Forecasts of Southeast Pacific Stratocumulus with the NCAR, GFDL and ECMWF models.

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1. Motivation

We illustrate the way the NCAR, GFDL and ECMWF models represent regions of persistent stratocumulus with global forecast simulations examined at a column in the South Eastern Pacific (20S-85W).

Stratocumulus clouds play an important role in the seasonal cycle of the Eastern Pacific and the global climate by exerting a strong cooling effect on the surface. These clouds are very complex to parameterize in GCMs because: they are only a few hundred meters thick. Therefore, they are difficult to represent with the current climate model vertical resolution. - they are maintained by a complex set of interactions between the cloud layer and its environment, which are not always well understood (Figure 1).

2. The Eastern Pacific Investigation of Climate (EPIC) column

This location (Figure 2) has been chosen because of the availability of observational datasets and accurate analyses.

- The WHOI buoy provides a long-term time-series of surface meteorological variables.
- The MK ECMWF analysis (which uses a combined Mass-flux/K-diffusion scheme) provides a realistic state of the EPIC column except the boundary layer height is too shallow (Figures 3-4).

5. Mechanisms controlling the PBL height.

A key problem common to the 4 models is that the forecasted PBL height is too low compared to observations (Figure 10). In the section 4, we presented the results of a single 5-day forecast starting on October 16. However, the ensemble of forecasts (starting on October 11-22) reveals various features.

- The ECMWF model shows a steady PBL with no significant decrease or increase of the inversion height.
- The NCAR and NCAR-UW forecasts show 2 typical behaviors: either the PBL is maintained or it collapses, while the observations during the same period do not show any shallowing of the PBL. Climate runs with the NCAR model also show an inability to maintain the proper PBL depth.
- The GFDL forecasts have periods during which the boundary layer becomes shallower. The collapse is less dramatic than in the NCAR forecasts but it is more pronounced than the ECMWF ones.

Role of omega in the collapse of the PBL

SCM simulations with the NCAR model shows that the vertical pressure velocity is one of the determinant factors in the maintaining/shallowing of the PBL height (Figure 11).

Correlation between PBLH and LHFLX

The NCAR model decently represents the latent heat flux. However, the correlation between latent heat flux and boundary layer height in the NCAR model is stronger than in the observations (Figure 12).
3. Models and forecast framework

Models
We use the following models:
- the ECMWF model with the MK PBL scheme (a combined Mass-flux/K-diffusion scheme)
- the GFDL model
- the NCAR model: which uses Holtslag-Boville (1993) for the boundary layer and Hack (1994) for the shallow convection.
- the NCAR-UW model: similar to the NCAR model but with different parameterizations of PBL and shallow cumulus. It uses the turbulence scheme of Grenier-Bretherton (2001) which includes explicit entrainment at the top of the PBL coupled with a shallow cumulus scheme which includes the determination of cloud-base mass flux based on surface layer turbulent kinetic energy (TKE) and convective inhibition near the cloud base.

Forecast framework
In the CAPT protocol, we realistically initialize the model with analyses and we then run the model in forecast mode to determine the drift from the analyses and/or available field data. This method allows us to diagnose model parameterization deficiencies (Figure 5).

4. Forecasts for the EPIC Period
We initialize the models (NCAR, NCAR-UW, ECMWF and GFDL) with the ECMWF MK analyses for every day of the period October 11-22, 2001. For each initialization, we run the model for 5 days obtaining an ensemble of forecasts with various features. As an illustration, we present the forecasts starting on October 16 at 12 UTC and we compare the 5-day forecasts with observations (Figure 6-9).