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Quantifying causal teleconnections to drought and fire risks in Indonesian Borneo

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Motivation and Objectives

- Identify large-scale ocean-atmosphere causal links leading to droughts and fires
- Evaluate the likelihood of unprecedented drought and fire risks
- Unfold possible changes of drought and fire risks and their drivers under a warming climate

→ Develop climate risk assessment and resilience building strategies for droughts and peatland fires in Central Kalimantan Province, Indonesian Borneo

More on kali-project.com

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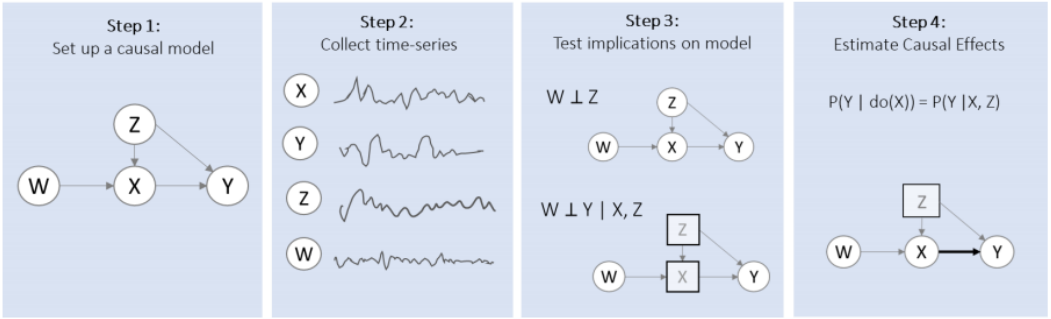
Source of pictures: The Guardian (2015)

Identify causal links leading to droughts and fires



Knowledge-guided Casual Inference (Kretschmer et al. 2021, *BAMS*)

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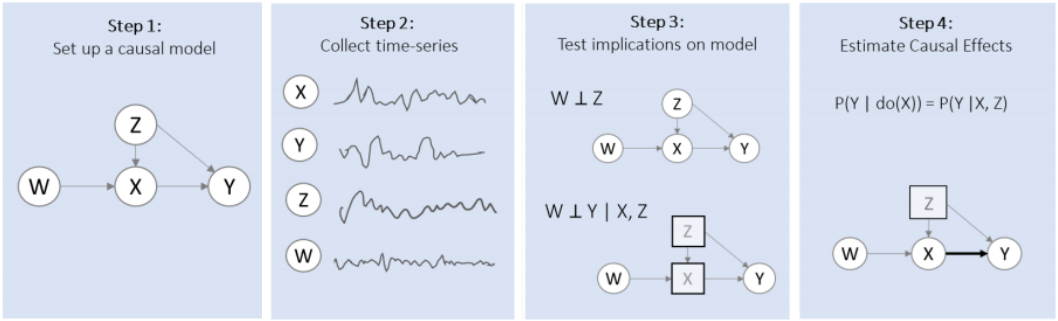
Identify causal links leading to droughts and fires



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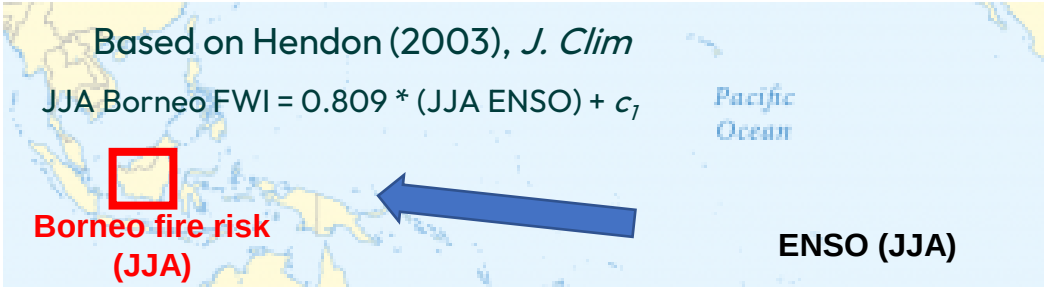

Contingency table of FWI vs. ENSO

FWI (JJA)	La Niña	Neutral	El Niño
Dry	0%	8.3%	25%
Normal	12.5%	12.5%	8.3%
Wet	20.8%	12.5%	0%

Niño3.4 SST (JJA)

- Based on standardised and detrended data from ERA5 and Niño 3.4 SST from NOAA

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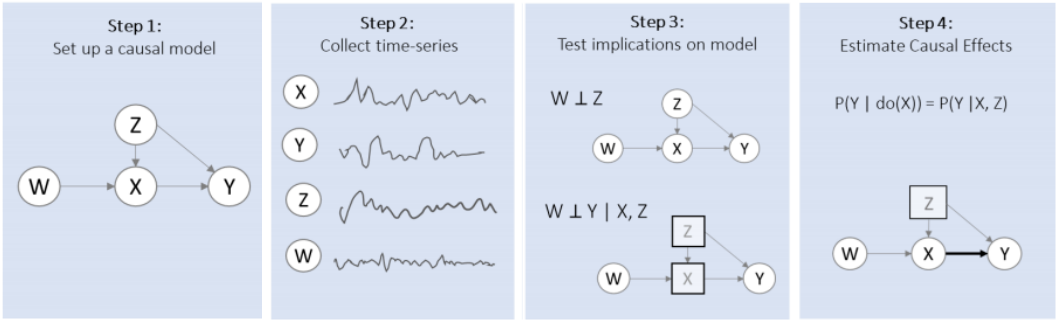
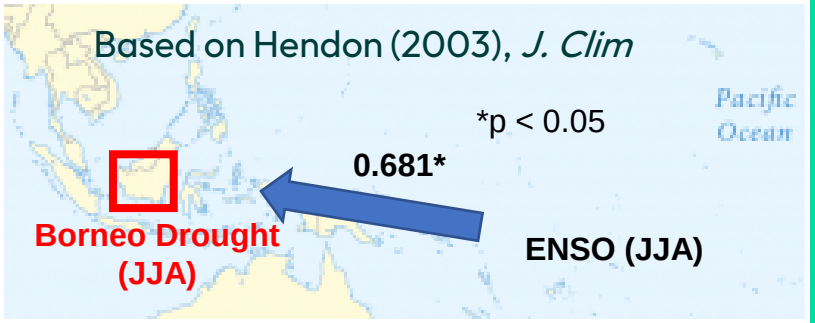
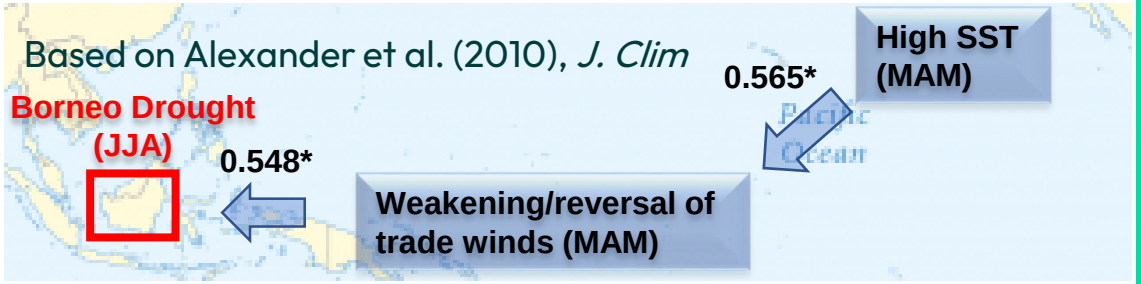
Identify causal links leading to droughts and fires





Knowledge-guided Casual Inference (Kretschmer et al. 2021, *BAMS*)

JJA Borneo Drought = 0.681* (JJA ENSO) + c_1
MAM Zonal Wind = 0.565* (MAM SST) + c_2
JJA Borneo Drought = 0.548* (MAM Zonal Wind) + c_3
JJA Borneo Drought = 0.209 (MAM SST) + c_4



- Based on standardised and detrended CHIRPS precipitation, HadISST, and ERA5 wind data

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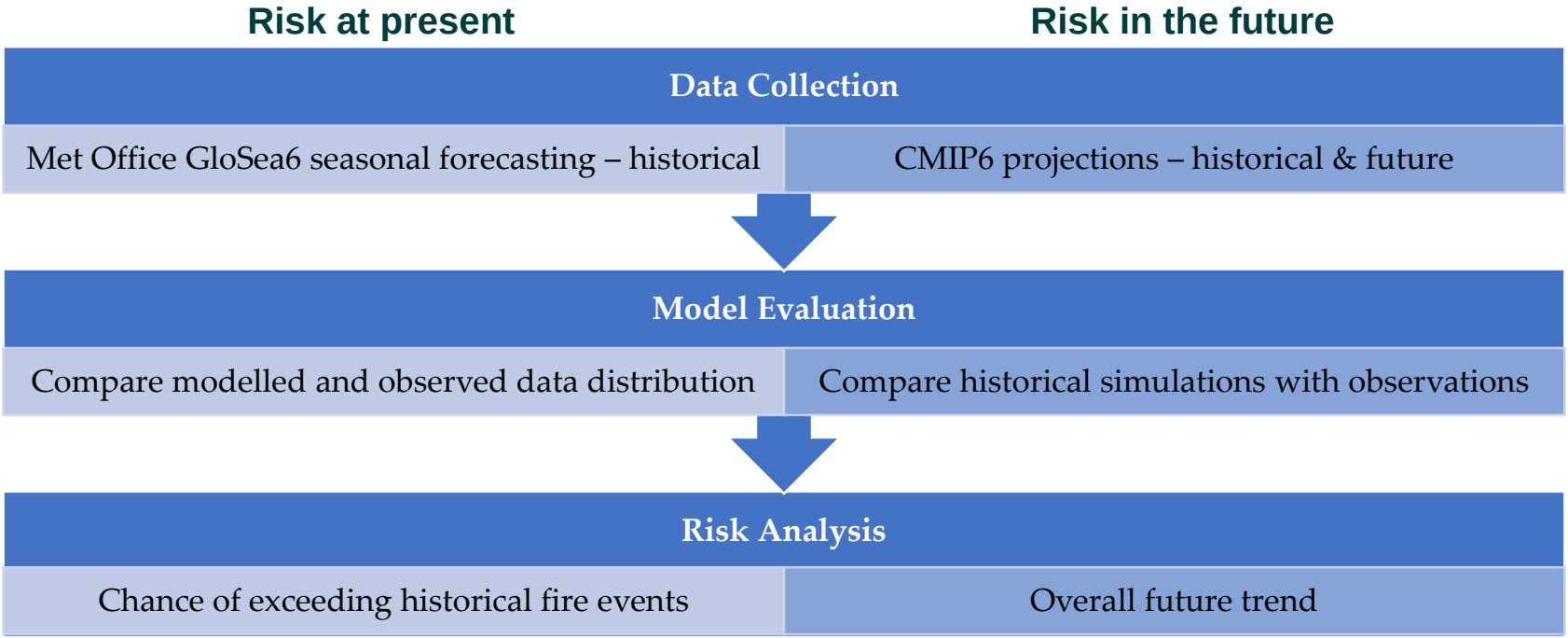
Evaluate present and future drought and fire risks



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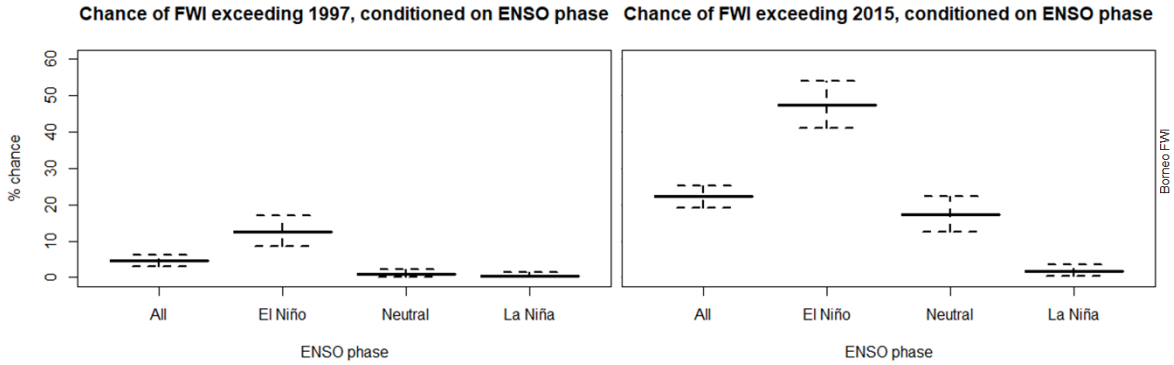
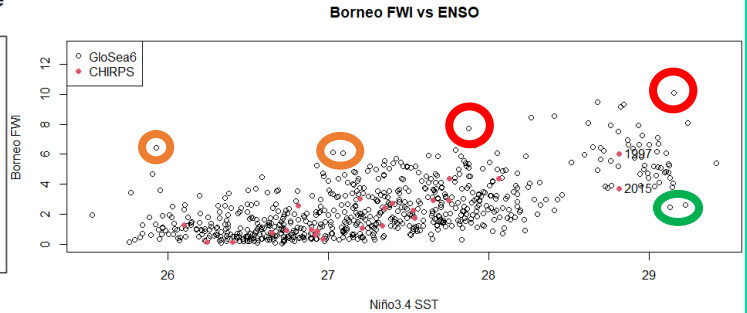
Likelihood of unprecedented drought and fire risks





- Based on GloSea6 seasonal hindcast ensemble runs from 1993 – 2016
- Under an El Niño, there is about a 50% chance that Fire Weather Index (FWI) exceeds that in 2015, which is approximately 2 times and 25 times greater than under neutral ENSO and La Niña conditions, respectively.
- FWI during historical fires may still be exceeded under neutral ENSO and La Niña conditions, associated with Indian Ocean Dipole (IOD), East Asian Summer Monsoon, or extratropical drivers.

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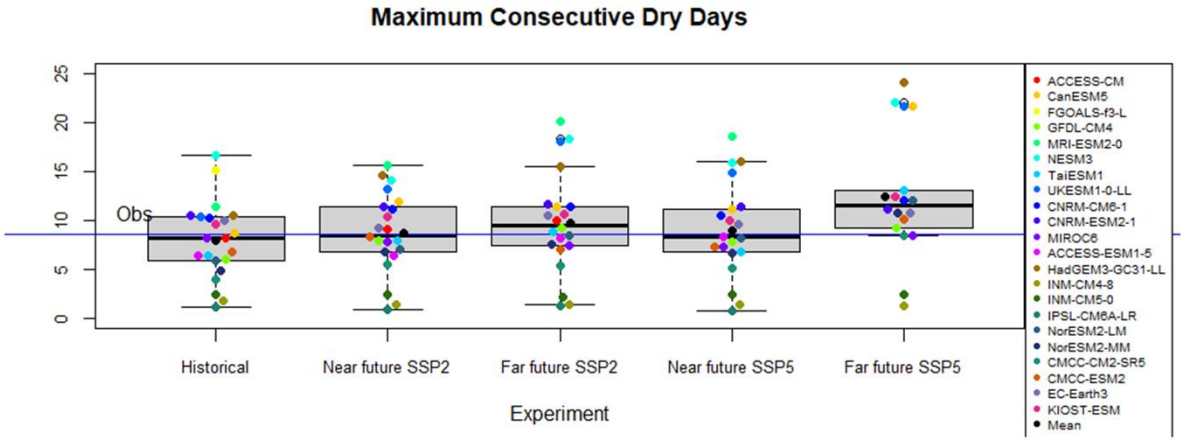
Future drought and fire risks



- Under SSP585 scenario, maximum number of consecutive dry days will increase significantly ($p = 0.016$) in the far future (2061 – 2100) compared with historical baseline (1981 – 2014).

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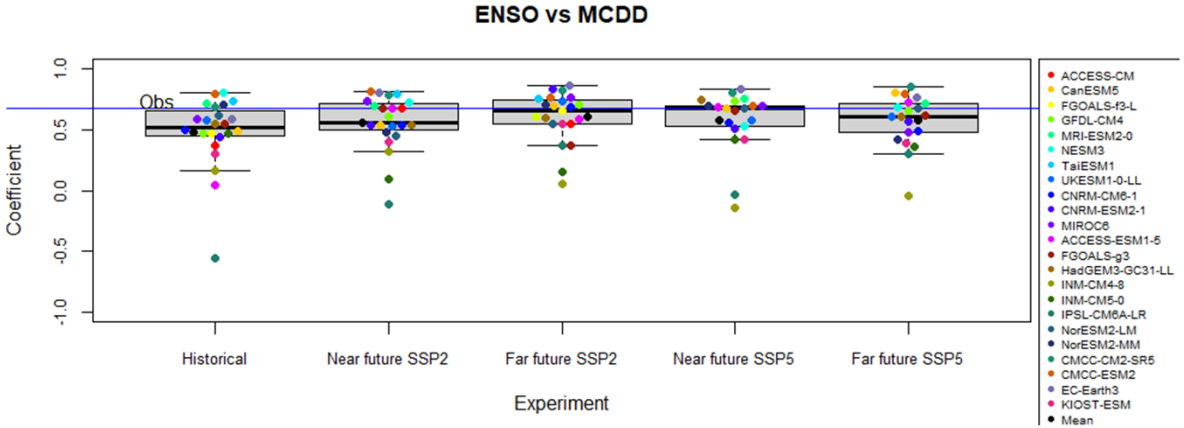
Future drivers of drought and fire risks



- There is no clear trend of relationship between ENSO and Borneo drought towards the future.

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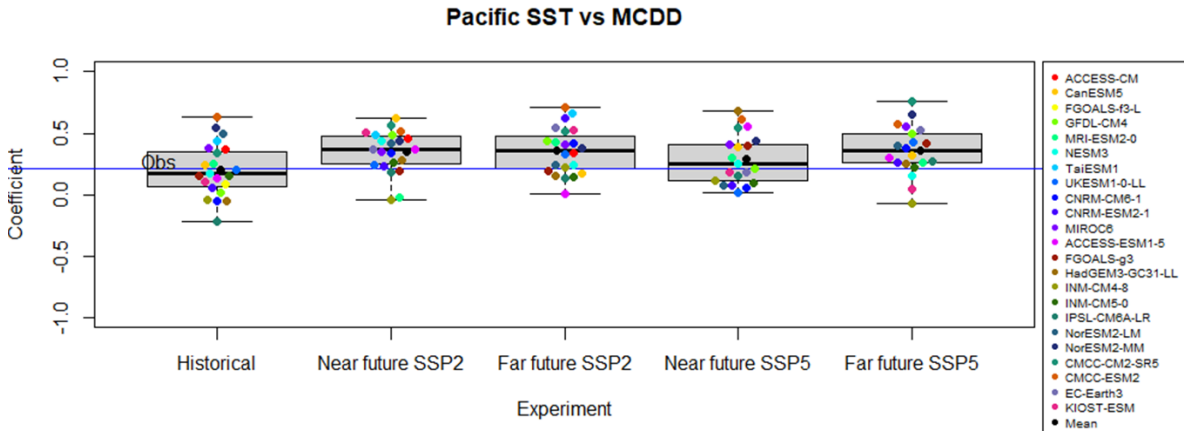
Future drivers of drought and fire risks



- Under SSP5, Pacific SST as a driver of maximum number of consecutive dry days will strengthen significantly ($p = 0.026$) in the far future (2061 – 2100) compared with historical baseline (1981 – 2014).

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Conclusions

Using a causal framework to quantify teleconnections, we find that:

- Strong associations are observed between boreal summer droughts in Indonesian Borneo, El Niño conditions, and elevated SSTs over eastern North Pacific in the preceding boreal spring.
- An El Niño event substantially elevates the risk of unprecedented fires, but they are still possible under other ENSO phases.
- Droughts in Indonesian Borneo may worsen in the future, which could be attributed to the strengthening of wind-evaporation-SST feedback as evidenced by enhanced relationship between Borneo drought and SST over eastern North Pacific in the preceding boreal spring.

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