Towards Early Warning Systems for Drought and Fire Risk in the Caribbean: Analysing Data for Trinidad and Tobago

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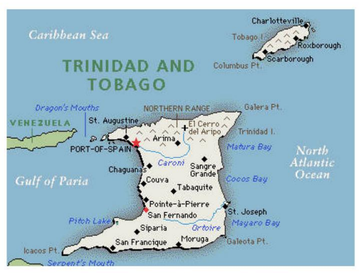
RESEARCH OBJECTIVES

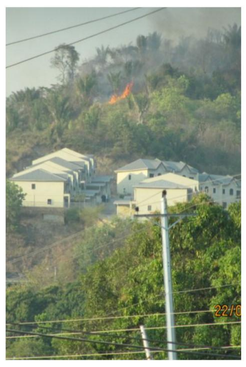
To understand the viability and potential of available climate information for early warning systems for drought in Trinidad and Tobago (T&T), using 2010 drought as case study

Specific actions:

- Mapping the availability and accuracy of station precipitation and locally-sourced drought data proxies, with various precipitation and vegetation satellite data
- Investigating the potential use of information towards improved understanding of signs and circumstances of onset of drought-like conditions in Trinidad and Tobago

RATIONALE FOR RESEARCH





- Concerns of drought Jan-May 2010 (social, print media)
  - Lowest ever Feb rainfall total for Trinidad recorded in 2010
- Physical, economic & social impacts: fire hazards, water scarcity, water rationing, food security & price inflation
- IPCC 2007 AR4 outlook: role of climate change leading to drier conditions within (much of) the Caribbean
  - Annual temperature increase between 1.4°C to 3.2°C (median: 2.0°C), for region at end of 21st century (high conf.)
  - Annual precipitation changes between -39% and +11% (median: -12%), region-wide
  - NAO, ENSO changes associated with general drying effect
- Need for risk minimisation: EWS, national drought policy
  - Given current vulnerability and level of resilience, increased & periodic disaster risk for drought, fire susceptibility possible

DATA SOURCES

Table 1: *Summary of Available Rainfall Data*

Satellite Data Product	Temporal Resolution	Data Frequency	Spatial Resolution
CPC Merged Analysis of Precipitation (CMAP)	Jan 1979 – Nov 2011	monthly pentad	2.5°
Global Precipitation Climatology Project (GPCP)	Jan 1979 – Jan 2010	monthly	2.5°
Tropical Rainfall Measuring Mission (TRMM)	Jan 1998 – Dec 2013	daily 3-hourly	0.25°
CPC Morphing Technique (CMORPH)	Feb 2005 – Mar 2014	daily 3-hourly	0.25°

Station Precipitation Data	Temporal Resolution	Data Frequency	Spatial Resolution
Global Historical Climatology Network (GHCN)	Jan 1946 – Aug 2013	monthly	16 stations*
Piarco Data (T&T Met Office)	Jan 1995 – Nov 2011	daily	1 station
T&T Data (WRA Reports)	Jan 1995 – Dec 2008	monthly	15 stations

Table 2: *Summary of Available Vegetation Data*

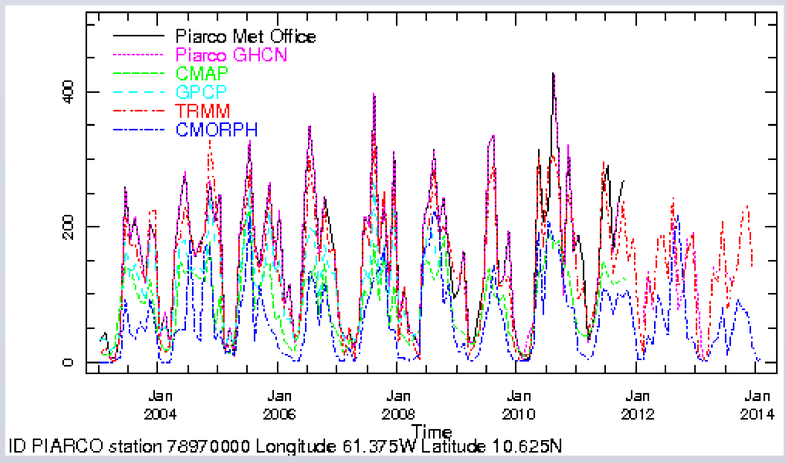
Satellite Data Product	Temporal Resolution	Data Frequency	Spatial Resolution
NDVIg from NOAA-AVHRR	1 Jul 1981 – 31 Dec 2006	15-day comp.	~8 km
MODIS (NDVI, EVI, NDWI)	18 Feb 2000 – present	16-day comp.	~250 m

Local Data	Source
Media Reports, Fire Incidence	Survey of online media, December 2009 – June 2010
Disaster Data	T&T Office of Disaster Preparedness and Management
Bushfire Data	Forestry Division, T&T Ministry of Housing and the Environment

- T&T Data Ranges: 60.5° to 62° West Longitude; 10°to 11.5° North Latitude
- Research has targeted use of freely available and downloadable data
- All Satellite Data obtained from and analysed through the Data Library of Columbia University's International Research Institute for Climate and Society (IRI): http://iridl.ldeo.columbia.edu/

PRELIMINARY RESULTS

Figure 1: *Comparison of Station Rain Gauge Data with Satellite Rainfall Products at Piarco Station (Airport)*



- General similar performance of precipitation values, but some variation for specific periods (e.g. 2010 drought)
- Satellite values tend to underestimate "true" rainfall
  - Lowest approx. error average is -15.5 mm/month (TRMM)
- TRMM and GPCP satellite data seem closely correlated to GHCN station data
  - Note: spatial resolution, data gaps, possible data biases

Table 3: *Comparison of Error Statistics between GHCN Station Data and Various Satellite Data at Piarco*

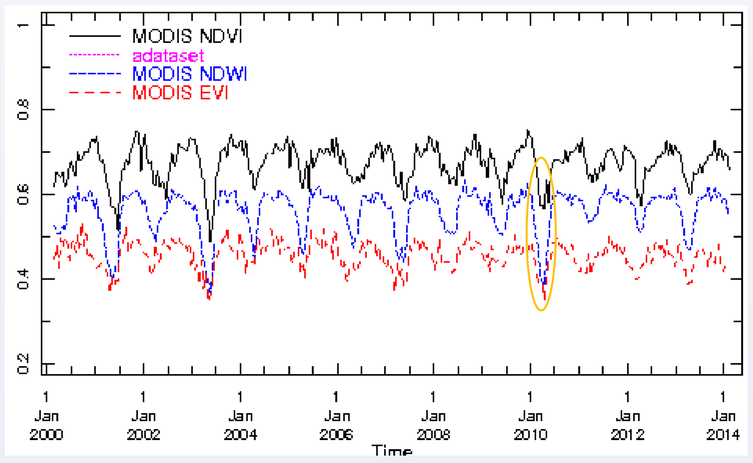
	CMAP Jan '98-Nov '11	GPCP* Jan '98-Sep '08	TRMM* Jan '98 – Nov '13	CMORPH* Jan '03 – Feb '14
Average	-70.63588	-41.489	-15.00235	-92.20594
Root Mean Square	98.77417	58.83873	34.73603	117.5814
Correlation	0.804837	0.9897339	0.9576664	0.6703253

** With 92% monthly average (non-missing values)*

Table 4: *Comparison of precipitation data at Piarco for Jan-May 2010*

	Jan '10	Feb '10	Mar '10	Apr '10	May '10
Piarco Met Office	17.60	2.10	4.40	60.20	313.80
Piarco GHCN	18.00	2.00	40.00	60.00	-
CMAP	17.98	7.56	9.92	57.90	132.37
TRMM	0.88	0.29	0.12	26.92	192.81
CMORPH	4.41	14.93	5.13	57.39	301.84

Figure 2: *Comparison of Vegetation Estimates*



- Review of vegetation indices show similarly trending values
- Instances of severe decline shown to exist particularly in early months (dry season) of 2001, 2003 and 2010
- For 2010, declines in indices were "at the right times", i.e. when media reports signaled increased drought/fire activity
  - Could suggest potential for use in early warning of agricultural and ecosystems drought impact onset
- Potential use of vegetation index as early warning proxy for drought impacts ('drought watch')
- Low level of NDWI can indicate risk of less vegetation moisture; could be good signal for fire risk
  - Note: Due to different timescales for comparison, NDVIg not shown; inconsistencies between NDVI products are present

FURTHER ANALYSIS REQUIRED

General trends of satellite-local data performance need to be further and better analysed.

- Given limited availability of data, temporally and spatially, need to source and use alternative climate information
- Given limited accuracy of data, need to ensure consistency and verification before use in early warning systems
- Given limited acknowledgement of local T&T context, need to encourage more relevant investigation and analysis for effective uptake

Analysis in Progress:

- Using daily data for T&T (one station point), aim to define the degree of agreement between satellite and station data for peak rainfall within varying short windows of time (4, 7, 10, 21 day intervals)
  - As a starting point, this offers insight on the number of correlation "hits" between satellite and station data, towards more informed development of EWS for T&T
- With verified fire, drought events and other disaster data, vegetation signals can be better interpreted

POSSIBLE RESEARCH SYNERGIES

- Ongoing regional work on Standardised Precipitation Index (SPI) in drought monitoring (national agencies/CIMH/UWI)
  - Use of Climate Predictability Tool (CPT) in developing SPIs for forecasting meteorological drought
  - Note: SPI is suggested proxy for meteorological drought/excessive rainfall onset & prediction
- Development of Drought Early Warning Information Systems (DEWIS) by CIMH
- Efforts to develop ground-based data corrected TRMM precipitation estimate by agencies in Caribbean, based on work done in Central America
- Collation and analysis of economic and social data and impacts of drought in the Caribbean

INFERENCES OF RESEARCH

- Climate knowledge can offer validation of potential and utility of satellite estimates for T&T
- Better understanding of data can inform actions at the wider Caribbean level, and small islands/states in general
- Application of climate data could lead to improved information, awareness and response pathways for local drought and fire risk
- With socio-economic data, climate knowledge can help inform action strategies for reducing drought and fire risk and vulnerability
- Better use, accuracy and awareness of data can inform efforts on climate services and partnerships
- Broader identification possible towards resilience-building of small islands against the impacts and consequences of climate change

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- Trinidad and Tobago Office of Disaster Preparedness and Management
- Forestry Division, Trinidad and Tobago Ministry of Housing and the Environment

Comments? Questions?

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- IPCC 2007 AR4: Climate Change 2007: Working Group I: The Physical Science Basis, Section 11.9.3.1 Caribbean
- NDVI: Normalised Difference Vegetation Index
- EVI: Enhanced Vegetation Index (more optimised for, and responsive to, a decoupling of the canopy background signal and a reduction in atmosphere influences, when compared to the NDVI's sensitivity to chlorophyll)
- NDWI: Normalised Difference Water Index (a remote sensing estimate of vegetation liquid water content from space)
- MODIS: Moderate Resolution Imaging Spectroradiometer (a key instrument aboard the Terra (EOS AM) and Aqua (EOS PM) satellites)
- AVHRR: Advanced Very High Resolution Radiometers