Summer midlatitude stationary wave patterns synchronize Northern Hemisphere wildfire occurrence

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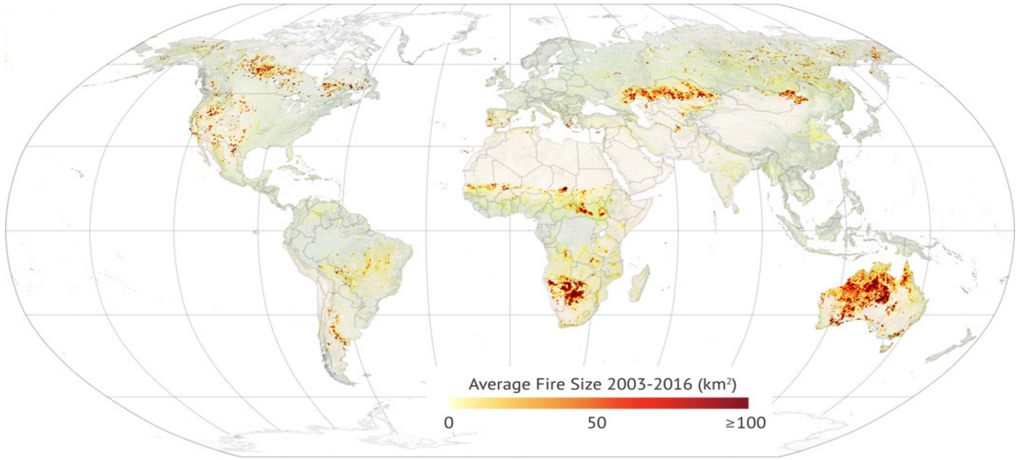
Wildfire …

- any type of uncontrolled fire that is spreading across wildland, forest, grasslands …
- started naturally (lightning) or by humans
- impacts on humans, wildlife and the economy

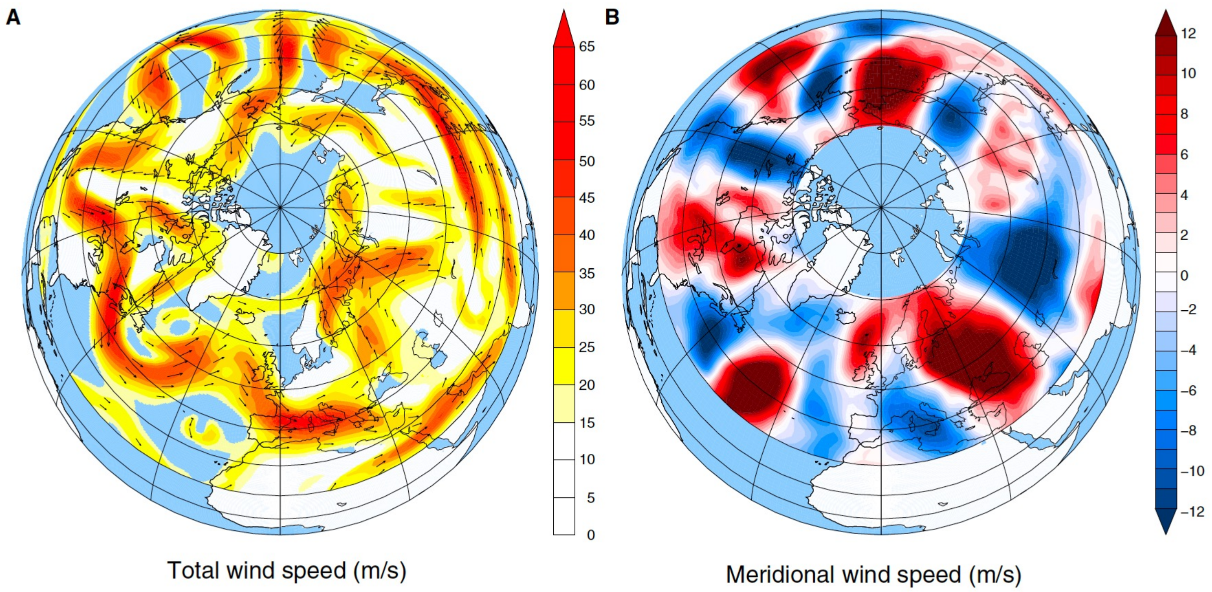


The average fire size across the world from 2003-16, ranging from zero (white) to 100sq km (dark red). Source: NASA Global Fire Atlas

Fires in Fort Collins, CO (10/2020)

Stationary wave

- planetary-scale waves
- excited by topography, diabatic heating and by transient eddy heat and momentum fluxes
- transport heat, moisture and momentum around the climate system
- play an important role in regional climates



Upper-level hemispheric circulation in May 2014 revealing a quasi-stationary wave 6 pattern from Stadtherr et al. (2016).

Stationary waves – wildfire occurrence

Synchronization?

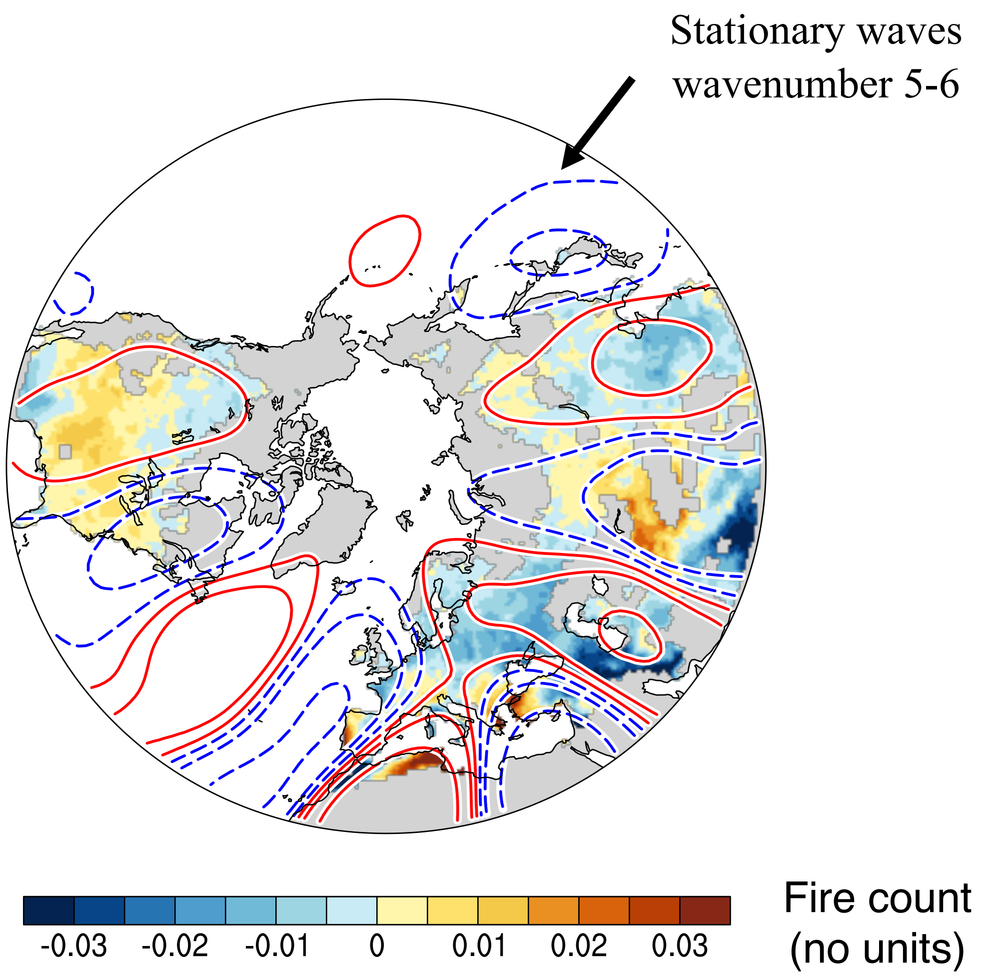
- Midlatitude stationary waves → increase fire occurrences in specific regions
- Whether hemispheric-scale atmospheric disturbances can synchronize the occurrence of wildfires across the NH.

Impacts of global warming?

NCAR Community Earth System Model version 2 Large Ensemble (CESM2-LE)

- 50 ensemble members
- $0.9^{o} \times 1.25^{o}$ (latitude x longitude)
- Historical (1981-2010)
- Future SSP370 scenario (2071-2100)
- Boreal summer (May-October)

Relationship between the stationary wave pattern and wildfires



Maps of Singular Value Decomposition (SVD1) during the historical simulation

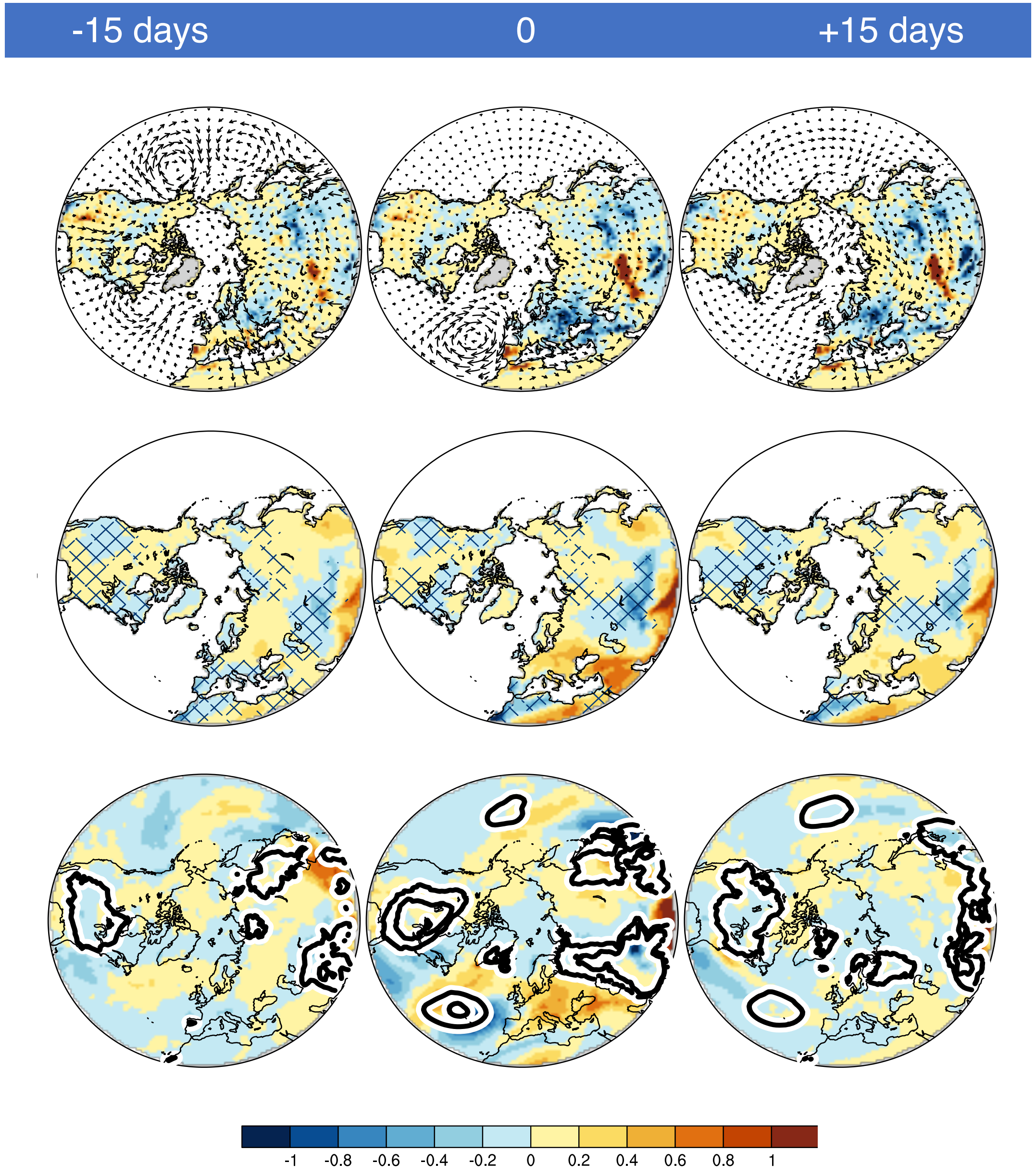
➢ Zonal wavenumber 5-6 structure:

- High-pressure centered over the eastern U.S., southern EU, and northern Asia
- Low-pressure centers located in between

➢ Fire count anomalies associated with the wave pattern:

- Positive fire anomalies → surface high-pressure center (east side of the upper-tropospheric ridge)
- Negative fire anomalies → surface low-pressure center (east side of the upper-tropospheric trough)

Atmosphere-land interaction?



Lead-lag regression maps of the PC1 of stationary waves to other fields in the historical simulation

Burned area
850 hPa winds

→ positive fire anomaly occurs along the eastern side of the anticyclone over the Eurasian continent but occurs slightly around the center of the anticyclone over the western North America

Relative humidity
Soil moisture

→ negative anomalies generally located over the low relative humidity region

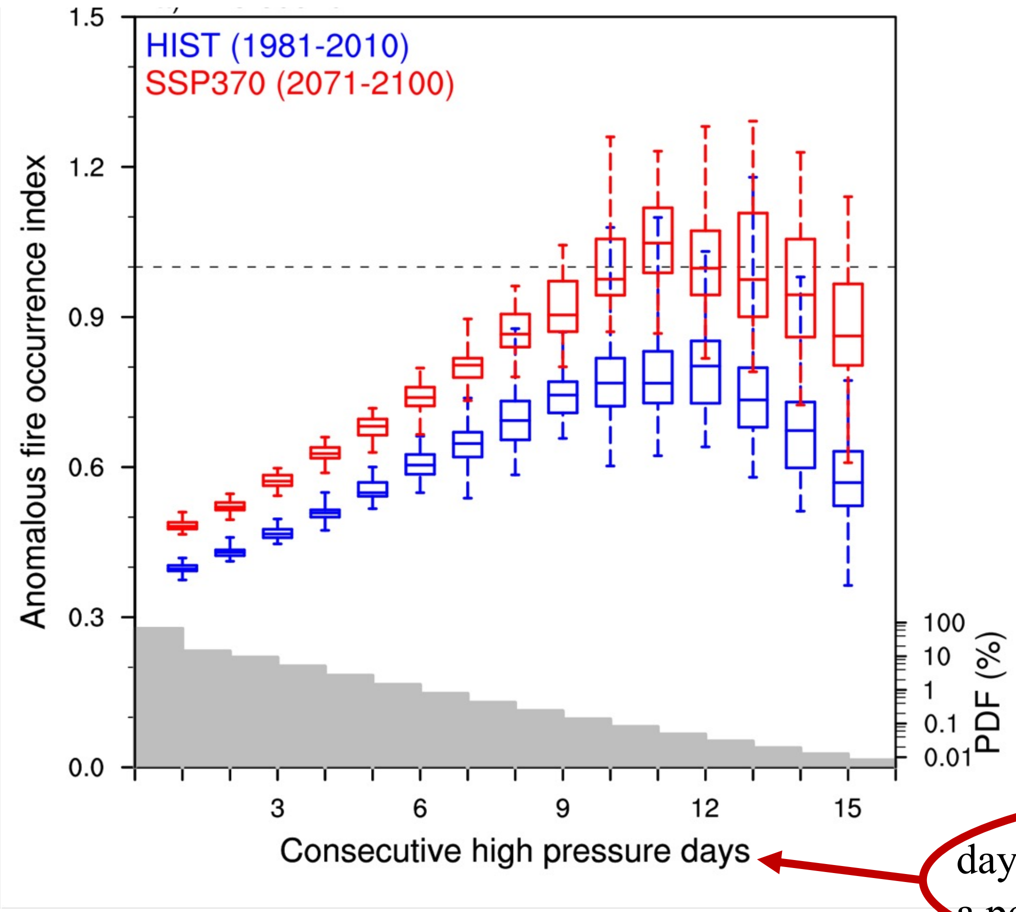
Precipitation
Temperature

→ dry heatwave collocated with the stationary wave pattern

➢ The stationary wave pattern modulates wildfires

Linkage between persistence of high-pressure days and wildfire

fire count$_{\text{(consecutive high-pressure days)}}$/fire$_{\text{mean}}$)

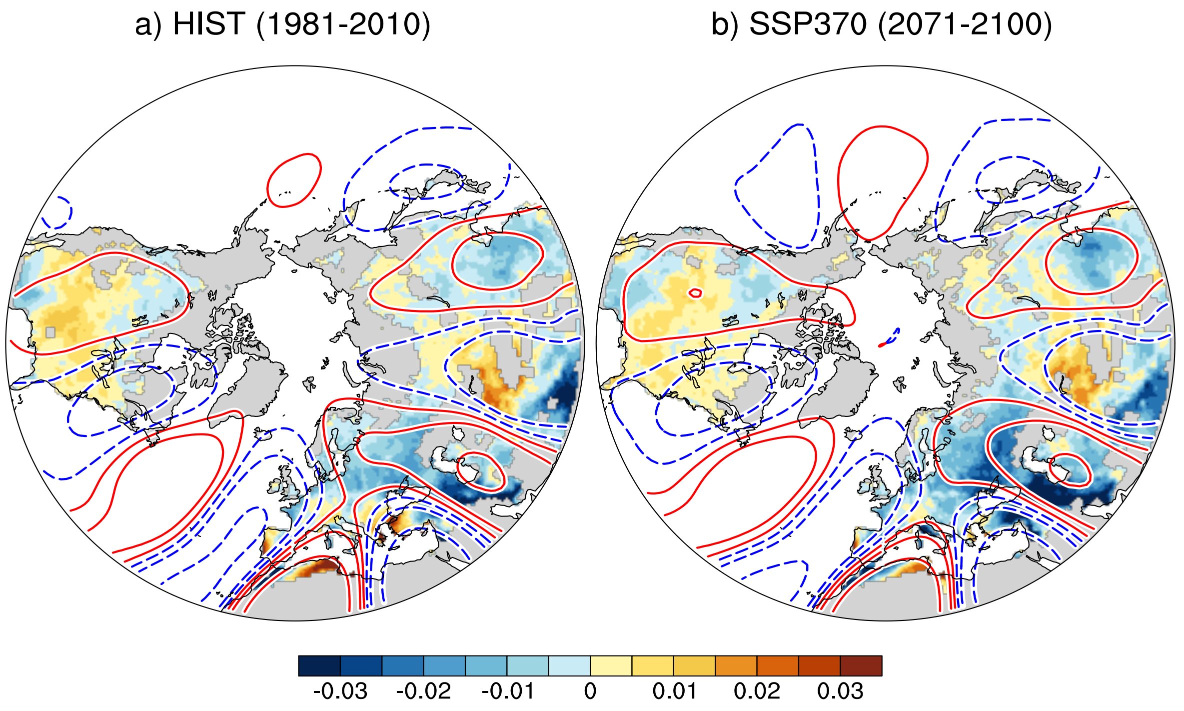


no change between the current and future climates

days with vertical descending motion, defined as a positive value of omega at 500 hPa, $\omega 500 > 0$

➢ The longer the period of high-pressure days, the higher the chance for wildfires to occur

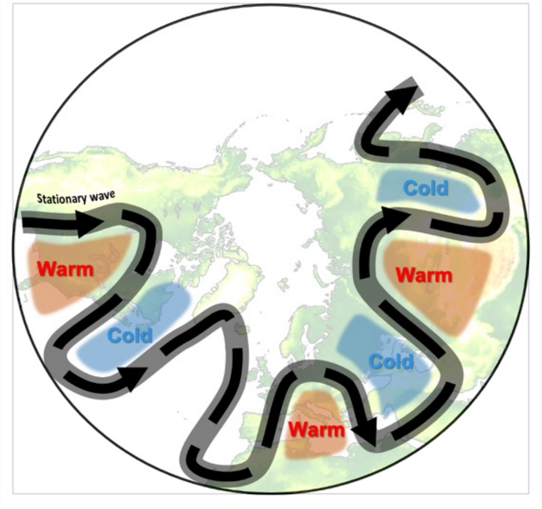
Response to global warming

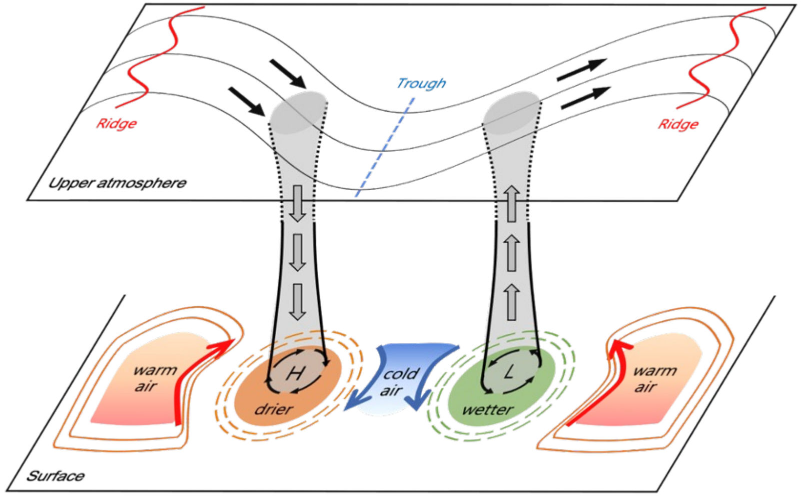


→ factors other than changes in stationary wave patterns alone are responsible for the increase in wildfires since the change in wave patterns over land is very small

- more dryness over land due to relative humidity decreases (Byrne & O'Gorman, 2013)
- weakening and shifting of storm tracks (Gertler et al., 2020; Lee et al., 2021)
- expansion of subtropical high-pressure systems (Lin & Chan, 2015)
- increase in Arctic lightning might also increase fire risk (Chen et al., 2021)
- El Niño/Southern Oscillation (ENSO; Fang et al., 2021)
- expansion and intensification of agriculture, fire suppression management
- …

Summary





- Concurrence between zonal wavenumber 5-6 stationary wave pattern and wildfire over the Northern Hemisphere midlatitudes
- More persistent high-pressure conditions drastically increase wildfire probabilities
- Midlatitude wildfire variability is projected to intensify due to changes in climate background conditions

Thank you!