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Solar Radiation as an input to the FWI System

DRAFT Note on CFFDRS2025 updates and changes

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Canadian Forest Service Fire Danger Group 2024

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Summary

This document is intended as a draft information note, to describe to those who are interested in the standards and use of solar radiation monitors and equipment for the calculation of the new Grassland components in the Fire Weather Index System 2025 (FWI2025). It is intended that this version is a living document and will be included as part of the larger documentation describing the Next Generation Canadian Forest Fire Danger Rating System (CFFDRS2025) components.

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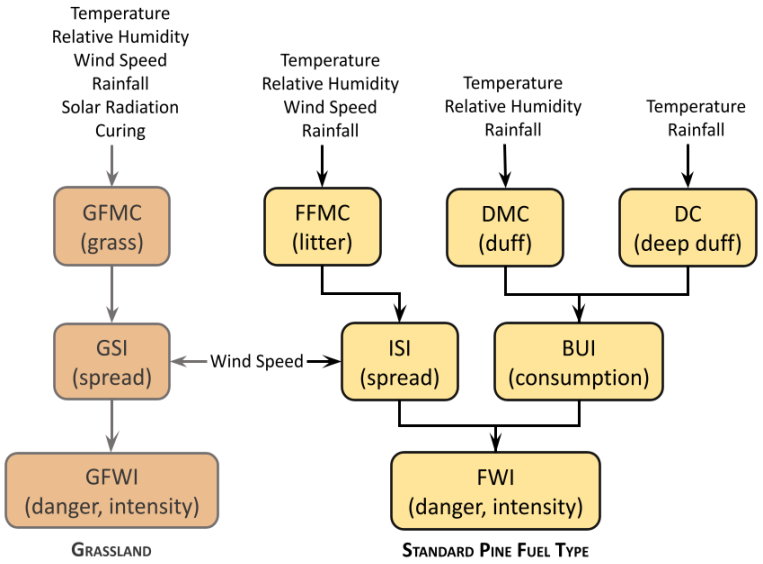

Figure 1: Diagram of FWI2025, including the new inputs and Grass Fuel Moisture Code (GFMC), Grass Spread Index (GSI), Grass Fire Weather Index (GFWI).

Part of the updates to the Canadian Forest Fire Danger Rating System (CFFDRS2025) includes the introduction of a new, optional set of indices for open grasslands in the Fire Weather Index System (FWI2025) (Figure 1). To calculate these indices, there are two additional inputs for calculating the Grass Fuel Moisture Code (GFMC); solar radiation and state of curing. There are several sources one can use to gather this data. In this document, we will focus on solar radiation data collection, and the option to use sensors on weather stations to collect these data. Importantly, solar radiation is necessary in open fuels like grasslands to capture the extra contribution to the drying rate that sunlight provides. For example, on a clear day solar radiation can heat a fully exposed matted grass layer by about 20°C above the surrounding air temperature. By capturing the more rapid drying of grassland fuels due to solar radiation, grassland potential ignition and spread can be quantified separately from forest potential rates.

There is a wide range in cost and quality across pyranometers, even a low-cost pyranometer provided by a standard supplier of weather instrumentation would be sufficient for use with the CFFDRS2025.

Similar to the weather station and sensor standards for the inputs to the current FWI System (temperature, relative humidity, wind speed and precipitation), the station location and equipment for CFFDRS2025 should follow the same standards as set out by the World Meteorological Organization (WMO). The sensor and setup for gathering solar radiation information should also follow these standards. Details of the standards can be found in WMO(2018) *The Guide to Instruments and Methods of Observation (WMO-No.8)*.

Solar radiation, often referred to as shortwave radiation, is measured with pyranometers which are designed to measure incoming solar radiation (both that coming directly from the sun and diffuse radiation that has been scattered by the atmosphere) from the entire hemisphere of the sky above it. CFFDRS2025 requires “open-sky” solar radiation; so there should be no vegetation or structures near the pyranometer. The preexisting siting requirements for fire weather stations fulfills this requirement.

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However, care should be taken to ensure that the weather station mast or other instruments do not cast a shadow on the pyranometer. Solar radiation is measured with an instrument that is levelled with an internal spirit bubble or electronic levelling sensor and is not aligned with the ground slope. The guide to the measurement of solar radiation and details on pyranometers can be found in Volume 1 of the WMO-No. 8 Guide, and table 7.4 of this Guide describes characteristics of operational pyranometers. There is a wide range in cost and quality across pyranometers, even a low-cost pyranometer provided by a standard supplier of weather instrumentation would be sufficient for use with the CFFDRS2025. However, care should be taken to ensure that a "broad-spectrum" pyranometer is used, and *not* a Photosynthetically Active Radiation (PAR) sensor. It is likely that any provider of fire weather stations will be able to add a pyranometer to existing stations and include solar radiation as a standard variable in the data-stream.

Most pyranometers measure solar radiation in W/m-2 (some may measure in kW/m-2), and the measurement should be an average over the hour (like the wind speed measurement, at least a 10minute average). It may be that automatic weather stations for other applications such as agricultural monitoring and some avalanche, climate, and roadway observations stations may already include solar radiation measurement that can be integrated into agency fire weather data processing systems.

For those who may be interested in understanding how the FWI System is using solar radiation, it is useful to consider how users currently interpret grass fuel moisture and for those who are familiar with assessing fuel moisture with help from the *"Field guide for predicting fire behaviour in Ontario's Tallgrass Prairie"* (Kidnie et al. 2010). In this previous application of grass fuel moisture calculation for use in the field during prescribed burning, solar radiation was estimated from the standard top of atmosphere calculation (using latitude, longitude and day of year) and an assessment of 'cloud cover' (e.g. Clear, Scattered, Broken, Overcast) made by the user onsite. The GFMC calculation in FWI2025 effectively replaces this step by directly using direct measurements of solar radiation for routine fire weather station observations going forward. Note that the FWI2025 input units of solar radiation is expecting kW/m-2. For historical fire weather observations without solar radiation measurements, widely used approaches to estimate hourly solar radiation from observed hourly temperature, humidity, latitude, and month of the year is available to use alongside FWI2025. Forecast solar radiation in the open (i.e. analogous to station observations) is available at an hourly time step using any widely used weather model with a 2 to 4 day forecast period. Any fire weather systems using numerical weather forecasts can readily be updated to ingest the additional data inputs.

This document is intended for those who are evaluating the possible sources of information for solar radiation as an input to the FWI2025 and CFFDRS2025. Any feedback from users regarding the information contained, if there are outstanding questions would be welcome. Feedback can be sent directly to Natasha.Jurko@NRCan-RNCan.gc.ca

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References

Kidnie, S. M., Wotton, B. M., & Droog, W. N. (2010). Field guide for predicting fire behaviour in Ontario's Tallgrass Prairie. Elgin County Stewardship Council Special Publication. Ontario Ministry of Natural Resources, Aylmer, Ont. https://ostrnrcan-dostrncan.canada.ca/handle/1845/246080

World Meteorological Organization WMO (2018) Guide to Instruments and Methods of Observation *https://library.wmo.int/idurl/4/41650*

World Meteorological Organization WMO (2018) Volume 1 of the Guide to Instruments and Methods of Observation *https://library.wmo.int/idurl/4/68695*

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