OPERATIONAL USE OF INFRARED CLOUD ANALYSERS IN AUTOMATIC OBSERVING NETWORKS AND FOR AERONAUTIC APPLICATIONS.

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1. INTRODUCTION

Over the twenty past years meteorological observation became more and more automatic for various parameters like visibility, wind, temperature, precipitation, … . The cloud cover measurement followed the same process with the growing use of rotating beam ceilometers and the newer laser beam ceilometers in order to determine the cloud height locally, however the cloud amount and the cloud typology stayed and are still in many locations determined with a subjective aspect by human observers.

2. SKY CONDITIONS ALGORITHM

To bypass the subjective (repeatability, accuracy) aspect of human observation that should be performed for climatologic and aeronautic purposes day and night time, some institutions like the US National Weather Service defined a statistical process based on multiple shots of a laser beam ceilometer (LBC) and establishing a statistic of returned signal (cloud presence: back scattered signal). This algorithm is a significant improvement of cloud cover intensity automatic measurement locally if the altitude wind speed is weak or along the propagation axis of cloud cells with powerful winds. Unfortunately, if you give a quick look through your window during overcast or broken clouds conditions you can see easily a two dimensional inhomogeneity of the cloud cover. This difficulty could be by passed easily using several LBC homogeneously installed over a surface of several squared kilometres and gathering data in one computer for processing, unfortunately long distance data transmissions requires significant and costly infrastructures moreover the sampling synchronization of the different LBC deployed should be improved.

3. SATELLITE IMAGES

The different space programs around the world over the forty past years allowed development of hi-tech imageries technologies in different wavelength intervals (thermal, water vapor, visible) and now some high quality pictures are "off the shelf" available. These pictures are extremely well suited for macro scale, but unfortunately for meso and micro scale use the spatial resolution is too weak for an accurate analysis of the cloud cover. Moreover, very often several layers are present in the troposphere and the satellite will be not able to watch the lower one that is the most climatologically active.

4. CLOUDS IMAGERS CONCEPT AND HISTORY

Previous paragraphs show to overpass the lack described the need for a monitoring instrument at a reasonable cost in order to allow a massive deployment and establishing pictures as close as possible of 2 π sr field of view. Roughly 10 years ago, some preliminary tests were performed with regular fish eye photographic pictures post processed with micro densitometry analysis (Gardiner et al.). Considering the amount of treatment generated to monitor the cloud cover intensity with a significant accuracy this method remained marginal. Later some instruments like the Total Sky Imager (TSI) from Yankee Environmental Systems appeared. This system based on the

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analysis of a picture issued from a video camera snapshot determines the presence of thick and thin clouds using the blue/red ratio. This instrument provides interesting results at day time unfortunately due to its technology none night time. Simultaneously to the TSI development some authors as Gaumet et al. showed the possibility to solve the night time problem using single pyrometers mounted on a dual degree of freedom turret could provide cloud intensity. Other authors (Gillotay et al. – Besnard et al.) optimized the method with turrets equipped of several sensors allowing a faster sampling frequency (see figure 1).

Figure 1

Moreover processing temperature data with a modeled temperature profile (Hedin – Labitzke et al.) or with a profile issued from a radio sound ceiling height can be estimated. With a similar principle measuring absorbed solar radiations in the range of water vapor (5 µm), the water content of the sky dome around the observation location can be measured then by subtraction with the thermal picture previously described, the water content of clouds can be reached.

Some readers of this article could think that the optimal solution of the problem is a IR CCD camera equipped with a IR transparent fish eye lens. Technically speaking, they are fully right however the price (over 100000 USD) and technical requirement (cooling liquid of the CCD, environmental survival of optical parts) place it out of concern for a monitoring equipment. However for research purpose or for a reference instrument the discussion for the use of such a technology remains open.

5. INFRARED CLOUD IMAGERS USES

The range of uses for infrared cloud imagers is extremely wide. Three main topics could be determined :

5.1 CLIMATOLOGIC NETWORKS

In climatologic networks, sensors should provide data answering to requirements of WMO regulations that will be used as input in variational models or to create in official data basis archives. Sensors for such a system should process data and transmit a ASCII strings through a serial communication and following interval preset by the user or recommended by a regulation.

5.2 SCIENTIFIC INSTRUMENTS

The purpose of scientific studies is not to retrieve synthetic strings of data but to store a maximum of data in order to define process used in climatologic networks.

Infrared cloud imagers provide a tremendous amount of data which can be used in various fields like solar UV radiative transfer, global warming, solar energy conversion, … . To clarify the relation between cloud imagers and scientific purposes, we will now focus our explanations on the radiative transfer issues .

The interest for ground level UVB radiation appeared with the discovery of the stratospheric ozone layer depletion. Several models appeared at that time like DISORT (Stamness et al.) and STREAMER (T. Ackerman, Winsconsin State University). The comparison with instrumentation showed a good agreement by clear and overcast sky unfortunately the coherence in broken clouds conditions is extremely weak. Several groups (e.g. Gillotay et al. – Wang and Lenoble) conducted investigations and showed that the cloud could not be considered as an optical neutral filter and that it was necessary to proceed calculating radiances integrated in a final step to obtain a global irradiance and to know where (Zenith angle and height) cloud cells were located.

Now with cloud imagery these studies could be reinvestigated again.

5.3 SURVEY INSTRUMENTS

It is well known since several centuries that clouds are responsible or have a significant part in many hazardous climatologic phenomena for human activities like air transportation, floods and agriculture:

Airports authorities should provide “take off clearance” to aircrafts, following a checklist defined by ICAO and FAA and both including cloud cover intensity and ceiling height requirements at the clearance time.

As shown in figure 2, a cloud cover imager can provide without any sophisticated treatment a view of the cloud cover state around the airfield.

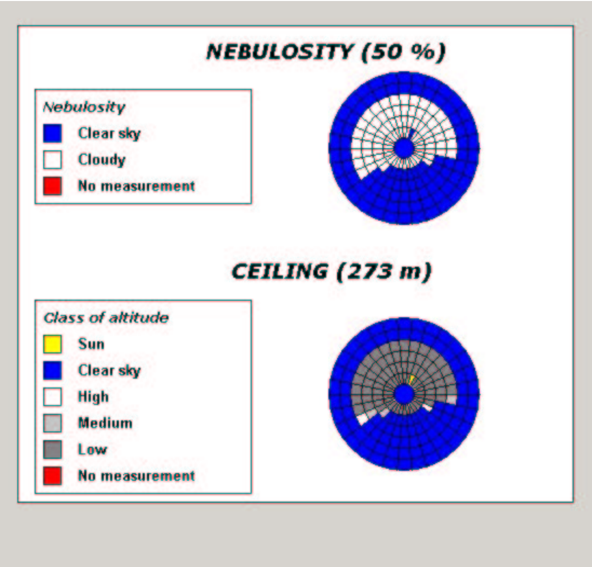

Figure 2

Through this basic picture, the airport traffic supervisor know where cloud cells are located either homogeneously dispersed over the instrument field of view or concentrated in one area. In addition, the cloud class diagram provides significant information’s for take off and landing decisions.

Other parameters still under development could be reached with the same hardware structure and provide locally a short term forecast :

- Cloud cells direction.
- Cloud cells speed.
- Cloud cells water content.

-Interpolation of data provided by several Nephelo instruments and/or data provided by satellites.

The analysis of recent flooding events in the south east of France showed that conservative decisions for citizen and facilities were not taken by local authorities due to the lack of both local cloud cover monitoring and of methods to achieve it.

6. CONCLUSIONS

Infrared cloud imagers will not explain totally the cloud phenomenon as physics are still investigating about their genesis, but they can fill the last “manual” part in the ground based observation network. Some people can think that such instrument is a “human observer” killer. We don’t share this opinion; our feeling is that the “human observer” job will be no more to go outside to watch the sky or to measure water height in a beaker but to watch displays and to verify and confirm coherence of data as illustrated in figure 3.

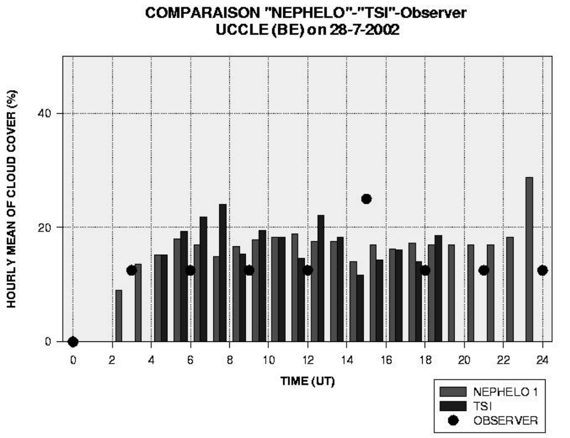

Figure 3

7. ACKNOWLEDGMENTS

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