

13 November 2024



CURRENT STATE OF HEAT, WILDFIRE AND DROUGHT MODELLING AT ECMWF

Francesca Di Giuseppe



STATE OF THE CLIMATE

Key events in 2023

- Heatwave
- Wildfire
- Drought
- Storm
- Coldwave
- Flood
- Marine heatwave
- Windstorm

Records

- Highest number of days with **'extreme heat stress'**
- Largest area of Europe affected by at least **'strong heat stress'**
- Largest **wildfire**
- Highest December **river flows**
- Largest proportion of **renewable energy generation**
- Warmest **marine heatwave** in the northeastern Atlantic

**According to preliminary estimates for 2023 from the International Disaster Database. Estimates of the impacts of heatwaves in 2023 are not yet available.*

Impacts*

- Losses estimated at **€13.4 billion**
- Flooding affected around **1.6 million people**
- Storms affected around **550,000 people**, and wildfires **36,000**
- At least **63 lives lost** due to storms, **44** to floods and **44** to wildfires
- 81% of economic losses attributed to flooding

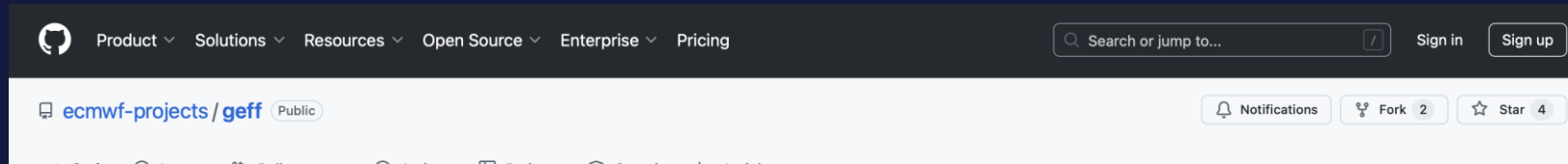
Across Time scales

- **FORECASTS (up to 10 days)**
 - Real-time application – Support warning and civil protection mechanisms. Typical products are physical value
- **SEASONAL OUTLOOK**
 - Prepare for resource management, support planning. Typical products are deviations from mean states
- **REANALYSIS**
 - Helps understand shifts in long-term trends and define mitigation strategies. Typical products are trends

WILDFIRE

Fortran open access code for fire danger index

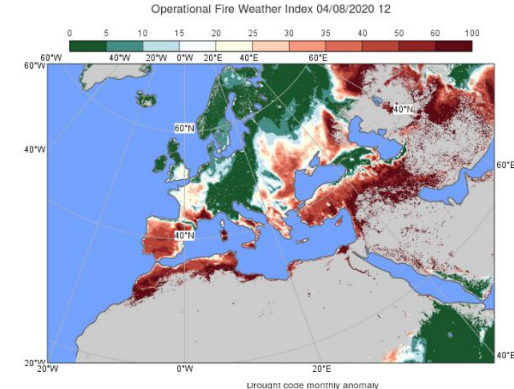
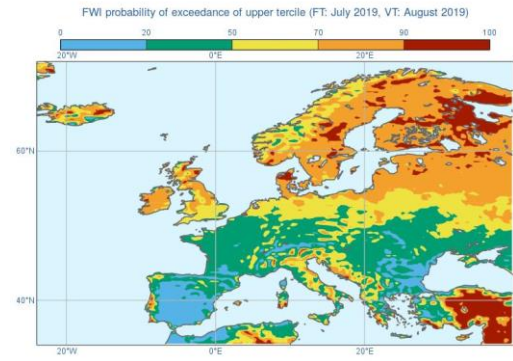
Reproducible work flow



Products

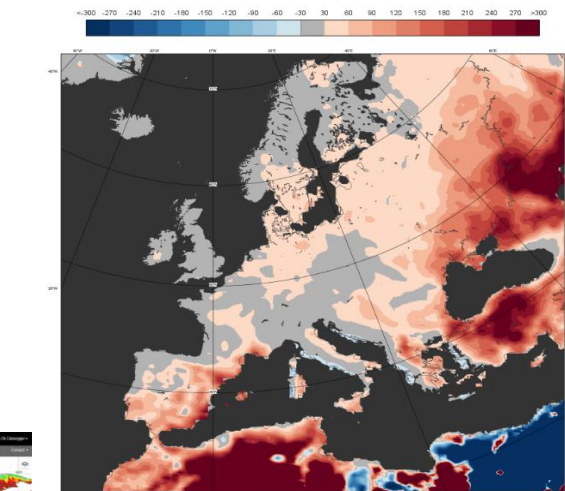
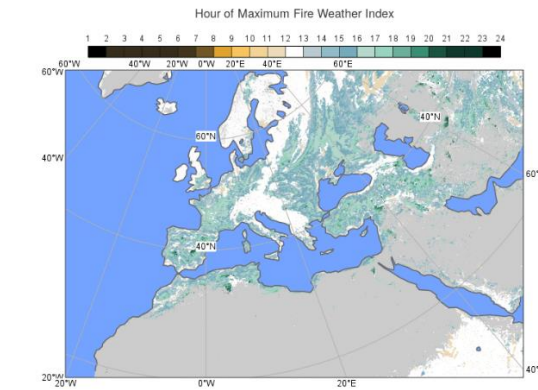
Real time
(up to 10/15 days)

FWI, MARK5, NFDRS
VPD, Hot-Dry-Windy
Aristotle Fuel, All-
Weather, Windy
MF- Vegetation stress
IPMA- susceptibility



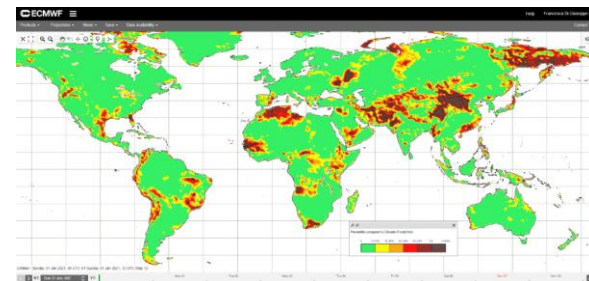
Real time
(up to 10/15 days)

Anomalies, Rankings,
Probabilities of
exceedance
EFI, SOT



Seasonal
(up to 6 months)

Seasonal FWI
Seasonal hindcast
(CDS)



NRT (5 days delay)

ERA5 Reanalysis(CDS)
ERA5-Land

Data driven
Experimental
products

POF, FOPI, PIL



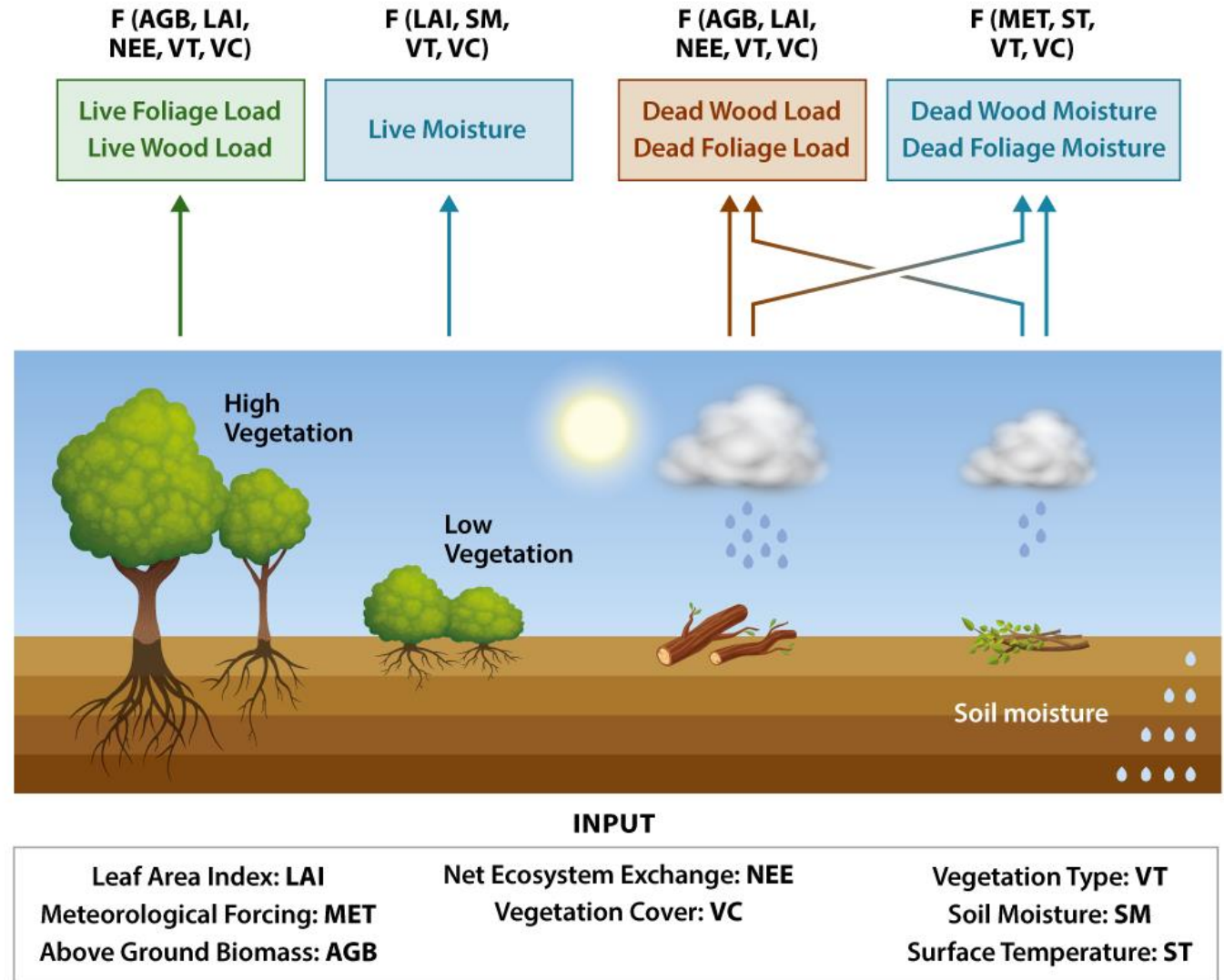
Fuel is one of the important *missing* component to forecast fire

Vegetation Load/Moisture informed by:

- Satellite Observations
- Land Surface Modelling
- NWP Variables

Real-time and in historic:

- Global
- 9km Resolution (1km in prep.)
- Daily
- 2010-2021 (ext. in prep.)



<https://doi.org/10.5194/bg-21-279-2024>
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Article Peer rev

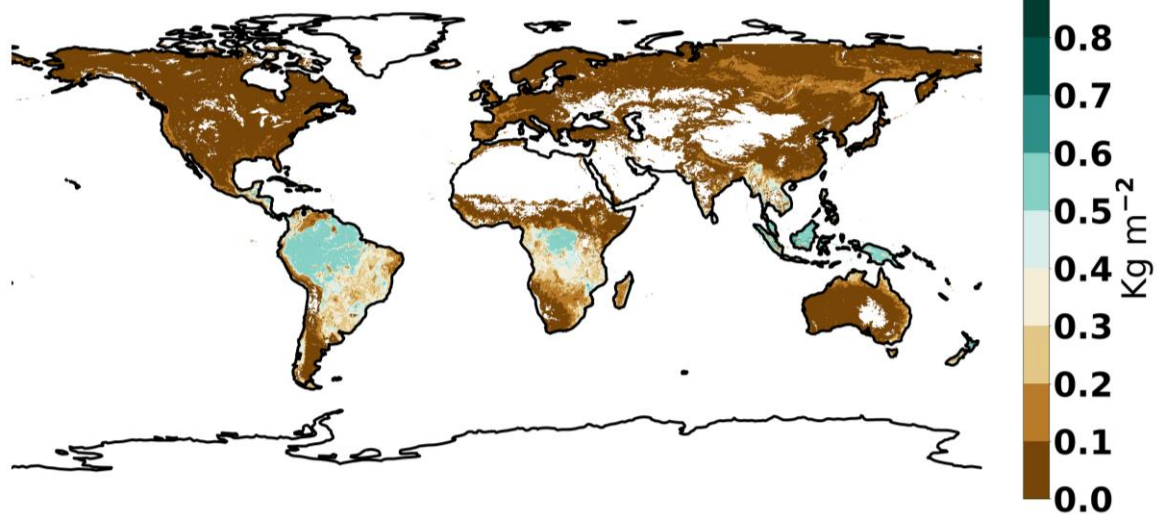
Research article | ©

A global fuel characteristic model and dataset for wildfire prediction

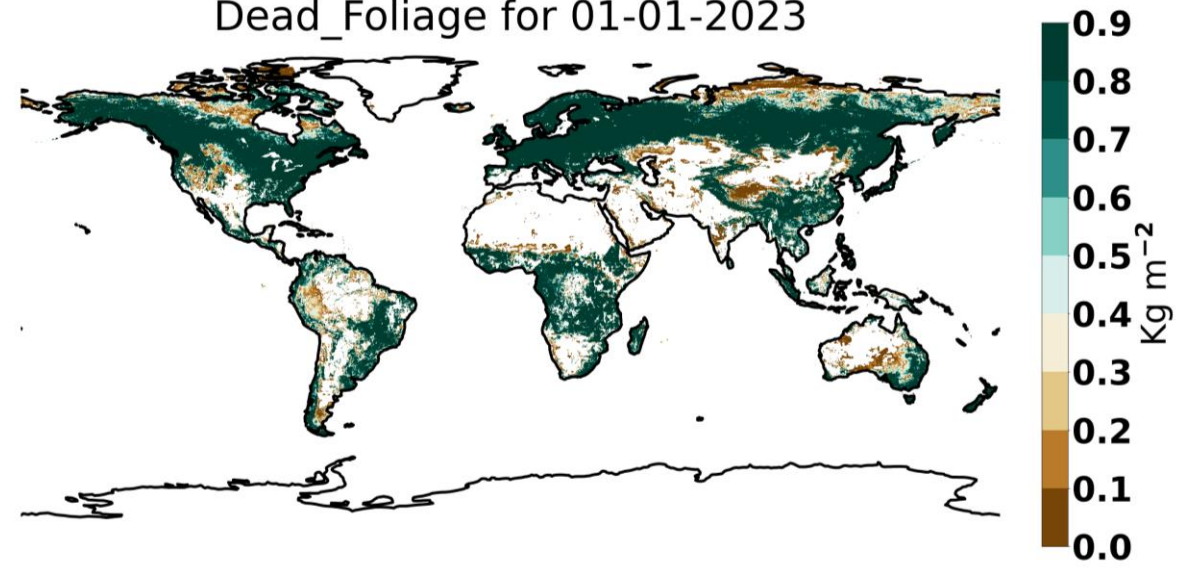
Joe R. McNorton and Francesca Di Giuseppe

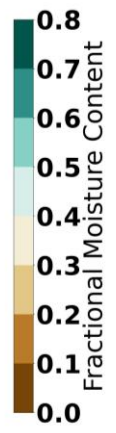
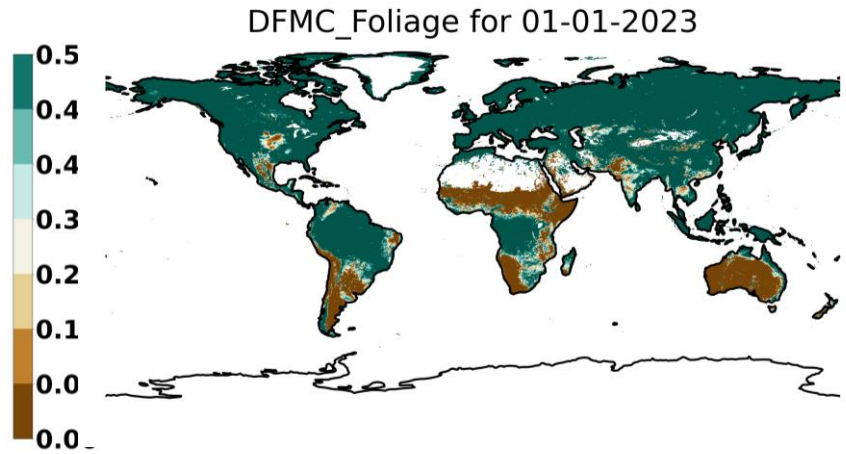
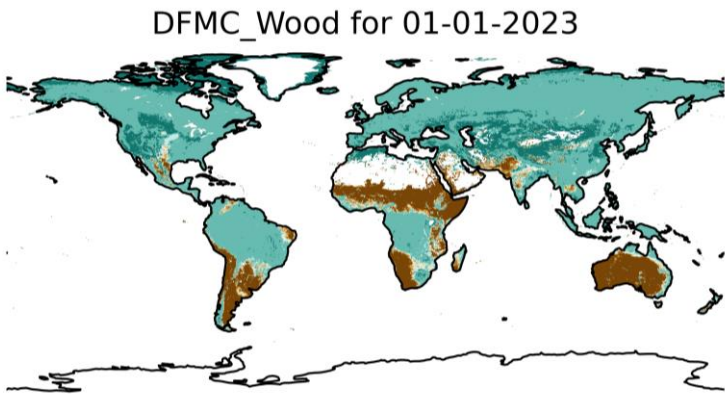
McNorton and Di Giuseppe 2024

Live_Leaf for 01-01-2023

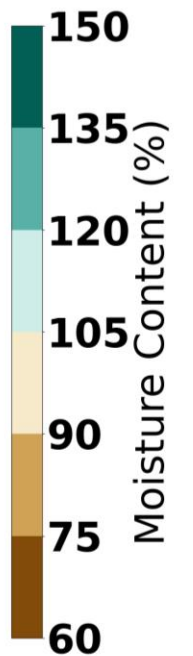
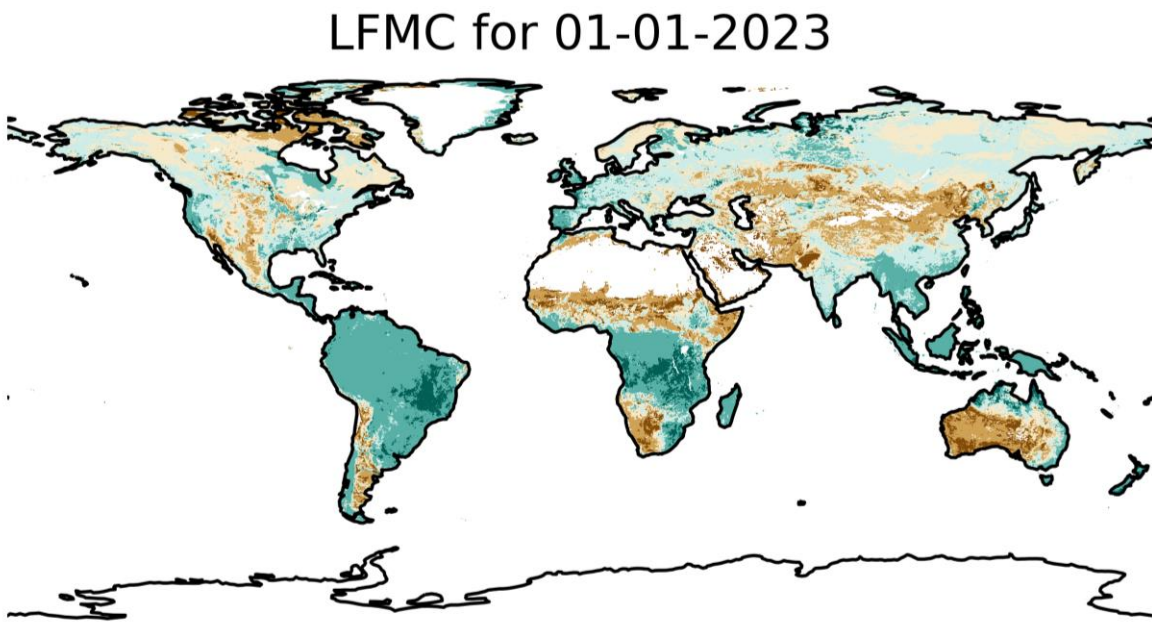


Dead_Foliage for 01-01-2023





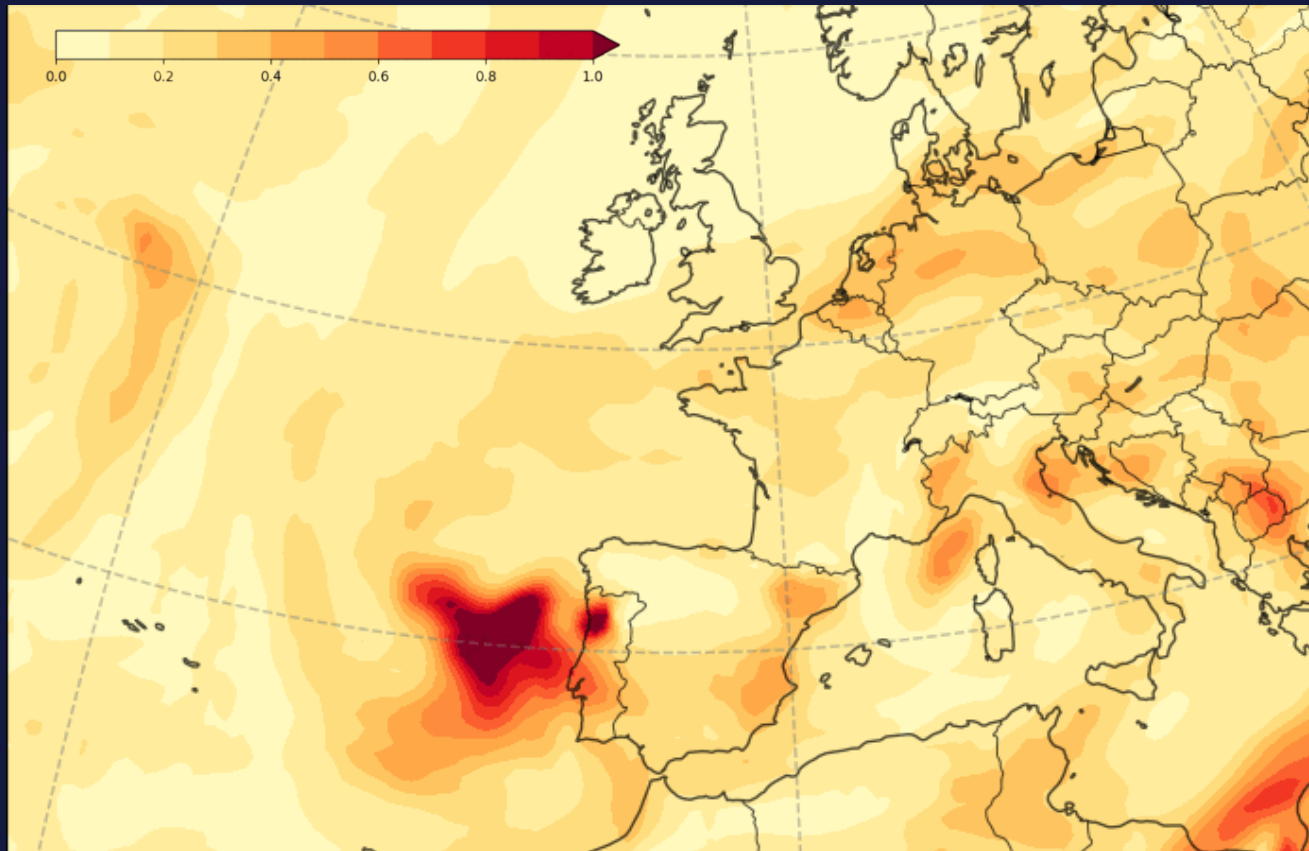
Evolution of moisture content in **dead** biomass



Evolution of moisture content in **live** biomass

Representation of aerosols

Smoke aerosols from wildfires



CAMS total aerosol optical depth 5-day forecast initialised on 18 September 2024 at 12 UTC and valid for 18-23 September 2024

Source: CAMS/ECMWF



FORECATS	SEASONAL	REANALYSIS
✓	✓	✓

DROUGHT

Meteorological drought

as a trigger for food and water insecurity causing crises



drought

exposed and vulnerable population

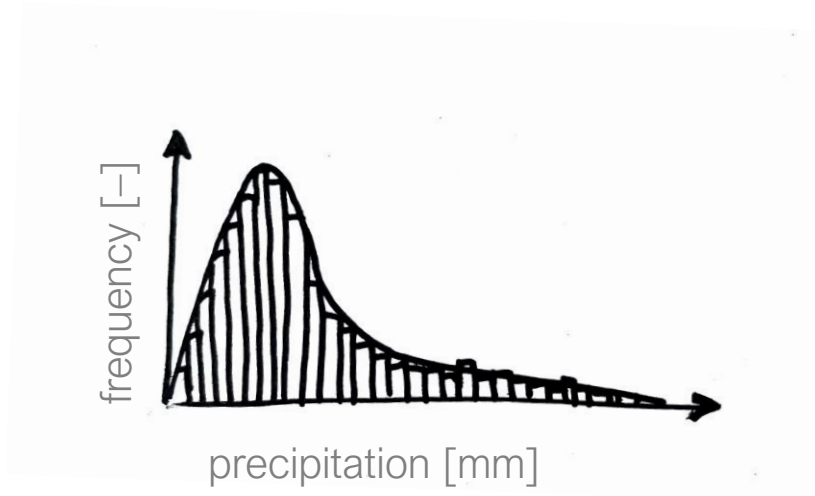


water scarcity & food insecurity

crisis

Standardized drought indicators

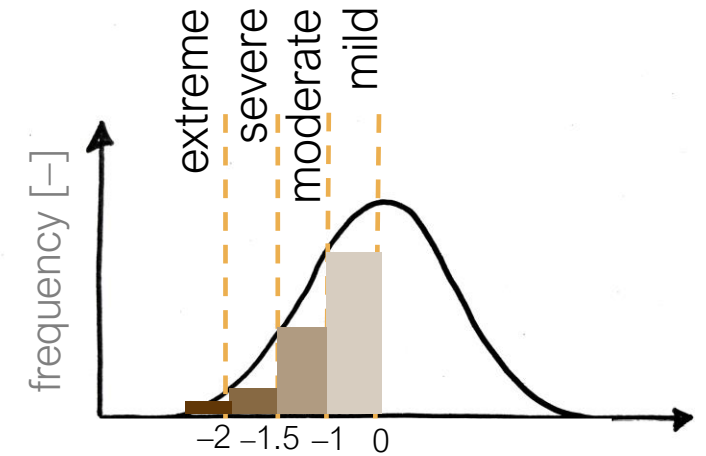
Deviation of a water flux/storage from the norm during a reference period



1 | Fit a distribution



2 | Normalisation



3 | Event identification

McKee et al., 1993: The relationship of drought frequency and duration to time scales

Standardized drought indices

DRYFALL

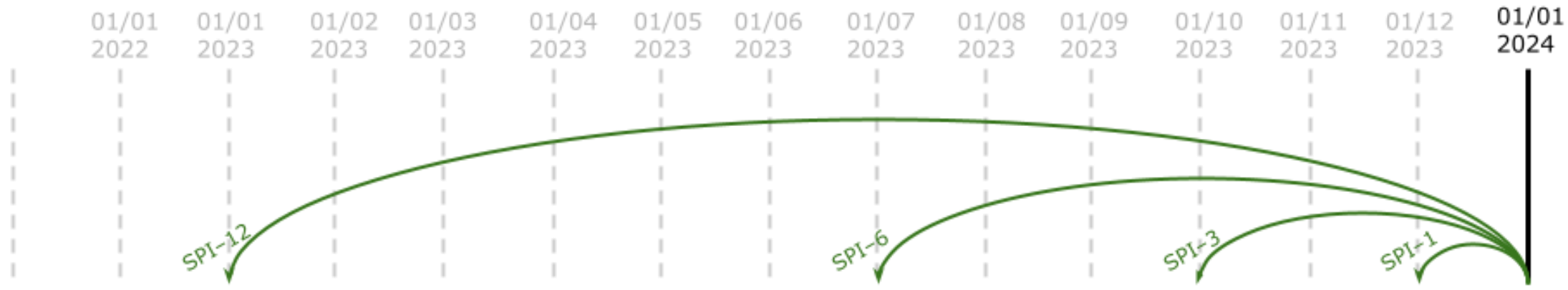
— An ECMWF library for the calculation of drought indices —

```
python dryfall.py
--input precipitation.grb
--output spi12.nc

--drought_index 'SPI'
--input_ref precipitation_ref.grb --landmask mask.grb
--distribution 'gamma' --remove_zeros True
--window 12 --window_unit months
--integration_frequency_string '%Y-%m'
--nevents_min 5
--max_zeros 0.3 --pzero_replace True --pzero_center_mass True
--significance_test 'shapiro' --significance_alpha 0.05
```

Standardized drought indicators

Deviation of a water flux/storage from the norm during a reference period



McKee et al., 1993: The relationship of drought frequency and duration to time scales

Examples

Increasing impact with increasing accumulation window

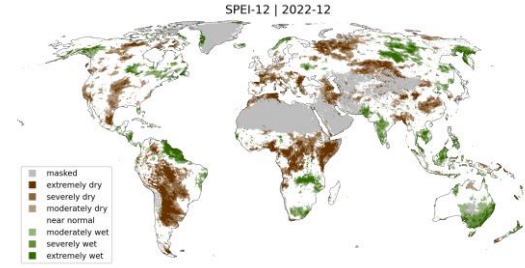
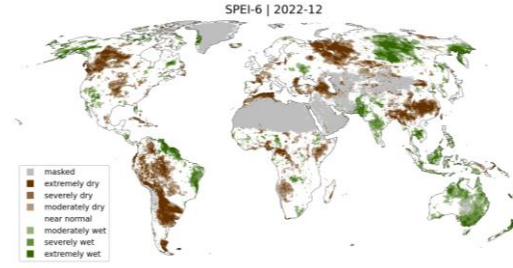
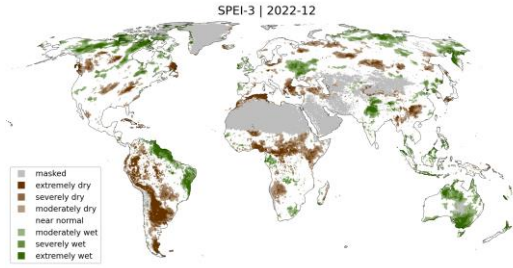
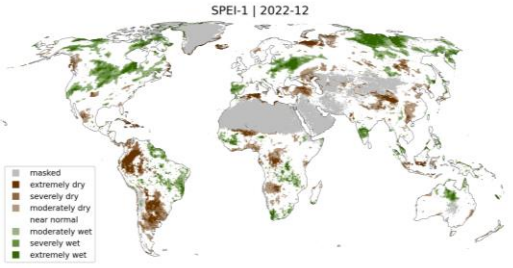


SPI-1
SPEI-1

SPI-3
SPEI-3

SPI-6
SPEI-6

SPI-12
SPEI-12



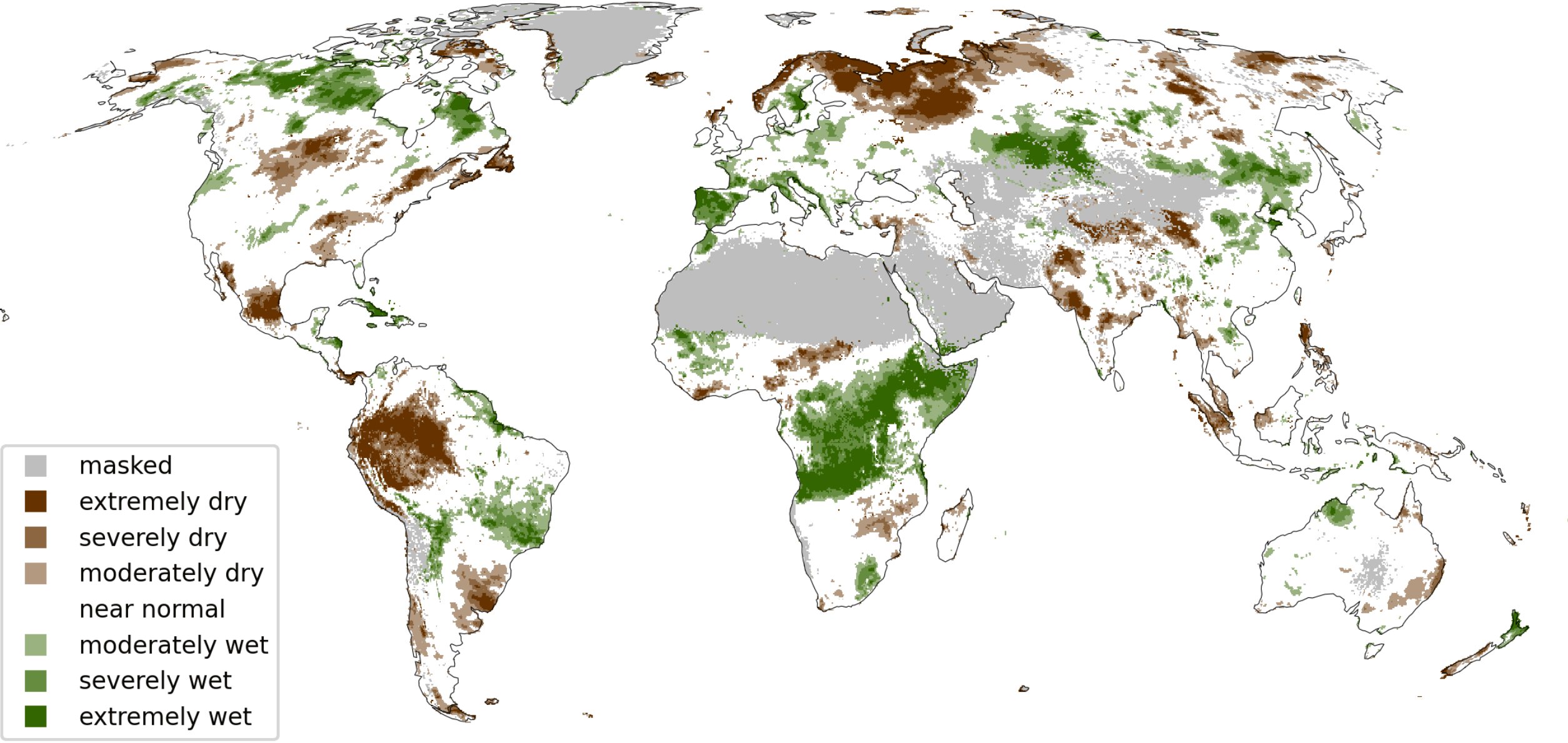
Low soil moisture
Reduced flow in smaller creeks

Reduced stream flow
Low levels in water reservoirs

Reduced groundwater recharge



SPEI-12 | 1960-12

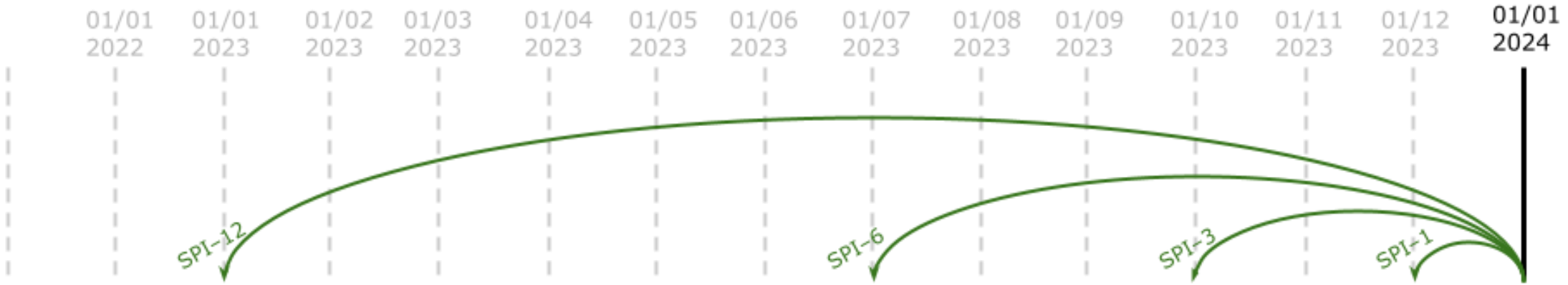


- masked
- extremely dry
- severely dry
- moderately dry
- near normal
- moderately wet
- severely wet
- extremely wet

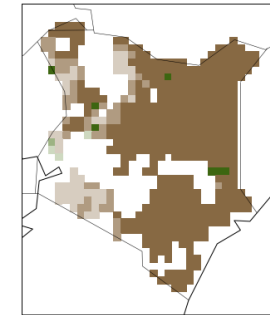
Data sets based on ERA5

SPI	
SPI-1	SPI-24
SPI-3	SPI-36
SPI-6	SPI-48
SPI-12	

SPEI	
SPEI-1	SPEI-24
SPEI-3	SPEI-36
SPEI-6	SPEI-48
SPEI-12	

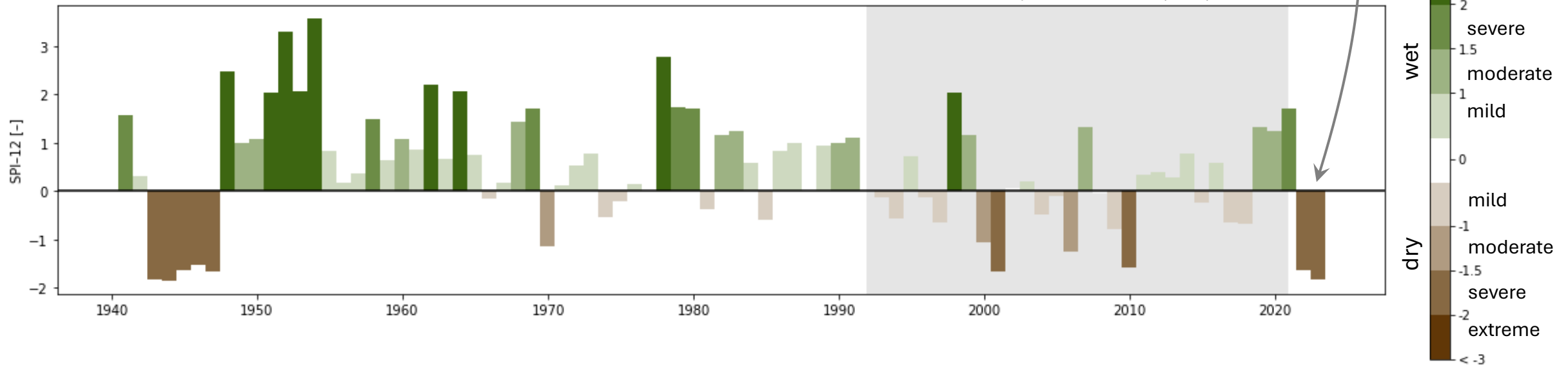


Recent droughts over Kenya



Droughts in Kenya (SPI-12)

Reference period: 1991–2020 (ERA5)



Warning

1 Mar 2024

The production stack of the ECDS now uses the production Keycloak. Users might need to recreate their accounts!

Dive into the wealth of data made available by the European Centre
for Medium-Range Weather Forecasts (ECMWF)

**API**

Access the full data store catalogue, with search and

**Training**

ECMWF data tutorials

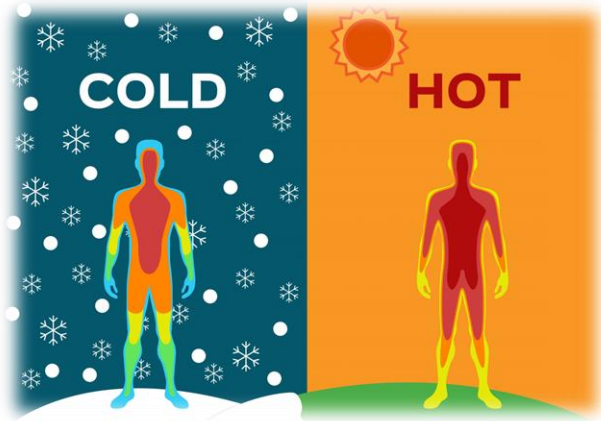
**earthkit**

Open-source Python tools simplifying data access,

	FORECASTS	SEASONAL	REANALYSIS
	✓	✓	✓
	⊘	Coming soon	✓

HEAT

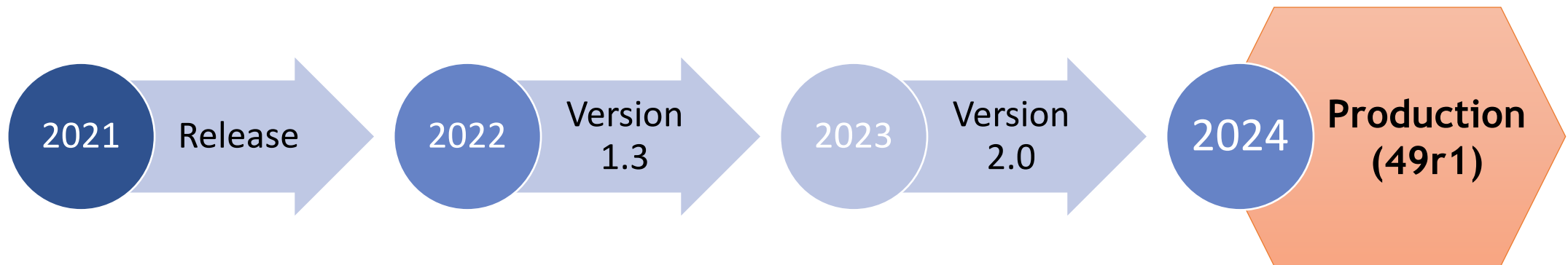
Predicting heat and cold (stress)v



therm^ofeel

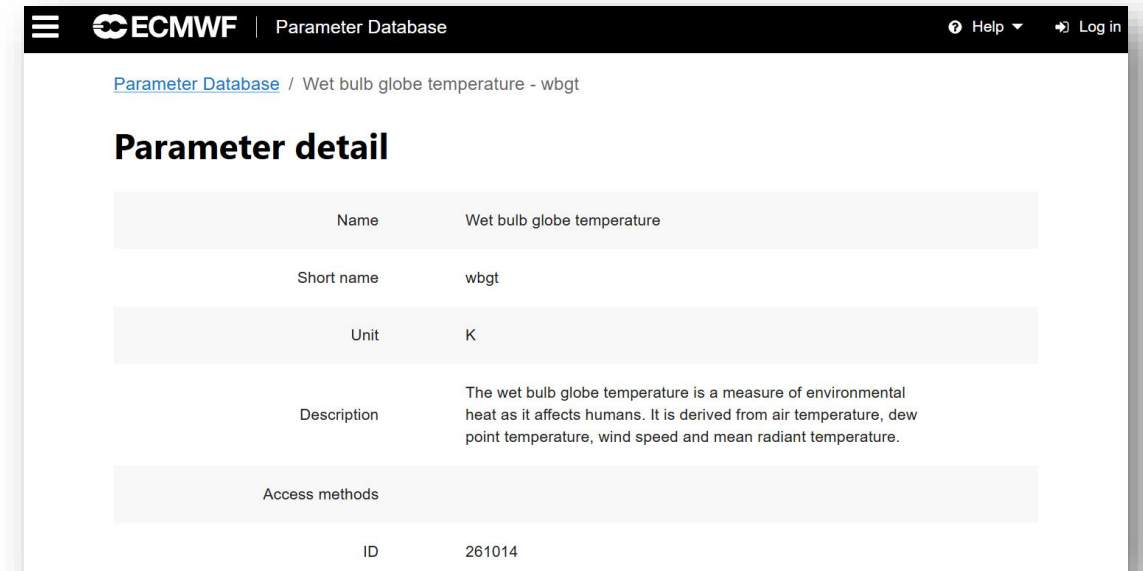
Python library to calculate human thermal comfort indices

- └ Build-up or loss of body heat due to meteorological factors
- └ Cumulative effect with physiology and clothing



Predicting heat and cold (stress)

1. Wet bulb globe temperature
2. Universal thermal climate index
3. Heat index
4. Wind chill factor
5. Apparent temperature
6. Humidex
7. Normal effective temperature



ECMWF | Parameter Database

Parameter Database / Wet bulb globe temperature - wbgt

Parameter detail

Name	Wet bulb globe temperature
Short name	wbgt
Unit	K
Description	The wet bulb globe temperature is a measure of environmental heat as it affects humans. It is derived from air temperature, dew point temperature, wind speed and mean radiant temperature.
Access methods	
ID	261014

2024

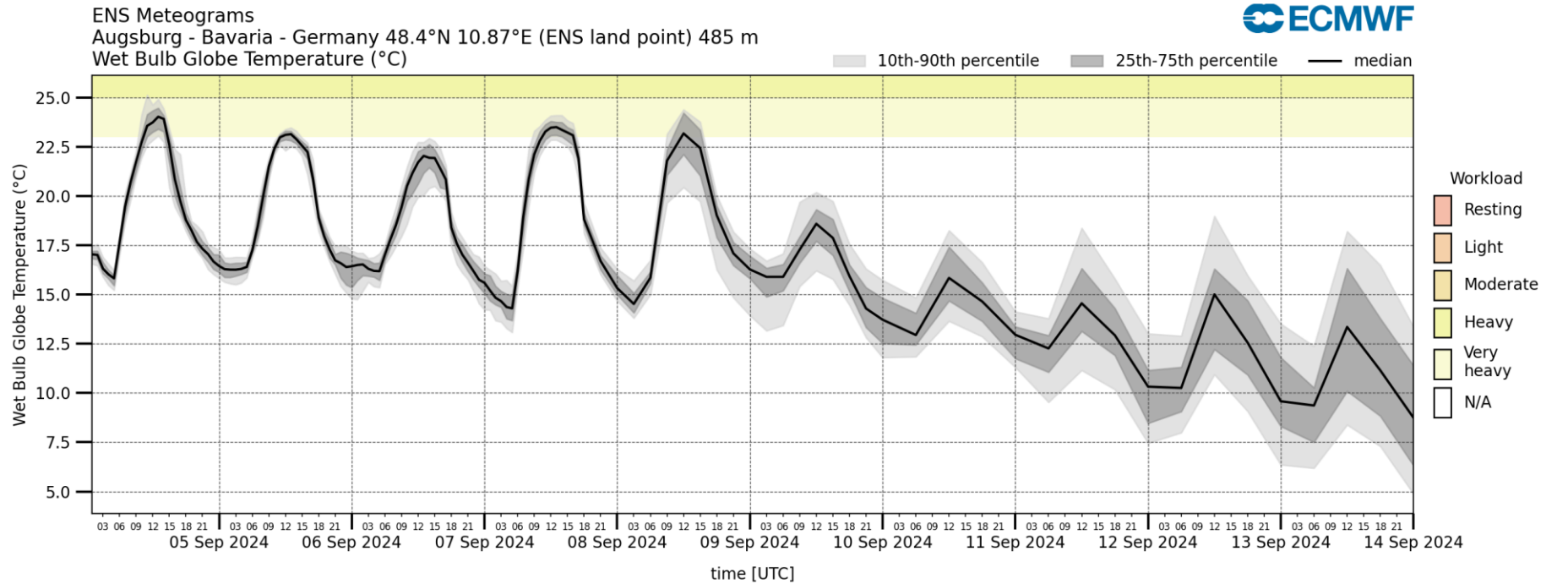
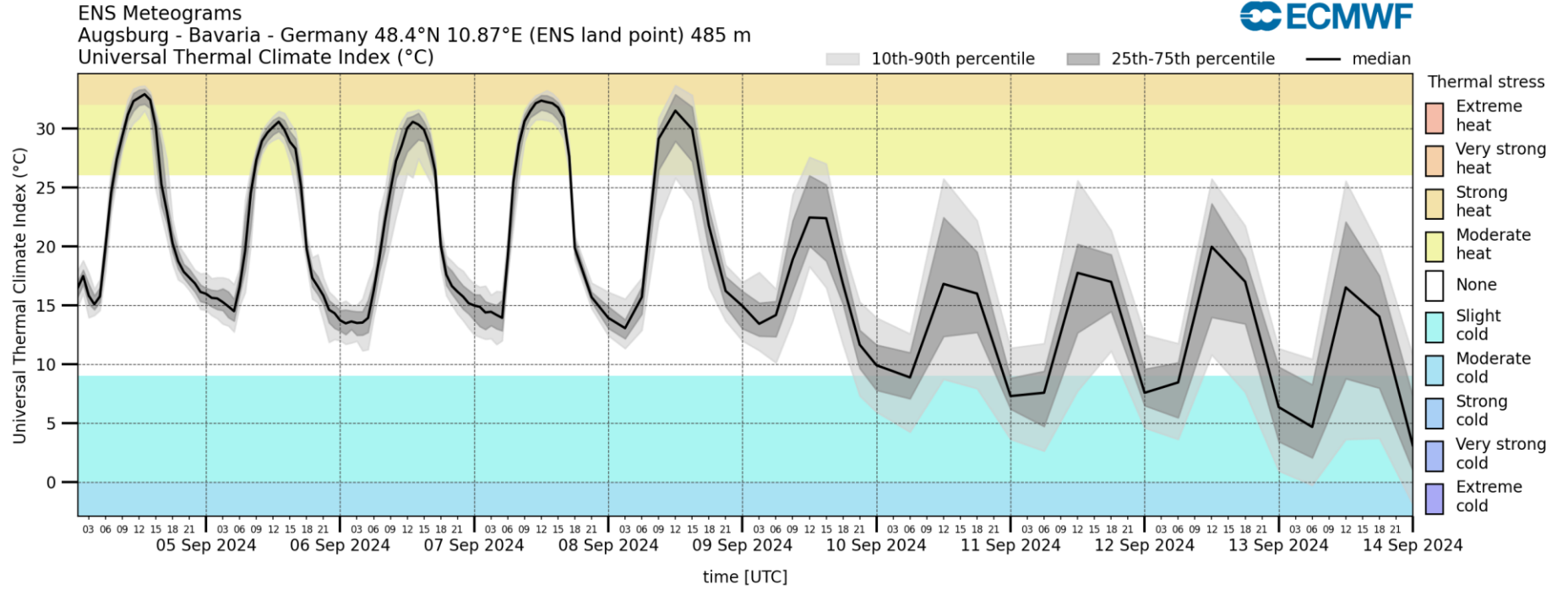
Production
(49r1)

Claudia Di Napoli

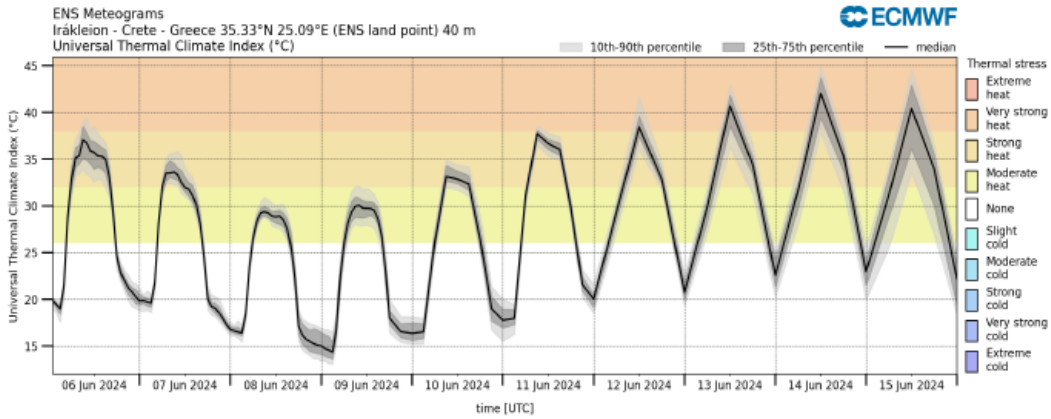
- Physiological stress
- Considers clothing
- Heat and cold range

Measures of environmental heat (from temperature, humidity, wind, radiation) as it affects humans

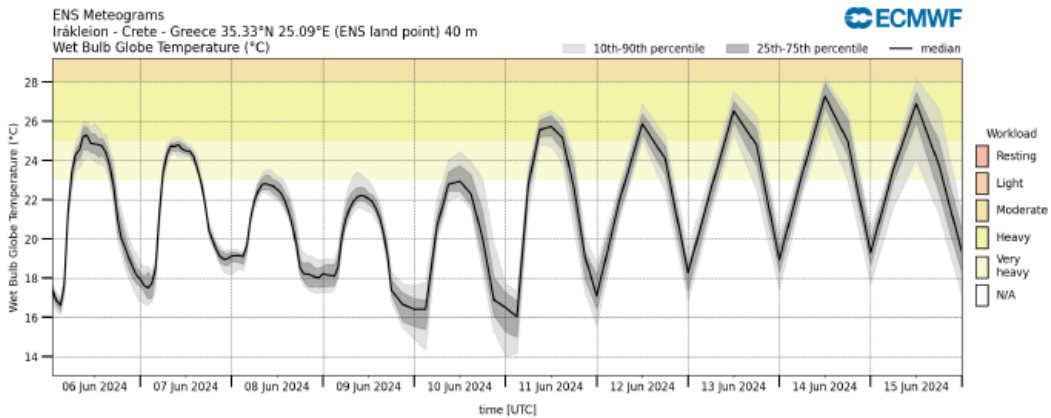
- Occupational exposure limits
- ISO (the International Organization for Standardization) standard 7243:2017
- Heat range only



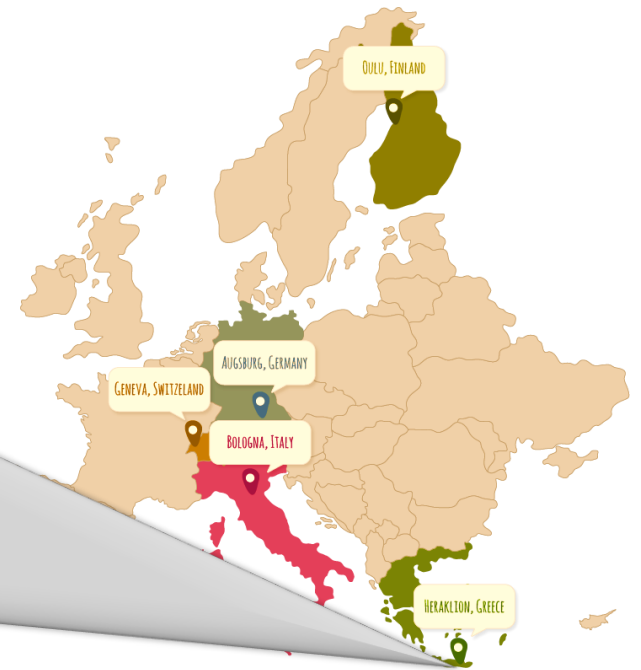
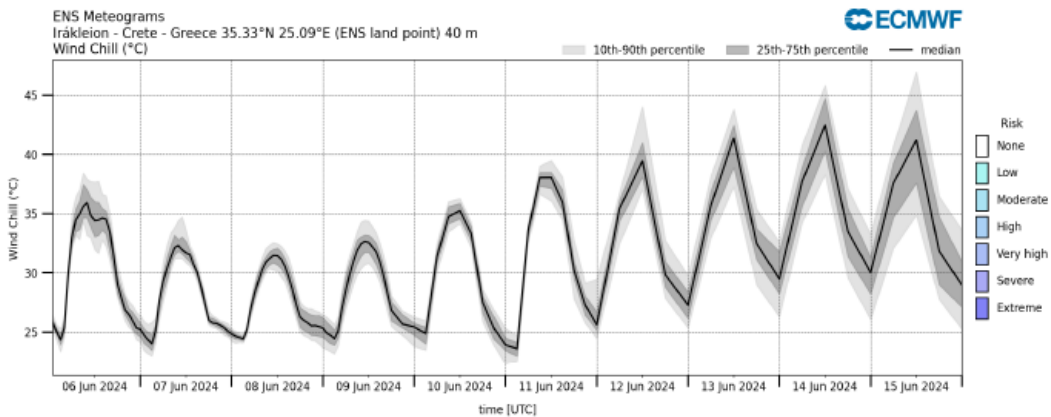
Universal Thermal Climate Index



Wet Bulb Globe Temperature



Wind Chill Temperature



	FORECATS	SEASONAL	REANALYSIS
	✓	✓	✓
	⊘		✓
	✓	⊘	✓

Evolution

Compound occurrence (es. Combined probability of occurrence)

Question: How many time you observe the combined occurrence of events

Synchronicity (Spatial co-occurrence of events)

Question: how large should be a drought or an
heat wave to substantially increase the occurrence of fires

Cascading effects (causality)

Question: how many times would you expect one
events to occur **because** of another occurrence

- Hamming distance