An Evaluation of The Met. Office Global NWP Model by Comparison with ARM Data in the Tropical Western Pacific

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Summary

Global NWP (Numerical Weather Prediction) forecasts for the Tropical Western Pacific (TWP), produced by The Met. Office's Unified Model, are compared with observations made at the Atmospheric Radiation Measurement (ARM) Cloud and Radiation Testbed (CART) site on Manus Island during July 1998. These data are used to investigate the source of some of the more persistent model systematic errors in the tropics. The model cloud and surface radiation fields are examined. A comparison with infrared satellite data is undertaken.

Specifications: Observations and Model

High frequency measurements were used from the following instruments:

- Surface meteorology sensors (precipitation rate)
- Radiosonde ascents (temperature profiles at 00Z every day)
- Skyward-pointing radiometers [shortwave (SW) and longwave (LW) surface fluxes]
- Viasala ceilometer and micropulse lidar (backscatter profiles).

The operational global NWP model running during July 1998 was as follows:

- Grid-point model, 90-km resolution in tropics, 30-hybrid levels, 20-min. physics timestep, 3-hour radiation timestep
- Mass flux convection scheme [including convective momentum transport, but without (convective available potential energy) CAPE closure]
- 6 LW bands and 4 SW bands in the radiation scheme
- Analysis correction data assimilation scheme (ARM synop obs not assimilated).

Temperature Errors in the Tropics

The model systematic temperature error is known to be a cool bias beneath the tropical tropopause and a warm bias in the mid-troposphere. Figure 1 compares the T+24 forecast temperature with that recorded by radiosonde ascents, at 00Z every day during July 1998. The tropopause cool bias is clearly episodic, not constant. The daily mean observed precipitation rate, also plotted, makes it clear that the cool bias is associated with convective events, which suggests that model convection is too weak, too shallow, or is uncorrelated with real convection.

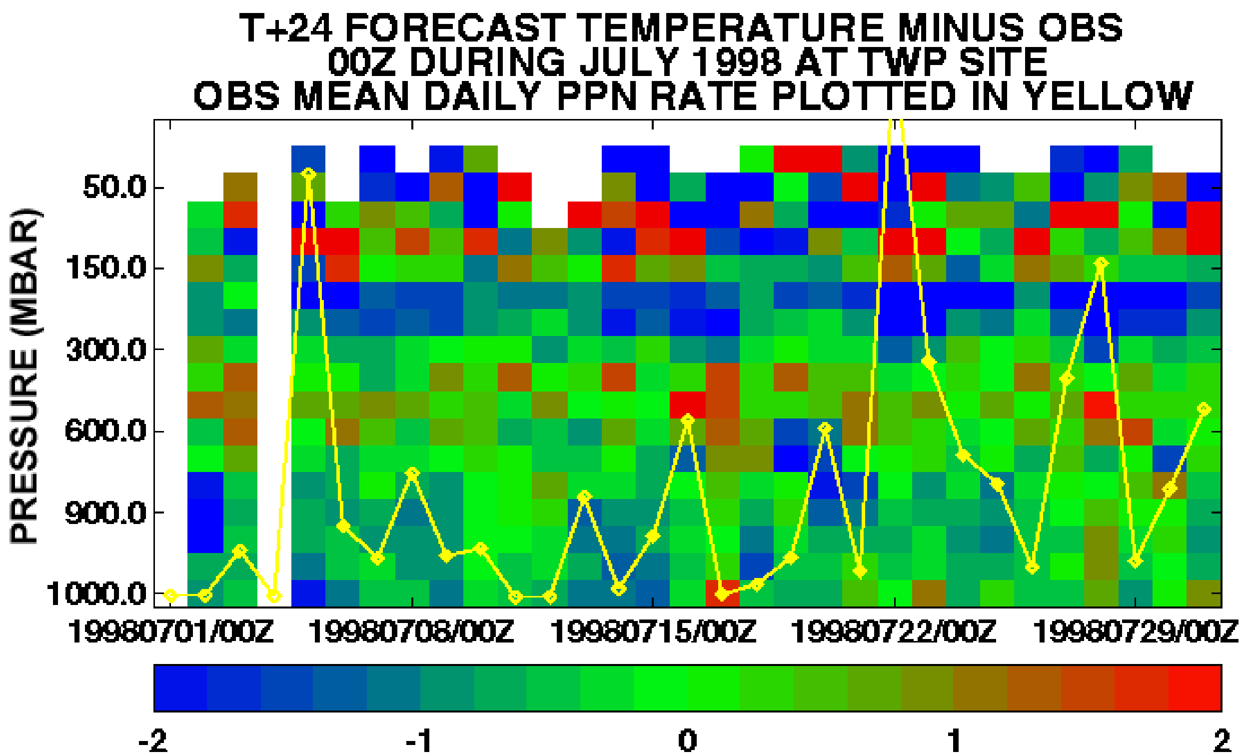

Figure 1. T+24 model forecast temperature error with respect to sonde ascents, at 00Z every day during July 1998. Observed mean daily precipitation rate also plotted.

Surface radiation

Figure 2 shows the difference between the model and observed downwelling surface SW and LW radiative fluxes, every 3 hours during July 1998. The 3-hourly averaged model and observed precipitation rates are also plotted. They show that the errors fall into two regimes: "rainy" days, when there is insufficient radiative forcing in the model (SW too large and LW too small); and "dry" days when there is excess model forcing (vice versa). In other words, there appears to be less variability in the model tropical cloud amounts than in reality. Figure 3 shows that the diurnal variation of the observed surface fluxes is not reproduced in the model.

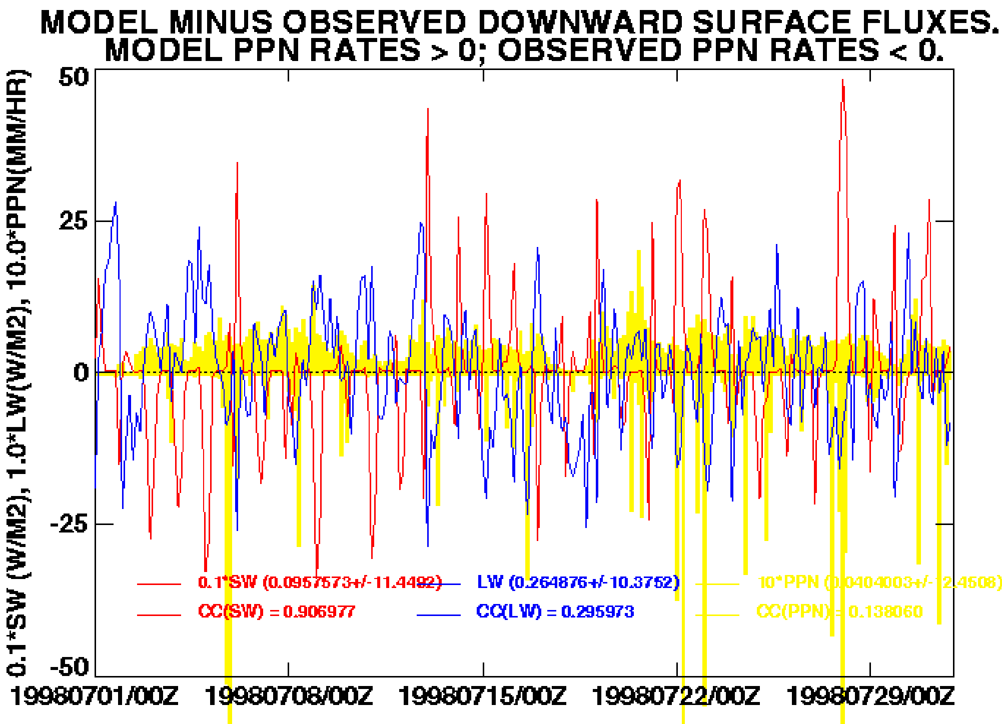

Figure 2. T+3 model surface downwelling SW and LW radiative flux error with respect to radiometer measurements, every 3 hours during July 1998. Three-hourly averaged model ppn rate plotted positively; corresponding observed ppn rate plotted negatively.

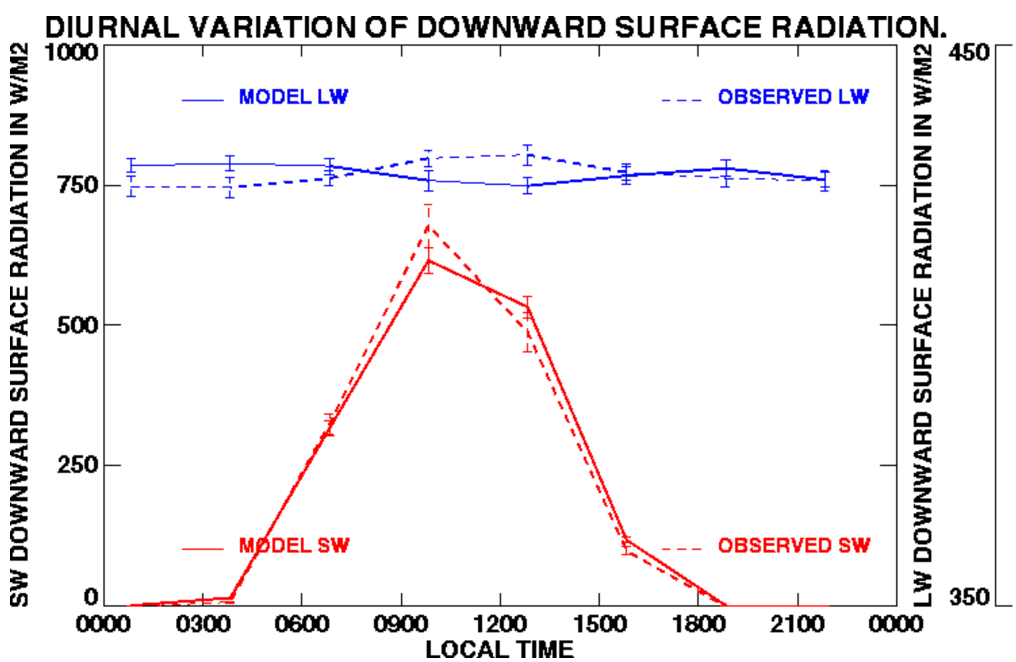

Figure 3. Mean diurnal variation of model and observed surface downwelling SW and LW radiative fluxes, plotted with their standard errors.

Top-of-the-Atmosphere (TOA) Radiation

Satellite-observed infrared brightness temperatures can be used to validate the model by calculating the corresponding model fields through a suitable calibration of the outgoing LW flux through the atmospheric window at the TOA. Corresponding images for two days shown in Figure 4 reinforce the picture of insufficient model cloud variability. The same is true, to a lesser extent, over the whole of the tropics.

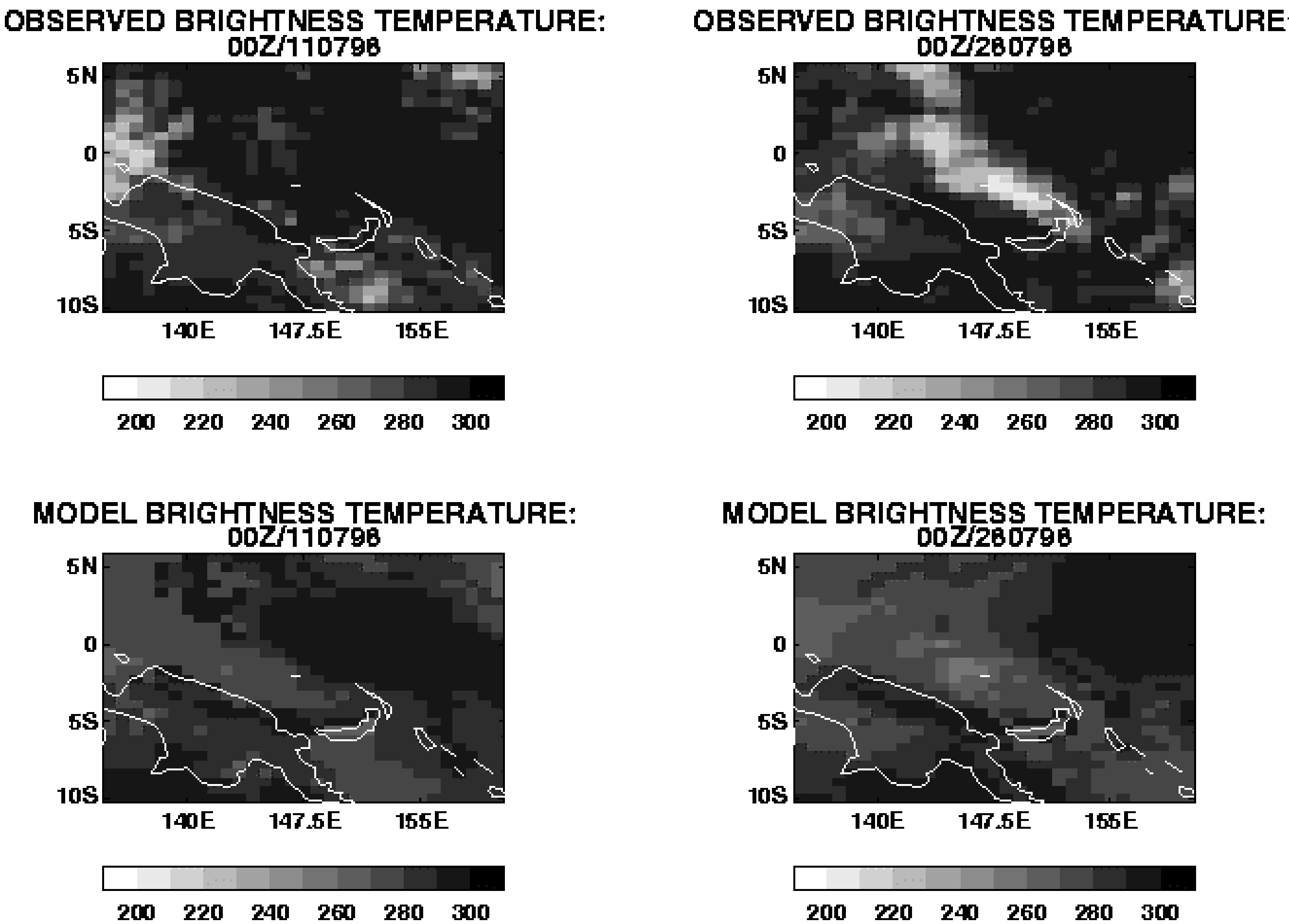

Figure 4. T+0 model infrared brightness temperature around the ARM TWP site at 00Z on July 11, 1998, and 00Z on July 28, 1998, together with the corresponding satellite images.

Conclusions

- The tropopause cool bias is intensified during convective periods.
- Diurnal variation of model and observed surface radiation are out of phase.
- Model cloud amounts show less variation than in reality.

ARM measurements provide a rich source of data for the evaluation of NWP models. More use should be made of them in this direction.

Acknowledgments

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