# Climate Change Effects on Wildland Fire Risk

## in the Northeastern United States and Great Lakes Region

Gaige Hunter Kerr
The Johns Hopkins University

28th Conference on Climate Variability and Change | January 11, 2016

CNN U.S. » Crime + Justice | Energy + Environment | Extreme Weather | Space + Science

# Wildfires threaten homes in Idaho, Washington, California and Oregon

By Ralph Ellis and Laura Smith-Spark, CNN
Updated 10:06 PM ET, Sun August 16, 2015

**CNN | August 16, 2015**


CNN U.S. » Crime + Justice | Energy + Environment | Extreme Weather | Space + Science

Wildfires

Los Angeles Times

Nation

There aren't enough firefighters to fight all the Western wildfires

Los Angeles Times | August 18, 2015

Chicago Tribune

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Chicago Tribune | August 23, 2015

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## 'Heads up' for Washington wildfires that spread 100 square miles in a day

Los Angeles Times

Nation

firefighters to fight all the

US | Tue Sep 1, 2015 10:20pm EDT

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## Largest wildfire in Washington state history claims 176 homes

SEATTLE | BY MIKE ROSENBERG

REUTERS

# Reuters | September 1, 2015


The Atlantic | September 15, 2015


Chicago Tribune | September 21, 2015


The Washington Post | December 9, 2015


USA Today | December 17, 2015

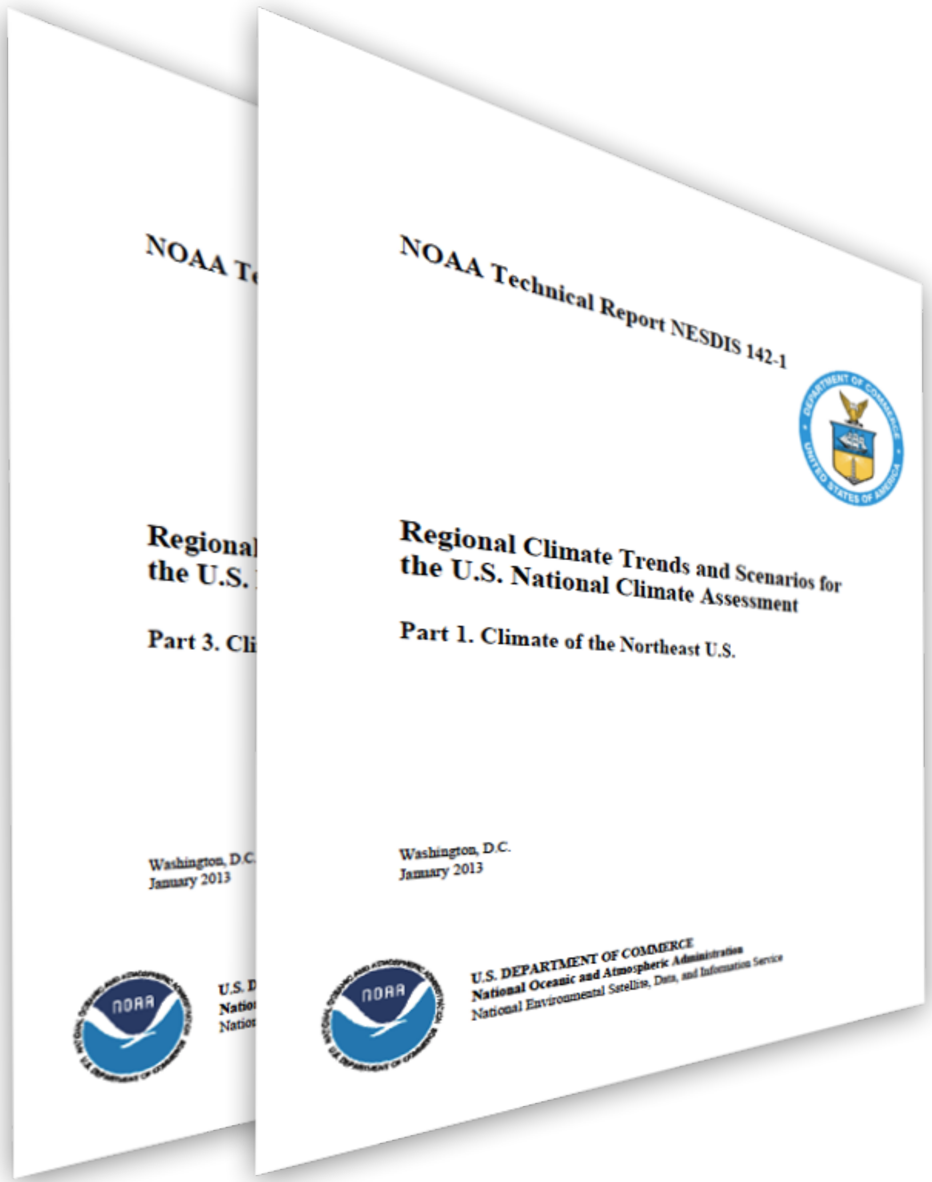
# “The agency is at a tipping point.

Climate change has led to fire seasons that are now on average 78 days longer than in 1970 [...] the acreage burned may double again by mid-century.”

U.S. Forest Service | August 4, 2015

- Statistically significant increase in temperature
- Lengthening of the frost-free season
- Increase in average annual precipitation but a downward seasonal change during summer
- Simulated increase in the average annual number of consecutive warm days

NOAA Technical Reports, **January 2013**




Northeast
Great Lakes

# Fire Weather Simulations


Vol. 31: 85–95, 2006

CLIMATE RESEARCH
Clim Res

Potential impact of climate change on fire risk in the Mediterranean area

M. Moriondo[1,*], P. Good[2], R. Durao[3], M. Bindi[1], C. Giannakopoulos[2], J. Corte-Real[3]

1. INTRODUCTION

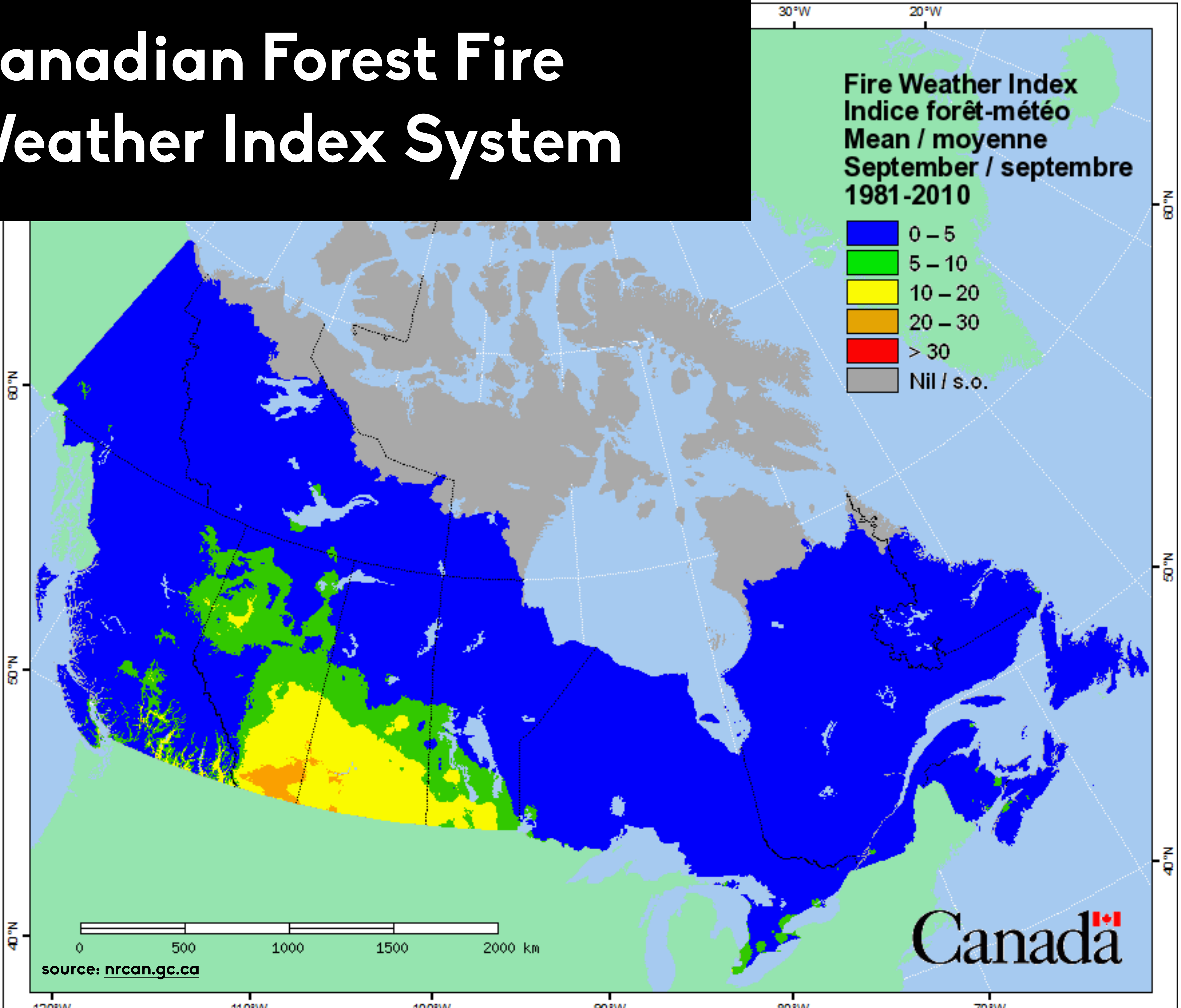
Mediterranean forests are regularly subjected to a large number of fires. About 50000 fires destroy from 700 × 10³ to 1000 × 10³ ha of Mediterranean forests annually, causing enormous economic and ecological destruction (Velez 1997). In particular, the data collected reveal that, according to the average burnt area per fire, Greece has the most severe forest fire problems among the European Union countries. It has been estimated that the average burned area per fire was 39.4, 28.5, 19.7 and 15.3 ha in Greece, Spain, Italy and Portugal, respectively (Dimitrakopoulos 1994). The destruction of forests is of great concern, as this has many side effects e.g. floods, soil erosion and consequent loss of fertility (Court-Picon et al. 2004, Iliadis 2004). Furthermore, it has been demonstrated that forest fires play a fundamental role in determining the net carbon balance of the forest (Kurz et al. 1995). Thus, they may affect greenhouse gas emissions with consequent feedback on climate change (Flannigan et al. 2005).

*Email: marco.moriondo@unifi.it

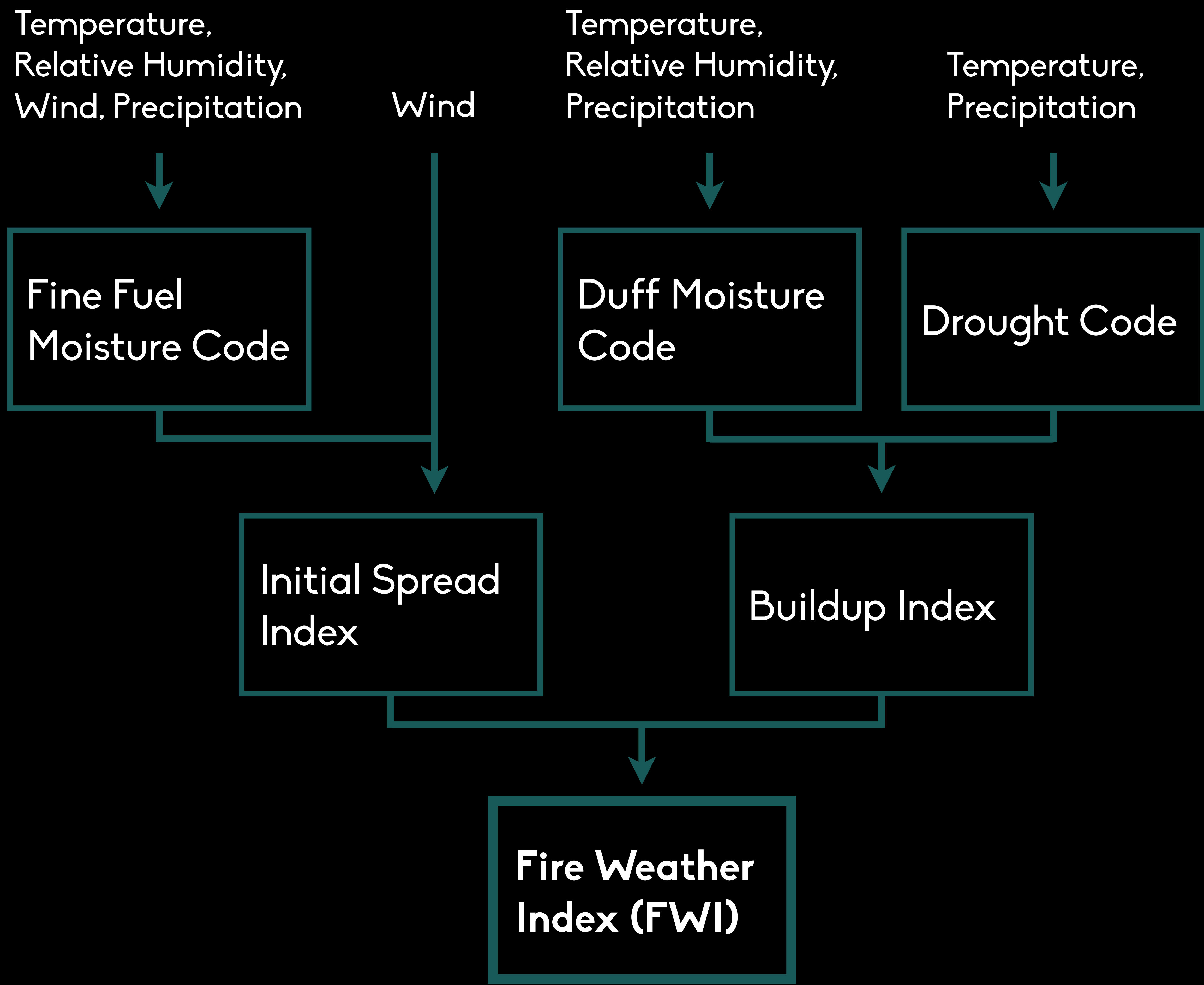
“ Forest fires [...] are highly sensitive to climate change because fire behaviour responds immediately to fuel moisture, which is affected by precipitation, relative humidity, air temperature and wind speed. ”

Climate Research,
**June 2006**

# Canadian Forest Fire Weather Index System




source: nrcan.gc.ca


Temperature,
Relative Humidity,
Wind, Precipitation
Wind
Temperature,
Relative Humidity,
Precipitation
Temperature,
Precipitation
Fine Fuel Moisture Code
Duff Moisture Code
Drought Code
Initial Spread Index
Buildup Index
Fire Weather Index (FWI)

# Climate Simulations

# COordinated Regional climate Downscaling EXperiment

WCRP CORDEX

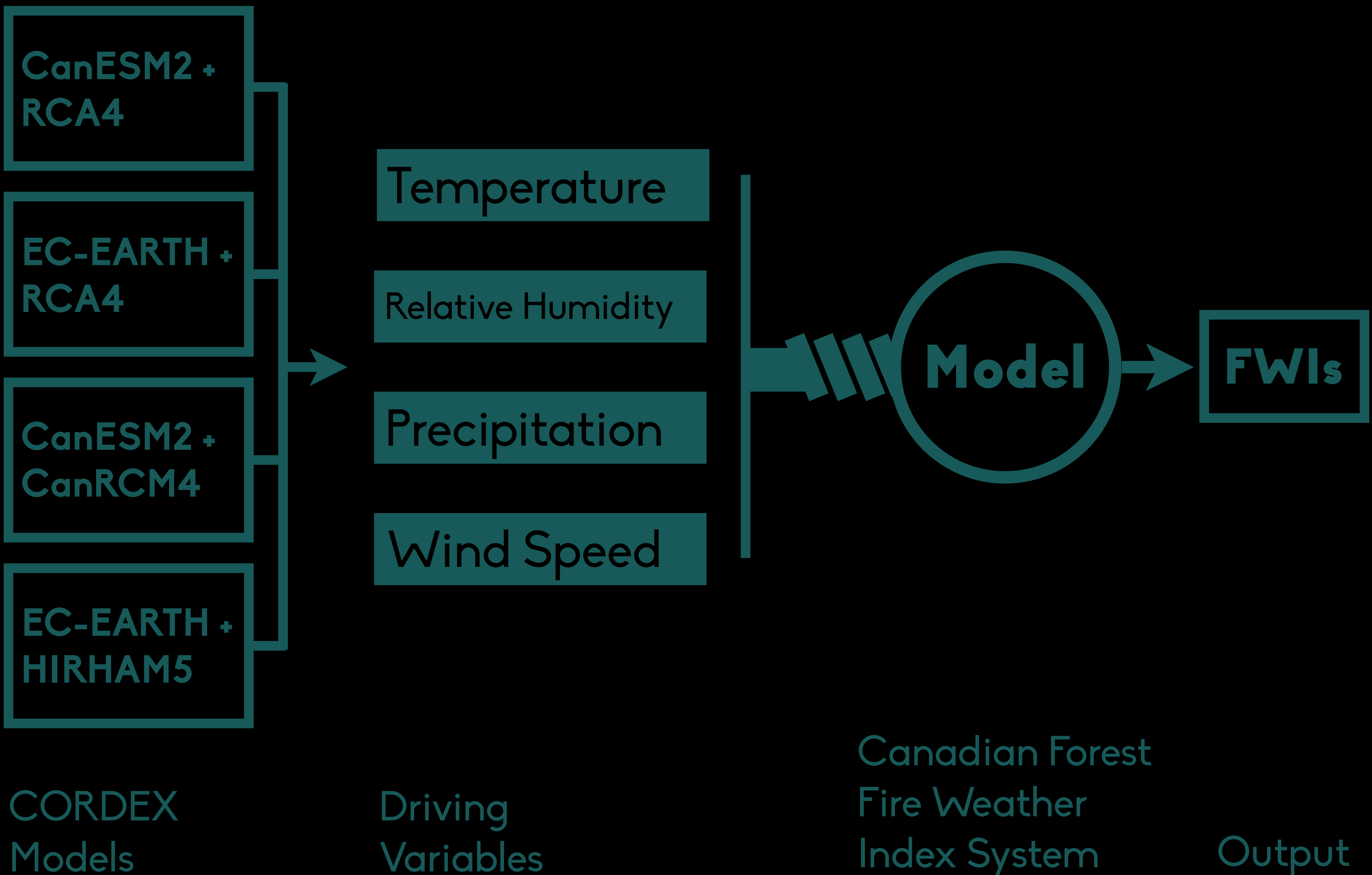
WMO

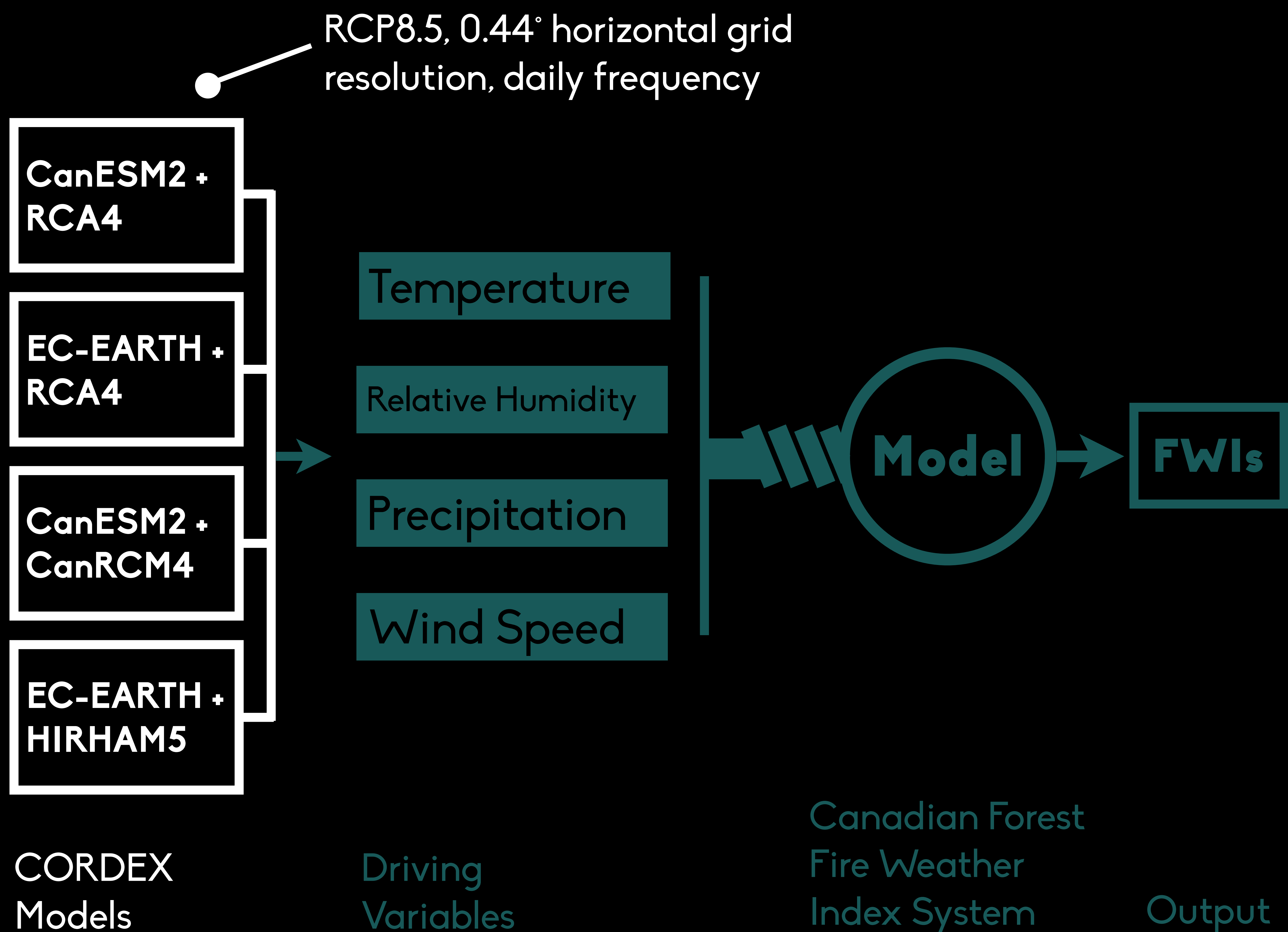
UNESCO

IOC

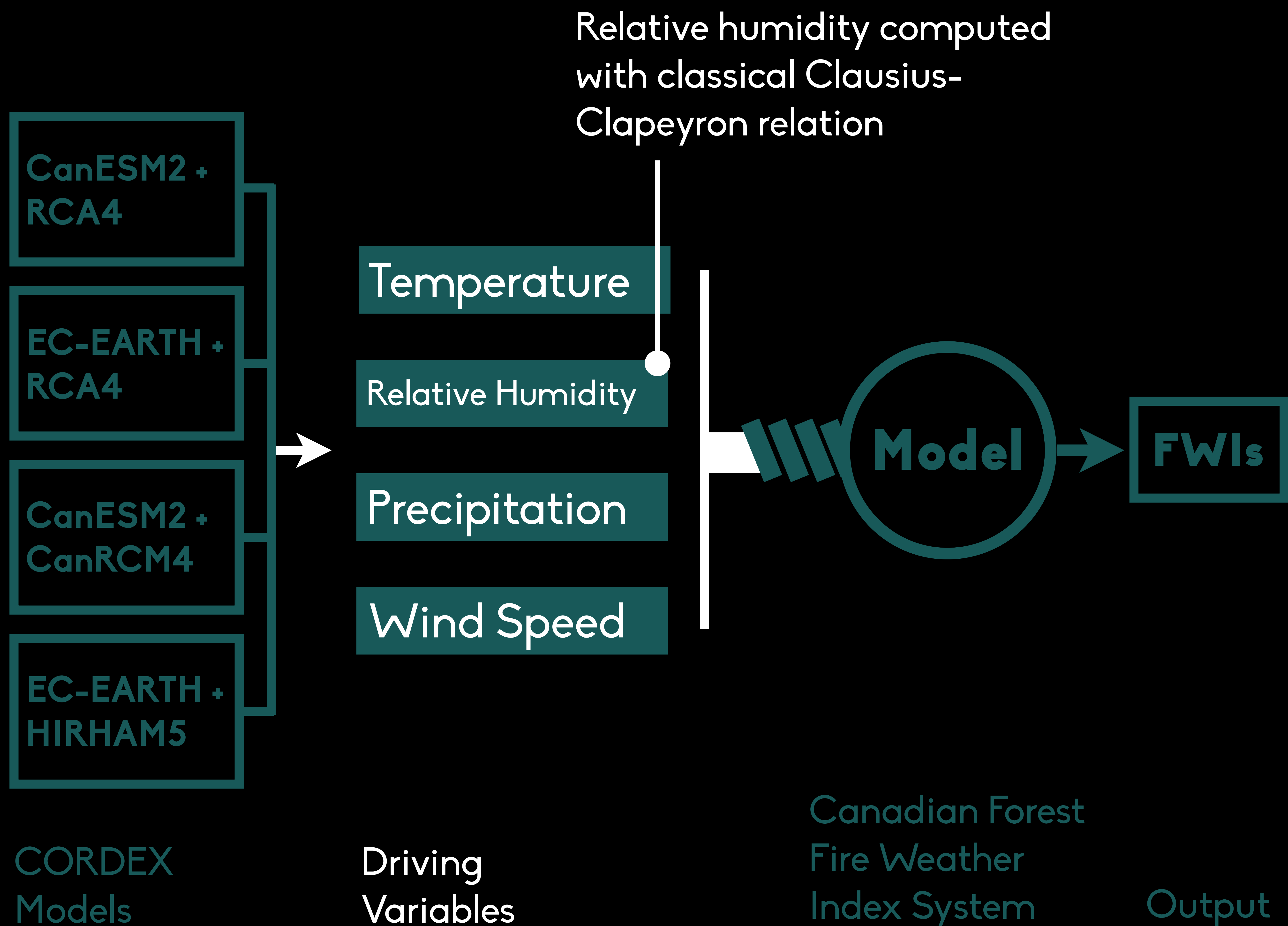
ICSU

International Council for Science

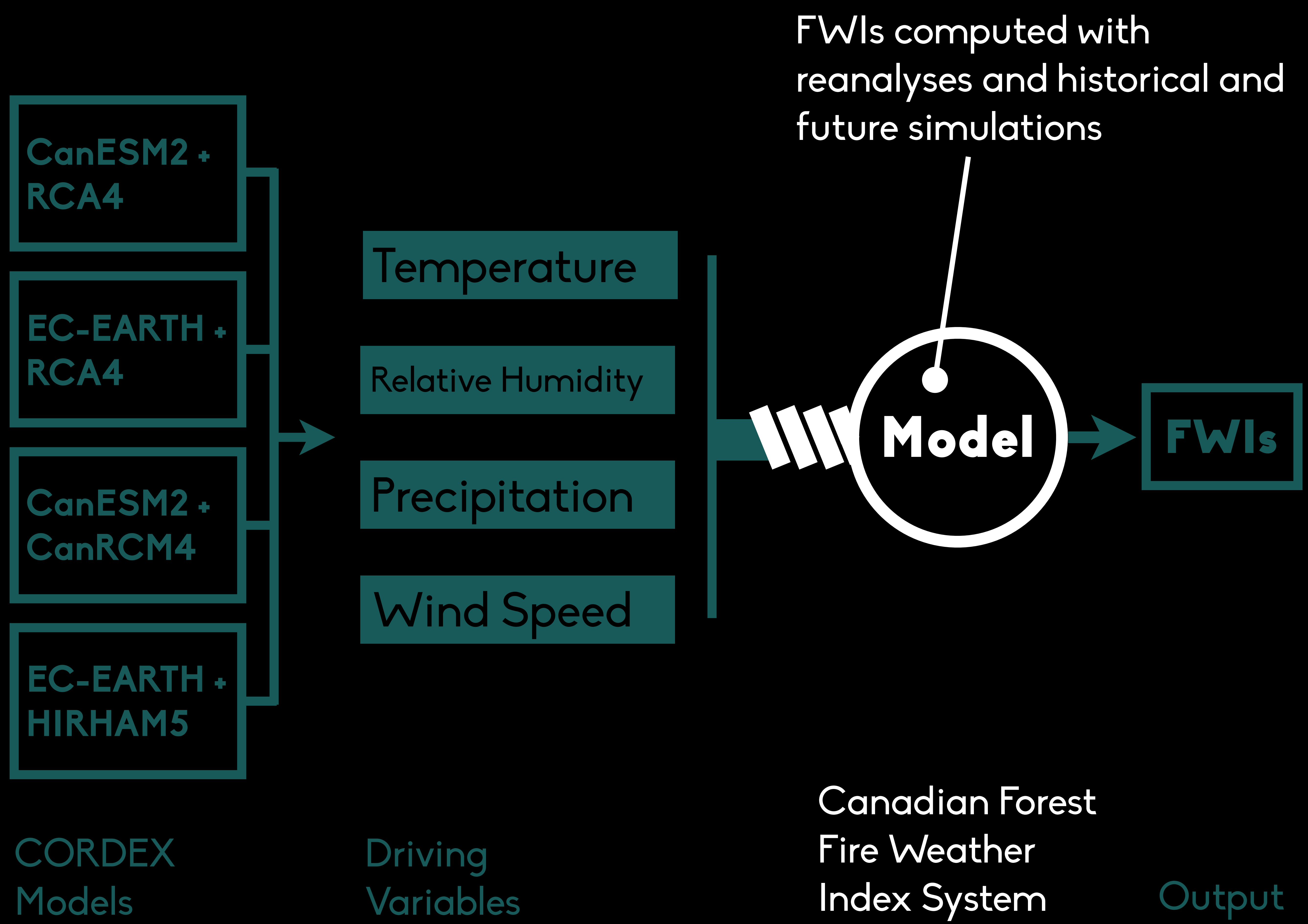

CanESM2 + RCA4
EC-EARTH + RCA4
CanESM2 + CanRCM4
EC-EARTH + HIRHAM5
Temperature
Relative Humidity
Precipitation
Wind Speed
Model
FWIs
CORDEX Models
Driving Variables
Canadian Forest Fire Weather Index System
Output

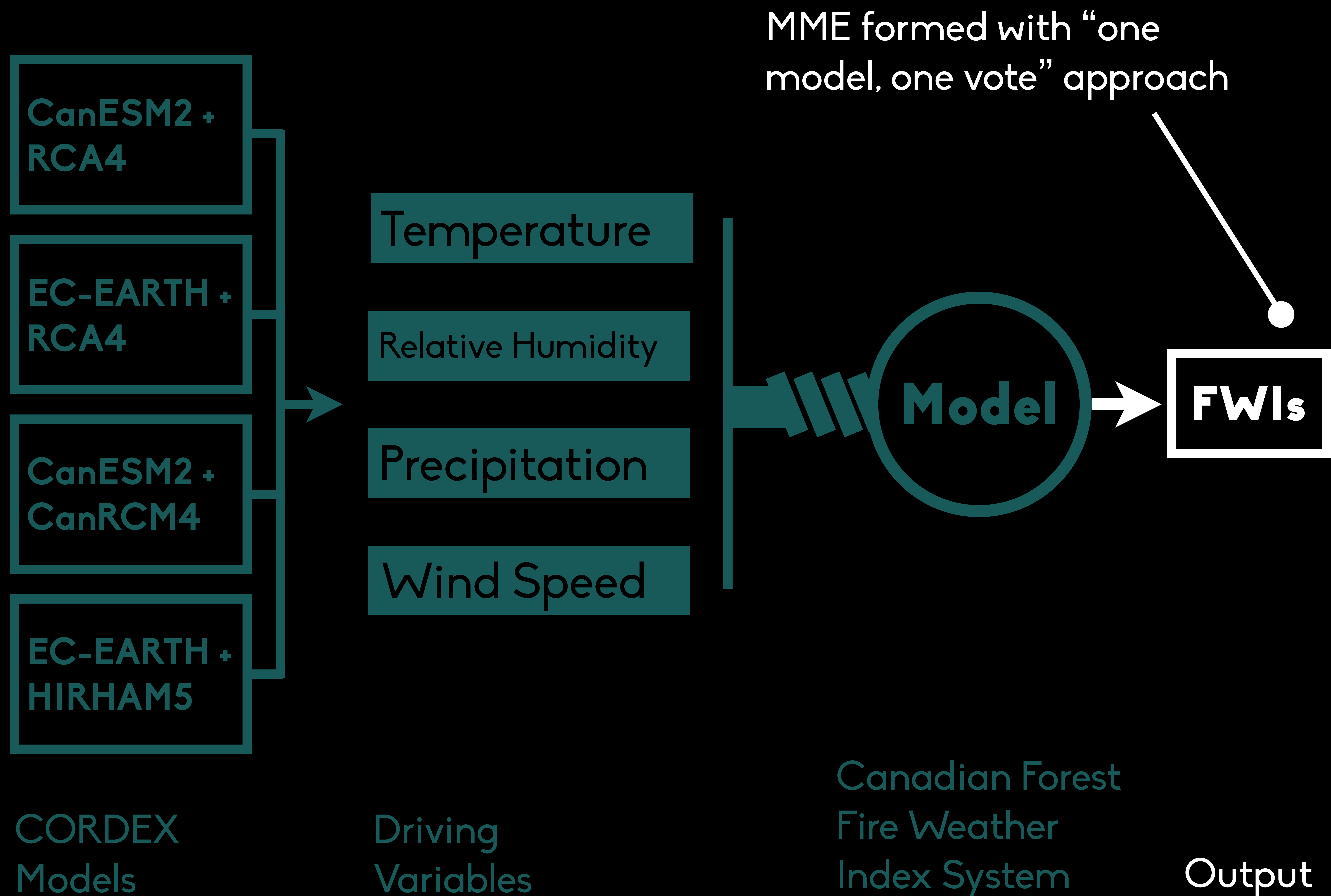


RCP8.5, 0.44° horizontal grid resolution, daily frequency
CanESM2 + RCA4
EC-EARTH + RCA4
CanESM2 + CanRCM4
EC-EARTH + HIRHAM5
Temperature
Relative Humidity
Precipitation
Wind Speed
Model
FWIs
CORDEX Models
Driving Variables
Canadian Forest Fire Weather Index System
Output



Relative humidity computed with classical Clausius-Clapeyron relation
CanESM2 + RCA4
EC-EARTH + RCA4
CanESM2 + CanRCM4
EC-EARTH + HIRHAM5
Temperature
Relative Humidity
Precipitation
Wind Speed
Model
FWIs
CORDEX Models
Driving Variables
Canadian Forest Fire Weather Index System
Output


FWIs computed with reanalyses and historical and future simulations
CanESM2 + RCA4
EC-EARTH + RCA4
CanESM2 + CanRCM4
EC-EARTH + HIRHAM5
Temperature
Relative Humidity
Precipitation
Wind Speed
Model
FWIs
CORDEX Models
Driving Variables
Canadian Forest Fire Weather Index System
Output

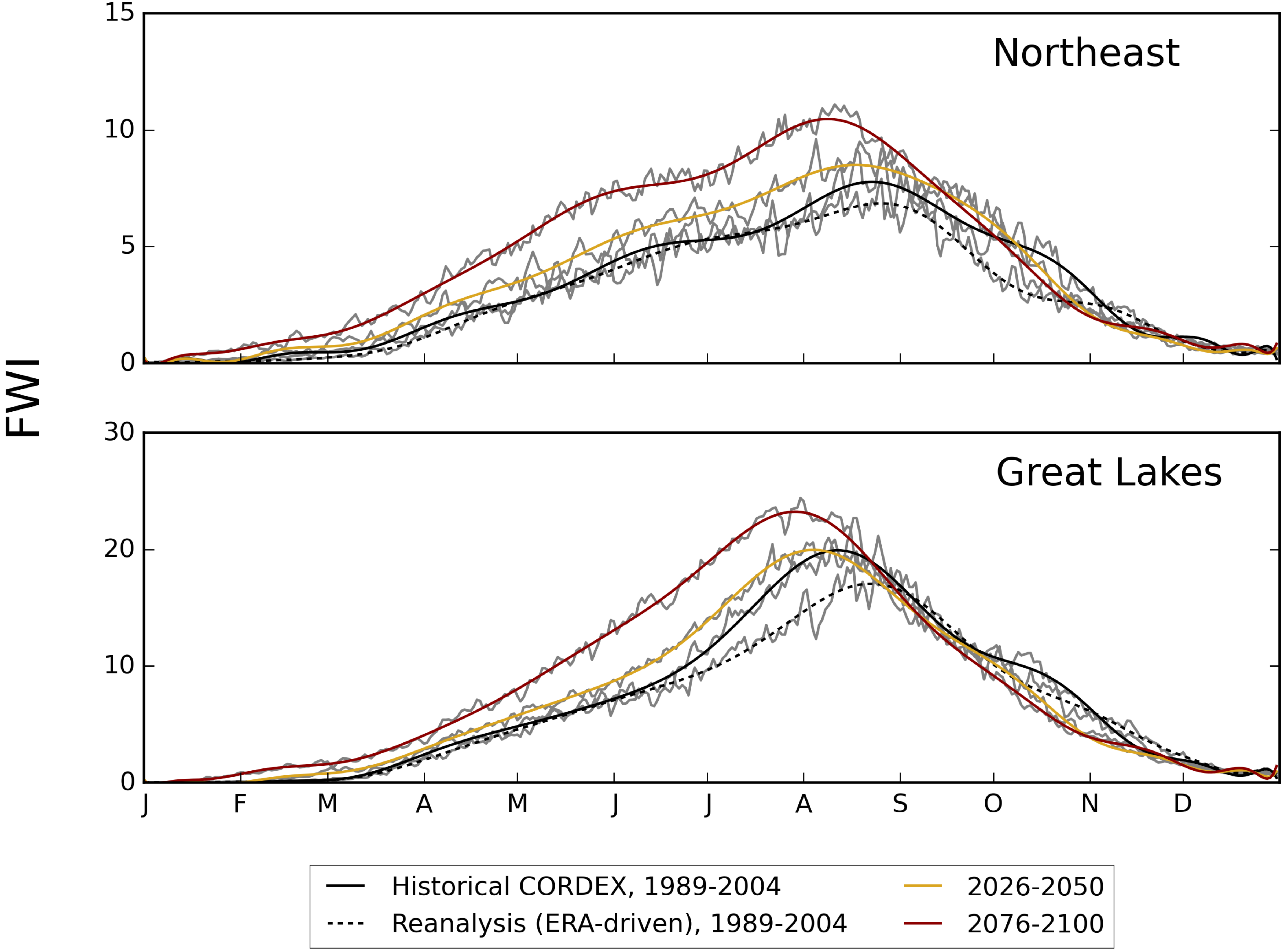

MME formed with "one model, one vote" approach
CanESM2 + RCA4
EC-EARTH + RCA4
CanESM2 + CanRCM4
EC-EARTH + HIRHAM5
Temperature
Relative Humidity
Precipitation
Wind Speed
Model
FWIs
CORDEX Models
Driving Variables
Canadian Forest Fire Weather Index System
Output

Changing magnitude of FWIs

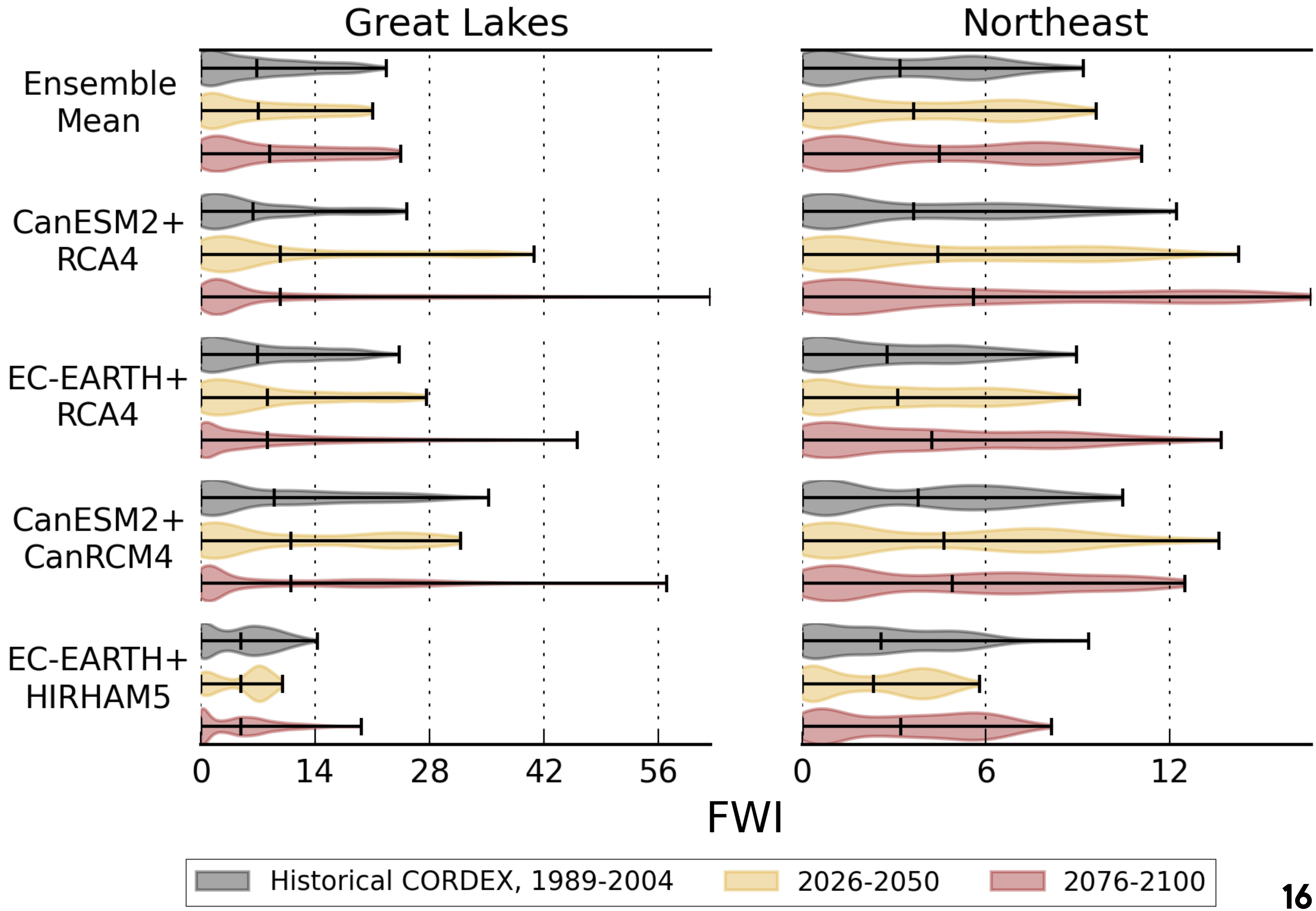
Changing shape of the fire season

Changing high risk episodes

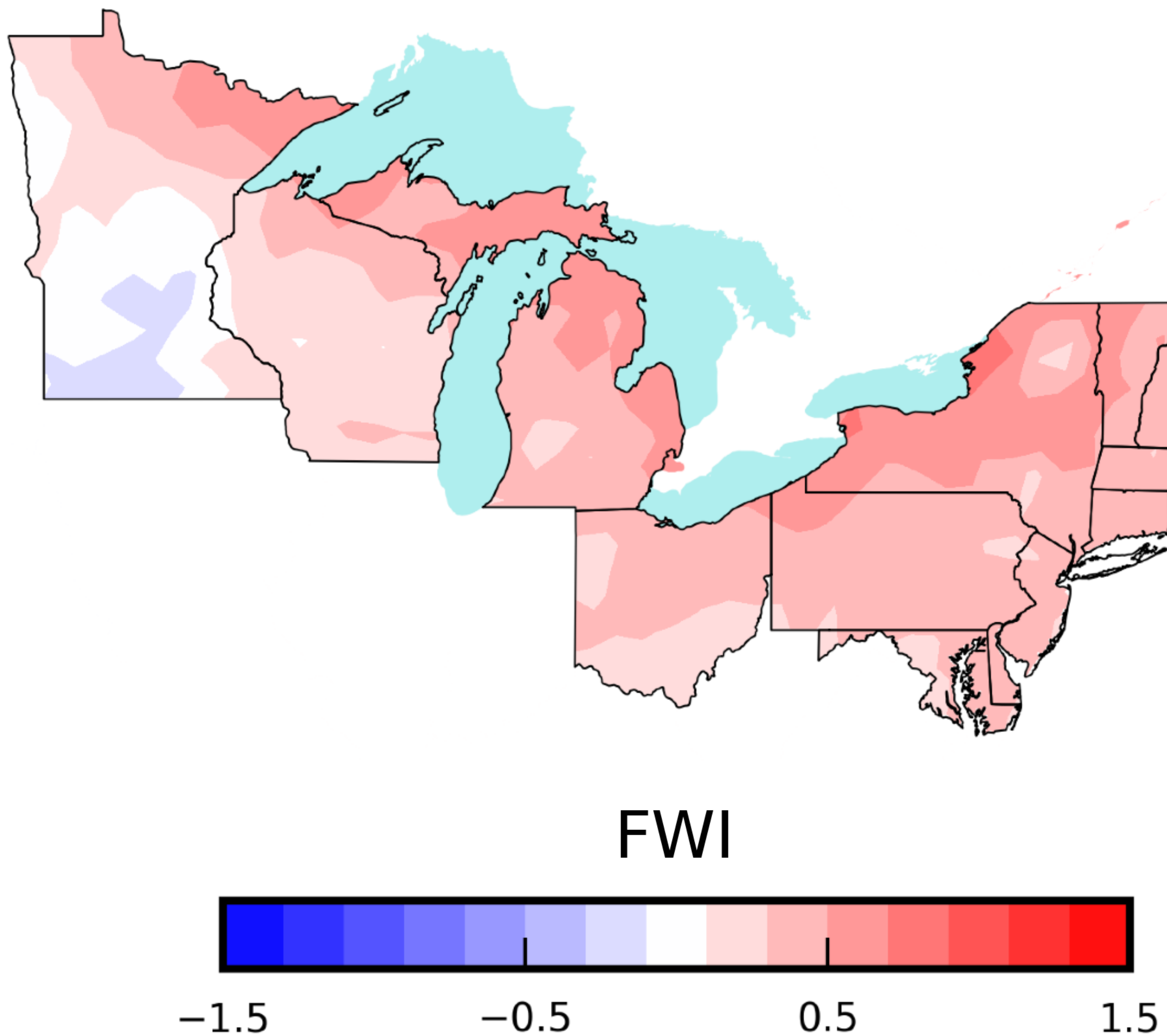
# Changing magnitude of FWIs

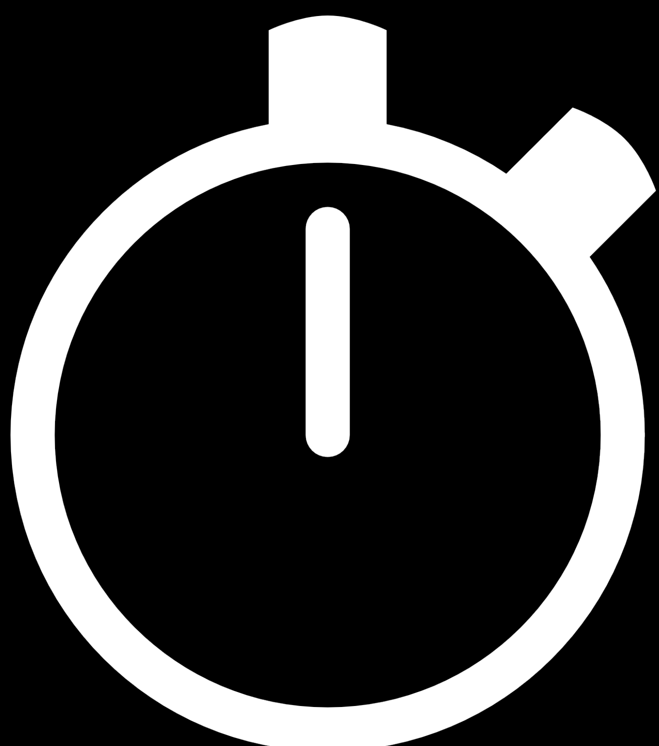


FWI
15
10
5
0
Northeast
30
20
10
0
Great Lakes
J
F
M
A
M
J
J
A
S
O
N
D
Historical CORDEX, 1989-2004
Reanalysis (ERA-driven), 1989-2004
2026-2050
2076-2100

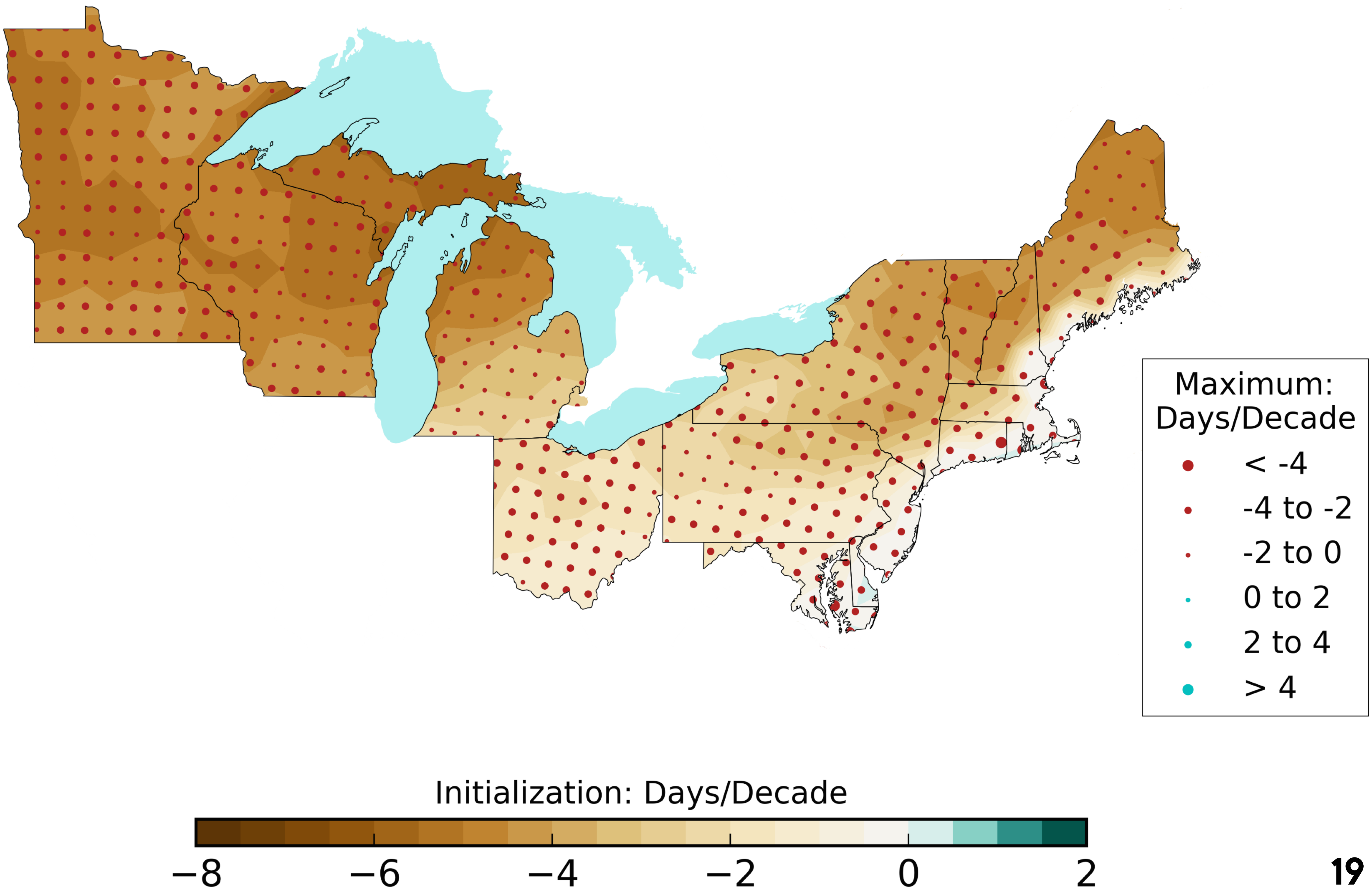

Great Lakes
Northeast
Ensemble Mean
CanESM2+ RCA4
EC-EARTH+ RCA4
CanESM2+ CanRCM4
EC-EARTH+ HIRHAM5
0
14
28
42
56
0
6
12
FWI
Historical CORDEX, 1989-2004
2026-2050
2076-2100

# Trend Decade$^{-1}$ (1989-2100)

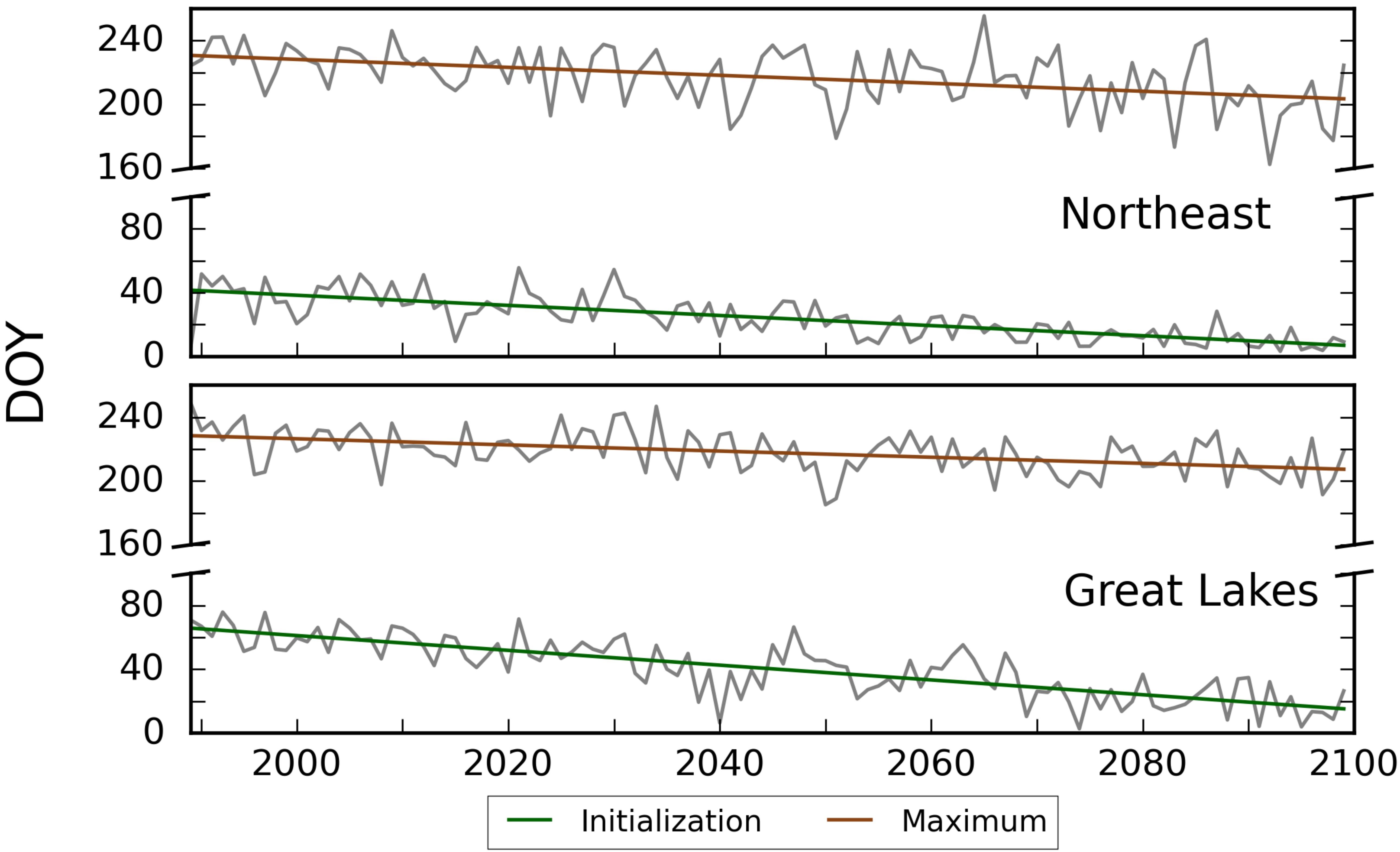




# Changing shape of the fire season

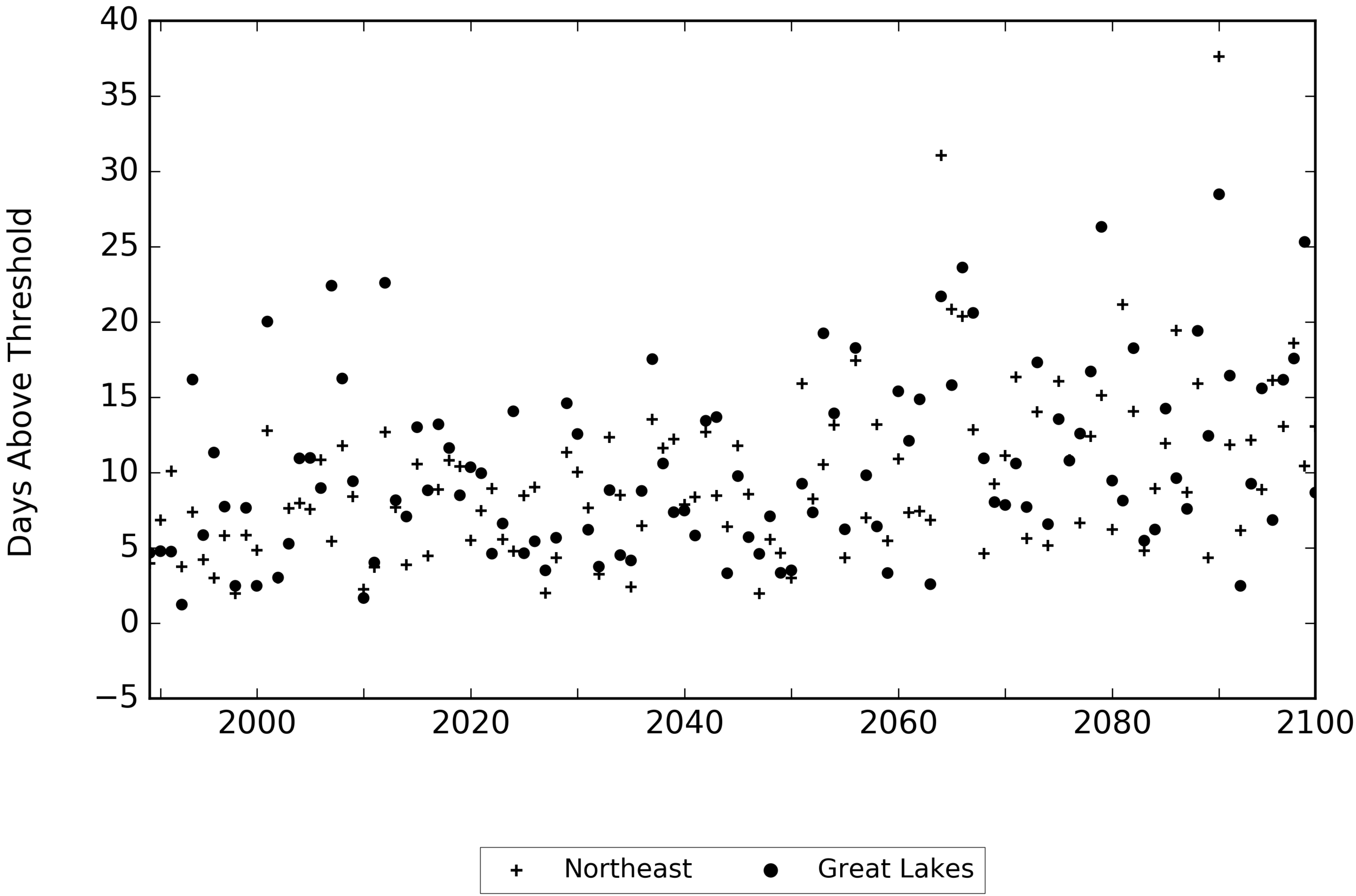


Maximum: Days/Decade
< -4
-4 to -2
-2 to 0
0 to 2
2 to 4
> 4
Initialization: Days/Decade
−8
−6
−4
−2
0
2

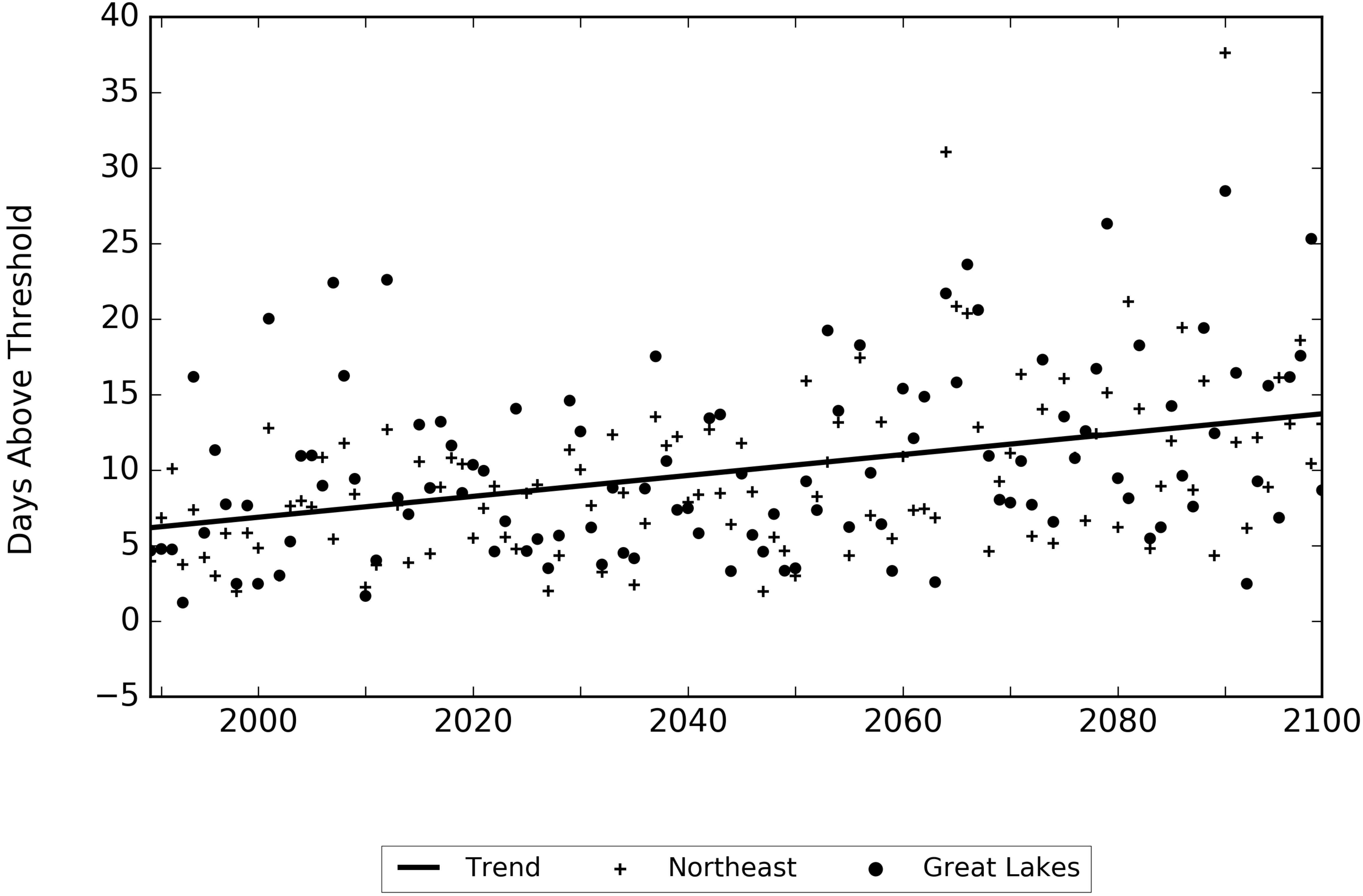


DOY
240
200
160
80
40
0
Northeast
240
200
160
80
40
0
Great Lakes
2000
2020
2040
2060
2080
2100
Initialization
Maximum

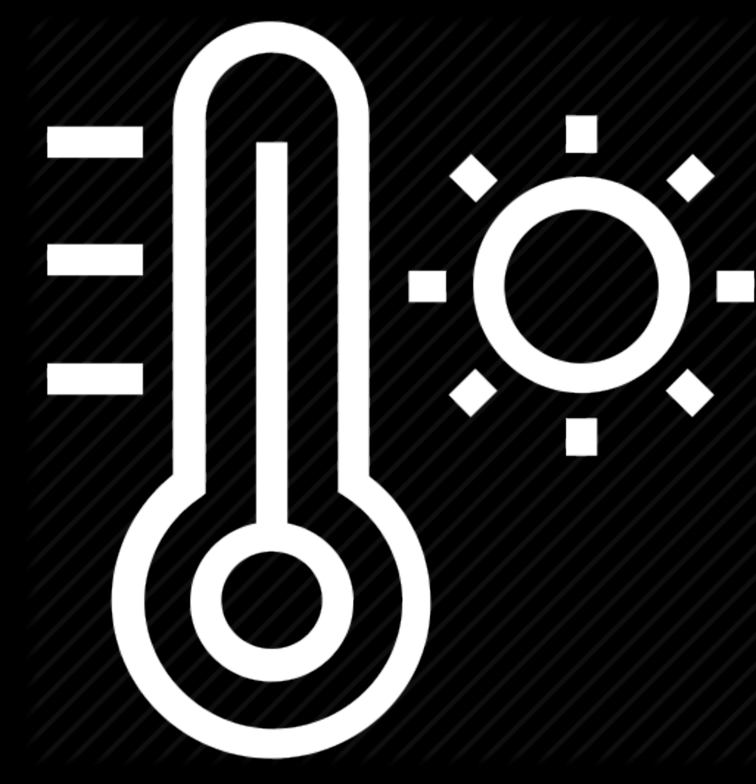
# Changing high risk episodes



Days Above Threshold
40
35
30
25
20
15
10
5
0
−5
2000
2020
2040
2060
2080
2100
Northeast
Great Lakes


Days Above Threshold
40
35
30
25
20
15
10
5
0
−5
2000
2020
2040
2060
2080
2100
Trend
Northeast
Great Lakes

# Understanding Simulated Changes



# Four driving variables — four cases

**1.** **historical** temperature
future relative humidity
future wind speed
future precipitation
} $FWI_{\text{adjusted, temp}}$

**2.** future temperature
**historical** relative humidity
future wind speed
future precipitation
} $FWI_{\text{adjusted, RH}}$

$$FWI_{\text{percentage change}} = \frac{FWI_{\text{adjusted}} - FWI_{\text{future}}}{FWI_{\text{future}}} \cdot 100\%$$

# Four driving variables — four cases

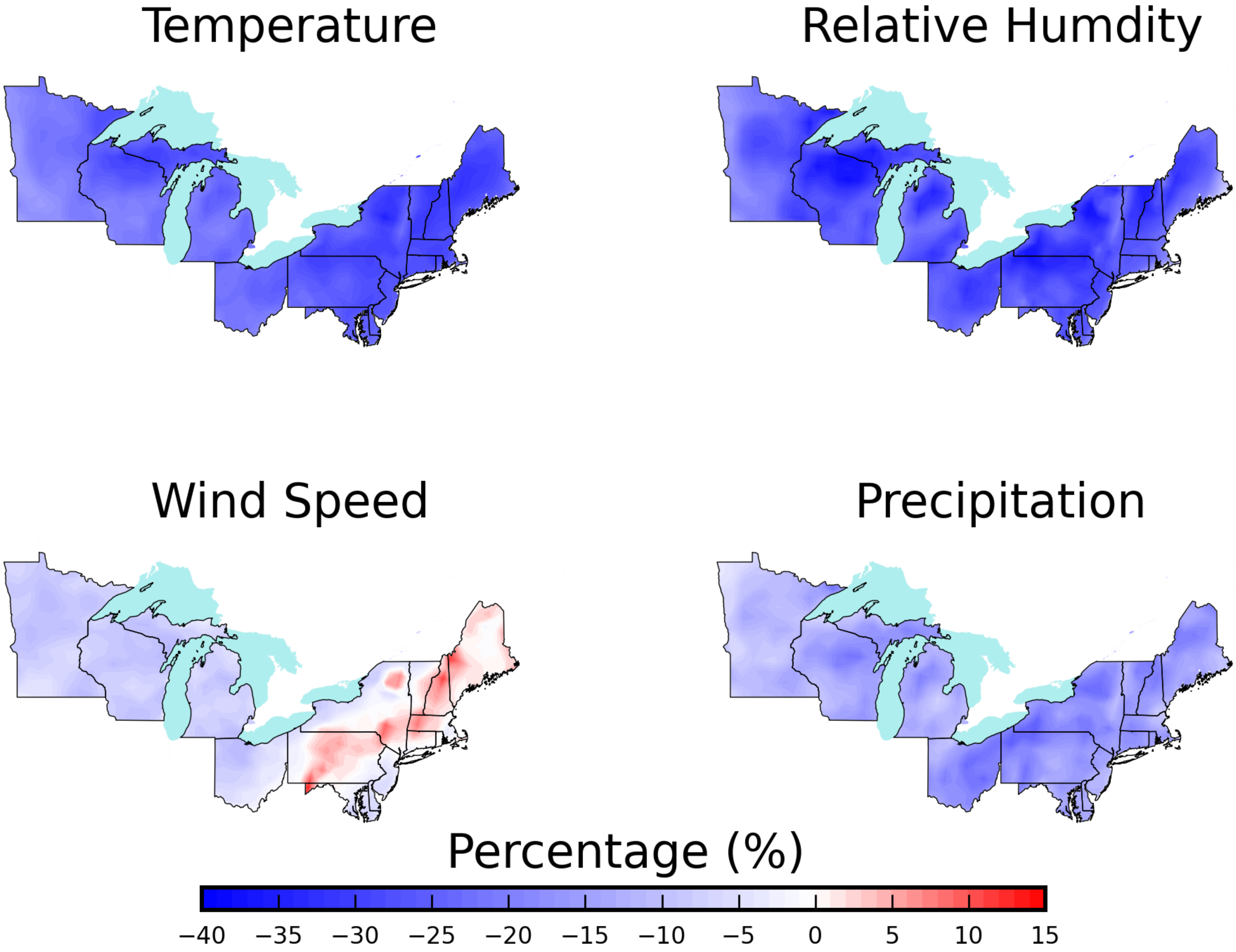
**3.** future temperature
future relative humidity
**historical** wind speed
future precipitation

} $FWI_{\text{adjusted, wind}}$

**4.** future temperature
future relative humidity
future wind speed
**historical** precipitation

} $FWI_{\text{adjusted, precip}}$

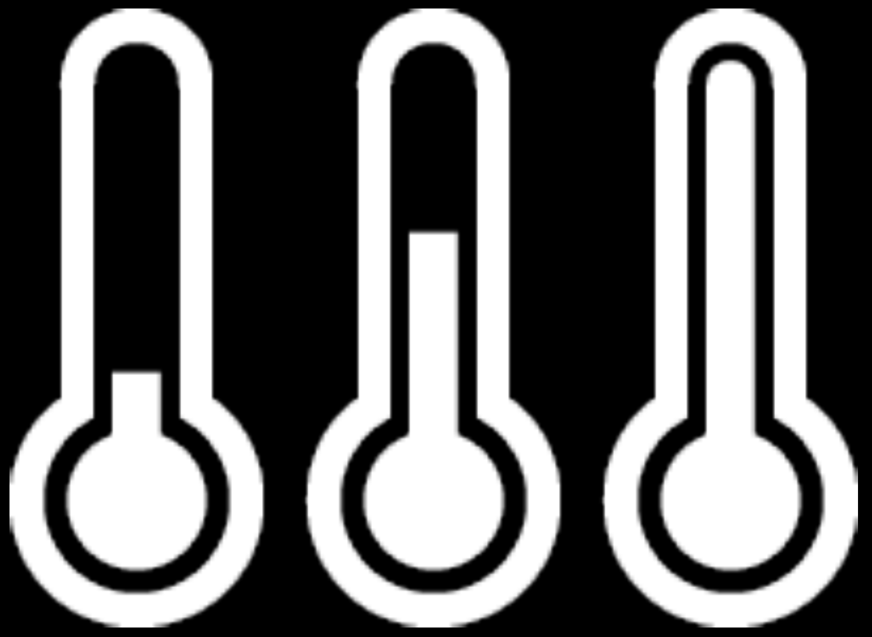
$$FWI_{\text{percentage change}} = \frac{FWI_{\text{adjusted}} - FWI_{\text{future}}}{FWI_{\text{future}}} \cdot 100\%$$


Temperature
Relative Humdity
Wind Speed
Precipitation
Percentage (%)
−40
−35
−30
−25
−20
−15
−10
−5
0
5
10
15

# Summary

- Increased wildland fire risk during the 21st century with largest increases in northern portions of the focus region
- Significant changes in the date of the initialization of the Canadian Forest Fire Weather Index System and the peak of the wildland fire season
- Increasing duration of high risk episodes

# Acknowledgments



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