Application Note AN M158

3-D Reconstruction of Gas Clouds by Passive Infrared Spectroscopy and Tomography

Keywords	Instrumentation and Software
Imaging Remote Sensing, Tomographic Reconstruction, 3-D Cloud Model, Cloud Distance, Cloud Dimensions, Concentration Distribution	SIGIS 2, HI 90, OPUS RS Tomography Software Module (1828156)

Introduction

Imaging remote sensing by Fourier transform infrared (FTIR) spectroscopy provides a method of identifying gaseous compounds from long distances and for generating (2-D) images of gas clouds that are otherwise invisible to the human eye. The dimensions, as well as the location of the source of the gas cloud can quickly be assessed. However, the distance between the observer and the cloud and the dimensions of the cloud along the line of sight are not available if a single image is measured. If images of the cloud are measured from at least two different positions at the same time, the 3-D shape and the position of the cloud becomes available. Moreover, the concentration distribution of the compound within the cloud can be calculated from the retrieved column densities.[1]

Imaging remote sensing is a well-established technique used by first responders and emergency response forces worldwide to identify and visualize dangerous gas clouds from safe distances and to assess the dimension, propagation direction and the source of a gas cloud. The technique is also implemented in the industry for permanent monitoring of chemical plants for emissions and potential gas leakages, as well as to secure critical infrastructure against threats of chemical accidents or attacks.

3-D Visualization of Gas Clouds

An FTIR imaging remote sensing system generates 2-D projection images of the gas cloud. The position and propagation direction of the cloud is displayed in an intuitive way

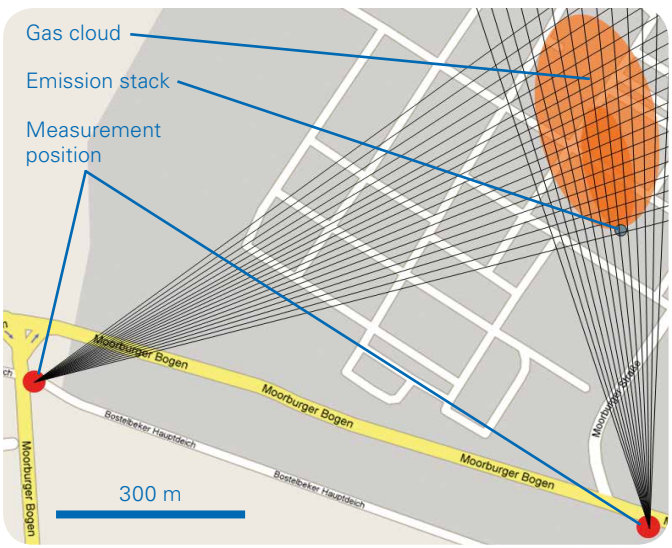

Figure 2: Gas cloud emitted from an industrial emission stack measured from two different positions to retrieve the 3D-shape and the position of the cloud.

as an overlay of a video image and the result of the spectral analysis. To pinpoint the location of a cloud in space and to generate a 3-D cloud model, at least two systems are used. The cloud position, as well as its dimensions can be calculated and oftentimes the gas concentration distribution within the cloud can be determined from the column densities.

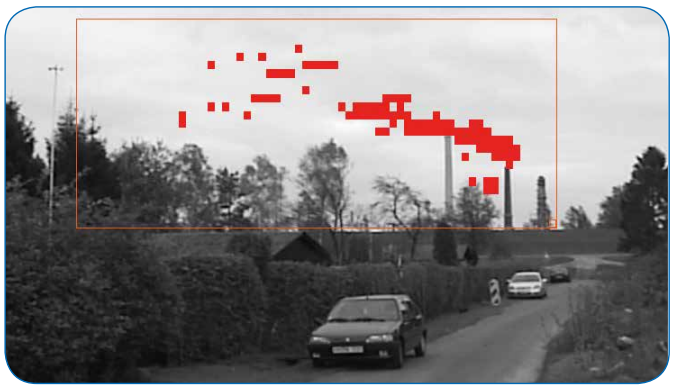

Figure 3: 2-D identification image of a gas cloud above an industrial emission stack of a refinery measured by the SIGIS 2.

Tomography Software Module for OPUS RS

The tomography software module (1828156) for OPUS RS calculates a 3-D model of a gas cloud by tomographic reconstruction from two 2-D images of a gas cloud. The two images must be measured at the same time by two imaging remote sensing systems under a permissible observing angle α between the two systems and the cloud, with $5° < \alpha < 175°$ since a tomographic reconstruction is not possible if the two systems are in one line with the gas cloud.

As an output a **kml file** is generated that is compatible with typical GIS software such as **Google Earth**™ or **ArcGIS**™.

Tomography software module for OPUS RS
for two passive imaging FTS (1828156):

- Generates a **3D model by tomographic reconstruction** from two measured images of a gas cloud.
- Output compatible with typical **GIS software**.
- The 3D model gives the cloud position, **distance** and dimensions.
- Often the **concentration distribution** can be retrieved.

By means of evaluating 2-D column densities together with the retrieved cloud model the concentration distribution of a compound within the cloud can be calculated with tomography algorithms.

Figure 4: 3-D identification model of a gas cloud above an industrial emission stack displayed in Google Earth™.

As an additional feature, basic control parameters can be automatically be sent to the two systems in order to find a cloud from a second system, after it has been identified from the first system. The 3-D models are then generated automatically upon simultaneous and geometrically matching data arrives from both systems at the evaluation computer.

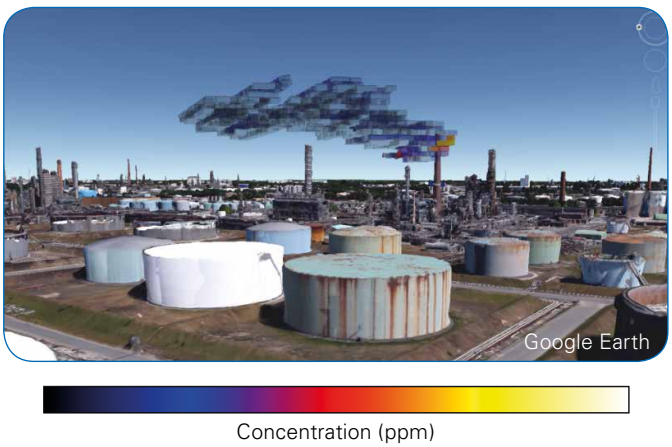

Figure 5: Three-dimensional concentration distribution of an ammonia cloud around an industrial emission stack viewed in Google Earth™. Light colors indicate high and dark colors indicate low concentrations.

References

1 P. Rusch, R. Harig, 3-D Reconstruction of Gas Clouds by Scanning Imaging IR Spectroscopy and Tomography, IEEE SENSORS JOURNAL, VOL. 10, NO. 3, MARCH 2010.

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