Towards early responds to desert locust swarming in eastern Africa

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INTRODUCTION & OBJECTIVES

- Locust plagues are a serious threat to agricultural production, food security and the environment in many parts of the world, but especially in eastern Africa
- Controlling locusts at the adult life cycle stage is extremely difficult, hence a comprehensive early warning alert system is needed to facilitate early response at a juvenile stage.
- The German Aerospace Center (DLR) in cooperation with the International Centre of Insect Physiology and Ecology (icipe) (Kenya), have teamed up to develop a geospatial monitoring routine that can predict timing of locust hatching in eastern Africa
- The monitoring routine is based on spatially explicit geospatial data, particularly from satellite observations, while locally assembled field survey data on hatching of bands (from Sudan and Kenya) are used as reference data.
- Specifically, a fuzzy logic model was implemented that uses data ranges from newly available climate data (temperature and rainfall at 1 km grid cell resolution from the NASA Power platform; https://power.larc.nasa.gov/) and processed satellite observations (on vegetation density/"greenness").
- The development of an early response mechanism based on predicting the timing of hatching, is a first step in operationalizing an early response to locust infestations at juvenile stage of the pest development for control strategies to be easily applied.

Fig 1 : Locust bands invading a tree in Kenya

METHODS

- Given the time range between hatching and formation of hopper bands, we estimated the timing of hatching for several periods within the rainy seasons (October to March), for both countries, respectively.
- A spatially explicit model output showing hatching probability was produced for Kenya, showing hatching "hot spot" areas, and associated timing of hatching, in Turkana and Marsabit counties, respectively.
- Specifically, data science was used to develop a rule set based on the environmental variables for hatching timing, in both regions.
- The rules were then implemented using a fuzzy set Mamdani type inference model, prompting replicating and expressing knowledge regarding hatching and no hatching.
- The Mamdani type inference is described as a series of IF-THEN rules:

$$Rj\!: IF\ x1\ is\ M1(x1)\ AND\ \ldots AND\ xn\ is\ Mn(xn)$$

$$THEN\ (y\ is\ N)$$

- The IF section of the rule is the antecedent, and the THEN part is the consequent.
- The fuzzy logic system's final step converts the fuzzy variables created by the fuzzy rules back into actual probability (0 or 1), which can then be utilized to perform the intended simulation

Fig 2-4: Shows our study area which is in the Red Sea State of Sudan, the Data Summary used in developing the model, and our target area of Turkana County in Kenya.

STUDY AREA

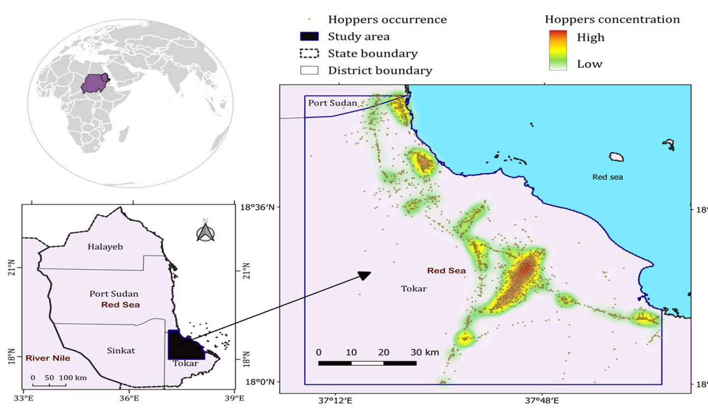
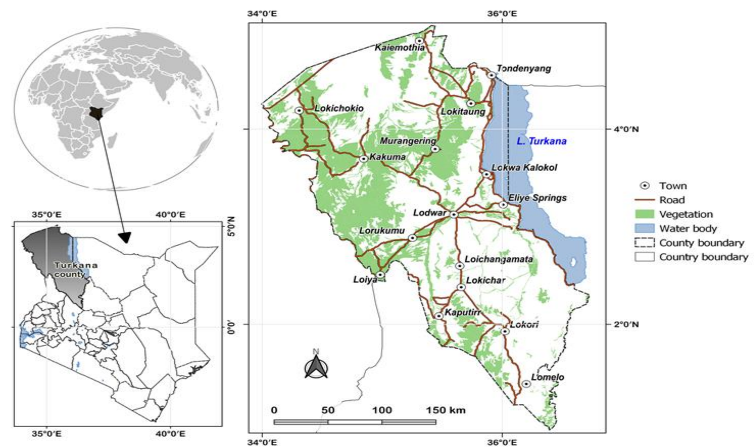


Fig.2-4

DATA SUMMARY

Data	Type	Unit	Source	Spatial Resolution	Year Range
Hoppers	Desert Locust	Observation	Central Institution for Desert Locust Research and Control (CIDLRC) http://m.desertlocust-crc.org/Pages/countryprofile.aspx?CMSId=800323&lang=EN&I=0&DId=0&CId=sd	——	2014 To 2021
Maximum Temperature	Weather	°C	TerraClimate: Monthly Climate and Climatic Water Balance for Global Terrestrial Surfaces, University of Idaho https://developers.google.com/earth-engine/datasets/catalog	4638.3m	2013 To 2021
Minimum Temperature	Weather	°C	TerraClimate: Monthly Climate and Climatic Water Balance for Global Terrestrial Surfaces, University of Idaho https://developers.google.com/earth-engine/datasets/catalog	4638.3m	2013 To 2021
Precipitation Accumulation	Weather	mm	TerraClimate: Monthly Climate and Climatic Water Balance for Global Terrestrial Surfaces, University of Idaho https://developers.google.com/earth-engine/datasets/catalog	4638.3m	2013 To 2021
Soil Moisture	Environment	mm	TerraClimate: Monthly Climate and Climatic Water Balance for Global Terrestrial Surfaces, University of Idaho https://developers.google.com/earth-engine/datasets/catalog	4638.3m	2015 To 2021
Greenness	Environment	Dekads since vegetation onset	IRI: EU VITO DevCoCast http://iridl.ldeo.columbia.edu/SOURCES/.EU/.VITO/.DevCoCast/.greenness	250m	2013 To 2020 - August

TARGET AREA



OUTPUTS

Data assessment

Fig. 5-9 shows the 0-1 membership functions attained for the environmental variables used, including satellite-predated "greenness" over the regions and the years 2017 to 2021.

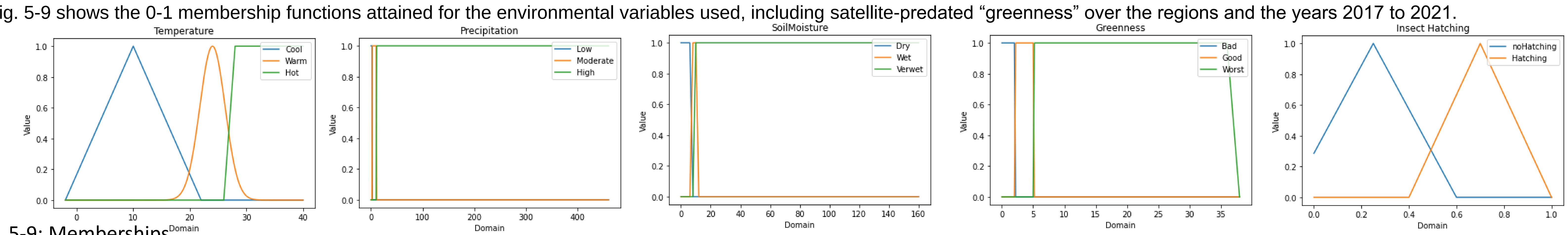


Fig. 5-9: Memberships

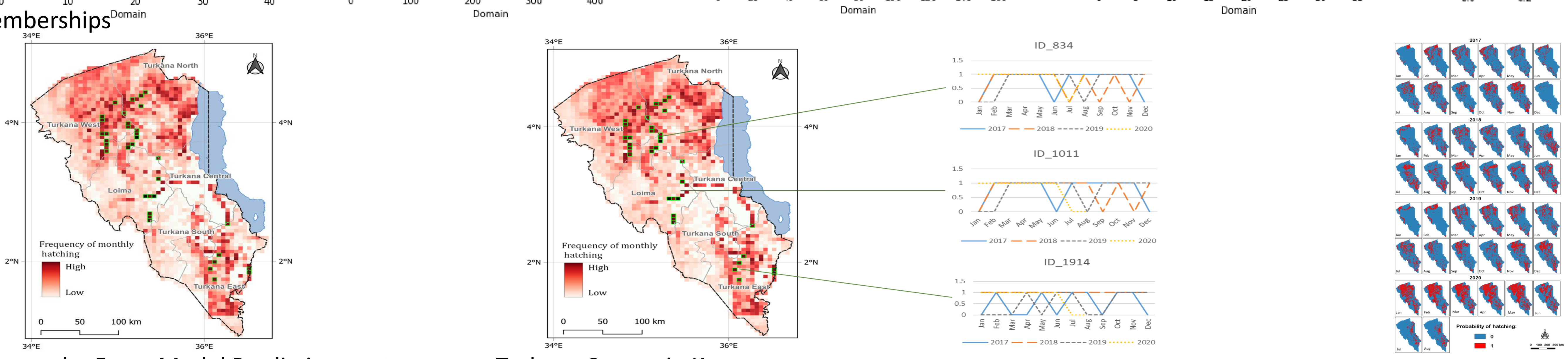


Fig 10-11: Shows the Fuzzy Model Predictions outputs over Turkana County in Kenya

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