Assumed PDF in cloud cover parametrization in GFS

Cloud water and cover in GFS

- Cloud water is prognostic variable
  - Convective detrainment (SAS)
  - Grid-scale condensation (Zhao and Carr, 1997)
- Xu and Randall (1996) (Moorthi-modified from Xu/Randall)

Assumed PDF method

- Assume perfect cloud water and use assumed PDF method and cloud water to calculate cloud cover:
  - Uniform distribution (qt and s)
    - Le Treut and LI (1991) and its variation
  - Triangle distribution (qt and s)
    - Smith (1990) and its variation

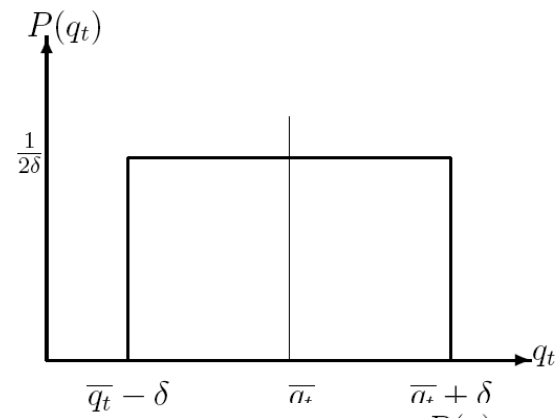
$$C = \int_{q_s}^{\infty} P(q_t) dq_t, \qquad C = \int_{-Q_c}^{\infty} P(s) ds$$

$$\overline{q}_l = \int_{q_s}^{\infty} (q_t - q_s) P(q_t) dq_t, \qquad \overline{q}_l = \int_{-Q_c}^{\infty} (Q_c + s) P(s) ds$$

Uniform distribution

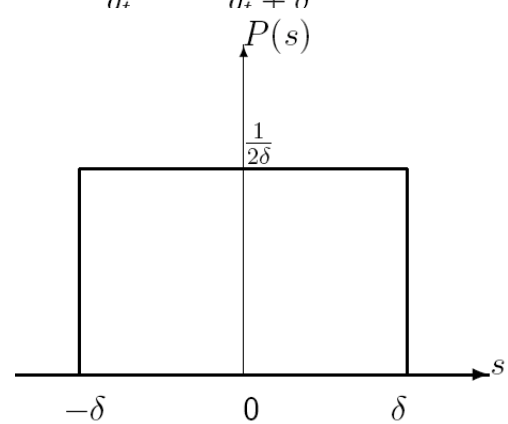
- Qt (total water)(u)

$$C = \begin{cases} \frac{1}{1+(\frac{q_s-\overline{q_v}}{\overline{q_l}})^{\frac{1}{2}}} & ; q_l > 0 \\ 0 & ; q_l = 0 \end{cases}$$



- s (defined by Smith 1990)(su)

$$C = \begin{cases} 0 & ; \overline{q}_l = 0 \\ \frac{1}{1+\sqrt{1-\frac{Q_c}{\overline{q}_l}}} & ; \overline{q}_l > 0 \text{ and } \overline{q}_l \neq Q_c \\ 1 & ; \overline{q}_l \leq Q_c \end{cases}$$



$$s = a_L(q_t' - \alpha_L T_l')$$

$$Q_c = a_L\{\overline{q}_t - q_s(\overline{T}_l, p)\}$$

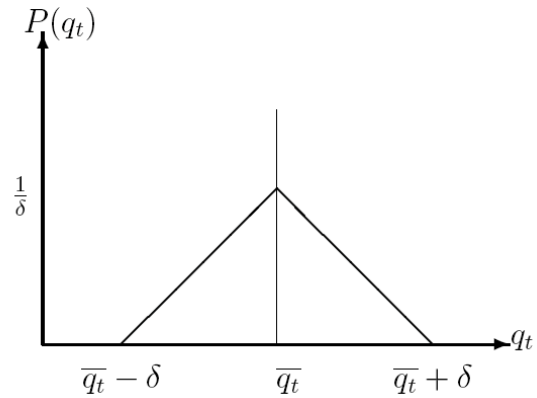
$$\alpha_L = \frac{\partial q_s}{\partial T}\Big|_{T=\overline{T}_l}$$

$$a_L = \frac{1}{1 + \frac{L\alpha_L}{C_p}}$$

Triangle distribution

- Qt (total water) (δ is function of $\overline{q}_l$) (t)

$$C = \begin{cases} 0 & ; q_s > \overline{q}_t + \delta \\ \frac{1}{2\delta^2}(\overline{q}_t + \delta - q_s)^2 & ; \overline{q}_t \leq q_s \leq \overline{q}_t + \delta \\ 1 - \frac{1}{2}(\frac{q_s - \overline{q}_t}{\delta} - 1)^2 & ; \overline{q}_t - \delta \leq q_s \leq \overline{q}_t \\ 1 & ; q_s \leq \overline{q}_t - \delta \end{cases}$$

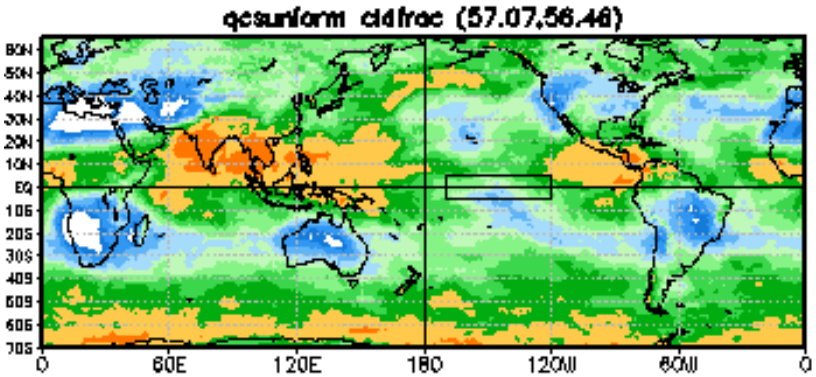


- S (Smith1990)(st)

$$C = \begin{cases} 0 & ; Q_N \leq -\sqrt{6} \\ \frac{1}{2}(1 + \frac{Q_N}{\sqrt{6}})^2 & ; -\sqrt{6} < Q_N \leq 0 \\ 1 - \frac{1}{2}(1 - \frac{Q_N}{\sqrt{6}})^2 & ; 0 < Q_N \leq \sqrt{6} \\ 1 & ; \sqrt{6} \leq Q_N \end{cases} \quad \overline{q}_l = \begin{cases} 0 \\ (1 + \frac{Q_N}{\sqrt{6}})^3/\sqrt{6} \\ Q_N + (1 - \frac{Q_N}{\sqrt{6}})^3/\sqrt{6} \\ Q_N \end{cases}$$

Off-line test results (1) total cloud (t382, new physics, monthly mean)

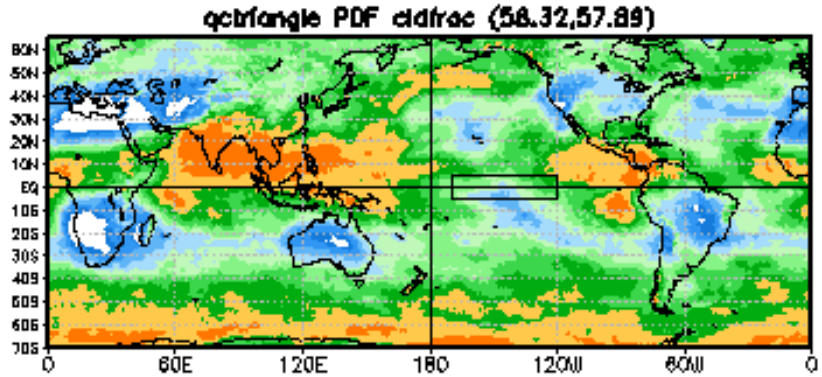
su



30S–30N: 0.769
60S–60N: 0.801

30S–60S: 0.854
30N–60N: 0.860

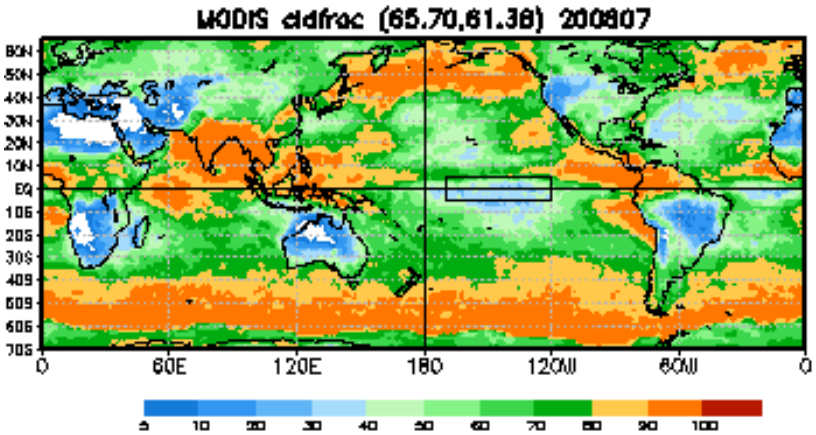
st



30S–30N: 0.781
60S–60N: 0.800

30S–60S: 0.855
30N–60N: 0.876

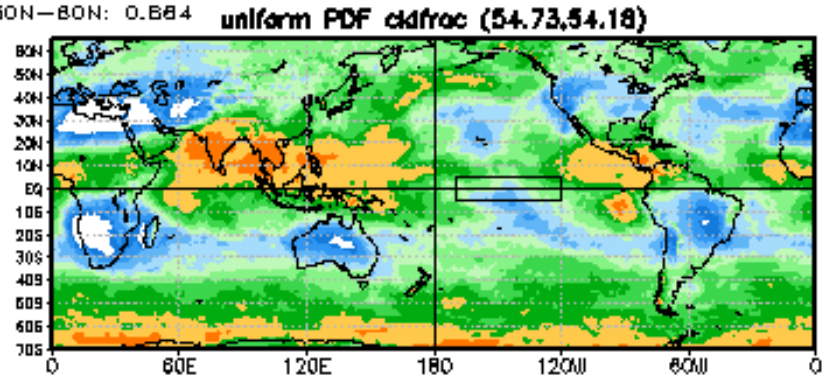
obs



30S–30N: 0.770
60S–60N: 0.789

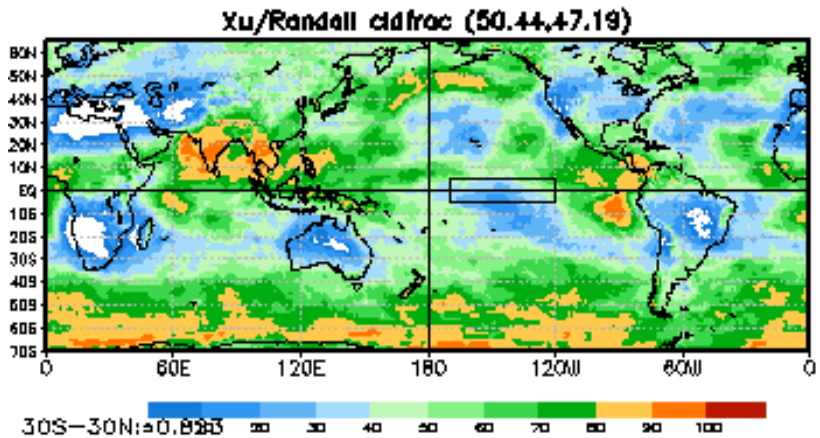
30S–60S: 0.849
30N–60N: 0.864

u

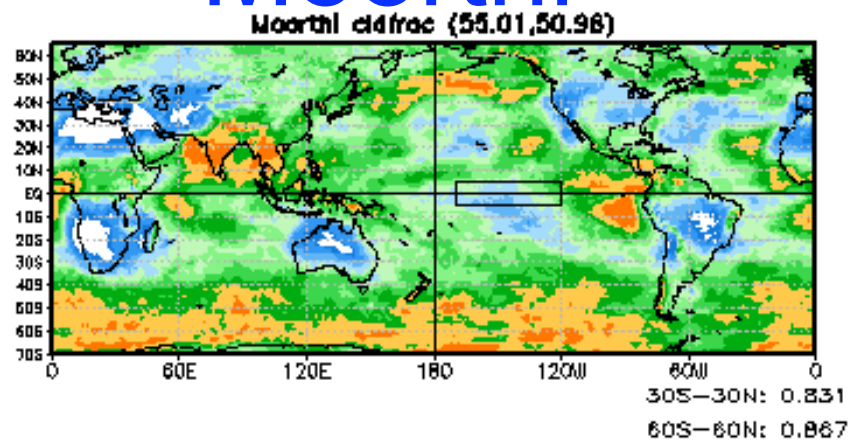


Off-line test results (2) total cloud

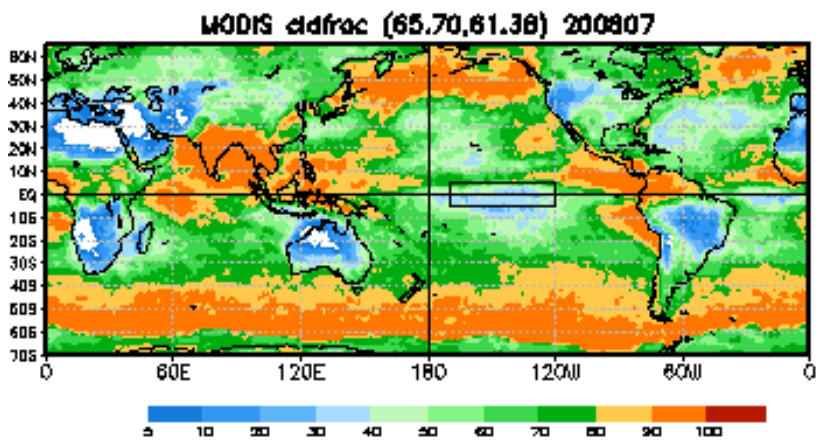
Xu/Randall



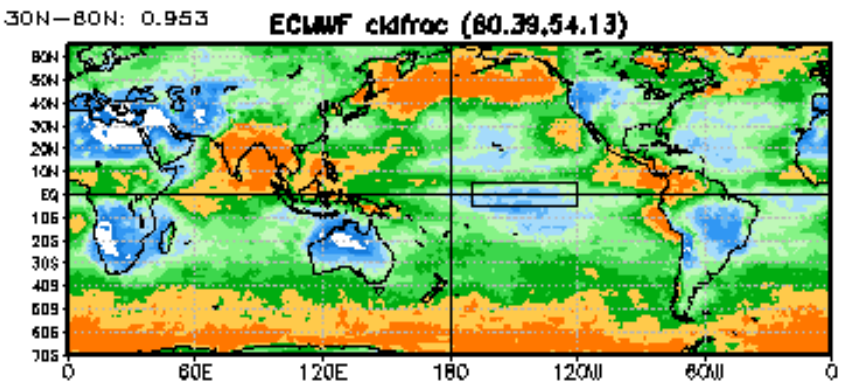
Moorthi



obs



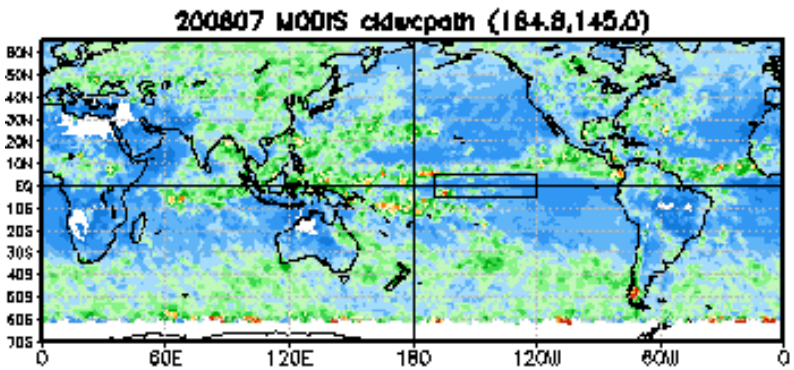
EC



30S–30N: 0.929
60S–60N: 0.936
global: 0.855
30S–60S: 0.898
30N–60N: 0.953

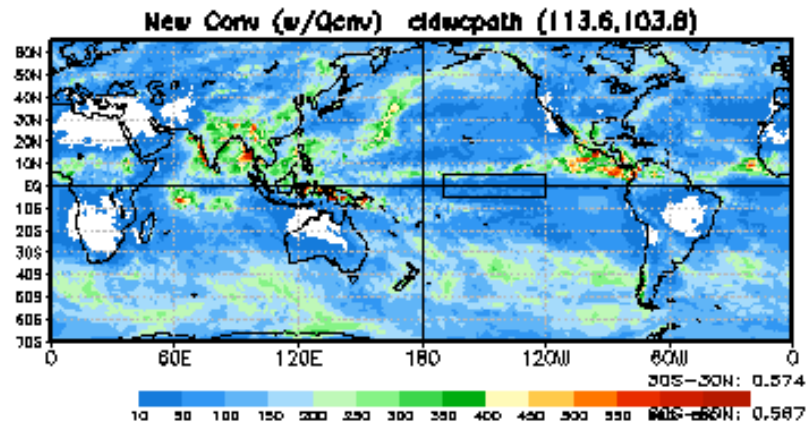
Off-line test results: cloud water Path

MODIS



30S–30N: 0.447
80S–80N: 0.497
30S–60S: 0.432
30N–60N: 0.365
global: 0.488

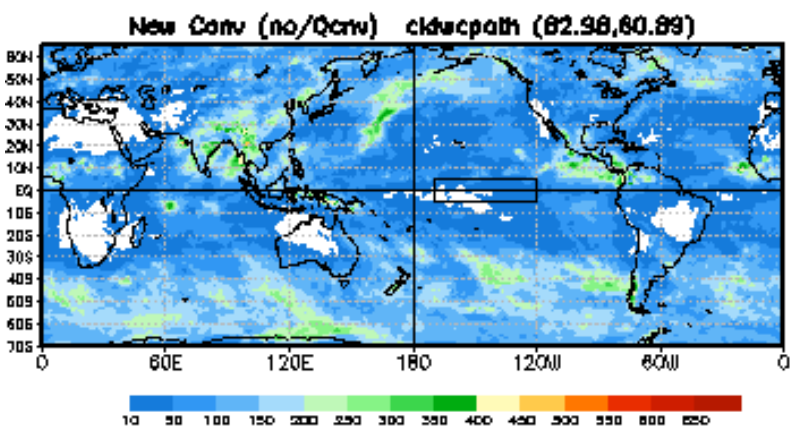
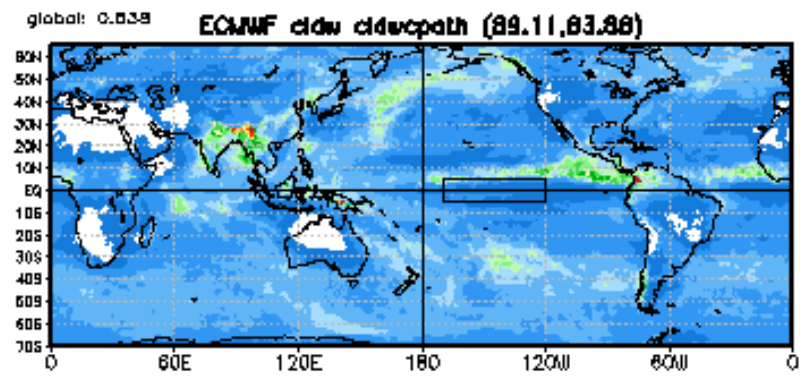
Qconv



30S–30N: 0.812
60S–60N: 0.657
30S–60S: 0.410
30N–60N: 0.318
global: 0.638

30S–30N: 0.574
80S–80N: 0.587
30S–80S: 0.487
30N–60N: 0.443
global: 0.546

No Qconv



EC