

## ***Interactive comment on* “Evaluation of the hydrological cycle of MATCH driven by NCEP reanalysis data: comparison with GOME water vapor field measurements” by R. Lang and M. G. Lawrence**

### **Anonymous Referee #2**

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#### General comments:

This paper evaluates the water vapor and precipitation fields as simulated in the MATCH chemical transport model in comparison with several independent observational data sets. In addition, the paper proposes the 3-year data set of clear-sky column water vapor retrievals from the GOME instrument as a tool for evaluated model simulated water vapor fields. The evaluation of model physics that influence the hydrological cycle, and the contribution of an additional column water vapor data set, are

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useful additions to the literature. This paper should be published in ACP following revisions. I find no need for substantive changes to the analysis presented in the paper, however I recommend a restructuring of the paper with careful editing for clarity, and I raise a couple of issues regarding the evaluation of model physics parameterizations.

Specific comments:

The paper is quite lengthy and many parts of the paper are verbose. The authors are encouraged to seek out text that does not contribute to the main point of the paper and consider removing it. The authors are also encouraged to restructure the paper, perhaps such that the figures and discussion regarding each major finding of the paper appear together and in one clearly labeled section of the paper. I had to read the paper over several times before I had a clear sense of what were the key findings of the analysis and what were the less important technical points.

It is not clear to me that there is a need for section 7. For example, the first half of section 7.1 addresses the differences between GOME water vapor and NVAP water vapor over central S. America and Africa. These differences are mentioned twice in section 6.1 (p.7937,l.2 and p.7938,l.10-14). Why not simply include the full discussion of this issue once in section 6.1? Especially since this seems to be a technical issue related to the GOME retrieval and not particularly important to the issue of representing the global hydrological cycle in MATCH.

The discussion contained in the first paragraph of section 7.3 (starting p.7947,l.17) needs to be clarified. The various comparisons between MATCH, NRA, GPCP and GOME get muddled up quite a bit and I had to reread this several times before I felt I had it figured out. The main point from this section seems to be that in regions dominated by deep convection, MATCH underestimates water vapor content and water vapor residence time, while overestimating the precipitation rate. This is an important conclusion from the paper and the case for this needs to be explained clearly in one place in the paper.

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Another important point that gets lost in the confusing structure of this paper is that in some cases errors in water vapor or precipitation may be consistent in both MATCH and NRA, and therefore are likely a result of an element common to the two models. The authors frequently implicate the evaporation rate. On the other hand, in some cases errors are not consistent in MATCH and NRA, and the errors in MATCH are likely to be associated with the MATCH cloud and convection parameterizations. I think the authors are arguing that these errors are generally consistent with a more vigorous conversion of vapor to rain in MATCH in regions of deep convection. However, I spent quite some time flipping back and forth between sections 6, 7 and 8 attempting to confirm that this interpretation is correct and that the regional analyses discussed are largely consistent with this interpretation. I am not sure I succeeded, and I am still confused as to how robust this conclusion is. Again, this point needs to be clearly explained in one place in the paper.

Are the authors able to rule out the possibility that common water vapor content errors at regional spatial scales in MATCH and NRA may be caused by errors in water vapor transport, rather than errors in evapotranspiration? For example, in the case of continental Europe, I would suspect that precipitation significantly exceeds evaporation (perhaps you can check this in the NRA). This would suggest that there is a net flux of water vapor into the region. Perhaps this transport is overestimated in MATCH and NRA? p.7947,l.7-9

The authors argue that regional differences between MATCH and NRA precipitation rate and water vapor residence time reveal problems related to the microphysics, such as autoconversion and the evaporation of precipitation (p.7947,l.9; p.7948,l.1-3; p.7948,l.28 thru p.7949,l.1; p.7953,l.9-14). I think there may be more fundamental issues, such as water vapor transport and convective closure, that cannot be ruled out. The fraction of rain in most regions of deep convection that results from evaporation within 1000km of the region is less than 20% (Trenberth, Climate Change, 39, p.667, 1998). Thus the moisture made available to a storm for precipitation is largely con-

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trolled by convergence of moisture at very large scales (relative to rain clouds). In the absence of a trend in water vapor or cloud water content, precipitation must balance that regional convergence of moisture (and the 20% contributed by the regional-scale evaporation rate). Also, in the Zhang convection scheme any CAPE generated by a build up of heat or moisture at low levels (or decreases in the upper troposphere) will be balanced by convection with the excess moisture precipitating out. The formulation of this closure determines the rate at which convection responds the dynamical convergence of moisture. Could regional differences in MATCH and NRA precipitation be a result of differences in the formulation of this convective closure?

Finally, these issues suggest a limitation to usefulness of interpreting regional water vapor residence times (such as those under the 'Europe' and 'Indian Ocean' headings in Table 2, and discussed p.7946,1.5-10). If less than 20% of the precipitation is locally evaporated, then you cannot really say with much certainty how long the remaining 80% of the water vapor in that region has been in the vapor form. I think the quantities should remain in the paper, but this caveat should be addressed.

Technical corrections:

P.7925,1.3: 'criterium' should be 'criterion'.

p.7941,1.19-22: MATCH rain rates are lower along the ITCZ than in the GPCP observations. How is this consistent with the conclusions discussed above regarding the overestimate of the conversion rate of vapor to precipitation and the corresponding underestimate of water vapor residence time for regions dominated by deep convection?

p.7946,1.18: Replace 'observations than MATCH' with 'observations as MATCH'.

p.7946,1.19: Replace 'along the ITCZ but also' with 'along the ITCZ and also'. Same sentence: replace 'masses, Canada' with 'masses, for example Canada'.

The sentence, p.7946,1.15-20 concludes that the precipitation errors over Northern Hemisphere continents are similar in MATCH and NRA. This is directly contradicted

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in the regional analysis of Europe discussed p.7947,l.23-25.

p.7947,l.10-15: I cannot find a specific discussion in section 4 regarding the contribution of evaporation errors to precipitation errors. In light of my arguments above regarding moisture transport and convection. Can the authors clarify why evaporation errors are particularly important?

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