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## Reply on RC1

Johann Stamm et al.

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Author comment on "A technique for volumetric incoherent scatter radar analysis" by  
Johann Stamm et al., Ann. Geophys. Discuss.,  
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Thank you for the valuable feedback

The model in the article does not consider time variations in other ways than that the neutral wind is assumed to vary slowly. There could be cases where a feature in electric field or neutral wind moves with a velocity large enough to be inside several voxels within one loop of transmit beams. For example the auroral arc could move over the field of view over this time. The electric field changes would then appear blurred in the output data.

Including a time component that considers changes in the measured plasma within one integration time into the model would be possible. It could be implemented similar to the dependency on the volume.

Another way of handling rapid time-variations could be to shorten the integration time. The price to pay for avoiding motion-blurring this way is increased uncertainties. One could then apply a Kalman filter to the time domain. This is outside the scope of this study.

For Figure 11, we removed three beams completely to see how missing beams effect estimates and uncertainties. This could also be interpreted as an extreme valley in electron density. The result was that these are little affected. We expect that the technique could be applied in cases where faster scan times are used with beams in more sparse pointing directions leading to slightly larger uncertainties.

We will add to our manuscript a discussion of this topic:

The presented framework assumes that the ionosphere does not change faster than the integration time, which is 70 s for the presented example. Spatial and temporal variations occurring faster than the integration time will thus be blurred out. One way to mitigate this is to take into account in which direction the beam points at every point in time such that the model connects the time the measurement is taken to the results. Another possible mitigation procedure, is to use a shorter integration time. The latter will have increased uncertainty which may be compensated to some extent by a Kalman filter. A third option would be to use fewer beams as this needs shorter integration time. The regularization will then try to fill the gaps as best as possible as illustrated in the example above.

In general we can state that an improved time-resolution requires measurements in fewer

pointing-directions, that is either covering a smaller volume with a compact set of beams or a more sparse set of beams covering a large volume.