NOAA CREST

Tropical Montane Cloud Forests: Importance and Challenges in a Changing Environment

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Tropical Montane Cloud Forests (TMCFs)

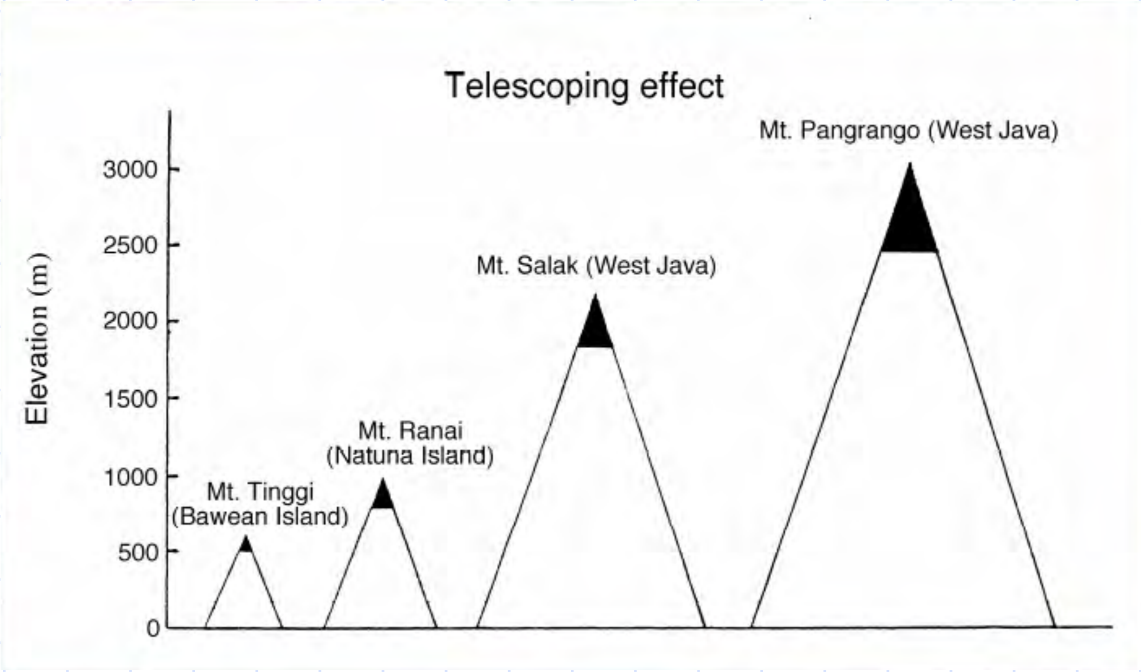
- What are cloud forests? Where are TMCFs located? What are the different types of TMCFs?
- What is the hydrological function and ecological importance of TCMFs?
- What is the impact of global and regional climate changes in the hydrological cycle of TMCFs?

What are cloud forests?

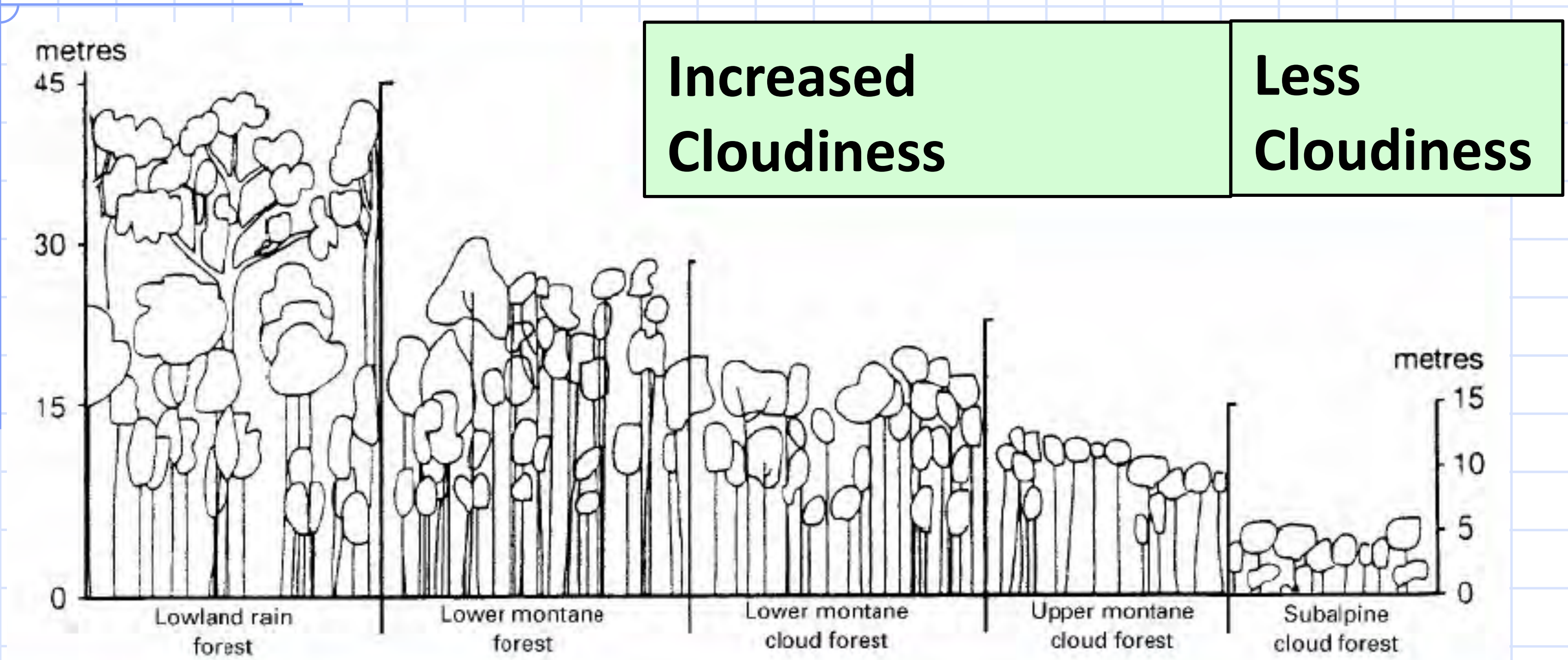
- TMCF is an evergreen montane moist forest characterized by a persistent low-level cloud cover, usually at or below the vegetation canopy level.
- TMCFs exhibit an abundance of mosses covering the ground and vegetation due to moisture introduced by orographic cloud formation.
- Dependent on local climate, there is a relatively small band of altitude in which the atmospheric environment is suitable for cloud forest development.

Where are TMCFs located?

- On continental mountains TMCFs typically occur between 1500 - 3000 m asl. On oceanic islands cloud forests can be found as low as 500 m.
- The form and appearance of TMCFs varies greatly according to prevailing wind, altitude, soil type, and how often they are enveloped in clouds.



Where are TMCFs located?



- On lower mountain slopes cloud forest trees are usually 15-20 m tall. At higher altitudes, where the forest is more consistently in the clouds, trees are shorter and covered in more moss, forming upper montane cloud forests.

Where are TMCFs located?

Why are TMCFs important?

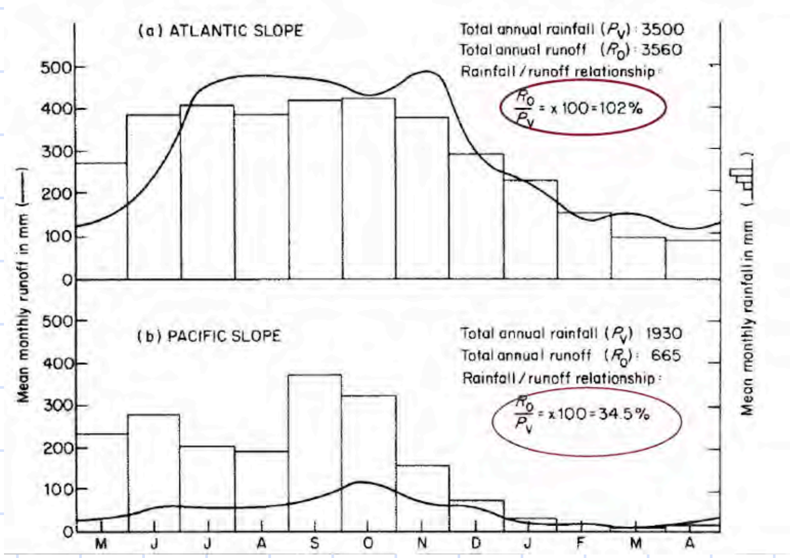
- As tropical rain forests disappear, TMCFs gain importance as natural reserves.
- Because of unique climate conditions, TMCFs are rich in endemic species (flora and fauna) and promote biodiversity.
- The direct intercept of moisture by the vegetation canopy, combined with reduced evaporation due to less radiation, produces greater hydric efficiency and fresh water production.

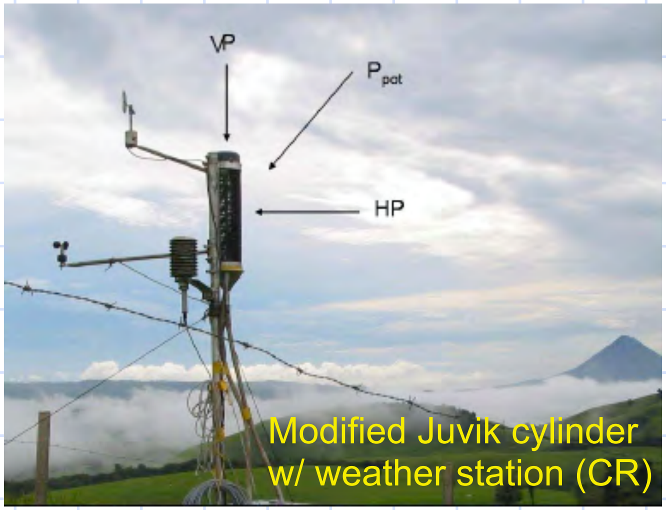
Why are TMCFs important?

- Fresh water production from vertical rain is 15–20 % of horizontal rainfall, but can reach 50-60 % in certain conditions.
- TMCFs provide water that feeds lands of subsistence farmers, and large-scale agriculture down stream.
- Millions of people depend on the freshwater flowing from the cloud forests. Tegucigalpa, Dar es Salaam, Quito, Mexico City, San Juan (PR).

Hydrological Function of TMCFs

- High streamflow values in the Atlantic slope of TMCFs in Costa Rica are attributed to extra fresh water production due to orographic cloud formation in the prevailing easterly winds.
- Recent measurements in this CR watershed determined the large contribution of wind transported rain to the total precipitation observed.
- Similar measurements of HP are proposed for TMCFs in PR and DR.





Modified Juvik cylinder w/ weather station (CR)

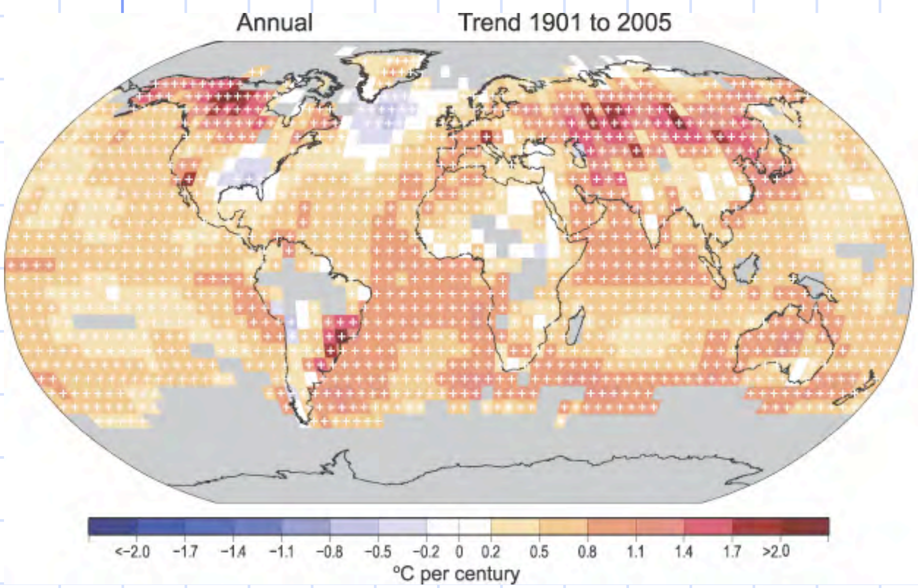
Hydrological impact of global and regional climate changes in TMCFs

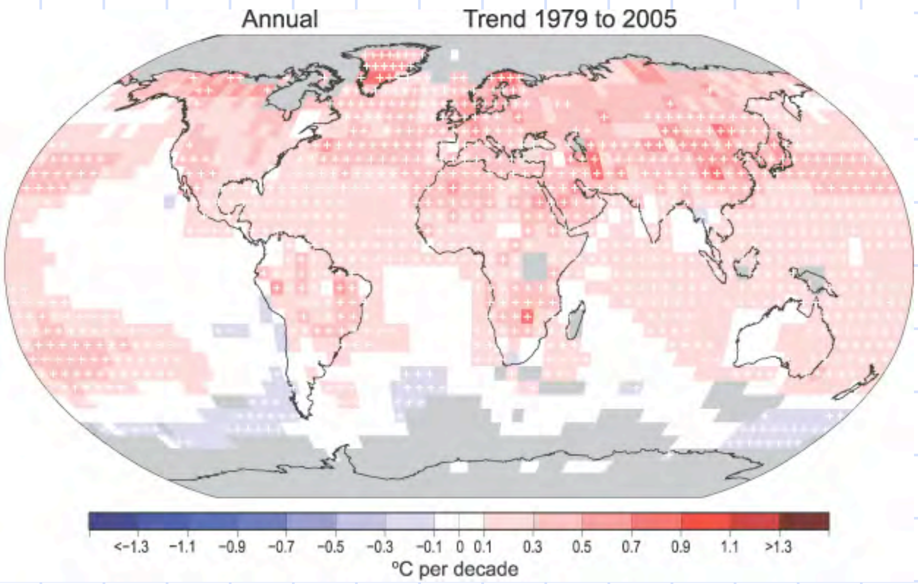
Under conditions of LCLU changes (e.g., deforestation, urbanization) and global climate change (i.e., global warming), what is the combined effect of these two factors in TMCFs?

A series of numerical atmospheric simulations are proposed to separate the signals of these factors. The Regional Atmospheric Modeling System (RAMS) will serve as the main research tool as we attempt to answer the posed research question while addressing specific problems in the Caribbean islands of Puerto Rico and Hispaniola.

Cases of Northeastern Puerto Rico and Enriquillo Basin (Hispaniola)

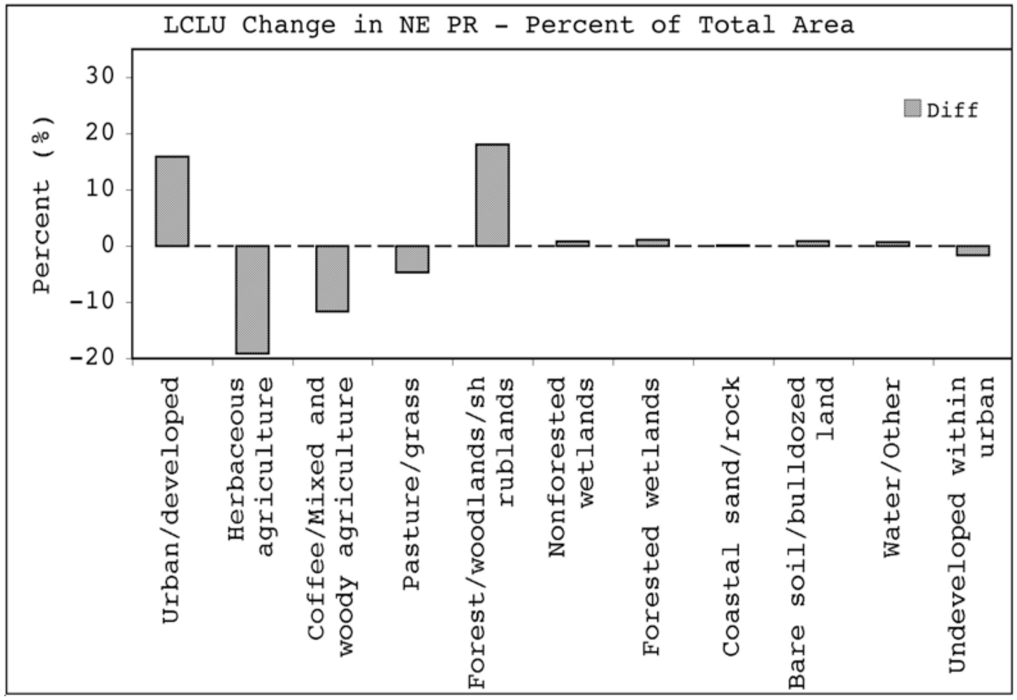
IPCC WG1 4th Assessment Report: Climate Change 2007, The Physical Science Basis

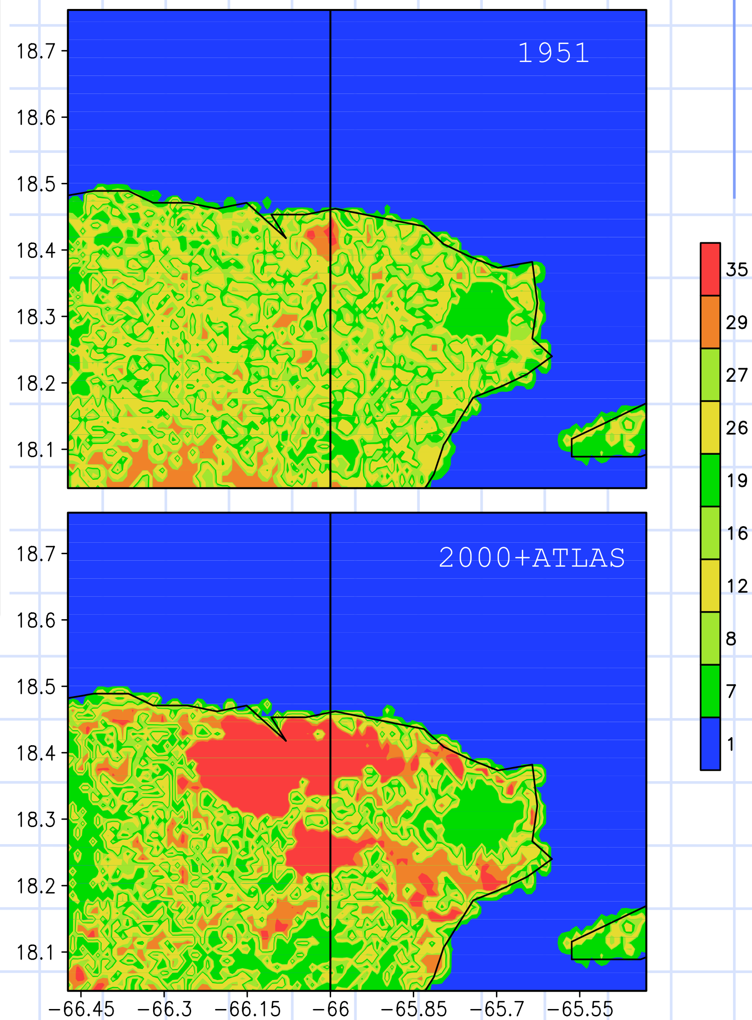




Trenberth, K.E., et al., 2007: Observations: Surface and Atmospheric Climate Change. In: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., et al. (eds.)]

LCLU Specifications - Northeastern PR

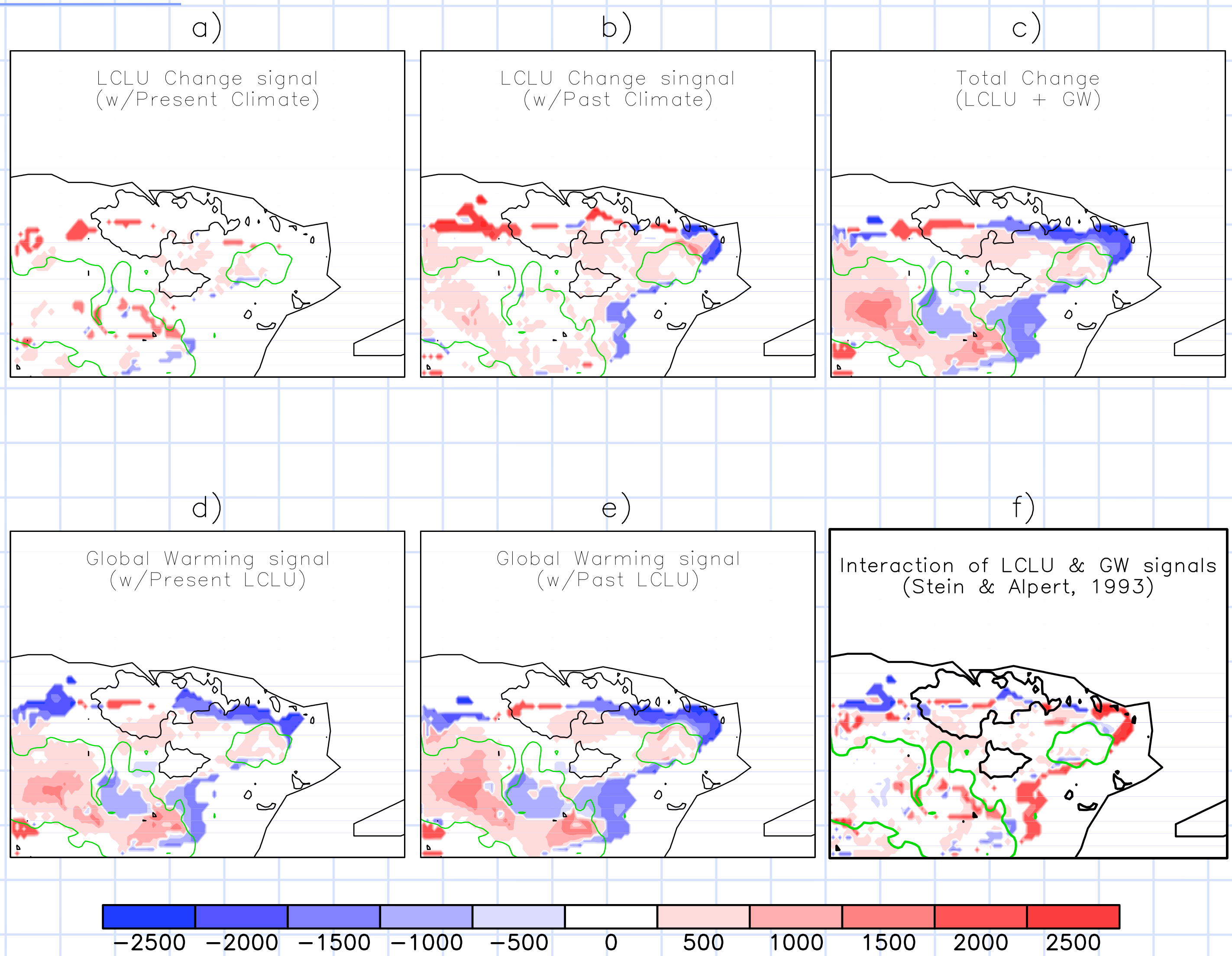




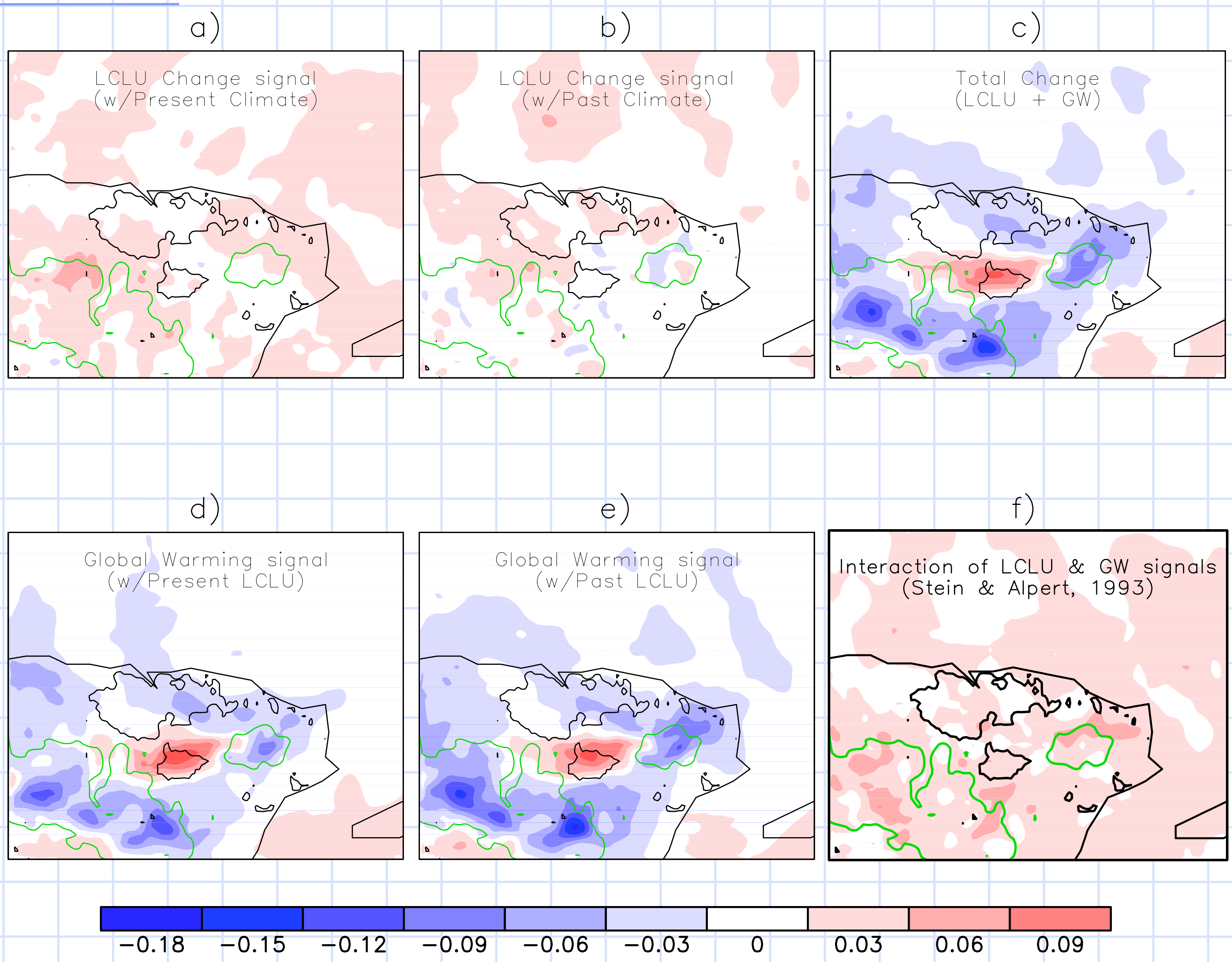
Northeastern Puerto Rico

Description	class	1951	2000	Diff
Background/water	0			
Urban/developed	30	1.92	17.81	15.89
Herbaceous agriculture	8	19.19	0.09	-19.10
Coffee/Mixed and woody agriculture	12	12.38	0.76	-11.62
Pasture/grass	27	33.73	28.99	-4.74
Forest/woodlands/shrublands	3	9.37	27.43	18.06
Nonforested wetlands	16	0.00	0.76	0.76
Forested wetlands	19	0.00	1.08	1.08
Coastal sand/rock	26	0.00	0.14	0.14
Bare soil/bulldozed land	29	0.00	0.91	0.91
Water/Other	1	0.23	0.93	0.70
Undeveloped within urban	7	1.71	0.00	-1.71

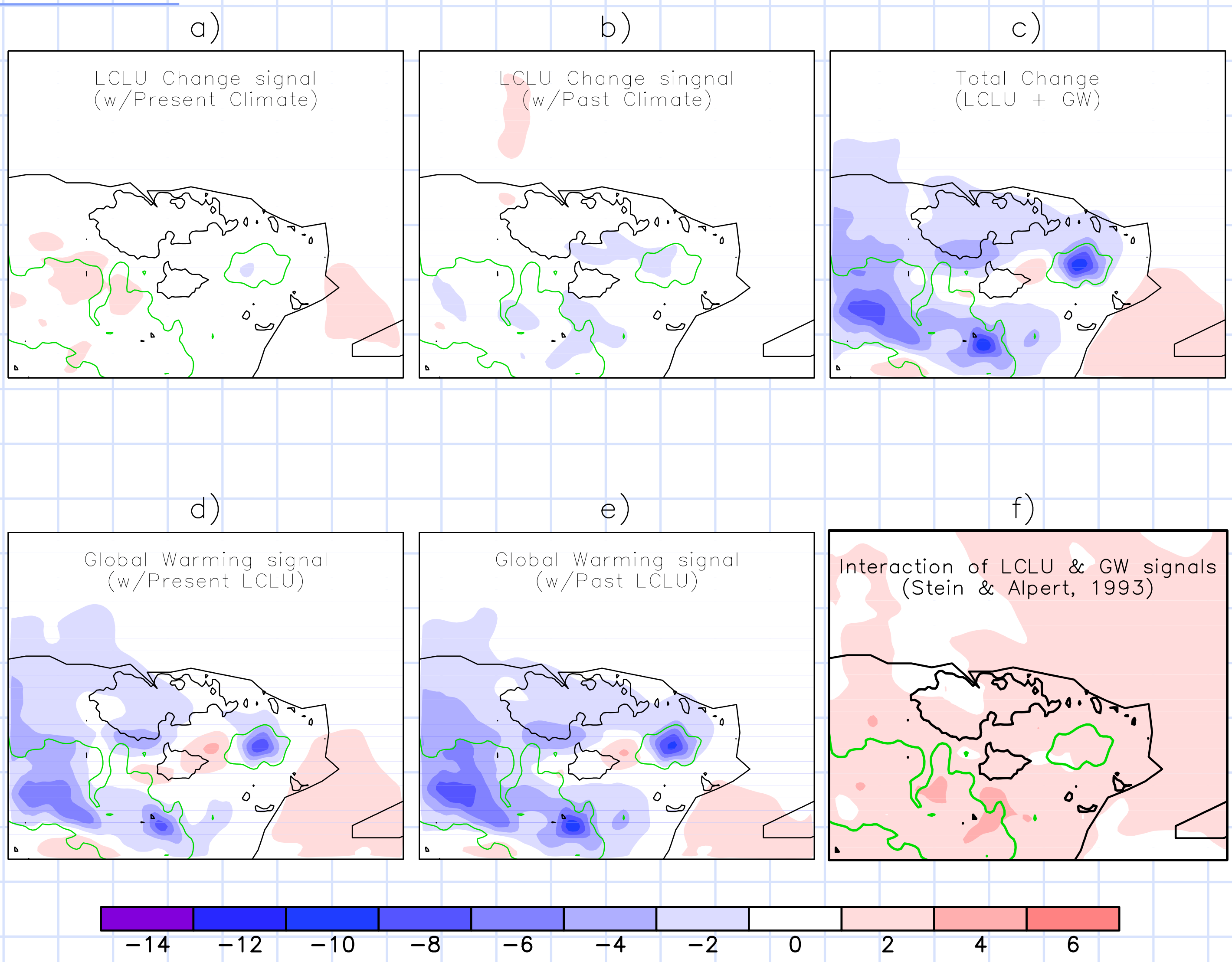
Model Results: Cloud Base Height Difference, 0.01 Mixing Ratio (g kg^{-1})



Model Results: Total Column Liquid Water Content Difference (g kg^{-1})



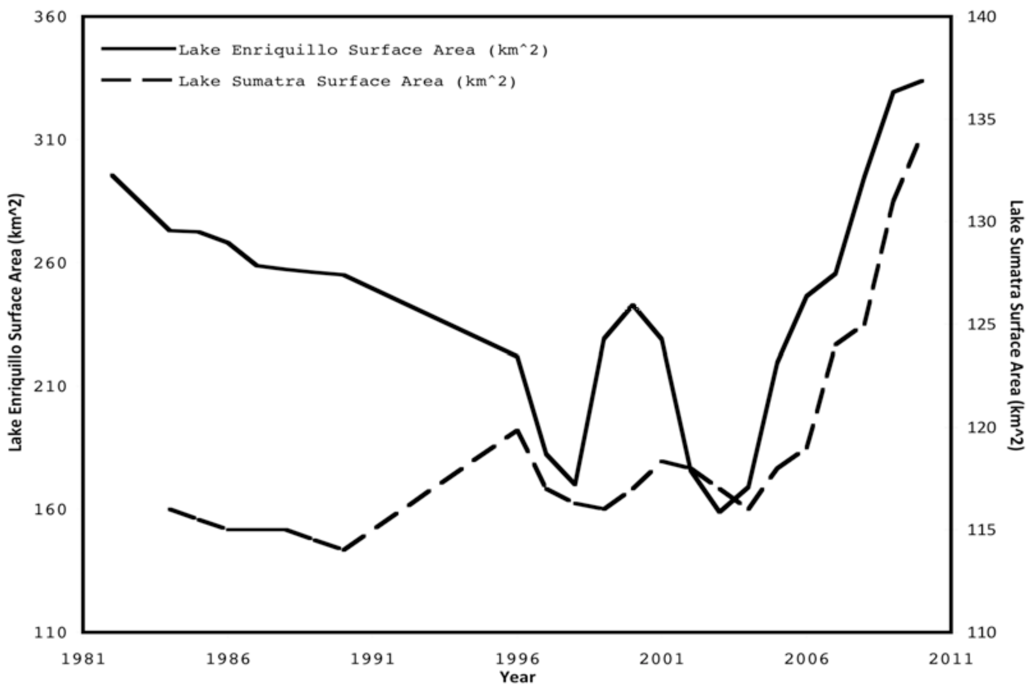
Model Results: ERS (3-Month) Accumulated Precipitation Difference (%)

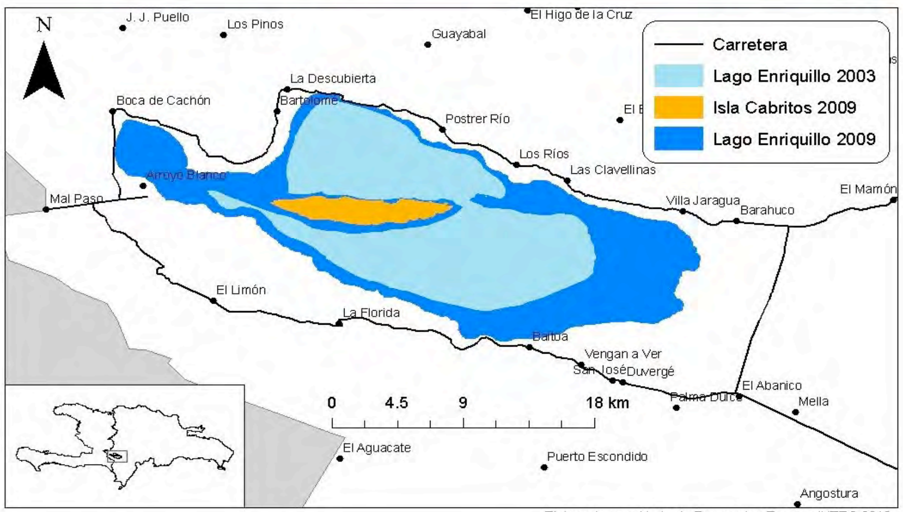


The Enriquillo Watershed

- The Enriquillo and Sumatra lakes are saltwater lakes located in a rift valley that is a former marine strait created around 1 million years ago when the water level fell and the strait was filled in by river sediments.
- Lake Enriquillo size has doubled in size from 2004 to 2009.
- In the region of the lake, average precipitation has increased by ~40%, and average SST around Hispaniola has increased ~ 1˚C, both in the last 30 years.

Average Enriquillo and Sumatra Lakes Surface Area 1984-2009





Elaborado por el Lab. de Percepcion Remota INTEC 2010.

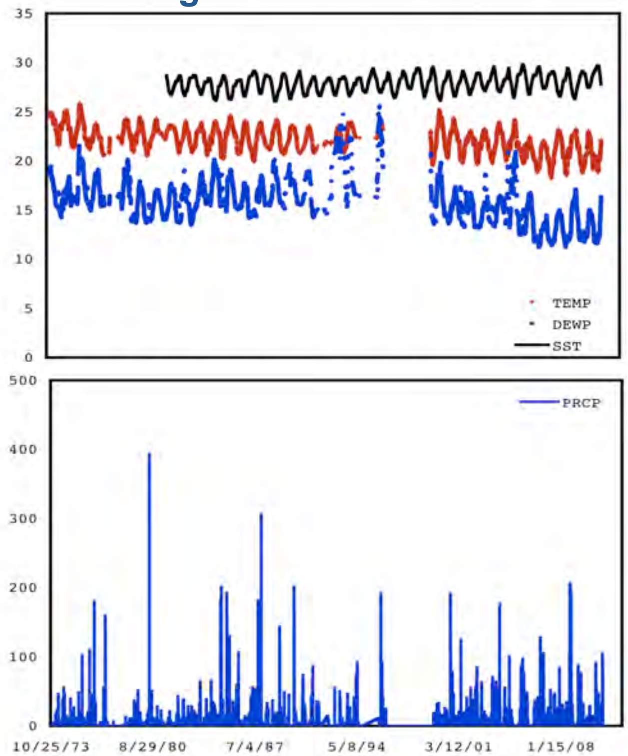
Using Landsat images the surface area of the lake for past 30 years was calculated. The remote sensing measurements were analyzed in ArcGIS

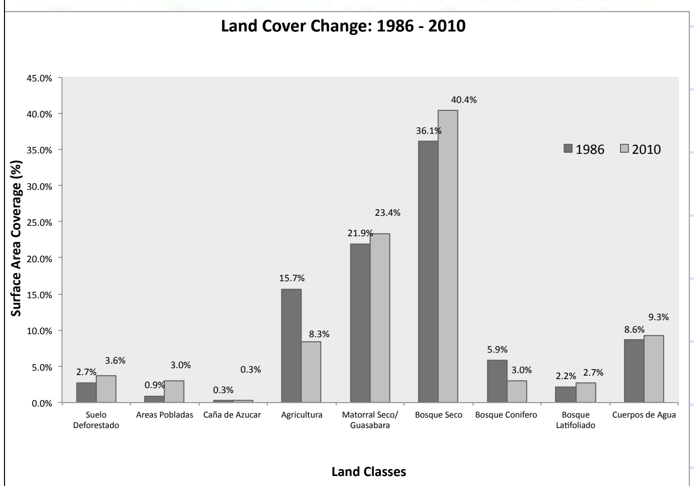
SOCIAL IMPACT

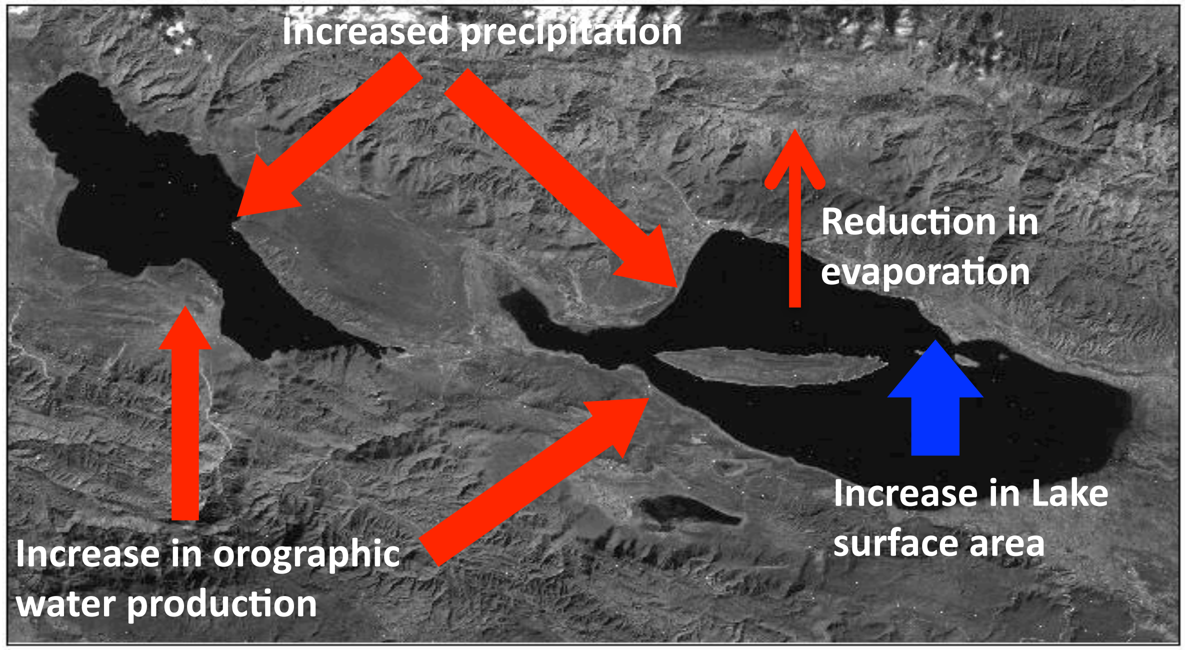
- Flooding of 16 communities in two provinces
- 10 000 affected farmers and families
- Over 18 685 hectares of agricultural land flooded
- Flooding and damages of over 1 000 properties

Why is the Surface Area of the Lakes Changing Dramatically?
A Hydro-Meteorology Hypothesis

Regional Climate Data





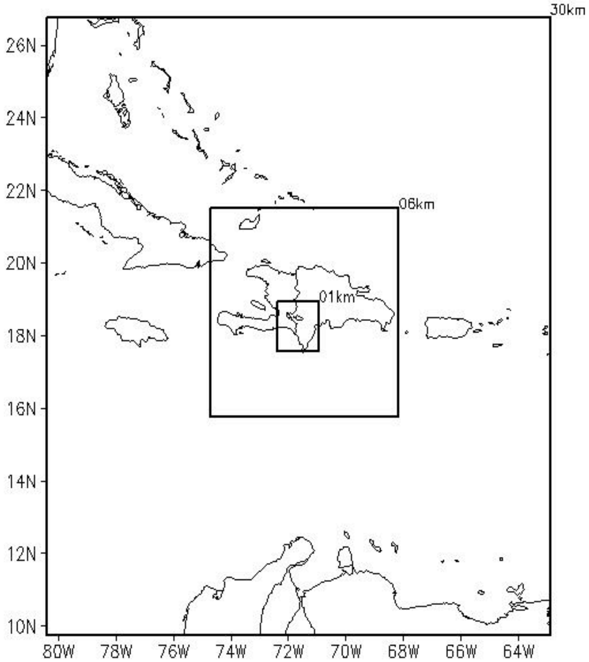


- Increased moisture in the lake area due to increased SSTs surrounding the lake basin
- Increasing runoffs due to changes in use of surrounding land and increased precipitation
- Increasing fresh water production in the area due to increased horizontal rain produced mainly by orographic cloud formation in the surrounding cloud montane forests

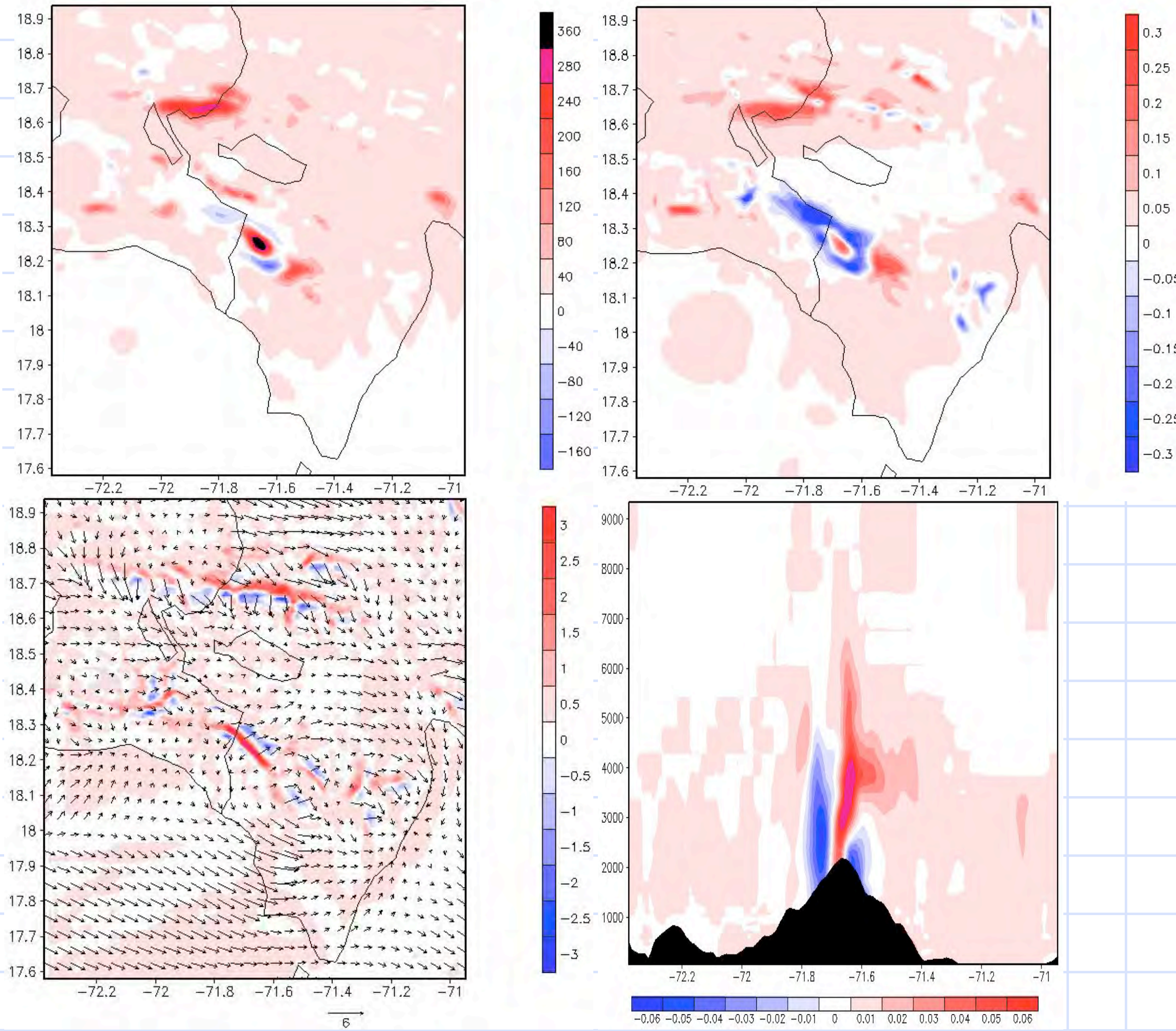
A combination of these factors could lead to Total Lake Surface Area increase

A Hydro-Meteorology Hypothesis Tested with Atmospheric Modeling: Preliminary Results April 2004 (Lowest Point) and 1995 (Shrinking Period)

Total surface precipitation and Total liquid water content between 700-1500 m



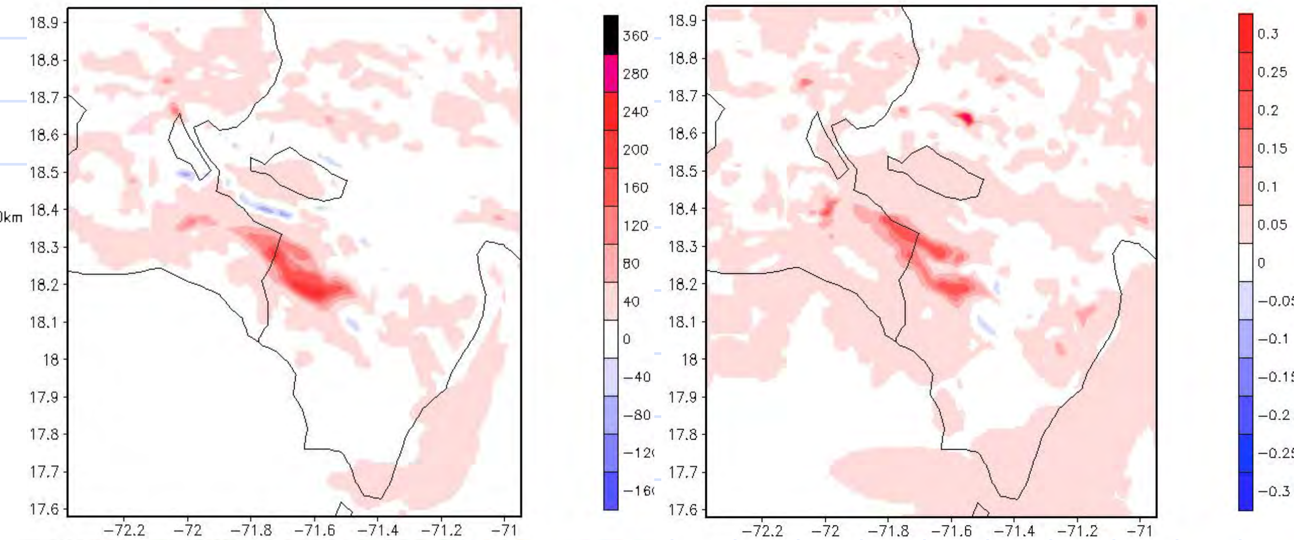
Modeling grids. Grid 3 showing model topography (c. int. 450 m)

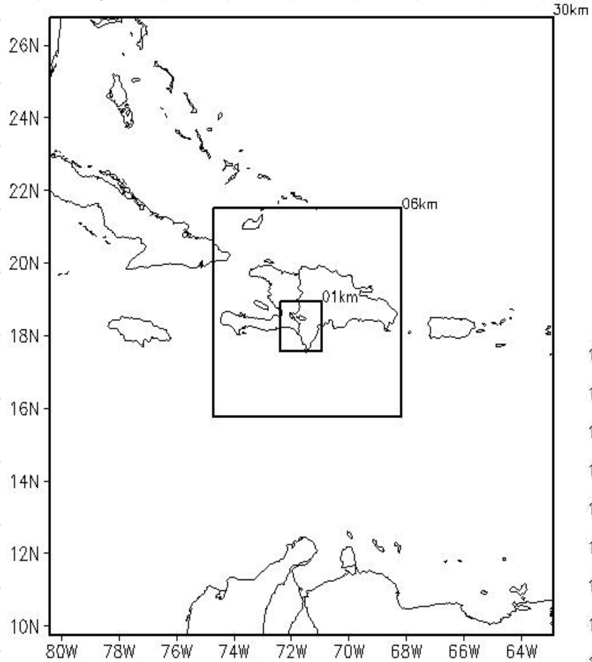


Averaged surface wind (vectors) with vertical motions (contours) and Total liquid water content along cross-section at 18.25 N Lat.

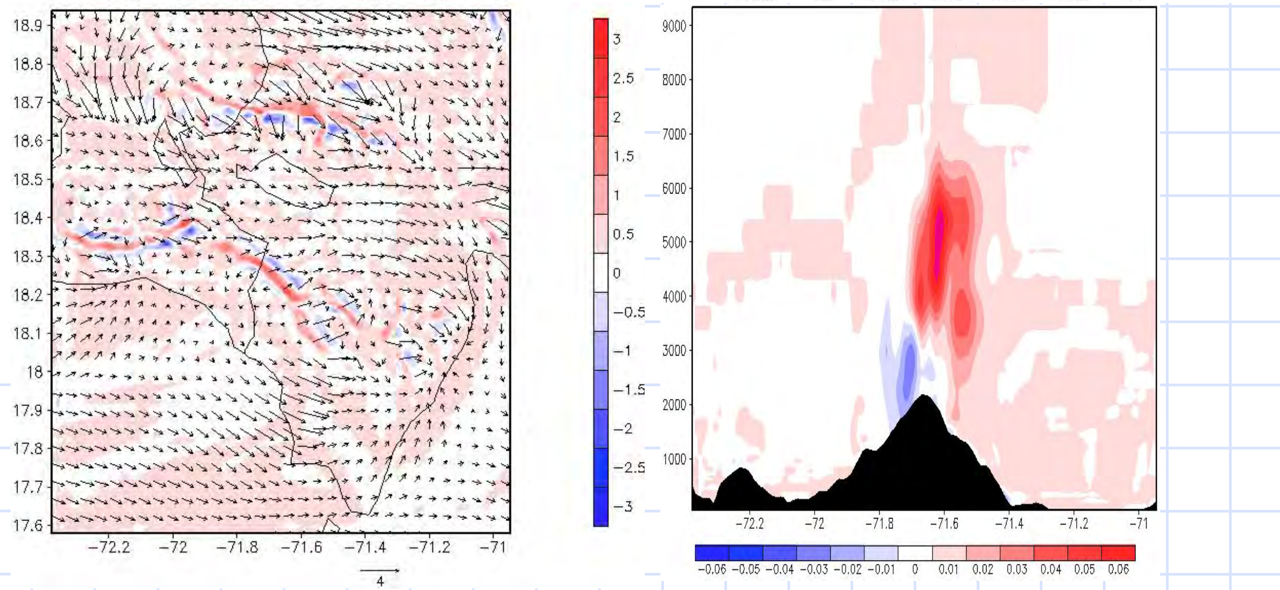
A Hydro-Meteorology Hypothesis Tested with Atmospheric Modeling: Preliminary Results April 2010 (Growth) and 1995 (Shrinking Period)

Total surface precipitation and Total liquid water content between 700-1500 m





Modeling grids showing horizontal resolution of each.



Averaged surface wind (vectors) with vertical motions (contours) and Total liquid water content along cross-section at 18.25 N Lat.