The Canadian Airport Nowcasting System (CAN-Now): An Overview

by

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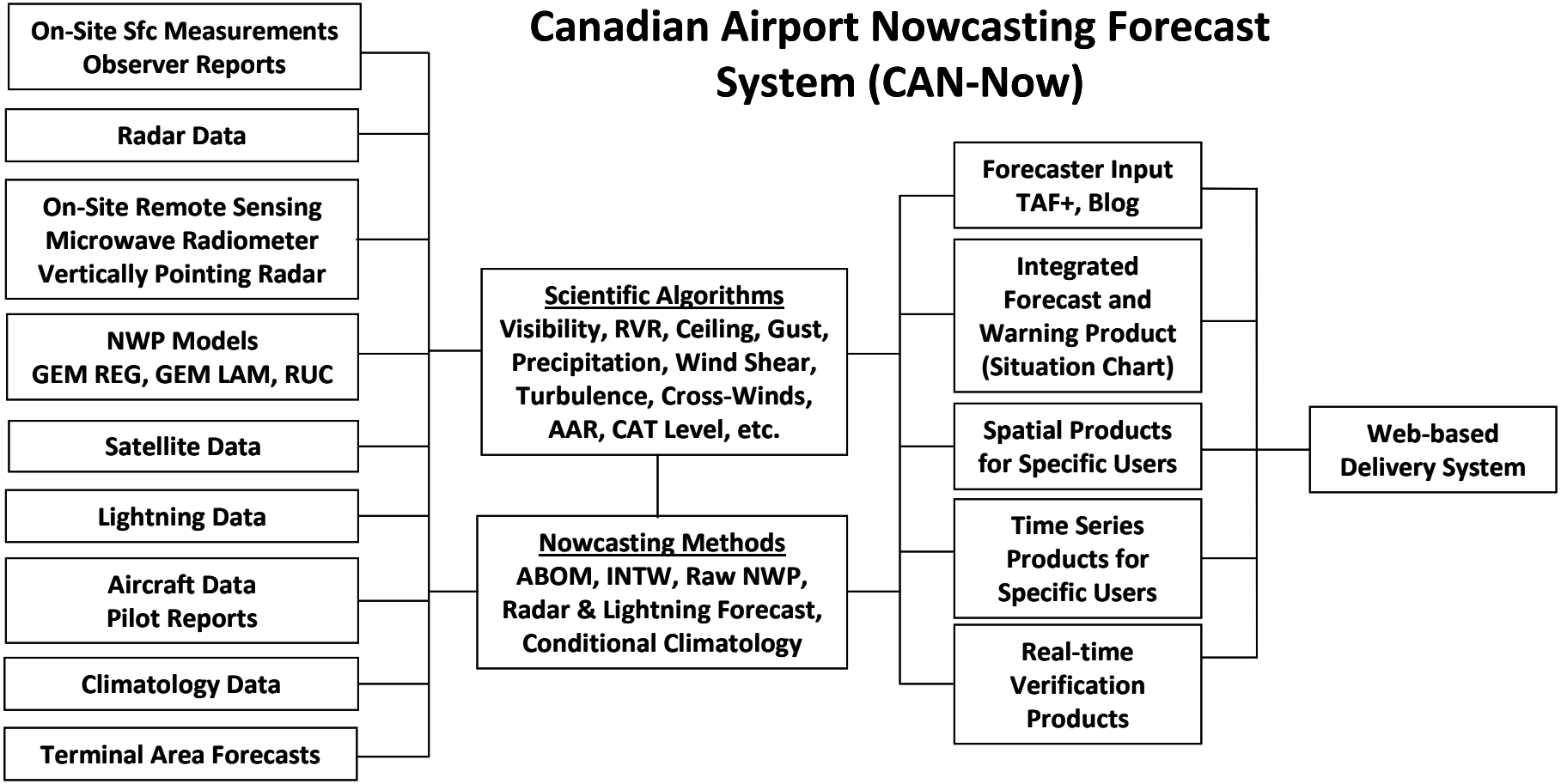
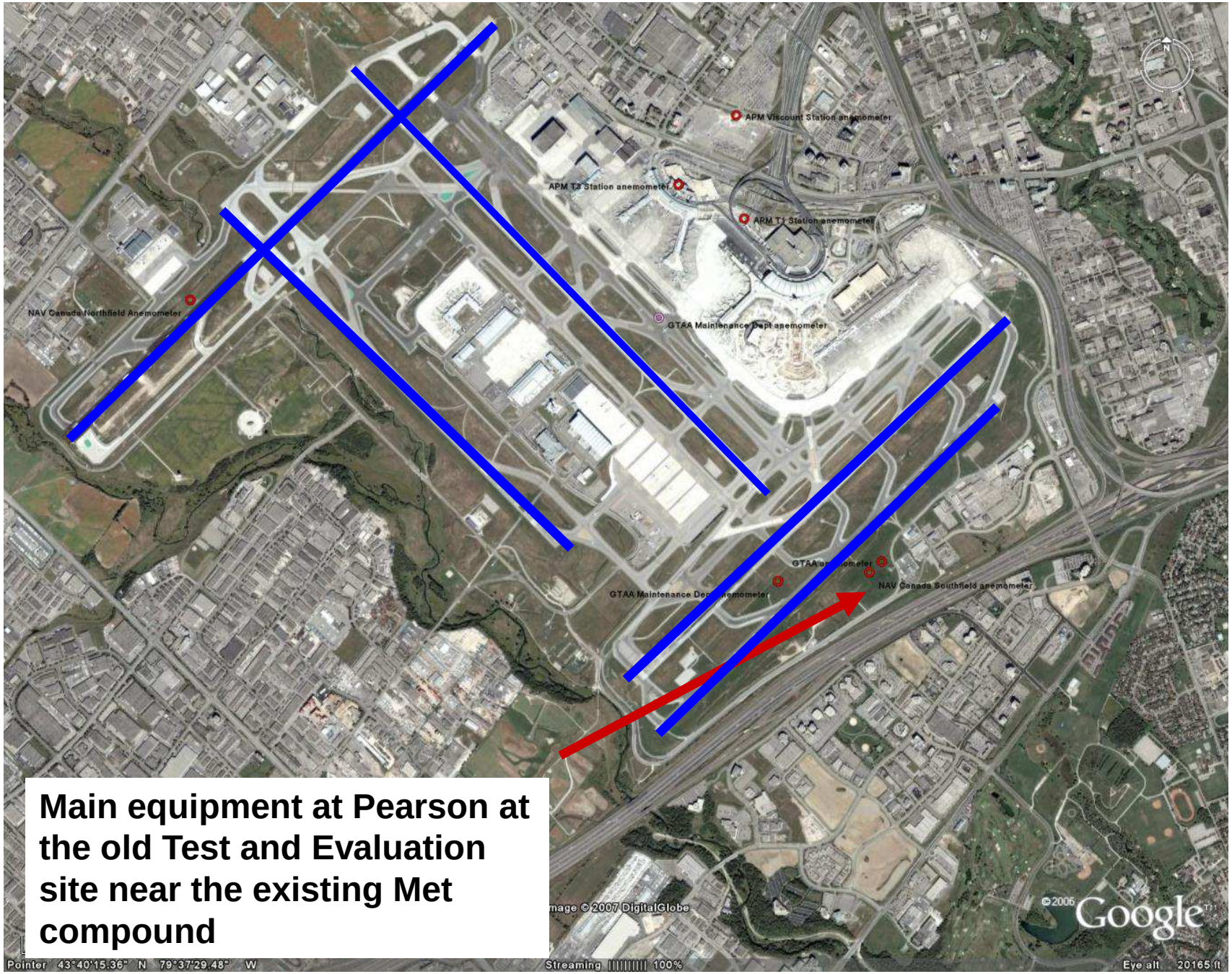
Canadian Airport Nowcasting (CAN-Now)

- To improve short term forecasts (0-6 hour) or Nowcasts of airport severe weather.
- Develop a forecast system which will include routinely gathered information (radar, satellite, surface based data, pilot reports), numerical weather prediction model outputs, and a limited suite of specialized sensors placed at the airport.
- Forecast/Nowcast products will be issued with 1-15 min resolution for most variables.
- Test this system, and its associated information delivery system, within an operational airport environment (e.g. Toronto and Vancouver International Airports).

Canadian Airport Nowcasting Forecast System (CAN-Now)



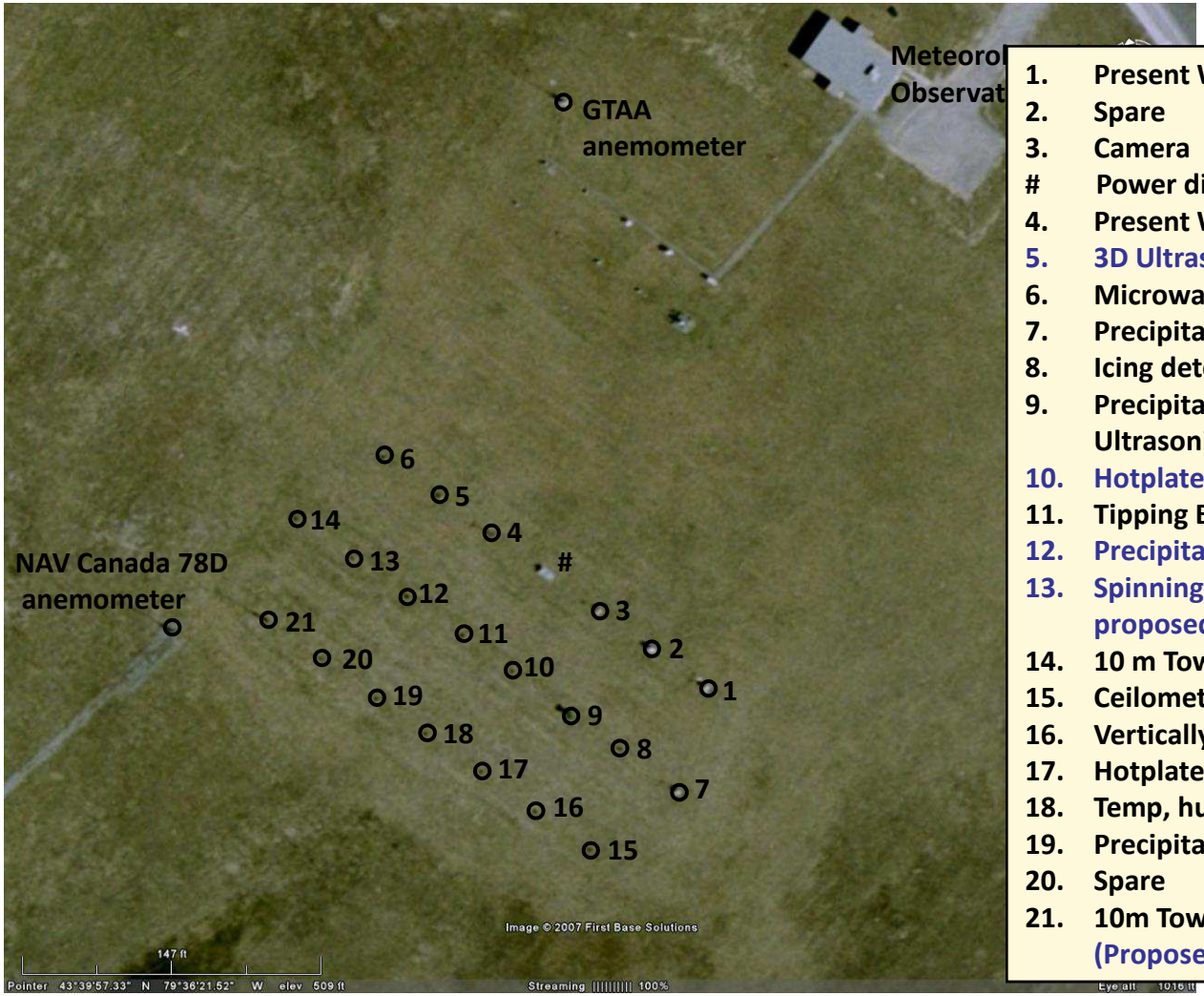
Isaac, G.A., Bailey, M., Boudala, F.S., Cober, S.G., Crawford, R.W., Donaldson, N., Gultepe, I., Hansen, B., Heckman, I., Huang, L.X., Ling, A., Mailhot, J., Milbrandt, J.A., Reid, J., and Fournier, M. (2012), The Canadian airport nowcasting system(CAN-Now). In Press Meteorological Applications. (now online)



Main equipment at Pearson at the old Test and Evaluation site near the existing Met compound

Pearson Instrument Site

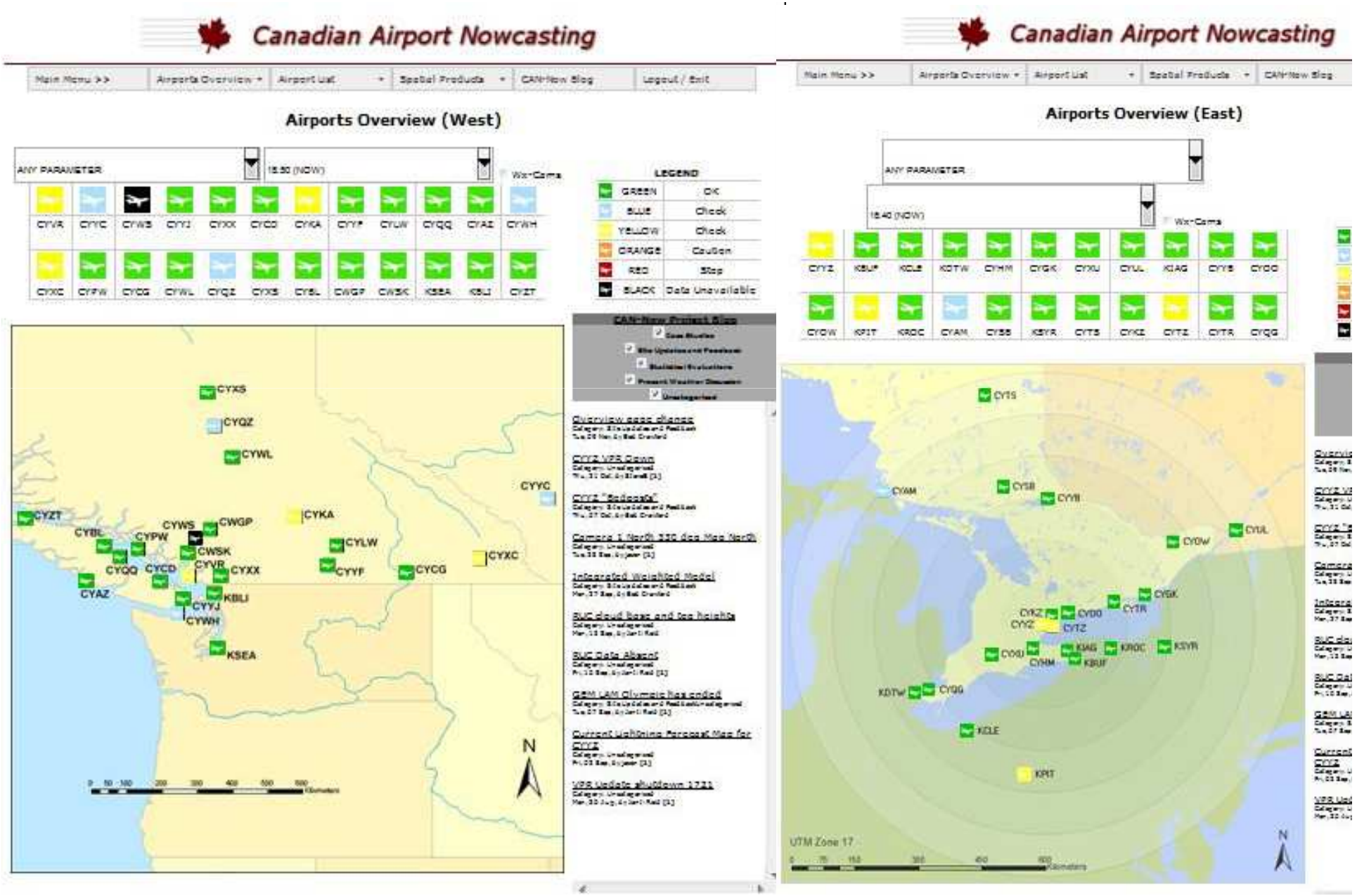
- 21 instrument bases with power and data feeds.
- 10m apart; rows 15m apart



1. Present Weather Sensor (Vaisala FD12P)
2. Spare
3. Camera
Power distribution box
4. Present Weather Sensor (Parsivel)
5. 3D Ultrasonic Wind Sensor (removed)
6. Microwave Profiling Radiometer (Radiometrics)
7. Precipitation Occurrence Sensor (POSS)
8. Icing detector (Rosemount)
9. Precipitation gauge (Belfort) with Nipher Shield
   Ultrasonic snow depth
10. Hotplate (Yankee – removed)
11. Tipping Bucket rain gauge TB3
12. Precipitation Switch
13. Spinning arm, liquid/total water content probe -- proposed
14. 10 m Tower, 2D ultrasonic wind sensor
15. Ceilometer (Vaisala CT25K)
16. Vertically Pointing 3 cm Radar (McGill)
17. Hotplate Precipitation Meter (Yankee)
18. Temp, humidity, pressure, solar radiation
19. Precipitation gauge (Geonor) with Nipher Shield
20. Spare
21. 10m Tower Spare

(Proposed or removed equipment)

CAN-Now Situation Chart



Canadian Airport Nowcasting

Main Menu | Situation Chart | Obs / Model Plots | GEM Pt Forecasts | TAFs & METARs | CAN-Now Blog

Situation Chart for CYYZ

TAF Plus | SIMCOE | WATERLOO | LINNG | MANS | Rwy: ☑ 05/23 ☑ 06/24RL ☑ 15/33RL

Thresholds — CYYZ METEOROLOGICAL NOWCAST : VALID AT 2011-02-02 10:00 UTC [INTW, GEM_REG_MOLTS, GEM_LAM_MOLTS, RUC, OBS, M300]

	10:00	10:10	10:20	10:30	10:40	10:50	11:00	11:10	11:20	11:30	11:40	11:50	12:00	13:00	14:00	15:00	16:00
	OBS	+10m	+20m	+30m	+40m	+50m	+1h	+1:10h	+1:20h	+1:30h	+1:40h	+1:50h	+2h	+3h	+4h	+5h	+6h
05/23 WINDS	050 17G23	030 17G23	030 17G23	030 17G23	030 17G23	030 17G23	030 17G23	030 17G23	030 17G23	030 17G23	030 17G23	030 17G23	040 17G23	030 17G24	040 16G24	040 14G22	040 12G23
06/24RL WINDS	050 17G23	030 17G23	030 17G23	030 17G23	030 17G23	030 17G23	030 17G23	030 17G23	030 17G23	030 17G23	030 17G23	030 17G23	040 17G23	030 17G24	040 16G24	040 14G22	040 12G23
15/33RL WINDS	050 17G23	030 17G23	030 17G23	030 17G23	030 17G23	030 17G23	030 17G23	030 17G23	030 17G23	030 17G23	030 17G23	030 17G23	040 17G23	030 17G24	040 16G24	040 14G22	040 12G23
VISIBILITY	3/4SM	1 5/8SM	1 5/8SM	1 5/8SM	1 5/8SM	1 5/8SM	1 5/8SM	1 3/4SM	1 3/4SM	1 3/4SM	1 7/8SM	1 7/8SM	1 7/8SM	2 1/4SM	2 3/4SM	3SM	P6SM
CEILING	007	009	009	009	009	009	009	008	008	008	007	007	007	009	012	009	009
SHEAR/TURB																	
PRECIP	T	T	T	T	0004	0008	0007	0007	0007	0006	0006	0008	0020	0004	0002	T	0003
TSTM & LTNG																	
ICING						068	050	043	043	036	036	030	030	043	036	030	036

Thresholds — CYYZ OPERATIONS NOWCAST : VALID AT 2011-02-02 10:00 UTC [INTW, GEM_REG_MOLTS, GEM_LAM_MOLTS, RUC, OBS, M300]

	10:00	10:10	10:20	10:30	10:40	10:50	11:00	11:10	11:20	11:30	11:40	11:50	12:00	13:00	14:00	15:00	16:00
	OBS	+10m	+20m	+30m	+40m	+50m	+1h	+1:10h	+1:20h	+1:30h	+1:40h	+1:50h	+2h	+3h	+4h	+5h	+6h
WX-ONLY AAR		62	62	62	62	62	62	62	62	62	62	62	62	62	62	62	62
CAT LEVEL	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I
05/23 COND																	
06/24RL COND																	
15/33RL COND																	

Thresholds as applied on Situation Chart

Crosswinds:

Dry RWY (precipitation rate ≤ 0.2 mm/h and visibility ≥ 1 SM):

x-wind (knots) < 15	:	GREEN	
15 ≤ x-wind (knots) < 20	:	YELLOW	
20 ≤ x-wind (knots) < 25	:	ORANGE	
x-wind (knots) ≥ 25	:	RED	(NOT PERMITTED)

Wet RWY (precipitation rate > 0.2 mm/h or visibility < 1 SM):

x-wind (knots) < 5	:	GREEN	
5 ≤ x-wind (knots) < 10	:	YELLOW	
10 ≤ x-wind (knots) < 15	:	ORANGE	
x-wind (knots) ≥ 15	:	RED	(NOT PERMITTED)

Visibility:

vis (SM) ≥ 6	:	GREEN	(VFR)
3 ≤ vis (SM) < 6	:	BLUE	(MVFR)
½ ≤ vis (SM) < 3	:	YELLOW	(IFR)
¼ ≤ vis (SM) < ½	:	ORANGE	(BLO ALTERNATE)
vis (SM) < ¼	:	RED	(BLO LANDING)

CAT-level:

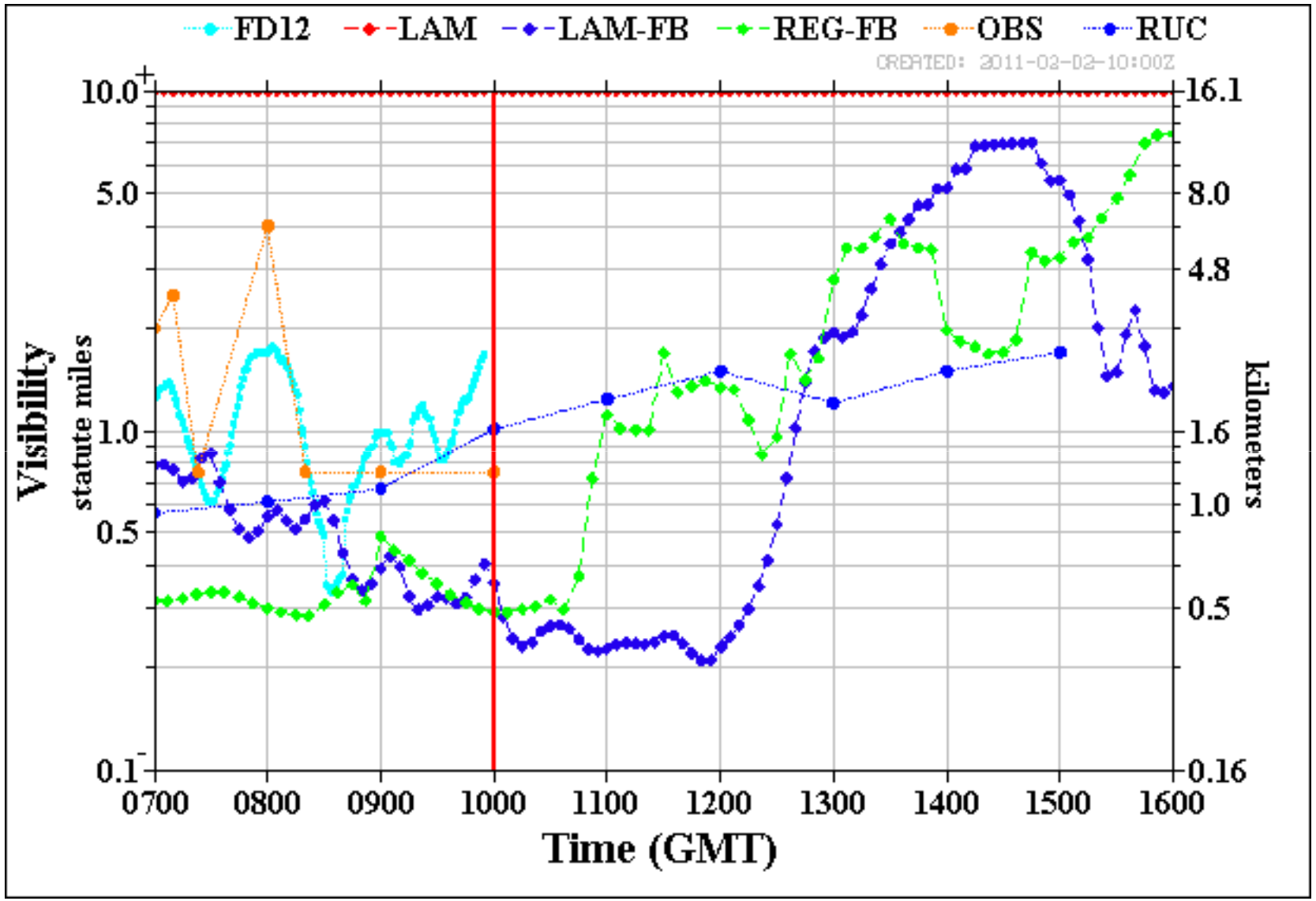
RVR (ft) < 600			RED (NOT PERMITTED)
600 ≤ RVR (ft) < 1200	-or-	ceiling (ft) < 100	: RED (CAT IIIa)
1200 ≤ RVR (ft) < 2600	-or-	100 ≤ ceiling (ft) < 200	: ORANGE (CAT II)
2600 ft ≤ RVR < 3 SM	-or-	200 ≤ ceiling (ft) < 1000	: YELLOW (CAT I)
3 ≤ RVR (SM) < 6	-or-	1000 ≤ ceiling (ft) < 2500	: BLUE (MVFR)
RVR (SM) ≥ 6	-and-	ceiling (ft) ≥ 2500	: GREEN (VFR)

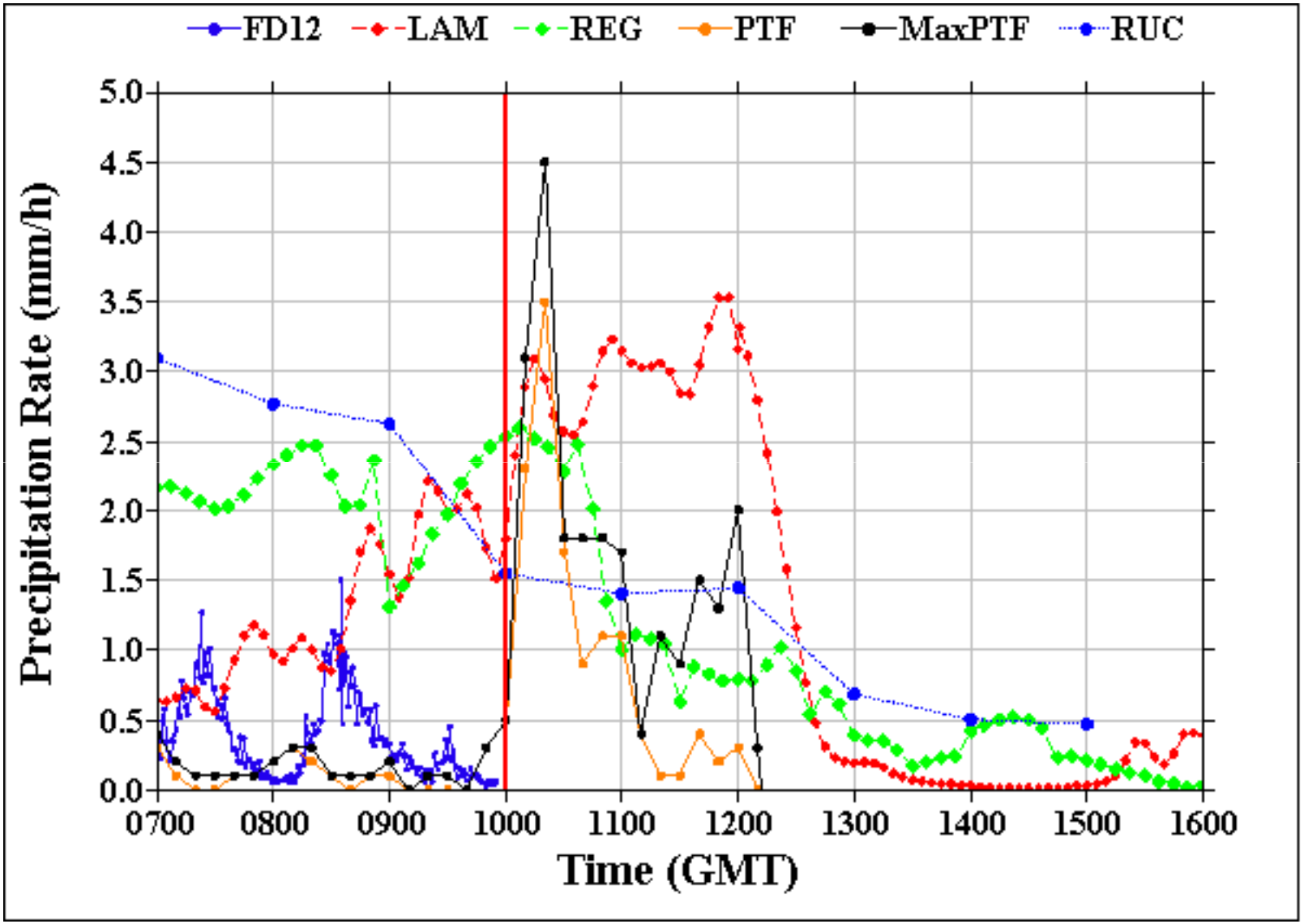
RWY Condition:

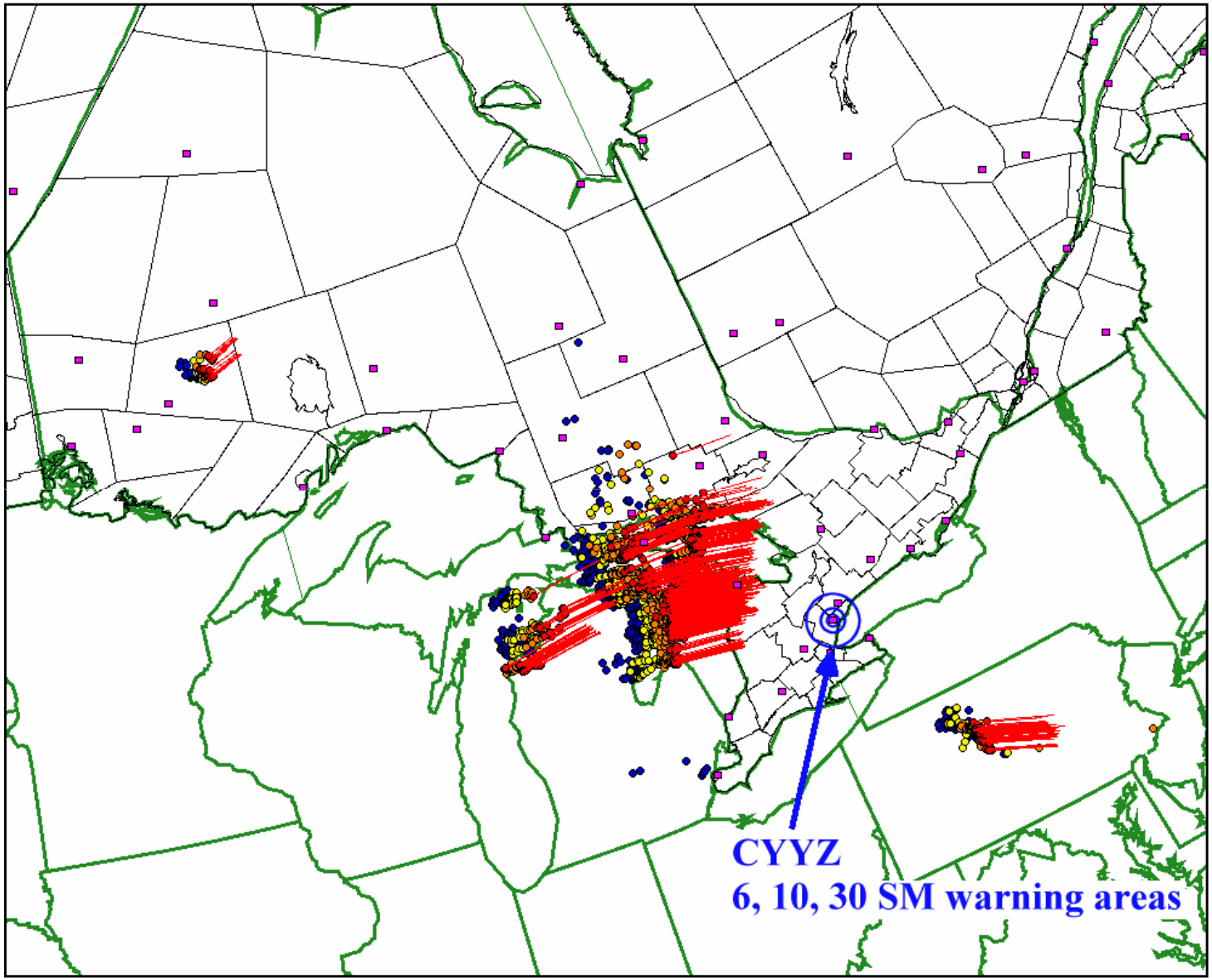
precipitation rate (mm/h) > 0.2 : ORANGE (Possible WET rwy)
precipitation rate (mm/h) ≤ 0.2 : YELLOW (Possible DRY rwy)

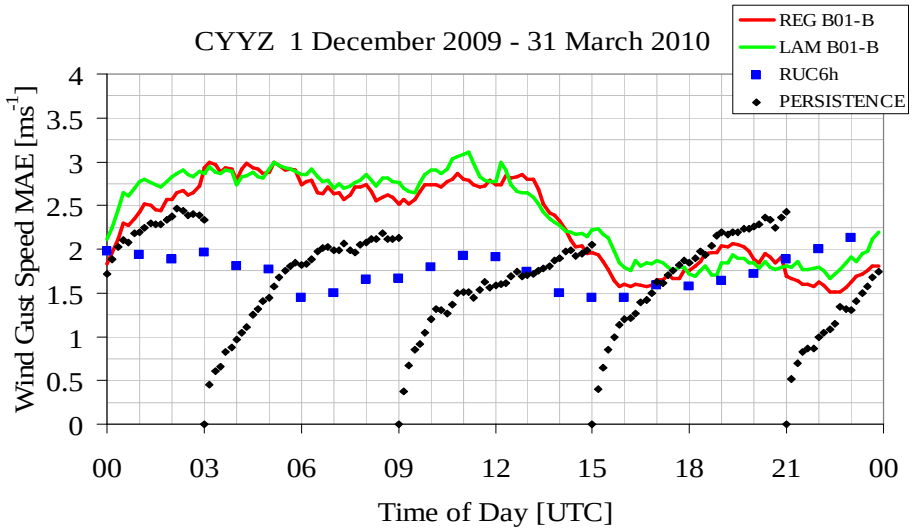
Wx Only AAR:

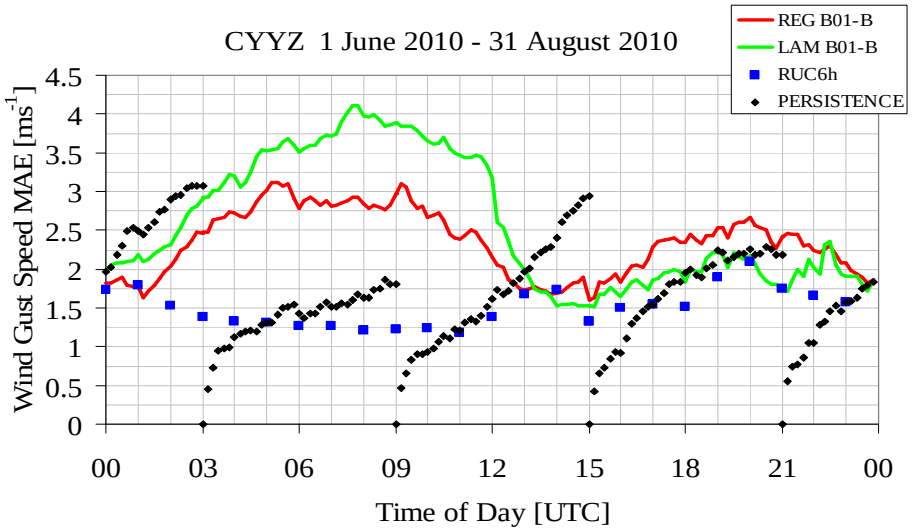
Cell colour is based on meteorological conditions – same as CAT-level
Meteorologically-limited theoretical maximum AAR determined from look-up table of documented AAR values based on runway configuration and meteorological conditions (CAT-level).
Runway configuration determined solely from crosswind thresholds for maximum potential capacity.

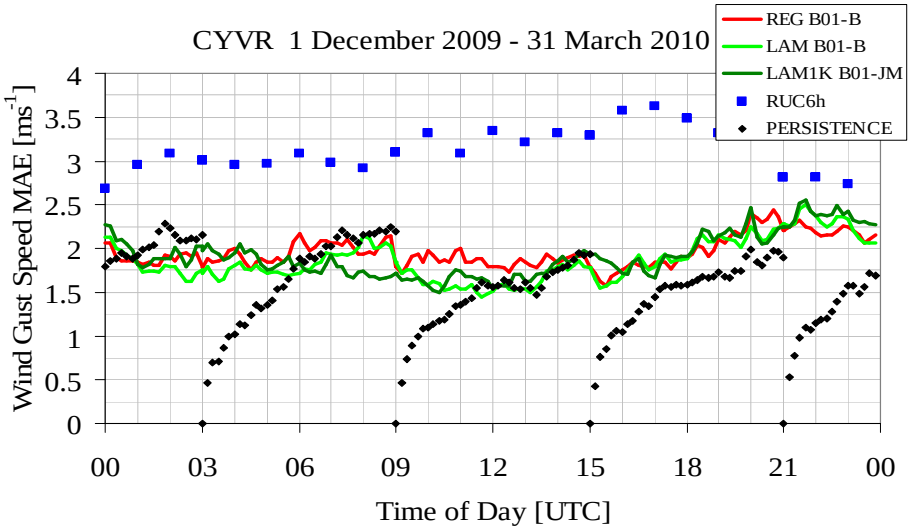

FD12
LAM
LAM-FB
REG-FB
OBS
RUC
CREATED: 2011-02-02-10:00Z
10.0
5.0
1.0
0.5
0.1
16.1
8.0
4.8
1.6
1.0
0.5
0.16
Visibility
statute miles
kilometers
0700
0800
0900
1000
1100
1200
1300
1400
1500
1600
Time (GMT)

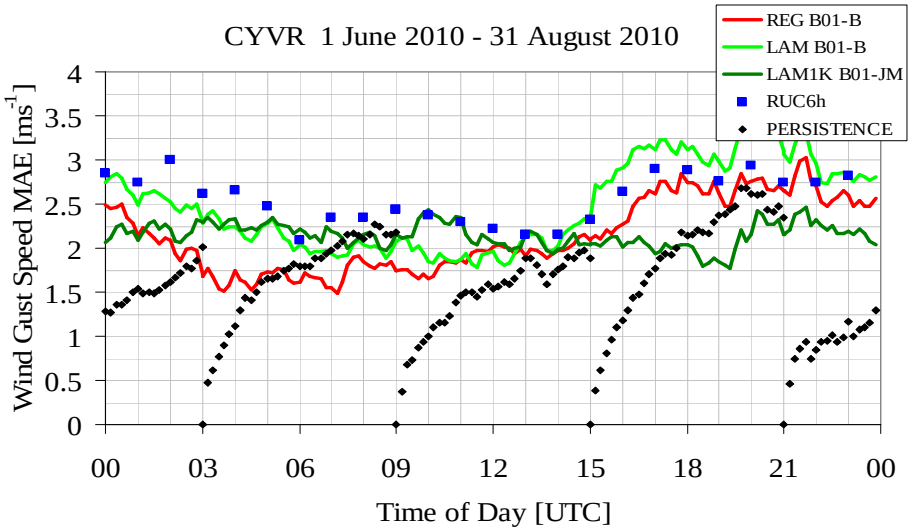

FD12
LAM
REG
PTF
MaxPTF
RUC
Precipitation Rate (mm/h)
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0700
0800
0900
1000
1100
1200
1300
1400
1500
1600
Time (GMT)


CYYZ
6, 10, 30 SM warning areas


CYYZ 1 December 2009 - 31 March 2010
REG B01-B
LAM B01-B
RUC6h
PERSISTENCE
Wind Gust Speed MAE [ms-1]
Time of Day [UTC]
00 03 06 09 12 15 18 21 00

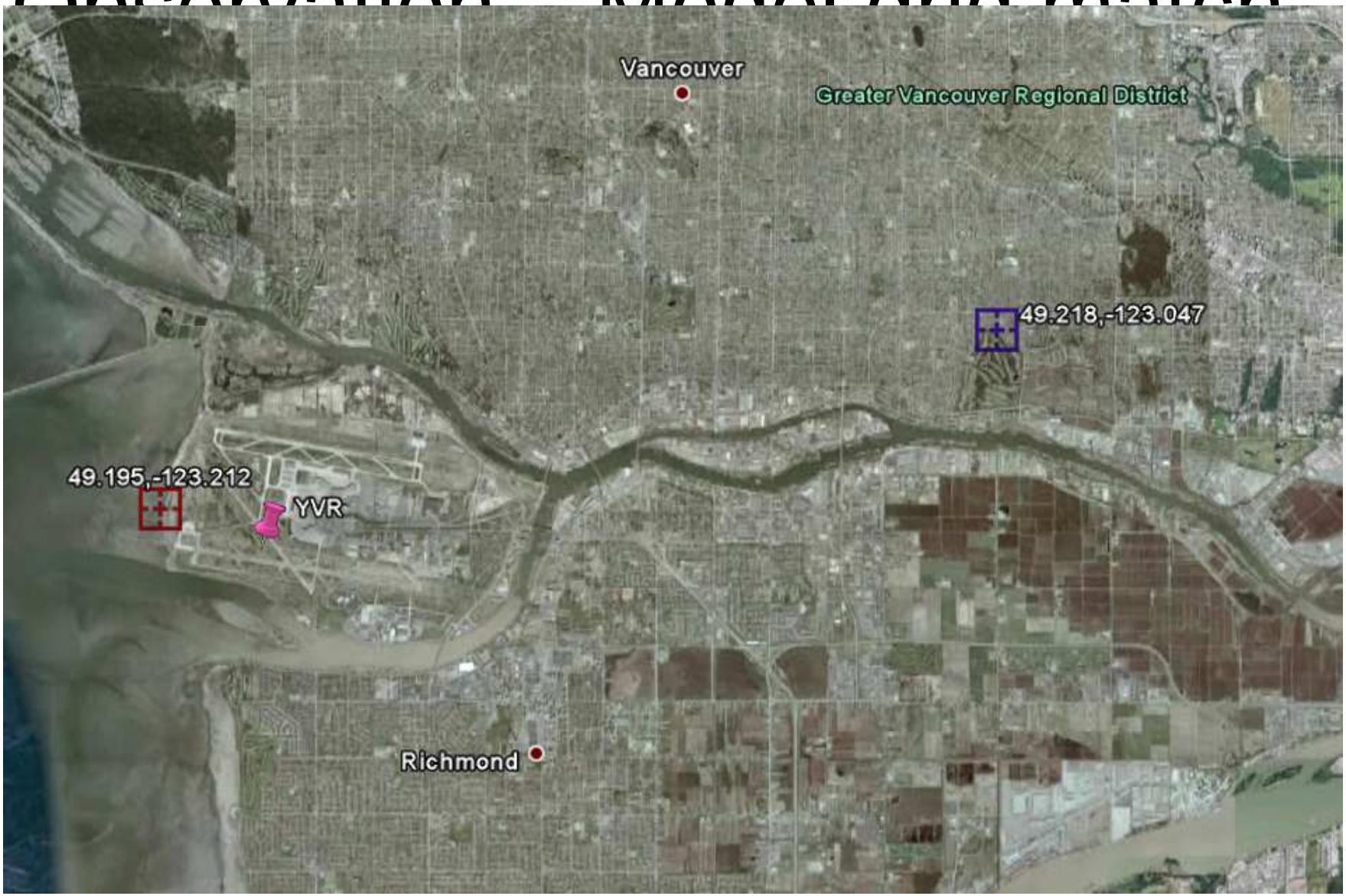

CYYZ 1 June 2010 - 31 August 2010
REG B01-B
LAM B01-B
RUC6h
PERSISTENCE
Wind Gust Speed MAE [ms-1]
Time of Day [UTC]
00 03 06 09 12 15 18 21 00


CYVR 1 December 2009 - 31 March 2010
REG B01-B
LAM B01-B
LAM1K B01-JM
RUC6h
PERSISTENCE
Wind Gust Speed MAE [ms-1]
Time of Day [UTC]
00 03 06 09 12 15 18 21 00


CYVR 1 June 2010 - 31 August 2010
REG B01-B
LAM B01-B
LAM1K B01-JM
RUC6h
PERSISTENCE
Wind Gust Speed MAE [ms-1]
Time of Day [UTC]
00 03 06 09 12 15 18 21 00

Variable	WINTER CYVR MAE					SUMMER CYVR MAE				
	REG	**LAM**	**RUC 6h**	**CLI**	**LAM1K**	**REG**	**LAM**	**RUC 6h**	**CLI**	**LAM1K**
Temperature (^{o}C)	**1.4**	**1.1**	**1.7**	**2.7**	**1.4**	**1.3**	**1.3**	**4.4**	**1.6**	**1.4**
Relative Humidity (%)	**8.0**	**7.7**	**10.5**	**9.2**	**7.2**	**8.8**	**6.4**	**14.0**	**6.5**	**7.2**
Wind Speed (m s^{-1})	**1.4**	**1.4**	**2.6**	**1.7**	**1.3**	**1.6**	**1.6**	**1.7**	**1.5**	**1.5**
Wind Direction (deg)	**40.8**	**42.4**	**48.3**	**55.5**	**42.6**	**39.1**	**44.2**	**48.6**	**59.5**	**46.3**
Max Wind Speed (m s^{-1})	**2.0**	**1.9**	**3.1**	**N/A**	**1.9**	**2.2**	**2.5**	**2.5**	**N/A**	**2.2**
Crosswind Rwy 1 (m s^{-1})	**1.8**	**1.4**	**1.9**	**N/A**	**1.4**	**1.4**	**1.5**	**1.5**	**N/A**	**1.4**
Crosswind Rwy 2 (m s^{-1})	**2.0**	**1.7**	**2.7**	**N/A**	**1.6**	**1.7**	**1.6**	**1.8**	**N/A**	**1.6**

Observation – Model grid match



J. Reid 2010

Two New Nowcasting Techniques Which Combine Model(s) and Observations

Adaptive Blending of Observations and Models (ABOM)

$$\hat{V}_{k+p} = o_k + s_p\left(\hat{o}_{k+p} - o_k\right) + r_p\left(m_{k+p} - m_k\right)$$

- $\hat{V}_{k+p}$: Forecast at lead time p
- o_k: Current Observation
- $s_p\left(\hat{o}_{k+p} - o_k\right)$: Change predicted by obs trend
- $r_p\left(m_{k+p} - m_k\right)$: Change predicted by model

INTW

INTW combines predictions from several NWP models by weighting them based on past performance (6 hours) and doing a bias correction using the most recent observation.

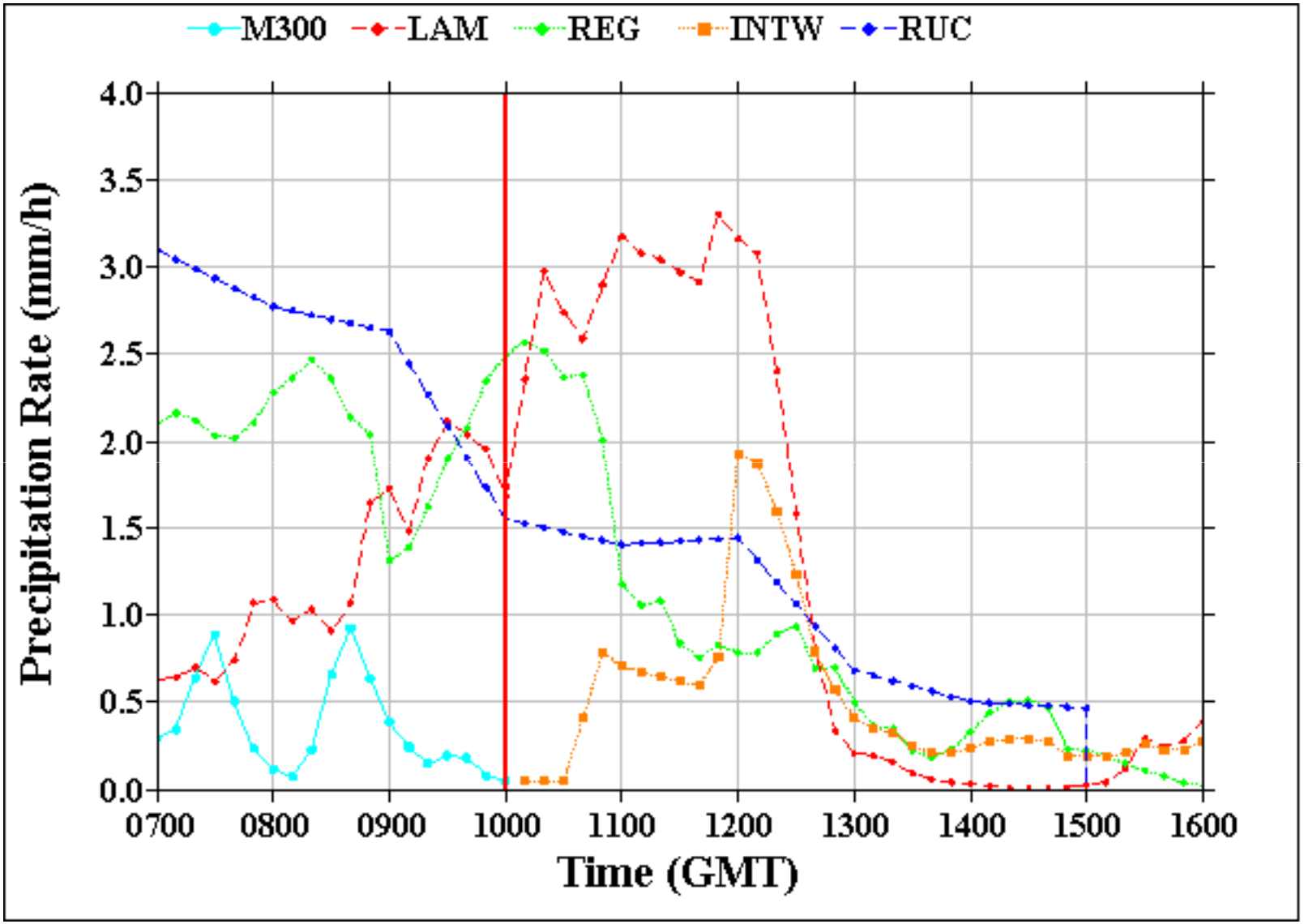
References for Nowcasting Techniques

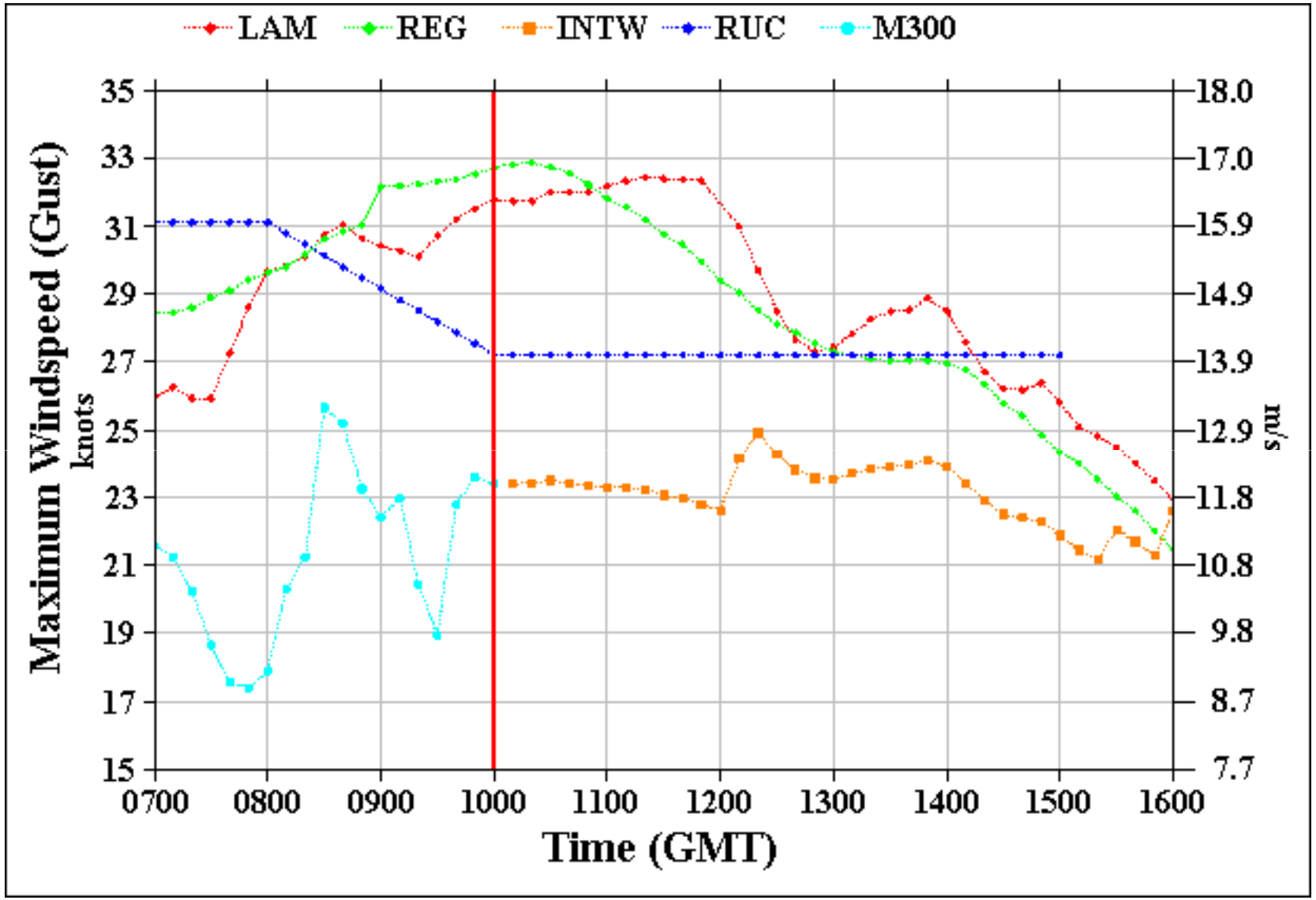
Bailey, M.E., Isaac, G.A., Gultepe, I., Heckman, I., and Reid, J. (2012), Adaptive Blending of Model and Observations for Automated Short Range Forecasting: Examples from the Vancouver 2010 Olympic and Paralympic Winter Games. Accepted to Pure and Applied Geophysics

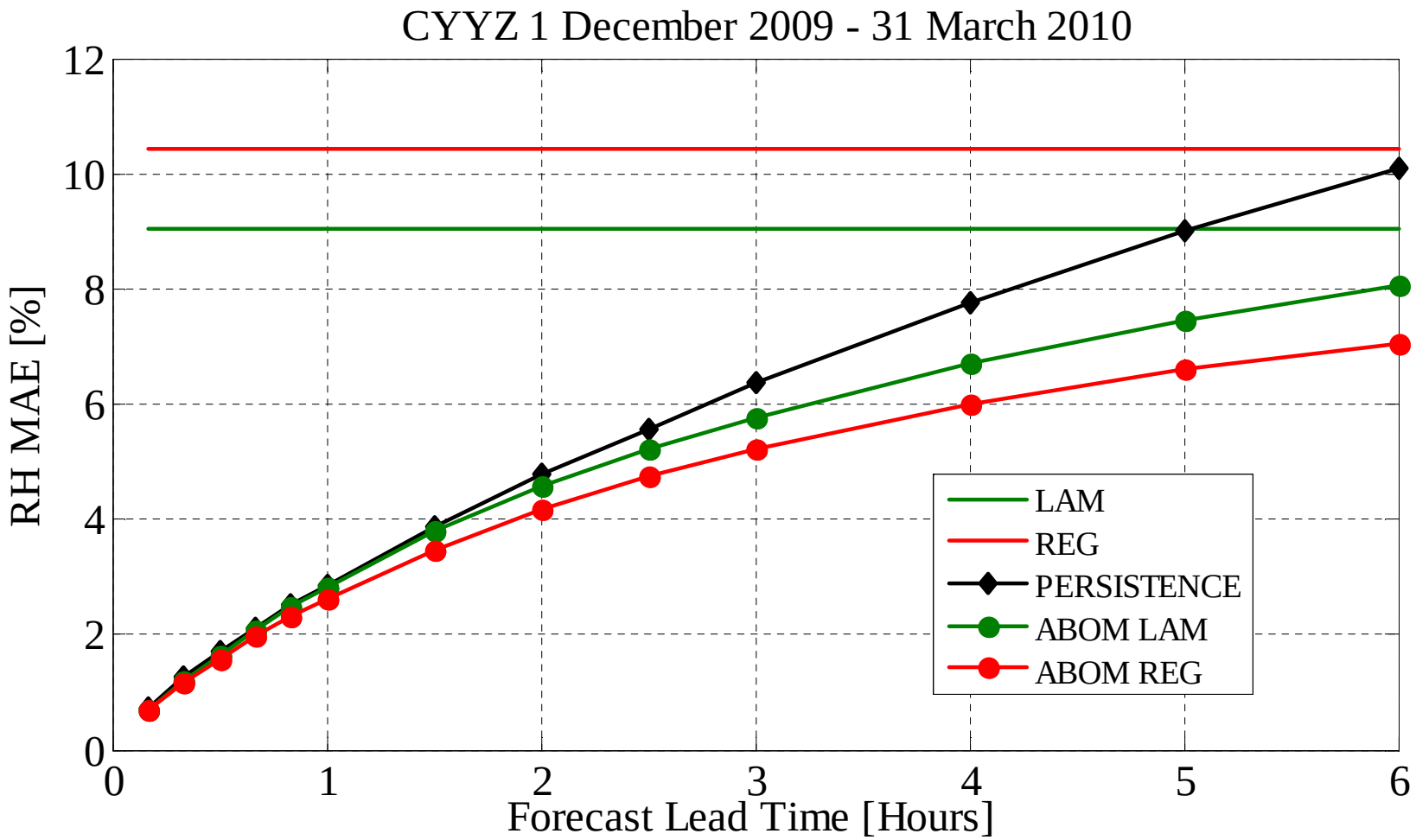
Huang, L.X., Isaac, G.A., and Sheng, G. (2012), Integrating NWP Forecasts and Observation Data to Improve Nowcasting Accuracy. In Press Weather and Forecasting (Now Online)

Huang, L.X., Isaac, G.A., and Sheng, G. (2012), A New Integrated Weighted Model in SNOW-V10: Verification of Continuous Variables. Accepted to Pure and Applied Geophysics

Huang, L.X,, Isaac, G.A., and Sheng, G. (2012), A New Integrated Weighted Model in SNOW-V10: Verification of Categorical Variables. Accepted to Pure and Applied Geophysics


M300
LAM
REG
INTW
RUC
Precipitation Rate (mm/h)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0700
0800
0900
1000
1100
1200
1300
1400
1500
1600
Time (GMT)


LAM
REG
INTW
RUC
M300
Maximum Windspeed (Gust)
knots
m/s
35
33
31
29
27
25
23
21
19
17
15
18.0
17.0
15.9
14.9
13.9
12.9
11.8
10.8
9.8
8.7
7.7
0700
0800
0900
1000
1100
1200
1300
1400
1500
1600
Time (GMT)


CYYZ 1 December 2009 - 31 March 2010
RH MAE [%]
Forecast Lead Time [Hours]
0
2
4
6
8
10
12
0
1
2
3
4
5
6
LAM
REG
PERSISTENCE
ABOM LAM
ABOM REG

Mean Absolute Error (MAE) for Significant Variables
(From 1 December 2009 to 31 March 2010 for CYYZ and CYVR)

Variables	CYYZ MAE				CYVR MAE			
	REG	LAM	RUC	INTW	REG	LAM	RUC	INTW
Temperature (^{o}C)	1.7	2.3	1.9	1.0	1.4	1.1	1.7	0.8
Relative Humidity (%)	10.5	9.0	12.3	5.4	8.0	7.7	10.5	5.0
Wind Speed (m s^{-1})	1.6	1.2	1.4	1.0	1.4	1.4	2.6	1.2
Max Wind Speed (m s^{-1})	2.3	2.4	1.7	1.4	2.0	1.9	3.1	1.4
Crosswind Rwy 1 (m s^{-1})	1.9	2.0	1.7	1.3	1.8	1.4	1.9	1.2
Crosswind Rwy 2 (m s^{-1})	1.9	2.0	1.7	1.3	2.0	1.7	2.7	1.4
Crosswind Rwy 3 (m s^{-1})	1.9	2.0	1.5	1.2	N/A	N/A	N/A	N/A

GEM REG: Run 4 times per day 0, 6, 12, and 18 UTC; GEM LAM East: Run once per day at 12 UTC; RUC: Run once per hour but only 6 h forecast used.; GEM LAM Olympic 2.5km (West): Run twice per day at 9, 21 UTC up to Dec 9 and 6, 15 UTC afterwards; GEM LAM Olympic 1km (West): Run twice per day at 11, 23 UTC up to Dec 9 and 11, 20 UTC afterwards
INTW: MAE run every 10 min and averaged over the first 6 hours of the forecast.

NWP Model with Minimum MAE in CAN-Now for Winter Dec 1/09 – Mar 31/10 and Summer June 1/10 to Aug 31/10 Periods

Variables	CYYZ		CYVR	
	Winter	Summer	Winter	Summer
Temperature	REG	RUC	LAM	REG
Relative Humidity	LAM	LAM	LAM	LAM
Wind speed	LAM	RUC	LAM	LAM
Wind gust	RUC	RUC	LAM	REG
Xwind 1	RUC	RUC	LAM	REG
Xwind 2	RUC	RUC	LAM	LAM
Xwind 3	RUC	RUC		

Based on First 6 Hours of Forecast

INTW and NWP Models with Minimum MAE in CAN-NOW

Variables	CYYZ		CYVR	
	Winter	Summer	Winter	Summer
Temperature	INTW	INTW	INTW	INTW
Relative Humidity	INTW	INTW	INTW	INTW
Wind speed	INTW	INTW	INTW	INTW
Wind gust	INTW	INTW	INTW	INTW
Xwind 1	INTW	INTW	INTW	INTW
Xwind 2	INTW	INTW	INTW	INTW
Xwind 3	INTW	INTW		

Winter period – Dec. 1, 2009 to Mar. 31, 2010

Summer period - June 1 to August 31, 2010

Time (h) for Model to Beat Persistence

Variable	LAM		REG		RUC		INTW	
	CYYZ	CYVR	CYYZ	CYVR	CYYZ	CYVR	CYYZ	CYVR
TEMP	6	3	4	3.5	4.5	5	2.5	0.5
RH	6	6	no	6	no	no	3.5	3
WS	2.5	3.5	4.5	3.5	3	no	1	2.5
GUST	no	no	no	5	3.5	no	1.5	1.5

Winter

Variable	LAM		REG		RUC		INTW	
	CYYZ	CYVR	CYYZ	CYVR	CYYZ	CYVR	CYYZ	CYVR
TEMP	2.5	2.5	2.2	2.5	1.5	no	0.5	0.5
RH	3	3	3.2	4.5	3	no	1	1
WS	3	5	3.5	5	2.2	no	1.5	2.5
GUST	no	no	5.5	no	2.2	no	0.5	4

Summer

Huang, L.X., G.A. Isaac and G. Sheng, 2011: Integrating NWP Forecasts and Observation Data to Improve Nowcasting Accuracy, In Press Weather and Forecasting (Now Online)

Categories Being Used in CAN-Now Analysis

	Table 2 (From Bailey's CAWW Talk)							
Variable	**Category 1**	**Category 2**	**Category 3**	**Category 4**	**Category 5**	**Category 6**	**Category 7**	**Category 8**
Winds	< 5 kts	5 ≤ w < 10 kts	10 ≤ w < 15 kts	15 ≤ w < 20 kts	20 ≤ w < 25 kts	w ≥ 25 kts	-	-
Wind Direction	d ≥ 339 & d < 24º (N)	24 ≤ d < 69º (NE)	69 ≤ d < 114º (E)	114 ≤ d < 159º (SE)	159 ≤ d < 204º (S)	204 ≤ d < 249º (SW)	249 ≤ d < 294º (W)	294 ≤ d < 339º (NW)
Visibility	v < 1/4 SM	1/4 ≤ v < 1/2 SM	1/2 ≤ v < 3 SM	3 ≤ v < 6 SM	v ≥ 6 SM	-	-	-
Ceiling	c < 150 ft	150 ≤ c< 400 ft	400 ≤ c< 1000 ft	1000 ≤ c< 2500 ft	2500 ≤ c< 10000 ft	c ≥ 10000 ft	-	-
Precip Rate	r = 0 mm/hr (None)	0 < r ≤ 0.2 mm/hr (Trace)	0.2 < r ≤ 2.5 mm/hr (Light)	2.5 < r ≤ 7.5 mm/hr (Moderate)	r > 7.5 mm/hr (Heavy)	-	-	-
Precip Type	No Precip	Liquid	Freezing	Frozen	Mixed (w/Liquid)	Unknown	-	-

Model	Variable	CYYZ Winter		CYYZ Summer	
		Original M-C HSS / ACC	Relaxed M-C HSS / ACC	Original M-C HSS / ACC	Relaxed M-C HSS / ACC
REG	Ceiling	0.45 / 0.62	0.46 / 0.61	0.36 / 063	0.30 / 0.55
	Precipitation Rate	0.30 / 0.70	0.26 / 0.62	0.23 / 0.86	0.19 / 0.78
	Visibility (BI09)	0.28 / 0.78	0.27 / 0.70	0.15 / 0.78	0.16 / 0.73
LAM	Precipitation Rate	0.29 / 0.73	0.27 / 0.67	0.18 / 0.91	0.18 / 0.85
	Visibility (BI09)	0.24 / 0.75	0.25 / 0.71	0.08 / 0.80	0.11 / 0.77
RUC 6h	Ceiling	0.24 / 0.47	0.25 / 0.45	0.33 / 0.67	0.33 / 0.63
	Precipitation Rate	0.40 / 0.84	0.40 / 0.81	0.18 / 0.90	0.18 / 0.85
	Visibility	0.22 / 0.66	0.19 / 0.60	0.16 / 0.74	0.15 / 0.70

HSS: What was the accuracy of the forecast in predicting the correct category, relative to that of random chance?
ACC: Overall, what fraction of the forecasts were in the correct category?

Summary

- **RH predictions are poor, barely beating climatology. (Impacts visibility forecasts)**
- **Visibility forecasts are poor from statistical point of view. (also require snow and rain rates)**
- **Cloud base forecasts, although showing some skill, could be improved with better model resolution in boundary layer.**
- **Wind direction either poorly forecast or measured.**
- **Overall statistical scores do not show complete story. Need emphasis on high impact events.**
- **Selection of model point to best represent site is a critical process.**

Summary -- continued

- **The web-based Situation Chart is a useful quick glance tool for alerting users to potential problems. Specific users generally require tailored displays focusing on their needs.**
- **There is a need for measurements at high time resolution. Conditions at the airport can vary quickly on scales of several minutes.**
- **There is value in using more than one numerical weather forecast model in the products. Often one model captures a high impact event more accurately than another.**
- **The nowcast systems developed, especially the INTW system, have demonstrated skill. In the future, it might be useful to use INTW forecasts for the algorithms predicting such parameters as precipitation rate, visibility, and ceiling.**
- **Currently using CAN-Now products to produce a First Guess TAF**

Questions?