Using High-res. WRF Simulations to Improve Convective Parameterization in CAM

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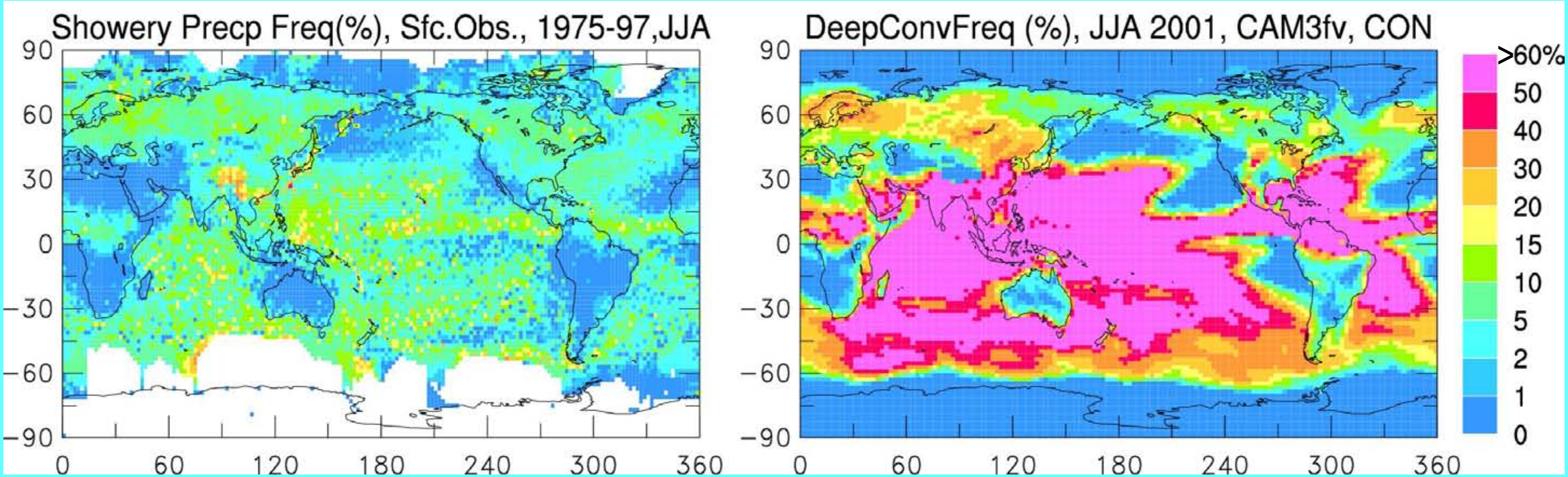
Changhai Liu provided the WRF simulations
Jimy Dudhia provided helpful comments

Motivation

- **Deep Convection fires too frequently in CAM:** drizzling too much, a common problem in most GCMs

Surface Obs. | CAM3fv



- **Cause: deep convection is allowed whenever there exists positive CAPE (>75 J/kg) in CAM.**

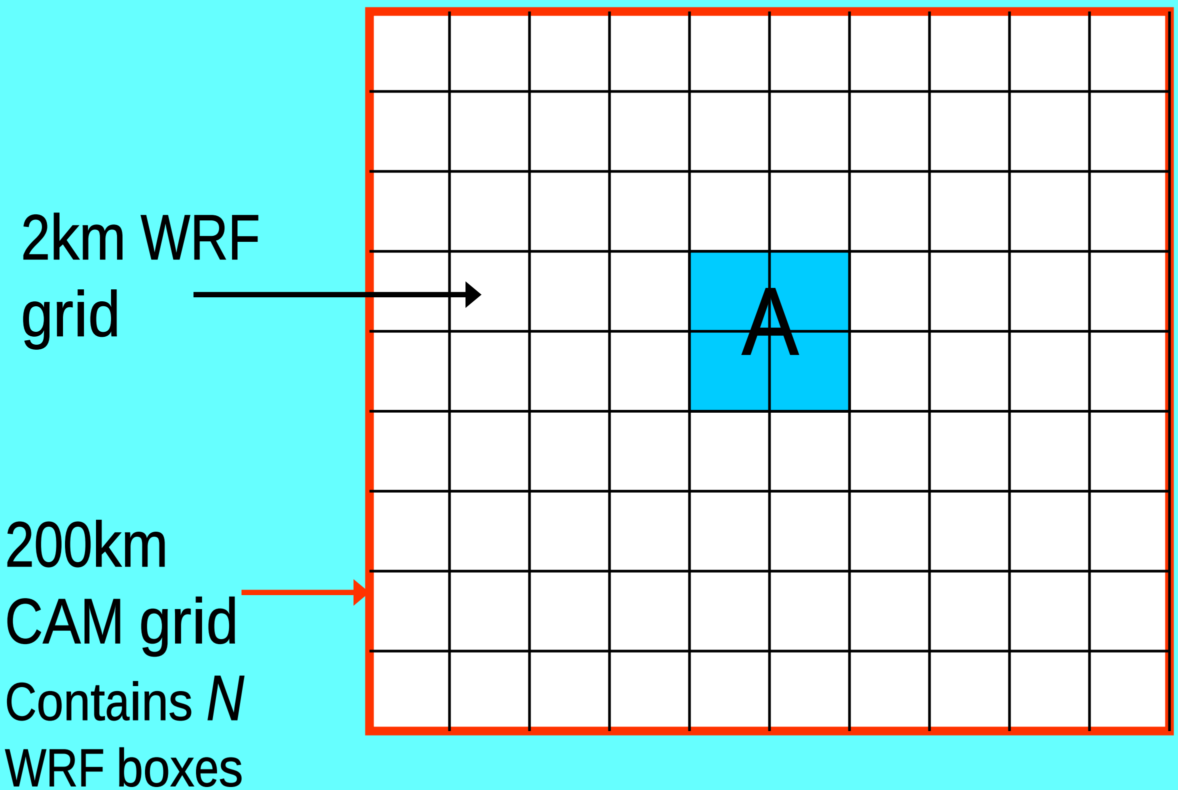
Convective Trigger Functions

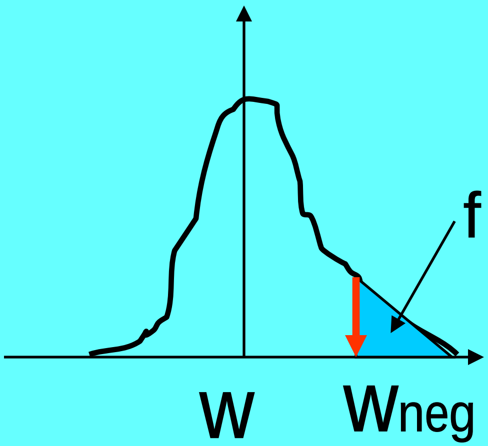
- Rogers & Fritsch'96 proposed a general framework for convective trigger functions:
  W > Wneg, but their estimate of the subgrid vertical velocity w is not suitable for GCMs.

- Bretherton et al.'04 assumed a Gaussian subgrid distribution of w at the inversion layer, with the variance=0.5*TKE (turbulence kinetic energy within the PBL), but TKE is not well resolved at GCM resolution, especially over complex terrain.

A New Trigger/Closure Function for CAM

- **Convection occurs only over a subgrid area where w > w_{neg} within a CAM grid box if there exists such an area.**





If $f*N > 1$, then convection occurs over nint(fN) 2km-grids, and M_{flux}= w A

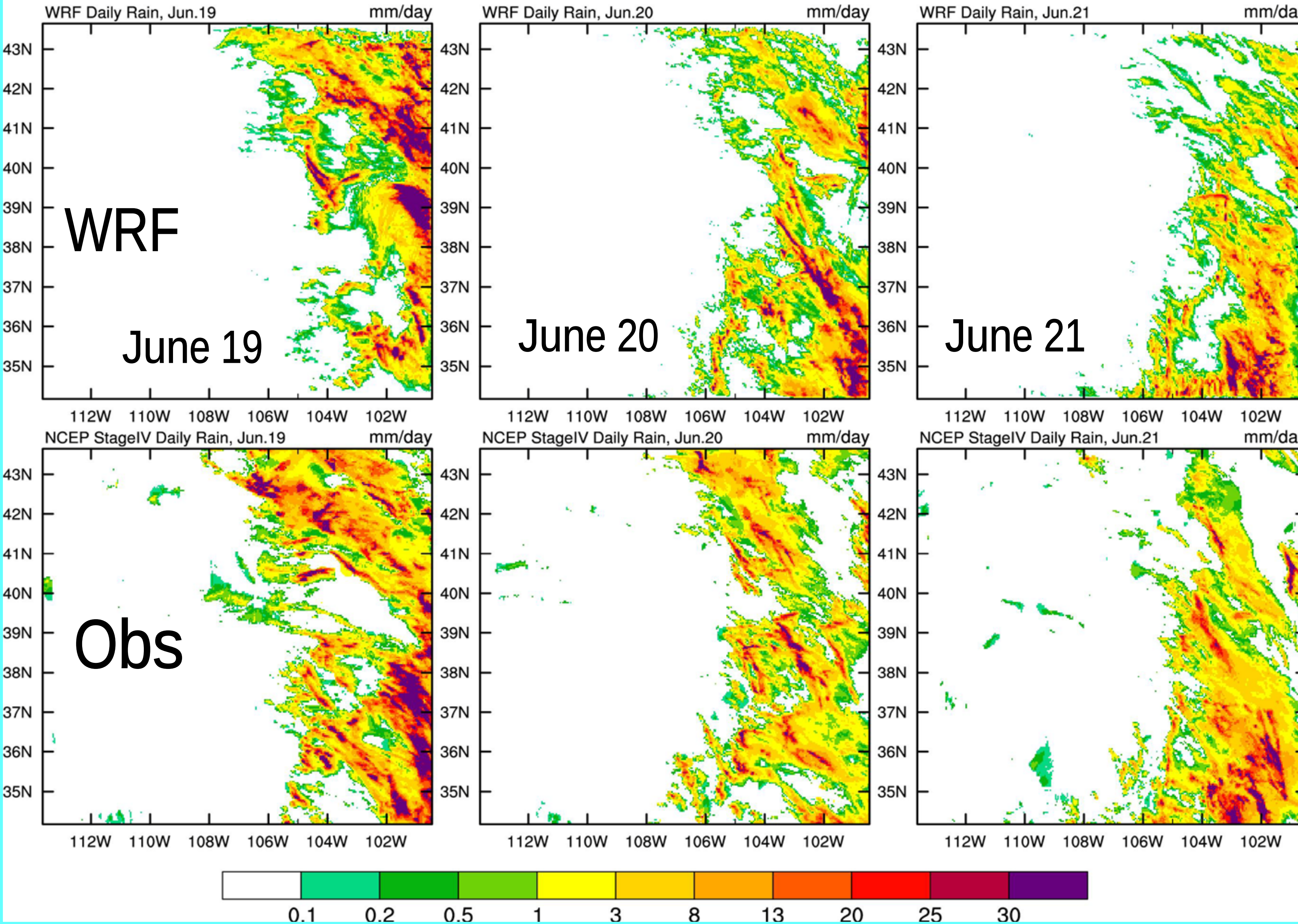
Subgrid Distribution of w

- PDF(w) = f(σ_h,SHFLX, etc.),

  σ_h=s.d.of elevation within a GCM box

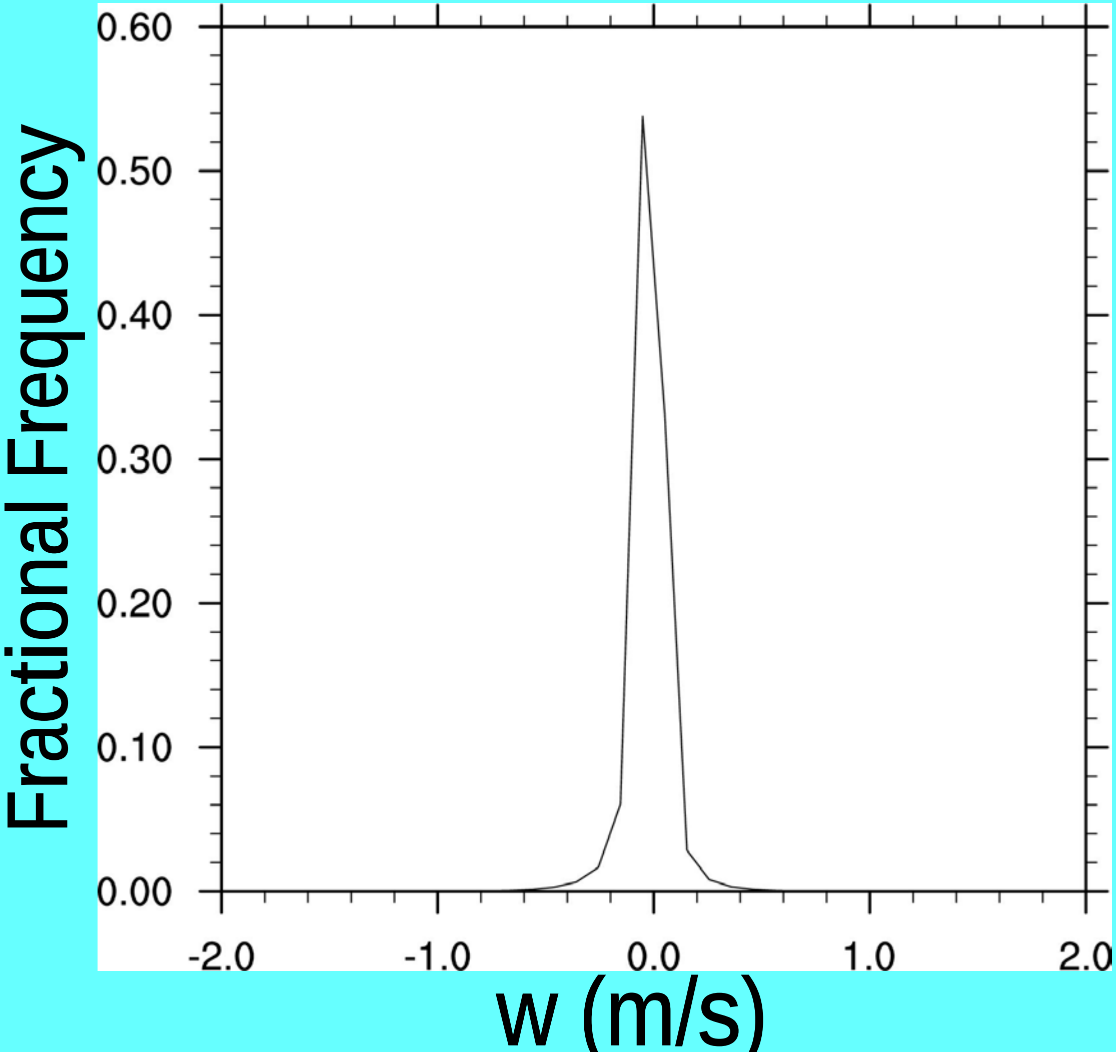
- A WRF 2-km simulation over the western U.S. was used to determine this PDF(w). Convection is resolved explicitly in this simulation.

Daily Precipitation During June 19-21,2007



WRF 2-km w distribution within a CAM grid box

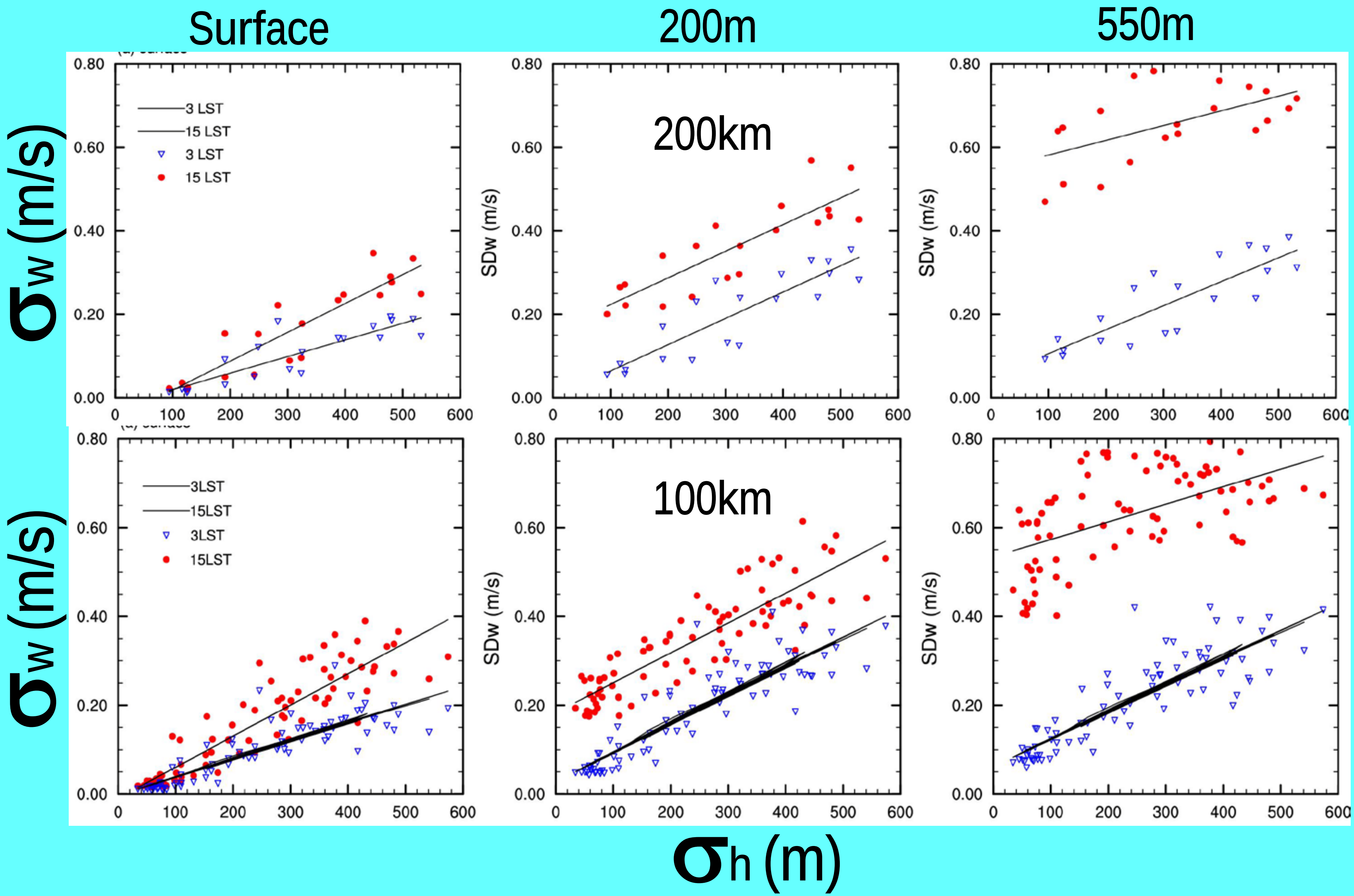
Approximately Gaussian



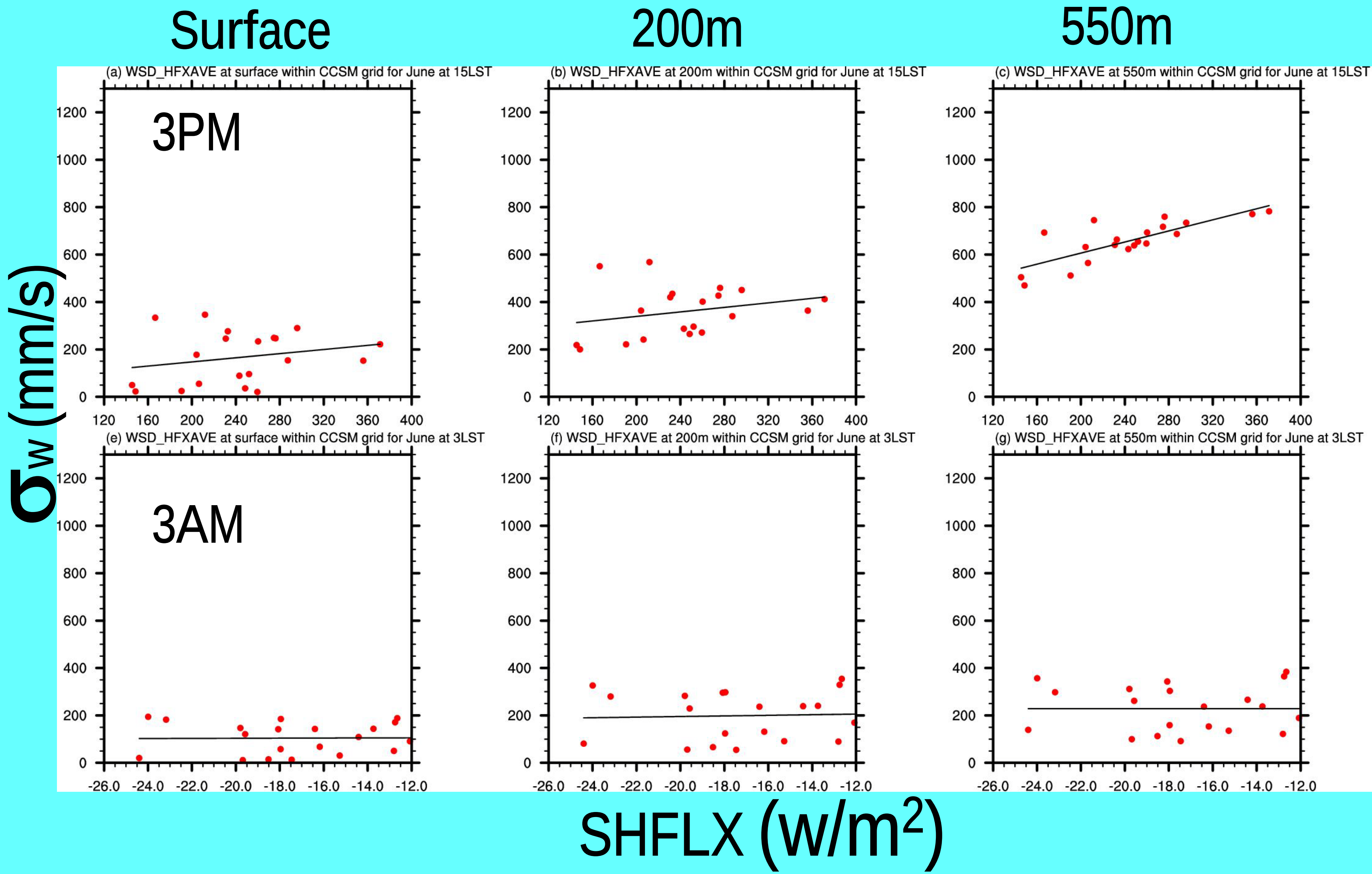
The mean = GCM w

Only need the S.D. (σ_w)

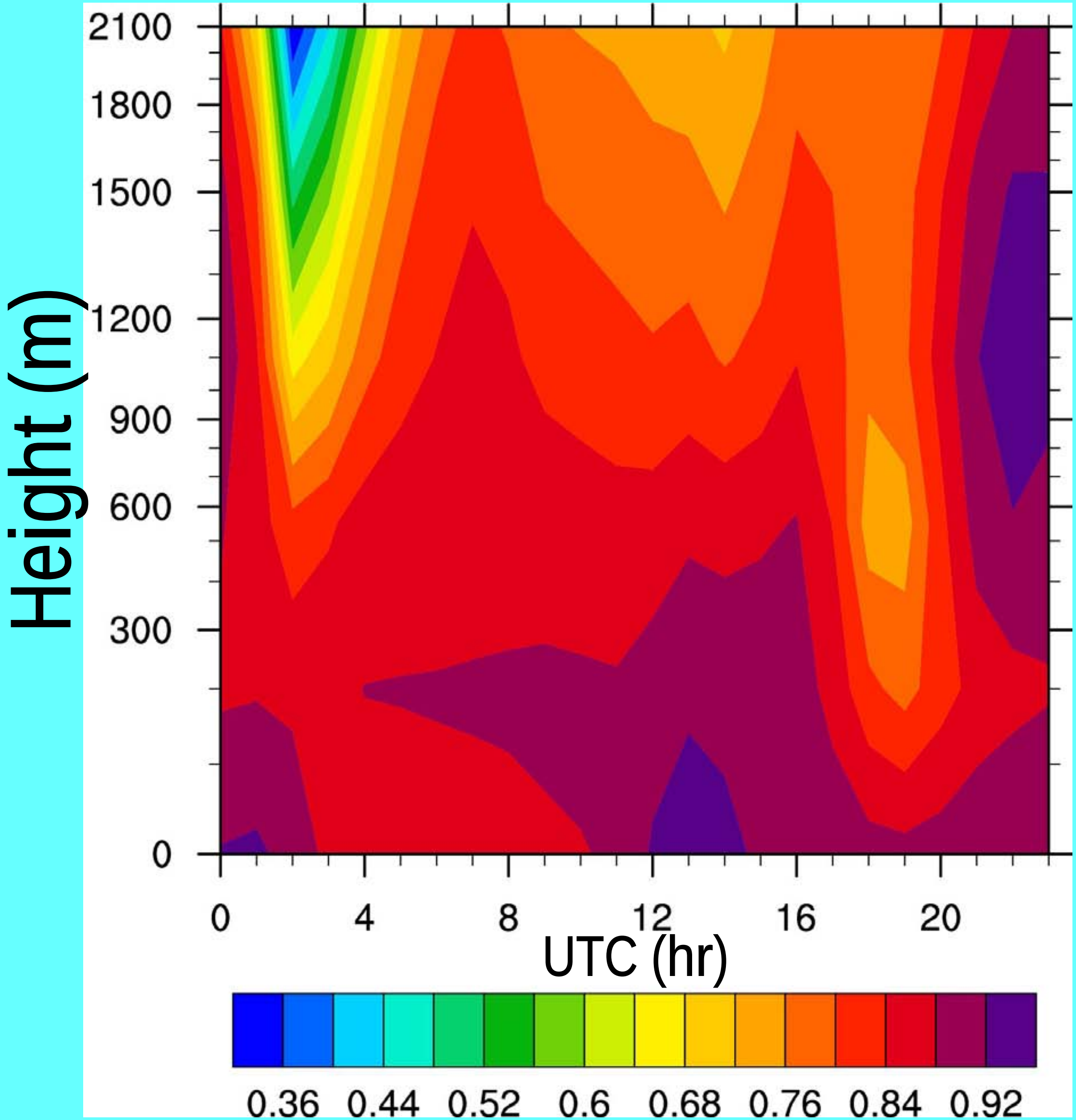
S.D. of w vs. S.D. of Elevation



S.D. of w vs. Mean SH Flux



Correl. Coeff. of σ_w vs. $\sigma_{w'}$ ($\sigma_{w,SHFLX}$)

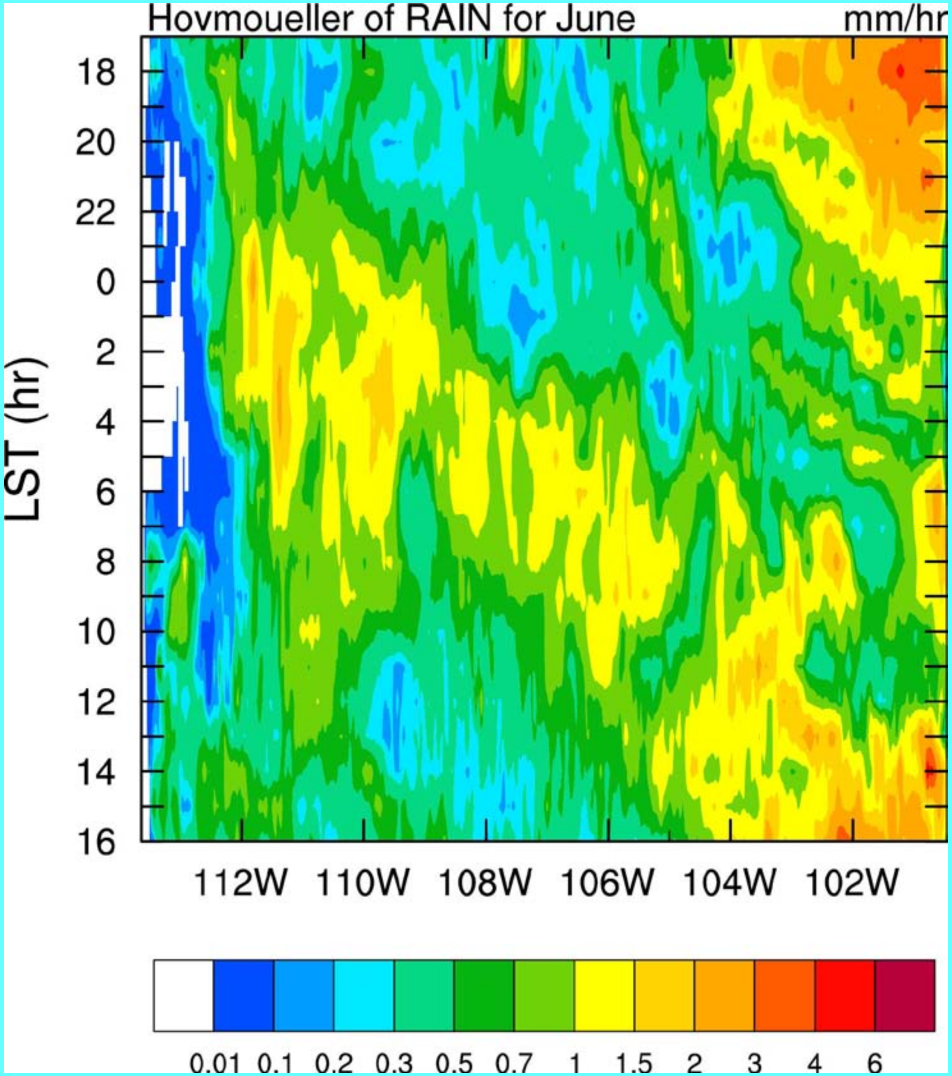


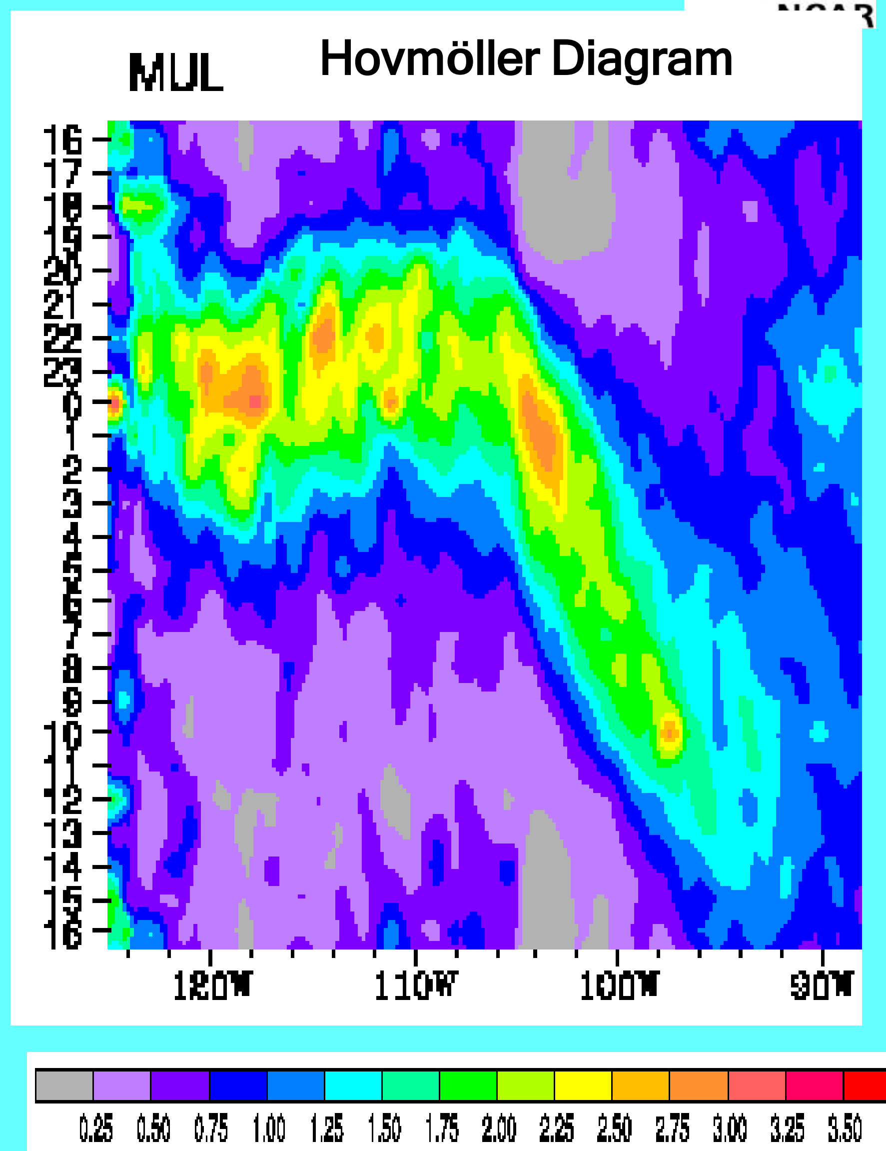
Future Work

- We are still analyzing WRF simulations to validate whether W > Wneg is a good trigger function.

- We are trying to make and analyze 500m WRF simulations.

- We will then apply the Gaussian w distribution and W_{neg} (estimated from CAM T and q profiles) to compute the factional area (f*N) for deep convection within a CAM grid.


Hovmoueller of RAIN for June
mm/hr
LST (hr)
18
20
22
0
2
4
6
8
10
12
14
16
112W
110W
108W
106W
104W
102W
0.01
0.1
0.2
0.3
0.5
0.7
1
1.5
2
3
4
6


MUL
Hovmöller Diagram
16
17
18
19
20
21
22
23
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
120W
110W
100W
90W
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00
2.25
2.50
2.75
3.00
3.25
3.50

S.D. of w vs. Mean Sfc. Air Temp.