

# Developing cloudiness climatologies from satellite imagery to map cloud forests and other vegetation features over the tropical Americas

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## MOTIVATION

Mapping the distribution of vegetation types can be a complicated task, especially in remote locations. One example of this is determining the distribution of so-called tropical "cloud forests". These regions, as their name implies, are forests that are immersed within clouds for a large fraction of the time. Because these environments have high relative humidity, are usually very rainy, and are generally well above freezing, there is luxuriant plant growth. These regions also show very high diversity of plants and animals, and so they are important to map accurately to aid in conservation planning.

Mapping vegetation from the ground is difficult, given the lack of easy access to many areas of the tropics. Satellite mapping is logical, though it still requires ground truth. Here we exploit available MODIS and GOES imagery to show the possibilities for mapping cloudiness at high spatial resolution. *We do not attempt to estimate rainfall* - a common objective for atmospheric scientists, but rather the cloud cover, or reflectivity. Our simple assumption is that areas with very frequent daytime cloud cover can be related to cloud forests and other vegetation features closely tied to topography.

*Cloud forests are likely to be those areas where mid-day cloudiness (reasonably well-estimated from MODIS imagery) is a maximum - as nighttime cloudiness is relatively unimportant for determining potential evapotranspiration.*

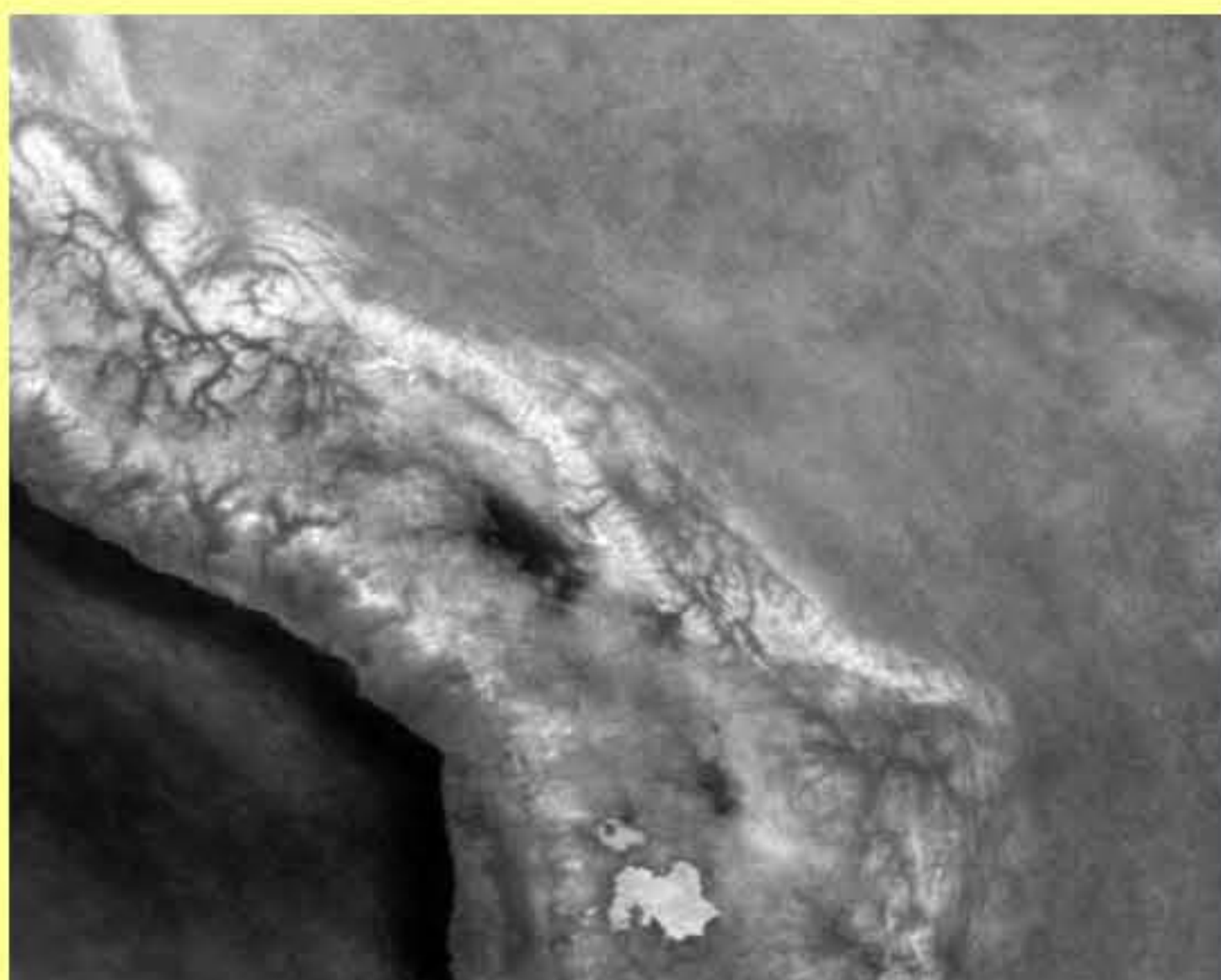


Fig. 1. Average of December-February GOES visible (1km pixel) images at 1745 UTC for the year 2004-5. Note that Lake Titicaca is dark (minimum cloudiness), most canyons are dark (little cloudiness). Other features include the large and highly reflective Salar de Uyuni (dry lake) near the bottom, and the region of less stratocumulus along and off the coast of Peru and Chile. Compare with the MODIS composites at right.



Fig. 4. Composite of 2 years of MODIS Terra and Aqua images for the region including Sao Paulo and Rio de Janeiro, Brazil. Note the very narrow cloudy belt very close to the coast. This corresponds to the cloudiest part of the region known as the Mata-Atlantica. An interior range of mountains corresponds to the second region of high cloudiness. Colors have been somewhat enhanced.

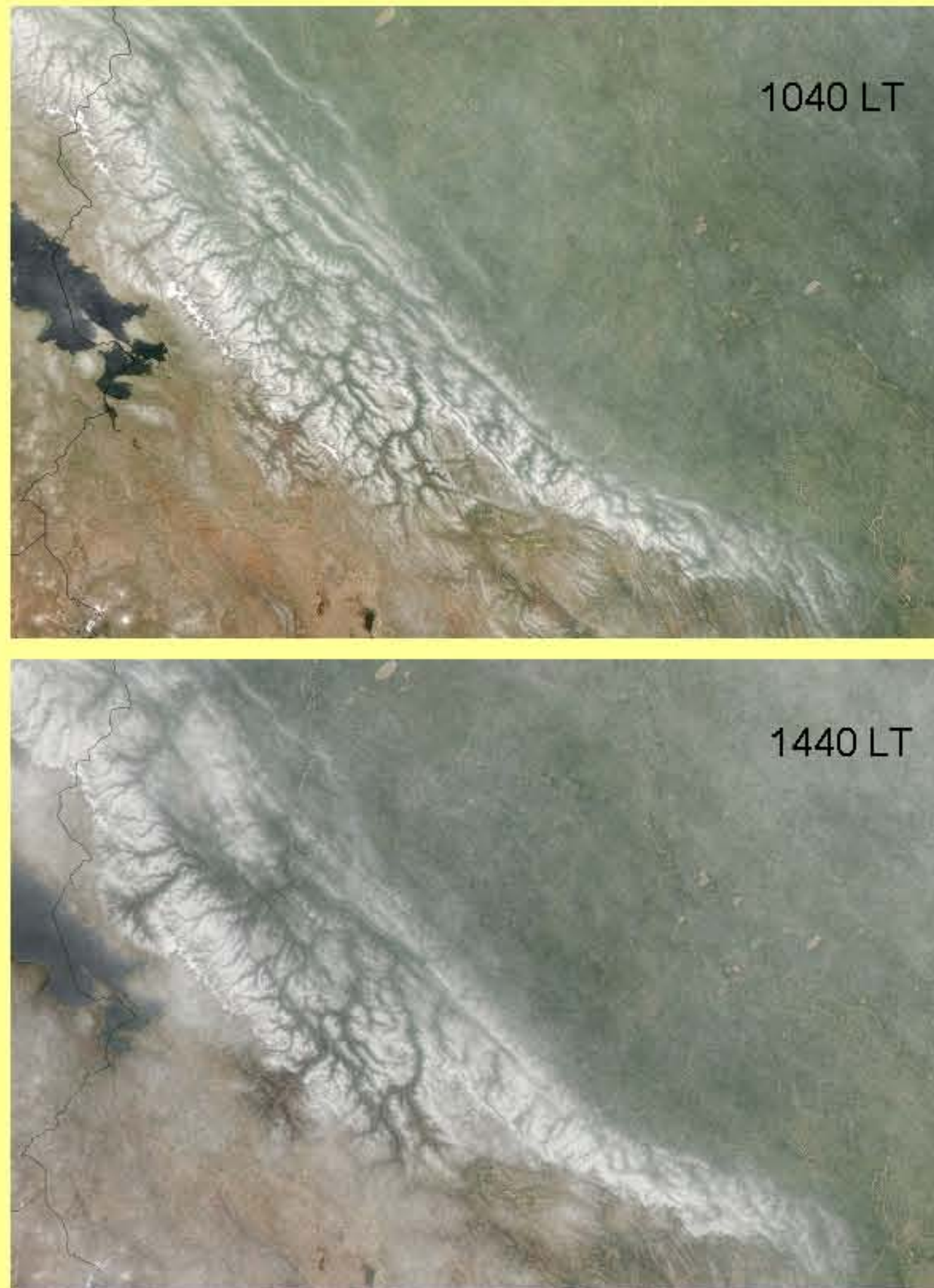


Fig. 2. Terra composite (above) (~1040 LT) and Aqua composite (below) (~1440 LT). Each composite used 60 images. Note the more diffuse nature of cloudiness in Aqua composite - due to a deeper boundary layer and probably greater dispersion of cloudiness away from primary genesis sites as the day progresses. Compare the 1440 LT (1740 UTC) composite with the Fig. 1 GOES composite.

## KEY POINTS

- 1) The value of high spatial resolution imagery is that it shows the strong gradients in cloudiness that are often associated with strong gradients in vegetation. Routine climatological data usually smooths out rainfall gradients, and cloudiness gradients - important for controlling evapotranspiration, is not commonly measured from surface sites.
- 2) Our composites clearly show the very strong role of topography in modulating the overall cloudiness, and we hope they will serve to stimulate our intended audience (ecologists, biogeographers, zoologists, botanists etc.) to use these sources of data for their work.

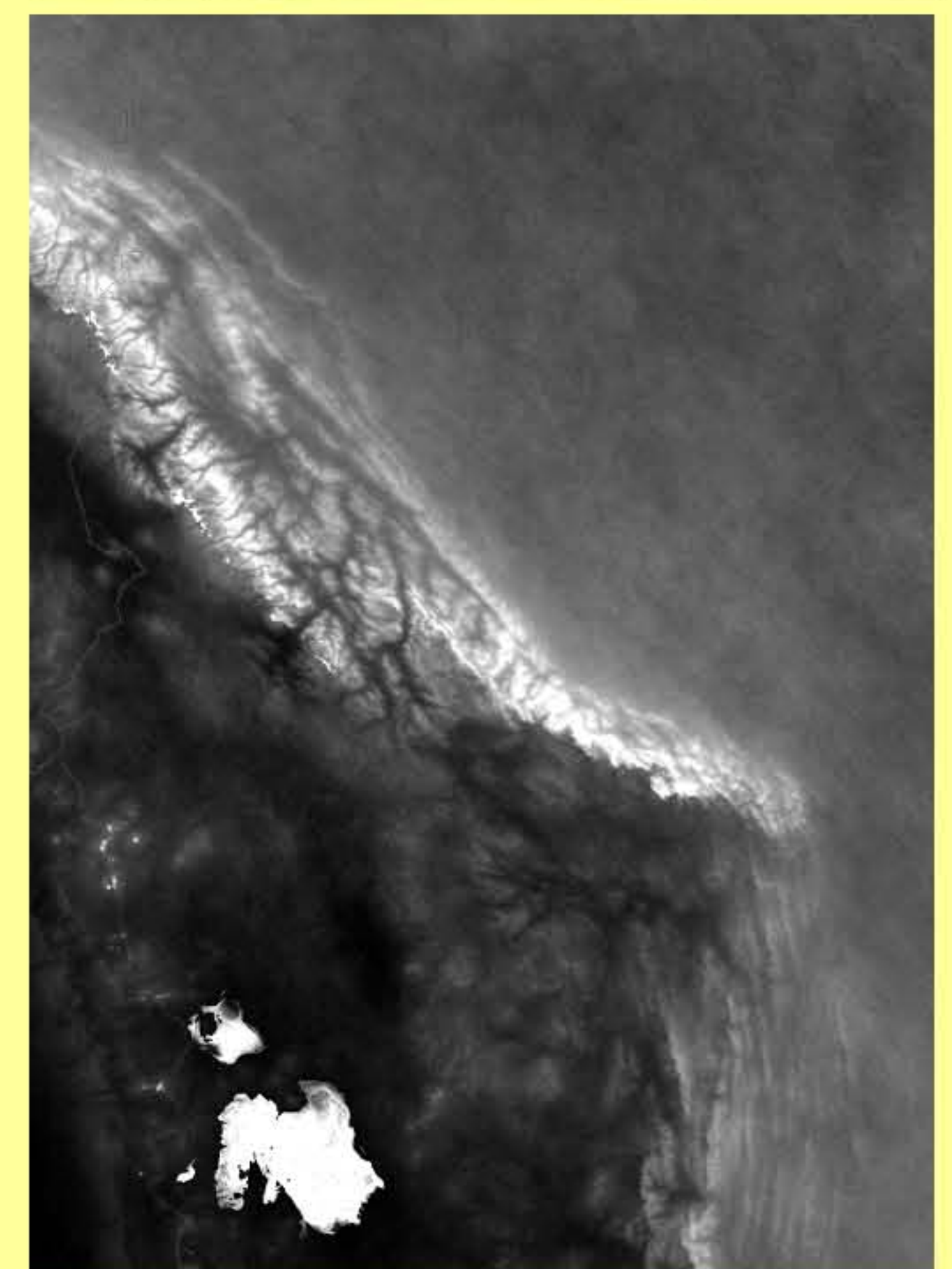


Fig. 3. Average of all Terra and Aqua MODIS images from last 2 years. Top image shows true color image, bottom is cloud, according to selection procedure based on histogram of brightness (to remove ground reflectivity). Very bright areas (Salt flats and permanent snow/glaciers for example) remain.

Fig.5. Costa Rica and part of southern Nicaragua and western Panama (to right). This MODIS composite is based on both Terra and Aqua images from the dry season, Jan-March, 2004 and 2005. During this period the trade winds are relatively strong from the east and the Pacific side of Central America is relatively cloud-free. The very sharp boundary of the clouds over northern Costa Rica is apparent, as is the effect of canyons on the cloud cover over southeastern Costa Rica (valleys have less cloudiness). High cloud amounts on the isolated volcanic peaks in Lake Nicaragua are also evident.



## ACKNOWLEDGEMENTS

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