Appendix A: Summary table and schematics showing taxonomy of candidate emissions quantification technology (Phase 1).

Table A.1: Summary of available methane quantification technologies

Technology	Survey Type	Detection Level	Concentration Dimension	Minimum Detection Limit (MDL)	Precision	Applicability	Limitations	Technology Readiness Level (TRL)
Ultraviolet Doppler Optical Absorption Spectroscopy	Fixed Location	Facility	Point Concentration (0D)	0.5-1 ppm-m	95%	LDAR programs (standalone or in combination with screening technologies)	Rain, snow, fog, and/or clouds reduce measurement abilities due to strong attenuation in the UV-Vis region.	9
OGI/QOGI Camera	Handheld	Component	Single Channel (1D)	0.44 m3/day	50-80%	LDAR programs (standalone or in combination with screening technologies)	Require a temperature difference between the emission plume and the local background (0.5 degrees to detect the gas; 3.0 degrees to quantify the mass flow rate). Must be between 1.5-4.6 m from the plume. Operating temperatures between -20 to +50 degrees Celsius.	7+
Dual Frequency Comb Spectroscopy	Fixed Location	Facility	Single Channel (1D)	2.10 m3/day	within 0.222 kg/hr with absolute deviation of 27%	LDAR programs (standalone or in combination with screening technologies)	Precipitation reduces signal path.	4-7

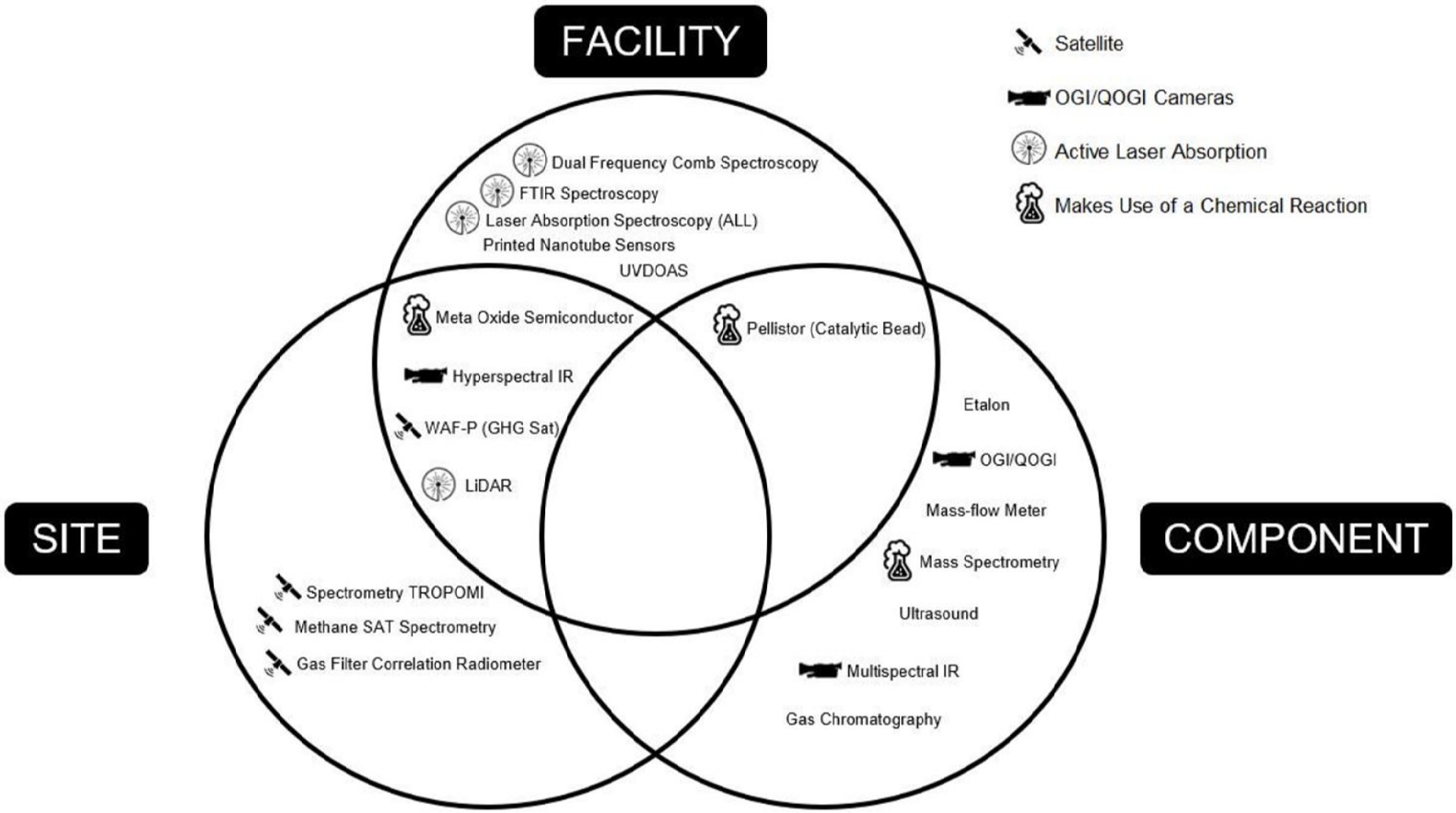
Airborne TDLAS (Bridger)	Aerial	Facility /Site	Imaging (2D)	29.22 m^3/day at 1 m/s wind 73.06 m^3/day at 3 m/s wind 21.92 m^3/day under ideal conditions	68%	Monitoring emissions from pipeline along ROW and remote/sparse arrangements of well sites. Screening technology for LDAR programs.	Standing water and snow absorb incident laser, leading to conservative emission estimates. Research is ongoing in developing a system that addresses this problem. Wind speed estimations limit accuracy of quantification (>3 m/s). A sufficient swath is required to meet the maximum efficiency of the technology. Drone applications are also less efficient than aircraft-mounted TDLAS.	9
Multispectral IR Camera	Handheld	Component	Imaging (2D)	13.211 m^3/day	1 K from -15°C to 150°C	LDAR programs (standalone or in combination with screening technologies)	Most MS cameras have warm filters, which disallows measurements of gases at near ambient temperatures. (MS cameras with cold filters are being developed.)	9

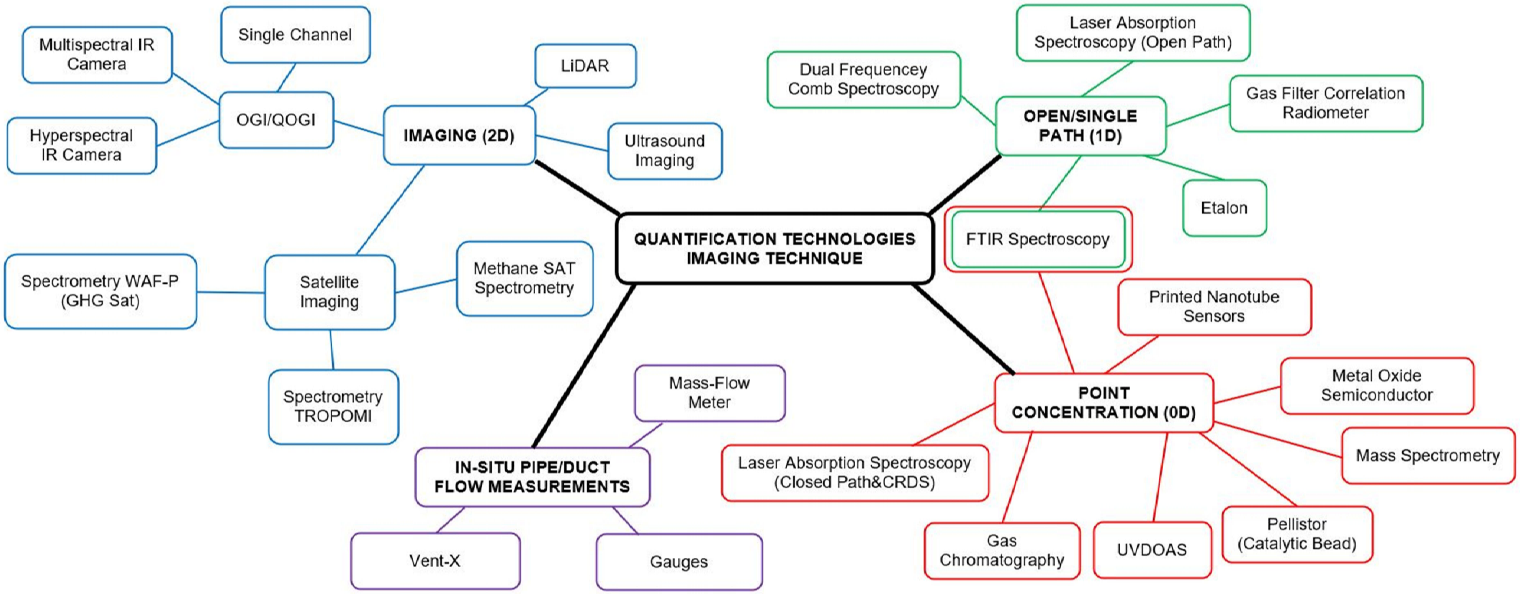
Spectrometry WAF-P (GHGSat)	Satellite	Facilities /Site	Imaging (2D)	36,529 m^3/day in 3 m/s wind speeds	13-60%	Monitoring emissions from pipeline along ROW and remote/sparse arrangements of well sites. Screening technology for LDAR programs.	Requires clear skies for observations; can revisit a site every 2 weeks.	7+
Hyperspectral IR Camera	Fixed Location	Component /Facility	Imaging (2D)	5.81 m^3/day (3.4 m distance) 10.34 m^3/day (5.9 m distance) at 4.5 m/s wind speed	up to 0.25 cm^{-1}	LDAR programs (standalone or in combination with screening technologies)	Operating temperatures between -20 and +40 degrees celsius. Sensitive to high wind speeds. Measurement distance must be within 100 m of the sources.	7+
Spectrometry TROPOMI	Satellite	Site	Imaging (2D)	153,424 m^3/day	0.60%	Monitoring emissions from pipeline along ROW and remote/sparse arrangements of well sites. Screening technology for LDAR programs.	Limited by the visibility of the atmosphere (i.e., cloud coverage). Solar zenith can also limit the ability for detection.	7+
Gas Filter Correlation Radiometer	Aerial, Satellite	Site	Single Channel (1D)	Satellite: 547.95 m3/day	Developing; theoretically within 1 ppm	Monitoring emissions from pipeline along ROW and remote/sparse arrangements of well sites. Screening technology for LDAR programs.	Requires clear skies for observations. Measurements require a high solar zenith angle.	4/7

Pellistor (Catalytic Bead)	Handheld, Fixed Location,	Component /Facility	Point Concentration (0D)	500 ppm - 5%	100%	LDAR programs (standalone or in combination with screening technologies)	Sensitive to high humidity, large temperature differentials, and environmental contaminants.	9
FTIR Spectroscopy	Vehicle, Aerial, Fixed Location	Facility	Single Channel (1D)	11.4 ppb	63-73%	Monitoring emissions from pipeline along ROW and remote/sparse arrangements of well sites. Screening technology for LDAR programs.	The survey time required for measurements is inversely proportional to the spectral resolution (distance travelled by the mirror in the interferometer).	9
Ultrasound Imaging	Handheld, Fixed Location	Component	Single Channel (1D)	8.5 g/hr	90%	LDAR programs (standalone or in combination with screening technologies)	Requires pressure drop to detect emissions.	4/7
MethaneSAT Spectrometry	Satellite	Site	Imaging (2D)	2 ppb over 1.5 km2	Satellite observations typically fall between <1-5% (not Methane SAT specific)	Monitoring emissions from pipeline along ROW and remote/sparse arrangements of well sites. Screening technology for LDAR programs.	Sensitive to low solar zenith and high wind speeds.	7+
Metal Oxide Semiconductor (MOS)	Handheld, Fixed Location	Facility /Site	Point Concentration (0D)	2-10 ppm	Within 0.36 ppm	Continuous monitoring of emissions on sites. LDAR Programs.	Sensitive to high humidity, large temperate differentials, and environmental contaminants. Exposure to large concentrations may de-sensitize the sensor irreversibly.	9

Mass-Flow Meter	Handheld, Fixed Location	Component	Point Concentration (0D)	1.4 standard liters per minute	Within 2%	LDAR programs (standalone or in combination with screening technologies)	No longer manufactured. Highly dependent on daily calibration procedures.	9
Laser Absorption Spectroscopy - Cavity Output	Fixed Location, Handheld UAVs, Vehicle	Facility	Point Concentration (0D)	30 ppb	87%	Monitoring emissions from pipeline along ROW and remote/sparse arrangements of well sites. Screening technology for LDAR programs.	Moderate interference from moisture - dried samples preferred for optimal analysis.	7+
Laser Absorption Spectroscopy - Closed Path (Multi)	Fixed Location, UAVs, Vehicle	Facility	Point Concentration (0D)	100 ppb	within 79 ppb	Monitoring emissions from pipeline along ROW and remote/sparse arrangements of well sites. Screening technology for LDAR programs.	Require specific environmental requirements for measurement.	7+
Mass Spectrometry	Handheld, Fixed Location	Component	Single Channel (1D)	1 ppb	Within 3.4%	Continuous monitoring of emissions on sites. LDAR Programs.	Requires controlled environment (i.e., vacuum system).	9
Gas Chromatography	Handheld, Fixed Location	Component	Single Channel (1D)	1 ppb	Within 3% to 6% of true conc.	Continuous monitoring of emissions on sites. LDAR Programs.	Calibration and purge required prior to use. Calibration frequency varies based on instrument.	9

Printed Nanotube Sensors	Fixed Location	Facility	Point Concentration (0D)	5 ppm	Developing - Currently focused on detection rather than actual quantificatio n	Continuous monitoring of emissions on sites. LDAR Programs.	Unknown	4/7
Laser Absorption Spectroscopy - Open Path	Fixed point, UAVs, Vehicle	Facility	Single Channel (1D)	2 ppm*m	90-97%	Monitoring emissions from pipeline along ROW and remote/sparse arragements of well sites. Screening technology for LDAR programs.	Measurement path length from 5 - 500 m. Wind limitations 2-10 m/s	7+
Etalon	Handheld, Vehicle, Fixed Location	Component	Single Channel (1D)	100 ppb	0.1 µm + 0.3 µm/m	Continuous monitoring of emissions on sites. LDAR Programs.	Highly dependent on surface reflectivity of the crystals; reflecting surfaces must be parallel and flat.	7+
Laser Absorption Spectroscopy - Closed Path (Single)	Fixed point, UAVs, Vehicle	Facility	Point Concentration (0D)	Relative to total pressure of the cell; 88 ppb	90-97%	Monitoring emissions from pipeline along ROW and remote/sparse arrangements of well sites. Screening technology for LDAR programs.	Require specific environmental requirements for measurement.	7+


FACILITY
SITE
COMPONENT
Satellite
OGI/QOGI Cameras
Active Laser Absorption
Makes Use of a Chemical Reaction
Dual Frequency Comb Spectroscopy
FTIR Spectroscopy
Laser Absorption Spectroscopy (ALL)
Printed Nanotube Sensors
UVDOAS
Meta Oxide Semiconductor
Pellistor (Catalytic Bead)
Hyperspectral IR
WAF-P (GHG Sat)
LiDAR
Etalon
OGI/QOGI
Mass-flow Meter
Mass Spectrometry
Ultrasound
Spectrometry TROPOMI
Methane SAT Spectrometry
Gas Filter Correlation Radiometer
Multispectral IR
Gas Chromatography


QUANTIFICATION TECHNOLOGIES IMAGING TECHNIQUE
IMAGING (2D)
Multispectral IR Camera
Single Channel
Hyperspectral IR Camera
OGI/QOGI
LiDAR
Ultrasound Imaging
Satellite Imaging
Spectrometry WAF-P (GHG Sat)
Methane SAT Spectrometry
Spectrometry TROPOMI
OPEN/SINGLE PATH (1D)
Laser Absorption Spectroscopy (Open Path)
Dual Frequencey Comb Spectroscopy
Gas Filter Correlation Radiometer
Etalon
FTIR Spectroscopy
POINT CONCENTRATION (0D)
Printed Nanotube Sensors
Metal Oxide Semiconductor
Mass Spectrometry
Laser Absorption Spectroscopy (Closed Path&CRDS)
Gas Chromatography
UVDOAS
Pellistor (Catalytic Bead)
IN-SITU PIPE/DUCT FLOW MEASUREMENTS
Mass-Flow Meter
Vent-X
Gauges

Appendix B: Technology Providers for the First Field Test (Phase 2).

Table B.1: Candidate technology providers.

Measurement resolution	Technology platform	Technology principle	Candidate service provider	Interest in first campaign	Participated in first campaign
Inspection class	Handheld QOGI	Single-channel QOGI	Greenpath Energy	X	
			AGAT Labs	X	X
			Davis Safety Consulting	X	
			Resolve Solutions		
			SAIT[1]	X	X
	Stationary	Non-thermal IR + transport model	Kuva Systems		
		Unclear	Project Canary		
		Unclear	Qube		
	Drone-based	Spectroscopy	SAIT	X	X
		Infrared	SeekOps		
Screening Class	Truck-based	Open-path spectroscopy	Boreal Laser	X	X
		Open-path spectroscopy	University of Calgary		
Rapid Screening Class	Aircraft-based	Airborne TDLAS-WMS and LiDAR	Bridger Photonics	X	
		SWIR hyperspectral	GHGSat	X	X
		LWIR hyperspectral	Karios Aerospace		
		LWIR hyperspectral	Telops/LSI[2]	X	

Notes: 1. Camera was operated by UW personnel (Nagorski), who received FLIR QOGI training
2. Last minute cancellation due to aircraft issue

Appendix C: Generic Provider Agreement

INDEPENDENT CONTRACTOR AGREEMENT

THIS AGREEMENT (the "**Agreement**") is made as of July 22, 2022.

BETWEEN:

AROLYTICS INCORPORATED, a corporation formed pursuant to the federal laws of Canada (the "**Corporation**")

- and -

(Service Provider), a company incorporated pursuant to the laws of _____ (the "**Contractor**")

(each, a "**Party**" and, collectively, the "**Parties**")

RECITALS:

A. The Corporation wishes to engage the Contractor for the purpose of providing the services described in the attached Schedule "A" and such other services that may be reasonably incidental to them or to which the Parties may agree from time to time (collectively, the "**Services**").

B. The Contractor has agreed to provide the Services to the Corporation in accordance with, and subject to, the terms of this Agreement.

The Parties agree as follows:

ARTICLE 1
ENGAGEMENT

1.1 Engagement. The Corporation engages the Contractor to provide the Services and the Contractor agrees to provide the Services on the terms and conditions of this Agreement.

1.2 Performance of Duties. The Contractor agrees to provide the Services for and on behalf of the Corporation. The Contractor represents and warrants to the Corporation that they have the required skills, abilities, qualifications and experience to perform the Services. In performing the Services, the Contractor will:

(a) act honestly, diligently, in good faith and in the Corporation's best interests;

(b) exercise the care, diligence and skill of a reasonably prudent person performing similar services in comparable circumstances;

(c) act in accordance with sound industry standards and practices;

(d) act in accordance with all applicable laws, regulations and standards;

(e) devote sufficient time and attention to the Corporation's business and affairs to perform the Services effectively and to the best of their ability; and

(f) comply with the Corporation's policies and procedures in effect from time to time.

1.3 Personal Nature. The Contractor will not subcontract any portion of the Services without the Corporation's prior written consent.

1.4 Other Engagements. The Corporation acknowledges and agrees that the Contractor may undertake work for other businesses provided that such work does not hinder the proper, timely and efficient performance of the Services or otherwise breach the terms and conditions of this Agreement.

1.5 Reporting. Upon the Corporation's request, the Contractor will provide reports regarding the Contractor's progress and performance of the Services.

1.6 Independent Contractor. In performing the Services under this Agreement, the Contractor will at all times be an independent contractor of the Corporation and not an employee. Nothing in this Agreement will be construed as, or have the effect of constituting, any other relationship between the Parties, including one of agency, partnership or joint venture, or of creating any employer and employee relationship.

1.7 Risk and Insurance. The Contractor will provide the Services under its own supervision and risk. The Contractor will provide all work space, equipment and materials to complete the Services. The Contractor will have the sole responsibility to obtain suitable insurance coverage for the Contractor while performing the Services.

ARTICLE 2
REMUNERATION

2.1 Compensation. The Corporation will pay the Contractor the compensation set out in the attached Schedule "A", plus applicable taxes (the "**Contractor Fees**"). The Contractor will be responsible for remitting all applicable taxes and levies for which the Contractor may be liable at law in respect of any payments to it from the Corporation. To the extent that the Corporation is required by any applicable law or order to withhold any sum from a payment, the Corporation will be entitled to do so.

2.2 Indemnity. The Contractor agrees to indemnify and hold harmless the Corporation and its directors, officers, and employees, from and against any liabilities, damages, fines, interest or penalties on account of the Contractor's failure to make any payments, withholdings, deductions or remittances as may be required by law to be made by Contractor, including in respect of any amounts paid to the Contractor under this Agreement.

ARTICLE 3
TERM & TERMINATION

3.1 Term. This Agreement will remain in force until terminated in accordance with its terms. This Agreement shall automatically terminate upon the dissolution, winding-up, or bankruptcy of a Party.

3.2 Early Termination. Any Party may terminate this Agreement at any time by giving at least thirty (30) days advance notice to the non-terminating Parties.

3.3 Effect of Termination. In the event that this Agreement is terminated for any reason, the Contractor shall be entitled to any portion of the Contractor Fees earned but not paid and, subject to Section 2.4, any expenses incurred by the Contractor but not reimbursed, in each case up to and including the date of termination.

ARTICLE 4
NOTICES

4.1 Delivery of Notice. Any notice relating to or required or permitted to be given in accordance with, this Agreement will be in writing and will be personally delivered, couriered, emailed or mailed as follows:

(a) if to the Corporation, at its head office addressed to the President's attention; and (b) if to the Contractor, at the address set out on the signature page of this Agreement.

4.2 Time of Delivery. Any notice will be deemed to have been received: (a) if delivered, couriered, or emailed, on the next business day following when it is delivered; and (b) if mailed, on the fifth (5th) day (excluding Saturdays, Sundays and holidays) after it is mailed.

4.3 Change of Address. Each Party may change its address for the purpose of this Article 4 by delivering written notice of such change as set out in Section 4.1.

ARTICLE 5
GENERAL

5.1 Representation. The Contractor represents and warrants to the Corporation that their execution and delivery of, and performance of their obligations under, this Agreement does not and will not conflict with, breach, violate or cause a default under any contract, agreement, instrument, order, judgment or decree to which any of them is a party or by which any of them is bound.

5.2 Equipment. The Contractor agrees that all items the Corporation furnishes or provides to the Contractor and all of the Corporation's material and equipment used by the Contractor while engaged under this Agreement (collectively, the "**Corporation Property**") belong exclusively to the Corporation. The Contractor agrees to turn over to the Corporation all Corporation Property in its possession or under its control immediately at the Corporation's request or, in the absence of a request, upon the termination of this Agreement.

5.3 Use of Equipment. The Contractor shall not use any Corporation Property to access or store illegal material of any kind, including but not limited to material that might be considered pornographic or offensive to others working for the Corporation. All information stored on the Corporation Property is subject to review by any individual the Board designates and, except where such information is unrelated to the Corporation's business, is the Corporation's property. The Corporation is not responsible for the control of any personal information the Contractor places on the Corporation Property.

5.4 Email. If the Corporation provides the Contractor with an internet email address then the Contractor expressly acknowledges that such email address is not a personal or confidential address. None of the Contractor's email is confidential to him or her and the Corporation's management or any person the Board designates may review it at any time.

5.5 Guarantee by the Principal. Each of the covenants made in this Agreement in favour of or for the benefit of the Corporation by the Contractor is hereby guaranteed by the Contractor.

5.6 Severability. Each provision of this Agreement shall be legal, valid and enforceable to the fullest extent permitted by law. If a court of competent jurisdiction finds any provision of this Agreement or portion thereof to be void, invalid, illegal or unenforceable, the remainder of this Agreement or the application of such provision or portion thereof shall not be affected thereby.

5.7 Amendments and Waiver. This Agreement or any provisions may only be amended with both Parties' written consent. Any waiver must be in writing and any waiver of breach is not a waiver of any subsequent breach.

5.8 Entire Agreement. This Agreement supersedes all prior agreements, negotiations and discussions, whether oral, written or otherwise, between the Parties with respect to its subject-matter. This Agreement contains the final and entire understanding and agreement between the Parties with respect to its subject-matter. The Parties will not be bound by any terms, conditions, statements, covenants, representations, or warranties, whether oral, written or otherwise, not contained in this Agreement.

5.9 Governing Law. This Agreement is governed and construed by the laws of the Province of Nova Scotia and the applicable federal laws of Canada, and the Parties will submit to the jurisdiction of the courts of the Province of Nova Scotia.

5.10 Assignment. The Contractor may only assign this Agreement with the Corporation's express prior written consent. The Corporation may assign to another person or entity any of its rights under this Agreement, including, without limitation, any successor in interest to the Corporation or its business operations.

5.11 Counterparts and Electronic Execution. The Parties may execute this Agreement in counterparts and may execute and deliver this Agreement in electronic form that can create a printed copy. When signed, each counterpart will be deemed an original and together will constitute the same agreement.

[signature page follows]

SIGNED as of the day and year first above written.

AROLYTICS INCORPORATED

Per: _____
Name:
Title:

(Service Provider)

Per: _____
Name:
Title:

CORPORATION AND CONTRACTOR ADDRESS FOR NOTICES:

1401 1 St SE, Calgary, AB T2G 2J3
Attention: Kevin Fritz
E-mail: kevin.fritz@arolytics.com

Contractor Address:

Attention:
E-mail:

Principal Address:

Attention:
E-mail:

SCHEDULE "A"

Description of Services and Compensation

The “Contractor” refers to (Service Provider).
The “Corporation” refers to Arolytics Incorporated.

Description of Services:

The General Service:
The Contractor is being contracted to quantify the emissions from various controlled gas releases occurring during the field campaign (Sept 25-Oct 1, 2022). The Contractor will quantify the emissions from each controlled gas release using their emission quantification technology and report their emission rate estimates.

The Field Campaign:
The Contractor will be present and ready to deploy their methane quantification technology at the Carbon Management Canada Field Research Station between Sept 25th and Oct 1st, inclusive, unless instructed otherwise by the Corporation. The Corporation will provide the Contractor a schedule for each of these days, outlining the specific times of day when they are expected to be ready to quantify a methane emission source. The schedule for each day is subject to change due to logistical or weather-related reasons. The contractor is expected to, within reason, adhere to the schedule and any scheduling changes.

The Corporation will provide the contractor with general information about the potential range of controlled gas releases scheduled for the field campaign, including locations of the release, the physical release points, and the release rates. Specific information about individual controlled gas releases will not be provided to the Contractor, with exception of a description of the release location. For all intents and purposes, the controlled gas releases are part of a single-blind emission quantification study.

Emission Quantification Protocol:
The Contractor is expected to perform all stages of their emission quantification process (including preparation, data collection, and analysis) using the standard protocol that they use (or plan to use) when hired for oil and gas facility inspections, unless instructed otherwise by the Corporation. As such, the Contractor is responsible for collecting all data that is required to quantify an emission using their standard protocol. If opportunities arise to trial a non-standard emission quantification protocol, the Contractor should notify the Corporation before proceeding.

Reporting:
The Contractor will report all emission rate estimates using a template provided to them by the Corporation. The Contractor is expected to report their emission rate estimates by Oct 22nd, 2022 (3 weeks after the end of the field campaign).

The emission quantification performance of each Contractor during the field campaign, including an analysis of the Contractor’s reported emission rate estimates and the actual release rates, will be disseminated directly to Petroleum Technology Alliance Canada (PTAC), in the form of a final project report. The Contractor will be named in the final report to PTAC. The report will be delivered to PTAC by December 2023.

The Contractor will receive the controlled gas release data from the field campaign for their own use. This data will be delivered to the Contractor 7 days after PTAC has received the final report. The Contractor may not publish this data until it has first been published by PTAC.

An analysis of the uncertainty associated with the Contractor’s emission quantification approach will be reported as part of a scientific publication by December 31, 2023.

Compensation:

The Contractor will receive partial compensation for the costs that they will incur when participating in the field campaign. Compensation is for the purpose of supporting the costs which the Contractor will incur, but not necessarily to cover them completely.

(Service Provider) Specific:

(Service Provider) is only expected to participate during XX days of the field campaign; the date of their participation will be selected to ensure safe and favourable flight and measurement conditions. (Service Provider) and the Corporation will mutually agree on the date that (Service Provider) will participate. It is possible that multiple dates for participation will be selected, in which case a final decision will be made the morning of each date.

It is possible that another aircraft will be taking measurements at the same time as the (Service Provider) aircraft. If so, it is expected that (Service Provider) will make a reasonable effort to coordinate with the Corporation and the other aircraft to ensure a safe and logical flight for both aircrafts. If at any point (Service Provider), the other aircraft, or the corporation feels that simultaneous flights cannot be conducted safely, the corporation will cancel the flight of the other aircraft. It is (Service Provider)'s responsibility to inform the corporation of any safety concerns that they identify.

(Service Provider) will receive a total of $XXXX.XX from the Corporation as compensation for the costs they will incur while participating in the field campaign.

Appendix D: Weather Conditions at FRS during the First Field Campaign

The performance of most methane quantification technologies depends strongly on the ambient conditions during the measurement. Key parameters include wind speed, wind direction, ambient temperature, and cloud cover. While not normally classified as a weather parameter, background methane concentration may also affect the performance of these quantification technologies, and, particularly at CMC's FRS, may fluctuate due to nearby petroleum and livestock operations.

Accordingly, these parameters were monitored throughout the field campaign using a range of instrumentation. The objective of these measurements are: (1) to provide boundary conditions needed to post-process the data from the quantification technologies[1]; (2) as an overall assessment of whether the conditions during the field campaign are representative of overall weather patterns for the site, and thus the "fairness" of the tests; and (3) multiple measurements provide an indication of the uncertainty of each measurement, which propagate into the overall methane quantification uncertainty.

Wind speed, wind direction, temperature, relative humidity, and ambient methane concentrations are measured using the technologies defined in Table 2 of the report. Wind speed, wind direction, temperature, and relative humidity are also compared with values obtained from the Meteoblue model.

The sources of meteorological data recorded measurements at varying frequencies. The Meteoblue model provides predicted wind speeds at hourly intervals. The Davis weather station (cup-and-ball anemometer) recorded wind speeds every minute, and the Kuva and Boreal ultrasonic anemometers recorded wind speeds approximately every 90 seconds and at fifteen minute intervals. In order to compare these different sources of meteorological data, wind speeds are mapped to one minute intervals by interpolation.

Wind speed: Figure D.1 shows wind speed plotted every minute. In general, wind speeds obtained from the Davis cup anemometer and the Boreal 3D ultrasonic anemometer are generally similar, while those from the Kuva anemometer were typically slightly higher. Differences in wind speeds as a function of source may be due to the positioning of the anemometers, both with respect to ground level and facilities on the ground that might affect the wind. The Kuva anemometer is mounted on a camera exactly 31.5 feet (9.6 m) above a 6 m tower. The Boreal 3D anemometer was mounted about 1.5 m above ground level and the Davis cup anemometer was on top of the ATCO trailer (~3 m). Features like the FRS surface facilities and building might also affect wind speeds and directions locally. The Kuva anemometer wind speeds follow trends generally similar to the Meteoblue predictions, which are inferred at a height of 10 m above the ground. Yet, there is some temporal misalignment between these two wind estimates. In general, one would expect ultrasonic anemometers to be more accurate than cup anemometers, and, since the Kuva anemometer was available throughout the complete duration of the field campaign, that wind speed source is employed as the preferred wind speed.

[1] Technology providers are expected to obtain these boundary conditions independently; for this reason, Boreal laser provided their own anemometer, while GHGSat relied on wind speeds from the Meteoblue model.

Figure D.2 shows histograms of wind speeds measured during the field campaign and those over the previous 9 years. These results highlight that the wind speeds during the field campaign are representative of those from this region for this time of year.

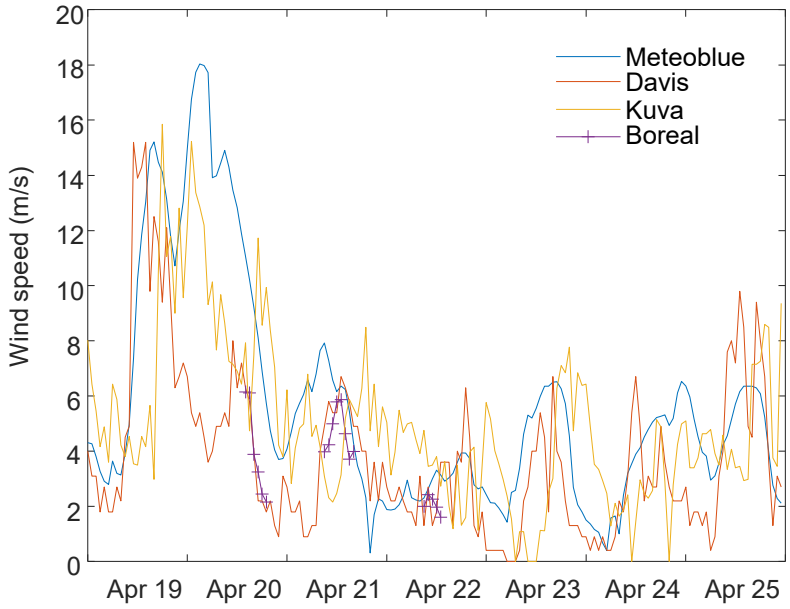


Figure D.1: Wind speeds during the field campaign.

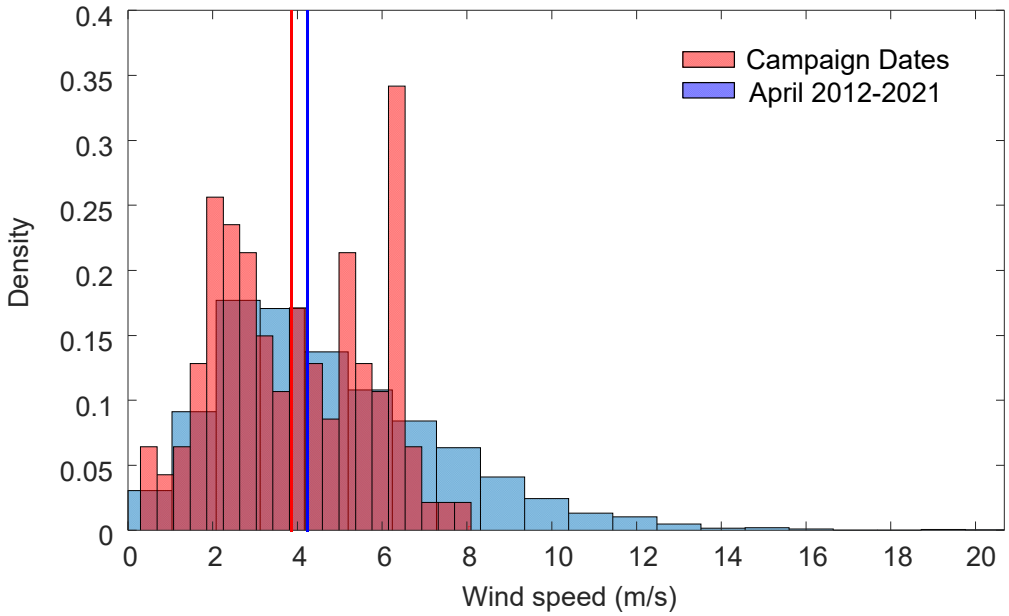


Figure D.2: Histograms of wind speeds during field campaign, and wind speeds over the previous 9 years. Median wind speeds are shown as a dashed line. (Meteoblue wind model.)

Wind direction: The Meteoblue-predicted wind direction is plotted in Figure D.3 (a), while the deviation of the wind directions from the Davis, Kuva, and Boreal anemometers is shown in Figure D.3 (b). (Wind direction indicates the direction from which the wind is blowing.) Wind directions indicated by the Davis and Boreal anemometers were generally consistent with those from the

Meteoblue model, while there is a greater discrepancy between the wind direction found using the Kuva anemometer and the other two models. Given that there are unspecified mechanical and temporal uncertainties in the consistency of the Kuva camera rotation and because the inferred wind direction captured is instantaneously recorded using unsynchronized clocks, the one minute average wind direction recorded by the Davis station is preferred.

Ambient temperature and relative humidity: The Davis weather station also provides ambient temperature and relative humidity. These parameters, along with the parameters predicted by the Meteoblue model, are plotted in Figure D.4.

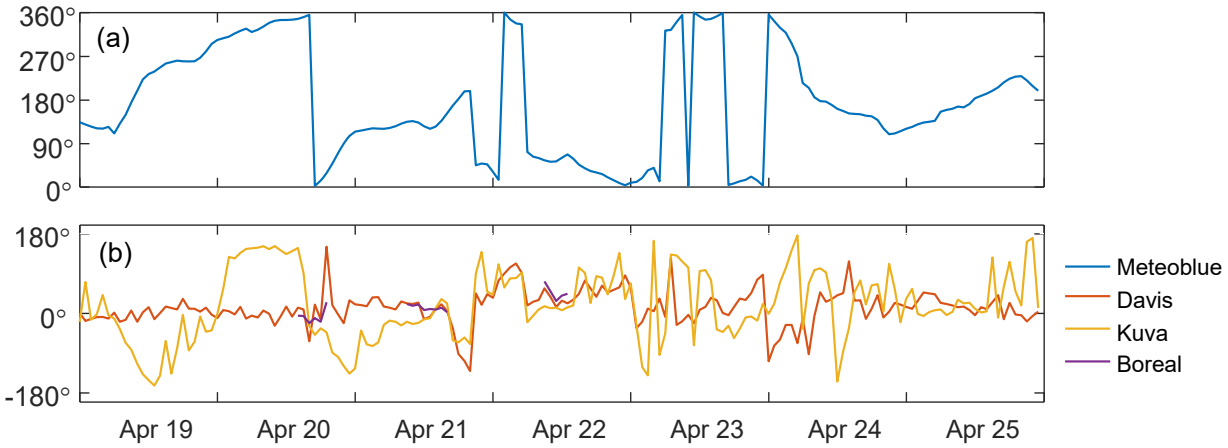


Figure D.3: (a) Wind direction predicted by Meteoblue; (b) deviations from the Meteoblue wind direction predicted by the Kuva, Boreal, and Davis anemometers.

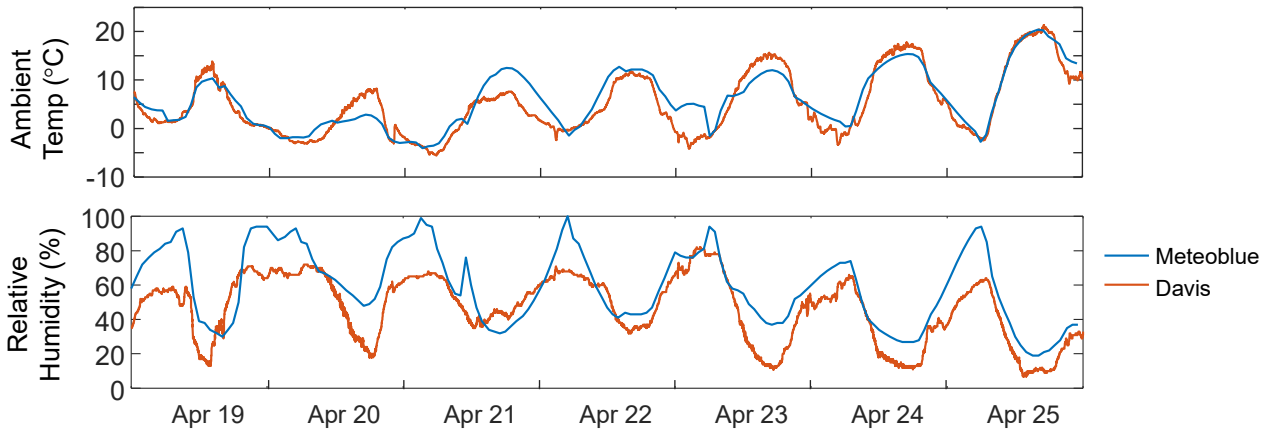


Figure D.4: Ambient temperature and relative humidity from the Davis weather station and Meteoblue weather forecast.

Ambient methane concentrations: Ambient methane concentrations are obtained from three sources: (1) the Picarro cavity ring-down spectrometer (CRDS); (2) the Boreal (truck-mounded) TDLAS; (3) the SAIT (drone-mounted) TDLAS. The CDRS which was installed at the ATCO trailer; concentrations were induced from outside the trailer through a hose into the instrument.

The TDLAS measurements were taken when the truck or drone is outside of a methane plume. TDLAS systems infer the concentration through wavelength modulated spectroscopy, in which the tunable diode laser "sweeps" a specific methane line. For this reason, the TDLAS instruments only provide concentrations of the principal methane isotope. The cavity ring-down spectrometer contains multiple laser diodes tuned to other methane isotopes, as well as the methane to ethane ratio; these parameters are useful for attributing a methane emission to a particular source. Of these instruments, the CRDS should be considered the most accurate.

Methane concentrations from these instruments are plotted in Figure D.5 (*a*); with the exception of April 23, the methane concentration remained close to regional background concentrations of approximately 2 ppm. During the afternoon of April 23, when the testing moved to the vicinity of a conventional flare stack the local background methane concentration increased abruptly to 4 ppm, with one reading of 7 ppm. A comparison of the methane/ethane ratio shown in Figure D.6, combined with the wind direction plot in Figure D.5 (*b*) and the composition of the release gas, suggests that this spike occurred when the plume released from the 3.18 m stack reached the ATCO trailer. (See Figure 3.)

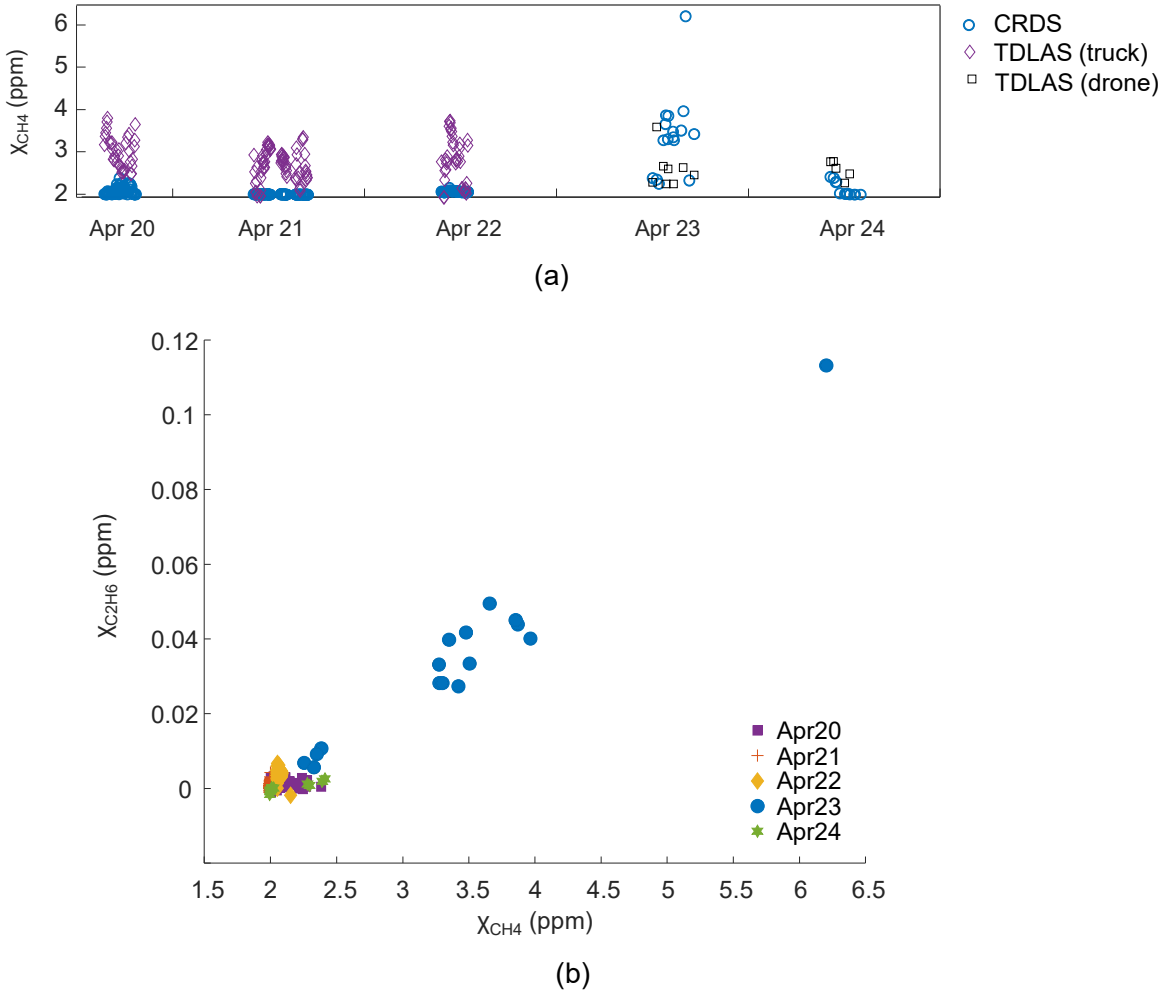


Figure D.5: (a) ambient methane concentrations recorded by the CRDS and TDLAS systems; (b) the high ethane-to-methane ratio measured by the CRDS. The spike on April 23 are likely due to a methane release at the 3.18 m stack that blew to the ATCO trailer.

Cloud cover: While the drone and truck systems are unaffected by cloud cover, the performance of the SWIR hyperspectral imager used by GHGSat infers methane column densities from the attenuation of solar radiation reflected from the ground; therefore this technique is sensitive to clouds that obscure incident solar radiation. QOGI-derived plume velocity estimates may also be affected by the motion of background clouds.

Cloud cover was not measured directly but was instead taken from the Meteoblue cloud cover forecast and observations from the two nearest airports, Lethbridge (CYQL, ~100 km S), and Medicine Hat (CYXH, ~110 km W). Manual cloud observations are done in three hour increments during daylight hours, and are defined using the terms summarized in Table D.1.

Table D.1: Terms used to define cloud cover (Source: ECCC)

Observation term	Cloud cover
Clear	< 1/10
Mainly Clear	1/10-4/10
Mostly Cloudy	5/10-9/10
Cloudy	10/10

Figure D.6 shows the hourly cloud cover from the Meteoblue forecast, and the range of sky cover from the station observations during the GHGSat measurements (April 23 and April 24). Measurements on the second day were terminated at the request of GHGSat due to cloud cover. The photo of the sky taken at 3 PM MST are consistent with the airport observations but are inconsistent with the Meteoblue forecast. These results highlight that GHGSat measurements were carried out under conditions that were more challenging in terms of cloud cover than indicated by

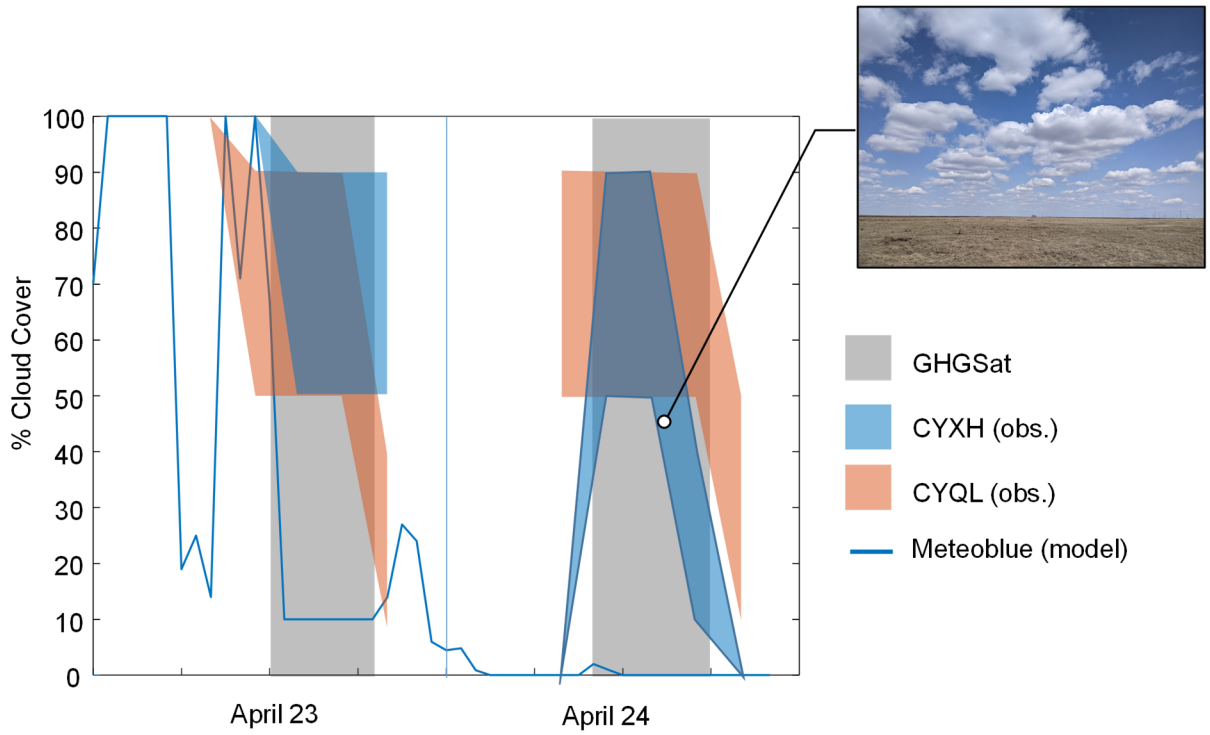


Figure D.6: Cloud cover forecast from Meteoblue and observations from Lethbridge and Medicine Hat Airports during GHGSat measurements. The photo shows the sky cover at 3 PM MST on April 24.

the Meteoblue forecast. Moreover, the distance between the CMC FRS and the nearest airports, coupled with the infrequency with which sky cover is observed, limit the reliability of these reported observations. Therefore, detailed and frequent (hourly or half-hourly) sky observations will be carried out during the second field campaign.