CRREAT

Nuclear Physics Institute of the CAS
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CZECH TECHNICAL UNIVERSITY IN PRAGUE

INSTITUTE OF ATMOSPHERIC PHYSICS
CAS

Role of actual atmospheric variables in the model of cosmic ray induced ionization

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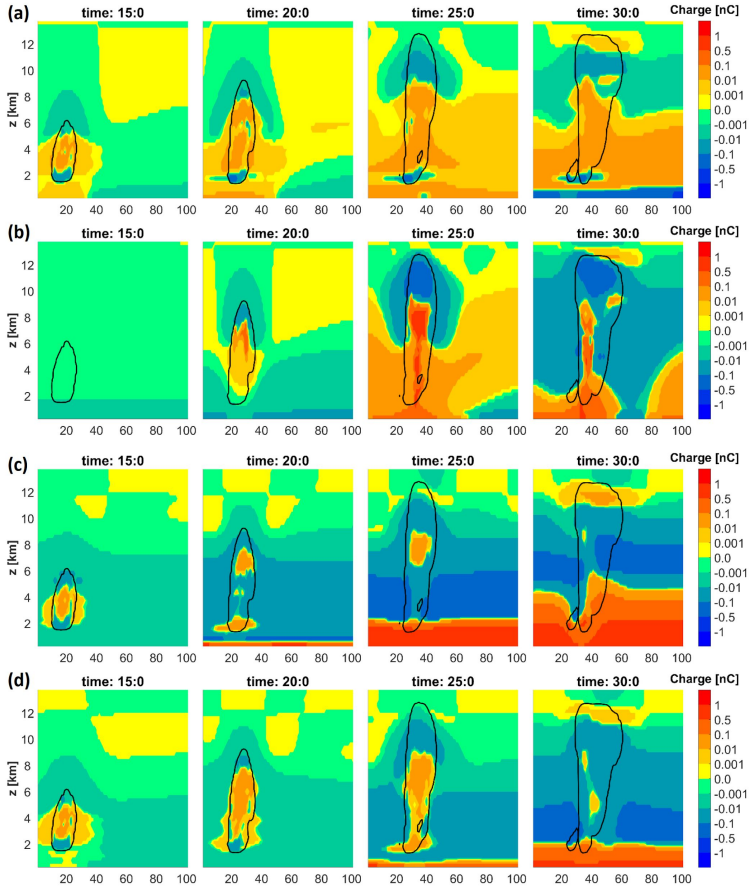
Cloud Electrification Model (CEM)



- **model of storm electrification** - based on numerical weather prediction **COSMO**
- developed at the **Institute of Atmospheric Physics of the CAS**
- uses function of cosmic ray induced ionization induced - **G function**
- can be used for a parametrization of real weather in the storm condition including **water content and charge structure**

Graph: development of storm cloud calculated with CEM for three different vertical profiles of G functions (analytical, 250, 600, and 1500 MV ofsular modulation potential). X axis represents number of grid points. Preliminary results.

Small ion parametrization equation

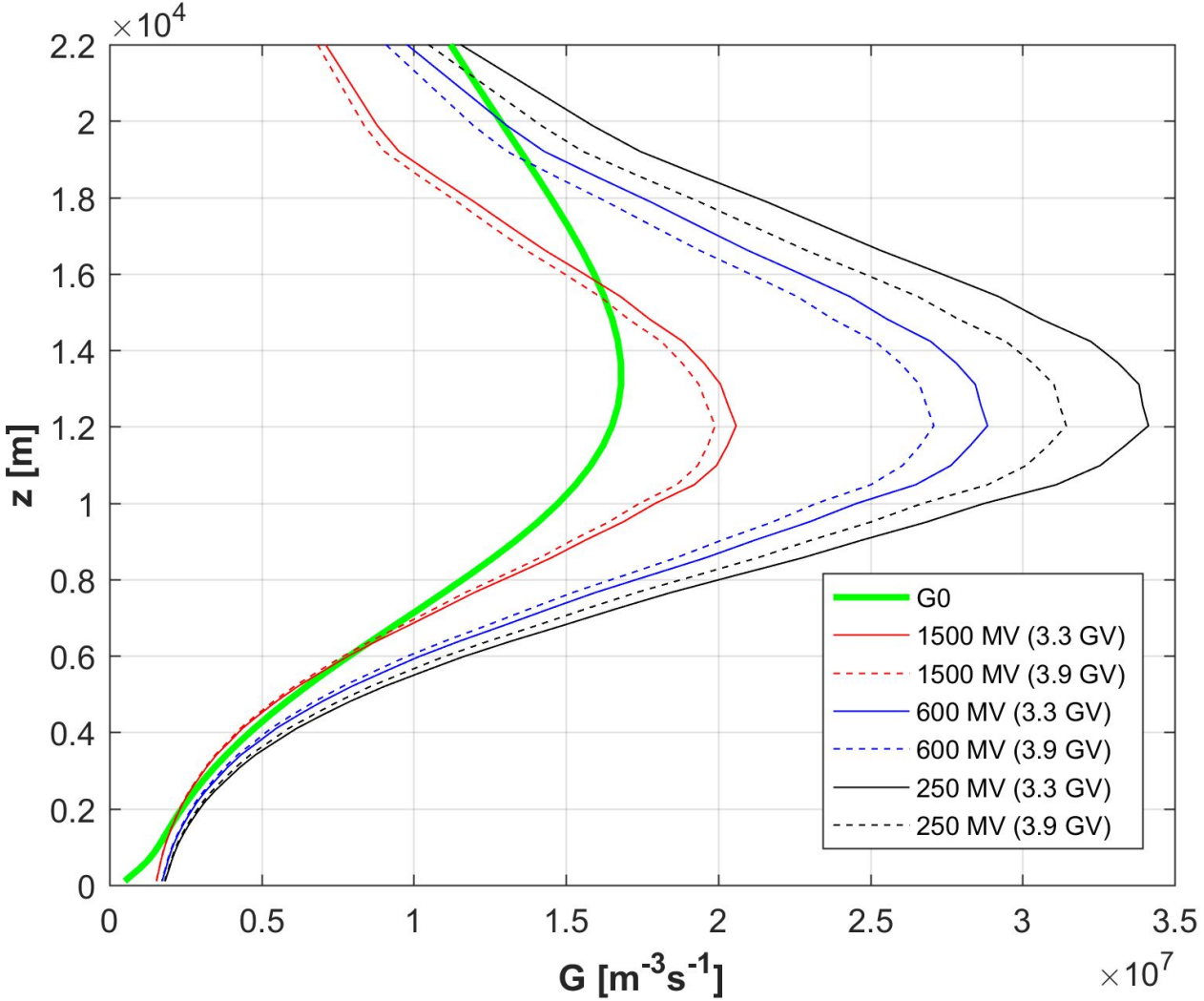
$$\frac{\partial n_\pm}{\partial t} = -\nabla(n_\pm \boldsymbol{V} \pm n_\pm \mu_\pm \boldsymbol{E} - K_m \nabla n_\pm) + G - \alpha n_+ n_- - S_{at} + S_{pd} + S_{evap}$$

n_+, n_-	positive and negative ion concentrations
$n_\pm V$	advection
$n_\pm \mu_\pm \boldsymbol{E}$	ion drift motion
$K_m \nabla n_\pm$	turbulent mixing
G	background cosmic ray ion generation rate
$\alpha n_+ n_-$	ion recombination rate
S_{at}	attachment to hydrometeors
S_{pd}	point discharge current from the surface
S_{evap}	release of any charge as ions from hydrometeors that evaporate completely

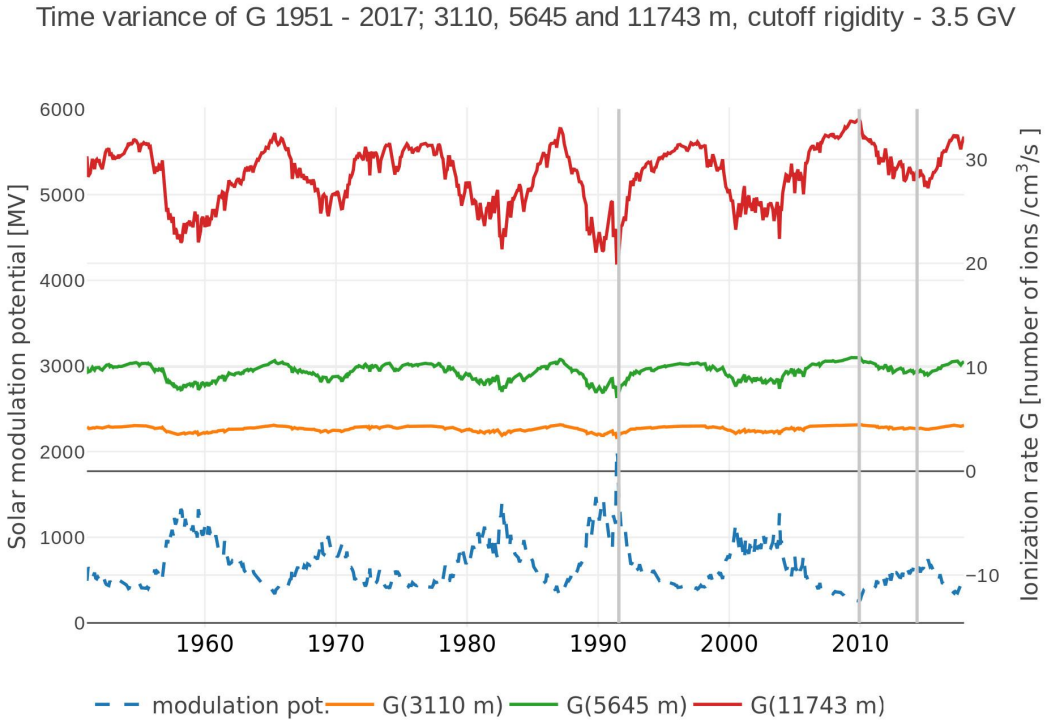
G function

G - vertical profile of cosmic ray induced ionization of the atmosphere

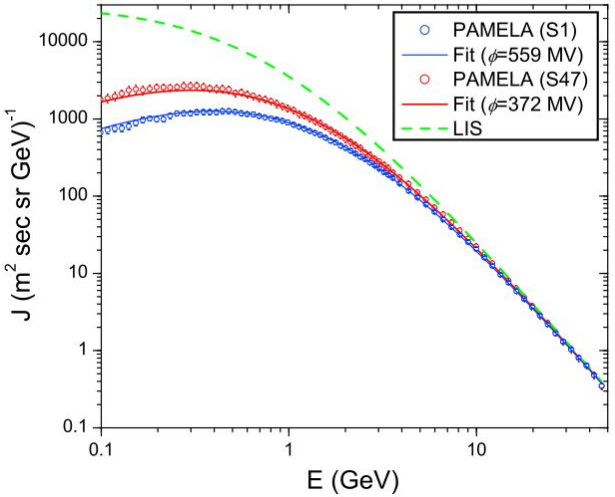
The Graph shows different G profiles calculated with the CRAC:CRII model for different solar activities and cut off rigidities.



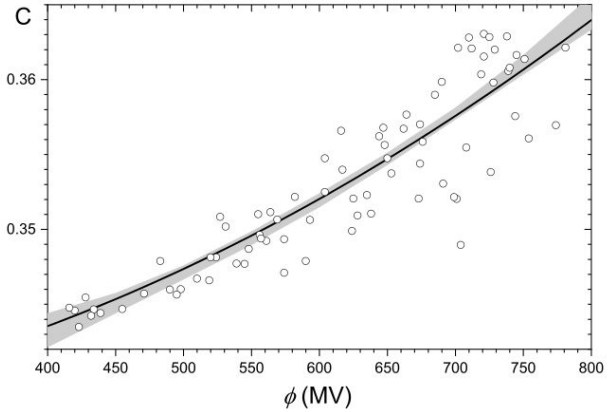
Use of CRAC:CRII model for CEM



Solar modulation of cosmic ray spectrum*

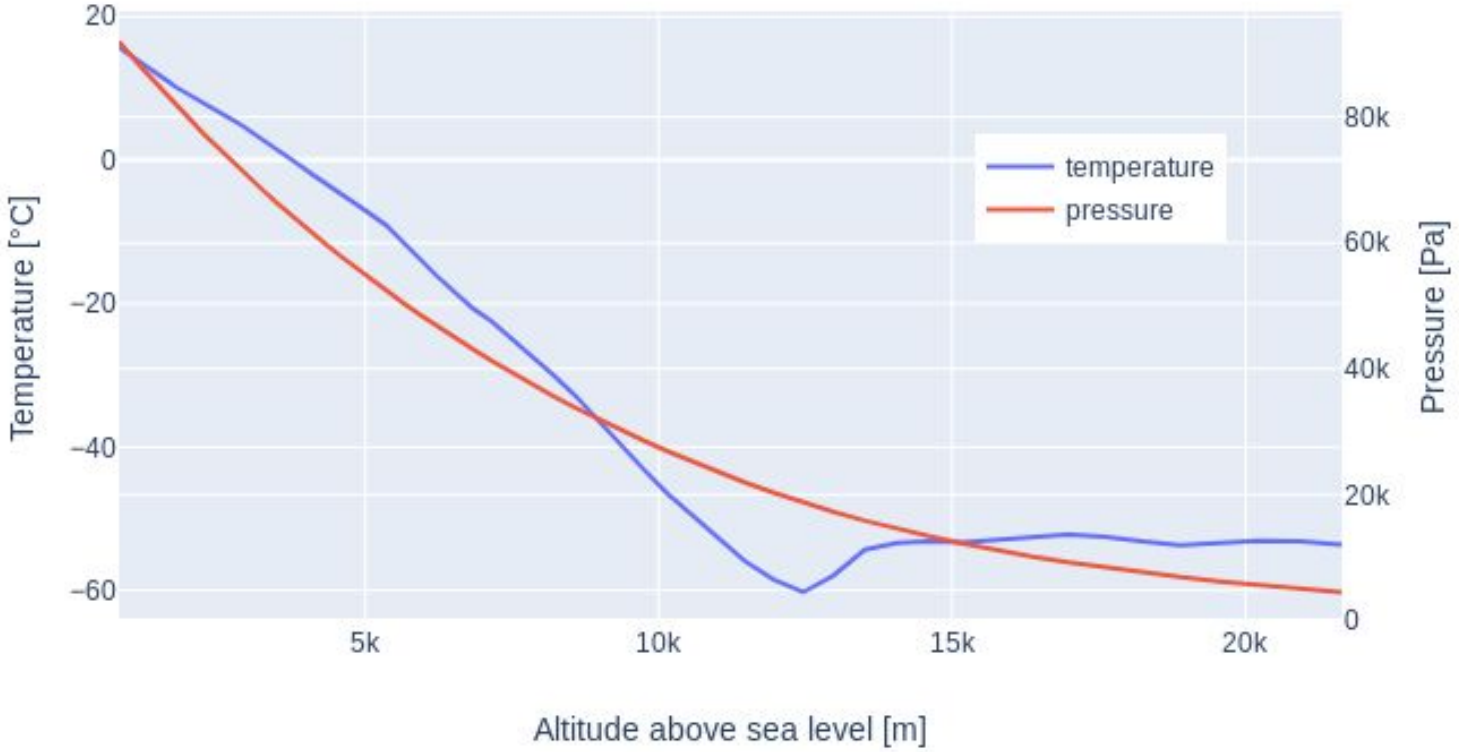


Solar modulation of heavier ion/proton ratio**



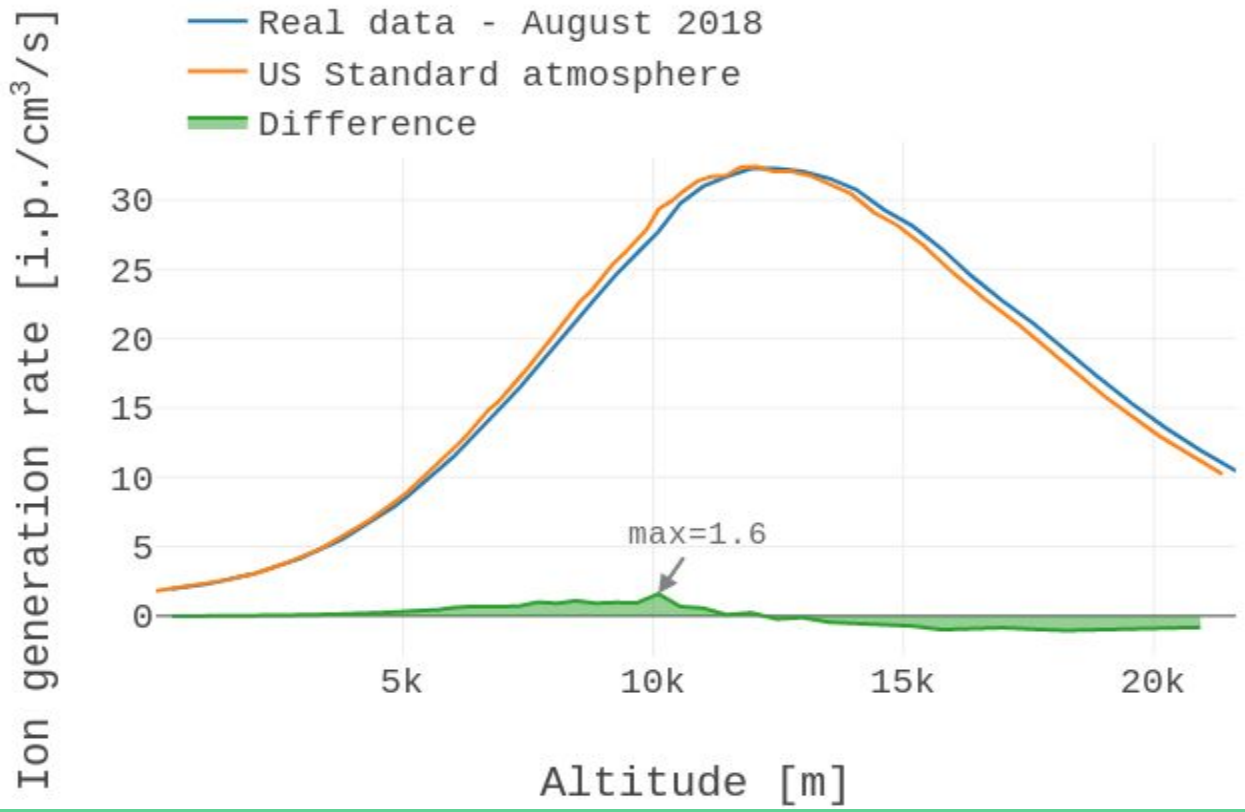
* Usoskin, I. G., *et al.* (2017), Heliospheric modulation of cosmic rays during the neutron monitor era: Calibration using PAMELA data for 2006–2010, *J. Geophys. Res. Space Physics*, 122, 3875– 3887,
** Koldobskiy, S. A., *et al.* (2019). Validation of the neutron monitor yield function using data from AMS-02 experiment, 2011–2017. *Journal of Geophysical Research: Space Physics*, 124, 2367– 2379.

COSMO exported atmospheric profile

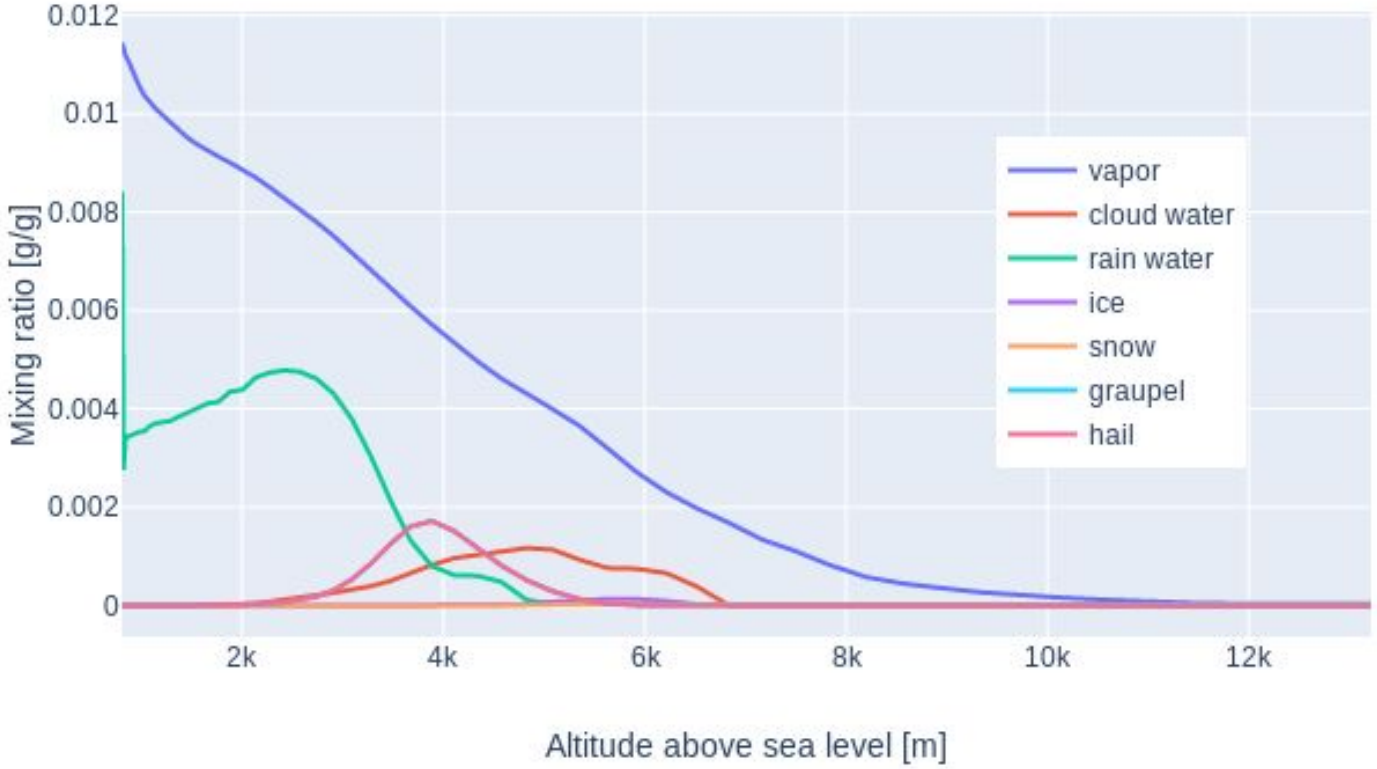


Correction to realistic pressure-height relation - CRAC:CRII

data taken from COSMO model for August 24, 2018 - profile with highest amount of included water

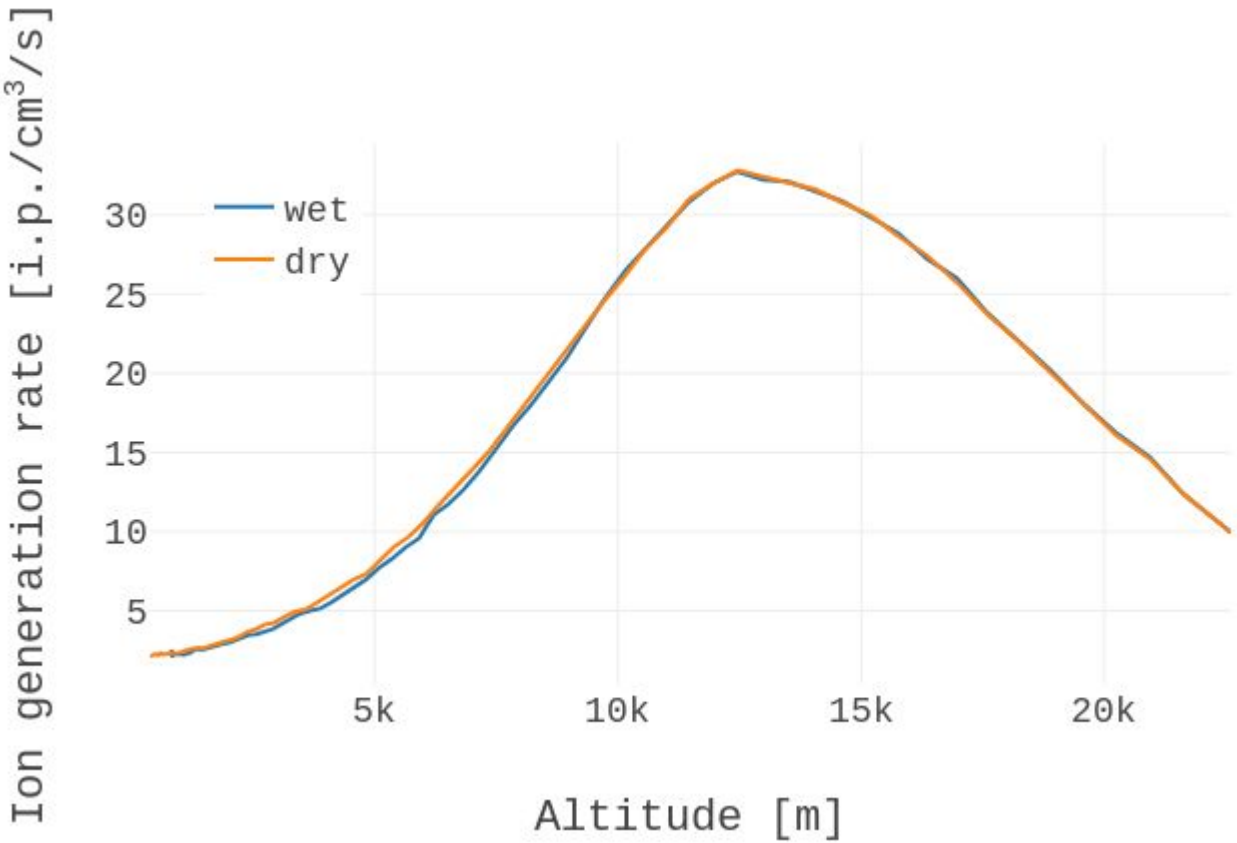


COSMO exported atmospheric profile



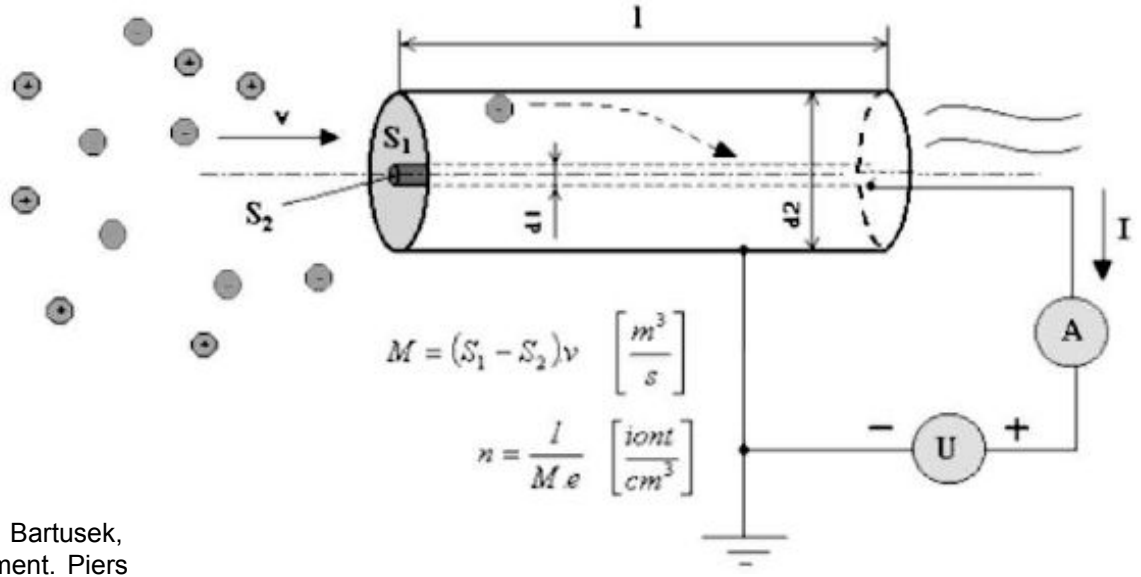
Correction to realistic cloud water content

data taken from COSMO model for August 24, 2018 - profile with highest amount of included water, MCNP Monte Carlo simulation



Plans for future

- PHITS based calculations
  - PARMA model of cosmic ray particles spectra
  - data from CEM-COSMO
  - electric field
- measurements of ambient ions
  - Gerdien tube
  - especially near the ground



Vojtek, Tomas & Skoupil, Tomas & Fiala, Pavel & Bartusek, Karel. (2006). Accuracy of Air Ion Field Measurement. Piers Online. 2. 412-415. 10.2529/PIERS050905095240.