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The Residence Time of Water in the Atmosphere Revisited

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This paper revisits the knowledge on the residence time of water in the atmosphere. Based on state-of-the-art data of the hydrological cycle we derive a global average residence time of 8.9±0.4 days (uncertainty given as one standard deviation). We use two different atmospheric moisture tracking models (WAM-2layers and 3D-Trajectories) to obtain atmospheric residence time characteristics in time and space. The tracking models estimate the global average residence time to be around 8.5 days based on ERA-Interim data. We conclude that the statement of a recent study that the global average residence time of water in the atmosphere is 4–5 days, is not correct.

We derive spatial maps of residence time, attributed to evaporation and precipitation, and age of atmospheric water, showing that there are different ways of looking at temporal characteristics of atmospheric water. Longer evaporation residence times often indicate larger distances towards areas of high precipitation. From our analysis we find that the residence time over the ocean is about 2 days lower than over land.

It can be seen that in winter, the age of atmospheric moisture tends to be much lower than in summer. On the Northern Hemisphere, due to the contrast in ocean-to-land temperature and associated evaporation rates, the age of atmospheric moisture increases following atmospheric moisture flow inland in winter, and decreases in summer.

Looking at the probability density functions of atmospheric residence time for precipitation and evaporation we find long-tailed distributions with the median around 5 days.

Overall, our research confirms the 8–10 days traditional estimate for the global mean residence time of atmospheric water, and our research contributes to a more complete view on the characteristics of the turnover of water in the atmosphere in time and space.

In the light of this session, our results show that the turnover of water is relatively fast, but water travels quite far, which explains why it is so hard to make both weather and hydrological predictions on time spans longer than a week.