Fires in the Third Pole: How coupled Atmosphere-Ocean interaction and Climate Change Fuel a Multi-System Crisis

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Wildfires : Past to Present

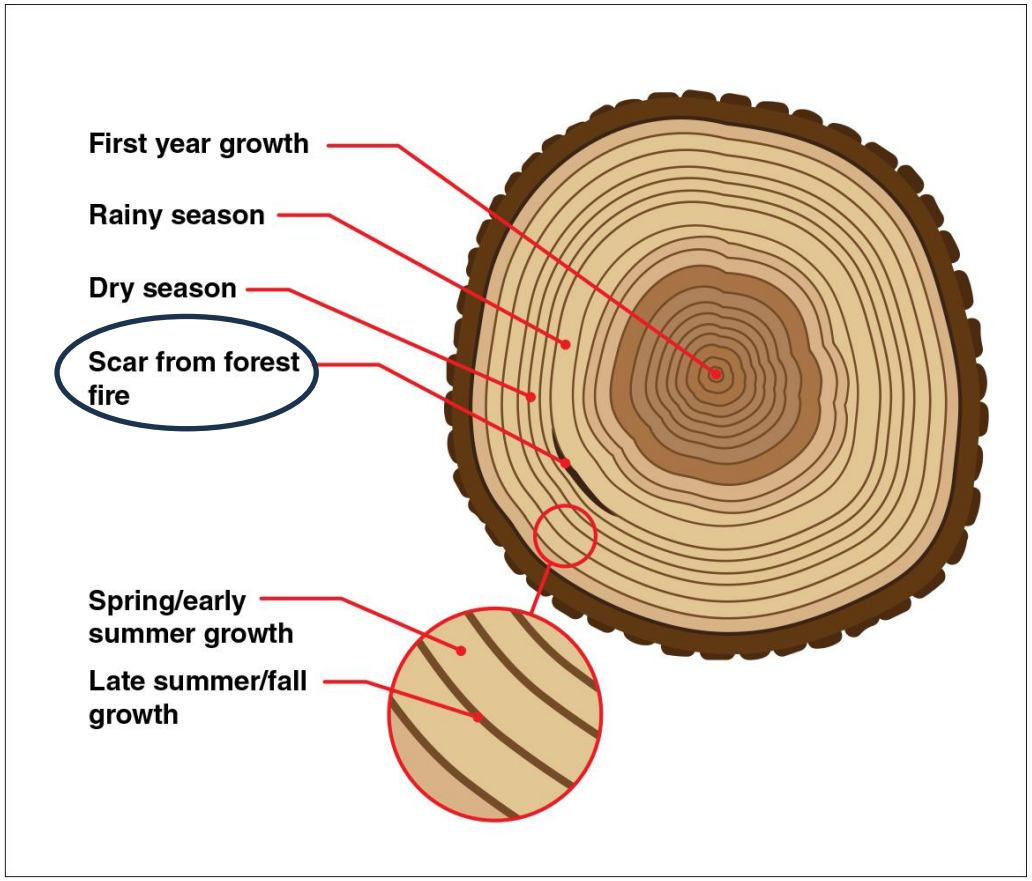
Wildfire has been an important process affecting the Earth's surface and atmosphere for **over 350 million years**, and human societies have co-existed with fire since their emergence.

A forest fire may be defined as an uncontrolled and freely spreading combustion that consumes natural fuels. When a fire burns out of control, it is known as a wildfire (India State of Forest Report)

Wildfires are affected by three factors: (a) Fuel, (b) Oxygen, and (c) **Heat – Limiting Factor**

Heat is governed by the prevailing meteorological conditions, which govern the soil moisture and the availability of moisture on the fuels.

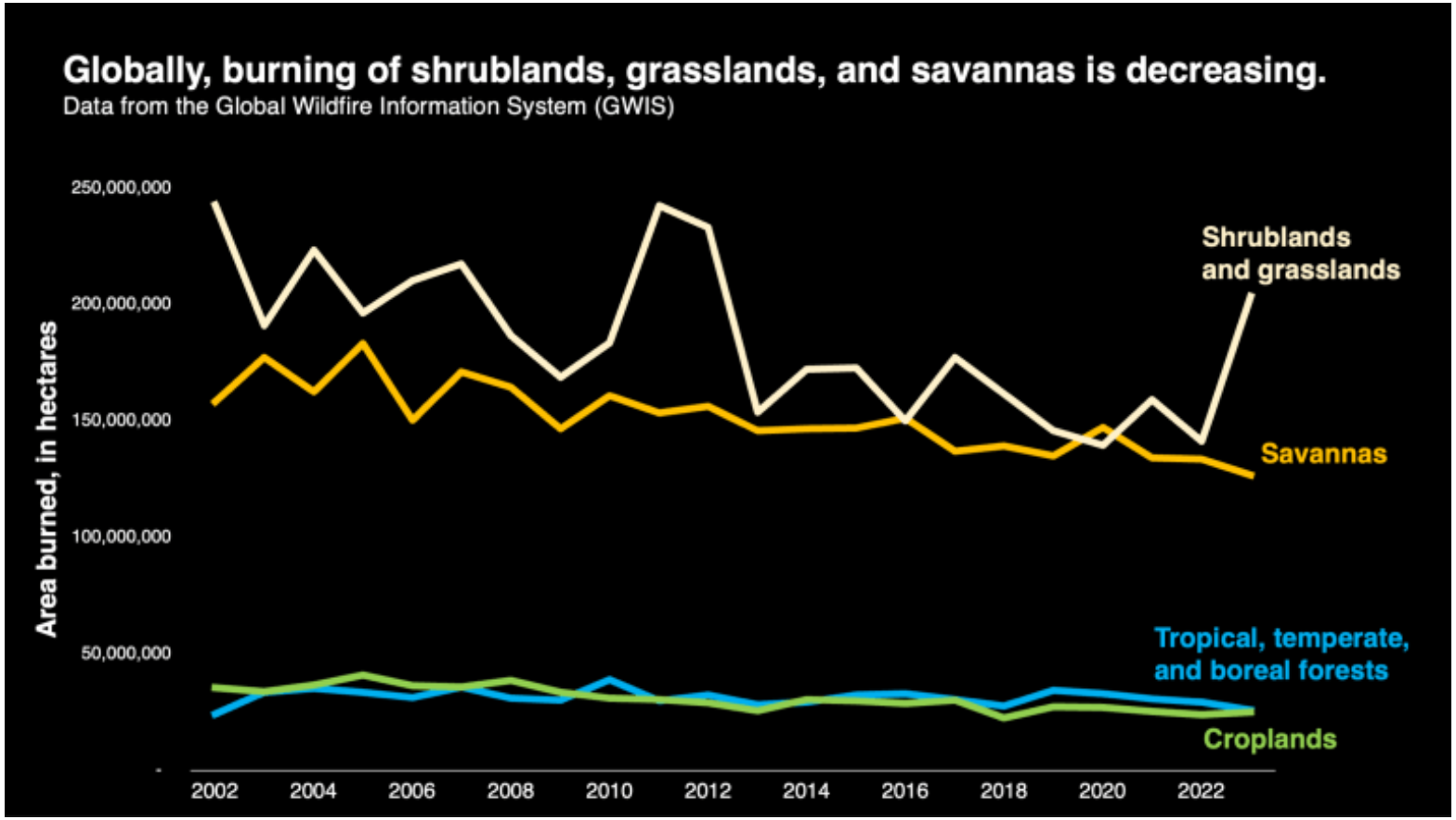
Wildfires can be natural or artificial. However, the spread of fires is governed by the local topography, prevailing meteorology and the fuel conditions.



Forest fire scars from the tree rings as paleoproxies.

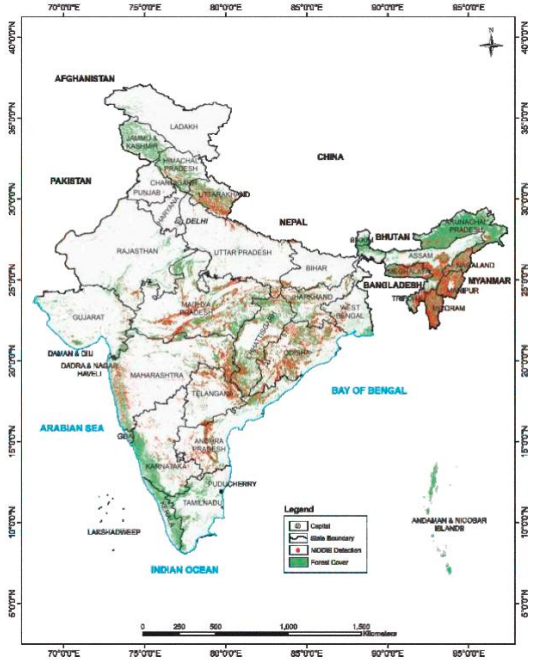
In the era of climate change and global warming, wildfires have arisen as a pressing issue across the globe, with **forested land burning at an accelerated rate**.

Wildfires burnt area

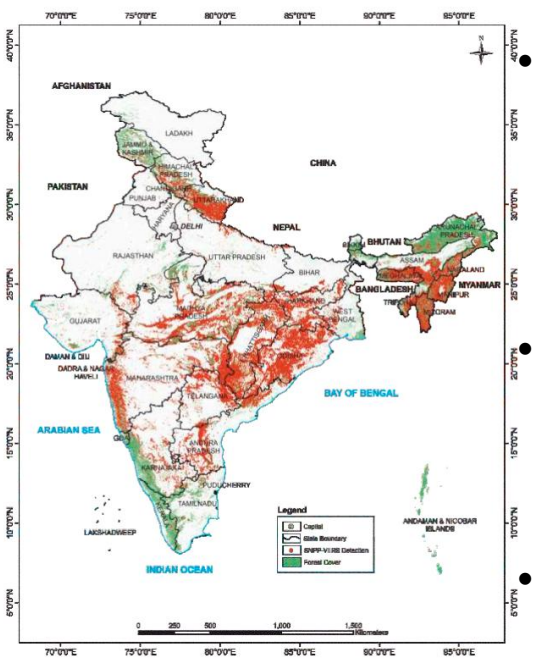


The total carbon emitted from fires is around 2 Pg C per year, due to forest accounting for an increasing fraction of burned area, which has a greater carbon emission intensity than grassland.

Wildfires in India



MODIS



SNPP

- In India 54.40% of forests are exposed to occasional fires, 7.49% to moderately frequent fires and 2.40% to high incidence levels while 35.71% of India's forests have not yet been exposed to fires of any real significance.
- Nearly 4 % of the country's forest cover is extremely prone to fire, whereas 6% of forest cover is found to be very highly fire prone (ISFR 2019).
- A number of **52,785 forest fires were detected using MODIS** (Moderate Resolution Imaging Spectro-radiometer) sensor and **3,45,989 forest fires were detected using SNPP-VIIRS** (Suomi-National Polar-orbiting Partnership - Visible Infrared Imaging Radiometer Suite)in forest fire season from Nov 2020 to June 2021.


Almora, Uttarakhand


IMD Ranichauri, Uttarakhand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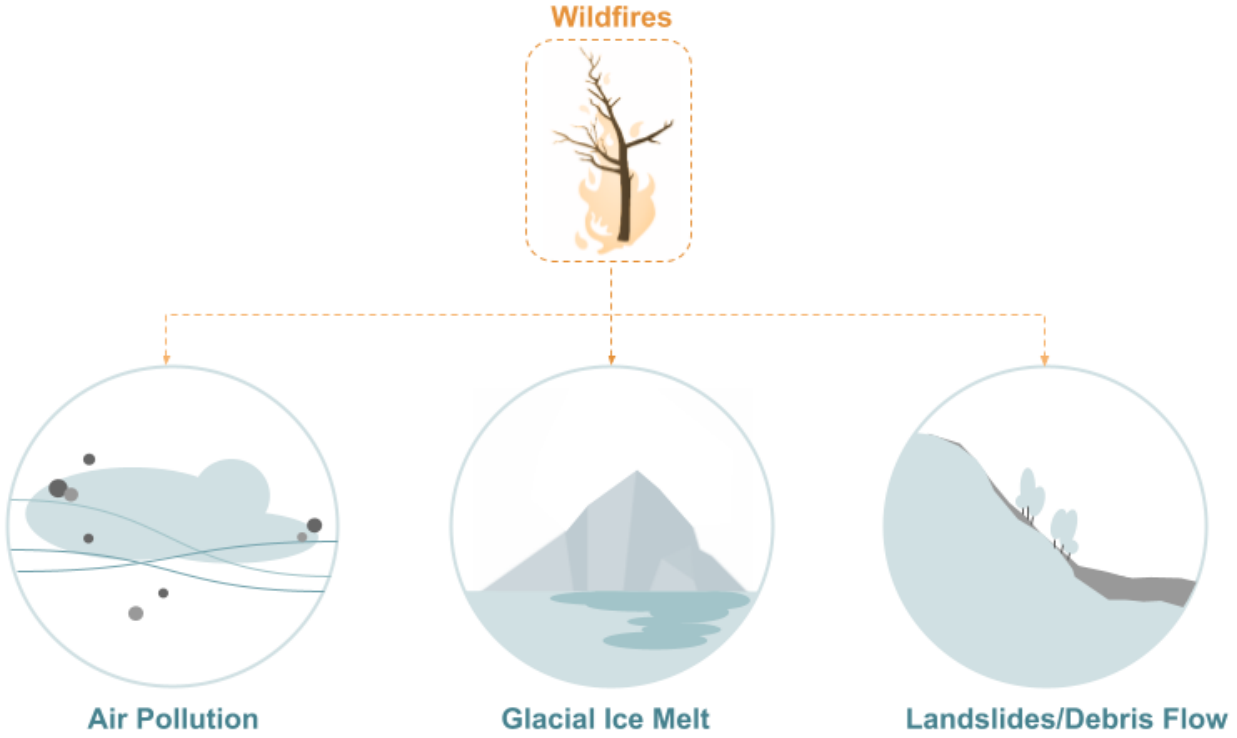
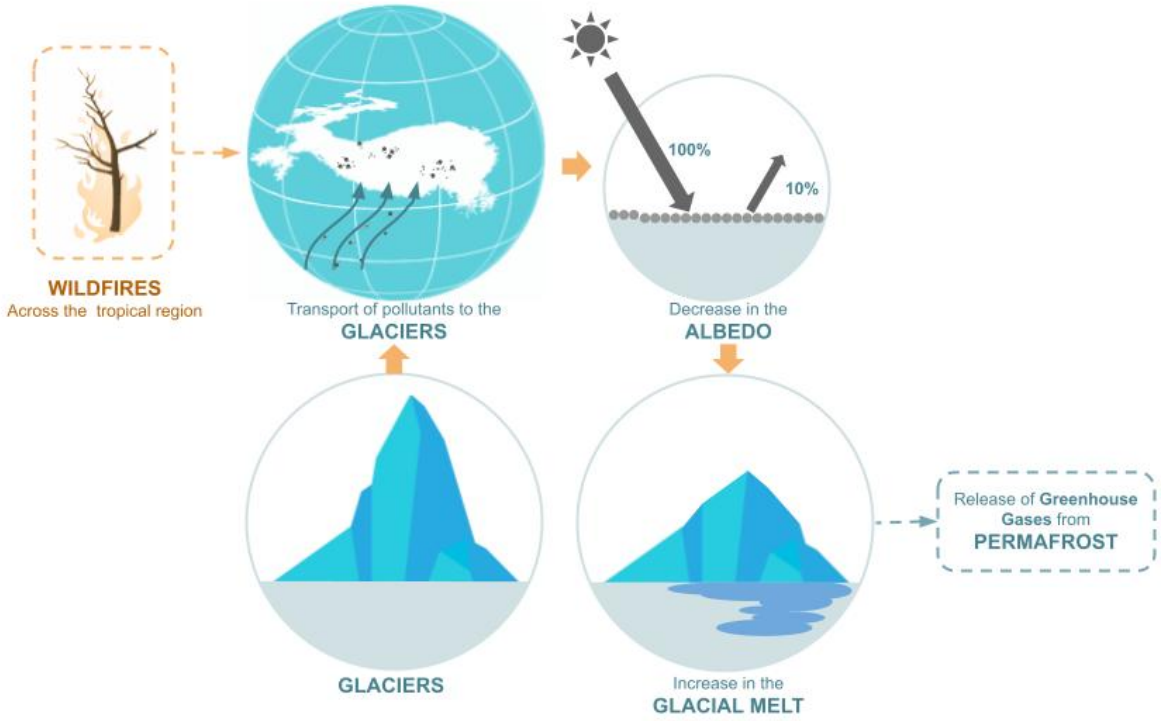
Impacts of Wildfires: Multi-System Crisis





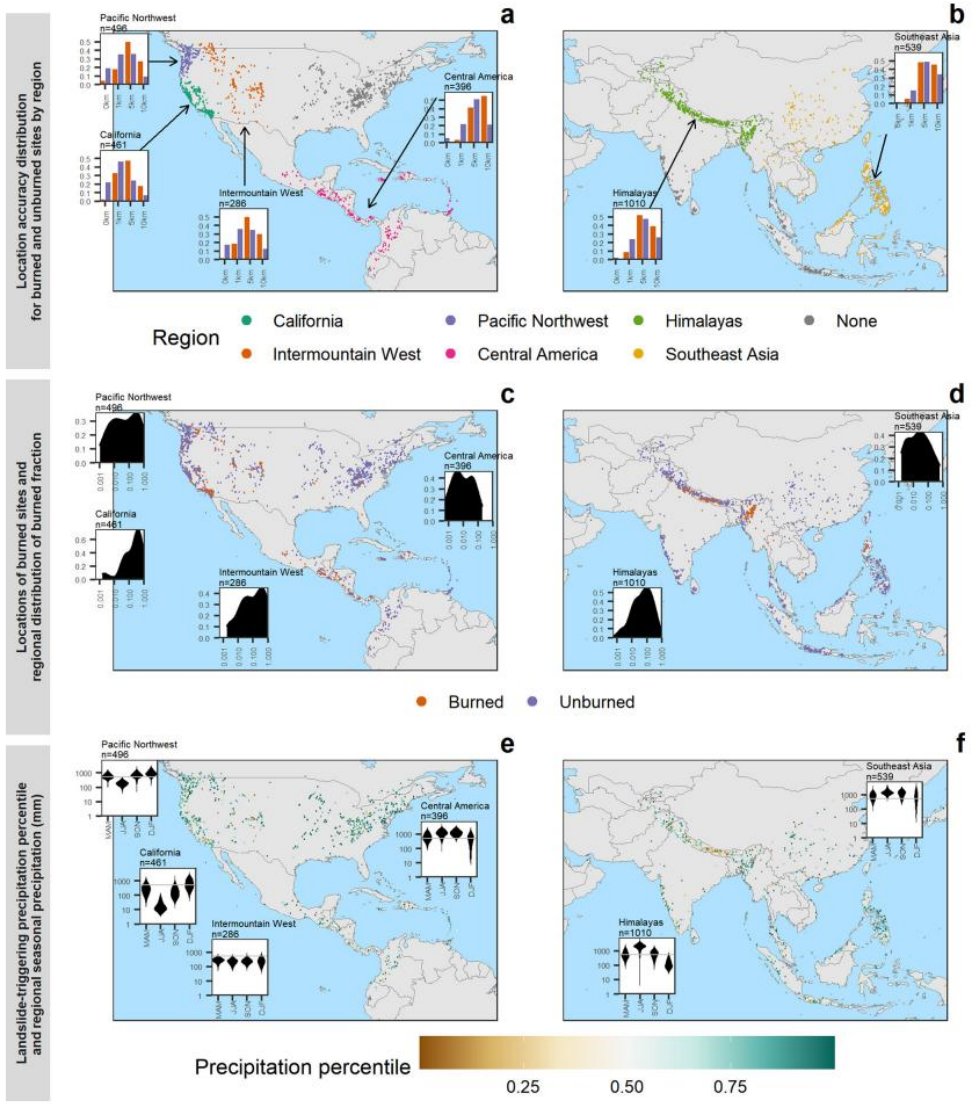
The effects of black carbon on albedo reduction and radiative forcing may be responsible for about 15% of the glacier melt in the southeastern Tibetan Plateau currently (You and Xu, 2022, Nat. Geo.)

More than half of the black carbon deposited on Himalayan glaciers can be attributed to vegetation fire emissions in non-monsoon months (You and Xu, 2022, Nat. Geo.)

Wildfires and Debris Flow

- Wildfires change the hydrologic and geomorphic response of watersheds, which has been associated with cascades of additional hazards and management challenges. Among these **post-wildfire events are shallow landslides and debris flows.**

- An analysis of the seasonality of mass movements at burned and unburned locations shows that mass-movement-triggering storms in burned locations tend to exhibit different seasonality from rainfall-triggered mass movements in areas undisturbed by recent fire, with a variety of seasonal shifts ranging from approximately 6 months in the Pacific Northwest of North America to 1 week in the Himalayan region



E. S. Culler et al.: A data-driven evaluation of post-fire landslide susceptibility

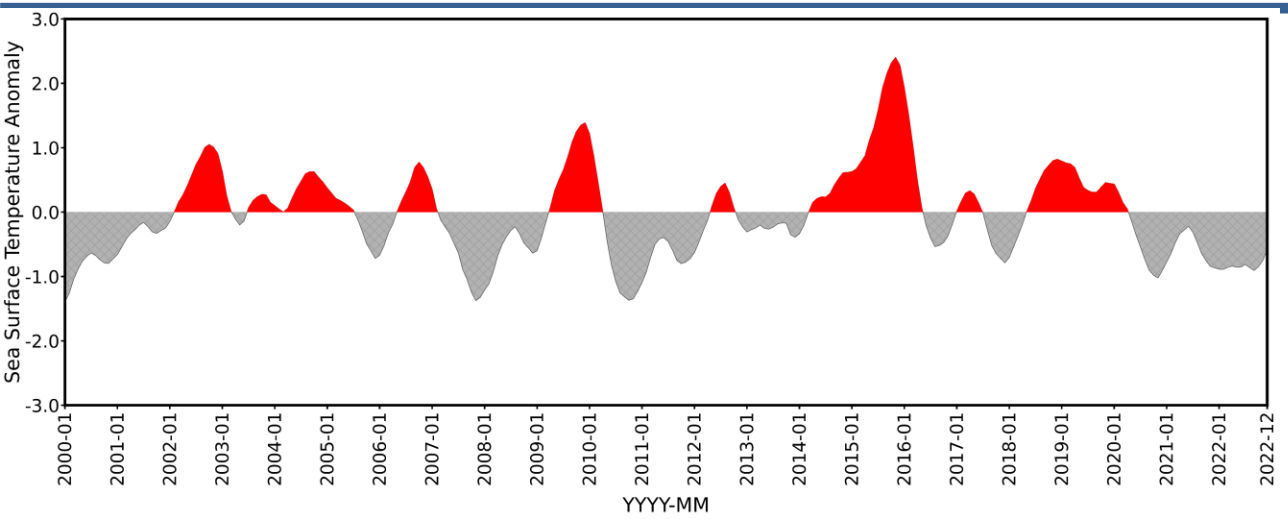
Propagation of wildfires post-ignition

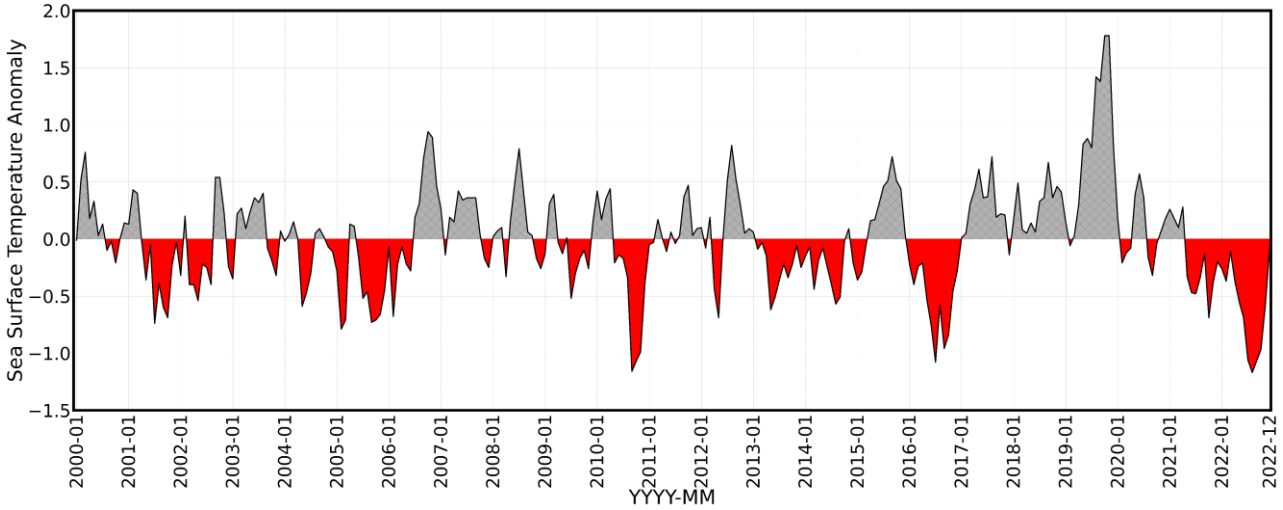
Rapid growth of wildfires over an 8-day period in Quebec, Canada in June, 2023. This animation was made using satellite detections of active fires and hotspots, displayed in NASA's FIRMS tool.

Credit: NASA

Wildfires and Coupled Atmosphere-Ocean Interaction

Prabhakaran and Srivastava, QJRMS (2024)

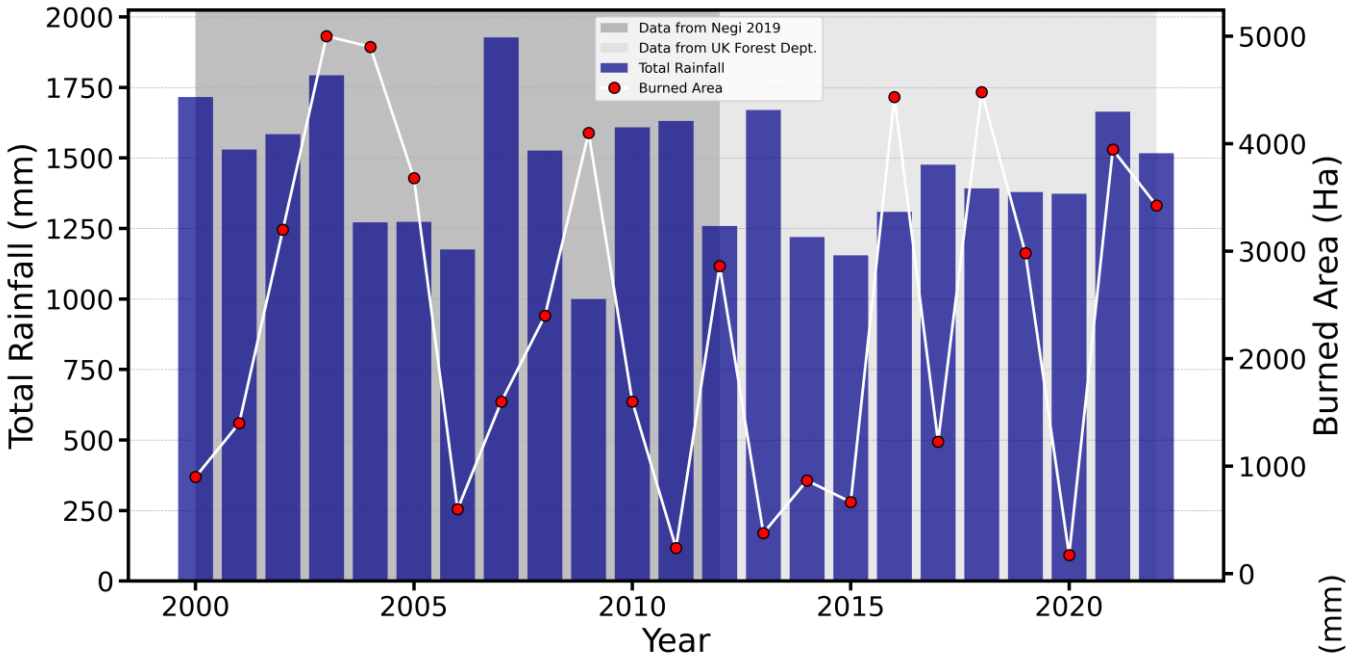




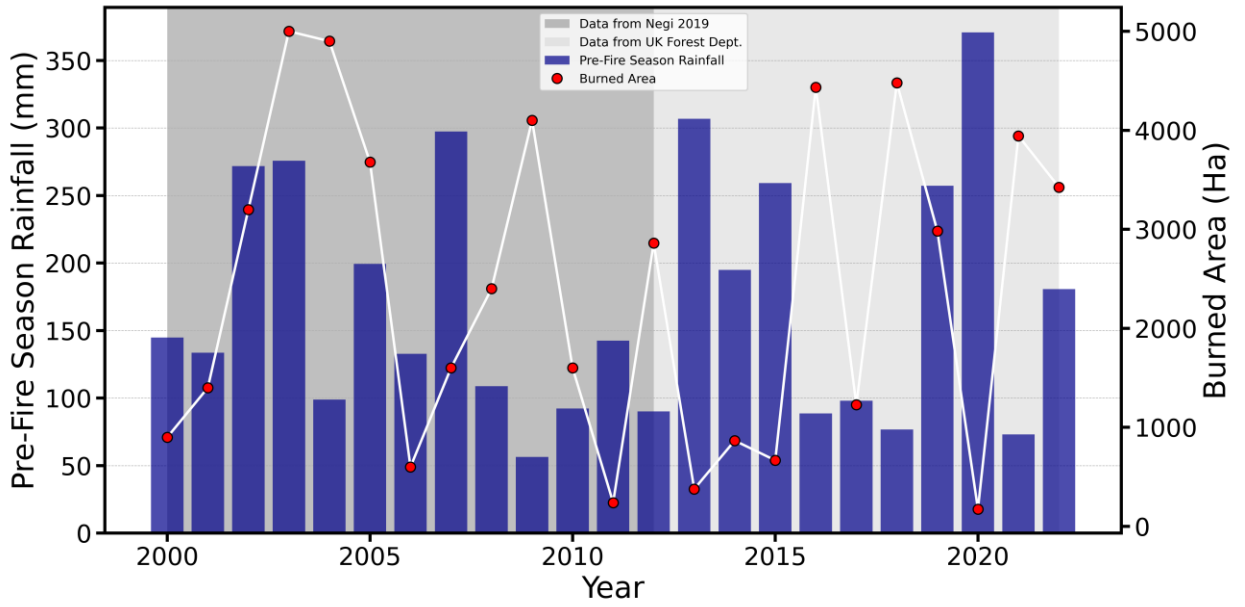
Year	ENSO phase	IOD phase	Rainfall (mm)	Pre-fire rainfall (mm)	Burned area (ha)
2002	El Niño	Negative IOD	1,584.7	271.8	3,200
2006	El Niño	Negative to positive IOD	1,175.5	132.8	600
2007	La Niña	Positive IOD	1,927.7	297.4	1,600
2009	La Niña to El Niño	Negative IOD	1,000.1	56.4	4,100
2010	La Niña	Positive to negative IOD	1,609	92.3	1,600
2011	La Niña	Positive IOD	1,631.6	142.6	240
2013	La Niña	Positive to negative IOD	1,670.3	306.9	377.29
2015	El Niño	Negative to positive IOD	1154.6	259.3	666.6
2016	El Niño	Negative IOD	1,308.7	88.7	4,433.75
2018	La Niña to El Niño	Positive IOD	1,392.3	76.8	4,478.53
2019	El Niño	Positive IOD	1,379	257.3	2,981.55
2020	La Niña	Positive IOD	1,373	370.8	172.69
2021	La Niña	Negative IOD	1,664.5	73.2	3943.78
2022	La Niña	Negative IOD	1,517.3	180.7	3425.05

Wildfires & Pre-Fire Season Precipitation

Prabhakaran and Srivastava, QJRMS (2024)



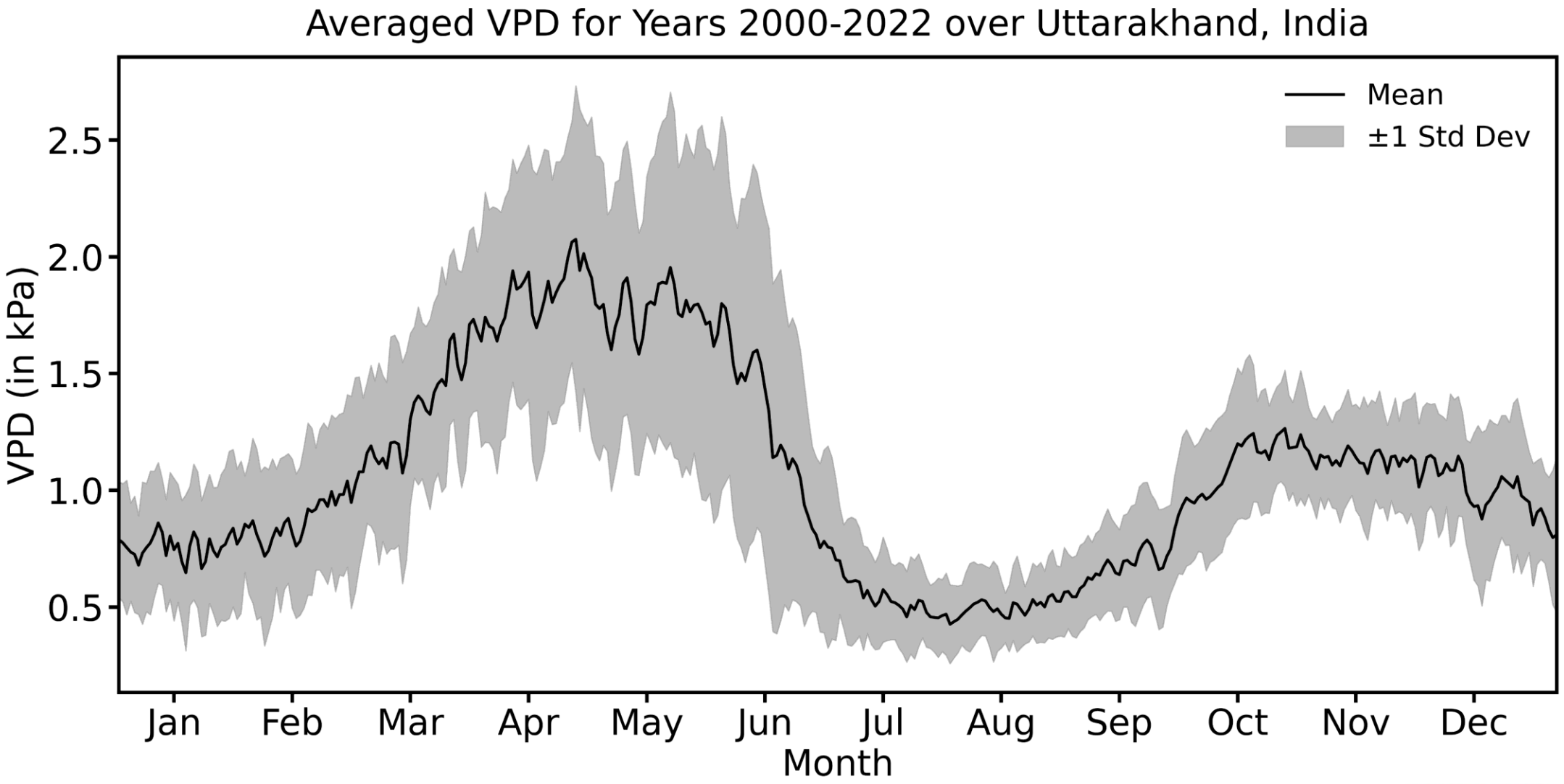
Plot representing (a) Total precipitation (b) pre-fire season precipitation vs Burned area over Uttarakhand, India. Pre-fire season precipitation is calculated over a duration from November of the preceding year to March of the succeeding year.



- Pre-season precipitation hold negative correlation with the burned areas while the total rainfall impact on burned areas are least established from the analysis.

Wildfires & Vapor pressure deficit

Prabhakaran and Srivastava, QJRMS (2024)



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Data Loggers
CR300 & CR1000X

India Meteorological Department Supersite, Ranichauri, Tehri Garhwal Uttarakhand, India

- **IMD, IIT Roorkee, DST, ANRF**

Thank You!