Detecting active fires from space using Himawari-8: a report from the regional New South Wales trial

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Continuous monitoring fires over Australia using Himawari-8 geostationary satellite data (available every 10 minutes) has the potential to change lives.

Active-fire hotspots are routinely available from polar-orbiting satellites such as MODIS and VIIRS (Giglio et al. 2003; Giglio et al. 2016; Schroder et al. 2014) over Australia. Active-fire hotspots from those systems are only available a few times a day, with the specific times dictates by the satellite orbits themselves. With satellite orbits not necessarily concurring with time of maximum fire activity. In late 2015 though, the Japanese Meteorological Agency launched the Himawari-8 geostationary satellite, with full-disk observations (including Australia) available every 10 minutes (Bessho et al. 2016). These frequent observations have the potential to support continuous real-time satellite monitoring of active fires over Australia.

Scientific background

Mid-infrared satellite channels are sensitive to the radiant output from fires. The presence of fire causes mid-infrared brightness temperatures to increase. Mid-infrared satellite channels are so sensitive to fires, that even fires too small to be spatially resolved can cause rises in brightness temperature (Dozier 1981). The detection of fires using mid-infrared satellite channels is complicated though by the presence of clouds, as sunlight reflected from clouds can also cause rises in mid-infrared brightness temperature. Hence, the success of active-fire detection algorithms hinges on the successful removal of or handling of cloud-affected mid-infrared satellite data.

Existing systems either use additional data or cannot be used uniformly over all of Australia. The Wildfire Automated Biomass Burning Algorithm active fire hotspot system over North and South America uses GEOS geostationary satellite data uses additional numerical weather prediction cloud information (Schmidt et al. 2012). Other fire detection (Koltunov et al. 2016; Xu et al. 2017; Hally et al. 2019) and mapping algorithms (Wickramasinghe et al. 2016) require a separate cloud mask, tying the success of the algorithm to the success of the separate cloud mask algorithm.

In 2018, RMIT developed a geostationary fire-hotspot algorithm that required no separate cloud mask and no additional numerical weather prediction information. The algorithm (referred to here as H8IBRA) was applied to Himawari-8 data and involved calculating statistics over bio-geo-physical-regions, sub-seasons and times-of-day to detect rises in mid-infrared sky (MIR) brightness temperature that were unlikely to be due to cloud. The algorithm dynamically-tuned to 419 bioregions (Australia, 2000) over Australia (Engel et al. 2018). While the H8IBRA algorithm showed potential when applied to Himawari-8 data over all of Australia for a full year period, during daytime hours, when compared against active fire detections from MODIS/VIIRS polar-orbiting satellites, it had been set-up to run in over sub-seasons rather than in a real-time environment.

Trial setup

As a way of accelerating the exciting H8IBRA research toward industry utilisation, the New South Wales Rural Fire Service (NSW RFS) proposed to the research team a real-world 'live' trial of the experimental satellite fire detection algorithm

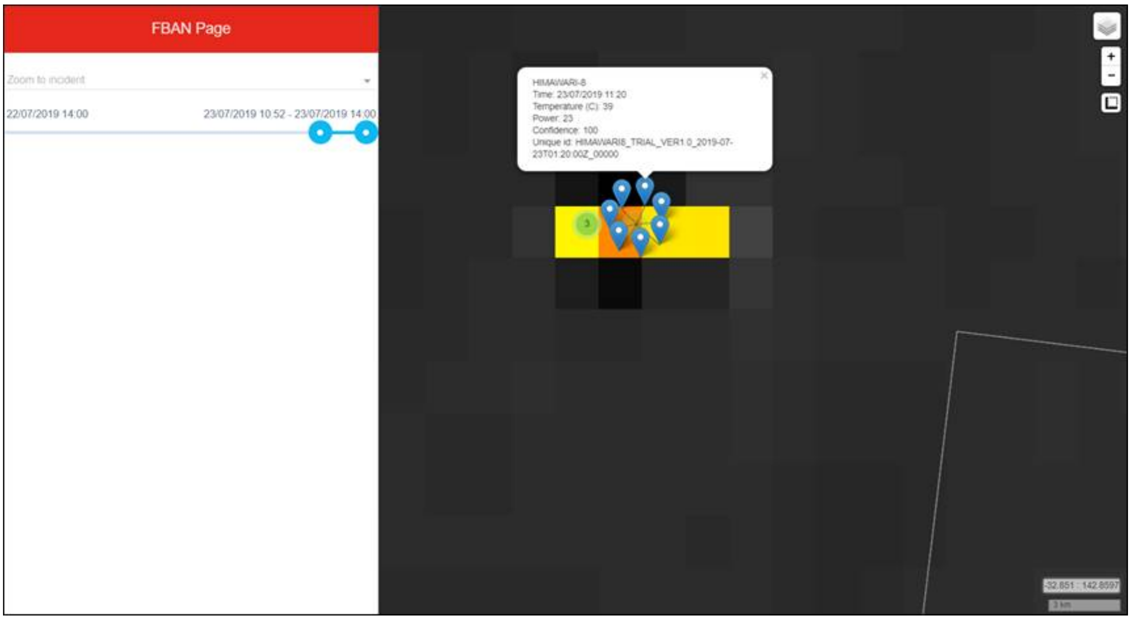

Figure 1: Example of operational use of the H8IBRA trial hotspots.

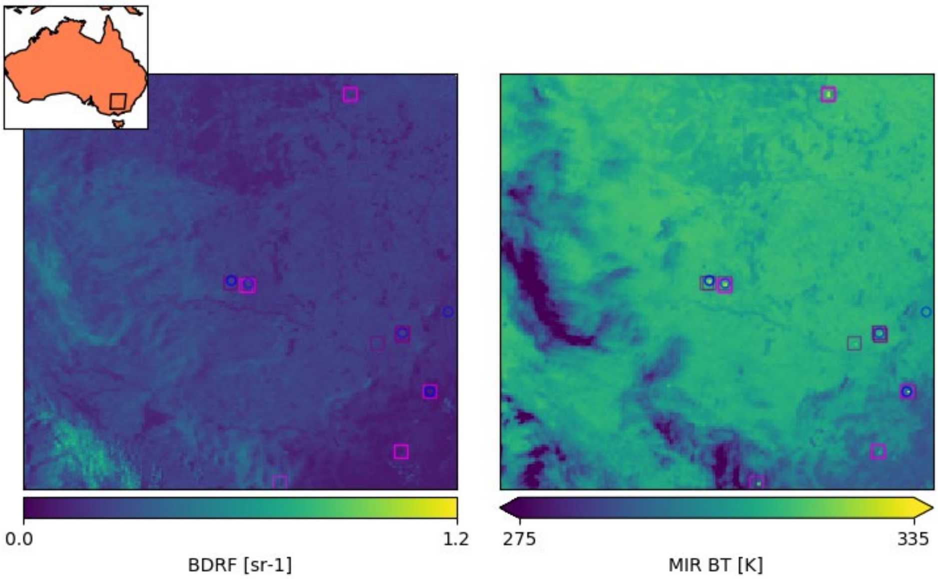

Figure 2: 0410 UTC 17th April 2019 Himawari-8 0.64 μm (at 2km resolution) (left) and 3.9 μm (right) data over NSW (see inset). Hotspot detections are shown from VIIRS (blue circles) and H8IBRA (magenta -- 0410 UTC; purple -- 0400 UTC).

under development. The RMIT project leaders were keen to pursue the near-real-time (NRT) trial to identify opportunities to refine their work in a practical setting, as well as obtain real-world performance data.

A trial was set up that ran over NSW every 10 minutes over 24 hours, from 0500 UTC 12 March 2019 to 05 UTC 18 April then from 0500 UTC 6th May 2019 to 0500 UTC 24 July 2019. First, RMIT researchers modified the H8IBRA algorithm to make it produce NRT active fire hotspots (manuscript in preparation). The Australian Bureau of Meteorology then provided access to the Himawari-8 data in NRT. RMIT researchers downloaded Himawari-8 data in NRT to a local machine, processed the data, and uploaded the active-fire hotspots to NSW RFS. The delay between data arrival and hotspot delivery (using limited computing resources) being on the order of minutes.

The NSW RFS invested time and expertise to incorporate RMITs work into existing systems so it could run in parallel with currently operational satellite detection systems. Hotspot data were ingested by a server at the NSW RFS and published through existing map server infrastructure as a geoJSON feature layer. Users were then able to view hotspots through an internal website along with latest MIR and false-colour visible images, and incident information. Controls in the website allowed users to filter hotspots reported over the previous 24-hour period and to view information about each hotspot (Figure 1).

The website was available to a limited number of skilled fire behaviour analysts who were briefed on the use and limitations of the hotspots information.

Integration of RMIT produced hotspots with agency systems made it much easier to interpret hotspots by providing context through incident information and other base layers such as vegetation maps or air photos. The real-time trial also provided an opportunity to rapidly adjust and iterate the detection algorithm. Feedback on the algorithm sensitivity was used to make adjustments which were then visible to users almost immediately.

Embedding research data into agency systems was a powerful way of validating user needs and providing feedback on the algorithms. This approach could be used in future for other research projects where trial data can be produced and tested in an operational context.

Evaluation of the accuracy of the H8IBRA hotspot is still being completed. An example though of the satellite inter-comparison of H8IBRA hotspots to MODIS and VIIRS hotspots can be seen in Figure 2. Initial findings indicate that bright hotspots in Himawari-8 are routinely detected, but that H8IBRA thresholds may be set too high to detect dimmer Himawari-8 hotspots. There is also evidence of "brand new" H8IBRA active-fire hotspots detections becoming available be due to the higher spatiotemporal availability Himawari-8 observations.

Future

Future areas of work stemming from this study may include modifications to the H8IBRA algorithm to attempt to detect dimmer Himawari-8 hotspots. Additional trial may also be run in different seasons, and different Australian regions. Finally, further investigations into the optimal use of such high-volume NRT active-fire hotspots in an operational setting may be completed.

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