Urban Environments in Asia- science , modelling, policy

- Julian Hunt

Malaysian Commonwealth Studies Centre

Univ of Cambridge, Trinity College ,

Univ Coll London,

- David Carruthers, J Stocker,CERC Ltd
- Y.Aktas UCL

*Y Fan, Yuguo Li (HKU)

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APPLICATIONS OF RESEARCH ON URBAN ENVIRONMENT -(NOTE; TROPICS & CLIMATE CHANGE)

* ANCST;STGS-URBAN POLLN; HAZARDS –(Reports IN Current scoence , and J Env Science (China))

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1. PLANNING ON LOCAL TO GLOBAL SCALES -> (more choices)

(EG WINDS (), POLLUTION, GREEN ENVIRONMENT, BUILDINGS –SATELLITE TOWNS ;INDUSTRY, AGRICULTURE , OROGRAPHIC CHANGE – COASTS /HARBOURS)

2. RESILIENCE
(EG HAZARDS (frequencies ,magnitudes) –WINDS , FLOODS, FIRES,TEMPERATURE , SFERICS, Forest Fires,Dust Storms
IMPACTS –EG Health ,Transport , -> RECOVERY (Local. global)

3 REDUCE ENVIRONMENTAL EFFECTS FROM URBAN OPERATIONS (people.transport, industry,energy,construction,)

4. GLOBAL POLICY OBJECTIVES –Reduced Temp Rise ; Monsoon

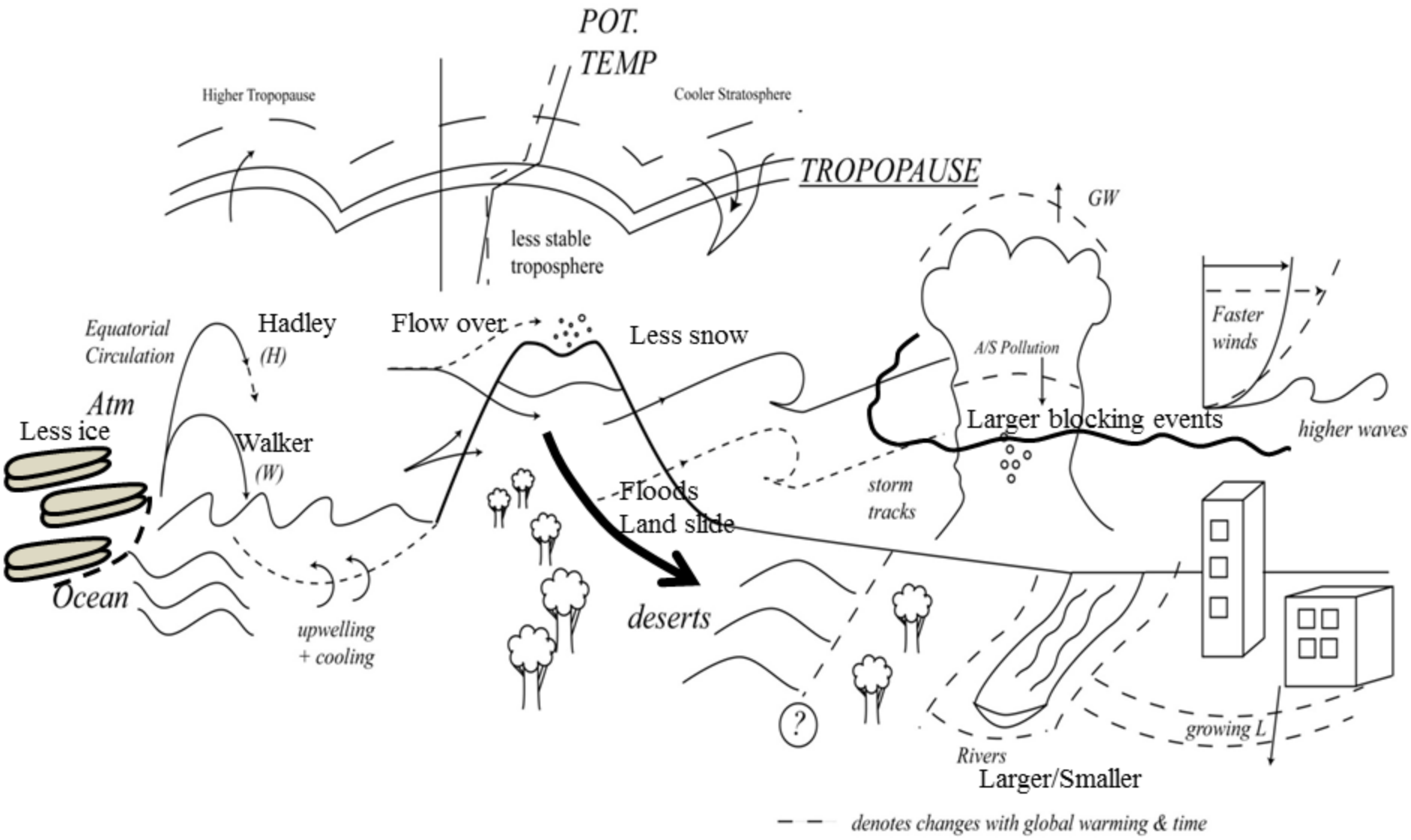
Factors in changing urban atmospheric environments

•Growth in population ,use of energy ,land , resources lead to rapi
changes on time scale 10years -size,
-loss of environmental quality (air, water, ground,nature)
- hazards (multiple)

•Urban changes faster than global and regional env. change
-typical 50years (given global emission scenarios)

•Note qualitative changes in critical environmental processes
with profound effects on urban areas in Asia. .
-variability, time periods and patterns of extremes
- jet streams, blocking , global oscillations (temp, wind, precip , floods,dust ..)

CHANGE IN GLOBAL CARBON EMISSIONS –VIA POLITICS?



MECHANISMS OF CLIMATE CHANGE PRODUCED BY GREEN HOUSE GASES.-

Note regional variations , which have to be considered for urban strategies -

Applying Richardson conflict model to mutual decarbonisation (eg countries 1,2)

|Likely (?) future carbon emissions (Q(t)) and investments in carbon energy (IC)

| o o o o ~ exp(-ƛ $_1$t)

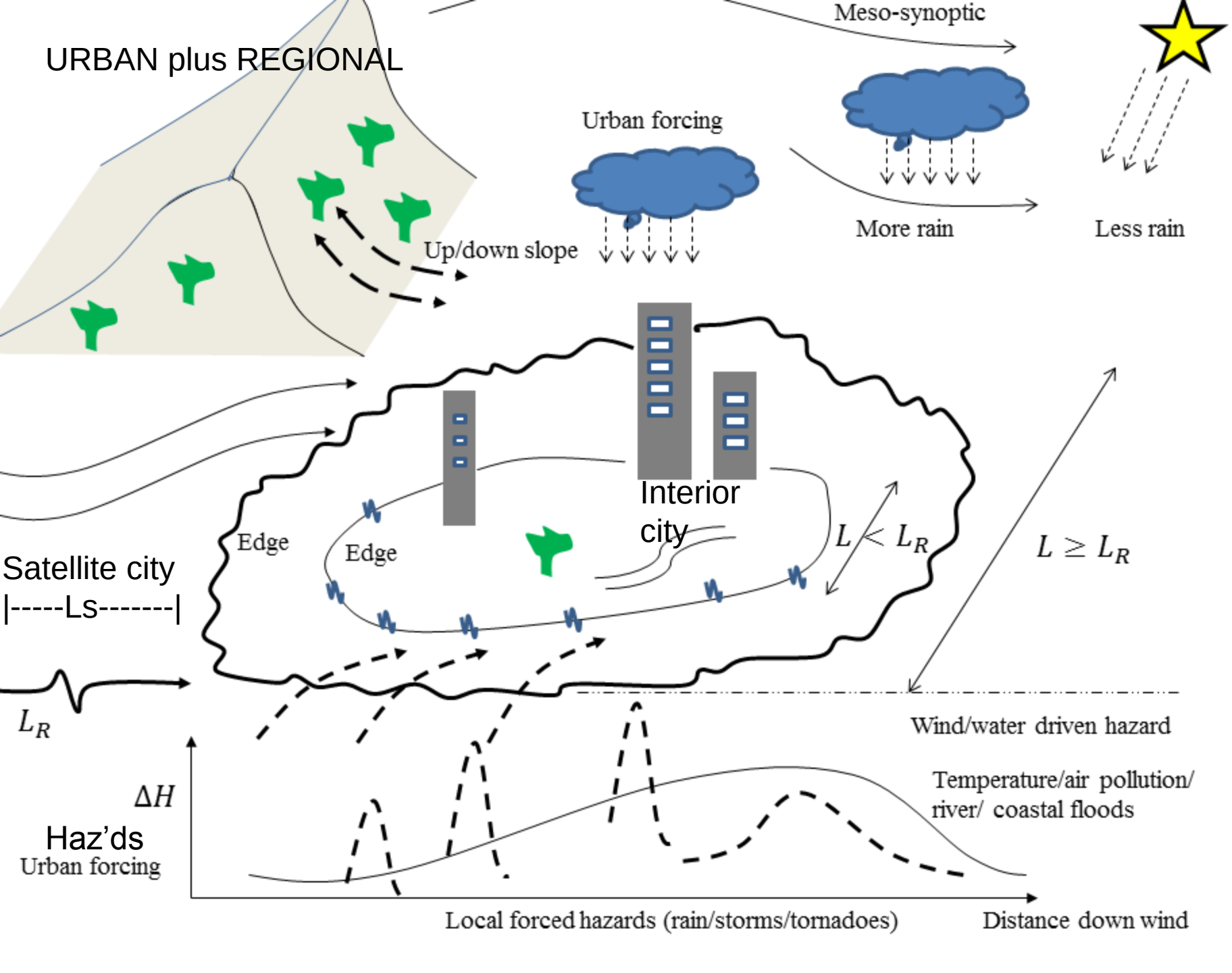
o o o

| o ~ exp (- ƛ$_2$ t) o

|

----------2015----------→ Time t

Future developments for Urban areas –rising temp over centuries -but carbon emissions decrease (except for high pop growth countries)?


URBAN plus REGIONAL
Meso-synoptic
Urban forcing
More rain
Less rain
Up/down slope
Interior city
Edge
Edge
Satellite city
|-----Ls-------|
$L < L_R$
$L \geq L_R$
L_R
Wind/water driven hazard
Temperature/air pollution/ river/ coastal floods
ΔH
Haz'ds
Urban forcing
Local forced hazards (rain/storms/tornadoes)
Distance down wind

RESEARCH QUESTIONS /METHODS FOR URBAN SCALE

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* GREEN AREAS/ INNER CITY AREAS –Jakarta – SATELLITE CITIES (BENEFIT?)

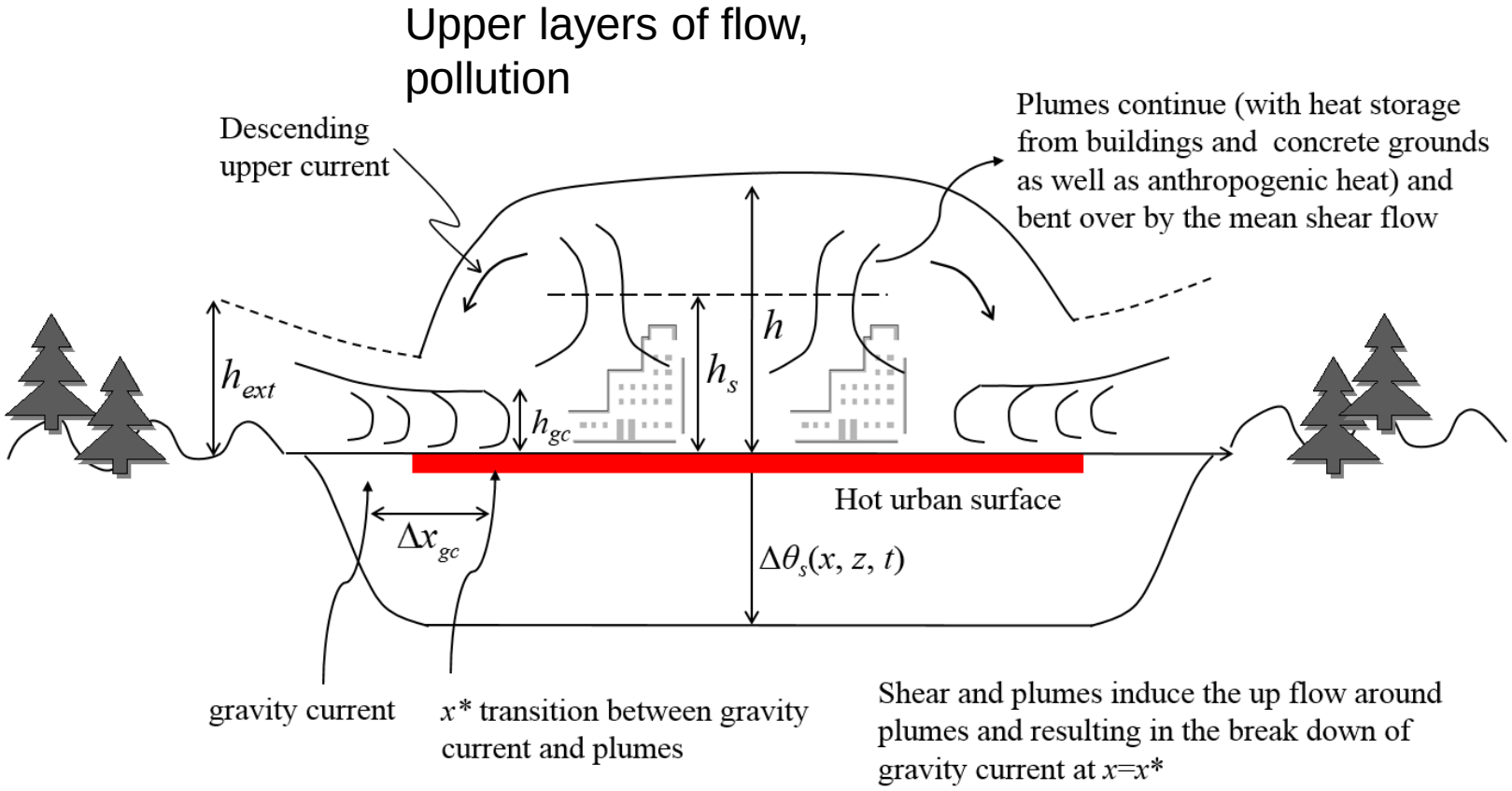
* URBAN DATA ; DRONES IN STREETS –IMPERIAL ? ,DATA ASSIMILATION IN URBAN AREAS -HKUST, HKMO+CERC

GLOBAL SCALE –TEMP RISE , ATM BLOCKING WORSENS ENV EFFECTS IN URBAN AREAS;

MONSOON TRENDS -> LOCAL INCREASE IN INDIA

MOUNTAINS->FLOODS->SURFACE OCEAN TEMP->TC IN URBAN AREAS (?) .

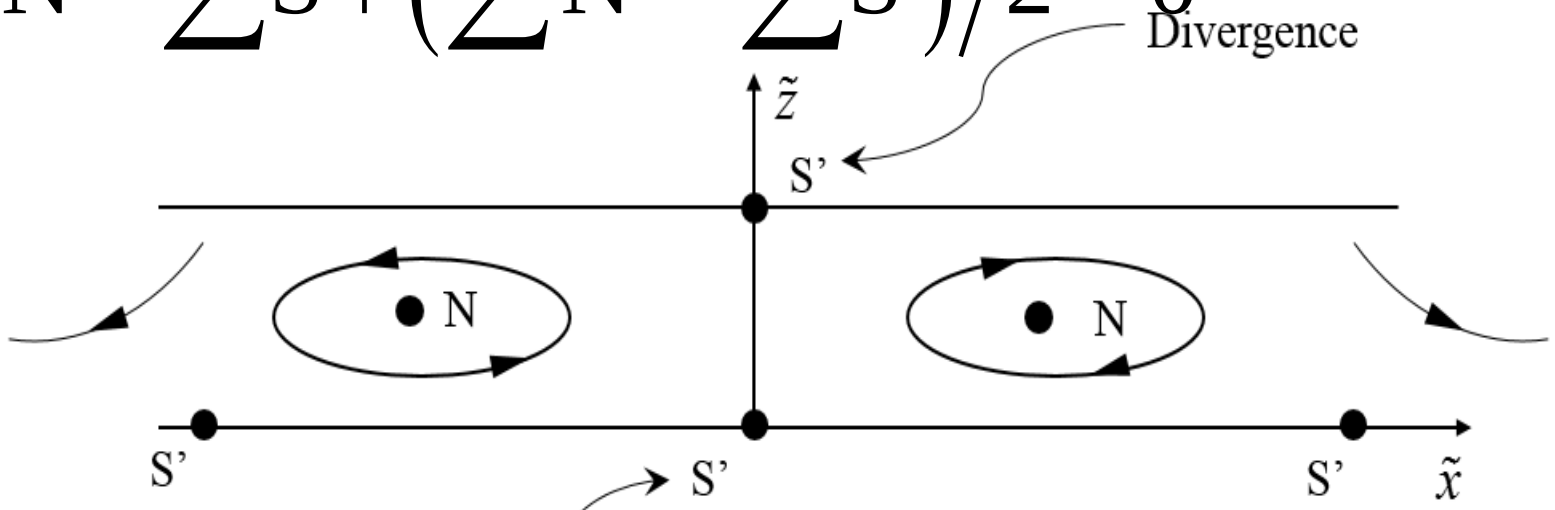
Transition convective and gravity current flows in large urban b-layer (no wind-)



YiFan , Y.Li , JH 2017) –use of Lab experiments ; shows variable turbulence structure and topology

Topology of convective flow

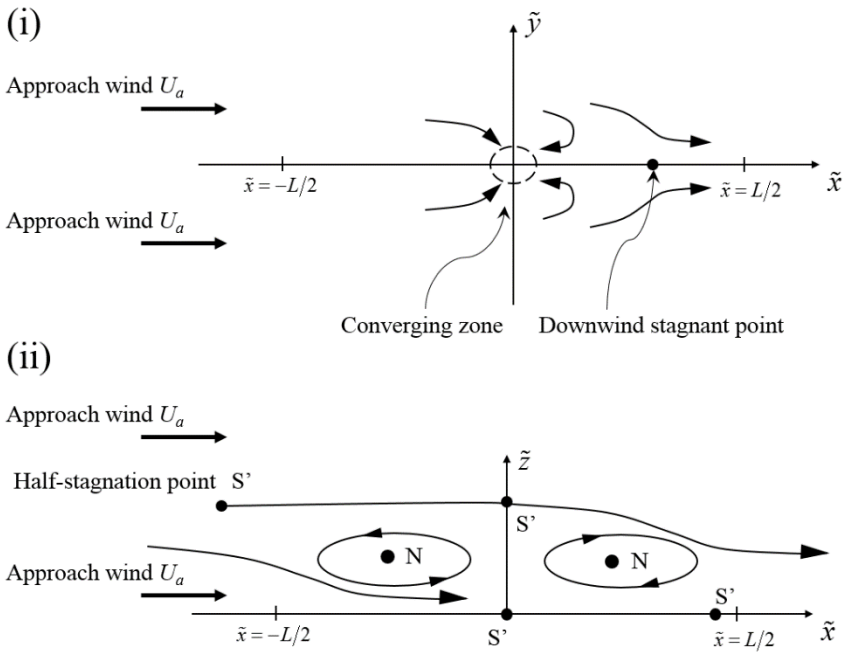
$$\sum \mathrm{N} - \sum \mathrm{S} + \left(\sum \mathrm{N}' - \sum \mathrm{S}'\right) / 2 = 0$$



N nodes. S saddle ' S' half saddle

YiFan et al

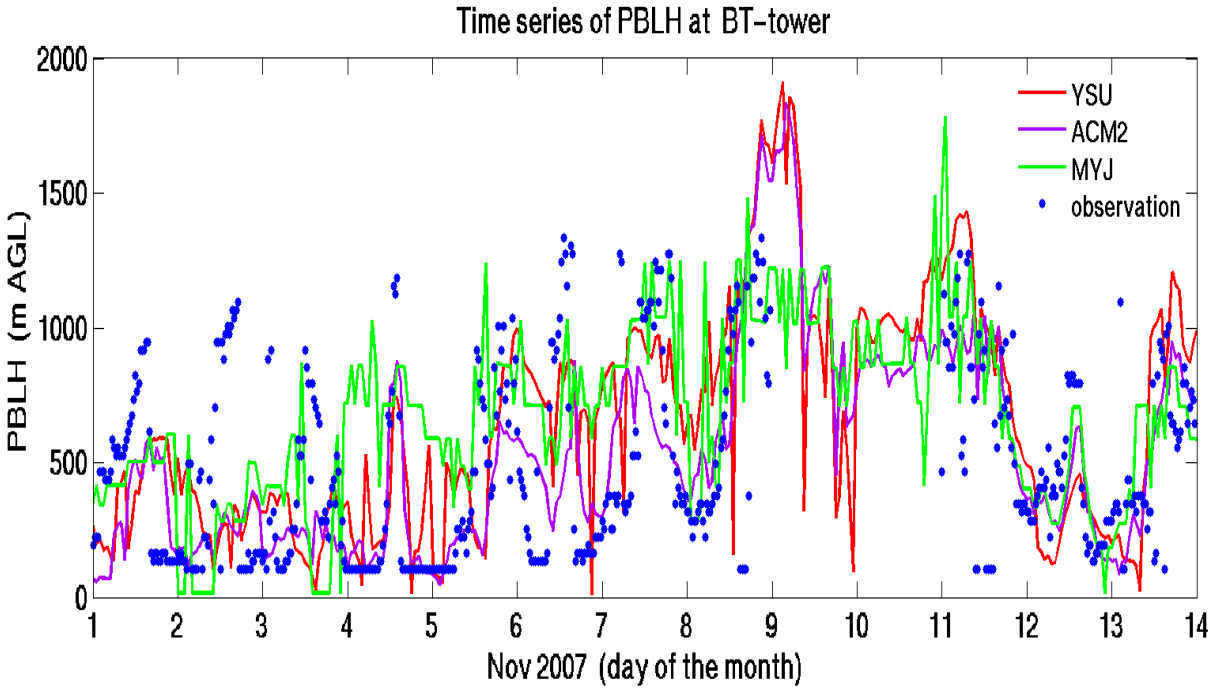
Topology of stream lines with weak approach flow



YiFan , et al . Note change in singular points.-affects dispersion.

Mesoscale modelling and data over large cities- Inversion –wrf data assim (Xie Bo et al)

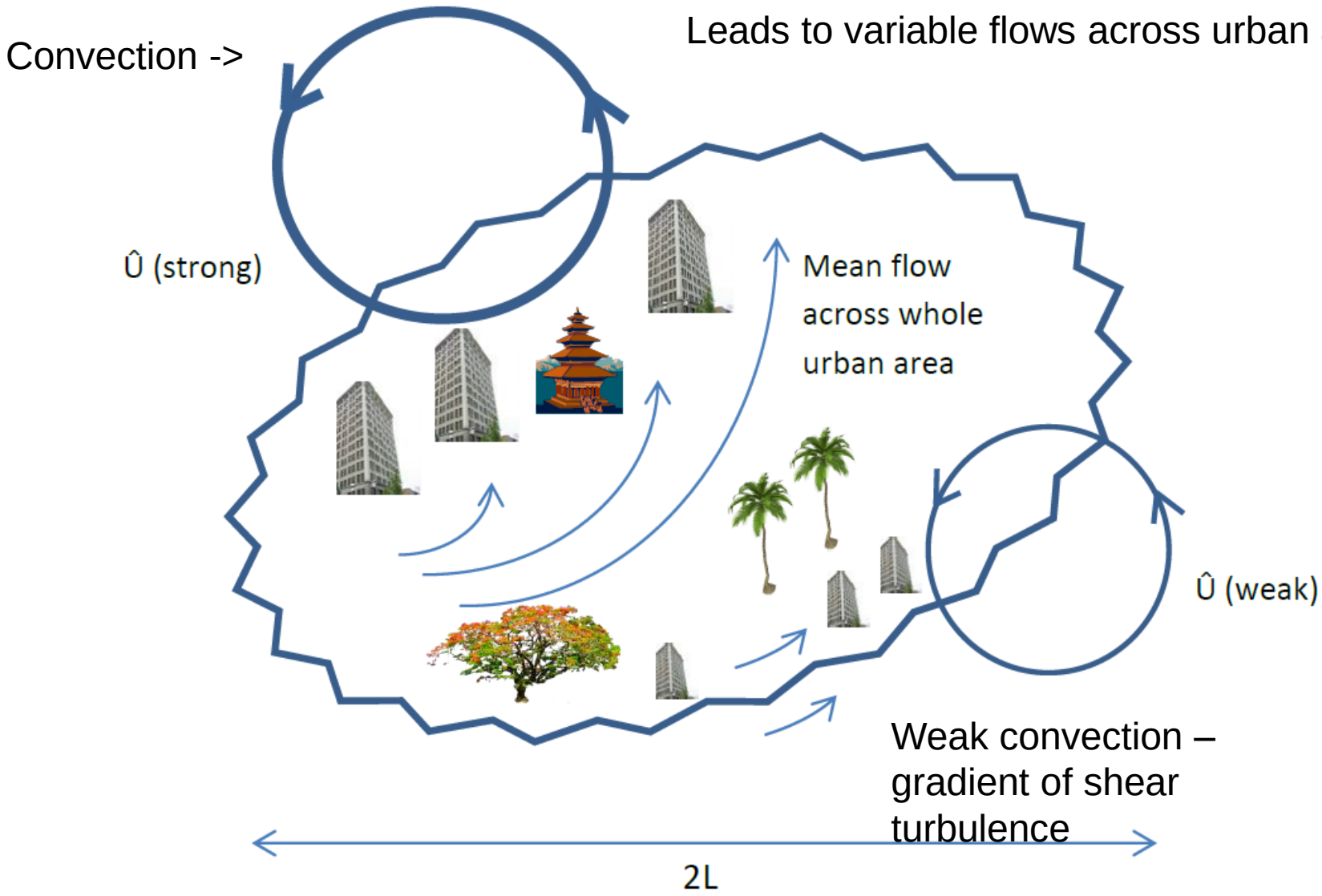
Boun'dy Layer Height H over London



Comparative study HKUST, CERC—demonstrates need to have tall tower For validation. –in London BT tower in centre –typical errors 200-300m ,

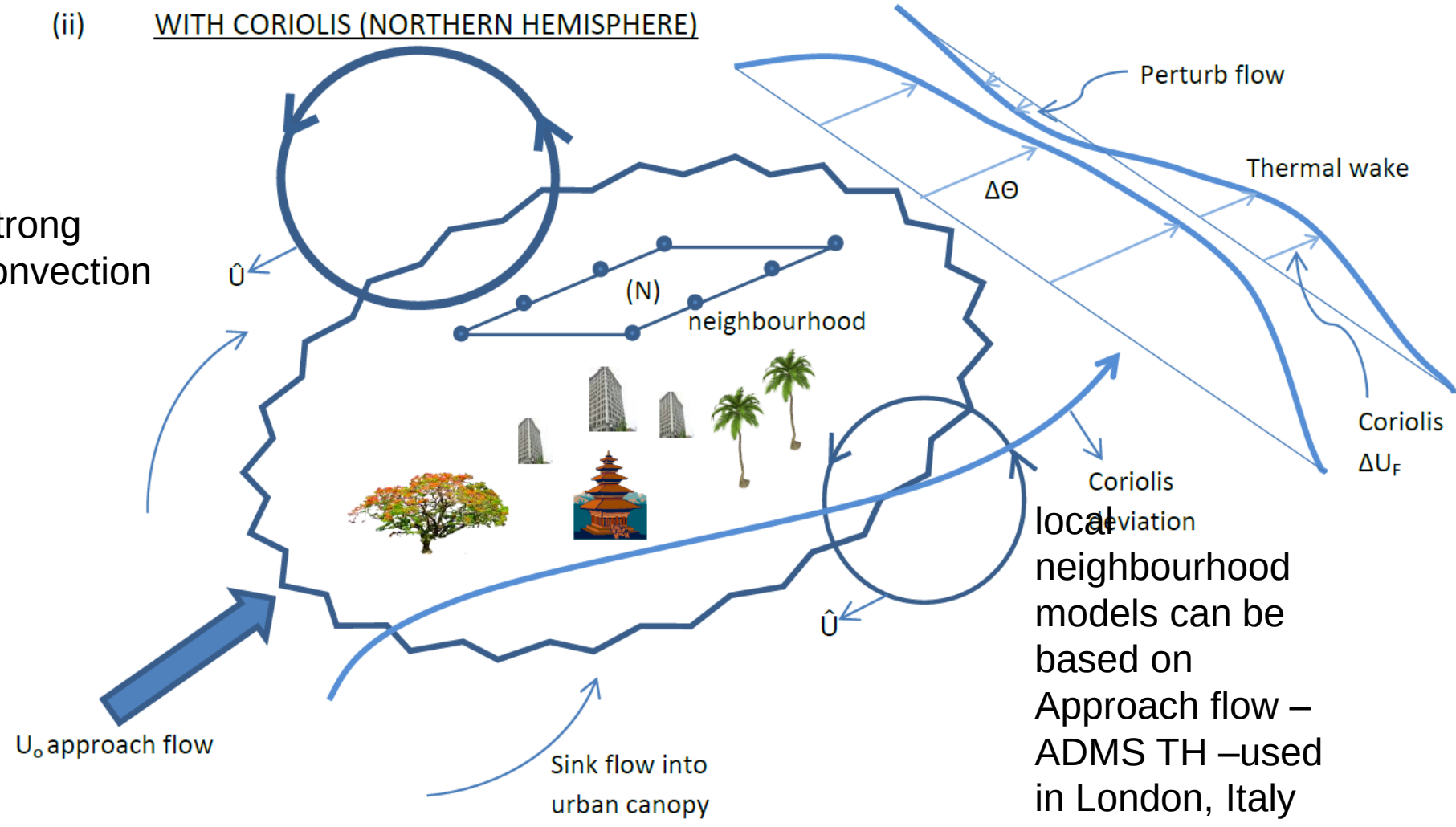
New data needed for city canyons (?) –use of drones ?

(i) NO MEAN ADVECTION WITH ASYMMETRIC HEATING & CONVECTION (NO CORIOLIS)



Note sensitivity to h/Lmo and gradient of roughness

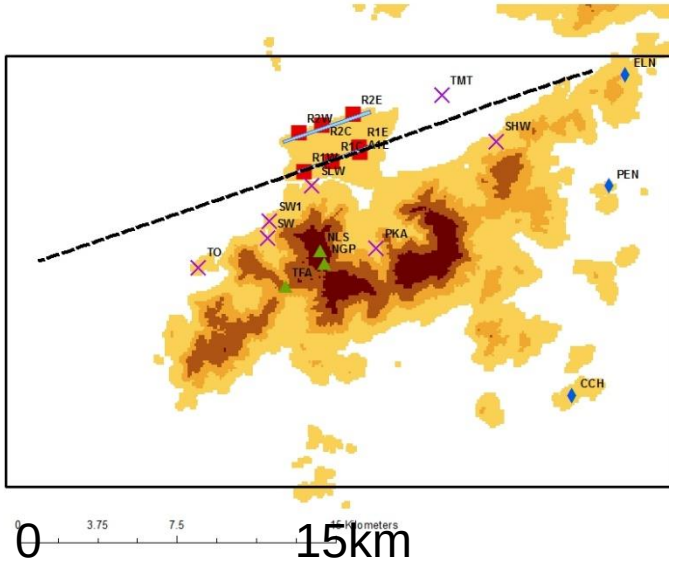
Weak approach flow with cross flow driven thermal gradients and Coriolis effects downwind.

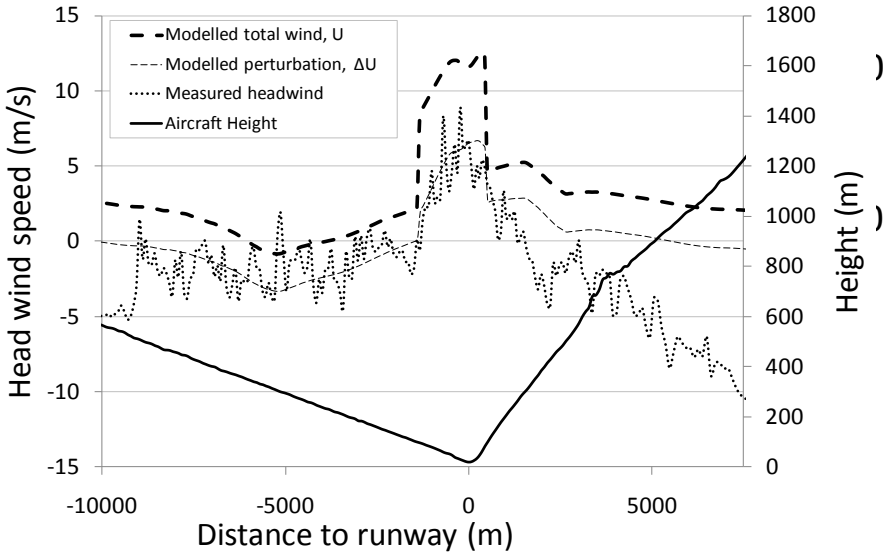


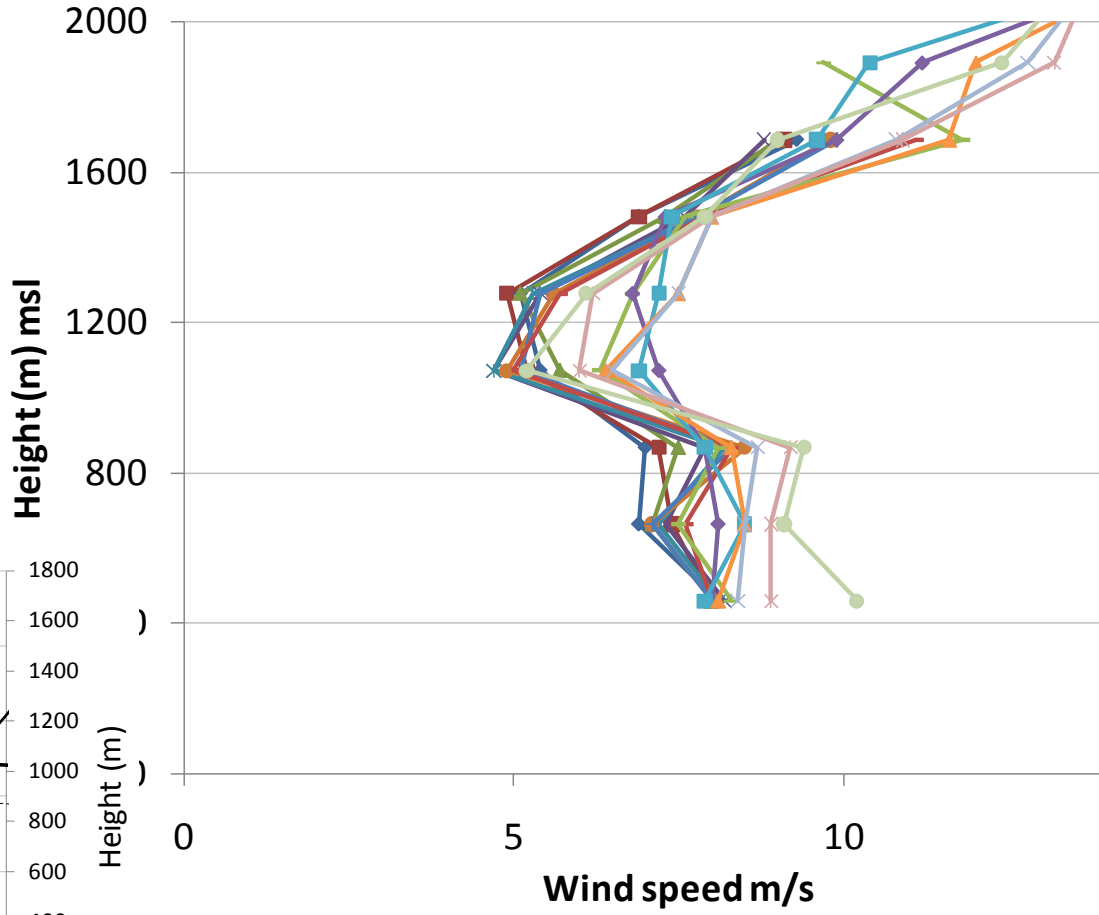
local neighbourhood models can be based on Approach flow – ADMS TH –used in London, Italy

Ů= CHANGE IN U_O

Surface/profiler data +real time modelling over hills –demo at hk int airport JStocker,PWChan;DC JH 2015)







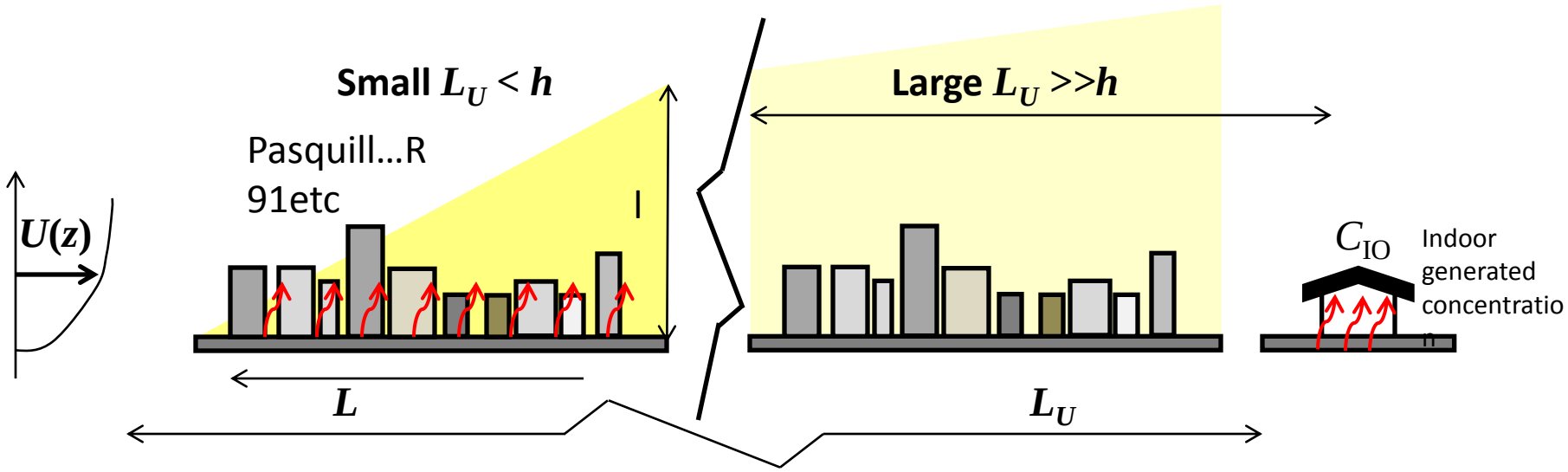
Other Lidar data is also available

Urban flows over sloping terrain

- ‘Weak mean flows induced by anisotropic turbulence impinging onto planar and undulating surfaces’
- By K. NAGATA , H. WONG, J. C. R. HUNT , S. G. SAJJADI , P. A. DAVIDSON (J Fluid Mech ,vol 556,2006)
- theory/lab expt shows mean flow rising towards tops of hills driven by convective turb => improved local model for Asia?.

Calculation of Concentration in Small/Large Urban Areas -assume quasi-steady winds (Aktas et al)

$z \sim h$ $(\sim 1km)$



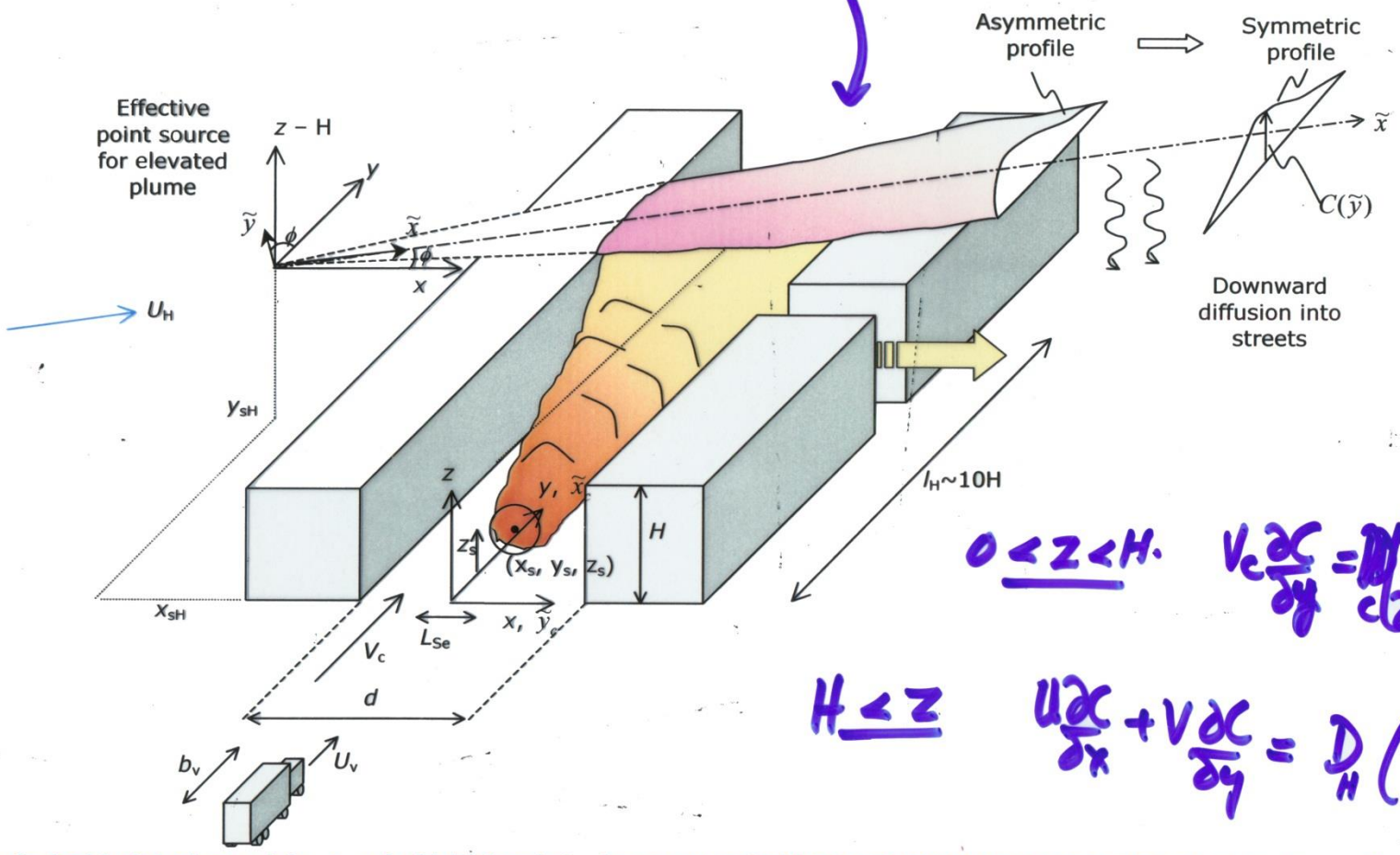
SMALL ($L_U << h$): pollutants, convection heat q / unit area/sec; dispersion depth l

Outdoor Concentration ⇨ $C_o U(l) \quad l \sim qx \sim ql$ ⇨ $C_o \sim q/U$ Independent of L

Indoor Concentration ⇨ $C_I \sim C_{Io} + C_o$ Dominated by indoor sources

DISPERSION MODEL IN STREET CANYON IN CROSS FLOW ABOVE THE BUILDINGS

note $C \propto \exp(-\#D/(V_c H^4))$



$0 < z < H$. $V_c \frac{\partial C}{\partial y} = D_H \left(\frac{\partial^2 C}{\partial z^2} + \frac{\partial^2 C}{\partial y^2} \right)$

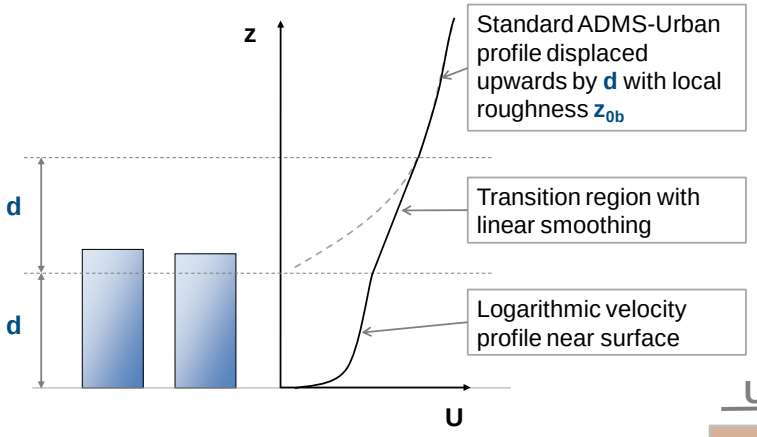
$H < z$ $u \frac{\partial C}{\partial x} + V \frac{\partial C}{\partial y} = D_H \left(\frac{\partial^2 C}{\partial z^2} + \frac{\partial^2 C}{\partial y^2} \right)$

Figure 6– Accidental release at (x_s, y_s, z_s) of initial scale L_{Se} in a canyon of width d and height H with crosswind, showing how on the Building/Street scale the plume is advected along canyon a distance y_{sH} and then carried downwind in a cloud/plume that initially is skewed (along the street), but far downwind on neighbourhood scale returns to standard Gaussian form. (x_{sH}, y_{sH}) is the location of the virtual source for dispersion over the Neighbourhood scale. Note that vehicles with scale b_v and speed U_v also affect the turbulence.

Air quality and high wind studies: Hong Kong EPD study

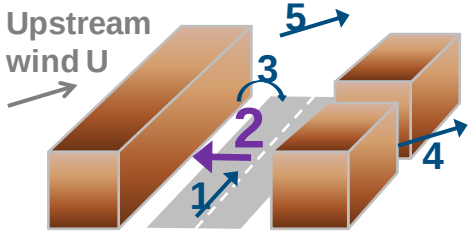
- Project for Hong Kong Environmental Protection Department (HK EPD)
- Contracted to develop a high-resolution modelling system that:
  - allows for the tall buildings and deep street canyons in Hong Kong
  - 'nests' within the regional modelling system used by the HK EPD
- ADMS-Urban developed to model
  - Urban Canopy flow

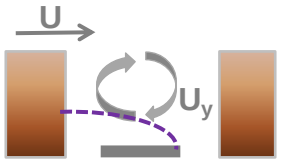
    Three-part velocity profile: calculated from parameters derived from **3D-buildings data** using CERC's **GIS Tools**



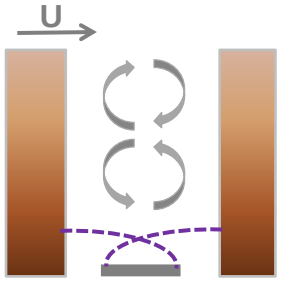
  - Advanced street canyons:

    Five-component source: module inputs from parameters derived from **3D-buildings** & **road location data**





Shallow canyon: single circulation



Deep canyon: multiple circulation

Actions and research for Ancst

- 1.More modelling research and measurements on special features of low latitude urban boundary layers -
- 2.Data,models, for special characteristics and variability of local heating , humidity pollution dispersion=> local/adjustable f'casts ; regional climate modelling, and applications ; hazards, agriculture etc

3.-> Special Topic Group –focus(?)on these topics –and joint research with 'high latitude' groups