ADVANCES IN A STUDY OF SKY QUALITY FOR ASTRONOMICAL OBSERVATIONS IN COLOMBIA

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ABSTRACT

The aim of this study is to determine the sky quality in Colombia to astronomical observations in the optic. Images in infrared (6.7 and 10.7 μm) were analyzed from GOES meteorological satellite in three night times for four years (2008 to 2014). A novel methodology was followed to determine how clear or cover were those skies. Meteorological data also were used from the weather stations network of the national meteorological institute, IDEAM. A correlation between threshold temperature and altitude was found for a historical data series about 30 years. Annual cloud covering was computed over the whole country and it was classified the nights as clear or usable based on the definition of a quality factor.

DATA ACQUISITION

The primary aim of this work is to derive the number of clear nights. To quantify the amount of clear sky over Colombia sites we used different set of data collected at both ground and satellite facilities. The ground base data are available thanks to the courtesy of the Institute of Hydrology, Meteorology and Environmental Studies (IDEAM) of Colombia.

Fig 1. Map of Colombia. Light blue frame involve the IDEAM's weather stations.

The number of clear night are also performed via combinations between ground-based and satellite-based data. In particular we used GOES meteorological satellites that have geostationary orbits, because the very high stationary orbit (~36000 km) provides an extremely stable conditions and it is not influenced by the phenomena of the high exosphere (Cavazzani et al. 2011). The geostationary satellites have orbits over the Earth Equator and provide a large coverage of the globe.

The GOES weighting function for B3 and B4 are shown in a **Fig. 2**.

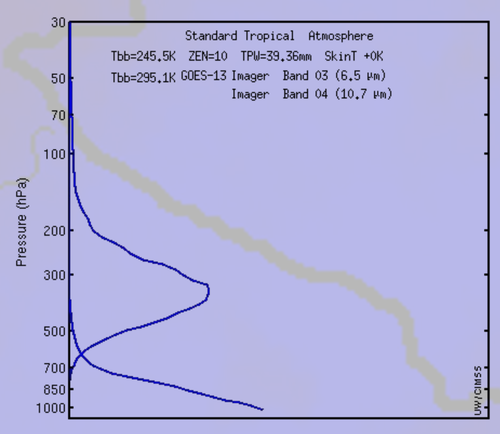

Fig 2. Weighting function examples for bands B3 and B4 of the Goes13 for an atmosphere standard tropical, a zenit angle of 10°, a percentage column moisture of 100% and a skin temperature adjustment of 0K.
Courtesy: http://cimss.ssec.wisc.edu/goes/wf/

METHODOLOGY

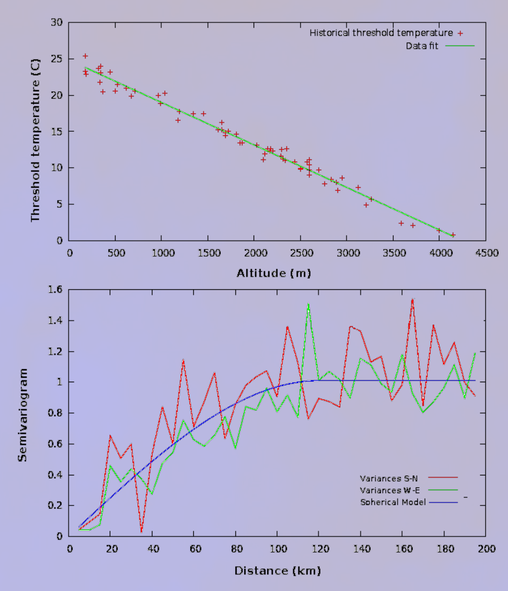

Fig 3. *Top:* Relationship between the threshold temperature versus altitud. The interpolation is better for altitudes greater than 500 metres.
Bottom: Semivariogram for the irregular points of ~400 weather stations of IDEAM. The semivariogram represents the average variances in height. A spherical model fitted with n=0.048, s=1.01 y r=120. Green is the W-E semivariogram, and the red is S-N semivariogram.

Several authors (Erasmus & Zarasin, 2002, Cavazzani et al. 2010, Hidayat et al. 2012), proposed a methodology based in satellite images for sites testing in the time night. They established a criterion for to identify whether the measured values from satellite images correspond to clear or covered nights. The general relationship take the general form as:

$$T_B \geq T_T \rightarrow clear$$
$$T_B < T_T \rightarrow covered \qquad \textbf{(1)}$$

where T_B is the temperature value measured for satellite at 10.7μm, and T_T is a some threshold temperature yet to be defined. This threshold temperature is a reference temperature that is able tell us whether the satellite has detected a cloud or not. A cloud will be detected whether the satellite temperature is less than $T_T = T_S - 3\sigma$, where T_s is the surface mean temperature of the weather stations average by month for 30 year, and σ its respective standard deviation.

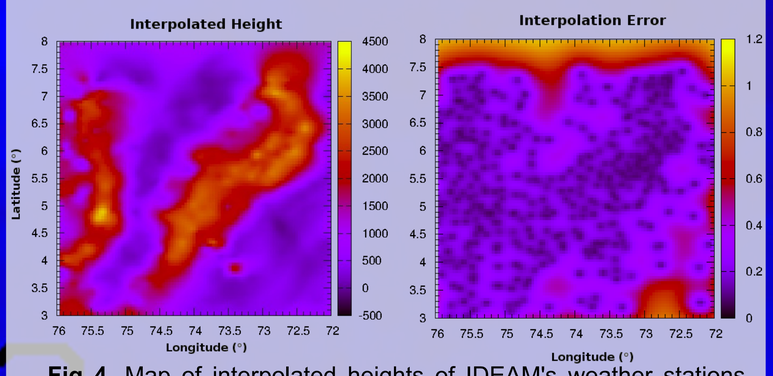

Fig 4. Map of interpolated heights of IDEAM's weather stations (left) and their respective truncation errors (right). The orange regions on the map on the left sites represents the Eastern and Central Mountain Range of Colombia. The purple regions represent both the Magdalena Valley and plains foothills of the East Mountain-Range.

CONCLUSIONS

The threshold temperatures shown a linear correlation with altitude (**Fig 3 Top**). This result is powerful, it means that we do not need knowing the surface temperature in all places for know whether there is a cloud or not. It is enough to know the altitude of a place, then calculate the threshold temperature using the linear relationship shown in Fig. 2 and then used the relations **(1)**.

In orden to compare data of satellite images with ground data, a semivariogram model was fitted to data that shows in **Fig 2 bottom.** An spatial intepolator Kringing was used to determine the altitude on each point of data satellite, the result is shown in the **figure 3**.

We used about 5500 images in B4 to determine the cloud covering using both satellite and ground data in three night instants: early night, midnight and end of the night.

We defined the Quality Factor (Q) that is a number between 0 and 100 that define the night cloud covering quality. Q100% is a night without cloud during all instants. Q0% is a completely covered night.

The **Fig. 5.** shows the number of nights with a quality factor of 50 for 2011.

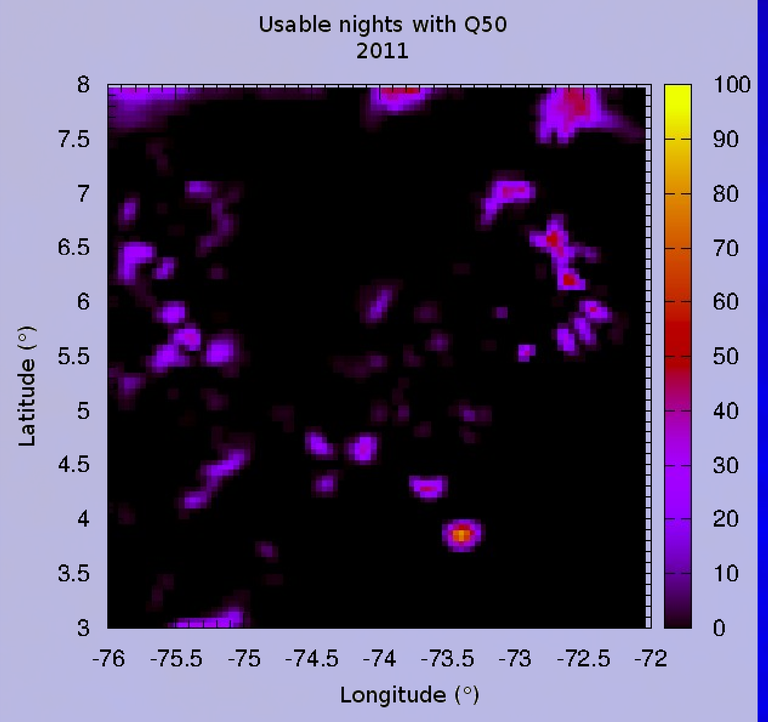

Fig 5. Clear sky fraction for the 2011 with a quality factor of 50%. This is a scenario in which half of the nights are cloud-free. We call those nights as usable nights. Less than 100 nights per year are usables in Colombia.

REFERENCES

[1] Erasmus, D. Sarazin, M. Utilizing satellite data for evaluation and forecasting application at astronomical sites. IAU site 2000, ASP Conference Series. Vol. 266, 2002.
[2] S. Cavazzani, S. Ortolani1, V. Zitelli, Y. Maruccia Fraction of clear skies above astronomical sites: a new analysis from the GOES12 satellite, Arxiv: 1011.4815v1.
[3] T. Hidayat, P. Mahasena, B. Dermawan, T. W. Hadi, P. W. Premadi and D. Herdiwijaya. Clear sky fraction above Indonesia: an analysis for astronomical site selection. Monthly Notices. Volume 427, Issue 3, 20 NOV 2012.