Modeling Tropical Cyclone Tracks and Intensity Using Historical Storm Data

Pulong Ma, Department of Statistics, Iowa State University

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Tropical Cyclones

A **tropical cyclone** is the generic term for a non-frontal synoptic scale low-pressure system over tropical or sub-tropical waters with organized convection and definite cyclonic surface wind circulation (Holland 1993).

Saffir-Simpson Hurricane Scale for Tropical Cyclones

A tropical cyclone can be classified based on **maximum sustained wind speeds** (MWS) using the **Saffir-Simpson hurricane scale** (SSHS):

- Category one: MWS is in [33, 43) (m/s).
- Category two: MWS is in [43, 50) (m/s).
- Category three: MWS is in [50, 58) (m/s).
- Category four: MWS is in [58, 70) (m/s).
- Category five: MWS is greater than 70 m/s.

One knot is 0.514 m/s.

IBTrACS Data

The International Best Track Archive for Climate Stewardship (IBTrACS) project:

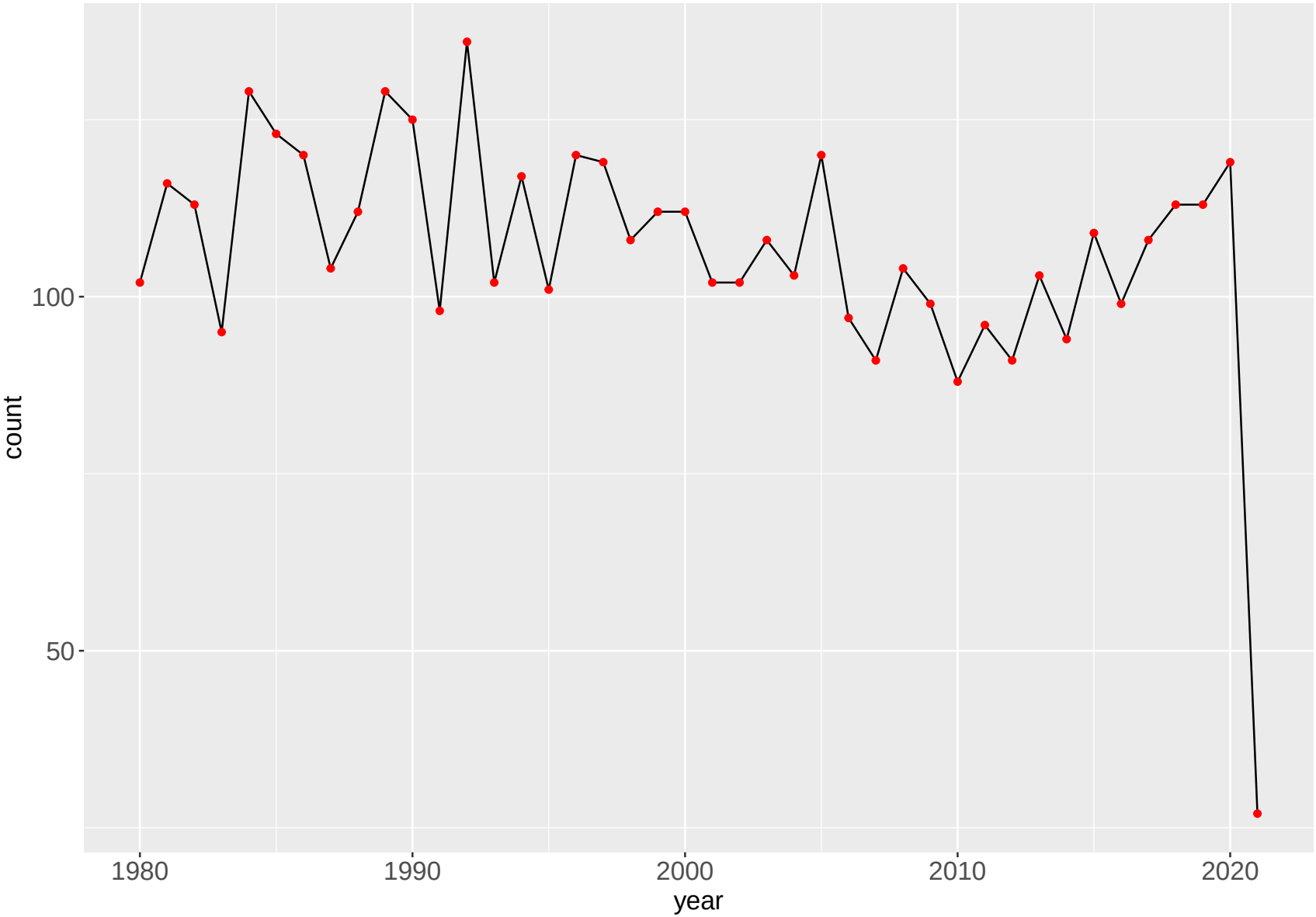
- contains the most complete global set of historical tropical cyclones;
- combines information from numerous tropical cyclone datasets;
- simplifies inter-agency comparisons by providing storm data from multiple sources in one place;
- combines recent and historical storm data in one dataset.

Read IBTrACS Data into R

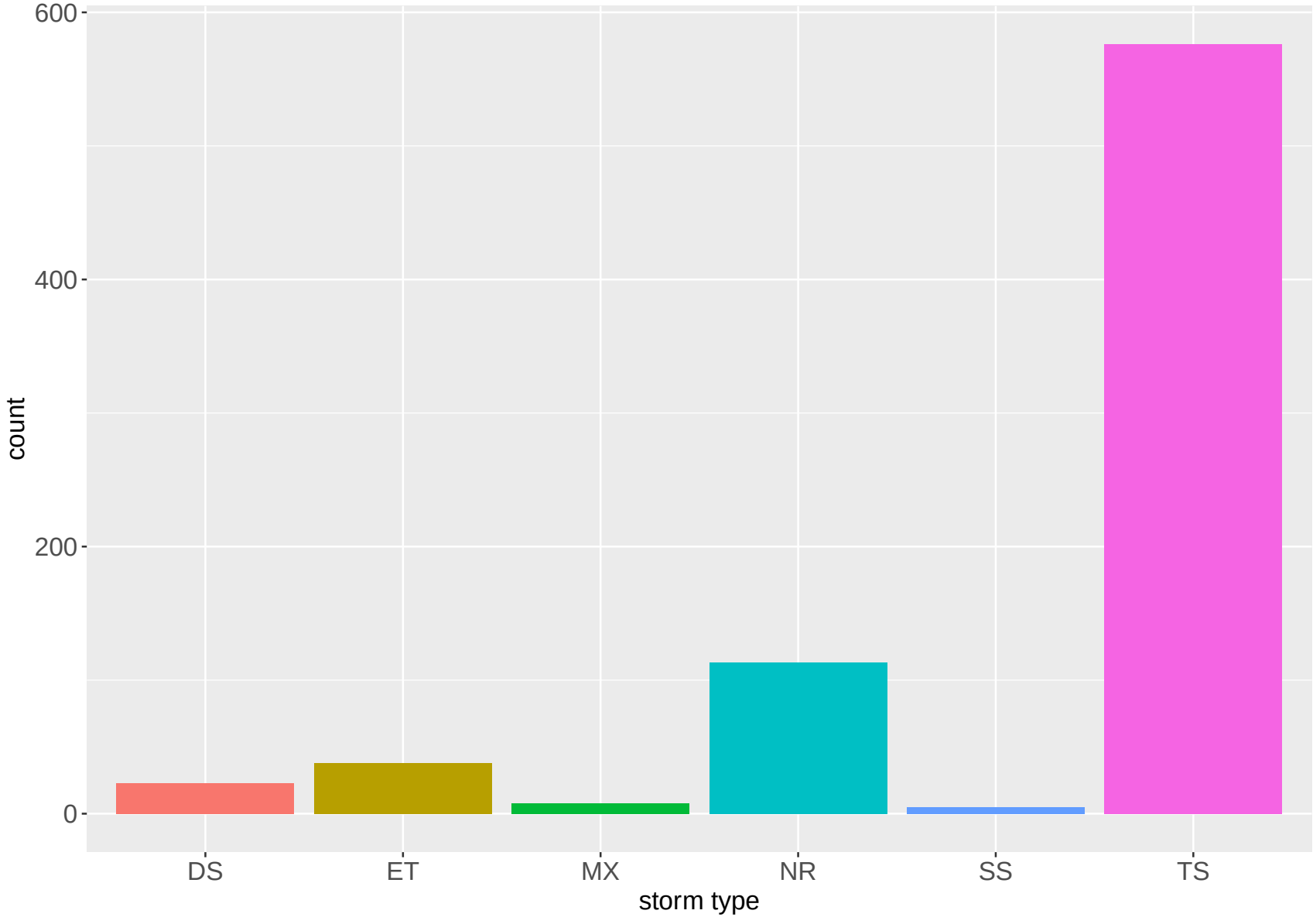
```
library(ggplot2)
library(plyr)
library(ncdf4)
storms = nc_open("IBTrACS.since1980.v04r00.nc")
name = ncvar_get(storms, "name")
season = ncvar_get(storms, "season")
count = as.numeric(table(season))
year = as.numeric(names(table(season)))
Lat = ncvar_get(storms, "lat")
Lon = ncvar_get(storms, "lon")
nature = ncvar_get(storms, "nature")
basin = ncvar_get(storms, "basin")
## Maximum sustained wind speed
mws = ncvar_get(storms, "wmo_wind") * 0.514  # kt to m/s
## Minimum central pressure
mcp = ncvar_get(storms, "wmo_pres")
nc_close(storms)
```

Storm Counts

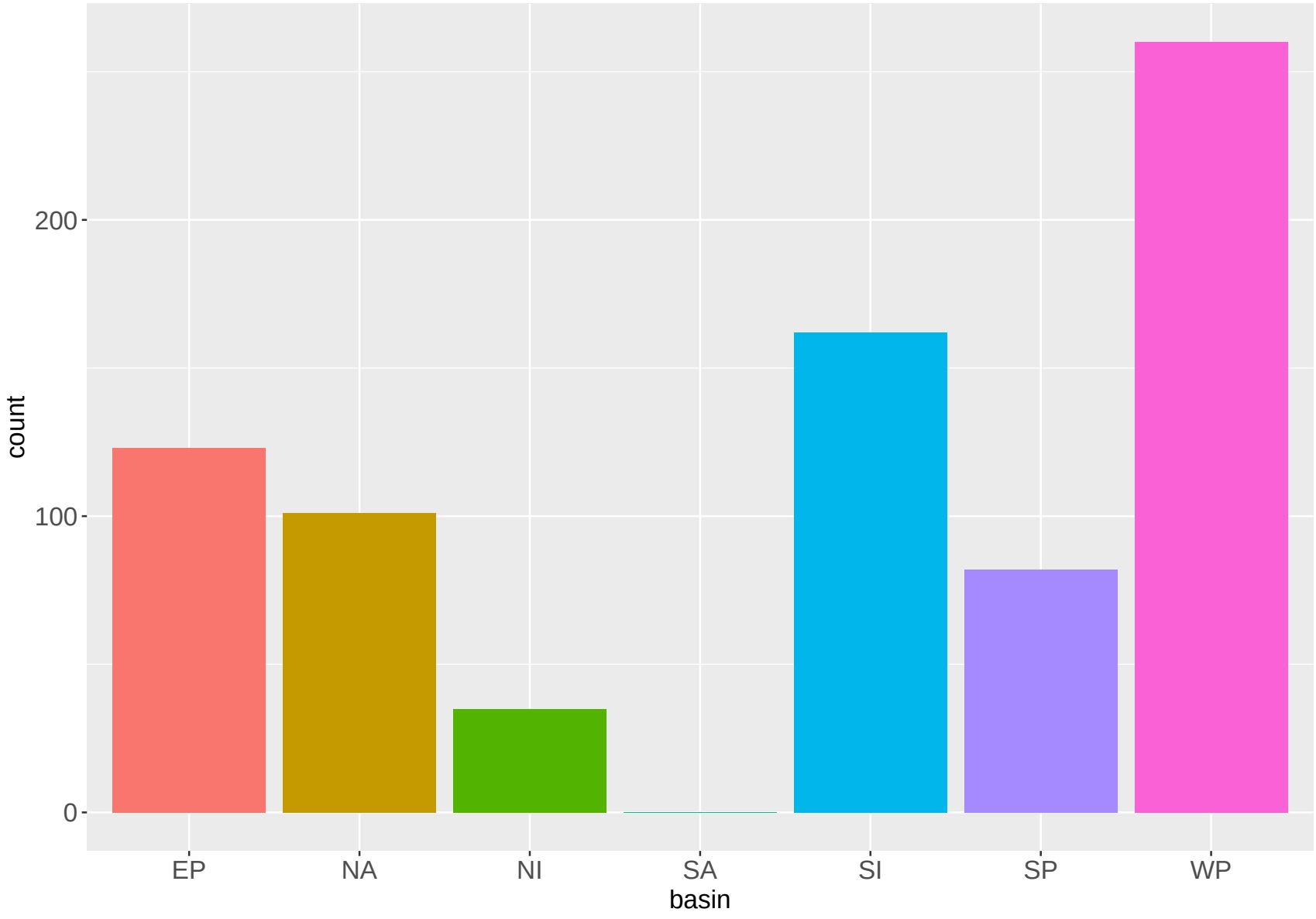
- How to model storm counts across year?



Storm Types



Storms per Basin



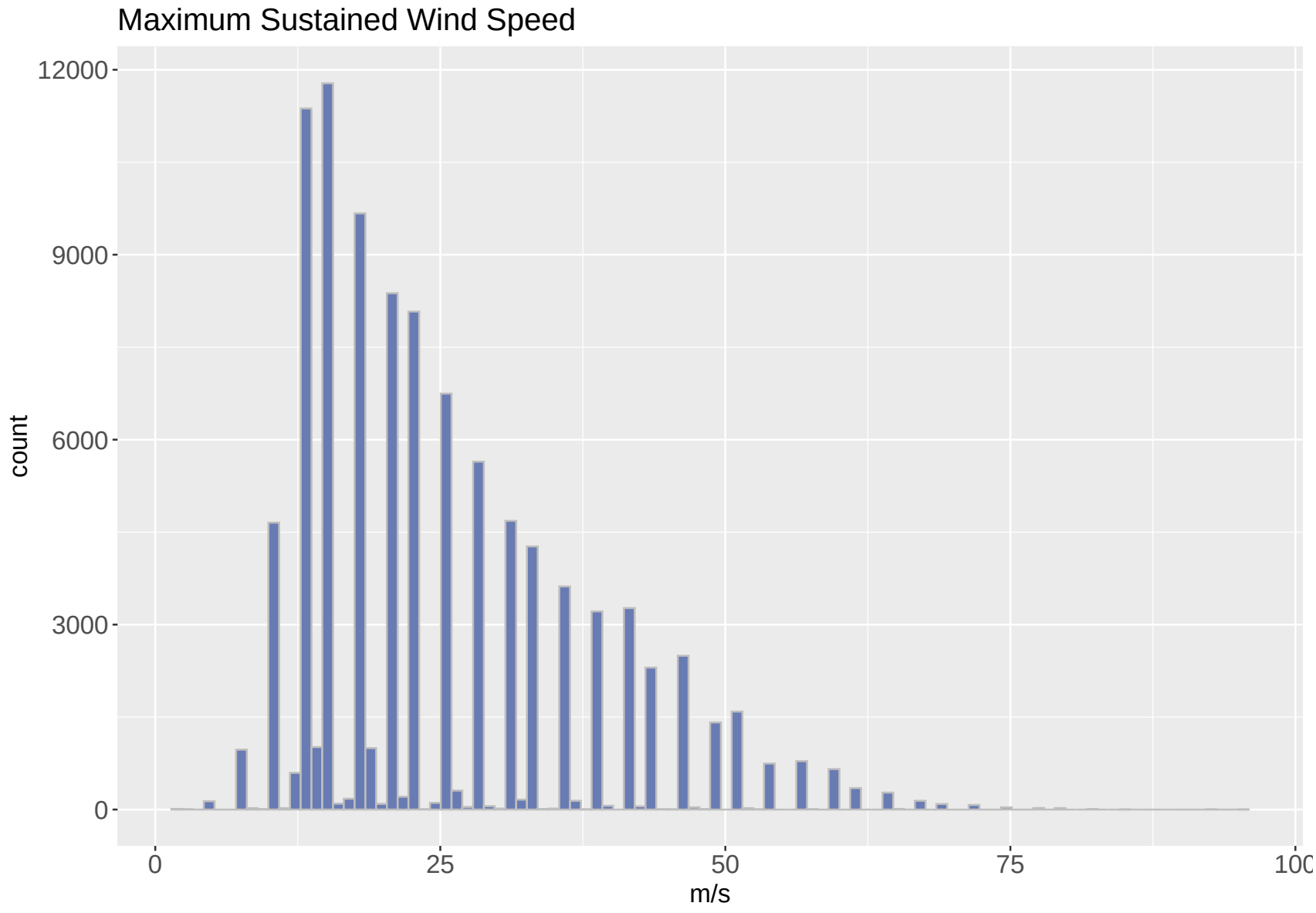
Maximum Sustained Wind Speed

The maximum sustained wind speeds for tropical cyclones are the highest surface winds occurring within the circulation of the system.

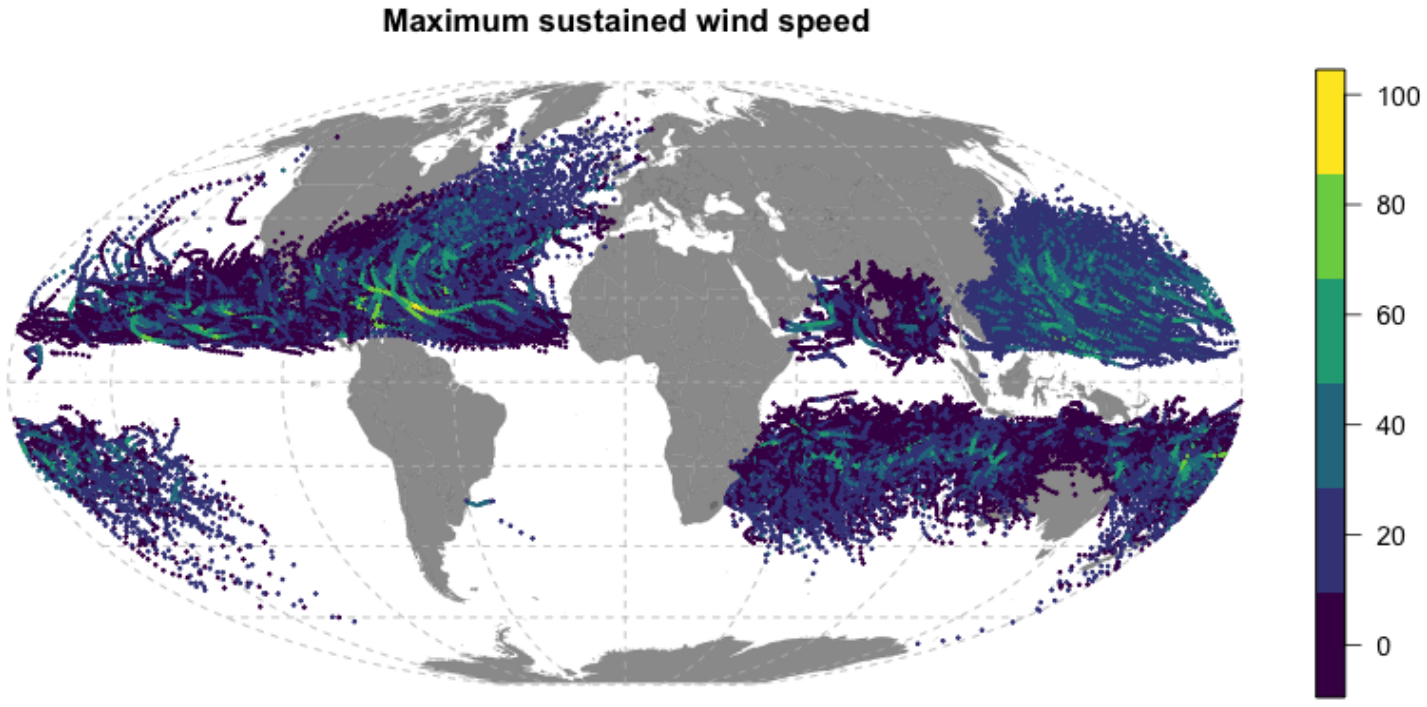
- spatial resolution: 0.1° (~10km)
- temporal resolution: 6 hours
- coverage: 70° N to 70° S and 180° W to 180° E, 1841-present

Histogram of MWS: 1980 - 2021

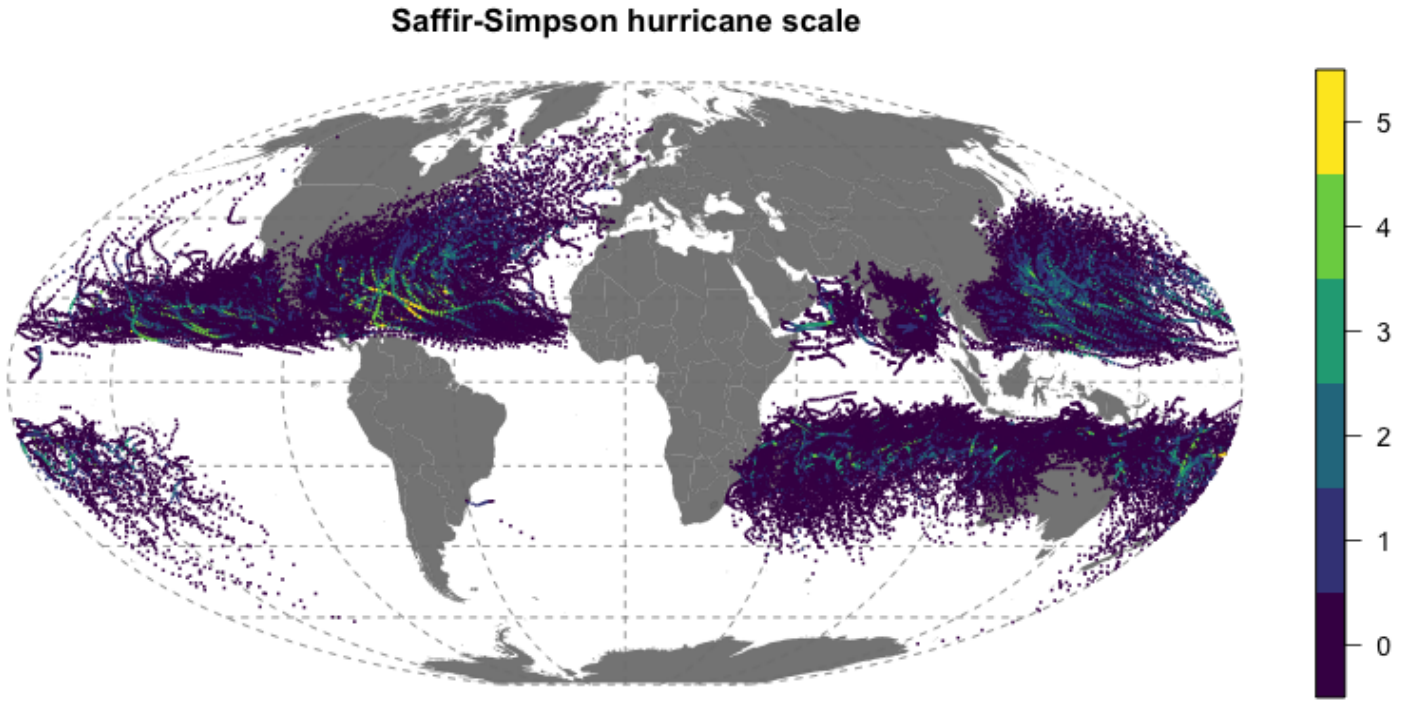
- How to model the distribution of MWS?



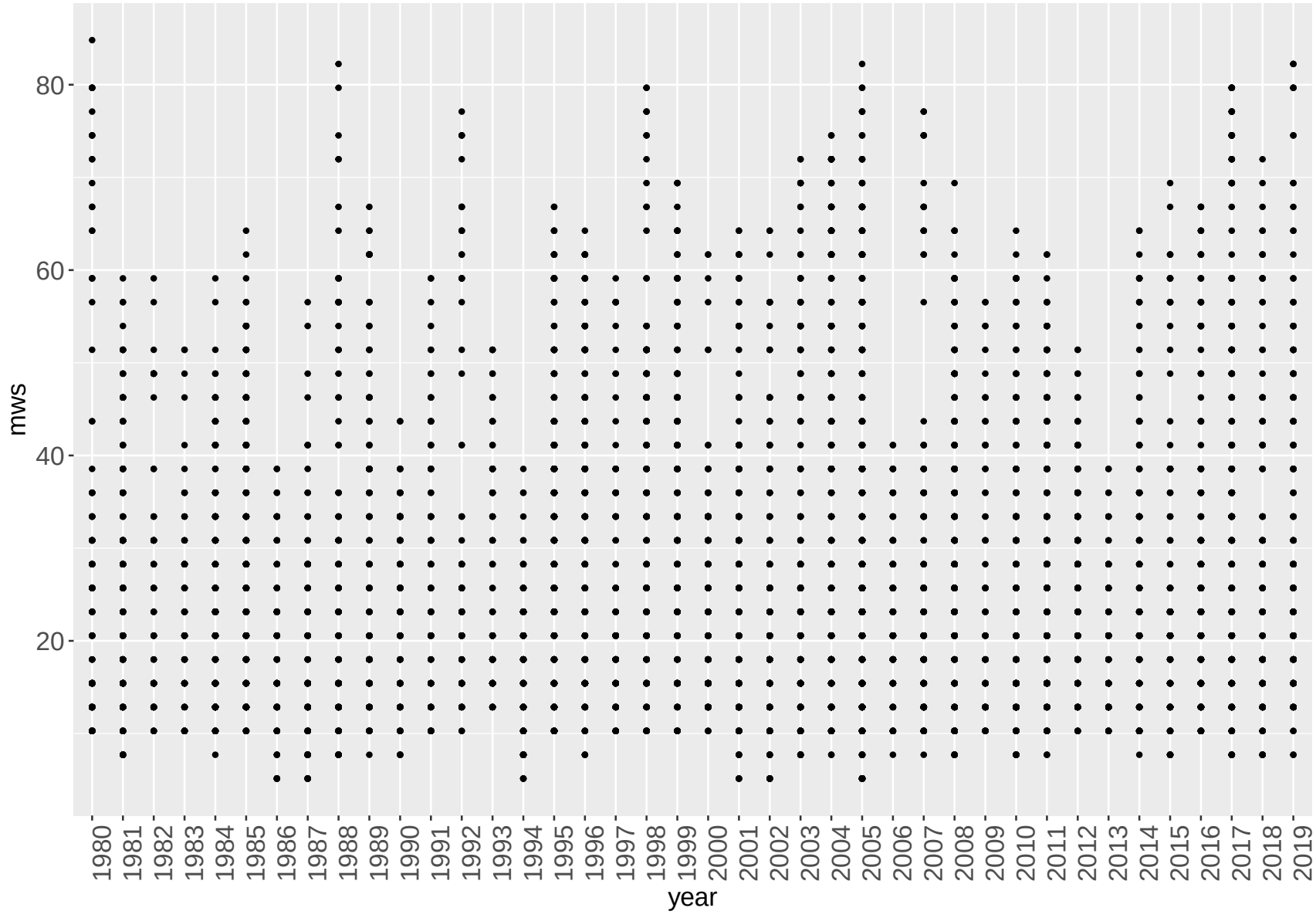
Global Map of MWS: 1980 - 2021



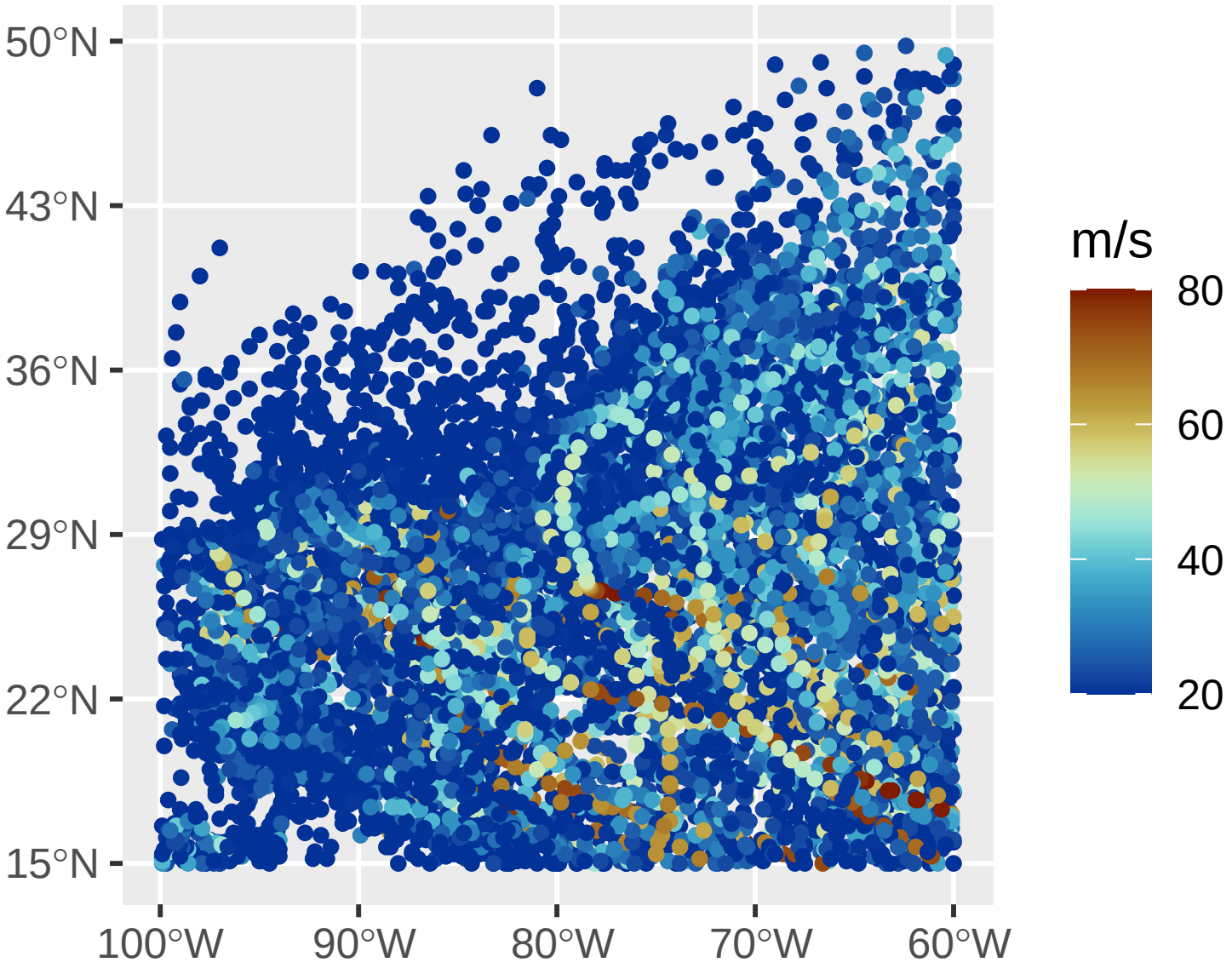
Global Map of SSHS: 1980 - 2021



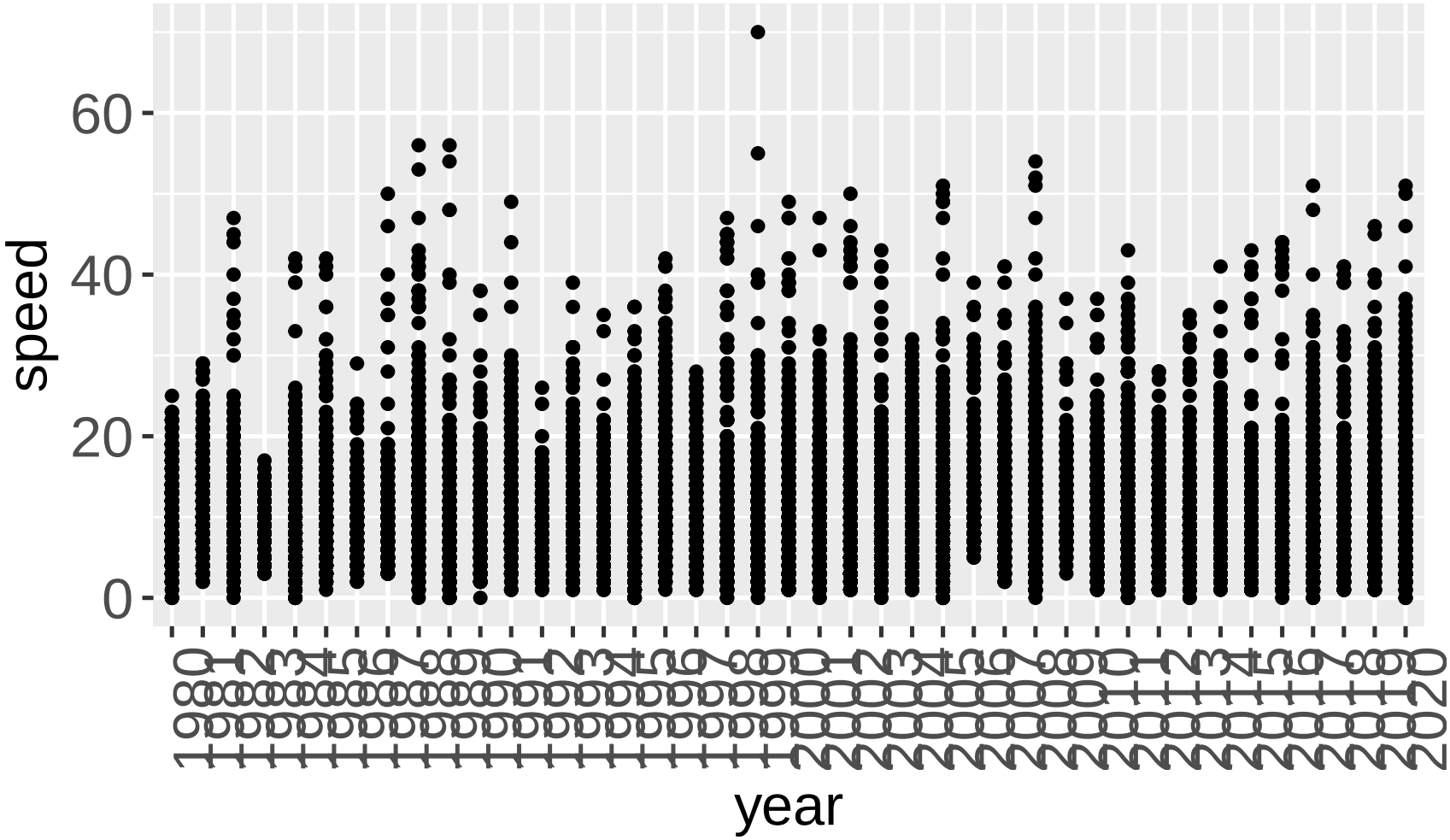
MWS against Year over North Atlantic



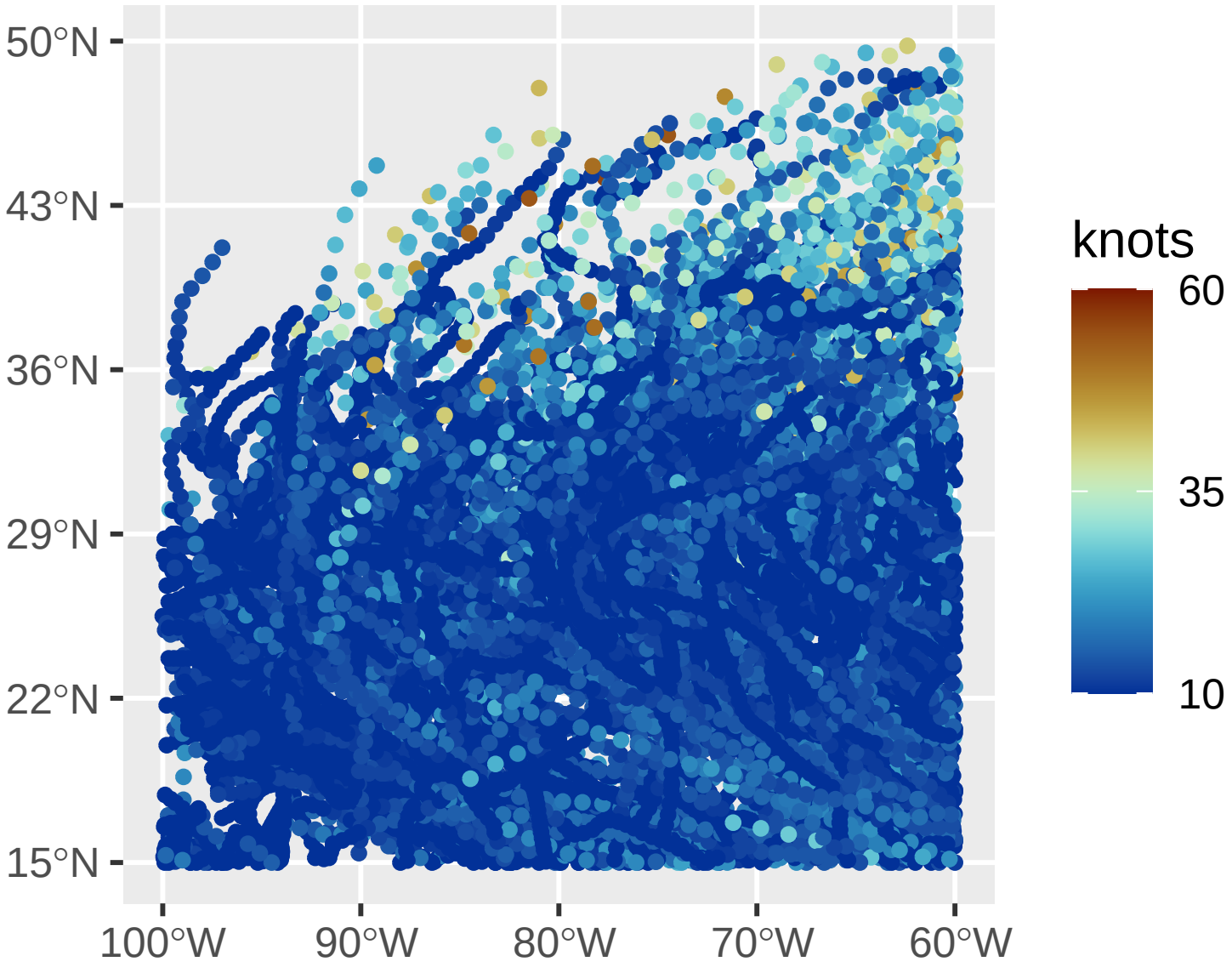
Spatial Map of MWS over North Atlantic



Forward Speed against Year over North Atlantic



Spatial Map of Forward Speed over North Atlantic



Scientific Questions

What are the scientific questions that can be addressed?

- How do we model the number of storms per year?
- How do we model the spatial/temporal distribution of the MWS?
- How do we model the hurricane intensity?
- ...