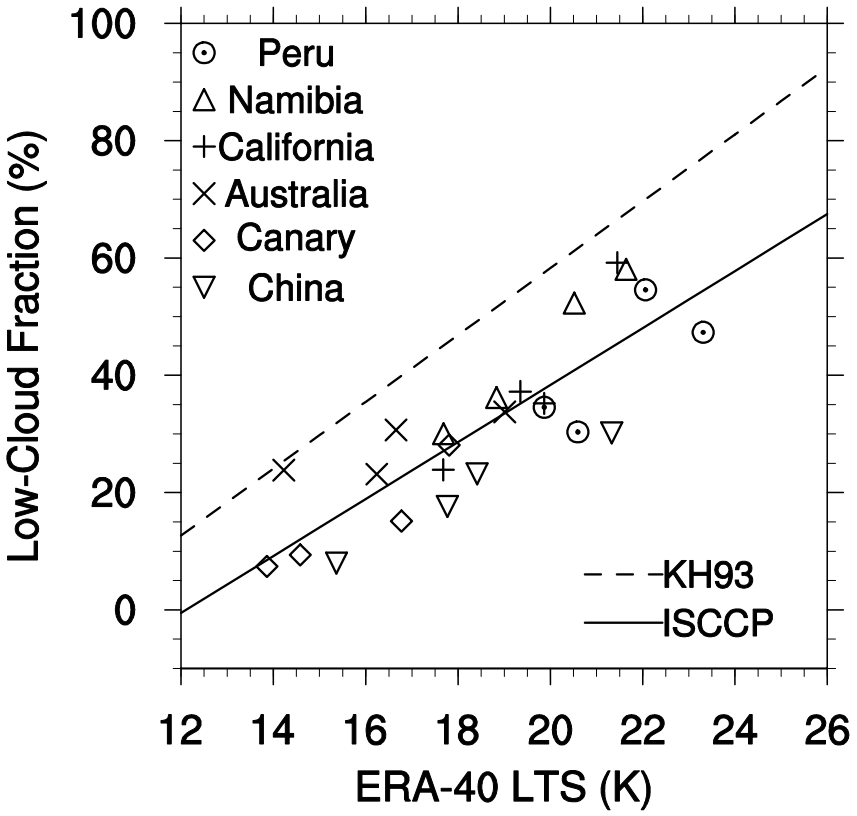
Interpreting low-cloud climatology using a mixed-layer model

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)

$$\frac{d}{dt}\langle s\rangle = \frac{E\left(s_+ - \langle s\rangle\right) + V\left(s_- - \langle s\rangle\right) - F_+ + F_0}{h} \qquad \text{-Adv\_s}$$

$$\frac{d}{dt}\langle q\rangle = \frac{E\left(q_+ - \langle q\rangle\right) + V\left(q_- - \langle q\rangle\right)}{h} \qquad \text{-Adv\_q}$$

$$\frac{dh}{dt} = E + \overline{w}. \qquad \text{-Adv\_h}$$

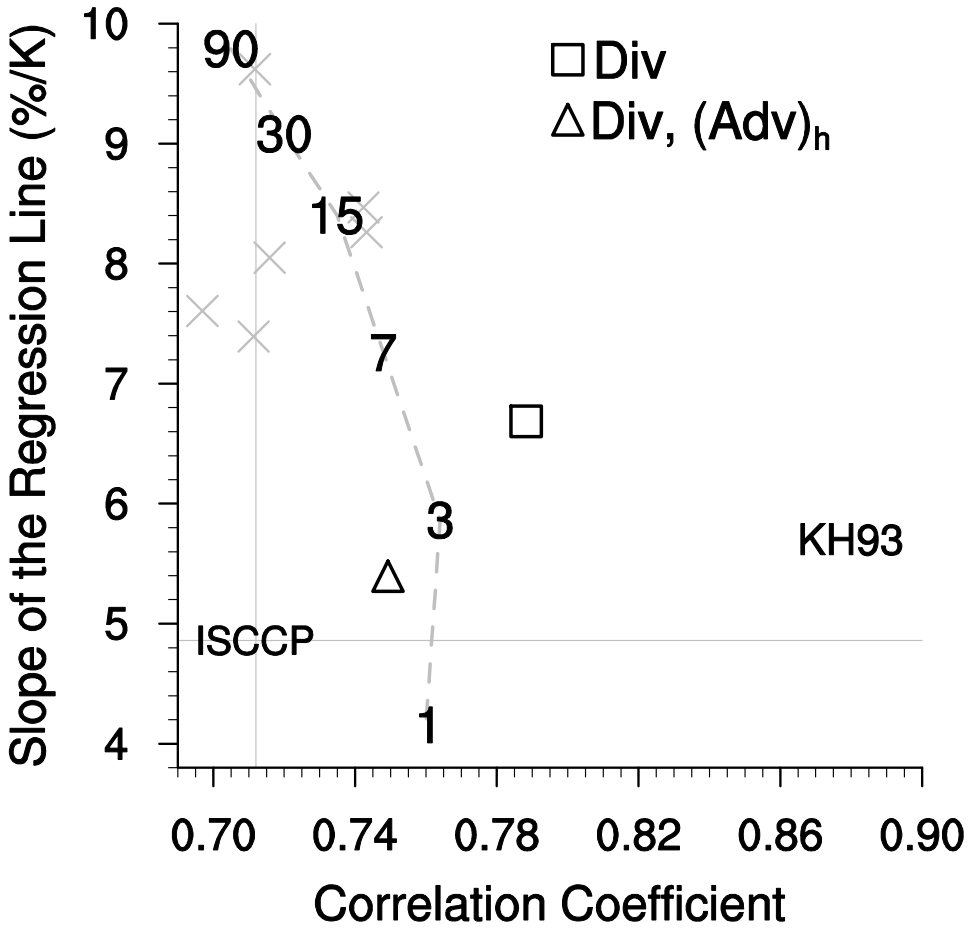
W = D*h

Entrainment using LL98 + windsheer

•Pursue equilibrium solutions at domains D > 0.5*10^(-6) /s and h_e < 2000m

• boundary condition from ERA-40 (at each T85 grid point) averaged at various time scales: 90 days (seasonal mean) to 1 day (daily mean)

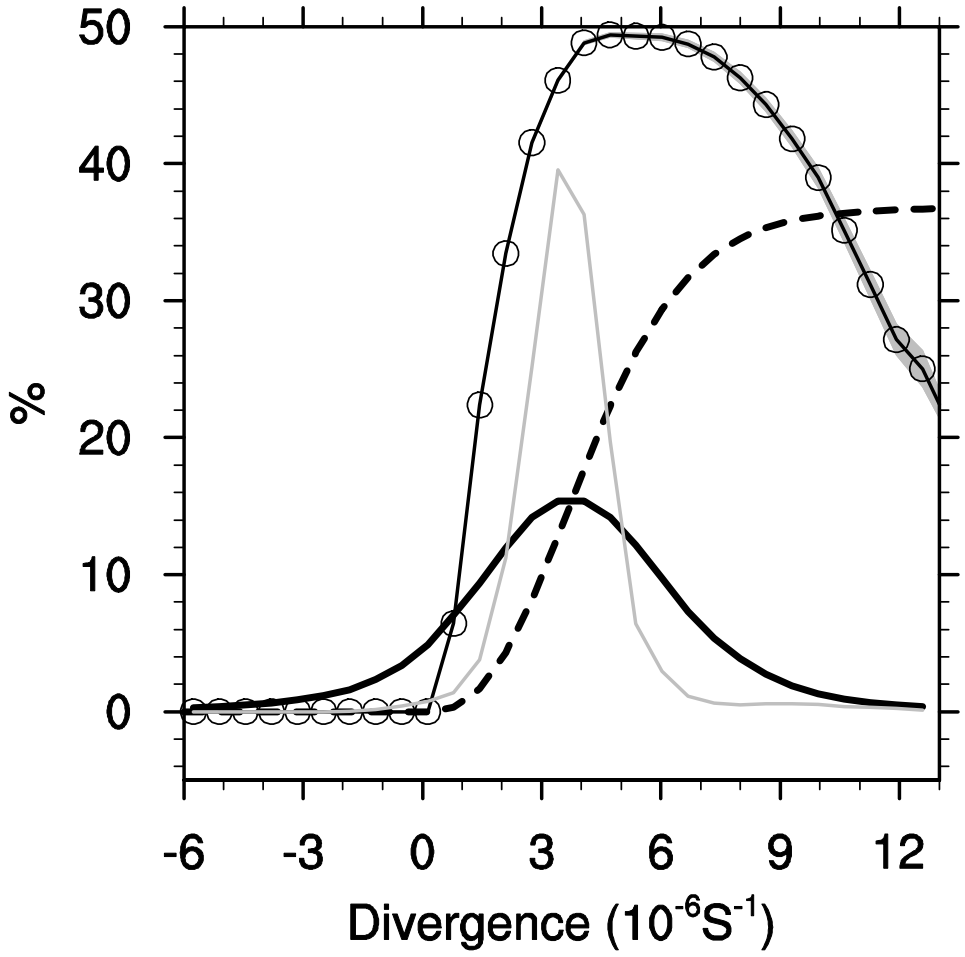
Low Cloud Fraction and Lower Tropospheric Stability (LTS)



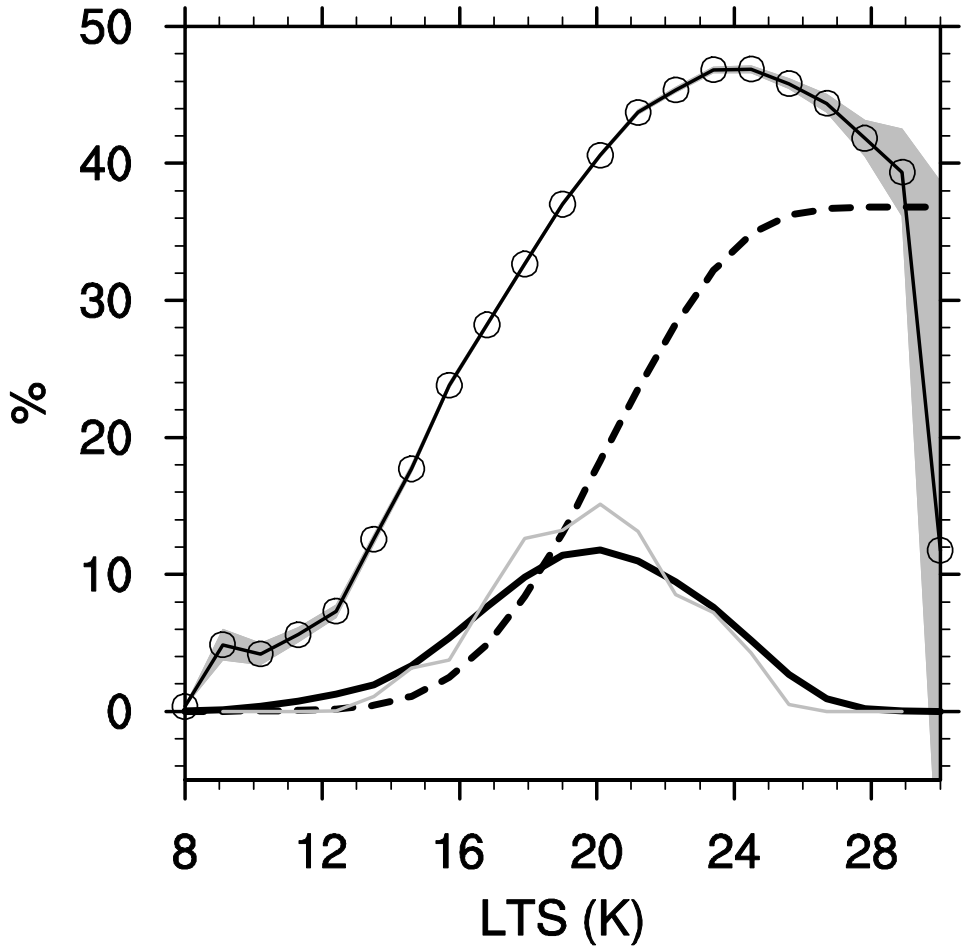
remarks

- Mixed layer model is able to represent low cloud fraction climatology when incorporating synoptic variability of divergence

Divergence vs. Low cloud fraction



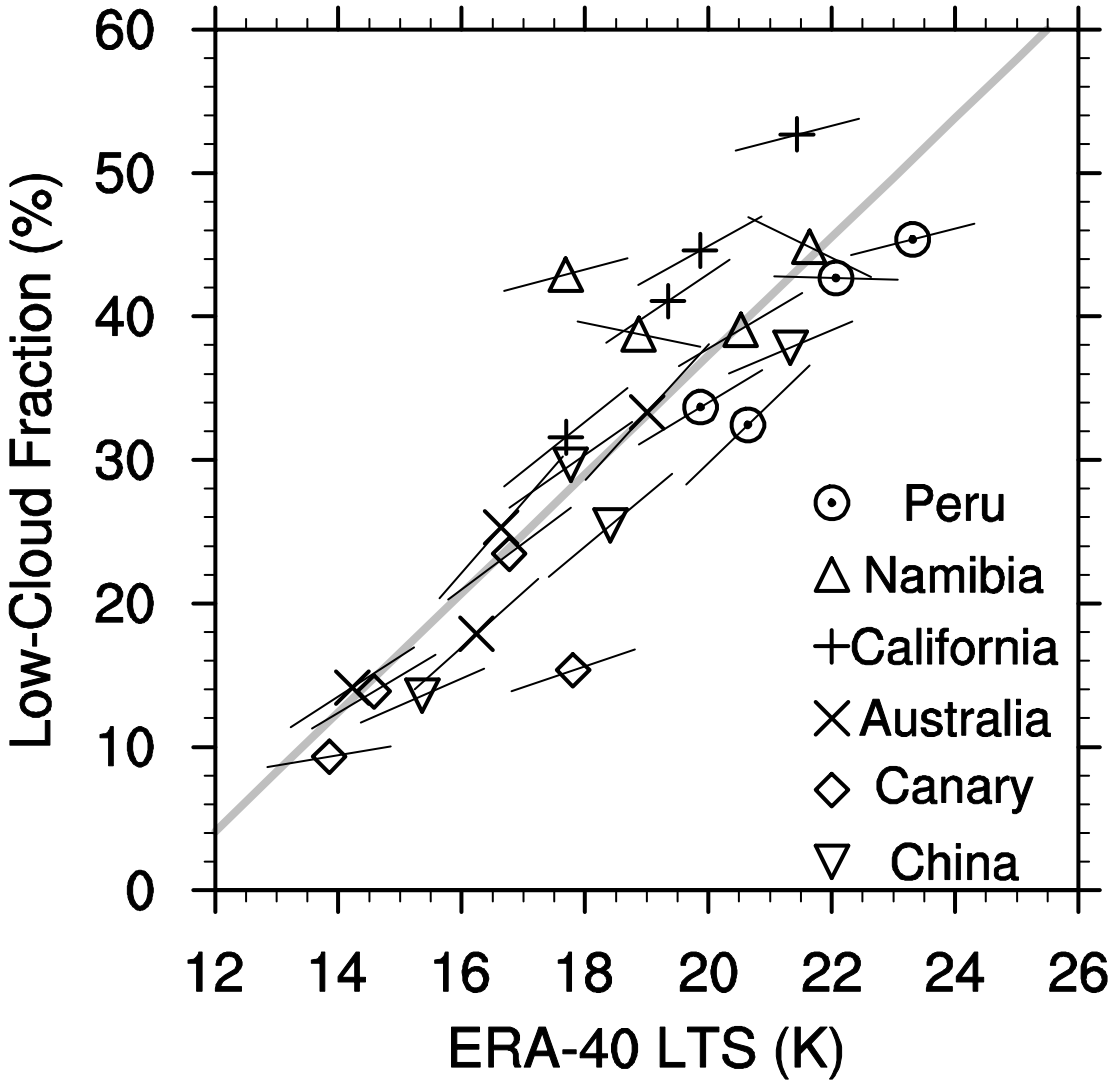
LTS vs. Low cloud fraction



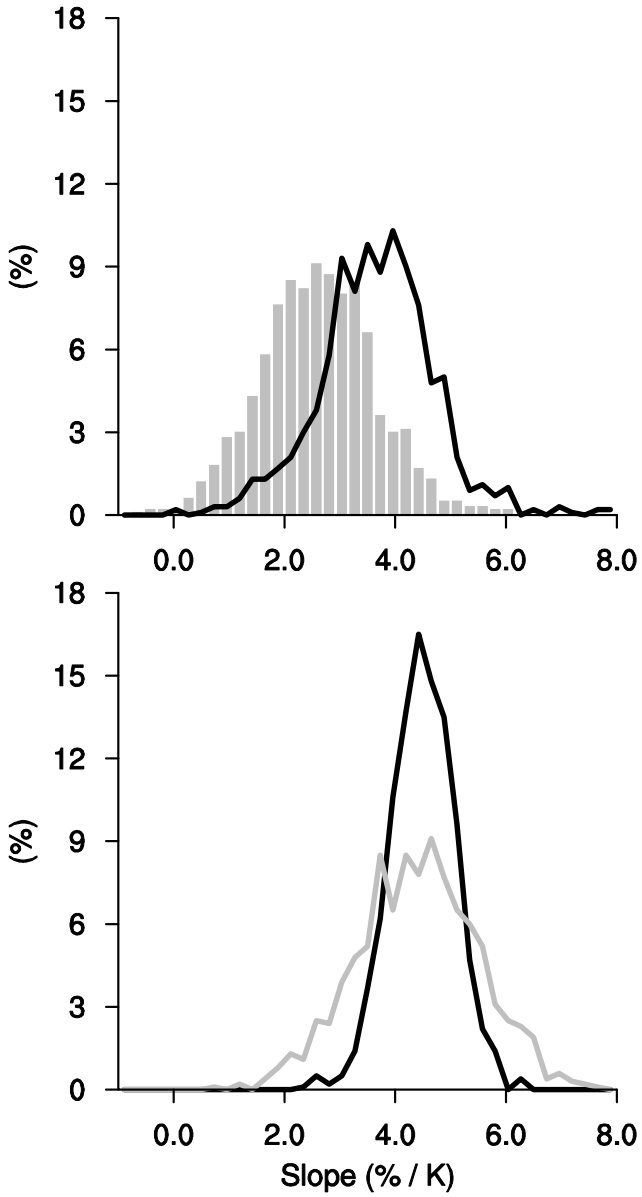
remarks

- 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



Low Cloud Fraction and Lower Tropospheric Stability



remarks

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

The end