CEOS WG Disasters
Wildfire Pilot Implementation Plan
March 2021

<table>
<tr><td>Wildfire Pilot
October 2020- end 2023
Theme area: Wildfire risk mitigation</td><td rowspan="2">Co-Leads:
Dr. Joshua M. Johnston, Canadian Forest Service (CFS)
Helena van Mierlo, Canadian Space Agency (CSA)
Dr. Doug Morton, NASA
Dr. Peter Moore, United Nations - Food and Agriculture Organization (UN-FAO)

User Implementation Lead: CFS & FAO
CEOS Implementation Lead: CSA & NASA

Contributing projects:
- GOFC-GOLD Active Fire review study
- DLR FireBird Missions
- CSA WildFireSat (WFS) Mission
- NASA/UC-Irvine C-FIRES Proposal
- NASA Fire Earth Information System Pilot</td></tr>
<tr><td>Geographic areas of focus:
Global terrestrial vegetated landmass</td></tr>
<tr><td>Partners:
CEOS partners:
NASA, ESA, ISRO, NOAA, CNES, DLR, CSIRO, ROSKOSMOS, ASI, CSA, GA

Other partners:
NRCan-CFS, ECCC, GOFC-GOLD Fire IT, ASA, INGV, UMD, AEM, USDA, UK-OS, WMO, NOA, AU BOM, UN GGIM WG Disasters, UN-FAO, UQ, KCL, CAS, ANU, UAF</td><td>Pilot objectives:
To provide a fundamental basis for defining global priorities for active-fire monitoring and characterization (the motivation for this pilot is described in detail in Appendix A.)

Four specific objectives have been identified
1) Conduct a detailed inventory and gap analysis of existing and proposed EO systems suitable for global active-fire monitoring
2) Conduct a detailed analysis of global stakeholders and end-users of near-real-time active-fire EO data
3) Define targeted user requirements for active fire remote sensing systems for the disaster mitigation applications
4) Propose a way forward in coordinating global wildfire monitoring activities

CEOS objectives:
1) Identify the global wildfire EO stakeholder and end-user communities
2) Demonstrate that global wildfire disaster risk mitigation is possible through a coordinated approach to global active-fire monitoring via EO</td></tr>
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Description:
Objectives 1 and 2 may be conducted simultaneously, and the results will inform Objectives 3 and 4.

Objective 1:

- Work directly with the GOFC-GOLD Fire IT to conduct preliminary reviews and generate an inventory of active-fire systems and products (e.g. Wooster et al. (in prep)), to include/consider
    - Capabilities of individual systems and products
    - End of life projections for existing systems
    - Future public and commercial systems
- Use the EO current and future systems inventory to construct a timeline of global coverage density/quality for the foreseeable future
- Pair the EO systems timeline with a geospatial climate change modelled timeline to assess future capacity from expected changes in global wildfire activity, and identify strategic gaps in future fire monitoring

Objective 2:

- Solicit the members of the GOFC-GOLD Fire IT and affiliated Regional Networks to enumerate their international and local stakeholders and end-users
- Request assistance from the FAO Forestry Department's wildfire team in identifying stakeholders not captured in the initial screening (e.g. those in developing countries)
- Based on the initial findings, adopt a more regionally specialized approach where necessary to ensure direct interactions with fire management agencies and regional users/interest groups
- Categorize stakeholders according to
    - Organization type (e.g. government, industry, academia)
    - Stake/role in active-fire EO (e.g. SBEO data reception/storage, cal-val operators, data service provider, airborne data provider, i.e. any role in the chain of getting SBEO data to the end-user)
- Categorize end-user groups according to
    - Organization type (e.g. government, industry, academia)
    - Data level required (e.g. raw data, L-1,2,3, etc)
    - Type of application (e.g. emergency response, etc)
    - Urgency (e.g. Near-real-time, 1 hr latency, etc)
- Ask end-users
    - to identify the extent to which SBEO data supports their organization
    - which tools they use to access the EO data
    - what limitations and barriers they have encountered in operationalizing these tools

Objective 3:

- Employ an approach similar to that for targeted mission such as WildFireSat in defining User Requirements (https://doi.org/10.3390/s20185081) for addressing specific gaps/limitations defined in Objectives 1 and 2
- Segment regional and operational gaps into separate challenges which can be addressed by specific EO missions (e.g. LEO, GEO, HEO) at specific temporal gaps in the future timeline
- Identify general measurement and precision specifications required for active-fire monitoring and characterization for reference in future system designs
- Adapt specific examples of how these requirements can accommodate various spatial and temporal resolutions typical of various orbit/mission configurations

Objective 4:

- Use results of Objective 1 to establish a timeline and road map that can be used to ensure adequate global wildfire monitoring is achieved and maintained for the foreseeable future
- Use results of Objective 2 to identify and establish communities of practice to ensure efficient knowledge exchange in the operational application of emerging EO capabilities
- Use results of Objective 3 to guide the technical design of future systems to ensure that Objective 1 is delivered to the standards required by the stakeholders identified in Objective 2

CEOS contribution to pilot:
The primary contribution required from CEOS members is access to technical and planning information relating to their existing and planned satellite missions which may have utility in active-fire EO. The project team will consult the various CEOS working groups to identify relevant frameworks and approaches, particularly for engaging with the international community for Objective 2, and in the delivery of Objective 4.

Key pilot outputs/deliverables:
The pilot will generate a master report on the current and future state of global active-fire monitoring via EO detailing the results of Objectives 1-4.

Additional outputs for each Objective include

Objective 1:

- Peer-reviewed publication/s presenting the findings of the projected gap analysis in the context of climate change

Objective 2:

- Creation of sub-group/s capable of representing global user requirements for future endeavors/impact assessments (from identification of the global community of wildfire monitoring stakeholders and end-users)

Objective 3:

- Peer-reviewed publication/s describing the scientific approach to defining and adapting user requirements for active-fire monitoring for various mission types (e.g. LEO; GEO; HEO)

CEOS outputs/deliverables:
Objective 4 will enable CEOS to identify a global strategy for future global active-fire monitoring via EO and a framework for future mission coordination.

Key outcomes:

1) Explore existing and anticipated gaps in wildfire EO capabilities
2) Identify the global community of wildfire stakeholders and end-users, and establish a framework for ongoing interaction and collaboration
3) Articulate user requirements for active-fire remote sensing
4) Propose a way forward to closing existing and future gaps

The pilot project will consider the need for conducting comparable projects for other disciplines of wildfire EO (e.g. pre-fire and post-fire monitoring).

The pilot project will link space- with air- and ground- measurements where applicable.

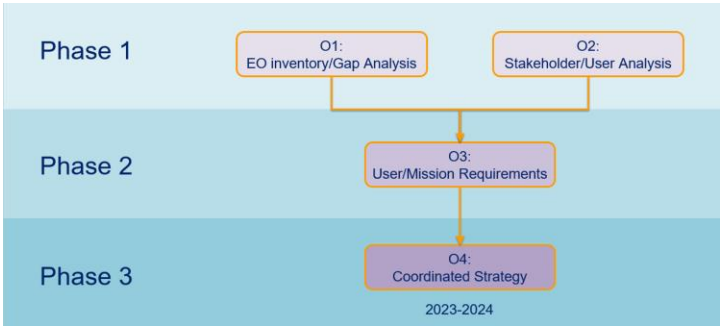
The pilot project will include both governmental initiatives and commercial efforts to conduct a detailed inventory and gap analysis of existing and proposed EO systems.

Key end-user communities:

- Wildfire managers and suppression agencies
- Interdisciplinary experts in integrated fire management
- Governmental and regional disaster coordination bodies
- Air quality and health monitoring agencies
- Carbon accounting and land cover/use reporting groups
- Natural resource managers and policy makers
- Forestry, mining, power generation, telecommunications, transportation, infrastructure industrial stakeholders
- Academia, public and private research groups
- CEOS member agencies

Milestones and schedule:

Progression and dependencies of the 4 pilot objectives are shown below. Results of Objectives 1 and 2 are required to prioritize developments for Objective 3, and all components will be compiled and summarized in Objective 4.



2021-2022:

Objective 1:

- Assemble datasets to form a spatial and temporal global fire regime dataset with climate change projections on 5 year intervals (2020-2050)
- Identify existing and future active fire EO capabilities and coverage areas
- Map existing EO coverage and future projections on 5 year intervals
- Develop metrics for analysing fire regime and EO capability change correlations

Objective 2:

- Outreach to regional networks and partners to identify stakeholders and end-user communities
- Engage end-users (directly or through regional partners) to identify:
    - Agency responsibilities, priorities and perceive challenges in the future
    - User sophistication level (i.e. level of training, agency capacity/policy)
    - Current level of use and use cases

2022-2023:
Objective 1:

- Finalize scientific analysis, peer-reviewed publications

Objective 2:

- Document regional end-user capacity and requirements for EO and HQP development
- Develop a global knowledge exchange strategy to advance end-user up take of active wildfire EO data

Objective 3:

- Identify mission profiles (GEO, LEO, HEO) required to address gaps in Objective 1
- Link the mission profiles to the primary end-user group and their respective priorities, based on the spatial temporal location of identified gaps
- Draft User and Mission Requirements for the mission profiles

2023-2024:
Objective 4:

- Merge outputs of Objectives 1-3 into a strategic plan for adapting wildfire EO to mitigate the evolving risk of disasters under climate change
    - Objective 1 – current and future gaps and associated risks
    - Objective 2 – regional end-users at risk of the consequences of Objective 1, and framework for regional targeted engagement
    - Objective 3 – user and mission requirements to guide the development of EO systems to address these gaps
    - A proposed timeline for new systems development, outreach and primary stakeholders at each stage

EO data requirements:
The initial focus will be availability of EO active fire data sources (i.e. thermal IR enabled systems). For Objective 1, no direct requirement for EO data is envisioned, but access to technical and programmatic information related to system design, capabilities, and projected commissioning/decommissioning timeframes may be requested.

As the pilot progresses, direct access to wildfire EO data may be required to engage regional stakeholders and demonstrate potential use cases for their needs. Active fire products will be accessed through the Global Wildfire Information System, and/or NASA FIRMS and Worldview portals.

Main contributions by partner:
Project leadership:
NRCan, CSA, UN FAO, NASA

Scientific steering panel:
NASA, ECCC, UMD, USDA, NOAA, KCL, ANU

Existing and planned EO system information:
NASA, CSA, ESA, ISRO, ASA, CNES, DLR, ROSKOSMOS, ASA, NOAA, CAS

Regional partner engagement:

NRCan, UN FAO, INGV, ESA, ISRO, ASA, CNES, AEM, CSIRO, Ordnance Survey, WMO, NOA, ROSKOSMOS, AU BOM, UN GGIM WG-Disasters, ASI, GA, KCL, CAS, ANU, UAF

Data access:
ESA, NASA, NOAA

Capacity building and outreach activities:
Objective 2 will focus on outreach and capacity building. In regions where knowledge and expertise is limited, the pilot is expected to initiate capacity building processes. The extent to which the pilot will be involved in these initiatives is uncertain; however, contributing partners (e.g. UN agencies) are anticipated to continue engaging with these groups beyond the pilot.

Suggested evaluation criteria:

1. Explicit identification of existing and future gaps in wildfire EO capabilities relative to climate change
2. Identification of a global community of wildfire stakeholders and end-users
3. Definition and documentation of user requirements for global active-fire monitoring via EO
4. Proposal and documentation of a strategic path for closing existing and future gaps in global active-fire monitoring via EO

Pilot contributors (as of March, 2021):
Vince Ambrosia, NASA
Stefania Amici, INGV
Olivier Arino, ESA
Philippe Bally, ESA
Bimal Bhattacharya, ISRO
Reece Biddiscombe, ASA
David Borges, NASA
Alan Cantin, NRCan
Allison Craddock, NASA JPL
Ivan Csiszar, NOAA
Didier Davignon, ECCC
Pierric Ferrier, CNES
Christian Fischer, DLR
Louis Giglio, UMD
Adrian Guzman Gonzalez, AEM
Alex Held, CSIRO
Everett Hinkley, USDA
David Hodgson, Ordinal Survey
Ken Holmlund, WMO
Dan Johnston, NRCan
Joshua Johnston, NRCan
Sebastian Kleim, DLR
Haris Kontoes, NOA
Andrey Kuklin, Roscosmos
Agnes Lane, AU BOM
Simone Lloyd, UN GGIM WG-Disasters
Antonio Montuori, ASI
Peter Moore, FAO
Doug Morton, NASA

Norman Muller, GA
Dorella Papadopoulou, ARGANS (ESA)
Amy Parker, CSIRO
Mike Pavolonis, NOAA
Stuart Phinn, UQ
Ellen Ramirez, NOAA
GS Rao, ISRO
Arijit Roy, ISRO
Wilfrid Schroeder, NOAA
Daniel Thompson, CFS
Helena van Mierlo, CSA
Jean Paul Vernier, NASA
Martin Wooster, KCL-UK
Weiyuan Yao, CAS
Marta Yebra, ANU
Robert Ziehl, UAF

Appendix A: CEOS Wildfire Pilot Overview

Global Wildfire Challenges

Globally wildfires burn nearly 4.3M km^{-2} annually. Climate drives fuels and moisture patterns and thereby controls fire regimes, and climate change compounded by continued population growth and expansion of wildland urban interface is contributing strongly to increased global wildfire activity and frequency of catastrophic wildfire events in recent years (e.g. Australia 2009, 2019/20; California 2018; South America 2019; Mediterranean/Greece 2018; Arctic 2019, Canada 2016, 2017, 2018), and an expansion of these events to unprecedented regions (e.g. Northern Europe).

Wildfire Earth Observation (EO) science

Wildfire EO dates back to the early days of satellite weather observations. The quality of EO data sources as well as the scientific techniques for observing global wildfire activity have evolved dramatically.

Wildfire EO is categorized into three phases:

- **Pre-fire characterization** of: vegetative fuels, live/dead fuel moisture, and soil moisture
- **Active-fire observation**: new fire detection, perimeter mapping, and energy and emissions characterization
- **Post-fire effects**; burned area and severity and impacts/recovery assessment

Despite no operational satellite systems designed explicitly for routine global wildfire monitoring, wildfire remote sensing science relying on exploitation of existing EO data streams are mature. Some countries implement local pre-, active-, post-fire monitoring systems (e.g. Brazil, Canada, USA, South Africa), while the Global Wildfire Information System (GWIS) provides global EO fire monitoring services. Near-real-time smoke and air quality monitoring is available both regionally and globally. Post-fire assessments monitor global carbon emissions and implications of climate change on wildfire activity. The Global Observation of Forest Cover and Land Dynamics (GOFC-GOLD) Fire Implementation Team (Fire IT) coordinates downstream science and product developments and has enabled the success of the fire monitoring community.

A coordination challenge

Almost all applications for wildfire monitoring products are derived from EO systems designed for general purposes. EO systems built for wildfire disaster management would prioritize low data latencies, unique overpass times, and spectral/spatial/temporal resolutions not in existing EO systems. Despite the leadership of the GOFC-GOLD Fire IT in downstream activities, their mandate does not extend to coordinating mid- and up-stream wildfire EO activities, contributing to its ad hoc nature.

While scientific applications of EO data have been successful, exploiting these systems for disaster response and management is problematic. The lack of standardization in EO wildfire products has led to the slow adoption rate of scientific methods into operations, and regional applications of the same EO data sources vary. For example, when the International Charter for Space and Major Disasters is enacted for wildfire emergencies (e.g. Canada, 2016; South Africa, 2018; Australia, 2020; Argentina, 2020), the required data types are often not known and requests for data acquisition are not targeted and can

overwhelm data centers. Many one-off products are created manually with limited value to the emergency responders, as opposed to the efficient, automated, application of robust science-based tools.

The understanding of regional gaps has enabled some countries to develop purpose-built wildfire monitoring missions (e.g. FireBIRD; WildFireSat). There has been a recent surge in commercial proposals to provide pay-for-service fire detection and/or monitoring satellite constellations (e.g. FireBall, Ororatech). Although these are potentially very useful, they remain largely disjointed, and without any formal international coordination there is a risk of redundancy.

The Way Forward

Global coordination of the mid- and up-stream wildfire EO initiatives would enable the development of virtual constellations for pre-, active-, and post- wildfire monitoring, with standardized processing and product delivery, ensuring maximum value to emergency management from EO systems and an efficient adaptation to the increasing threat of wildfires driven by climate change.

Given the operational shortcomings of existing wildfire monitoring capabilities and data requirements for tactical applications being far beyond future mission considerations, a first step to a coordinated global approach to wildfire monitoring would be to identify global and regional gaps in capabilities and define priorities and requirements for future satellite developments. Therefore a pilot study is proposed to conduct EO systems inventories and suitability assessments, a present and future gap analysis for each phase of fire monitoring (pre-, active-, post-fire), and detailed user requirements for each application.

Appendix B: Acronyms

Term	Definition
AEM	Agencia Especial Mexicana (Mexican Space Agency)
ANU	Australian National University
ASA	Australian Space Agency
ASI	Agenzia Spaziale Italiana (Italian Space Agency)
BIRD	Bi-Spectral Infrared Detection (DLR)
BOM	Bureau of Meteorology (Australia)
CAS	Chinese Academy of Sciences
CEOS	Committee on Earth Observation Satellites
CFS	Canadian Forest Service
CNES	Centre national d'études spatiales (French Space Agency)
CSA	Canadian Space Agency
CSIRO	Commonwealth Scientific and Industrial Research Organisation (Australian government agency)
DLR	Deutsche Luft- und Raumfahrtgesellschaft (German Space Agency)
ECCC	Environment Canada and Climate Change
EO	Earth Observation
ESA	European Space Agency
GA	Geoscience Australia
GEO	Geostationary Orbit
GEO	Group on Earth Observation
GOFC	Global Observation of Forest Cover
GOLD	Global Observation of Land Dynamics
GWIS	Global Wildfire Information System
HEO	Highly Elliptical Orbit
INGV	Istituto Nazionale di Geofisica e Vulcanologia (Italy)
ISRO	Indian Space Research Organization
IT	Implementation Team
JPL	Jet Propulsion Laboratory
KCL	King’s College London
LEO	Low Earth Orbit
NASA	National Aeronautics and Space Administration
NOA	National Observatory of Athens (Greece)

NOAA	National Oceanic and Atmospheric Administration
NRCan	Natural Resources Canada
OS	Ordnance Survey (UK)
SBEO	Space-Based Earth Observation
UAF	University of Alaska Fairbanks (USA)
UK	United Kingdom
UMD	University of Maryland
UN	United Nations
UN-GGIM	Regional Committee of United Nations on Global Geospatial Information Management
UQ	The University of Queensland (Australia)
USFS	United States Forest Service
WFS	WildFireSat
WG	Working Group
WMO	World Meteorological Organization