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Problems with kernel matrices for a retrieval of H_2O using Arts and Qpack

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H_2O-Radiometer @ 183GHz

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- measurements by aircraft once a year during 1 week

- measurements 1998-2002 "old system"
  retrieval by old working software

- 2003 modification of the instrument.

- measurements 2003-2004 "new system" with problems
  retrieval problems with new software (Arts & Qpack)

measurement example
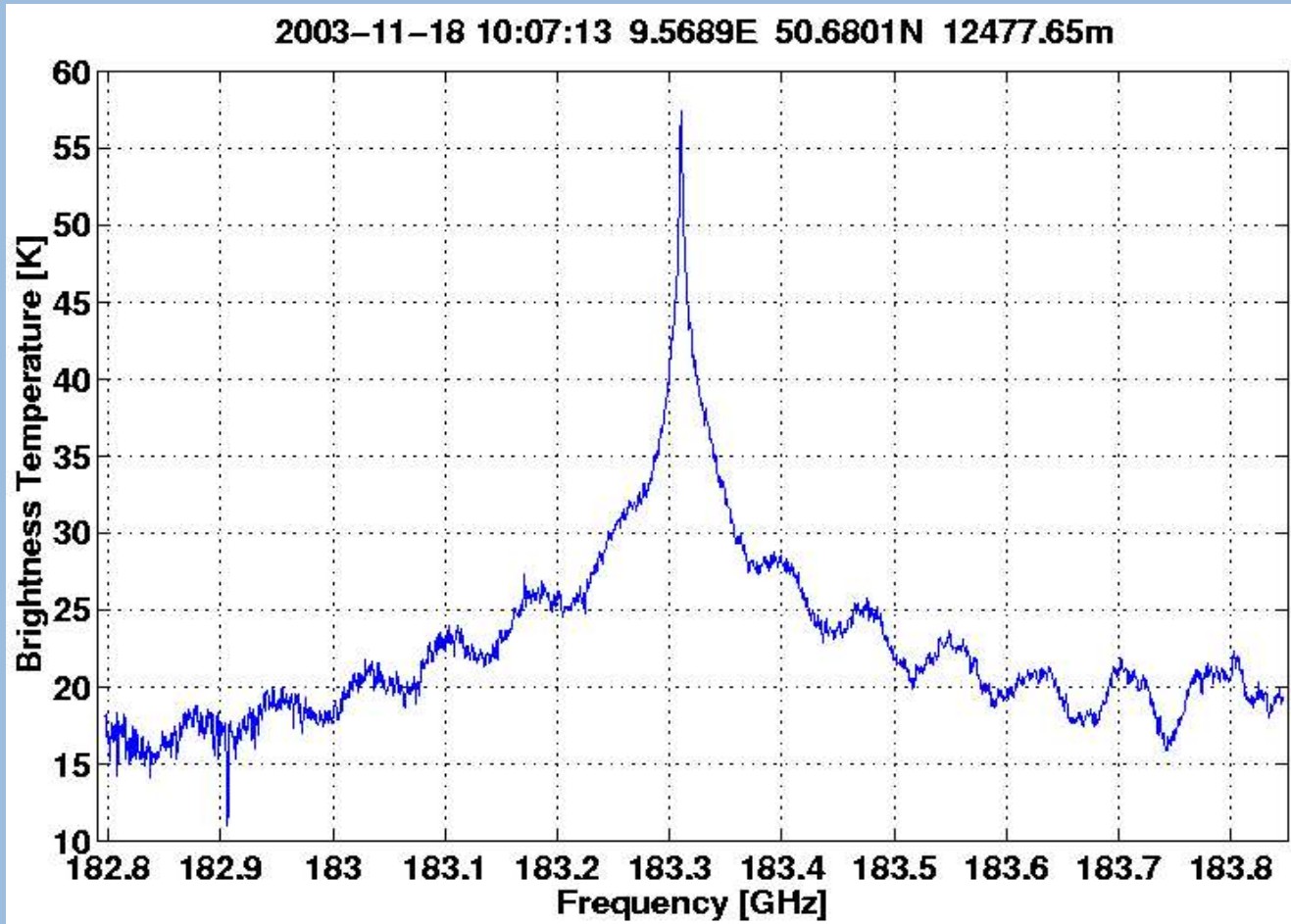
- **standing waves**

- **double sideband**

  - **Qpack**

simulation of a retrieval

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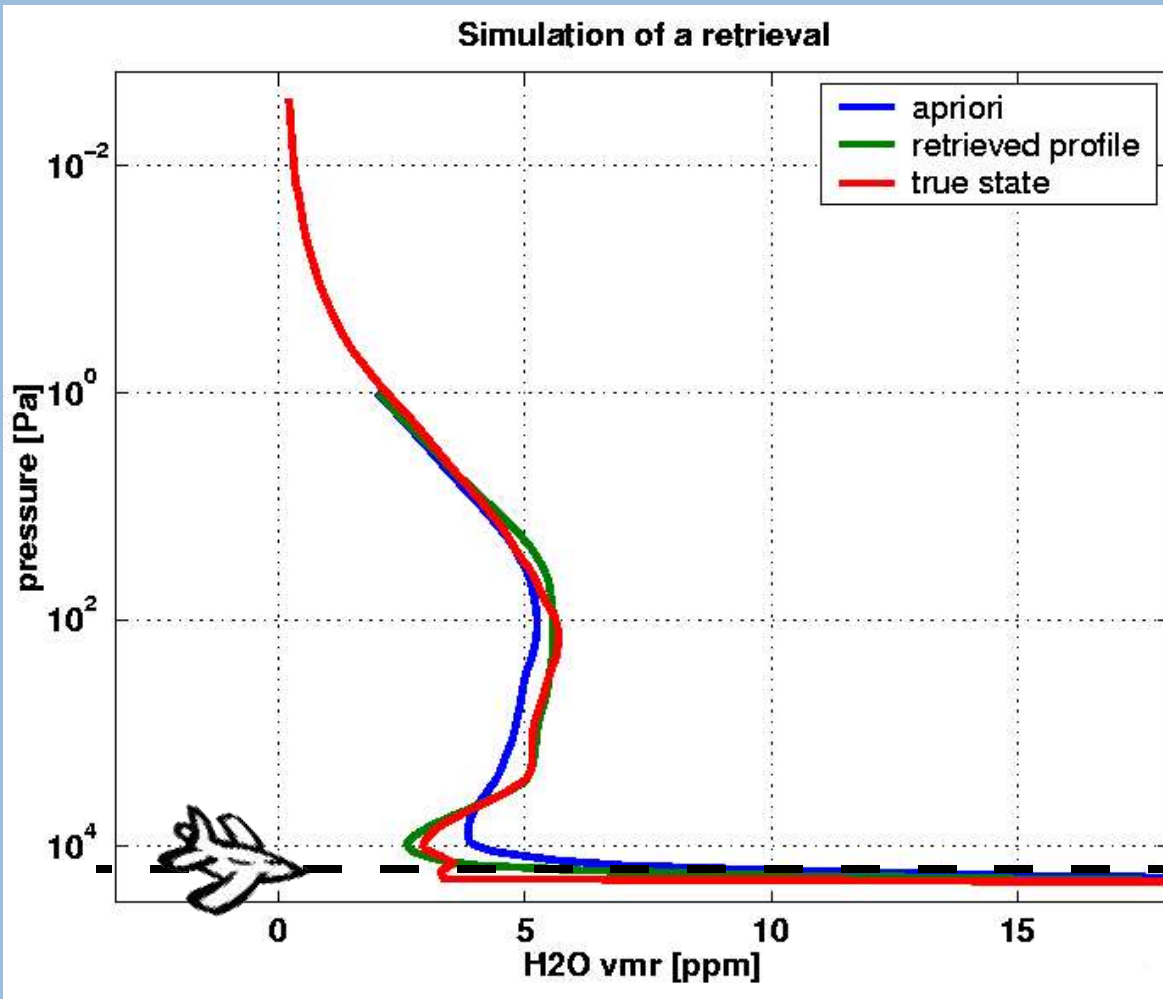
input:
* apriori
* temperature profile
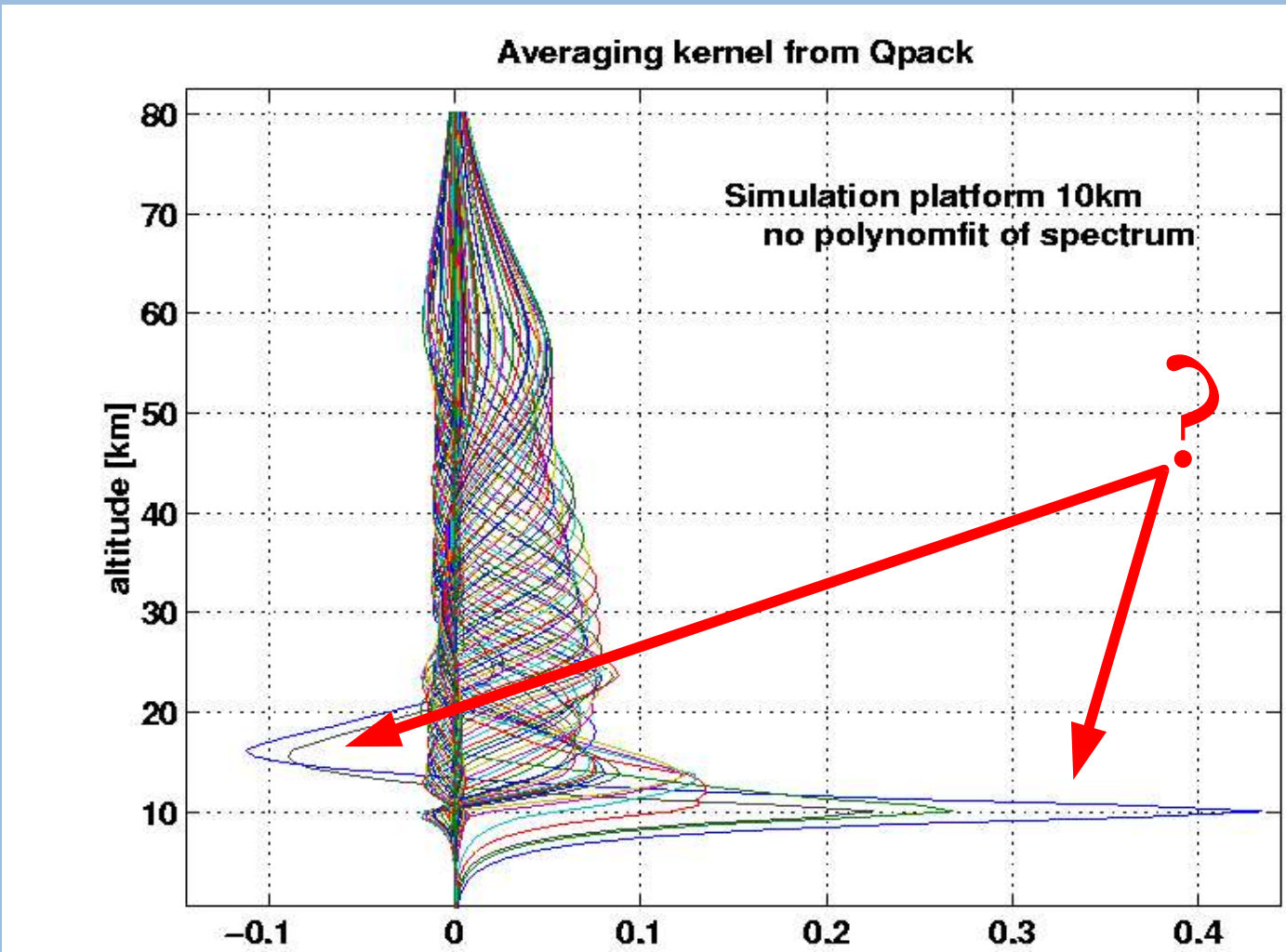* sensor character

output:
* profile
* **A**
* **Kx**
* **Dy**

averaging kernel matrix A

◆ needed for comparisons
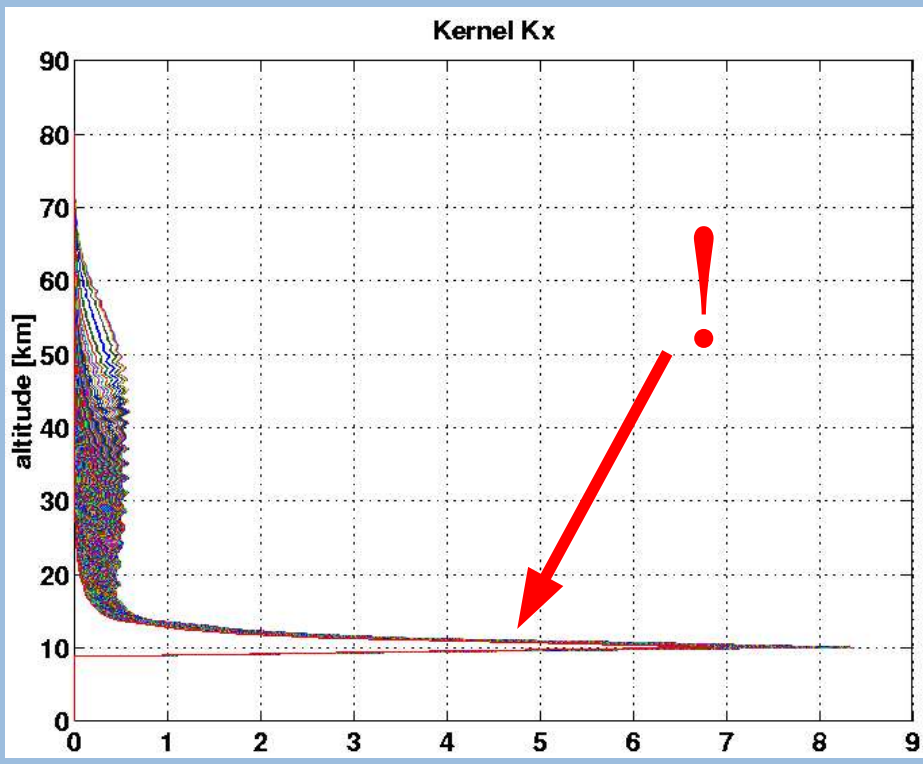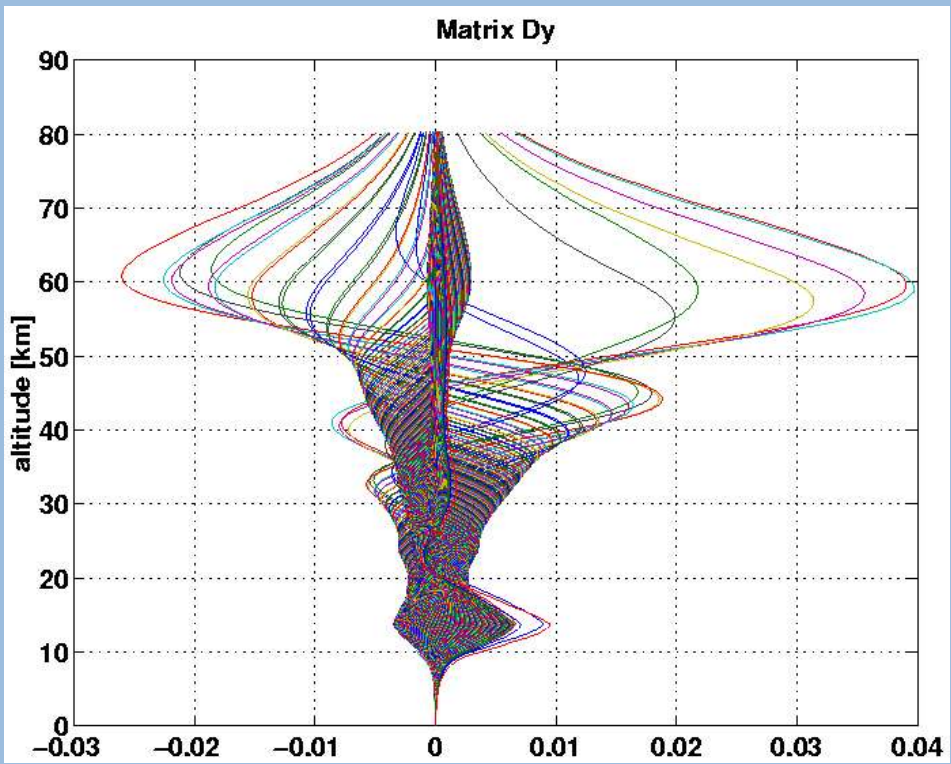
$$\hat{x} = x_a + A \cdot (\tilde{x} - x_a)$$

- → $\tilde{x}$ is an atmospheric state
- → x_a is the apriori
- → $\hat{x}$ is the state we would see with our radiometer.

typical **A** from a simulation

Averaging kernel from Qpack

Simulation platform 10km
no polynomfit of spectrum

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where does the problem come from?

$$\mathbf{A} = \mathbf{D_y} \cdot \mathbf{K_x} \qquad D_y = \frac{\partial R}{\partial y}\,; K_x = \frac{\partial F}{\partial x}$$

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search for the problem

- line strength

- platform altitude
  discontinuity at platform?

- comparison of retrieval setup
  (working 22GHz vs. 183GHz)

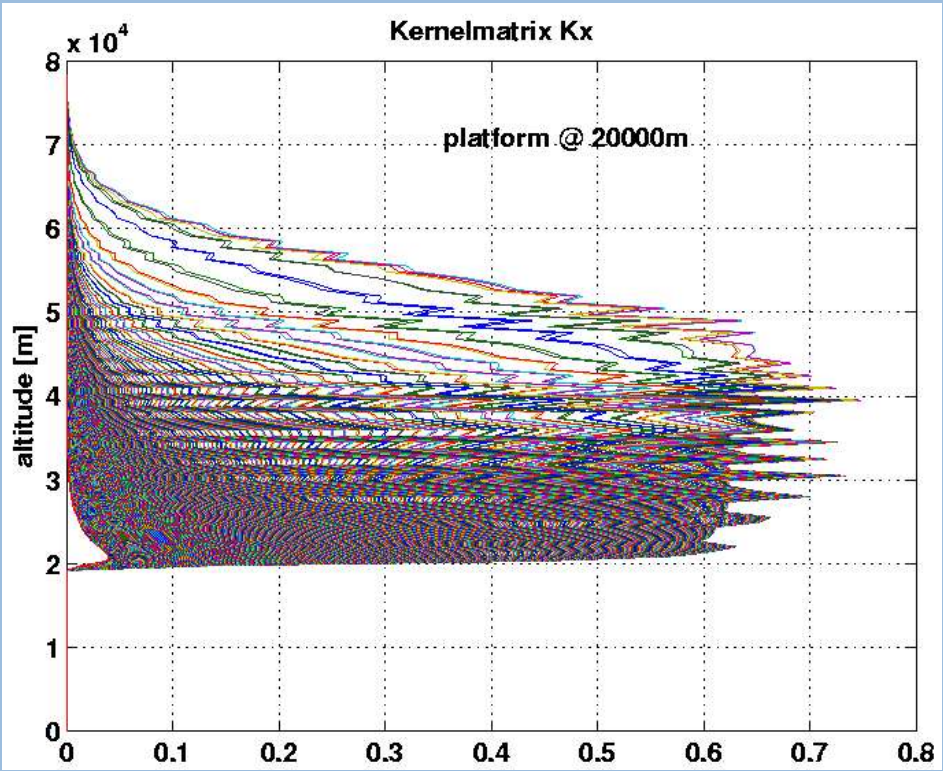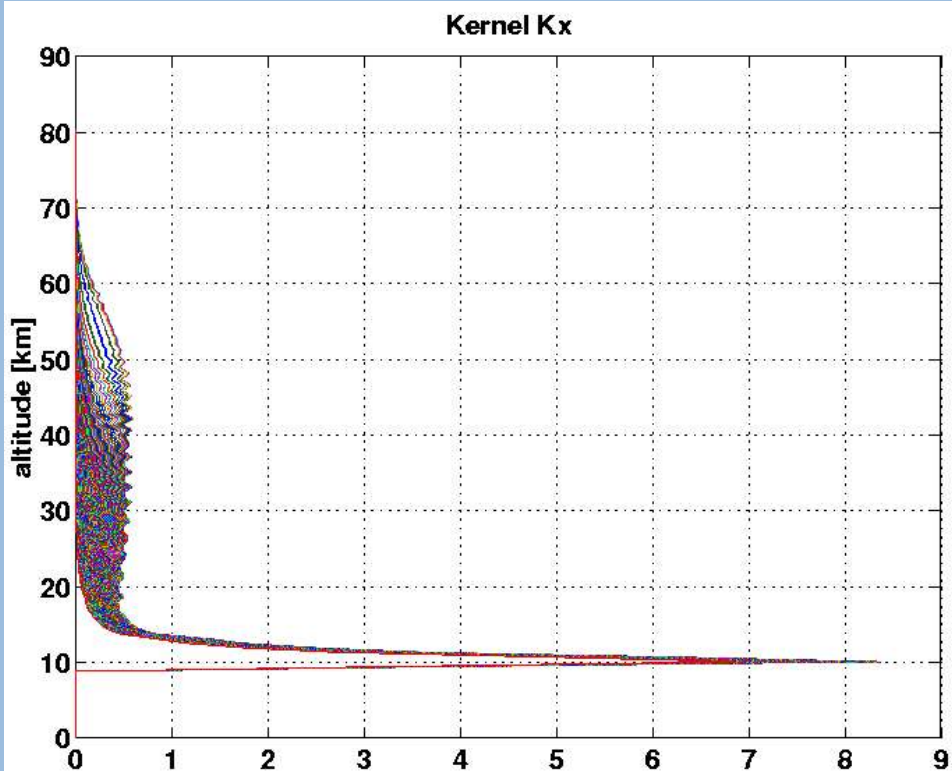- calculation of $\mathbf{K_x}$ numerically

Kernel Kx
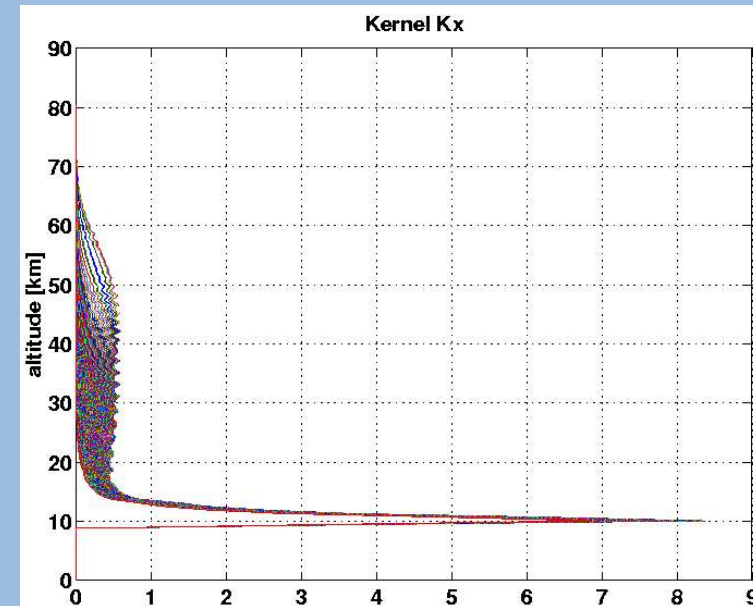
line strength

simulation with

+ a reduction of line strength (parameter S in Hitran) of the 183GHz line by factor 10 and 100.

+ the weaker line at 22GHz

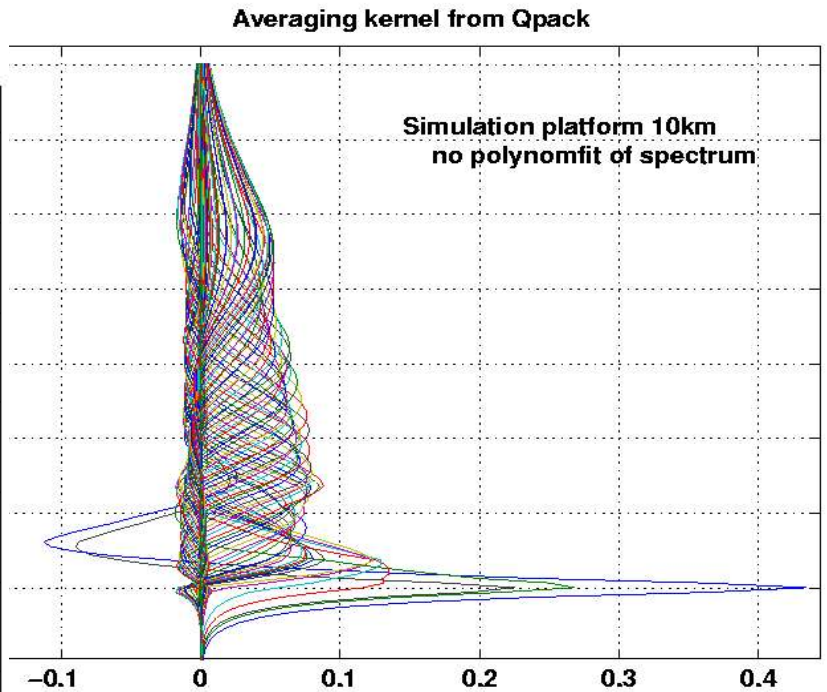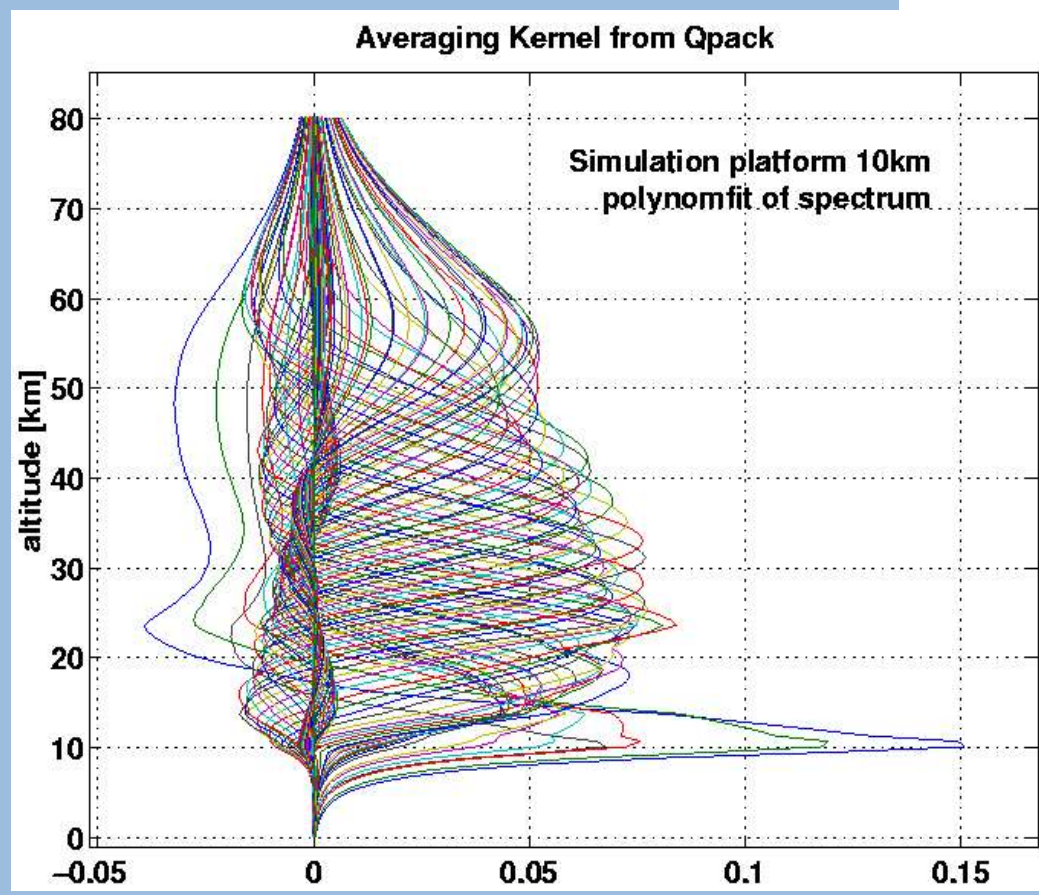$$\Rightarrow \text{ same effects are seen in } \mathbf{K_x} \text{ and } \mathbf{A}$$

platform altitude

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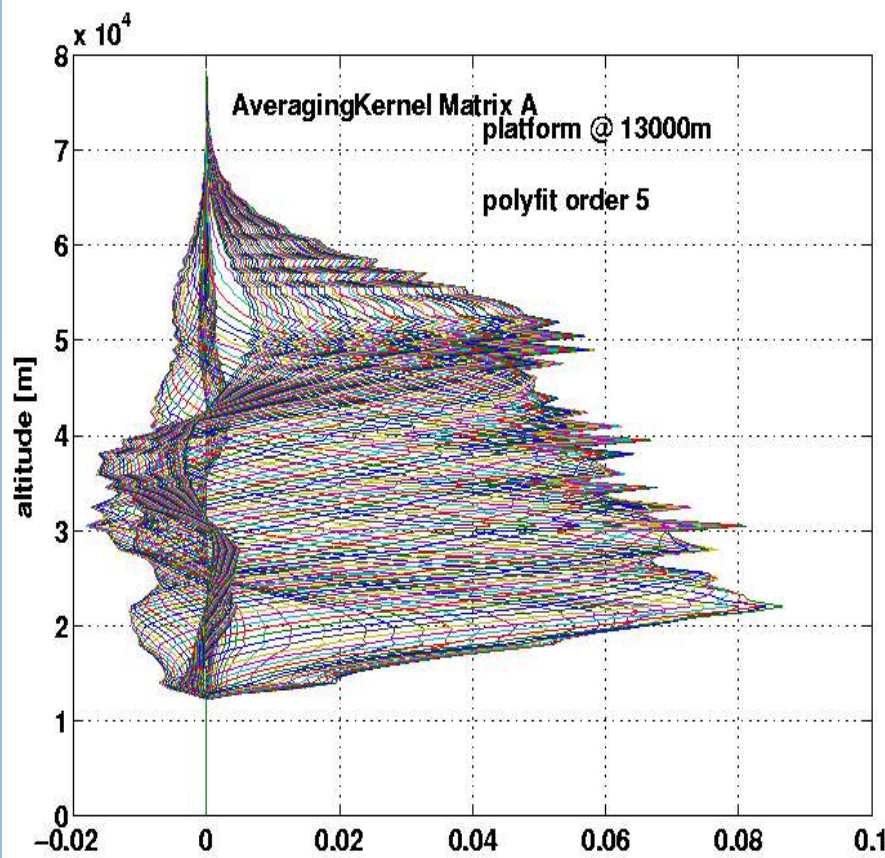## simulation with different platform altitude levels
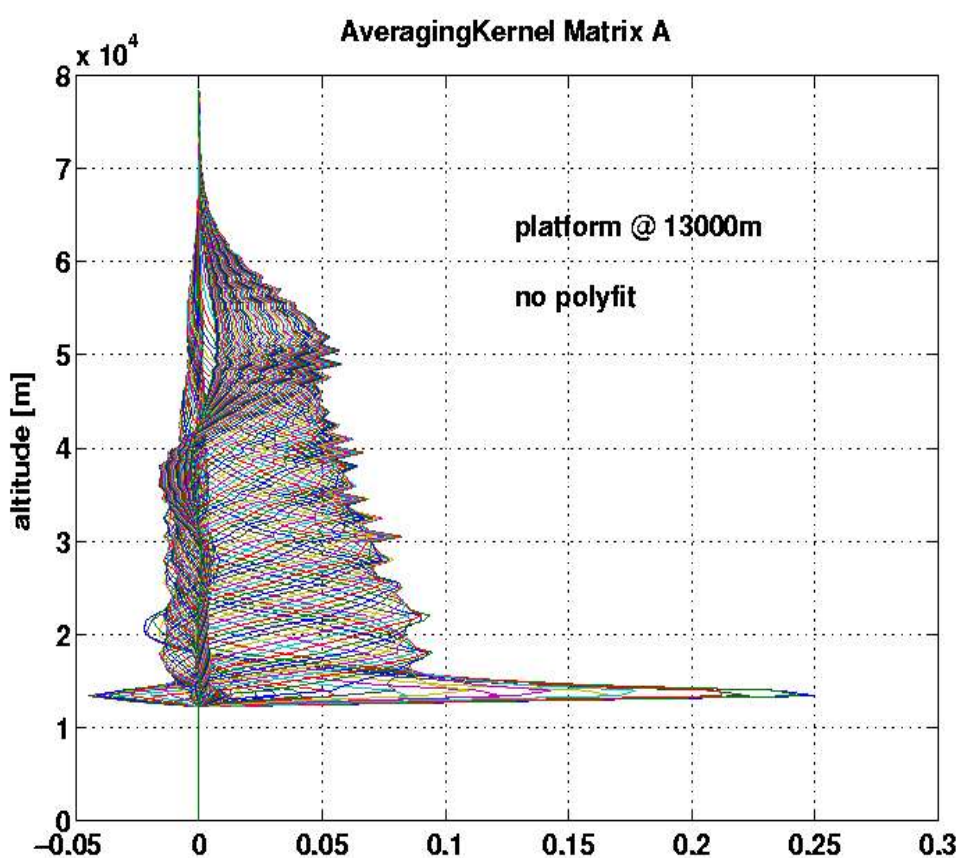
comparison of setup at 22GHz

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uses a polynomfit of the spectrum

Averaging Kernel from Qpack

Simulation platform 10km
polynomfit of spectrum

Averaging kernel from Qpack

Simulation platform 10km
no polynomfit of spectrum

simulation around hygropause

comparison to numerical calculation

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K_x from Arts

$$K_x{}' = \lim_{\Delta x \to 0} \frac{F(x + \Delta x) - F(x)}{\Delta x}$$

Kernel Kx

Numerical Kernel Kx

Using Arts as Forward Model
Varying a profile by $\Delta x = 1e{-}12$
at each gridpoint
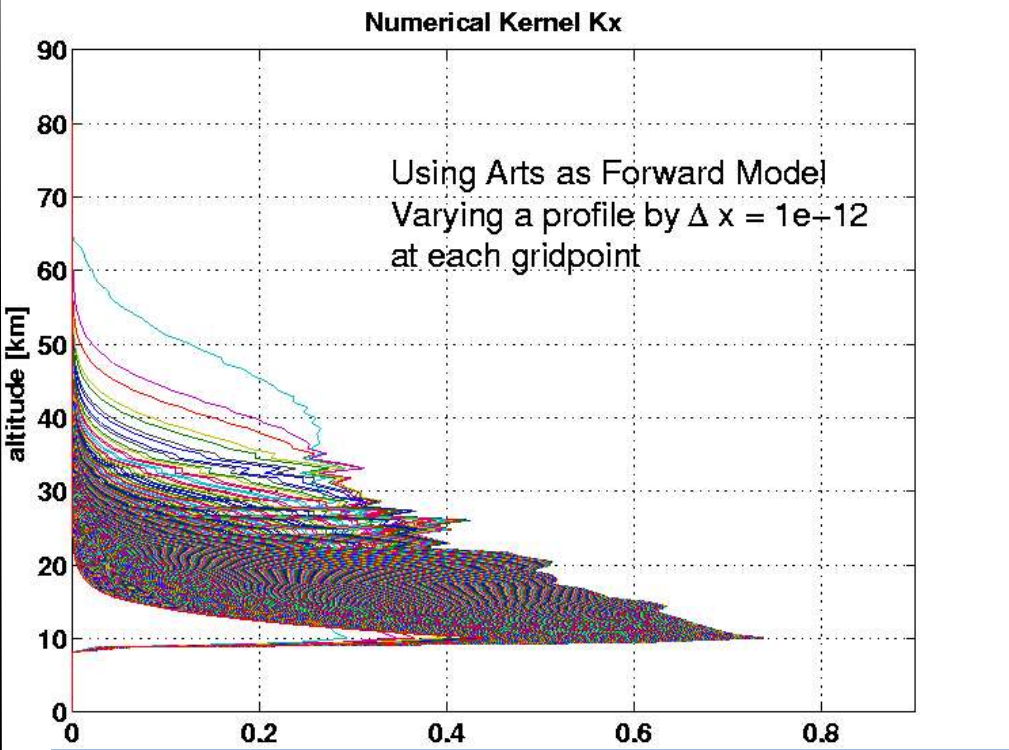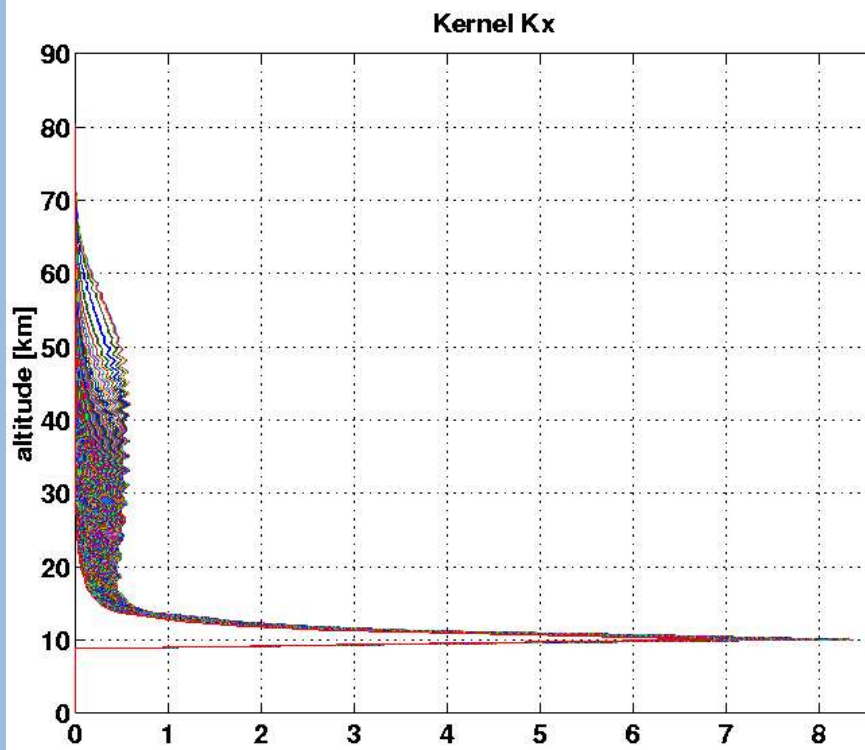
averaging kernel with numerical Kx'

$$\Rightarrow \mathbf{A'} = \mathbf{Dy} \cdot \mathbf{Kx'}$$

Averaging kernel = Dy*numericalKernel

Simulation
polynomfit of spectrum

Kx calculated numerically

altitude [km]
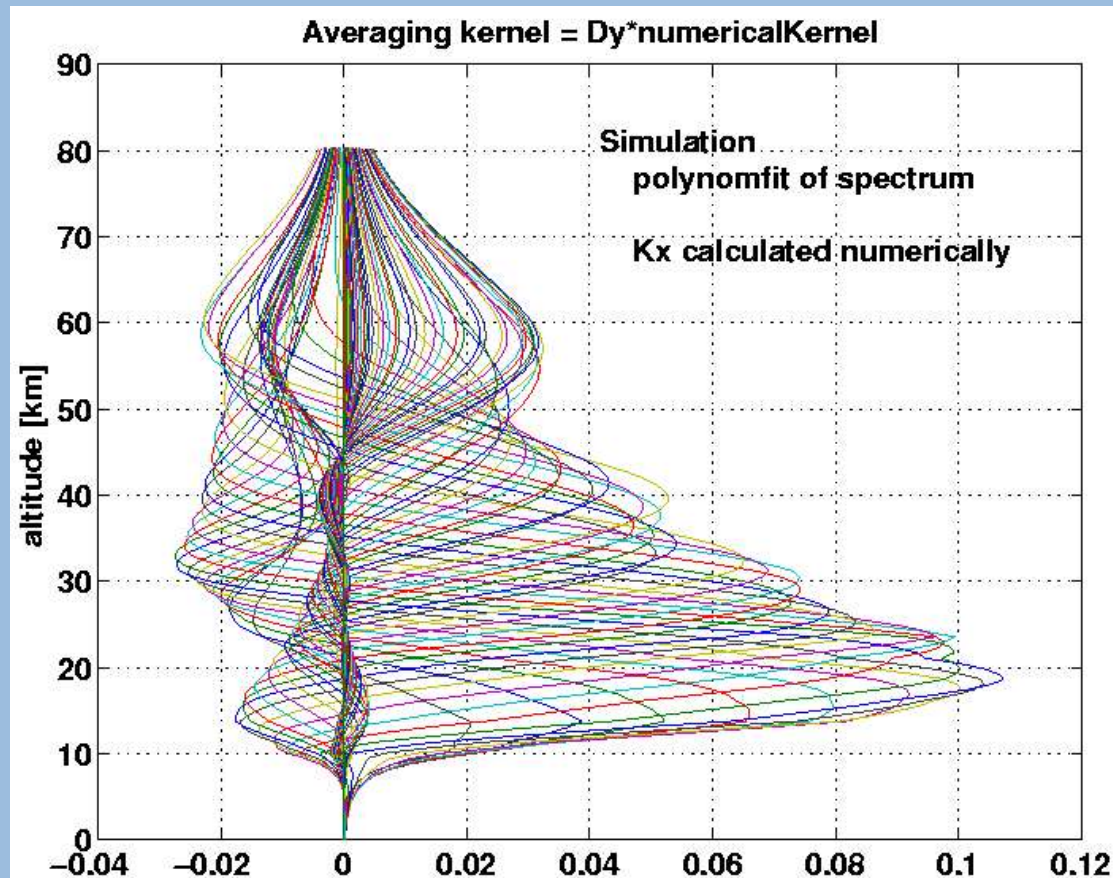
summary

unwanted peaks in the matrix **A**

simulations showed us:

- the peaks are coming from the matrix K_x

- line strength has no effects

- the peaks disappears when being above hygropause

numerical calculation of $\mathbf{K_x}$ does not show the peaks