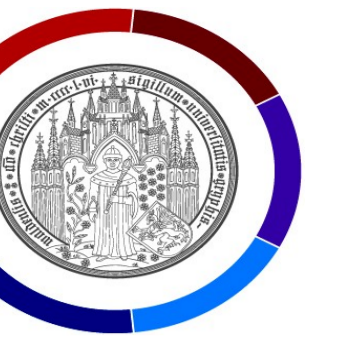


# Mega-Droughts of The Last Millennium - What are their Causes and Impacts?

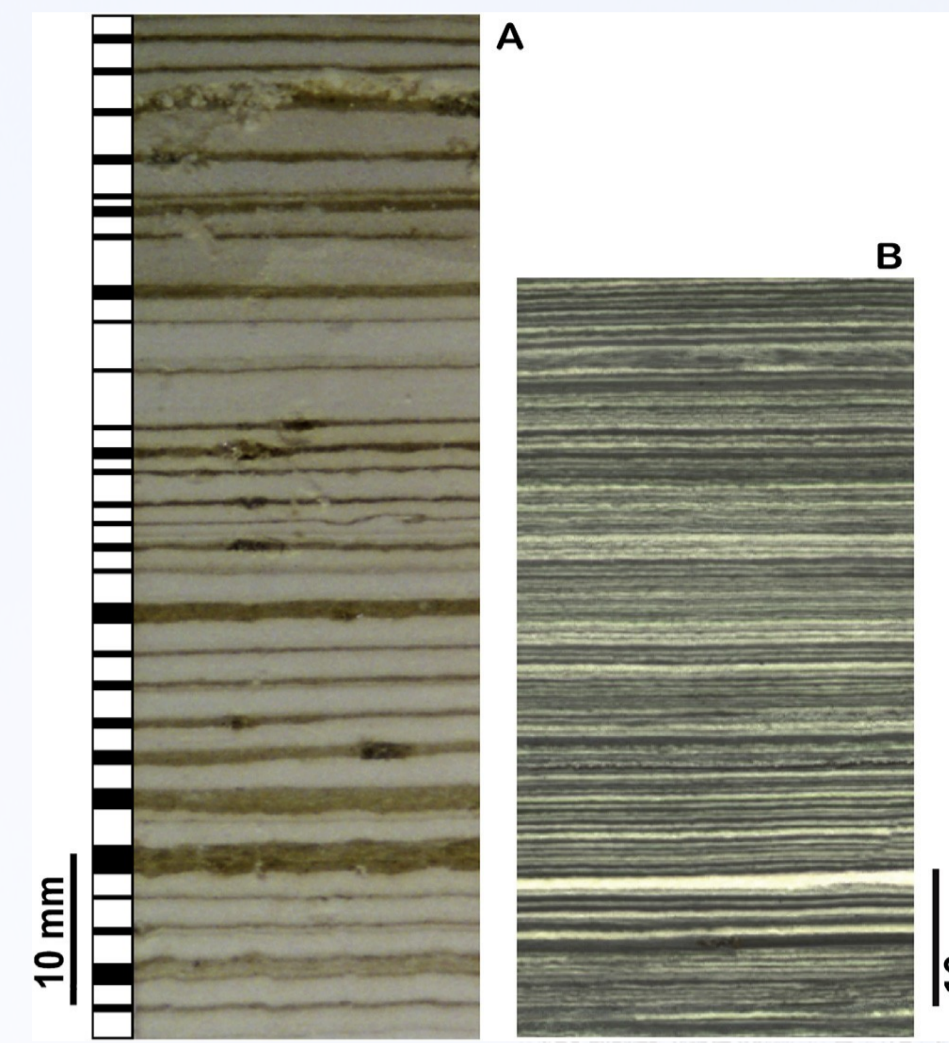


## Meaning of a Mega-Drought:

A prolonged period of negative deviation in water balance compared to the climatological norm in a given area.  
"A formally accepted climatological definition does not exist" [1].

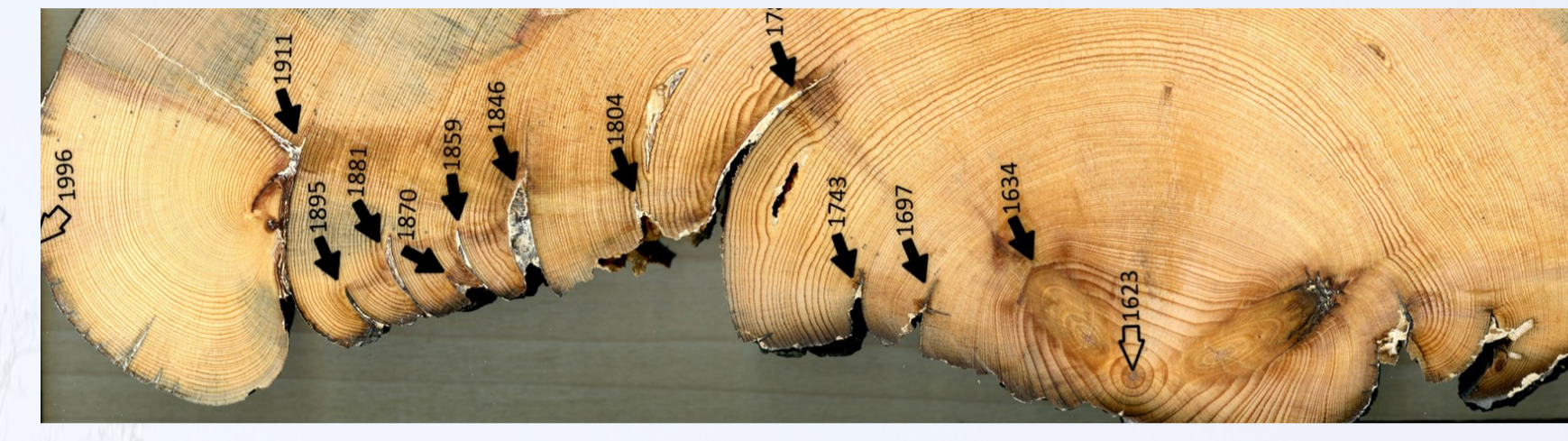
## How do we gain information about Mega-Droughts?

### • Lake and Ocean Sediments



[2]

### • Tree rings



<http://www.rmtr.org/images/s-FireScar.jpg>

### • Documentary Evidence



[3]

## Causes for Mega-Droughts are not always clear!

### • Natural Forcing:

- Increasing Temperatures and Aridity [1,6]
- Decreasing Temperature Difference between Land and Ocean [1,5,6]
- Ocean/ Atmospheric Circulation [1,4,6]
- Reinforcing Factors [1,5,6]

### • Non-Natural Forcing

- Anthropogenic Influences [1,6]

## Impacts are seen in:

### • Ecologically:

- Low Lake, River and Groundwater Levels [1,3]
- Environmental Deterioration [1]
- Collapse of the Food Base [1,3]

### • Socially:

- Famines and Disease [1,3,5]
- Political Instability [1,3,5]
- Social Changes [1,3,5]

## Example: Ming Dynasty Mega-Drought (MDMD) [5]

### Causes:

- sparked by a natural Drought Event in 1637
- reinforced by a Volcanic Eruption in 1641
- Volcanic Eruption caused a weakened East Asian Summer Monsoon

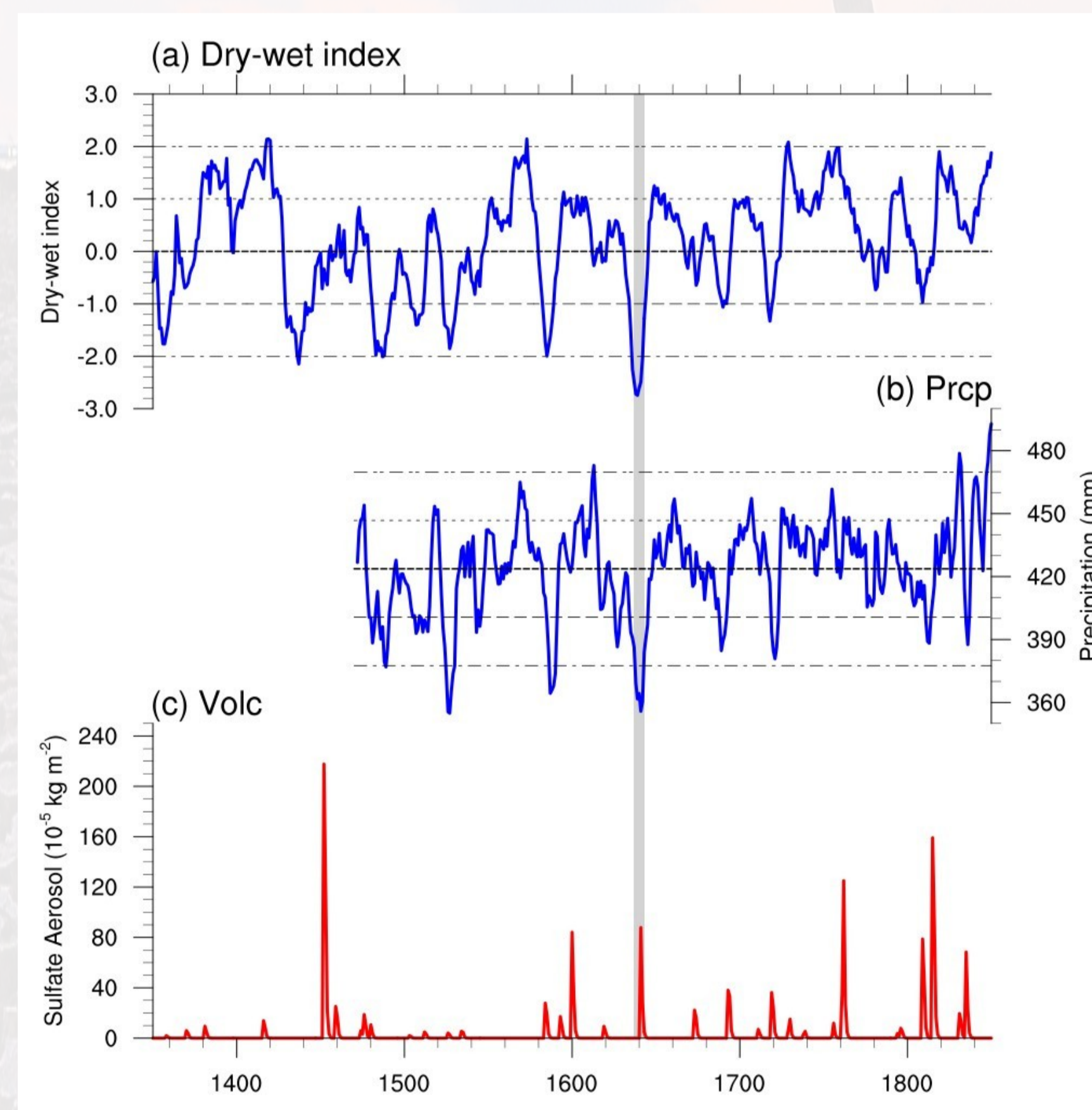


Fig. 1: The MDMD in reconstructions. (a) the reconstructed Dry-Wet-Index; (b) The reconstructed 5-year running mean summer precipitation; (c) The reconstructed sulphate aerosol. [5]

### Impacts:

- Food Crises
- Famines
- Plagues
- Wars
- End of Ming Dynasty and Beginning of Qing Dynasty in 1644

## Conclusion/ Future outlook:

- Better Definition of Mega-Drought is needed to improve understanding and ease strategy development
  - Future Mega-Droughts will be different than past ones
  - Our current climate trend supports the possibility of future Mega-Droughts
- Modern scientist still try to uncover the connection of single factors for Mega-Drought occurrence

## References:

- [1] Sinha, A. et al. (2011). A global context for megadroughts in monsoon Asia during the past millennium. *Quaternary Science Reviews* 30 (1-2): 47-62.
- [2] Zolitschka, B. et al. (2015). Varves in lake sediments – a review. *Quaternary Science Reviews* 117, 1-41.
- [3] Brázdil, R. et al. (2018). Documentary data and the study of past droughts: a global state of the art. *Climate of the Past* 14, 1915-1960.
- [4] Back, R. (2009). West Africa faces 'megadroughts'. <http://news.bbc.co.uk/2/hi/science/nature/8003060.stm?b> (20.6.2020)
- [5] Chen, K. et al. (2020). One Drought and One Volcanic Eruption Influenced the History of China: The Ming Dynasty Mega-drought. *Geophysical Research Letters*. ESSOAr, Earth and Space Science Open Archive.
- [6] Woodhouse, C.A. et al. (2010). A 1200-year perspective of 21st century drought in southwestern north America. *PNAS* 107 (50), 21283-21288.
- [7] Kaufman, M. (2019). The warming U.S. foretells the return of dreaded megadroughts. <https://mashable.com/article/southwest-megadroughts-future/?> (23.06.2020)