PRECIPITATING CONVECTIVE REGIMES IN DARWIN (AUSTRALIA) AND THEIR SIMULATION USING THE WRF MODEL.

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1. PRECIPITATION REGIMES

A clustering algorithm (Anderberg 1973) was applied to Frequency with Altitude Diagrams (FAD’s) (Yuter and Houze 1995) derived from four years of hourly radar data to objectively define four tropical precipitation regimes that occur during the wet season over Darwin, Australia, Figure 1. The order of the panels in this figure is in terms of the relative frequency of occurrence (RFO) of each regime, which is shown in the top left-hand corner of each panel. A fifth regime with no-precipitation also exists but due to its trivial nature is not plotted. However for completeness the RFO of this regime is displayed on the right hand side of each panel.

The precipitation regimes defined are distinguished in terms of convective intensity, presence of stratiform precipitation and precipitation coverage. Regime 1 consists of patchy convection of medium intensity and low area coverage. Regime 2 contains strong convection with relatively small area coverage. Regime 3 is comprised of weak convection with large area coverage and large stratiform regions and regime 4 contains strong convection with large area coverage and large stratiform regions. Analysis of the seasonal cycle, diurnal cycle and regime occurrence as a function of monsoon activity indicate that regimes 1 and 2 are characteristic of continental convection, while regimes 3 and 4 are characteristic of maritime convection.

Further confirmation of the different character of the regimes is derived by evaluating the convective and stratiform contributions to rainfall for each regime. Regime 1 is comprised of 76% convective precipitation, 24% stratiform precipitation and has a total volume coverage (TVC) of 2% (A TVC value of 2% means that 2% of the volume scanned by the radar contains detectable hydrometeors). Regime 2 is comprised of 65% convective precipitation, 35% stratiform precipitation and has a TVC of 10%. Regime 3 is comprised of 36% convection precipitation, 64% stratiform and has a TVC of 18%. Regime 4 is comprised of approximately equal contributions from stratiform and convective precipitation and has a TVC value of 26%.

2. MODEL SIMULATIONS

With the physical nature of each regime clearly established the Weather Researching and Forecasting model (WRF) was employed to determine if the model is able to capture the broad characteristics of the four precipitation regimes. The WRF model was run using a series of nested domains, the inner most domain having a grid spacing of approximately 1.25 km in each horizontal direction.

To compare model simulations directly to the FADS derived from radar, model microphysical data was converted to simulated radar reflectivities. The simulated reflectivities were then interpolated to the same vertical levels and averaged horizontally to match the resolution of the radar data (2.5km in each horizontal direction). With the simulated reflectivities in approximately the same format as the radar observations FADS were created for each hour of the model simulation. These FADs were then assigned to one of the precipitation regimes by finding the minimum euclidean distance of the simulated FAD to the observed regime centroids.
Figure 1: The four precipitation regimes defined by the K-means algorithm. Regimes are ordered (most to least) by their relative frequency of occurrence (RFO). The RFO of the “zeroth” regime, the regime containing time periods that have no precipitation over the entire radar domain, is shown for completeness.
To evaluate all four precipitation regimes two case studies were performed to capture the broad range of meteorological conditions encountered in the Darwin region. These case studies were chosen to coincide with the Tropical Warm Pool International Cloud Experiment (TWP-ICE) (May et al. 2008) so that the extensive observational data set could be used for further model evaluation.

Over the course of the TWP-ICE field campaign Darwin experienced a variety of meteorological conditions ranging from monsoon conditions during the early part of the experiment to break conditions during the latter. A six day monsoon simulation starting at 12 UTC on the 24/01/2006 was used to evaluate the WRF’s models ability to replicate regimes 3 and 4, and a six day break simulation started at 12 UTC on the 09/02/2006 was used to evaluate the models ability to replicate regimes 1 and 2.

2.1. MONSOON SIMULATION

The WRF model roughly captured the temporal pattern of regime change during the monsoon simulation, Figure 2 (a). The model was not able to capture the high frequency changes between precipitation regimes but was able to roughly capture the low frequency component. When the simulated regimes did not agree with the radar the simulated FADS were generally assigned to a higher precipitation regime. The model was rarely found in regime 1 and stayed in regime 4 longer than the radar. The WRF model may have a problem with suppressing convection once it has been initiated, however at this stage this has not been fully investigated.

2.2. BREAK SIMULATION

The break simulation was unable to capture the change in regimes as seen by the radar. Precipitation was underestimated during the break simulation with the model regimes rarely changing from regime 1. A problem with the break simulation that could lead to the underestimation of precipitation is that the model was unable to simulate a number of squall lines that were seen in the observational data. This is likely due to the fact that the squall lines are not being generated in the outer domains where convective parametizion is required.

REFERENCES

