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Water vapour, temperature and aerosol retrievals using RALMO Raman LIDAR at the Payerne GRUAN site

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ICM7 - 7th GRUAN Implementation-Coordination Meeting , Matera, Italy, 23-27 February 2015

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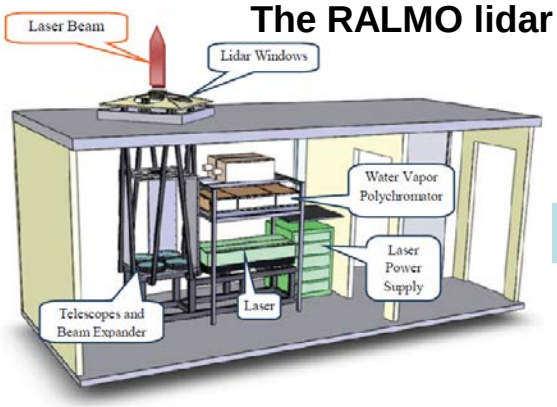
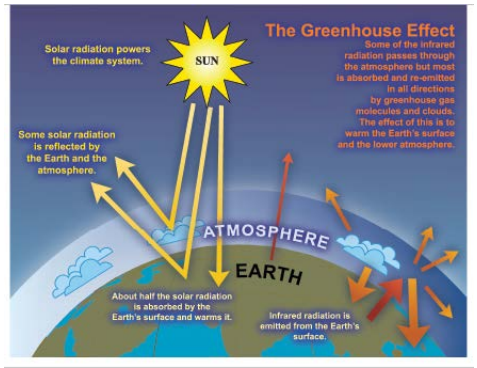
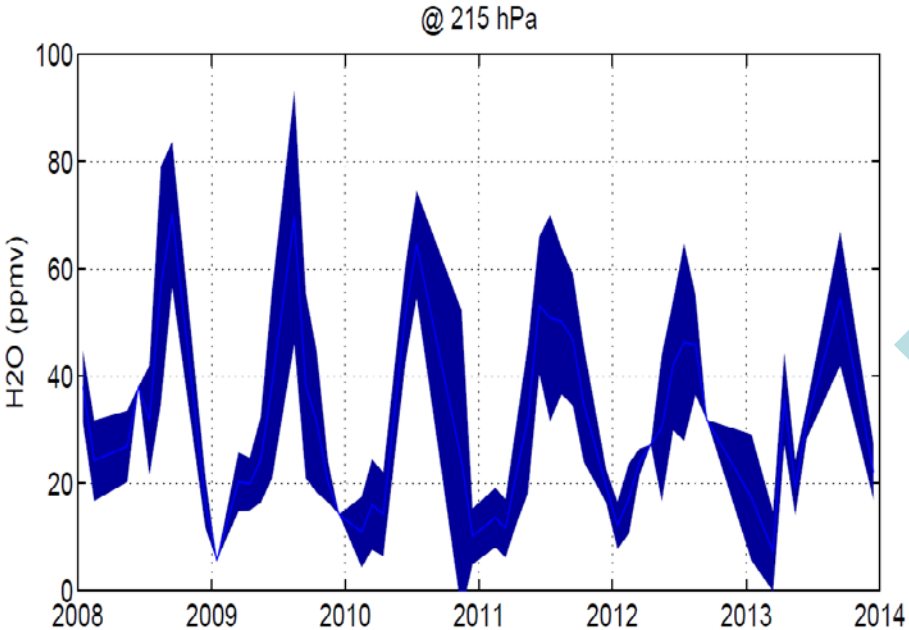
Water Vapour
Upper Troposphere and lower Stratosphere

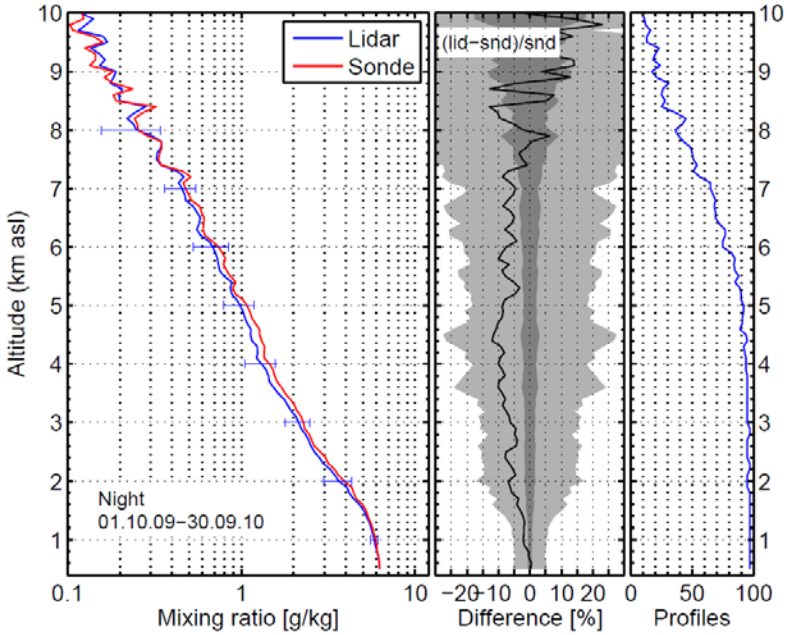
The RALMO lidar



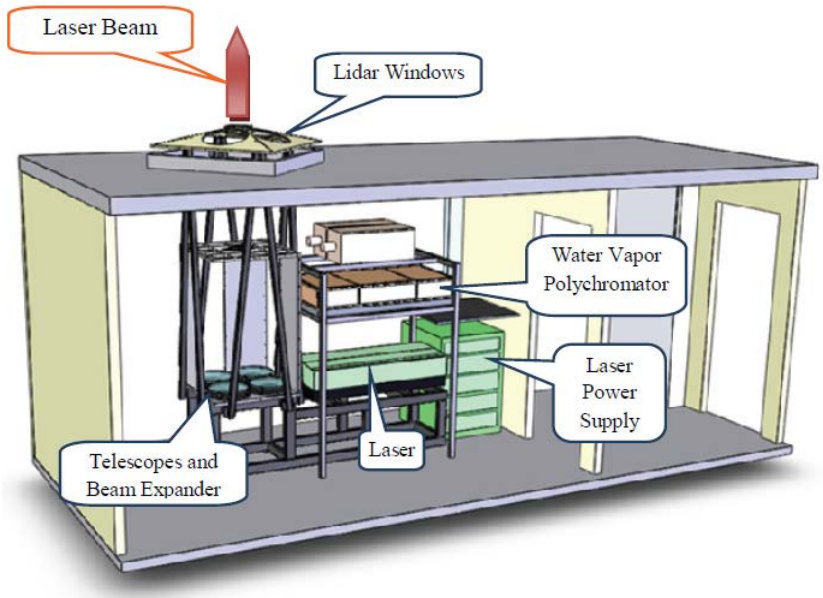


6 year time series

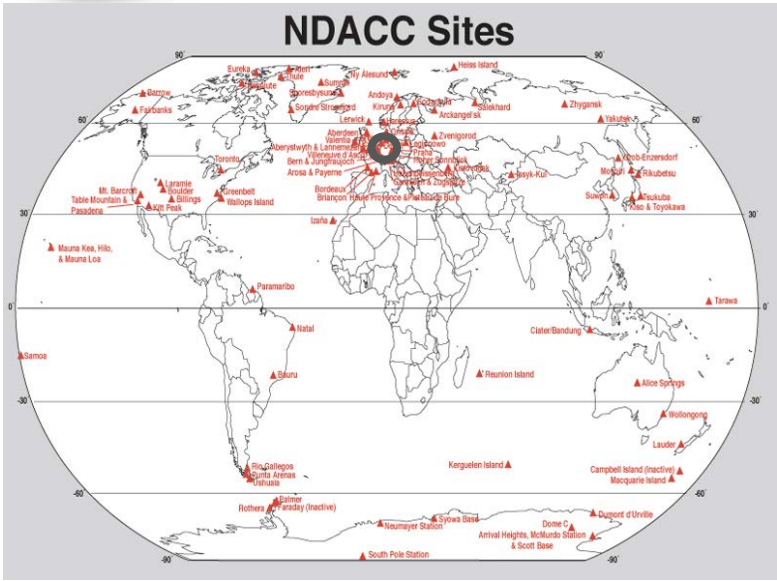


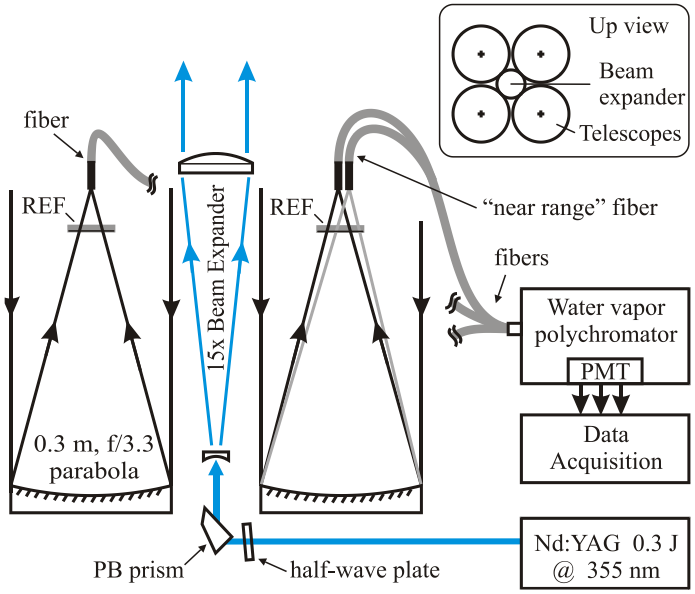


RALMO instrument



- Operated in Payerne, Switzerland
- Since 2008
- Fully automatic Raman lidar
- Day and nighttime operation
- Narrow FOV and bandwidth
- High laser power





Data Processing

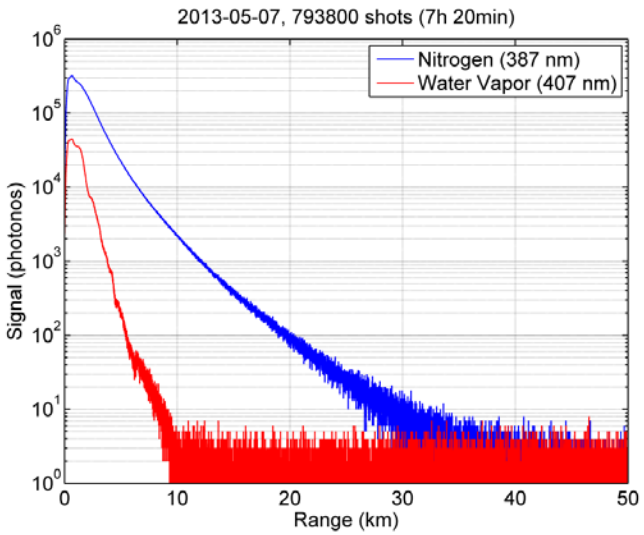
Pre-processing

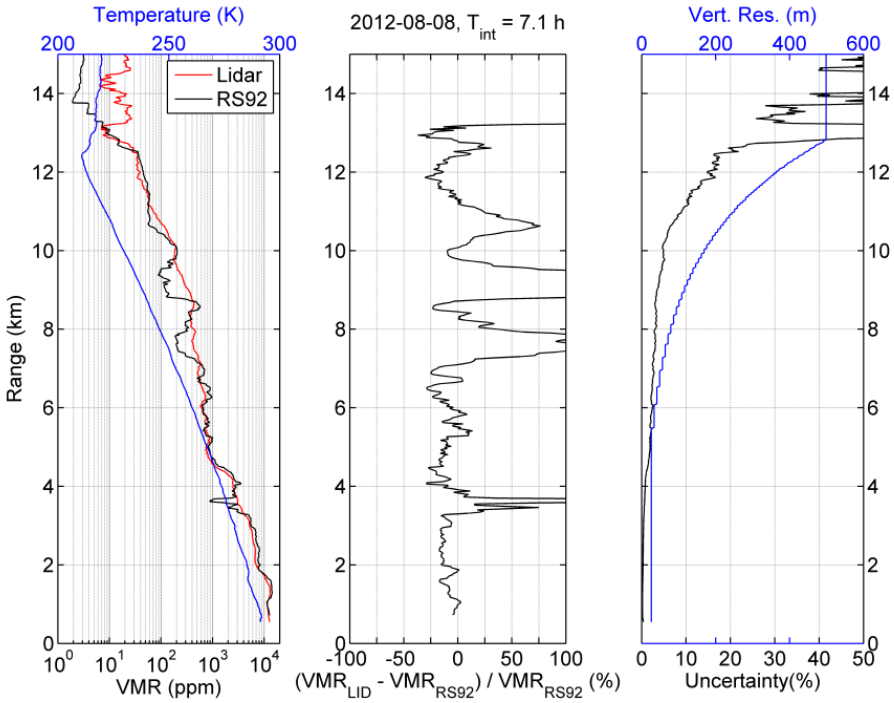
- Summation of measurements
- Background correction
- Range correction
- Rayleigh extinction corr.
- No: Aerosol corr.
- No: Saturation corr.

Water Vapour Retrieval

- Vertical Filtering
- Calculation of mixing ratio
- Uncertainty estimation

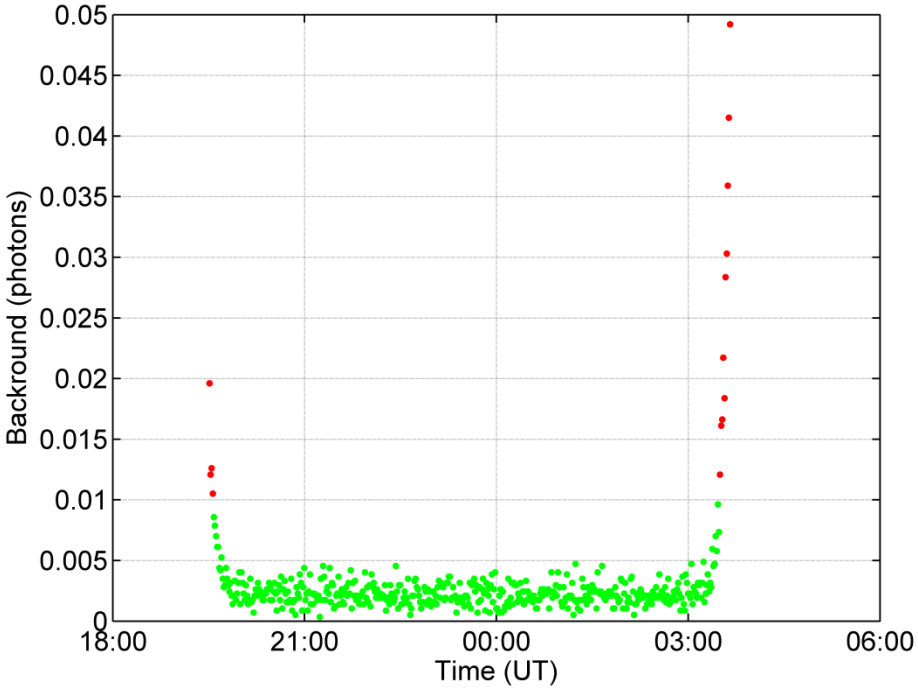
Calibration

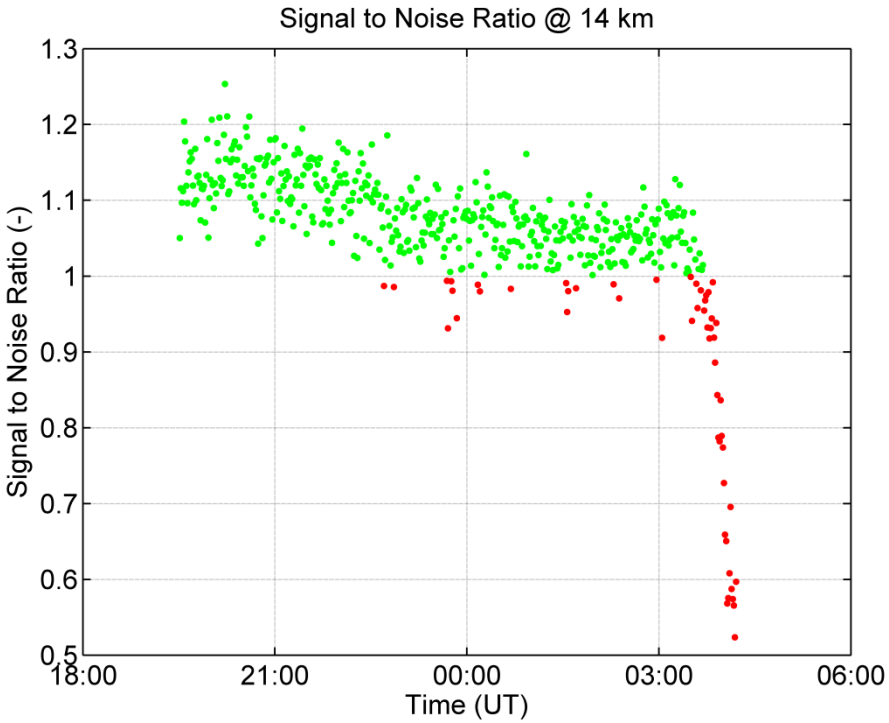




Pre-Processing

Only nighttime data with low background and sufficient signal to noise ratio (SNR) are considered:





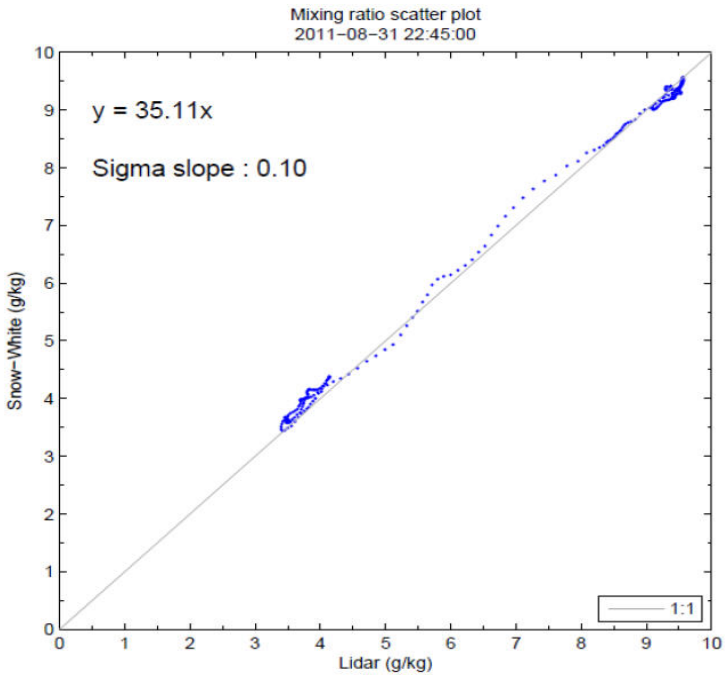
- B = mean(S(z>40km));
- B < 0.01

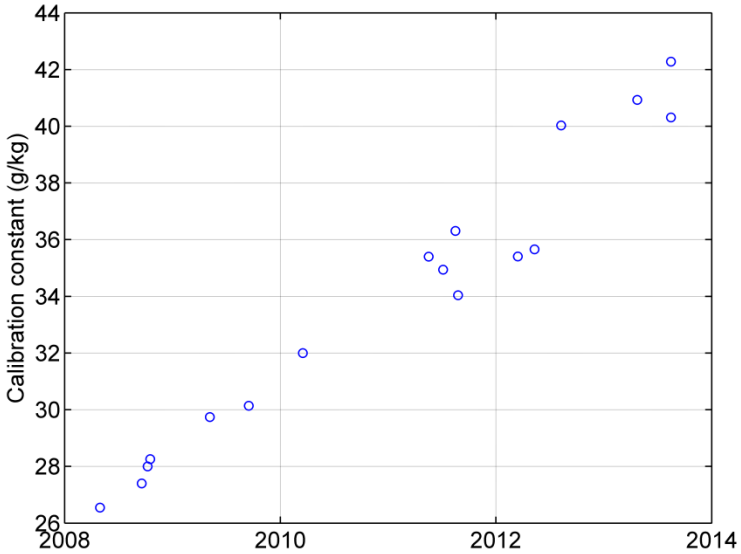
- SNR = (S-B) / sqrt(S)
- SNR(z>13.5 & z<14.5)>1

Calibration

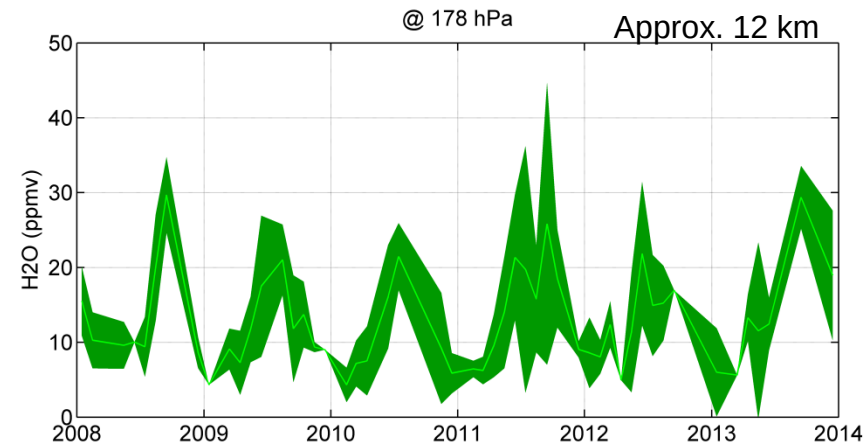
- External calibration in lower troposphere.
- Reference is SnowWhite hygrometer.
- Least squares fit.

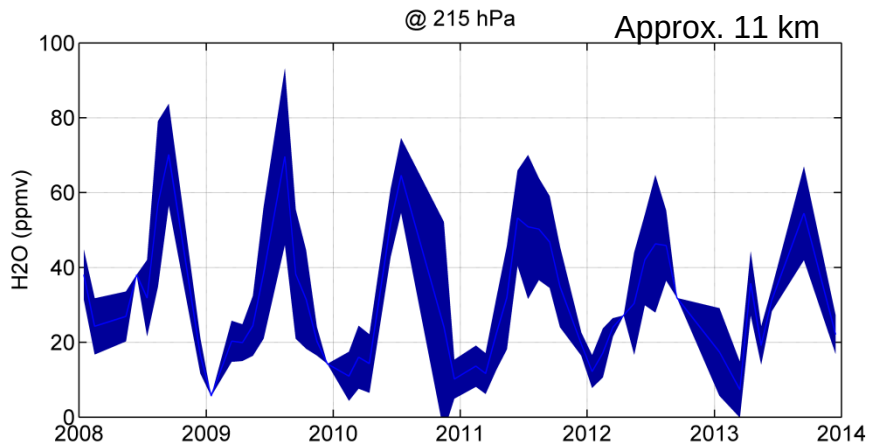
- Drift in calibration factor needs to be corrected for with regular calibrations.
- Drift in calibration factor is explained by uneven aging of the photomultiplier tubes.
- An internal automatic calibration of the N_2 and WV aging factor of the PMT is now in place.

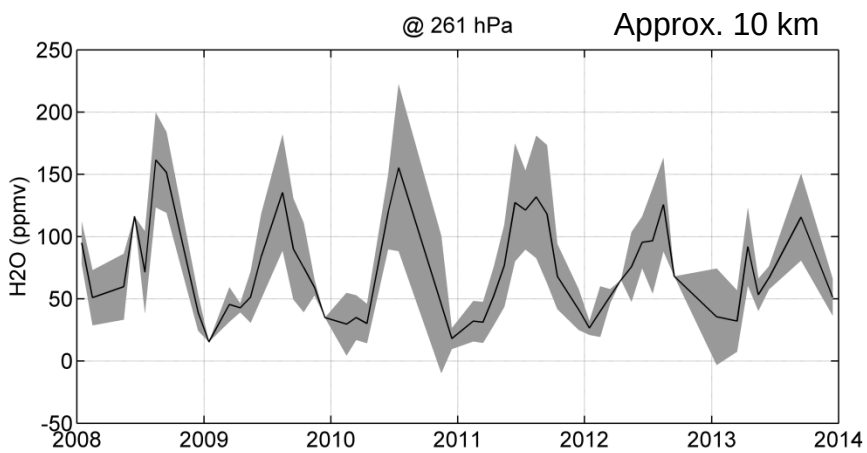




6 Year Time Series



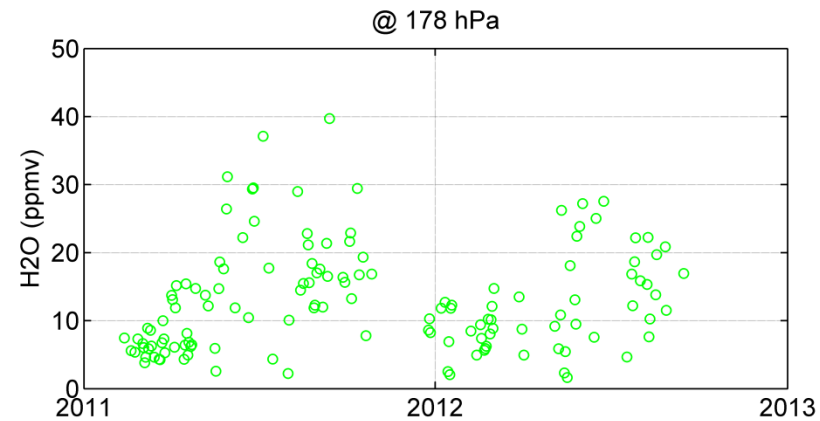


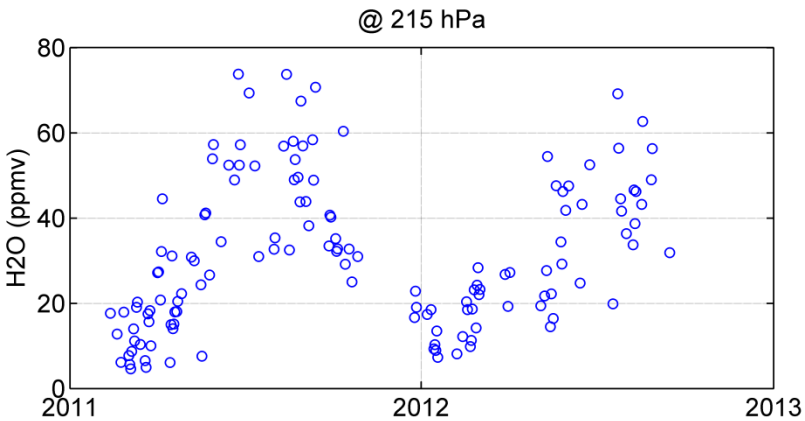


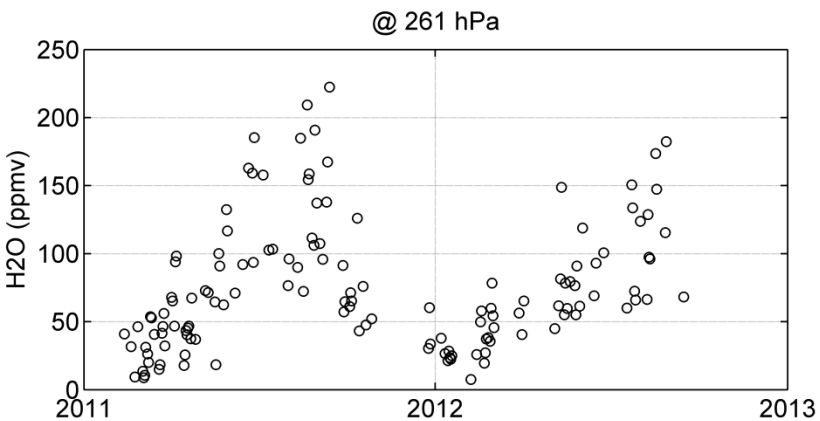
- Monthly mean values
- Shading indicates monthly variability

- Clear annual cycle with maximum in summer.
- Generally higher variability in summer.

Variability



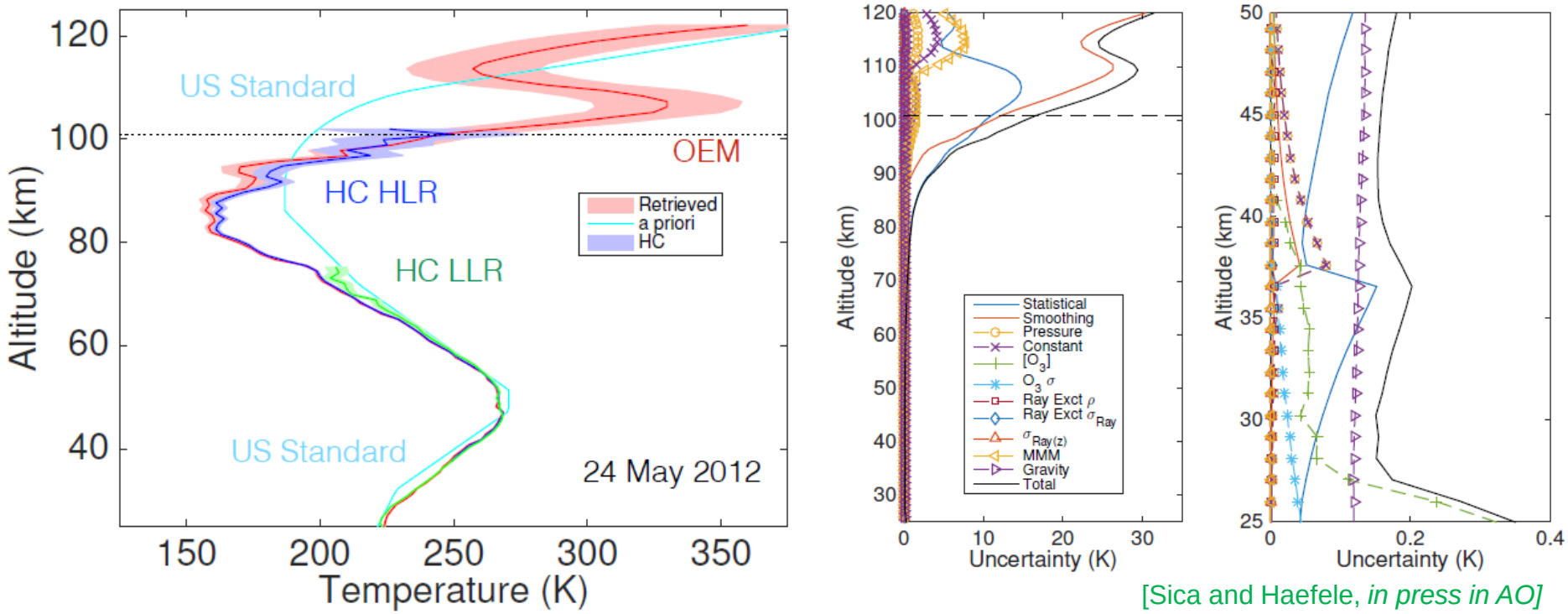




- Indication for higher variability in summer.

Optimal Estimation Method for Lidar

- Widely used in passive remote sensing
- Full characterization of retrieval (averaging kernel)
- Full uncertainty budget on profile per profile basis
- Ideal framework to combine measurements (high/low , lidar/mwr, …)
- Implementation for water vapor Raman lidar ongoing

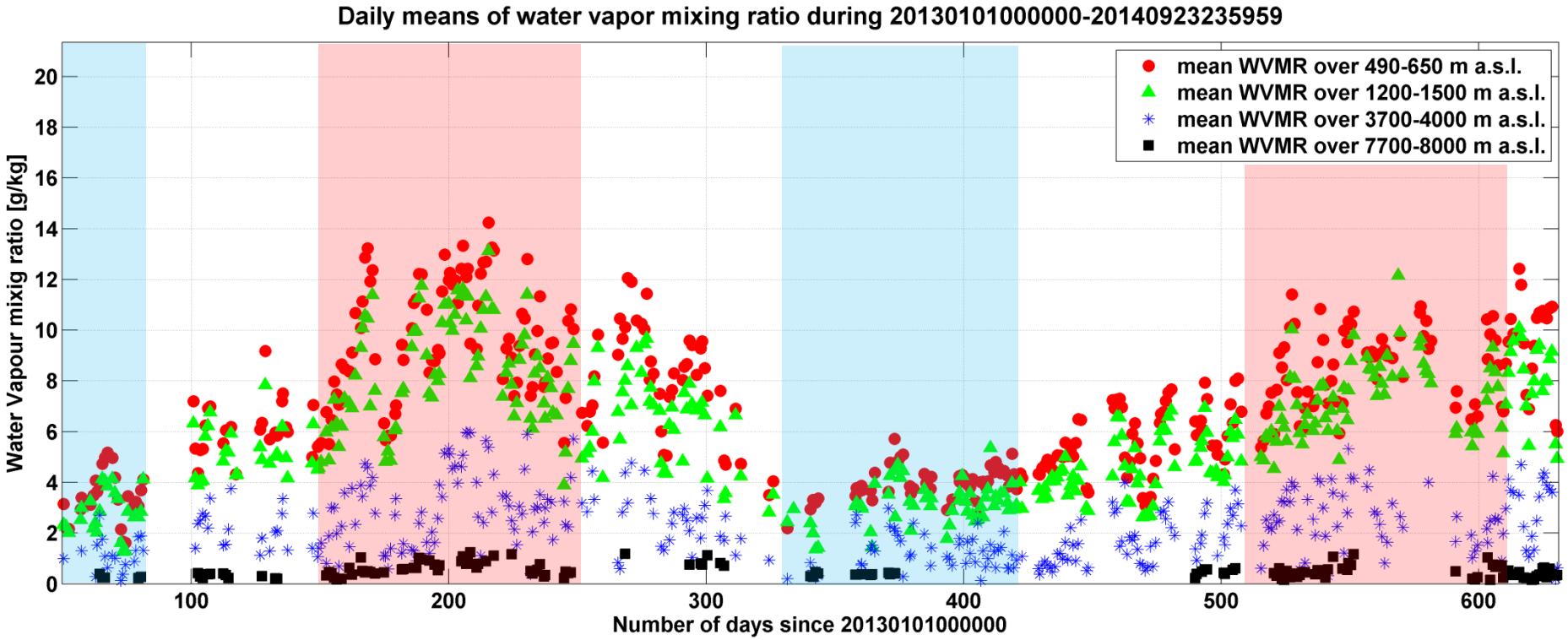


[Sica and Haefele, *in press in AO*]

WV and Aerosol timeseries
Troposphere

RALMO data timeseries: 201301-201410

Water vapour mixing ratio

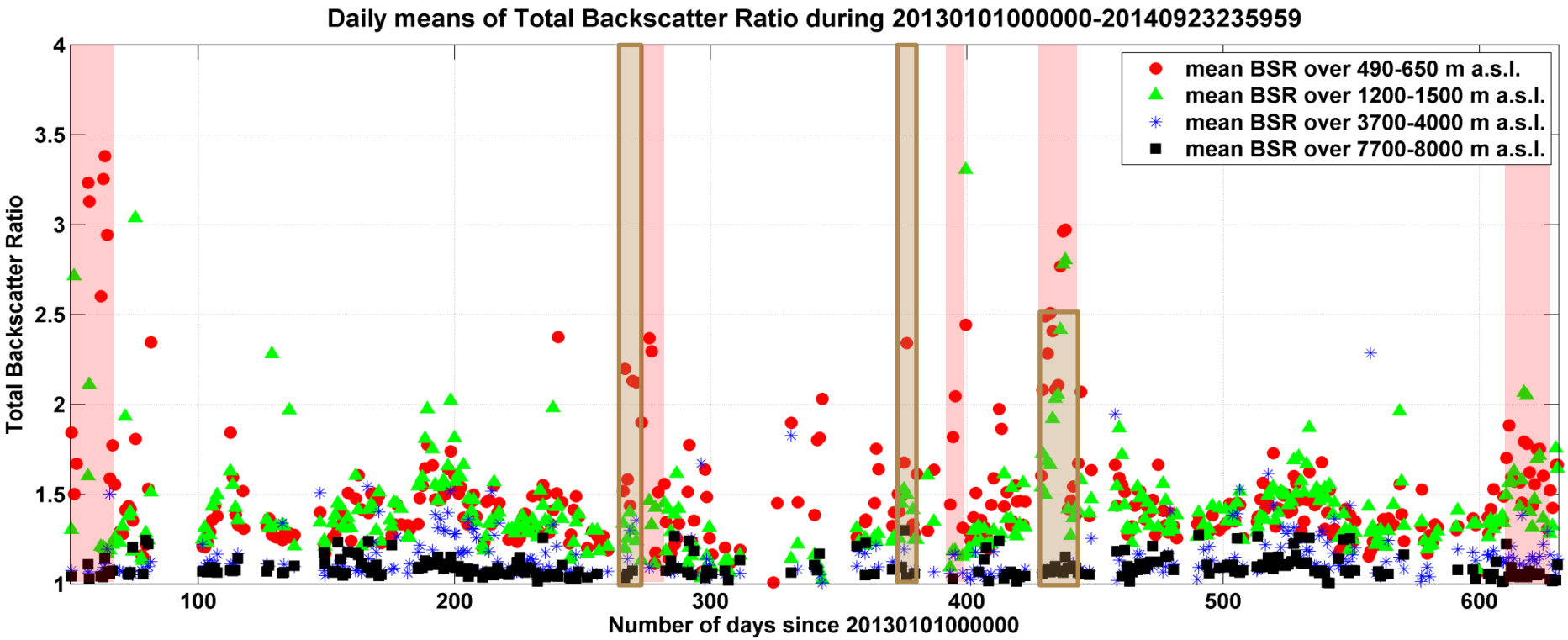


Winter

Summer

RALMO data timeseries: 201301-201410

Total BackScatter Ratio (**cloudy profiles are screened**)



SDE (Saharan Dust Event)

Central and southern European pollution (CSEP)

SDE and pollution

Total BackScatter Ratio (**cloudy profiles are screened**)

Mean values during Jan 2013-Oct 2014

$$\overline{BSR}_{490-650} = 1.50 \pm 0.35$$

$$\overline{BSR}_{1200-1500} = 1.41 \pm 0.27$$

$$\overline{BSR}_{3700-4000} = 1.15 \pm 0.14$$

$$\overline{BSR}_{7700-8000} = 1.15 \pm 0.25$$

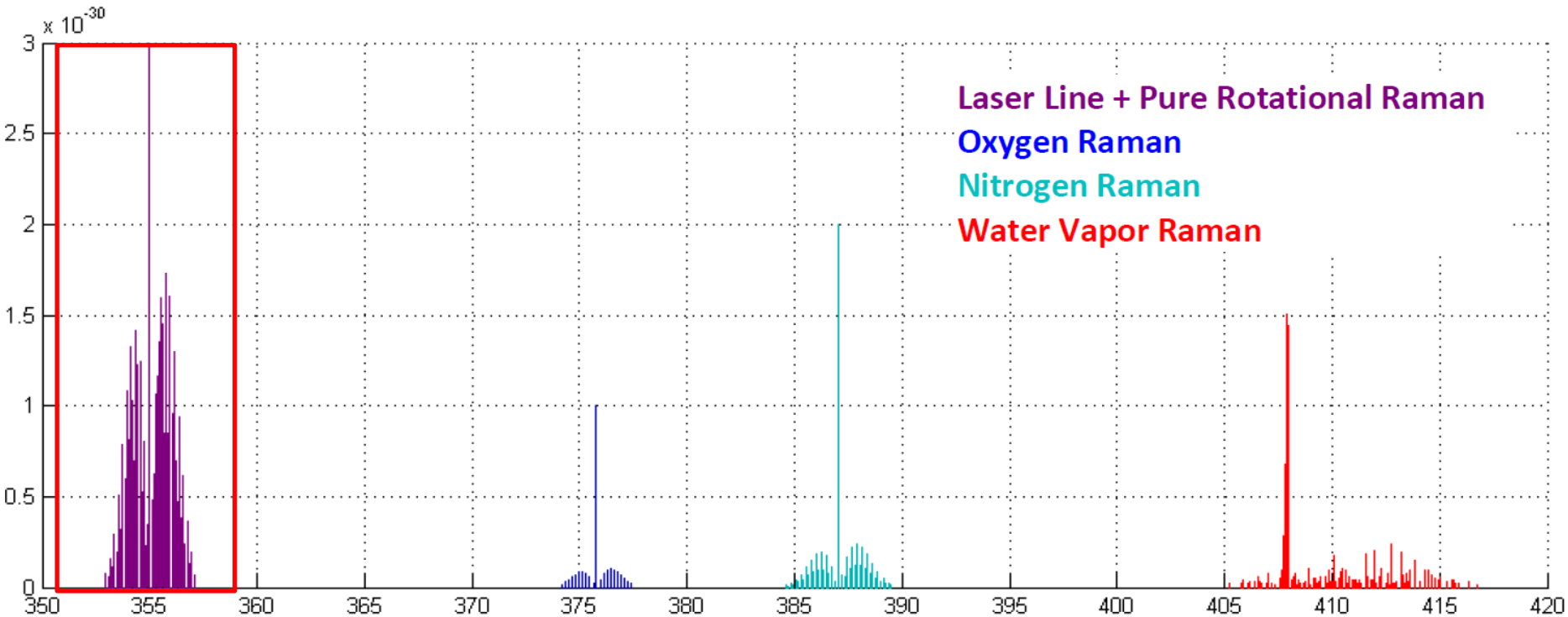
Mean layer m a.s.l.	SDE		CSEP	
	Mean	Max	Mean	Max
490-650	2.15	2.96	2.14	3.38
1200-1500	1.70	2.78	1.62	2.78
3700-4000	1.12	1.35	1.12	1.38
7700-8000	1.08	1.30	1.08	1.34

PRR extinction and backscatter
Troposphere

PRR extinction and backscatter coefficient are calculated using the total PRR, stokes and anti-stokes rotational signals. The temperature dependence of the spectrum is thus reduced to a minimum.

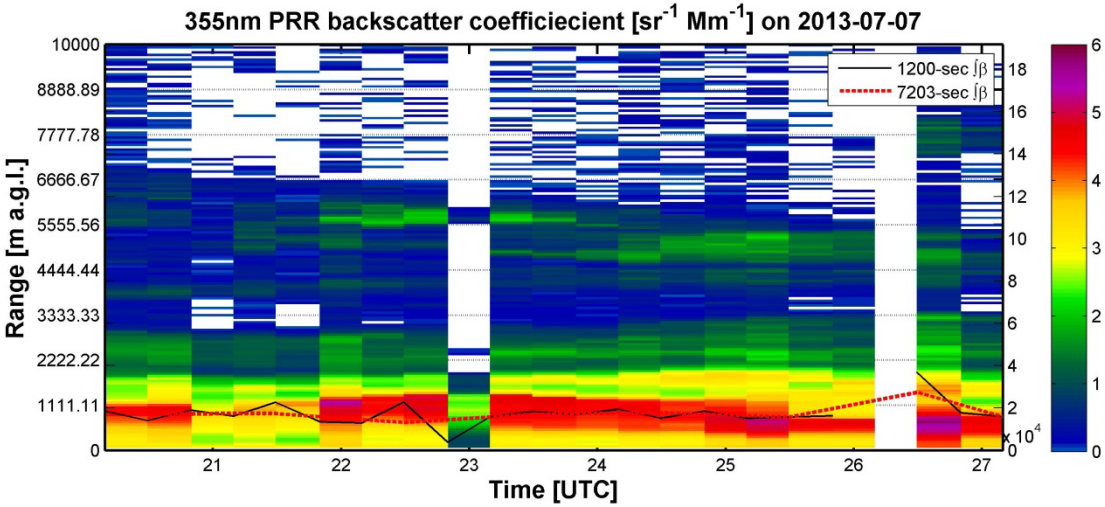
$$\alpha_a(z) = -\frac{1}{2}\frac{\mathrm{d}}{\mathrm{d}z}\left[\ln\frac{S_R(z)}{S_m(z)}\right]$$

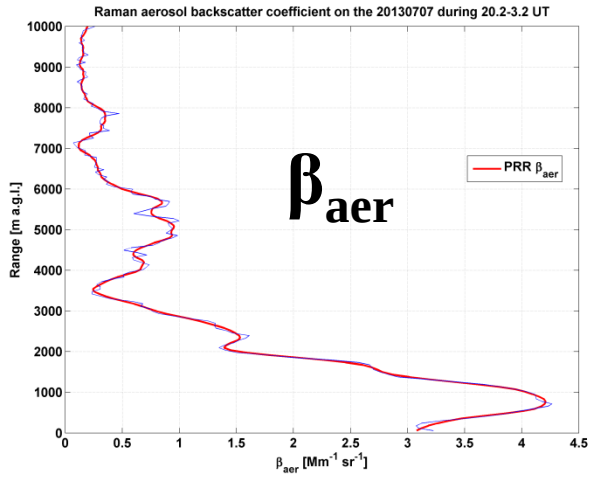
S_R = O + S branches

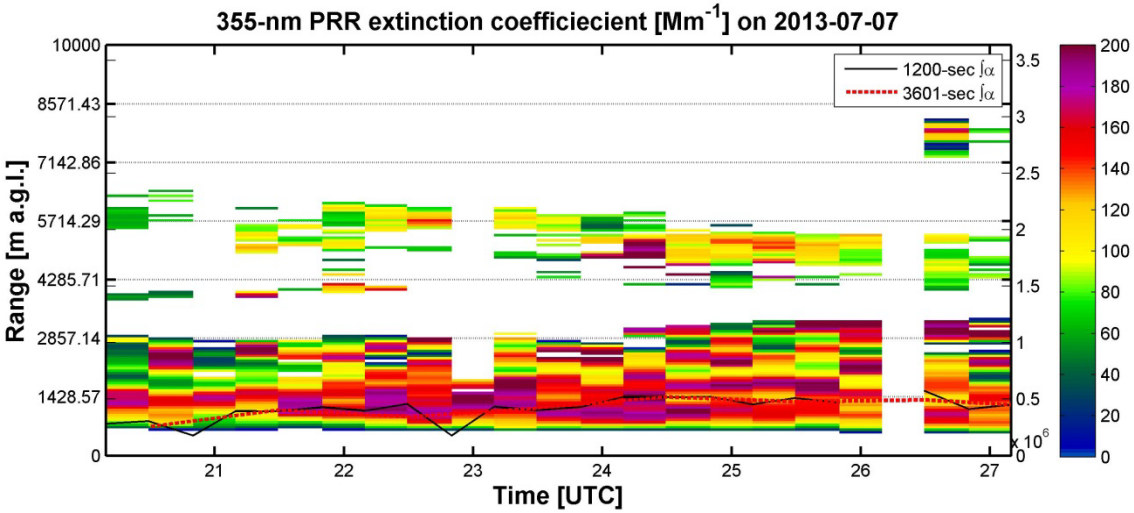


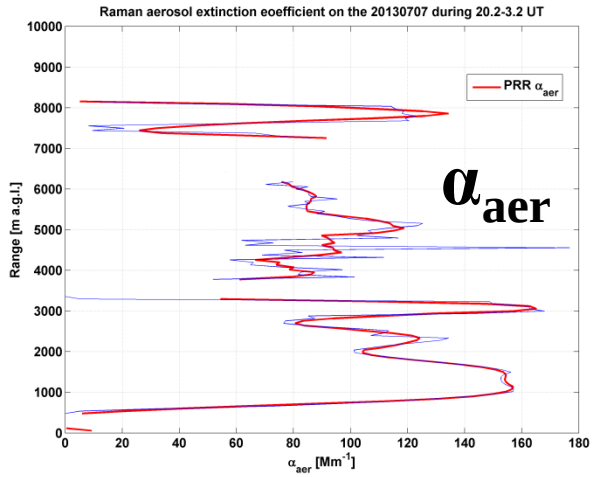
Canadian fires, 7-8 July 2013

60-m vertical resolution
20 minutes temporal resolution









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Canadian fires, 7-8 July 2013

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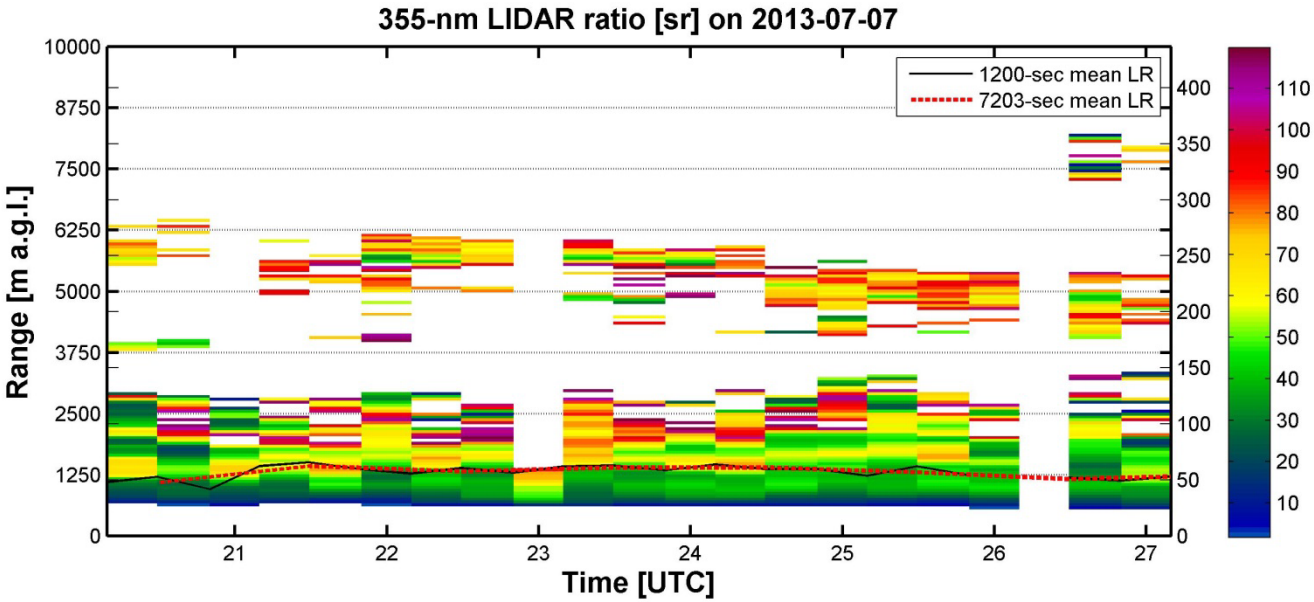
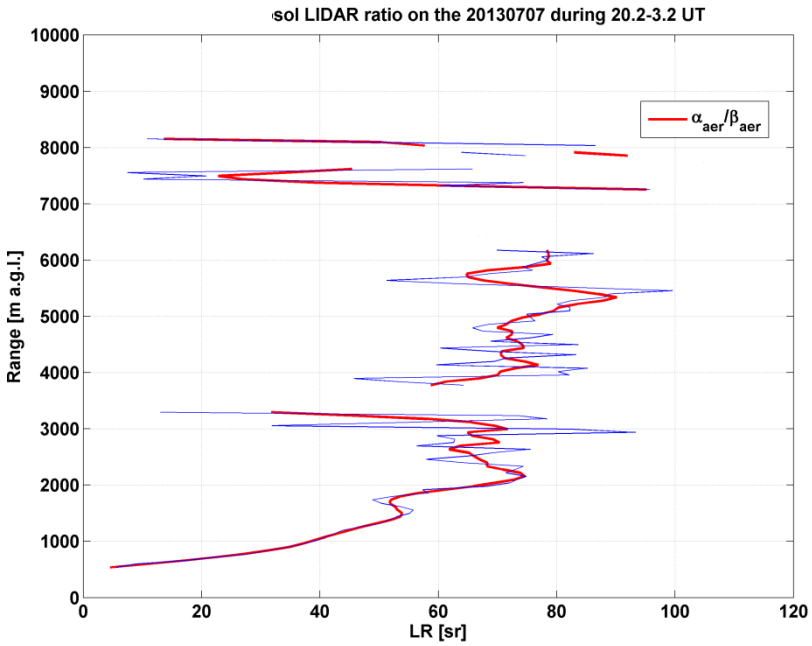
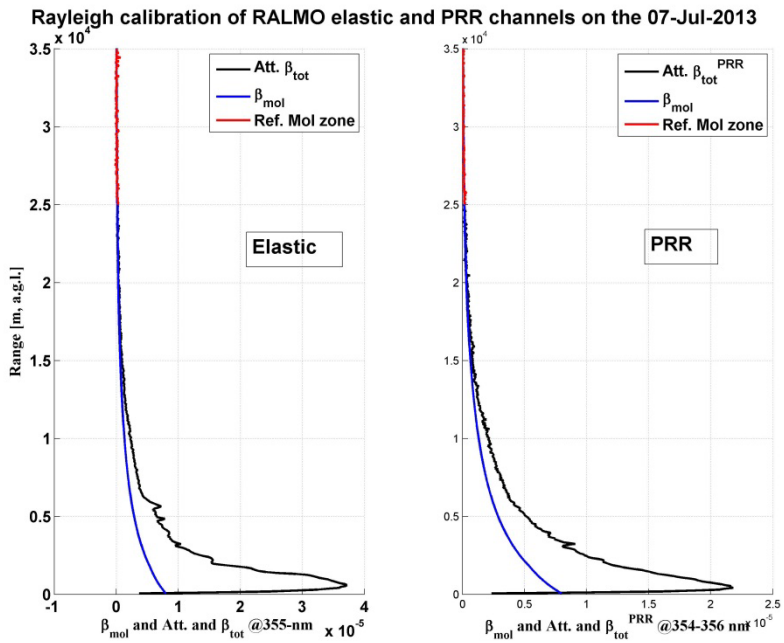
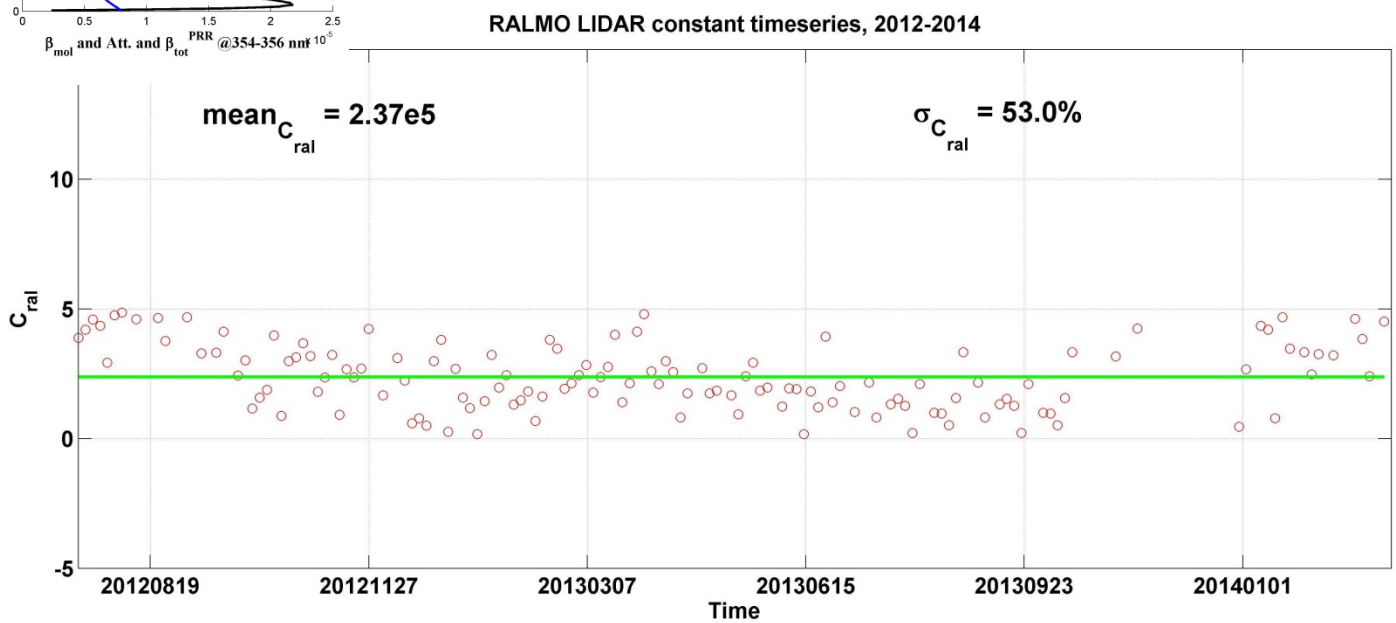




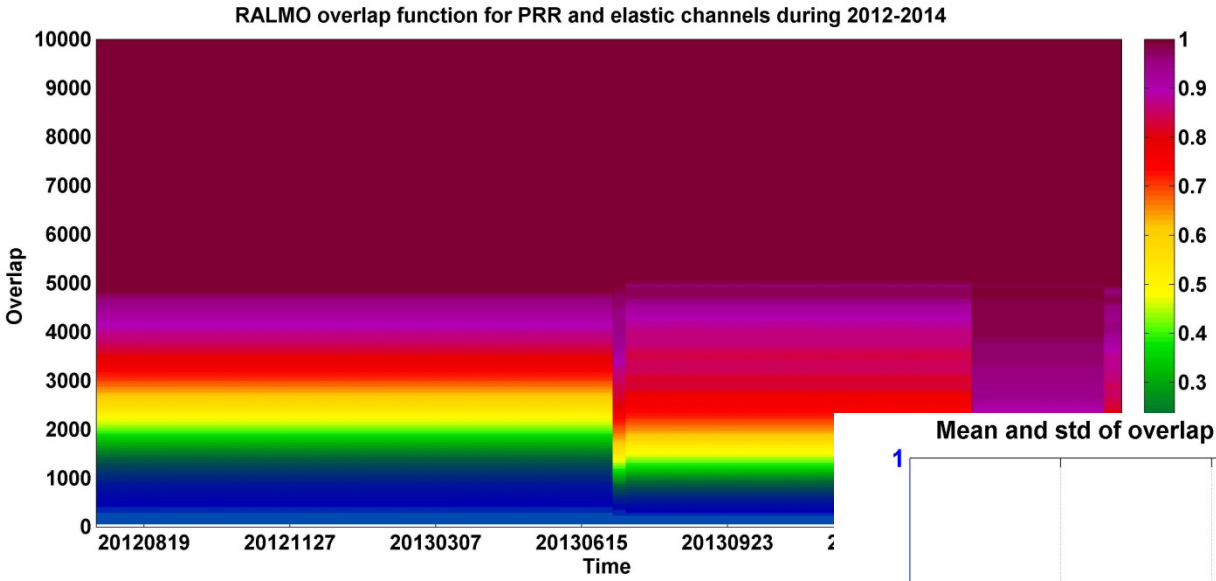
60-m vertical resolution
20 minutes temporal resolution

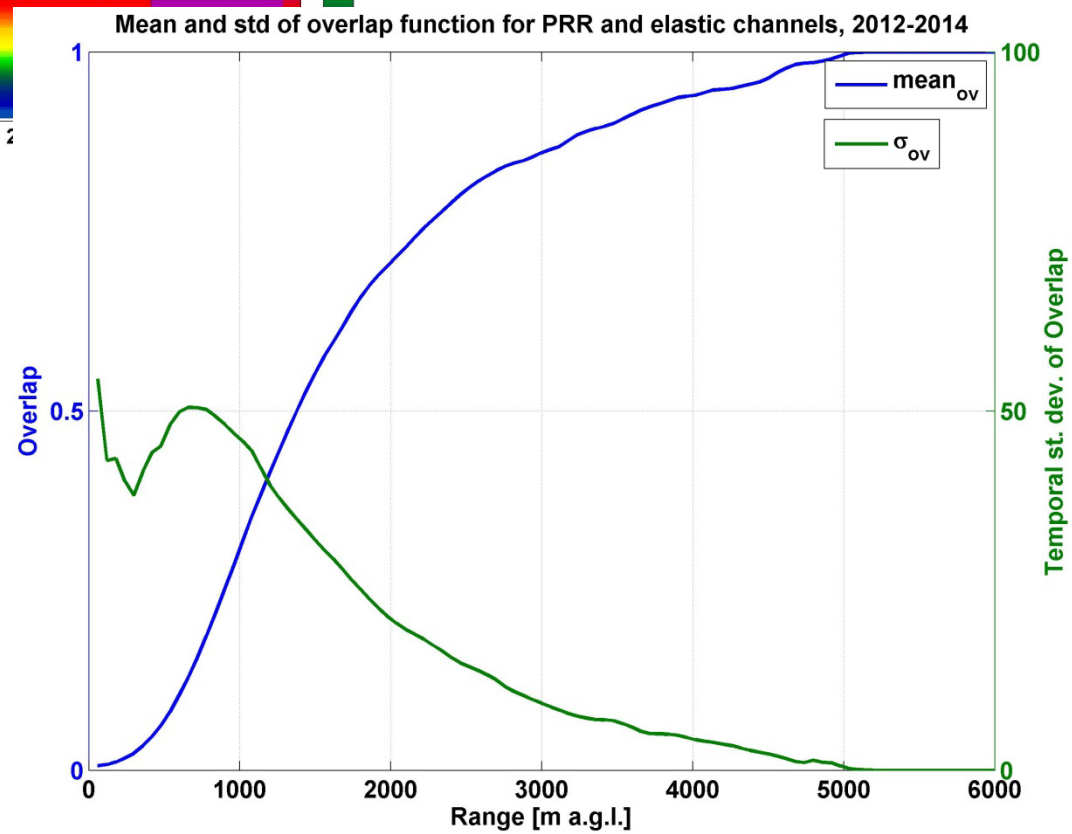
RALMO calibration and overlap correction



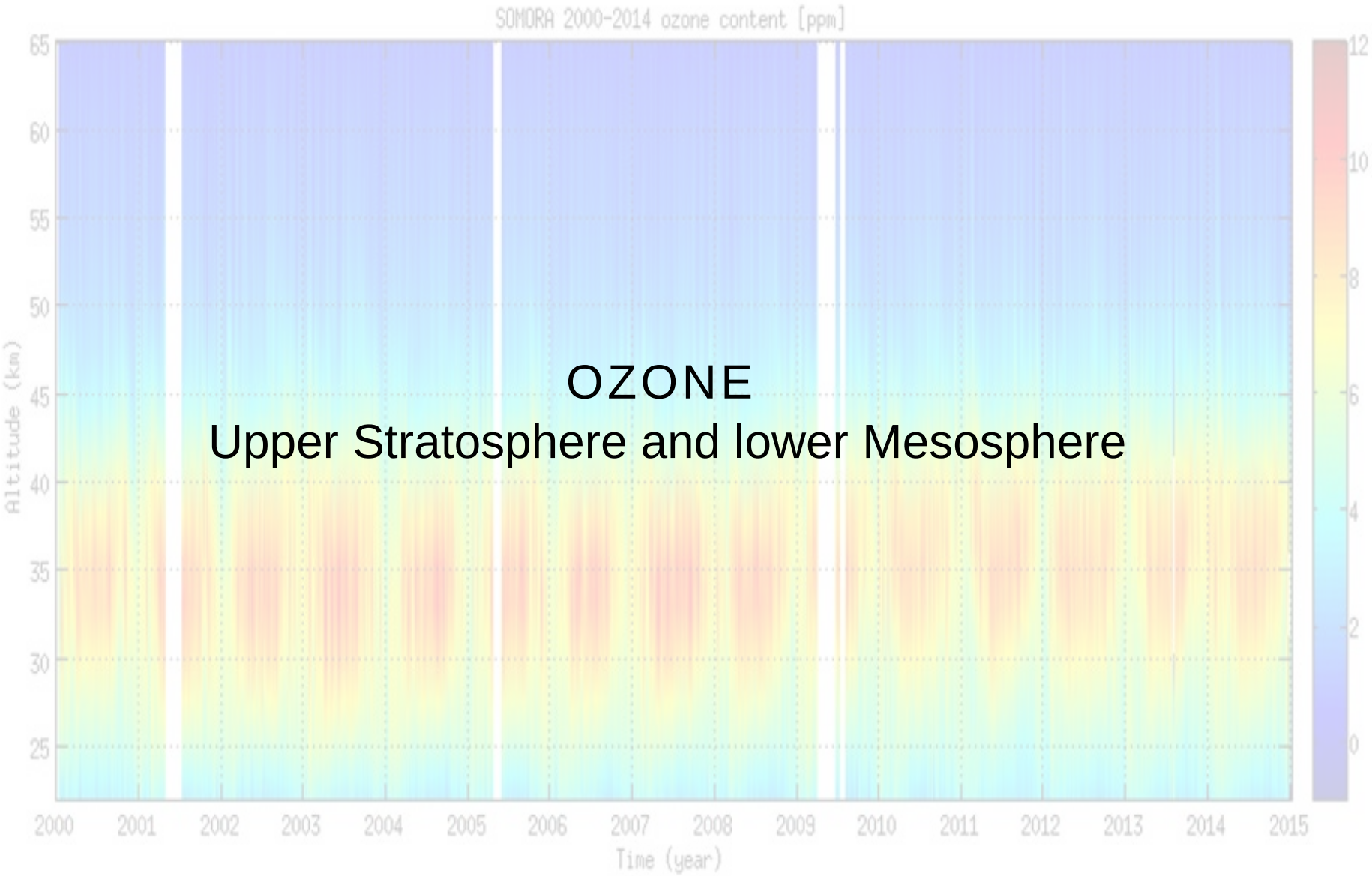


RALMO overlap correction





The temporal variability of the overlap correction function peaks at 700 m with ~50% of relative change during 2012-2014. The mean stdv over the range 0-5 km is **20%**.



OZONE

Upper Stratosphere and lower Mesosphere

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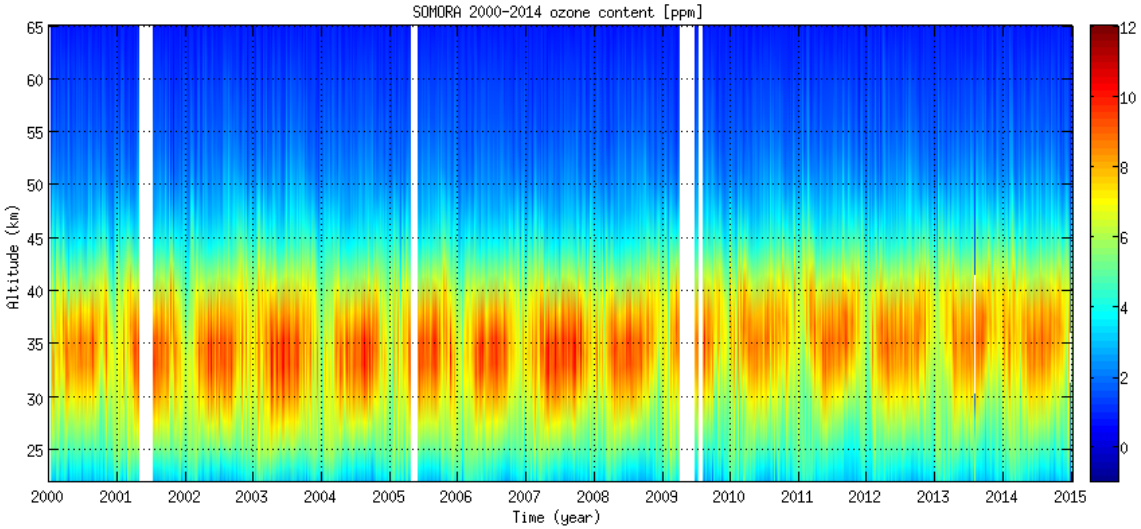
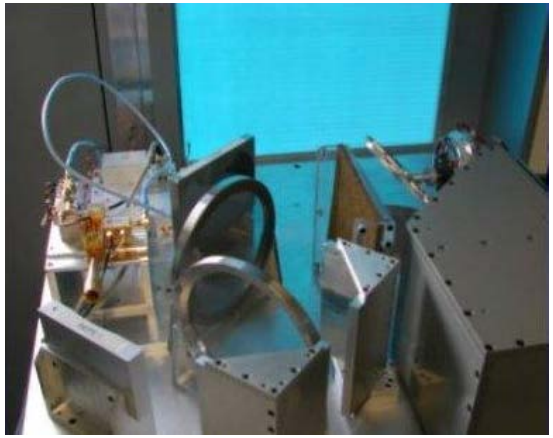
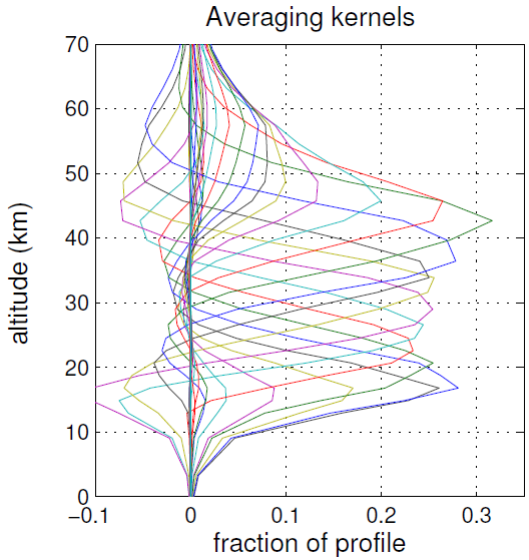
SOMORA

Stratospheric Ozone Monitoring Radiometer

Stratospheric ozone







Instrument Characteristics	
Radiometer type	Total power, single sideband
Calibration	Hot-cold
Center frequency	142 GHz
Bandwidth / resolution	1 GHz / 61 kHz
Spectrometer	AOS (until 2012) and FFTS (since 10/2010)

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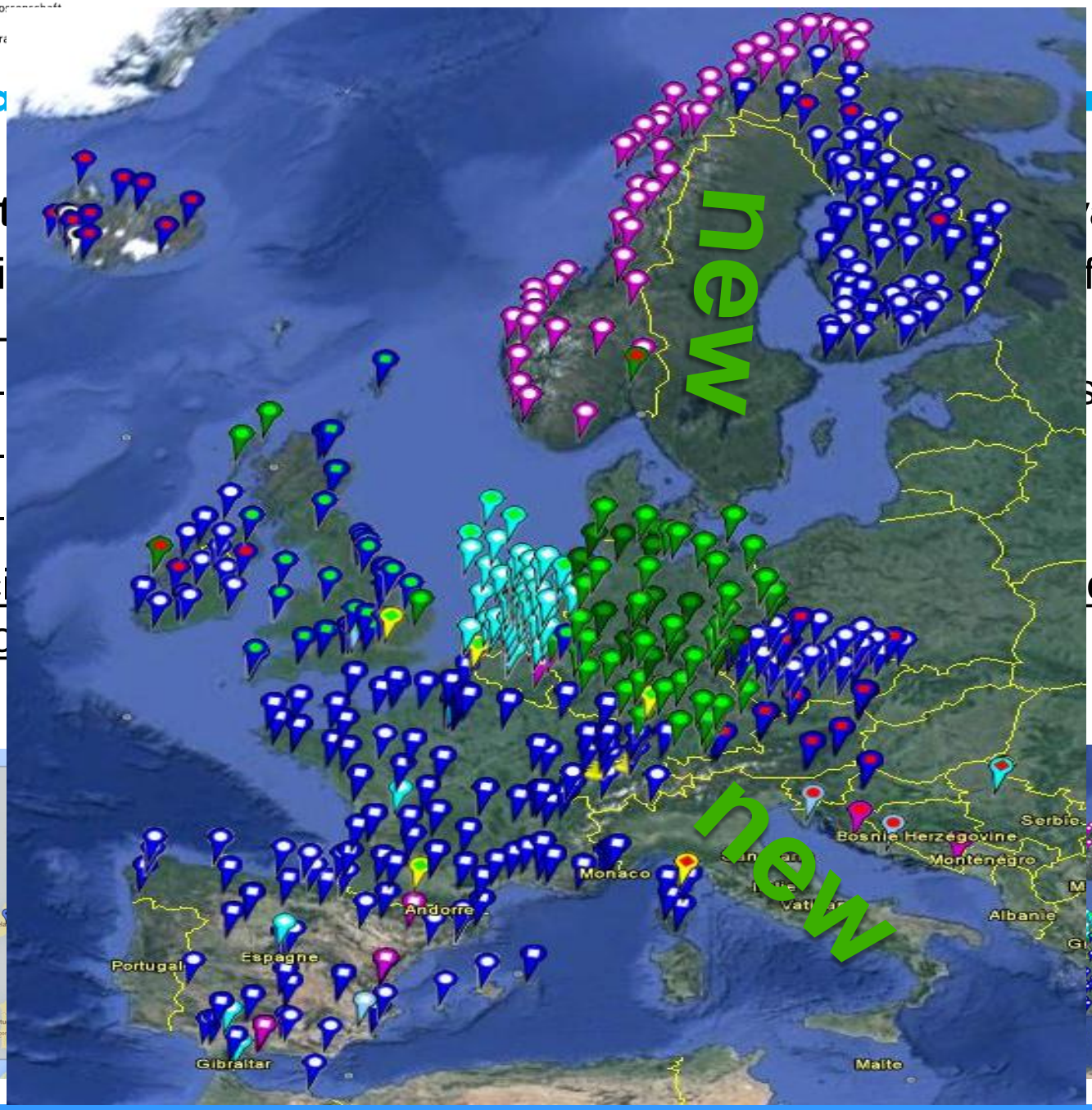

Wrapping up…

- RALMO performs good-quality WV measurements in the UTLS with SNR>1 and T_{int} of few hours. An OEM has been developed to characterize the temperature and WV retrievals by providing the uncertainty budget.
- The inspection of timeseries of WV and BSR variables allows for the separation of seasonal and advected layers.
- An automatic procedure is in place to calculate the extinction and backscatter coefficients from the total PRR signal.
- The RALMO system stability and calibration is monitored.
- SOMORA ensures the monitoring of stratospheric and mesospheric ozone above Payerne since year 2000.