The NOAA Next Generation Fire System (NGFS) - Readme

Background:

The Next Generation Fire System (NGFS), which is part of the VOLcanic Cloud Analysis Toolkit (VOLCAT) software base, is a collection of satellite sensor agnostic algorithms and tools designed to enable the delivery of actionable information and analysis-ready data for critical active fire applications. The NGFS exploits spectral satellite measurements from the visible, shortwave infrared, mid-wave infrared, and longwave infrared portions of the electromagnetic spectrum, along with advanced spatial and temporal metrics, to detect fires in a manner that is consistent with human expert analysis of satellite imagery, which, by definition, is artificial intelligence. The NGFS estimates fire intensity via the fire radiative power product. The NGFS fire detection and intensity products are highly resilient to atmospheric obstructions, such as clouds and smoke. The NGFS employs an event-centric data model, automatically tracking fire events, thereby supporting critical use cases and advanced data queries. The NGFS combines satellite-based fire events with independent data layers that provide essential context for decision-making and analysis. These layers include National Weather Service (NWS) fire weather outlooks and Red Flag Warnings, National Interagency Fire Center (NIFC) wildfire incident perimeters, geopolitical boundaries, government agency jurisdiction boundaries, persistent anomaly sources, and biomass fuel data. The NGFS generates products with terrain-corrected geolocation from geostationary and low-earth orbiting satellites. The event-based data model and accurate geolocation allow results from multiple sensors to be readily combined within downstream applications.

The NGFS is closely tied to the NESDIS Fire Storefront Project to ensure impactful service delivery. The NGFS, in combination with the Fire Storefront, is specially designed to 1) provide satellite-derived information that helps reduce response time to a new fire incident, 2) enhance weather and fire monitoring in support of fire incident management, 3) enable improved fire emissions monitoring, smoke forecasts, and fire behavior/spread forecasts, 4) enhance understanding of long-term fire trends and patterns, and 5) simplify access to fire products and information. The NGFS capabilities and fire storefront will continue to evolve as guided by the NESDIS Wildland Fire Program user engagement activities, the Bipartisan Infrastructure Law, and NOAA-wide priorities. The NGFS project is a Disaster Relief Supplemental Appropriations and Bipartisan Infrastructure Law supported collaboration between NOAA, the University of Wisconsin - Madison, Colorado St. University, the University of Maryland, the University of Alaska - Fairbanks, and the University of California - San Diego.

Data Availability and Description:

All NGFS products are non-operational and should be considered experimental. While every effort is made to ensure timely and continuous delivery of high-quality products, disruptions or product quality anomalies may occur. Any use of experimental NGFS data for decision-making is at the end user's sole risk.

Output from the NGFS is available as comma-separated value (CSV) files, where each row in a CSV file provides information for a specific fire pixel for a given observation time, satellite, and

scan domain. Keyhole Markup Language (KML) and geoJSON formats are also available. NGFS fire pixels are available for each satellite image processed ("scene" files) and as daily compilations ("daily" files). Scene and daily files have the following structure.

Scene:
NGFS_FIRE_DETECTIONS_{satellite}_{sensor}_{sector}_{CCYY}_{MN}_{MD}_{DOY}_{HH}_{MM}_{SS}<.csv, .geojson, or .kml>

Example:
NGFS_FIRE_DETECTIONS_GOES-17_ABI_Mesoscale2_2019_10_24_297_04_29_51.csv

Daily:
NGFS_FIRE_DETECTIONS_{satellite}_{sensor}_{sector}_{CCYY}_{MN}_{MD}_{DOY}<.csv, .geojson, or .kml>

Example: NGFS_FIRE_DETECTIONS_GOES-17_ABI_Mesoscale2_2019_10_24_297.csv

Table 1 (GOES-R ABI) and Table 3 (JPSS VIIRS) describe each field in the scene and daily NGFS files.

The NGFS also generates feature-level output files, where each data record represents a fire feature. Features comprise one or more objects determined to be part of the same fire event. Each object is composed of one or more spatially connected pixels. Multi-object features are only possible when co-located fire incident data is available. Otherwise, each feature is composed of a single object. Each feature data record contains summary information, such as total feature fire radiative power within a given satellite image and time since initial detection. A feature ID is also provided to allow easy cross-referencing with pixel-level detections and extraction of feature time series. Feature files have the same structure as the pixel output files, except "NGFS_FIRE_DETECTIONS" is replaced by "NGFS_FEATURE_DETECTIONS." Each field in the feature output files is defined in Table 2.

Finally, the NGFS also produces daily event summaries, where each data record is a summary of

Table 1: GOES-R satellite series field definitions for scene and daily NGFS files. Note that all latitude and longitude coordinates use terrain-corrected geolocation.

Column	Field	Units	Description
1	latitude	Degrees N	Center of nominal 2 km pixel
2	longitude	Degrees E	Center of nominal 2 km pixel
3	bright_t7	K	ABI band 7 (3.9 μm) brightness temperature of the fire pixel
4	latitude_c1	Degrees N	Corner 1 of nominal 2 km pixel
5	longitude_c1	Degrees E	Corner 1 of nominal 2 km pixel
6	latitude_c2	Degrees N	Corner 2 of nominal 2 km pixel
7	longitude_c2	Degrees E	Corner 2 of nominal 2 km pixel
8	latitude_c3	Degrees N	Corner 3 of nominal 2 km pixel
9	longitude_c3	Degrees E	Corner 3 of nominal 2 km pixel
10	latitude_c4	Degrees N	Corner 4 of nominal 2 km pixel
11	longitude_c4	Degrees E	Corner 4 of nominal 2 km pixel
12	pixel_area	km^2	Area of nominal 2 km pixel. Pixels are larger than 2 km away from the satellite subpoint.
13	acq_date_time	UTC	Date and time of the first observation in the satellite image
14	pixel_date_time	UTC	Date and time of the fire pixel
15	satellite	n/a	Name of satellite (e.g., GOES-16)
16	scan_domain	n/a	Name of GOES-R satellite scan domain: Mesoscale1, Mesoscale2, CONUS, or Full-Disk
17	confidence	n/a	Confidence in fire detection. Currently always “nominal.”
18	version	n/a	NOAA Next Generation Fire System (NGFS) version
19	bright_t13	K	ABI band 13 (10.3 μm) brightness temperature of the fire pixel
20	frp	MW	Pixel-integrated fire radiative power (FRP). FRP saturation occurs at large values (> 450K) of bright_t7.
21	quality_flag	n/a	1: fire detection is based on robust signal, 3: fire detection is primarily based on persistence

22	frp_transmittance	unitless	The MWIR all-sky atmospheric transmittance used to correct the FRP for atmospheric attenuation.
23	type	n/a	0: presumed vegetation fire, 1: detected fire is co-located with a known fire incident, 2: detection is co-located with a persistent emitter, 3: detection is co-located and consistent with a known solar farm, 4: detection is spectrally consistent with a solar farm reflection, but the solar farm is not in current database, 5: Likely urban source
24	type_description	n/a	A string that describes the feature type (e.g., “Possible Wildland Fire,” “Ferrous-metal”, “Solar panel,” etc.)
25	daynight	n/a	D = Daytime fire, N = Nighttime fire
26	country	n/a	Name of country where fire pixel is located
27	state	n/a	Name of state where fire pixel is located (NULL outside of the U.S.)
28	county	n/a	Name of county where fire pixel is located (NULL outside of the U.S.)
29	gacc_id	n/a	Name of Geographic Area Coordination Center where fire pixel is located (NULL outside of the U.S.)
30	nws_region	n/a	National Weather Service region: ER=Eastern Region, WR=Western Region, etc. (NULL outside of the U.S.)
31	nws_wfo_code	n/a	National Weather Service Weather Forecast Office (WFO) code (e.g., KOTX) (NULL outside of U.S.)
32	nws_wfo_name	n/a	National Weather Service Weather Forecast Office (WFO) name (e.g., Spokane, WA) (NULL outside of the U.S.)
33	nws_fire_wx_code	n/a	Fire weather information is only valid in the U.S. 1: Extreme SPC outlook and/or Red Flag Warning, 2: Critical SPC outlook or Fire Weather Watch, 3: Elevated SPC outlook, 4: Nominal or unknown fire weather conditions
34	known_incident_name	n/a	Fire incident name. Only provided if the satellite detected fire feature is co-located with a known incident in the National Interagency Fire Center (NIFC) database. NULL otherwise.
35	known_incident_type	n/a	WF=wildfire, RX=prescribed fire
36	known_incident_id	n/a	Integrated Reporting of Wildfire Information (IRWIN) fire incident ID. Only provided if the

			satellite detected fire feature is co-located with a known incident in the National Interagency Fire Center (NIFC) database. NULL otherwise.
37	solar_zenith_angle	degrees	Solar zenith angle at the center of the nominal fire pixel
38	satellite_zenith_angle	degrees	Satellite zenith angle at the center of the nominal fire pixel
39	feature_tracking_id	n/a	The tracking ID of the fire feature associated with the current fire pixel. The tracking ID is a combination of the ISO formatted image date/time and NGFS feature index (NNNN) when the fire feature was initially detected (e.g., 2019-08-02T12:56:30Z_0001).
40	feature_frp	MW	The total fire radiative power of all of the pixels in the feature at the present observation time.
41	feature_tracking_duration	days	The duration of continuous detection for the fire feature associated with the current fire pixel. The duration is expressed in fractional days.
42	latitude_b5	Degrees N	Center of 1-km 1.6 μm pixel where fire signal is greatest
43	longitude_b5	Degrees E	Center of 1-km 1.6 μm pixel where fire signal is greatest
44	latitude_c1_b5	Degrees N	Corner 1 of 1-km 1.6 μm pixel where fire signal is greatest
45	longitude_c1_b5	Degrees E	Corner 1 of 1-km 1.6 μm pixel where fire signal is greatest
46	latitude_c2_b5	Degrees N	Corner 2 of 1-km 1.6 μm pixel where fire signal is greatest
47	longitude_c2_b5	Degrees E	Corner 2 of 1-km 1.6 μm pixel where fire signal is greatest
48	latitude_c3_b5	Degrees N	Corner 3 of 1-km 1.6 μm pixel where fire signal is greatest
49	longitude_c3_b5	Degrees E	Corner 3 of 1-km 1.6 μm pixel where fire signal is greatest
50	latitude_c4_b5	Degrees N	Corner 4 of 1-km 1.6 μm pixel where fire signal is greatest
51	longitude_c4_b5	Degrees E	Corner 4 of 1-km 1.6 μm pixel where fire signal is greatest
52	image_element	n/a	The one-based element index of the fire pixel,

			within the source satellite image, at the nominal 2-km resolution. The index is a function of the geostationary scan domain.
53	image_line	n/a	The one-based line index of the fire pixel, within the source satellite image, at the nominal 2-km resolution. The index is a function of the geostationary scan domain.

Table 2: GOES-R satellite series field definitions for NGFS feature files. Note that all latitude and longitude coordinates use terrain-corrected geolocation.

Column	Field	Units	Description
1	latitude	Degrees N	Center of nominal 2 km pixel that is representative of overall feature
2	longitude	Degrees E	Center of nominal 2 km pixel that is representative of overall feature
3	pixel count	unitless	Number of pixels in a feature
4	object count	unitless	Number of objects in the feature
5	acq_date_time	UTC	Date and time of the first observation in the satellite image
6	feature_date_time	UTC	Date and time of the fire feature
7	satellite	n/a	Name of satellite (e.g., GOES-16)
8	scan_domain	n/a	Name of scan domain (e.g., CONUS)
9	confidence	n/a	Confidence in fire detection. Currently always “nominal.”
10	version	n/a	NOAA Next Generation Fire System (NGFS) version
11	total_frp	MW	Total fire radiative power (FRP) for all pixels in a fire feature
12	maximum_frp	MW	FRP for the satellite pixel containing the highest FRP in a fire feature
13	quality_flag	n/a	1: fire detection is based on robust signal, 3: fire detection is primarily based on persistence
14	frp_transmittance	unitless	The MWIR all-sky atmospheric transmittance used to correct the FRP for atmospheric attenuation. This is the minimum transmittance considering all pixels in a feature.
15	type	n/a	0: presumed vegetation fire, 1: detected fire is co-located with a known fire incident, 2: detection is co-located with a persistent emitter, 3: detection is co-located and consistent with a known solar farm, 4:

			detection is spectrally consistent with a solar farm reflection, but the solar farm is not in current database, 5: Likely urban source
16	type_description	n/a	A string that describes the feature type (e.g., “Possible Wildland Fire,” “Ferrous-metal”, “Solar panel,” etc.)
17	daynight	n/a	D = Daytime fire, N = Nighttime fire
18	country	n/a	Name of country where fire feature is located
19	state	n/a	Name of state where fire feature is located (NULL outside of the U.S.)
20	county	n/a	Name of county where fire feature is located (NULL outside of the U.S.)
21	gacc_id	n/a	Name of Geographic Area Coordination Center where fire feature is located (NULL outside of the U.S.)
22	nws_region	n/a	National Weather Service region: ER=Eastern Region, WR=Western Region, etc. (NULL outside of the U.S.)
23	nws_wfo_code	n/a	National Weather Service Weather Forecast Office (WFO) code (e.g., KOTX) (NULL outside of U.S.)
24	nws_wfo_name	n/a	National Weather Service Weather Forecast Office (WFO) name (e.g., Spokane, WA) (NULL outside of the U.S.)
25	nws_fire_wx_code	n/a	Fire weather information is only valid in the U.S. 1: Extreme SPC outlook and/or Red Flag Warning, 2: Critical SPC outlook or Fire Weather Watch, 3: Elevated SPC outlook, 4: Nominal or unknown fire weather conditions
26	known_incident_name	n/a	Fire incident name. Only provided if the satellite detected fire feature is co-located with a known incident in the National Interagency Fire Center (NIFC) database. NULL otherwise.
27	known_incident_type	n/a	WF=wildfire, RX=prescribed fire

28	known_incident_id	n/a	Integrated Reporting of Wildfire Information (IRWIN) fire incident ID. Only provided if the satellite detected fire feature is co-located with a known incident in the National Interagency Fire Center (NIFC) database. NULL otherwise.
29	solar_zenith_angle	degrees	Mean solar zenith angle of the fire feature
30	satellite_zenith_angle	degrees	Mean satellite zenith angle of the fire feature
31	feature_tracking_id	n/a	The tracking ID associated with the fire feature. The tracking ID is a combination of the ISO formatted image date/time and NGFS feature index (NNNN) when the fire feature was initially detected (e.g., 2019-08-02T12:56:30Z_0001).
32	feature_tracking_duration	days	The duration of continuous detection for the fire feature. The duration is expressed in fractional days.
33	water_fraction	% [0-1]	The percentage fire feature pixels that are at least partially over a water surface.

Table 3: JPSS satellite series field definitions for scene and daily NGFS files

Column	Field	Units	Description
1	latitude	Degrees N	Center of nominal 375 m pixel
2	longitude	Degrees E	Center of nominal 375 m pixel
3	bright_ti4	K	VIIRS imagery band 4 (3.74 μm) brightness temperature of the fire pixel
4	latitude_c1	Degrees N	Corner 1 of nominal 375 m pixel
5	longitude_c1	Degrees E	Corner 1 of nominal 375 m pixel
6	latitude_c2	Degrees N	Corner 2 of nominal 375 m pixel
7	longitude_c2	Degrees E	Corner 2 of nominal 375 m pixel
8	latitude_c3	Degrees N	Corner 3 of nominal 375 m pixel
9	longitude_c3	Degrees E	Corner 3 of nominal 375 m pixel
10	latitude_c4	Degrees N	Corner 4 of nominal 375 m pixel
11	longitude_c4	Degrees E	Corner 4 of nominal 375 m pixel
12	pixel_area	km^2	Area of nominal 375 m pixel. Pixels are larger than 375 m away from the satellite subpoint.
13	acq_date_time	UTC	Date and time of the first observation in the satellite image
14	pixel_date_time	UTC	Date and time of the fire pixel
15	satellite	n/a	Name of satellite (e.g., NOAA-20)
16	confidence	n/a	Confidence in fire detection. Currently always “nominal.”
17	version	n/a	NOAA Next Generation Fire System (NGFS) version
18	bright_ti5	K	VIIRS imagery band 5 (11.45 μm) brightness temperature of the fire pixel
19	frp	MW	Pixel integrated fire radiative power (FRP). FRP saturation occurs at large values (> 450K) of bright_t7.

20	quality_flag	n/a	1: fire detection is based on robust signal, 3: fire detection is primarily based on persistence, 4: aggregate pixel when scan overlap occurs, 5: redundant fire pixel when scan overlap occurs
21	frp_transmittance	unitless	The MWIR all-sky atmospheric transmittance used to correct the FRP for atmospheric attenuation.
22	type	n/a	0: presumed vegetation fire, 1: detected fire is co-located with a known fire incident, 2: detection is co-located with a persistent emitter, 3: detection is co-located and consistent with a known solar farm, 4: detection is spectrally consistent with a solar farm reflection, but the solar farm is not in current database, 5: Likely urban source
23	type_description	n/a	A string that describes the feature type (e.g., “Possible Wildland Fire,” “Ferrous-metal”, “Solar panel,” etc.)
24	daynight	n/a	D = Daytime fire, N = Nighttime fire
25	country	n/a	Name of country where fire pixel is located
26	state	n/a	Name of state where fire pixel is located (NULL outside of the U.S.)
27	county	n/a	Name of county where fire pixel is located (NULL outside of the U.S.)
28	gacc_id	n/a	Name of Geographic Area Coordination Center where fire pixel is located (NULL outside of the U.S.)
29	nws_region	n/a	National Weather Service region: ER=Eastern Region, WR=Western Region, etc. (NULL outside of the U.S.)
30	nws_wfo_code	n/a	National Weather Service Weather Forecast Office (WFO) code (e.g., KOTX) (NULL outside of U.S.)
31	nws_wfo_name	n/a	National Weather Service Weather Forecast Office (WFO) name (e.g., Spokane, WA) (NULL outside of the U.S.)

32	nws_fire_wx_code	n/a	Fire weather information is only valid in the U.S. 1: Extreme SPC outlook and/or Red Flag Warning, 2: Critical SPC outlook or Fire Weather Watch, 3: Elevated SPC outlook, 4: Nominal or unknown fire weather conditions
33	known_incident_name	n/a	Fire incident name. Only provided if the satellite detected fire feature is co-located with a known incident in the National Interagency Fire Center (NIFC) database. NULL otherwise.
34	known_incident_type	n/a	WF=wildfire, RX=prescribed fire
35	known_incident_id	n/a	Integrated Reporting of Wildfire Information (IRWIN) fire incident ID. Only provided if the satellite detected fire feature is co-located with a known incident in the National Interagency Fire Center (NIFC) database. NULL otherwise.
36	solar_zenith_angle	degrees	Solar zenith angle at the center of the nominal fire pixel
37	satellite_zenith_angle	degrees	Satellite zenith angle at the center of the nominal fire pixel
38	feature_tracking_id	n/a	The tracking ID of the fire feature associated with the current fire pixel. The tracking ID is a combination of the ISO formatted image date/time and NGFS feature index (NNNN) when the fire feature was initially detected (e.g., 2019-08-02T12:56:30Z_0001).
39	feature_frp	MW	The total fire radiative power of all of the pixels in the feature at the present observation time.
40	feature_detection_duration	days	The duration of continuous detection for the fire feature associated with the current fire pixel. The duration is expressed in fractional days.

Table 4: JPSS satellite series field definitions for NGFS feature files.

Column	Field	Units	Description
1	latitude	Degrees N	Center of nominal 2 km pixel that is representative of overall feature
2	longitude	Degrees E	Center of nominal 2 km pixel that is representative of overall feature
3	pixel count	unitless	Number of pixels in a feature
4	object count	unitless	Number of objects in the feature
5	acq_date_time	UTC	Date and time of the first observation in the satellite image
6	feature_date_time	UTC	Date and time of the fire feature
7	satellite	n/a	Name of satellite (e.g., GOES-16)
8	confidence	n/a	Confidence in fire detection. Currently always “nominal.”
9	version	n/a	NOAA Next Generation Fire System (NGFS) version
10	total_frp	MW	Total fire radiative power (FRP) for all pixels in a fire feature
11	maximum_frp	MW	FRP for the satellite pixel containing the highest FRP in a fire feature
12	quality_flag	n/a	1: fire detection is based on robust signal, 3: fire detection is primarily based on persistence
13	frp_transmittance	unitless	The MWIR all-sky atmospheric transmittance used to correct the FRP for atmospheric attenuation. This is the minimum transmittance considering all pixels in a feature.
14	type	n/a	0: presumed vegetation fire, 1: detected fire is co-located with a known fire incident, 2: detection is co-located with a persistent emitter, 3: detection is co-located and consistent with a known solar farm, 4: detection is spectrally consistent with a solar farm reflection, but the solar farm is not in current database, 5: Likely urban source

15	type_description	n/a	A string that describes the feature type (e.g., “Possible Wildland Fire,” “Ferrous-metal”, “Solar panel,” etc.)
16	daynight	n/a	D = Daytime fire, N = Nighttime fire
17	country	n/a	Name of country where fire feature is located
18	state	n/a	Name of state where fire feature is located (NULL outside of the U.S.)
19	county	n/a	Name of county where fire feature is located (NULL outside of the U.S.)
20	gacc_id	n/a	Name of Geographic Area Coordination Center where fire feature is located (NULL outside of the U.S.)
21	nws_region	n/a	National Weather Service region: ER=Eastern Region, WR=Western Region, etc. (NULL outside of the U.S.)
22	nws_wfo_code	n/a	National Weather Service Weather Forecast Office (WFO) code (e.g., KOTX) (NULL outside of U.S.)
23	nws_wfo_name	n/a	National Weather Service Weather Forecast Office (WFO) name (e.g., Spokane, WA) (NULL outside of the U.S.)
24	nws_fire_wx_code	n/a	Fire weather information is only valid in the U.S. 1: Extreme SPC outlook and/or Red Flag Warning, 2: Critical SPC outlook or Fire Weather Watch, 3: Elevated SPC outlook, 4: Nominal or unknown fire weather conditions
25	known_incident_name	n/a	Fire incident name. Only provided if the satellite detected fire feature is co-located with a known incident in the National Interagency Fire Center (NIFC) database. NULL otherwise.
26	known_incident_type	n/a	WF=wildfire, RX=prescribed fire
27	known_incident_id	n/a	Integrated Reporting of Wildfire Information (IRWIN) fire incident ID. Only provided if the satellite detected fire feature is co-located with a known incident in the National Interagency Fire Center (NIFC) database. NULL otherwise.

28	solar_zenith_angle	degrees	Mean solar zenith angle of the fire feature
29	satellite_zenith_angle	degrees	Mean satellite zenith angle of the fire feature
30	feature_tracking_id	n/a	The tracking ID associated with the fire feature. The tracking ID is a combination of the ISO formatted image date/time and NGFS feature index (NNNN) when the fire feature was initially detected (e.g., 2019-08-02T12:56:30Z_0001).
31	feature_detection_duration	days	The duration of continuous detection for the fire feature. The duration is expressed in fractional days.
32	water_fraction	% [0-1]	The percentage fire feature pixels that are at least partially over a water surface.