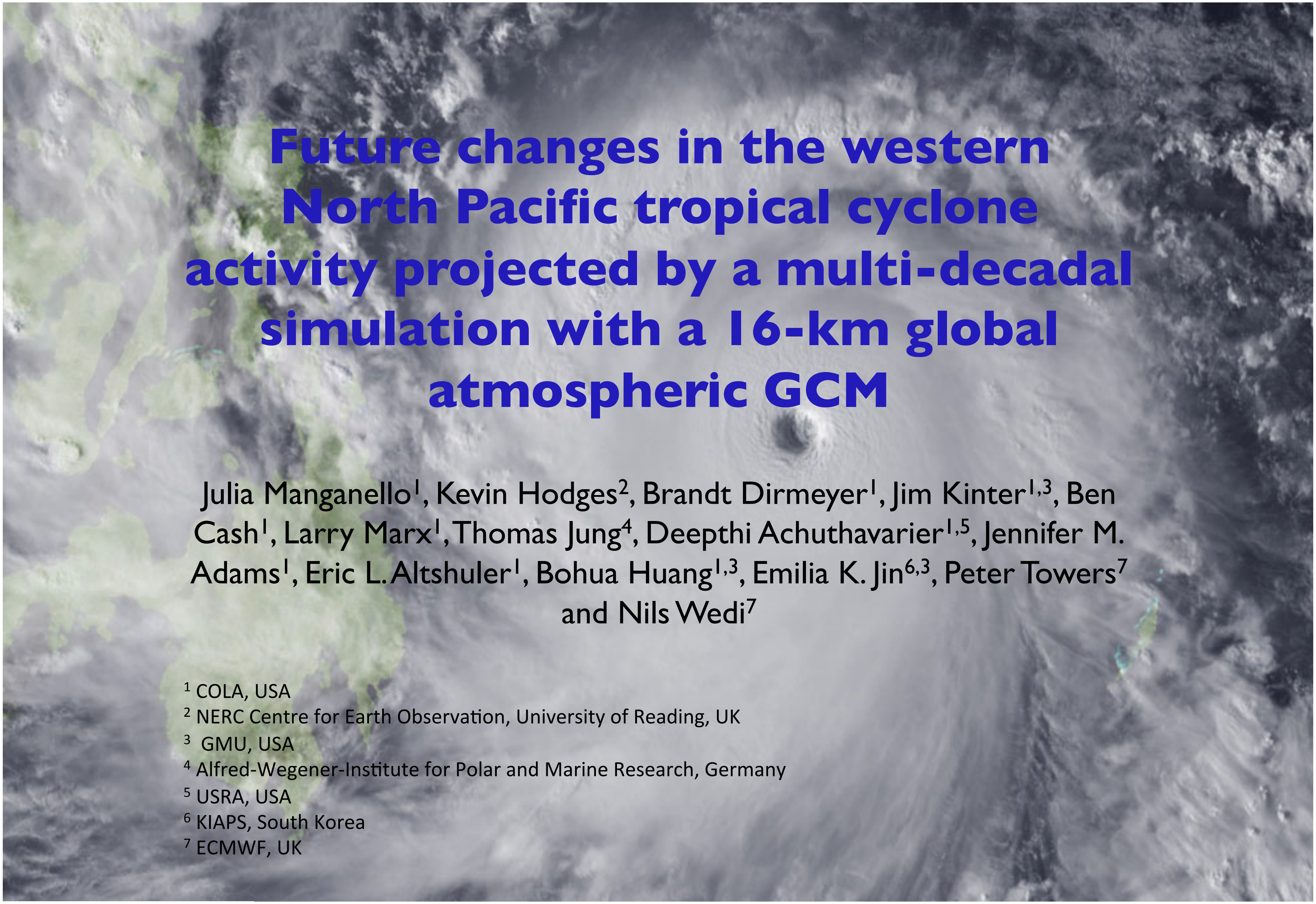

Future changes in the western North Pacific tropical cyclone activity projected by a multi-decadal simulation with a 16-km global atmospheric GCM

Julia Manganello[1], Kevin Hodges[2], Brandt Dirmeyer[1], Jim Kinter[1,3], Ben Cash[1], Larry Marx[1], Thomas Jung[4], Deepthi Achuthavarier[1,5], Jennifer M. Adams[1], Eric L. Altshuler[1], Bohua Huang[1,3], Emilia K. Jin[6,3], Peter Towers[7] and Nils Wedi[7]

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COLA Center for Ocean-Land-Atmosphere Studies

ECMWF IFS Experiments (Project Athena)

Experiment	Model	Resolution	# of Cases	Years	Length
AMIP	T1279	16 km	1	1960-2007	47 years
	T159	125 km			
Time-slice (TS)	T1279	16 km	1	2070-2017	47 years
	T159	125 km			

- Integrated Forecast System (IFS) is an operational weather forecast model.
- 91 levels in the vertical.
- Uses hydrostatic approximation and parameterized convection.

- **SST and sea ice:**
  AMIP: same 1.125° used for the ERA-40 reanalysis (monthly – before 1990; weekly – starting 1990; daily – starting 2002).
  TS: differences in the annual cycle between 2065-2075 and 1965-1975 from the IPCC AR4 CCSM3.0 are added to the 1960-2007 observed record. GHG concentrations in IFS follow IPCC A1B.

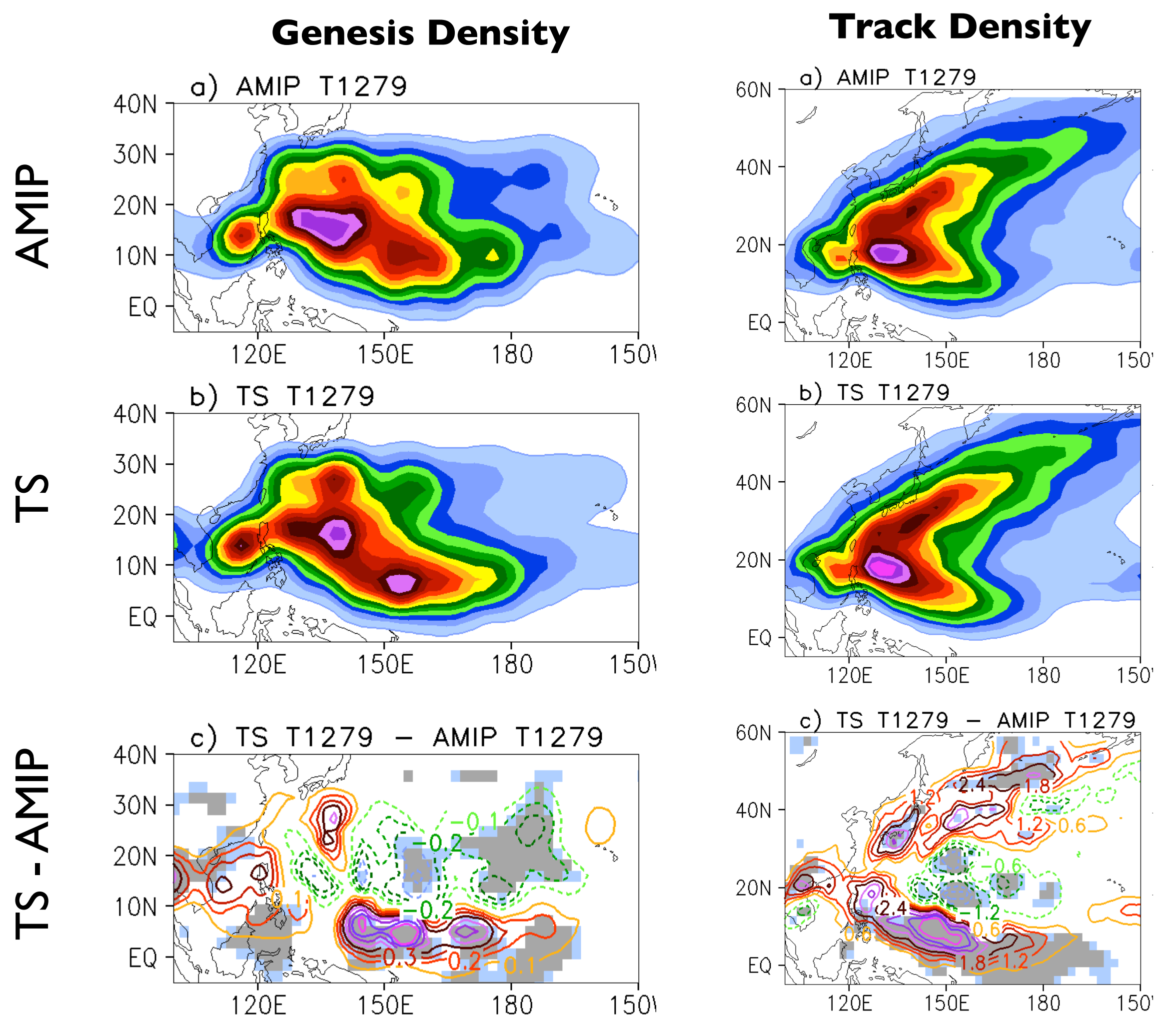
Projected changes: TC frequency, intensity and the PDI

	TS - AMIP (T1279)		
	Tropical Storm	CAT 1-2	CAT 3-5
Total TC frequency, counts per season	+2.2 (+7%)		
TC frequency per storm category	**-2.4** (-12%)	**+1.3** (+17%)	**+ 3.3** (+70%)
Power Dissipation Index, *1.e11 m^3/s^2	**+1.8** (+51%)		
Mean Peak Intensity, m/s	**+3.4** (+12%)		
Mean Lifetime, days	+0.02 (+0.1%)		

- for MJJASON season, based on 47 years of data
- Values in **bold** are statistically significant at the 95% confidence level.

Manganello et al. (2014), J. Climate, accepted (cond.)

Projected changes: genesis and tracks

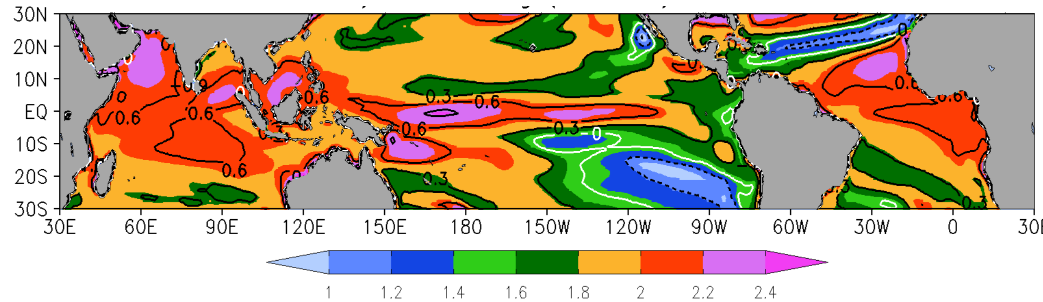


Shading shows differences that are statistically significant using a permutation Monte Carlo approach (Hodges 2008).

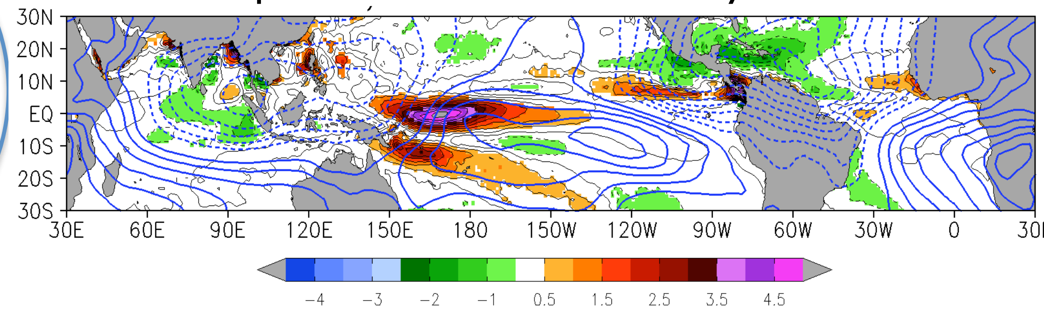
Projected changes: environmental influences

TS – AMIP (T1279)

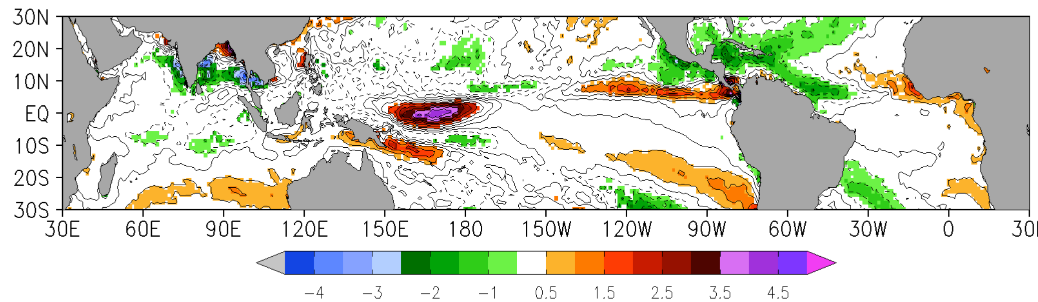
Sea Surface Temperature



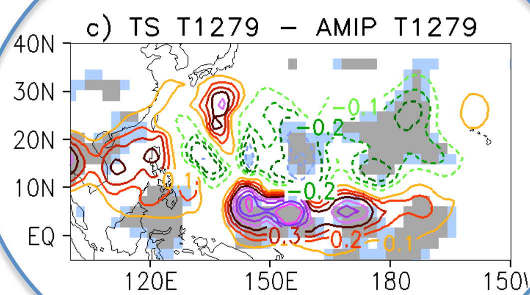
Precipitation and 850-hPa Velocity Potential



Negative of 500-hPa Omega



Genesis Density

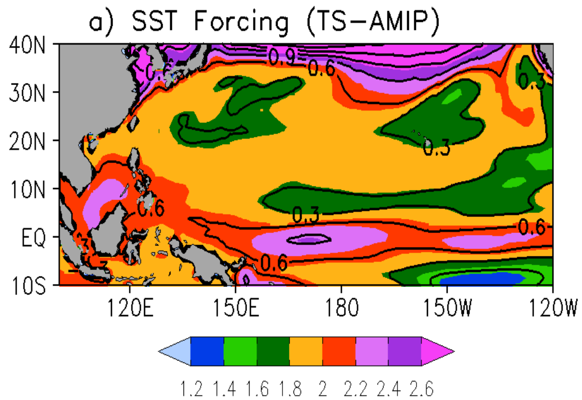


MJJASON means

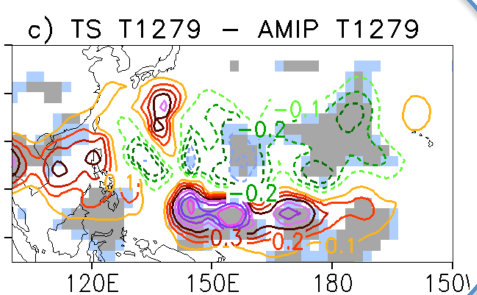
Shading denotes changes that are statistically significant at the 95% confidence level.

Projected changes: environmental influences, cont.

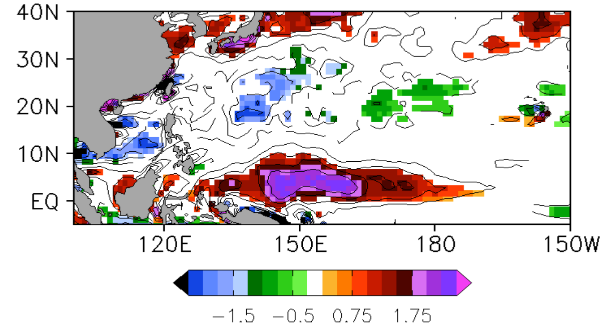
TS – AMIP (T1279)



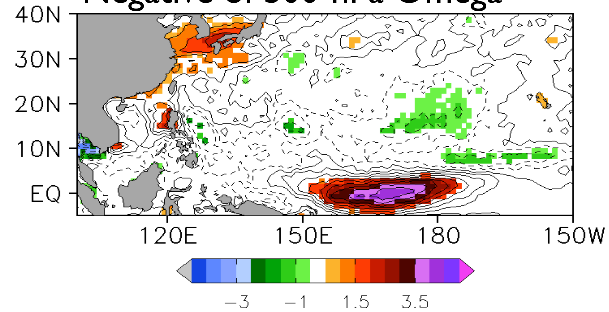
Genesis Density



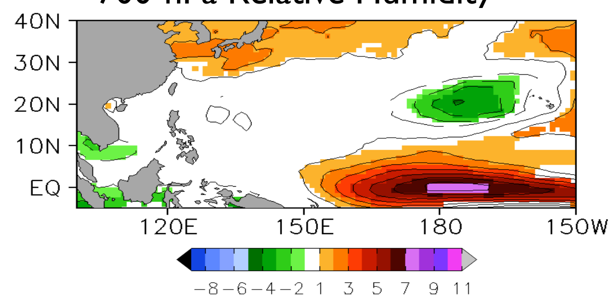
850-hPa Relative Vorticity



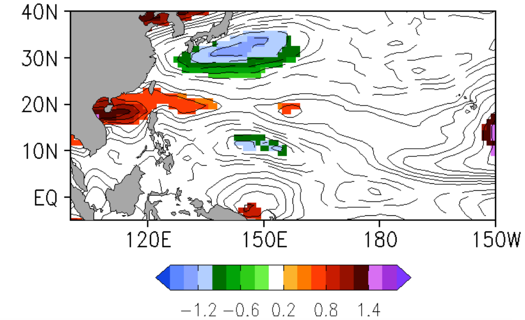
Negative of 500-hPa Omega



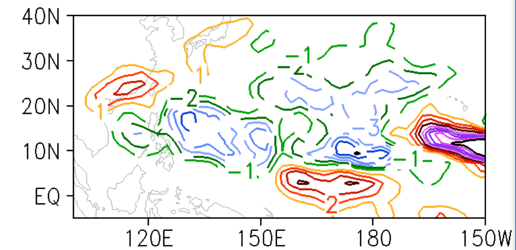
700-hPa Relative Humidity



Vertical Wind Shear



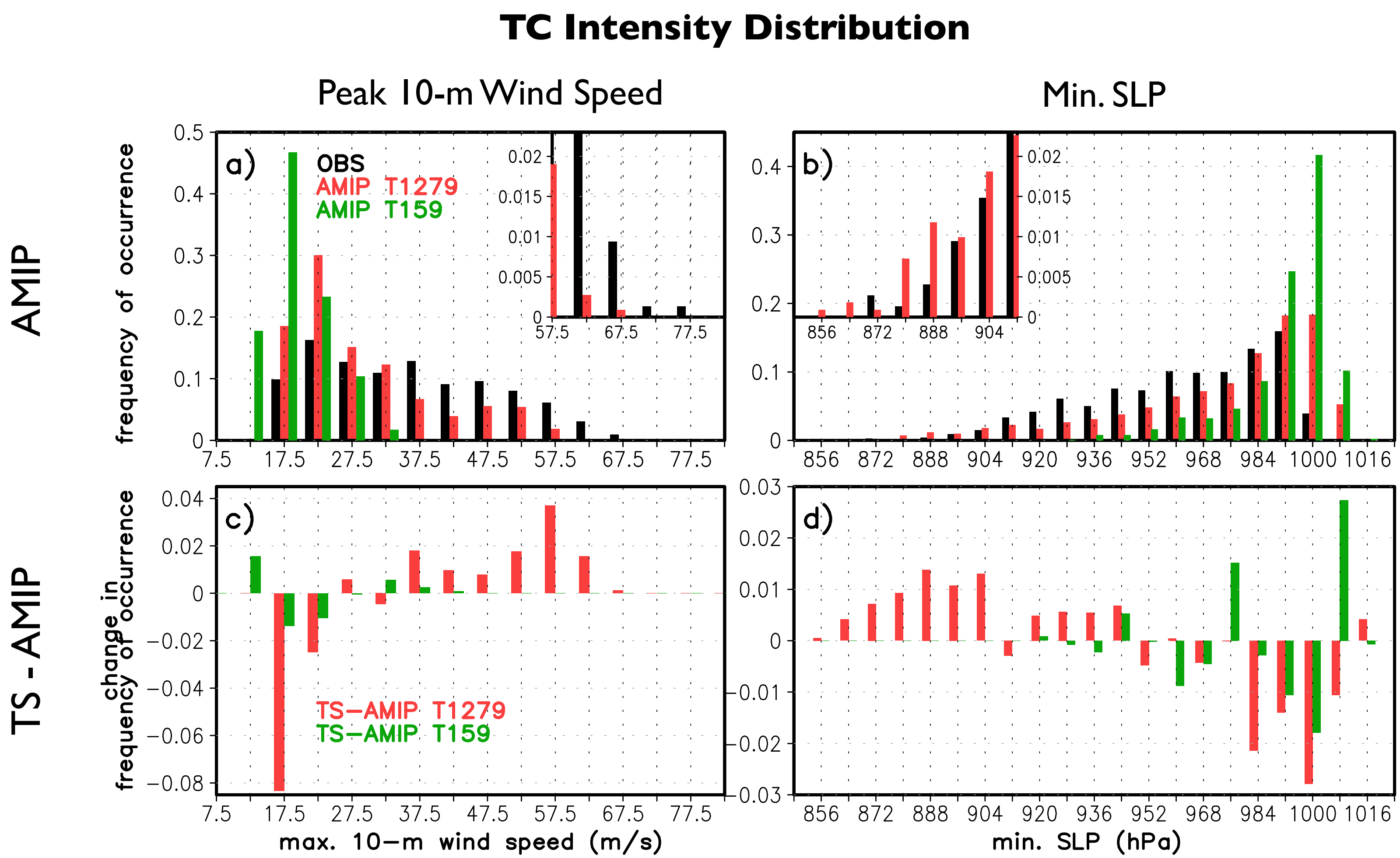
Track Density of the Synoptic-Scale Tropical Disturbances



MJJASON means

Shading denotes changes that are statistically significant at the 95% confidence level.

Projected changes: TC intensity



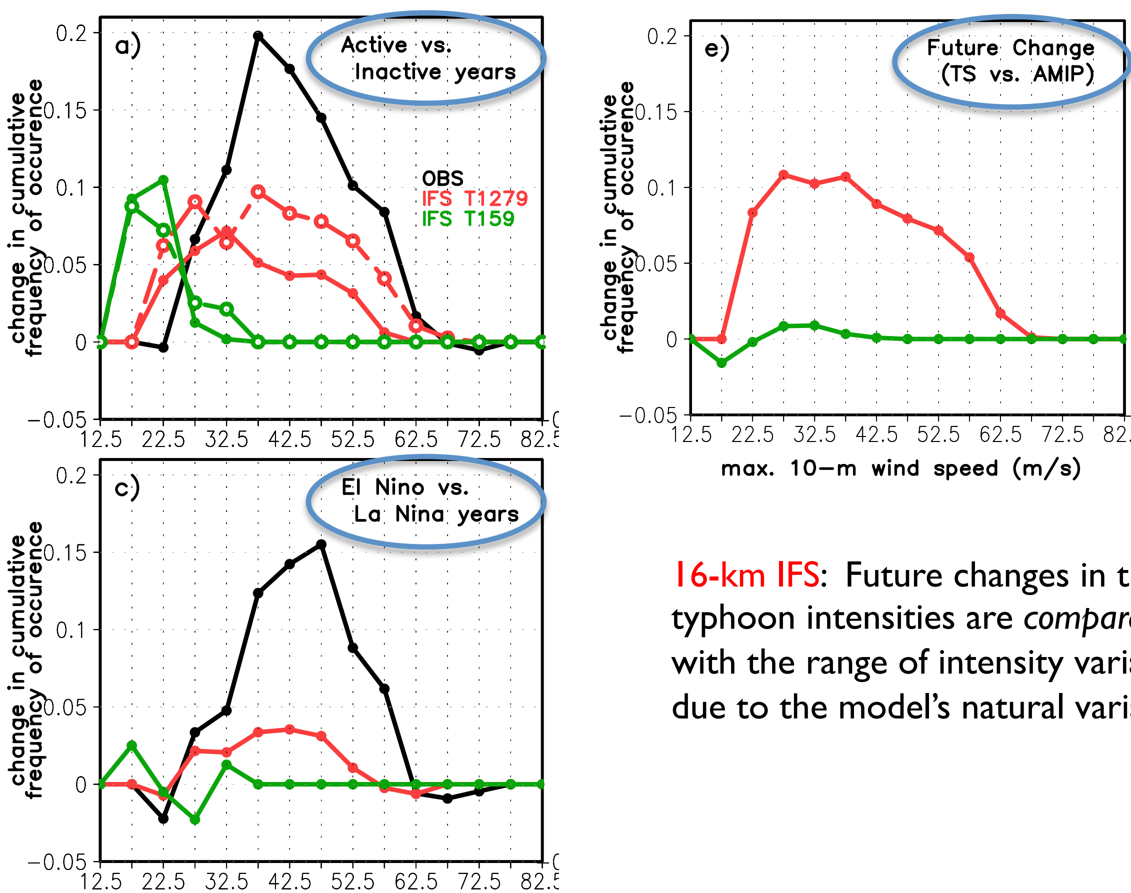
Projected changes: TC intensity, cont.

Changes in the Cumulative Distribution of the TC Intensity

Based on the OBS

Based on the MODEL

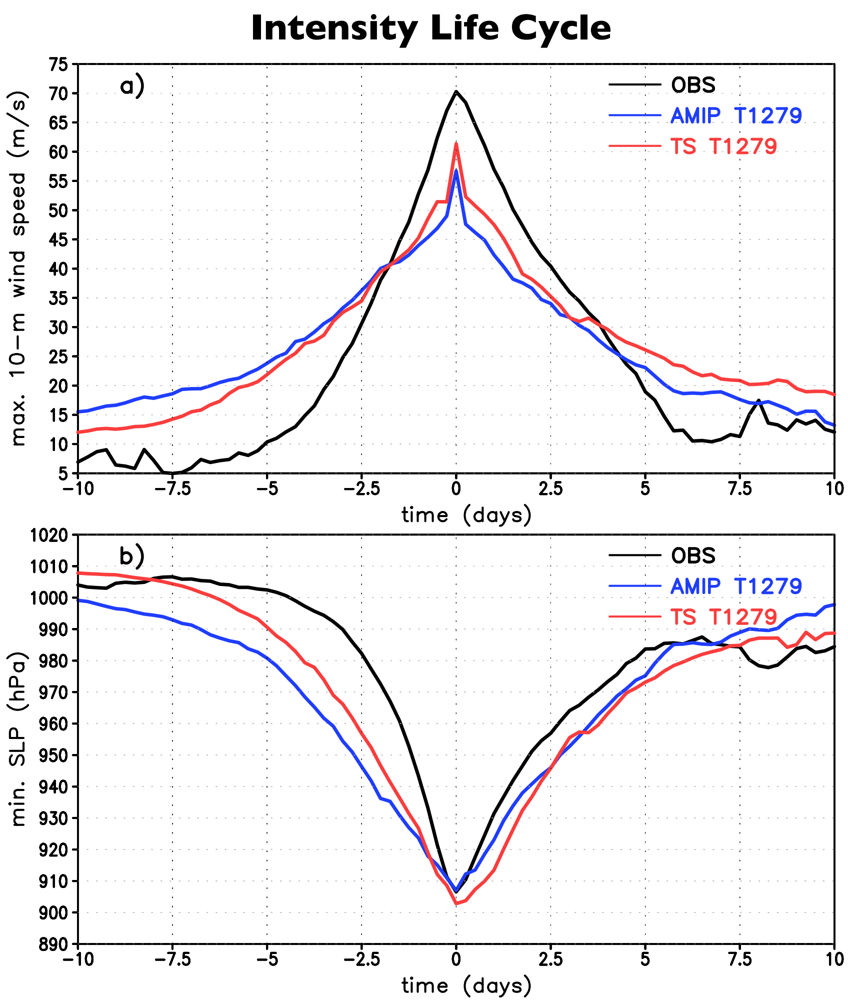
OBS
IFS T1279
IFS T159



16-km IFS: Future changes in the typhoon intensities are *comparable* with the range of intensity variations due to the model's natural variability.

Projected changes: composite analysis

AMIP T1279
TS T1279

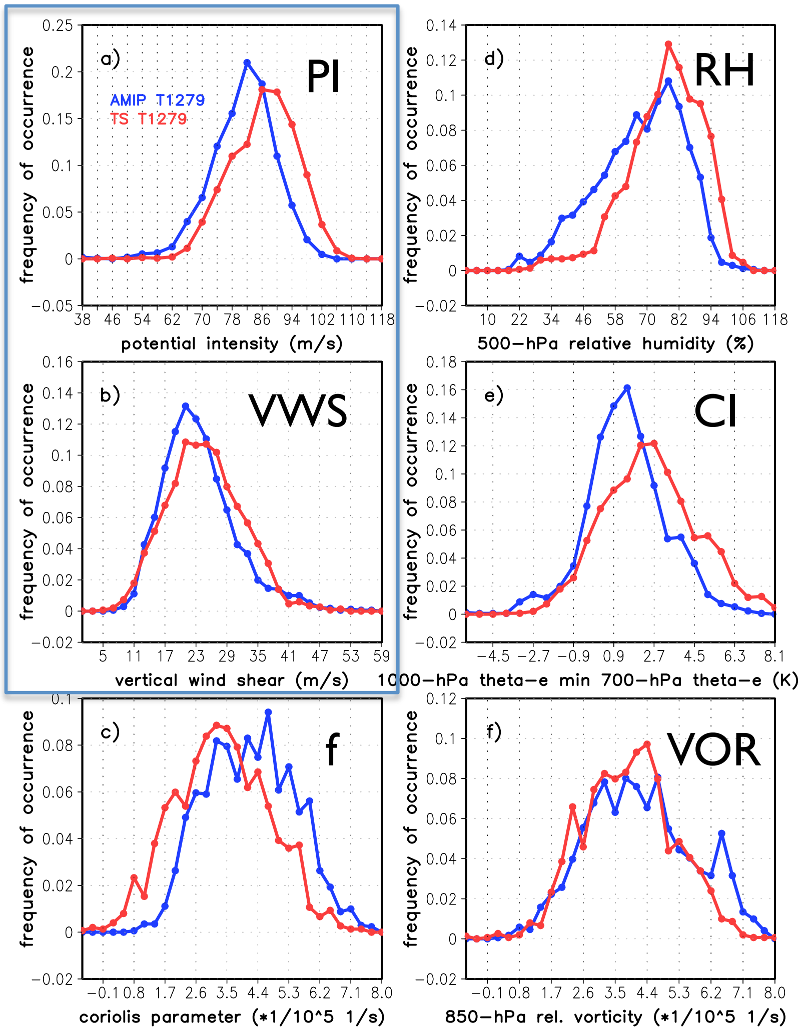


Super-typhoon Composites

	OBS	AMIP T1279	TS T1279
# of storms	48	47	47
Max. 10-m wind speed, m/s	>=65.0 or CAT 5	>= 54.0 or CAT 4	>=58.5 or CAT 4
Intensification time, days	5.6	13.8	11.7

Projected changes: composite analysis, cont.

Frequency distributions of storm-ambient conditions
(for super-typhoon composites during their intensification phase)



AMIP T1279
TS T1279

Upward shift in the frequency of the most intense TCs could be due to:

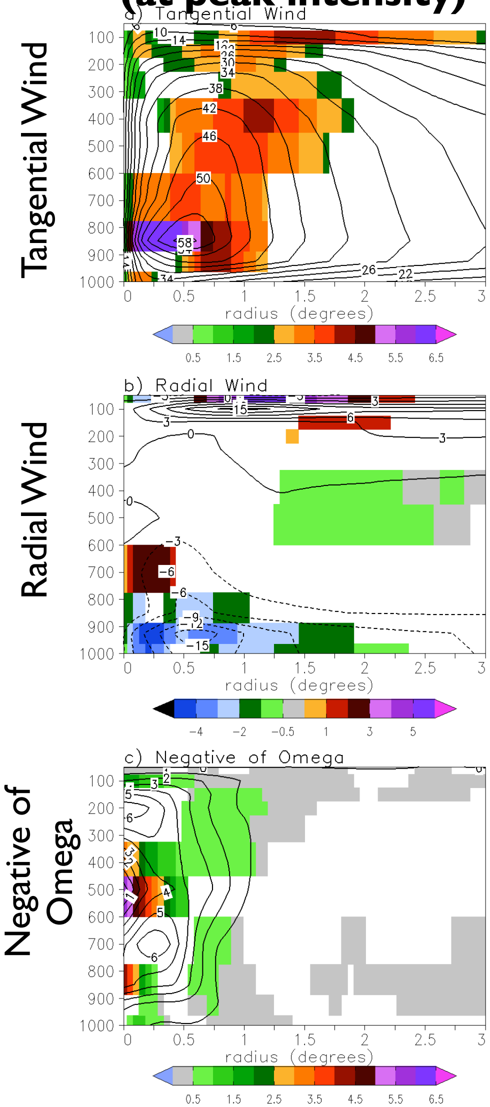
1. an increase in their lifetime,
2. higher intensification rate,
3. an increase in potential intensity (PI) or decrease in VWS, for instance.

These factors are not necessarily mutually exclusive!

Wing et al. (2007), Kossin and Camargo (2009)

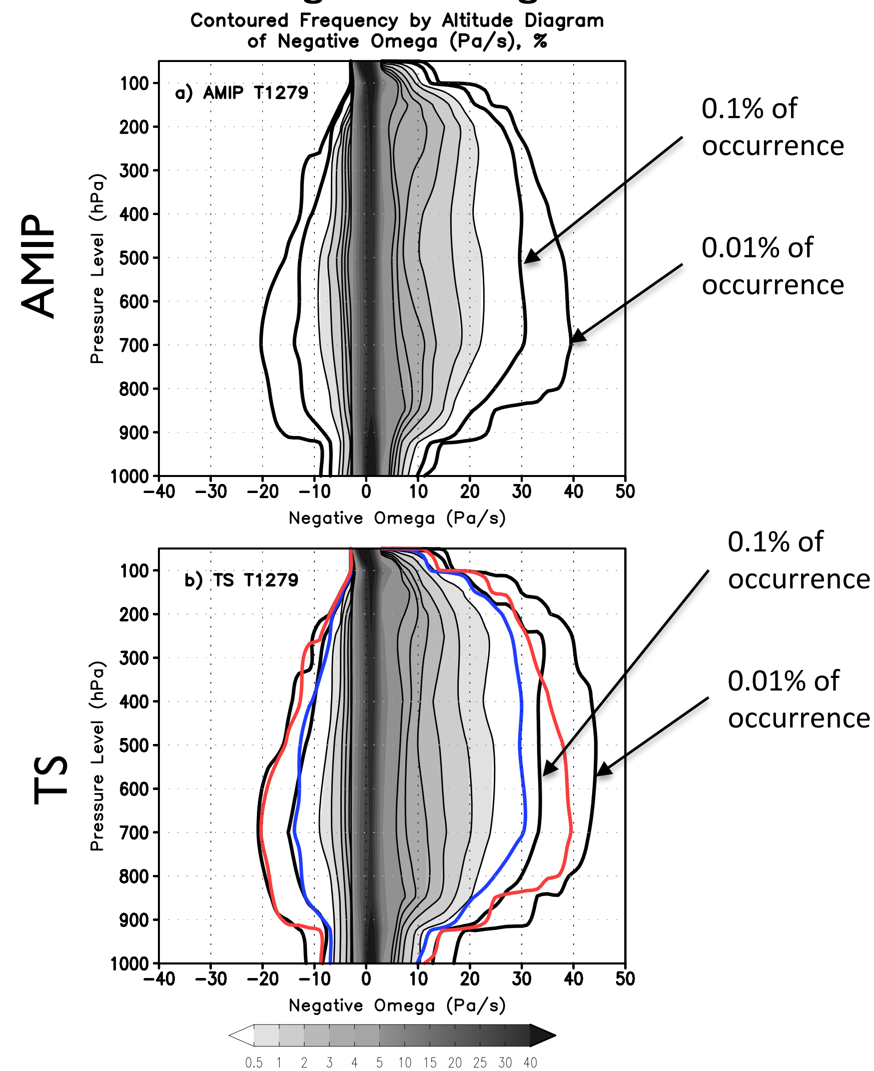
Projected changes: dynamical structure of the composites

Azimuthal Means (at peak intensity)



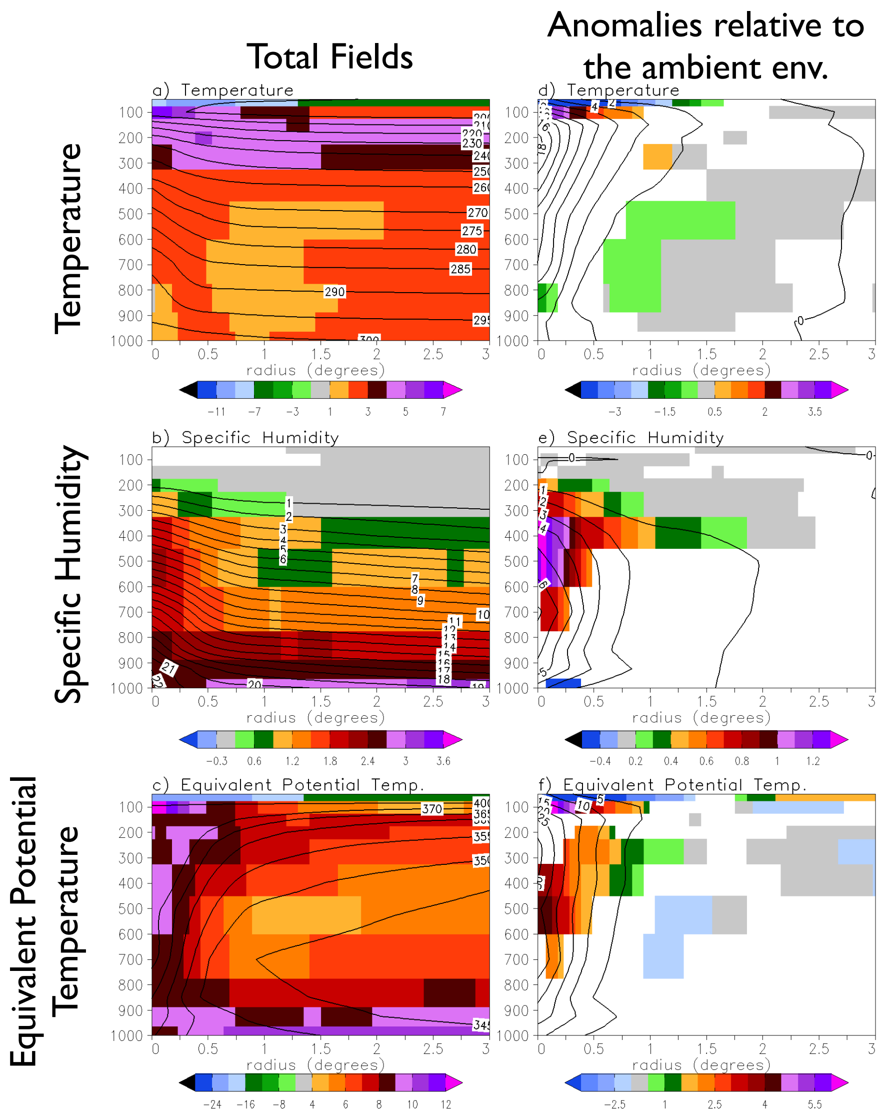
Shading denotes changes that are statistically significant at the 95% confidence level.

CFAD of Negative Omega



Projected changes: thermodyn. structure of the composites

Azimuthal Means (at peak intensity)



Summary:

The 16-km ECMWF IFS shows that in a future climate scenario, such as obtained from the CCSM3.0 A1B experiment:

- The change in the typhoon frequency is small and insignificant due to a clear southward shift in the genesis locations. This shift appears to be driven by the increase in the deep convective activity in the central equatorial Pacific and concomitant strengthening of the monsoon trough in the southeast.

- The frequency of the hurricane-strength and of very intense (CAT 3-5) typhoons increases significantly, accompanied by a reduction in the frequency of weaker storms.

- The mean peak intensities and the development rate of super-typhoons increases, which is consistent with their tendency to develop more to the south and within a thermodynamically more favorable environment.

- The structural changes of super-typhoons include:
  - system-scale amplification of the primary and secondary circulations, with the signs of contraction,
  - upward shift in the outflow level and the frequency of the most intense updrafts,
  - moist entropy gain in the inflow layer and the eyewall, and a deeper warm core.