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Initial observations from surveying the global fire management community and their usage of Earth observation wildfire data sources

Natural Resources Canada
Canadian Forest Service
Great Lakes Forestry Centre
Information Report
GLC-X-37

The Great Lakes Forestry Centre, Sault Ste. Marie, Ontario

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Cover photo: Yukon, Wildland Fire Management Branch

Cataloguing information for this publication is available from Library and Archives Canada.
Initial observations from surveying the global fire management community and their usage of Earth observation wildfire data sources. (Information Report, GLC-X-37).
Issued also in French under the title: Observations initiales issues d'une enquête auprès de la communauté mondiale de gestion des incendies et de son utilisation des sources de données d'observation de la Terre sur les incendies de forêt.
McFayden, C. ; MacPherson, L. ; Crowley, M.A. ; de Jong, M.C. ; Turbelin, A. ; Hope, E.S. ; Lynham, T.J. ; Sponarski, C.C.; Nadeau, S. ; Sloane, M. ; Dufour, D.; Morton, D.C. ; and Johnston, J.M.
Electronic monograph in PDF format.
Includes bibliographical references.
PDF:
ISBN 978-0-660-72184-2 ISSN 2562-0738
Cat. no.: Fo123-2/37-2024E-PDF
Paper:
ISBN 978-0-660-72185-9 ISSN 0832-7122
Cat. no.: Fo123-2/37-2024E

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Overview

Satellite Earth Observation (EO) data products are powerful sources of fire intelligence for the organizations that manage wildland fire around the globe. However, this potential can only be fully realized if the EO active fire data and products (EO-AFDP) are implemented within systems and workflows in these wildland[1] fire management organizations (Johnston et al. 2020). Here, we present the initial results of an international survey done to support our understanding of global end-users of EO-AFDP.

This survey was carried out in support of the Wildfire Pilot, an initiative of the Committee on Earth Observing Satellites (CEOS) Working Group on Disasters. The Wildfire Pilot aims to provide a basis for defining global priorities for active-fire monitoring and user characterization. The outcomes of this survey, and other projects under the Wildfire Pilot will provide insight into the barriers to and facilitators for the implementation and uptake of EO-AFDP for wildland fire management.

- **For more** information on the scope and other work of the Wildfire Pilot, https://ceos.org/ourwork/workinggroups/disasters/wildfire-pilot/

Implementation and uptake of EO-AFDP in fire management

To fully realize the potential from EO-AFDP usage, a given fire management organization requires a suitable level of capacity (the requisite capabilities and resources) to achieve the desired or needed levels of implementation (top-down, organizational adoption in polices and process) and uptake (bottom-up, the trust from the people within the organization) for EO-AFDP usage in fire management decision-making. To understand the capacity needs for implementation and uptake of EO-AFDP there must be an understanding of the characteristics of fire management organizations and their current use of EO-AFDP as a baseline. This bulletin summarizes the descriptive results from a recent survey exploring qualitative indicators of organizational implementation and uptake of EO-AFDP in operational wildland fire management.

Survey Methods

Aim of Survey

The aim of the survey was to carry out first level engagement with potential EO-AFDP end-users to broadly characterize:

1. the organizational structures of wildland fire management end-user organizations (e.g., jurisdiction, objectives, and activities);
2. how EO-AFDP are used and trusted (e.g., the types, purposes, level of experience);
3. the barriers and facilitators to access and usage;
4. the perspectives on usefulness and underserved communities; and
5. aspirations for the future direction and the focus for developments.

[1] The use of 'wildland' and 'wildfire' may be culturally insensitive, and we acknowledge the importance of land and fire stewardship by Indigenous people across the globe since time immemorial.

Scope of Survey

The range of possible EO-AFDP (e.g., raw data and imagery, derived products like hotspots, area burned maps) and end-users (i.e., firefighters, emergency management, researchers, landowners) is incredibly vast, especially when considered at the global scale. The scale, scope and what constitutes 'fire management' is understandably varied across geographies, environments, and cultures (e.g., Pandey et al. 2023). To address the complexity of "what is fire management" in a survey, we started with a set of definitions to guide the respondents. We defined aspects of fire management, end-users and EO-AFDP as follows:

Definitions used in the survey (adapted from McFayden et al. 2023 and references therein):

- **Wildland Fire Management**: The activities concerned with the protection of people, property, and wildland areas (e.g., forest, bush, shrubland, grassland) from wildland fire, which may include the use of fire for the attainment of wildland management and other land use objectives (e.g., forest management). Aspects include strategies for the prevention, mitigation, and response to wildland fire. Typically carried out by a land management agency, organization, or group (i.e., not a personal property owner). This description excludes structural firefighting.
- **Operational Wildland Fire Management**: Planning for and carrying out the operational activities of wildland fire management, such as wildland fire discovery, suppression, monitoring, and mitigation on behalf of a land management agency or group.
- **End-user:** Those who are responsible for operational wildland fire management on their land base.
- S**pace-based Earth Observation (EO)**: Data and products derived from satellite data for the detection and/or characterization of wildfires on the landscape.
- **EO active wildland fire management products**: Help end-users answer questions related to wildfire management, and includes information on the location, timing, and characteristics of a wildfire.

Survey design

The survey questions were a mix of closed-ended, Likert style responses, option selection, and open-ended, free text responses. The survey had 37 questions and included 'skip logic' to reduce response burden. For example, after collecting responses on wildland fire management organizational structures, if the respondent did not identify EO as used in their organization the EO use specific questions were unavailable to the respondent. All respondents were asked about potential barriers to EO data accessibility and use perspectives. There were 37 questions for EO users, and 12 questions for non-EO users. See Appendix 1 for the survey questions. Survey data were collected voluntarily, and participants were welcome to skip questions and opt out at any time. No personal identifying information was collected, and data were anonymized. Participants were advised that the data would be used by the CEOS Wildfire Pilot Team in subsequent publications for the given aim of the survey.

Survey distribution

The survey was developed and circulated globally using an online survey hosting service in both French and English. The survey is estimated to have reached >16,000 individuals via direct email distribution from networks and personal contacts (Table 1). We used snowball sampling and those who received the survey were encouraged to circulate it further to their contacts. This therefore makes a response rate not possible to calculate.

The survey was shared through known EO user networks such as the Global Observations of Forest Cover and Land Use Dynamics (GOFC-GOLD) Regional Networks the NASA FIRMS distribution list which we acknowledge results in a heavy EO userbase and FIRMS bias. We also distributed postcards with a QR code link to the survey in-person, targeting fire management organizations more broadly at the 8th International Wildland Fire Conference in Portugal (May 2023, Wildfire 2023).

While we encouraged broad participation with a focus on 'operational wildland fire management', we recognize the survey method does not account for the differences in how Western fire management differs from Indigenous fire stewardship (e.g., Lake et al, 2018), nor the other ways fire management is approached across the globe. To this end, the method of survey distribution may have missed potential end-users, including Indigenous peoples who may rely on satellite data but may not be connected within government fire management organization e-mail distribution lists or academic networks.

Table 1. Networks or groups approached with the survey, alphabetical.

Asian Forest Cooperation Organization (AFoCO)
Assuring the Future Forests through Integrated Risk Management (AFFIRM)
Australian Emergency Management Spatial Information Network
Canadian Association of Fire Chiefs
Canadian provincial and territorial fire management agencies
Committee on Earth Observing Satellites (CEOS) Working Group on Disasters
Digital Earth Africa
European Forest Fire Information System (EFFIS) user network
Expert Group on Forest Fires (EGFF) for Europe
Expert Group on Forest Fires of the Latin America and Caribbean Region
FirEUrisk Consortium
Food and Agricultural Organization of the United Nations (FAO)
Global Observations of Forest Cover and Land Use Dynamics (GOFC-GOLD) Fire Implementation Team and Regional Networks
Global Wildfire Information System (GWIS) user network
Global Wildland Fire Network (GFMC)
International Society for Photogrammetry and Remote Sensing (ISPRS) Student Consortium (SC)
NASA Fire Information for Resource Management System (NASA FIRMS) contact and email alert lists
NASA SERVIR Amazonia Hub, West Africa Hub, Asia Hub
PyroLife
Regional Centre For Mapping Of Resources For Development (RCMRD)
Remote Sensing Applied to Tropical Environments (RSATE)
Tactical Fire Remote Sensing Advisory Committee (TRFSAC)
United States Forest Service (USFS)
Personal contacts of the co-authors were also contacted in: Spain; United Kingdom; France; North, West, East and South Africa; Australia; Switzerland; Central and South America.

Survey Descriptive Results

The following infographics provide a summary of selected survey question responses regarding the attributes of EO-AFDP end-users in a wildland fire management context.

There was a total of 247 respondents representing organizations from across the globe. Respondents applied a broad interpretation of 'fire management', representing universities, parks and conservation authorities, municipal agencies, volunteer firefighter groups, industry (e.g., energy, forestry), national and regional government fire management agencies, service providers, meteorological agencies, space agencies and private landowners. Several organizations had multiple respondents: one organization had 6 respondents, 6 organizations had 3 respondents, and 4 organizations had two respondents.

Figure 1 is an infographic of select characteristics of the organizational structure of wildland fire management end-users. Questions characterize the country the organization operates in, the type of organization, the jurisdiction, objective for fire management, activities performed by the organization and whether EO-AFDP is used. Of the 247 total respondents, 216 (87 %) stated their organizations use EO-AFDP.

Figure 2 illustrates the characteristics of the use of EO-AFDP by the fire management organizations. Questions pertain to the duration of use of EO-AFDP, the kinds of fire management activities EO-AFDP is used for, who the users within the organization are, the types of EO data used, familiarity with existing platforms and the trust the organization has in EO-AFDP.

We present the number of respondents as a percentage of all respondents (247) in Figure 1 and percentage of respondents who stated their organizations use EO-AFDP (216) in Figure 2. In some cases, respondents were allowed to select multiple responses, which is why the percentages for a single graphic can add up to more than 100%, which is the case for: 'Organizational activities', 'Objectives', 'What are the users of EO active fire data', 'What are the users of EO active fire data using it for'. Except for the questions 'How long has EO data been used' and 'Organizational trust,' where the responses should add up to 100%, we do not list the number of respondents who skipped questions.

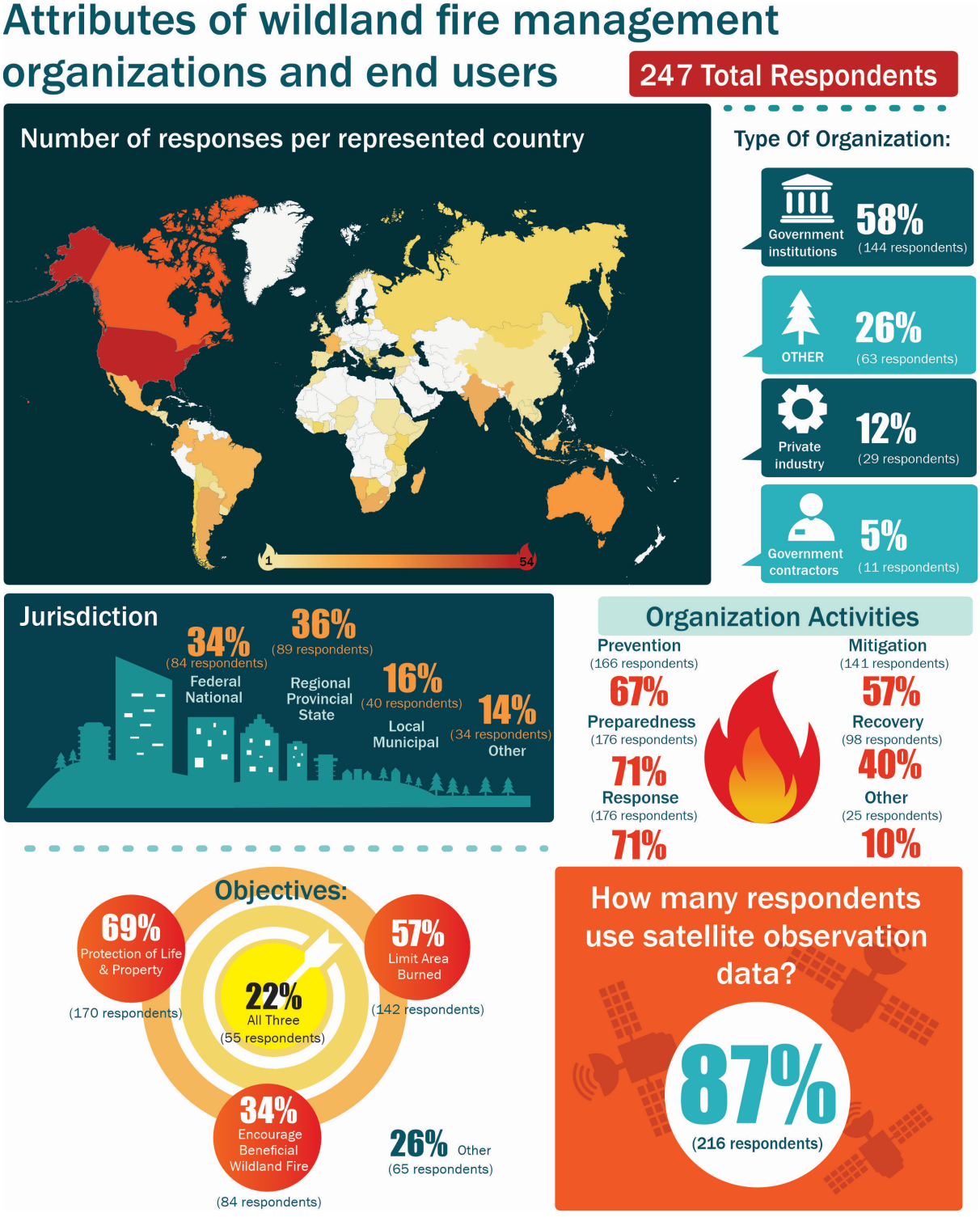

Figure 1. Infographic of fire management organization representation. This infographic presents responses from all survey respondents (n=247). Number of respondents in parentheses.

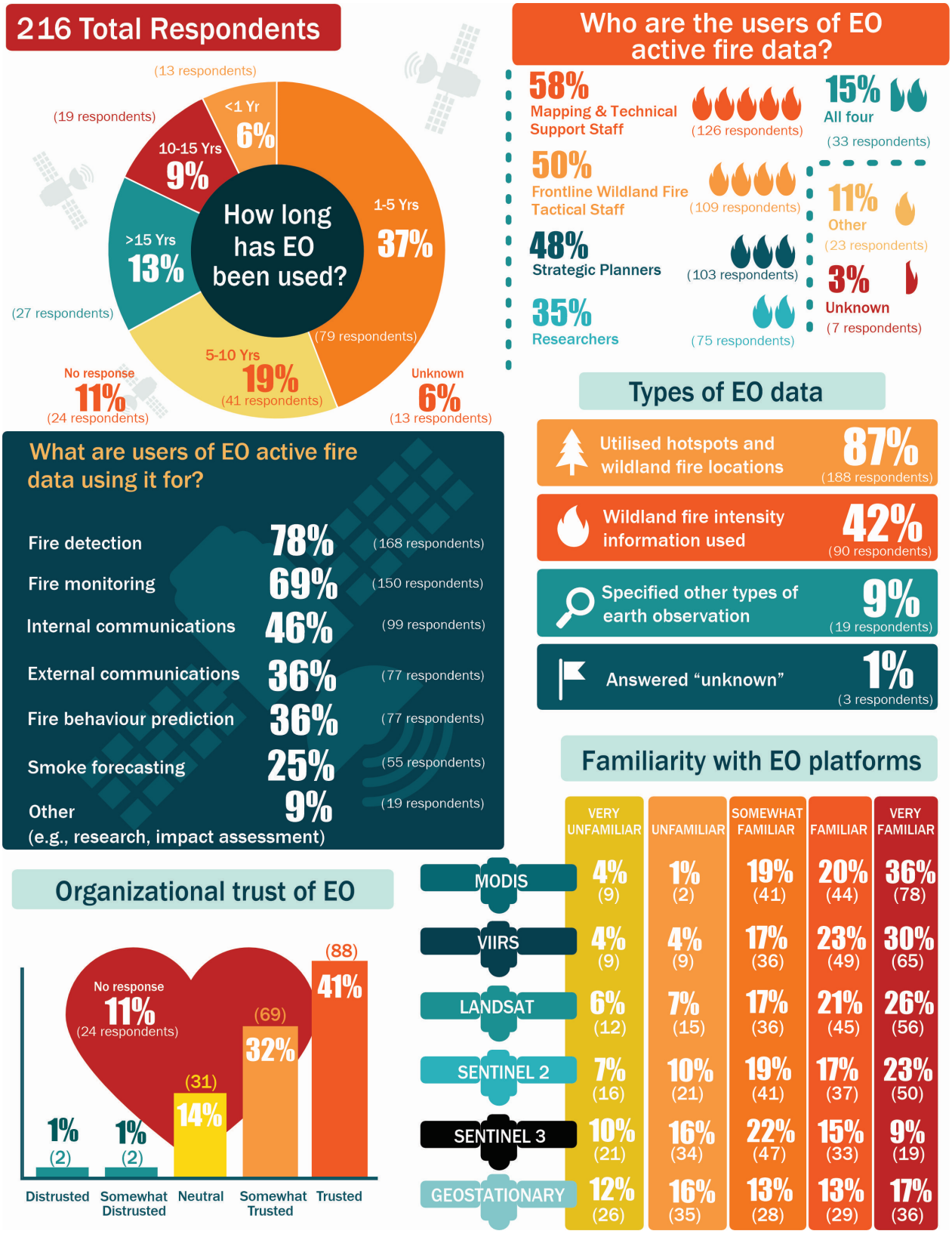

Figure 2. Infographic of EO-AFDP fire management organizational use. This infographic presents responses from only those survey respondents who indicated that their agency uses satellite data (n=216). Number of respondents in parentheses.

Observations and Perspectives

While our survey responses have a North American bias, we received responses from most areas of the world. Most respondents were affiliated with governmental fire management organization (58%). The regional, provincial, or state jurisdiction was most represented with 36% of respondents. Fire response and preparedness activities had the greatest number of responses (71%). Most respondents reported that their organization's objectives were the protection of life and property (69%). It is encouraging that 87% of respondents reported use of EO-AFDP in their organizations.

While many respondents indicated their organization has long established use of EO-AFDP (41 % > 5 years of use), a similar number of organizations are relatively recent adoptees (43 % < 5 years of use), suggesting that there is more recent growth in the uptake of EO-AFDP for fire management. Likewise, it is encouraging that many respondents report at least some level of organizational trust in EO-AFDP (73%).

Of those organizations that use EO-AFDP the primary use is for fire detection (78%), a relatively large number of users (69 %) are also making use of the products for fire monitoring. Within organizations the largest group of end-users are mapping and technical support staff (58%). 'Hotspot' data (points indicating the location and timing of fires) are the most used type of data by respondent's organizations (87%).

Of the organizations that use EO-AFDP, familiarity with EO platforms is generally high, especially for those platforms that have well established and widely available active fire products. For example, MODIS has been in operation since the early 2000s, with fire products accessible for ~20 years, and 75% of respondents were at least somewhat familiar with it. Similar familiarity was found for VIIRS (70%), Landsat (64%), and Sentinel 2 (59 %). However, there was less familiarity with Sentinel 3 (46%), and Geostationary satellites (43%). Sentinel-3 does not yet have a publicly available hotspot product, while geostationary satellites likely have fewer operational applications for fire management due to coarser spatial resolution and the ability to 'see' fewer fires than most polar orbiting satellites (see de Jong & McFayden 2023 for details).

Barriers to access EO-AFDP by fire management organizations persist and a range of responses were provided. Generally, responses fell into the 9 categories in Figure 3 (respondents could select more than one barrier). Barriers that did not fit any theme well were classified as 'other' and range in diversity and therefore make up the largest category. These other barriers include overall data availability, data dissemination methods, and permissions as a few examples. Furthermore, other respondents highlighted that smoke and cloud limit the usefulness of EO-AFDP, which may hinder uptake if these products are seen as of limited value.

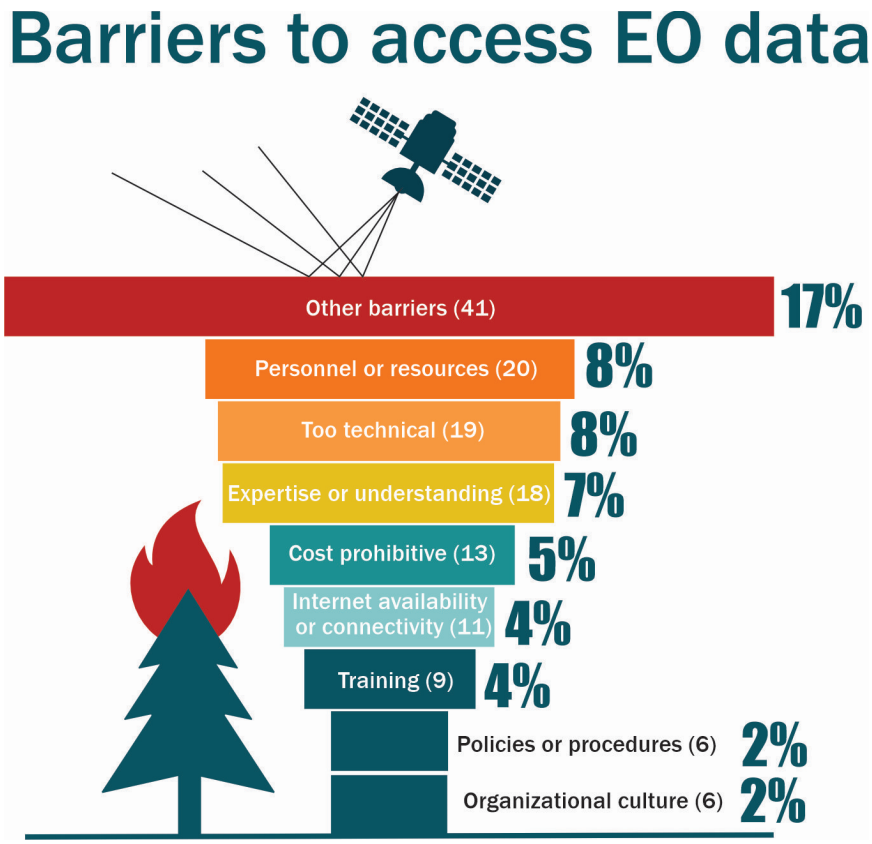

Figure 3. Barriers to access EO data from EO users and non-users organizations.

Limitations

Although we encouraged broad participation with a focus on 'operational wildland fire management', there is a bias toward EO users because of who we distributed the survey to (Table 1), a good portion of networks we approached are connected to EO initiatives. We acknowledge that our survey approach is likely insufficient to attain a deep understanding or adequate representation of global end-users. We also do not differentiate respondents reporting from the same organization or explore differences between their organizational assessment. Furthermore, there are underrepresented countries, groups and peoples that our survey method was not tailored for or accessible to (e.g., reliance on existing digital networks such as the FIRMS mailing list). The insights from this work may identify areas with low representation that could indicate the need for locally focused, culturally sensitive relationship building to better address a shared understanding. Future work may include carrying out locally focused semi-structured interviews to better increase inclusivity and our shared understanding.

Next Steps

The data from this survey will be used in further analysis to explore associations between different attributes of 'fire manager' EO-AFDP end-users. This may provide insight into different organizational archetypes (e.g., EO-AFDP trusting organizations). Looking for similarities in attributes of organizational fire management, EO-ADFP use, barriers and aspirations may inform recommendations for where, and what kinds of, capacity development efforts are needed for EO-AFDP in operational fire management.

Acknowledgement

This work was facilitated by the Government of Canada's WildFireSat mission team and done in support of the CEOS Working Group on Disasters, Wildfire Pilot. We especially thank Peter Moore who supported the early stages and design of the survey as the Forestry Officer of the Forest Fire Management & Disaster Risk Reduction, FAO-Food and Agriculture Organization of the United Nations when the project commenced. Lynne Dalgleish from ThinkLink Graphics assisted in the design of infographics. David Young and Alex Zahara of the CFS provided thoughtful comments.

We thank the following for assisting in the survey distribution: Jesus San-Miguel (Joint Research Centre of the European Commission), Krishna Prasad Vadrevu and Diane Davies (NASA), Helene De Boissezon (Centre national d'études spatiales), Everett Hinkley (United States department of Agriculture, Forest Service), Tina Saryeddine (Canadian Association of Fire Chiefs), Marta Yebra (Australian National University), Chelene Hanes and Natasha Jurko (Natural Resources Canada, Canadian Forest Service), Jennifer Zhu (Canadian Space Agency). We also thank the participation of the various networks and people who helped circulate and respond to the survey. Any omission is involuntary.

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Appendix 1 – Survey questions

Section 1: Characterizing the organizational structure of wildland fire management end-users

- Please provide the name of the wildland fire management organization you represent.
- What type of wildland fire management organization do you represent?
    - Government (e.g., branch, agency, department, etc.)
    - Contract to government (e.g., contract wildland fire suppression)
    - Private industry (e.g., forest owner)
    - Other (please specify)
- Please indicate which country your wildland fire management organization operates in.
- If appropriate, please indicate the region your wildland fire management organization operates in (e.g., province, state, territory, etc.).
- What jurisdiction does your organization operate in?
    - Federal
    - Regional/Provincial/State
    - Local/Municipal
- What are the objectives of your wildland fire management organization? Please select all that apply.
    - Protect life and property
    - Limit area burned
    - Encourage beneficial wildland fire
    - Other (please specify)
- Which of the following activities are performed by your wildland fire management organization? Please select all that apply.
    - Prevention - use of law/regulation, education, enforcement
    - Preparedness - readiness, planning, daily coordination-alert of firefighting resources
    - Response - the discovery/detection, dispatch, first response, containment, suppression, command and control
    - Mitigation - fuel reduction, community protection zones, fuel breaks, use of fire
    - Recovery - environmental repair, economic loss reduction, community welfare
    - Other (please specify)

Section 2: Characterizing the use of Earth Observation data

- Are Earth Observation data and active wildland fire management products used within your fire management organization?
    - Yes
    - No
- How are Earth Observation data and active wildland fire management products used within your fire management organization? Please select all that apply.
    - Wildland fire discovery/detection
    - Behaviour prediction
    - Active wildland fire monitoring
    - Smoke forecasting
    - Internal communications (e.g., situational awareness)
    - External communications (e.g., public messaging)
    - Unknown
    - Other (please specify)
- What kind(s) of Earth Observation data does your wildland fire management organization use for active fire management? Please select all that apply.
    - Raw data use and viewing
    - Raw data downloaded to support internal decision support products
    - Decision support products produced by an external organization (please indicate the product and organization)
    - Unknown
    - Other (please specify)
- What types of Earth Observation data and active wildland fire management products are used by your wildland fire management organization? Please select all that apply.
    - Hotspots and wildland fire location information
    - Wildland fire intensity information (Fire Radiative Power, temperature, etc.)
    - Unknown
    - Other (please specify)
- How long has your fire management organization used Earth Observation data and active wildland fire management products?
    - Less than one year
    - Between 1 and 5 years
    - Between 5 and 10 years
    - Between 10 and 15 years
    - More than 15 years
    - Unknown
- Please describe where your organization acquires its Earth Observation data or active wildland fire management products. For example, an online platform of some kind (FIRMS, GWIS, etc.), a direct downlink, or from a third party or private company (Planet, etc.).

- Who within your wildland fire management organization uses Earth Observation data and active wildland fire products? Please select all that apply.
    - Frontline wildland fire tactical staff (shorter term decision making, fire level)
    - Strategic planers (longer term decision making, larger areas)
    - Mapping and technical support staff
    - Researchers
    - Unknown
    - No User
    - Other (please specify)
- Please describe when Earth Observation data and active wildland fire management products are used. Are they employed in all situations (e.g. daily planning), or only for specific events (e.g., when in a triage situation, disaster management, etc.)?
- How often are the Earth Observation data and active wildland fire management products used? Please select all that apply.
    - Daily
    - Weekly
    - Monthly
    - As Needed
    - Unknown
    - Other (please specify)
- How trusted are the Earth Observation data and active wildland fire management products within your organization? (e.g., will your agency dispatch firefighting resources on hotspot detections, or monitor a fire without an aircraft and a person?)
    - Distrusted
    - Somewhat distrusted
    - Neutral
    - Somewhat trusted
    - Trusted
- Does your wildland fire management organization also perform research and product development with Earth Observation data?
    - Yes
    - No
- Please briefly describe the research and product development with Earth Observation data that your wildland fire management organization performs.
- Is the use of Earth Observation data and active wildland fire management products formalized in the policies and processes of your organization (e.g., is there a policy that directs or governs its use)?
    - Yes
    - No
- Please briefly describe the policies and processes within your organization that formalize the use of Earth Observation data and active wildland fire management products.
- Please describe if Earth Observation data are used solely for active wildland fire management, or also used to support other aspects of wildland fire management. (e.g., health impacts/smoke air quality monitoring, pre-fire fuel characteristics, post-fire reporting, etc.)

- Do you have personnel specializing in Earth Observation within your organization in the following capacities: (please select all that apply)
    - Earth Observation specialists
    - Modelers who can carry out wildland fire modelling
    - Remote sensing specialist who understands Fire Radiative Power (FRP) and its role in determining wildland fire intensity
    - A GIS/Mapping specialist who understands how to derive products such as active perimeters, burning areas to disseminate to field staff
    - Unknown
    - None
- Does your wildland fire management organization provide training in any of the following areas: (please select all that apply)
    - Basic Earth Observation data use and collection
    - Background to thermal infrared, FRP and how they can be applied to wildland fire management.
    - Smoke plume modelling
    - Interpretation of Earth Observation products for wildland fire suppression (hotspot/active area maps etc.).
    - Unknown
    - None
    - Other (please specify)
- How familiar is your wildland fire management agency with the following sources of satellite Earth observation data?
    - MODIS
    - VIIRS
    - Landsat
    - Sentinel 2
    - Sentinel 3
    - Geostationary satellites (GOES, Metosat, Himawari etc.)
        1. Very unfamiliar
        2. Unfamiliar
        3. Somewhat familiar
        4. Familiar
        5. Very familiar

Section 3: Characterizing the barriers (or facilitators) for Earth Observation use

- Please rate the overall integration of Earth Observation within your wildland fire management organization. Assume 5 is very integrated (meaning there is a high level of knowledge, training, technology, product, and policy/procedures for use) and 1 is not used/integrated at all.
    1. Unintegrated
    2.
    3. Somewhat integrated
    4.
    5. Very integrated

• Please rate the overall accessibility of Earth Observation data within your wildland fire management organization. Assume 5 is very accessible by wildland fire management organizations, and 1 is not at all accessible.

1. Not at all accessible
2.
3. Somewhat accessible
4.
5. Very accessible

- Are there any barriers to accessing Earth Observational data? If so, what are they? (i.e., are there any reasons why your organization might like to use remote sensing data, but cannot?)
- Are there any facilitating features that support access to Earth Observation data? If so, what features are working well?

Section 4: Aspirations

- Overall, how much do you agree that your fire management agency has access to useful Earth Observations products for wildland fire management?
    1. Totally disagree
    2.
    3. Neither agree or disagree
    4.
    5. Totally agree
- What should the priority be for the development of future Earth Observation wildfire management data products?
- Are there any Earth Observation wildfire management data products or tools under development within your organization? If so, please describe.
- What other groups or stakeholders would benefit from access to Earth Observation active wildland fire products?
- Are there any barriers to accessing Earth Observational data? If so, what are they? (i.e., are there any reasons why your organization might like to use remote sensing data, but cannot?)
- What should the priority be for the development of future Earth Observation wildfire management data products?
- Are there any Earth Observation wildfire management data products or tools under development within your organization? If so, please describe.
- What other groups or stakeholders would benefit from access to Earth Observation active wildland fire products?