Tropical Cyclones in a regional climate change projections with RegCM4 over Central America CORDEX domain

Gulilat Tefera Diro
diro@sca.uqam.ca

Centre ESCER, University of Quebec at Montreal (UQAM), Montreal, Canada

Thanks to
F. Giorgi, R. Fuentes-Franco, K. Walsh, G. Giuliani, E. Coppola

—

May 2014

Introduction

- Tropical Cyclones (TCs) are one of the high impact extreme events affecting many regions.
- Q. how do their characteristics (intensity, frequency, duration) change under greenhouse gas warming?
- Several studies with GCM w.r.t climate projections tend to agree on the characteristics of future TC activity on global scale.
- The change in specific ocean basins are however more uncertain, for example in Atlantic basin some found a decrease (e.g. Bengtsson et al., 2007) and others found the opposite (e.g. Oouchi et al., 2006), or found no significant change or the result depends on the model configuration (e.g., Murakami et al., 2010)
- This implying the need for further regional investigations

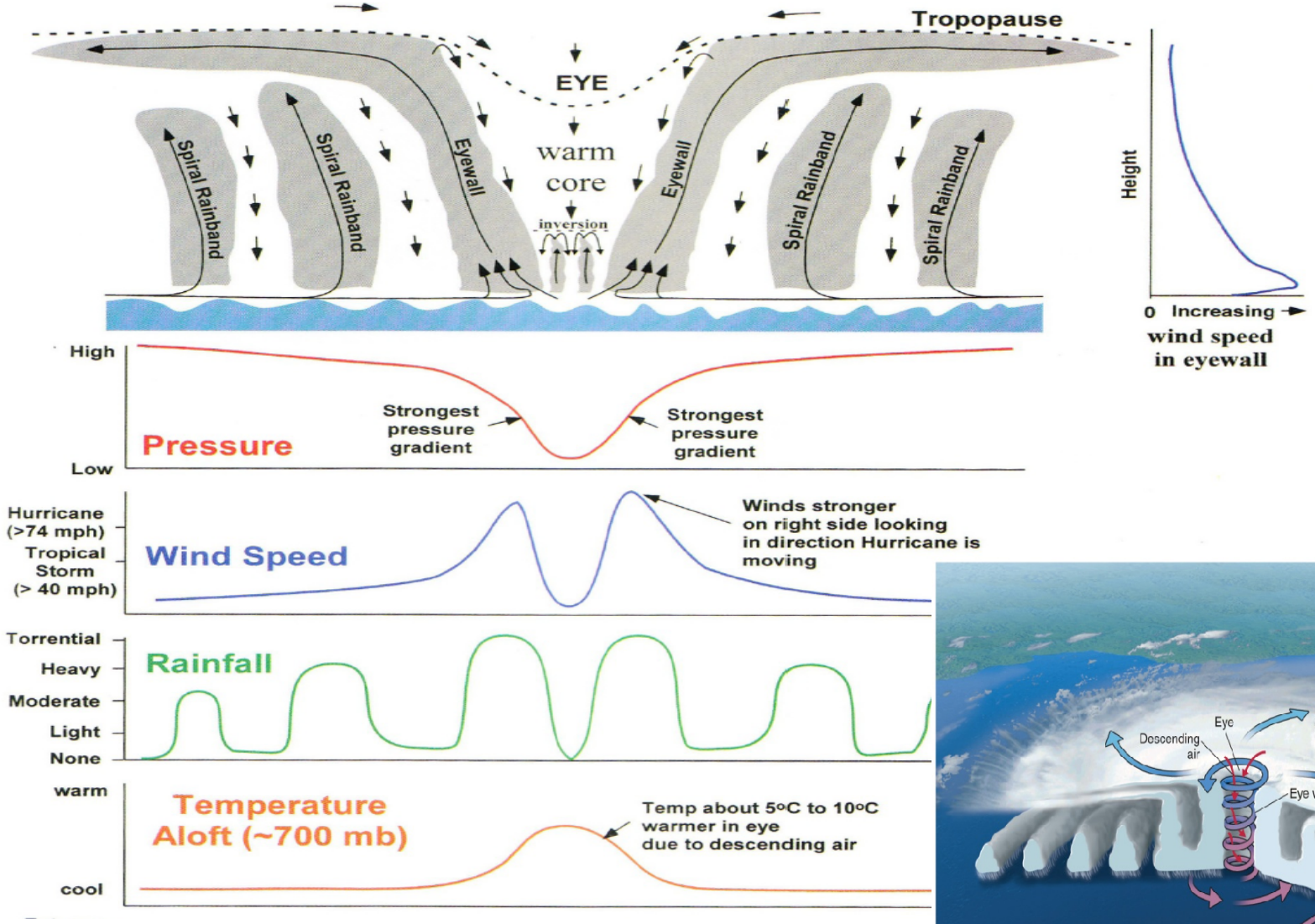
RegCM (4.3) set up

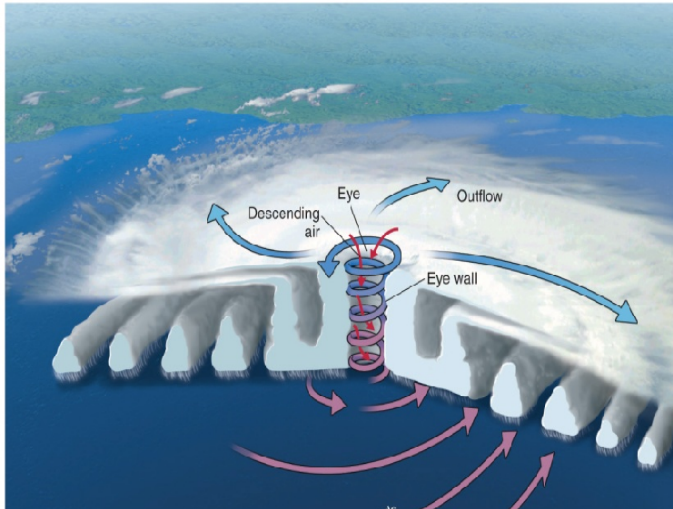
- The model domain is following the CORDEX Central America specification(15W - 145W and 25S-42N)
- Horizontal resolution is 50km, and vertically 18 σ levels
- Perfect Boundary Condition integration :
  - ERA-Interim for Initial and LBC
  - BATS for land surface processes
  - Convection:Emanuel over ocean and Grell over land
- The scenario integrations: 4 ensemble runs
- Two model configurations each driven by two CMIP5 GCMs
  - The two configurations are (Grell-BATS) and (Eman-CLM)
  - The two CMIP5 GCMs are HadGEM2-ES and MPI-ESM
  - simulation period is 1970 - 2100 with GHG forcing from the RCP8.5 pathway

Data and analysis period

- Observed TCs are obtained from the Unisys Web site (http://weather.unisys.com/hurricane/)/
- The dataset consists of six hourly best-track data
- TCs with intensity corresponding surface wind of $17.5 ms^{-1}$ or greater are considered in the analysis
- Validation is performed for the ERA-Interim driven and for the GCM control (present day) runs.
- The analysis is carried out for 22 years of the present period (1982 - 2003)
- The future period considered is the last 22 years of the 21 century

Some features of TCs





TC detection method

The detection criteria are similar to Walsh et al., (2004) and are as follows:

- The relative vorticity at 850hPa must be greater than 1.0 x10^{-5} s^{-1}
- There must be a closed pressure minimum within the radius of 100km. This minimum pressure is then defined as the center of the cyclone.
- The minimum surface pressure satisfying the above criteria is at least 2 hPa lower than the averaged surface pressure over the surrounding 2X2 grid boxes.
- The 10m surface wind speed must exceed 17.5m s^{-1}
- The minimum pressure at the center of the cyclone at the genesis must be over ocean points where the SST is higher than $26^0 C$.

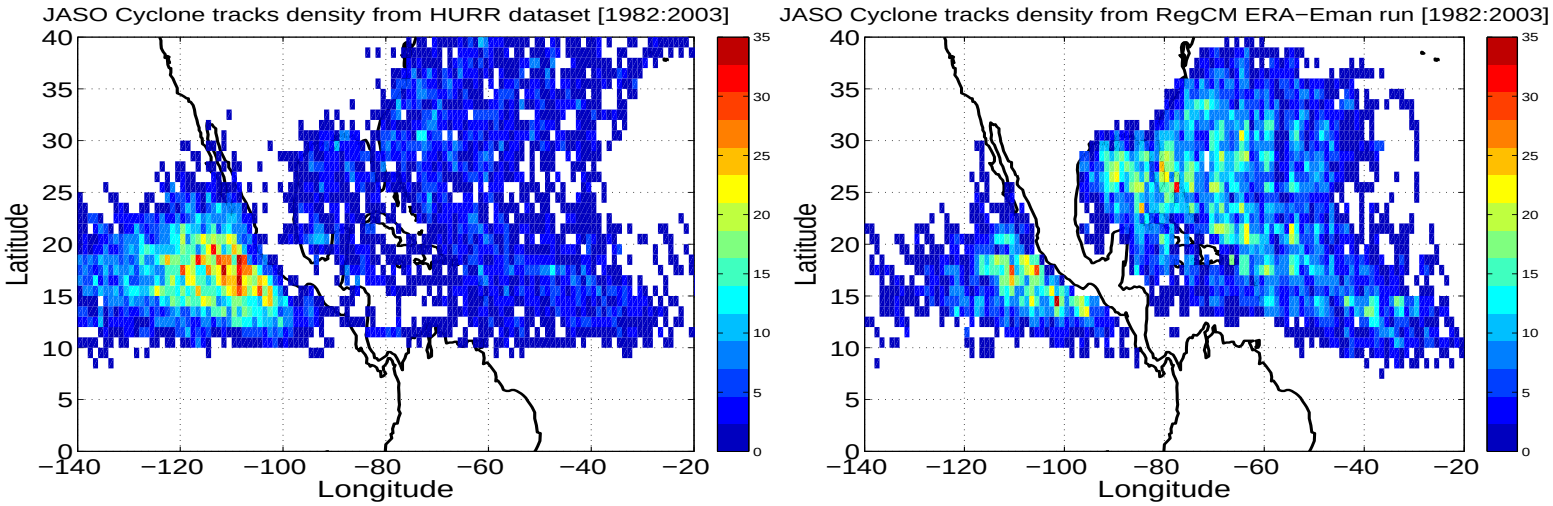
TC tracking procedure

Tracking is performed on those grid points satisfying the detection criteria. The following procedure is used to create a tracking database

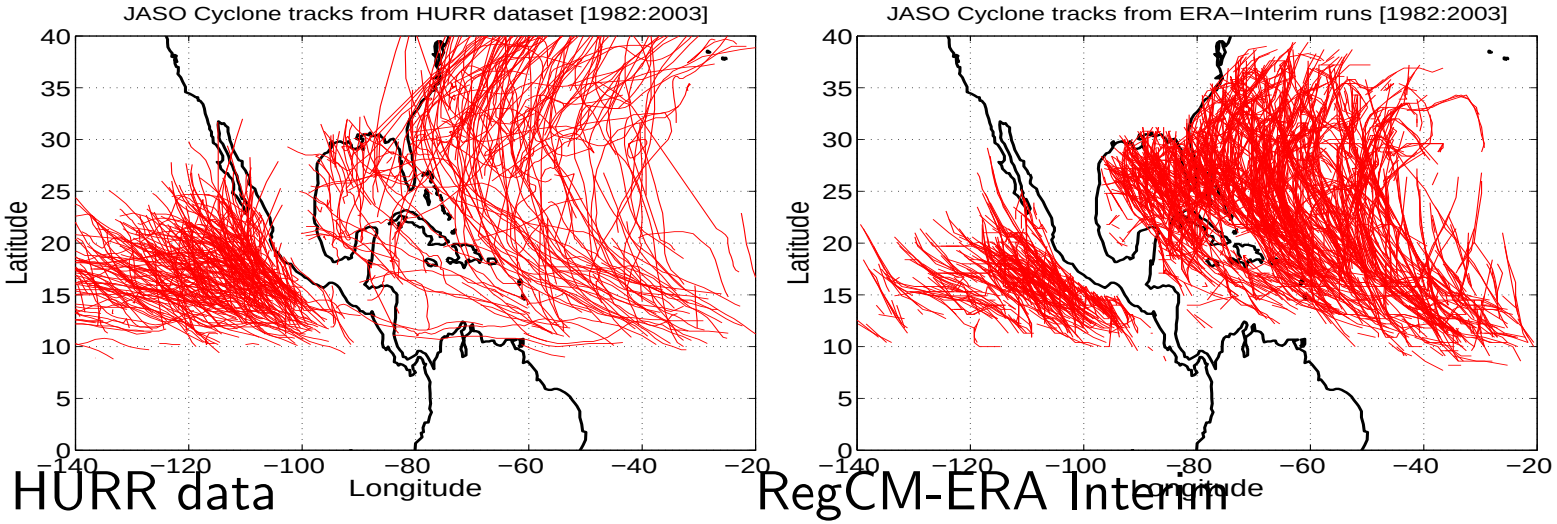
1. For each detected cyclone point, a check is performed on each six hourly sample to see whether there are cyclones during the 24 hour period within a radius of 6 X 6 longitude-latitude grid boxes.
2. If there are some cyclones detected satisfying the previous condition, then the closest cyclone is chosen as belonging to the same track as the initial one.
3. To qualify as a track, there must be more than one detection within the next 24 hours and within a 6 X 6 longitude-latitude grid boxes.

ERA-Interim forced runs

Frequency and track

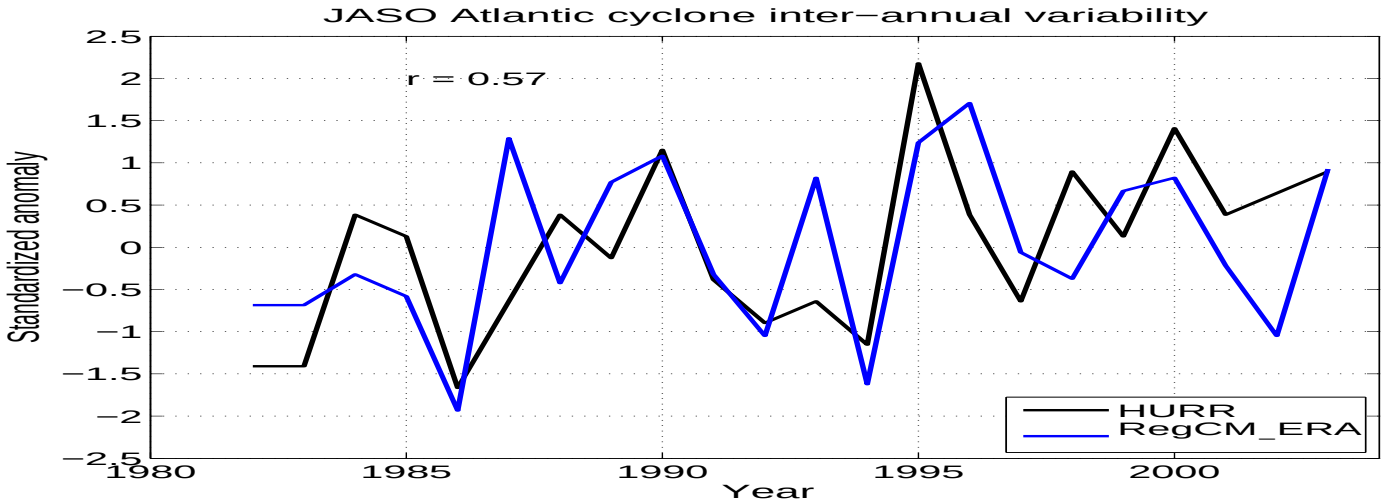


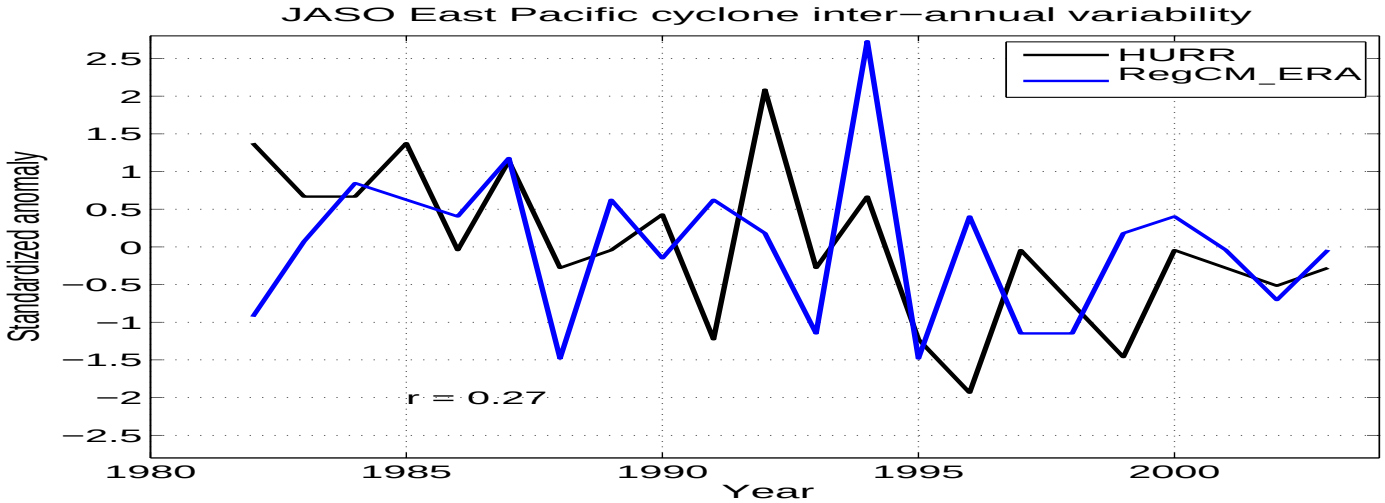
The model underestimate the TC frequency over Pacific but overestimates over Atlantic



HURR data RegCM-ERA Interim

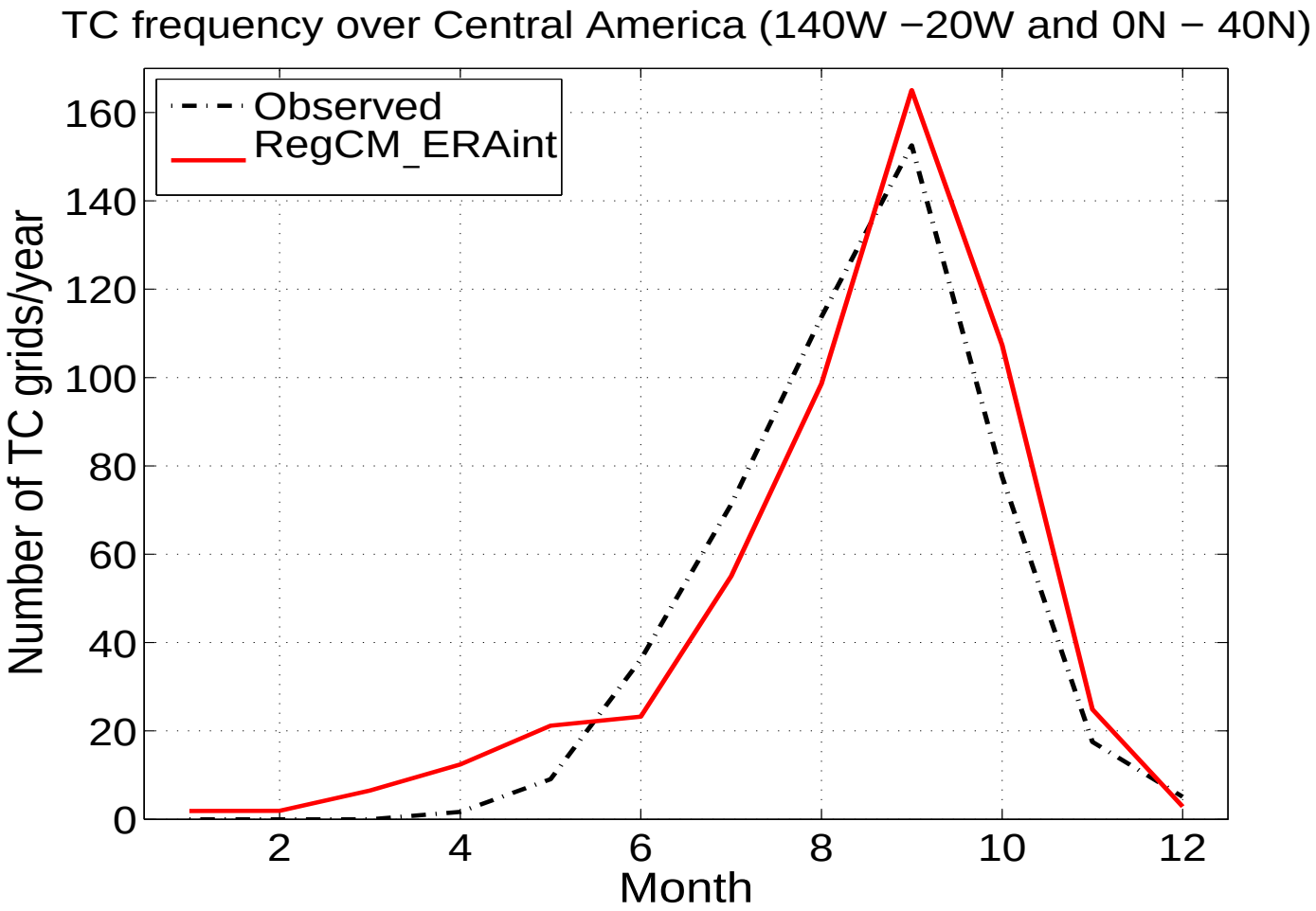
Inter-annual variability:





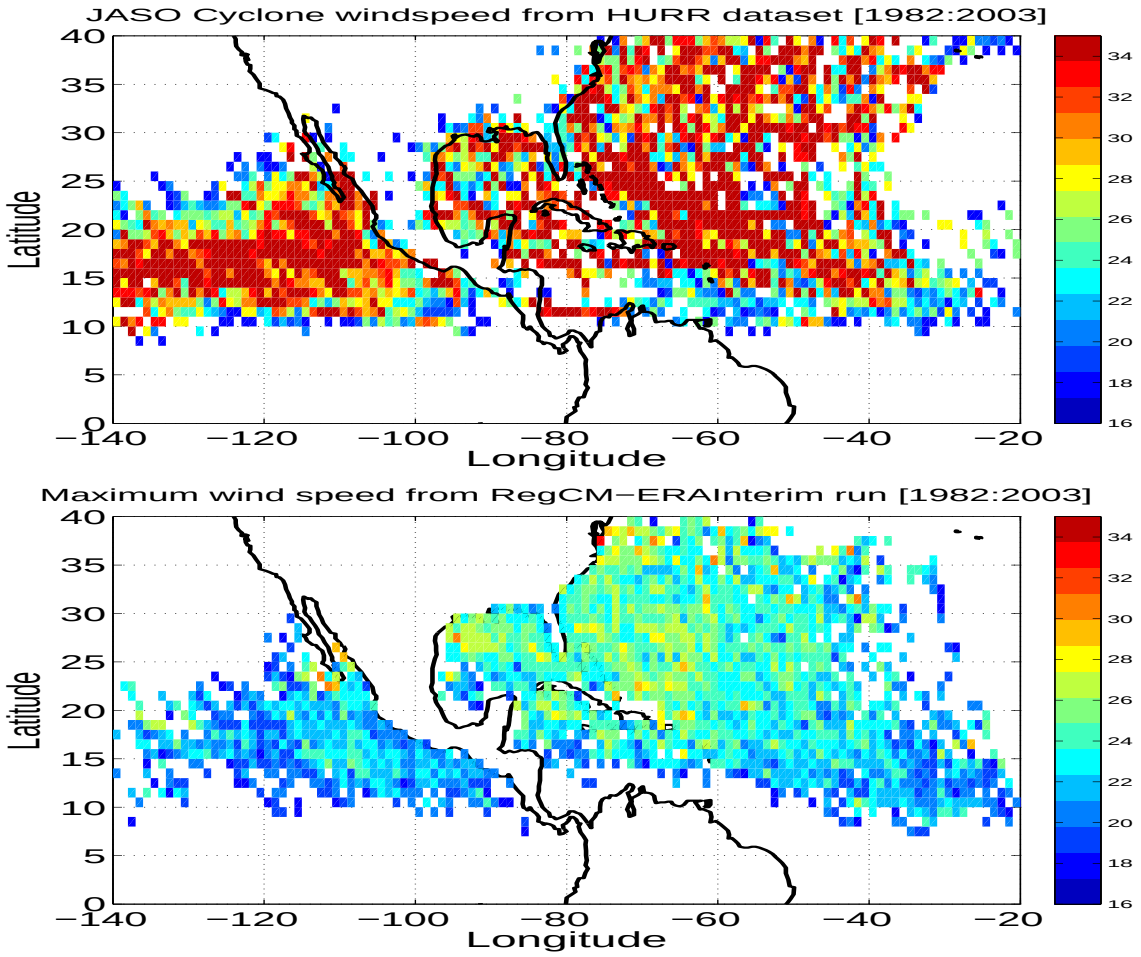
RegCM4 realistically simulated the interannual variability TCs over North Atlantic

Annual cycle



RegCM4 realistically simulated the annual cycle of TCs

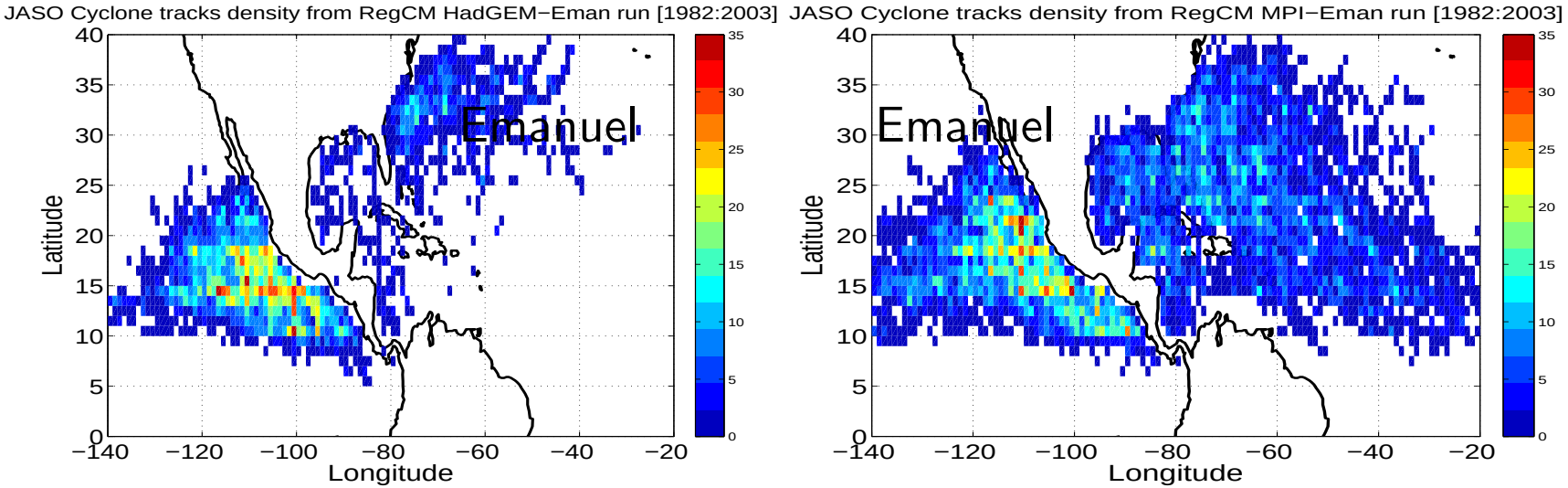
Intensity



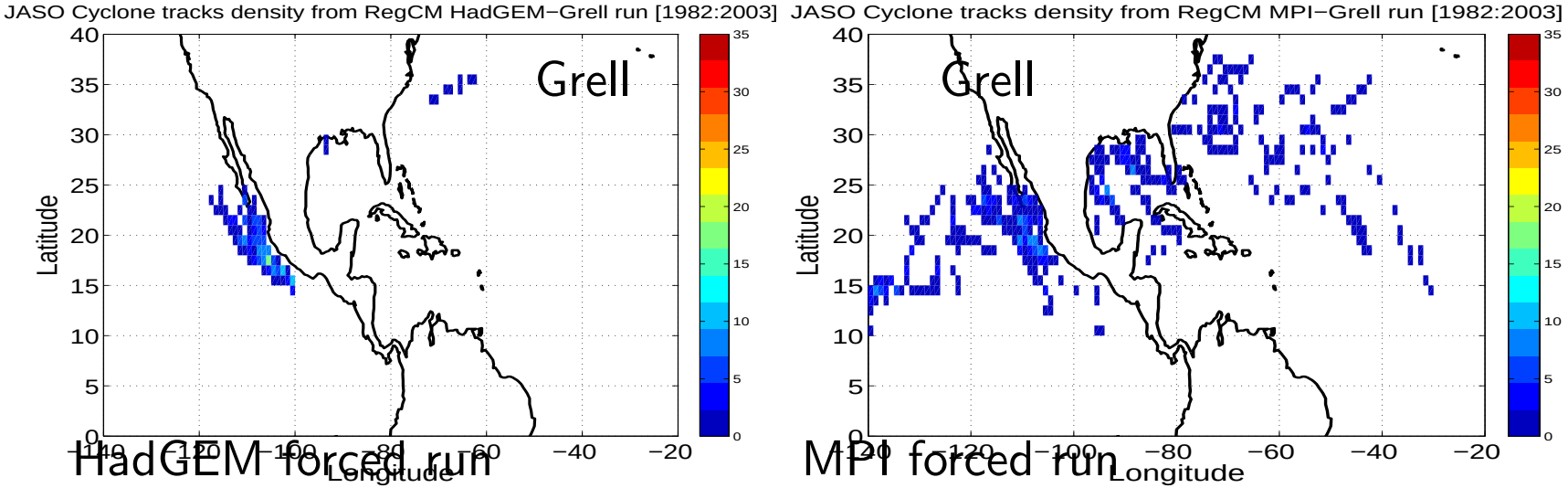
50km is still coarse to simulate intense cyclones

Present day GCM forced runs

Impact of model physics on TC climatology

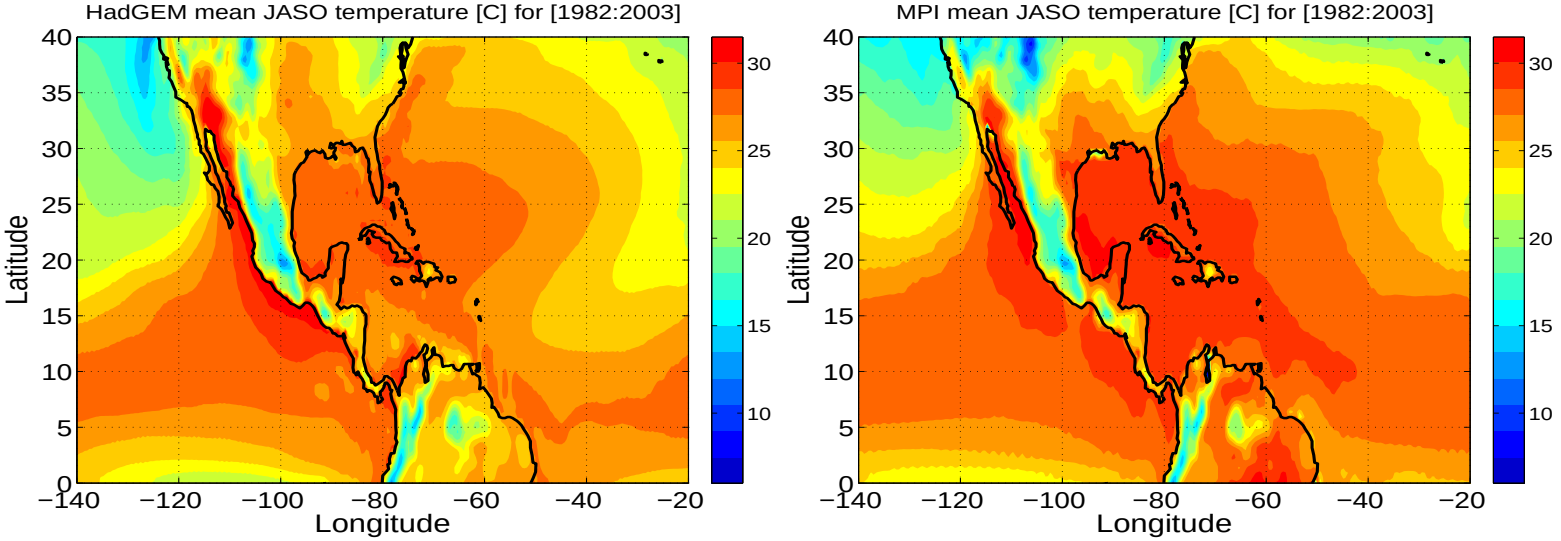


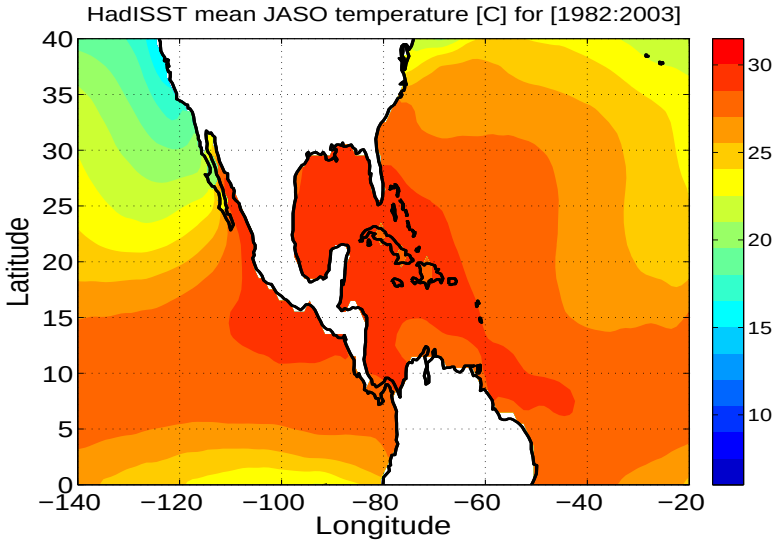
Grell produces less TCs irrespective of the boundary forcing



HadGEM forced run MPI forced run

Why HadGEM produced less TCs over tropical Atlantic

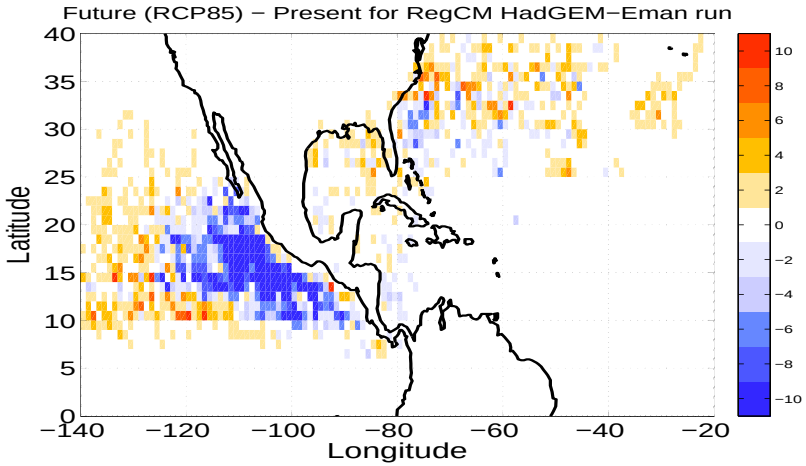


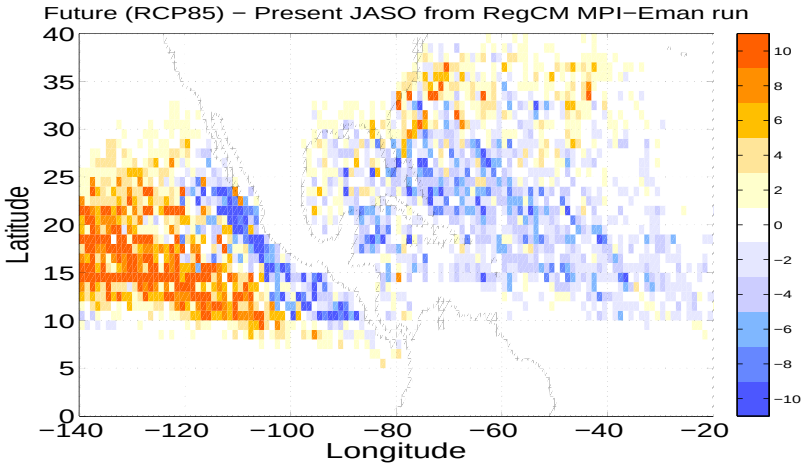


HadGEM SST is colder over the tropical Atlantic

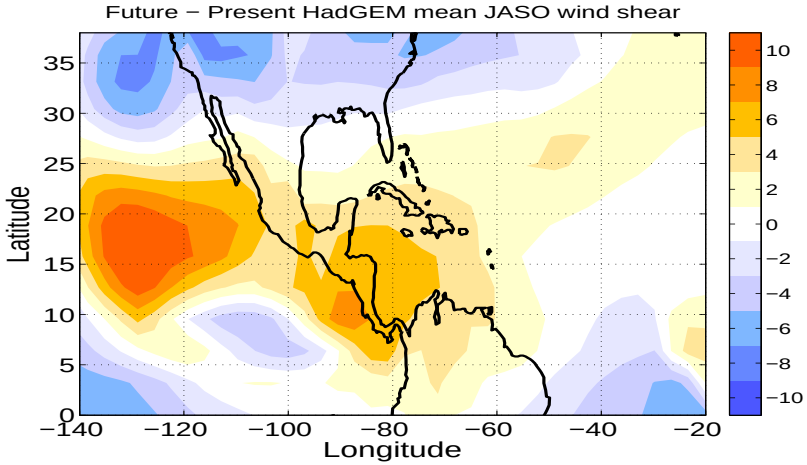
Future Changes

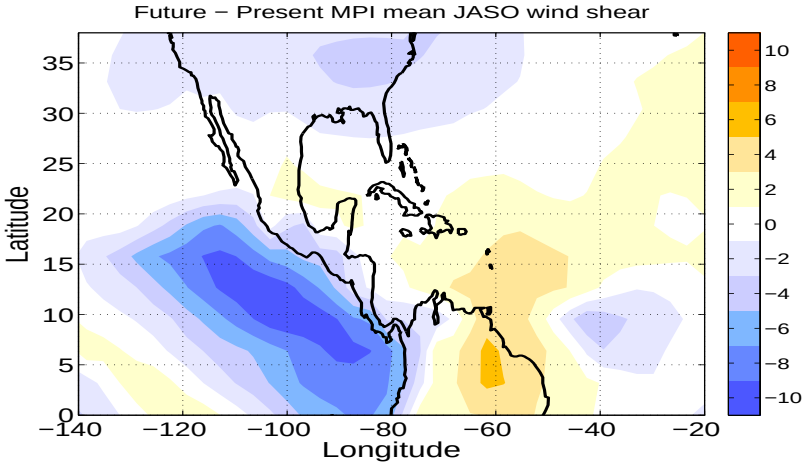
Future Changes for JASO: TC Frequency





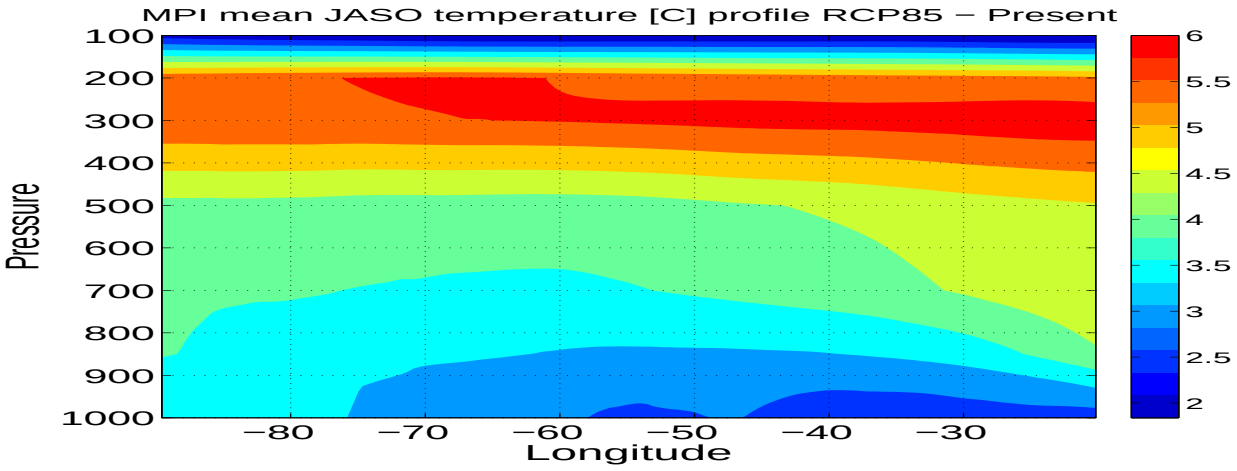
A decrease in TC frequency over the tropical Atlantic



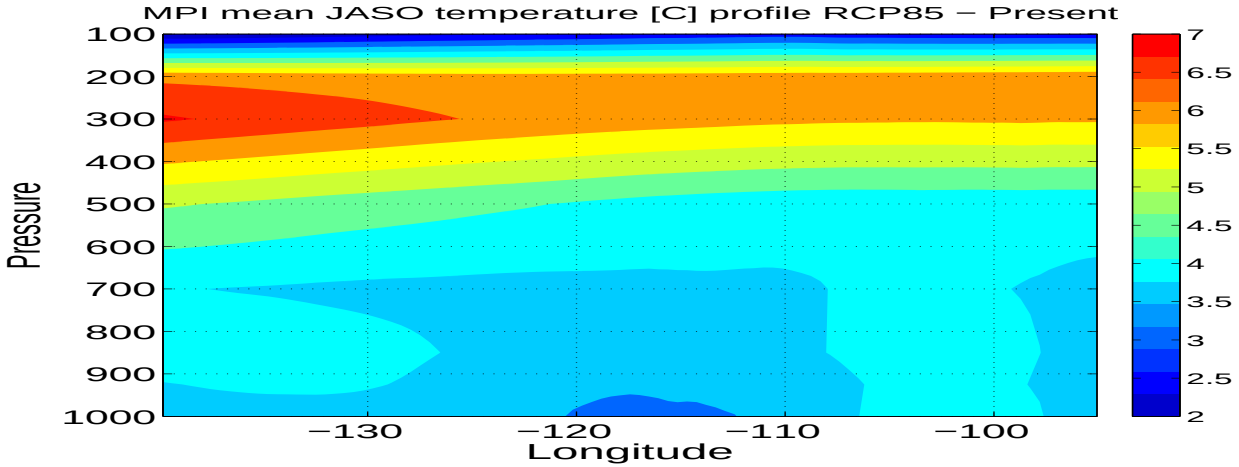


These might be related to the increase in the wind shear over the tropical Atlantic

Frequency vs stability (Temperature profile)



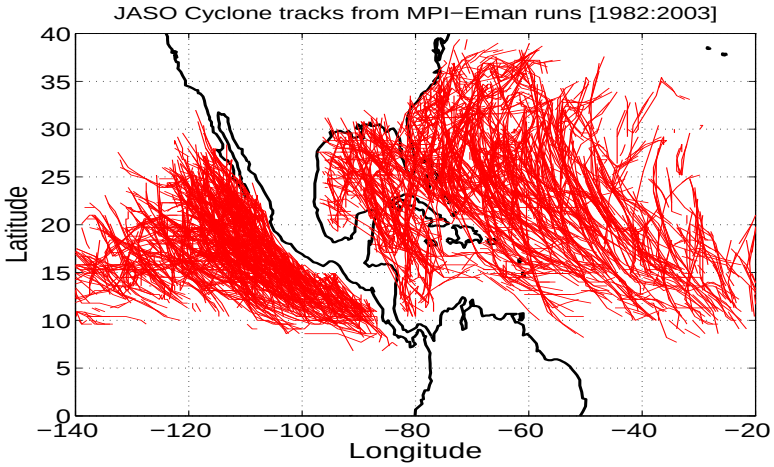
Atlantic

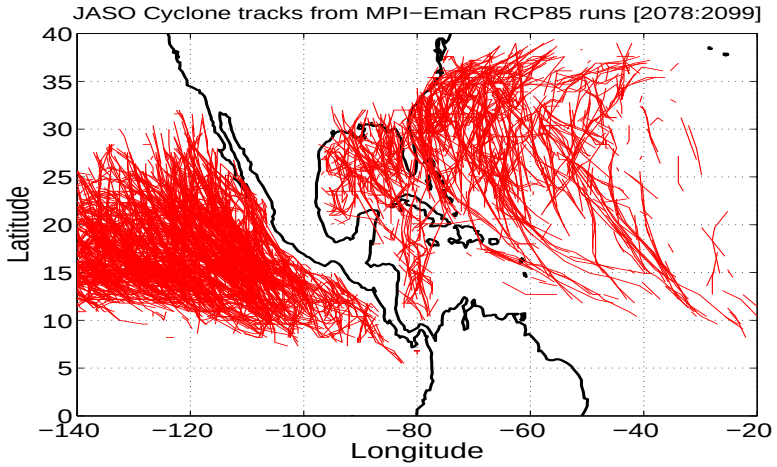


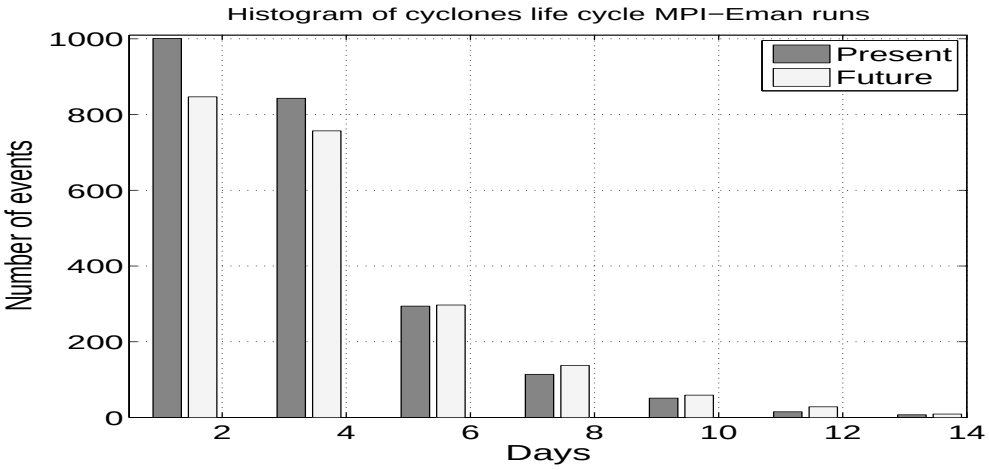
East Pacific

more stable atmosphere in the future climate

Future Changes: Tracks and life cycle

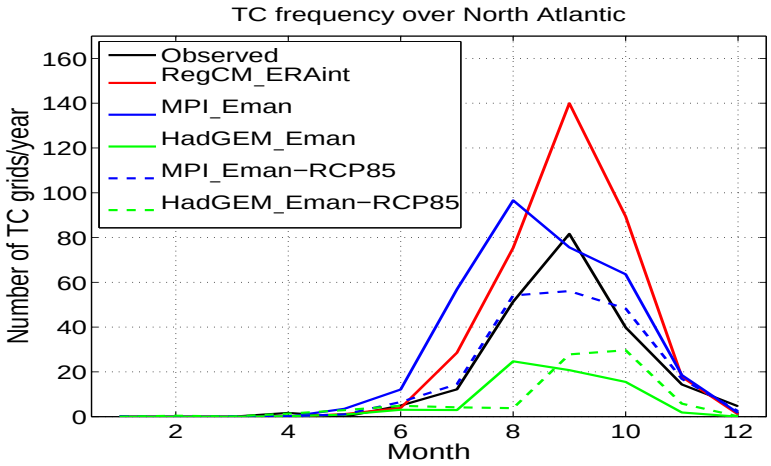


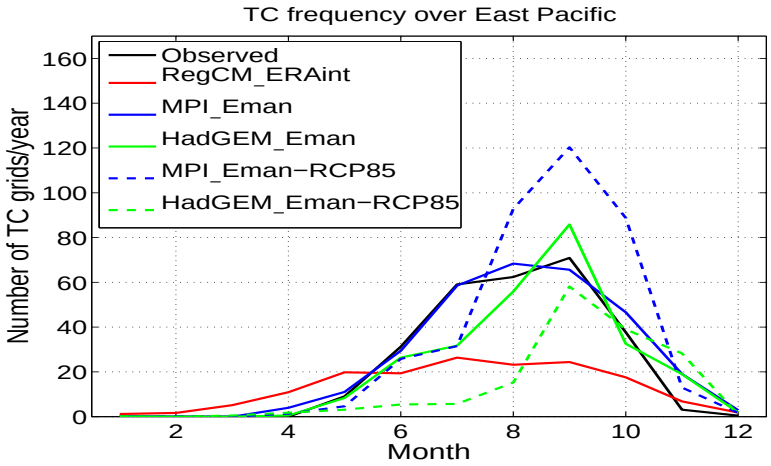




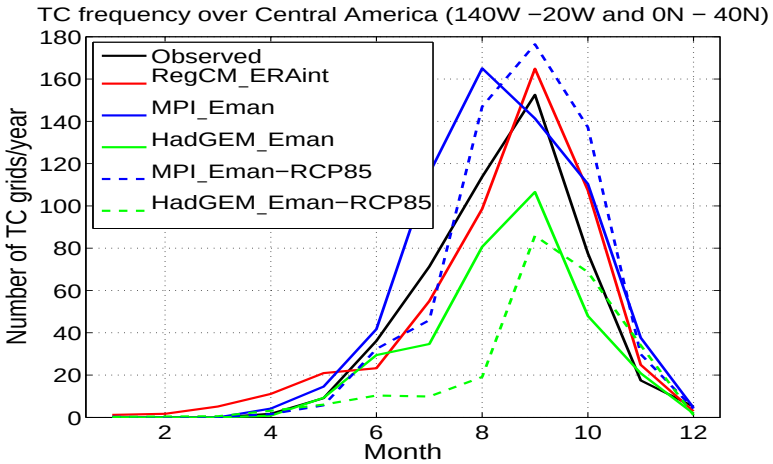
The frequency of TCs particularly over tropical Atlantic decreases, however those will get reduced in number are the short lived ones

Annual Cycle: Atlantic vs East Pacific

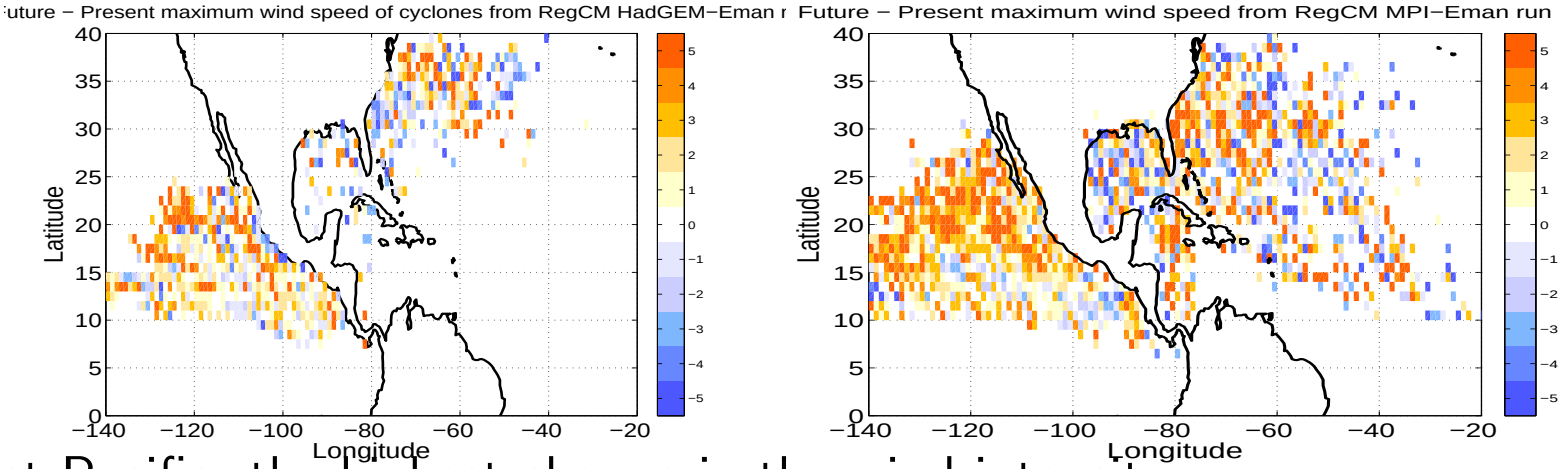




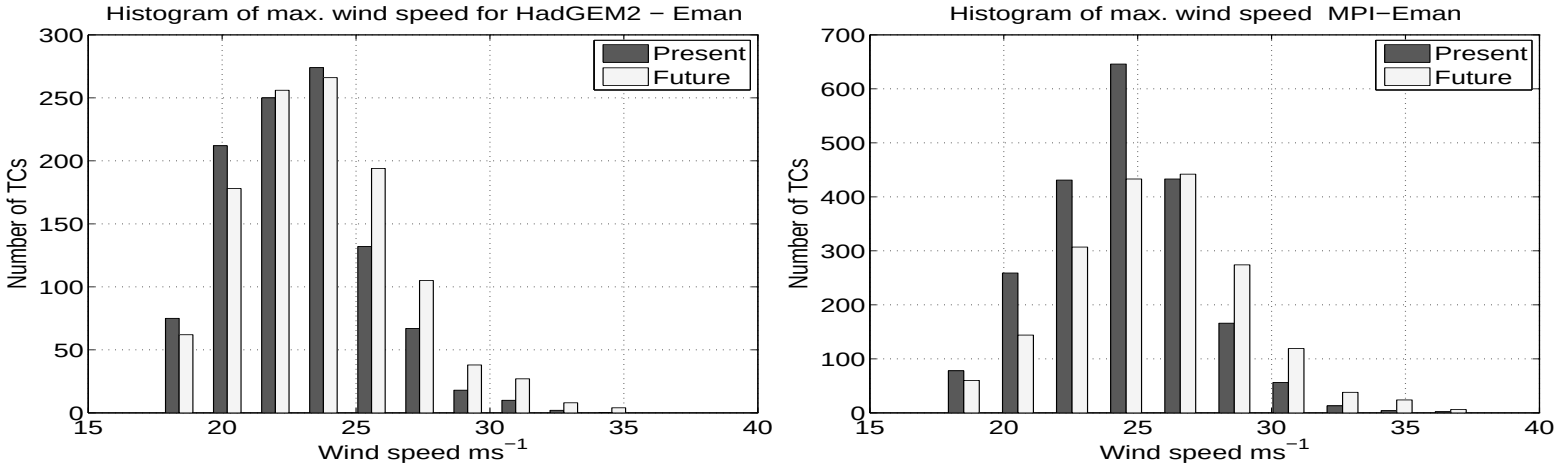
- MPI run suggests an increase in the frequency over Pacific, whereas almost the opposite in HadGEM run
- Over the Atlantic basin, HadGEM2 shows a shift in the TCs season whereas MPI favours the reduction



Future Changes: Intensity

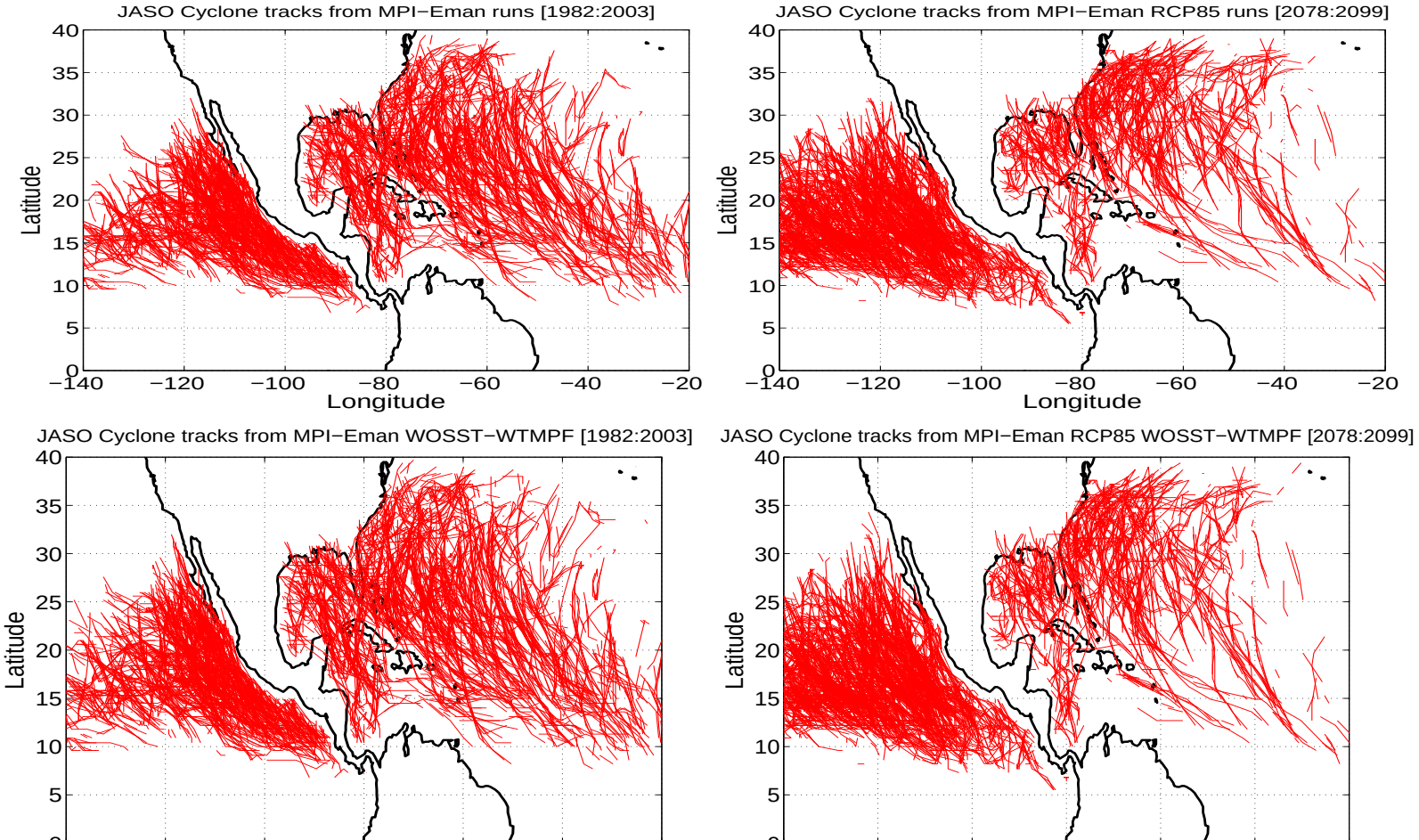


East Pacific- the highest change in the wind intensity

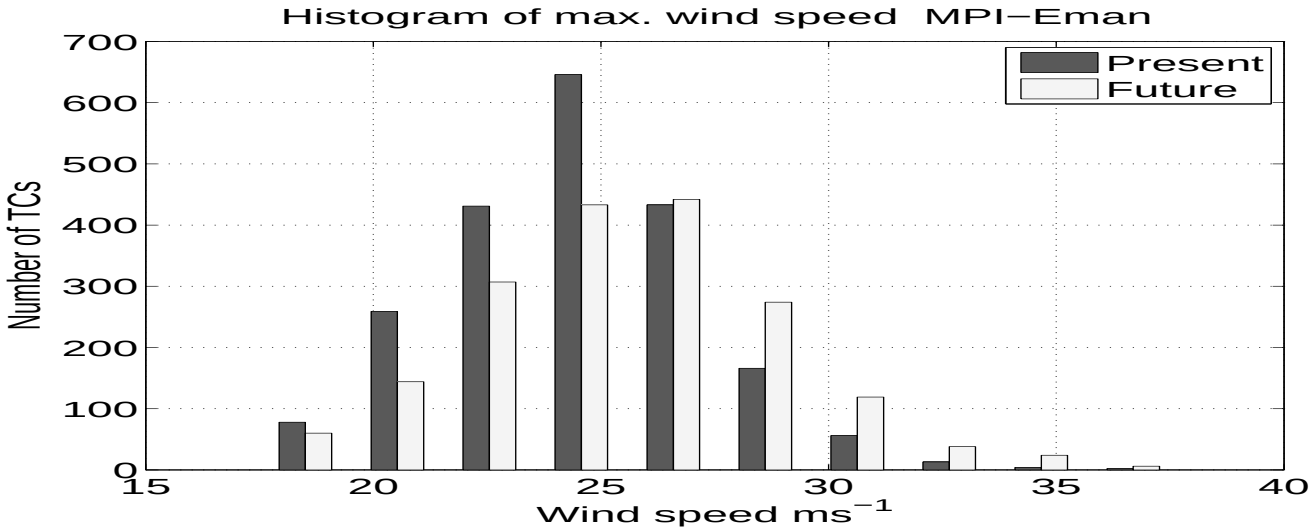


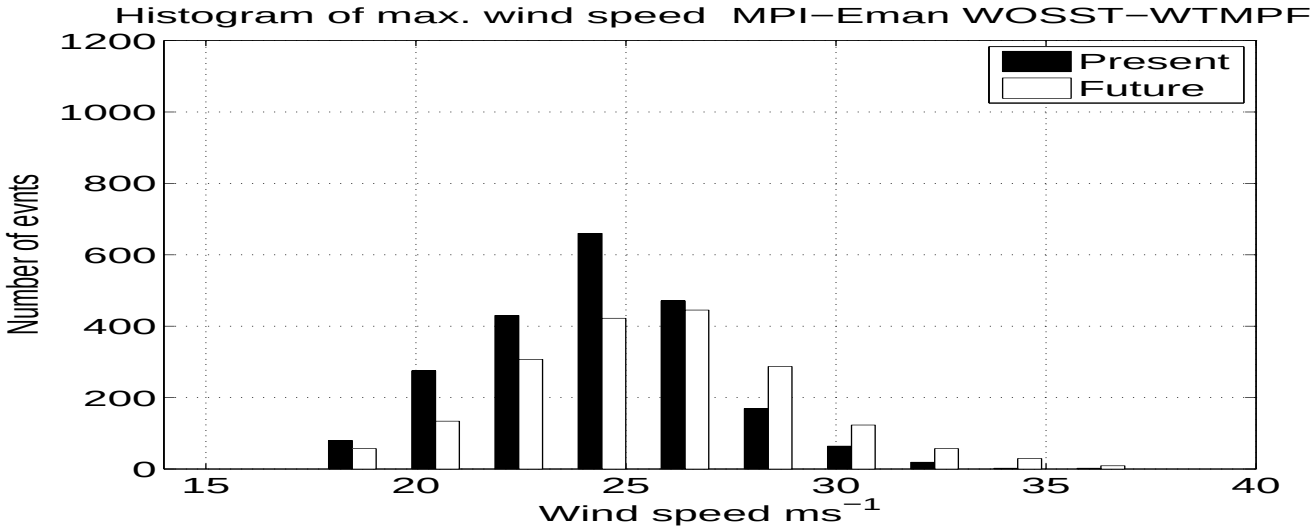
A decrease in the weak TCs but an increase in the frequency of the strongest TCs

The impact of using SST threshold in the detection procedure on the differences in tropical cyclone formation between current and future climate.

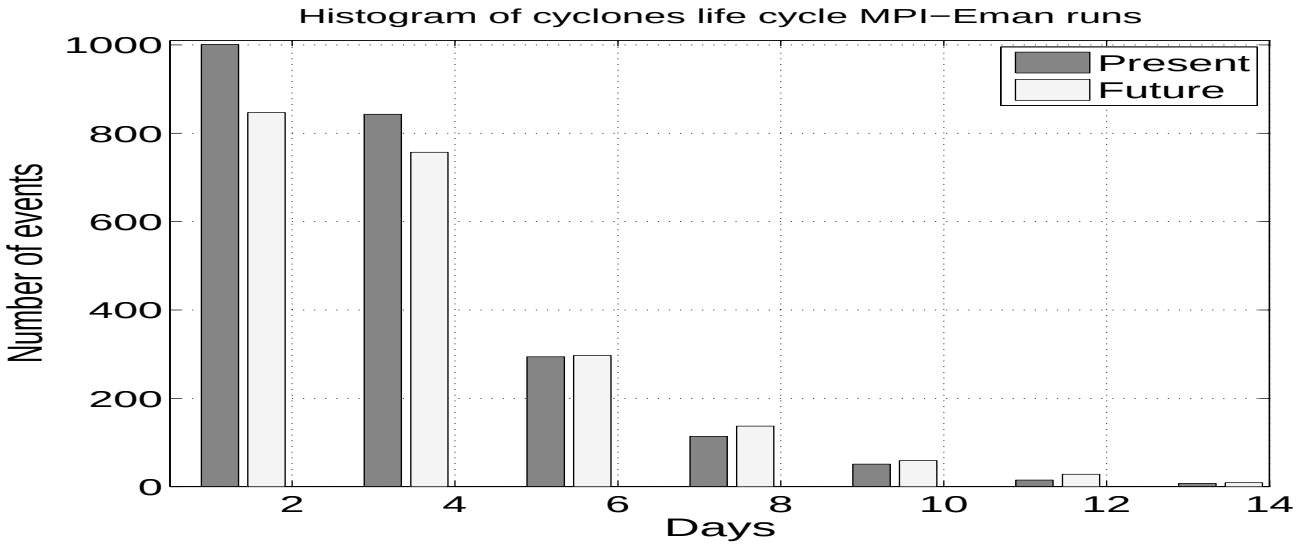


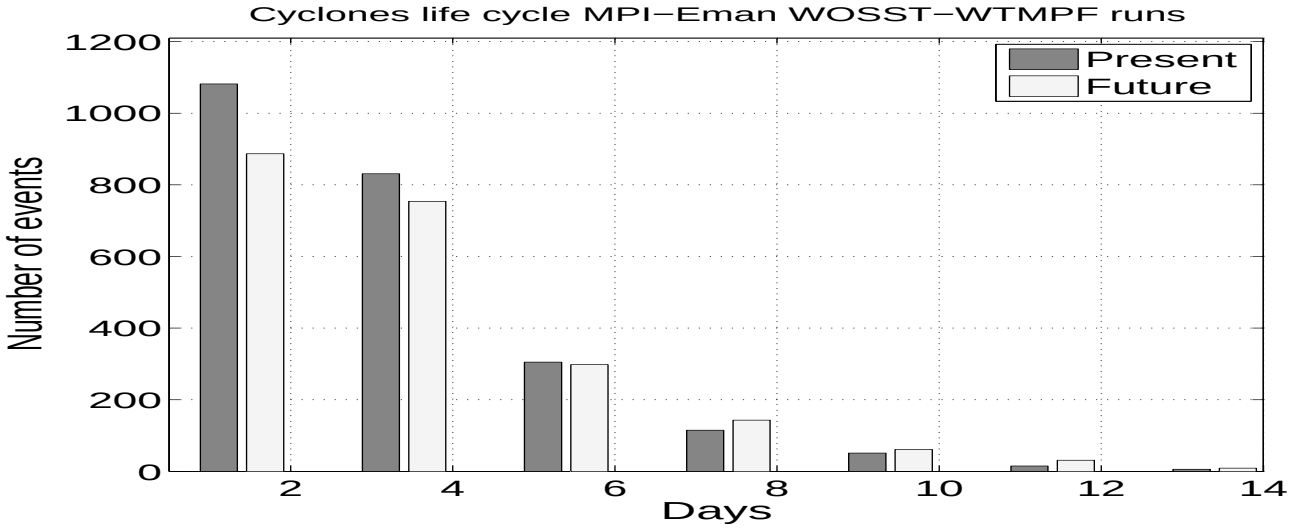
Impact of SST threshold on Intensity





Impact of SST threshold on life cycle





Conclusions

- TC climatology is found to be very sensitive to the convection scheme, and Grell scheme produces very few TC counts.
- HadGEM2-ES forced RegCM4 produces unrealistic TC counts over the tropical Atlantic because of a cold SST bias there.
- The MPI-ESM forced RegCM-Emanuel configuration reproduced well the TC climatology for the present climate and proven to be the best combination.
- Results under the RCP8.5 scenario suggest that the future frequency of the most intense TCs will increase but the number of week and short lived TCs will decrease.
- The overall frequency of TCs decreases in the tropical Atlantic and coastal regions of the Pacific but increases over Central Pacific and northern Atlantic.
- Removing the SST threshold from the detection criterion does not change the result substantially.