Machine Learning Cloud Mask Action Plan

Bands used in TERRA MODIS cloud mask in order of importance (first three most important)

1- Band 2
   a. 0.86 microns, water looks very dark, clouds are still very bright
2- Band 26
   a. 1.38 microns, water vapor absorption band obscures surface (lots of water vapor near Earth's surface), high clouds above will be seen as very bright
3- Band 31
   a. 11 microns, proxy to temperature, clouds are usually colder than the surface
4- Band 1
5- Band 22
6- Band 27
7- Band 35
8- Band 32

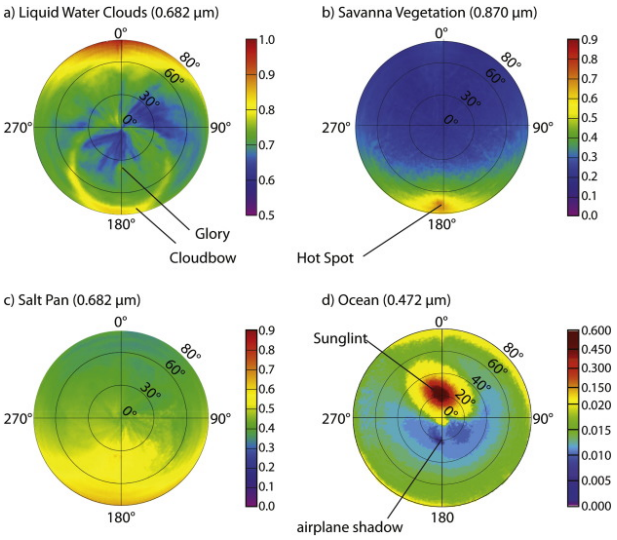
Ancillary data

Sun-View Geometry

Measured radiance is a strong function of the solar zenith angle, satellite viewing zenith angle, and relative azimuthal angle (angle of satellite minus angle of sun on the azimuthal plane). Each radiance at each pixel has these angles associated with it. They give information about how different surface types reflect light at different angles and wavelengths. The water surface reflects differently than a liquid/ice cloud surface, so it contains a wealth of information. Below is an example demonstrating this from (Gatebe, 2016) https://doi.org/10.1016/j.rse.2016.03.029 . BRDF (Bidirectional Reflectance Distribution Function) but is it varies directly with radiance. Notice how different the pattern is from graph to graph

"4. Optical characteristics of BRDF

Comparison of BRDF patterns is facilitated by converting to BRF, a non-dimensional quantity equivalent to BRDF times π. Fig. 4 shows a composite representation of the BRF as a function of reflected zenith (θ) and azimuth (φ) angle, where the distance from the center of the circle (radius) corresponds to the viewing zenith angle (0°–80°) and the polar angle is the viewing azimuth angle relative to the sun direction (0°–360°). The forward scattering direction corresponds to an azimuth of 0°, while the backscattering direction corresponds to an azimuth of 180°. The color of the polar diagram shows the magnitude of the measured BRF from nadir to nearly the horizon and for the full range of azimuth angles."



Day of Year

The day of the year contains information about the temperature of the ocean surface and the solar zenith angle due to the season. Surface type in this region of the world over ocean shouldn't change much though

What else to consider?

Brightness Temperature

MODIS' cloud masking algorithm often makes use of brightness temperature. Which simply involves taking bands and passing them through a function to get the temperature it would be if it were a black body and all the radiance received at the sensor came from that blackbody. Because clouds are higher and therefore colder than the surface and because different wavelengths interact differently according to temperature (Plank Radiance function), the expected difference in brightness temperature can tell us if a scene is clear or cloudy. Below is what MODIS uses and the equation to get brightness temperature (BT).

$$BT(L,\lambda) = \frac{hc}{(\lambda * 1e-6)k_b \ln(\frac{2hc^2}{(\lambda * 1e-6)^5 L * (1e6)} + 1)}$$

$$h = 6.626e-34\ joule\ seconds$$

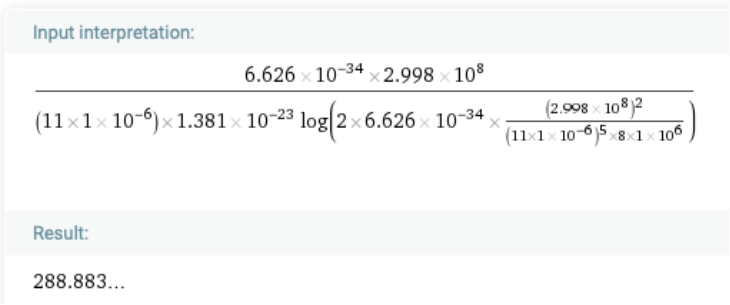
$$k_b = 1.381e-23 \frac{joules}{kelvin}$$

$$c = 2.998e8 \frac{meters}{second}$$

$$L = measured\ randiance\ @ \frac{joule * seconds}{meters^2 * micrometer * steradian}$$

$$\lambda = wavelength\ @\ micrometers$$

For L=8 and lambda = 11



MODIS uses: (notice some are differences between two BTs; L is radiance at that wavelength)
NOTE: Machine learning algorithms might find the non-linear relationships described here without calculating BT, i.e. just use the raw radiance as input.

1- BT(λ =11) - BT(λ =3.9) bands 31 and 22 respectively
2- BT(λ =6.7) band 27
3- BT(λ =13.9) band 35
4- BT(λ =11) - BT(λ =12) bands 31 and 32 respectively
5- BT(λ =11) band 31