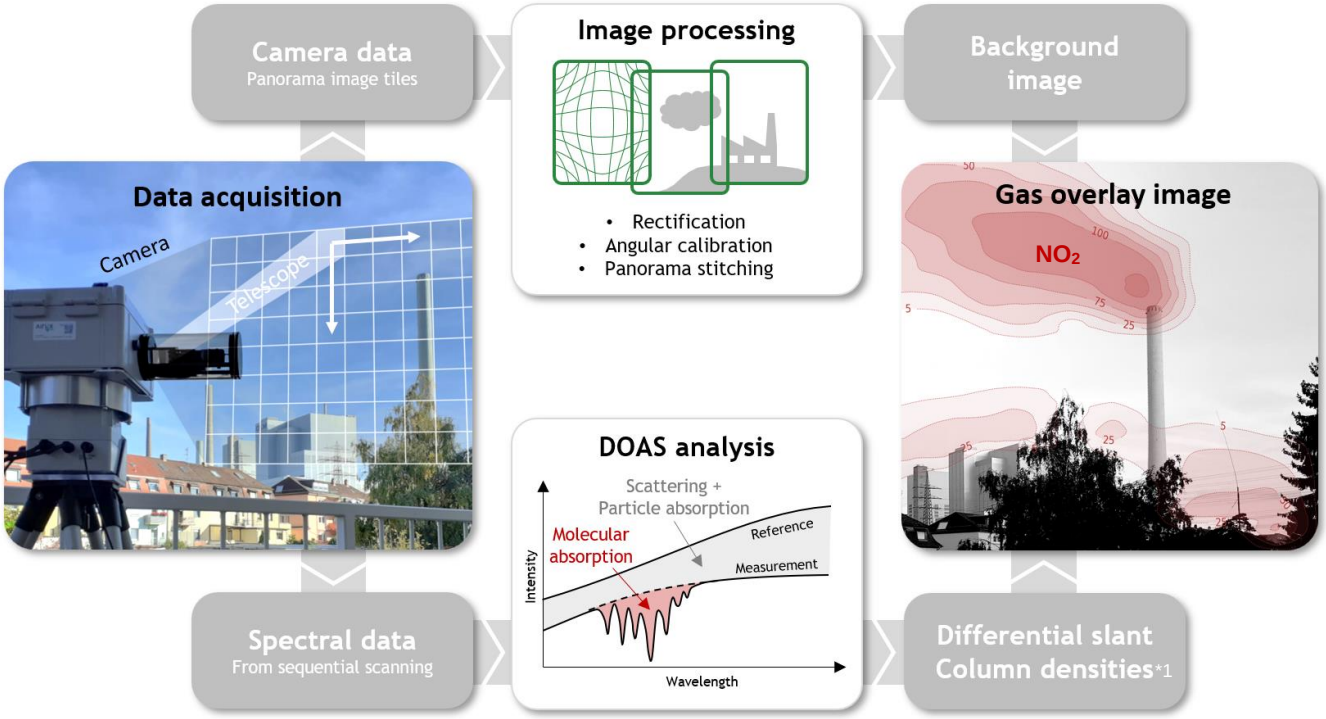
SkySpec Imaging Software-Package

AUTOMATIC PROCESSING OF SKYSPEC SPECTRAL AND CAMERA DATA FOR GAS IMAGING



- Gas camera application with the Sky-Spec instrument
- Detectable gases: NO_2, SO_2, O_4, HCHO, BrO, H_2O, HONO, IO and CHOCHO
- Creates overlays of camera images and gas signal as differential slant column densities (dSCDs[*1])
- Fully automatic data acquisition, spectral evaluation and image processing
- Output provided as images in common formats as well as text-files for further individual processing
- Camera-telescope calibration included
- Portability:
  - Runs on any Windows computer
  - Run on the control computer of your measuring SkySpec to obtain real-time results
- Easy configuration:
  - Scanning area up to 360° panorama
  - Flexible temporal and spatial resolution
  - Flexible image layout and format
  - Adaptable DOAS fit settings

Must be ordered in conjunction with a SkySpec 2D instrument

[1]For definition of differential slant column density (dSCD), see Section "Measurement principle" on page 7 of SkySpec overview datasheet*

EXAMPLE APPLICATIONS

GENERAL MONITORING

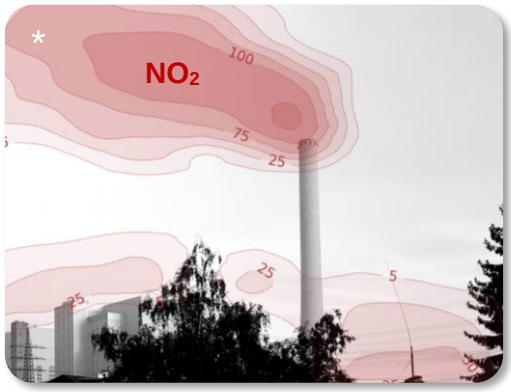
Place the instrument on an elevated location and apply the Imaging Software-Package to turn it into a “gas-webcam”. Monitor large areas from a single measurement location, identify the problematic regions, or study atmospheric transport and chemistry.

Compared to the rather scientific output the standard SkySpec Evaluation-Package, the data product of the Imaging Software-package is much more intuitive and accessible to the broader public. Images are available and ready to publish in near-real-time.

LEAK DETECTION

Scan over industrial facilities to detect gas leaks. Trade sensitivity for temporal and spatial resolution for particularly fast detection.

The software can be configured to raise automatic warnings for each measured gas. Comprehensive filtering and threshold settings are available to maximize reliability.



POINT SOURCE MONITORING

Targeted scanning over point sources allows to determine the spatially resolved composition of point emission plumes (factories powerplants, volcanoes, …) at safe distance of up to several kilometres to potentially restricted or hazardous sources. Emission fluxes of the different gases can be derived with high accuracy when combining the gas signal of the plume with auxiliary wind speed data.

**Articifial data*

PERFORMANCE

HIGHLIGHTS

BENEFITS	PROPERTIES & INNOVATION
State-of-the-art DOAS analysis	• *Automatic spectral correction, including detector nonlinearity* • *DOAS fit accounts for inelastic scattering, spectrometer straylight and I_0-effects* • *Arbitrary gas free direction can be used for reference spectrum*
Full automation	• *Single software package for data acquisition, DOAS evaluation and imaging processing* • *Automatic reinitialization after instrument reboot*
Real-time analysis	• *Watch the image build up while data is recorded* • *Get the complete image few seconds after data recording*
Post-processing	• *(Re-)evaluate existing imaging datasets e.g. with different settings*
Intuitive output	• *Fully processed images in common formats (png, jpg, svg, pdf, …)* • *Trace gas dSCDs as textfiles*
Flexible layout	• *Visualise a single species or multiple gases at once* • *Adapt colors and scales* • *Add or remove indicators for measurement area, telescope sampling locations and other diagnostic parameters* • *Various filtering and interpolation options*
Easy setup & configuration	• *Accurate and stable angular calibration of camera and telescope performed at Airyx* • *Package preconfigured and optimised for your specific instrument to achieve best accuracy* • *Preinstalled and ready to run when ordered with a SkySpec control computer*

GAS DATA SPECIFICATIONS

Values refer to differential slant column densities (dSCD). Values assume free view into the sky with integration time $t_{int} = 10$ s per pixel. Exact specifications depend on atmospheric and lighting conditions. Detection limits degrade when looking onto objects (e.g. for leak detection).

Parameter	Quantity [unit]	NO_2	SO_2	HCHO	BrO	H_2O	O_4	HONO	IO	Glyoxal
Limit of detection (1σ)	dSCD [molec cm^{-2}]	1e15	1e16	8e15	2.5e13	1e22	1e41 *1	5e14	1e13	5e14
Measured SNR (urban)	Signal-to-noise ratio	200	< 0.5	1.3	0.4	30	300	4	< 0.5	< 1
	Assumed dSCD [molec cm^{-2}]	2e17	4e15	1e16	1e13	3e23	3e43 *1	2e15	5e12	5e14
Spatial resolution	Horizontal	Adjustable. Limited by telescope field of view to > 1° per Pixel. Typical number of pixels: $n_h = 15$								
	Vertical	Adjustable. Limited by telescope field of view to > 0.3° per Pixel. Typical number of pixels: $n_v = 15$								
	Notes	Images show bicubic interpolated data								
Temporal resolution	Integration time per pixel (t_{int}) [s]	Adjustable. Typical: 5 to 10 s. Detection limits scale with $1/\sqrt{t_{int}}$								
	Time per image	$n_h \times n_v \times (t_{int} + 2\text{ s})$ → Typical: $15 \times 15 \times 10$ s ≈ 40 min								

*1 *in units of molec² cm⁻⁵*
*2 *in units of %*

BACKGROUND IMAGE PROPERTIES

GENERAL INFORMATION

Background images are by default recorded with the integrated large field of view camera(s), mounted on the azimuth motorized telescope housing. The camera viewing elevation is fix. An azimuthal panorama image covering the user defined measurement-area is recorded automatically during measurement.

See “Example Data” section for example background images.

DEFAULT CAMERA PROPERTIES

Parameter		Single camera image	Background panorama image
Resolution	Horizontal [px]	720	Up to ~2200 (for 360° panorama) *3
	Vertical [px]	576	Up to ~720 *3
	Angular [px/°] *1	6	~6 px *3
	Comment	Standard PAL format, fisheye appearance	Composition of multiple rectified images covering the scanned area
Camera axes motorisation	Pan/azimuth	Motorized over 190° range → Two cameras on opposite sides required for full 360° coverage.	
	Pitch/elevation	Fixed (mounted on upper rotating telescope housing)	
Field of view	Vertical	Vertical: ~80° from -10° to 70° viewing elevation, adaptable	Adapts to scanned area limited by camera vertical field of view
	Horizontal	120°	Up to 360°, adapts to scanned area
Angular calibration accuracy*2	Vertical	~1°	
	Horizontal	~0.5°	

**2 Only applies for objects in far distance compared to camera-telescope-parallax.*
**1 Varies over image due to distortion/rectification*
**3 Effective resolution, technical resolution can be higher since image rectification involves oversampling*

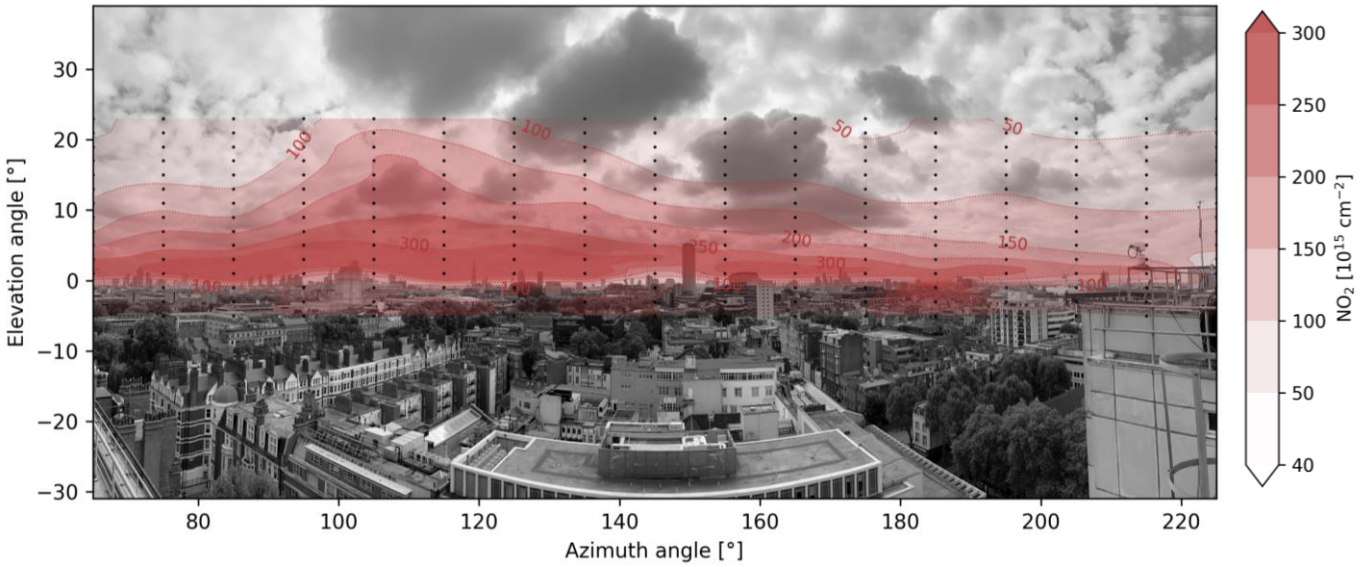
HIGH RESOLUTION IMAGE SERVICE

For long-term measurements at a fixed location, Airyx offers a service to permanently integrate a high-quality image of the environment into the evaluation routine. Record a panorama image for instance with your SLR and Airyx will perform the angular calibration and integration into the evaluation routine.

EXAMPLE DATA

EXAMPLE RESULT

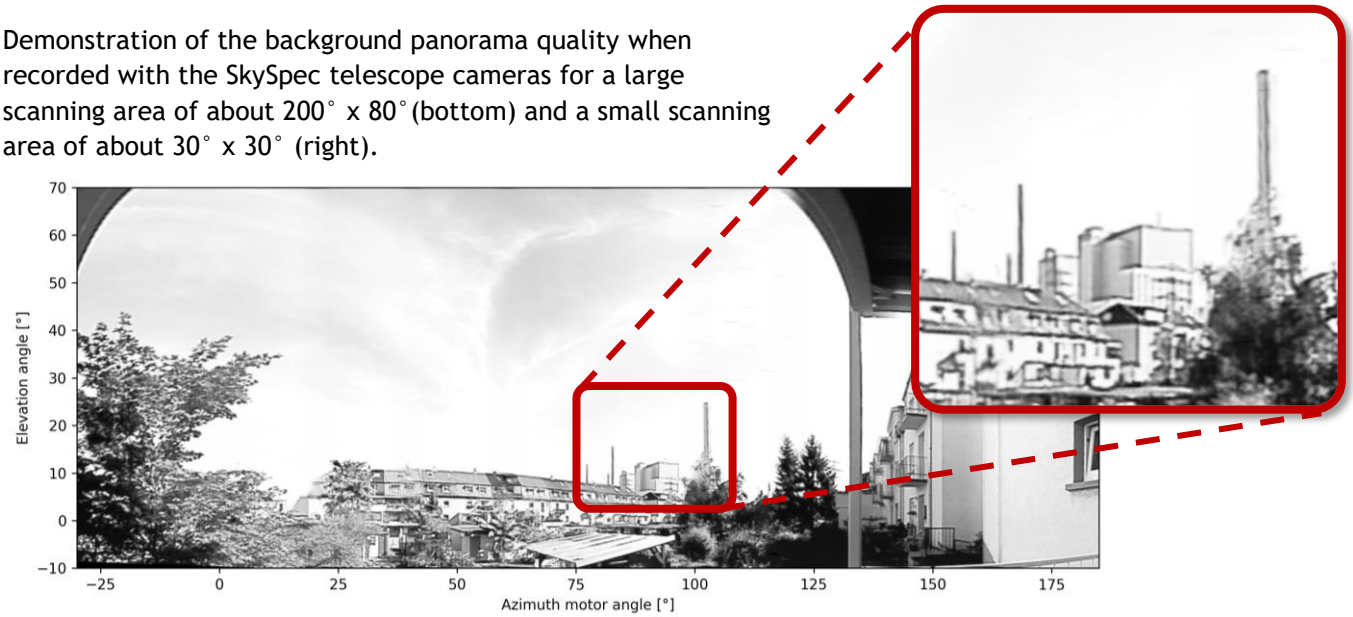
Image of NO_2 above the London skyline as produced by the Software. In this example, indicators of actual telescope sampling points (black dots), angular axes, isolines and color-bar have been activated. For the background image, the “high resolution image service” (see above) was applied.



Measurements performed in cooperation with Robert Ryan, Eleanor Smith, Karn Vohra and Eloise Marais, Department of Geography, University College London.

DEFAULT BACKGROUND IMAGE

Demonstration of the background panorama quality when recorded with the SkySpec telescope cameras for a large scanning area of about 200° x 80° (bottom) and a small scanning area of about 30° x 30° (right).



For further example data of spectra, dSCD time series and DOAS fit results, see the “SkySpec Overview and Evaluation Package” datasheets