# Vicarious Calibration of GOES Imager Visible Channel


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The Geostationary Operational Environmental Satellite (GOES) has been providing valuable measurements since 1975. A total of 14 have been launched, of which ten have been retired, two are currently operational, and two are reserved on-orbit. The last one of the current series, GOES-P, will be launched in 2010. These GOES will serve the nation and the international community till 2016 and beyond, before replaced by the next generation of GOES-R.

All GOES has an imaging instrument (sounding instrument was added since 1994) and all Imagers has a visible channel, but until the next generation of GOES-R, the current and previous GOES has no onboard calibration device for visible channel. This shortcoming has seriously limited the quantitative and climate applications of this channel, whose responsivity can decrease to half of its original value over a satellite's lifetime. For weather applications such as cloud detection that is often based on some threshold, unknown degradation compromises the accuracy of the products. For climate applications such as trend analysis or construction of climate data record (CDR) using measurements from multiple satellites, GOES visible data without post-launch calibration would be of little value.

NOAA recognized this long term data record as an important contribution to the scientific community, and is committed to provide consistent, continuous, and accurate calibration for this important scientific asset. Several vicarious calibration methods have been developed over the years, and were presented at previous IGARSS (Wu et al 2005) and elsewhere. An early attempt, encouraged by the success of vicarious calibration of the solar channels on the Advanced Very High Resolution Radiometer (AVHRR), uses the Grand Desert in Sonora, Mexico, as calibration target. This method achieved reasonable success, however unlike polar orbiting satellite, GOES does not have the luxury of viewing calibration site near its nadir. Also, the limited choices of desert within GOES field of regard (FOR) are often “living desert” with some vegetation that is subject to climate variation such as El Niño.

Another approach is to use star as calibration targets. GOES routinely views selected stars to aid the tracking of its orbit and attitude. Since stellar irradiance is constant for most stars, these measurements have been used for calibration. In the early days, most effort was dedicated to the re-processing of the data because they were not intended for calibration. A later challenge was to treat the intra-annual variation of the signal. Great progress has been made recently.

Since 2005, NOAA has implemented operational calibration for GOES Imager visible channel based on inter-calibration with Moderate Resolution Imaging Spectroradiometer (MODIS). A significant advantage is that MODIS is calibrated, so GOES can be calibrated absolutely instead of trending only. The central problem at the time was the difference in spectral response function of MODIS and GOES. A new challenge now is the age of MODIS, i.e., whether they will outlast all GOES.

At about the same time NOAA investigated, in collaboration with USGS, the feasibility of using the Moon as calibration target. It was concluded that measurements of opportunity would not be sufficient for calibration. In the following years, NOAA made special collection of monthly lunar observations. Occasionally the Moon was observed nearly consecutively while it transects through the GOES FOR. These provided valuable insights and possibility for calibration.

Deep convective clouds (DCC) have long been used for calibration. Recent advances in modeling its bidirectional reflectance distribution function (BRDF) reduce its uncertainty and make it more attractive. Although it is relative calibration (trending) only, it is globally available at any time and easily observed, therefore is ideal for inter-calibration of all geostationary satellite at any time in the past and future.

Finally, GOES visible channel can also be calibrated using radiative transfer model (RTM).

Often, these calibration methods were developed for specific applications, emphasizing on some aspects of calibration, for accuracy of a single satellite or compatibility of series of satellites, and so forth. This paper will discuss the advantages and limitations of each method for weather and climate requirements, with the goal of defining the optimal strategy that combines the strength of all methods.

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