Implementation of ARM derived ice water content in NWP model

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A cloud validating scheme was developed and has been running operationally at the Bureau of Meteorology since the early 90s (Rikus, 1997). This scheme uses physical parameterizations identical to those used in the Bureau of Meteorology Global Assimilation and Prediction System (GASP) and the forecast fields from GASP to generate narrow band brightness temperatures corresponding to a number of spectral infrared channels of geostationary satellites (e.g. GMS). The model cloud and radiation schemes are then validated by comparison of the modelled brightness temperature with the real satellite imagery.

One particular problem in the GASP system identified with this scheme is that the GASP model does not produce enough cold brightness temperatures in the tropics; the satellite image shows an appreciable percentage of brightness temperature below 200K whilst the minimum model brightness temperatures are only around 220K. After a series investigation the problem is found to be due to the ice water content diagnosed from the cloud temperature which is too low at the cold cloud temperature region. The implementation of a new diagnostic scheme proposed by Wang and Sassen (2002) based on the ARM lidar observation leads to a significant improvement in the model simulations.

Figure 1a-b shows a comparison between the modelled brightness temperature and measurements from GMS5 satellite imagery on 6 June 2002. The model generally captures the major characteristics of the brightness temperature distribution pattern observed by the satellite. But the modelled temperature is not cold enough compared with satellite results, especially over the tropical region. The minimum brightness temperature observed by the satellite is 193K but the modelled minimum value is only 222K. The difference is 29K. We have examined four other ice cloud optical property schemes and found that for the maximum ice water content used in the calculations the maximum difference in brightness temperature due to using different scheme is 8K, not big enough to explain the discrepancy between modelled results and observations.

Recently, Wang and Sassen (2002) presented a new relationship between ice water content and temperature determined from 4 years (1997-2000) of lidar-radar observations collected at the Southern Great Plains, at the site of the cloud and radiation testbed of Atmospheric Radiation Measurement (ARM) program in Oklahoma. They compared their results with aircraft observations taken over the mid-latitudes and found that the ice water content derived from the aircraft observations is higher for warm ice clouds ($T > -35^{O}C$) and lower for cold ice clouds ($T < -40^{O}C$). Figure 1c shows the relationship between ice water content and temperature determined using our scheme (solid curve) and that determined by Wang and Sassen (dotted curve). The symbols represent the aircraft observations to which the solid curve was fitted. The brightness temperature determined with the ARM scheme is shown in figure 1d. Clearly, the improvement from these changes is significant. This can be seen from the clouds over the tropics which are brighter than those shown in figure 1b. The other clear evidence is the modelled minimum brightness temperature which drops from 222K to 208K. This improvement indicates that the ice water content at cold temperatures in the GASP system is too small; it also raises a question on

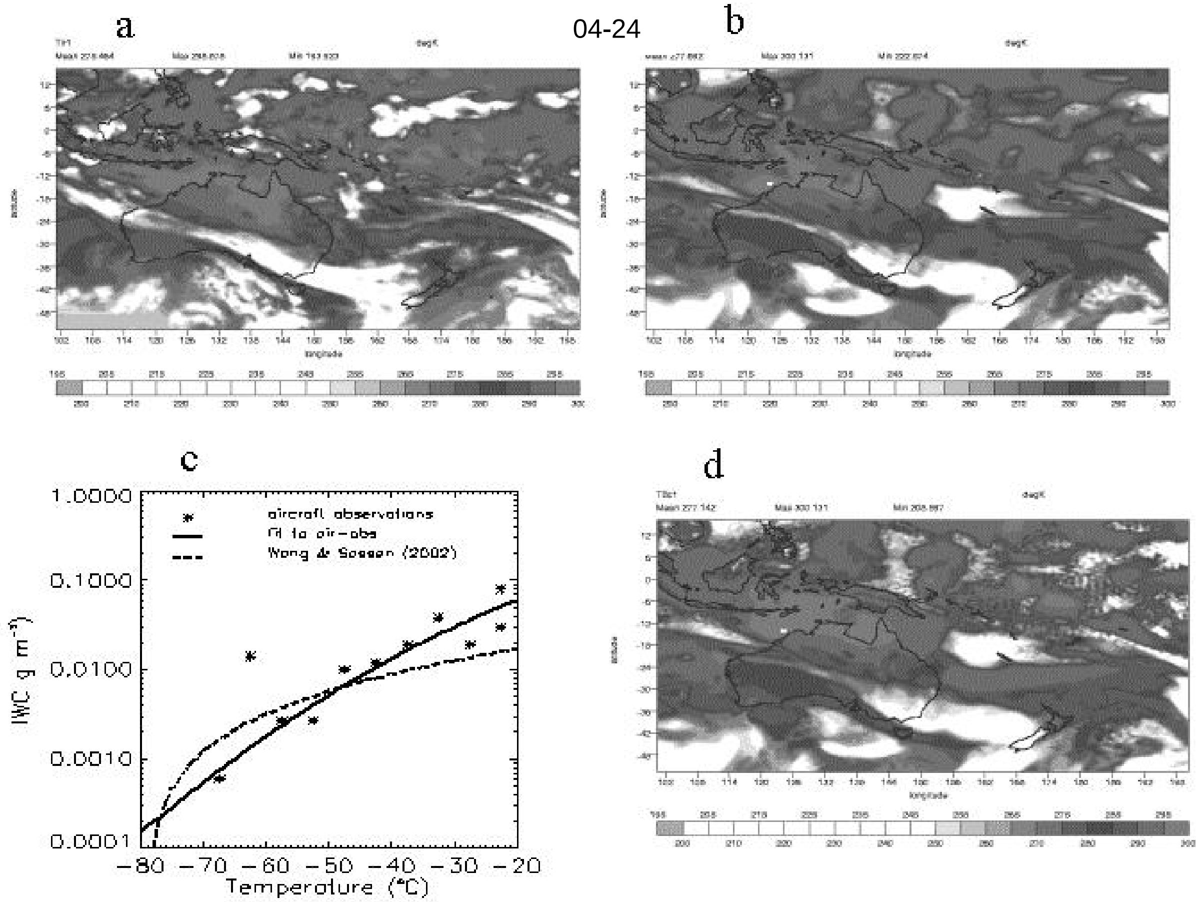

Figure 1: Panel a shows the brightness temperature from GMS5 satellite on 6 June 2002. Panel b is the modelled results using the original GASP ice water content scheme. Panel d is the same as panel b but using the Wang and Sassen ice water content scheme. panel c presents the ice water content as a function of cloud temperature determined using both the GASP scheme based on aircraft observation (solid curve) and Wang and Sassen scheme (dashed curve). The symbols in panel c represents aircraft observations.

the accuracy of ice water content measurements from aircraft at cold temperature region as the diagnostic ice water content scheme used in the GASP model is based on aircraft measurements.

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