

The Impact of Cold Air Outbreaks on Global Lightning

GLM Science Meeting

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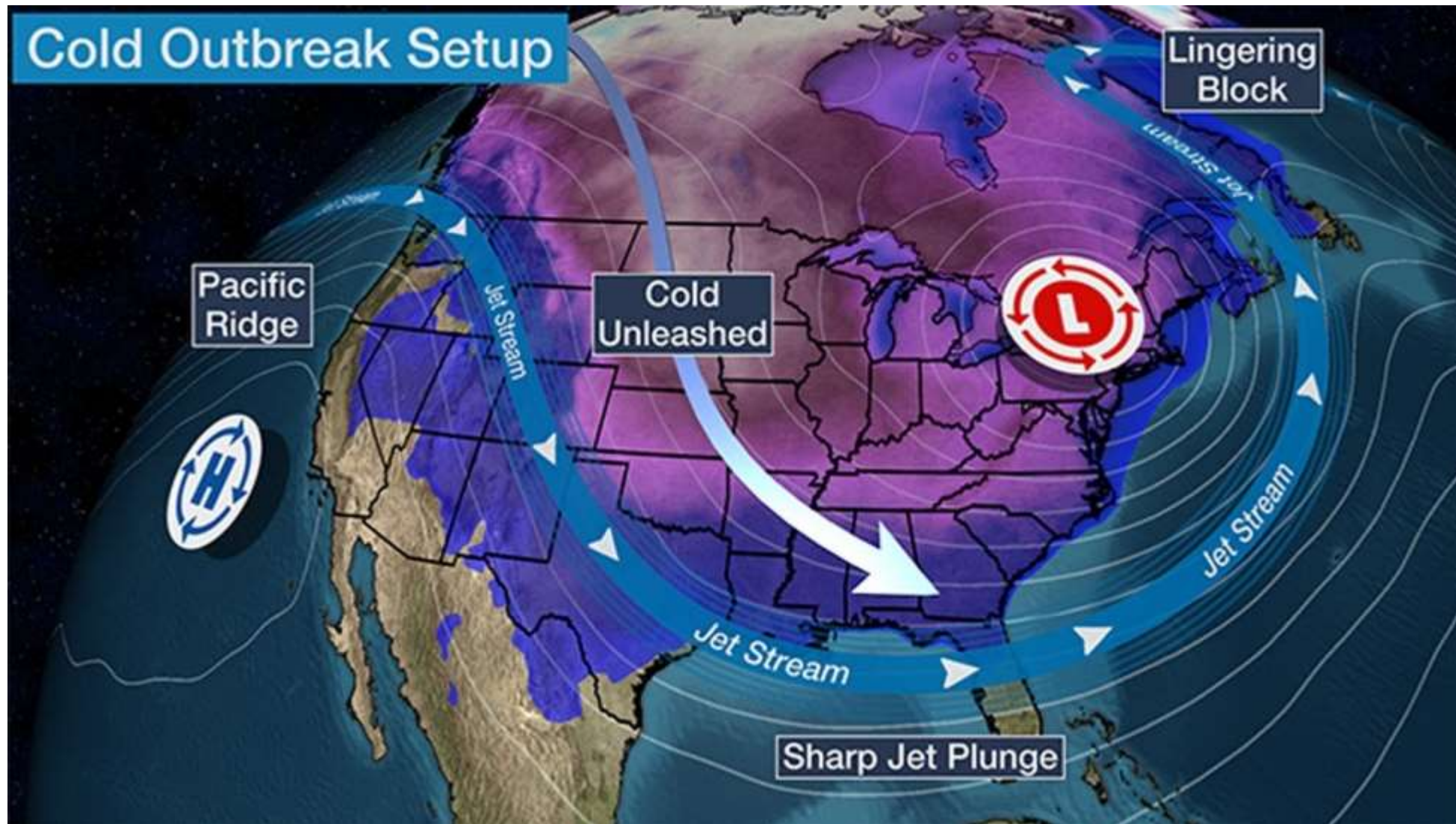
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Evidence for global lightning variation with temperature on many time scales

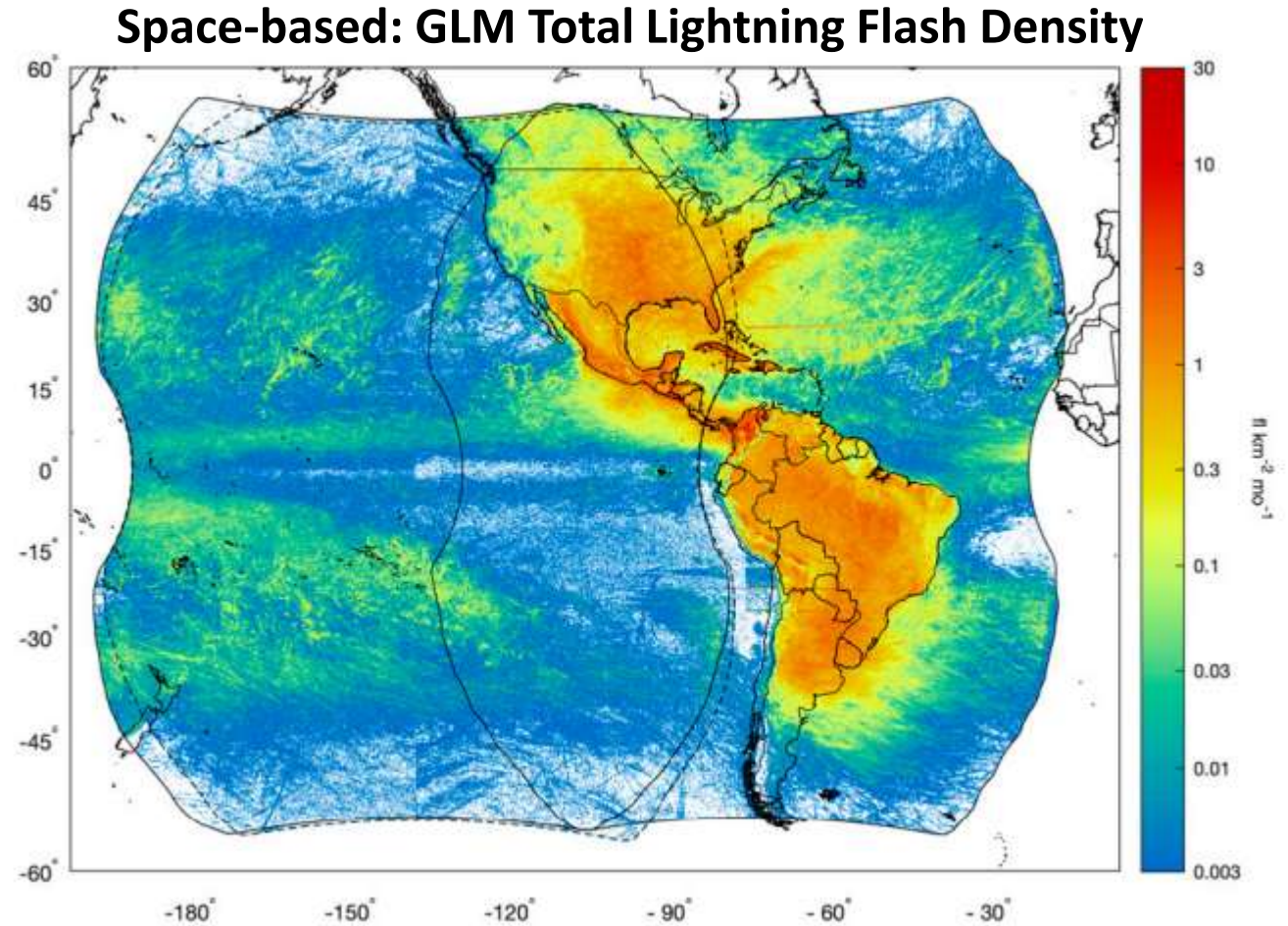
- Diurnal (Price, 1993) +20% per °C
(Markson, 2007) +7% per °C
- Semiannual (Williams, 1994) +20-30% per °C
- Annual (Williams, 1994) +11% per °C
- Super-El Nino (Williams, 1992; Satori et al., 2009) 10% per C

Cold polar outbreaks



GLM Coverage: the American “chimney”

- Total Lightning Stroke Density
 - Consistent, Harmonized Data
- Global 10 km x 10 km (0.1 x 0.1 deg)
- Temporal (Monthly, Daily, Hourly)
- Space-based Optical:
 - NASA TRMM/ISS - LIS
 - NOAA/NASA GOES - GLM
 - CMA FY-4 - LMI
 - EUMETSAT MTG - LI
- Ground-based RF (commercial data):
 - GLD360 (Vaisala)
 - ENTLN (Earth Networks)
 - WWLLN (Univ. Washington)
 - Regional Networks (IC/CG)



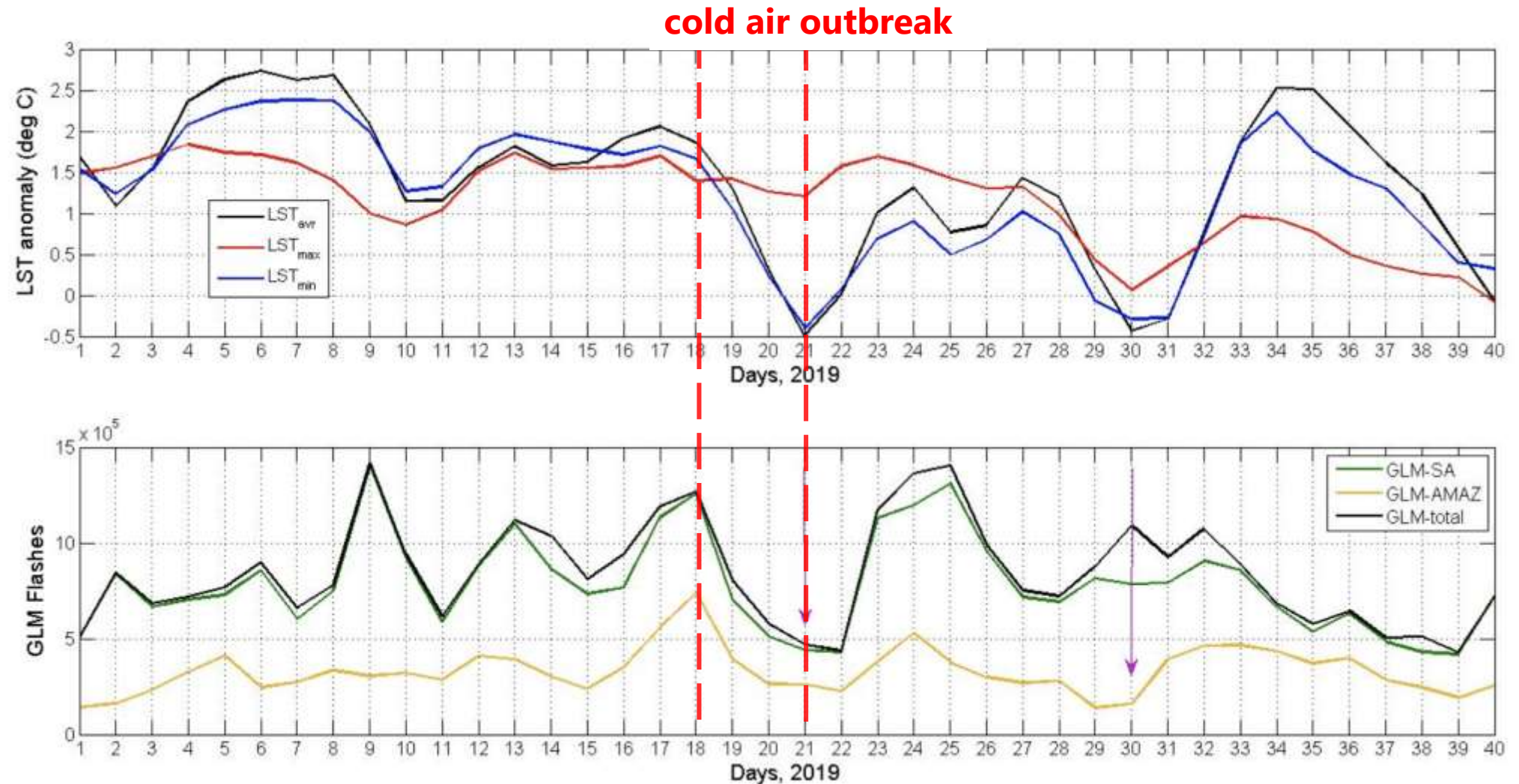
Combined G16 and G17 GLM flash densities from 1 Dec 2018 to 31 May 2020 with units of flash count per square kilometer per month (after Rudlosky and Virts, 2021, MWR, DOI: 10.1175/MWR-D-20-0242.1).

A Cold Air Outbreak from both Poles Concurrently

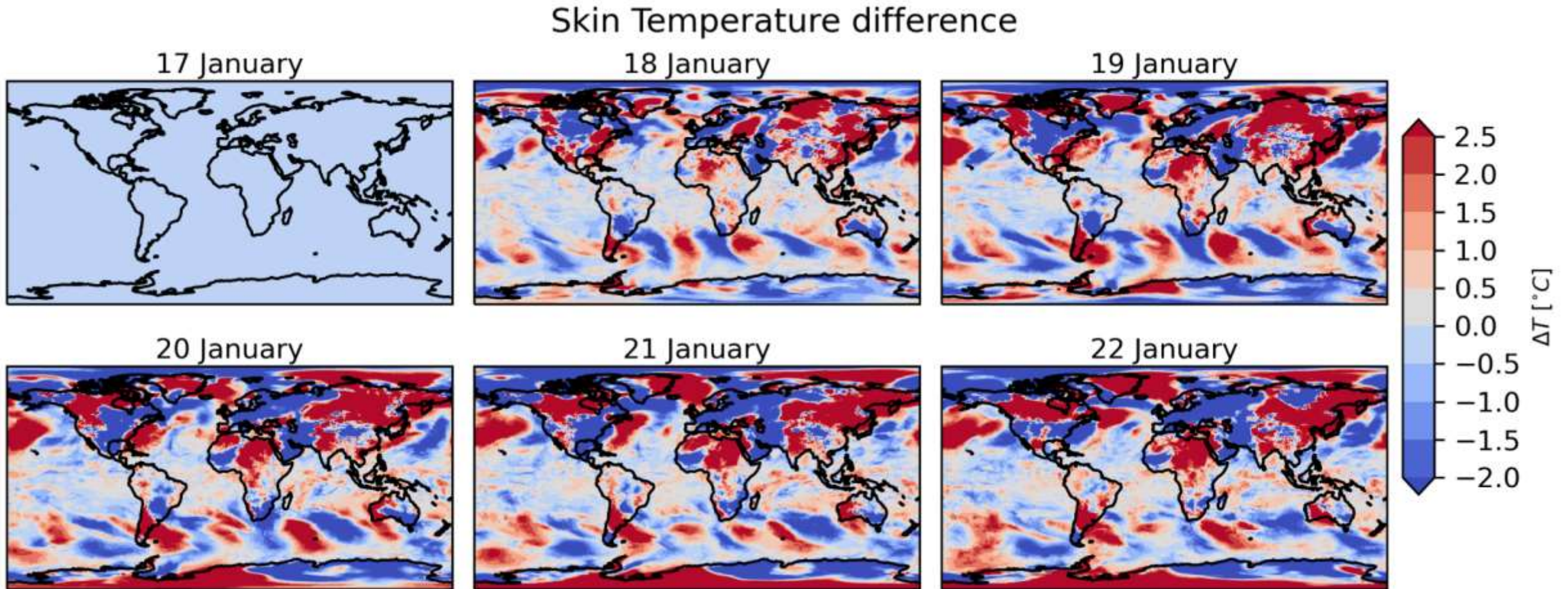
- January 17-22, 2019
- Factor-of-two reduction in GLM lightning for Western Hemisphere
- Impacts on both South American (GLM) and African lightning
- Tropical region accessed by outbreaks from both poles
- Intrusion from the Arctic impacts Mexico and Isthmus of Panama
- Intrusion from Antarctica impacts Amazon lightning via Paraguay

Global land surface temp anomaly (top)

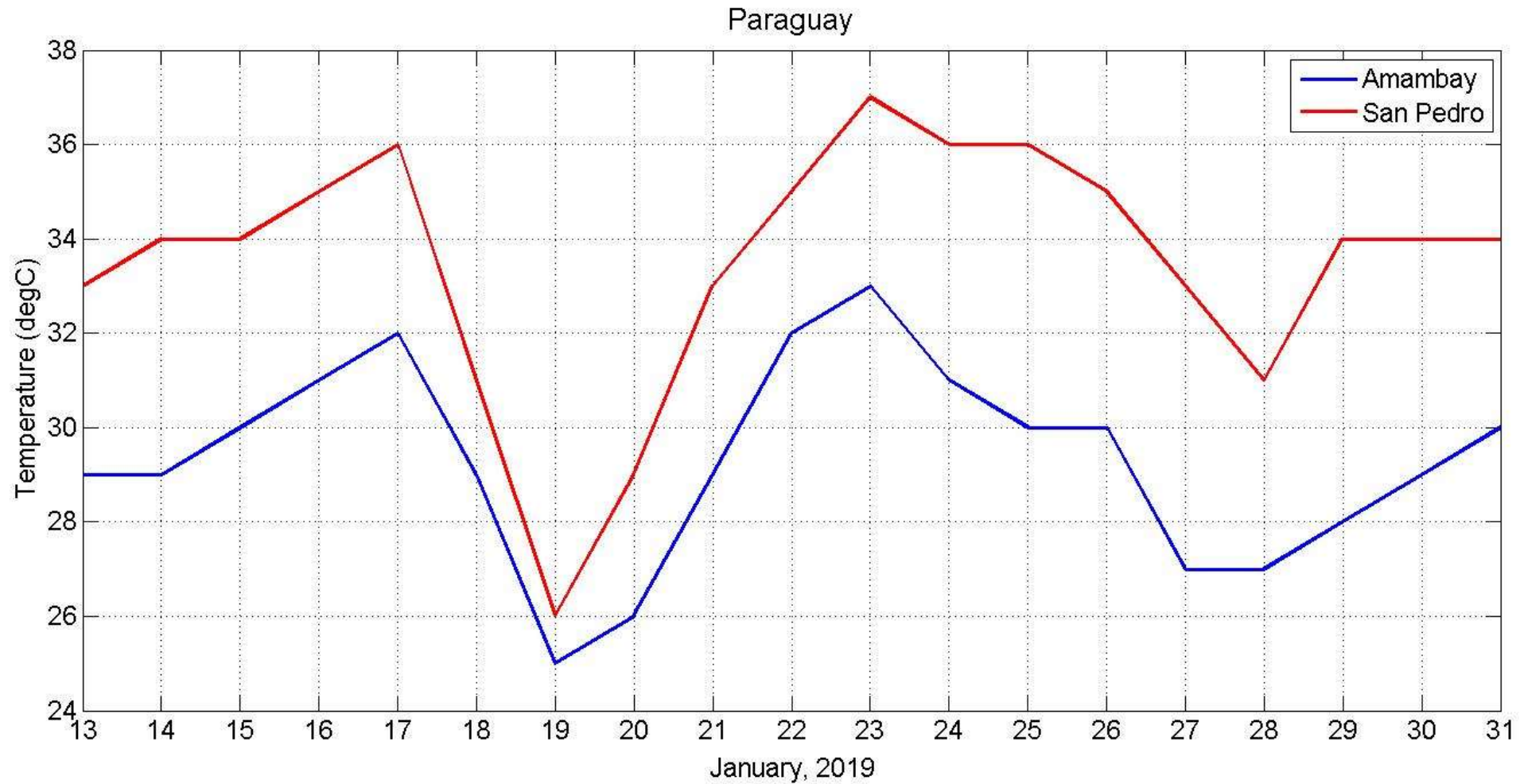
GLM daily total flashes (bottom)



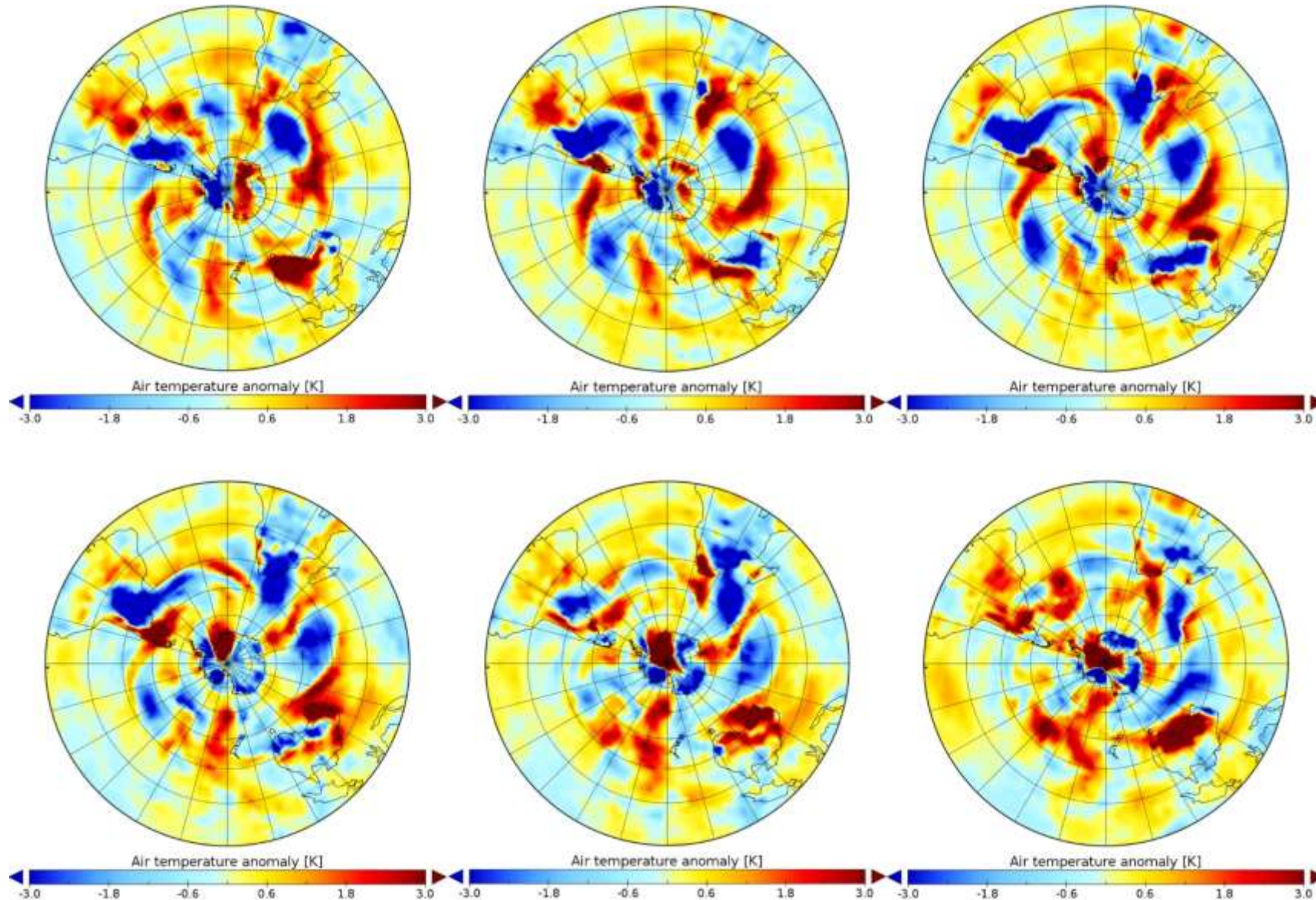
6-day evolution of ERA5 skin temperature anomaly for January 2019 cold air outbreak



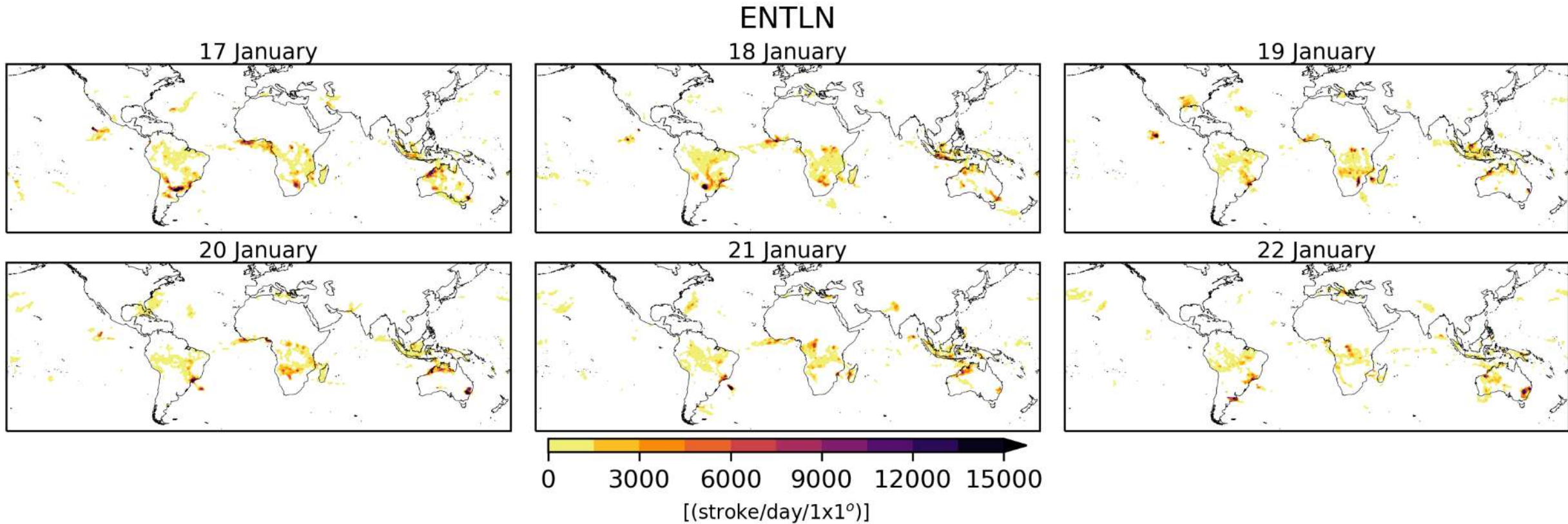
Temperature drops in Paraguay 23 S



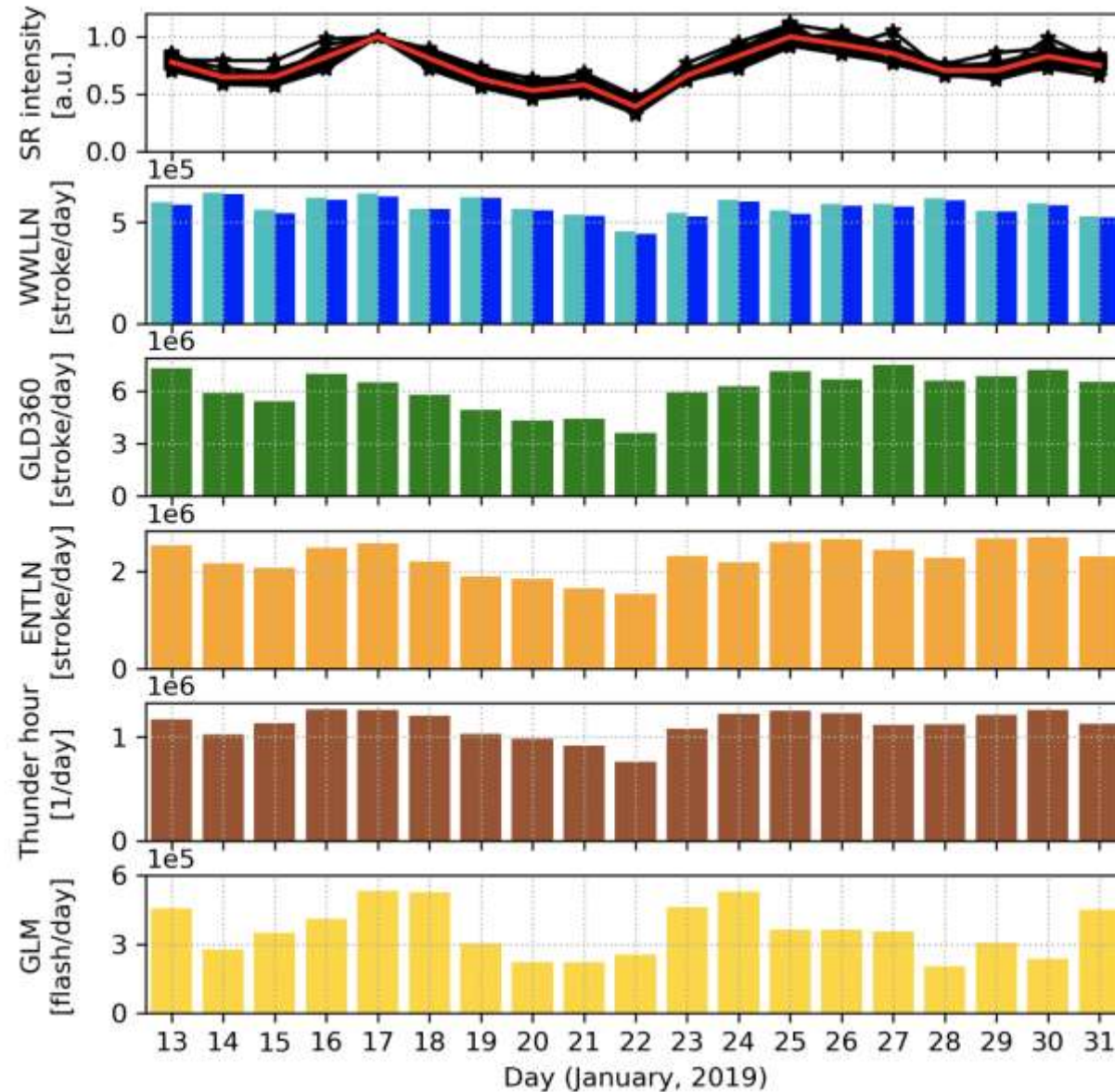
South Pole View on 6 consecutive days



ENTLN observations for six days



Global lightning variations for 19 days



Lightning sensitivity to temperature: Jan 17 to 20, 2019 double pole outbreak

- Lightning diminishment over 3 days, entire Western Hemisphere
- 0.7 million flashes per day/1.2 million flashes per day = 58%
- Assume no change in other chimneys, global drop = $58\%/3 = 19\%$

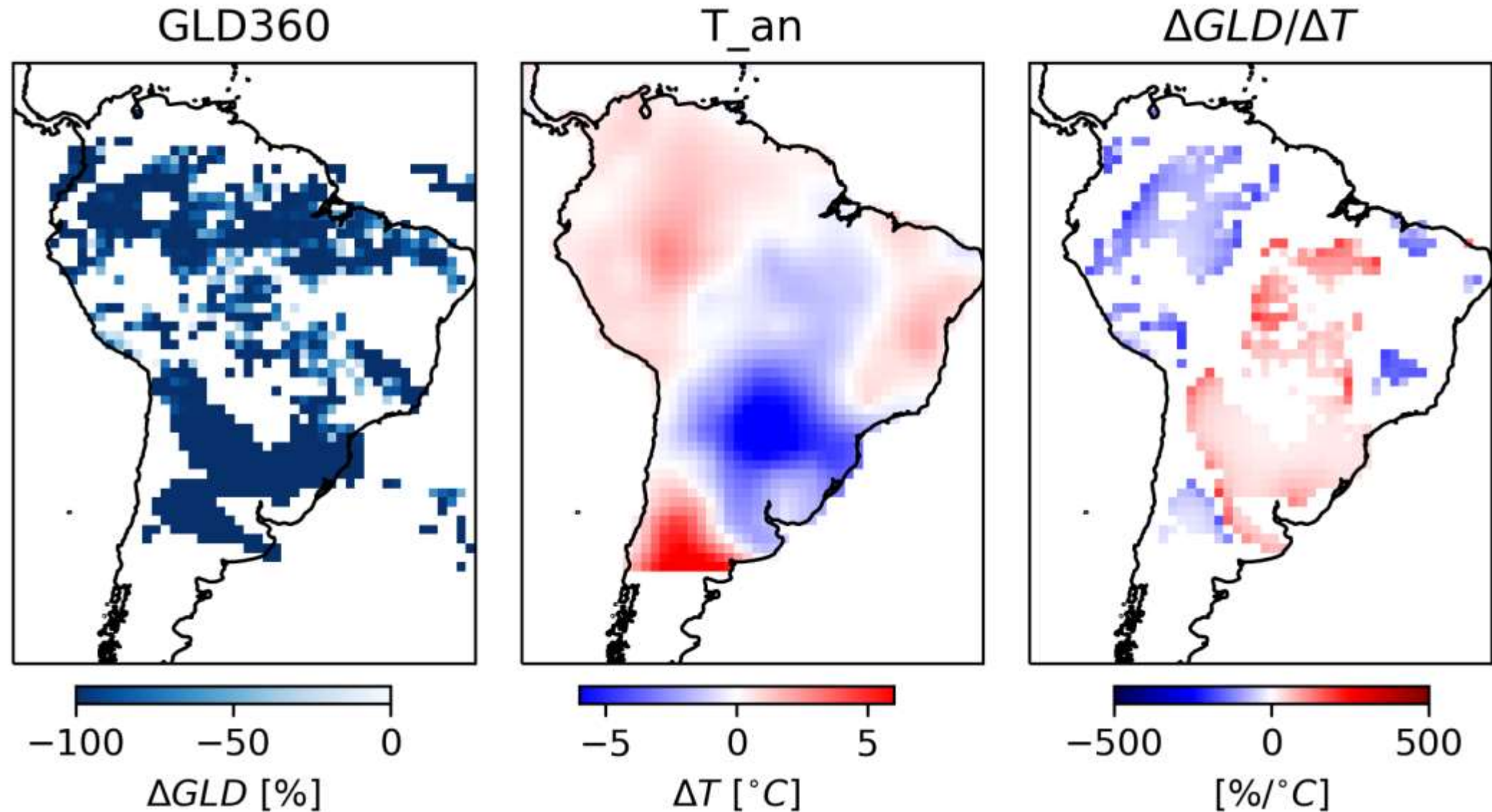
- Global temperature drop over 3 days (NOAA dataset) = 0.3 C

- Global sensitivity: $19\%/0.3\text{ C} = 63\% \text{ per degree C}$

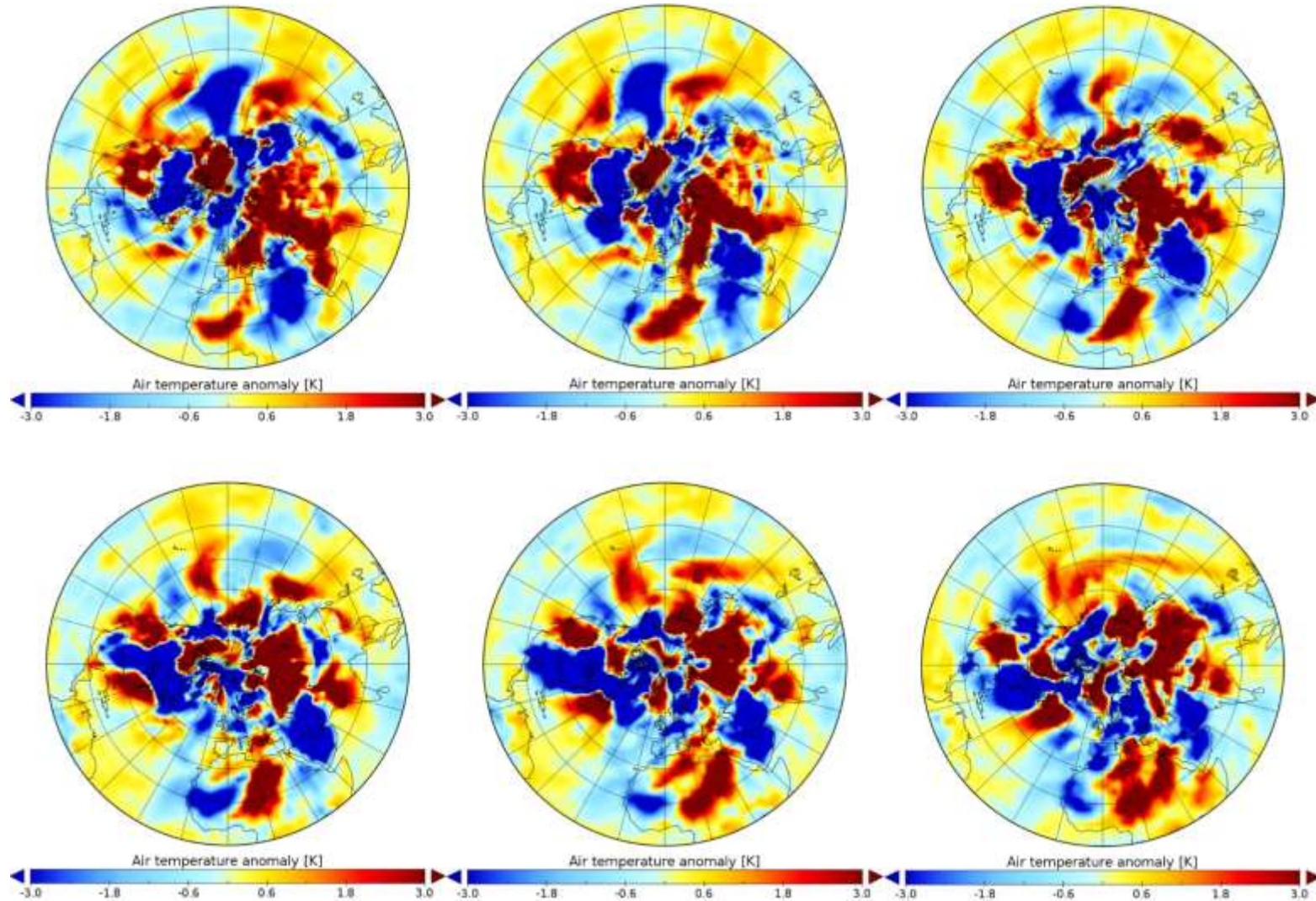
Simultaneous outbreaks from both poles

- How common are they?
- What is the physical basis?

Lightning and temperature changes over 3 days

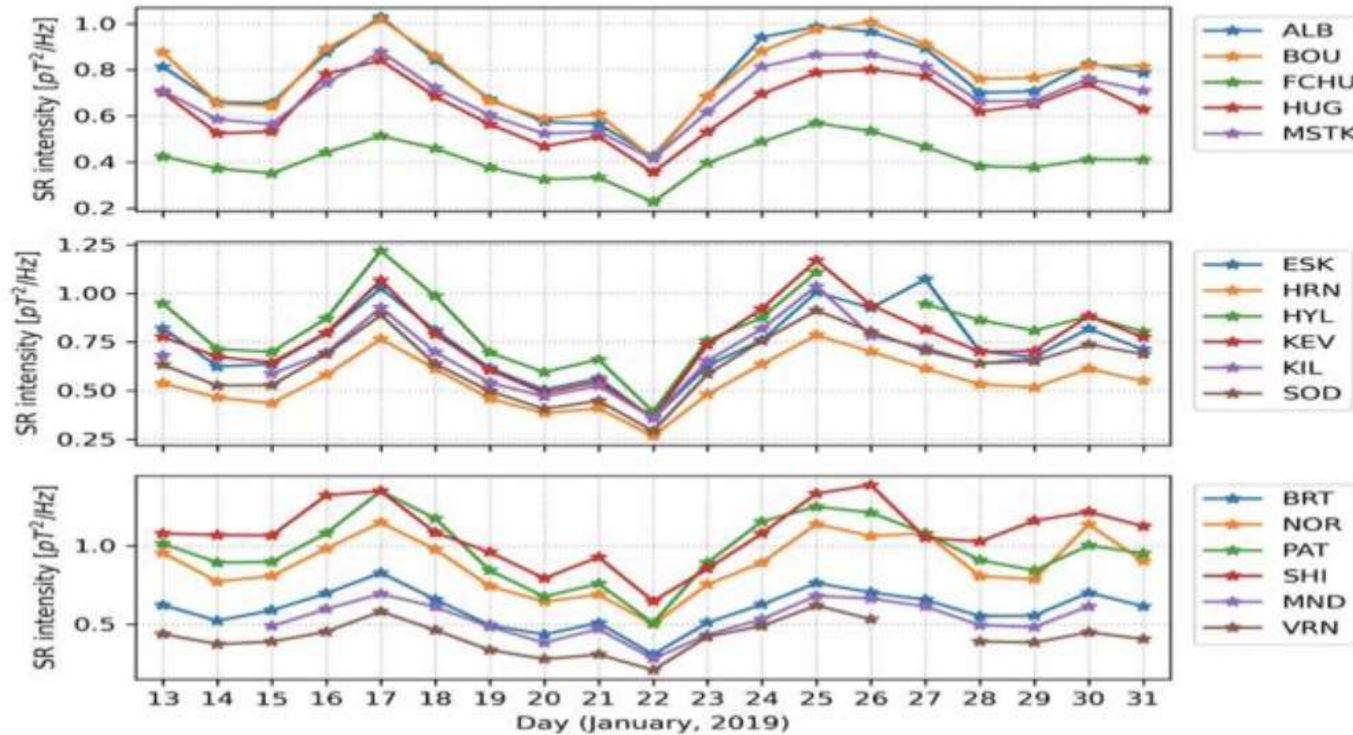


North Pole View on 6 consecutive days

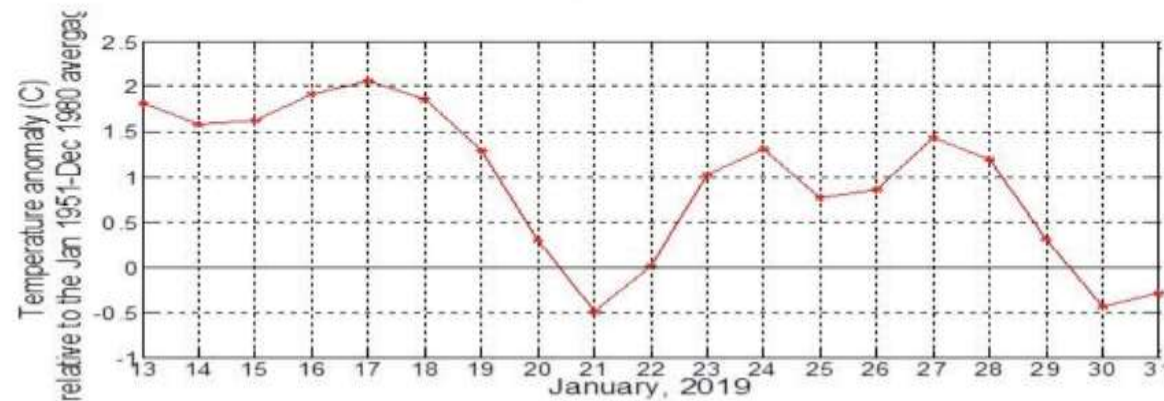


Global lightning variations based on many-station Schumann resonance measurements for 19 days

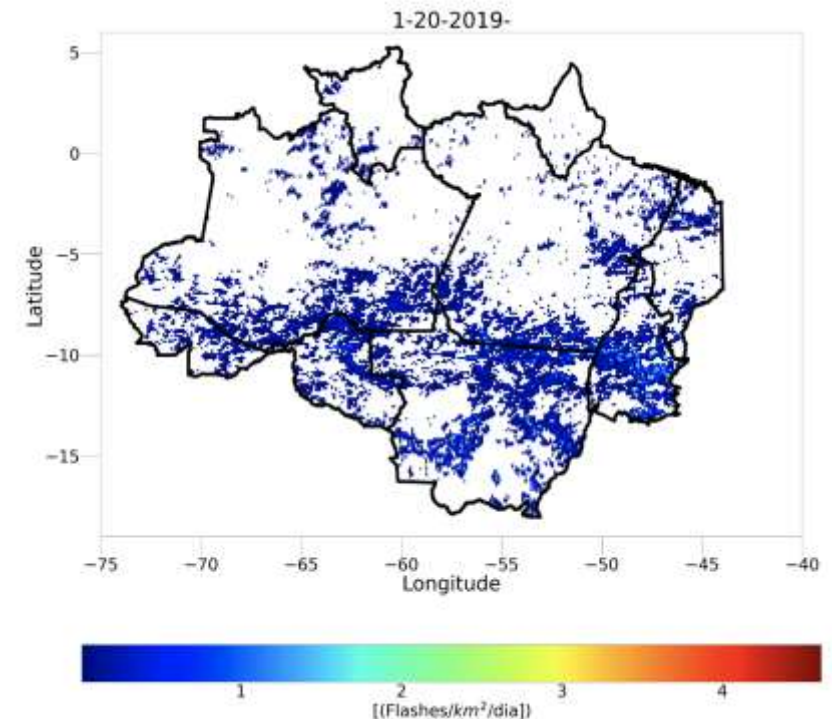
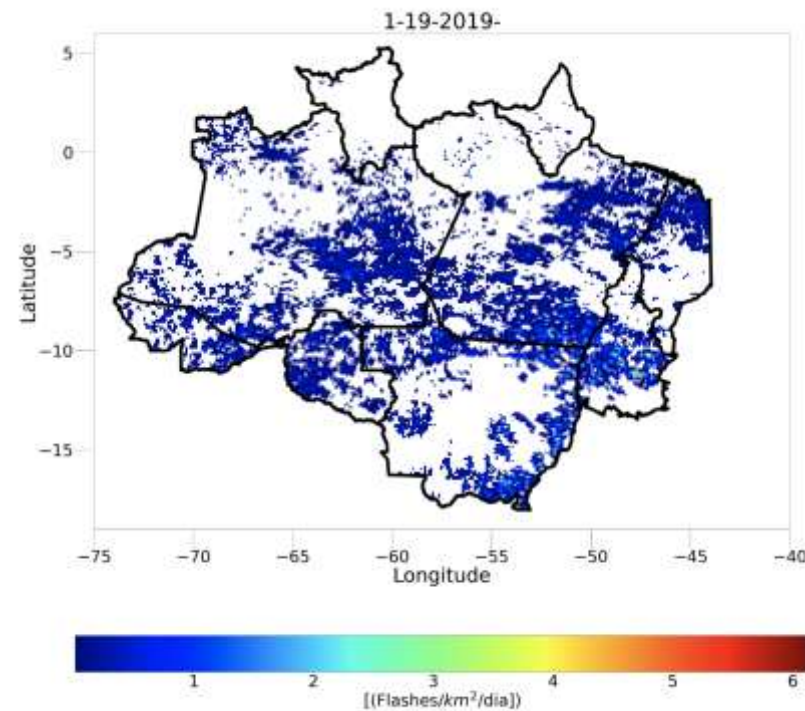
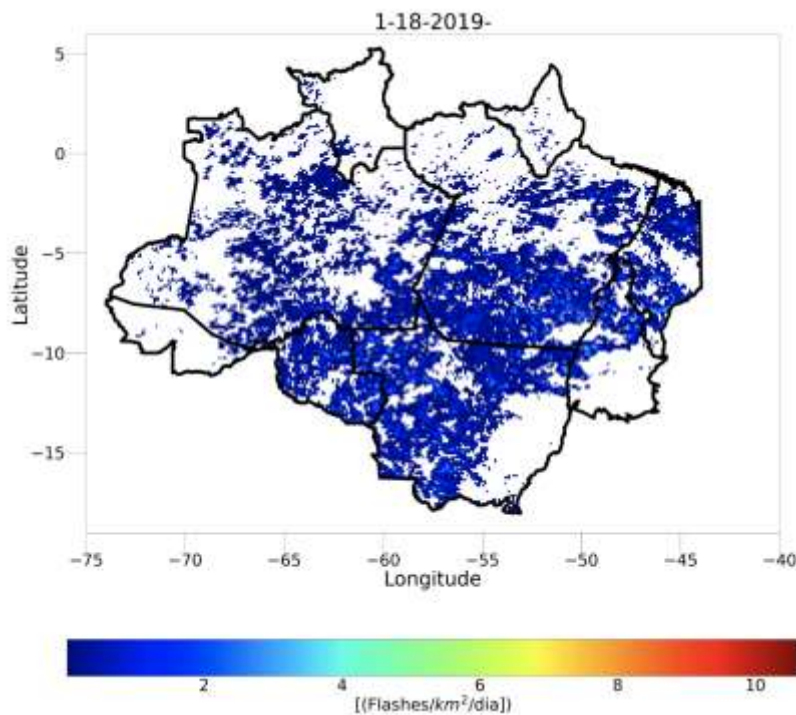
Schumann resonance records



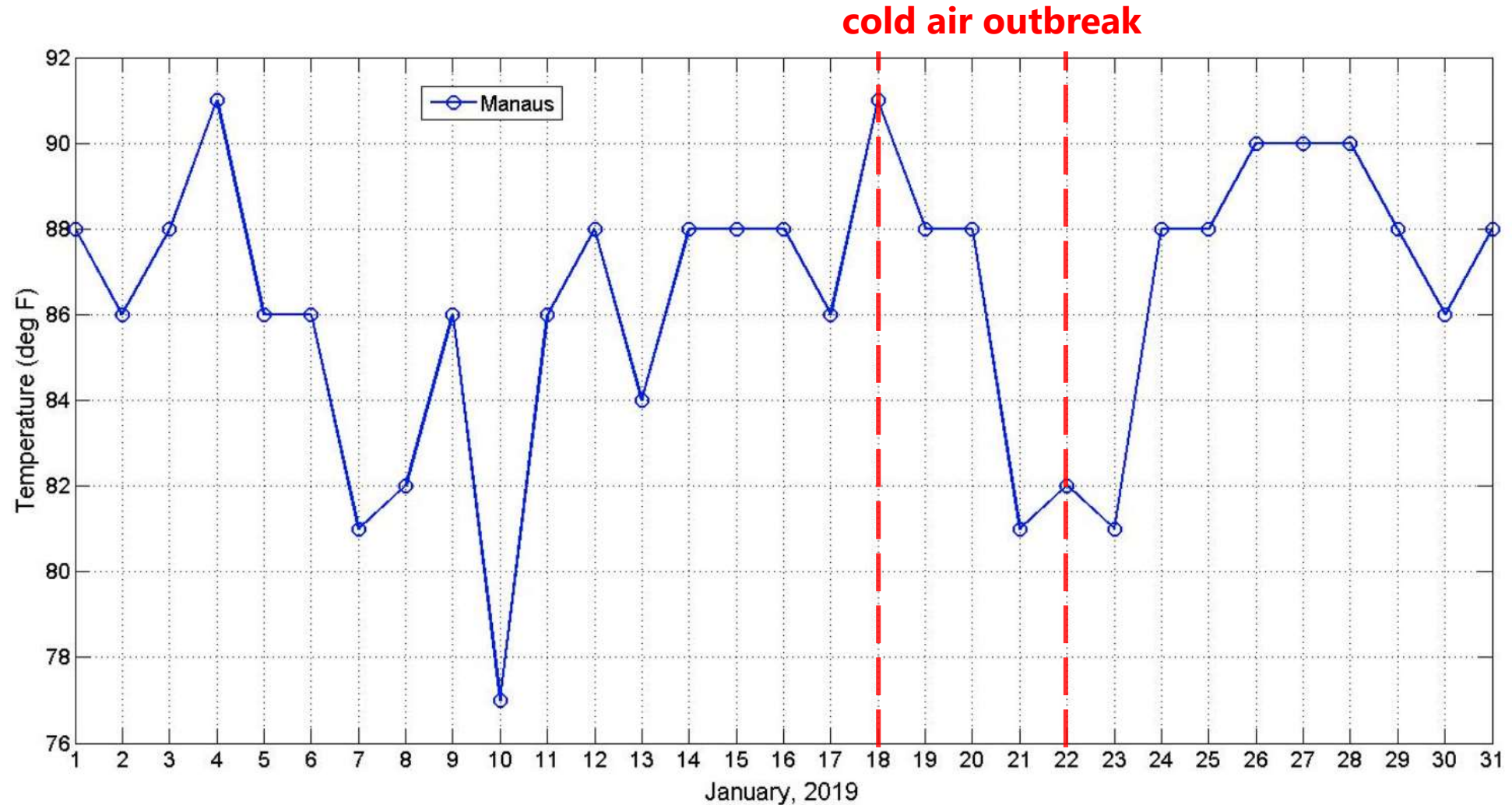
Global land temperature anomaly



3-Day diminishment of GLM lightning in Amazon region (Jan 18, Jan 19, Jan 20)



Temperature variation at Manaus, Brazil (3° S)



ENTLN lightning for 6 consecutive days

