Bushfire tracking system using Himwari-8 AHI

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Introduction

Wildfire is an important part of the eco-system supporting regeneration and diversification of plants. However, wildfires near semi-urban areas pose a risk to both life and property. Effective wildfire management and early warning systems are key to saving lives and property. Extensive research has been conducted using satellite remote sensing for fire detection and burned area mapping. MODIS (Moderate Resolution Imaging Spectroradiometer) fire hotspot products are currently one of the best sources of data for wildfire detection, and are used by the sentinel hotspot project to map active fires in Australia. Twice daily observations and the 1km pixel resolution, however, limit the use of MODIS fire hotspots for near real time fire monitoring.

The new Himawari-8 geo-stationary satellite was launched late last year by JAXA (Japan Aerospace Exploration Agency). On board AHI (Advance Himawari Imager) is a 16 channel hyper spectral sensor that provides high temporal data every 10 minutes covering an entire earth hemisphere. This makes it ideal for near real time forest fire monitoring. MODIS fire hotspot algorithm is based on applying a contextual threshold condition to the Middle Infrared (MIR) and Thermal Infrared (TIR) channels. As AHI has similar wavelength channels to MODIS, this algorithm can be applied to AHI images to provide a more frequent map of active fires. However the spatial resolution (2km pixel size) and sensitivity of the AHI MIR and TIR channel may limit the usefulness of this data. For instance, if the ability of the sensor to detect and monitor active fire fronts that are smaller than the 4 km^2 ground area that is covered by the sensor pixel is yet to be explored. Although a number of sub pixel detection techniques have been developed to improve the fire detection for similar coarse resolution sensors, real world applications of such techniques has been limited due to low reliability.

This research will examine the use of AHI data over two stages, active fire monitoring and fire intensity mapping. The aim of the active fire monitoring stage is to utilise the higher resolution near infrared (NIR) 1 km resolution and RED (500 m resolution) channels to improve the spatial accuracy for fire monitoring. Two hypothetical algorithms have been proposed that will be evaluated to identify the optimum approach to achieve this aim. The second stage of this research investigates the use of AHI derived fire radiant energy (FRE) for fire line intensity mapping.

This research also aligns with bushfire and natural hazard CRC project A4: 'Disaster Landscape Attribution, Active Fire Detection and Hazard Mapping' objectives. It is highly anticipated that the proposed algorithms will provide reliable fire line maps and fire line intensity data at 500m spatial resolutions. Thus enabling near real time mapping of bushfire, providing vital information for fighting bushfires.

Research Questions

- Can the multi-temporal, multi-spatial Himwari-8 AHI bands be combined for optimal fire detection and tracking?
- Can smoke be distinguished from fire and background non-fire surfaces?
- Can fire area detection be used to improve Fire Radiant Energy (FRE) calculation?
- How to incorporate FRE and fire duration for fire severity mapping?

Research

This research aims to develop algorithms to accurately map near real time fire line at 500m resolutions and to calculate fire line intensity. First stage of the research looks into two proposed hypothetical algorithms for fire line mapping using AHI. The first algorithm is based on a dynamic contextual threshold for 500m RED, 1km NIR and 2km MIR channels. Threshold conditions will be applied in sequence staring with MIR channel to identify thermal difference compared to neighbouring background pixels. Once the possible fire MIR pixel is identified, NIR reflectance difference is calculated using non-fire day image with same time stamp. A threshold condition is then applied based on the land-cover present in the pixel. The third step utilises the RED channel to identify the pixel with the highest smoke density. Finally RED pixel with the heights smoke density that falls within a flagged NIR pixel is identified as a fire line pixels. The second algorithm is based on time series pattern recognition. A time series is developed using a new normalized index “Fire Index” based on the RED and NIR channels. Time series pattern recognition is used to track changes in Fire Index values to identify the ignition, burning and smouldering stages of a 500m pixel. Both algorithms will be evaluated utilising cross comparison and validation data to quantify the true performance of the algorithms.

The second stage of the research looks in to improving the fire radiant energy (FRE) calculation using MIR channel. Radiant energy from smouldering areas in coarse resolution pixels causes errors in FRE calculation. Thus new proposed algorithm will use data from fire line maps to calculate the smouldering area with in the pixel. Radiance from smouldering area will be calculated using time series observations data and applied to FRE algorithm as correction.

Summary

The research is focused on utilizing the multi-resolution and high frequency data from AHI to develop new algorithms for fire line mapping and fire intensity calculation. Two algorithm are proposed for fire line mapping and FRE calculations are improved by using accurate fire area calculation and correcting for radiant from smouldering areas. The algorithms developed are expected to provide near real time mapping of fire at 500m resolution and accurate calculation of fire intensity. This will be highly useful to effectively execute bushfire control measures as well as input data for bushfire prediction models.