Evaluating clouds in the AM3 model using atmospheric classification

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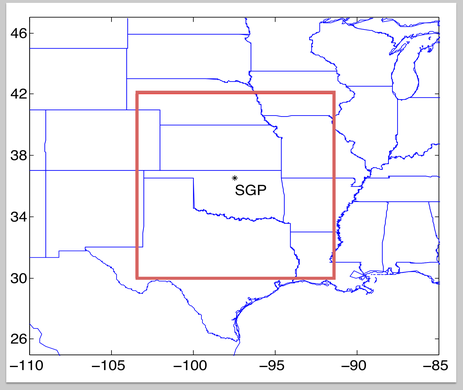
Motivation

- 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.

Input Data

- ECMWF ERA-Interim reanalysis fields
  T, U, V, RH, PS
  13 years (1997-2010) of 4x daily snapshots
  9 x 9 horizontal grid, 7 vertical levels



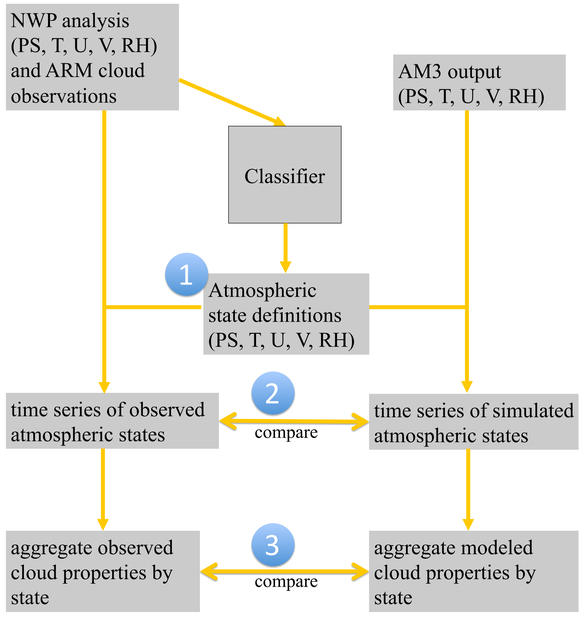
- Vertically pointed millimeter radar at the ARM program Southern Great Plains site provides simultaneous cloud occurrence observations used to test temporal stability and distinctness of states.

Model setup

- Atmosphere Model 3 (AM3) from GFDL (Donner et al. 2011)
- 2 x 2.5 resolution
- 11 years (2000-2010), 4x daily snapshots
- Historical SSTs
- Instrument simulator output

Questions? Email *sevans@atmos.uw.edu*

Conceptual flow chart



1 Examples of atmospheric states

Each atmospheric state has a distinct, recognizable meteorology. The states which occur in autumn / winter / spring are identifiable as different stages of synoptic systems passing through the region. The states which occur in summer reflect the variability in temperature, humidity, and surface pressure.

State 5 – warm front to the south

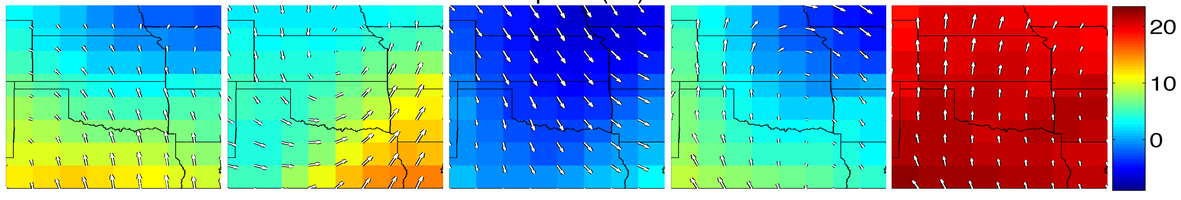
State 18 – cold front across the middle

State 19 – cold post-frontal northerlies

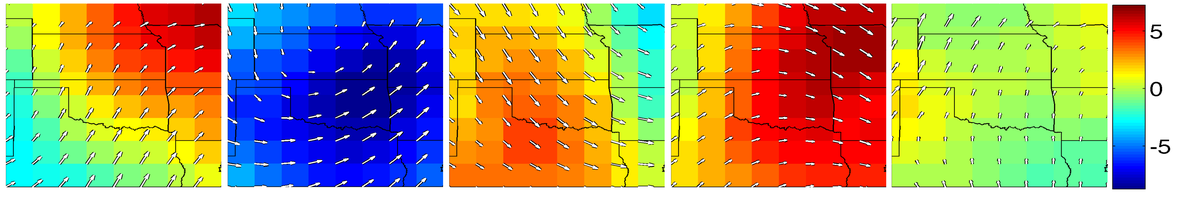
State 13 – anticyclonic with high pressure

State 11 – hot summer southerlies

875 mb dew point (°C) & winds

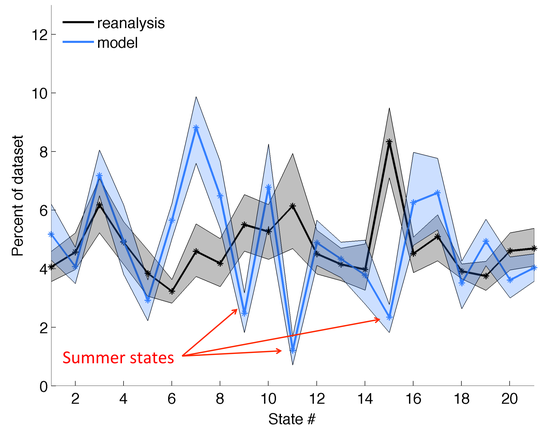


Surface pressure anomaly (mb) & 750 mb winds



2 Distribution of states

- Each model event (6 hour snapshot) is sorted into the atmospheric state it most closely matches.
- Summer states appear much less frequent in the model.

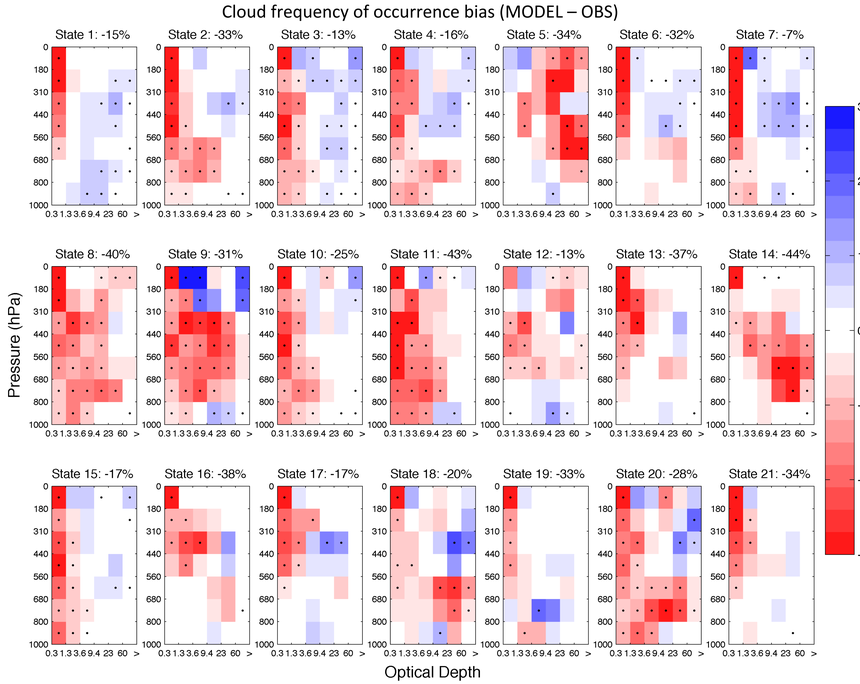


	Warm fronts	Cold fronts	Northerlies	Anticyclonic	Summer
States	4, 5, 8, 17	12, 14, 18, 20	2, 6, 16, 19, 21	1, 7, 13	3, 9, 10, 11, 15
ECMWF	18%	17%	21%	13%	31%
Model	21%	16%	25%	18%	20%

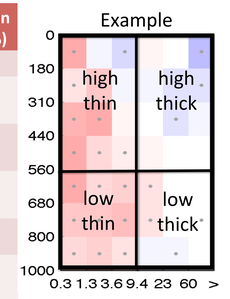
3 Model cloud properties compared to ISCCP

We compare ISCCP joint histograms of optical depth and cloud top pressure for each state. For the model, this comes from the ISCCP instrument simulator.

Cloud frequency of occurrence bias (MODEL – OBS)



	States	Frequency bias	High thick bias (%)	Low thick bias (%)	High thin bias (%)	Low thin bias (%)
All States			1	-1	-18	-5
Warm fronts / warm sector	4, 5, 8, 17	3	-3	-4	-14	-5
Cold fronts	12, 14, 18, 20	-1	0	-8	-12	-5
Northerlies	2, 6, 16, 19, 21	4	2	0	-32	-2
Anticyclonic	1, 7, 13	5	4	1	-21	-2
Summer	3, 9, 10, 11, 15	-11	2	1	-15	-10



Conclusions

Occurrence of states

- The atmospheric states are recognizable weather patterns.
- The model does not produce the summertime patterns frequently enough. This may be due to a cold bias in the model

Model cloud properties

- The model does not produce enough thin cirrus under all conditions.
- In conditions of large-scale ascent (fronts) the model does not produce enough thick cloud.
- In conditions of parameterized convection (northerlies, anticyclones, summer) the model produces too much thick cloud.
- For thin clouds, the overall bias is dominated by within-state errors. For thick clouds, both within-state and frequency of occurrence errors are important to the overall bias.