ATMOSPHERIC EXTINCTION COEFFICIENT AND CLOUD BASE HEIGHT DETERMINATIONS BY USING A SINGLE PULSE EYESAFE LIDAR

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KEY WORDS:
LIDAR, CLOUD BASE HEIGHT, ERBIUM:GLASS, EYESAFETY,CEILOMETER

1 INTRODUCTION
A cloud base height indicator using a single pulse solid state laser, called ALTO, has been developed for aeronautical purposes by SOPELEM-SOFRETEC company in association with the French Meteorological Office. Meteo-France investigates a method to obtain a vertical profile of atmospheric extinction coefficient. This method is used to determine cloud height, to locate backscattering layers and to allow the identification of the hydrometeor nature in the lower part of the atmosphere (mist, fog or precipitation). The performances of this equipment in term of LIDAR capabilities were presented in detail in a previous paper 1.

2 METHOD OF CLOUD BASE HEIGHT DETERMINATION

2.1 Lidar equation
The lidar backscatter intensity \( P(H) \) arriving at the receiver from the height \( H \) is given by the following single-scattering equation:

\[
P(H) = \frac{K_0 \beta(H) e^{-\int_0^H \alpha(h) \, dh}}{H^2}
\]

Where:
- \( K_0 \) is the apparatus constant,
- \( \alpha(h) \) the attenuation coefficient which characterizes the optical path between cloud and ground (m^{-1}),
- \( \beta(H) \) the backscatter coefficient which characterizes the cloud droplet density at height \( H \) (m^{-1} sr^{-1}).

Only single scattering is considered and molecules and haze contribution can be assumed negligible compared with clouds and precipitation one.
In a homogeneous atmosphere $\beta$ and $\alpha$ are constant and consequently $P(H)$ decreases smoothly with height. In presence of a cloud layer, the signal undergoes a rapid increase of backscattering when light penetrates into the cloud, which is due to change of $\beta(H)$.

2.2 Inversion of lidar signals

To determine $\alpha(h)$ from the lidar equation, we must have some functional relationship between $\beta(h)$ and $\alpha(h)$. A convenient form which has been shown by experiment to be reasonable is the power law:

$$\beta = C \alpha^k$$

Assuming that $k$ is a constant, KLETT\(^2\) has suggested a solution to the lidar equation that is mathematically stable and converges for lidar returns obtained under some of the more interesting atmospheric conditions, such as the presence of stratus layers.

The solution $\alpha(H)$ of the lidar equation is:

$$\alpha = \frac{P(H)H^2}{P(H_m)H_m^2 m + 2 \int_{H_m}^H P(h)h^2 dh}$$

KLETT avoids instabilities by choosing the boundary value at the far end $H_m$ of the range interval, thus inverting the lidar equation in the backward instead of the forward direction.

2.3 Determination of cloud-base height

The lidar signature of a cloud layer is a sharp peak which can be easily detected. The cloud base is usually considered at the beginning of the sudden increase of the backscatter signal. However, there are clouds for which the signal does not undergo a sharp increase at their bottom. This is the case when clouds are located just above fog, haze or precipitation. Consequently, the cloud base height determination is more difficult and becomes unprecise.

This cloud base detection uncertainty is overcome by using the inversed signal expressed in attenuation coefficient unit $\alpha(H)$. The cloud base is then located by calculation of the derivative $\Delta \alpha / \Delta H$.

An increase of the signal is detected over 3 data samples and the corresponding height $H_0$ located at the first data sample.
3. LASER PRINCIPLE AND PERFORMANCES USED IN ALTO CEILOMETER

The ceilometer is derived from technologies used by Sopelem-Sofretec in laser range-finders and shown on picture. The optical system is composed of a transmitter and a receiver with optical axes arranged in parallel monostatic configuration. The transmitter is a rugged Q-switched solid-state laser. The laser amplifier media is a glass rod doped with Erbium generating a stimulated emission at 1.54 µm wavelength with typically 8 mJ pulse energy. The backscattered signal from clouds is focused on a detector by a Galilean telescope. A photodiode associated with a sunlight filter allows a good signal to noise ratio. The signal is amplified, digitized by a 8 bit fast analog-digital converter which samples at intervals of 10 meters. The unit generates a light pulse every 15 seconds and the cloud height is then calculated by a microprocessor within this time.

<table>
<thead>
<tr>
<th>Features</th>
<th>Performances</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cloud Range</td>
<td>30 to 3500 m</td>
</tr>
<tr>
<td></td>
<td>50 to 7500 m (enhanced version)</td>
</tr>
<tr>
<td>Range resolution</td>
<td>10 m (all over the range)</td>
</tr>
<tr>
<td>Transmitter type</td>
<td>Q-Switched Erbium:Glass</td>
</tr>
<tr>
<td>Transmitted energy</td>
<td>8 mJ/pulse</td>
</tr>
<tr>
<td>Transmitted wavelength</td>
<td>1.54 µm</td>
</tr>
<tr>
<td>Receiver diameter</td>
<td>65 mm</td>
</tr>
<tr>
<td>Receiver photodiode type</td>
<td>InGaAs PIN (APD for enhanced version)</td>
</tr>
<tr>
<td>Signal processing</td>
<td>KLETT inversion type</td>
</tr>
<tr>
<td>DATA</td>
<td></td>
</tr>
<tr>
<td>Transmitted informations on RS232 line 1</td>
<td>-2 cloud base heights and thickness</td>
</tr>
<tr>
<td></td>
<td>-precipitation, haze and fog discrimination</td>
</tr>
<tr>
<td></td>
<td>-estimation of vertical visibility</td>
</tr>
<tr>
<td></td>
<td>-extinction profile</td>
</tr>
<tr>
<td>MAINTENANCE</td>
<td></td>
</tr>
<tr>
<td>Transmitted informations on RS232 line 2</td>
<td>-Build in Test</td>
</tr>
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<td></td>
<td>-state of transmitter, receiver</td>
</tr>
<tr>
<td>MODEM available</td>
<td></td>
</tr>
</tbody>
</table>

Table 1: Main features of the ALTO ceilometer
4. ADVANTAGES OF THE APPLIED DESIGN
The development criteria of all new LIDAR generation, as ALTO ceilometer, require the best optimization between the three main following points:

- Eyesafety
- Performances through atmosphere
- High capabilities and modularity of the instrument

All these three goals can be achieve by using the 1.54 μm Erbium:Glass solid state laser transmitter.

4.1 Eyesafety considerations

Many LIDAR applications operate in the near Infra-red (0.8 to 1.1 μm) such as the diode laser. At these wavelengths, the laser energy is transmitted through the eye and focused on the retina where even small amounts of laser energy can cause permanent eye damages. Thus, for laser applications where the operator cannot be effectively protected, an "eyesafe" laser is very desirable. The recent revision of the almost widely accepted laser safety standard, ANSI Z 136.1-1993 or EN 60825-1-1994 extends the eyesafe wavelength window from 1.5 to 1.8 microns. The wavelength range which has until very recently been considered to be safest was a narrow band around 1.55 μm.

Thus a new solid state laser, as Er:Glass, offer the great advantage to obtain high energy pulse in "eyesafe" operating environment. With technologies in agreement with the eyesafe laser standard, new horizons are now possible.

As can be seen in the following figure 1, the limit of 7.9 mJ for a single pulse is two order of magnitude higher than surrounding wavelengths and four order of magnitude higher than for the near Infra Red (0.9 to 1 μm).

ALTO was designed to be a CLASS 1 laser equipment, for both operation and maintenance purposes.

![Figure 1: CLASS1 Accessible Emission Limit (AEL) for lasers (EN60825-1:1994)](image-url)
4.2 High atmospheric transmission

A lot of studies was performed in the past and more recently, on the comparison of atmospheric performances at different existing wavelength for rangefinders (especially for military purposes at 1.54 and 1.06μm).

Calculations using atmospheric data bases as LOWTRAN 3 and HITRAN 4 or field test experiments 4-5 have all showed a lower absorption of atmosphere at 1.54 μm. This laser line brings a notable improvement of range under various weather conditions compared to lower wavelengths, where the aerosol absorption gets stronger.

In this way, range could be increased from 10% up to 50%, depending of atmospheric conditions:

- rain (rate from 1 to 4 mm/h)
- thin to moderate fog (atmospheric visibility from 1.5 to 0.5 km)
- clear to hazy atmosphere (atmospheric visibility from 23 to 5 km)

Experimental data obtained with our equipment confirm high performance in typical situations as low visibilities and rain (see § 5).

4.3 Capability and modularity of the instrument

The high peak power (>200kW) passing through the atmosphere offers a lot of design advantages:

- **high Signal to Noise Ratio** (SNR), even by using low sensitivity and standard detector (as PIN photodiode), in all atmospheric situations described above. The SNR is also enhanced by lower solar irradiation around 1.5μm,
- the **low natural divergence of the laser** beam (4mrd), allows to minimize the size of the optical components in both transmitter and receiver channels (lens diameter of few tenth of millimeter), with a simplified optical design,
- **fast signal detection time** within a single laser pulse allows higher measurement rates (up to 1Hz) compared to classical accumulation laser pulse method, especially for distances higher than 1500 m,
- proved **reliability** in extreme environments (temperature, shocks and vibrations).

The choice of this design, with high peak power solid state laser, opens real new potential applications for such LIDAR equipment, such as:

- **higher cloud detection range** (up to 25 000 ft/ 7500 m) with no significant modifications. This could be achieved easily by using an avalanche photodiode detector.
- **low weight** (less than 3 kg) and **very compact** (about 1 liter) hand held LIDAR with range capability up to 5000 ft (~ 1500 m).

Moreover, we have to keep in mind on the existing or future compact laser sources (diode pumped) which are, at present time, in development in laboratories.
5. TYPICAL RESULTS
The inversion process has been carried out following two zones:

- The first concerns the zone the high isolated clouds
- The second, when the reference range \( h_m \) is chosen at the range where the amplitude of the signal vanishes in the noise level.

Ground visibilities calculated from extinction coefficient data are of the same order of magnitude that from transmissometer measurements.

By low visibility measurements, dense fog situations can be identified. This information related to low stratus is very important for landing operations and safety.

Examples of extinction coefficient profiles \( \alpha(h) \) calculated from the lidar returns selected during rain episodes for which the ground visibility was about 7000-8000 m are presented in Fig. 3 and 4. These examples show that under moderate rain, cloud-bases above 500 m can be easily detected, even in presence of multiple cloud layers.

Figure 4 shows an example of temporal evolution of cloud ceiling performed under rain, and observed with the erbium-glass ceilometer and a diode laser cloud-base height sensor. We can see that the slow increase of the cloud-base from 1700 to 2500 m is well-observed by the erbium-glass ceilometer whereas the diode laser instrument has difficulties to reach the cloud-base for heights greater than 1800 m. After 8 h 38, when the cloud-base decreases to 500 m, the two instruments are again in good agreement. This temporal representation, under light and moderate rain, has been selected from many similar observations.

Figure 5 is the corresponding statistical comparison derived from 5014 rain measurements achieved with these two ceilometers. We can see that the erbium ceilometer hits clouds in 95% of cases whereas the diode laser instrument hits them in only 69% of these cases. These experiments put in evidence the high performances of the erbium-glass transmitter under precipitation.

More data, especially in heavy rain, will be needed to fully interpret these effects.

6. CONCLUSION
By using a 1.54 \( \mu m \) laser, this new ceilometer shows advantages compared to classical equipments. At this wavelength, class 1 eye-safety requirements are fulfilled with high output power solid state laser which offers high measurement capabilities.

A signal processing software using the Klett LIDAR inversion method gives the cloud base height data and weather informations such as fog from the extinction profile.

Our experiments have shown that ranges are greatly improved in presence of precipitating hydrometeors, compared to classical laser diode ceilometers.

The future work on this instrument in 1995, will be focused on the analysis of signals under snow and heavy rain.
7. REFERENCES
1. J.L. Gaumet et al "Cloud base height measurements with single pulse Er:glass laser ceilometer ";
9th symposium on meteorological observation and instrumentation (P100).
2. J.D. Klett "Stable analytical inversion solution for processing lidar returns", Applied Opt. 20, 211-
3. E. Gregor et al "20 Hz eyesafe laser rangefinder for air defense";
5. W.N. Nixon et al "Dependence of the propagation loss in laser ranging systems on the meteorological
visibility and target/receiver range ".
Fig. 2 Backscatter an extinction profiles during a light rain episode (visibility : 8000m).
Fig. 3 Backscatter and extinction profiles during a rain episode.
Fig 4. Temporal evolution of cloud ceiling observed with diode laser and erbium glass ceilometers during a rain episode.

Fig 5. Diode laser and erbium glass ceilometer comparison of measurements in rain. The performances are compared with percentages of cloud hits (the total number of measurements is 5014).
Correlation lidar measurements of meteorological characteristics in conditions of atmospheric condensation

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ABSTRACT

At a lidar sounding of atmosphere meteorological parameters (wind velocity and direction profile) the precipitation more often is considered as a hindrance, which limits the distance and accuracy of the measurements and in some instances performs the measurements impossible. But in the course of investigations it has been found that in certain situations the precipitation increase efficiency of lidar sounding. In this case the distance and accuracy of sounding are increased. Primarily this is true for low watery of precipitation, which has the intensity no more than 1.5 mm/h. Furthermore, the possibility of determinations of the microstructure and integral characteristics of precipitation area is existed.

The investigations were performed using the correlation scanning three-path lidar with vertical scheme of sounding. In the course of measurements the spatial-temporal series of the reflected by precipitation optical signals were amassed. The handling of the lidar data based on the correlation-spectral method.

The study of the optical signals reflected from precipitation showed that increase of the wind velocity sounding efficiency is available by amplification of the signal fluctuation components. Limitations on the rain rate are caused by that for powerful rain a maximum of the dropsize distribution function is displaced in side of the high quantities which are not carried by air flows and useful information for estimating of wind velocity give the raindrops with dimensions no more than 0.6 mm in diameter.

As the lidar allows to make a vertical cut of the precipitation area, that it was seen the moving of forward and reverse fronts of the precipitation area at the spatial range of the optical signals. From a comparison of the fronts positions in different times the drop speed of the different rain group is determined. This allowed to estimate the range size raindrops and raindrop size distribution function was determined. The knowledge of precipitation microstructure parameters allows obtained integral characteristics of precipitation area: rain rate (mm/h), watery (g/m³), raindrop concentration (1/m³).

1. THE INSTRUMENT AND METHODOLOGY

The investigations were performed using the scanning three-path lidar with vertical scheme of sounding. The lidar operated in the pulsed mode. The start-up of laser is performed in
three certain positions of one the scanning period. This provides a possibility of obtaining the
information from different scattering volumes. The lidar sounded the atmosphere as high as
2.5 km with spatial resolution about 20 m. The such scheme of sounding allows to make the
vertical cut of the precipitation area.

Based lidar parameters:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy in pulse</td>
<td>0.1 J</td>
</tr>
<tr>
<td>Wavelength</td>
<td>532 nm</td>
</tr>
<tr>
<td>Divergence</td>
<td>0.5 mrad</td>
</tr>
<tr>
<td>Pulse duration</td>
<td>15 ns</td>
</tr>
<tr>
<td>Telescope</td>
<td>0.3 m</td>
</tr>
<tr>
<td>A/D conversion</td>
<td>8-byt resolution</td>
</tr>
<tr>
<td>Spatial resolution</td>
<td>10-20 m</td>
</tr>
<tr>
<td>Number of level sounding</td>
<td>128</td>
</tr>
<tr>
<td>Set of data time</td>
<td>20-30 min</td>
</tr>
</tbody>
</table>

The handling of the lidar data based on the correlation-spectral method.\(^1\) Previously
handling of the temporal range lidar returns includes highly frequency filtration and trend-
removal. Furthermore, on a basis of fast Fourier transform the cross-correlation functions
and phase spectra are calculated. The wind velocity and direction are determined at the shift
of the cross-correlation function maximum of the temporal range of lidar returns and at
amounts of phase spectra tilt.

The analysis of spatial and temporal range of lidar returns obtained in condition of rain
showed that possibility of the precipitation area characteristic measurements is existed. In the
meteorology of the precipitation area a convention classified such parameters as shape,
vertical and horizontal size and boundaries, phase of evolution, transfer velocity, structure.
In practice the structure precipitation area is described by appropriate integral parameters:
rain rate (mm/h), watery (g/m\(^3\)), concentration of precipitation particles (m\(^{-3}\)). The integral
characteristics are calculated from measured microstructure data of precipitation, that is
determined from raindrop size and fall velocity distribution.

The microstructure characteristics of the precipitation area are estimated on a basis of fact,
that in the course of raindrops falling it occurs the drop gravitational separation. As the lidar
allows to make a vertical cut of the precipitation area, that at the spatial range of the optical
signals it was seen the moving of forward and reverse fronts of the precipitation area in which
raindrops are with maximum and minimum diameter respectively. From a comparison of the
fronts positions in different times the drop speed of the different rain group is determined
and on a basis of data obtain by Gunn and Kinzer\(^2\) it is estimated the maximum and
minimum sizes of raindrops in precipitation area. As size of the scattering lidar volumes is
small (part and unit of cube meter), that for all time one contents a small quantities of
raindrops (from units to several hundred). From a little of vertical scattering lidar volume
dimention and action of the gravitational separation it follows that dropsizes in this volume

\(^1\) From: "Lidar Meteorology" by A. V. Ivanov and A. V. Novikov (1992).
and the contributions of each drop to lidar return are equal. By this means of the signal
dispersion reflected from this layer is proportional to drop number $N_H$ and therefore the
variation coefficient $W_H$ for layer on altitude $H$ is defined as

$$W_H \equiv \frac{1}{\sqrt{N_H}}. \quad (1)$$

Therefore, measuring the variation coefficient for a given layer, it may be defined the drop
number $N_H$ in unit volume. Determination $N_H$ sequentially for all layer of precipitation area
gives dropsize distribution function.

The knowledge microstructure parameters of precipitation area allows to determine the
integral characteristics. The concentration of precipitation particles $N$ (m$^{-3}$) can be obtained as

$$N = \sum_i N(a_i). \quad (2)$$

where $N(a_i)$ is drop number of diameter $a_i$ in volume unit, $i$ is change in the region from
$a_{\min}$ to $a_{\max}$. The rain rate $I$ (mm/h) at the instant sounding is given by

$$I = \frac{4\pi}{3} \sum_i a_i^3 N(a_i) V(a_i). \quad (3)$$

where $V(a_i)$ is raindrop fall velocity. The rain watery $W$ (g/m$^3$), i.e. the quantities number
of water in cube meter at rainfall is obtained as

$$W = \frac{4\pi}{3} \sum_i a_i^3 N(a_i). \quad (4)$$

The rain rate is the determining factor, which identifies transparency in rain area. Korrelation relationship between attenuation coefficient of optics radiation $\alpha$ (km$^{-1}$) and
rain rate is expressed empirical equation

$$\alpha = 0.21 I^{-0.74}. \quad (5)$$

The relationship between rain rate and watery is given by

$$W = 0.065 I^{0.88}. \quad (6)$$
The vertical sizes and boundaries of precipitation area were estimated on the correlation matrix analysis obtained from the temporal range of lidar returns. The transfer velocity of area estimated on measurements of wind velocity at that time.

2. MEASUREMENTS AND RESULTS

The measurements was performed in summer-autumn 1993-1994 near Tomsk (Siberia). The sounding were carried out in conditions of powerful Cb and Ns clouds, when probability precipitation is high. Synchronous with parameters of rains it was measured wind velocity and direction in layer from 100 meters to low boundary clouds. The duration of temporal range of lidar returns was about 30 minutes.

The study of the optical signals reflected from precipitation showed that increase of the sounding efficiency is available by amplification of the signal fluctuation components. For lidar system using the correlation procedure of data handling, the increase of the signal variation coefficient brings to increase of signal to noise ratio and sounding distance. By this means, the raindrops represent by natural tracers. Limitations on the intensity of precipitation are caused by that for powerful rain a maximum of the dropsize distribution function is displaced in side of the high quantities. The performed analysis showed that useful information for estimating of wind velocity is given by raindrops with dimensions no more than 0.6 mm in diameter. Besides, when the rain rate increases it is simultaneously increased the low limit altitude begining with which the measurements of wind velocity is possible. This is due to the fact that it occurs the vertical and horizontal raindrop separation.

The wind velocity and direction are determined at the shift of the cross-correlation function and at amounts of phase spectra tilt. The analysis of phase and coherence spectra is showed. that in precipitation area the interval of informing frequencies is increased. As viewed from Fig. 1 the level coherence spectrum in all frequency range is 0.8-0.95, that indicates on high informing of measurements. As to the cross-correlation function obtained from lidar data of precipitation area has a high level of correlation (higher 0.95). At the same time outside of precipitation area it is observed the fast decrease of level coherence.

Fig. 1. Phase spectrum $\theta(f)$ (curv.1) and coherence spectrum $\gamma^2(f)$ (curv.2) obtained from precipitation area 25 August 1993. Altitude - 1600 m.
Fig. 2 shows wind velocity and direction profiles obtained in condition of rain. The checking the lidar data for accuracy was carried out by way of the theodolite measurements. In this case the distance to clouds determined from lidar signals.

![Wind velocity and direction profiles](image)

Fig. 2. Wind velocity and direction profiles. 1- 11 June 1994; 2- 25 August 1993; 3- 13 June 1994. Short length shows the 95% confidence level.

On the described method it was determined the precipitation area parameters. In Fig. 3 it is shown the histogram of raindrop size distribution obtained on data averaging for 6 seconds. The histogram gives the content particles $N$ in each class of size $r$, where $r$ is radius.

As an approximation for dropsize distribution function was selected Hrgian-Mazin distribution, which is a particular case of $\Gamma$-distribution

$$f(a) = Aa^2 \exp\{-\beta \cdot a\}.$$  \hspace{1cm} (7)

where $a$ is drop diameter, $A, \beta$ is parameters, which calculated on method put forward Poliakova.
The comparison of the theoretical and experiment drop-size distribution showed their agreement with probability 0.95. The integral characteristics of precipitation area were calculated by (2-6). Measured microstructure data and calculated integral parameters shown in table 1.

Table 1. Parameters of different rains obtained by correlation lidar.

<table>
<thead>
<tr>
<th>DATE</th>
<th>TIME</th>
<th>I, mm/h</th>
<th>W, g/m³</th>
<th>α, km⁻¹</th>
<th>N, m⁻³</th>
<th>r_max, mm</th>
<th>r_min, mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>25.08.93</td>
<td>18h25m</td>
<td>7.7</td>
<td>0.39</td>
<td>0.9</td>
<td>388</td>
<td>1.3</td>
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<tr>
<td>11.06.94</td>
<td>2h15m</td>
<td>4.8</td>
<td>0.25</td>
<td>0.63</td>
<td>620</td>
<td>1.3</td>
<td>0.15</td>
</tr>
<tr>
<td>13.06.94</td>
<td>14h20m</td>
<td>6.3</td>
<td>0.3</td>
<td>0.64</td>
<td>590</td>
<td>1.5</td>
<td>0.1</td>
</tr>
</tbody>
</table>

The spatial boundaries of precipitation area were determined on the correlation matrix analysis. Example of correlation matrix is showed in table 2. The analysis of matrix components showed that the disruption of correlation bonds are on the level of forward and revers of precipitation area fronts, what has a simple physical meaning. Besides, as it saw from the table 2 the precipitation zone has the disruption vertical structure. Low zone boundary represents the altitude 1300 m, upper - 1700 m. Average vertical size of zone for measurement time was about 400 m. Because, relative error in determination linear size of precipitation area in meteorology is taken at a level of about 30% owing to blur the transition region so obtained result may well suffice.
Table 2. The correlation matrix obtained by temporal ranges of lidar returns from precipitation area. Date-25 August 1993, time-18h25m.

<table>
<thead>
<tr>
<th>H, m</th>
<th>1000</th>
<th>1100</th>
<th>1200</th>
<th>1300</th>
<th>1400</th>
<th>1500</th>
<th>1600</th>
<th>1700</th>
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</thead>
<tbody>
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<td>1.00</td>
<td>0.99</td>
<td>0.95</td>
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<td>0.49</td>
<td>0.55</td>
<td>0.27</td>
<td>0.48</td>
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<td>0.42</td>
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<td>0.54</td>
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<td>0.42</td>
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The spatial-temporal evolution of precipitation area with instant conception and time inception of rain can be followed on a spatial range of lidar returns in dissimilar times. This is showed Fig. 4. Besides, rain was prediction beyond 2-3 minutes before downfall first drops.

Fig. 4. The spatial-temporal evolution of lidar returns from the precipitation area. Date-25 August 1993, time-18h25m, Δt = 2 sec.

In the course of development the precipitation area travels different phases: stature, ripeness and break-up. Each phase is characterized by the duration. In the course of our measurements it were determined characteristics only of precipitation area in phase of stature.
On the base of obtained results we may conclude that correlation lidar preserves the operation of wind velocity and direction in low intensity precipitation conditions. Besides it is substantiated the possibility of determining of number other rain parameters.

3. REFERENCES