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Canada

AvRDP: First Results from Toronto Pearson International Airport

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Outline

1) ECCC Contributions to AvRDP
2) Pearson Met Site Overview
3) Nowcasting Systems Overview
4) Preliminary MET Verification Results at Pearson
5) Future Plans including an update at Iqaluit NU

Overview of :
ECCC Contribution to AvRDP
Toronto Pearson Met Site
Nowcasting Systems

ECCC Contribution: 2 AvRDP Airports

AvRDP Host Airport

- Collect meteorological observations including surface, advanced remote sensing and NWP data and to provide them to AvRDP Participants to execute nowcasting or model simulations over the airport

- Conduct inter-comparison and verification in order to assess each nowcast system's performance (Phase 1) and to contribute to the translation and study of ATM impact (Phase 2)

Toronto Pearson International Airport (CYYZ)

43° 40′ 36″ N
79° 37′ 50″ W

Runwa
05
15L/3
15R/3
06L/2
06R/2

Canada's larg
& busiest airp

400 000 flights
38M passengers
annually (2014)

CYYZ Met Site

Pearson Supersite for MET Observations (CYYZ)

… And more!

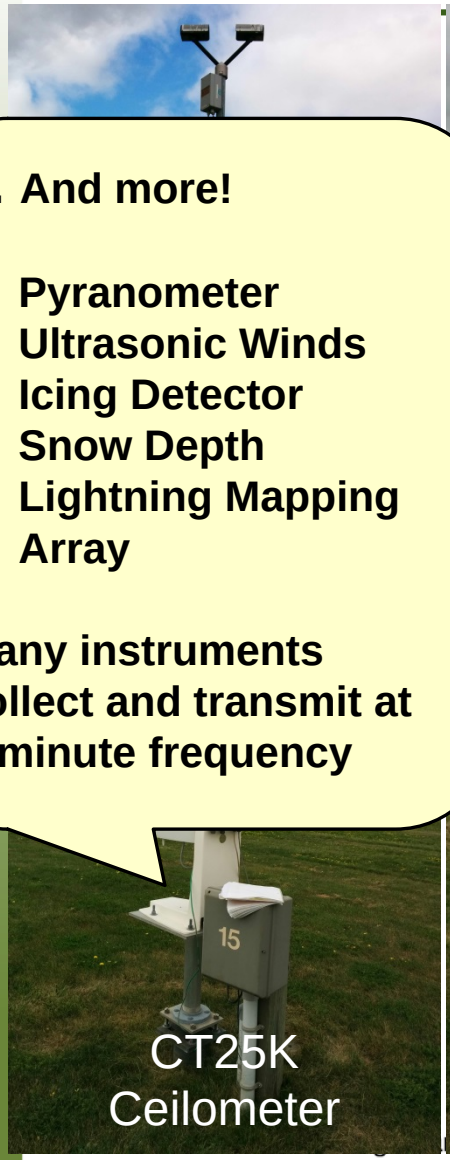
- **Pyranometer**
- **Ultrasonic Winds**
- **Icing Detector**
- **Snow Depth**
- **Lightning Mapping Array**

Many instruments collect and transmit at 1-minute frequency


POSS


FD12P


X-Band VPR


CT25K Ceilometer


Jenoptik Ceilometer


WXT520


Web Cameras

NWP & Nowcasting Systems

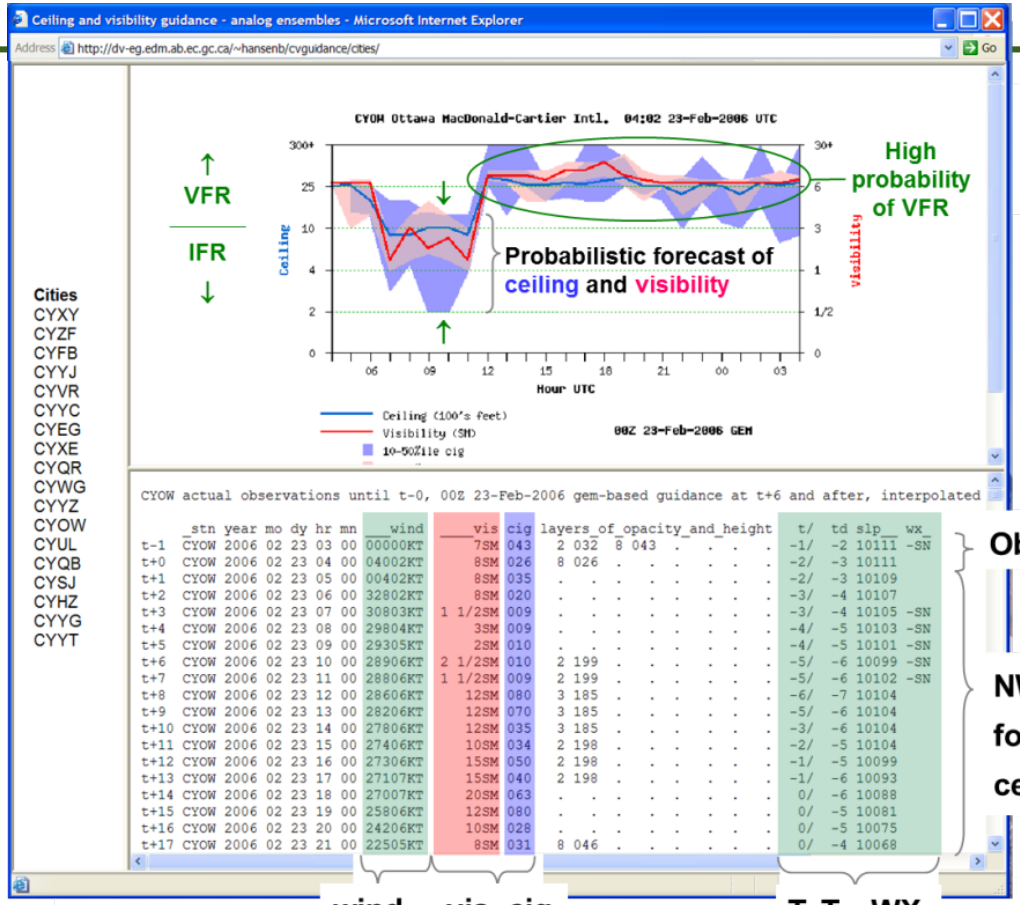
System	Acronym	Type	Status
GEM High Resolution Deterministic Prediction System (2.5km)	HRDPS	NWP	Near-operational
GEM Regional Deterministic Prediction System (10km)	RDPS	NWP	Operational
Aviation Conditional Climatology	ACC	Climatology-based with OBS and NWP	Near-operational
Aviation Conditional Climatology w/OBS only	ACC-OBS	Climatology-based with OBS	Near-operational
Integrated Weighted Nowcasting	INTW	Blended NWP and observations	Research
Integrated Nowcasting System	INCS	Blended NWP and observations	Operational
CARDS Point Forecast	PTF	Radar-based	Operational

Aviation Conditional Climatology (ACC) (1)

- Uses airport climatology, observations and NWP to produce deterministic and probabilistic forecasts of **ceiling** and **visibility**
  - Prevents forecasting an event that has little or no chance of occurrence for that site
  - Tends not to forecast extreme or unusual events
  - Provides timing and duration guidance for PBL effects which are poorly handled by models
    e.g. stratus break up, radiation fog dissipation
  - Will flag extreme events when they are forecast which is relevant for quality control

Bjarne Hansen, 2007: A Fuzzy Logic–Based Analog Forecasting System for Ceiling and Visibility. Wea. Forecasting, 22, 1319–1330. doi: http://dx.doi.org/10.1175/2007WAF2006017.1

Aviation Conditional Climatology (ACC) (2)



Probabilistic forecast of ceiling and visibility made every hour and with each new model run.

24-h forecast of PDF, or 0.1, 0.3, and 0.5 quantiles.

Observations

NWP and analog forecasts of ceiling and visibility

(From Hansen)

- For ACC-OBS the same concept is used with input from only latest observations to make a trend forecast
- Sometimes referred to as “climatological persistence”

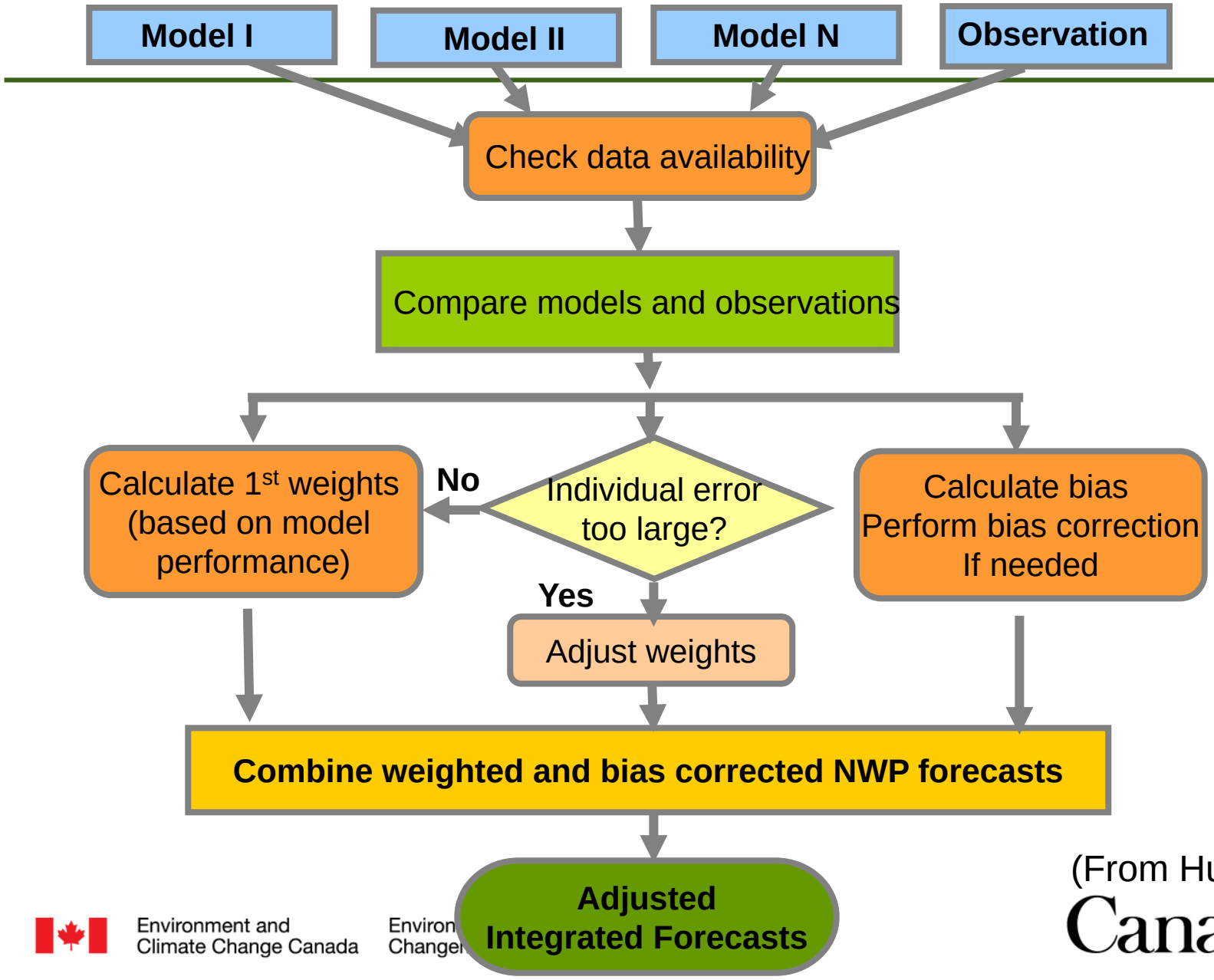
Integrated Weighted (INTW) Nowcasting

- Blends observations and *n*-number of NWP model forecasts to form a single integrated nowcast out to 8 hours
- Requires matching observation and NWP variable at a site. INTW has been demonstrated for **temperature, relative humidity, wind speed, wind direction, wind gust, visibility** and **ceiling**
- Successfully demonstrated during the SNOW-V10, FROST-2014 Winter Olympic and 2015 Toronto Pan Am Games projects

Laura X. Huang, George A. Isaac, and Grant Sheng. (2012) Integrating NWP Forecasts and Observation Data to Improve Nowcasting Accuracy. Wea. Forecasting, 27, 938–953. DOI: 10.1175/WAF-D-11-00125.1

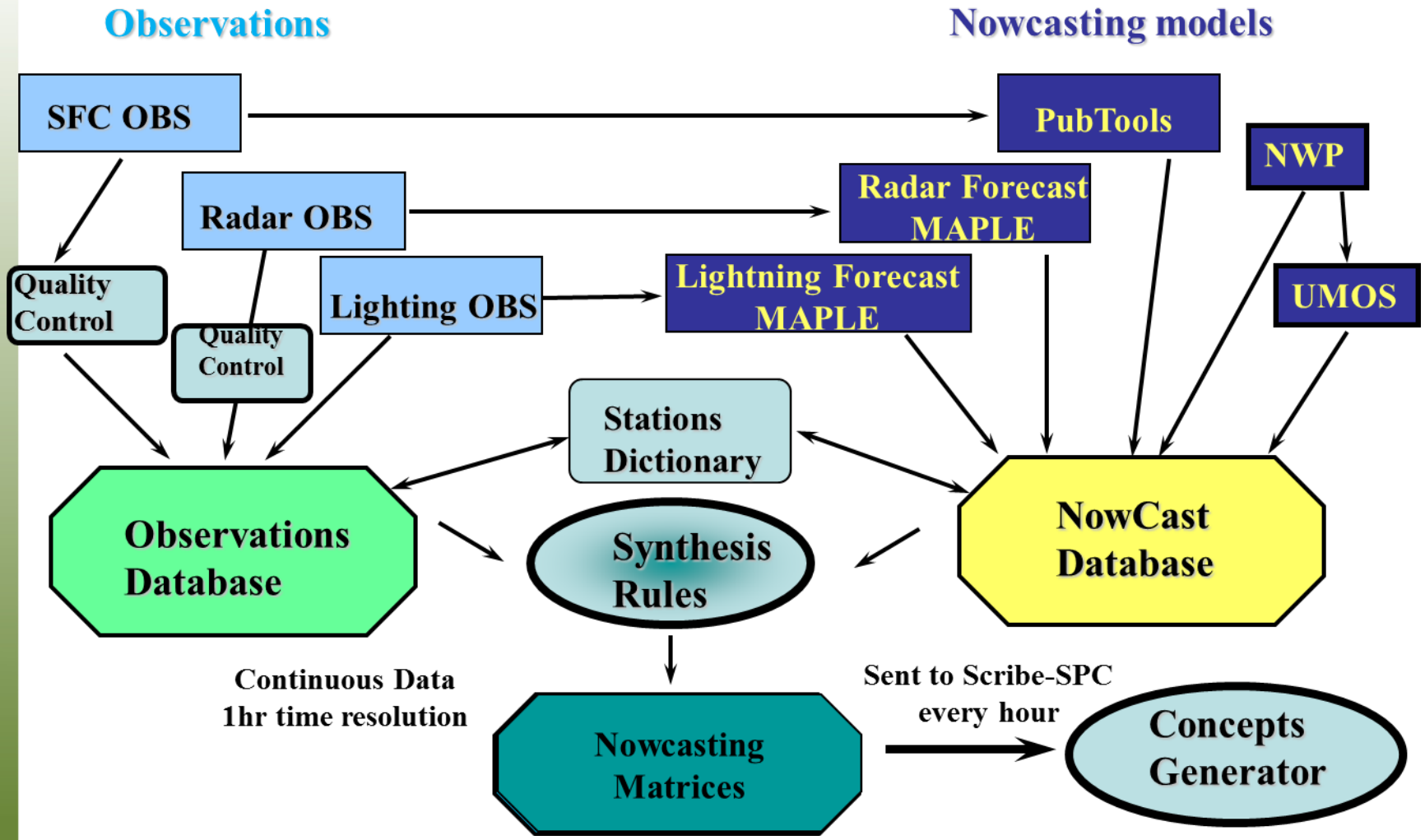
Laura X. Huang, George A. Isaac, Grant Sheng. (2014) A New Integrated Weighted Model in SNOW-V10: Verification of Continuous Variables. Pure and Applied Geophysics 171:1-2, 277-287. DOI: 10.1007/s00024-012-0548-7

INTW Nowcasting Flowchart



(From Huang)

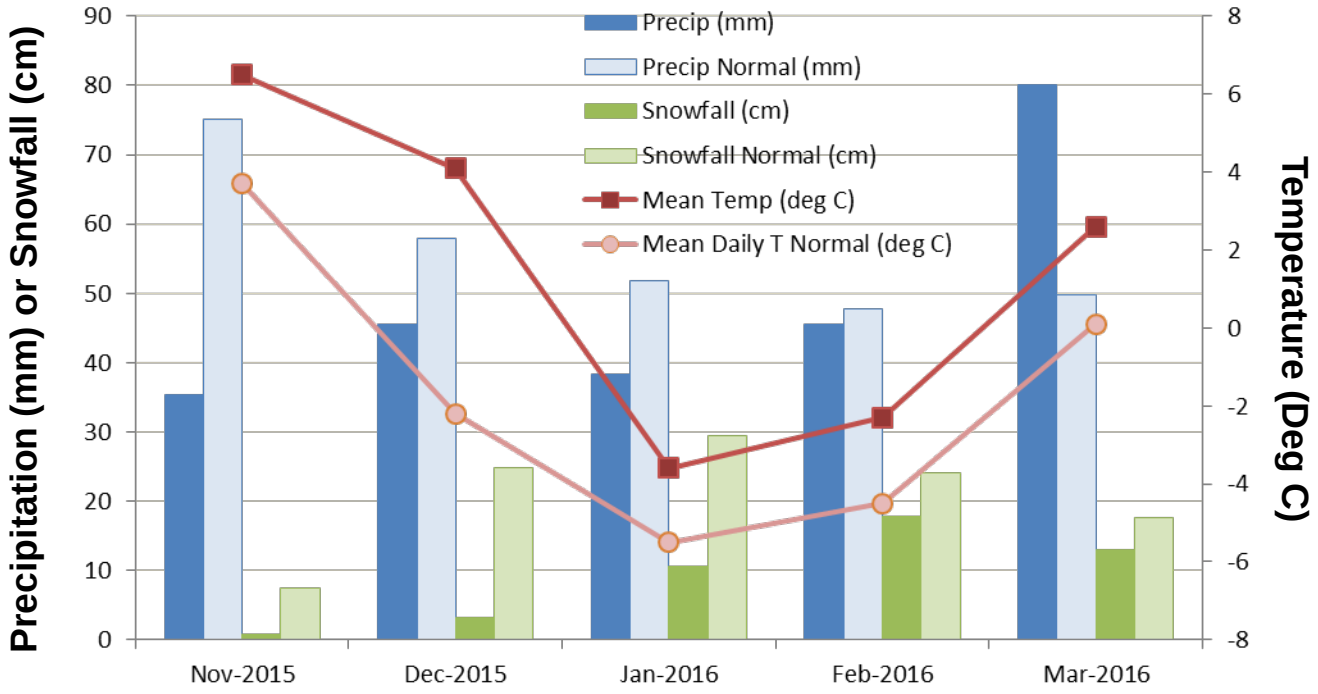
Integrated Nowcasting System (INCS)



From: Marc Verville and Claude Landry, 2014. Integrated Nowcasting System (INCS), WWOCS 2014, August 19, 2014, Montreal, Quebec.

Preliminary MET Verification Results at Pearson during IOP-1

Winter IOP-1 at CYYZ: 2015.11.01 – 2016.03.31



Source: http://climate.weather.gc.ca/

1981-2010 Normals from Climate Station: 6158733

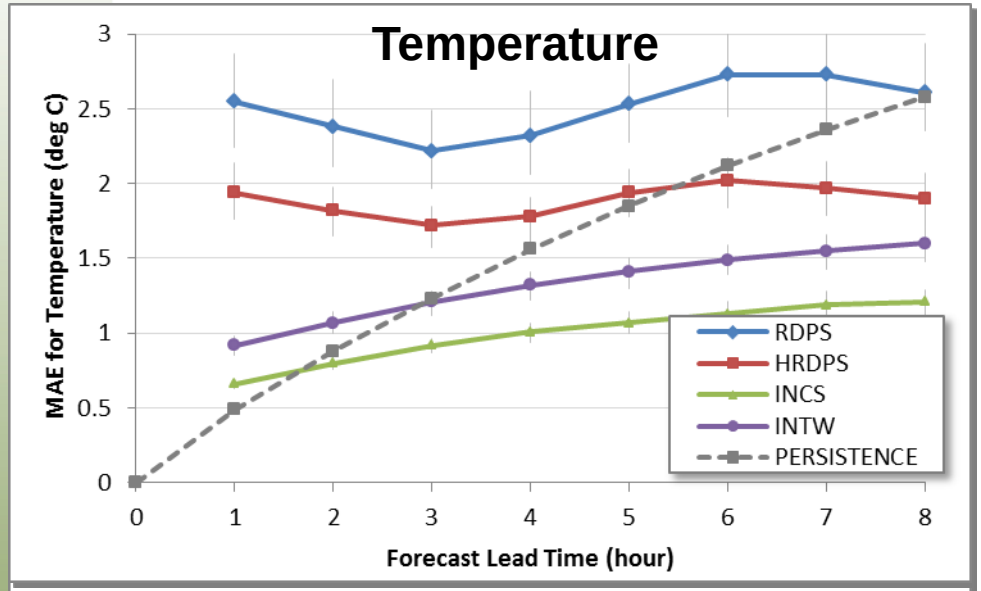
2015-2016 data from Climate Station: 6158731

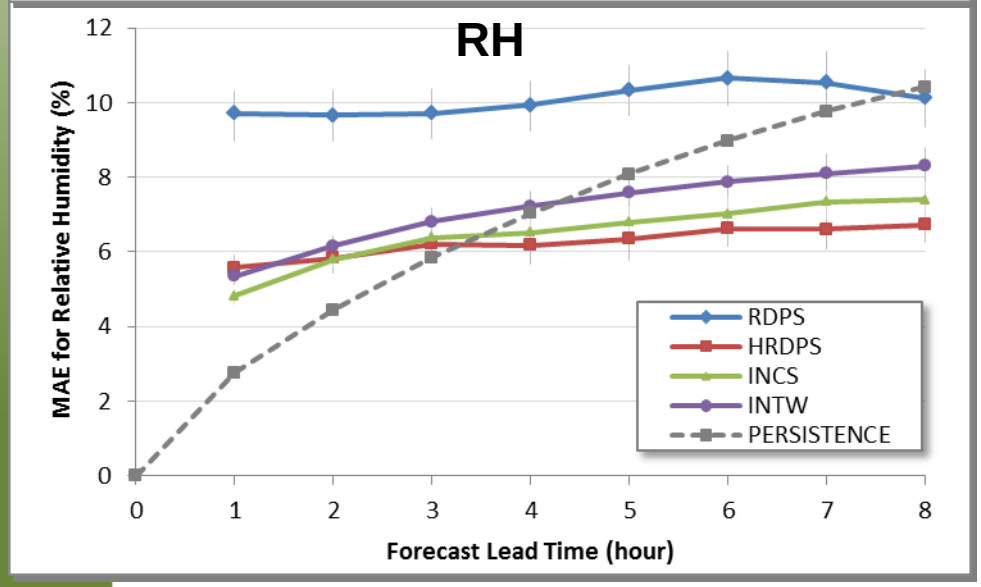
This past winter, generally Toronto …

- was warmer than normal
- had less snowfall than normal
- except for March, had overall less precipitation than normal

	IOP-1	Normal
Total Snow	45 cm	104 cm
Total Precip	245 mm	282 mm

CYYZ MET Verification: 2015.11.01 – 2016.03.31 (1)

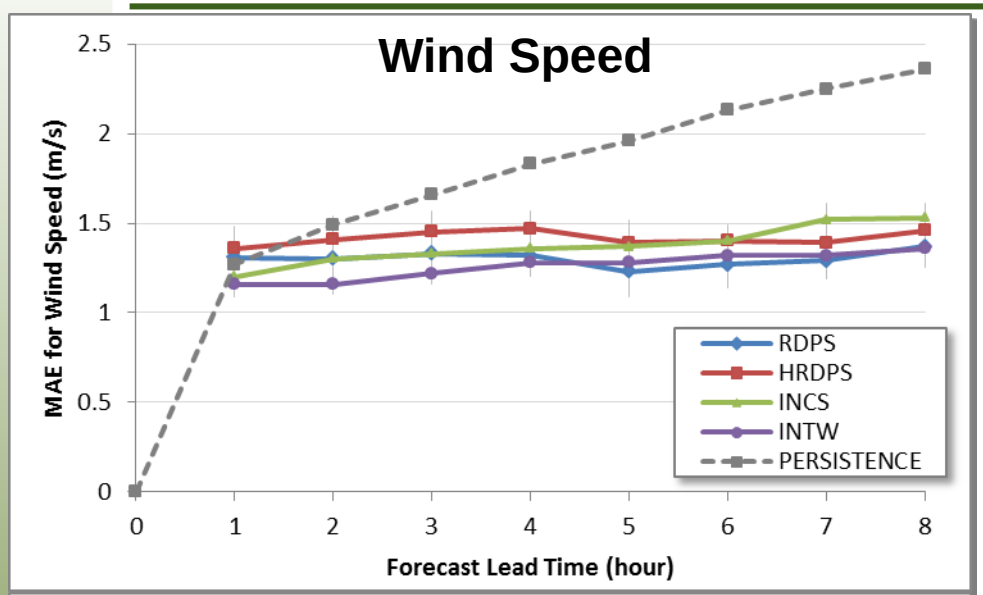


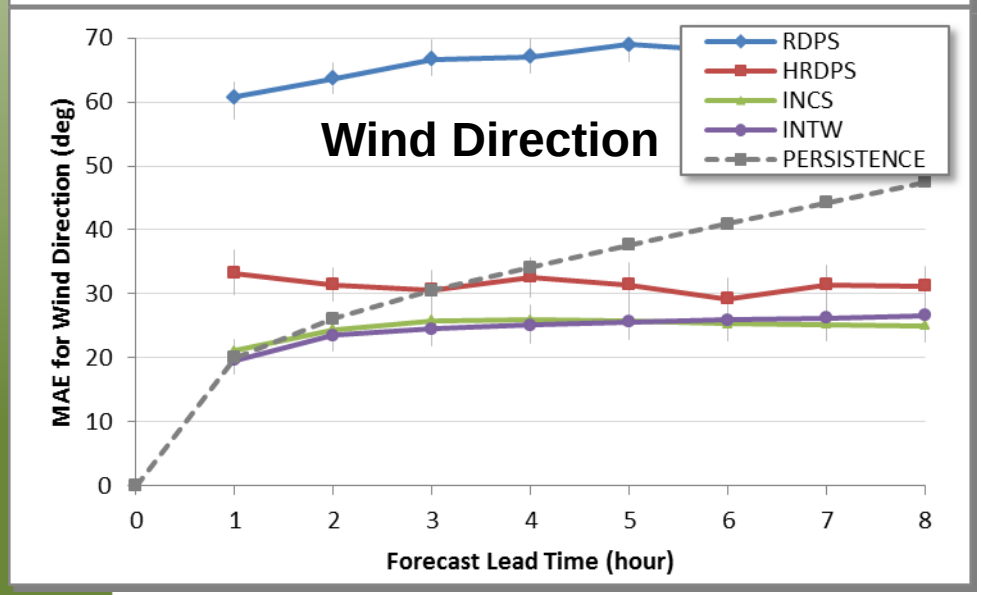


Verification Summary

- Mean absolute error stratified by forecast lead time (1→8 hours)
- INTW, INCS run hourly
- NWP runs 4 x day
- 95% confidence intervals included
- Obs-NWP blended nowcasts improve upon raw models
- Nowcasts seen to beat persistence by 2-3 hours for T and RH

CYYZ MET Verification: 2015.11.01 – 2016.03.31 (2)



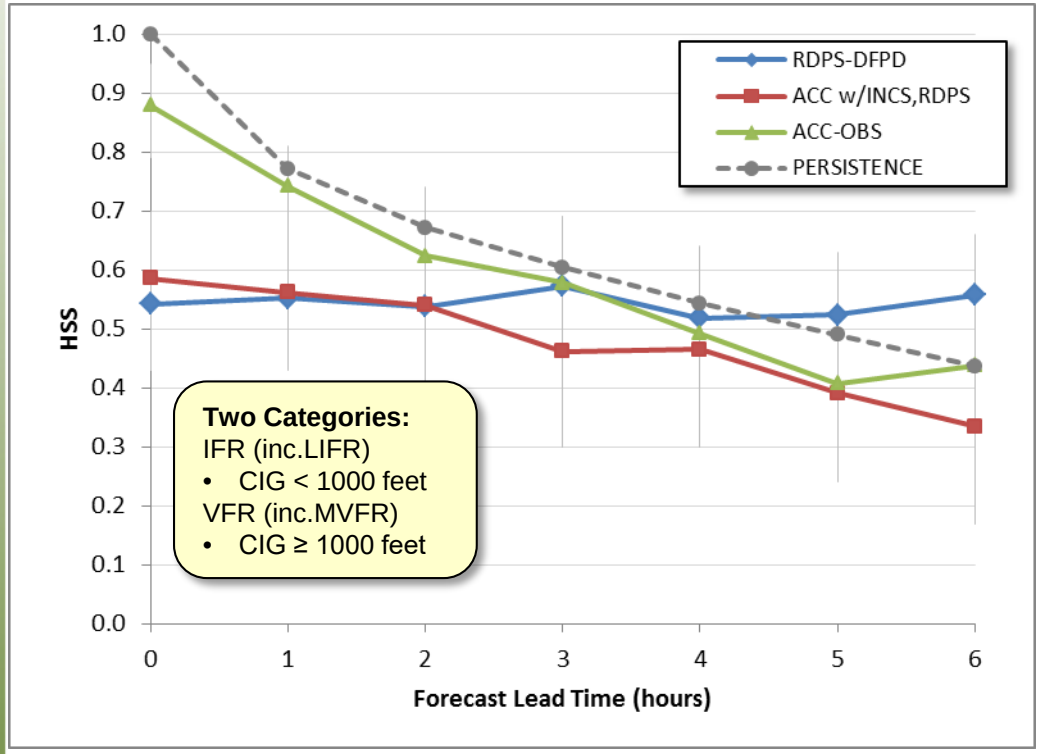


Verification Summary

- Same set-up as previous
- Obs-NWP blended nowcasts improve upon raw models
- Nowcasts seen to beat persistence by 1 hour lead time for winds

CYYZ MET Verification: 2015.11.01 – 2016.03.31 (3)

Ceiling (CIG)



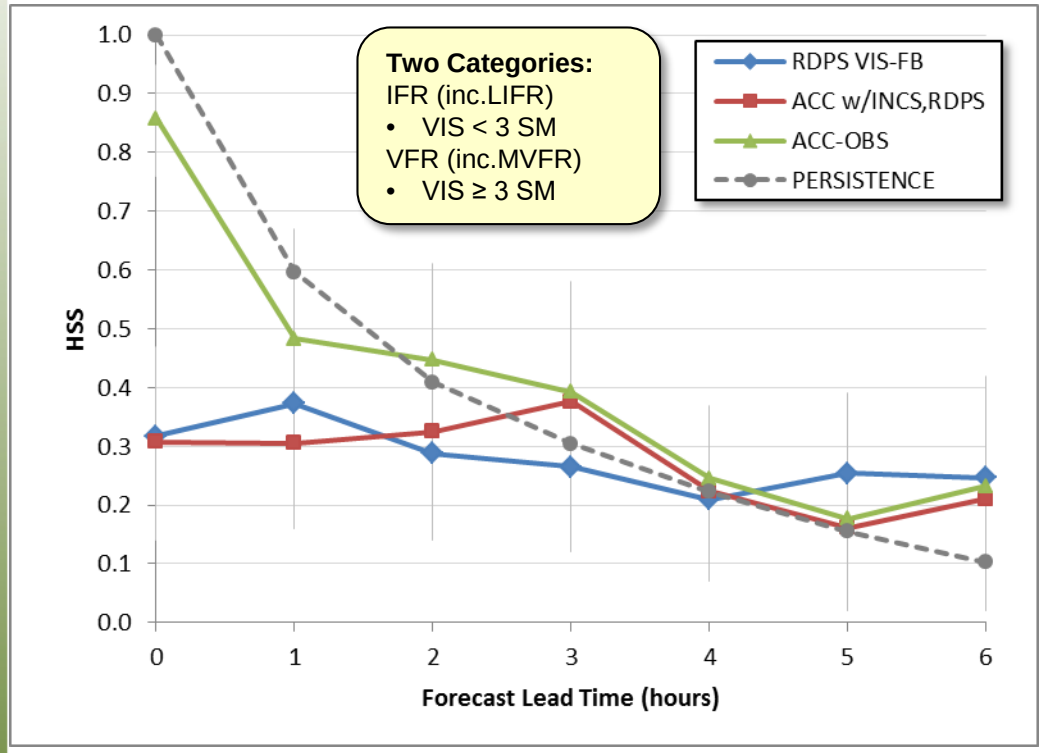
Verification Summary

- Multi-categorical HSS calculated using IFR and VFR categories
- Data from ACC runs at 3, 9, 15 and 21 Z
- RDPS NWP from 0, 6, 12, 18 Z runs + 3-9 h
- 95% confidence intervals included

RDPS Ceiling – R&D NWP post-processing algorithm developed and implemented by Ling and Crawford (ECCC)

CYYZ MET Verification: 2015.11.01 – 2016.03.31 (4)

Visibility (VIS)



Verification Summary

- Same as set-up as previous
- ACC-OBS has the highest scores for CIG and VIS for the first ~ 3 hours (not including persistence)
- ACC and models start beating persistence at 4-5 hours

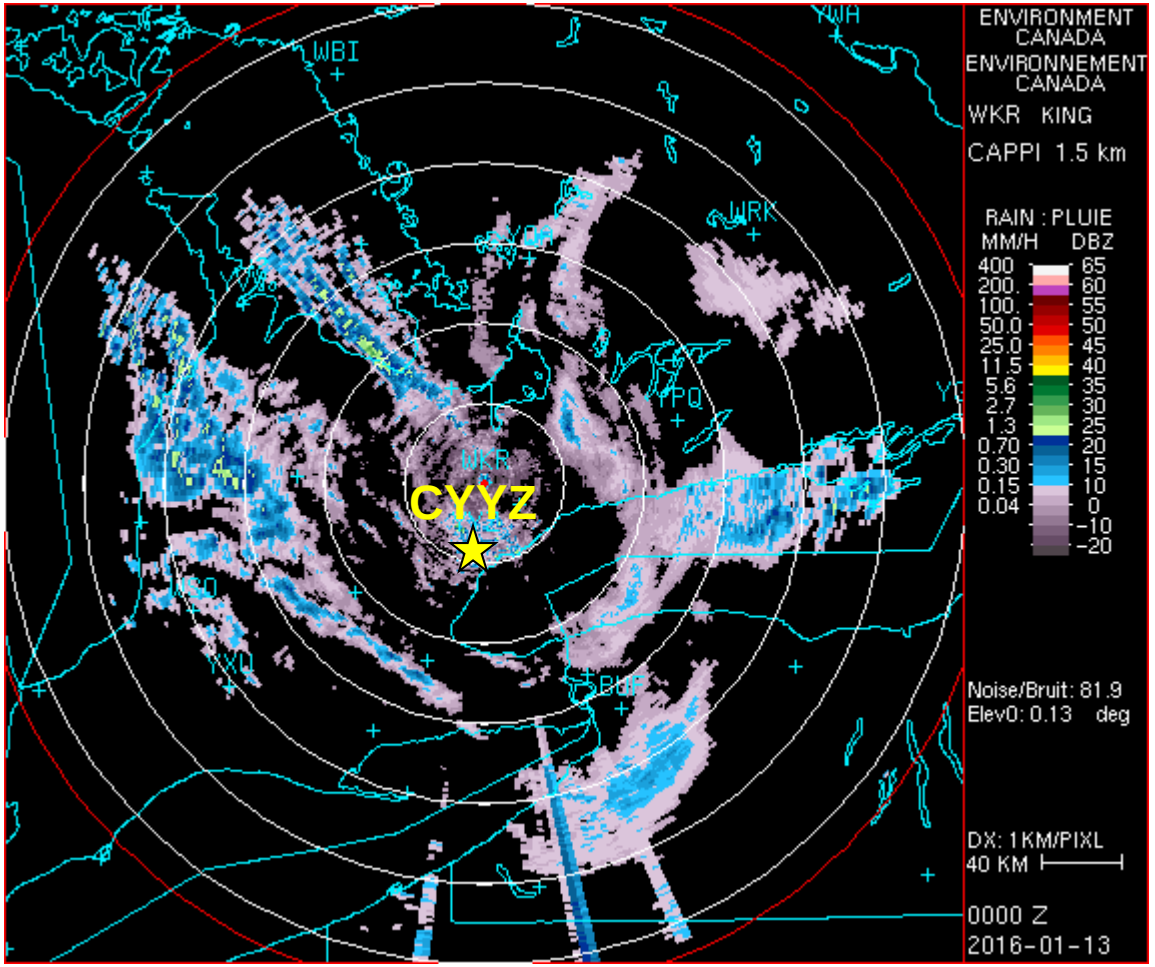
Boudala, F. S. and G. A. Isaac, 2009. Parameterization of visibility in snow: Application in numerical weather prediction models, J. Geophys. Res., 114, D19202.

Boudala, F.S., G. A. Isaac, R. W. Crawford, and J. Reid, 2012: Parameterization of Runway Visual Range as a Function of Visibility: Implications for Numerical Weather Prediction Models. J. Atmos. Oceanic Technol., 29, 177–191.

CYYZ MET Verification: 2015.11.01 – 2016.03.31 (5)

CARDS Point Forecast for Precipitation

- ~3 hour precipitation nowcast derived from the extrapolation of radar echoes whose motions are computed using cross correlation of CAPPI images
- IOP results during at CYYZ showed that persistence was the consistent winner over PTF



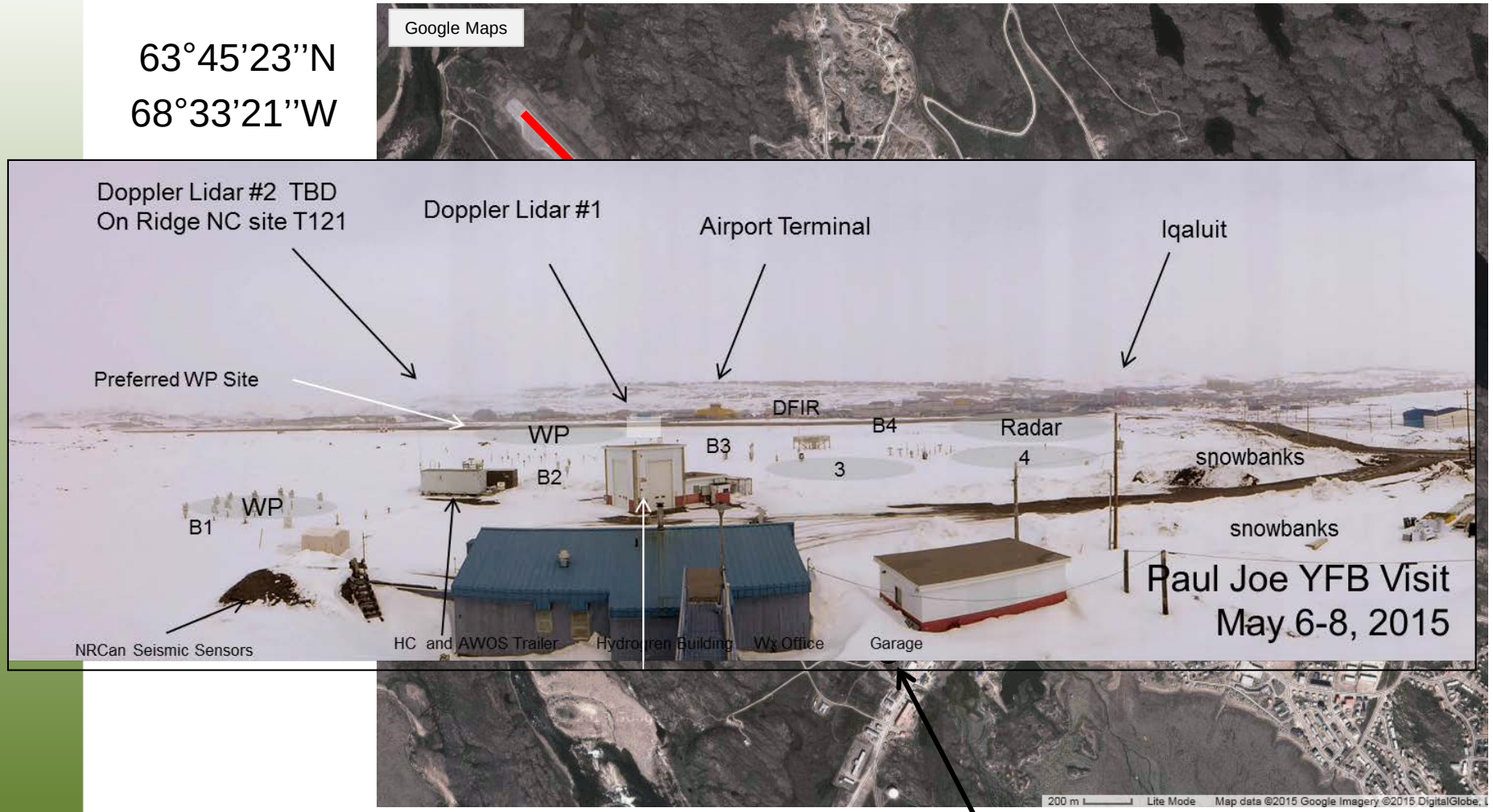
Future Plans including Iqaluit, NU

Future Plans

- Phase 1
  - Complete IOP-1 summary
    - Prepare data sets for project submission / data sharing
    - Prepare verification summary report
  - Winter IOP2 (2016-2017)
    - CYYZ Toronto
    - CYFB Iqaluit
- Phase 2
  - Further investigation into ATM / Ops impact component

Iqaluit Airport (CYFB)

63°45’23’’N
68°33’21’’W



Iqaluit Supersite for MET Observations (CYFB)

- Environment & Climate Change Canada weather station in Iqaluit, NU
- Goal: Integrated observing system for the Canadian Arctic

- Focus on improving NWP models and ground-based satellite calibration / validation with international collaborators

ECCC: Zen Mariani, Paul Joe, Gabrielle Gascon, Armin Dehghan, Peter Rodriguez

Instrument	Manufacturer	Deployment	Measurement(s)
Ka-Band Radar	METEK	Sept. 2015	Line-of-sight wind speed and direction, cloud & fog backscatter, depolarization ratio
Ceilometer	VAISALA	Sept. 2015	Cloud intensity and height, aerosol profiles, PBL height
Radiometer	Radiometrics	Sept. 2015	Profiles of T, RH, dew point T, vapor density
PWD 52 Vis. Sensor	VAISALA	Sept. 2015	Visibility, precipitation type
Doppler Lidar	HALO	Sept. 2015	Line-of-sight wind speed and direction, aerosol backscatter, depolarization ratio
PIP snowflake camera	N/A	Sept. 2015	Snowflake images
Surface met obs.	Misc.	Ongoing	Surface T, RH, pressure, winds, precipitation
Radiosondes	VAISALA	Ongoing	Profiles of T, RH, pressure, winds
Doppler Lidar	HALO	Aug. 2016	Line-of-sight wind speed and direction, aerosol backscatter, depolarization ratio
Scintolometer (x2)	Scintec	Aug. 2016	Turbulence, crosswind, heat flux
Aerosol LiDAR	N/A	Aug. 2016	Profiles of aerosols, T, RH, pressure, water vapour, and aerosol size & shape
Multi angle snowflake camera	N/A	Aug. 2016	Snowflake images

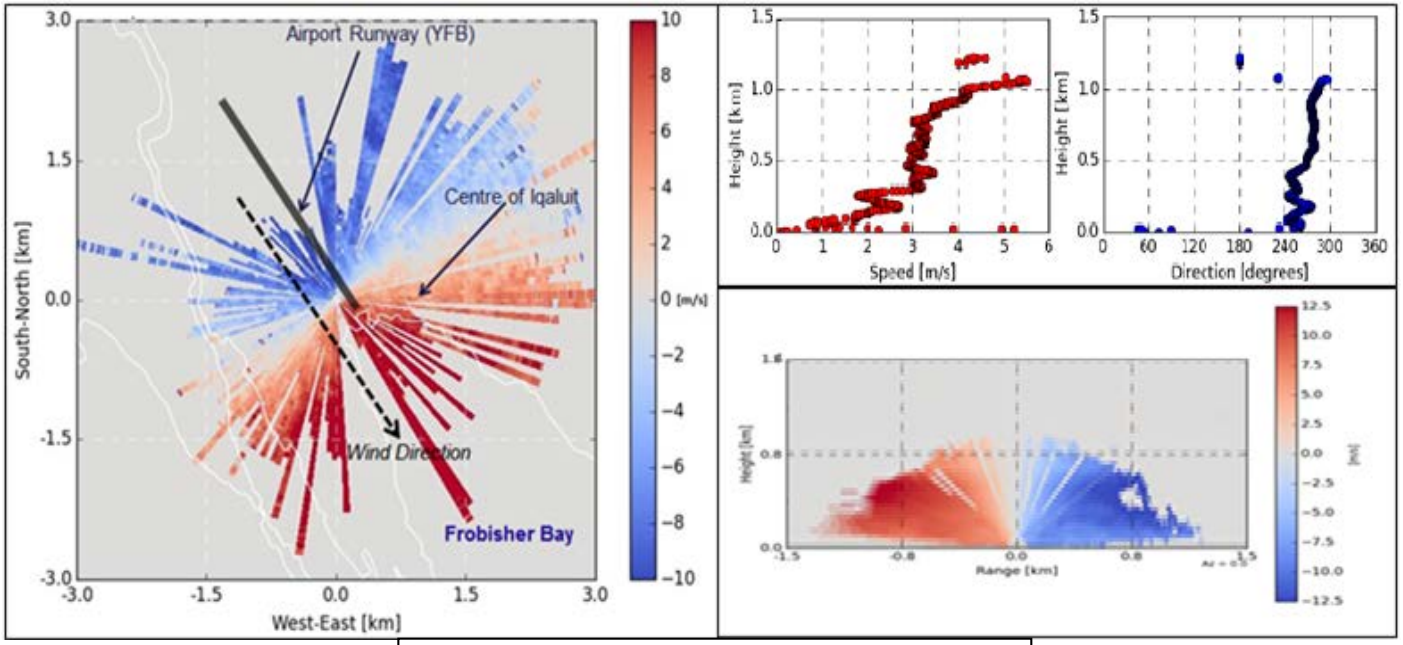
Doppler Lidar Observations in CYFB

Doppler Lidar wind measurements every 5 minutes up to ~4 km

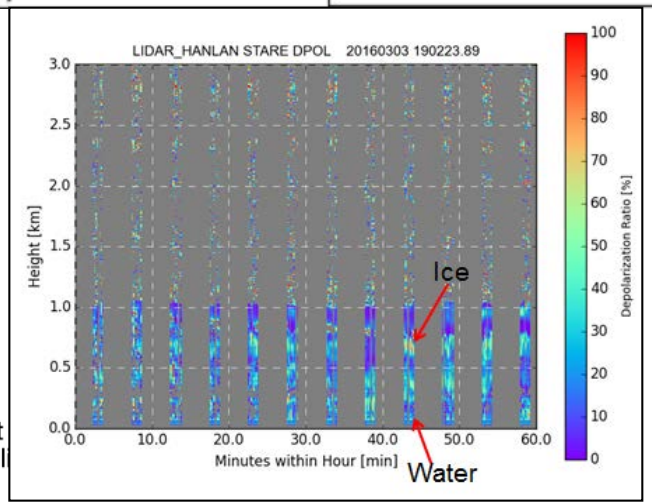
Lidar horizontal surface wind map

Top: Lidar vertical wind profile

Bottom: Lidar North-South vertical scan



Depolarization ratio observations determine particle composition



Zen Mariani, ECCC

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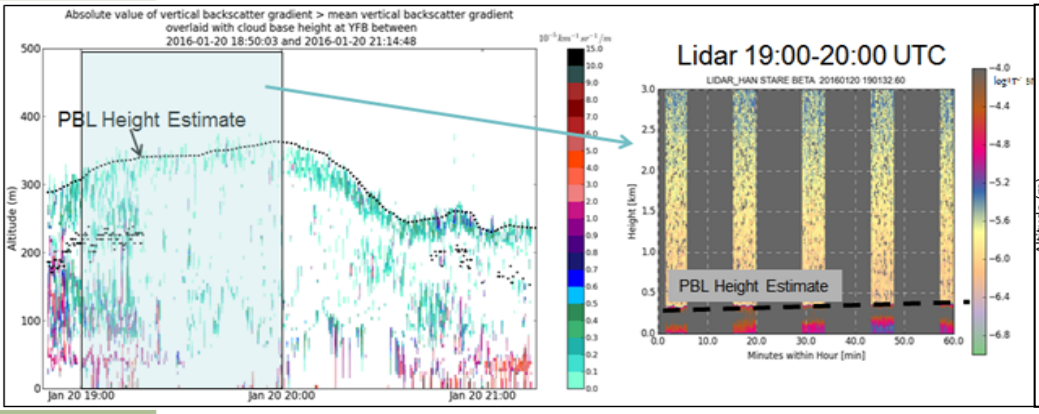
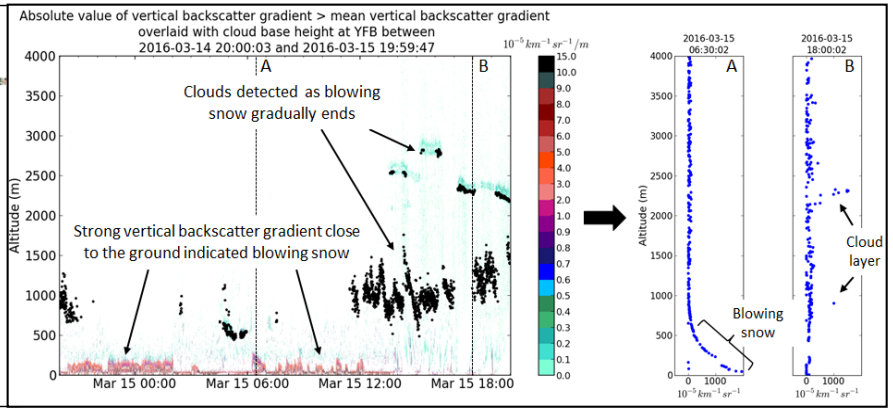
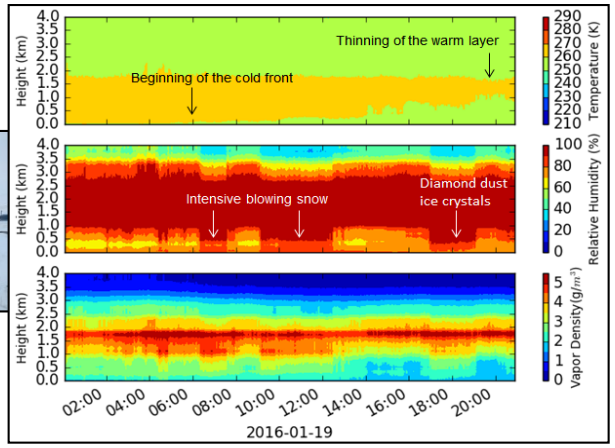
CYFB MET Products: Examples

Ceilometer/Lidar planetary boundary layer height, cloud base height, and blowing snow observations

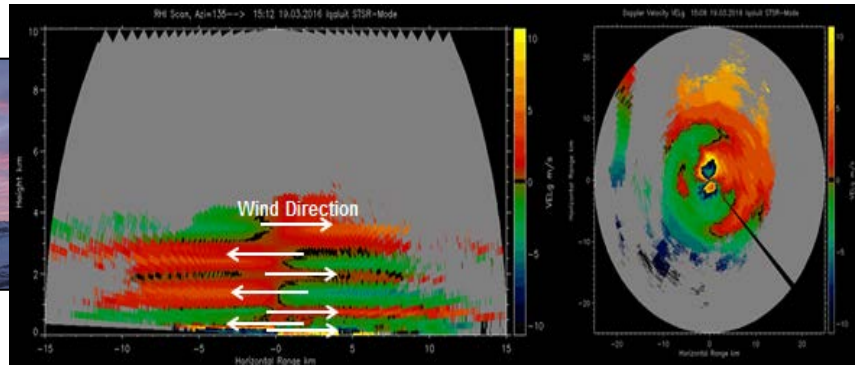




Radiometer T, RH, and vapour density profiles during blowing snow and diamond dust (ice crystals)



Ka-Radar Doppler Wind observations of stratified atmosphere



ECCC: Zen Mariani, Paul Joe, Gabrielle Gascon, Armin Dehghan.

Acknowledgements

- Peter PW Li, AvRDP Project Lead (HKO)
- Scientists and Colleagues at ECCC MRD (RPN, ARMP)
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Questions?

Thank You!

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