Current Developments and Challenges in Operating an Environmental Research Observatory in the Sudan Savanna in West Africa - Ten Years of WASCAL Observatory Experience

28th September 2023,
2nd TERENO-OZCAR Conference, Bonn, Germany

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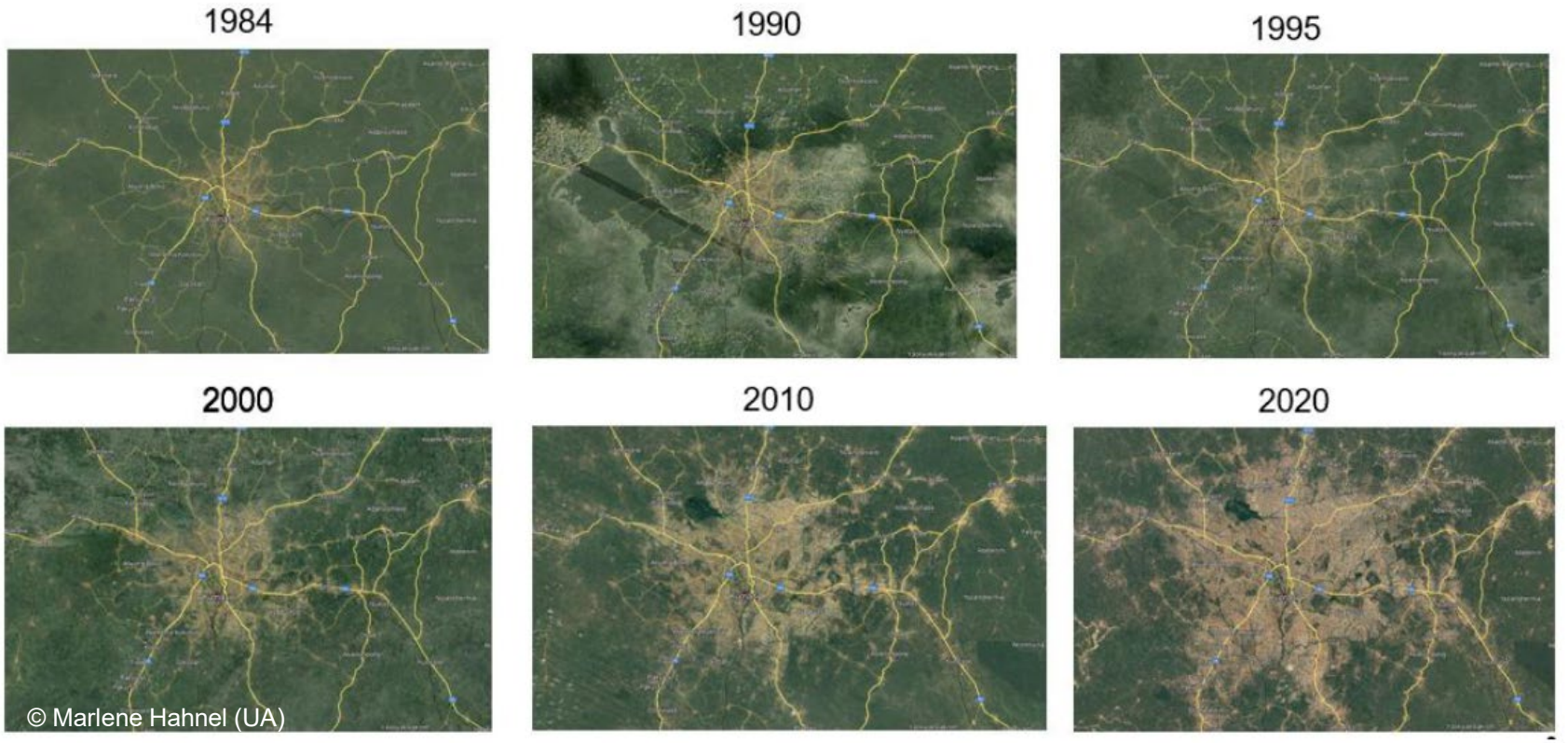
Motivation

- West Africa is characterized by strong land cover changes in rural and urban places due to a tremendous population increase
  - Example 1: Urbanisation (Kumasi/Ghana)
  - Example 2: Agricultural expansion (Sudan-Sahel)

Example 1: Urbanization around Kumasi (Ghana)

500.000 inhabitants

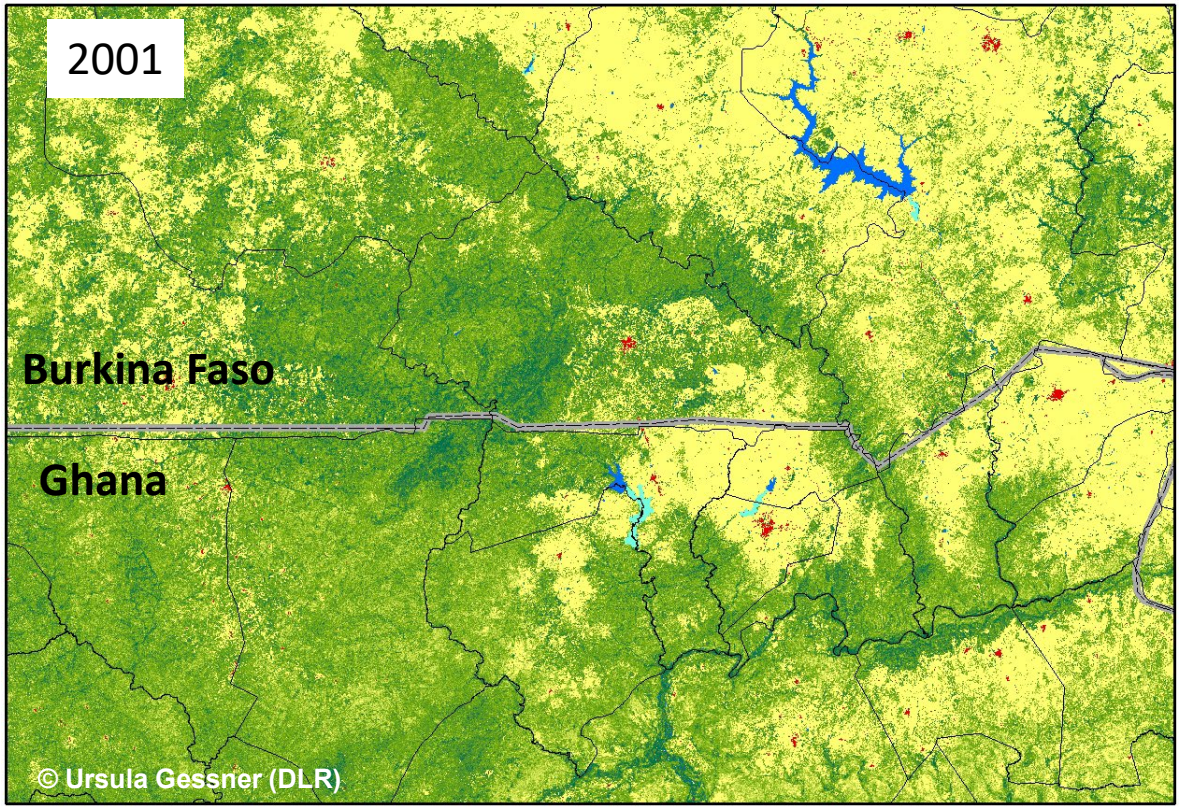
population increase



population increase

3.4 million

Example 2: Agricultural Expansion Sudan Savanna

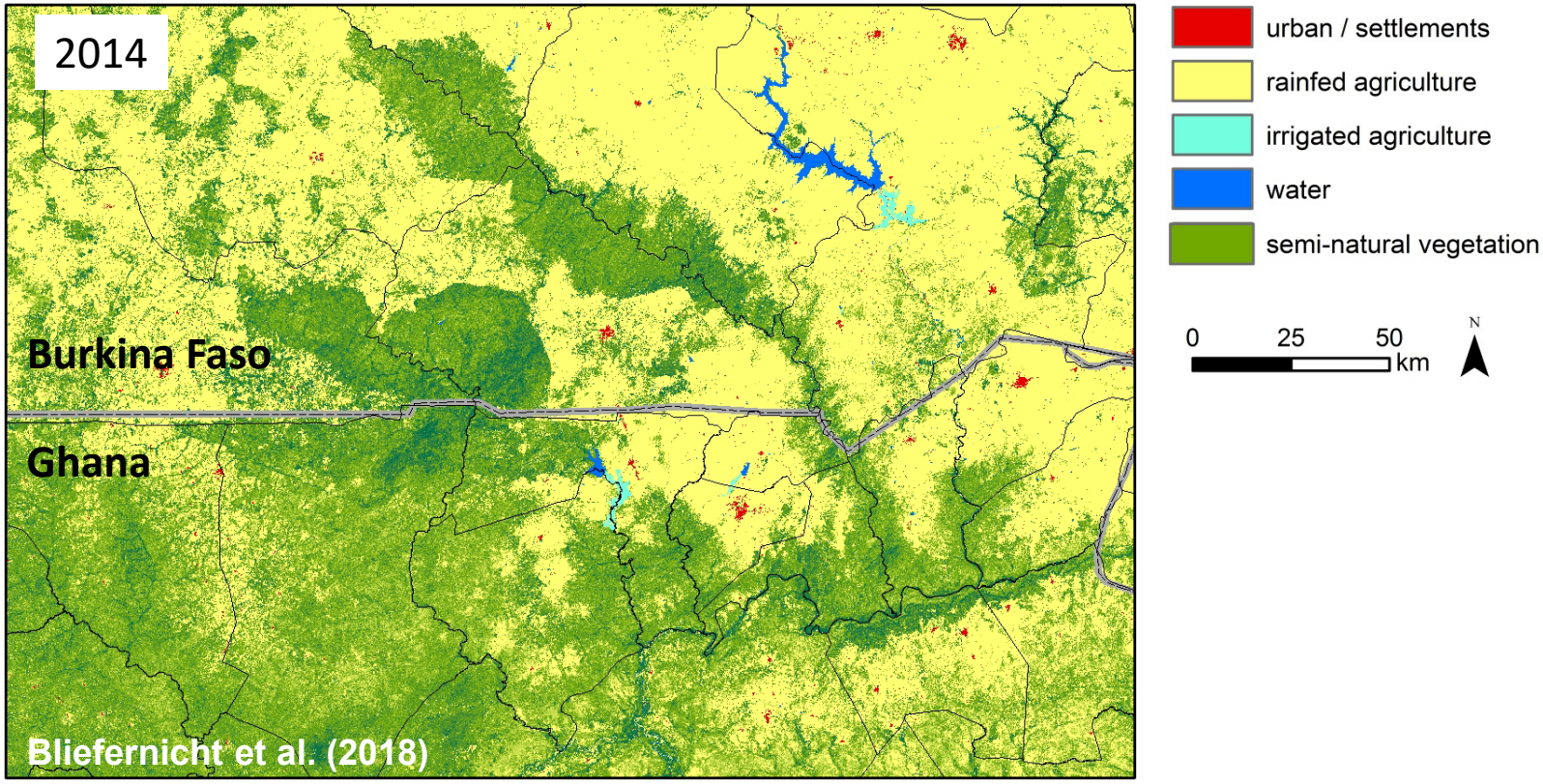


urban / settlements
rainfed agriculture
irrigated agriculture
water
semi-natural vegetation

0 25 50 km

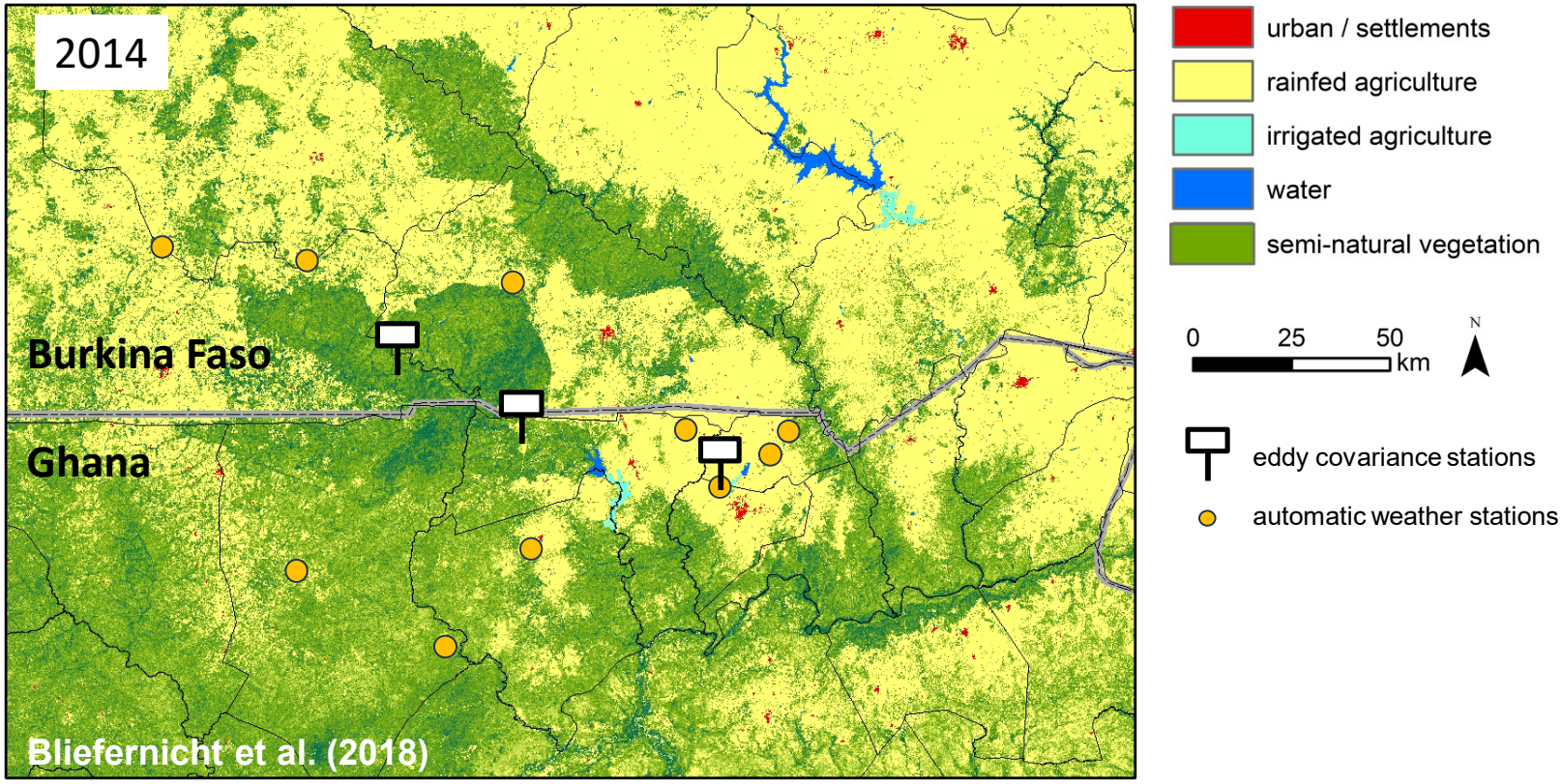
N

Example 2: Agricultural Expansion Sudan Savanna



increase of rainfed agriculture of approximately 20% within 13 years

Establishment of the WASCAL Observatory



The observatory is running since January 2013

Objectives

- overview about the status quo and current developments of the WASCAL observatory ….

  … two core measurement periods:

  - phase 1: 2013 to 2016
  - phase 2: 2022 to 2024

- present selected results and scientific findings from the field experiments

- illustrate the challenges to operate this observatory in Sudan-Sahel zone

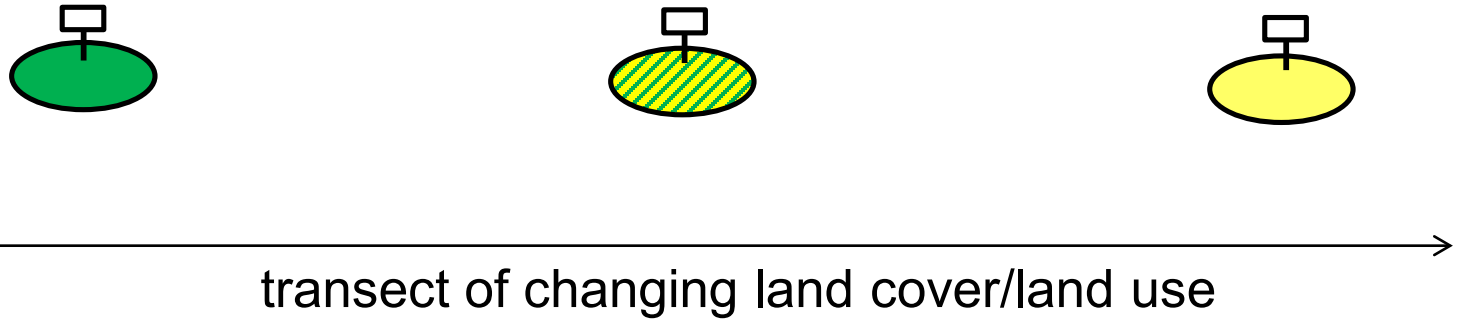
Phase 1: Micrometeorological Experiment

Goal: analyze the impacts of land use changes
on land surface properties (e.g., albedo) and land atmosphere exchange processes (e.g., heat fluxes, net ecosystem exchange)

site A: pristine sudan savannah

site C: mixture between A and B

site B: grassland + strongly degraded



transect of changing land cover/land use

- similar climate and other site characteristics (soil type, …)
- but different vegetation characteristics due to land use practices

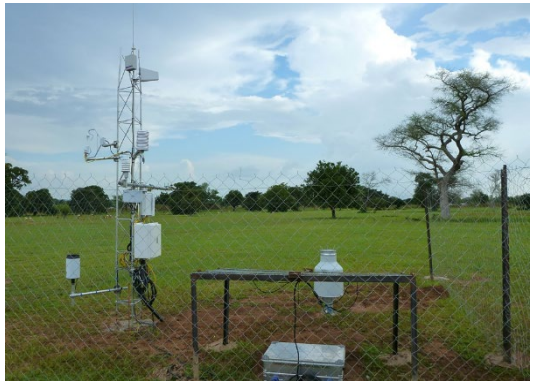
Phase 1: Micrometeorological Experiment

Goal: analyze the impacts of land use changes
on land surface properties (e.g., albedo) and land atmosphere exchange processes (e.g., heat fluxes, net ecosystem exchange)

pristine savanna (2013)

cropland (2012)

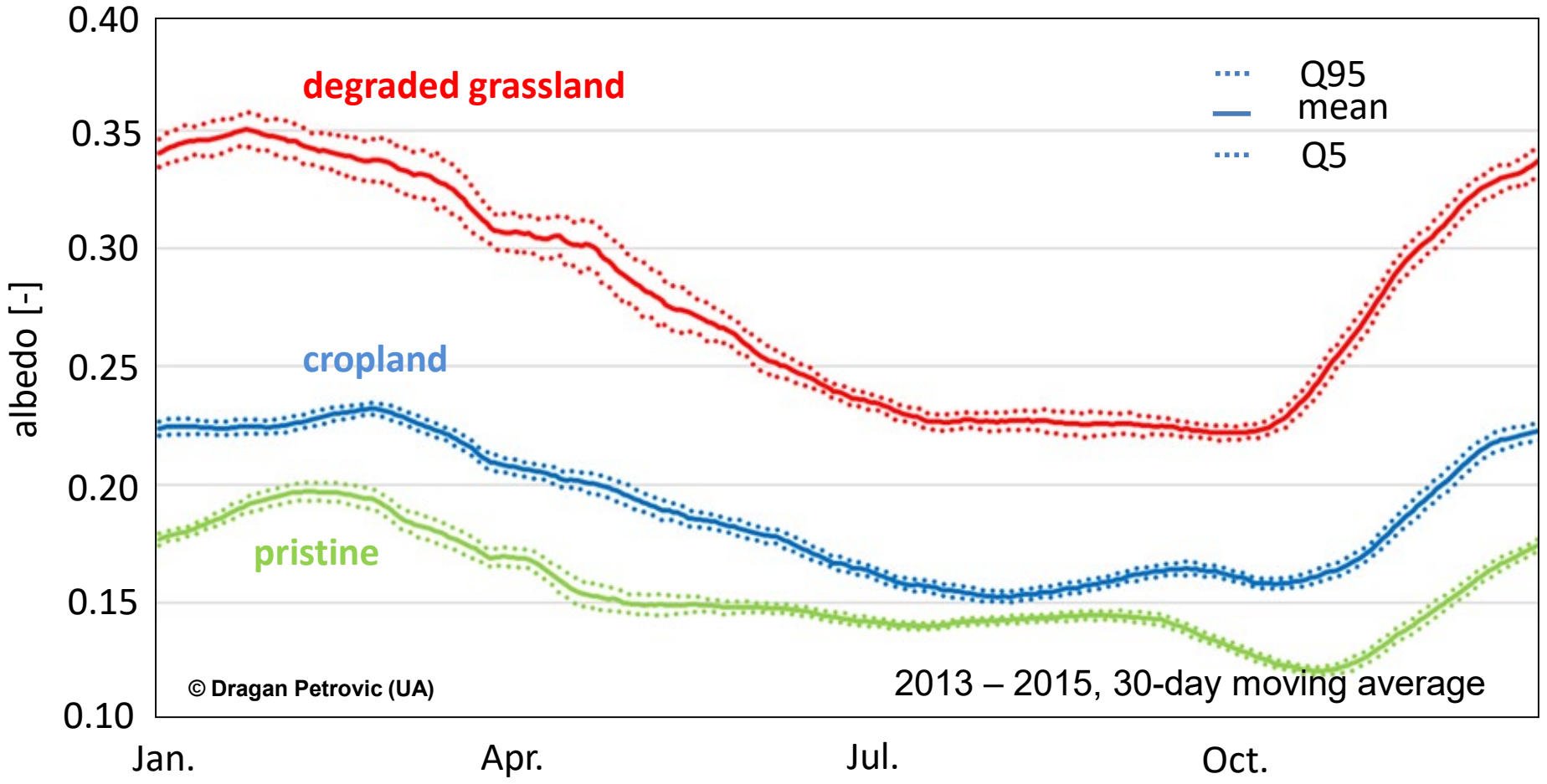
degrad. grassland (2012)



transect of changing land cover/land use

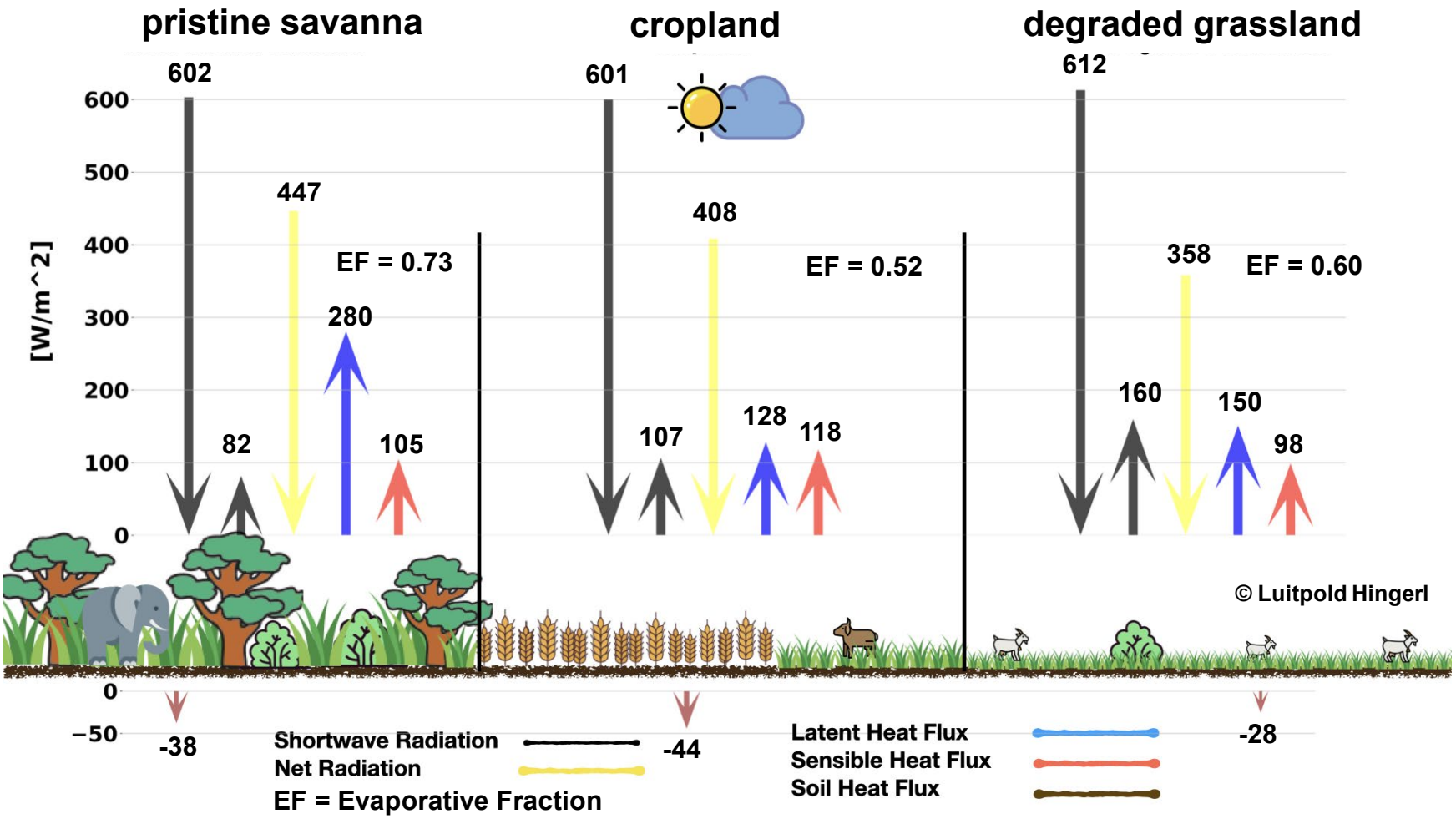
994 mm	960 mm	978 mm
sandy loam	loamy sand	loamy sand

Phase 1: Albedo



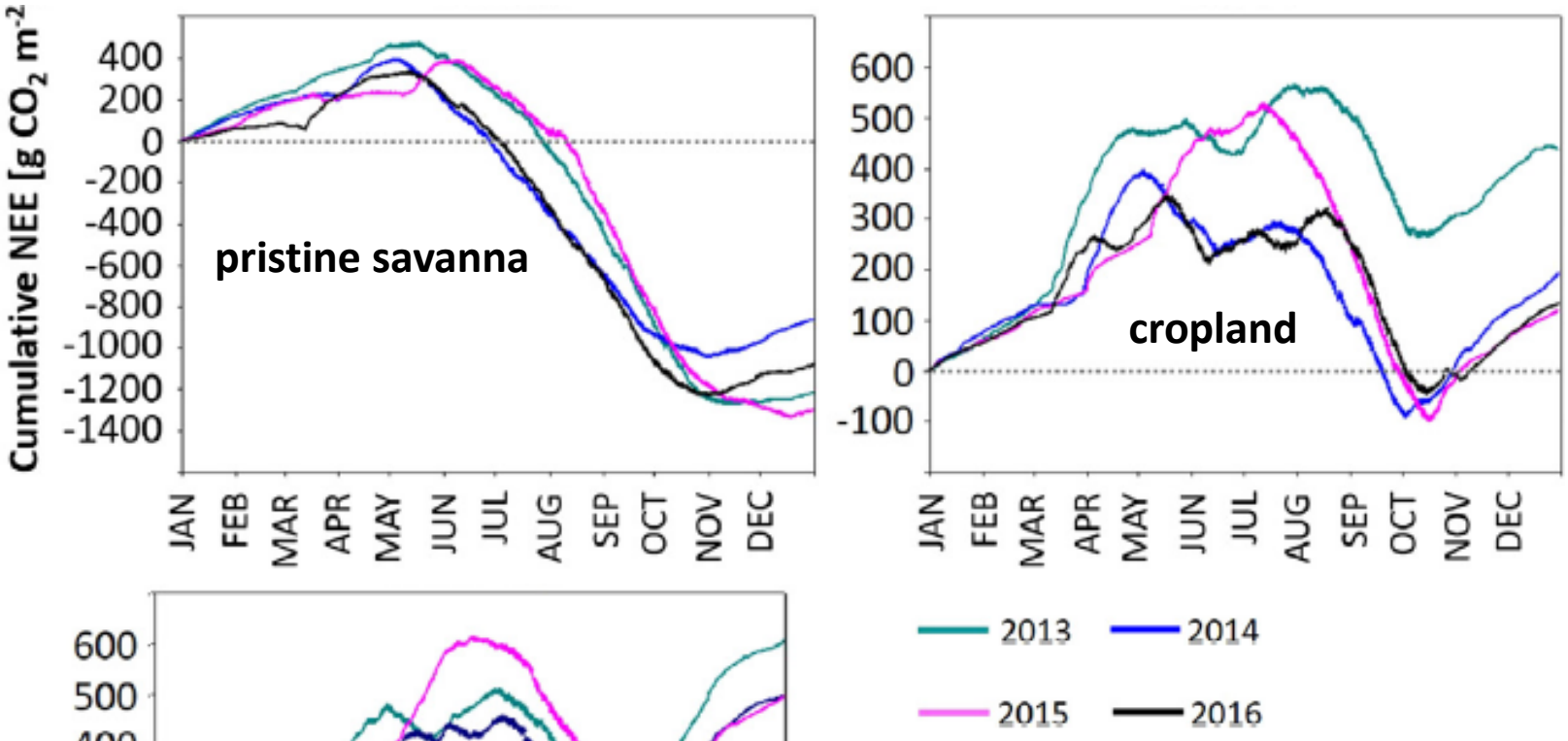
grassland site with much higher albedo (0.29) vs. pristine site (0.16) leads to a significant change of net radiation and associated fluxes

Phase 1: Energy Balance – Post Monsoon (SON)



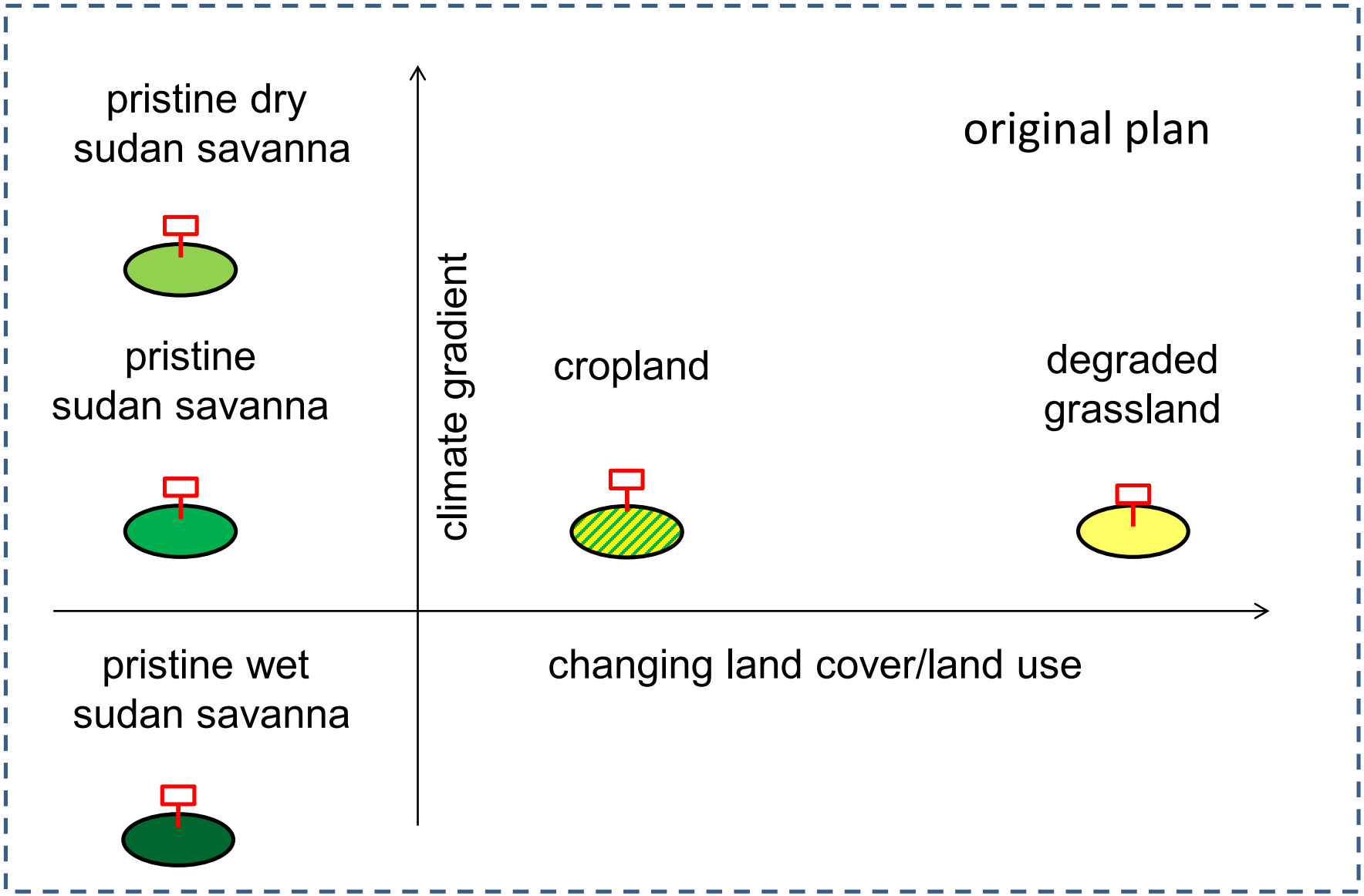
(much) lower net radiation at cropland and grassland site with clearly lower latent heat fluxes

Phase 1: CO_2 fluxes (NEE)



strong CO_2 differences
pristine savanna acts as CO_2 sink, the others as sources

Phase 2: Extension of Micromet. Experiment



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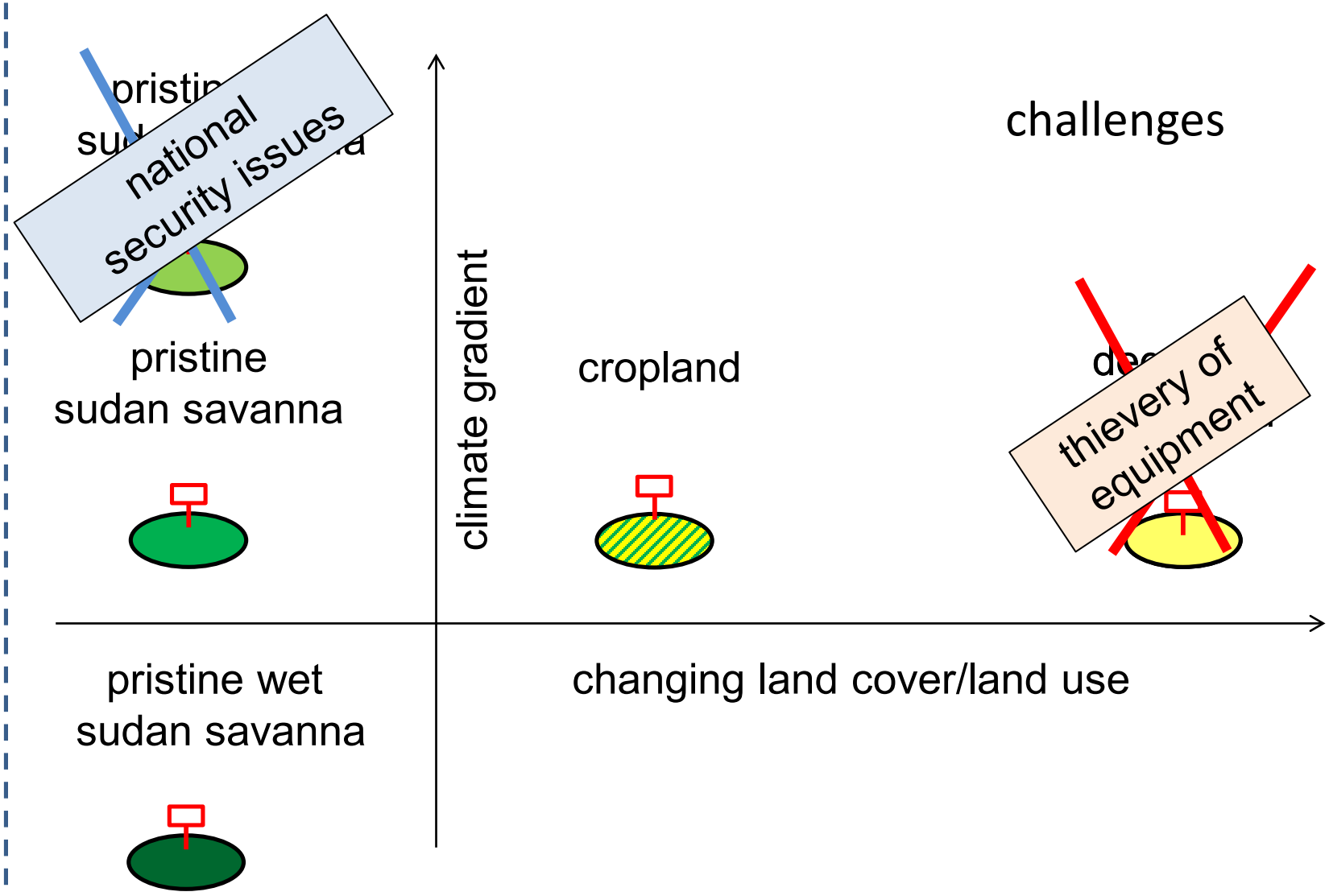

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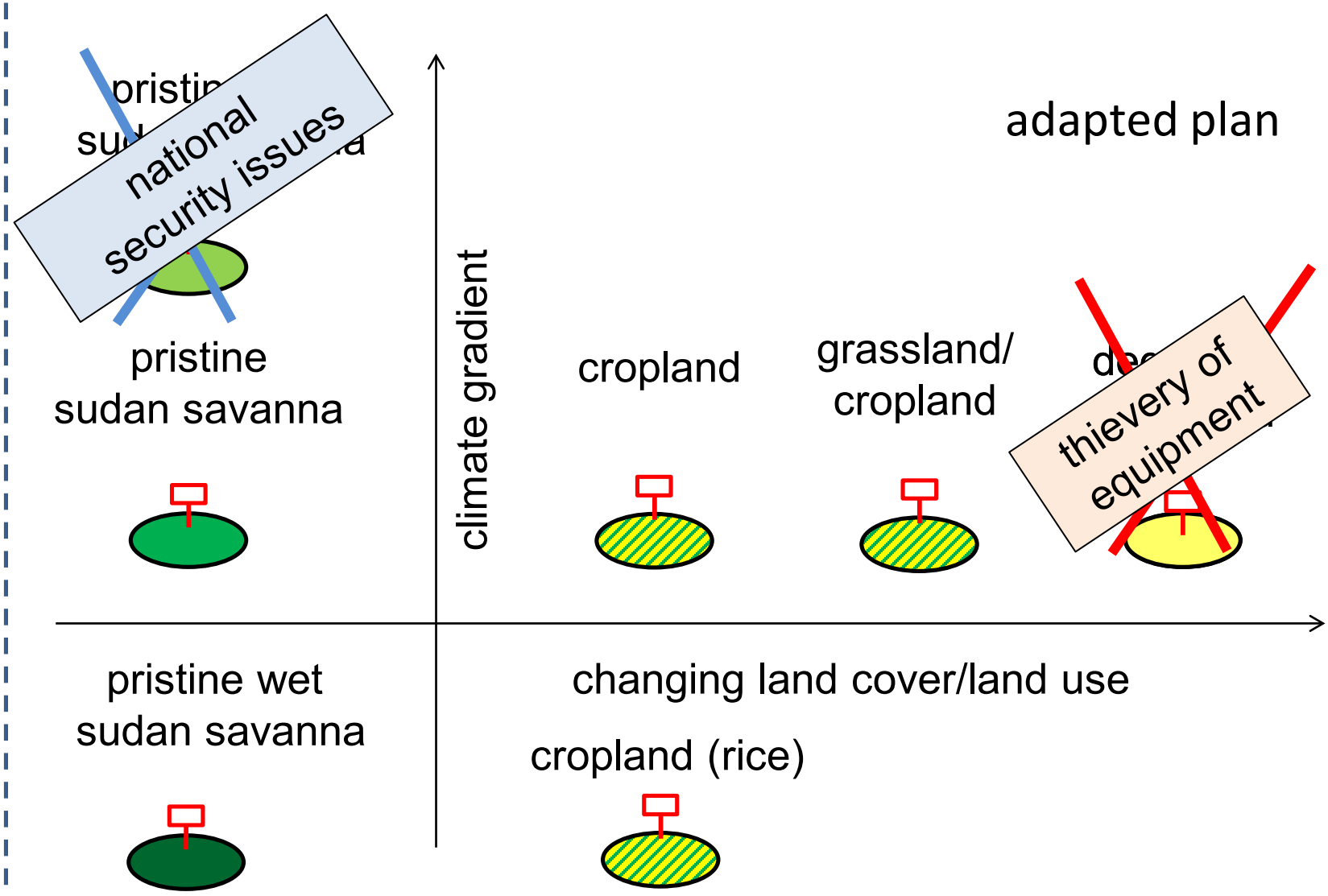
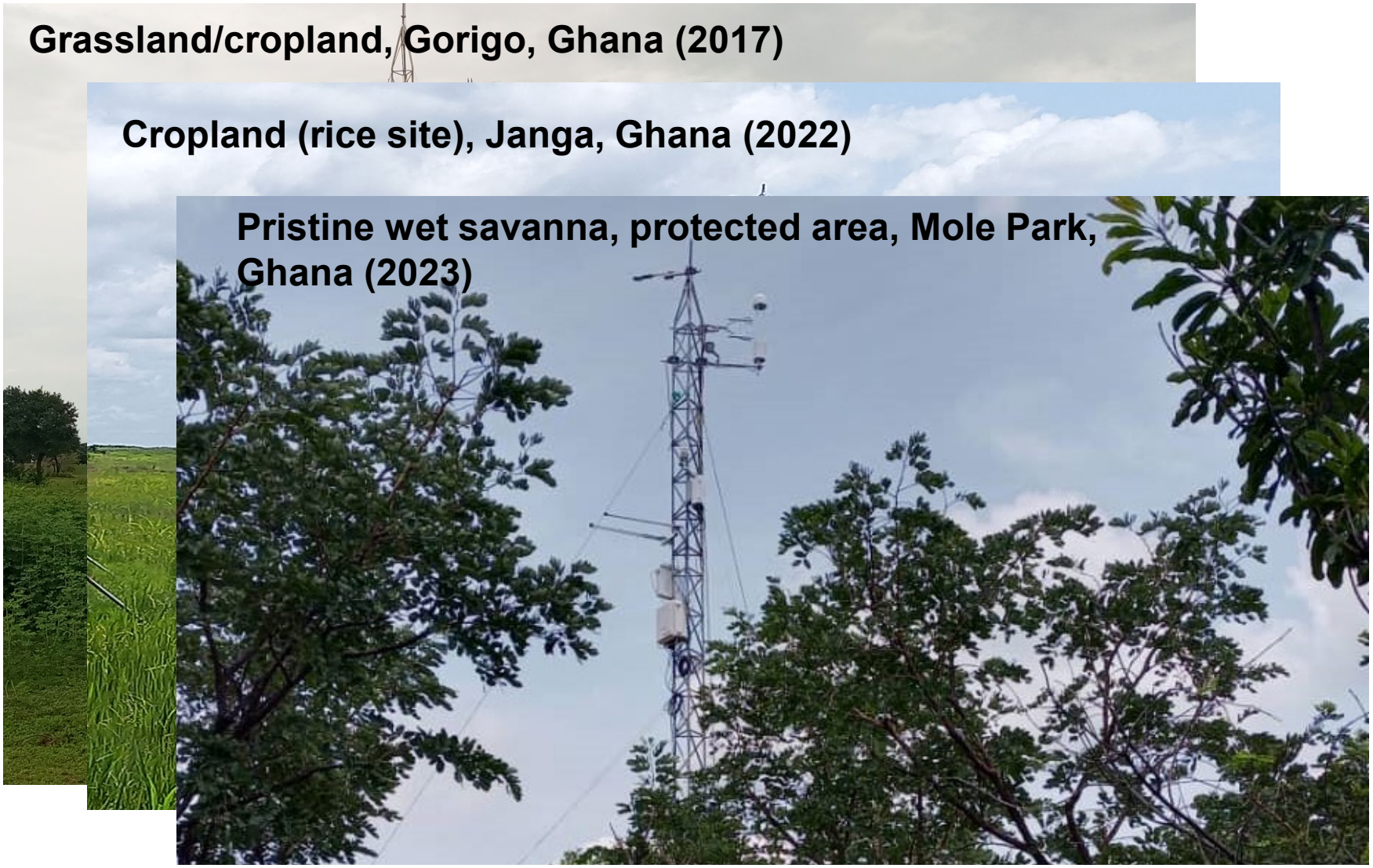


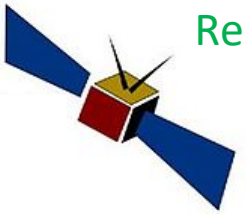
Phase 2: New identified Eddy Covariance Sites



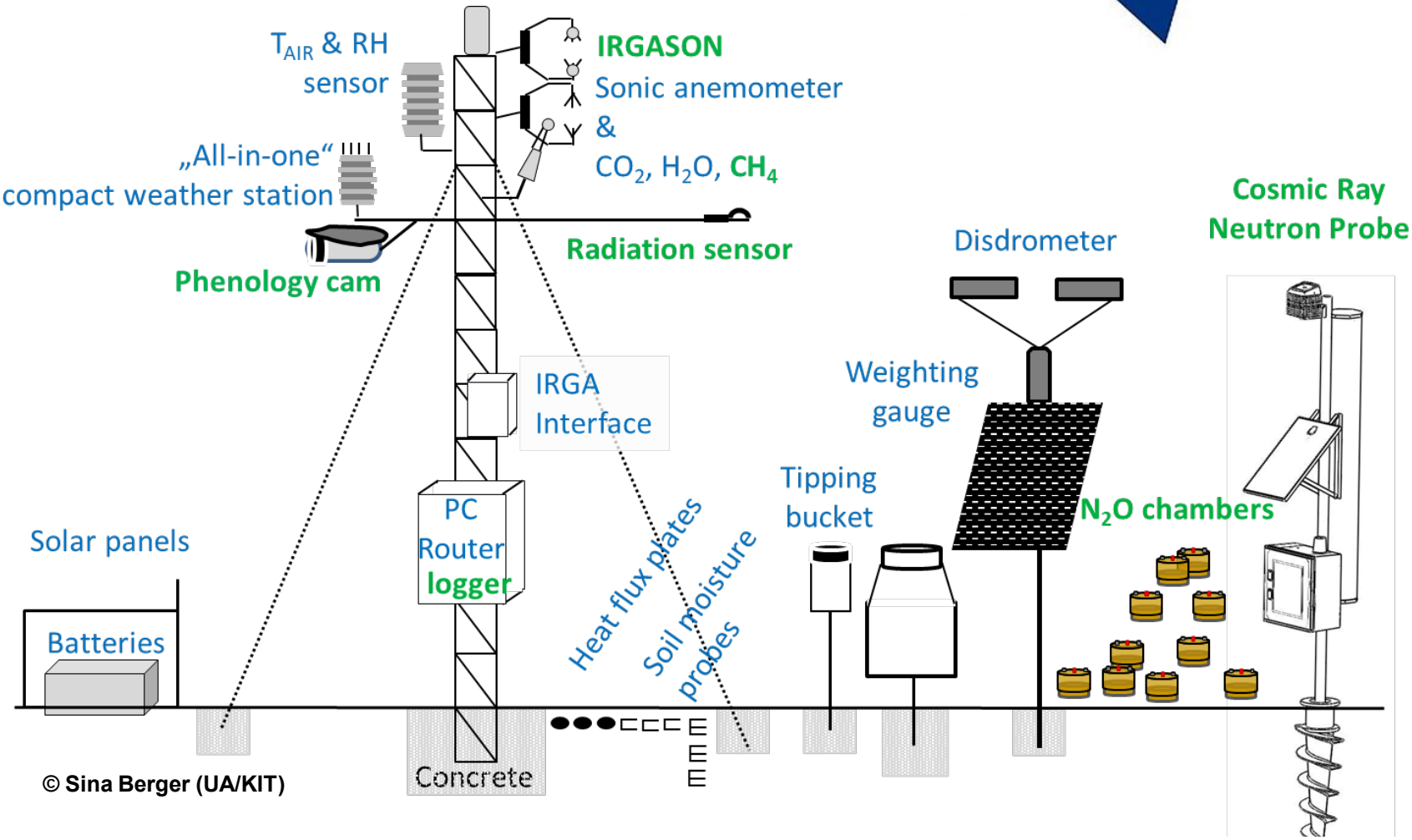
Phase 2: Additional Equipment at EC sites

phase 1: 2013 - 2016

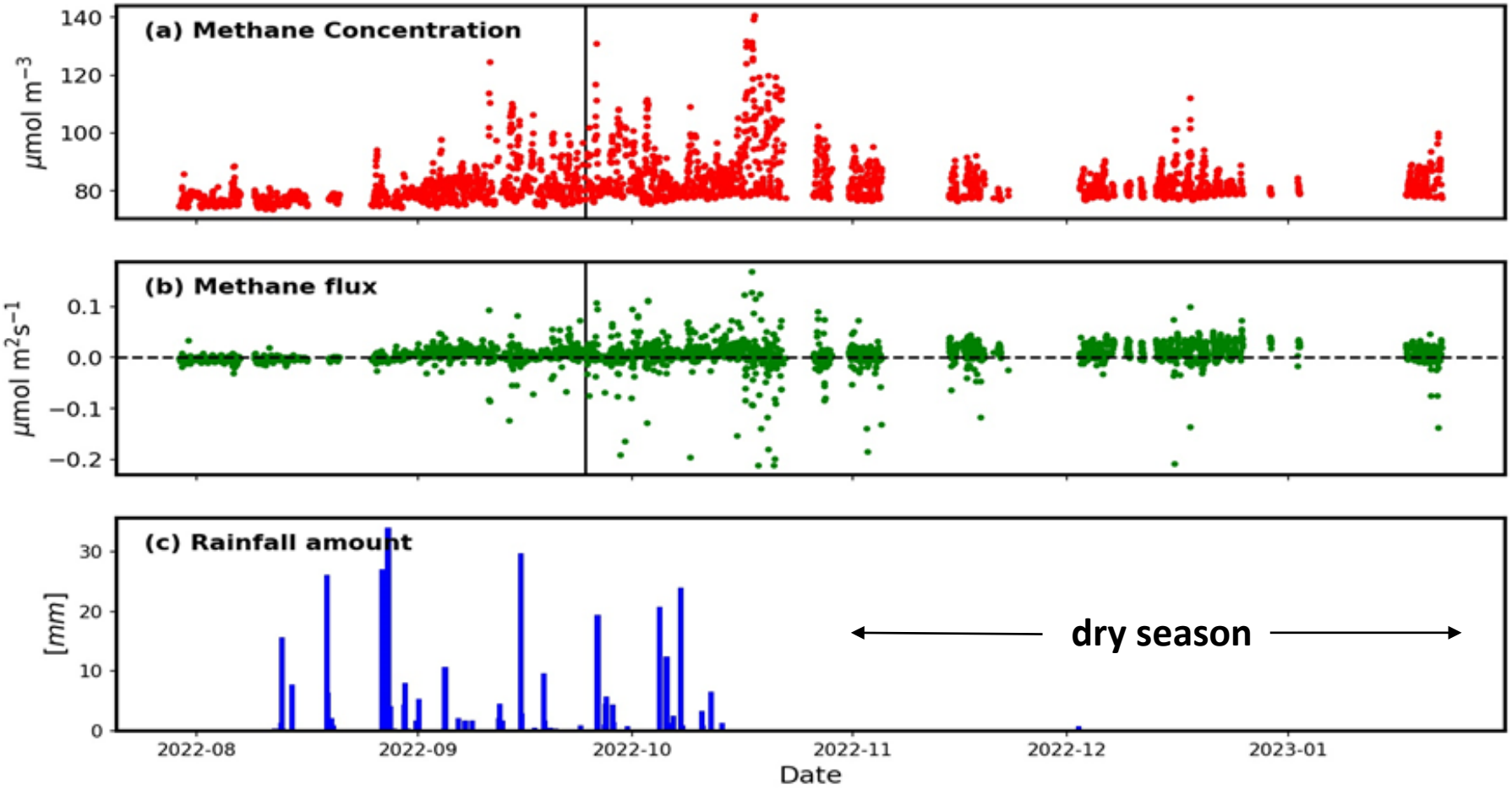
phase 2: 2022 - 2024



Remote sensing



Phase 2: First Methane Mesurements



Summary and Conclusions

- The WASCAL Observatory is continuously running since 10 years in the West African Sudan Savanna, although its operation remains highly difficult and challenging
  - contains many unique observatory elements with interesting (first) findings
  - rich and unique dataset for land surface studies in a data-poor region
  - test bed for model development and remote sensing studies
- Long-term and smooth operation: strong partnerships with keen scientists, continuous base funding and political stable conditions are essential

Thank You!

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WASCAL
West African Science Service Centre on Climate Change and Adapted Land Use

EC site in Sumbrungu *© Harald Kunstmann*

Thank You!

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WASCAL
West African Science Service Centre on Climate Change and Adapted Land Use

EC site in Sumbrungu *© Harald Kunstmann*

Many challenges

Technical challenges
- Regular maintenance
- Wild fires
- Vandalism & thefts
- Data transfer and provision

Scientific challenges
- Quality control
- Data gap filling
- Specific research questions
- User-oriented data products

Administrative challenges
- Land acquisition
- Long-term operation
- Political stabitlity

Technical challenges

Regular maintenance is often a wild adventure

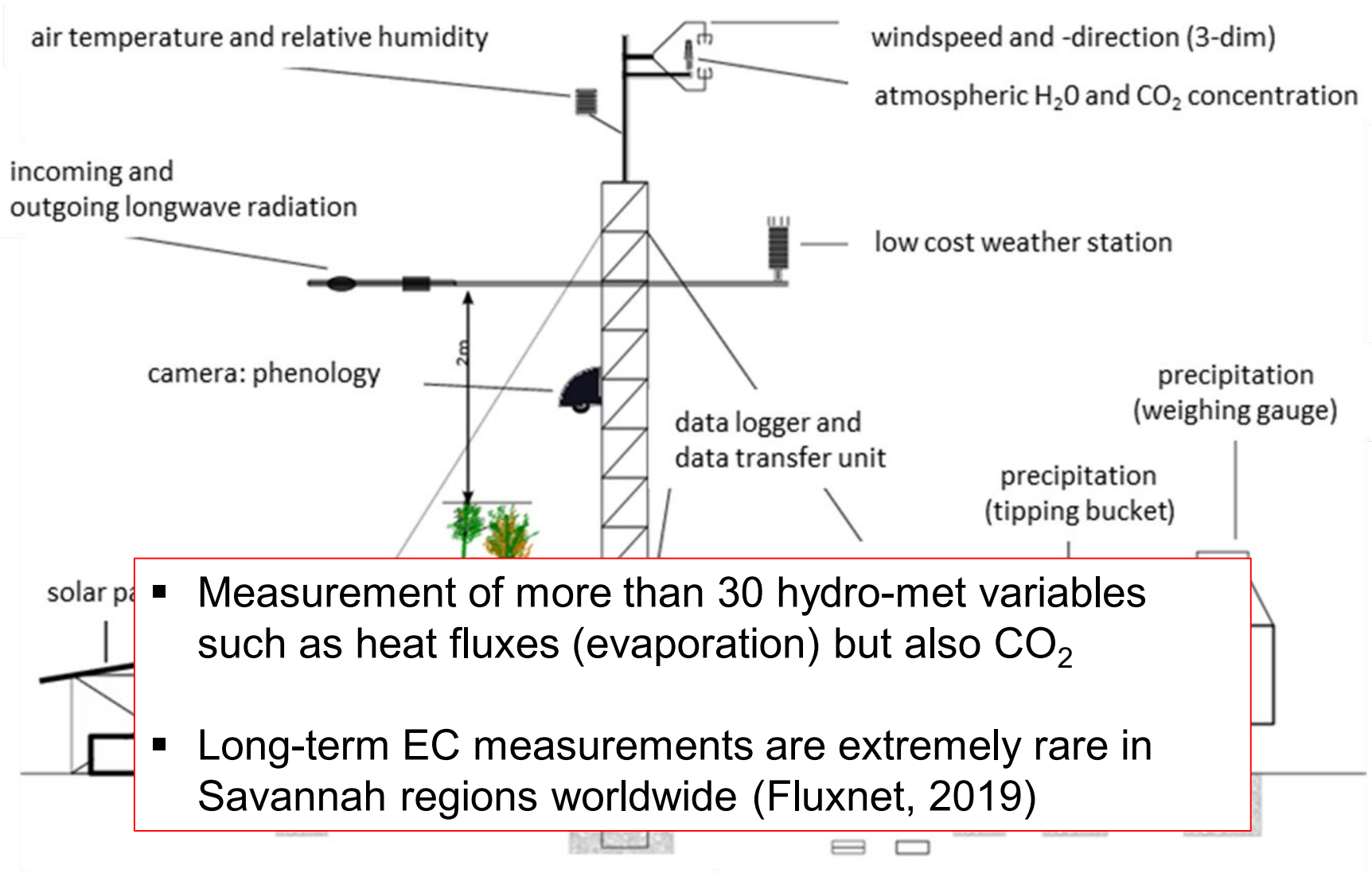
Heavy Nissan Patrol seriously stuck in deep mud [left] & [right]

Same as above, very helpful people [left] & another incident with the same car [right]

Technical challenges

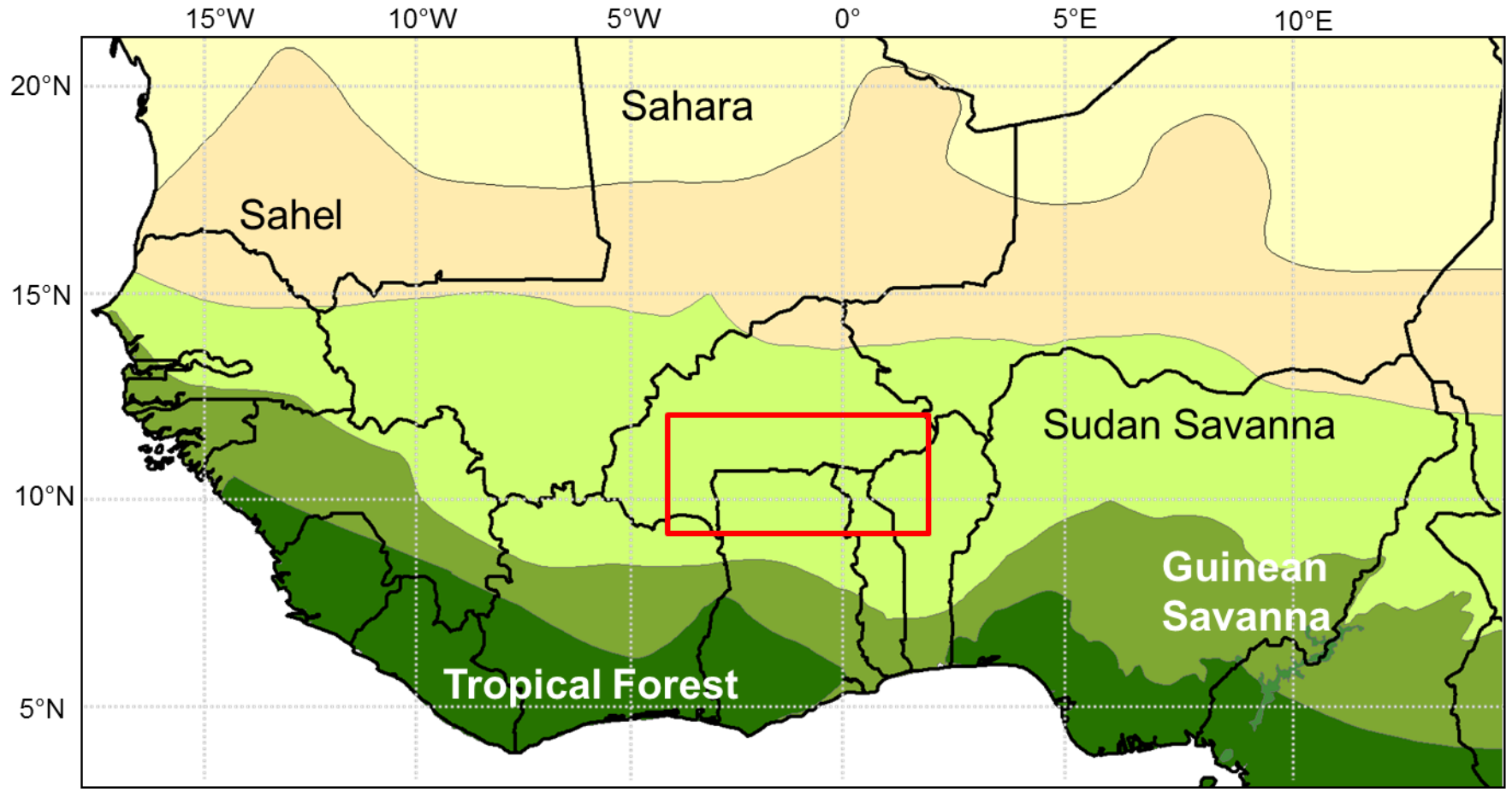
Wild fire endangers the equipment

Equipment of an Eddy Covariance (EC) station



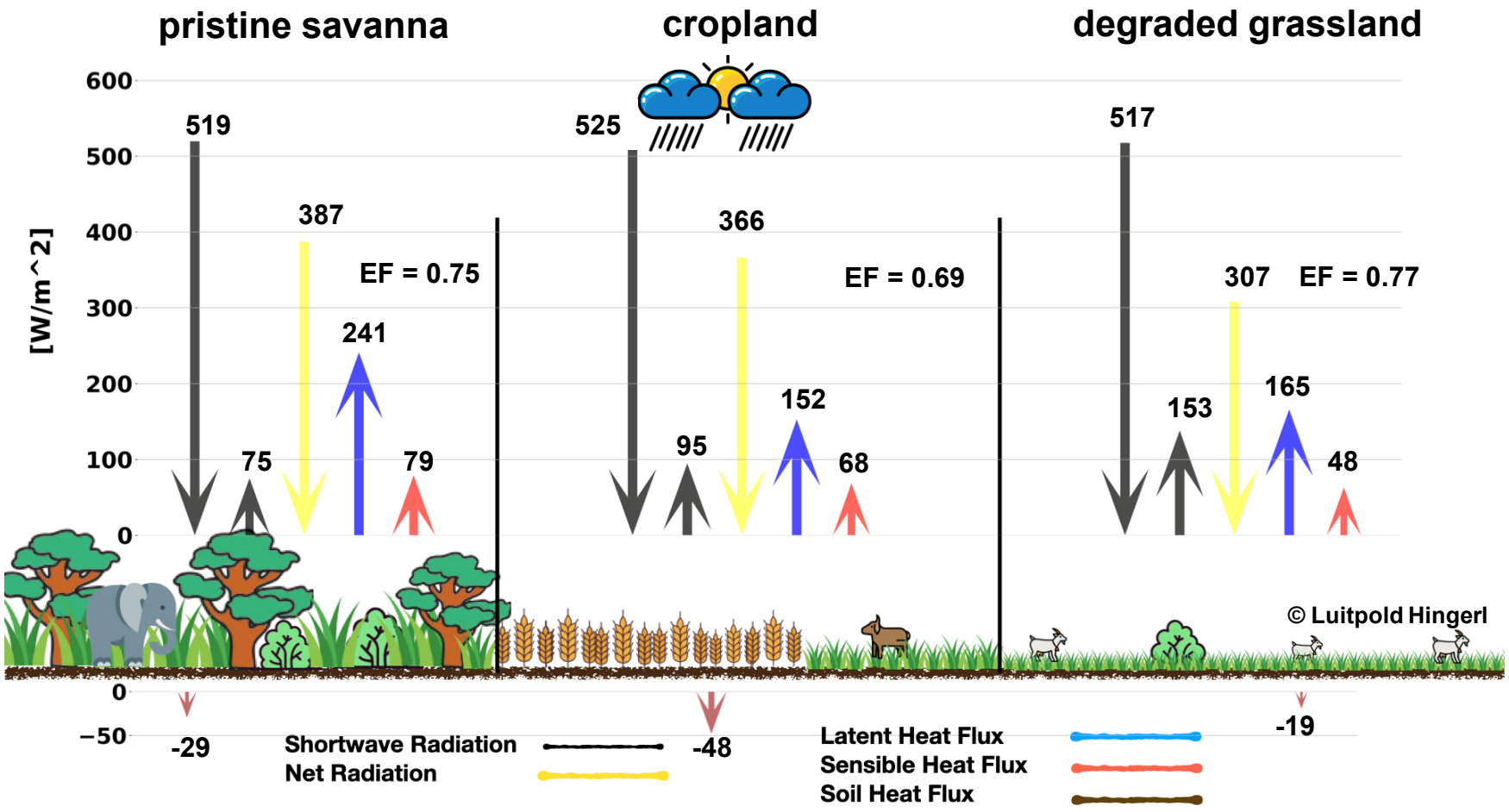
- Measurement of more than 30 hydro-met variables such as heat fluxes (evaporation) but also CO_2
- Long-term EC measurements are extremely rare in Savannah regions worldwide (Fluxnet, 2019)

Land Use Change due to Agricultural Expansion



Sudan Savanna in South Burkina Faso, North Ghana and North Benin semi-arid region, 700 to 1100 mm/a, rainy season: April to October

Phase 1: Energy Balance – Rainy Season



much lower net radiation at grassland site and therefore smaller heat fluxes