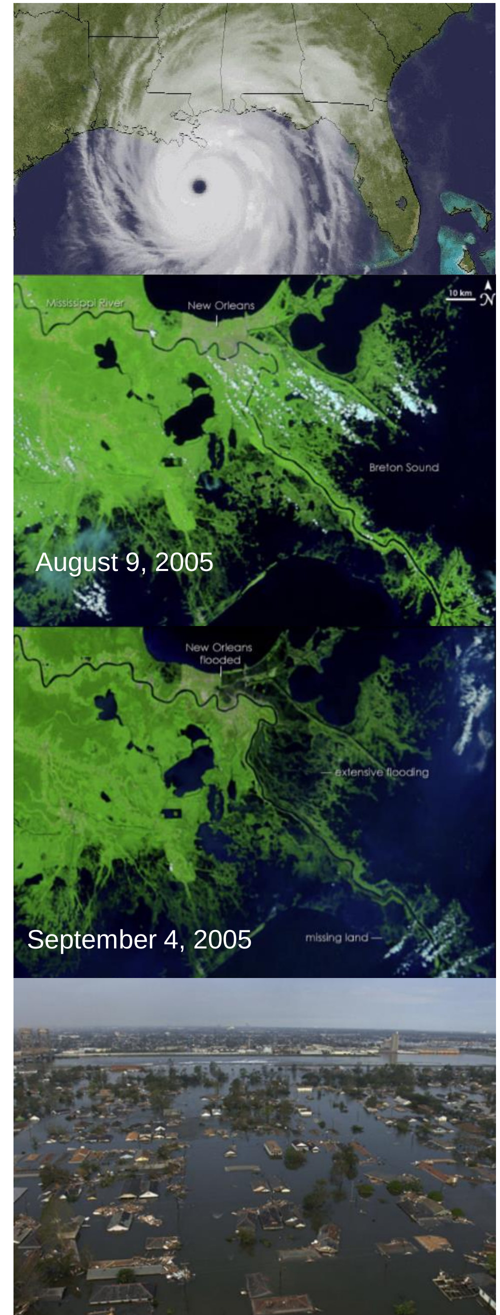
Forests Disturbances Drive Changes in Biogeochemical Climate Feedbacks

… could we model those disturbances?



Robinson Negron-Juarez

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MARDI GRAS
NEW ORLEANS
2020
Mardi Grass, February 25 2020

Forests Disturbances Drive Changes in Biogeochemical Climate Feedbacks

GEOPHYSICAL RESEARCH LETTERS, VOL. 35, L23401, doi:10.1029/2008GL035683, 2008

Hurricane driven changes in land cover create biogeophysical climate feedbacks

Robinson I. Negrón Juárez,[1] Jeffrey Q. Chambers,[1] Hongcheng Zeng,[1] and David B. Baker[1]

Disturbance from hurricanes:

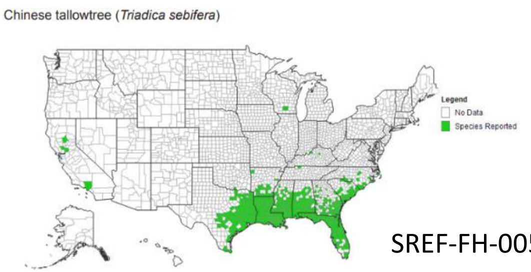
- ❖ Vegetation
- ❖ Topography
- ❖ Wind speed

Tropical storms: Hurricane/cyclones/typhoons :

- Produce mortality of hundreds of million of trees.

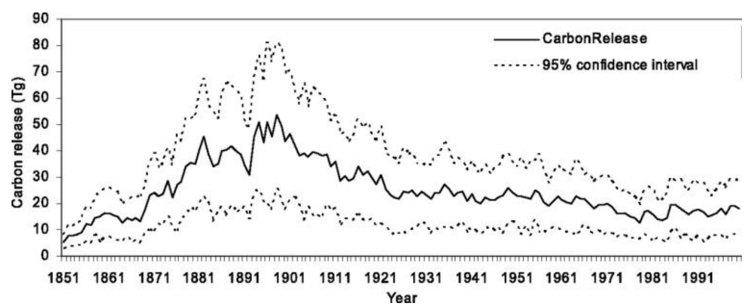
Hurricane Katrina: 320 M trees Chambers et al. *Science*, 2007 (10.1126/science.1148913)

- Bio-geophysical/chemical & forest composition changes.



SREF-FH-005 November 2016

- Large source of CO_2 emission to the atmosphere (~ tents of Tg C).



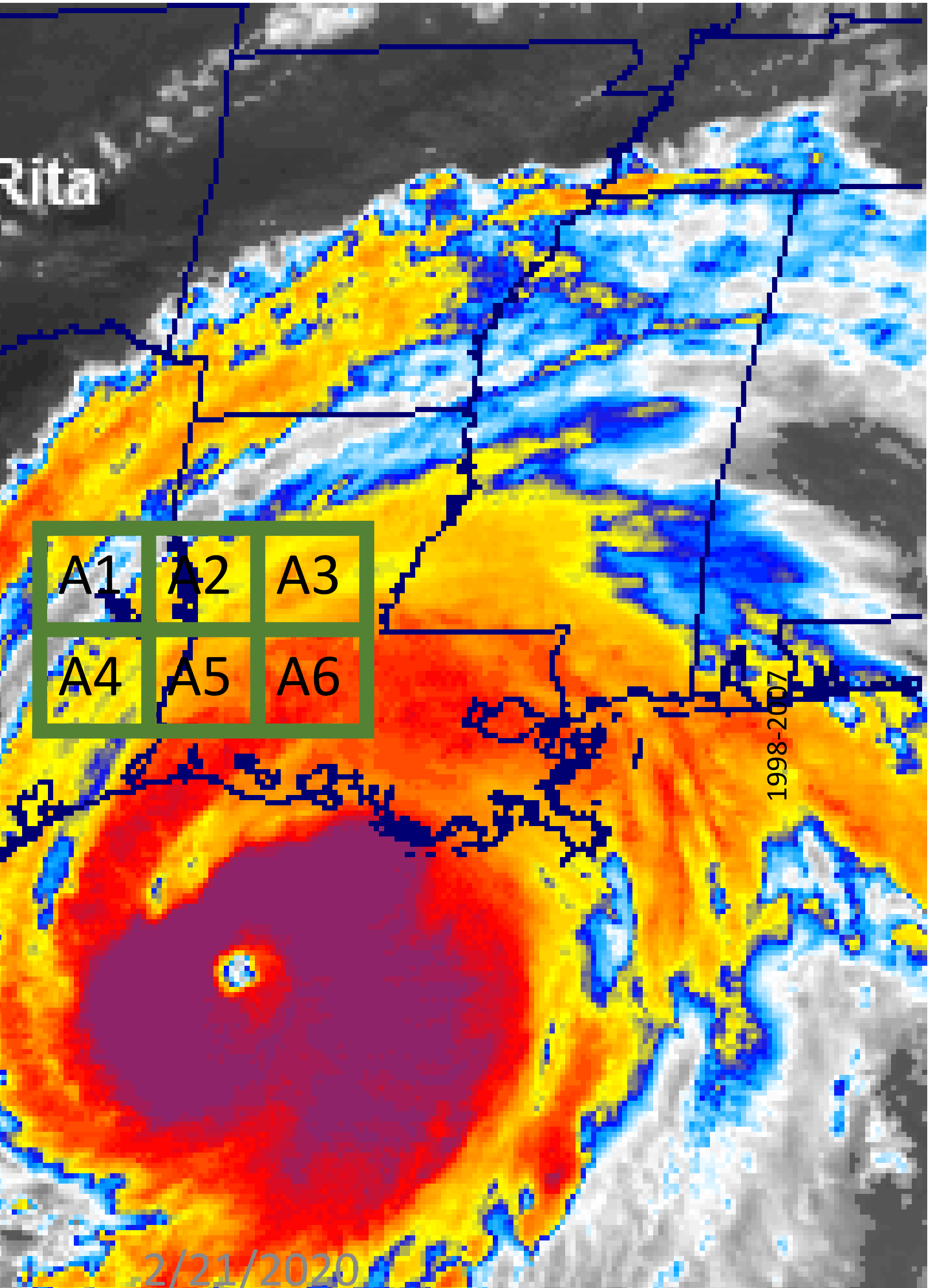
Zeng et al. 2009, PNAS
https://doi.org/10.1073/pnas.0808914106

- Becoming more destructive

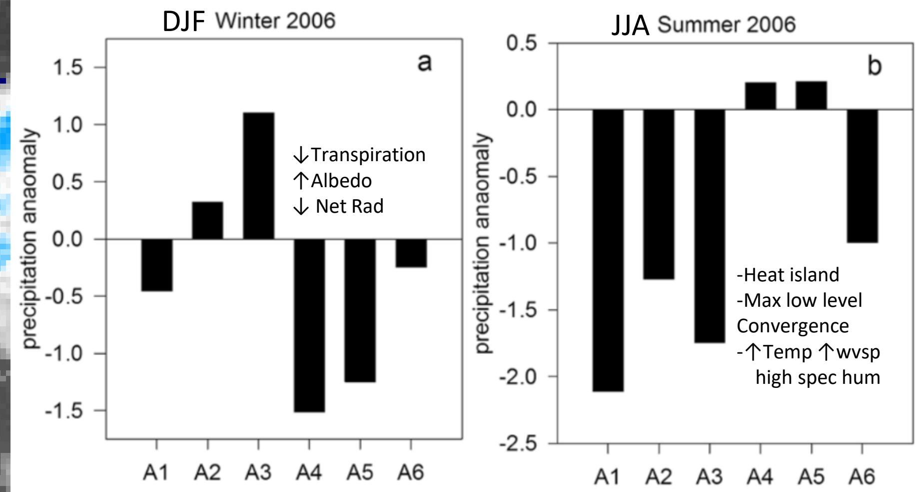
M. Uriarte et al. *Nature Comm*, 2019
https://doi.org/10.1038/s41467-019-09319-2

C. Patricola & M. Wehner, *Nature*, 2018
https://doi.org/10.1038/s41586-018-0673-2

Vegetation



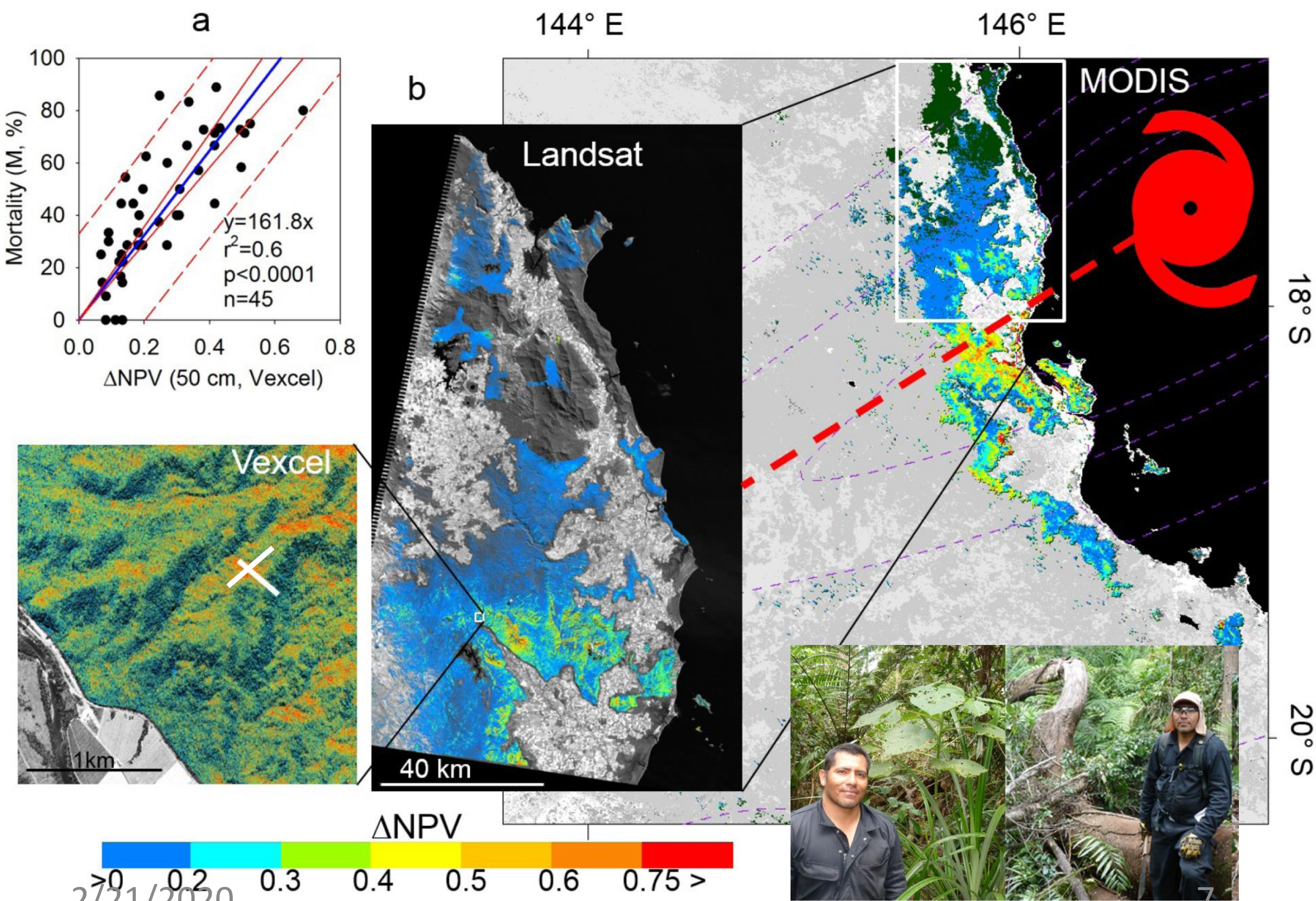
24 September 2005



Biogeophysical effects: decrease in precipitation the following winter, and an increase during the subsequent summer season.

Biogeochemical effects: Committed carbon emission of 48 Tc C (32-43% net annual US carbon sink).

Negron-Juarez et al. GRL 2008
https://doi.org/10.1029/2008GL035683



a
Mortality (M, %)
100
80
60
40
20
0
0.0
0.2
0.4
0.6
0.8
ΔNPV (50 cm, Vexcel)
y=161.8x
r²=0.6
p<0.0001
n=45
b
144° E
146° E
18° S
20° S
Landsat
MODIS
Vexcel
1km
40 km
ΔNPV
>0
0.2
0.3
0.4
0.5
0.6
0.75 >

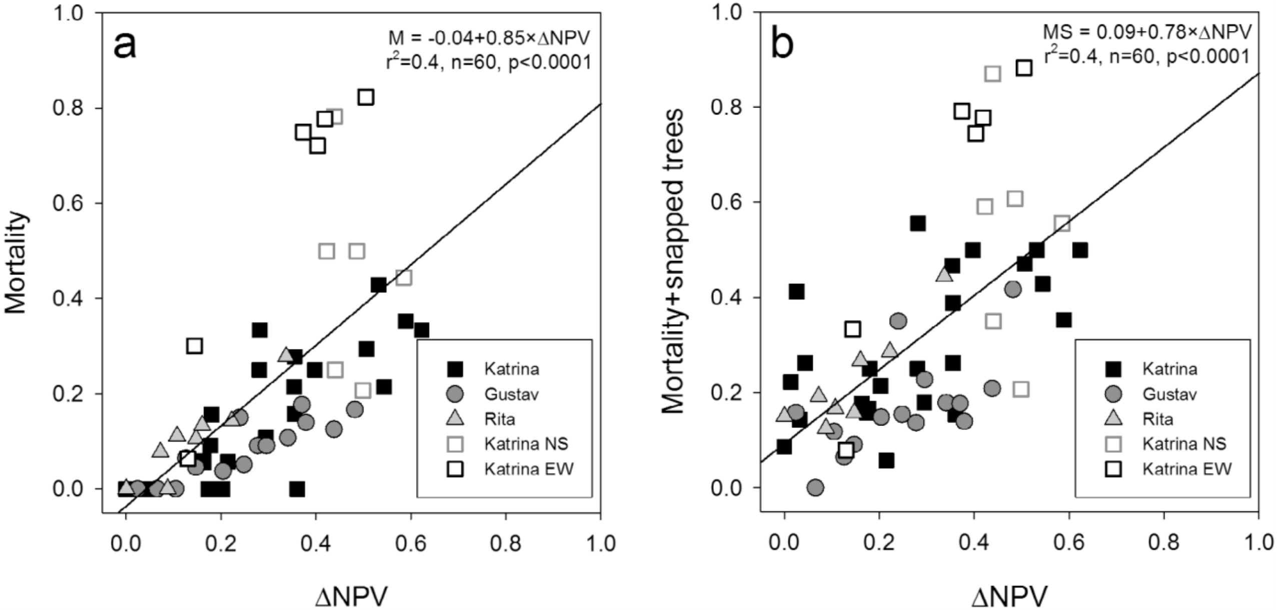
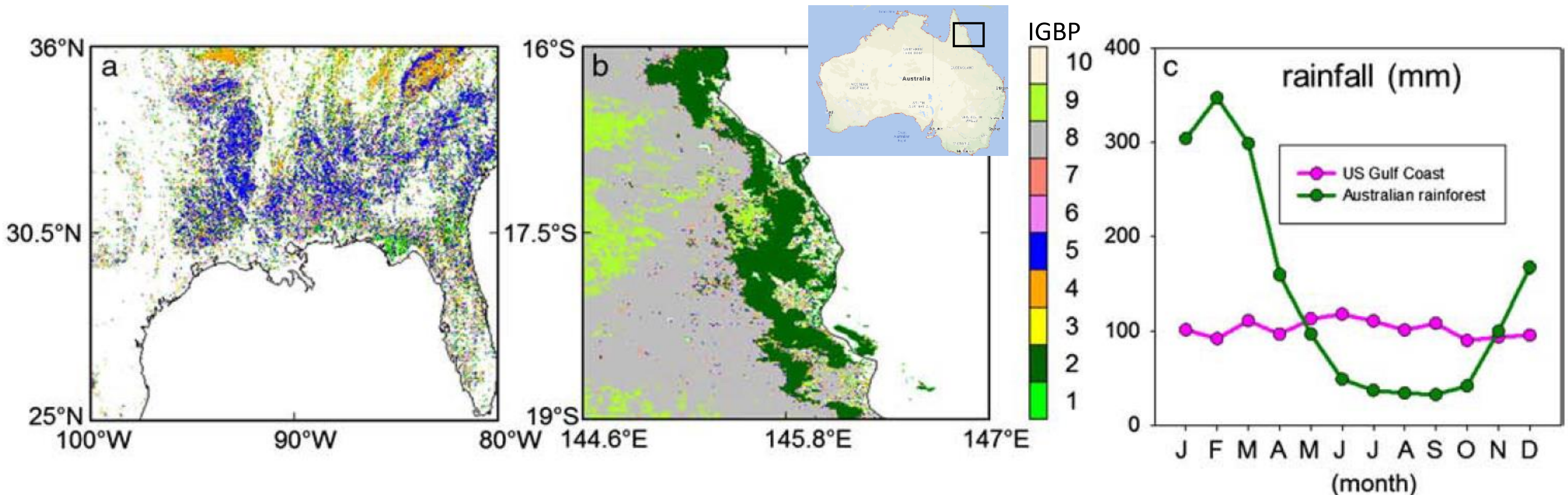


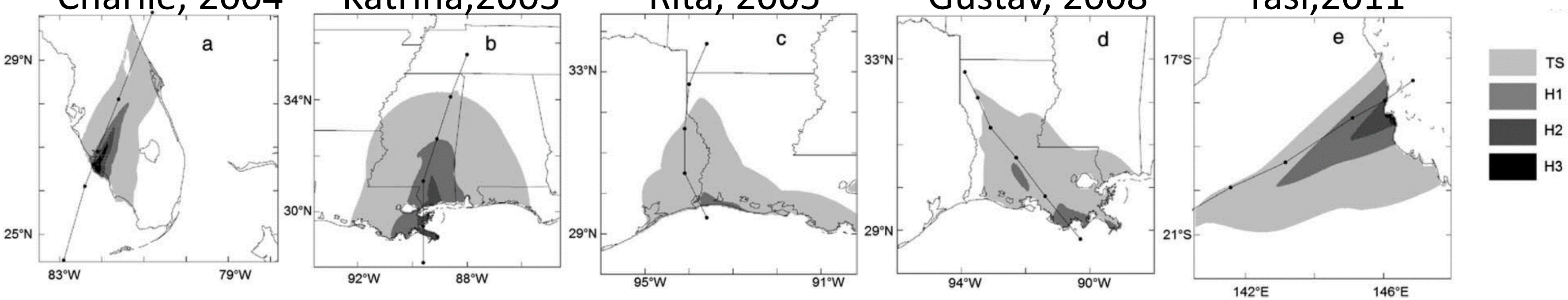
Figure 2. (a) Tree mortality and (b) tree disturbance (mortality plus snapped trees) rates from 60 plots located at different study areas (Figure 1) and Landsat-derived ΔNPV.

Assessments of large-scale disturbance produced by hurricanes in forest ecosystems.

Negron-Juarez et al. JGR-B 2010
https://doi.org/10.1029/2009JG001221



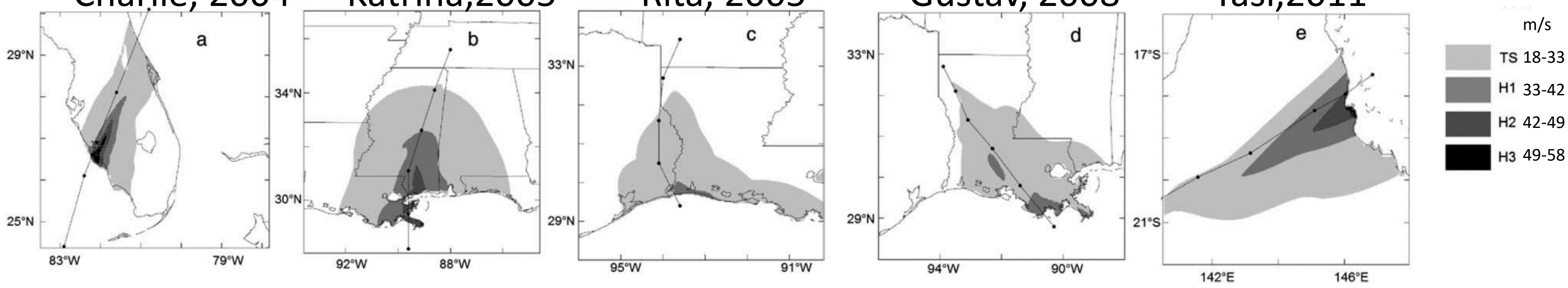
Charlie, 2004 Katrina,2005 Rita, 2005 Gustav, 2008 Yasi,2011



(MCD12Q1). 1: Evergreen needleleaf forest, 2: Evergreen broadleaf forest, 3: Deciduous needleleaf forest, 4: Deciduous broadleaf forest, 5: Mixed forest, 6: Closed shrublands, 7: Oper shrublands, 8: Woody savanna, 9: Savannas, 10: Grasslands. (c) Climatological precipitation (based period 1971–2000) in the study areas (areas encompassed in a and b) using Global Precip

Negron-Juarez et al, RSE 2014
https://doi.org/10.1016/j.rse.2013.09.028

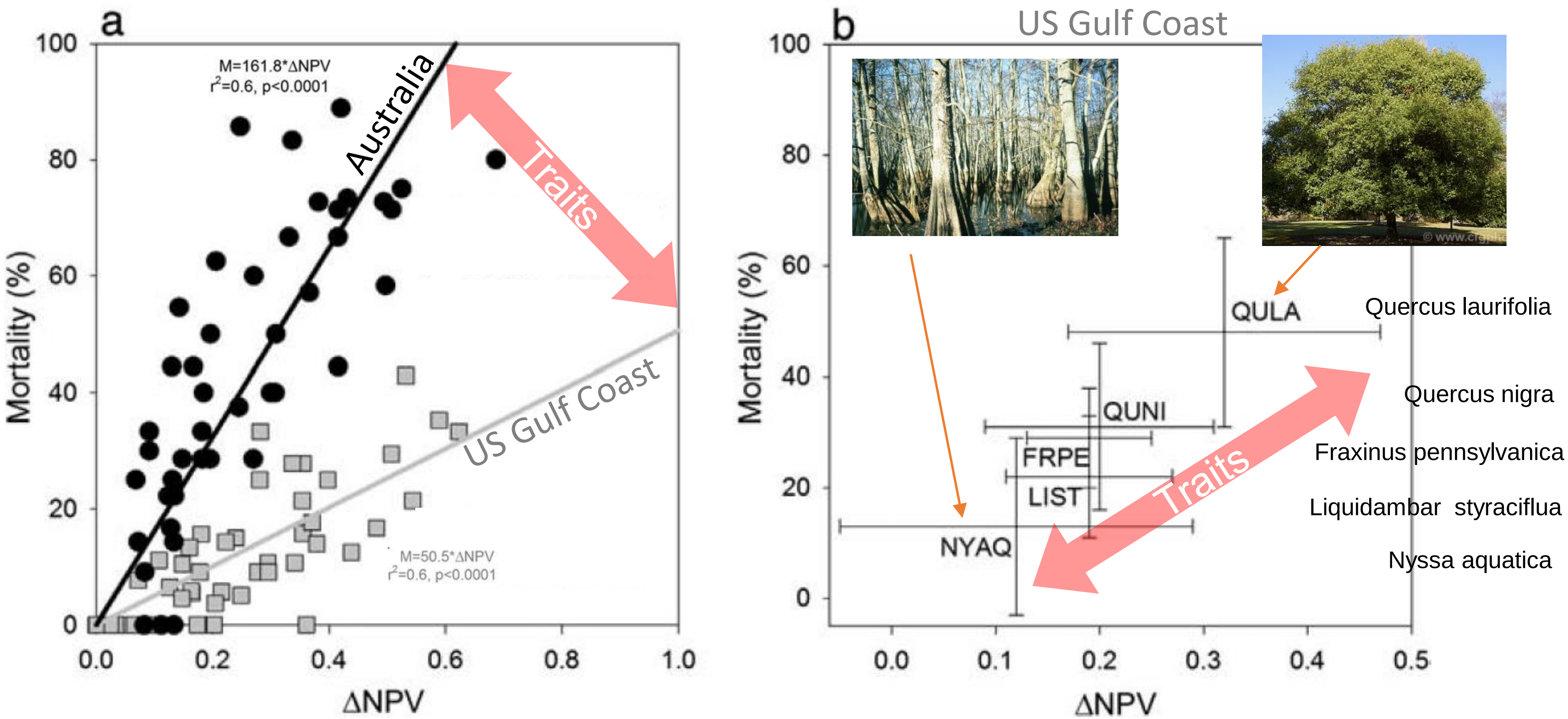
Charlie, 2004 Katrina,2005 Rita, 2005 Gustav, 2008 Yasi,2011



Katrina,2005

Yasi,2011

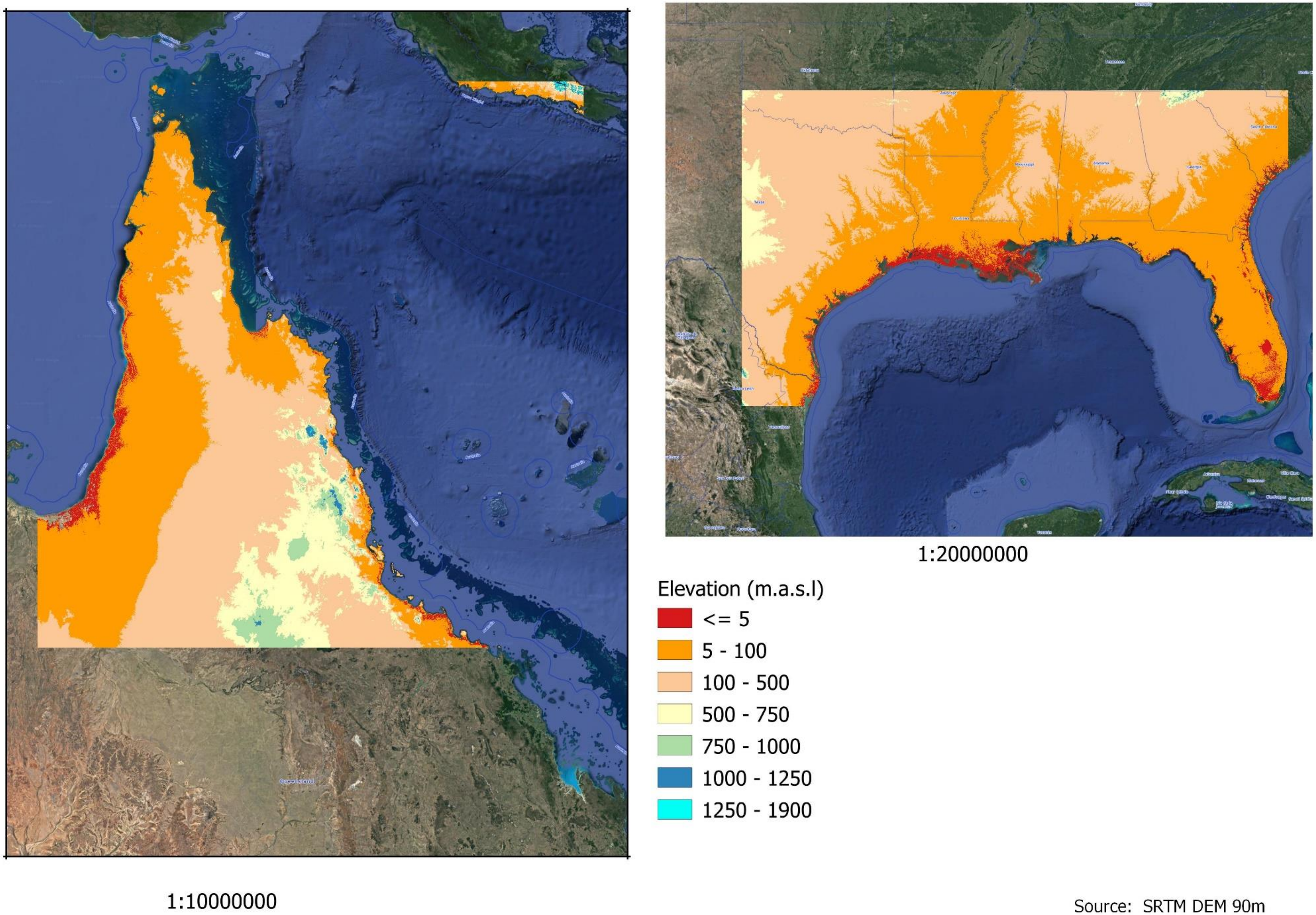
Negron-Juarez et al, RSE 2014
https://doi.org/10.1016/j.rse.2013.09.028



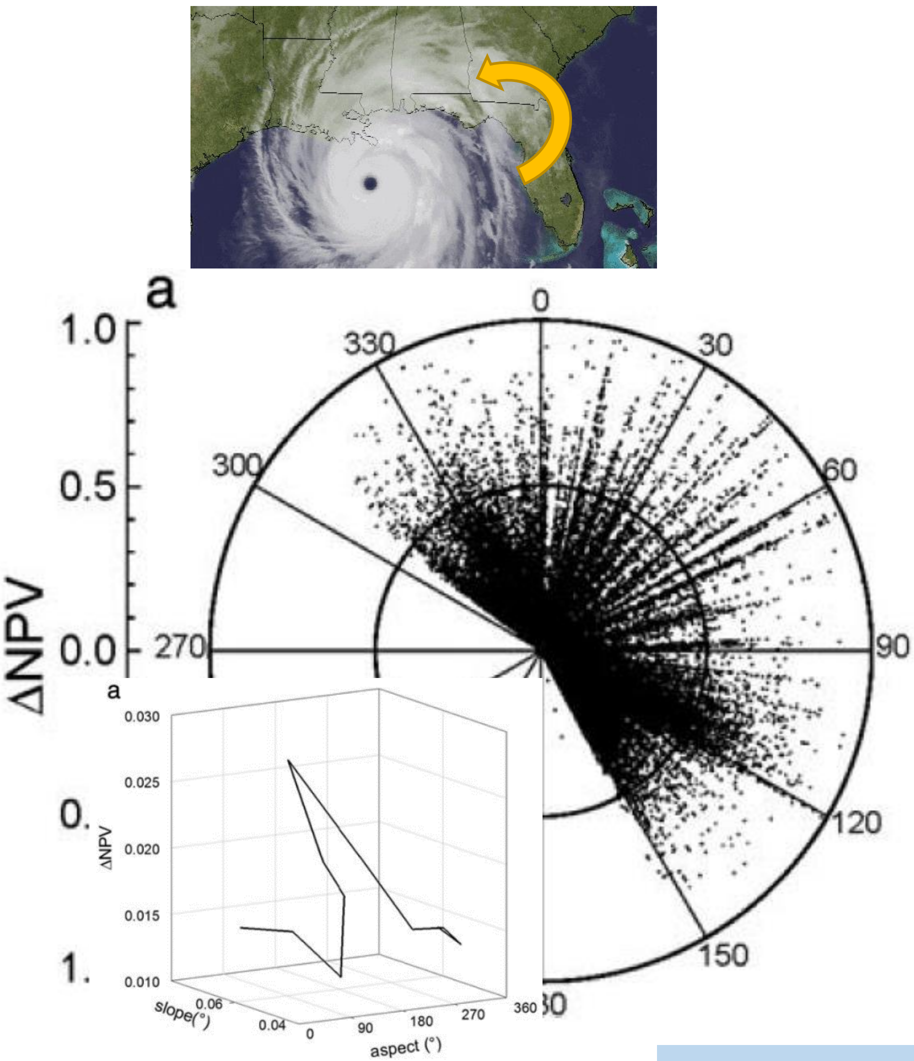
Negron-Juarez et al, RSE 2014

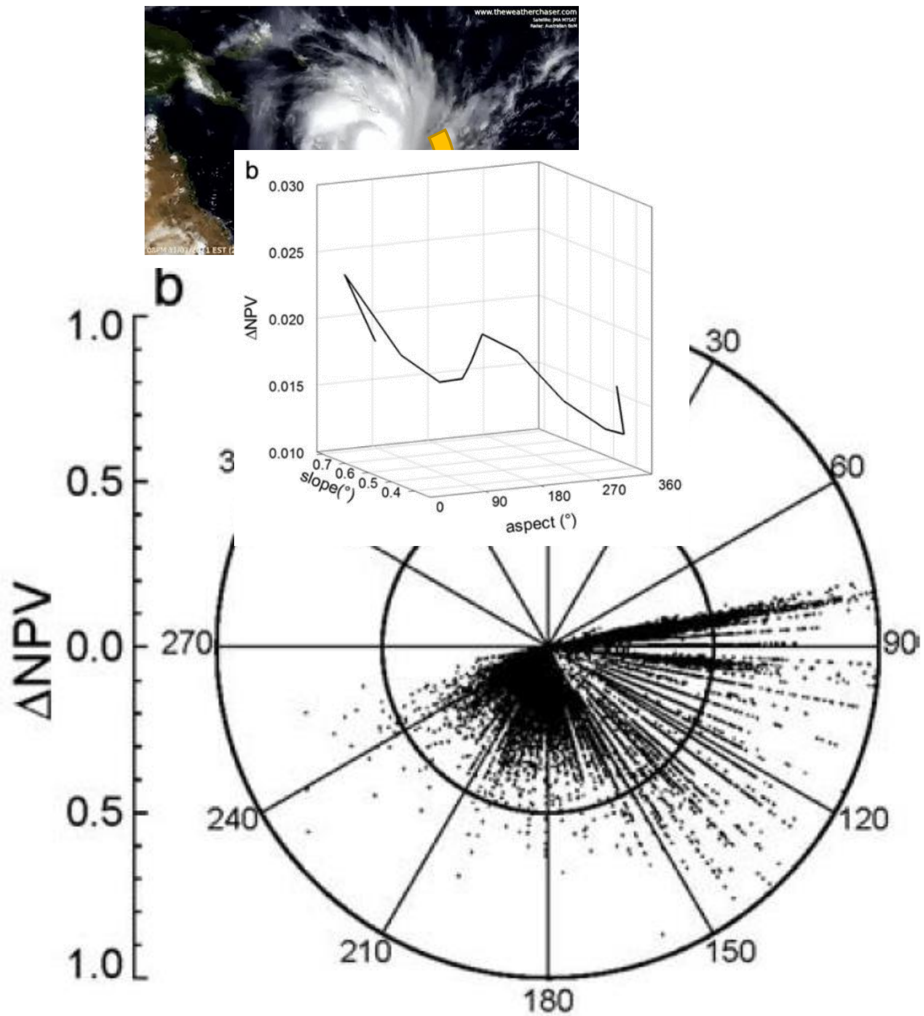
https://doi.org/10.1016/j.rse.2013.09.028

Topography



Source: SRTM DEM 90m





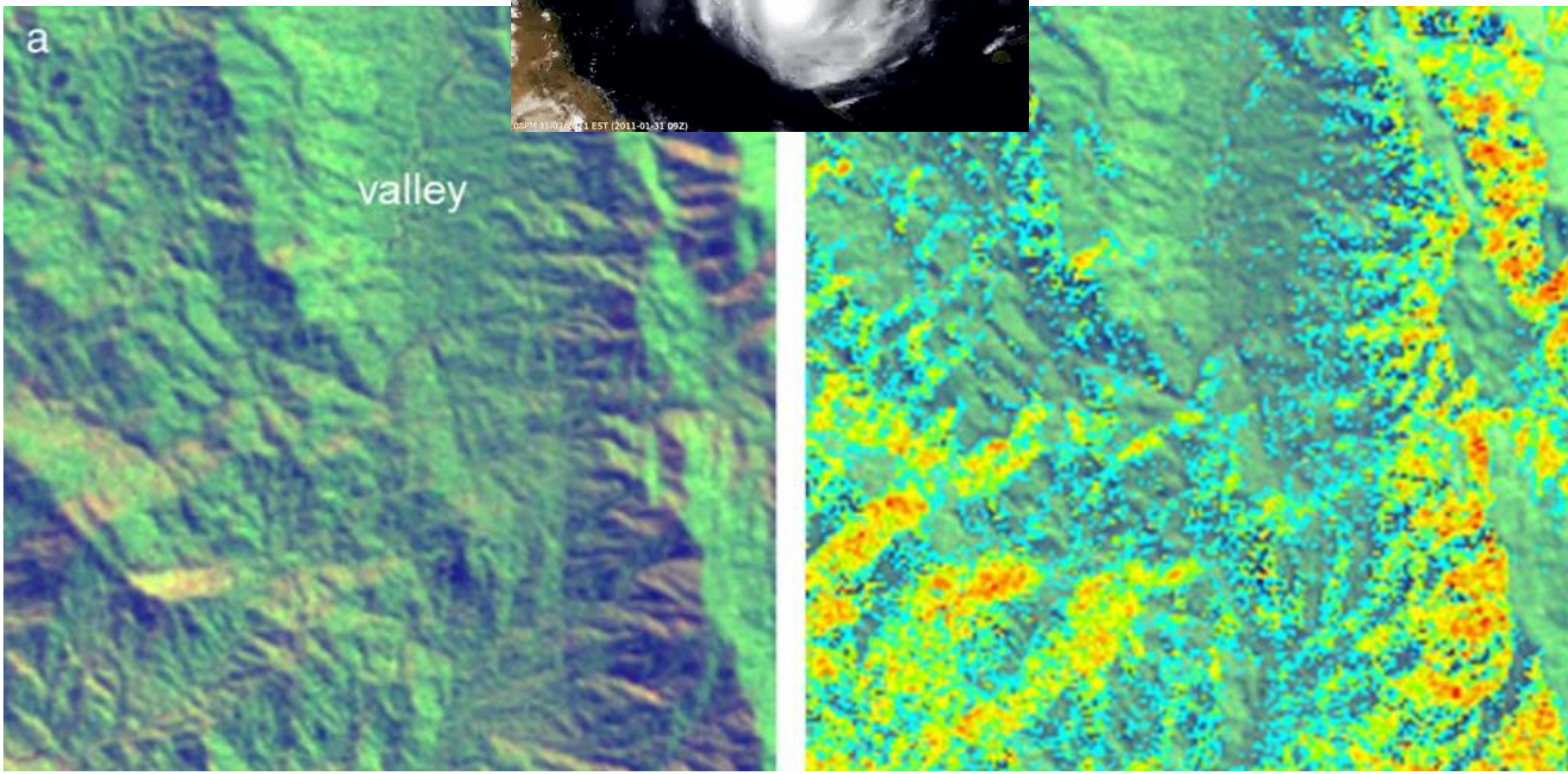
Slope and aspect matter

Katrina

Yasi

Negron-Juarez et al, RSE 2014

https://doi.org/10.1016/j.rse.2013.09.028



Negron-Juarez et al, RSE 2014
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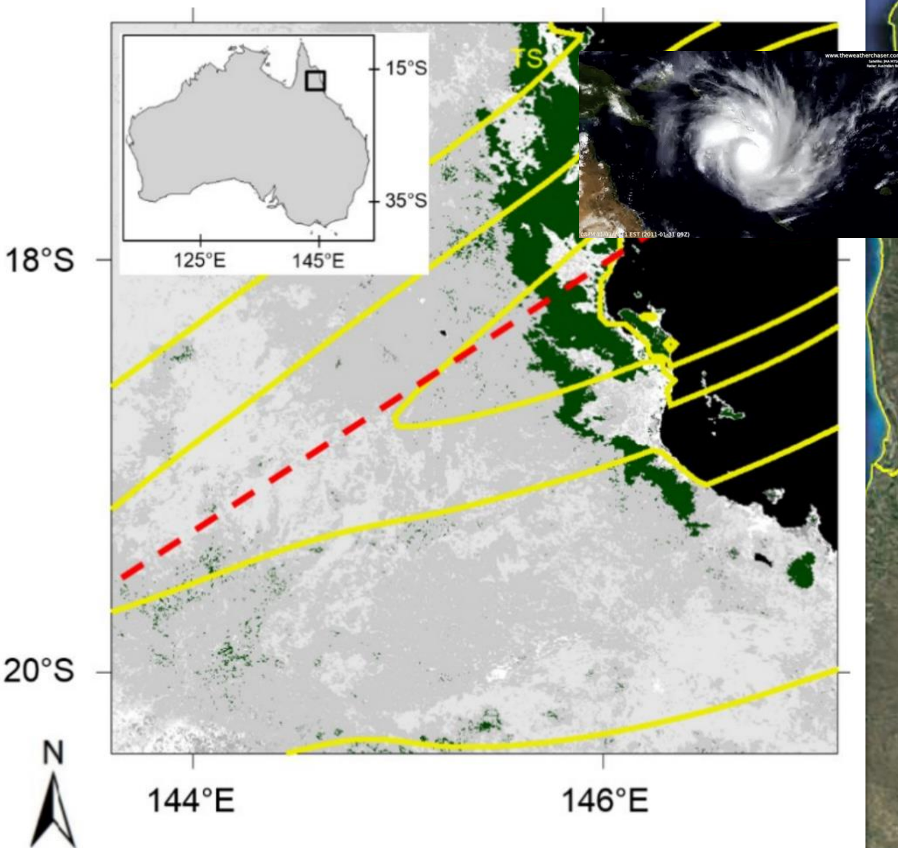
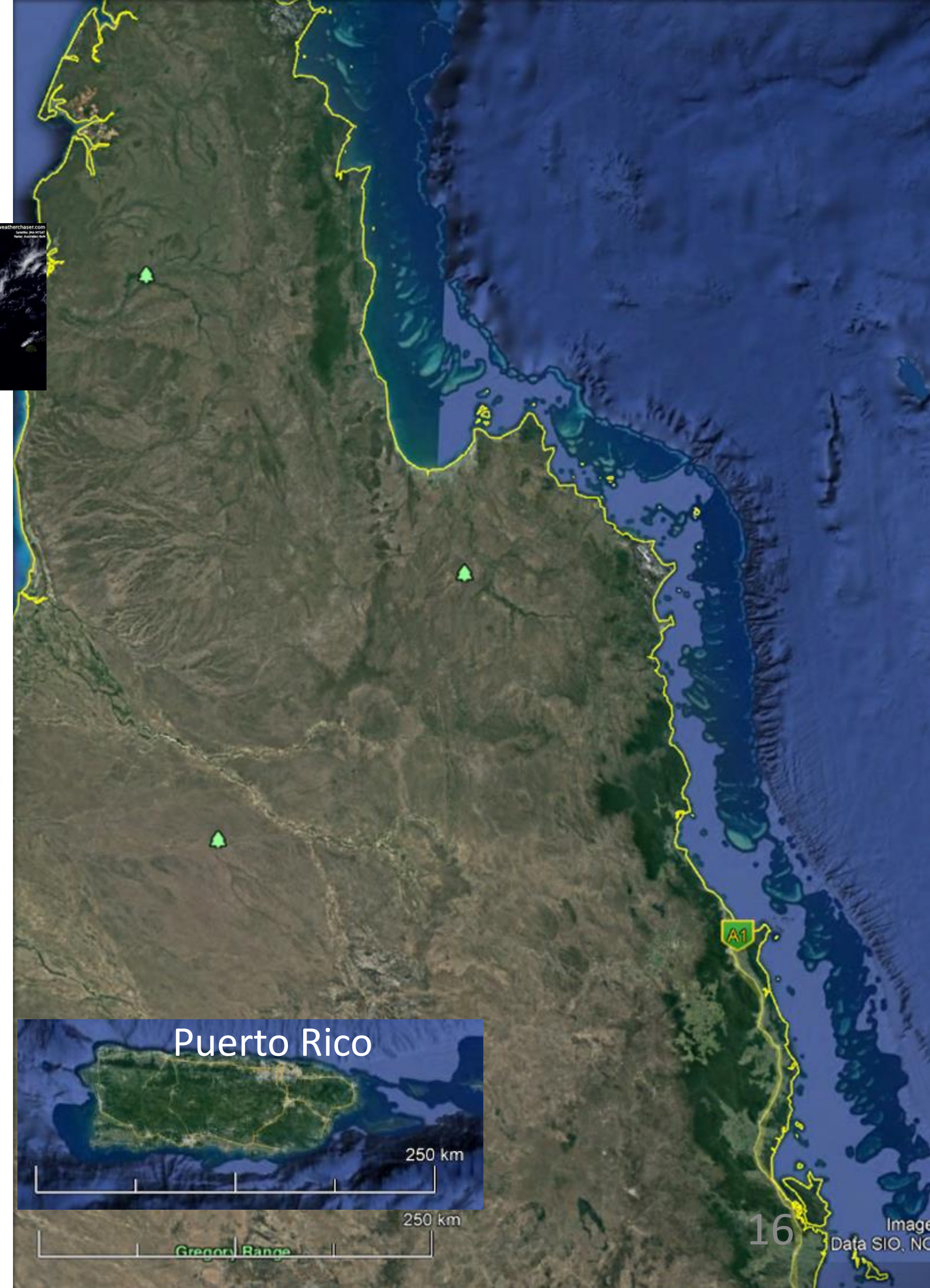
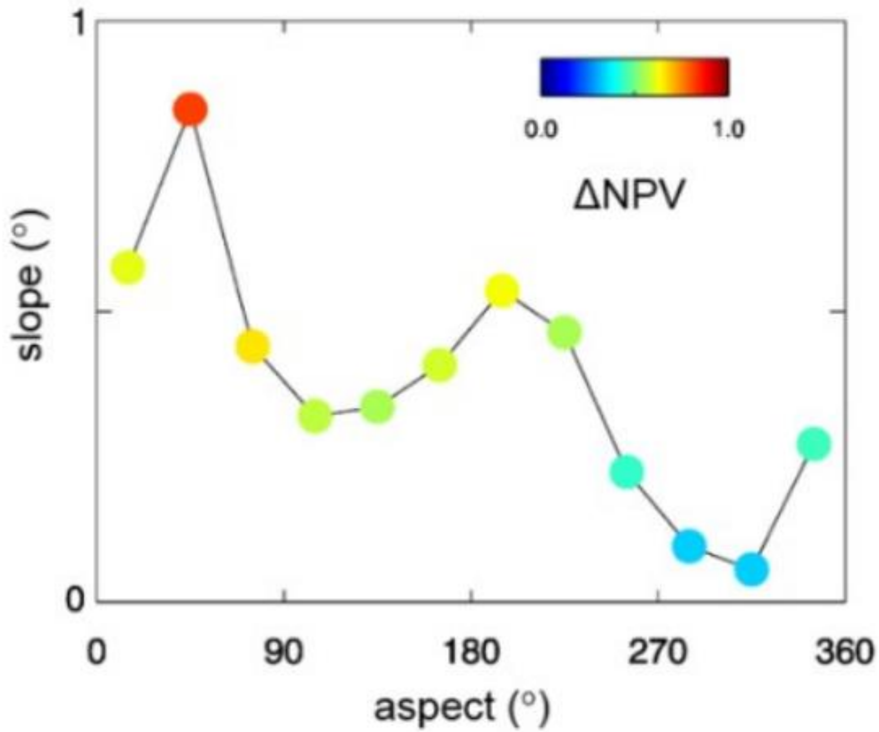
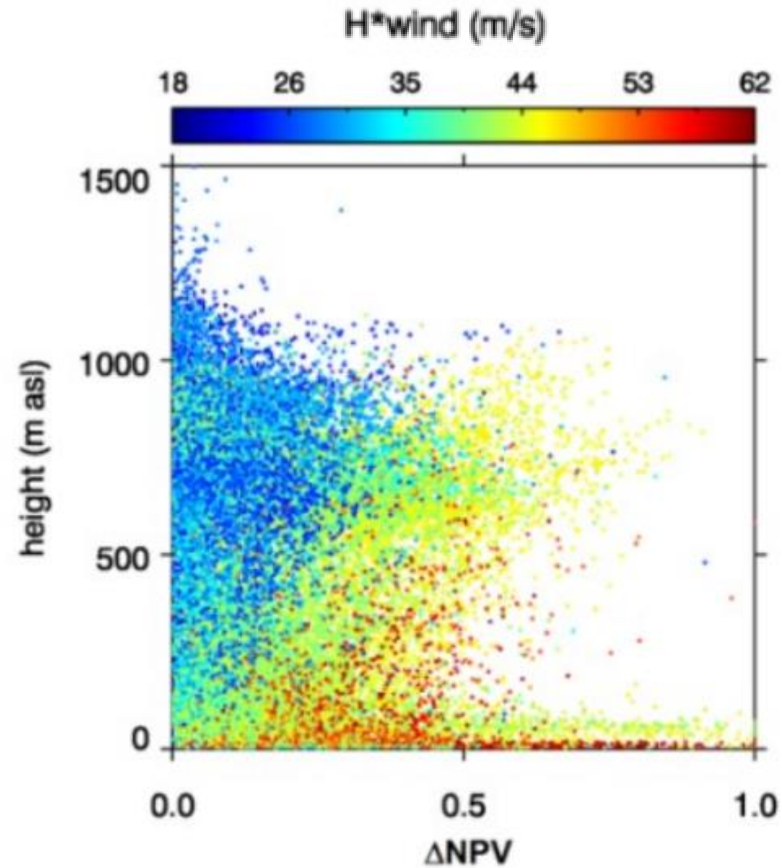




Negron-Juarez et al. Rem Sen 2014
https://doi.org/10.3390/rs6065633





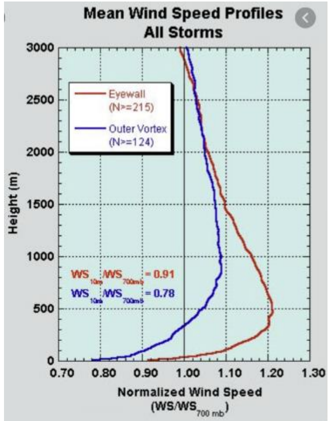
Negron-Juarez et al. Rem Sen 2014
https://doi.org/10.3390/rs6065633

- The highest level of forest disturbance occurred in forests along the path of the cyclone track (±30°).

- Disturbance decreased with decreasing slope and with an aspect facing off the track of the cyclone

- Disturbance increase with surface elevation was also observed.

- Complex terrain interactions act to speed up wind at higher elevations.



https://www.nhc.noaa.gov/aboutwindprofile.shtm

Negron-Juarez et al. Rem Sen 2014
https://doi.org/10.3390/rs6065633

Wind speed

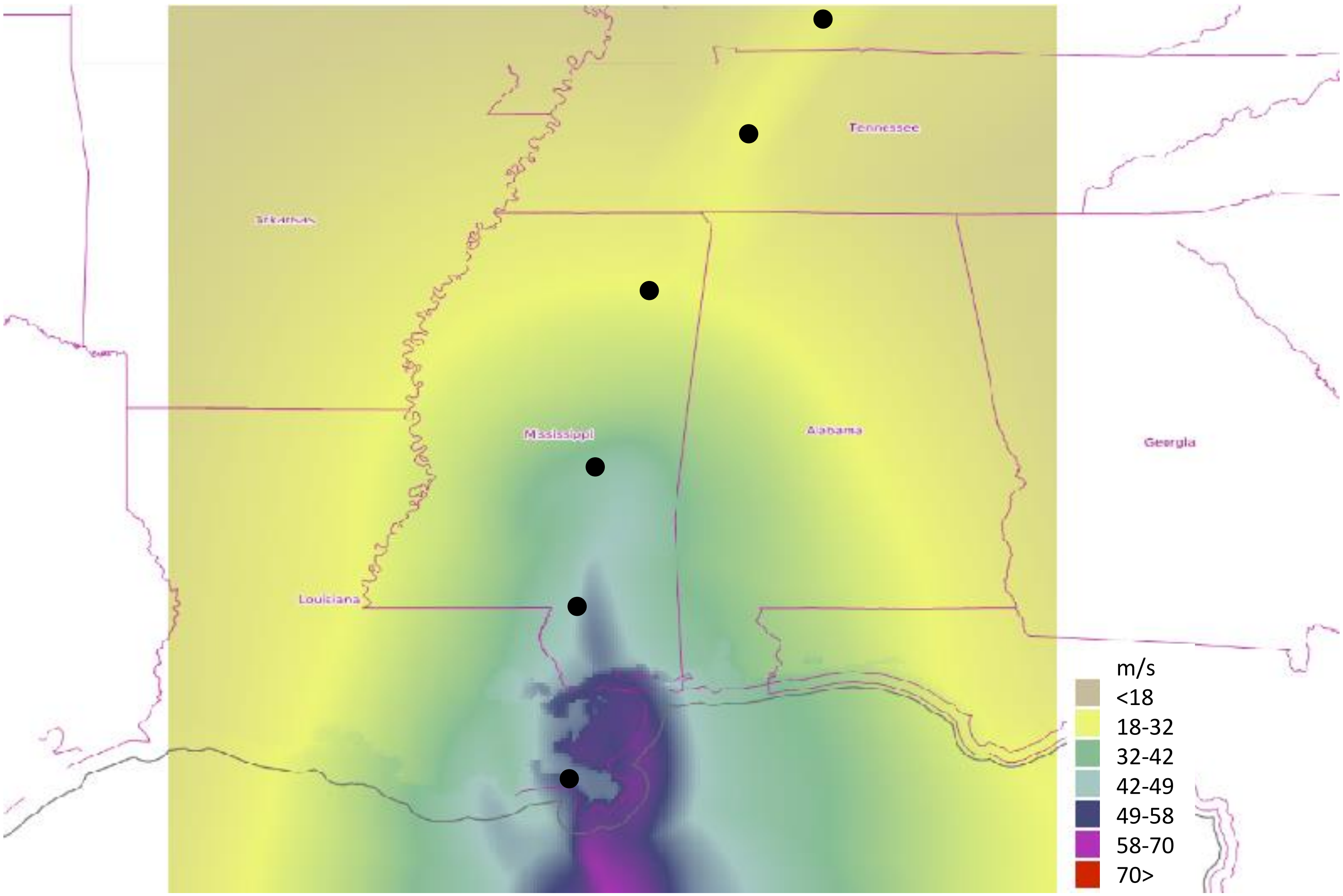
H*WIND Tropical Cyclone Observing System

The Hurricane Research Division Real-time Hurricane Wind Analysis System (H*WIND): Mark Powell

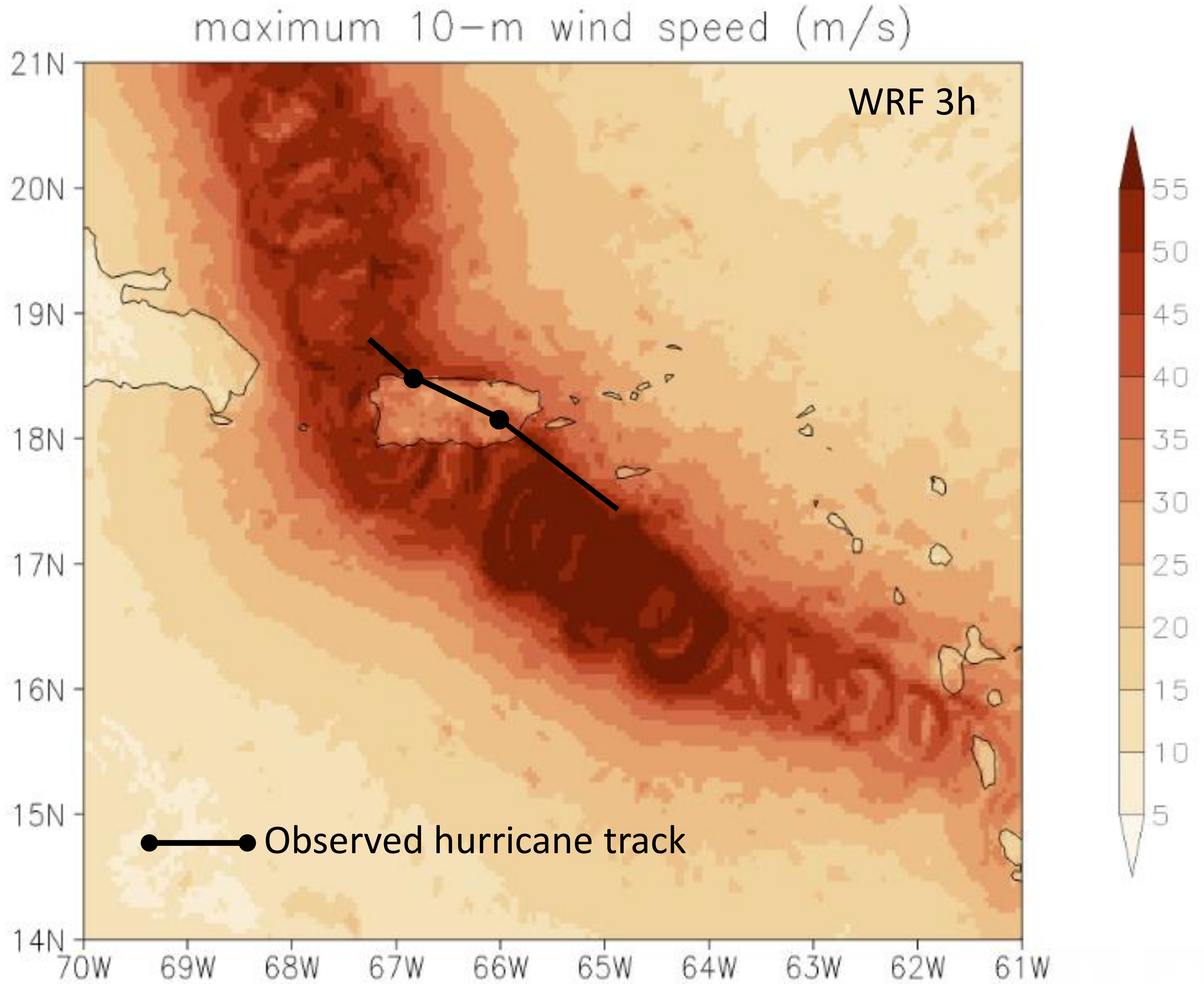
ingests realtime tropical cyclone observations measured by land-, sea-, space-, and air-borne platforms

Common framework for

- ❑ height (10 m or 33 feet above earth surface)
- ❑ exposure (marine or open terrain over land)
- ❑ averaging period (maximum sustained 1 minute wind speed): highest average wind over either a one-minute time span

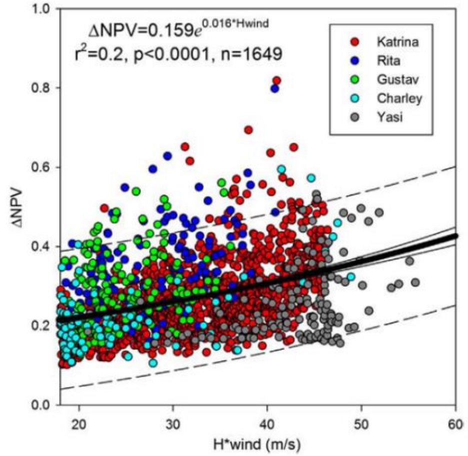


H*wind : Katrina


maximum 10–m wind speed (m/s)
WRF 3h
Observed hurricane track
21N
20N
19N
18N
17N
16N
15N
14N
70W
69W
68W
67W
66W
65W
64W
63W
62W
61W
55
50
45
40
35
30
25
20
15
10
5

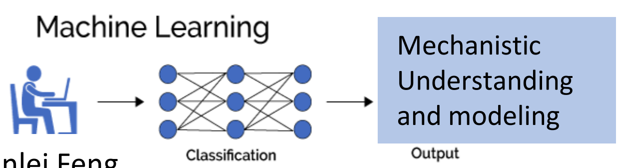
Could we model hurricane disturbances?

❑ Wind as the only variable predicting tree mortality



Negron-Juarez et al. RSE, 2014

❑ Better models



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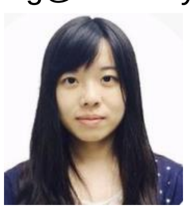
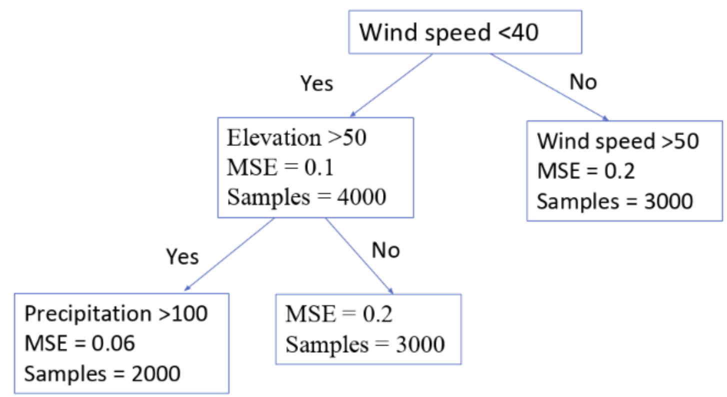


Approaches

- Train on decision tree, random forest, and support vector machine (SVM) algorithms
- Calculate average MSEs of validation
- Derive relative importance of factors

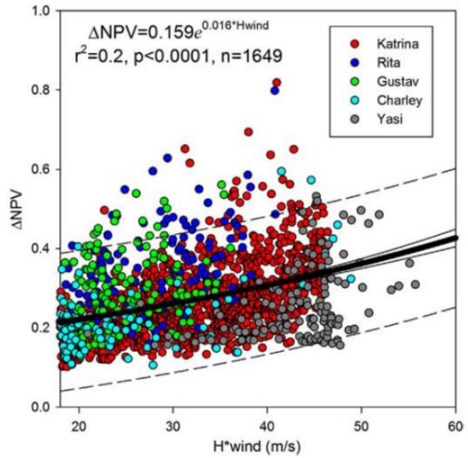


Decision Tree Illustration Graph

- **Mean Square Error**

$$\mathrm{MSE} = \frac{1}{n}\sum_{i=1}^{n}(Y_i - \hat{Y}_i)^2.$$

❑ Wind as the only variable predicting tree mortality

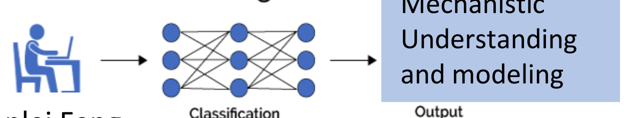


Negron-Juarez et al. RSE, 2014

❑ Better models

Approaches

Machine Learning



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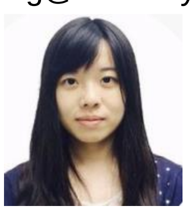

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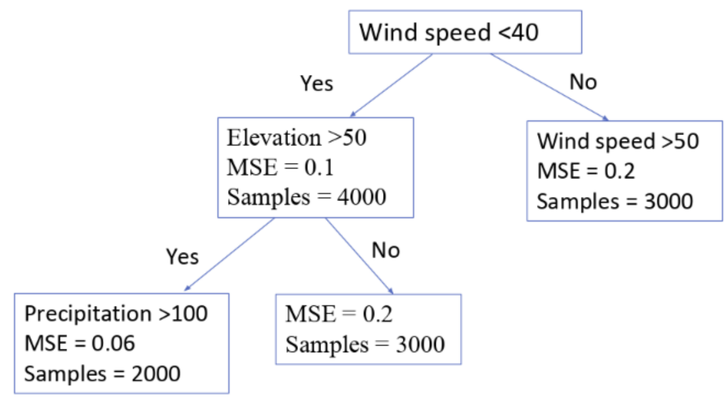

Decision Tree Illustration Graph

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Tropical storms: Hurricanes/cyclones/Typhoon		
Vegetation	Topography	Wind
❑ Tree species ❑ Traits (growth, functional, structural)	❑ Slope ❑ Aspect ❑ masl	❑ H*wind speed
-Cohort -Traits	Global data available	Sustained wind from Atm models

Discussion…