Interpreting low-cloud climatology using a mixed-layer model

Yunyan Zhang, Bjorn Stevens & Brian Medeiros

LLNL, UCLA
@CMMAP 2008
Low Cloud Fraction and Lower Tropospheric Stability (LTS)

- Strong correlation at seasonal mean
- K-Line (Klein-Line)
- Empirically based parameterization
  - Potential inappropriateness
- Physically based parameterization
  - Representation?
  - What underlies?
Mixed-layer model (Lilly 1968)

\[
\frac{d}{dt} \langle s \rangle = \frac{E (s_+ - \langle s \rangle) + V (s_- - \langle s \rangle) - F_+ + F_0}{h} \quad -\text{Adv}_s
\]

\[
\frac{d}{dt} \langle q \rangle = \frac{E (q_+ - \langle q \rangle) + V (q_- - \langle q \rangle)}{h} \quad -\text{Adv}_q
\]

\[
\frac{dh}{dt} = E + \overline{w}. \quad -\text{Adv}_h
\]

\[W = D^*h\]

Entrainment using LL98 + windshear

• Pursue equilibrium solutions at domains \(D > 0.5\times10^{(-6)} \text{/s}\) and \(h_e < 2000\text{m}\)

• Boundary condition from ERA-40 (at each T85 grid point) averaged at various time scales: 90 days (seasonal mean) to 1 day (daily mean)
Low Cloud Fraction and Lower Tropospheric Stability (LTS)
• Mixed layer model is able to represent low cloud fraction climatology when incorporating synoptic variability of divergence
Divergence vs. Low cloud fraction
LTS vs. Low cloud fraction
remarks

• Low cloud fraction responds to divergence nonlinearly, sampling the full distribution of divergence is important

• This also makes simulations least susceptible to model bias

• Low cloud fraction responds to LTS almost linearly, and most of its variability at daily time scale has been represented at seasonal time scale
Low Cloud Fraction and Lower Tropospheric Stability

![Graph showing the relationship between Low-Cloud Fraction (%) and ERA-40 LTS (K). The graph includes data points for Peru, Namibia, California, Australia, Canary, and China.]
Low Cloud Fraction and Lower Tropospheric Stability
Remarks

• The relationship holds well in certain regimes but might be inappropriate outside.
The end