GOFC-GOLD 2022 GCOS Implementation Plan ECV requirements feedback

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Context

- Input requested at CEOS/CGMS Working Group Climate workshop on fire ECVs from EO
- "Sustained space observation capabilities for carbon related Earth System variables" WGClimate workshop, EUMETSAT, Darmstadt, Germany 18-20th May 2022
- Requested to provide feedback to the public review of the GCOS Implementation Plan 2022 (closed 3rd June) and/or provide a group response to GCOS via CEOS WGClimate (17th June)
- Ideally this would have been a response compiled at this GOFC-GWIS meeting

ECV Requirements

Four fire ECVs:

- Burned Area
- Active Fire
- FRP
- Combustion completeness

Requirements with respect to 3 levels:

- Threshold (T) - the minimum requirement to be met to ensure that data are useful.
- Breakthrough (B) - an intermediate level between threshold and goal which, if achieved, would result in a significant improvement for the targeted application. The breakthrough value may also indicate the level at which specified uses within climate monitoring become possible. It may be appropriate to have different breakthrough values for different uses.
- Goal (G) - an ideal requirement above which further improvements are not necessary.

ECV: Burned Area

Definition:

A gridcell is labelled as burned if the majority of the gridcell area is classified as containing burned vegetation. X_area means the horizontal area occupied by X within the grid cell. The extent of an individual grid cell is defined by the horizontal coordinates and any associated coordinate bounds or by a string valued auxiliary coordinate variable with a standard name of region.

Unit: m^2

ECV: Burned Area

Horizontal Resolution Unit: m Metric: minimum mapping unit (length of the side of pixel)	**G = 10 m (30m)** **B = 100 m (250m)** **T = 1000 m (0.25d)**	• 10 m goal reflects the need to better map small and spatially fragmented burned areas that cannot be resolved at lower spatial resolution & reflects the spatial resolution provided by recent (Sentinel-2) and planned (Landsat Next) global coverage EO missions • 1000 m threshold reflects experience using heritage AVHRR LAC data • Note that burned area products can be aggregated to lower spatial resolution (e.g. 0.25 degree grid cells) for climate modeling applications.
Temporal Resolution Unit: Day Metric minimum temporal period of the BA product	G = 1 day B = 10 days T = 30 days	• Threshold values specified regardless of cloud conditions
Timeliness Unit: Day Metric: Days when the BA product is accessible after fires occurred	G = 10 days B = 120 days T = 360 days	
Product Accuracy Unit: % Metric: average omission and commission errors	G = 5% B = 15% T = 25%	• Omission and commission errors derived by comparison of the Burned Area ECV with independent burned area datasets derived from higher spatial resolution satellite data that have at least 50% smaller native pixel resolution • The omission and commission errors should be approximately balanced (i.e., nearly equal)
Required Measurement Uncertainty (2-sigma)		• Unclear how this can be meaningfully quantified without a spatio-temporal Stage-3 CEOS Burned Area validation protocol and further research
Stability Unit: Measures of omission and commission over the available time period Metric: Assessment of whether a monotonic trend exists based on the slope (b) of the relationship between an accuracy measure (m) and time (t).	**G = 0%** **B = 1%** **T = 2% (not previously defined)**	• Percentage reflects the relative increase of decrease in reported global total burned area [km^2] over a 10 year period

ECV: Active Fire

Definition: Presence of a temporal thermal anomaly within a grid cell. Those thermal anomalies that are permanent should be linked to other sources of thermal emission (volcanos, gas flaring, industrial or power plants). Generally, the active fire maps are defined by the **satellite overpass time** when the thermal anomaly was detected.

Unit: m^2

ECV: Active Fire

Horizontal Resolution Unit: m Metric: minimum mapping unit	G = 50m **B = 250m (200m)** **T = 5000m (0.25d)**	• 50m goal reflects need to detect small and cool fires including underground peat fires and fires occurring under forest canopies • 5000m threshold reflects experience using legacy AVHRR GAC data
Temporal Resolution Unit: Minutes Metric minimum temporal period of the AF product	**G = 5 minutes (15min)** B = 120 minutes (2 hours) **T = 720 minutes (12 hours (1day)**	• 5 min goal reflects need to detect rapidly moving and short-lived fires • 2 hour breakthrough reflects need to monitor diurnal active fire variability • 12 hour threshold reflects experience with legacy fire data sets • Threshold values specified regardless of cloud conditions
Timeliness Unit: Day Metric: minimum lapse between satellite overpass and AF availability	**G = 1 Day (10 minutes)** **B = 7 Days (120minutes)** **T = 365 Days (1 day)**	For climate applications timeliness is less critical Requirement values reflect need to analyse climate anomalies and their effects shortly after fire occurrenceSub-daily timeliness not required as ECV is not expected to be used by fire managers
Product Accuracy Unit: % Metric: average omission and commission errors	**G = 5% with respect to active fires burning with FRP equal to 5 MW/km^2 in the detector ground footprint** **B = 5% with respect to active fires burning with FRP equal to 10 MW/km^2 in the detector ground footprint** **T = 5% with respect to active fires burning with FRP equal to 20 MW/km^2 in the detector ground footprint** **(5,15,25 % but from BA product requirements)**	Fire size and temperature are determining factors for active fire detection. An FRP threshold as a single variable to accounts for this. Omission and commission errors derived by comparison of the Active Fire ECV with independent contemporaneous active fire detections over burns that have measured FRP The omission and commission errors should be approximately balanced (i.e., nearly equal) Accuracy values are associated only with detecting fires.
Required Measurement Uncertainty (2-sigma)		• Unclear how this can be meaningfully quantified
Stability As BA	**G = 0%** **B = 1%** **T = 2% (not previously defined)**	• Percentage reflects the relative increase of decrease in reported global total count of active fire detection gridcells over a 10 year period

ECV: Fire Radiative Power

Definition: **Energy per unit time released by all fires burning within the pixel footprint Commonly it is expressed in W (or MW).** This variable is a function of the actual temperature of the active fire at the satellite overpass and the proportion of the grid cell being burned.

Unit: **W (or MW)**

ECV: Fire Radiative Power

Horizontal Resolution Unit: m Metric: minimum mapping unit (length of the side of pixel)	G = 50m **B = 250m (200m)** **T = 5000m (0.25d)**	• 50m goal reflects need to characterize small and cool fires including underground peat fires and fires occurring under forest canopies • 5000m threshold reflects experience using legacy AVHRR GAC data
Temporal Resolution Unit: Minutes Metric minimum temporal period of the FRP product	**G = 5 minutes (15min)** B = 120 minutes (2 hours) **T = 720 minutes (12 hours (1day)**	• 5 min goal reflects need to characterize rapidly moving and short-lived fires • 2 hour breakthrough reflects need to monitor diurnal active fire variability • 12 hour threshold reflects experience with legacy fire data sets • Threshold values specified regardless of cloud conditions
Timeliness Unit: Day Metric: minimum lapse between satellite overpass and AF availability	**G = 1 Day (10 minutes)** **B = 7 Days (120minutes)** **T = 365 Days (1 day)**	• For climate applications timeliness is less critical • Requirement values reflect need to analyse climate anomalies and their effects shortly after fire occurrence • Sub-daily timeliness not required as ECV is not expected to be used by fire managers
Product Accuracy Unit: **MW/km^2 of detector ground footprint** Metric: Physical SI units of FRP retrieval	**G = 0.5 MW/km^2 of detector ground footprint** **B = 1 MW/km^2 of detector ground footprint** **T = 2 MW/km^2 of detector ground footprint (missing)**	• Goal based on need to quantify FRP of small and cool smoldering fires
Required Measurement Uncertainty (2-sigma)	**G = 0.05 MW/km^2 of detector ground footprint** **B = 0.1 MW/km^2 of detector ground footprint** **T = 0.5 MW/km^2 of detector ground footprint (missing)**	• I.e., 10% of the product accuracy thresholds
Stability As BA	**G = 0%** **B = 1%** **T = 2% (not previously defined)**	• Percentage reflects the relative increase of decrease in reported global mean FRP for total burned area over a 10 year period

ECV: Combustion Completeness

- Definition: The fraction of fuel exposed to the fire that actually burns

- This ECV is still in the research and development phase and should be removed from the 2022 IP draft.

- Only limited peer reviewed literature on retrieval of combustion completeness from satellite data, with limited validation.

- At optical wavelengths, studies have suggested that only the numerical product of the combustion completeness and the sub-pixel fraction burned can be retrieved, i.e., combustion completeness alone cannot be unambiguously retrieved without knowledge of the sub-pixel fraction burned
  - Roy, D. P., & Landmann, T. (2005). Characterizing the surface heterogeneity of fire effects using multi-temporal reflective wavelength data. *International Journal of Remote Sensing*, *26*(19), 4197-4218.
  - Roy, D. P., Huang, H., Boschetti, L., Giglio, L., Yan, L., Zhang, H. H., & Li, Z. (2019). Landsat-8 and Sentinel-2 burned area mapping-A combined sensor multi-temporal change detection approach. *Remote Sensing of Environment*, *231*, 111254.
- If/when this ECV is eventually restored to the draft, the requirements for this ECV should be coupled with the Burned Area requirements as the combustion completeness of what is burned is desired.

IP 2016 Fire ECVs

ECV Products and Requirements for Fire

*These products and requirements reflect the Implementation Plan 2016 (**GCOS-200**). GCOS is reviewing and will update the requirements until 2022. More information on: **gcos.wmo.int**.*

PRODUCT	DEFINITION	FREQ.	RES.	REQUIRED MEASUREMENT UNCERTAINTY	STAB.	REF.
Burnt Area	Burned area means the area affected by the fire, including natural vegetation and croplands. X_area means the horizontal area occupied by X within the grid cell. The extent of an individual grid cell is defined by the horizontal coordinates and any associated coordinate bounds or by a string valued auxiliary coordinate variable with a standard name of region.	24 hours	30m	15% (error of omission and commission), compared to 30 m observations		None
Active Fire Maps	Presence of a temporal thermal anomaly within a grid cell. Those thermal anomalies that are permanent should be linked to other sources of thermal emission (volcanos, gas flaring, industrial or power plants). Generally, the active fire maps are defined by the date/hour when the thermal anomaly was detected	6 hours at all latitudes from Polar-Orbiting and 1 hour from Geostationary	0.25-1 km (Polar); 1-3 km (Geo)	5% error of commission; 10% error of omission; Based on per-fire comparisons for fires above target threshold of 5 MW/km² equivalent integrated FRP per pixel (i.e. for a 0.5 km² pixel the target threshold would be 2.5 MW, for a 9 km² pixel it would be 45 MW).		None
Fire Radiative Power	Amount of energy released by area unit. Commonly it is expressed in W/m2. This variable is a function of actual temperature of the active fire at the satellite overpass and the proportion of the grid cell being burned.	6 hours at all latitudes from Polar-Orbiting and 1 hour from Geostationary	0.25-1 km (Polar); 1-3 km (Geo)	10% integrated over pixel. Based on target detection threshold of 5 MW/km² equivalent integrated FRP per pixel (i.e. for a 0.5 km² pixel the target threshold would be 2.5 MW, for a 9 km² pixel it would be 45 MW).and with the same detection accuracy as the Active Fire Maps.		None

https://gcos.wmo.int/en/essential-climate-variables/fire/ecv-requirements