SkySpec unique Advantages

FAST AND ACCURATE POINTING FOR UV/VIS/IR REMOTE SENSING

Airyx SkySpec instruments are optimized for passive DOAS (Differential Optical Absorption Spectroscopy) applications according to VDI standard 4212. This optimisation comprises a number of unique advantages, of which many are crucial for accurate trace gas remote detection.

OPTIMIZED SPECTRAL RANGE

Focus on spectral range between 300 and 550 nm, which covers the absorption bands of nearly all UV/Vis detectable atmospheric gases.

HIGH SPECTRAL RESOLUTION

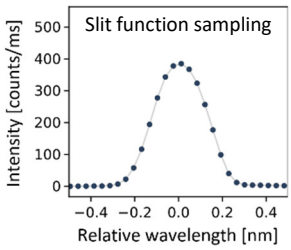
High Spectral resolution of < 0.5 nm (two spectrometer option) or < 0.7 nm (single spectrometer option) and a variability < 10% over the spectral range. This resolution is required to resolve the major features of typical gas absorption patterns with high quality.

SMALL FIELD OF VIEW

SkySpec field of views (FOV) are small, particular in the vertical direction (< 0.3° FWHM), which is an important prerequisite for the retrieval of trace gas and aerosol vertical profiles from passive DOAS observations at multiple viewing elevations. Larger FOVs increase the overlap of received light paths and violate various assumptions taken by current retrieval algorithms, ultimately degrading the vertical resolution and the accuracy of the retrieved profiles.

HIGH SPECTRAL SAMPLING

In contrast to most artificial light sources, sunlight (before entering Earth's atmosphere) exhibits strong spectral variability. Even tiny spectral shifts between recorded spectra can induce significant systematic errors in the DOAS evaluation if the spectrum is under-sampled (Platt and Stutz, 2008). This is often ignored but has been considered in the Airyx SkySpec spectrometer design. With more than 5 discretisation points (detector pixels) over the typical spectrometer slit function FWHM, SkySpecs achieve exceptional detection limits and low systematic errors compared to instruments of competitors.



INTEGRATED ELEVATION SENSOR

Particularly aerosol and trace gas vertical profiling applications require a high accuracy in viewing elevation. SkySpec telescopes feature an automatic real-time elevation correction, based on an integrated inclination sensor. The latter has been carefully calibrated and characterised at Airyx GmbH to achieve elevation angle accuracies better than 0.1 degree (1σ). This strongly simplifies operation for the user, since laborious alignment procedures (as for instance described in Donner, 2020) become obsolete. Furthermore, the real-time elevation correction makes SkySpec instruments ideal for applications on moving platforms like ships or cars.

HIGH LIGHT THROUGHPUT

The following SkySpec features maximize light throughput and thus minimize photon shot noise:

- Telescope and spectrometer are concerted to minimize loss of light
- Special backthinned CCD detectors feature high quantum efficiency, particularly in the UV spectral range
- Cross-section converting fibre bundles between telescope (fibres arranged in circular pattern) and spectrometer (fibres arranged in slit configuration) guarantee large throughput while maintaining a small field of view and a high spectrometer resolution.

HOMOGENEOUS SPECTROMETER ILLUMINATION

Homogeneous illumination of the spectrometer even when observing inhomogeneously illuminated scenes (e.g. cloud-edges) is achieved via mode mixing optical fibres between telescope and spectrometer.

NO POLARISATION-BIASES

The optical design of SkySpecs - particularly the presence of an optical fibre and the absence of mirrors – prevents polarisation sensitivity and resulting biases.

DIRECT-SUN AND SCATTERED-SKYLIGHT

Direct-sun and scattered skylight observation modes require different instrument optical properties:

- The extreme radiance difference of about 10^5 requires to adapt the instrument sensitivity.
- An additional homogenisation is required as the spectral properties of the Sun's emitted radiation strongly vary over the solar disc.
- While a small field of view (~0.3°) is desirable for scattered skylight profiling applications, a larger field of view (few degree) is necessary for direct-sun observations, to cover the entire solar disc

SkySpec 2D instruments approach these issues using a purpose-built motorised diffusor system, which can be moved into the telescope optical axis to switch between both modes and optimize the telescope properties correspondingly. Switching takes place within seconds. The SkySpec 2D is currently the only commercially available instrument which can provide high quality data for both modes.

SPECTROMETER STABILITY

Spectrometer properties (wavelength calibration, dark-current, offset, non-linearity, stray-light) are recorded at Airyx. Rugged construction and active temperature stabilisation (stability better than +/- 0.03°C) ensure exceptional stability. Furthermore, an optimized design of the optical spectrometer-telescope interface allows to (dis-)assemble the instrument without affecting any of the crucial properties. Calibration data recorded at Airyx can be used for DOAS applications over years, which strongly simplifies the data acquisition and evaluation procedures.

MINIMUM OUTSIDE MOVING PARTS

To minimize/simplify maintenance and to achieve exceptionally long lifetimes even under harsh environmental conditions, critical opto-mechanics is covered in a quartz glass cylinder. SkySpec 1D, Compact and Mini feature no (!) outside moving parts. 2D SkySpecs feature a single well protected outside axis for azimuthal movement.

LOW SPECTROMETER STRAYLIGHT

Color filters on the entrance slit and a special optical bench design in the spectrometers minimize internal stray-light (<1% over typical DOAS fitting ranges). Airyx evaluation algorithms further contain straylight corrections to remove any remaining systematic biases.

LOW POWER CONSUMPTION

Average power consumption of only ~30 W. Flexible supply e.g. via 12 V mains adapter, batteries or car cigarette lighter.

Literature:

Platt and Stutz: Differential Optical Absorption Spectroscopy, vol. 1, Springer Berlin Heidelberg, DOI: 10.1007/978-3-540-75776-4, 2008

Donner et al.: Evaluating different methods for elevation calibration of MAX-DOAS (Multi AXis Differential Optical Absorption Spectroscopy) instruments during the CINDI-2 campaign, Atmos. Meas. Tech., 13, 685–712, https://doi.org/10.5194/amt-13-685-2020, 2020.