Pollution Monitoring from Ground-Based & Satellite Remote-Sensing

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1. Introduction

Air Quality and Nitrogen Dioxide

- Air pollution can be defined as "*the presence of substances in the atmosphere, resulting from the activity of man or from natural processes, causing adverse effects to man and/or the environment*". (DEFRA)
- "*Clean air is considered to be a basic requirement of human health and well-being. However, air pollution continues to pose a significant threat to health worldwide*" WHO Air quality guidelines for particulate matter, ozone, nitrogen dioxide and sulphur dioxide - Global update 2005.
- Primary sources of air pollutants include combustion products from power generation and motor vehicles. Nitrogen Dioxide is produced in a number of combustion processes.
- Nitrogen dioxide can contribute to the formation of ozone and of secondary particles and is implicated in acidification and eutrophication.
- At relatively high concentrations, nitrogen dioxide may cause:
  - *inflammation of the airways,*
  - *may affect lung function, and*
  - *enhance responses to allergens in sensitized individuals.*
- EU directives have implemented Air Quality Management Areas (AQMAs); these are areas where air quality standards have been, or are predicted to be breached. In the UK there are 215 AQMAs for NO_2.

Nitrogen Dioxide in the United Kingdom", Air Quality Expert Group, p1, 2003
www.theepochtimes.com/n2/content/view/21080/
www.guardian.co.uk/environment/2009/may/12/emissions-pollution-premature-deaths/

Air Quality in Beijing 21/09/08

Air Pollution Over London

2. DOAS

Differential Optical Absorption Spectroscopy (DOAS)

- DOAS is used to derive concentrations of trace gases along a specific line of sight using unique narrowband absorption features in either an artificial light source or an extra-terrestrial light source. Here we discuss only passive DOAS techniques which use solar radiation as the light source.
- The basis for this technique is the Beer-Lambert law which is then enhanced by the inclusion of procedures which compensate for instrument artefacts and atmospheric processes, such as Mie, Rayleigh and inelastic Raman scattering to produce trace gas measurements.

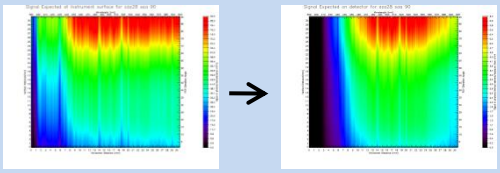
3. CityScan

- CityScan uses an advanced concentric spectrometer design, optimised for DOAS retrievals. (*Whyte et.al , AMT 2009*)
- The instrument has a wavelength range from 420-630nm and can complete a full 360˚ scan every 15 minutes with a 1˚ resolution.
- CityScan measures NO_2 in scattered sunlight in 180,000 different directions in every 360˚ rotation.

The CityScan Instrument

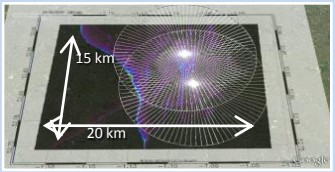
Instrument Modelling

- An instrument model has been developed which takes simulated spectra from the radiative transfer model, SCIATRAN and applies the calculated instrument response in order to give an expected signal at the detector.
- The instrument model takes into account many instrumental parameters. Including the wavelength dependant optical efficiency, exposure time and CCD readout strategies including pixel binning.
- The model outputs are then used to inform decisions regarding the instrument design, primarily regarding optical filters and CCD exposure times.

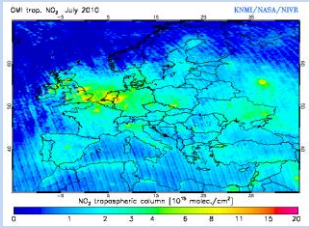


Example model outputs with a concentration of 5ppb NO_2 in the boundary layer. Left, SCIATRAN output. Right, calculated signal on the detector in photons/pixel/sec.

4. Satellite Data



The footprint of two instruments over Leicester illustrating the potential for satellite validation



Example output of NO_2 concentration from TEMIS for July 2010, http://www.temis.nl/.

- The footprint of two or more CityScan instruments will enable rapid measurements over a complete satellite pixel, this will provide an opportunity for satellite validation. The measurements will also allow investigation of the spatial variability within a satellite pixel.
- Data from the OMI instrument, onboard NASAs AURA satellite will initially be used for the investigation of spatial variability as it has a footprint most comparable with the footprint of two CityScan instruments.

5. Deployments

- Testing of two instruments will be performed in Leicester in 2011.
- Two instruments will be deployed in London during the NERC funded ClearfLo campaign in 2011 and 2012.
- Further deployments will take place at London Heathrow during 2011.

6. Summary

- Measurements of NO_2 concentrations, from both ground-based instruments and satellites, will provide enhanced information on spatial variability within an urban environment and at point sources.
- CityScan will produce a dataset with high spatial resolution which will provide a method for investigating the inhomogeneity of NO_2 concentration present within a single satellite pixel.

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