The editor comments are in plain text while the author response is in bold and blue.

The new text still gives no hints how to come from the radiative transfer equation to essentially different Jacobians. This is what I would like to see. Simply repeating text from earlier papers of co-authors does not help.

Meanwhile I found a paper: Chen, Y., Y. Han, P. Van Delst, and F. Weng (2010), On water vapor Jacobian in fast radiative transfer model, J. Geophys. Res., 115, D12303, doi:10.1029/2009JD013379 from where I could get an impression of how the Jacobians come up out of the radiative transfer equation. Something like this should at least be quoted for the interested reader. Probably the authors know even more basic derivations. These papers or books could and should be cited.

We are strongly interested to clarify this point – as we were in our previous response. It seems to us that we still need to clarify a misunderstanding – either we do not fully understand what is requested from us or the use of Jacobians within the set-up of the retrieval and within evaluation has not been made clear enough.

Eyre (1987) introduced the usefulness of Jacobians for the inversion of satellite observations into atmospheric state parameters. He started his considerations by mathematically describing how the observed signal depends on the atmospheric state. A basic inversion element is the Jacobian (K in Eyre, 1987). Jacobians are needed to understand the observed signal and are not an integral element of the radiative transfer equation. The latter is also evident from Eyre (1987) as he computes the Jacobians by applying a radiative transfer model to perturb HIRS and MSU observations (section 4). The direction is important: the logic line goes from the satellite to the atmospheric state with the help of Jacobians which are computed by applying a radiative transfer model. The line is not that the Jacobians are derived from radiative transfer equations and then used in the inverse problem. In other words, the radiative transfer equations can be solved with the help of a radiative transfer model. In most cases this will already be an approximation to the full complexity of radiative transfer. A special case is the tangent linear model. This model has a different perspective – it computes the signal at the satellite by applying Jacobians to the atmospheric state – that is, the contribution from individual parameters to the overall signal at satellite (In our case, it makes sense to use relative humidity Jacobians because the signal depends on the average RH – see Soden and Bretherton, 1996). If this is inverted the atmospheric state can be retrieved. The problem is that Jacobians depend on the atmospheric state and are not known a priori – they need to be computed/modelled from specific models, not from radiative transfer equations.

In Chen et al. (2010) Jacobians are defined as the "radiance derivatives with respect to the input-state-variables". Thus, Jacobians are derived from radiative transfer simulations and are not needed to compute radiative transfer. Chen et al. (2010) extend the application area data assimilation systems and further say: "While the radiative transfer forward model simulates satellite-observed radiances, the K-matrix model (Jacobian model) computes radiance derivatives with respect to the input-state variables." and is not used to compute radiances.

In Chen et al. (2010) the LBL model was used to assess the quality of various transmittance models with the goal to improve computations of Jacobians and fast RT calculations. It is important to

understand that the LBL model does not rely on Jacobians in order to compute radiances. Instead, Chen et al. (2010) discusses which of the three transmittance models leads to maximum improvement of fast radiative transfer simulations and Jacobians relative to LBL results. The transmittance model is needed to enable fast radiative transfer simulations and the radiances and the Jacobians are output of the model and used to assess the quality of the transmittance model.

We use the RTTOV (model A in Chen et al., 2010) to allow a fast computation of BT. The K-matrix model of RTTOV provides the Jacobians. Jacobians are essential output of radiative transfer models as used in data assimilation schemes and to design retrievals.

We do not use Jacobians to compute BT but to integrate the RH humidity profiles from ECMWF and from ARSA for retrieval set-up and evaluation. We define the Jacobian as d(BT)/d(RH) which is a consequence of the results shown by Soden and Bretherton (1996): the observed signal is proportional to an average RH over the upper troposphere.

The different weighting functions have been introduced by three different groups. Our reference is one out of three references.

The manuscript already states that the Jacobians are used for the vertical averaging operator <.> and for validation only. We change the manuscript as follows (the ACPD version is used to assign pages and lines):

P9614, l23, after last bullet: We added "Jacobians and their usefulness in deriving atmospheric state parameters from satellite observations are described in e.g., Eyre (1987)."

P9614, l23: "adapted operator"->"adapted averaging operator"

P9618, l10: Changed into "standard Jacobians, among them d(BT)/d(q) where q is the volume mixing ratio. d(BT)/d(q) is converted to J_RH by computing es d(BT)/d(q) where es is the saturation vapour pressure. J_RH is used to integrate the ARSA observations". And we also added: "Note that the results of Chen et al. (2010) who assessed three different transmittance models through their impact on simulated radiances and on Jacobians can be interpreted as follows: RTTOV can benefit from improvements to the transmittance model for the computation of Jacobians in cold and dry atmospheric conditions."

Unfortunately my question regarding the sentence "The estimated total uncertainty is the square root of the sum of the three variances and in this case is around 16–19% at one sigma" in section 5 has not been understood. I simply want to know to which quantity this sigma refers. This should be added ("... where sigma is the standard deviation of the prabability density function of xxx").

We changed the text into: "with a coverage probability of 68%." This way we indirectly assume that the uncertainty contributions follow a Gaussian PDF.

New references:

Chen, Y., Han, Y., Van Delst, P. and Weng, F.: On water vapor Jacobian in fast radiative transfer model, J. Geophys. Res., 115, D12303, doi:10.1029/2009JD013379, 2010.

Eyre, J.: On systematic errors in satellite sounding products and their climatological mean values. Q. J. R. Meteorol. Soc., 113, 279-292, 1987.