

# Recent and Near-Term Changes in Heat Stress

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## Mesoamerican Nephropathy or Global Warming Nephropathy?

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“A common theme is that the CKD is occurring in subjects working manually outside, directly exposed to sunshine, frequently in areas where there is significant water shortage or scarce access to potable water.

**“We propose that the Mesoamerican nephropathy is essentially a consequence of global warming, and may be one of the first major diseases described as a consequence of extensive fossil fuel use and the greenhouse effect “**

- The form of kidney failure, known as ***chronic kidney disease of non-Traditional origin (CKD-nT)***, is found from S. Mexico to Panama. It occurs only along the Pacific coast, particularly among male sugar cane cutters.
- Researchers have attributed ~ 20,000 deaths to this form of kidney failure over the past two decades in Central America.
- A similar epidemic among Sri Lanka sugar farmers, which has a hot climate like western Nicaragua. In response, ***the Sri Lankan government banned glyphosate.***



Manuel Antonio Tejarino, 49, cut sugar cane for nine years. Now his kidneys are failing, and he is too sick to work.

Jason Beaubien/NPR

Sugar cane is a perennial grass that requires high temperatures, plenty of sunlight, large quantities of water

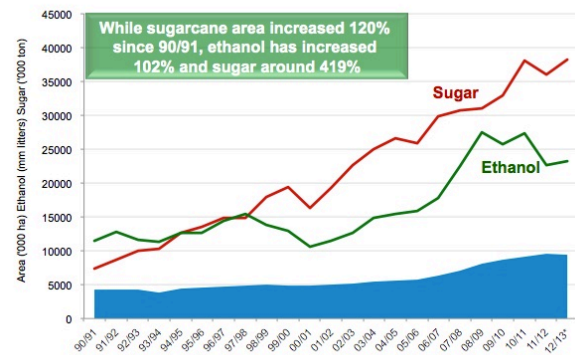
Optimum temperature for sprouting (germination) of stem cuttings is 32° to 38°c. It slows down below 25°, reaches plateau between 30°-34°, is reduced above 35° and practically stops when the temperature is above 38°.

Moisture and heat favor growth, while dry sunny periods and low night temperatures are favorable for maturation and sugar accumulation.



## Increased Exposure

SUGARCANE IN BRAZIL: HARVESTED AREA, ETHANOL & SUGAR PRODUCTION



Sources: IBGE and UNICA. Prepared by UNICA.  
Note: \* estimated

## The Mesoamerican nephropathy: a regional epidemic of chronic kidney disease?

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### Dehydration, Heat Stress, Exposure to Agrochemicals

The causes of this disease remain unknown, but recurrent dehydration, unregulated alcohol (lija) and exposure to agricultural products have been suggested as potential causes [8].

The First International Research Workshop on MeN met in Costa Rica in November 2012 to discuss how to establish the extent and degree of MeN, examine relevant causal hypotheses, and to focus efforts to control or eliminate the disease burden.

This workshop established that the cause of MeN remains uncertain; however, the group suggested that repeated episodes of occupational heat stress and water and solute loss, in combination with exposure to other nephrotoxic medication, or exposure to inorganic arsenic, leptospirosis or pesticides, might be responsible for this epidemic [9].

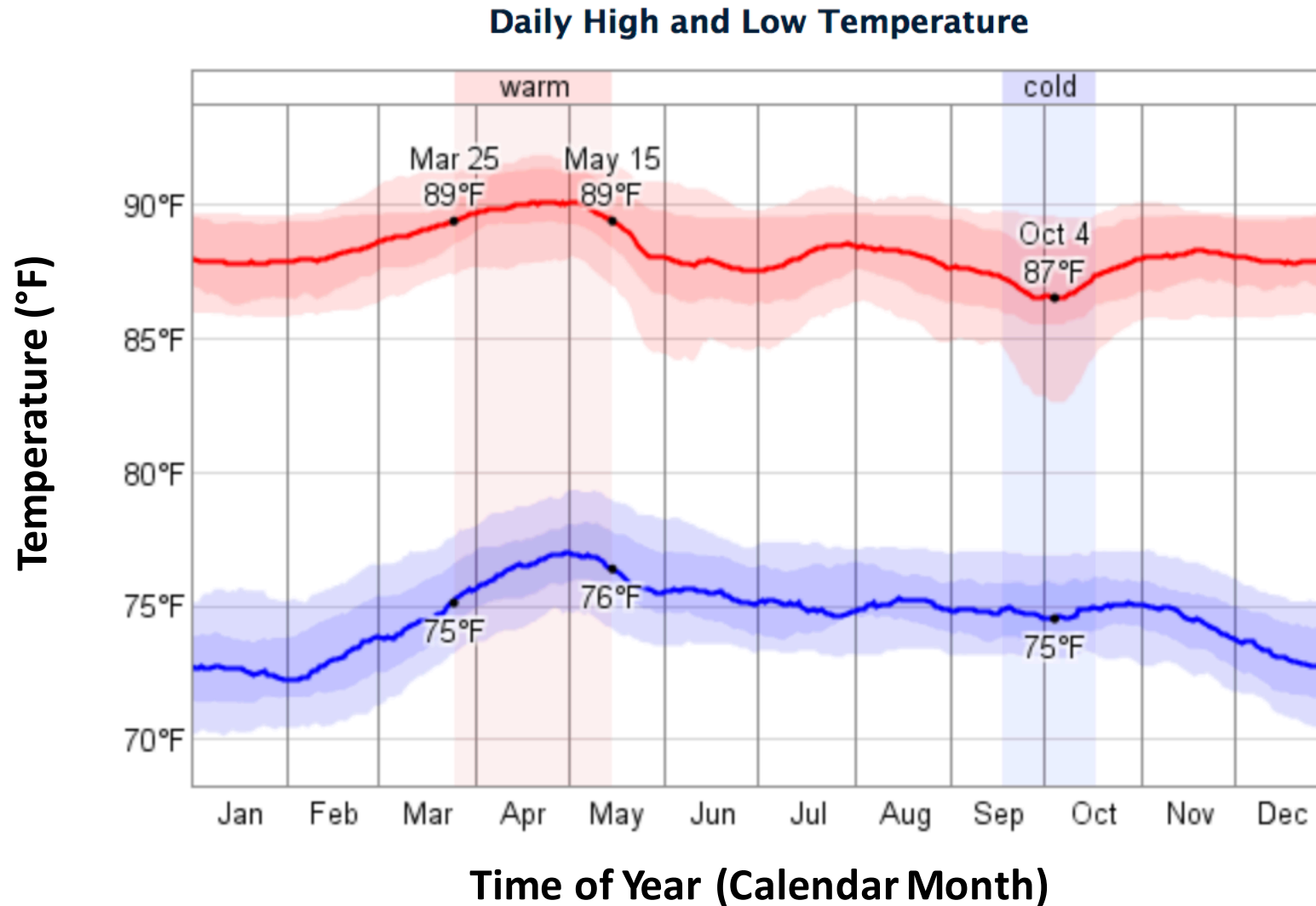
Central America has a long-standing history of misuse of agrochemical products [10], and some pesticides commonly used in this region are clearly nephrotoxic and may be responsible for the MeN [11–13].

More studies are urgently needed to establish the causes of MeN and role of pesticides in this epidemic to implement public health interventions that might put an end to this epidemic in Central America.

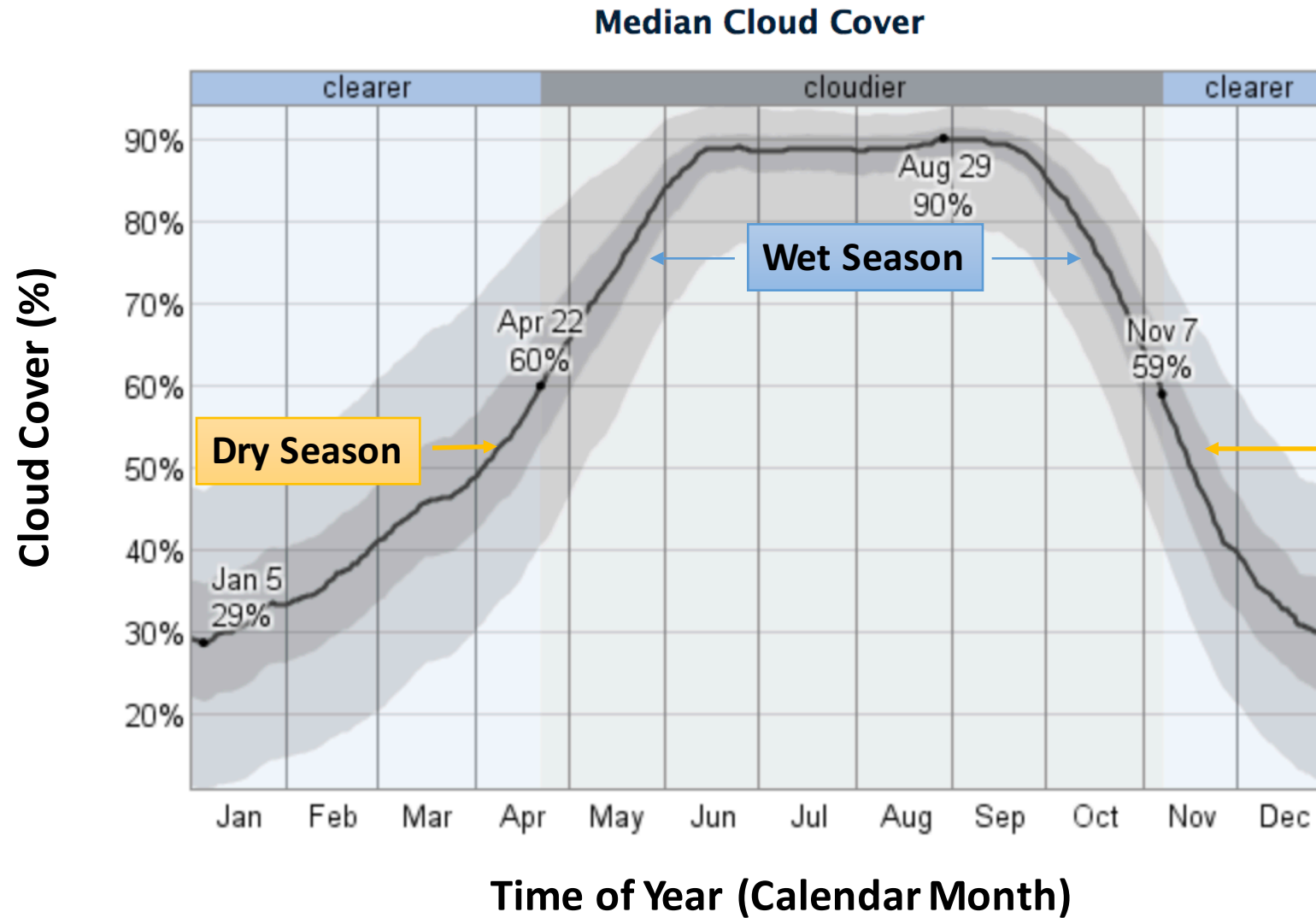
## **Part I: What are Key Characteristics of Current Climate in Central America Sugarcane Region?**



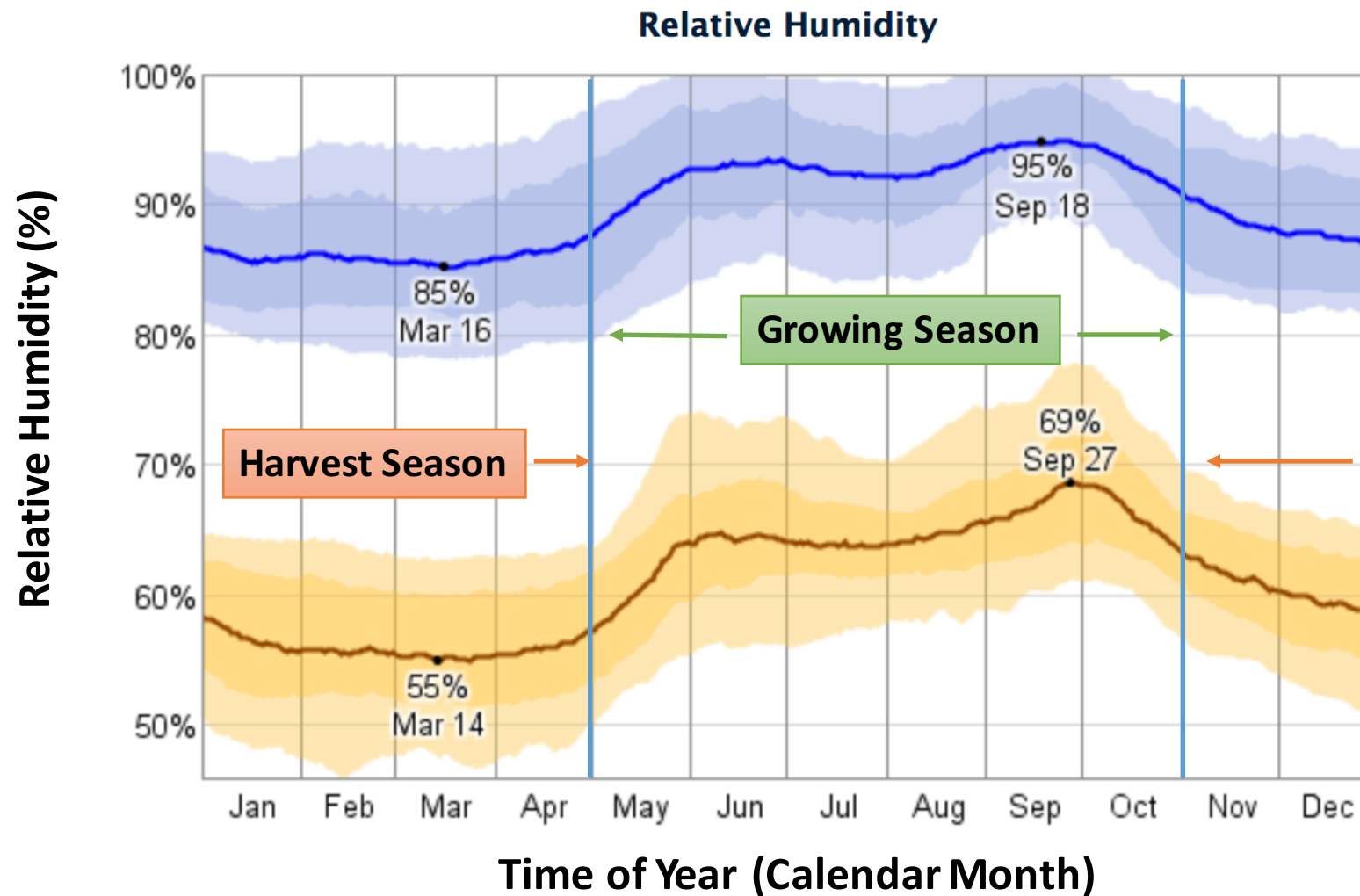
Tapachula International Airport (Tapachula, Mexico: ~500*ft* elevation)



## Tapachula International Airport (Tapachula, Mexico)

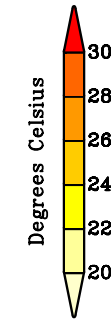
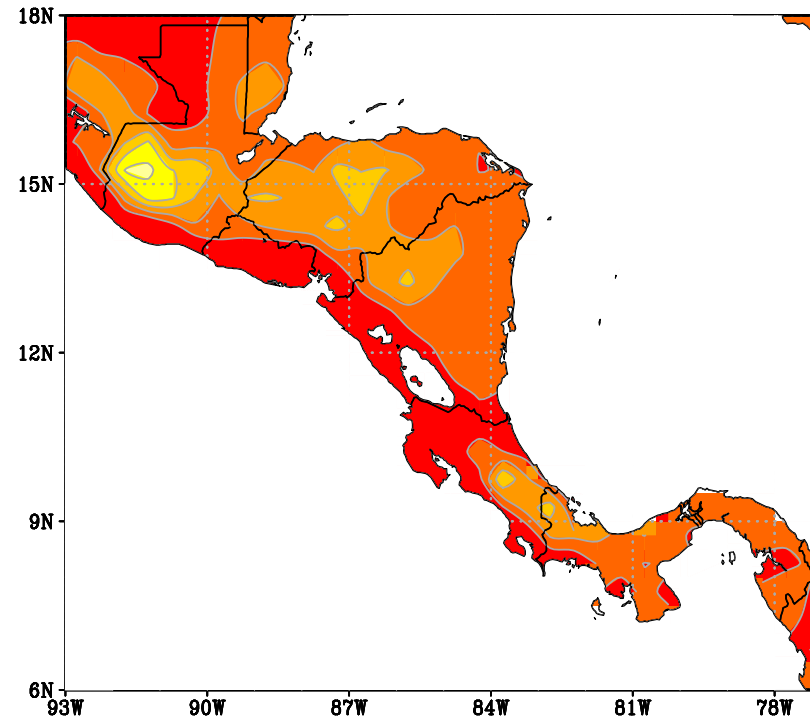


## Tapachula International Airport (Tapachula, Mexico)



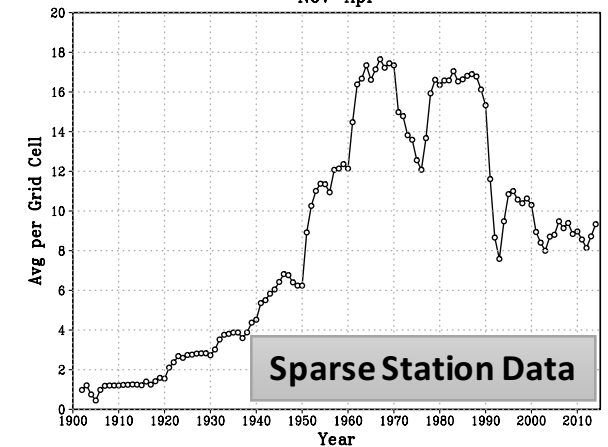
# Observed Climatological Daytime Temperature during *Sugarcane Harvest Season*

Average Nov–Apr T<sub>mx</sub> Temperature  
Station Based



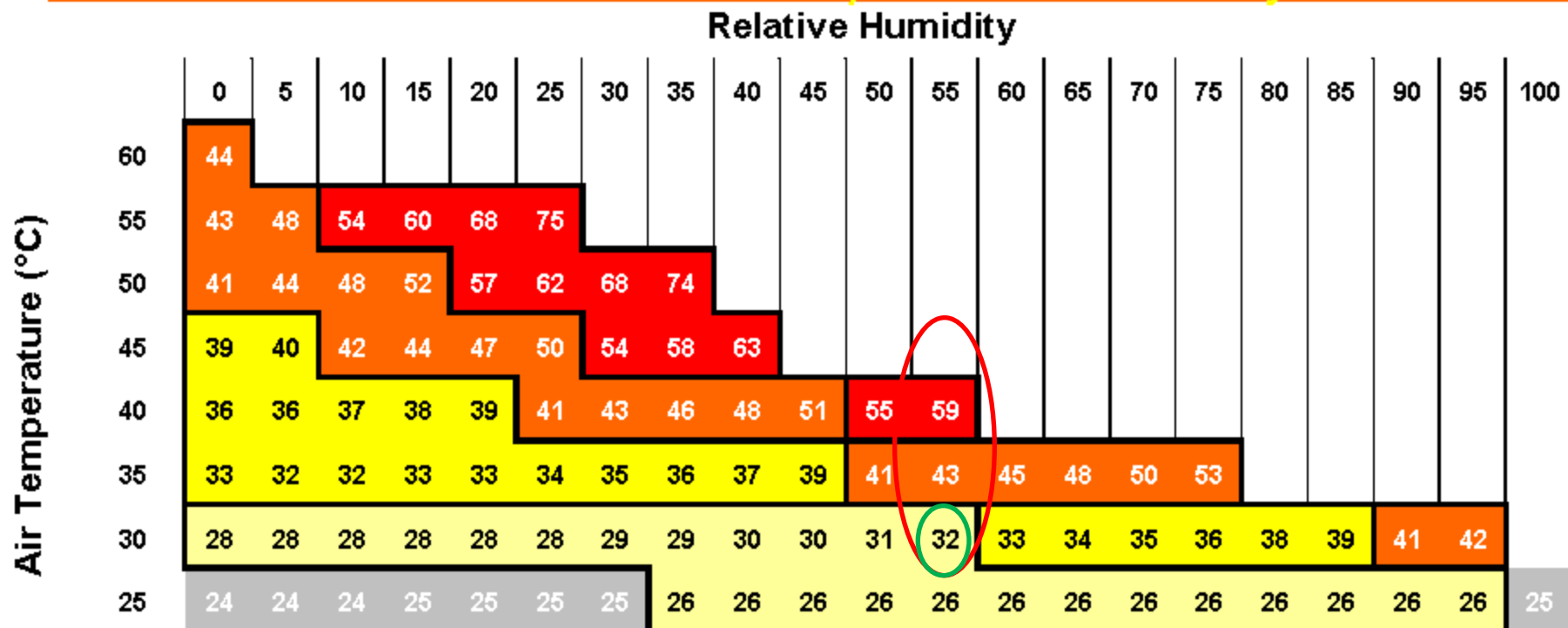
Pacific coastal region : Daily T<sub>max</sub> ~30-32°C

Temperature Station Counts over Central America  
Nov–Apr



## Heat Index

*how hot the combination of temperature and humidity feels*



- Extreme Danger (54°C or higher).** Heatstroke or sunstroke likely.
- Danger (41 – 54°C).** Sunstroke, muscle cramps, and/or heat exhaustion likely. Heatstroke possible with prolonged exposure and/or physical activity.
- Extreme caution (33 – 40°C).** Sunstroke, muscle cramps, and/or heat exhaustion possible with prolonged exposure and/or physical activity.
- Caution (26 – 32°C).** Fatigue possible with prolonged exposure and/or physical activity.

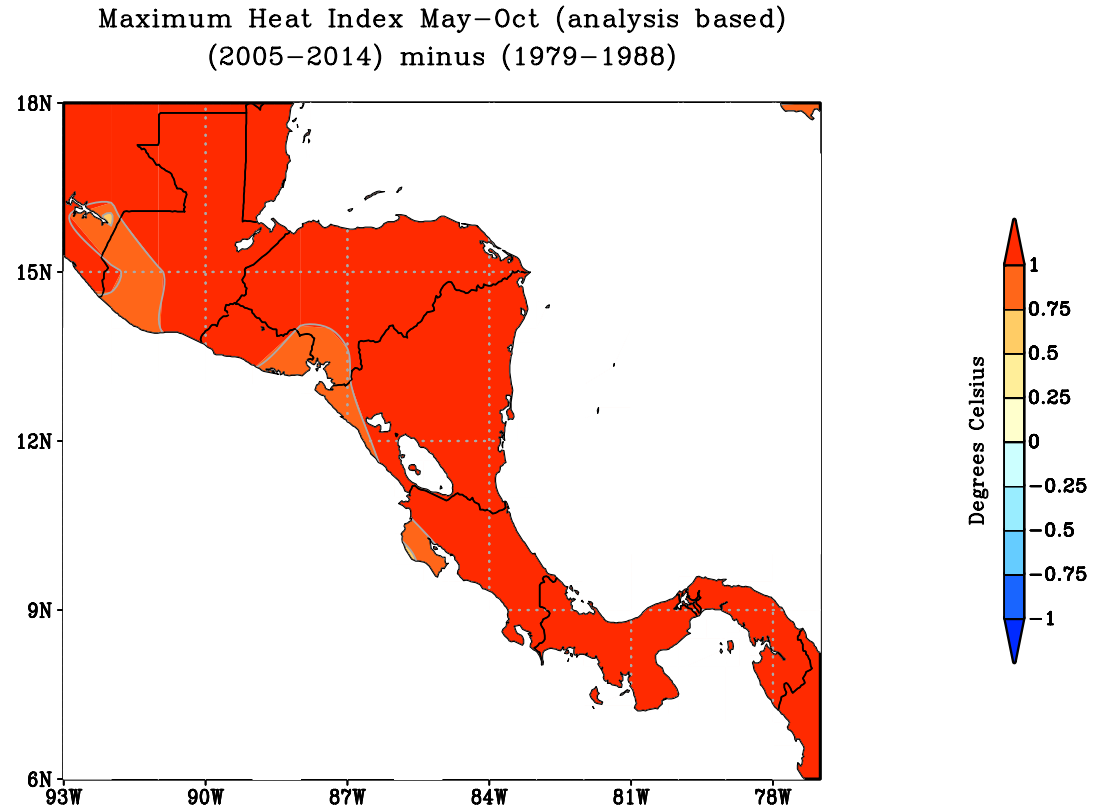
## Take away: re: Climatological Central American Temperature and Heat Stress

- The Pacific Coast region is the warmest portion of Central America; *ocean effects/terrain*
- Pacific Coast Nov-Apr (harvest season) air temperatures  $\sim 1^{\circ}\text{C}$  warmer than May-Oct: *small seasonal cycle*
- Pacific Coast Nov-Apr (harvest season) is less humid than May-Oct; *dry season*
- The daytime air temperature ( $\sim 32^{\circ}\text{C}$ ) and heat index values ( $\sim 35^{\circ}\text{C}$ ) are similar during the harvest season

**Part 2: What is Known about Climate Trends in Central America Sugarcane Region?**  
*(2005-2014) to (1979-1988)*

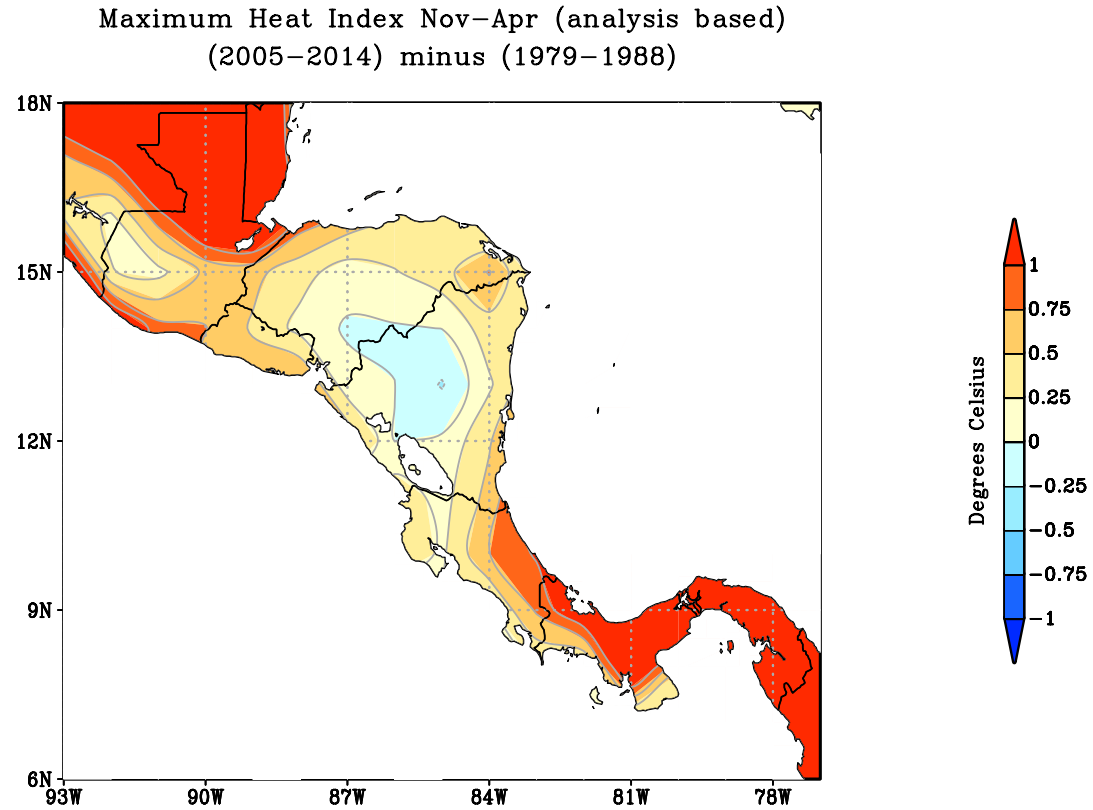
# **“Observed” Change in Daytime Heat Stress: Sugarcane Growing Season**

*May-Oct, comparing (2005-2014) to (1979-1988)*



# **“Observed” Change in Daytime Heat Stress: Sugarcane Harvest Season**

*Nov-Apr, comparing (2005-2014) to (1979-1988)*



## Take away: re: Recent Observed Climate Trends in Central America Sugar Cane Region

- Heat stress has probably increased  $\sim 1^{\circ}\text{C}$  throughout the year (*there is observational uncertainty*).
- Heat stress has *likely risen less during the sugarcane harvest season* compared to the growing season.
- Heat stress has risen mostly due to increases in daytime temperature, not due to humidity increases.
- ***Only a “modest” rise in the Pacific Coast harvest season heat stress since 1980 ( $< \sim 1^{\circ}\text{C}$ )***

## Take Away re: Climate Change During the Period of Surging CKD-nT Deaths

- Daytime heat stress in the Central American Pacific coast region has risen since the 1980s
  - *the rise in heat stress has likely been less than 1°C during harvest season*
  - *the rise in heat stress has likely been more than 1°C during growing season*
- It is plausible that *CKD-nT* increase over the last 20 yrs has been more about climate and health rather than about climate change and health.
  - *what is worker exposure during the growing season when largest warming has occurred?*
- An ironic twist is that increased sugarcane demand, partly to mitigate climate change effects and reduce fossil fuel burning, has likely increased human exposure to health risks in sugarcane harvesting.

## **Part 3: How is Heat Stress Expected to Change in Coming Decades?**

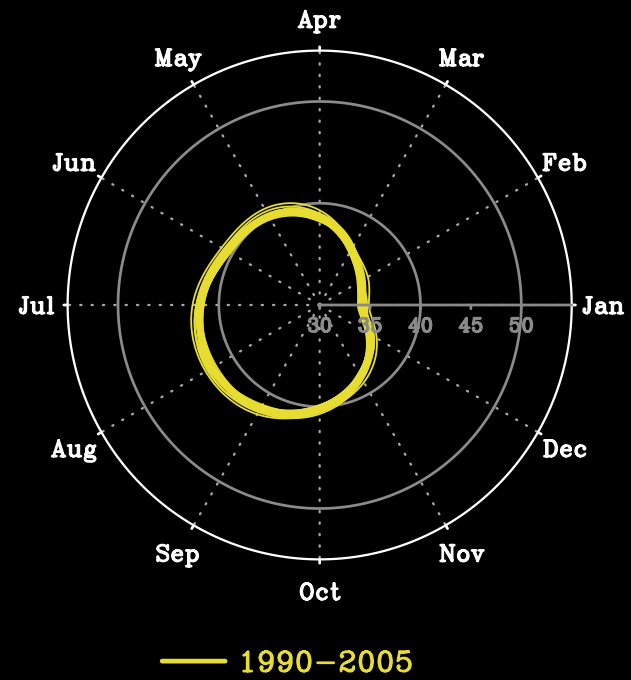
# Climate Model Projection

## NCAR Community Earth System Model (CESM1)

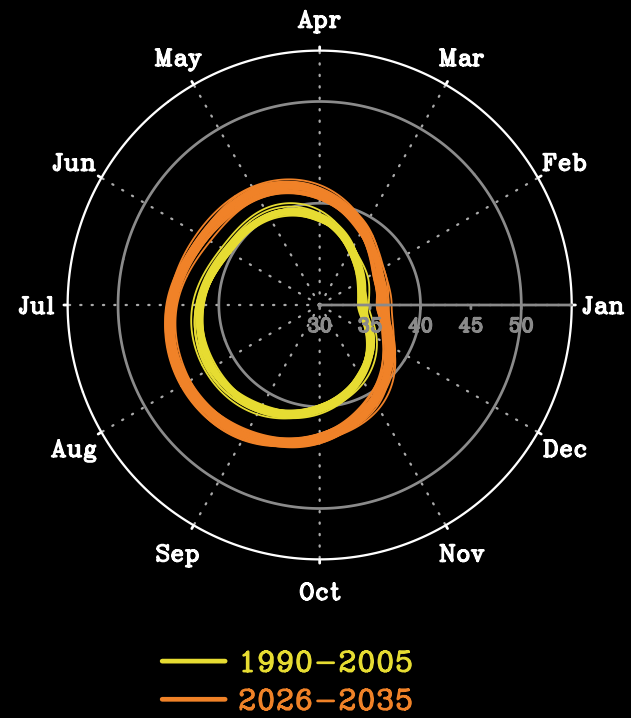
- Global ocean-atmosphere-land model
- Resolved atmospheric spatial scales  $\sim 100\text{km}$
- Driven by historical greenhouse gas/anthropogenic aerosols plus solar and volcanic variability 1920-2005
- Forced by projection of global GHG emissions (RCP8.5) from 2006-2100.
- Forty-member ensemble
- Diagnose simulated heat stress (calculated from 4-x daily temperature/relative humidity):
  - 1990-2015 (calibration and reference)
  - 2026-2035
  - 2071-2080

**Kay, J. E.,** and Coauthors, 2015. The Community Earth System Model (CESM) Large Ensemble Project: A Community Resource for Studying Climate Change in the Presence of Internal Climate Variability, *Bulletin of the American Meteorological Society*, 96, 1333–1349.

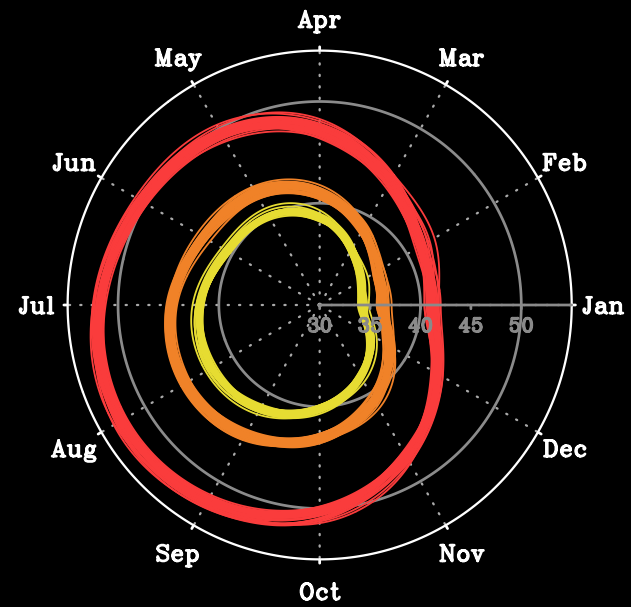
Southwest Coastal Central America  
Max Heat Index Climatology



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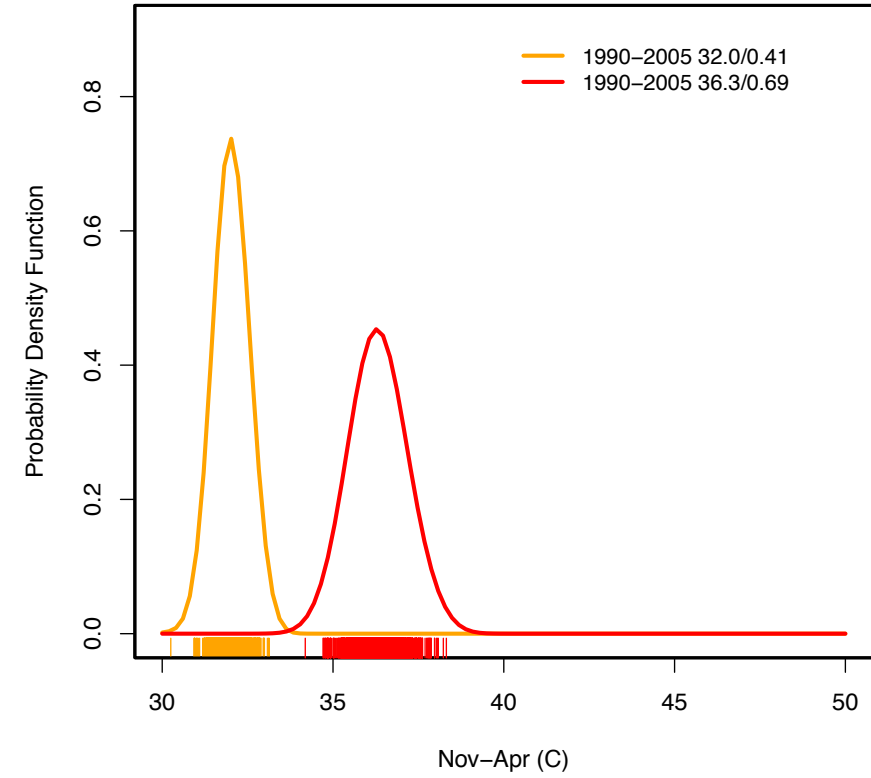


Southwest Coastal Central America  
Max Heat Index Climatology

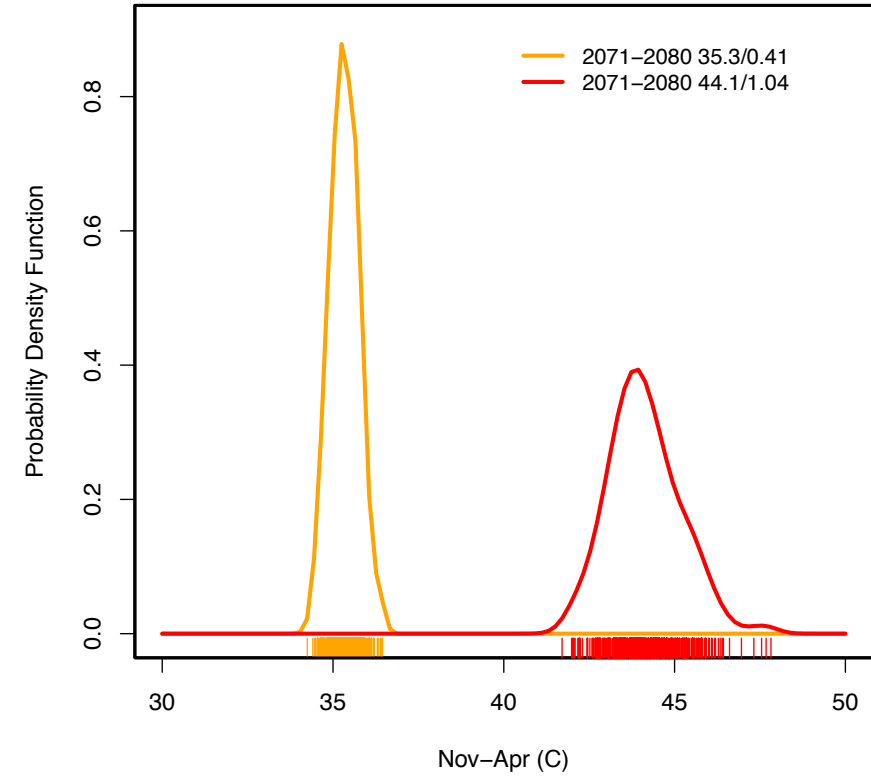


— 1990-2005  
— 2026-2035  
— 2071-2080

Southwest Coastal Central America  
Nov–Apr Max Temperature/Heat Index



Southwest Coastal Central America  
Nov–Apr Max Temperature/Heat Index



## Take away: re: Future Heat Stress Changes in Central America Sugarcane Region

- Heat stress will increase much more than temperature in Central America  
--- *non-linear relation between heat stress and temperature in hot/humid conditions*
- Heat stress in the harvest season projected to be ~2-3°C greater in 2026-2035 than during 1990-2015.  
--- *typical values near 40°C (104°F) in March/April dangerous for prolonged exposure*
- Heat stress in the harvest season projected to be ~7-9°C greater in 2071-2080 than during 1990-2015.  
--- *typical values above 45°C (113°F) in March/April approaching extreme danger for prolonged exposure*
- Heat stress in the growing season to increase more, **and exceed 50°C in 2071-2080.**

## Summary Comments/Interpretations

- Recent increases in heat stress (2005-'14 vs 1979-'88) have been small during the harvest season (less than 1°C)
  - *Mesoamerican nephropathy in the last several decades is unlikely due to global warming*
  - *Mitigation of the warming effects, to date, appears to be amendable thru simple adjustments in harvest practices*
- An acceleration is expected in heat stress rise over the next several decades.
  - *Sugarcane cropping activities will become virtually impossible within about 2 generations owing to extreme heat stress (independent of other hazards) based on current practices.*