Potential benefits of urban High-Resolution NWP Predictions to Air quality modelling

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Overview

**Planetary Boundary-Layer Height (PBLh)**
- Air Quality models need the PBLh
- In GEM model PBLh diagnostics from surface layer parameters
- Recent efforts to improve such diagnostics (ongoing at RPN-A)

**Urban GEM-LAM, sub-km (downscaling to 250 m here)**
- Boundary-layer details achieved with high-resolution NWP
- Evidence of the impact on the urban fabric on
  - turbulence,
  - internal boundary-layers,
  - Convergence fronts (eg, interactions with sea and lake-breezes)
- Diagnostics based on vertical profiles of meteorological variables

**Problems and solutions**
- Scientists have pulled-out hair about determination of PBL...
  **here are some PBLh attempts (1st, 2nd, 3rd) !**
- Other turbulent characteristics could be more relevant
  vertical velocities, TKE, Tau, Heat and moisture fluxes
In Leroyer et al. (2014), Vancouver

1st attempt for PBLh Diagnostics based on $\Theta$ vertical profiles

Model vertical profile
26 levels < 1500 m

Grid point evaluation with a ceilometer
Models at different resolution
Urban GEM-LAM over GTA

- One-year testbed experiment over the Greater Toronto Area (GTA)
- Context of 2015 Pan-American Games project, see tomorrow's talk (Belair et al.)
250-m GRID SPACING, *Urban fraction in the grid cell*
Influence of the urban area on the lake-breeze front

- 18 July 2014
- cumulus inland
- ideal Lake-breeze

CONTROL RUN (13 LT)

• Vertical Velocities

TIME (UTC–5)

ELEVATION (m ASL)

TIME (UTC–5)

Updrafts: green ↑ red ↑ ↑ white ↑ ↑ ↑
Downdrafts: dark blue↓ purple ↓ white ↓ ↓ ↓

CTRL RUN (z=525 m Above Lake Level)

NO URBAN PROCESSES

INFLUENCE OF THE URBAN AREA ON THE LAKE-BREEZE FRONT: Vertical Velocities

CONTROL RUN (13 LT)

• Cumulus inland
• Ideal Lake-breeze

ELEVATION (m ASL)

TIME (UTC–5)

Updrafts: green ↑ red ↑ ↑ white ↑ ↑ ↑
Downdrafts: dark blue↓ purple ↓ white ↓ ↓ ↓

CTRL RUN (z=525 m Above Lake Level)

NO URBAN PROCESSES
Influence of the urban area on the turbulence

15 July 2015

- Strong synoptic flow (NW) prevents Inland penetration of the lake breeze
- Influence of the urban area is not predominant on the front location for this case
- However, increase of turbulence in late afternoon north from the front

CTRL RUN (z=525 m Above Lake Level)

NO URBAN PROCESSES
Evaluation of the lake-breeze front

2nd attempt for PBLh

- Automatic grid-point PBLh diagnostics
- Find inflection based on vertical profiles of
  \( \Theta_v \) (virtual pot. Temp., spec. Humidity (instable),
  \( \rightarrow \) surface-layer parameters (stable conditions)
28 July 2015

2\textsuperscript{nd} attempt for PBLh

- Sometimes questionable
- Artefacts?
• Diagnostics based on $\Theta_v$, find inflection now from the top
• pbl for 28 July 2015 + filter (Savitsky-Golay)

3rd Attempt for PBLh

Lake shore

After 15 minutes!
Should we try to determine the PBLh?

Other turbulent features of interest

Challenges: residual layer? Several inflections? Growing mixed layer? Detrainment?

• Turbulence at such resolution: grid-scale (parametrized) + resolved
• Turbulent Kinetic Energy (TKE)
• Heat and Moisture Fluxes ($w'\Theta'$ & $w'q'$)
• Momentum fluxes ($\tau$)

Eg, growing mixed layer
(In Turbulence in the atmosphere
J. C. Wyngard)
• TKE (15 min averaged)
• Locate PBLh at $TKE_{\text{critical}}$ (in literature $TKE_{\text{critical}} \approx 0.03 \text{ m}^2\text{s}^{-2}$ blue contour)

Here methods TKE and inflection quite agree
Here methods TKE and inflection (3rd attempt) DO NOT really agree!
$W'\Theta'$

→ Exploring heat and momentum turbulent fluxes

15 July 2015  1830 UTC
Persistent near shore front

15 July 2015

Propagating front

28 July 2015
Conclusions

Planetary Boundary-Layer Height (PBLh)
• No revolution: It is difficult to get automatic PBLh diagnostics in urban GEM-LAM → but it is worth having a guess
• Can be used for lower resolution model
• Planed evaluations with observations
• Could Air Quality models be designed not to use PBLh?

Benefits of urban and high-resolution modelling system for use to air quality
• Impact of urban and surface heterogeneities on small-scale meteorological processes
• Detailed turbulence representation
• Detailed advection

Limitations
Too low resolution of emissions inventories
THE END

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