A comparison of model short-range forecasts and the ARM Microbase data.

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CONTENTS

FIGURES

1. INTRODUCTION:

For the fourth quarter ARM metric we will make use of new liquid water data that has become available, and called the "Microbase" value added product (referred to as OBS, within the text) at three sites: the North Slope of Alaska (NSA), Tropical West Pacific (TWP) and the Southern Great Plains (SGP) and compare these observations to model forecast data. Two time periods will be analyzed March 2000 for the SGP and October 2004 for both TWP and NSA. The Microbase data have been averaged to 35 pressure levels (e.g., from 1000hPa to 100hPa at 25hPa increments) and time averaged to 3hourly data for direct comparison to our model output.

2. FORECASTS:

The Climate Change Prediction Programs (CCPP) and ARM Parameterization Testbed (CAPT) is a joint project of the U.S. Department of Energy's Office of Science/Biological and Energy Research (BER). We use analyses of global weather from numerical weather prediction (NWP) centers, in conjunction with field observations such as those provided by ARM, to evaluate parameterizations of sub-gridscale processes in global climate models. *Simply stated, we run realistically initialized climate models in forecast mode to determine their initial drift from the NWP analyses and/or from the available field data, thereby gaining insights on model parameterization deficiencies.*

The CAPT protocol, which is analagous to a common NWP approach for development of forecast models, is also potentially useful for diagnosing parameterization problems that may produce systematic model errors on climate time scales. The goal is to adapt this NWP-inspired technique to a degree sufficient for its practical application in the development cycles of climate models.

a. MODEL DATA:

Forecasts are initialized at 00UTC daily and run for approximately three days in length. After an initial time period of 12 hours, where the model comes to equilibrium with its new imposed conditions we sample these forecasts for the next 24 hours (e.g., hours 12-36 of the forecast), we then generate an appended time series of the model output and compare these results to robust high frequency (e.g., ARM) data. Results shown will be for two differing time periods. For the SGP we examine the time period "2000-03-01 15:00" through "2000-03-30 12:00" (N=232). For both the NSA and TWP we use the time period "2004-10-5 6:00" through "2004-10-22 9:00" (n=138). For our two time periods of interest, we use differing initializing data. For march 2000 (SGP) we use the European Centre for Medium Range Weather Forecasts ERA40 reanalyses data and for the October 2004 (NSA and TWP) we use the National Aeronautics and Space Administration-Data Assimilation Office (NASA-DAO) analyses. Within this work we compare results from the National Center for Atmospheric Research, CAM3.1 model and the Geophysical Fluid Dynamics Laboratory AM2 model. Model output is a nearest grid point value from the closest model grid point to the ARM station locations.

3. RESULTS:

a. Cloud Fraction

A time-height plot of cloud fraction is shown in figure 1 for the SGP. Time height plots for the NSA and TWP will not be given in order to emphasize the statistics derived from such two dimensional fields. An examination of this figure shows the Microbase data (Figure 1, top panel), to exhibit episodes of vertical cloud extent and low-lying clouds which are reasonably well represented in the CAM3 (Figure 1, middle panel) and AM2 (Figure 1, bottom panel) forecasts. Figure 2 is a three panel plot for the SGP where results for the CAM3 are in blue and AM2 are in Black. The top panel is the temporal correlation of cloud fraction between the Model and Microbase data, the middle plot is the Root Mean Square Error (RMS) between these two data and the bottom plot is the bias (as Model- OBS). The correlation reaches a maxima for the AM2 at approximately 860hPa (r=0.7) and the CAM3 at approximately 500hPa (r=0.53). Both models exhibit a diminishment of correlative value as they approach the surface and increase in height from their level of maxima value. For the RMS both Models exhibit a somewhat similar shape and magnitude. A peak of RMS can be seen in the region 960hPa to 700hPa and again near 300hPa. The Bias shows both Models having too little cloud fraction near 800hPa. Figure 3 shows these same plots but for the NSA. The correlation (top panel) for AM2 exhibits a large maximum near the surface and 400hPa (r=0.7). CAM3 shows a maxima of correlation near the surface (r=0.6) and another of lesser magnitude near 500hPa (r=0.4). The RMS Shows both Models having similar maxima near 800hPa with values of 0.7. The bias (bottom panel) shows both Models having too much cloud fraction near the surface and too little near 800hPa. In Figure 4 we show the same three panels but for the TWP. The correlation between the Microbase and Model data shows the AM2 (black line) having nearly zero to slightly negative values through the entire modeled atmosphere. The CAM3 (blue line) shows a slightly positive correlation from the surface to approximately 400hPa (r=0.2) and above that level becomes negative (r=-0.2). The RMS for AM2 seems somewhat vertically fixed at a value near 0.28 and the CAM3 maximizes in RMS near 200hPa with a value of 0.75. The bias shows both AM2 and CAM3 having nearly the right amount of clouds in the lower levels but CAM3 has too many near200hPa.

A plot of Integrated cloud fraction for all three sites can be seen in Figure 5. The top panel is for the SGP (March 2000, N=232), the middle for NSA (October,2004, N=138) and bottom for TWP (October 2004, N=138). In all three plots black is the Microbase data, blue is the CAM3 and red is the AM2 data. Subsequent statistics discussed with the text are derived form such two dimensional fields. For the integrated cloud amount at the SGP we derive a correlation of 0.55 and 0.37 for the AM2 and CAM3 respectively. The RMS is 0.39 and 0.47 for the AM2 and CAM3. The bias is -0.06 for AM2 and -0.147 for CAM3. For the NSA we find a correlation of r=0.14 for the AM2 and r=-0.18 for the CAM3. The RMS is 0.42 for AM2 and 0.52 for CAM3. The bias is 0.03 for AM2 and -0.23 for CAM3. For the TWP we find a correlation of 0.20 for AM2 and -0.28 for CAM3, the RMS is 0.42 and 0.67 for AM2 and CAM3 respectively. The bias is -0.22 for AM2 and 0.53 for CAM3.

b. Liquid Water Concentration

Figure 6 shows the gridbox average Liquid Water Concentration (LWC) at the SGP (as log10(gm/m3)) for the Microbase data (top panel) CAM3 (middle panel) and AM2 (bottom panel). It can be seen from this figure that the models do a reasonable job of capturing the temporal variations and vertical structure of LWC at the SGP. Statistics that follow are derived from such two dimensional fields. Figure 7 is a three panel plot with correlation at the top, RMS in the middle and Bias on the bottom for LWC at the SGP. For the SGP CAM3 (blue line) maximizes in correlation near 600hPa with values near r=0.4 and falls to negative values near the surface and TOA. For AM2 (black line) its correlation values maximize near 800hPa and have values near r=0.3. The RMS for each model mimics each other quite closely with maxima near 860hPa and values of 0.25gm/m3. The bias shows both models having too little liquid in the lower atmosphere. Figure 8 shows these same plots but for the NSA. The correlation between the Microbase and Model output shown (top panel) shows a wide range of values that varies significantly by model level and individual model. The RMS are small in numerical value with peaks near the surface. The bias shows both models having too little liquid water content in the lower atmosphere and the CAM3 having slightly too much in the middle atmosphere. Figure 9 shows the same plots but for the TWP. The correlations for both models with the Microbase data are small in value. The CAM3 maximizes with a correlation value of value of r=0.3. The RMS values for each model lie in the lower atmosphere right on top of each other, with values in excess of 0.4 gm/m3 at 840hPa. The bias shows both models having too little LWC in the lower atmosphere

Figure 10 shows the vertically integrated LWC in gm/m2 for the SGP (top panel, March 2000), NSA (middle panel, October 2004) and TWP (bottom panel, October 2004). Microbase data are in black, AM2 is red and CAM3 is blue. Statistics derived in the text are gathered from such data. For the SGP we find a correlation of r=0.39 for AM2 and r=0.45 for CAM3. The RMS is 431.1 gm/m2 for AM2 and 406.3 gm/m2 for CAM3. The bias are -79.4 gm/m2 for AM2 and -129.1 gm/m2 for CAM3. For the NSA we find a correlation of r=0.00 for the AM2 and a value of r=-0.24 for CAM3. The RMS are 109.4 gm/m2 for AM2 and 184.7 for CAM3 gm/m2. The bias is found to be -53.8 for AM2 and 59.1 for CAM3. For the TWP we find correlations of r=-0.11 for AM2 and r=0.18 for CAM3. The RMS is found to be 648.8 gm/m2 for AM2 and 613.8 gm/m2 for CAM3. The bias is -190.5 gm/m2 for AM2 and -102.4 gm/m2 for CAM3.

c. Ice Water Concentration

Figure 11 shows the gridbox average Ice Water Concentration (IWC) at the SGP (as log10(gm/m3)) for the Microbase data (top panel) CAM3 (middle panel) and AM2 (bottom panel). In this figure one can see the reasonable simulation of the vertical extent and temporal variation of IWC at the SGP. Statistics that follow are derived from such two dimensional fields. Figure 12 is the a three panel plot with correlation at the top, RMS in the middle and Bias on the bottom for IWC at the SGP. For the SGP CAM3 (blue line) maximizes in correlation near 500hPa with values near r=0.33 and falls to near zero correlation at the surface and TOA. For AM2 (black line) its correlation values maximize near 600hPa and have values near r=0.35. The RMS show the AM2 having maximum values (of 0.075 gm/m3) near 700hPa and CAM3 having its maximum RMS near 500hPa with values of 0.05gm/m3. Bias values are nearly the same for both CAM3 and AM2. In figure 13 (top panel) the NSA exhibits for both models large correlations near the surface, lesser values near 800hPa and larger values in the mid-tropsphere. The AM2 maximizing at r=0.6 at 400hPa. The RMS for both models exhibits similar shapes and magnitudes with maxima at 840hPa. The bias at the NSA shows both models to have too little IWC near 900hPa. In figure 14 we find the IWC correlation to be small at the TWP. AM2 maximizes with values of r=0.28 at 600hPa and CAM3 with r=0.12 at 420hPa. RMS for both models are nearly the same with maximum values of 0.05 gm/m3 at 400hPa. Bias values for both models are small and show the Microbase to have slightly more IWC than the models can simulate.

Figure 15 shows the vertically integrated IWC in gm/m2 for the SGP (top panel, March 2000), NSA (middle panel, October 2004) and TWP (bottom panel, October 2004). Microbase data are in black, AM2 is red and CAM3 is blue. Statistics derived in the text are gathered from such data. For the SGP we find a correlation of r=0.24 for the AM2 and a value of r=0.45 for the CAM3. The RMS is 262.4 gm/m2 for AM2 and 168.5 gm/m2 for CAM3. The bias is -4.5 gm/m2 for AM2 and -46 gm/m2 for CAM3. For the NSA we find correlations of r=-0.20 for AM2 and r=-0.29 for CAM3 and the RMS is 145.4 gm/m2 for AM2 and 75.1 gm/m2 for CAM3. Bias at NSA is found to be -2.5 gm/m2 for AM2 and -29.1 gm/m2 for CAM3. At the TWP we find correlations of r=-0.06 for AM2 and r=0.14 for

CAM3. RMS values are 248.5 gm/m2 for AM2 and 242.2 gm/m2 for CAM3. The bias are found to be -94.6 gm/m2 for AM2 and -66.6 gm/m2 for CAM3.

We have successfully compared the model forecast data to the new ARM "Microbase" data, which fulfills the fourth quarter metric. Results show that there is good agreement in both the time height as well as integrated quantities for the SGP and reasonable agreement at the NSA. However the TWP site shows significantly lesser agreement for both time height and integrated quantities examined herein.

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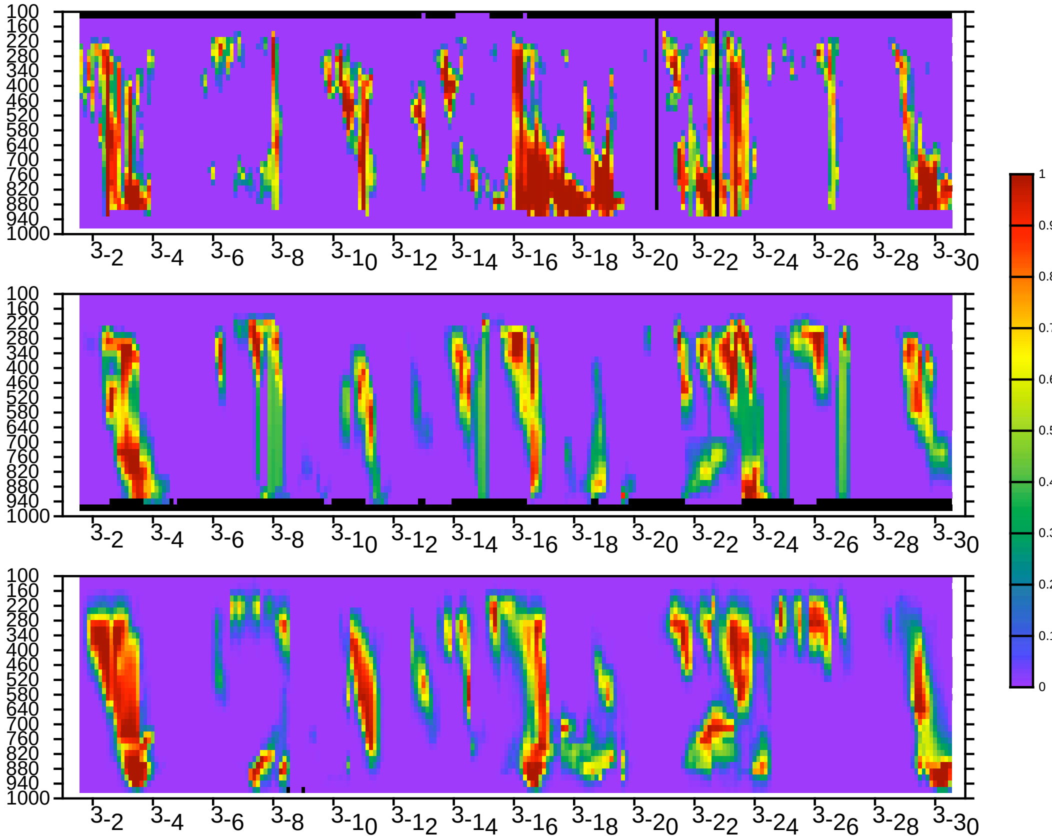

Figure 1. A two dimensional plot of the cloud fraction at the SGP (N=232), Microbase (top), CAM3 (middle) and AM2 (bottom).

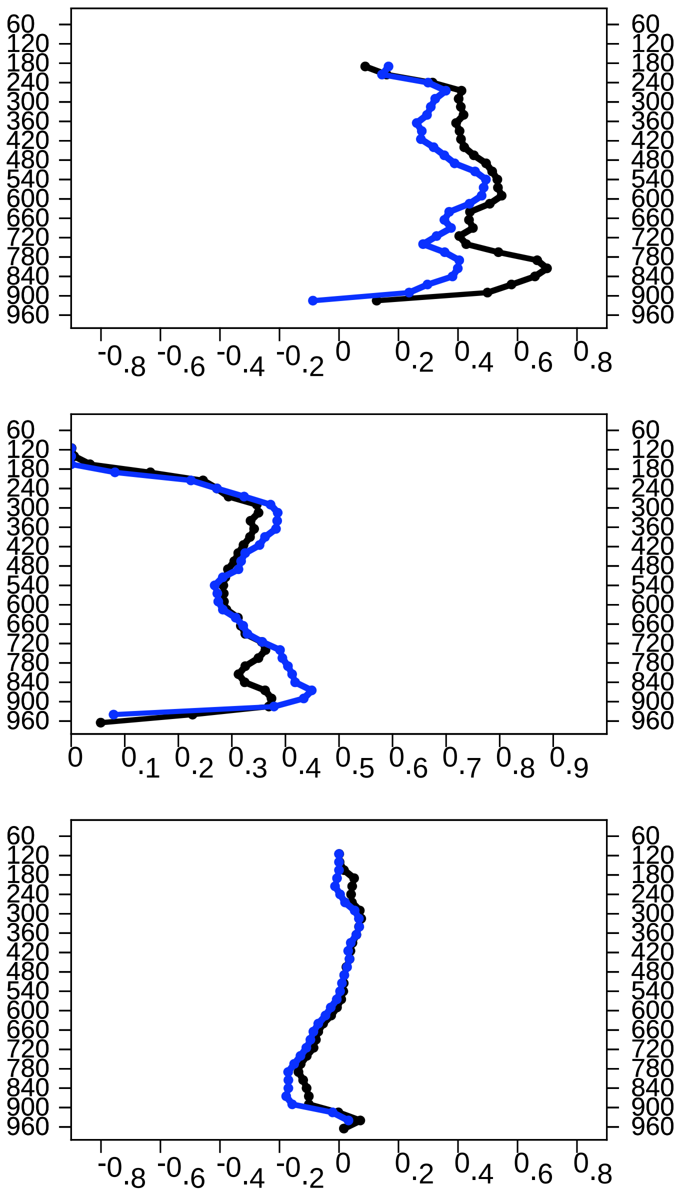

Figure 2. Comparisons of cloud fraction at the SGP. (CAM3=Blue and AM2=Black). Correlation (top), RMS (middle) Bias (bottom).

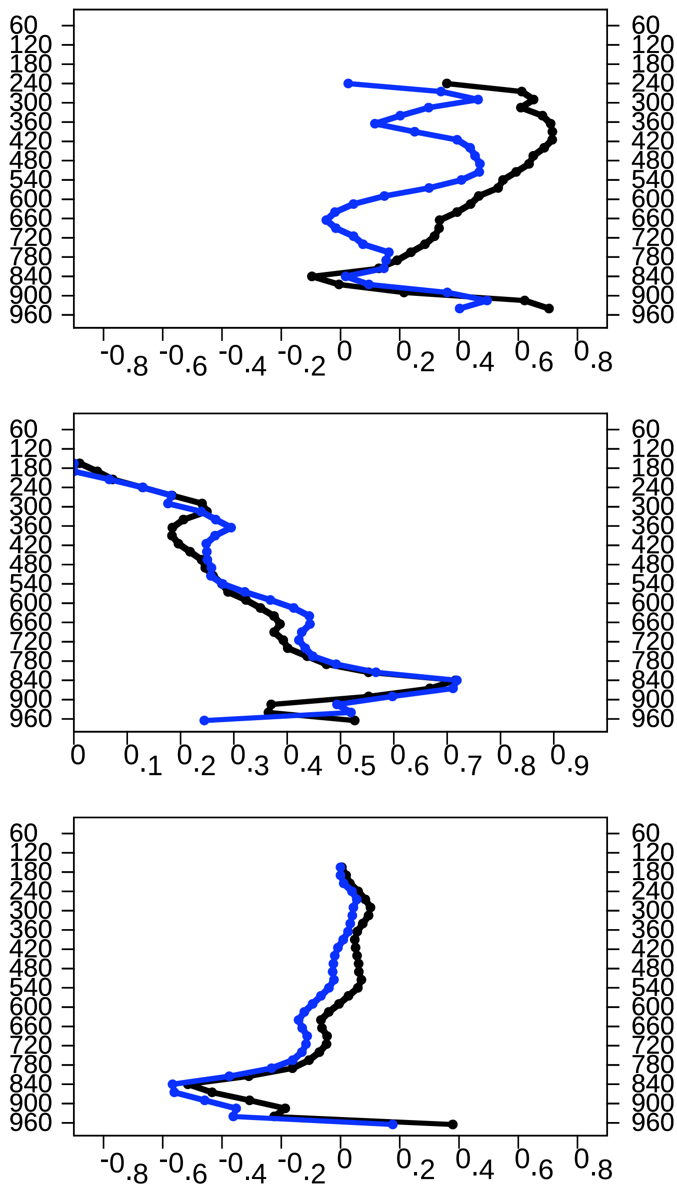

Figure 3. Comparisons of cloud fraction at the NSA. (CAM3=Blue and AM2=Black). Correlation (top), RMS (middle) Bias (bottom).

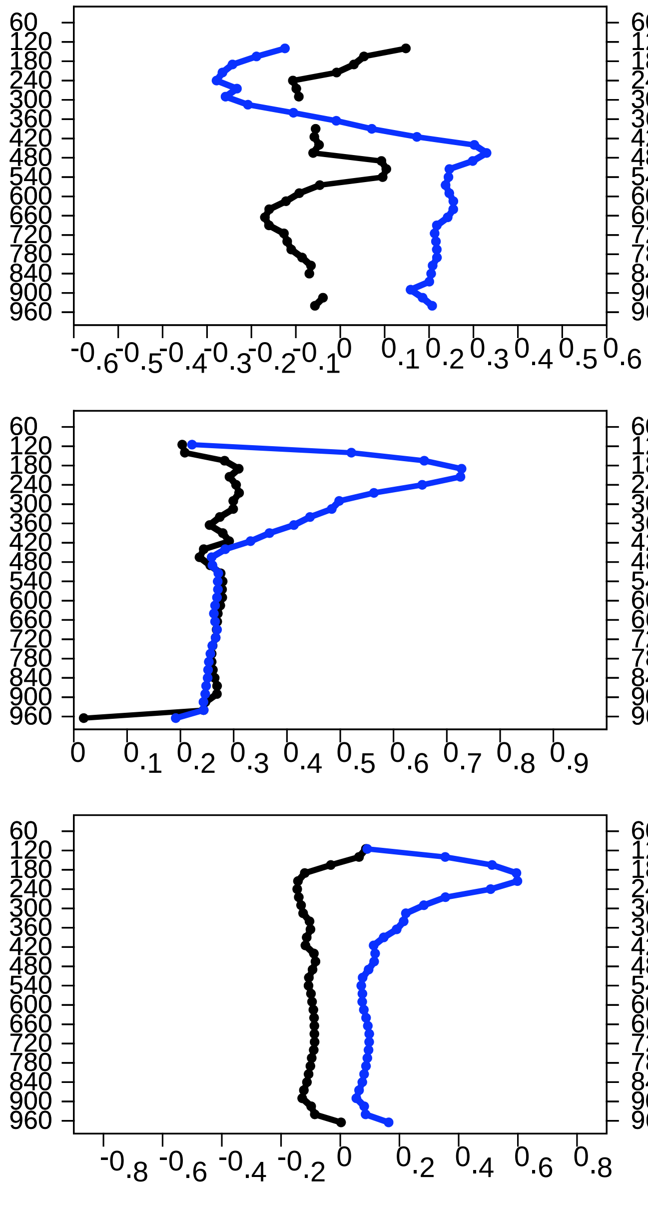

Figure 4. Comparisons of cloud fraction at the TWP. (CAM3=Blue and AM2=Black). Correlation (top), RMS (middle) Bias (bottom).

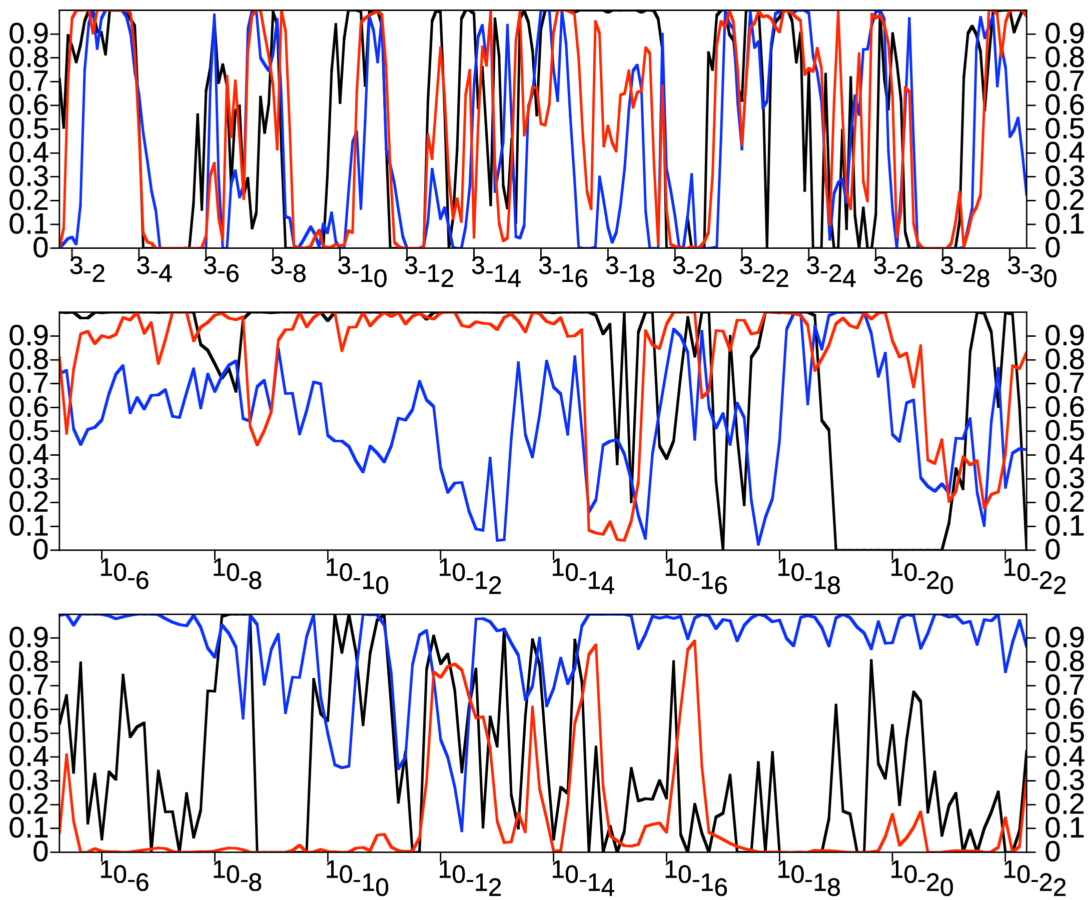

Figure 5. Time series of vertically integrated cloud fraction at the SGP (top, March 2000), NSA (middle, October 2004) and TWP (bottom, October 2004). Microbase=black, CAM3=blue AM2= red

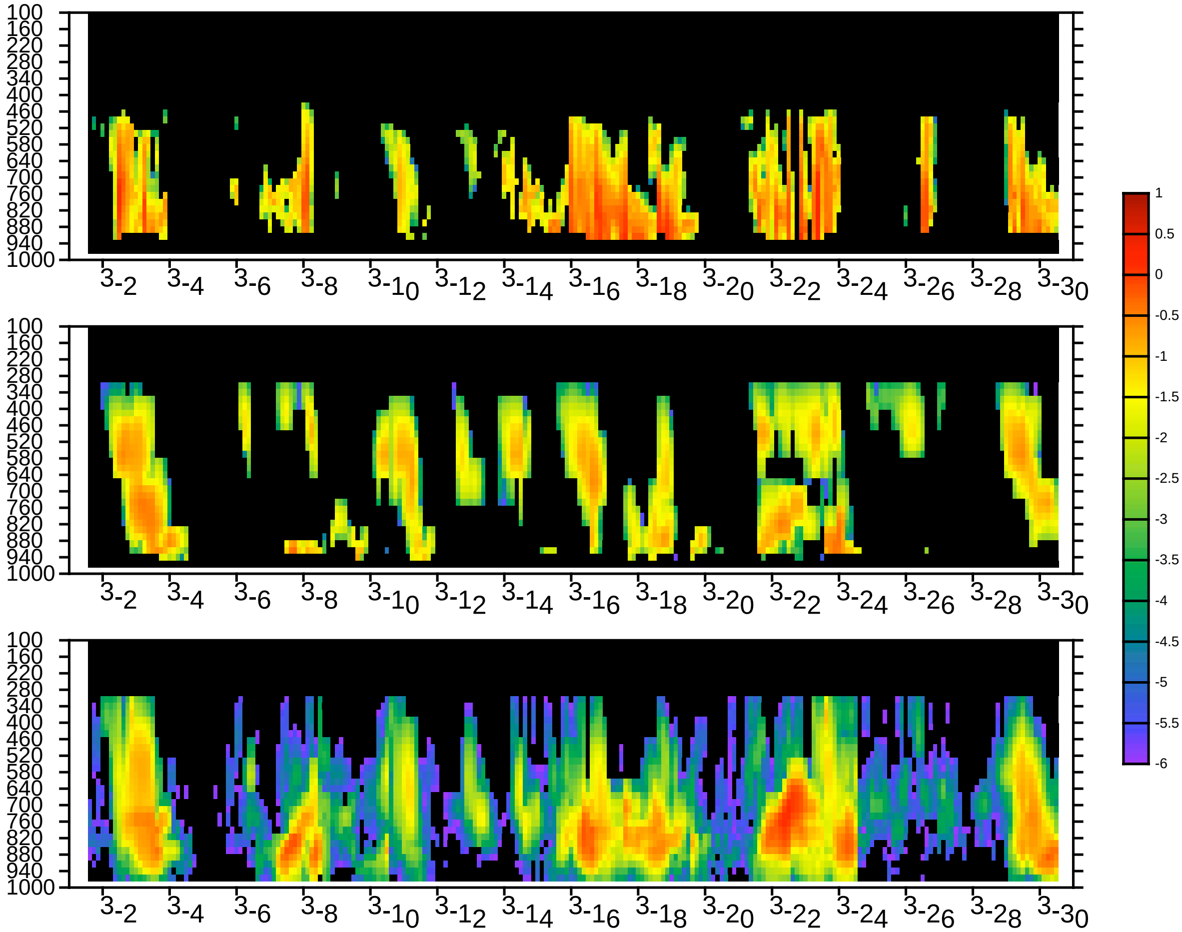

Figure 6. Time height plot of LWC (as log10(gm/m3)) at the SGP. Top is the Microbase data, middle is CAM3 and bottom is AM2.

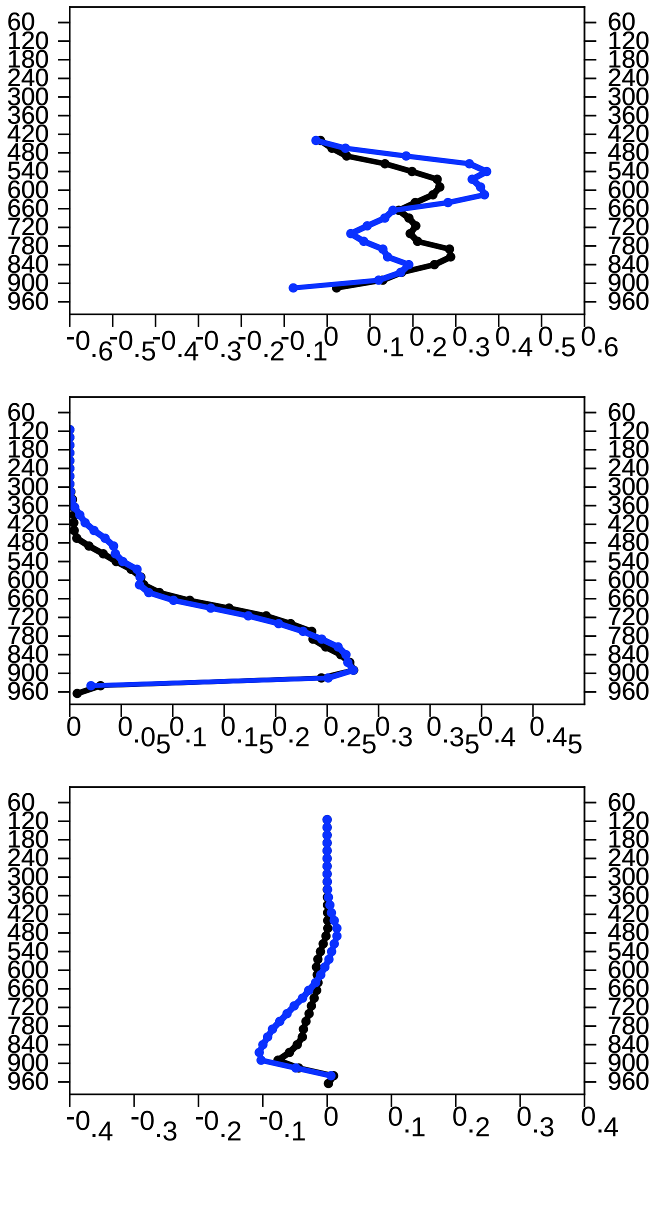

Figure 7. Comparisons of LWC (gm/m3) at the SGP. (CAM3=Blue and AM2=Black). Correlation (top), RMS (middle) Bias (bottom).

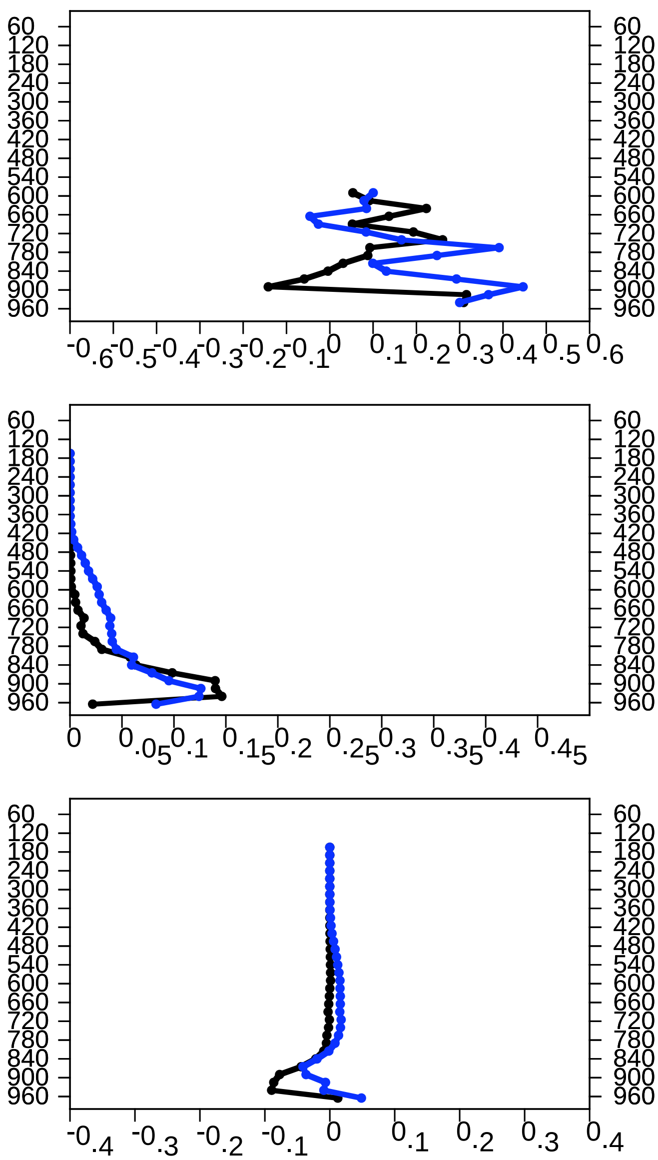

Figure 8. Comparisons of LWC (gm/m3) at the NSA. (CAM3=Blue and AM2=Black). Correlation (top), RMS (middle) Bias (bottom).

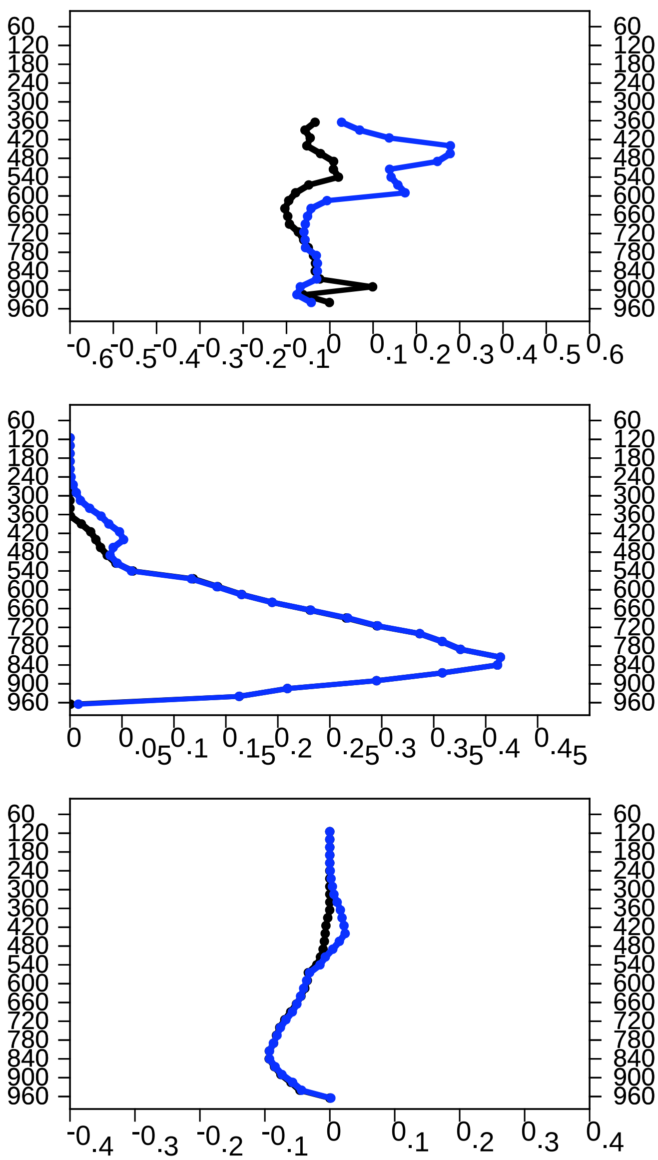

Figure 9. Comparisons of LWC (gm/m3) at the TWP. (CAM3=Blue and AM2=Black). Correlation (top), RMS (middle) Bias (bottom).

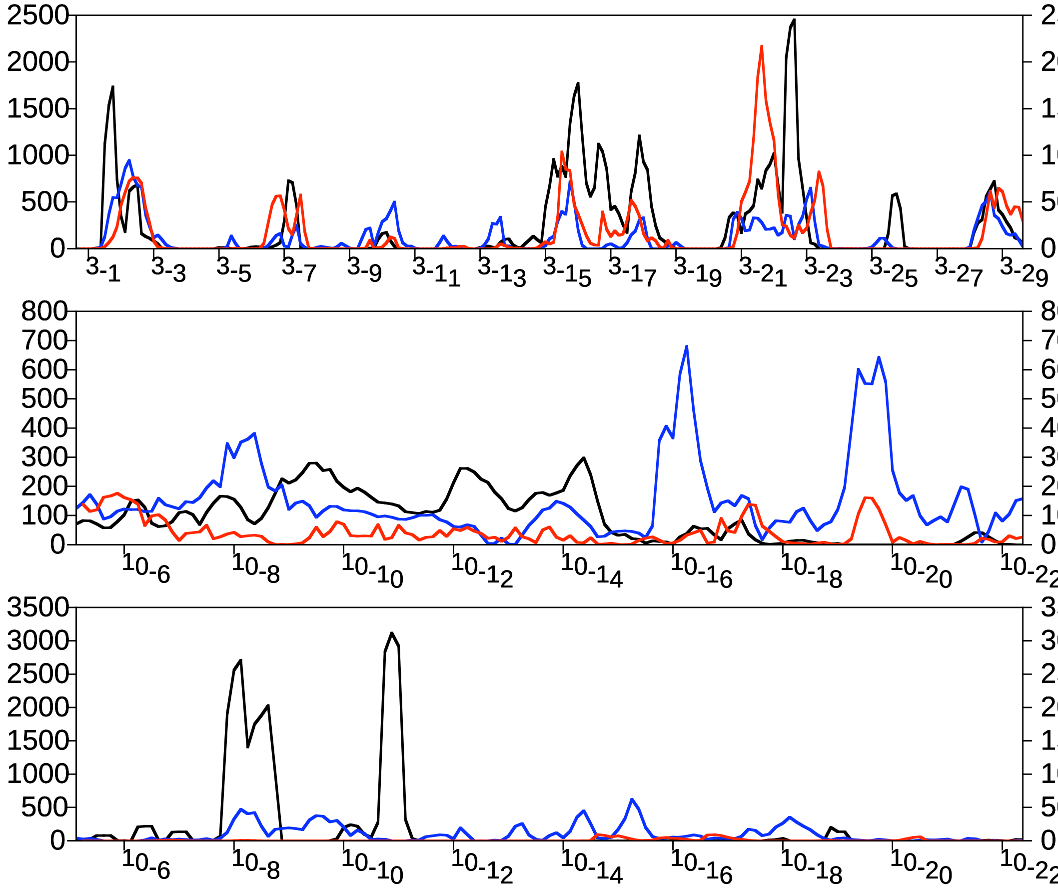

Figure 10. Time series of vertically integrated LWC (gm/m2) at the SGP (top, March 2000), NSA (middle, October 2004) and TWP (bottom, October 2004). Microbase=black, CAM3=blue AM2= red

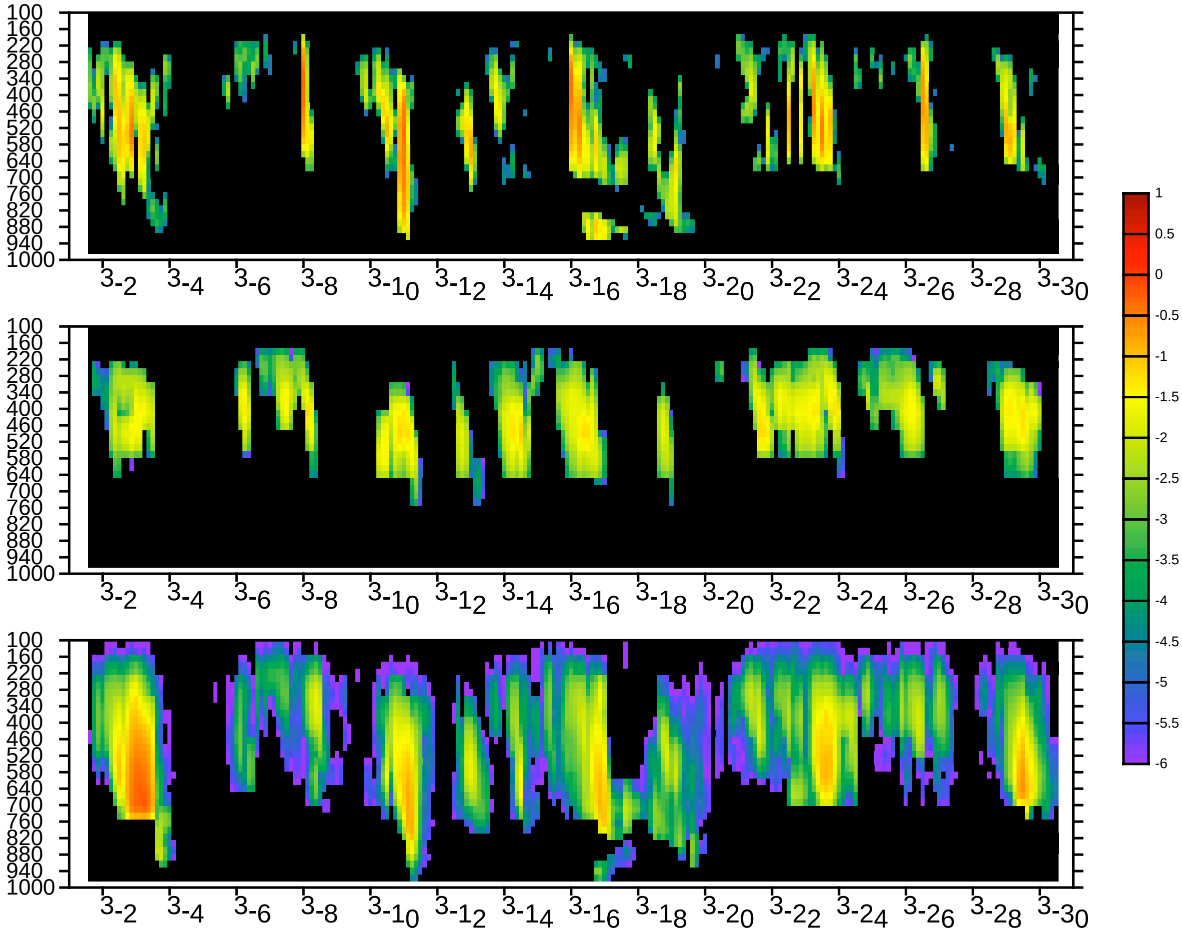

Figure 11. Time height plot of IWC (as log10(gm/m3)) at the SGP. Top is the Microbase data, middle is CAM3 and bottom is AM2.

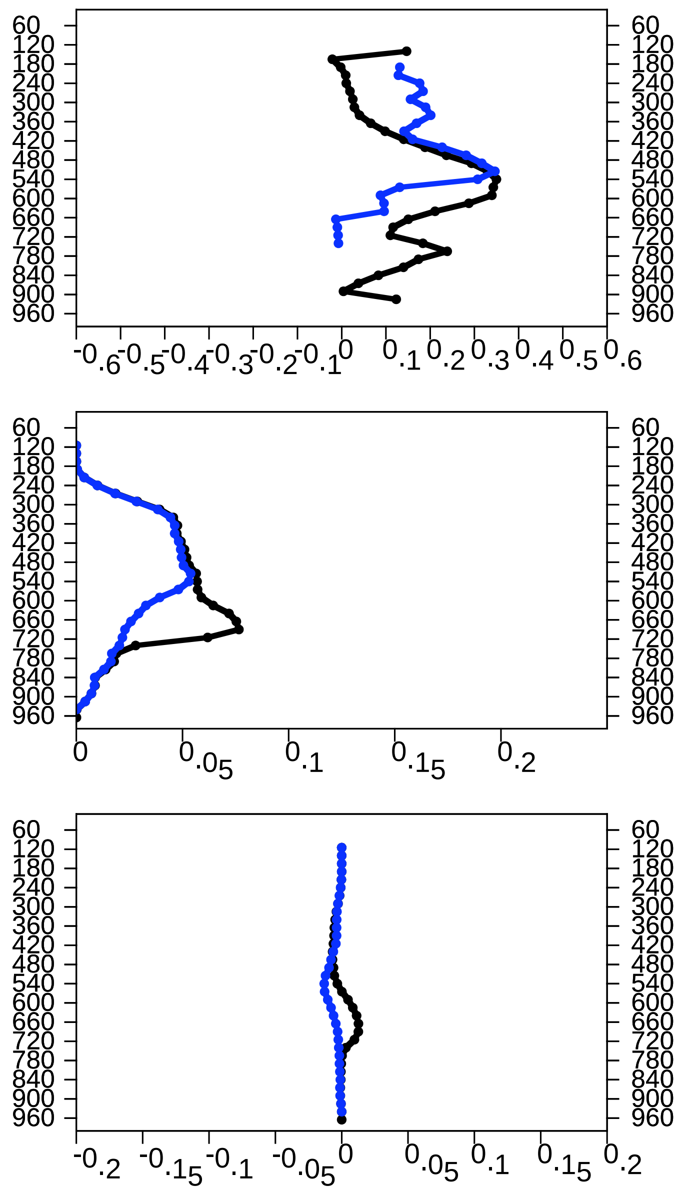

Figure 12. Comparisons of IWC (gm/m3) at the SGP. (CAM3=Blue and AM2=Black). Correlation (top), RMS (middle) Bias (bottom).

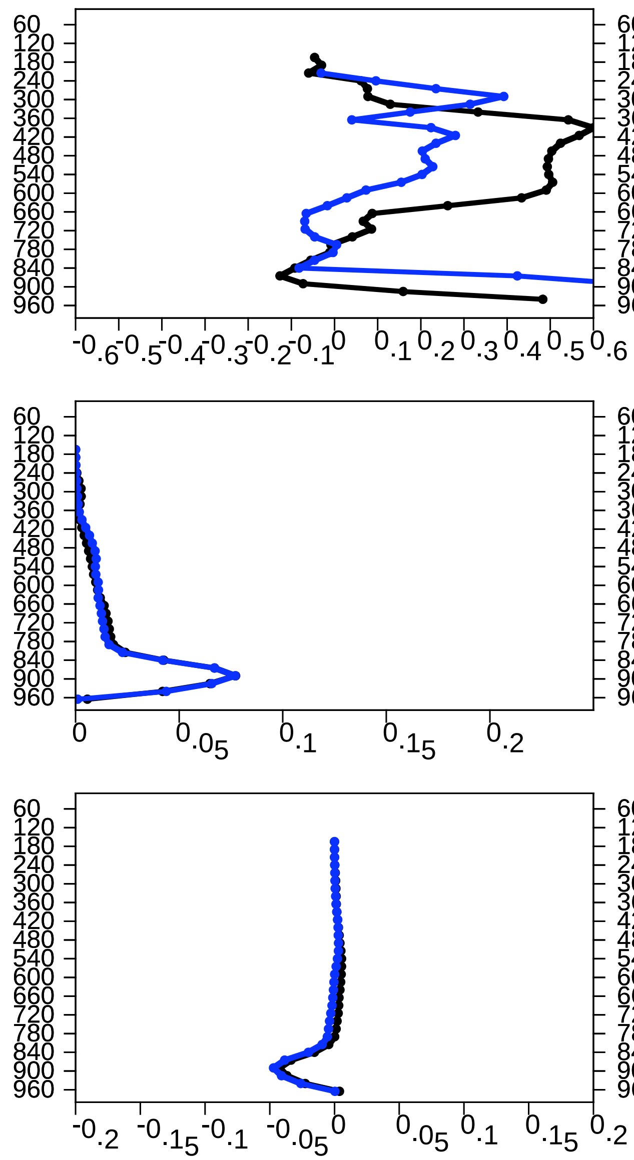

Figure 13. Comparisons of IWC (gm/m3) at the NSA. (CAM3=Blue and AM2=Black). Correlation (top), RMS (middle) Bias (bottom).

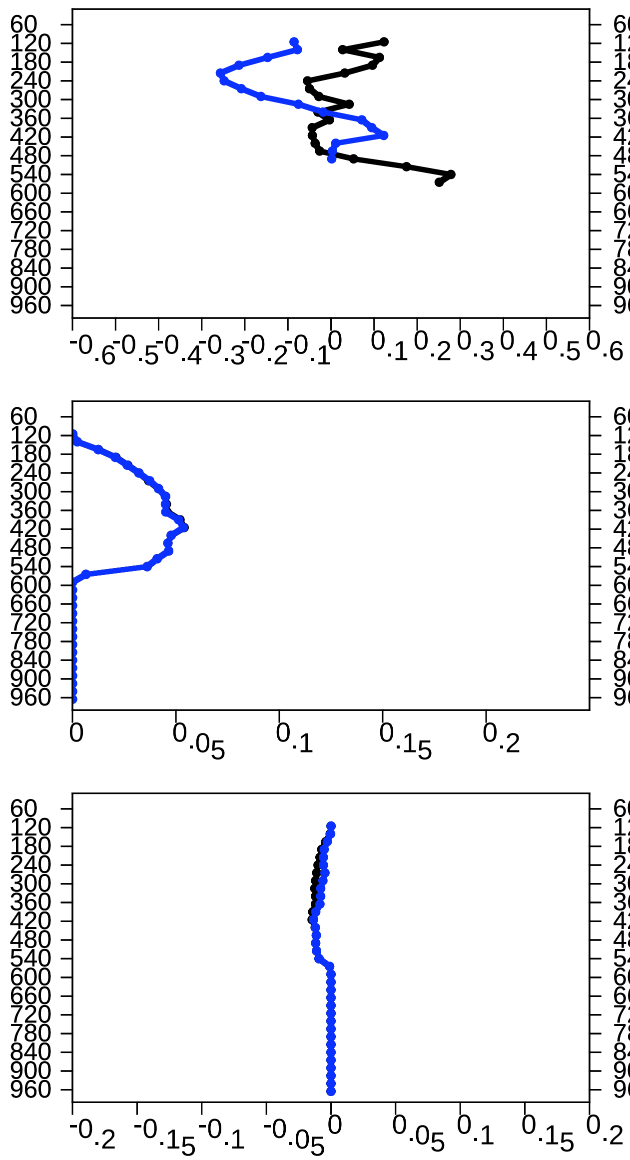

Figure 14. Comparisons of IWC (gm/m3) at the TWP. (CAM3=Blue and AM2=Black). Correlation (top), RMS (middle) Bias (bottom).

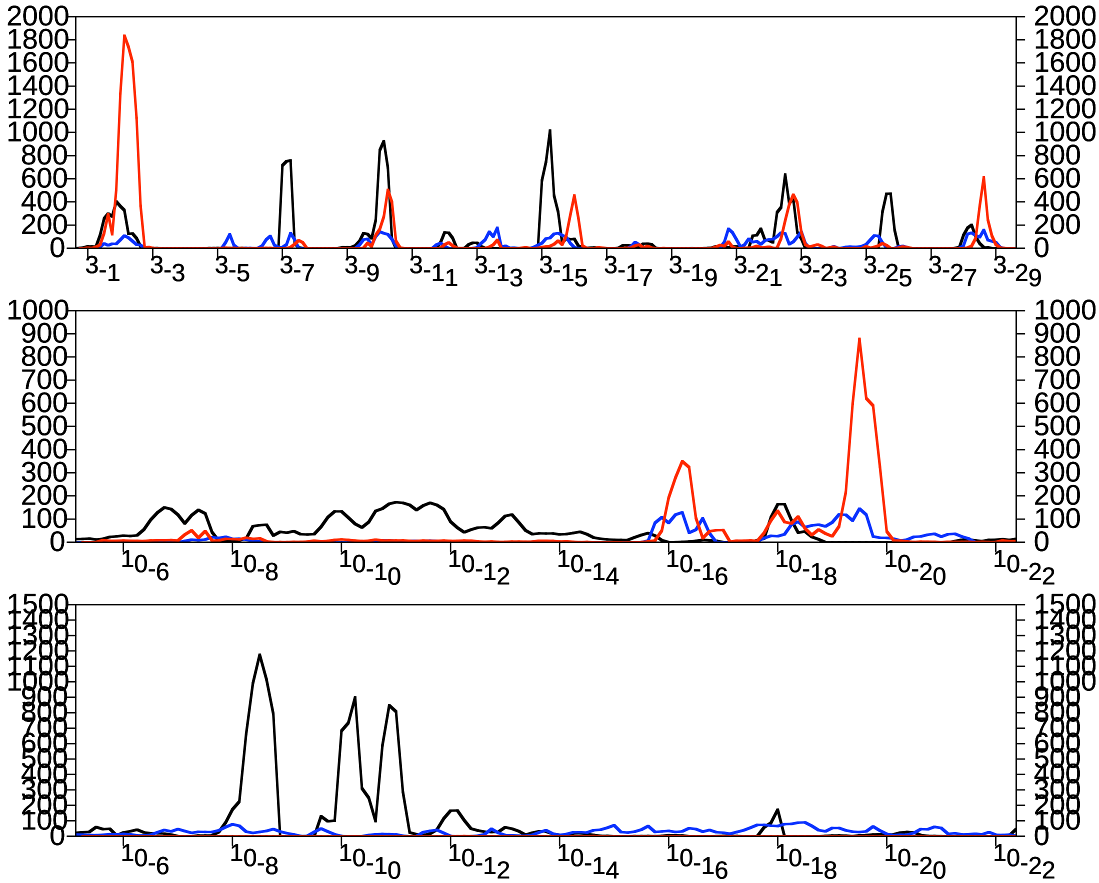

Figure 15. Time series of vertically integrated IWC (gm/m2) at the SGP (top, March 2000), NSA (middle, October 2004) and TWP (bottom, October 2004). Microbase=black, CAM3=blue AM2= red

4. CONTACTS

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