The effect of a non-linearity in the radiometric response of the OMI instrument

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Date: 8 December 1999
Subject: Non-linearity
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Definition

The non-linearity of the radiometric response is defined as the relative deviation of the instrument response from the radiometric input. Note that any requirement for the non-linearity has to be valid for the complete dynamic range.

Method

A typical non-linearity occurs when the instrument response is a quadratic function of the radiometric input, while a linear dependence is assumed. In this study such situation is considered in all simulations.
Then, for a certain maximum non-linearity m, radiometric input signal x, minimum signal x_{min}, maximum signal x_{max}, the instrument response y can be written as

$$y(x) = a\left(\frac{x - x_{min}}{x_{max} - x_{min}}\right)^2 + b\left(\frac{x - x_{min}}{x_{max} - x_{min}}\right) + c\,, \qquad [1]$$

where $a = 2\cdot(1+m-p)\cdot(x_{max}+x_{min})$,
$b = (1+m)\cdot(x_{max}-x_{min}) - a$,
$c = (1+m)\cdot x_{min}$.

The deviation $z(x)$ of the response from a linear response is given by

$$z(x) = \frac{y(x) - x}{x}\,. \qquad [2]$$

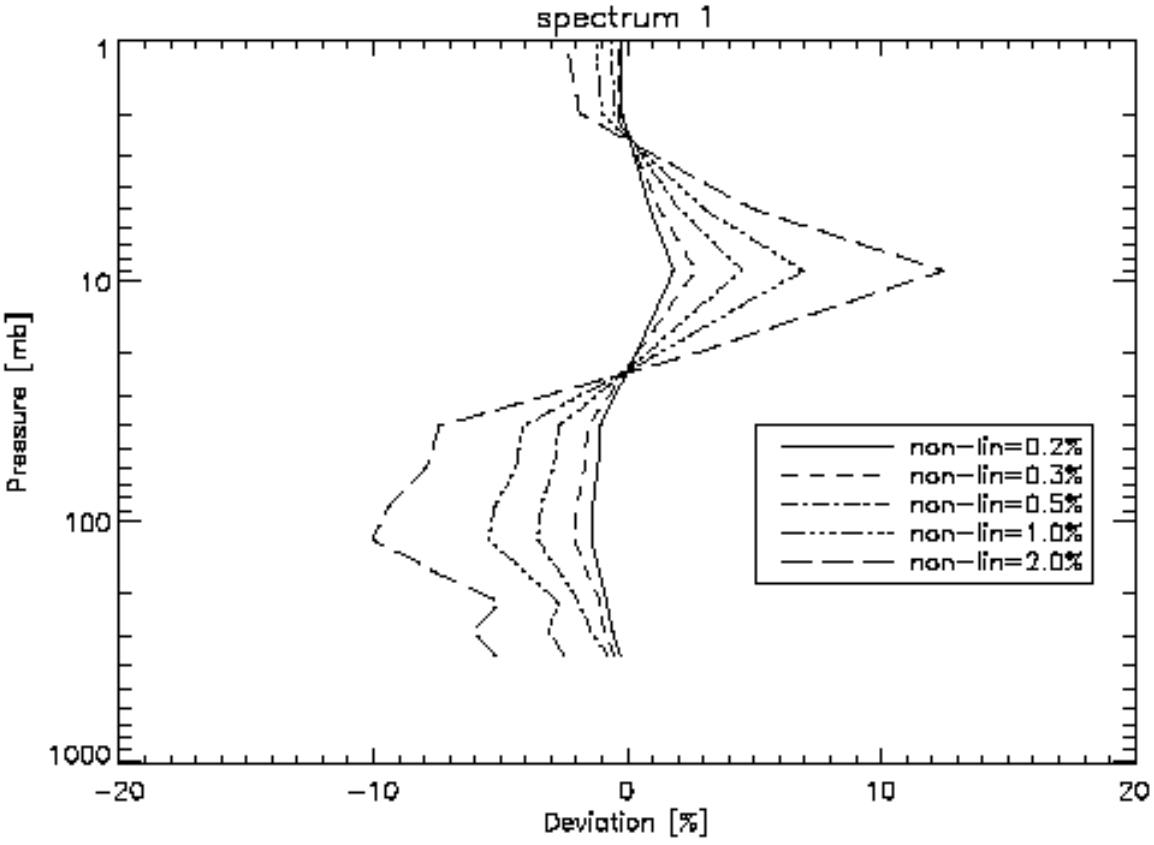
The parameter p is calculated from the following set of conditions :

$$z(x_{min}) = m$$
$$z(x_{max}) = m \qquad [3]$$
$$z(x_e) = -m \quad \text{where} \quad \frac{\partial z(x_e)}{\partial x} = 0$$

From this conditions follows the parameter p (calculated by Bert van den Oord) :

$$p = 1 - m\sqrt{1 - \left(\frac{x_{max} - x_{min}}{x_{max} + x_{min}}\right)^2}\,. \qquad [4]$$

A set of 13 simulated GOME spectra is distorted according to equation 1 and the non-linearities in Table 1. For all these spectra profiles are retrieved and compared to the reference profile retrieved from the spectra without non-linearity. The deviations between these profiles are given in the Figures for each of the 13 spectra.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1000
−20
−10
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10
20
Deviation [%]
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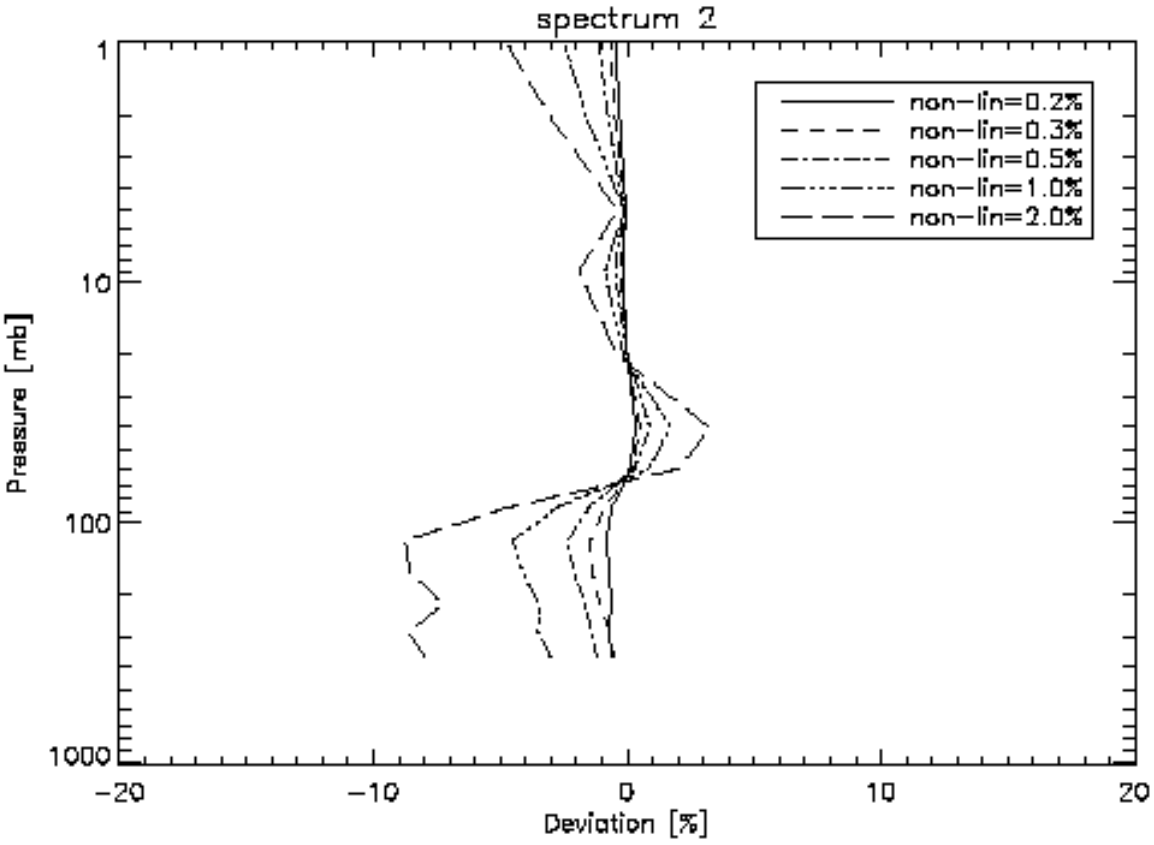
non−lin=0.3%
non−lin=0.5%
non−lin=1.0%
non−lin=2.0%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non−lin=0.3%
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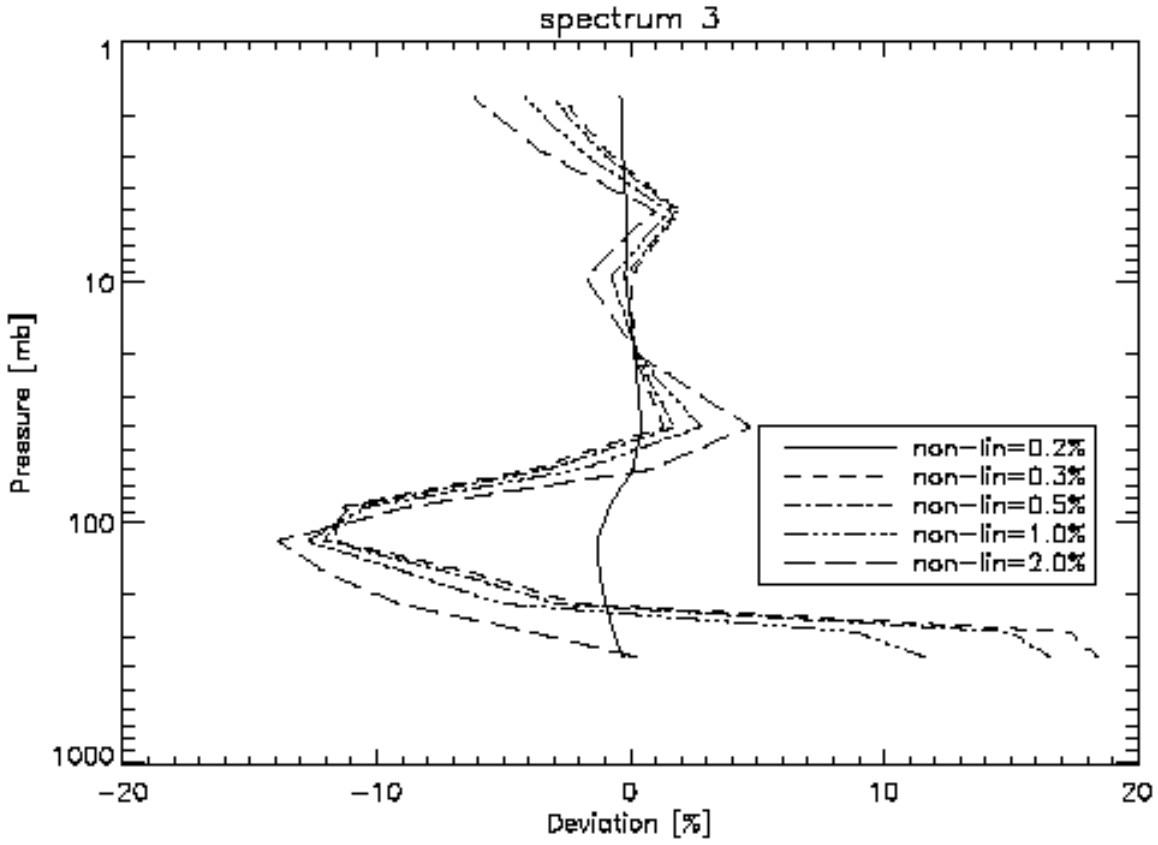
non−lin=1.0%
non−lin=2.0%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Pressure [mb]
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100
1000
−20
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0
10
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Deviation [%]
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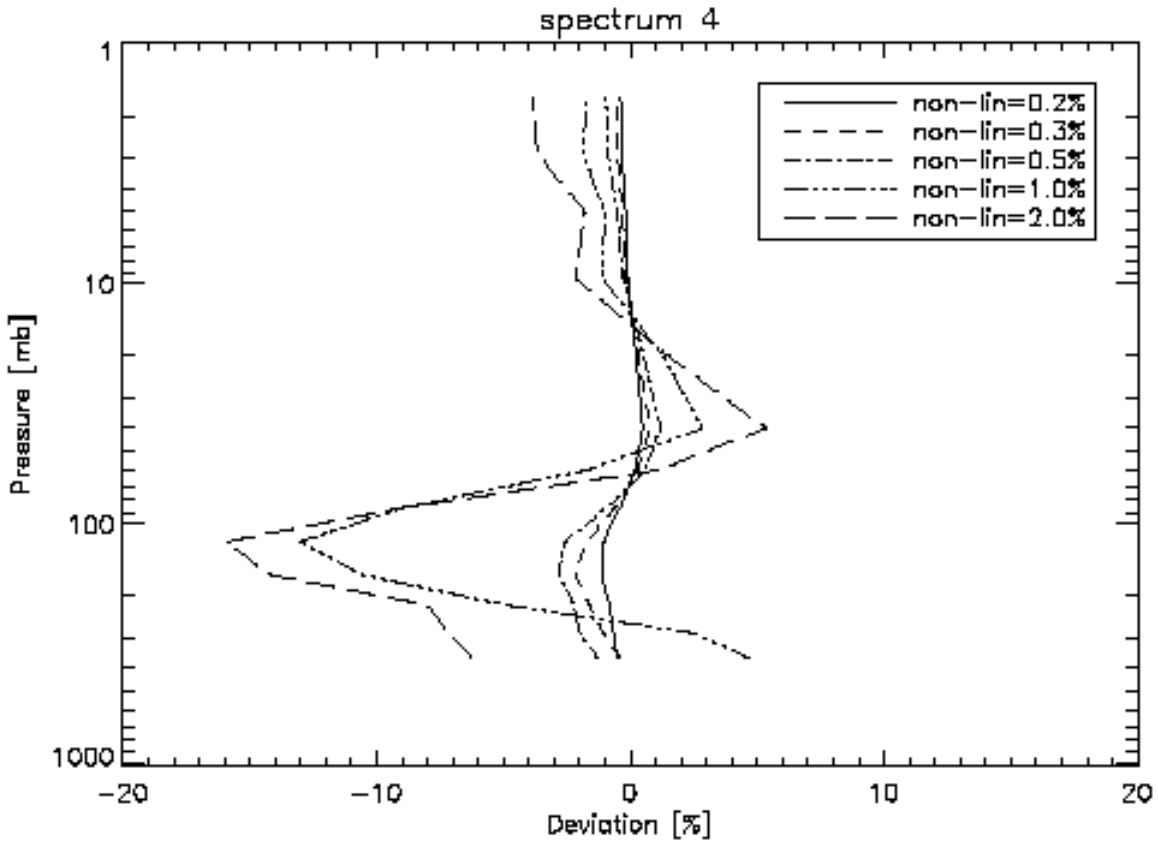
non−lin=0.3%
non−lin=0.5%
non−lin=1.0%
non−lin=2.0%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1000
−20
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Deviation [%]
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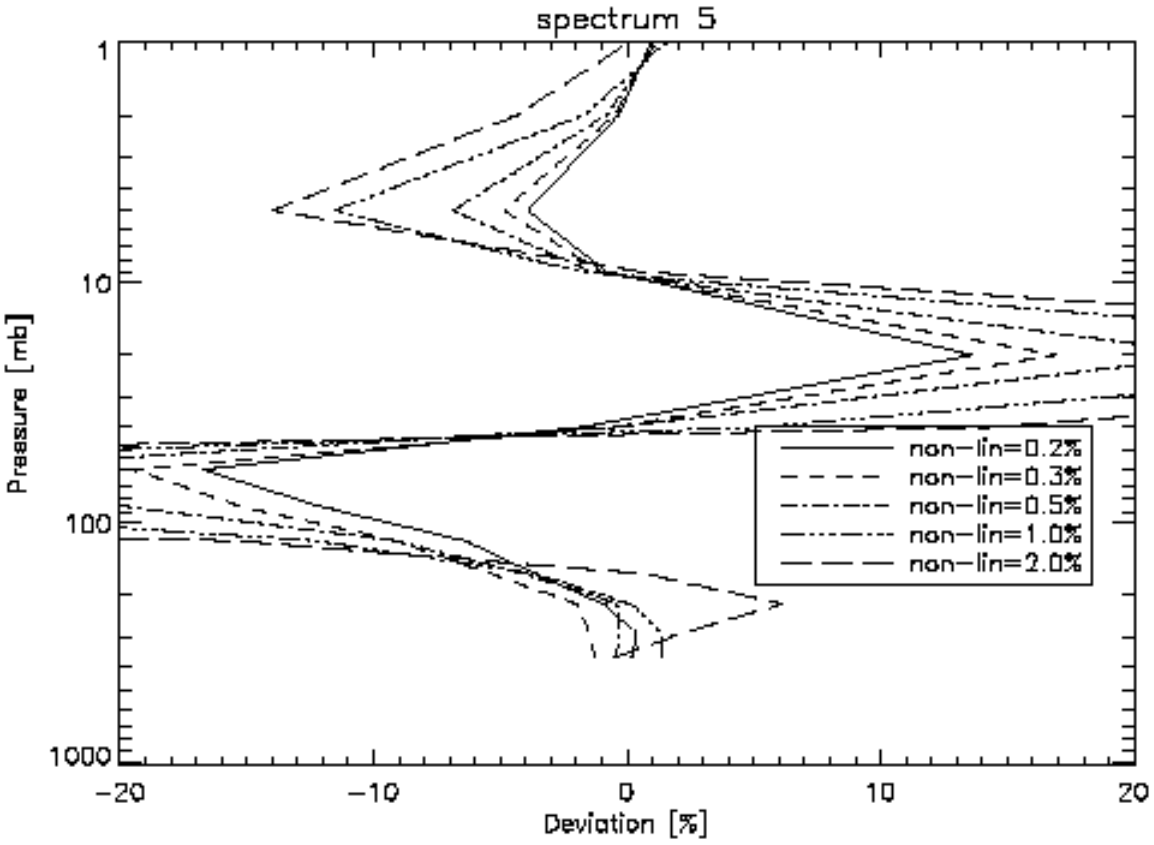
non−lin=0.3%
non−lin=0.5%
non−lin=1.0%
non−lin=2.0%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Pressure [mb]
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1000
−20
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10
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Deviation [%]
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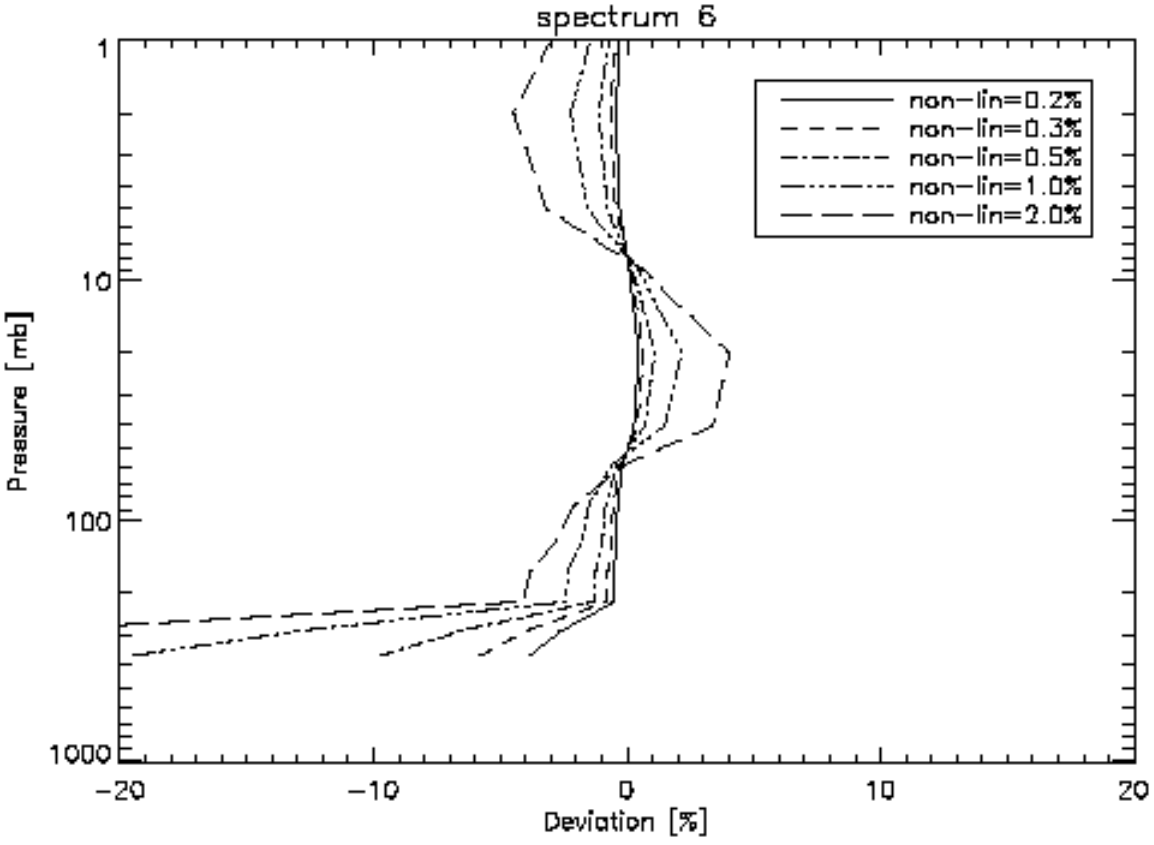
non−lin=0.3%
non−lin=0.5%
non−lin=1.0%
non−lin=2.0%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Pressure [mb]
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1000
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10
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Deviation [%]
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non−lin=0.3%
non−lin=0.5%
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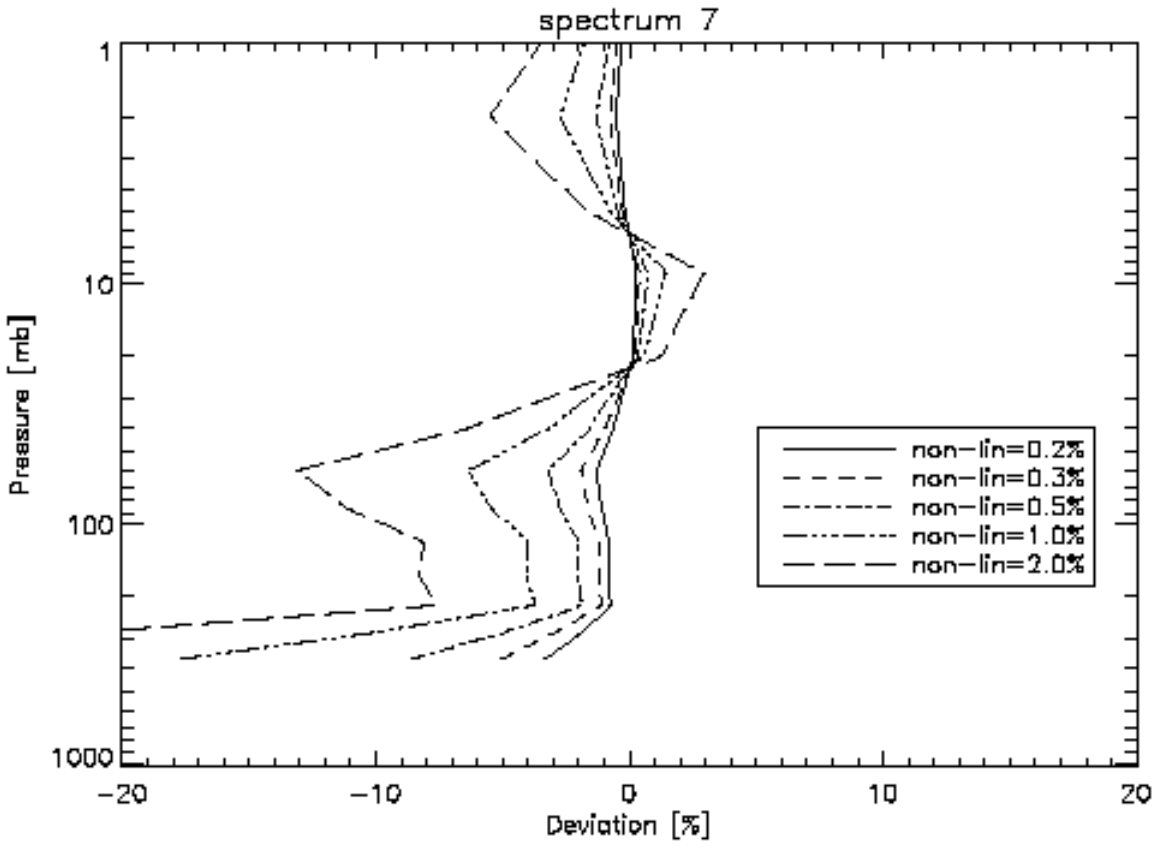
non−lin=2.0%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Pressure [mb]
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1000
−20
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0
10
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Deviation [%]
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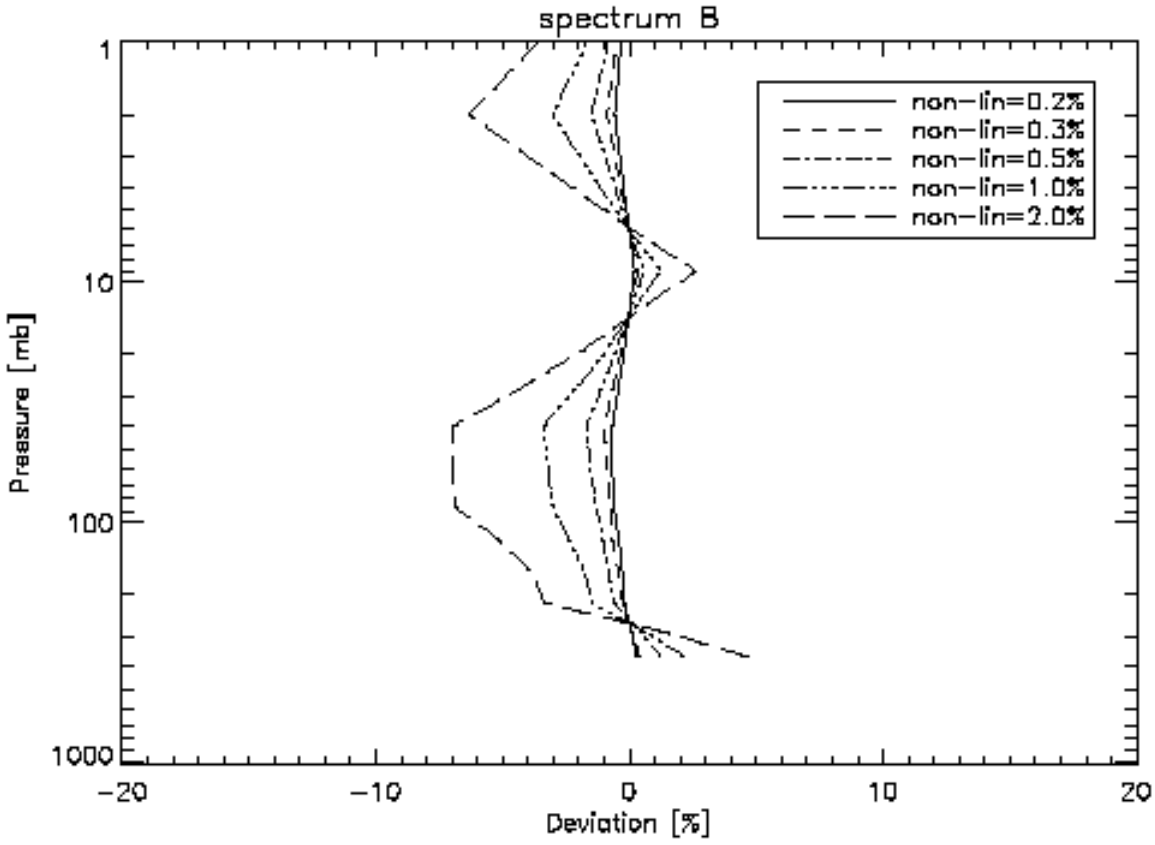
non−lin=0.3%
non−lin=0.5%
non−lin=1.0%
non−lin=2.0%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Pressure [mb]
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100
1000
−20
−10
0
10
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Deviation [%]
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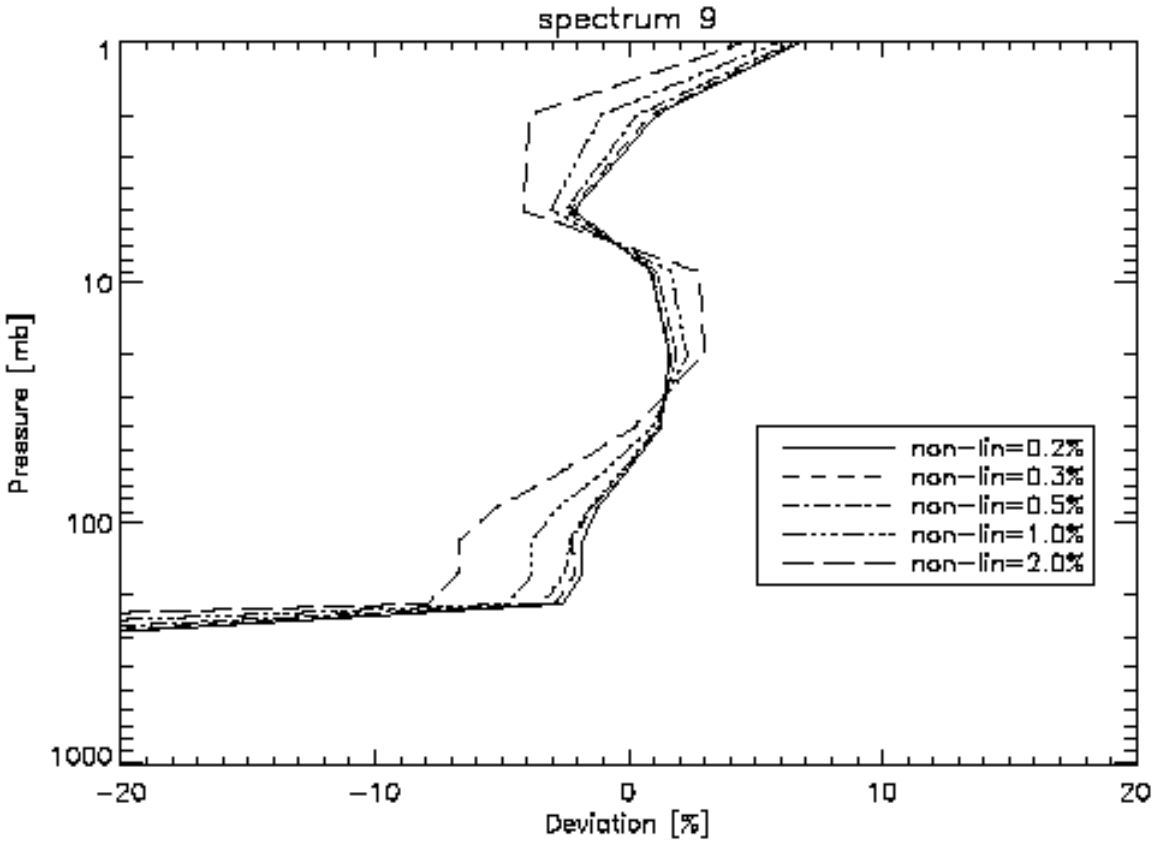
non−lin=0.3%
non−lin=0.5%
non−lin=1.0%
non−lin=2.0%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Deviation [%]
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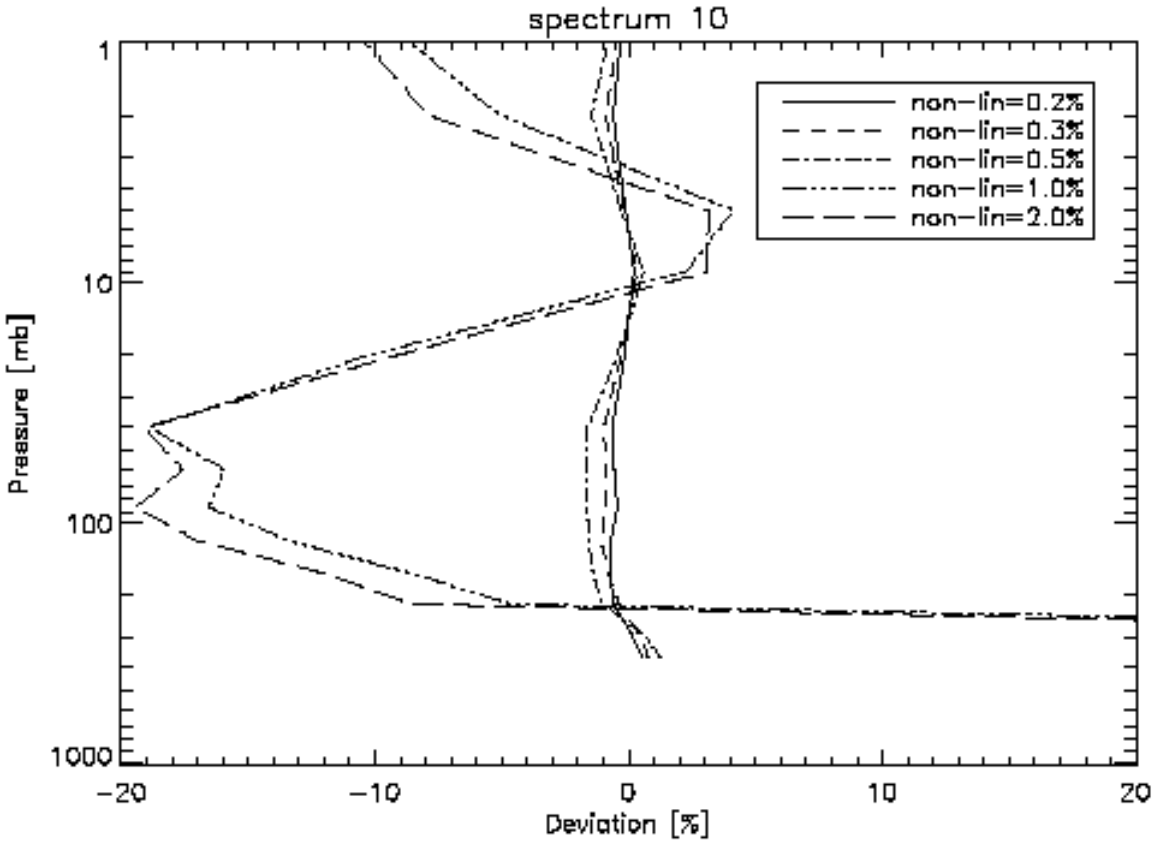
non−lin=0.3%
non−lin=0.5%
non−lin=1.0%
non−lin=2.0%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Pressure [mb]
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100
1000
−20
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Deviation [%]
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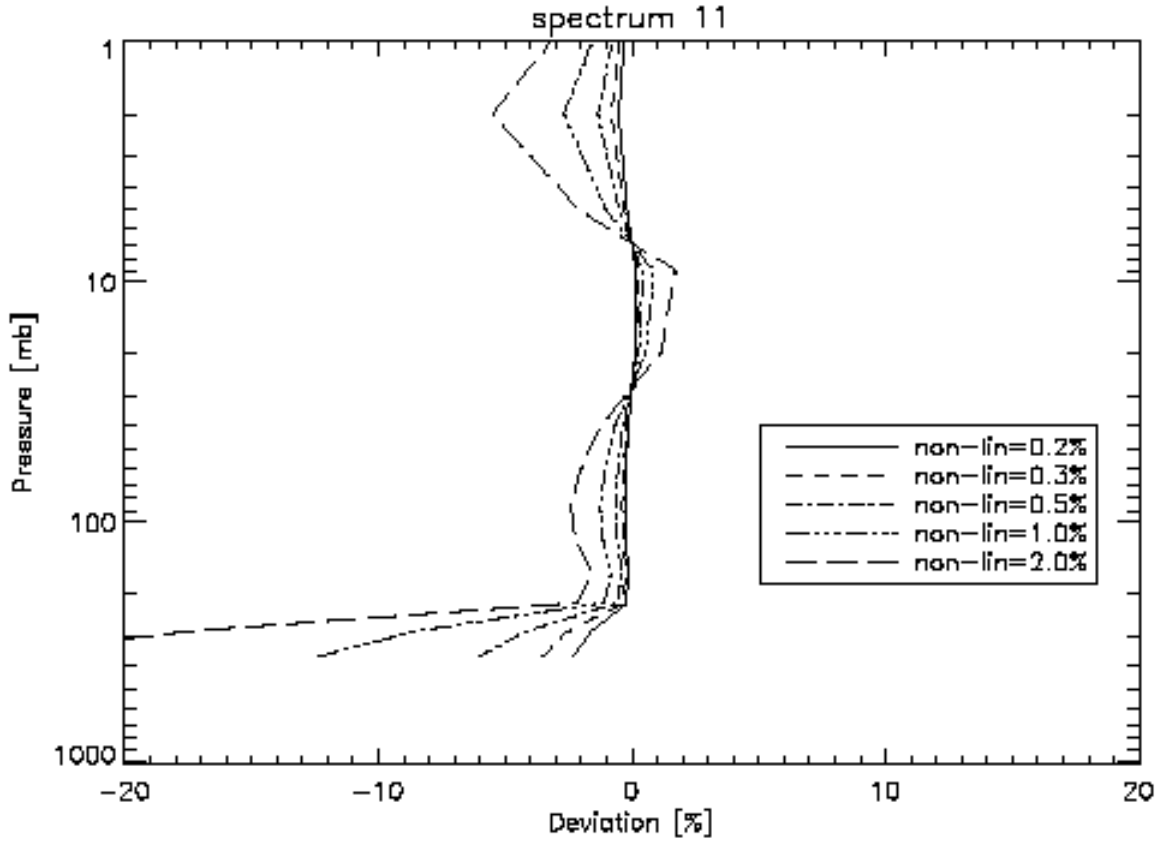
non−lin=0.3%
non−lin=0.5%
non−lin=1.0%
non−lin=2.0%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Pressure [mb]
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100
1000
−20
−10
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Deviation [%]
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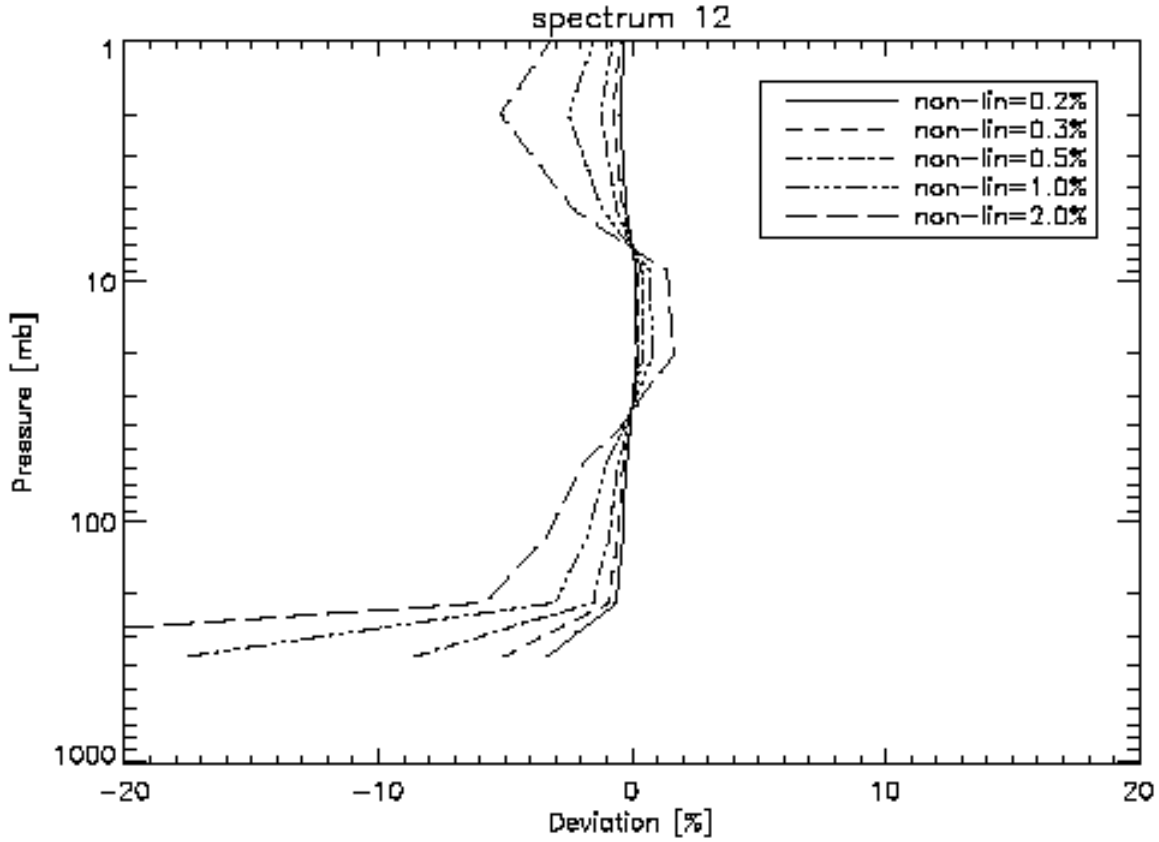
non−lin=0.3%
non−lin=0.5%
non−lin=1.0%
non−lin=2.0%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Pressure [mb]
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Deviation [%]
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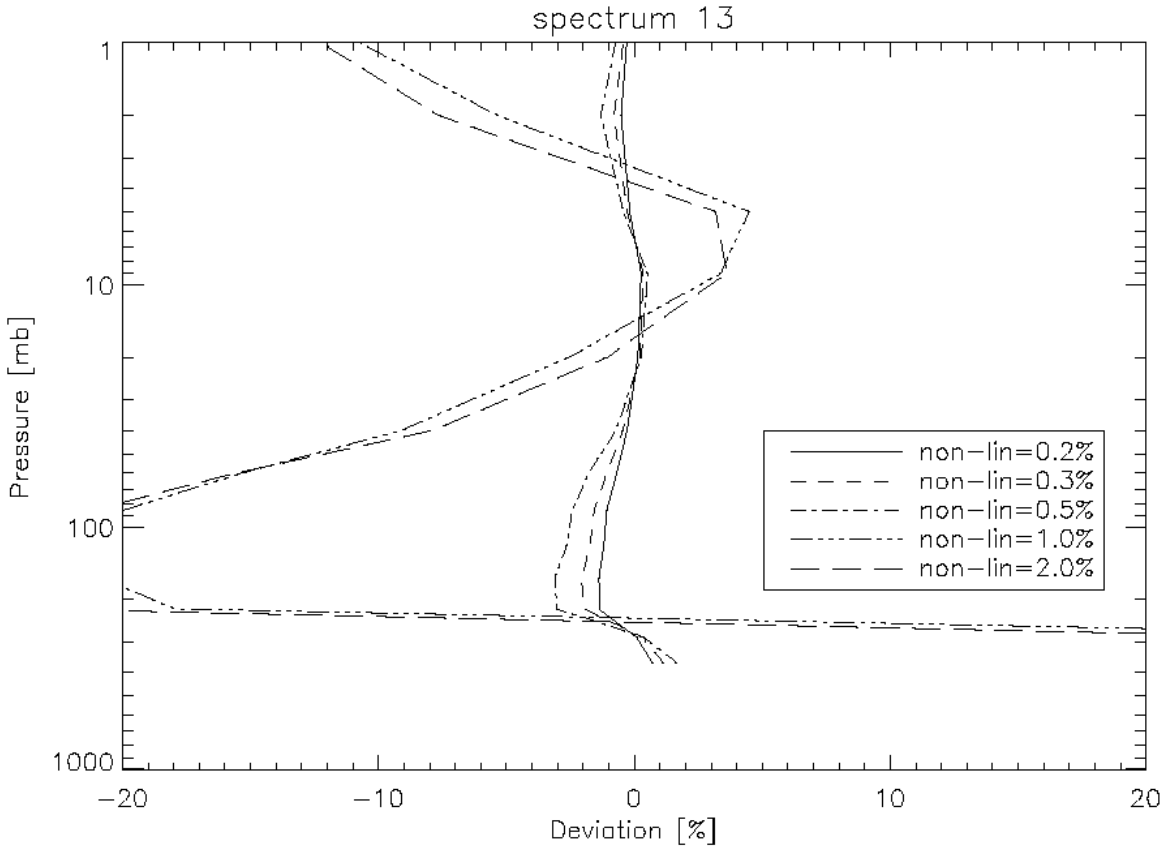
non−lin=0.3%
non−lin=0.5%
non−lin=1.0%
non−lin=2.0%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Pressure [mb]
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1000
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Deviation [%]
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non−lin=0.3%
non−lin=0.5%
non−lin=1.0%
non−lin=2.0%