Remote sensing instruments

Since Dobson constructed his first ground based ultraviolet spectrometer to measure total ozone in the 1920's, a great variety of atmospheric remote sensing instruments and techniques have been designed. The techniques cover different parts of the electromagnetic spectrum, and are founded on different physical properties such as scattering, emission, refraction, transmission (occultation), etc. Remote sensing techniques are generally divided into two main parts; passive and active. In addition, many different geometries are available, such as zenith, nadir, slant or limb, which can be applied for ground based or space borne platforms, see figure below.

The focus will be on satellite measurements.

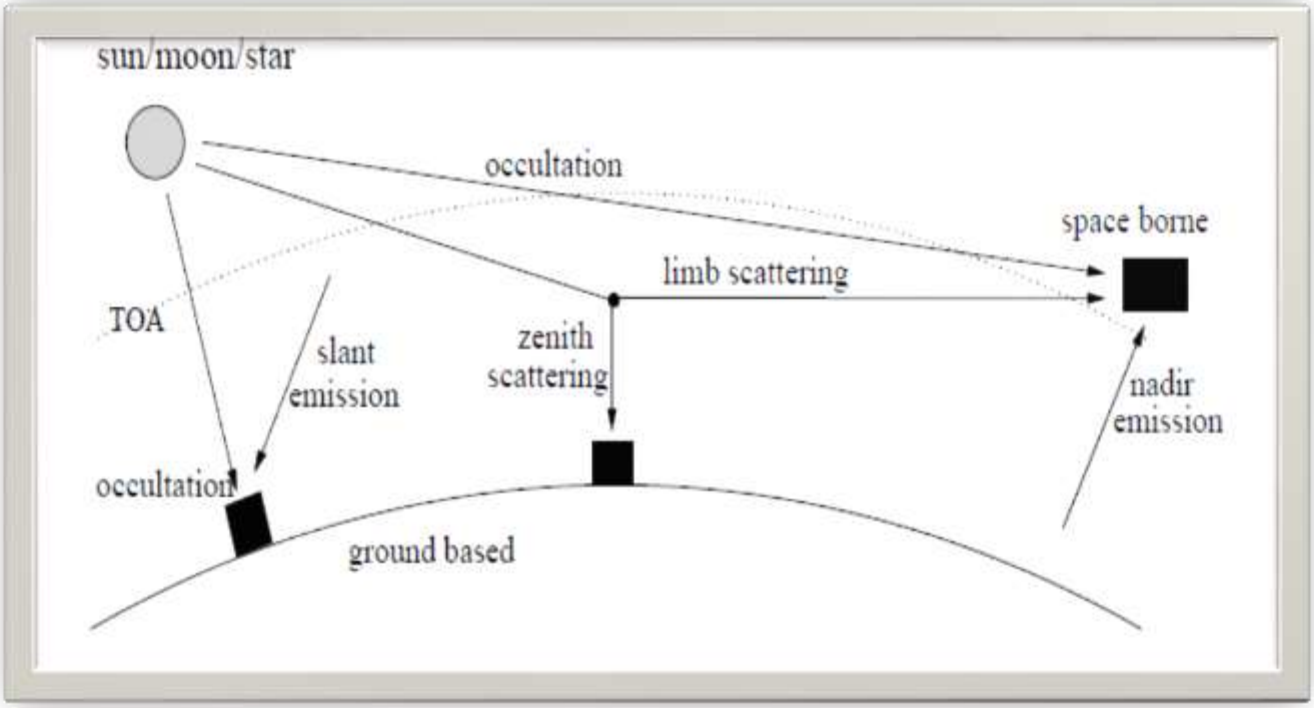
1- Remote sensing platforms

Many possible platforms for atmospheric remote sensing, with their specific advantages and disadvantages, can be identified. Ground based instruments are maintainable and stable which is useful for providing long time series, however they give poor spatial coverage and are generally sensitive to tropospheric clouds, turbulence and water vapor. Balloons may be used to measure profiles with high vertical resolution and can reach the stratosphere (up to 35 km).

Their major disadvantage is that their flight track cannot not be actively controlled and their limited coverage. Aircraft can be used for controlled flights up to 20 km and can provide better coverage, but are not suitable for global measurements with spatial, temporal and vertical resolution.

Satellites are suitable for global coverage measurements an a daily basis. Geo-stationary orbits with an altitude of 35900 km give continuous measurements with high temporal resolution but are limited to 60̊ coverage in longitude and may only be used efficiently up to latitudes of ±60̊ Near polar low Earth orbits (LEO) with altitudes of 600-850 km will give near global coverage. Satellites are expensive and have a lifetime limited to a few years, which make long time series impossible.

Multi satellite missions with similar instruments may of course provide better temporal and spatial coverage or longer time series.



Measurement geometries for passive atmospheric sounding

2- Passive techniques

A passive instrument is an electromagnetic receiver covering some parts of the electromagnetic spectrum. Atmospheric constituents leave their specific absorption or emission fingerprints in these spectra, which can be used to derive concentrations

Dobson ground based spectrometers have been used since 1920 for measuring total ozone. Little height information can be deduced and the spatial coverage is off course limited, but with the advantage of possible long time series. Ground based microwave radiometers or infrared (FTIR) instruments

can be used to retrieve vertical profiles, using pressure broadening of emission lines with a vertical resolution between 5 and 10 km

The traditional source of global stratospheric minor species information has been nadir satellite instruments such as BUV/SBUV (Solar Backscatter Ultra Violet instrument) on-board the Nimbus and NOAA satellites

Higher vertical resolution ≈1 km) and accuracy can be achieved in solar occultation mode.

The measurements provided by these instruments give poor spatial coverage, limited to about 15 sunrise and 15 sunset profiles in one latitude band per day.

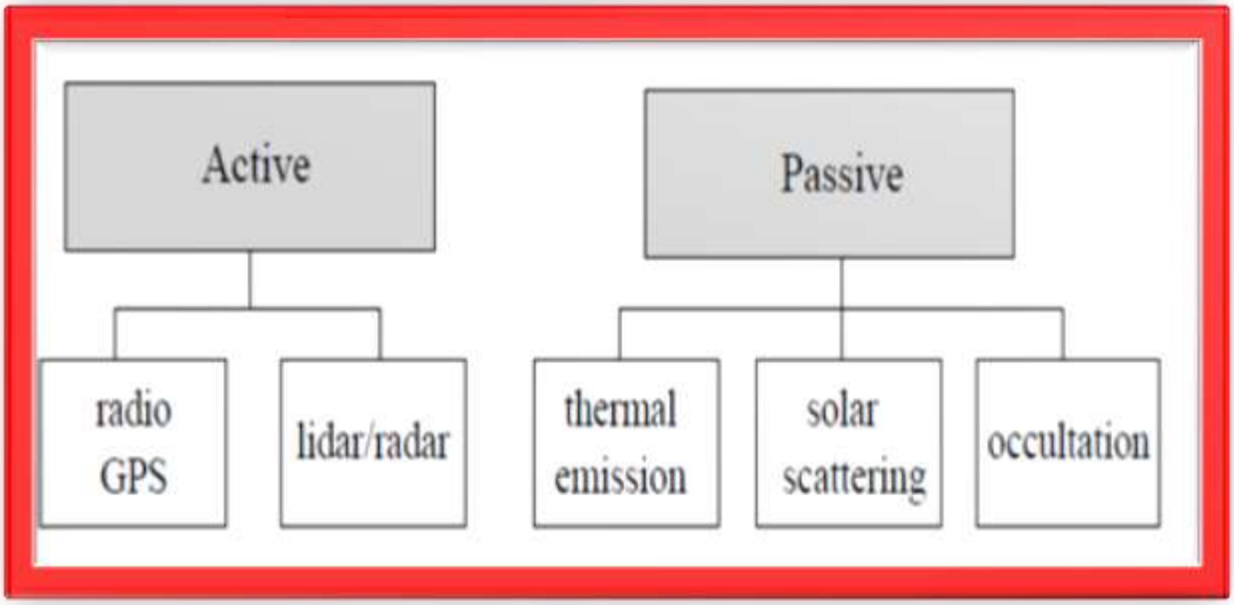
3- Active techniques

Most satellite instruments used for atmospheric sounding have been passive, since they are easier to maintain. Active remote sensing techniques includes

GPS occultation, for retrieving tropospheric water vapor concentrations and stratospheric temperatures, using the delay in the GPS signal.

LIDAR (LIght Detection And Ranging) and DIAL (Differential

Absorption Lidar) detect target species by studying differential absorption and the time delay at two wavelength of the reflected beam. The techniques are extensively used in ground-based tropospheric measurements but also for space-borne missions such as the Lidar In-space Technology Experiment (LITE)



Remote sensing techniques for atmospheric sounding