2020.12.10 TBXFLARE 🔥 schema documentation

Flaring Schema

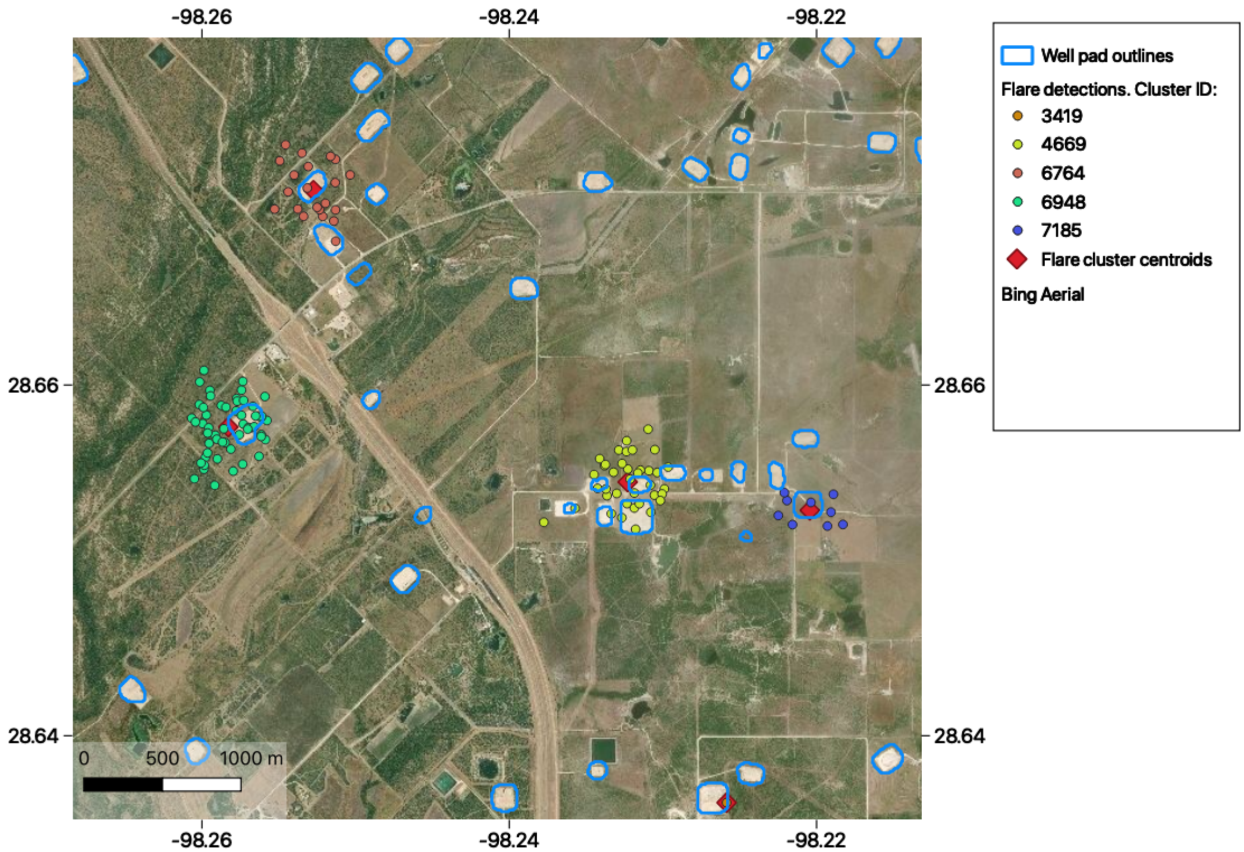
- `ts_flaring_power_MW` (string): Flaring Radiative Power (FRP) time series for the flare source, in a list of json-style objects, with keys “time” (date and time of flare detections), “value” (FRP measured by VIIRS in MW), “cluster_ID” (identifier of the flare cluster to which to detection contains). For example: [{"time": "2020-07-28 20:06:00", "value": 24.5116, "cluster_id": 27224}, {"time": "2020-07-29 08:30:00", "value": 4.97414, "cluster_id": 27224}, {"time": "2020-07-30 08:12:00", "value": 2.16927, "cluster_id": 27224}]
- `ts_flaring_energy_daily_GJ` (string): daily Flaring Radiative Energy (FRE) time series for the flare source, in a list of json-style objects, with keys “time” (date and time of the mid point of the time bin) “time_start” (date and time of the start of each time bin), “time_end” (date and time of the end of each time bin), “value” (FRE released in the interval [time_start, time_end]). For example: [{"time": "2020-06-04 12:00:00", "time_start": "2020-06-04 00:00:00", "time_end": "2020-06-04 23:59:59", "value": 3.16}, {"time": "2020-06-10 12:00:00", "time_start": "2020-06-10 00:00:00", "time_end": "2020-06-10 23:59:59", "value": 4.43}]
- `ts_flaring_energy_weekly_GJ` (string): weekly Flaring Radiative Energy (FRE) time series for the flare source, in a list of json-style objects, with keys “time” (date and time of the mid point of the time bin) “time_start” (date and time of the start of each time bin), “time_end” (date and time of the end of each time bin), “value” (FRE released in the interval [time_start, time_end]). For example: [{"time": "2020-06-04 12:00:00", "time_start": "2020-06-01 00:00:00", "time_end": "2020-06-07 23:59:59", "value": 2.24}, {"time": "2020-06-11 12:00:00", "time_start": "2020-06-08 00:00:00", "time_end": "2020-06-14 23:59:59", "value": 34.45}]
- `ts_flaring_energy_monthly_GJ` (string): monthly Flaring Radiative Energy (FRE) time series for the flare source, in a list of json-style objects, with keys “time” (date and time of the mid point of the time bin) “time_start” (date and time of the start of each time bin), “time_end” (date and time of the end of each time bin), “value” (FRE released in the interval [time_start, time_end]). For example: [{"time": "2019-03-16 12:00:00", "time_start": "2019-03-01 00:00:00", "time_end": "2019-03-31 23:59:59", "value": 102.47}, {"time": "2020-02-15 12:00:00", "time_start": "2020-02-01 00:00:00", "time_end": "2020-02-29 23:59:59", "value": 67.90}]
- `flaring_energy_recent_GJ` (float): amount of energy released through flaring over the past 90 days in GJ.
- `flaring_energy_2yr_GJ` (float): amount of energy released through flaring over the past 730 days in GJ.

Technical design and methods

FLARE DETECTION CLUSTERING

It is necessary to cluster together flare detections given the spatial resolution of the VIIRS instrument (375m) is of the same order of magnitude as the distance between some well pads. Clustering multiple detections improves the precision of the geographic location of the detections. The centroid point of the flare cluster is used as the assumed location of the flare stack.

The map below shows a region in the Eagle Ford basin in Texas where flaring has been detected. The filled circles show each flare detection, these are colour coded by flare cluster. The red diamond symbols represent the cluster centroids.



The above map shows that it is much easier to identify the well pad to which to assign flaring detections by considering the cluster centroid points.

CALCULATING RADIATIVE ENERGY FROM POWER

The radiative power (FRP) emitted by a flare can be derived from satellite measurements. It is an instantaneous quantity that is valid at the moment of the satellite overpass (see Determining fire radiative power (FRP) for more information on methods used in active fire products to obtain a measurement of FRP). However, to be able to perform comparisons of flaring between different well pads (or other facilities), we need to determine how much radiative energy (FRE) has been released by each flare over given time periods.

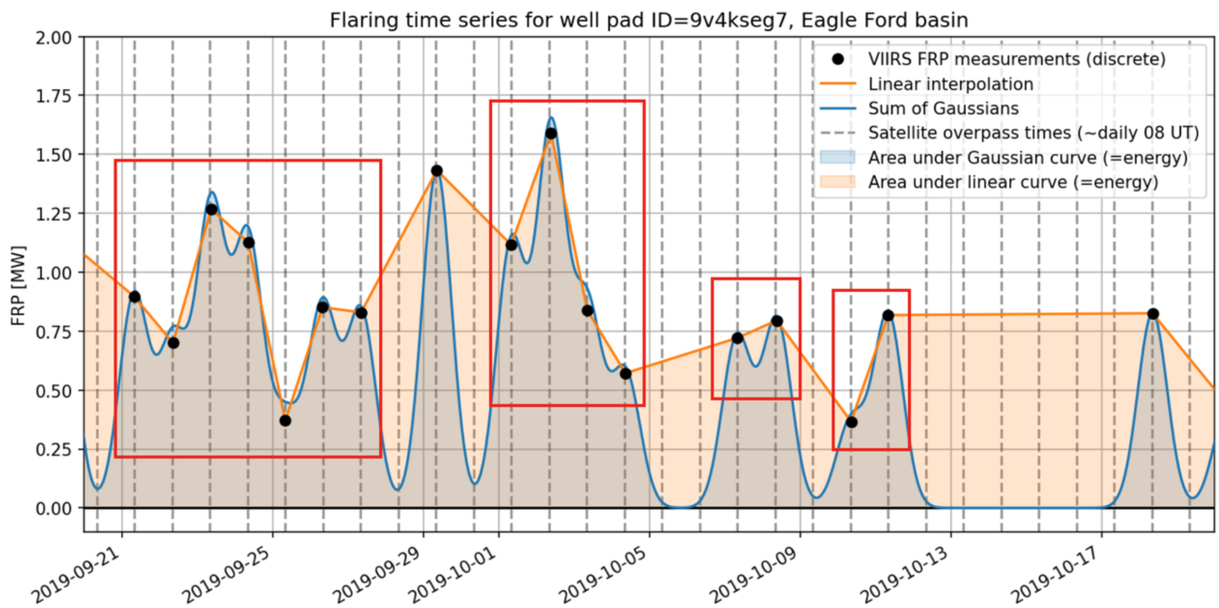
Since power is energy per unit time (1 Watt = 1 Joule per second), the energy released by a fire can be determined by multiplying the FRP measurement by the duration of of the fire detection. If we can obtain the emitted power as a continuous function of time, this is equivalent to integrating the continuous FRP time series over a time step Δt:

$$FRE = \int_{\Delta t} FRP(t)\, dt,$$

where FRE is the radiative energy released by the flare over Δt. The TBXFLARE service calculates energy time series over three time steps: daily, weekly, and monthly.

Obtaining a continuous curve of FRP as a function of time for each flare source requires interpolating between the satellite measurements. The TBXFLARE service uses a sum of Gaussian functions based on the satellite FRP measurements to obtain a continuous function of time and fill in the gaps between the satellite overpasses. Compared to a simple liner interpolation, this method produces a more accurate estimate of emitted powers, and has the advantage of most likely being an *underestimate* of actual flaring energies.

As an example, below is the time series of FRP for a single well pad between 20 September 2019 and 20 October 2019:



In the graph above, the black points are the discrete measurements of radiative power by the satellite. Two methods of creating a continuous function are shown:

- in orange lines: a simple linear interpolation,
- with a blue curve: a sum of Gaussian functions centred on the time of each satellite measurement (ti), with amplitude the power of the measurement (FRPi) and with full widths at half maximum (FWHM) of 22 hours:

$$\mathrm{FRP}(t) = \Sigma i[\mathrm{FRPi} \times g(ti, \mathrm{FWHM} = 22\,\mathrm{hours})],$$

where FRP(t) is the radiative power as a continuous function of time, i is an individual flare observation by the satellite, and g is a Gaussian function of unit height.

The area under each curve represents the energy release, so the orange area in the graph above represents energy values that would be obtained with the linear interpolation method, and the blue area represents energy values using the summed Gaussian method. The vertical grey dashed lines show the times of expected overpass of the Suomi-NPP satellite.

The parameters of the Gaussian method are chosen such as:

- when there is a flare detection at each consecutive satellite overpass (shown by the red boxes), the energies derived from both methods are very similar,
- when there are gaps between the flare detections, the power curve from the Gaussian method drops smoothly to almost zero before the first non-detection, and begins rising again at about the time of the last non-detection.