P2.5 RADIATIVE IMPACT OF CLOUDS AND WATER VAPOR VARIATIONS ABOVE 300 MB FROM LONG-TERM NVAP AND ISCCP OBSERVATIONS

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The NASA Water Vapor Data set now includes an estimate of water vapor above 300 mb. Similarly the International Cloud Climatology Project and other cloud climatology estimates high-level clouds at those levels in the atmosphere. Using the day-to-day and month-to-month fluctuations in these fields we have estimated the radiative impact of these fluctuations around the mean climate situation. We see that changes in cloud properties dominate the radiative impact of water vapor on cloudy days. But that significant radiation changes occur on clear days due to water vapor changes. Ultimately this paper addresses the questions for cloud and water vapor feedback in the Earth's climate system.

1. INTRODUCTION

Here we report on an analysis of the radiative heating profiles estimated with a typical radiation code initialized by water vapor and cloud properties. The improved NASA Water Vapor Data set, NVAP, (Randel, 1996) includes an estimate of water vapor above 300 mb as well as 3 lower levels in the atmosphere. The International Satellite Cloud Climatology Project, ISCCP, (Rossow and Gardner, 1993) provides cloud amounts and liquid or ice water path measurements overlapping in time with the NVAP data set. Our goal is to estimate the radiative impact of real changes in the atmosphere in the period of the satellite record during the last two decades.

To begin, we initialized the radiative transfer model (Stephens et al 2002) with monthly observations and then perturbed those by 10% to see the relative impact of the various constituents. Because the monthly means are not instantaneous observations, the resulting heating rates are at best representative of the real atmosphere, but here we are interested in the changes around the climatology, not the absolute values. We believe, however, that the relative change is representative of the likely change in the atmosphere if that change were to have occurred. These toy experiments will lead to a better understanding of the relative importance of each component of the atmosphere and their climate impact. As this study evolves, we will attempt to estimate profiles of radiative heating over the last 10 years.

2. RESULTS

By adding water vapor to the upper atmosphere below the tropopause, one would expect heating to occur below because the water vapor will increase the downward IR flux since it is warmer than space. In addition, it will cool the atmosphere above because it is colder than the atmosphere below. For our tests we calculated the heating rate profiles for average conditions and added 10% to the observed water vapor above 300 mb and recalculated the profile. Figure 1 is a super position of the difference of many heating profiles in a latitude band. Figure 2 shows that the infrared impact of the water is greatest in the stratosphere near the equator.

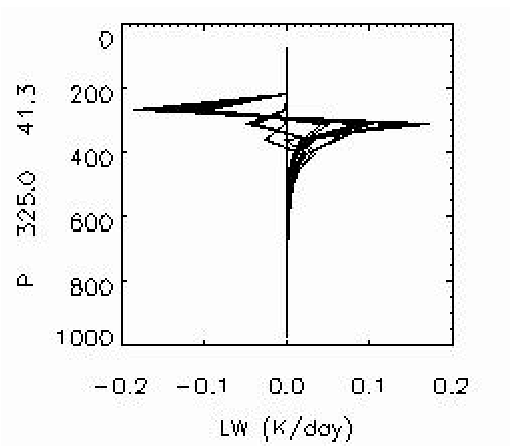

Figure 1 shows the Infra Red effects of adding 10% to the upper level water vapor. Many profile differences are superimposed at 41° North. This shows the expected result: cooling of the stratosphere and heating of the troposphere.

The interesting results come when cloud changes are compared to water vapor changes. ISCCP provides ice water path and mean pressure for cirrus clouds and liquid water path and pressure for stratus clouds. Again experiments were performed by calculating the heating profile with the mean conditions and then adding 10% to the water paths. Figure 3 shows both the infrared effects and short wave effects at noon in January. The short wave changes are comparable to the long wave changes at noon, but they are less if averaged over a diurnal cycle. At this time of year and at this latitude the changes would be comparable although the water vapor changes seem bigger.

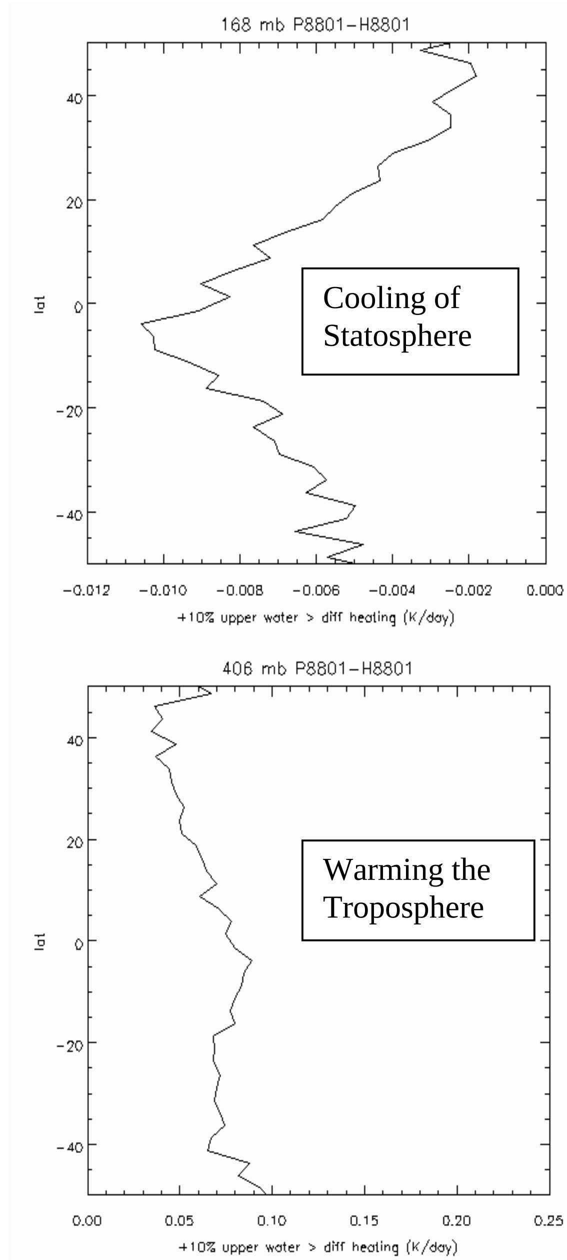

Figure 2 shows the zonal means at two different pressure levels. The results beyond 50 degrees are not accurate because there is very little vapor in the upper atmosphere.

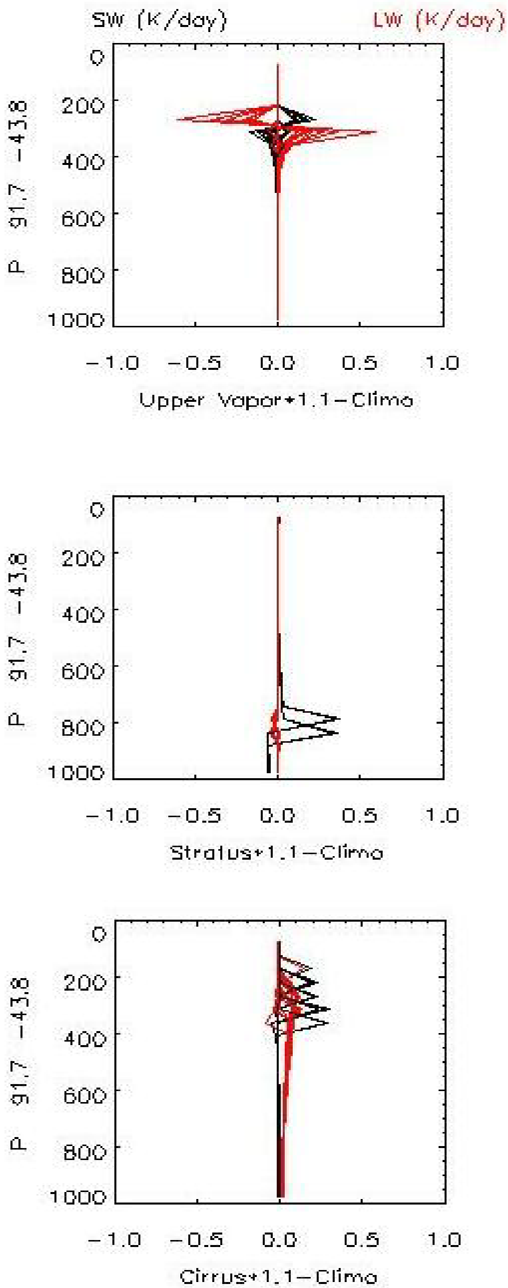

Figure 3 shows sample profiles with changes in water vapor, cirrus clouds and stratus clouds in the 43^o South latitude band. These show a super position of many profiles. For the short wave results there are the noontime variations for January sun position.

To get some summary of these effects, we average the **maximum** difference in each profile. Our interest here it to decide which component is more important in the heating profile. It looks like changes in cirrus have the biggest impacts in the infrared and the visible. Stratus has a significant impact in the visible because changes in water path change the albedo.

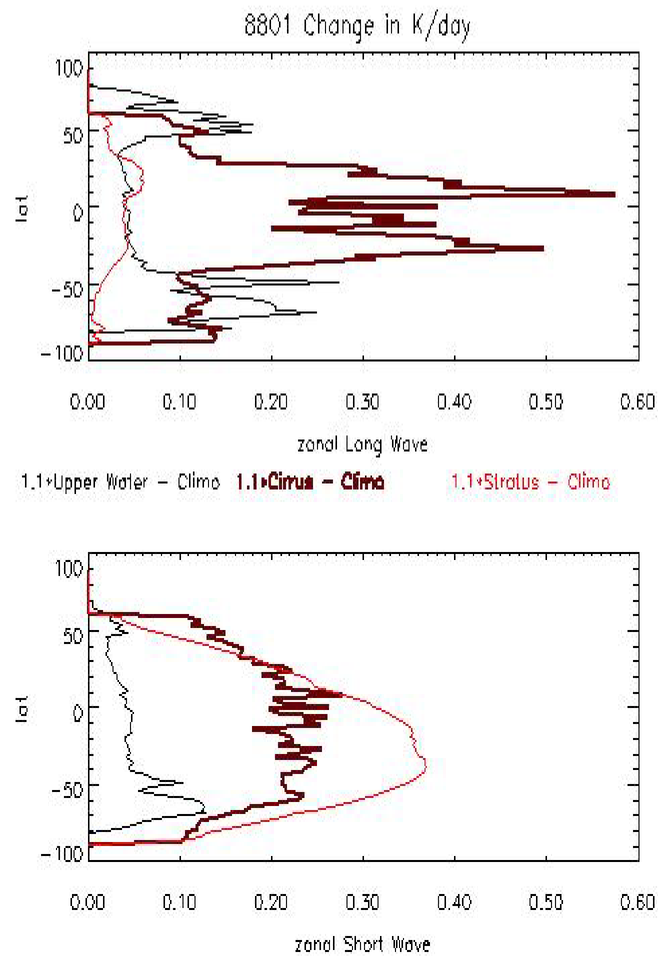

Figure 4 shows the zonal average of all the **maximum** differences. These are the average of the absolute values, so some deviations are negative.

Figure 5 shows the zonal average change at each pressure level and for each parameter. Although the shading is subtle, changes in the cirrus have an impact throughout the atmosphere whereas the water vapor and stratus changes are more local. In contrast Figure 6 factors in the cloud amount in each location the cirrus and stratus calculations. That reduces the impacts seen in figure 4 because the Earth is not covered by 100% cirrus or stratus. We have not yet run the diurnal cycle simulation to get the net effect, but it looks like the IR effects are dominating for the cirrus case.

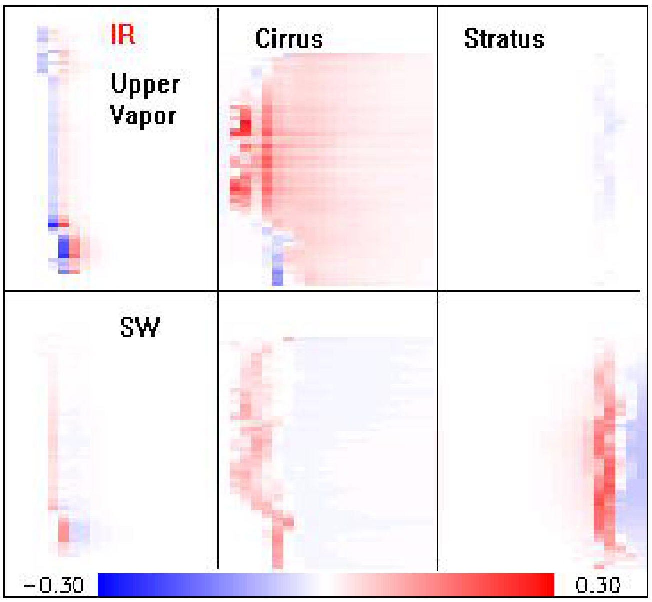

Figure 5: the zonal average change in heating (K/day) at different pressure levels and for the three components and short and long wave terms.

3. CONCLUSIONS

We started this research because of the startling conclusions of Lindzen et al (2001) who discussed observed water vapor changes. We have found that the effects of cloud changes are comparable in size to the water vapor effects especially for cirrus. Estimating water vapor feedbacks require detailed studies of the likely cloud changes as well as the water vapor changes.

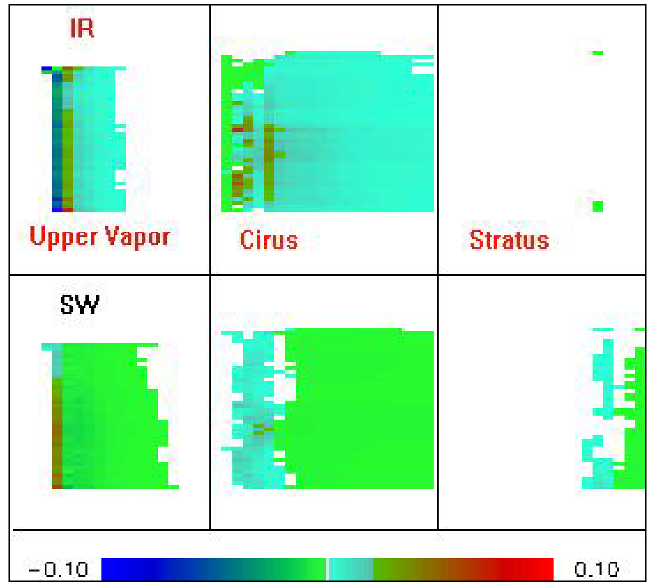

Figure 6: the zonal average change in heating (K/day) at different pressure levels and for the three components and short and long wave terms times the corresponding cloud amounts

4. ACKNOWLEDGEMENTS

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