PYROMET Technical Documentation

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Authors: Giannaros T.M., Koletsis I., Papavasileiou G., Parliari D.
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Changelog

Version	Date	Description
0.9	2026-09-14	Added a List of Abbreviations (Section 1.3); corrected sensor terminology for consistency (Campbell Scientific FMS, Section 3.1) and updated the variable table header to “Sampling interval & aggregation” (Section 3.2); added brief fire-weather-significance introductions to the VPD, DFMC_d, and HDW subsections (Sections 4.3–4.5); added wind-height-adjustment cross-references clarifying u_{10} vs $u_{6.1}$ usage across CFFWIS1987, CFFWIS2025, and NFDRSv4 (Sections 4.6–4.8); corrected a typo (NFDRSv3 → NFDRSv4, Section 4.8); and fixed stale section cross-references (Section 2.1 → Section 2; Section 4.2 → Section 3.2) (Giannaros)
0.8	2026-09-04	Fixed naming inconsistencies (CFFWIS2025), typos, spelling consistency (British English), and reference formatting; removed Section 2.1 station photos pending re-shoots with consistent framing; applied FLAME Brand Guidelines v1.0 (colors, typography, logo header) (Giannaros)
0.7	2026-09-03	Document revised by group members
0.6	2026-06-27	Section 4.2: logarithmic height adjustment now applied to wind gust speed ($u\_g_{,5}$ → $u\_g_{,10}$, $u\_g_{,6.1}$) in addition to sustained wind speed (Giannaros)
0.5	2026-06-12	Updated metadata for the Soufli, Rodopi, and Taxiarchis stations
0.4	2026-06-08	Updated G step check thresholds (doubtful 600→800 W m^{-2}, erroneous 900→1300 W m^{-2}); updated u persistence threshold (1.8→3.2 km h^{-1}) and condition (mean_above 3.6→9.0 km h^{-1}) (Giannaros)

Version	Date	Description
0.3	2026-06-06	Updated station metadata; removed Tegea, updated info for Pineios, Lavrio, and Ampeliko (Giannaros)
0.2	2026-05-22	Corrected G range upper limit to 1600 W m^{-2} (Giannaros)
0.1	2026-05-21	Initial draft (Giannaros)

1. Preamble

1.1 Purpose and Scope

This document is the technical reference for the PYROMET Remote Automated Weather Station (RAWS) network, operated by the FLAME Fire Meteorology Group of the METEO Unit of the National Observatory of Athens (NOA).

1.2 Document Outline

Section	Title	Availability
1	Preamble	Public
2	Network Overview	Public
3	Instrumentation	Public
4	Derived Fire Weather Variables	Public
5	Data Quality	Public
6	Data Access	Public

1.3 List of Abbreviations

Abbreviation	Meaning
agl	Above ground level
asl	Above sea level
BI	Burning Index (NFDRSv4)
BUI	Buildup Index (CFFWIS)
CEMS	Copernicus Emergency Management Service
CFFDRS2025	Canadian Forest Fire Danger Rating System (2025 update)
CFFWIS	Canadian Forest Fire Weather Index System
CORINE	Coordination of Information on the Environment (EU land cover classification)
DC	Drought Code (CFFWIS)
DFMC_d	Dead Fuel Moisture Content, derived (modelled)
DMC	Duff Moisture Code (CFFWIS)
DSR	Daily Severity Rating (CFFWIS)
EFFIS	European Forest Fire Information System
ERC	Energy Release Component (NFDRSv4)
FFMC	Fine Fuel Moisture Code (CFFWIS)
FMC	Fuel Moisture Content
FMS	(Dead) Fuel Moisture Sensor
FWI	Fire Weather Index (CFFWIS)
GSI	Growing Season Index (NFDRSv4)
HDW	Hot-Dry-Windy Index
IC	Ignition Component (NFDRSv4)
ISI	Initial Spread Index (CFFWIS)
KBDI	Keetch-Byram Drought Index
NFDRSv4	National Fire Danger Rating System, version 4
NOA	National Observatory of Athens
QC	Quality Control
RAWS	Remote Automated Weather Station
SC	Spread Component (NFDRSv4)
TDR	Time Domain Reflectometry
VPD	Vapor Pressure Deficit
WMO	World Meteorological Organization

2. Network Overview

PYROMET is a nationwide network designed to monitor fire weather conditions across Greece in support of the computation of standardized fire weather and danger indices for both research and operational applications. Each station measures standard meteorological variables (air temperature, relative humidity, wind speed and direction, precipitation, solar radiation, and barometric pressure) at 10-minute intervals using Davis Vantage Pro 2 instrumentation. Three stations are additionally equipped with Campbell Scientific dead fuel moisture sensors (FMS), providing direct measurements of 10-h fuel moisture content.

The network currently comprises 14 RAWS; a summary of all stations is provided in the table below, with FMS-equipped stations indicated in the FMS column. Station IDs link to the station's live page on the public PYROMET dashboard (`https://pyromet.fireweather.eu/station.html?id=<StationID>`).

ID	Name	Latitude (°N)	Longitude (°E)	Elevation (m asl)	Region	FMS	Operational since
23460	Loutraki	37.978625	23.047447	450	Corinthia	No	2026-05-16
23461	Penteli	38.059113	23.897598	709	Attica	Yes	2026-04-30
23462	Taxiarchis	40.424659	23.496783	880	Chalkidiki	Yes	2026-06-13
23463	Pineios	37.868388	21.183053	49	Elis	No	2026-05-30
23464	Lavrio	37.728193	24.000257	256	Attica	No	2026-05-30
23465	Kalamata	37.037574	22.124475	18	Messenia	No	2026-05-15
23466	Perachori	38.454364	22.862819	243	Boeotia	No	2026-05-14
23467	Rodopi	41.200787	25.345347	661	Rhodope	No	2026-06-13
23468	Geraki	37.017311	22.652033	313	Laconia	No	2026-05-30
23469	Soufli	41.203049	26.276824	147	Evros	No	2026-06-13
23470	Mariou	35.196464	24.426370	174	Rethymno	No	2026-05-30
23471	Imittos	37.960693	23.771096	289	Attica	Yes	2026-05-01
23472	Ampeliko	39.054266	26.301801	460	North Aegean	No	2026-06-04
23474	Schinokapsala	35.047527	25.895675	405	Lasithi	No	2026-06-04

2.1 Station Descriptions

Station 23460 — Loutraki

The station is hosted by Loutraki Perachora Forest Fire Protection Association and the Municipality of Loutraki-Perachora-Agioi Theodoroi. It is located on a ridge exposure, with no nearby hazards or obstructions.

Station 23461 — Penteli

The station is hosted by DESFA and Municipality of Penteli. It is located on an open hillside, with no nearby hazards or obstructions.

Station 23462 — Taxiarchis

The station is hosted by Rodamos Guesthouse, in the Municipality of Polygyros. It is located on a ridge exposure. Trees to the south of the station may affect wind and solar radiation measurements.

Station 23463 — Pineios

The station is hosted by Municipality of Pineios and the “PINEIOS” Volunteer Group. It is located on a plain, with no nearby hazards or obstructions.

Station 23464 — Lavrio

The station is hosted by the Municipality of Lavreotiki and WWF Greece (Reforestation Unit). It is located on a ridge exposure, with no nearby hazards or obstructions.

Station 23465 — Kalamata

The station is hosted by the Institute of Olive Tree, Subtropical Crops & Viticulture (IOSV), Department of Olive & Horticultural crops (ELGO-DIMITRA), in the Municipality of Kalamata. It is located on a plain within a peri-urban area. Nearby buildings may cause shadowing, resulting in possible abrupt declines of measured solar radiation during the afternoon-to-evening transition hours.

Station 23466 — Perachori

The station is hosted by the Greek Search and Rescue Association of Livadia (Livadia R.E.E.D.) in the Municipality of Levadeon. It is located on an open hillside, with no nearby hazards or obstructions.

Station 23467 — Rodopi

The station is hosted by the Hellenic Rescue Team, Department of Rhodope, in the Municipality of Iasmos. It is located on a ridge exposure, with no nearby hazards or obstructions.

Station 23468 — Geraki

The station is hosted by Panagiotis Theodorakakos, in the municipality of Evrotas. It is located in a valley, with no nearby hazards or obstructions.

Station 23469 — Soufli

The station is hosted by Thomas Papatsilekas, in the municipality of Soufli. It is located on a plain, with no nearby hazards or obstructions.

Station 23470 — Mariou

The station is hosted by the Municipality of Agios Vassileios and ENA Rethymno Team. It is located at the foot of a mountain, with no nearby hazards or obstructions.

Station 23471 — Imittos

The station is hosted by SPAY, in the municipality of Vyronas. It is located on a hill top, with no nearby hazards or obstructions.

Station 23472 — Ampeliko

The station is hosted by the Civil Protection Directorate of the North Aegean Region, in the municipality of Mytelene. It is located on a ridge exposure, with no nearby hazards or obstructions.

Station 23474 — Schinokapsala

The station is hosted by the Municipality of Ierapetra and the Hellenic Red Cross, Regional Department of Ierapetra. It is located on a ridge exposure, with no nearby hazards or obstructions.

3. Instrumentation

3.1 Sensor Specifications

Each PYROMET station is built around the Davis Vantage Pro 2 (6825CM Vantage PRO2, GroWeather Cabled ISS, Metric) weather station platform, paired with a 24-h fan-aspirated radiation shield. Three stations are additionally equipped with a Campbell Scientific FMS. The table below summarises the sensor specifications.

Variable	Sensor type	Range	Resolution	Accuracy	Instrument
Air temperature	Thermistor	−40 to +65 °C	0.1 °C (-23.3 up to +37.8 °C, 0.2 °C otherwise)	±0.3 °C (+15.6 °C to +37.8 °C); ±1.7 °C (at −40 °C); ±1.1 °C (at +65 °C)	Davis VP2
Relative humidity	Capacitive	0–100 %	1 %	±3 % RH (0–90 %); ±4 % RH (90 up to 100%)	Davis VP2
Precipitation	Single spoon tipping bucket	0–100 mm h^{-1}	0.2 mm	±3 % (≤50 mm h^{-1}); ±10 % (>50 mm h^{-1})	Davis VP2
Wind speed	Three-cup anemometer	0.5–89 m s^{-1}	0.1 m s^{-1}	±5 %	Davis VP2
Wind direction	Wind vane	1–360 °	1 °	±3 °	Davis VP2
Solar radiation	Silicon pyranometer	0–1800 W m^{-2}	1 W m^{-2}	±5 %	Davis VP2
Barometric pressure	Capacitive transducer	540–1100 hPa	0.1 hPa	±1.0 hPa	Davis VP2
Dead fuel moisture content	Time Domain Reflectometry	0–70 %	0.1 %	±1.25 % (0-10 %); ±2 % (10-20 %); ±3.4 % (20-30 %); ±4.11 % (30-50 %)	Campbell CS506

Notes: Wind speed starting threshold: ~0.2 m s^{-1}. Sensor specifications are given in SI units; wind speed is stored in km h^{-1} in the PYROMET database (Section 3.2). Solar radiation spectral range: 400–1100 nm (silicon photodiode response). Air temperature and relative humidity sensors are housed in a 24-h fan-aspirated radiation shield. Dead fuel moisture sensor applies to stations 23461 (Penteli), 23462 (Taxiarchis), and 23471 (Imittos) only.

3.2 Measured Variables

The table below lists all variables measured by the PYROMET network, with their associated instrument, observation height, sampling interval, and station applicability. All meteorological variables are measured by the Davis Vantage Pro 2 platform at 10-minute intervals. Dead fuel moisture content is measured only at FMS-equipped stations (23461, 23462, 23471) and at a different sampling and transmission schedule.

Variable	Symbol	Unit	Instrument	Observation height	Sampling interval & aggregation	Stations
Air temperature	T	°C	PN Junction Silicon Diode Thermistor (Davis VP2)	2 m agl	2.5 sec, averaged on 10 min time interval	All
Relative humidity	RH	%	Film capacitor element (Davis VP2)	2 m agl	2.5 sec, averaged on 10 min time interval	All
Precipitation	P	mm	Single spoon tipping bucket rain gauge (Davis VP2)	2 m agl	2.5 sec, summed on 10 min time interval	All
Wind speed	u	km h^{-1}	Solid state magnetic sensor, Three-cup anemometer (Davis VP2)	5 m agl	2.5 sec, averaged on 10 min time interval	All
Wind gust speed	u_g	km h^{-1}	Solid state magnetic sensor, Three-cup anemometer (Davis VP2)	5 m agl	2.5 sec, maximum across 10 min time interval	All
Wind direction	dd	cardinal text (degrees)	Wind vane with potentiometer (Davis VP2)	5 m agl	2.5 sec, dominant direction on 10 min time interval	All
Solar radiation	G	W m^{-2}	Silicon photodiode (Davis VP2)	2 m agl	50 secs to 1 min, averaged on 10 min time interval	All
Barometric pressure	p	hPa	Capacitive pressure transducer (Davis VP2)	1 m agl	1 min, averaged on 10 min time interval	All

Variable	Symbol	Unit	Instrument	Observation height	Sampling interval & aggregation	Stations
Dead fuel moisture content	FMC	%	CS506 TDR sensor (Campbell Scientific)	10 cm	10 min	FMS stations only

4. Derived Fire Weather Variables

4.1 Overview

The PYROMET network supports the computation of six fire weather variables and index systems, listed in the table below. Single-variable products are computed at 10-minute (VPD, HDW) or hourly (DFMC_d) resolution from the raw or aggregated observations. Multi-variable systems (CFFWIS1987, CFFWIS2025, NFDRSv4) are computed at daily resolution from aggregated or time-specific observations, following the input conventions of each system. Full computation procedures, including input aggregation rules, wind speed height adjustment, and implementation references, are provided in subsequent sections.

Product (Units)	Acronym	Type	Primary inputs	Reference
Vapor Pressure Deficit (hPa)	VPD	Single variable	T, RH	Allen et al. (1998)
Dead Fuel Moisture Content (%)	DFMC_d	Single variable	VPD	Rodrigues et al. (2024)
Hot-Dry-Windy Index ($m\ s^{-1}$ hPa)	HDW	Single index	T, VPD, u_{10}	Srock et al. (2018)
Canadian Forest Fire Weather Index System 1987 (dimensionless)	CFFWIS1987	Multi-variable system	T, RH, u_{10}, P	Van Wagner (1987)
Canadian Forest Fire Weather Index System 2025 (dimensionless)	CFFWIS2025	Multi-variable system	T, RH, u_{10}, P	Canadian Forest Service Fire Danger Group (2025)
National Fire Danger Rating System, version 4 (dimensionless)	NFDRSv4	Multi-variable system	T, RH, $u_{6.1}$, P, G	Jolly et al. (2024)

4.2 Wind Speed Height Adjustment

Several fire weather indices and systems computed by PYROMET (HDW, CFFWIS1987, CFFWIS2025) assume wind speed measured at a standard height of 10 m above ground level, whereas the NFDRSv4 system assumes wind speed measured at a height of 6.1 m (20 feet) above ground level. PYROMET anemometers are installed at 5 m agl (Section 3.2). A height adjustment is therefore applied to all wind speed observations before any derived variable computation. The raw 5 m wind speed (u_5) and wind gust speed ($u\_g_{,5}$) are retained in the database unchanged; the height-adjusted values u_{10}, $u_{6.1}$, $u\_g_{,10}$, and $u\_g_{,6.1}$ are computed and stored as separate derived variables.

Wind speed and wind gust speed are adjusted from 5 m to 10 m and 6.1 m agl using the logarithmic wind profile, which assumes neutral atmospheric stability:

$$u_{10} = u_5 \cdot \frac{\ln(10/z_0)}{\ln(5/z_0)}$$

$$u_{6.1} = u_5 \cdot \frac{\ln(6.1/z_0)}{\ln(5/z_0)}$$

The same adjustment is applied identically to wind gust speed (u_g,$_{5}$ → u_g,$_{10}$ and u_g,$_{6.1}$), using the same station z_0 value.

where z_0 is the aerodynamic roughness length (m).

Roughness length (z_0) values are assigned per station by identifying the CORINE Land Cover 2018 class at each station location and applying the EMD lookup table (CORINE 2018 to Roughness Length Lookup).

Station ID	Name	CORINE class (2018)	CORINE description	z_0 (m)	u_{10}/u_5	$u_{6.1}/u_5$
23460	Loutraki	3.1.2	Coniferous forest	0.500	1.301	1.086
23461	Penteli	3.2.3	Sclerophyllous vegetation	0.056	1.154	1.044
23462	Taxiarchis	3.1.1	Broad-leaved forest	0.500	1.301	1.086
23463	Pineios	2.2.3	Olive groves	0.400	1.274	1.079
23464	Lavrio	3.2.4	Transitional woodland-shrub	0.400	1.274	1.079
23465	Kalamata	1.1.2	Discontinuous urban fabric	0.400	1.274	1.079
23466	Perachori	2.2.3	Olive groves	0.400	1.274	1.079
23467	Rodopi	3.1.1	Broad-leaved forest	0.500	1.301	1.086
23468	Geraki	3.2.3	Sclerophyllous vegetation	0.056	1.154	1.044
23469	Soufli	2.4.2	Complex cultivation patterns	0.056	1.154	1.044
23470	Mariou	2.4.3	Land principally occupied by agriculture, with significant areas of natural vegetation	0.056	1.154	1.044
23471	Imittos	3.2.3	Sclerophyllous vegetation	0.056	1.154	1.044
23472	Ampeliko	3.1.2	Coniferous forest	0.500	1.301	1.086
23474	Schinokapsala	2.4.3	Land principally occupied by agriculture, with significant areas of natural vegetation	0.056	1.154	1.044

Adjustment factors are computed as $\ln(h/z_0) / \ln(5/z_0)$ where h is the target height (10 m for HDW, CFFWIS1987, CFFWIS2025; 6.1 m for NFDRSv4).

For certain stations, the original CORINE 2018 land cover classification was revised based on expert knowledge of the site and its surroundings. For Station 23466 (Perachori), the original class (1.1.2, Discontinuous urban fabric) was revised to class 2.2.3 (Olive groves), which better represents the land cover of the station's immediate area.

> **Important:** z_0 values are derived from a generalised CORINE land cover lookup table and carry inherent uncertainty, particularly for forested land cover classes where values differ across sources. The logarithmic wind profile adjustment additionally assumes neutral atmospheric stability. Users should be aware of these assumptions when interpreting height-adjusted wind speed values and derived fire weather variables.

4.3 Vapor Pressure Deficit (VPD)

VPD is a measure of the atmospheric air's drying potential. In simple terms, it represents how much thirsty the air is. High values of VPD mean that the air is missing water, hence resulting in faster and more efficient dry out of vegetation.

Vapor pressure deficit is the difference between the saturation vapor pressure at a given air temperature and the actual vapor pressure. It quantifies the atmospheric demand for water and is a direct measure of the drying power of the air. VPD is increasingly recognised as a robust predictor of fire behaviour and fire-season severity, particularly under climate change conditions. Within the PYROMET computation pipeline, VPD additionally serves as an intermediate input for DFMC_d (Section 4.4) and HDW (Section 4.5).

VPD is computed at 10-minute resolution from air temperature (T) and relative humidity (RH) using the Magnus formula as formulated in FAO-56 (Allen et al., 1998).

Saturation vapor pressure (e⍰, kPa):

$$e_s = 0.6108 \cdot \exp\left(\frac{17.27 \cdot T}{T + 237.3}\right)$$

Actual vapor pressure (e_a, kPa):

$$e_a = \frac{RH}{100} \cdot e_s$$

Vapor pressure deficit (VPD, hPa):

$$VPD = (e_s - e_a) \times 10$$

Parameter	Symbol	Unit
Air temperature	T	°C
Relative humidity	RH	%
Saturation vapor pressure	e⍰	kPa
Actual vapor pressure	e_a	kPa

Parameter	Symbol	Unit
Vapor pressure deficit	VPD	hPa

References:

- Allen, R.G., Pereira, L.S., Raes, D. and Smith, M. (1998). *Crop Evapotranspiration — Guidelines for Computing Crop Water Requirements*. FAO Irrigation and Drainage Paper 56. Food and Agriculture Organization of the United Nations, Rome.

4.4 Dead Fuel Moisture Content — Derived (DFMC_d)

Dead fuel moisture is the single strongest physical control on ignition ease and early fire spread rate. DFMC_d extends that control variable to every PYROMET station, not only the three fitted with a physical sensor.

Dead fine fuel moisture content can be estimated from meteorological observations using empirical or semi-mechanistic models. Research using a global dataset of fire behaviour experiments has shown that VPD-based models provide better estimates of dead fine fuel moisture content than models relying on temperature and relative humidity separately, and that semi-mechanistic models accounting for vegetation type perform best overall (Rodrigues et al., 2024). DFMC_d is therefore estimated from VPD, itself derived from T and RH (Section 4.3), following the modelling approach recommended by that study.

DFMC_d represents the theoretical moisture content that fine dead fuels would reach under sustained exposure to ambient atmospheric conditions. It complements the direct sensor measurements of dead fuel moisture content (Section 3.2, FMC) available at FMS-equipped stations, and extends spatially consistent DFMC estimates to all stations.

DFMC_d is computed at **hourly** resolution. Hourly VPD is derived from hourly averages of T and RH computed from the 10-minute data stream, using the equations in Section 4.3. The 1-hour timelag of fine dead fuels means that using instantaneous 10-minute VPD values as model input is not physically appropriate.

$$DFMC_d = 1.19 + 19.81 \cdot \exp\left(-0.29 \cdot \frac{VPD}{10}\right)$$

Parameter	Symbol	Unit
Vapor pressure deficit	VPD	hPa
Dead fuel moisture content (derived)	DFMC_d	%

The division of VPD by 10 converts from hPa to kPa, which is the unit assumed by the model parameterisation.

> **Note:** DFMC_d is a modelled estimate based on atmospheric conditions. It represents 1-hour dead fuel moisture and differs conceptually from the sensor-based FMC measurements, which reflect the actual moisture state of a physical wooden dowel element exposed at the station site and represent 10-hour dead fuel moisture. The two products are not directly comparable.

References:

- Rodrigues, M., Resco de Dios, V., Sil, A., Camprubi, A.C. and Fernandes, P.M. (2024). *VPD-based models of dead fine fuel moisture provide best estimates in a global dataset*. Agricultural and Forest Meteorology, 346, 109868.

4.5 Hot-Dry-Windy Index (HDW)

The HDW index combines vapor pressure deficit and wind speed into a single index that characterizes the simultaneous occurrence of dry atmospheric conditions and strong winds. This is the synoptic regime most strongly associated with rapid fire spread and large fire events. HDW does not incorporate fuel state or antecedent drought; it is an atmospheric index sensitive to short-term, high-intensity fire weather.

HDW is computed at 10-minute resolution from VPD (Section 4.3) and height-adjusted wind speed at 10 m agl (u_{10}, Section 4.2):

$$HDW = \frac{u_{10}}{3.6} \times VPD$$

Division by 3.6 converts u_{10} from km h^{-1} to m s^{-1}. The resulting index has units of m s^{-1} hPa.

Parameter	Symbol	Unit
Height-adjusted wind speed (10 m agl)	u_{10}	km h^{-1}
Vapor pressure deficit	VPD	hPa
Hot-Dry-Windy Index	HDW	m s^{-1} hPa

The 10-minute HDW time series can be aggregated to daily resolution by taking the maximum value over each 24-hour period, consistent with the operational use of the index for daily fire weather assessment.

References:

- Srock, A.F., Charney, J.J., Potter, B.E. and Goodrick, S.L. (2018). *The Hot-Dry-Windy Index: A New Fire Weather Index*. Atmosphere, 9(7), 279.

4.6 Canadian Forest Fire Weather Index System 1987 (CFFWIS1987)

The Canadian Forest Fire Weather Index System (CFFWIS) is a meteorologically driven system for assessing fire danger. It is the primary fire danger rating system used operationally in Europe, including through the Copernicus Emergency Management Service (CEMS) European Forest Fire Information System (EFFIS).

CFFWIS comprises six components arranged in a hierarchical structure. Three fuel moisture codes track the moisture content of different fuel layers:

Code	Name	Fuel layer represented
FFMC	Fine Fuel Moisture Code	Surface litter and fine fuels

Code	Name	Fuel layer represented
DMC	Duff Moisture Code	Loosely compacted organic matter
DC	Drought Code	Deep organic matter and heavy fuels

Three fire behaviour indices are derived from the moisture codes:

Index	Name	Represents
ISI	Initial Spread Index	Rate of fire spread
BUI	Buildup Index	Total fuel available for combustion
FWI	Fire Weather Index	Overall fire intensity

A severity rating, the Daily Severity Rating (DSR), is also derived from FWI.

4.6.1 Inputs and Observation Time

CFFWIS1987 is computed once daily from observations of T, RH, u_{10}, and accumulated 24-hour precipitation (P), extracted from the 10-minute archive at a fixed observation time of **15:00 Europe/Athens**. This time falls within the afternoon window of peak fire weather conditions in Greece (14:00–17:00 local time) and is the basis for all PYROMET CFFWIS1987 outputs. Wind speed (u_{10}) is height-adjusted to 10 m agl as described in Section 4.2; CFFWIS1987 does not use the 6.1 m adjustment applied for NFDRSv4 (Section 4.8).

Input	Symbol	Unit	Derivation from 10-min archive
Air temperature	T_{1500}	°C	Instantaneous value at 15:00
Relative humidity	RH_{1500}	%	Instantaneous value at 15:00
Wind speed (10 m agl)	$u_{10,1500}$	km h^{-1}	Instantaneous u_{10} at 15:00 (Section 4.2)
24-hour precipitation	P_{24}	mm	Sum of all 10-min P records from 15:10 on day d−1 to 15:00 on day d

Note: The Van Wagner (1987) equations were parameterised using observations taken at local solar noon. Using a 15:00 observation time will produce systematically higher fire danger ratings than noon-based implementations under equivalent conditions. PYROMET CFFWIS1987 values should not be directly compared with systems using noon observations without accounting for this difference.

4.6.2 Season Initialisation

At the start of each fire season, startup values for the three moisture codes (FFMC, DMC, DC) are required. DC startup accounts for overwintering moisture carryover using the `startupDC()` function (Section 4.6.3) provided by the implementation. FFMC and DMC are initialised to standard default values ($FFMC_0$ = 85, DMC_0 = 6) per Van Wagner (1987) unless station-specific startup values are available.

4.6.3 Implementation

CFFWIS1987 is computed using the `cffwis.py` module from the `cffdrs` Python package:

```
from cffwis import dailyFFMC, dailyDMC, dailyDC, dailyISI, dailyBUI,
 dailyFWI, dailyDSR
```

The module is available at: https://github.com/gagreene/cffdrs (Licence: MIT)

References:

- Van Wagner, C.E. (1987). *Development and Structure of the Canadian Forest Fire Weather Index System*. Canadian Forestry Service, Forestry Technical Report 35.

4.7 Canadian Forest Fire Weather Index System 2025 (CFFWIS2025)

CFFWIS2025 is a module of the next-generation Canadian Forest Fire Danger Rating System (CFFDRS2025). It modernises the calculation methodology of the classic FWI system while preserving its structure and relative simplicity. The primary methodological change is that CFFWIS2025 uses hourly weather data rather than a single daily observation, allowing fire danger calculations to better capture the implications of within-day variations in weather conditions. CFFWIS2025 remains a daily, landscape-level planning tool; changes include improving daily weather tracking, reconciling different versions of codes and indices, and introducing new codes and indices.

CFFWIS2025 retains the six classic codes and indices of CFFWIS1987 (FFMC, DMC, DC, ISI, BUI, FWI) and additionally introduces new optional codes and indices for grassland fuels, following the same hierarchical structure as the pine forest codes.

4.7.1 Inputs and Hourly Aggregation

CFFWIS2025 ingests the complete diurnal cycle of hourly weather observations. As with CFFWIS1987, wind speed (u_{10}) is height-adjusted to 10 m agl per Section 4.2; the 6.1 m adjustment ($u_{6.1}$) used by NFDRSv4 (Section 4.8) does not apply here. Hourly values are derived from the 10-minute archive by aggregating six consecutive 10-minute records per hour as follows:

Input	Symbol	Unit	Aggregation from 10-min archive
Air temperature	T	°C	Mean of 6 records
Relative humidity	RH	%	Mean of 6 records
Wind speed (10 m agl)	u_{10}	km h^{-1}	Mean of 6 records (Section 4.2)
Hourly precipitation	P	mm	Sum of 6 records

Hourly records are timestamped at the end of the aggregation window (e.g., the record for 15:00 aggregates the 10-minute observations from 14:10 to 15:00 Europe/Athens).

4.7.2 Implementation

CFFWIS2025 is computed using the Python implementation in the `FWI/` directory of the `cffdrs-ng` repository maintained by the Canadian Forest Service Fire Danger Group (NRCan):

https://github.com/nrcan-cfs-fire/cffdrs-ng (Licence: GPL-2.0)

> **Note:** PYROMET maintains both CFFWIS1987 and CFFWIS2025 in parallel to support ongoing validation and transition.

References:

- Canadian Forest Service Fire Danger Group 2025. The 2025 update to the FWI system: Structures, changes, and interpretation. Information Report GLC-X-42.

4.8 National Fire Danger Rating System, Version 4 (NFDRSv4)

NFDRSv4 is a fuel- and weather-driven fire danger assessment system originally developed for operational use in the United States. Version 4 is the current implementation. A key modernisation introduced in NFDRSv4 is the replacement of lookup-table dead fuel moisture estimates with the Nelson continuous dead fuel moisture model, which operates at sub-daily time steps and enables hourly computation of fire danger indices.

NFDRSv4 produces several output components, the most operationally significant of which are:

Component	Acronym	Represents
Energy Release Component	ERC	Potential heat release per unit area
Spread Component	SC	Rate of fire spread potential
Burning Index	BI	Flame length potential
Ignition Component	IC	Probability of ignition from a firebrand
Growing Season Index	GSI	Live fuel moisture phenology estimate

NFDRSv4 incorporates the Keetch-Byram Drought Index (KBDI) as its drought component, tracking cumulative drying of deep fuels over the fire season. It requires fuel model information (derived from land cover data), a static terrain parameter (slope class), a station's average annual precipitation, and a KBDI start value, in addition to the meteorological inputs T, RH, $u_{6.1}$, P, and G.

4.8.1 Inputs and Temporal Resolution

NFDRSv4 is computed at **hourly resolution**, exploiting the continuous dead fuel moisture model introduced in version 4. Hourly inputs are derived from the 10-minute PYROMET archive by aggregation to the top of each hour. Wind speed ($u_{6.1}$) is height-adjusted to 6.1 m agl as described in Section 4.2, the only PYROMET system using this height convention; HDW, CFFWIS1987 and CFFWIS2025 all use the 10 m adjustment (u_{10}) instead.

Input	Symbol	Unit	Derivation from 10-min archive	Type
Air temperature	T	°F	Hourly mean of 10-min records, converted from °C	Meteorological
Relative humidity	RH	%	Hourly mean of 10-min records	Meteorological
Wind speed (6.1 m agl)	$u_{6.1}$	mi h^{-1}	Hourly mean of 10-min records, converted from km h^{-1} (Section 4.2)	Meteorological
Hourly precipitation	P	in	Hourly sum of 10-min records, converted from mm	Meteorological
Solar radiation	G	W m^{-2}	Hourly mean of 10-min records	Meteorological
Fuel model	—	—	Static (Section 4.8.2)	Static
Slope class	—	1–5	Static[1] (Section 4.8.2)	Static
Average annual precipitation	—	in	Static (Section 4.8.2)	Static
KBDI start value	—	0–800	Static (Section 4.8.2)	Static

[1] Slope class mapping: 1 = 0–25%, 2 = 26–40%, 3 = 41–55%, 4 = 56–75%, 5 = 76%+. The DEM-derived slope in degrees is converted to percentage and assigned to the appropriate class.

4.8.2 Station Fuel Models, Slope Classes, and Drought Initialization Parameters

The table below summarises the fuel models, slope classes, average annual precipitation, and KBDI start values defined for each of the PYROMET stations.

Station ID	Name	CORINE description	Assigned fuel model	Slope class	Average annual precipitation (in)	KBDI start value
23460	Loutraki	Coniferous forest	X	2	15.84	100
23461	Penteli	Sclerophyllous vegetation	X	1	17.96	100
23462	Taxiarchis	Broad-leaved forest	Y	1	25.90	100
23463	Pineios	Olive groves	W	1	31.12	100
23464	Lavrio	Transitional woodland-shrub	X	1	12.31	100
23465	Kalamata	Discontinuous urban fabric	W	1	36.66	100
23466	Perachori	Olive groves	W	1	26.47	100
23467	Rodopi	Broad-leaved forest	Y	1	30.33	100

Station ID	Name	CORINE description	Assigned fuel model	Slope class	Average annual precipitation (in)	KBDI start value
23468	Geraki	Sclerophyllous vegetation	X	1	24.72	100
23469	Soufli	Complex cultivation patterns	W	1	28.84	100
23470	Mariou	Land principally occupied by agriculture, with significant areas of natural vegetation	W	1	23.21	100
23471	Imittos	Sclerophyllous vegetation	X	1	15.14	100
23472	Ampeliko	Coniferous forest	X	1	28.07	100
23474	Schinokapsala	Land principally occupied by agriculture, with significant areas of natural vegetation	W	1	10.66	100

4.8.3 Implementation

NFDRSv4 is computed using the NFDRS4py Python package: https://github.com/j-tenny/NFDRS4py Forked from: https://github.com/firelab/NFDRS4 (USFS Missoula Fire Lab) Licence: MIT

The implementation uses the `process_df` method, which accepts a pandas DataFrame of hourly meteorological observations in FW21-compatible format and returns hourly NFDRS indices. Meteorological inputs are sourced from the per-station FW21 archive produced by the PYROMET preprocessing pipeline. The full archive is passed to `process_df` on each daily run to ensure adequate spin-up of the Nelson dead fuel moisture model and the KBDI (minimum 14 days of prior data recommended).

References:

- Jolly, W.M., Freeborn, P.H., Wallace, J. and Brittain, S. (2024). *Modernizing the US National Fire Danger Rating System (version 4): Simplified fuel models and improved live and dead fuel moisture calculations*. Environmental Modelling and Software, 181, 106181.

5. Data Quality

5.1 Philosophy and Approach

Quality control (QC) of PYROMET data follows the guidelines for AWS data QC set out in WMO-No. 488 (Guide to the Global Observing System, Appendix VI.2). The primary objectives are the detection of missing data and errors, the assignment of quality flags to all observations, and, where possible, the correction or estimation of erroneous values.

Two principles govern the PYROMET QC system:

Original values are always preserved. When a value is flagged as Doubtful, Inconsistent, or Erroneous, the original measured value is retained in the database alongside the flag. Flagged values are not silently overwritten; any corrected or estimated replacement is stored as a separate quantity.

Quality must be demonstrable at every stage. Flags are assigned progressively as data pass through QC stages. A flag assigned during automated QC may be revised during manual review as additional information becomes available. The current flag on any record reflects the most recent QC assessment.

Derived fire weather variables (Section 4) are computed from all observations carrying a Good or Doubtful flag. When one or more inputs carry a Doubtful flag, the derived variable is computed and assigned a Doubtful flag to propagate the uncertainty transparently. Observations carrying an Erroneous or Missing flag are excluded from derived variable computation; the corresponding derived variable is assigned a Missing flag.

5.2 Data Quality Levels

PYROMET data are processed through two QC tiers.

Automated QC runs as a sequential pipeline on every data ingestion cycle, whether processing archived data in batch mode or ingesting new observations in near-real time. It covers all algorithmic checks: completeness checks, range checks, step checks, persistence checks, and internal consistency checks. Flags are assigned to individual observations without human intervention.

Manual QC consists of twice-yearly retrospective reviews of observations that accumulated Doubtful flags during automated QC. Reviews are conducted at the end of the fire season (November) and at the start of the following season (April). The purpose of each review is to determine whether Doubtful-flagged values should be confirmed as Good, reclassified as Erroneous, or corrected. Fan failure monitoring follows its own review schedule and is conducted separately from the Doubtful flag review.

Dead fuel moisture content (FMC) observations are delivered in daily batches and are therefore subject to automated QC retrospectively rather than in real time. FMC observations are included in the twice-yearly manual reviews alongside the meteorological variables.

5.3 Quality Flag Scheme

All PYROMET observations carry a numeric quality flag. The flag scheme follows WMO-No. 488 (Guide to the Global Observing System, Appendix VI.2) and comprises five categories:

Flag	Label	Meaning
0	Good	Data are accurate; errors do not exceed the specified tolerance
1	Inconsistent	One or more cross-variable relationships do not meet defined criteria
2	Doubtful	Data are suspect; the value has failed a QC check but cannot be definitively rejected without further review
3	Erroneous	Data are wrong; errors exceed the specified tolerance
4	Missing	No observation is available for this timestamp

A Doubtful flag is assigned when a value fails a single-variable check (range, step, or persistence) but the failure may reflect an extreme meteorological event or calm/stationary conditions, rather than a sensor error. Doubtful values are used in derived variable computation, with the Doubtful flag propagated to the result; they are also retained for twice-yearly manual review (Section 5.2). An Inconsistent flag is assigned specifically when a cross-variable relationship that must hold physically is violated; both variables involved in the inconsistency are flagged.

5.4 QC Test Categories

Five categories of QC tests are applied to PYROMET observations.

Completeness check. Each expected 10-minute record is verified to be present. Missing records, whether due to transmission interruption, sensor outage, maintenance operations, or data logger failure, are assigned Flag 4. The cause of the gap, where determinable, is recorded in the QC log.

Range check. Each observation is verified to fall within physically plausible limits for the variable and the station location. Values outside the defined limits are flagged Erroneous (Flag 3).

Step check. The rate of change between successive observations is verified not to exceed physically plausible limits. An unrealistically large step between two consecutive 10-minute values is indicative of a sensor spike or transmission artefact. Values failing the step check are flagged Doubtful (Flag 2) or Erroneous (Flag 3) depending on the magnitude of the exceedance.

Persistence check. The variability of a variable over a defined rolling window is verified to meet a minimum threshold. Insufficient variability over an extended period, not attributed to calm/stationary conditions, is indicative of a frozen or stuck sensor. Values failing the persistence check are flagged Doubtful (Flag 2).

Internal consistency check. Physically constrained relationships between variables are verified. Violations (e.g., wind speed larger than wind gusts) result in an Inconsistent flag (Flag 1) or, for checks where the physical violation is meteorologically plausible, a Doubtful flag (Flag 2), applied to all variables involved in the violated relationship.

5.5 Known Limitations

Fan failure. If the aspiration fan in a station's radiation shield fails, the temperature and humidity sensors revert to passive-shield behaviour, introducing a positive temperature bias and a corresponding humidity bias under low-wind, high-radiation conditions. This failure mode produces a non-automatic flag in the data stream. Detection relies on cross-station comparison and manual inspection.

Dead fuel moisture sensor latency. FMC observations are received in a daily batch and are therefore subject to a delay of up to 24 hours relative to real time. QC of these data is always retrospective. No real-time quality flag is available for FMC during the observation day.

Wind direction resolution. Wind direction is stored as cardinal text (Section 3.2), which limits the precision available to temporal consistency checks. No step or persistence check is applied to wind direction; plausibility is verified through the range check (valid cardinal values) and the internal consistency check with wind speed.

6. Data Access

6.1 Data Availability and Format

PYROMET data are available to external users subject to the terms described in Section 6.2. Observations are archived from the operational start date of each station (Section 2) and are updated with a latency of approximately 15 minutes.

Live conditions for each station can be viewed on the public PYROMET dashboard (see Section 2 for per-station links). Bulk data (10-minute, hourly, and daily archives) are provided separately, on request, as described below.

Parameter	Value
Access method	Bulk data request via email (see below)
URL / endpoint	N/A (bulk data are not served via a public API or download endpoint)
File format	CSV
Temporal resolution	10 minutes for main and derived variables, hourly for FMC
File naming convention	PYROMET_<StationID>_<StationName>_<Resolution>_<StartDate>-<EndDate>.csv, where Resolution ∈ {10min, hourly, daily} and dates are YYYYMMDD (Europe/Athens). Example: PYROMET_23461_Penteli_10min_20260430-20260717.csv
Time reference	Europe/Athens

For data access requests, technical enquiries, or to report data quality issues, contact:

Theodore M. Giannaros, Principal Investigator of PYROMET, thgian[at]noa[dot]gr. Ioannis Koletsis, Operations Manager of PYROMET, koletsis[at]noa[dot]gr.

6.2 Terms of Use and Citation

PYROMET data are provided free of charge for **non-commercial use** (scientific research, education, and operational fire management) and are shared **on request** via the contacts listed in Section 6.1. Redistribution to third parties and any commercial use require prior written permission from the FLAME Fire Meteorology Group. Data are made available under the terms of the **Creative Commons Attribution–NonCommercial 4.0 International licence (CC BY-NC 4.0)**.

Users of PYROMET data are requested to cite the network as follows:

> FLAME Fire Meteorology Group (2026). *PYROMET: A Remote Automated Weather Station network for fire weather monitoring in Greece.* National Observatory of Athens (NOA), METEO Unit. Data retrieved [access date] from the FLAME Fire Meteorology Group (https://fireweather.eu).