



**We know that the Arctic is warming**

**So we ask:**

**What is the impact on**

**Lightning Occurrence**

**In the Arctic?**

Alaskan glacier calving

ARCUS seminar 3/10/22 by R. Holzworth

# Lightning in the Arctic

By Robert Holzworth, Univ of Washington

## To be covered:

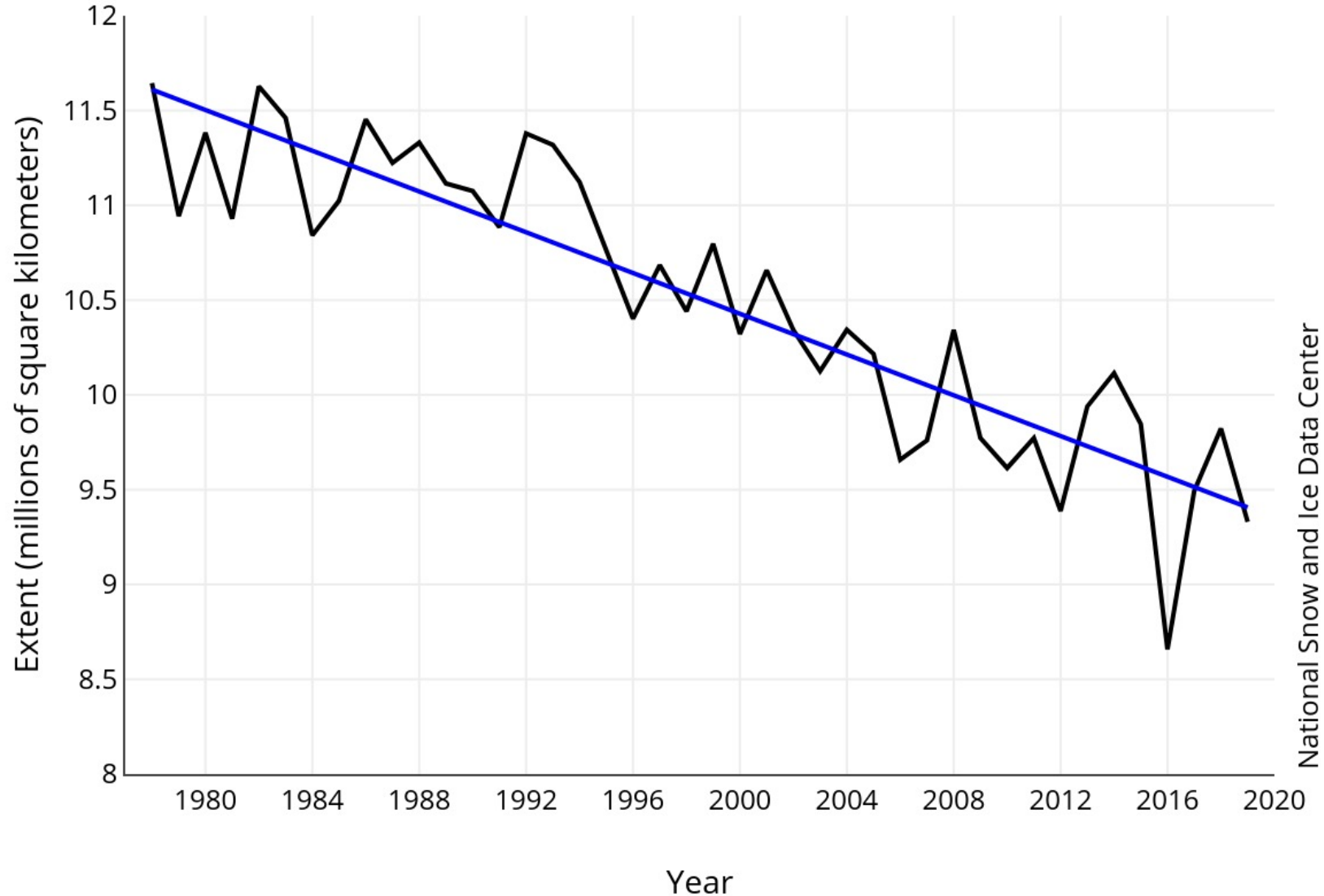
- Background on Arctic climate change and Global lightning detection
- What is the evidence for Arctic lightning increase?
- Direct comparison to Global temperature Anomaly
- Future prediction of Arctic lightning

Alaskan glacier calving

Many images in this talk are from

Global Lightning at High Latitudes, R. Holzworth, et al, GRL, 2021

Average Monthly Arctic Sea Ice Extent  
November 1978 - 2019



**The whole  
Arctic is  
warming up  
And Fast!**

# Permafrost melt

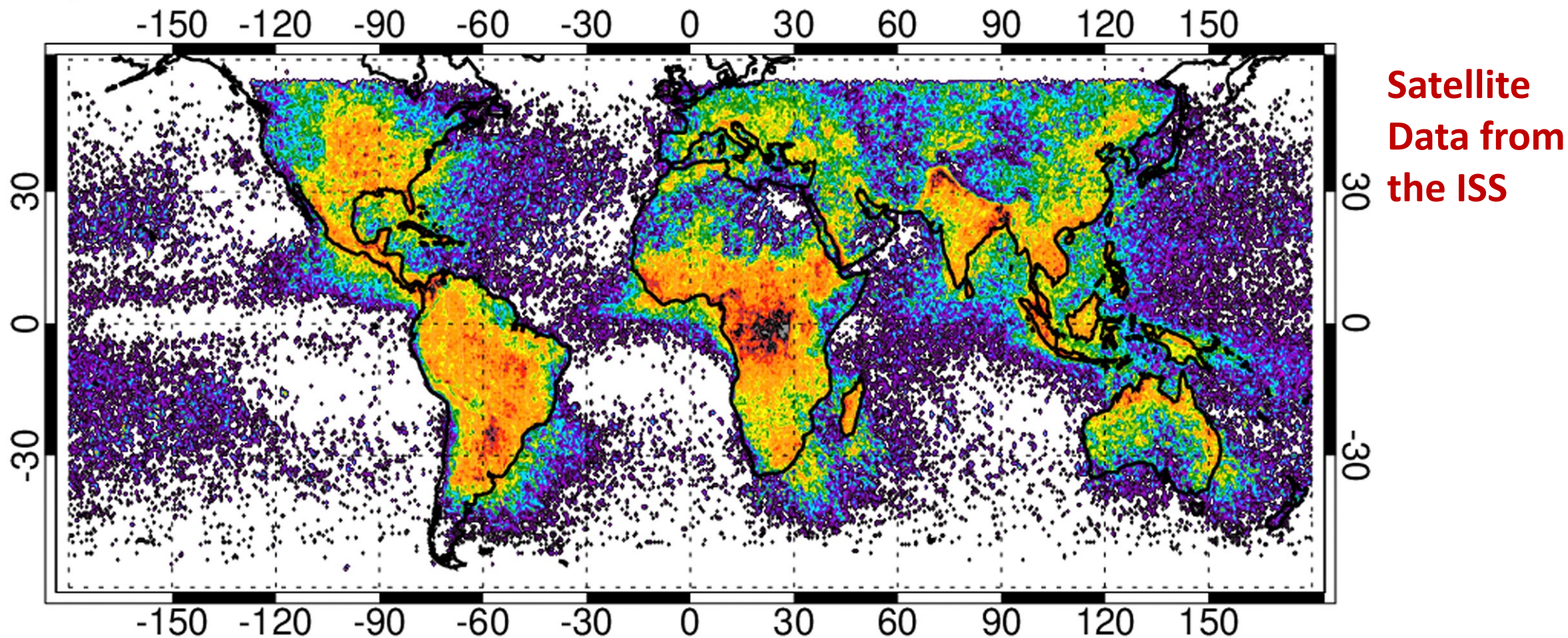


From: The Arctic Intitute, A. Bykova, 2020

# LIS 0.5° Annual Lightning Climatology

(a)

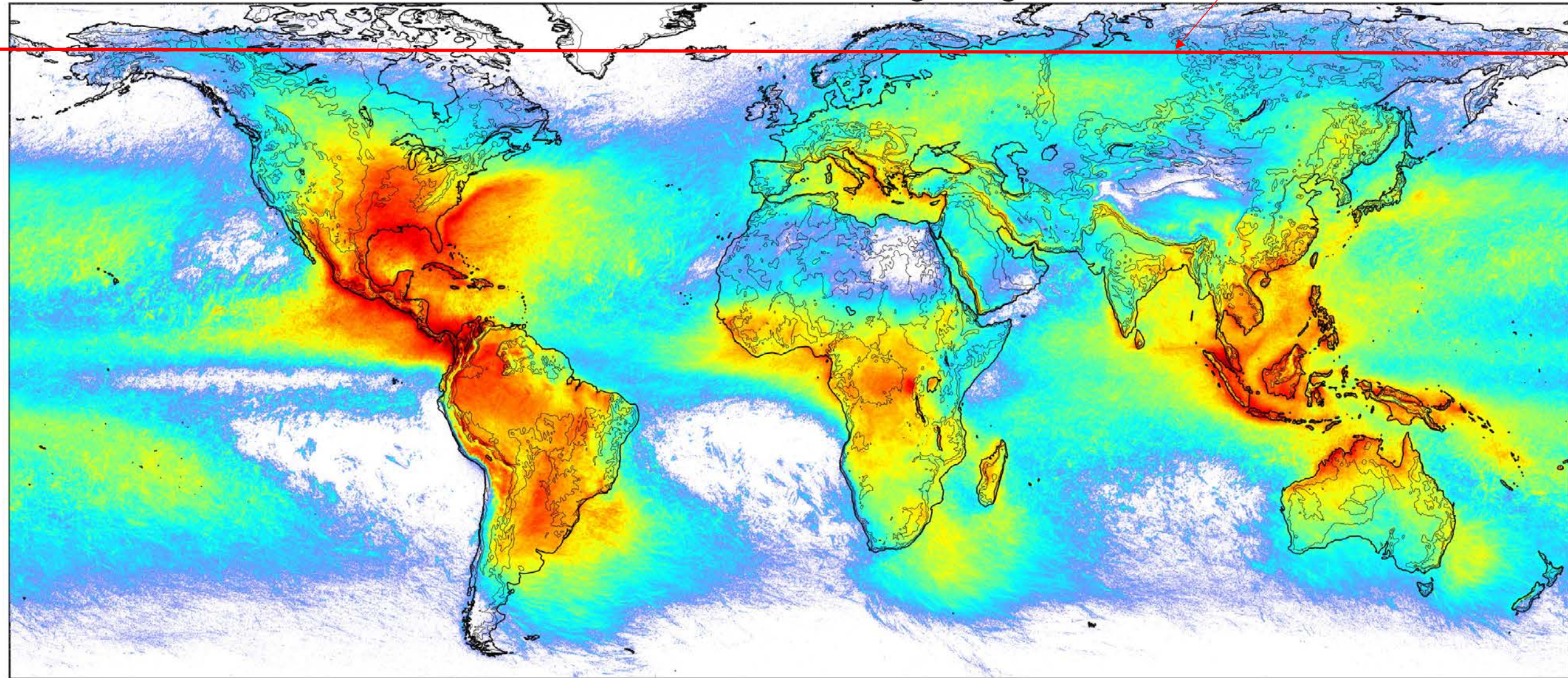
ISS LIS Mar 2017-Feb 2020



No satellite lightning instruments detect lightning above 70 degrees due to orbit limits

# Annual-mean WWLLN lightning

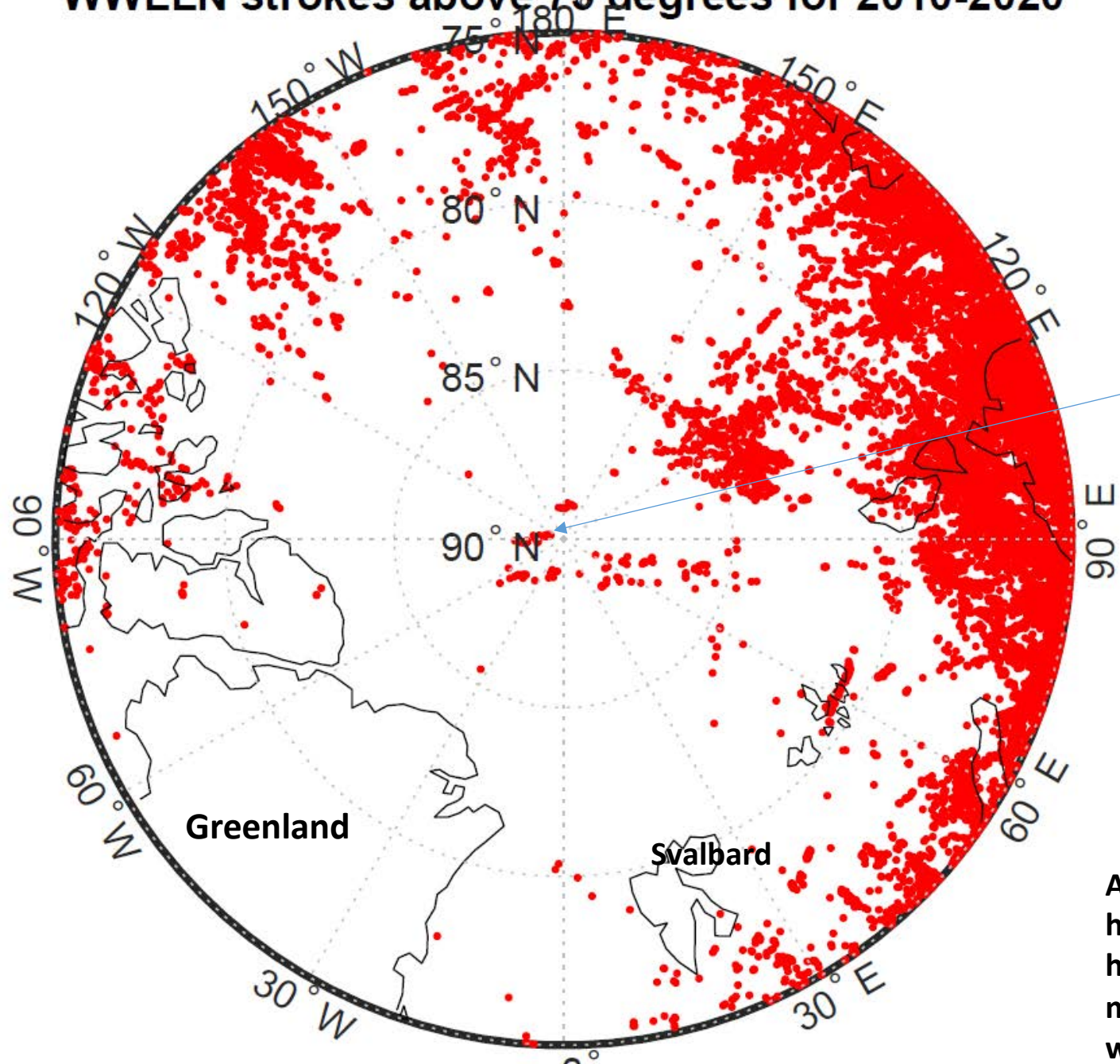
65N



[http://wwlln.net/climate/wwlln\\_annual.png](http://wwlln.net/climate/wwlln_annual.png)

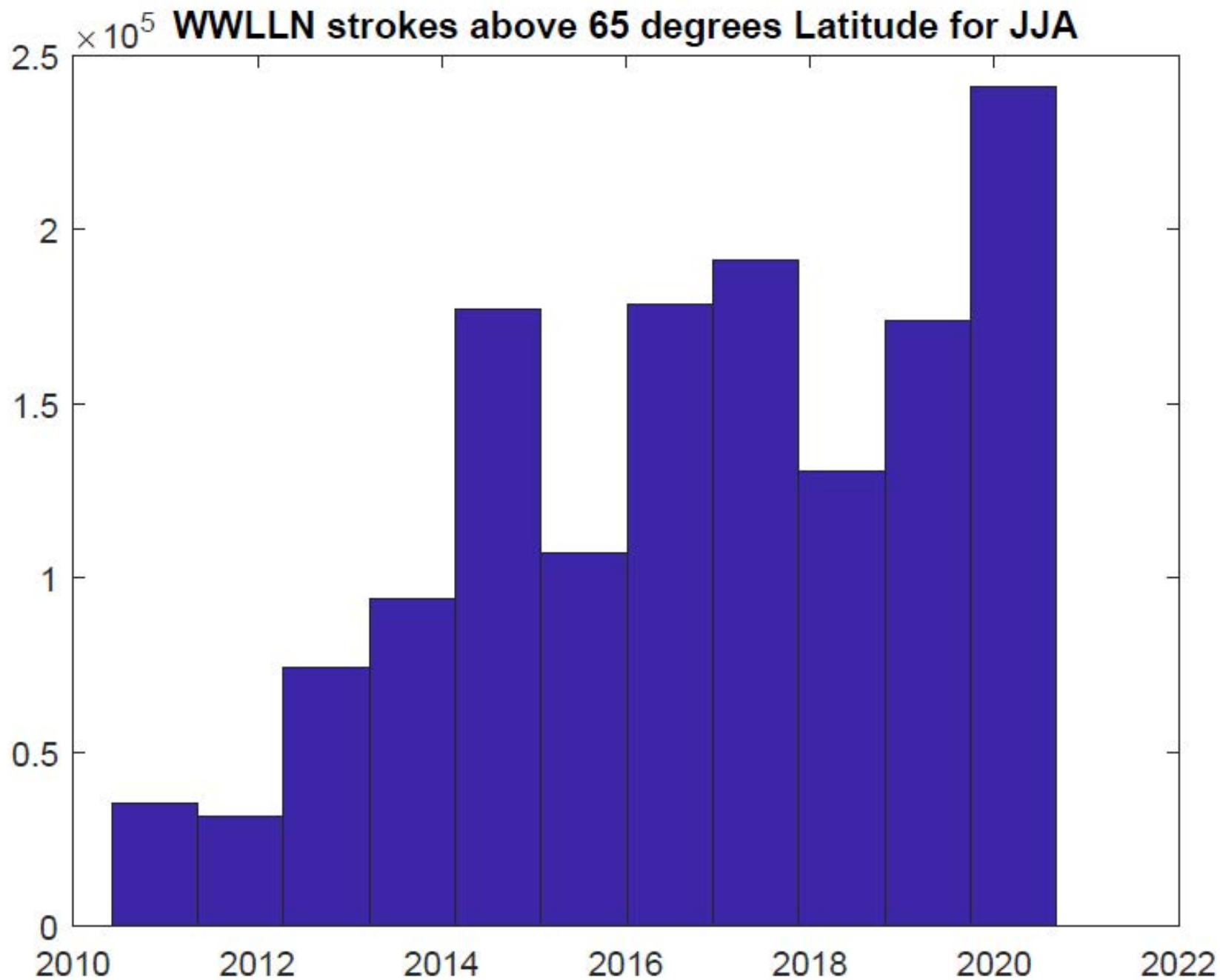
10 km x 10 km pixel resolution 2008-2019 ( $>2 \times 10^9$  strokes)

# WWLLN strokes above 75 degrees for 2010-2020



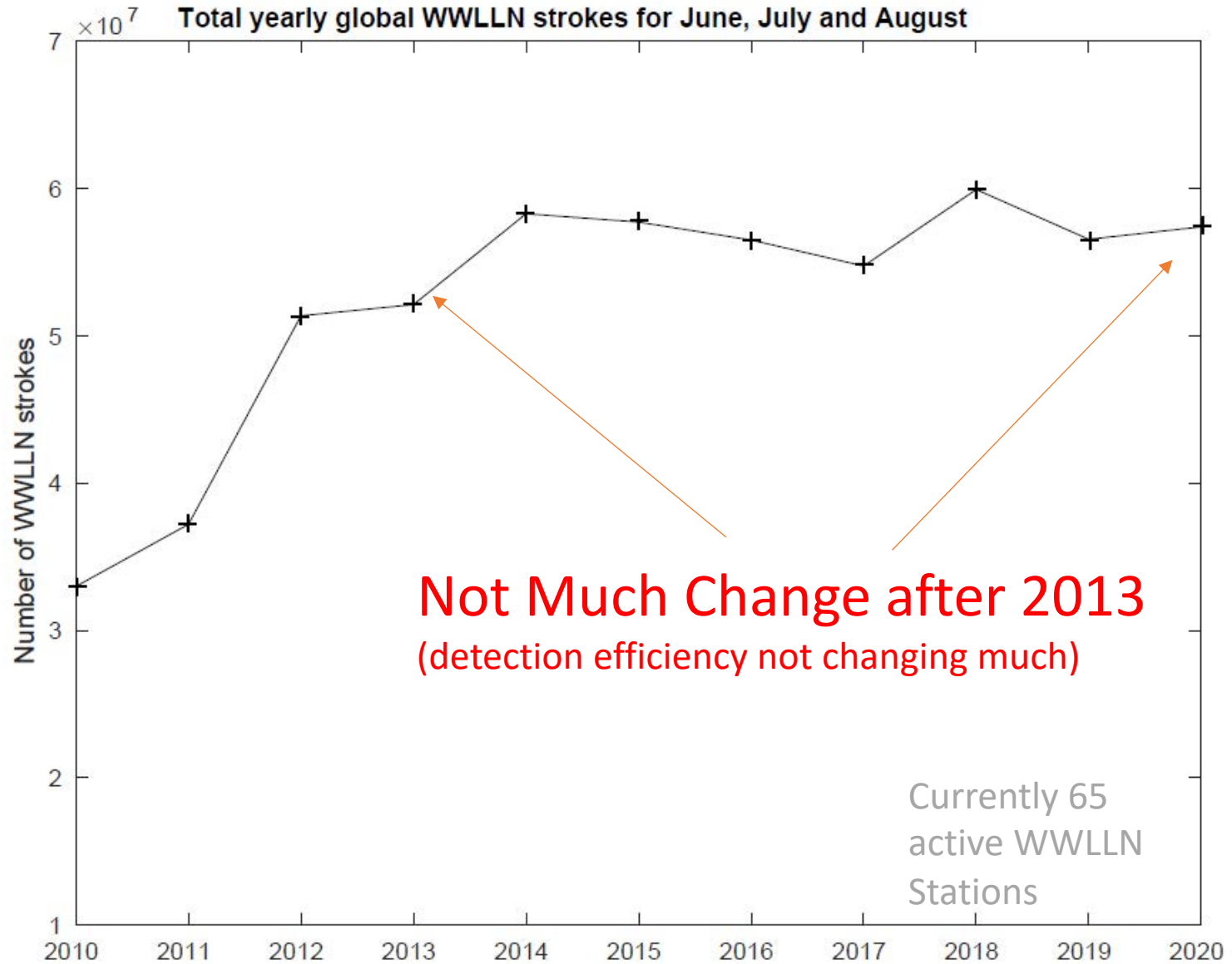
**28 strokes on  
August 13, 2019  
Within 100 km of  
North Pole**

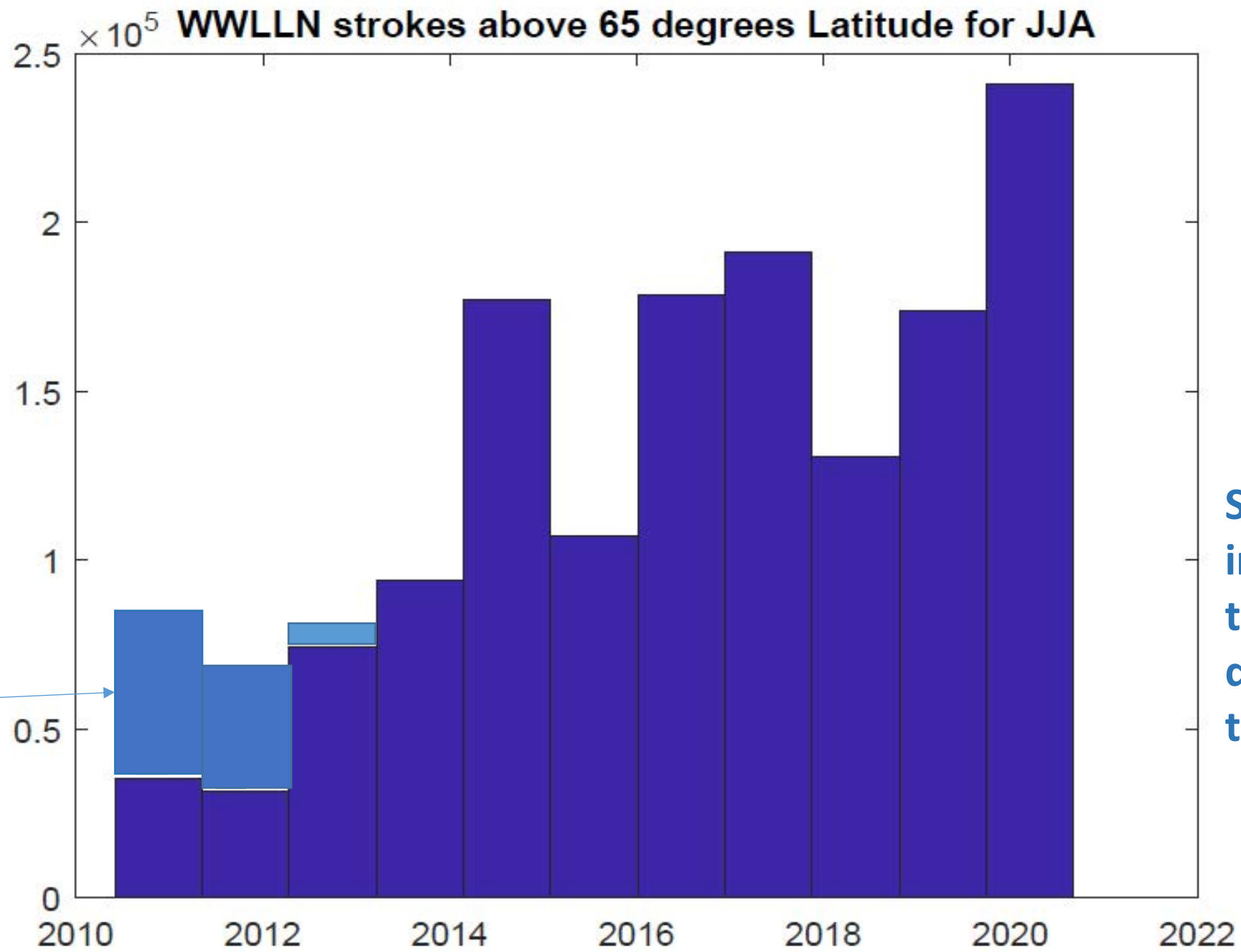
Also See report in  
<https://www.washingtonpost.com/weather/2019/08/12/lightning-struck-within-miles-north-pole-saturday-rapid-arctic-warming-continues/>



**Actual WWLLN  
strokes located  
above 65°  
Over 100,000  
strokes/year  
(JJA)  
(and growing)**



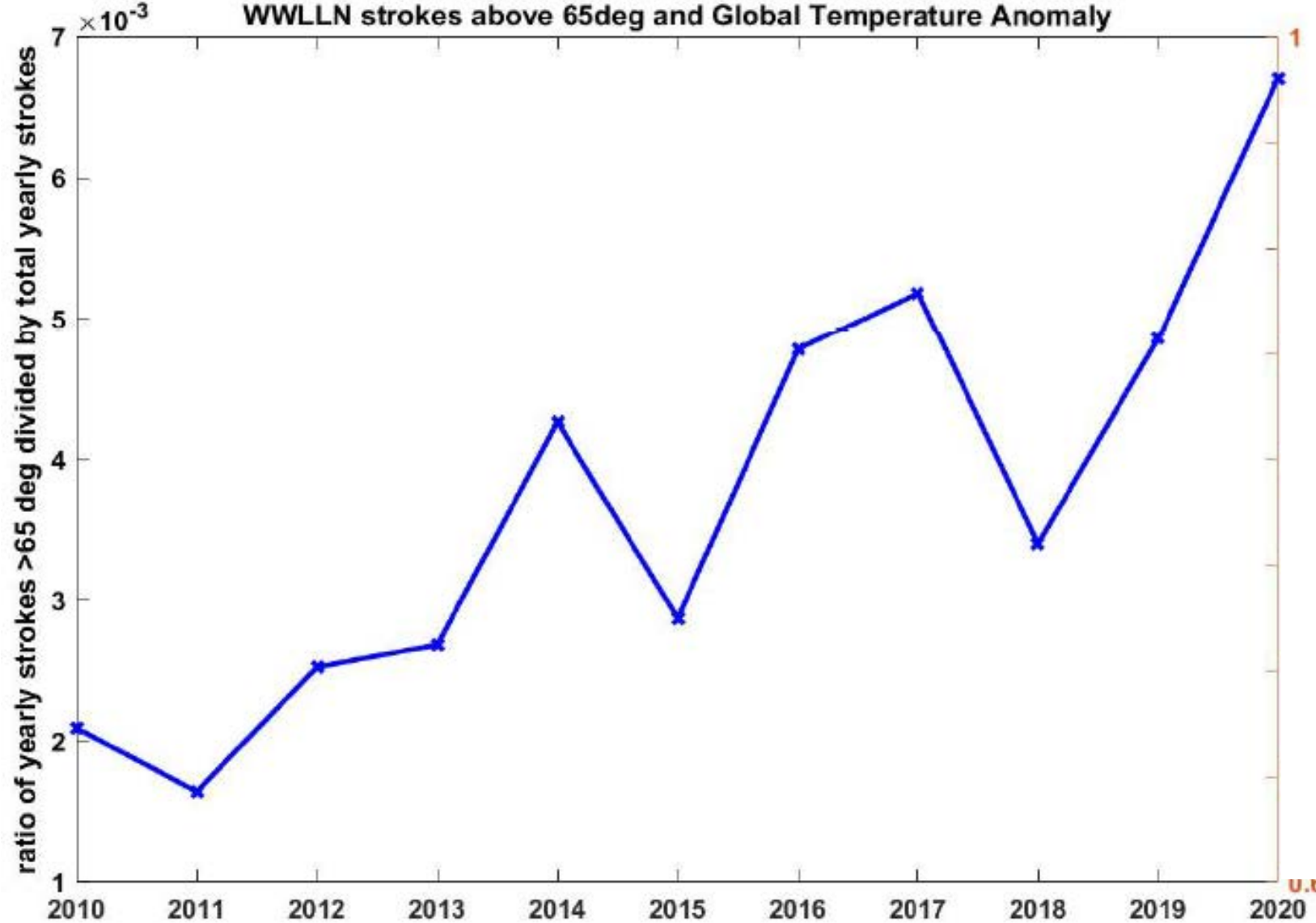




Adjusted to 2013 detection efficiency

Still a clear increase in total lightning detected in the Arctic

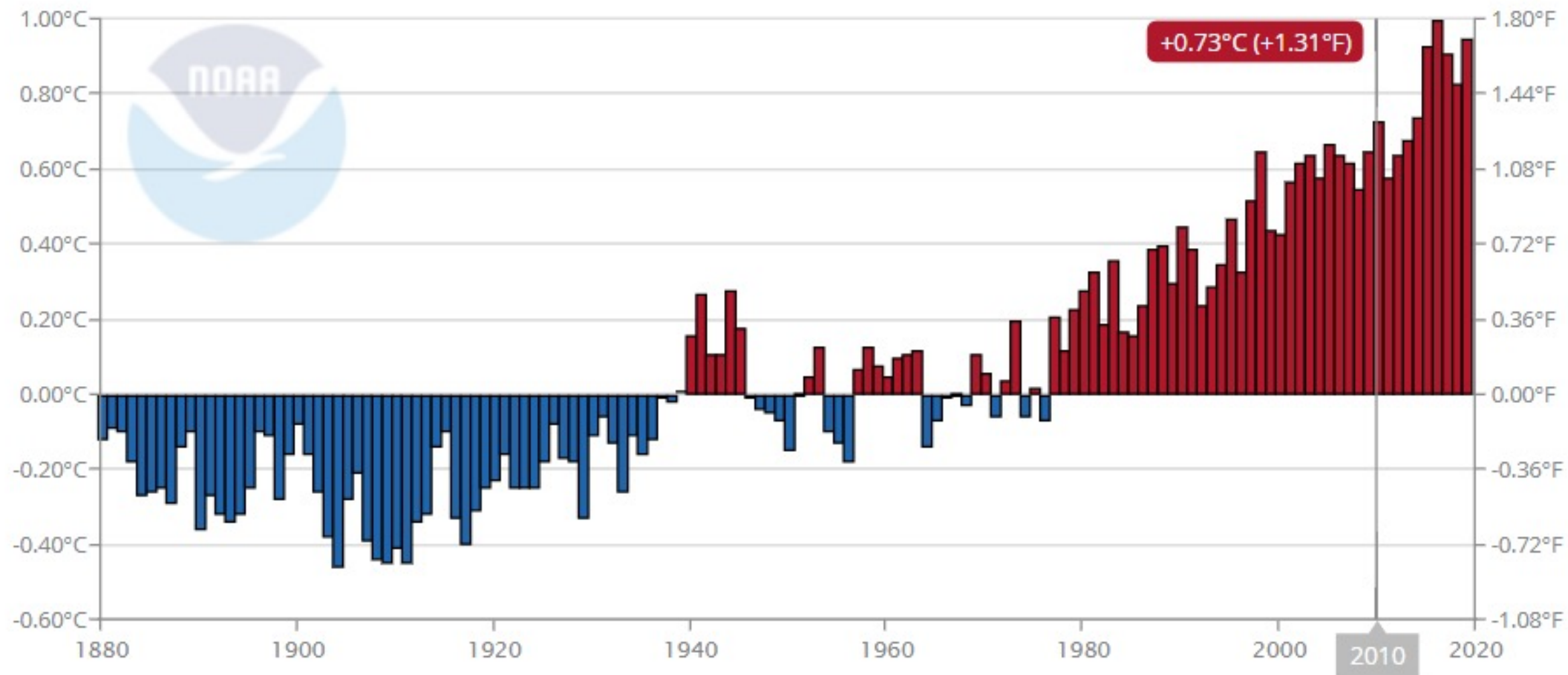
# Ratio of total yearly strokes above 65° to Global Total Strokes for JJA



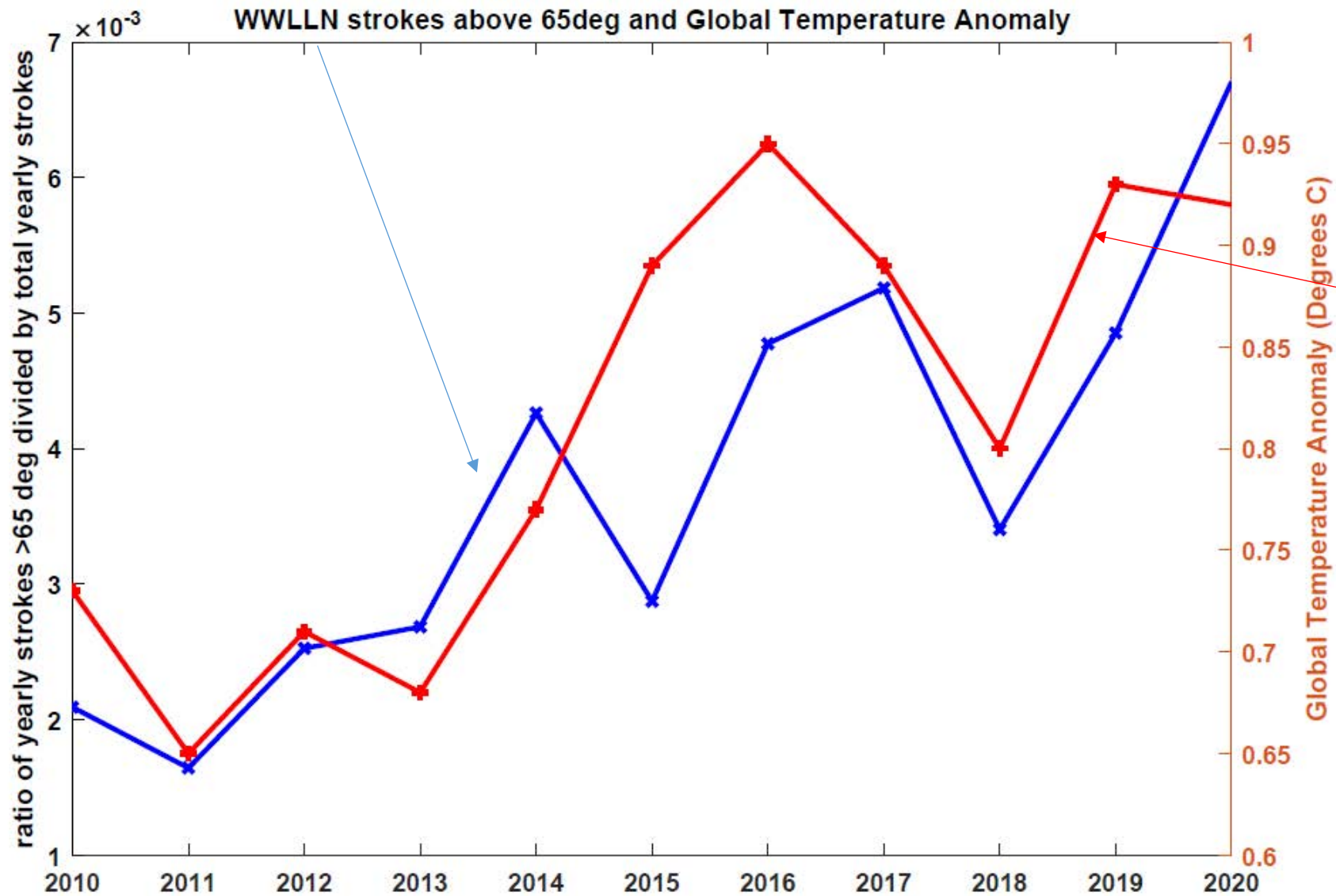
This Normalizes yearly WWLLN strokes to total Global Strokes during JJA

Global Land and Ocean  
January–December Temperature Anomalies

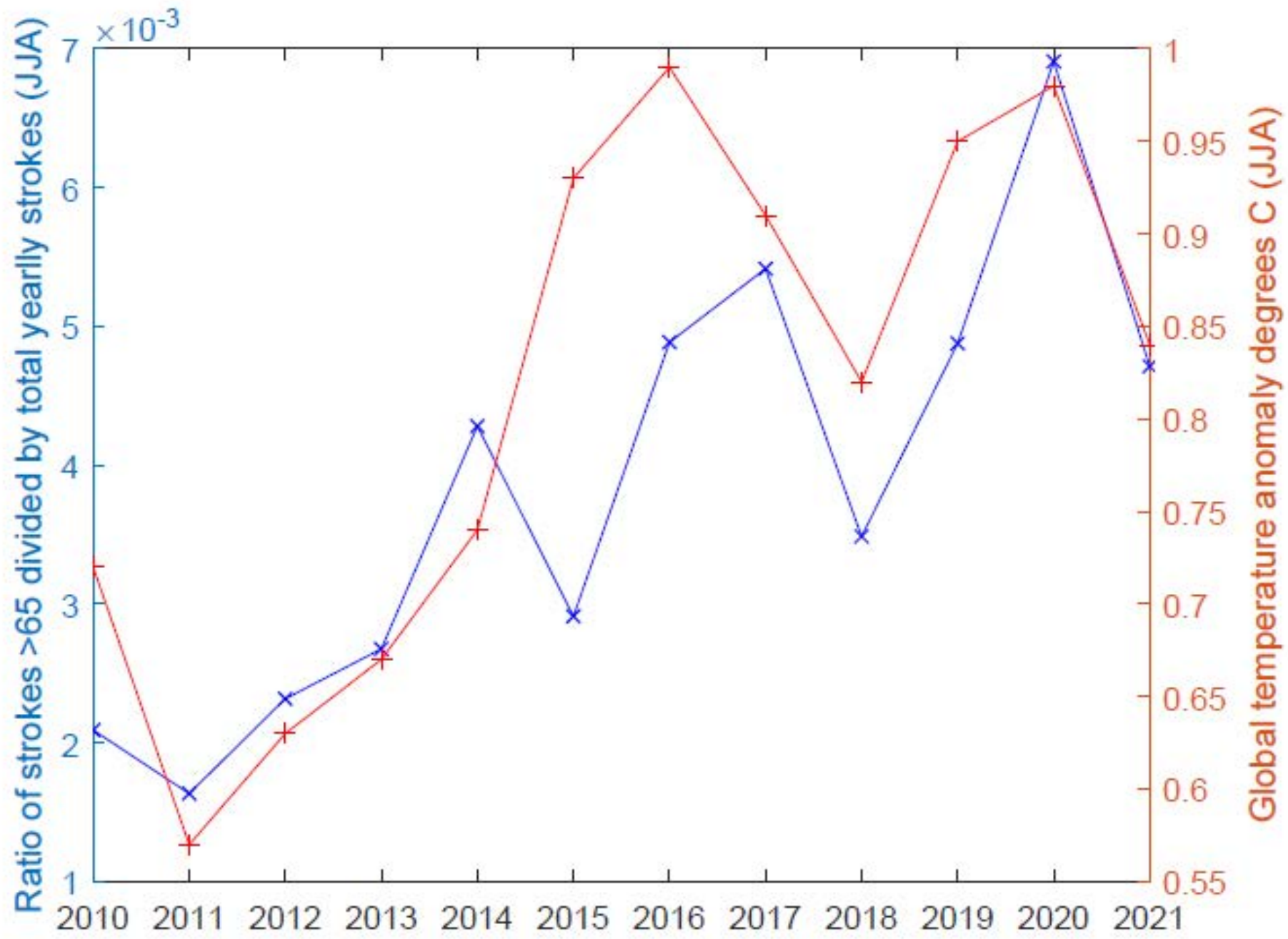
Focus time for this paper  
**2010-2020**

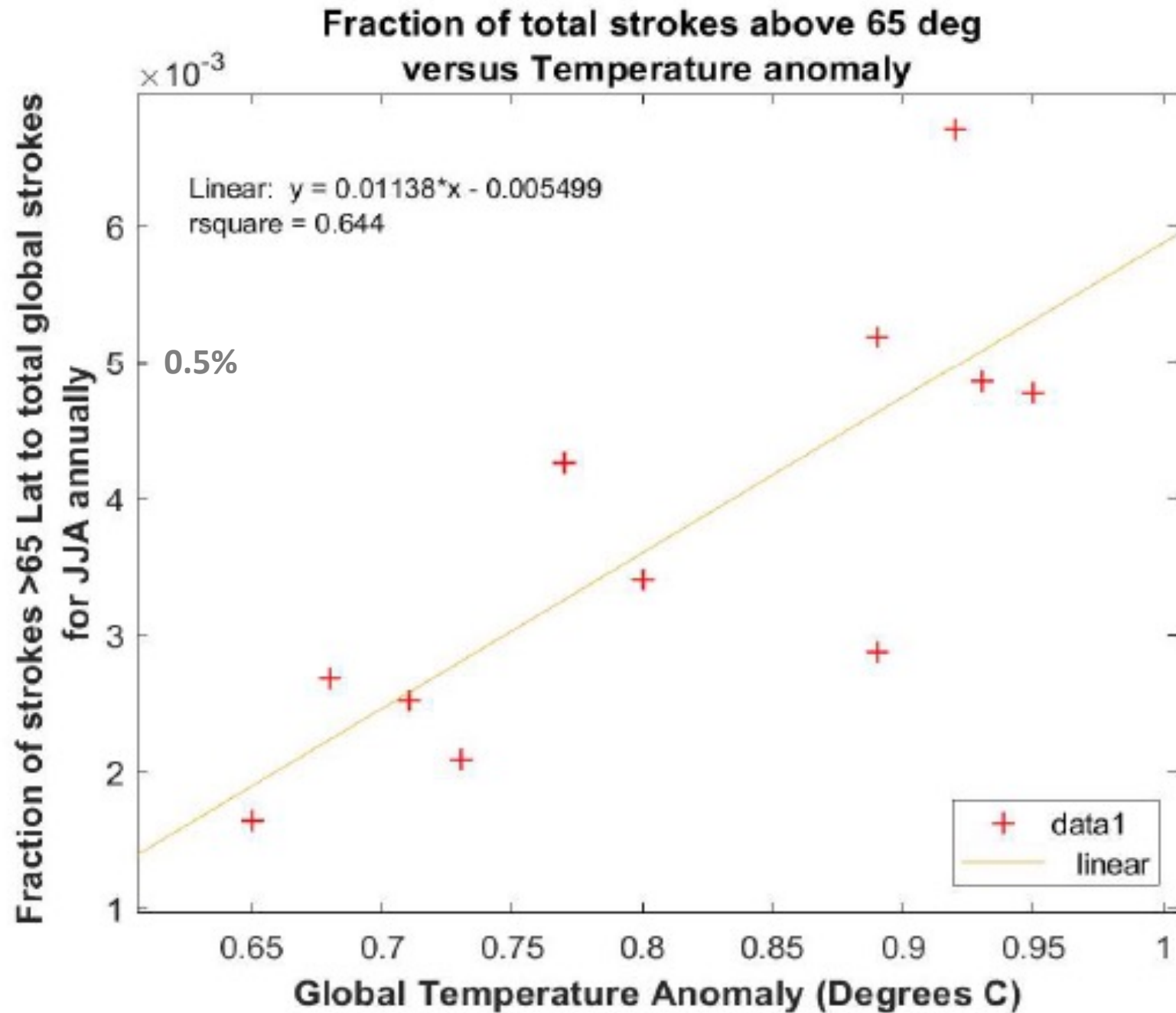


[https://ncdc.noaa.gov/cag/global/time-series/globe/land\\_ocean/ann/8/1880-2020](https://ncdc.noaa.gov/cag/global/time-series/globe/land_ocean/ann/8/1880-2020)

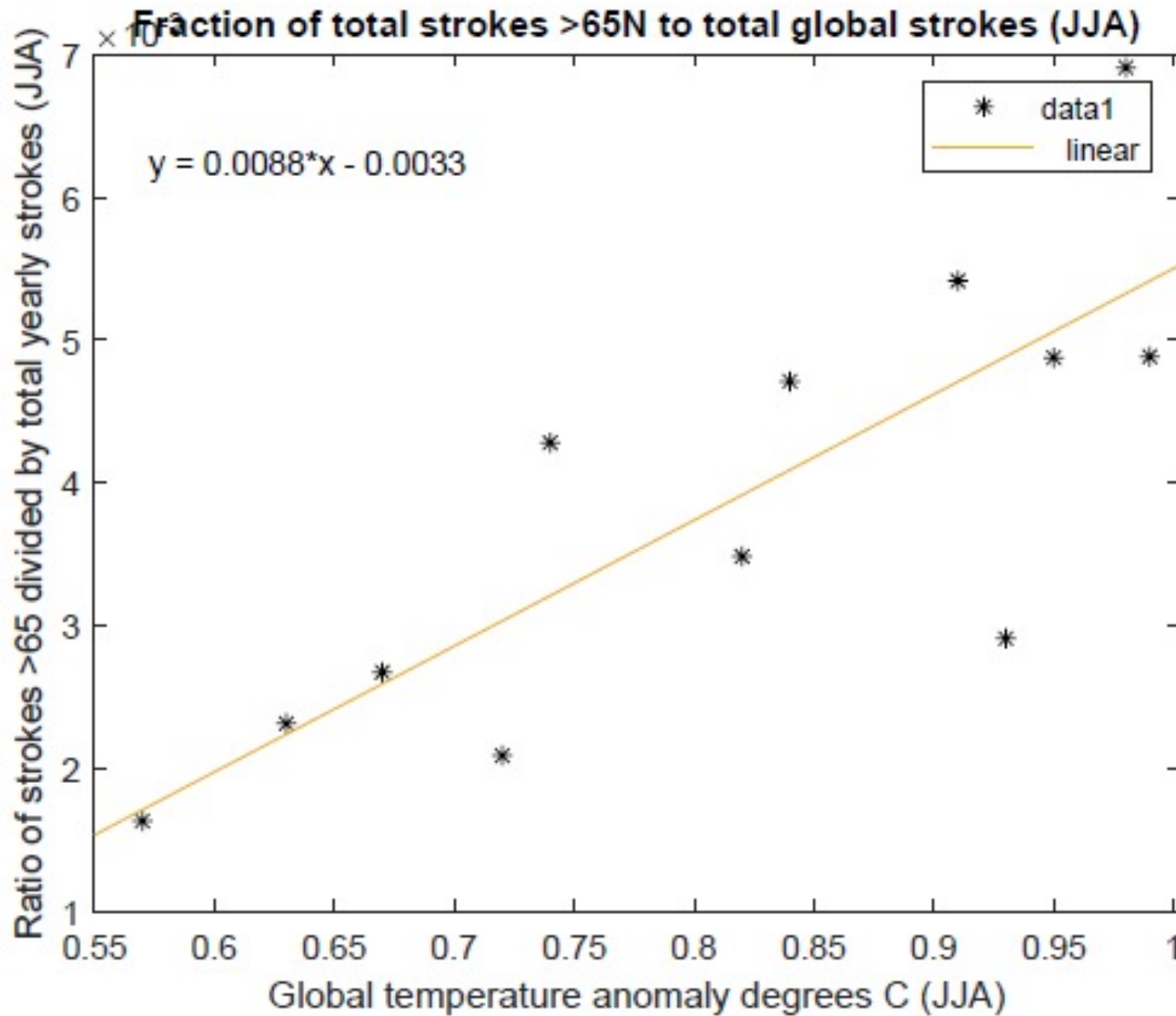


Global  
Temperature  
Anomaly  
(NOAA) from  
year 2000  
WRT 1981 to  
2010 average





Using data from the earlier plot

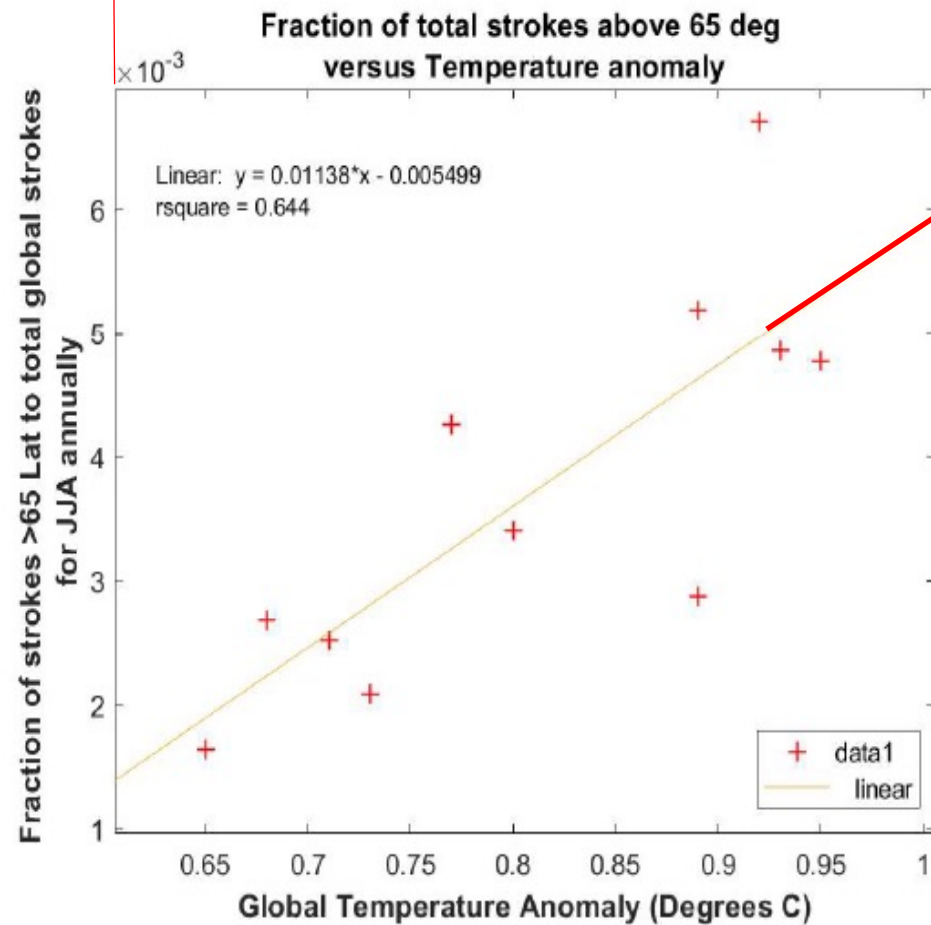


**Over the decade 2010-2020 Arctic lightning increased by 300%**

**if this trajectory continues until the anomaly reaches 1.5° C there will be another 200% increase from today's level.**



**.011 or 1.1%**



**Prediction:**  
**As Temp Anomaly**  
**increases by 0.5°C to**  
**1.45°C**  
**Then Ratio increases to**  
**0.011 (1.1%) – i.e. over**  
**a 100% increase above**  
**2020 value**

**1.45°C**

Projected conclusion: Number of Arctic Lightning strokes will be **100% Higher than in 2020 (factor of 2 increase)** by the time the global Temperature Anomaly increases another 0.5° C



Siberian lightning storm (credit: SiberianTimes)

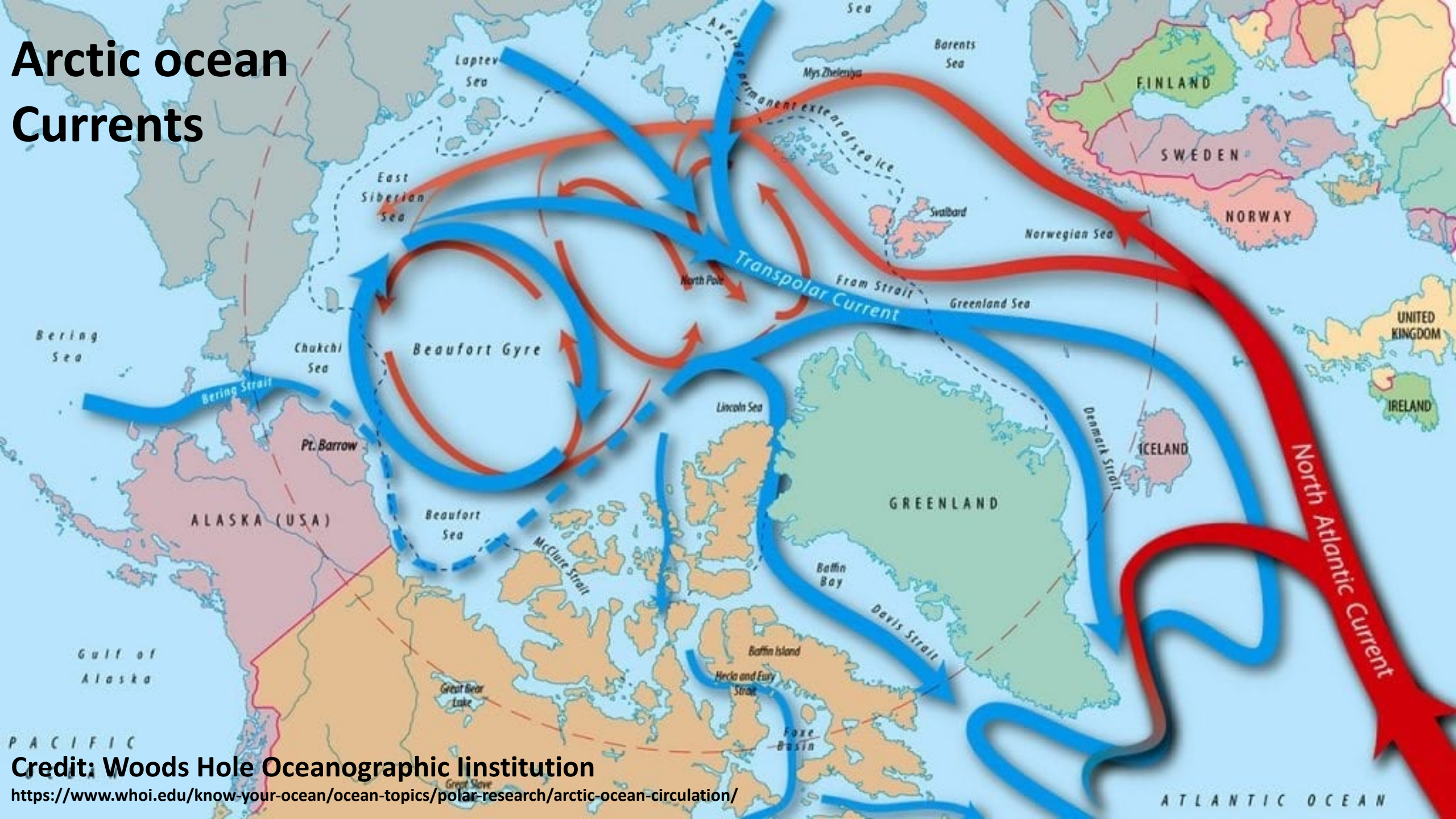
**Thanks for listening !**

**Questions?**

**Presenter contact:  
Robert Holzworth  
bobholz@uw.edu**

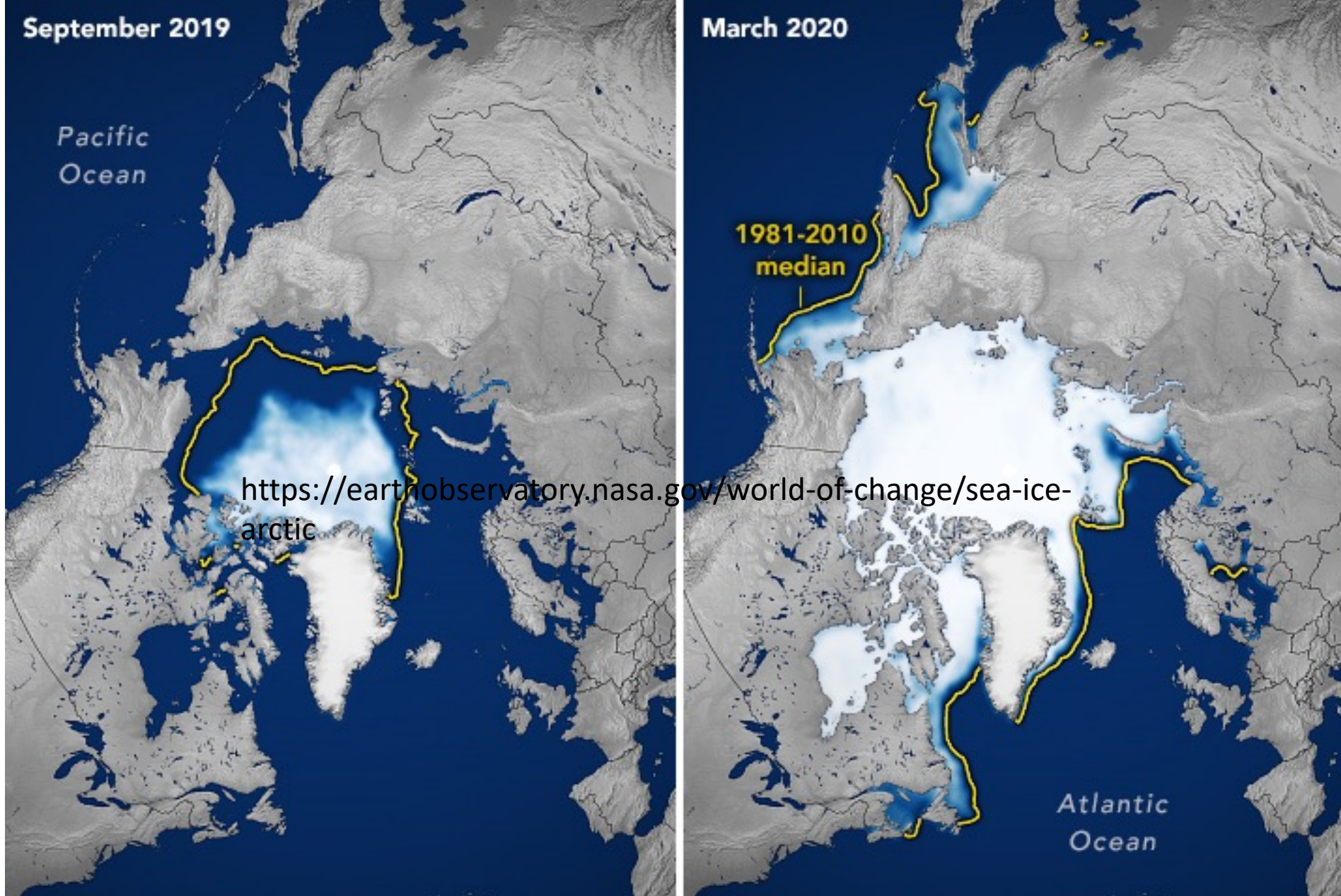
**Some slides below for further discussions**

# Arctic ocean Currents

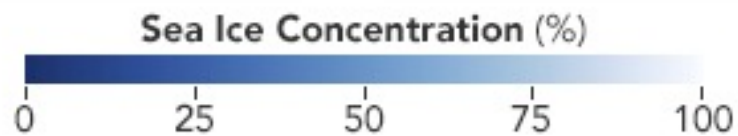


Credit: Woods Hole Oceanographic Institution  
<https://www.whoi.edu/know-your-ocean/ocean-topics/polar-research/arctic-ocean-circulation/>

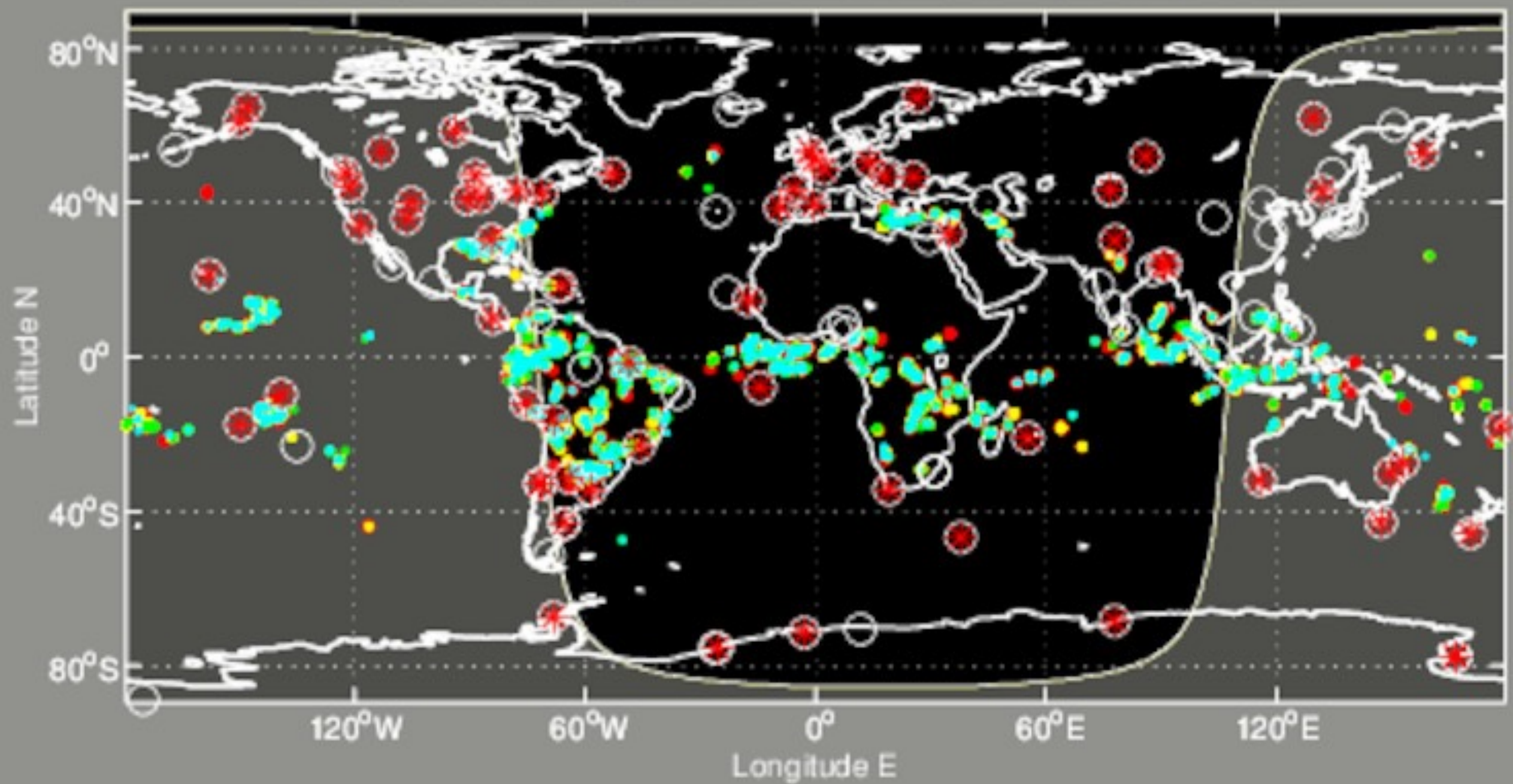
# Arctic Sea Ice Extent

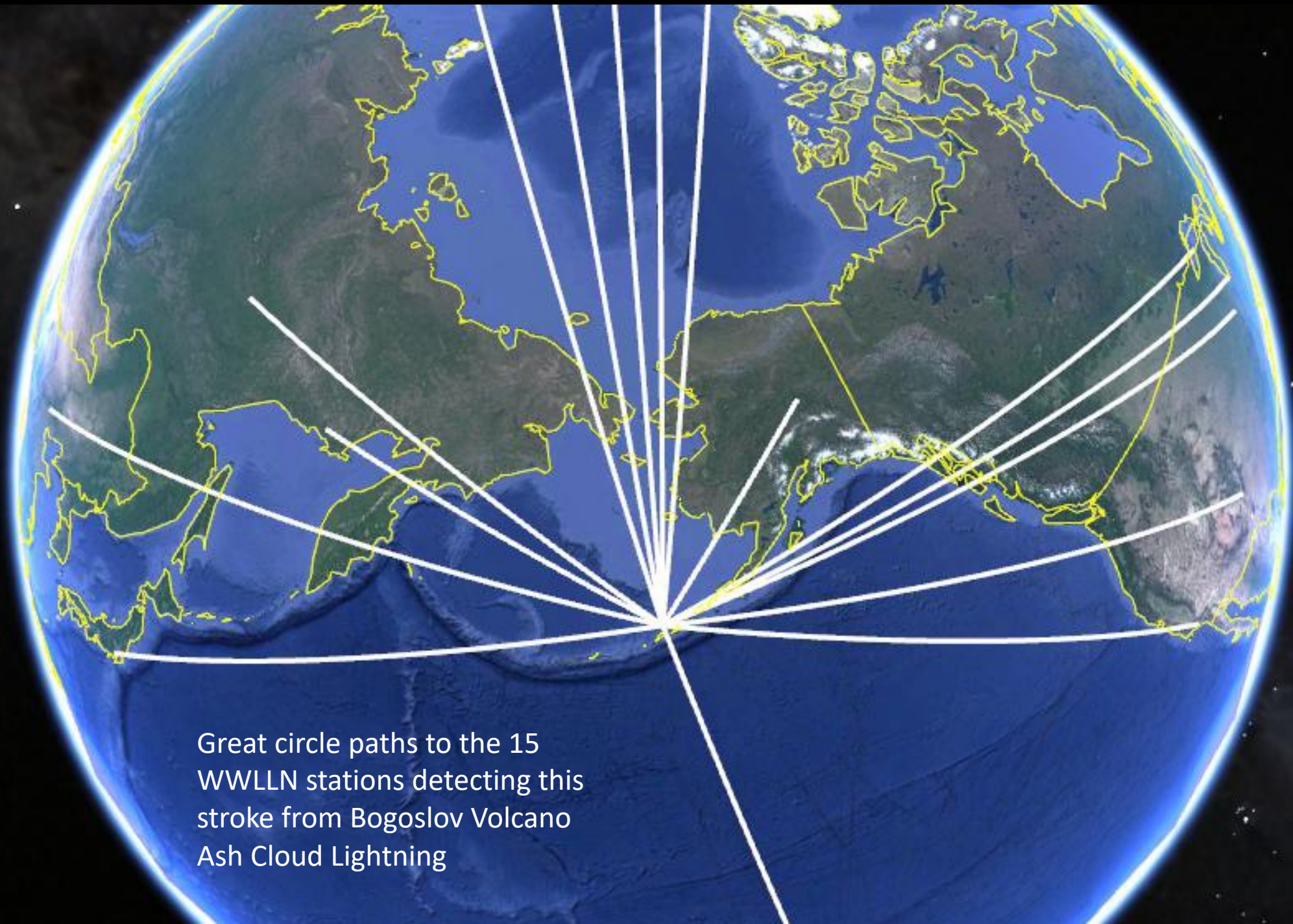


<https://earthobservatory.nasa.gov/world-of-change/sea-ice-arctic>



Stroke (flash4) Lightning Events on 09/03/2022, 40min prior to 23:10:00 UT





Great circle paths to the 15  
WWLLN stations detecting this  
stroke from Bogoslov Volcano  
Ash Cloud Lightning

Results: E-Field power

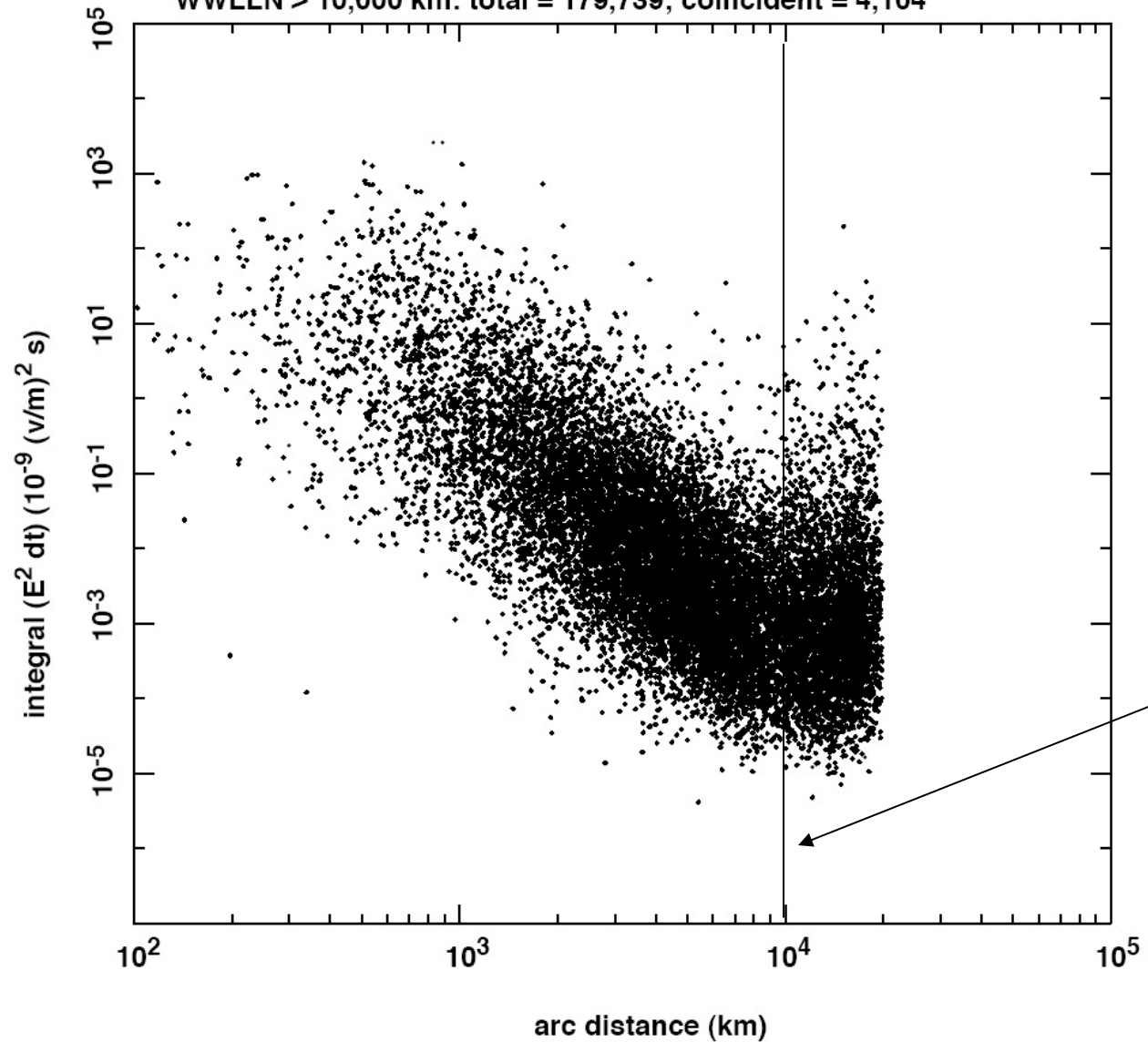
versus distance

20081104 - 20101130

total VEFI peaks: 420,265

WWLLN < 10,000 km: total = 179,730; coincident = 12,170

WWLLN > 10,000 km: total = 179,739; coincident = 4,104



**Energy per stroke  
observed at  
C/NOFS**

Note up-turn after ¼ -  
way-round the earth  
from refocusing