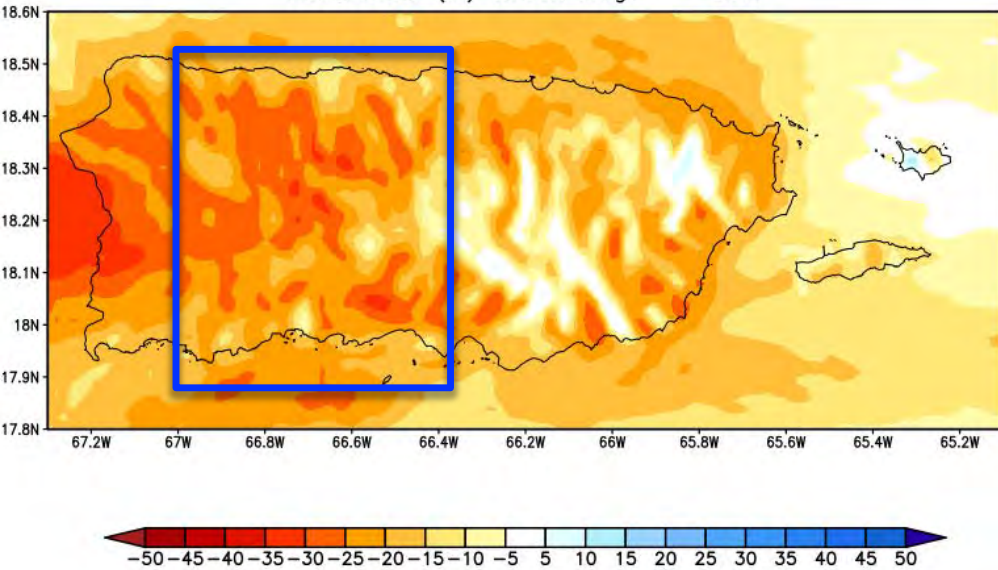


WRF-CCSM Precip. - Wet Season
Difference (%) Island Avg. = -20%

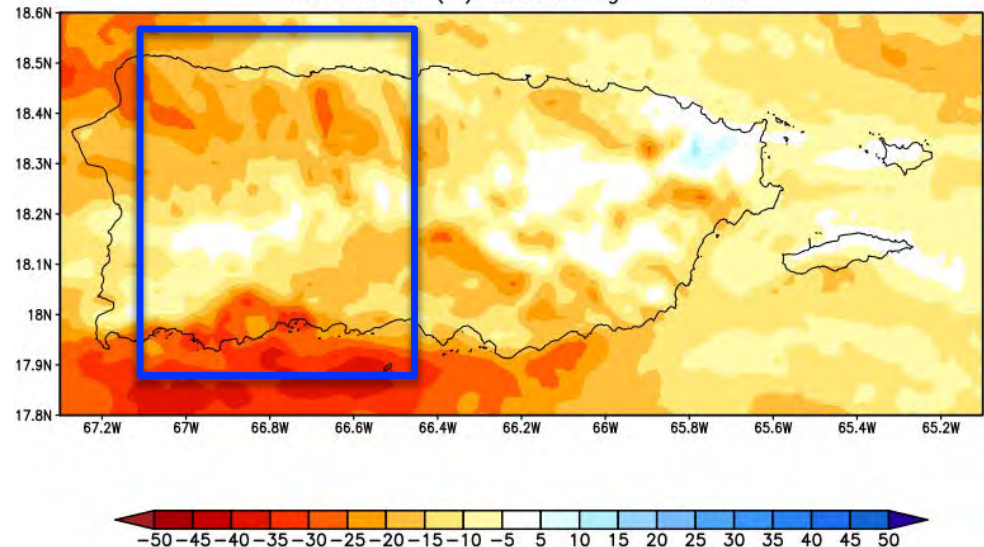


1) Projections that reflect reality given constraints of GCMs and oceanic context.

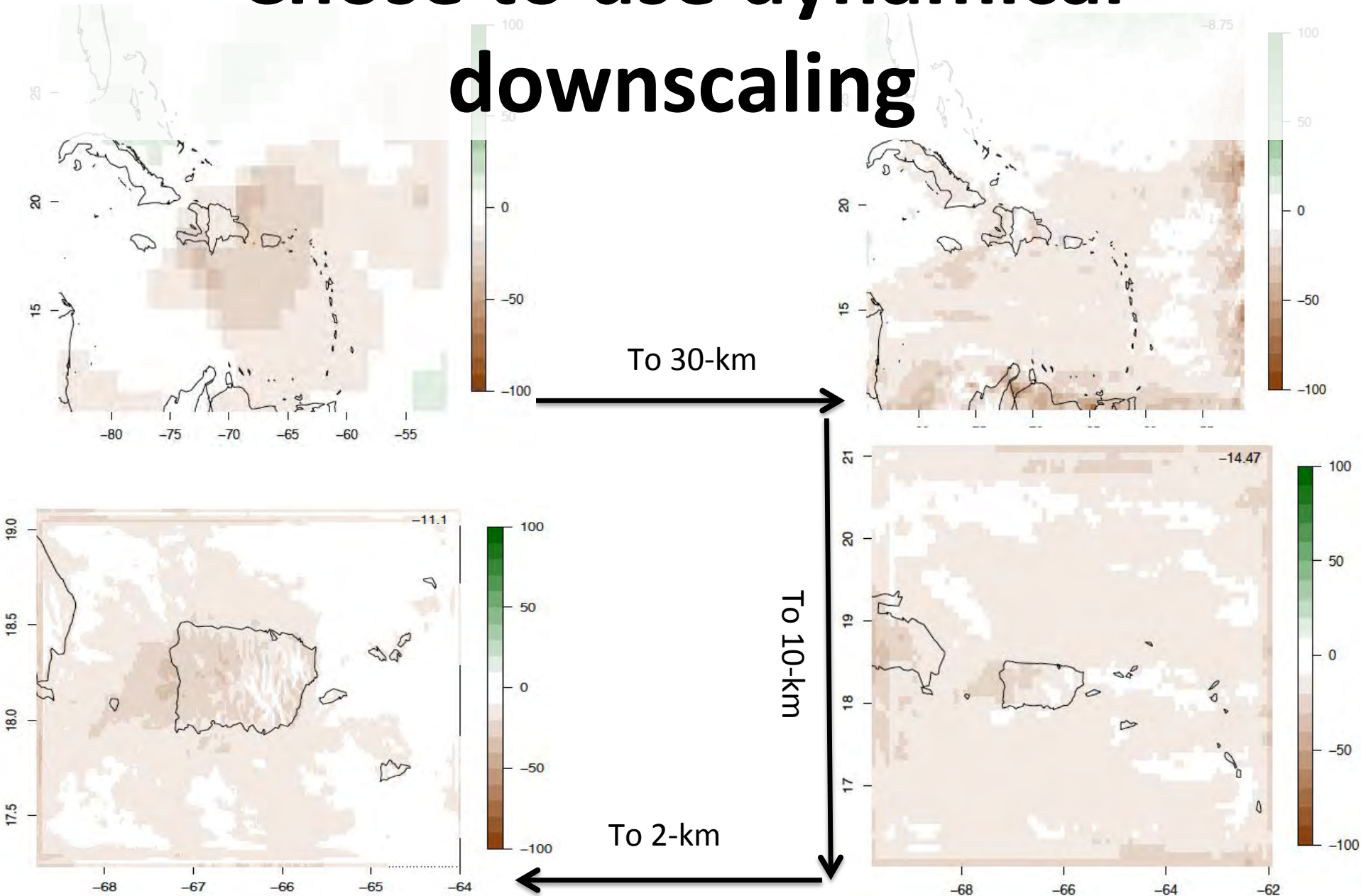
2) Simulate precipitation and other covariates response to the anthropogenic forcings across Puerto Rico.

****Elicit expert knowledge to select relevant climate variables.**

WRF-CNRM Precip. - Wet Season
Difference (%) Island Avg. = -13%



Chose to use dynamical downscaling



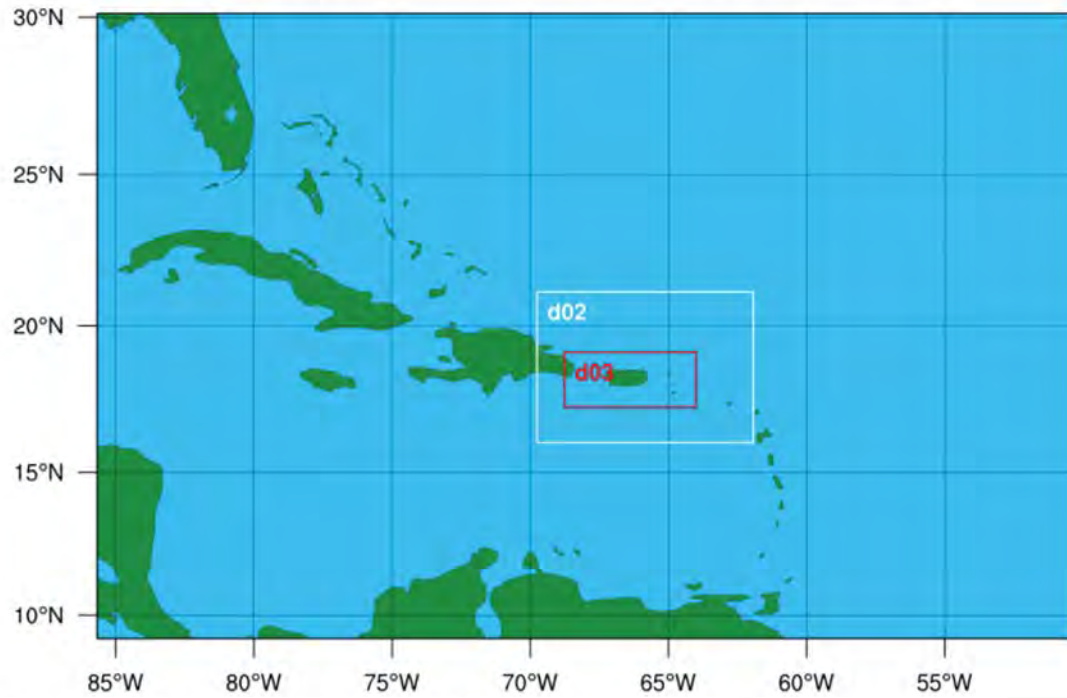


OUR GOAL: 2-KM Horizontal Resolution With Hourly Output Using multiple RCM-GCM combinations

To 2-km

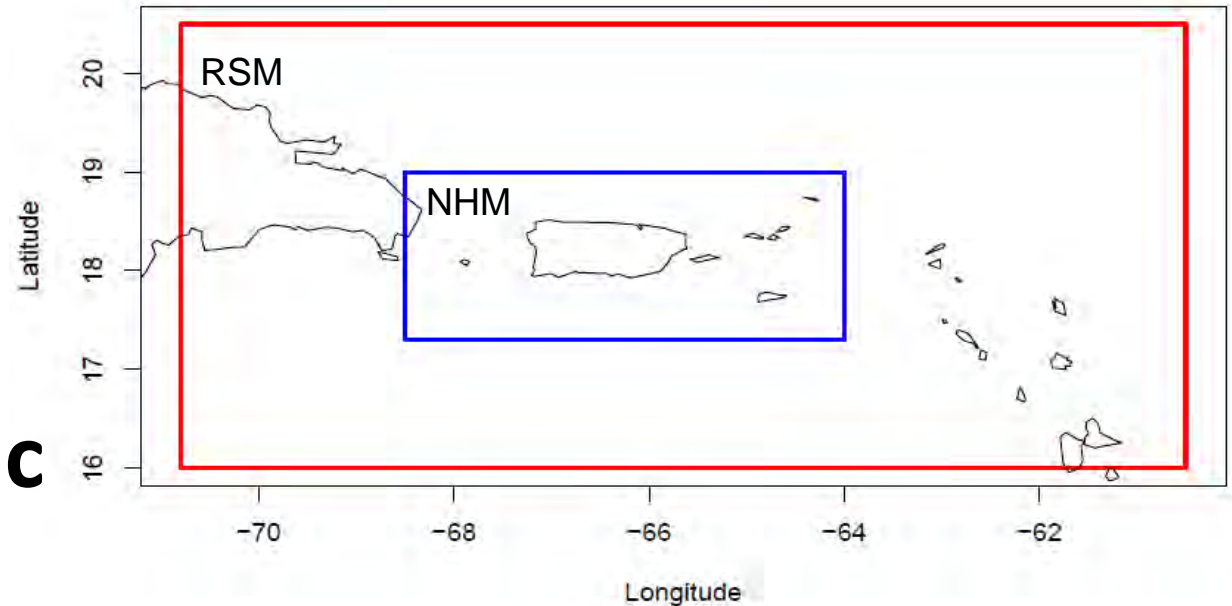
To 10-km

WRF Domain Configuration



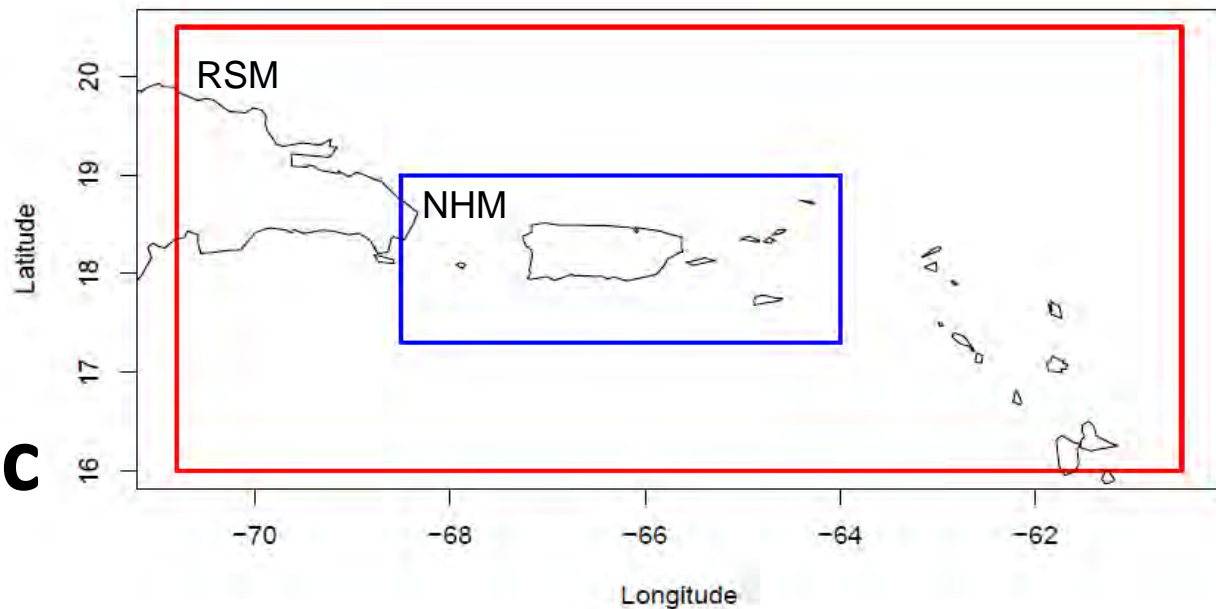
Weather Research and Forecasting Model (WRF)

Regional Spectral Model (RSM) and the Non-Hydrostatic Model (NHM)



Collaboration with Vasu Misra at FSU

**Regional
Spectral Model
(RSM) and the
Non-Hydrostatic
Model (NHM)**



Select Global Climate Models to Downscale Scenario RCP8.5 (High GHG Emissions)

*Historical (1986-2005) and Future (2041-2060) * indicates completed*



CNRM-CM5

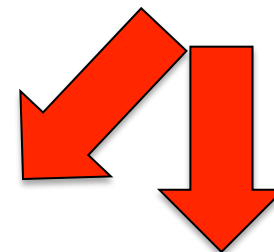
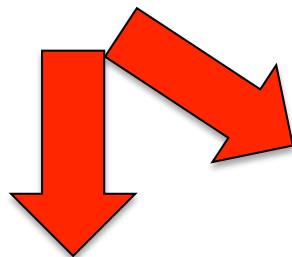
CCSM4

GFDL-CM5



WRF

RSM-NHM



WRF-CCSM4*
RSM-NHM-CCSM4*

WRF-CNRM-CM5*

RSM-NHM-GFDL-CM5

Experimental Design for Regional Climate Modeling

- ***THREE GCMs***
 - CCSM4, CNRM5, GFDL-CM3
- ***TWO RCMs***
 - WRF, NHM-RSM
- ***TWO 20 year periods***
 - 1986-2005 (past)
 - **2040-2060 (future)**
 - RCP 8.5 – high fossil fuel emissions scenario

Many More Physical Variables Available

(and relationships between variables are maintained)

- Surface
 - Rainfall, Temperature, Humidity, winds, soil moisture/temperature, runoff, evapotranspiration, pressure
- Above canopy
 - As above, plus others
 - Mixing height, vertical winds
- Radiation
 - Incoming, outgoing, diffuse, net, cloud fraction
- Diagnostic Variables
 - Height of cloud base,
 - Statistical : Heat Wave duration, extremes, percentiles, etc.

Many More Physical Variables Available

- Surface
 - Rainfall, Temperature, Humidity, winds, soil moisture/temperature, runoff, evapotranspiration, pressure
- **Time, Storage, and Processing Constraints => Cannot Retain All Variables at All Time Steps**
 - Mixing height, vertical winds
- Radiative Fluxes
 - Incoming, outgoing, diffuse, net, cloud fraction
- Diagnostic Variables
 - Height of cloud base,
 - Statistical : Heat Wave duration, extremes, percentiles, etc.

2-Day Stakeholder workshop hosted by CLCC in San Juan to refine climate model output



IDEA IS TO HAVE CLIMATE PROJECTIONS THAT ARE SPECIFIC TO THE DECISION, BUT ALSO RELEVANT TO OTHER SCIENTIFIC/ ECOLOGICAL QUESTIONS





How could climate change affect shade coffee production?



Providing public goods

Follow-up workshop in August 2016 to discuss available modeling outputs



Providing public goods

Rank climate variables based on *ecological significance*

Temperature	Variable	Keep	Why	Temporal Scale	Notes
	Air temperature at pressure levels	yes	It might have effects on the canopy and sensitive species	Daily	if hourly, need more info on which levels
	Air temperature at 2m	yes	Rate of ecosystem processes, decomposition rates, tolerance of species, animal physiology, ET	Hourly	
	Ground temperature	yes	amphibians and reptiles, ground surfaces processes	Daily/hourly	
Moisture					
	Relative humidity at pressure levels	yes	important for gas exchange for leaves	daily/hourly	
	Specific humidity at 2m	yes	for amphibians and reptiles	daily	
	Dewpoint Temperature	yes	use for calculation of RH	daily	
	Canopy wetness	yes	live fuel moisture, plant disease, soil chemistry, thrufall, flooding modeling	hourly	same time step as precipitation
Precipitation					
	Convective precipitation	no			
	Total precipitation	yes	many reasons	hourly	rainfall recommended at 15 minutes for exploration
Winds					
	Speed, direction at 10m	yes	ET, traffic patterns, fire risk, wind mills	hourly	needed at 2m, discussion regarding the air quality modeling if there really is a need for hourly winds

Used this dialogue to help retain necessary climate model data

Downscaled Climate Variables

	Variable
Temperature	
	Air temperature at pressure levels
	Air temperature at 2m
	Ground temperature
	Soil Temperature
Moisture	
	Relative humidity at pressure levels
	Specific humidity at 2m
	Dewpoint Temperature
	Canopy wetness
Precipitation	
	Convective precipitation
	Total precipitation
	Soil Moisture
Winds	
	Speed, direction at 10m
	Speed, direction at pressure levels
	Vertical velocity at pressure levels

	Variable
Radiation	
	Solar radiation down
	Solar radiation up
	Terrestrial radiation down
	Terrestrial radiation up
Clouds	
	Bottom height (for low, medium, high clouds)
	Top height (for low, medium, high clouds)
	Cloud cover % (low, medium, high, total)
Pressure	
	Surface pressure
	Pressure tendency (i.e., time-derivative of pressure, indicates pressure rising or falling)
	Geopotential height (i.e., height of pressure levels)
Energy Fluxes	
	Sensible
	Latent
	Ground
	Potential evapotranspiration

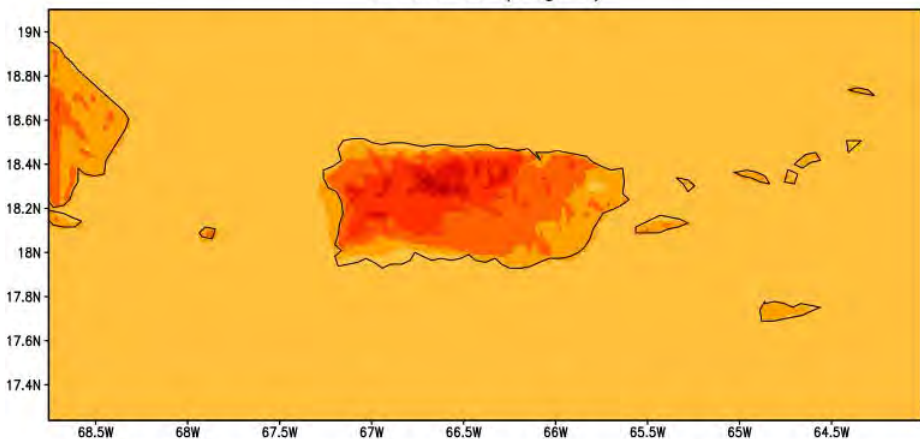
Exceeded **1 million** CPU hours to accomplish the downscaling for just one of the regional climate models.



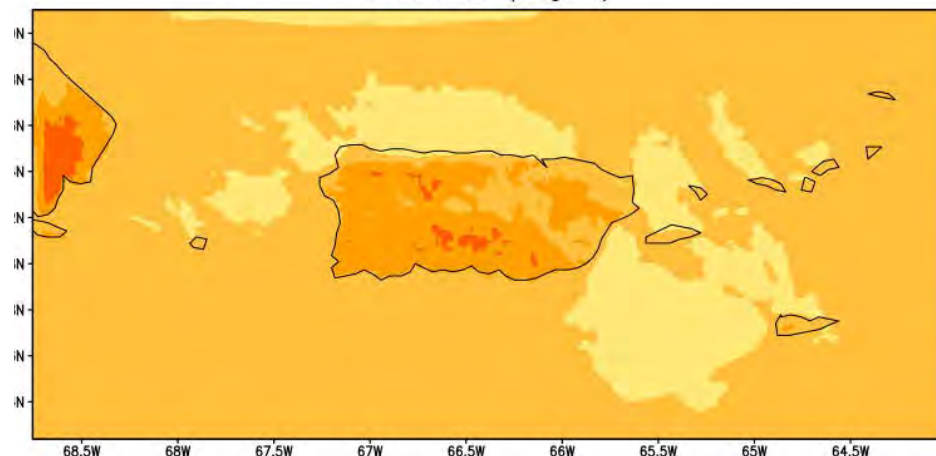
We reduced ~1 Petabyte of model output to < 20TB with the knowledge of climate variables to retain from prior workshop

Maximum 2-m Temperature Change annual average

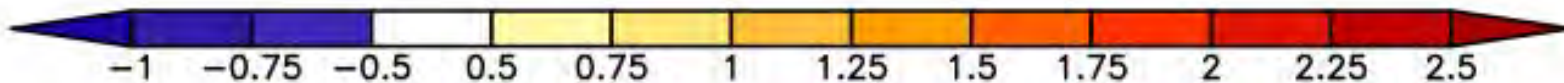
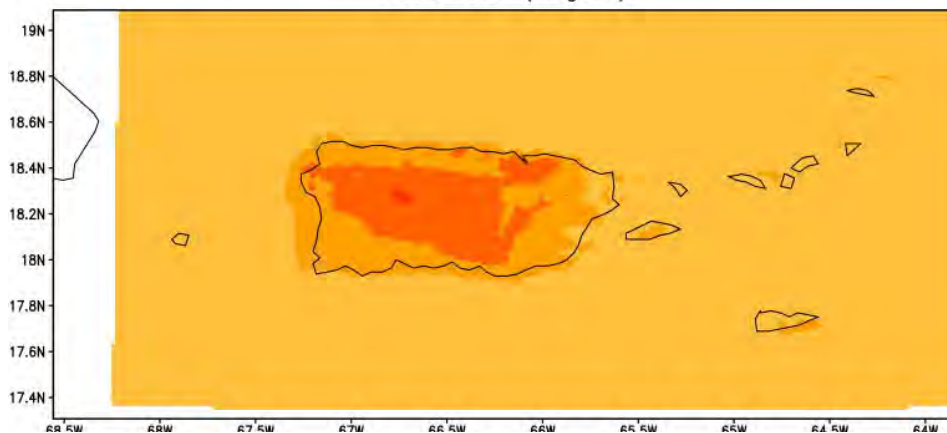
WRF-CCSM Max. Temperature - Annual
Difference (Deg. C)



WRF-CNRM Max. Temperature - Annual
Difference (Deg. C)



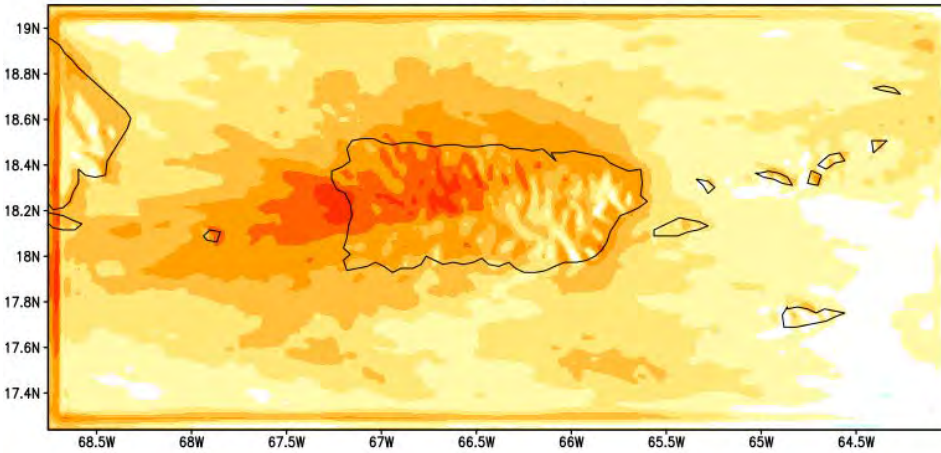
RSM-NHM CCSM Max. Temperature - Annual
Difference (Deg. C)



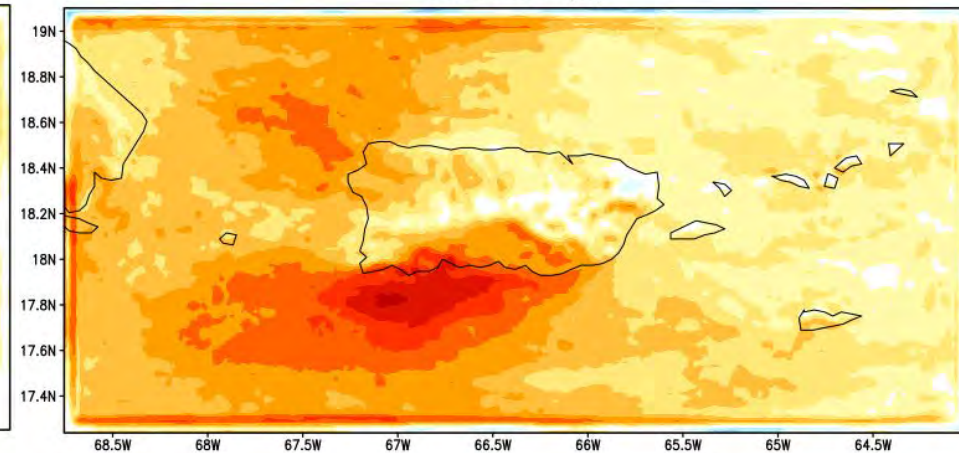
Precipitation Change

percent change for the annual total

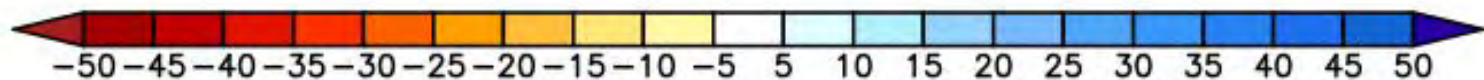
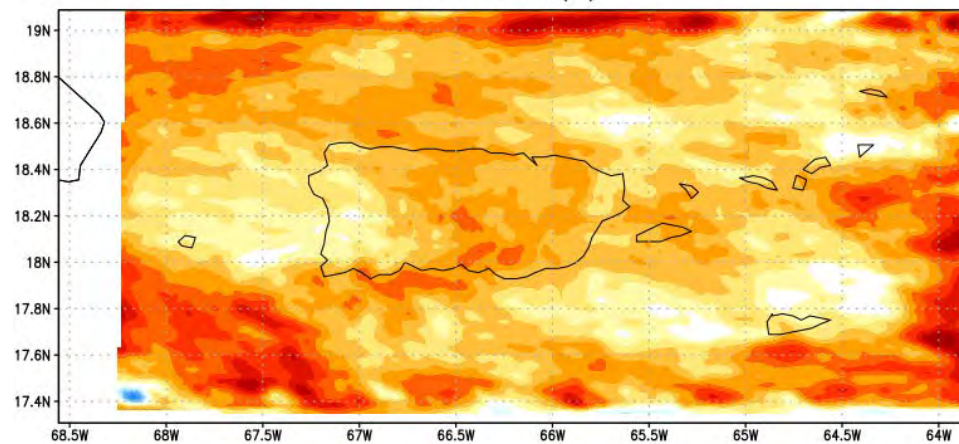
WRF-CCSM Precip. - Annual
Difference (%)

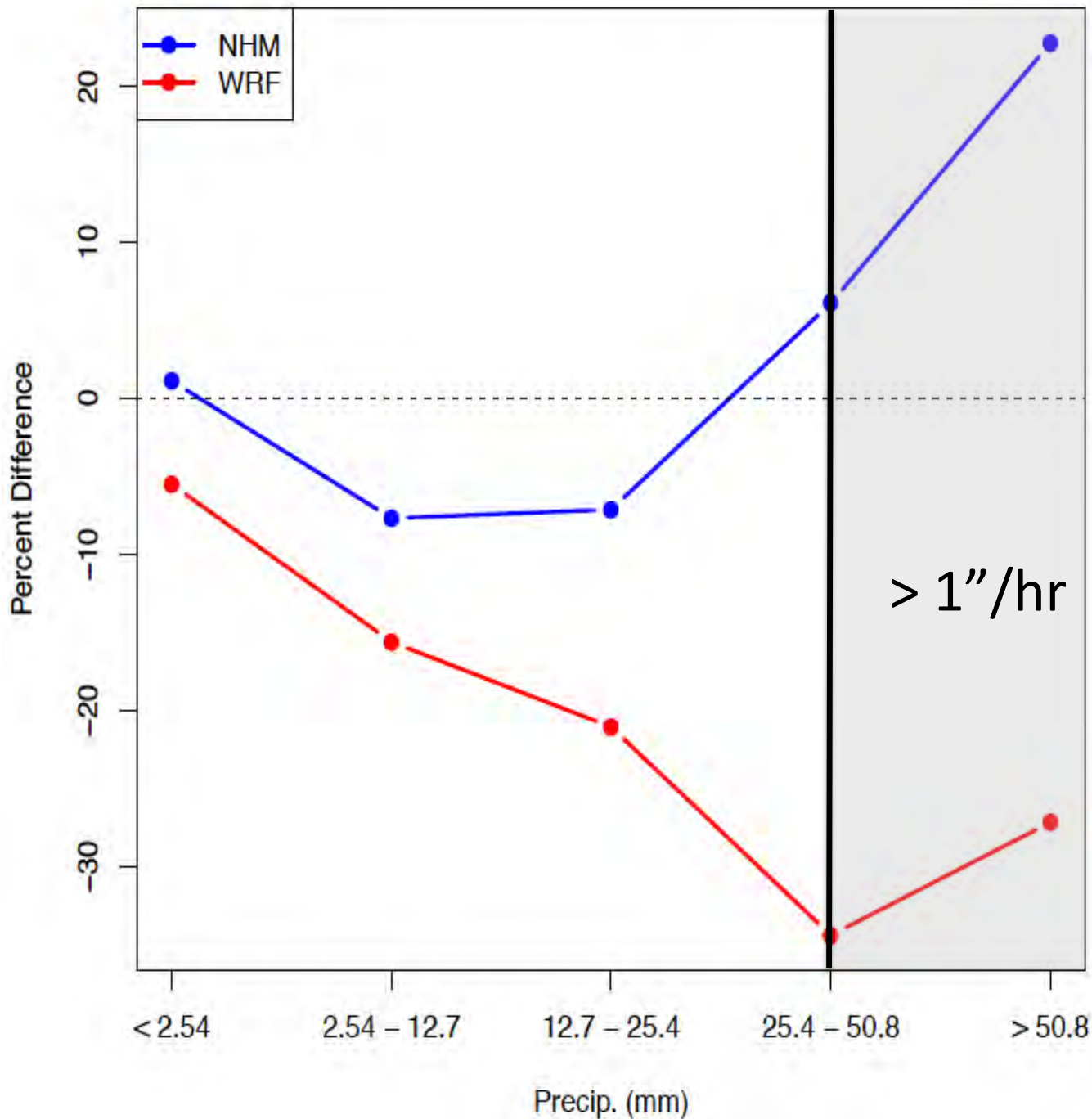


WRF-CNRM Precip. - Annual
Difference (%)



RSM-NHM CCSM Precip. - Annual
Difference (%)



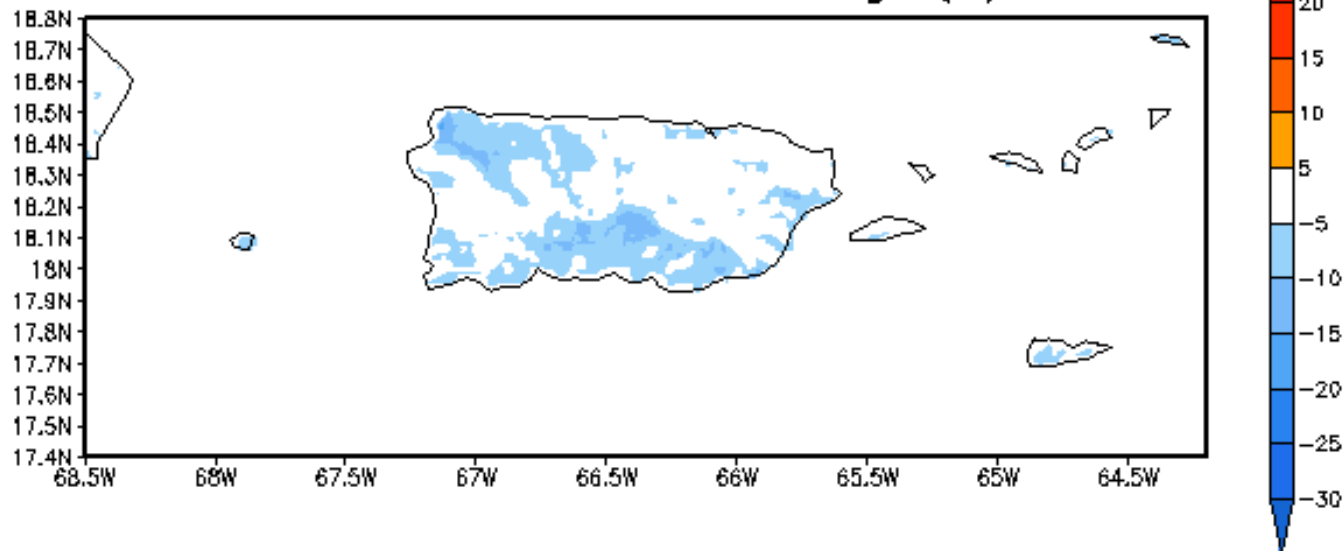


Hourly
rainfall bin %
difference

> 1"/hr

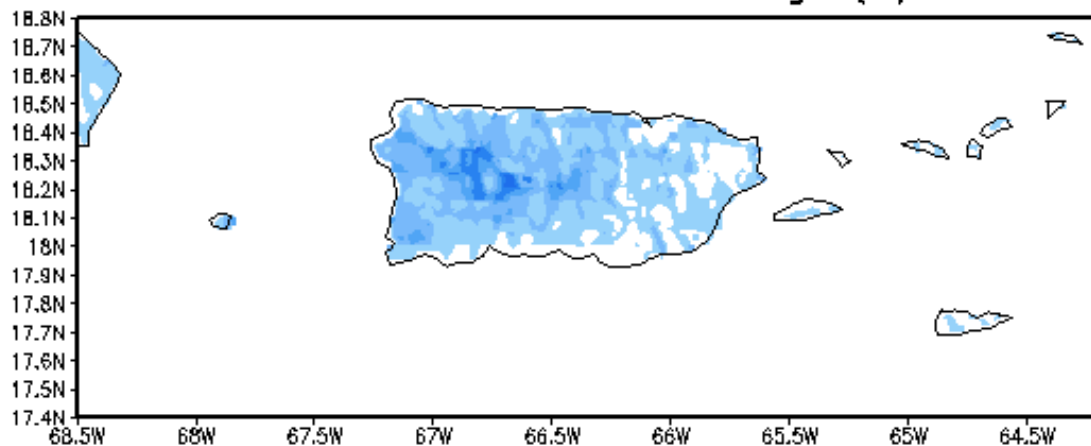
ECOREGION
ANALYSIS
(Subtropical
wet forest -
wet season)

CNRM Soil Moisture (0 to 10cm) – WET SEASON
Relative Soil Moisture Change (%)

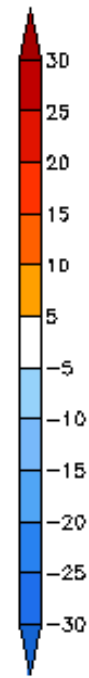
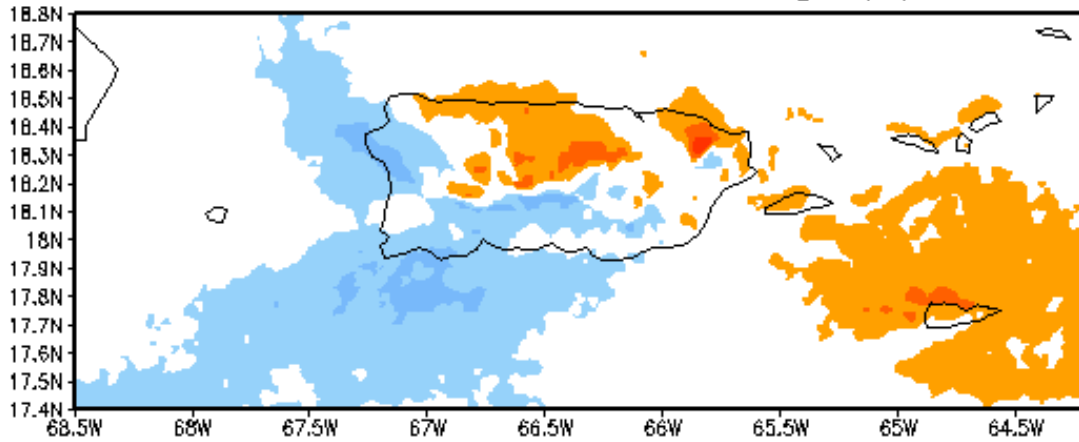


Projected Changes Soil Moisture

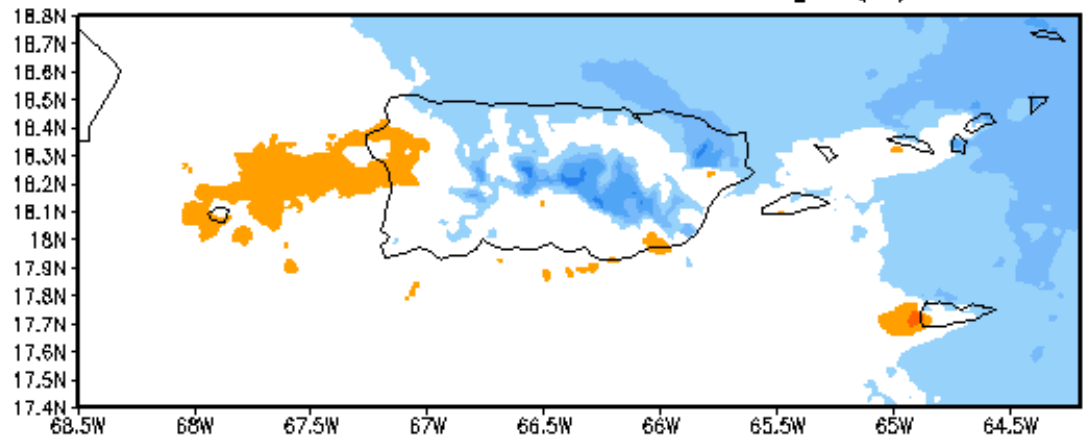
CCSM Soil Moisture (0 to 10cm) – WET SEASON
Relative Soil Moisture Change (%)



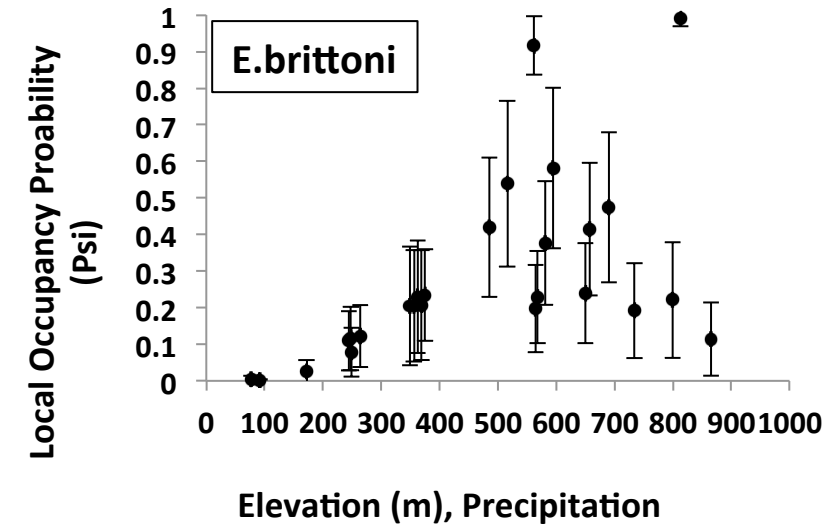
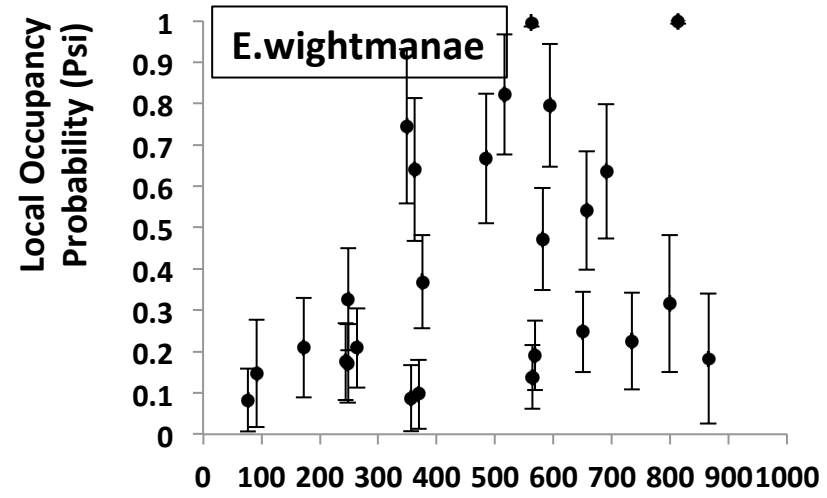
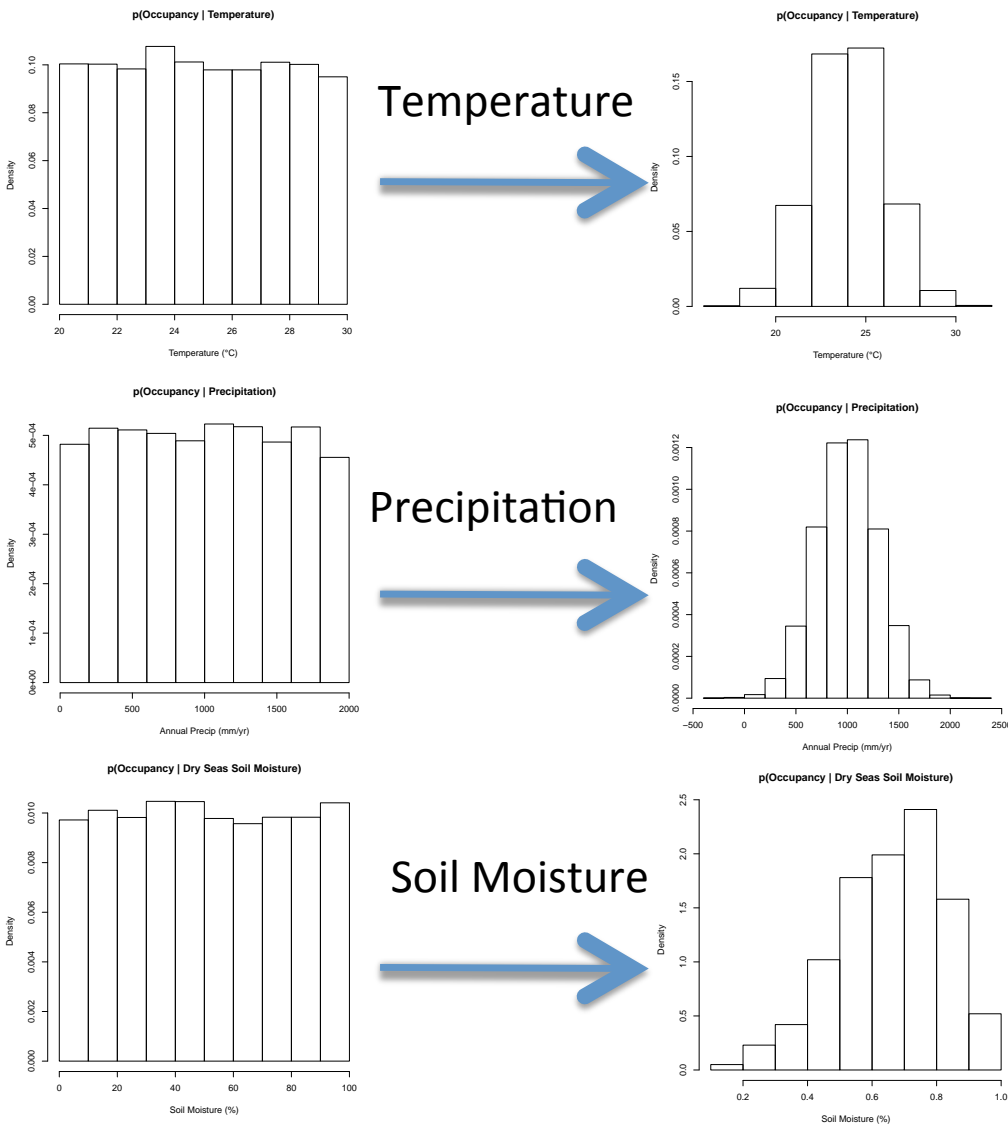
CNRM Low-Level Clouds (sfc to 700hPa) - DRY SEASON
Relative Cloud Fraction Change (%)



CCSM Low-Level Clouds (sfc to 700hPa) - DRY SEASON
Relative Cloud Fraction Change (%)



**Low-level Cloud
Fraction**



What are the environmental limits of these species?



Use acoustic recorders to estimate occupancy of three species across environmental gradients



Estimate occupancy based on recorded calls

▼ a87

Apr 28, 2014

a87, Apr 28, 2014 1:56 AM

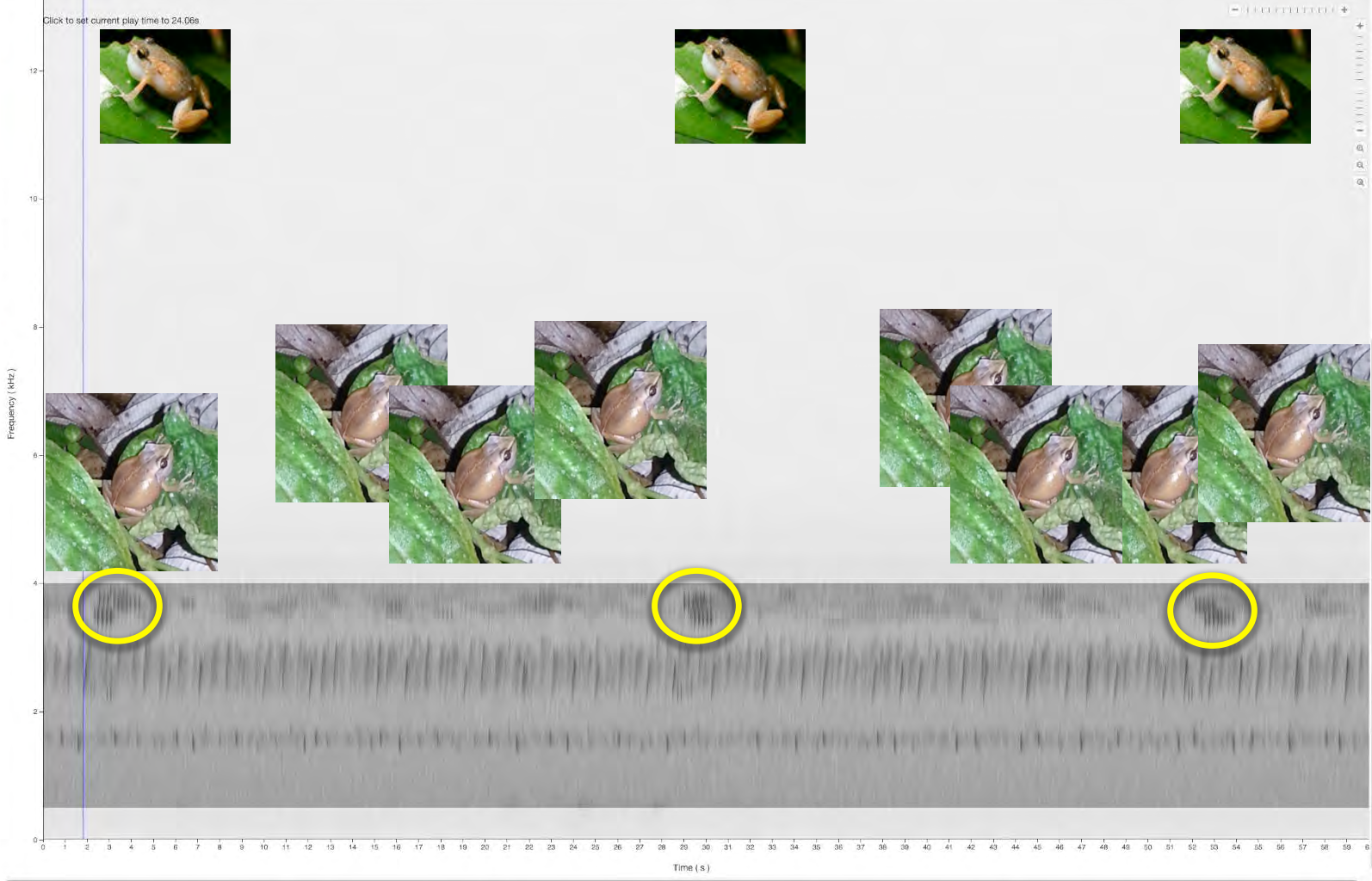
a87, Apr 28, 2014 1:57 AM

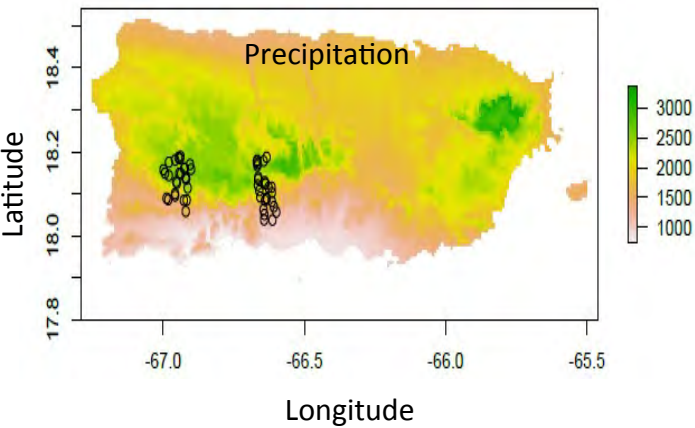
▶ 1.81 s
24.06 s, 6.9 kHz

▼ a87-2014-04-28_01-56.flac
No tags associated to this recording.

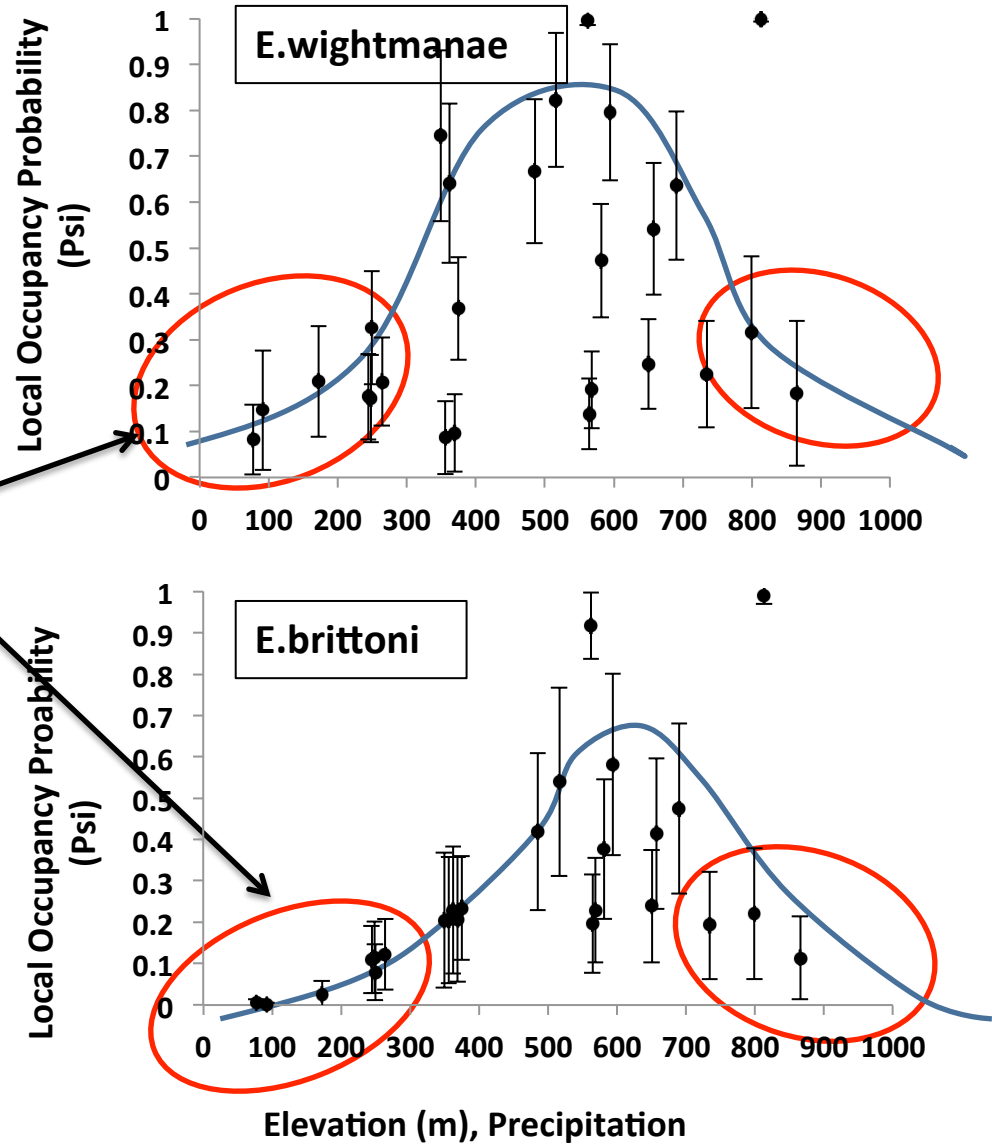
Species Presence Validation 2 / 4

Training Sets



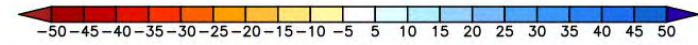
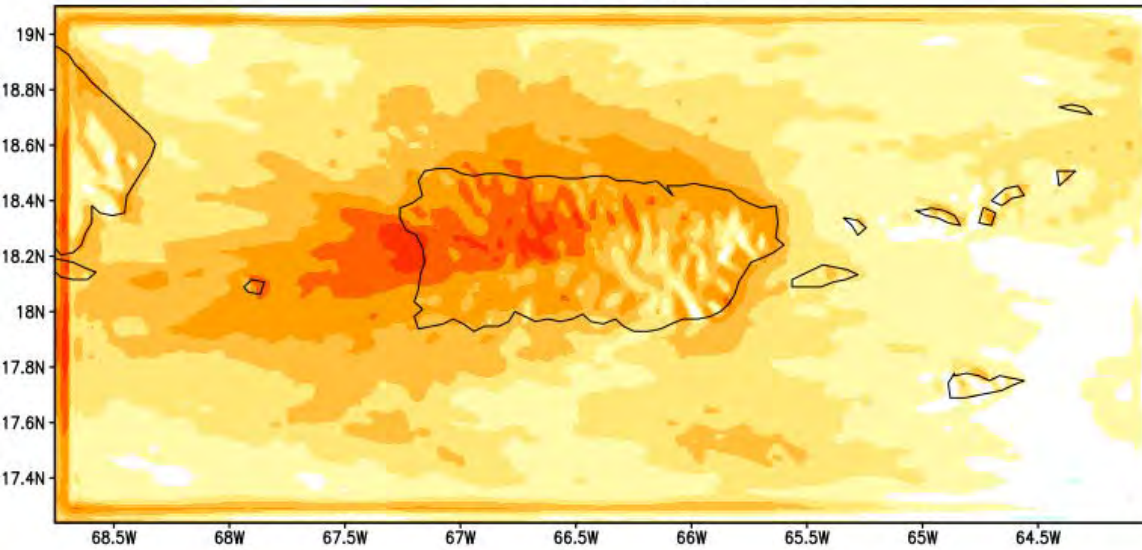


How could these gradients change with climate change?

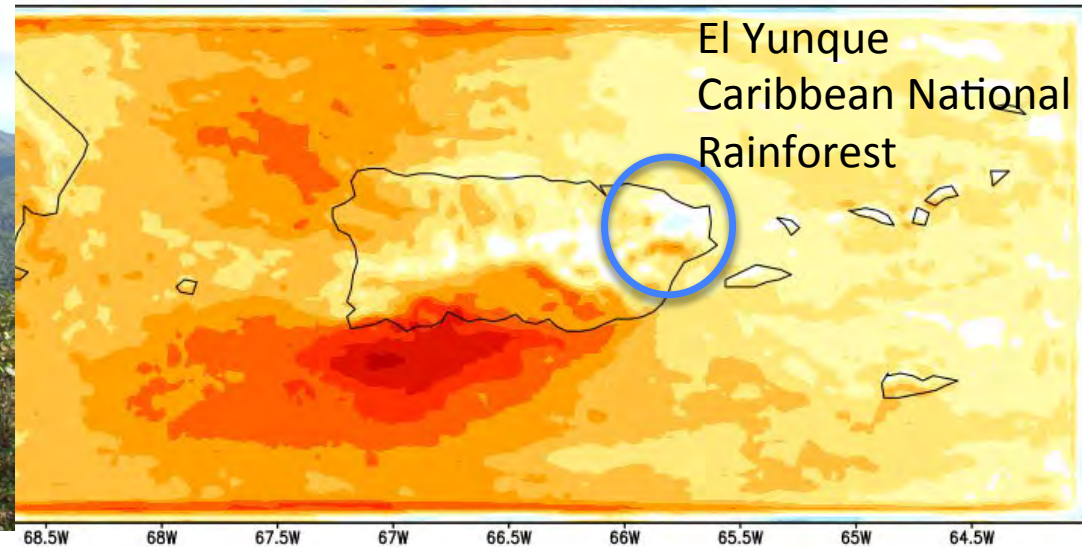


NEXT STEPS

WRF-CCSM Precip. - Annual
Difference (%)

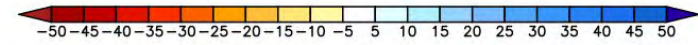
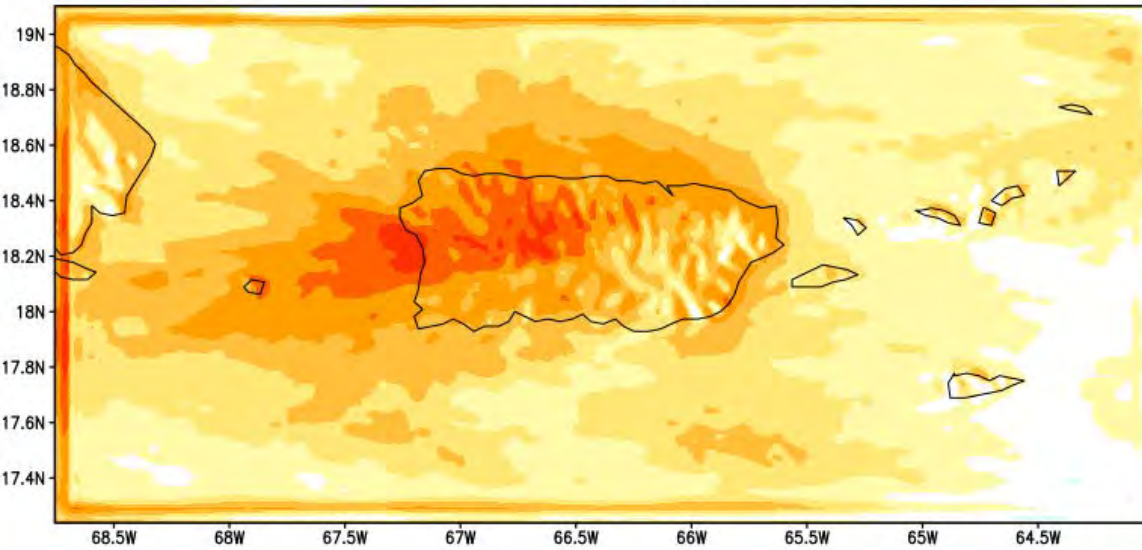


CNRM Precip. - Annual
Difference (%)

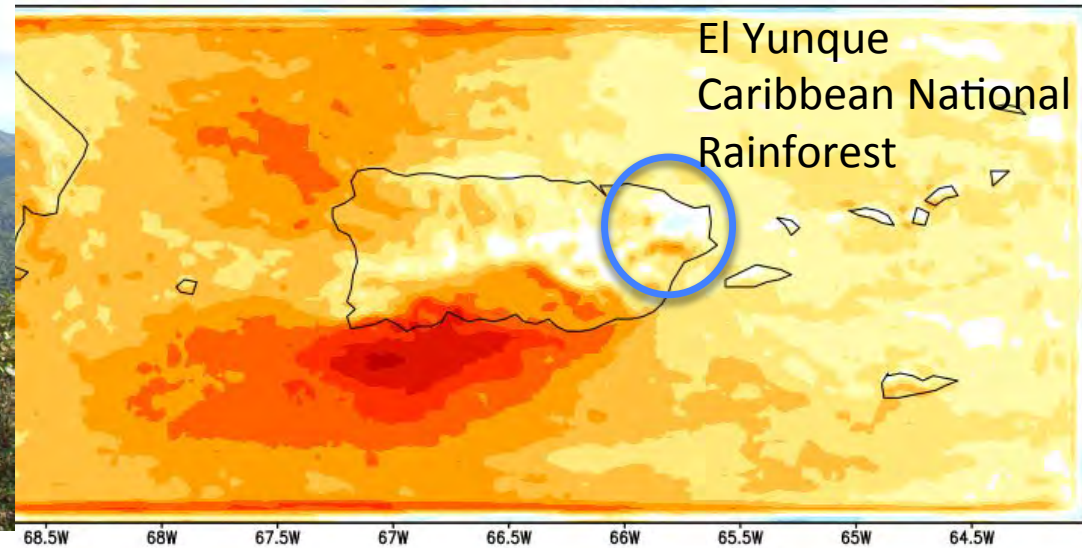


Next steps: Explore resilience of windward slopes

WRF-CCSM Precip. - Annual
Difference (%)



CNRM Precip. - Annual
Difference (%)



El Yunque
Caribbean National
Rainforest



Potential to couple to WRF-Hydro Model

Hybrid downscaling

Select Global Climate Models to Downscale Scenario RCP8.5 (High GHG Emissions)

*Historical (1986-2005) and Future (2041-2060) * indicates completed*



CNRM-CM5

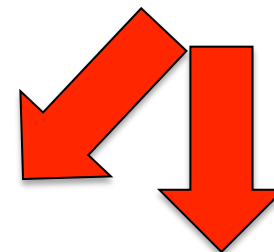
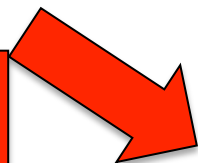
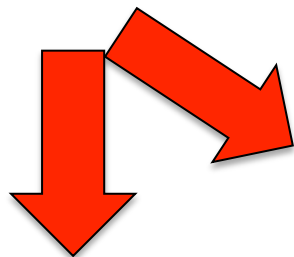
CCSM4

GFDL-CM5



WRF

RSM-NHM



WRF-CCSM4*
RSM-NHM-CCSM4*

WRF-CNRM-CM5*

RSM-NHM-GFDL-CM5

Global Climate Models to Downscale
Scenario RCP8.5 (High GHG Emissions)
Historical (1986-2005) and Future (2041-2060)

CNRM-CM5

CCSM4

GFDL-CM5

WRF

RSM-NHM

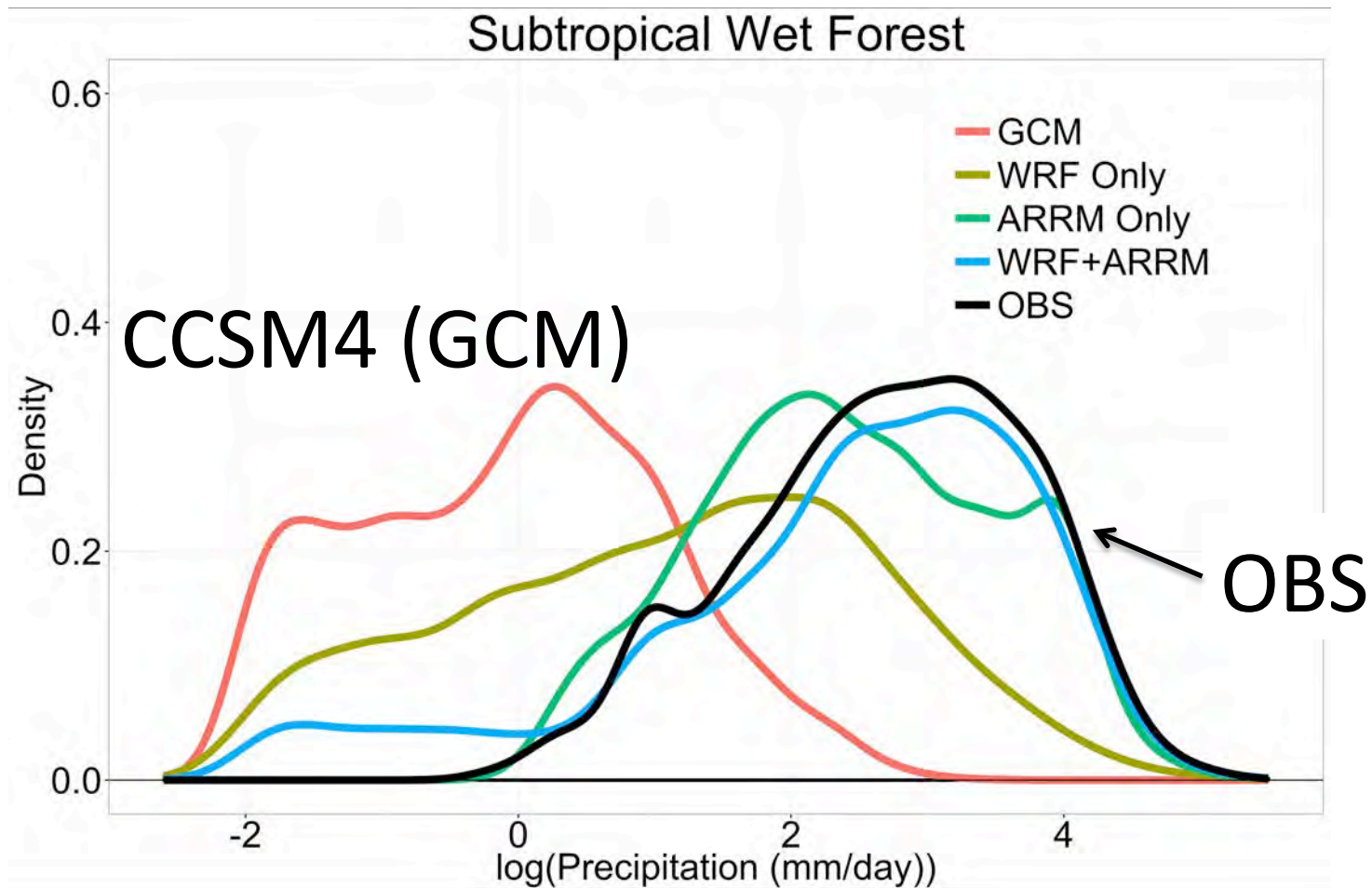
WRF-CCSM4
RSM-NHM-CCSM4

WRF-CNRM-CM5

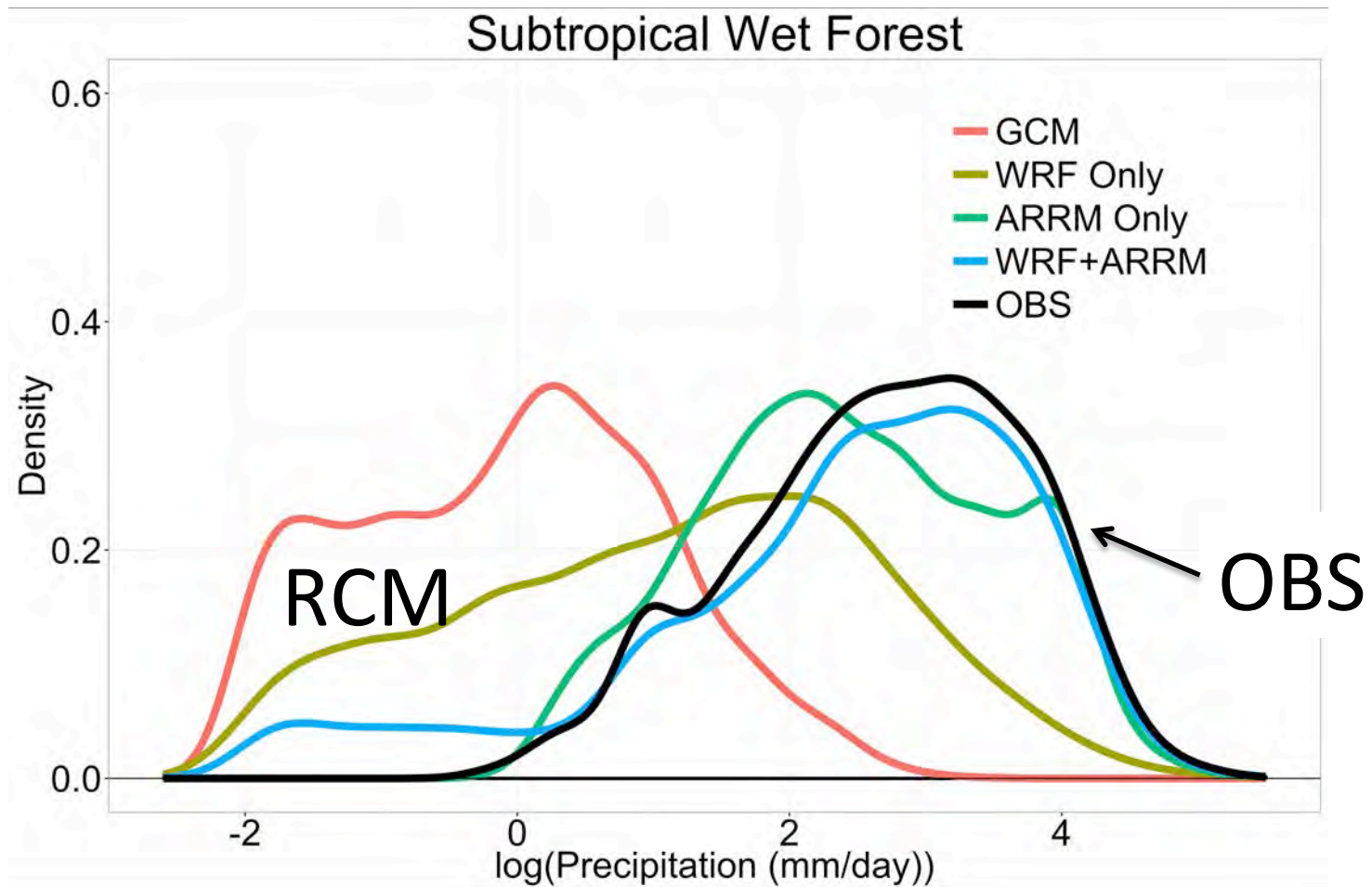
RSM-NHM-GFDL-CM5

ARRM-WRF-CNRM-CM5

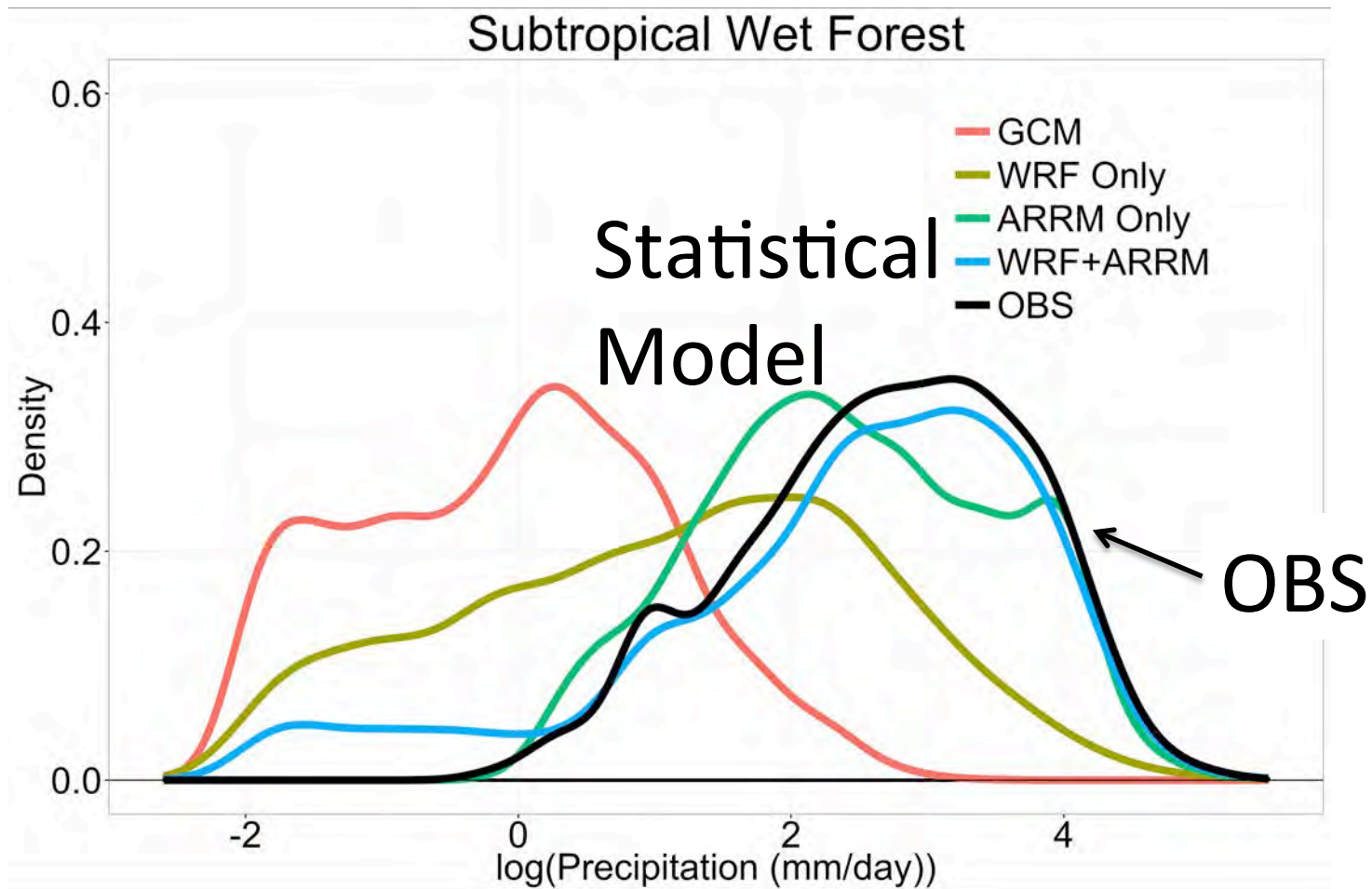
ARRM-WRF-CCSM4



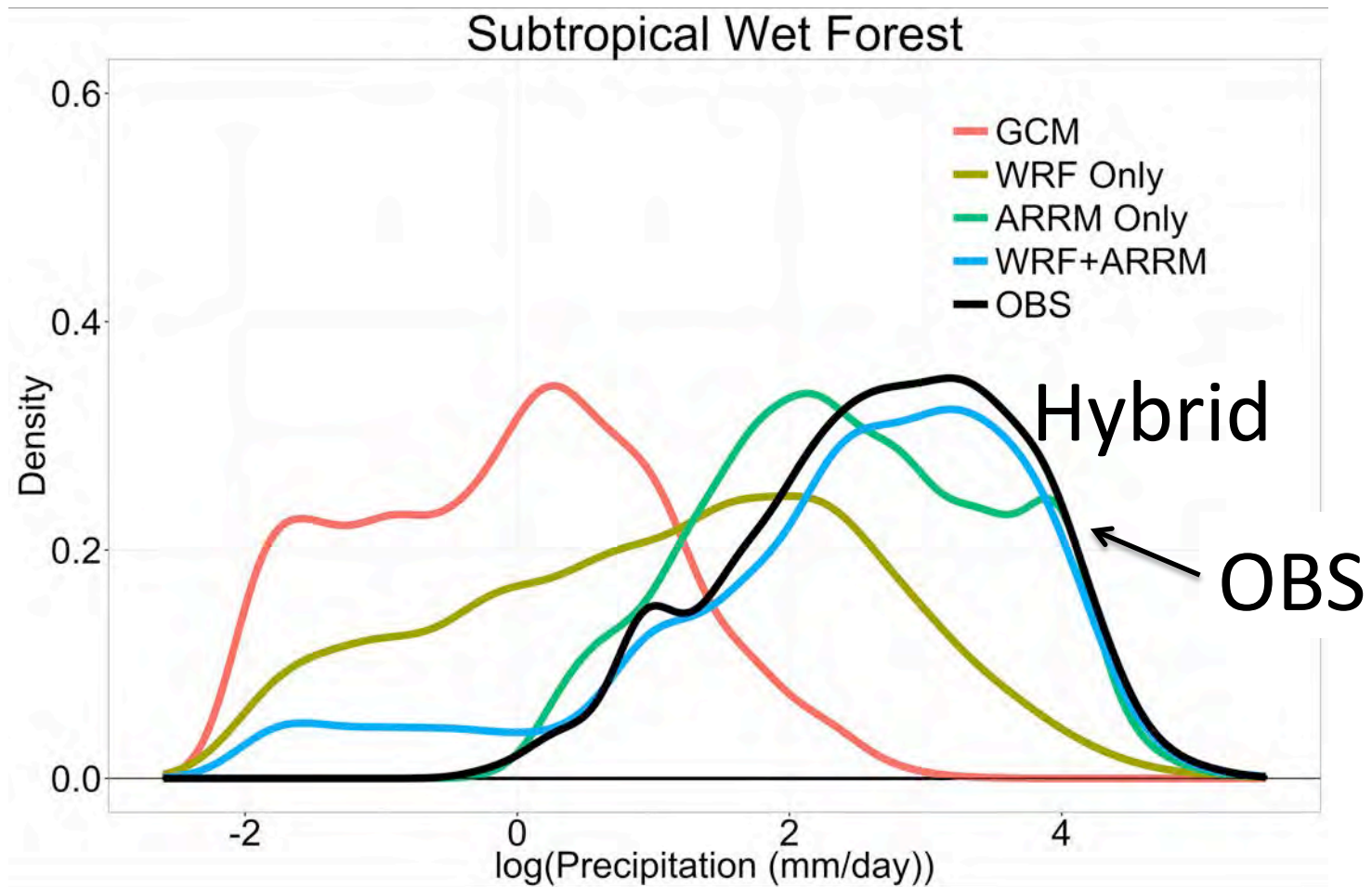
Combining statistical and dynamical
downscaling approaches



Combining statistical and dynamical
downscaling approaches



Combining statistical and dynamical downscaling approaches



Combining statistical and dynamical
downscaling approaches



Taking occupancy modeling a step further.
Is reproduction occurring at occupied sites? Are sites being occupied by a few individuals or by “many”?
Plus genetic work to establish population structure.



Augment field work with terraria experiments to test eco-physiological limits (w/colleagues at Univ. Puerto Rico)



Geo Data Portal Show Geo Data Portal Info



Specify Area of Interest

Upload Shapefile or Draw a Polygon or Find Feature From ScienceBase

- Available Areas of Interest:
- sample:Alaska
 - sample:CONUS_States
 - sample:CSC_Boundaries
 - sample:FWS_LCC
 - draw:KlamathBasin
 - draw:MMI_LakeB1

Geo Data Portal (GDP)

Web-based access to and processing of global change data to address climate and landscape change



THANKS!
QUESTIONS?