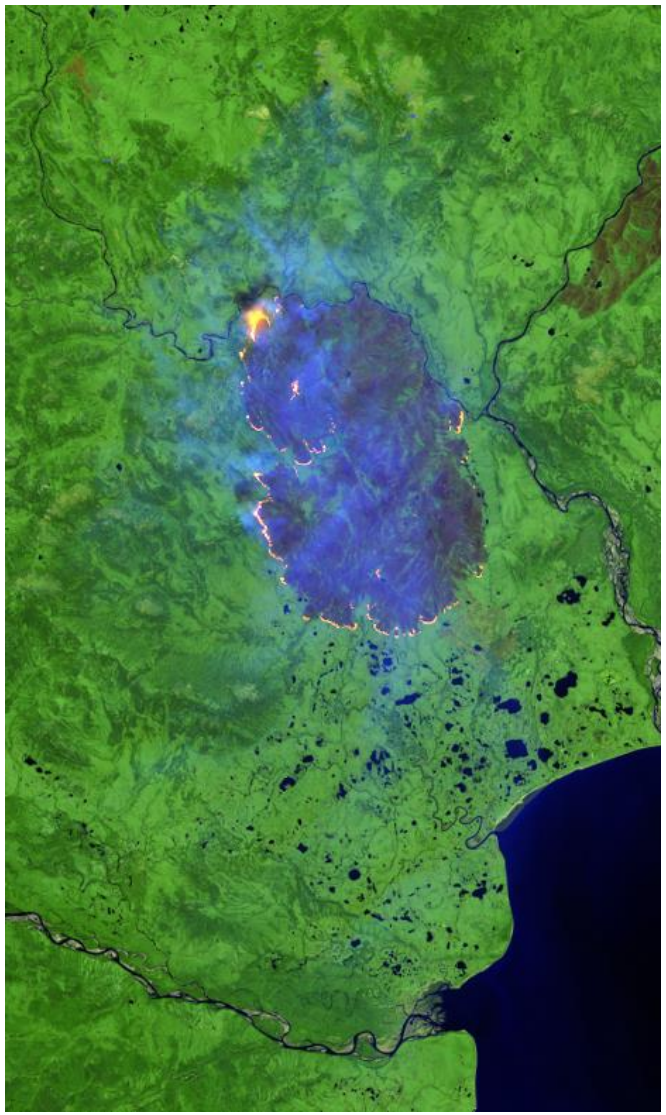


Watching the World Burn: Satellite Insights into Global Wildfire Activity

Dr. Will Maslanka

National Centre for Earth Observation
NATURAL ENVIRONMENT RESEARCH COUNCIL

Will Maslanka | William.maslanka@kcl.ac.uk | NCEO King's College London

KING'S College LONDON

About Me

MMET Meteorology with a year in Oklahoma

(University of Reading / Oklahoma University)

PhD: Extinction of Microwave Radiation in Snow

(University of Reading / Finnish Meteorological Institute)

Postdoctoral Research Assistant in Remote Sensing (RADAR)

Soil Moisture Observations for Natural Flood Management

(University of Reading)

Postdoctoral Research Associate in Earth Observation Sciences

High Latitude Wildfire Observations and Emission Estimations

(King's College London)

Dr. Will Maslanka

Remote Sensing Scientist

National Centre for Earth Observation
NATURAL ENVIRONMENT RESEARCH COUNCIL

KING'S College LONDON

Outline

Credit: NASA EOSDIS/LANCE and GIBS/Worldview

Introduction to Wildfires

Overview of Remote Sensing of Wildfires

How are Global Wildfire Patterns changing

Wildfire Emissions of Greenhouse Gases

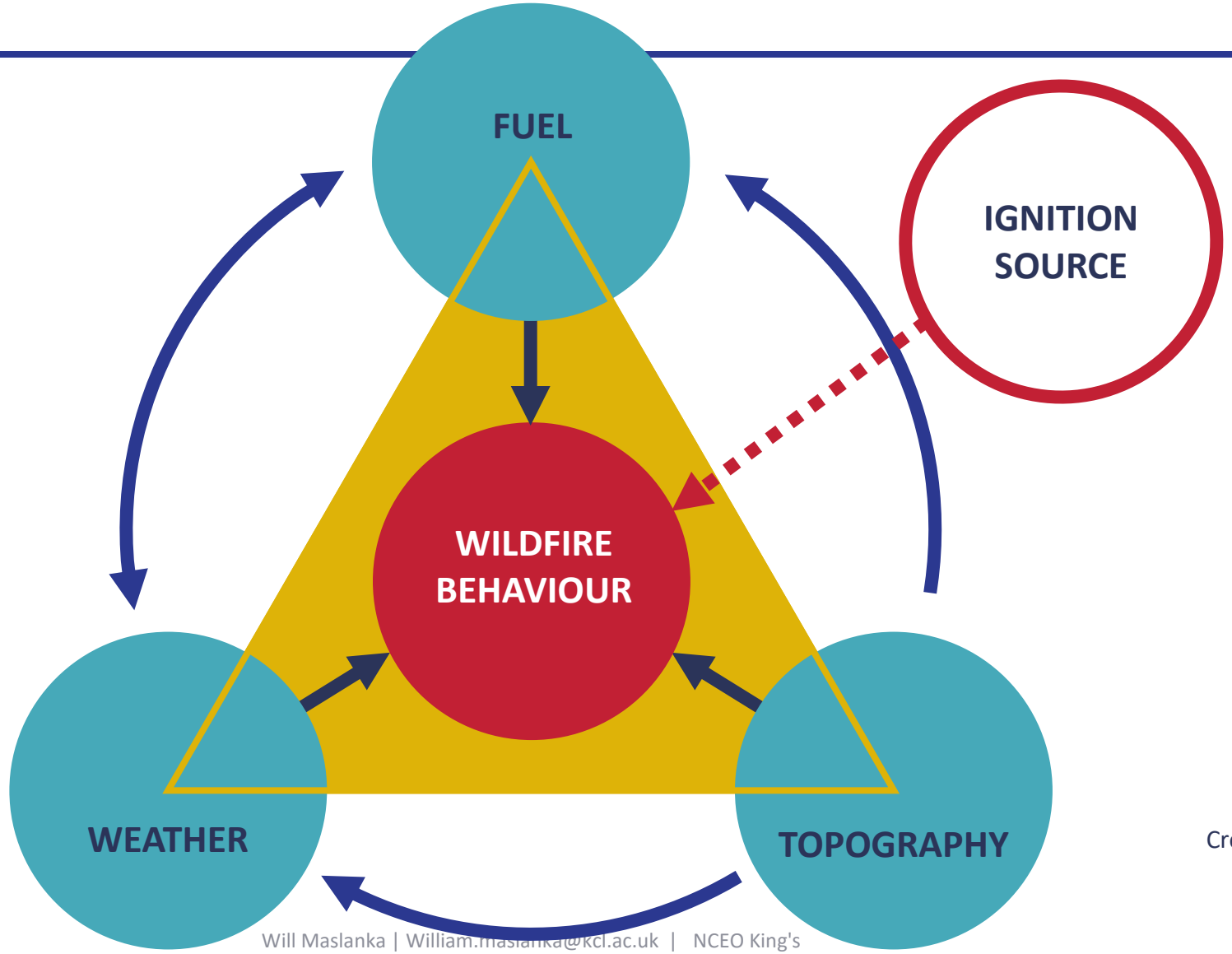
What do I mean by “Wildfire”

Credit: BBC News / EPA

A wildfire is an unusual or extraordinary free-burning vegetation fire that poses significant risk to social, economic, or environmental values. It may be started maliciously, accidently, or through natural means.

Spreading like Wildfire: The Rising Threat of Extraordinary Landscape Fires, UNEP 2022

What does a Wildfire need?



Credit: Countryman, 1966
Credit: Spreading like wildfire, *UNEP 2022*

Why do we care about Wildfires?

Societal Risk

- Loss of life, destruction of homes, communities, way of life
- Air quality degradation → 100,000's early deaths each year globally
- Important for Fire Management

Economic Risk

- Destruction of industry, supply lines, transport routes
- Directly damaging existing tree stock, altering landowners risk expectation

Environmental Risk

- Loss of vegetation, habitats
- Emission of particulate matter (Soot, GHG) into atmosphere and surface

BBC NEWS

Nova Scotia battles its largest wildfire on record

Canada wildfire smoke leaves millions under air quality advisory

Corfu latest Greek Island to evacuate over wildfires

Canada wildfires: At least 30,000 households in British Columbia told to evacuate

Europe heatwaves: Wildfires rage in Greece as temperatures soar

'Very high' wildfire risk in parts of Scotland

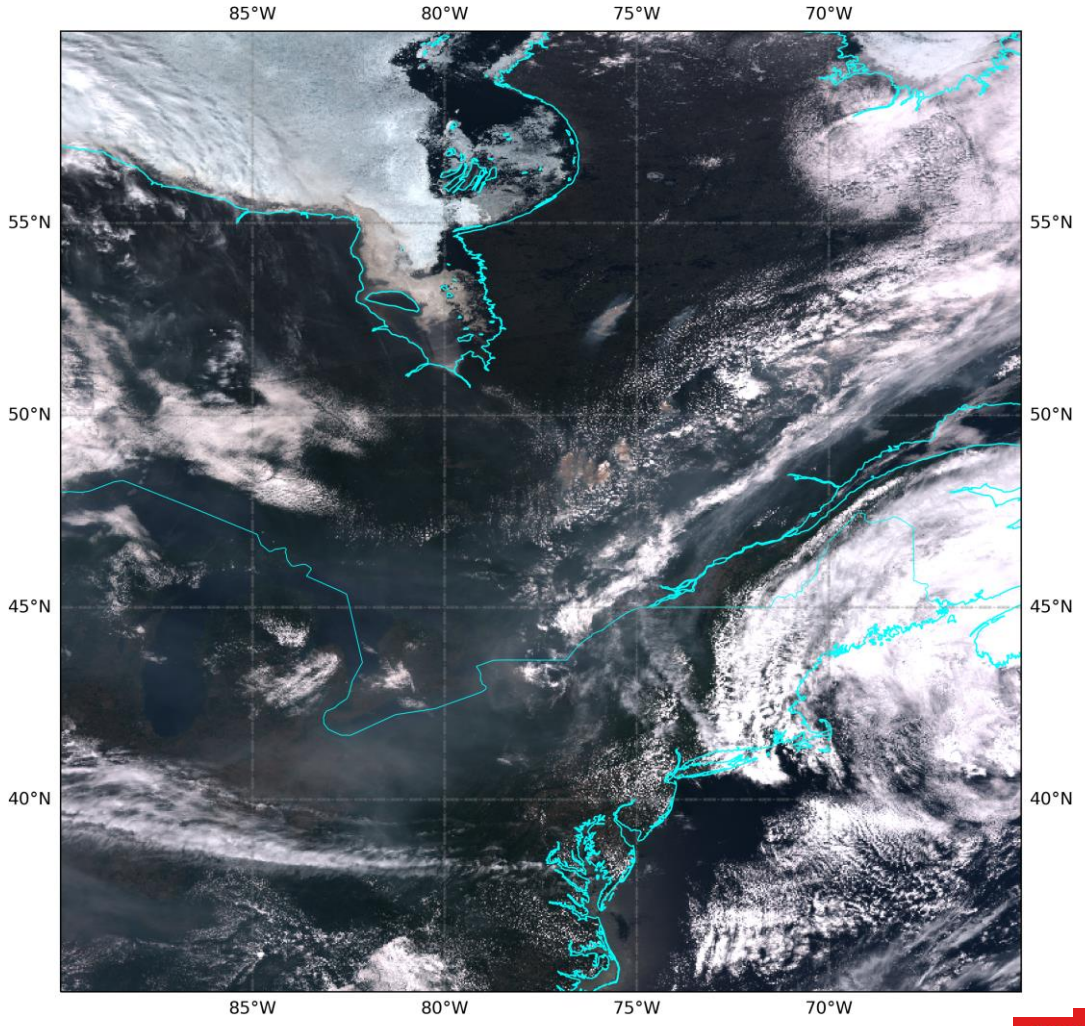
Why do we care about Wildfires?

To assess the location of risk, we need to know where the fire is

- Locally, Regionally, Globally

Only way to do this at the scales required is via ***remote sensing from space***

- Accurate and timely



Remote Sensing of Wildfires: The Basics

Observation of the energy released by the wildfire

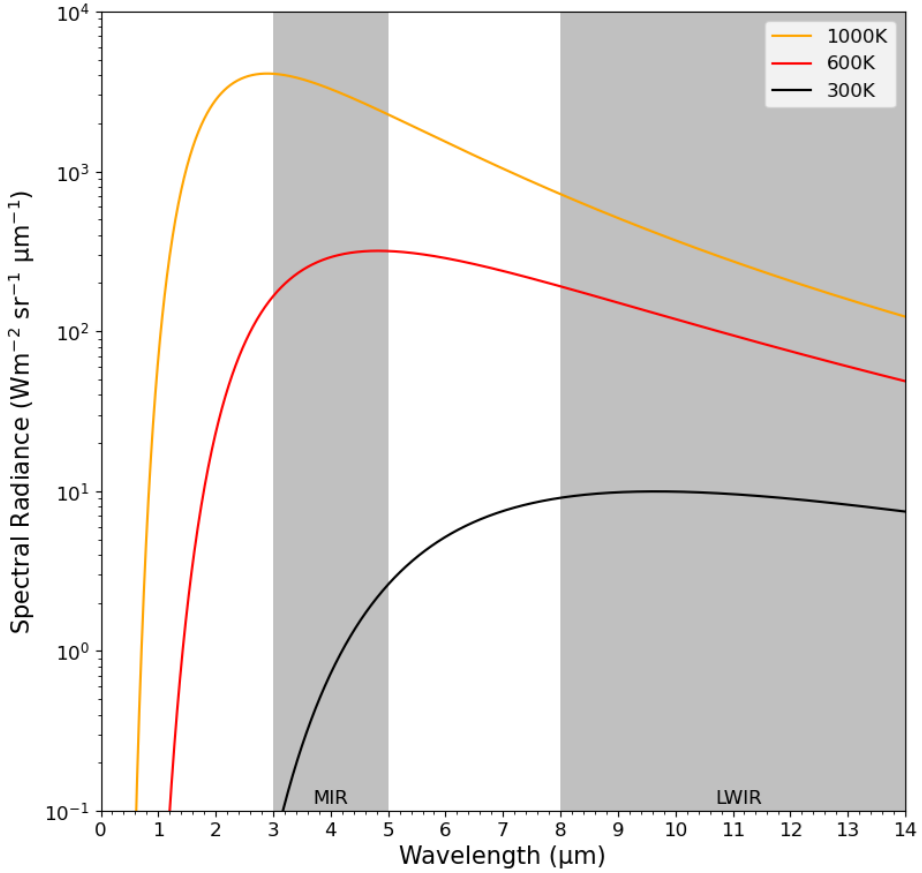
- Of the total energy released, 10-20% released as EM radiation
- Radiative energy release from fire >> radiative energy release from non-fire - (Planck's Radiation Law)

Active Fire: detects pixels that are burning at the time of the overpass under relatively cloud free conditions

- Fire Radiative Power (Wm^{-2})

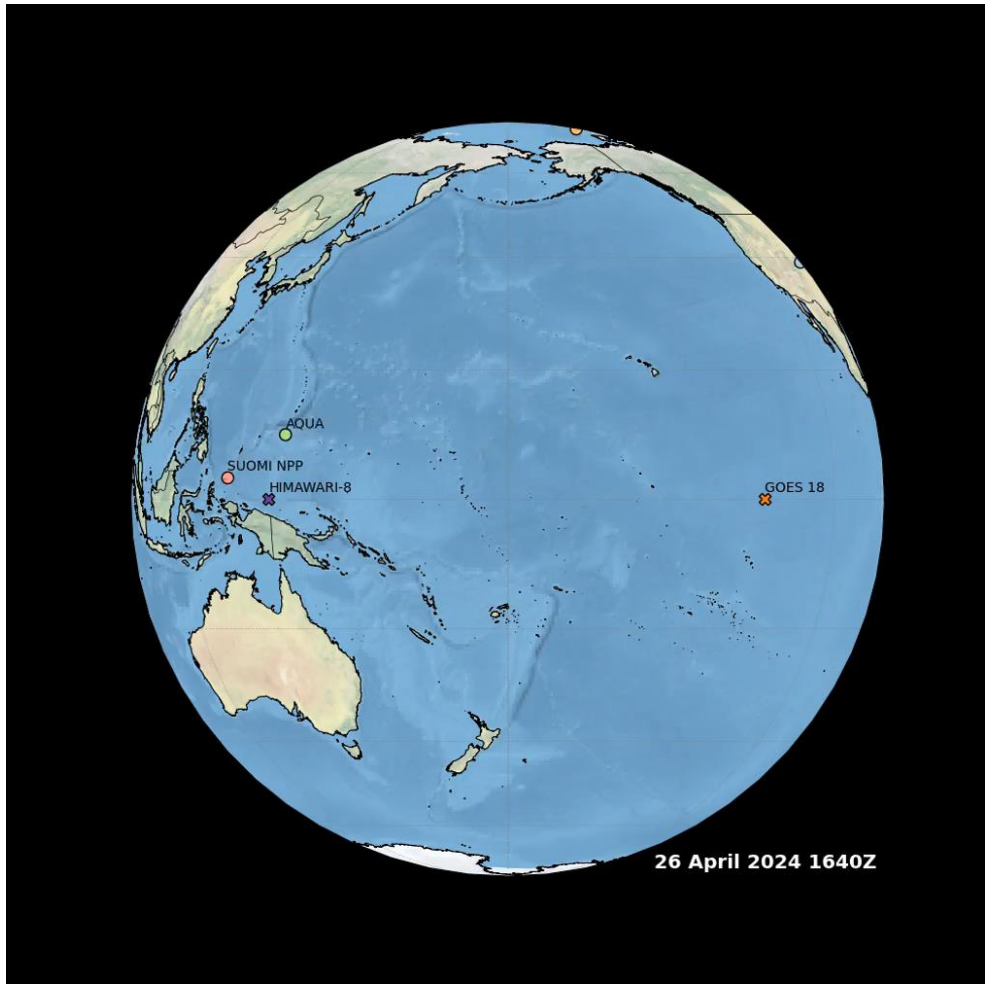
Burnt Area: maps the spatial extent of fire and vegetation loss

- Spatial Extent (m^{-2})
- Date of Burn



Credit: Wooster et al. 2021

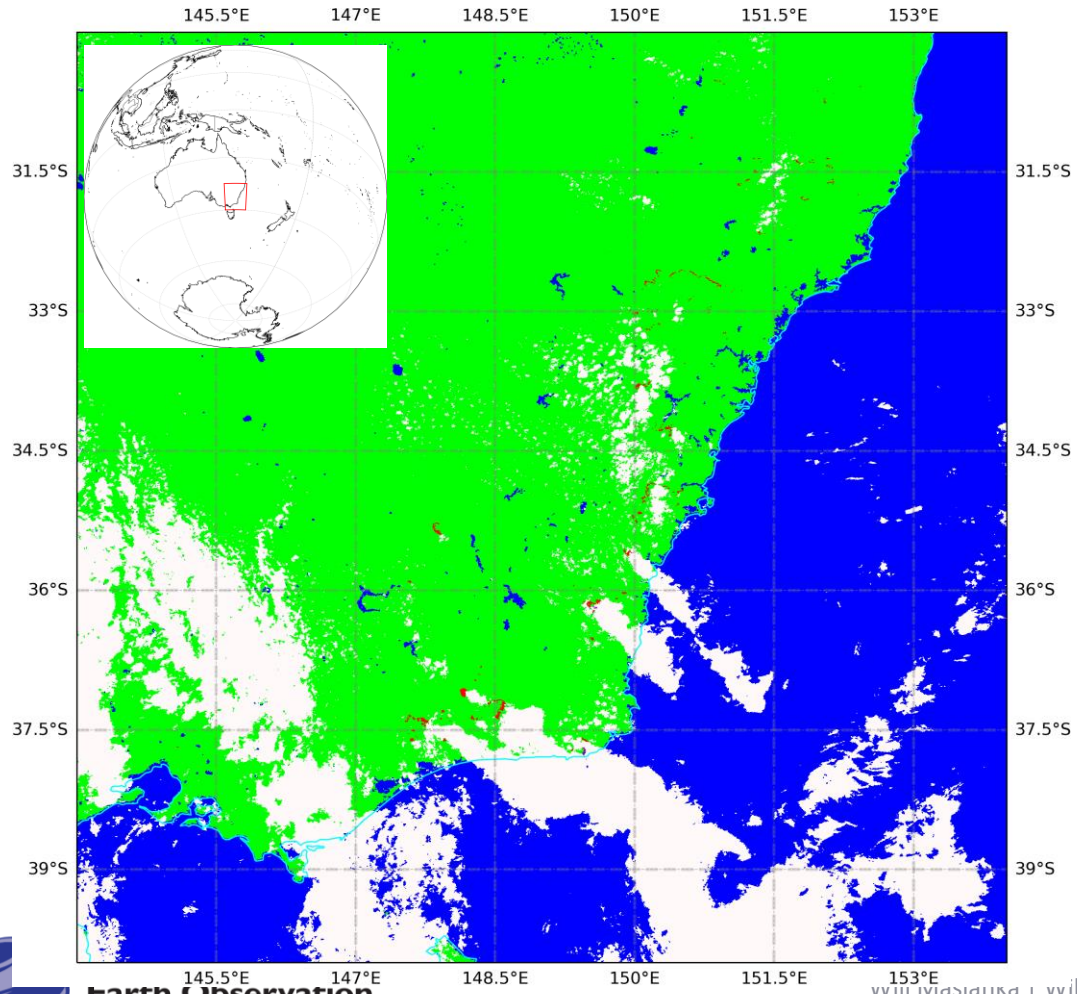
Remote Sensing of Wildfires: The Satellites



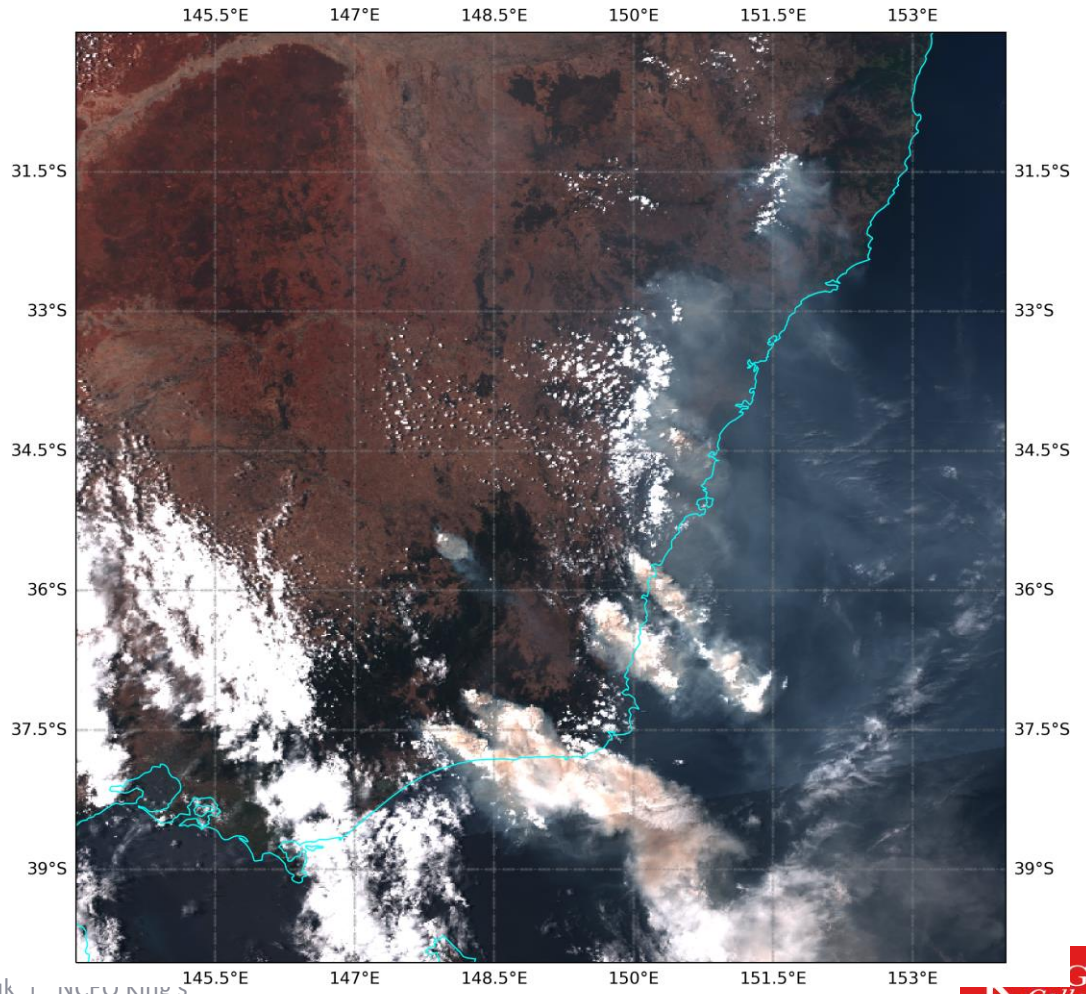
Space-based remote sensing best way to get global coverage

Polar/Sun-Synchronous (SSO)	***Geostationary (GEO)***
Orbit North-South	Orbital Period = Earth Rotation Period
Swath Observation	Full Disk Observation
High Spatial Resolution (≤ 1km)	High Temporal Resolution (~10-15 mins)
Poor Temporal Resolution	Poor Spatial Resolution at “Edges”
3 Instruments on 7 satellites	5 GEO for Fire Observation
MODIS – AQUA/TERRA (NASA)	GOES-18 (NOAA)
VIIRS – Suomi NPP + JPSS 1/2 (NASA/NOAA)	GOES-16 (NOAA)
SLSTR – Sentinel 3A + B (ESA)	MSG-2 (ESA)
	MSG-3 (ESA)
	Himawari-8 (JMA)

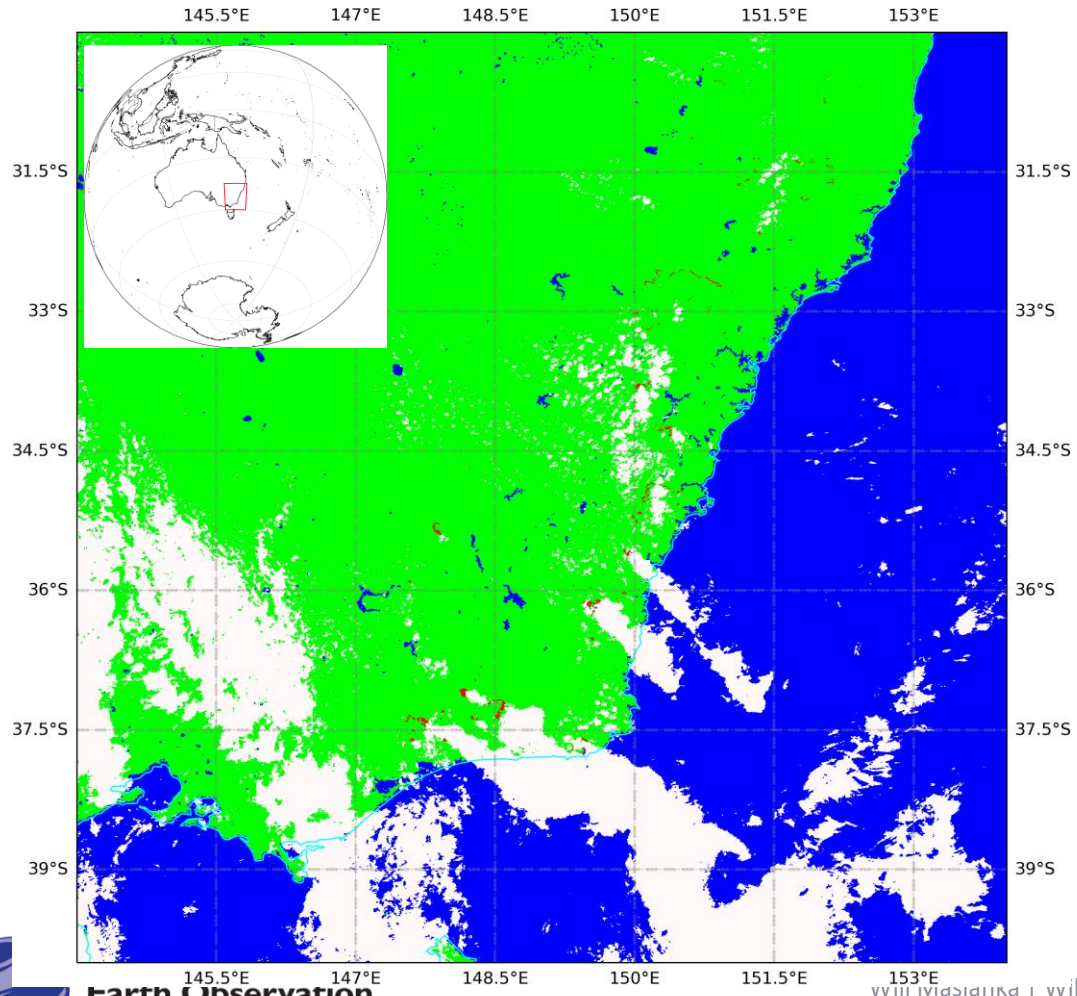
Remote Sensing of Wildfires: The Fires



SE Australia
30/12/19



Remote Sensing of Wildfires: The Fires



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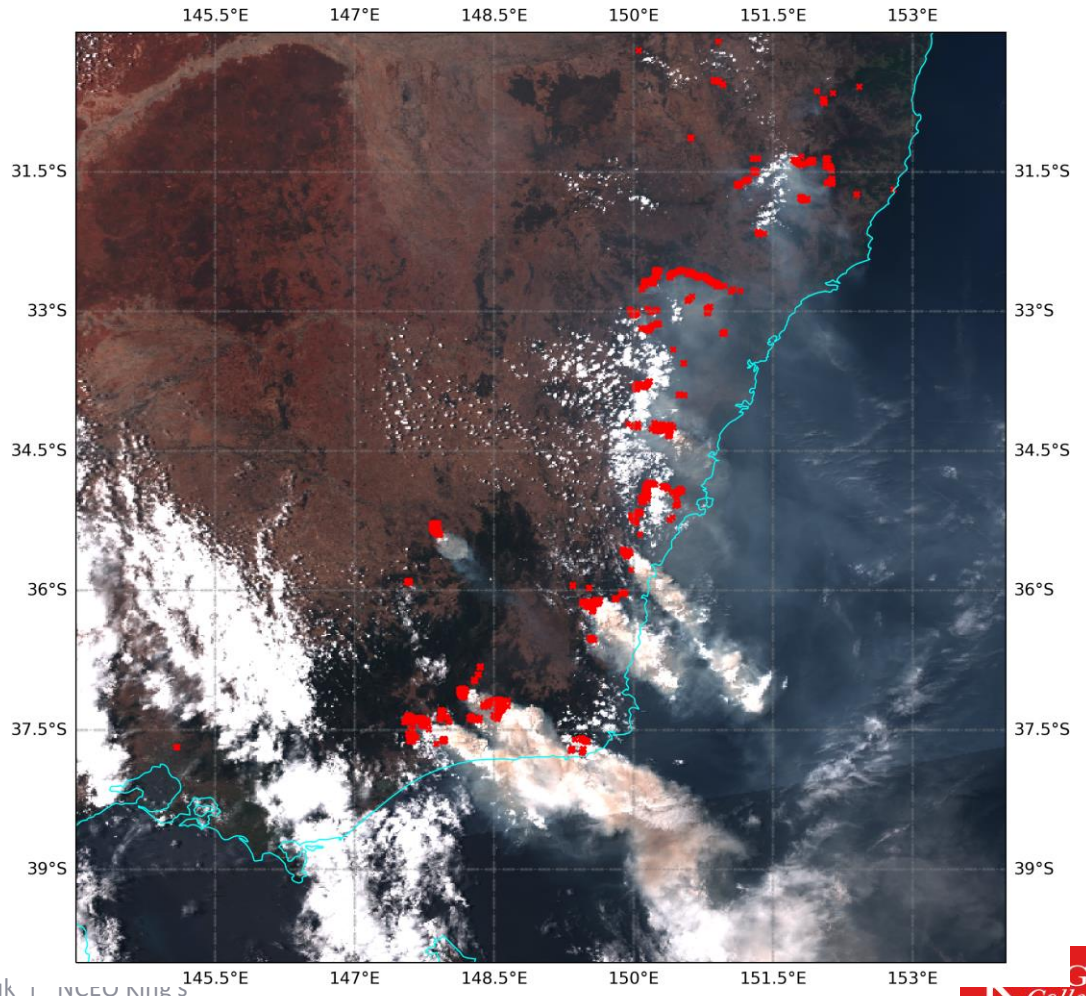

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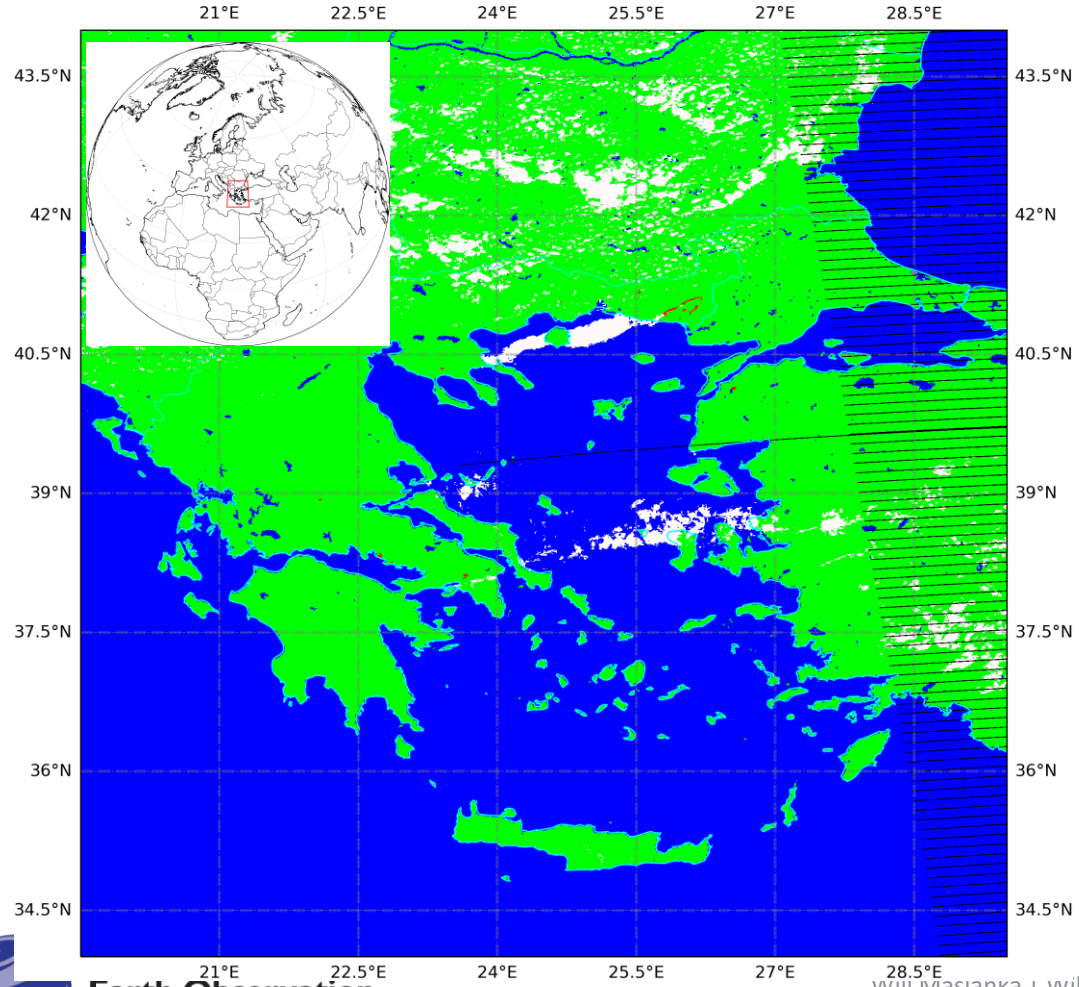
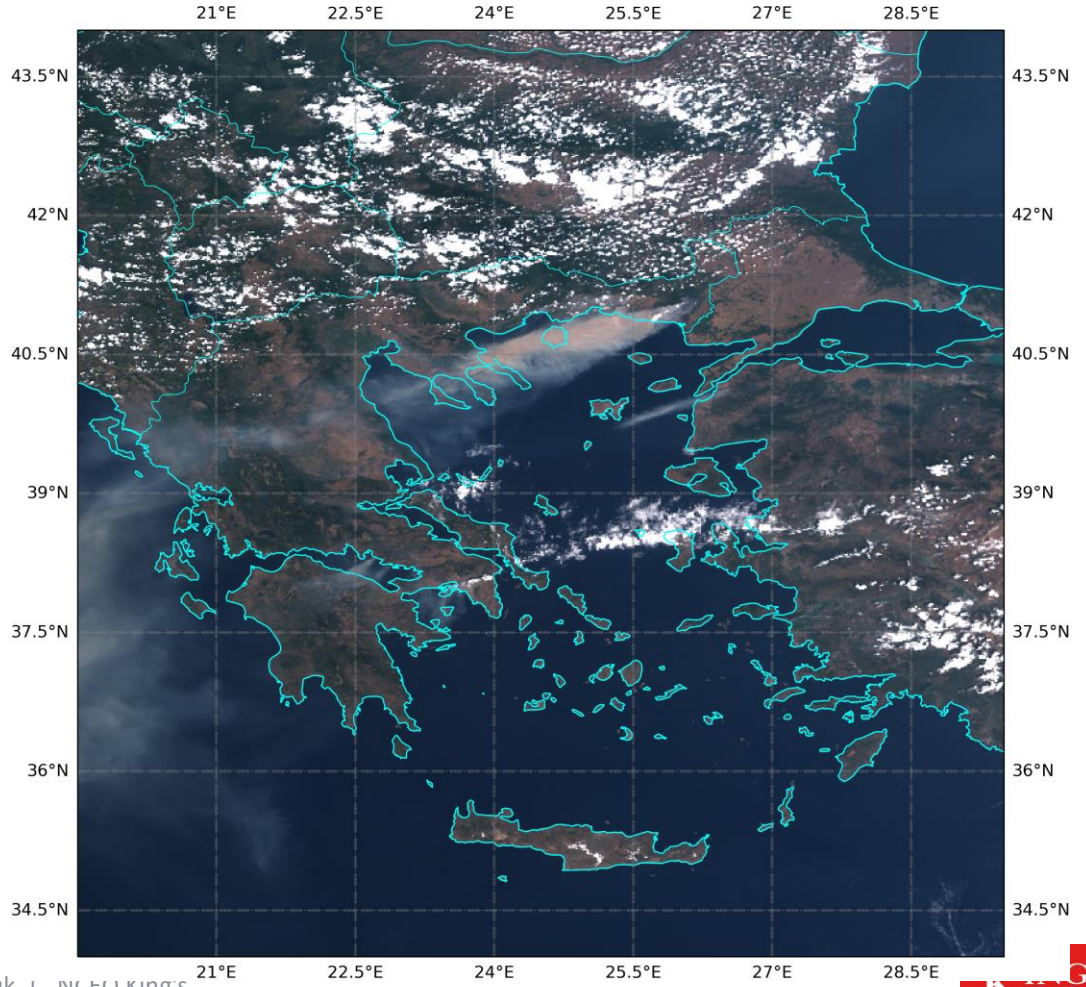


Greece
22/08/23



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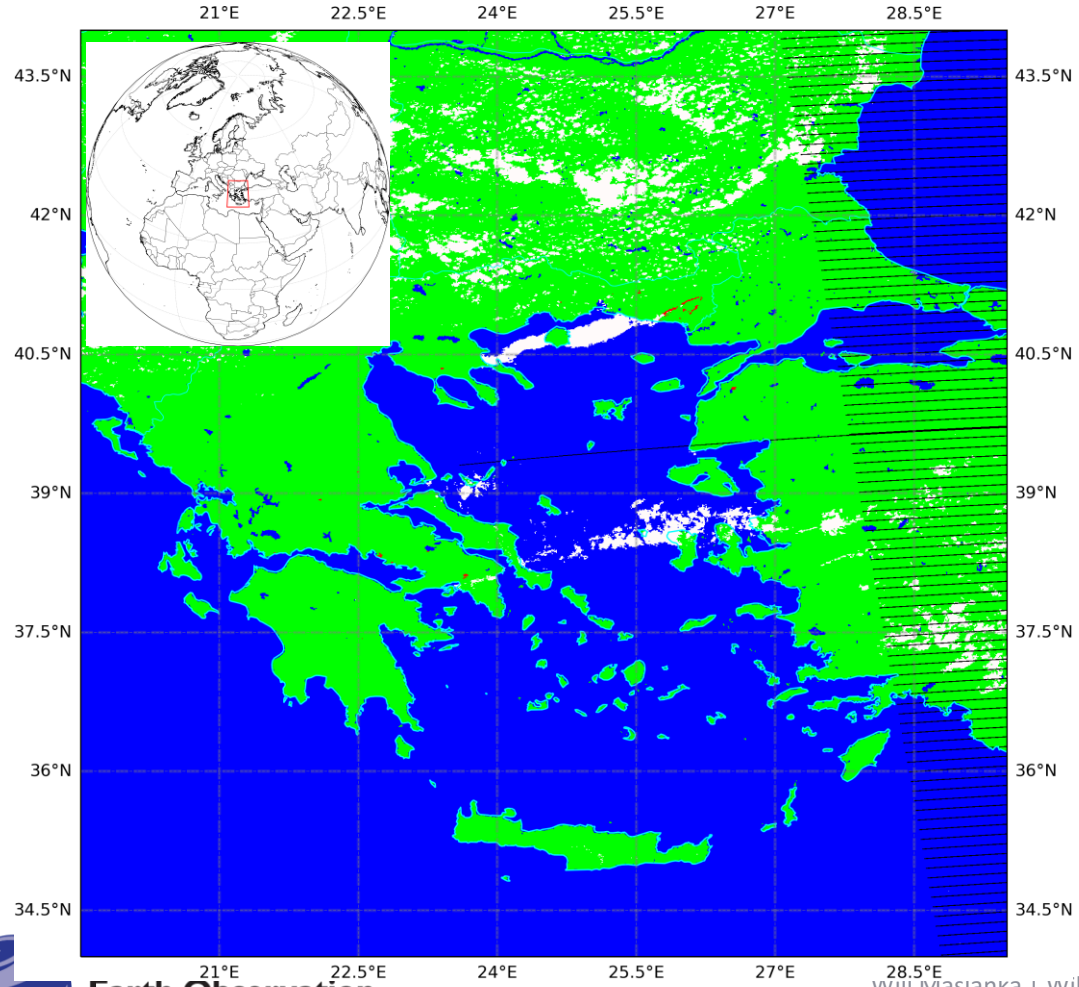

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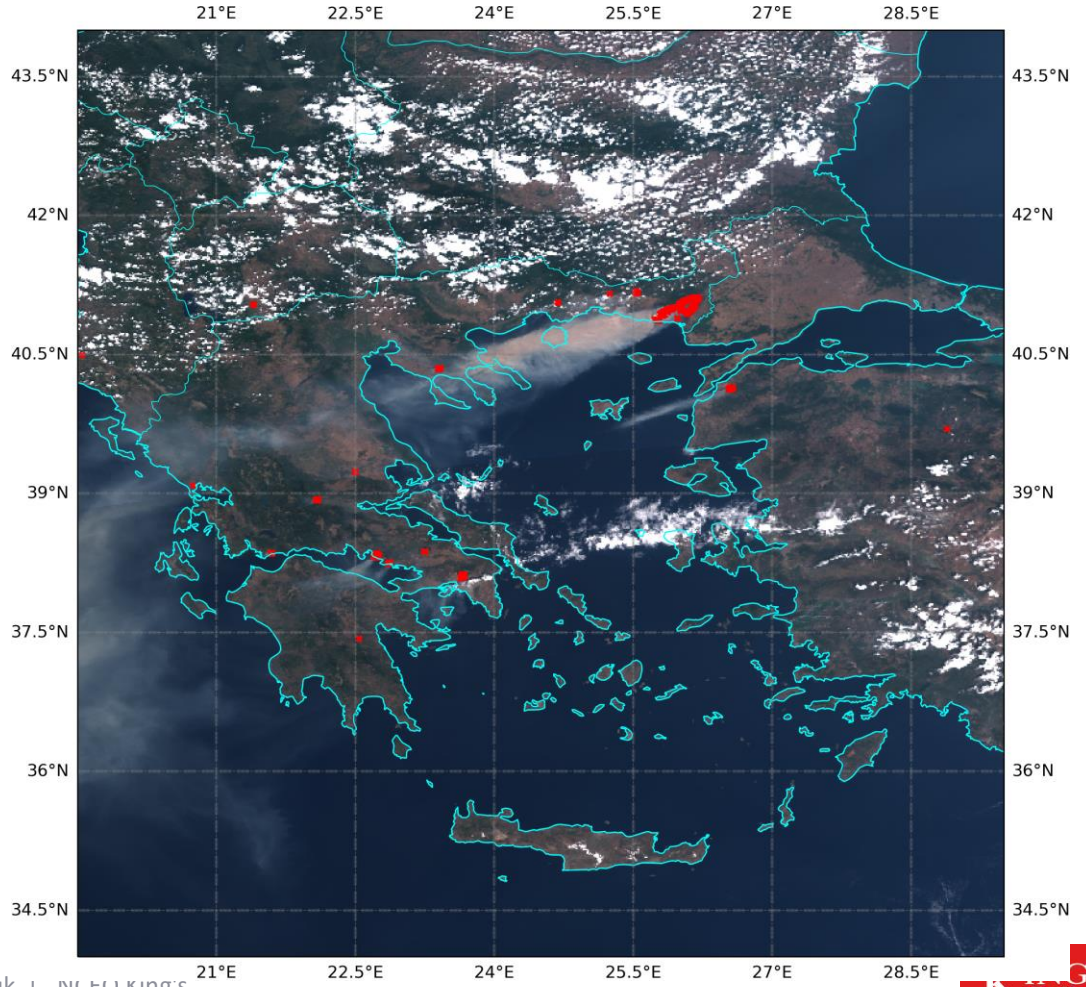

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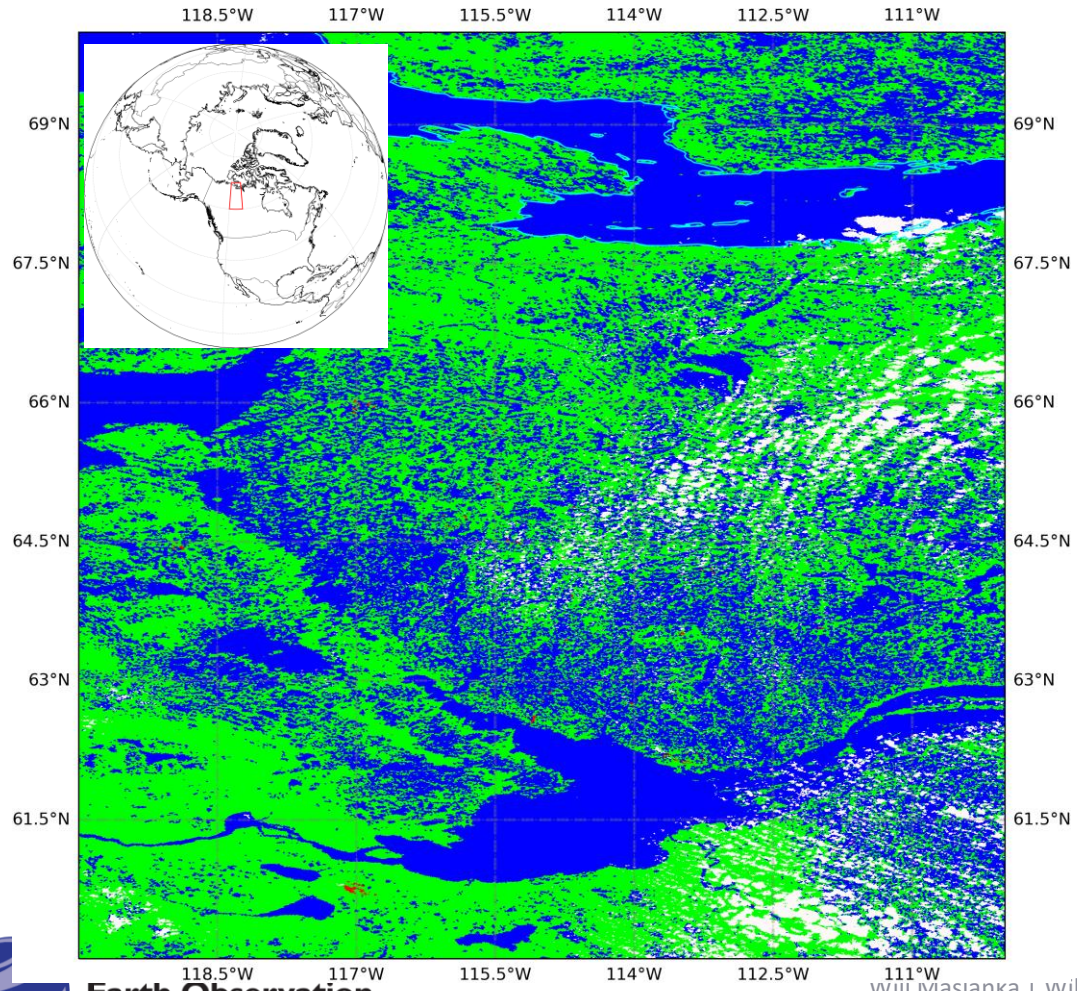
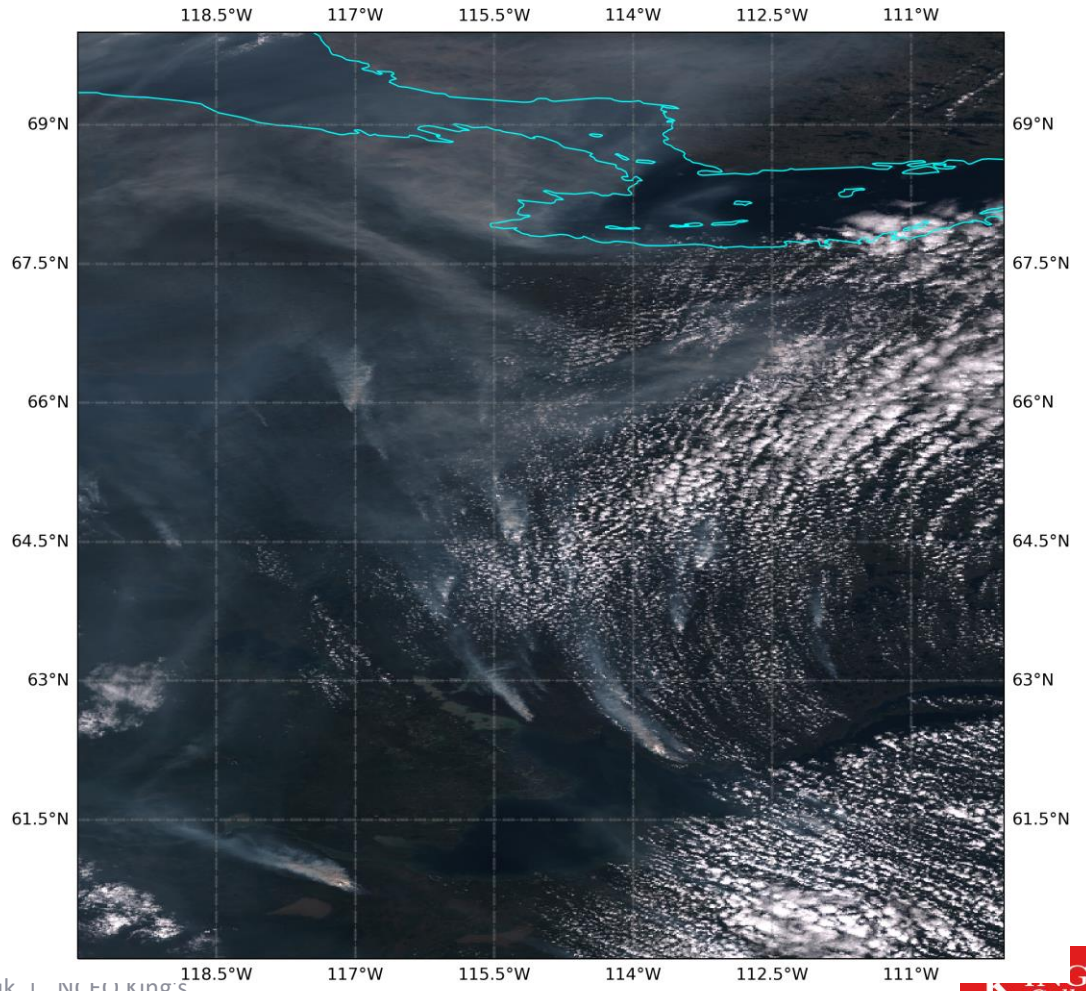


NW Canada
08/08/23



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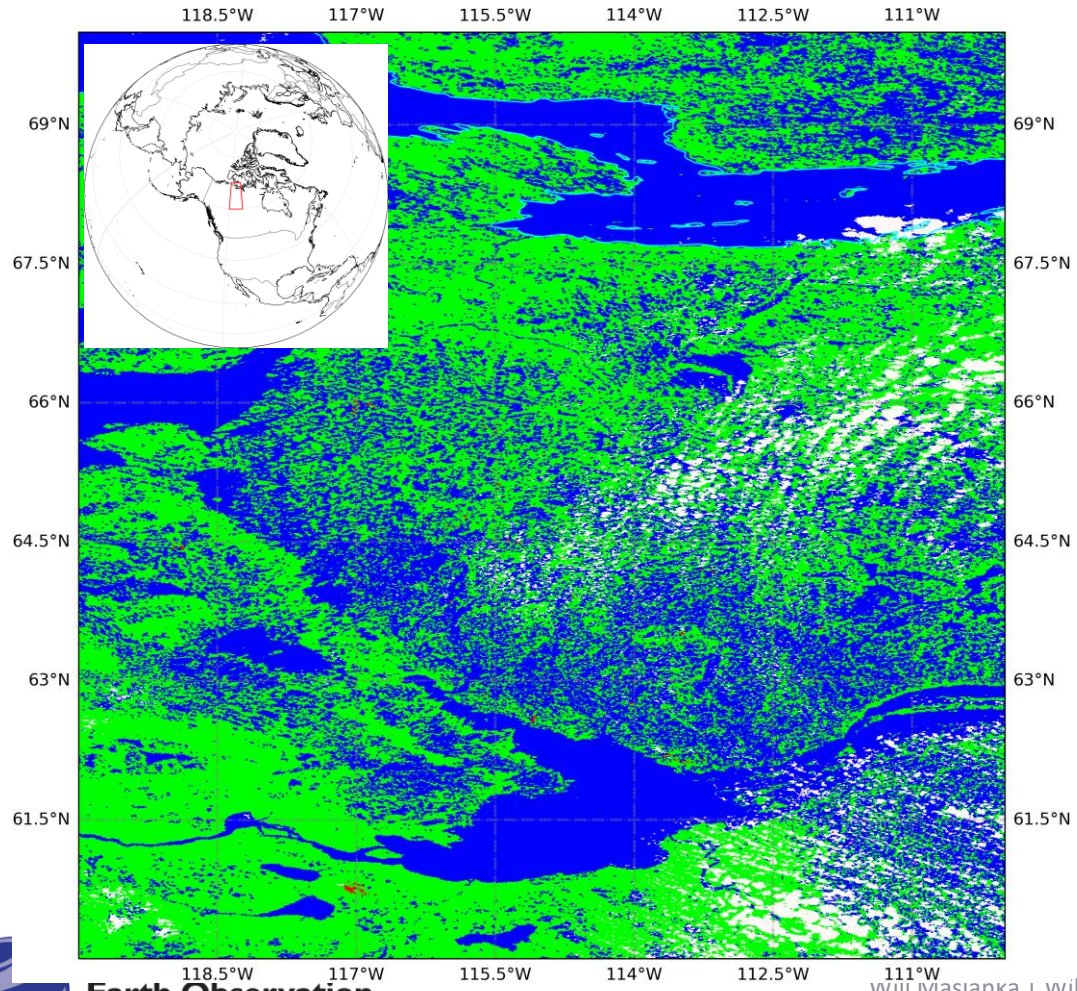

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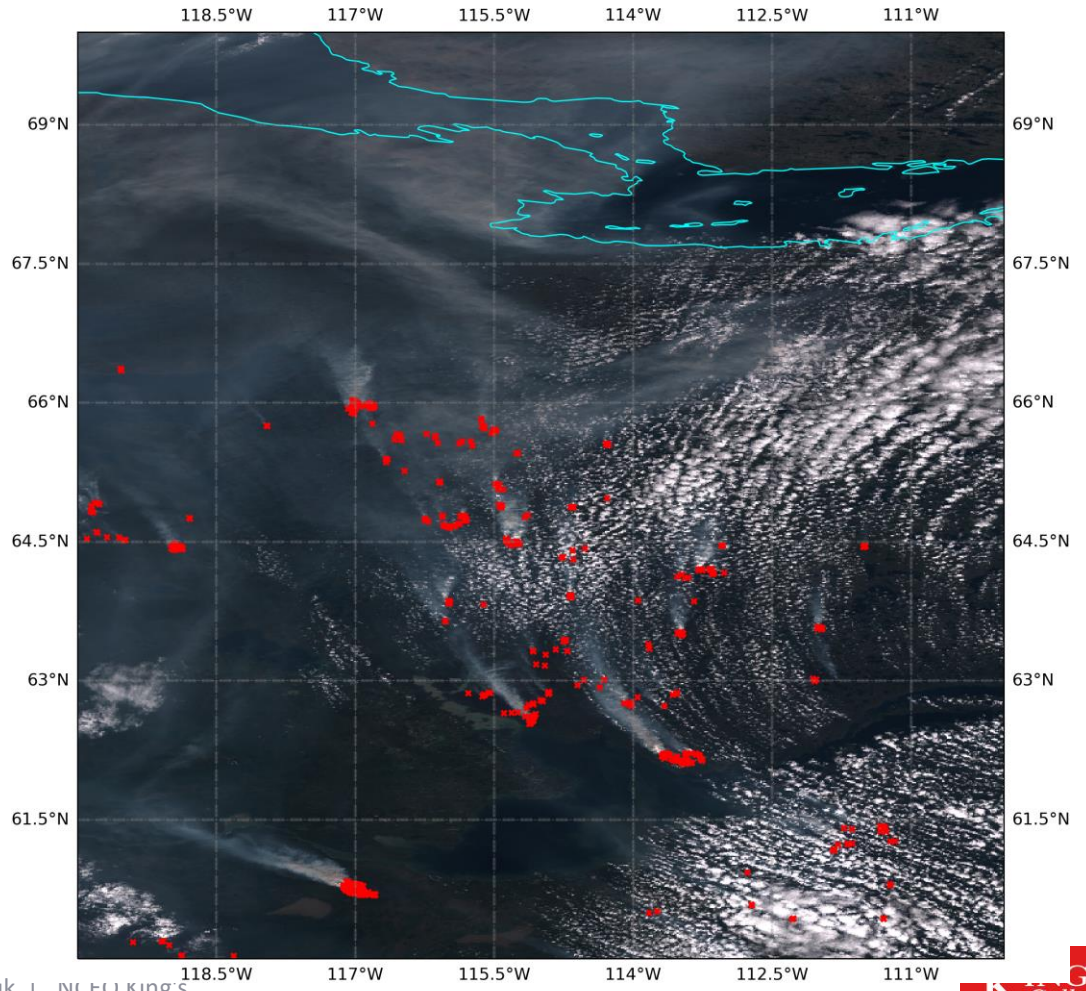
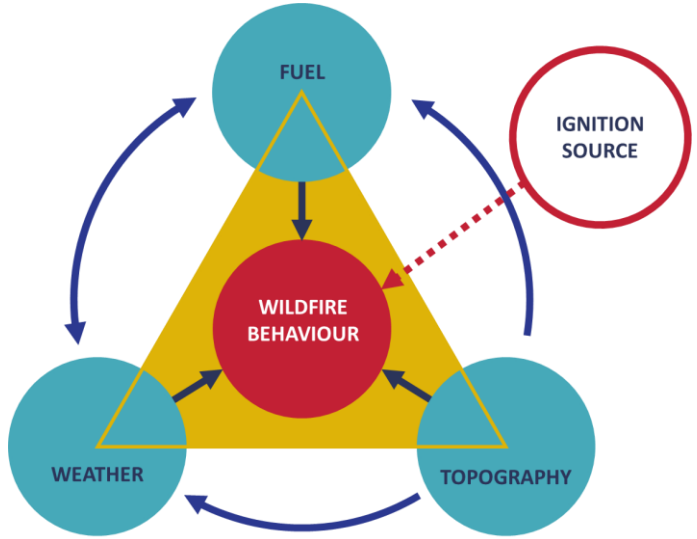


How are Wildfires changing?

Global Wildfire activity impacted by changes to fuel and weather

- Anthropogenic and Natural sources.



How are Wildfires changing?

Global Wildfire activity impacted by changes to fuel and weather

- **Anthropogenic** and Natural sources.

Human-induced landscape change influences ignition sources

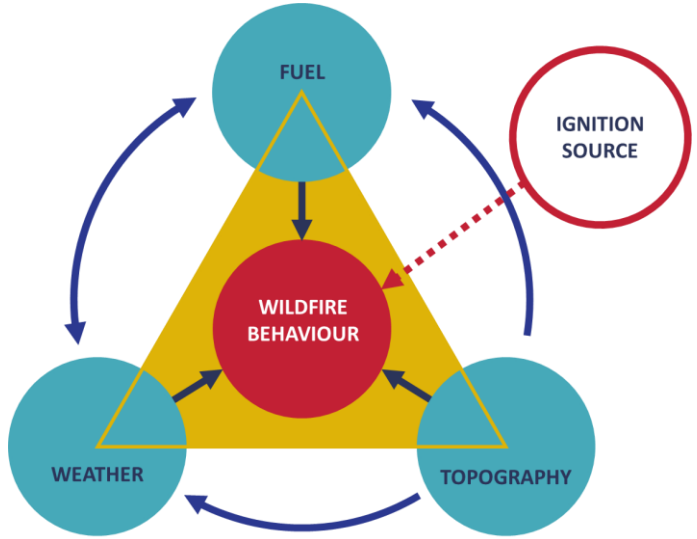
- Use fire to burn forested areas, manage agricultural areas (Increase)

Human-induced landscape change influences fuel

- Logging, Cattle Grazing (Reduce)
- Abandonment/Reforestation (Increase)
- Land fragmentation (Increase/Decrease, biome dependant)

Human-induced landscape change influences weather

- Deforestation impacts regional evapotranspiration, cloud cover, and precipitation.



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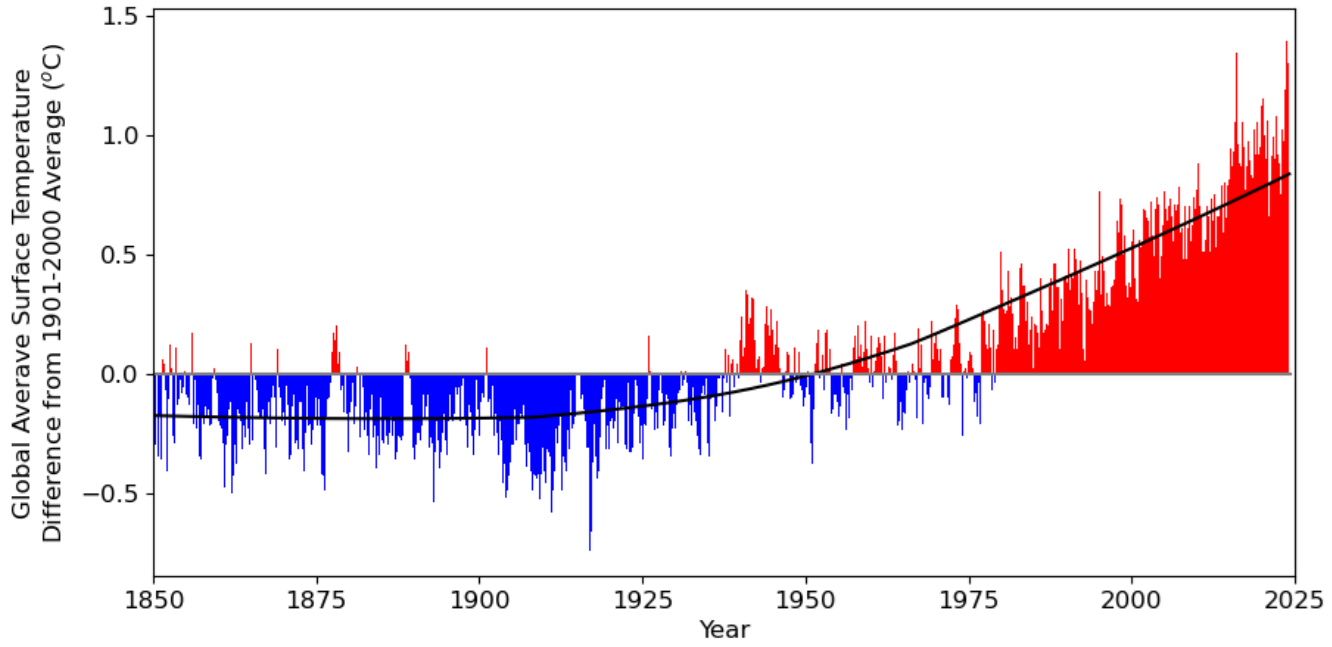
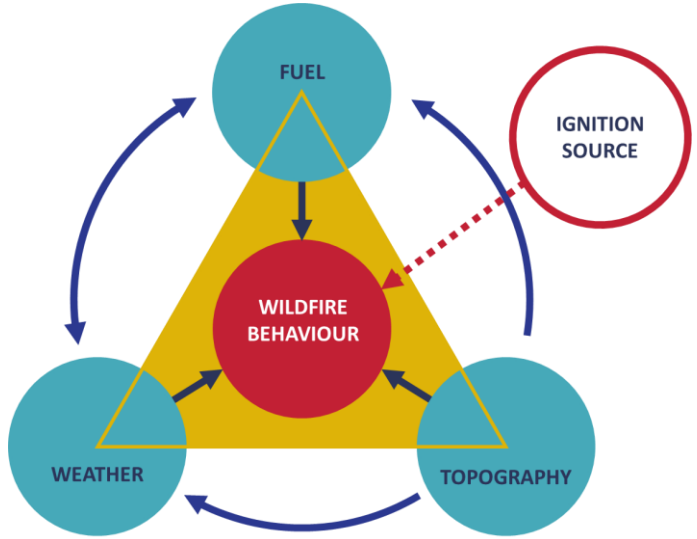




How are Wildfires changing?

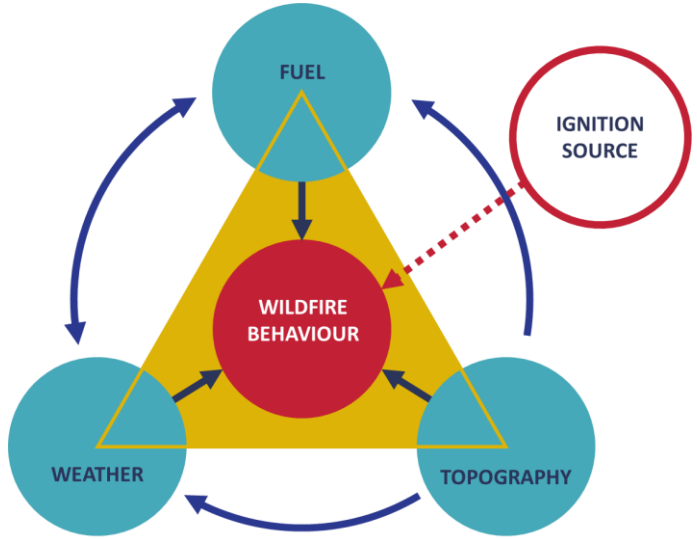
Global Wildfire activity impacted by changes to fuel and weather

- **Anthropogenic** and Natural sources.

Human-induced climate change influences weather

- Higher temperatures
- Rainfall anomalies
- Strong winds (Seasonality and strength)

→ Longer Wildfire Seasons



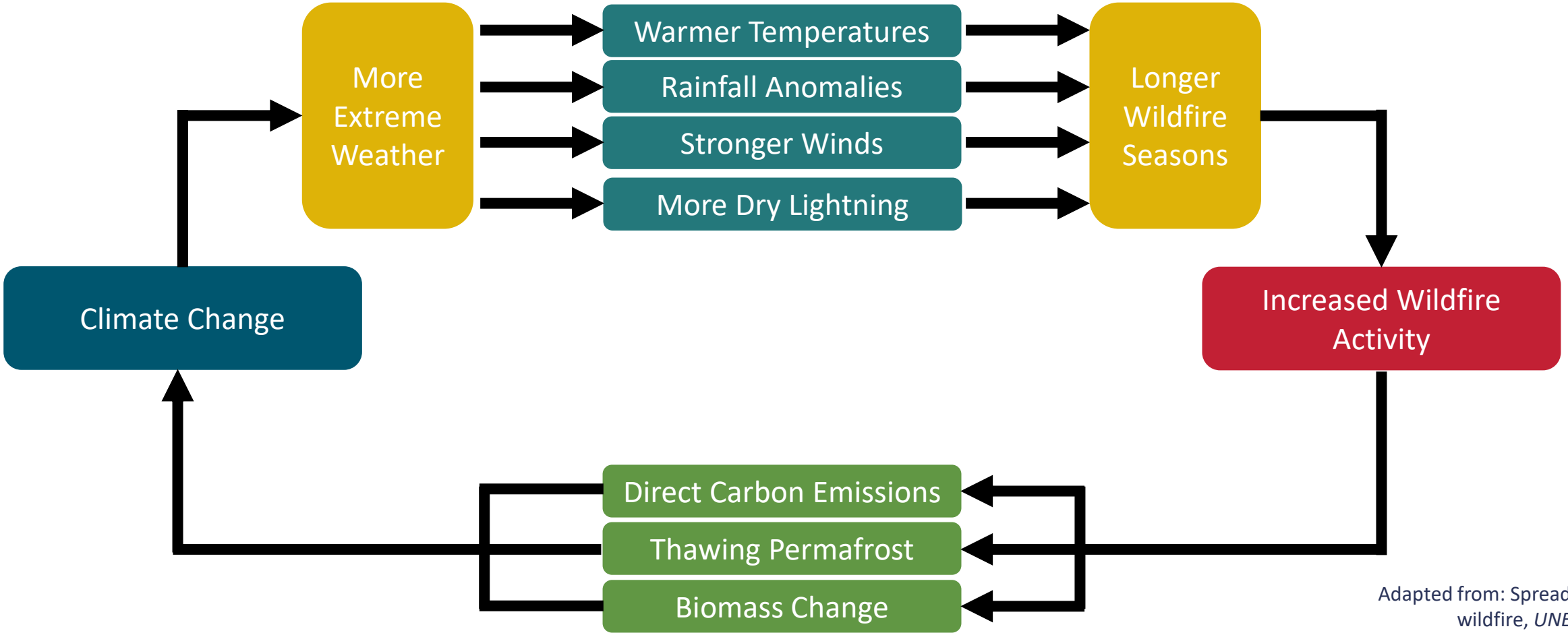
Human-induced climate change influences fuel

- Thawing Permafrost (increase in available fuels)

Human-induced climate change influences ignition sources

- Warmer Temperatures → More Moisture in the Air → Increased chance of thunderstorms and dry lightning

How are Wildfires changing?



Adapted from: Spreading like wildfire, *UNEP 2022*

How are Wildfires changing?

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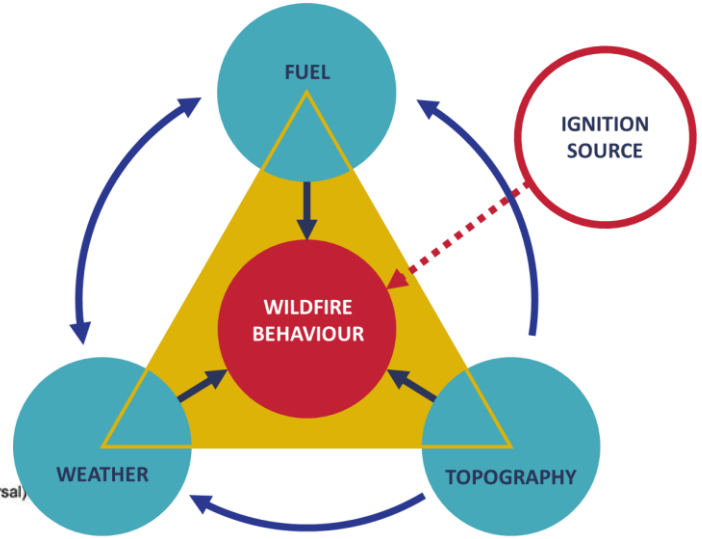
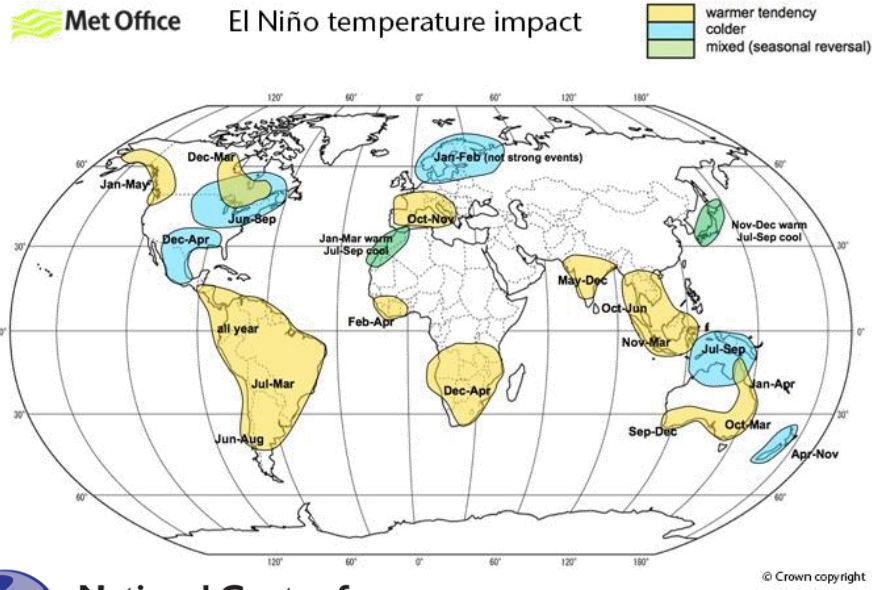
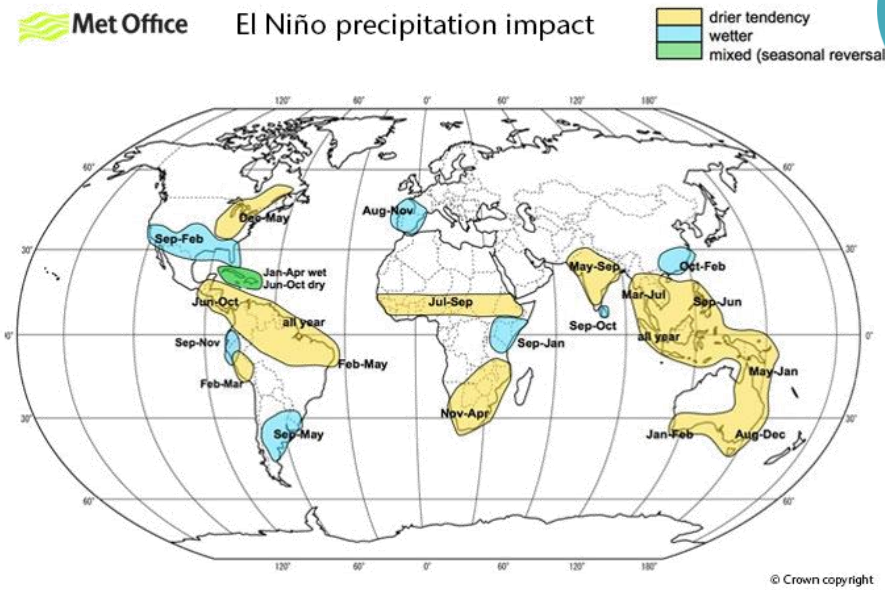


El Nino Southern Oscillation (ENSO) – oscillation of surface sea temperatures

- Influences global circulation patterns
- Impacts regional temperature and rainfall patterns





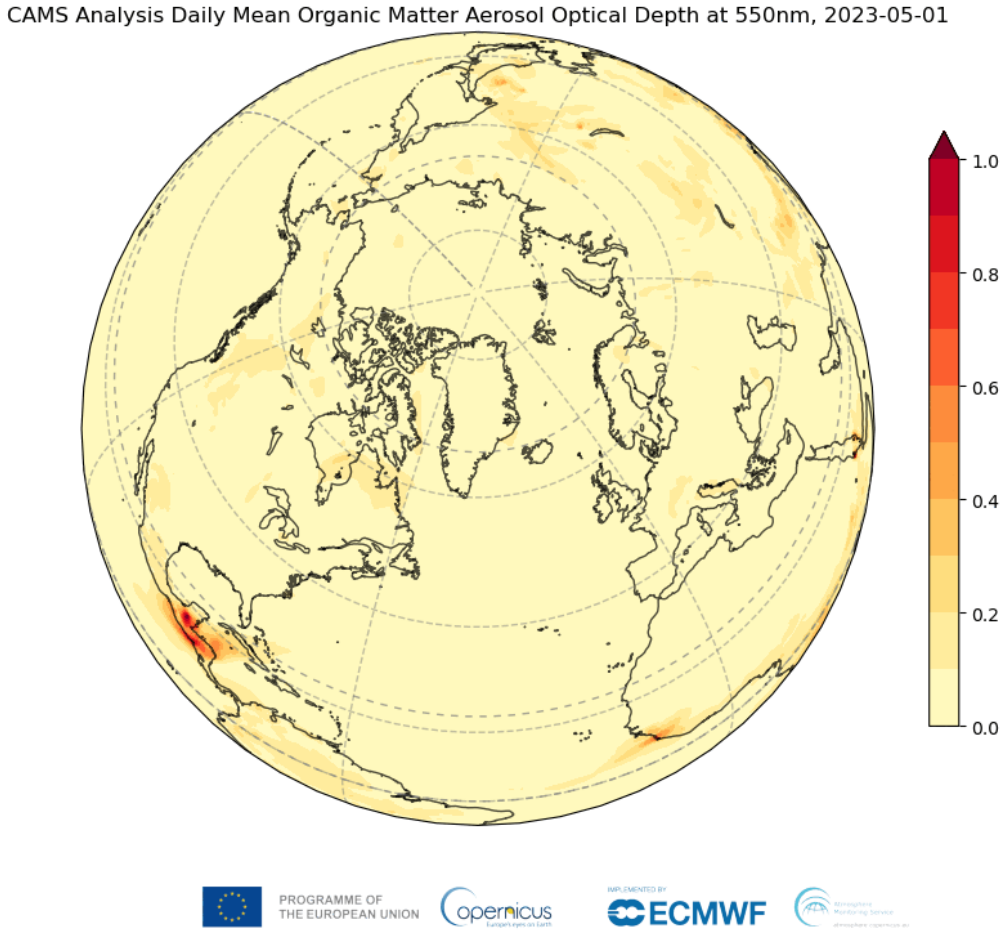
What about the smoke?

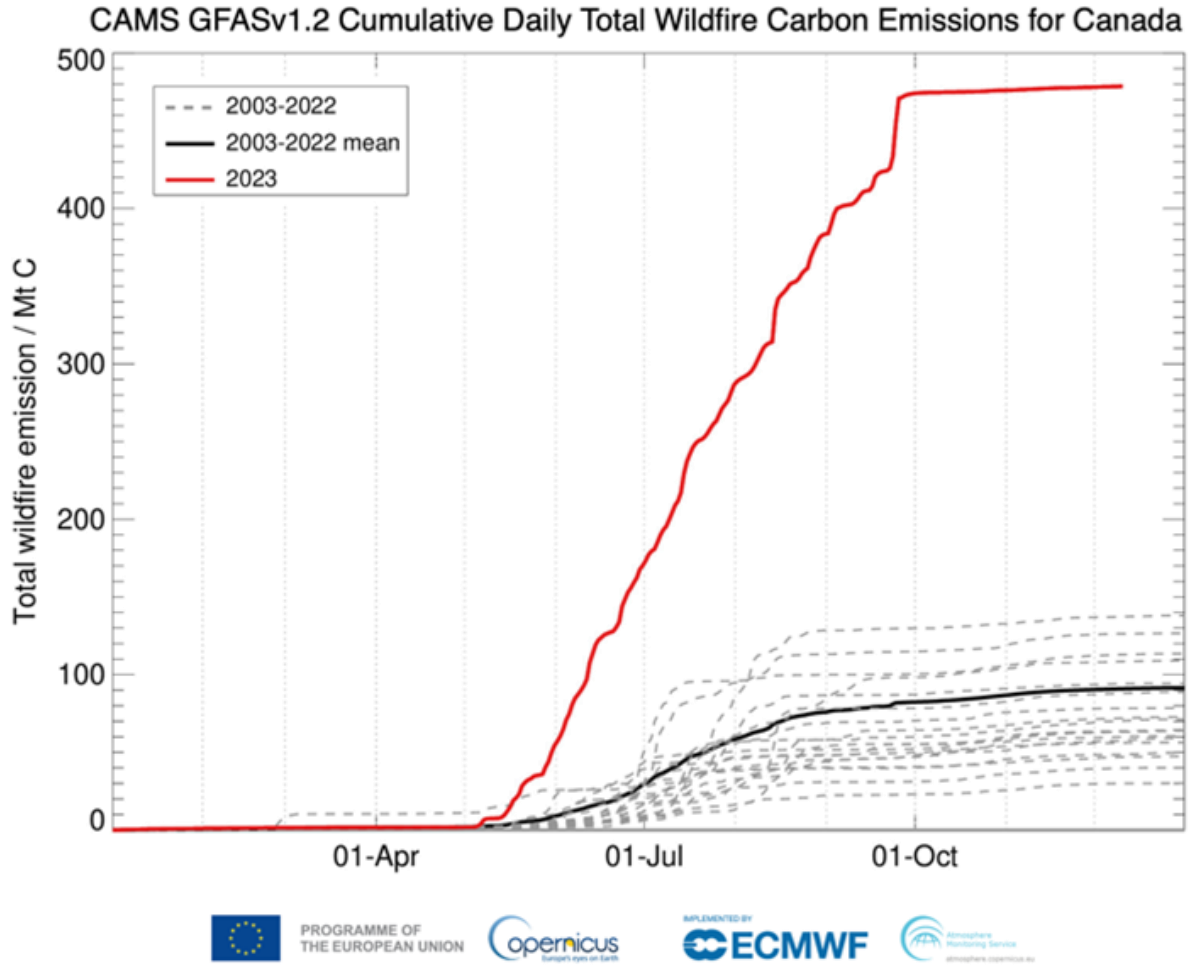
Fires contribute to the net build-up of atmospheric CO_2 during combustion, deforestation, and peatland burning.

- Black Carbon, Particulate Matter, CO, CO_2, CH_4, other trace gases
- 25% - 35% of total CO_2 net emission to atmosphere (GTOS68, T13 Fire Disturbance)
- 2023: 2.2bn tonnes of CO_2 (Copernicus Atmosphere Monitoring Service)

Credit: J. Kelly, L. Richardson-Foulger

How much smoke?





Estimating Emissions

Two categories: Bottom-up and Top-down

Estimating Emissions

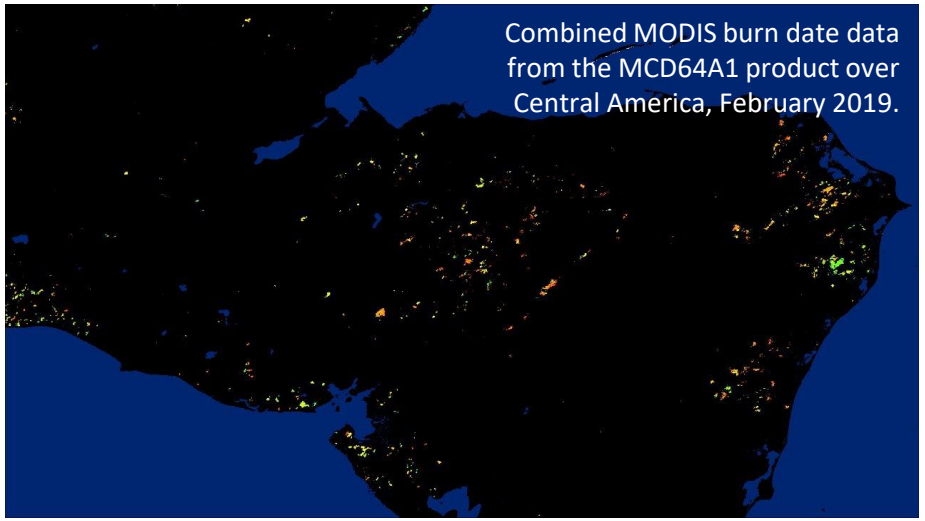
Two categories: **Bottom-up** and Top-down

Bottom-up approaches primarily use satellite estimates of Burnt Area (sometimes Active Fires) to get **Dry Matter Consumed (DMC)**

- Satellite estimates of pre-fire fuel load
- Laboratory assumptions combustion completeness

Knowing DMC, can estimate emissions using **Emission Factors** for specific biomes (Tropics, Temperate, Boreal, Agricultural)

Relatively uncertain fuel load and combustion completeness assumptions lead to the most significant uncertainty in this approach.



Combined MODIS burn date data from the MCD64A1 product over Central America, February 2019.

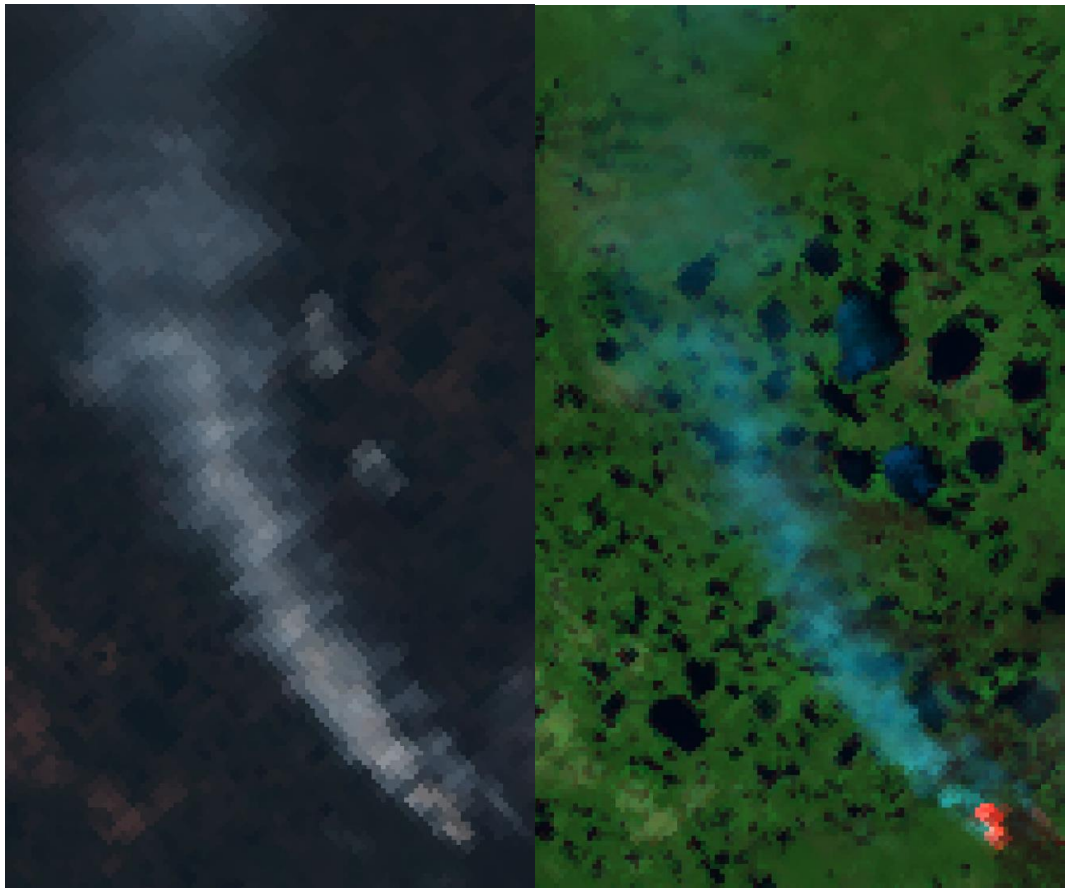
Estimating Emissions

Two categories: Bottom-up and **Top-down**

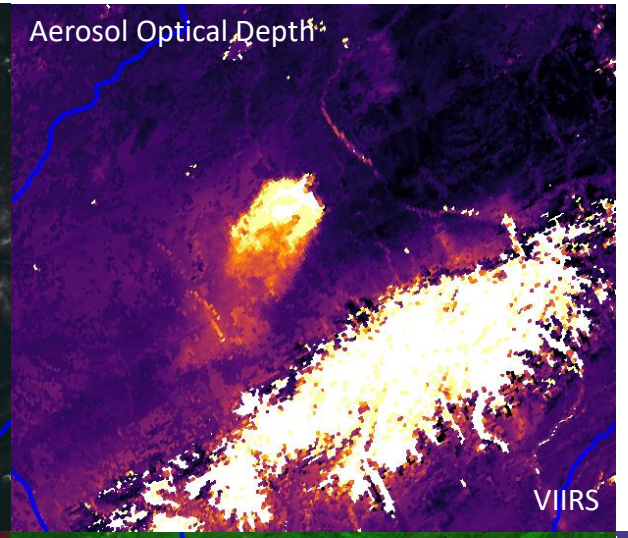
Top-down bypasses the need for pre-fire fuel load and combustion completeness and relates fires directly to emissions (i.e. Total Particulate Matter (TPM) or directly to one emission species).

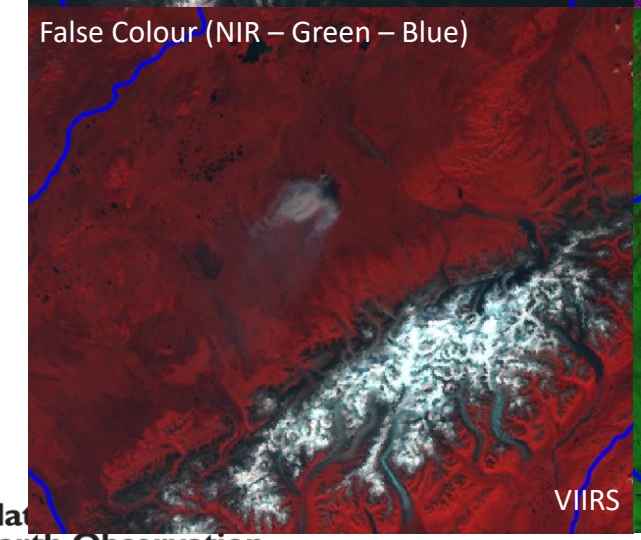
Once such Top-down approach is the Fire Radiative Energy Emission (**FREM**) approach.

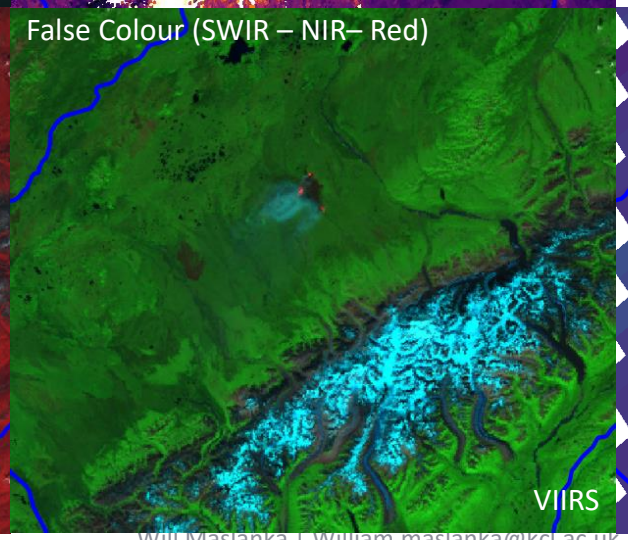
- Directly links observations of Active Fires to TPM or CO
- Africa, SE Asia with Geostationary Satellites
- High Latitudes with Polar Orbiting Satellites
- Grouped by Biomes

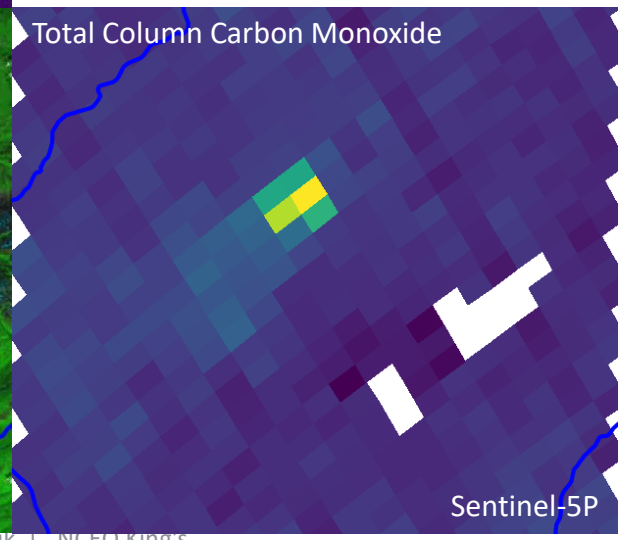


Estimating Emissions with FREM









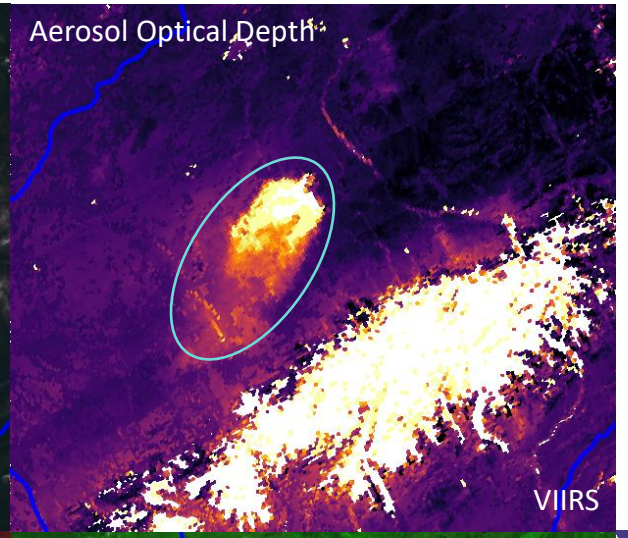
VIIRS (S-NPP)

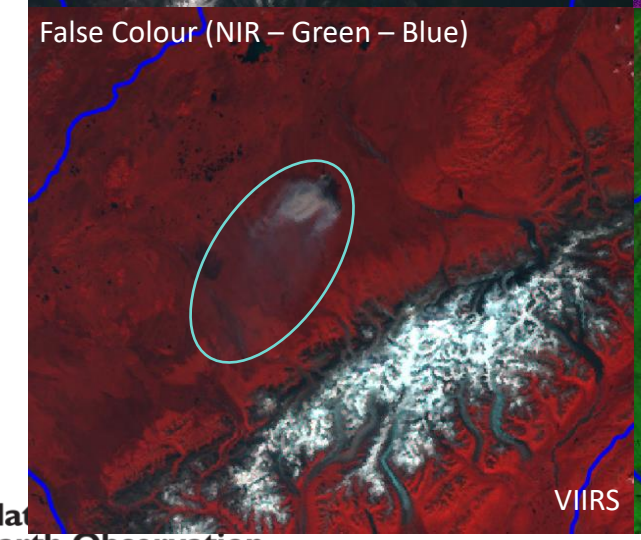
- Plume Identification
- Fire Identification and Radiative Energy (FRE)

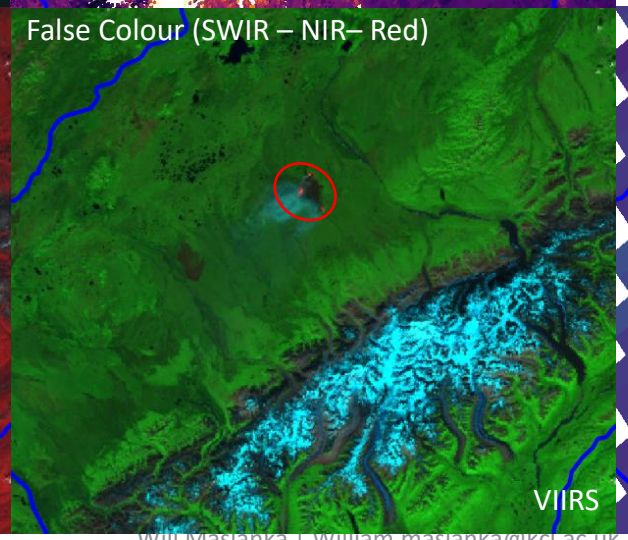
Sentinel-5P

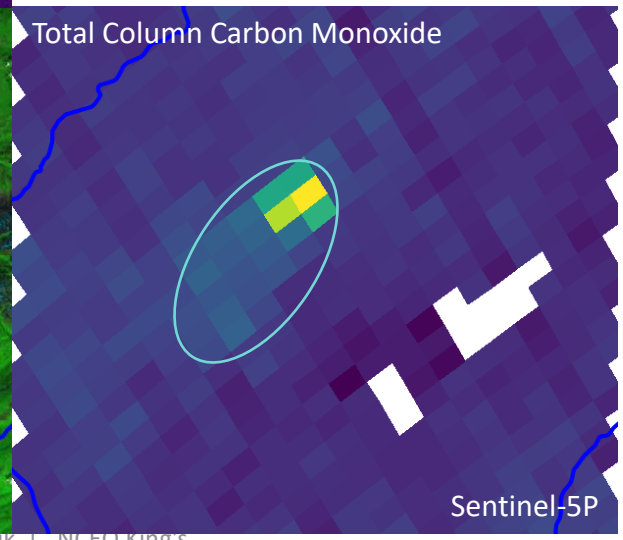
- Carbon Monoxide Observations
- Near-simultaneous with VIIRS (S-NPP)

Estimating Emissions with FREM









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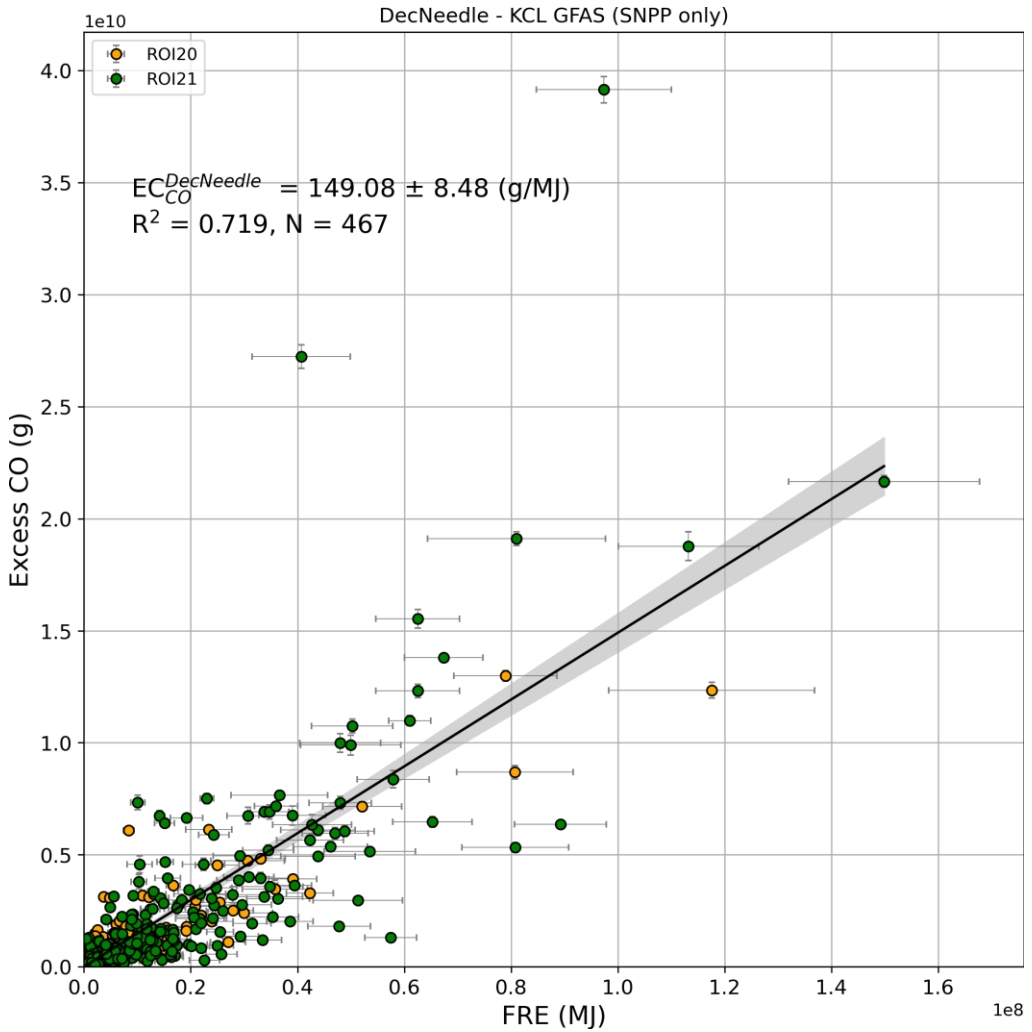


In Summary

Introduction to Wildfires

- Fire Behaviour Triangle (fuel, weather, and topography)

Remote Sensing of Wildfires

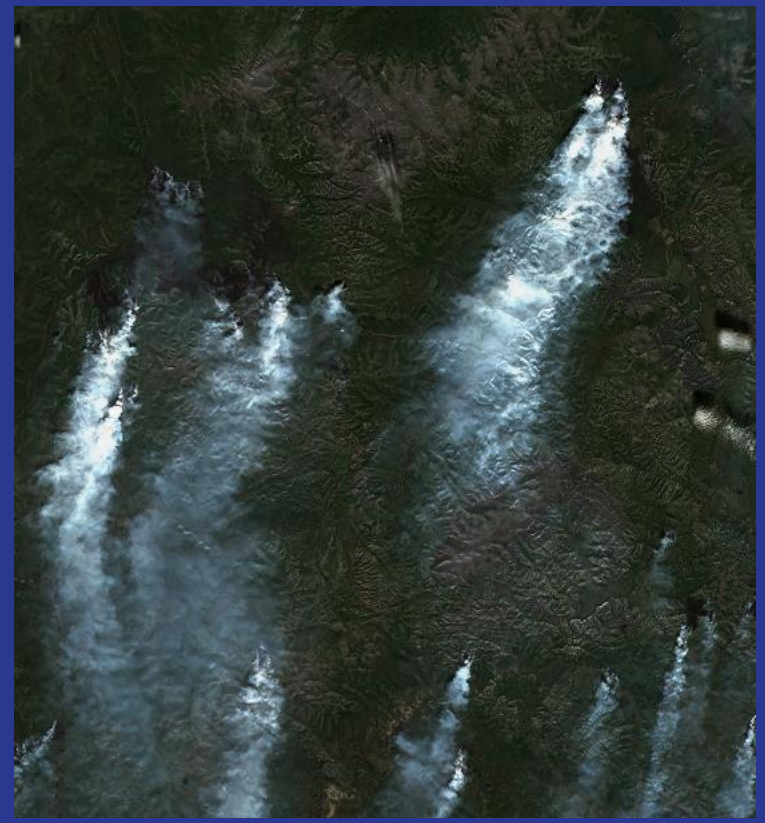
- Using Geostationary and Polar Orbiting to estimate Radiative Energy
- Only way to get regional / national / global observations

How are Global Wildfire Patterns Changing?

- Warming Planet = More Fires
- Anthropogenic and Natural sources of change

Wildfire Emissions of Greenhouse Gases

- FREM approach to High Latitude Fires



Thanks for listening!

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NATURAL ENVIRONMENT RESEARCH COUNCIL

Will Maslanka | William.maslanka@kcl.ac.uk | NCEO King's College London

KING'S College LONDON

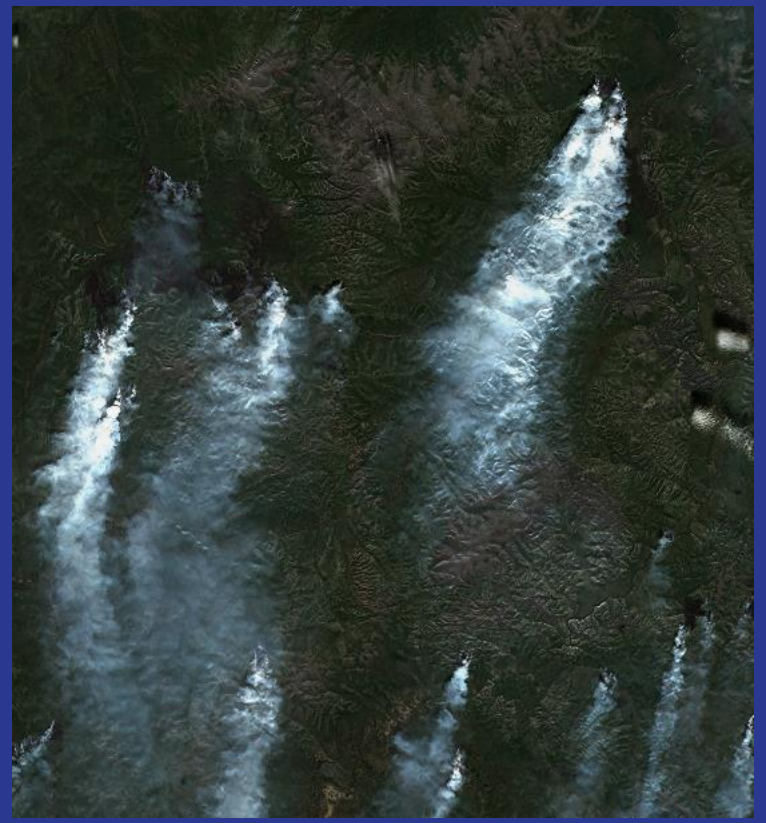
Want more information?

Introduction to King's Earth Observation & Wildfire Research Group

@KCLwildfire_EO

@kclgeography

@NCEOscience



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