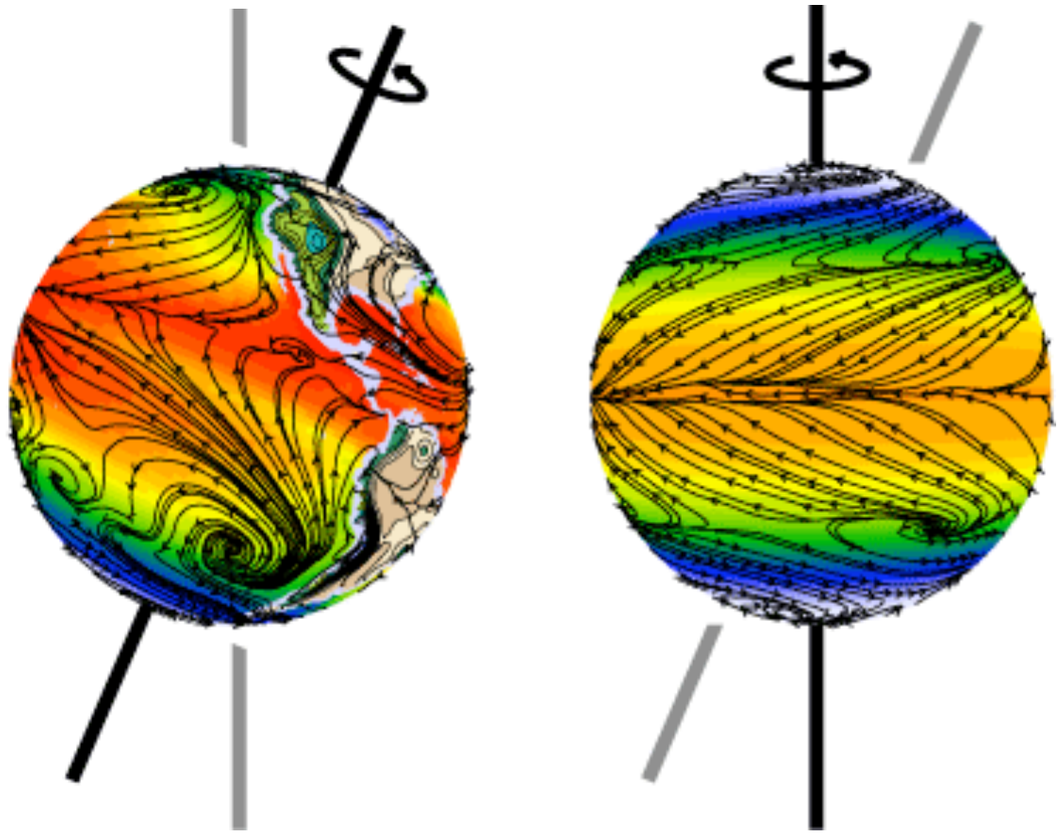
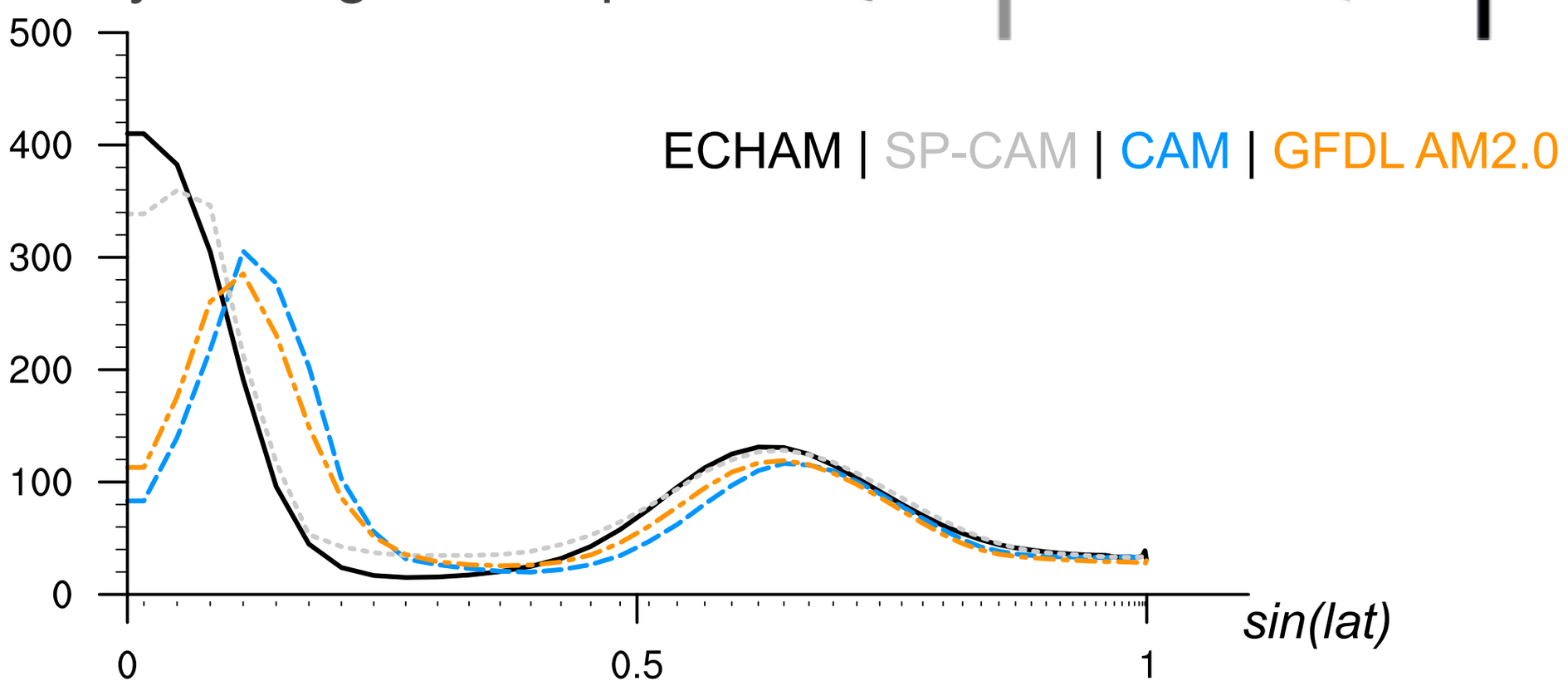
Adventures with ECHAM

Bjorn Stevens

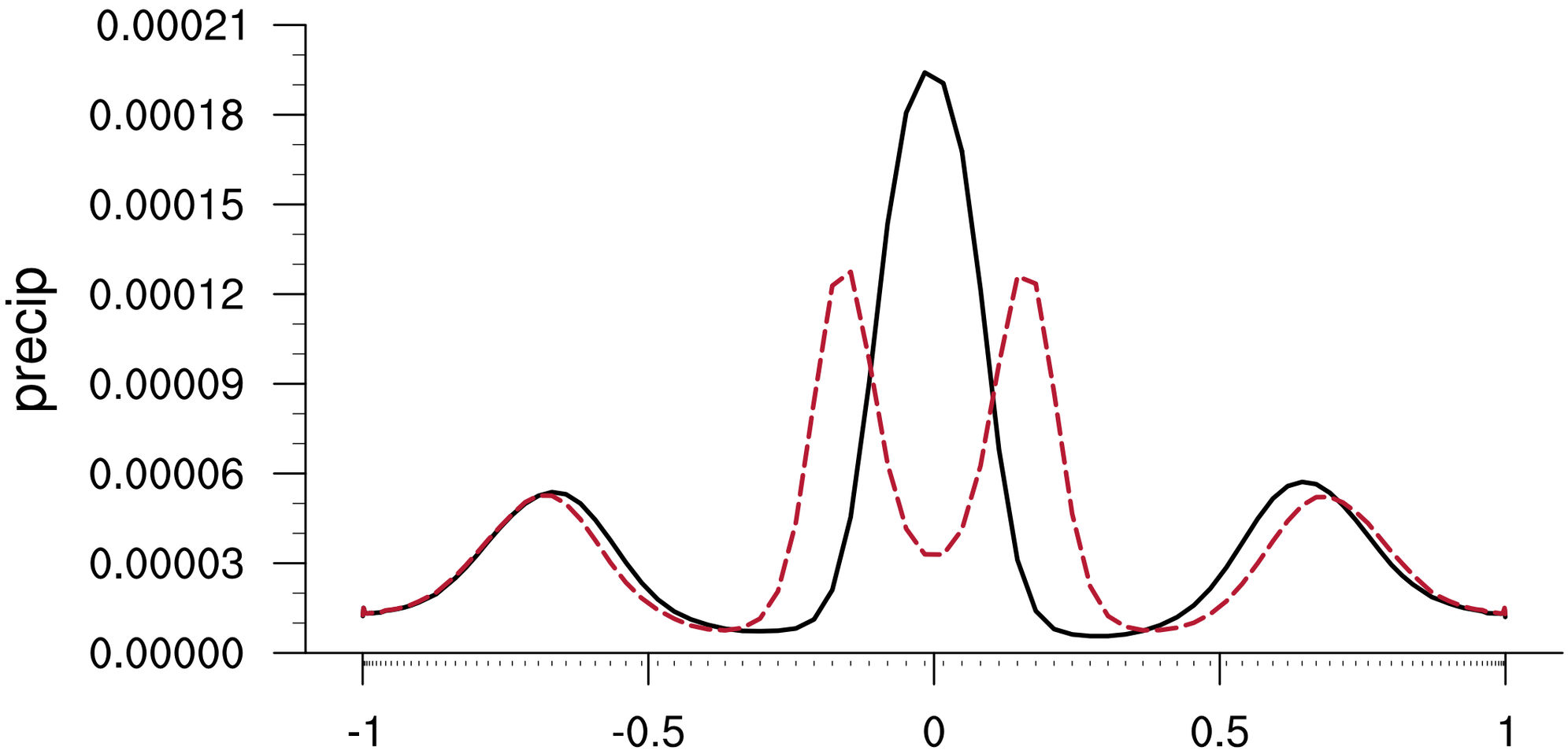
What got me started



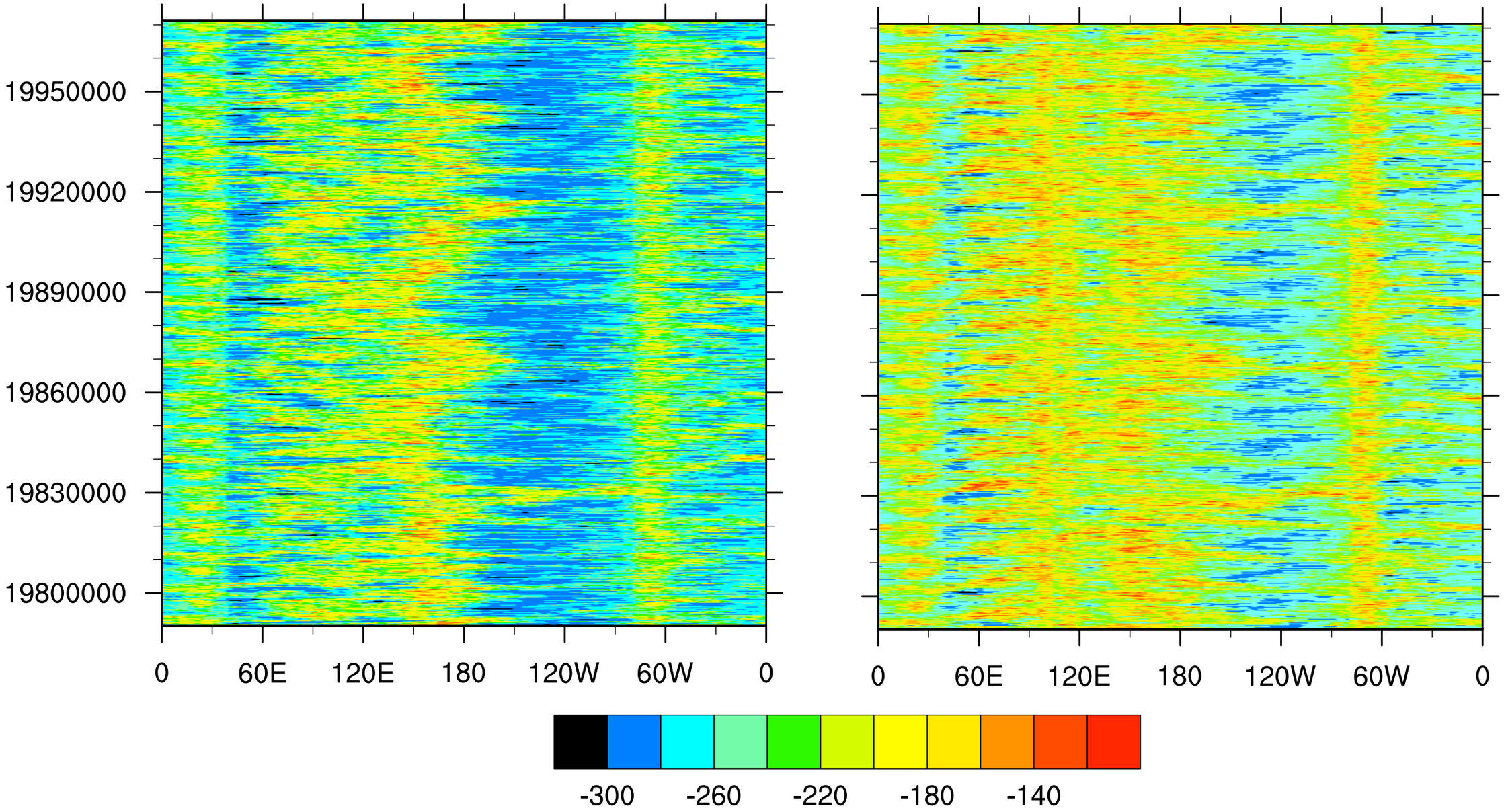
Zonally Averaged Precipitation



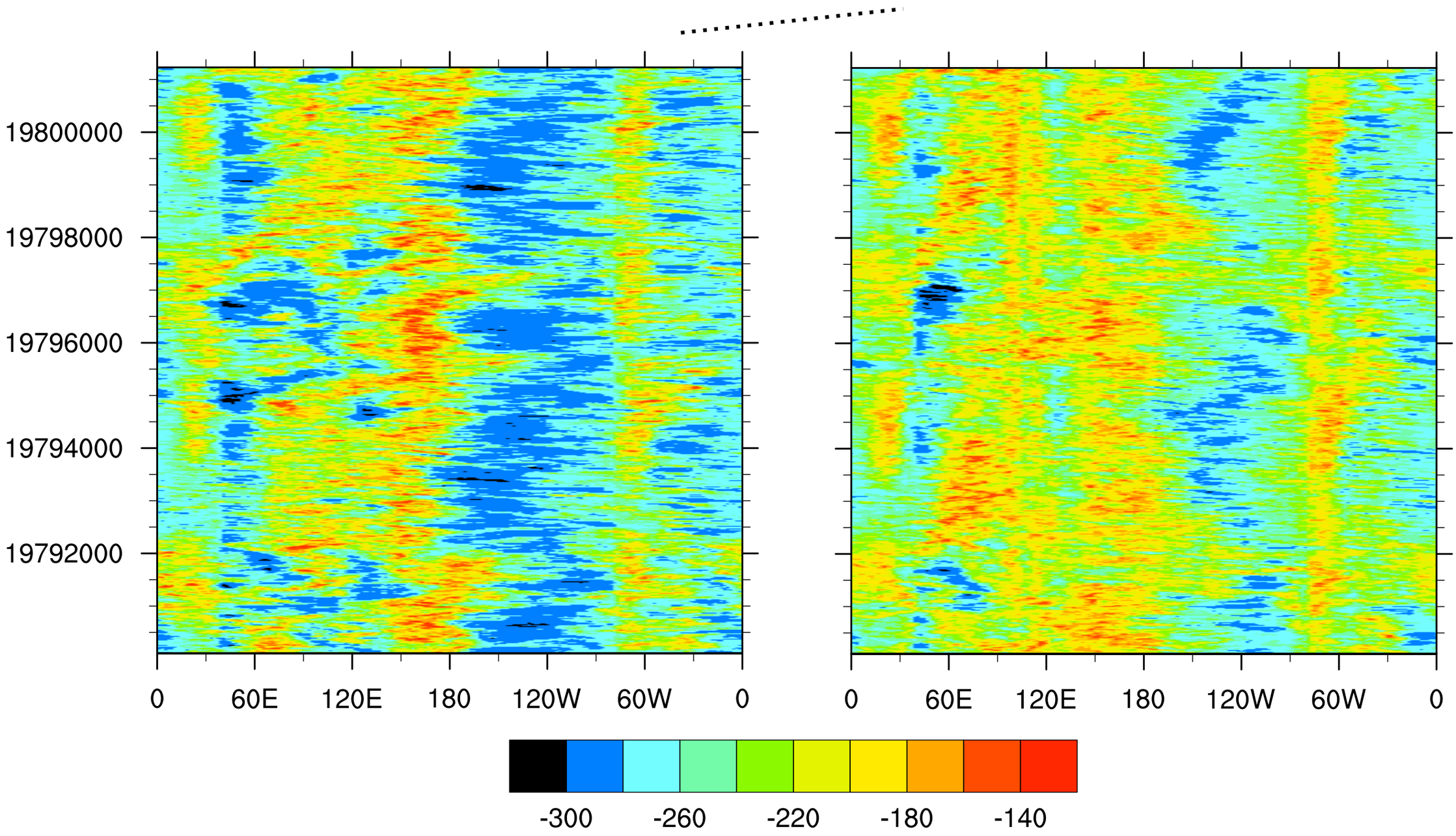
ECHAM Tiedtke versus Classic Tiedtke



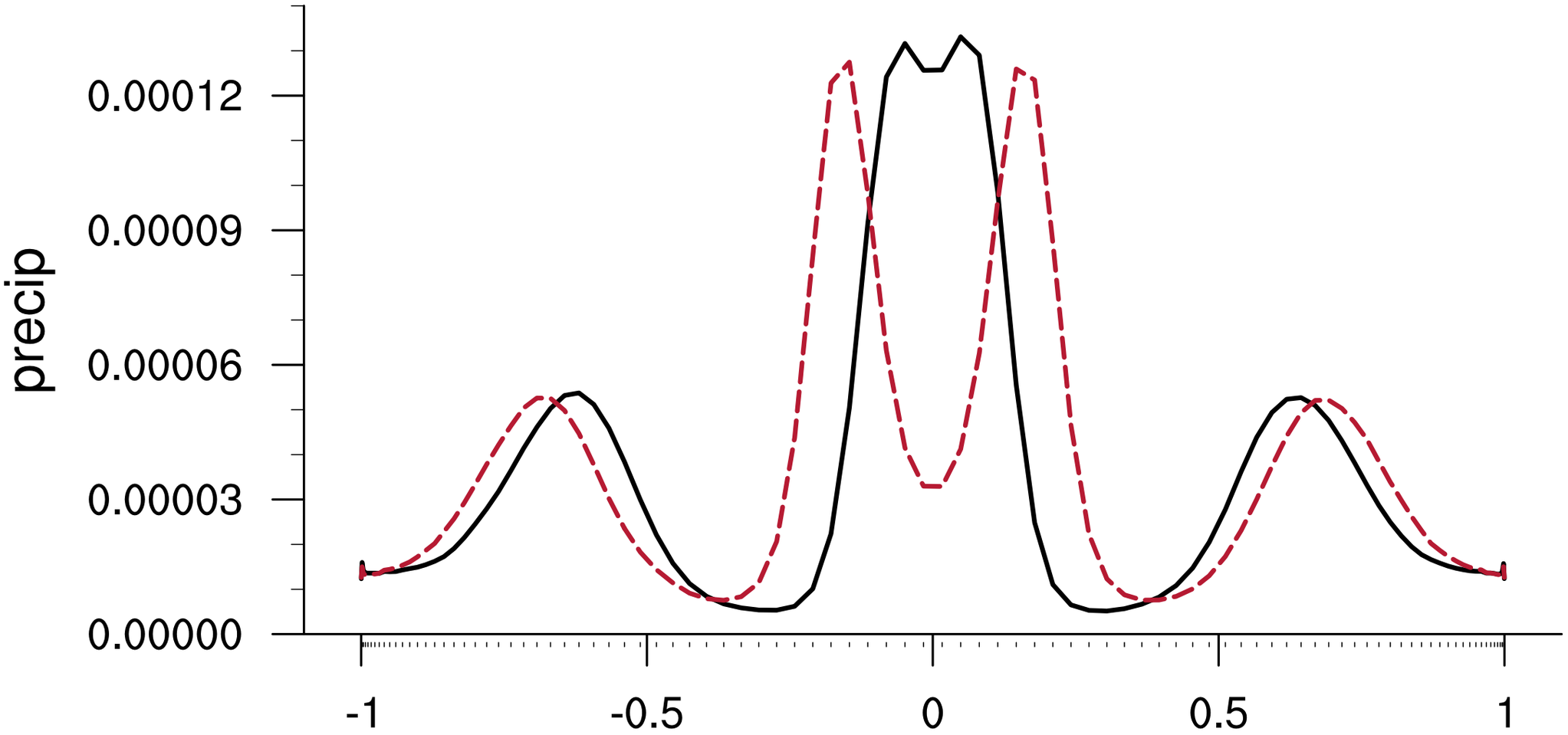
Time-Longitude OLR (15 years AMIP)



Time-Longitude OLR (2 years AMIP)



A hybrid scheme (only CAPE closure) versus Classic Tiedtke



Remarks

Nordeng closure was on the left, and no surprise, making convection harder seems to have nice implications for variability.

Perhaps we have a nice signature of some of the key issues in the Aqua Planet.

The closure (rather than the mixing assumptions) carries most of the difference between pure Tiedtke and what we use in ECHAM.

As an aside ,the climate-change response of convection also depends on closure, i.e., double-ITCZ closures broaden Hadley's cells, single ITCZ closures deepen Hadley's cells.

Designing a New Vertical Coordinate (1/4)

Several Issues:

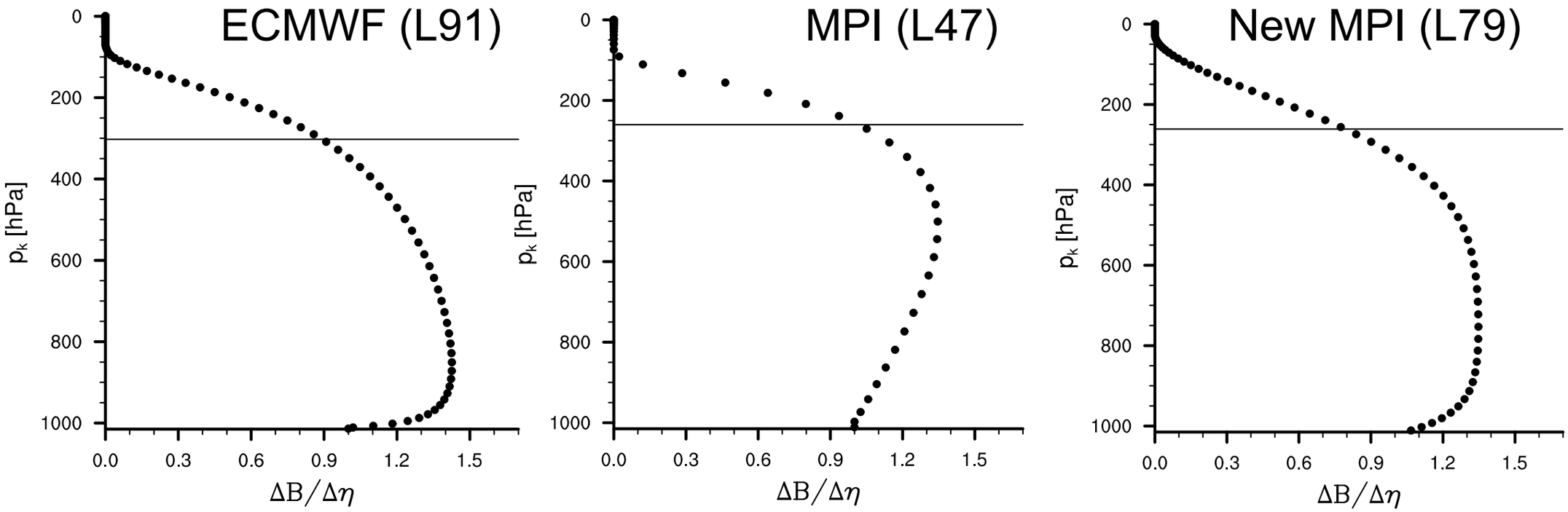
- We want to realize the form of the distribution (rather than manually add or subtract levels).
- Desire finer near surface discretization
- Uniform discretization through troposphere (and possibly to stratopause or higher)
- Would like to control the position of the first mid-point
- Would like to pick a “nice” number of levels to manage cache well.

$$\delta z = z_0 \left[1 - z_* \exp(-z/z_b)\right] + z_1 \left(1 + \tanh\left(\frac{z - z_t}{\delta}\right)\right)$$

where

$$z = H \ln(p_s/p)$$

Designing a New Vertical Coordinate (2/4)



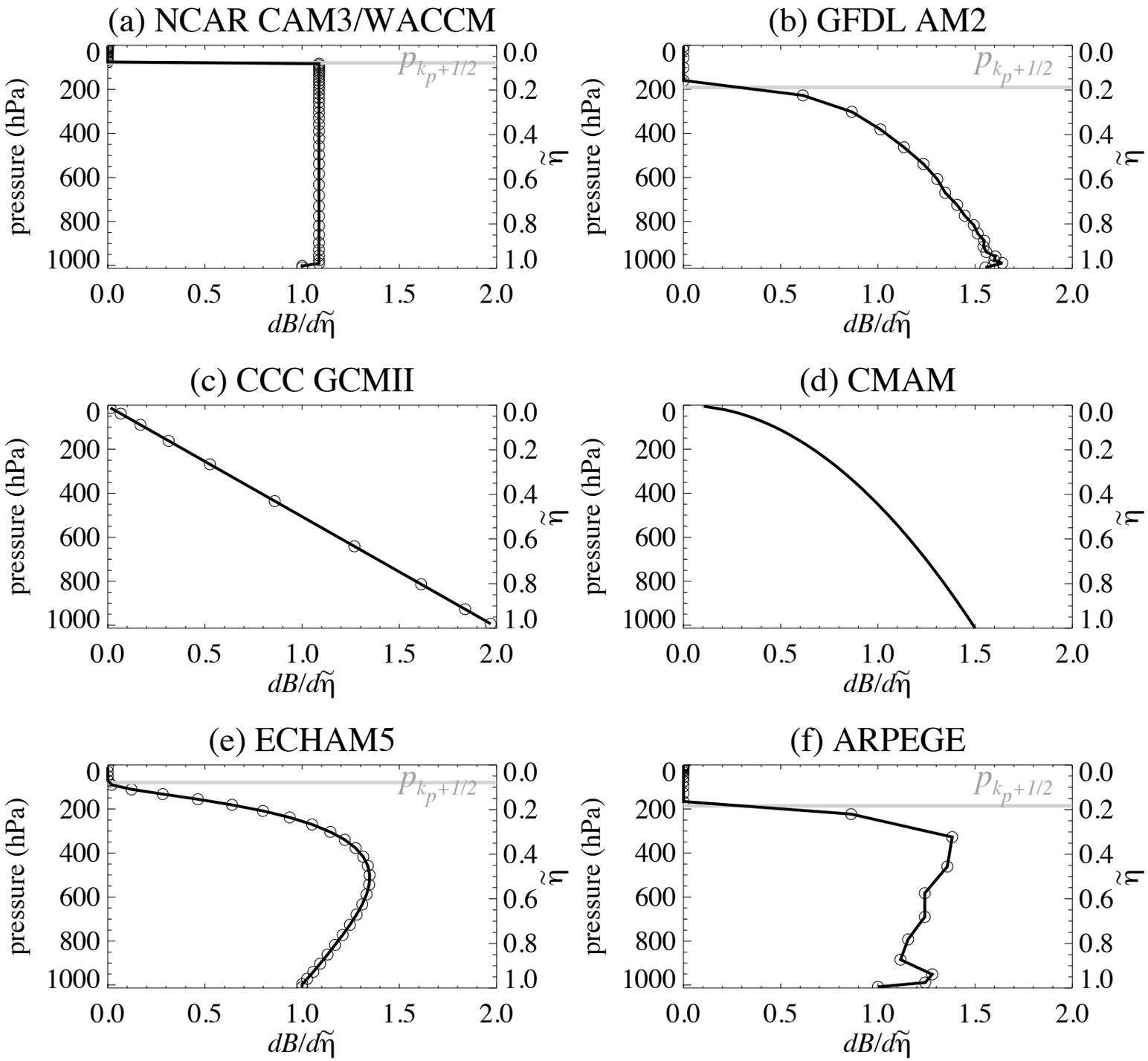
$$\eta = \frac{A}{p_s} + B \quad \text{hence} \quad \Delta\eta = \frac{\Delta A}{p_s} + \Delta B$$

$$\frac{\Delta B}{\Delta \eta} = c_4 \left\{ \frac{1 + c_2}{2} \left[1 + \cos(\pi (c_1 - 1 - x)^{\alpha}) \right] - c_2 e^{-x/c_3} \right\}$$

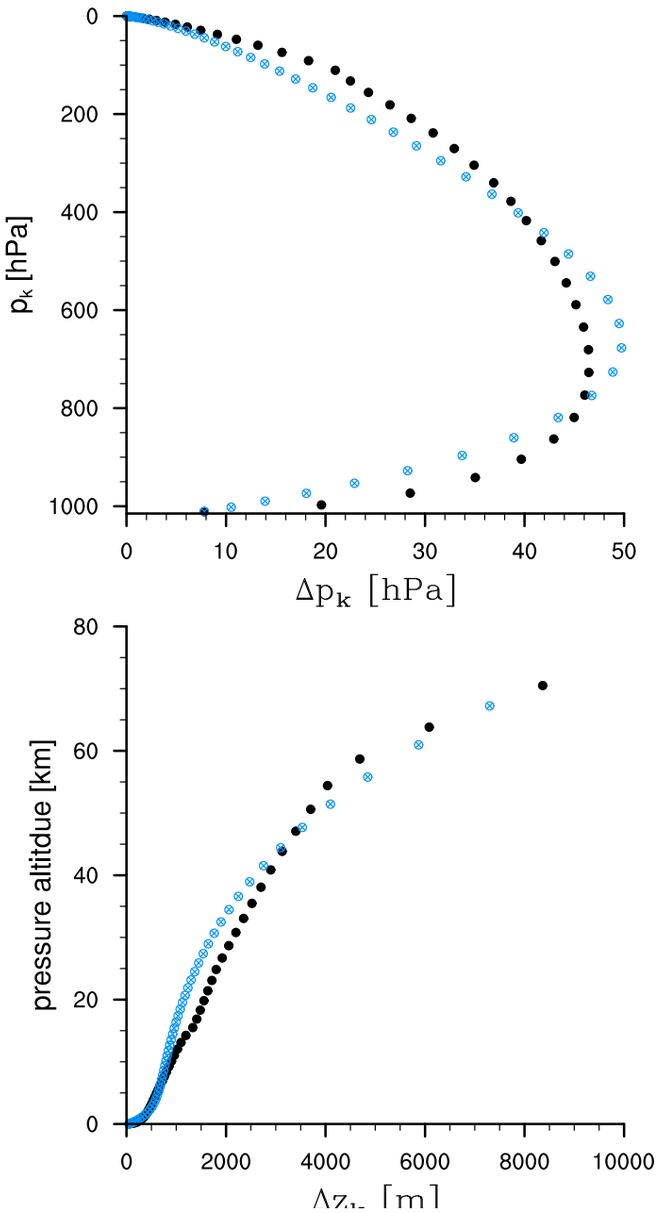
where

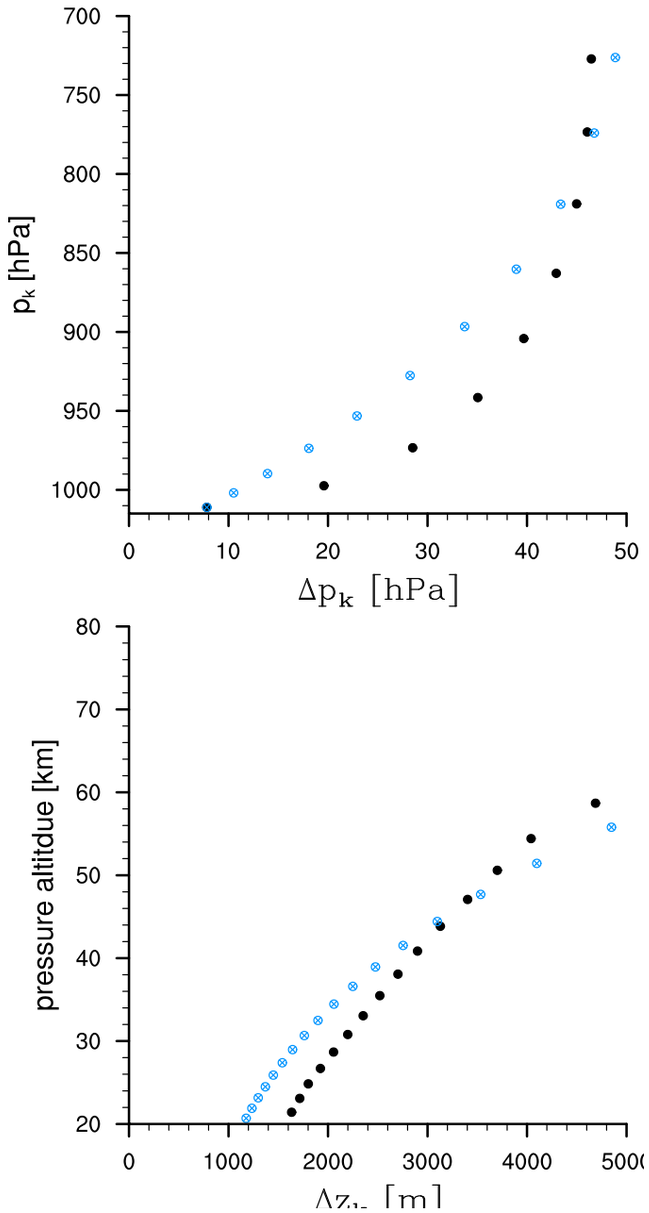
$$x = 1 - \eta$$

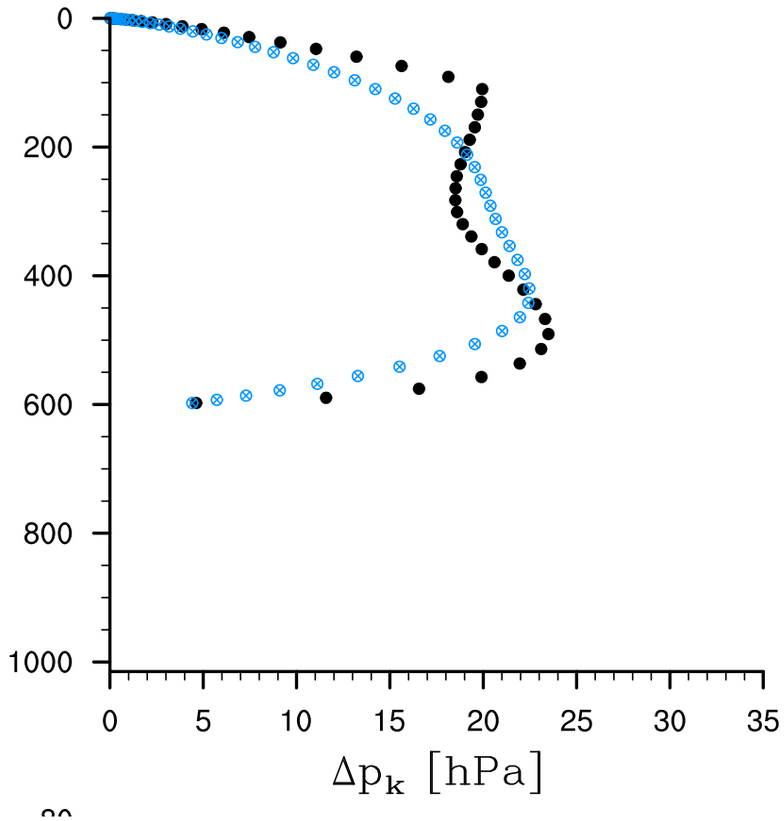
Designing a New Vertical Coordinate (3/4)



Designing a New Vertical Coordinate (4/4)

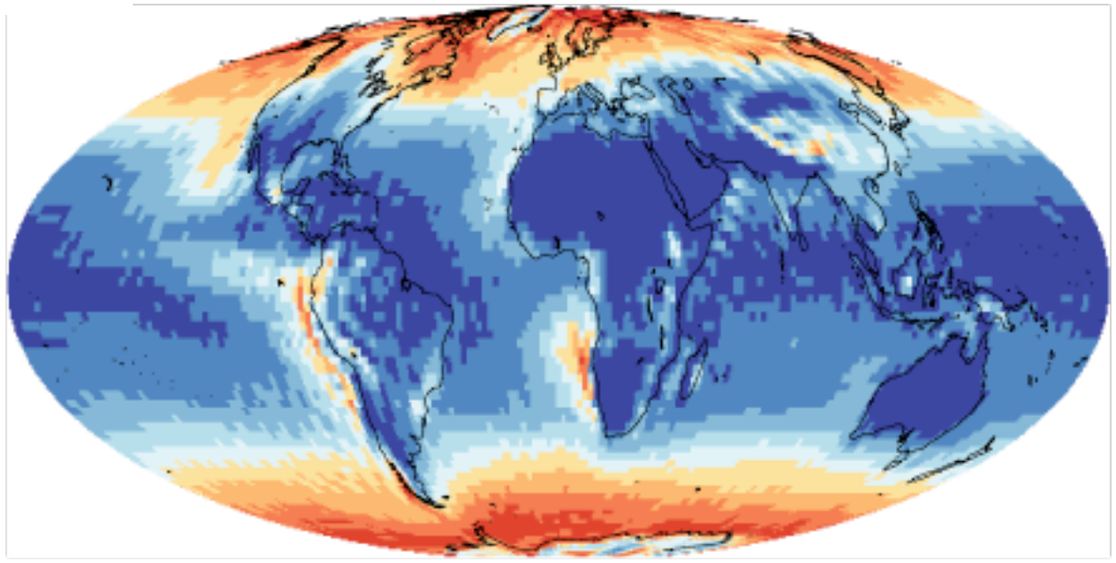




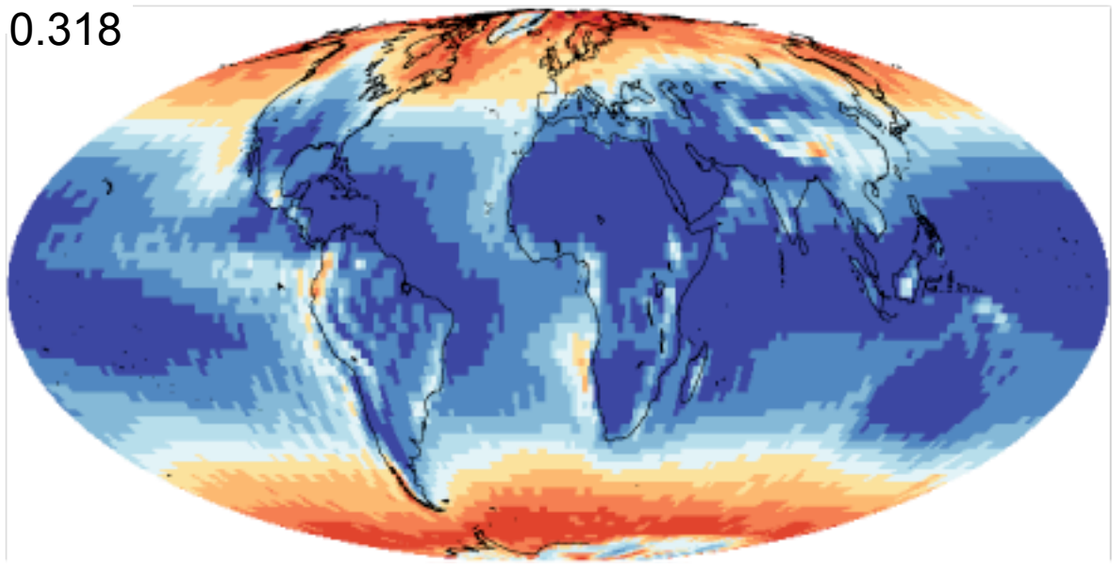


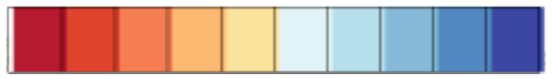
Control — Low Cloud Amount

0.320

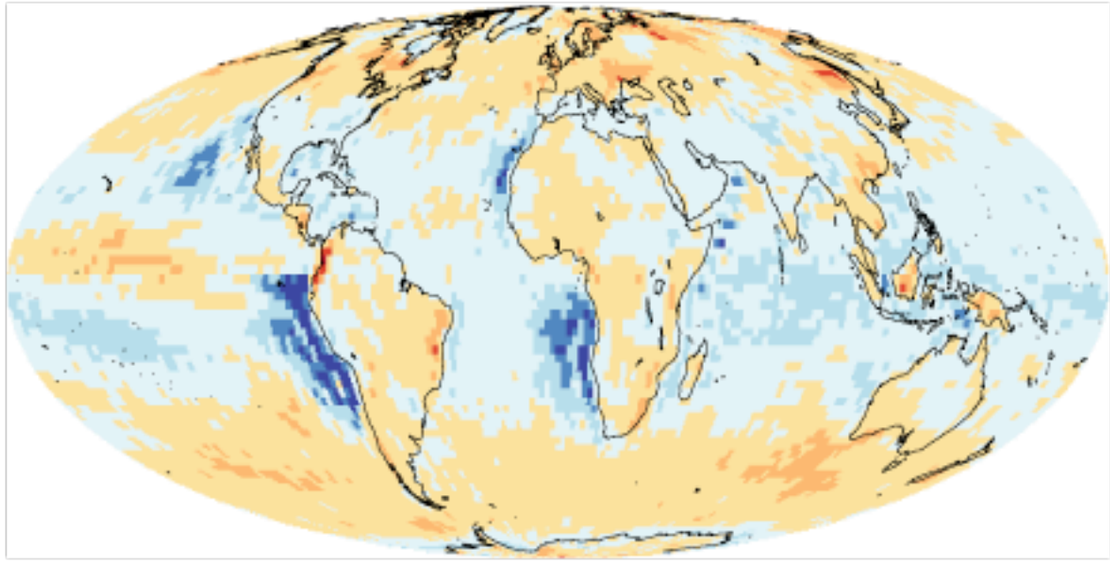


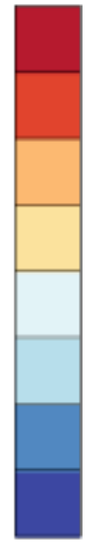
0.318





Difference

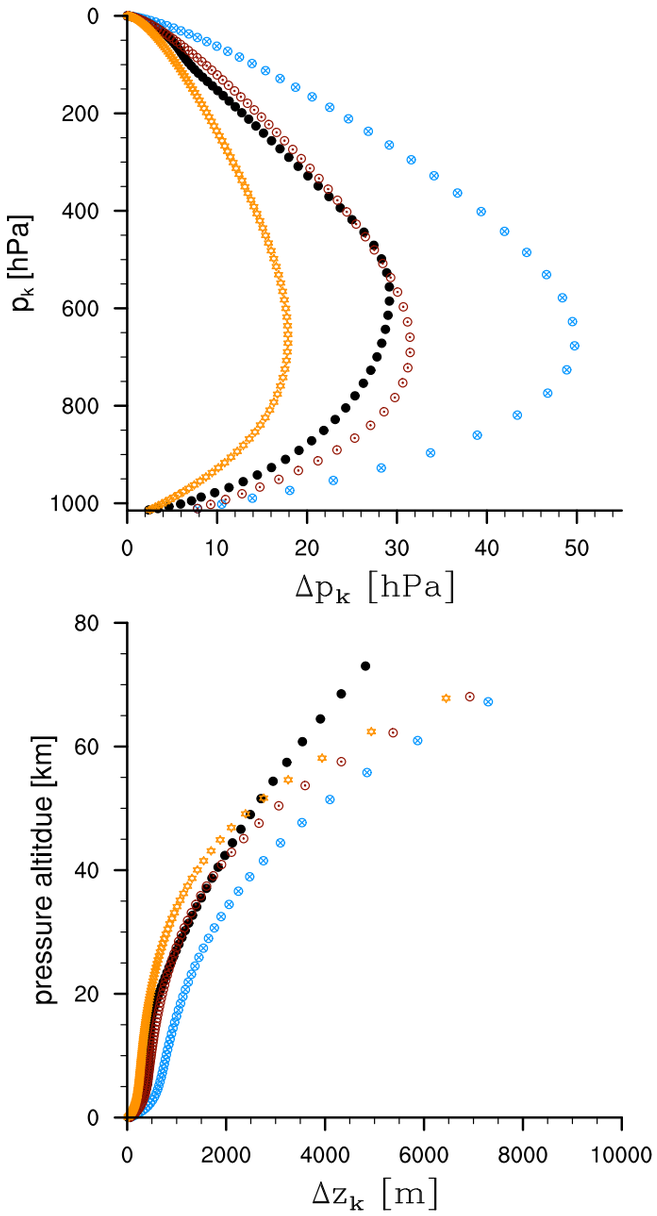


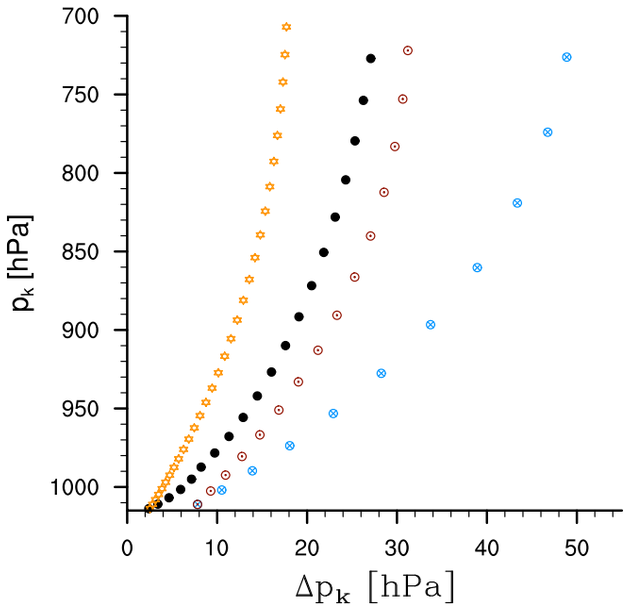


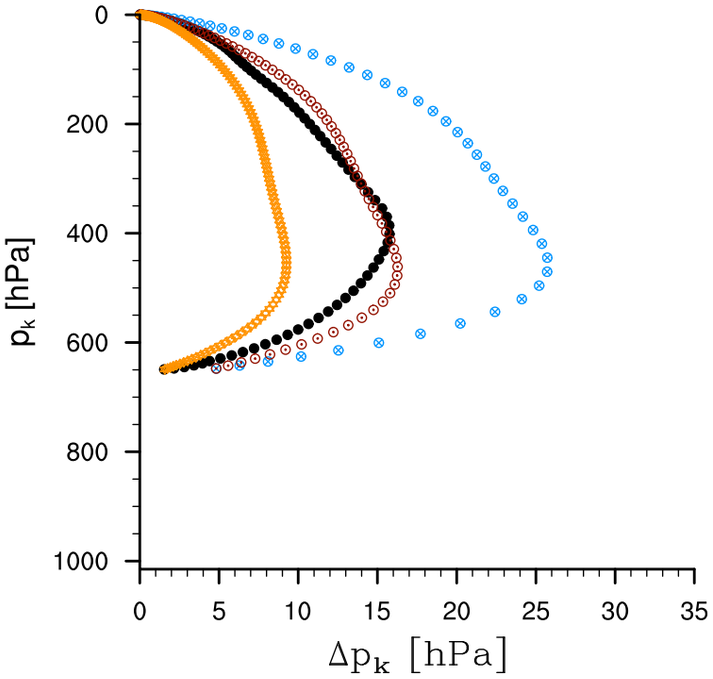
Remarks

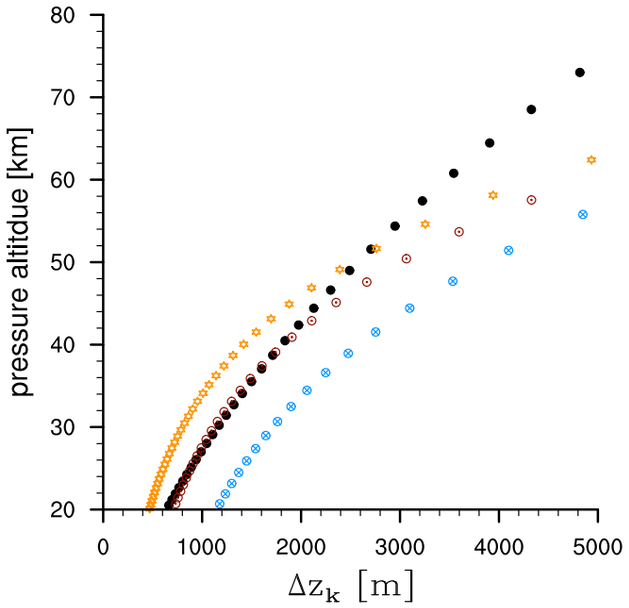
The main effects of small changes to the vertical grid is in the representation of stratocumulus

Families of Discretizations









Climate Change Inferences (FANGIO)

$$\lambda = \frac{\Delta T}{G} \quad \text{and} \quad \lambda/\lambda_c - 1 = \frac{\Delta CRE}{G}$$

Levels	λ	$\lambda/\lambda_c - 1$	TOA [W m^{-2}]
47	0.78	0.255	1.02
53	0.84	0.338	0.33
79	0.68	0.126	2.15

Summary

Order one changes in distribution of convection for small changes in parameterizations on an Aqua-Planet—Tropical Variability Proxy?

More reluctant parameterizations better represent tropical variability.

Model is relatively robust to resolution (run at L47, L53, L79 and L127), *i.e.,* no huge changes in basic structure of model solutions.

Low clouds are most sensitive, reflects weakness in ECHAM stratocumulus representation.

Cloud feedbacks are sensitive to vertical resolution—no real surprise here.