# Step change in boreal fire emissions? Canadian case study

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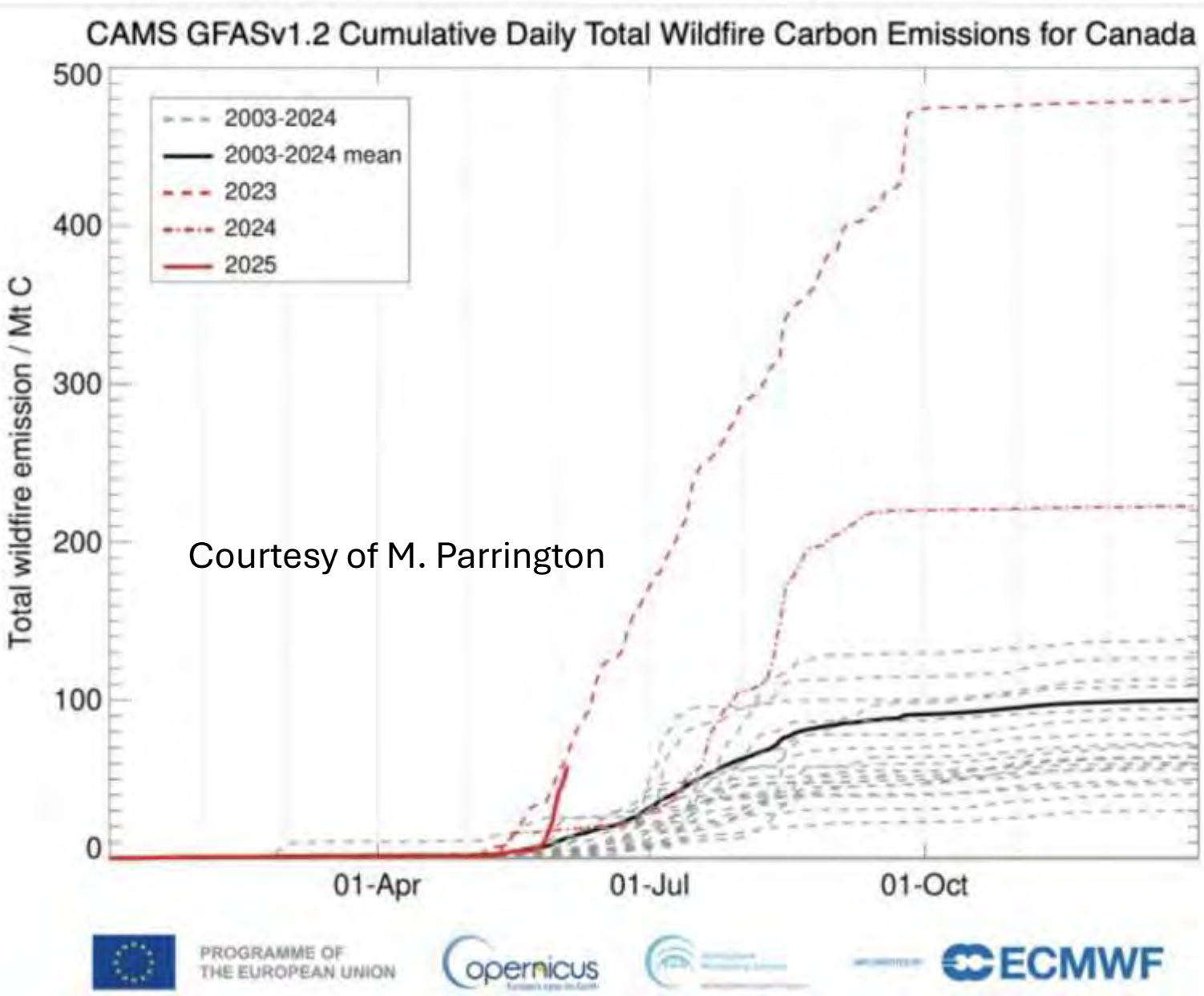
Photo credit: NWTFire

# This past week:


Sentinel2 image 2025.05.30




Courtesy of M. Parrington

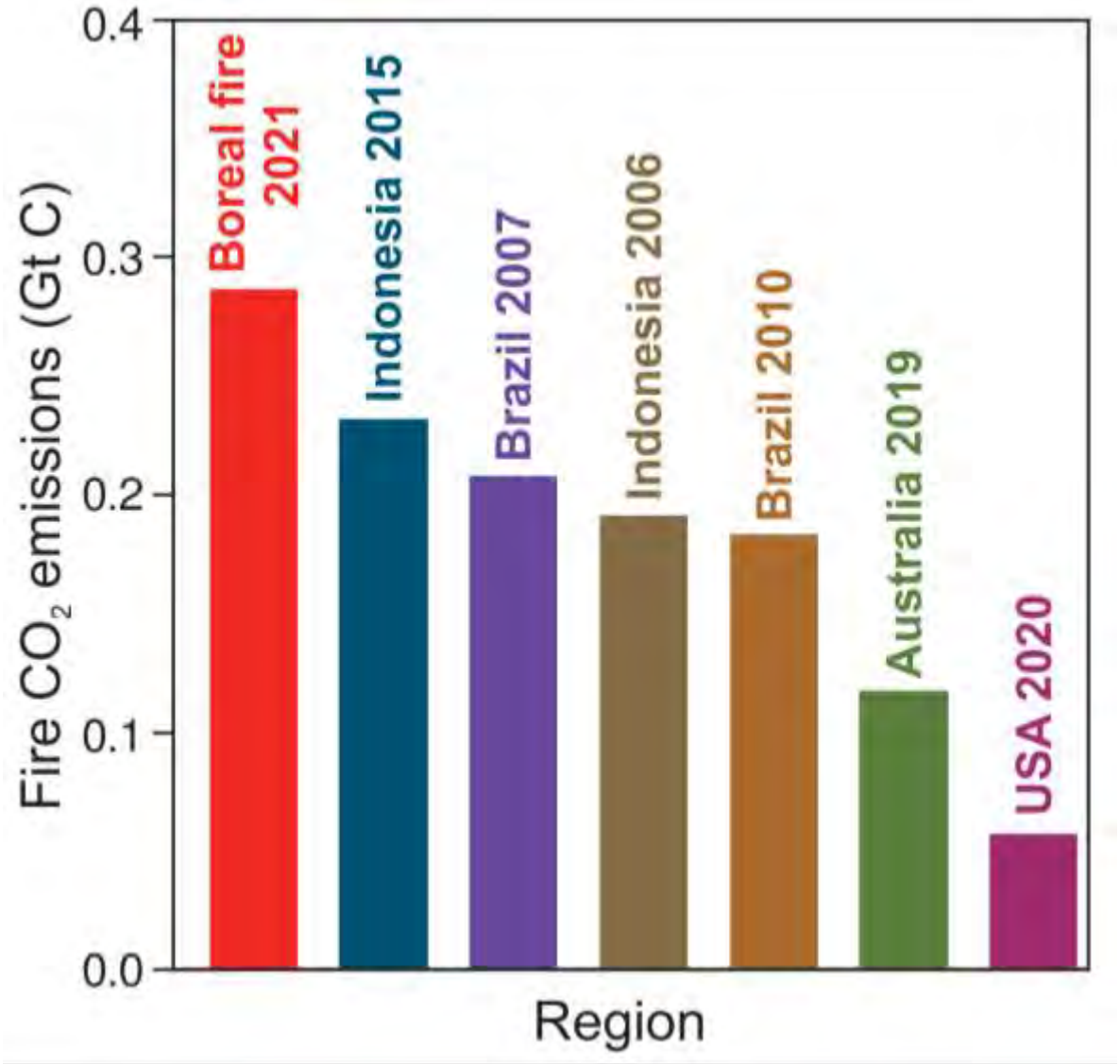
# CO fire plumes - IASI/Metop


LATMOS-ULB

CO total column (x $10^{18}$ molec/$cm^2$)

3 4 5 6 7 8 9

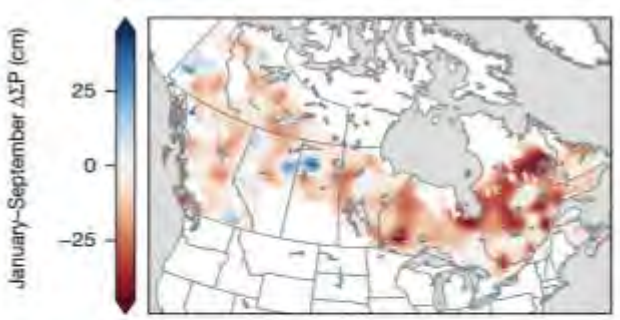
# Record-high CO2 emissions from boreal fires in 2021



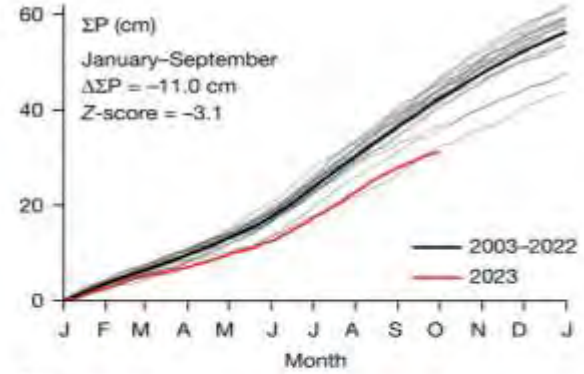

Comparisons of emission anomalies from boreal fires in 2021 with those from other large extreme fire events in different years. The emission anomalies of fires shown here are calculated as the difference in emissions between the target year and the 2000 to 2020 average.
*From Zheng et al., Science, 2023*

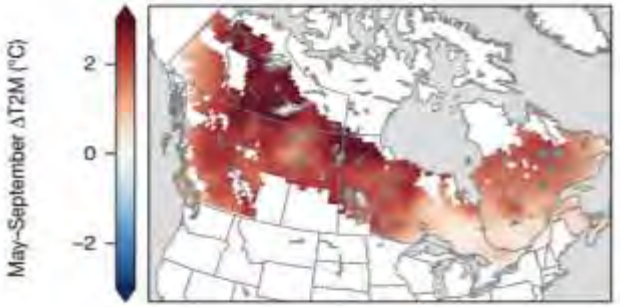
"Boreal fires, typically accounting for 10% of global fire carbon dioxide emissions, contributed 23% (0.48 billion metric tons of carbon) in 2021, by far the highest fraction since 2000."

# 2023 Fire Conditions vs. 2003-2022 (Byrne et al., Nature, 2024)

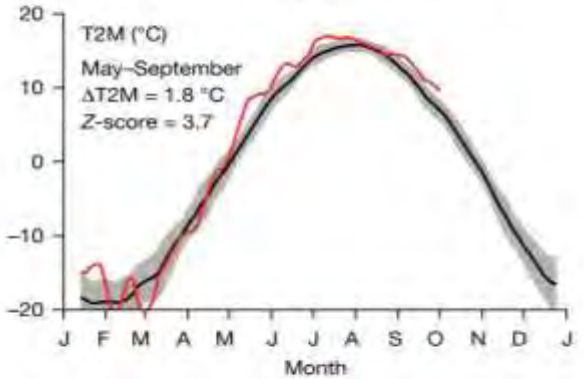


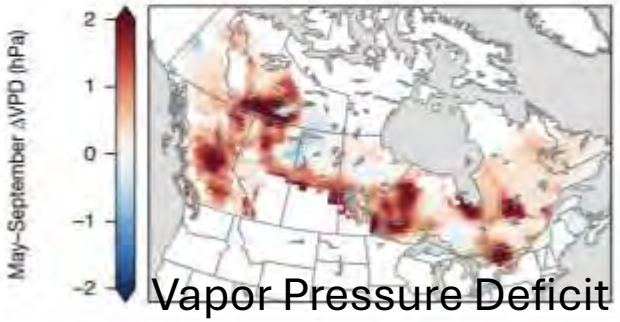

Precipitation Anomaly



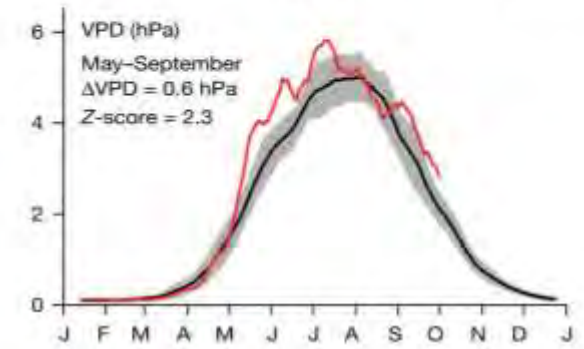




Temperature (2m) Anomaly

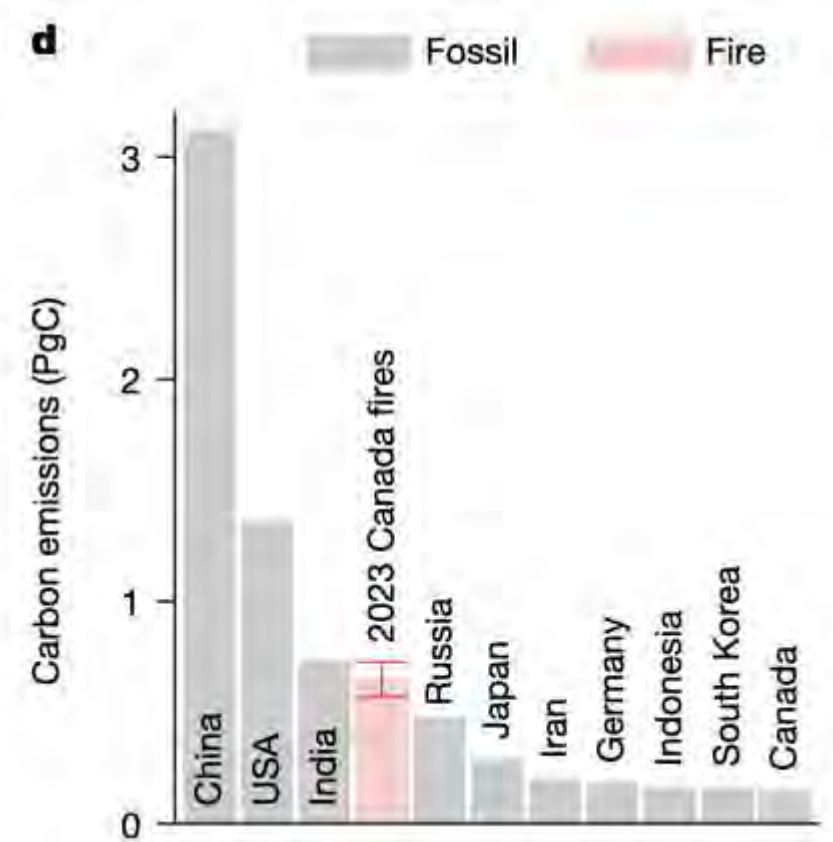


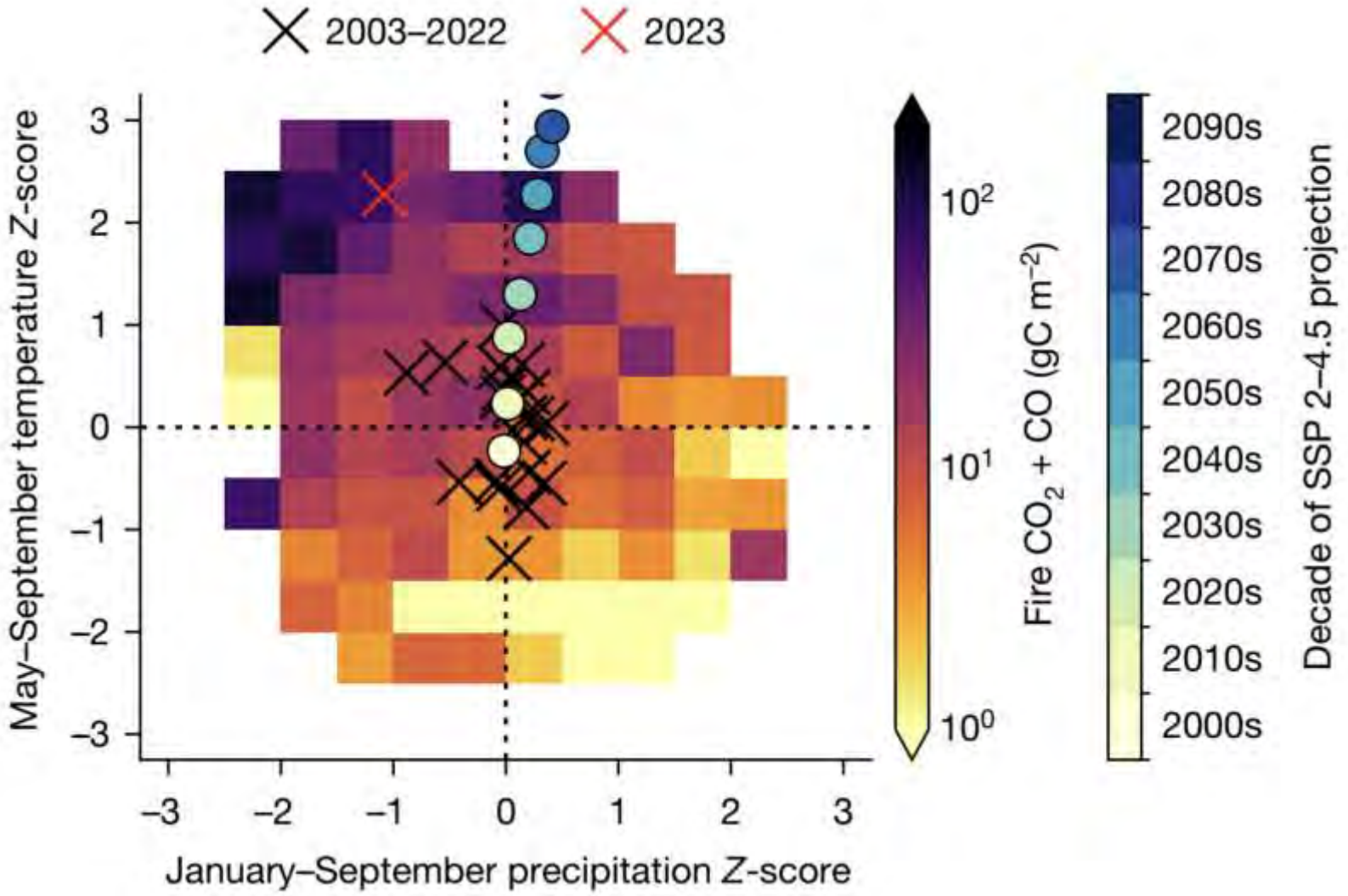

Vapor Pressure Deficit (VPD) Anomaly

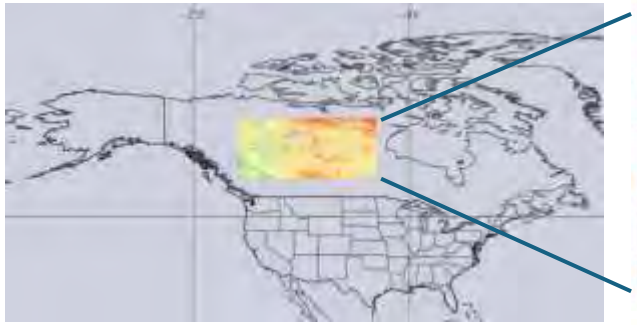



2023 Canadian Fire Emissions compared to FF Global Carbon Budget 2022

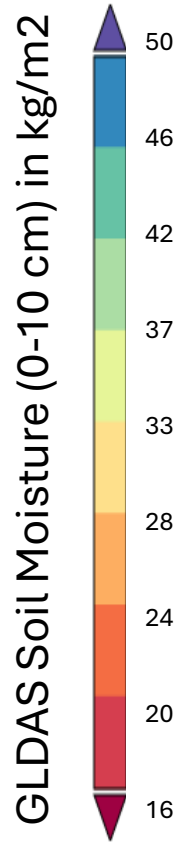


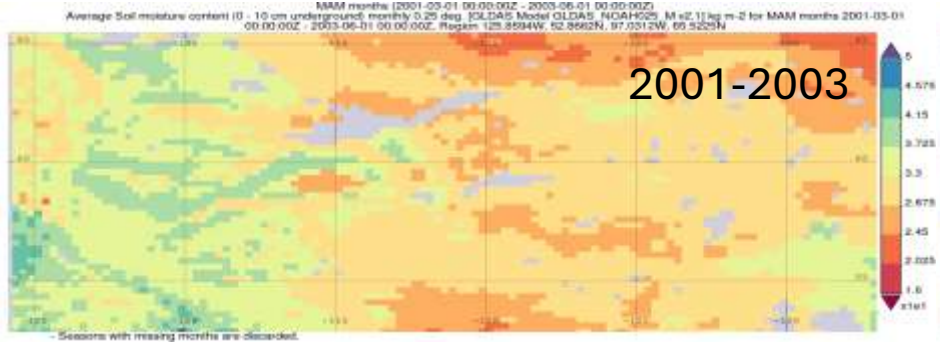
# 2023 Canadian Fires – Byrne et al, Nature, 2024

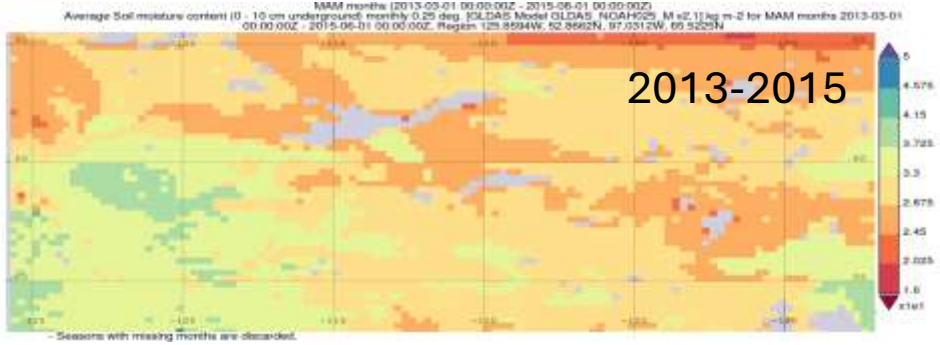


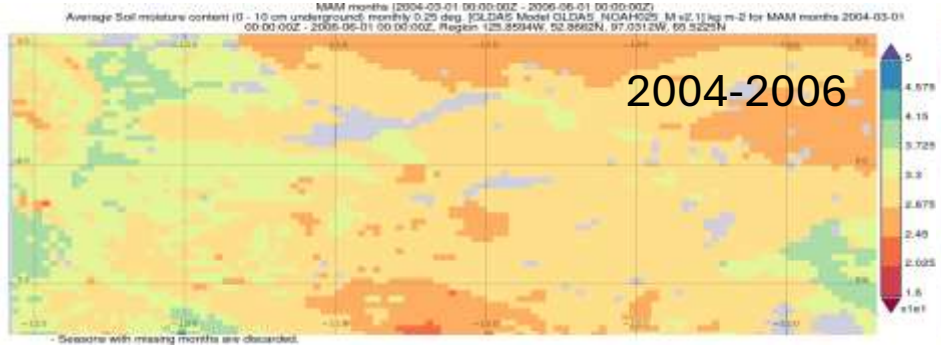


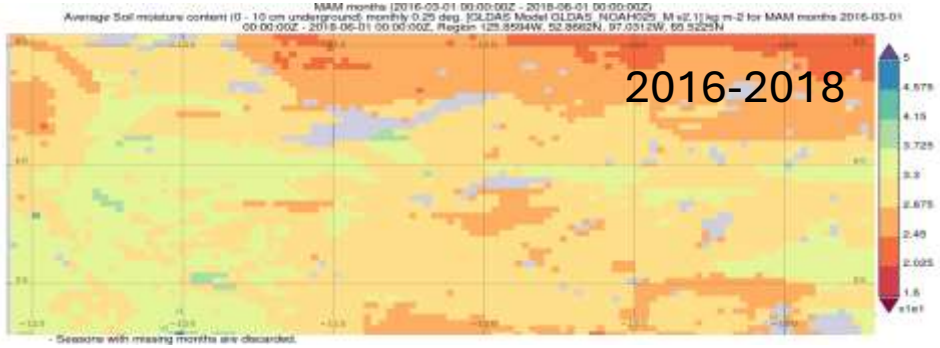
3-year Soil Moisture averages for MAM

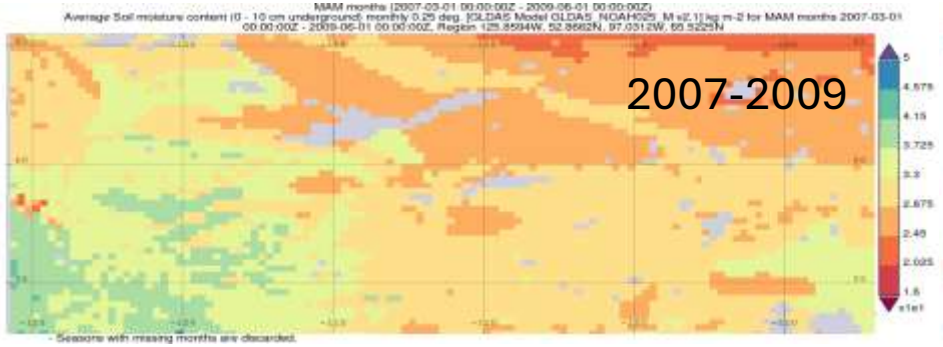


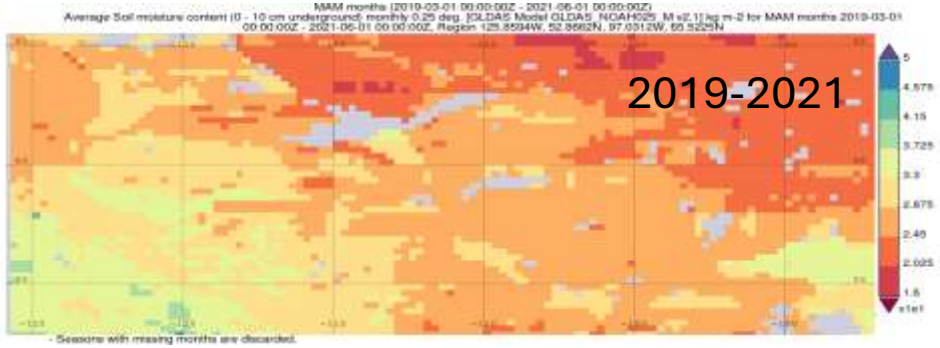



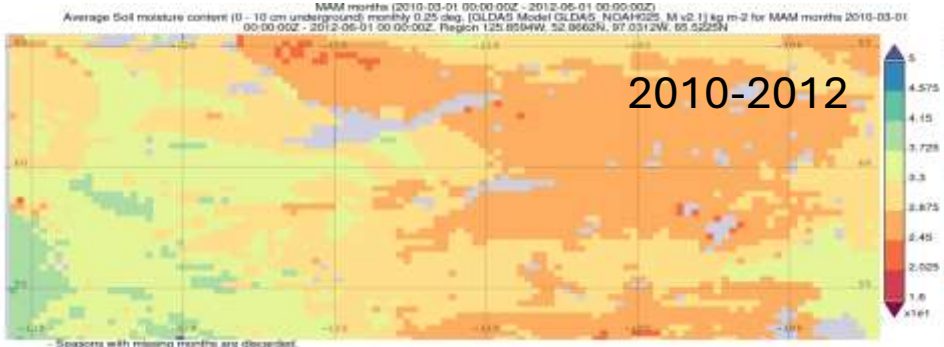



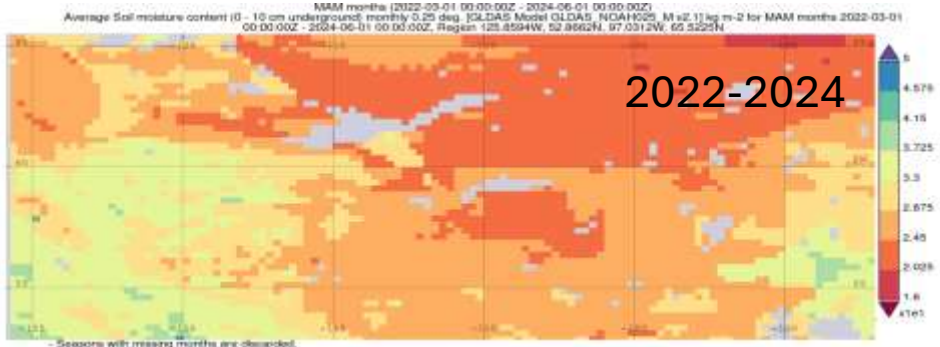



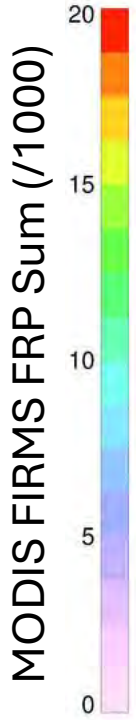



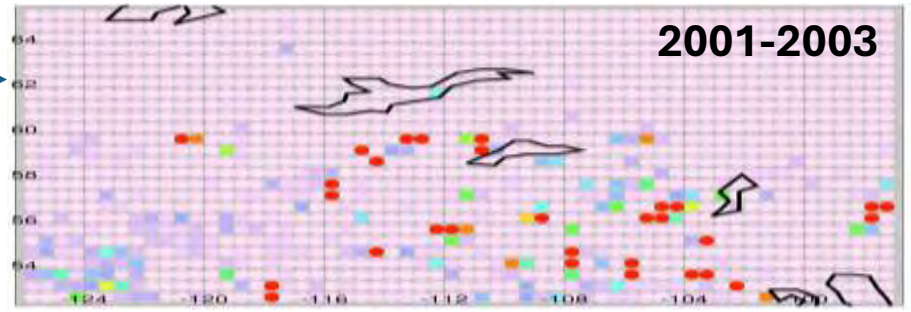



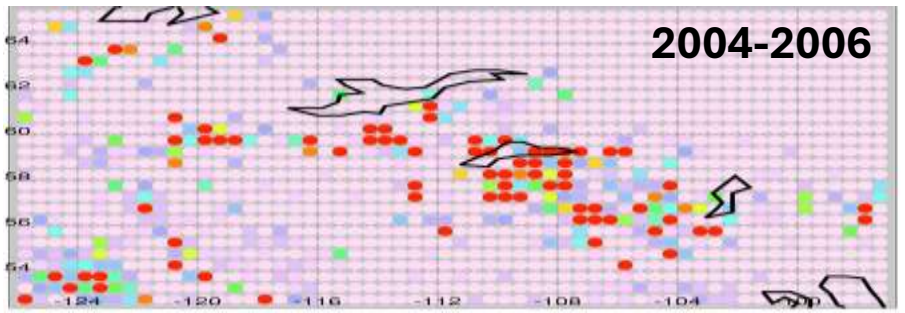



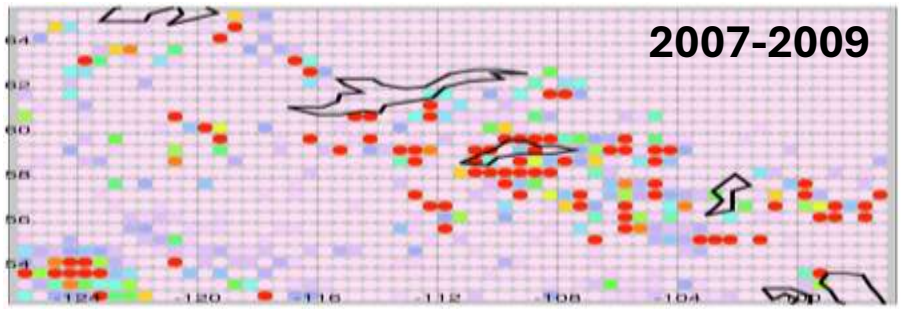

NCAR UCAR | ACOM

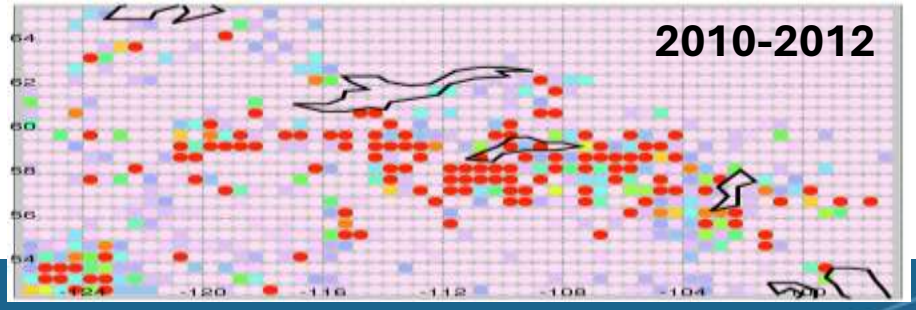
Note: 2001-2002
Terra/MODIS only

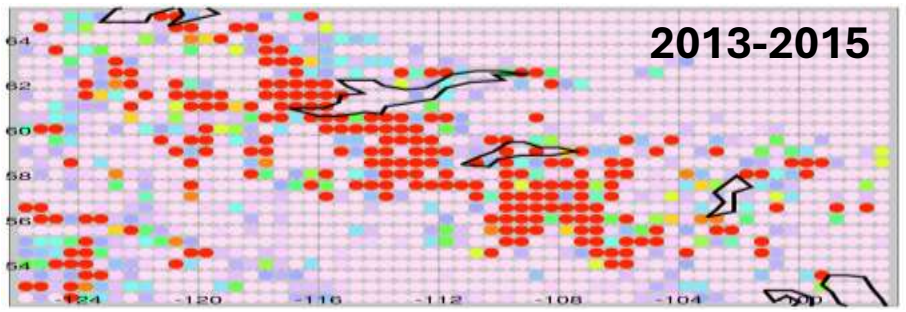


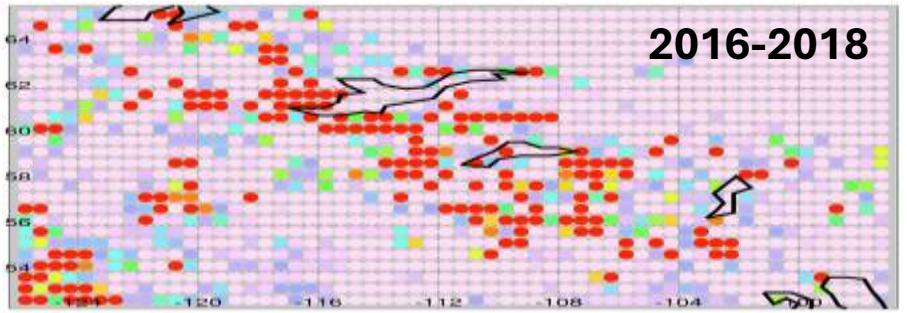



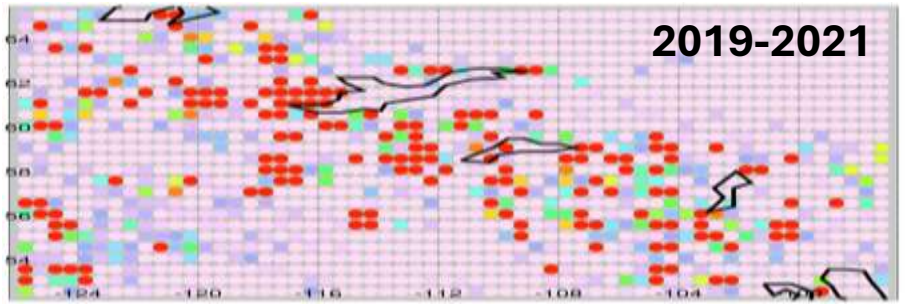



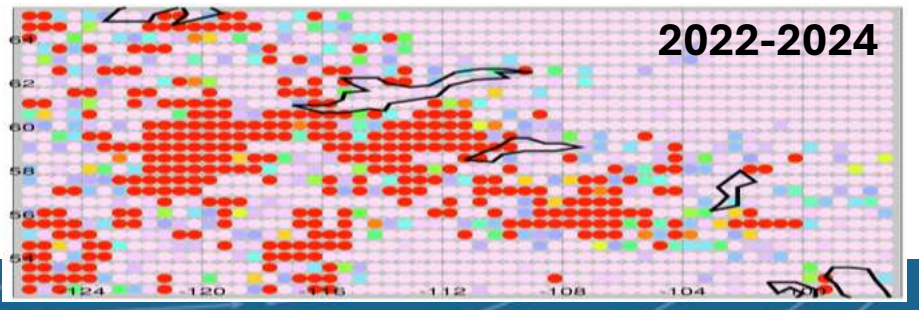



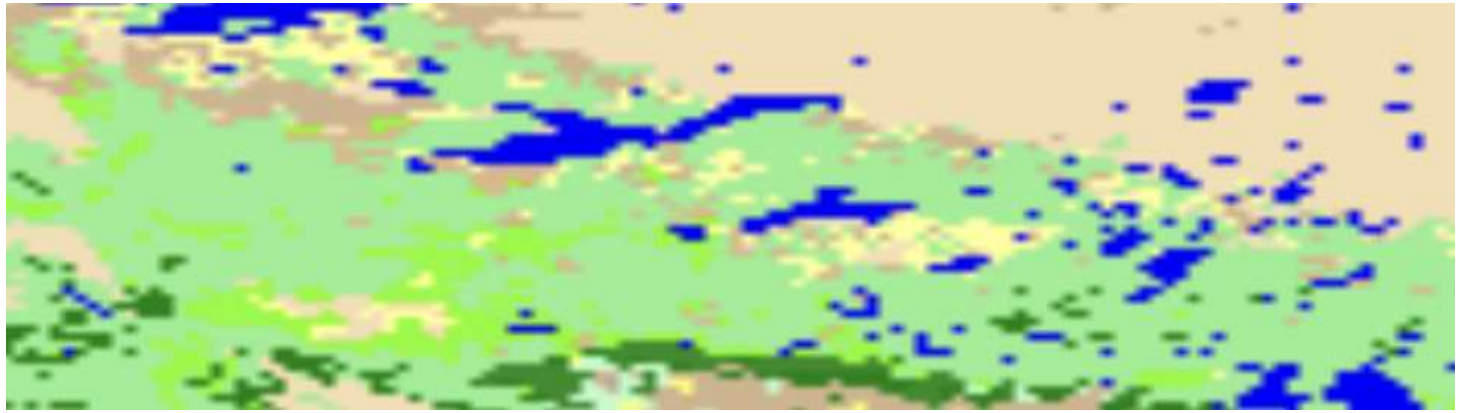



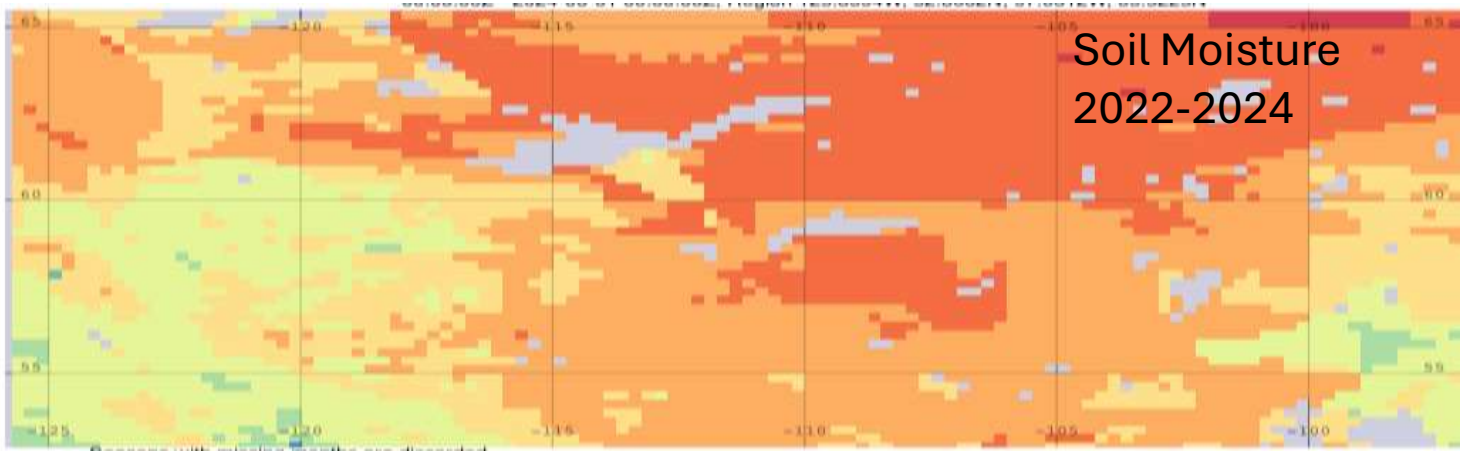



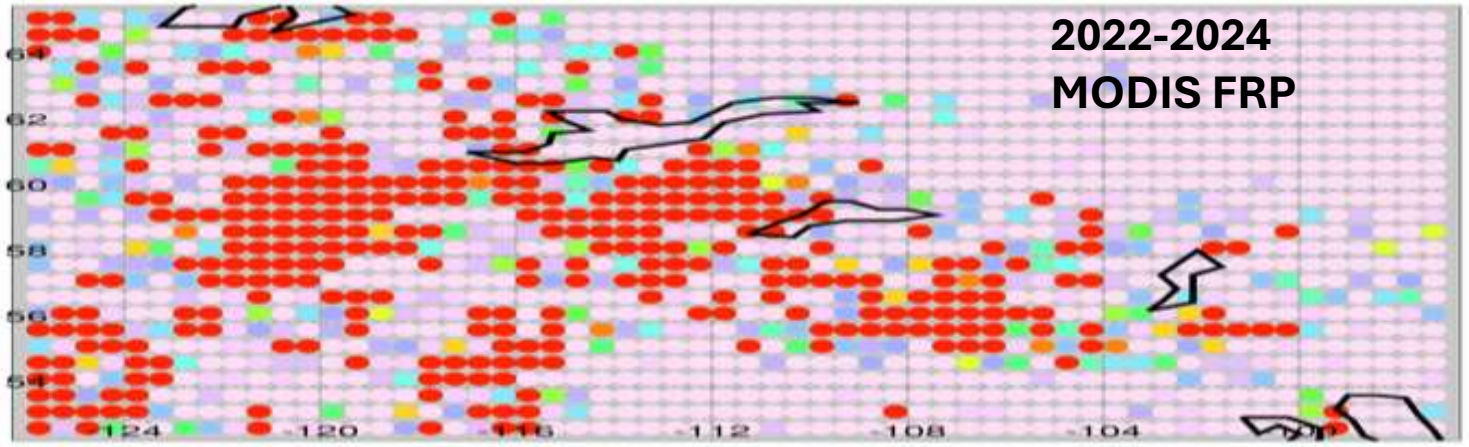



ESA Globcover project Land Cover





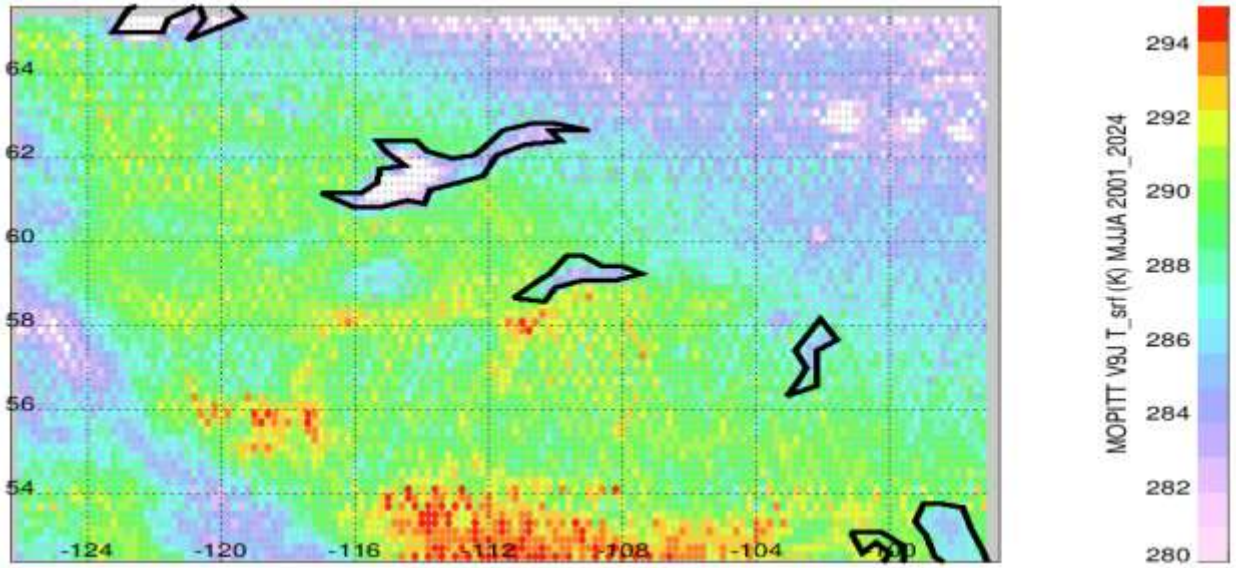
Soil Moisture
2022-2024



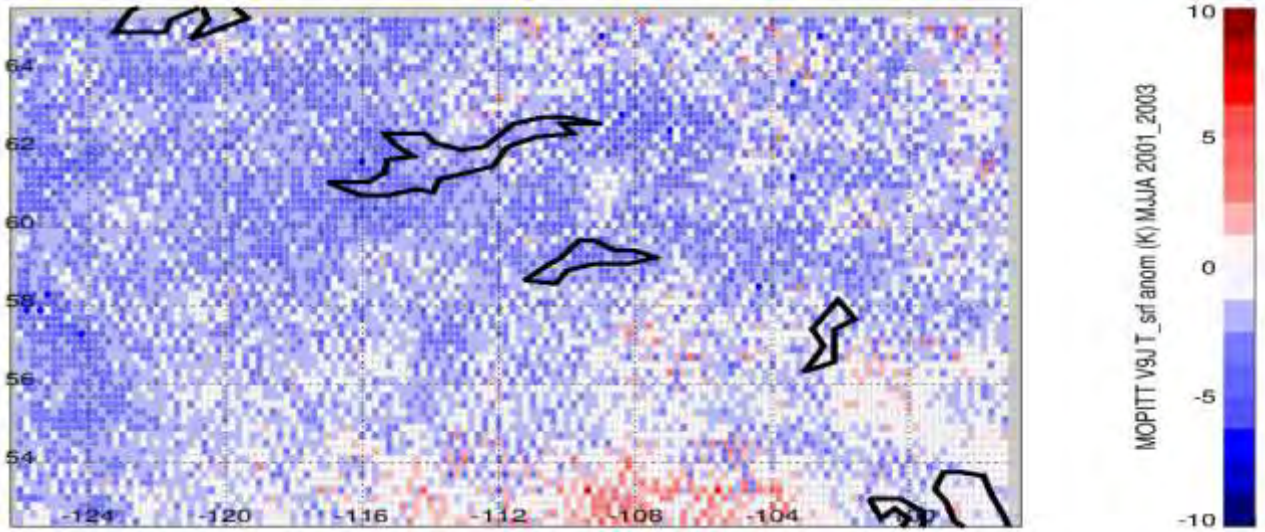
**2022-2024**
**MODIS FRP**

Post-flooding or irrigated croplands
Rainfed croplands
Mosaic cropland/vegetation
Mosaic vegetation/cropland
Broadleaved evergreen forest
Broadleaved deciduous forest
Open broadleaved deciduous forest
Closed needleleaved evergreen forest
Open needleleaved evergreen forest
Mixed broadleaved and needleleaved forest
Mosaic forest/shrubland/grassland
Mosaic grassland/forest/shrubland
Shrubland
Herbaceous vegetation/grassland
Sparse vegetation
Regularly flooded forest
Permanently flooded forest
Flooded grassland/vegetation
Artificial surfaces/urban areas
Bare areas
Water bodies
Permanent snow and ice

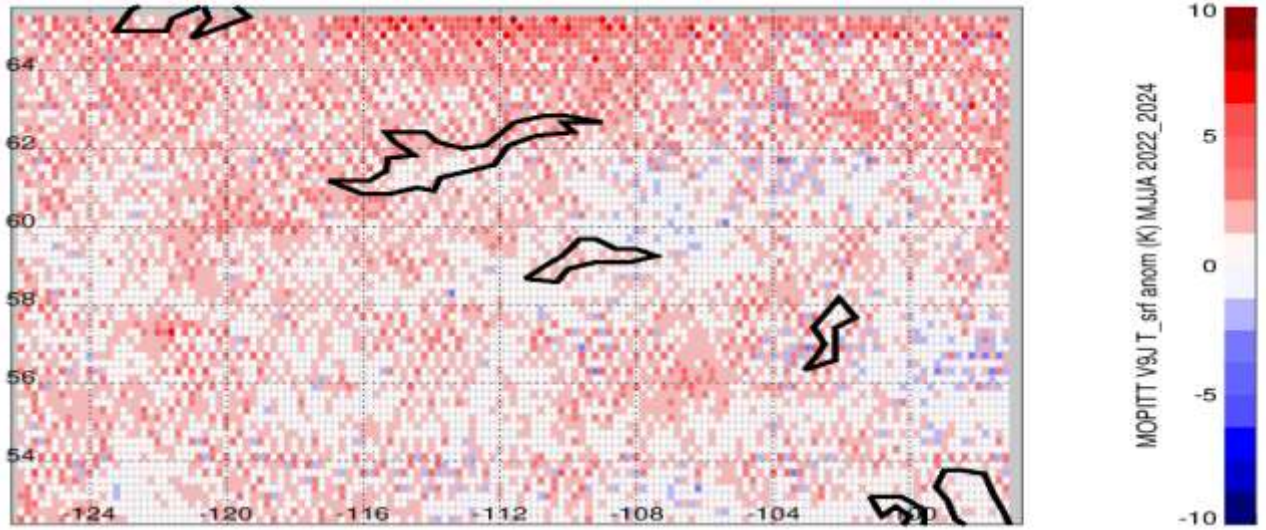
# MOPITT Surface Temperature (K)
# MJJA, 2001-2024



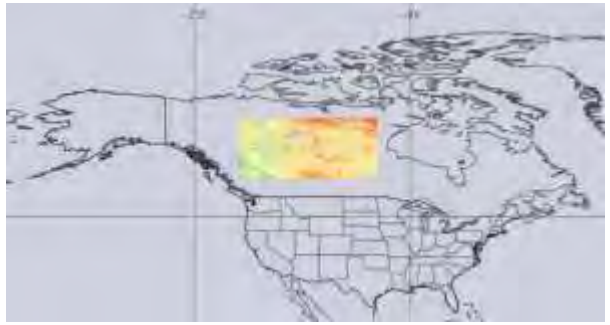

T_srf anomaly (K), 2001-2003

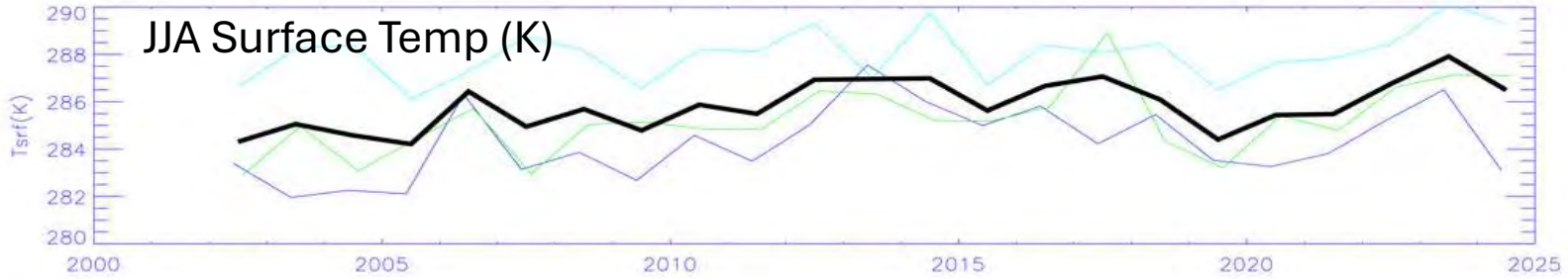


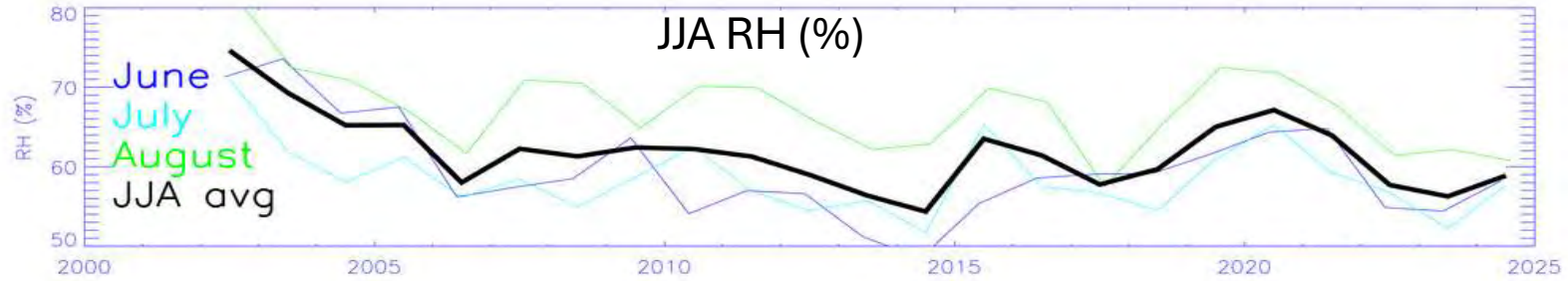

T_srf anomaly (K), 2022-2024

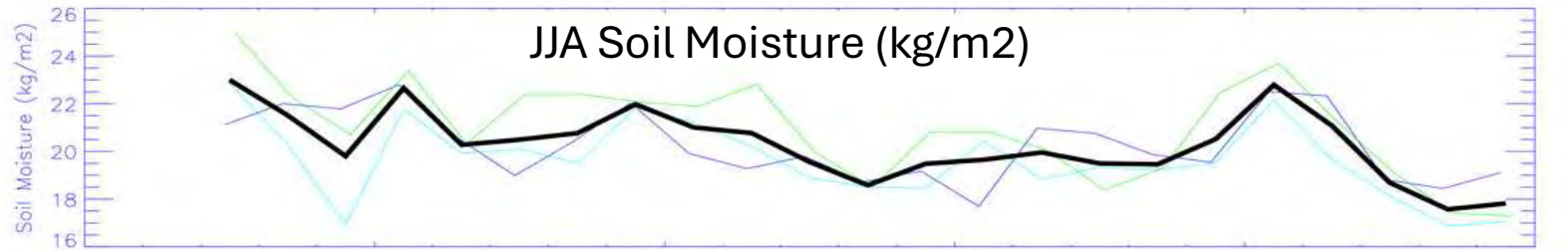


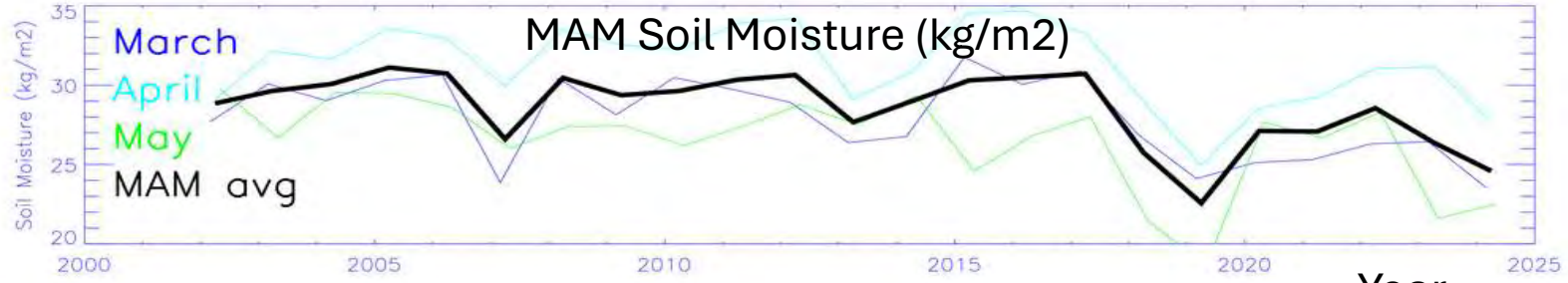
Time series for
97° to 126° W,
52.5° to 65.5° N





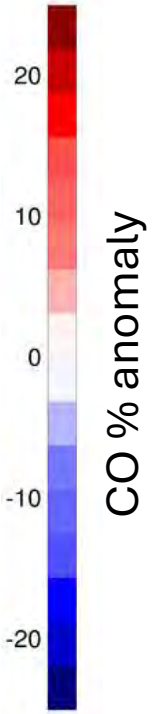



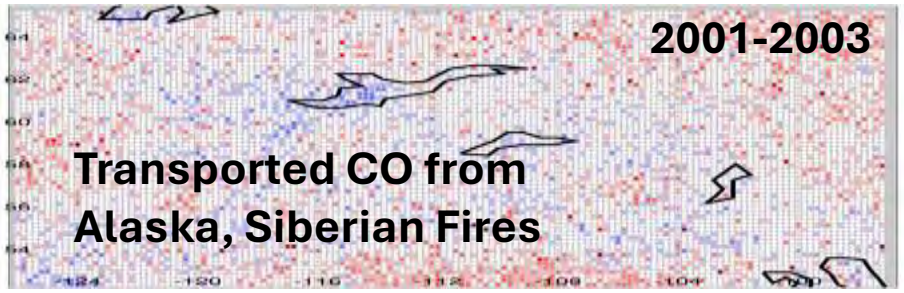



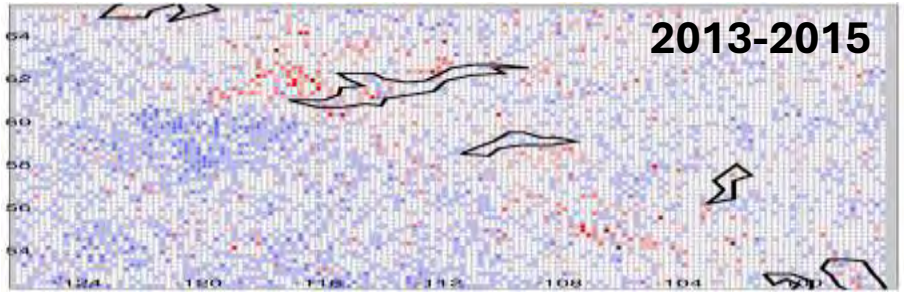



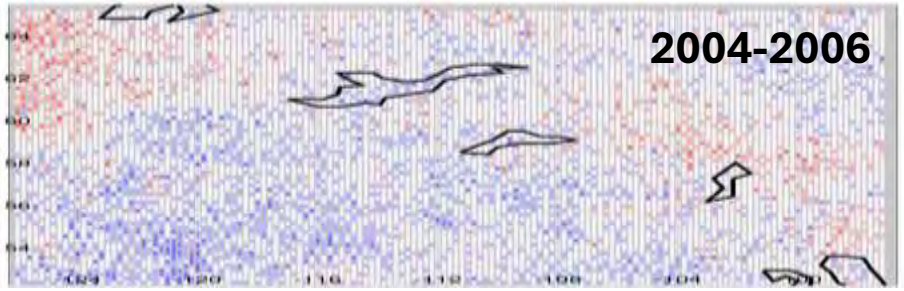

Year

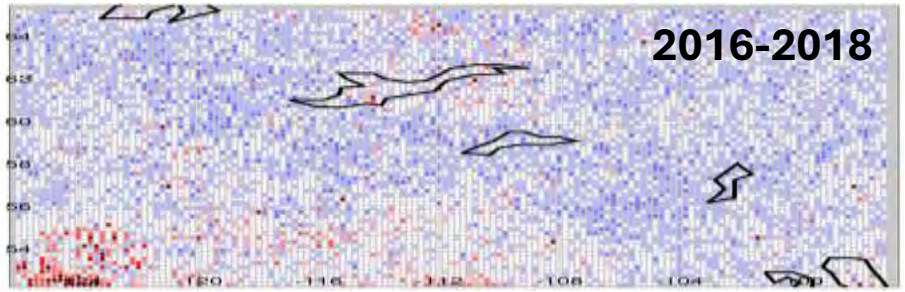
MOPITT V9J
Surface Layer CO
MJJA average
Anomaly compared to 2001-2024

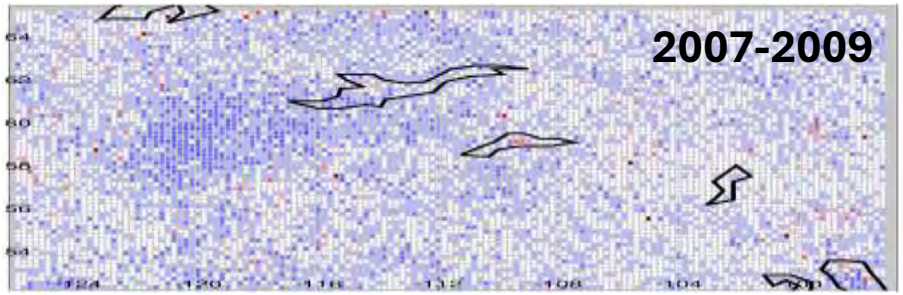


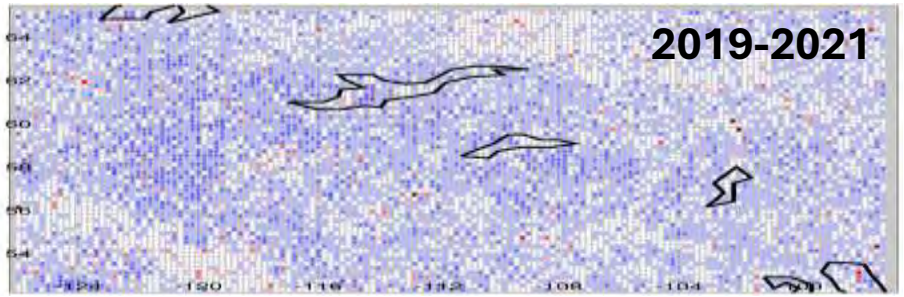



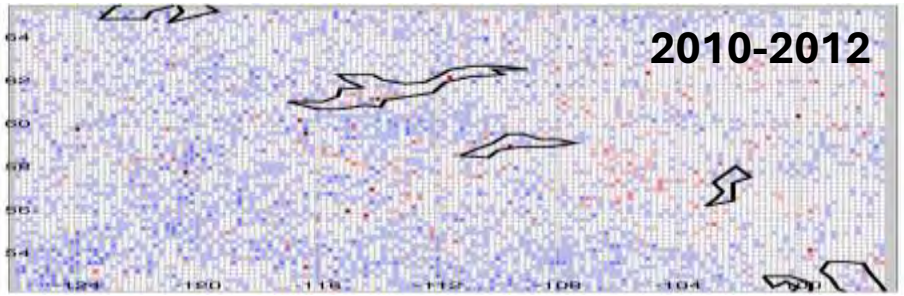



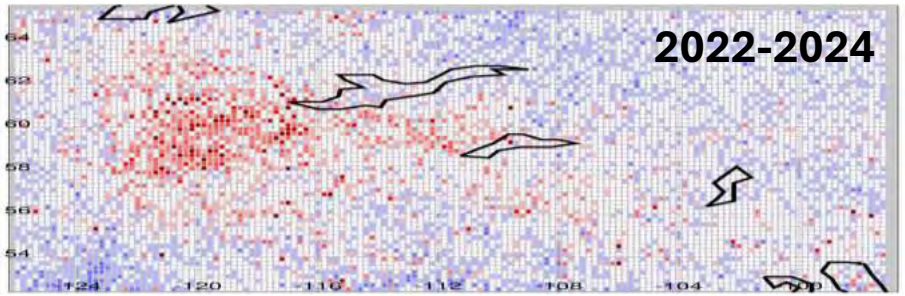



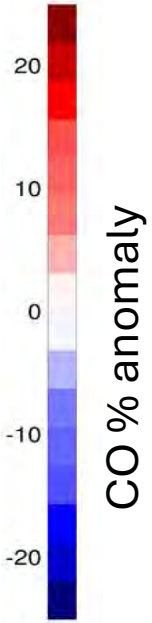



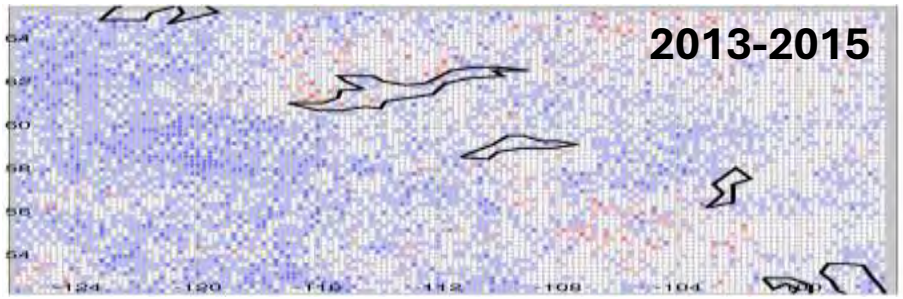



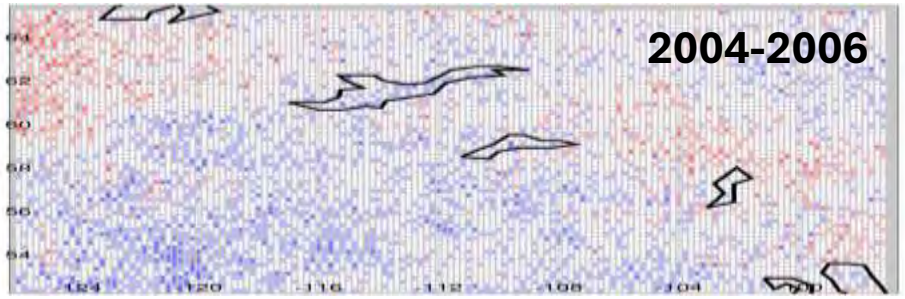



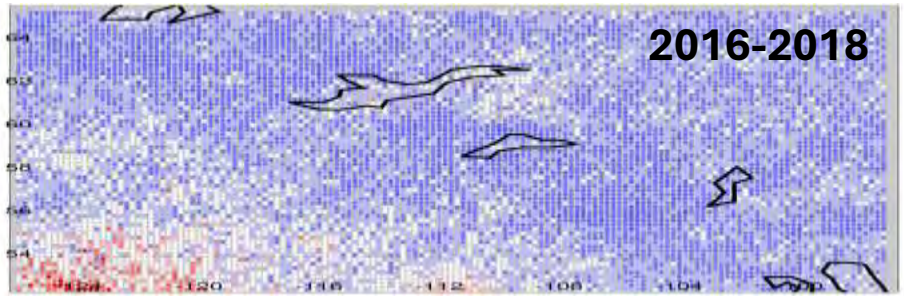
MOPITT V9J
Surface – 500 hPa
average CO
MJJA average
Anomaly compared
to 2001-2024

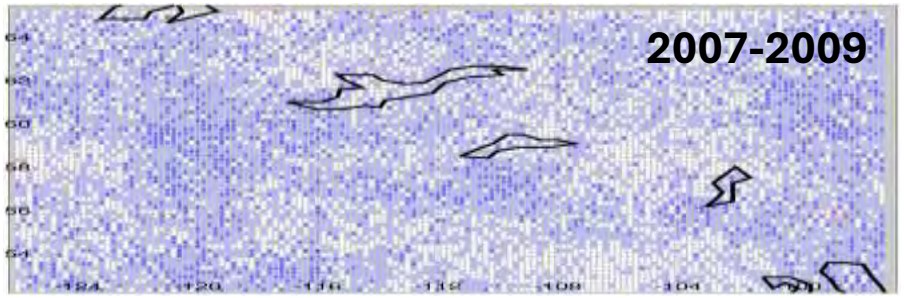


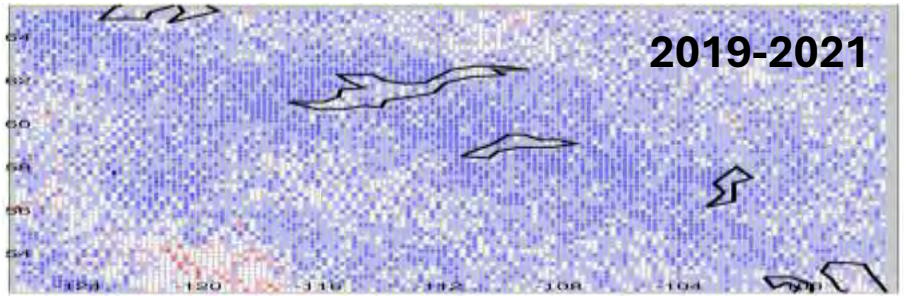


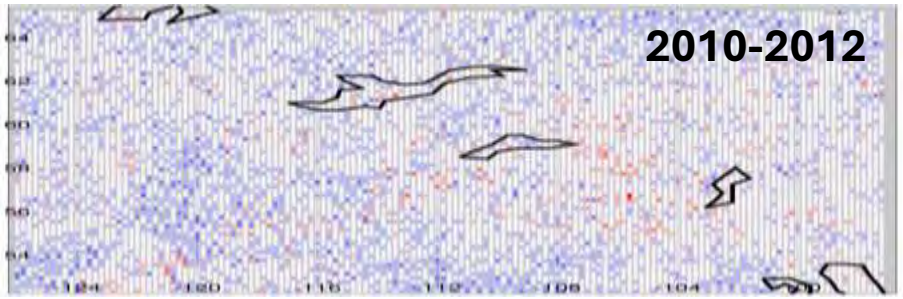


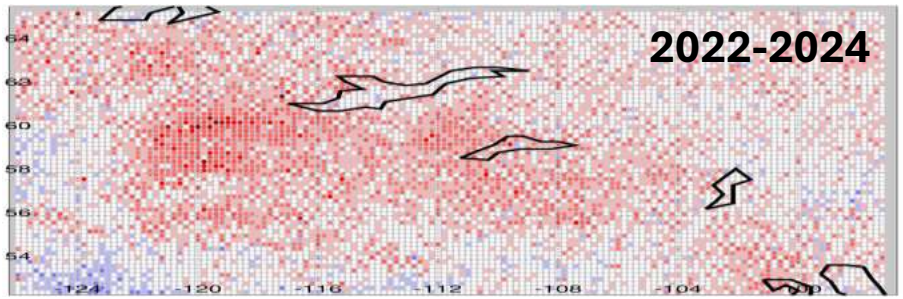



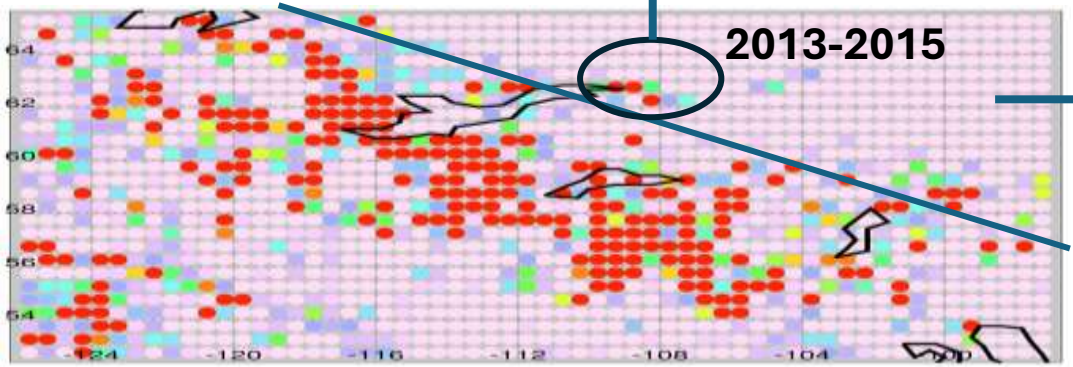



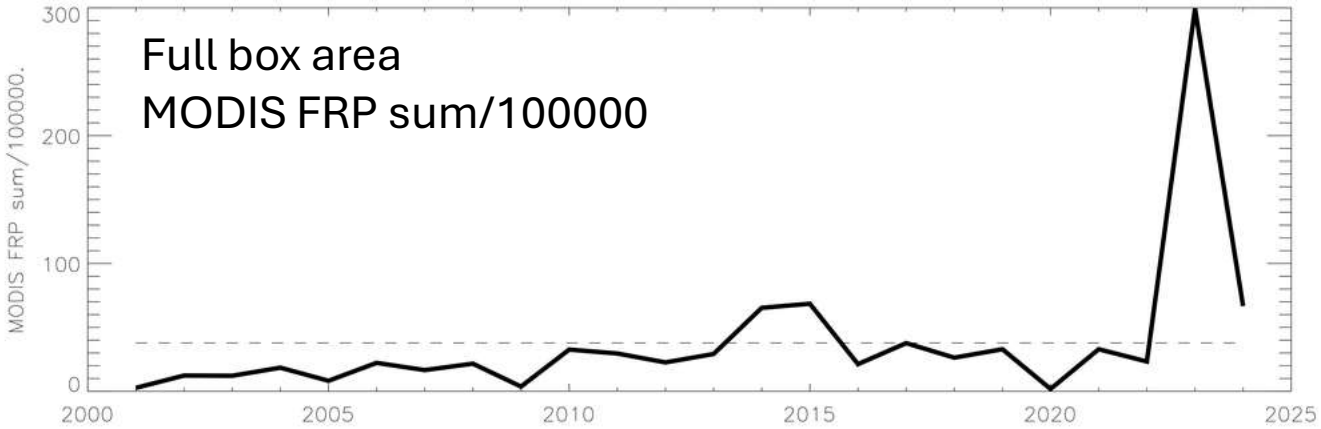



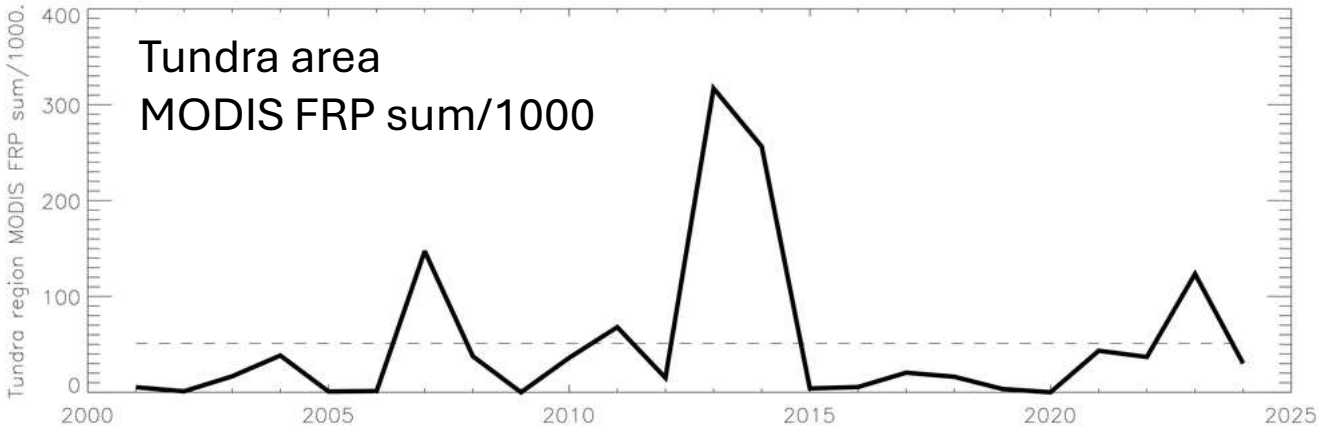



# Are we getting more fires in the tundra region?

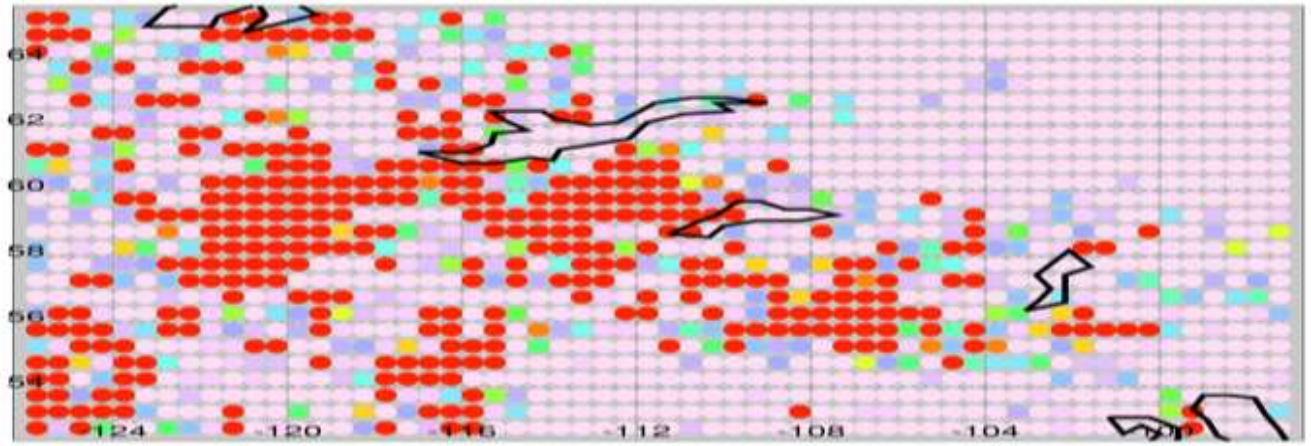




Year

# Summary & Next Steps

- 2023 was unprecedented year for Canadian fires
- General increase in fires over satellite record for region of study
- Fire increase corresponds to increasing surface temperature, decreasing in RH and soil moisture
- Not clear if fires in tundra region are increasing
- Future work will look at more fire condition indicators:
  - Vapor Pressure Deficit (VPD)
  - GRACE water table data
  - Water deficit (from satellite $\delta D$)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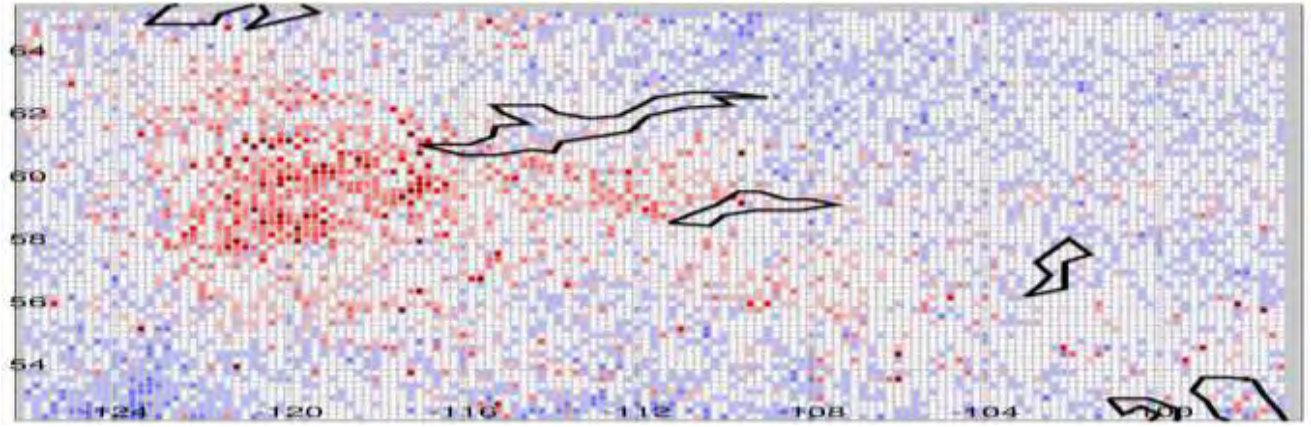
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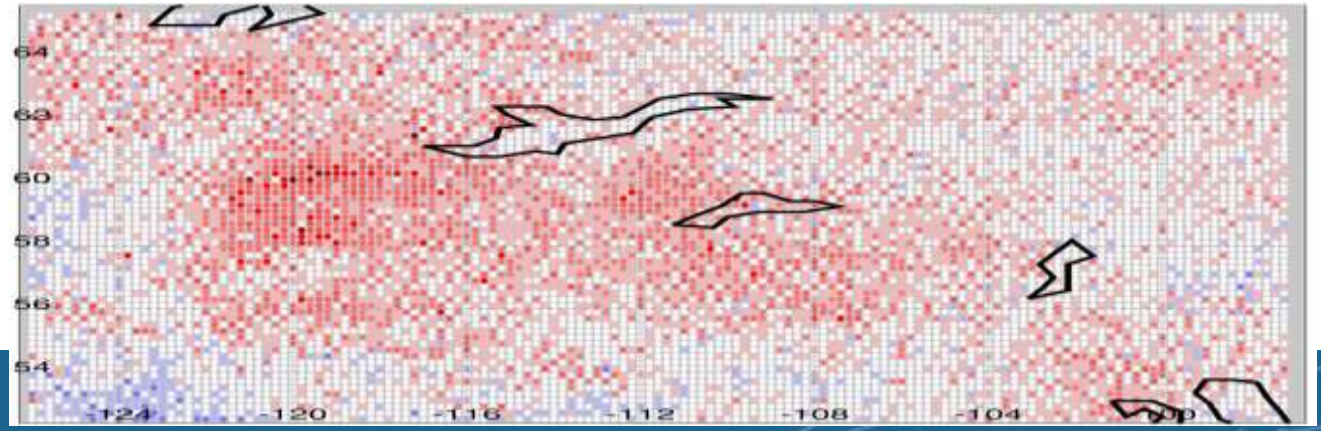
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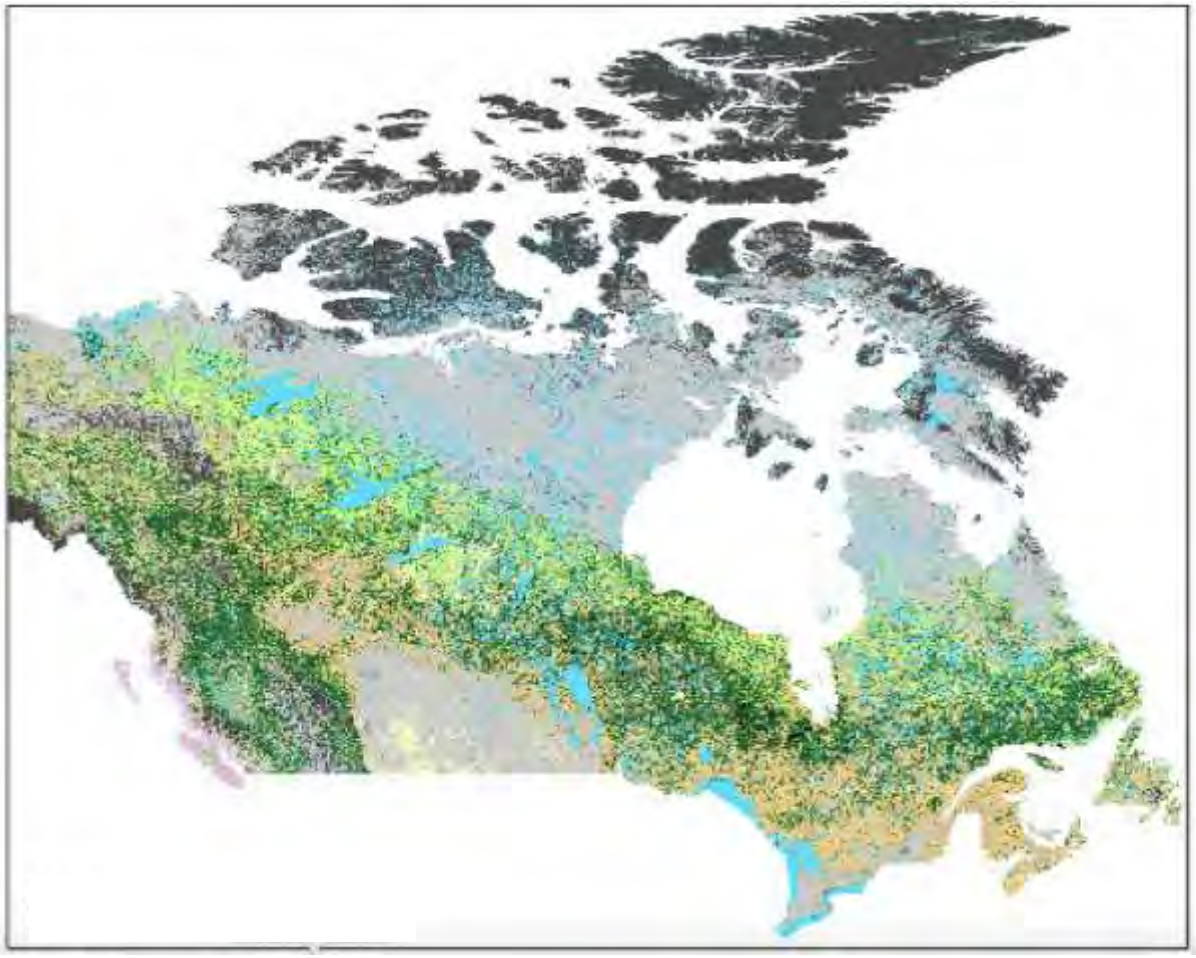
# Canadian Fire Fuel Types



| | |
|---|---|
| 122 | Vegetated Non-Fuel |
| 121 | Urban/Built-Up |
| 120 | Wetland |
| 119 | Non-fuel |
| 118 | Water |
| 116 | Matted Grass |
| 109 | Boreal Mixedwood-Leafless |
| 108 | Leafless Aspen |
| 107 | Ponderosa Pine – Doug Fir |
| 105 | Red/White Pine |
| 103 | Mature Jack or Lodgepole Pine |
| 102 | Boreal Spruce |
| 101 | Spruce-Lichen Woodland |

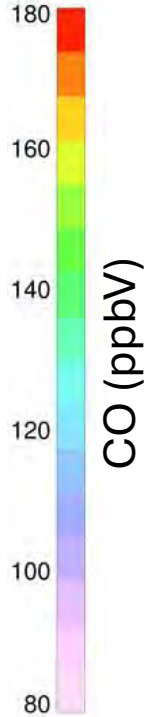


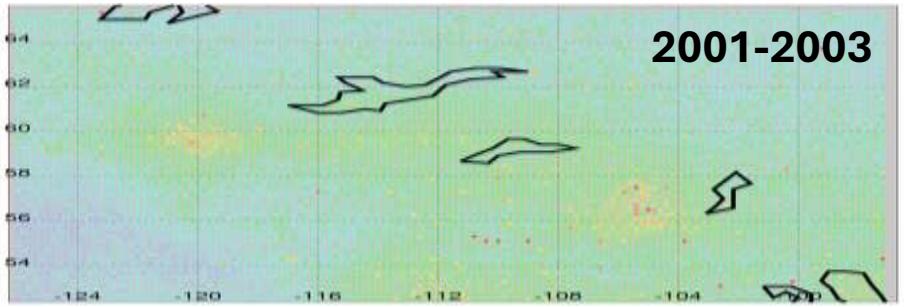
Nestola et al., Characterization of Fuel Types for the Canadian Region Using MODIS MCD12Q1 Data, *Fire, 2024*

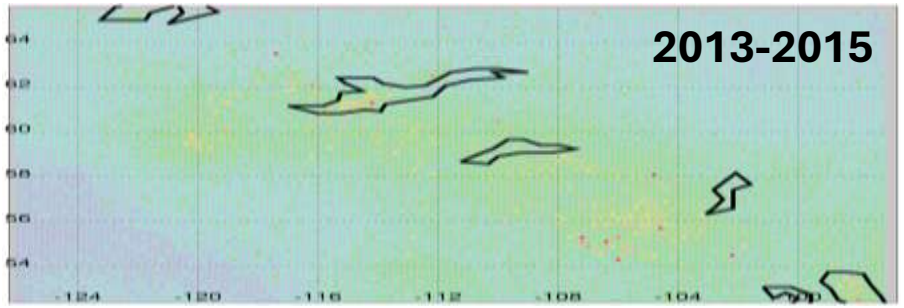
# MOPITT V9J Data

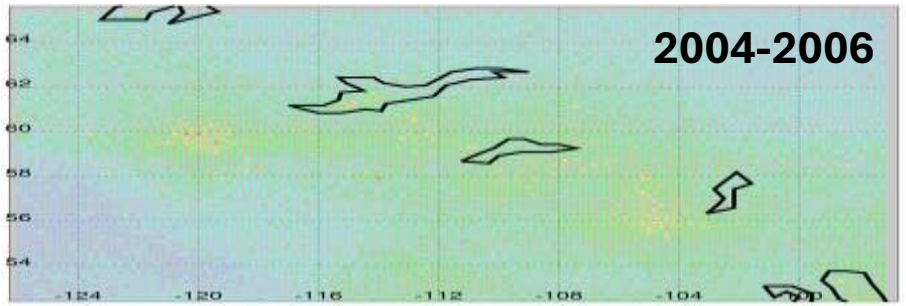
- 2001-2024
- MOPITT Side B failure in May 2001
- only 7 days with MOPITT Side A+B

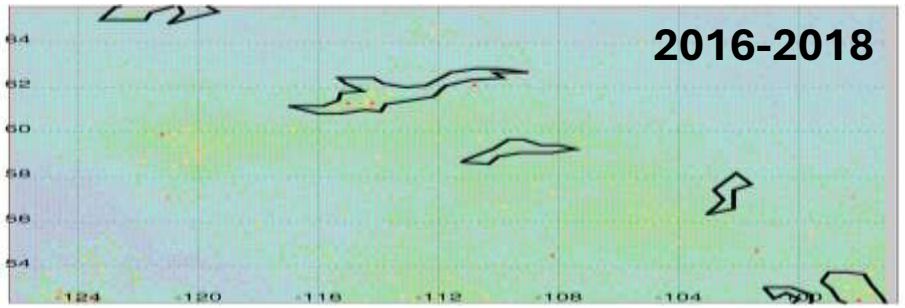
MOPITT V9J
Surface Layer CO
MJJA averages

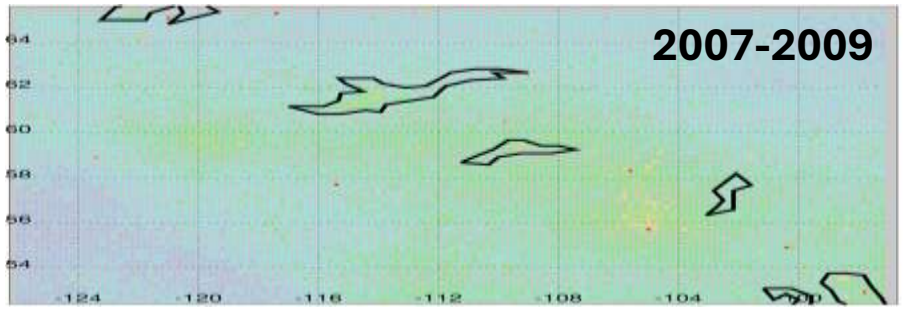


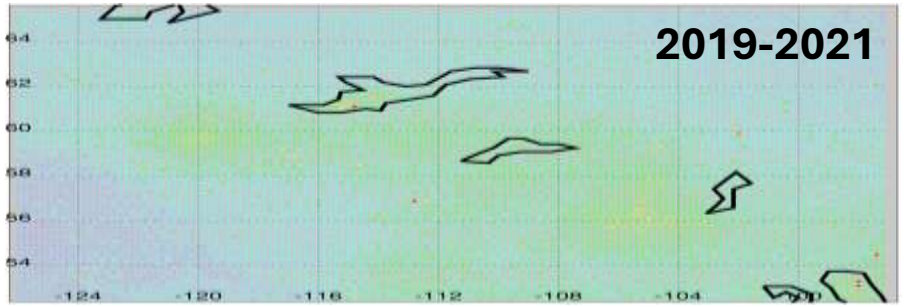



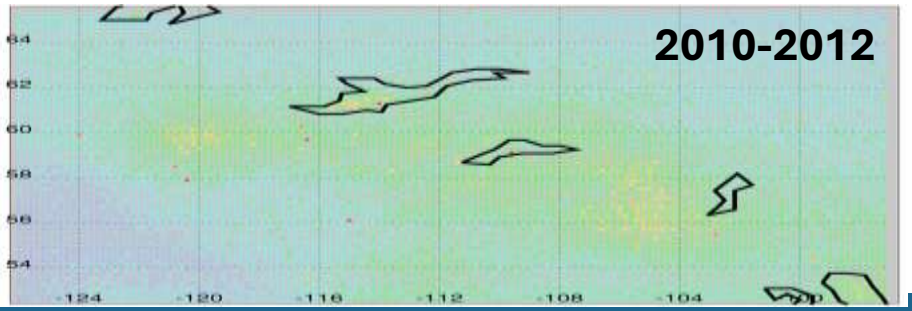



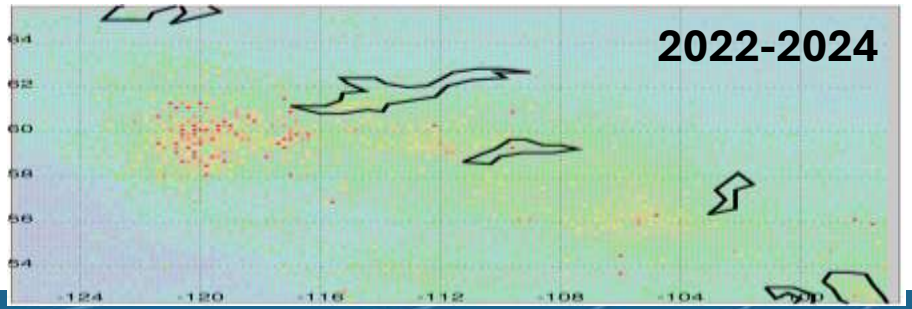



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Field, R. D. *et al.* Indonesian fire activity and smoke pollution in 2015 show persistent nonlinear sensitivity to El Niño-induced drought. *Proc National Acad Sci* **113**, 9204–9209 (2016).