

A large, vibrant rainbow arches across a light blue sky. Below the rainbow, there are several stylized white clouds with soft blue shading underneath, giving them a three-dimensional appearance.

Hydroclimate Project for Lake Victoria Basin (HYVIC)

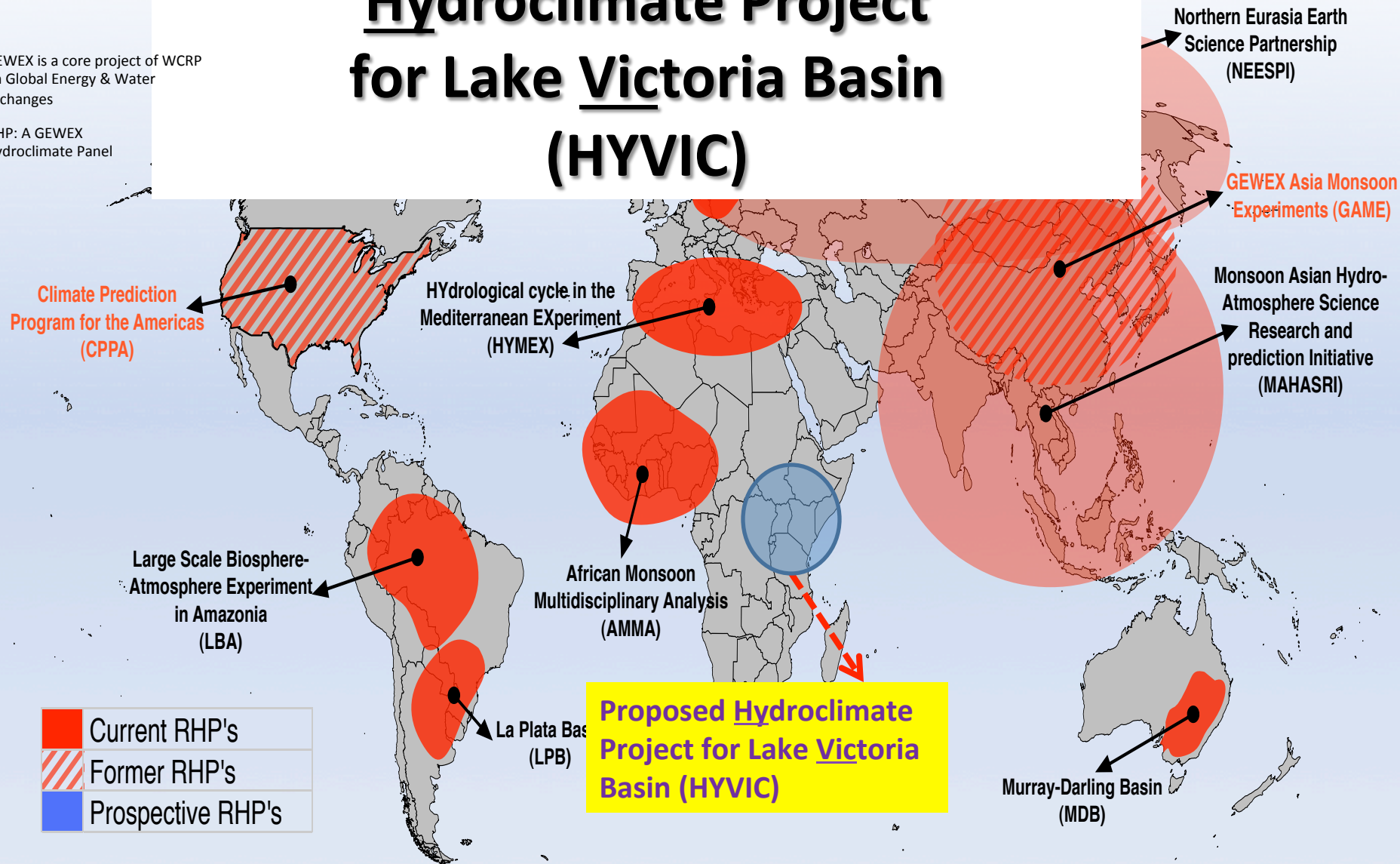
Meeting of the WCRP GEWEX Project
GHP, 10-17 July 2014.



Proposed GEWEX RHP Hydroclimate Project for Lake Victoria Basin (HYVIC)

GEWEX is a core project of WCRP
on Global Energy & Water
Exchanges

GHP: A GEWEX
Hydroclimate Panel



Lake Victoria Basin



- LVB is the social-economic nerve center for EA (Burundi, Rwanda, Kenya, Tanzania, Uganda) – 30 to 40 million
- Mainly rain fed agricultural economy with LV supplying fish as a major part of the diet
- Lake Victoria also provides hydroelectric energy and relatively inexpensive form of transportation
- Geopolitical significance of LVB as the source of the White Nile

Inspired by East African Community Feasibility Study

HYVIC has been inspired by the East African Community **feasibility study** that **made the recommendation for the creation of HYVIC**: : “Enhancing Safety of Navigation and Efficient Exploitation of Natural Resources over Lake Victoria and Its Basin by Strengthening Meteorological Services for Lake Victoria”

“... we suggest creation of the **Regional Hydroclimate Project (HYVIC) GEWEX ...**” ...
2012

The feasibility study **was funded by the EAC** (Semazzi et al; http://climlab.meas.ncsu.edu/Final_Report_LVBC.pdf)

EAC Feasibility Study Authors: Fredrick Semazzi (lead), Sandra Yuter, James Kiwanuka-Tondo, Lian Xie, Casey Burleyson, Bin Liu, Kara Smith, Pascal Waniha (NC State University; [USA](#)); Lynn Rose (Atmospheric Technology Services Company, Norman, OK; [USA](#)); Ruben Barakiza (Institut Geographique du [Burundi](#)), Peter Ambenje ([Kenya](#), Meteorology Department), Anthony Twahirwa ([Rwanda](#) Meteorological Service), Hamza Kabelwa ([Tanzania](#) Meteorological Agency), Ronald Wesonga ([Uganda](#) Meteorological Department), Laban Ogallo and Joseph Mutemi (University of Nairobi and ICPAC, [Kenya](#)) and Francis Kirudde ([Uganda](#), UMEME).

EAC=Burundi, Rwanda, Kenya, Uganda,
Tanzania

HyVic Planning Milestones

**HyVic Planning Meeting at University of Reading
(Photo taken by Dr. Rosalind Cornforth; July 2013)**



HYVIC International Planning Committee (IPC)

1. Fredrick Semazzi (Chair), North Carolina State University, USA; **IPC Chair & Lead HyVic US**
2. Richard Anyah, U. of Connecticut
3. Rita Roberts, NCAR/UCAR
4. Lian Xie, North Carolina State University
5. Kamazima Lwiza (Stony Brook University, NY, USA) - **(REQUEST GHP TO BE ADDED TO IPC)**
6. Steven Goodman (GSFC/NOAA) - **(REQUEST GHP TO BE ADDED TO IPC)**
7. Richard Ogutu (NAFRRI, Uganda); **Lead HyVic-EA (REQUEST GHP TO BE ADDED TO IPC)**
8. Laban Ogallo, Climate Prediction and Applications Centre (ICPAC), EA
9. Pascal Waniha, Tanzania Meteorology Agency (TMA), Tanzania
10. Andrew Githeko, Kenya Medical Research Institute, Kenya
11. Felix Mutua (Jomo Kenyatta University of Agriculture and Technology), Kenya
12. Rosalind Cornforth, University of Reading, **UK; Lead UK**
13. Helen Houghton-Carr, CEH/NERC
14. Caroline Bain, UKMO

HYVIC IPC Terms of Reference

- Update and finalize the science plan
- Set the overarching science questions to guide the project
- Prepare communication material for HyVIC
- Coordinate partnerships with funding agencies
- Coordinate proposal submissions to agencies



HyVic Network



NCAR/
UCAR



GRACE



Curtin
University
Australia

UConn



JOMO KENYATTA UNIVERSITY OF AGRICULTURE AND TECHNOLOGY
Setting Trends in Higher Education, Research and Innovation

UNIVERSITY OF CONNECTICUT



UbuntuNet Alliance
for Research and Education Networking



NC STATE UNIVERSITY



ICPAC-IGAD

NSF
Expedition



AfCli

X



AfClix
Africa Climate Exchange



University of
Reading

LVBC



Stony Brook
University



SoMAS
School of Marine and
Atmospheric Sciences

CEH-
UK



U



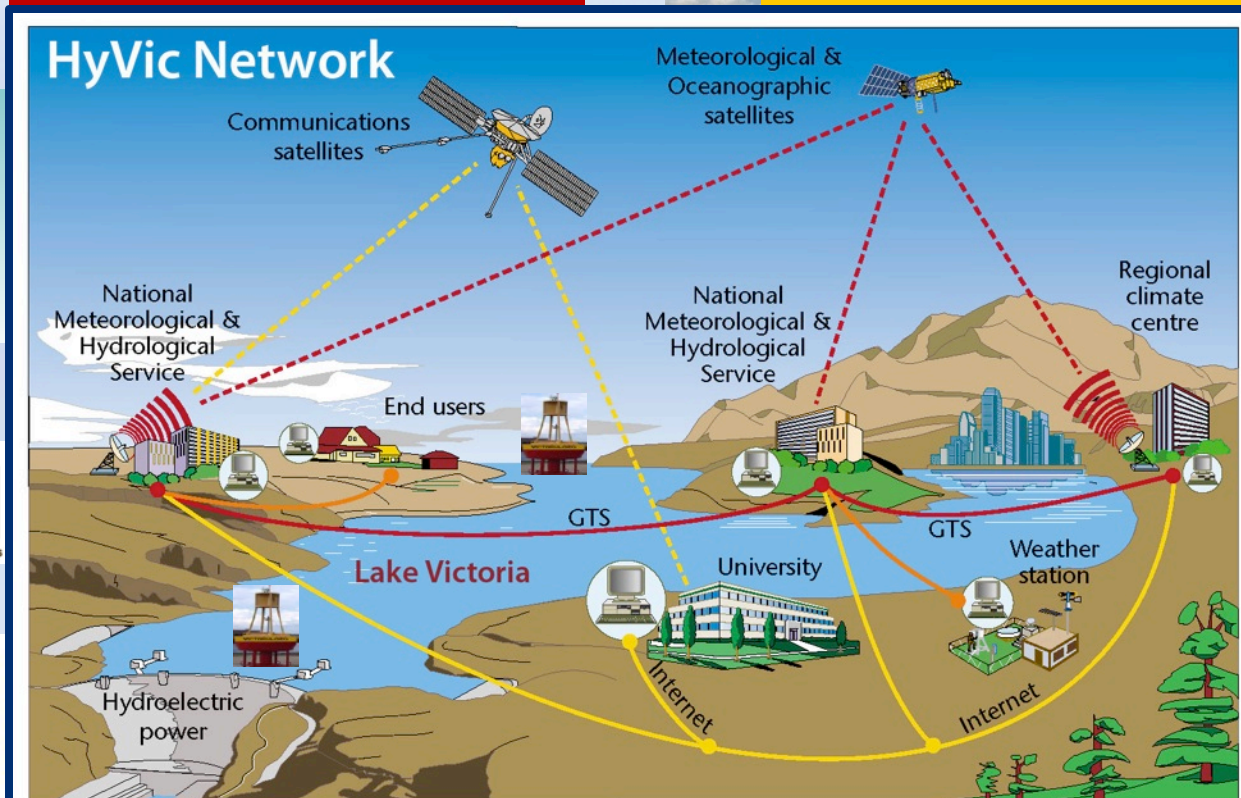
CSR
P



Met Office
Hadley Centre



World Meteorological Organization SWFD
Weather • Climate • Water



Institutional Coordination (Regional)

- **LVB-HyNEWS (Lake Victoria Basin - HydroClimate to Nowcasting for Early Warning Systems)**
- Formed to enhance the coordination, visibility and sustainability of HyVic, SWNDP (Severe Weather Nowcasting Development and Demonstration Project) and EAC NEWS (Navigation Early Warning System).
- **LVB HyNEWS Executive Council:** Governed by EC comprising Heads of NMHS, EAC/LVBC coordinator and AMCOMET Secretariat (invited observer).
- **LVB HyNEWS Task Force:** Projects' PIs and five NMHS technical contacts act as a day-to-day coordinating team.

MEETING OF HEADS OF METEOROLOGICAL SERVICES AND JOINT EAC/WCRP/WWRP WORKSHOP. *Meeting recommended the creation of HyNEWS to EAC Council of Ministers. The recommendation was approved* (photo taken from AMCOMET Newsletter 003, July 2014)



HyVic Coordination (continued ...)

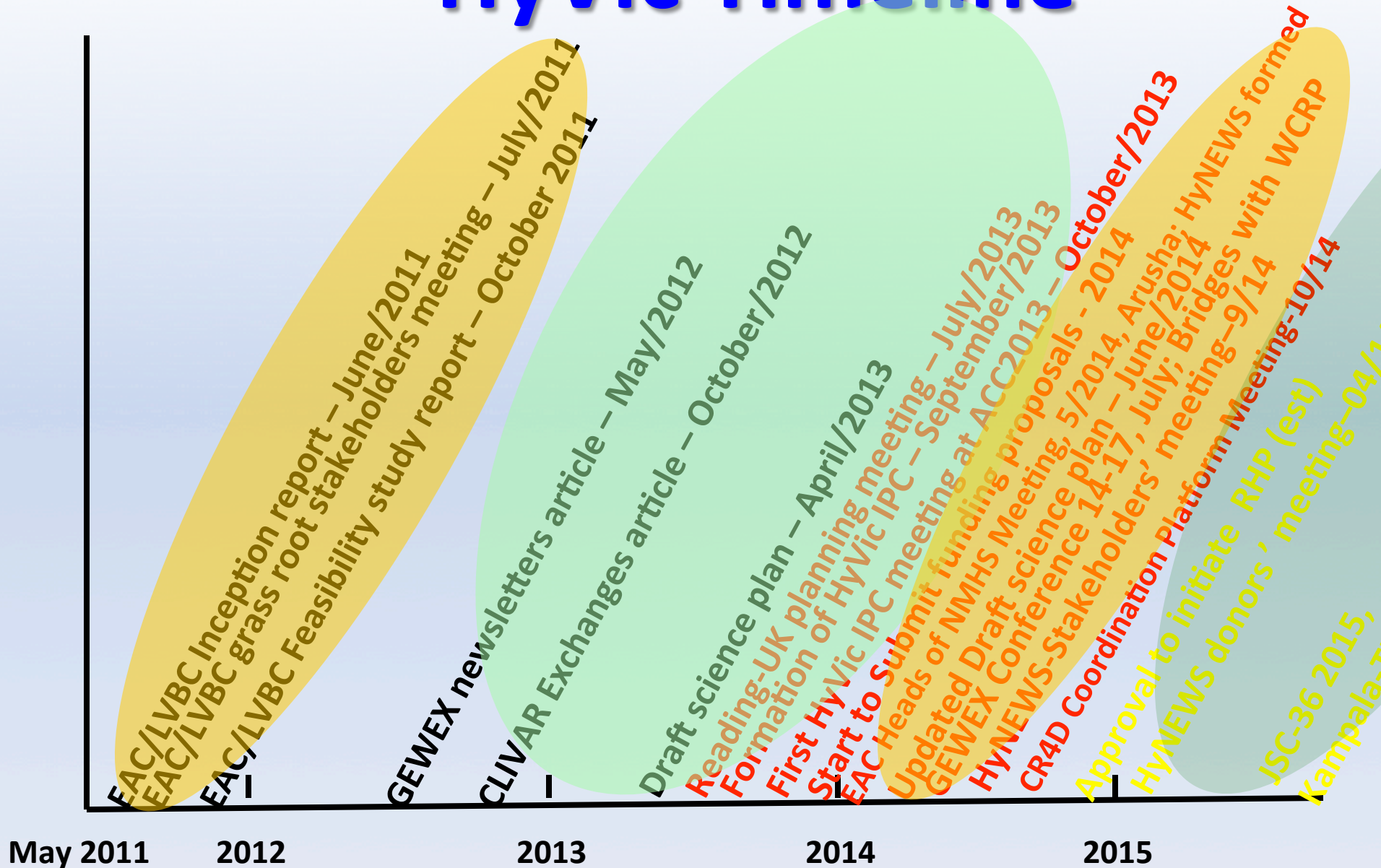
Institutional Coordination (Continental)

- Africa Climate Research For Development Coordination Platform (**CR4D**); outcome from ACC2013



African Climate Conference – October, 2013

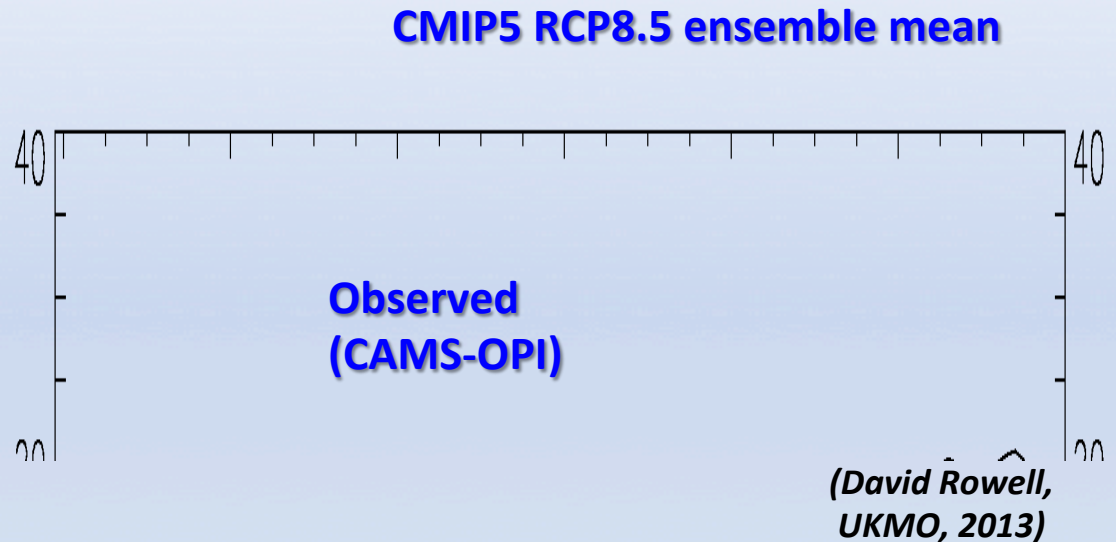
HyVic Timeline



High Level HyVic Science Questions

Past & Projected Climate (Rainfall)

Low-pass filtered rainfall (>10yr), MAM average over Greater Horn of Africa

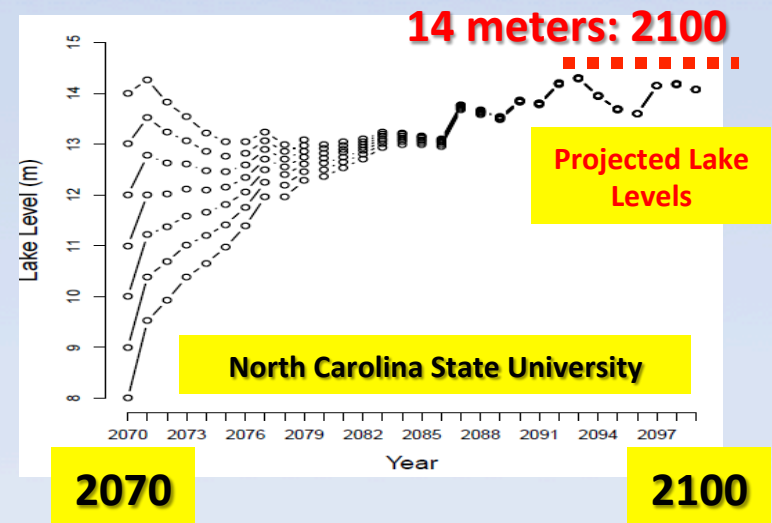
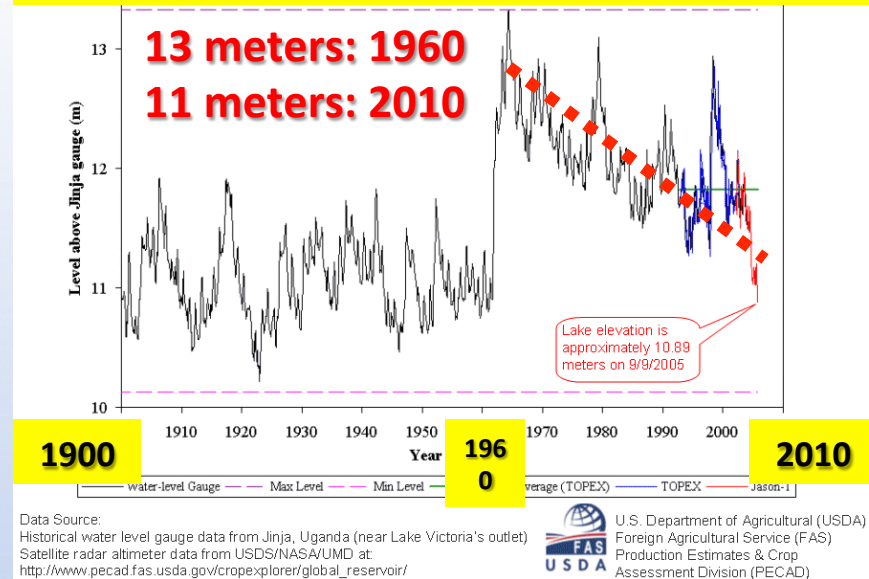


- Persistent past decline & projected reversal and increase
- Phenomenon known as the Eastern-Central African climate change paradox
- Could have profound implications on LVB sustainable development for more than 35 - 40 million people

Past & Projected Climate (lake levels)

- Persistent past decline & projected reversal and increase
- This phenomenon is the Eastern-Central African climate change paradox – 'Lake Victoria Basin Climate Change Paradox'
- Likely to have profound implications on LVB sustainable development for more than 35 - 40 million people

Past & Projected Lake Victoria Levels



RegCM downscaled rainfall for **2071-2100** used as input for the Tate et al (2004) WBM to compute the LL. (Smith, 2011); **evaporation is 13.5% above present level based on A2 scenario. Thus projection is 2 meters above present lake levels. (Kara et al, 2013)**

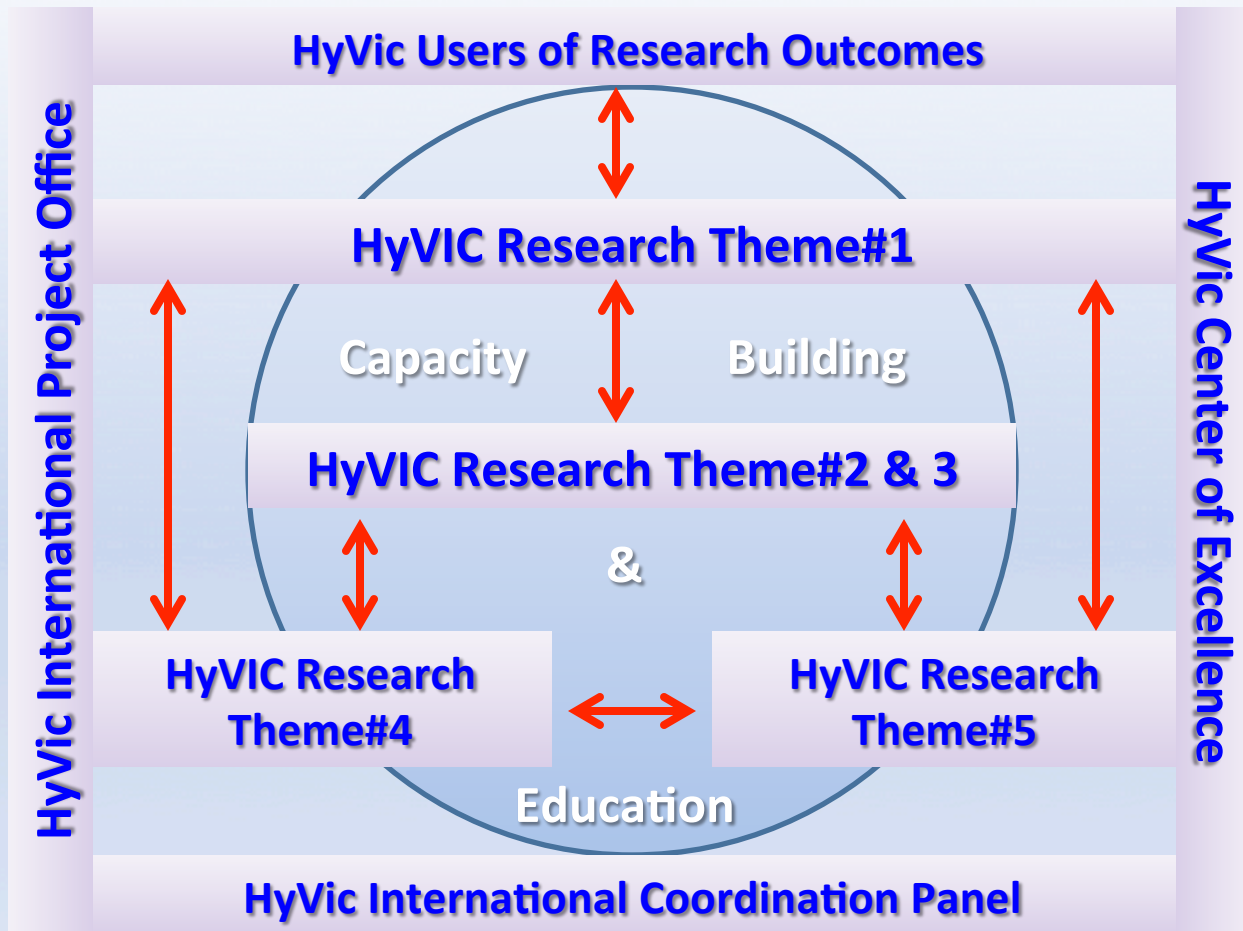
HyVic High Level Science Questions

The primary scientific challenge therefore is to reduce the present high levels of uncertainty associated with the paradox problem by ascertaining,

- (i) whether indeed the reversal will occur,
- (ii) the timing of when it will materialize and
- (iii) whether these two factors will be determinable at acceptable levels of confidence to inform the management of the leading regional climate sectors.

HyVic models will take into account the critical factors including the record projected Urbanization of the LVB and comprehensive modeling of the role of Lake Victoria water circulation and temperature on the basin's climate.

HyVIC Science Plan Components



HyVIC Research Theme-1: Translational Research Interface with Applications

HyVIC Research Theme-2: Severe Weather and Water Currents (collaboration with WWRP-LVP)

HyVIC Research Theme-3: Lake Victoria Basin Water Budget

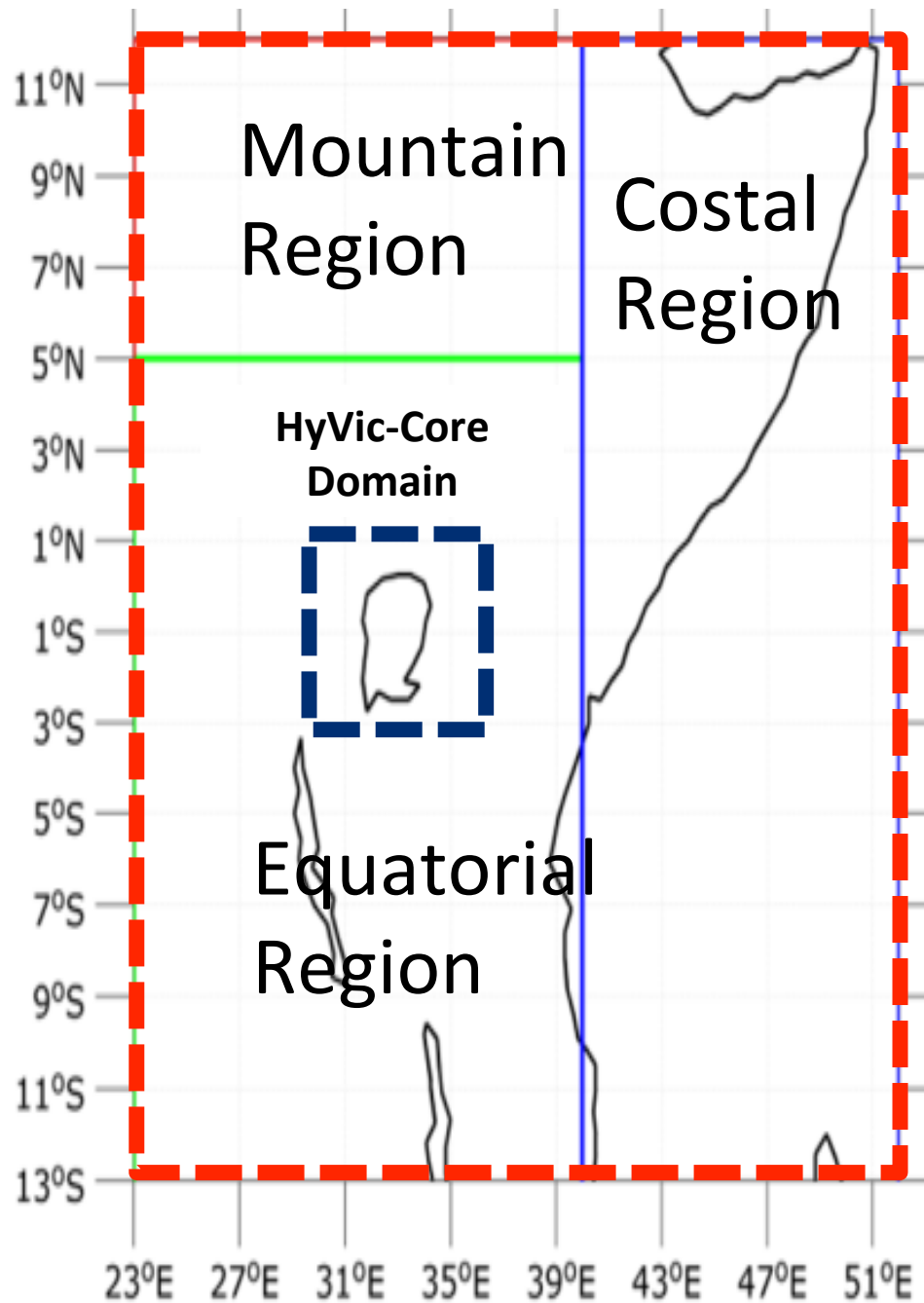
HyVIC Research Theme-4: Climate variability and model development

HyVIC Research Theme-5: Observation of the Hydroclimatological System

(Customized from GFCS)

HyVIC Research Theme-4: Climate variability and model development

HyVic-Greater Domain



Basin-Scale Hydroclimate

Climatology

(complex rainfall gradients that may be related to navigation safety)

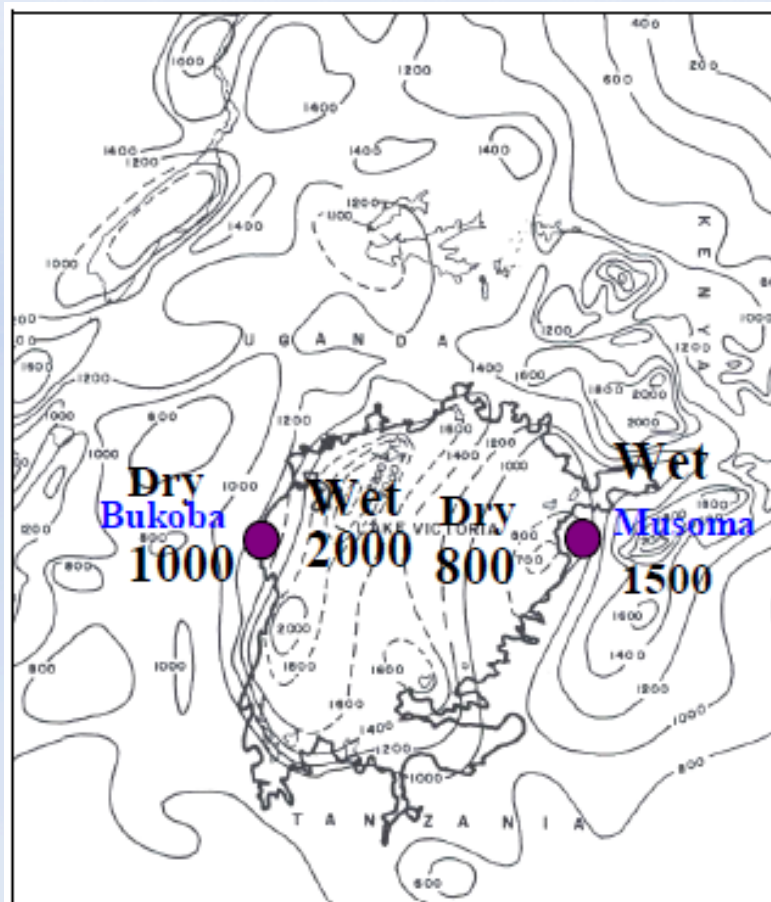
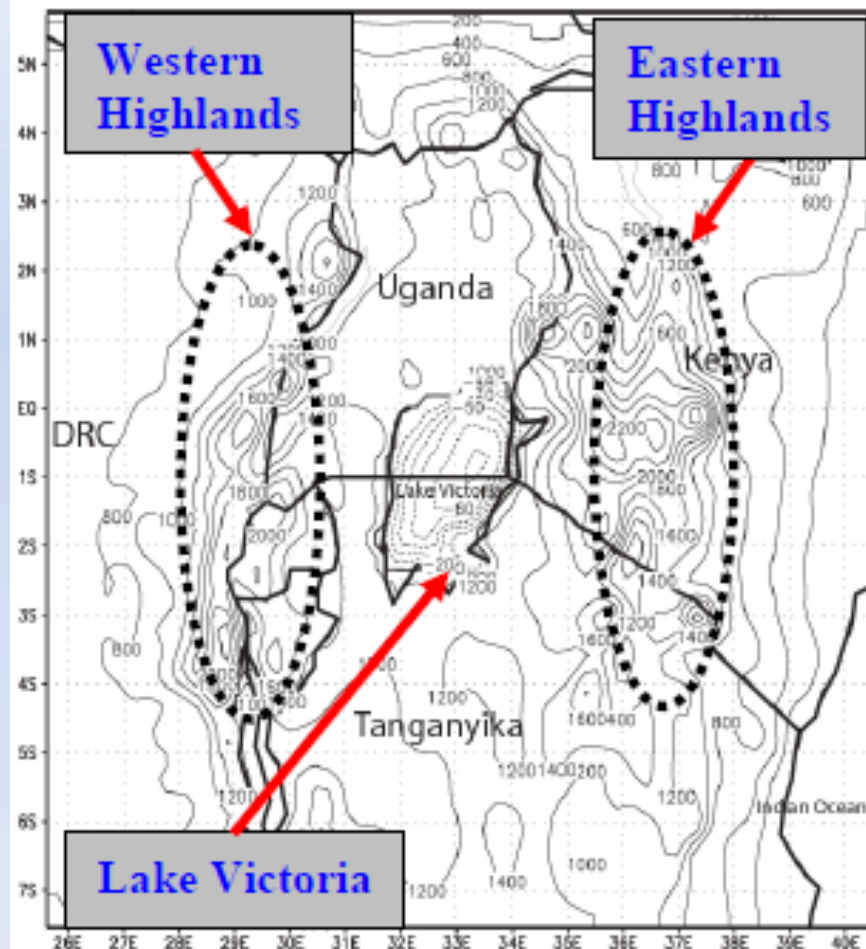


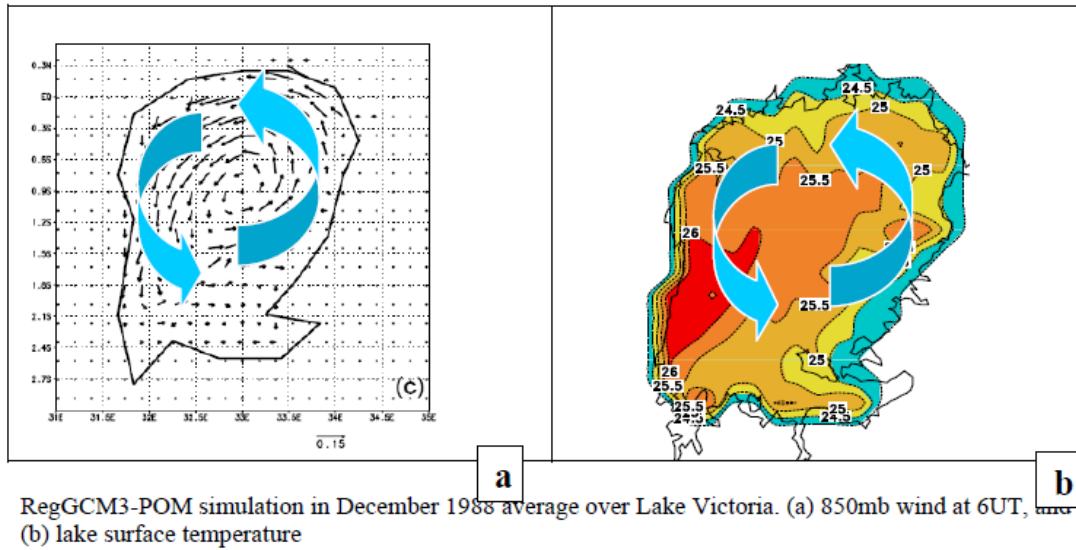
Fig.3: Observed Annual Rainfall (mm)



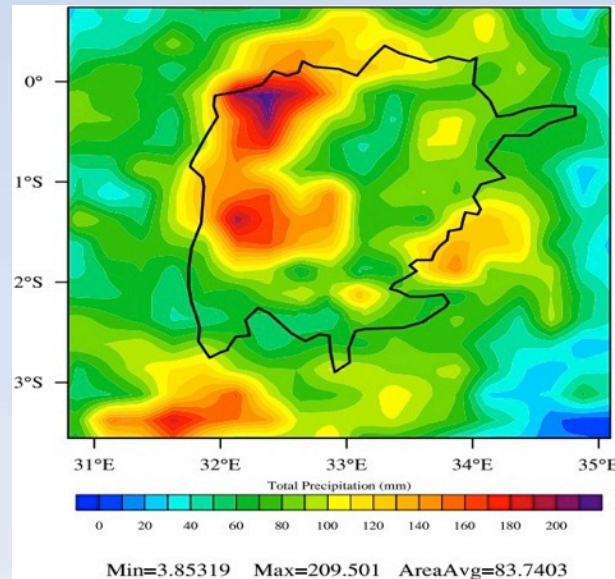
Climatology

Lake Water Currents & Temperature Patterns

Climate Model
Near Lake Surface
Air flow



Climate Model
Lake Surface
Temperature



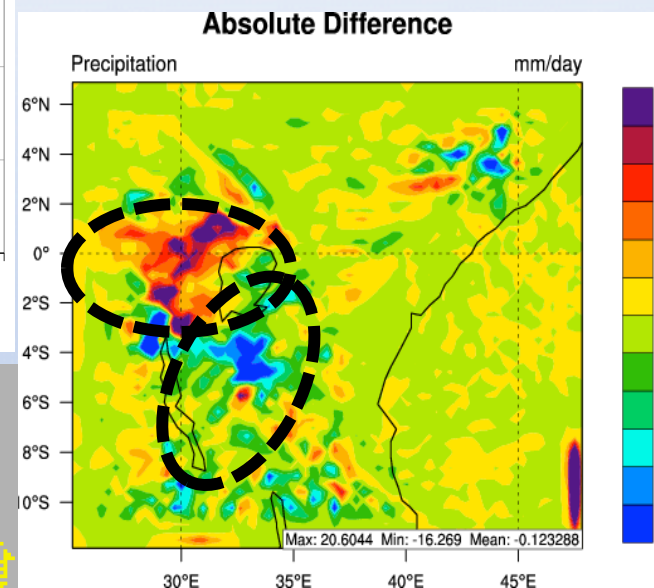
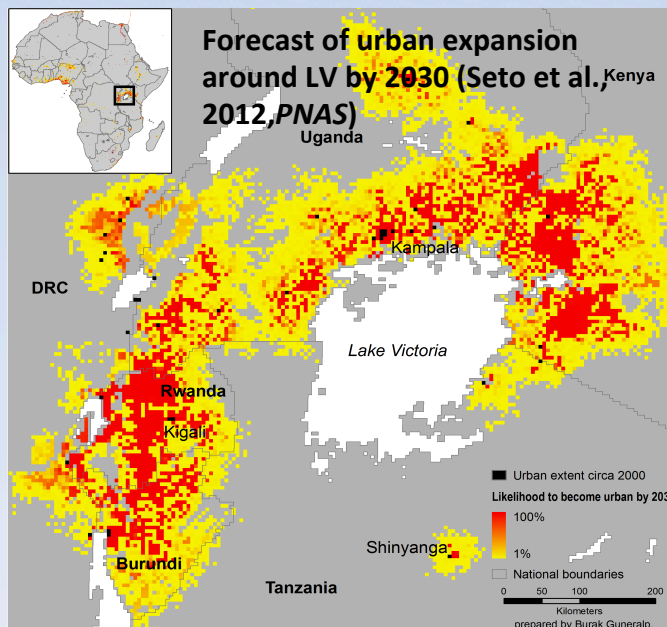
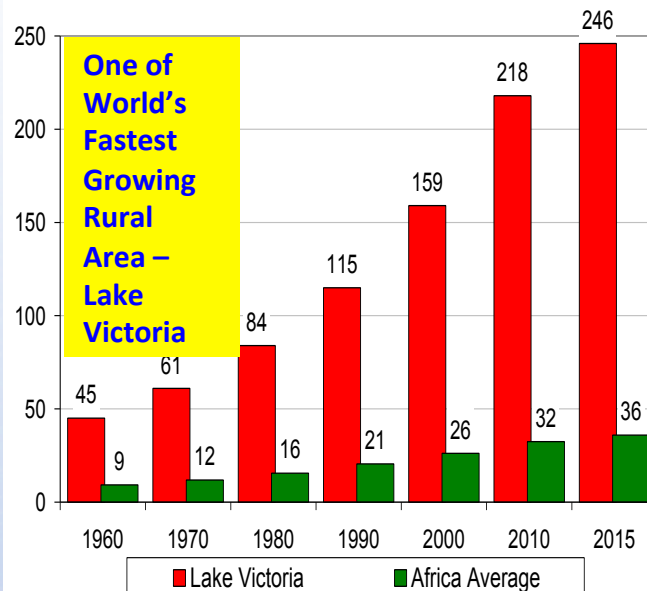
Satellite TRMM
Rainfall



Due primarily to high rural to urban migration, Kampala's population has grown at an average rate of 5.6 percent annually since the 1960s; Stunning growth between 1974 & 2008 (UNEP)



Potential Role of Land Surface Change

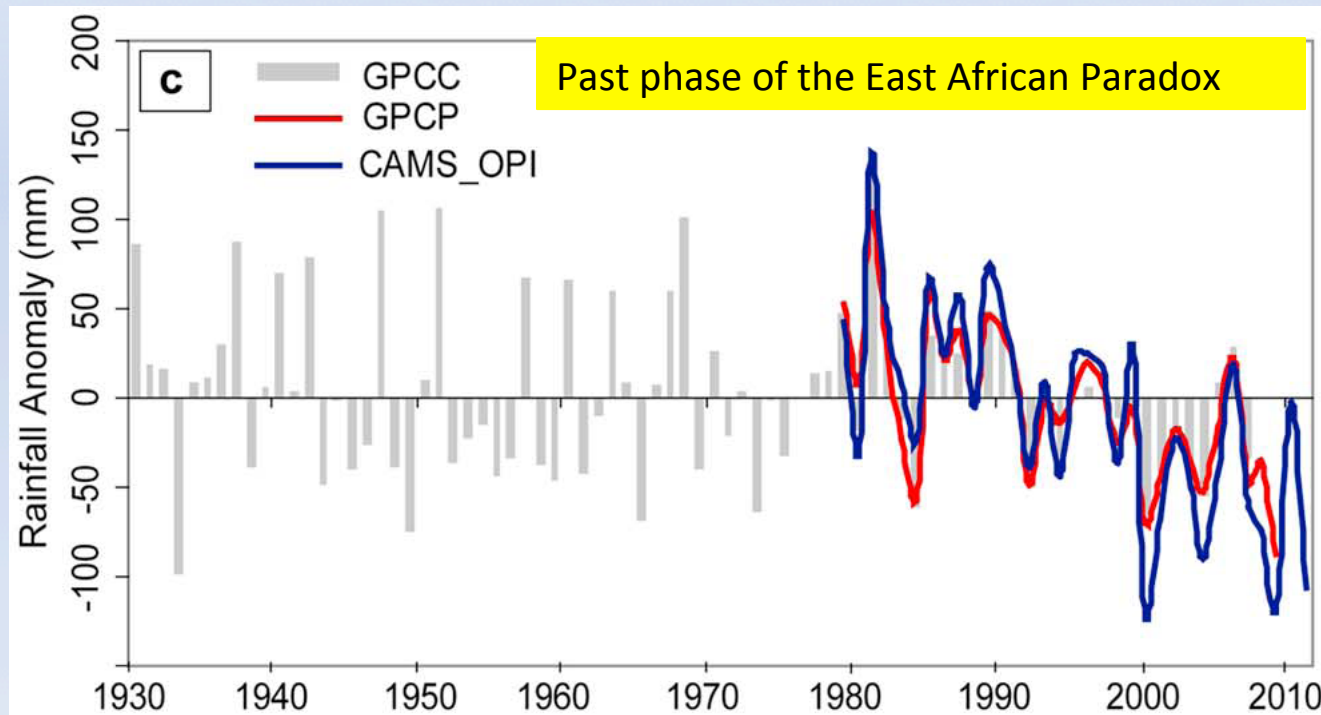


WRF Simulated change due to 2030 projected urbanization

Regional-Scale Climate

RT#4: HyVic Greater Domain Climate (involves Collaboration Opportunity with Clivar)

A recent and abrupt decline in the East African long rains



Anomalous MAM rainfall (from GPCP; mm/day) - (Lyon and DeWitt, 2012)

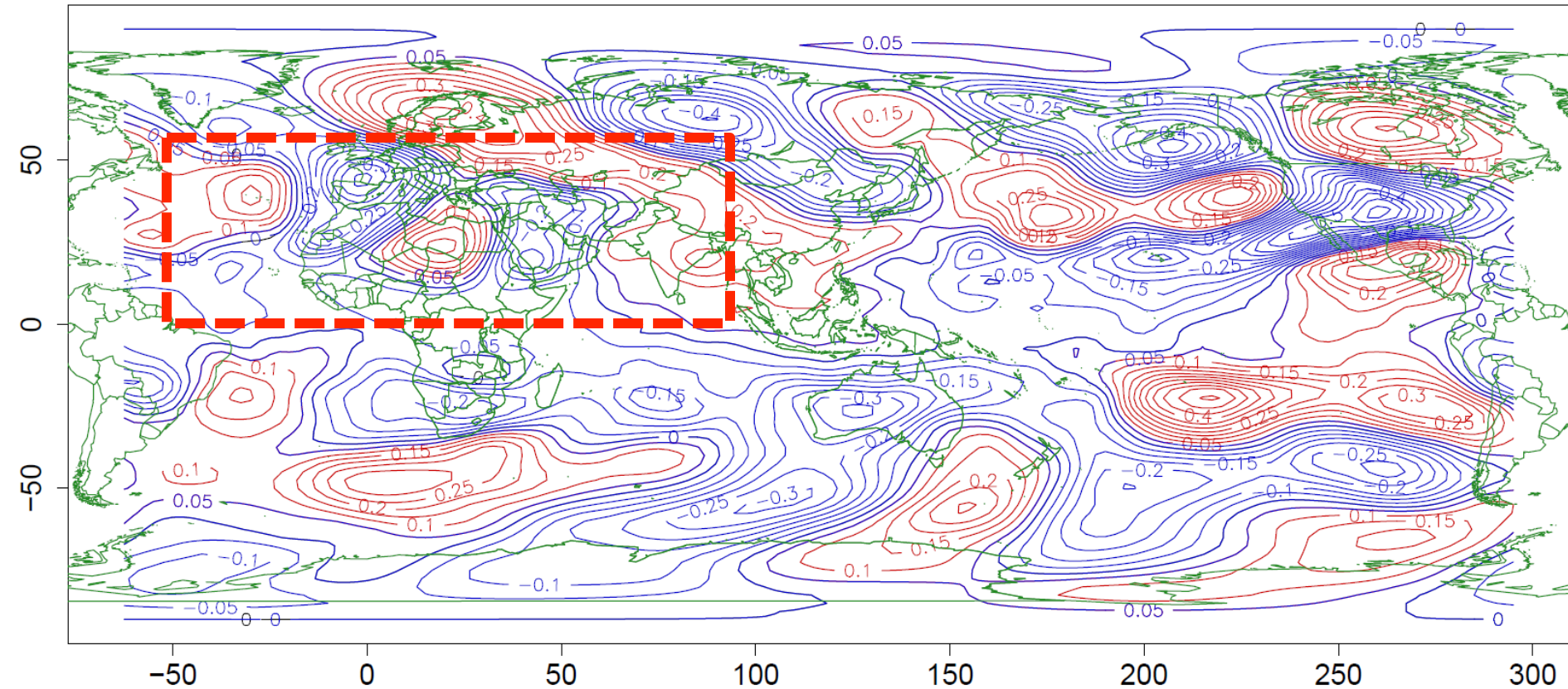
Major Controversy Regarding Cause of the Multi-decadal Decline (Persistent Drought - Opportunity for collaboration with GDIS)

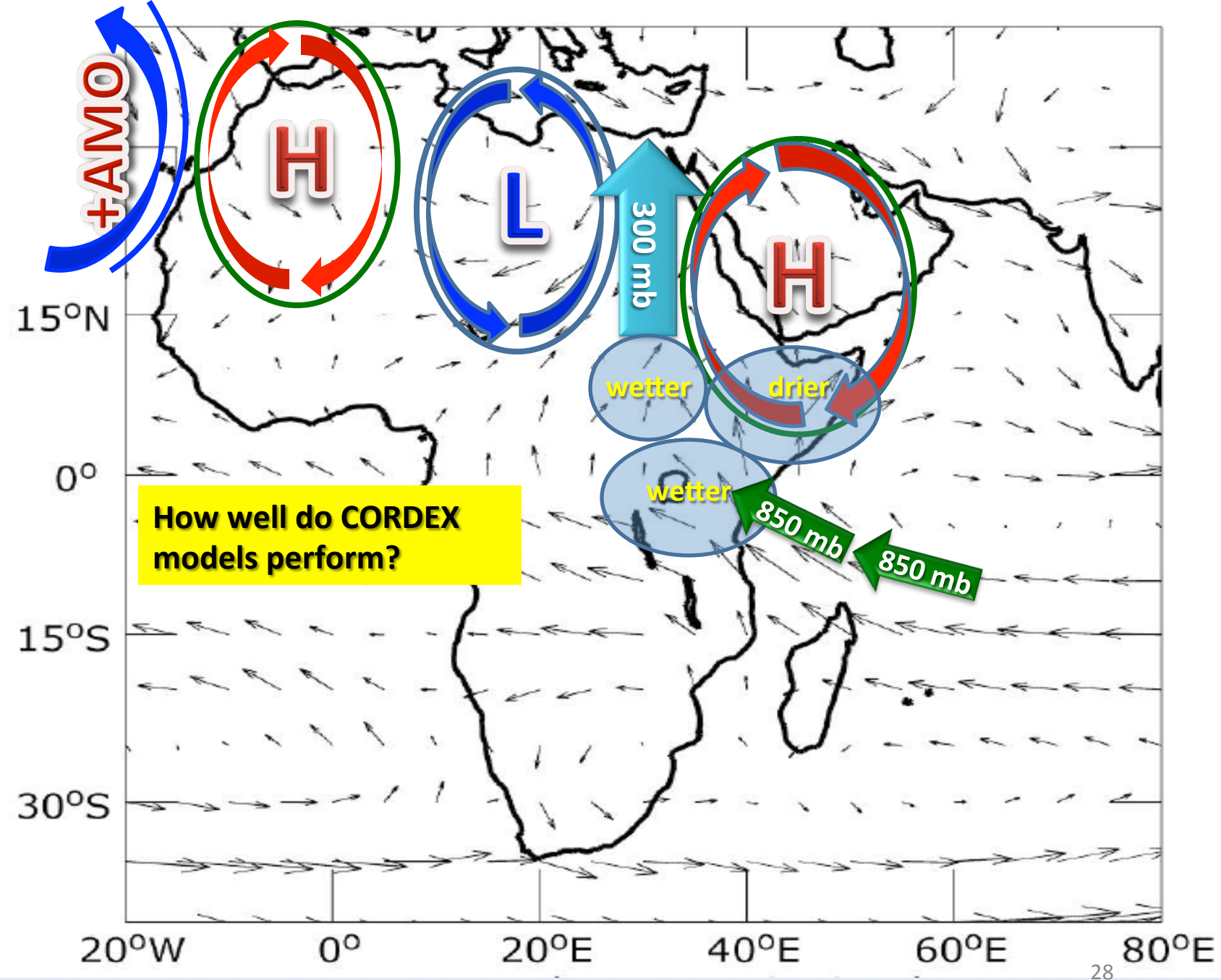
Yang, W., R. Seager, M. Cane, and B. Lyon, 2014: The East African Long Rains in Observations and Models. J. Climate, (in press)

- **Williams and Funk (2011):** Anthropogenic warming forced rapid warming of Indian Ocean SSTs; extended the warm pool and Walker circulation westward; resulting in a subsidence anomaly and drying over East Africa (Yang et al, 2014)
- **Lyon and DeWitt (2012):** On the contrary, linked the decline with a shift to warmer SSTs over the western tropical Pacific and cooler SSTs over the central and eastern tropical Pacific (Yang et al 2014)
- **Lyon et al. (2013):** More recently, have attributed the shift to natural multidecadal variability in the Pacific (Yang et al 2014)
- **Yang et al (2014):** Modeling evidence in support of Lyon et al. (2013)
- **Semazzi et al (2014):** The decadal variability of the cessation is dominated by AMO stationary Rossby wave; AMO contribution on MAM total season is same order of magnitude but less than Indo-Pacific

(left) All region (HyVic-GD) reconstructed rainfall area averages based on different combinations of EOFs (right) area averages for the HyVic-GD (south), HyVic-GD (north) and all region (i.e. HyVic-CD) reconstructed rainfall based on EOF2 . HyVic-GD (south) and HyVic-GD (north) are each about half of the domain and separated by along the 1 degree South latitude.

Coastal rainfall EOF1 (AMO-like mode) Composite (negative AMO phase) for geopotential and wind anomalies at 300mb.





Hydroclimate Monitoring

- What is the uncertainty among the traditional gridded rainfall data sets (GPCC, CRU etc) for East Africa in representing the relationships between the East African Monsoon and the dominant modes of natural decadal variability?
- What observations are required to monitor the phenomena?
- How can multi-proxy high-resolution palaeo-records, including coral and other high-resolution palaeo-records of hydrological and SST variability be applied to extend the record of PDO, AMO and ENSOD beyond the instrumental record to understand their relationship with decadal variability of East Africa rainfall?

Processes Studies

- How does climate change-driven response over East Africa and LVB interact with remote sources of natural decadal climate variability?
- What are the regional and basin physical mechanisms (e.g., tropical heating, orographic forcing, etc) that determine the regional and lake basin-scale response to remote sources of decadal natural variability (e.g., PDO, AMO and ENSOD) and how well do we understand them?

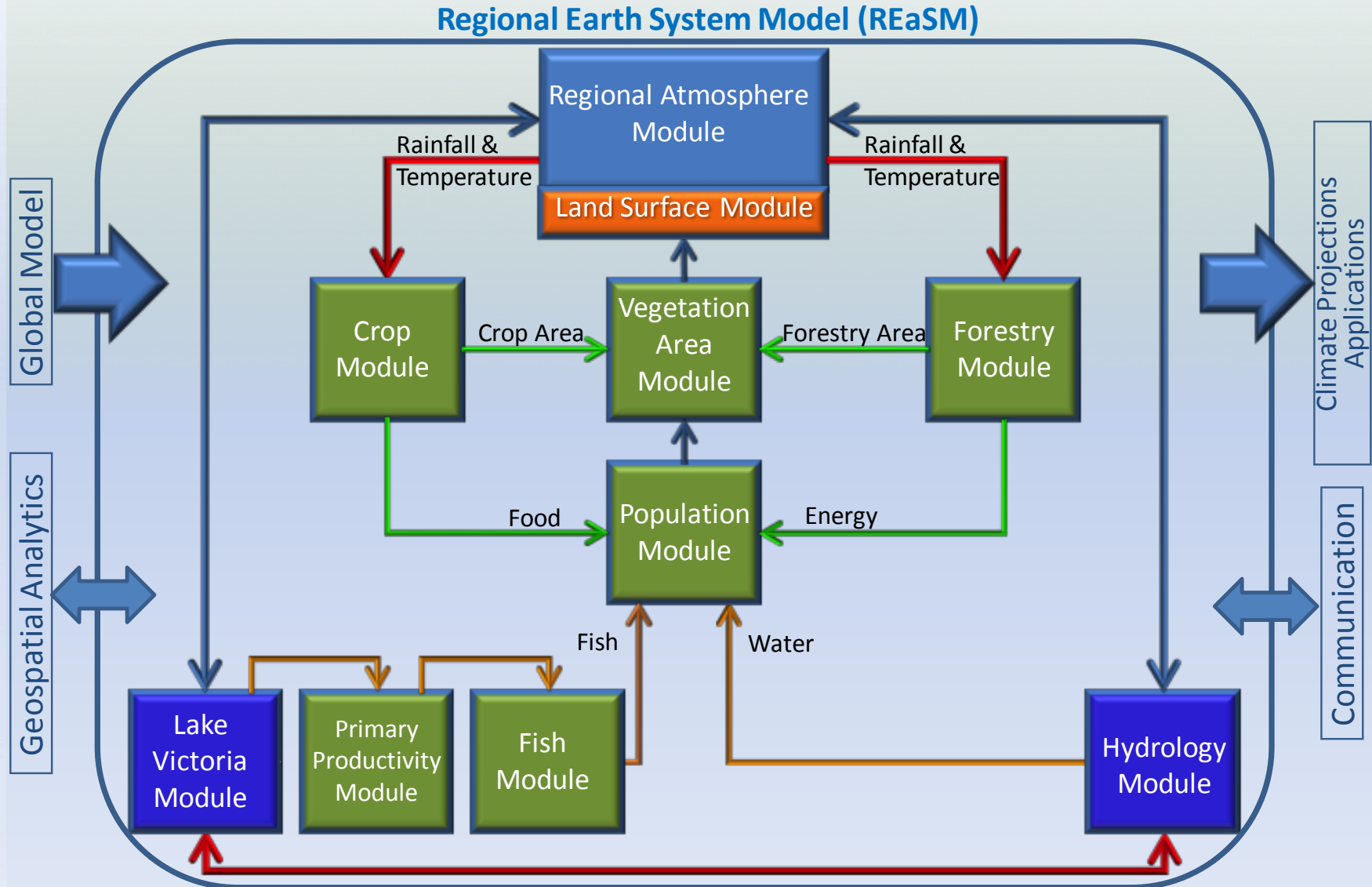
Model Evaluation and Model Development

- How well do we understand the response of the East African monsoon in models (e.g., linear models, CMIP, CORDEX, etc) to natural variability drivers including PDO, AMO and ENSOD?
- What are the appropriate model formulations for HyVic?
- What model skill is required to meet the application sectors needs initially focusing of agriculture/fisheries and hydroelectric power generation

HyVic Model Development Plan

RT#4: HyVic Core Domain Hydroclimate

HYVIC Regional Earth System Model (REaSM) Proposal

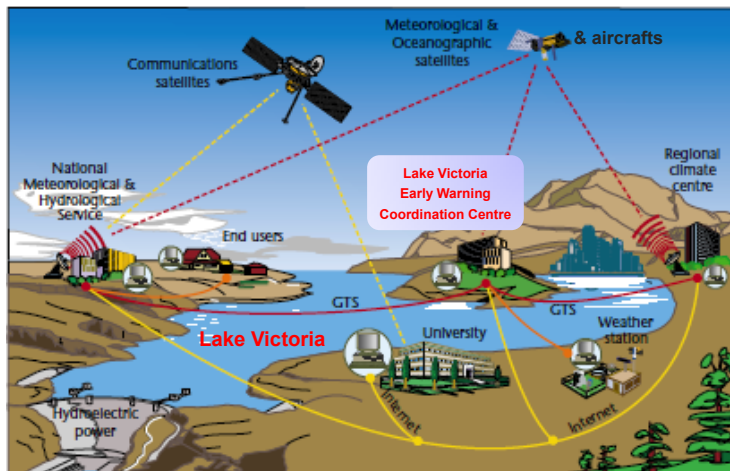


HyVic and LVB (WWRP) Observational Campaign

HyVIC Research Theme-5: Observation of the Hydroclimatological System

To understand and develop the capability of the variability of the hydrological components over Lake Victoria Basin this research theme will focus on the investigation of the variability on the primary time scales (intraseasonal, interannual, decadal and climate change time scales) in terms of the primary physical processes which are displayed below.

Atmospheric, Surface & Terrestrial Observations



Marine Observations for the 3-Dimensional Fluid System



Figure 17. Example of buoys being loaded onto the deck of deployment ship. The MV Jumuiya and other vessels that EAC may have commissioned should be deployed for Lake Victoria.

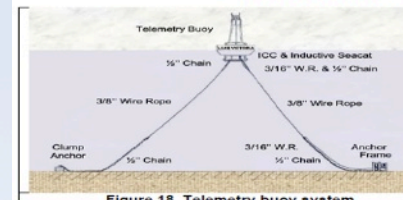


Figure 18. Telemetry buoy system.



Figure 19. Telemetry buoy sensors.

Applications Plan

HyVIC Research Themes: 1-5

**Observational
Rain Data**

**Model
Rain Data**

**Model Future
Rain Data**

Water Balance Model

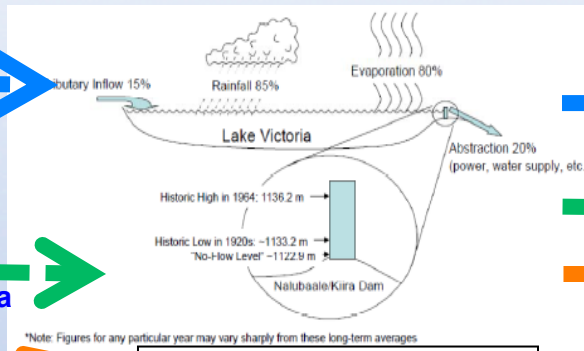
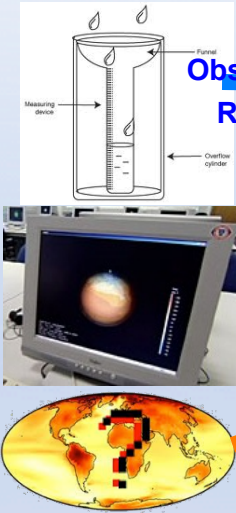
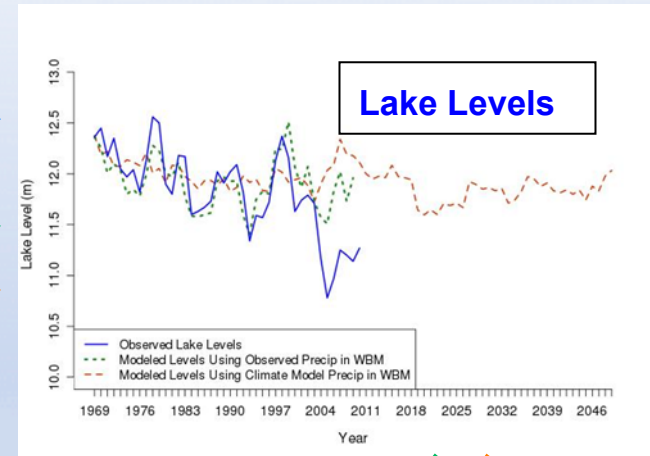
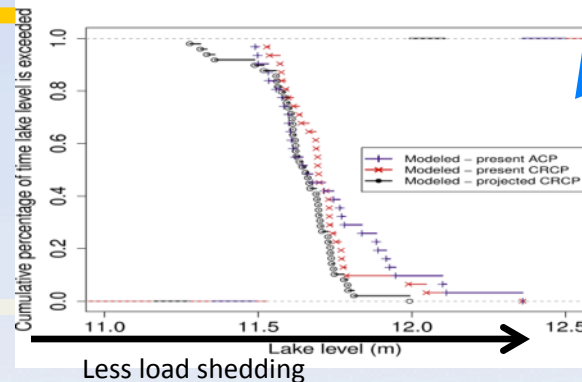
Lake Levels

**End User Metric:
Exceedance Curves (compare).**

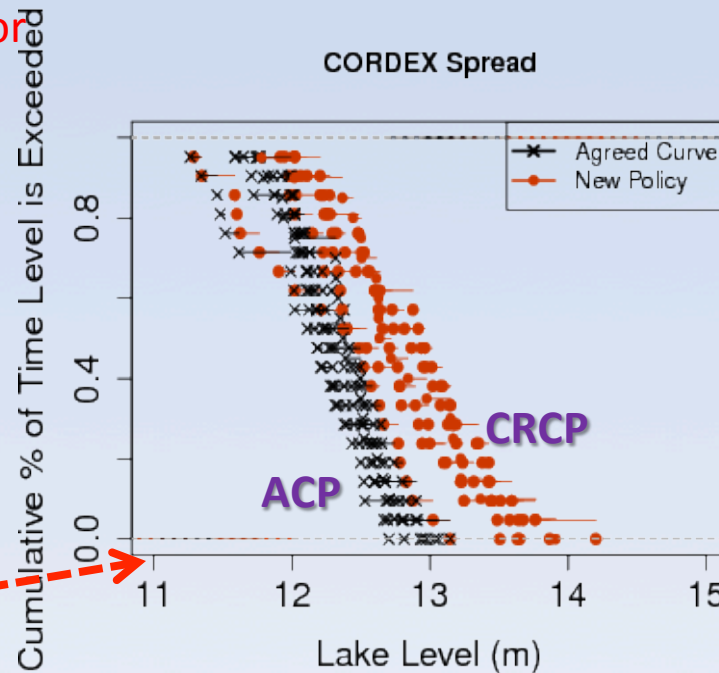
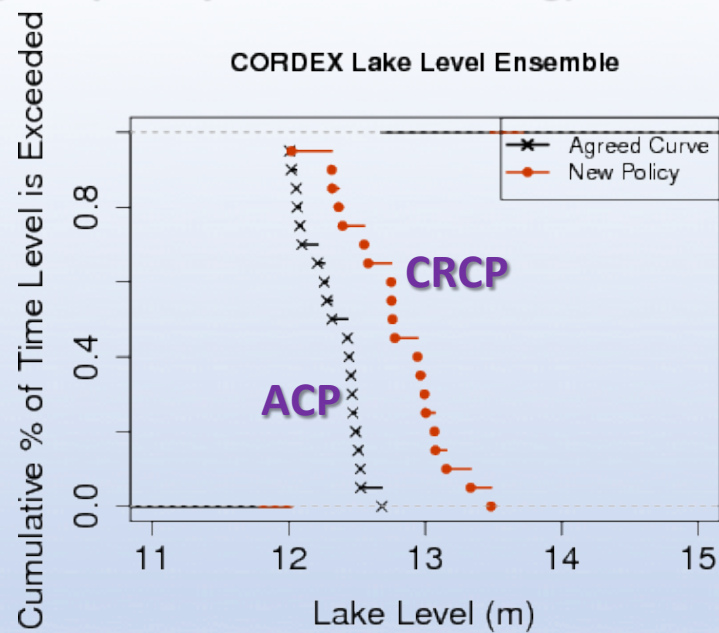
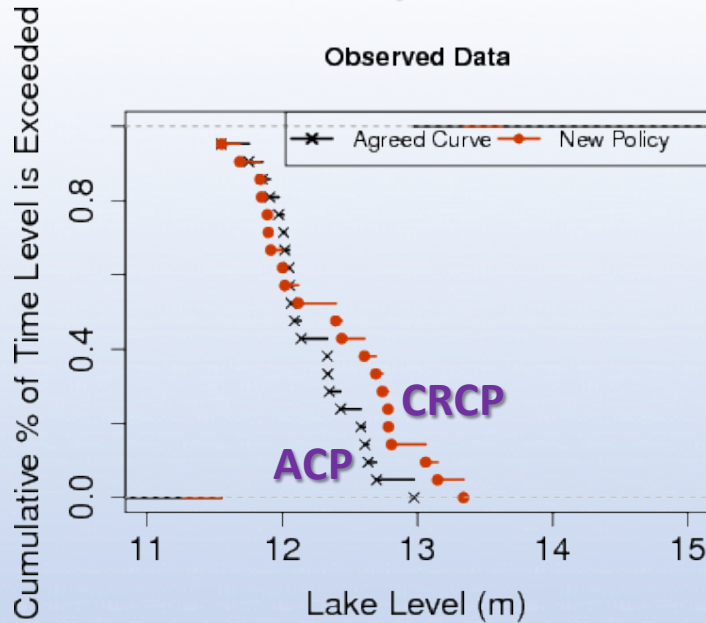
**High Exceedance
Less load shedding**

**Low Exceedance
More load shedding**

**Hydroelectric Dam
Operational Policy**



Estimated Exceedance of Lake Levels (Desirable to have % of exceeding low lake levels as high as possible thus minimizing frequency of load shedding)



**Hydroelectric Power Generation: Lake Level Rise;
Dam water release policy**

Comparison of percentage exceedance levels for the **ACP** and **CRCP** release rule policies based on,
 (top left) observed rainfall at the six raingauge stations and Tate et al. (2004) water balance model are used to estimate the lake levels,
 (top right) CORDEX RCMs ensemble average, and
 (bottom right) CORDEX RCMs ensemble spread percentage of the time lake level is exceeded (spread is a **measure of uncertainty**)

HyVic Research Mapping on GEWEX Science Question

GEWEX Questions	HYVIC Research Themes
GSQ -1: How can we better understand and predict precipitation variability and changes?	Theme #2 Theme #3 Theme #4 Theme #5
GSQ -2: How do changes in the land surface and hydrology influence past and future changes in water availability and security?	Theme #4
GSQ -3: How does a warming world affect climate extremes, and especially droughts, floods and heat waves, and how do land processes, in particular, contribute?	Theme #2
GSQ -4: How can understanding of the effects and uncertainties of water and energy exchanges in the current and changing climate be improved and conveyed?	Theme #1 Theme #3 Theme #4

HyVic – Collaboration Matrix

Climate Services	Pre-HyVic Capabilities	HYVIC-enabled Capabilities	HYVIC Research Themes	RHPs Projects	GEWEX Projects	WCRP Projects
Water (HEP)	Marginal capabilities based on RCOF rainfall tercile forecasts	Accurate predictions/projections of Lake levels & White Nile flow	Theme #1 Theme #3 Theme #4	AMMA, HyMex, SRB, ...	1,2,3,4	CLIVAR, WGRC, WGSIP
Agriculture	Climate Outlook Forum (COF) tercile rainfall amount probabilities	Higher Level Rainfall Metrics (amount, onset, end and dry/wet episodes)	Theme #1 Theme #3	AMMA, SRB	2	CLIVAR, WGRC, WGSIP
Fisheries	No capabilities	Water temperature and circulation	Theme #1			
DRR – High impact weather and its climatology	Marginal skill in forecasting high impact weather over lake for fishermen	Coupled Atmosphere-Lake model forecasting severe weather lake hydrodynamics	Theme #1 Theme #2	HyMex	3	CLIVAR, WGRC, WGSIP
Health	Climate Outlook Forum (COF) tercile rainfall amount probabilities	More accurate & relevant climate prediction & climate change projection products	Theme #1 Theme #4	AMMA		CLIVAR, WGRC, WGSIP
Other Sectors-1						
Other Sectors-2						
Operational Prediction	Mainly Statistical based prediction of regional averages	Numerical based prediction & higher geographical details.	Theme #4	All	4	CLIVAR, WGRC, WGSIP
Climate & Policy	Inadequate response to policy needs and	Responsive to policy needs & coordinated	Theme #1	All		

Funding

- (i) EAC Funding – planning phase
 - (ii) GEWEX IPO – planning phase
 - (iii) ClimDev - pending
 - (iv) USAID PREPARED - Pending
 - (v) NERC Future Climate for Africa (FCFA) proposal: Integrating Hydro-Climate Science into Policy Decisions for Climate-Resilient Infrastructure and Livelihoods in East Africa (HyCRISTAL) - \$20,000 for planning - Pending
- Creation of the HyNEWS consortium and CR4D are expected to yield funding opportunities
 - CR4D Coordination Platform Meeting-10/14 (Secretariat has been formed in part to manage proposals for funding)
 - HyNEWS donors ' meeting–04/15 (TBC)
 - HyVic needs a formal status of an RHP to be effective in funding proposals under HyNEWS and CR4D funding mechanisms.



Thank You

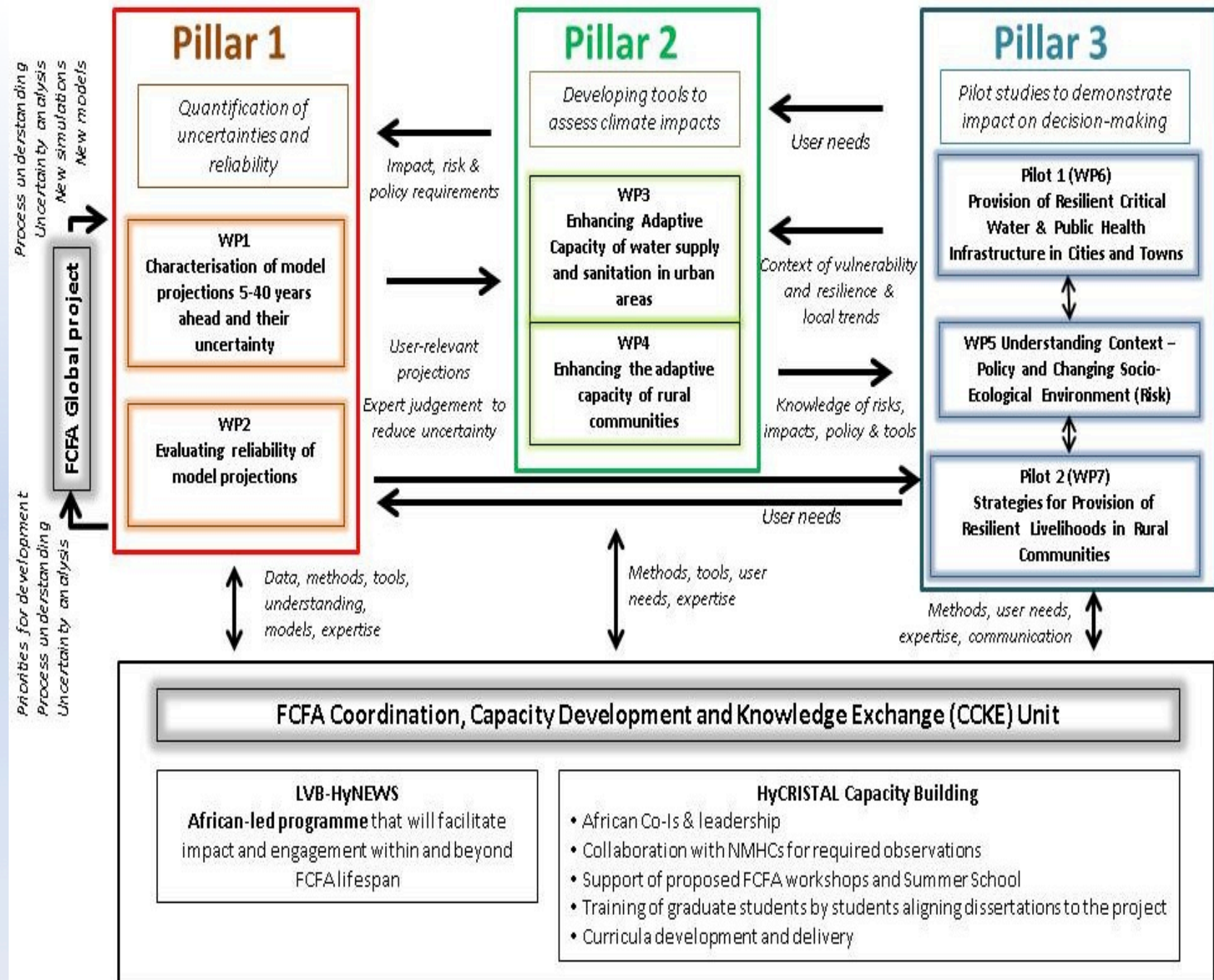


Figure 2: Schematic showing structure of HyCRISTAL and its interactions

Applications Plan

HyVIC Research Theme-3: Lake Victoria Basin Water Budget

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Rain Data**

**Model
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Water Balance Model

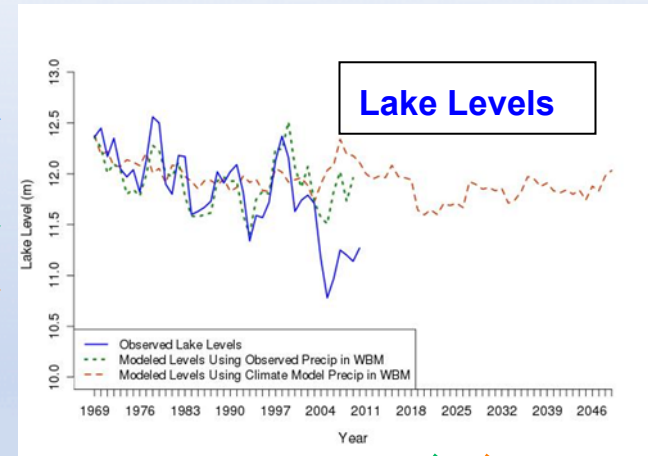
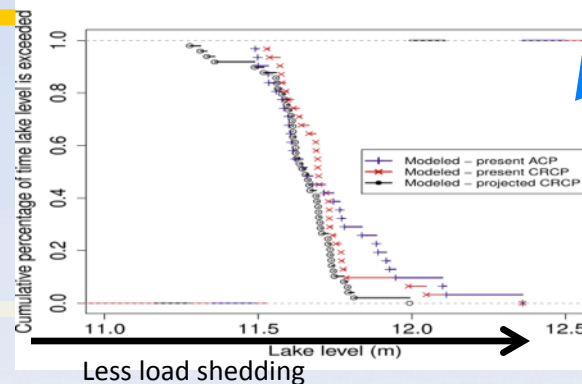
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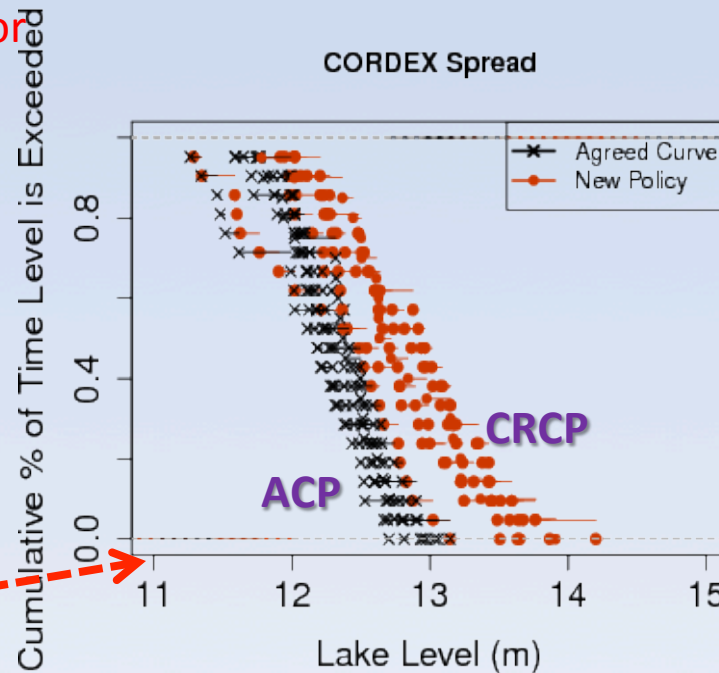
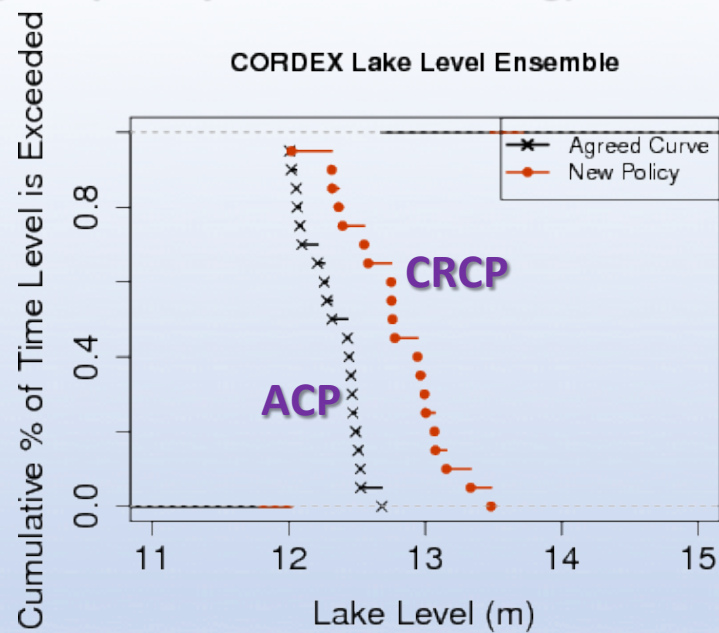
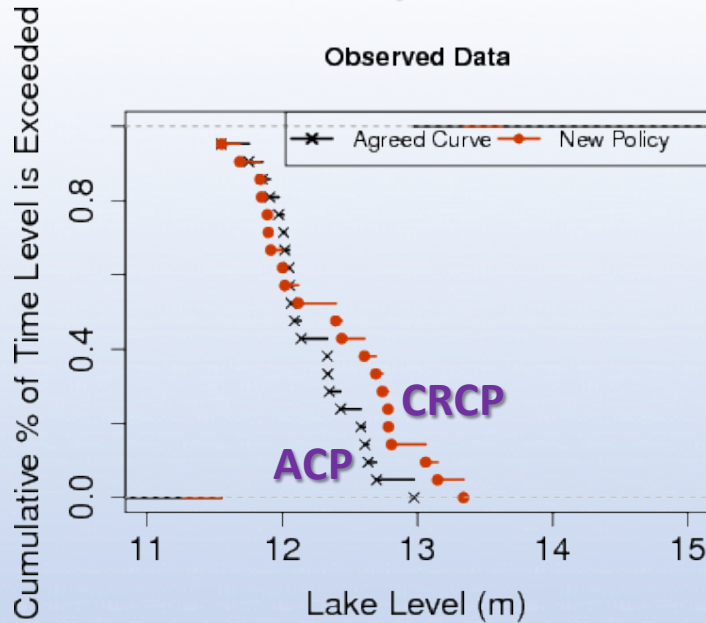
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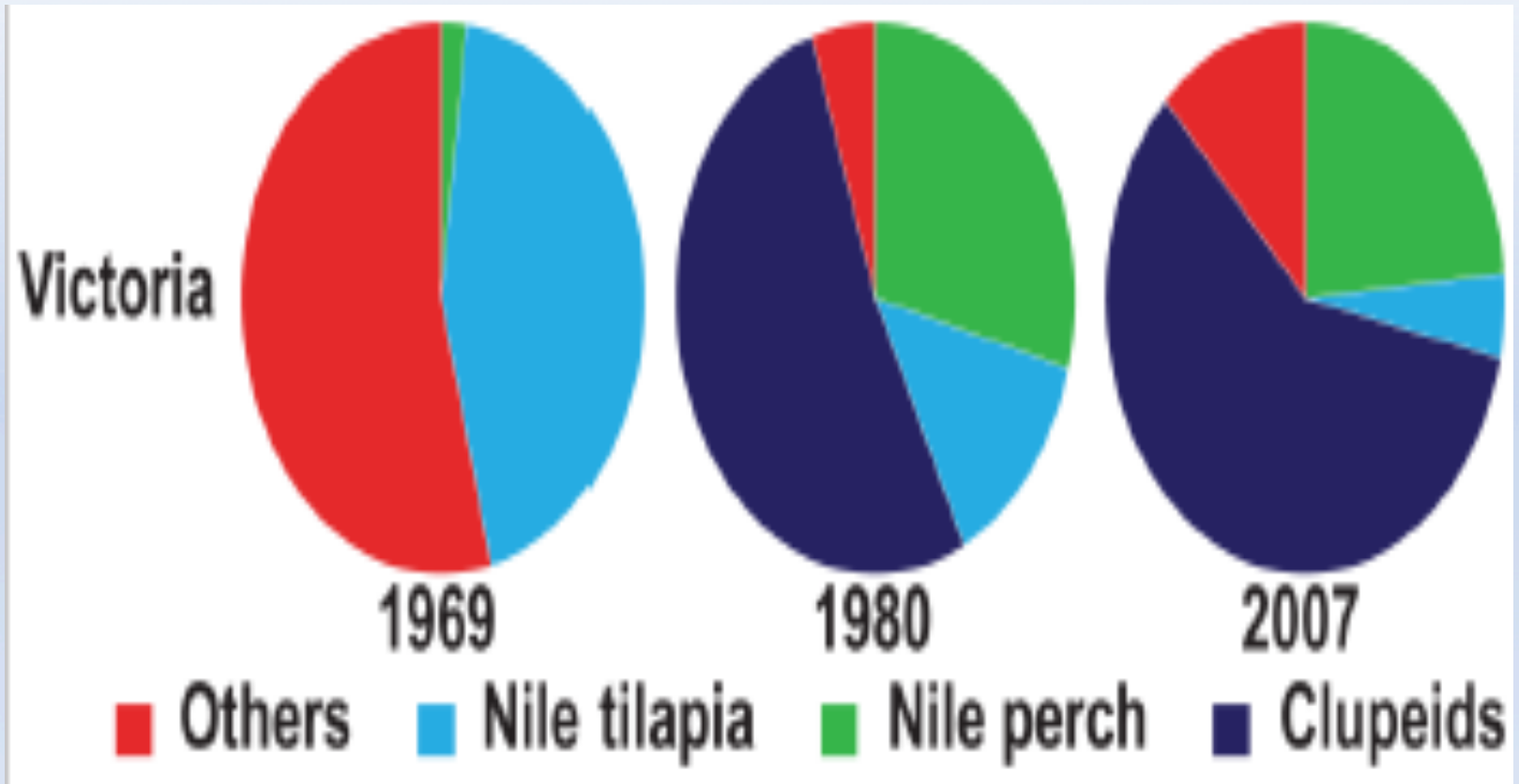
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Shifts in Fish Populations



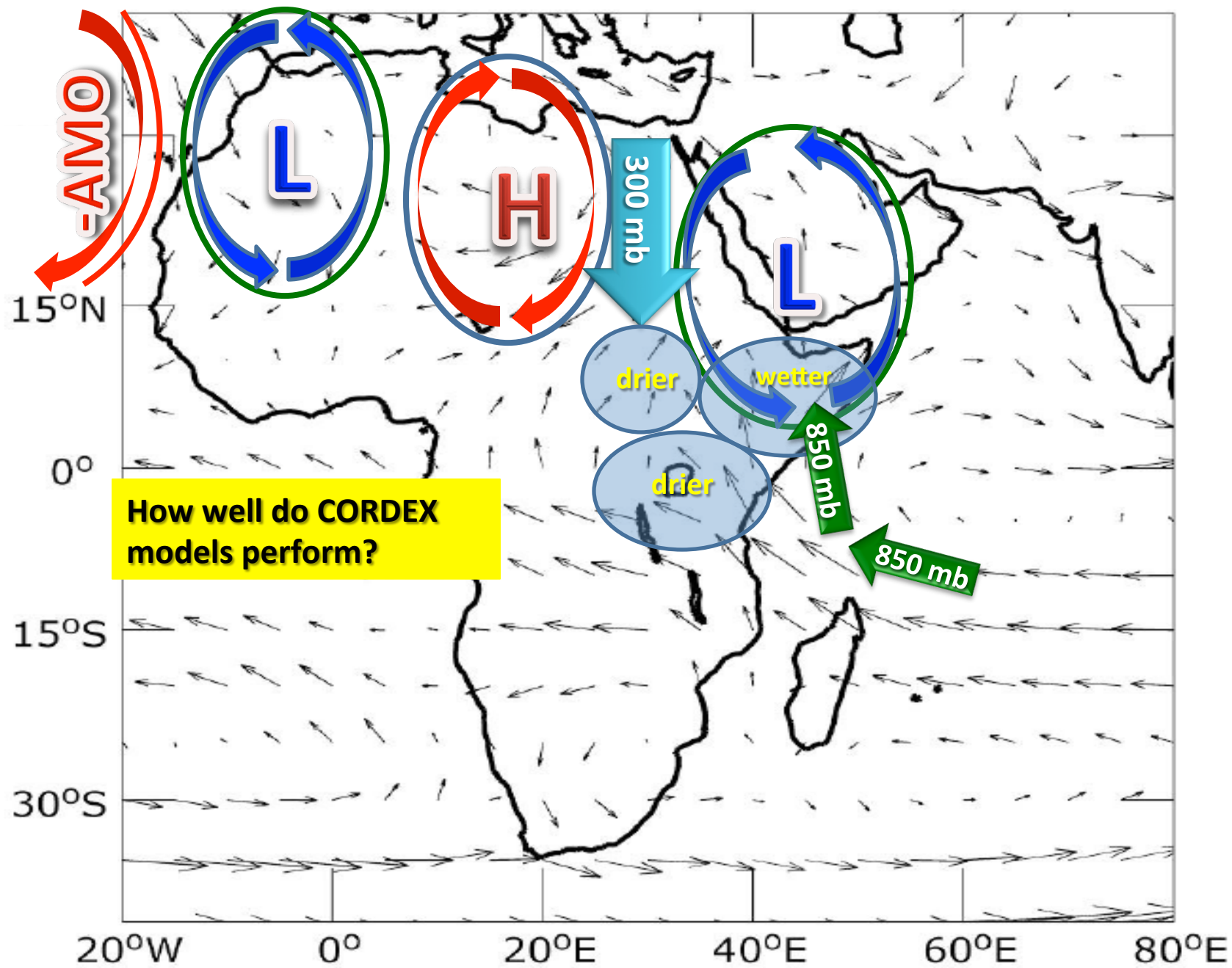
**Increased
dependence on the small pelagic
clupeids in Lake Victoria as climate intensifies**

Crop Adaptation – with NaFRRI

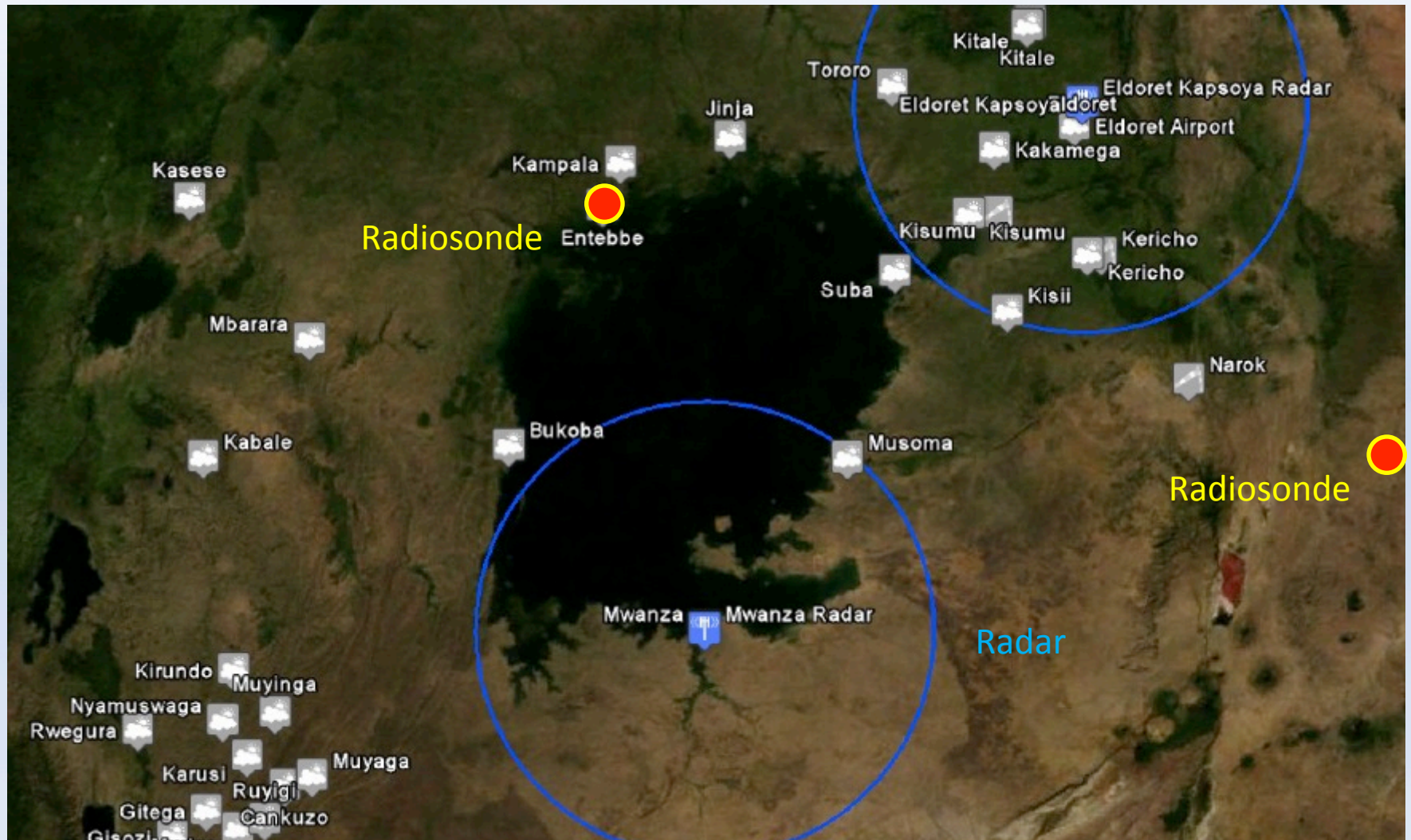
Crop adaptation

Adaptation strategies	Proportion (%)
Changed planting dates	38.3
Cultivated early maturing crops	22.4
Diversified crops	12.0
Carried out irrigation	11.0
Farmed near shore	9.4
Used drought resistant crops	7.0

The major crop adaptations included changing planting dates (38.3%), cultivating early maturing crops (22.4%), diversifying to other crops (12%), and irrigation (11%). More innovative fishers diversified to high value crops like pineapples, oranges, tomatoes, eggplants, cabbages which increased their income beyond what they used to get from fishing to the extent that some of them had quit fishing.

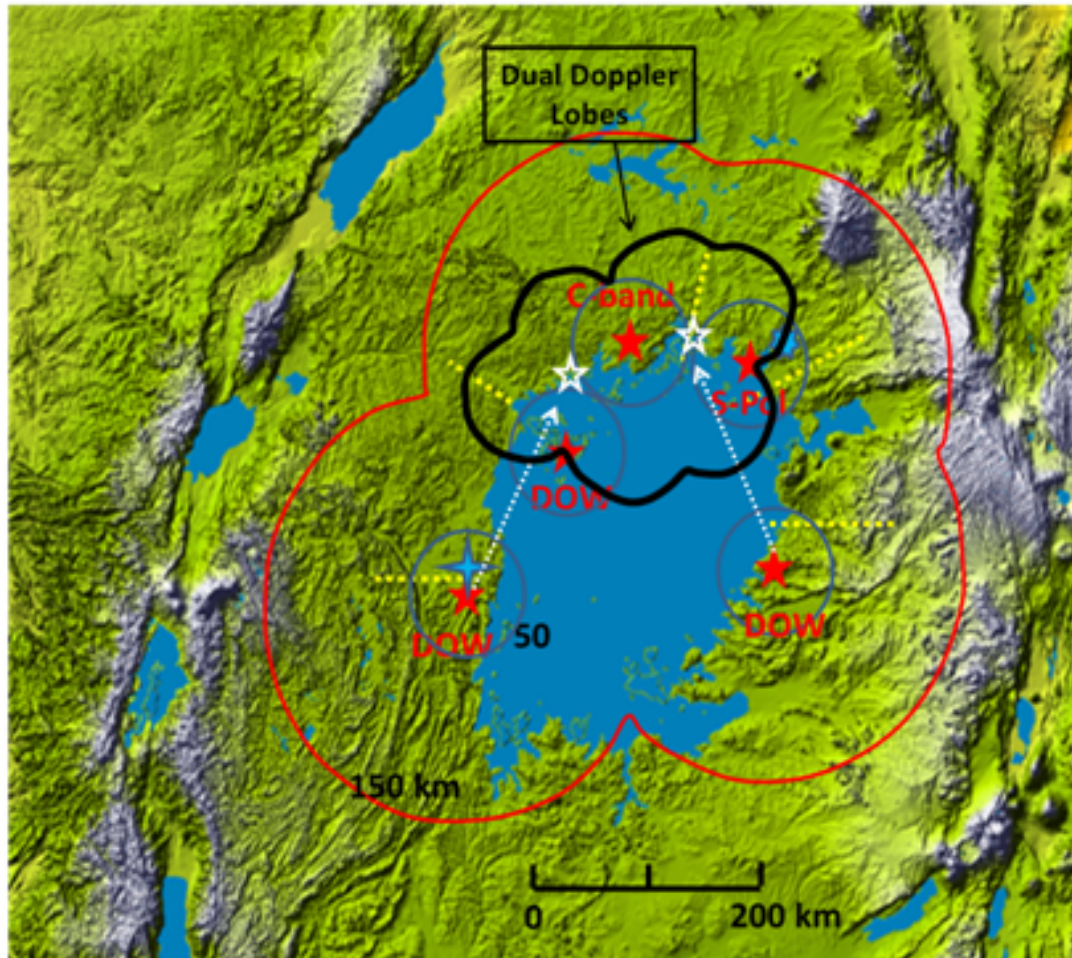


Existing and planned observations



UK Met Office are developing ATD lightning network and ship-borne meteorological observations

Field Project Proposal to NSF and other Funding Agencies (under preparation)



Red Stars –
surveillance radar

White Stars – hi res
radar, dual-doppler

Blue Star 6 – IOS

Blue Star 4 – Upper
Air Station

Yellow – Met Stns

S-Pol radar, 3 DOWS, 2 WV DIALS, Doppler radar, C-band radar, wind-profiler, microwave radiometer, GPS WV, surface stations. Also, ARM mobile facility

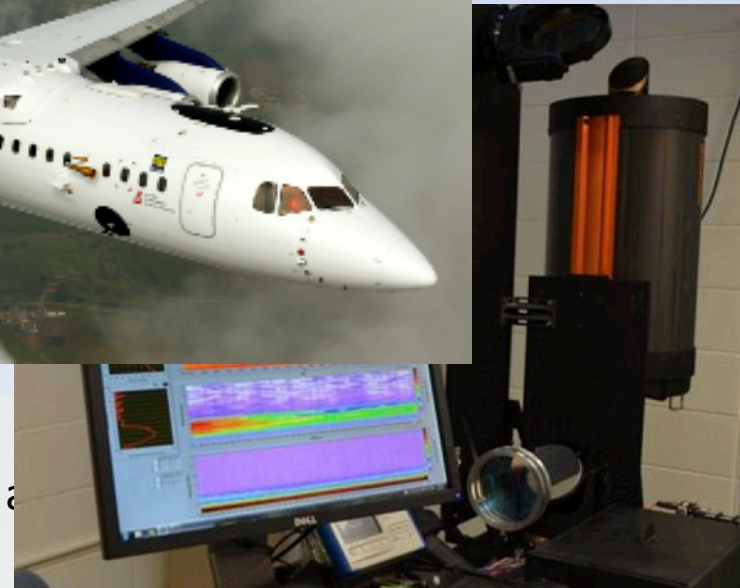
High Sensitivity S Pol Radar dual-pol Doppler radar is needed to monitor the clear air boundaries that initiate convection, the descending downdraft core that generates the strong downdraft winds and then the hazardous surface winds

High-resolution dual-Doppler from DOWs

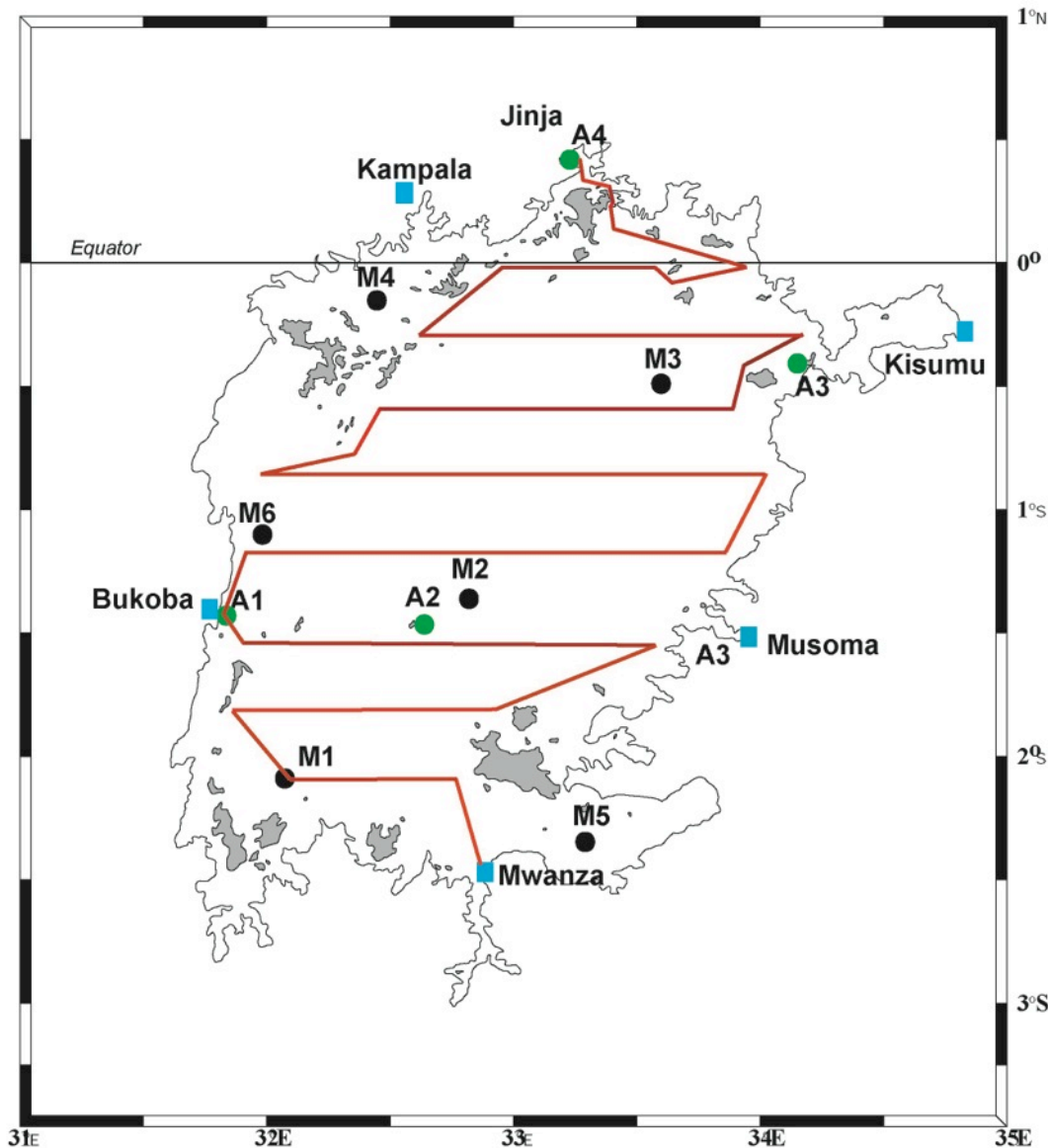


UK Bae-146 research aircraft

Frequent and localized soundings are required to monitor both the updraft and downdraft environments.



Proposed Marine Monitoring sites and ship survey track



- blue boxes show locations of major towns around the lake
- black circles indicate mooring sites which contain solar radiation, temperature, chlorophyll and turbidity sensors. acoustic Doppler current profiler capable of measuring waves.
- Air sampling stations for aerosol
- red line represents ship survey track which would take 6 days to complete. Two cruises would be required to sample both monsoon seasons.