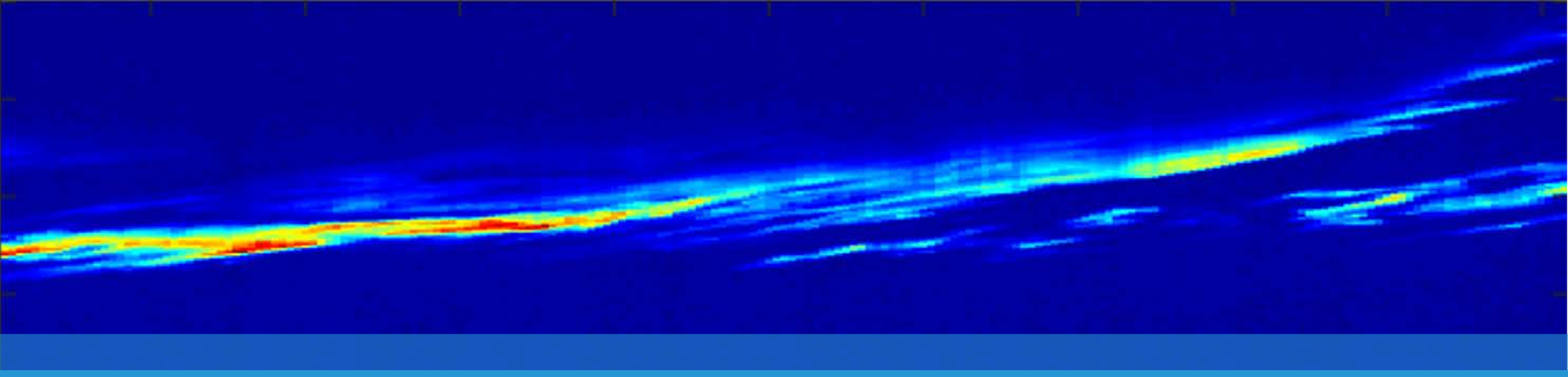


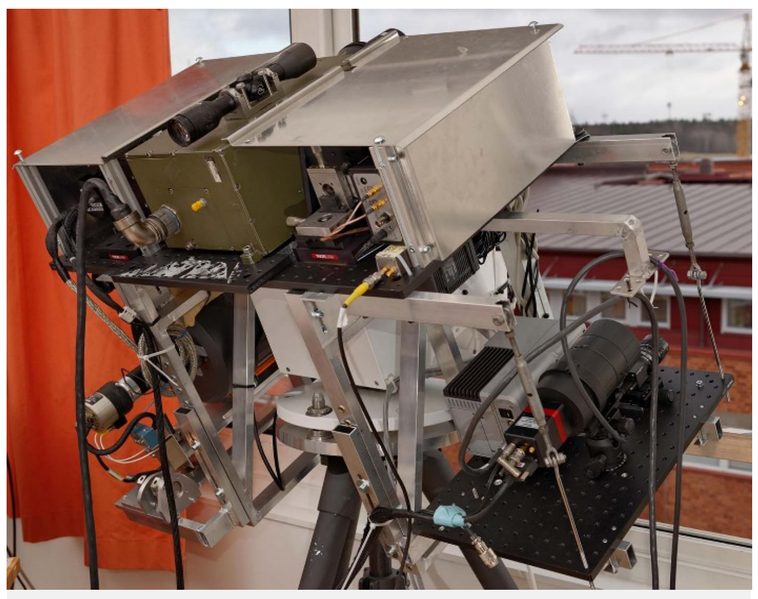
Cloud monitoring using Eye safe lidar and passive EO sensing

A study of low clouds, mostly cumulus clouds at altitude below 2 km, were performed using a lidar and images from different passive sensors. The aim was to combine eye safe lidar (1550 nm) data with camera images in the visible, short wave infrared (SWIR) and infrared (IR) to better estimate the cloud density and cloud coverage.

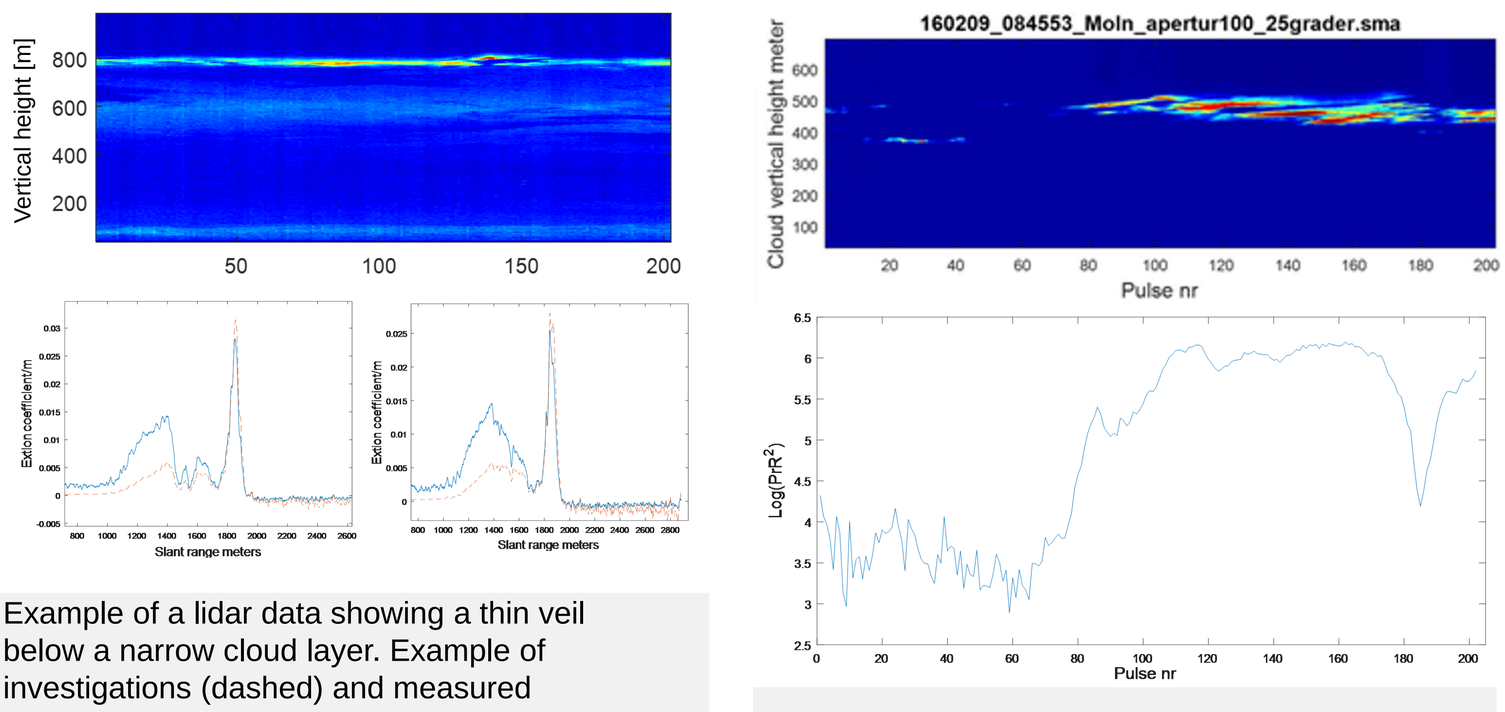
Authors

Ove Gustafsson, Ove Steinvall and Folke Berglund

FOI, Swedish Defence Research Agency

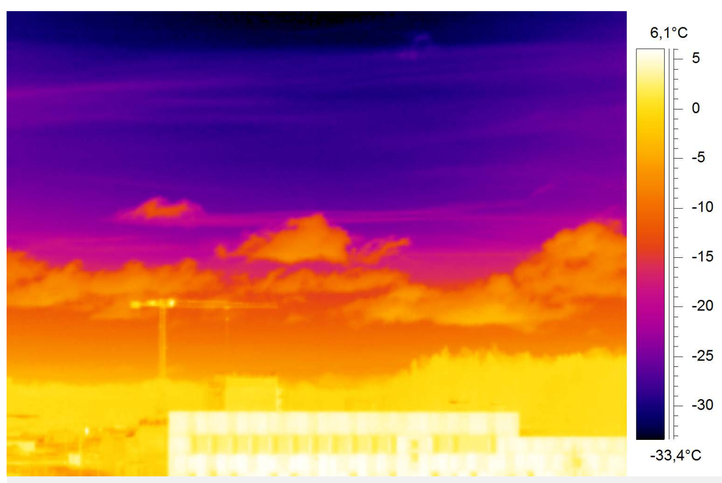


- Laser
- Two receivers with optics
- Data acquisition for the detector signals
- FLIR camera for infrared 8–9 µm
- SWIR camera for the 0.4–1.7 µm range
- VIS camera for RGB-imaging
- Hemispherical camera for whole-sky views



Example of a lidar data showing a thin veil below a narrow cloud layer. Example of investigations (dashed) and measured waveforms (full) to estimate the extinction variation along the cloud. The one-way integrated optical density (OD) transformed to height are 0.13, 0.15, respectively.

Example of cloud returns for 203 pulses. The colour coded cloud density and below the sum of $log(P_r R^2)$ compensated signal for each waveform which correlated well with the colour intensity cloud map.



IR-camera

The IR camera *ThermaCAM SC3000* from FLIR systems is sensitive for LWIR (8–9 µm) radiation. It has a view of field of 20° x 15° and 320 x 240 pixels resolution. All three cameras is controlled by a computer saving one picture each second.

SWIR - camera

The Short Wave InfraRed camera (0.4–1.7 µm), *OWL SWIR 640* from Raptor Photonics, is sensitive to both the visible and the SWIR range used. The field of view is 5.5° x 4.35° and the sensor resolution is 640 x 512 pixels.

Visible-camera

The third camera mounted on the pan & tilt head is a *Flea 3 GigE* from Point Grey. It is a small 1280 x 960 pixels colour camera that registers the visual spectrum with a field of view of 5.5° x 4.1°.

Conclusion

Clouds between 0-2 km often showed a layered structure.
Limited optical density probably allowing for observation through the cloud.
The comparison between the camera image intensities and the integrated range corrected lidar signals showed both negative and positive correlations.

The highest and positive correlation was obtained from comparing the lidar with the cloud temperature as derived from the FLIR camera
Under certain conditions the cloud which was dark in the SWIR appeared as white in the visible camera.