# Determination of the altitude range of our retrievals

Microwave radiometer MIAWARA-C at the Geophysical Observatory in Sodankylä (2010-01-15 - 2010-06-15)

Corinne Straub, Brigitte Tschanz, Niklaus Kämpfer

Motivation

- No common definition for the altitude range in which a retrieved profile is reasonable in terms of sensitivity to perturbations in the true atmospheric profile.

- Area of the averaging kernels (AoA), called measurement response, gives indication in what altitude range the measurement contributes to what extent to the retrieved profile.

- AoA does not contain enough information for a complete definition of the altitude range
  $\rightarrow$ no indication if perturbations in the true atmospheric profile are attributed to correct altitude.

Typical AVK

Typical AVK MIAWARA–C
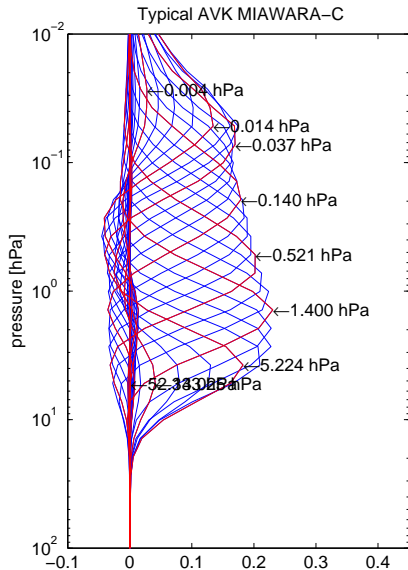
- ▶ Typical set of AVK of MIAWARA-C during the Lapbiat campaign.
- ▶ Pressure altitudes between 5 and 0.1 hPa AVK peak at the approximately right level.
- ▶ This is not true for altitudes higher or lower than that.

3 criteria for the altitude range of the retrieval given by Rodgers

1. AoA is close to unity
   $\Rightarrow$ retrieval is sensitive to the true profile.
2. Peaks of the AVK are located at the approximately right level
   $\Rightarrow$ perturbations in the true profile are attributed to correct altitude
3. Widths of the AVK are more or less uniform and comparable with or narrower than the those of the original weighting functions
   $\Rightarrow$ retrieval is reasonable in terms of the transferfunction

Retrieval used for the determination of the altitude range

1. MIAWARA-C single day retrieval during the Lapbiat 2010 campaign (2010-01-16).
2. Measurement noise: sigma=0.013K, Δf=30kHz
3. Baseline-Fit: Polynomial of 2nd degree and 3 sine fuctions.
4. Apriori profile: MLS-climatology
5. Apriori covariance: increasing from 15% @ 260 hPa to 65% @ 0.07 hPa

Averaging Kernels

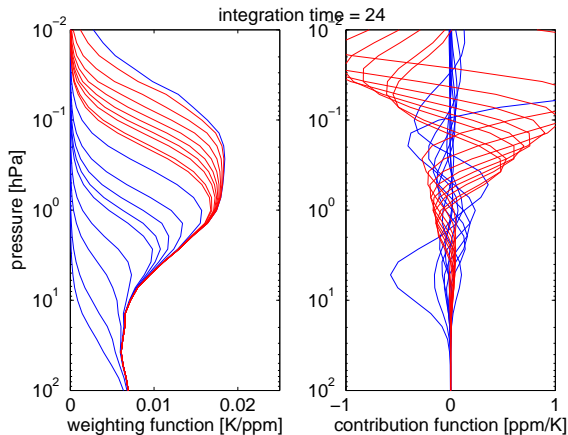Averaging Kernel Matrix with rows called AVK:

$$\mathbf{A} = \mathbf{G_y}\mathbf{K_x}$$

Kernel Matrix with rows called weighting functions:

$$K_{ij} = \frac{\partial \mathbf{F_i}(x)}{\partial x_j}$$

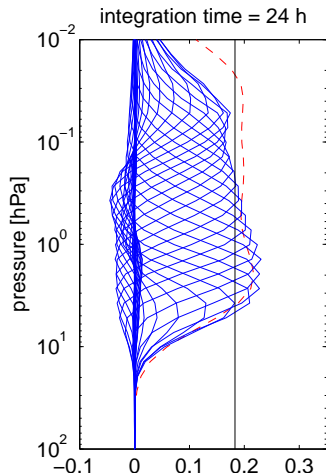Retrieval Gain Matrix with rows called contribution functions:

$$\mathbf{G_y} = (\mathbf{S_a}^{-1} + \mathbf{K_x}^T \mathbf{S_\epsilon}^{-1} \mathbf{K_x})^{-1} \mathbf{K_x}^T \mathbf{S_\epsilon}^{-1}$$

Weighting and Contribution Functions

Weighting and contribution functions for 10 channels at 0, 1, 2, 3, 4, 5, 10, 20, 50, 100 MHz from the line center (blue) and 2k channels where k=1:10 from the line center (red).

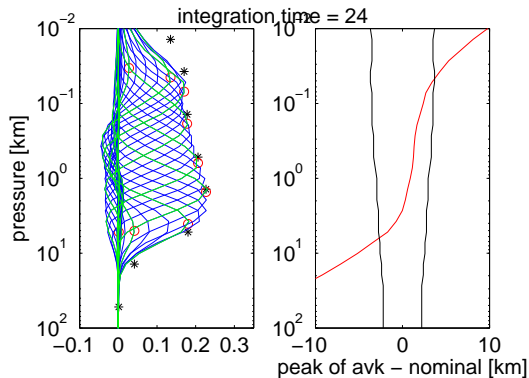# Area of the Averaging Kernels

integration time = 24 h

AVK and AoA/5. The black line marks the lower limit for the AoA.

Area of the Averaging Kernels, AoA, is plotted in red:

$$AoA(i) = \Sigma_j AVK(i,j)$$

- ▶ For MIAWARA-C 0.85 AoA is used to quantify the term close to unity.
- ▶ For a typical retrieval during the Lapbiat campaign this leads to a pressure range of **4 to 0.02 hPa**.

Peak height of the Averaging Kernels

- Nominal height should lie well within the altitude range covered by the AVK.
- 25% of the FWHM is used as upper limit for the difference between nominal and peak height.
- Leads to a pressure range of **6 to 0.05 hPa**.

Left: Peak (red circle) and nominal height (black star) for the AVK marked green. **Right:** Difference between nominal height and height of peak (red) and ±25% of FWHM (black).

Width of the AVK and the original weighting function

Assumption: Rodgers weighting functions = difference between the weighting functions of retrieval pressure levels.

They are found by the following process:

1. Difference between weighting function of one channel and the next ⇒ *DWF1*
2. Find pressure at the maximum of *DWF1*
3. Find *DWF1* with pressure closest to the middle between two pressure levels of retrieval ⇒ *DWF1(n)*
4. Difference between the weighting functions belonging to *DWF1(n)* ⇒ difference weighting functions
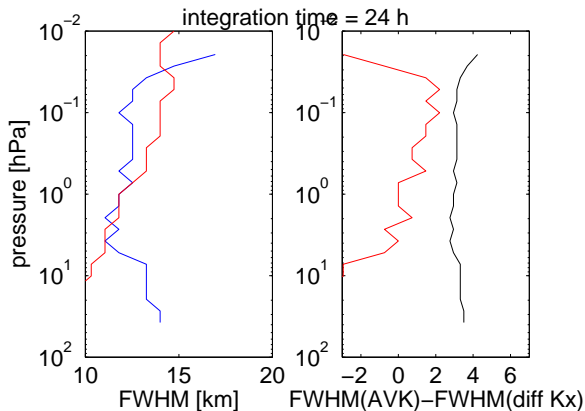
Width of the AVK and the original weighting function
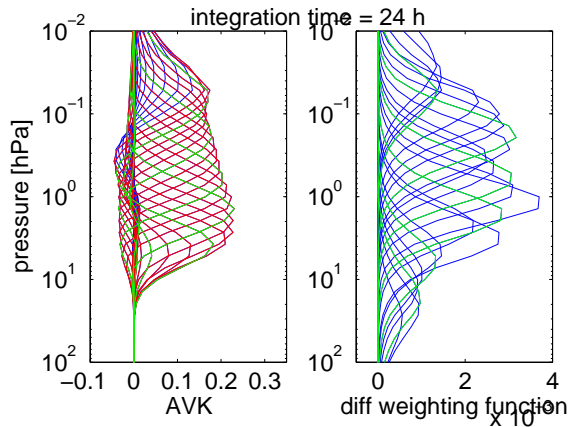
AVK and difference weighting function.

- ► The instrumental altitude limits are given by the bandwidth and the frequency resolution.
- ► These limits define the altitude range of the difference weighting functions, **40 to 0.02 hPa**.

Width of the AVK and the original weighting function

Left: FWHM of difference weighting function (blue) and FWHM of AVK (red). **Right:** Difference between FWHM of difference weighting function and FWHM of AVK red, 25% of FWHM of difference weighting function.

- 25% of the width of the weighting fuction is used as upper limit.
- This retrieval version seems to be reasonable in terms of the transfer function.

Compilation of the results for MIAWARA-C during the Lapbiat campaign

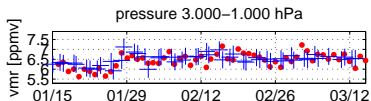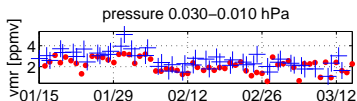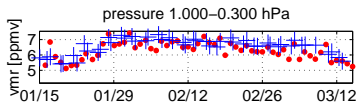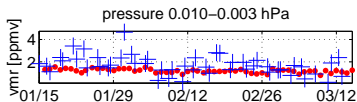| method	lower limit [hPa]	upper limit [hPa]
AoA	**4**	0.02
peak height	6	**0.05**
width of AVK and weighting functions	40	0.03

- ▶ All three criteria must be fulfilled at the altitude range a retrieval can be regarded as accurate.
- ▶ Upper limit can be increased by longer integratin times and a higher Δf.
- ▶ Lower altitude limit given by:
  - ▸ bandwidth of the spectrometer
  - ▸ baseline fit performed during the optimal estimation process
  - ⇒ difficult to decrease

The determined altitude range illustrated in actual profiles
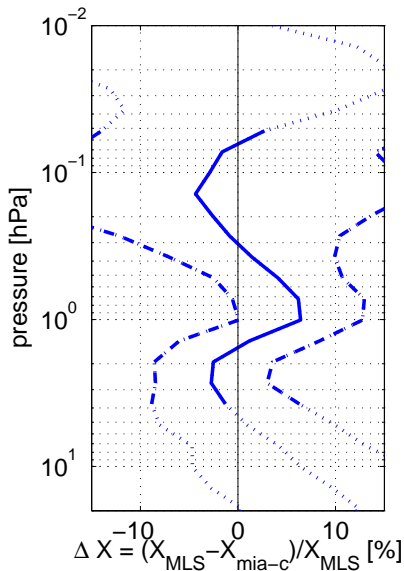
- ▶ Profiles of MIAWARA-C compared to the profiles of AURA/MLS. Altitude range of the retrieval is ploted solid.
- ▶ MLS profile is interpolated to the pressure grid of MIAWARA-C for the comparison.
- ▶ Mean difference of the profiles is within 7% in altitude range determined with the methode presented.

The determined altitude range illustrated in timeseries
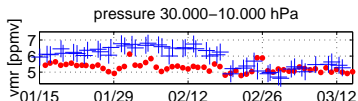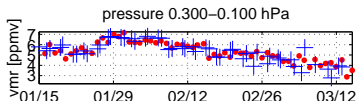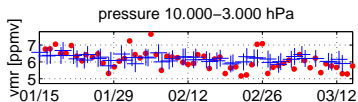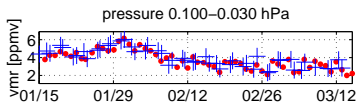
Conclusions

- A way to define the altitude range of retrievals using the Averaging Kernels has been shown on a concrete example.
- **AoA** (measurement response) indicates the altitude range in which the retrieval is sensitive to the true profile.
- **Peak height of the AVK** shows if perturbations in the true profile are attributed ot the correct altitude.
- **FWHM of the AVK compared to the one of the difference weighting functions** indicate the altitude range in which the retrieval is reasonable in terms of the transfer function.
- Altitude ranges determined are valid for the retrieval setup of MIAWARA-C during the Lapbiat campaign.
- Method used for the determination can basically be applied for each retrieval in which averaging kernels are calculated.