Tropical Cyclones and precipitation in 25 Km CAM4 and CAM5

Julio Bacmeister, Cecile Hannay, Richard Neale, Peter Lauritzen, Andrew Gettelman, John Truesdale, Julie Caron

Michael Wehner *(DoE/LBNL)*, Mark Taylor *(DoE/Sandia)*

Thanks to DoE, Warren Washington for computer time

NCAR NATIONAL CENTER FOR ATMOSPHERIC RESEARCH

NESL's Climate & Global Dynamics CGD

U.S. DEPARTMENT OF ENERGY

NSF

AMWG Meeting, 1-3 February, 2012

	CAM-4	CAM-5
PBL	Holtslag-Boville	UW diagnostic TKE (Bretherton and Park)
ShCu	Hack shallow convection	UW (Park and Bretherton)
Radiation	CAM radiation (Collins)	RRTMG
Cloud macro-phys	Rasch-Kristjansson, Zhang	Park et al.
Micro-physics	Rasch-Kristjansson	2 moment (Morrison Gettelman)
Aerosol	Prescribed bulk	Modal prognostic (Ghan,Liu) (*Prescribed BAM available for high resolution*)
Vertical grid	26-levels	30-levels (4 added in PBL)
Deep Conv	Zhang-Macfarlane w/ mods by Neale,-Richter →	*"*
Dynamical Core	FV latlon (Lin-Rood) →	*"*

Spectral Element Dycore implemented

Existing High-Resolution Experiments

CAM 4:

FV dycore 0.23x0.31

- 1979-present. 2 runs, 1 with GFDL tracking data available 6-hrly, 1 with everything recoverable but U850,V850.
- Future time-slice 2080-2100 (present day climo SSTs)+(CMIP5 RCP8.5 perturbation)

HadISST SSTs

CAM5:

FV dycore 0.23x0.31

- 1979-present (*Michael Wehner LBNL, prescribed BAM aerosols*)
- 18 month runs (2005-6) *(Both prescribed BAM and predicted MAM aerosols)*
- 18 month run w/out deep convection scheme
- 18 month runs w/precipitation loading effects

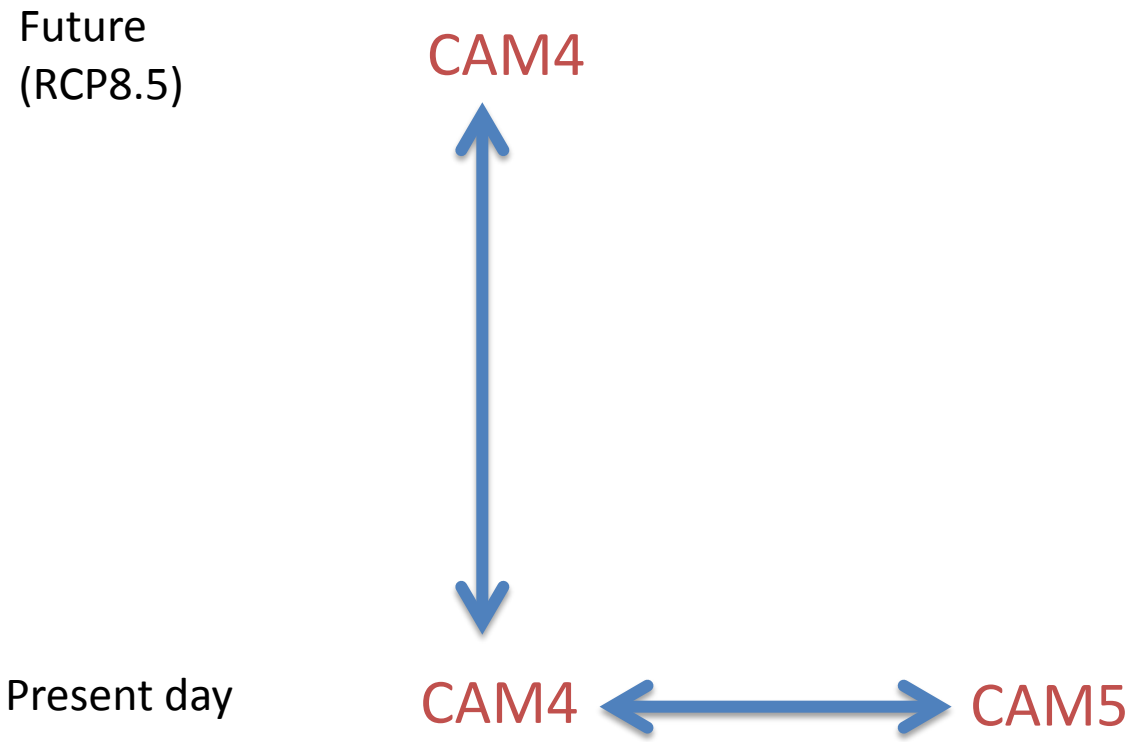
Spectral element (SE) dycore ~25km

- 12+ months (climo ssts)

Spectral element (SE) dycore ~12.5km

- Ongoing AMIP run 2004-

Precipitation and tropical cyclone comparisons

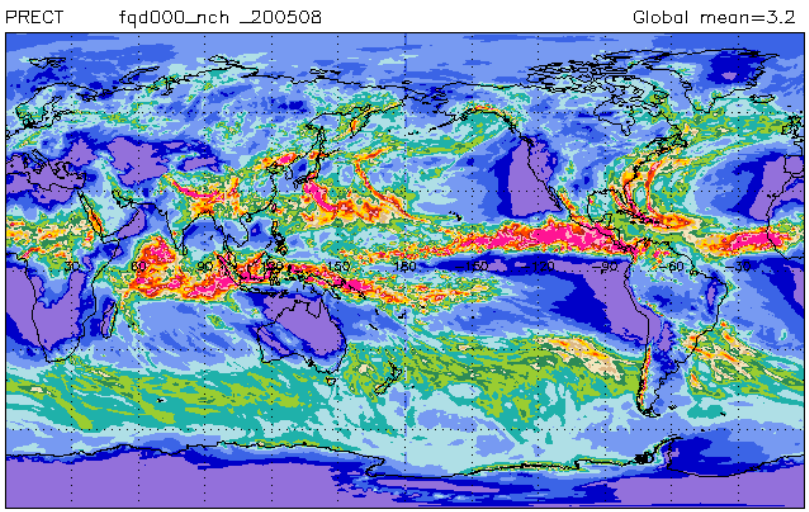


TC analysis in CAM4 just beginning

CAM5

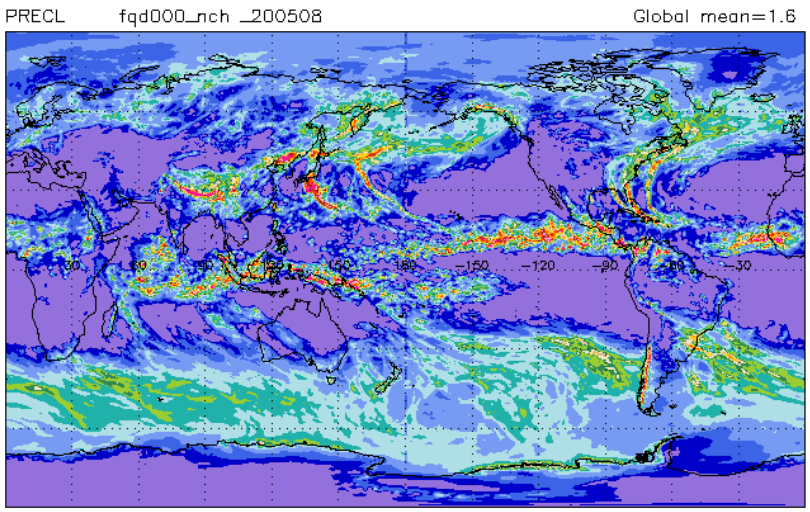
Total precip.

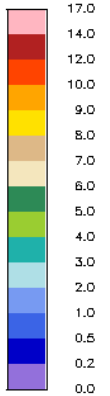
PRECT Global mean=3.2 mm d^{-1}



Large Scale precip.

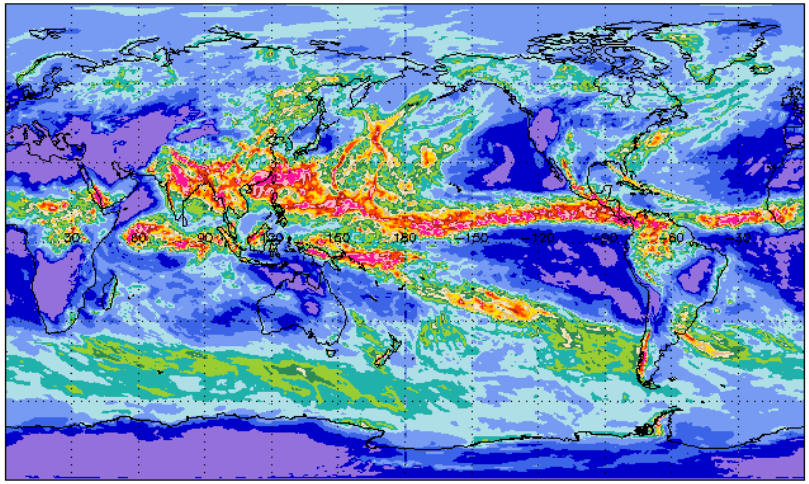
PRECL Global mean=1.6 mm d^{-1}



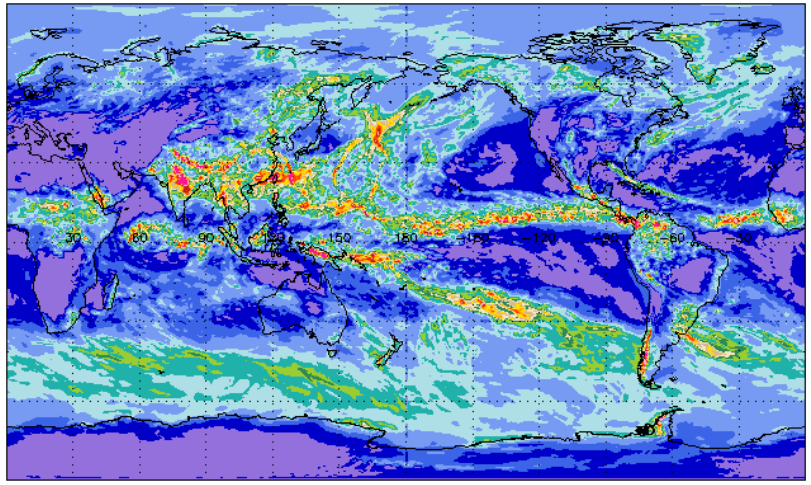


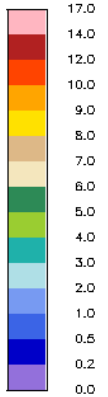
CAM4

PRECT Global mean=3.0 mm d^{-1}



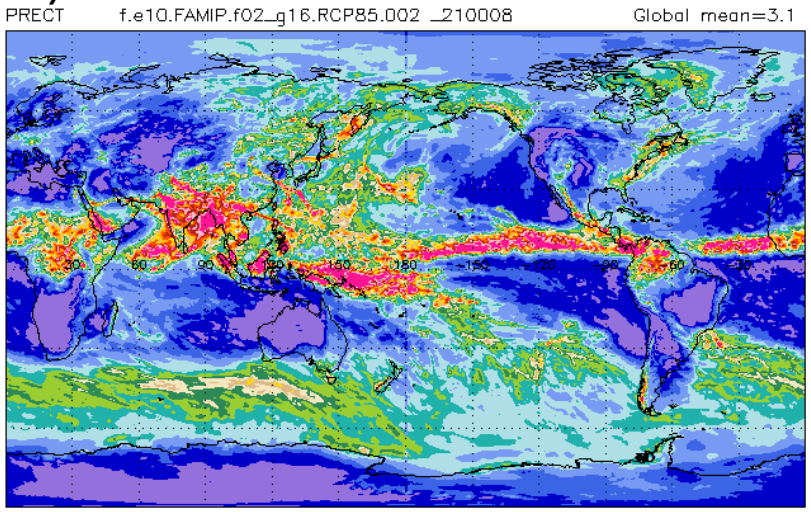
PRECL Global mean=1.9 mm d^{-1}





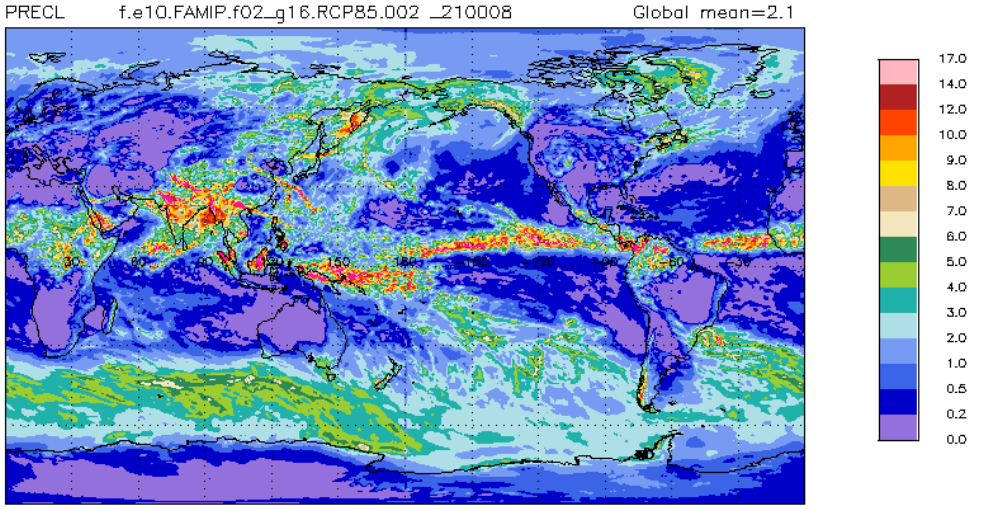
CAM4-*future* ***Total precip.***

08/2100 PRECT Global mean=3.1 mm d^{-1}



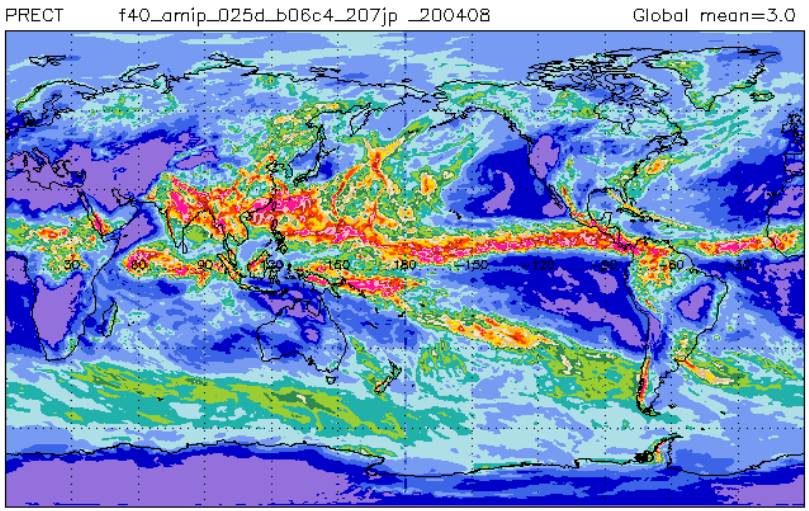
Large Scale precip.

PRECL Global mean=2.1 mm d^{-1}

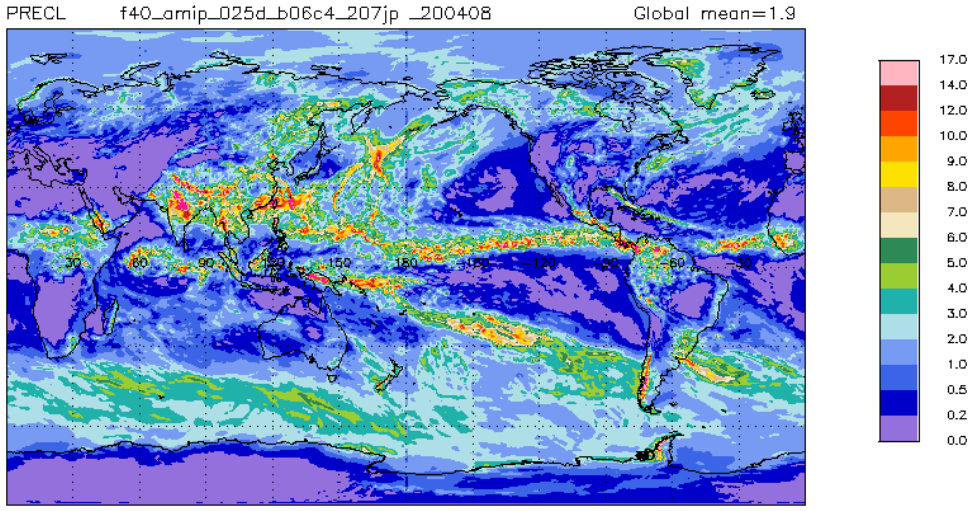


CAM4-*present*

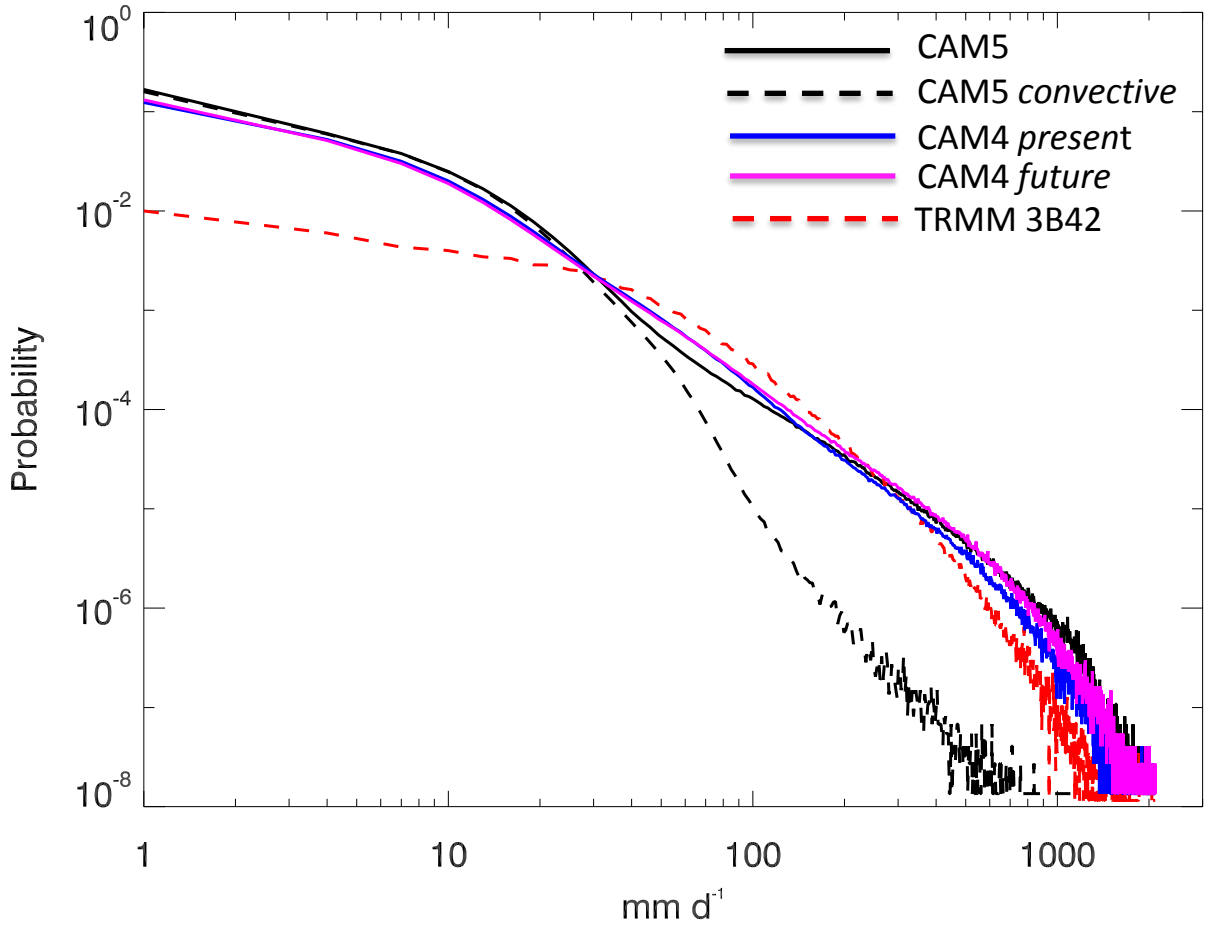
PRECT Global mean=3.0 mm d^{-1}



PRECL Global mean=1.9 mm d^{-1}



PDFs of instantaneous precipitation intensity 30°S-30°N (August)



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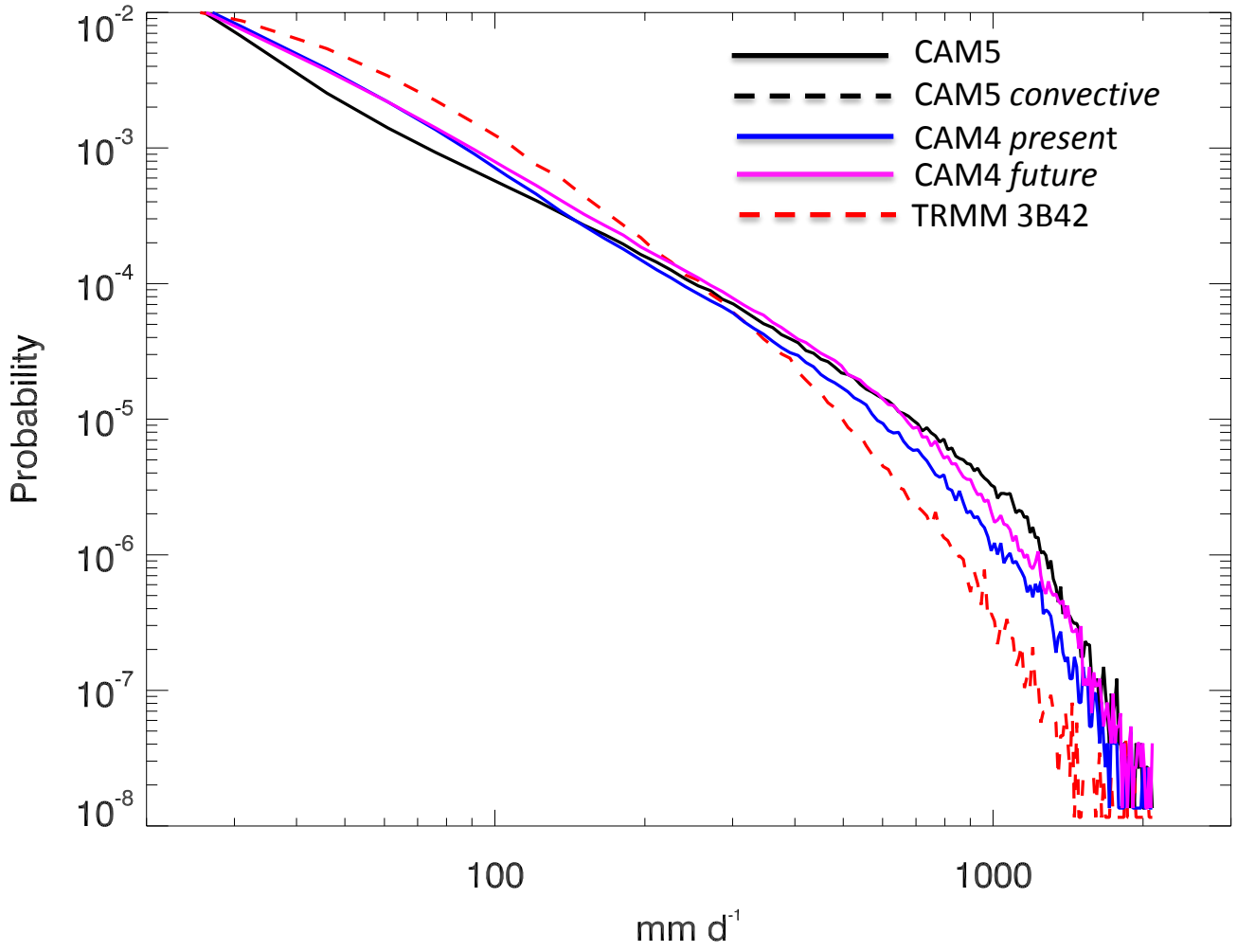
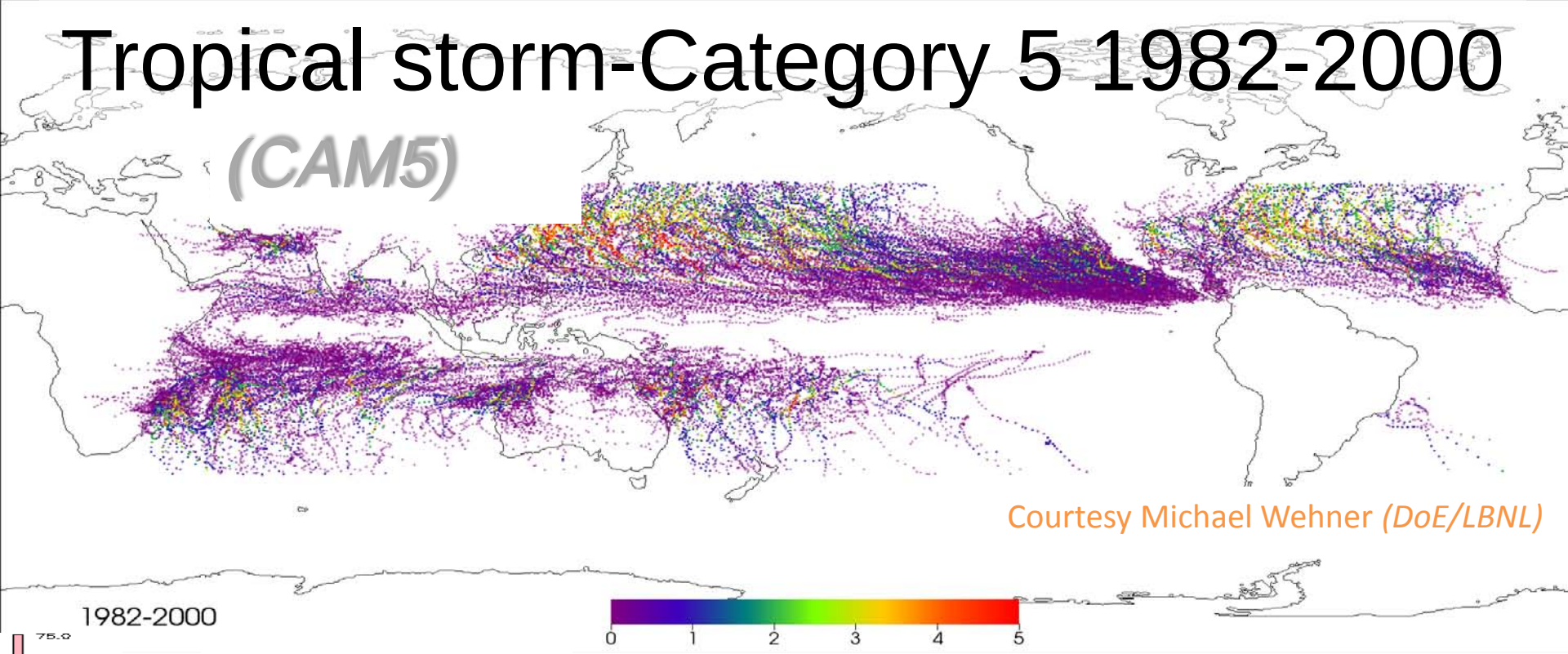
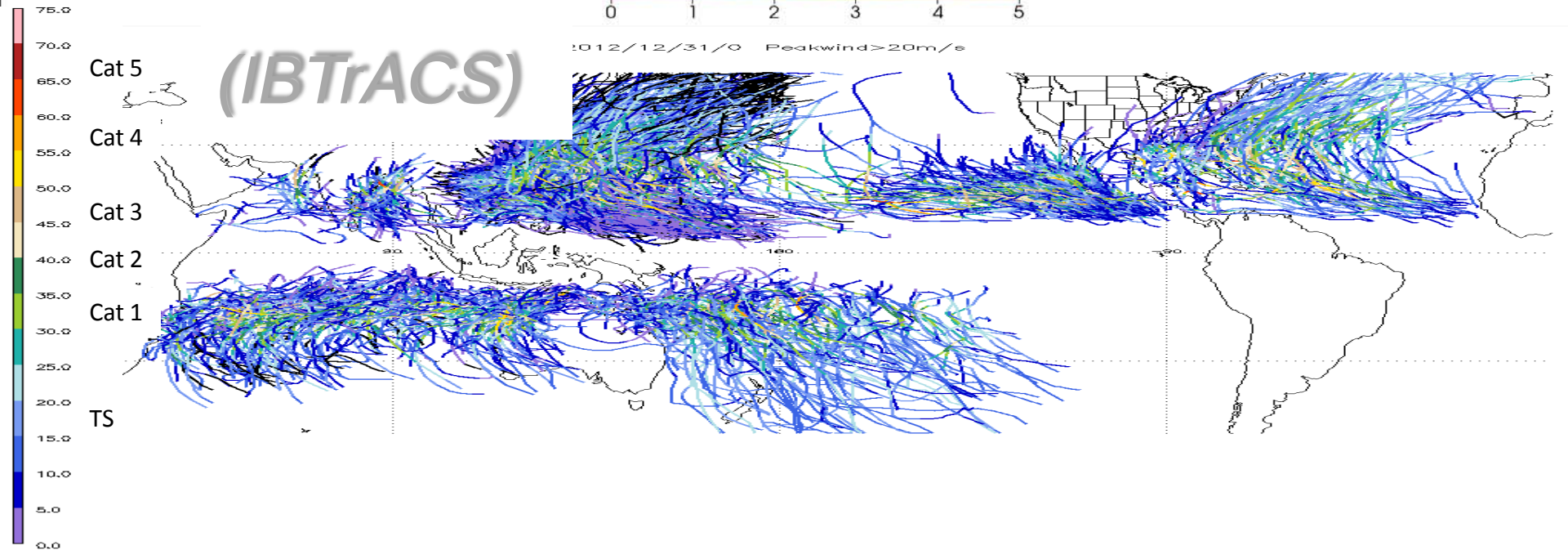


Tropical storm-Category 5 1982-2000

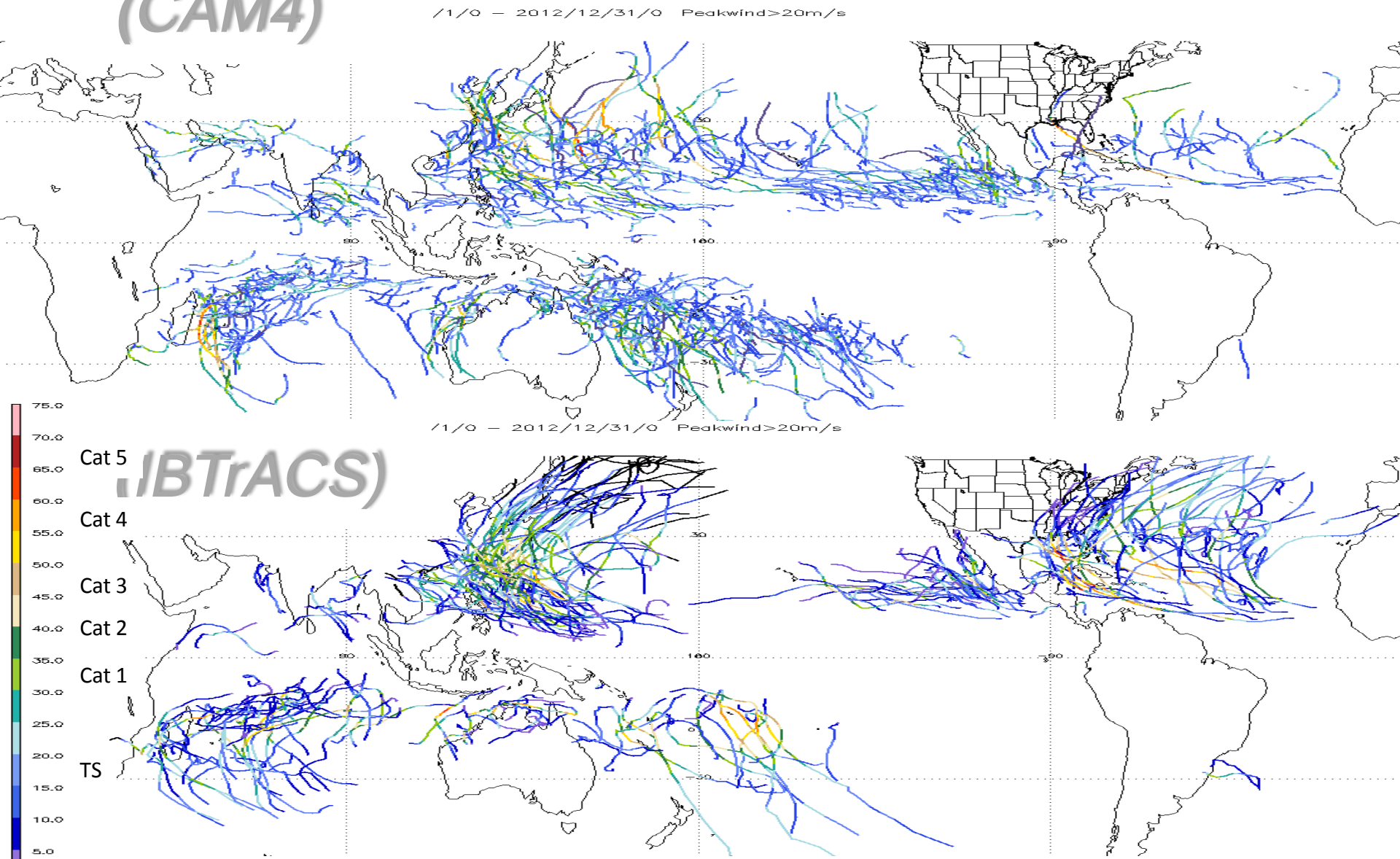


Courtesy Michael Wehner *(DoE/LBNL)*



Tropical storm-Category 5 2003-2005

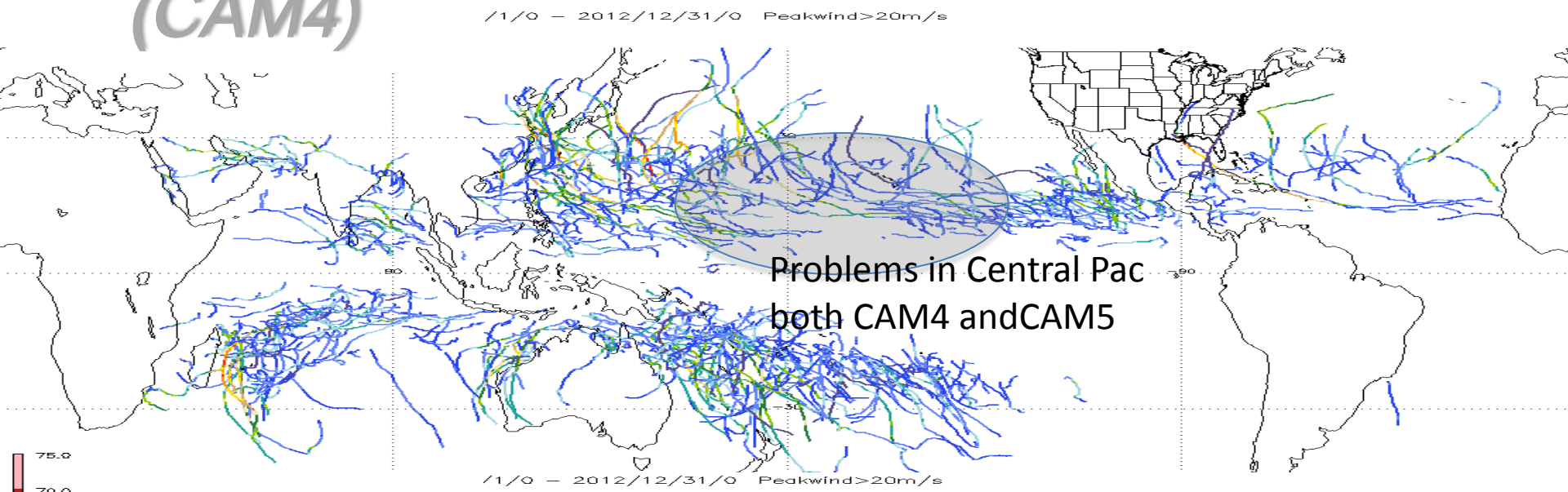
(CAM4)



(IBTrACS)

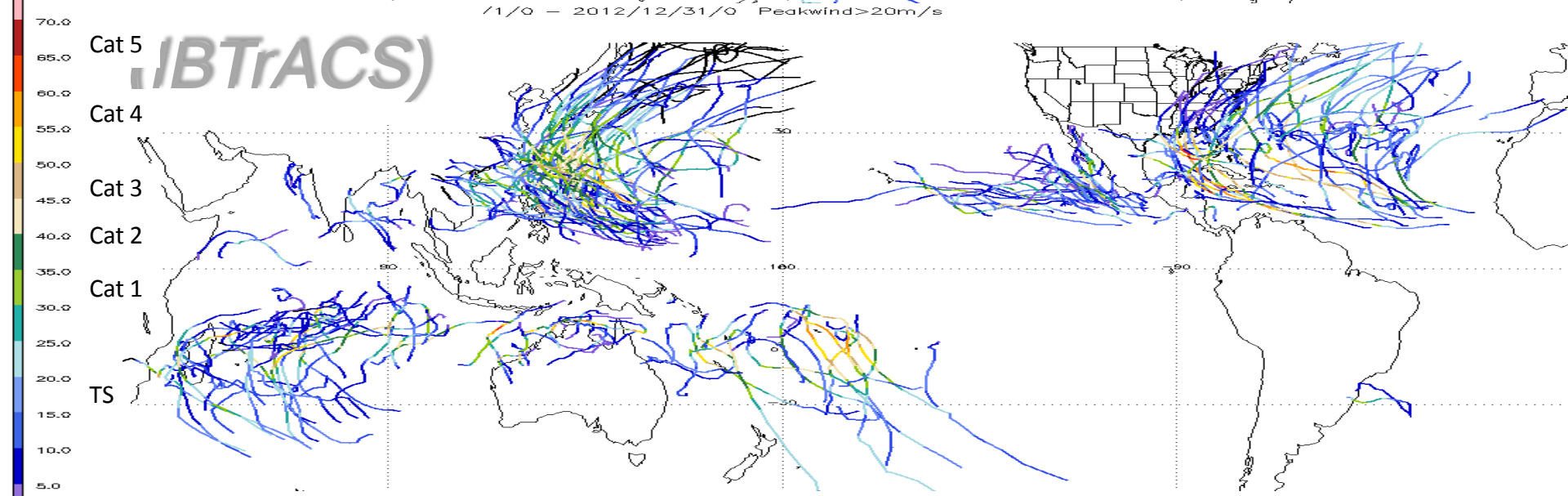
Tropical storm-Category 5 2003-2005

(CAM4)



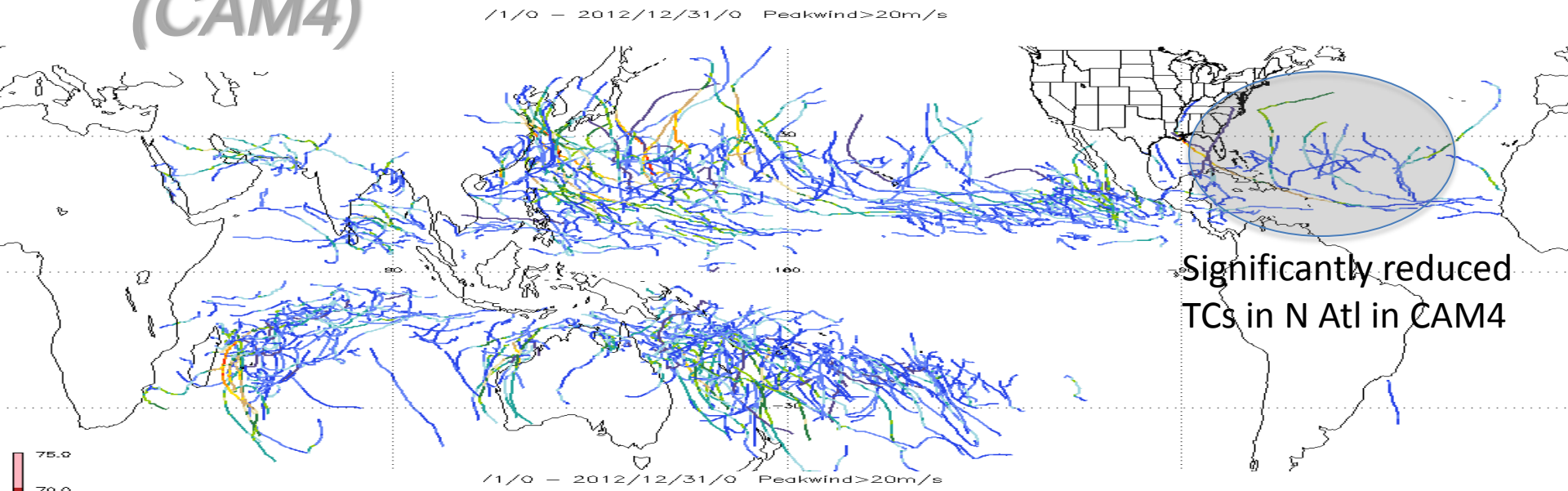
Problems in Central Pac
both CAM4 andCAM5

(IBTrACS)



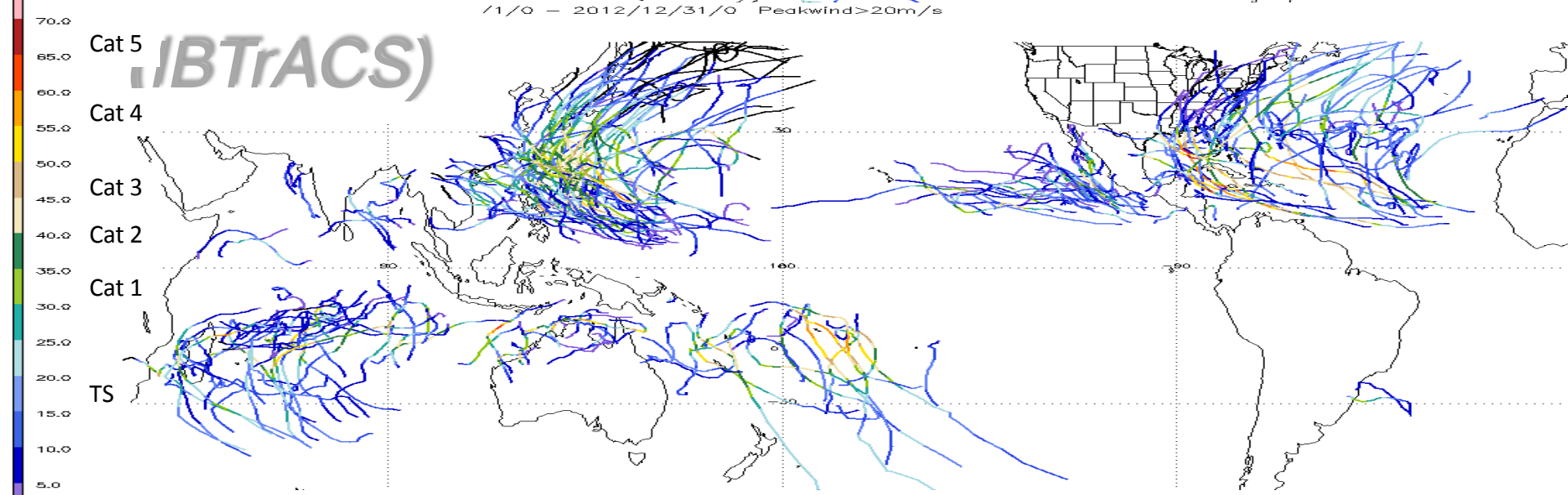
Tropical storm-Category 5 2003-2005

(CAM4)

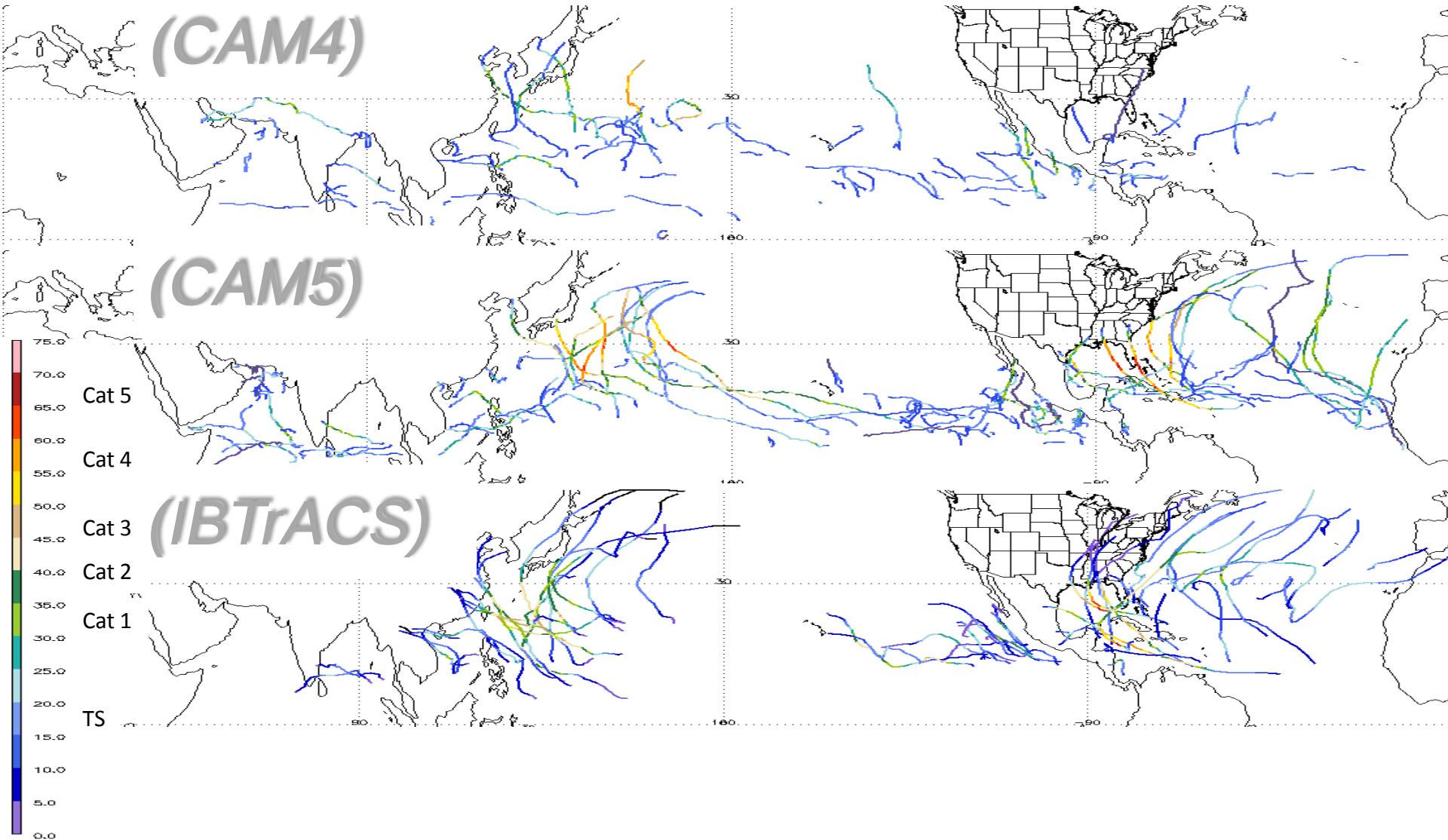


Significantly reduced TCs in N Atl in CAM4

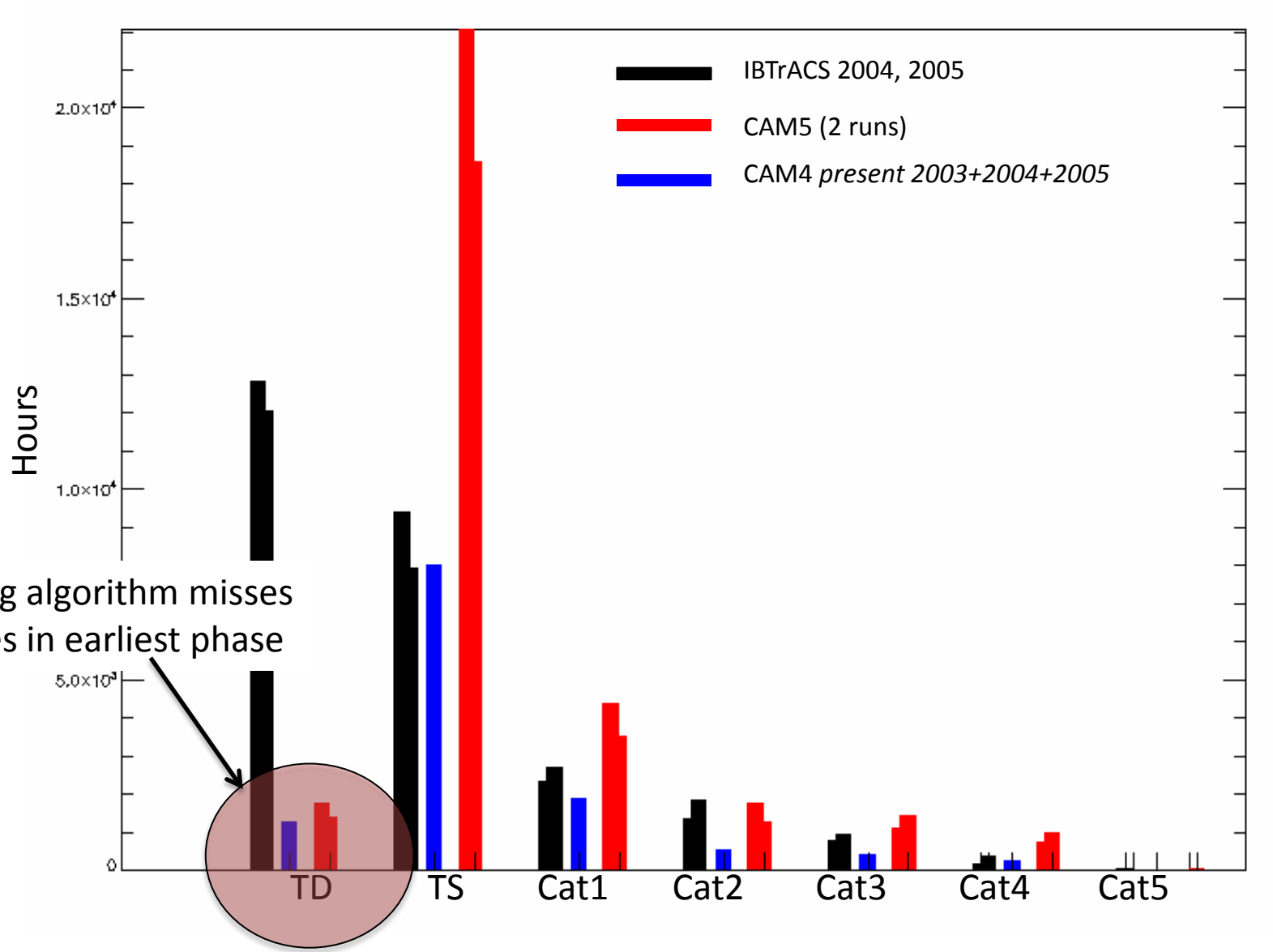
(IBTrACS)



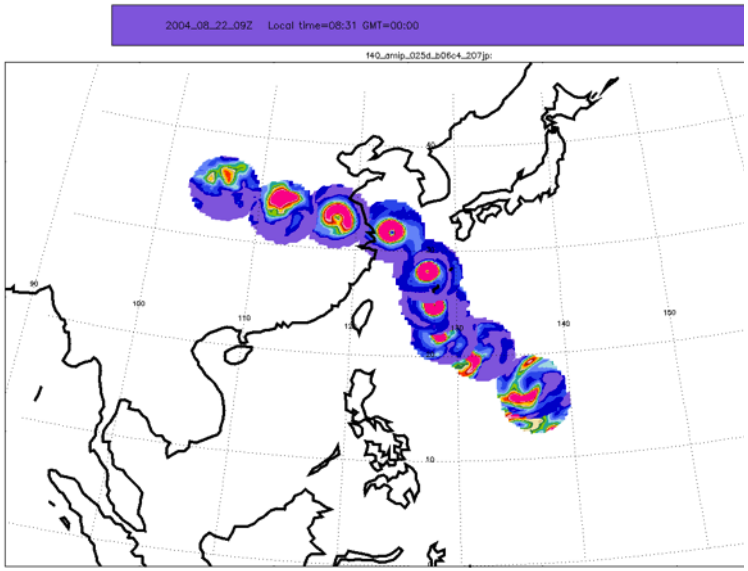
Tropical storm-Category 5
2005 JJASON

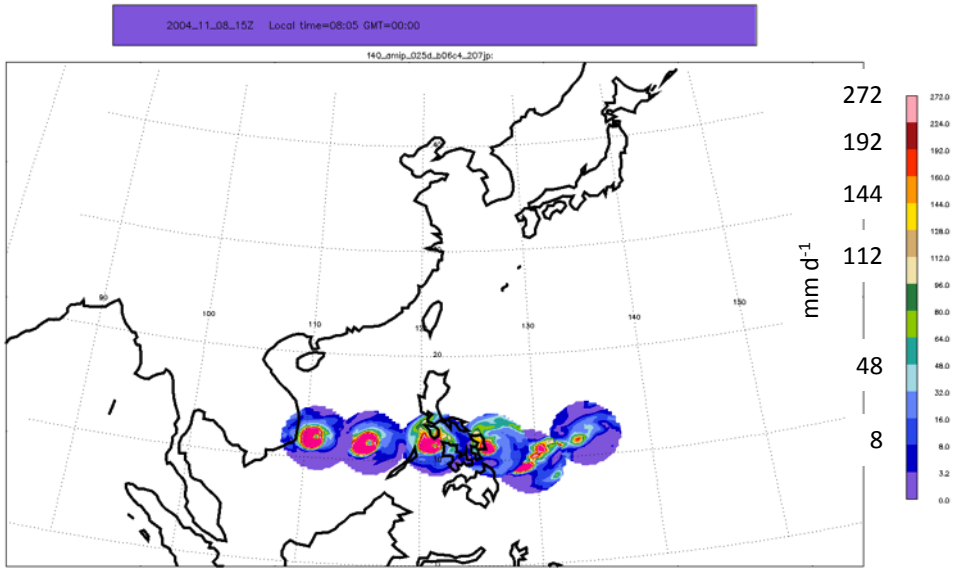


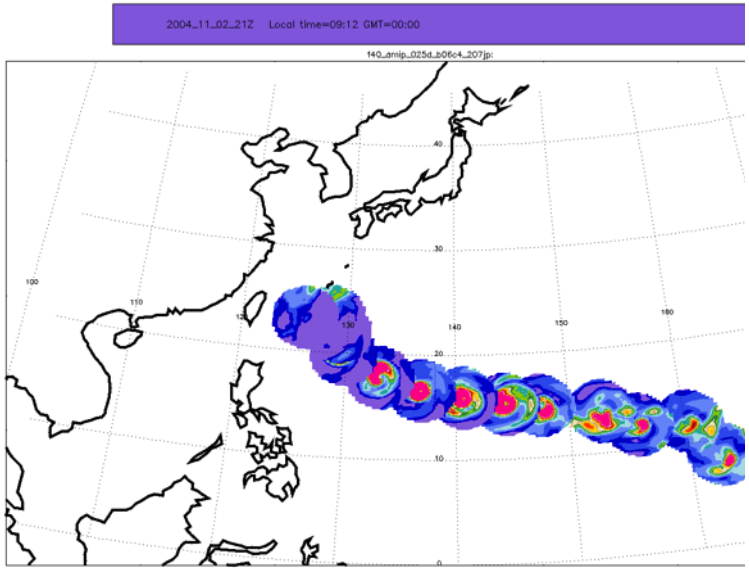
Time spent at Categories by tropical cyclones (hours)
All basins
Northern hemisphere TC season June – Dec

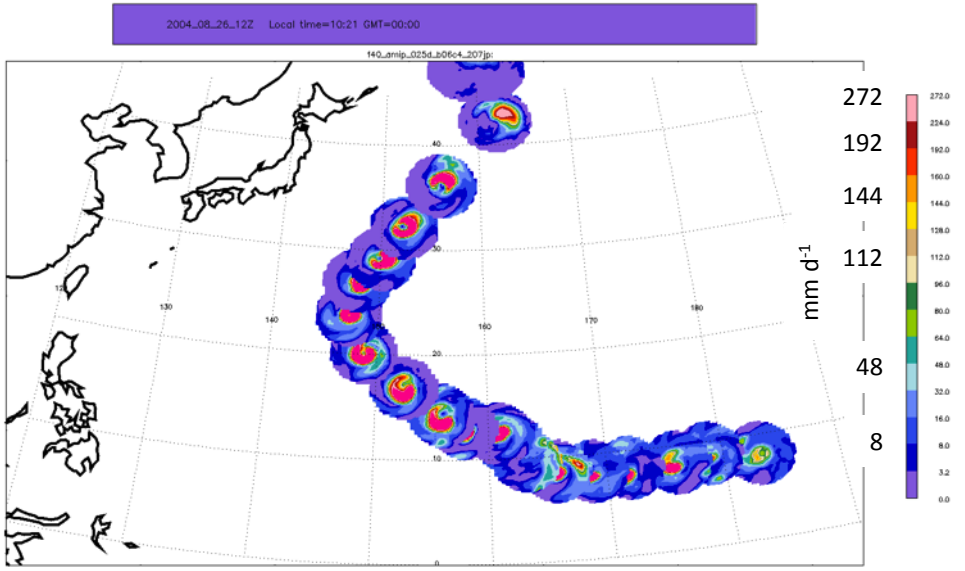


Four storms with highest wind speeds CAM4 2004 JJASOND



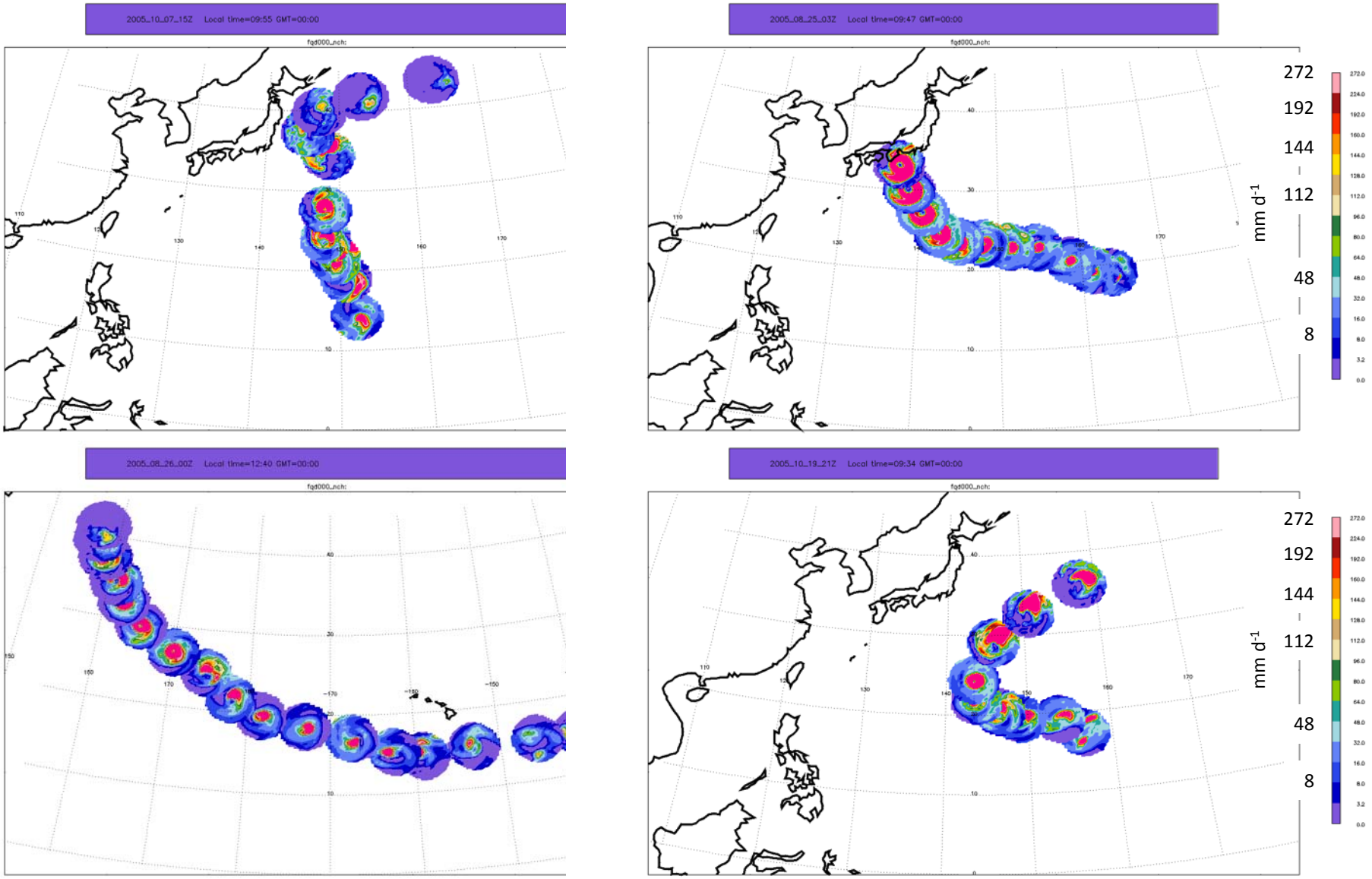






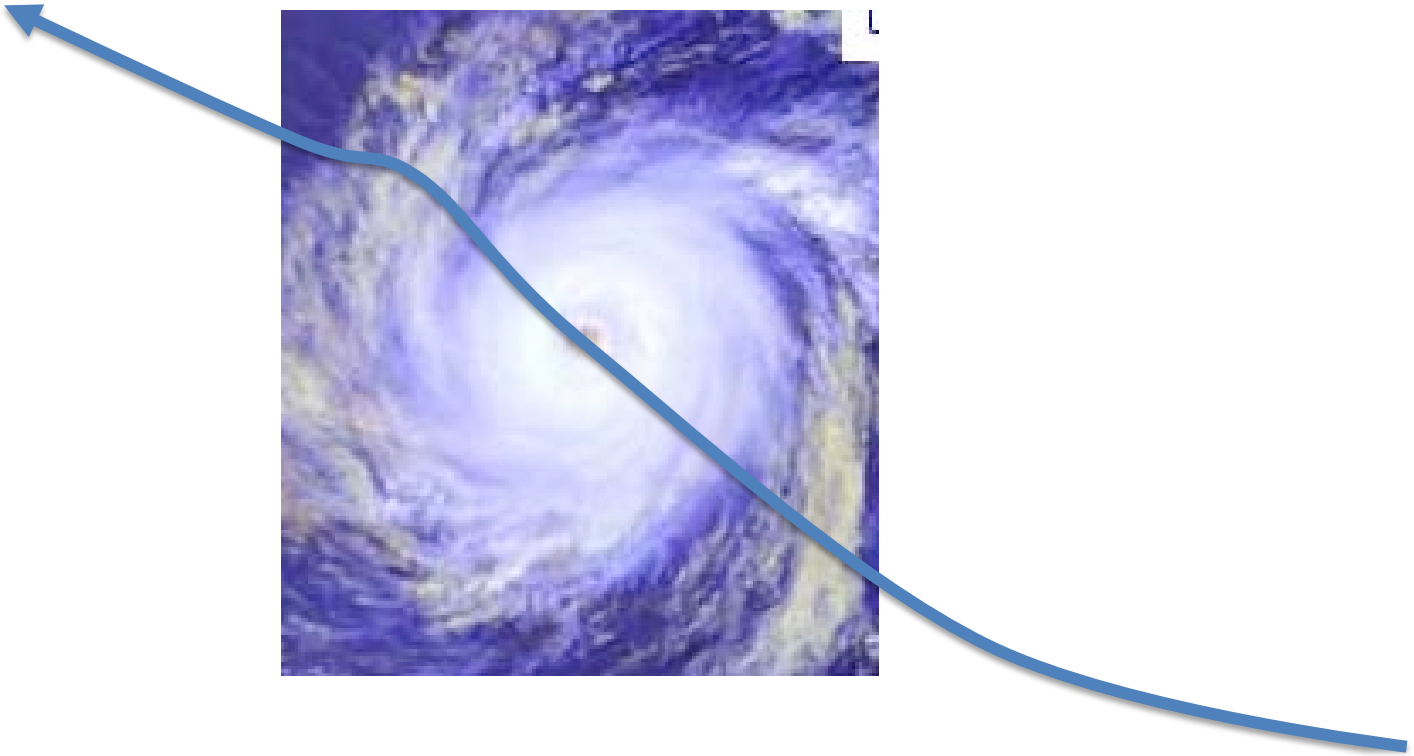
Shown: *Precipitation within 350 km radius of storm center, every 24 hours*

Four *W Pacific* storms with highest wind speeds CAM5 2005 JJASOND



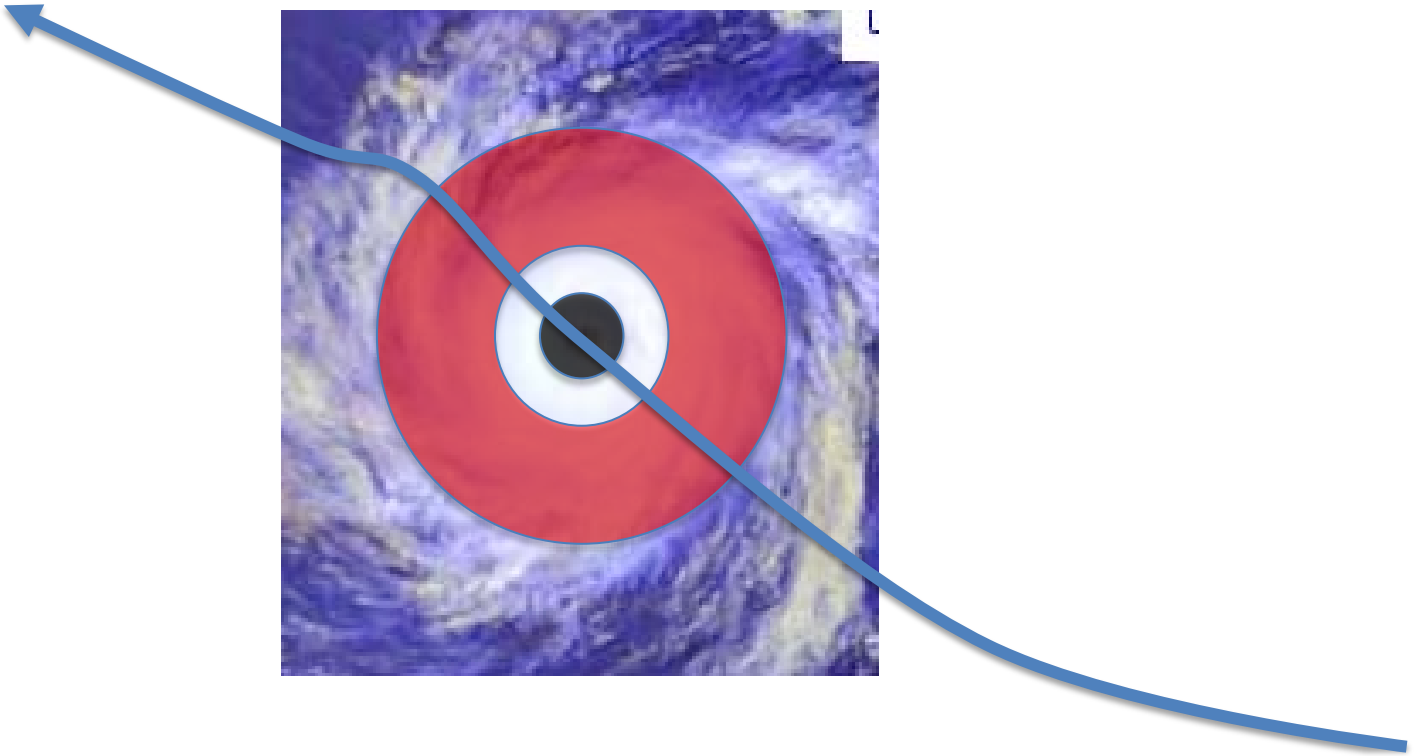
Shown: *Precipitation within 350 km radius of storm center, every 24 hours*

Time series of precipitation following storms in CAM5;
core r<50km (black) and ***storm exterior*** 500km>r>250km



Convective and large-scale precipitation separated

Time series of precipitation following storms in CAM5;
core r<50km (black) and ***storm exterior*** 500km>r>250km

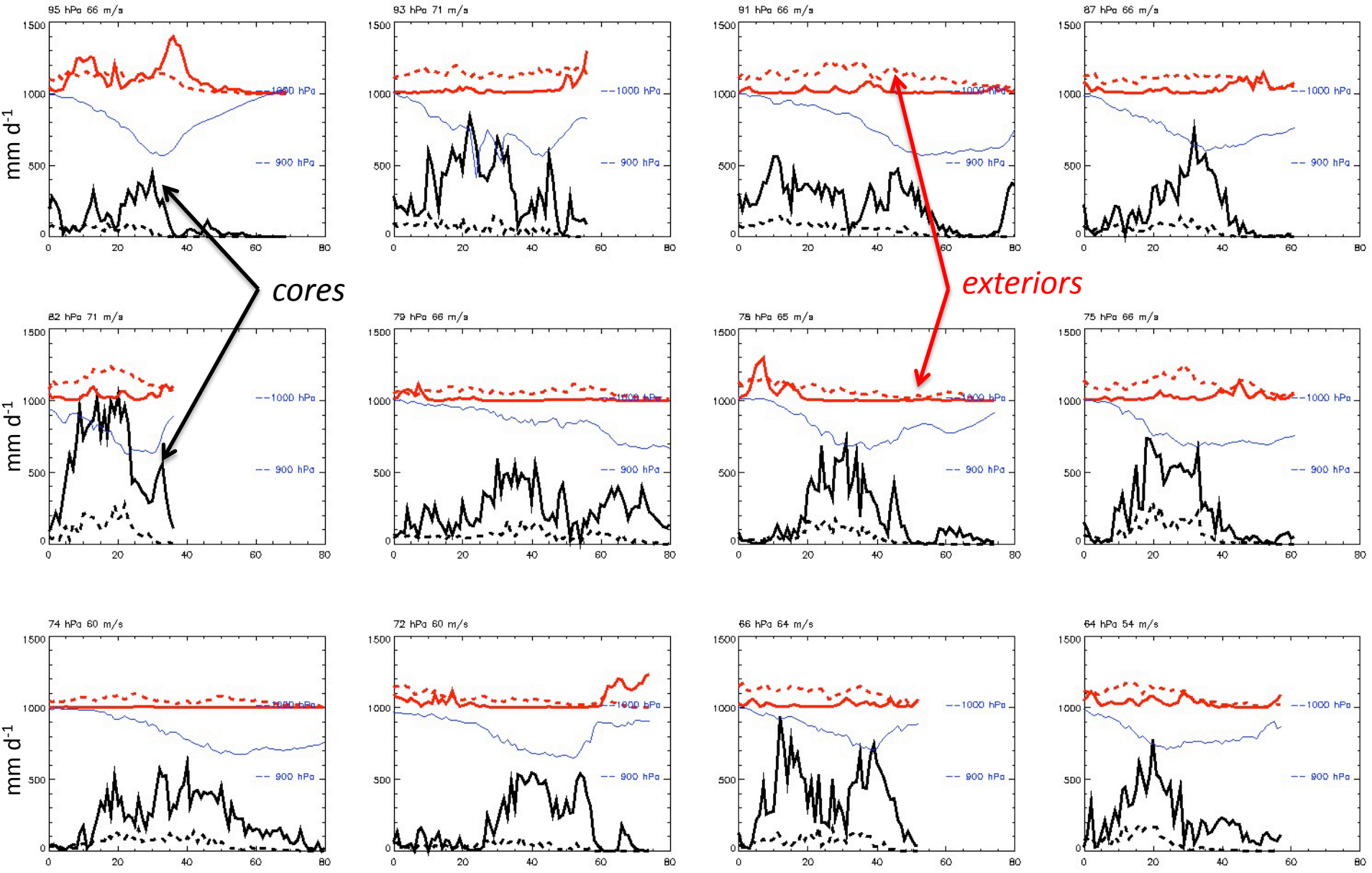


Convective and large-scale precipitation separated

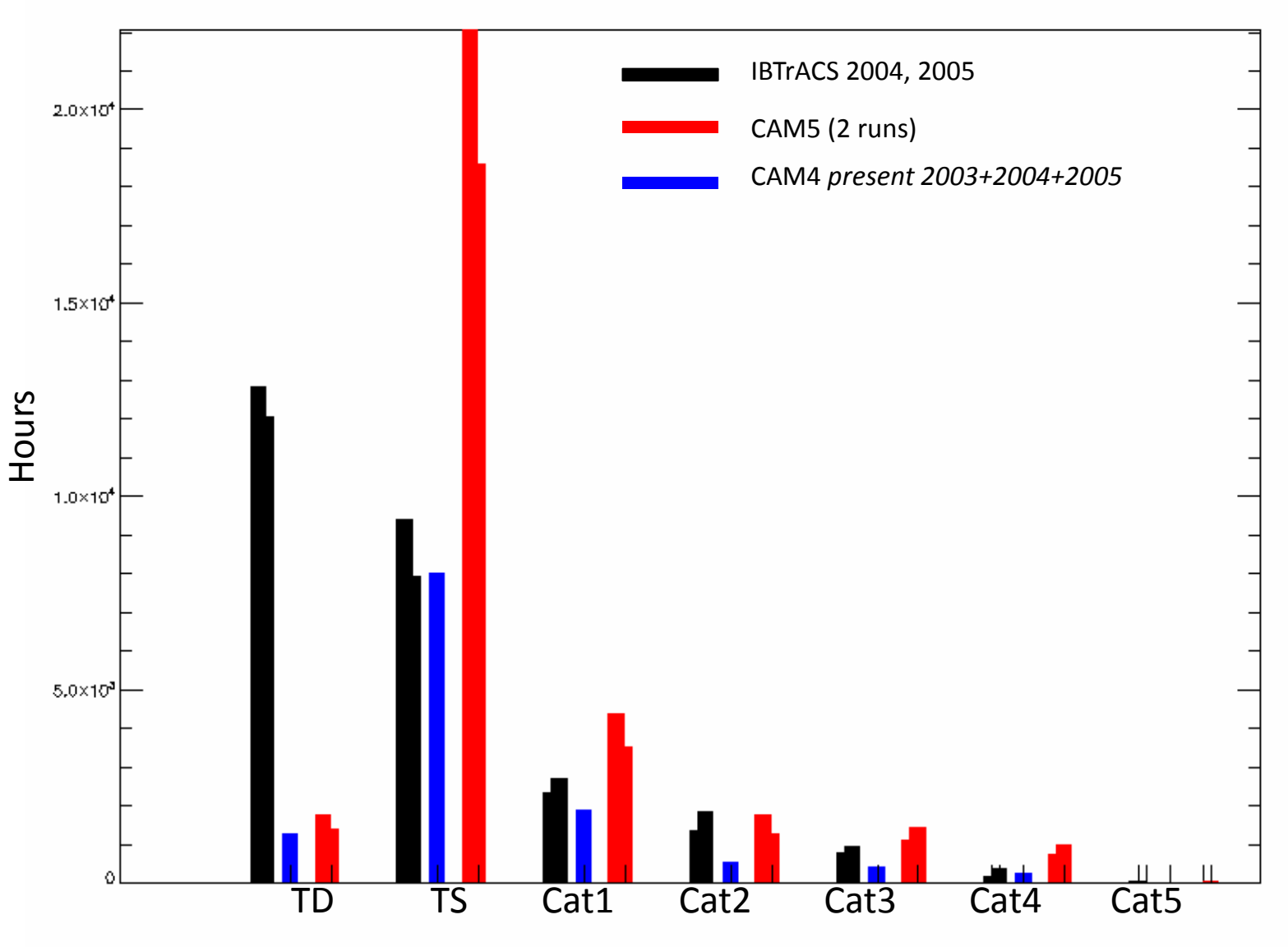
Precipitation time series in **storm cores** ***(black)***, **storm exteriors** ***(red)***.

Convective precip (dashed), Large-scale precip (solid).

Thin ***blue*** *lines show surface pressure.* ***Note overwhelming dominance of LS in cores***



Time spent at Categories by tropical cyclones (hours)
All basins
Northern hemisphere TC season June – Dec



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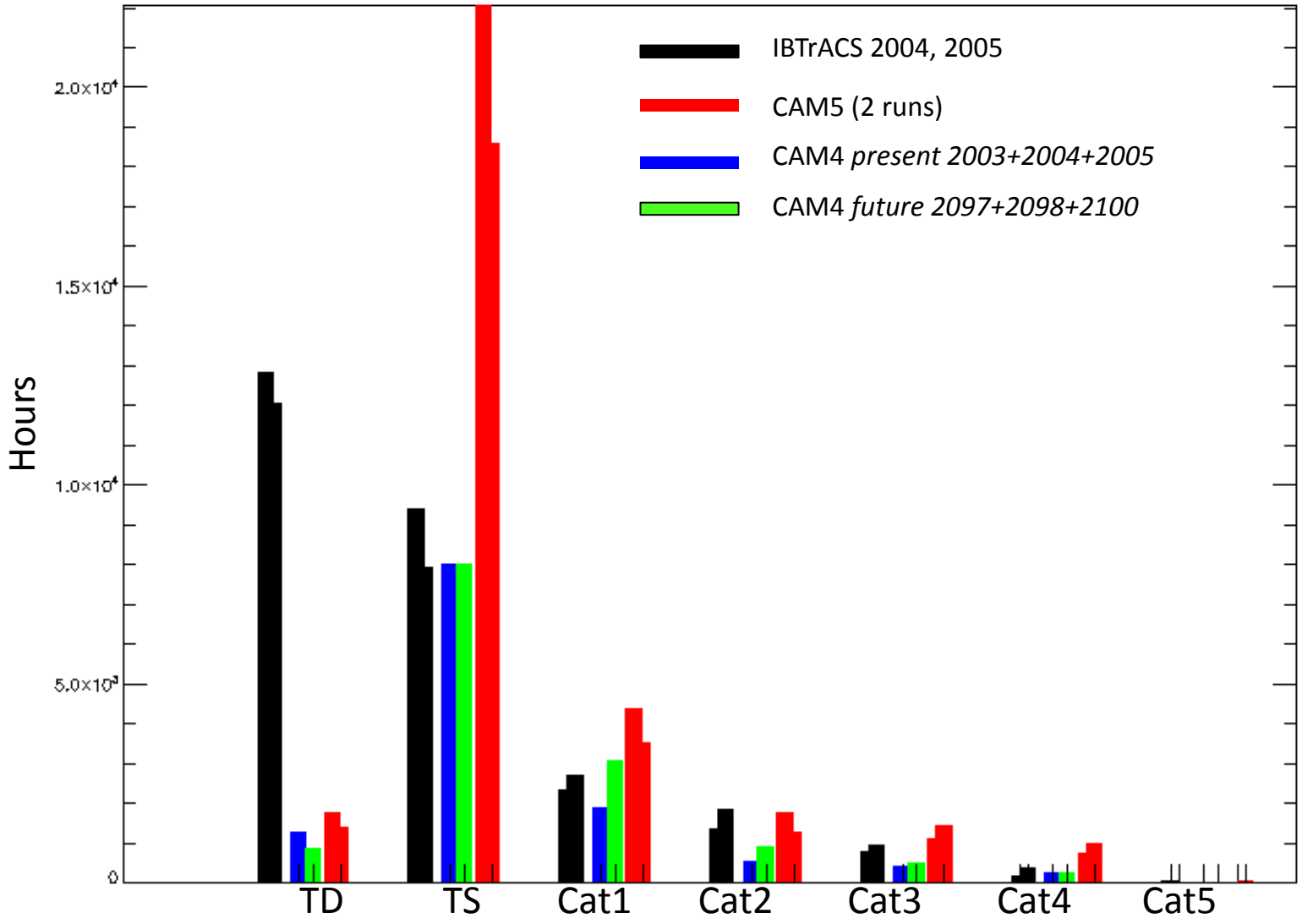
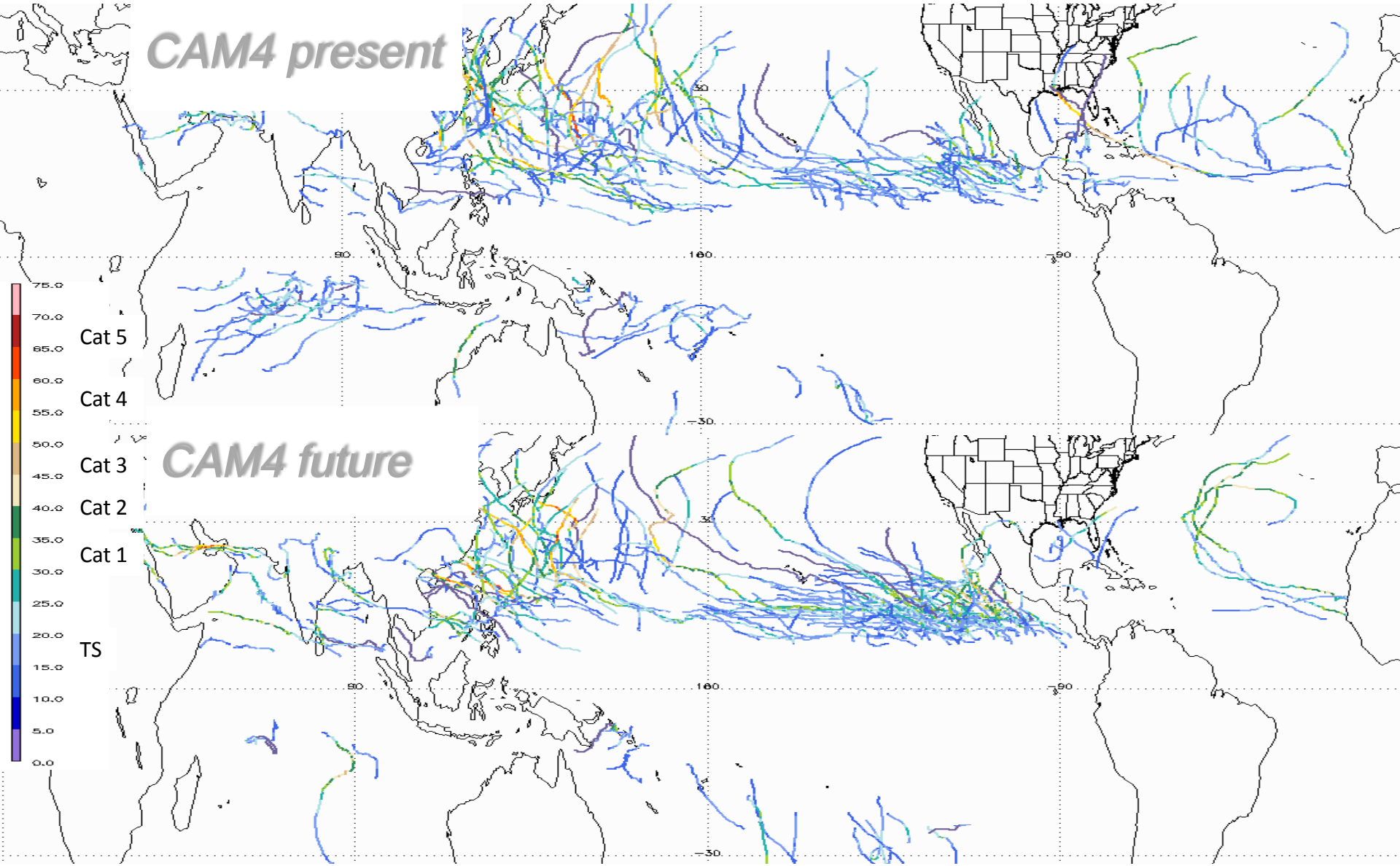
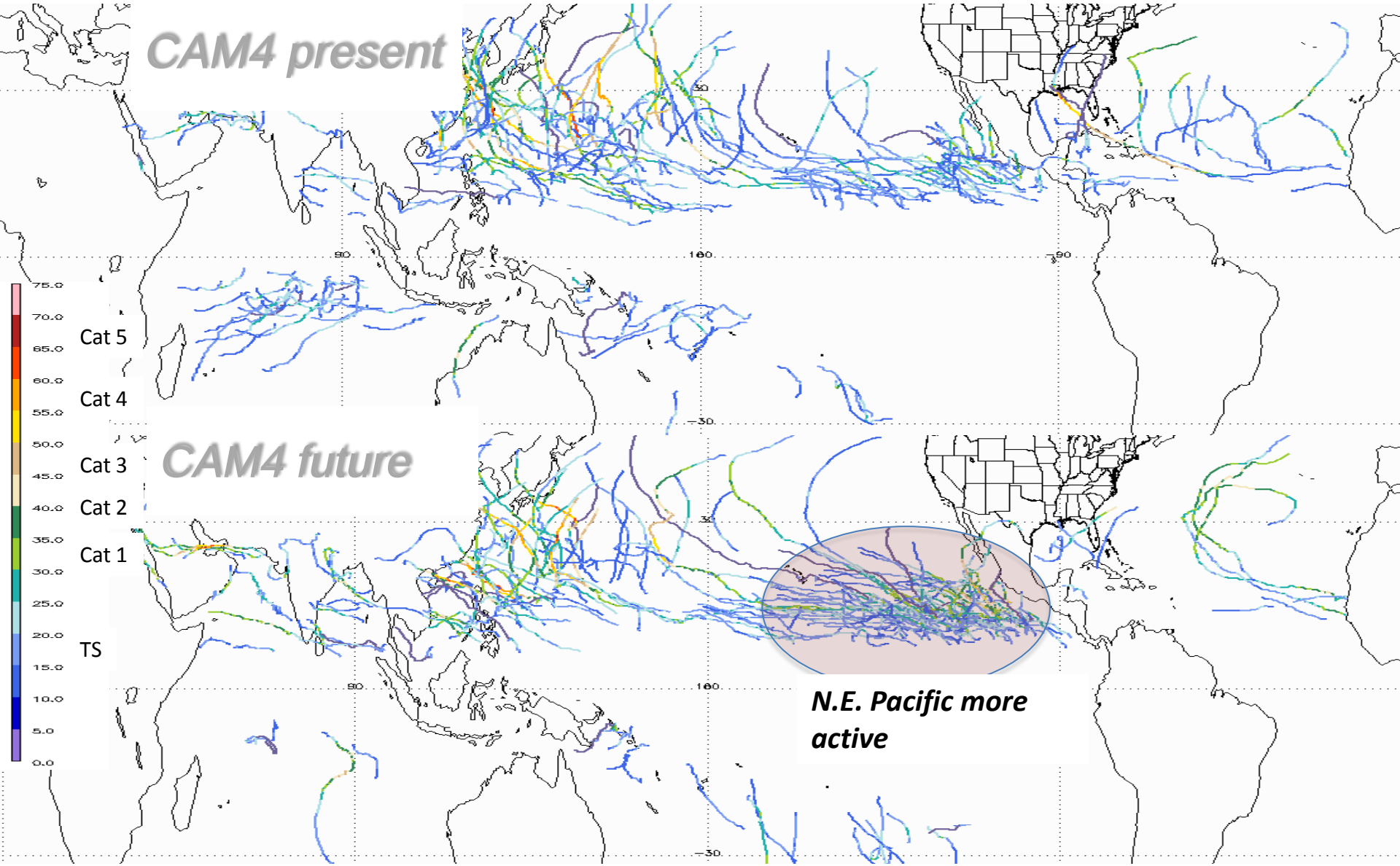


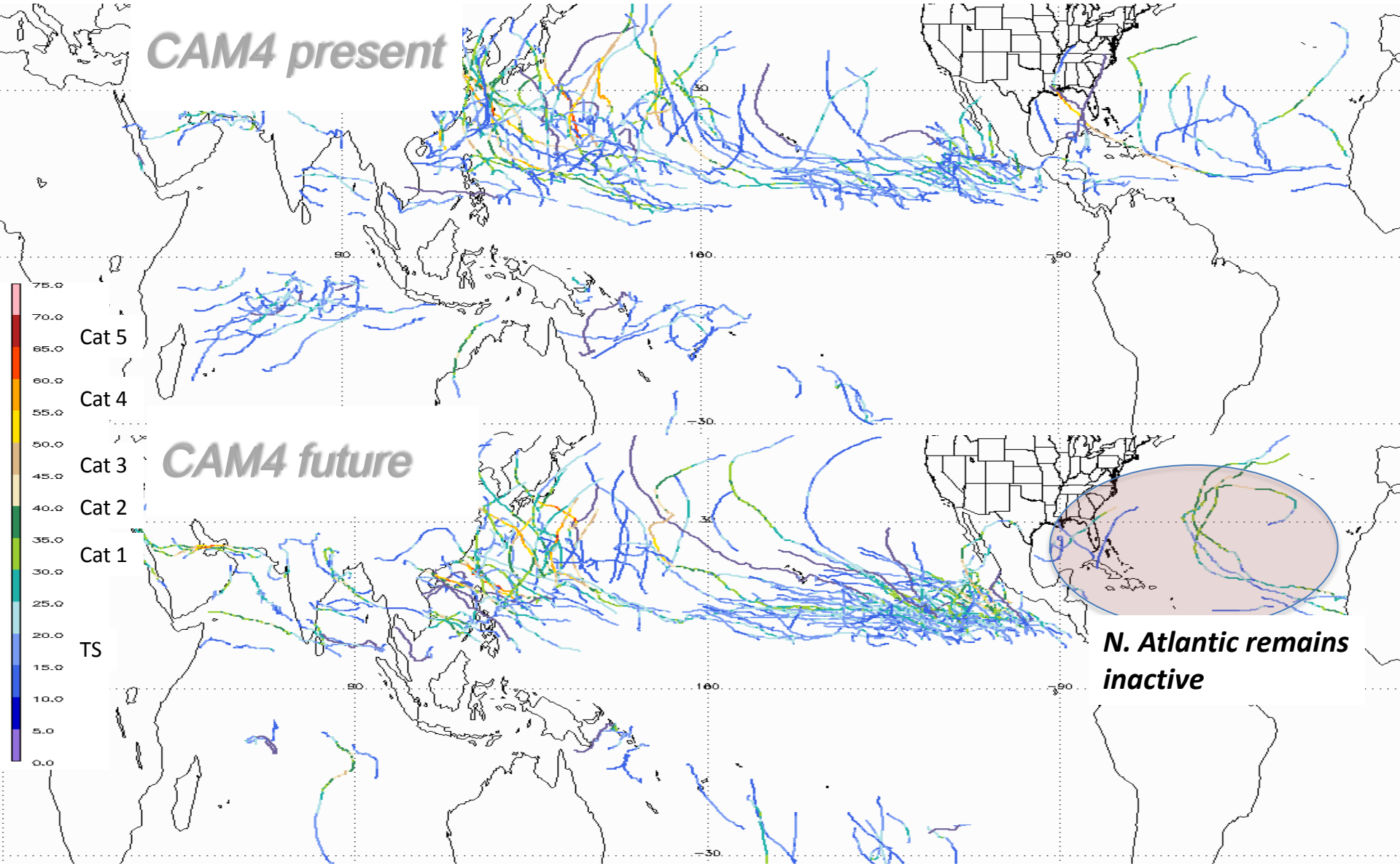
2003,2004,2005 vs. 2097,2098,2100



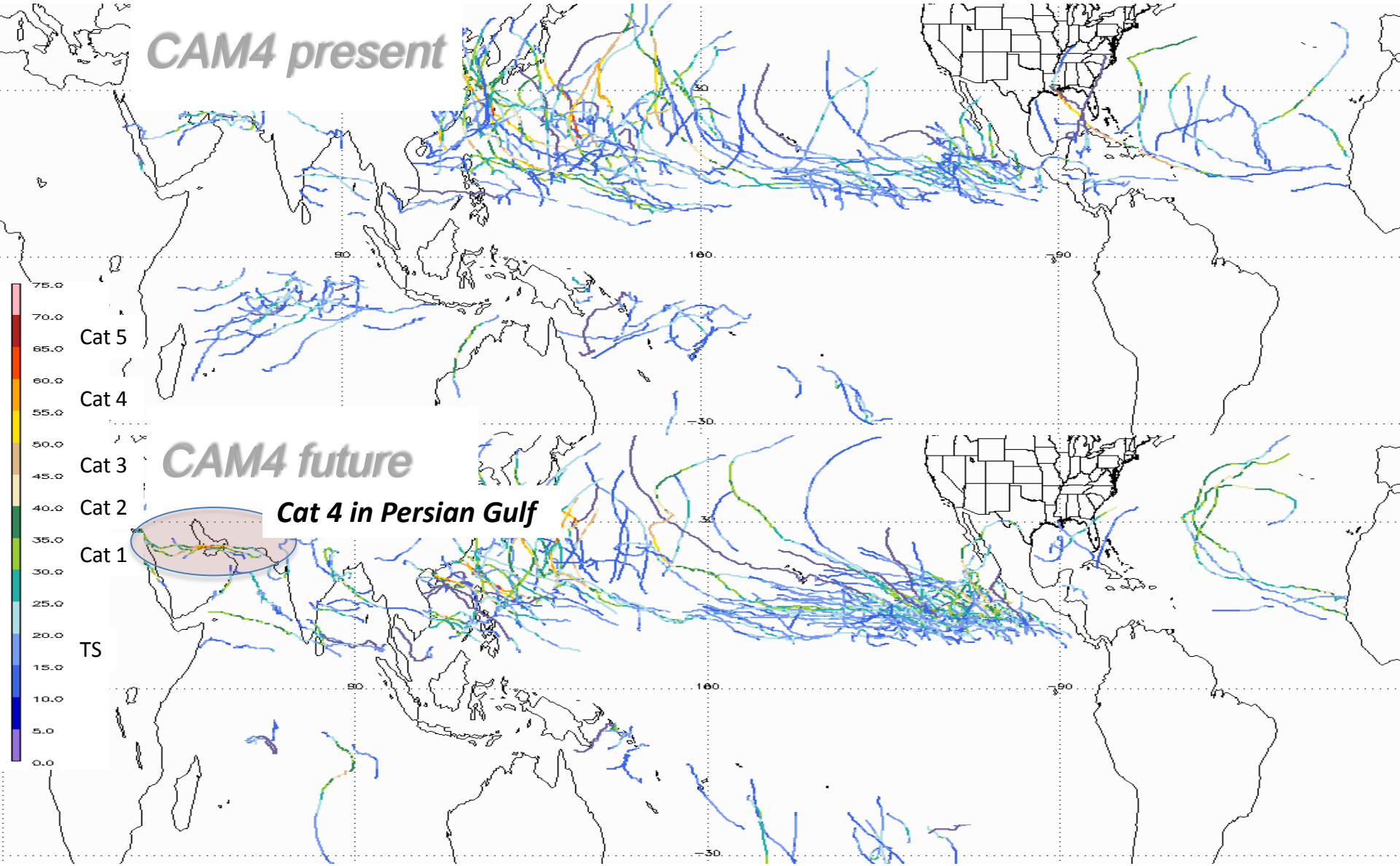
2003,2004,2005 vs. 2097,2098,2100



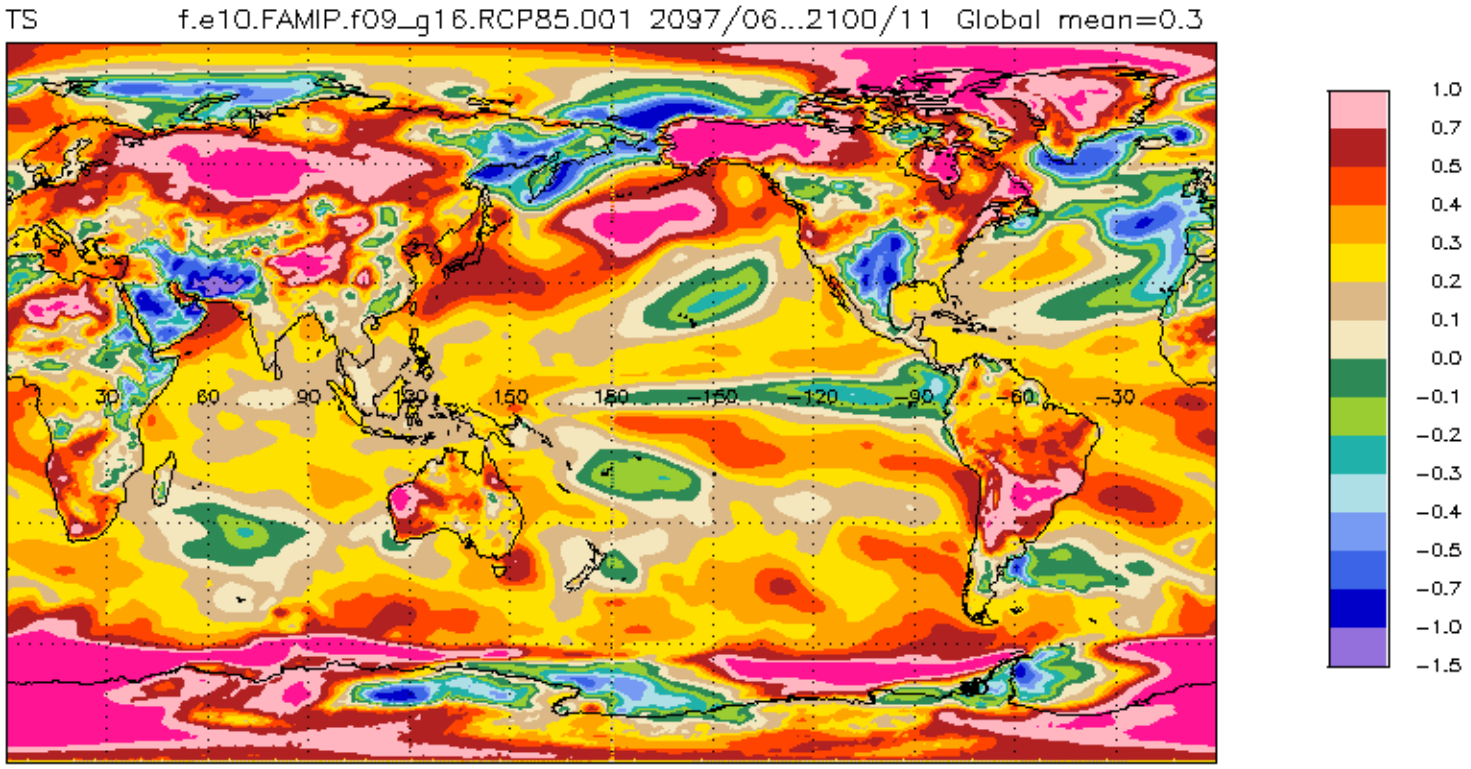
2003,2004,2005 vs. 2097,2098,2100



2003,2004,2005 vs. 2097,2098,2100



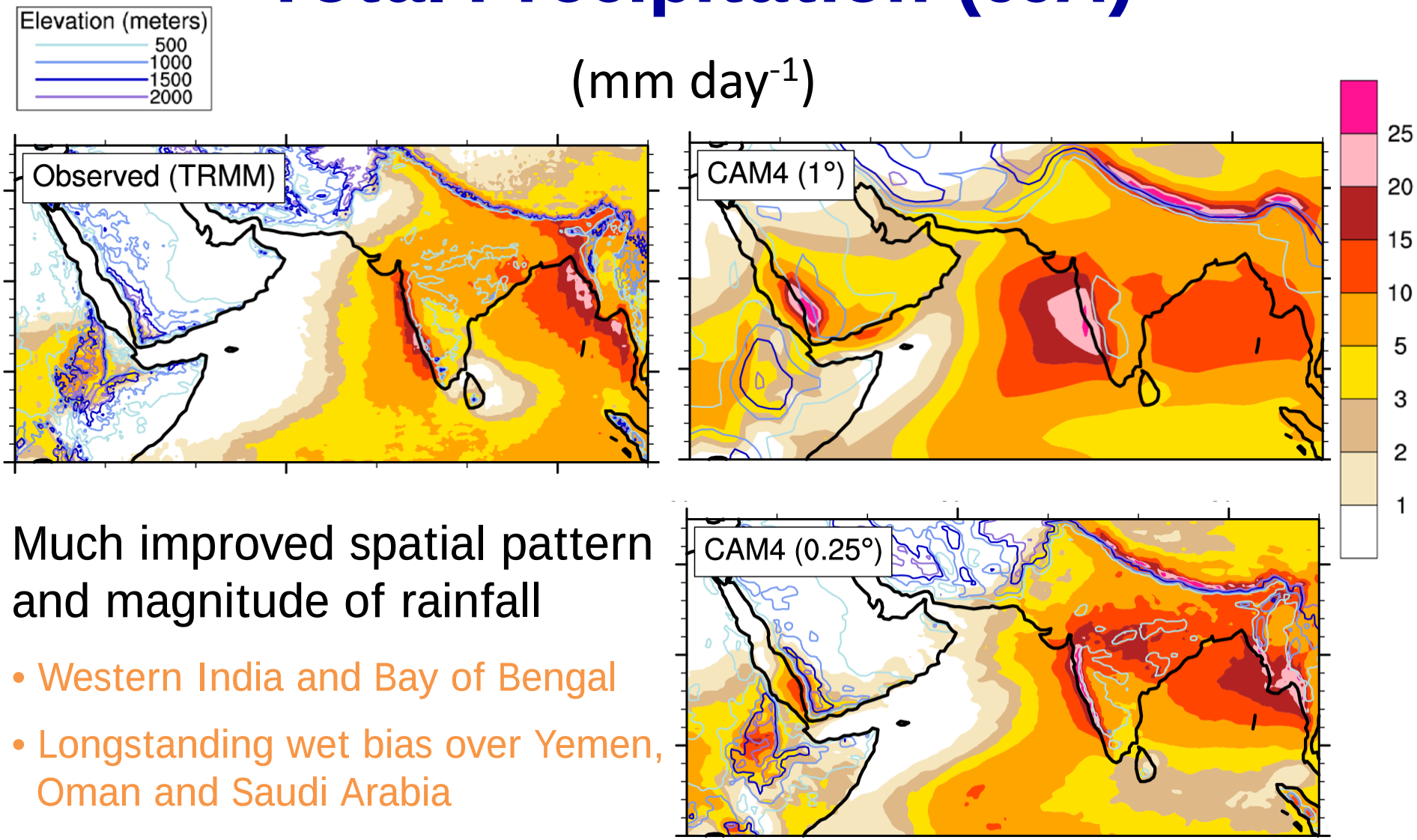
TS anomaly; JJASON 2097,2098,2100 vs. climo (2080-2100)



Topographic effects on precipitation with increasing resolution

Total Precipitation (JJA)

(mm day^{-1})

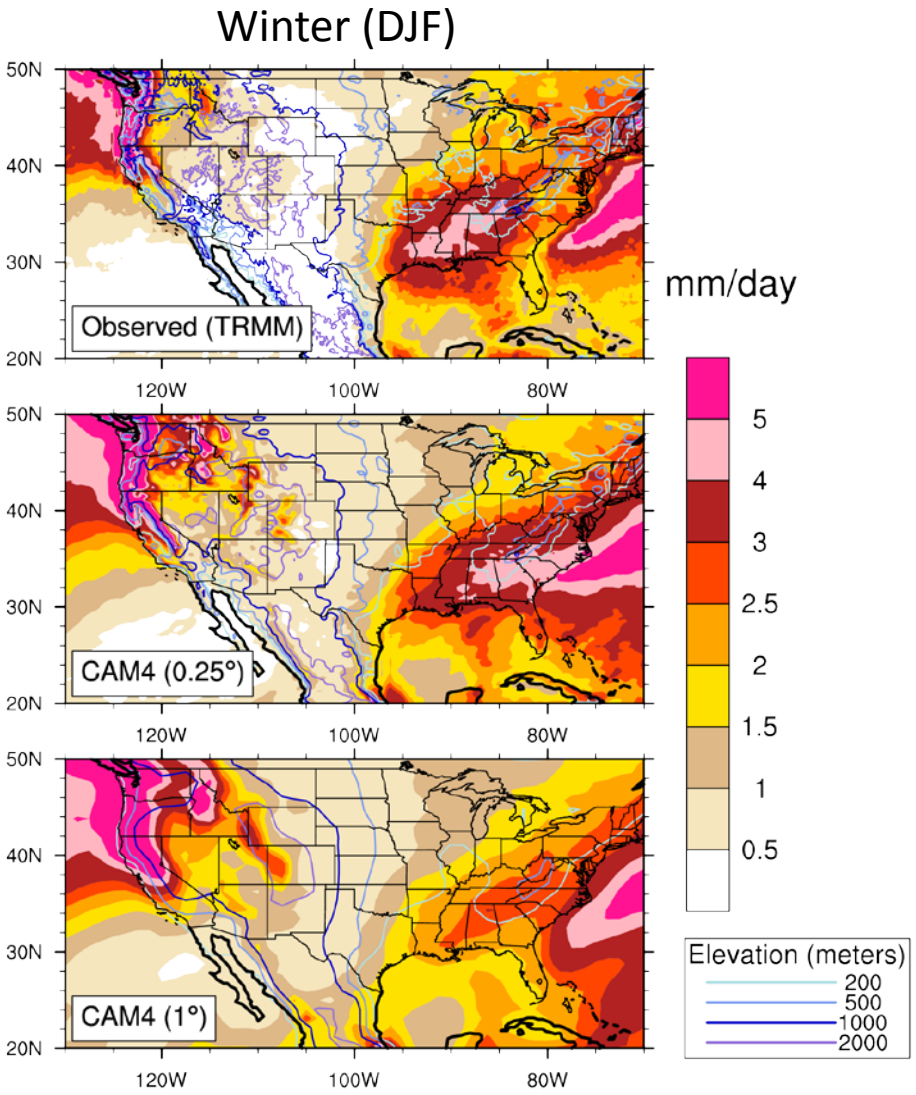


Much improved spatial pattern and magnitude of rainfall

- Western India and Bay of Bengal
- Longstanding wet bias over Yemen, Oman and Saudi Arabia
- Somali jet more realistic

Courtesy Rich Neale

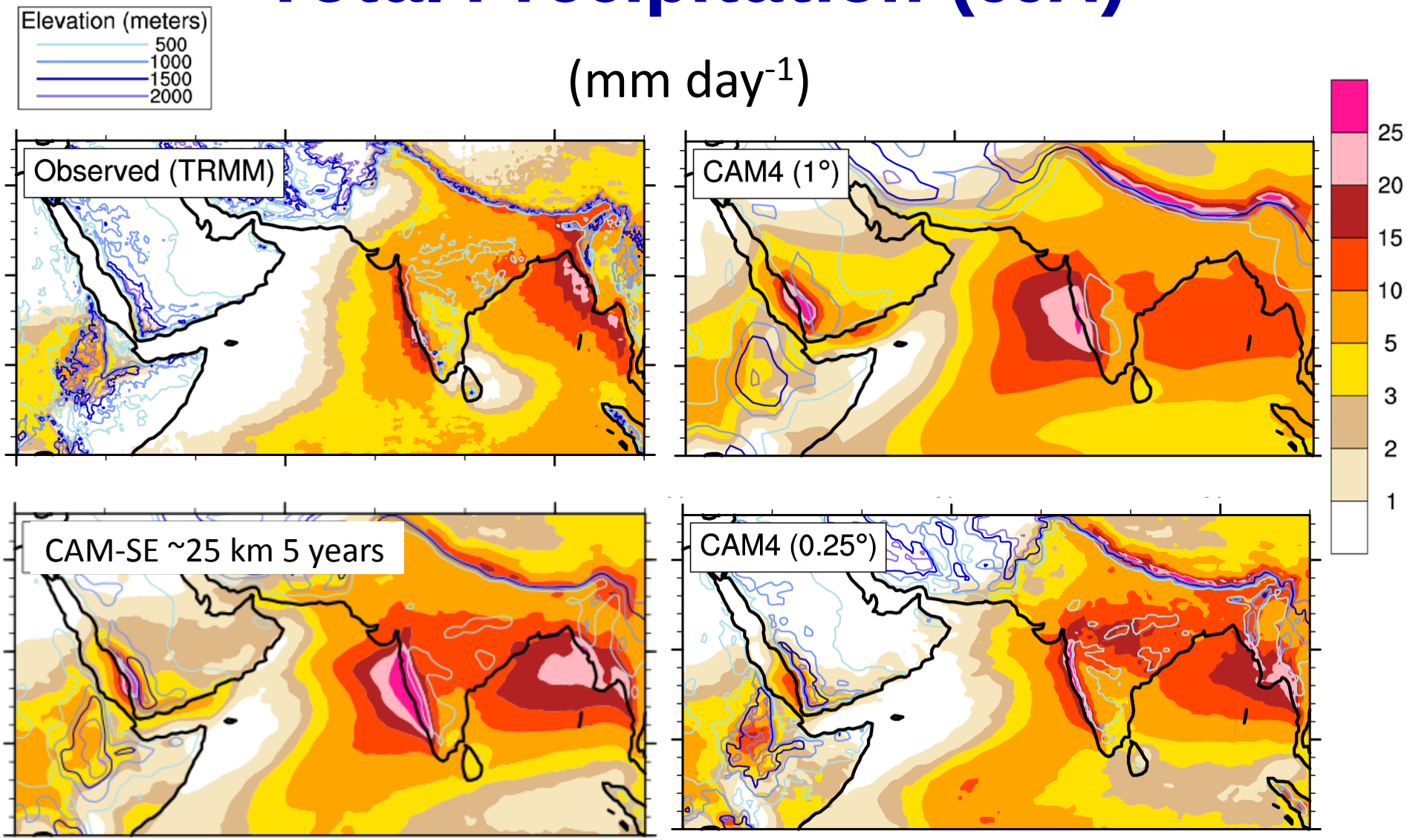
CAM4 US Precipitation



High-resolution/rough topography. Flow steered north into SE US carrying moisture

Total Precipitation (JJA)

(mm day^{-1})



Courtesy Rich Neale

Initial implementation of CAM-SE uses very smooth topography.
Reduces improvement in precipitation patterns related to topography

Conclusions

Cyclogenesis with CAM4 physics weaker than with CAM5 physics, especially in North Atlantic basin

-tropical storms sizes more similar in CAM4?

RCP8.5 seems to produce only weak impacts on CAM4 TC climatology

Simulated tropical cyclone cores are completely dominated by large-scale precipitation

There is probably a trade-off between topographic smoothing and regional improvements in precipitation w/ resolution

Questions and Future Work

Time slices with CAM5

Is weak cyclogenesis with CAM4 physics vs CAM5 related to large-scale variables or to physics? *Calculate potential intensity diagnostics etc..*

Implement GFDL cyclone tracking codes