SFIT4 – kB matrix calculation

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KB matrix calculation

Error calculation

Recall

Forward model and its derivative

$$\begin{aligned} y &= F(x) + \epsilon \\ K_{g,b} &= \frac{\partial F}{\partial x_{g,b}} \end{aligned}$$

The contribution function matrix is used to calculate the state from the spectrum $x = Dy$. The averaging kernel $A = DK$ provides a mappint from the original state to the retrieved state: $\hat{x} = x_A + DK(x - x_A)$. The complete error analysis for the retrieval is (compare Rodgers,2000)

$$\begin{aligned} \hat{x} - x &= (A - I)(x - x_A) && \text{Smoothing error} \\ &+ D_y \epsilon && \text{Retrieval noise} \\ &+ D_y \Delta F(x, b, \hat{b}) && \text{Forward model error} \\ &+ D_y K_b (b - \hat{b}) && \text{model parameter error} \end{aligned}$$

Model parameter error

The parameter x_b consist of two groups:

1. Parameters retrieved along with the atmospheric state x_g, e.g. interfering gases, instrumental parameters like slope or wavenumber shift.
2. Parameters which are not retrieved, but need to be used like FOV, MAX_OPD, temperature profile

The parameters in group 2 have errors and this are accounted for in the parameter error. In order to calculate them, we need the K_b matrix for the parameters which are not retrieved:

$$K_b = \frac{F}{\partial b}$$

They are calculated iin SFIT4 as the KB matrix. It is switched on in the sfit4.ctl file as
kb = T

KB matrix calculation

- The subkeys of kb can be chosen to specify for which parameters error matrices are calculated.
- Some parameters can also be retrieved, e.g. rt.curvature for the curvature of the transmission function.
- Parameters which are retrieved but also specified in kb are only retrieved, no *KB* entry is calculated for them. e.g.

  ...
  rt.slope = T
  kb.slope = T
  ...
  no kb entry for the slope is calculated.

KB matrix calculation

For some parameters it does not make sens to retrieve errors, either they are neglegable or they are better retrieve.

kb.dwshift dwshift shifts all lines of all gases except the retrieval gas. The line position error is taken care of in kb.line

fw.wshift this is usually retrieved and thus contributes to the interference error.

kb.max_opd the error for this is usually negligible. Because max_opd should be known to a very high accuracy. NOTE: Might be different for low resolution spectra.

KB matrix calculation

Error for apod and phase function

- If fw.apodisation_fcn and/or fw.phase_fcn are calculated as polynomial or fourier series (not retrieved!) the parameters are used to calculate the error matrix.
- if fw.apodisation_fcn or fw.phase_fcn is set FALSE, in the error calculation a three order polynomial is assumed and used to estimate the KB for the ILS