Climate Scenario in the Caribbean and its Possible Impact on Energy Security

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About CIMH

- WMO Regional Training Centre
- Centre for Research in Meteorology, Hydrology and Climatology
- Regional Data Centre
- Regional Instruments Centre
- Regional Centre of Excellence in Satellite Meteorology
- WMO Regional Climate Centre
- Caribbean Centre for Climate and Environmental Simulations
- WMO Pan American Centre for Sand & Dust Storm Warning Advisory & Assessment System (SDS-WAS)
- Advisor to regional governments and service provider to industry

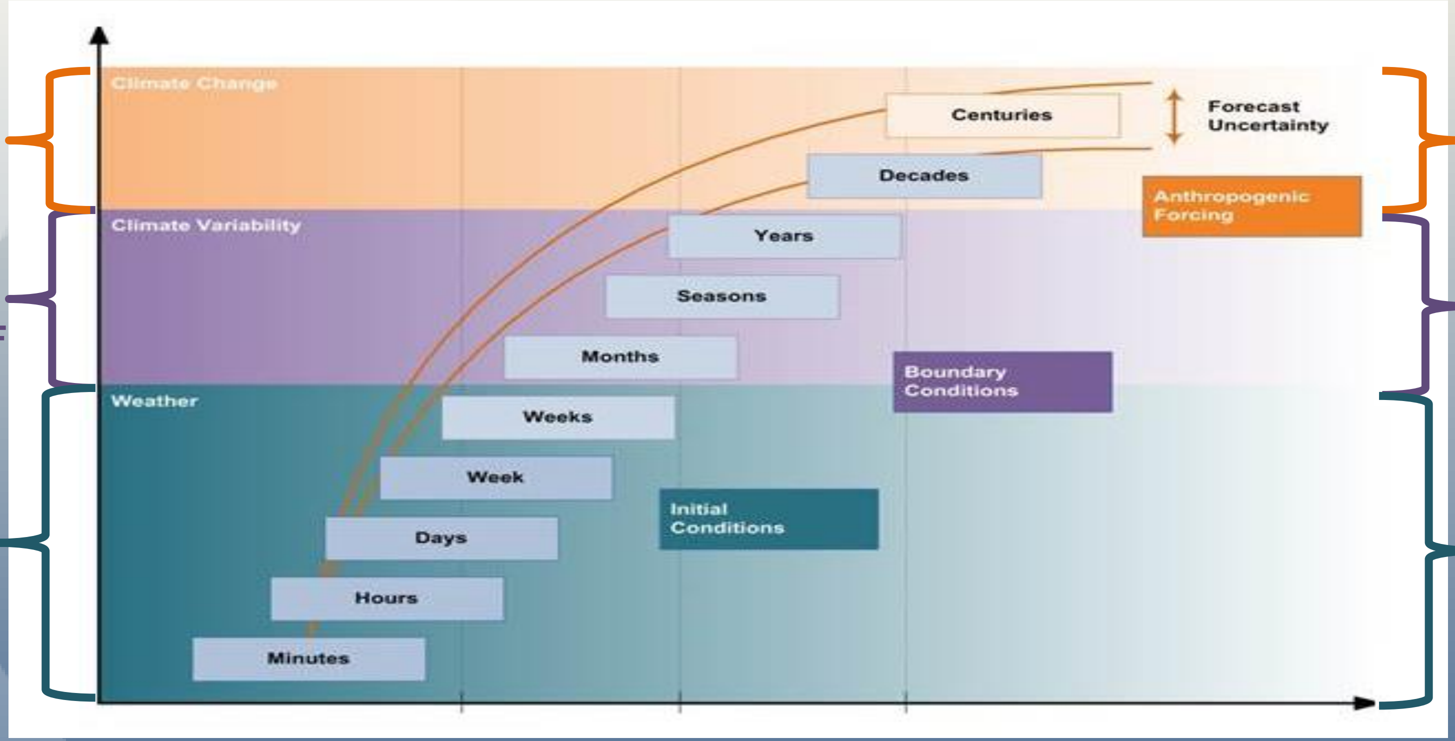
Functions of the Caribbean Institute for Meteorology and Hydrology

About CIMH…cont'd

CCCC C/CSGM Mona

CIMH/ CariCOF

NMHS/ CIMH (weather forecasts modeling, dust)



Climate change projections

Seasonal climate forecasts

Weather forecasts

Weather and climate Information to support decision-making across timescales

Background

Caribbean SIDS Vulnerabilities to a Changing Climate

- *Generally limited natural resources, with many already heavily stressed from unsustainable human activities*
- *A high concentration of population, socio-economic activities, and infrastructure along the coastal zone*
- *High susceptibility to frequent and more intense tropical cyclones (hurricanes) and to associated storm surge, droughts, tsunamis and volcanic eruptions*
- *Dependence on water resources for freshwater supply that are highly sensitive to sea-level changes*
- *Relative isolation and great distance to major markets, affecting competitiveness in trade*

Background…cont'd

Caribbean SIDS Vulnerabilities to a Changing Climate

- *Extreme openness of small economies and high sensitivity to external shocks*
- *Generally high population densities and in some cases high population growth rates*
- *Inadequate infrastructure in most sectors*
- *Limited physical size, effectively eliminating some adaptation options to climate change and sea-level rise*
- *Insufficient financial, technical and institutional capacities, seriously limiting the capacity of SIDS to mitigate and adapt to any adverse impacts of climate change.*

Background…cont’d

Almost all SIDS depend heavily on fossil fuels

- Power and water production
- Transport

Renewable sources of energy actively being exploited and/or explored in the Caribbean

- E.g. fuelwood, sugarcane bagasse, hydropower, wind, photovoltaics, geothermal, ocean technologies and solar water heating

Question: Are they vulnerable in a changing climate?

Background…cont'd

Energy Demand and Generation

The IPCC identified several climate related impacts likely to impact electricity demand and generation

- *Warmer and more frequent hot days and nights*
- *An increase in the frequency of heat waves*
- *More intense hurricanes*
- *Possible increase in coastal flooding from storm surges and sea-level rise*
- *Changes in the availability of water and rainfall patterns*

Expected Impacts

Tropical Cyclones

"It is likely that cyclone wind speeds and core rainfall rates will increase in response to human-caused warming. Analyses of model simulations suggest that for each 1°C increase in tropical sea surface temperatures, hurricane surface wind speeds will increase by 1 to 8% and core rainfall rates by 6 to 18%." (CCSP 2008)

Floods and Droughts

"Climate change leads to increasing frequency of extreme weather events evident around the globe. Unusually high rainfall, which many scientists agree is due to climate change, is a significant cause of floods. On the other hand droughts are becoming longer, harder and more frequent.“ (WWF 2014)

Expected Impacts…cont'd

Energy Sector	Hydro-climatic Vulnerabilities
Fossil fuels	• High winds, high waves/storm surge and flooding limiting production, and transport; • Climate shocks in external markets limit availability.
PV Solar	• High winds damaging installations; • Cloudiness and high aerosols concentrations limiting incoming radiation; • Elevated temperatures reducing PV panel performance; • Flooding and landslides potentially damaging poorly sited installations.
Wind	• High winds limiting turbine operations and safety of operations;
Hydro-electric	• Drought limiting water in reservoirs and flows to intakes; • Flash flooding due to rapid onset deep convective events; • High temperatures causing high evaporation rates; • Landslides impacting reservoirs and water siltation of intake waters
Geothermal	• Drought limiting volume of water available for injection; • Landslides (i) directly impacting site facilities; (ii) indirectly impacting the quality of water to be injected (high siltation); and (iii) limiting access to the sites
Ocean Technologies	• Sea level rise limiting infrastructure performance • High winds damaging infrastructure; • Significant wave heights/storm and surge damaging infrastructure; • Coastal flooding from runoff flooding infrastructure or limiting access to the site.

Observed Impacts

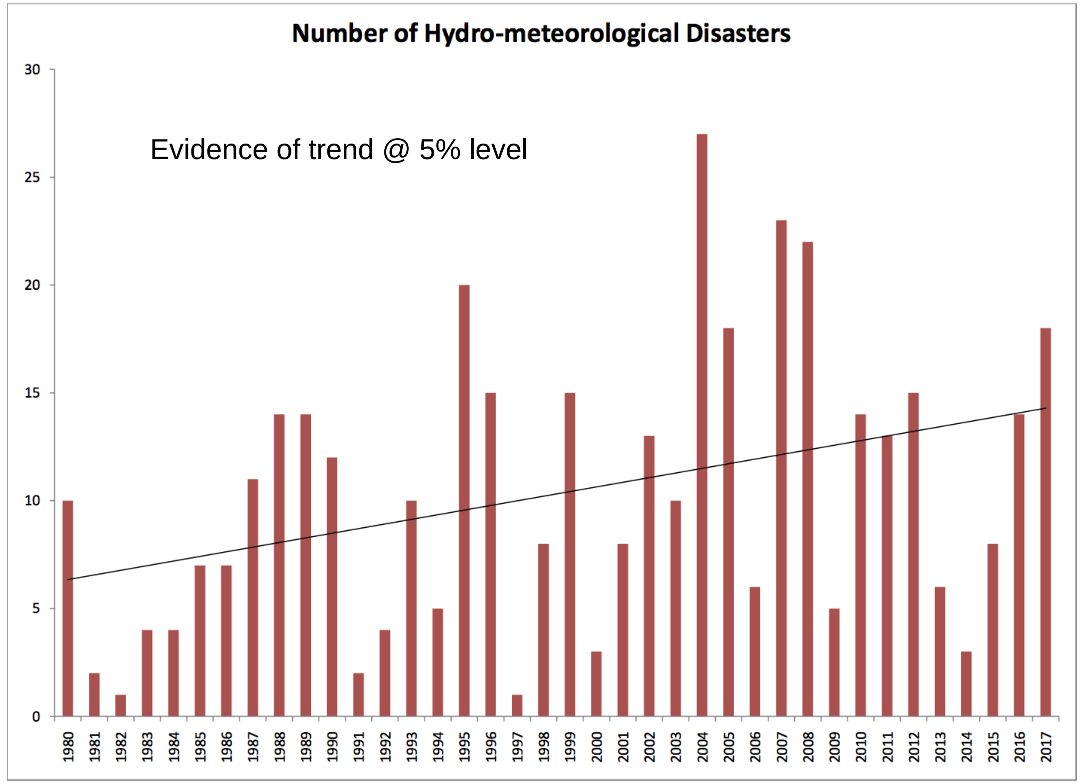
What is the state of play?

The Region has already experienced changes in climate

- *Mean warming in air and ocean surface temperatures*[1]
- *Increase in daytime/nighttime temperatures*[2]
- *Increase in maximum number of consecutive dry days and heavy rainfall events*[3]
- *Increase in the occurrence of extreme events*[4]
- *Rising sea levels*[5]

[1]Peterson et al. 2002; Stephenson et al. 2014; Jones et al. 2016; Antuña-Marrero et al. 2016; Glenn et al. 2015
[2],3Stephenson et al. 2014
[4]IPCC 2012
[5]Palanisamy et al. 2012; Torres and Tsimplis 2013

Observed Impacts…cont'd



Occurrence of hydro-met disasters in the Caribbean (1980 – 2017)
Source: EM-DAT 2017

Observed Impacts…cont’d

Power Plant and Distribution Systems

Station locations exposed to hydro-meteorological hazards. Intake structures impacted by debris flows

Flood impact VinLec hydro-electric power station resulting from Christmas Eve Flood (December, 2015) - Cumberland River nr Spring Village.

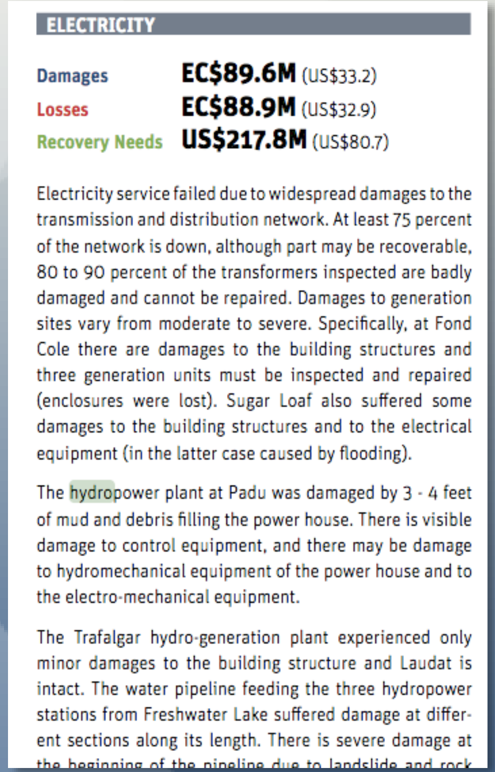
Observed Impacts…cont'd

Power Plant and Distribution Systems

Largely centralized systems with overhead and underground lines for distribution exposed to wind, landslide and flood impacts

Damage to distribution system in Dominica due to Hurricane Maria

Observed Impacts…cont’d



ELECTRICITY

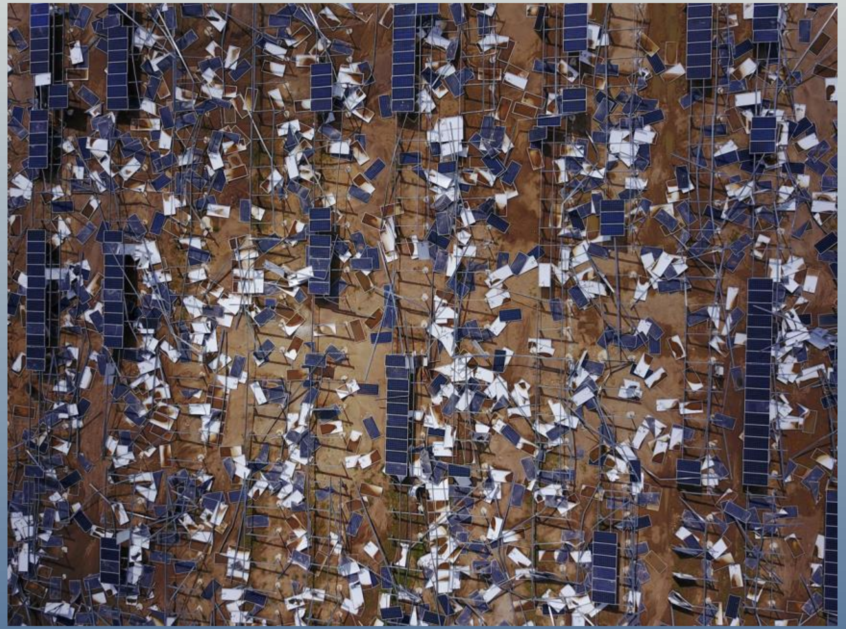
Damages	**EC$89.6M** (US$33.2)
Losses	**EC$88.9M** (US$32.9)
Recovery Needs	**US$217.8M** (US$80.7)

Electricity service failed due to widespread damages to the transmission and distribution network. At least 75 percent of the network is down, although part may be recoverable, 80 to 90 percent of the transformers inspected are badly damaged and cannot be repaired. Damages to generation sites vary from moderate to severe. Specifically, at Fond Cole there are damages to the building structures and three generation units must be inspected and repaired (enclosures were lost). Sugar Loaf also suffered some damages to the building structures and to the electrical equipment (in the latter case caused by flooding).

The hydropower plant at Padu was damaged by 3 - 4 feet of mud and debris filling the power house. There is visible damage to control equipment, and there may be damage to hydromechanical equipment of the power house and to the electro-mechanical equipment.

The Trafalgar hydro-generation plant experienced only minor damages to the building structure and Laudat is intact. The water pipeline feeding the three hydropower stations from Freshwater Lake suffered damage at different sections along its length. There is severe damage at the beginning of the pipeline due to landslide and rock

Damages to Dominica energy sector (Maria)



Puerto Rico’s Humacao Solar Power Plant due to Hurricane Maria – Restoration

Observed Impacts…cont'd

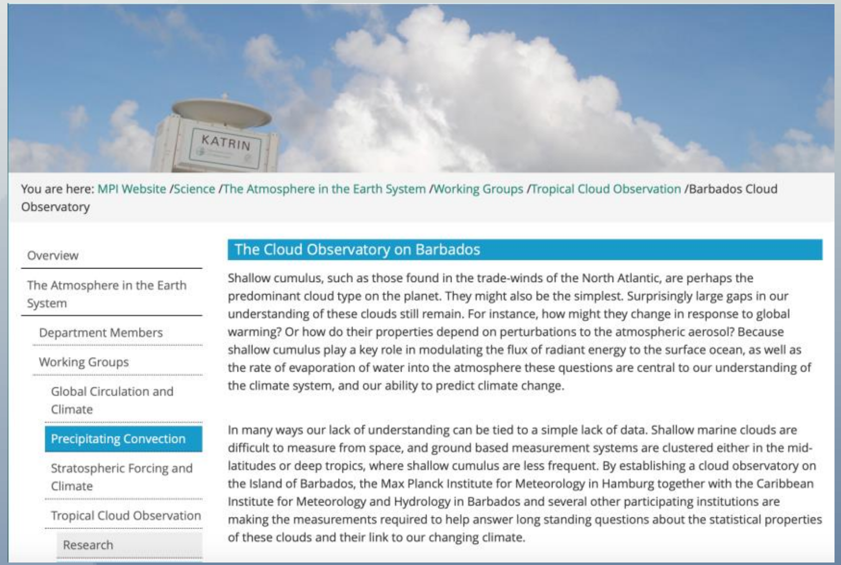
"When hydropower runs low in a drought, western states tend to ramp up power generation—and emissions—from fossil fuels. Droughts caused about 10 percent of the average annual carbon dioxide emissions from power generation in California, Idaho, Oregon and Washington between 2001 and 2015" – Stanford University

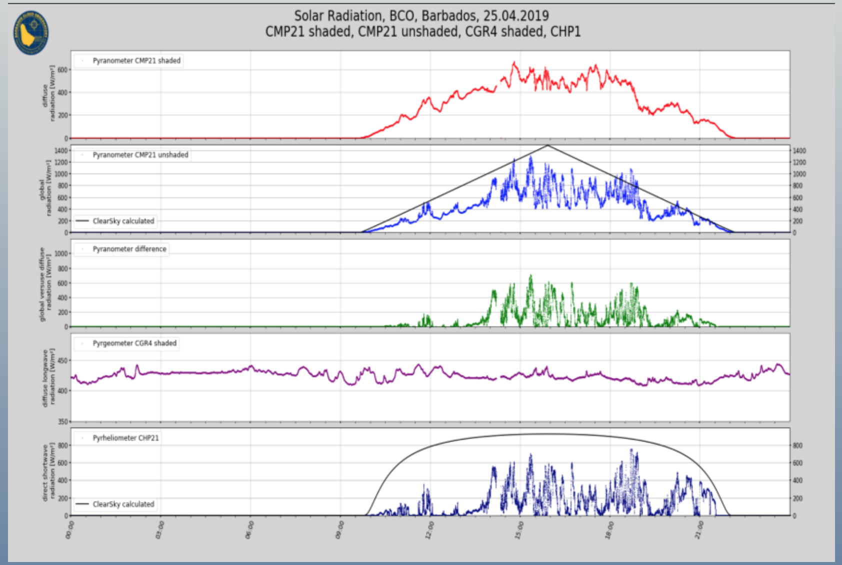
Research and Development

How can we reduce vulnerability?

Explore potential areas of collaboration with the energy sector to mitigate threats and maximize opportunities

Research and Development...cont'd





Barbados Cloud Observatory – How do shallow cumulus clouds change in response to global warming?

https://www.mpimet.mpg.de/en/science/the-atmosphere-in-the-earth-system/working-groups/tropical-cloud-observation/barbadosstation1/

Research and Development…cont'd

Feedback

Geostationary Lightning Mapper (GLM)

Space Research and Observations

Geostationary Lightning Mapper

The Geostationary Lightning Mapper (GLM) is a satellite-borne single channel, near-infrared optical transient detector that has been placed on the GOES-16 satellite in a geostationary orbit. This orbital position allows for GLM to measure a dedicated region that includes the United States with continous views capable of providing lightning detection at a rate never before obtained from space. GLM detects all forms of lightning during both day and night, continously, with a high spatial resolution and detection efficiency.

GOES-16 (formerly GOES-R) was launched in November 2016. GLM began operation in March 2017 after a dedicated satellite and instrument spin-up period. The use of a geospatial orbit provides increased severe storm warning lead time, earlier indication of impending lightning strikes to the ground, and total lightning detection with nearly uniform spatial coverage of approximately 10 km.

Scientists can now study the electrosphere over dimensions ranging from the Earth's radius all the way down to individual thunderstorms. Disseminating lightning information in near real time, on a continuous basis with other observable data, such as radar returns, cloud images, and other meteorological variables provides invaluable data to aid weather forecasters in detecting severe storms in time to give advance warning to the public.

The sudden increase in flash rate that has been found to be related to storm severity can now be detected for the measurement region. GLM products contain lightning events, groups and flashes.

YouTube video:
First images from GLM

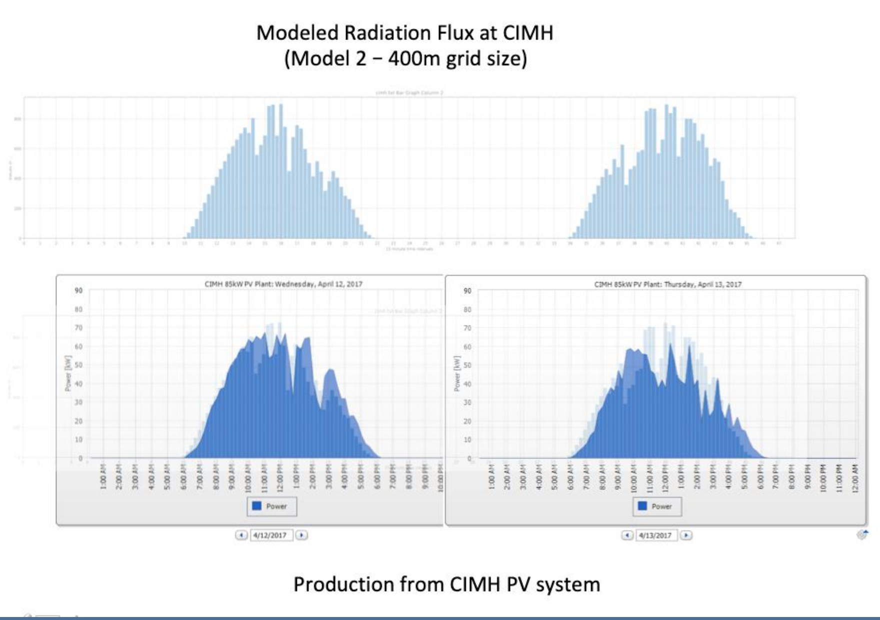
https://ghrc.nsstc.nasa.gov/lightning/overview_glm.html

GLM data are now available at NOAA CLASS.
The product to order has the family name: GOES-R Series GLM L2+ Data Product (GRGLMPROD).

CIMH and the CMO Headquarters Unit are currently evaluating new space-based technologies – Lightning Detection

Research and Development...cont'd

Suite of nowcasting and forecasting products being developed for the energy sector that will involve opportunities for innovation – will include data strategies and analytics.



Renewable Energy Production and Modelling @ CIMH

Research and Development…cont'd

Subdivided region into zones based on wind resource potential.
Generally, excellent wind resource across the region with good prospect for utility-scale wind power.

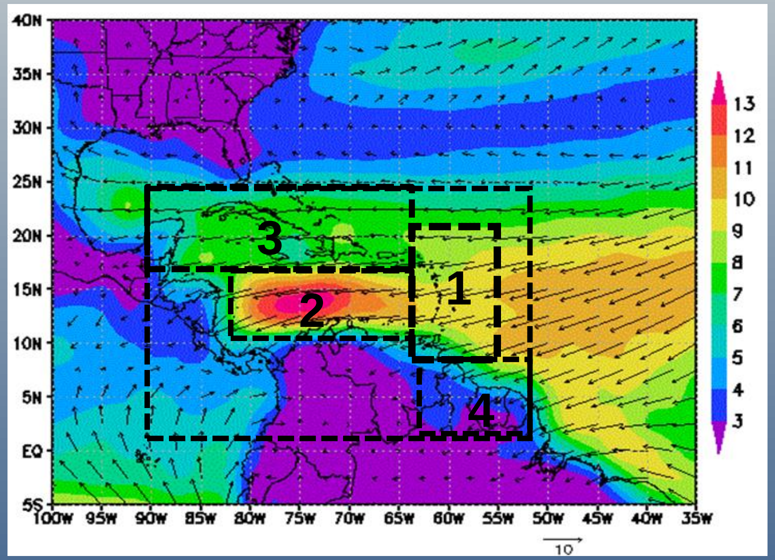
Zone 4: Minimum in the wind resource; varies from poor to fair; mean wind speeds are 3 to 4 ms^{-1} but increase to 5 to 7 ms^{-1} along the coast.

Zone 2: The maximum in the wind resource (CLLJ) ~over 13 ms^{-1} (class 7, superb).

Zone 1: The Eastern Caribbean, has a good to superb wind power resource with mean wind speeds ranging from 7 to 11 ms^{-1}.

Zone 3: The Greater Antilles, good to excellent resource (5 to 9 ms^{-1}).

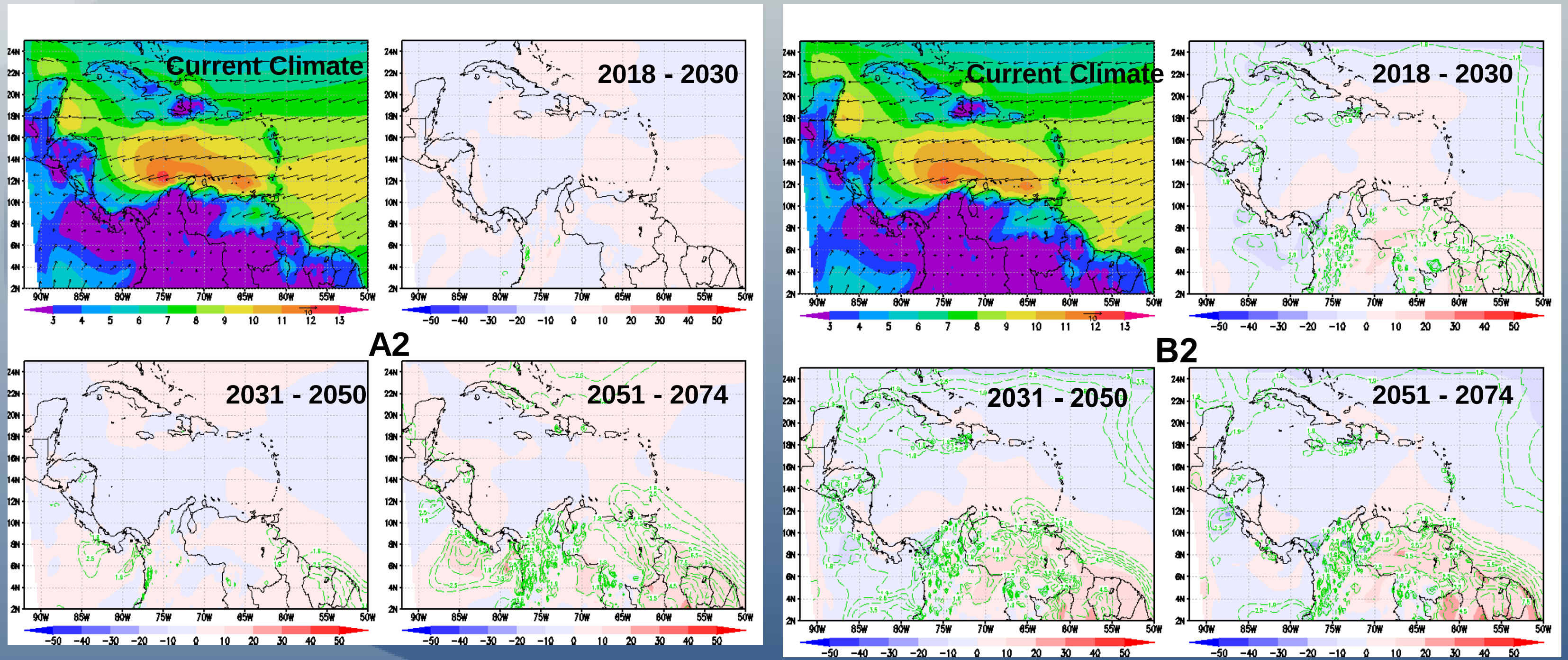
Zone 1 (E Caribbean)
Zone 2 (SW Caribbean…CLLJ)
Zone 3 (NW Caribbean)
Zone 4 (Guianas)



Potential Impact of Future Climate Change on Wind Resource – Study Region and Wind Climatology (1949 – 2015) at 50m

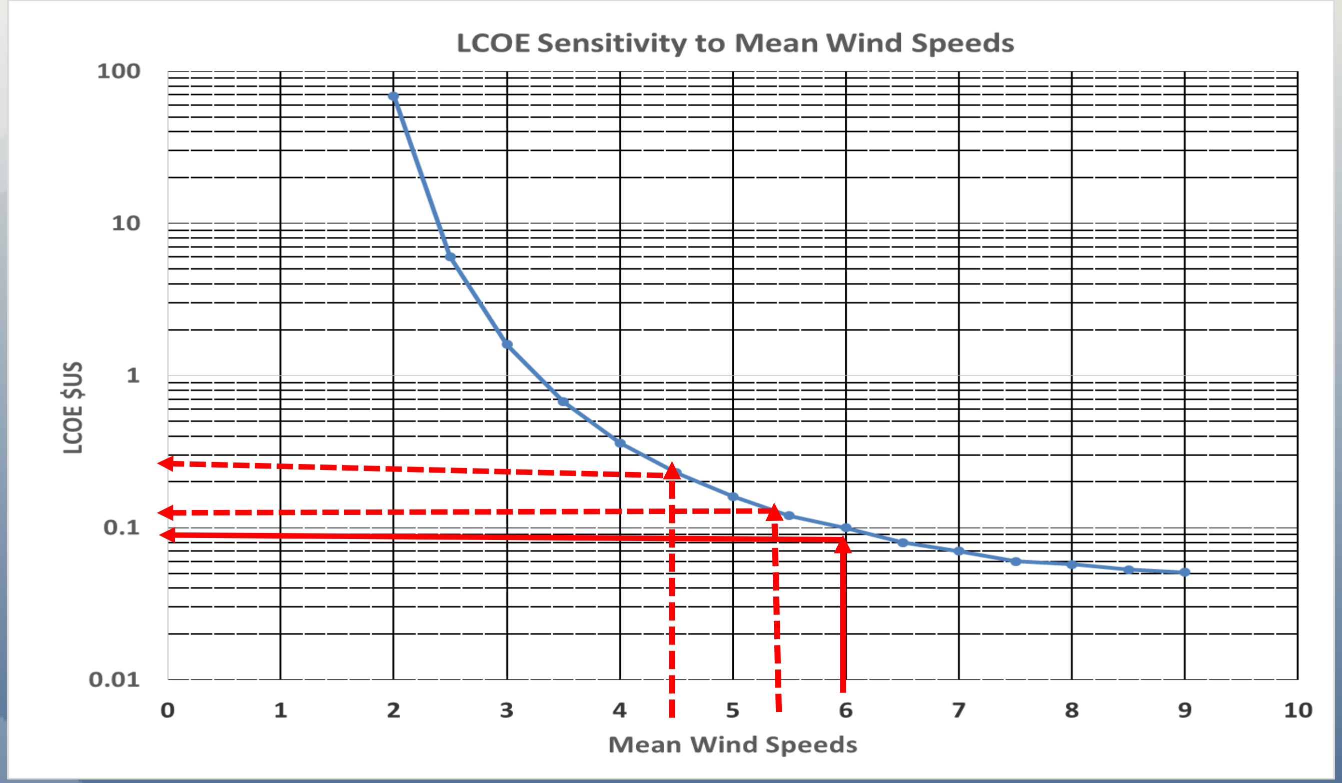
Research and Development…cont'd

Agreement in trends for both scenarios over the central and southern EC, southward through to the Guianas (increasing winds); the CLLJ and the western Caribbean (decreasing winds).



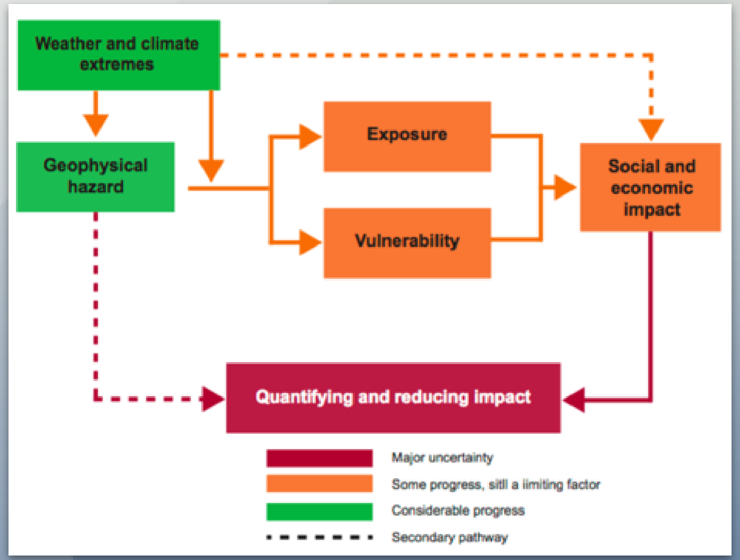
Potential Impact of Future Climate Change on Wind Resource - Results

Research and Development...cont'd

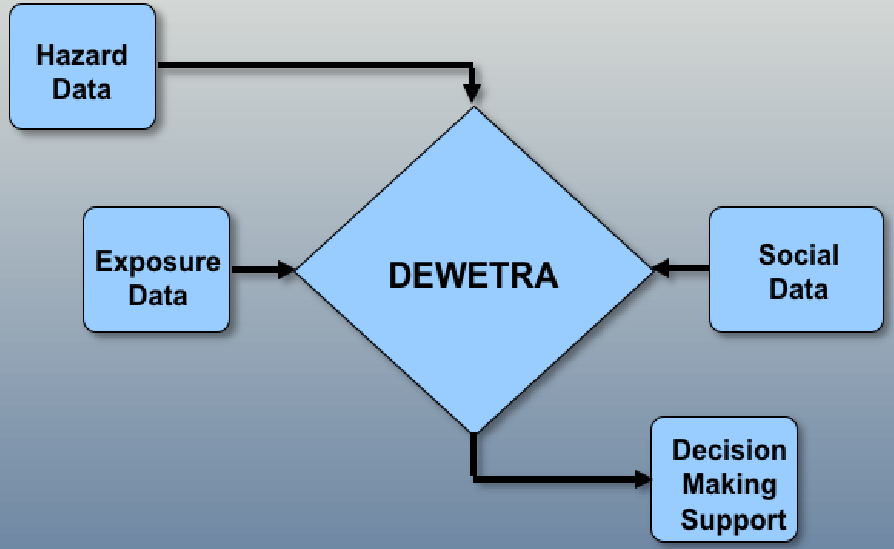


Barbados Case Study - LCOE fluctuates between $0.08 US and $0.13 US/kWh with projected wind speed fluctuations (< diesel based power ~ 0.30 US/kWh).

Research and Development...cont'd

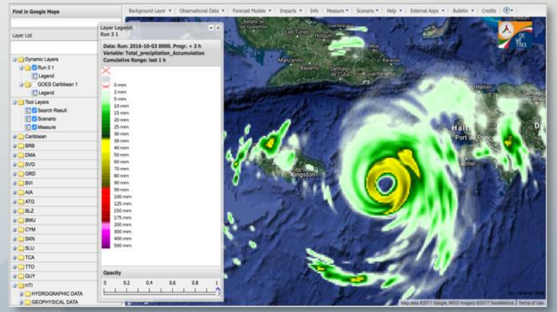


Impact-based Forecasting System
(source: WMO 2105)

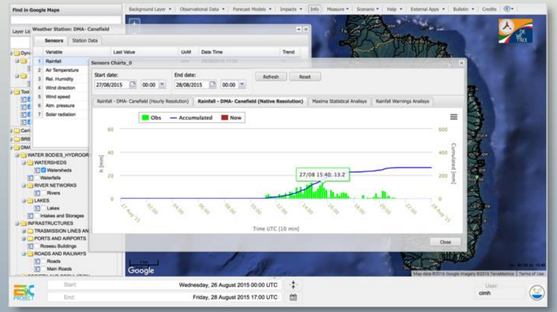


Caribbean Dewetra Platform

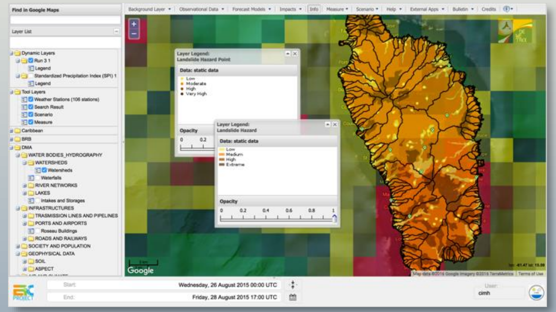
Research and Development...cont'd



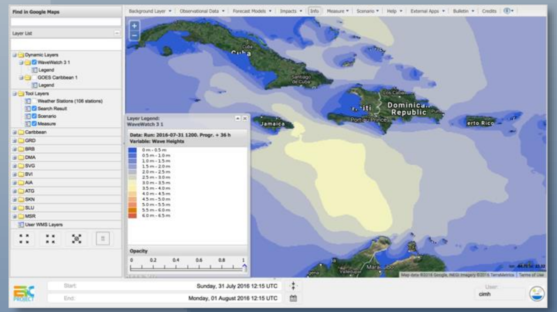
Numerical Weather Prediction



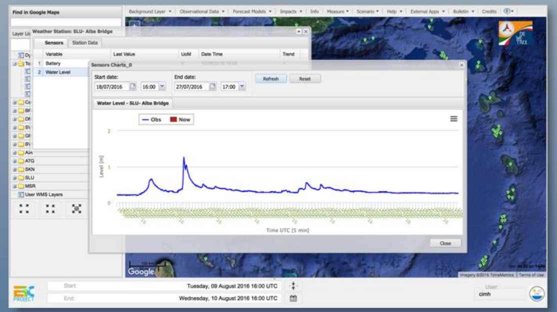
Automatic Weather Station



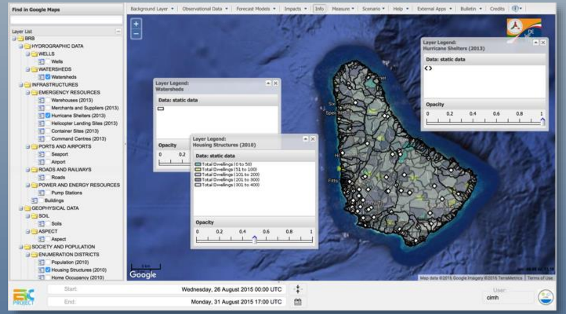
Hazard/Risk Exposure



Wave Height Prediction



Automatic Water Level Station

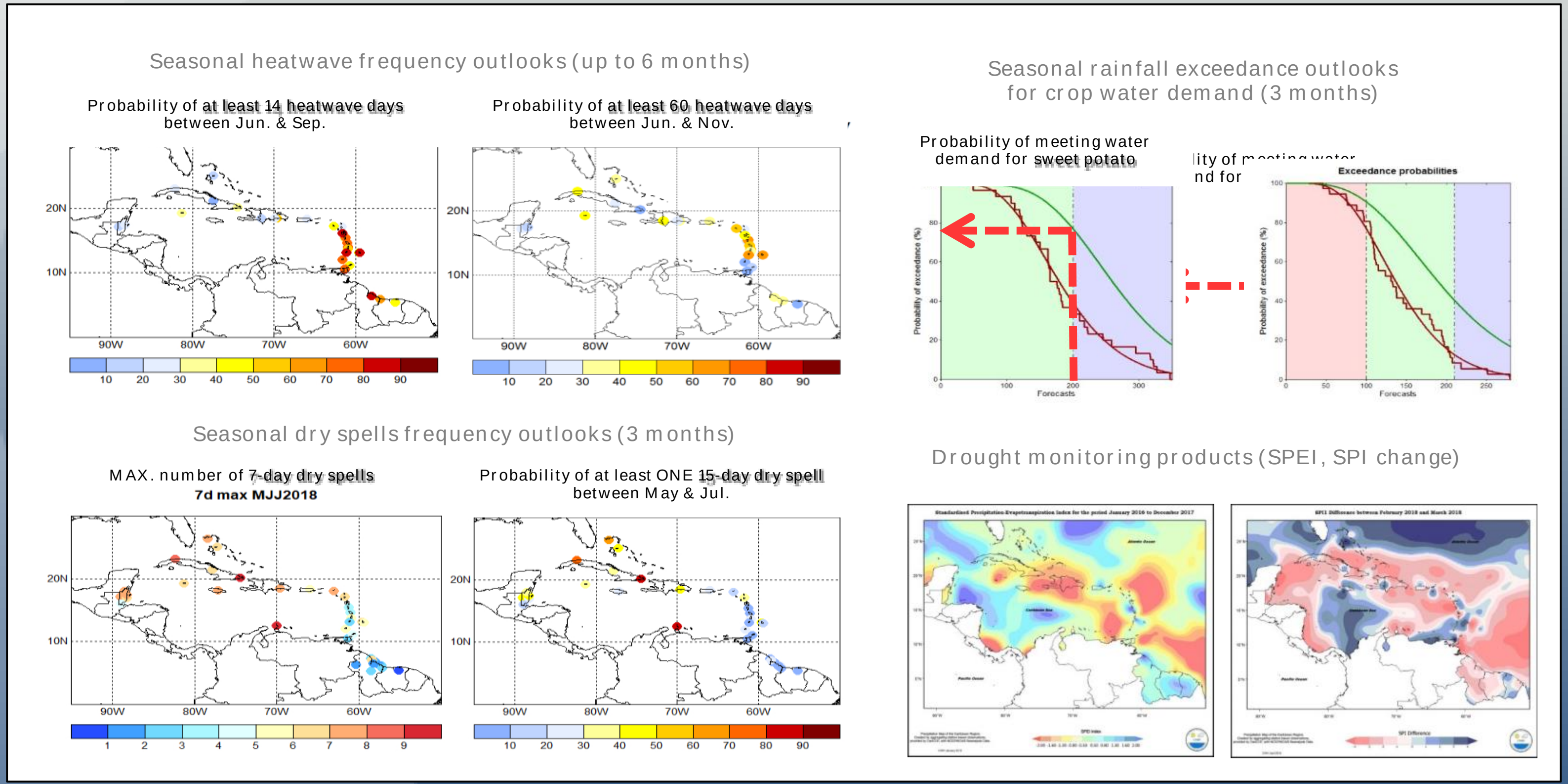


Population Vulnerability

Risk = Exposure x Vulnerability x Hazard

Research and Development...cont'd

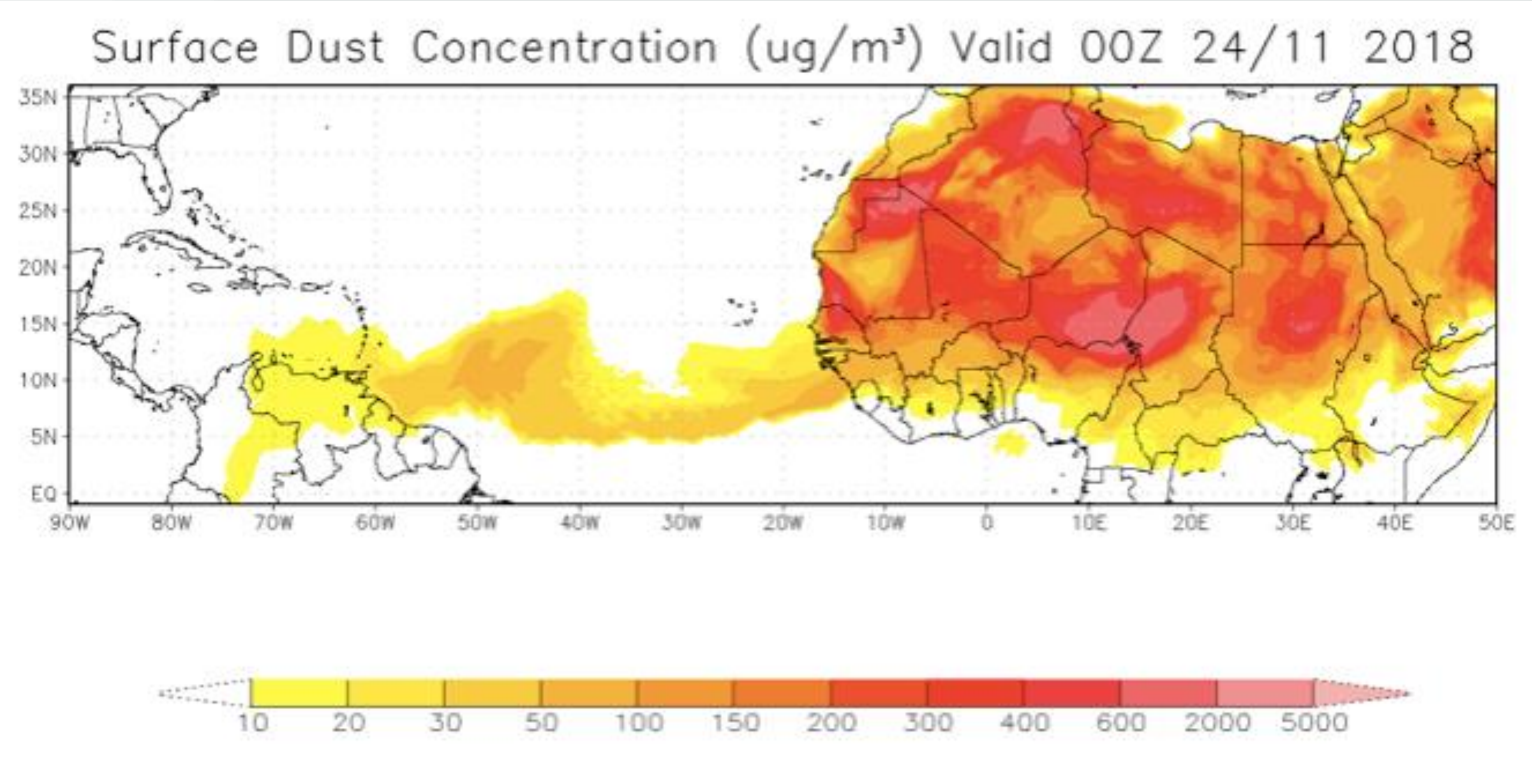
Co-design, co-develop and co-delivery of new products through the Consortium of Partners of the Caribbean Early Warning Information Systems Across Climate Time Scales (EWISACTS) – CCREEE is expected to represent the regional energy sector in EWISACTS.



Caribbean Climate Services Programme – Experimental Forecast and Monitoring Products

Research and Development…cont'd

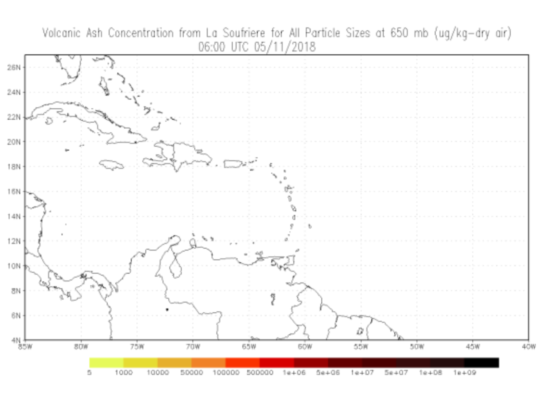
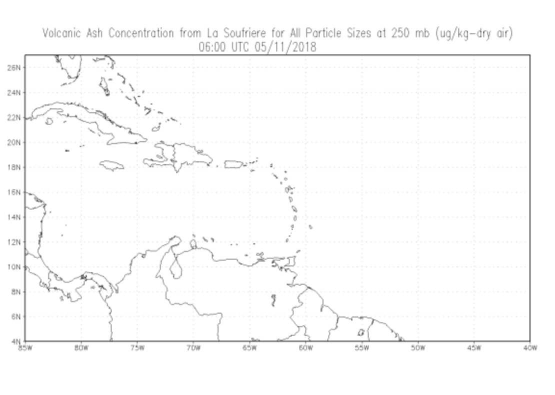
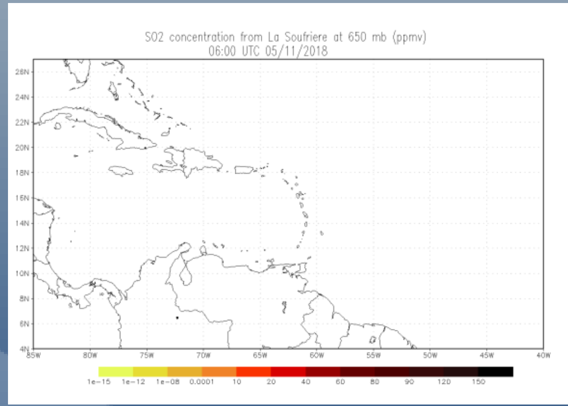
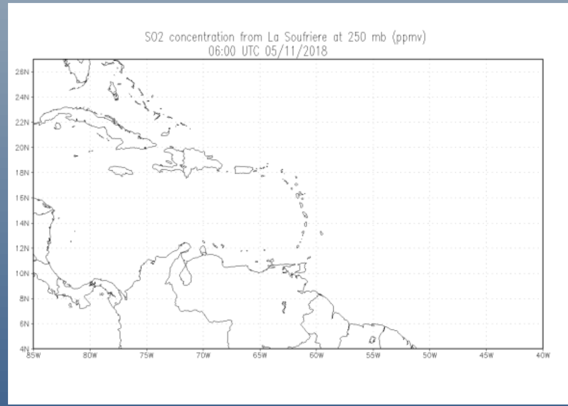
Significant dust limits the amount of incoming solar radiation reaching the earth's surface. This limits the performance of PV systems. Data can risk-inform PV energy forecast models.



Dust and Air Quality Forecasting Centre

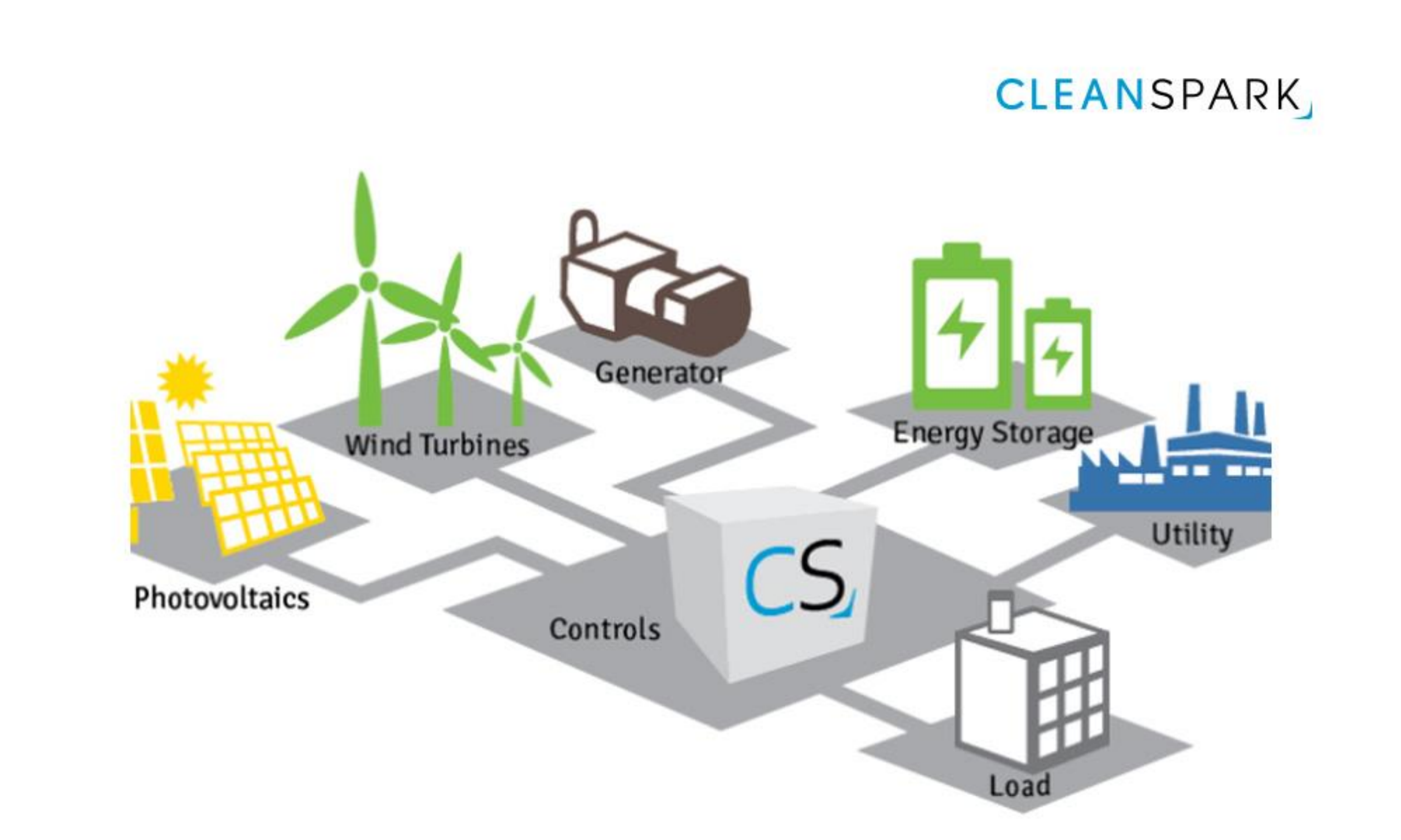
CIMH daily 7-day Sahara dust forecast

Research and Development...cont'd

	650 mb	250 mb
Ash Transport		
SO_2 Transport		

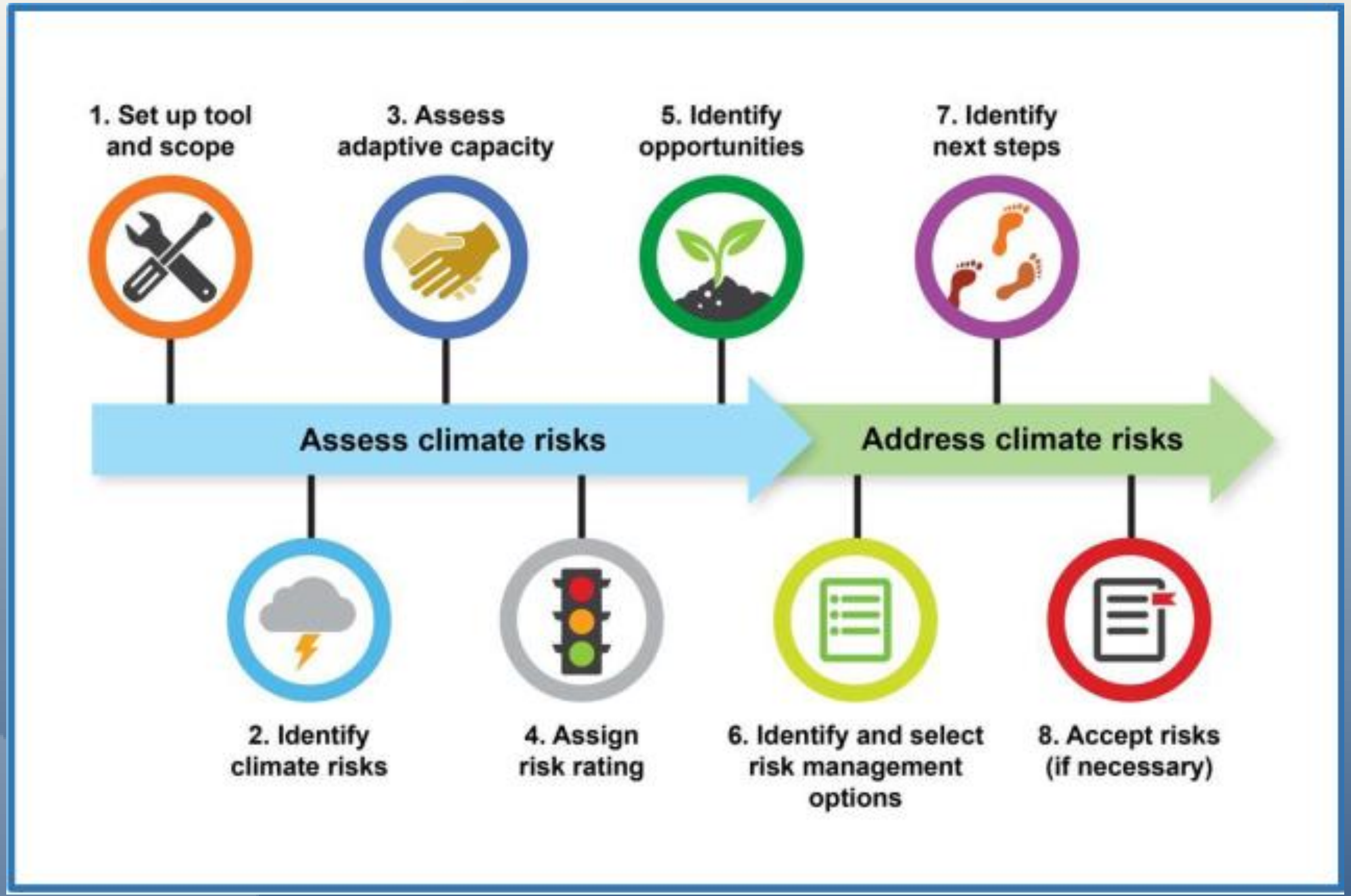
Experimental model (WRF-CHEM) to simulate volcanic ash and SO_2 transport - La Soufriere, St. Vincent. Scenario planning can risk-inform energy sector.

Building Resilience



Strengthening Delivery Systems – Hybrid MicroGrids

Building Resilience...cont'd



Climate Risk Screening and Management

Source: USAID

Building Resilience…cont’d

Source: www.roystonguest.com

Thank You

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Congreso Transición Energética
y Cambio Climático en el Caribe