RWDI

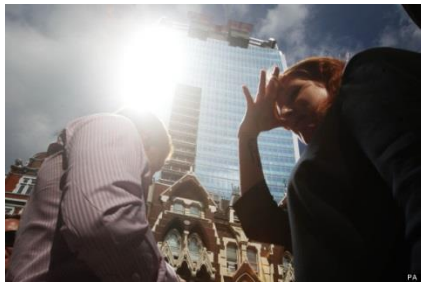
CONSULTING ENGINEERS & SCIENTISTS

Wind Analogue or Digital?

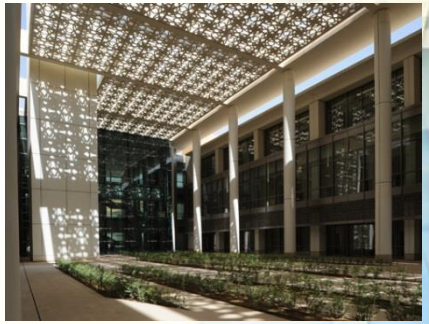
CIBSE Building Simulation Group 14th December 2015

Ruth Shilston MEng CEng MIMechE

Why are we interested in urban flows?



ISSUES



OPPORTUNITIES

Why the focus on wind?

Wind is the most significant variable affecting comfort in the UK climate

20 Fenchurch Street

Bridgewater Place, Leeds

London requires that the wind conditions for new developments are assessed for comfort and safety

section 2.3.7 …'Large buildings have the ability to alter their local environment and affect the micro-climate. For example, not only can particularly tall buildings cast a long shadow effecting buildings several streets away, they can ***influence how wind travels across a site****, potentially making it* ***unpleasant at ground level*** *…Where a proposed* ***development is significantly taller that it's surrounding environment****,* ***developers should carry out an assessment of its potential impact on the conditions at ground level,*** *and ensure the resulting design of the development provides suitable conditions for the intended uses …*
London Plan 2014

Talk contents

Culture › Architecture

London's new skyscrapers 'inflict serious harm' on capital's historic landscape, heritage watchdog warns

Architects have unveiled plans for One Undershaft, a 310m tower which would be the tallest so far in the City of London

Cahal Milmo Chief Reporter | @cahalmilmo | Thursday 10 December 2015 | 25 comments

121 shares

An artist's impression of how the City skyline will look upon One Undershaft's completion

- Wind comfort and safety criteria
- How wind in the urban environment is assessed
  - Early stage design
  - Assessment process
  - Climate data
  - Terrain roughness
  - Wind tunnel/CFD
- Comfort is more than just wind
- Wind analogue or digital?

CRITERIA

Wind comfort and safety

Lawson Comfort Criteria (exceeded 5% of the time)


> 4 m/s "Sitting" Light breezes desired for outdoor restaurants and seating areas where one can read a paper of comfortably sit for long periods


> 6 m/s "Standing" Gentle breezes suitable for main buildings entrances, pick-up/drop off points and bus stops


> 8m/s “Leisure Walking or Strolling“ Moderate breezes that would be appropriate for walking down a city centre street, park or plaza


> 10 m/s "Business Walking“ Relatively high speeds that can be tolerated if ones objective is to walk, run or cycle without lingering


> 12 m/s “Uncomfortable“ Winds of this magnitude are considered a nuisance for most activities, and wind mitigation is typically recommended

Lawson Criteria continued …

The onset of distress is defined in terms of an average windspeed (or equivalent mean) which shall not be exceeded for 0.022% of the Year or for 0.04% of any Season. (This is approximately equivalent to **one hour per year**)

- For areas where the general public are allowed the value of wind speed shall be 15 m/s.
- In areas where it would be unreasonable to expect "sensitive" people or cyclists to be, the value is 20 m/s.

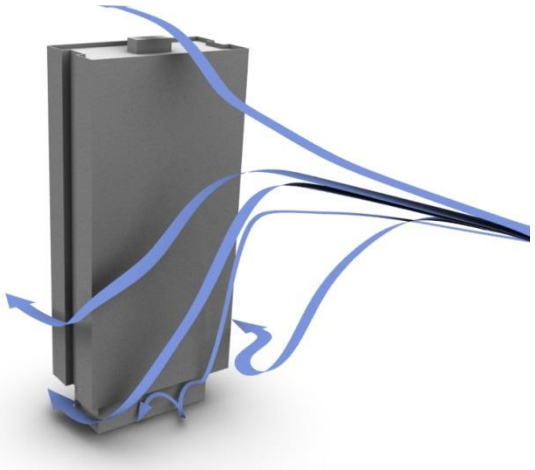
Two values are considered
1) Average or mean velocity ratio
2) Gusts, which are values averaged over 3 seconds

These two values are required because annoyance by the wind can arise for two different reasons;
i) The effort required to walk across the site.
ii) Gusts .. can turn an umbrella inside-out or cause a fall

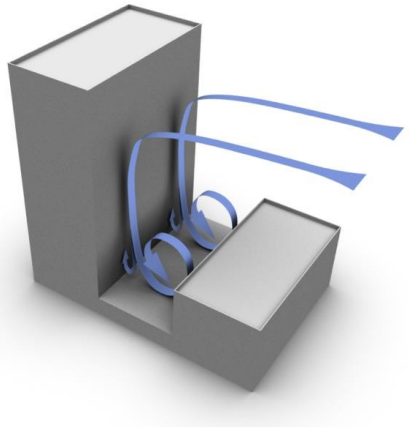
ASSESSMENT OF WIND

Key wind – building interactions

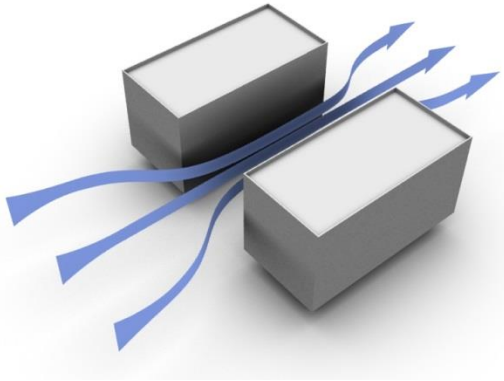
Buildings have the potential to create adverse wind conditions for pedestrians



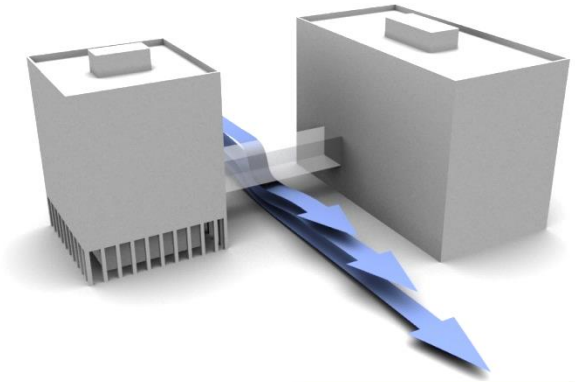
Broad building face creates “downwash”



Low building upwind increases effect



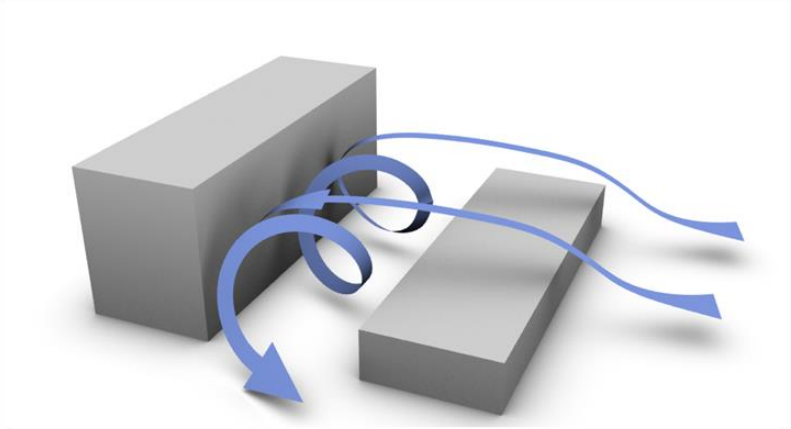
Gap between buildings creates Venturi Effect

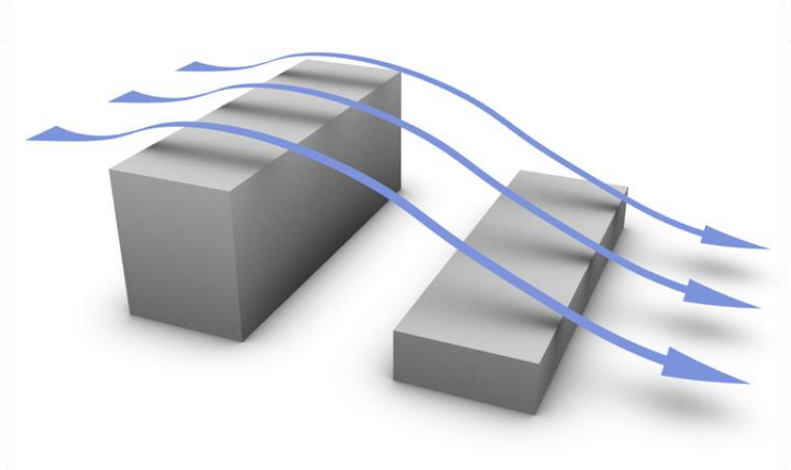


Wind is accelerated under the bridge

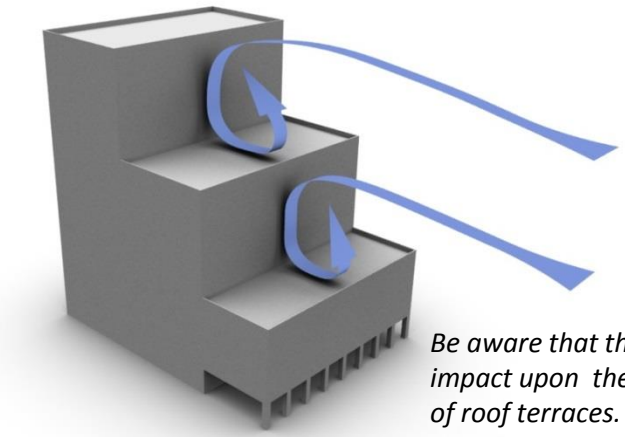
Mitigation through building form

Large scale massing changes can have a big impact - useful to consider early in the design.

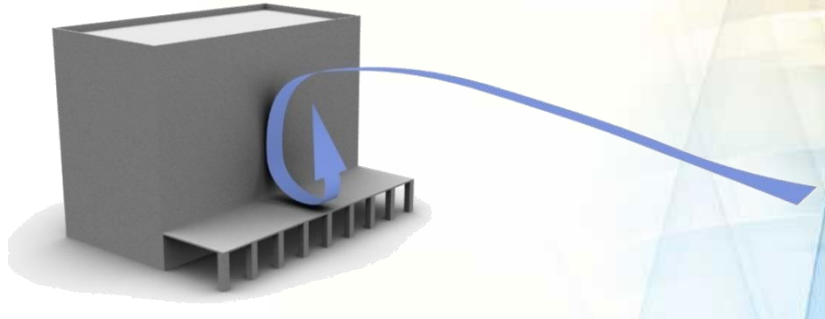




Re-orientating the buildings can solve many issues, especially those related to alignment with prevailing winds.

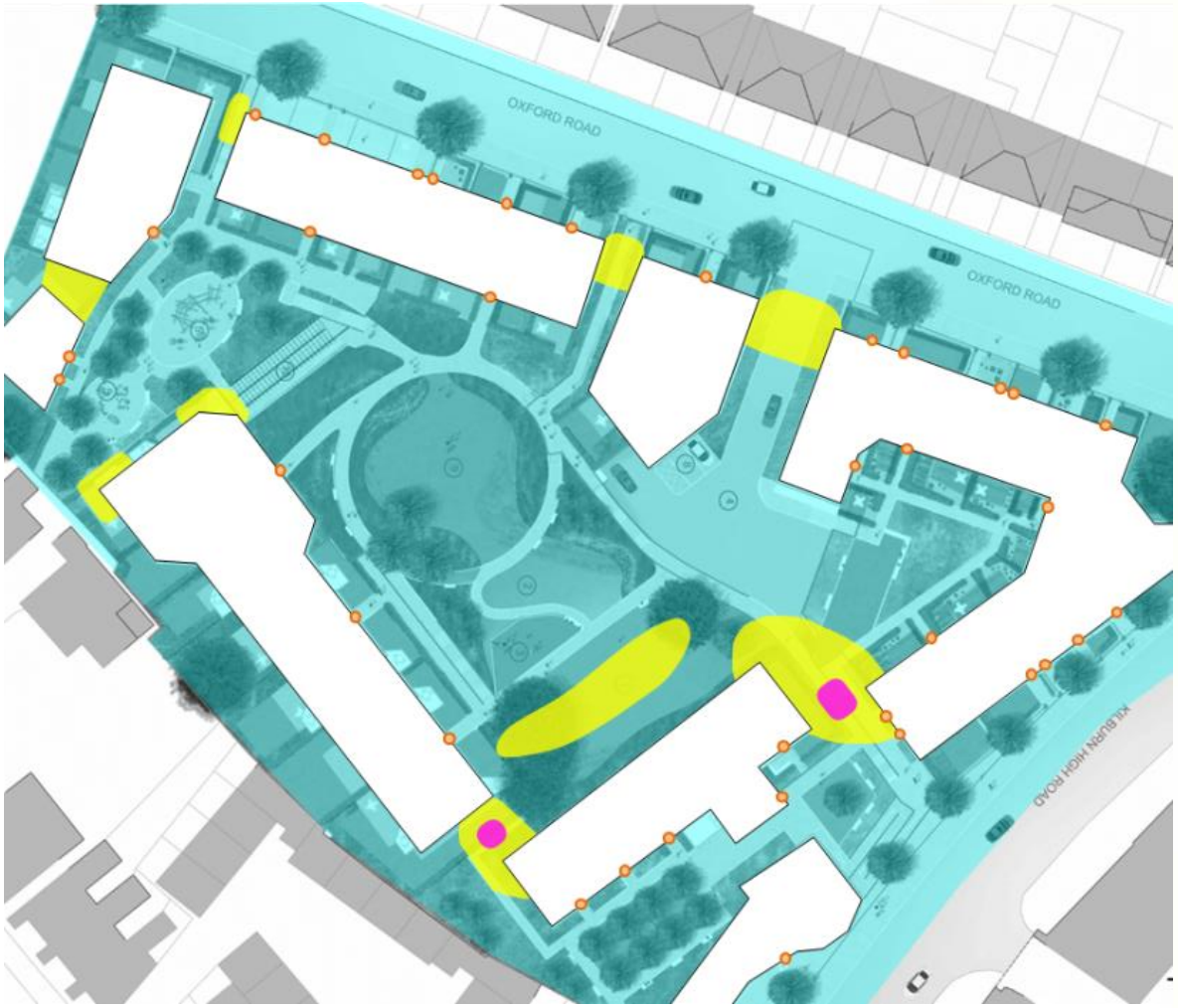


Be aware that this may impact upon the usability of roof terraces.



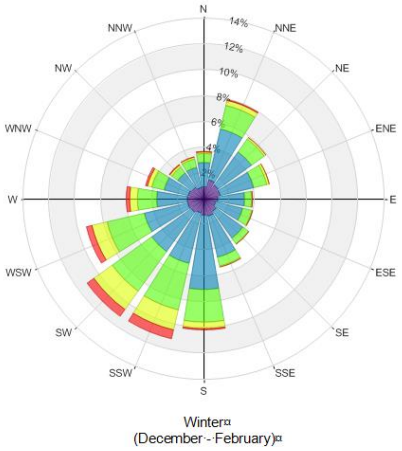
Stepping, canopies and colonnades can both be used to mitigate downdrafted winds

Desk based Lawson assessment



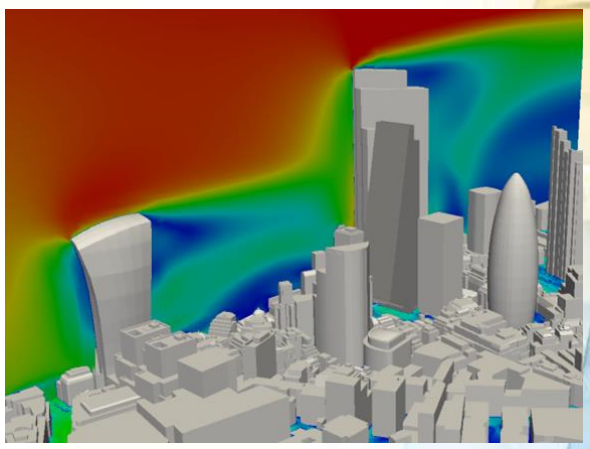
- Sitting
- Standing/Entrance
- Leisure Walking
- Business walking
- Uncomfortable

Wind assessment ingredients



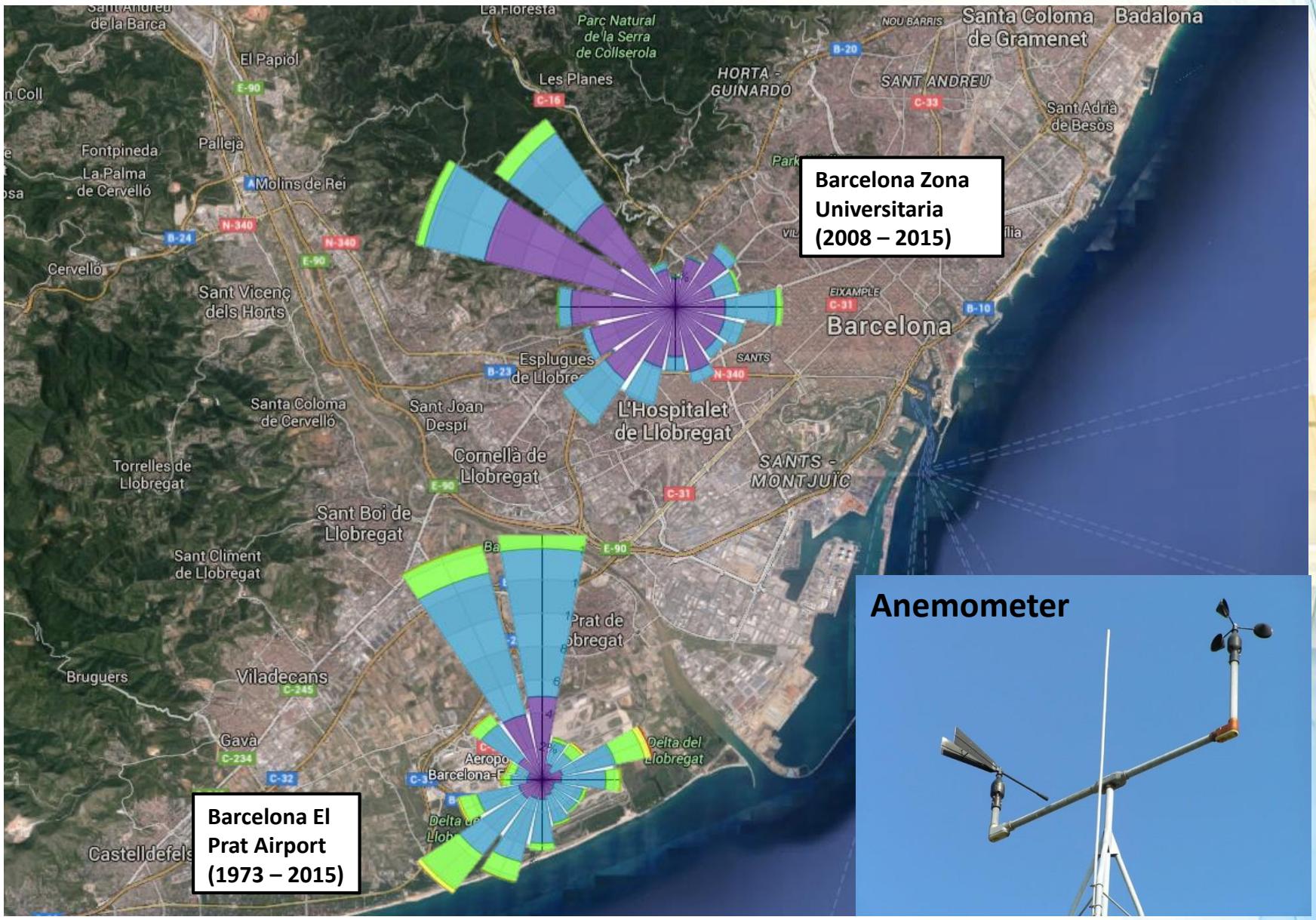
Meteorological data

Terrain roughness

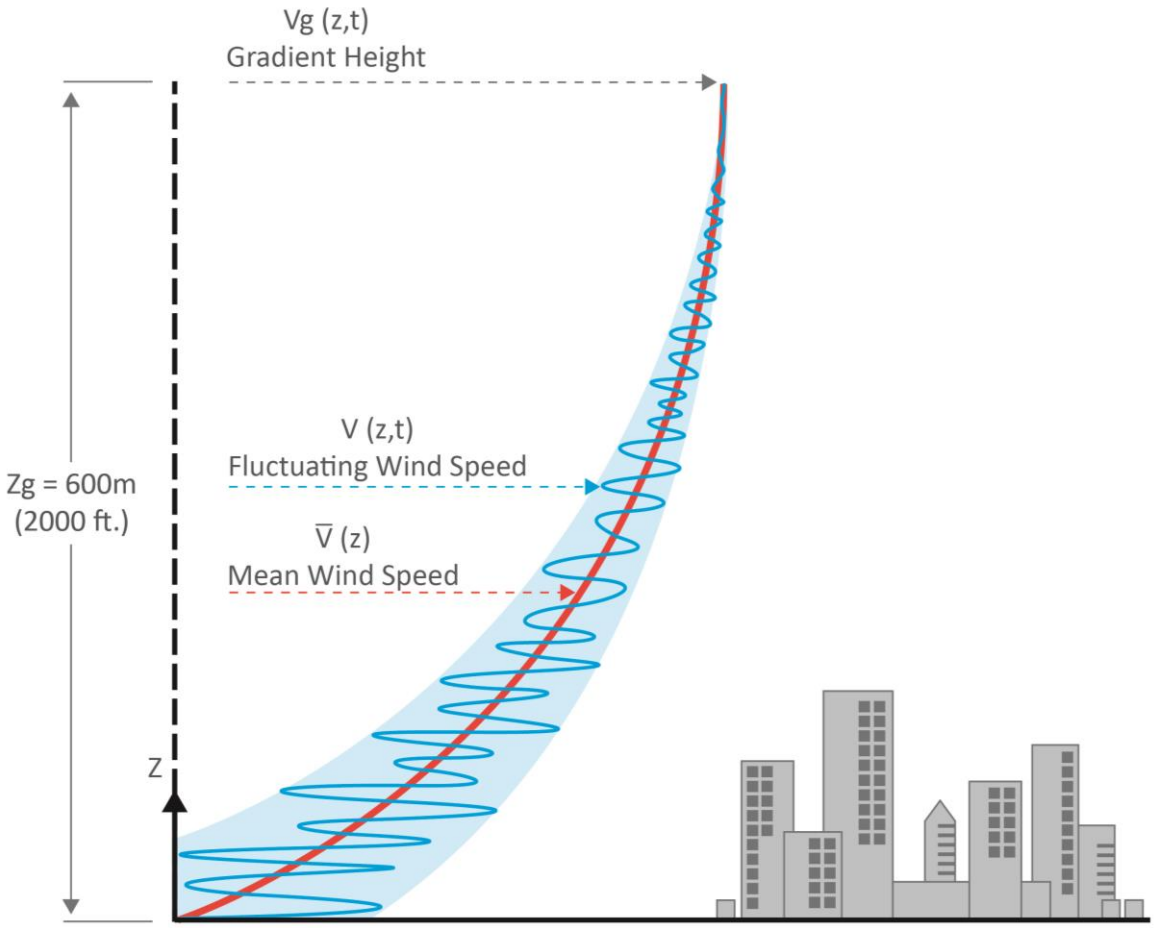


Local wind speeds
(CFD or Wind Tunnel)

Meteorological data



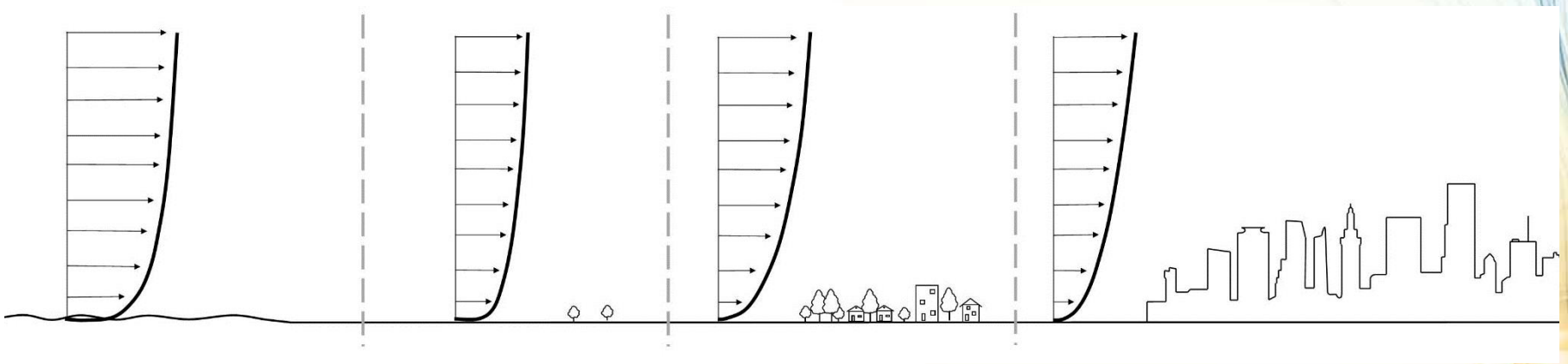
Planetary boundary layer and surface roughness



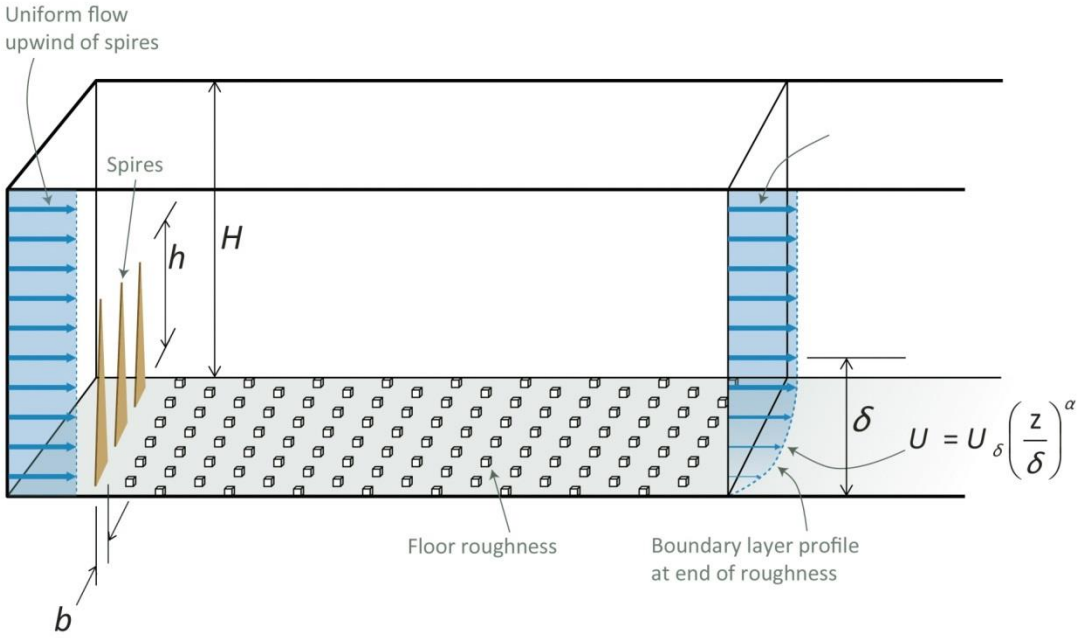
Built up Urban area – lots of obstructions

Open country – few obstructions

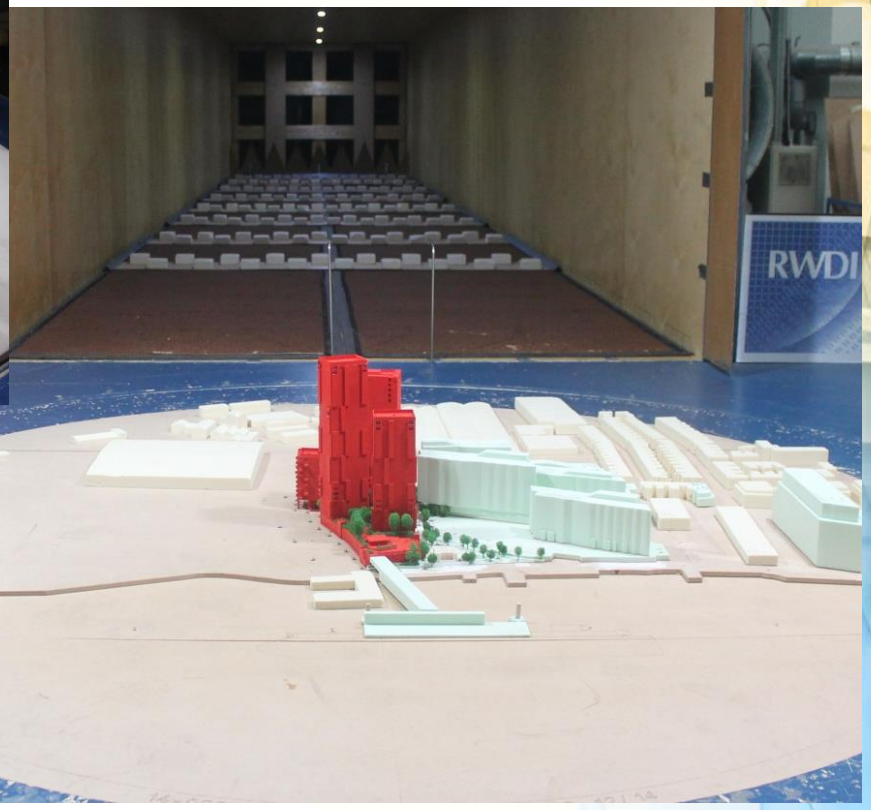
Profiles



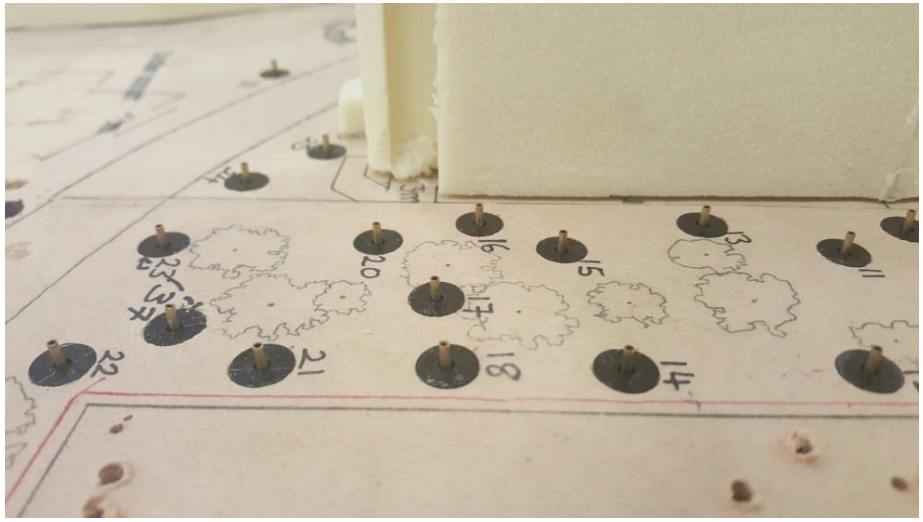
Open **Open/sub** **Suburban** **Urban**

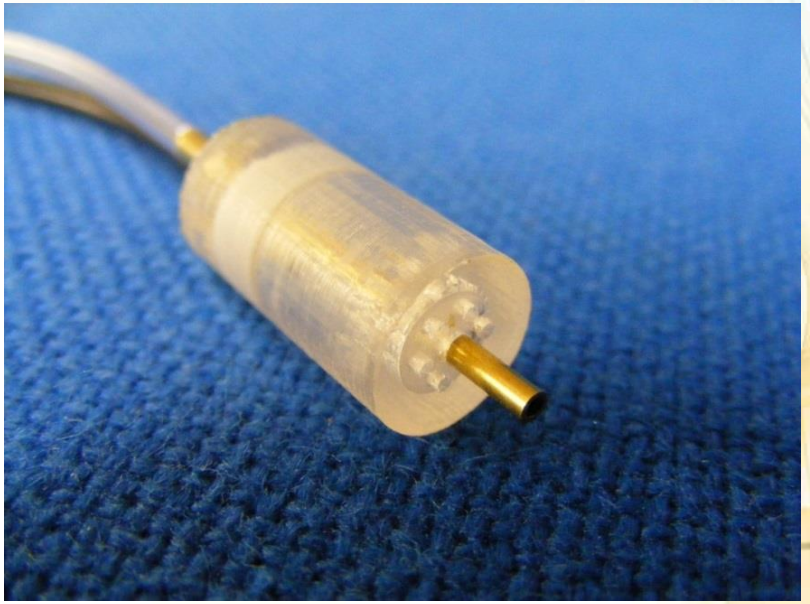


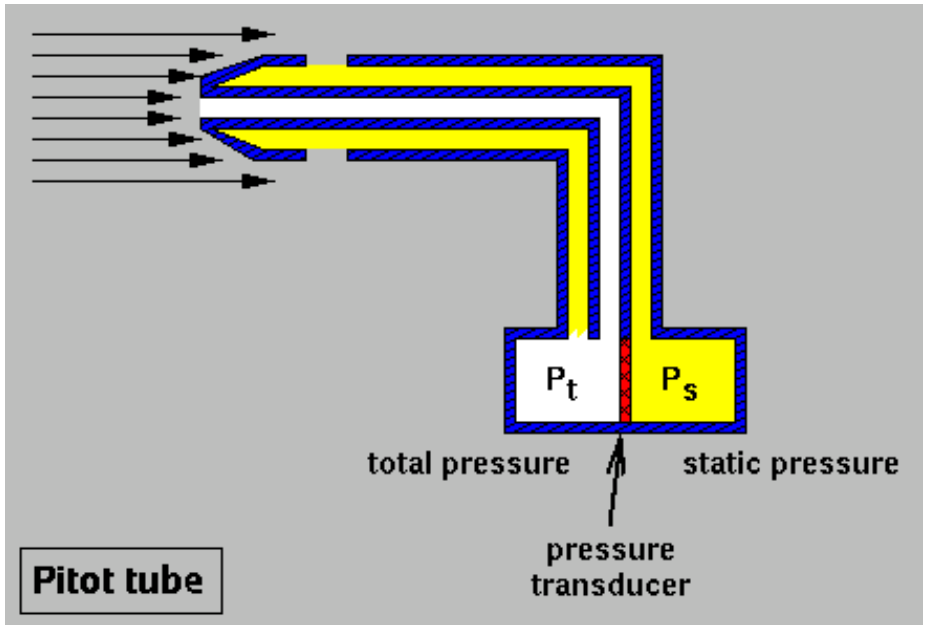
Wind tunnel model

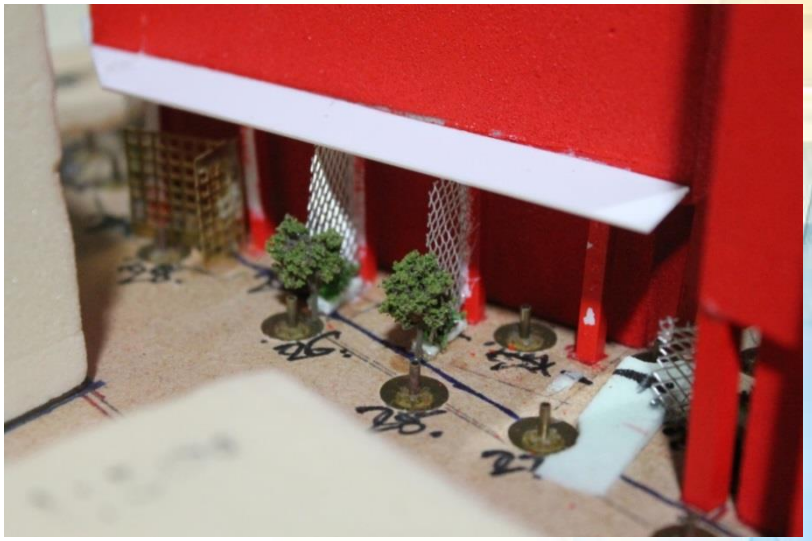


Measurement probes

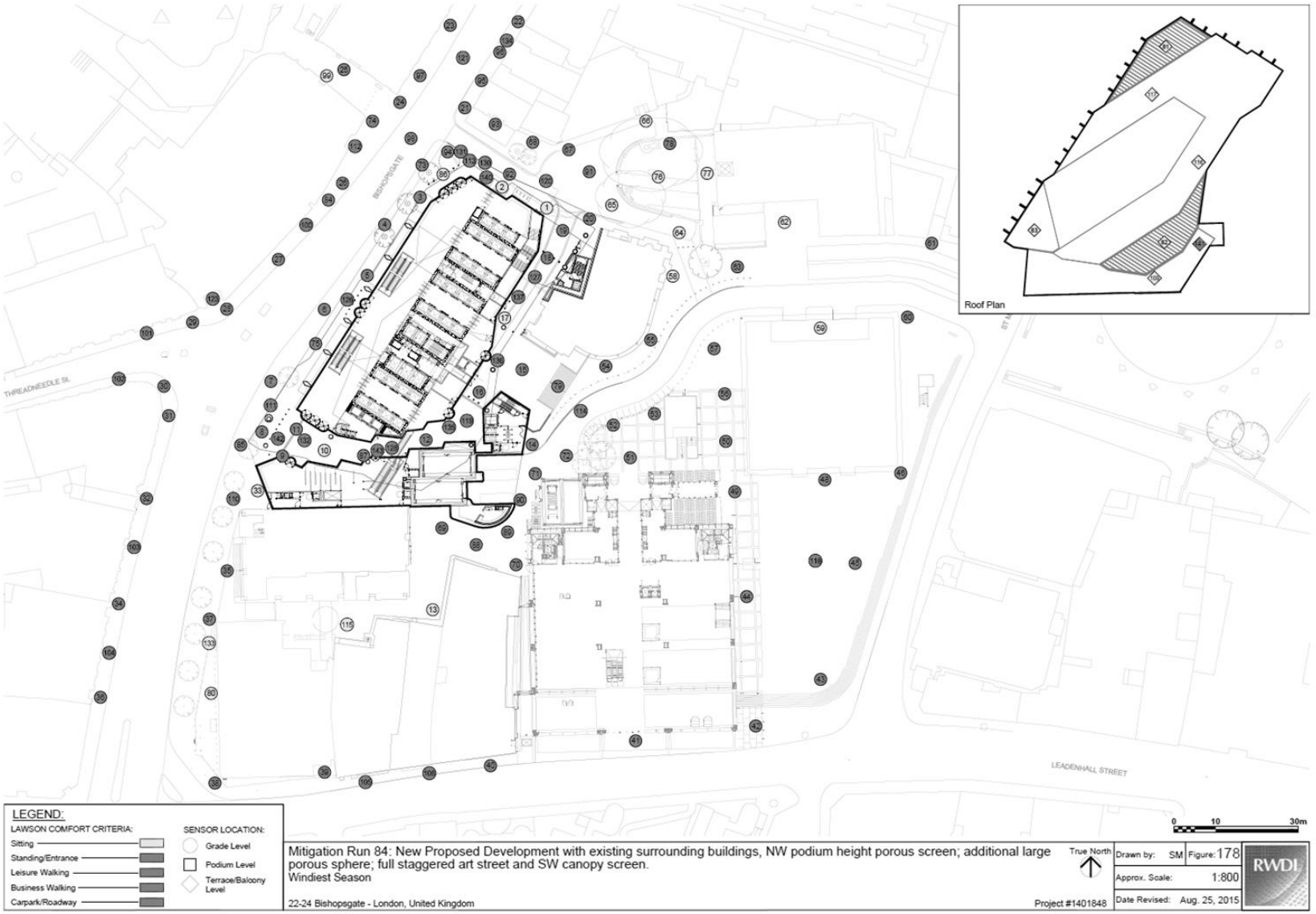




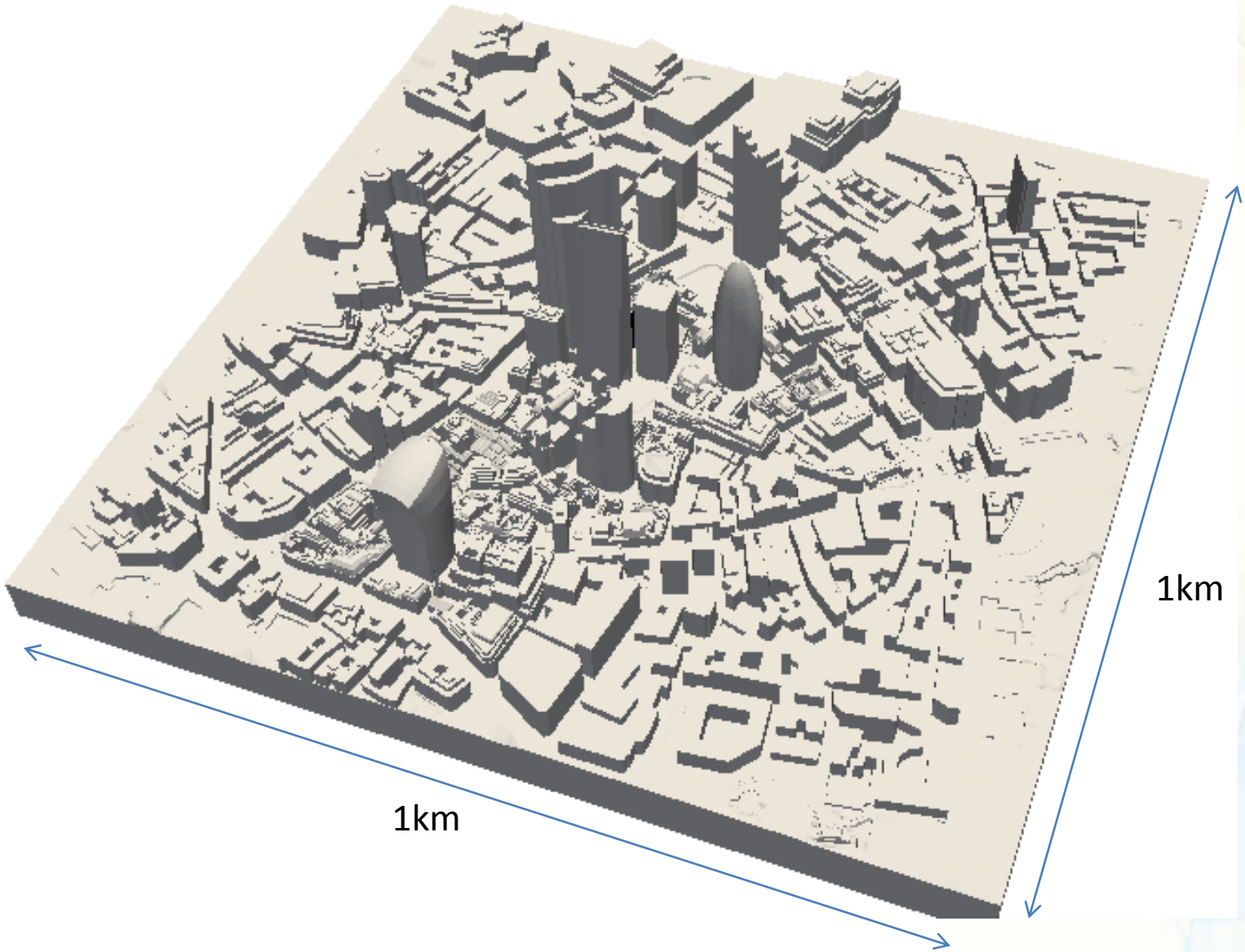




Wind tunnel output



Computational fluid dynamics model

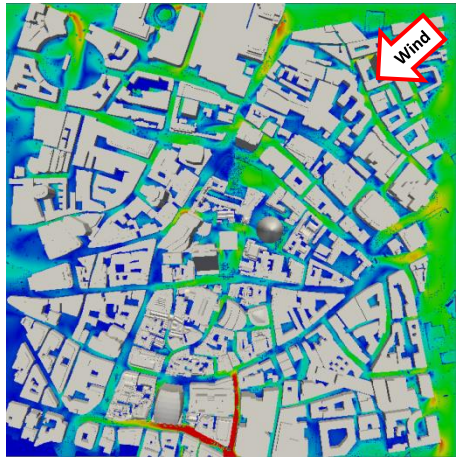


London CFD output

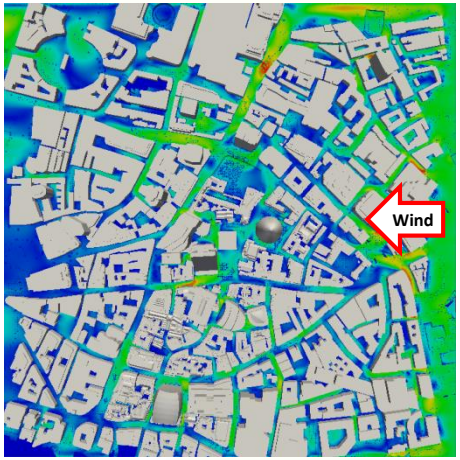
low — high

Output from steady state simulation, mean wind speeds only

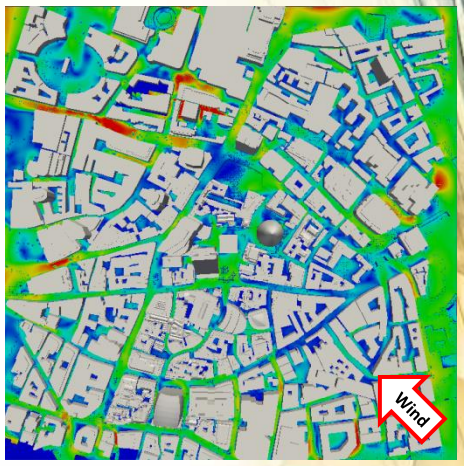
North



North East

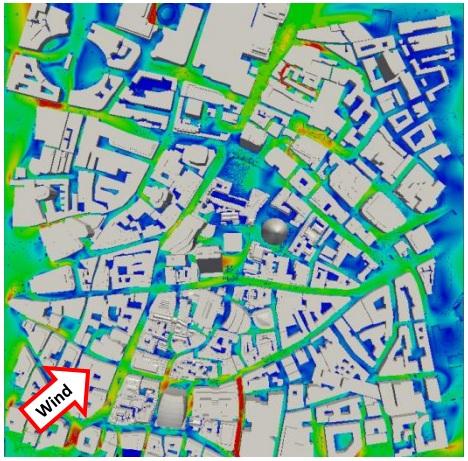


East



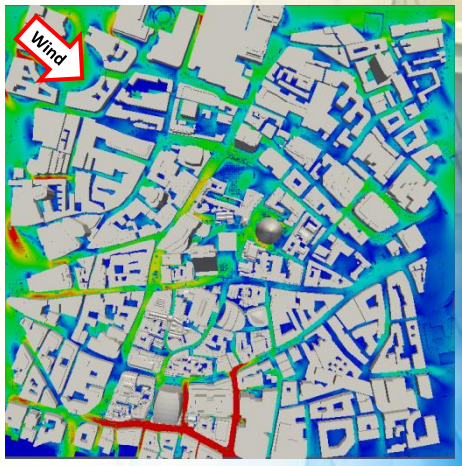
South East

South



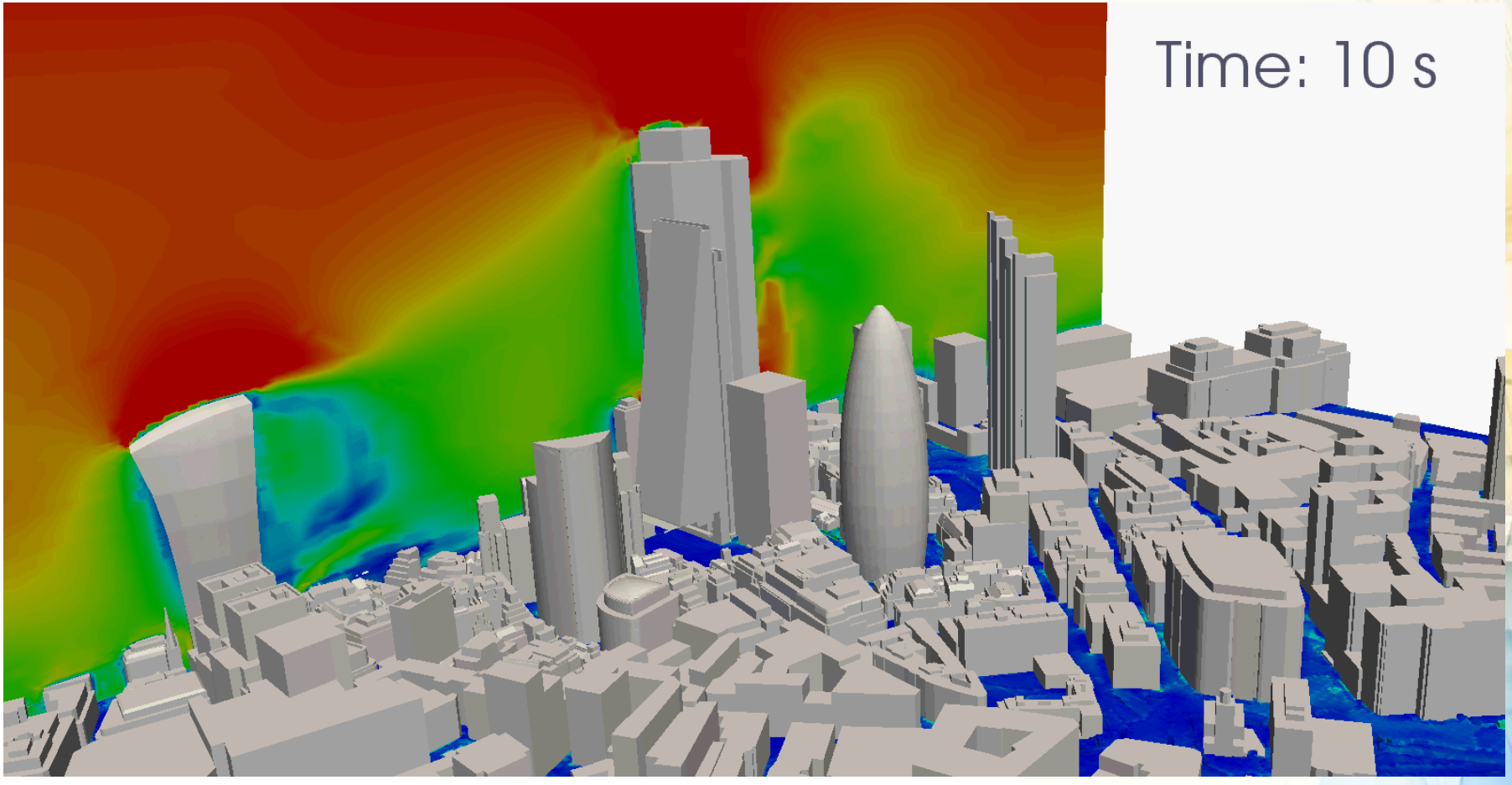
South West

West



North West

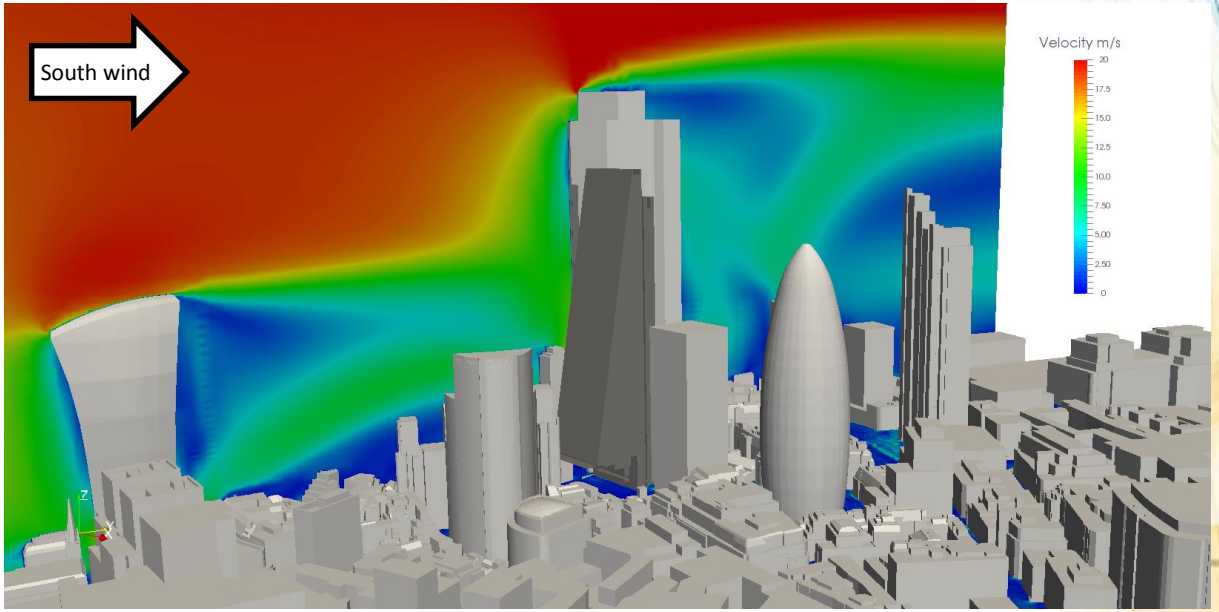
Transient wind CFD modelling



Steady state vs transient modelling

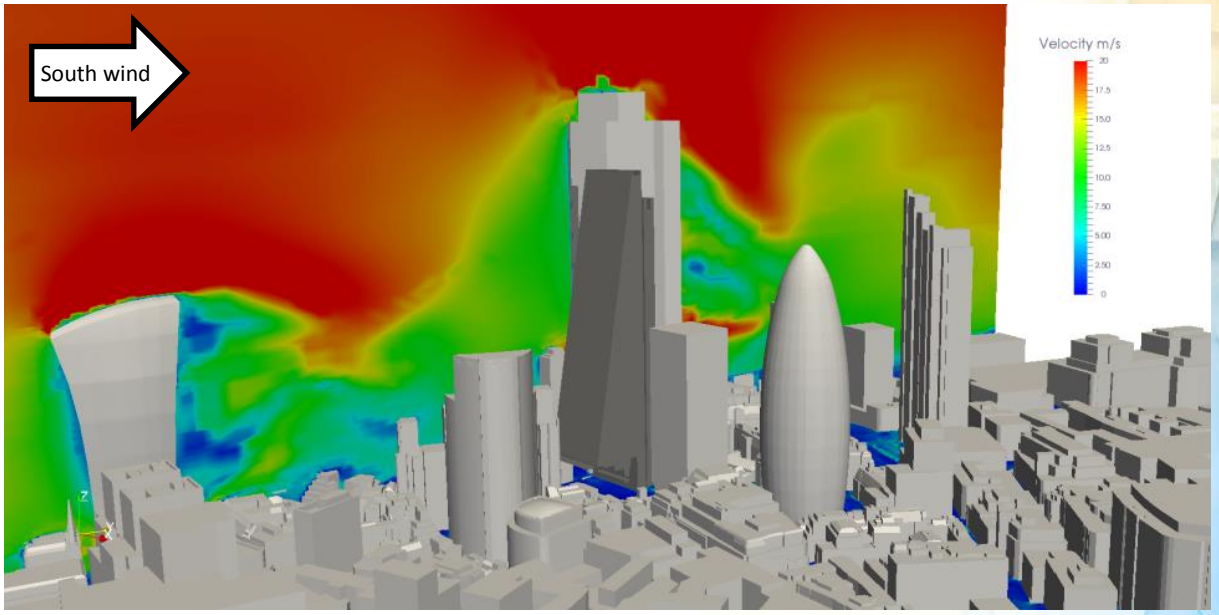
Steady state solution

- Quick and easy
- Only gives the mean component of wind
- Averaged turbulence modelling limits solution accuracy/applicability
- Gives the most ‘likely’ solution

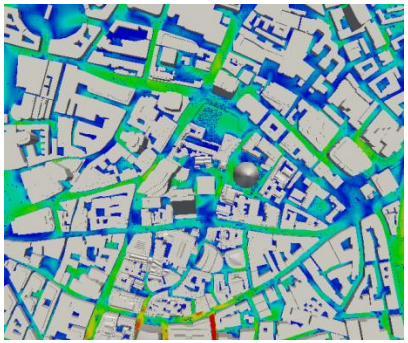


Transient solution

- Simulation is slower and harder to undertake
- Can provide mean and gust information
- Care still needs to be taken that the turbulence is modelled accurately
- Need to simulate >20 minutes of time to see a range of solutions



Comparing wind assessment approaches



Desk Study	CFD Simulation	Wind Tunnel Testing
Qualitative and typically conservative results	Qualitative or quantitative, depending approach	Quantitative
Useful for simple buildings/sites	Can be used for all building scales	Can be used for all building scales
Fast turnaround	Initial results are fast, but can be slower to iterate options	Initial results a slower, but fast to iterate options
Prevailing winds only	Typically 8 or 12 directions simulated	Up to 36 wind directions considered
Conditions local to the project site	Considers all pedestrian locations, near and far	Only locations where probes are placed
Wind behaviour predicted by an experienced engineer	Accuracy of modelling depends upon simulation undertaken	Currently the most accurate approach to model wind
Visual output illustrates ideas	Excellent visual output to see key flow features	Limited visual output

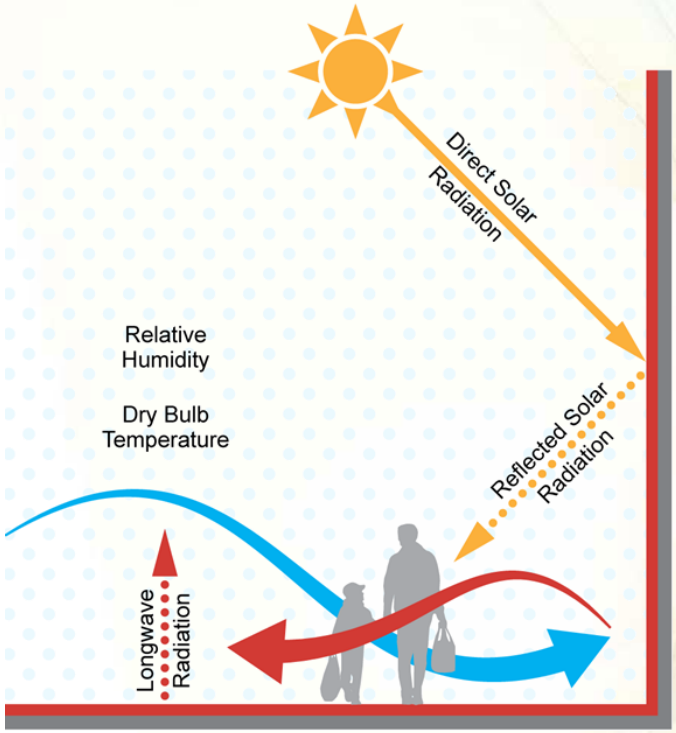
COMFORT

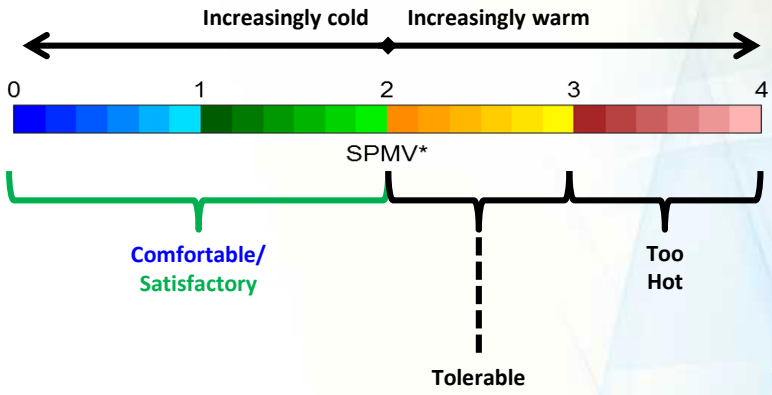
It is more than just wind

How do we determine how comfortable people are?

Comfort is a complex phenomena

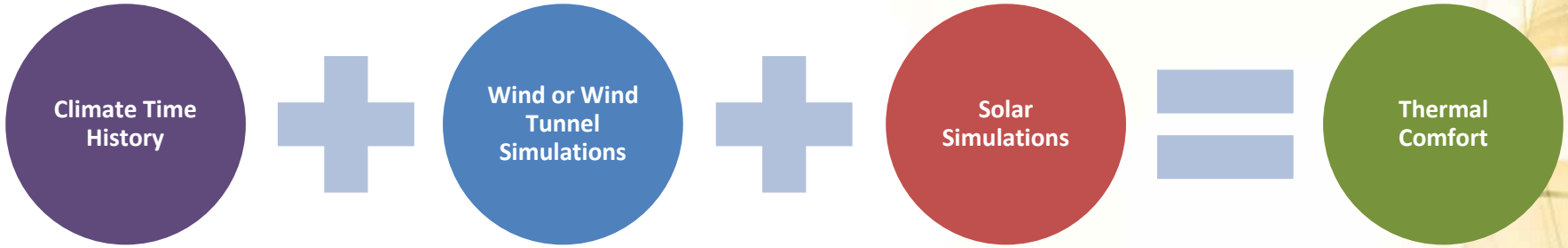
- Environment variables
  - Wind speed
  - Temperature
  - Relative Humidity
  - Radiant temperatures (solar impact, hot/cold surfaces)
- Personal factors
  - Clothing levels
  - Activity
- Other parameters like gender, height have a lesser role
- It varies from person to person
- Expectation is important

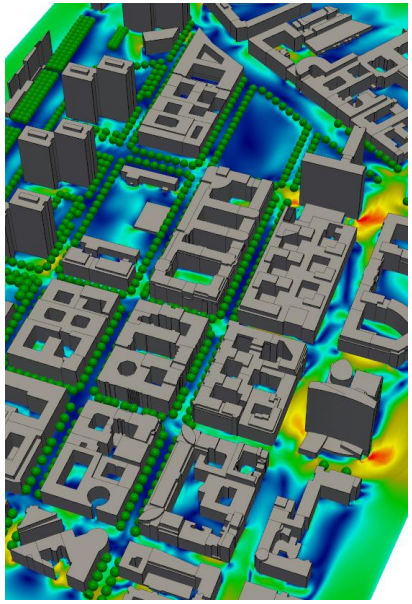


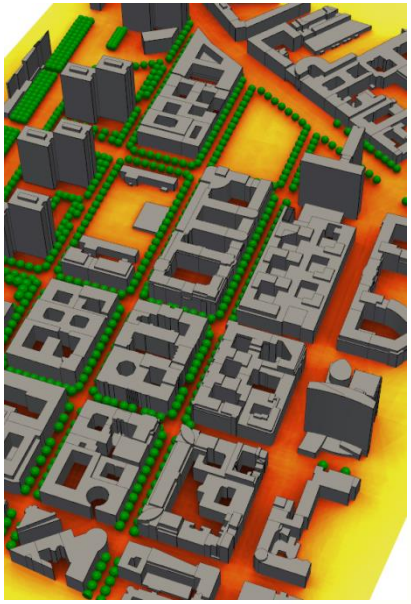


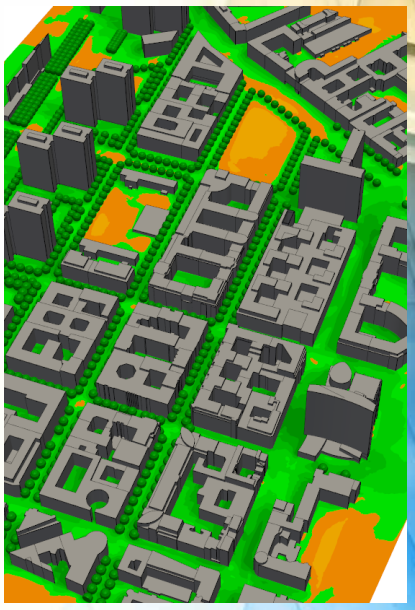
Outdoor thermal comfort

- Combines solar data, a local climate history and CFD simulations of the wind microclimate to predict pedestrian thermal comfort
- Scales ranging from single buildings to entire cities
- Helps designers create comfortable pedestrian spaces that promote walkability

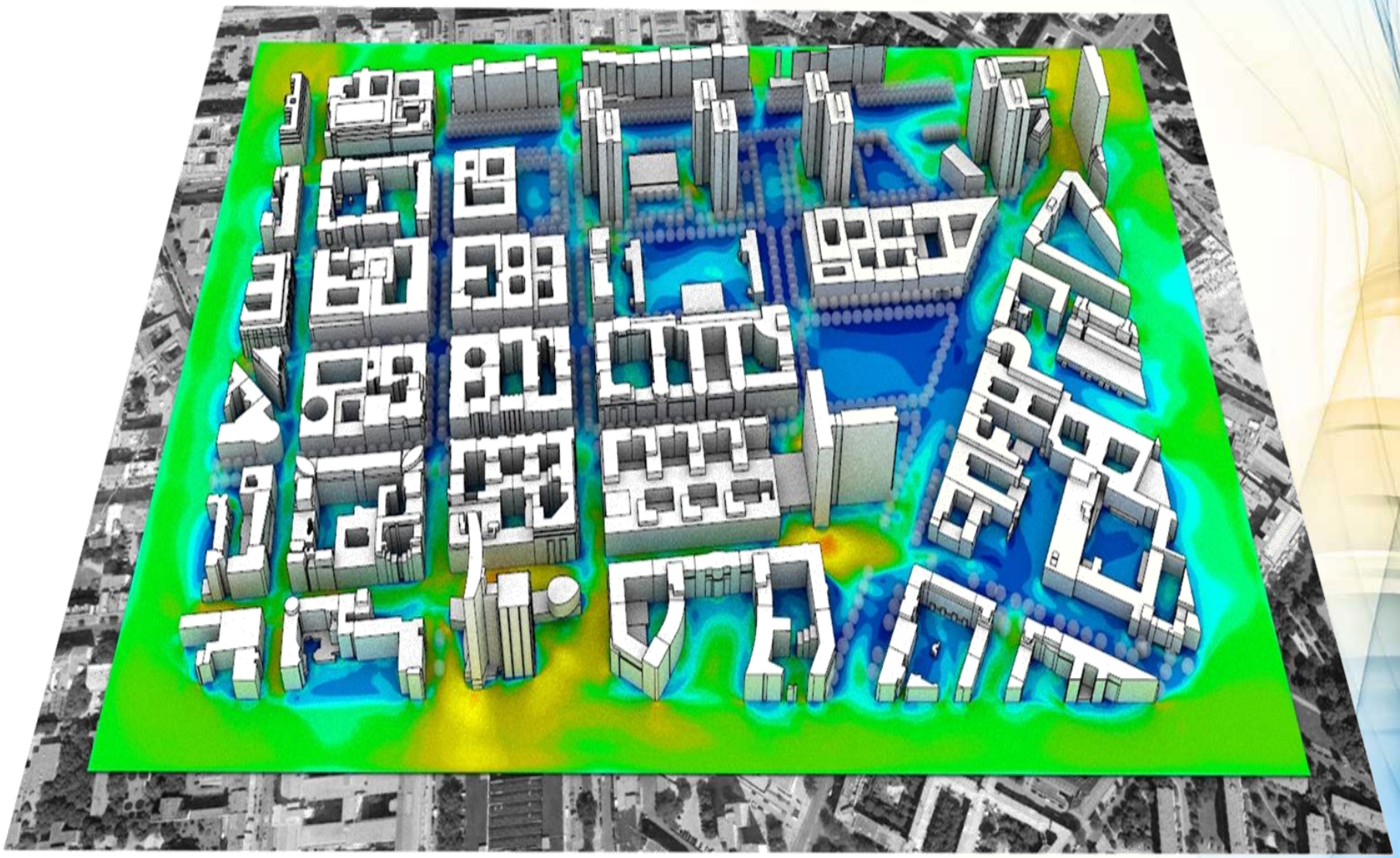








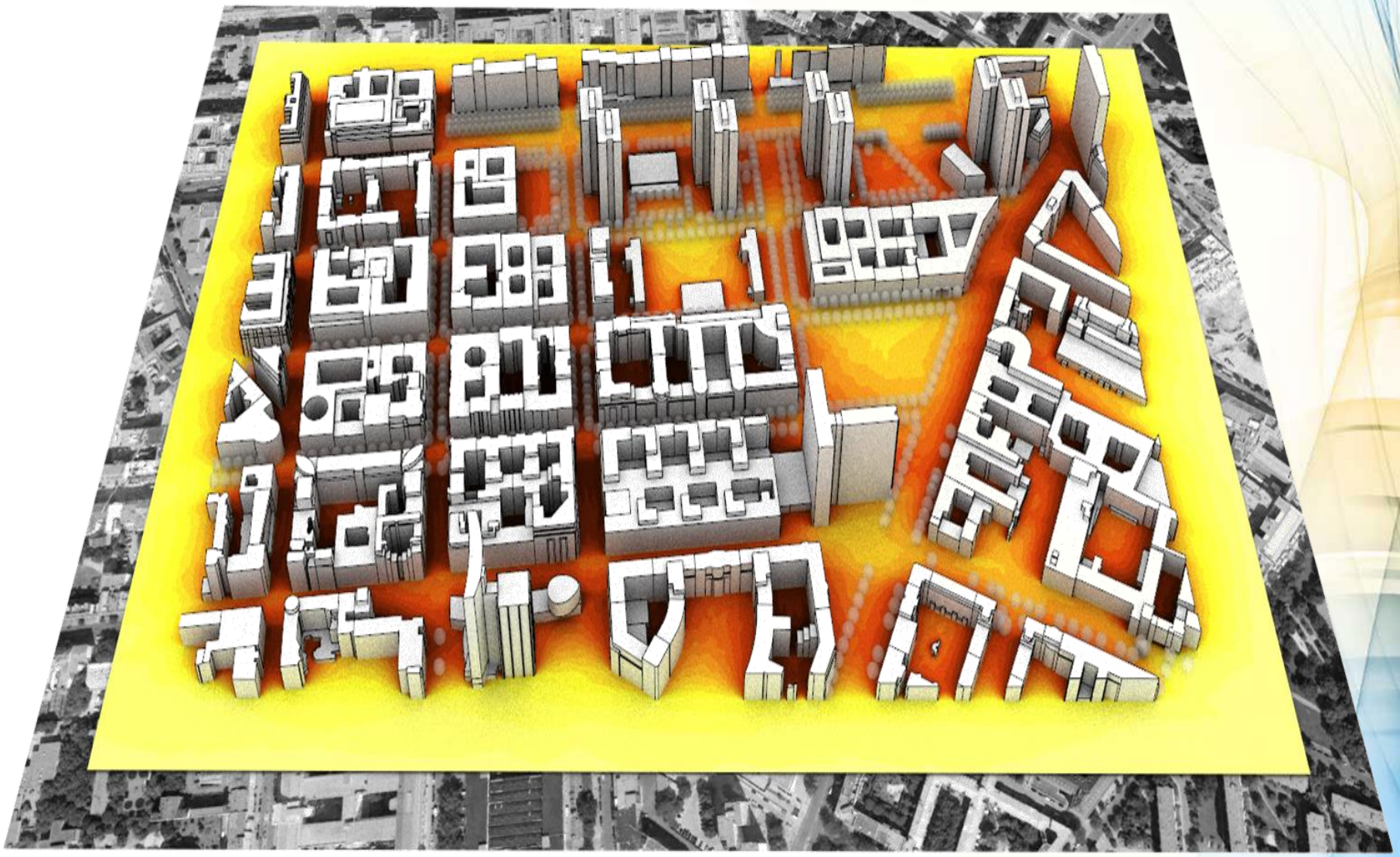
Berlin wind speeds



Annual mean wind speed (all directions)

low high

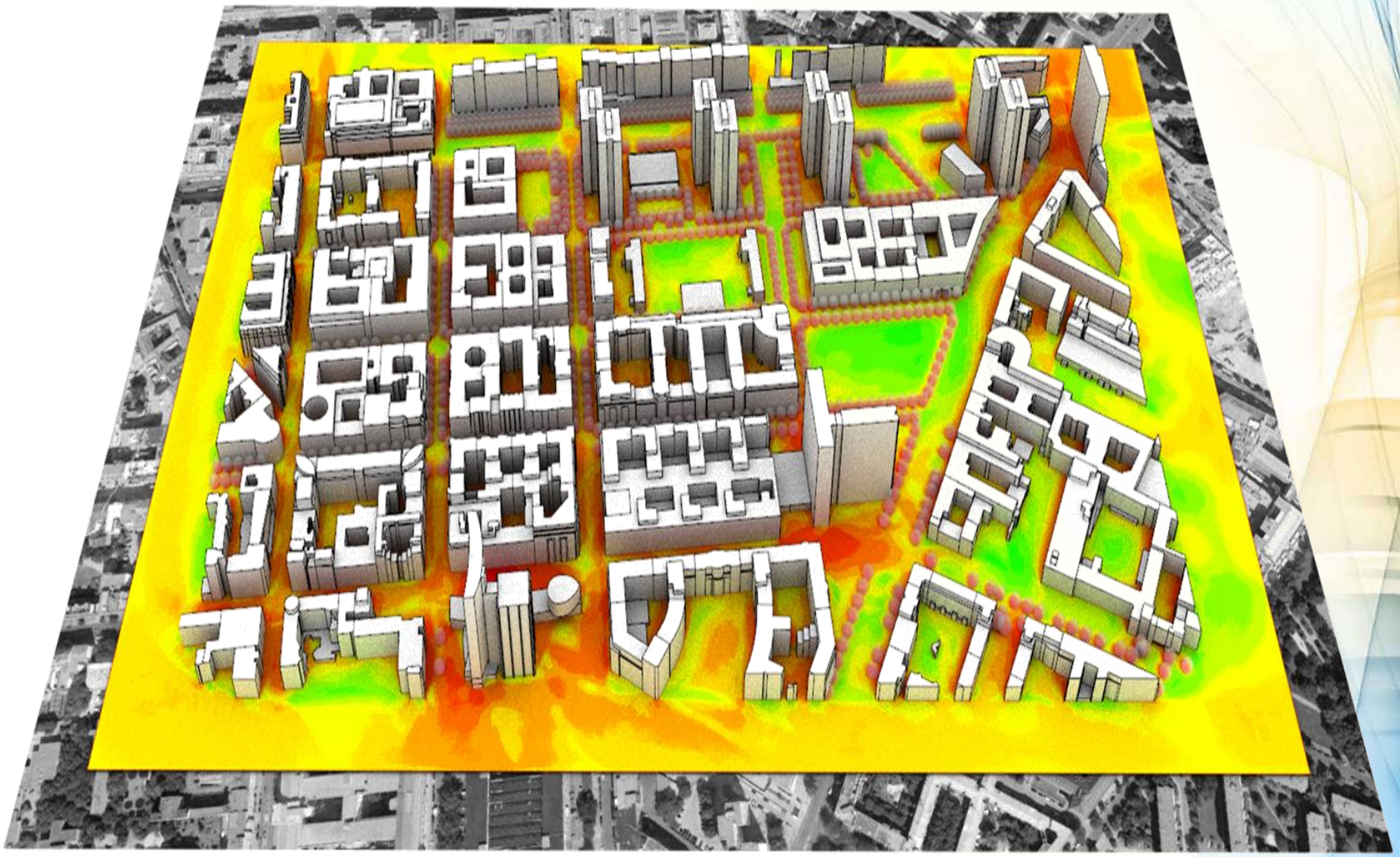
Berlin solar exposure



Sky view factors – annual average

low high

Berlin comfort



SPMV*

worse — better

WIND ANALOGUE OR DIGITAL?

Wind analogue or digital ?

Wind is inherently an analogue phenomenon and physical wind tunnel testing is the most accurate way to measure this analogue behaviour

However, we live in a digital age and wind can be modelled digitally. Similar to the music industry, we are getting very good at it!

What is important?

- Use appropriate climate data for your site
- Correct for the local terrain
- Accurately model both the mean and gust component of the wind
- Apply engineering judgement to the output of all tools
- Comfort is more than just wind