The COMTESSA project: Tomography of artificial SO_2 plumes with multiple SO_2 cameras for improving our understanding of plume dispersion and turbulence

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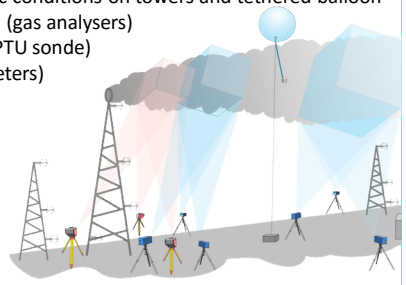
Experiment

Controlled release of trace gas SO_2 from tower

- Observation of SO_2 column densities from multiple viewing directions using SO_2 cameras (both UV and IR)
- Observation of atmospheric conditions on towers and tethered balloon
  H_2O and CO_2 concentration (gas analysers)
  Boundary layer structure (PTU sonde)
  Wind field (sonic anemometers)



SO_2 Cameras

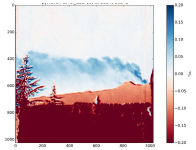


Fig: SO_2 camera image of Mt.Etna

Fig: new SO_2 cameras

SO_2 cameras deliver SO_2 column density images based on measured images of backscattered sunlight at different wavelengths. A set of 9 SO_2 cameras was developed to meet the requirements of COMTESSA in respect of spatial and temporal resolution.

	6 x UV	3 x IR
Camera Model	PCO.ultraviolet (dual camera)	Xenics Gobi-384 (triple camera)
Wavelength Bands	310 & 330 nm	8.6, 10 & 11 µm
Max. frame rate [Hz]	7.3	84
FOV [°]	14.7 x 11.1	13.7 x 10.3
Resolution [pixel]	1392 x 1040	384 x 288
Focal Length [mm]	25	40
Weight [kg]	8.3 + 11.6	7.5 + 11.7
Dimensions [cm]	21.5 x 21.5 x 29 28 x 25 x 45	21.5 x 23 x 26 28 x 24.5 x 40

Camera Observations and Modelling of 4D Tracer Dispersion in the Atmosphere

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1/11/2015 – 31/10/2020
Experiments: every year in spring & summer
Military facilities in Norway
High-resolution 4D tracer concentration field

COMTESSA's vision is to elevate the theory and simulation of turbulent tracer dispersion in the atmosphere to a new level by performing completely novel high-resolution 4D measurements.

Goals

SO_2 Camera technique
- Validation of SO_2 retrieval
- Comparison of UV and IR imaging

Tomography
- 3D reconstruction of SO_2 plume
- 3D optical flow analysis

Turbulent dispersion
- Richardson-Obukhov constant
- Parameterizations for Lagrangian models

Atmospheric boundary layer
- Test of Richardson-Obukhov law
- Relative dispersion and meandering of plume and puffs
- Statistics of velocity vector field and scalar concentration field
- Two-point concentration structure function

Modelling

Large Eddy Simulations

LES are used to examine the characteristics of the scalar field dispersing from a localized small source under a wide range of atmospheric boundary layer conditions

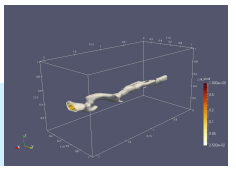

Fig: Low resolution simulation of the dispersion from a continuous tracer release in a neutrally stratified boundary layer generated in a wind tunnel.

Radiative Transfer Simulations

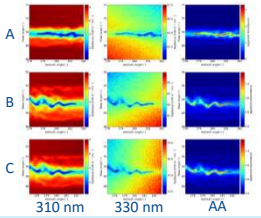

Fig: Intensities at 310nm (left), 330nm (middle) and apparent absorbance (right) as seen from locations A, B, C

Wavelength-selective intensity images as seen by the SO_2 cameras of the above concentration field are simulated using libRadtran and MYSTIC.

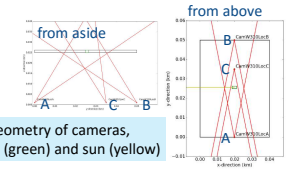

Fig: Geometry of cameras, plume (green) and sun (yellow)

Tomographic 3D reconstruction

Poster X5.492 Thu 17:30-19:00: Tomographic iterative reconstruction of a passive scalar in a 3D turbulent flow

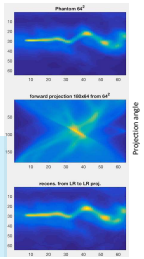

Fig: 2D Reconstruction of the integrated concentration field of the above LES. The phantom (upper panel) was forward projected to a sinogram (middle panel). The latter was then used for the reconstruction of the concentration field (lower panel)

Further Reading

Tracer experiments: Hanna 2010 16th Conference on Air Pollution Modelling
SO_2 plume imaging: Platt et al. 2015 J. Vol. Geo. Res (300) 7-21
Radiative Transfer: Emde et al. 2016 Geosci. Model Dev., 9, 1647–1672, 30
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Interested in knowing more?

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