**Referee #1:**

1. Introduction:
There is also an operational water vapour product from SCIAMACHY on ENVISAT available which should be mentioned. Since MERIS is on the same platform, a comparison (outside the scope of this paper) would probably be interesting.
*Yes, it would be worth to look at it, especially at the effect of fractional cloudiness in the large SCIAMACHY foot prints.*

2. Section 3: There is also an operational MERIS TCWV product. Is this based on the same algorithm as described in the present paper? Please clarify and specify potential differences.
*The operational MERIS TCWV product is based on the same measurement principle but is implemented as an Artificial Neural Network, not providing error estimates. Besides, the operational product does not account for the temperature- and pressure-dependency of the water vapour absorption lines, causing biases in cases of elevated surfaces or extreme temperature profiles.*

3. p. 6817, l. 12/13: Where is the solar incoming irradiance Ei taken from? Please provide a reference.
*The solar irradiance is taken from Thuillier, G., M. Herse, P. C. Simon, D. Labs, H. Mandel, D. Gillotay, and T. Foujols (2003). The solar spectral irradiance from 200 to 2400 nm as measured by the SOLSPEC spectrometer from the ATLAS 1-2-3 and EURECA missions. Sol. Phys.,* ***214:*** *1-22.*

4. p. 6818, l. 8-10: 'the transmittance is calculated for the four look-up table grid points closest to the actual surface pressure and temperature of the considered scene': How is the actual surface pressure and temperature derived, or is it taken from an external data set? Please clarify.
*The surface pressure is derived from converting land elevation to pressure, a digital elevation model is provided in MERIS L1b files. The surface temperature is extracted from NWP reanalyses, such as ERA Interim or the Global Forecast System. Will be added in the text.*

5. p. 6818, l. 11/12: 'The final transmittances of MERIS bands 14 and 15 are then calculated as a weighted average': Please explain which weights are used.
*A linear interpolation among the four closest grid points in temperature and pressure space is performed.* $T=w_{11}*T_{11} + w_{12}*T_{12} + w_{21}*T_{22} + w_{22}*T_{22.}$, *with* $w_{ij}$ *determined by the distance to the temperature grid point i and pressure grid point j, and* $total(w_{ij})=1$.

6. p. 6818, l. 24/25: 'The albedo retrieval over land can thus be performed using climatological mean values in case there is no additional information available.': Does this mean that it is possible to use climatological albedo data over land, or does it mean that other climatological data are used to determine the albedo? Have climatological data been used in the context of this study? If yes, which data? Please clarify.
*A climatological average value of the aerosol optical depth is used for the retrieval of the surface albedo, i.e.* $aot_{900nm} = 0.15$.

7. p. 6820, l. 11/12: The bias of 10—30% in TCWV mentioned in the text seems to be somewhat too high compared to Fig. 1. Does this mean that the bias is larger for other viewing geometries?
*The bias is a function of the viewing geometry, but you were right, the numbers in the text are too large and will be corrected.*

8. p. 6823, l. 8: Where is the NDVI taken from? Please provide a reference.
*The NDVI is calculated as NDVI = (ref860 - ref660) / (ref860 + ref660). We use the NDVI to estimate the uncertainty of the linear albedo extrapolation. NDVI can be calculated differently, but the above resulted in the clearest connection between NDVI and the error of the linear extrapolation.*

9. p. 6823, l. 19-23: Please give typical numbers for the overall uncertainties of the retrieved TCWV.
   *The uncertainty is mainly driven by the surface albedo. Therefore, the calculated uncertainty is below 5% over bright surfaces and can easily exceed 50% in the worst case (dry air over dark ocean).*

10. Section 4: After spatial averaging measurements were rejected which contain too few 'valid' MERIS data. What is the definition of 'valid'? Why is the filter criterium different for the different comparisons (e.g. 20% for Aeronet, 30% for SSM/I, 25% for MWR).
    *This is a valid objection. The validation section will be revised and the filter criteria will be homogenized.*

11. p. 6825, l. 16/17: 'The filtered subset was additionally screened for high aerosol loadings, undetected clouds and outliers, deviating by more than 3$\sigma$.': Please clarify: Is additional (external?) cloud/aerosol information used to identify cloud contamination or high aerosol loading, or is only the 3$\sigma$ criterium used?
    *See above.*

12. p. 6825, l. 20: Please provide a reference for the dry bias of the Aeronet measurements.
    *This is not a citation but a result of the validation study. The fact that the bias between MERIS and Aeronet is clearly larger than for all the other validation sources hints at a possible dry bias of Aeronet (not a proof though). The sentence will be rephrased correspondingly.*

13. p. 6826, l. 9: Please provide a reference for the GUAN radiosonde uncertainty.
    *E.g. Miloshevich, Larry M., Ari Paukkunen, Holger Vömel, Samuel J. Oltmans, 2004: Development and Validation of a Time-Lag Correction for Vaisala Radiosonde Humidity Measurements. J. Atmos. Oceanic Technol., **21**, 1305-1327.*

14. p. 6827, l. 13/14: 'A relatively large portion of points, sitting in the lower right part of the plot,...': This probably refers to the lower left part of the plot. Please confirm.
    *Yes, we meant those points in the lower left part, exhibiting a dry bias of MERIS for dry cases, due to undetected clouds in winter.*

15. Section 4.2.1: There are several SSM/I data sets and versions, please specify which one has been used and provide a reference.
    *We used the algorithm based on*
    *Phalippou, L., 1996: Variational retrieval of humidity profile, wind speed and cloud liquid water path with the SSM/I: Potential for numerical weather prediction, Q. J. R. Meteor. Soc., **122**, 327-355.*
    *and*
    *Deblonde, G.: NWP SAF User's Guide: Standalone 1D-var scheme for the SSM/I, SSMIS and AMSU, NWPSAF-MO-UD-001 Version 1.0, 2001.*

16. p. 6831, l. 8/9: 'Note that all shown configurations result in a wet bias of MERIS, except for setup 4' It seems from Fig. 8 that also setup 3 (2* continuum) does not result in a wet bias. Please explain.
    *Sorry, mistake in the text.*

**Referee #2:**

1. On line 145 the authors state that the radiance ratio differs from the transmittance due to the influence of the surface reflectance and atmospheric scattering. Are the authors assuming that the water vapor transmittance in channel 14 is 1.? Otherwise you cannot obtain the water vapor transmittance from the radiance ratio.
   *We don´t assume a transmittance of 1 for channel 14, instead we calculate it in the same way as for channel 15. However, the transmittance at 885nm is very close to 1, so from our point of view it is still justified to use the term water vapor transmittance. However, we will rephrase the sentence and include the fact that channel 14 is affected by water vapor absorption as well.*

2. Please explain what you mean on line 164 by “ adjusting the tabulated optical depths”. This seems somewhat backwards. I would think you would start with TCWV and calculate ODs. You appear to have pre-calculated ODs and are adjusting them to match the TCWV.
*We have calculated the gaseous optical depth $\tau_{i0}$ in a quasi-monochromatic spectral bin i for a fixed TCWV-value ($wv_0$). The corresponding gaseous optical depth for a different TCWV-value $wv_1$ is simply $\tau_{i1} = \tau_{i0} * wv_1/wv_0$. So, the text is somewhat mistakable and will be rephrased.*

3. I am going to summarize my understanding of the forward model. The authors should use this to determine where the gaps in their explanation are. Again, a flow chart would be very helpful. a. Ab initio a look-up table of optical depths is built using model X (which model)? b. This look-up table is indexed by pressure and temperature (and TCWV?) c. The estimated transmittance ratio is calculated (from the first guess described in section 3.2). d. This transmittance ratio is corrected for differences in spectral surface reflectance (should have equation here). e. Scattering correction is applied.
*This is very close. TCWV is not a dimension of the look-up table, see answer above. We used the HITRAN-2008 database and applied an advanced k-distribution technique, assuming a Voigt line shape.*
*We will include a flow chart and try to be more precise in the text.*

4. Where do the surface temperature and pressure come from?
*The surface pressure is derived from converting land elevation to pressure, a digital elevation model is provided in MERIS L1b files. The surface temperature is extracted from NWP reanalyses, such as ERA Interim or the Global Forecast System. Will be added in the text*

5. On line 176: how well correlated are the temperature profiles with the surface temperature? Please add a line or two to justify this statement, as the temperature profile has a significant impact on the retrieval of any species.
*The temperature profile effect is not quite as significant, we will add a figure to prove that it is sufficient to use the surface temperature (which is only moderately well correlated with the actual profile).*

6. On line 185, define $\alpha$.
*$\alpha$ is the surface albedo.*

7. On line 249: comment on the impact of the uncertainty in f on TCWV.
*If the uncertainty in f is large, the uncertainty of TCWV is large as well and the uncertainty of f is large when the surface reflectivity is low. Over bright surfaces, f only weakly depends on the unknown aerosol type, optical thickness and vertical distribution. Over a dark surface, there is a strong connection between f and these parameters. That´s why the uncertainty is large over the dark ocean and tiny over a bright desert surface.*

8. Provide a reference for the statement on line 328.
*This is just a short summary of the following validation section.*

9. Reference for bias in the Aeronet sun photometer measurements
*See above (response to referee #1, question 12)*

10. Reference for SSM/I TCWV accuracy.
*Within the ESA DUE GlobVapour project a rmse of 1.5mm and a bias of -0.5mm against MWR measurements at the Nauru ARM site were found (M.Stengel, DWD, personal communication).*

11. Is there an inconsistency on line 471? On line 242 the authors state that over ocean the surface reflectance is calculated with Cox and Munk.
*We use Cox and Munk to estimate the ocean surface reflectance but for the generation of the scattering correction look up tables it was not used. This is a possible source of the observed bias over ocean, although the error should be rather small over reasonably bright*

*areas (close to sun glint maximum). The channel ratio over a bright surface does hardly differ from the ratio over a VERY bright surface.*

12. Does MERIS do TCWV retrievals with sun glint or not? Please make this clear.
    *Yes, with the above mentioned limitation.*

13. Line 510, if LBLRTM is used to calculate the optical depths in the forward model state this in the FM section.
    *We used different models to test the effect on the retrieval bias, this will be made clear.*

14. Figure 8 is very interesting. The authors should show the perfect fit with MWR measurements they get with setup 4. However, setup 4 is unrealistic, as it is well known that the line wings are sub-Lorentzian; a better test would be to scale the continuum by a smaller factor than 2.0.
    *We will show the fit and specify the factor resulting in the best fit. However, it is important to keep in mind that spectroscopy is just one approach to explain the bias.*

**O´Dell:**

1. How much of the error comes from the temperature profile assumption? My colleague here found that globally, you could break down temperature profiles in terms of just 2 or 3 eigenvectors. You could redo your method for those eigenvectors, and sum them using a simple analysis to figure out how much of each eigenvector goes into a given temperature profile, which you could get from any met analysis (if you don't mind the lag time).
   *Yes, this is something to look at, although now out of scope for this paper. By the way, we found the same (3 eigenvectors do a good job). Maybe we could push the limits a little bit.*

2. What if you didn't fit versus R, but kept y = (L14, L15) ?
   *We can´t see how this could improve the retrieval performance. The parameter we are aiming at is the water vapour column, the channel ratio shows a strong sensitivity to it. For y = (L14, L15 ), part of the effort would be wasted for the retrieval of surface reflectance.*

3. P.6826: one of your main factors determining precision is surface albedo, and SGP is pretty bright, right? So it is certainly very precise over *bright* land, but maybe not as accurate over dark land?
   *Yes, this is certainly true, and we will state this clearly in the text.*

4. Error bar validation.
   *The validation of error bars is pretty ambitious and it strongly depends on the quality of the validation data. MWR seems to be accurate enough, but it is all at the same location, so we don´t see much variability in the uncertainty. Radiosondes and Aeronet sun photometers have an uncertainty of their own that seem to preclude such a study. We will look at GPS. By visual inspection, the uncertainty seems to be reasonable (inverse function of surface reflectance).*