P1.11

An intercomparison of MMCR and NCEP Global Model Clouds at the ARM SGP Site

Steven Lazarus*
Florida Institute ofTechnology, Melbourne FL
and

Steven K. Krueger
University of Utah, Salt Lake City UT

1. Introduction

In conjunction with the National Center for Environmental Prediction (NCEP), the University of Utah has been archiving (daily) column data from the NCEP Medium Range Forecast (MRF) model for various sites over the globe (Table 1). Four of these sites coincide with ARM facilities at Manus, Nauru, Barrow, and the Southern Great Plains Central Facility. Within the past year, the MRF underwent a significant upgrade in its cloud scheme - switching from a diagnostic to prognostic large-scale condensate scheme. Additionally, the rh-based subgrid-scale stratiform cloud fraction parameterization was replaced by a scheme that is a function of both large-scale relative humidity and predicted cloud water/ice (Xu and Randall, 1996). Herein, we attempt to evaluate the MRF cloud forecasts by comparing against data obtained from a vertically pointing millimeter cloud radar (MMCR).

As a precursor to examining cloud fraction and overlap, we focus on the short-term prediction of cloud amount by comparing diurnal composites of MRF and MMCR cloud *existence* (using 3 h forecasts from model forecast hours 12 to 48). We also present composited values of layer average vertical motion and maximum relative humidity. Statistics are presented for 2001 and are stratified by season.

2. Datasets

2.1 MRF

MRF data are currently collected at model grid points at 16 sites (see Table 1). The MRF data stream includes: surface radiation (LW up, LW down, SW up, SW down), TOA radiation (LW up, SW up), clouds (pbl, low, mid, high, & cloud fraction), profile (u/v wind, temperature, specific humidity, pressure, omega, temperature and moisture advective tendencies, cloud water/ice), and other fields (e.g., site specific model parameters, surface pressure, sensible/latent heat fluxes, etc.).

Table 1: MRF column data locations

	SITE	***LAT***	***LON***
1.	ARM SGP CF	36.61N	97.49W
2.	TWP - Manus	2.06S	147.50E
3.	TWP - Nauru	0.52S	166.92E
4.	NSA - Barrow	71.30N	156.68W
5.	Port Santo Madeira Island	33.00N	16.00W
6.	Subtropical cold regime	30.00N	140.00W
7.	Subtropical warm regime	34.00N	164.00E
8.	Midlatitude oceanic regime	52.75N	35.50W
9.	Arctic ocean point	77.00N	158.00W
10.	TOGA COARE point	2.00S	155.00W
11.	Amazon basin	10.88S	62.60W
12.	Eastern South Pacific	20.00S	85.00W
13.	Eastern South Pacific	27.00S	80.00W
14.	SW. Florida (Crystal)	26.00N	81.00W
15.	Bahamas (Crystal)	25.70N	79.00W
16.	Melbourne FL	28.10N	80.60W

2.2 MMCR

We use *merged moment* millimeter cloud radar data from the SGP (Clothiaux et al. 1999). These merged moment data are created using a statistical mask which selects the best reflectivity estimate from the MMCR's 4 modes (low clouds are flagged using ceilometer data). *We choose a 15 minute 'window' surrounding the MRF forecast time, and cloud is identified as present if the dBZ > -40.* Tests do reveal sensitivity to the choice of reflectivity threshold, but are not presented here.

3. Method

We examine *cloud existence* only (e.g., Mace et al., 1998), i.e. we evaluate model performance by identifying whether or not forecast clouds actually exist (i.e. radar reflectivity greater than -40 dBz) in each of 4 layers. Table 2 indicates the four possible outcomes for each of the cloud layers.

Table 2: Possible outcomes for cloud existence

	yes model	no model
yes radar	**cloud/cloud (green)**	**cloud/clear (yellow)**
no radar	**clear/cloud (red)**	**clear/clear (blue)**

MRF (at the SGP latitude) and the approximate corresponding MMCR cloud genera are selected using the following criteria:

	MRF	MMCR
PBL cloud	lowest 10% of atm	< 1400 m
low cloud	PBL top - 650 mb	1400 - 3600 m
mid cloud	650 mb - 350 mb	3600 - 8100 m
high cloud	< 350 mb	> 8100 m

In addition to the hit/miss cloud criteria given above, we composite averages of the layer maximum relative humidity and layer vertical velocity for each of the 4 criteria listed in Table 2. Results are presented for a *single* forecast (24 h) time valid at 0 UTC.

4. Preliminary results

In Figures 1-4, the pie charts represent % hits (blue/green) and misses (red/yellow) as listed in Table 2. We use the 24 h forecast only (valid at 0 UTC). Seasons are Winter (DJF), Spring (MAM), Summer (JJA), and Fall (SON). Note that there is a distinct seasonal dependence with marked improvement (over that of winter) in the number of hits for low and mid cloud during spring, summer and fall. Some of this improvement may be a result of the MRF upgrade in May 2001. High cloud is problematic for all seasons with the MRF producing excessive cloud cover. The MRF tends to produce too much cloud at this forecast time. This is particularly evident during the winter for all levels and for high clouds during each season. The winter 'miss' rate is near 50% for all levels with a seasonal maximum for summer high clouds (near 75%) due entirely to the MRF predicting clouds in the absence of observed clouds. With the exception of spring and summer high clouds, radar detected clouds in the absence of model predicted clouds is generally an infrequent event.

Composites of layer (low, mid, high) average maximum relative humidity (RH) and layer average vertical velocity (mPa s^{-1}) are also shown (Figs 1d,e-4d,e). Both winter and spring cases where the MRF produces clouds and the MMCR does not appears to be related to high model RH (Figs. 1d,e and 2d,e). The model RH is low for cases where the radar indicates cloud but the MRF does not. The excessive (winter/spring) MRF cloud cover may in

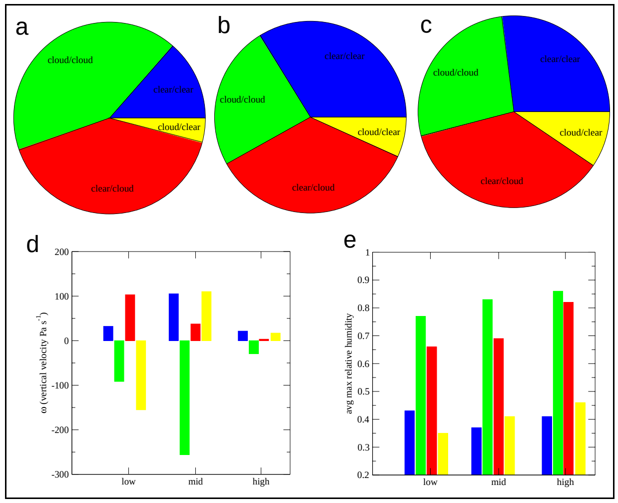

Figure 1: Pie diagram of hits (greens & blues) and misses (reds and yellows) for MRF 24 h forecast valid 0 Z a) low cloud, b) mid cloud, and c) high cloud for winter 2001, and bin diagrams for d) composite values of layer average vertical motion (mPa s^{-1}) and e) layer average maximum relative humidity.

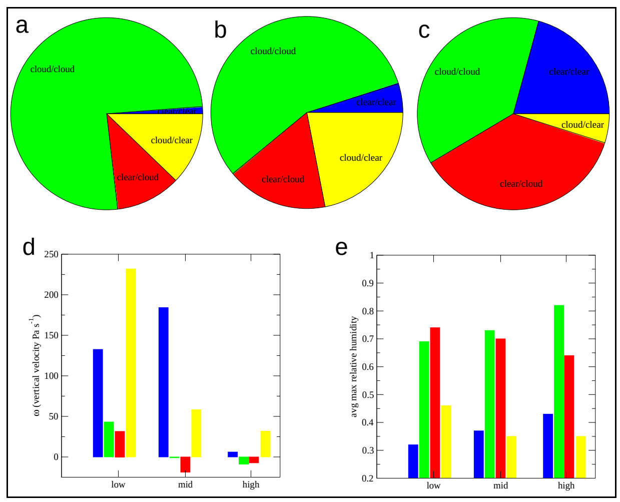

Figure 2: Same as in Figure 1 but for spring 2001.

part be related to the combination of rising motion (negative ω) and high RH (note that the latter is comparable to the RH for the radar/model cloud/cloud composite). The MRF also indicates rising motion for fall high clouds but relatively low RH. It is difficult to distinguish between the summer composite of RH for high clouds for the case where both the radar and model observe cloud and the case where MMCR indicates clear skies and the MRF predicts cloud (for this case ω is near zero). For two cases (spring low cloud and fall midlevel cloud) the composite RH is actually largest for the radar no cloud and MRF cloud scenario.

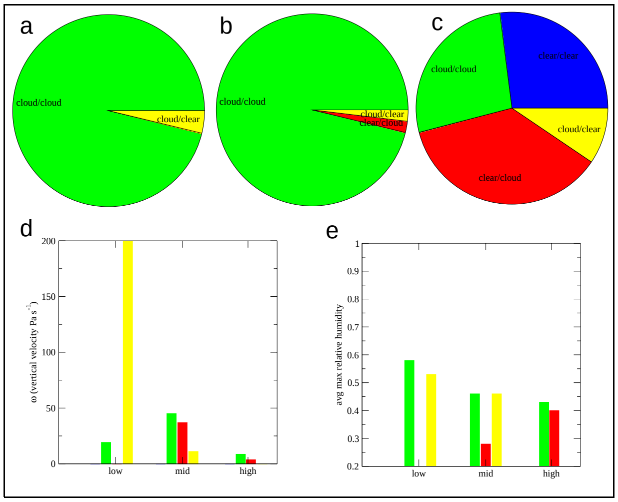

Figure 3: Same as in Figure 1 but for summer 2001.

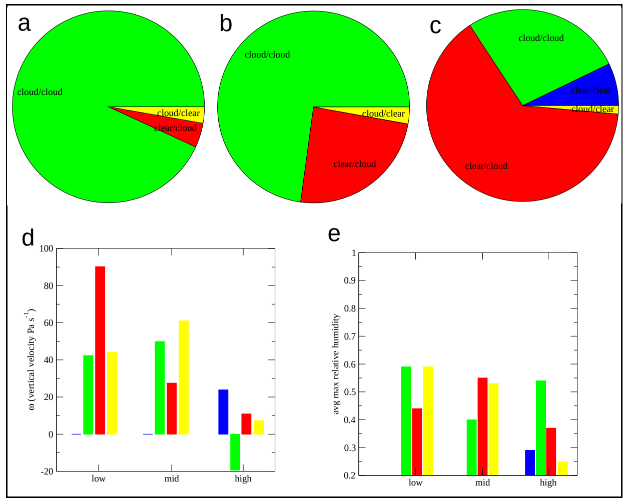

Figure 4: Same as in Figure 1 but for fall 2001.

5. Conclusion

We present a preliminary examination of the NCEP global model cloud fields by comparing predicted cloud with that observed by the MMCR for an entire year (by season) at a single forecast (24 h) time (0 Z). In part this study was designed as a precursor to the more complicated problems associated with cloud overlap and cloud fraction. Obviously, the latter are, in part, of secondary importance to the fundamental issue of cloud prediction in general (i.e., can the model predict the occurrence of clouds). As a follow-up to the results presented here, we plan to examine the observed RH profiles from the ARM SGP sonde launches in an effort to identify potential model problems related to moisture. Additionally, the ARM microwave radiometers can also be used to compare with model forecasts of both precipitable and column liquid water. It may also be instructive to identify and examine both periods where the model does and does not perform well. NCEP reanalysis data can be used to examine the large-scale dynamics associated with various model performance levels - with the hope of isolating model problems and better understand the associated cloud fields (e.g., Tselioudis 2000). We also plan to examine the extent to which model timing may impact our results (i.e., we show only a single forecast time).

6. References

Clothiaux, E. E., K. P. Moran, B. Martner, E. Brooks, T. Ackerman, P. Thomas, G. G. Mace, G. Gerald, T. Uttal, J. Mather, H. James, K. B. Widener, M. A. Miller,and D. J. Rodriguez, 1999: The Atmospheric Radiation Measurement Program Cloud Radars: Operational Modes. *J. Atmos. Oceanic Technol.*, Vol. **16**, pp. 819–827.

Mace, G. G., C. K. Jakob, and K. P. Moran, 1998: Validation of hydrometeor occurrence predicted by the ECMWF model using millimeter wave radar data. *J. Geophys. Res.*, 25, 1645-1648.

Tselioudis, G. and Yuanchong Zhang, 2000: Cloud and Radiation Variations Associated with Northern Midlatitude Low and High Sea Level Pressure Regimes. *J. Climate*, **13**, 312-327.

Xu, Kuanman and D. A. Randall, 1996: A Semiempirical Cloudiness Parameterization for Use in Climate Models. *J. Atmos. Sci*., **53**, 3084–3102.