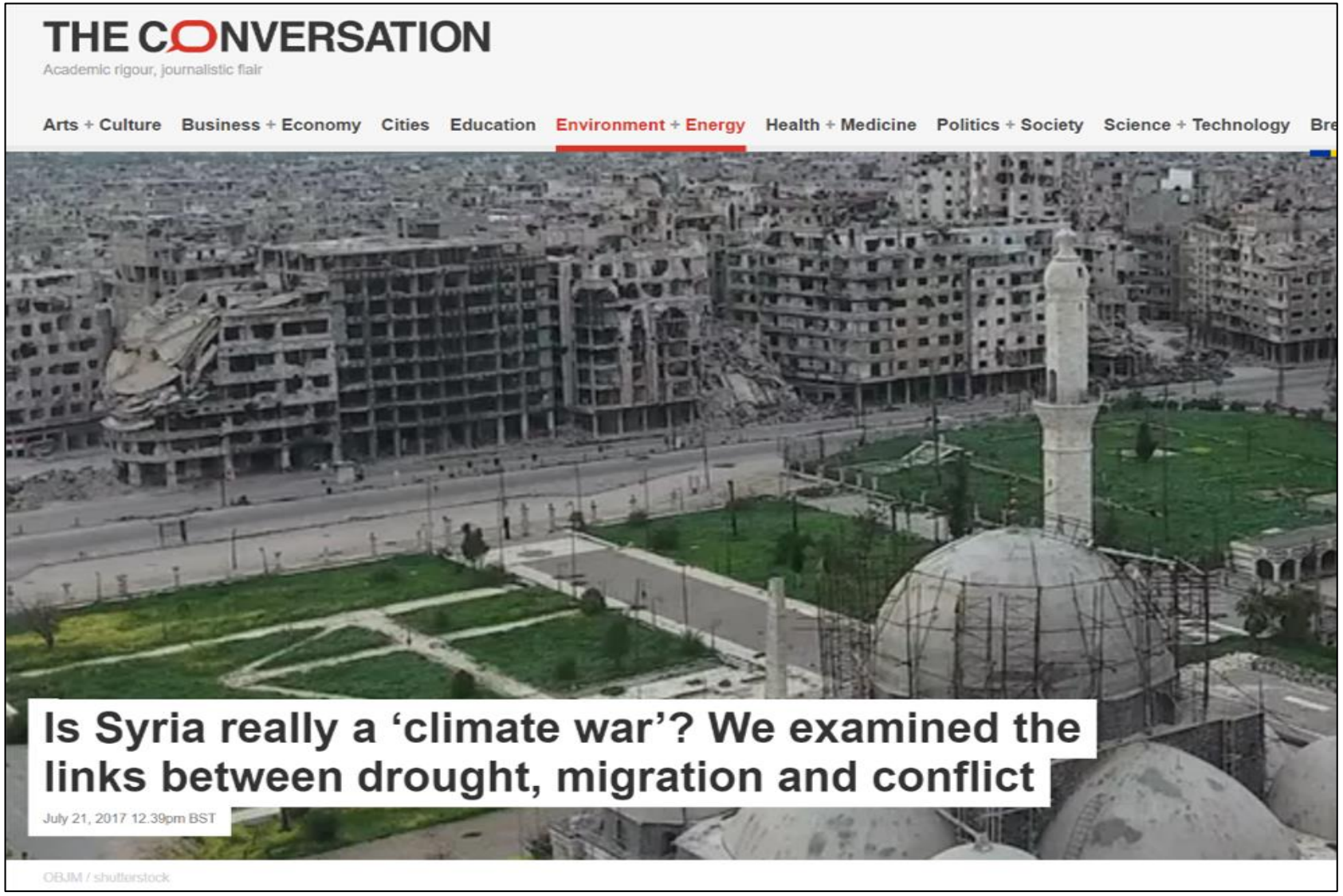
Consistent with historically observed increase in Euphrates spring-summer flood heights following tropical eruptions (previous slide).

Model output and figure courtesy of **Matthew Toohey**.

Volcanic Hydroclimatic Impacts on Mesopotamian Society

We again provide some highlights from ongoing work focusing on volcanic hydroclimatic impacts and responses in Assyria and Babylonia.

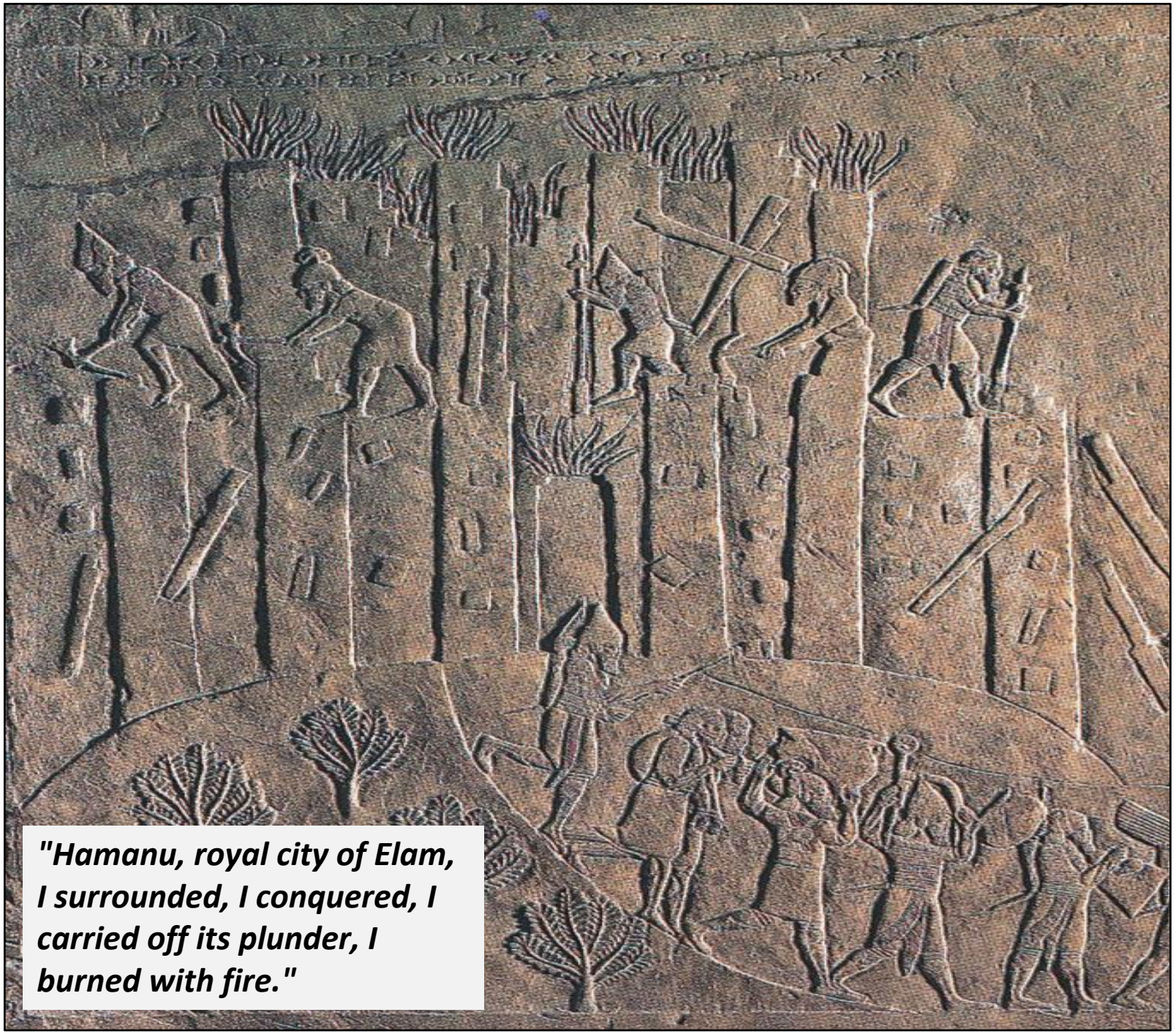
Why Study This?



https://theconversation.com/is-syria-really-a-climate-war-we-examined-the-links-between-drought-migration-and-conflict-80110

Contested role of climate in contemporary conflicts in this region (e.g. ongoing Syrian civil war associated with drought, 2007-2010).

Need for longer-term historical perspectives on links between climate and conflict in this region.



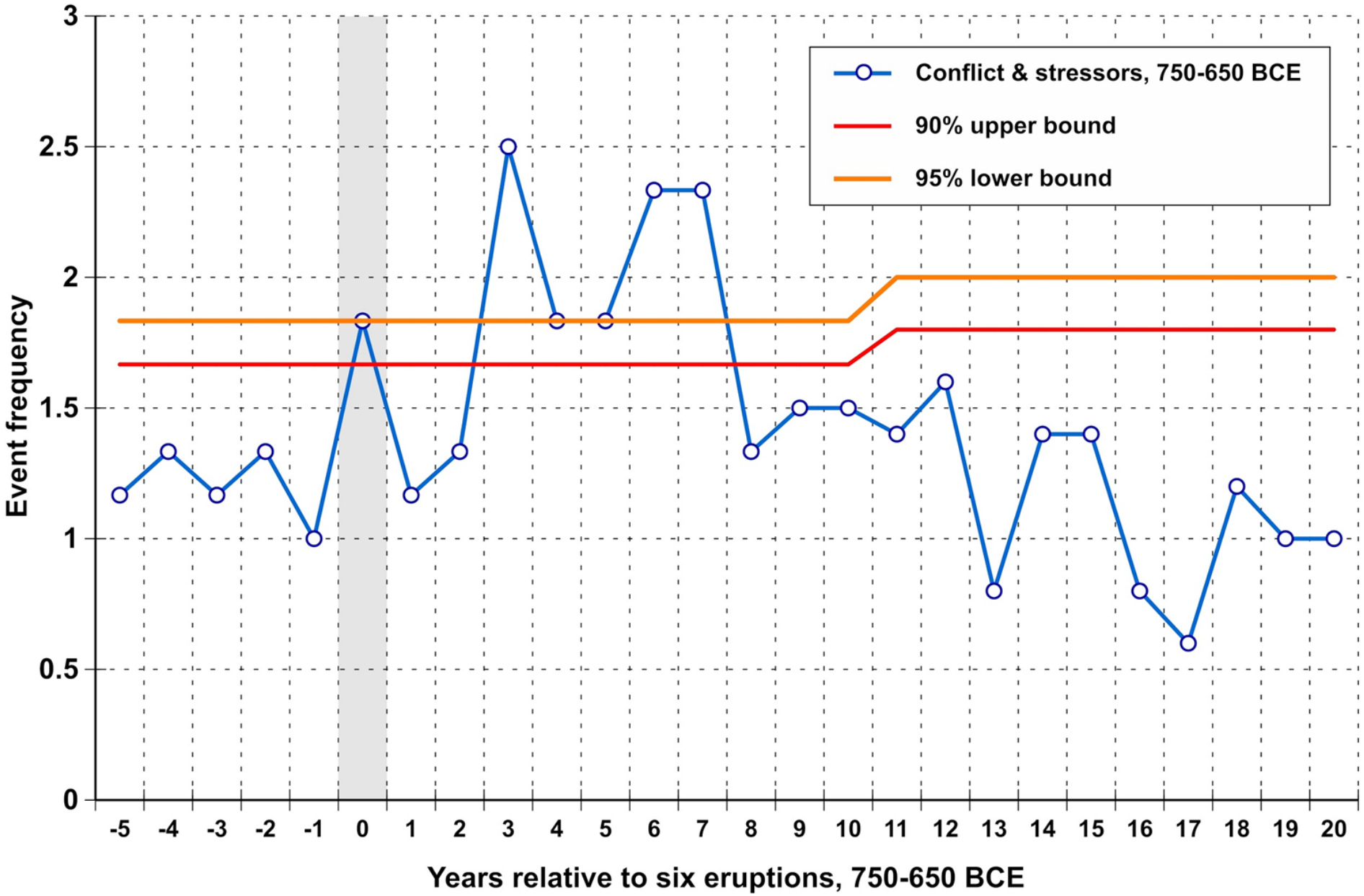
"Hamanu, royal city of Elam, I surrounded, I conquered, I carried off its plunder, I burned with fire."

Sacking of the city of Hamanu in Iran by Ashurbanipal, King of Assyria, 647 BCE.

Limestone relief from Assyrian capital of Nineveh, with King Ashurbanipal's proclamation (below left).

Work is ongoing on quantifying levels of annual violence, conflict and other societal stresses documented through time in such sources for the region.

Image of relief in British Museum.



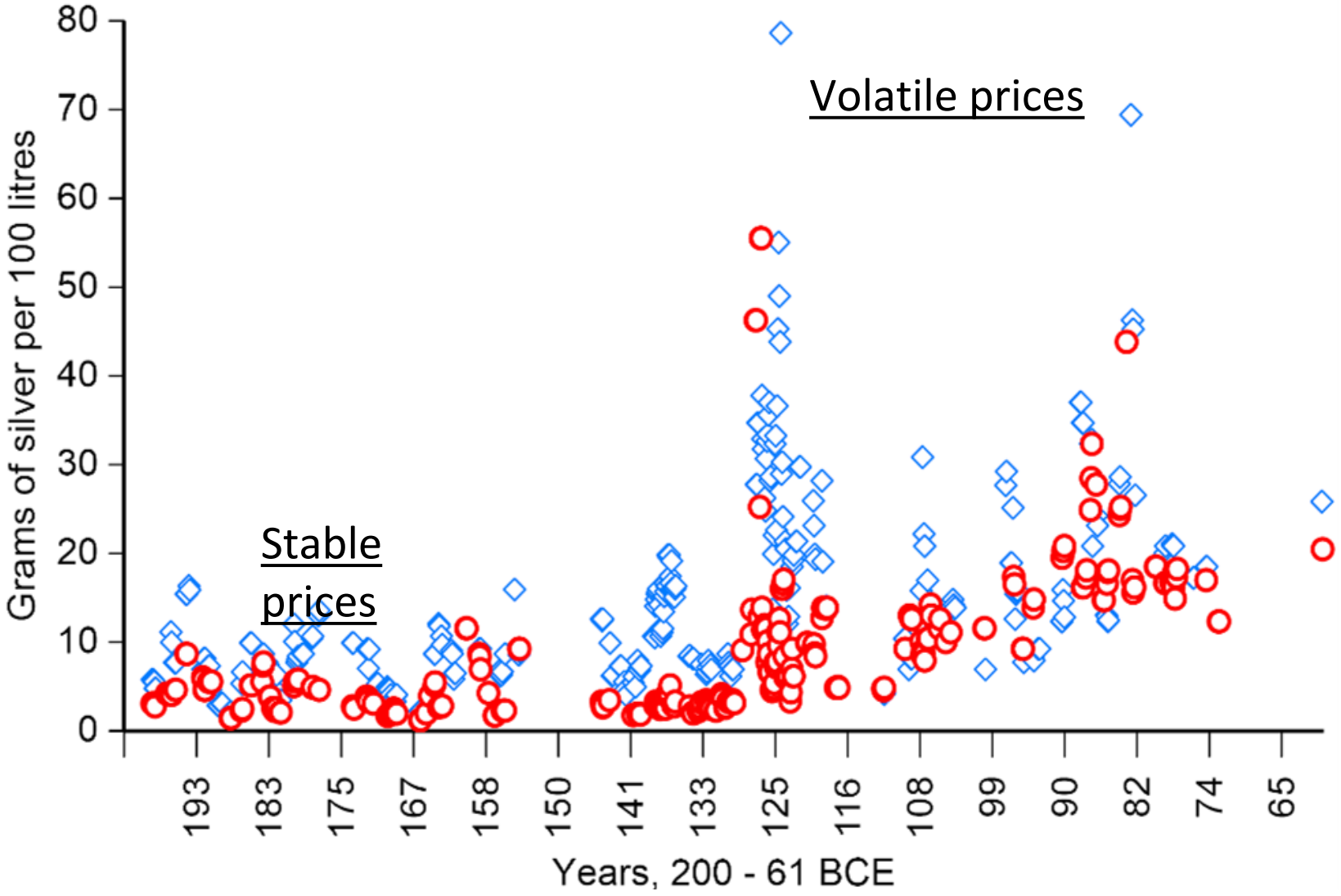
Six volcanic events with bipolar or extratropical Northern Hemispheric deposition signals are used in this analysis - data and dates courtesy of work in preparation. Provided courtesy of **Michael Sigl**.

Provisional superposed epoch analysis of the **annual frequency of documented conflicts** (internal conflict and external warfare) **and related societal stressors, relative to the dates of major explosive eruptions** in the period 750-650 BCE.

Average **event frequencies peak in the decade following these eruptions,** suggesting a role for hydroclimatic shocks in triggering or intensifying conflicts.

Potential mechanisms include **"scarcity induced resource competition"** (e.g. violence triggered by competition for food made scarce by hydroclimatic impacts of volcanism), **or opportunistic attacks** on rival kingdoms weakened by poor harvests.

Assessing Volcanic Hydroclimatic Impacts on Food Prices



Monthly prices for **barley** and **dates**, in Babylon, 200-61 BC

The Diaries provide "the most detailed [price] dataset of the ancient world, which can compete with datasets from modern history" (van der Spek, 2008).

Volcanic event dates from Sigl et al. (2015).

10% and 90% lower and upper bounds based upon Monte Carlo randomization with 1k iterations.

Superposed epoch analysis of **Barley prices in Babylon, 300-61 BCE,** taken from the astronomical diaries (courtesy of Bert van der Spek) **relative to the date of 20 major tropical and extratropical NH eruptions** between 300 and 75 BCE.

This is an initially counter-intuitive result, as we might expect prices to increase because of agricultural impacts of post-eruption climatic anomalies.

It is possible, however, that Babylonian **irrigated arable agriculture benefited from the apparent increase in Euphrates floodwaters observed post-eruption** (see previous slides).

Alternatively, some historians have hypothesized that **authorities in Babylon had a policy of intervening when food prices rose too high, by flooding the market with emergency stores of grain**, thereby artificially driving down prices.

Work is ongoing to further test this hypothesis.

Thank you!

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The work has benefited from interaction with colleagues in the Trinity Centre for Environmental Humanities, and the PAGES-funded “Volcanic Impacts on Climate and Society” working group - see www.pastglobalchanges.org/science/wg/vics/intro.

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Citations:

O’Brien, P. K. (ed.) (2007) *Oxford Atlas of World History: Concise edition*. Revised edition. Oxford: Oxford University Press.

Sigl, M. et al. (2015) "Timing and Climate Forcing of Volcanic Eruptions during the Past 2,500 years", *Nature*, 523, 543-549, doi:10.1038/nature14565.