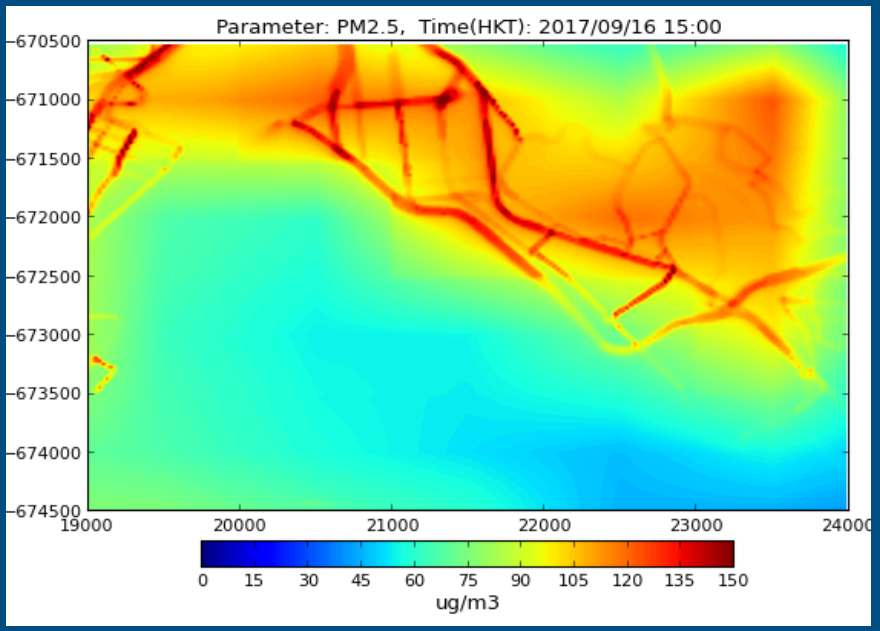
High-resolution air quality forecasting for Hong Kong



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16th Annual CMAS Conference

October 2017

Outline

- Motivation
- ADMS-Urban Regional Model Link system
- Hong Kong forecasting implementation
- Computational performance
- Concentration outputs
- Further work

Motivation

- Current ‘air quality health index’ at 16 monitoring sites

HIGHLIGHTS

Current AQHI: **General Stations** 4 to 5 **Roadside Stations** 4 to 5

Remarks:

(1) Time shown is in Hong Kong time.

(2) The AQHI information is based on real time data taken directly from EPD's Air Quality Monitoring Network.

(3) The hourly reported AQHI is for short term health risk communication; for health risks of long-term exposure of the air quality, please refer to the Annual Air Quality Index(Annual AQI).

(4) In case of station or equipment suspension due to maintenance, the data collection for calculation of AQHI at station will be affected, the data of most similar stations will then be adopted. Such AQHI will be shown in italics.

FORECAST of Health Risk

19-10-2017	Today P.M.	Tomorrow A.M.
General Stations	Low to High	Low
Roadside Stations	Low to High	Low

低 LOW 1 2 3 | 中 MODERATE 4 5 6 | 高 HIGH 7 | 甚高 VERY HIGH 8 9 10 | 嚴重 SERIOUS 10+

Air Quality Health Index

15:00 19-10-2017		AQHI	Health Risk
General Stations	Central/Western	4	Moderate
	Eastern	4	Moderate
	Kwun Tong	4	Moderate
	Sham Shui Po	4	Moderate
	Kwai Chung	4	Moderate
	Tsuen Wan	4	Moderate
	Tseung Kwan O	4	Moderate
	Yuen Long	5	Moderate
	Tuen Mun	5	Moderate
	Tung Chung	5	Moderate
	Tai Po	4	Moderate
	Sha Tin	4	Moderate
	Tap Mun	4	Moderate
Roadside Stations	Causeway Bay	5	Moderate
	Central	5	Moderate
	Mong Kok	4	Moderate

aqhi.gov.hk

Motivation

- Current ‘air quality health index’ at 16 monitoring sites
- Limited forecast (next day)
- No detail for wider urban area
- **P**ersonalised **R**eal time **A**ir quality **I**nformatics **S**ystem for **E**xposure (**PRAISE**-HK) project will
  - Create high-resolution air quality forecast for Hong Kong
  - Publish forecast via mobile app
  - Include route planning and personal health alerts

PRAISE HK | Empower the Public with Personalised Air Quality Information

praise.ust.hk

ADMS-Urban Regional Model Link system

- Combines regional model output (CMAQ, CAMx, EMEP4UK, CHIMERE, WRF-Chem) and local ADMS-Urban modelling for street-scale concentration output
- Avoids double-counting emissions by separating regional and local modelling using ‘mixing time’

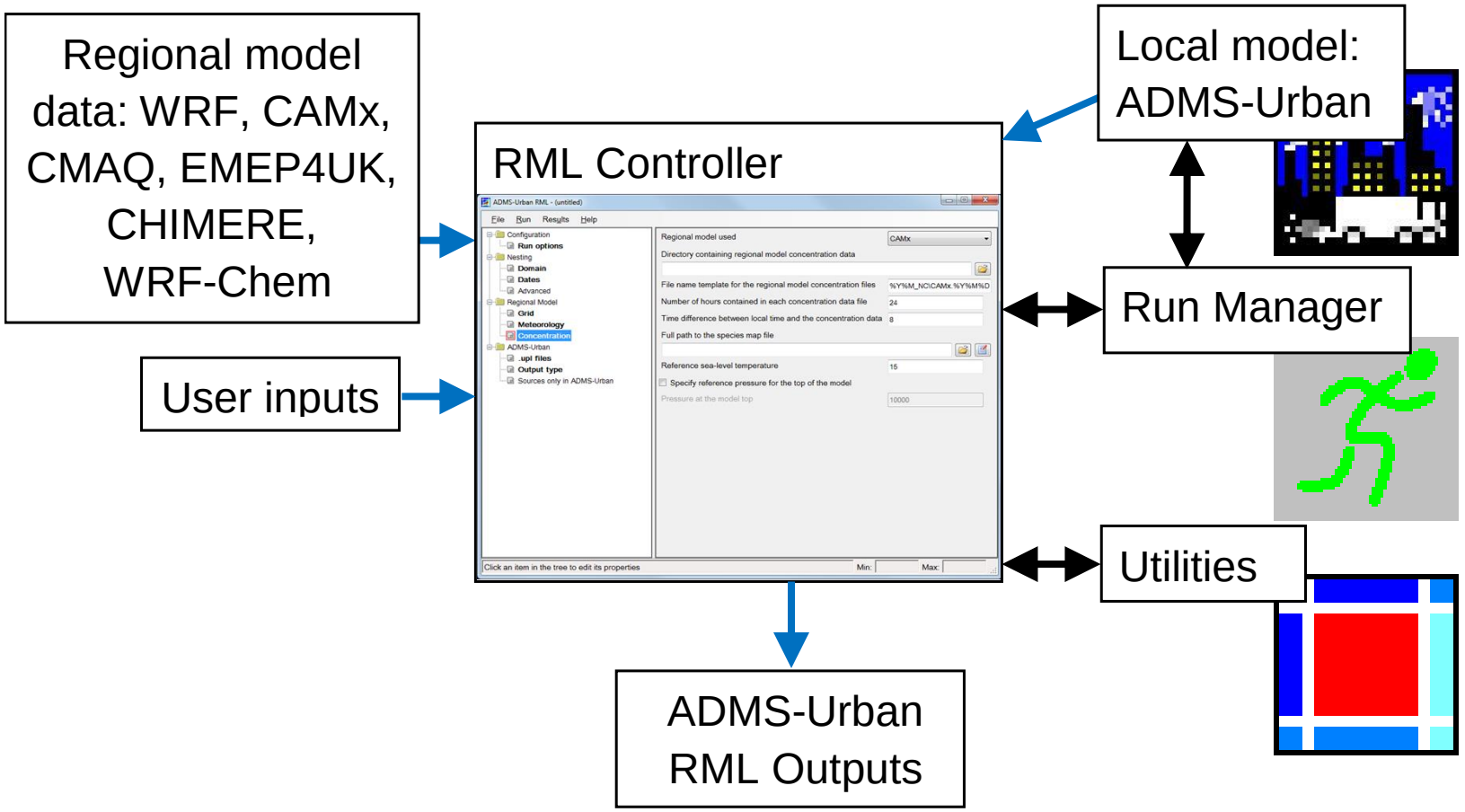
Concentration within nested domain	=	Regional modelling of emissions	-	Gridded locally modelled emissions (ΔT)	+	Explicit locally modelled emissions (ΔT)

ADMS-Urban Regional Model Link system

- Combines regional model output (CMAQ, CAMx, EMEP4UK, CHIMERE, WRF-Chem) and local ADMS-Urban modelling for street-scale concentration output
- Avoids double-counting emissions by separating regional and local modelling using ‘mixing time’
- Initial concept published 2012, automated system 2014
- Developments since 2014:
  - Support for CHIMERE and WRF-Chem added
  - System re-built on Linux and automation increased
  - Option to apply interpolation to regional model output

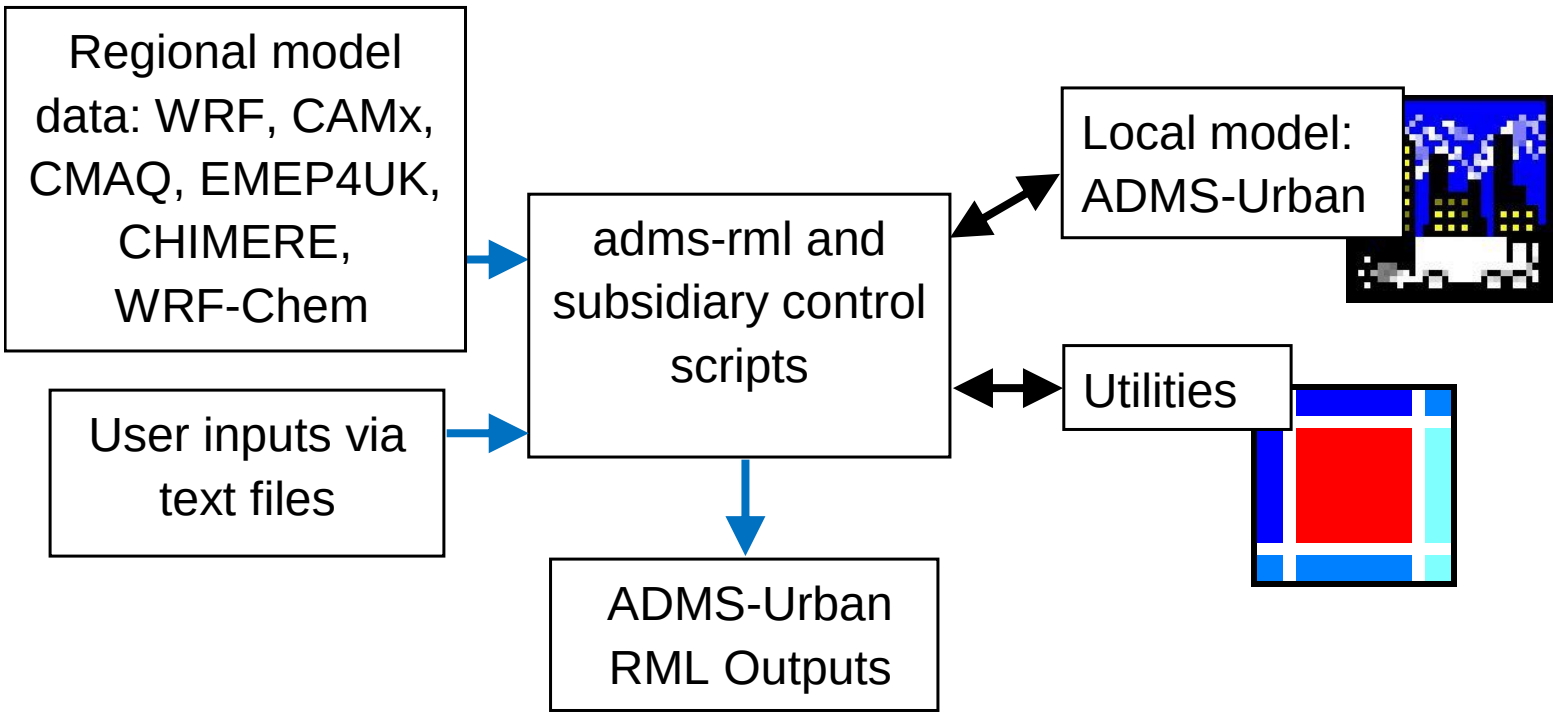
ADMS-Urban RML Windows

- Graphical interface, Run Manager for distributing runs across PCs



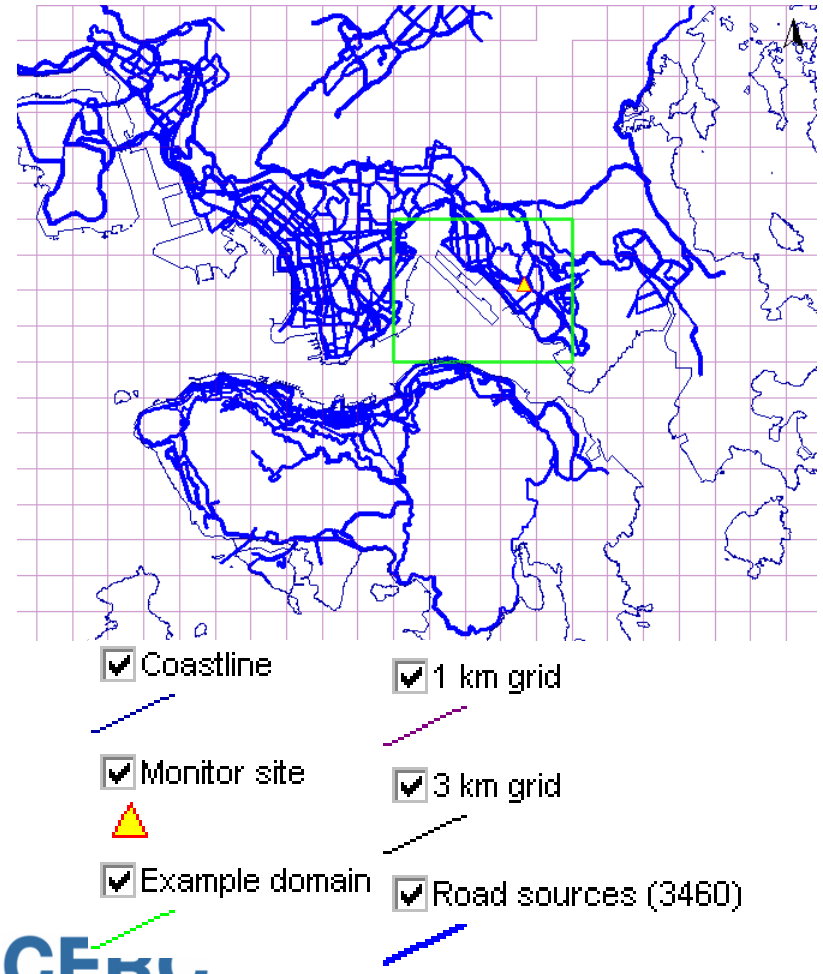
ADMS-Urban RML Linux

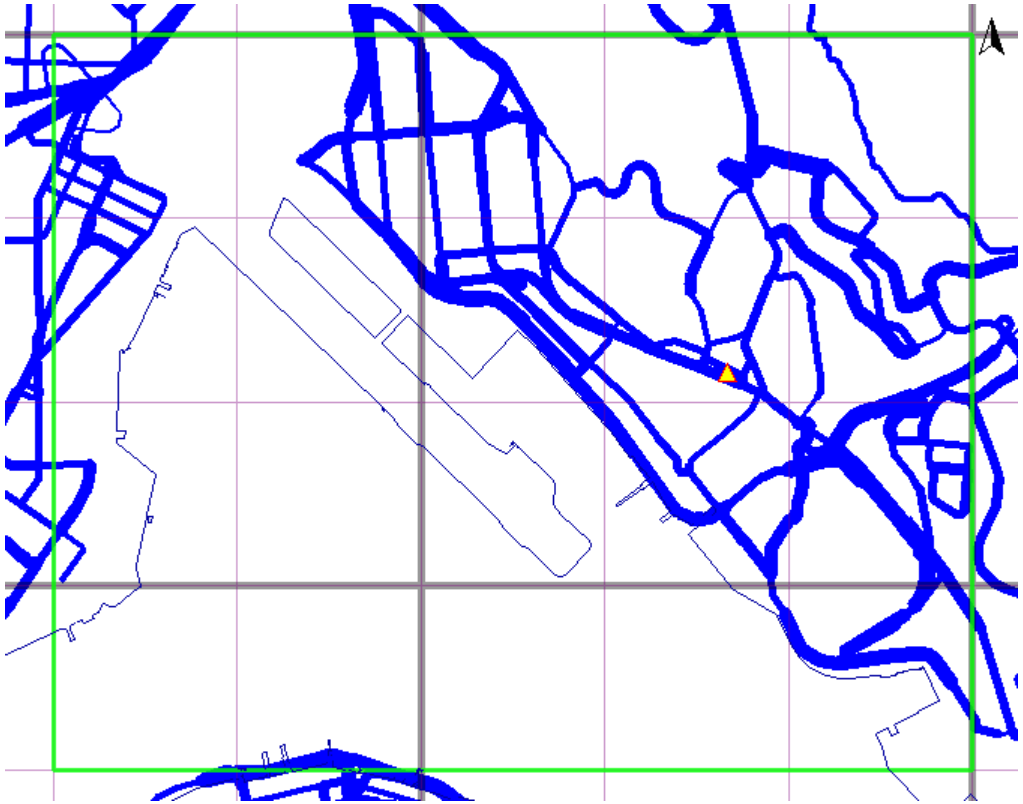
- RML Controller and Run Manager replaced by scripts
- Graphical interface replaced by text input files
- ADMS-Urban and utilities re-compiled for Linux



Hong Kong Forecasting Implementation

- Example 5x4 km domain



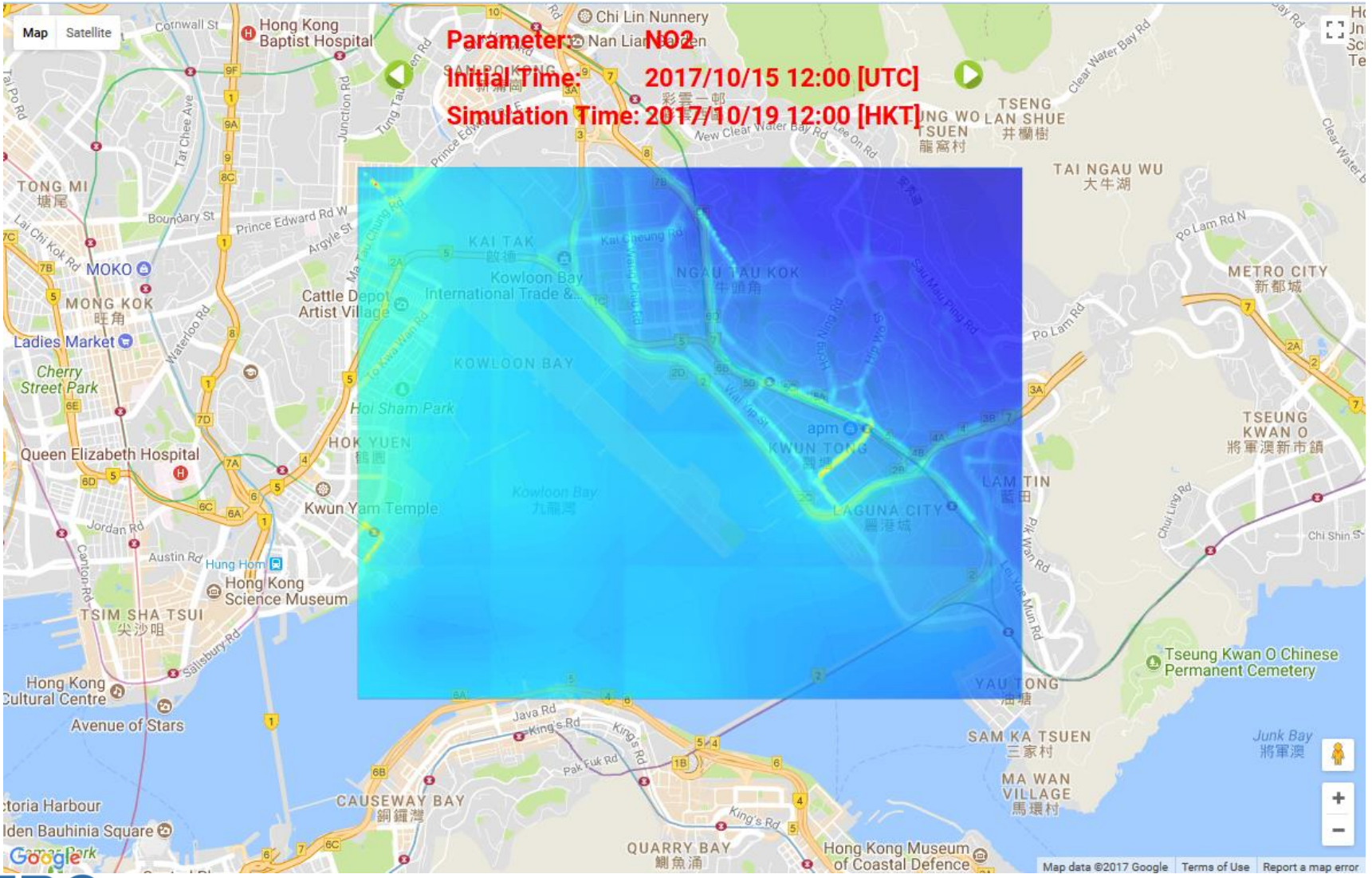


Hong Kong Forecasting Implementation

- Example 5x4 km high resolution domain
- 3 day forecast, run starts 4 am each day
- 7 output species
  - **NO_2**, NO_x, O_3, **$PM_{2.5}$**, PM_{10}, SO_2, CO
- Regional modelling from WRF and CMAQ
  - Domain resolutions 27 km, 9 km, 3 km, **1 km**
- **2010** emissions inventory
- Output concentrations displayed in Google Maps
- Trial period: 5th September – 2nd October 2017 (4 weeks)

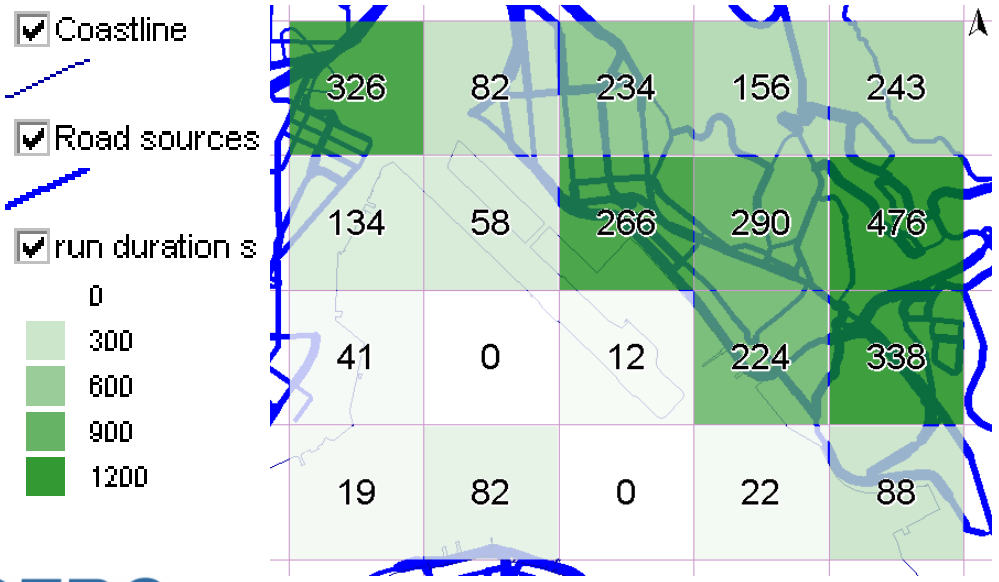
Hong Kong Forecasting Implementation

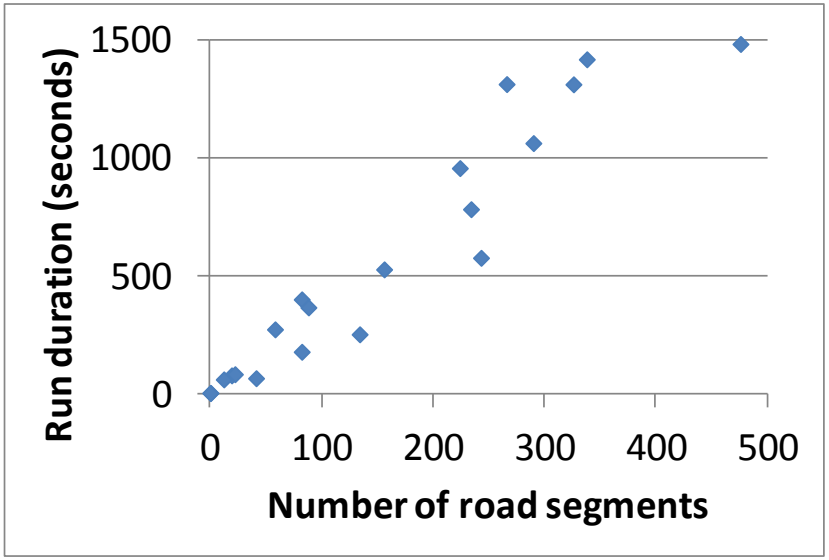
Output concentrations displayed in Google Maps



Computational performance: run time

- Short run time relative to regional modelling
  - WRF 1.8 hours, CMAQ 2.5 hours, ADMS-Urban RML 25 minutes (all per forecast day)
- ADMS-Urban RML run time dominated by ADMS-Urban local model runs with explicit sources
  - varies with density of road segments





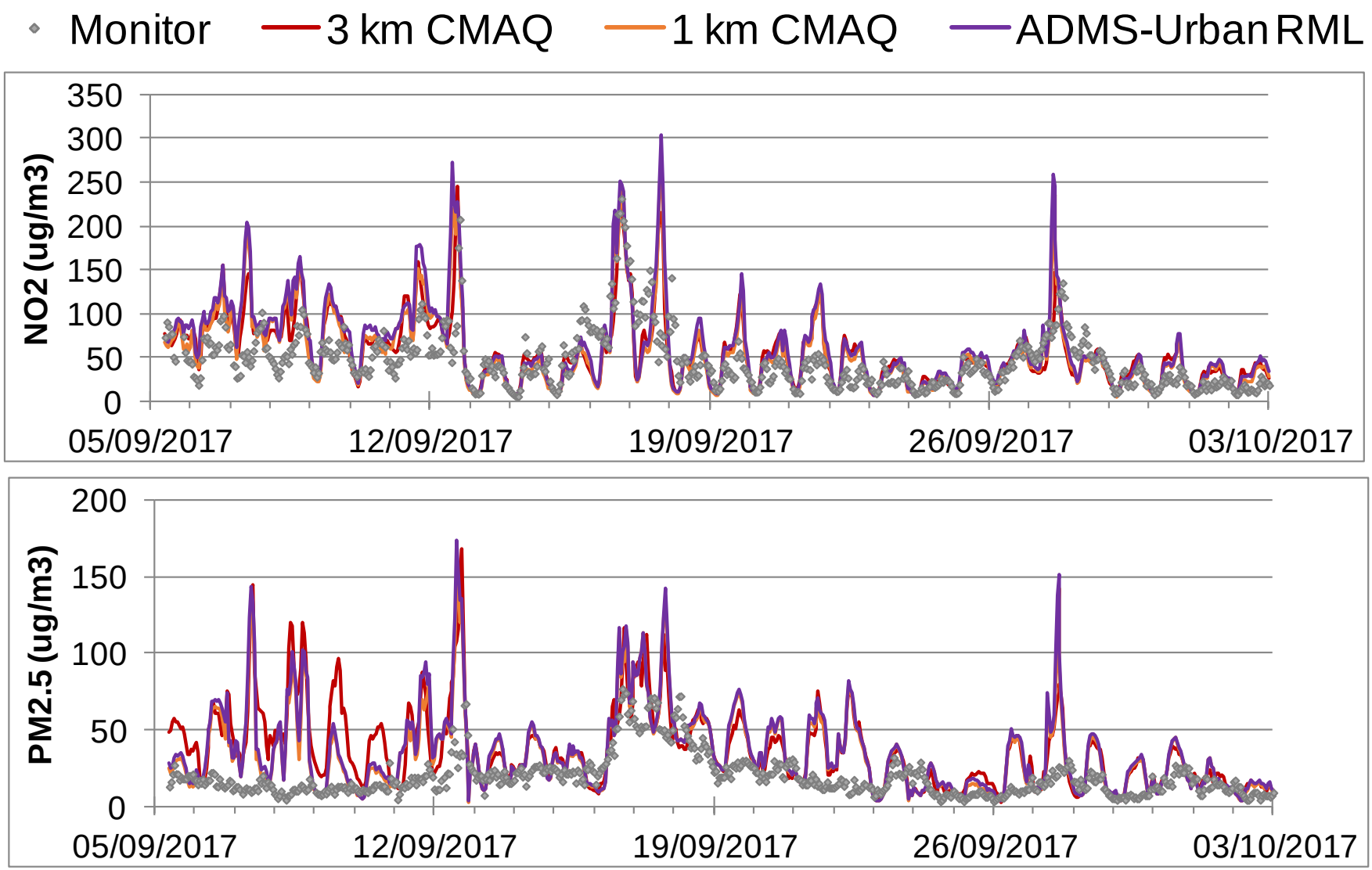
CERC

Computational performance: File size

- **Total** output file size for high-resolution domain **smaller** than CMAQ
- File size **normalised** by output area **larger** than regional models due to increased output point density
  - Average 4577 points/km^2
  - File size per output point smaller than CMAQ (fewer species)

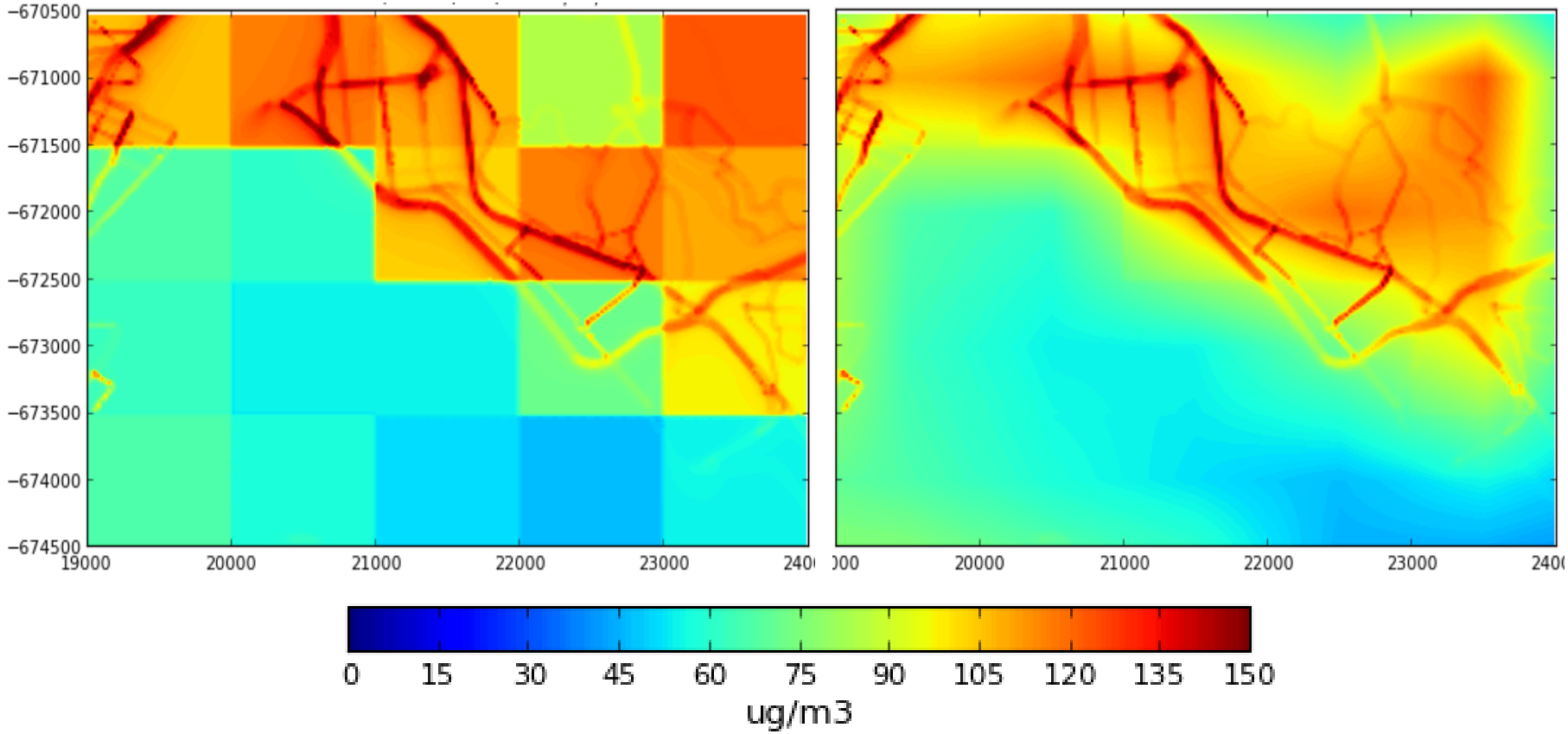
Model domain	Extent cells		Cell size km	File size	
	x	y		Total MB	Norm MB/km^2
CMAQ 3 km	152	110	3	213	0.001
CMAQ 1 km	179	125	1	278	0.012
ADMS-Urban RML	5	4	(1)	66	3.300

Concentration outputs: Time series



Concentration outputs: Interpolation

- Option to apply interpolation to regional model output
  - Example $PM_{2.5}$ concentrations for 16th September 2017 3pm local time

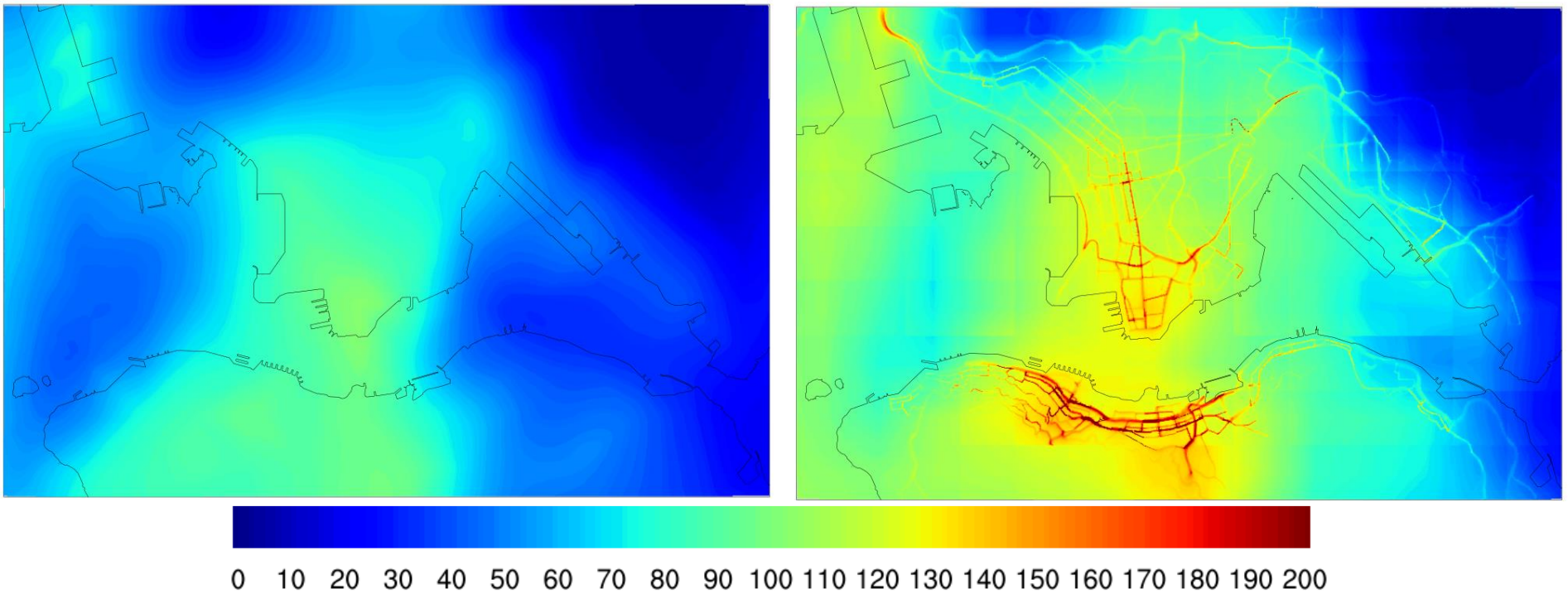


Further work

- Expand to bigger domain covering main urban areas of Hong Kong and Kowloon
  - Example NO_2 for 3pm local time 13th October 2017

CMAQ

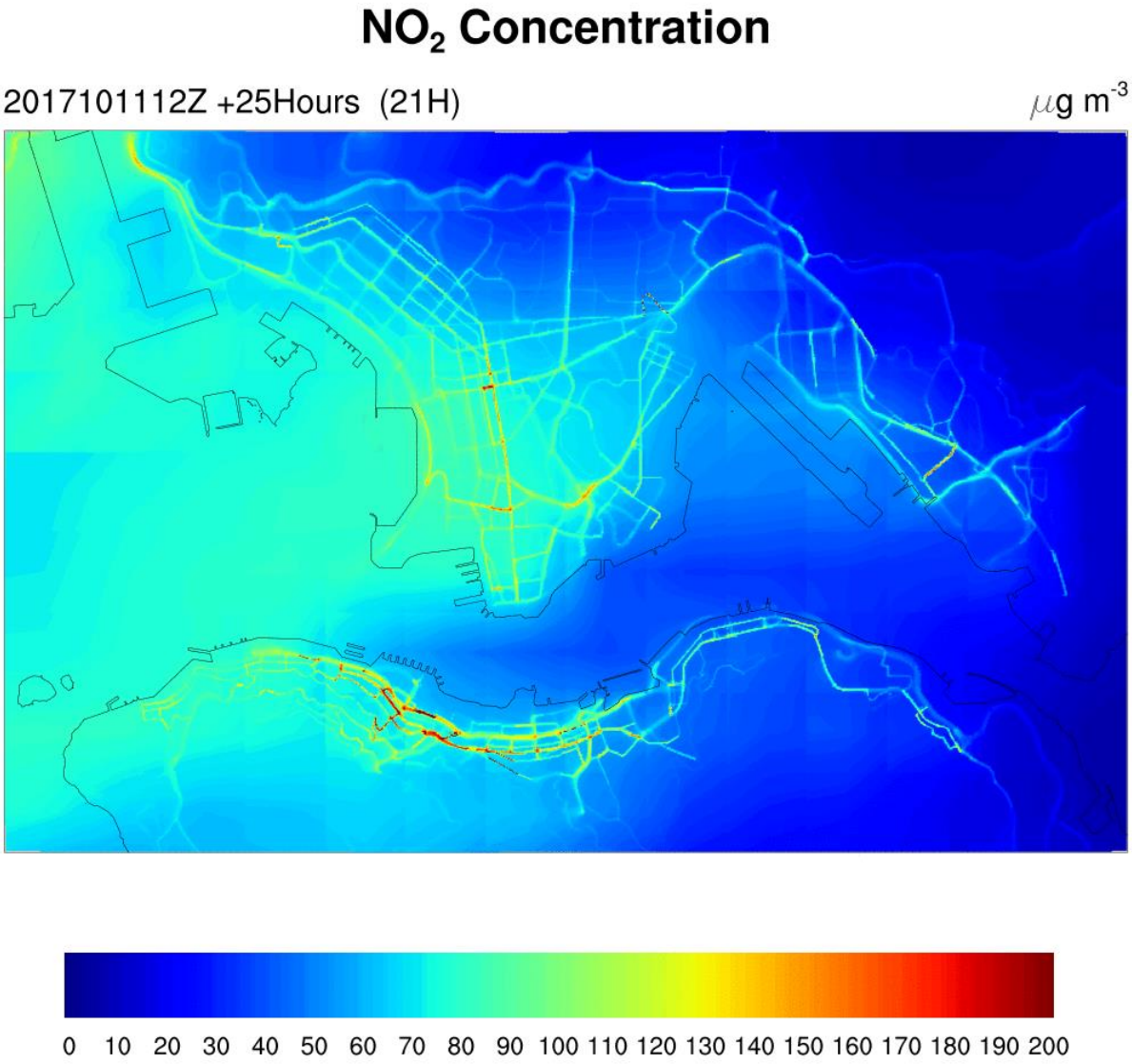
ADMS-Urban RML



Further work

- Expand to even bigger domain covering HKSAR
- Update emissions
  - 3D grid source in ADMS-Urban, automatic emissions conversion from CMAQ to ADMS-Urban
  - Time-varying profiles for individual roads
- Evaluate concentrations against all available monitors
- Release initial app (late 2018)
- Incorporate real-time traffic flow and concentration data
- Calculate indoor concentrations from outdoor forecast
- Include route planning and personalised alerts in app

Thank you


NO2 Concentration
2017101112Z +25Hours (21H)
μg m-3
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200

Extra slides

System implementation