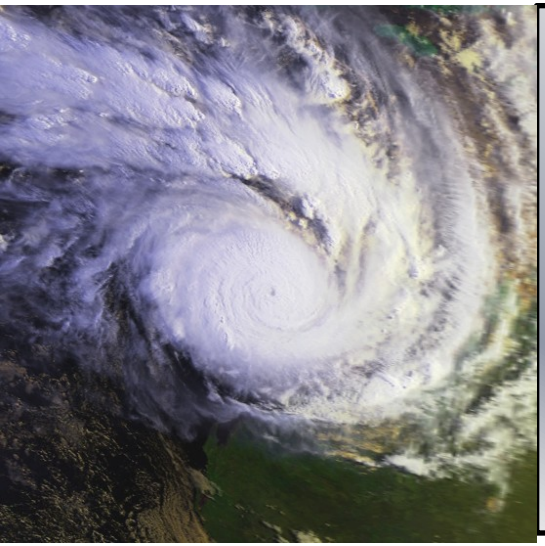
THE UNIVERSITY OF MELBOURNE

CLIVAR Working Group on Hurricanes workshop
5-7 June 2013



A phenomenon-based tracking scheme for high-resolution climate models

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Outline

A slightly modified tracking scheme

HWG results using this tracking scheme

Comparison to other HWG tracking results

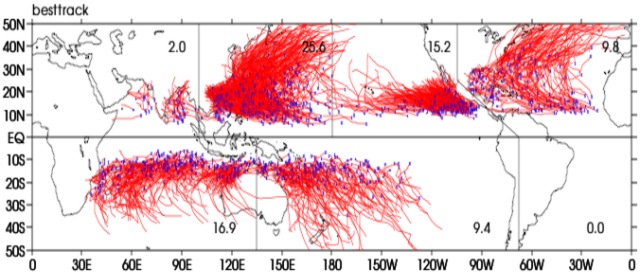
Some comments on conditions for TC formation in climate models versus actual formation

Acknowledgments: CLIVAR, GFDL, CSIRO, Naomi and co-chairs

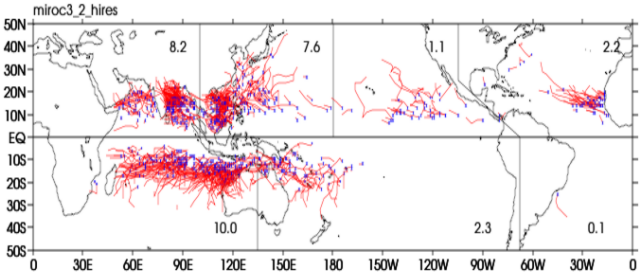
Previous version of CSIRO tracking scheme

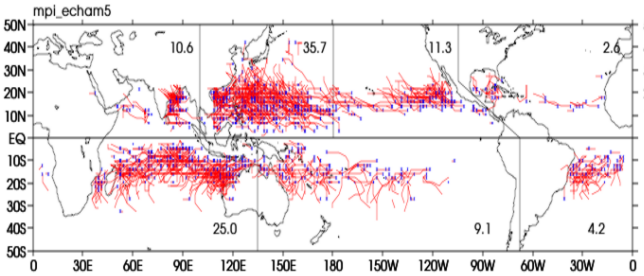
- Weak vorticity threshold (only used to speed up routine)
- Warm core thresholds (comparison of upper-level and lower-level winds and temperatures)
- 10 m wind speed resolution-dependent threshold (Walsh et al. 2007 J. Climate)
- Must be satisfied for at least 24 hours
- Problem: despite warm-core check, still required latitude limit to formation of 30^{o}

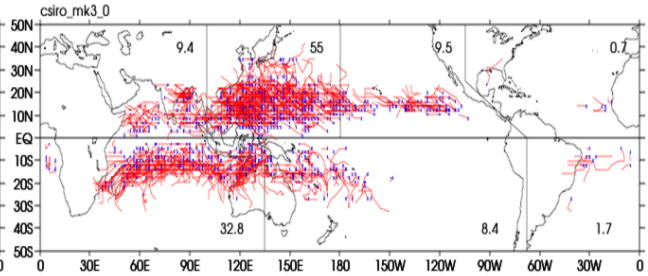
CMIP3 model cyclone tracks (with annual average genesis by basin) with previous version of CSIRO tracking scheme

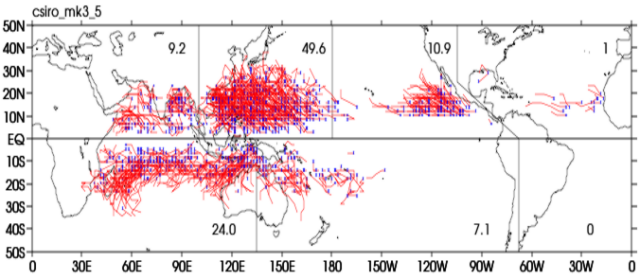


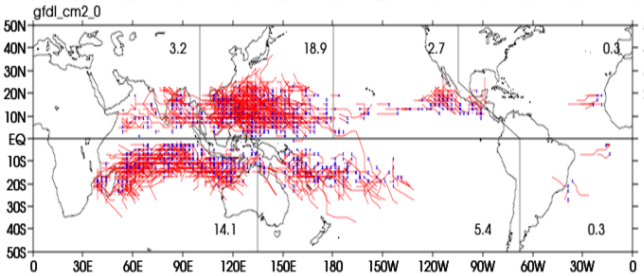
Best track

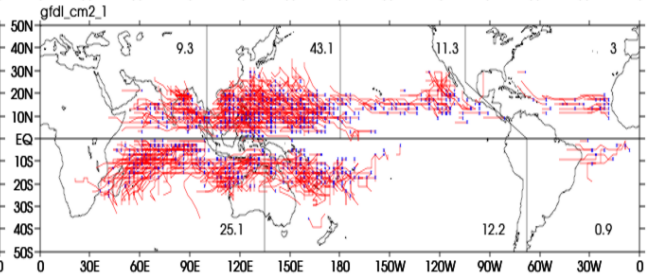


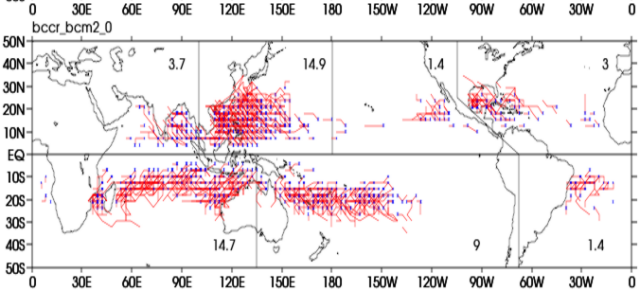


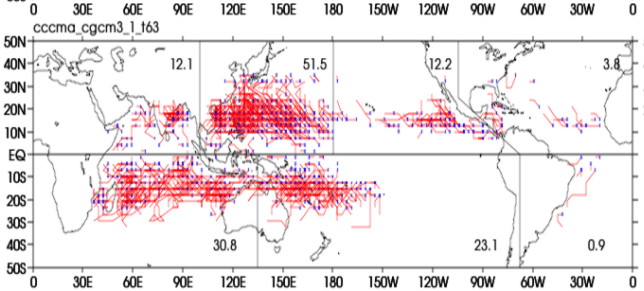


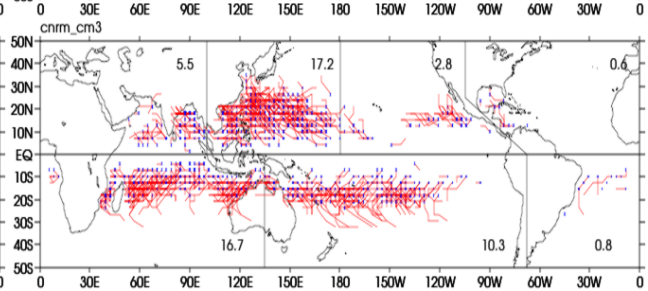






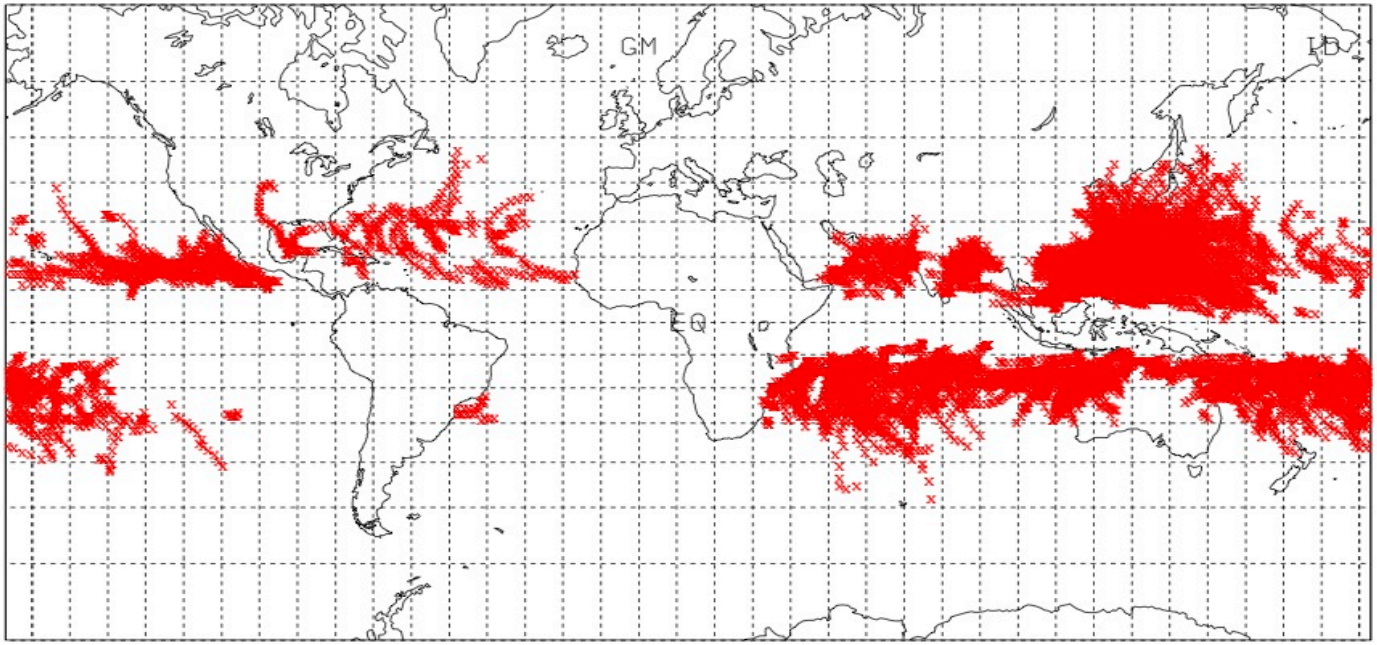






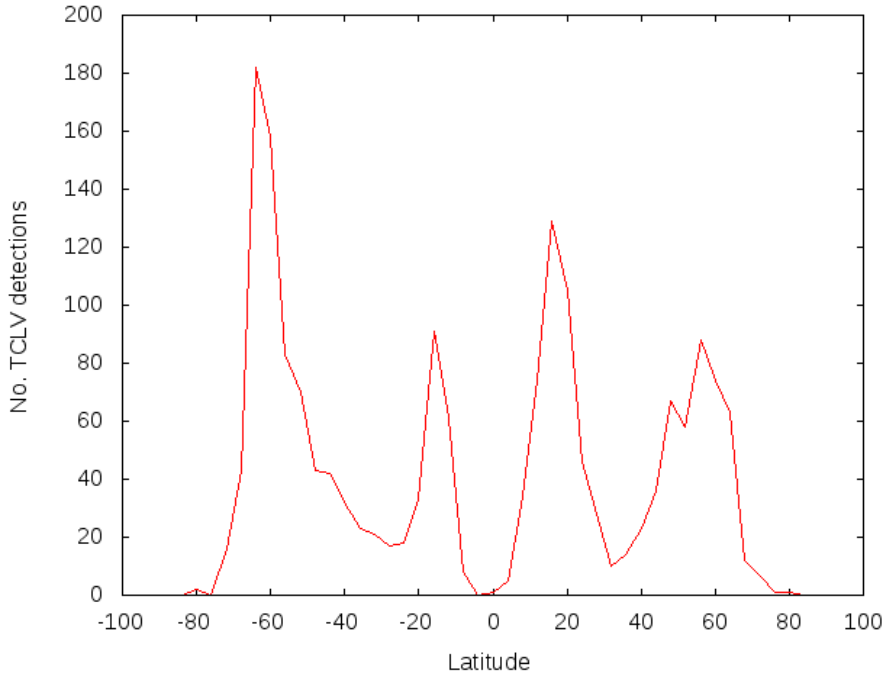
Walsh et al. (2013) Clim. Dyn.

Old version of tracking scheme applied to HWG data



HWG MRI model tracks for 20 years of Present Day experiment (tropical detections only)

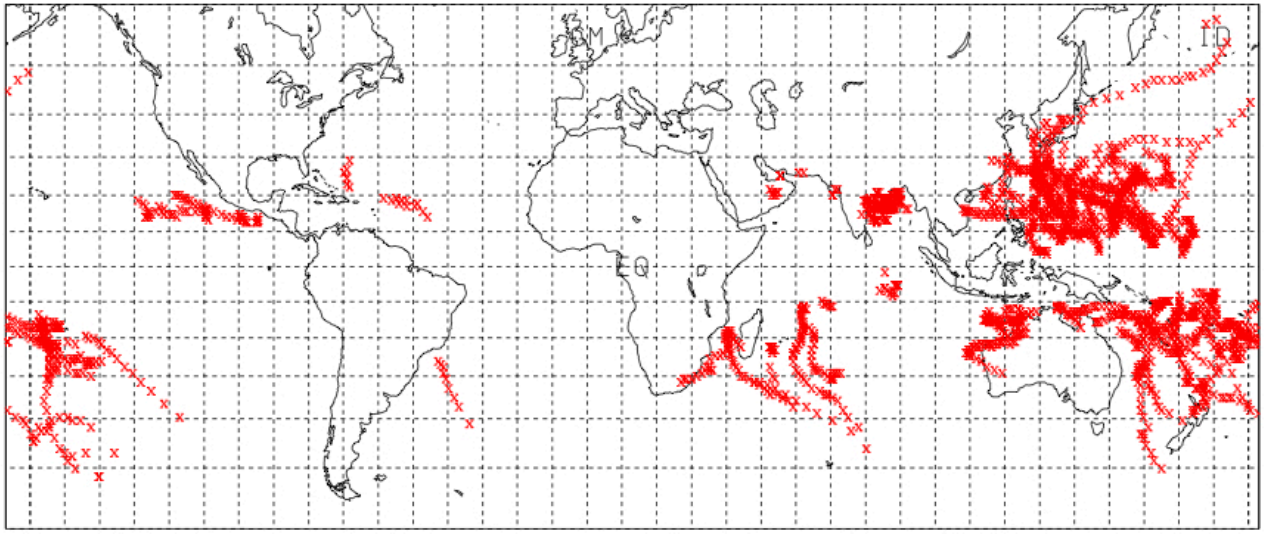
CSIRO tracking scheme – proposed modification



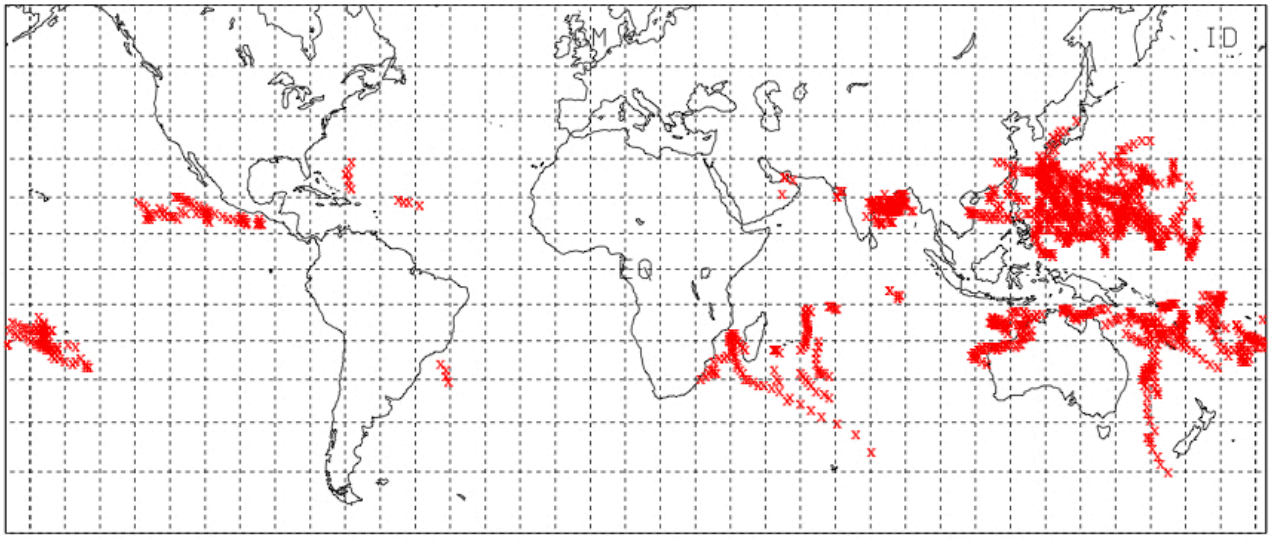
Latitudinal distribution of all detections for MRI Present Day experiment

- Same scheme as previously, with the following modifications:
  - warm-core temperature anomaly check is removed
  - distinguish TCs from extratropical cyclones based on the presence of TCs equatorwards of the extratropical ridge in each hemisphere
  - can this be used for a *very* different climate? NO. Not if TCs form well into midlats

Original CSIRO tracking scheme (applied to CMCC ECHAM5 1980)

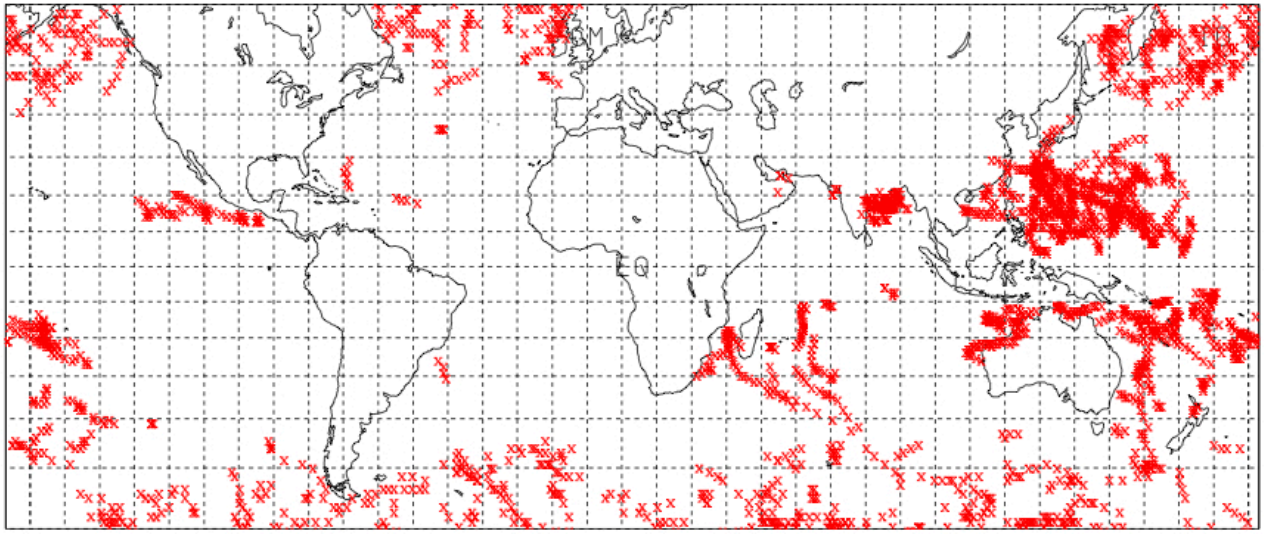


Relaxation of dynamical criteria removed



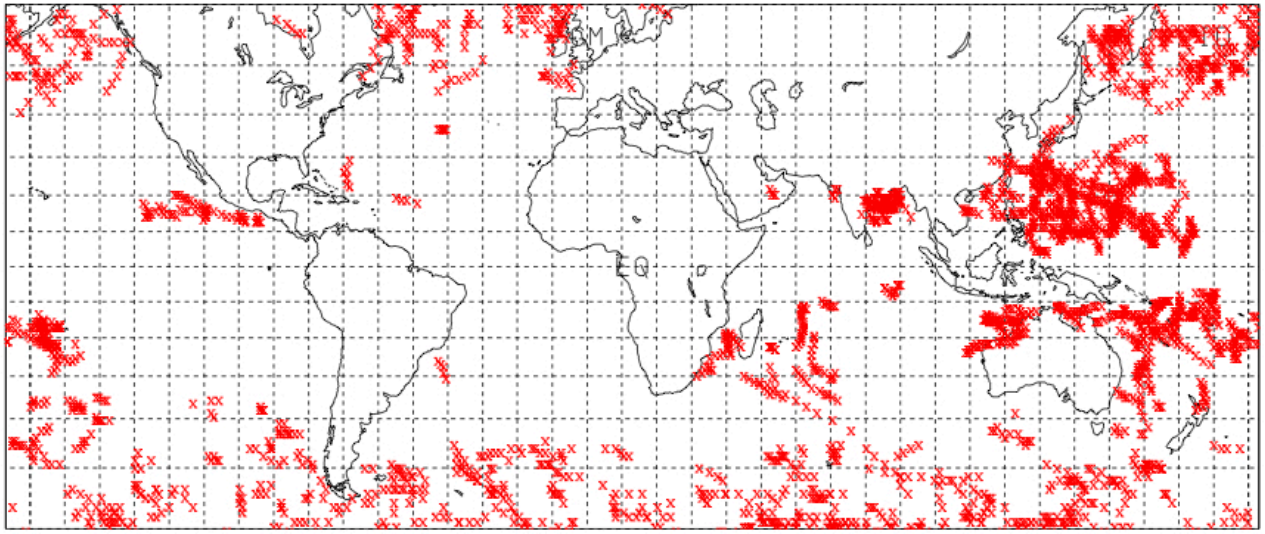
Latitude restriction removed

- Warm core criteria are not eliminating all extratropical detections.

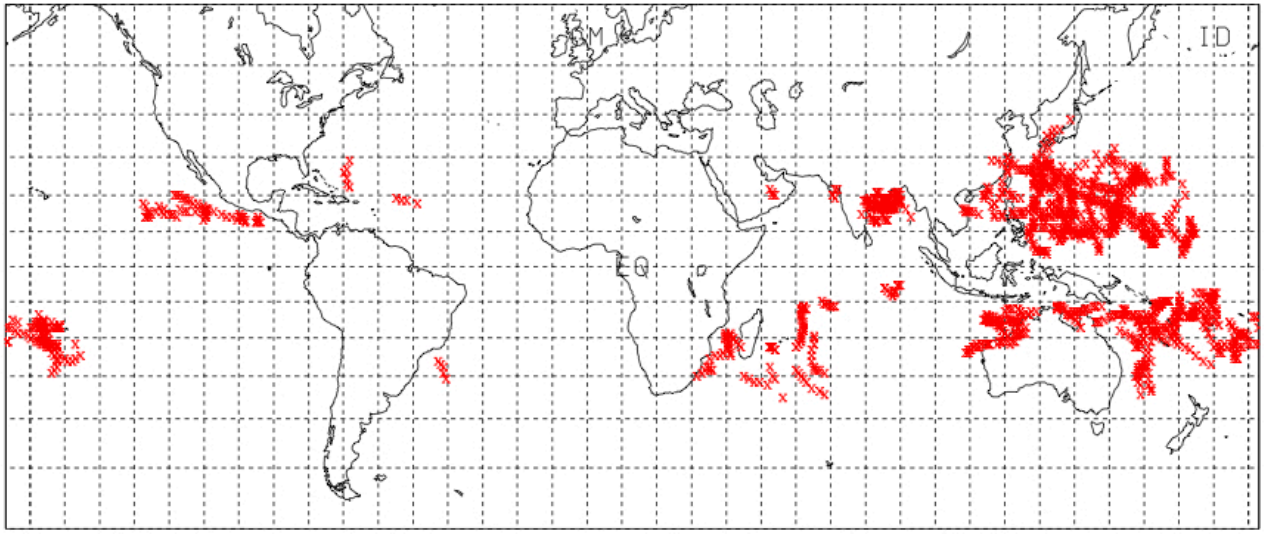


With temperature anomaly check removed

- Very little difference in tropical detections, substantial improvement in processing time

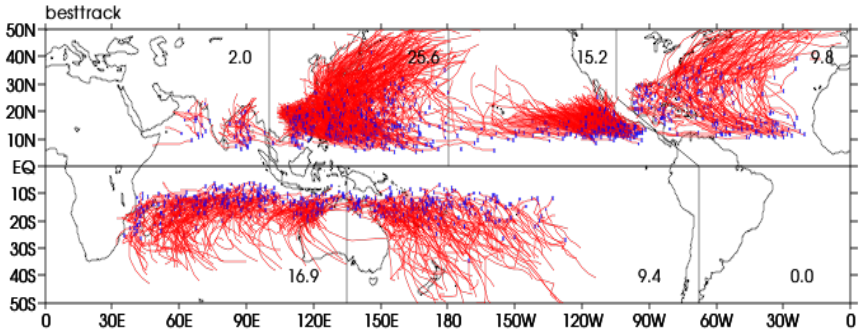


Imposing phenomenon-based latitude criterion

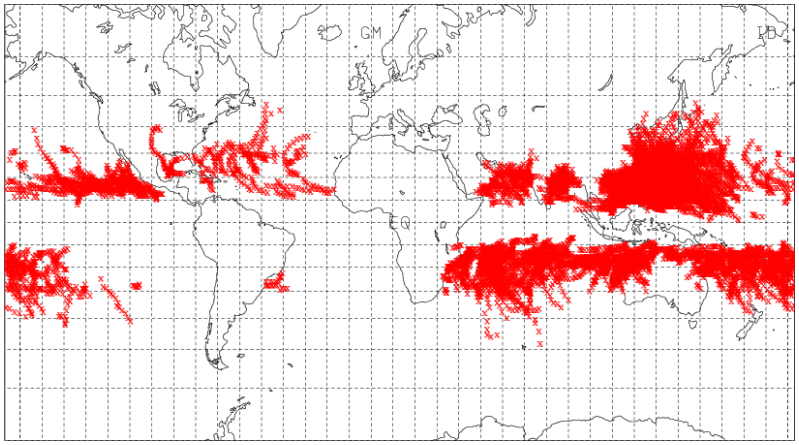


Models and HWG experiments analysed so far

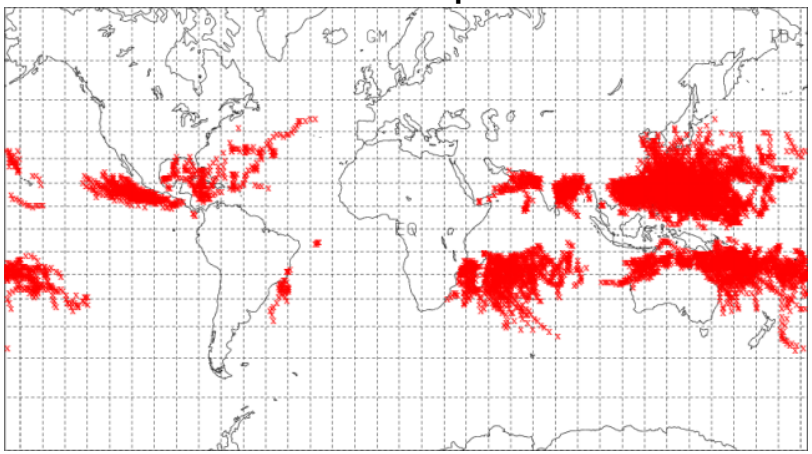
- Experiments
  - Present day SST, CO2
  - Uniform 2K added to SST, present day CO2
  - Present day SST, 2xCO2
  - 2K added to SST, 2xCO2
- Models
  - CMCC ECHAM5 T159 L31
  - NCEP GFS T126 L64
  - GISS 1 degree
  - MRI TL319 L64 (slightly different experimental methodology)



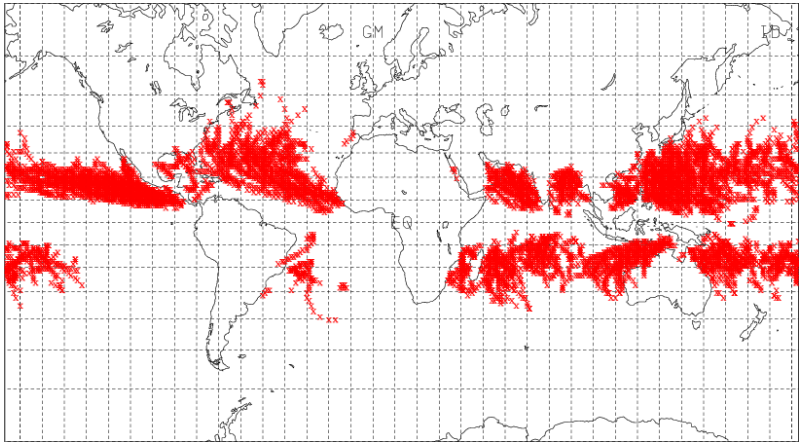
MRI amip

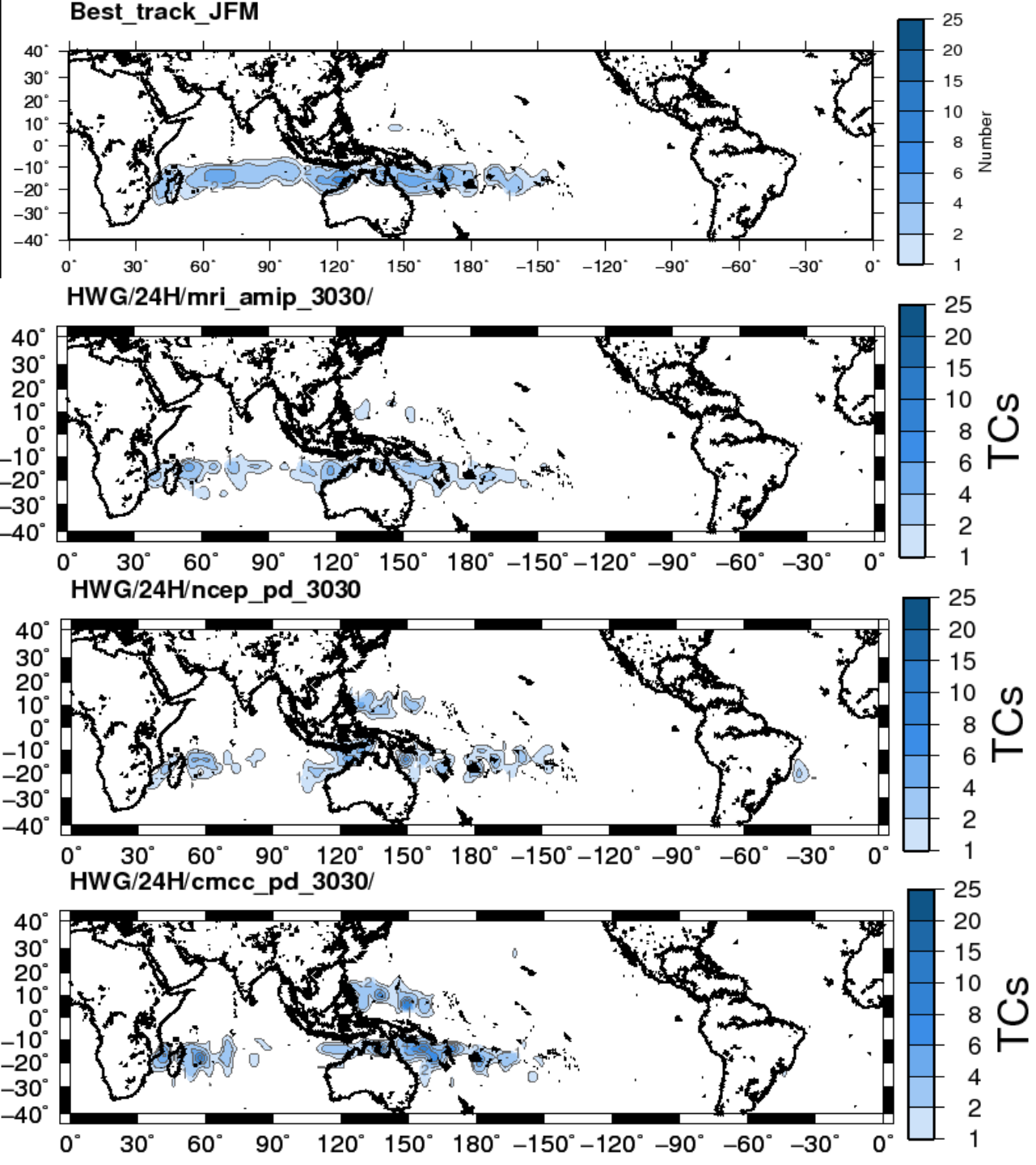


CMCC pd



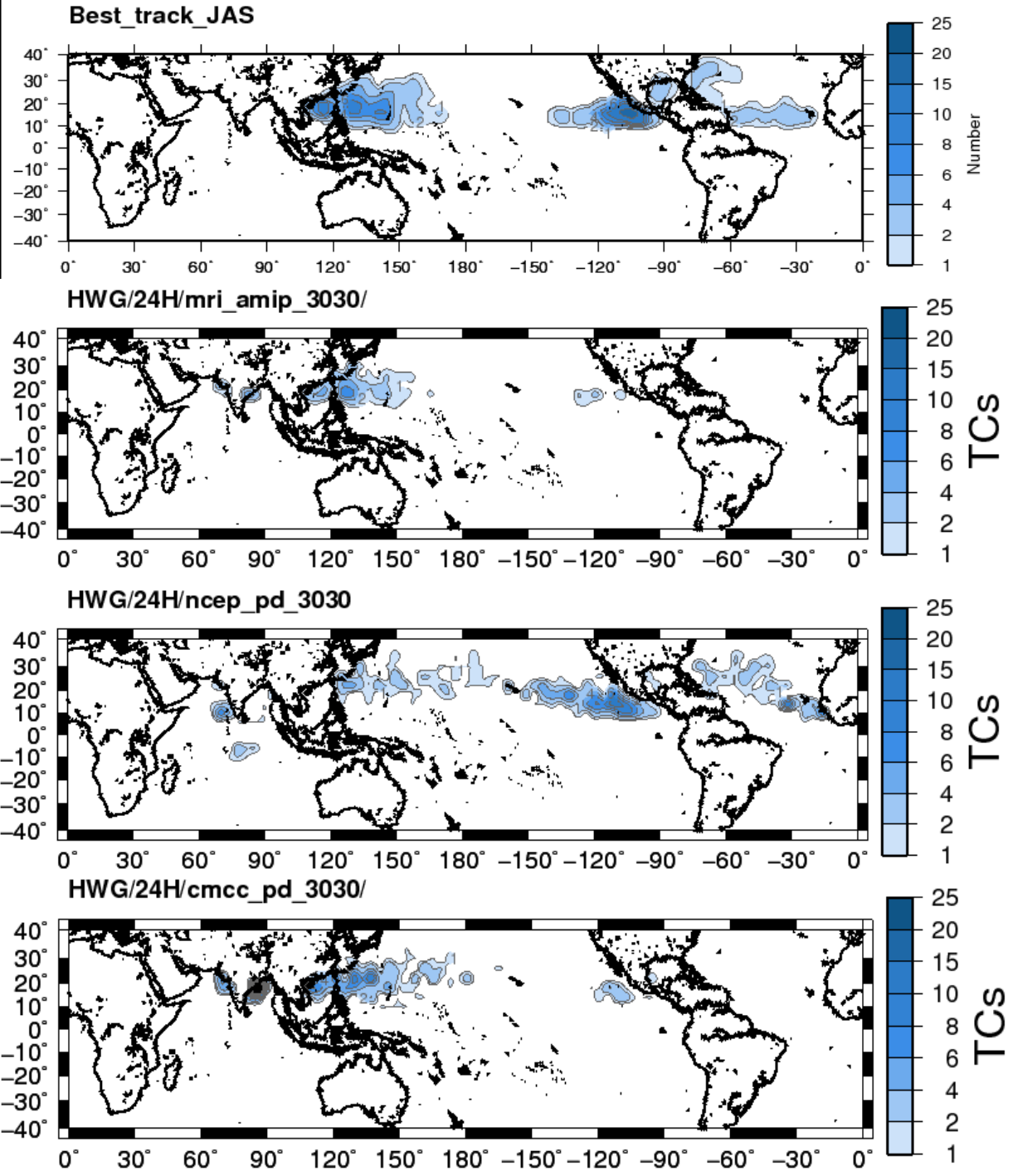
NCEP pd



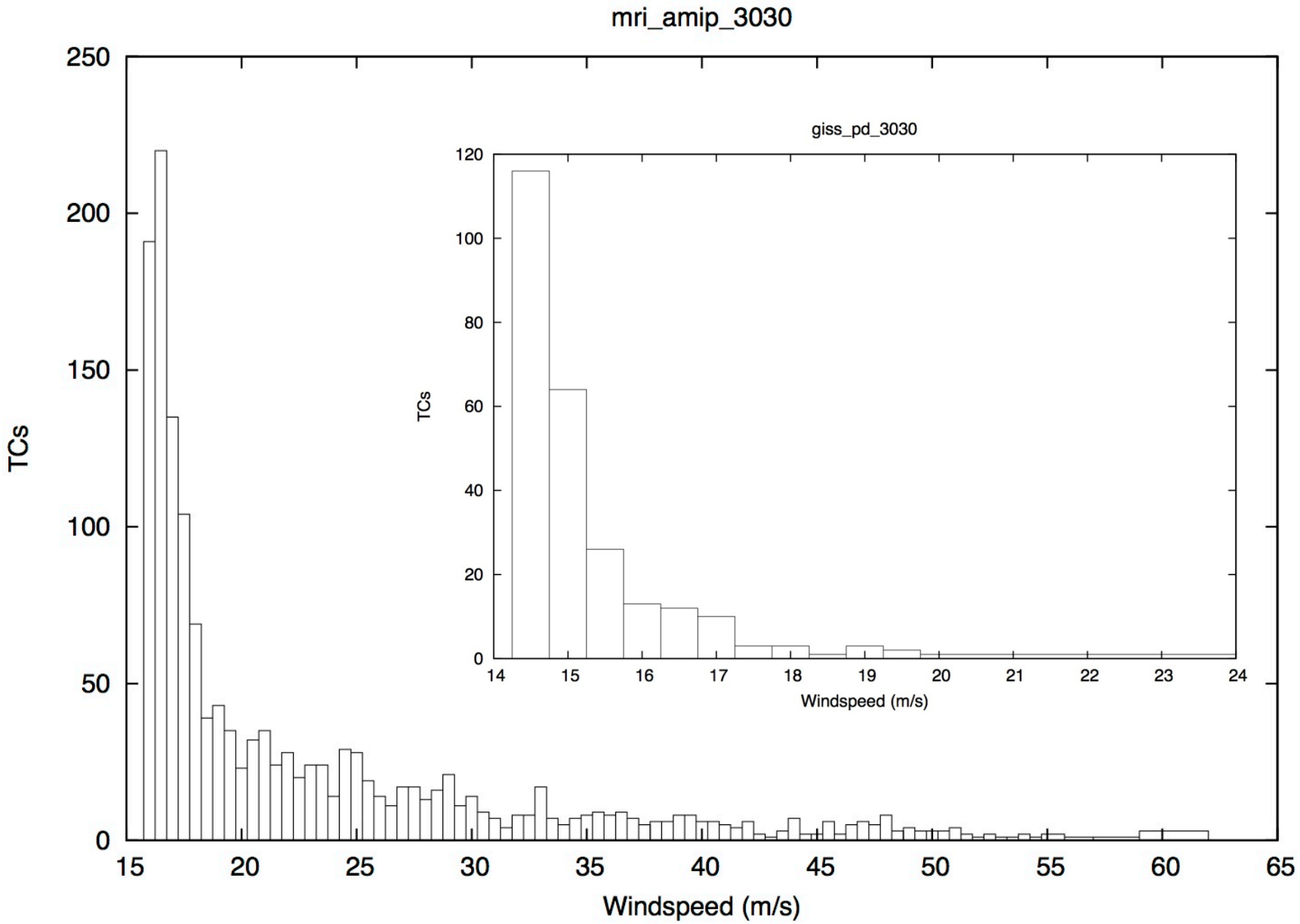


January to March TC genesis density per 4 degree box per 10 years, present day

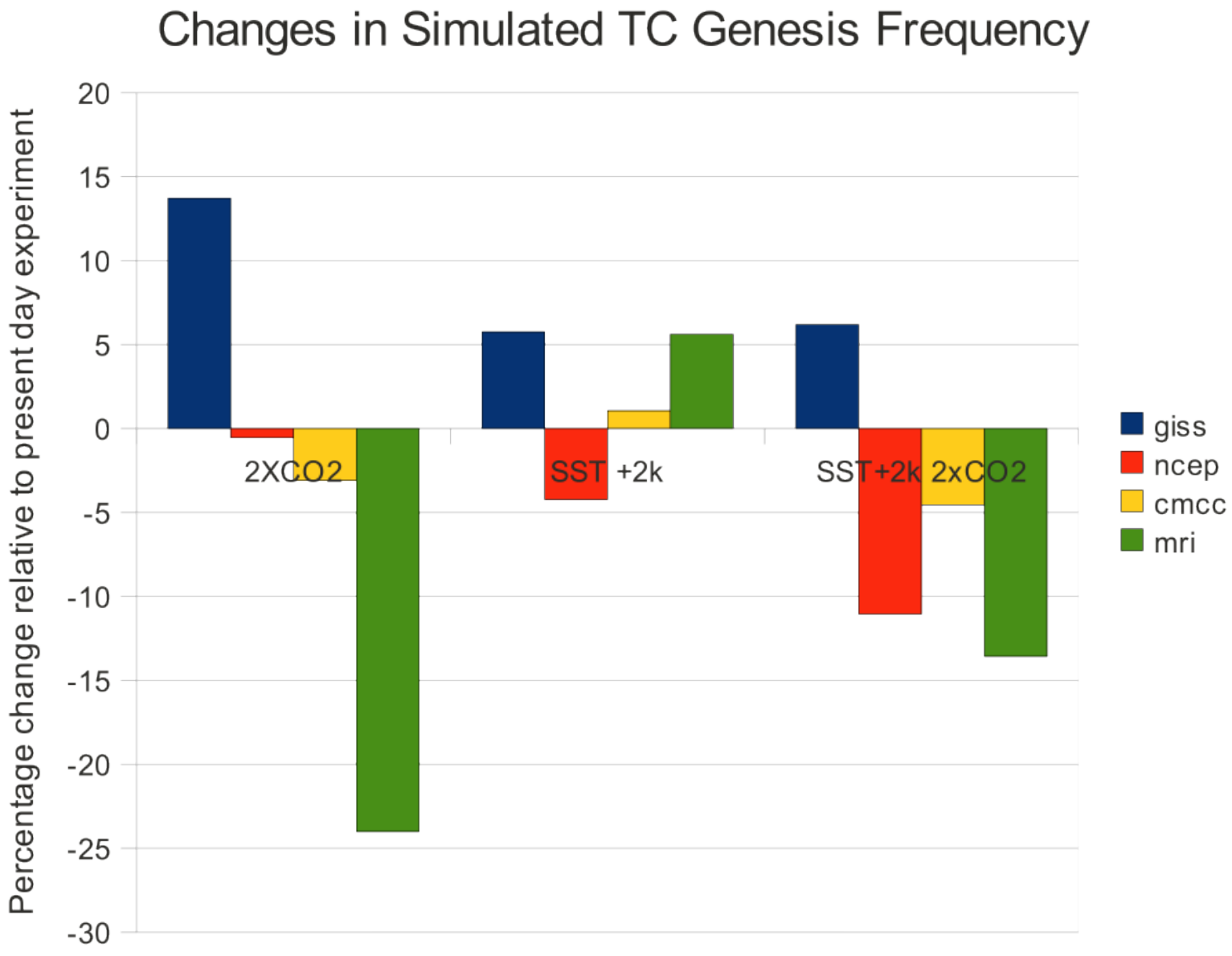
GISS numbers are low


Best_track_JAS
HWG/24H/mri_amip_3030/
HWG/24H/ncep_pd_3030
HWG/24H/cmcc_pd_3030/
Number
TCs
25
20
15
10
8
6
4
2
1
40°
30°
20°
10°
0°
−10°
−20°
−30°
−40°
0°
30°
60°
90°
120°
150°
180°
−150°
−120°
−90°
−60°
−30°
0°

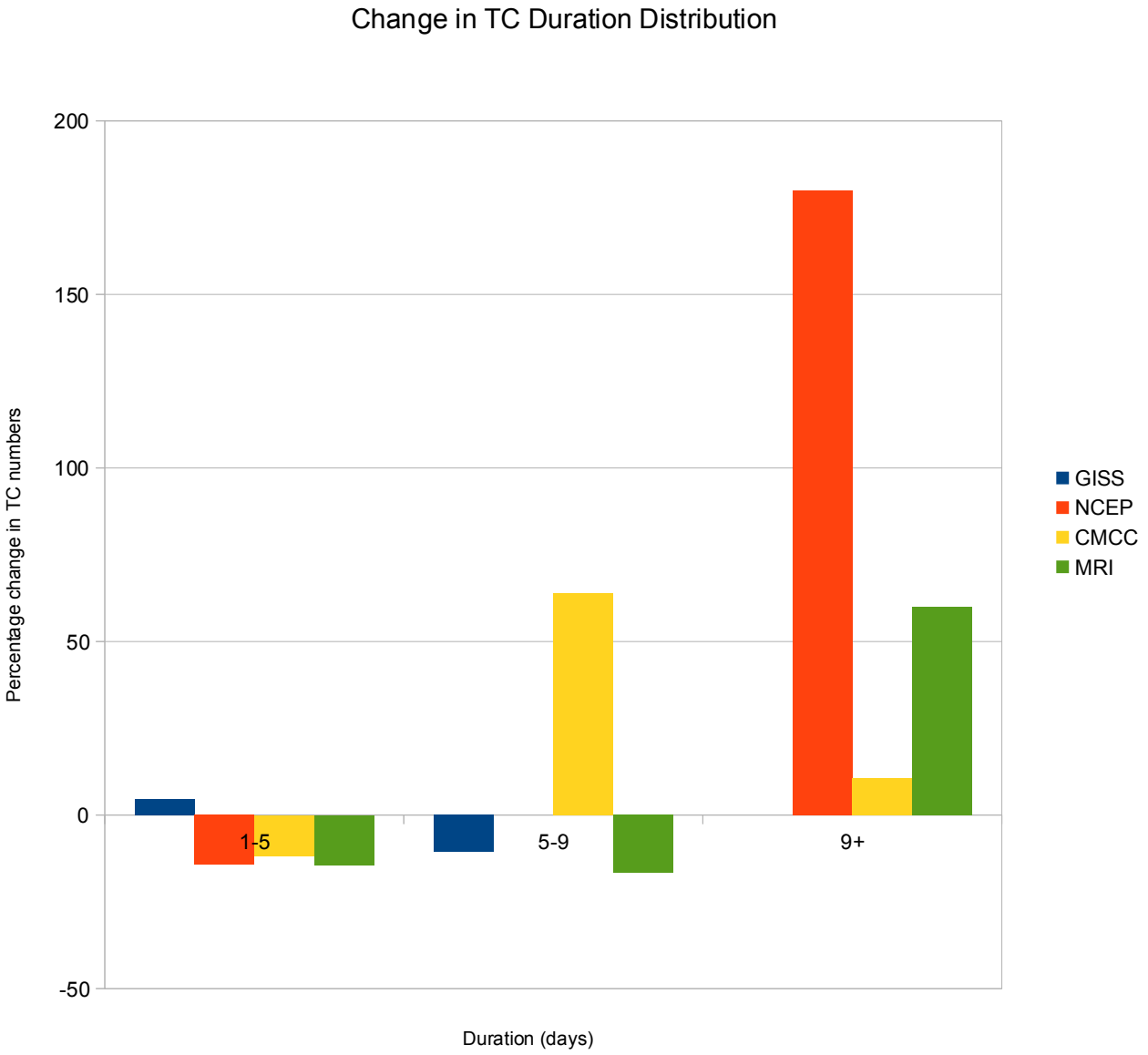
Same for JAS



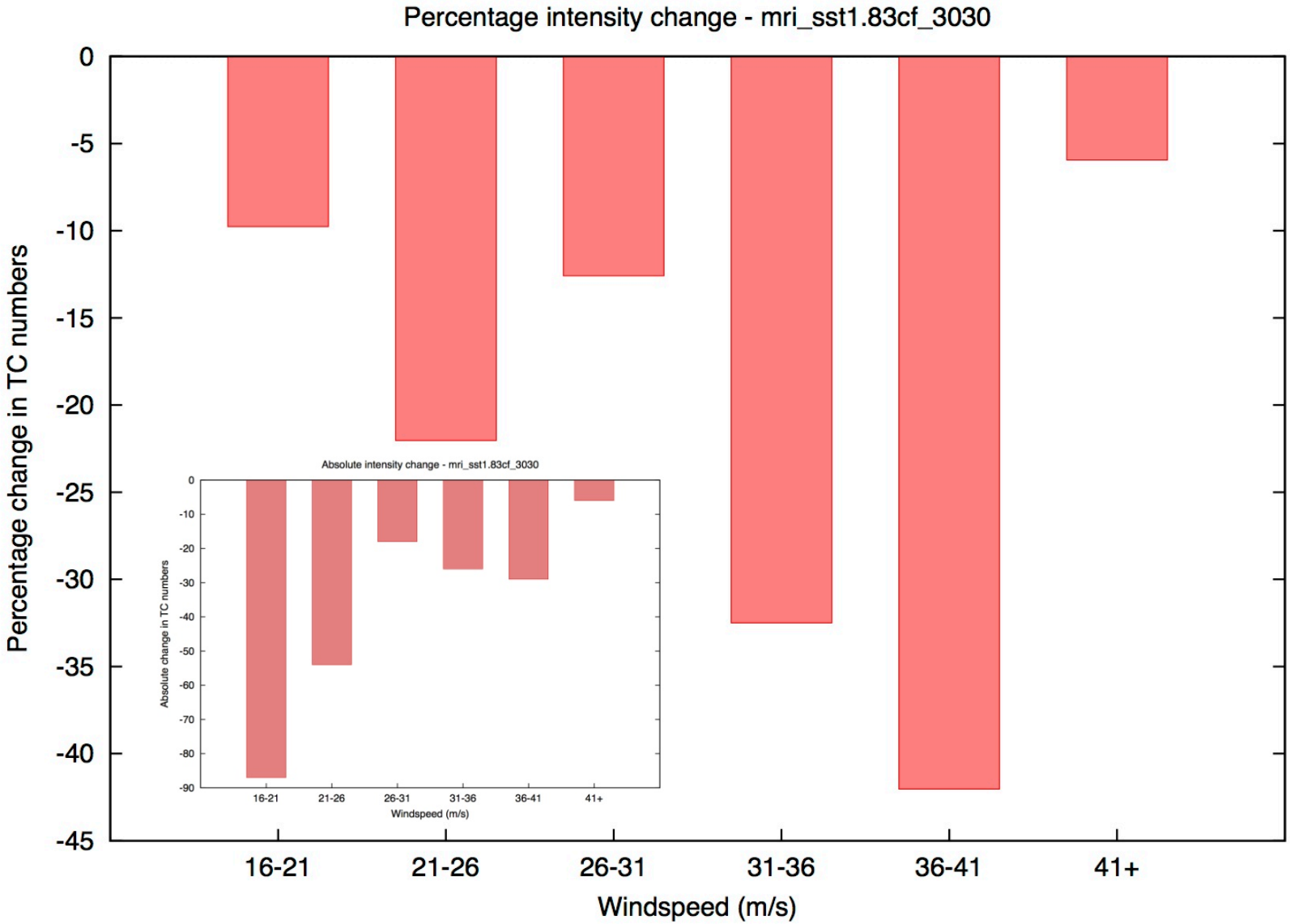
Simulated present day TC max windspeed distributions from the MRI (large) and GISS (inset) models



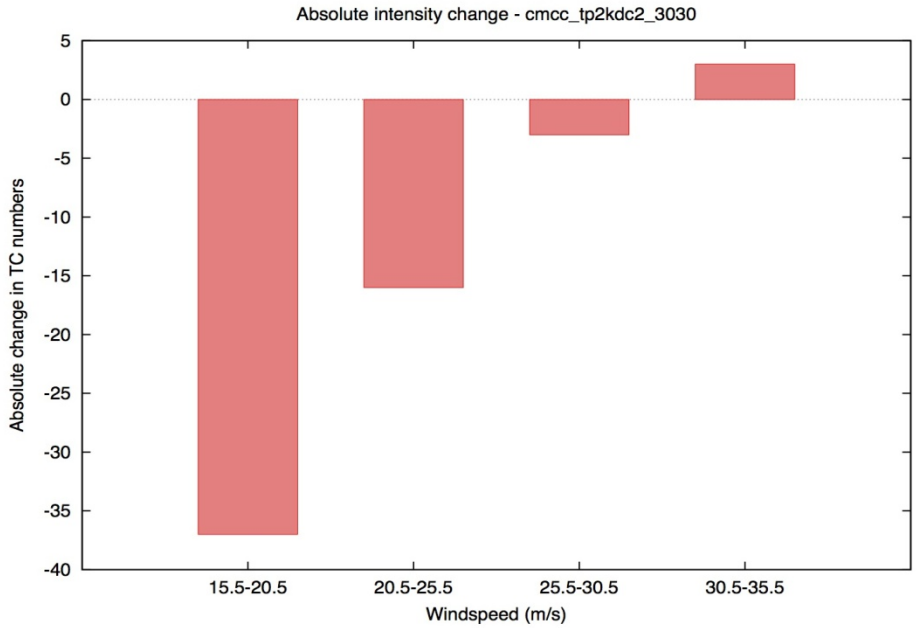
Percentage changes in TC numbers in the three altered climate experiments compared to the present day experiment for each model

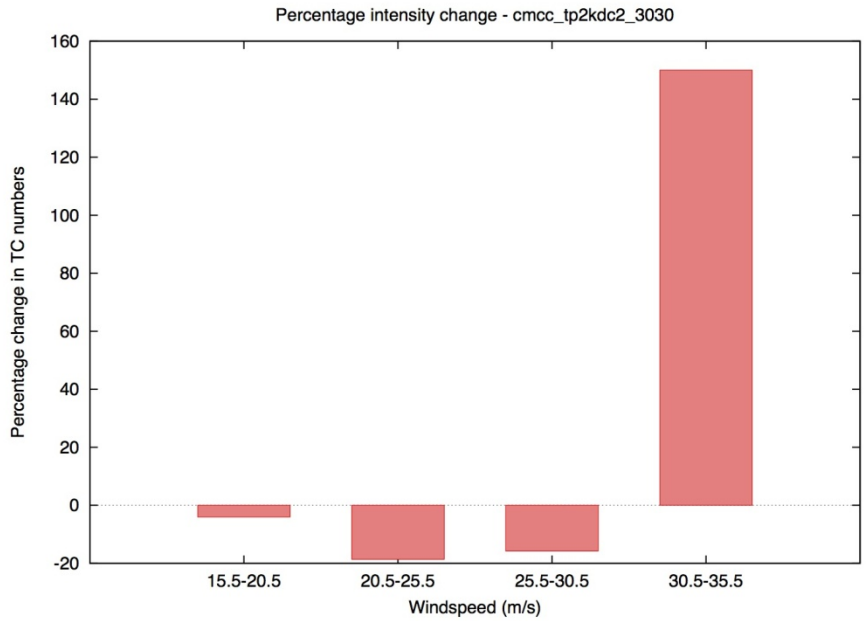


Changes in the duration distribution of TCs in the 2K SST increase plus CO2 increase experiment compared to the present day experiment for each model

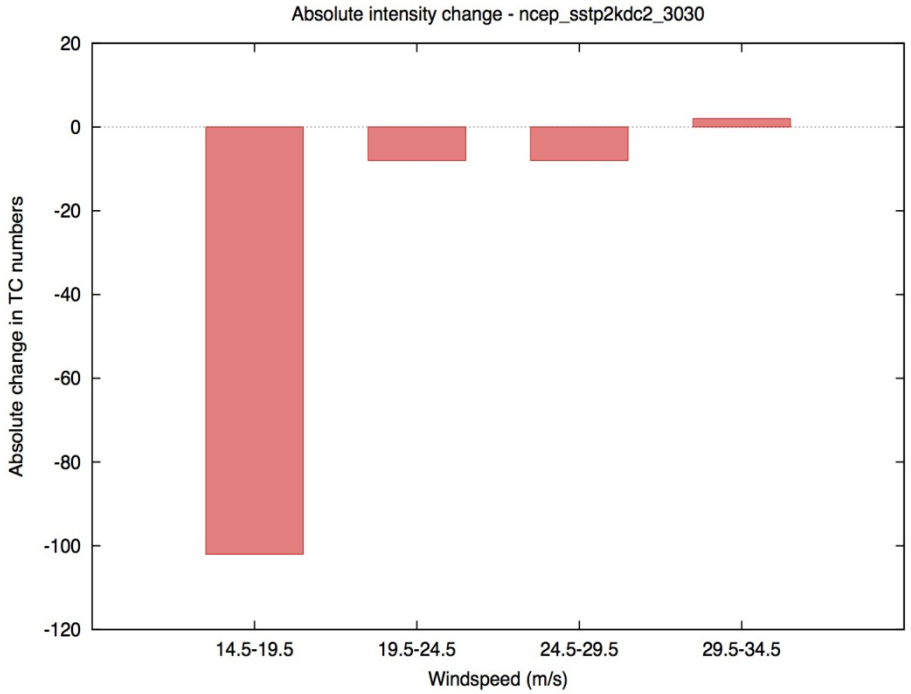


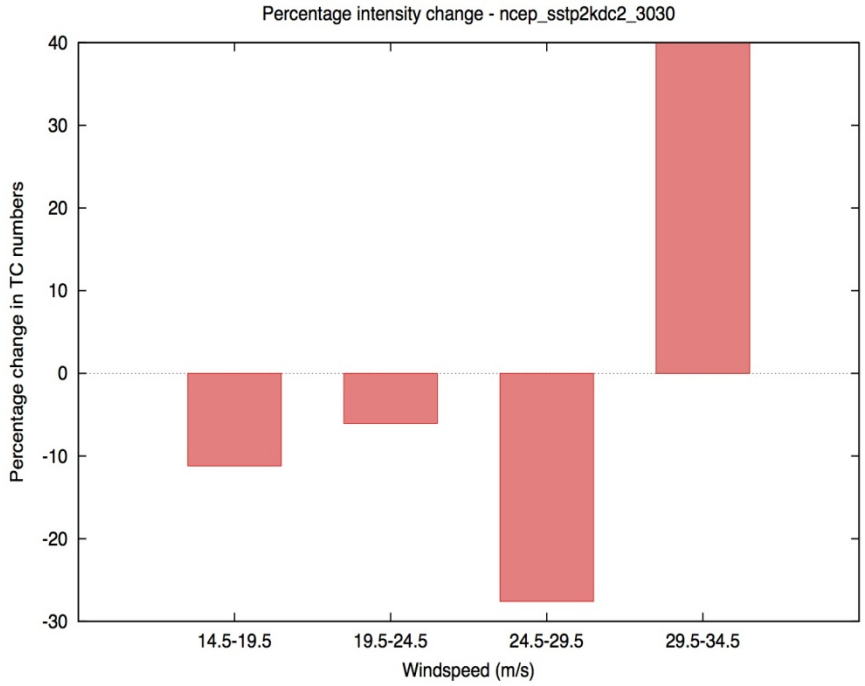
Percentage changes in the intensity distribution of TCs in the 2K SST increase plus CO2 increase experiment compared to the present day experiment for the MRI model; inset figure gives absolute changes



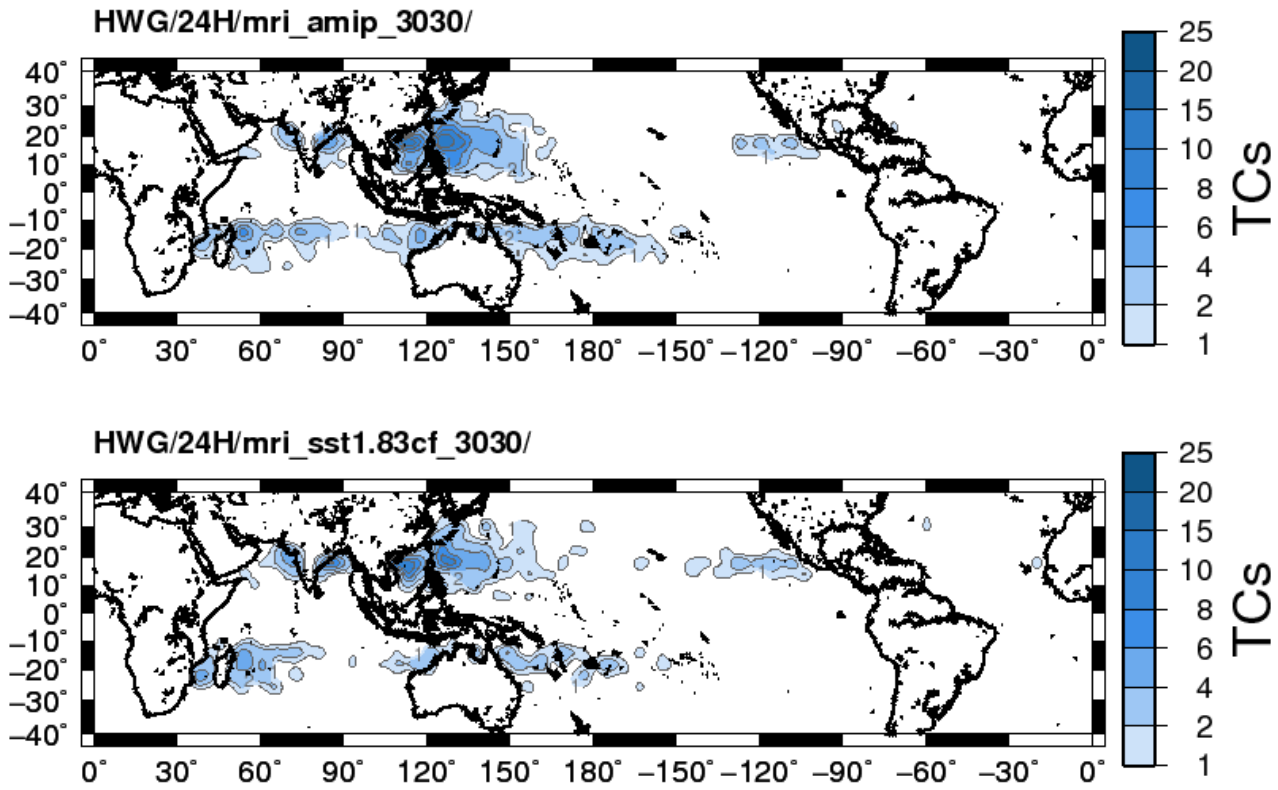


CMCC model changes in intensity distribution for 2K+2xCO2 experiment





NCEP model changes in intensity distribution for combined experiment



MRI TC genesis (per 4 degree box per 10 years) for the (present day) AMIP and future 2K+2CO2 experiments

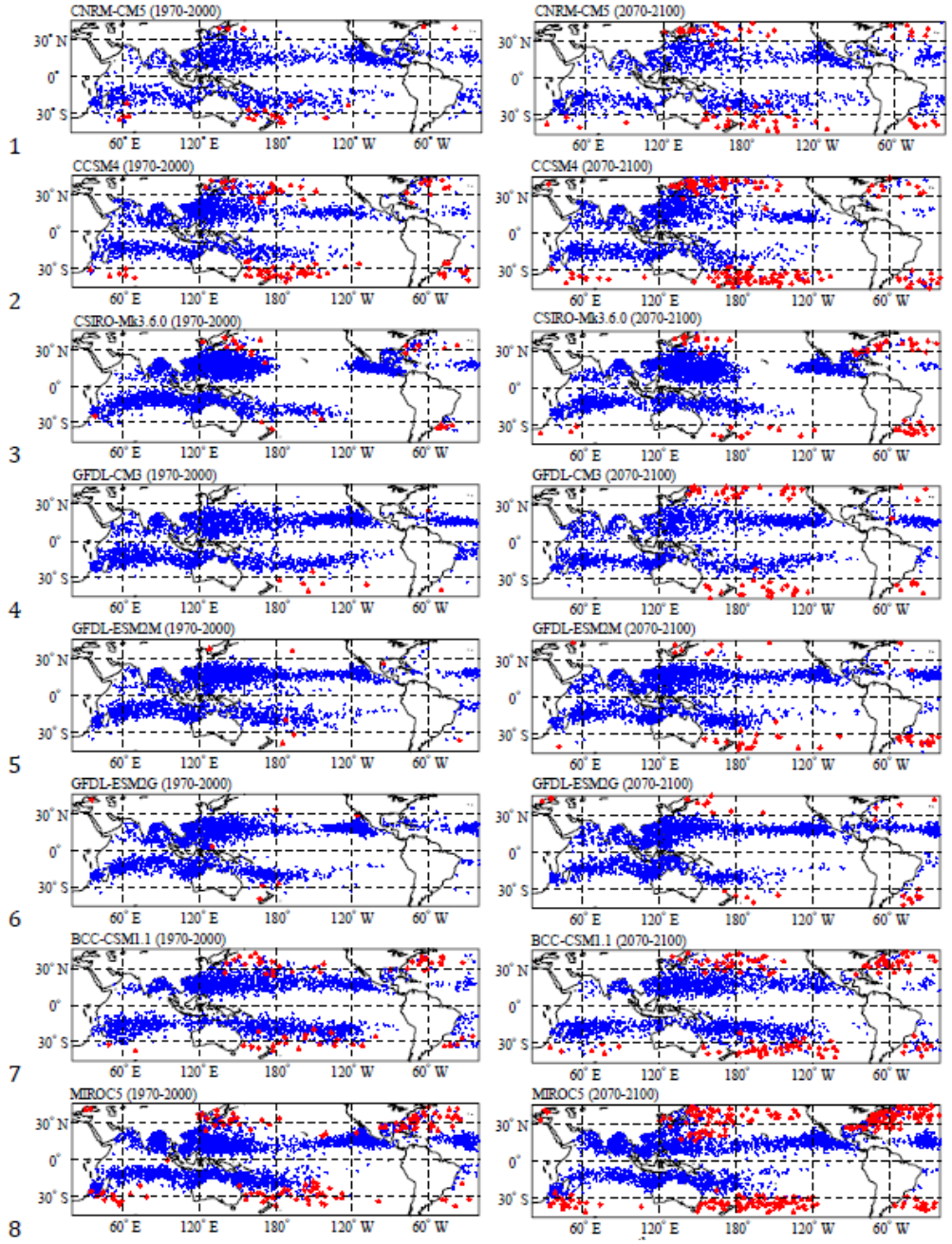
HWG (or similar exp.) TC genesis tracking comparison (this workshop)

Tracking	*Model*	*2K*	*2xCO2*	*2k2xCO2*
Hodges	HadGEM3 N230			
Oouchi	NICAM 14km			
Shaevitz	CAM5.1			
	CMCC ECHAM5			
	FSU COAPS			
	GEOS-5			
	GFDL C180AM2			
	GISS			
	NCEP GFS			
Zhao	GFDL HIRAM			
	GFDL C180AM2			
	CMCC ECHAM5			
	NCEP GFS			
	GEOS-5			
	GISS			
	CAM5.1			
	FSU COAPS			
Horn	GISS			
	NCEP GFS			
	CMCC ECHAM5			
	MRI			

Red: decrease
Blue: no change
Green: increase
White: no data

Another possible approach

- "Marsupial pouch" detector (Dunkerton et al 2009 Atmos Chem Phys)
  - Formation of a closed protective circulation as a prerequisite for tropical cyclone formation
- Detection scheme based on identification of closed circulation feature (Tory et al. 2013 submitted to J Climate)



CMIP5 models (those within 50% of observed numbers)
Blue: TCs
Red: subtropical storms

Tory et al. (2013) submitted to J Climate

HWG data – next steps

- Can we determine why the model results differ among each other for the same forcing?
- Can we determine why individual model results differ for different forcing?
- Can we use this analysis to inform a quantitative theory of tropical cyclone formation?

Summary

- Slightly modified version of CSIRO tracking scheme
  - runs much faster with no decrease in skill
  - needs fewer input variables
  - more scientifically justifiable latitude limits
- The direction of changes in TC numbers for a particular experiment in a model is not profoundly altered by using a different tracking scheme
  - Need to examine more quantitatively
- Summary of TC genesis changes in experiments:
  - 2K: combination of increases and decreases
  - 2CO2: mostly decreases
  - combined: mostly decreases (with one or two exceptions, those with a strong +ve response to 2K)