Assignment: Module 5

Learning Goals

Subject knowledge:

- Impacts of the AMM on Atlantic tropical cyclones
- Changes in the environmental conditions associated with the AMM that contribute to Atlantic tropical cyclone variability

Analysis skills:

- Composite analysis
- Calculate the vertical wind shear, which is often defined as the magnitude of the vector wind difference between two pressure levels.
- Rank correlation
- Multi-variable Poisson regression model
- Download and process CMIP6 data
- Construct the probability distribution function
- Test whether two distributions are significantly different from each other using the Mann-Whitney U Test

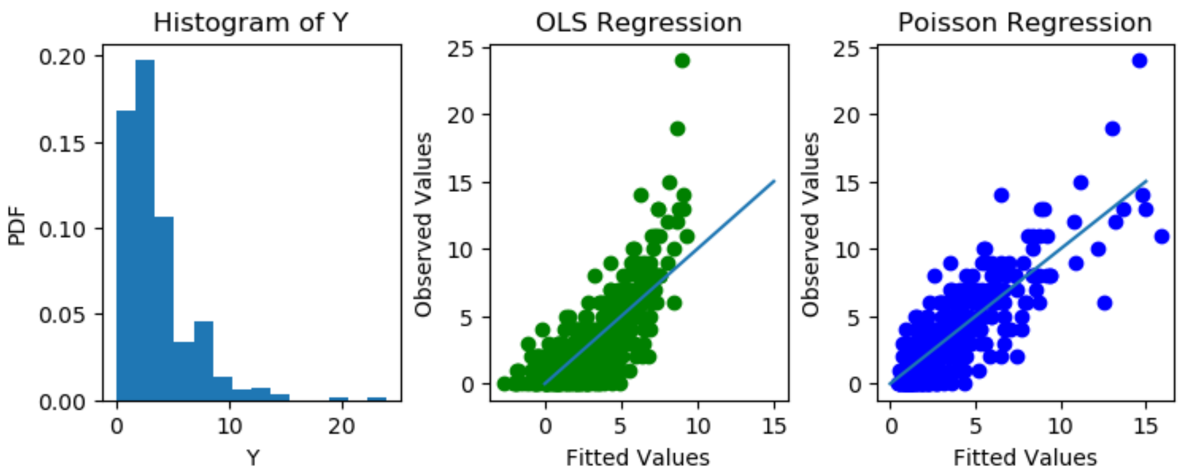
Example (for problem 2)

Please play with two sample scripts below

/data/zhuowang/a/zhuowang/ATMS521/Sample_Scripts/poisson_hist.py

/data/zhuowang/a/zhuowang/ATMS521/Sample_Scripts/poisson_fit_exp2.py

The first sample script “poisson_hist.py” plots the PDF of the Poisson distributions for mu=5 and mu=25. The second script “poisson_fit_exp2.py” compares Poisson regression with linear regression. The script will produce the following figure. The left panel shows the PDF of the sample data Y; the middle panel shows the linear regression of Y; and the right panel shows a Poisson regression of Y. Although both regressions miss some outliers, the Poission regression clearly does a better job.



Problem 1

The plot below shows tropical cyclone tracks for 10 years of strongest positive AMM anomalies and 10 years of strongest negative AMM anomalies during 1950-2015 JASO (color along tracks indicates the storm intensity). There were 94 named tropical cyclones in the positive years, and 68 in the negative years.

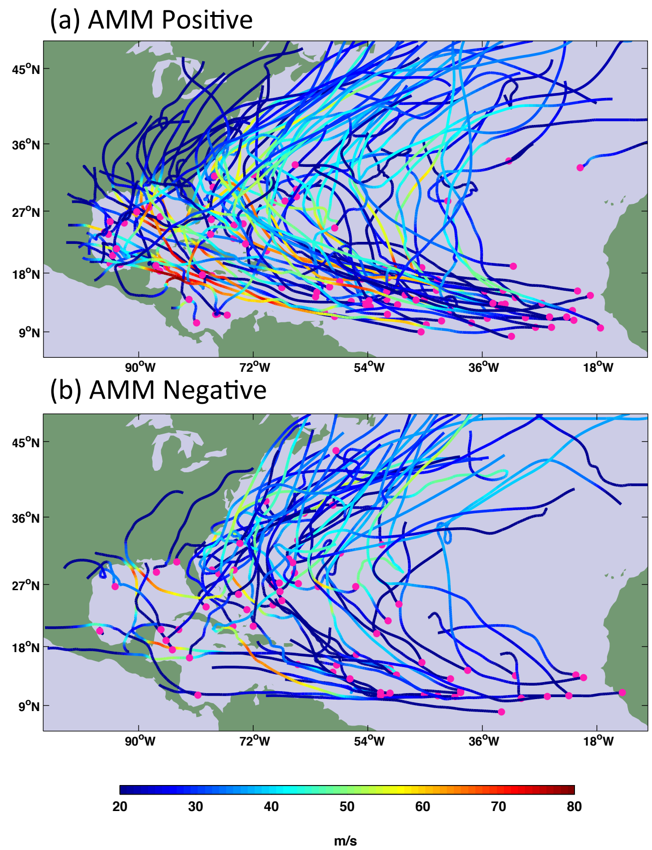


Figure 1 Composites of Atlantic tropical cyclones for (a) the positive phase and (b) the negative phase of the AMM. Pink dots represent the genesis locations and the colors along storm tracks indicate the storm intensity.

Construct the 600-hPa relative humidity difference and vertical shear difference between the AMM positive and negative phases by selecting 10 years of strongest positive AMM anomalies and 10 years of strongest negative AMM anomalies during 1950-2015 JASO. Highlight the composite differences exceeding the 95% confidence level using the two-sample t-test, and discuss how the AMM affects Atlantic tropical cyclone activity. Here we define vertical wind shear as the magnitude of the vector difference between the 850 and 200-hPa wind field:

$$VWS = \sqrt{(u_{200} - u_{850})^2 + (v_{200} - v_{850})^2}.$$

Input data:

/data/zhuowang/a/zhuowang/ATMS521/Data/AMM_sst.txt

/data/zhuowang/b/shared/NNR/monthly

Domain of analysis: 0-75N, 10-100W

Problem 2

Please develop a Poisson prediction model for the Atlantic hurricane count (HUR) during July-October (the hurricane season) following the steps below.

- Define two or three SST indices as predictors based on the figure below, which shows the composite SST differences during April-June (i.e., before the Atlantic hurricane season) between 10 most active and 10 most inactive hurricane seasons during 1950-2013.
- Construct the predictor array, denoted "X", using the SST indices defined above.
- Read the monthly mean hurricane count data and calculate the seasonal mean from Jul-Oct, denoted as "Y".
- Carry out the leave-one-out cross validation for Poisson regression with the selected predictors; the predicted hurricane counts are saved in the array "yhat".
- Calculate the rank correlation and RMSE between the predicted and observed hurricane counts during 1950-2013
- Make the following two plots: i) a scatter plot of Y and yhat; ii) time series of Y and yhat. Please indicate the rank correlation coefficient and RMSE between Y and yhat on your plots.

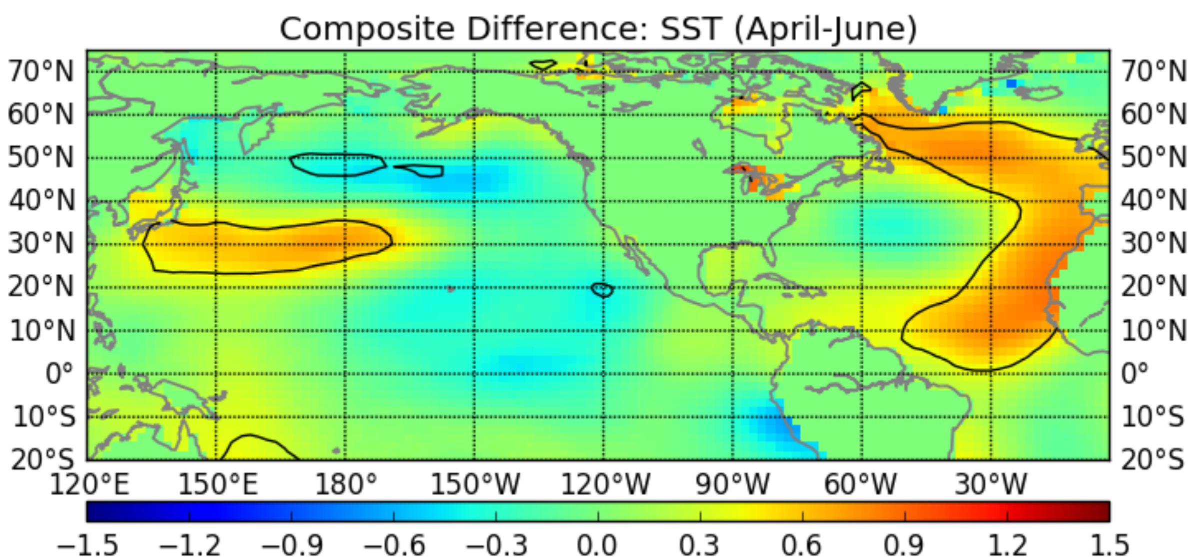


Figure 2 the composite SST differences during April-June (i.e., before the Atlantic hurricane season) between 10 most active and 10 most inactive hurricane seasons during 1950-2013.

Input data:

/data/zhuowang/b/shared/ERSST_v4/sst.mnmean.v4.nc
/data/zhuowang/a/zhuowang/ATMS521/Data/Hurricane_AT.txt

Output: plot of the observed and predicted time series of HUR; the rank correlation and RMSE between the two time series

Hints: Please see the sample script "poisson_fit_exp2.py" in the Example for Poisson regression. You can revise your MLR script from Assignment #2 for the cross validation.

Problem 3

Download the monthly mean surface air temperature and precipitation data for a list of selected models except CIESM (which does not have precipitation data) shown below from the CMIP6 data archive (https://esgf-node.llnl.gov/search/cmip6/) for 1949-2099 for SSP245. If a model has more than one ensemble members, please just download one member (Hints: you can use a "wget" script to download data, or try one of the ways at https://medium.com/pangeo/cmip6-in-the-cloud-five-ways-96b177abe396).

Model	Model	Model
ACCESS-CM2	CanESM5-CanOE	IPSL-CM6A-LR
ACCESS-ESM1-5	EC-Earth3	KACE-1-0-G
AWI-CM-1-1-MR	EC-Earth3-CC	KIOST-ESM
BCC-CSM2-MR	EC-Earth3-Veg	MCM-UA-1-0
CAMS-CSM1-0	EC-Earth3-Veg-LR	MIROC6
CAS-ESM2-0	FGOALS-f3-L	MIROC-ES2L
CESM2	FGOALS-g3	MPI-ESM1-2-HR
CESM2-WACCM	FIO-ESM-2-0	MPI-ESM1-2-LR
CIESM	GFDL-CM4	MRI-ESM2-0

We will examine the areal mean surface air T and precipitation over the US Great Plain:

1) Calculate the June-August seasonal mean surface air temperature from 1949 to 2099 averaged over the US Great Plain (30-50N, 95-110W) from each model, and plot the time series of the multi-model ensemble mean surface air temperature from 1949-2099 along with the 10-90% percentile.
2) Repeat the above analysis for the June-August seasonal mean precipitation averaged over the US Great Plain.
3) Construct and plot the probability distribution function of seasonal mean temperature during June-August averaged over the US Great Plain for the following two time periods using the GFDL-CM4 model output.
   - historical time period 1949-1999
   - future climate period 2049-2099
4) Please test whether the two distributions in 3.3 are significantly different from each other using the Mann-Whitney U Test.