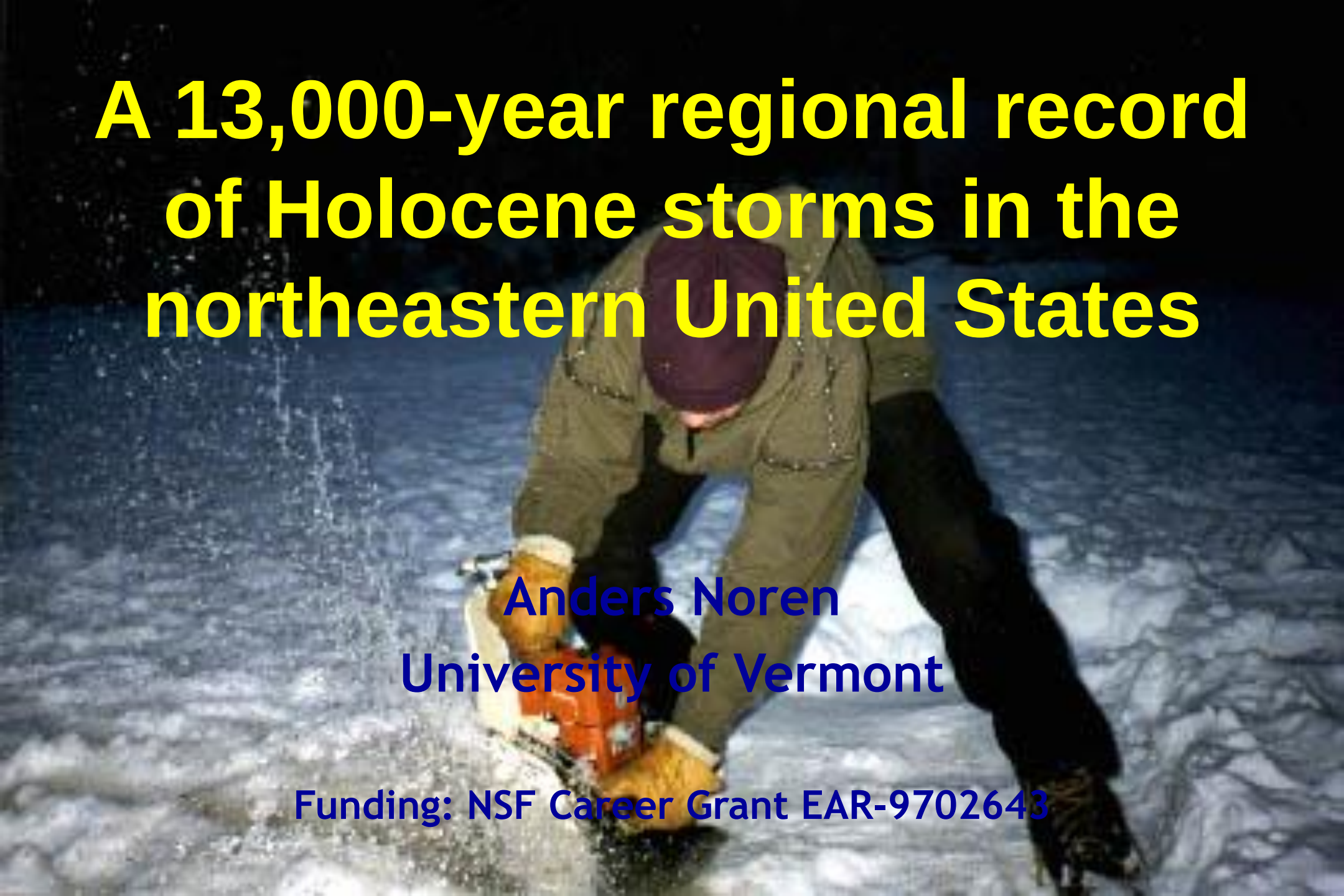


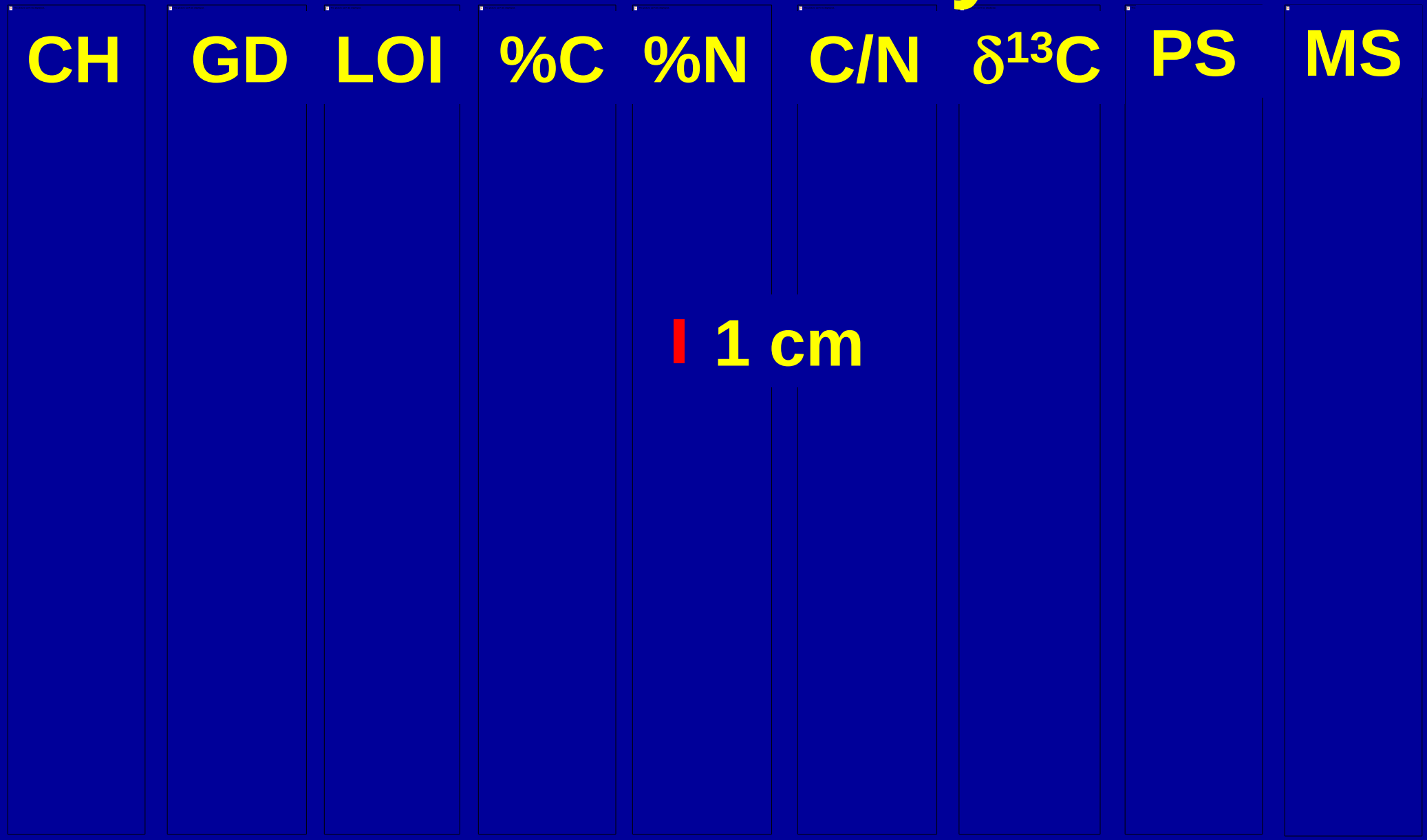
A 13,000-year regional record of Holocene storms in the northeastern United States

Anders Noren
University of Vermont

Funding: NSF Career Grant EAR-9702643

- Rain-induced erosion
- Deposition in lakes

Ritterbush Analyses



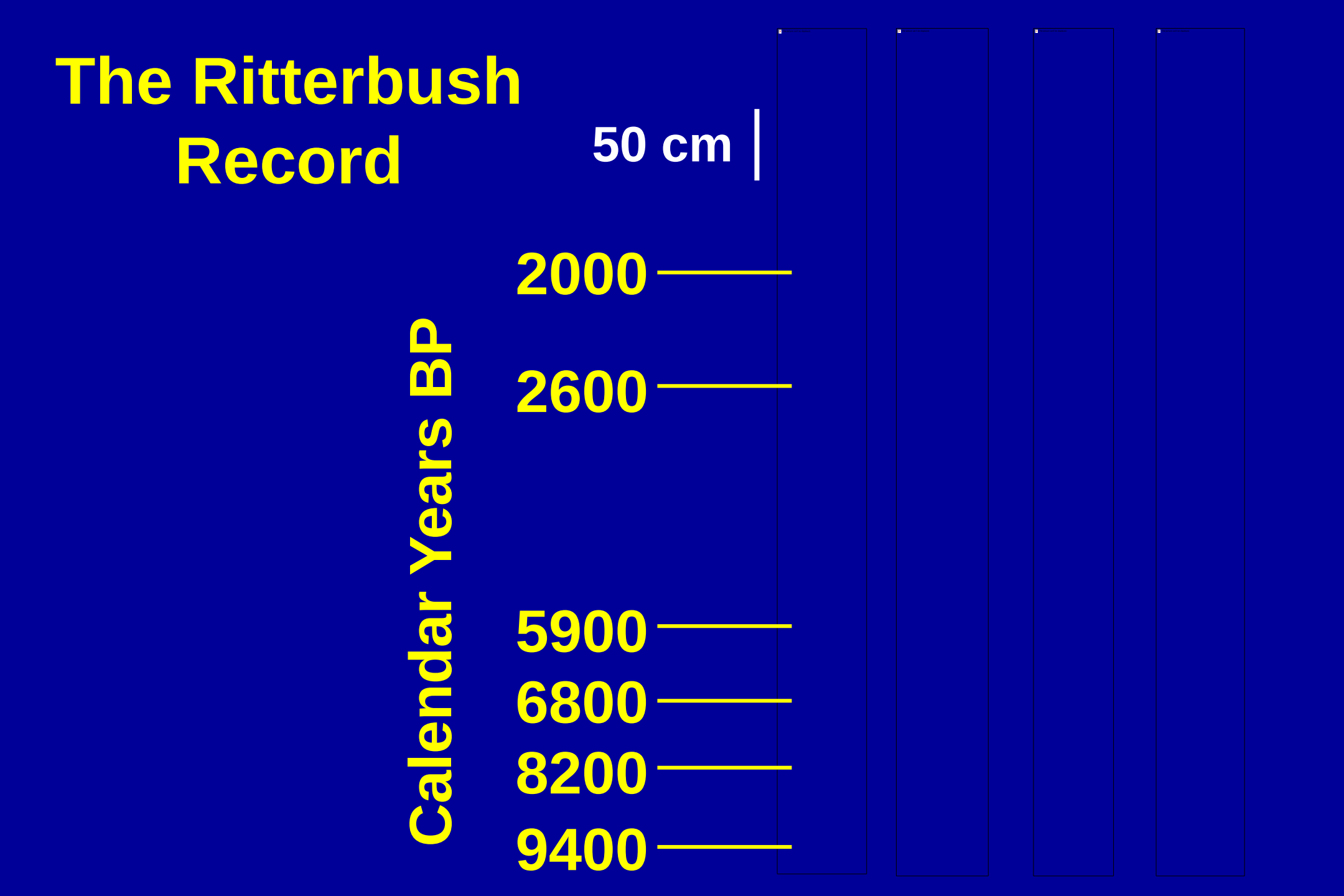
Other Mechanisms

- Earthquakes
- Snowmelt
- Lake-level fluctuations
- Removal of vegetation
    - Drought, disease
    - Fires
    - Human activity

Why Storms?

- Written records correlate with paleostorm reconstructions
  - Layer occurrence
  - Layer thickness

- Field observations


The Ritterbush Record
50 cm
Calendar Years BP
2000
2600
5900
6800
8200
9400

Questions

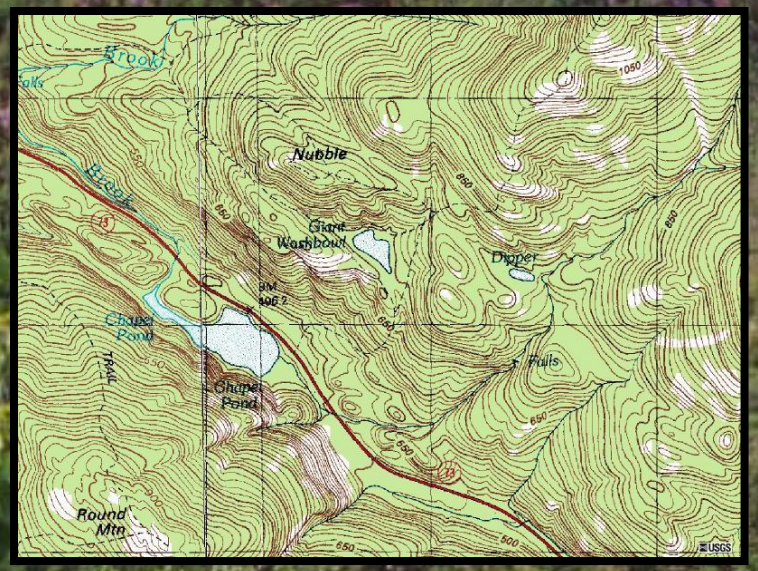
Does the Ritterbush record reflect regional processes?

- **Storm size: Hurricanes or localized storms? (Were layers deposited synchronously in multiple lakes?)**
- **Regional storm trends: Periods of increased storminess? Cycles?**

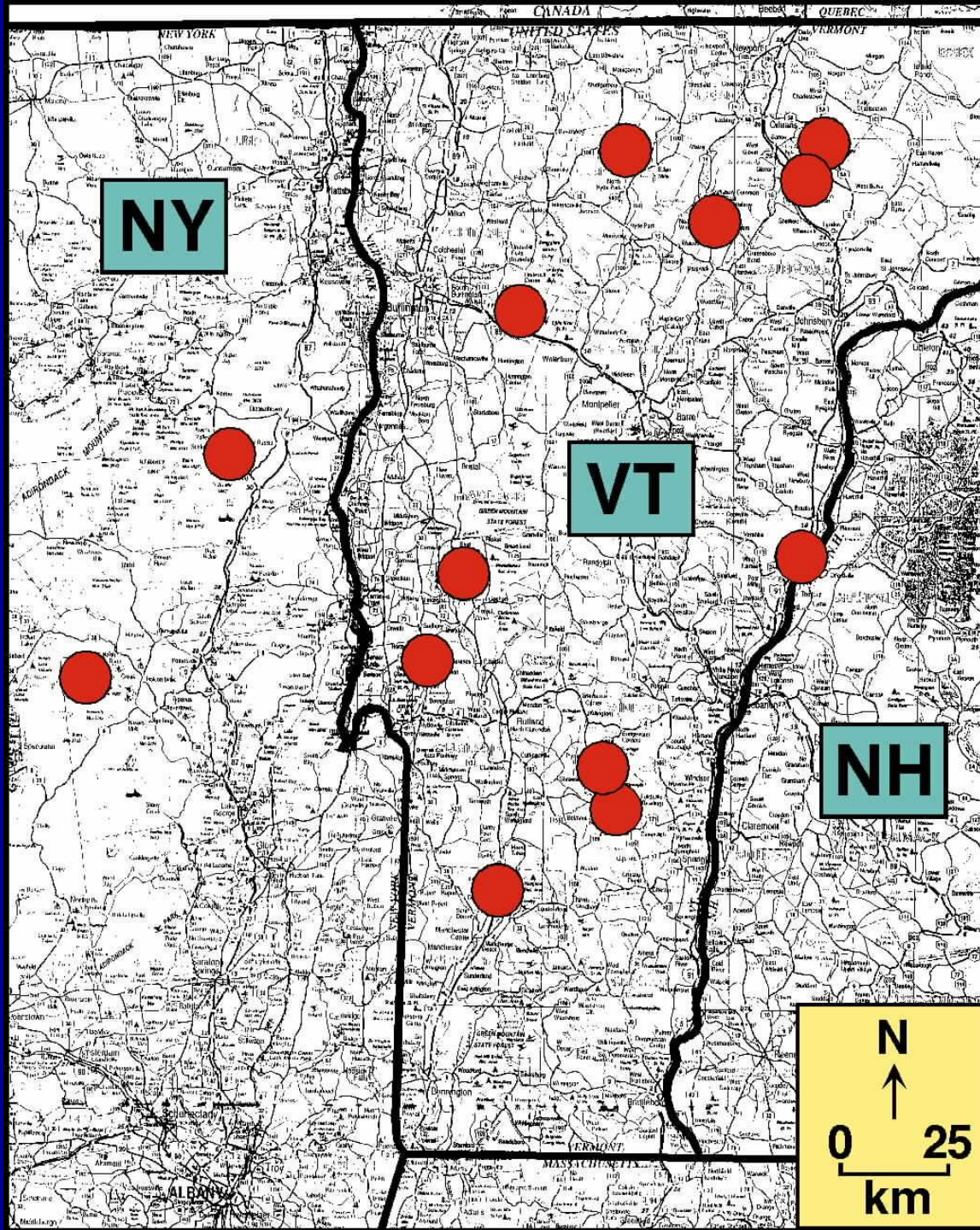
Climatic causes/controls?

Lake Characteristics

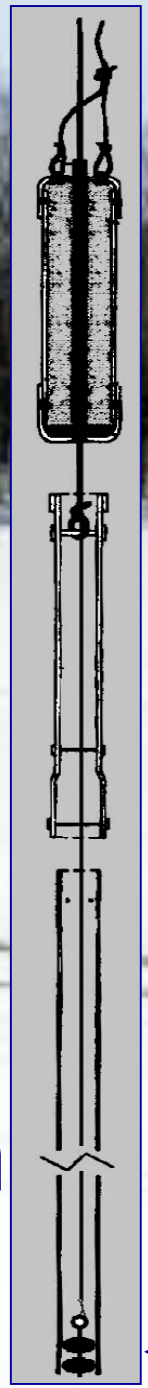
- Steep
- Deep
- Evidence of sediment transport



Lake Locations



Coring Device



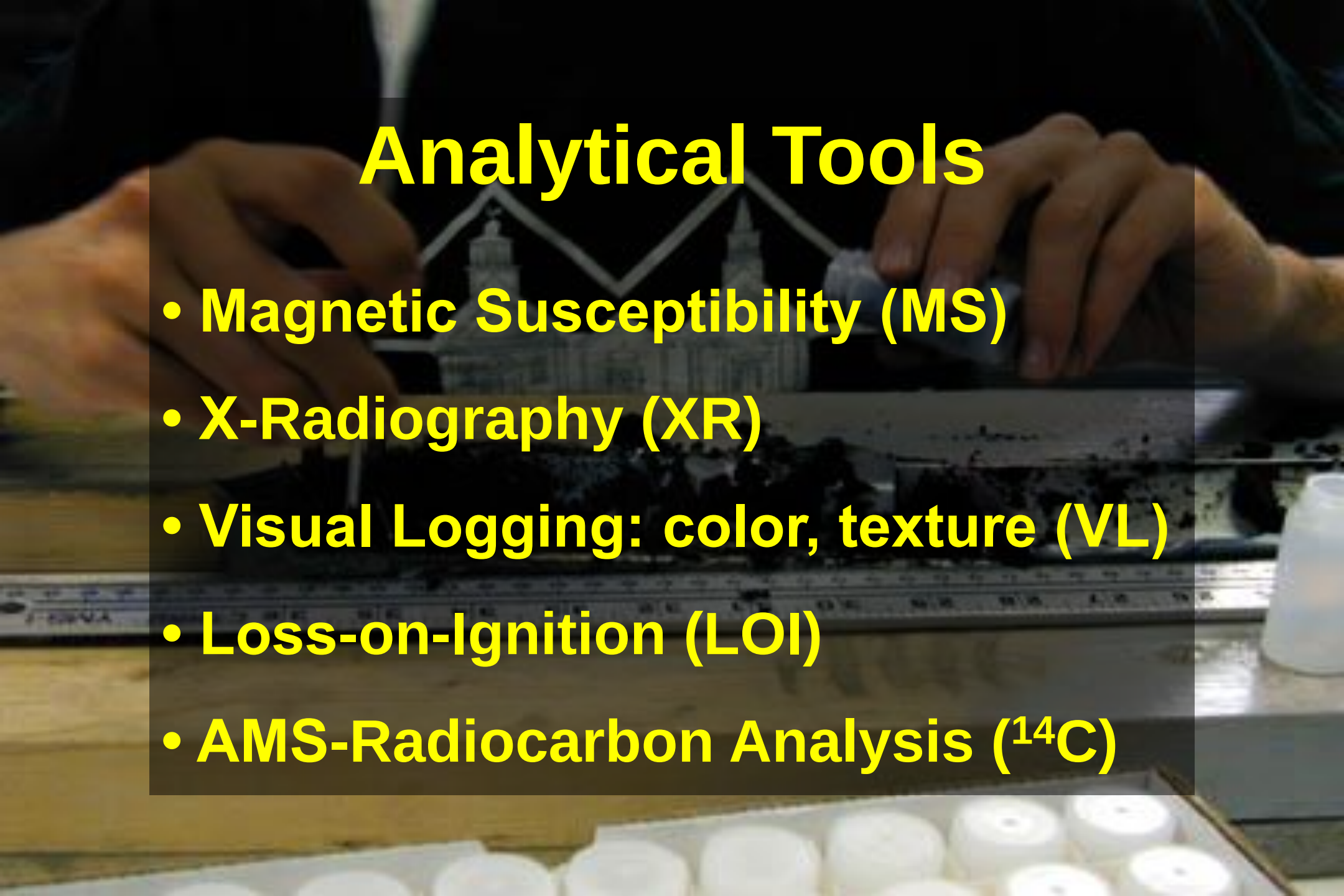
Driver

Head

Barrel

6m

Piston



Analytical Tools

- Magnetic Susceptibility (MS)
- X-Radiography (XR)
- Visual Logging: color, texture (VL)
- Loss-on-Ignition (LOI)
- AMS-Radiocarbon Analysis (^{14}C)

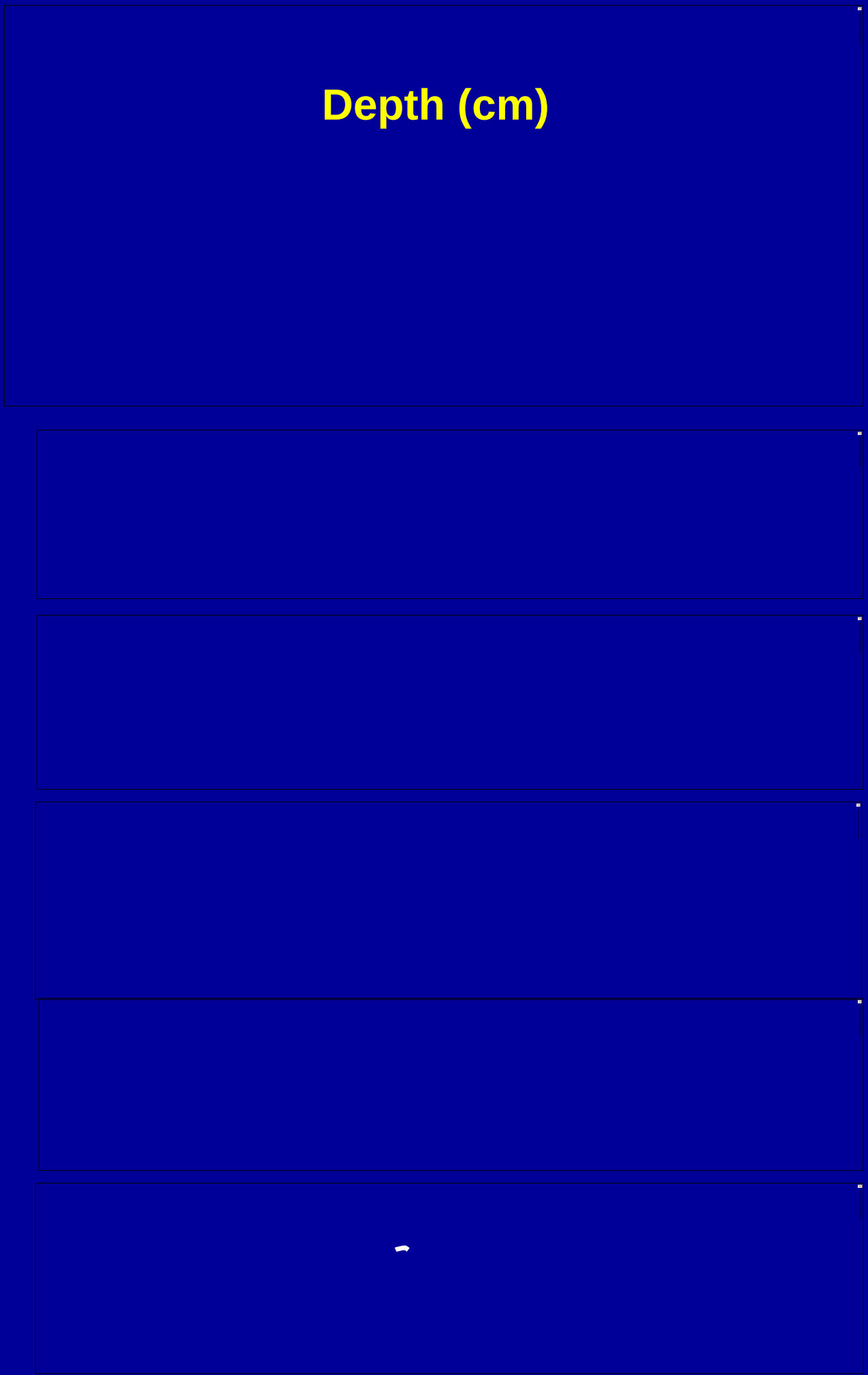
Depth (cm)

0 25

0 50

Time Series Filter

- Remove negative peaks
  > 1σ from median
- SSA reconstruction of
  remaining series
- Peaks > 1σ from
  reconstruction = SIGNIFICANT


Depth (cm)

COMP

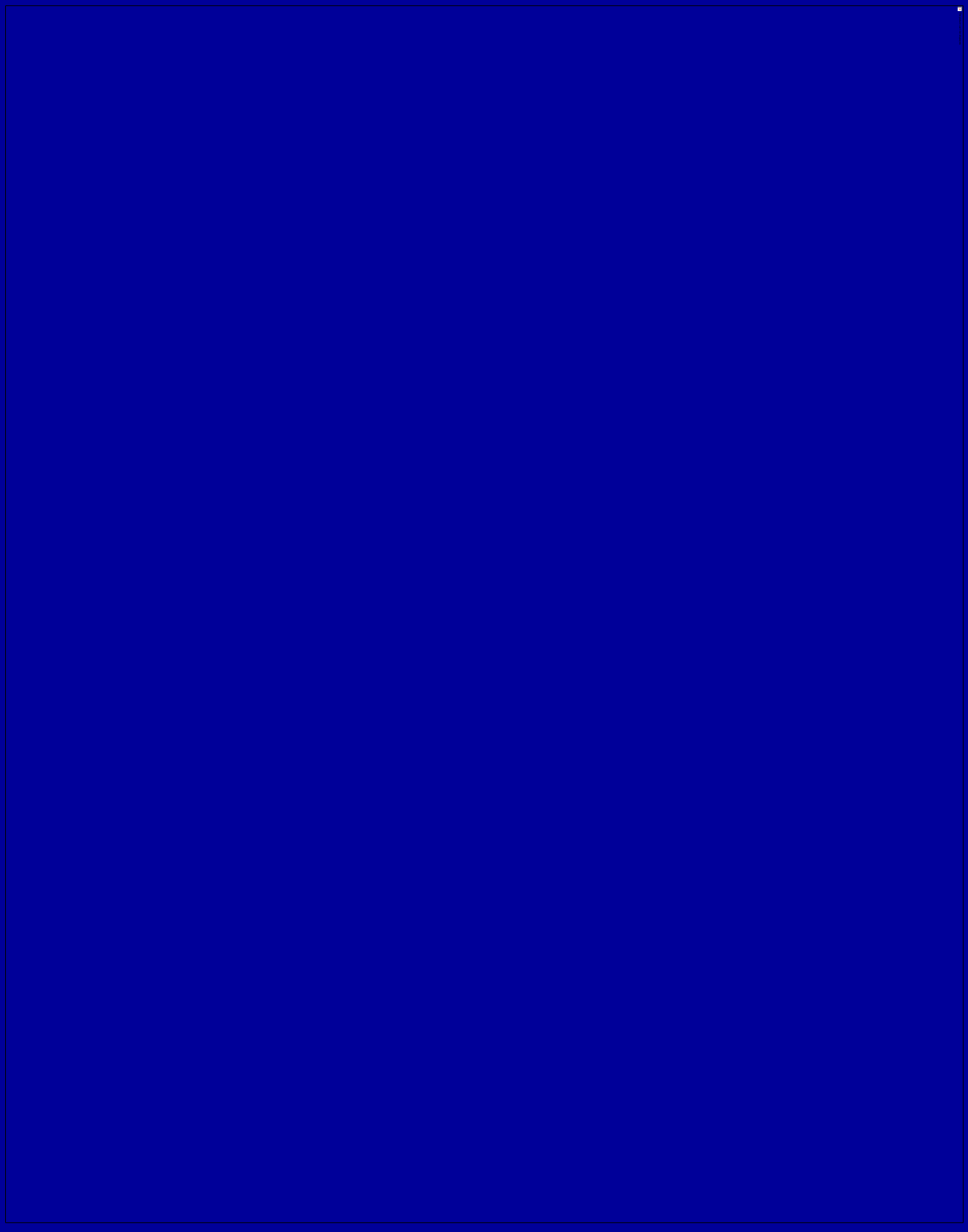
Depth (cm)

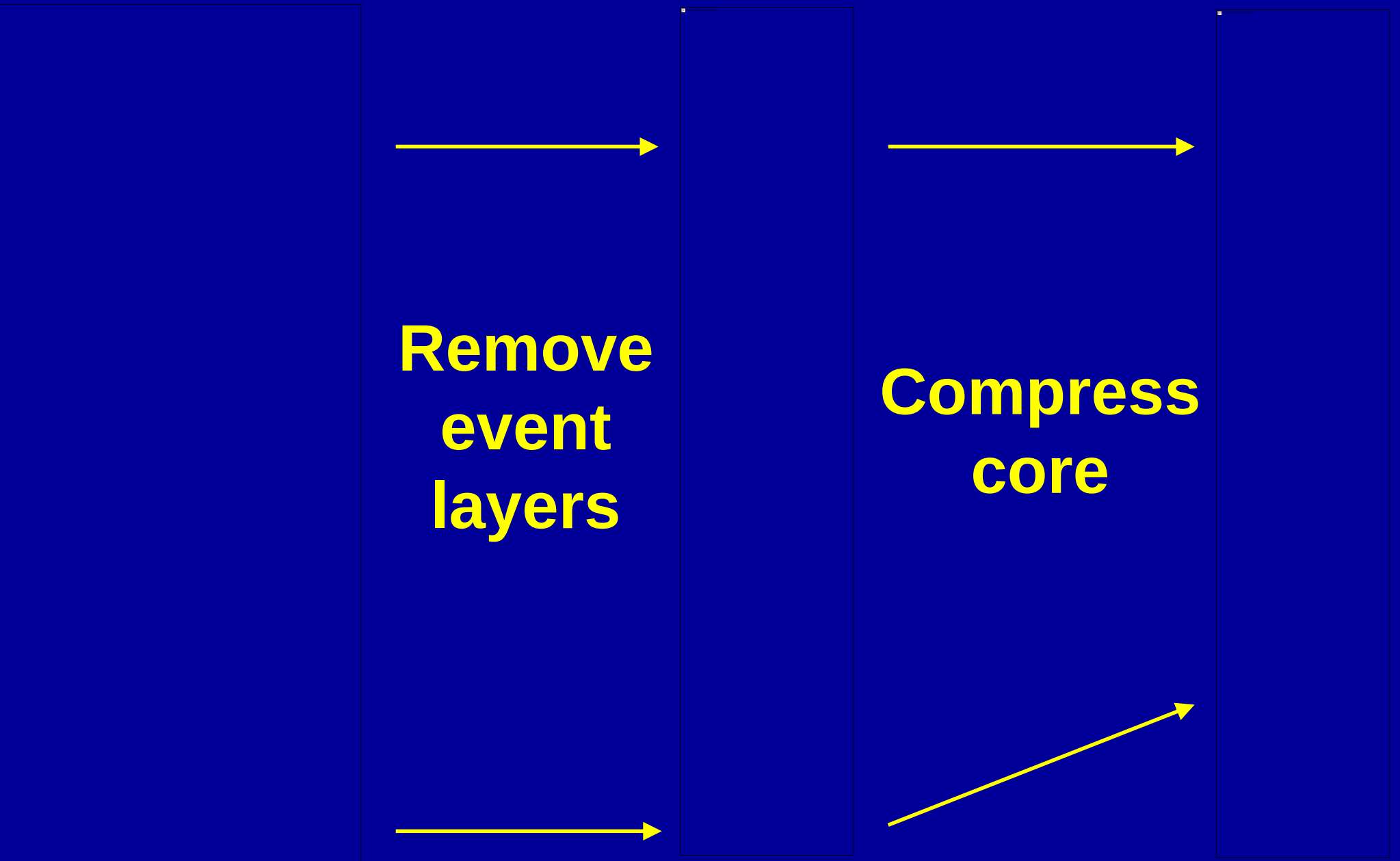
AMS ^{14}C Analysis

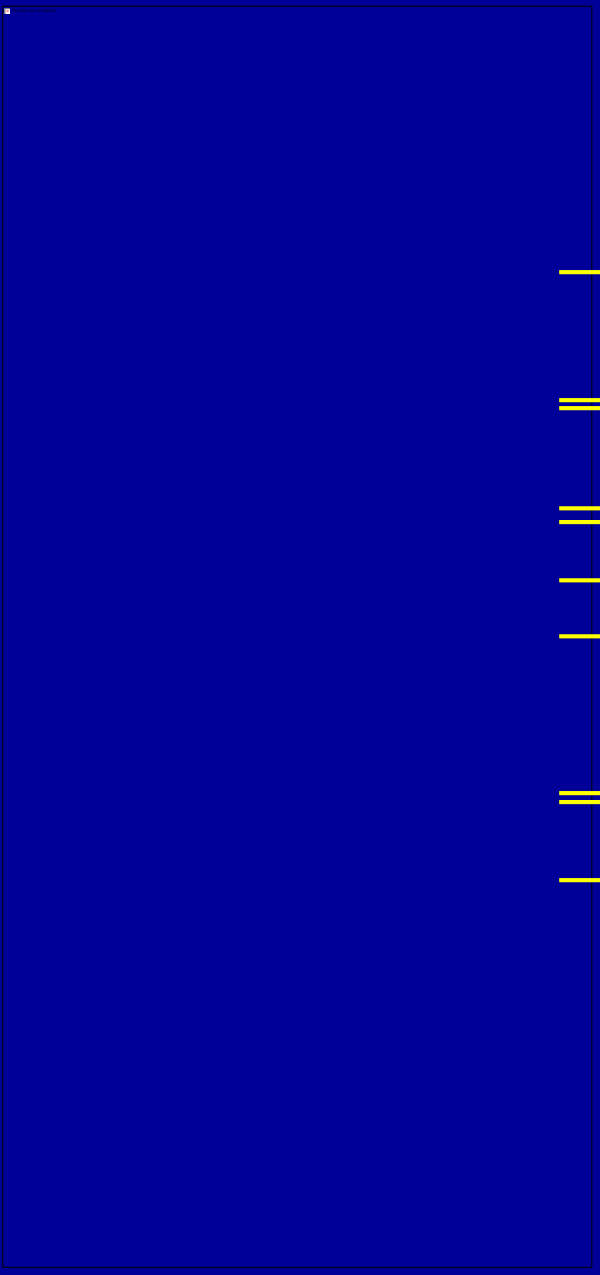
- 80 dates
- John Southon,
  Lawrence Livermore National Laboratory


^{14}C Years BP
Calendar Years BP

Depth (cm)




Remove event layers
Compress core



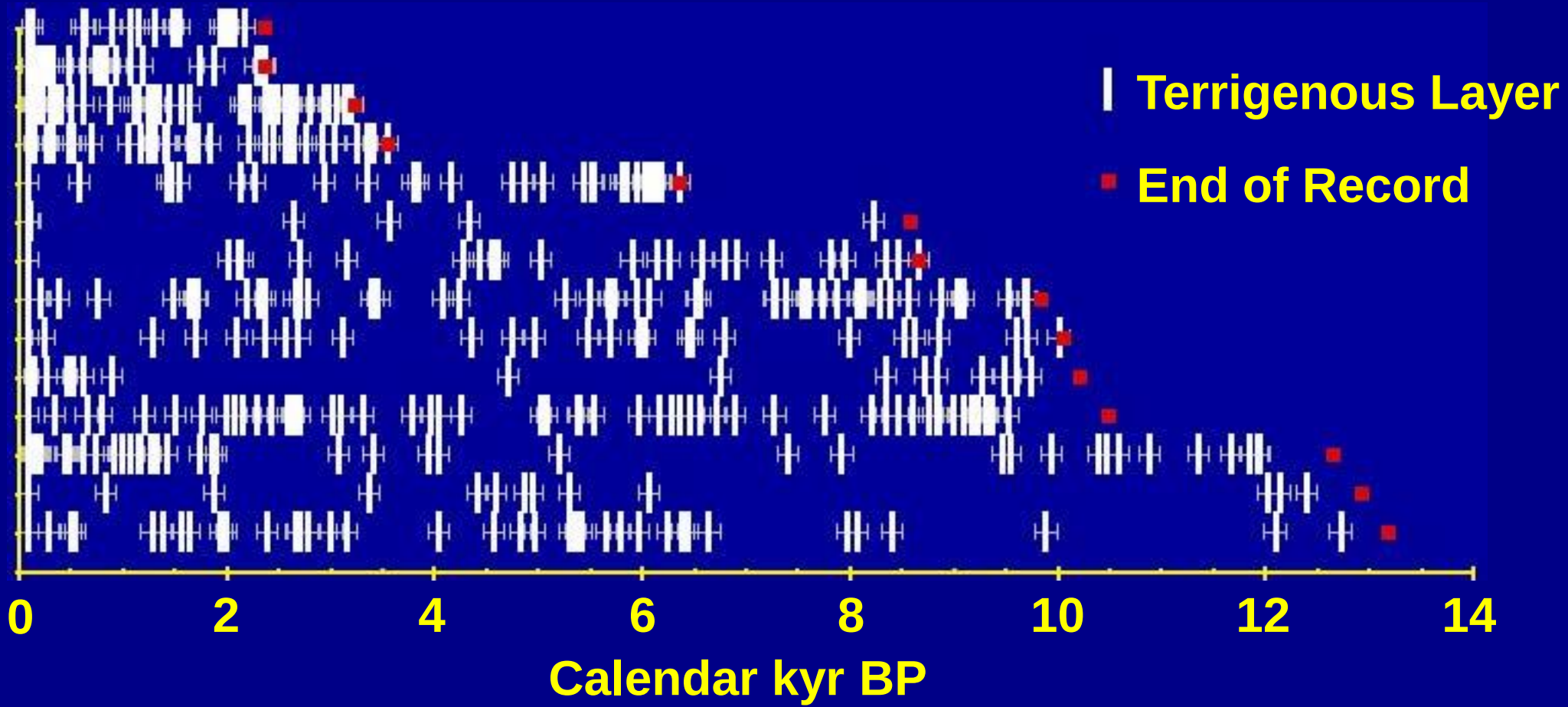
Events	Dates	Model Ages
	1400	1400
		2100, 2150
	3000	3000, 3120
		3400, 3790
		4800, 4950
	5200	5200

Discussion

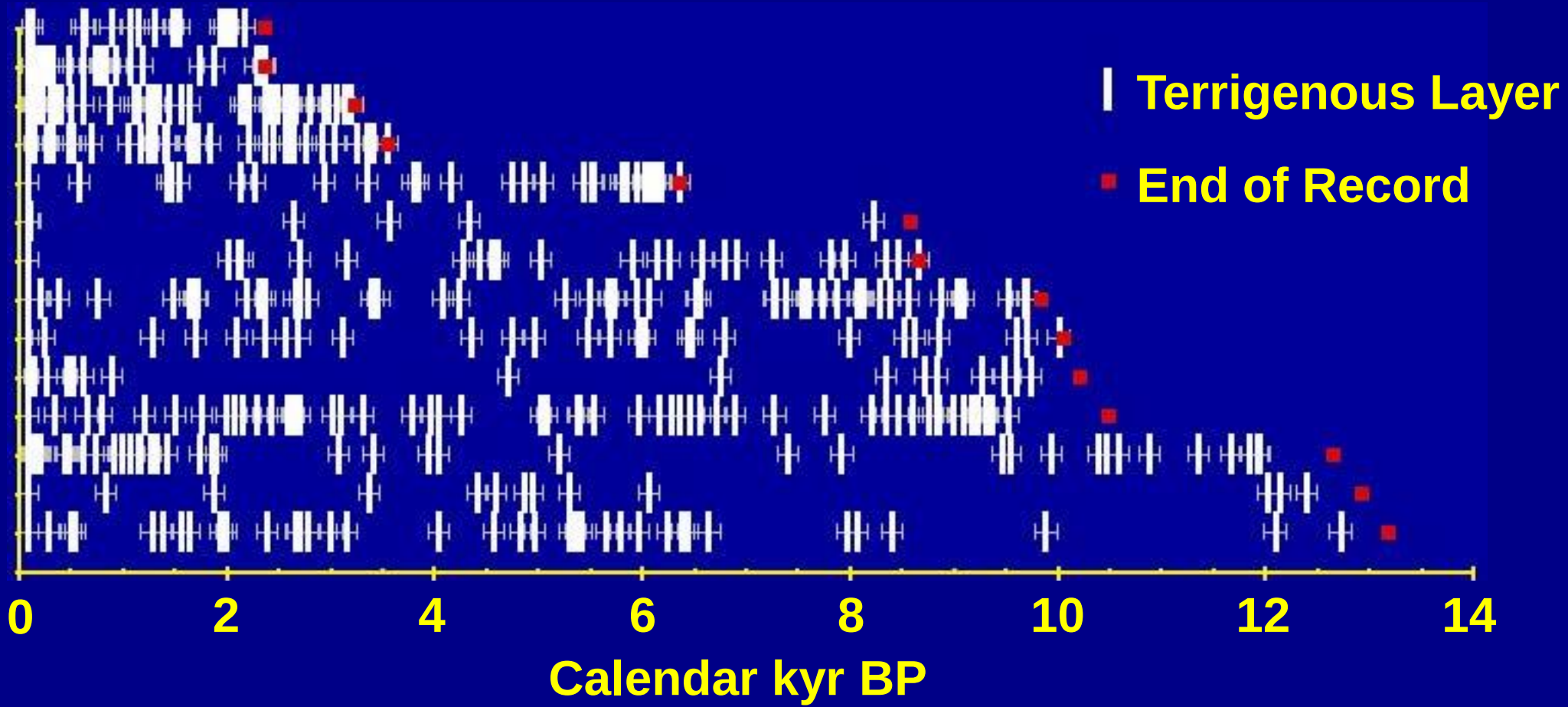
- Storm size
- Storm magnitude
- Storm frequency

—> Climate:
New England and
North Atlantic

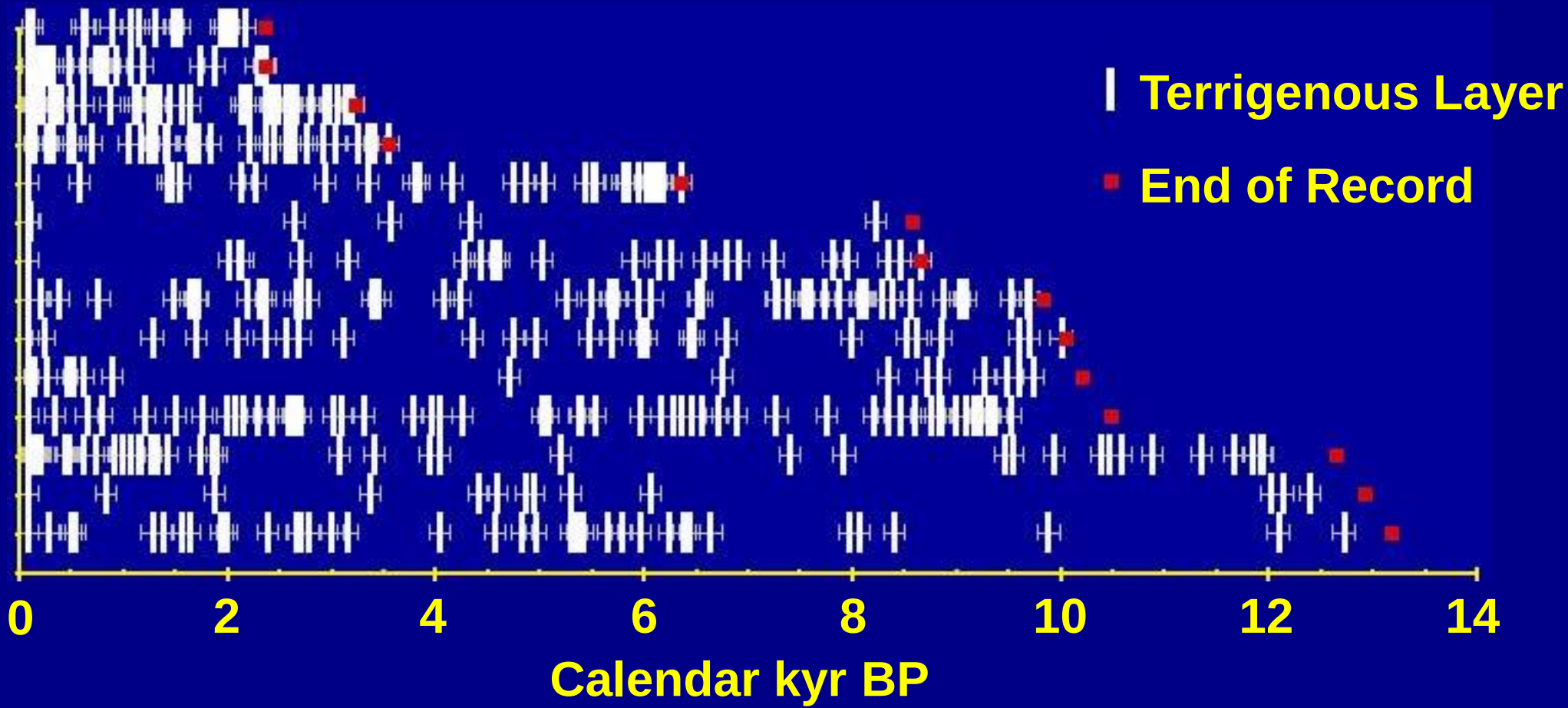
Storm Size


Terrigenous Layer
End of Record
0
2
4
6
8
10
12
14
Calendar kyr BP

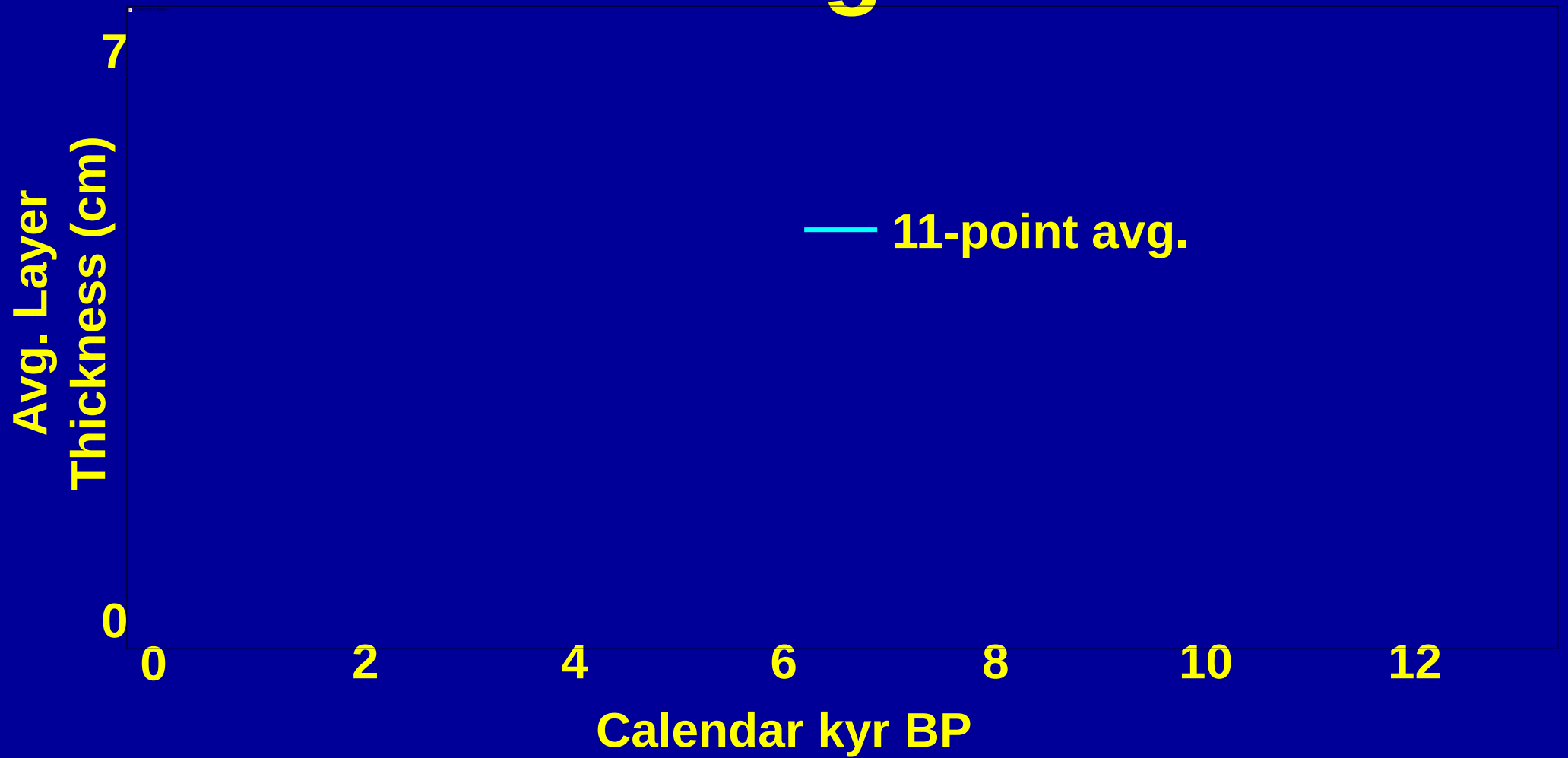
Storm Size



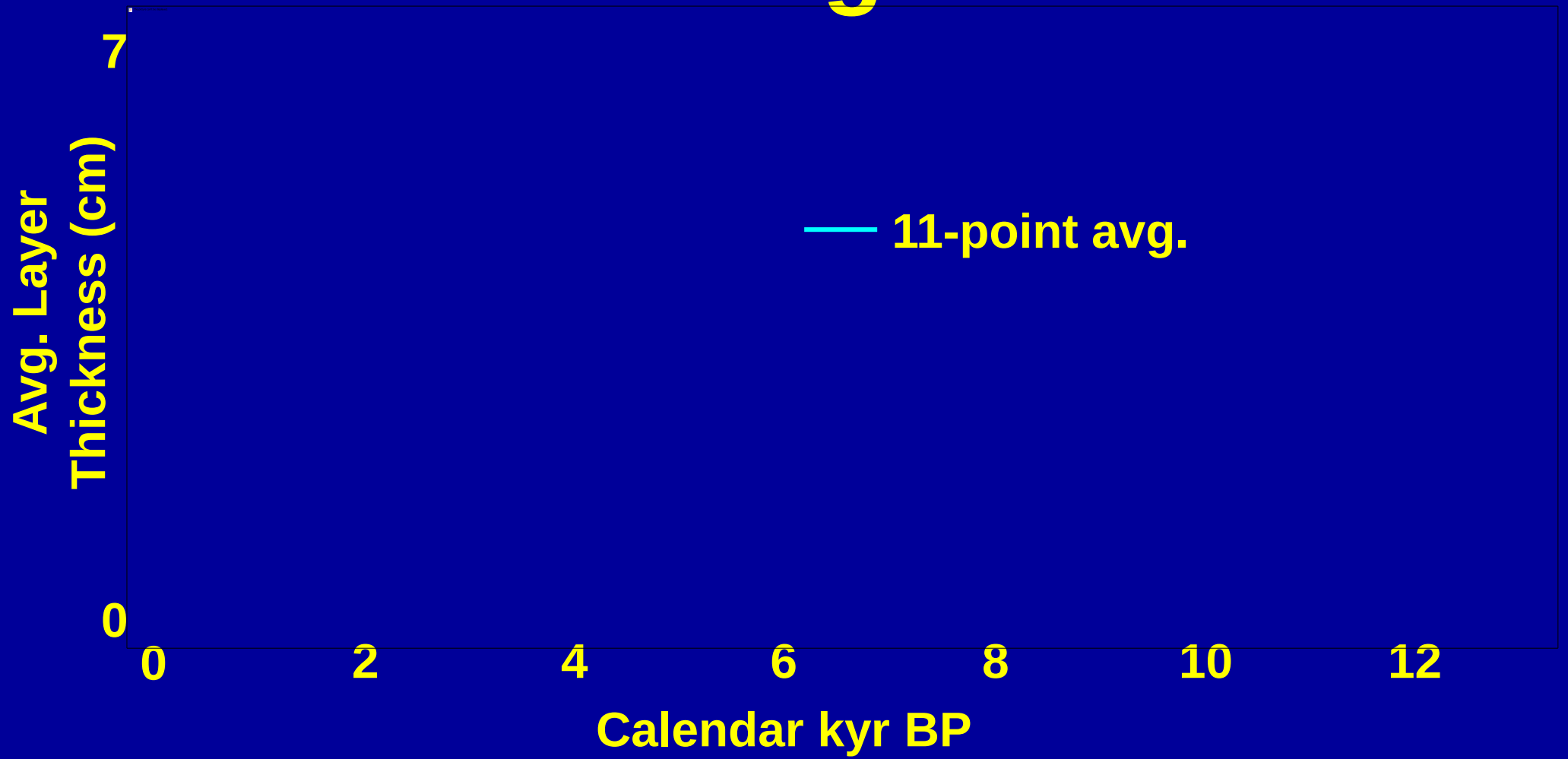
- Small storms locally as damaging as large


Terrigenous Layer
End of Record
0
2
4
6
8
10
12
14
Calendar kyr BP

Storm Magnitude

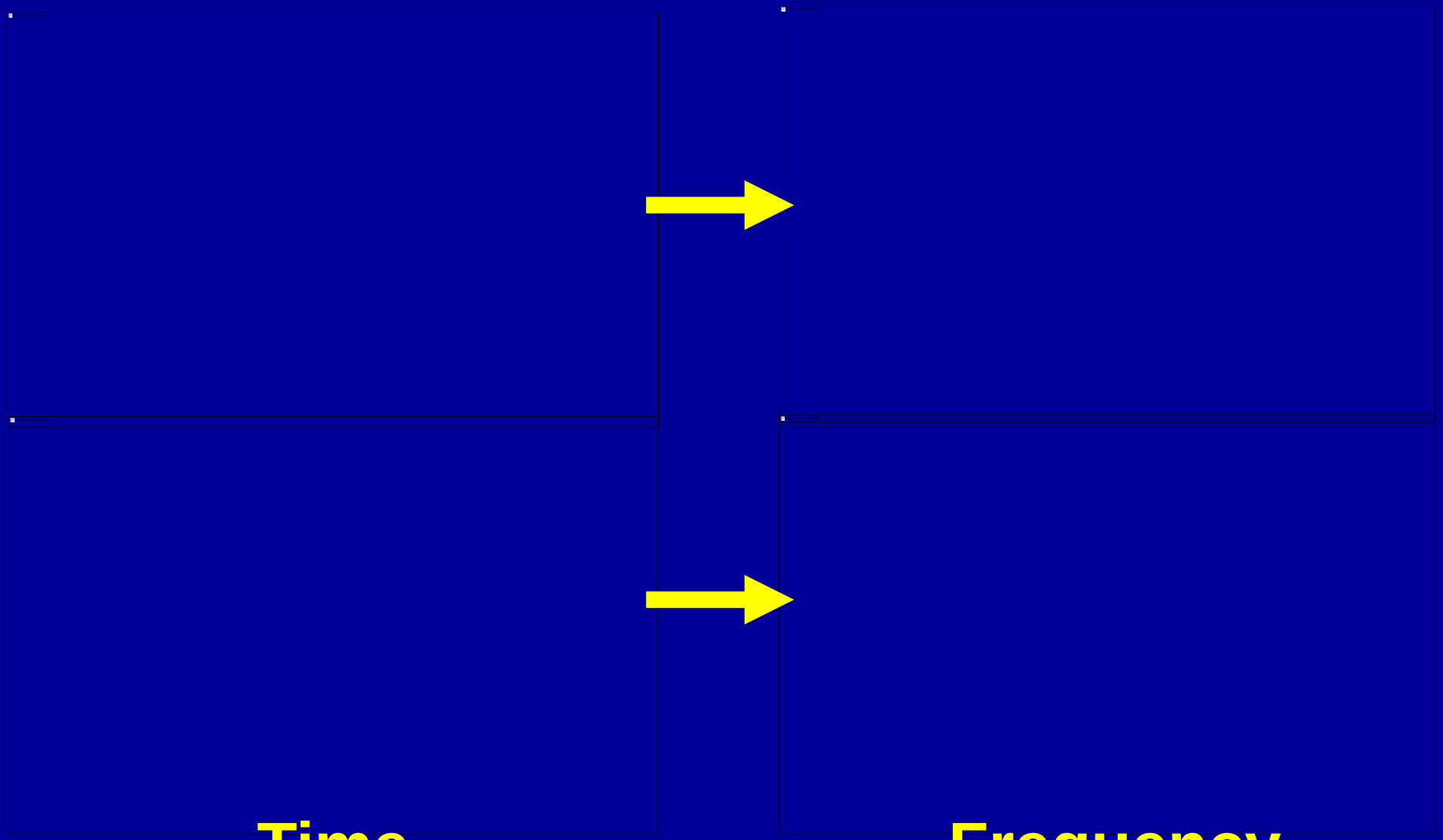


Storm Magnitude



- Magnitude highest in early and late Holocene

Spectral Analysis

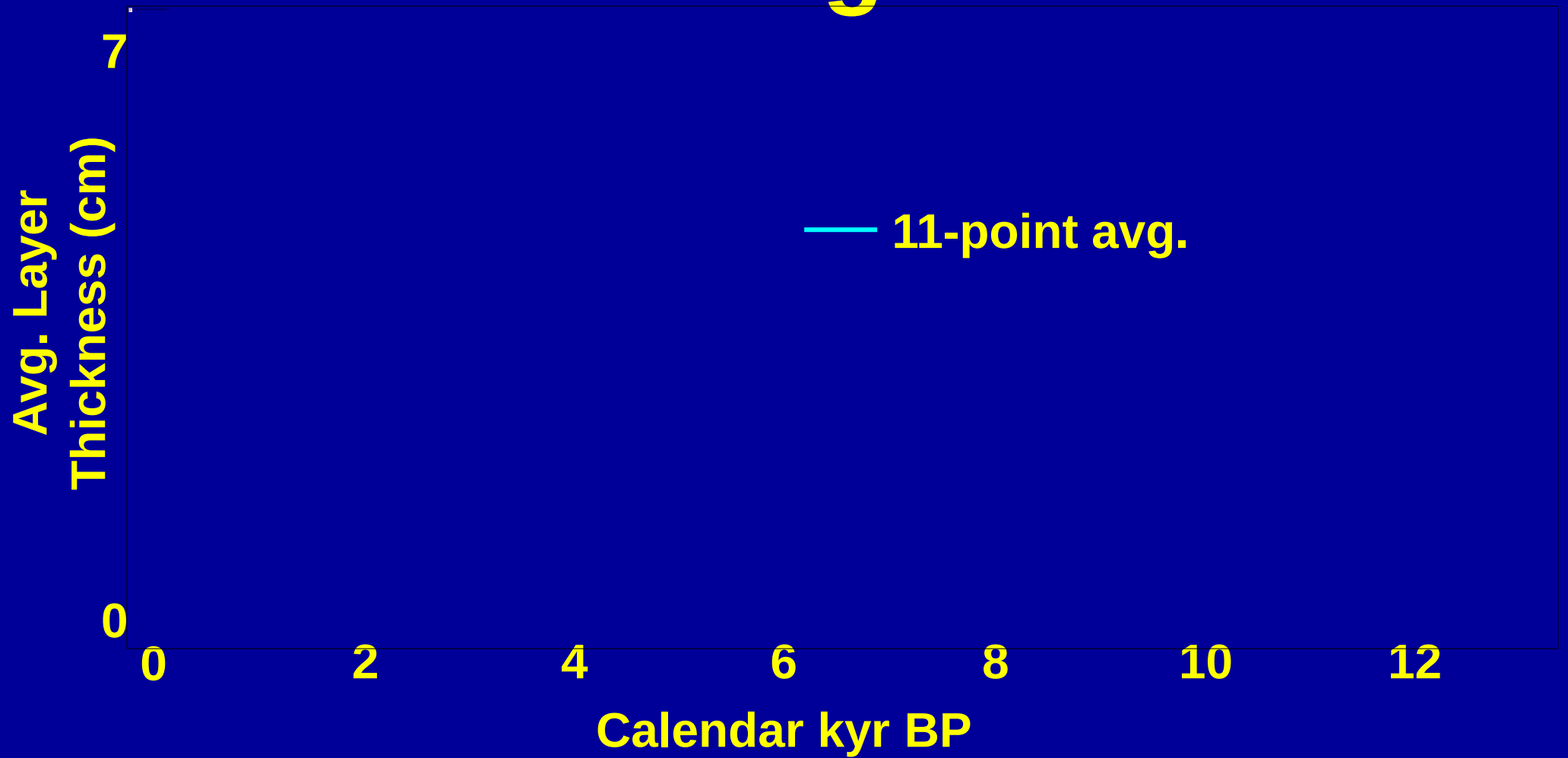


Another Spectrogram…

Time

Frequency

Storm Magnitude



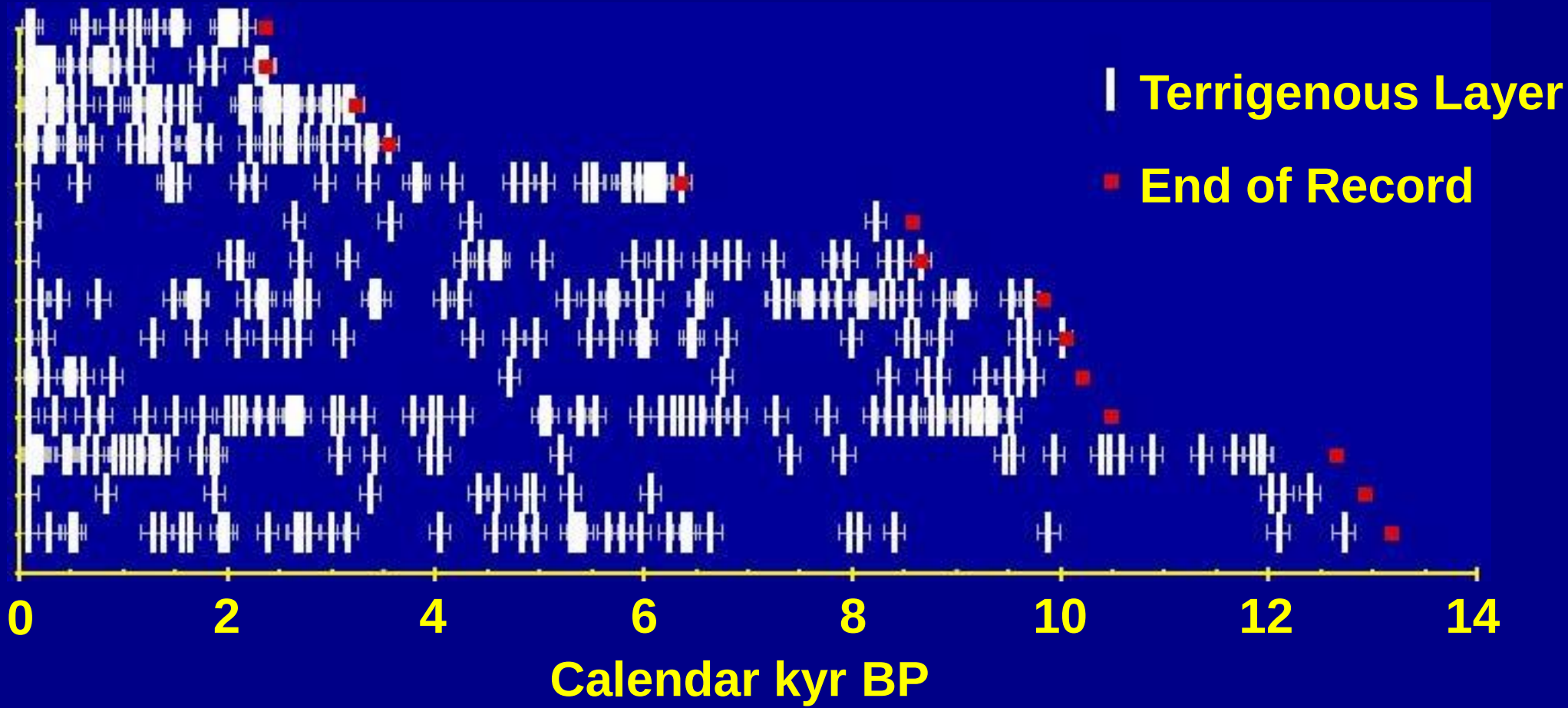
Storm Magnitude

Frequency (cycles/kyr)

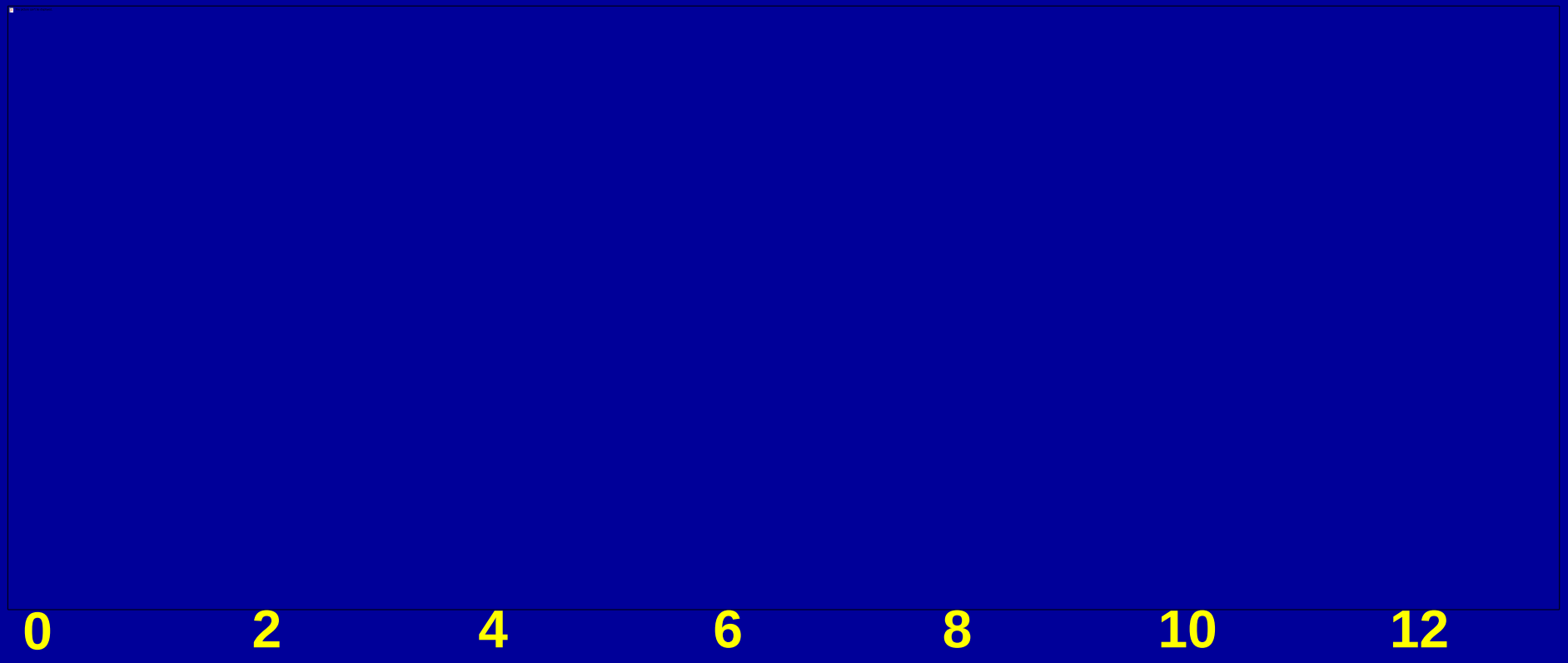
Storm Magnitude

Frequency (cycles/kyr)

- 500-year cycle: Ocean circulation? Solar?


Terrigenous Layer
End of Record
0
2
4
6
8
10
12
14
Calendar kyr BP

Storm Frequency

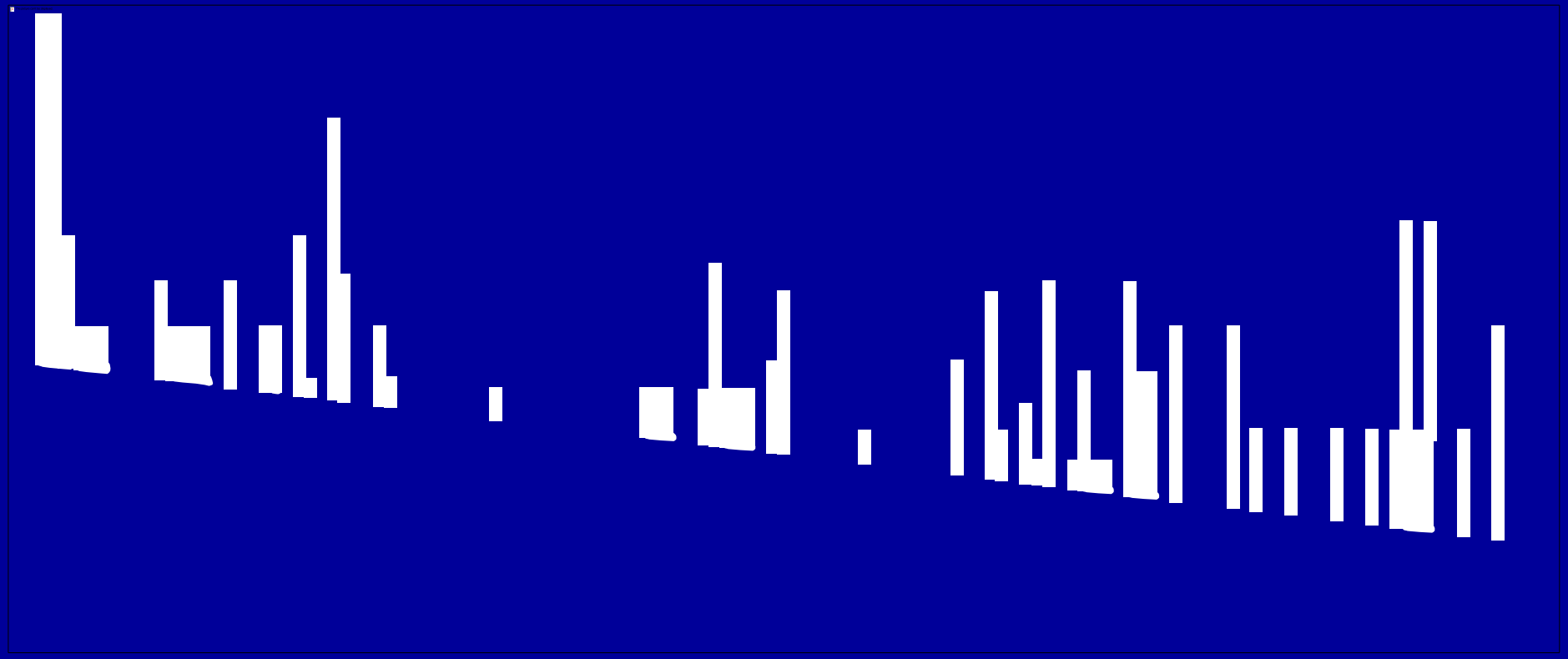


Storm Frequency

Frequency (cycles/kyr)

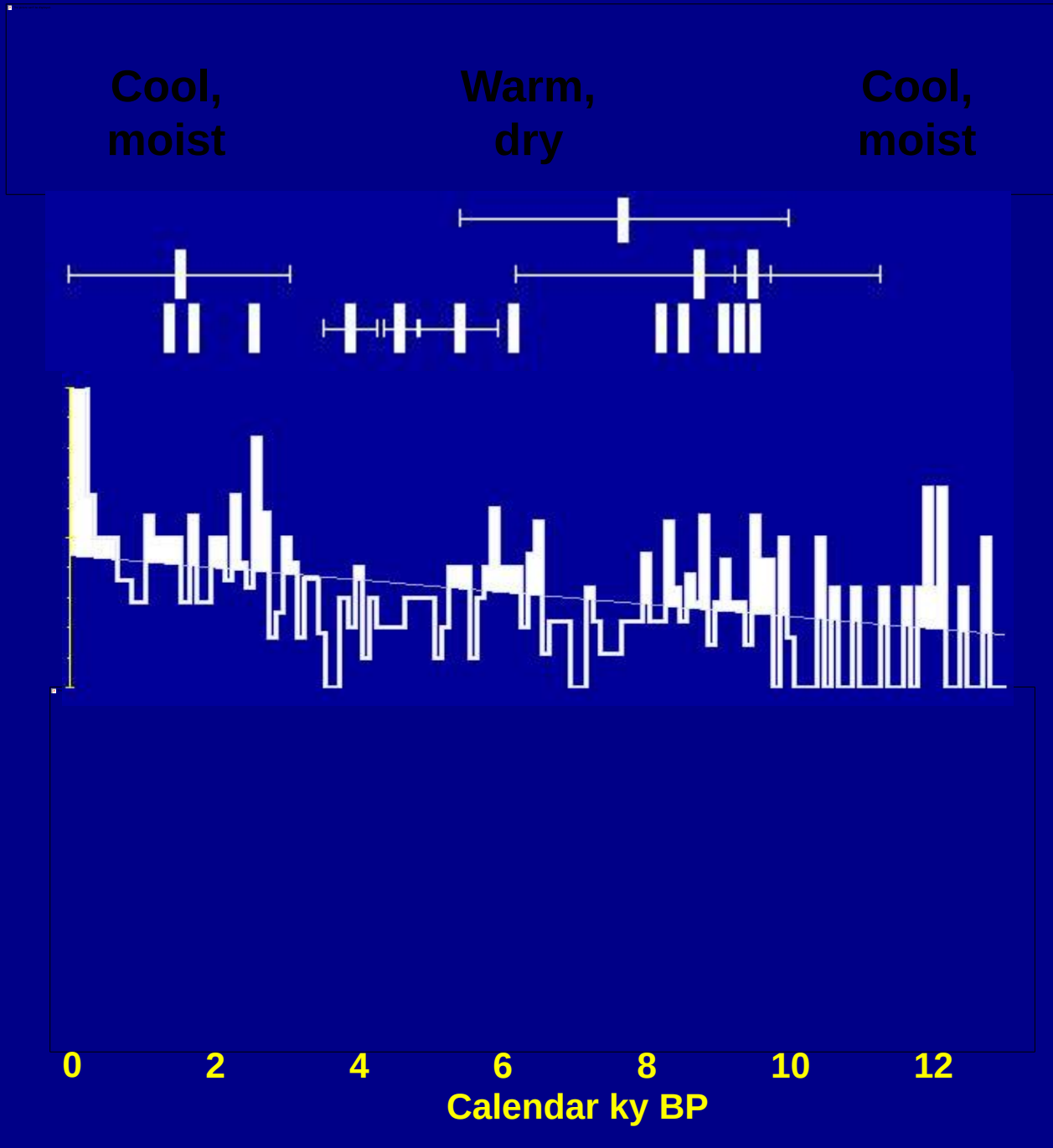
- 3000-year cycle

Storm Frequency

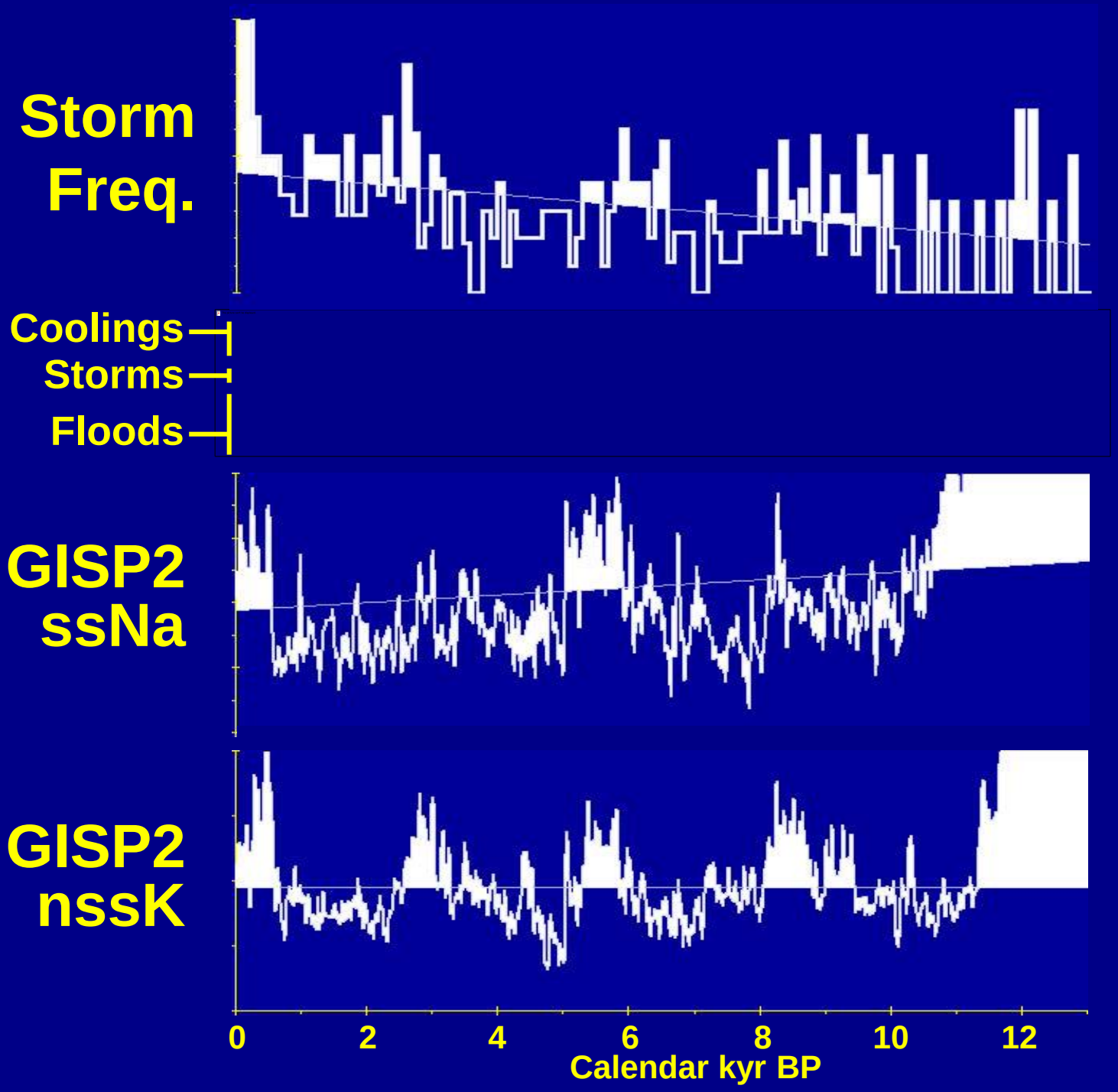


- 4 maxima; currently increasing—observed?

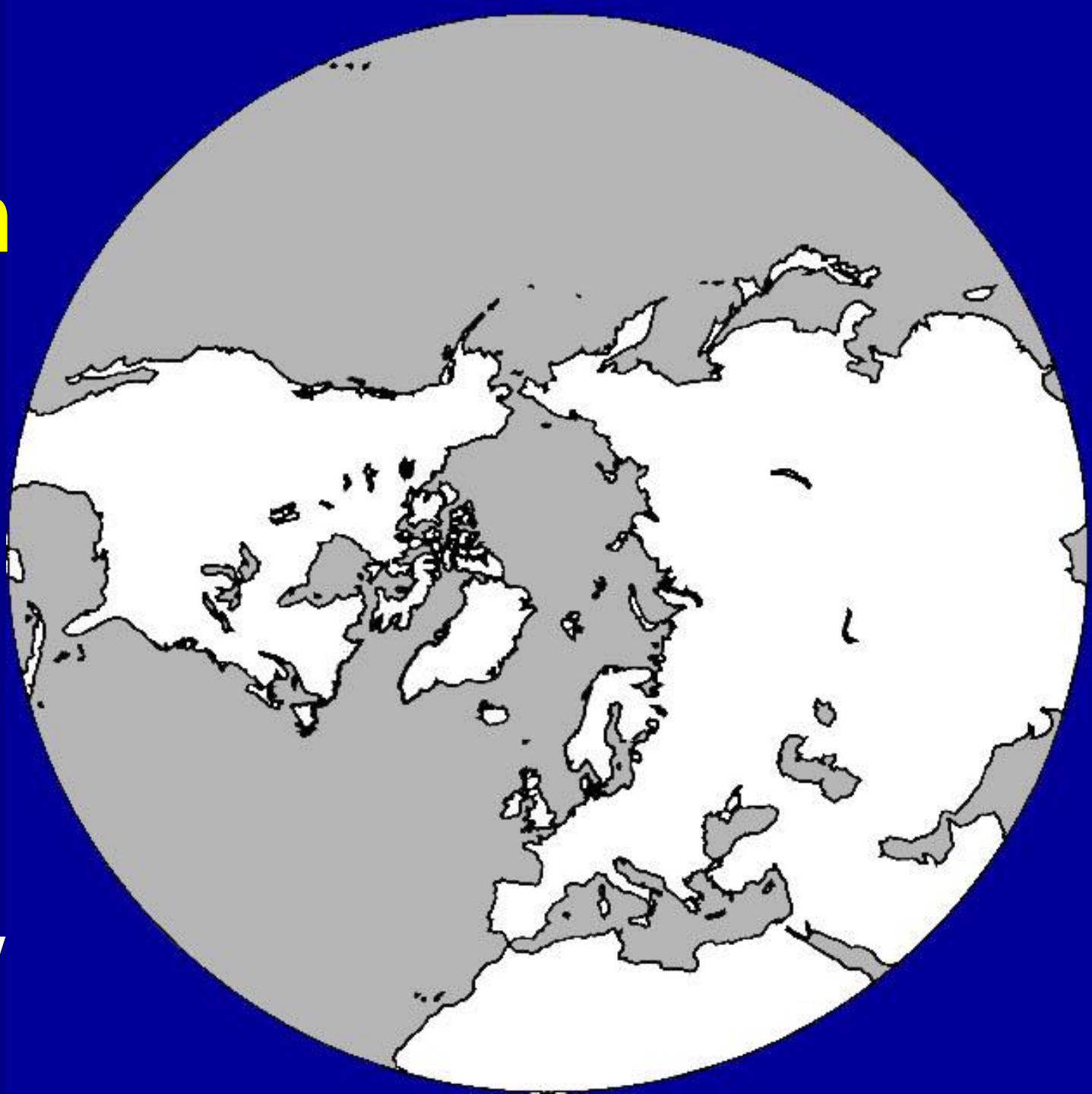
New England Climate



North Atlantic Climate



Arctic Oscillation



High phase

- zonal flow
- Europe warm

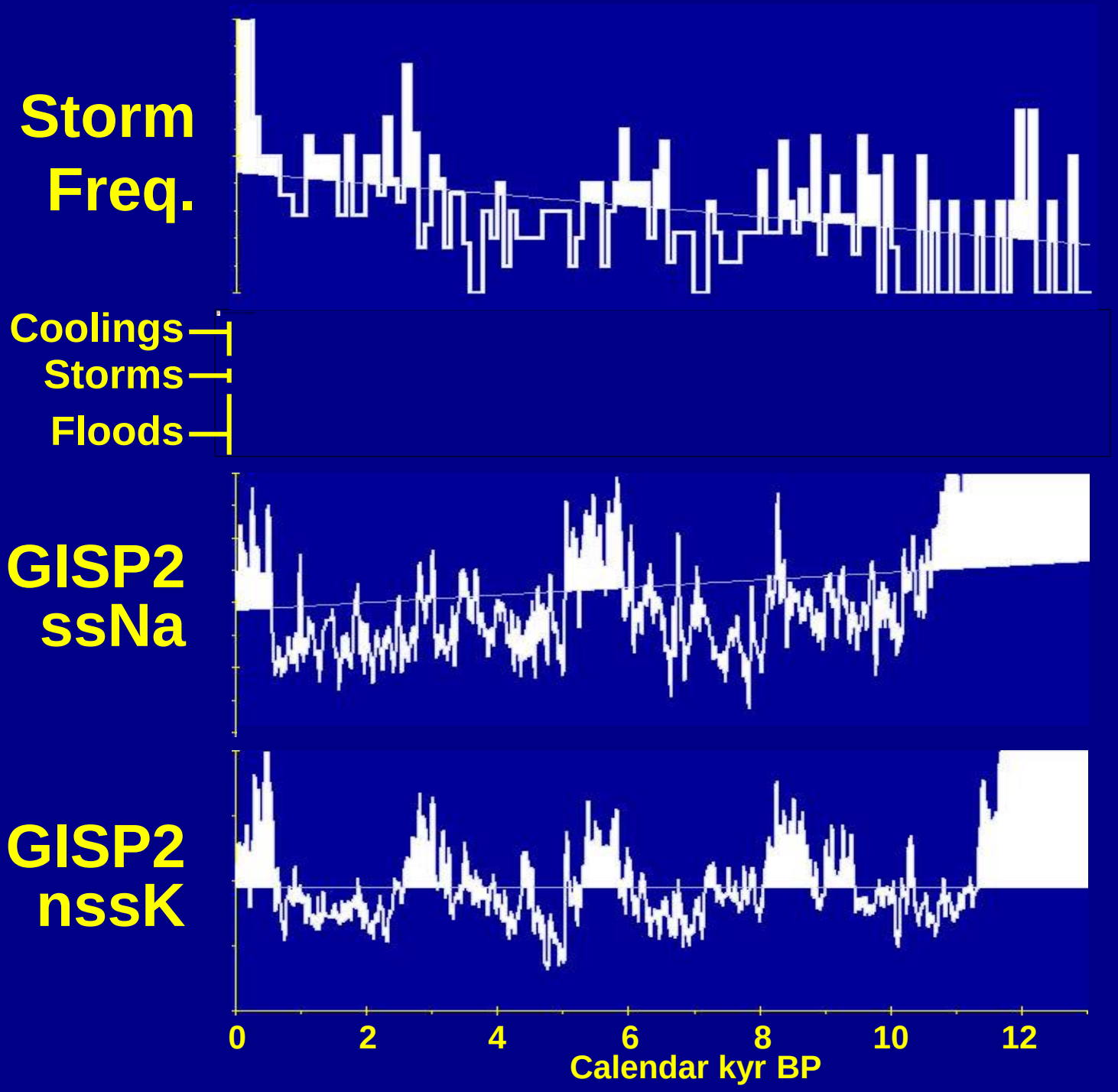
Low phase

- meridional flow
- Europe cold

Factors Pointing to AO Involvement

1. Storminess correlates with GISP2
   - GISP2 maxima imply meridional flow
   - Meridional flow :: low-phase AO
2. Storm maxima occur when Europe is cold
   - Cold in Europe :: low-phase AO
3. Modern relationship established

North Atlantic Climate



Implications of AO involvement

Dominant atmospheric modes

- AO, ENSO

Long-timescale climate forcing

- Ocean thermohaline circulation
- Solar variability

Conclusions

1. Storm Size

- Small storms locally as damaging as hurricanes/nor'easters

2. Storm Magnitude

- 500-year cycle: cause?
- Highest when climate is cool, moist

Conclusions

3. Storm Frequency

- 3000-year cycle
- 4 Holocene maxima
- Currently increasing—observed?
- Maxima correlate with fans, floods, storms, cool periods
- Relationships consistent with AO
- Probable solar forcing

Acknowledgements

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and the following people for their work and guidance.

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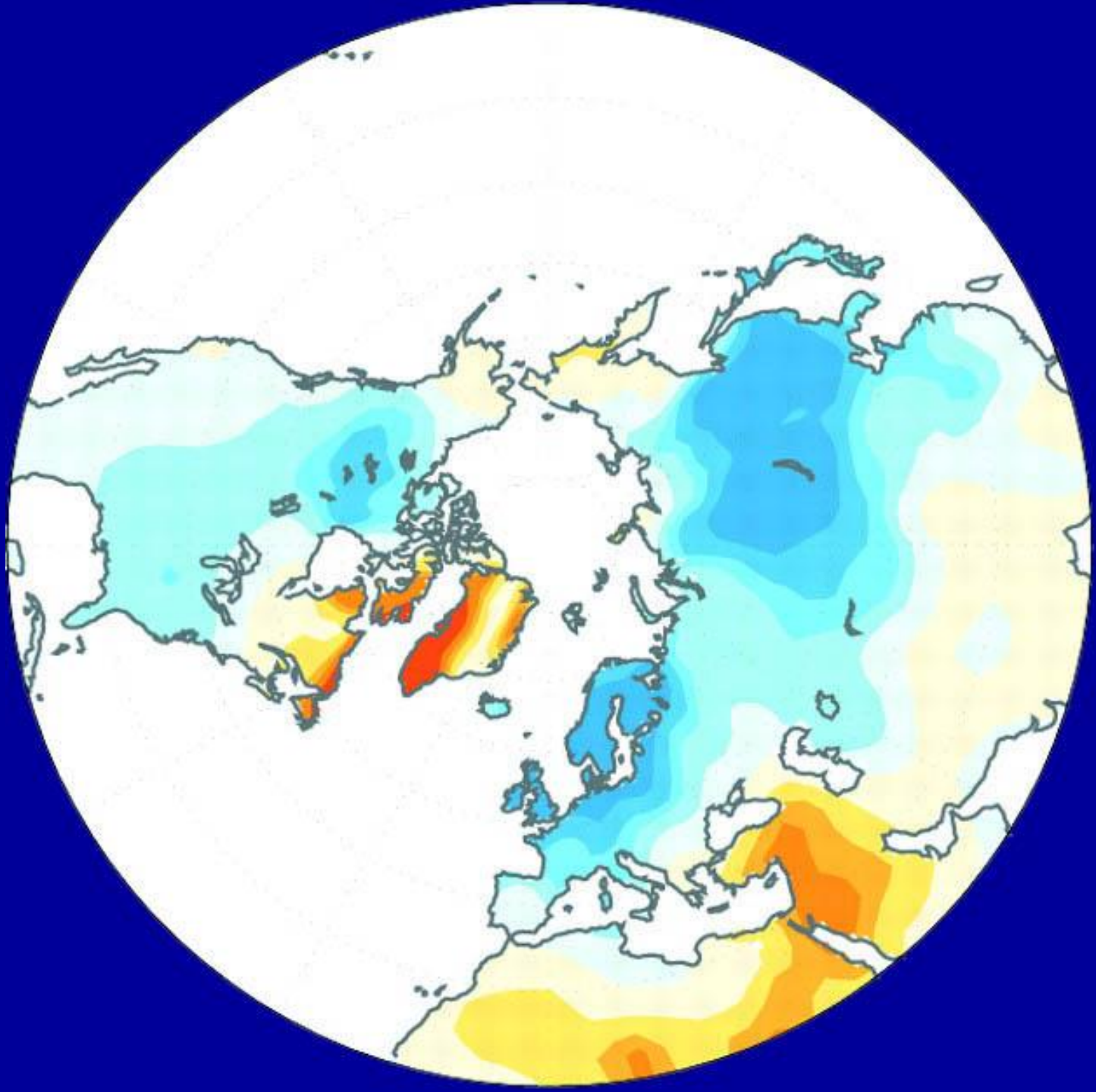
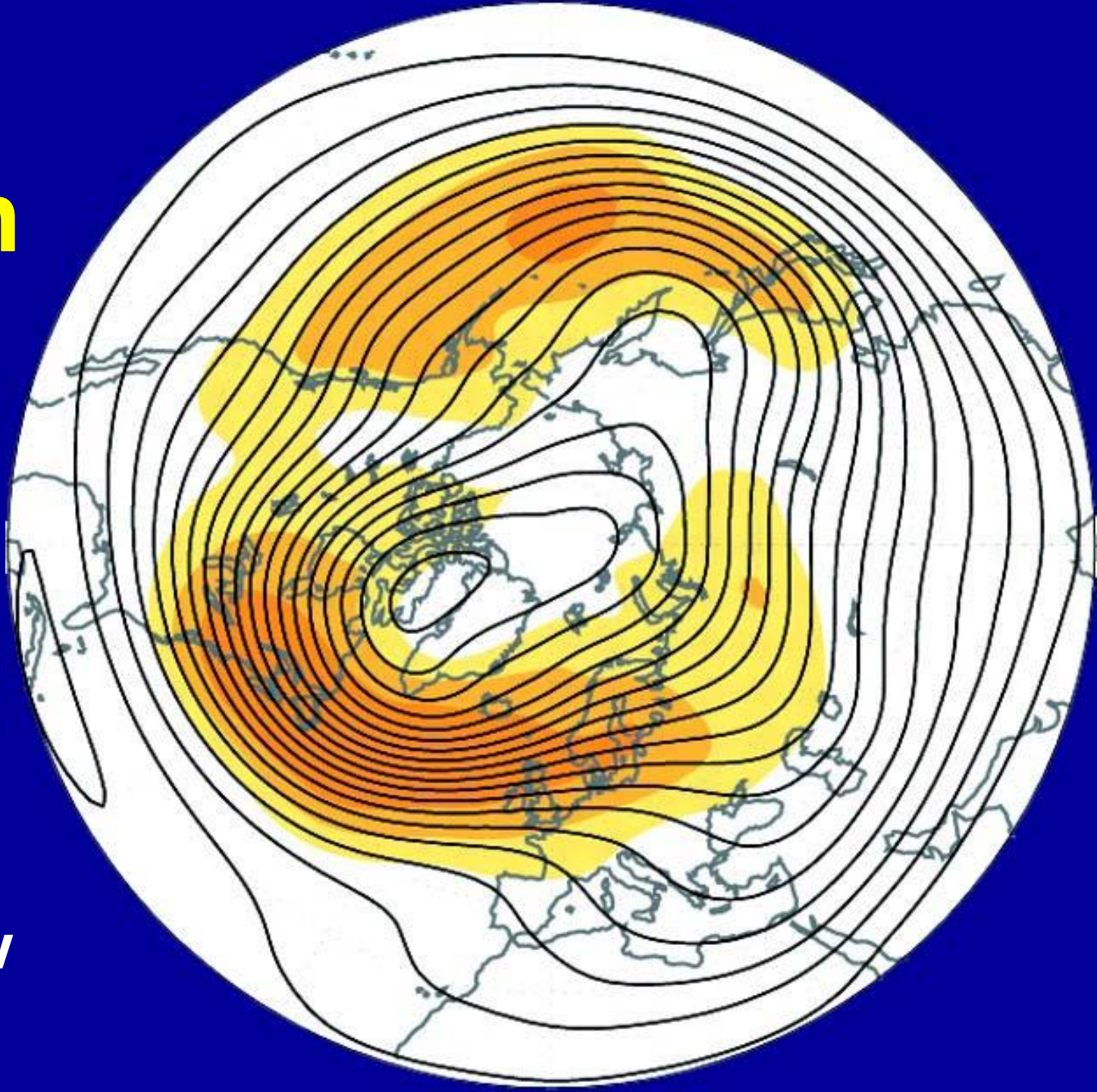
Laura Mallard
Christine Massey
Gagan Mirchandani
Kyle Nichols
Adam Parris
Simon Rupard
John Southon
Eric Steig
Stephen Turgeon
Carrie Williams
Stephen Wright
Geohydrology
Class 1999

Grain Size Analysis

Low-Phase AO Temp. Anomalies



Arctic Oscillation



High phase

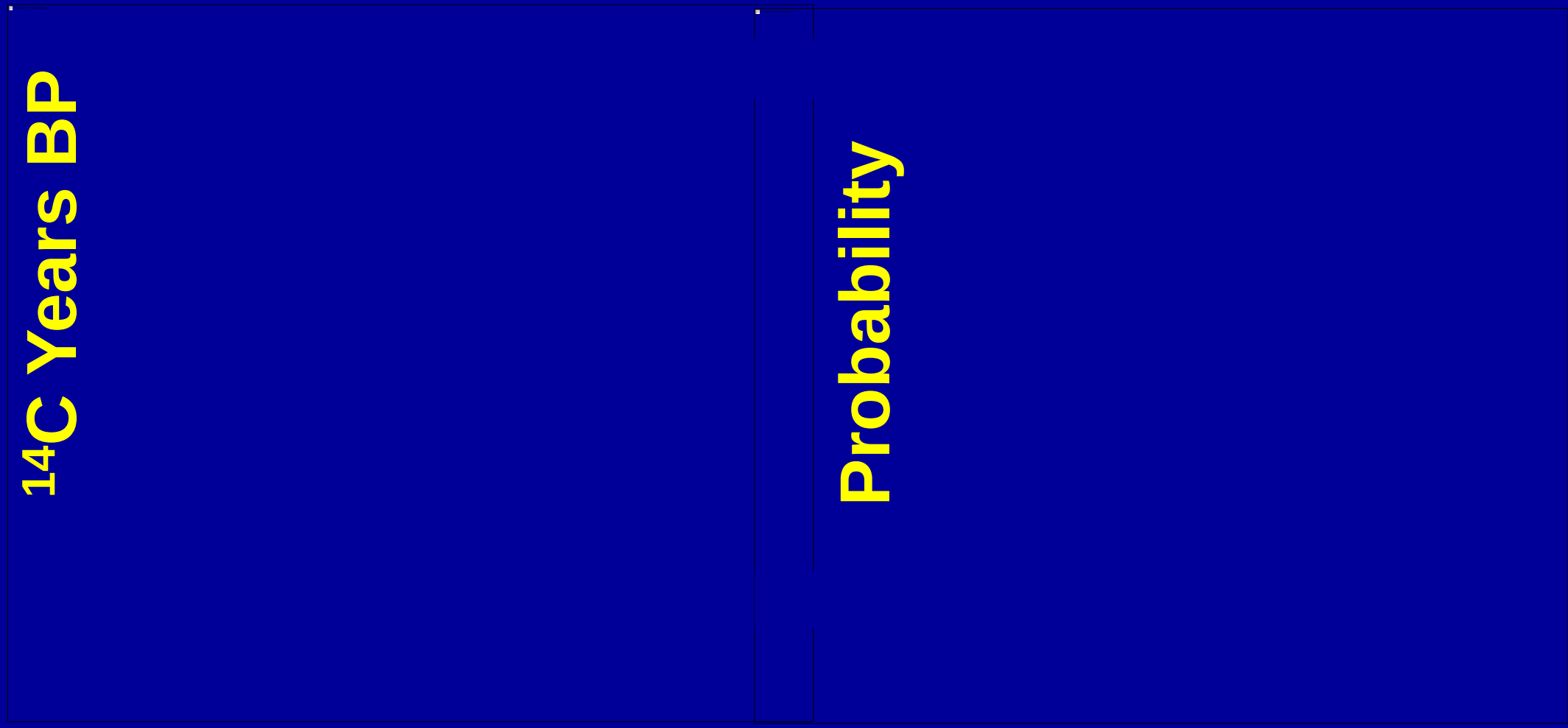
- zonal flow
- Europe warm

Low phase

- meridional flow
- Europe cold


Probability
Calendar Years BP

Calibration



Another Spectrogram…