

**Reproducibility.** All the source code and the real-world datasets are available at <https://anonymous.4open.science/r/RA-project-B78B/>. All our experiments were conducted on an AMD Ryzen 7 2700X Eight-Core Processor @3.70 GHz with 32GB of RAM. The algorithms are implemented in python 3.9.6 with the following packages and their corresponding dependencies:

- Numpy 1.22.3
- Pandas 1.4.2
- Scipy 1.8.0
- Scikit-learn 1.0.2
- Scikit-Ika 0.0.8
- Matplotlib 3.5.1
- Seaborn 0.11.2

As a base system, we used the Scikit-Ika system, an open-source implementation of methods for handling recurrent concept drifts. It continuously models evolving data streams, providing accurate predictions in real-time, using probabilistic networks and meta-information to predict a change in the data stream proactively.

**Data Preliminary analysis.** The original dataset consists of sensor readings from all five different towns with different time stamps. We first split the data into corresponding towns and aligned the timestamps of the readings from different sensors by rounding to the nearest minute. Figure 11 shows the aligned sensor readings for *Arrowtown*. For each sensor, a breakage in the continuity of the readings is indicated by a change in colour. From Figure 11, it is obvious that there exist many missing values for each of the sensors, and none of the sensors is consistently active during data collection. Similar to sensors in *Arrowtown*, this same problem is present in the other towns.

**Data Preprocessing.** To deal with the presence of a large number of missing values for each sensor. We first select a limited number of sensors that are comparatively consistent and are present for a substantial amount of time. The serial number of the sensor selected for each town are as follows:

- *Arrowtown*: ODIN-0212, ODIN-0153, ODIN-0173, ODIN-0005, ODIN-0157, ODIN-0182, ODIN-0207 and ODIN-0035.
- *Reefton*: ODIN-0211, ODIN-0204, ODIN-0162, ODIN-0214 and ODIN-0194
- *Masterton*: ODIN-SD-0314, ODIN-SD-0315 and ODIN-SD-0287
- *Cromwell*: ODIN-0179, ODIN-0185, ODIN-0157 and ODIN-0052
- *Invercargill*: ODIN-SD-0285, ODIN-SD-0297, ODIN-SD-0308 and ODIN-SD-0304

Between these sensors, there are still missing values present across different timestamps. All sensors readings at a timestamp are removed if any of the selected sensors contains a missing value at this timestamp.

In addition, for each town, we also select one of the sensors as the target sensor. The target sensor is chosen to be at

the centre of surrounding sensors. For each town, the serial number of the chosen target sensor is:

- *Arrowtown*: ODIN-0207
- *Reefton*: ODIN-0211
- *Masterton*: ODIN-SD-0315
- *Cromwell*: ODIN-0157
- *Invercargill*: ODIN-SD-0308

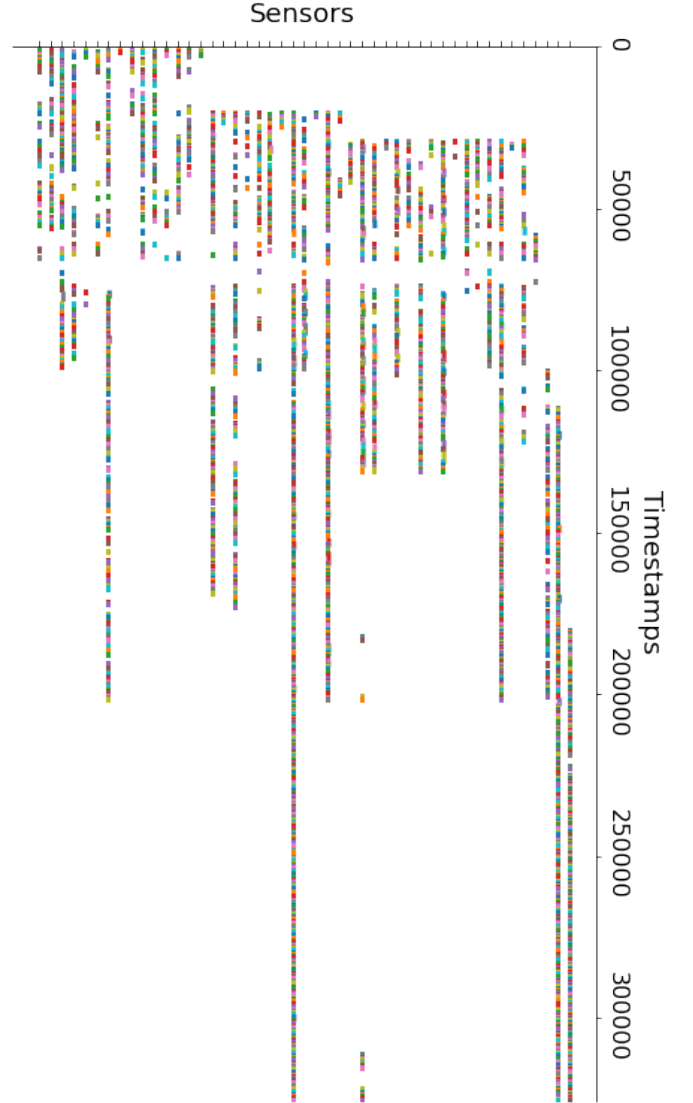


Fig. 11: Aligned sensor readings for *Arrowtown*

**Additional results.** Table IX shows the class-wise average precision and recall comparison between ARF and PEARL with different  $\alpha$ . Similar to accuracy, PEARL consistently outperforms ARF at different *AQI* levels. In addition, the class-wise average precision and recall with force transferred models are shown in Table X. The results show that only *Cromwell* and *Invercargill* are transferable between the towns, forcing model transfers onto datasets with low adaptability yields low performances across all classes.

TABLE IX: Class-wise average precision and recall for PEARL and ARF

			$AQI = 0$		$AQI = 1$		$AQI = 2$		$AQI = 3$		$AQI = 4$		$AQI = 5$	
			No.	PEARL	No.	PEARL	No.	PEARL	No.	PEARL	No.	PEARL	No.	PEARL
$\alpha = 10$	Arrows	PRC	14398	0.93±0.03	6328	0.87±0.04	3636	0.97±0.01	5109	0.83±0.06	310	0.92±0.03	19	0.00±0.00
		REC	14398	0.94±0.03	6328	0.92±0.02	3636	0.76±0.08	5109	0.94±0.02	310	0.39±0.23	19	0.00±0.00
	Reefion	PRC	5122	0.82±0.01	1377	0.56±0.01	399	0.66±0.15	381	0.53±0.03	29	0.00±0.00	1	0.00±0.00
		REC	5122	0.96±0.00	1377	0.47±0.02	399	0.04±0.01	381	0.24±0.03	29	0.00±0.00	1	0.00±0.00
	Masterton	PRC	2153	0.81±0.04	876	0.72±0.05	318	0.41±0.04	584	0.39±0.01	103	0.29±0.15	14	0.00±0.00
		REC	2153	0.88±0.01	876	0.71±0.09	318	0.20±0.09	584	0.45±0.01	103	0.01±0.01	14	0.00±0.00
	Cromwell	PRC	3250	0.95±0.02	1217	0.86±0.03	702	0.83±0.07	2035	0.82±0.01	435	0.71±0.05	75	1.00±0.00
		REC	3250	0.95±0.00	1217	0.84±0.02	702	0.58±0.04	2035	0.94±0.01	435	0.71±0.02	75	0.10±0.02
	Invercargill	PRC	5398	0.95±0.01	1670	0.90±0.02	463	0.63±0.04	576	0.93±0.02	24	0.00±0.00	4	0.00±0.00
		REC	5398	0.99±0.00	1670	0.82±0.04	463	0.77±0.04	576	0.69±0.06	24	0.00±0.00	4	0.00±0.00
$\alpha = 100$	Arrows	PRC	14398	0.93±0.03	6328	0.87±0.04	3636	0.97±0.01	5109	0.83±0.06	310	0.92±0.03	19	0.00±0.00
		REC	14398	0.94±0.03	6328	0.92±0.02	3636	0.76±0.08	5109	0.94±0.02	310	0.39±0.23	19	0.00±0.00
	Reefion	PRC	5122	0.82±0.01	1377	0.56±0.01	399	0.66±0.15	381	0.53±0.03	29	0.00±0.00	1	0.00±0.00
		REC	5122	0.96±0.00	1377	0.47±0.02	399	0.04±0.01	381	0.24±0.03	29	0.00±0.00	1	0.00±0.00
	Masterton	PRC	2153	0.80±0.04	876	0.72±0.05	318	0.41±0.04	584	0.39±0.01	103	0.29±0.15	14	0.00±0.00
		REC	2153	0.88±0.01	876	0.71±0.09	318	0.20±0.09	584	0.45±0.01	103	0.01±0.01	14	0.00±0.00
	Cromwell	PRC	3250	0.94±0.02	1217	0.86±0.03	702	0.83±0.07	2035	0.82±0.01	435	0.71±0.05	75	1.00±0.00
		REC	3250	0.95±0.00	1217	0.84±0.02	702	0.58±0.04	2035	0.94±0.01	435	0.71±0.02	75	0.10±0.02
	Invercargill	PRC	5398	0.95±0.01	1670	0.90±0.02	463	0.63±0.04	576	0.93±0.02	24	0.00±0.00	4	0.00±0.00
		REC	5398	0.99±0.00	1670	0.82±0.04	463	0.77±0.04	576	0.69±0.06	24	0.00±0.00	4	0.00±0.00
$\alpha = 1000$	Arrows	PRC	14398	0.93±0.03	6328	0.87±0.04	3636	0.97±0.01	5109	0.83±0.06	310	0.92±0.03	19	0.00±0.00
		REC	14398	0.94±0.03	6328	0.92±0.02	3636	0.76±0.08	5109	0.94±0.02	310	0.39±0.23	19	0.00±0.00
	Reefion	PRC	5122	0.82±0.01	1377	0.56±0.01	399	0.66±0.15	381	0.53±0.03	29	0.00±0.00	1	0.00±0.00
		REC	5122	0.96±0.00	1377	0.47±0.02	399	0.04±0.01	381	0.24±0.03	29	0.00±0.00	1	0.00±0.00
	Masterton	PRC	2153	0.80±0.04	876	0.72±0.05	318	0.41±0.04	584	0.39±0.01	103	0.29±0.15	14	0.00±0.00
		REC	2153	0.88±0.01	876	0.71±0.09	318	0.20±0.09	584	0.45±0.01	103	0.01±0.01	14	0.00±0.00
	Cromwell	PRC	3250	0.94±0.02	1217	0.86±0.03	702	0.83±0.07	2035	0.82±0.01	435	0.71±0.05	75	1.00±0.00
		REC	3250	0.95±0.00	1217	0.84±0.02	702	0.58±0.04	2035	0.94±0.01	435	0.71±0.02	75	0.10±0.02
	Invercargill	PRC	5398	0.95±0.01	1670	0.91±0.02	463	0.63±0.04	576	0.93±0.02	24	0.00±0.00	4	0.00±0.00
		REC	5398	0.99±0.00	1670	0.82±0.04	463	0.77±0.04	576	0.69±0.06	24	0.00±0.00	4	0.00±0.00

 TABLE X: Class-wise average precision and recall for force transferred model ( $T$ ) and not transferred model ( $\tilde{T}$ ) across different towns at  $\alpha = 100$ 

			$AQI = 0$		$AQI = 1$		$AQI = 2$		$AQI = 3$		$AQI = 4$		$AQI = 5$							
			No.	$\tilde{T}$	No.	$\tilde{T}$	No.	$\tilde{T}$	No.	$\tilde{T}$	No.	$\tilde{T}$	No.	$\tilde{T}$						
Arrowtown	Reefion	PRC	5122	0.95±0.01	0.95±0.01	1377	0.99±0.00	0.99±0.00	399	1.00±0.00	0.99±0.00	381	0.99±0.00	0.99±0.00	29	0.94±0.01	0.94±0.01	1	0.80±0.40	0.80±0.40
		REC	5122	1.00±0.00	1.00±0.00	1377	0.92±0.01	0.92±0.01	399	0.95±0.01	0.95±0.01	381	0.96±0.01	0.96±0.01	29	0.87±0.00	0.87±0.00	1	1.10±0.06	1.00±0.06
	Masterton	PRC	2153	0.90±0.00	0.90±0.00	876	0.99±0.00	0.99±0.00	318	0.99±0.00	0.99±0.00	584	1.00±0.00	1.00±0.00	103	0.94±0.01	0.94±0.01	14	0.80±0.40	0.80±0.40
		REC	2153	1.00±0.00	1.00±0.00	876	0.88±0.00	0.88±0.00	318	0.91±0.00	0.91±0.00	584	0.89±0.00	0.89±0.00	103	0.71±0.00	0.71±0.00	14	0.06±0.04	0.06±0.04
	Cromwell	PRC	3250	0.89±0.03	0.89±0.03	1217	0.99±0.00	0.99±0.00	702	1.00±0.00	1.00±0.00	2035	1.00±0.00	1.00±0.00	435	0.94±0.01	0.94±0.01	75	1.00±0.01	0.99±0.02
		REC	3250	1.00±0.00	1.00±0.00	1217	0.92±0.01	0.92±0.01	702	0.90±0.01	0.90±0.01	2035	0.85±0.05	0.85±0.05	435	0.71±0.21	0.71±0.21	75	0.31±0.22	0.32±0.23
	Invercargill	PRC	5398	0.94±0.00	0.94±0.00	1670	0.99±0.00	0.99±0.00	463	1.00±0.00	1.00±0.00	576	0.99±0.00	0.99±0.00	24	0.94±0.01	0.94±0.01	4	0.80±0.40	0.80±0.40
		REC	5398	1.00±0.00	1.00±0.00	1670	0.88±0.00	0.88±0.00	463	0.95±0.00	0.95±0.00	576	0.98±0.00	0.98±0.00	24	0.88±0.00	0.88±0.00	4	0.09±0.05	0.09±0.05
Reefion	Arrowtown	PRC	14398	0.95±0.00	0.95±0.00	6328	0.95±0.00	0.94±0.00	3636	0.97±0.00	0.96±0.00	5109	0.98±0.00	0.97±0.00	310	0.89±0.01	0.88±0.01	19	0.80±0.40	0.80±0.40
		REC	14398	0.99±0.00	0.99±0.00	6328	0.92±0.00	0.92±0.00	3636	0.91±0.00	0.90±0.01	5109	0.91±0.01	0.91±0.01	310	0.82±0.01	0.81±0.02	19	0.10±0.06	0.10±0.06
	Masterton	PRC	2153	0.95±0.00	0.93±0.01	876	0.92±0.00	0.88±0.00	318	0.74±0.00	0.66±0.01	584	0.87±0.00	0.73±0.02	103	0.62±0.02	0.31±0.02	14	0.00±0.00	0.00±0.00
		REC	2153	1.00±0.00	0.99±0.00	876	0.87±0.00	0.80±0.02	318	0.74±0.00	0.57±0.01	584	0.73±0.00	0.71±0.00	103	0.17±0.01	0.10±0.01	14	0.00±0.00	0.00±0.00
	Cromwell	PRC	3250	0.85±0.00	0.85±0.00	1217	0.82±0.00	0.81±0.00	702	0.84±0.01	0.80±0.01	2035	0.98±0.00	0.88±0.03	435	0.92±0.01	0.91±0.01	75	0.99±0.02	0.98±0.02
		REC	3250	0.99±0.00	0.99±0.00	1217	0.78±0.00	0.75±0.01	702	0.64±0.00	0.64±0.00	2035	0.66±0.00	0.66±0.00	435	0.73±0.02	0.46±0.11	75	0.57±0.02	0.43±0.10
	Invercargill	PRC	5398	0.94±0.00	0.94±0.00	1670	0.80±0.01	0.80±0.01	463	0.70±0.01	0.69±0.01	576	0.81±0.00	0.79±0.00	24	0.58±0.05	0.39±0.11	4	0.00±0.00	0.00±0.00
		REC	5398	0.94±0.00	0.94±0.00	1670	0.77±0.01	0.76±0.01	463	0.79±0.01	0.77±0.01	576	0.84±0.01	0.84±0.01	24	0.10±0.02	0.05±0.02	4	0.00±0.00	0.00±0.00
Masterton	Arrowtown	PRC	14398	0.95±0.01	0.95±0.01	6328	0.95±0.00	0.95±0.00	3636	0.96±0.00	0.95±0.00	5109	0.96±0.00	0.95±0.01	310	0.78±0.02	0.77±0.01	19	0.80±0.40	0.80±0.40
		REC	14398	0.99±0.00	0.99±0.00	6328	0.93±0.00	0.93±0.00	3636	0.89±0.00	0.89±0.00	5109	0.91±0.01	0.91±0.01	310	0.79±0.03	0.76±0.03	19	0.06±0.04	0.06±0.04
	Reefion	PRC	5122	0.94±0.01	0.93±0.01	1377	0.96±0.00	0.91±0.00	399	0.90±0.00	0.71±0.03	381	0.87±0.02	0.73±0.02	29	0.95±0.02	0.36±0.13	1	0.00±0.00	0.00±0.00
		REC	5122	1.00±0.00	0.98±0.00	1377	0.91±0.00	0.83±0.01	399	0.76±0.01	0.61±0.03	381	0.77±0.05	0.72±0.07	29	0.35±0.10	0.34±0.10	1	0.00±0.00	0.00±0.00
	Cromwell	PRC	3250	0.85±0.01	0.85±0.01	1217	0.85±0.00	0.85±0.00	702	0.87±0.00	0.87±0.00	2035	0.94±0.01	0.94±0.01	435	0.92±0.01	0.85±0.02	75	0.99±0.02	0.98±0.02
		REC	3250	0.98±0.00	0.97±0.00	1217	0.79±0.01	0.79±0.01	702	0.72±0.01	0.72±0.01	2035	0.81±0.02	0.79±0.01	435	0.77±0.03	0.76±0.02	75	0.49±0.01	0.49±0.04
	Invercargill	PRC	5398	0.84±0.01	0.84±0.01	1670	0.87±0.00	0.86±0.00	463	0.96±0.00	0.87±0.00	576	0.90±0.02	0.89±0.02	24	1.00±0.00	1.00±0.00	4	0.00±0.00	0.00±0.00
		REC	5398	0.97±0.00	0.97±0.00	1670	0.66±0.01	0.63±0.01	463	0.66±0.02	0.65±0.02	576	0.77±0.05	0.77±0.05	24	0.36±0.11	0.34±0.11	4	0.00±0.00	0.00±0.00
Cromwell	Arrowtown	PRC	14398	0.96±0.00	0.96±0.00	6328	0.93±0.00	0.92±0.00	3636	0.97±0.00	0.96±0.00	5109	0.98±0.00	0.97±0.00	310	0.93±0.01	0.91±0.00	19	0.99±0.02	0.99±0.02
		REC	14398	1.00±0.00	0.99±0.00	6328	0.94±0.00	0.93±0.00	3636	0.92±0.00	0.91±0.00	5109	0.93±0.00	0.93±0.00	310	0.87±0.00	0.83±0.00	19	0.48±0.01	0.48±0.01
	Reefion	PRC	5122	1.00±0.00	0.99±0.00	1377	0.89±0.00	0.76±0.01	399	0.90±0.00	0.80±0.01	381	0.94±0.00	0.93±0.00	29	0.93±0.01	0.74±0.01	1	0.99±0.02	0.84±0.03
		REC	5122	0.98±0.00	0.96±0.00	1377	0.94±0.00	0.88±0.01	399	0.91±0.00	0.73±0.01	381	0.96±0.00	0.90±0.00	29	0.82±0.00	0.84±0.00	1	0.57±0.02	0.57±0.02
	Masterton	PRC	2153	0.99±0.00	0.97±0.00	876	0.92±0.00	0.83±0.00	318	0.96±0.00	0.84±0.00	584	0.94±0.00	0.92±0.00	103	0.88±0.00	0.82±0.00	14	0.93±0.01	0.81±0.01
		REC	2153	0.99±0.00	0.97±0.00	876	0.95±0.00	0.87±0.01	318	0.87±0.00	0.78±0.00	584	0.96±0.00	0.93±0.00	103	0.84±0.00	0.83±0.00	14	0.64±0.01	0.64±0.01
	Invercargill	PRC	5398	1.00±0.00	1.00±0.00	1670	0.96±0.00	0.96±0.00	463	0.99±0.00	0.99±0.00	576	0.96±0.00	0.97±0.00	24	0.92±0.01	0.93±0.00	4	0.99±0.02	0.98±0.02
		REC	5398	1.00±0.00	1.00±0.00	1670	0.99±0.00	0.99±0.00	463	0.96±0.00	0.96±0.00	576	0.98±0.00	0.98±0.00	24	0.83±0.00	0.87±0.00	4	0.57±0.01	0.60±0.01
Invercargill	Arrowtown	PRC	14398	0.97±0.00	0.97±0.00	6328	0.94±0.00	0.94±0.00	3636	0.96±0.00	0.95±0.00	5109	0.98±0.00	0.95±0.00	310	0.93±0.01	0.89±0.01	19	0.80±0.40	0.80±0.40
		REC	14398	1.00±0.00	1.00±0.00	6328	0.94±0.00	0.93±0.00	3636	0.91±0.00	0.90±0.00	5109	0.92±0.00	0.92±0.00	310	0.82±0.00	0.57±0.02	19	0.09±0.05	0.09±0.05
	Reefion	PRC	5122	0.99±0.00	0.98±0.00	1377	0.93±0.00	0.84±0.01	399	0.86±0.00	0.76±0.00	381	0.90±0.00	0.82±0.01	29	1.00±0.00	0.21±0.02	1	0.00±0.00	0.00±0.00
		REC	5122	0.99±0.00	0.97±0.00	1377	0.95±0.00	0.91±0.00	399	0.90±0.01	0.68±0.01	381	0.94±0.00	0.81±0.01	29	0.18±0.02	0.14±0.01	1	0.00±0.00	0.00±0.00
	Masterton	PRC	2153	0.99±0.00	0.97±0.00	876	0.97±0.00	0.89±0.00	318	0.93±0.00	0.78±0.00	584	0.90±0.01	0.85±0.00	103	0.64±0.01	0.49±0.01	14	0.00±0.00	0.00±0.00
		REC	2153	1.00±0.00	0.98±0.00	876	0.96±0.00	0.89±0.00	318	0.85±0.01	0.73±0.01	584	0.93±0.00	0.87±0.00	103	0.65±0.01	0.61±0.00	14	0.00±0.00	0.00±0.00
	Cromwell	PRC	3250	1.00±0.00	1.00±0.00	1217	0.99±0.00	0.99±0.00	702	0.98±0.00	0.98±0.00	2035	0.99±0.00	0.99±0.00	435	0.92±0.00	0.96±0.01	75	0.99±0.02	0.89±0.09
		REC	3250	1.00±0.00	1.00±0.00	1217	0.99±0.00	0.99±0.00	702	0.97±0.00	0.97±0.00	2035	0.99±0.00	0.99±0.00	435	0.94±0.01	0.93±0.01	75	0.55±0.01	0.80±0.07