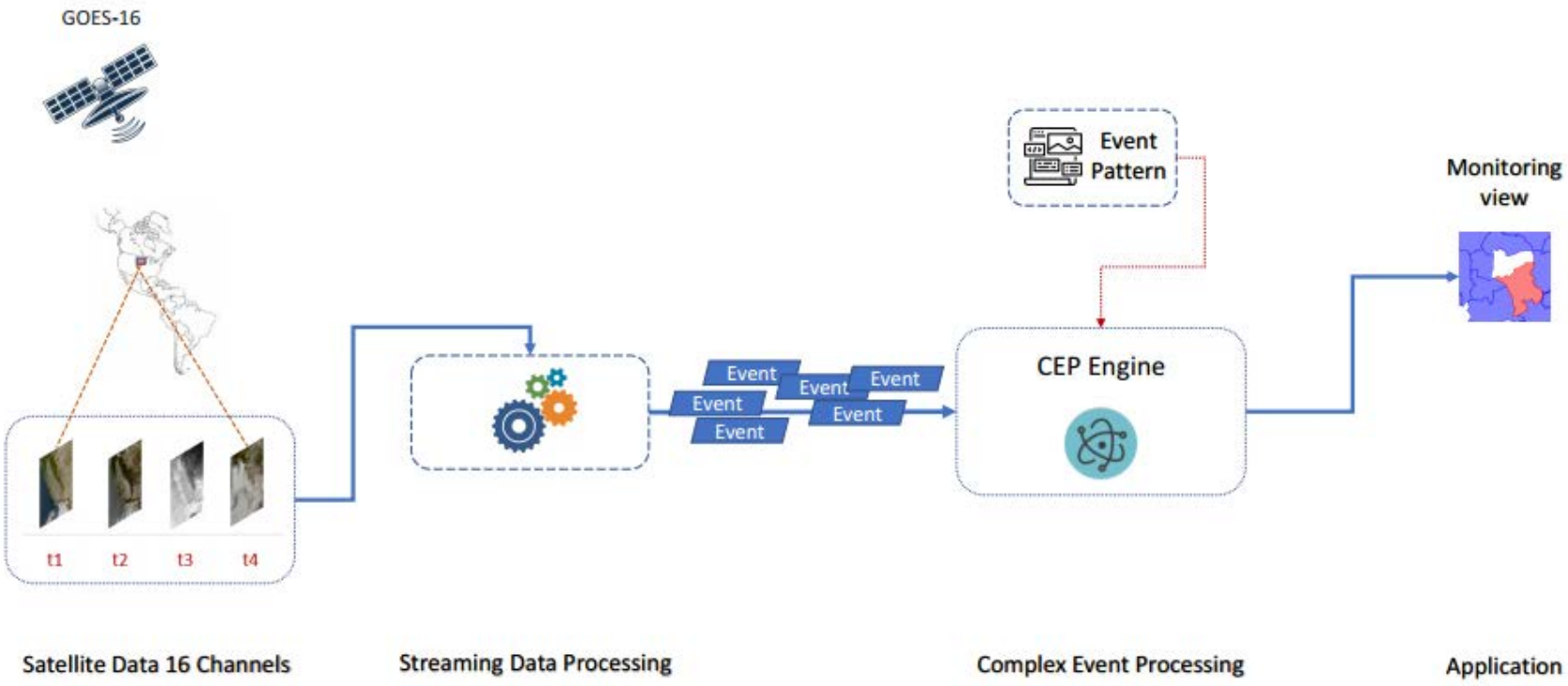
Bushfires

- Happen in many places: California (USA), Australia,…

- Common detection approaches:
  - Sensor network
    - Wireless sensor
    - Camera
  - Satellites

General Framework



Goes-16 Data

Goes-16 Satellite System

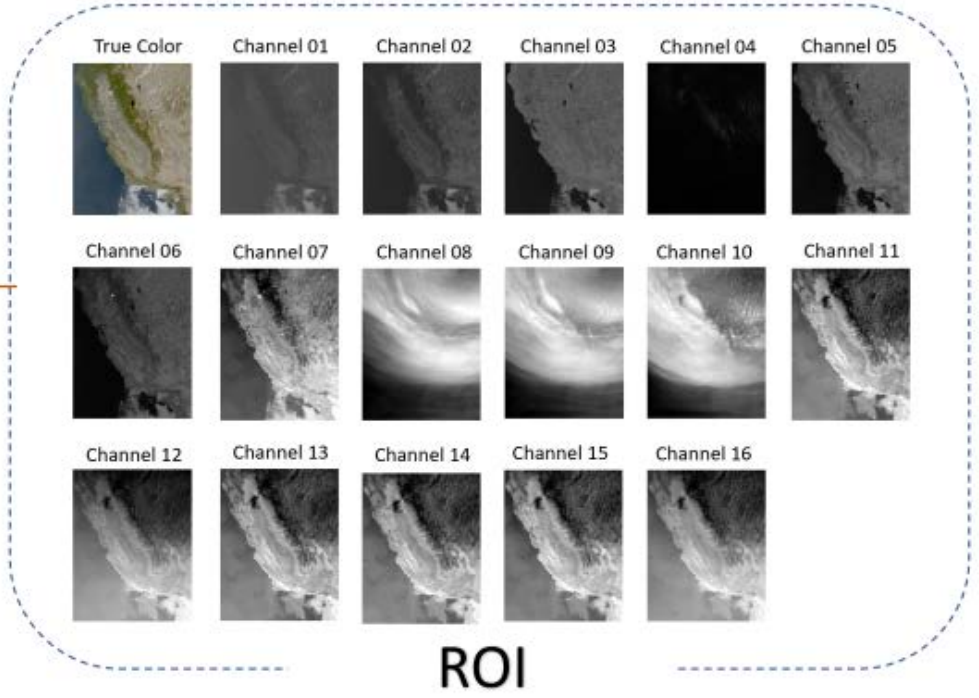
- GOES-16, part of the GOES-R project, a high-end satellite developed and managed by NASA and NOAA (USA), helps scientists observe weather fluctuations in the Western Hemisphere, from the coast of Chau Africa until New Zealand.
- GOES-16 uses the Advanced Baseline Imager (ABI) toolkit to scan the Earth in 16 different spectral bands by 16 channels, including infrared, near-infrared and visible light.

GOES-16

Band	Central λ (μm)	Pixel (km)	Nickname	Classification	Primary function
1	0.47	1	Blue	Visible	Aerosols
2	0.64	0.5	Red	Visible	Clouds
3	0.865	1	Veggie	Near-IR	Vegetation
4	1.378	2	Cirrus	Near-IR	Cirrus
5	1.61	1	Snow/Ice	Near-IR	Snow/ice discrimination, cloud phase
6	2.25	2	Cloud Particle Size	Near-IR	Cloud particle size, snow cloud phase
7	3.90	2	Shortwave Window	Infrared	Fog, stratus, **fire**, volcanism
8	6.9	2	Upper-level Tropospheric Water Vapor	Infrared	Various atmospheric features
9	6.95	2	Mid-level Tropospheric Water Vapor	Infrared	Water vapor features
10	7.34	2	Lower-level Tropospheric Water Vapor	Infrared	Water vapor features
11	8.5	2	Cloud-Top Phase	Infrared	Cloud-top phase
12	9.61	2	Ozone	Infrared	Total column ozone
13	10.35	2	Clean Infrared Longwave Window	Infrared	Clouds
14	11.2	2	Infrared Longwave Window	Infrared	Clouds
15	12.3	2	Dirty Infrared Longwave Window	Infrared	Clouds
16	13.3	2	CO2 Longwave Infrared	Infrared	Air temperature, clouds

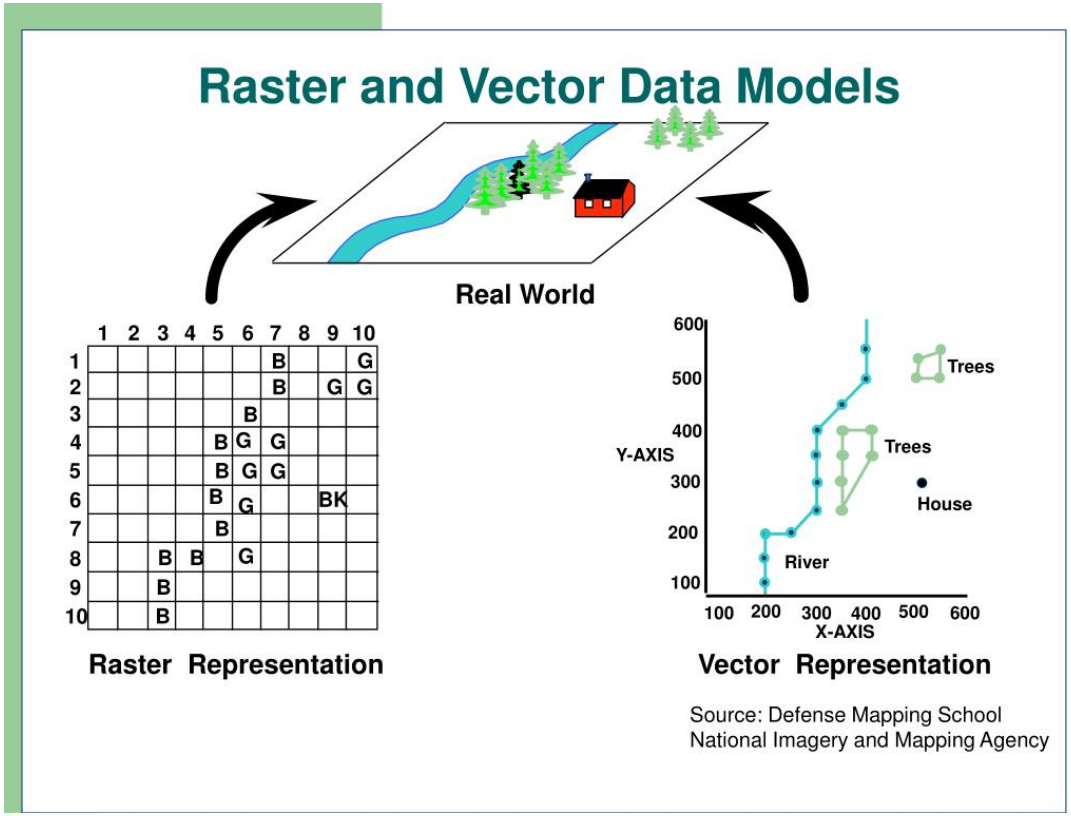
GOES-16 Data

- Satellite imagery is made up of radiation of the 16-channel spectral band
- CEP is based on spectral band radiation.



Spatial Data

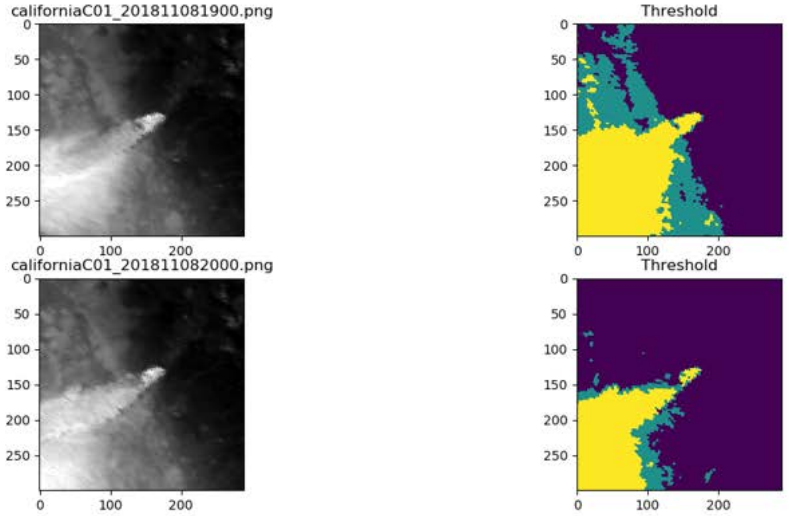
- GIS geographical system.
- Two data models:
  - Raster
  - Vector
- Polygon is a type of representation of vector data, from the vertices forming the boundary representing the inner section.

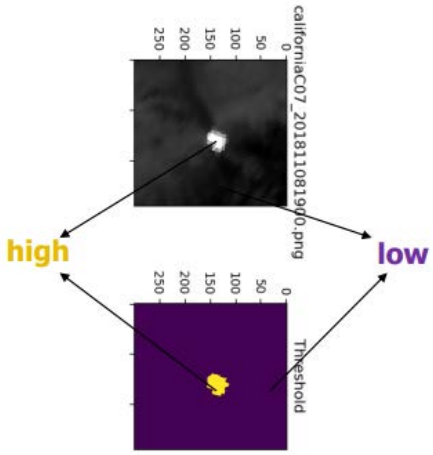


Data Pre-Processing

Clustering radiation levels

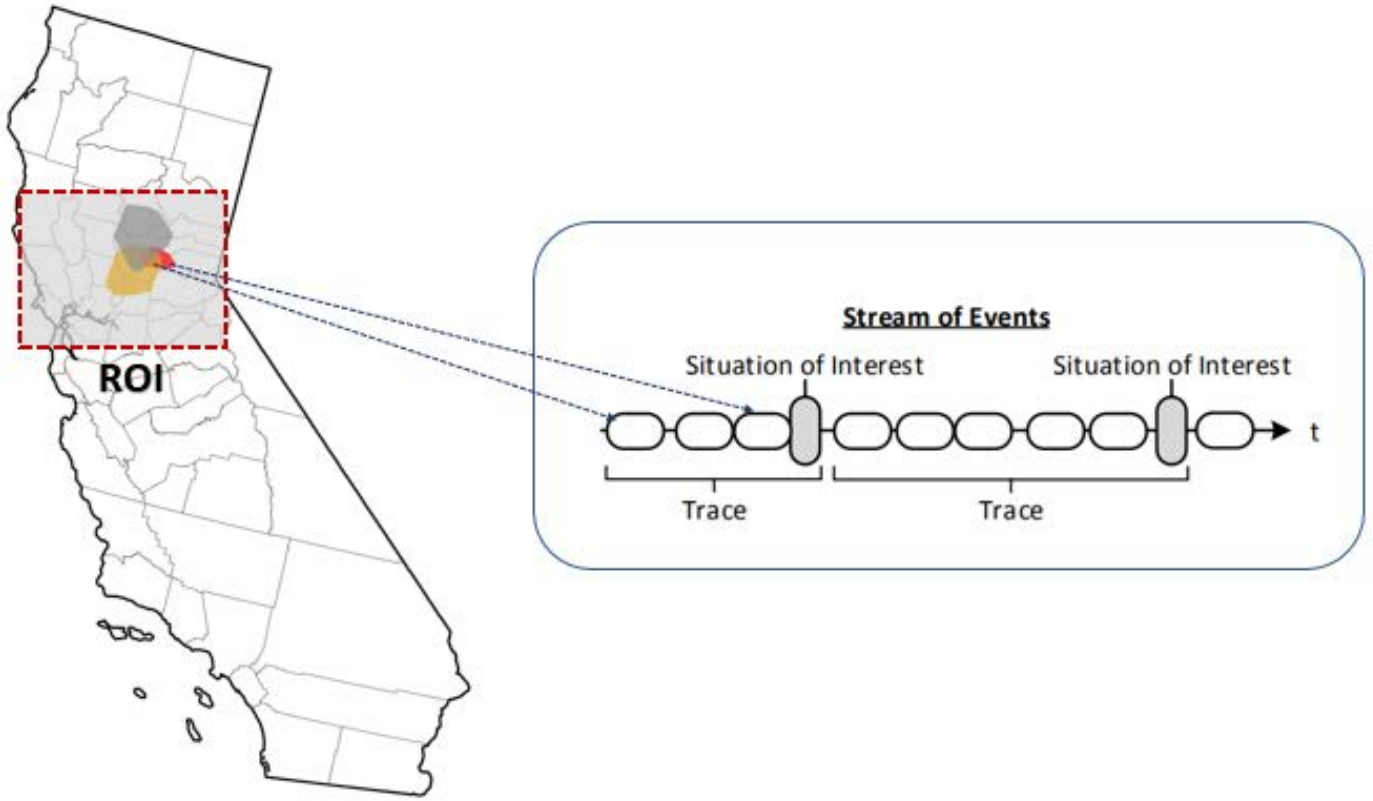
- Determine thresholds for classifying radiation levels per channel using kMeans.
- Clustering radiation data GOES-16 based on threshold
- Represent each cluster as a Polygon





Data Pre-Processing

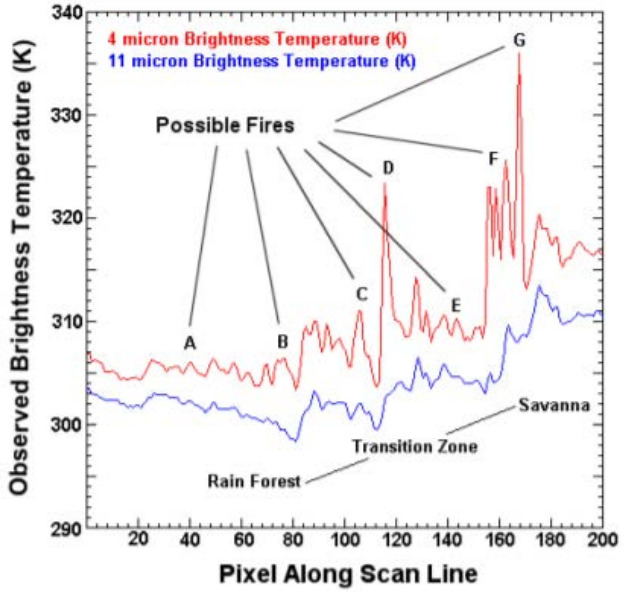
Create event stream from satellite data

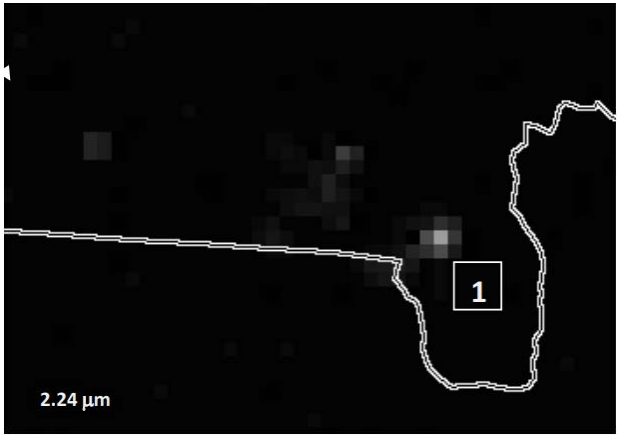


CEP for bushfire detection

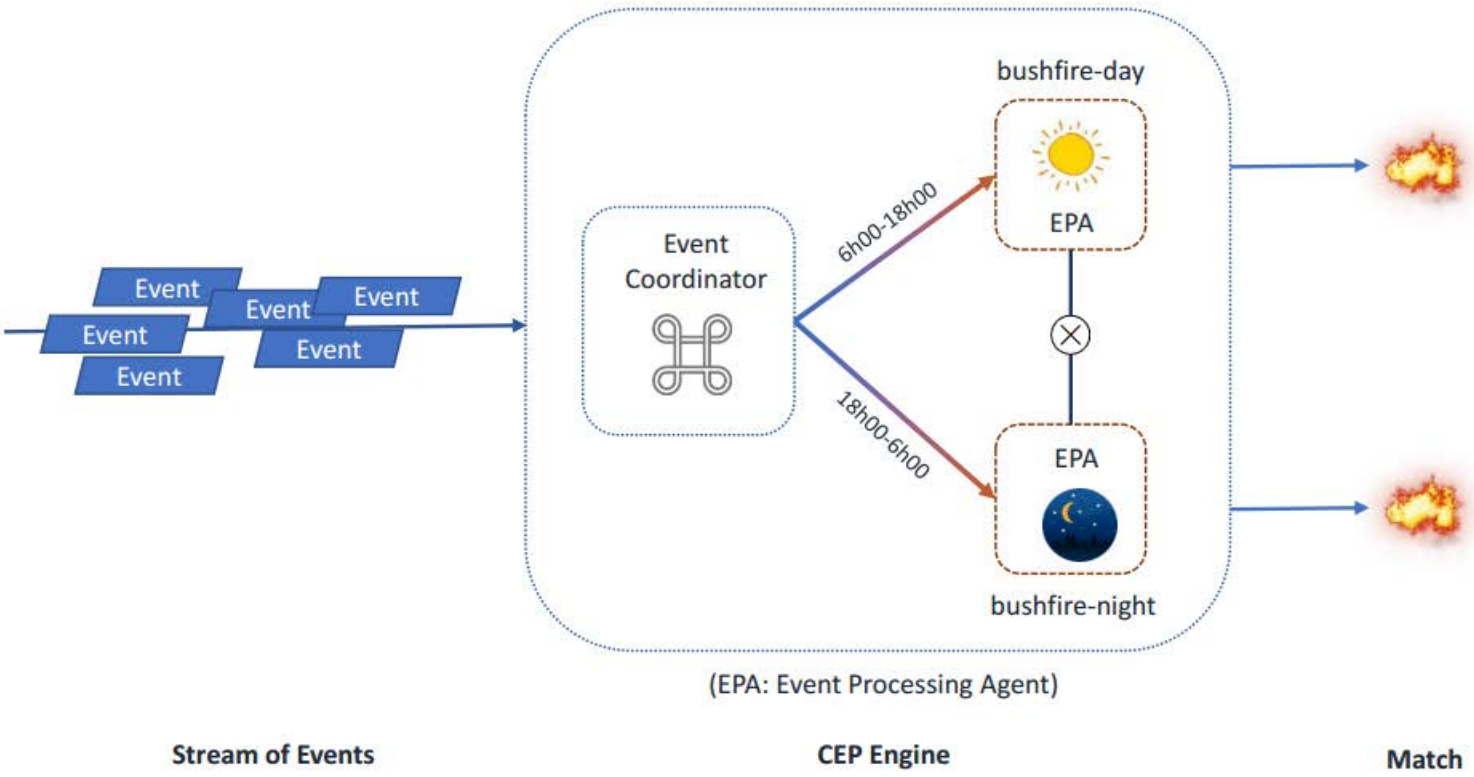
Important events

- Hotspot: Satellites work well depending on sunlight
  - Daytime: channel 7, 14
  - Nightime: channel 6
- CO_2 level: channel 16



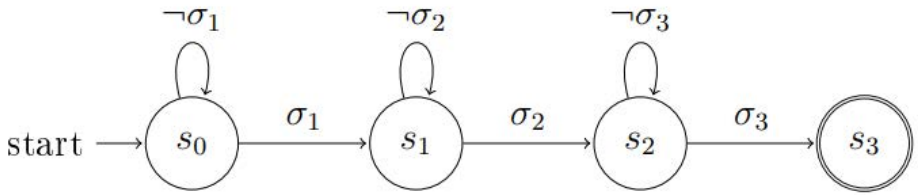


Architecture



CEP query sample - daytime

```
PATTERN bushfire-day SEQ (Satellite c07, Satellite c07minusC14, Satellite c16)
WHERE [boundary] AND c07.channelID = 1 AND c07.level = high
      AND c07.time >= 06h00 AND c07.time < 18h00
      AND c07minusC14.channelID = 714 AND c07minusC14.level = high
      AND c16.channelID = 16 AND c16.level = high
WITHIN 2h
RETURN (c16.time , INTERSECT(c07.boundary,c07minusC14.boundary,c16.boundary))
```



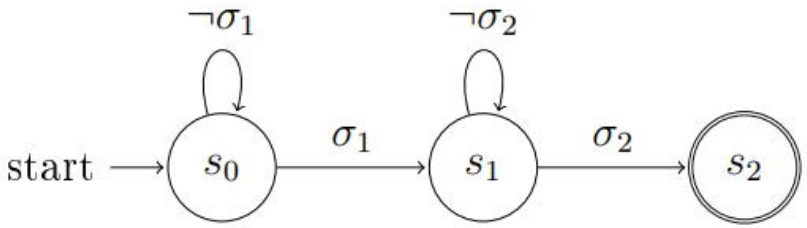
σ_1: c07.channelID = 7 & c07.level = high
& c07.time >= 06h00 & c07.time < 06h00

σ_2: c07.channelID = 7 & c07.level = high
& c07minusC14.boundary ∧ c07.boundary

σ_3: c16.channelID = 16 & c16.level = high
& c16.boundary ∧ c07minusC14.boundary ∧ c07.boundary

CEP query sample - nighttime

```
PATTERN bushfire-night SEQ (Satellite c06, Satellite c16)
WHERE [boundary] AND c06.channelID = 6 AND c06.level = high
      AND c06.time >= 18h00 AND c06.time < 06h00
      AND c16.channelID = 16 AND c16.level = high
WITHIN 2h
RETURN (c16.time, INTERSECT(c06.boundary,c16.boundary))
```



σ_1: c06.channelID = 6 & c06.level = high
& c06.time >= 18h00 & c06.time < 06h00
σ_2: c16.channelID = 16 & c16.level = high
& c16.boundary ∧ c06.boundary