From Extreme Weather to Climate Change in Africa

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The role of the IPCC is to assess on a comprehensive, objective, open and transparent basis the scientific, technical and socio-economic information, relevant to:

- understanding the scientific basis of risk of human-induced climate change
- Its potential impacts
- And options for adaptation and mitigation
Climate change Evangelist

- [https://youtu.be/T1eGJLqxxKQ](https://youtu.be/T1eGJLqxxKQ)
Some statements

1) Most of Africa’s natural disasters are hydrometeorological in origin

2) Natural disasters are challenging to predict, but we can plan for impending disasters and prepare for risks

3) Africa’s contribution to the greenhouse gas (GHG) emissions is negligible compared to developed countries (about 4% of global GHG emissions)

4) Africa is the most vulnerable to the impacts of climate change and disasters

5) Climate change will affect the weather systems differently in different regions of Africa

6) IPCC projects an increase in the intensity and frequency of extreme events (e.g. Floods, heatwaves, droughts and storms)

7) Climate is what you expect, Weather is what you get

8) Inferences about weather systems in a changing climate have been made from climate models (and not weather prediction models)
1) The IPCC projects an increase in frequency and intensity of extreme events

2) The predictability of hurricanes/cyclones is relatively better compared to other extreme events

3) This is illustrated by model agreement from different centres

4) Yet the impact of one hurricane in one country is devasting enough

5) What preparation is being put into the other common extreme events in Africa whose predictability is relatively more challenging than the hurricanes?

6) Take home message: As resources are being put into climate change policies and strategies, there is the need to develop weather infrastructure along side. As the impact of climate change will still be felt if emissions were reduced to zero even in 2020. We all know we are very far from that even by 2050

7) More needs to be done to reduce the impact of extreme events. For example, early warning must be coupled with early action
Zimbabwe
Storm Track

10/03/2019 at 16h
La Reunion Local Time

LEGEND:
- Weak low pressure area
- Tropical depression
- Moderate tropical storm
- Severe tropical storm
- Tropical cyclone
- Intense tropical cyclone
- Very intense tropical cyclone

Mean wind speed
- 34 km/h
- 55 km/h
- 80 km/h
- 110 km/h
- 140 km/h
- 170 km/h
- 210 km/h

Past analyzed track
Forecast track: Departure La Reunion Local Time
Extension for quadrants of mean winds greater than 85 km/h
Cone of potential track area

WARNING:
The potential track area depicts the track forecast uncertainty for days 1-5 of the forecast. It indicates that the entire 5-day's path of the center of the tropical system for which the track forecast has been made will remain within the cone about 75% of the time.

Hence being situated outside of the uncertainty cone does not mean that there is no risk of being affected by the tropical system. The uncertainty cone is for the system's center and does not consider the more or less large extension of potential damaging winds or rain surrounding this center.
Model Agreement – Cyclone Idai: 24hr lead time
13th to 16th March 2019
Model Agreement – Cyclone Idai: 24hr lead time
17th to 21st March 2019
Respective updates from Mozambique, Malawi and Zimbabwe on Impacts of Cyclone IDAI

<table>
<thead>
<tr>
<th></th>
<th>Deaths</th>
<th>Houses (partially or totally destroyed)</th>
<th>Schools affected</th>
<th>Classroom(s) affected</th>
<th>Health facilities partially destroyed</th>
<th>Health facilities completely destroyed</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mozambique</strong></td>
<td>603</td>
<td>240,000</td>
<td>137</td>
<td>4219</td>
<td>91</td>
<td>3</td>
</tr>
<tr>
<td><strong>Malawi</strong></td>
<td>60</td>
<td>288,371</td>
<td>154</td>
<td>672</td>
<td>975,000</td>
<td>86,976</td>
</tr>
<tr>
<td><strong>Zimbabwe</strong></td>
<td>344</td>
<td>17,000</td>
<td>971</td>
<td>192</td>
<td>270,000</td>
<td>294</td>
</tr>
</tbody>
</table>
1. Models agree in their forecast with different lead times (e.g. 24, 48 hrs.) – only 24 hr. lead time is shown

2. March 14, 2019 cyclone reached peak intensity with maximum winds of 195 km/h (120 mph) and minimum central pressure of 940mb in Mozambique

3. During the event, satellite picture showed the cyclone enter Mozambique and later retreated. The models in agreement captured this movement

4. There is growing confidence in the science of attribution - To quantify the link between some extreme weather events and climate change
Food for thought

1. Are we ready with the weather infrastructure to be able to predict these extreme events when the projections of the Intergovernmental Panel on Climate Change manifests?

2. Note the events will be weather events at the time of occurrence.

3. Studies in recent past, made projections for 2020. The year 2020 starts in a few months. How prepared are we to manage the projected events, should they occur? Examples of such studies:
   
a) Theobald, 2005: Landscape Patterns of Exurban Growth in the USA from 1980 to 2020

b) Hanaoka and Kainuma, 2012: Low carbon transitions in world regions: comparison of technological mitigation potential and costs in 2020 and 2030 through bottom-up analyses
Value of economic outcome

Could be increased:

1. By improving the forecast
2. By improving communication
3. By improving decision-making process
So what do we want?

1. A reliable, modern, and real-time weather, water and climate information services, supporting communities and countries towards meeting their climate resilience and economic development goals

2. To deliver daily weather forecasts and advise policy makers about climate variability and change
   - In doing so, support actions that protects lives and property from extreme weather and builds long-term climate resilience

3. An improved weather forecasting system will reduce loss of property and lives. Early Warning coupled with Early Action contributes to resilience
1. Although, strategies for coping with weather disasters are essentially of national concern, they involve international considerations for the following reasons

a) Science and practice of meteorology requires an international approach, and national storm warning systems are dependent upon international exchange of information

b) In many developing countries, technical assistance is needed in developing the NMHS, so as to improve the internal storm warning systems (SWIFT and Nowcasting, etc.)

c) In some cases, devastation calls for international relief measures.

2. Basic International arrangements – WWW, GARP

3. Tropical cyclones most devastating, however, tornadoes, floods, blizzards, droughts are other examples of the manifestation of natural disasters.
Resilience

1. The best response strategy is one that improves the resilience of
   Economies, Environment and societies

2. Requires an overall **development approach** which seeks
   a) To Mitigate the risks posed by climate change and variability to the attainment of the Sustainable Development Goals at the global level
   b) Ambitious and urgent global commitments required to tackle climate change and variability, **else most African countries will not be able to implement 2030 Agenda for Sustainable Development and the AU Agenda 2063**
   c) Resilience building requires decision making across time scales (weather prediction, seasonal climate prediction, climate change projections)
Decision-making across timescales

**Ready**
Seasonal forecasts

- Begin monitoring mid-range forecasts
- And short-range forecasts
- Update contingency plans
- Train volunteers
- Sensitize communities
- Enable early-warning systems

**Set**
Mid-Range forecasts

- Continue monitoring short-time-scale forecasts
- Mobilize assessment teams
- Alert volunteers
- Warn communities
- Local preparation activities

**Go!**
Short-Range forecasts

- Deploy assessment teams
- Activate volunteers
- Instruction to communities to evacuate, if needed
Weather-climate interface

1. Resilience to present day climate is necessary for resilience to the future

2. Impact-based weather forecasting is somehow necessary for climate resilience

3. Management –
   a) Emergency – Weather time scale
   b) Operational – Weather and Seasonal time scale
   c) Policy/Planning – Climate Change time scale

4. Decision
   ➢ Tactical – Weather information
   ➢ Strategic – Climate information
1) Seasonal prediction and its use is a potential entry point for addressing issues about climate change (near and future)

2) Coping strategy will inform adaptation measures

3) Seasonal Decisions in Agriculture
   a) Shall I Sow?
   b) Which cultivar?
   c) Shall I sell stock while the price is high?
   d) Shall I buy more stock while they are cheap?
   e) Shall I now invest off-farm?
   f) Shall I prepare for disaster
1) Deterministic skill of North American Multi-Model Ensemble

a) To predict Sahel rainfall with respect to lead time
   - Skill for regionally averaged rainfall for the JAS target season is essentially the same whether the forecast is made in February/March or it is made in June
   - The two dominant influences on Sahel rainfall, North Atlantic and global tropical oceans, shape predictability
   - MME skill hinges on the combination of skillful predictions of ENSO made with one model (CMC2-CanCM4) with those of North Atlantic SST made with another model (NASA-GEOSS2S)

b) An earlier prediction (2-3 months ahead) has consequences for decisions such as purchasing, stocking and distributing adapted seed varieties or preventing regional food insecurity

2) National Scale: Ongoing research for dynamical seasonal forecast in Ghana (e.g. Agyeman et al., 2017)
Climate Change
A 0.5degC reduction in global warming will shelter about 20% of global lands from strong increases and prevalence of combined hot extremes.

Compared to 2degC, the 1.5degC target helps avoid a new heat regime with unprecedented combined hot extremes becoming the norm in the tropics.

Previous univariate-based analyses underestimate both spatial scale and emergence rate of 0.5degC - added hotspots to hot extremes.

Chen_et_al_EF_2019
Simulation of relative impact of land cover and carbon dioxide to climate change from 1700 to 2100

Lamptey_et_al_JGR_2005
### Experiment 1 (GCM)

Lamptey et al., 2005 JGR

<table>
<thead>
<tr>
<th>Simulation</th>
<th>CO$_2$ (ppmv)</th>
<th>Vegetation</th>
</tr>
</thead>
<tbody>
<tr>
<td>P$_{17}$</td>
<td>280</td>
<td>natural</td>
</tr>
<tr>
<td>P$_{21}$</td>
<td>690</td>
<td>natural</td>
</tr>
<tr>
<td>A$_{21}$</td>
<td>690</td>
<td>Natural plus agriculture</td>
</tr>
</tbody>
</table>
\[ \frac{|A_{21} - P_{21}|}{|A_{21} - P_{21}| + |P_{21} - P_{17}|} \times 100 \]
Mean DJF 2m temp. difference due to (a) Increased CO$_2$ (b) agriculture

Lamptey et al., 2005 JGR
2m temperature change (% explained by LCC)

Lamptey et al., 2005 JGR
Mean JJA rainfall difference due to (a) Increased CO$_2$ (b) agriculture

Lamptey et al., 2005 JGR
Change in rainfall (%age explained by LCC)

Lamptey et al., 2005 JGR
DJF regional (WA) climate from GCM
Summary

1) LCC greatly modifies magnitude and spatial extent of climate due to increased Carbon dioxide

2) Urbanization and regional agriculture produced a decrease in diurnal temperature range
1) Impacts of both agriculture and urban land cover are more pronounced during summer

2) Urbanization increased mean temperature but decreased diurnal temperature range

3) Urbanization effect was widespread

Lamptey et al., 2005 GPC
Urban Land Cover

1) Effect of urbanization at global scale is minimal due to relatively small fraction of earth covered by urbanization

2) How important will the urban effect become globally with the expected increase in urbanization (will increase ground heat flux term) and population density (will increase anthropogenic term in the SEB equation)?

3) Possibility of a critical threshold of influence (in terms of modeling)
   - Can arise from convergence of increasing spatial resolution of GCM and expected growth in urban areas.

4) Influence of a land cover type varies with the percent land cover area

Lamptey, 2010 IJOC
Impact of land cover characterization over West Africa (RCM) -domain

Sylla et al, 2016 Clim Dyn
Impact of land cover characterization over West Africa (RCM) - simulation

1) Model: RegCM4.3
2) Resolution: 50km - Africa, 25km – West Africa
3) Coupled with NCAR CLM3.5
4) Simulation period: 1998 - 2010
5) Simulation 1 uses Coarse Resolution Vegetation
6) Simulation 2 uses Newer High Resolution improved Land Cover
7) Replacement of C4 and C3 grasses with corn and Tropical broadleaf evergreen trees in parts of West and Central Africa

Sylla et al, 2016 Clim Dyn
Temperature changes due to improved LC distribution

Changes in temperature greater in DJF than in JJA

Sylla et al, 2016 Clim Dyn
Precipitation changes due to improved LC distribution

Increase in precipitation during both DJF and JJA

Increase is via a stronger soil moisture feedback

Sylla et al, 2016 Clim Dyn
Summary from study

1) In DJF, increases in the frequency and intensity of precipitation events occur mainly over the Gulf of Guinea coastlines and Central Africa.

2) In JJA, changes are more heterogeneous.

3) The increased precipitation is caused by increased low level convergence and enhanced soil moisture feedback.

4) Wetter conditions are simulated over most part of the domain, even in regions where land cover changes are negligible.

5) Replacement of C4 grass with corn produces warming while replacement of C3 grass with tropical broadleaf evergreen trees produces cooling over over areas of change.

6) Results indicate land cover distribution should be accounted for in climate change experiments over West Africa.

Sylla et al, 2016 Clim Dyn
Potential Impacts of the Great Green Wall (GGW) on Climate Extremes in the Sahel

Saley et al., 2017 Atmos Sci Lett
Can regreening explain the occurrence of extreme weather events?
The Great Green Wall (GGW)

• Project: CEN-SAD and African Union
• Length: Dakar to Djibouti (> 7000km)
• Width: 15km
• 11 states involved
• Endogenous species

(Dia and Dupponois, 2010)
Regrowth Scenario (GGW) (1)

- Model: RegCM4
- Resolution: 50kmx50kmx18pres. level
- Period 1988-2012.
- Initial and Boundary Conditions: Re-analyzes ERA-Interim, Optimum Interpolation Sea Surface Temperature (OISST).
- A strip of vegetation on 14.08-15.84 °N wide.
Scenario de reverdissement (GGW) (2)

Control Experience (Ref)  
Default Continental Surface Settings.

<table>
<thead>
<tr>
<th>Model Biophysical Parameters</th>
<th>Vegetations Types</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Short gras</td>
</tr>
<tr>
<td>Vegetation albedo for wavelengths &lt; 0.7µm</td>
<td>0.1</td>
</tr>
<tr>
<td>Vegetation albedo for wavelengths &gt; 0.7µm</td>
<td>0.3</td>
</tr>
<tr>
<td>Soil color type</td>
<td>3</td>
</tr>
<tr>
<td>Roughness length (m)</td>
<td>0.05</td>
</tr>
<tr>
<td>Displacement height</td>
<td>0</td>
</tr>
<tr>
<td>Maximum leaf area index</td>
<td>2</td>
</tr>
<tr>
<td>Minimum leaf area index</td>
<td>0.5</td>
</tr>
<tr>
<td>Minimum stomatal resistance (s/m)</td>
<td>60</td>
</tr>
<tr>
<td>STEM (dead matter area index)</td>
<td>4</td>
</tr>
<tr>
<td>Root zone soil layer depth (mm)</td>
<td>1000</td>
</tr>
</tbody>
</table>

GGW scenario:  
Disturbance of the Biosphere-Atmosphere-Transfer Scheme (BATS)
Indices of extreme rainfall and temperatures

<table>
<thead>
<tr>
<th>INDICES</th>
<th>DEFINITION</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>CDD</td>
<td>Maximum number of Consecutive Days with precipitation &lt; 1mm</td>
<td>Day</td>
</tr>
<tr>
<td>CWD</td>
<td>Maximum number of Consecutive Days with precipitation &gt; 1mm</td>
<td>Day</td>
</tr>
<tr>
<td>RR1</td>
<td>Maximum number of Days with precipitation &gt; 1mm</td>
<td>Day</td>
</tr>
<tr>
<td>R99P</td>
<td>Annual cumulative rainfall (rain exceeds 99th percentile)</td>
<td>mm</td>
</tr>
<tr>
<td>TNx</td>
<td>Monthly maximum of the minimum temperature</td>
<td>°C</td>
</tr>
<tr>
<td>TNn</td>
<td>Minimum monthly minimum temperature</td>
<td>°C</td>
</tr>
<tr>
<td>TXx</td>
<td>Maximum monthly maximum temperature</td>
<td>°C</td>
</tr>
<tr>
<td>TXn</td>
<td>Minimum monthly maximum temperature</td>
<td>°C</td>
</tr>
<tr>
<td>DTR</td>
<td>Mean diurnal temperature difference (Tmax - Tmin)</td>
<td>°C</td>
</tr>
</tbody>
</table>
Effects of GGW on extreme rainfall

- Increase in numbers of rainy days (RR1), and intense rainfall (R99P);
- Precocity of the beginning of the rainy seasons (CDD)
Effects of GGW on temperature extremes

- Increased thermal amplitude (DTR) on the GGW band
The recent regreening and the implementation of the GMV would lead to:

An increase in rainy days;
An increase in the frequency and amplitude of intense rainfall;
A precocity of the beginnings of the rainy seasons.
An increase in the daily thermal amplitude

The (hypothetical) Sahelian re-greening strengthens the Land-Atmosphere feedback, which in turn alters the frequency and magnitude of climatic extremes in the subregion.
Concluding Food for thought

1. **Weather Prediction**: To what extent are we paying attention to building or improving infrastructure for weather prediction, as the projected increase in frequency and intensity of Extreme Events will occur on weather time scales, when the time comes?

2. **Climate Resilience**: To what extent are we paying attention to weather and seasonal time scales, in addition to formulating climate change policies and strategies, recognizing that resilience building requires decisions and action across time scales?

3. **LULCC vs GHG Emissions**: While preparing for the impact of climate change in Africa, is it worth considering the role of Land Use Land Cover Change as well?
Global Targets and implementation in Africa

1) UN Agenda 2030 – Sustainable Development Goals (SDGs)
2) 2015 Paris Climate Agreement
3) Sendai framework for Disaster Risk Reduction 2015-2030
4) Global Framework for Climate Services (GFCS) – For example National, EU funded Intra-ACP
5) AU Agenda 2063 https://au.int/en/agenda2063
6) African Ministerial Conference of Ministers on Meteorology (AMCOMET) Integrated African Strategy on Meteorology (Weather and Climate Services) (Investing in Weather and Climate Services for Development)
7) African Space Policy (meteorological input)
8) Climate Research for Development in Africa (CR4D-Africa)
9) Africa Hydromet Programme

AU 2063 – implementation will involve high level sector documents on other sectors such as Agriculture (e.g. Malabo Declaration, CADAP), DRR, etc.
1) SP1: Increase Political Support and Recognition of NMHSs and related WMO Regional Climate Centres

2) SP2: Enhance the Production and Delivery of Weather and Climate Services for Sustainable Development

3) SP3: Improve Access to Meteorological Services in particular for the Marine and Aviation Sectors

4) SP4: Support the Provision of Weather and Climate Services for Climate Change Adaptation and Mitigation

5) SP5: Strengthen Partnerships with Relevant Institutions and Funding Mechanisms
THANK YOU