Proceedings for the 6th International Fire Behaviour and Fuels Conference
April 29 – May 3, 2019, Sydney, Australia
Published by the International Association of Wildland Fire, Missoula, Montana, USA

Development of a National Approach of Grassland Curing Assessment

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Abstract

Depending on the growth stage of grass, certain physiological characteristics, such as water content and degree of curing (senescence), determine the susceptibility of grass to ignite or to propagate a fire. In Australia, grassland curing is an integral component of the Grassland Fire Danger Index (GFDI), which is used to determine the Fire Danger Ratings (FDRs). Inaccurate assessments of curing provide imprecise information for fire behaviour modelling and FDR determination. Approaches used to assess grassland curing and fire behaviour vary between states and territories. There is still a lack of standardised and consistent approach at the national level. Such variation results in inconsistent GFDI values across the country.

In Victoria, Australia, an approach that combines near real-time satellite data and ground-based observations was implemented operationally by the Country Fire Authority (CFA) from 2010 to 2014. From 2014 to 2016, the Victorian technique was trialled for other five states and territories. However, the automated online system and satellite-based model remain tailor-made for individual jurisdictions, which still inhibit consistency at state/territory borders. Since 2018, CFA aims to work towards an improved approach that involves a national model and centralised automated online system for more accurate and streamlined grassland fuel measurement and assessment. With ongoing support from multiple agencies at both state/territory and federal levels, GFDI calculations will become more accurate and consistent at a national level.

Introduction

In Australia, the GFDI is calculated from a number of inputs including the degree of grassland curing, expressed as the fraction of dead material in a grassland (Cheney and Sullivan, 2008). Approaches used to assess grassland curing and fire behaviour vary between states and territories in Australia. Such variation results in inconsistent GFDI values across the country, and constrains the continuity of GFDI values at state/territory borders.

Fire management agencies across Australia have historically used either ground-based visual observations or satellite observations for operational curing assessment. These techniques alone have inherent limitations providing imprecise information for modelling fire behaviour and determining FDRs (Martin *et al.*, 2015). In Victoria, from 2010 to 2014, a new automated technique that amalgamates near real-time satellite data and ground-based observations was implemented by CFA to accurately assess grassland curing through an online system. The real-time satellite data, named MapVictoria, is provided daily by the Bureau of Meteorology (denoted hereafter as the Bureau). Ground observations are entered via the online system by a growing network of volunteer observers across Victoria. MapVictoria data and ground observations are combined to produce an integrated model named Victorian Improved Satellite Curing Algorithm

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(VISCA) (Martin *et al.*, 2015). Since 2013, VISCA curing maps are produced and used operationally each fire season for accurate fire danger calculations of grasslands in Victoria.

From 2014 to 2016, the Commonwealth Attorney General's Department National Emergency Management Projects (NEMP) supported CFA to collaborate with fire management agencies from other jurisdictions in Australia to trial the Victorian automated technique for multiple states and territories to improve the assessment of grassland curing nation-wide (Wright *et al.*, 2016). Participating states and territories include Queensland (QLD), New South Wales (NSW), Australian Capital Territory (ACT), South Australia (SA) and Tasmania (TAS). Grassland curing products for each jurisdiction are provided (by CFA) on a weekly basis during the fire season. Personal communication with the fire agencies indicates the VISCA products have been used operationally in VIC, QLD, ACT, SA and TAS, and partially used operationally in NSW.

Further improvements are still in need. The automated online system and VISCA model remain tailor-made for individual jurisdictions, which still inhibits consistency and standardisation. The MapVictoria model was originally developed for Victoria. It does not perform well in landscapes with arid and discontinuous fuels and savannas in part of NSW, Western Australia (WA) and Northern Territory (NT). Therefore, VISCA curing maps are currently not produced for WA and NT. Since 2018, CFA aims to work towards an improved approach that involves a national model, named the National Improved Satellite Curing Algorithm (NISCA), and a centralised automated online system for more accurate, standardised and consistent grassland fuel measurement and assessment. With ongoing support from multiple agencies, GFDI calculations will become more accurate and consistent on the national level.

Methodology

Automated Online System

In Victoria in 2013, an online system was developed and deployed operationally, which resides on a CFA on-premises infrastructure to facilitate an automated operational workflow for VISCA map production. The workflow progresses from signing up new observers and validators, through to collating ground observations, to producing a VISCA map for Victoria, to generating data reports. After consulting with each participating jurisdiction, five individual online systems were developed and trialled to cater for various system requirements. For each of them, the automated online system was enhanced by being transformed into a hybrid cloud-based environment (Figure 1). This involves seamlessly integrating both public cloud-based services and shared on-premises resources that are only accessible within the CFA network. The hybrid approach presents advantages including cost-saving benefits, development agility, and implementation flexibilities.

For each online system, the public cloud infrastructure comprises:

- a mobile-friendly web portal hosted on a public cloud as the front-end;
- an operational database on a public cloud to store real-time data including observations, site and user profiles, and VISCA curing maps;

- a web application server utilising RESTful (REpresentational State Transfer) Application Programming Interfaces (APIs) between the web portal and the operational database to handle data manipulation, and take advantage of other scalable cloud-based resources.

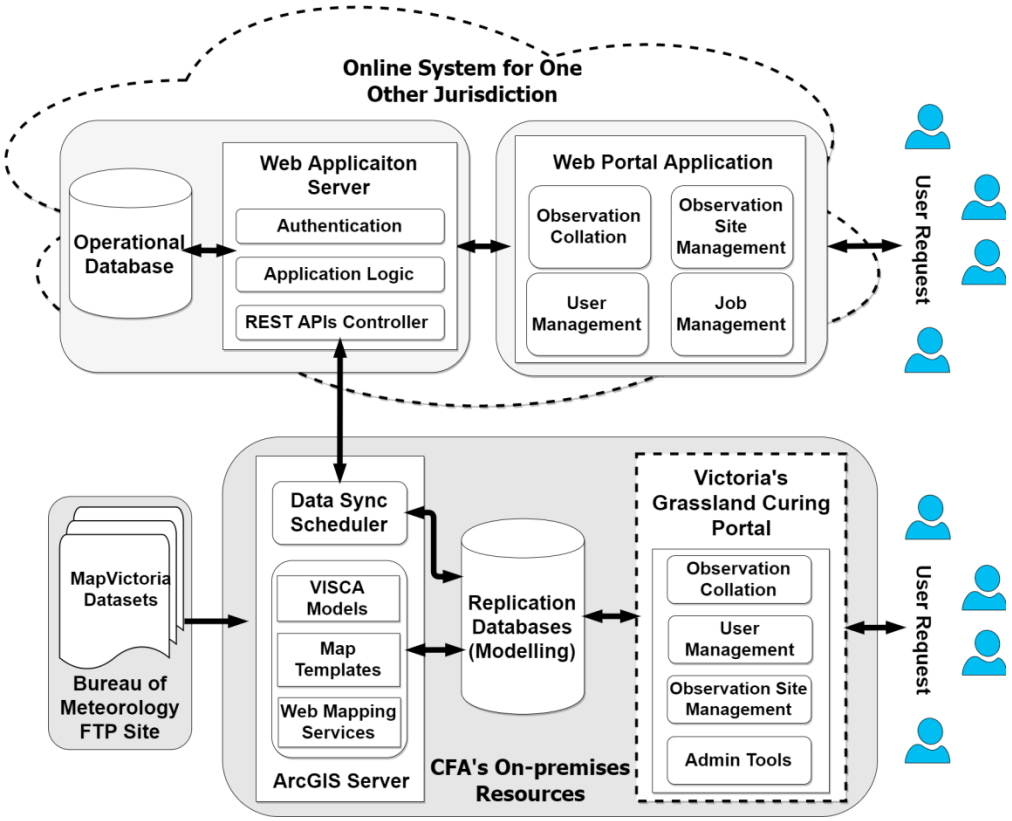

Figure 1 Architectural Components of the hybrid cloud implementation (illustrations of an online system for one other jurisdiction and the Victoria's Grassland Curing Portal respectively)

Shared by all five jurisdictions, the CFA's on-premises infrastructure includes:

- an ESRI ArcGIS Server where VISCA models for all participating jurisdictions are deployed as Geo-processing web services, and triggered via the online system;
- for each jurisdiction, a replication database on a Microsoft SQL Server that is directly accessible by the VISCA model;
- Data Sync Scheduler. Due to restricted access to the CFA's network, the VISCA model cannot directly access the operational database in the cloud. To address this issue, a data synchronisation was scheduled to copy only the weekly updated data from the operational database to the replication database directly accessed by the VISCA model.

Next, a role-based login is provided for users to access the online system's web portal. Each role is given a different level of access.

- Observers, collecting field data, can access details of their associated observation site(s) and can enter weekly observations.
- Validators can access details of observers, sites and observations from within their designated region/district, and they can validate observations entered by observers.

- An administrator has full access to all system functions including data collation, site and user management, running the VISCA model, map production and data reporting. For each participating jurisdiction (except Tasmania), the online system can access ground observations from neighbouring jurisdictions. This enables the administrator to select which observations from other jurisdictions they wish to use for their jurisdictional VISCA curing map, and which observation sites can be viewed by other jurisdictions.

Ground Observations

In Victoria, the observations are entered online by a well-established network of 330+ volunteer observers from 500+ observation sites (Table 1) with use of a grassland curing guide (CFA 2014a), a grassland curing field card (CFA 2014b) and an online training package (CFA 2014b). Since trialling the Victorian approach for five other jurisdictions (from 2014 onwards), visually assessed curing observations are entered once a week, into the online system for each jurisdiction, from a total of 1000+ observation sites (Table 1) during each jurisdiction's individual fire danger period. For each jurisdiction, ground observations are validated by operational personnel (known as validators), and are utilised in the VISCA model to adjust the MapVictoria satellite observations.

Table 1 Ground based observation network (as of January 17, 2019) across ACT, NSW, QLD, SA, TAS and VIC.

Observation Day	**Jurisdiction**	**Number of Observation Sites**	**Number of Observers**
Monday (and Thursday)	VIC	508	335
Wednesday	TAS	29	21
Wednesday	QLD	80	42
Thursday	NSW	188	105
Thursday	SA	208	115
Thursday	ACT	10	23
Total		**1023**	**641**

Satellite Observations

MapVictoria data, with a resolution of 500 metres, are processed and updated on a daily basis by the Bureau using a direct feed of MODIS satellite data into the CFA server, with "no data" pixels representing water-bodies or cloud cover. As an example, mosaicked MapVictoria data and ground observations are presented in Figure 2 from February 24th 2019 to February 28th 2019.

VISCA Curing Maps

For each jurisdiction, the MapVictoria satellite data and ground-based observations (Figure 2) are integrated to produce six VISCA curing maps with use of the online system. Any under- or over-estimation of curing derived from satellite is minimised by applying various maximum distances of a field observation's influence (ground based influence) across different jurisdictions. Through the online system, ground observations have not only influenced the VISCA model within each jurisdiction but also the VISCA models for the neighbouring jurisdictions, with the exception of Tasmania.

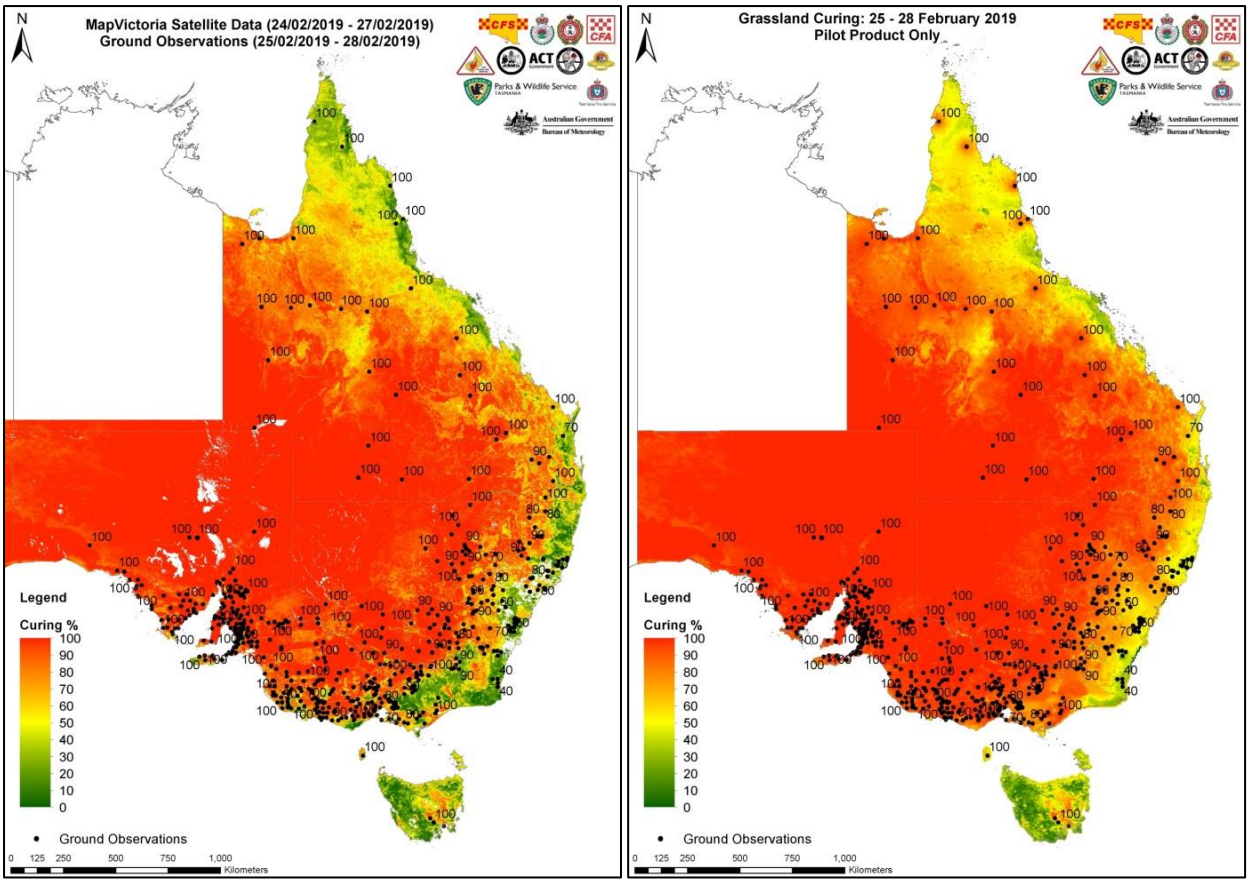

Figure 2 Left: MapVictoria Satellite Curing Data processed (by the Bureau of Meteorology) on the following dates: 24/02/2019 (VIC), 26/02/2019 (QLD/TAS), 27/02/2019 (ACT/NSW/SA) and Visually Assessed Ground Observations validated online on the following dates: 25/02/2019 (VIC), 27/02/2019 (QLD/TAS), and 28/02/2019 (ACT/NSW/SA). Right: VISCA Grassland Curing Mapping (25/02/2019 – 28/02/2019)

Future Development

Precise and near real-time information for FDR determination at the national level requires an up-to-date and automated supply of accurate and consistent assessments of grassland curing from all jurisdictions in Australia. The current online system and VISCA model both remain tailor-made for individual jurisdictions; which still inhibits consistency at state/territory borders. Operational personnel (in CFA) still need to manually trigger the map production for each jurisdiction.

The national curing (NISCA) model will need to include coverage across Western Australia and Northern Territory. The MapVictoria satellite model was originally designed for landscapes in Victoria, and it does not perform well in landscapes with arid and discontinuous fuels and savannas in part of NSW, WA and NT. NSW does not use VISCA operationally due to the limitations. To overcome these issues, therefore, NISCA will need to allow for the use of other satellite models in areas where MapVictoria performs poorly and field observations are inadequate for ground validation.

The national online system will continue to be cloud-based. It will feature a centralised database and allow for ground-based grass fuel data to be reported from multiple states and territories across Australia via a single and consistent web portal. The NISCA model will be able to directly access the database and be accessed by the online system. NISCA will also need to be deployed in a cloud-based environment to take advantage of scalable cloud computing services for improved performance. It would be beneficial to all jurisdictions that national curing (NISCA) maps can be automatically produced on a daily basis with satellite data and collated ground observations readily available. Therefore, the online system will need to support more automated workflow and data processing operationally. This improved approach will be integrated into the proposed National Fire Danger Rating System led by The Australasian Fire and Emergency Service Authorities Council (AFAC).

Conclusions

Across Australia, methods used to assess grassland curing vary between states and territories. Inaccurate assessment of grassland fuels result in inaccurate FDRs. In Victoria, CFA has contributed to improved GFDI calculations through the development and deployment of an effective automated technique for operational curing assessment. Multiple state fire and land management agencies have trialled the Victorian approach through participating in the NEMP project. Improved and consistent grassland curing maps and GFDI calculations across South Eastern Australia are achieved. To support more accurate, standardised and consistent grassland fuel measurement and assessment across the entire country, since 2018, CFA aims to work towards an improved approach that involves a national model (NISCA) and a centralised automated online system. With ongoing support from multiple agencies on both state/territory and federal levels, more accurate and spatially representative grass fuel information in fire danger indices will be achieved across the country.

Acknowledgements

The authors would like to thank the following end-users for their ongoing support and collaboration with the NEMP Project. From Queensland: Andrew Sturgess, Simon Dawson, Francis Hines, Peter Timmers, and Florence Fang (QFES). From NSW: Simon Heemstra, Laurence McCoy, Maree Larkin, Jessica Wells, and Stuart Matthews (NSW RFS). From ACT: Malcolm Gale, Adam Leavesley, and Bethany Dunne (ACT Parks and Conservation Service). From Tasmania: Daniel Hoar, Mark Chladil, Samuel Ferguson (TFS), David Taylor, Paul Black, and Eddie Staier (Tasmania Parks and Wildlife Service). From South Australia: Rob Sandford, Phil McDonough (CFS), and Simeon Telfer (DEWNR). The authors would also like to thank Tom Sanderson (CFA) and Ian Grant (BOM) for ongoing support.

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