

# CompAQS/Cityscan - the Air Quality Spectrometer

Roland Leigh

Rosemarie Graves, Jasdeep Anand, James Lawrence, Chris Whyte, Paul  
Monks

*Earth Observation Science Group, University of Leicester.*

Mike Cutter, Dan Lobb, Mark Chang  
*Surrey Satellite Technology Ltd*

# Motivations



- Clean air is considered to be a basic requirement of human health (WHO)
- Reduces life expectancy in UK on average by 7-8 months
- £15bn p.a. cost to UK
- Requirement for global solution management.



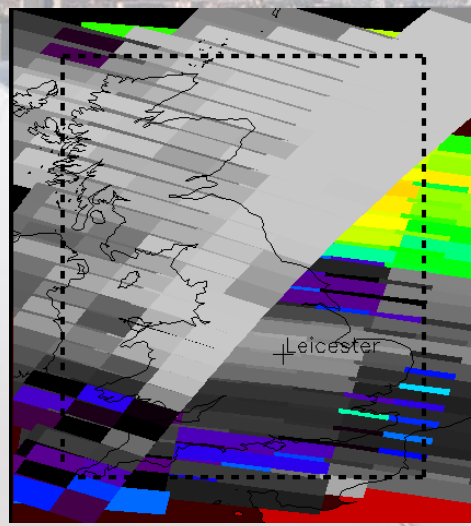
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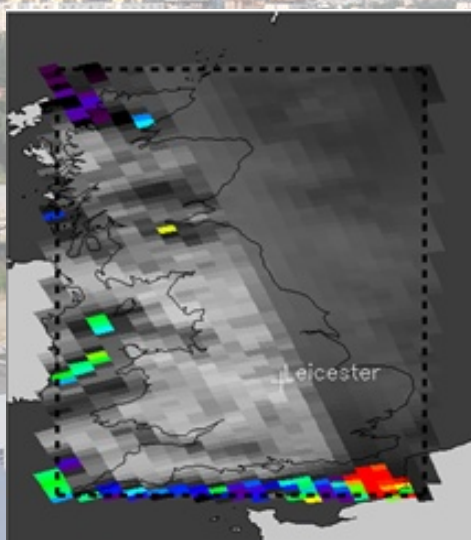
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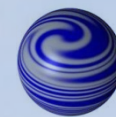


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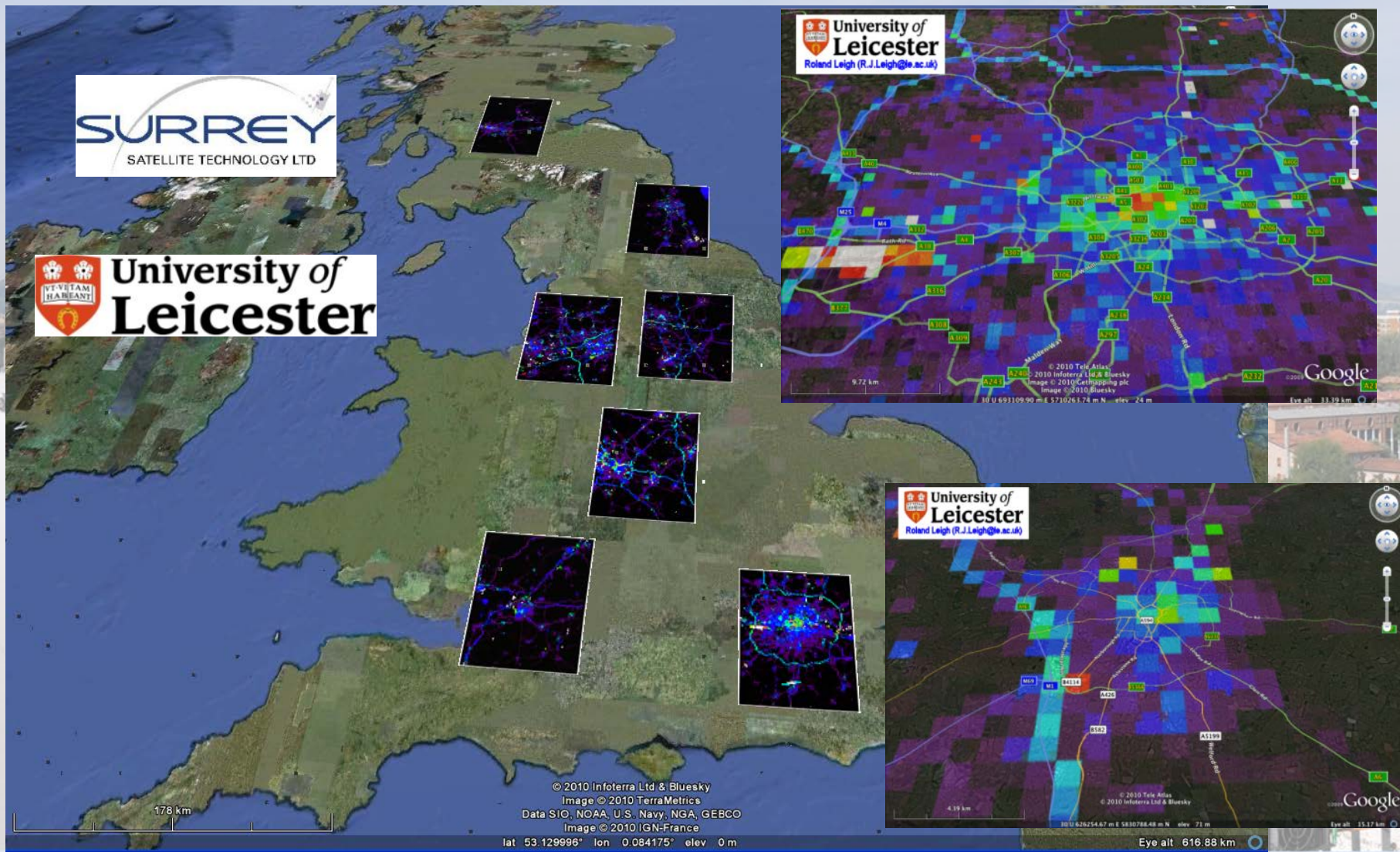


OMI





# The CompAQS mission concept





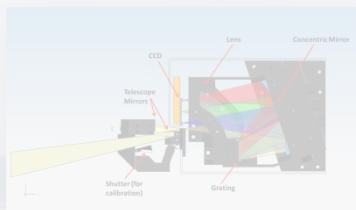
D.Lobb,  
Applied  
Optics  
1994

CEOI (Technology)

CompAQS phase 1

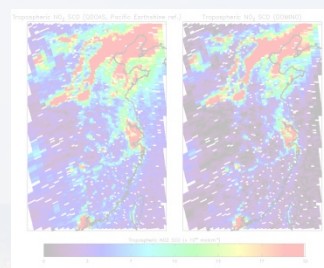
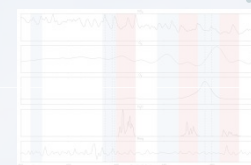


CompAQS phase 2,  
Imaging entrance  
optics



(PhD) Mission Development

UCAM

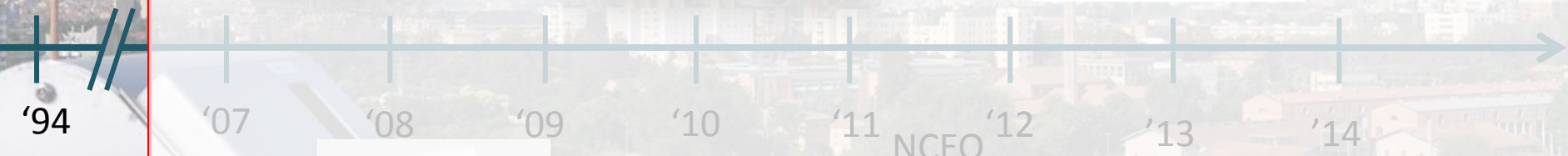


(PhD) Urban remote sensing of NO<sub>2</sub>

Air Quality during  
Olympics (ClearfLo)



Design and Development  
of 2/3 CityScan  
instruments



# CompAQS Heritage

- In 1994 Dan Lobb (SSTL) proposed a spectrometer optimised for DOAS retrievals.

## Theory of concentric designs for grating spectrometers

D. R. Lobb

A concentric optical design for a grating spectrometer is described. General aberration theory is given for a family of designs of similar form, showing close similarities with the theory for conventional concentric imagers used in microlithography. Control of stray radiation in the concentric grating spectrometer is discussed.

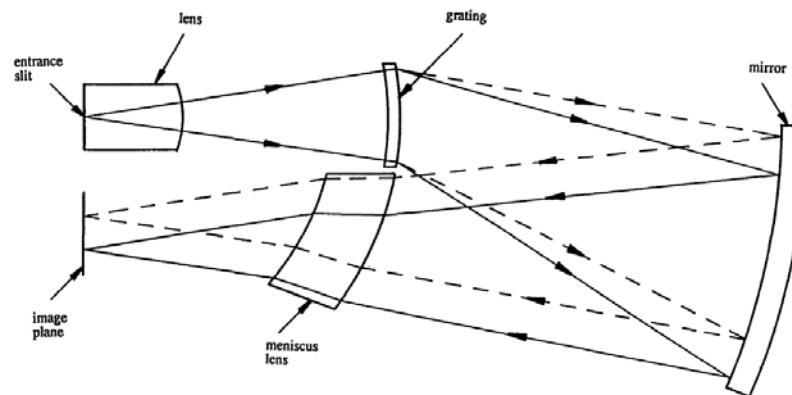


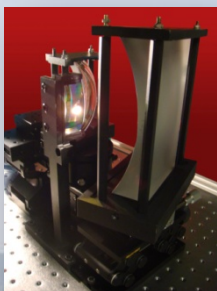
Fig. 5. Transmitting grating system.



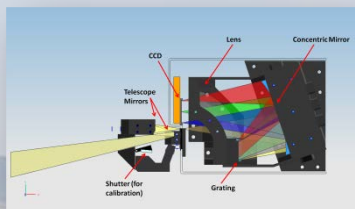
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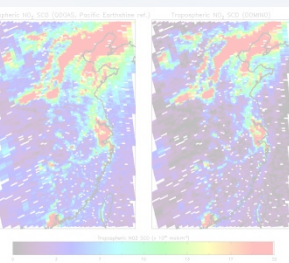
CompAQS phase 1



CompAQS phase 2,  
Imaging entrance optics



(PhD) Mission Development



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Design and Development  
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(PhD) Urban remote sensing of NO<sub>2</sub>

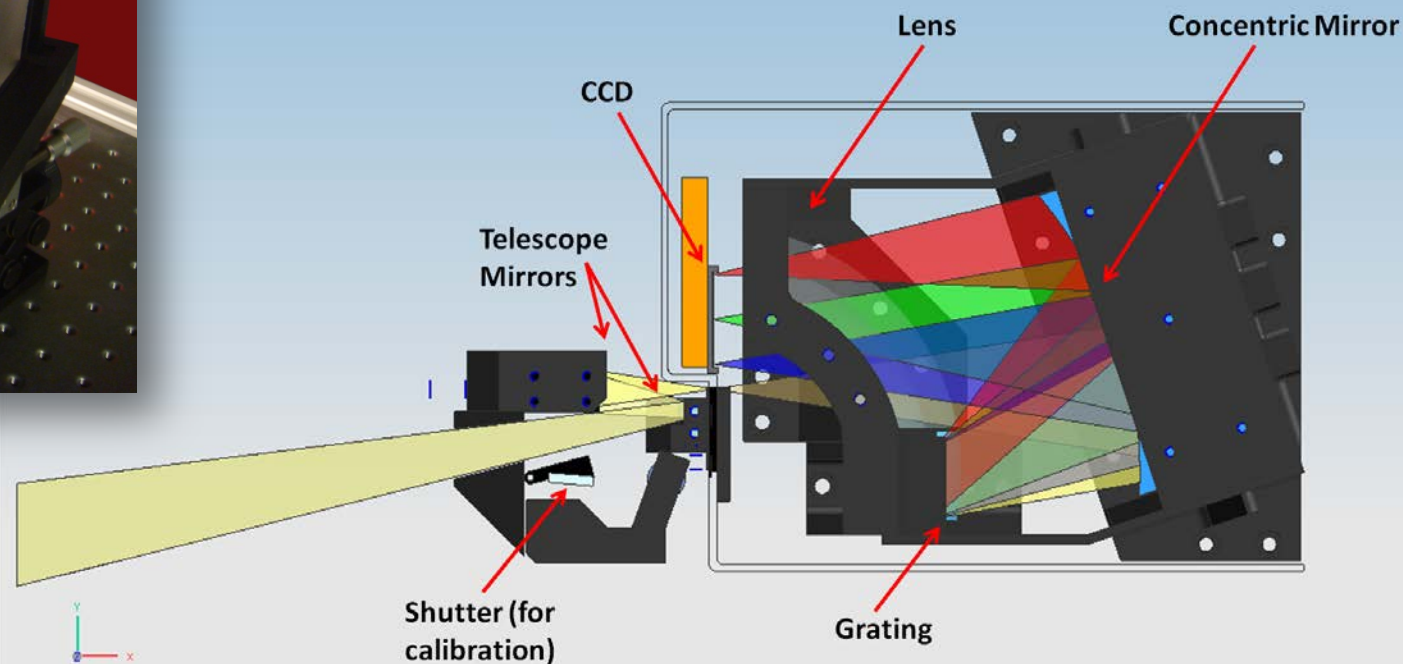
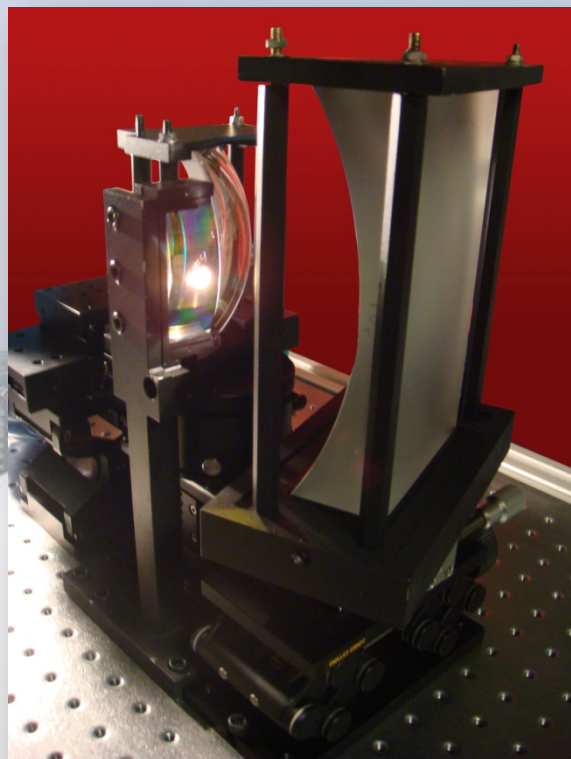
Air Quality during  
Olympics (ClearLo)





# CompAQS (Phase1 & 2) to CityScan

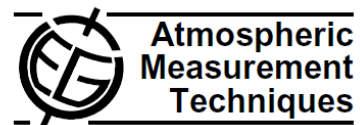
- CompAQS demonstrator 2007-9
- CityScan 2011





# Phase 2 Completion

Atmos. Meas. Tech., 2, 789–800, 2009  
www.atmos-meas-tech.net/2/789/2009/  
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## Assessment of the performance of a compact concentric spectrometer system for Atmospheric Differential Optical Absorption Spectroscopy

C. Whyte<sup>1</sup>, R. J. Leigh<sup>1</sup>, D. Lobb<sup>2</sup>, T. Williams<sup>2</sup>, J. J. Remedios<sup>1</sup>, M. Cutter<sup>2</sup>, and P. S. Monks<sup>3</sup>

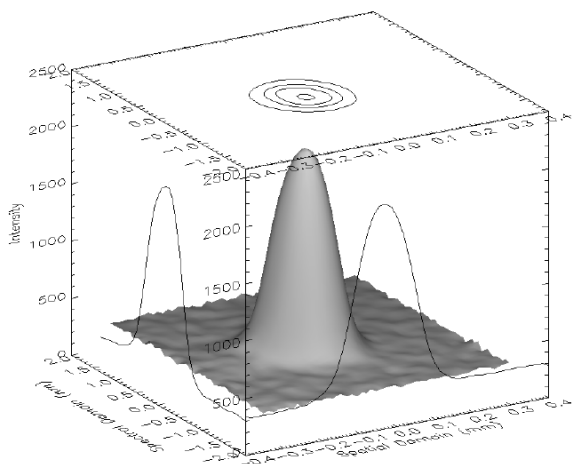


Fig. 9. A 3-D representation of the spatially resolved 404.66 nm mercury emission.

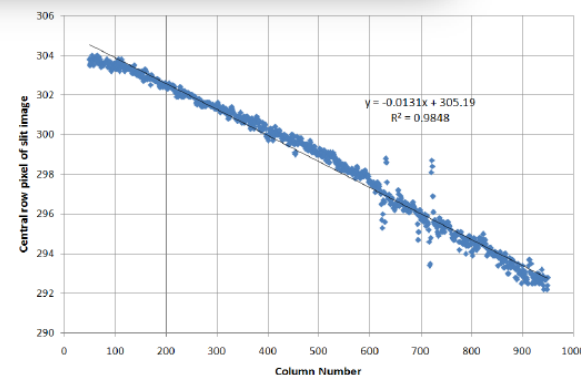
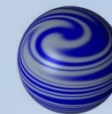
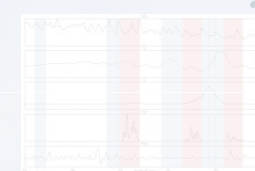


Fig. 10. A measurement of the “smile” in the CompAQS spectrometer system. The overall slope of the plot is due to a minor rotation of the CCD detector with respect to the focal plane. Sub-pixel values were obtained using a combined smoothing/spline interpolation routine. Features around column 620 and 710 result from artefacts on the CCD surface, and not deviation of the image.

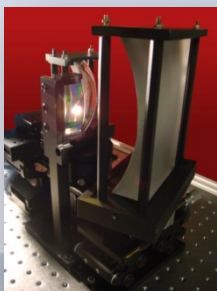


CEOI (Technology)

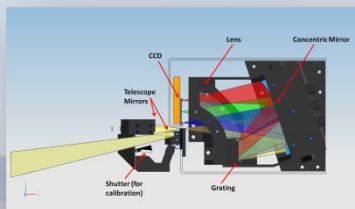
UCAM



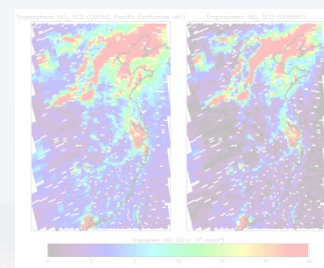
CompAQS phase 1



CompAQS phase 2,  
Imaging entrance optics



(PhD) Mission Development



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Applied  
Optics  
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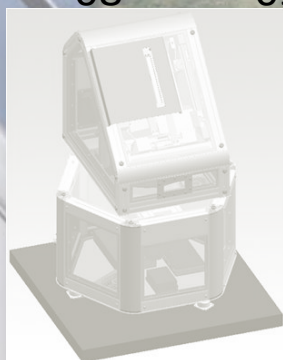
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Design and Development  
of 2/3 CityScan  
instruments

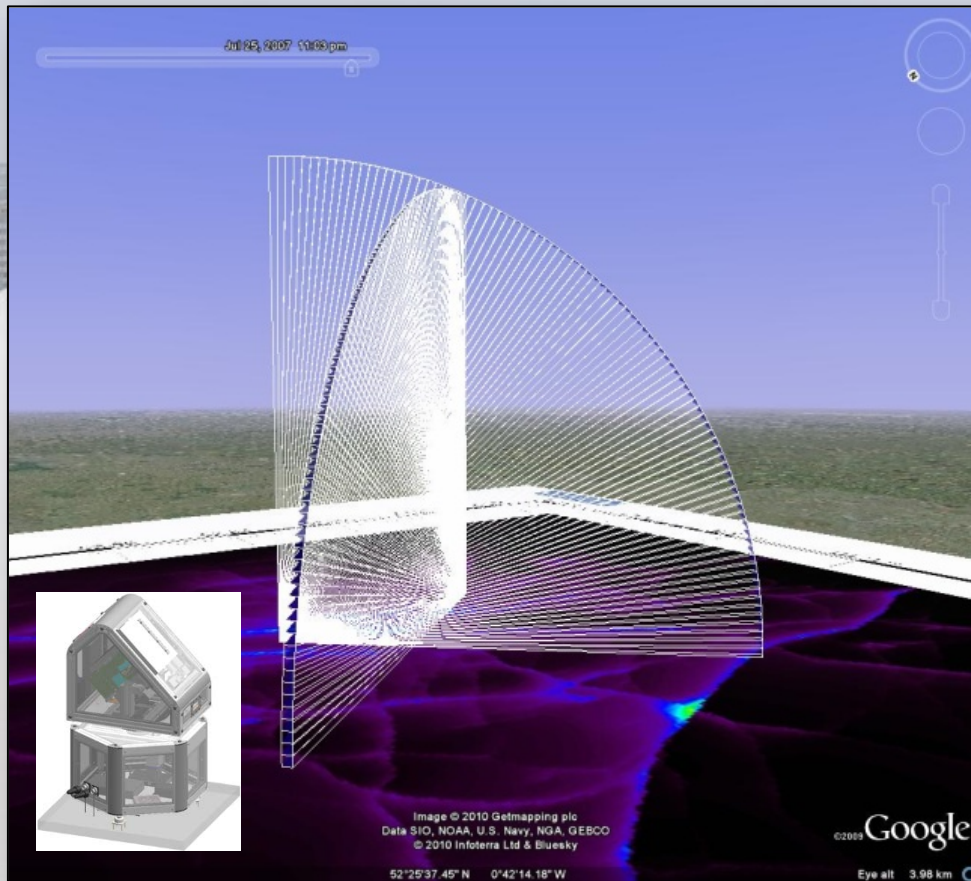
(PhD) Urban remote sensing of NO<sub>2</sub>

Air Quality during  
Olympics (ClearLo)





- Incorporating the CompAQS spectrometer.
- Provides a weatherproof, thermally controlled housing which rotates in a full 360° every 6 minutes.



- The CompAQS spectrometer provides a 95° FOV which, in combination with the rotation provided by CityScan, gives a full hemispherical imager.
- Intersecting FOVs of multiple instruments offer the potential of gas tomography on a city-wide scale.

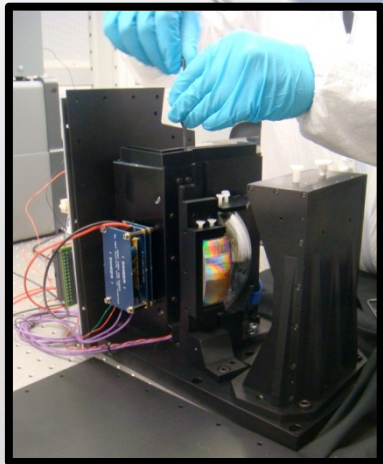


# University of Leicester

Centre for  
**e** Instrumentation



**National Centre for Earth Observation**  
NATURAL ENVIRONMENT RESEARCH COUNCIL

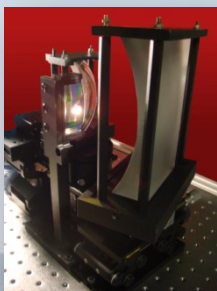




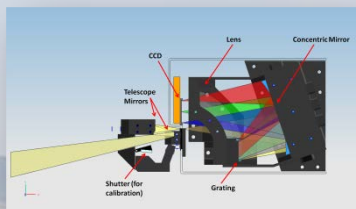
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UCAM

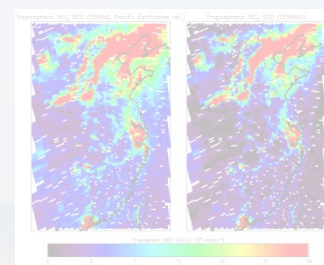
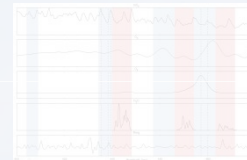
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CompAQS phase 2,  
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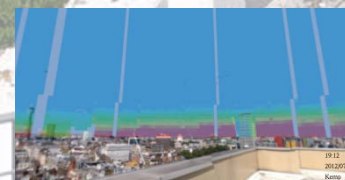
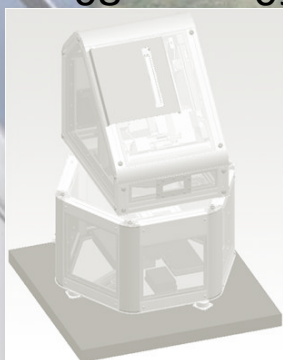
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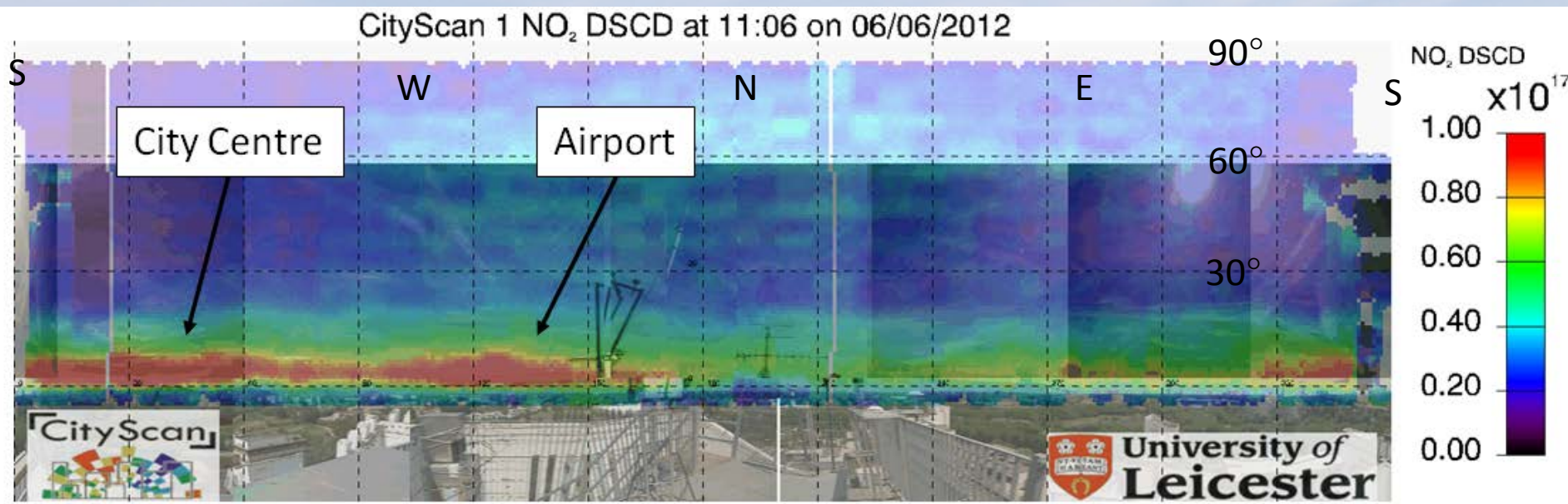
NCEO

(PhD) Urban remote sensing of NO<sub>2</sub>

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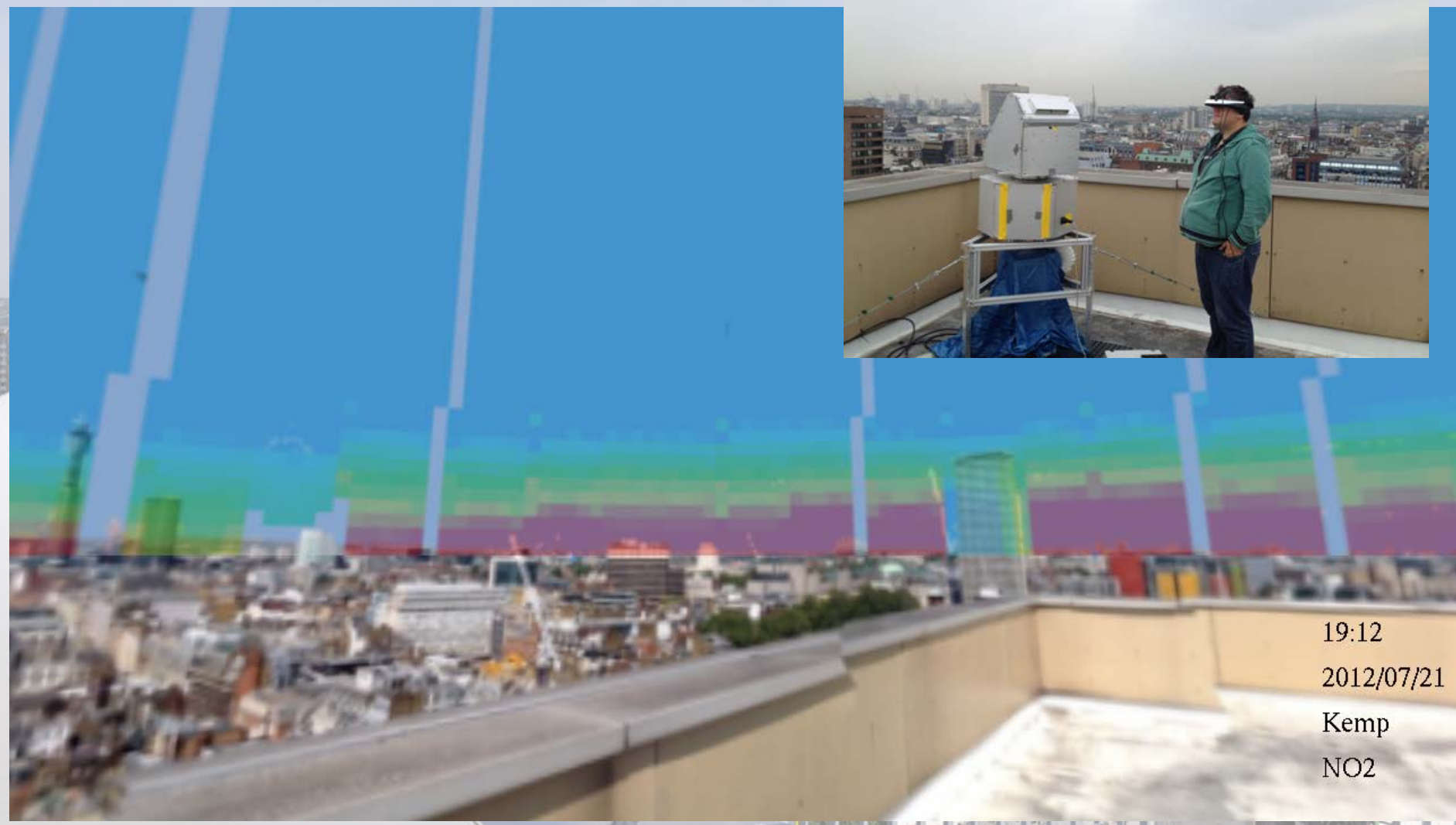


Bologna – June 2012

See: Rosie Graves, CEOI Session, Today, 16:15  
Posters by Roland Leigh and Rosie Graves.



Try out our VR headset during the poster session



19:12  
2012/07/21  
Kemp  
NO2

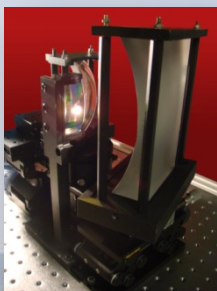


# Timeline

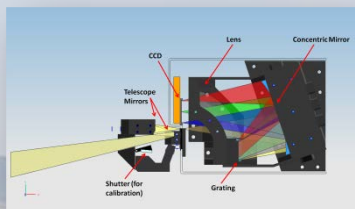


CEOI (Technology)

CompAQS phase 1

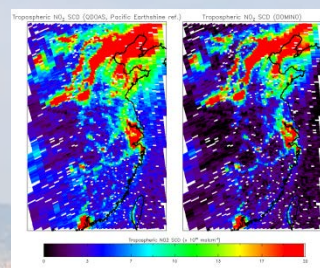
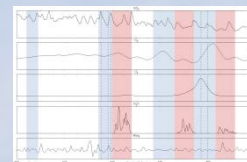


CompAQS phase 2,  
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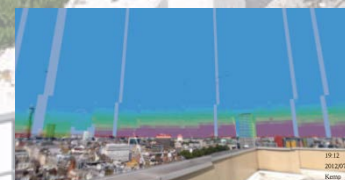
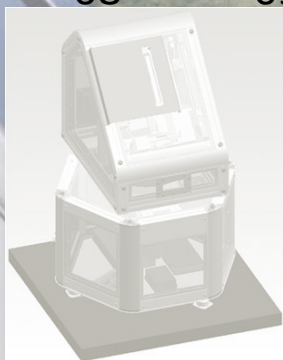
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(PhD) Urban remote sensing of NO<sub>2</sub>

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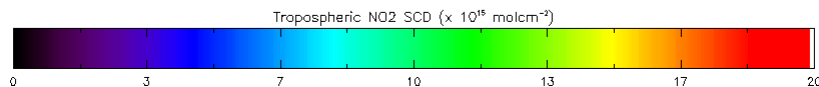
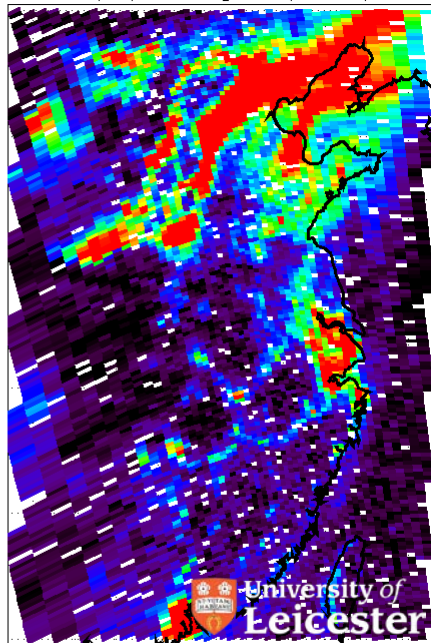
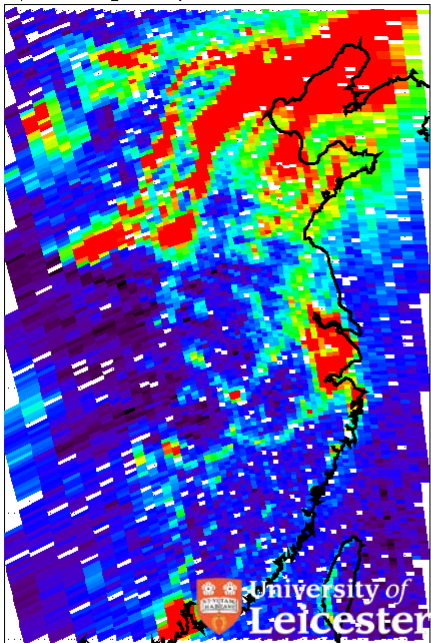






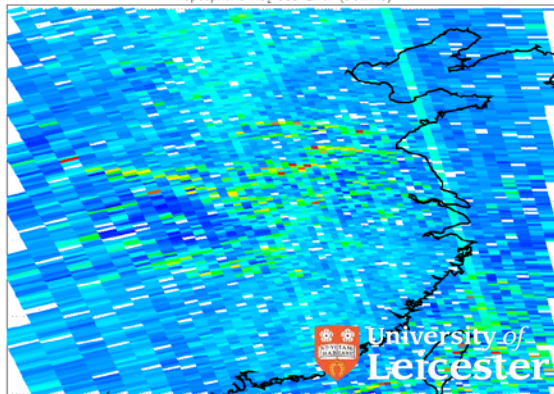
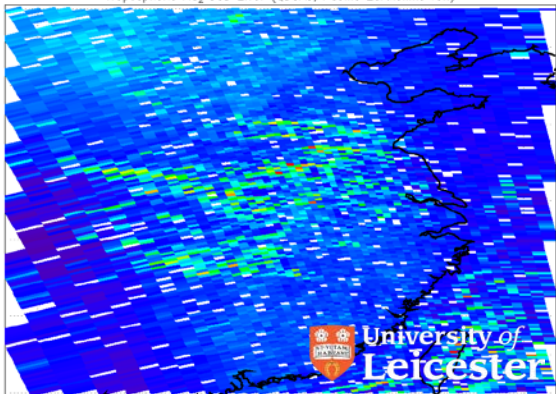
Tropospheric NO<sub>2</sub> SCD (QDOAS, Pacific Earthshine ref.)

Tropospheric NO<sub>2</sub> SCD (DOMINO)



Tropospheric NO<sub>2</sub> SCD Error (QDOAS, Pacific Earthshine ref.)

Tropospheric NO<sub>2</sub> SCD Error (DOMINO)



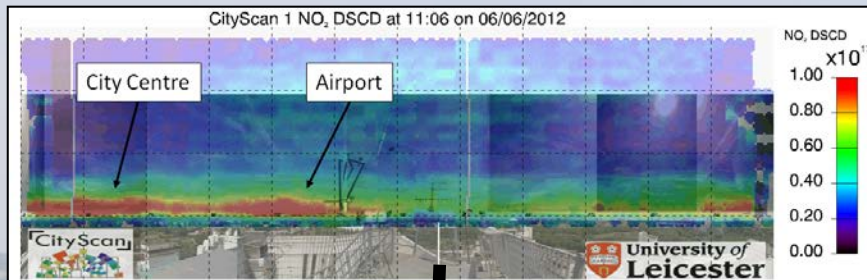
# Mission development

Use of an earthshine reference spectrum for NO<sub>2</sub> from space.

See: Poster by Jasdeep Anand

# The **U**ltra-**C**ompact **A**ir quality **M**apper (UCAM)

A CEOI seedcorn study between the University of Leicester and SSTL

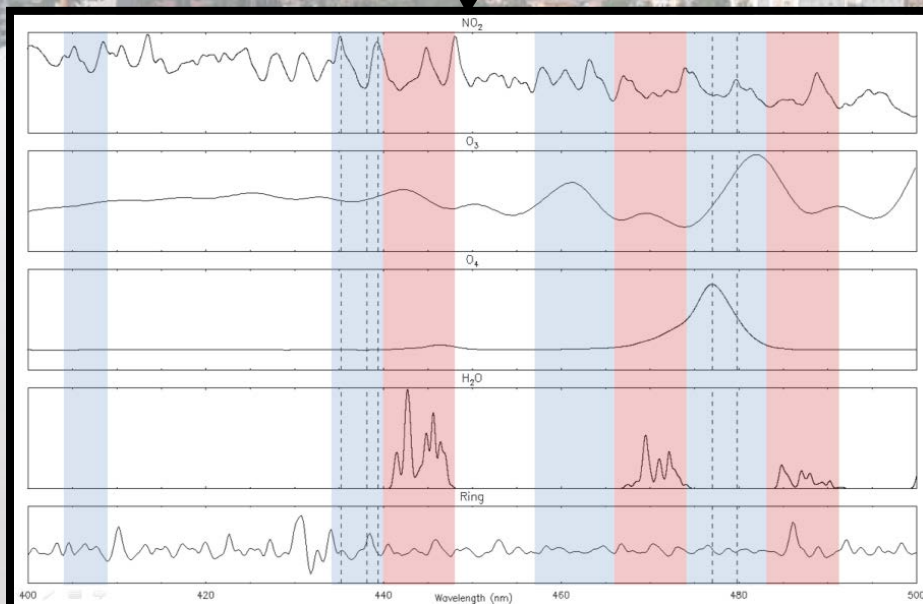


Shoe-boxed size CompAQS  
imaging spectrometer

UCAM pushbroom or full  
imaging NO<sub>2</sub> mapper

- Filter (discrete wavelength) retrieval using a neural network
- Real-time retrieval
- 10% of the volume
- 10% of the mass
- <10% of the data volume

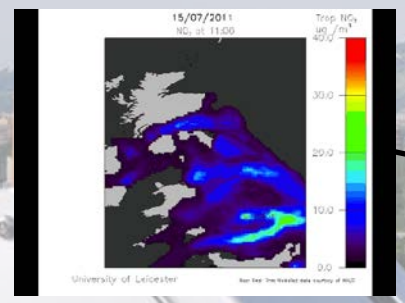
See: Poster by James Lawrence



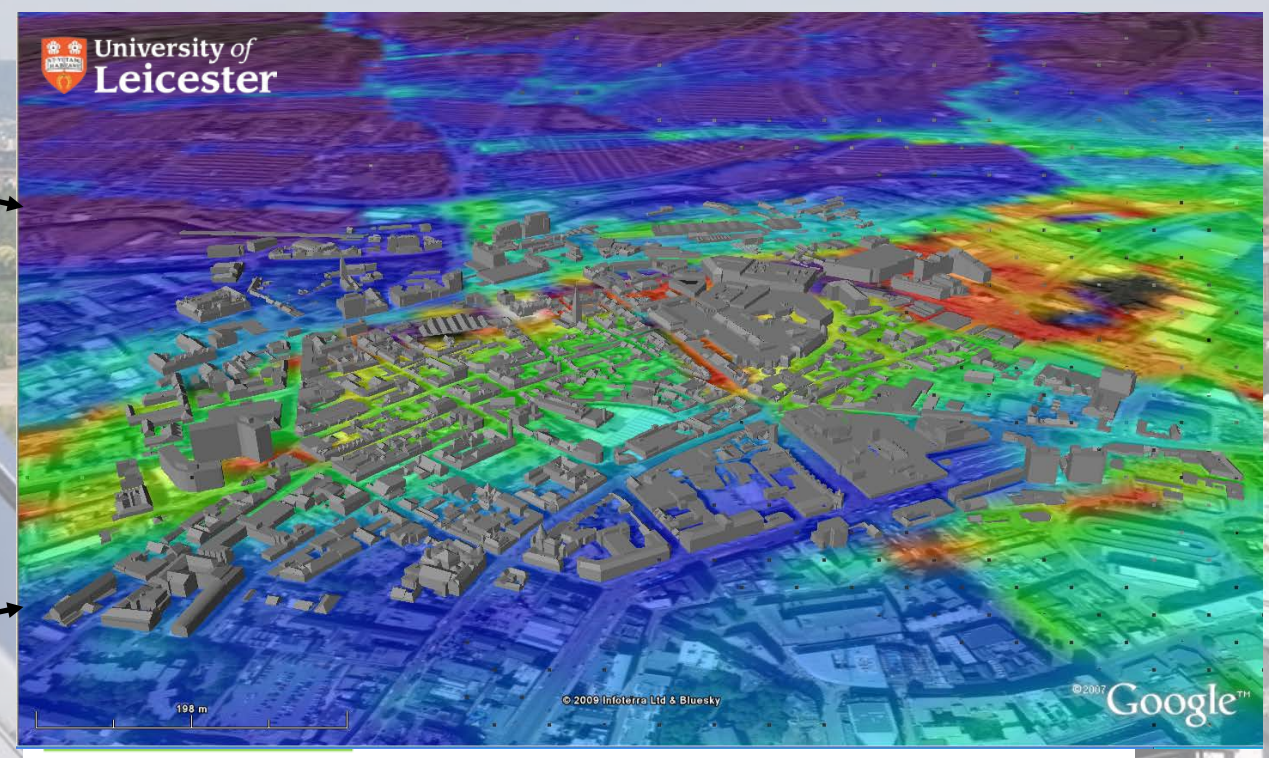
# Applications

## iTRAQ – An integrated traffic and air quality management tool.

Earth Observation Data



AQ measurement and modelling



See: Talk by Roland Leigh – Thursday 2pm Carbon and Climate

# Conclusions

- Imaging NO<sub>2</sub> works well using CompAQS
- CityScan is proving to be a useful demonstration platform for CompAQS while opening a new area of 3D gas field analysis over urban environments.
- UCAM may reduce scales further.
- Mission-enabling developments are underway, including removal of solar reference, and development of smaller, lighter, low-data concepts.
- Applications such as iTRAQ will continue to be developed which make use of remotely-sensed NO<sub>2</sub> data for urban management systems.

# Acknowledgements

- Funding Bodies
  - NERC, CEOI, NCEO, Environment Agency, SSTL, EMDA.
- Air Quality Group Leicester
  - Paul Monks
  - Rosemarie Graves
  - James Lawrence
  - Jasdeep Anand
  - Chris Whyte
- Surrey Satellite Technology Ltd
  - Mike Cutter
  - Dan Lobb
  - Mark Chang

To find out more  
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Email me:  
[R.J.Leigh@leicester.ac.uk](mailto:R.J.Leigh@leicester.ac.uk)