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A partnership in weather and climate research

University of Reading

National Centre for Atmospheric Science
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Joint Weather and Climate Research Programme

Tropical cyclones in present and future climates in a hierarchy of model resolutions

Malcolm Roberts, Matthew Mizielinski,

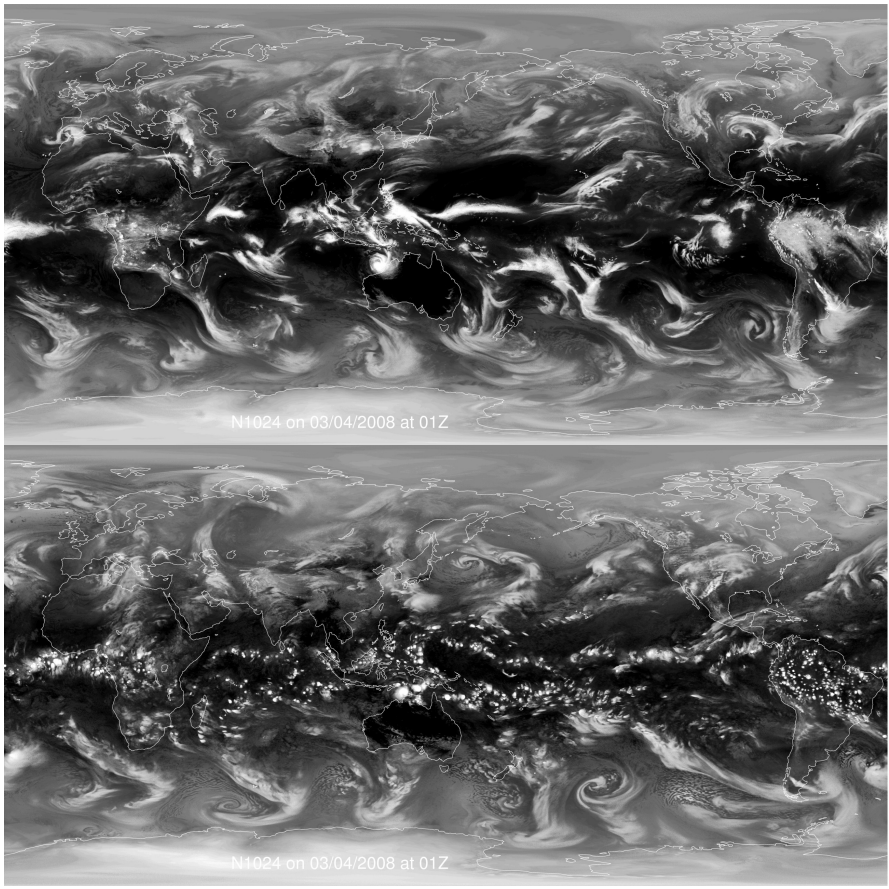
Jane Strachan + Met Office

(with special thanks to Joanne Camp for the analysis tools)

Pier Luigi Vidale, Marie-Estelle Demory,

Reinhard Schiemann

+ NCAS-Climate, University of Reading



Talk plan

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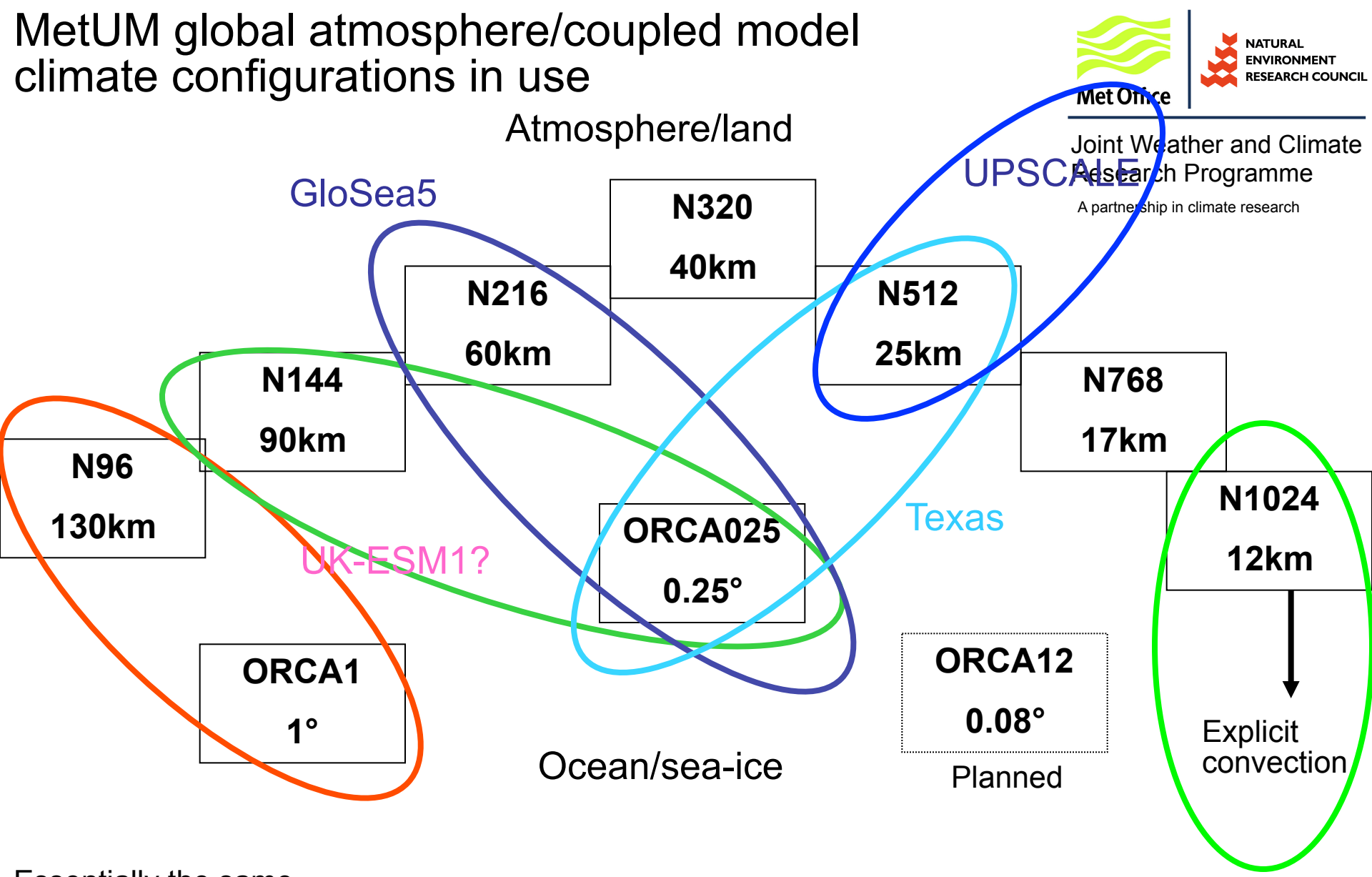
- UPSCALE project
  - Tropical cyclone properties
    - present day and future timeslice climate
- HWG experiment results
- Conclusions

MetUM global atmosphere/coupled model climate configurations in use



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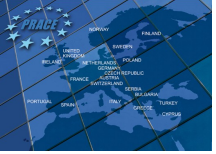
Essentially the same physics/dynamics parameters used throughout model hierarchy

Project to assess impact of global explicit convection



The PRACE-UPSCALE Project

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UK on PRACE - weather resolving Simulations of Climate for globAL Environmental risk

Current "numerical mission" of the JWCRP High-resolution climate modelling team

PI: P.L. Vidale, NCAS-Climate, Reading

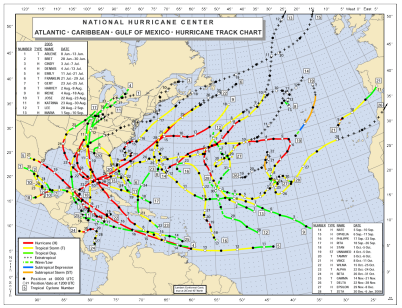
In 2011 we demonstrated our capability in effectively exploiting 4'800, and up to 12'000 CRAY XE6 cores. As an ensemble of GCMs, we could **concurrently use up to 60'000 cores.**

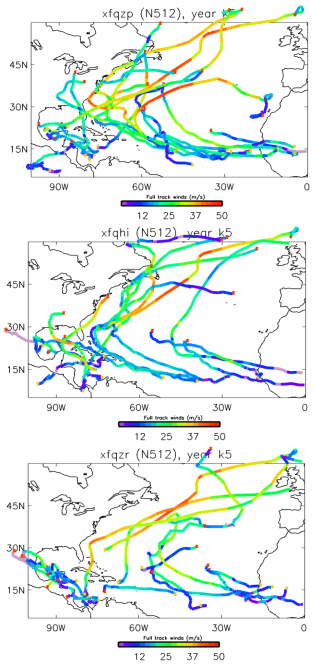
AWARD: 144 million core hours, for 1 year, 2012. ← **Largest HPC grant at this time, in any science area, worldwide. Since superceded.**

Completed:

1.HadGEM3-A multi-decadal simulations at N96 (130 km) to N512 (25 km)
85 levels to 85km GA3.0 config (Walters et al, 2011)

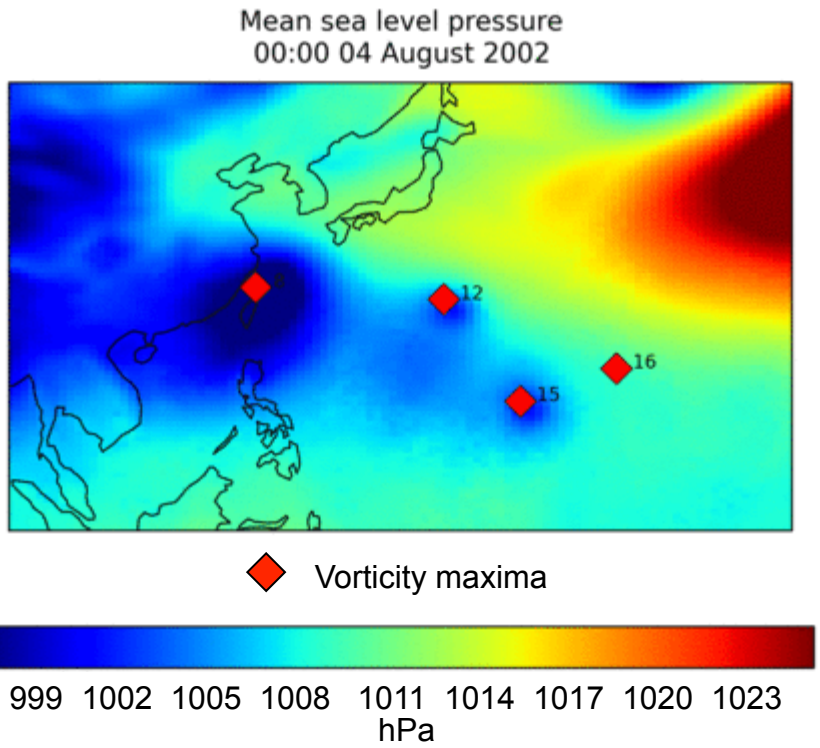
- present climate simulations N96 and N512
  - forced with OSTIA SSTs 1985-2011
  - 5 ensemble members, 27 years each
- future climate simulations at N512
  - 3 ensemble member, 27 years each
  - following RCP8.5
  - SST: daily OSTIA + HadGEM2-ES RCP8.5 2100 ΔSST (global av ~ 4K)



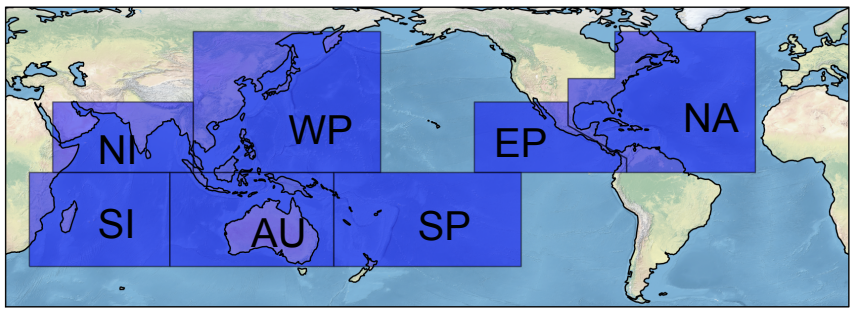


Tropical storm tracking: TRACK

- Tropical storms are located and tracked in GloSea5 using **TRACK** (Hodges, 1996).
- **Tracking**: maxima in 850 hPa relative vorticity on common T42 grid
- Minimum 2 day lifetime
- Includes check for a **warm core**.
- **Exactly** the same algorithm used in all of the following (no tuning)
- Obs – HURDAT + JTWC – mainly compared model to observed hurricanes

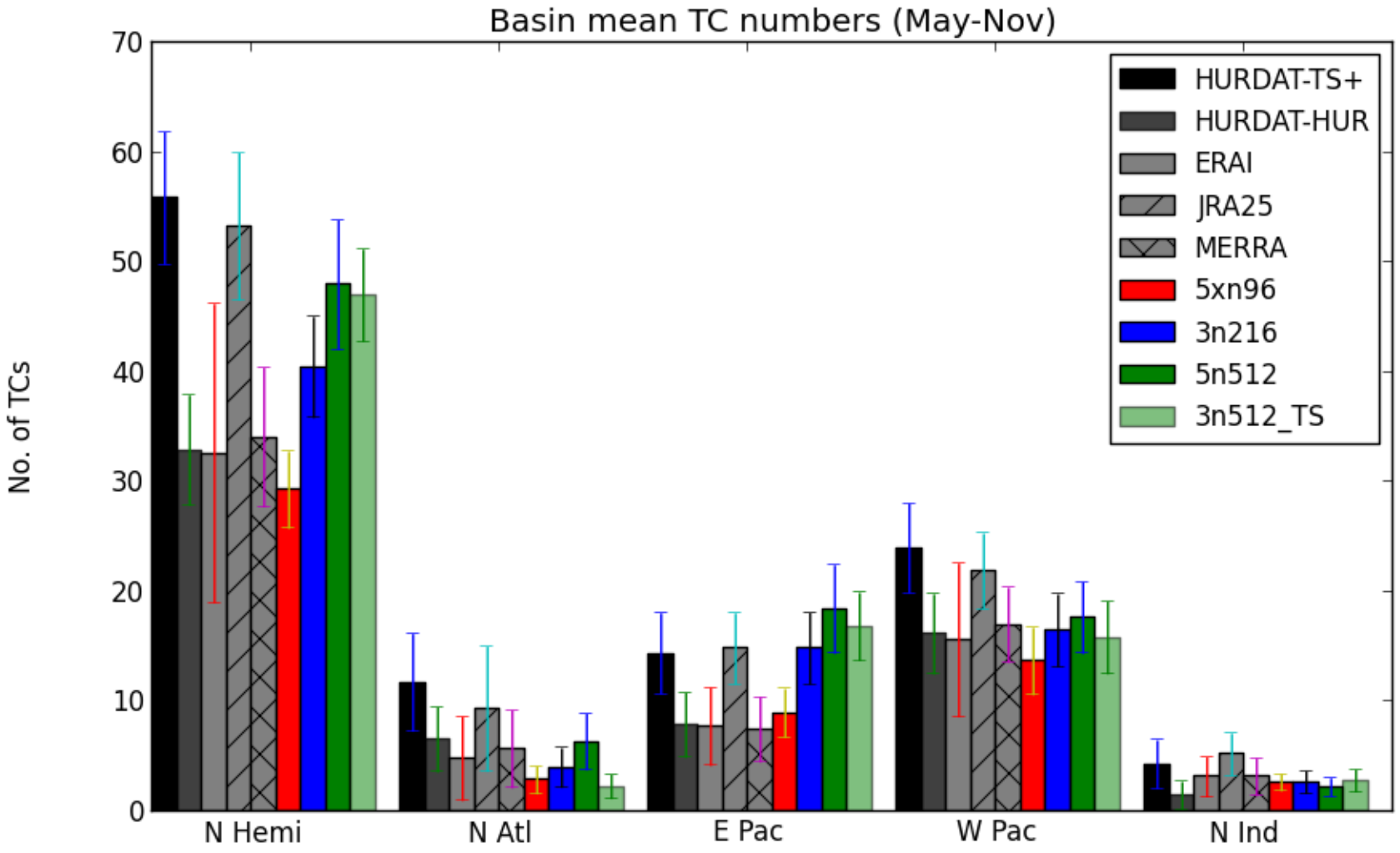


Tracking regions

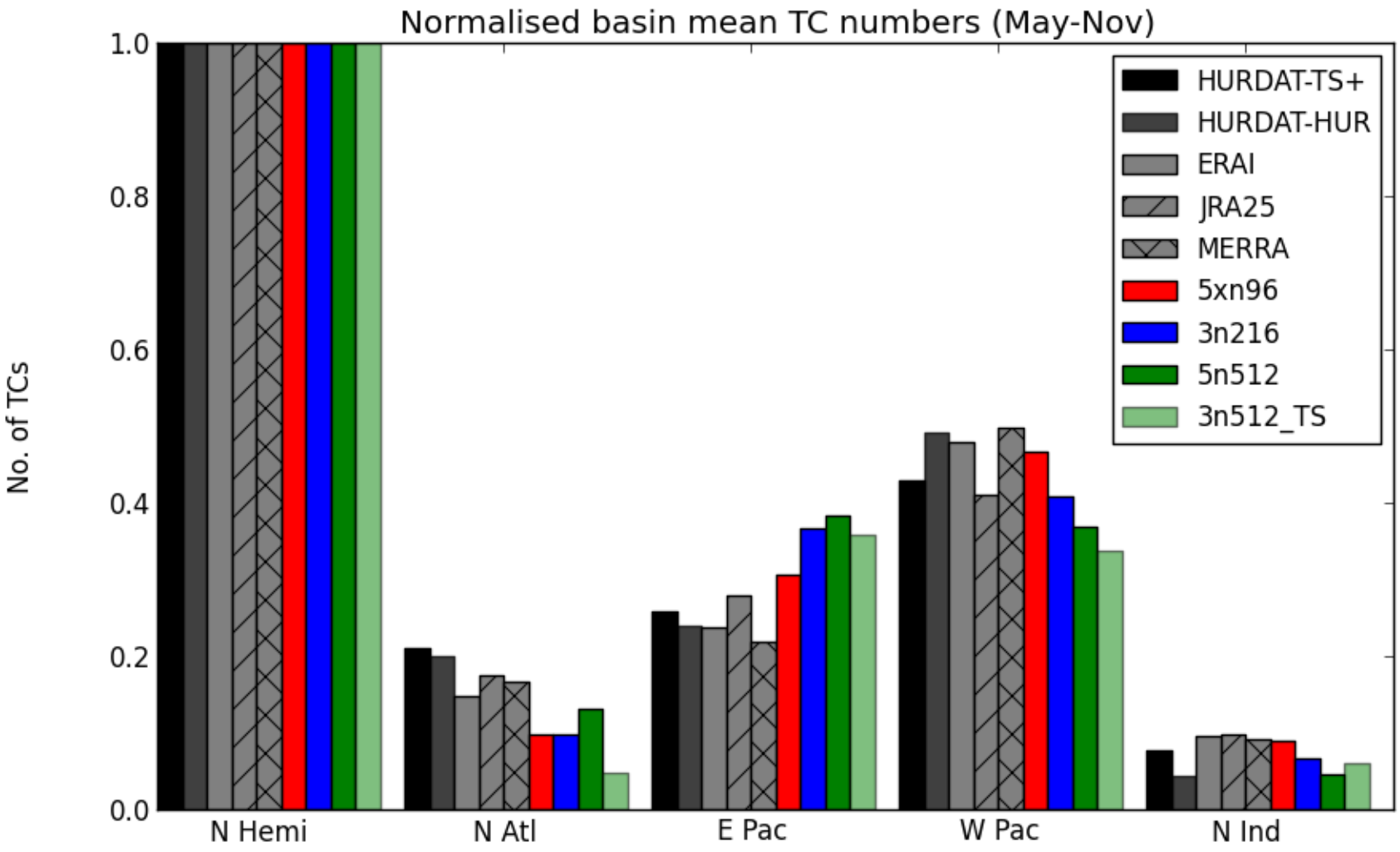


Mean NH basin counts – 1986-2010

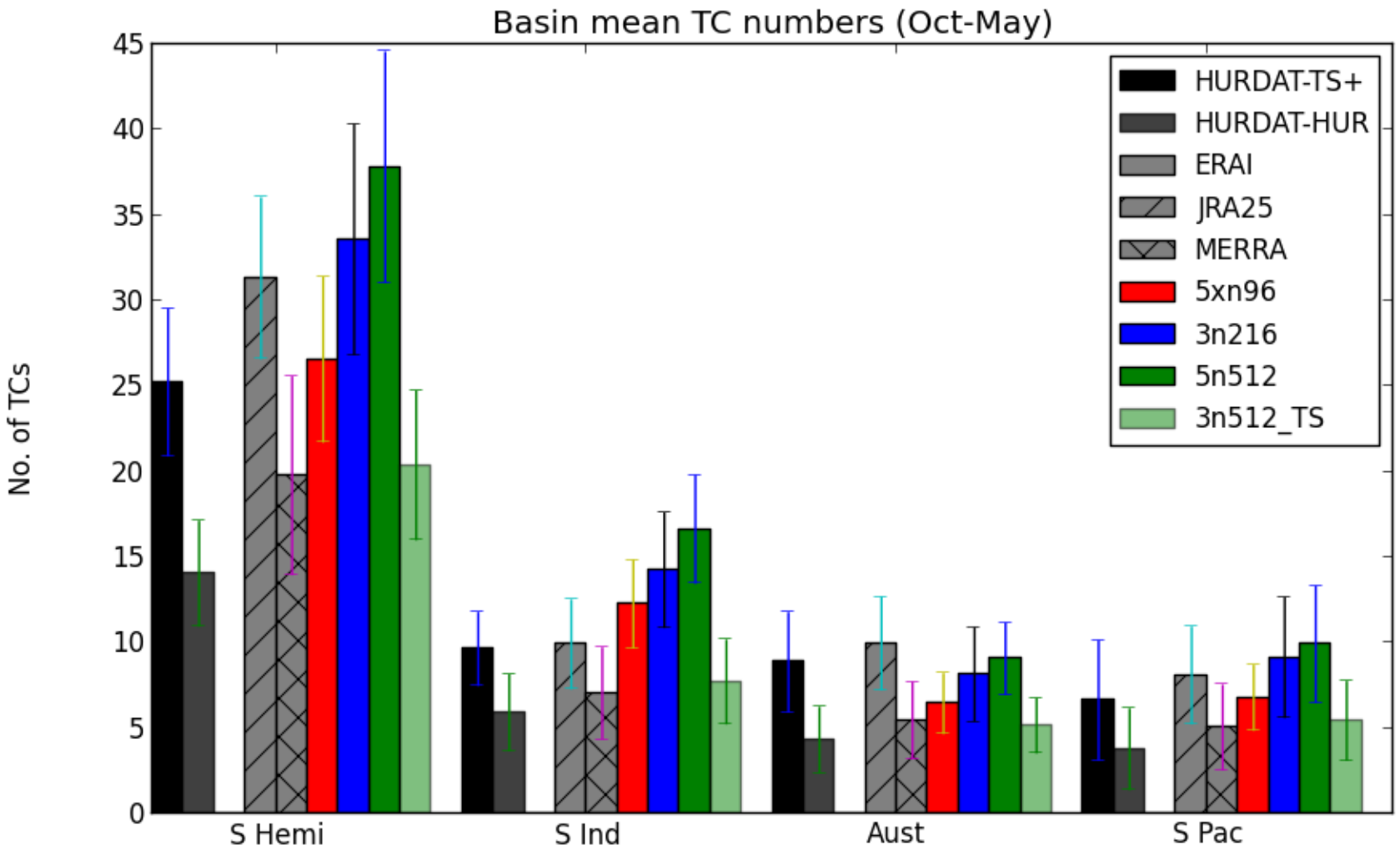
Standard deviation indicated by line



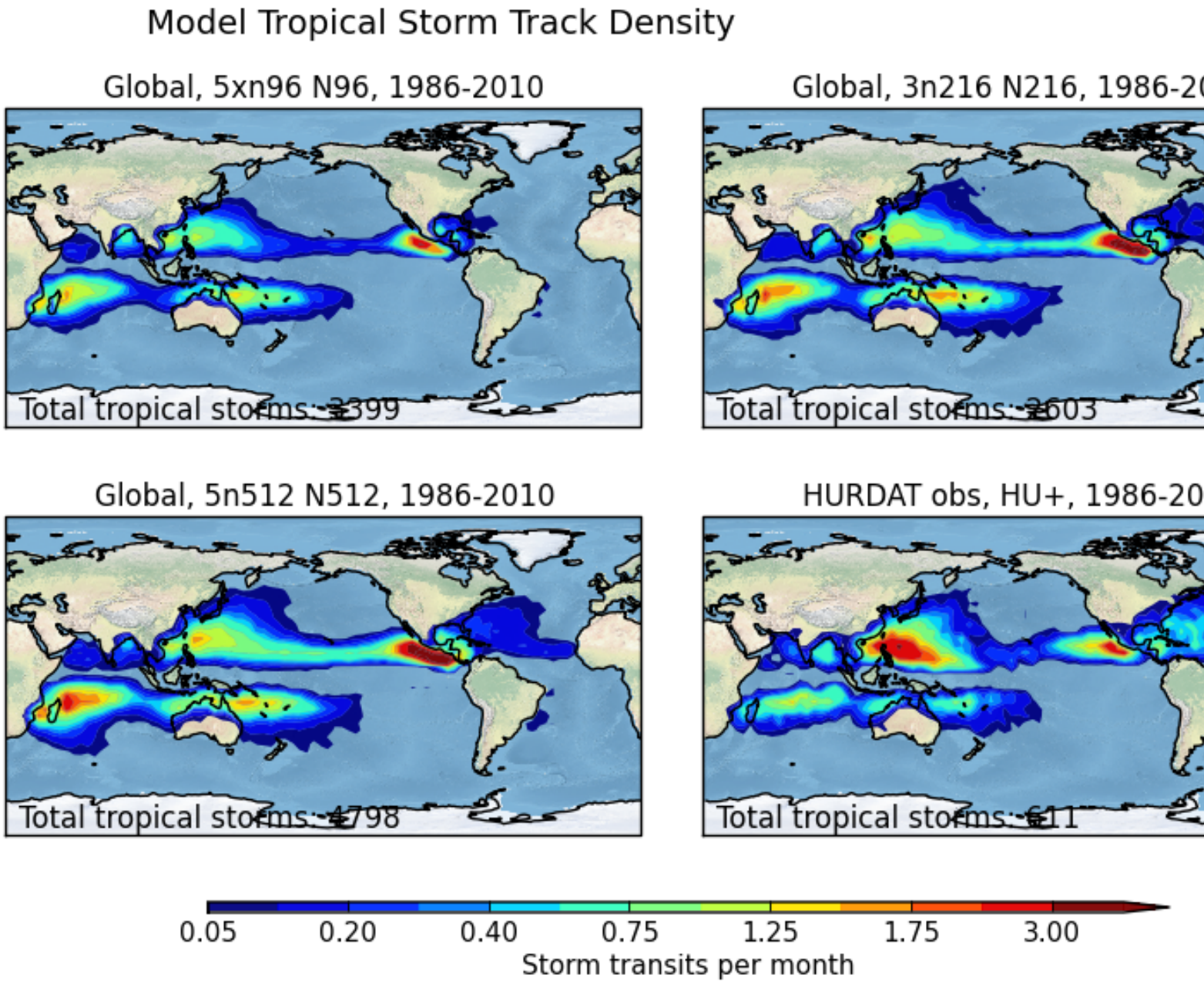
Normalised NH basin counts – 1986-2010



Mean SH basin counts – 1986-2010



Track density from model ensembles and observations



Track density – Timeslice – present day

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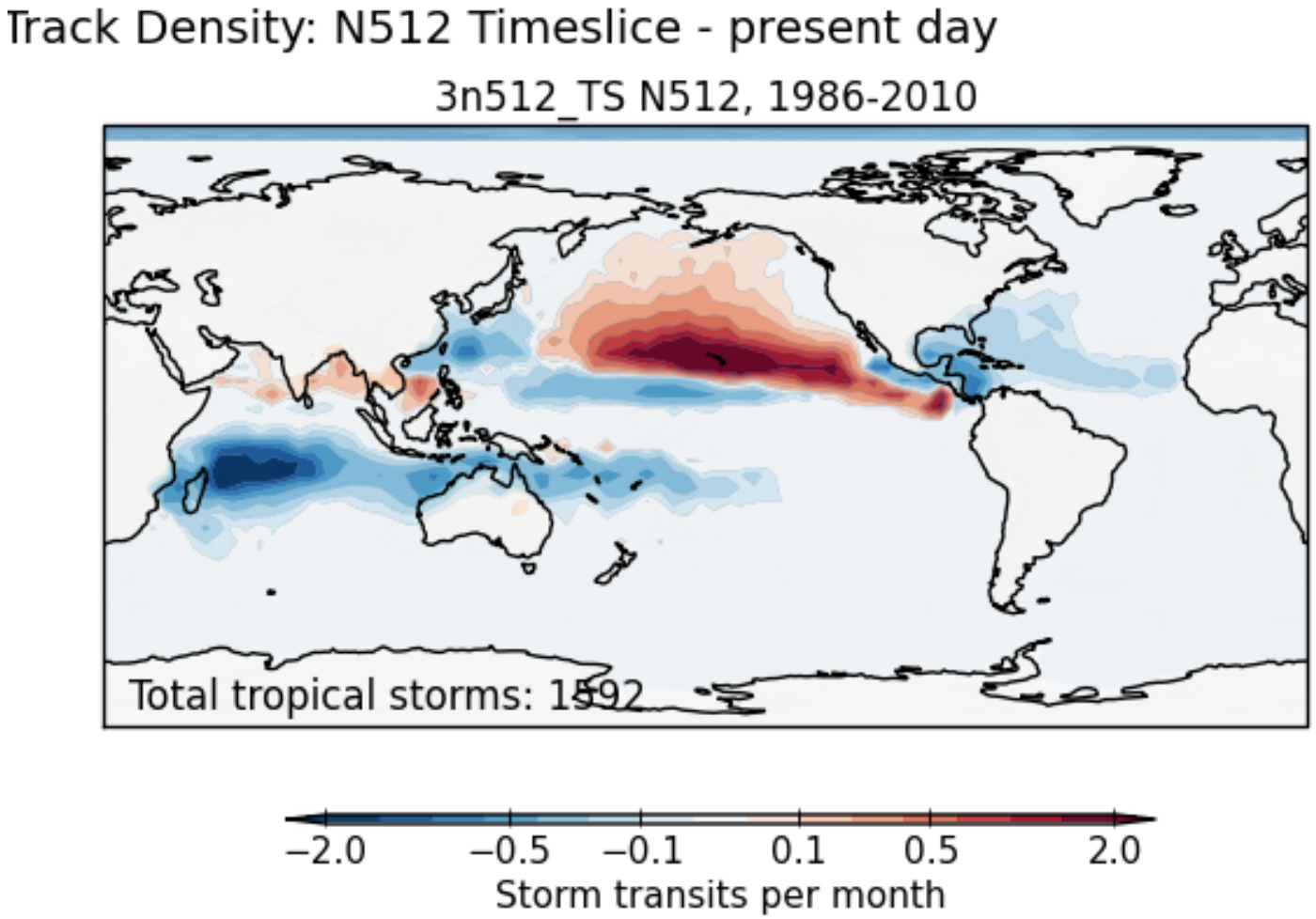
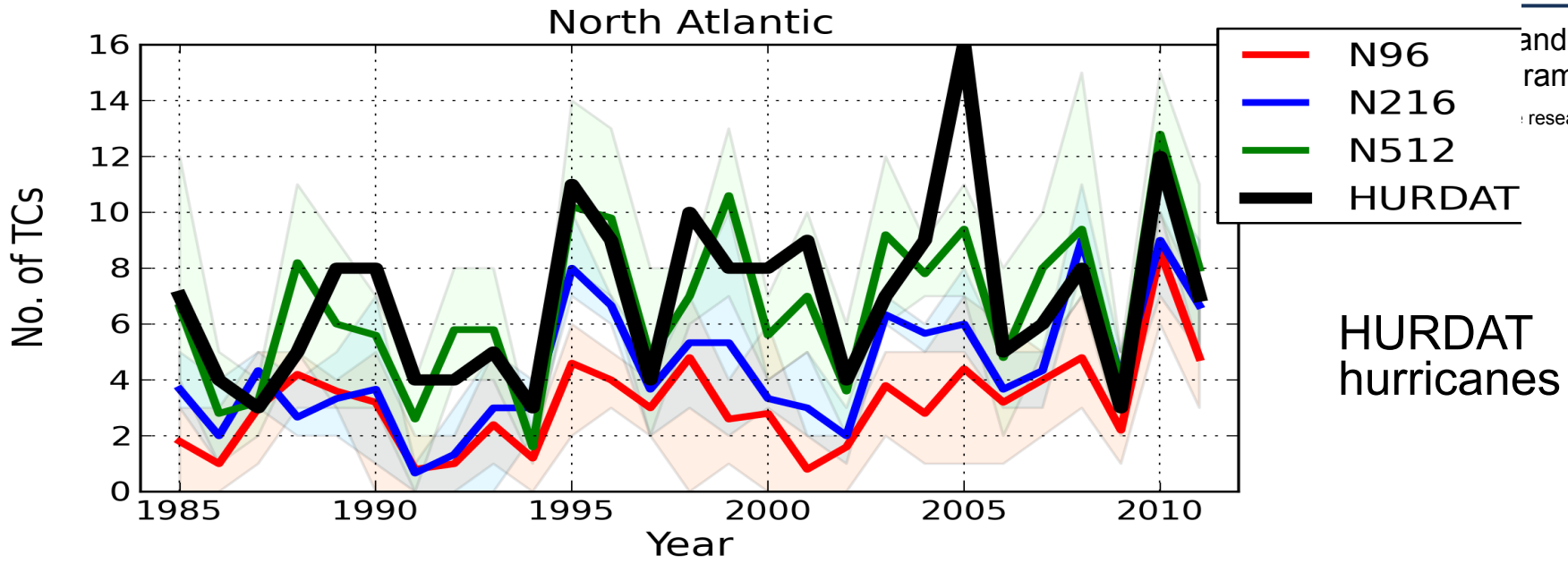
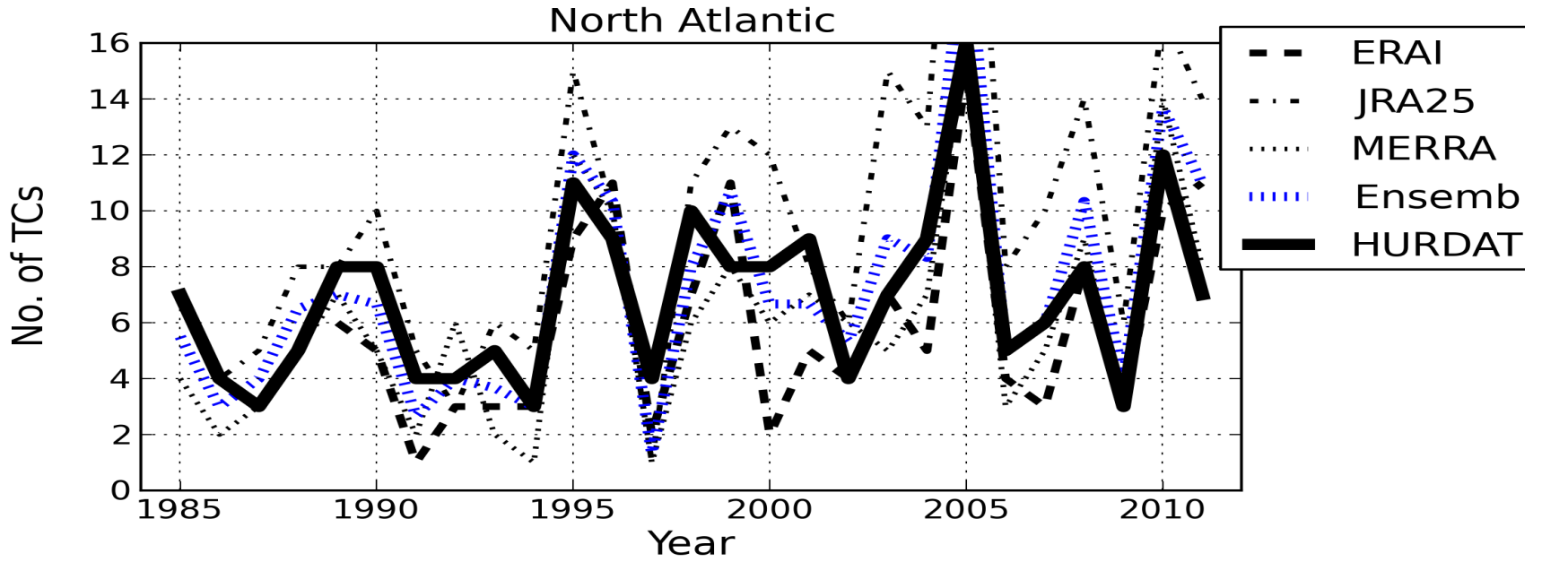


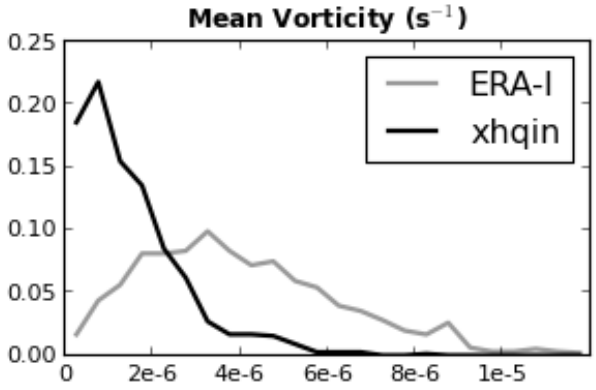
Solid line = ensemble mean, shading = ensemble range

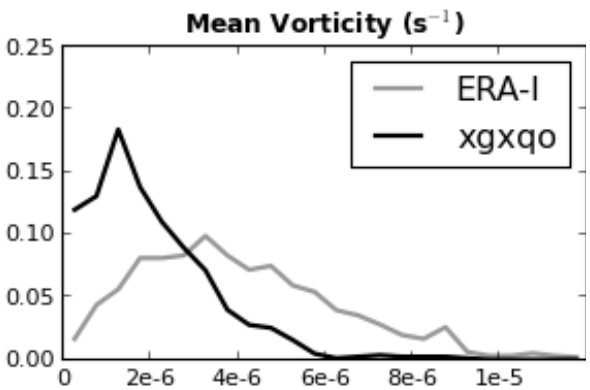


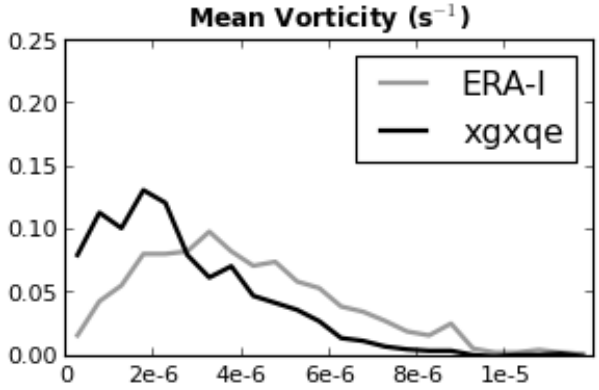
HURDAT hurricanes

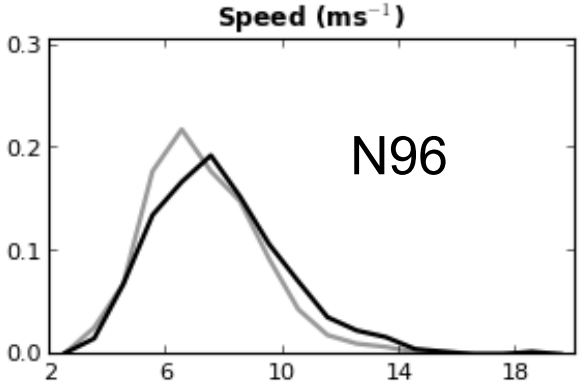


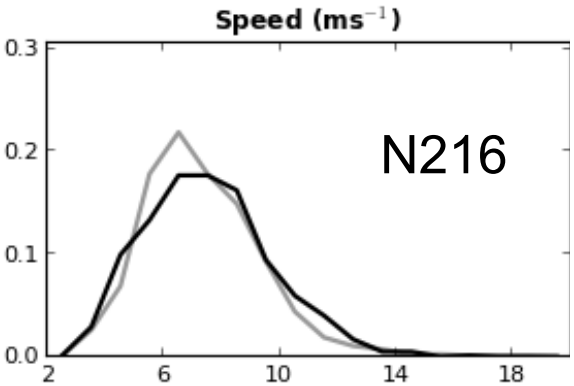
African Easterly wave properties at N96, N216 and N512 resolutions

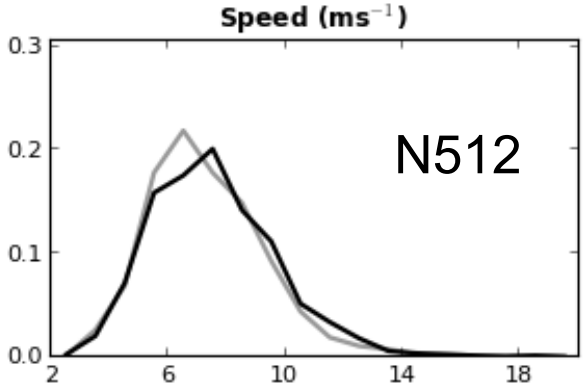


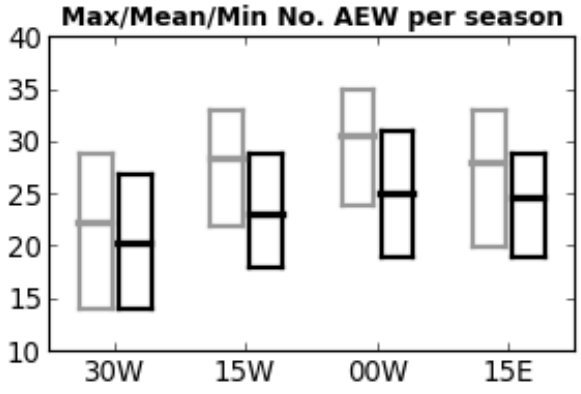


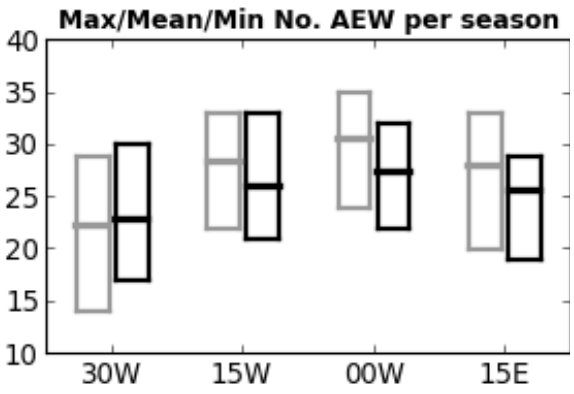


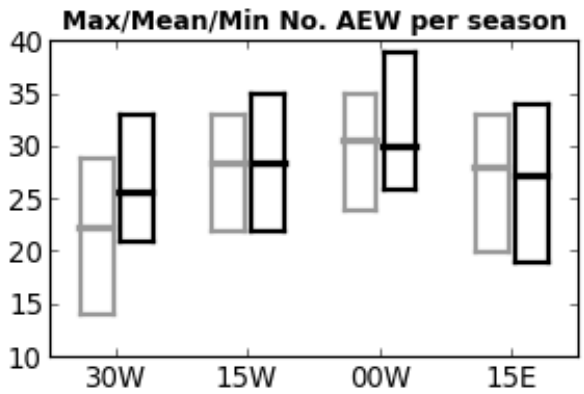












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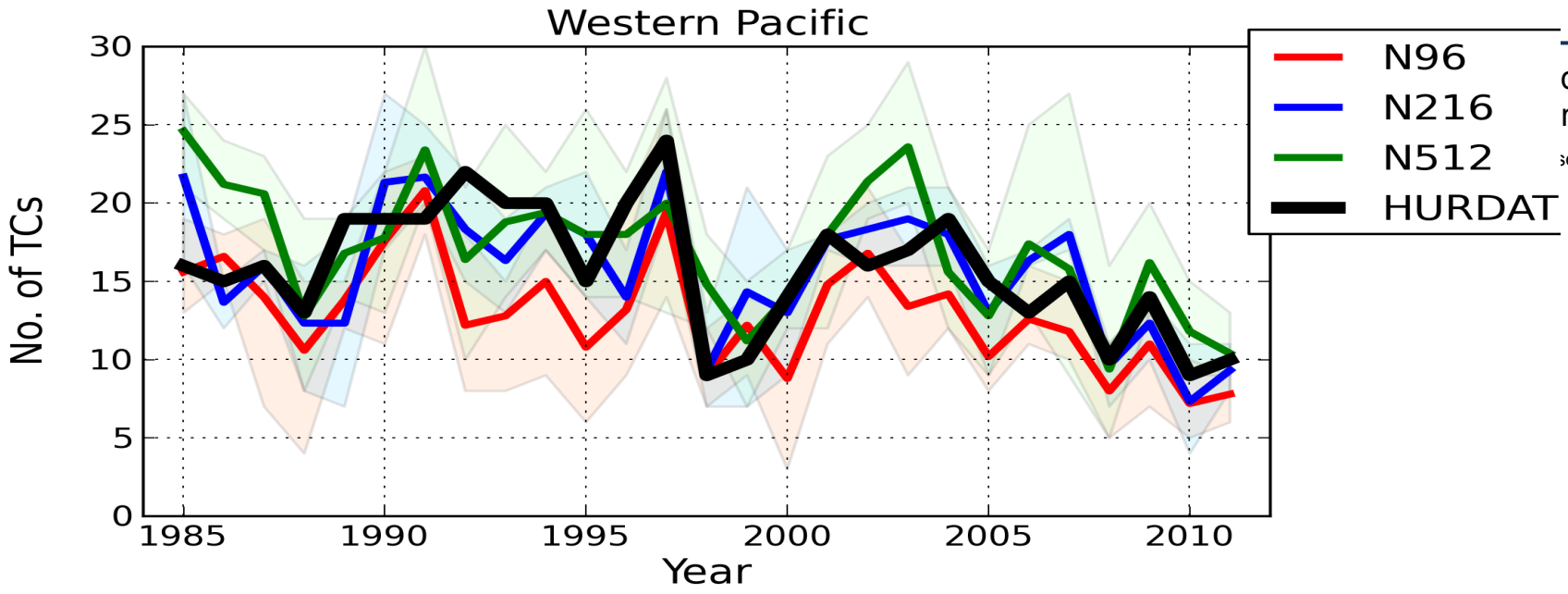

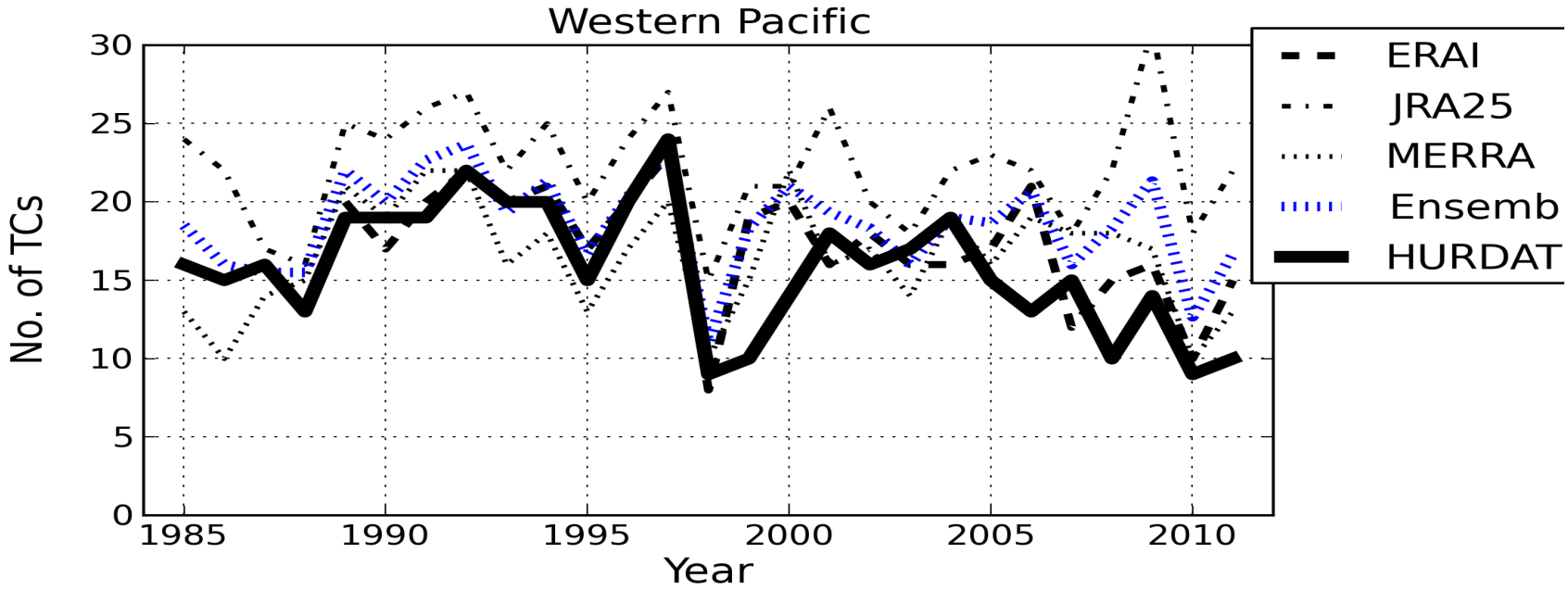

TC correlations (1985-2011) vs HURDAT

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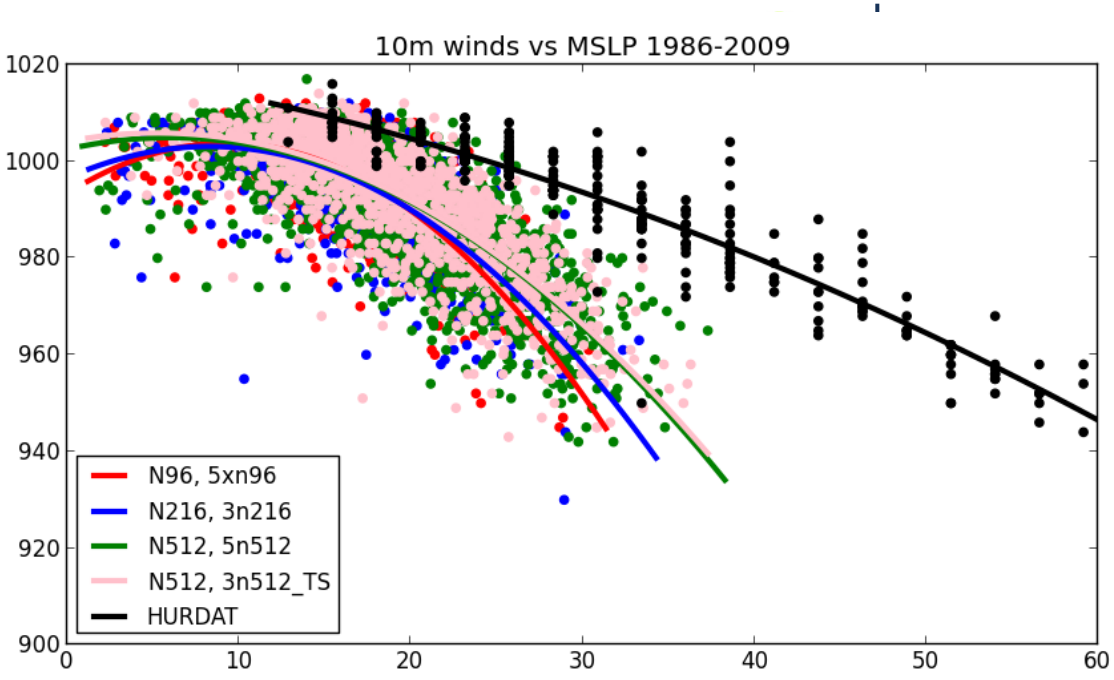
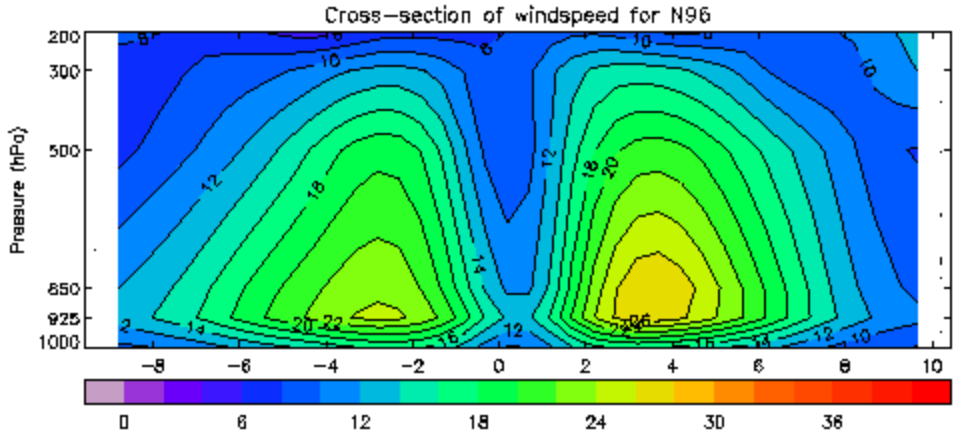
Resolution Basin	N96 (5 member)	N216 (3 member)	N512 (5 member)	Reanalyses
Atlantic	0.57, 0.58, 0.47, 0.37, 0.38 (0.60)	0.56, 0.67, 0.41 (0.64)	0.65, 0.67, 0.57, 0.57, 0.69 (0.76)	0.78, 0.88, 0.89 (0.9)
W Pacific	0.58, 0.57, 0.58, 0.58, 0.51 (0.71)	0.7, 0.52, 0.62 (0.74)	0.45, 0.49, 0.53, 0.42, 0.44 (0.60)	0.4, 0.54, 0.57 (0.69)
E Pacific	0.35, 0.29, 0.04, 0.34, 0.14 (0.3)	0.34, 0.47, 0.34 (0.5)	0.28, 0.34, 0.4, 0.2, 0.21 (0.33)	0.02, 0.56, 0.26 (0.51)
Indian	0.05, -0.16, -0.34, -0.06, -0.07 (-0.17)	0.08, -0.02, -0.16 (-0.12)	0.31, -0.34, -0.36, -0.44, -0.11 (-0.34)	0.29, 0.39, 0.39 (0.4)

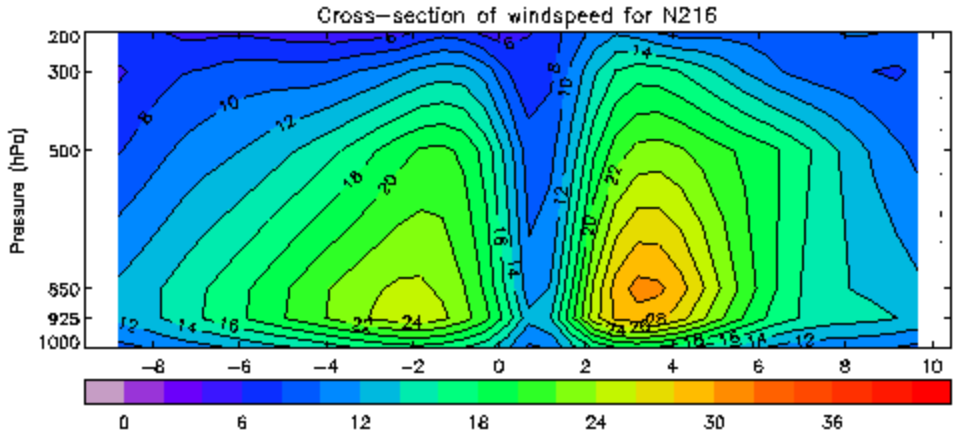
NH tropical cyclone intensity (wind speed vs MSLP) for
(top) 10m wind

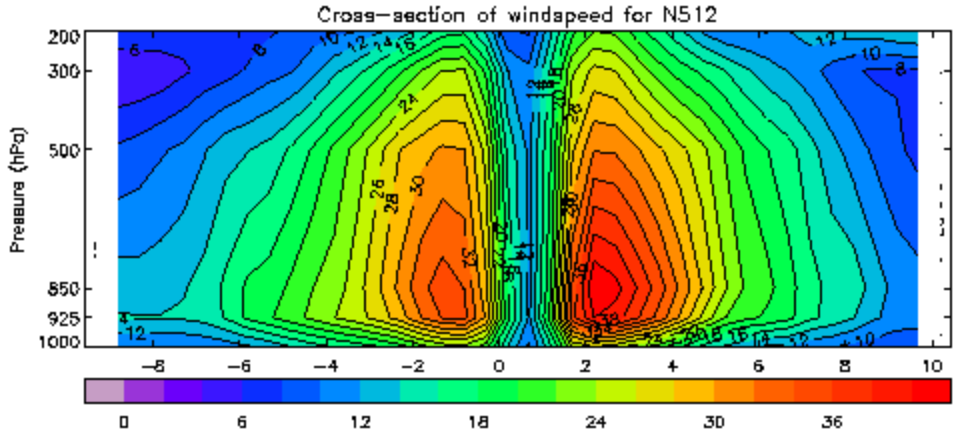
(bottom) 925hPa winds

(HURDAT is 10m in both)









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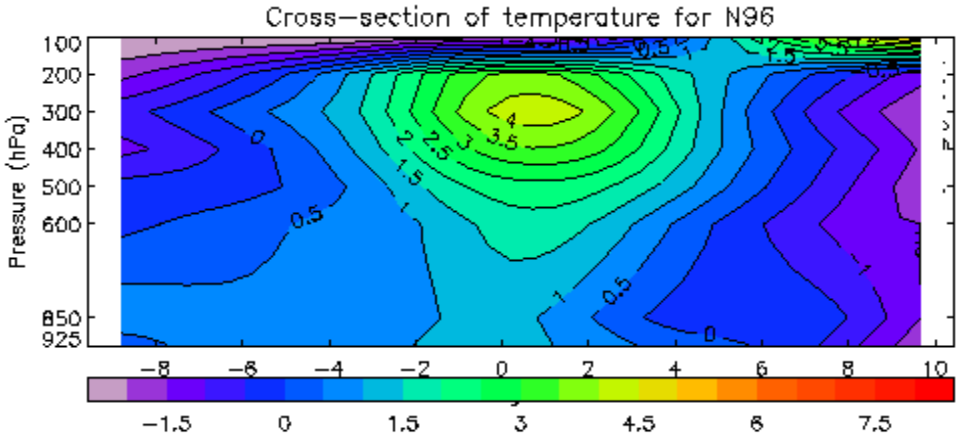
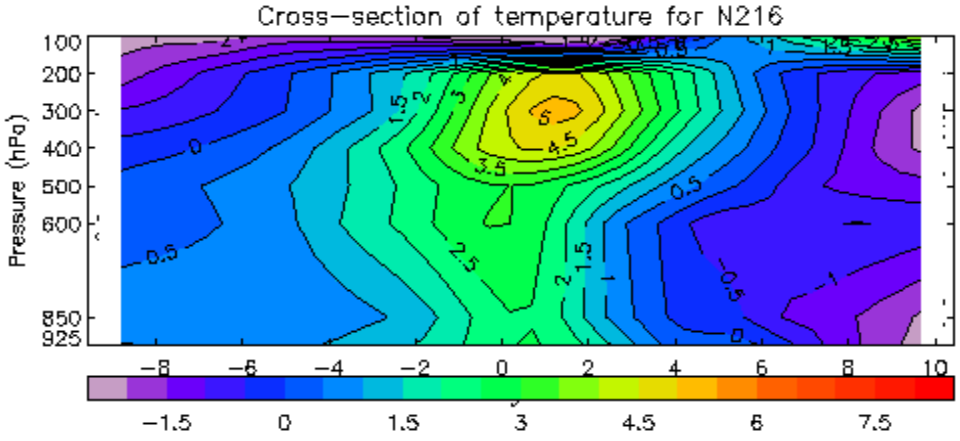
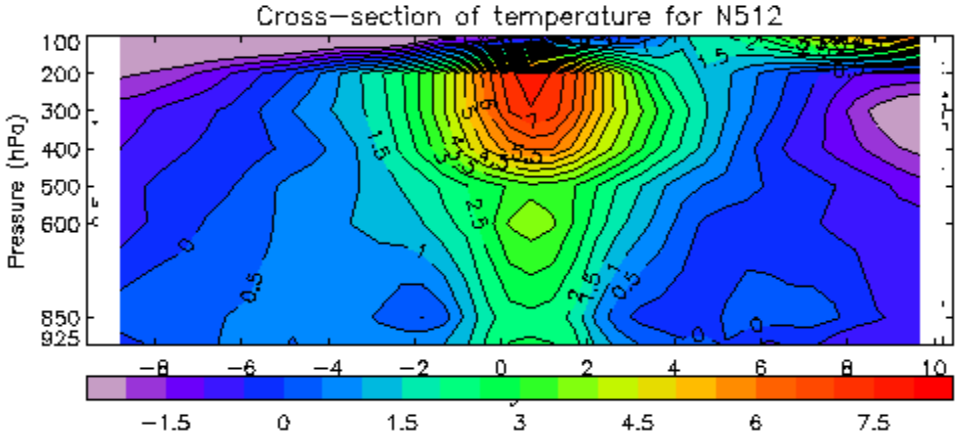
Composite structure from 10 strongest storms at peak – cross-section of wind speed from N96, N216 and N512 models







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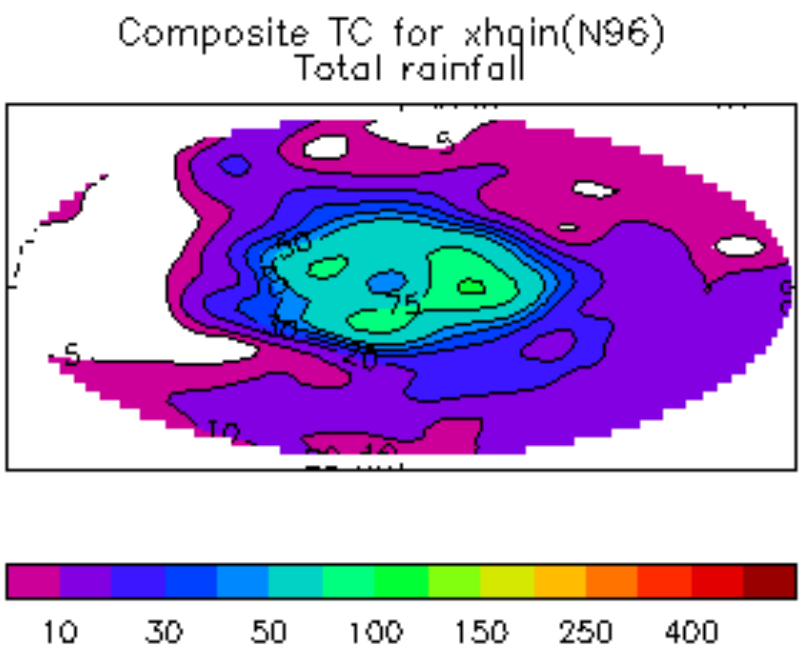
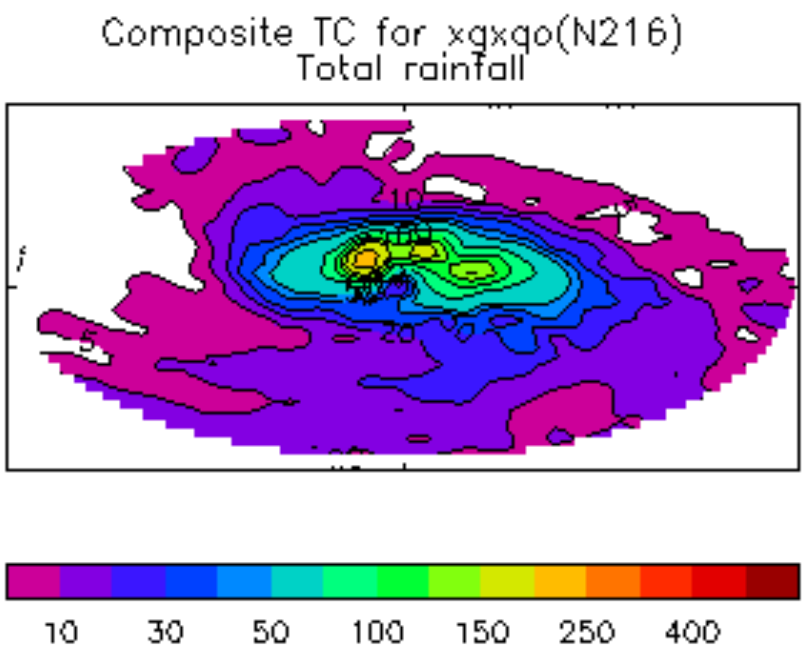
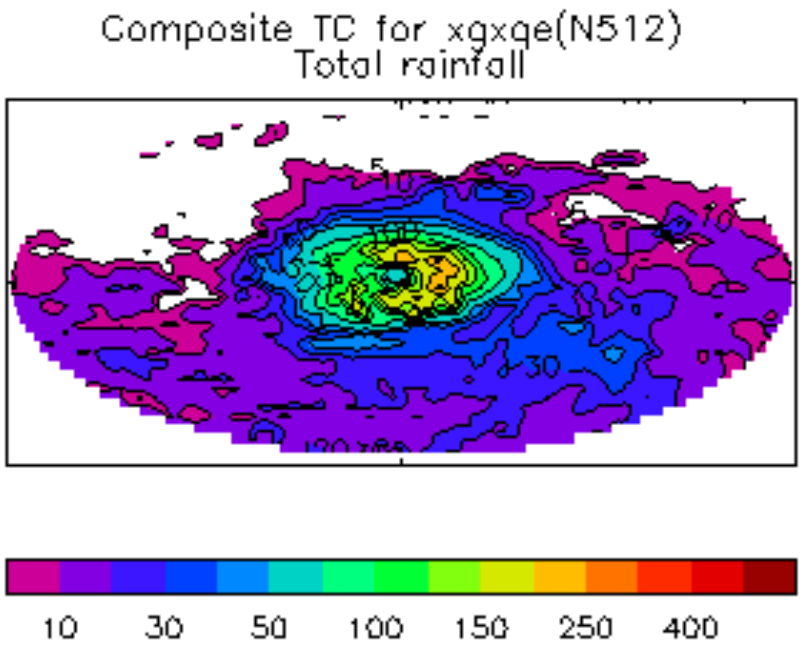
Composite structure from 10 strongest storms at peak – cross-section of temperature anomaly from N96, N216 and N512 models

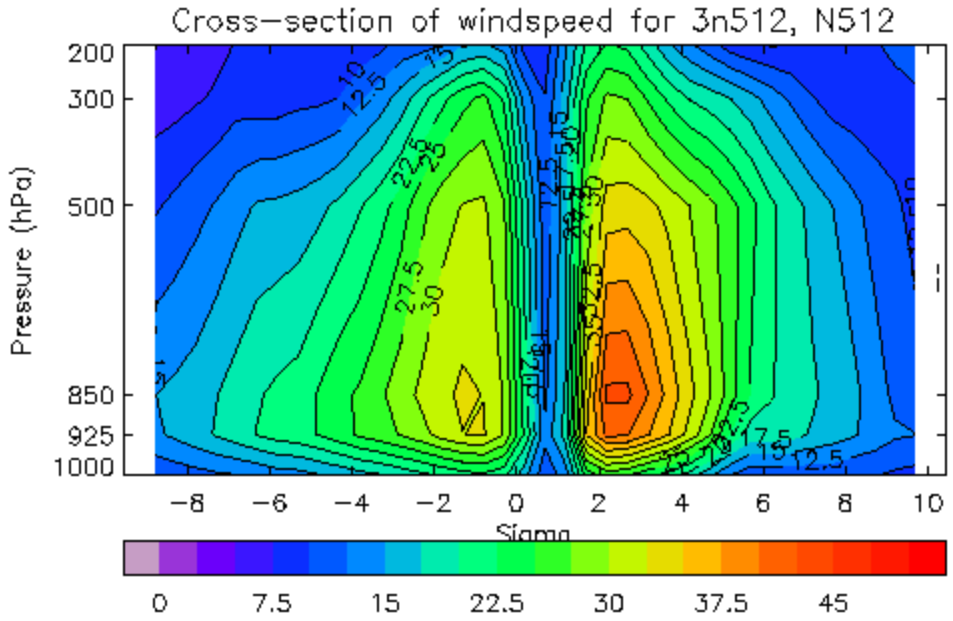


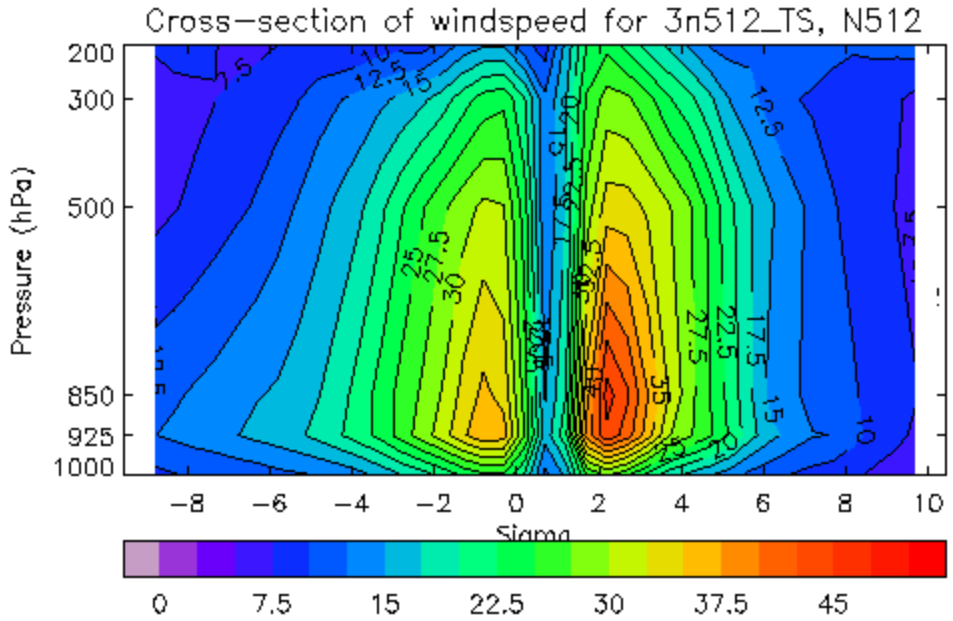




Composite structure from 10 strongest storms at peak – precipitation from N96, N216 and N512 models

mm/day





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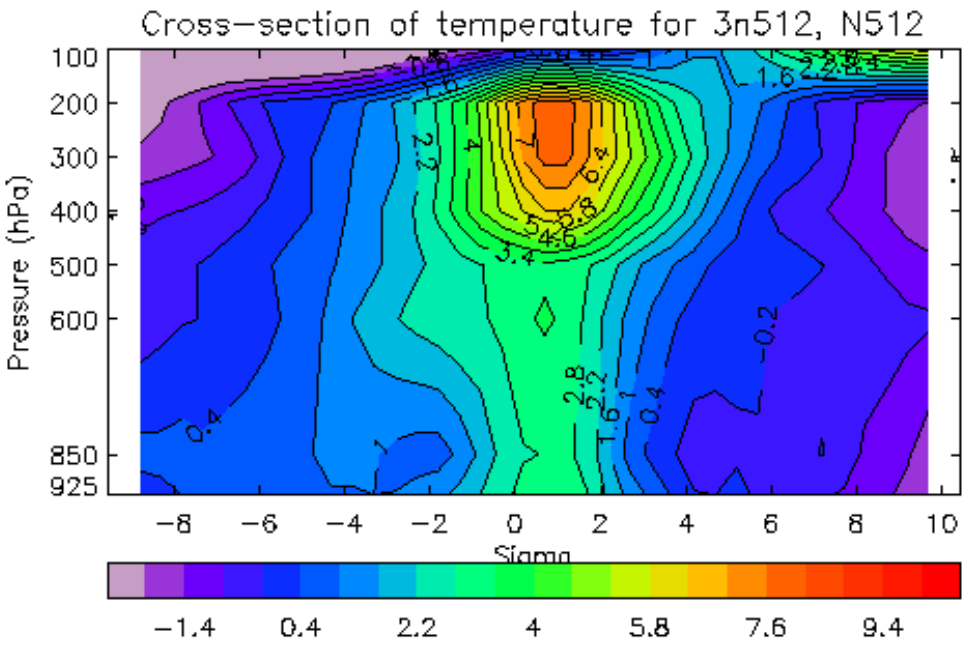
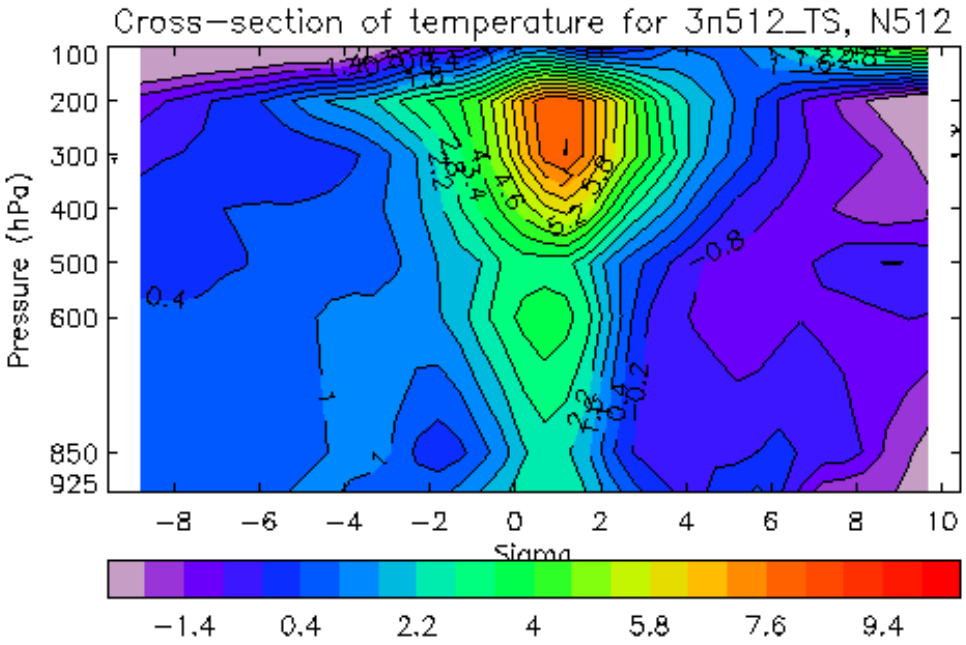
Composite structure from 10 strongest storms at peak – cross-section of wind speed from

(top) N512 present day and

(bottom) N512 timeslice





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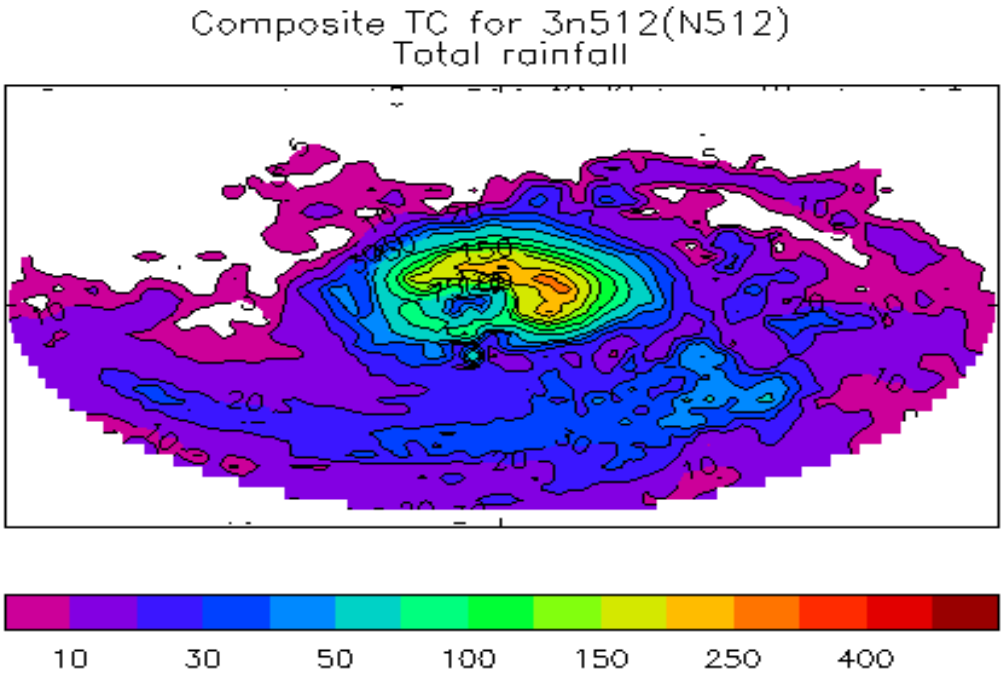
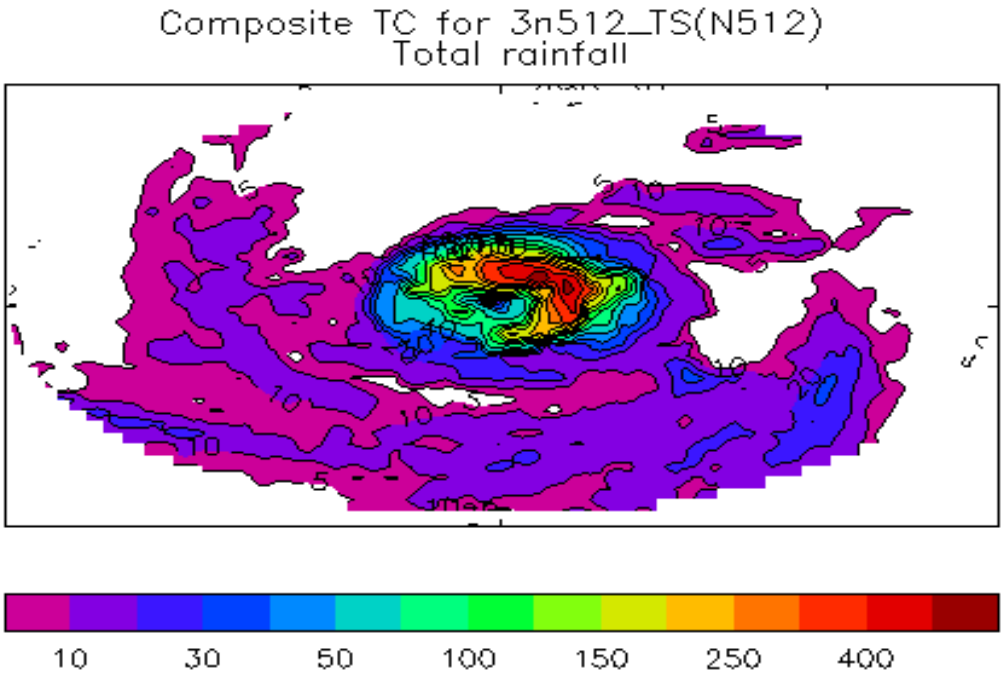
Composite structure from 10 strongest storms at peak – cross-section of wind speed from N512 present day and N512 timeslice





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Composite structure from 10 strongest storms at peak – precipitation from N512 present day and N512 timeslice

mm/day

Track density difference: Nino - Nina

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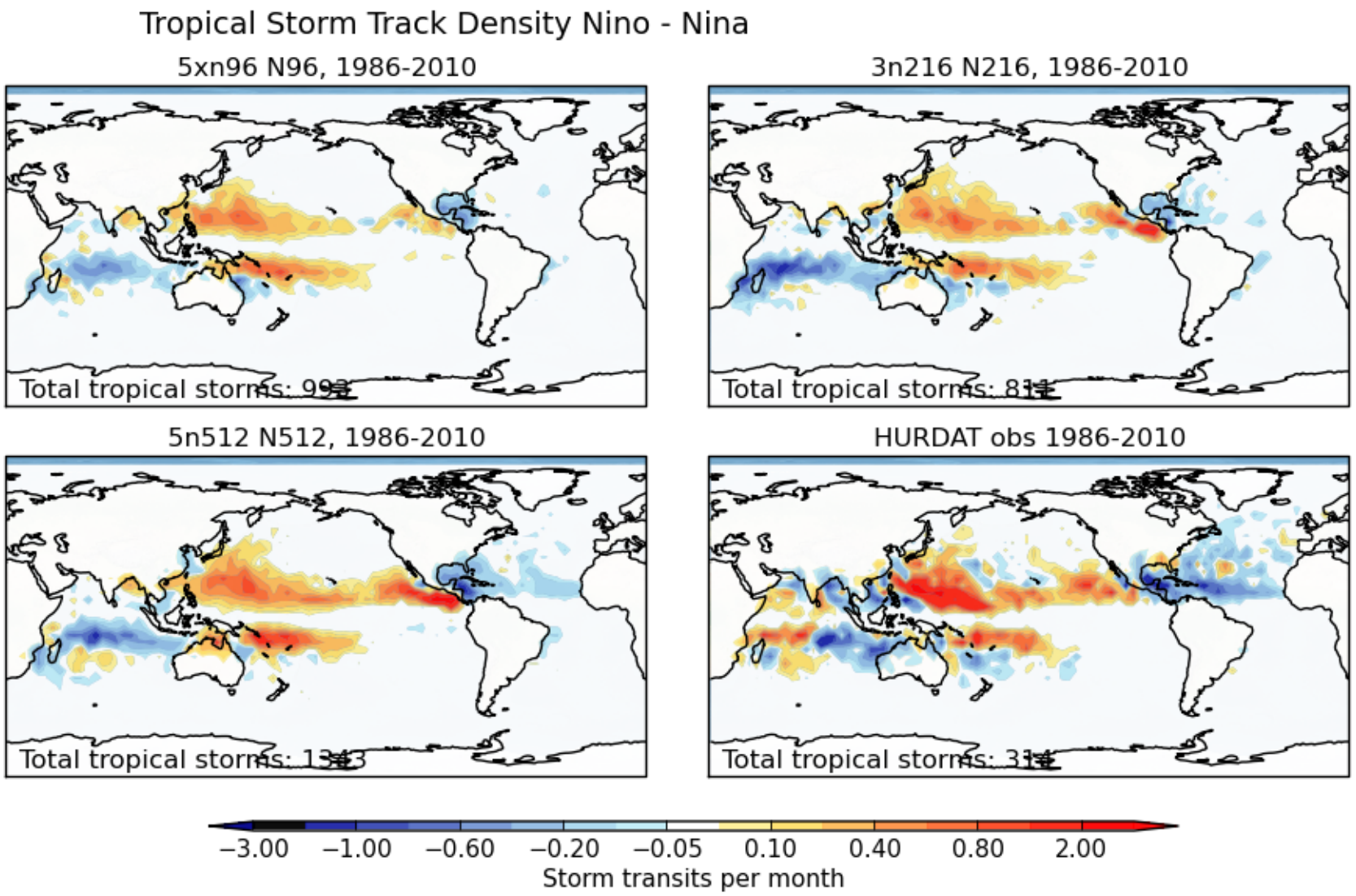
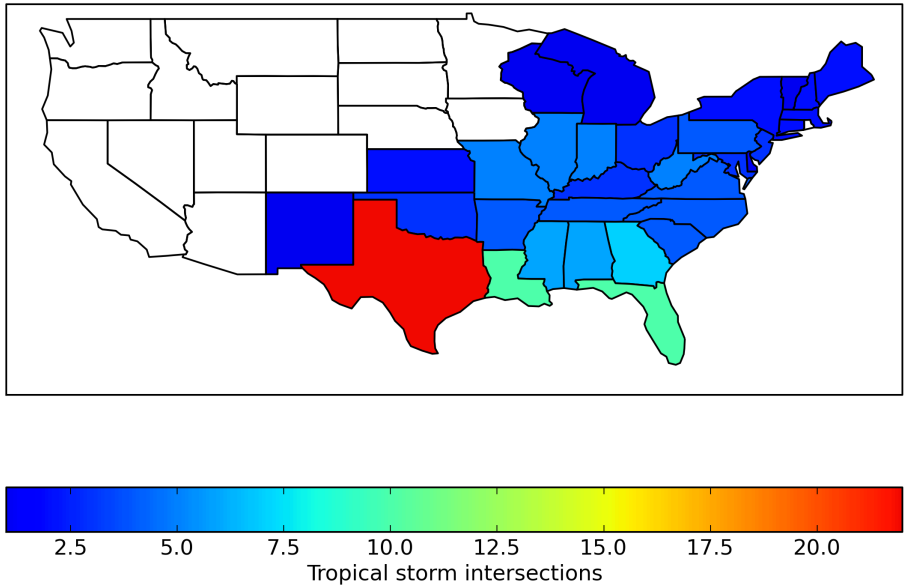
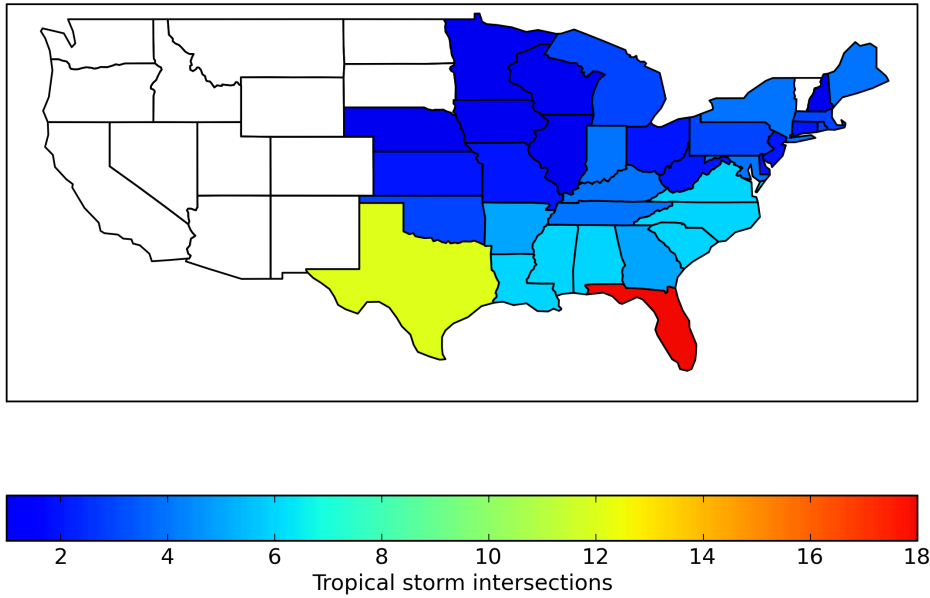


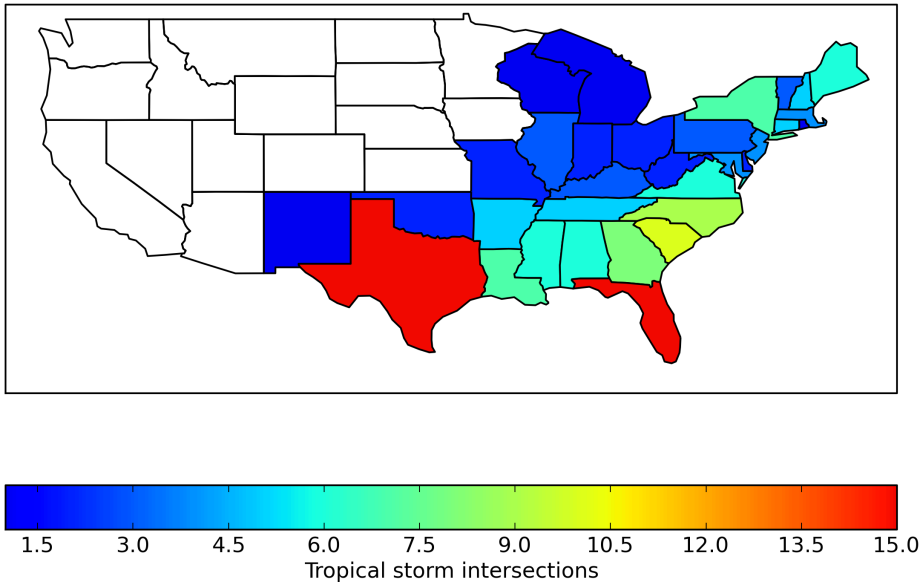
Model N96_xhqin tropical storm crossings by US state
June-November 1985-2011



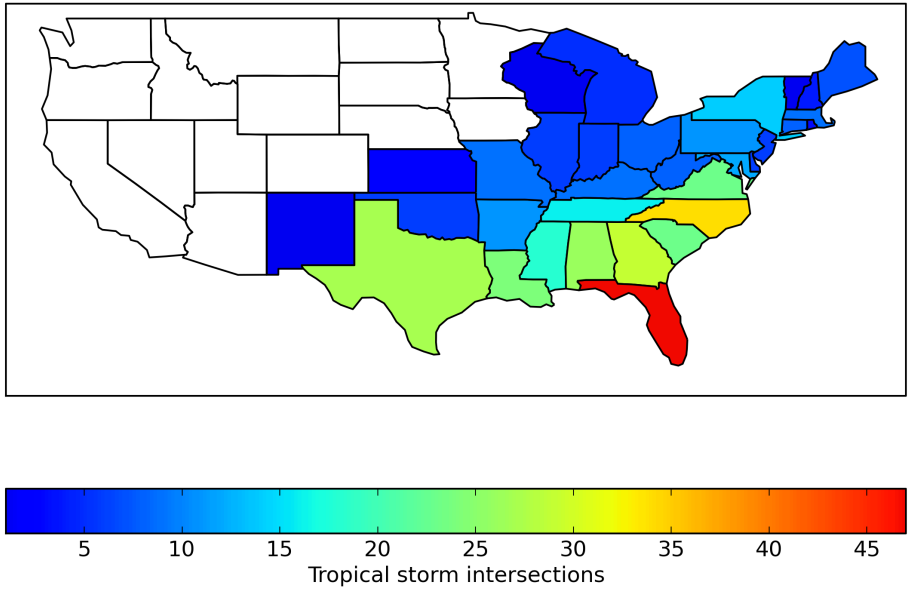
Model N216_xgxqo tropical storm crossings by US state
June-November 1985-2011



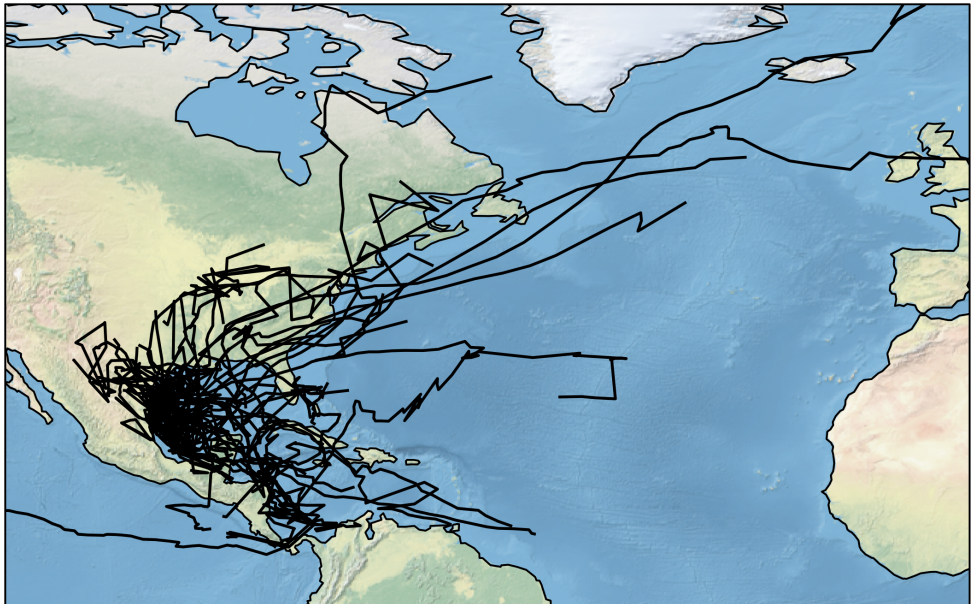
Model N512_xgxqe tropical storm crossings by US state
June-November 1985-2011



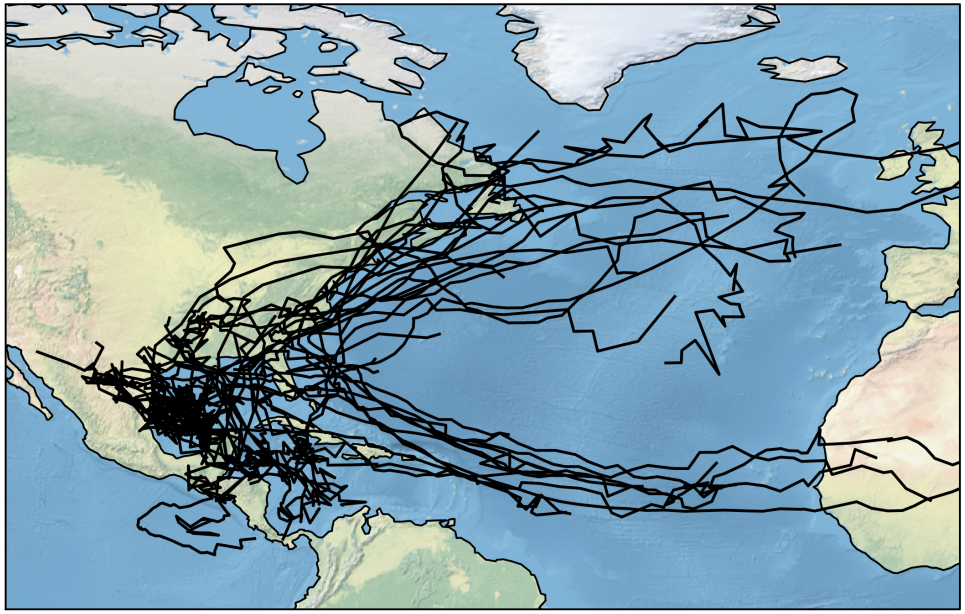
Observed tropical storm crossings by US state
June-November 1985-2011



Model N96_xhqin US tropical storm crossings
June-November 1985-2011



Model N512_xgxqe US tropical storm crossings
June-November 1985-2011



Total tropical storms: 35

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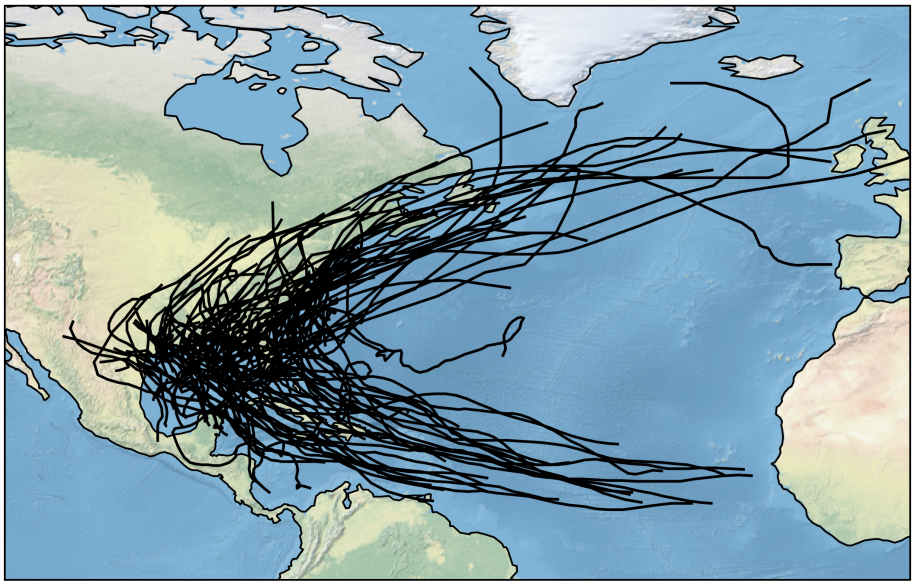
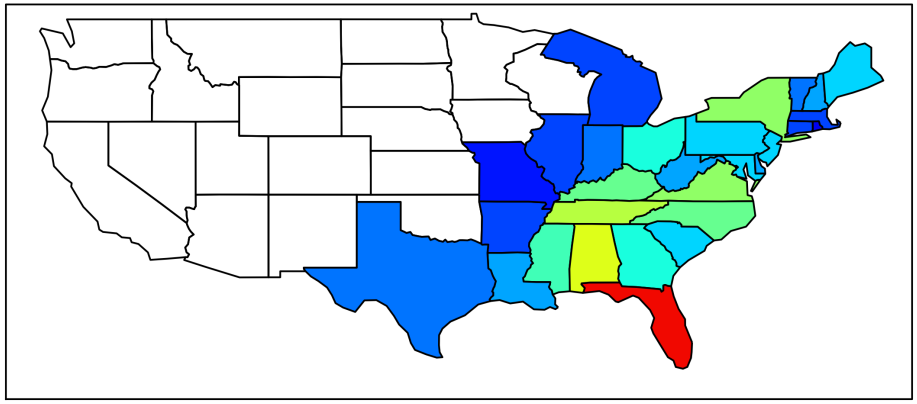
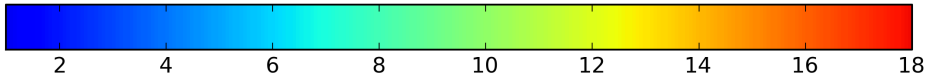
Observed US tropical storm crossings
June-November 1985-2011



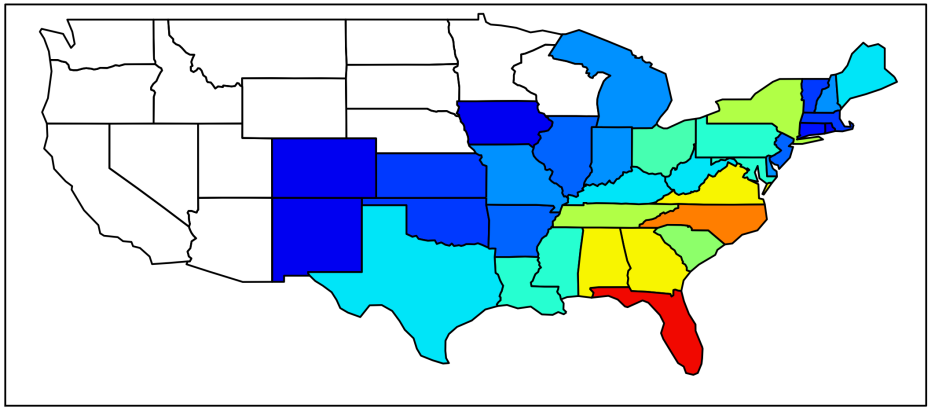
Total tropical storms: 101

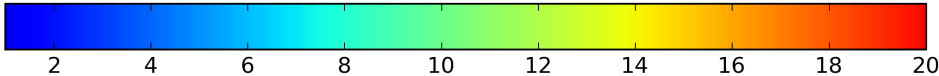
Model ERAI_erai tropical storm crossings by US state
June-November 1989-2011



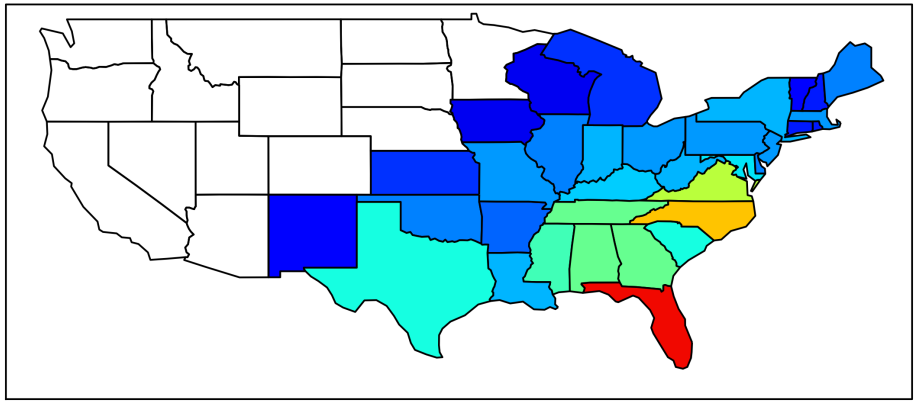


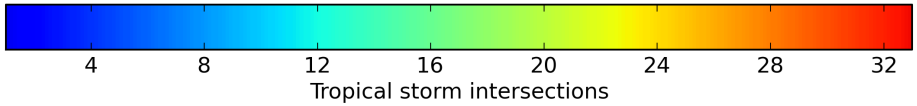
Model MERRA_merra tropical storm crossings by US state
June-November 1989-2011



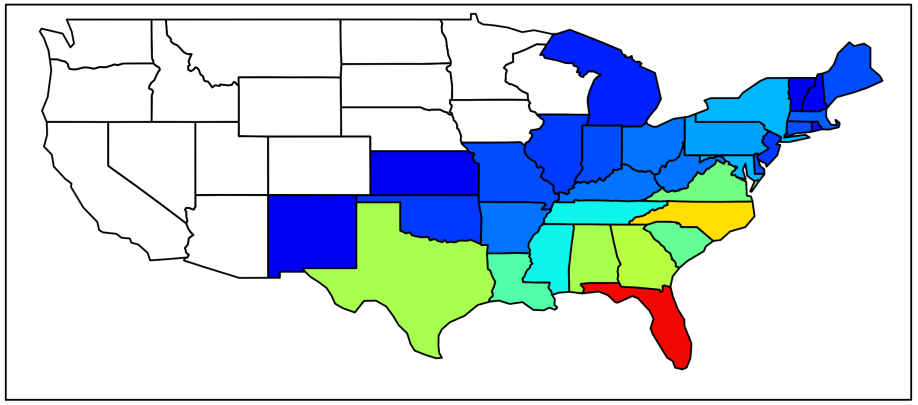


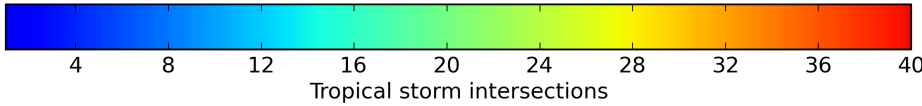
Model JRA25_jra25 tropical storm crossings by US state
June-November 1989-2011





Observed tropical storm crossings by US state
June-November 1989-2011





HWG experiments

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- Little analysis done
- Only 8-10 years with higher resolution models

HWG experiments
NH basin mean

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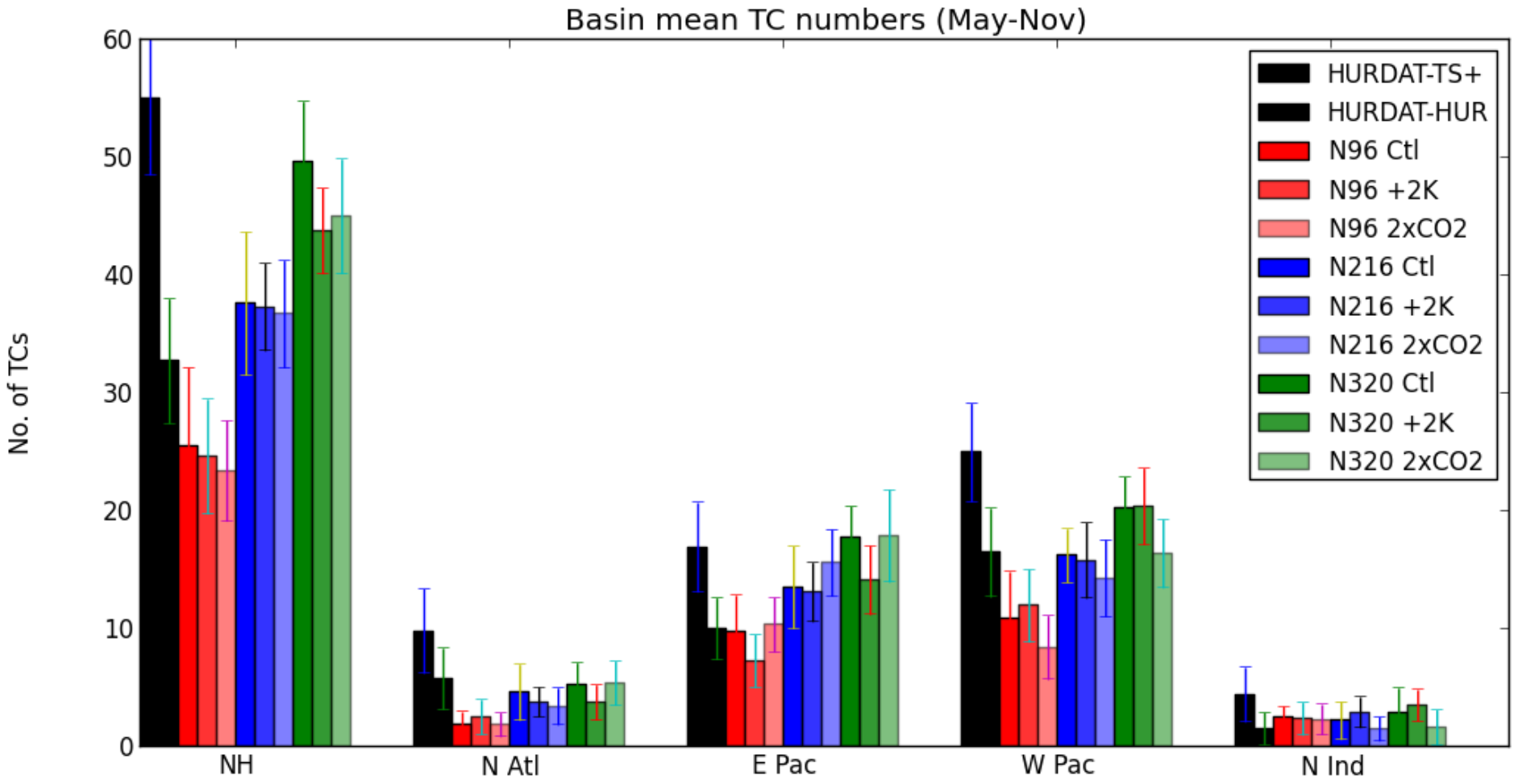

HWG experiments
SH basin mean

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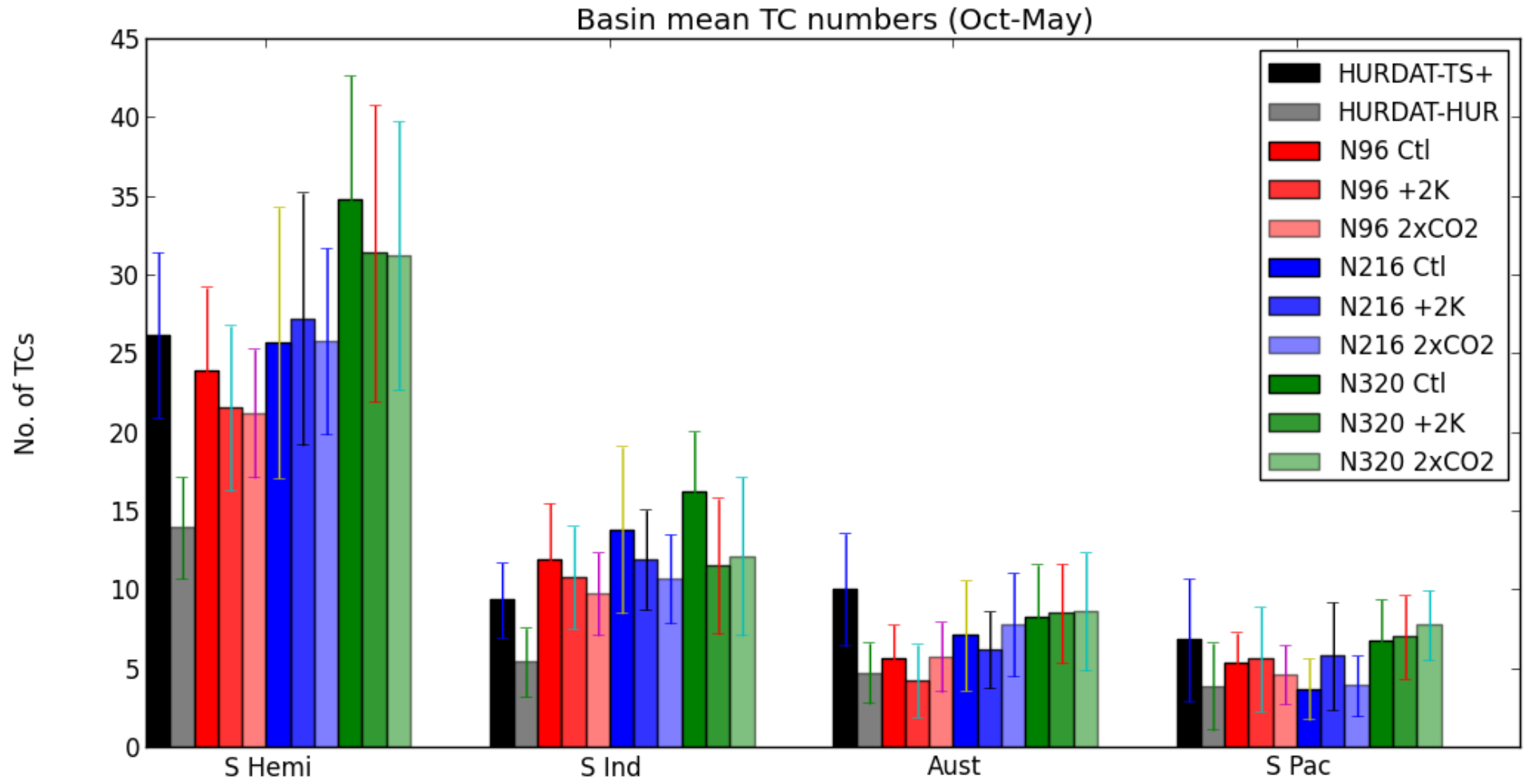
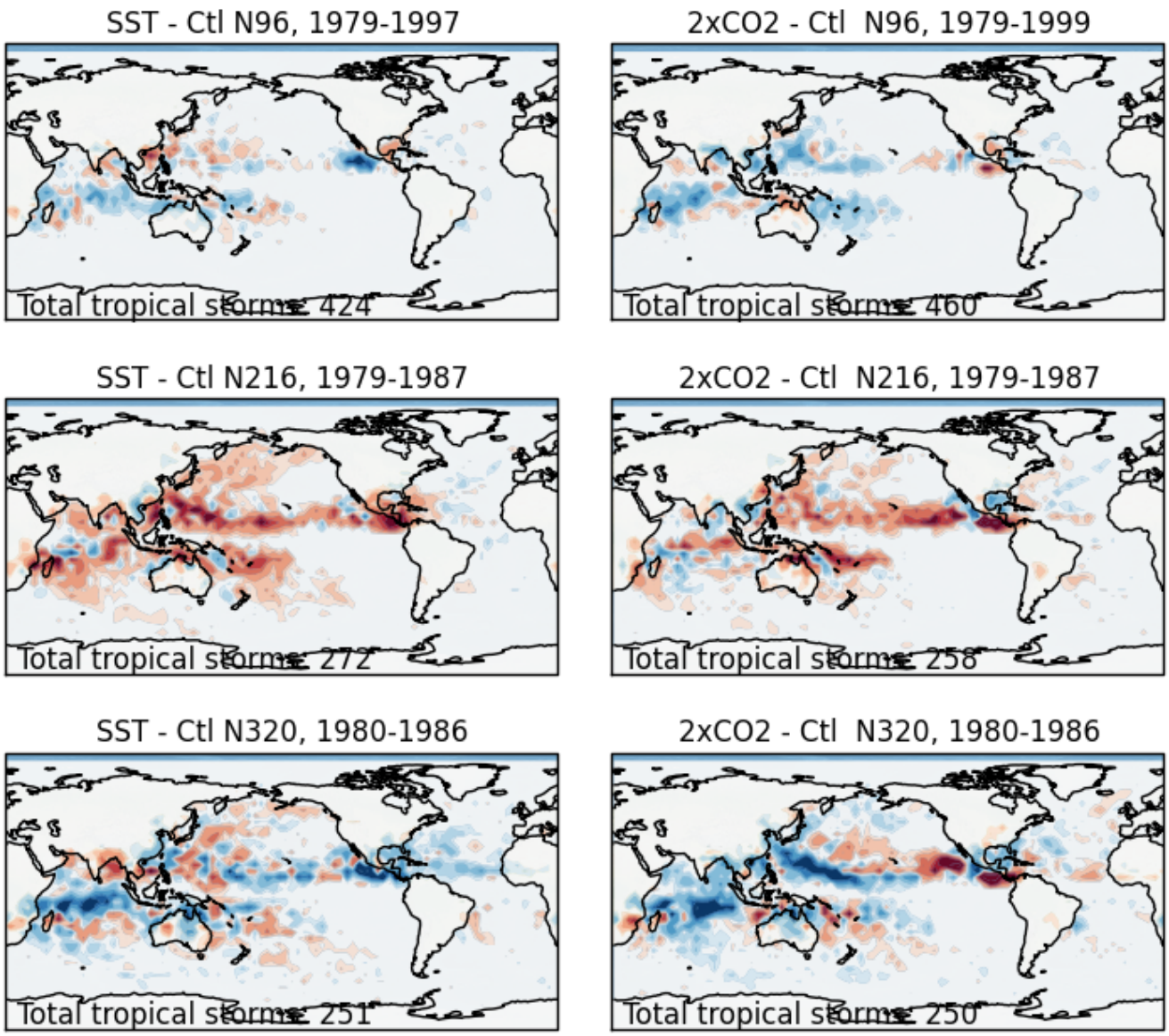


Tropical Storm Track Density



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Summary

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- General improvements at higher resolution
  - Increase in storm numbers, and slightly improved interannual correlations, particularly in Atlantic
  - US landfalling storm distribution dependent on model resolution
    - due to genesis position mainly?
- Common errors
  - Too many SH storms
  - Weak intensities
  - Too few landfalling storms in N Atlantic
- HWG experiments
  - No significant change in numbers of storms at any resolution
  - Track density changes variable

Future/ongoing work

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- Further analysis of UPSCALE and HWG experiments
  - Understanding sensitivities to resolution/forcing
- Work with improved dynamical core (ENDGame)
  - Indications of some significant improvements at low resolution, high resolution ongoing
- Understand weak intensity of storms
  - PhD student working on this

Difference in surface temperature Timeslice – present day

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