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Project Stream 1: the ARDC Bushfire History Data Project

Work Package 5: National burnt area products analysed from Landsat and Sentinel 2 satellite imagery

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A special thank you to Kane Orr, Norman Mueller, Simon Oliver, Trent Kershaw, Alla Metlenko, all our lovely collaborators and stakeholders, EMSINA, the Mindaroo Foundation and to the Australian Research Data Commons.

Project context and overview

- Project Stream 1: the ARDC Bushfire History Data Project: GA (NLI and DEA) and EMSINA
- Five work packages and aimed to harmonise State and National burnt area data to enable a Nationally consistent way to understand and represent the impacts of fire within Australia: ARDC - Bushfire Data Challenges (arcgis.com)
- Work Package 5: implement a suite of automated EO-based algorithms currently in use by State and Territory agencies, to produce National-scale data products describing the timing, location, and extent of bushfires across Australia.

Photo, ARDC https://ardc.edu.au/program/bushfire-data-challenges/

Presentation overview

1. **Milestone 6 deliverables: burnt area mapping approach.**

    a) Approach report

DISCLAIMER

Data products generated for this Project are interim and developmental in nature and are under further advancement. Datasets or visualisations should not be used for safety of life decisions. The purpose of this information is for strategic decisions, rather than tactical decisions. For local updates and alerts, please refer to your State or Territory emergency or fire service.

    a) A cloud based burnt area analysis platform

    b) National scale historic burnt area demonstrator datasets produced on the burnt area analysis platform

    c) Small scale burnt area demonstrator datasets for multiple historic burnt area workflows

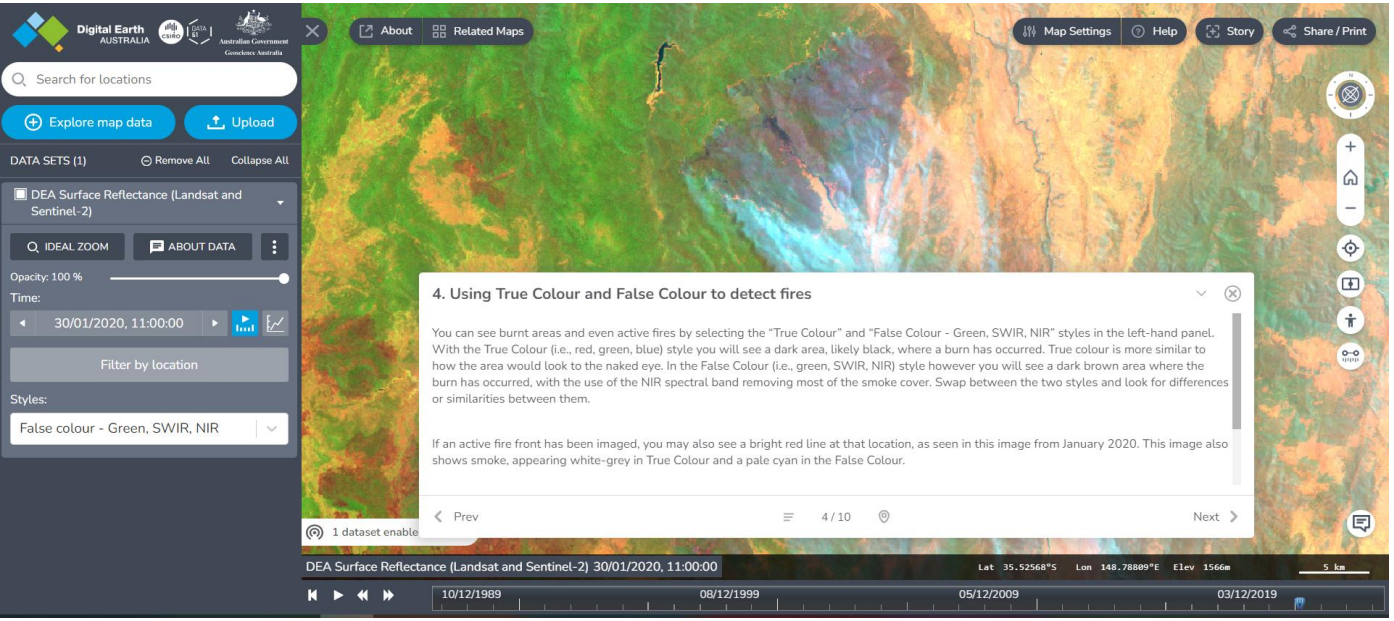
    d) A quantitative comparative assessment of burnt area methods

Milestone 7 deliverables: national burnt area products analysed from Near Real Time (NRT) Landsat and Sentinel 2 satellite imagery; delivering capability and fit for purpose data

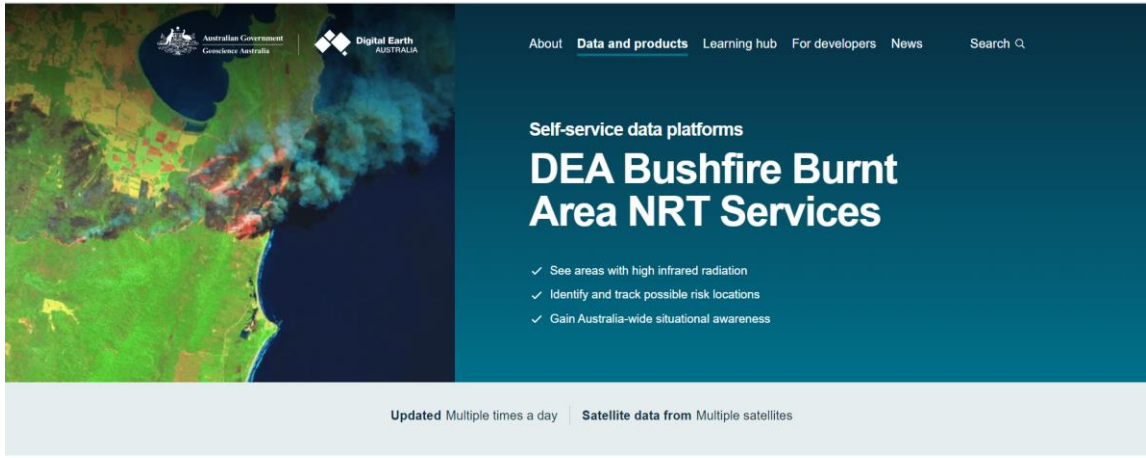
a) A User guide for NRT burnt area analysis on DEA Maps

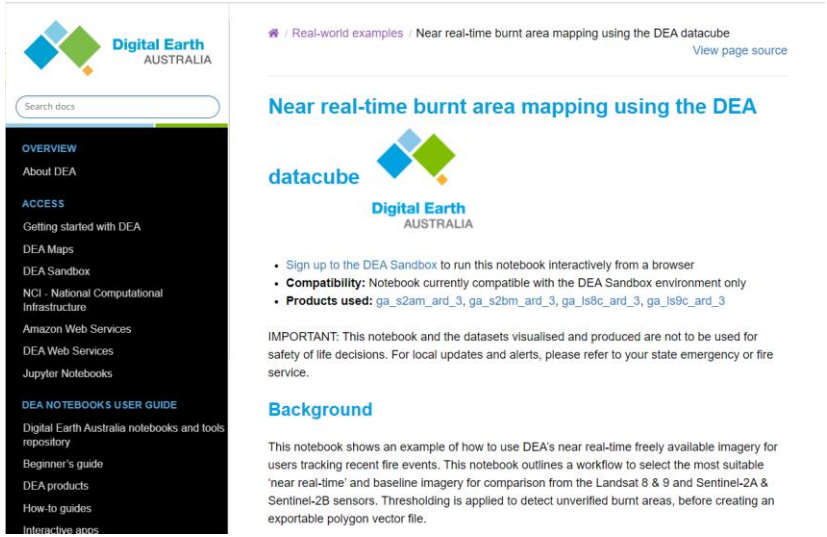
b) A Jupyter Notebook and a user guide for NRT burnt area analysis on DEA Sandbox

https://maps.dea.ga.gov.au/story/DEABurntAreaNRT



https://www.dea.ga.gov.au/products/dea-bushfire-burnt-area-near-real-time-services





1. Milestone 6 deliverables: burnt area mapping approach.
2. Milestone 7 deliverables: national burnt area products analysed from Near Real Time (NRT) Landsat and Sentinel 2 satellite imagery; delivering capability and fit for purpose data
3. **Milestone 8 deliverables: the foundations for a historic burnt area analysis capability; National burnt area products analysed from Landsat and Sentinel-2 satellite imagery.**
    a) A cloud based burnt area analysis platform
    b) National scale historic burnt area demonstrator datasets produced on the burnt area analysis platform
    c) Small scale burnt area demonstrator datasets for multiple historic burnt area workflows
    d) A quantitative comparative assessment of burnt area methods

3a. The Historic Burnt Area Processing Pipeline

- Tak (5, 7, 8) and Sentinel (2a and 2b) satellites.
- Id within the Australian landscape and then generates products and mapping s
- Ru computational infrastructure and was designed to st lopment, deployment, proc a sharing processes.
- Incor up of powerful services, including: Argo, Apache Airflow, itbucket code repositories, Amazon Web S) Auto Scaling Groups (ASG), AWS S3, The Ope The Geoscience Australia Docker re Services, Web Mapping Services (WMS).

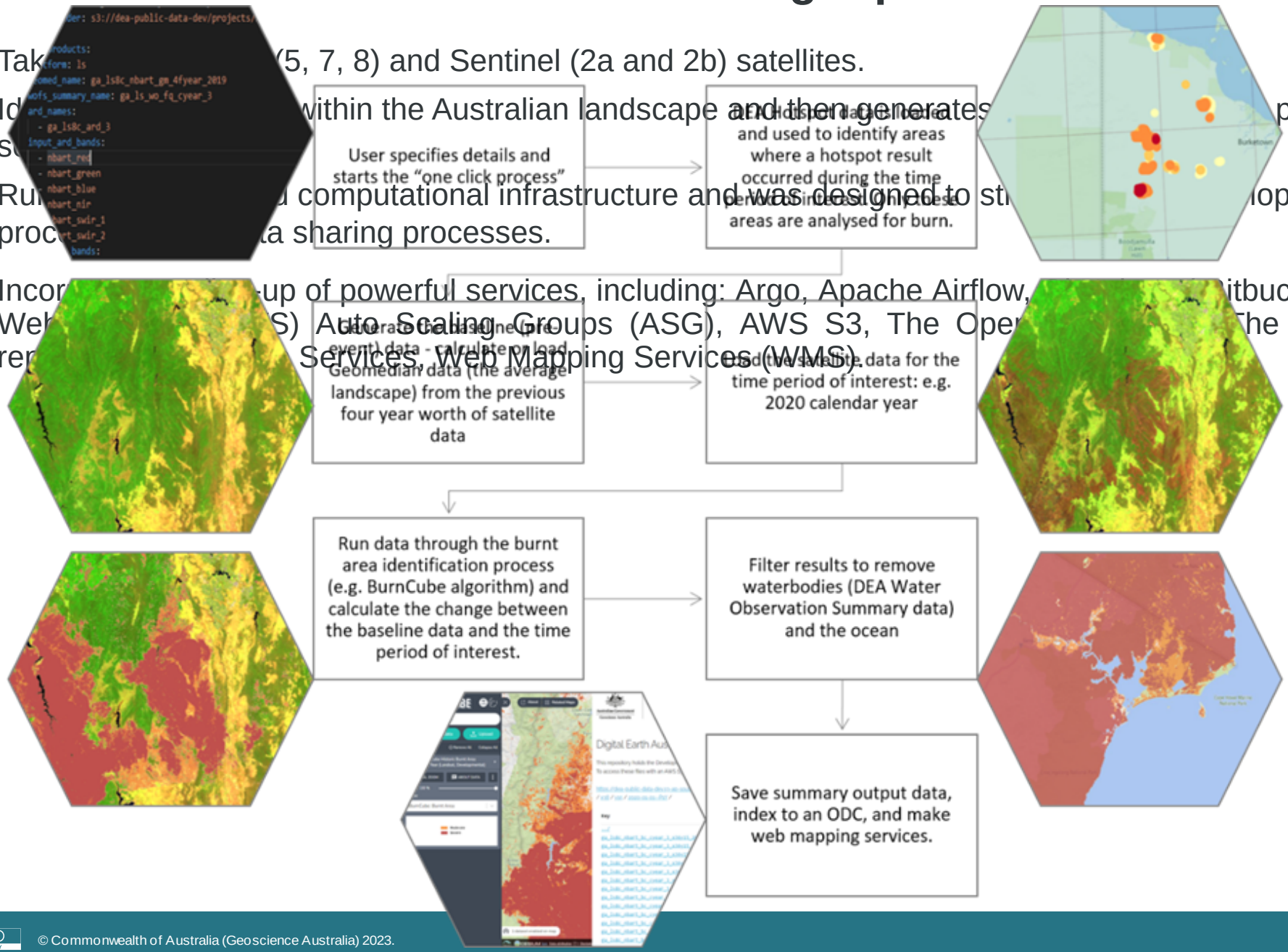
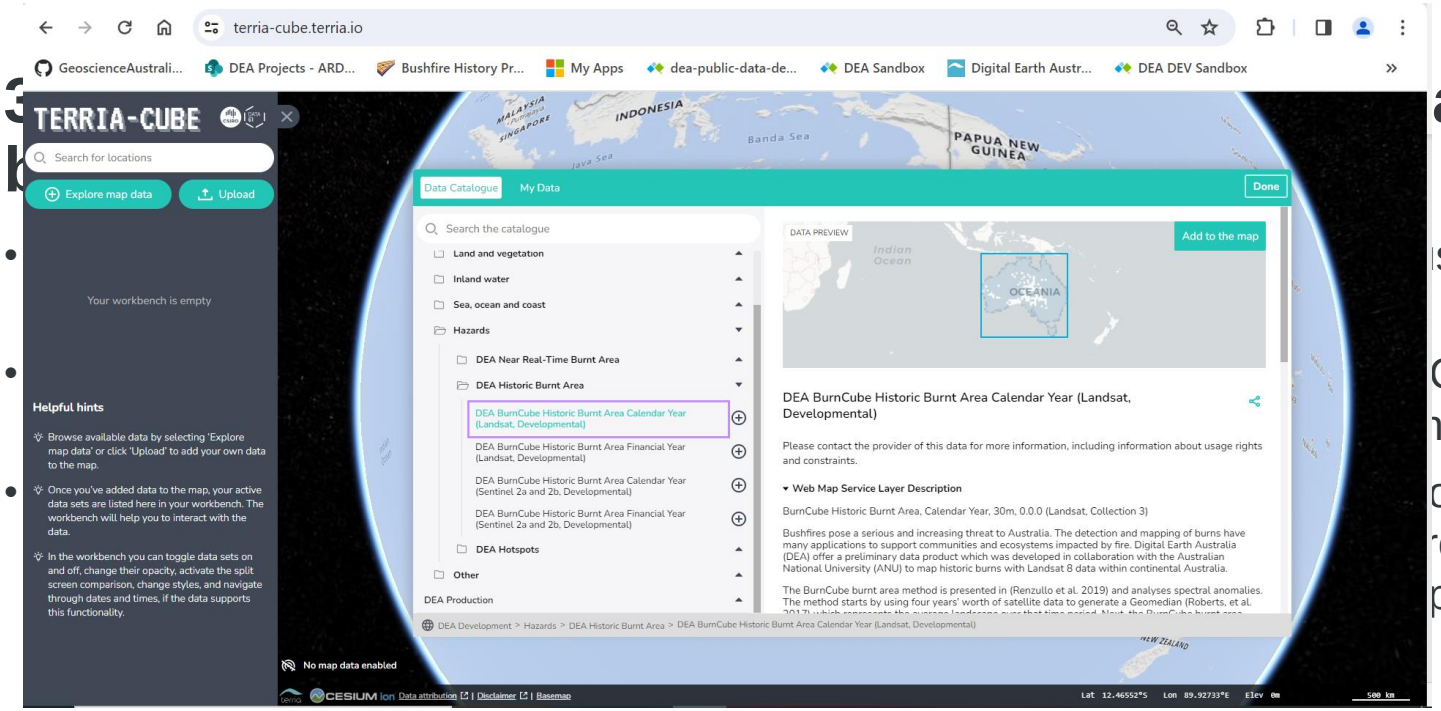
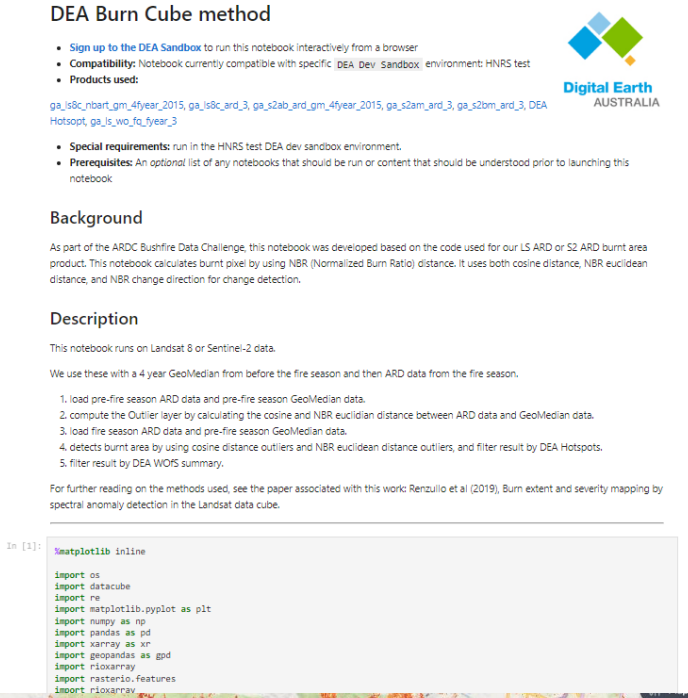


Figure. A simplified overview of the Historic Burnt Area Processing Pipeline.



https://terria-cube.terria.io/#share=s-iaw7s8IQzILs7HIOEg8ca0vcA6W



DEA Burn Cube method

- Sign up to the DEA Sandbox to run this notebook interactively from a browser
- **Compatibility:** Notebook currently compatible with specific `DEA Dev Sandbox` environment: HNRS test
- **Products used:**

ga_ls8c_nbart_gm_4fyear_2015, ga_ls8c_ard_3, ga_s2ab_ard_gm_4fyear_2015, ga_s2am_ard_3, ga_s2bm_ard_3, DEA Hotsopt, ga_ls_wo_fq_fyear_3

- **Special requirements:** run in the HNRS test DEA dev sandbox environment.
- **Prerequisites:** An *optional* list of any notebooks that should be run or content that should be understood prior to launching this notebook

Background

As part of the ARDC Bushfire Data Challenge, this notebook was developed based on the code used for our LS ARD or S2 ARD burnt area product. This notebook calculates burnt pixel by using NBR (Normalized Burn Ratio) distance. It uses both cosine distance, NBR euclidean distance, and NBR change direction for change detection.

Description

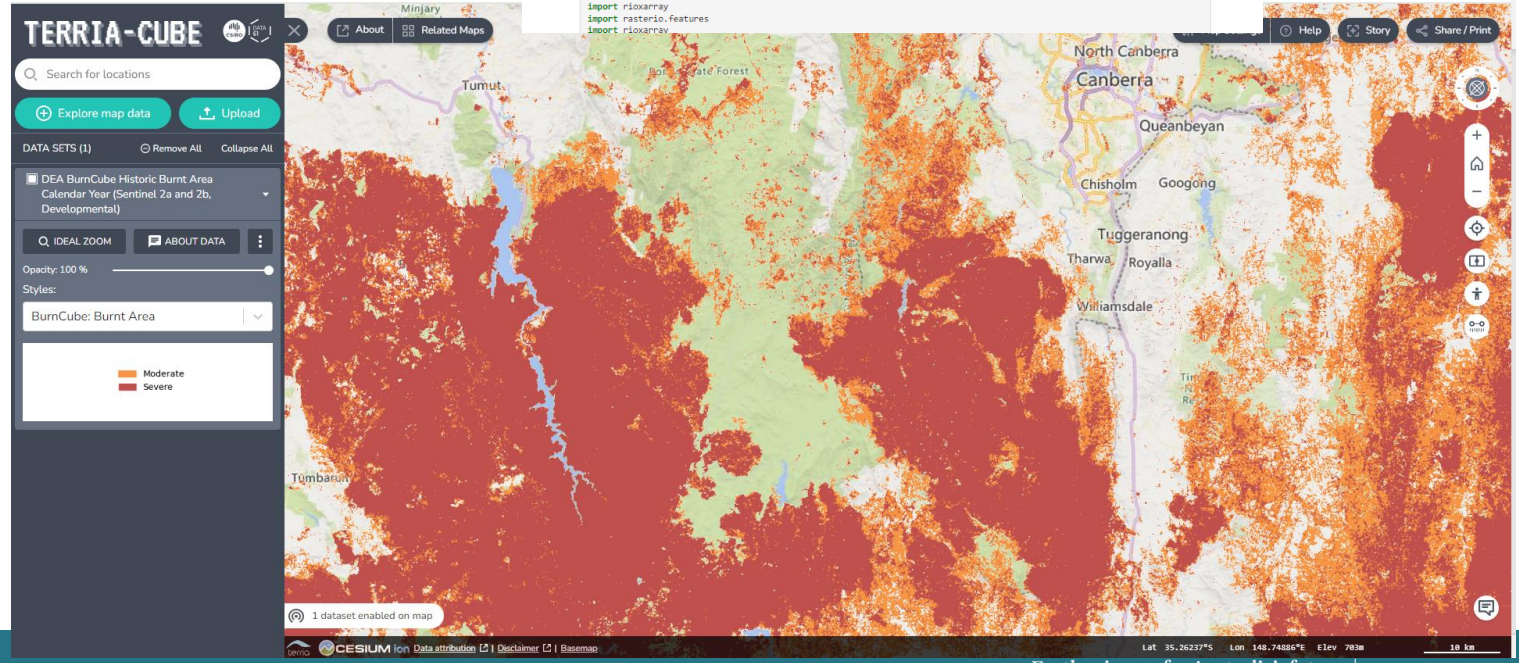
This notebook runs on Landsat 8 or Sentinel-2 data.

We use these with a 4 year GeoMedian from before the fire season and then ARD data from the fire season.

1. load pre-fire season ARD data and pre-fire season GeoMedian data.
2. compute the Outlier layer by calculating the cosine and NBR euclidian distance between ARD data and GeoMedian data.
3. load fire season ARD data and pre-fire season GeoMedian data.
4. detects burnt area by using cosine distance outliers and NBR euclidean distance outliers, and filter result by DEA Hotspots.
5. filter result by DEA WOfS summary.

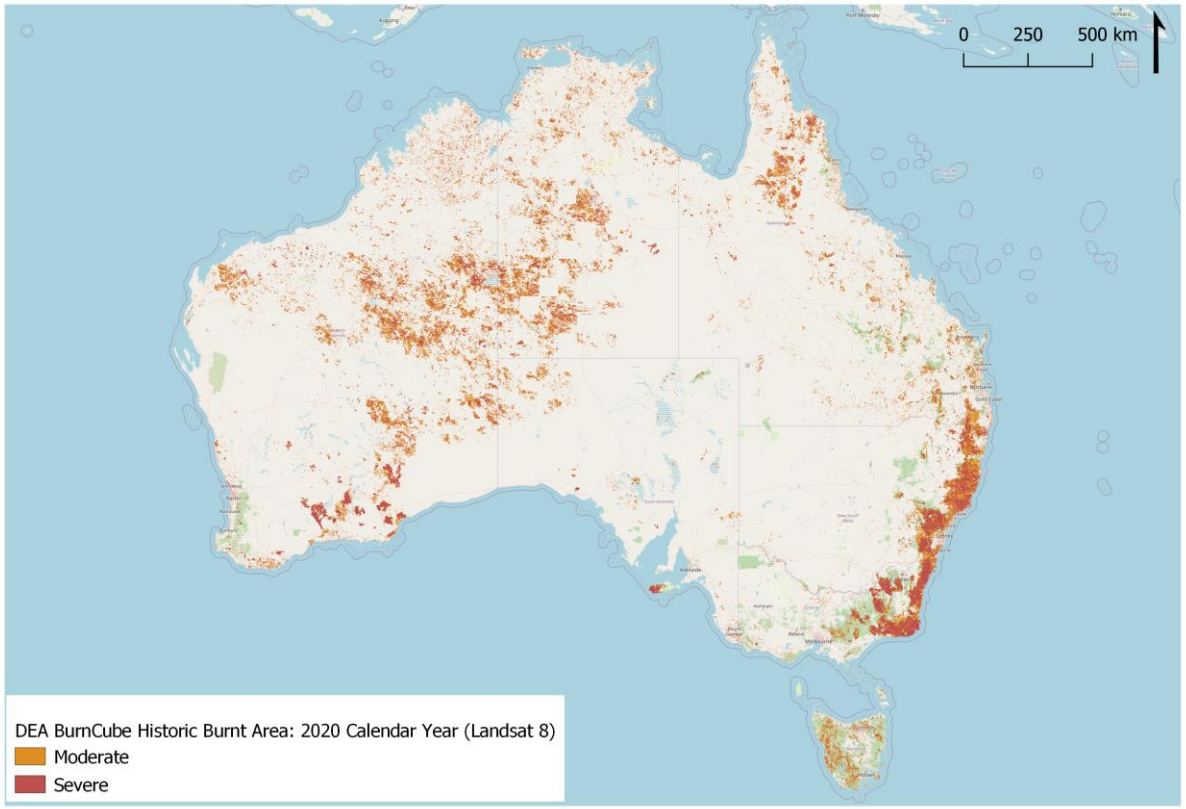
For further reading on the methods used, see the paper associated with this work: Renzullo et al (2019), Burn extent and severity mapping by spectral anomaly detection in the Landsat data cube.

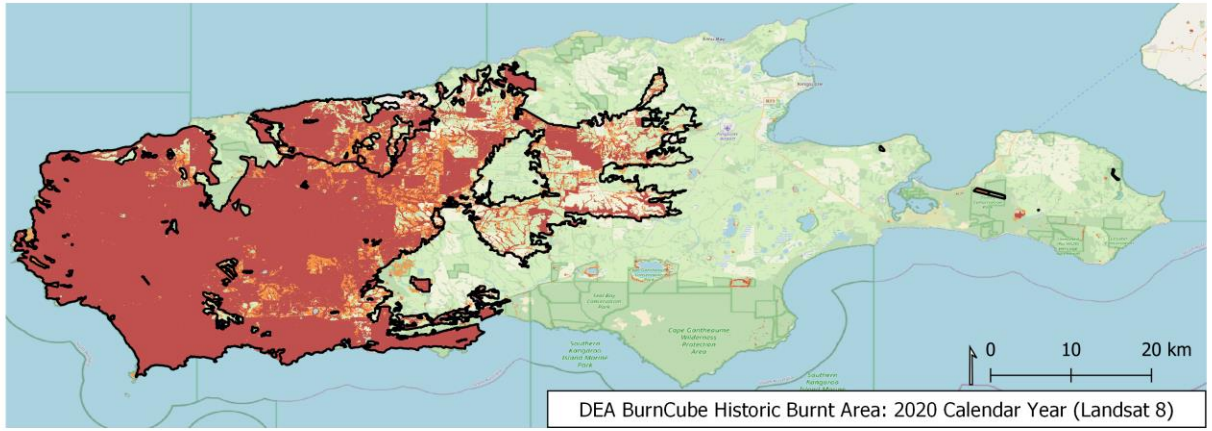
```
%matplotlib inline

import os
import datacube
import re
import matplotlib.pyplot as plt
import numpy as np
import pandas as pd
import xarray as xr
import geopandas as gpd
import rioxarray
import rasterio.features
import rioxarray
```

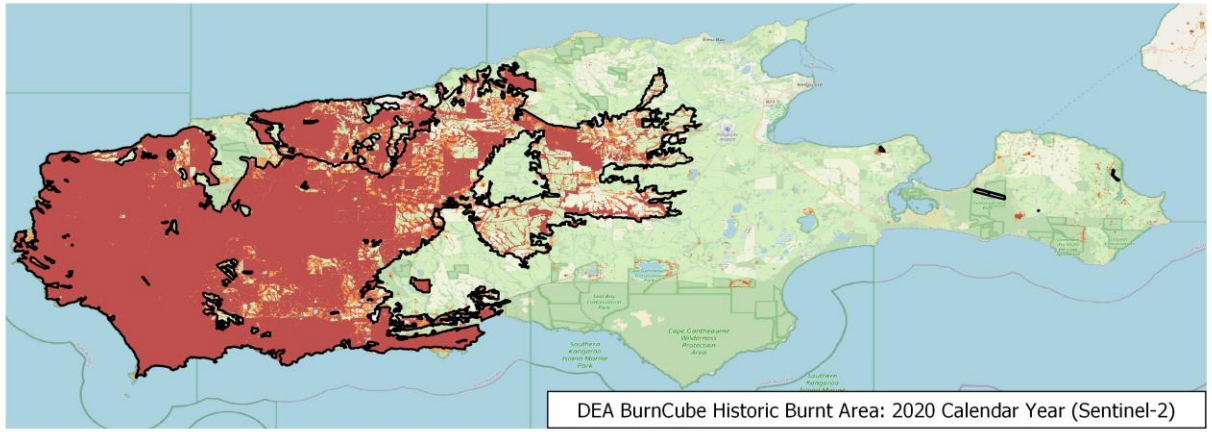


Caveat: BurnCube results are generated as a developmental dataset and a minimal viable product. While available for use through prototype and developmental access platforms, this interim product has not been officially released by DEA and is not seen as a production ready, quality assured or an ongoing maintained or produced product. BurnCube results are an example of how a burnt area product can be produced on DEA infrastructure, BurnCube results are not the burnt area product championed by DEA. This is an interim step towards a nationally consistent product that describes the timing, location, and extent of bushfires across Australia.

National scale historic burnt area demonstrator datasets produced on the burnt area analysis platform: BurnCube

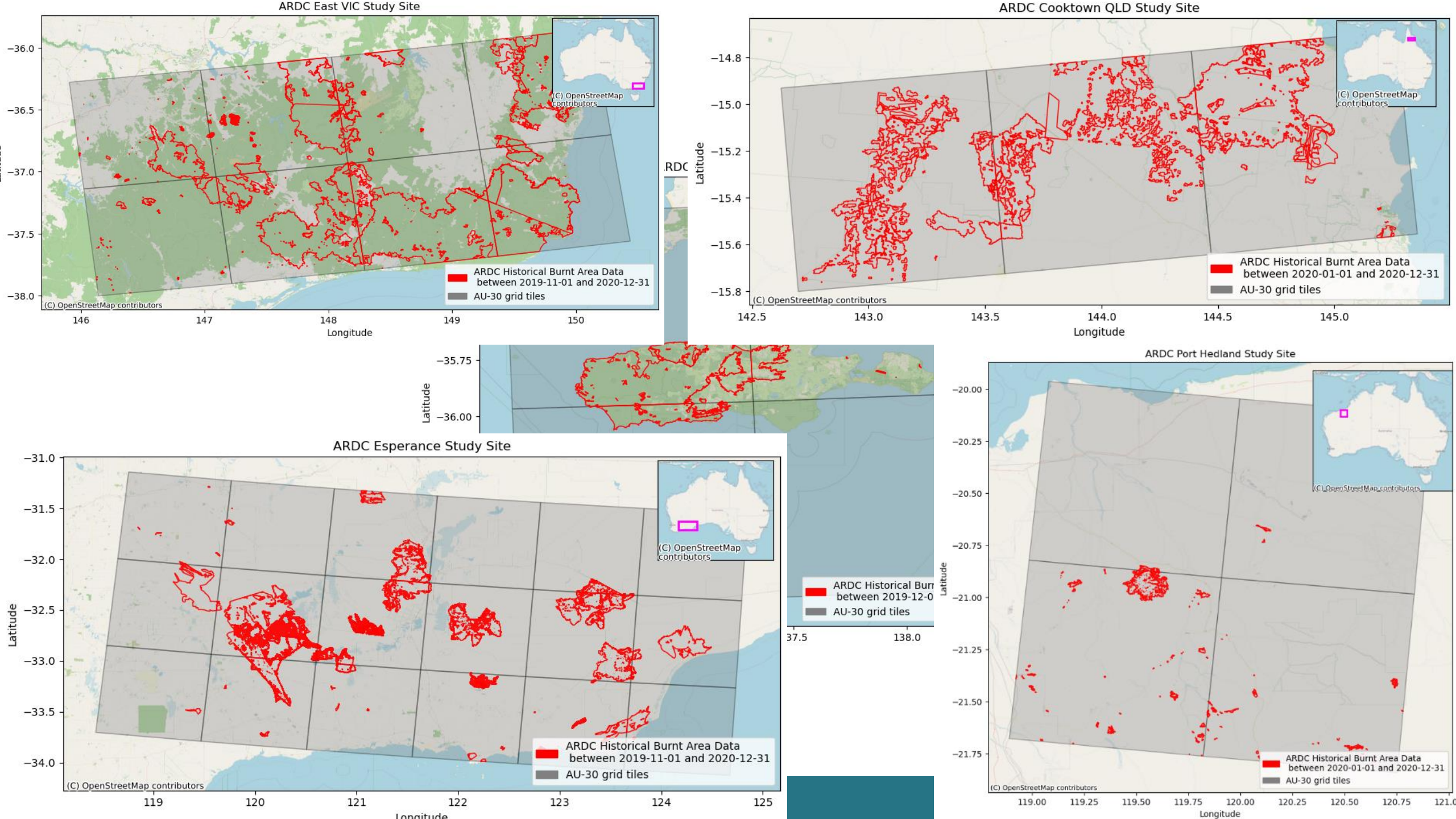




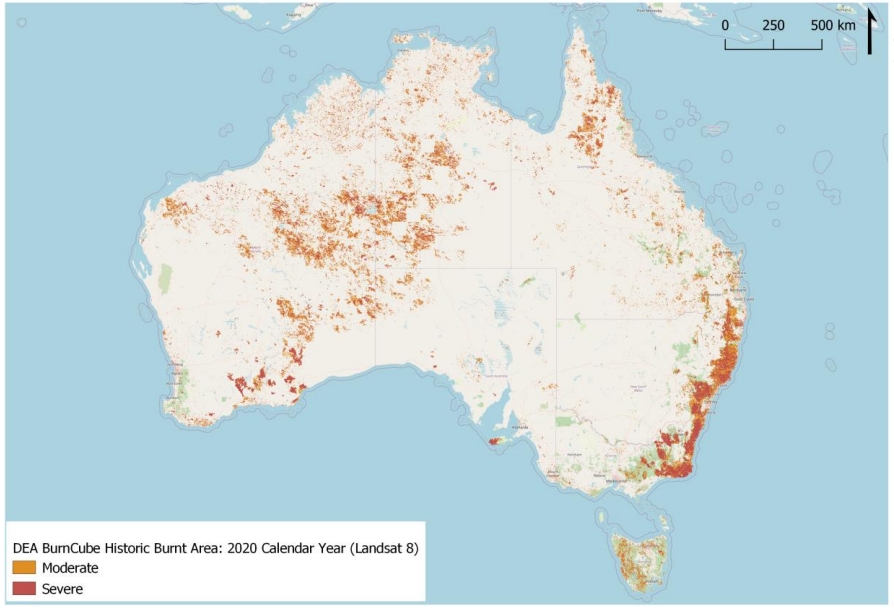


3c. Small scale burnt area demonstrator datasets for multiple historic burnt area workflows

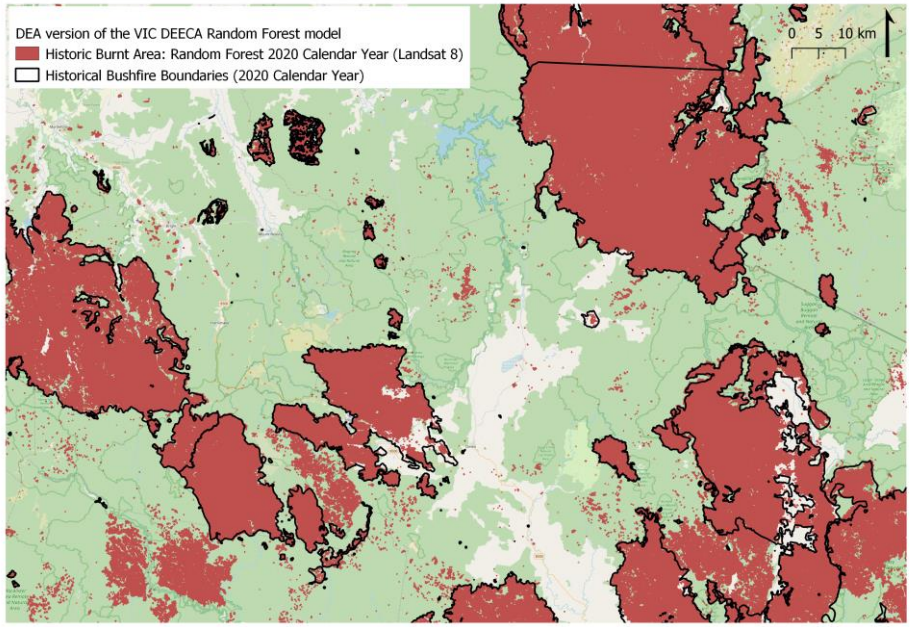
- Aim:
  - Use a range of burnt area identification methods to understand what would be required to create a national product.
  - Create data samples to test the feasibility and suitability of different algorithms within multiple areas of Australia.
  - Use data samples to build a validation process and begin to test uncertainty and how multiple models could be combined in the future to produce a weighted burnt area dataset.
  - End goal = set up the foundations for generating a nationally consistent but thematically appropriate burnt area product describing the timing, location, and extent of bushfires across Australia.
- Four burnt area identification algorithms were chosen to create bushfire extent data samples throughout different climatic areas in Australia:
  - BurnCube (Geoscience Australia, ANU, (Renzullo et al. 2019)).
  - Burnt Area Characteristics (Geoscience Australia, ACS NRT burnt area MVP, unpublished methodology).
  - Random Forest (Victorian, Tasmanian and New South Wales Governments). Based on method as described in Collins et al. (2018).
  - Queensland RapidFire (Queensland Government, (Van den Berg et al. 2021)).
- Input and outputs investigated:
  - Landsat and Sentinel 2 input data.
  - Calendar year and financial year summary results.
  - Raster and vector outputs.


ARDC East VIC Study Site
ARDC Historical Burnt Area Data between 2019-11-01 and 2020-12-31
AU-30 grid tiles
(C) OpenStreetMap contributors
Latitude
Longitude
ARDC Cooktown QLD Study Site
ARDC Historical Burnt Area Data between 2020-01-01 and 2020-12-31
AU-30 grid tiles
(C) OpenStreetMap contributors
Latitude
Longitude
ARDC Esperance Study Site
ARDC Historical Burnt Area Data between 2019-11-01 and 2020-12-31
AU-30 grid tiles
(C) OpenStreetMap contributors
Latitude
Longitude
ARDC Port Hedland Study Site
ARDC Historical Burnt Area Data between 2020-01-01 and 2020-12-31
AU-30 grid tiles
(C) OpenStreetMap contributors
Latitude
Longitude

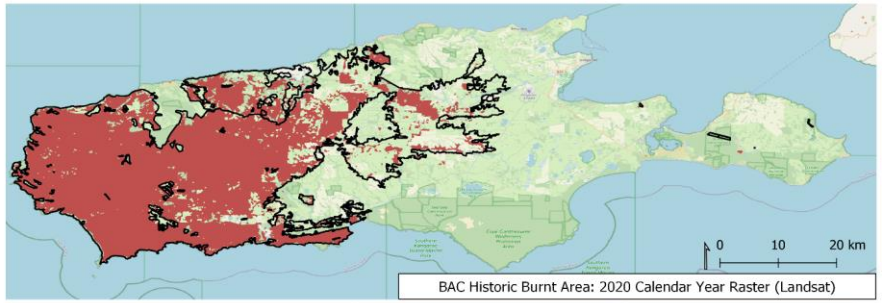
3c. Small scale burnt area demonstrator datasets for multiple historic burnt area workflows

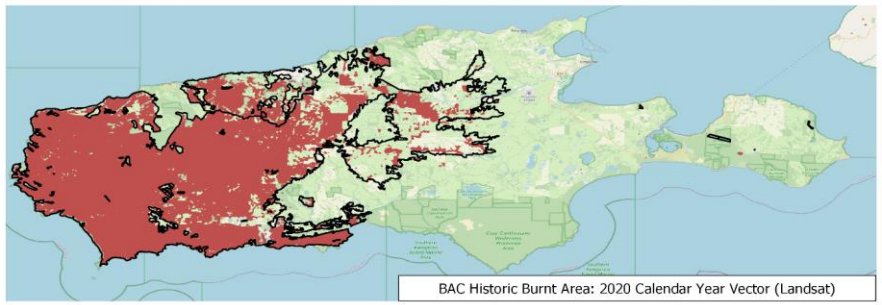


1. BurnCube

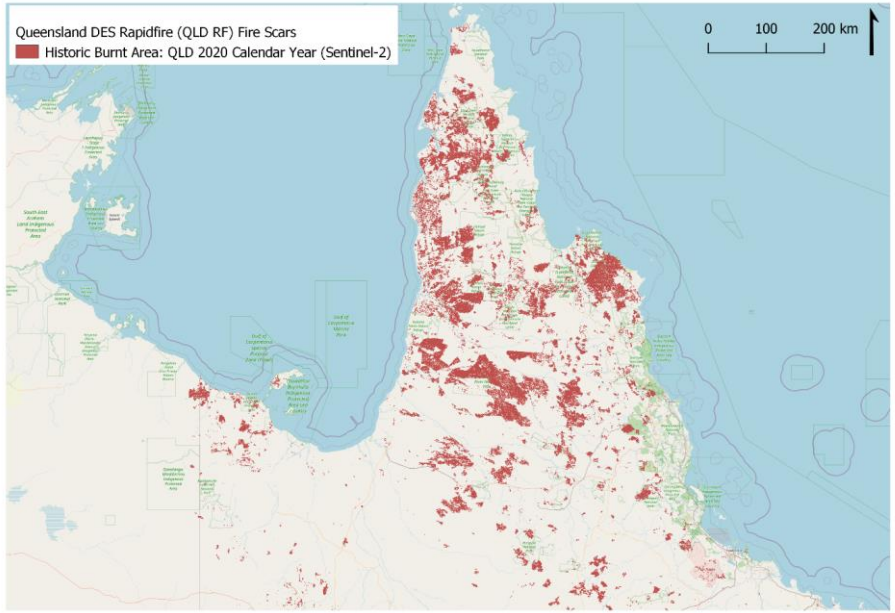


2. Random Forest





3. Burnt Area Characteristics



4. Queensland RapidFire

3d. A comparative assessment of burnt area methods

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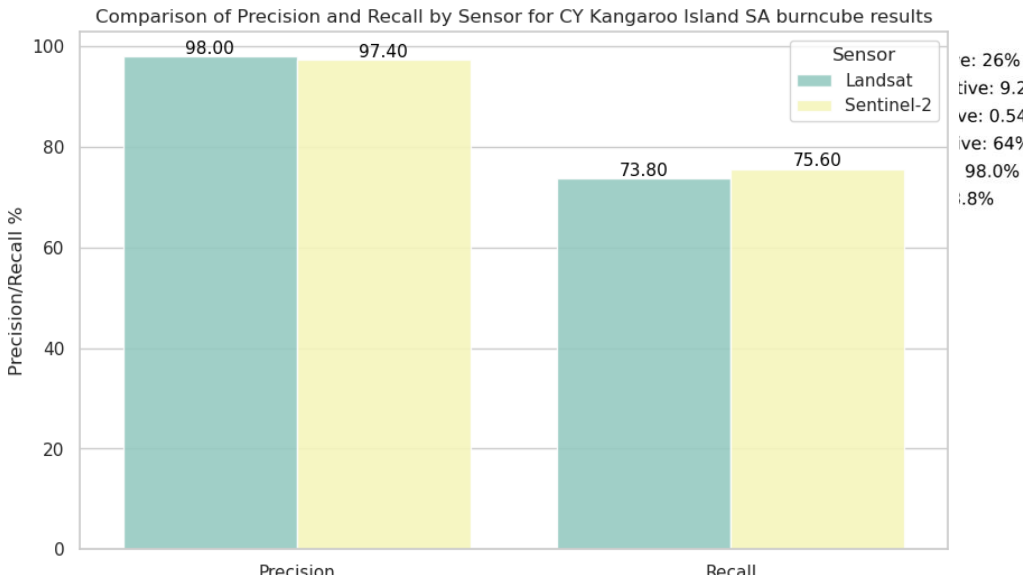
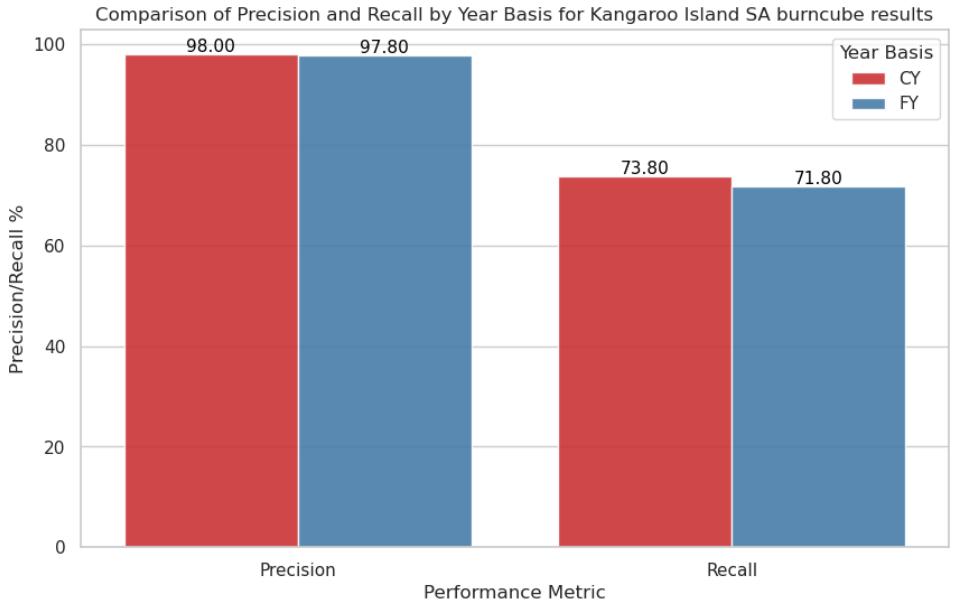
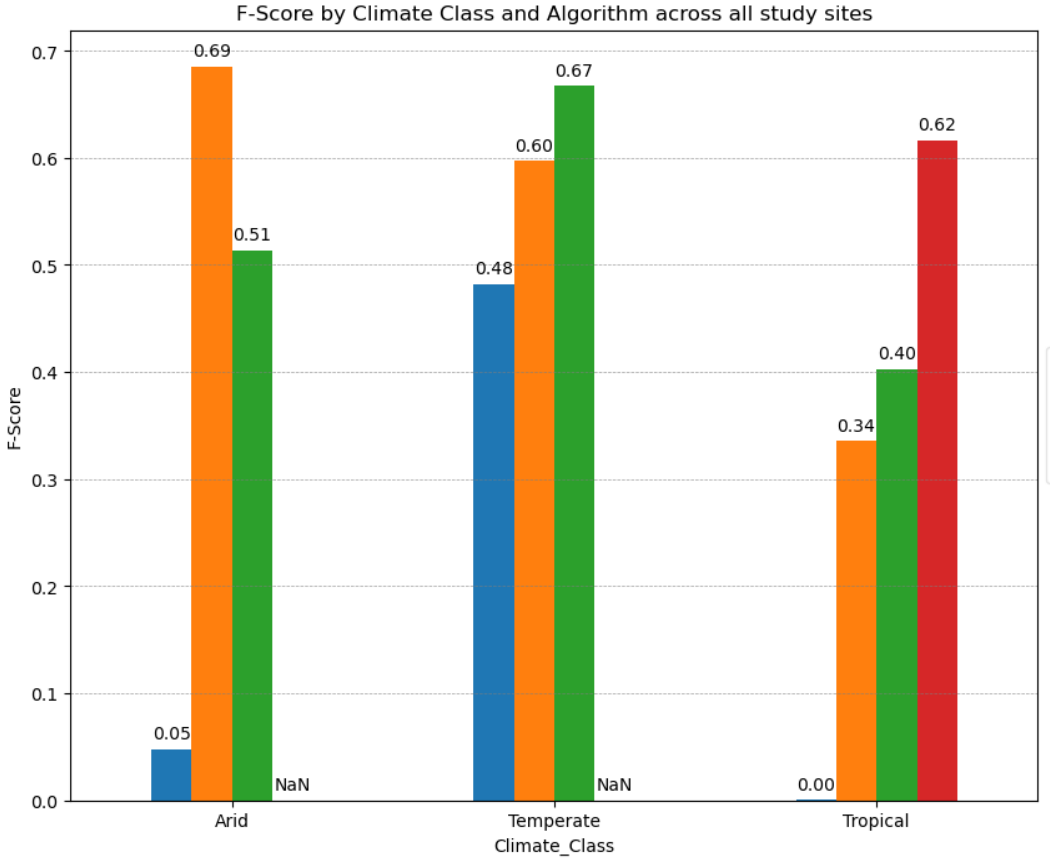
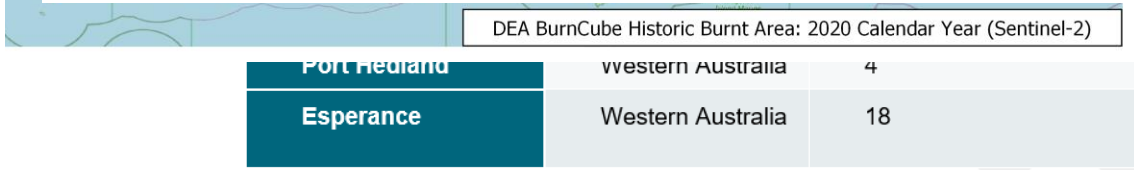
4. Thematic









Port Hedland	Western Australia	4
Esperance	Western Australia	18

3d. A comparative assessment of burnt area methods

- Proof-of-concept uncertainty process to investigate how results from multiple models could be combined in the future to produce a weighted burnt area dataset across mainland Australia and Tasmania.
- An Ensemble/Consensus style uncertainty layer was created with varying levels of complexity.
- A prototype Jupyter notebook was created to test ways to examine the probability, binary prediction, and uncertainty of an area being burnt.
- The interim results from the various burnt area algorithms were used within this analysis.

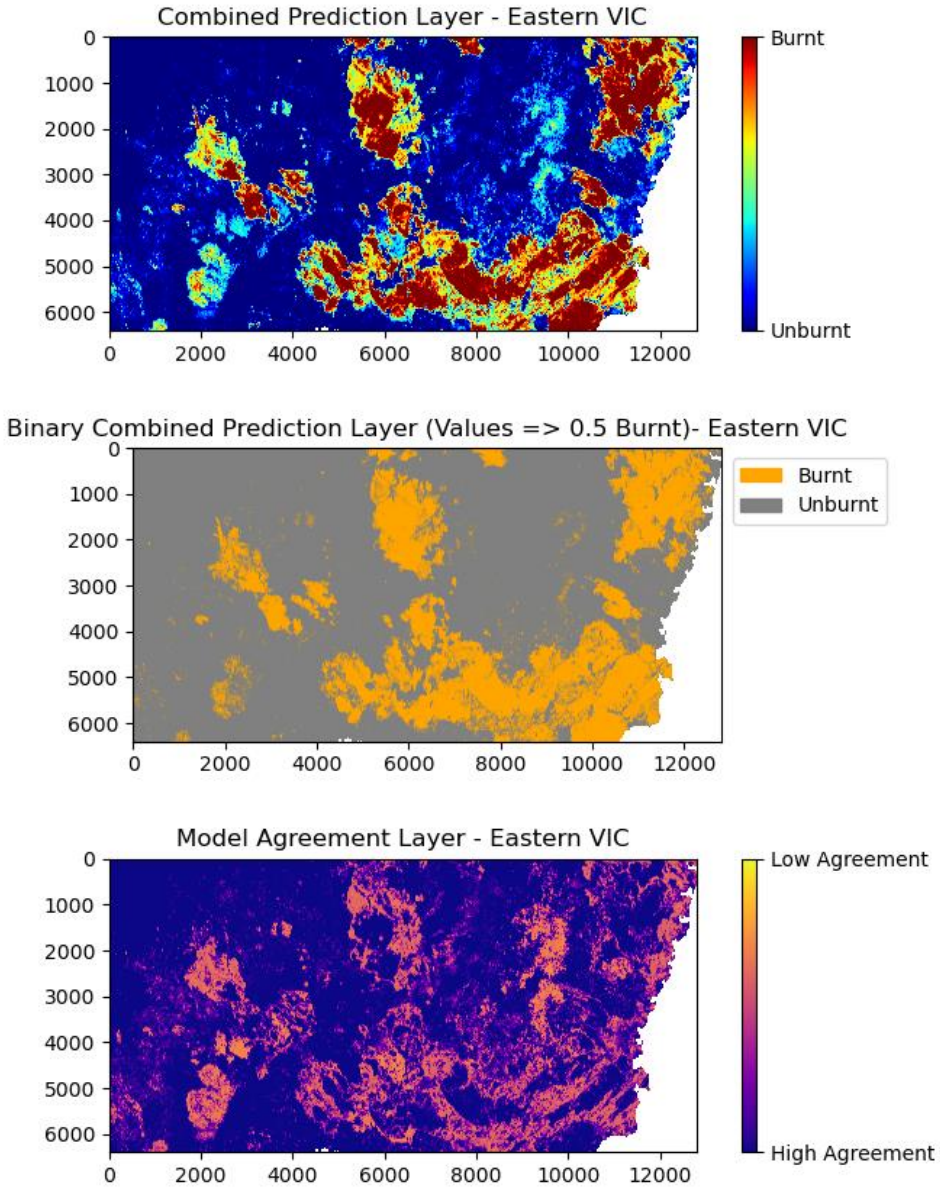


Figure: Interim burnt area results were combined from the BurnCube, BAC and the DEA VIC RF algorithms.

3d. A comparative assessment of burnt area methods

Next steps for realising continental-scale burnt area mapping

- Product generation costing overview.
- Technical feasibility of model implementation by DEA.
- Data quality and method suitability.
- Future work:
    - The option to combine multiple burnt area algorithms.
    - Validation work.
    - Uncertainty and confidence work.
    - Operational raster to vector processing.

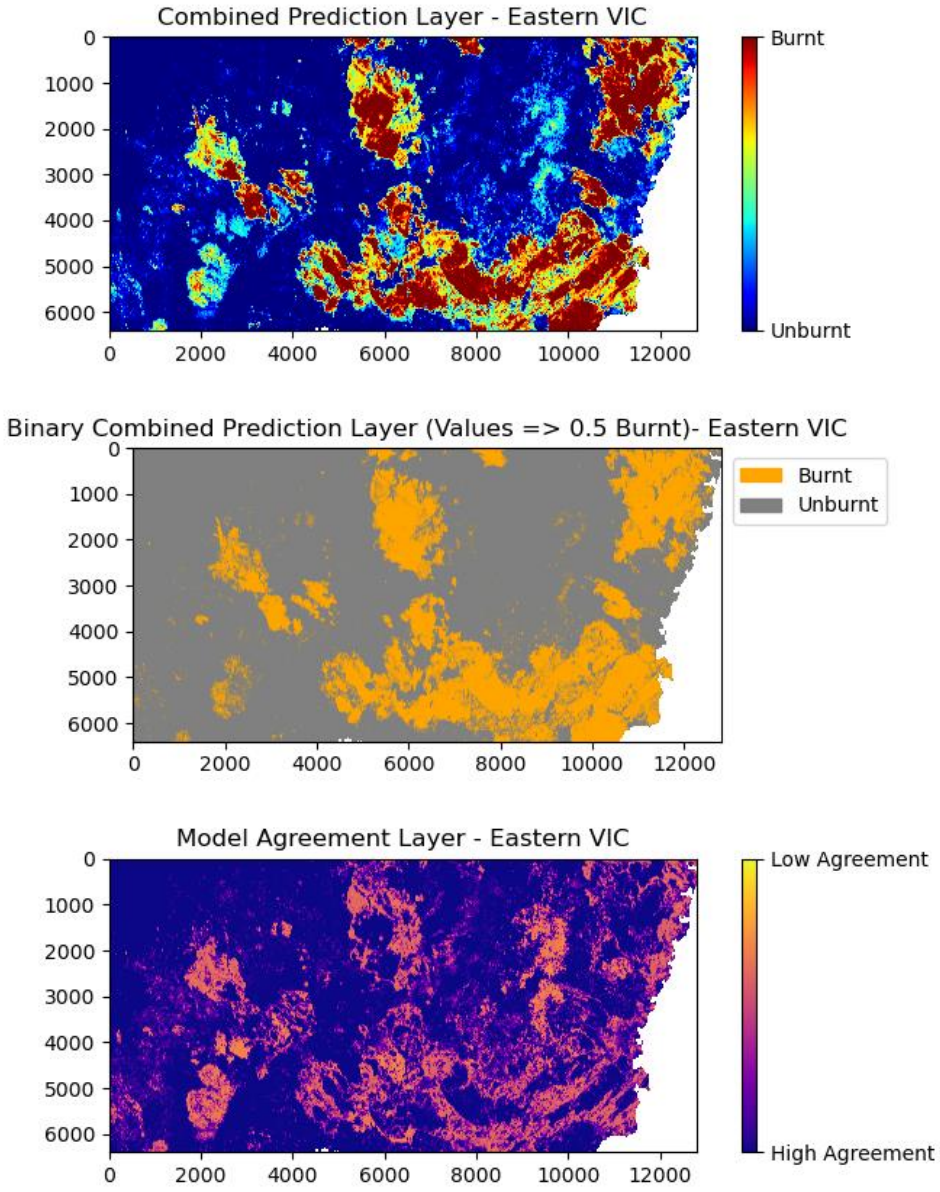


Figure: Interim burnt area results were combined from the BurnCube, BAC and the DEA VIC RF algorithms.

Conclusion

- Australia has complex fire regions, regimes, and management requirements.
- DEA have successfully produced the foundations for generating a nationally consistent data product that describes the timing, location, and extent of bushfires across Australia.
- Enabling the mapping of fire across state boundaries and throughout our diverse range of landscapes (e.g., differing climate, geology, landform, vegetation, and biodiversity) is a critical component of post-fire recovery and future land management. This work will strengthen national assessment of damage, as well as assisting in the prediction of future fuel loads and risks.
- With the current momentum, DEA intend to continue the work towards progressing deliverables for at least another two years with the National Bushfire Intelligence Capability (NBIC), Work Package W1C: Burnt Area Mapping, Activity 4: Remote Sensing.

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Thank you!

Questions?

Further information

earth.observation@ga.gov.au
https://www.dea.ga.gov.au/