Atmospheric classification to relate large-scale dynamics and clouds

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Introduction

• General Circulation Models (GCMs) have difficulty representing clouds, and determining the source of the errors is challenging.

• Because GCMs do not predict specific weather events, model output cannot be directly compared to observations. Rather, long term averages of model and observational data are usually compared. This obscures the source of any errors that may exist.

• Compositing model and observational data by atmospheric state is an alternative method of making comparisons. In this case, when errors are found, the physical conditions which caused the errors are better known.

Methods

• Multiple years of ECMWF reanalysis fields (T, U, V, SLP, RH) comprise our input data. We use a competitive neural network to define an initial set of states

• An issue common to many clustering studies is the proper selection of the number of clusters. We use an iterative technique (Marchand, et al. 2006 & 2009) to determine the optimal number of states and millimeter cloud radar data from ARM sites to test the statistical significance of the states.
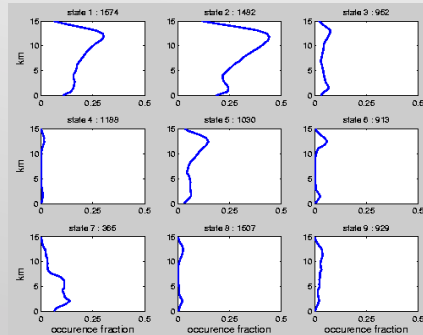
Algorithm flow chart
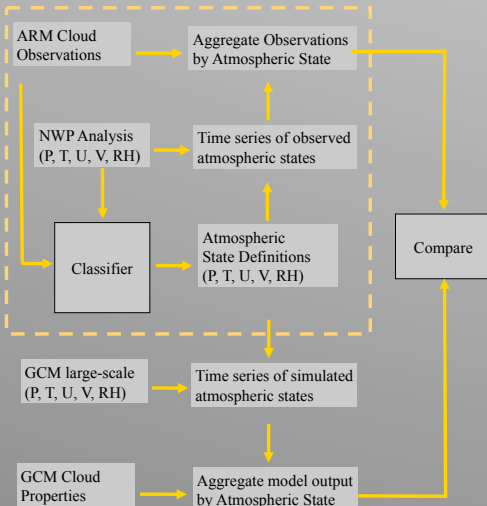
Darwin, Australia

In the tropics, the technique identifies states which represent modes of intraseasonal variability.

Cloud occurrence profiles

Precipitation distributions

Monsoon
Transition
Dry Season

1 - 5.8% raining
2 - 11% raining
3 - 1.4% raining
4 - 0.71% raining
5 - 1.5% raining
6 - 0.34% raining
7 - 2.1% raining
8 - 0.55% raining
9 - 0.17% raining

State 9 – isolated convection

• Fraction of the time the vertically pointed millimeter radar at Darwin observed cloud at each level.

• The algorithm requires that each state produce a distinct cloud profile.
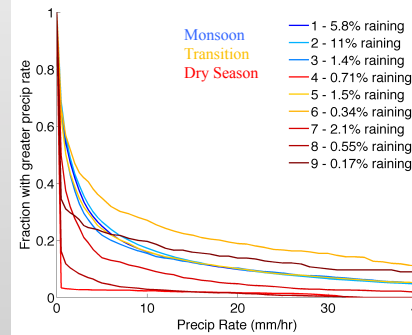
• Frequency and intensity of precipitation measured at the Darwin ARM site.

• These can provide insight into the nature of each of the states.
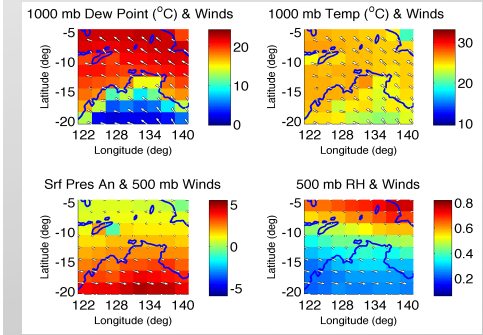
• An example of the dynamics which define a state. In this case the dynamics look like a typical dry season state.

• Knowing that this state produces rare but intense precipitation identifies it as isolated convection.
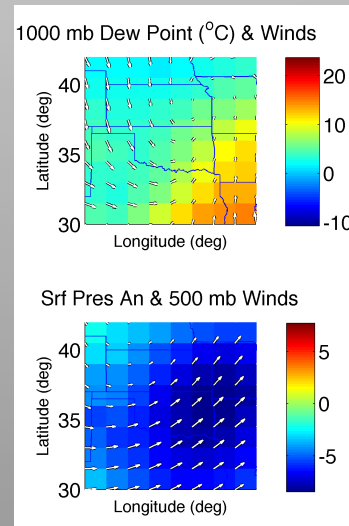
Southern Great Plains

In locations with greater day-to-day variability, the classifier identifies distinct weather systems – producing many more states.

State 3 - an approaching cold front
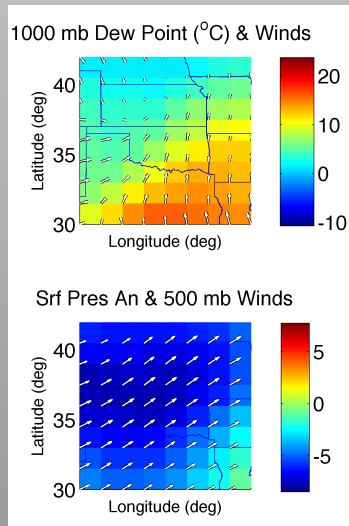
State 15 – the front has passed

Cloud Profiles – many states are identified. Red shading denotes summertime occurrence, blue shading wintertime.

Pre-frontal convection

post-frontal stratiform