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# UNDER COVER

## Thermal all-sky imagers capture cloud positioning in the blink of an eye, day and night

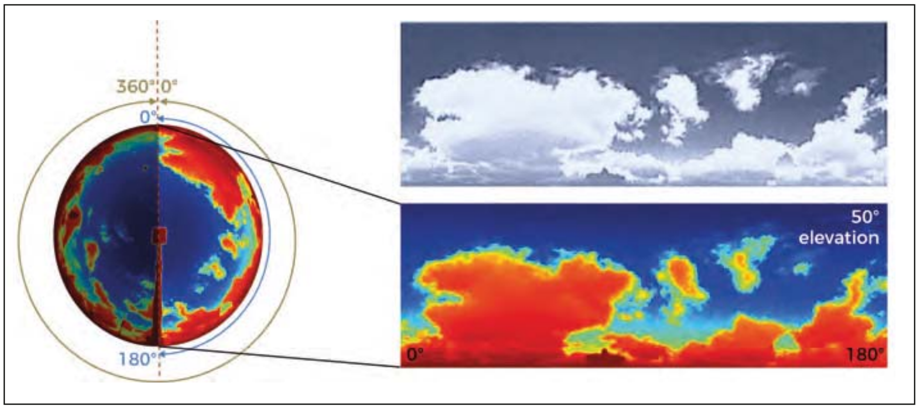
Reporting on cloud cover from the ground is essential for various applications, particularly small-scale weather modeling processes, short-term solar energy forecasting, air traffic management, UV radiation studies, astronomical observations and long-term records of local atmospheric processes for climate studies.

The biggest areas of interest for cloud reporting are cloud cover, cloud height and, to a greater extent, cloud classification (low, middle, high).

To function efficiently, air traffic controllers at airports need real-time sky images from all around the facility. A real-time view of the surrounding sky at all times, day and night, helps observation of the evolution of convective clouds and improves the airport's safety against potential weather hazards. Also, having predictive information about cloud cover – ranging from half a minute to half an hour ahead – helps prepare for sudden changes in the weather and visibility.

The need for precise cloud-cover reporting and a 2D map of irradiance at ground level is also growing in importance for the field of solar plant operations. Indeed, accurate power forecasts from photovoltaic or concentrated solar power are necessary for the efficient integration of variable solar resources. Very short-term forecasting based on the use of thermal sky imagers is particularly sought-after for microgrid hybridization projects. If solar energy is installed to reduce the fuel consumption of generator sets (gensets), a cut of over half can only be achieved with trustworthy information on the arrival of clouds – to give time to prepare the thermal units.

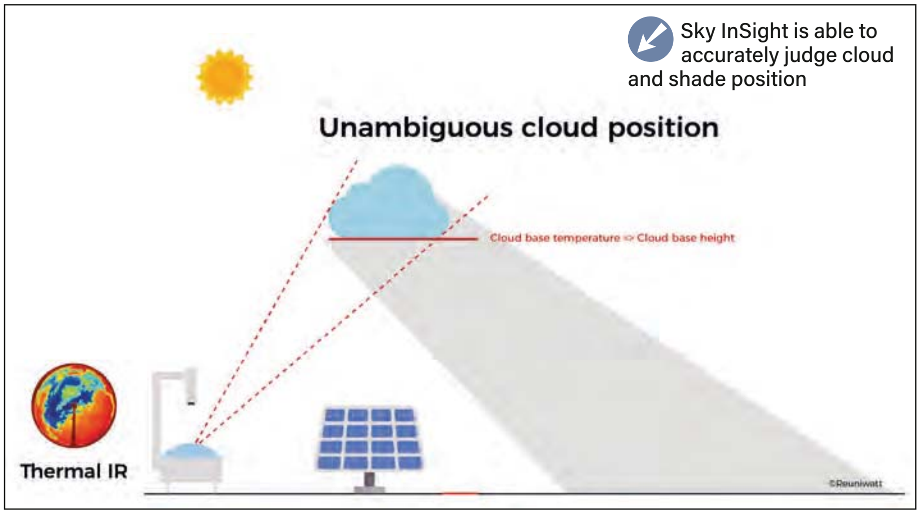
Panoramic layout of hemispherical images taken by the thermal sky imager




### DAY AND NIGHT CLOUD COVER

Ground-based all-sky imagers observe macroscopic clouds automatically at high temporal and spatial resolution at an affordable price. They avoid the subjectivity of an observer and greatly reduce costs for ground-based cloud observations.

Some modern cloud-reporting techniques include the use of ceilometer data, but these are not accurate enough for airport use due to the high spatial and temporal variability of the sky around such locations, which may strongly differ from the zenithal line-of-sight of the ceilometers. This technique and others involving human observers have also been shown to have a tendency to overestimate the cloud cover.




Sky InSight is able to accurately judge cloud and shade position

All-sky imagers can fulfill the task of autonomous cloud cover reporting, with various qualities depending on the capacity to deal with sun ray orientation effects. Visible cameras are affected by sun glare and by grazing light. They also don't collect information at night. Thermal infrared imagers, such as the Sky InSight by Reuniwatt, have no such limitations as they can see day and night with the same accuracy and automatically provide cloud-cover and cloud-fraction observations every 30 seconds. A panoramic view of the sky is also produced and sent to air traffic controllers or forecasters in any remote place to help them make the right decisions.

## CLOUD HEIGHT SENSING

Cloud imagers can retrieve the cloud amount and the cloud base height (CBH). Again, this parameter is extremely useful for main applications such as weather and solar power production forecasting. During the day, stereographic analysis using overlapping scenes can be applied with two or more visible cameras. This technique excludes the first and last hours of daylight due to low sun elevation. Also, the cameras must be at a sufficient distance from one another – from one to several miles – which raises operational constraints for installation, maintenance and communication.

Thermal all-sky infrared imagers work on the variability of the long-wave radiation received, which is related to the height of the clouds. Thus, the cloud information is measured from a single position.

## INTELLIGENT CLOUD IMAGER

The CBH retrieval method is based on a machine-learning algorithm, integrating a multilayer artificial neural network. The algorithm is trained on an observation site that benefits from being able to reference CBH collocated data, as would be provided by a ceilometer facing a certain direction.

The measured numerical counts for the pixels of the camera corresponding to the pointing area of the lidar beam have been spatially averaged to be comparable with the reference CBH.

The results displayed in Figure 1 show the actual comparison with a reference lidar in a tempered mid-latitude site. It shows a linear agreement between the CBH values retrieved with the Sky InSight and those observed by the lidar, with a fairly good correlation of 86%. High CBH presents a small bias, explained by the thinness and semi-transparency that characterizes most clouds at these altitudes.

There are two main reasons for inaccurate low CBH readings: vertical accumulation of high clouds can be seen as a low cloud; and averaging low cloud borders and clear skies can lead to an erroneous higher CBH.

To minimize these false detections, Reuniwatt's engineers have recently added a multiple cloud flag function and better detection of cloud edges. It helps solve the issue of low clouds below 1km (0.6 miles). At airports, Sky InSight can be combined with ceilometer information for detecting very low CBH, which is key for airport safety. No doubt the instrument will be present in the observation packages of new and modernized airports and used to largely improve the solar production forecasting. ∎

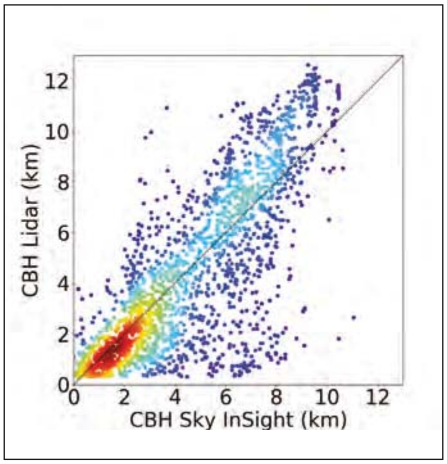
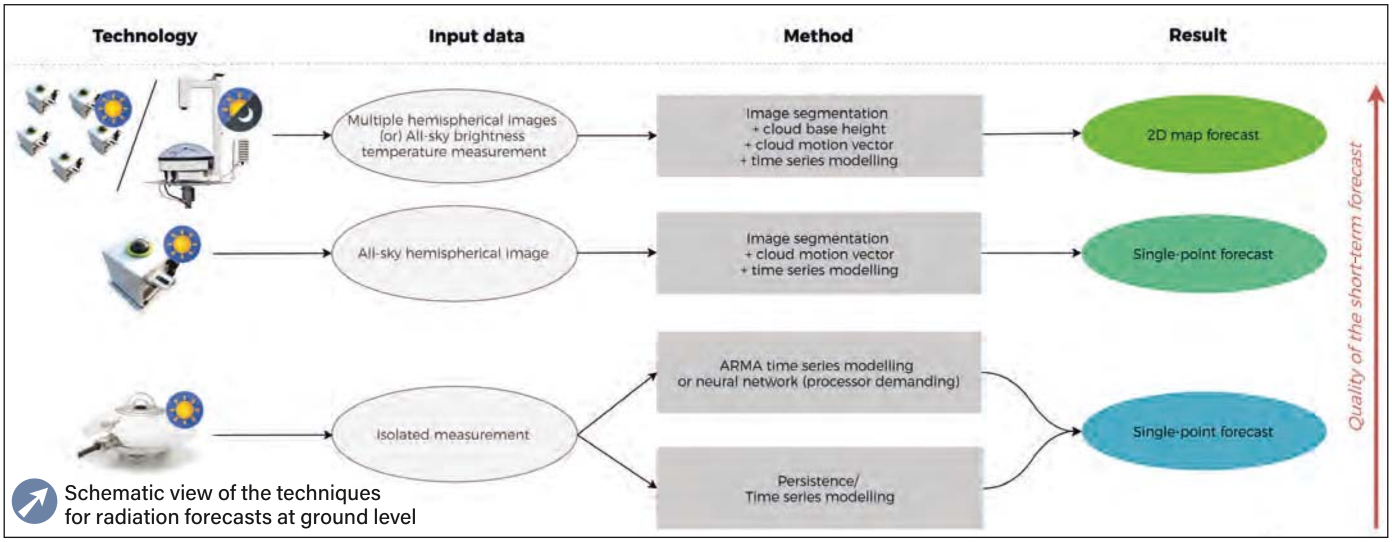



Figure 1: Comparison of cloud base height calculated by the Sky InSight and by lidar




Schematic view of the techniques for radiation forecasts at ground level