Drizzling low clouds at Graciosa Island - how does the ECWMF model perform?

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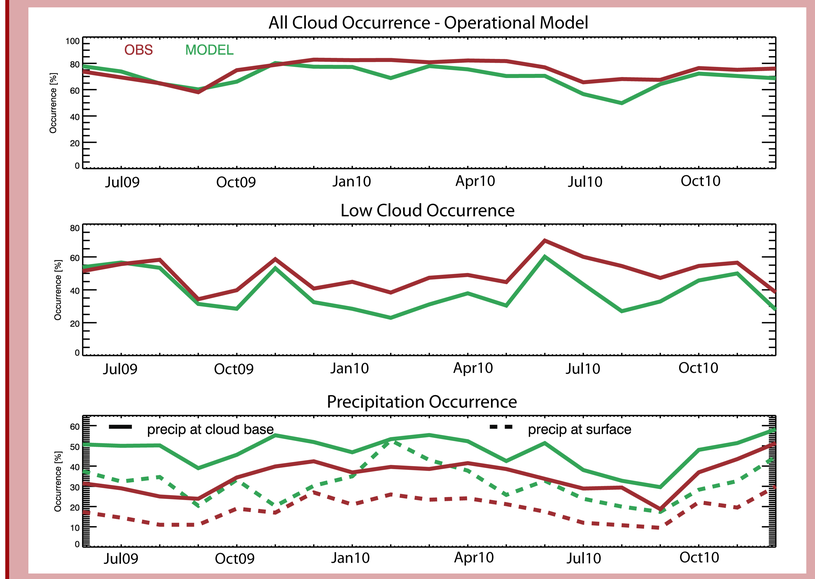
1 Monthly Cloud and Precipitation Occurrence

The ARM Mobile Facility was stationed on Graciosa Island in the Azores for 19 months. A review of the observations (Remillard et el. 2012) reveals that low clouds (cloud top ≤ 3km) are the most commonly observed cloud type. Clouds also frequently produce precipitation, though only a fraction of the precipitation (1/2 to 2/3) reaches the surface.

In comparison, the **ECMWF model underestimates low cloud occurrence**, which is also reflected in the total cloud occurrence. **Precipitation is produced too frequently**, and a larger proportion of the precipitation reaches the surface, particularly in winter when precipitation intensity is greater.



Overall cloud occurrence slightly too low

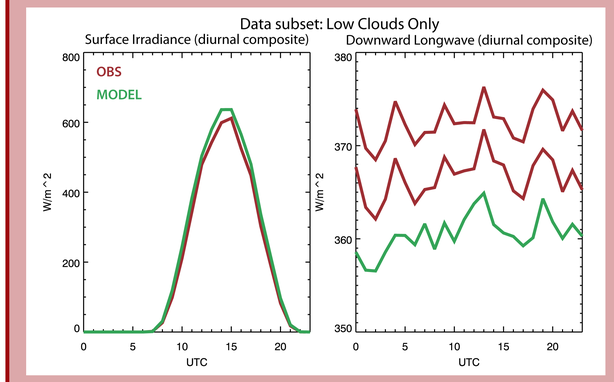
Low cloud occurrence too low, but month-to-month variability well captured

Precipitation occurrence too high at cloud base and the surface

Observed cloud and precipitation occurrence reproduced from Remillard et al. (2012)

Surface Radiation and Liquid Water Path

A look at the surface downward radiation reveals that **surface irradiance is overestimated**, and downward longwave radiation underestimated. This error stems primarily from low clouds and is evident when a subset of the data containing only samples with low clouds present is considered.



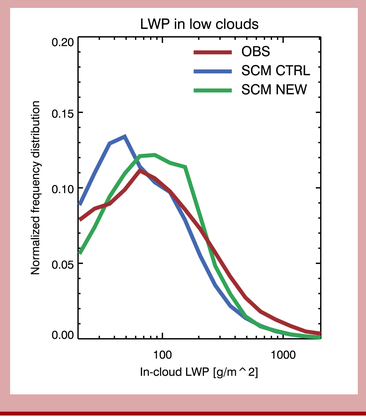
Noise in diurnal composite is due to subsetting procedure - individual samples do not necessarily come from consecutive hours.

Two measurements are available for downward longwave radiation, which are offset by about 6 W m^{-2}. However, the model's radiation is underestimated against either observational record.

2

The error in surface radiation associated with low clouds has several causes: The model often underestimates cloud fraction and produces broken low clouds when overcast conditions are observed. In addition, liquid water path (LWP) is underestimated in overcast low clouds.

The model produces clouds with low liquid water path too frequently, and underestimates the occurrence of clouds with higher LWP.



Single Column Model Experimentation

To address the model errors in cloud and precipitation occurrence, as well as cloud liquid water path, a set of new parameterizations are tested in the single column model environment:

- The **boundary layer scheme** is modified to be more consistent with the shallow convection parameterization. This enables the BL scheme to produce overcast clouds more readily.
- The existing Sundqvist **scheme for autoconversion and accretion is replaced** with the Khairoutdinov and Kogan (2000) parameterization. This leads to a more non-linear relationship between LWP and precipitation, and results in higher in-cloud LWP and reduced precipitation occurrence at cloud base.
- The assumptions for the **droplet size spectrum and precipitation evaporation** from Abel and Boutle (2012) are adopted. This increases evaporation of light precipitation below cloud base, and reduces surface precipitation.

3

Results

With the new parameterizations in place, the model's **cloud and precipitation occurrence improve appreciably**. The surface radiation is also in better agreement with observations.

Testing of the parametric changes in the full model is well underway and promising: top of the atmosphere radiation improves, and forecast performance remains good.

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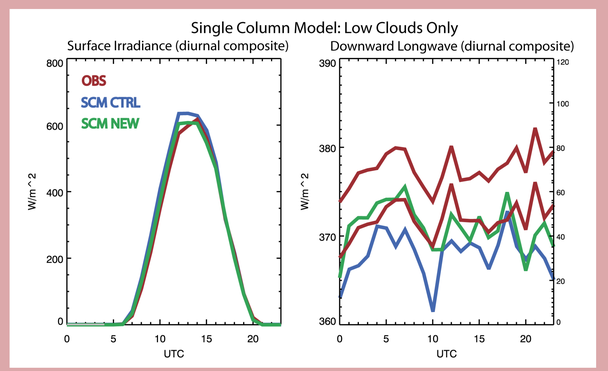

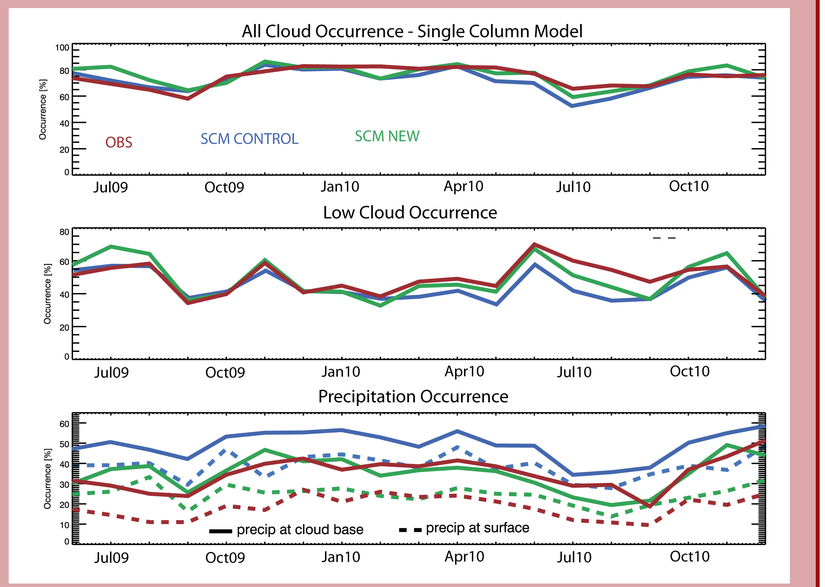

Better agreement in cloud and precipitation occurrence, and surface radiation with new parameterizations in the SCM.

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References can be found on the reverse side of the hand-outs.