Karlsruher Institut für Technologie
Institut für Meteorologie und Klimaforschung (IMK-IFU)
Garmisch-Partenkirchen, Germany

Stratospheric Aerosol Measurements at Garmisch-Partenkirchen

Hannes Vogelmann, Stefan Biggel, Matthias Perfahl, Thomas Trickl

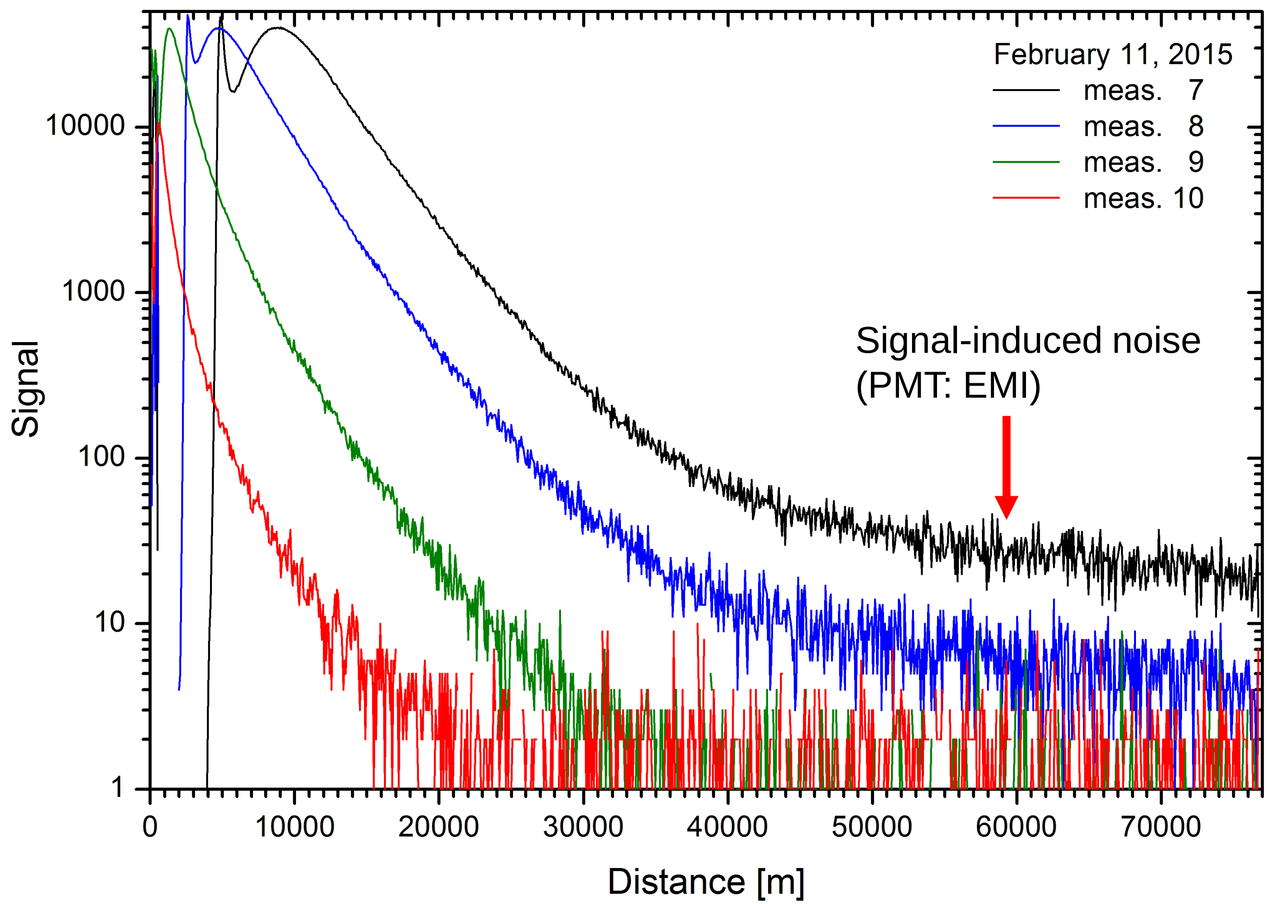
System Status

- Measurements continued until 2/2015 at low rate. Fatal system damage: No data storage possible after measurements; in addition: scanner broken, container in a terrible state
- Autumn 2016: Decision made to integrate the lidar into ozone DIAL (same size of receiver, automatic system control); optical components purchased for 20 k€, also for a 532-nm HSRL channel and 1064-nm channel; replace old GCR4 laser by Powerlite 8020 from H_2O DIAL
- 2017: Very successful testing of powerful 532-nm aerosol channel at UFS (H_2O DIAL) with 100-Hz Nd:YAG from Innolas); we observed August 2017 smoke plume at 16-20 km with high S/N.
- Remote control of laser, transient digitizer and dome implemented and successfully tested. **Final decision: Continue NDACC aerosol mesurements at UFS (2675 m a.s.l.)**
- 4/2018: FAST Comtec 5 GHz photon counting system added; interference issues of counter eliminated (parallel to same issues in Raman lidar)
- April 2018: Remote control of photon counter demonstrated; **start of routine measurements**
- Future: Implement also 1064 nm and HSRL channels

Data evaluation and archiving

Processing of old data fomat implemented into HSRL program finished; main issues system:

- Signal-induced noise: corrections critical above 35 km; just 2000 shots per profile
- Attenuation to extend photon counting to low altitudes creates noise

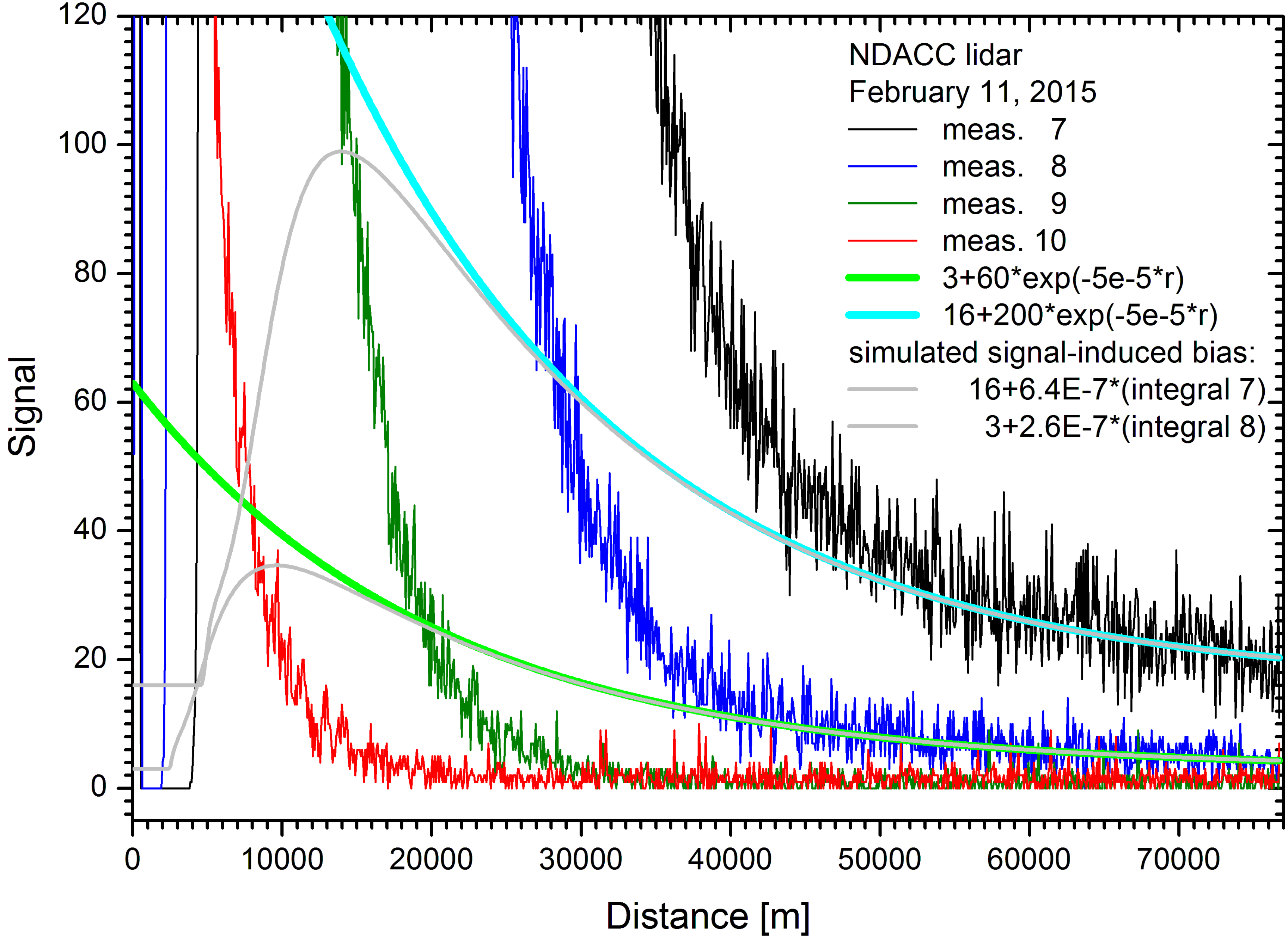


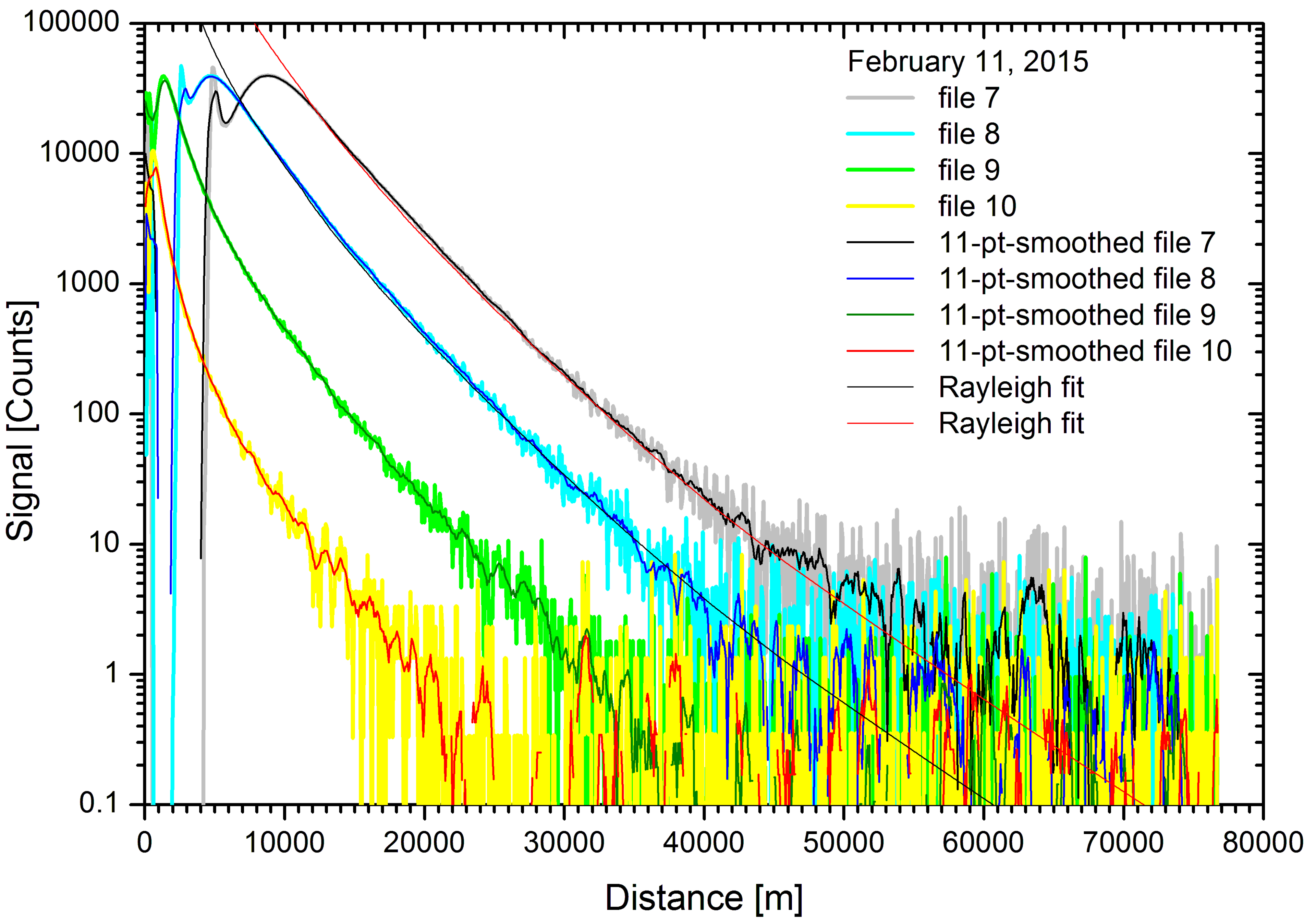
Processing chain (semi-automatic; visualization and manual correction is possible for the most critical steps):

- Correct signal-induced noise; dead-time correction (H. Jäger)
- Use Hohenpeißenberg monthly ozone climatology for correcting the profiles
- Import sonde and NCEP data and calculate Rayleigh profile up to > 70 km
- Klett inversion of all four profiles (can be re-iterated with modified reference values, but is mostly robust without this)
- Automatic „glueing“ of the relevant segments of the four β_P profiles
- Export in IFU, Ames and EARLINET NetCDF formats; Ames export is done in a separate program importing all IFU files from a given month.
- Just the implementation of the relevant procedures for the new data format is missing, but this effort is moderate.

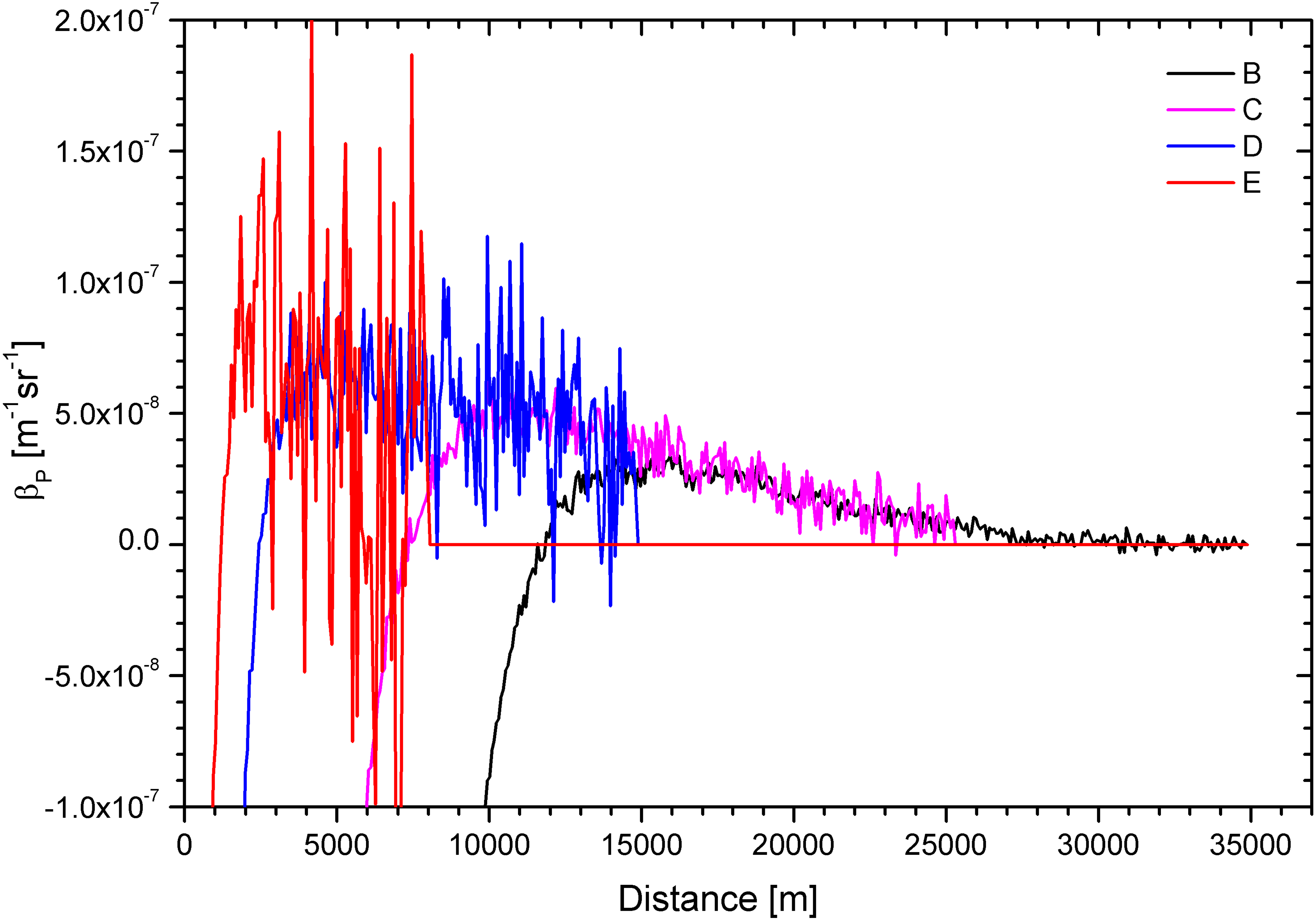
Conclusion:

- Without manual interference and visualization the data evaluation **can now be achieved within 1 min** (which excludes the import of the sonde and NCEP data)
- The sounding programme can be intensified quite considerably

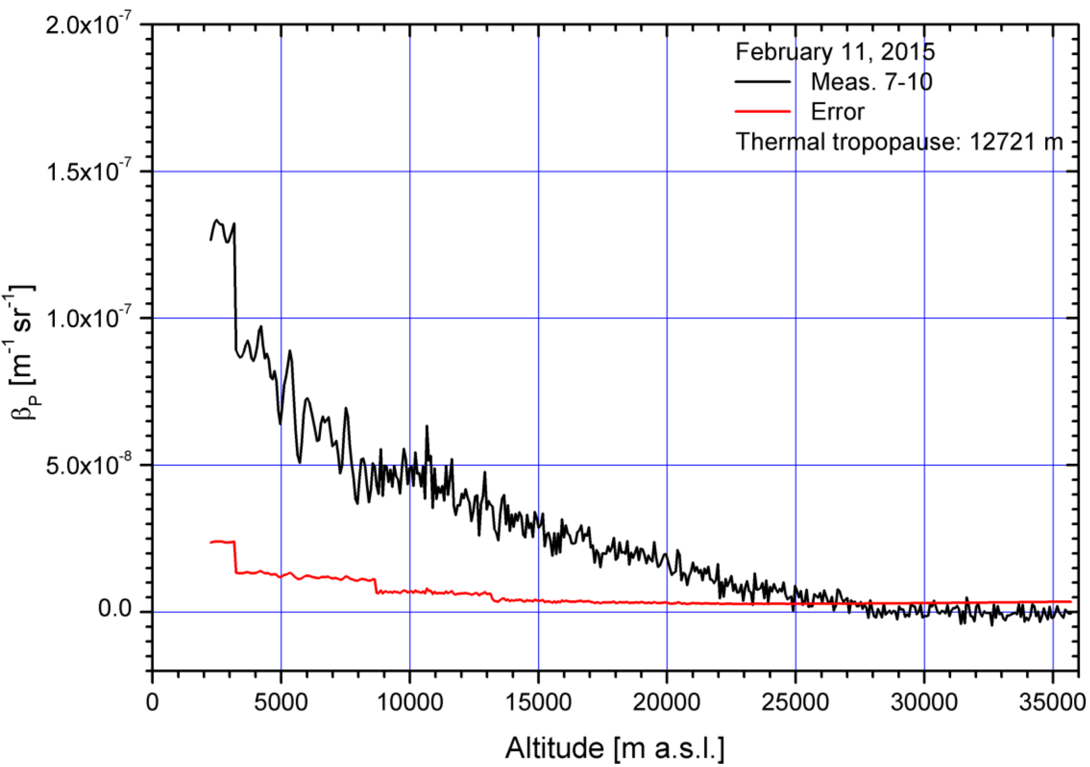

NDACC lidar
February 11, 2015
meas. 7
meas. 8
meas. 9
meas. 10
3+60*exp(-5e-5*r)
16+200*exp(-5e-5*r)
simulated signal-induced bias:
16+6.4E-7*(integral 7)
3+2.6E-7*(integral 8)
Signal
Distance [m]
0
20
40
60
80
100
120
0
10000
20000
30000
40000
50000
60000
70000



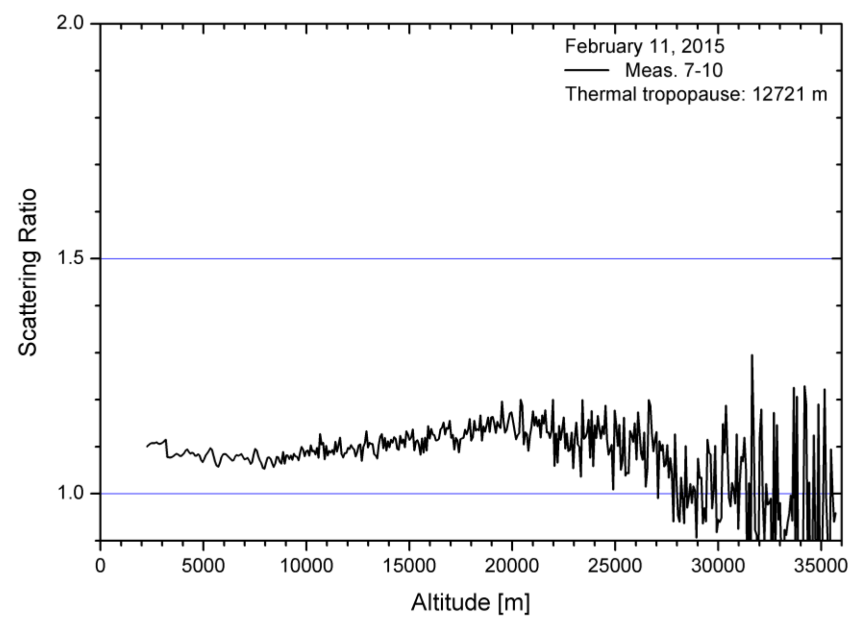
February 11, 2015
file 7
file 8
file 9
file 10
11-pt-smoothed file 7
11-pt-smoothed file 8
11-pt-smoothed file 9
11-pt-smoothed file 10
Rayleigh fit
Rayleigh fit
Signal [Counts]
Distance [m]
100000
10000
1000
100
10
1
0.1
0
10000
20000
30000
40000
50000
60000
70000
80000



2.0x10^-7
1.5x10^-7
1.0x10^-7
5.0x10^-8
0.0
-5.0x10^-8
-1.0x10^-7
βP [m^-1sr^-1]
0
5000
10000
15000
20000
25000
30000
35000
Distance [m]
B
C
D
E

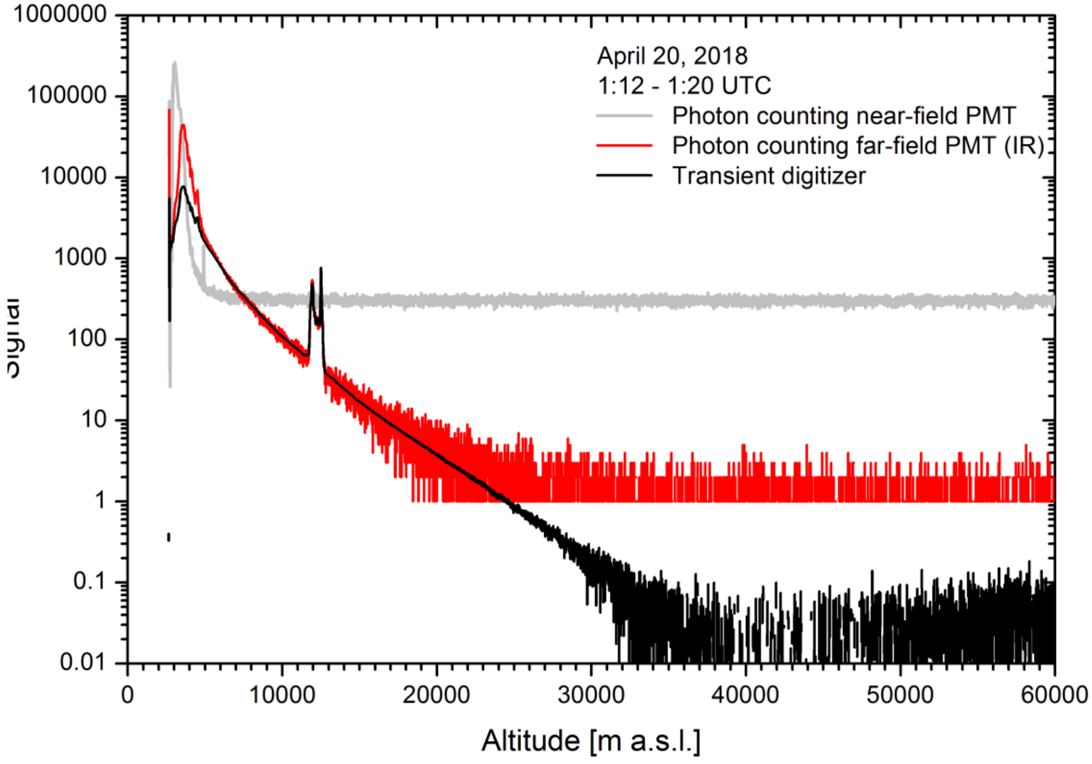


IFU Output file:
β_P, β_{Ray}, scattering ratio, error



Advantages of new approach:

- Higher repetition rate, use of interference filters to block background light: range extension to 45 km (J.-P. Vernier) should be possible
- No more signal-induced noise
- Use of transient digitizer plus photon counter: no dead-time correction needed



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Karlsruher Institut für Technologie

Funding situation: 1 position eliminated in 2019; proposal submitted

Reviewed Publications 2016-2018 (NDACC-relevant topics):

S. Kremser, L. W. Thomason, M. von Hobe, M. Hermann, T. Deshler, C. Timmreck, M. Toohey, A. Stenke, J. P. Schwarz, R. Weigel, S. Fueglistaler, F. J. Prata, J.-P. Vernier, H. Schlager, J. E. Barnes, J.-C. Antuña-Marrero, D. Fairlie, M. Palm, E. Mahieu, J. Notholt, M. Rex, C. Bingen, F. Van-hellemont, A. Bourassa, J. M. C. Plane, D. Klocke, S. A. Carn, L. Clarisse, T. Trickl, R. Neely, A. D. James, L. Rieger, J. C. Wilson, B. Meland, Rev., Stratospheric aerosol - Observations, processes, and impact on climate, Rev. Geophys. **54** (2016), doi: 10.1002/ 2015RG000511, 58 pp. (highly cited!)

T. Trickl, H. Vogelmann, A. Fix, A. Schäfler, M. Wirth, Bertrand Calpini, G. Levrat, G. Romanens, A. Apituley, K. M. Wilson, R. Begbie, J. Reichardt, H. Vömel, M. Sprenger, How Stratospheric Are Deep Stratospheric Intrusions into the Troposphere? − LUAMI 2008, Atmos. Chem. Phys. **16** (2016), 8791-8815

T. Leblanc, R. J. Sica, J. A. E. van Gijsel, S. Godin-Beekmann, A. Haefele, T. Trickl, G. Payen, F. Gabarrot, Proposed standardized definitions for vertical resolution and uncertainty in the NDACC lidar ozone and temperature algorithms. Part 1: Vertical resolution, Atmos. Meas. Tech. **9** (2016), 4029-4049; 18-pp. supplement

T. Leblanc, R. J. Sica, J. A. E. van Gijsel, S. Godin-Beekmann, A. Haefele, T. Trickl, G. Payen, and G. Liberti, Proposed standardized definitions for vertical resolution and uncertainty in the NDACC lidar ozone and temperature algorithms. Part 2: Ozone DIAL uncertainty budget, Atmos. Meas. Tech. **9** (2016), 4051-4078

P. Hausmann, R. Sussmann, T. Trickl, M. Schneider, A decadal time series of water vapor and D/H isotope ratios above Mt. Zugspitze: transport patterns to Central Europe, Atmos. Chem. Phys. 17 (2017), 7635-7651

C. Bingen, C. E. Robert, K. Stebel, C. Brühl, J. Schallock, F. Vanhellemont, N. Mateshvili, M. Höpfner, T. Trickl, J. E. Barnes, J. Jumelet, J.-P. Vernier, T. Popp, G. De Leeuw, S. Pinnock, Stratospheric aerosol data record for the climate change Initiative: development, validation and application to chemistry-climate modelling, Remote Sensing of Environment **203** (2017) 296–321

M. G. Schultz, S. Schröder, O. Lyapina, O. Cooper, I. Galbally, and many others (> 90!!!), Tropospheric Ozone Assessment Report: Database and Metrics Data of Global Surface Ozone Observations, Elem. Sci. Anth. 5 (2017), 58, DOI: https://doi.org/ 101525/elementa.244, 25 pp.

A. Gaudel, O. R. Cooper, and many others, Tropospheric Ozone Assessment Report: Present-day distribution and trends of tropospheric ozone relevant to climate and global atmospheric chemistry model evaluation, Elem. Sci. Anth., in press (2017)

Under review: T. Trickl, H. Vogelmann, L. Ries, H. E. Scheel, M. Sprenger, The underestimated role of stratosphere-to-troposphere transport on tropospheric ozone, Atmos. Chem. Phys. Disc. **18** (2018), https://doi.org/10.5194/acp-2017-1192, 37 pp.