Canada Wide Mapping of Vegetation Properties

Natural Resources Canada
Richard Fernandes, Francis Canisius, Gang Hong, Lixin Sun, Darren Janzen, Rasim Latifovic

Digital Earth Canada:

Federal Gov’t Needs & Requirements Workshop

Section A: Overview of the EO Application

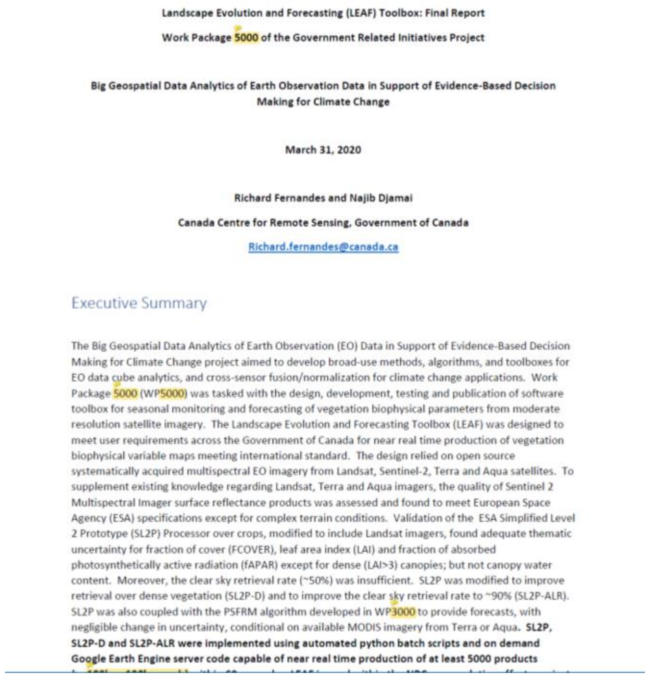
Section A: Overview of the EO Application

User Product Requirements

Global

Space Agencies

Canada



Landscape Evolution and Forecasting (LEAF) Toolbox: Final Report

Work Package 5000 of the Government Related Initiatives Project

Big Geospatial Data Analytics of Earth Observation Data in Support of Evidence-Based Decision Making for Climate Change

March 31, 2020

Richard Fernandes and Najib Djamai

Canada Centre for Remote Sensing, Government of Canada

Richard.fernandes@canada.ca

Executive Summary

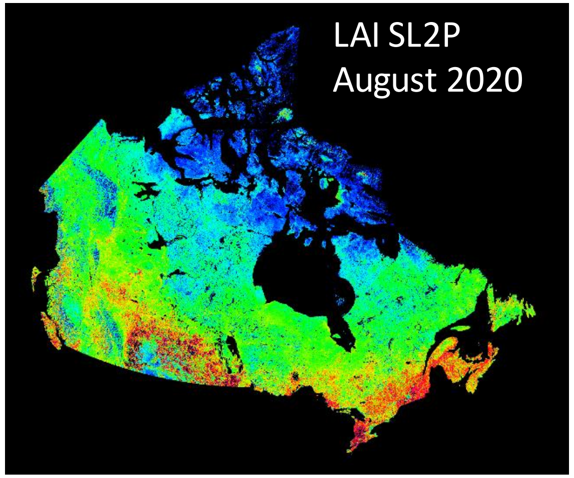
The Big Geospatial Data Analytics of Earth Observation (EO) Data in Support of Evidence-Based Decision Making for Climate Change project aimed to develop broad-use methods, algorithms, and toolboxes for EO data cube analytics, and cross-sensor fusion/normalization for climate change applications. Work Package 5000 (WP5000) was tasked with the design, development, testing and publication of software toolbox for seasonal monitoring and forecasting of vegetation biophysical parameters from moderate resolution satellite imagery. The Landscape Evolution and Forecasting Toolbox (LEAF) was designed to meet user requirements across the Government of Canada for near real time production of vegetation biophysical variable maps meeting international standard. The design relied on open source systematically acquired multispectral EO imagery from Landsat, Sentinel-2, Terra and Aqua satellites. To supplement existing knowledge regarding Landsat, Terra and Aqua imagers, the quality of Sentinel 2 Multispectral Imager surface reflectance products was assessed and found to meet European Space Agency (ESA) specifications except for complex terrain conditions. Validation of the ESA Simplified Level 2 Prototype (SL2P) Processor over crops, modified to include Landsat imagers, found adequate thematic uncertainty for fraction of cover (FCOVER), leaf area index (LAI) and fraction of absorbed photosynthetically active radiation (fAPAR) except for dense (LAI>3) canopies; but not canopy water content. Moreover, the clear sky retrieval rate (~50%) was insufficient. SL2P was modified to improve retrieval over dense vegetation (SL2P-D) and to improve the clear sky retrieval rate to ~90% (SL2P-ALR). SL2P was also coupled with the PSFRM algorithm developed in WP3000 to provide forecasts, with negligible change in uncertainty, conditional on available MODIS imagery from Terra or Aqua. **SL2P, SL2P-D and SL2P-ALR were implemented using automated python batch scripts and on demand Google Earth Engine server code capable of near real time production of at least 5000 products**

Section A: Overview of the EO Application

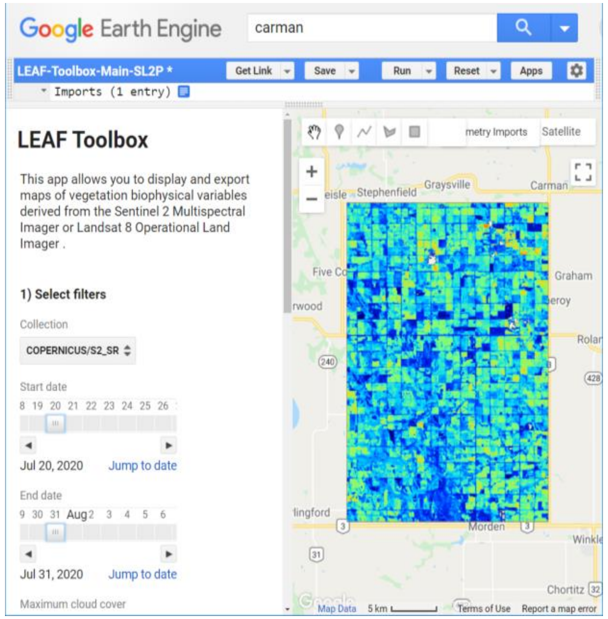
Products

Parameter	Abbrev.	Definition	Units	Range
Directional hemispherical albedo	Albedo	Ratio of upper hemisphere reflected to incident direct solar illuminaton at local overpass time.	ratio	[0,1+]
Fraction absorbed PAR	fAPAR	Fraction of incident PAR absorbed by vegetation at ~10am local standard time for direct solar illumination.	fraction	[0,1]
Fraction cover	fCover	Fraction of canopy cover projected on local horizontal datum.	fraction	[0,1]
Hemispherical directional reflectance	Rho	Ratio of sunlight reflected in direction of sensor to incident illumination at local overpass time	ratio	[0,1+]
Land Cover	LC	Land cover.	NALCMS legend	19 classes
Leaf Area Index	LAI	Have the total foliage surface area per unit ground area projected on local horizontal datum.	m2 foliage/m2 horizontal ground area	0-20
Leaf chlorophyll content	Cab	Mass of chlorophyll a and b per unit LAI.	g chlorophyll a+b/m^{-2} half foliage surface area	0-100
Leaf water content	Cw	Mass of H20 per unit LAI.	g H20/m^{-2} half foliage surface area	0-10

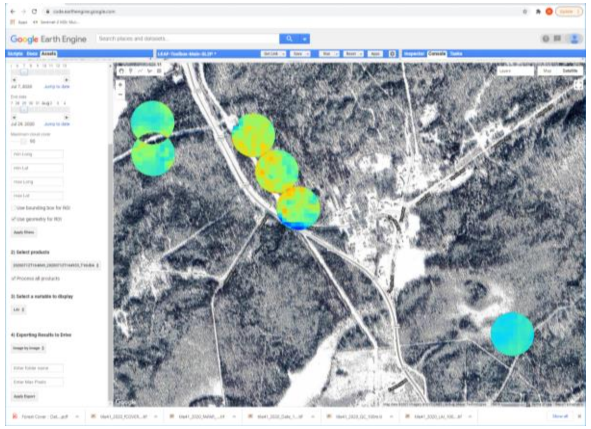
Data



Service

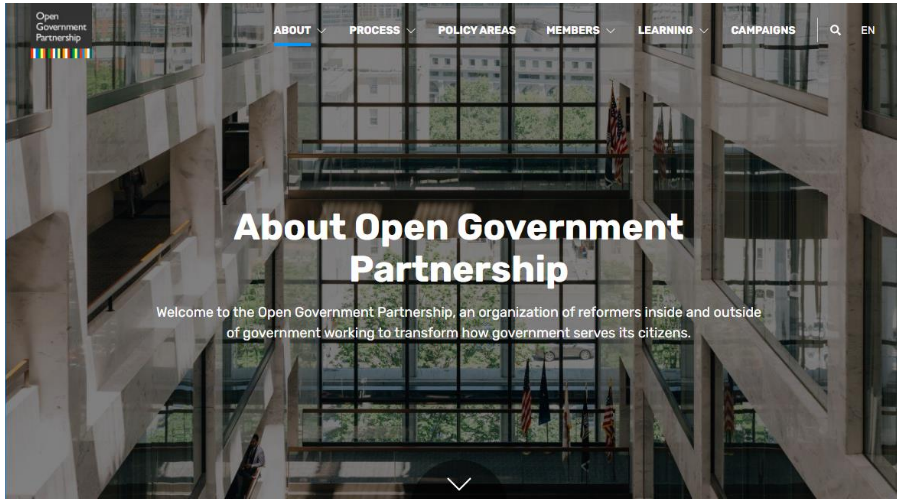


Quality Assurance



Section A: Overview of the EO Application

Design Philosophy: Free and Open



Commitments

Rows: 1-5 / 73 Page 1 of 15 Items: 5

Search Title, ID, Submitted, Country and Policy Areas

Title	ID	Submitted	Country	Policy Areas
User-Friendly Open Government	CA0064	2018	Canada	Open Data
Financial Transparency and Accountability	CA0065	2018	Canada	Anti-Corruption
Corporate Transparency	CA0066	2018	Canada	Anti-Corruption
Digital Government and Services	CA0067	2018	Canada	Digital Governance
Open Science	CA0068	2018	Canada	Open Data

What is open data?

Open data is defined as structured data that is machine-readable, freely shared, used and built on without restrictions.

The key things to remember about open data are:

- **Availability and access**: the data must be available as a whole and at no more than a reasonable reproduction cost, preferably by downloading over the internet. The data must also be available in a convenient and modifiable form.
- **Re-use and redistribution**: the data must be provided under terms that permit re-use and redistribution including the intermixing with other datasets.
- **Universal participation**: everyone must be able to use, re-use and redistribute. There should be no discrimination against fields of endeavour or against persons or groups. For example, 'non-commercial' restrictions that would prevent 'commercial' use, or restrictions of use for certain purposes (e.g. only in education), are not allowed.

Section A: Overview of the EO Application

System User Requirements

Natural Resources Canada

LEAF

Landscape Evolution and Forecasting Toolbox

USER REQUIREMENTS

	Name	Company	Date	Signature
Prepared by :	Richard Fernandes	CCRS	March 1, 2019	
Checked by :	Najib Djamai	CCRS		
Approved by :	Darren Janzen	CCRS		

Document reference :	LEAF-TN-001-CCRS
Issue.Revision :	1.1
Date :	01/03/2019
Client :	NRCan/CSA
Ref., Tender :	GEODE GRIP

System Load Requirements

Category	Baseline	Threshold	Goal	Description
Number of systems running	2	10	100	Number of deployed systems on single cloud service.
Number of users per system	10	1000	unlimited	Number of registered users
Maximum number of parallel service requests per system	2	Max(10,1% of user base)	Max(100,10% of user base)	Number of active service requests within system.
Maximum number input of L1A scene per request	1000	1500	1500	Assumes processing begins at L1B. Number of scenes in one request (~1500 scenes cover Canada for one sensor; 5000 ensures coverage from both sensors and territorial water). Includes scenes produced by temporal interpolation.
Maximum number output scenes per request	1000	1500	5000	Includes scenes produced by temporal interpolation.

Section A: Overview of the EO Application

System Design

Natural Resources Canada

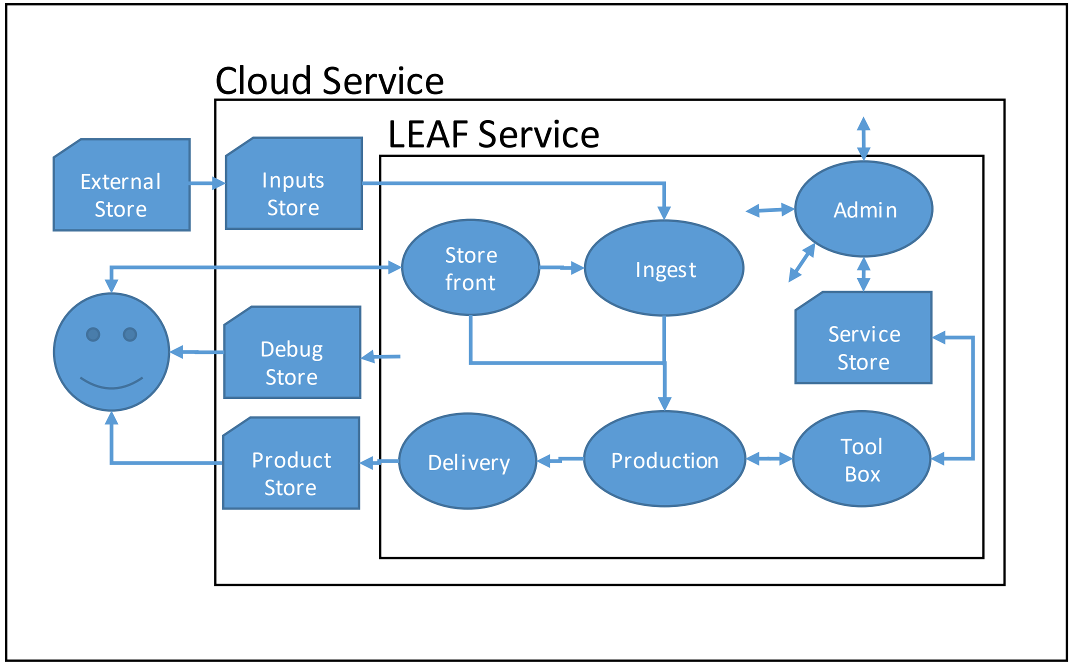
LEAF-Toolbox

Landscape Evolution and Forecasting Toolbox

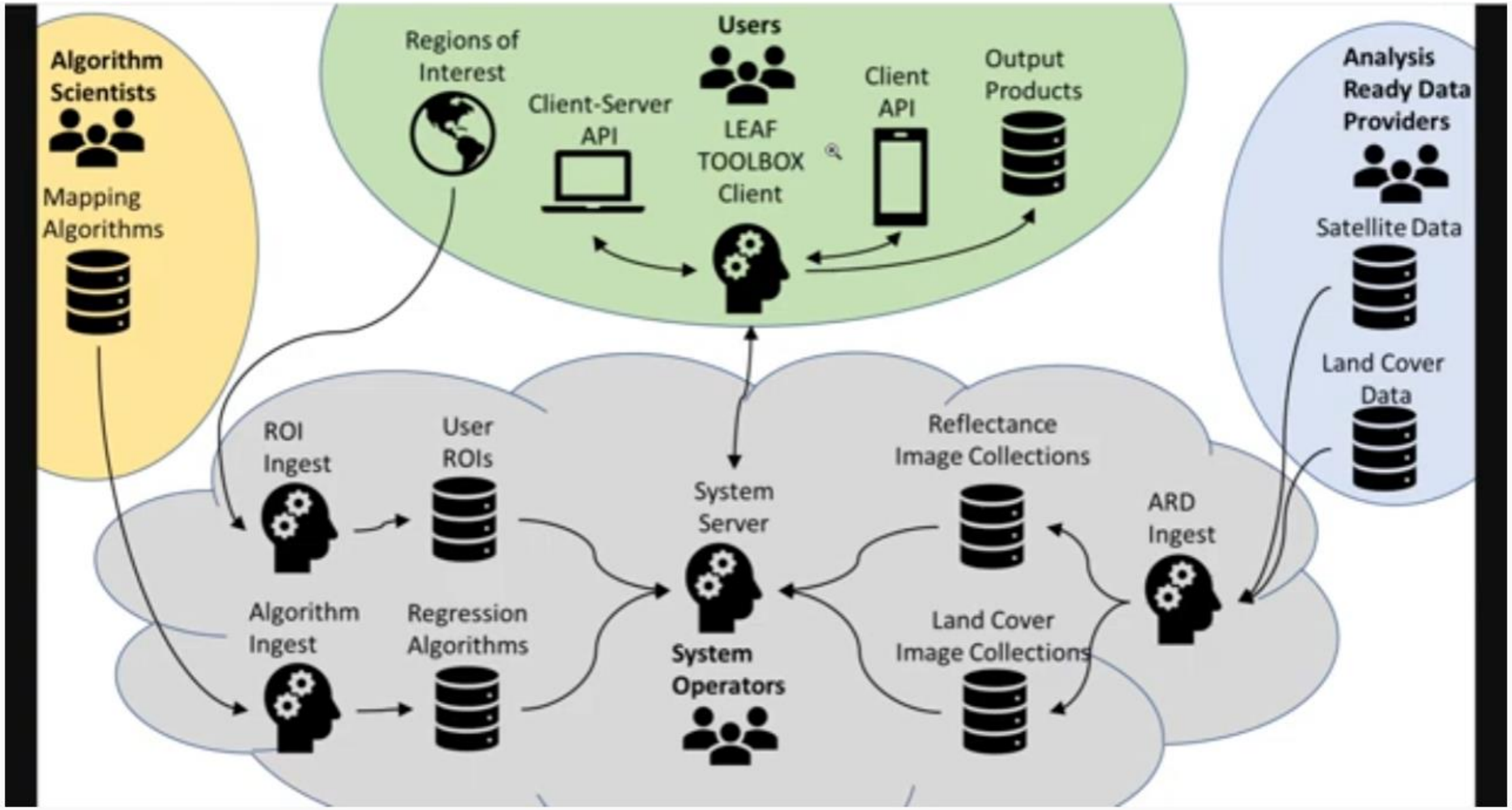
Cloud Service System Design

	Name	Company	Date	Signature
Prepared by :	Richard Fernandes	CCRS	March 1, 2019	
Checked by :	xx	CCRS		
Approved by :	Darren Janzen	CCRS		

Document reference :	LEAF-TN-002-CCRS
Issue.Revision :	1.1
Date :	15/04/2017
Client :	NRCan/CSA
Ref., Tender :	GEODE GRIP



Section A: Overview of the EO Application



Landscape Evolution and Forecasting Toolbox Overview

20 views • Nov 17, 2020

0 0 SHARE SAVE ...

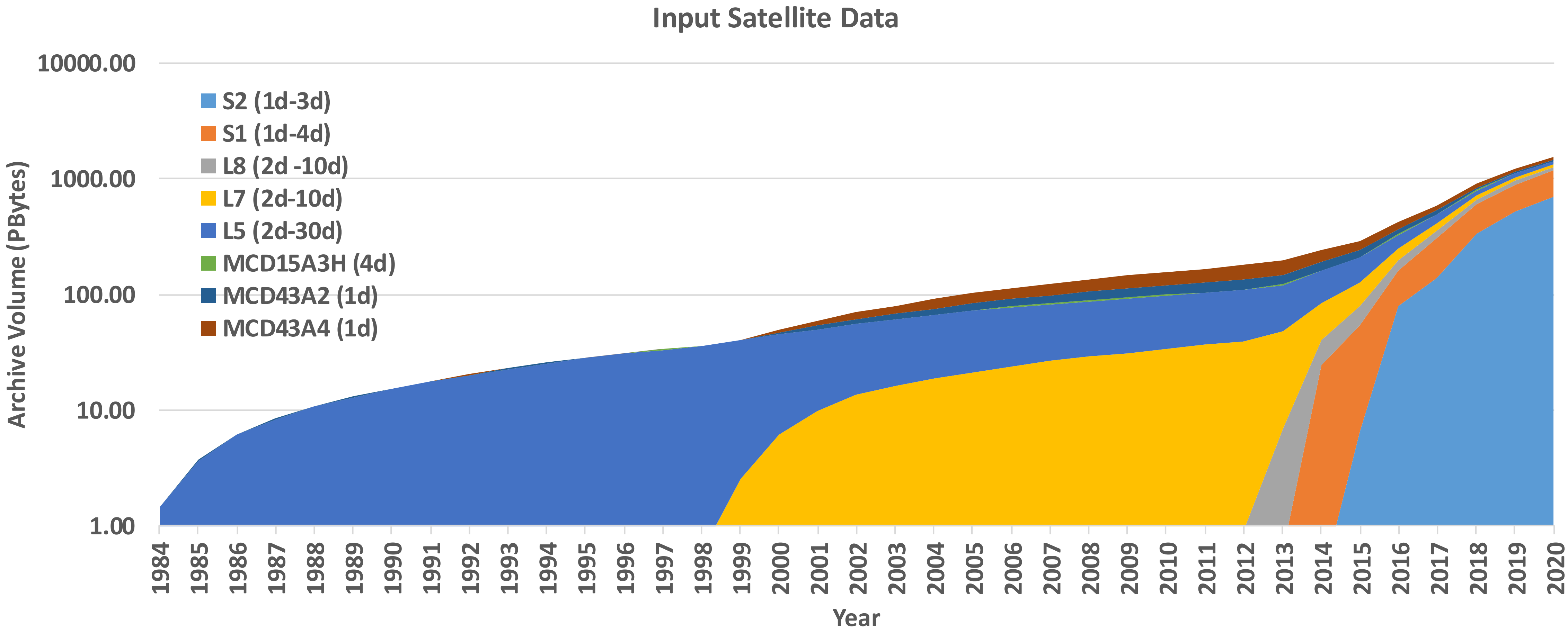
R Richard Fernandes

ANALYTICS EDIT VIDEO

A general overview of the Landscape Evolution and Forecasting Toolbox for mapping vegetation using satellite imagery. https://github.com/rfernand387/LEAF-T...

Section B: Addressing Specific Questions

Section B.1: Input Data Requirements



Free and Open: Google: Earth Engine ARD
USGS: L5,L7,L8: USGS GEOTIFF, MODIS: EOS NetCDF; ESA: S1,S2: ESA SAFE

Not Free but Open: AWS: L5,L7,L8: USGS GEOTIFF; S1,S2: ESA SAFE; MODIS: EOS NetCDF

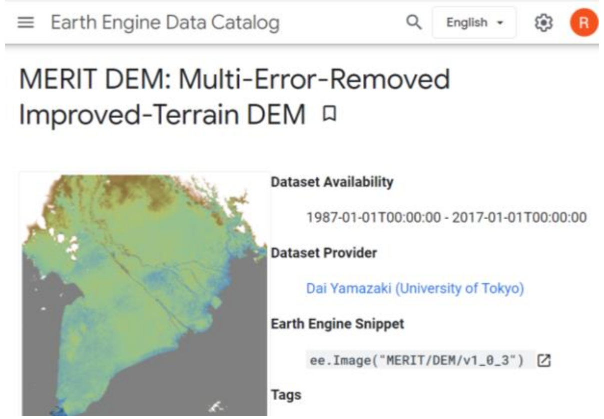
Free but Not Open: CCRS: L5,L7,L8: NLSC Raw

Section B.2: Other Data Requirements

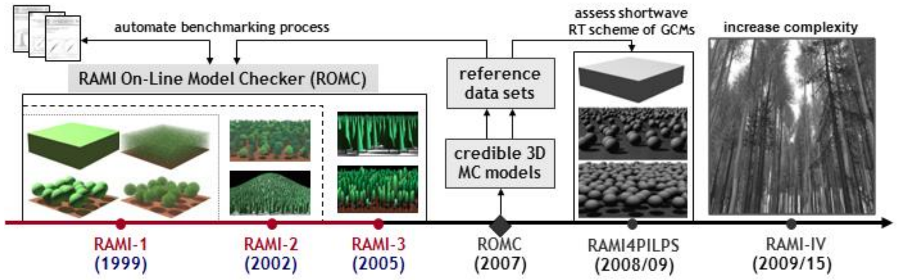
NALCMS 30m LC (in GEE)

CGLS 100m LC (in GEE)

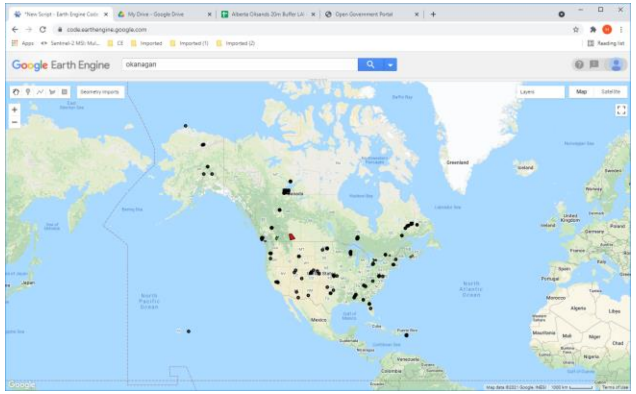
MERIT 30m DEM (in GEE)



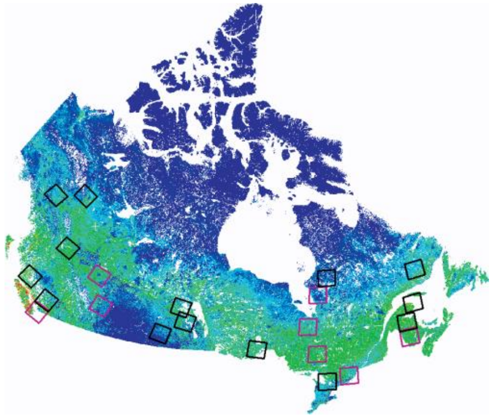
Radiative Transfer Model Simulations



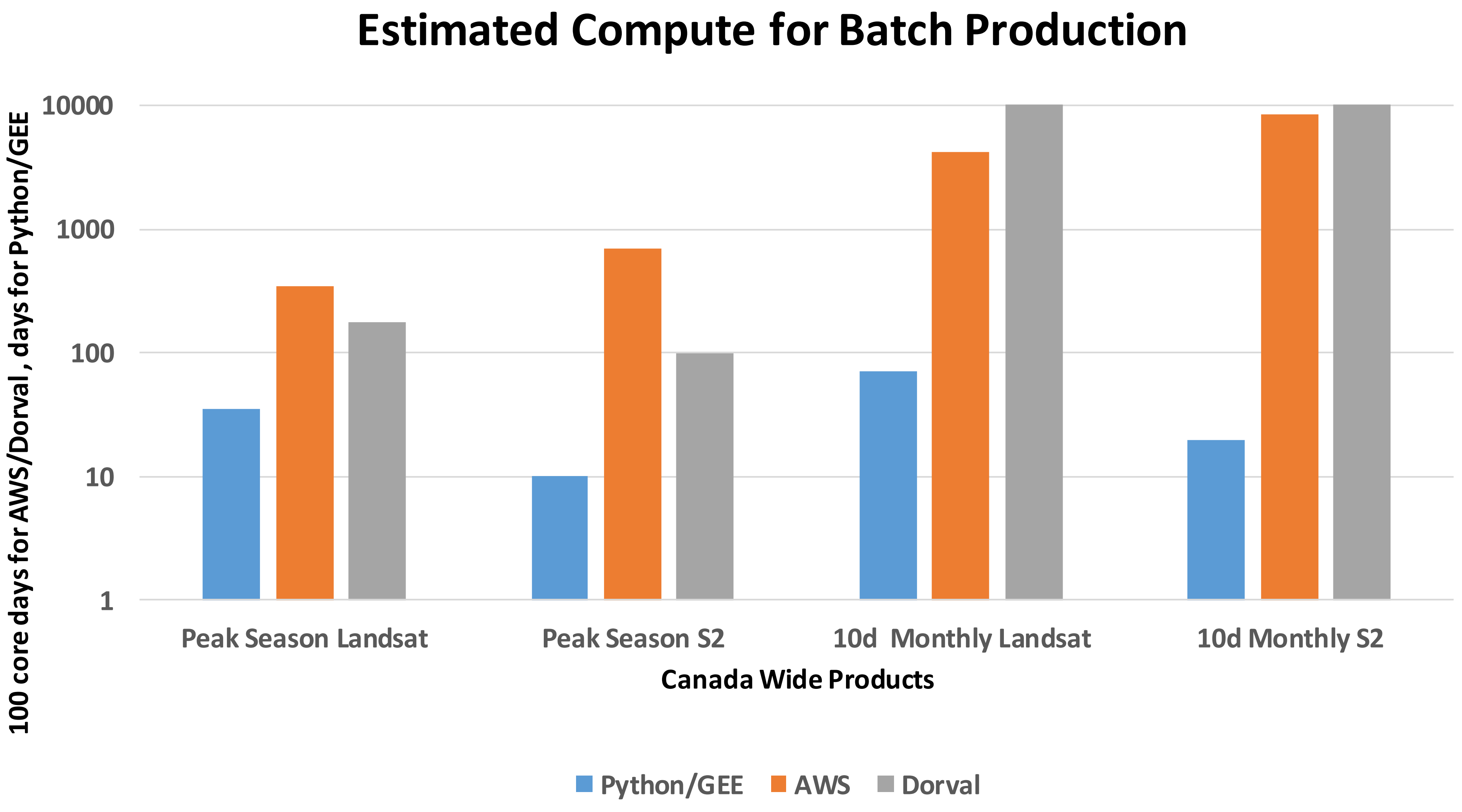
CEOS CAL/VAL Networks/Data



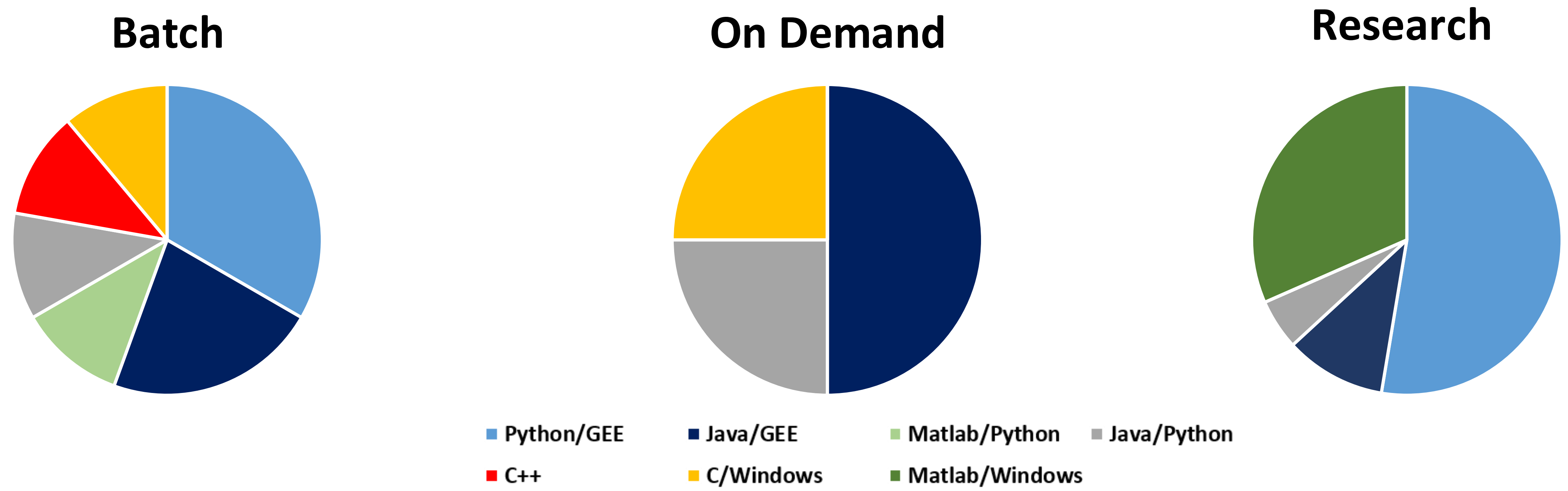
Canadian CAL/VAL Data



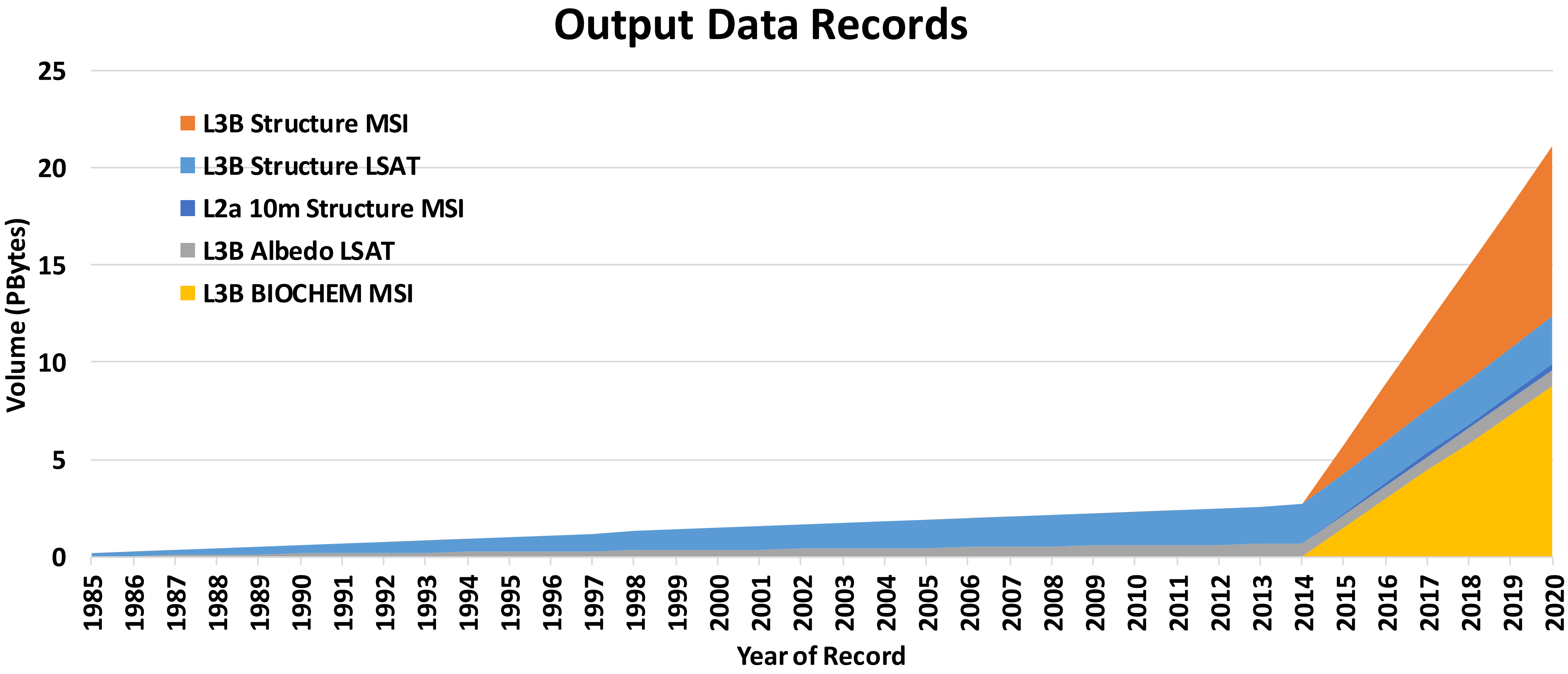
Section B.3: Compute Requirements



Section B.4: Technologies, Software, and Standards



Section B.7: Outputs / End-User Requirements



Section B.8: Costs

- System Costs (annual 2020 $1000) , not including outputs>2020

Use Case	Infrastructure		Software		Design and Maintenance		Archive	
	Present	Future	Present	Future	Present	Future	Present	Future
Batch	10	20	5	0	100	50	5	20
On Demand	5	5	0	0	50	50	0	0
Research	15	10	10	5	100	100	5	5
Validation	5	10	10	5	100	50	0	5
Total	35	45	25	10	350	250	10	30

Section B.9: Challenges

Leadership Turnover


THE GLOBE AND MAIL* REPORT ON BUSINESS SUBSCRIBE FROM $1.99/WK REGIST

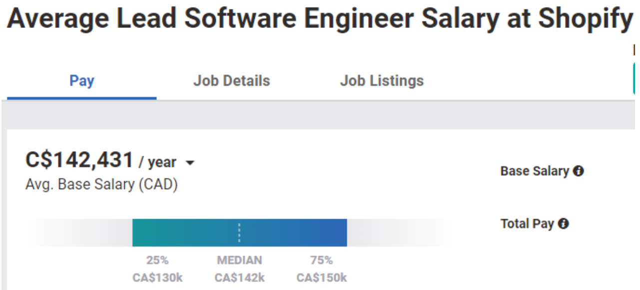
CANADA WORLD BUSINESS INVESTING OPINION POLITICS SPORTS LIFE ARTS DRIVE REAL ESTATE PODCASTS WATCHLIST

Canada's chief information officer Alex Benay leaving to join AI startup Mindbridge

SEAN SILCOFF › TECHNOLOGY REPORTER
PUBLISHED AUGUST 7, 2019

TRENDING

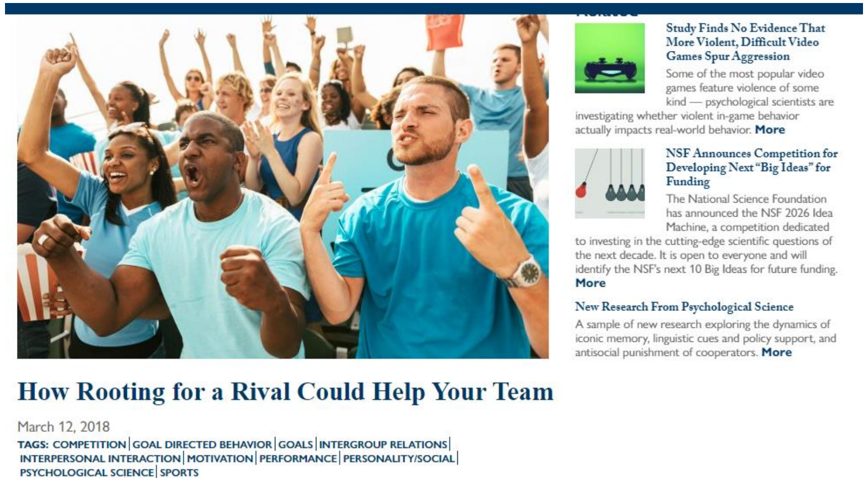
Wrong/Poor Incentives




Applications Developer- Intermediate and Senior Level

Important
Do not discuss your application with others (including on social media) besides your partner, or close family members - who should also be reminded about the need to be discreet.

Closing Date	2021-06-30	Location	Ottawa, Ontario
Reference Number	17-968-08-064	Salary Range	$73,970 - $89,970 $84,050 - $102,250
Job Category	Experienced	Status	Indeterminate (permanent) or Term
Who Can Apply	Canadin Citizens		


Study Finds No Evidence That More Violent, Difficult Video Games Spur Aggression
Some of the most popular video games feature violence of some kind — psychological scientists are investigating whether violent in-game behavior actually impacts real-world behavior. More

NSF Announces Competition for Developing Next "Big Ideas" for Funding
The National Science Foundation has announced the NSF 2026 Idea Machine, a competition dedicated to investing in the cutting-edge scientific questions of the next decade. It is open to everyone and will identify the NSF's next 10 Big Ideas for future funding. More

New Research From Psychological Science
A sample of new research exploring the dynamics of iconic memory, linguistic cues and policy support, and antisocial punishment of cooperators. More

How Rooting for a Rival Could Help Your Team

March 12, 2018
TAGS: COMPETITION | GOAL DIRECTED BEHAVIOR | GOALS | INTERGROUP RELATIONS | INTERPERSONAL INTERACTION | MOTIVATION | PERFORMANCE | PERSONALITY/SOCIAL | PSYCHOLOGICAL SCIENCE | SPORTS

Wrong Business Practices

"Every day … fighting your own system in order to engage with the citizens and stake holders … every single day … is quite exhausting really," he wrote on Facebook. "No wonder people don't see government as efficient, transparent, etc; we literally hide behind rules created pre-computer age … process often trumps leadership too often

traditional government approach to handling projects — which takes long periods of time to define a project before it's sent out to be bid on through government procurement systems — doesn't work in the modern era.

maybe we can accelerate the pace of change in government if we engage differently with the outside world and procure differently

Section B.9: Challenges

We do not suffer from an excess of virtuous ambition.

KPMG adds Alex Benay as partner in Ottawa

29 November 2019 | Consulting.ca | 2 min. read

Profile

KPMG

More news on

Government

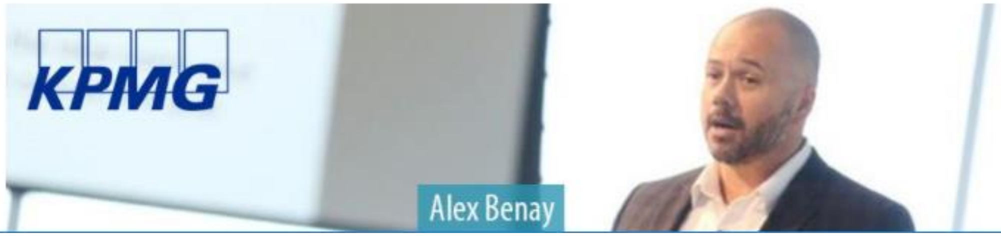
People

KPMG Canada has appointed Alex Benay, the former chief information officer for the Canadian government, as a partner in the firm's digital and government solutions practice.

Based out of KPMG's Ottawa office, Benay will help public sector clients implement digital solutions such as AI, blockchain, cloud, data security and privacy, and digital identification.

He previously spent three months at Ottawa startup MindBridge AI, where he was chief client officer. In the role, he was responsible for guiding the global growth strategy of the company, which uses AI to help auditors and regulators analyze data and identify fraud. He will continue to serve as an advisor at MindBridge in addition to his work with KPMG.

Prior to that, Benay spent two-and-a-half years as CIO for the federal government, where he was responsible for modernizing the government's digital infrastructure.



Respect for Democracy

The system of Canadian parliamentary democracy and its institutions are fundamental to serving the public interest. Public servants recognize that elected officials are accountable to Parliament, and ultimately to the Canadian people, and that a non-partisan public sector is essential to our democratic system.

Respect for People

Treating all people with respect, dignity and fairness is fundamental to our relationship with the Canadian public and contributes to a safe and healthy work environment that promotes engagement, openness and transparency. The diversity of our people and the ideas they generate are the source of our innovation.

Integrity

Integrity is the cornerstone of good governance and democracy. By upholding the highest ethical standards, public servants conserve and enhance public confidence in the honesty, fairness and impartiality of the federal public sector.

Stewardship

Federal public servants are entrusted to use and care for public resources responsibly, for both the short term and long term.

Excellence

Excellence in the design and delivery of public sector policy, programs and services is beneficial to every aspect of Canadian public life. Engagement, collaboration, effective teamwork and professional development are all essential to a high-performing organization.

Section A: Overview of the EO Application

- Vegetation Properties: GCOS User Requirements/Canadian User Requirements
- Goal: Free and open best estimates of vegetation properties for every point in space and time across Canada with uncertainties following CEOS protocols. Free and open access to code and data (including cal/val data).
- What this is not: Climate dataset. Highest performance estimate.

Section B.9: Challenges

- We (especially management) do not suffer from an excess of ambition
  - Identify and solve issues of common good; leave the rest for industry,universities.
- Moving targets for computing policies associated with moving managers.
  - Security for free and open is not same as for other IM/IT
  - Managers need to have recognized technical qualifications and experience in systems design OR we need to pay (a lot) for consultants.
- Use cases are in the dark ages or non existent.
  - Increase planning/investment to support free and open compute and access
- Limited HQP and increasing costs of HQPs
  - At present a UW co-op is more qualified than most staff for systems implementation. They are also paid more on graduation. Need to work collaboratively with other governments, NGOs and industry groups.
- Non-agile procurement, inertia in systems and HQP.
  - Make procurement more granular.
  - Require micro-disruption (load testing, focus feedback, critical design reviews)

Section B.3: Compute Requirements

- Batch Use Cases (monthly products required from 2000+ for 10months/year)
  - B1: L3B National Scale 1 Month S2 Composite 20m Resolution
    - Python,GEE: 1d
  - B2: L3B National Scale Annual L8 (TOA) Composite 30m Resolution
    - Python,GEE: 1d
    - C++ , Dorval Cluster: 7d
  - B3: L3B 10000km2 , 1 Month S2 Composite 10m Resolution
    - Python, GEE: 1d (using resampling without super resolution)
- On Demand Use Cases (per user)
  - D1: L3B Composite given <1000 Sentinel 2 L2A Granules
    - LEAF Toolbox Java, GEE: 1min
    - Python,GEE: 1min
    - Python, Matlab, AWS: 1d (100 cores,)
  - D2: L2B Production given <100 Sentinel 2 L2A Granules
    - LEAF Toolbox: 10min
    - Python + GEE: 2min
    - Python, Matlab, AWS: 1d (100 cores)
  - D3: L2B Production given <100 Sentinel 2 L1b Granules
    - Python, Matlab, SNAPPY, AWS: 1d (100 cores)
- Research Algorithms
  - PSRFM Temporal Downscaling: 1 Landsat WRS or Sentinel 2 Tile, 180days temporal downscaling
    - MATLAB, Windows: 1-2d depending on MODIS access (48 core workstation)
    - Python,GEE: 1d (8 core workstation)
  - Active Learning Recalibration: 1 MSI L2B Product
    - Python, GEE: 10min
    - JAVA, GEE: 1min
  - FLIGHT RT Model Simulations: 100000 simulations
    - MATLAB,C, Windows 1wk (24 core workstatation)

Section B.4: Technologies, Software, and Standards

- Can you describe your current technology stack? Your current software requirements?
  - Refer to
- Are there standards you follow and/or recommend?
  - No
- Can you describe your use of proprietary software? Open source technologies?
  - MATLAB/ARC transitioning to Python/QGIS/GEE
- What type of interface best supports your workflow (e.g. graphical user interface, broad analytics supporting API, IDE, command prompt)
  - Depends on use case but GUI driven for all but research compute.
  - Do not make an alanytics API – make open source interfaces.
- Are there significant differences between your current system and what you would like to see in a well-designed DEC platform?
  - Lack of official access to Google Cloud.
  - Corporate links to ESA and US Earth Explorer hubs for ingest and export.

Section B.5: Operating System / Architecture

- Describe your operating system / architecture
    - Cloud, off premises for operations and validation.
    - Desktop workstation (could be Google Cloud or AWS) for Research compute.
    - Not operational. Backed-up via Google Drive/Github. 24/7 to extent of google and Microsoft service agreements.
- Are there significant differences between your current system and what you would like to see in a well-designed DEC platform?
    - My platform is not supported by SSC. Critical to get access to Google Cloud.
    - DEC platform is not run within GoC but decentralized as redundant micro-services
    - Bottleneck is output and archive – maybe we don’t need this if we can compute on demand.

Section B.7: Outputs / End-User Requirements

- As best possible – can you describe expected usage for the outputs from your application/analysis (e.g. # of users (internal and external), frequency of data access, volume of data accessed)?
  - Climate studies – 1-10/year
  - Environmental assessments – 1-10/year
  - Land surface parameterization in regional models – 1/year
  - Public Awareness / Researchers - ??
- Are outputs generated dynamically, or as static products?
  - Both

Section B.6: Collaboration Considerations

- Who are your collaborators?
  - Provincial Natural Resources Ministries, GCOS, ESA Satellite Programmes, EU Climate Initiatives, US Dept. of Interior, NASA
  - Within GoC research collaboration not highly rewarded in terms of career progression
- Are there aspects to the architecture required to support collaboration (e.g. shared workspaces, user communities, etc)?
  - Implement Google Cloud + Google Earth Engine + Google Drives/Docs for lowest costs possible
  - Missing flexible data portal (link to US Earth Explorer or ESA Science Hub?)
  - Transition to compute and delivery via internet of things (mobile first, cars etc next)
- Who do you need to be able to collaborate with on a well-designed DEC system (federal, provincial, academic, private sector, international, etc)?
  - Open systems, commoditized cloud architecture and resources
  - Users only pays on extraction or for above baseline compute
  - Interoperable with European and American open systems for EO compute
  - No GoC firewalls for free and open science and data