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INTERCOMPARISON OF GROUND BASED METHODS FOR DETERMINATION OF TROPOSPHERIC CLOUD BASE AND CLOUD COVER AMPLITUDE.

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1. INTRODUCTION

Since several years, study of tropospheric clouds became a field of major interest for meteorologists due to their influence in weather forecast at macro, meso and micro scales, in atmospheric radiation transfer modelling (e.g. solar UV radiations) and also in modelling and forecasting the chronic air pollutions. This need induced development of several methods and instruments described below.

2. METHODOLOGIES DESCRIPTION

2.1 Introduction

In the list of techniques presented here after it is necessary to establish a discrimination between "local" meaning that they provide data in one point of the sky dome (Chernyik-Elkridge method, ceilometer) and "global" like TSI, Nephelo and human observer.

2.2 Nephelo

The instrument we developed during the last two years is based on the measurement of cloud base temperature by means of infrared spectrometry (Gillotay et al. – 2001). Seven detectors set with an increment of 12° from the zenith angle and allowing a field of view of 144° over the sky dome are mounted on a rotating turret stepping by increments of 12°. Retrieved temperatures are processed considering emissivity of clouds (Davies – 2001) and temperature profile versus altitude (Hedin et al. – 1991). The Nephelo provides nebulosity, day and night every 5 minutes, evaluation of ceiling height and sun visibility flag.

2.3 Total Sky Imager (TSI)

This instrument designed and manufactured by Yankee Environmental Systems is based on a CCD camera placed on top of an hemispheric mirror. At regular interval set by the user, pictures are stored and processed by a simple radiation transfer model.

This instrument provides only day time percentage of thick and thin clouds.

2.4 Ceilometer

We will not describe again this technique known and used since a long time and providing day and night time data. In this comparison, we used it only for ceiling height determination as the ASOS algorithm from NWS was not implemented in the data collection system in use.

2.5 Chernyik Elskridge method

This method is a special processing of regular radio-sounding data following equations (1) and (2) :

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$$.d^2(T)/dz^2 >= 0 \qquad (1)$$

$$.d^2(RH) <= 0 \qquad (2)$$

This method uses the “Arabey diagram” for determination of nebulosity. Our use of this method was limited by the low number of data available (two soundings per day).

2.6 Human observer

This method still widely used around the world is the oldest one and its repeatability and its accuracy are strongly debated.

3. NEBULOSITY COMPARISON

For this comparison, two aspects were studied systematically Nephelo versus TSI and Nephelo versus human observer. This choice was motivated by the fact that TSI and human observer are two qualified methods already in use in several observing systems. Figure 1 shows one record of the first aspect of the comparison.

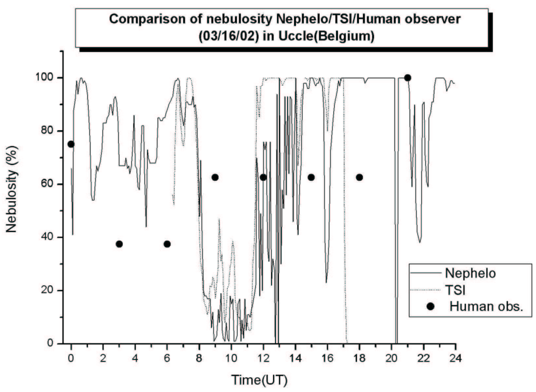

Figure 1

This figure shows a similarity of variations between measurements of the two instruments. The differences of intensity could be explained by a weak sensitivity of Nephelo to thin clouds and also by the fact that the parallel plan model used in the TSI has a range of validity limited to weak zenith angle. Our study shows also an over estimation of thin clouds by the TSI due to optical interferences at the interface between the “shadowing band” and the mirror.

Unfortunately, due to characteristics of the TSI the comparison is valid only during day time.

On figure 2, we present a Nephelo/human observer comparison performed in Uccle/Belgium (WMO Station # 6447) 4/19/2001. Circles show human observer data and bars Nephelo nebulosity data hourly averaged.

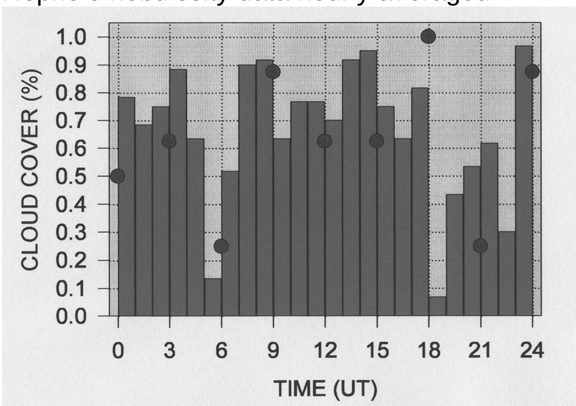

Figure 2

We provided previously statistic data relative to the accordance between both methods (Gillotay et al. – 2001)

4. CEILING HEIGHT COMPARISON

Figure 3 shows ceiling heights obtain by a ceilometer in Trappes (France) and first cloud layer obtained using Chernyk-Elskridge with radio-sound launched 06/02/01 at 12:00 UT.

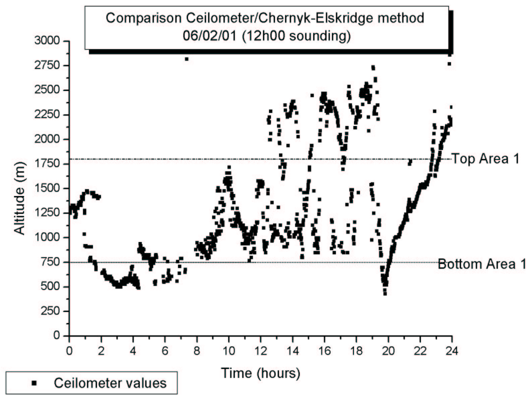

Figure 3

This figure shows that both methods lead to rather consistent results, as previously mentioned cloud cover has a significant roughness and the radio-sounding is going through the cloud layer certainly at a different location compared to the laser spot. An other issue to be considered is the duration of validity of Temperature and Relative Humidity profile obtained with the radio-sounding.

We performed also a second type of comparison between Nephelo and Ceilometer. The accuracy of altitude computed by Nephelo has a great sensitivity to difference between true and theoretical profile. Moreover, it is necessary to well consider that the Nephelo computes an average ceiling height over the visible part of the sky dome while the ceilometer provides a punctual measurement. Figure 4 shows one example. During this "broken clouds" day, nebulosity percentage decreased creating a drift of curves that we can explain by the fact that Nephelo is a global method and ceilometer a local one.

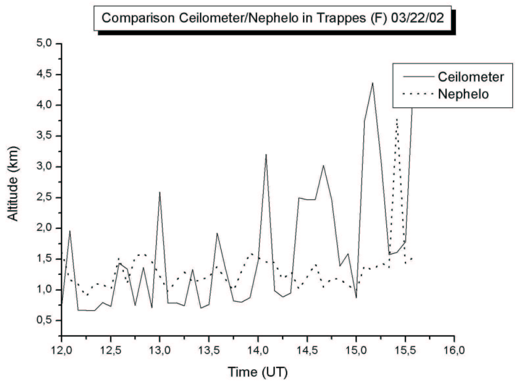

Figure 4

5. CONCLUSION

All tested methods show a convergence. Due to the complexity of the cloud phenomenon (definition of the cloud/no cloud interface, roughness of cloud layers), it is presently impossible to define the reference techniques.

The Chernyk Elksridge method is an interesting phenomenological approach, unfortunately due to the small number of sounds launched per day (2 per day) by a limited number of stations around the world is adequate for climatologic studies over a long period (Chernyk et al.- 2001) but not for current monitoring in meteorological stations or sensitive places like airports.

The "OCTA" unit is extremely well suited for human observation; instruments as TSI and Nephelo allow an accuracy of one percent to be reached.

Our comparison showed a complementarity between:

i) "Global" methods (instruments like Total Sky Imager from Yankee Environmental Systems and Nephelo.

ii) "Local" like ceilometers.

This conclusion is due to the fact that Nephelo or TSI will define "how much clouds" are present in the accessible portion of the sky dome while the ceilometer will define the altitude of the cloud base over the measurement site, we may consider as the ceiling height.

Finally, to be complete, a study of the dynamic aspects of the cloud layers appears as being useful to consider. The experimental capture of this property, presently under investigation, requires a global view of the sky dome as well as a sufficient time sampling. These characteristics, offered by the Nephelometer, will permit 24 hours a day dynamic studies in a short future.

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