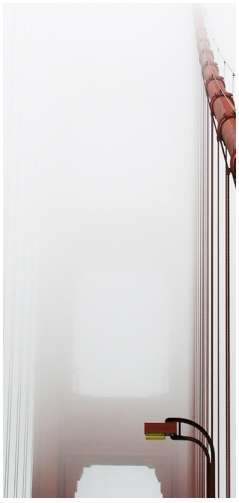
April 2011

GOES-R Aviation Products
Visibility



What Is GOES-R?

The Geostationary Operational Environmental Satellite - R Series (GOES-R) is the next generation of National Oceanic and Atmospheric Administration (NOAA) geostationary Earth-observing systems. Superior spacecraft and instrument technology will support expanded detection of environmental phenomena, resulting in more timely and accurate forecasts and warnings. The Advanced Baseline Imager (ABI), a sixteen channel imager with two visible channels, four near-infrared channels, and ten infrared channels, will provide three times more spectral information, four times the spatial resolution, and more than five times faster temporal coverage than the current system. Other advancements over current GOES capabilities include total lightning detection (in-cloud and cloud-to-ground flashes) and mapping from the Geostationary Lightning Mapper (GLM), and increased dynamic range, resolution, and sensitivity in monitoring solar X-ray flux with the Solar UV Imager (SUVI). GOES-R is scheduled for launch in 2015.

What Is Visibility?

Visibility is the greatest horizontal distance at which selected objects can be seen and identified. Reduced visibility often occurs during periods of heavy rain and snow and also occurs when sunlight is scattered or absorbed by atmospheric particles. Fog droplets and haze particles are small enough to scatter and absorb sunlight, leading to reduced visibility. The meteorological definition of fog is a cloud (stratus) which has its cloud base on or close to ground, and reduces visibility to less than 1 km.

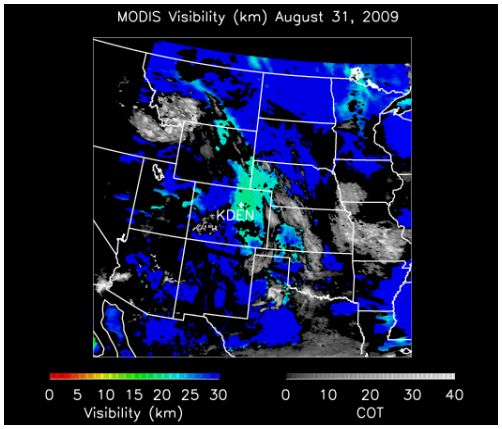
Haze is caused when sunlight encounters tiny pollution particles in the air. More pollutants mean more absorption and scattering of light, which reduces visibility. The attenuation of light due to scattering and absorption by atmospheric particles is referred to as extinction. In general, scattering is the primary cause of light extinction and therefore visibility reduction. The smallest pollution particles (< 2.5 microns) scatter sunlight more efficiently then larger particles.

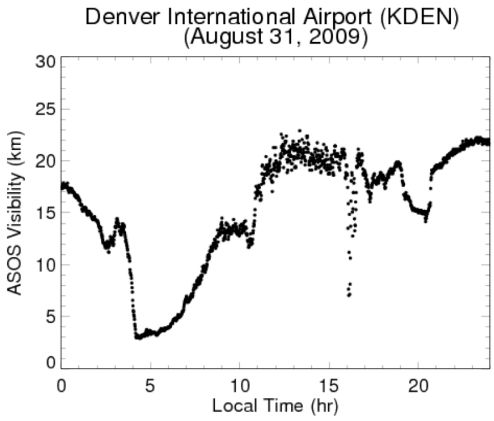
What Hazards Are Associated With Reduced Visibility?

Visibility is a leading safety factor in determining aircraft flight rules, pilot certification, and aircraft equipment required for taking off or landing. Federal Aviation Regulations require that aircraft operations at airports must be conducted under Instrument Flight Rules (IFR) when the prevailing visibility is below three statute miles (approximately 5km). One of the worst accidents in aviation history occurred in 1977 when two Boeing 747s collided in heavy fog at the Tenerife airport in the Canary Islands, resulting in 583 fatalities. This accident occurred when a KLM flight that was taking off crashed into a Pan Am aircraft that was taxiing on the runway. While the fundamental cause of the accident was determined to be failure of the KLM pilot to obtain takeoff clearance, limited visibility due to fog was considered a major factor contributing to the accident. Significant changes in visibility can occur between regularly scheduled Aviation Routine Weather Report (METAR) observations and can affect aircraft safety. Smoke from wildfires can have a significant effect on local visibility, even far down-wind of the fire location. In late August through mid October 2009, the Station Fire, near Los Angeles, CA burned a total of 160,577 acres and was the 10th largest fire in California since 1933. Smoke from the Station Fire was transported far down-wind, affecting visibility over much of the western US.

Top: *Fog over San Francisco, CA.* ***Bottom:*** *Haze layer in the Grand Canyon (Reproduced from "Introduction to Visibility," by William C. Malm, Air Resources Division, National Park Service).*

GOES-R (Geostationary Operational Environmental Satellite-R Series)





Far Left: *August 31st* ***Visibility*** *retrievals based on MODIS AOD proxy measurements (over Denver at 10:45am Mountain Standard Time) show a broad area of reduced* ***Visibility*** *that extends throughout eastern Colorado, western Kansas and western Nebraska northward into eastern parts of Wyoming and central Montana. Lowest* ***Visibilities*** *(<15km) are found near Denver, CO at this time. Prior to the MODIS overpass, the Denver International Airport METAR reported scattered cloud cover and haze.* ***Left:*** *ASOS measurements show that* ***Visibility*** *at the Denver International Airport was abruptly reduced from near 12km to less than 3km (~2 miles) at 4:00am and remained below 5km until 7:00am due to smoke from the Station Fire.*

How Will GOES-R Retrieve Visibility?

ABI daytime retrievals of clear-sky aerosol optical depth (AOD) and day/night cloud optical depth (COD) provide estimates of the column integrated extinction. If we assume that all of the extinction occurs within the planetary boundary layer (PBL), the retrieved optical depth divided by the PBL depth can be used to estimate surface extinction. Once the extinction is determined, **Visibility** is estimated using Koschmieder's Law ($V = 3/\sigma$), where V is the **Visibility** and σ is the extinction coefficient in km^{-1}. The resulting surface **Visibility** estimate will be most accurate when the PBL is well mixed. The ABI AOD retrieval is used to estimate surface **Visibility** under hazy conditions. The ABI fog/low cloud detection algorithm is used to identify scenes with reduced surface **Visibility** under cloudy conditions.

Monthly bias corrections for Poor, Low, Moderate, and Clear **Visibilities** are being developed based on statistical regression of proxy Moderate Resolution Imaging Spectroradiometer (MODIS) AOD and GOES COT measurements against Automated Surface Observing System (ASOS) extinction measurements. ASOS **Visibility** sensors measure forward scattering of light in a mid-visible wavelength (550 nanometers) and convert the measured scattering to Sensor Equivalent **Visibility** using Koschmieder's Law.

What Are the Benefits?

The GOES-R **Visibility** retrieval will provide a satellite-based estimate of boundary layer slant range **Visibility** to augment existing measurements from surface networks. The ability of GOES-R to continuously monitor **Visibility** over the continental US will allow smoke and fog related transportation hazards to be monitored in real time, providing valuable information to the Aviation Weather Center (AWC), National Weather Service (NWS), Federal Aviation Administration (FAA), and Department of Transportation (DOT). In addition to these important safely considerations, reduced visibility due to regional haze also obscures the view in our nation's parks. The Clean Air Act authorizes the United States Environmental Protection Agency (EPA) to protect visibility, or visual air quality, through a number of different programs, including the EPA's Regional Haze Rule. The ability of GOES-R to continuously monitor **Visibility** in remote regions of the US will improve **Visibility** monitoring within our National Parks and provide useful information to the regional planning offices responsible for developing mitigation strategies required under the EPA's Regional Haze Rule.

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Research and Development Partners for Visibility Product

- NOAA National Environmental Satellite, Data, and Information Service, Center for Satellite Applications and Research (NESDIS/STAR)
- NOAA NESDIS National Climatic Data Center (NCDC)
- NOAA National Weather Service, Automated Surface Observing Systems program (NWS/ASOS)
- US Environmental Protection Agency (EPA)
- University of Wisconsin, Space Science and Engineering Center (UW-Madison, SSEC)

On the Web

http://www.nws.noaa.gov/asos/index.html
http://www.epa.gov/visibility/

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