Seeing the City for all the Buildings

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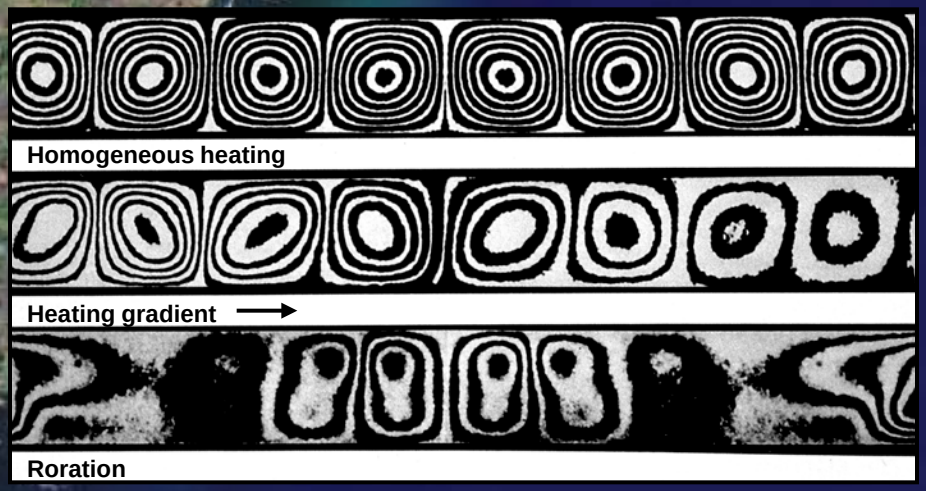
Duluth, MN, neighborhood

Timbouctou, Mali, neighborhood

Gibbs Roundsavall: "suburban sprawl" (detail)
19" x 24", enamel on aluminium, 2005

Pattern: Spatial Scales

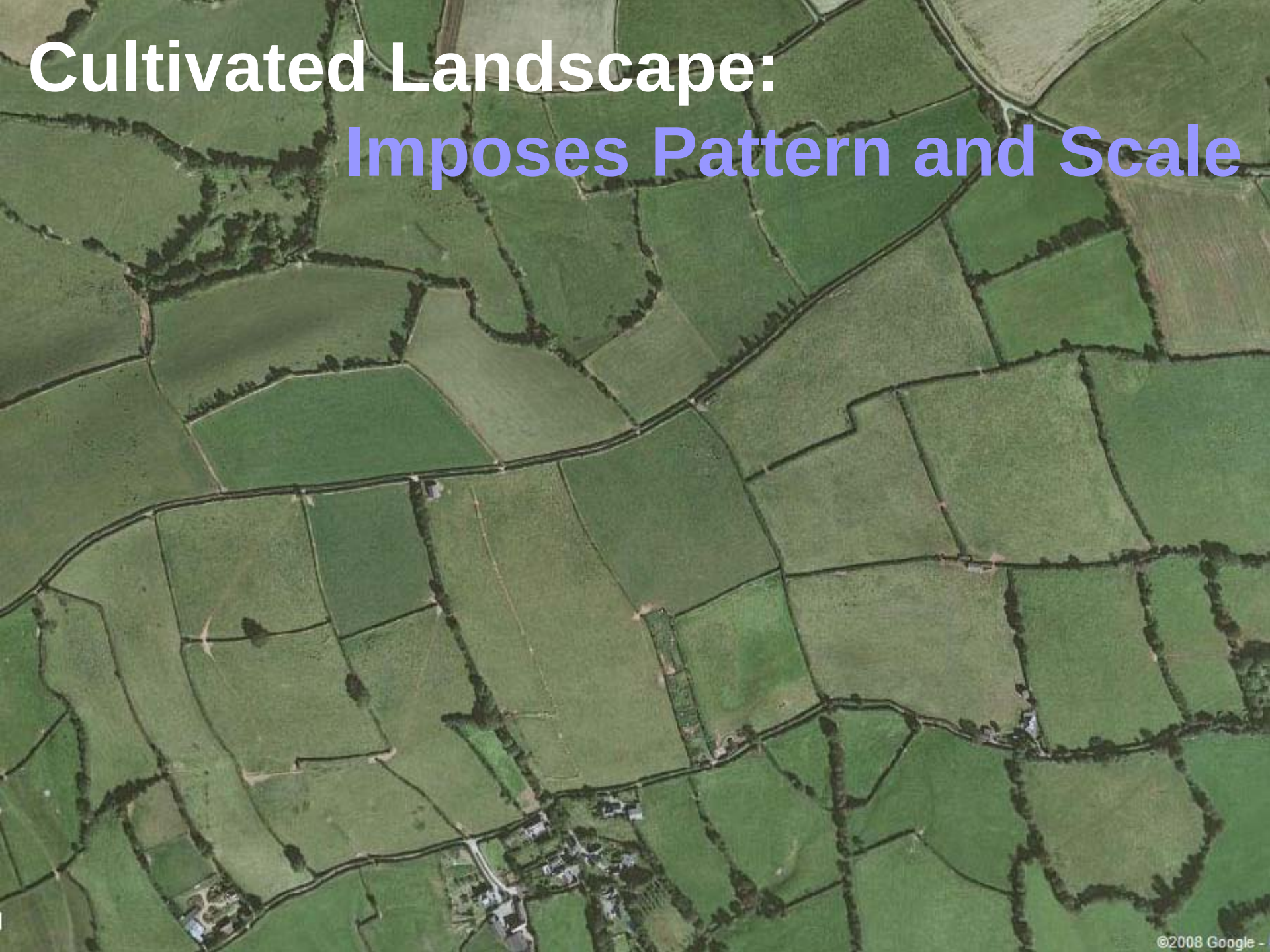
The atmosphere sometimes organizes into patterns and distinct spatial scales



(from: Album of Fluid Dynamics)

2 mi
5 km


Cultivated Landscape:
Imposes Pattern and Scale


Cultivated Landscape:
Imposes Pattern and Scale
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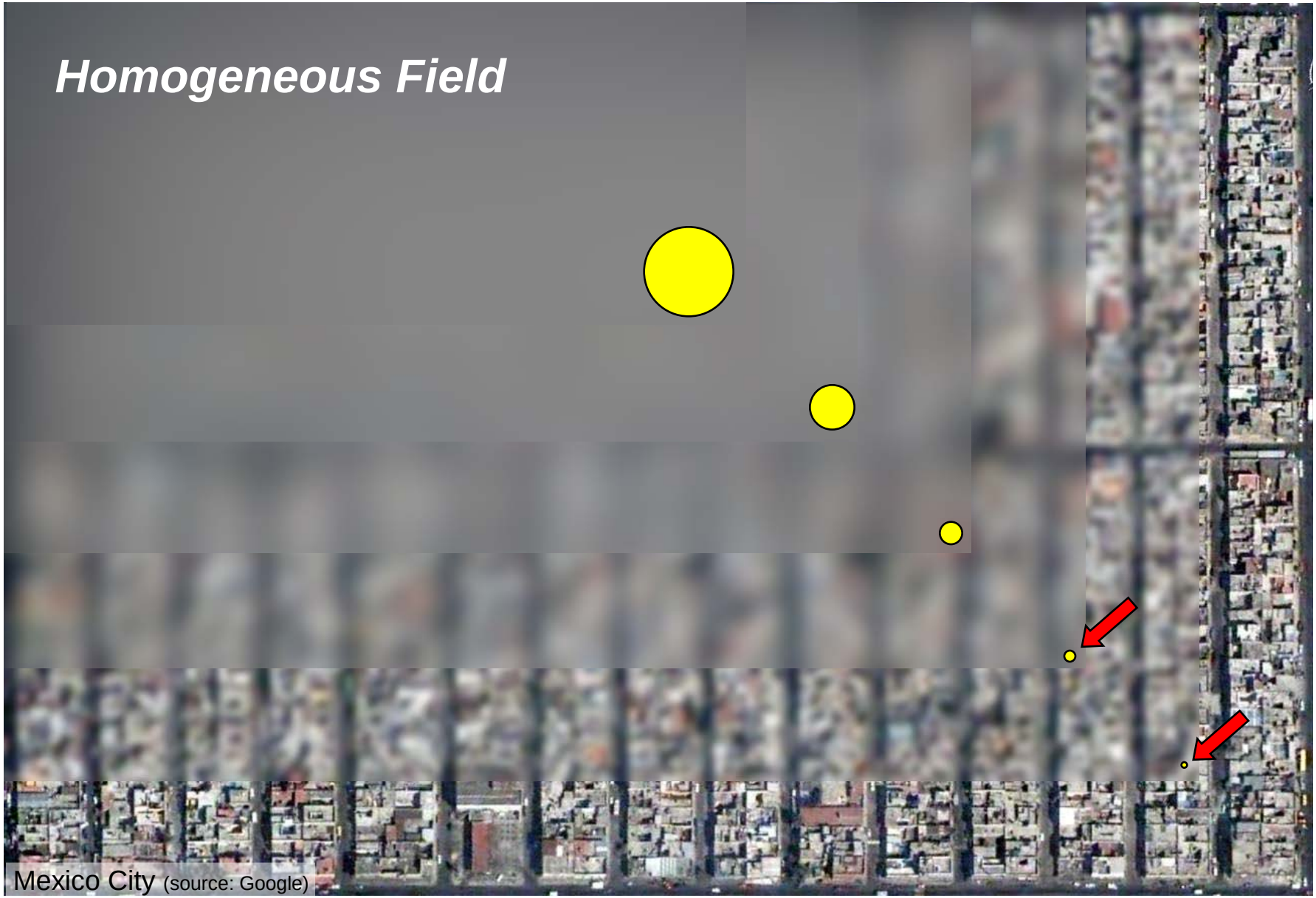
Cultivated Landscape:
Imposes Pattern and Scale

Measured Variability depends on Resolution:

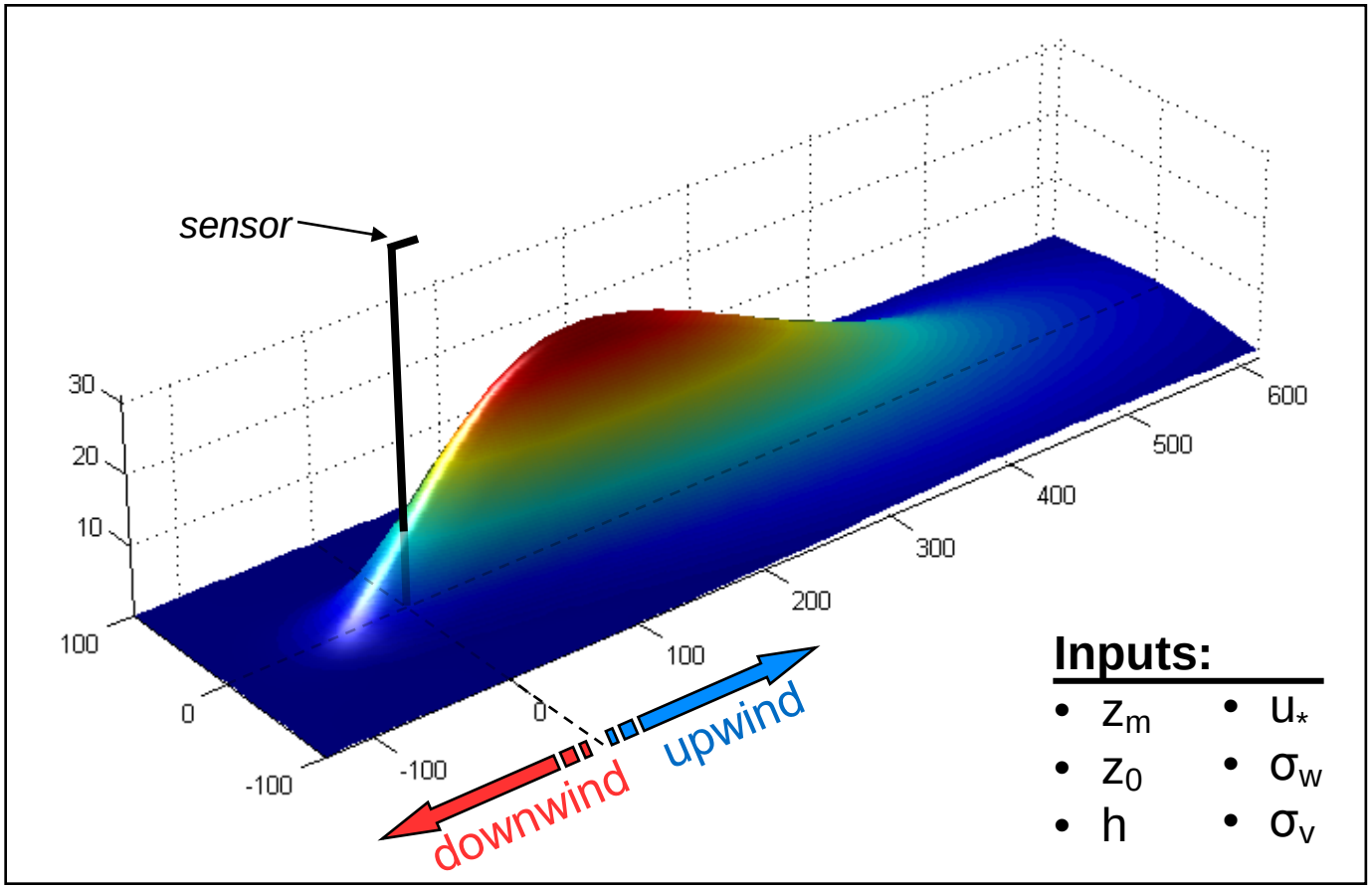
the Scale of Measurement



Flux Footprint = *spatial* ***filter****, "field of view"*

$$F(\mathbf{x}) = \iint_{\Re} Q_s(\mathbf{x}') \cdot f(\mathbf{x} - \mathbf{x}') \cdot d\mathbf{x}' = Q_s * f$$

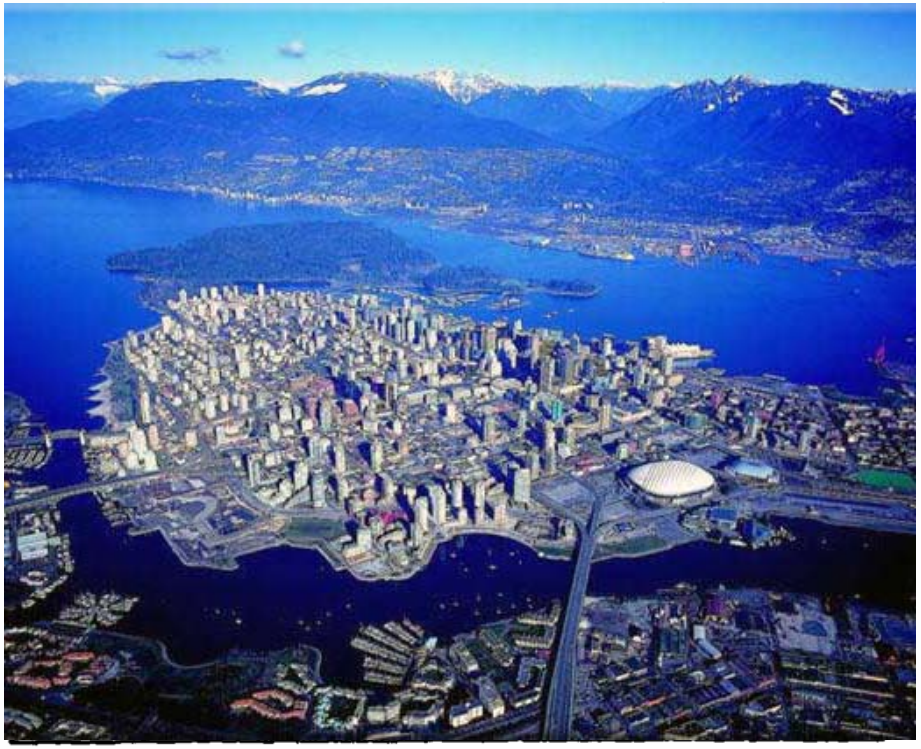
(**convolution** of the **source distribution**, Q_s, with the **footprint**, f)



Schmid 1994 (*Boundary-Layer Meteorol.*, **67**, 293-318)

Does the Footprint Concept Actually Work?

Vancouver, B.C., Canada: Summer 1986



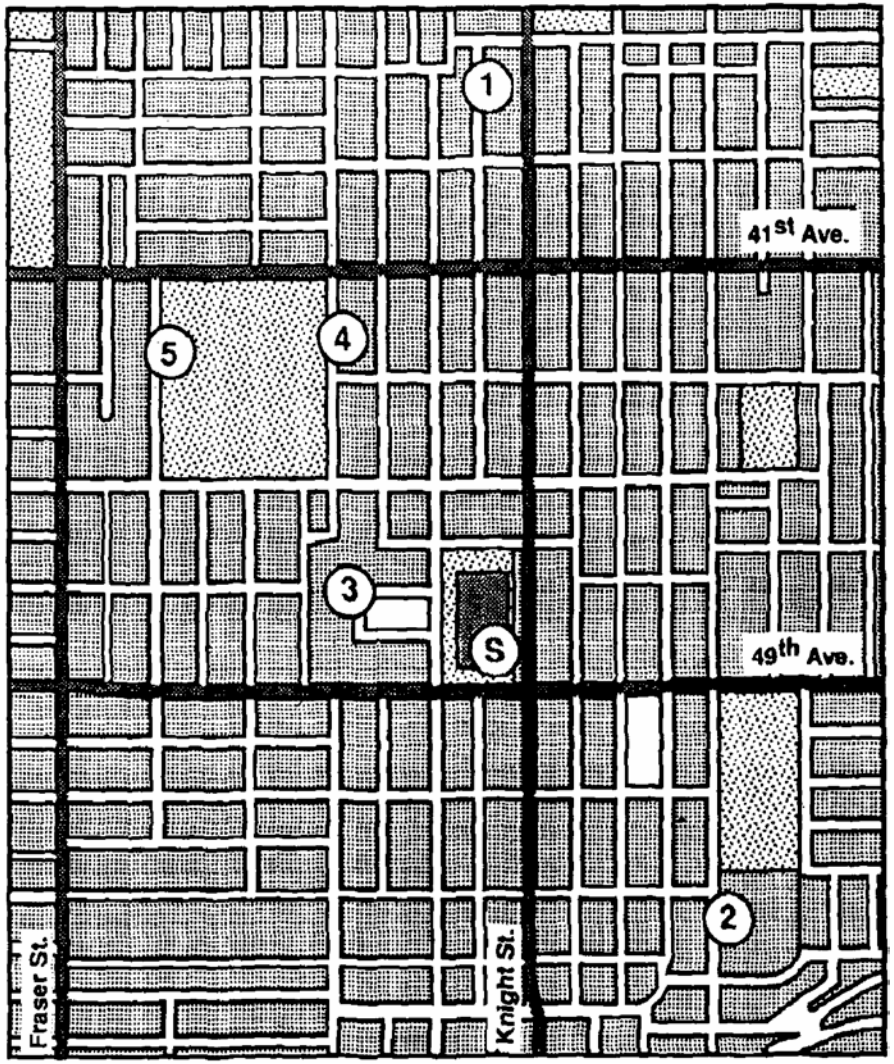
housing blocks

parks

S Sunset Tower Site
1 Culloden Site
2 Argyle Site
3 Waverley Site
4 Memorial Site East
5 Memorial Site West

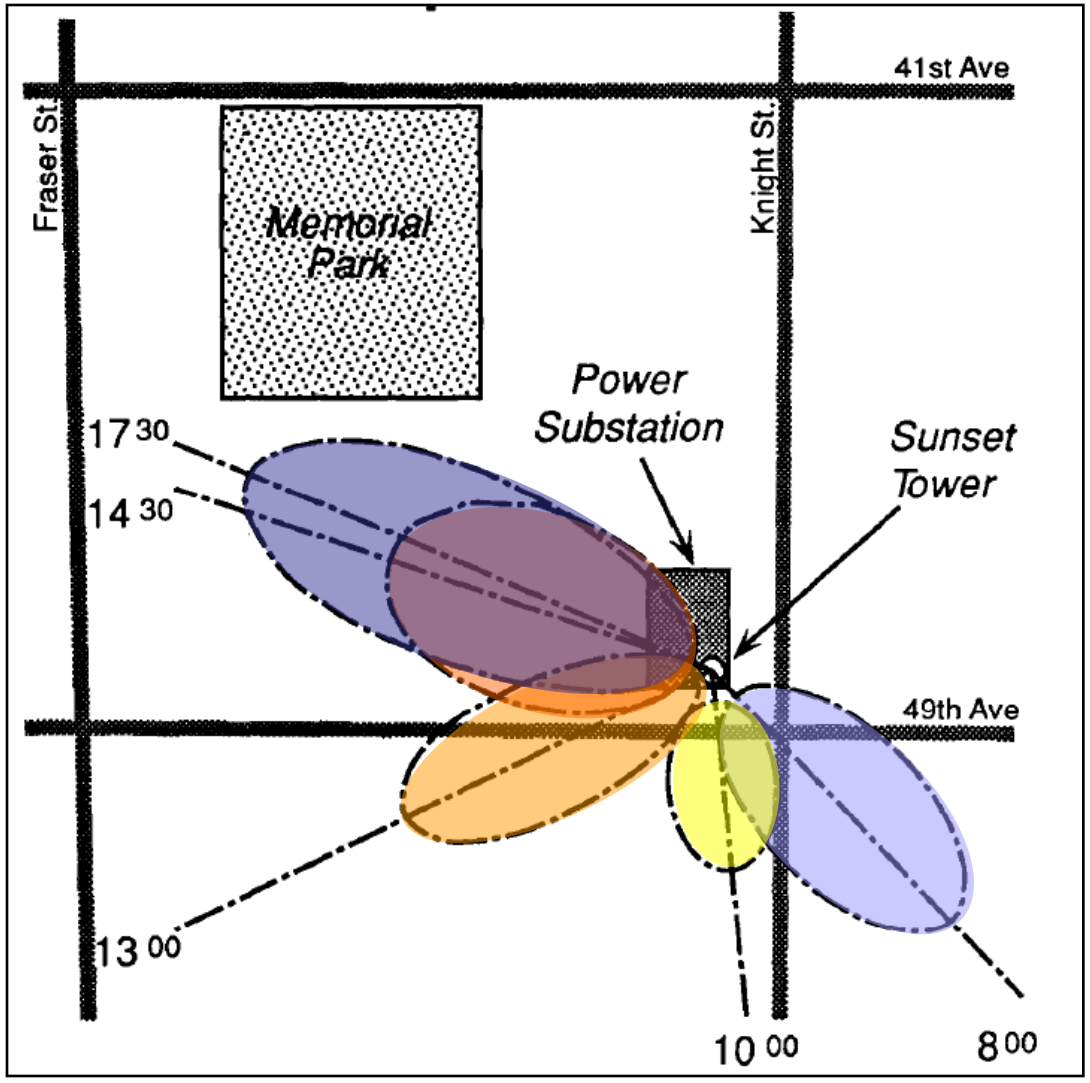
0 0.5 1 km

Scale of Blow-up



Schmid *et al.*, BLM 1991

"Field of View" / Footprint Varies with Time



- Turns with wind direction
- Small in unstable conditions
- Larger in neutral/stable conditions

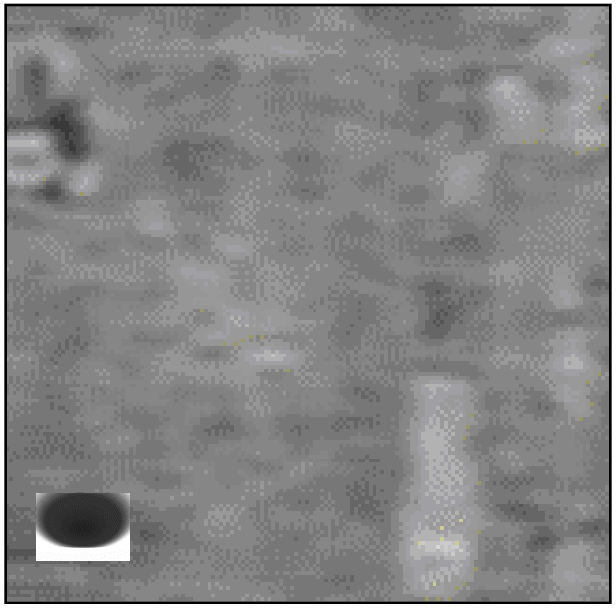
(after Schmid et al. 1991)

Is the Vancouver Suburban Study Area Homogeneous?

(regarding a turbulent flux sensor at 30 m)

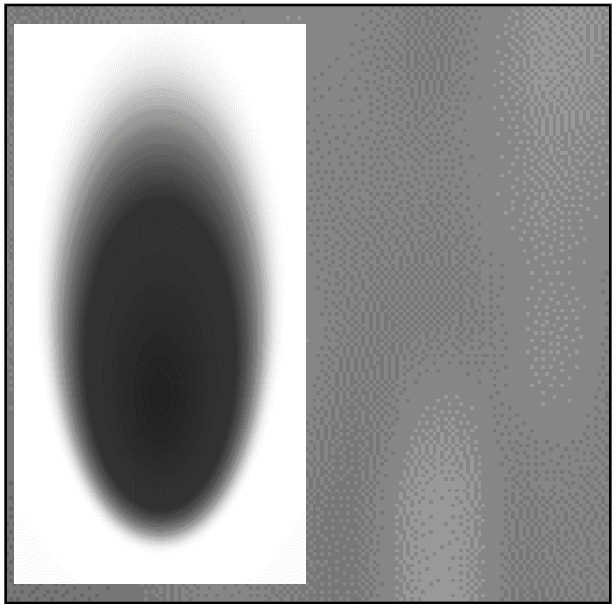
Vancouver Temperature Distribution
at full resolution (from airborne IR scanner)

as "seen" by a flux sensor at 30 m in unstable conditions



variability reduced to 18%

as "seen" by a flux sensor at 30 m in near-neutral conditions



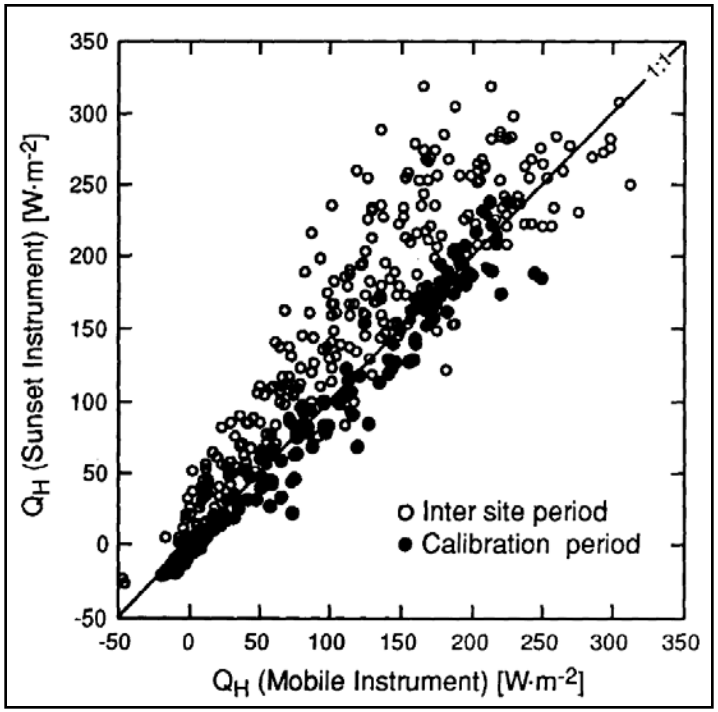
variability reduced to 4%

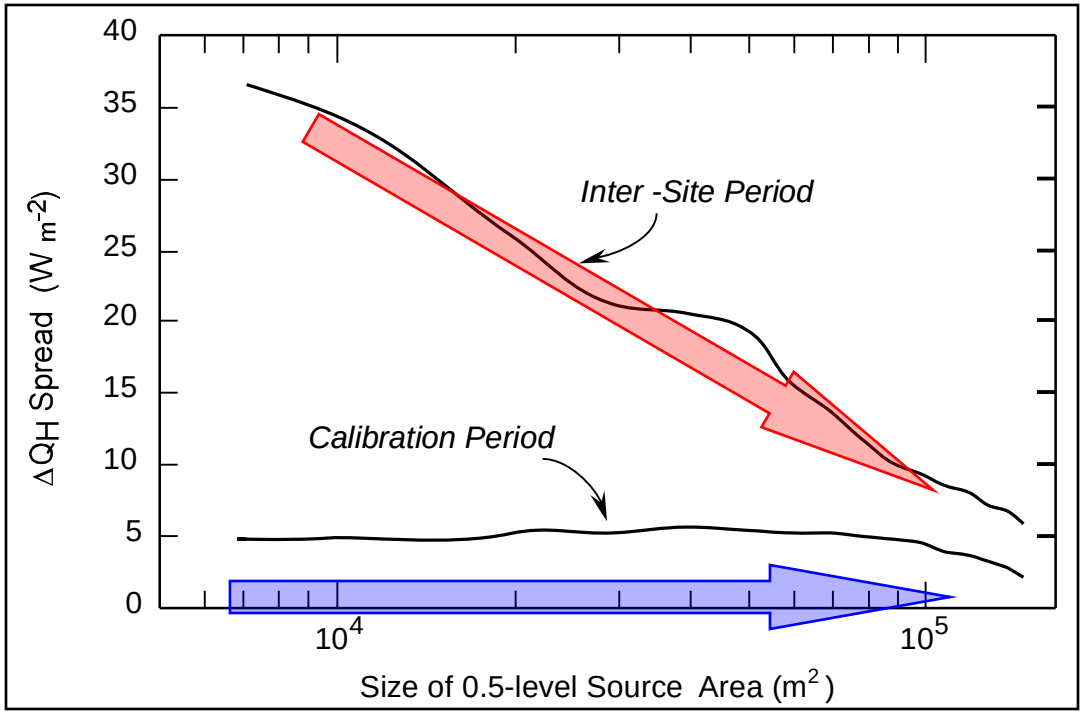
- **in unstable conditions: expect spatial variability**
- **in near-neutral/stable conditions: expect homogeneity**

Measured Spatial Variability of Sensible Heat Flux (Q_H) in Residential Vancouver Area (1986)

- ○ Q_H variations within ~ 1 km
- ● instrument uncertainty

Q_H variations decrease with **increasing source area** (= effective spatial averaging)





spatial representativeness

Schmid *et al.*, BLM 1991; Schmid, AgForMet 1997

Conclusions

- **Surface patterns impose atmospheric scales**
- **Averaging over at least a pattern-unit provides a "scale of homoeneity"**
- **Measurements at scales of homogneity are basis for generalisation**
  (e.g., at the micro-, local-, or suburban-scale)

Lynn Basa: "Sprawl", acrylic on canvas, 12" x 12", 2007

Thanks to...

Tim Oke's sprawled urban climate team!

Ten urban climate doctoral graduates: (L to R, back row) Rachel Spronken-Smith ‘94, Jamie Voogt ‘95, Matthias Roth ‘91, Hans Peter Schmid ’88, Helen Cleugh ‘90, Sue Grimmond ‘88, Manuel Nunez ‘74, Tim Oke, (L to R, front row) Kathy Runnalls ‘02, Kat Richards ‘99, Andres Soux [Photo – 1998]