

A First Look at Results from the Toronto 2015 Environment Canada Pan Am Science Showcase (ECPASS)



David Sills

Science and Technology Branch, Toronto, ON

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Environment and
Climate Change Canada

Environnement et
Changement climatique Canada

Canada

Outline

- **ECCC and the Games**
- **ECPASS Experimental Design**
- **Results**
 - **Mesoscale analyses**
 - **LiDAR**
 - **NWP**
 - **Thunderstorm prediction**
 - **Air Quality**
- **Summary**



Canada



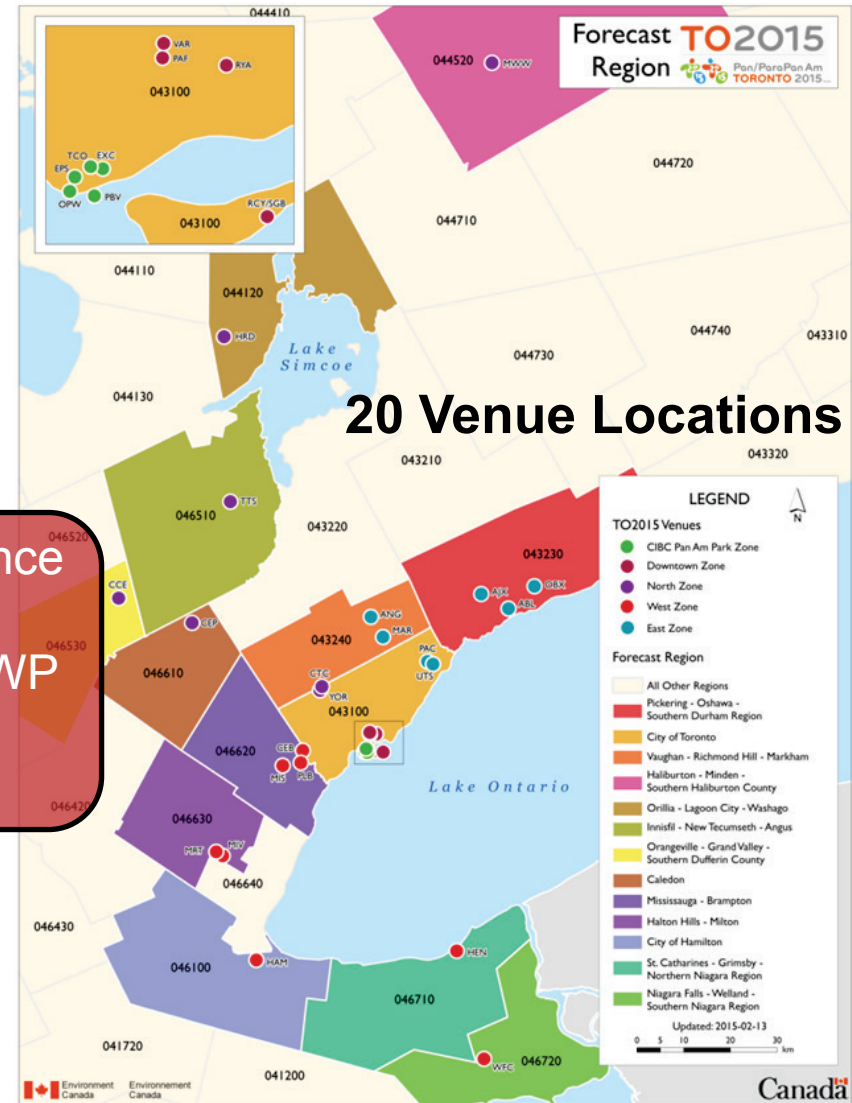
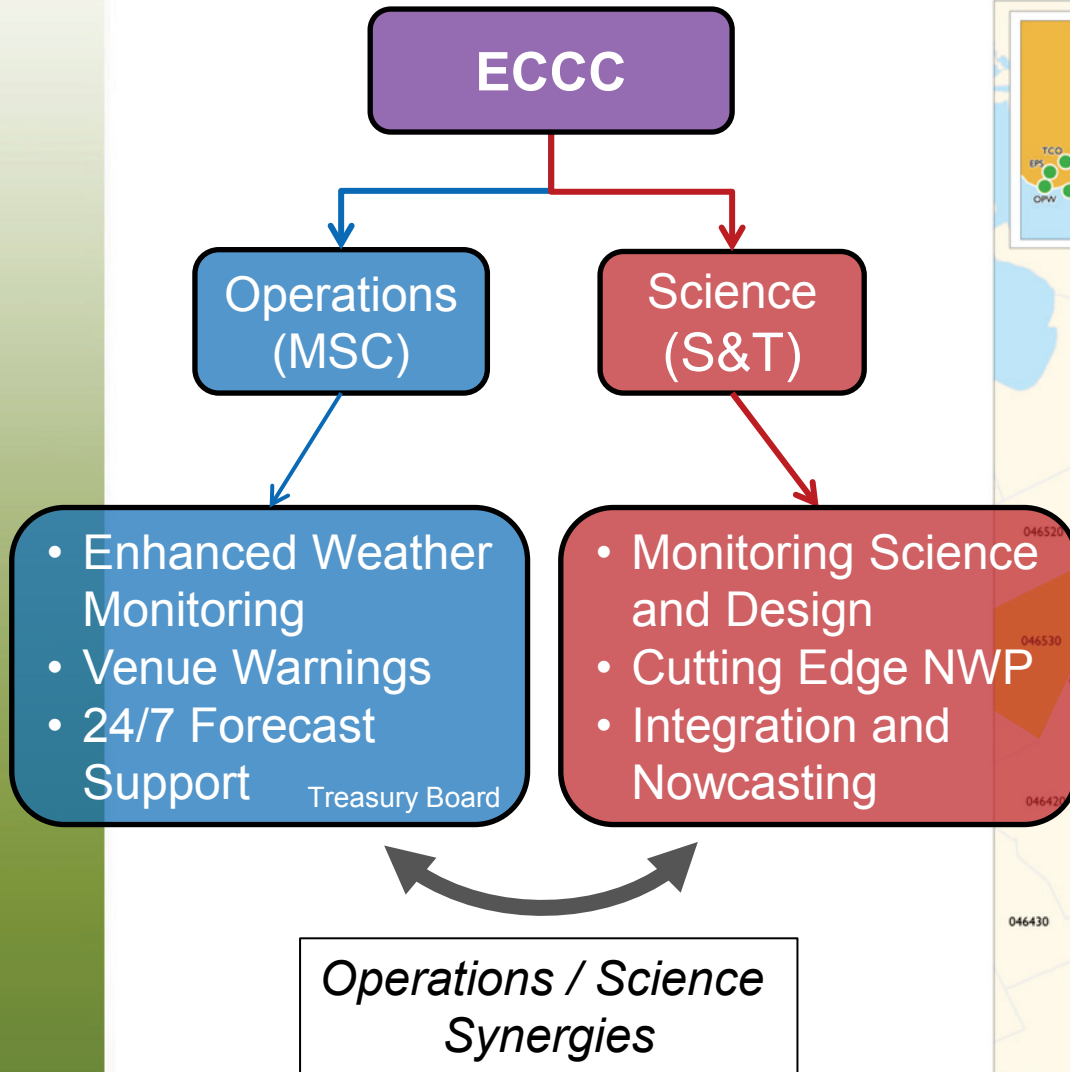
Pan Am / Parapan Am Games

- Large regional international summer sporting event, staged every four years somewhere in the Americas
- In Toronto July 10-26 and August 7-15, 2015

SCOPE:	2010 Vancouver Olympics	2015 Pan and Parapan Am Games
Countries	80	42
Athletes and Coaches	2600	8000 – Pan Am 2000 – Parapan Am
Volunteers	20,000	23,000
Number of Sports	16 – Olympics (10 outdoors) 4 – Paralympics	40 – Pan Am (18 outdoors) 10 – Parapan Am
Range of Spectator Seating	1,500 to 18,000	1,500 to 20,000 (potentially 70,000 for Opening/Closing)

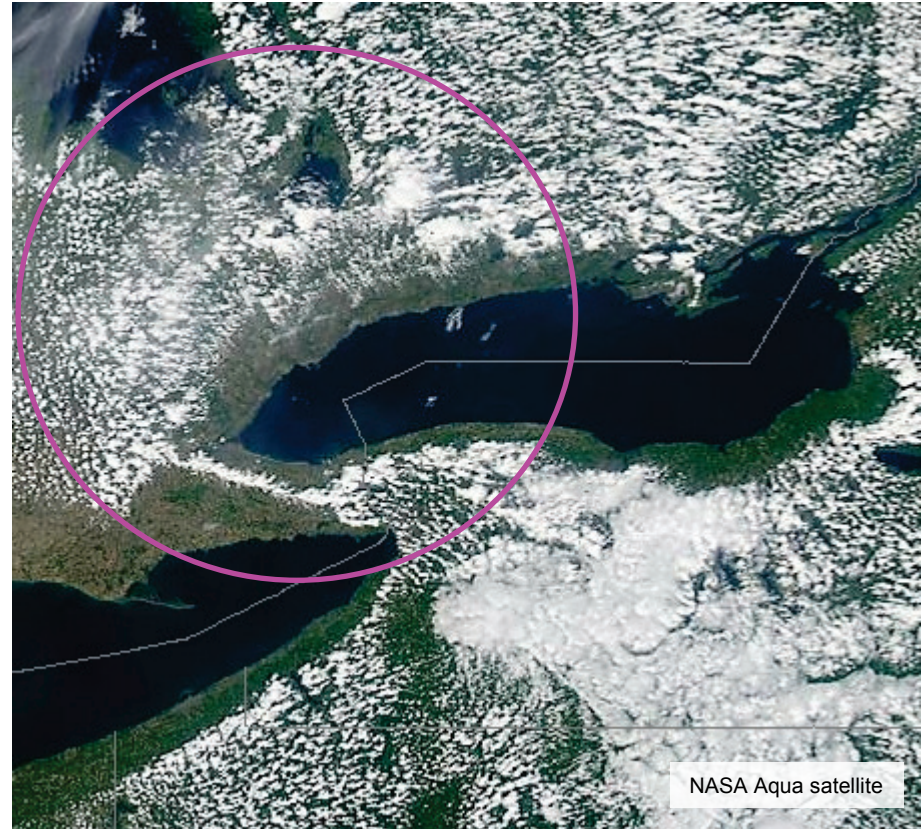


ECCEC Role / Mandate



ECPASS Objectives - Science

- Lake breeze focus – significant influence on thunderstorms and air pollution
- Legacy data sets for process studies and NWP validation



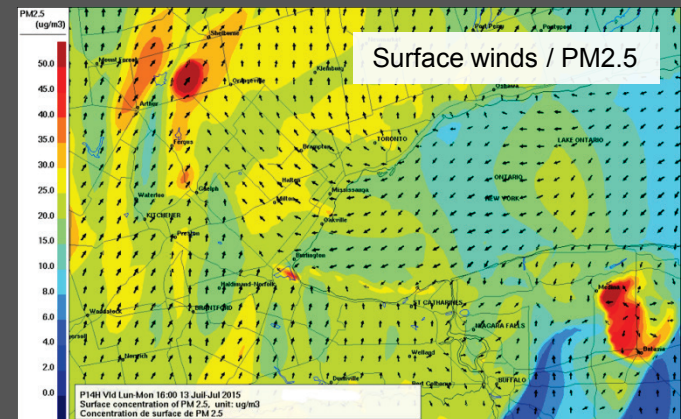
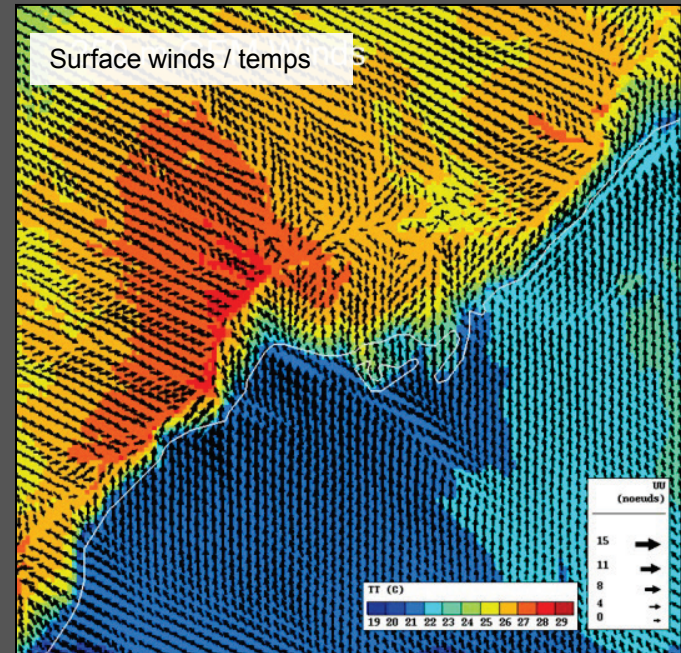
Experimental Design

- 55 new surface stations
 - 1-min data
 - Including 10 S&T 10 m ATMOS stations
- 2 meteorology 'supersites'
 - Oshawa (PUMS)
 - Pearson Airport
- 14-stn total lightning system
 - SOLMA
- 1 mobile AQ lab
 - CRUISER
- 3 mobile met/AQ vehicles
 - AMMOS
- 2 Doppler LiDARs
 - 1 mobile, 1 fixed

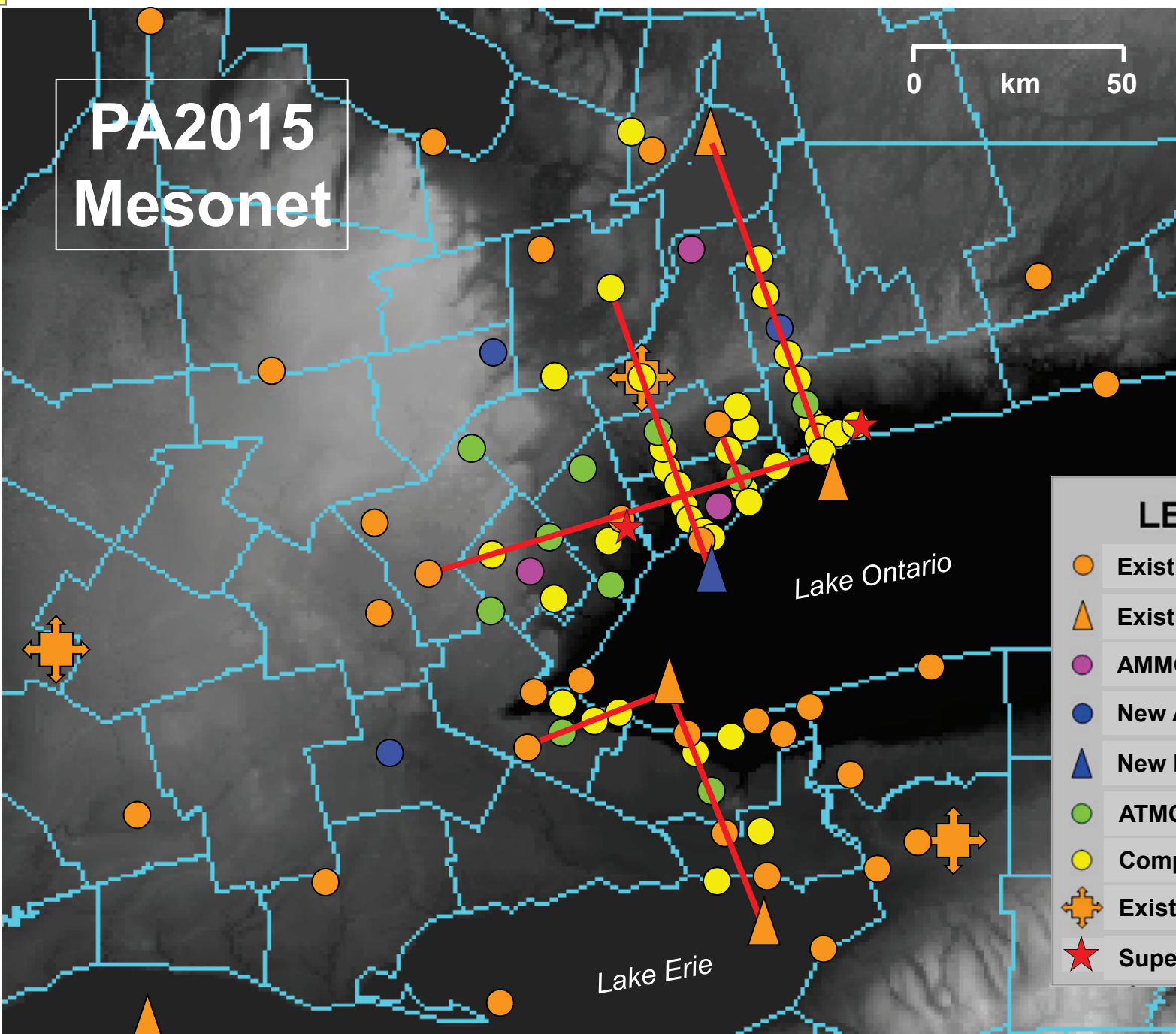
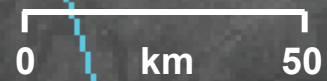


Experimental Design

- 1 Waverider buoy and 2 instrumented boats
 - Sailing venue
- Rawinsonde launches
 - 4 per day during Pan Am only
- 4 UV sensors
- 250 m urban HRDPS model
 - Cascade from 2.5 / 1 km
- 2.5 km GEM-MACH AQ Model
 - Online coupled met/chem
- Lake and wave modelling
- Website for real-time data access / blogging



PA2015 Mesonet

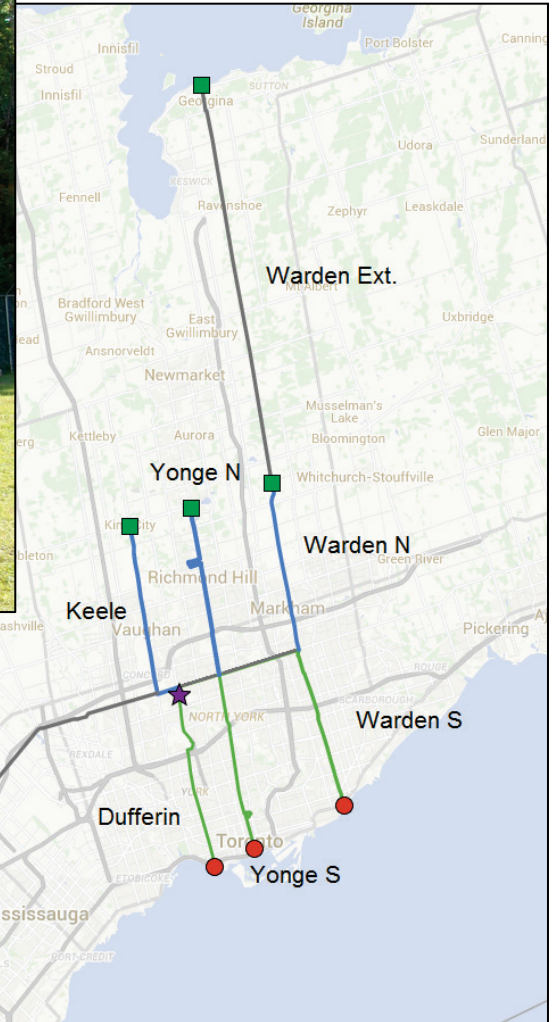


LEGEND	
	Existing Sfc Stn
	Existing Buoy
	AMMOS Mobile Stn
	New Auto8 Stn
	New Buoy
	ATMOS 10m Sfc Stn
	Compact Sfc Stn
	Existing Radar
	Supersite

Lake Ontario

Lake Erie

AMMOS Mobile Measurements



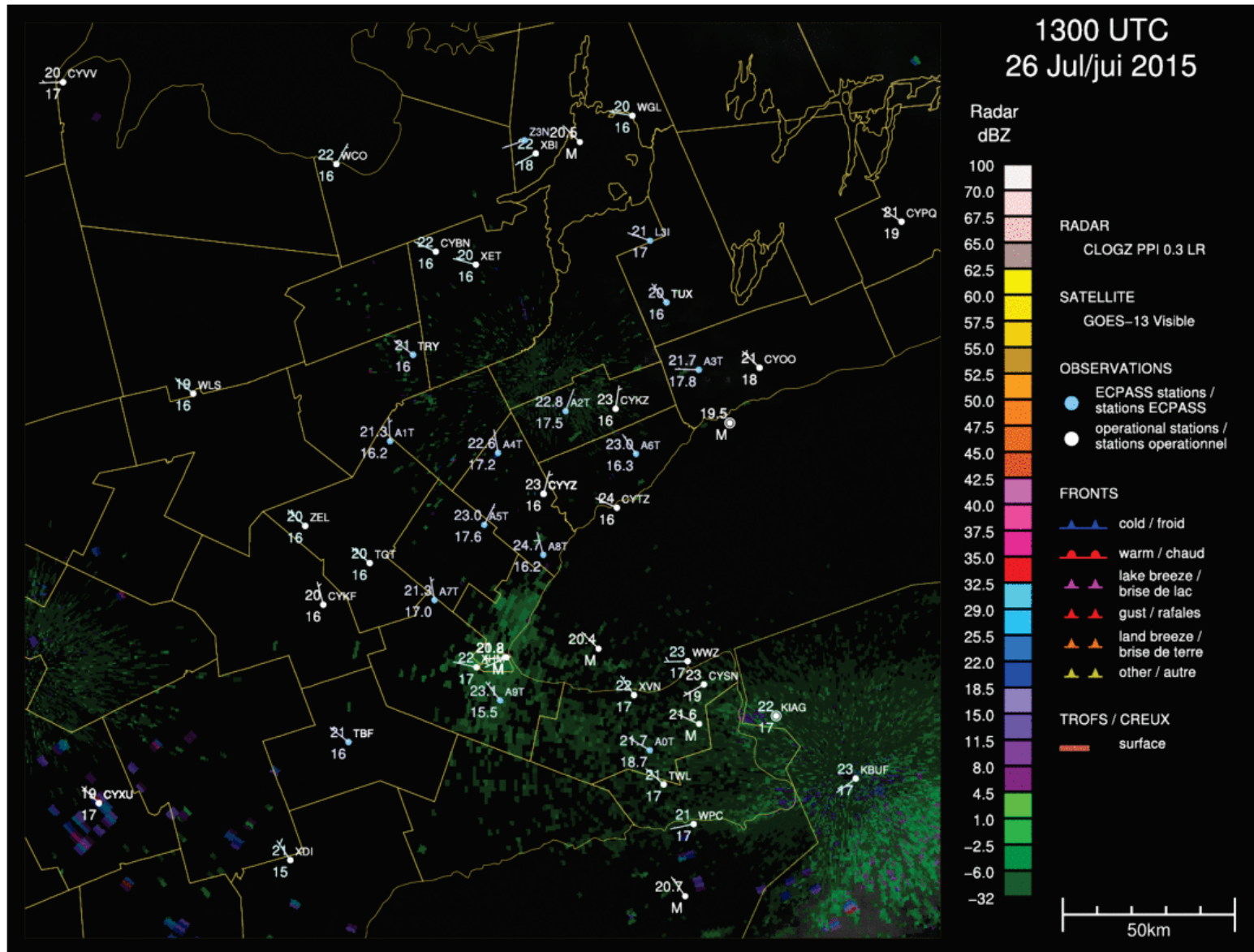
- Automated Mobile Meteorological Observing System (AMMOS) x 3
- Met (@ 1 sec) + AQ
- Sampling lake-breeze fronts, gust fronts, heat stress, air quality and urban heat island effects

ECPASS Stats Summary

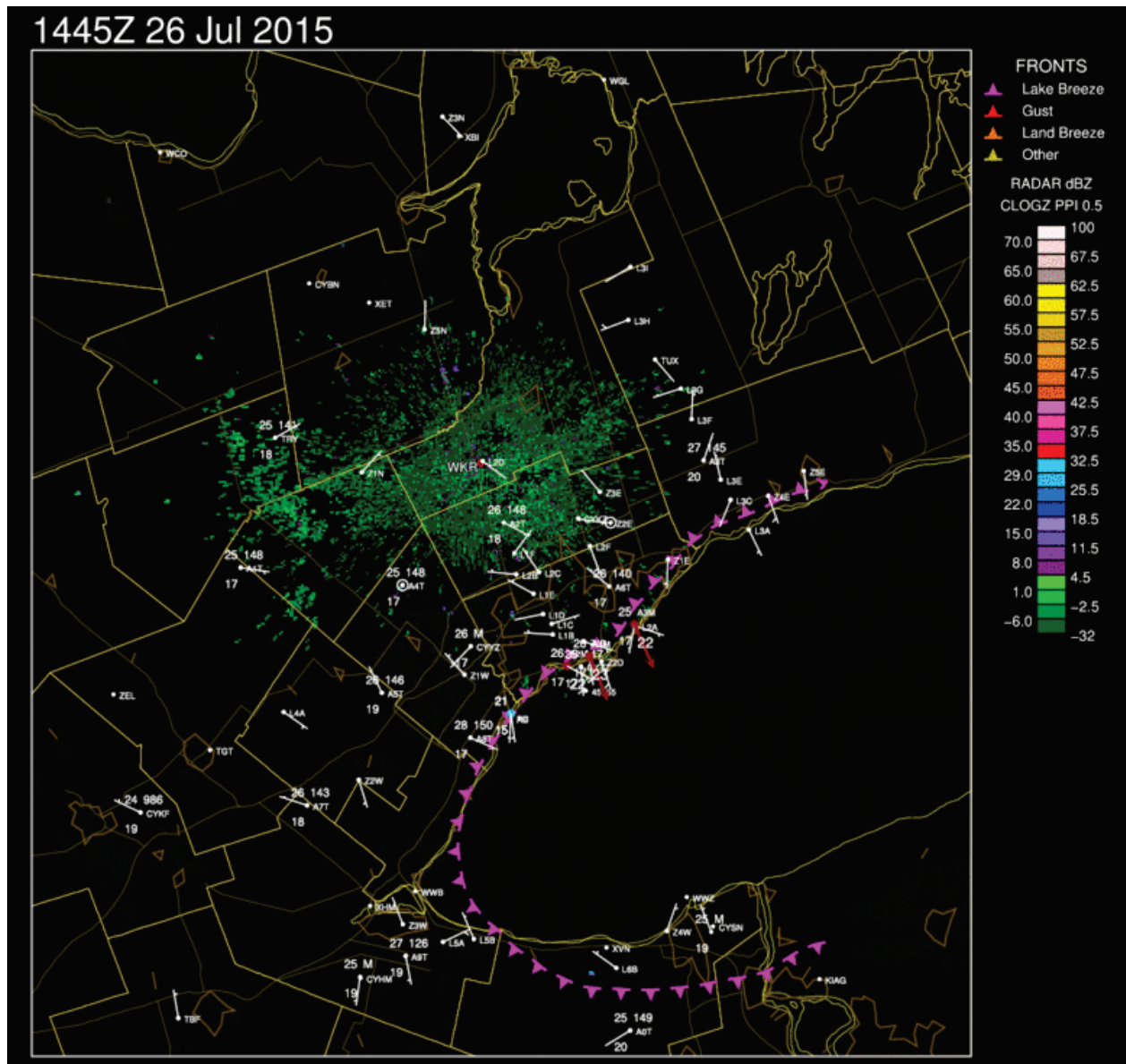
	Project Days	Lake Breeze Days	Thunderstorm Days	Severe Weather Days	AQHI>=4	30+C Days
Pan Am	17	16	7	2	12	6
Inter-Games	11	11	6	4	5	6
ParaPan Am	9	8	5	0	5	1
Total	37	35	18	6	22	13
		94.6%	48.6%	16.2%	59.5%	35.1%

- Fairly typical summer weather climatologically
- Near-shore lake temps ranged from 12C to 24C
- An impressive 21-day episode from July 18 to August 7 where lake breezes were recorded on both Lake Ontario and Lake Erie!

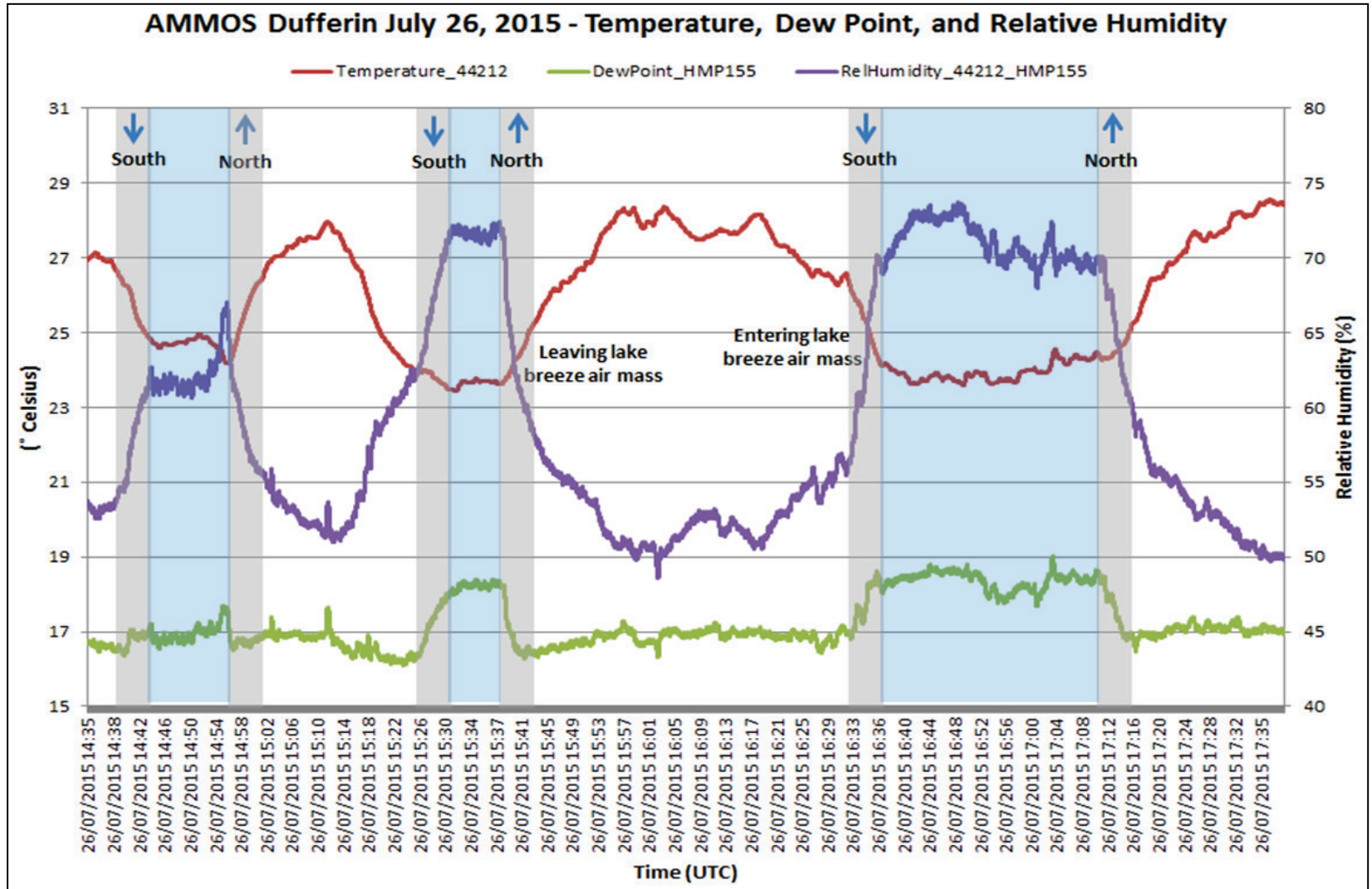
Hourly Mesoanalyses



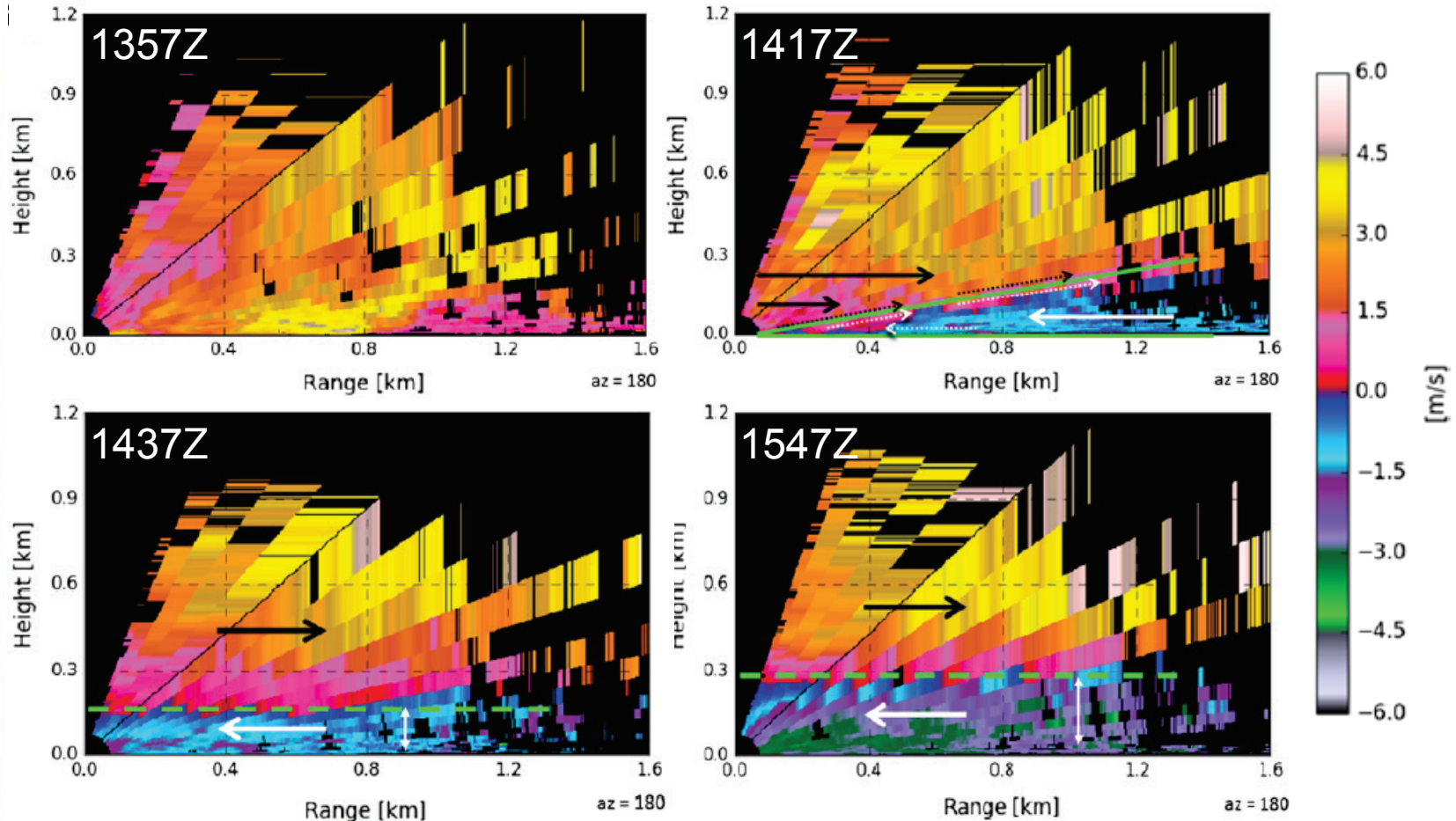
Realtime 5-min Mesoanalyses



AMMOS Mobile Measurements

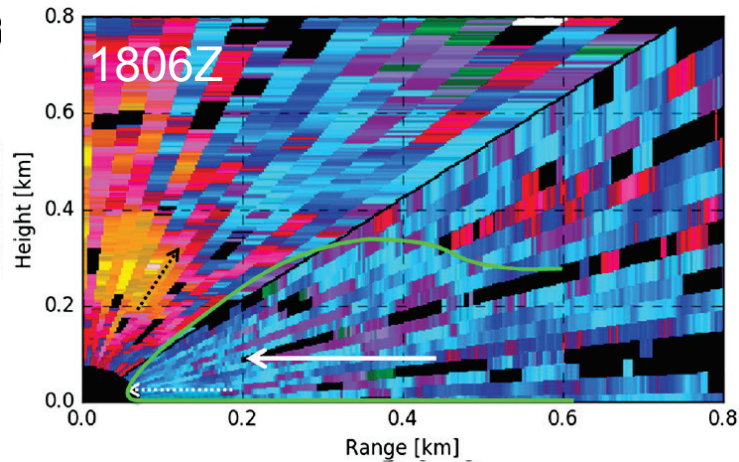


LiDAR Measurements

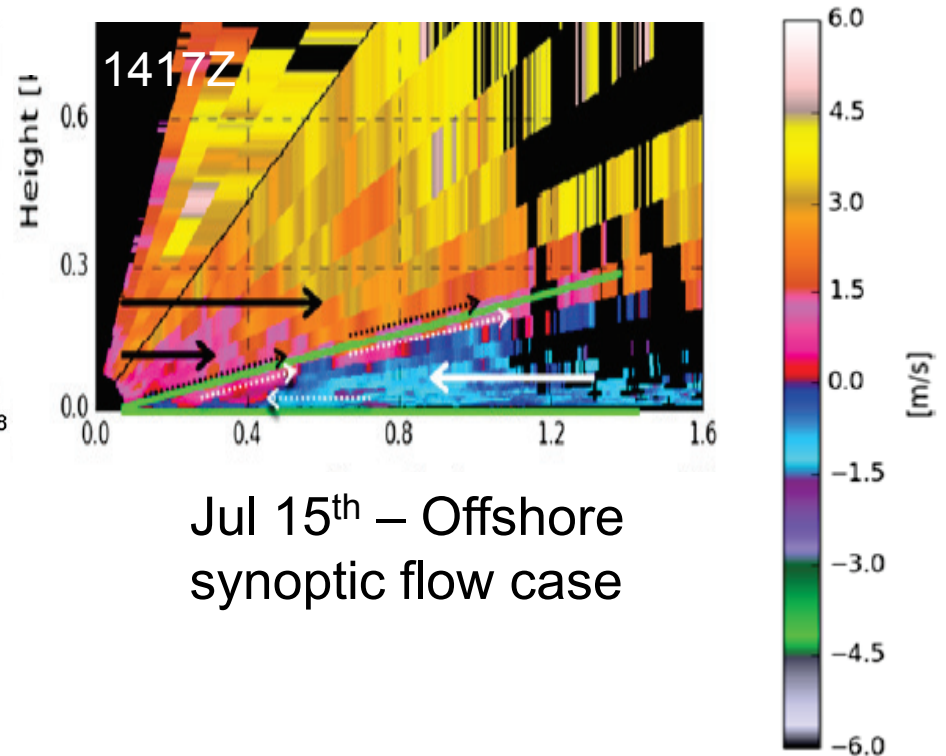


Jul 15th – Offshore synoptic flow case

LiDAR Measurements

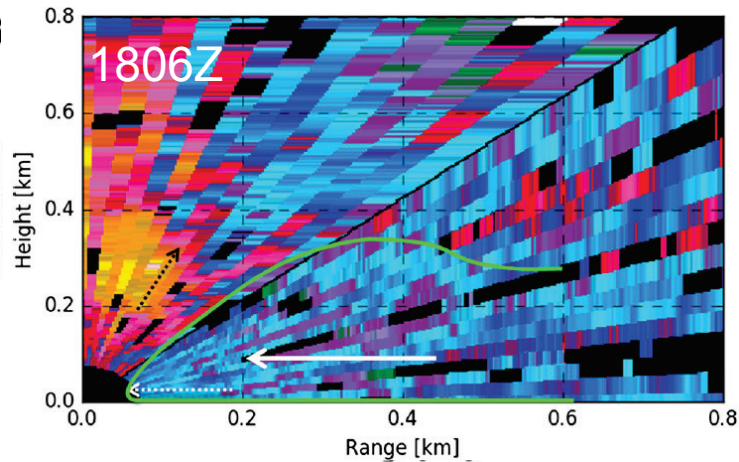


Aug 9th – Onshore synoptic flow case (inland)

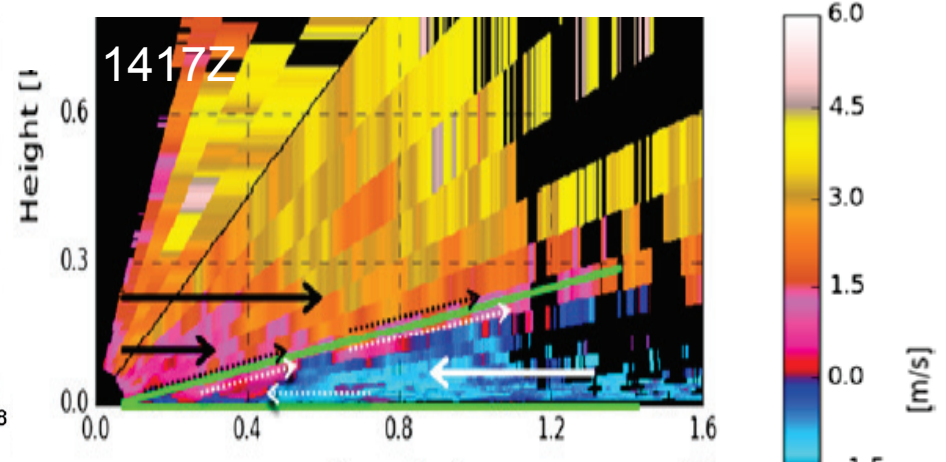


Jul 15th – Offshore synoptic flow case

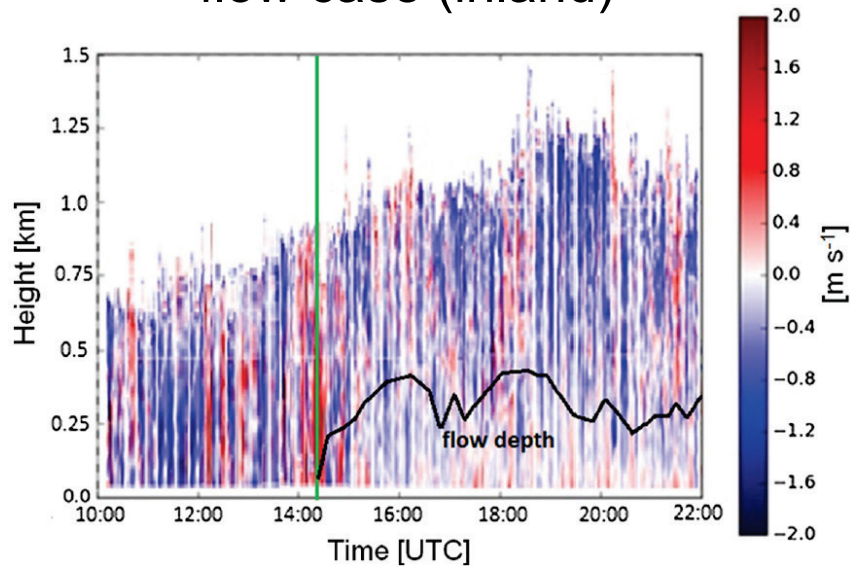
LiDAR Measurements



Aug 9th – Onshore synoptic flow case (inland)

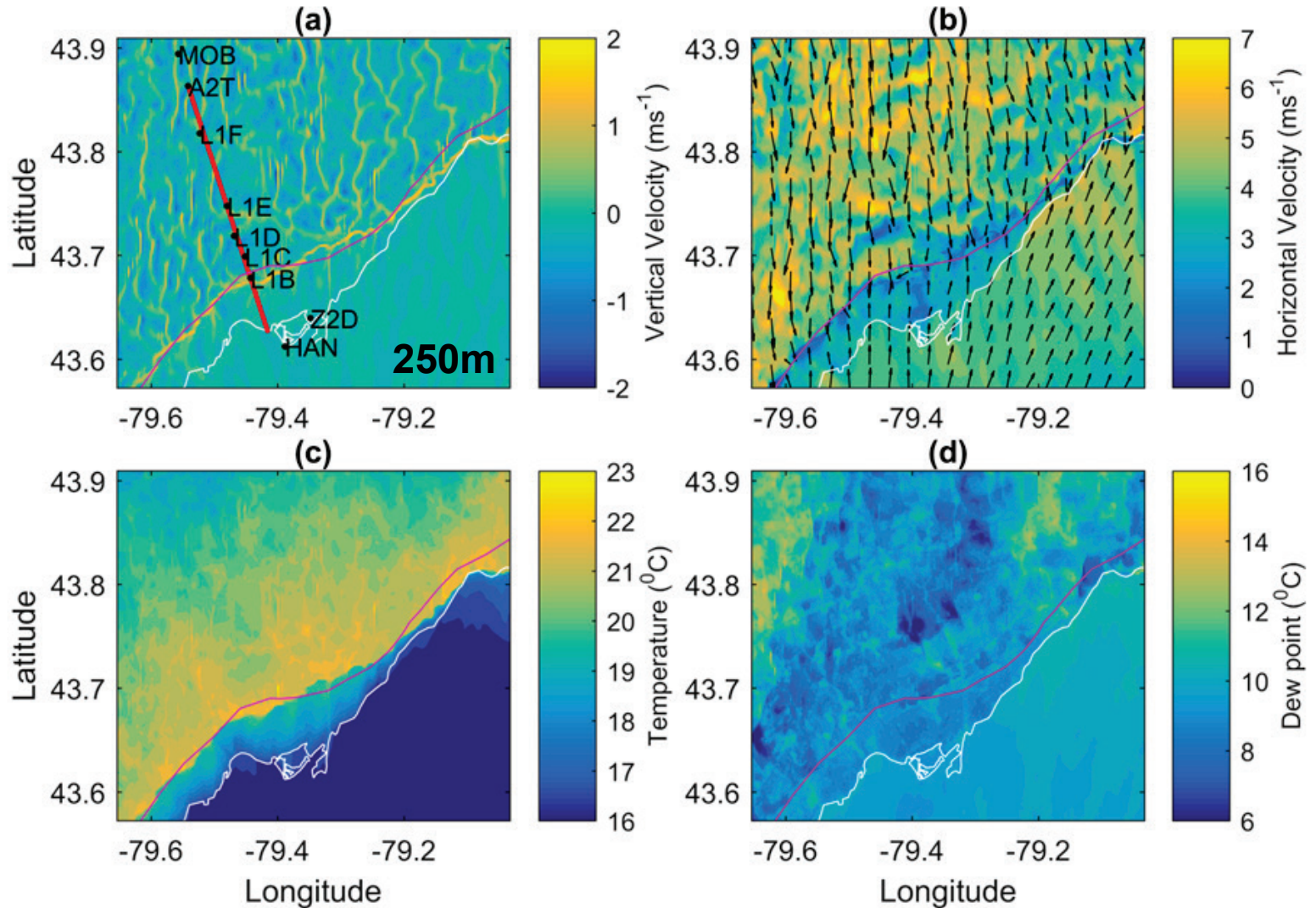


Jul 15th – Offshore synoptic flow case



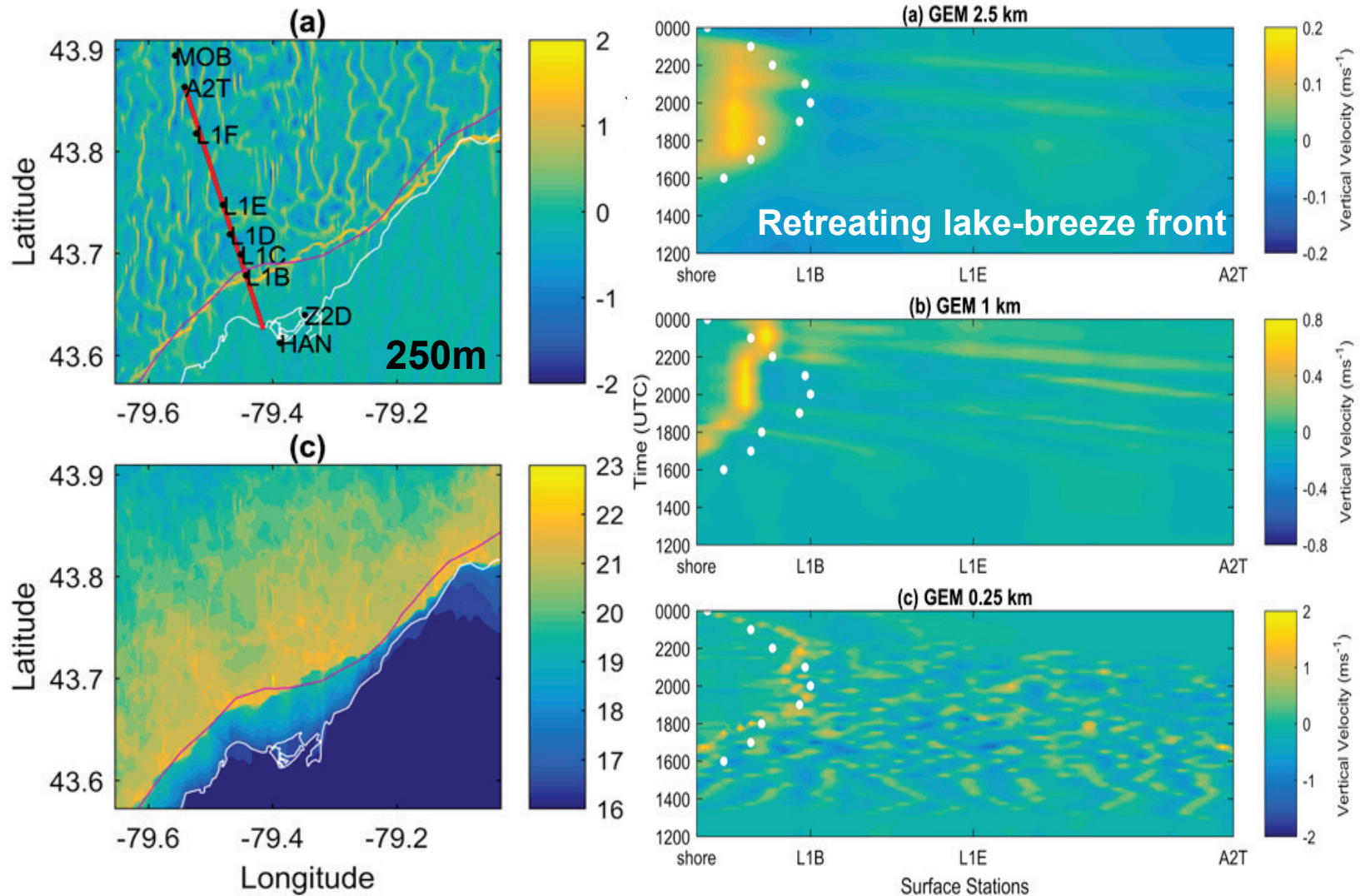
HRDPS Performance

Dehghan, A., Z. Mariani, S. Leroyer, P. Joe, D. Sills and S. Bélair, 2017: Evaluation of modeled lake breezes using an enhanced observational network in southern Ontario: case studies. Submitted to *J. Applied Meteorol. Climatol.*



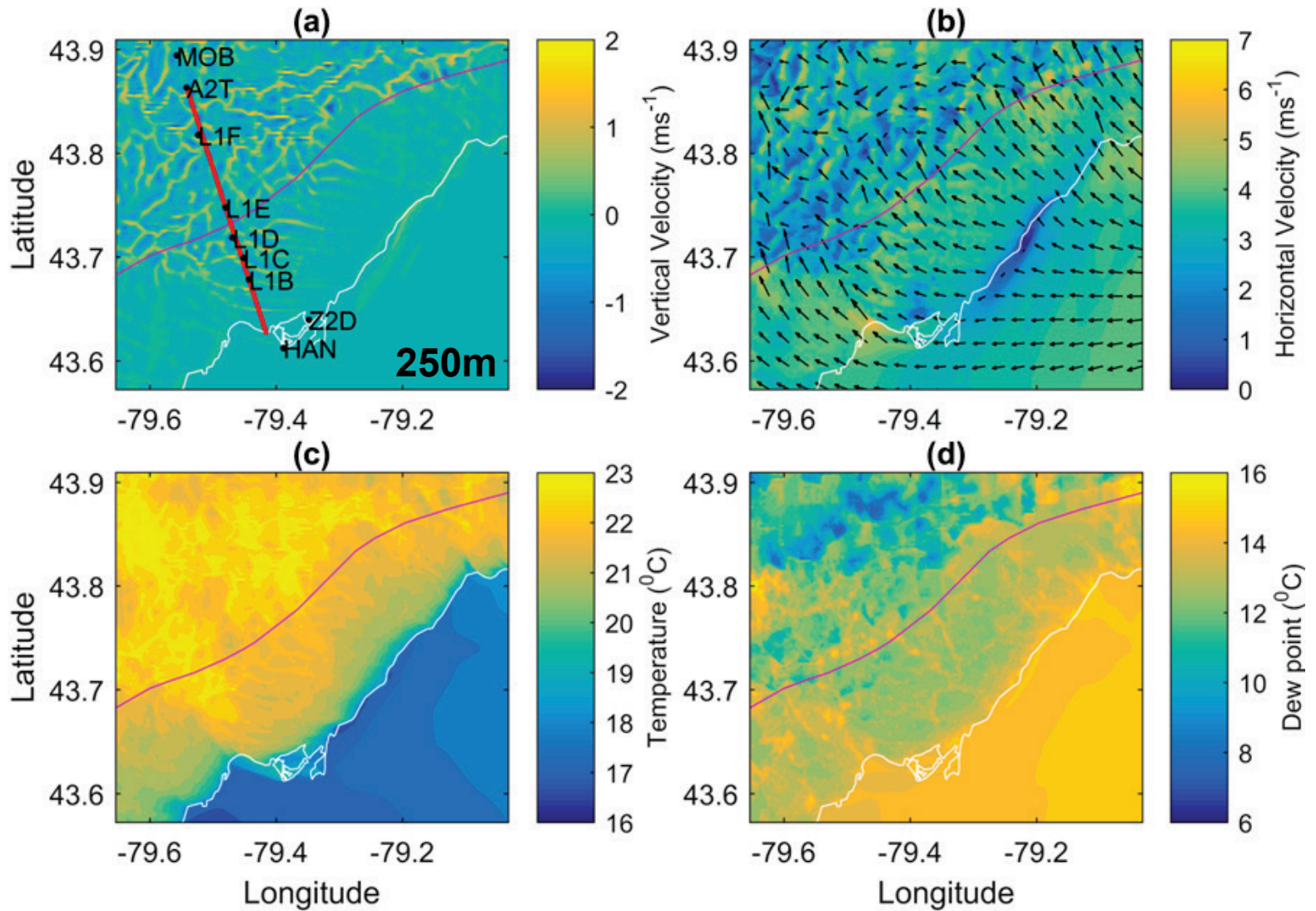
Jul 15th – Offshore synoptic flow case

HRDPS Performance



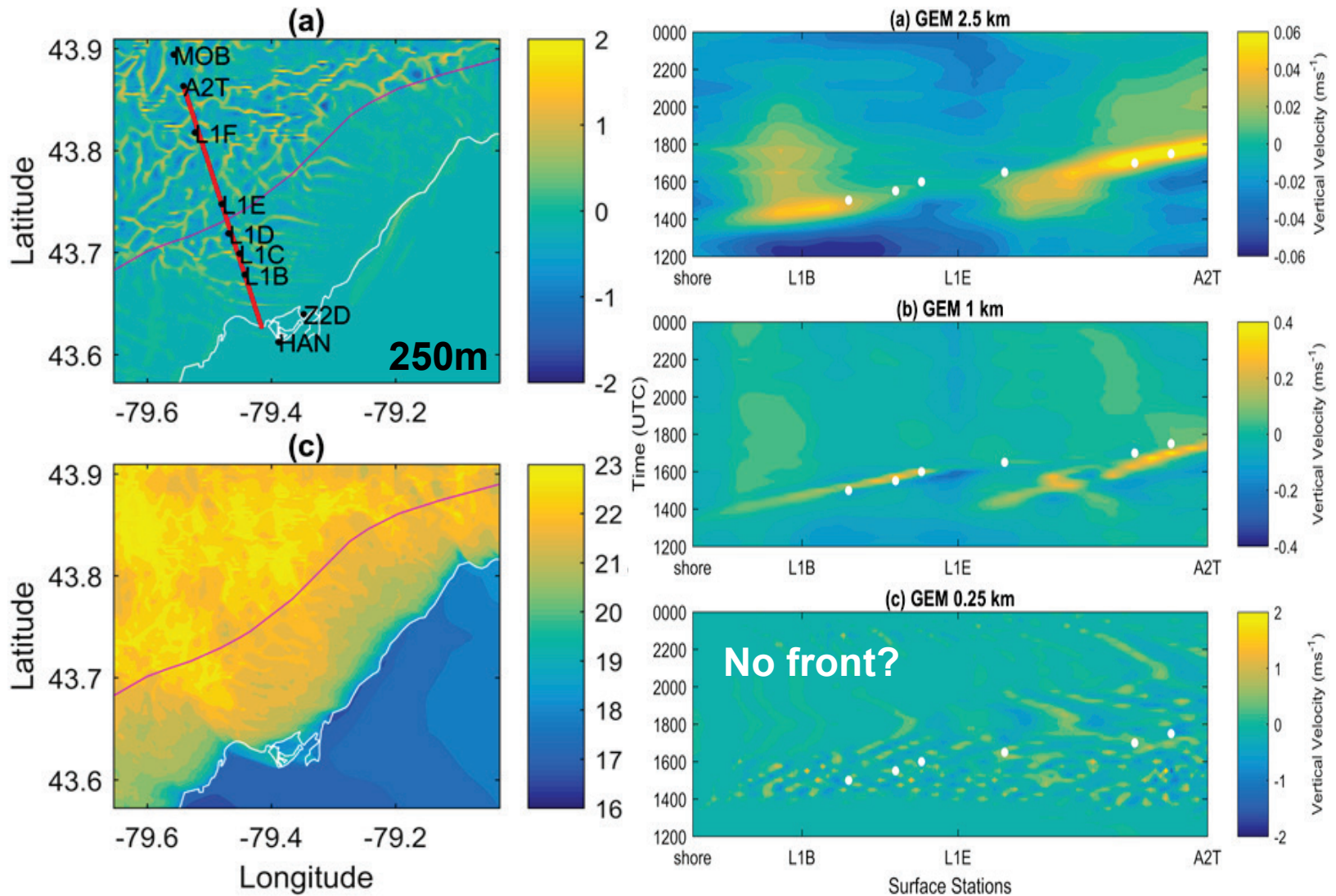
Jul 15th – Offshore synoptic flow case

HRDPS Performance



Aug 9th – Onshore synoptic flow case

HRDPS Performance



Aug 9th – Onshore synoptic flow case

'Next Gen' Demonstration

- The 2015 Toronto Pan / ParaPan Am Games presented a unique opportunity to demonstrate and evaluate a MetObject-based prediction system prototype
- Integrated and employed enhanced monitoring and NWP data focused on lake-breeze front influence on severe weather / AQ
- Generated experimental products to help support Pan Am and OSPC forecasters during the Games
- At a 'Research Support Desk' in the OSPC operations / Pan Am Desk area





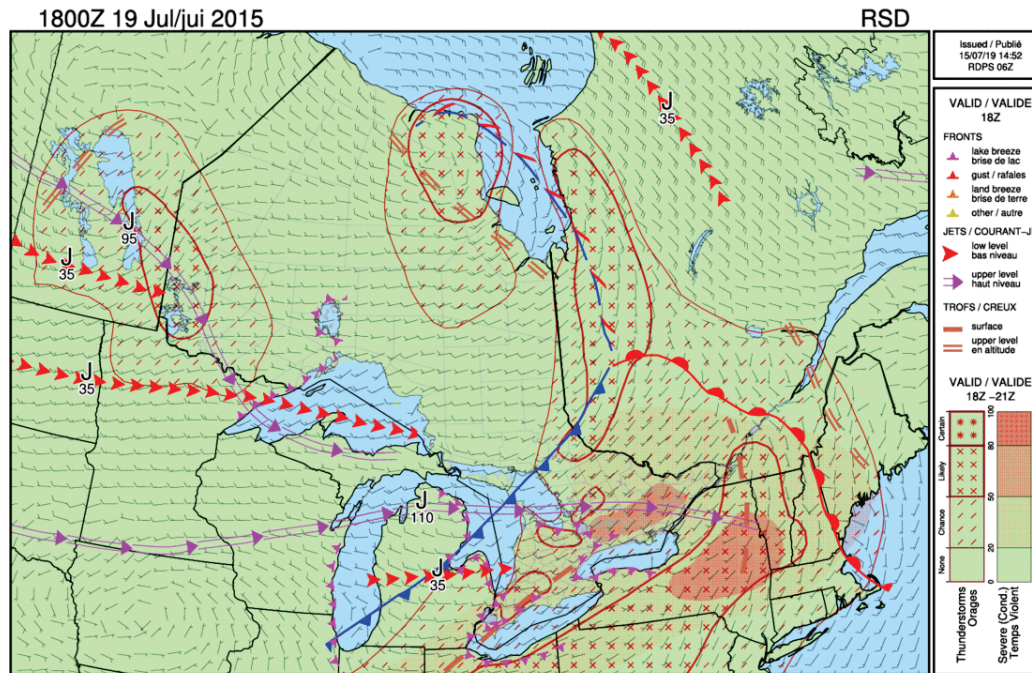
'Next Gen' Demonstration

CHALLENGE: find the best way to combine human skills with automated prediction techniques for better forecasting, nowcasting and alerting

- *Make most effective use of latest observational and NWP advances + algorithm developments*
- *Exploit, maintain and build forecaster expertise with area-based ADP via MetObject approach*
- *Use iCAST (Sills et al. 2009) MetObject prototype to integrate forecasting, nowcasting and alerting functions into one multiscale semi-automated system with advanced verification*



RSD1 Synoptic Space / Time Scale

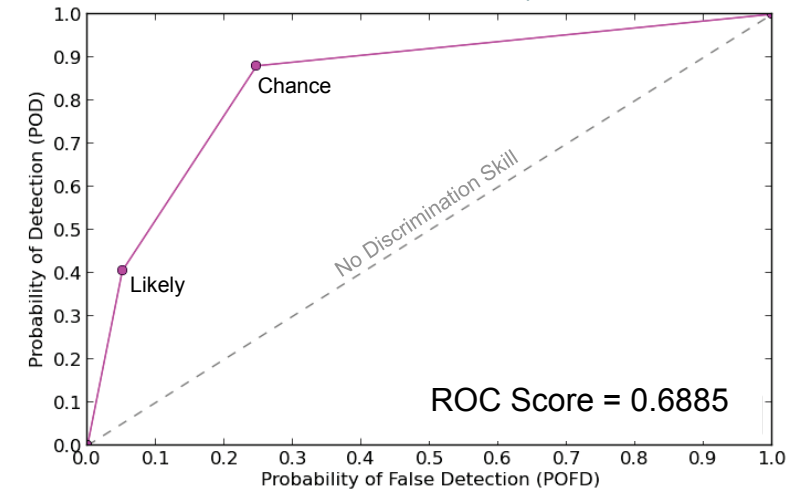
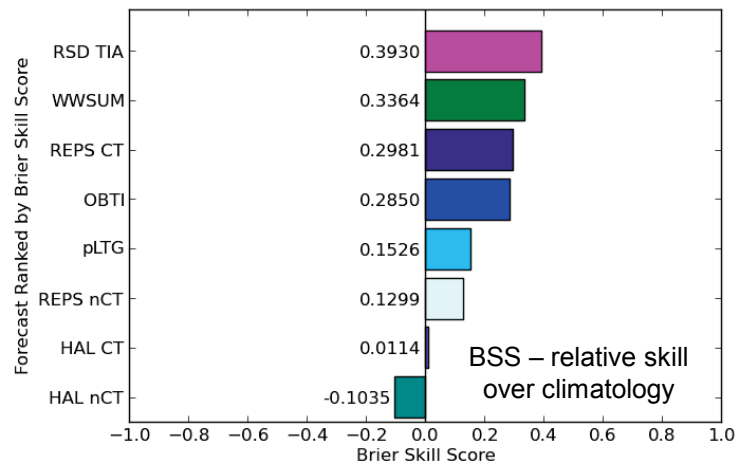
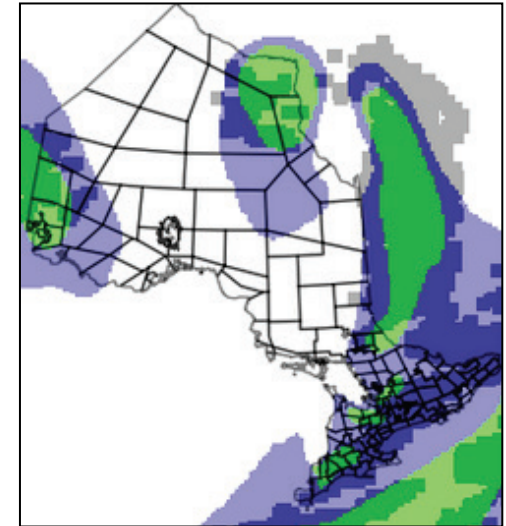
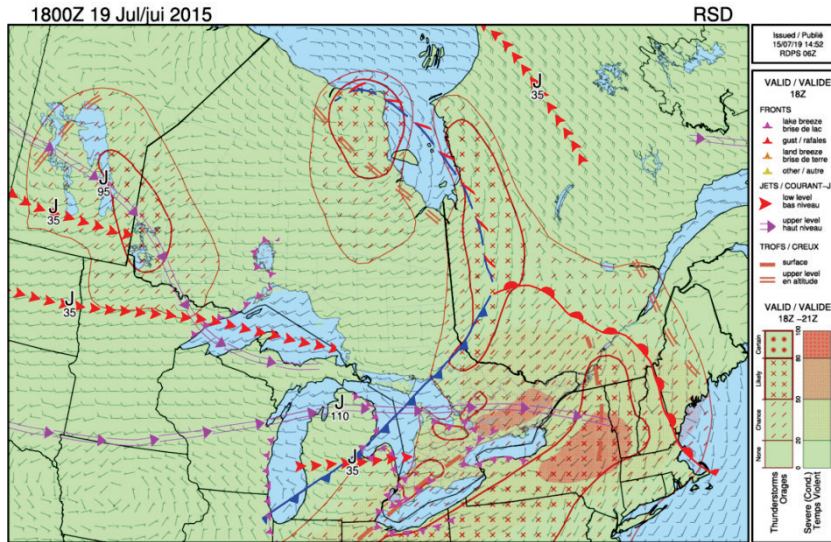


Mix of
'ADP' MetObjects
and
'Weather Element'
MetObjects

MetObject prognoses at 'key frames' for T0+3 hr to T0+72hr:

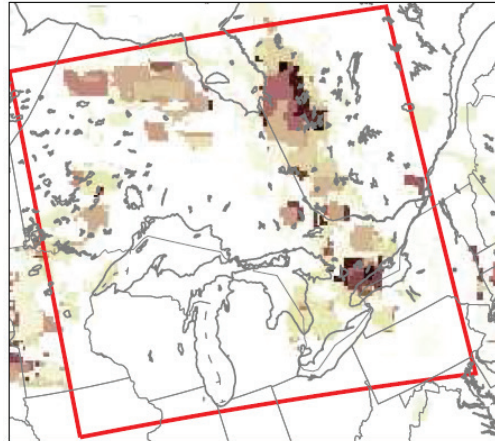
- Synoptic-scale and mesoscale features important for convection based on observations, det/ens/pp NWP guidance, conceptual models, etc.
- Probabilistic areas for thunderstorm likelihood and severity
- Derived outlooks, interpolated animations, time series, verification products

Real-Time Verification

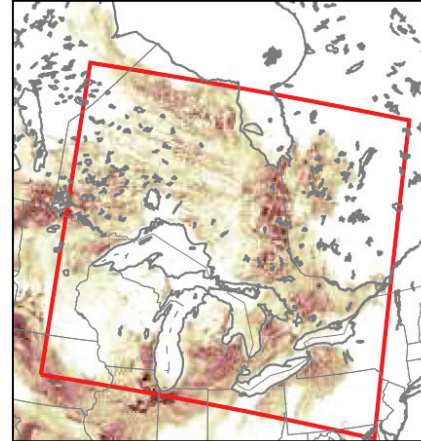


Post-Project Verification

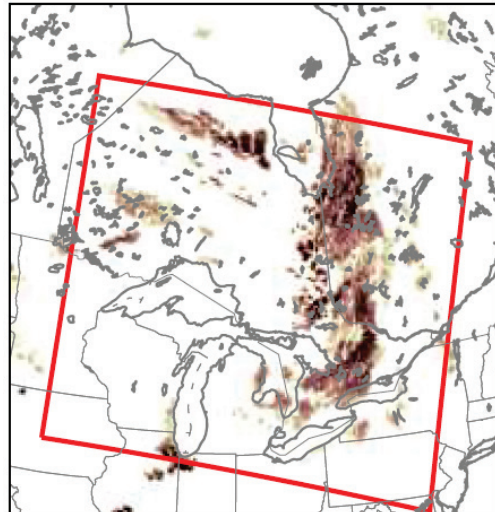
Burrows
Statistical
($\Delta x=15$ km)



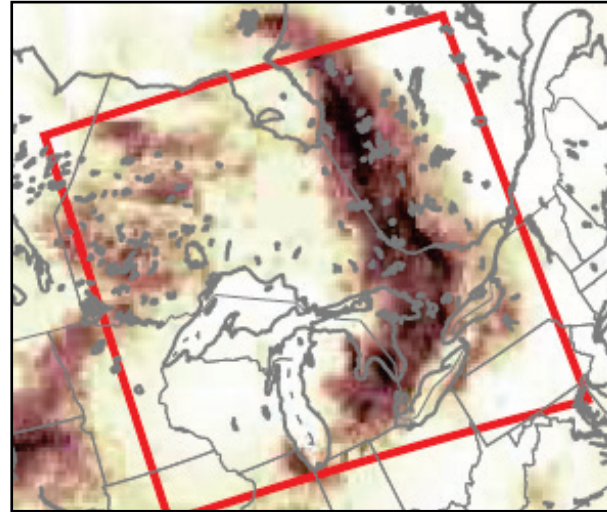
Thunderstorm
Initiation
Ingredients
($\Delta x=10$ km)



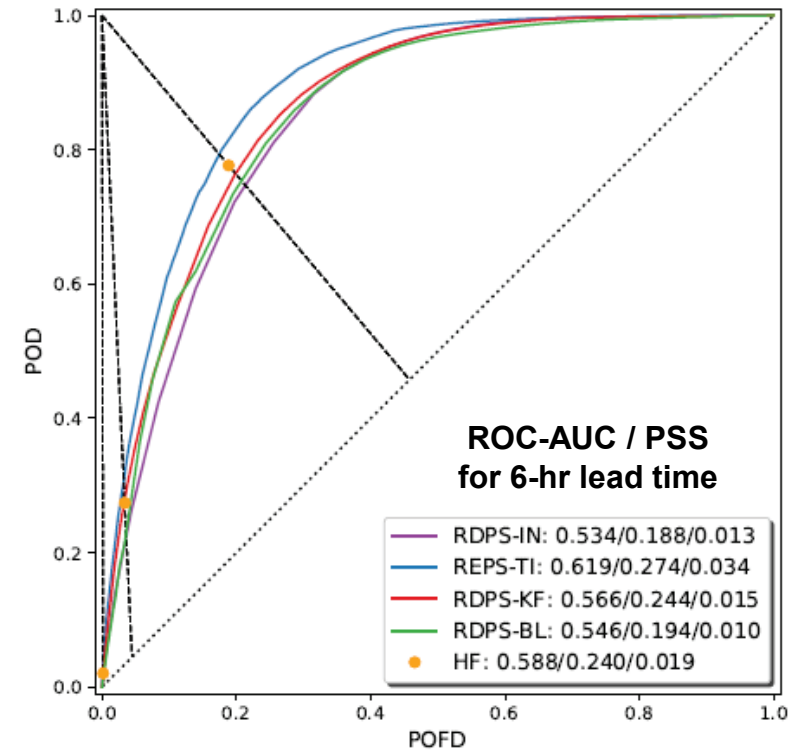
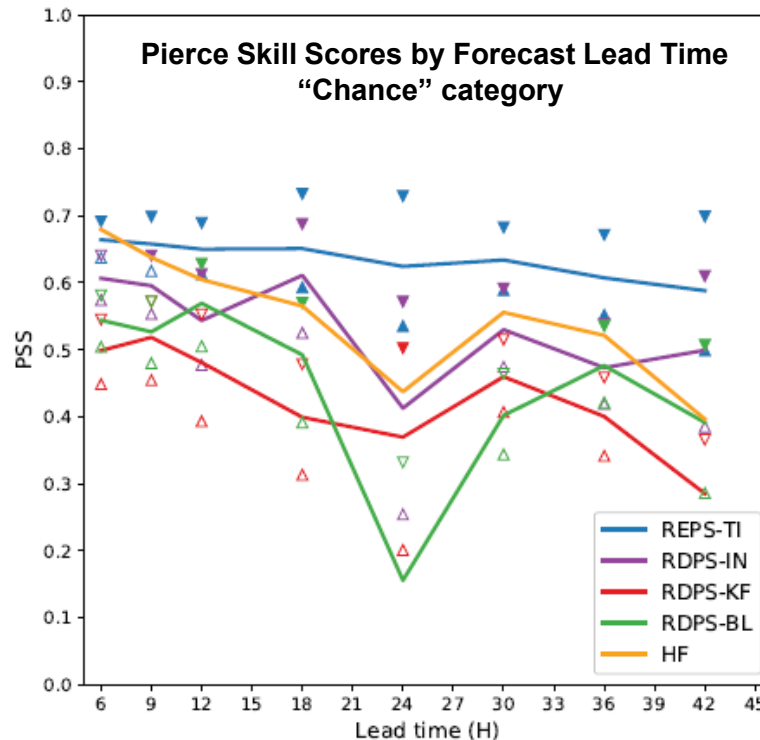
Model KF
Convection
Param.
($\Delta x=10$ km)



REPS
($\Delta x=15$ km)



Post-Project Verification



From Brunet, Driedger and Sills, 2018 (in preparation)

- Post-processing by optimal smoothing / dilation results in improved skill and better discriminative power for all NWP forecasts – KF even gets slightly better than REPS(!)



AQ Observations

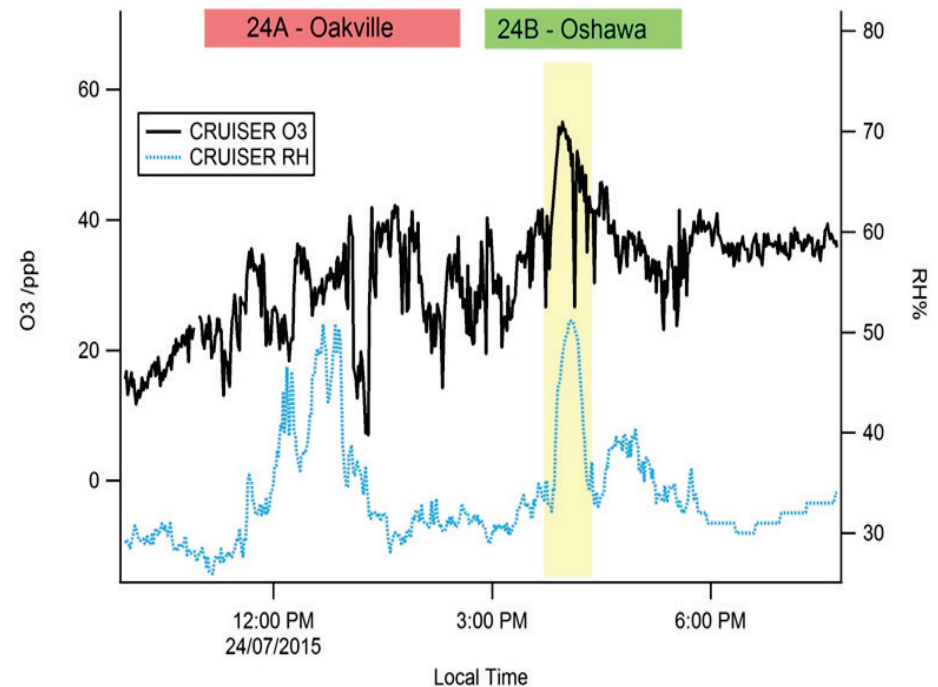
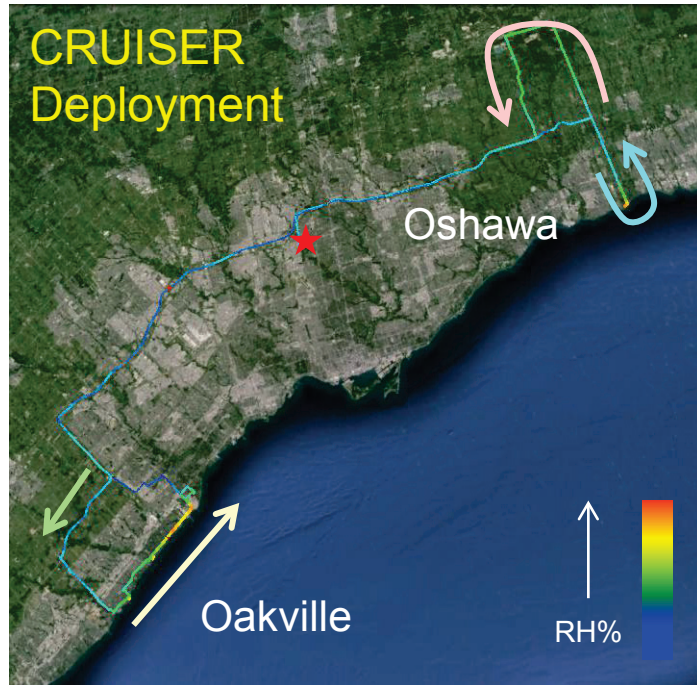
Courtesy Jeff Brook/ECCC

- Goals were to employ CRUISER in urban areas to study spatial and temporal patterns of pollutants and their relationship to urban meteorology
- Evaluate high-resolution (2.5 km) GEM-MACH v2
- Mobile measurements made near routine monitoring sites (e.g., Resources Rd., Downtown T.O., Downsview)
- High time resolution datasets (1 – 5 sec data)



Data: black carbon, NO, NO₂, O₃, HCN, PM, VOCs + met

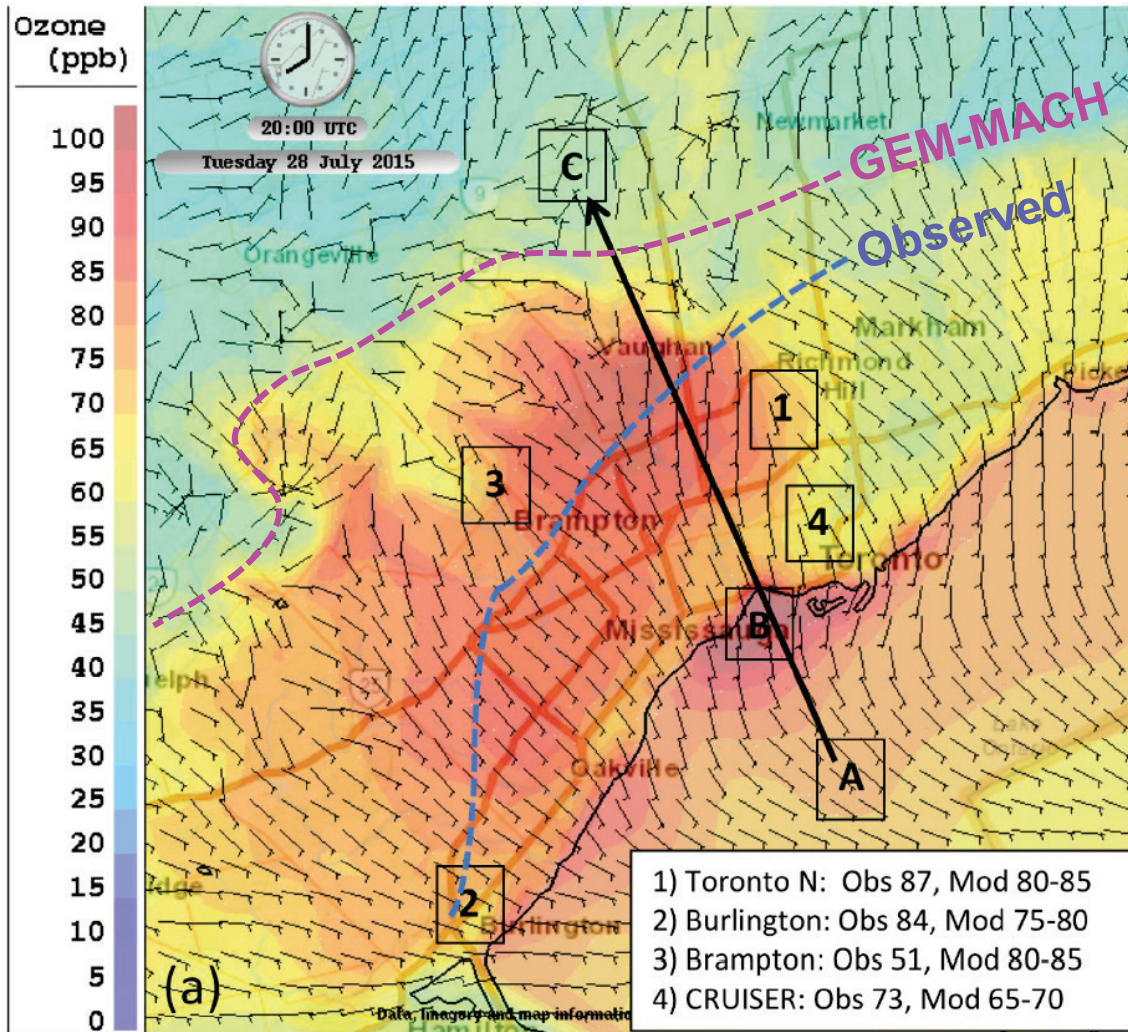
AQ Observations



- July 24th: No change in O3 in Oakville when penetrating lake breeze (RH \uparrow), but later in the day in Oshawa O3 increased > 70 ppbv when CRUISER passed into lake air \rightarrow more processed air

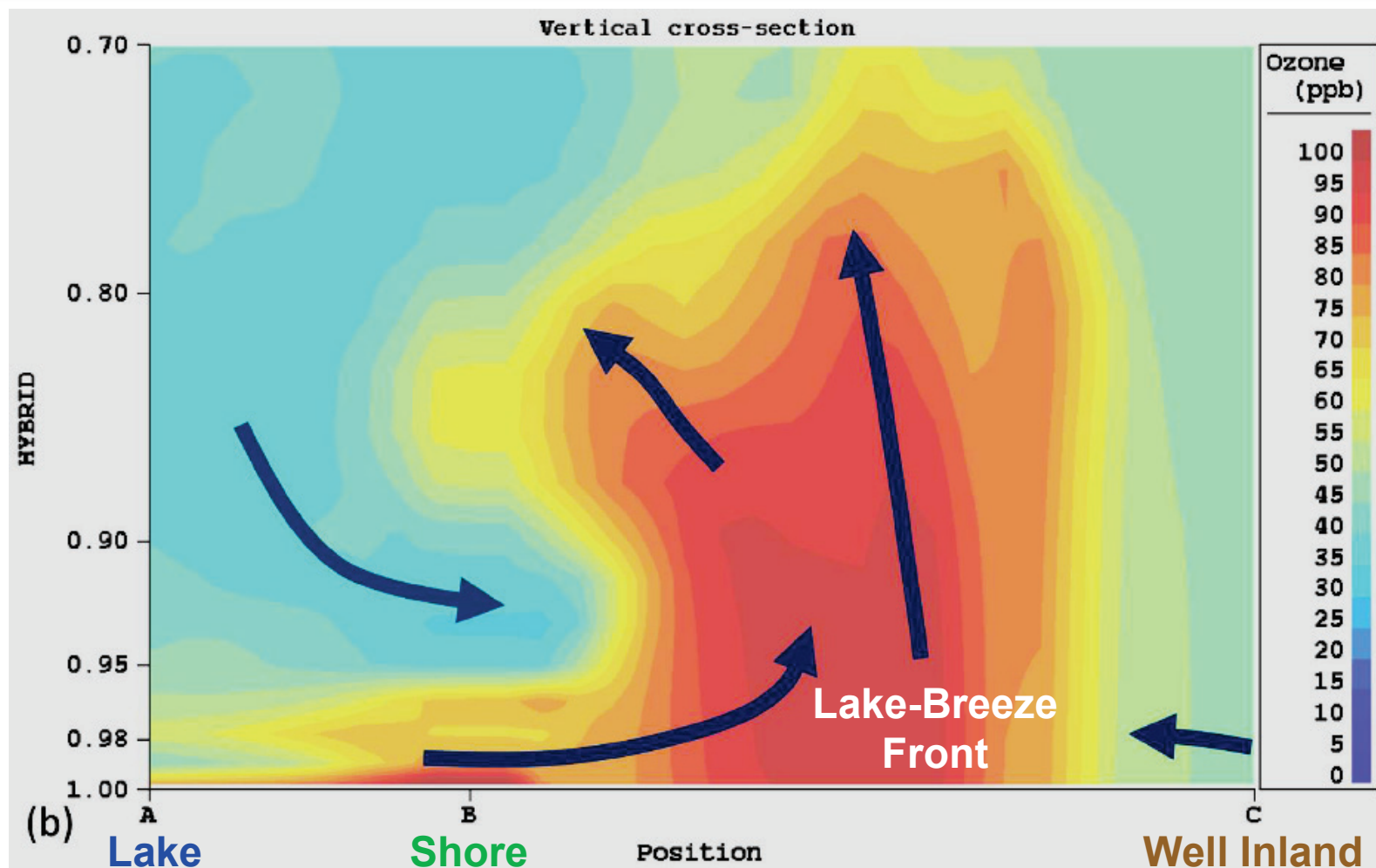
AQ Modelling

Joe, P. and co-authors, 2018: The Environment Canada Pan and ParaPan American Science Showcase Project, *BAMS*, in press.



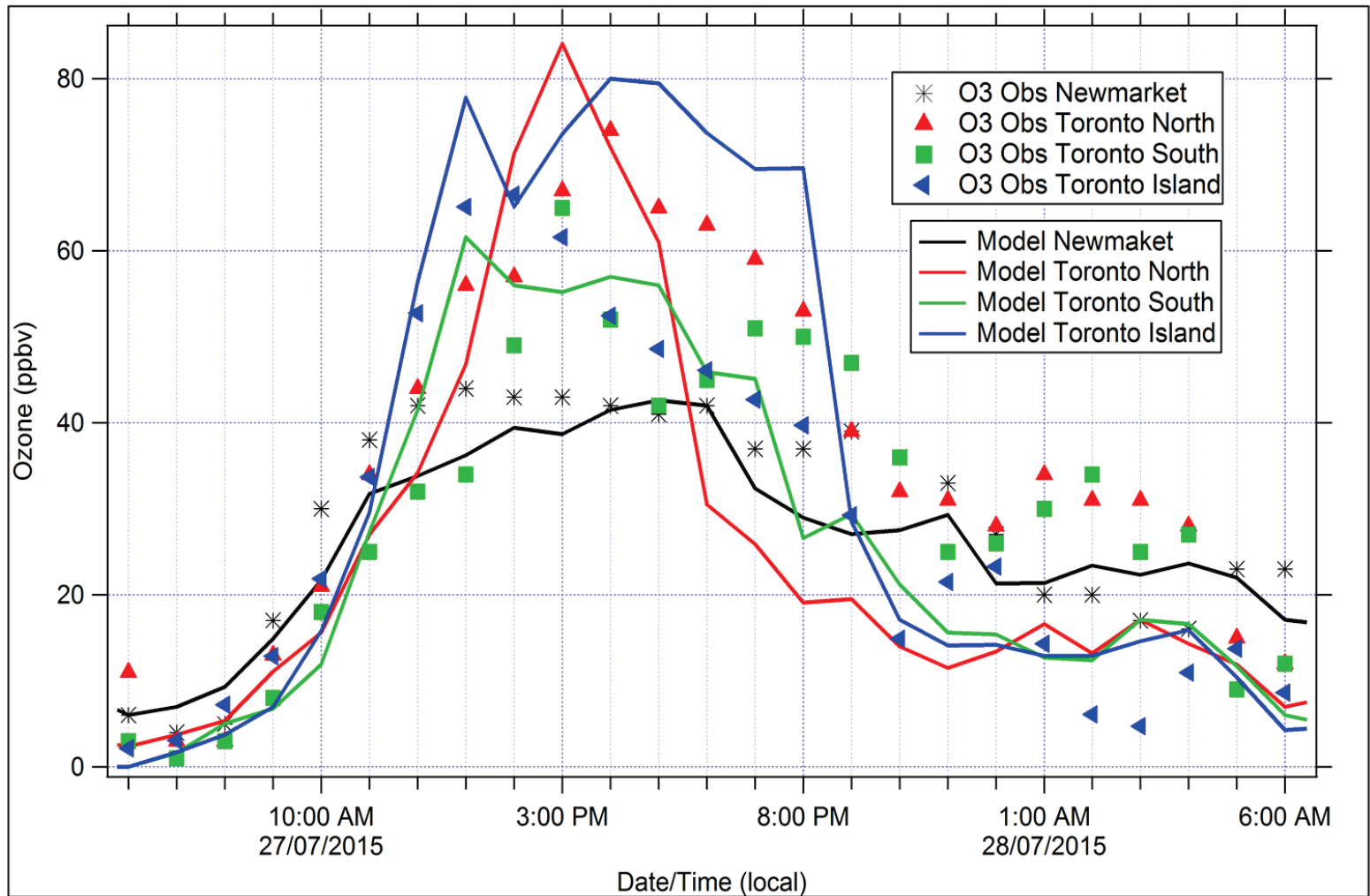
- Hi-res (2.5 km) GEM-MACH v2 / 2.5 km emissions
- Jul 28th prediction shows up to 95 ppbv O_3 behind lake-breeze front, higher than observed
- GEM-MACH front much further inland at 20 UTC than observed front

AQ Modelling



- Some question as to whether ozone at lake surface is real...

AQ Modelling



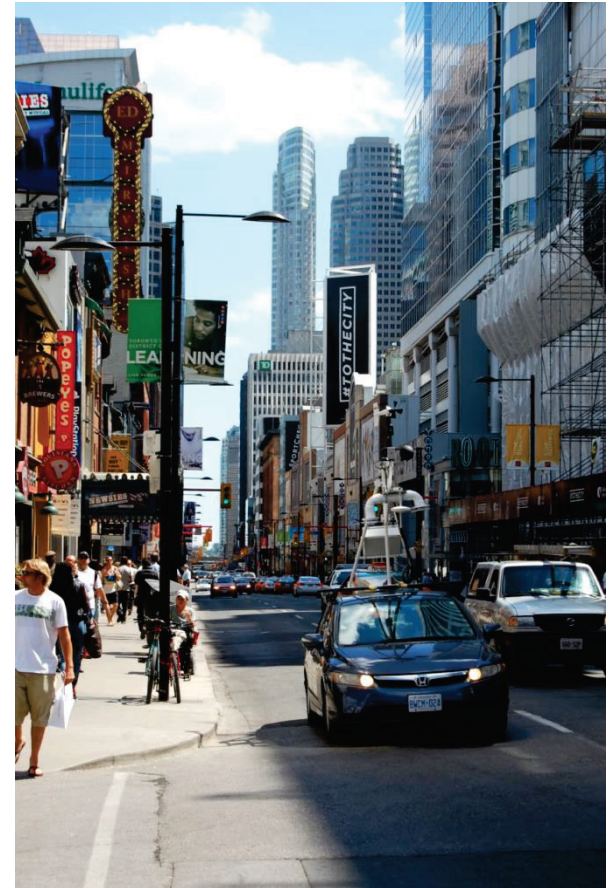
Summary

- The Toronto 2015 Pan / ParaPan Am Games provided a focal point for collaborative science activities and accelerated a number of projects
- Unique, world-class data set for process studies and hi-res model validation – numerous reports, presentations and publications, and more to come
- All data to be available via the open data portal (some are there now)
- *Many* lake breeze cases but ‘big event’ / boundary-initiated severe storms didn’t materialize...Field Studies 101



Acknowledgements

- Mesonet – John Macphee, Joan Klaassen
- LiDAR – Zen Mariani, Paul Joe
- HRDPS NWP – Stephane Belair, Sylvie Leroyer, Armin Dehghan
- RSD Forecasters – Neil Taylor, Helen Yang, Anna-Belle Filion
- MetObject Demo – Norbert Driedger, Brian Greaves, Emma Hung, Dominique Brunet, Bill Burrows
- AQ – Jeff Brook, Craig Stroud



Thank you!

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