Observations of resonant scattering in the thermosphere and upper mesosphere in the winter season of 2021

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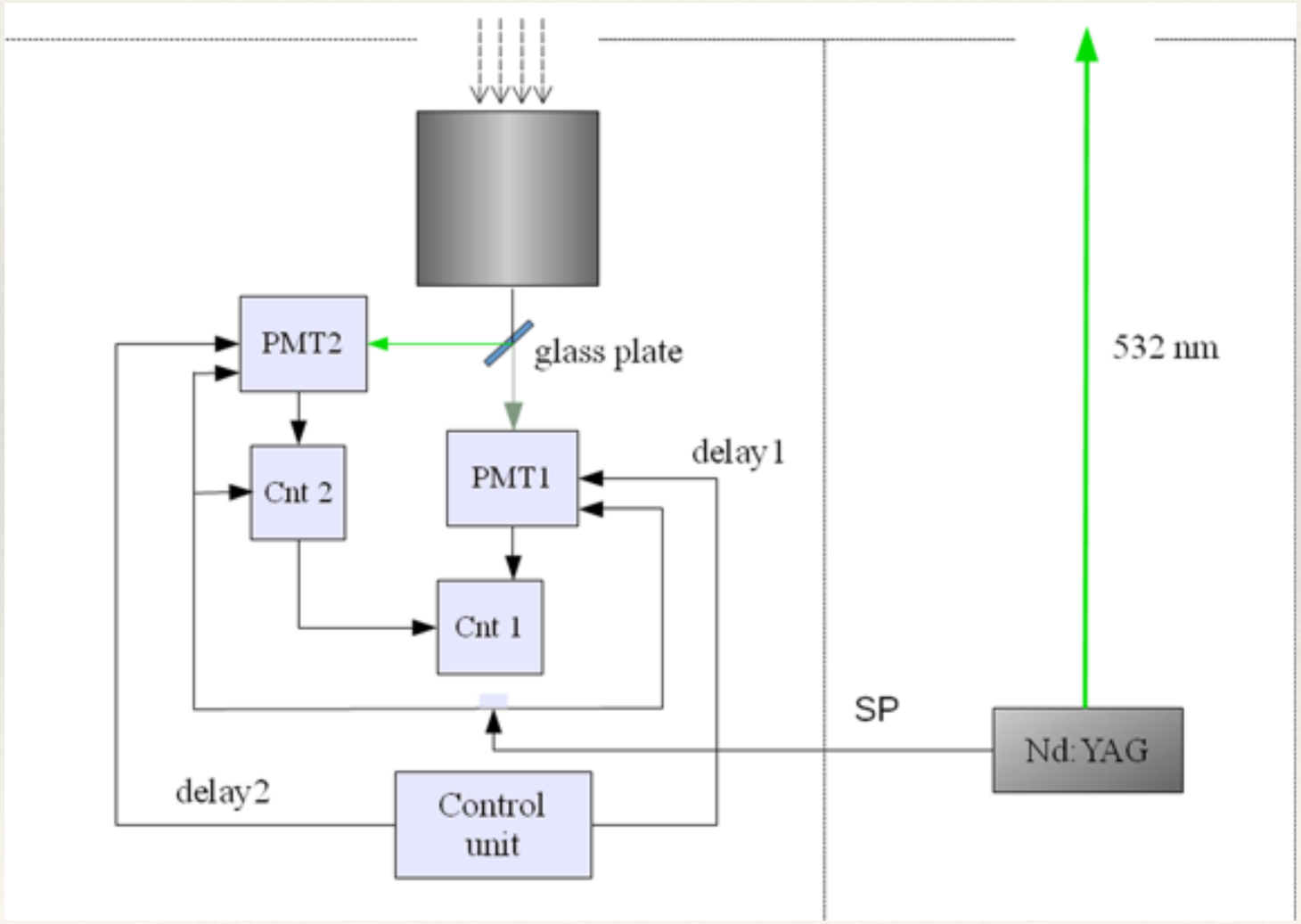
Equipment and measurement methods

- Lidar scheme: SP - sync pulse generated by laser, Cnt - photon counter. PMT - photomultiplier tube, delay - blocking pulse duration μs, set in the control unit.



Equipment and measurement methods

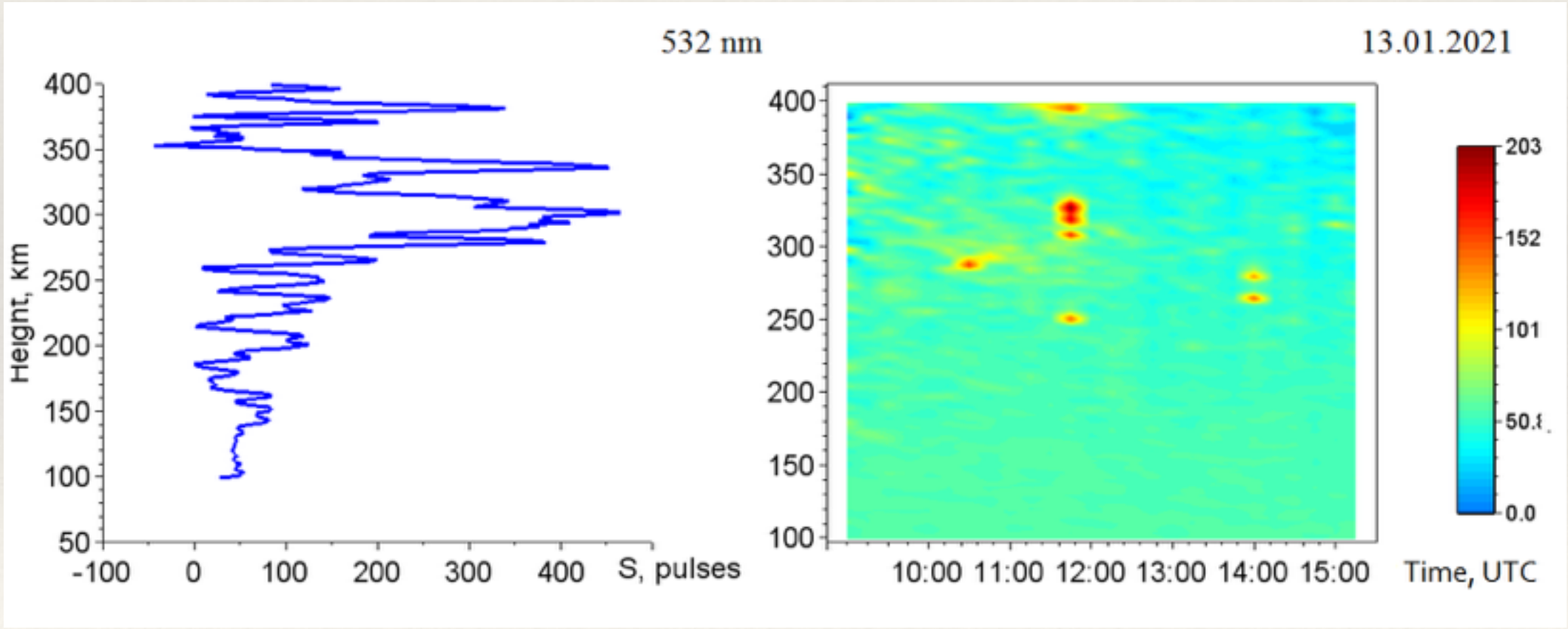
- A lidar with a Nd: YAG laser was used to generate radiation at a wavelength of λ = 532.08 nm. To exclude photomultiplier illumination from near-field signals in both receiving channels, the photomultiplier was electronically locked. A dipole transition was studied for an excited nitrogen ion with a wavelength of 532 nm.

	Component	Wavelength	Lower level	Term	J	Top level	Term	J
1	NII	532,0958	$2s2p^2(^4P)$	$^5P°$	1	$2s2p^2(^4P)$	^5P	2

- The state of the ionosphere was monitored according to the results of measurements of the Parus A ionosonde. The computers controlling the operation of the ionosonde and lidar are synchronized by GPS

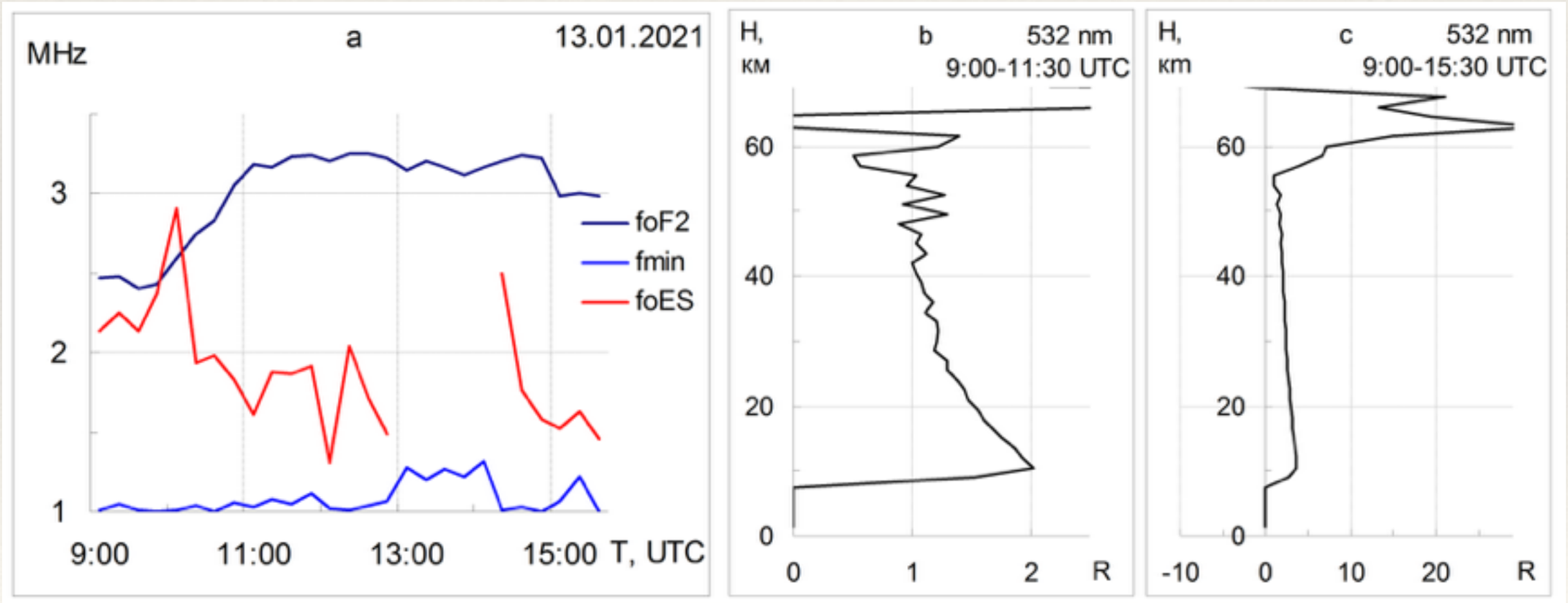
Experimental data

- January 7, 13 and 27 and in February 5, 12 and 15, mild precipitations appeared. This figure shows the values of the total “signal-background” modified by multiplying by the coefficient $k = (H / 100)^2$, where H is the height in km.

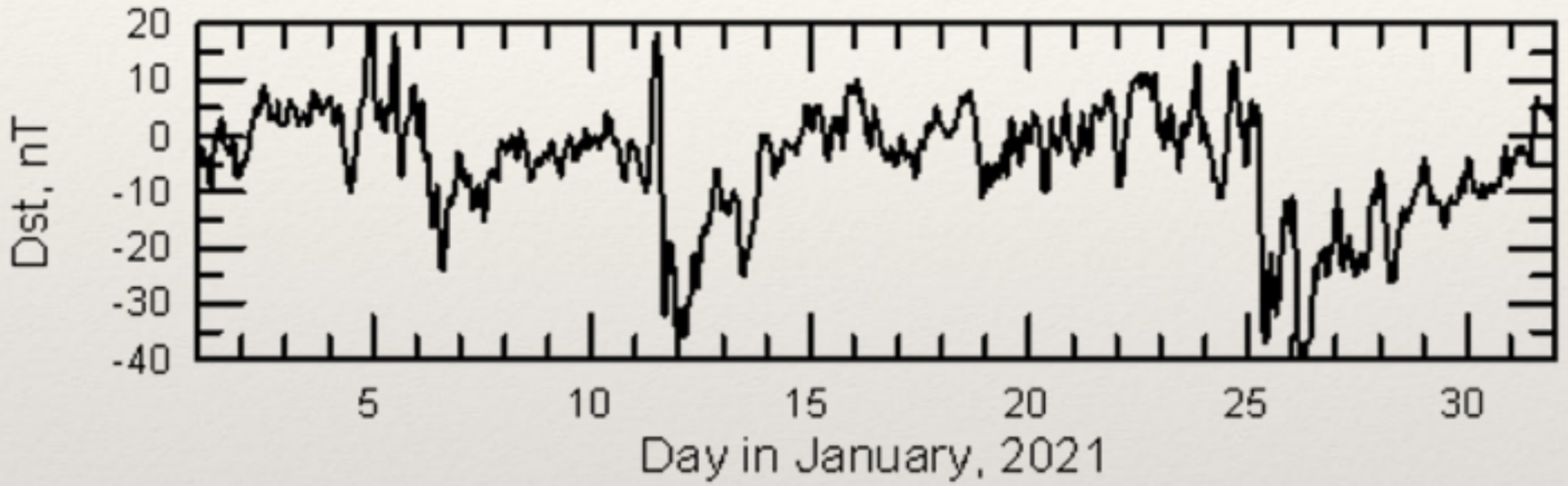


Experimental data

- Figure shows the results of atmospheric sounding by the Parus-A ionosonde: (a), the profile of the scattering ratio for the first 2.5 hours of observations (b) and the total overnight profile (c). Attention is drawn to the behavior of the ionospheric parameters fmin and foEs. The time intervals for the accumulation of lidar signals were chosen taking into account the fact that at the beginning of observations the fmin values were close to their usual values of about 1.



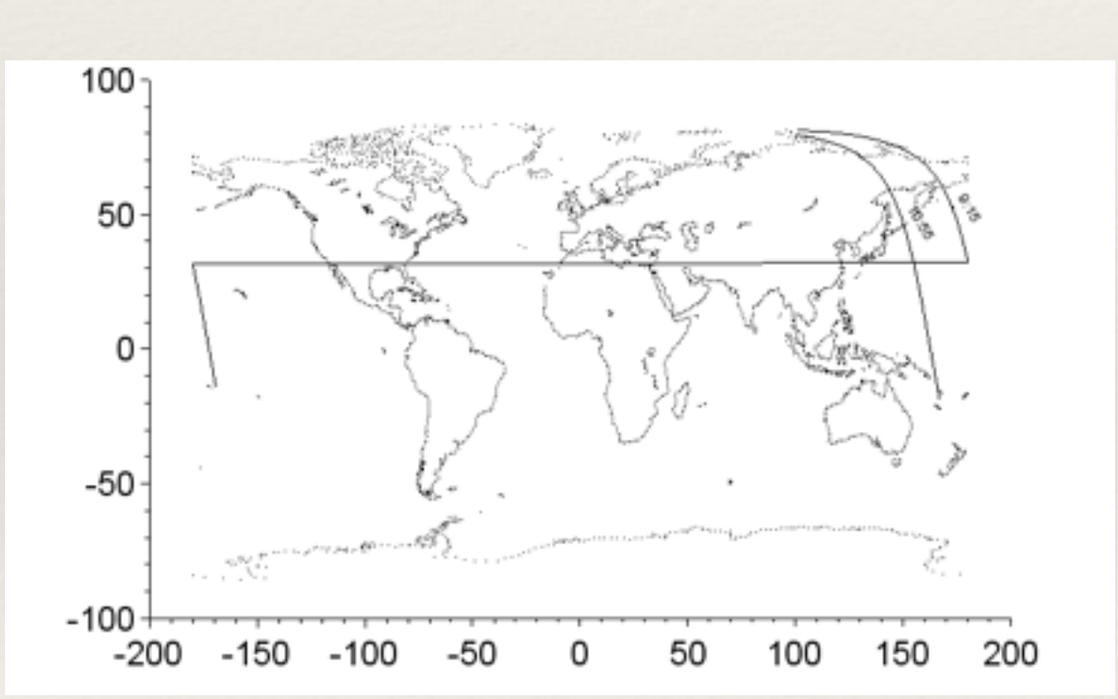
Experimental data

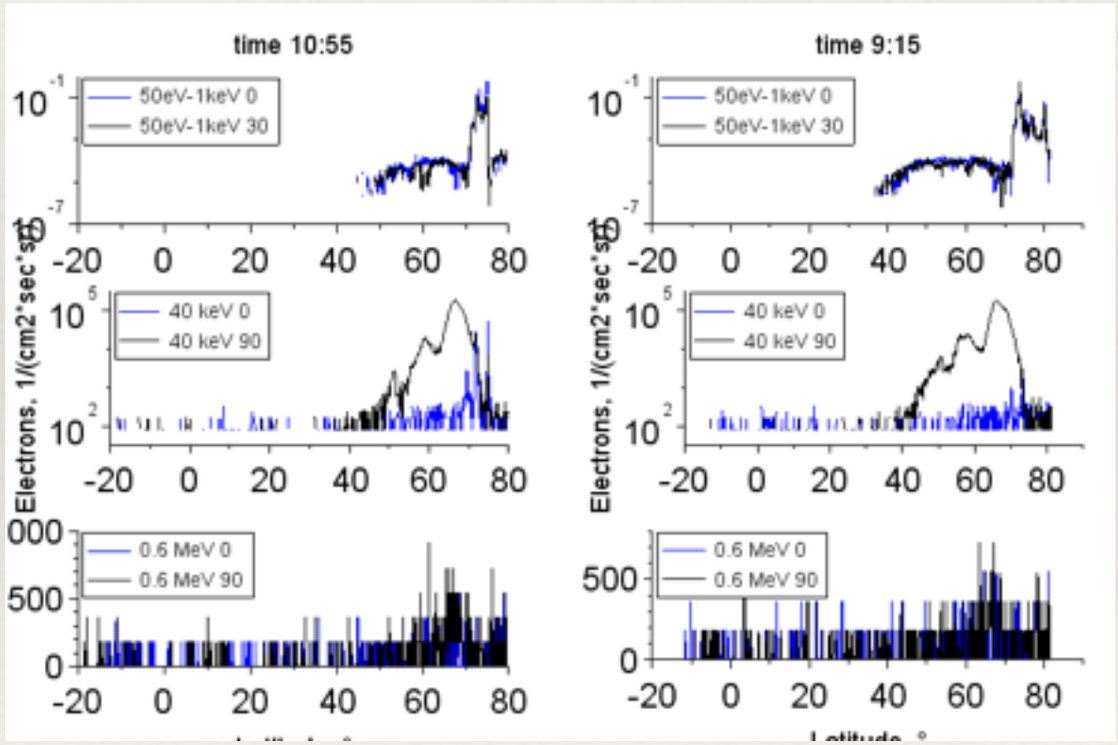


- Dynamics of the geomagnetic activity index Dst in January 2021. Small negative variations are associated with recurrent magnetic storms.

The discussion of the results

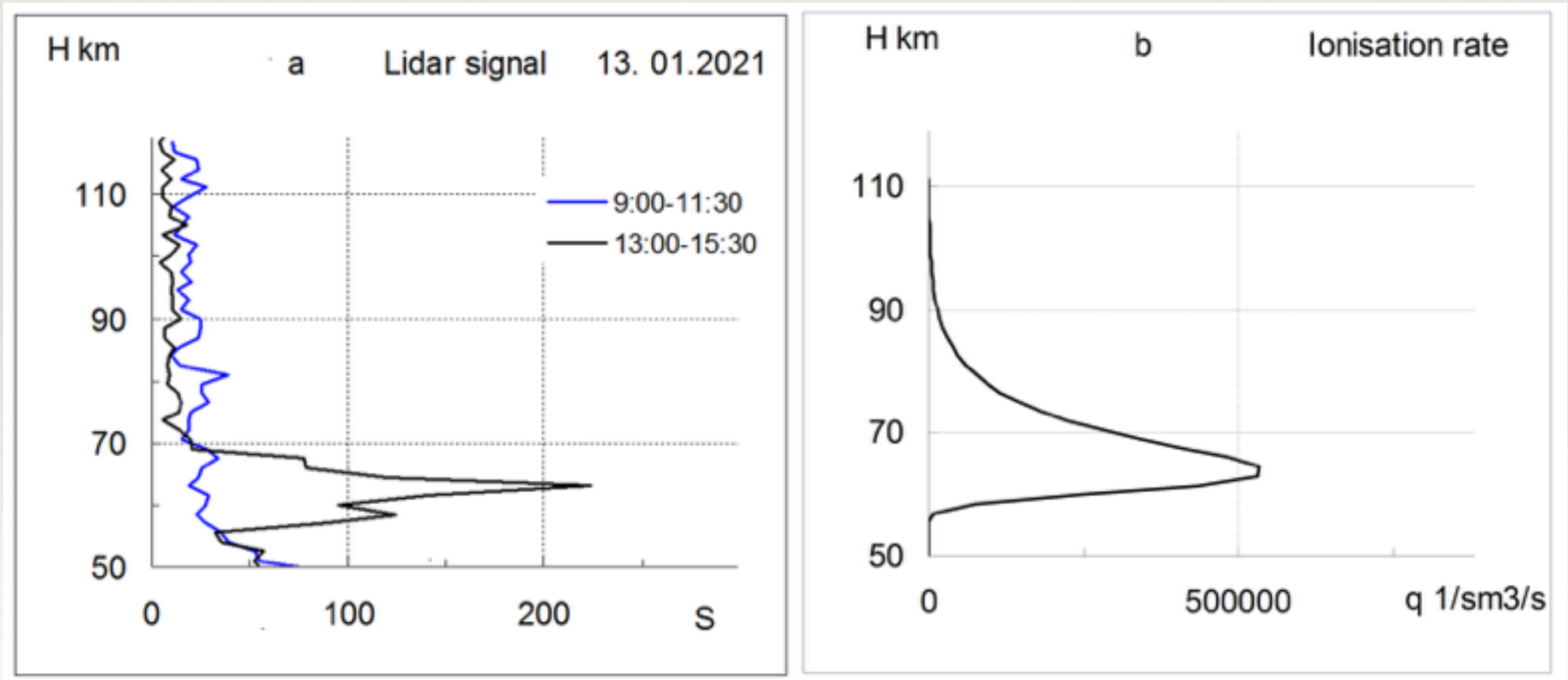
- Electron fluxes recorded on the Metop 1 satellite during lidar observations on January 13, 2021.



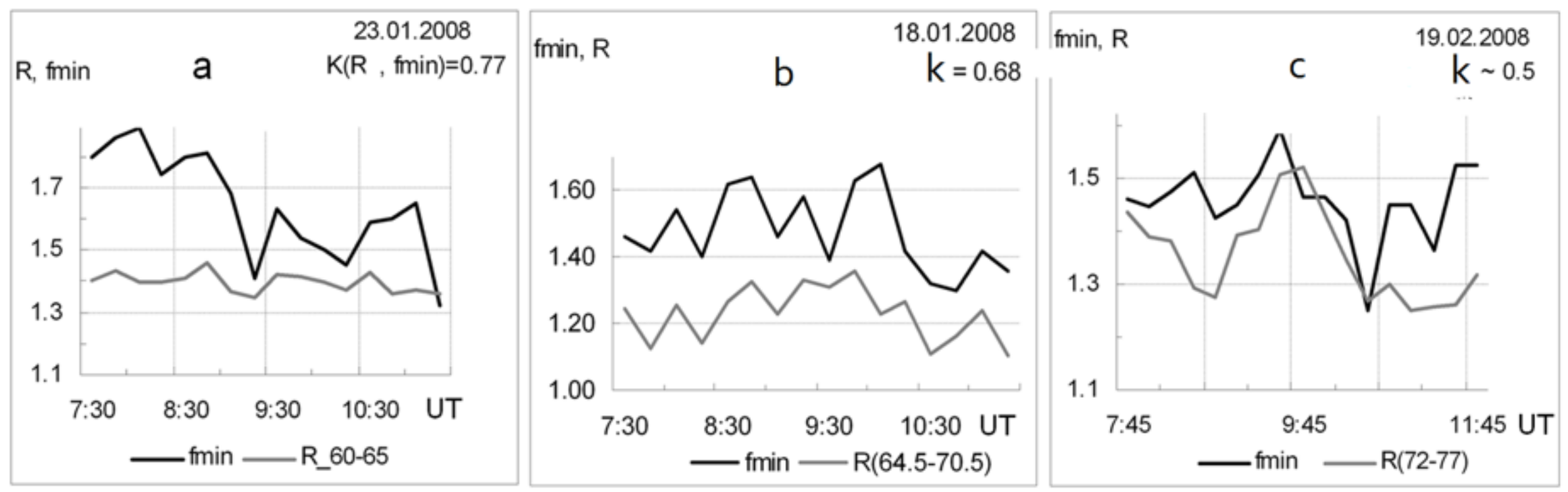


The discussion of the results

- The profiles of lidar signals in the range of 50–110 km for the same accumulation intervals were compared with the ionization rate profile for a monoenergetic electron flux constructed. It is shown that the height of the maximum of the ionization rate coincides with the height of the maximum of the signal for an electron flux with an energy of 500 keV.



The discussion of the results



- Correlation of the ionospheric parameter fmin with the scattering ratio R in the mesosphere.

Conclusions

- The experimental data obtained on the correlation of the lidar signal with the ionospheric fmin provide direct experimental evidence for the possibility of imaginary aerosol formation in the mesosphere.

- It is shown that resonance scattering on excited oxygen and nitrogen atoms can appear during the magnetospheric recovery phase after geomagnetic storms.