

Tropical cyclones and seasonal means in high-resolution CAM 5 runs.

Julio Bacmeister
Jerry Olson

*useful discussions with Rich Neale, Dave Williamson,
Andrew Gettelman Joe Tribbia and others*

High resolution runs 0.23x0.31 lat-lon

Five day forecasts:

Initialized using MERRA reanalysis u,v,T,q on August 25 2005 12Z

- control: “out-of-the-box” CAM-5
- No ZM/NR deep con. (*UW remains*)
- RAS replaces ZM/NR
- Entrainment mods to UW shallow scheme

1997 and 2005 storm seasons:

- So far only “out-of-the-box” CAM-5
- Comparison run at 2.0x2.5

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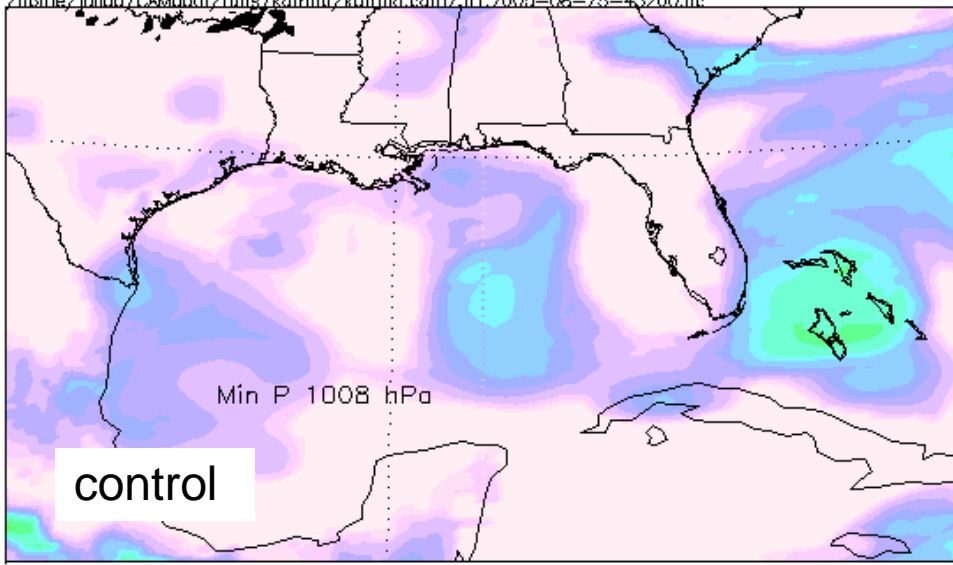
NOT TODAY

1997 and 2005 storm seasons:

- So far only “out-of-the-box” CAM-5
- Comparison run at 2.0x2.5

1.5538 [-90,90]
1.5399 [-40,40]

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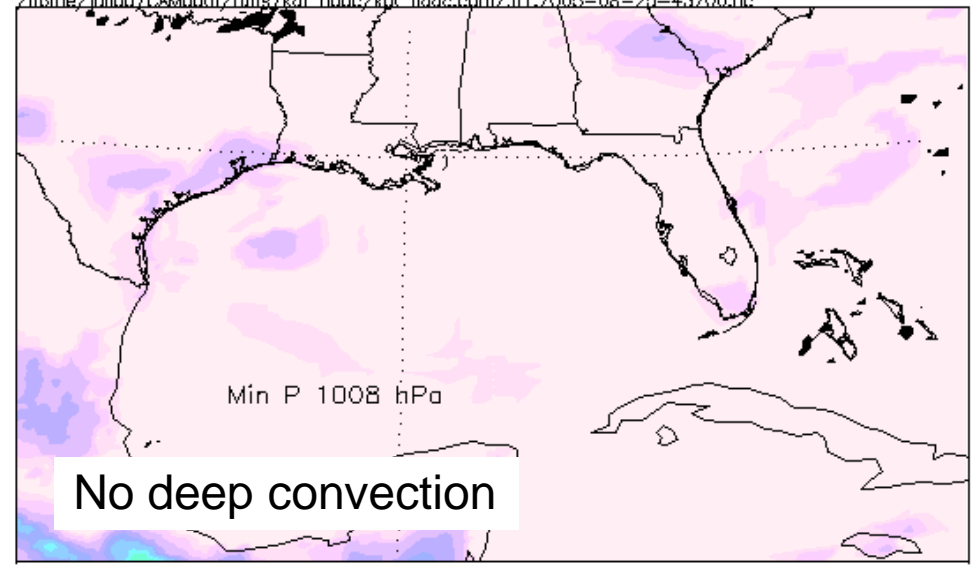


-1.00 0.00 0.50 1.00 2.00 4.00 6.00 8.00 12.0 16.0 26.0 32.0 48.0 64.0 80.0 100. 120.0

2005-08-25-43200 12Z

0.8900 [-90,90]
0.5959 [-40,40]

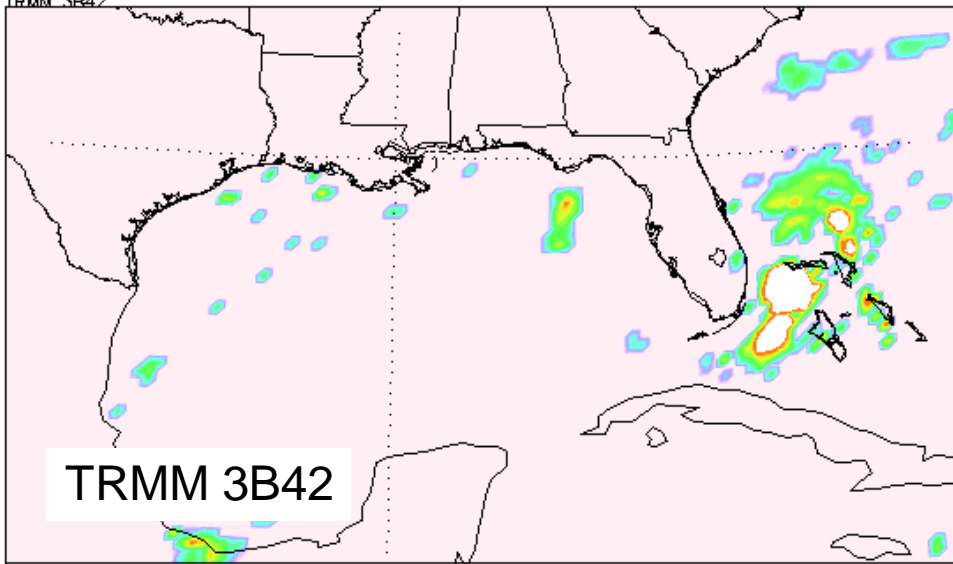
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-343.9162 [-90,90]
-410.3521 [-40,40]

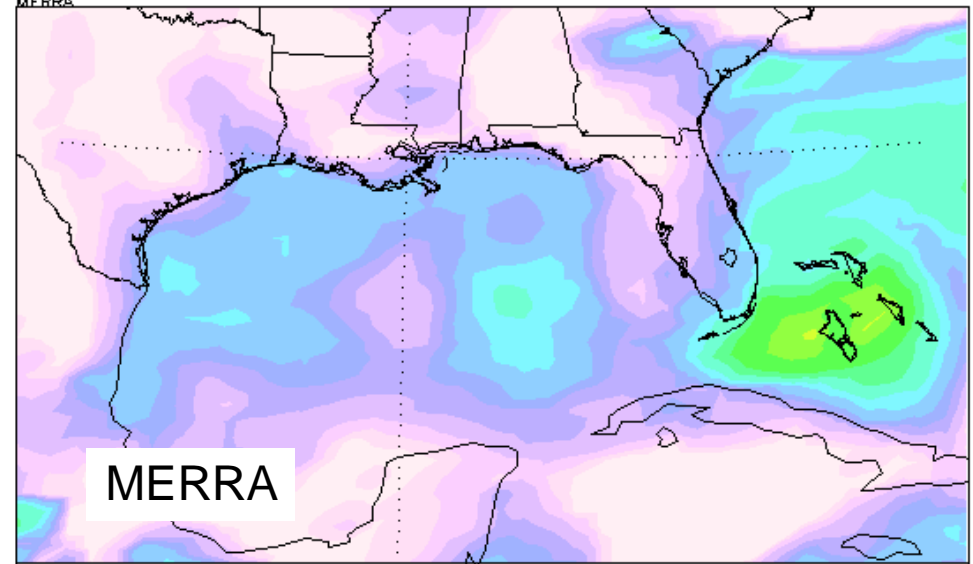
TRMM 3B42



-1.00 0.00 0.50 1.00 2.00 4.00 6.00 8.00 12.0 16.0 26.0 32.0 48.0 64.0 80.0 100. 120.0

3.1030 [-90,90]
3.4285 [-40,40]

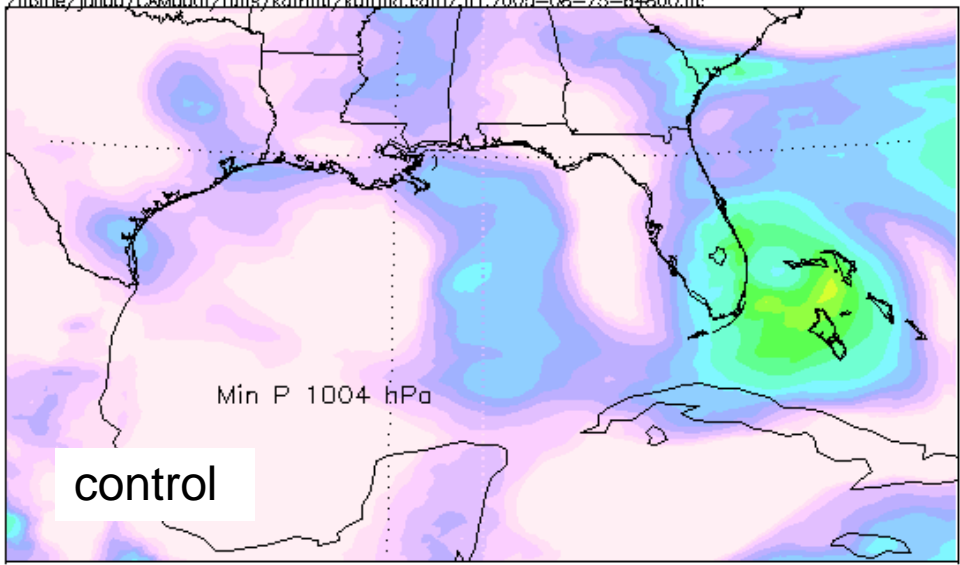
MERRA



-1.00 0.00 0.50 1.00 2.00 4.00 6.00 8.00 12.0 16.0 26.0 32.0 48.0 64.0 80.0 100. 120.0

2.2312 [-90,90]
2.3762 [-40,40]

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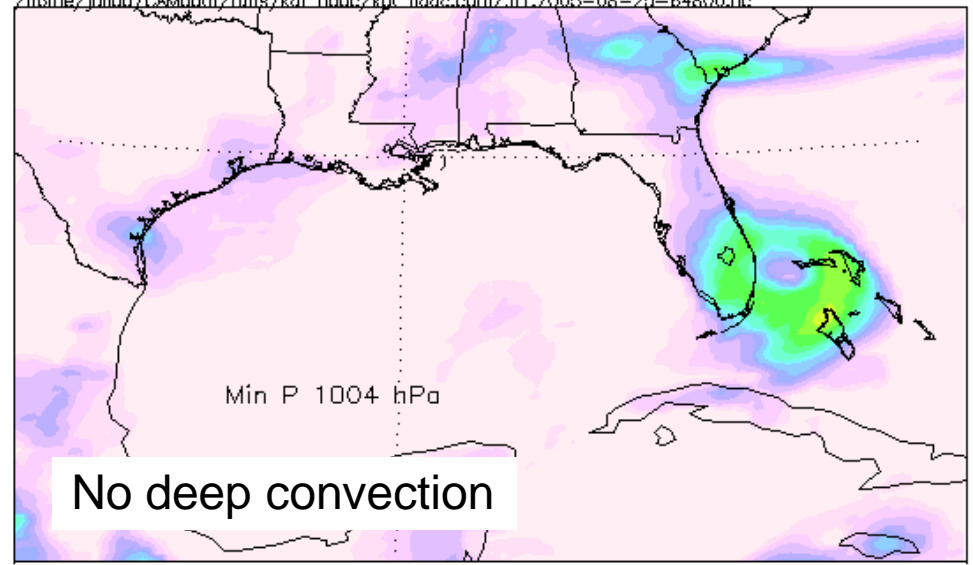


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2005-08-25-64800 18Z

1.6709 [-90,90]
1.5219 [-40,40]

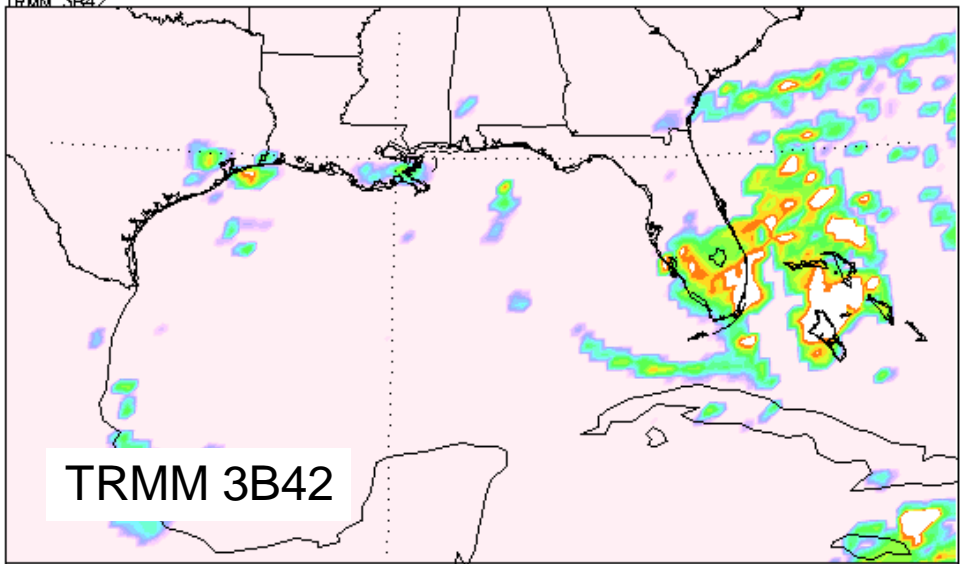
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-1.00 0.00 0.50 1.00 2.00 4.00 6.00 8.00 12.0 14.0 26.0 32.0 48.0 64.0 80.0 100. 120.0

3.1465 [-90,90]
3.2790 [-40,40]

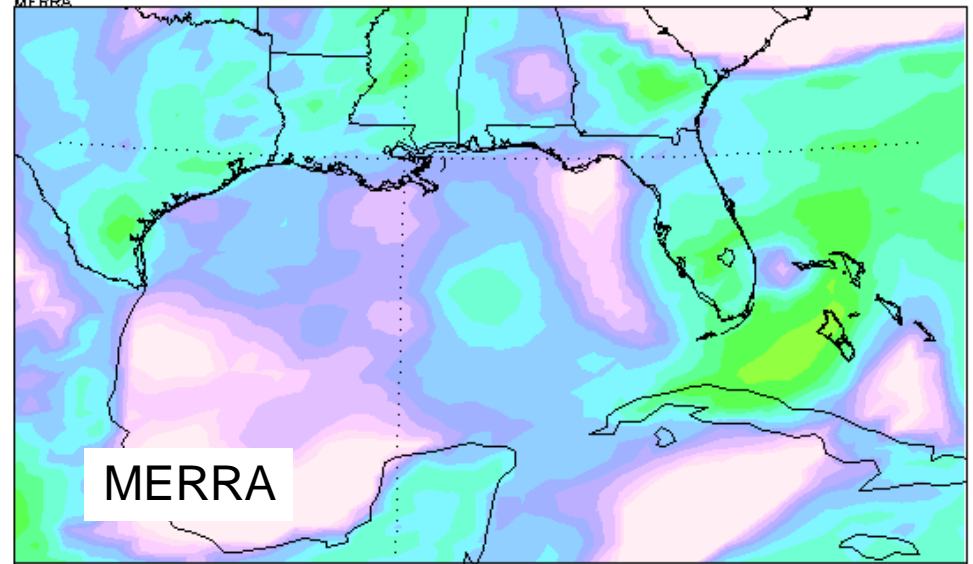
TRMM 3B42



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3.1770 [-90,90]
3.5805 [-40,40]

MERRA



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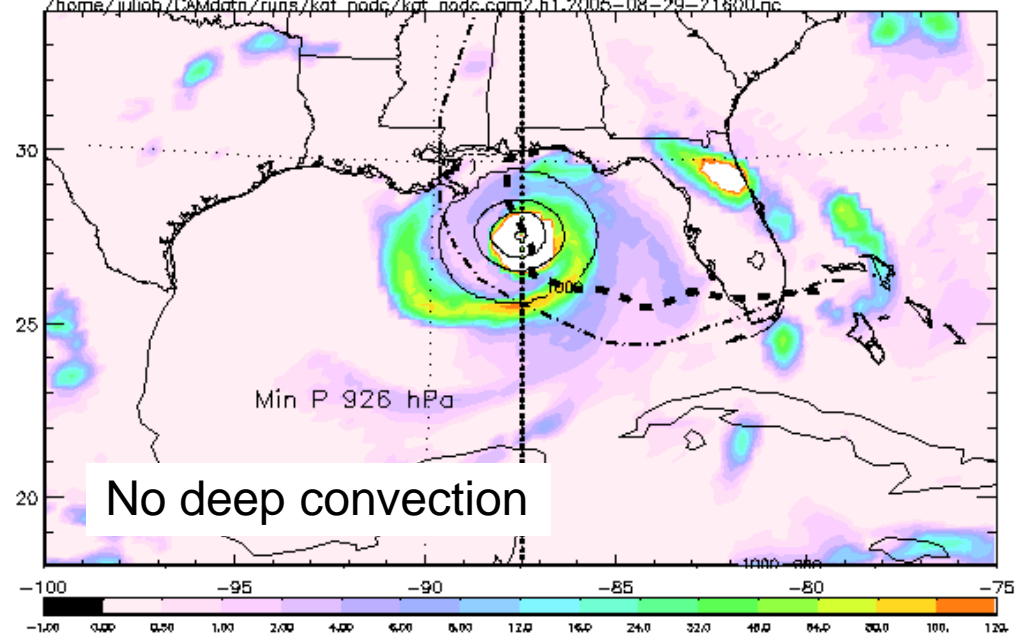
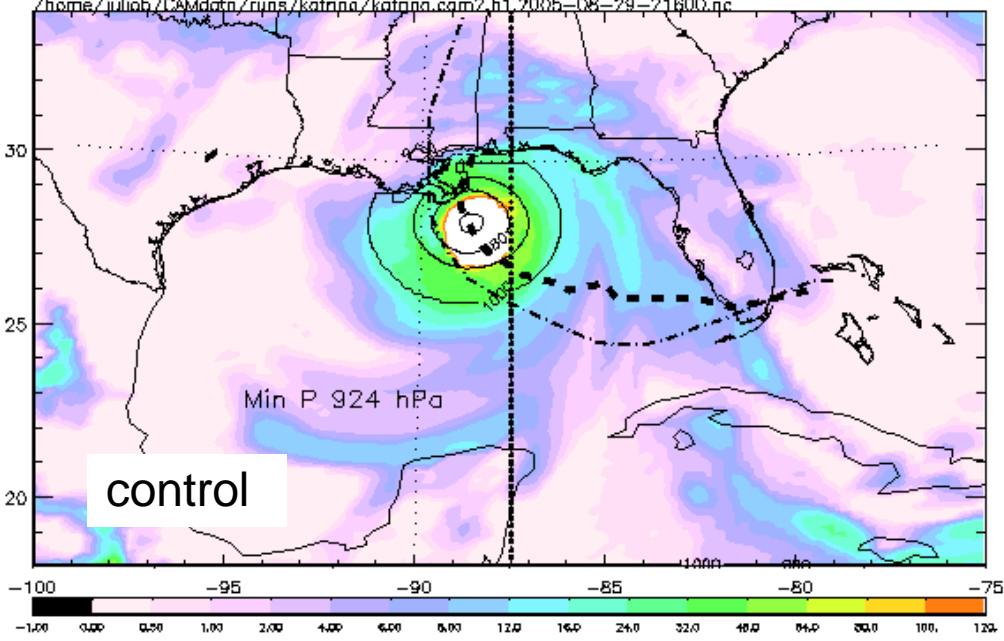
3.1708 [-90,90]
3.6937 [-40,40]

2005-08-29-21600 06Z

3.3357 [-90,90]
3.9413 [-40,40]

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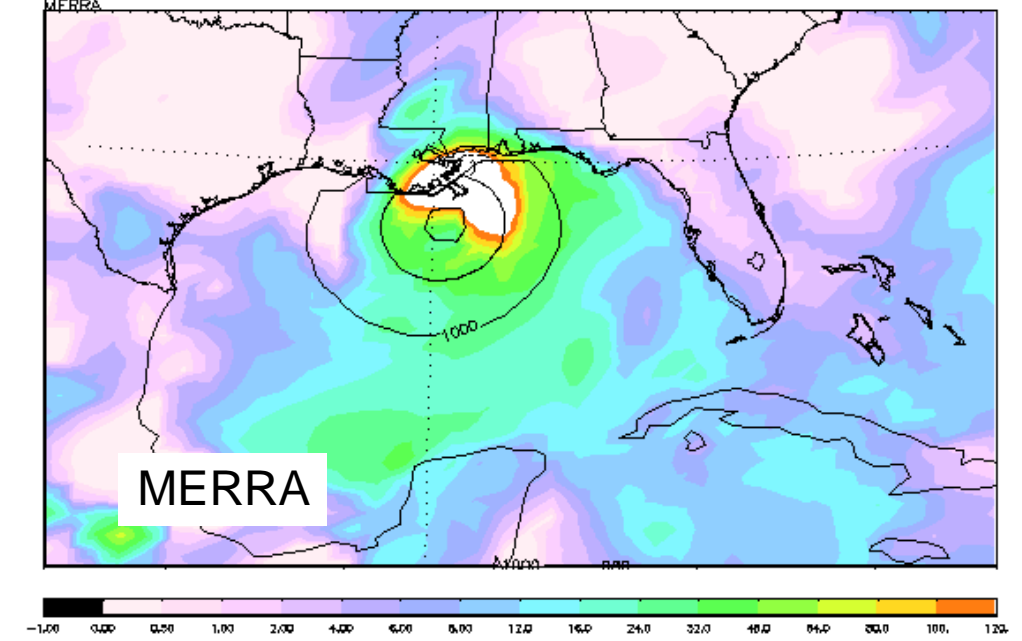
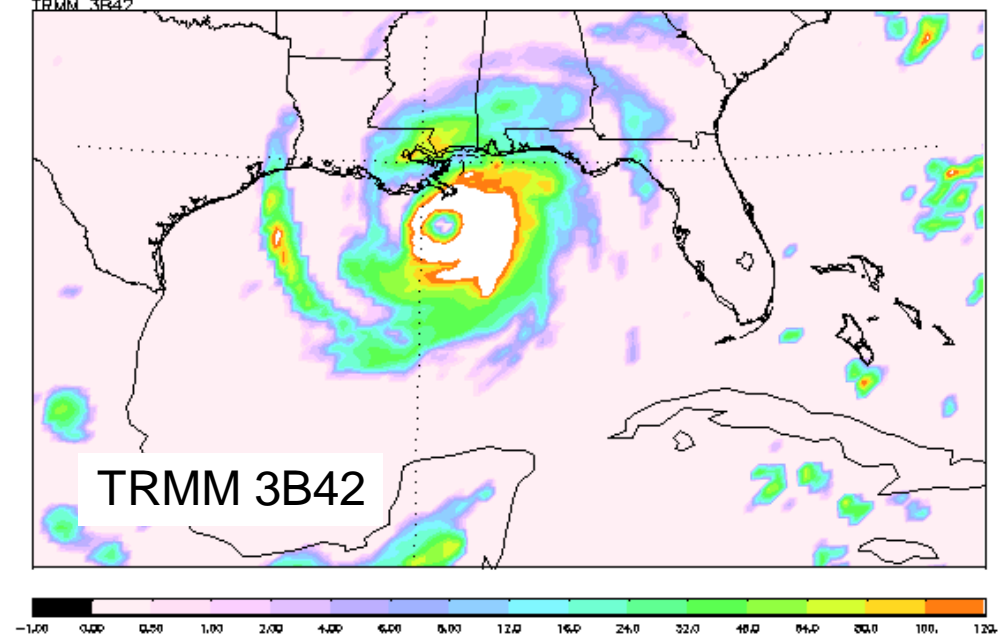


2.4330 [-90,90]
2.6896 [-40,40]

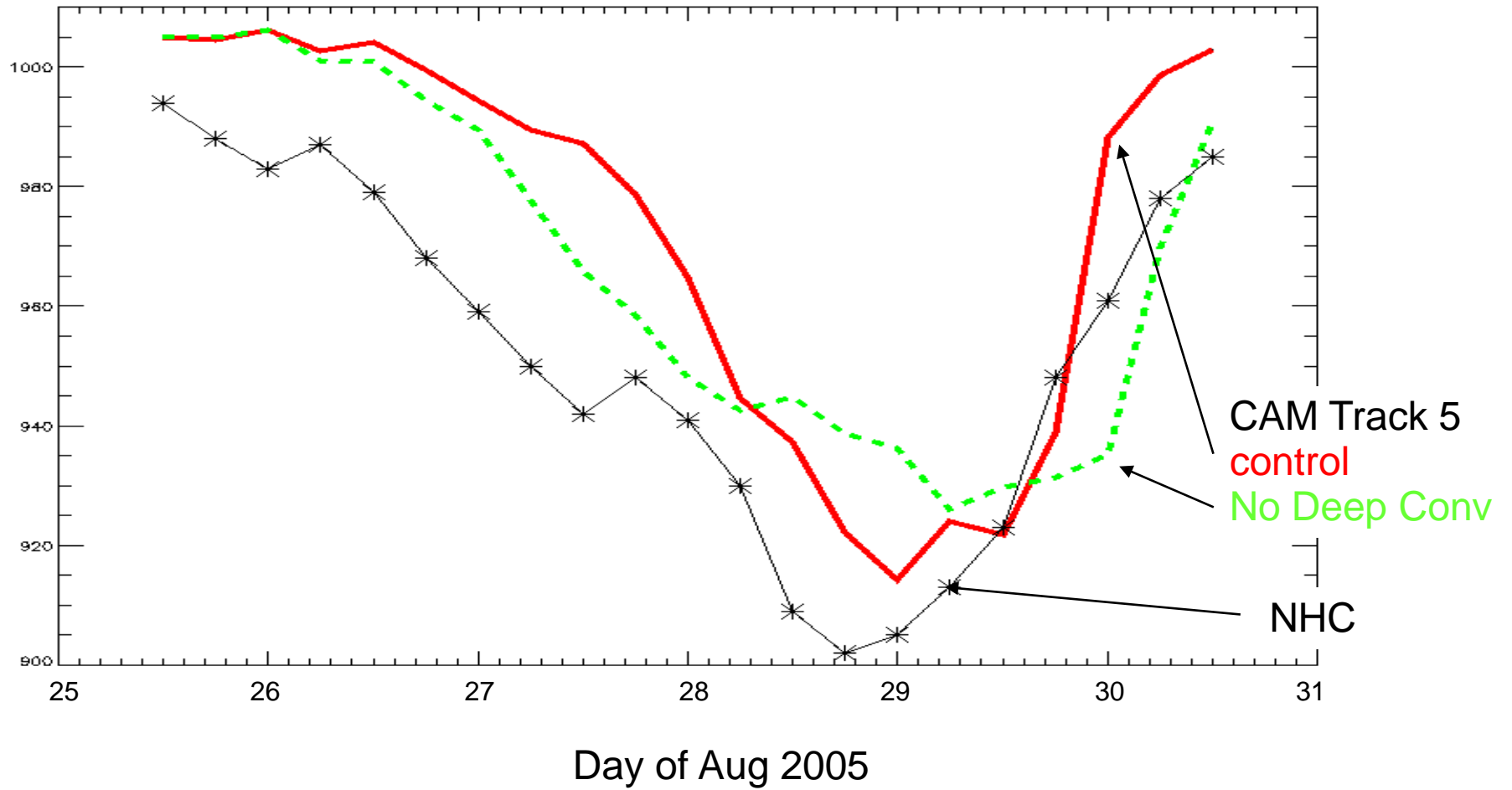
3.0918 [-90,90]
3.5851 [-40,40]

TRMM 3B42

MERRA

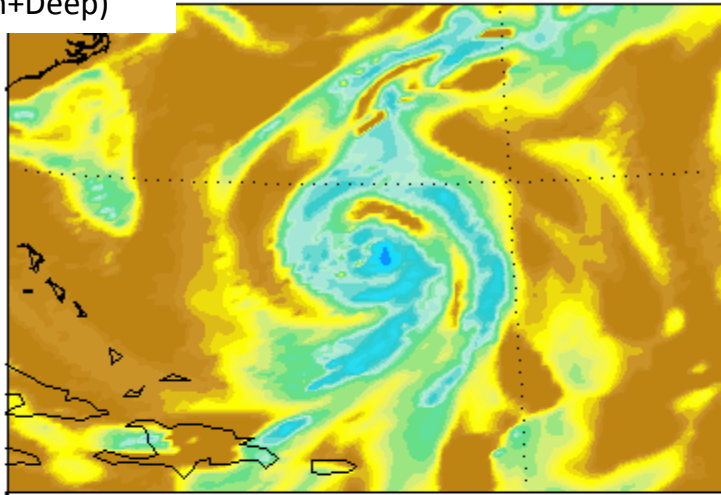


Minimum Surface Pressure



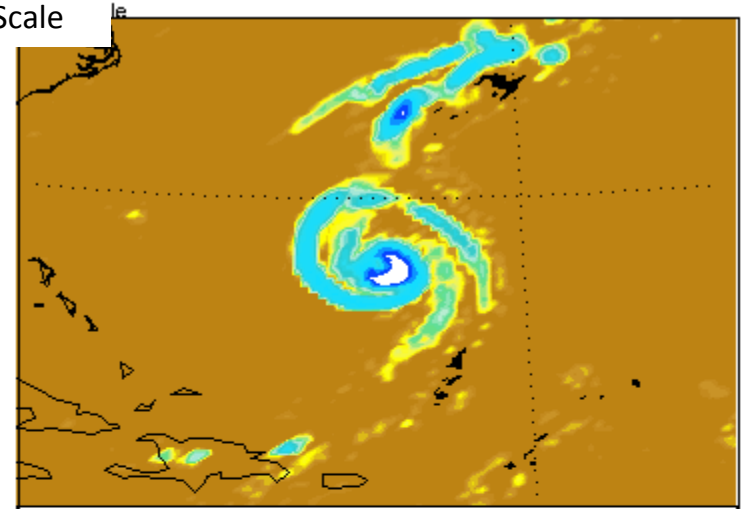
Cores of simulated storms dominated by *grid-scale precipitation*

Convective
(Sh+Deep)



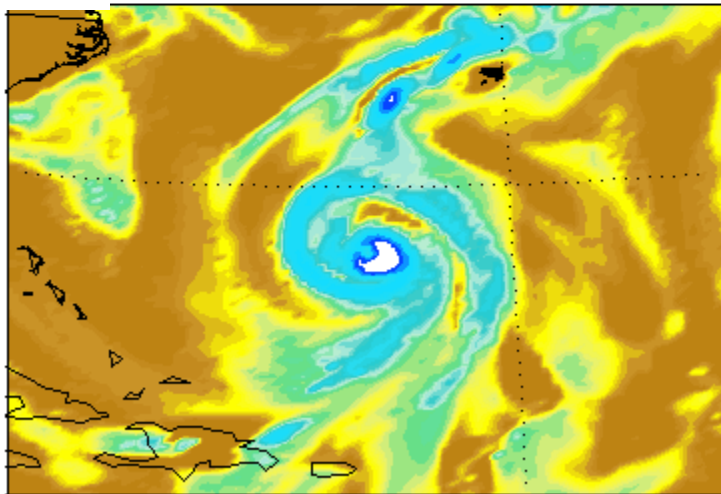
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Large
Scale



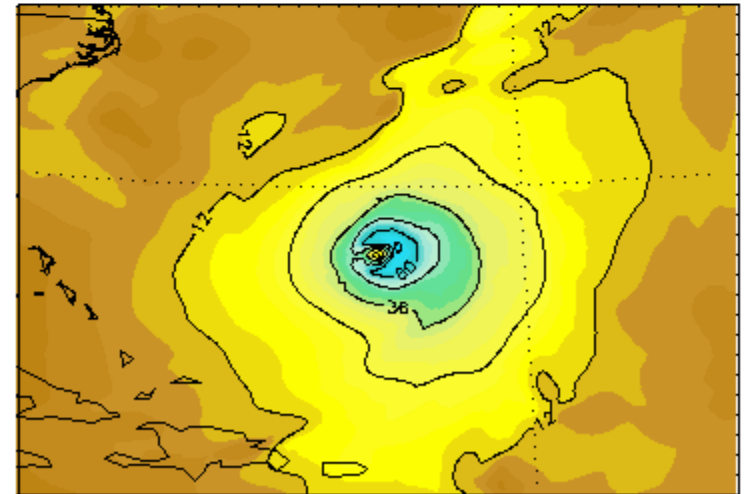
-1.00 / 0.002 / 0.01 / 0.02 / 0.03 / 0.04 / 0.05 / 0.06 / 0.07 / 0.08 / 0.09 / 0.10 / 0.11 / 0.12 / 0.13 / 0.14 / 0.15 / 0.16 / 0.17 / 0.18 / 0.19 / 0.20 / 0.21 / 0.22 / 0.23 / 0.24 / 0.25 / 0.26 / 0.27 / 0.28 / 0.29 / 0.30 / 0.31 / 0.32 / 0.33 / 0.34 / 0.35 / 0.36 / 0.37 / 0.38 / 0.39 / 0.40 / 0.41 / 0.42 / 0.43 / 0.44 / 0.45 / 0.46 / 0.47 / 0.48 / 0.49 / 0.50 / 0.51 / 0.52 / 0.53 / 0.54 / 0.55 / 0.56 / 0.57 / 0.58 / 0.59 / 0.60 / 0.61 / 0.62 / 0.63 / 0.64 / 0.65 / 0.66 / 0.67 / 0.68 / 0.69 / 0.70 / 0.71 / 0.72 / 0.73 / 0.74 / 0.75 / 0.76 / 0.77 / 0.78 / 0.79 / 0.80 / 0.81 / 0.82 / 0.83 / 0.84 / 0.85 / 0.86 / 0.87 / 0.88 / 0.89 / 0.90 / 0.91 / 0.92 / 0.93 / 0.94 / 0.95 / 0.96 / 0.97 / 0.98 / 0.99 / 1.00

total



-1.00 / 0.002 / 0.01 / 0.02 / 0.03 / 0.04 / 0.05 / 0.06 / 0.07 / 0.08 / 0.09 / 0.10 / 0.11 / 0.12 / 0.13 / 0.14 / 0.15 / 0.16 / 0.17 / 0.18 / 0.19 / 0.20 / 0.21 / 0.22 / 0.23 / 0.24 / 0.25 / 0.26 / 0.27 / 0.28 / 0.29 / 0.30 / 0.31 / 0.32 / 0.33 / 0.34 / 0.35 / 0.36 / 0.37 / 0.38 / 0.39 / 0.40 / 0.41 / 0.42 / 0.43 / 0.44 / 0.45 / 0.46 / 0.47 / 0.48 / 0.49 / 0.50 / 0.51 / 0.52 / 0.53 / 0.54 / 0.55 / 0.56 / 0.57 / 0.58 / 0.59 / 0.60 / 0.61 / 0.62 / 0.63 / 0.64 / 0.65 / 0.66 / 0.67 / 0.68 / 0.69 / 0.70 / 0.71 / 0.72 / 0.73 / 0.74 / 0.75 / 0.76 / 0.77 / 0.78 / 0.79 / 0.80 / 0.81 / 0.82 / 0.83 / 0.84 / 0.85 / 0.86 / 0.87 / 0.88 / 0.89 / 0.90 / 0.91 / 0.92 / 0.93 / 0.94 / 0.95 / 0.96 / 0.97 / 0.98 / 0.99 / 1.00

Wind speed



-3.00 / 0.002 / 0.005 / 0.01 / 0.02 / 0.03 / 0.04 / 0.05 / 0.06 / 0.07 / 0.08 / 0.09 / 0.10 / 0.11 / 0.12 / 0.13 / 0.14 / 0.15 / 0.16 / 0.17 / 0.18 / 0.19 / 0.20 / 0.21 / 0.22 / 0.23 / 0.24 / 0.25 / 0.26 / 0.27 / 0.28 / 0.29 / 0.30 / 0.31 / 0.32 / 0.33 / 0.34 / 0.35 / 0.36 / 0.37 / 0.38 / 0.39 / 0.40 / 0.41 / 0.42 / 0.43 / 0.44 / 0.45 / 0.46 / 0.47 / 0.48 / 0.49 / 0.50 / 0.51 / 0.52 / 0.53 / 0.54 / 0.55 / 0.56 / 0.57 / 0.58 / 0.59 / 0.60 / 0.61 / 0.62 / 0.63 / 0.64 / 0.65 / 0.66 / 0.67 / 0.68 / 0.69 / 0.70 / 0.71 / 0.72 / 0.73 / 0.74 / 0.75 / 0.76 / 0.77 / 0.78 / 0.79 / 0.80 / 0.81 / 0.82 / 0.83 / 0.84 / 0.85 / 0.86 / 0.87 / 0.88 / 0.89 / 0.90 / 0.91 / 0.92 / 0.93 / 0.94 / 0.95 / 0.96 / 0.97 / 0.98 / 0.99 / 1.00

Katrina forecasts:

Surprisingly good intensity forecast both with and without ZM/NR deep convection.

Storm cores dominated by grid-scale precipitation even with deep scheme on.

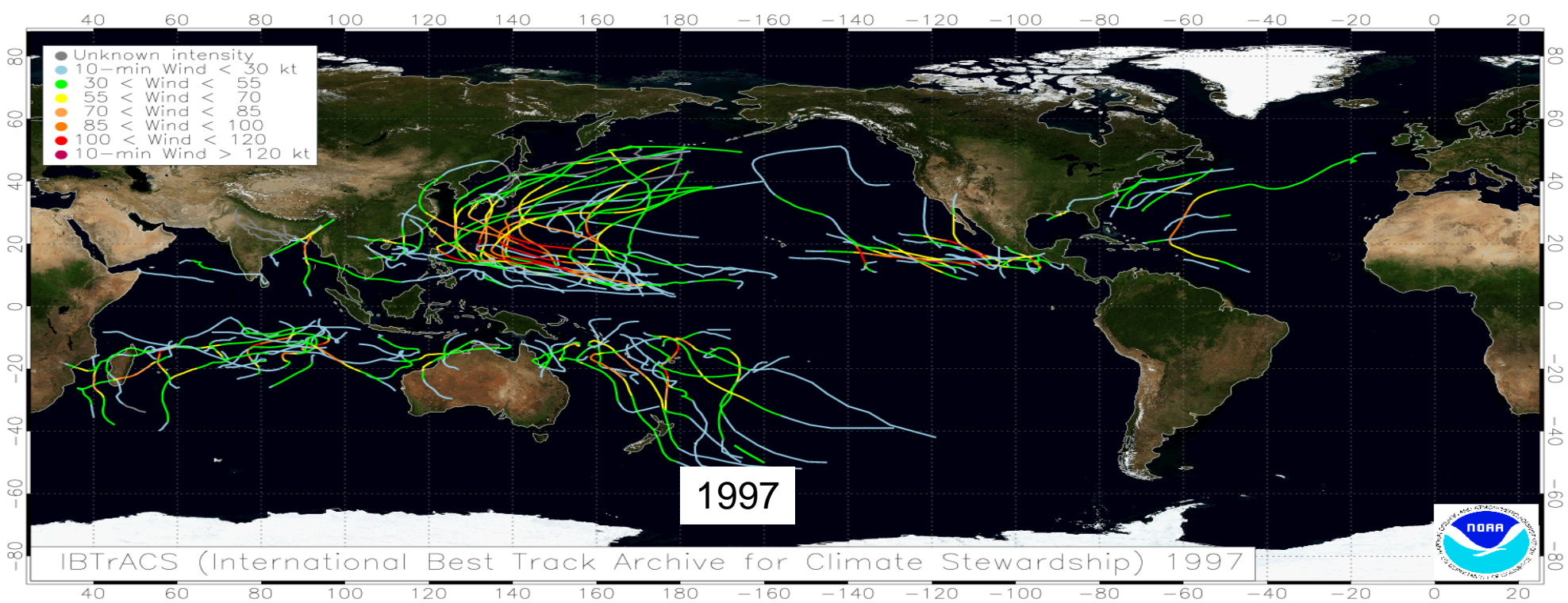
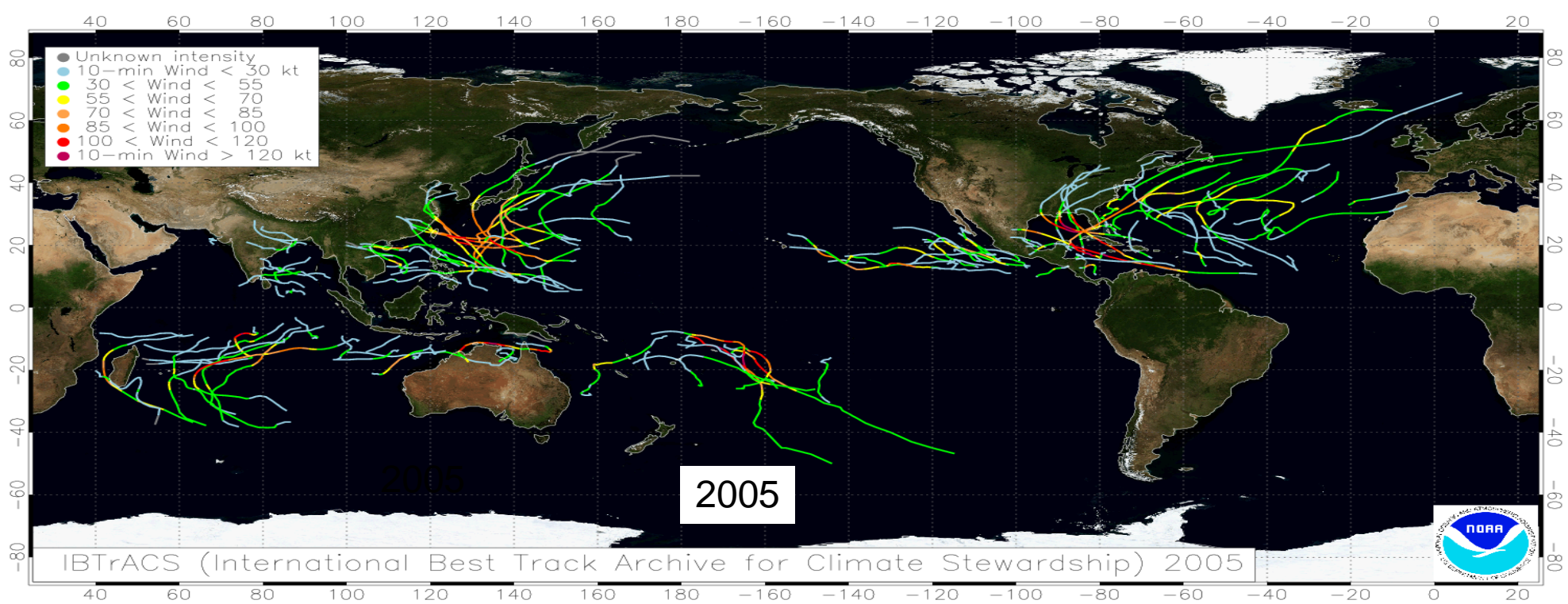
-How does ZM/NR know to step aside?

1997 and 2005 seasons:

Initialized using false-date reanalysis u,v,T,q over June 1 SSTs. Run until Oct. 15

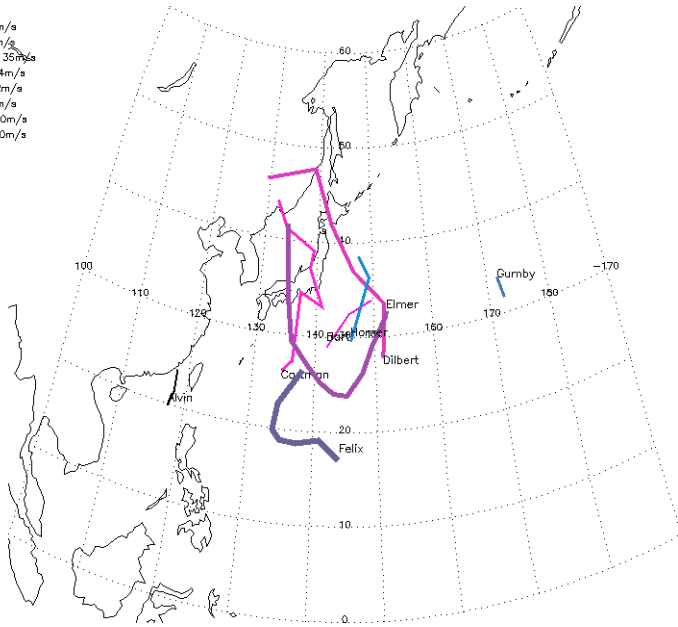
1997: Strong El Nino, weak activity in Atlantic strong in W. Pacific

2005: Extremely active Atlantic, somewhat below normal in W. Pacific



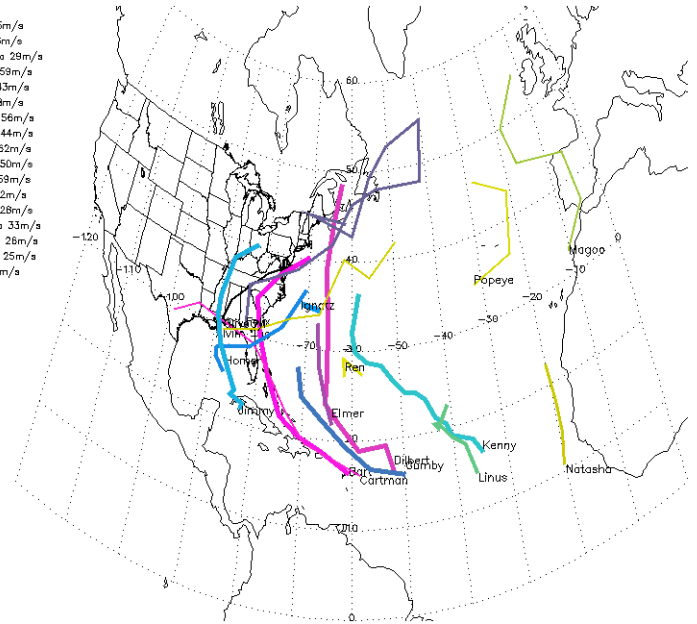
CAM Track 5 0.23x0.31 "2005" Tropical cyclone tracks June 1 to Oct 15

Alvin: 0619-21 893hPa 25m/s
 Bart: 0630-02 897hPa 27m/s
 Cartman: 0728-04 958hPa 35m/s
 Dilbert: 0826-01 954hPa 44m/s
 Elmer: 0831-10 939hPa 52m/s
 Felix: 1007-13 923hPa 62m/s
 Gumbly: 1008-09 995hPa 30m/s
 Homer: 1012-14 995hPa 30m/s



CAM Track 5 0.23x0.31 "2005" Tropical cyclone tracks June 1 to Oct 15

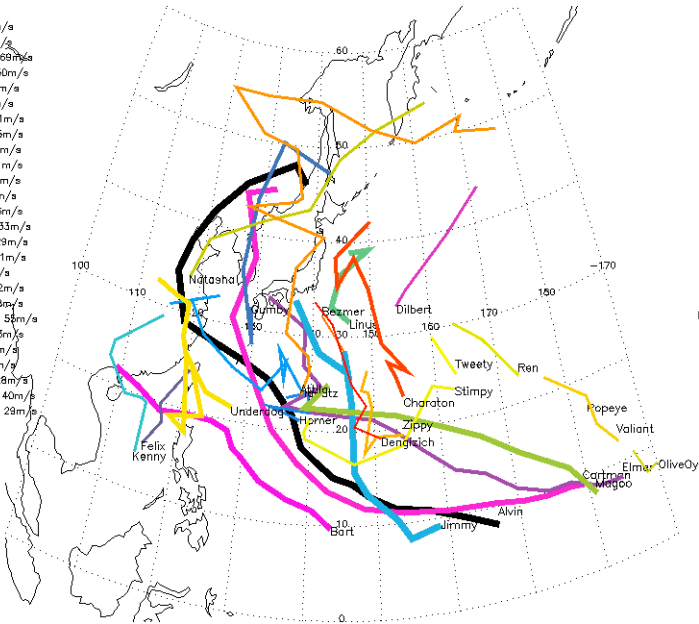
Alvin: 0605-08 858hPa 25m/s
 Bart: 0714-22 863hPa 56m/s
 Cartman: 0722-31 977hPa 29m/s
 Dilbert: 0803-12 922hPa 59m/s
 Elmer: 0825-28 968hPa 43m/s
 Felix: 0825-07 911hPa 38m/s
 Gumbly: 0829-03 934hPa 56m/s
 Homer: 0831-06 970hPa 44m/s
 Ignatz: 0903-04 936hPa 62m/s
 Jimmy: 0910-19 951hPa 50m/s
 Kenny: 0912-25 928hPa 59m/s
 Linus: 0921-28 977hPa 42m/s
 Mago: 0929-04 929hPa 28m/s
 Natasha: 0930-03 991hPa 33m/s
 OliveOyl: 0930-06 995hPa 28m/s
 Pepeye: 1002-05 985hPa 25m/s
 Ren: 1011-14 990hPa 32m/s



2005

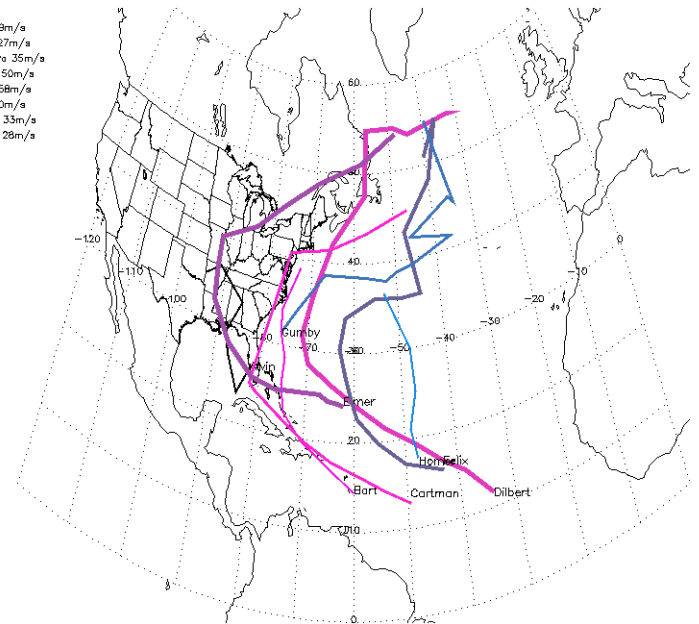
CAM Track 5 0.23x0.31 "1997" Tropical cyclone tracks June 1 to Oct 15

Alvin: 0627-16 898hPa 71m/s
 Bart: 0627-08 929hPa 68m/s
 Cartman: 0702-18 902hPa 69m/s
 Dilbert: 0703-06 1000hPa 30m/s
 Elmer: 0706-22 957hPa 47m/s
 Felix: 0712-15 964hPa 33m/s
 Gumbly: 0722-27 928hPa 41m/s
 Homer: 0724-28 986hPa 35m/s
 Ignatz: 0724-02 970hPa 33m/s
 Jimmy: 0726-04 931hPa 71m/s
 Kenny: 0727-02 944hPa 38m/s
 Linus: 0801-05 942hPa 61m/s
 Mago: 0808-16 914hPa 66m/s
 Natasha: 0808-14 970hPa 33m/s
 OliveOyl: 0811-13 964hPa 29m/s
 Pepeye: 0814-14 993hPa 31m/s
 Ren: 0815-17 998hPa 34m/s
 Stimp: 0816-22 993hPa 32m/s
 Tweety: 0816-17 968hPa 36m/s
 Underdog: 0817-27 914hPa 53m/s
 Valiant: 0821-24 984hPa 35m/s
 Zippy: 0825-01 972hPa 35m/s
 Albia: 0901-20 934hPa 32m/s
 Bermer: 0902-03 895hPa 28m/s
 Charaton: 0904-13 982hPa 40m/s
 Denglich: 0907-12 980hPa 28m/s



CAM Track 5 0.23x0.31 "1997" Tropical cyclone tracks June 1 to Oct 15

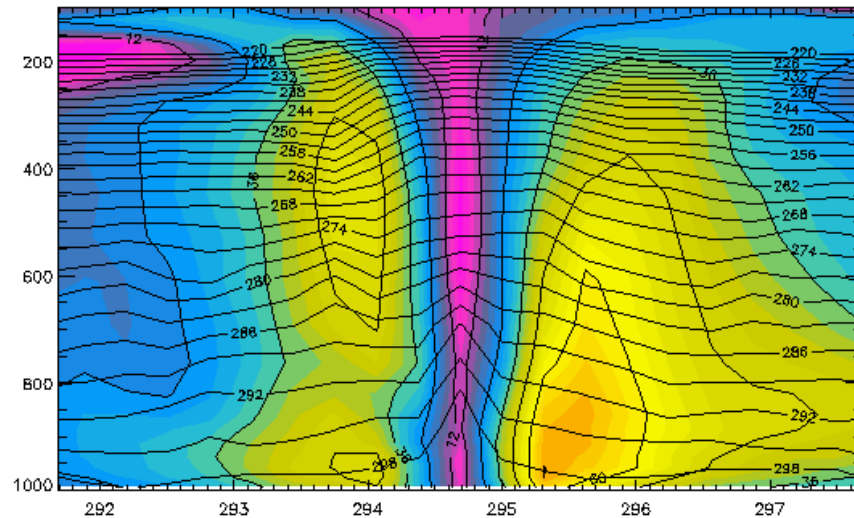
Alvin: 0602-08 969hPa 28m/s
 Bart: 0622-30 1002hPa 27m/s
 Cartman: 0722-04 992hPa 35m/s
 Dilbert: 0802-19 956hPa 50m/s
 Elmer: 0827-11 963hPa 58m/s
 Felix: 0831-14 898hPa 40m/s
 Gumbly: 0922-04 979hPa 33m/s
 Homer: 1008-13 995hPa 28m/s



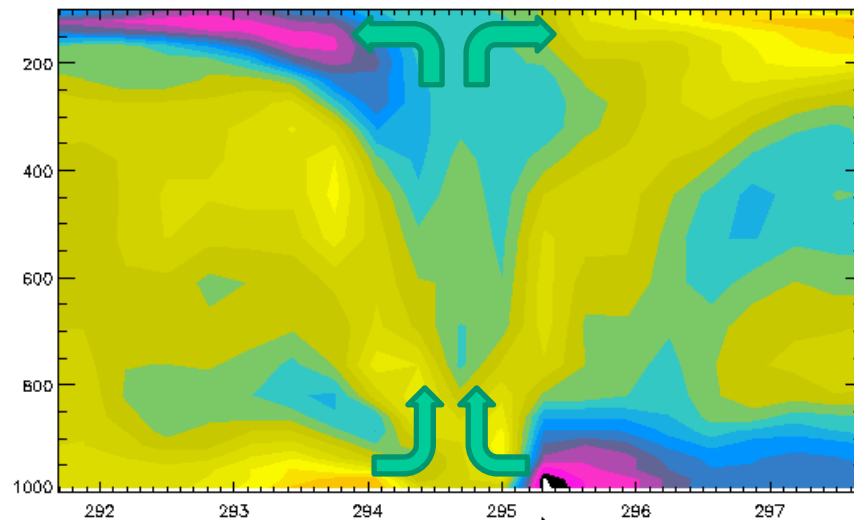
1997

East-west section through "Dilbert" close to peak on 8/8, P=922 hPa, winds~60 m/s

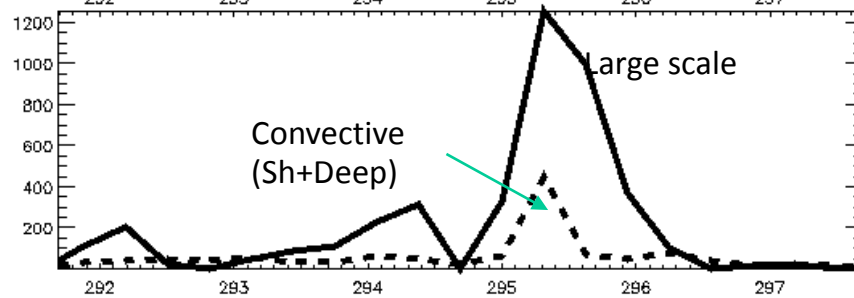
Colors: V_{mag}
Lines: T



Colors: U
Inflow and outflow



Precipitation mm/d



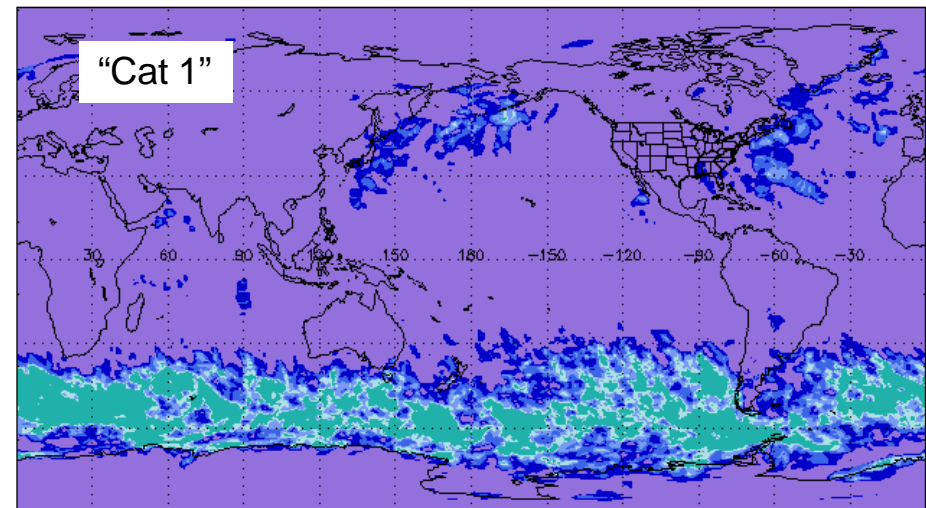
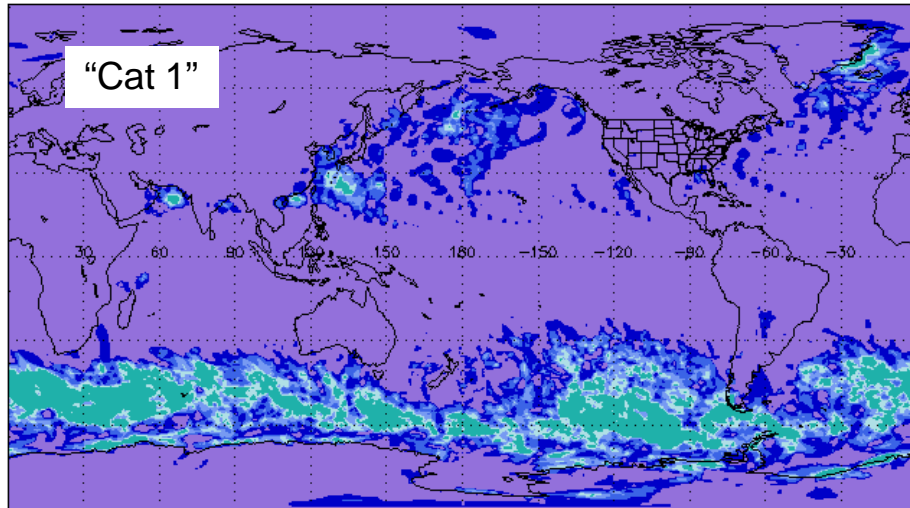
Storm Days: P is -10 hPa below monthly mean .AND. Maximum 900 hPa wind within ~ 125 km is >30 m/s (“Cat1”) or >50 m/s (“Cat3”)

1997

2005

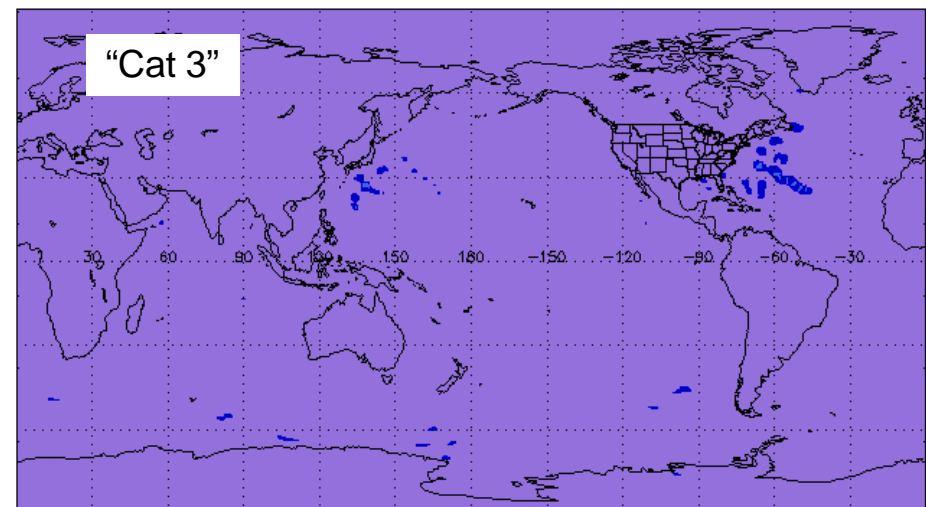
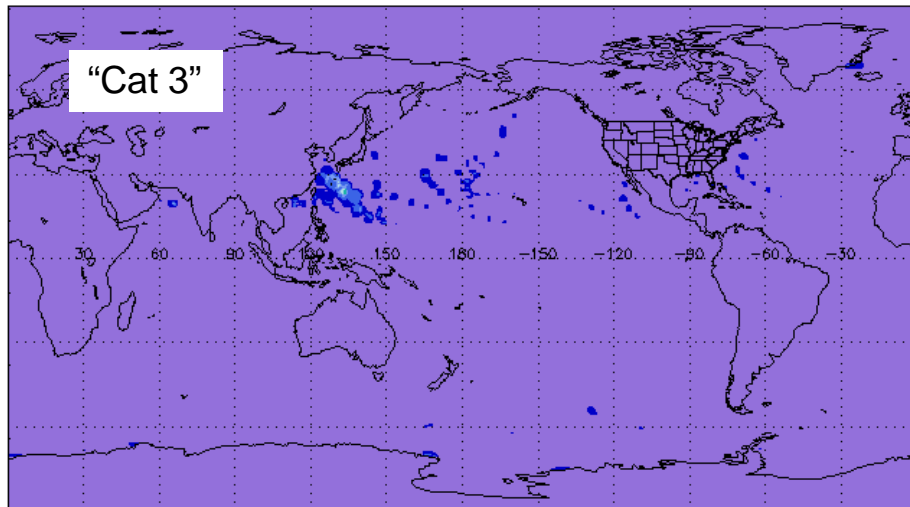
Days with $W > 30$ m/s and $P^* < -10$ hPa at 12 Z June 1 – Oct 15 1997

Days with $W > 30$ m/s and $P^* < -10$ hPa at 12 Z June 1 – Oct 15 2005



Days with $W > 50$ m/s and $P^* < -10$ hPa at 12 Z June 1 – Oct 15 1997

Days with $W > 50$ m/s and $P^* < -10$ hPa at 12 Z June 1 – Oct 15 2005



1997 and 2005 seasons:

Encouraging; W Pacific storms more intense, two over 70 m/s; variability in number of storms has correct sign in both basins,

BUT ...

W. Pacific much too sensitive

* $V_{\max} > 33$ m/s

IBTrACS 1997:2005 ratio * 19:15

CAM 24:8 !!!!

Atlantic maybe not sensitive enough

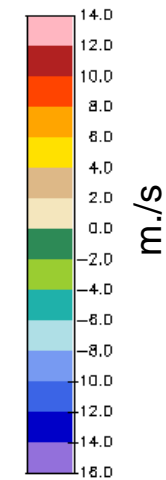
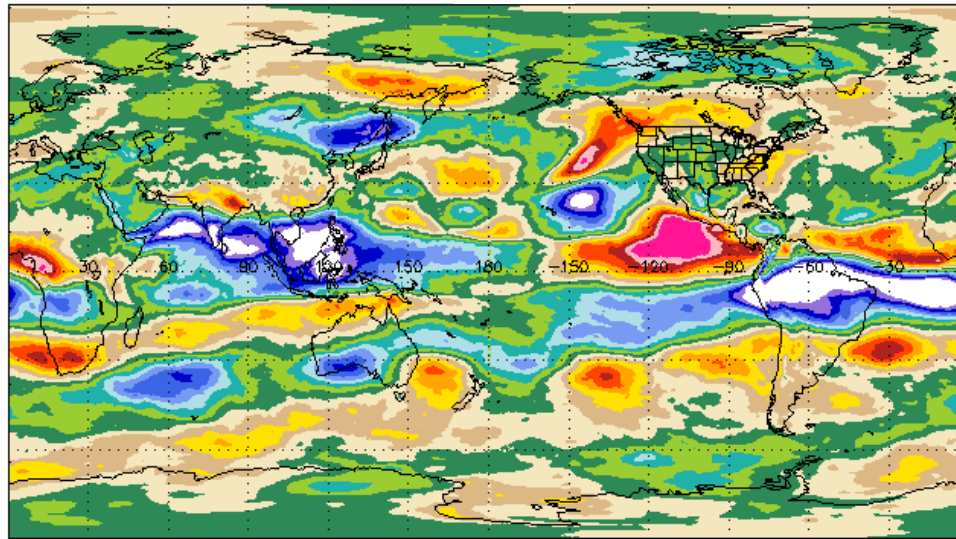
IBTrACS 1997:2005 ratio 3:15

CAM 5:12

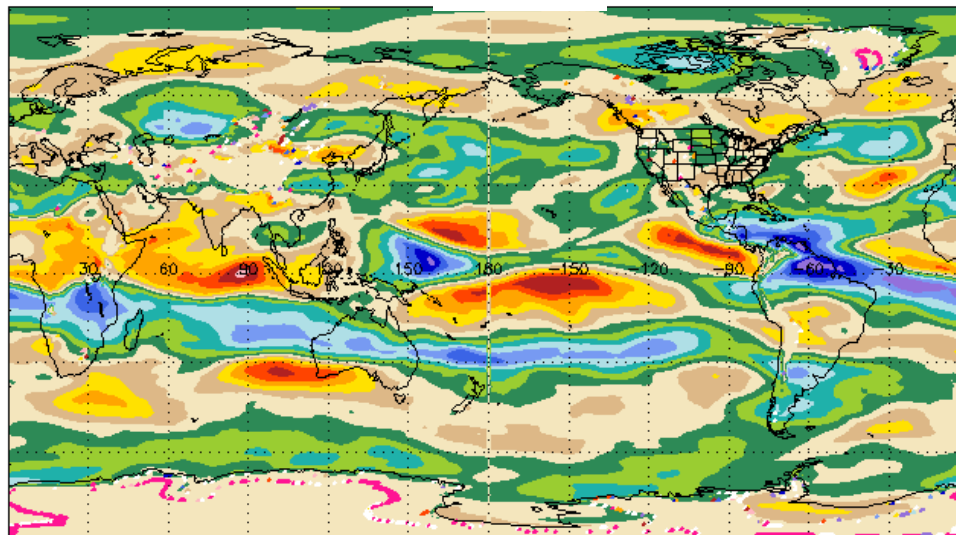
Caveat: One run per season. Zhao et al (2009) find spread in numbers, e.g., N. Atl. 2005 ($n \sim 10-17$) over 4 different ensemble members

Seasonal mean (JAS) 850-200 hPa wind shear difference between 2005 and 1997
Positive=> stronger shear in 2005

CAM



MERRA



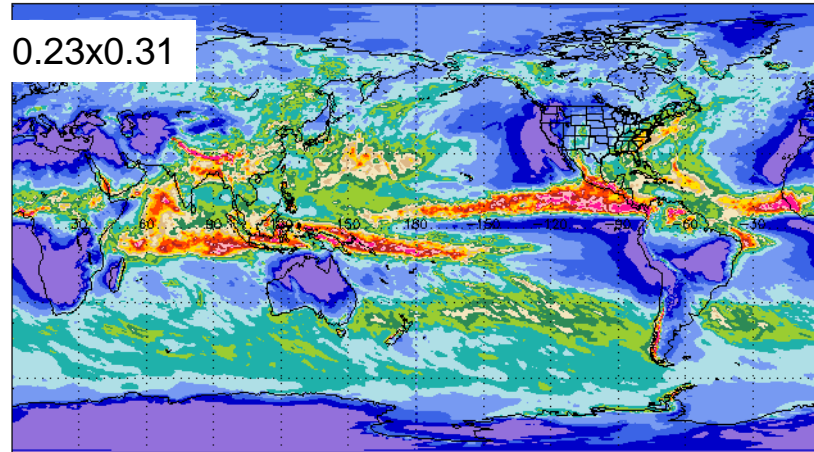
Wind shear does not seem to be the key

Other Seasonal Means

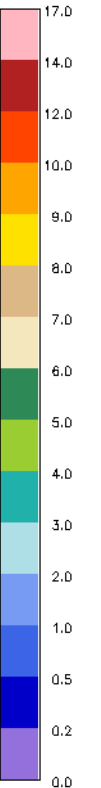
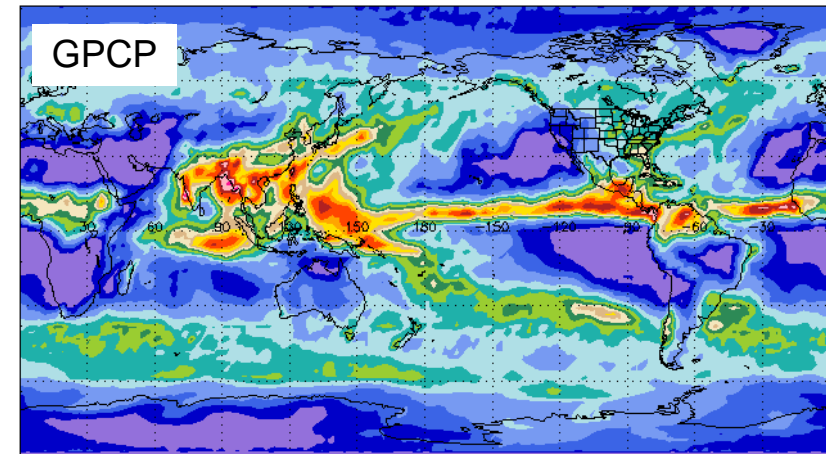
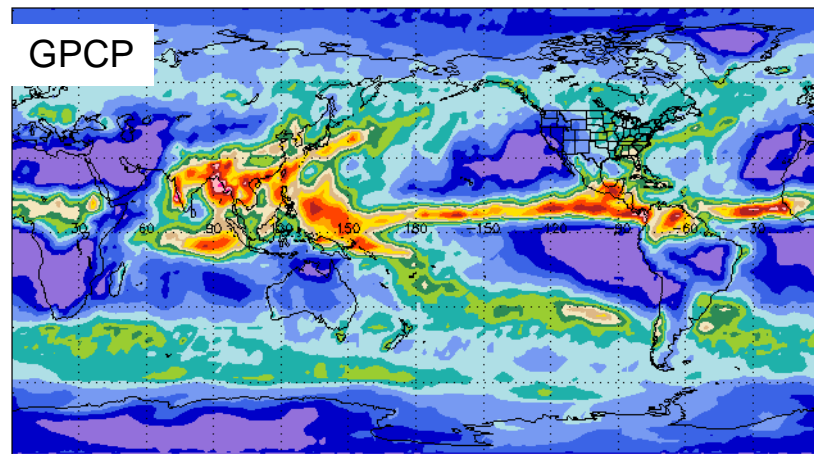
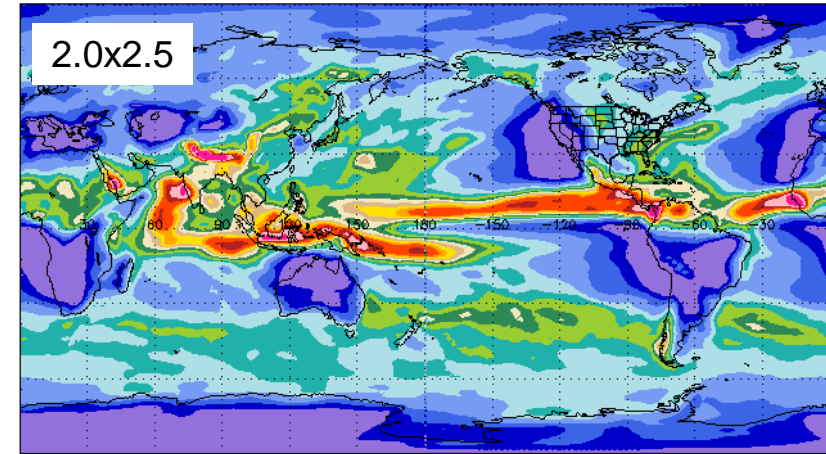
Including comparisons with 2.0x2.5

Seasonal Mean precipitation JJA 2005

Precip. JJA_2005 Global mean=3.2 W/r

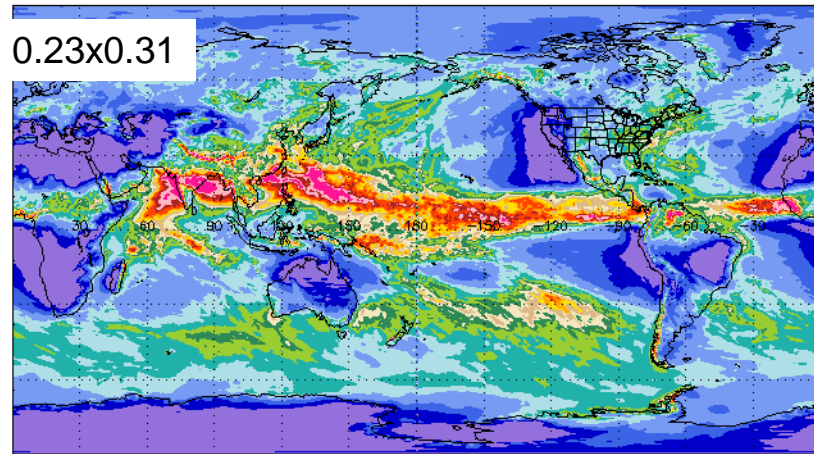


Precip. JJA_2005 Global mean=3.1 W/m²

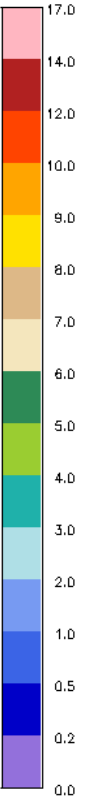
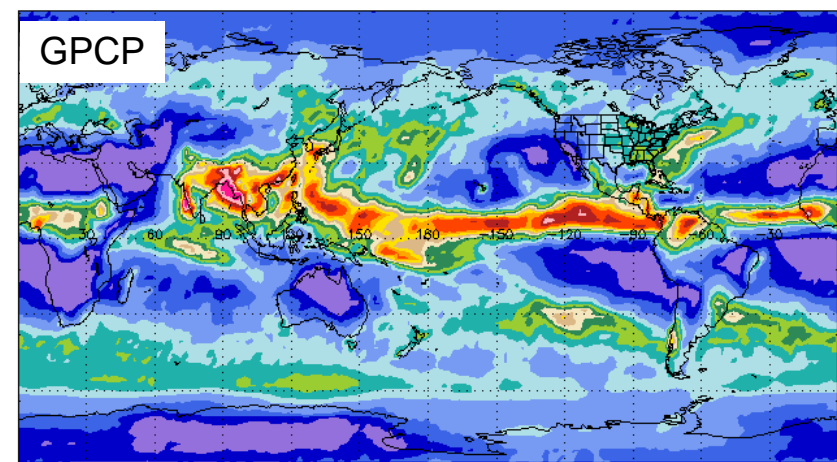
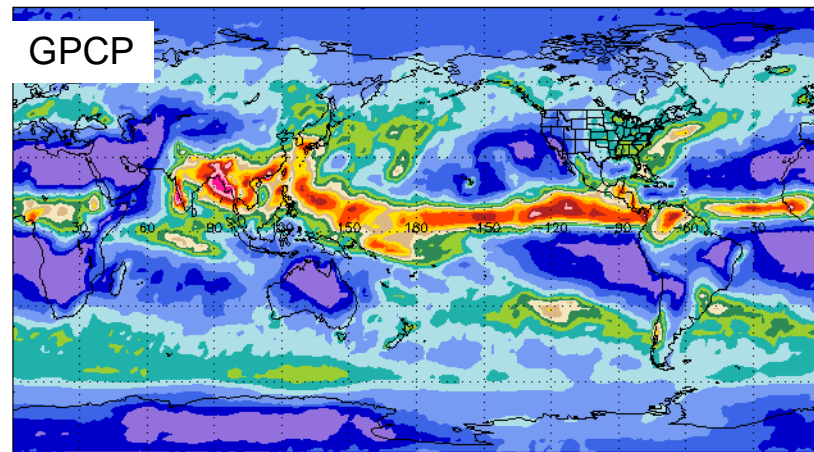
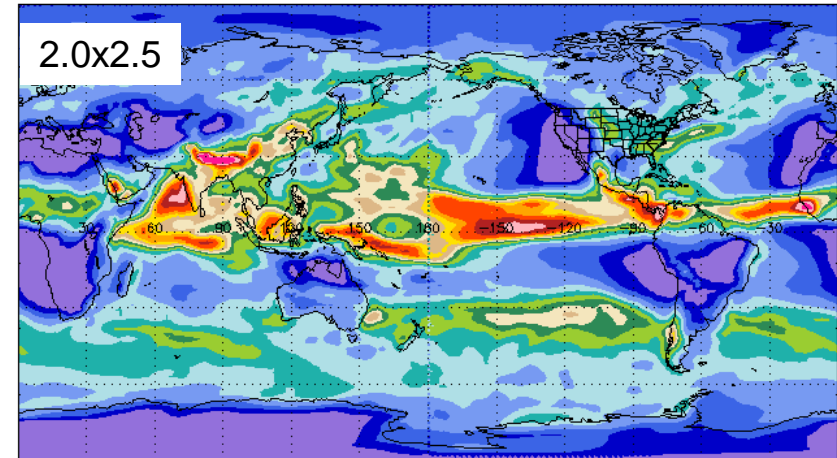


Seasonal Mean precipitation JJA 1997

Precip. JJA_1997 Global mean=3.2 W_v

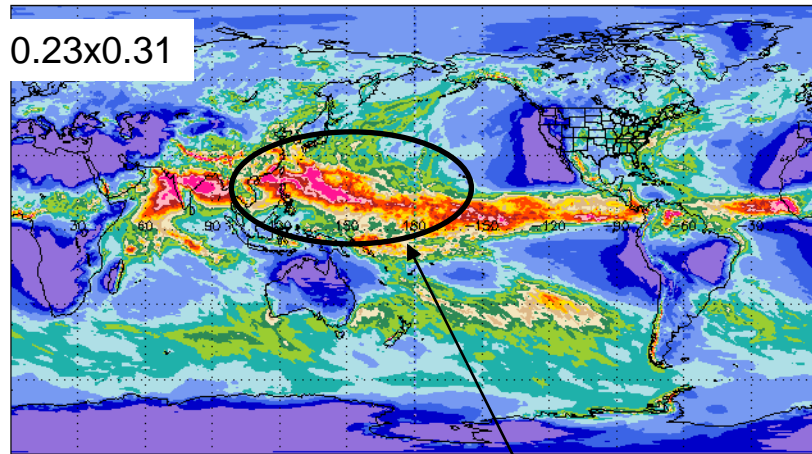


Precip. JJA_1997 Global mean=3.0 W/m²

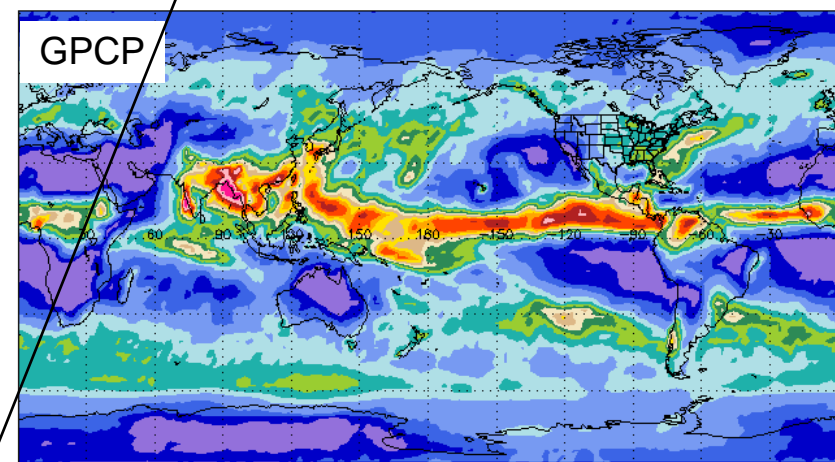
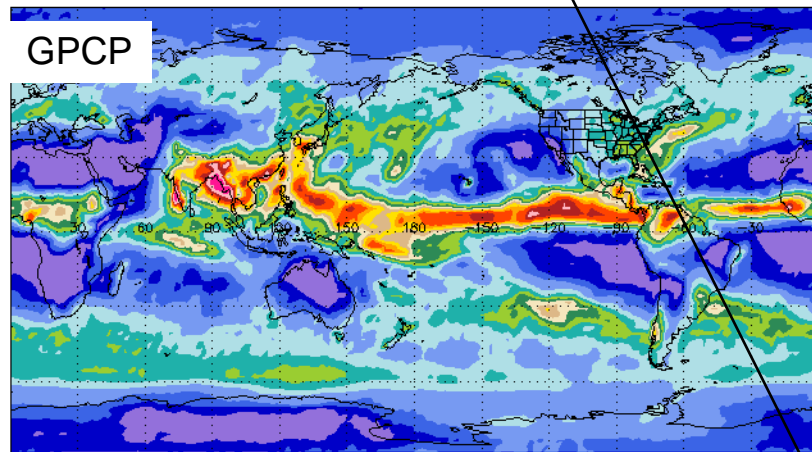
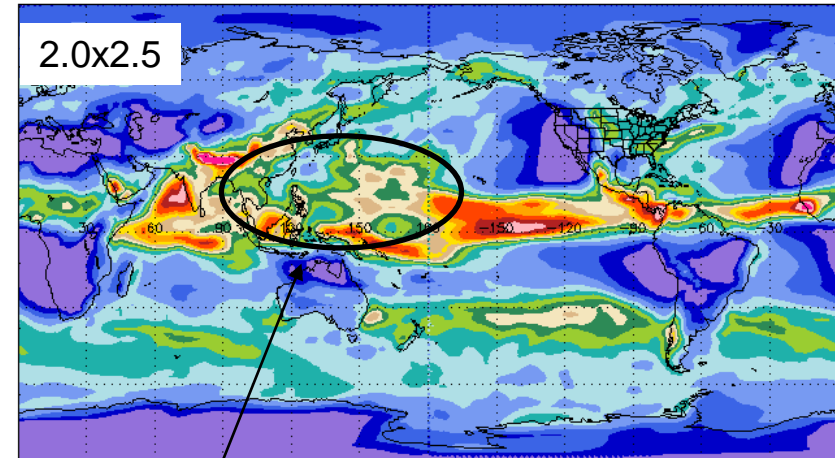


Seasonal Mean precipitation JJA 1997

Precip. JJA_1997 Global mean=3.2 W_v



Precip. JJA_1997 Global mean=3.0 W/m²

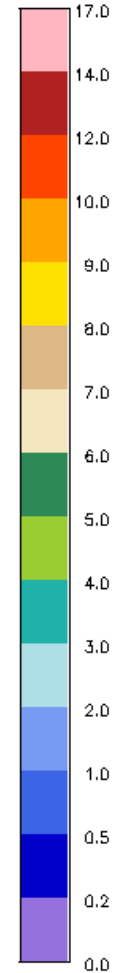
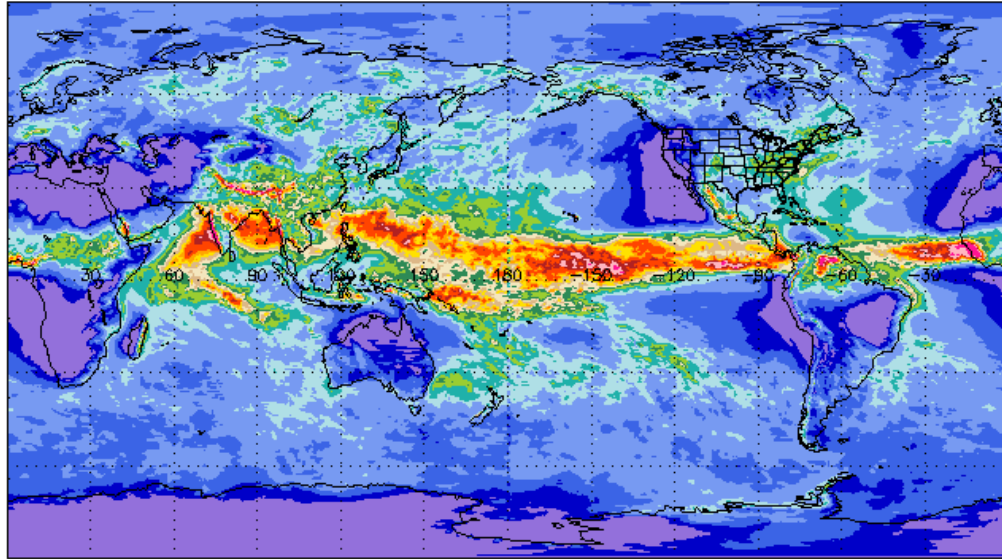


A real seasonal mean difference/improvement due to increased resolution!!!

“non-storm” precipitation JJA 1997

“Storm” definition hampered by once daily PS U,V output.

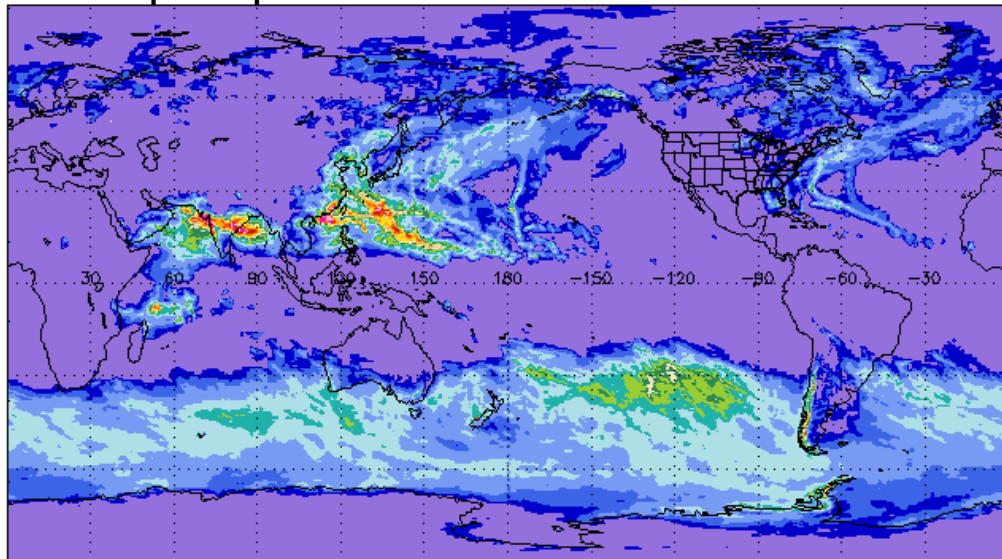
Here “storm” means **daily mean** PS 3 hPa lower than monthly mean and inst. winds at (day0,day+1) 12Z > 20 m/s (within 125 km)



0-40N means

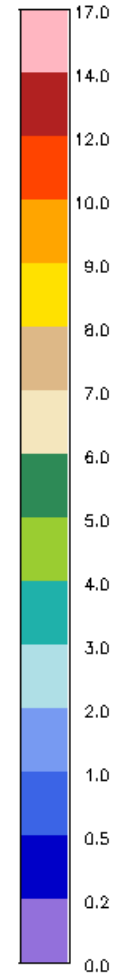
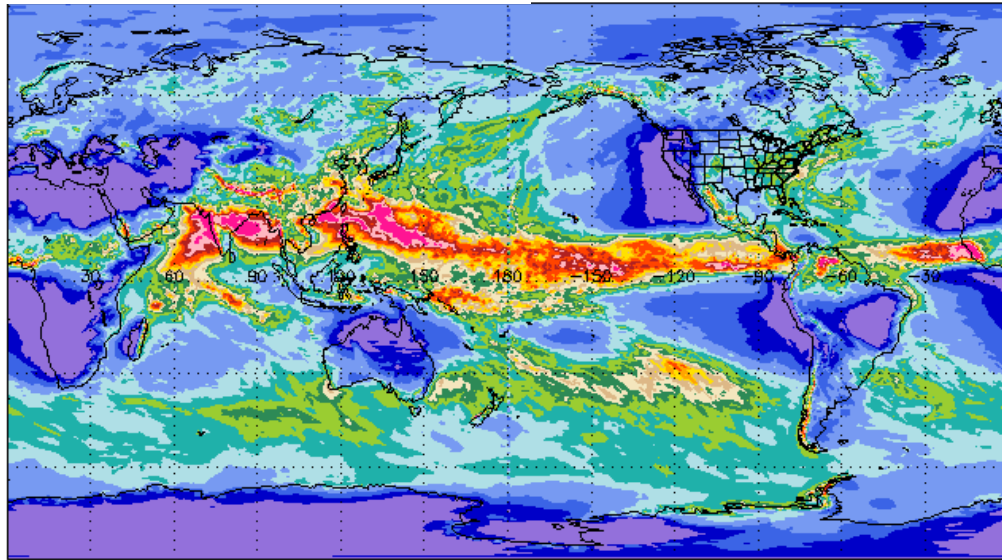
Tot. storm prec=0.81
LS “ =0.43

Storm precipitation JJA 1997



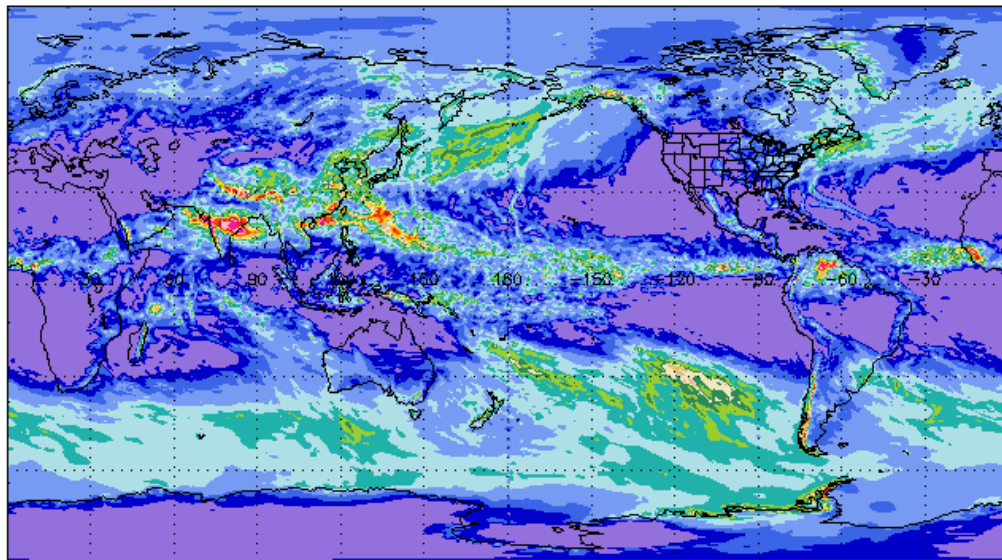
Total precipitation

Global mean=3.2 W/m²



grid-scale precipitation

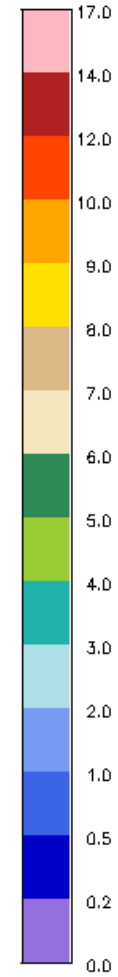
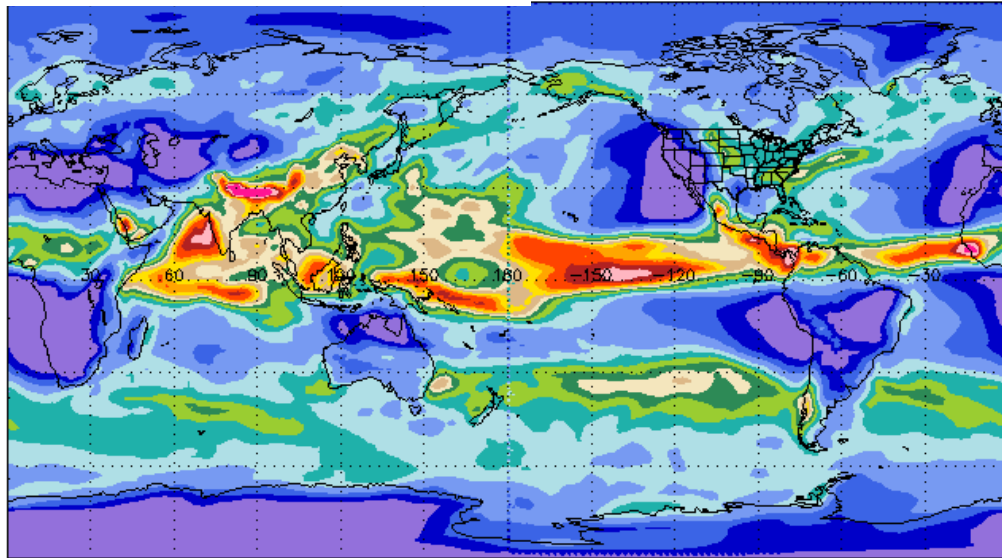
Global mean=1.5 W/m²



Two – degree simulation

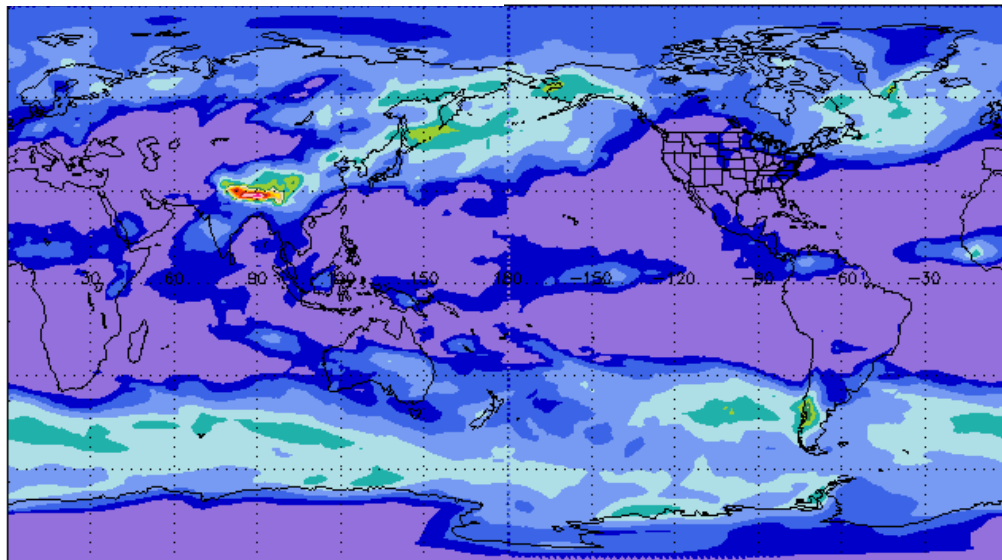
Total precipitation

Global mean=3.0 W/m²



grid-scale precipitation

Global mean=0.8 W/m²

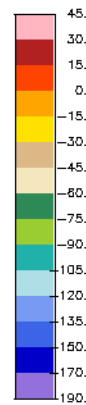
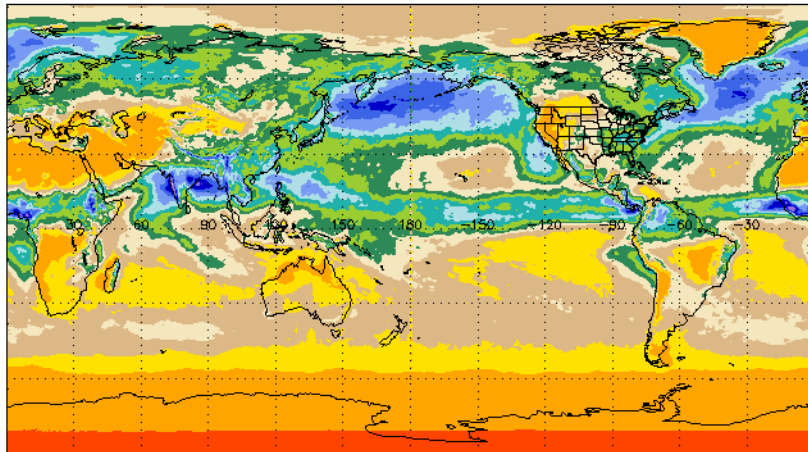


Shortwave cloud forcing

0.23x0.31

1997

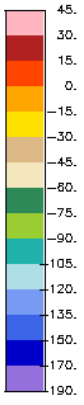
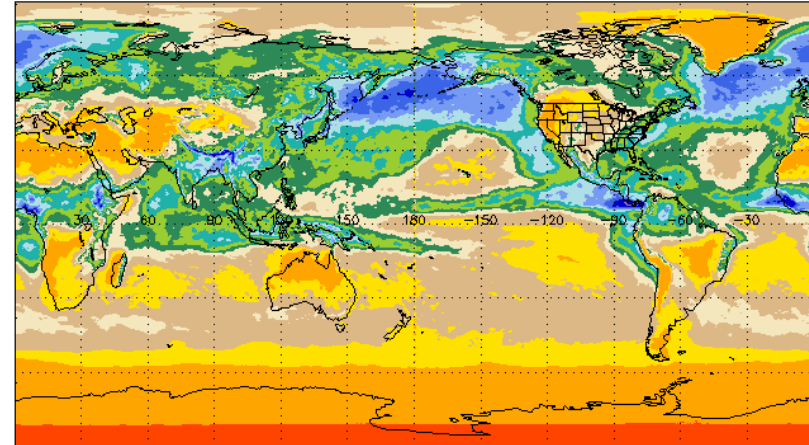
Global mean= -52.0 W/m^2



0.23x0.31

2005

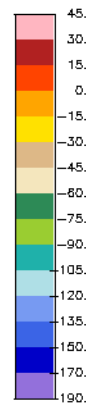
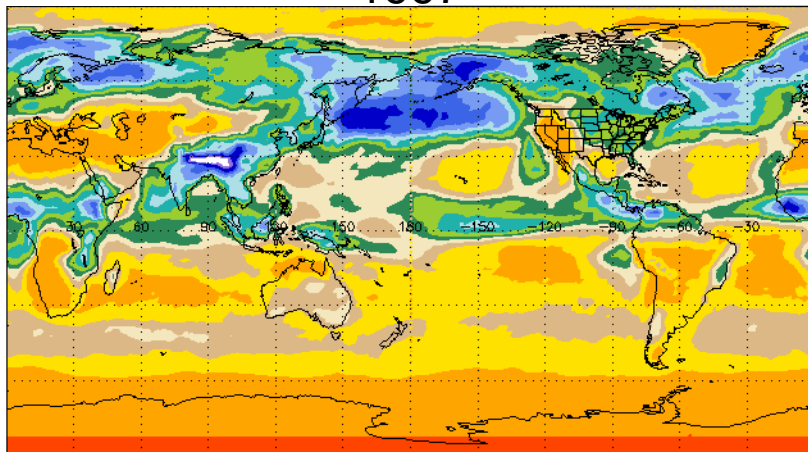
Global mean= -52.1 W/m^2



2.0x2.5

1997

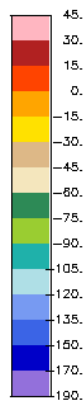
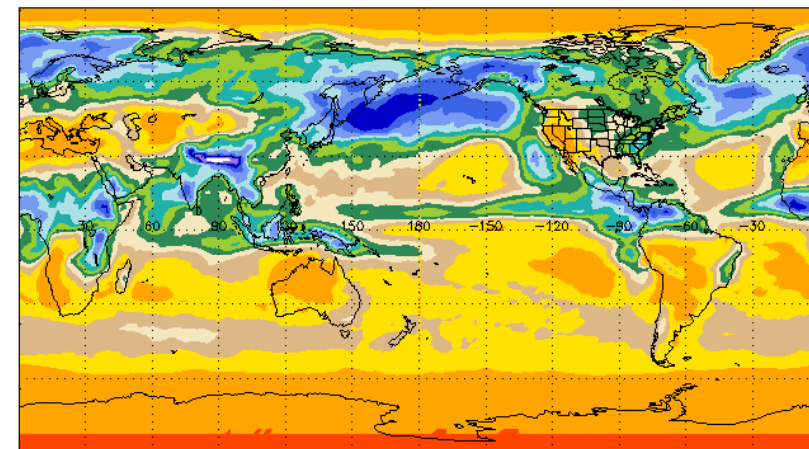
Global mean= -48.2 W/m^2



2.0x2.5

2005

Global mean= -49.6 W/m^2

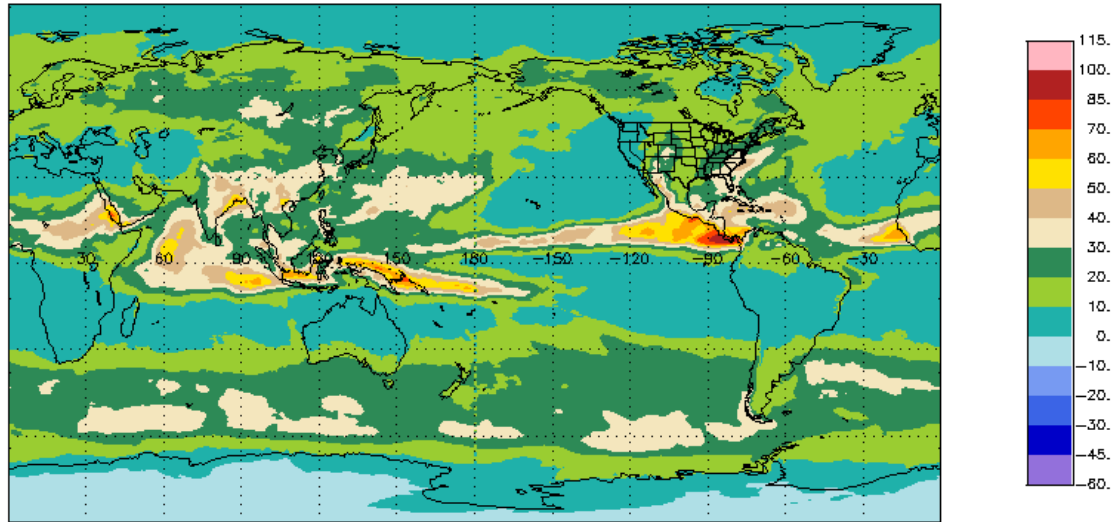


Resolution sensitivity of SWCF in Track 5 / CAM 5 has opposite sign to that in Track 1 / CAM 4 (*A Mirin's runs SWCF: 50.1 W m^{-2} (2.0x2.5) \implies 44.2 (0.23x0.31)*)

Longwave cloud forcing

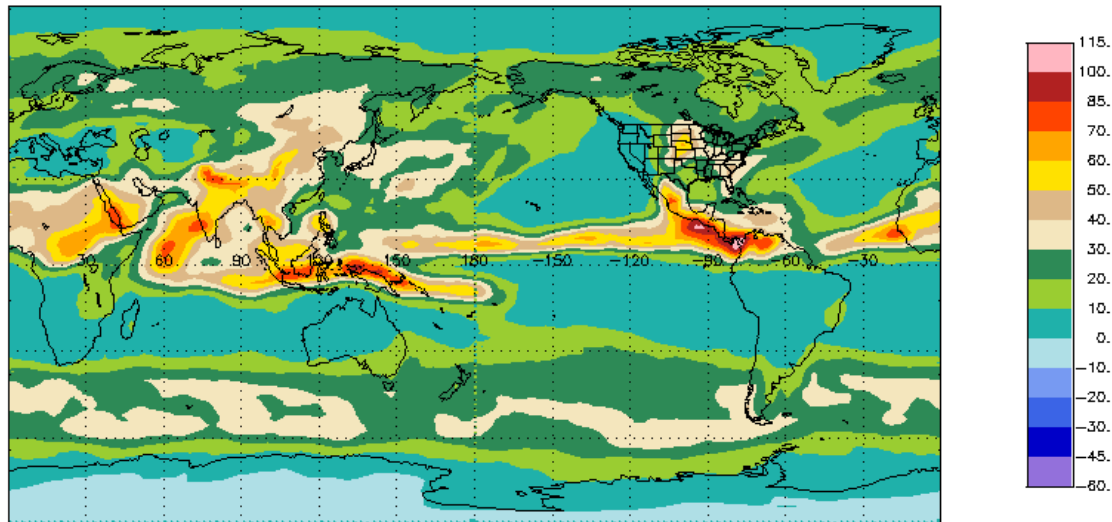
0.23x0.31

Global mean=18.1 W/m²



2.0x2.5

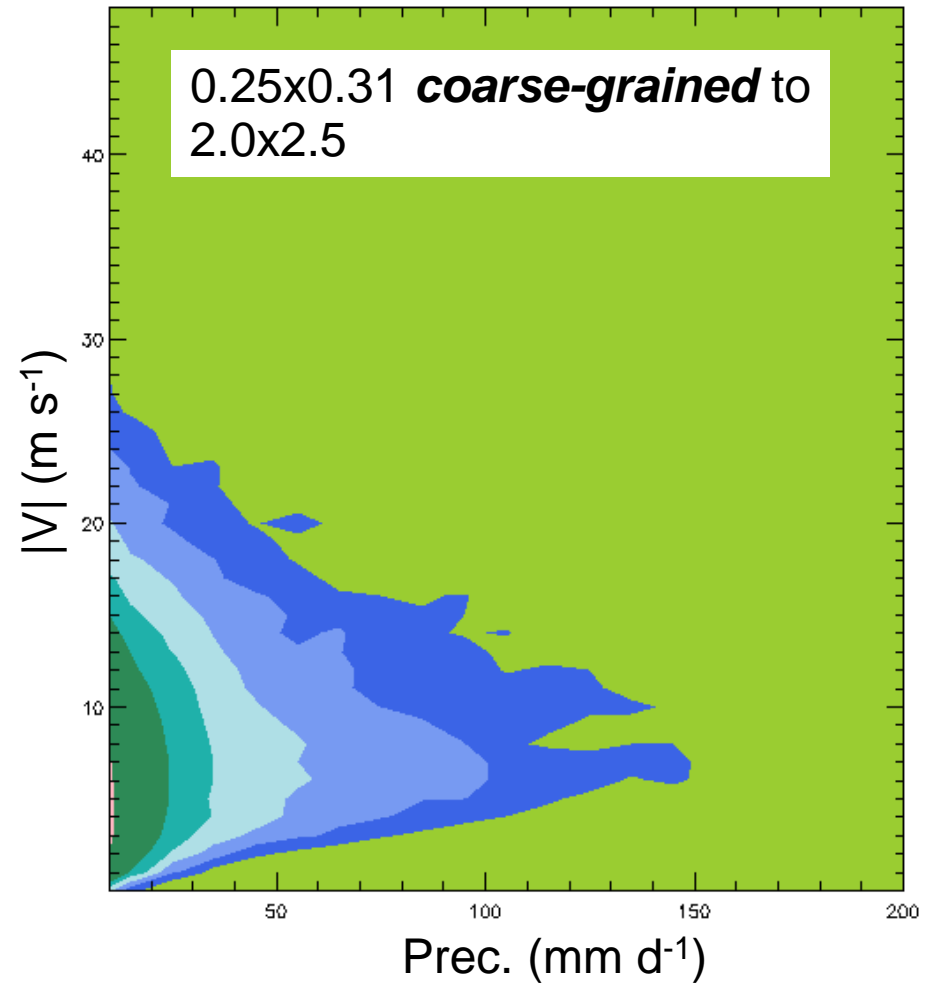
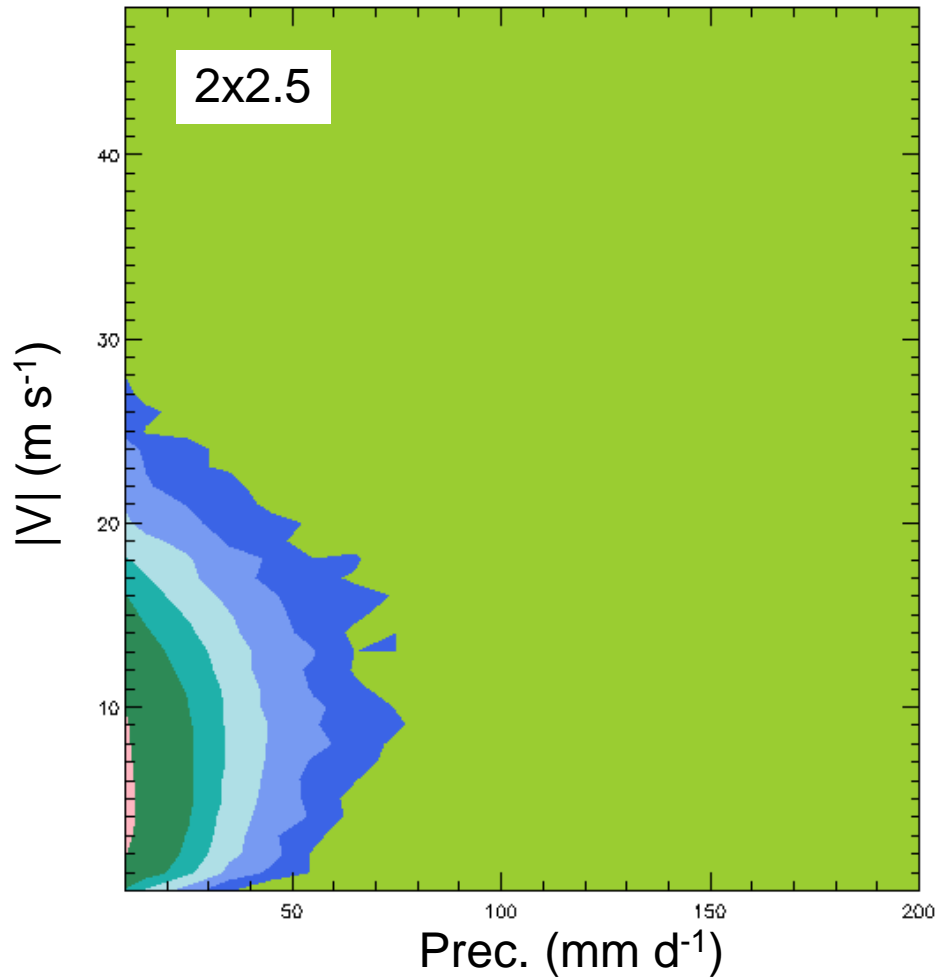
Global mean=21.4 W/m²



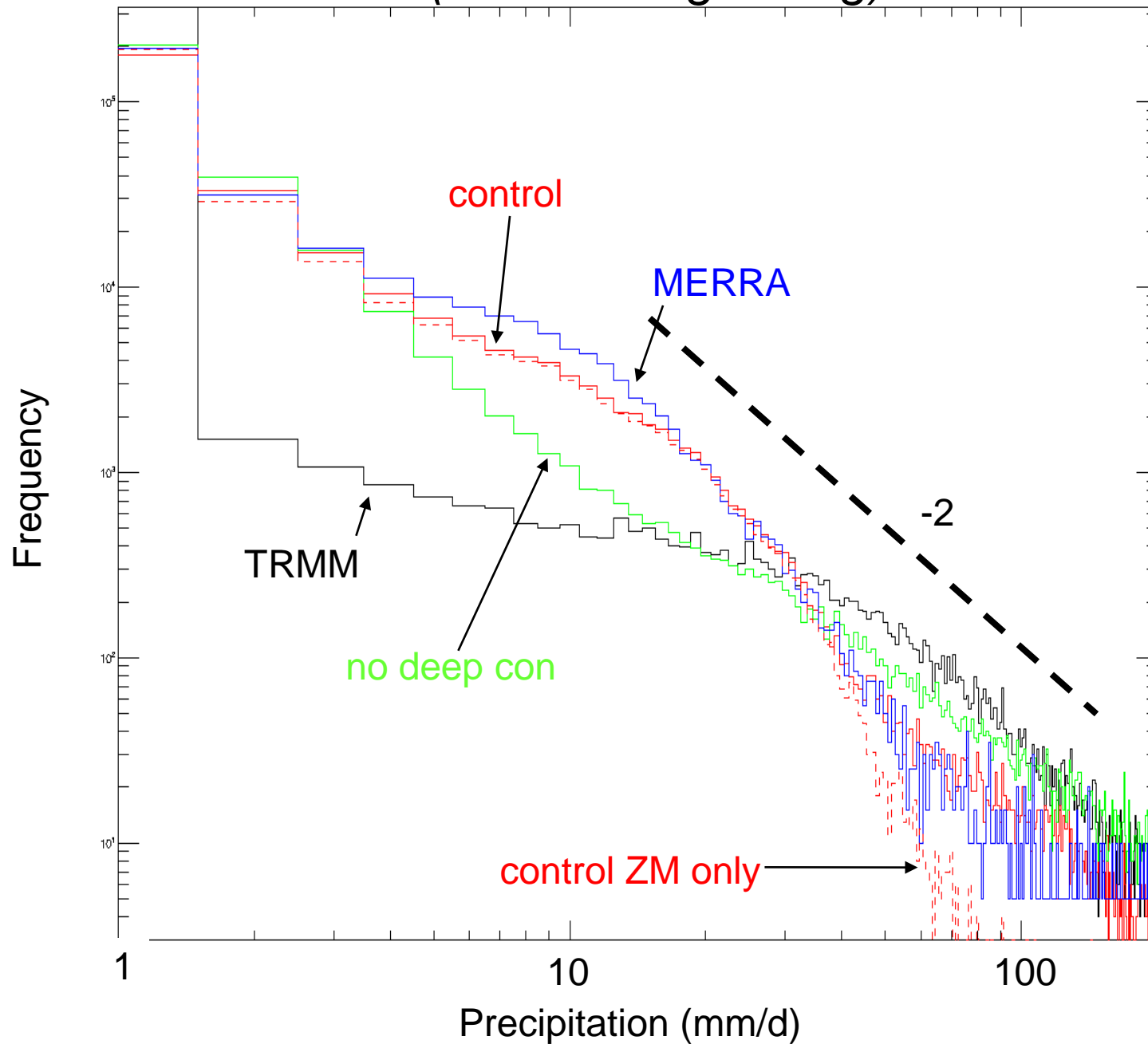
A Mirin's runs : LWCF: 28.4 (2.0x2.5) ==> 21.6 (0.23x0.31)
Same sign but stronger effect

Some statistics

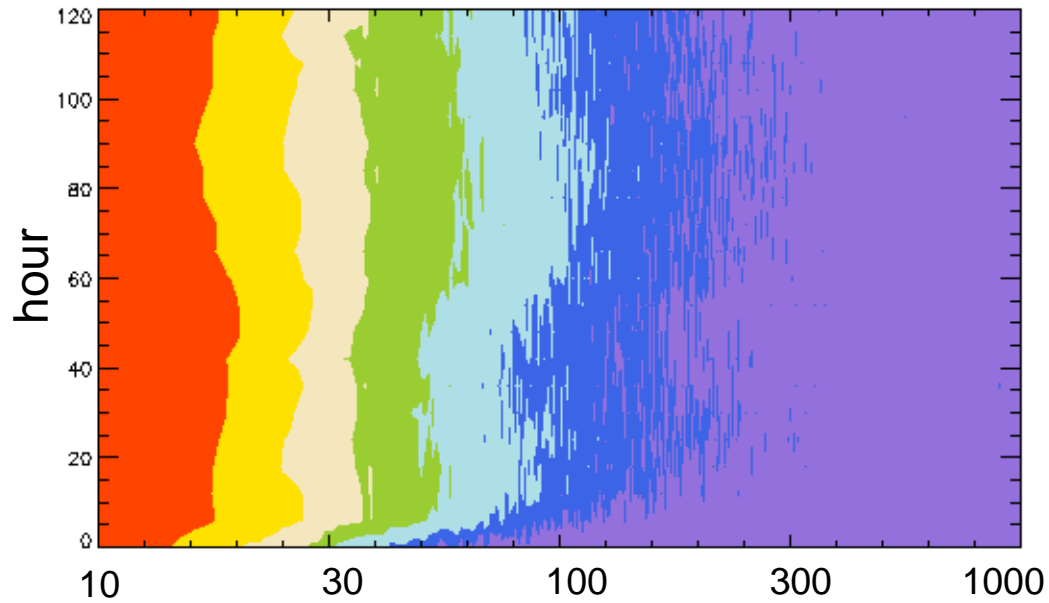
Joint PDFs of precipitation rate and wind speed at 900 hPa
(instantaneous ,once-daily for June 1 to Oct 15 1997)



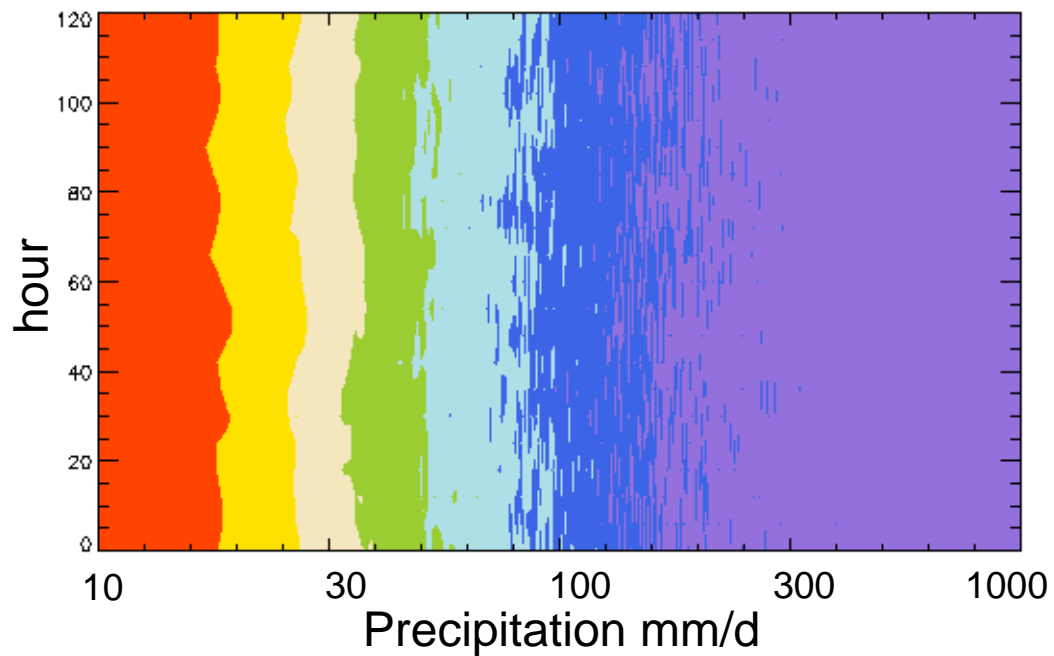
PDFs of precipitation intensity (log-log) 30S - 30N (no coarse-graining)



Time evolution of precipitation intensity PDF



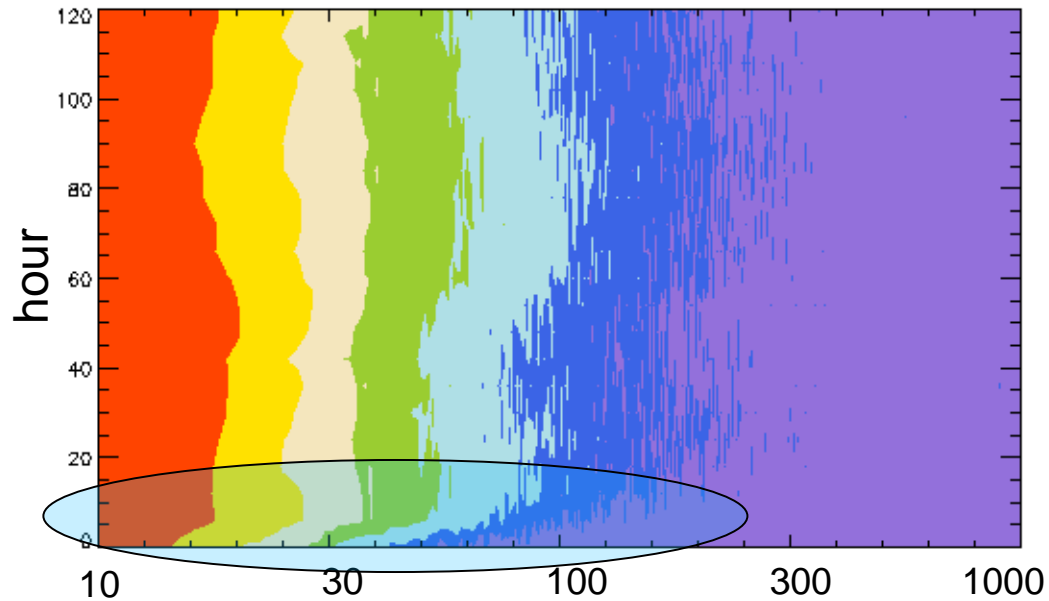
5-day forecast run



5-day segment of
seasonal run

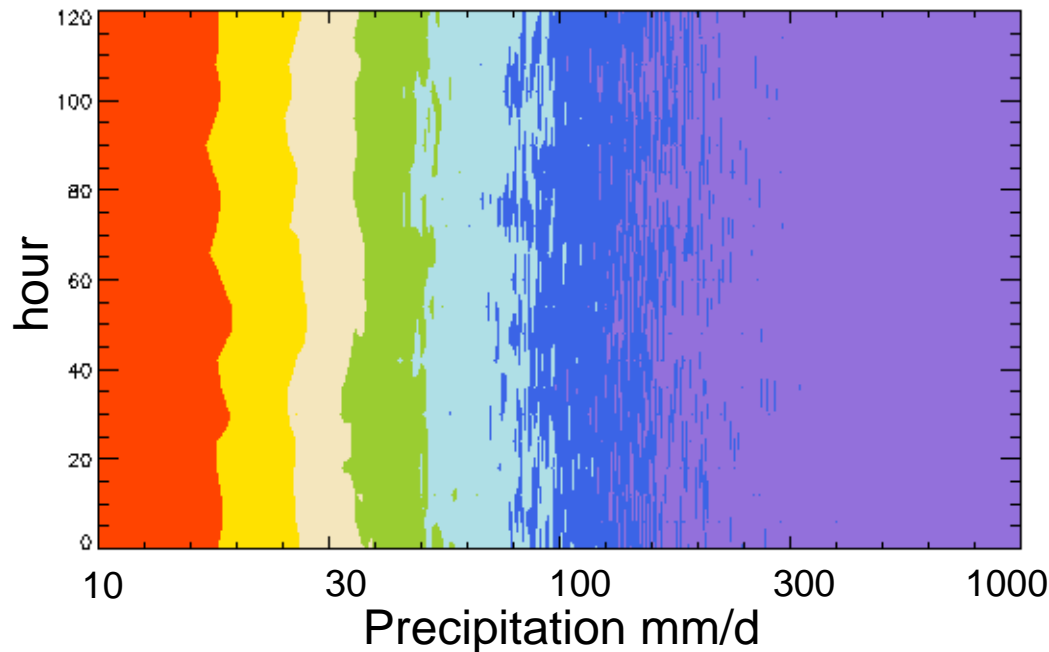
*(days ~85-90, i.e.,
well spun-up)*

Time evolution of precipitation intensity PDF



Rapid spinup of precip stats

5-day forecast run



5-day segment of
seasonal run

*(days ~85-90, i.e.,
well spun-up)*

Summary and Conclusions

Some encouraging aspects in tropical cyclone simulations. *ZM/NR deep scheme not toxic to cyclones.*

High resolution improves JJA 1997 seasonal precipitation possibly due to resolved mesoscale dynamics.

Precip intensity statistics in forecast and climate runs are similar (and spin up within 24 hrs)

Some problems in fully parameterized runs.

-weak extremes, excessive moderate rain