

Review of “Source apportionment of atmospheric water over East Asia – a source tracer study in CAM5.1” for *Geoscientific Model Development*.

Summary:

This paper describes the implementation of a new Atmospheric Water Tracer (AWT) scheme in the NCAR Community Atmosphere Model Version 5.1 (CAM5.1). This new feature is then used to examine the sources of precipitation and water vapor for the Yangtze River Valley, Southern China, and the South China Sea. It is found that the North Atlantic, Northwest Pacific, and Northern Indian Ocean are the dominant moisture sources for the three regions, along with evaporation from Asia itself. In particular, it is found that the Indian ocean-based moisture sources tended to be largest in summer, during the monsoons, while the Pacific was the largest source during the rest of the year.

Recommendation:

The application of atmospheric water tracers to the Southeast Asian region is certainly interesting, and can provide new insights into the hydrological cycle and processes of this important region. However, there is potentially one major flaw in the implementation of the water tracers in CAM5.1 that must be addressed before it is fully accepted, as well as a few other concerns that are listed in the next few sections. Thus I am recommending **major revisions** for this article. Once these issues have been dealt with, then I believe the paper will be ready for publication.

Major issues:

1. This is not an issue in terms of the science presented here, but it is important to note that water tracers already exist in CAM5, up through CAM5.3, and is at least partially described here:

<http://onlinelibrary.wiley.com/doi/10.1002/2016MS000649/full>

Thus although this does not take away from the science results presented here, it might be more beneficial if this work was presented in a less model-development focused journal, as these particular developments have already been done for this same model.

2. If am understanding your description of the water tracer implementation correctly, then the way you are treating the water tag tendencies from deep convection is sadly not valid, and will cause mass conservation issues which could put into question the scientific results shown here. The reason is because the convective tendency is partly generated by the transport of water vapor in the vertical, which may not have the same water tracer ratio as the level at which you are calculating the tendency. Thus this change in the ratio will result in the implicit addition or removal of water mass. For example, one component of the deep convective vapor tendency is:

$$\frac{\partial q_v}{\partial t} = \frac{\partial}{\partial z} (M_u q_u)$$

Using your formulation, the resulting tag equation would be:

$$\frac{\partial q_{v,tg}^k}{\partial t} = R \frac{\partial q_v}{\partial t} = R \left(\frac{\partial}{\partial z} (M_u q_u) \right), \quad R = \frac{q_{v,tg}^k}{\sum_{k=1}^n q_{v,tg}^k}$$

Discretizing the vertical derivative results in something akin to:

$$\frac{\partial q_{v,tg}^k}{\partial t} = R \left(\frac{(M_{z_2} q_{z_2} - M_{z_1} q_{z_1})}{z_2 - z_1} \right) = \frac{(M_{z_2} R q_{z_2} - M_{z_1} R q_{z_1})}{z_2 - z_1}$$

Which shows that the only way your formulation can work is if the water tag ratios were exactly the same for both vertical levels on which the deep convection is being applied, which is almost certainly not true. Otherwise, the assumed ratio will be different than the actual water tag ratio, and thus result in a mass conservation error.

The only way to eliminate this problem is to have the water tracer tendency calculated in the exact same way as regular water, e.g.:

$$\frac{\partial q_{v,tg}^k}{\partial t} = E_{tg}^k - C_{tg}^k - \frac{1}{\rho} \frac{\partial}{\partial z} (M_u q_{u,tg}^k + M_d q_{d,tg}^k - M_c q_{v,tg}^k)$$

where the phase changes are calculated using the ratio method you described:

$$C_{tg}^k = \left(\frac{q_{v,tg}^k}{\sum_{k=1}^n q_{v,tg}^k} \right) C$$

If this is how you are actually doing it, then I would recommend just re-wording this section. However, if this is an issue, then I must recommend you either modify your existing algorithms to fix this issue, or simply re-do your experiments with the already existing water tracer implementation present in CAM5. Finally, I should note that the reason this error may not be showing up in your supplemental error figures is because you are examining the sum of all your water tags, and not the individual tags themselves (and thus allowing mass conservation errors of different signs to cancel each other out).

Minor issues:

1. On line 27, I would avoid stating that water vapour is the most important component of the atmosphere, as that is probably just one's opinion. Instead maybe say something like "water vapour is one of the most important components of the atmosphere".
2. It is unclear to me how you are calculating the water tracer vapor tendency produced by the shallow convection, as most of the description focuses solely on the condensate. Could you add a sentence or two describing the shallow convection's water tracer vapor tendency? Also, if it is implemented in the same way as the deep convection, then the major issue described above will also need to be dealt with for the shallow convection as well.
3. In Section 2.7, it is stated that the sum of all tagged water tendencies should be equal to the tendency of the standard water model substance. However, it is unclear what occurs if this rule is

violated. In particular, if this requirement is not met, what is done to the individual water tracers themselves in order to ensure that the summed tendencies are brought back to the value of the standard water tendency?

4. One line 537, I would replace “(colours, unit: 1)” with “(colours, unit: ratio of tagged precip over total precip)”, or at least something that is more descriptive than just the number one. I would do the same for the “unit: 1” reference in Figure 5 as well.
5. I would describe what the vectors are in the caption of Figure 3 as is done in the main text.
6. In Figure 5b, it is difficult to tell which pink contour corresponds to the “0.2” amount, as the label overlaps multiple contour lines. If possible, can you shift the label over such that it is more clear which contour line it is referring to? Possibly making the label smaller might also help in this situation as well.
7. It might be good to include some sort of legend for Figures 6, 7, and 8 that re-states which water tag each color corresponds to. This will help lessen the reader’s need to constantly go back to Figure 1 to determine what water tag each color represents.

Grammatical issues:

1. Need to make sure that when you have list of three or more objects in a sentence, that commas are used like so:

x, y, and z

Instead, you often times have:

x, y and z

This makes it seem that y and z are together as one idea, when in reality they are separate. So, just make sure to have a comma before the “and” whenever a list is involved.

2. On lines 81 and 82, replace “isotope data not only reflect the water cycle” with “isotope data reflects more than just the water cycle”. The reason being that “not only” is a conjunction I believe, and so the phrase would need a “,but” at the end, as in “not only x, but also y”.
3. On line 82, I would replace “and that sensitivity” with just “and sensitivity”.
4. On lines 97 and 99, replace “Neal” with “Neale”.
5. On line 222, I would replace “sum MMRs” with “summed MMRs”.
6. On line 241, I would replace “compared with” with “compared to”.
7. On line 266, I would replace “over the North Africa” with just “over North Africa”.
8. On line 366, I would replace “NAO” with “North Atlantic Ocean”, as none of the other regional acronyms are used in this particular sentence.

9. On line 390, I would replace “over few regions” with “over a few regions”. It might also be beneficial to spell out NAM instead of using the acronym here, although that is probably just personal preference.