Evaluating RDT and CRR performance in tropical Africa

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The African SWIFT Project

GCRF African SWIFT (Science for Weather Information and Forecasting Techniques) project aims to develop sustainable African weather forecasting capability.

Collaboration between UK, international and African partners.

Improved nowcasting capability identified by African partners as a priority.

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Motivation

- NWCSAF products now available for many forecasters in tropical Africa.
- Forecasters need to understand performance in order to use appropriately.
- Some evaluation over South Africa (Coning et al, 2015; Gijben& Coning, 2017), but no validation in much of tropical Africa.
- Focus on RDT-CW and CRR products based on feedback from SWIFT weather forecasting testbed (Nairobi April 2019.)
- Focus on "Guinea Coast" region, 1 March – 1 August 2019, v2016 software.

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"Truth" GPM microwave

Sub-daily rainfall gauge data sparse in tropical Africa. No operational radar.

"**Truth**": GPM IMERG V06 final: "High quality" rainfall estimates. 30 minutes, 0.1°. Based solely on microwave measurements from the GPM constellation.

- Completely independent of NWCSAF (doesn't use SEVIRI measurements) ☺
- More accurate than full GPM estimates. ☺
- Only available microwave instrument satellite overpasses. ☹

Microwave only
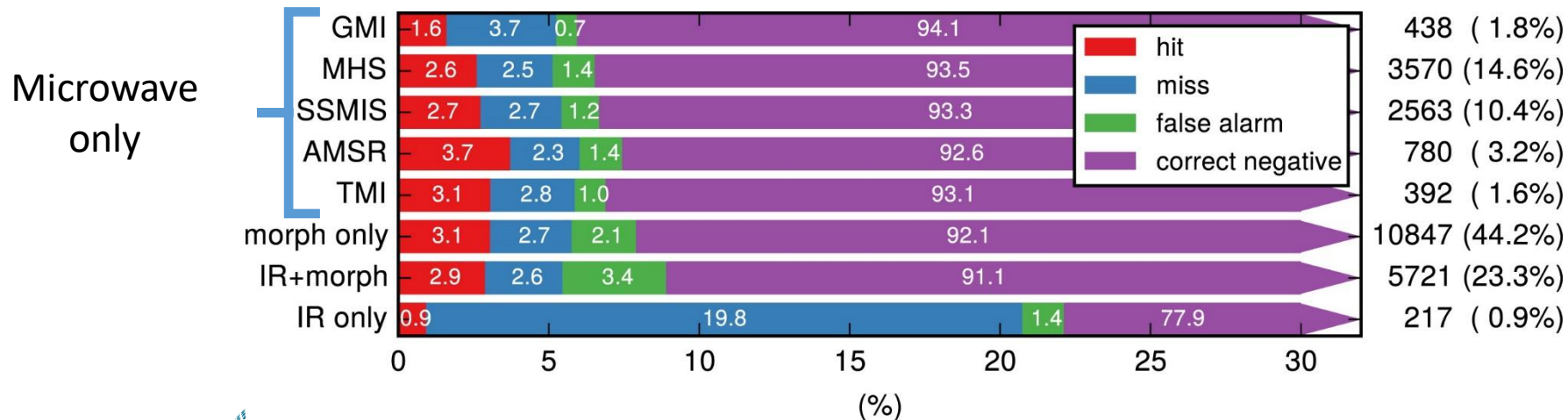
Skill for rain occurrence
Tan et al. (2016)

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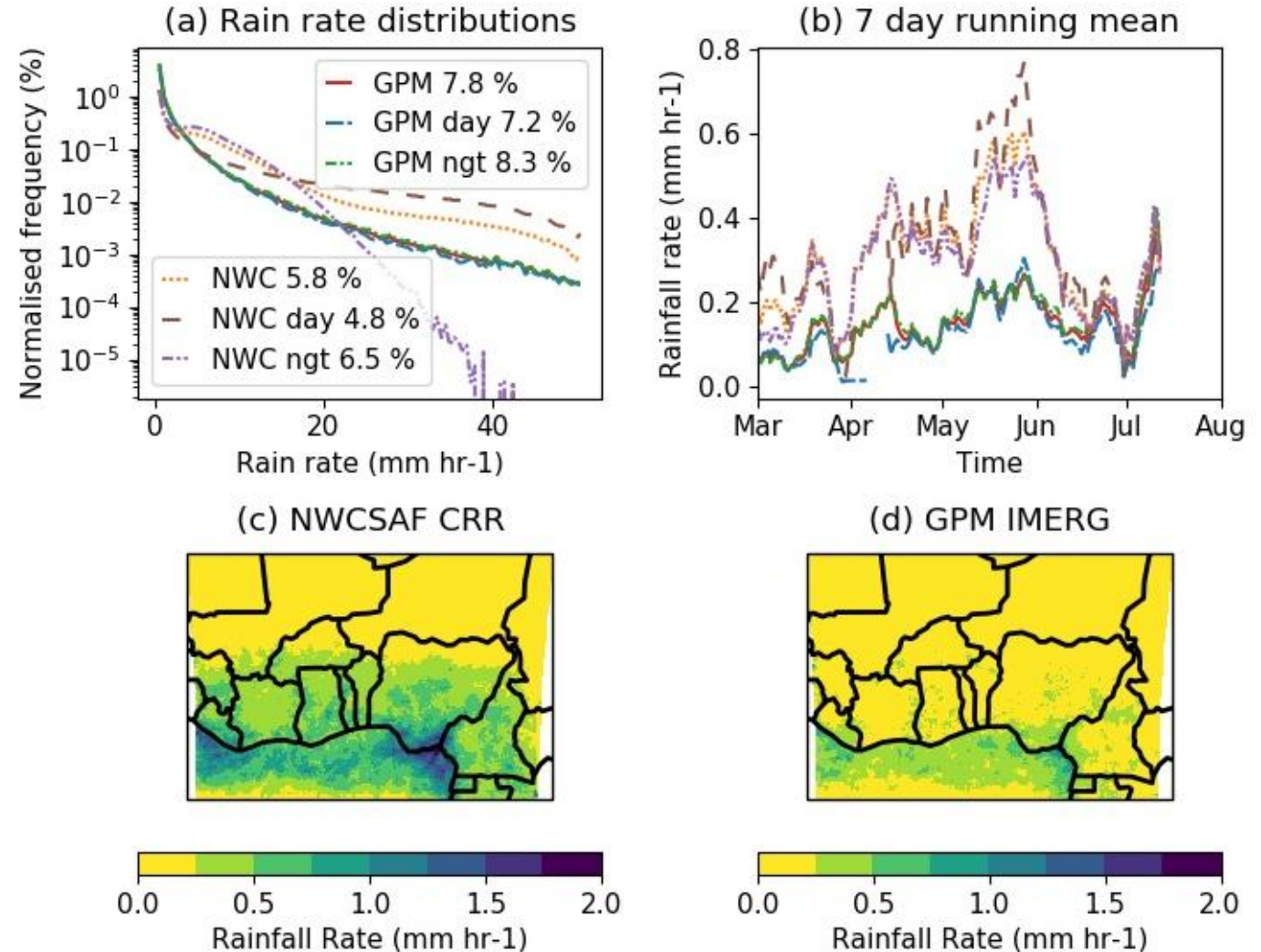GCRF African SWIFT

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Guinea Coast rainfall climatologies

For analysis of climatology and all skill score calculations, CRR averaged to GPM resolution (half hourly, 0.1°).
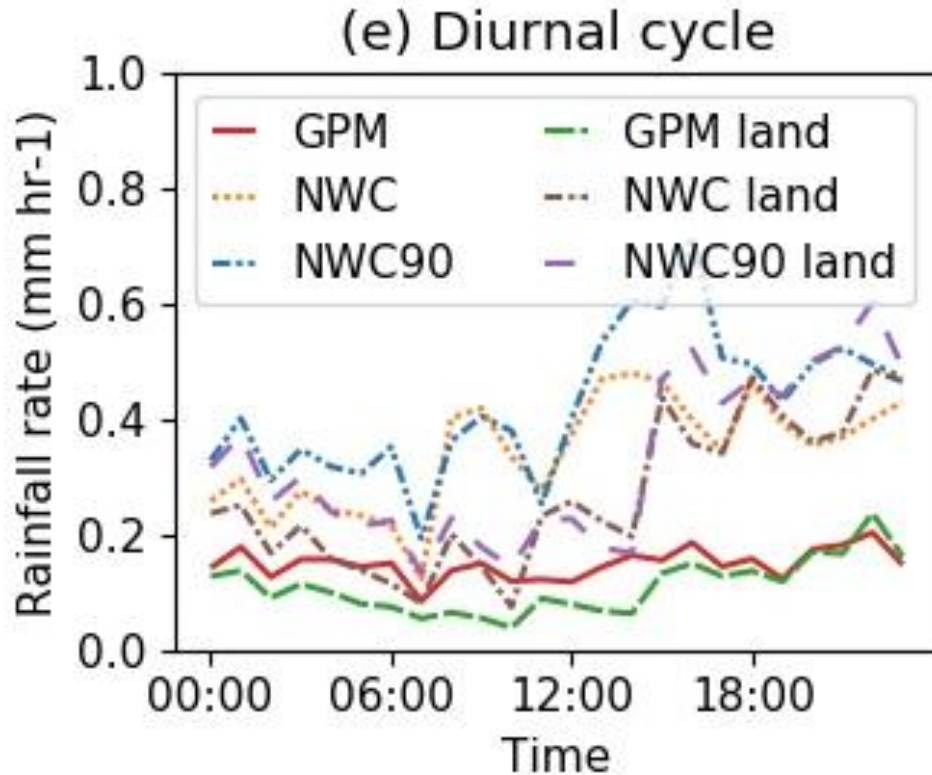
CRR rainfall rate distributions show large day-night differences.

CRR overestimates rainfall.

No obvious location errors for CRR

(a) Rain rate distributions

GPM 7.8 %
GPM day 7.2 %
GPM ngt 8.3 %

NWC 5.8 %
NWC day 4.8 %
NWC ngt 6.5 %

(b) 7 day running mean

(c) NWCSAF CRR

(d) GPM IMERG

Rainfall Rate (mm hr-1)

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Guinea Coast rainfall diurnal cycle climatology

(e) Diurnal cycle

Legend: GPM, NWC, NWC90, GPM land, NWC land, NWC90 land

Ocean represents <20 % of domain but receives >40% of rainfall.

CRR overestimates mean rainfall over both land and ocean.

Phase of diurnal cycle good! Amplitude not too bad once account for mean differences.
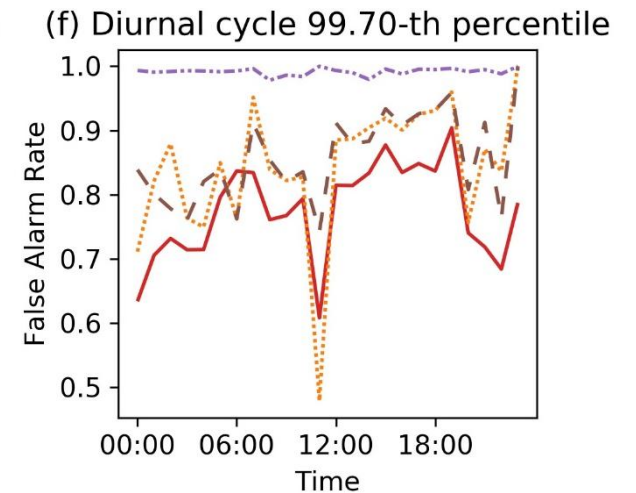
Mean rainfall increase with extrapolation.

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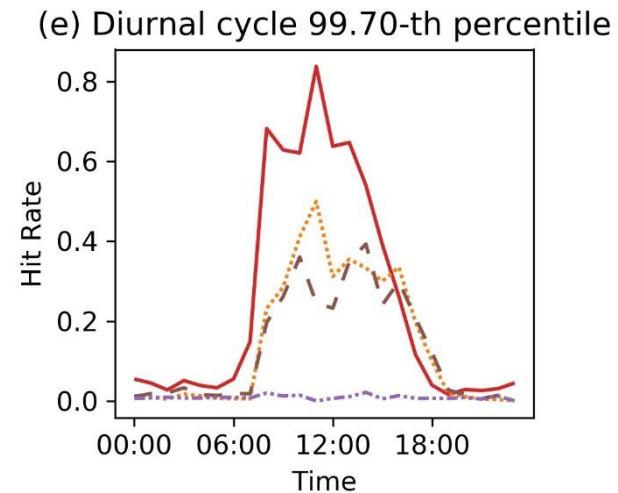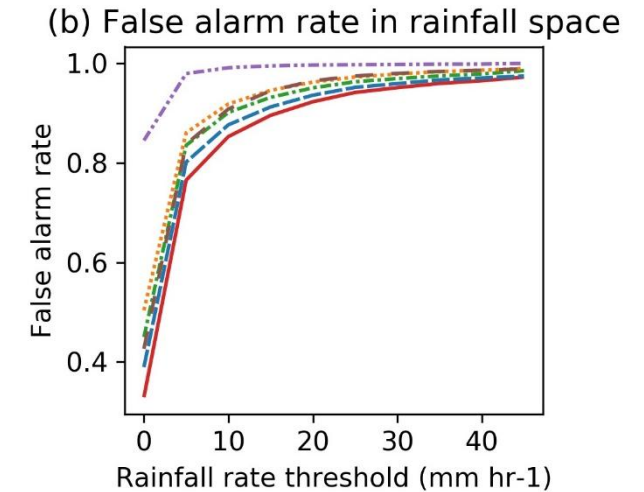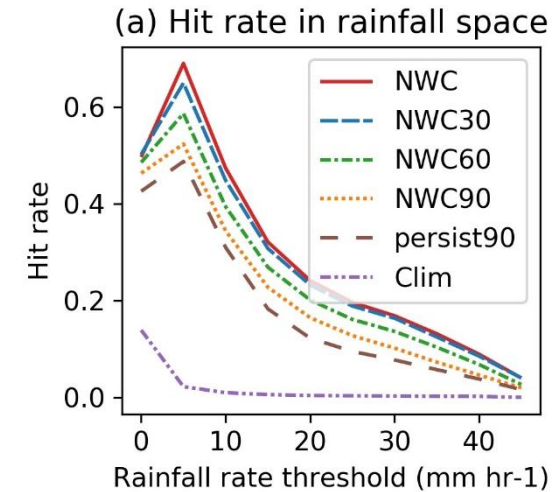https://africanswift.org/

CRR skill

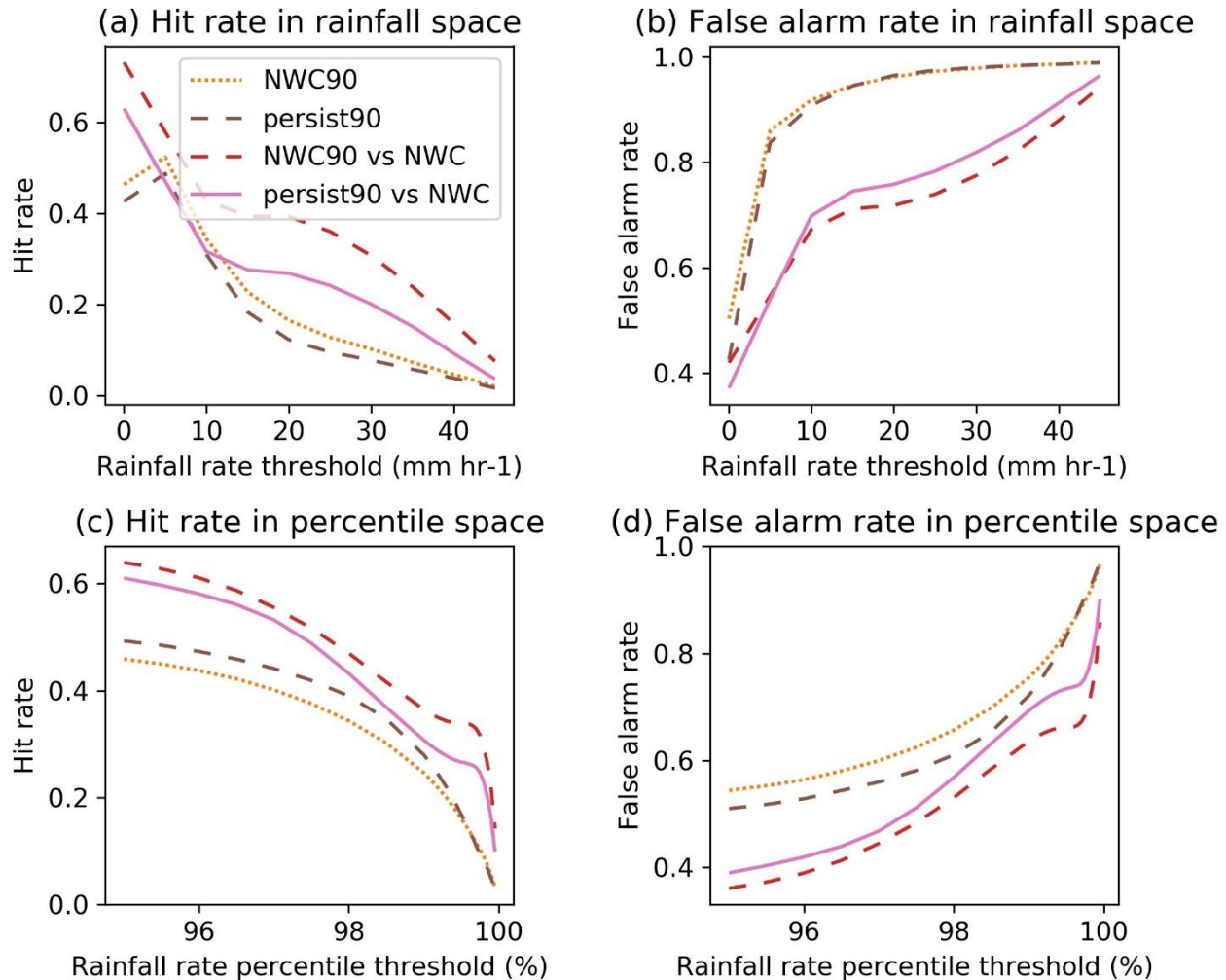Skill decreases for larger rain rate thresholds.

Skill for 90 minute extrapolation remains much better than climatology, but worse than persistence!

Comparison in percentile space reduces false alarm rates.

Skill much better during the day.

(a) Hit rate in rainfall space

(b) False alarm rate in rainfall space

(e) Diurnal cycle 99.70-th percentile

(f) Diurnal cycle 99.70-th percentile

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Why does persistence beat extrapolation?

(a) Hit rate in rainfall space

Legend:
- NWC90
- persist90
- NWC90 vs NWC
- persist90 vs NWC

(b) False alarm rate in rainfall space

(c) Hit rate in percentile space

(d) False alarm rate in percentile space

Persistence better than extrapolation against GPM

But extrapolation better than persistence against CRR retrieval.

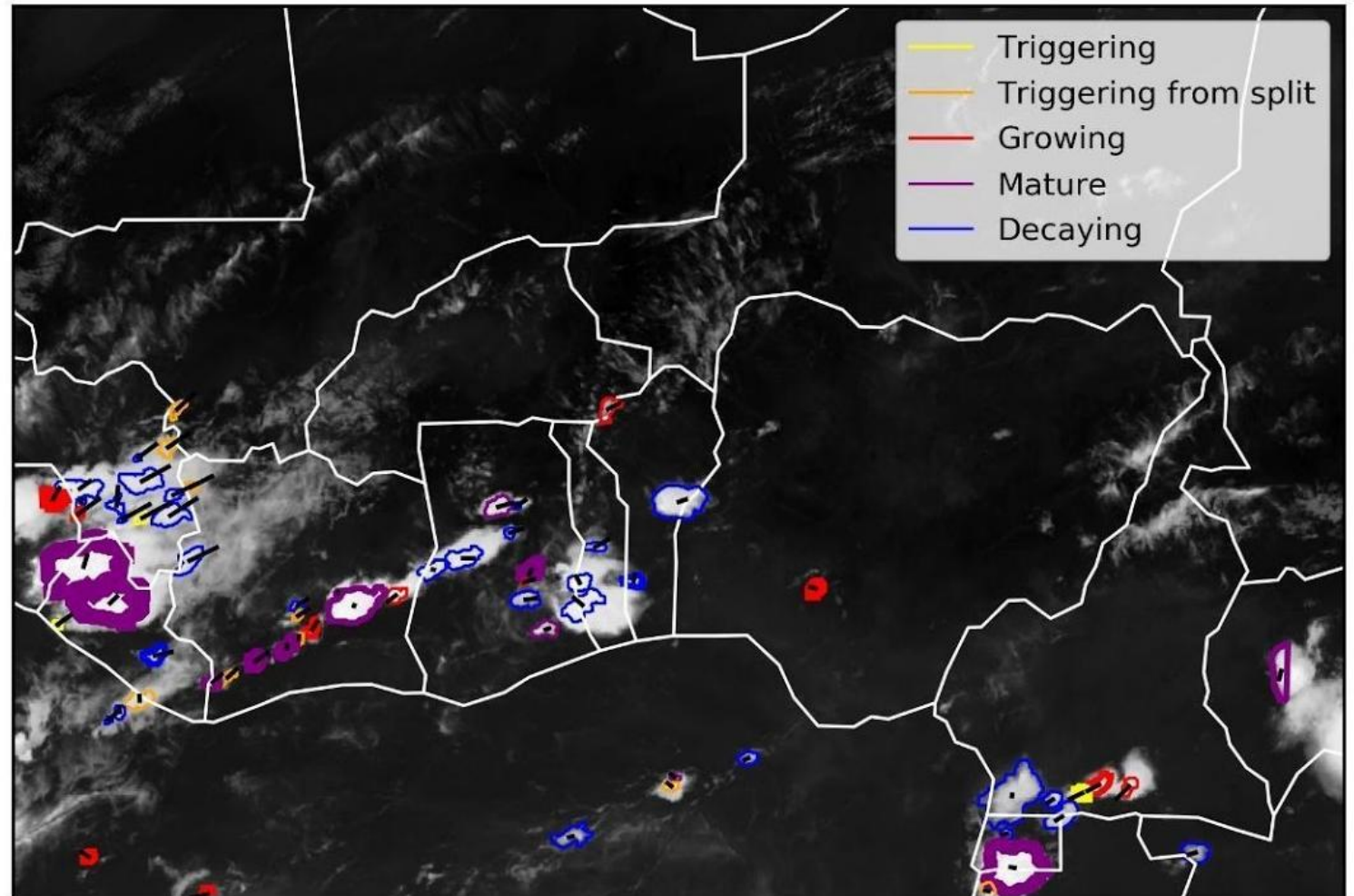I.e. improved skill for persistence is likely due to fortuitous cancellation of errors.

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Interpretation of RDT in tropical Africa

Focus on properties shown in NWCSAF imagery (i.e. phase, severity, future track).

Interpretation rather than evaluation! How does phase/severity relate to precipitation?

(b) NWCSAF rapidly developing thunderstorms 18Z 1/4/2019

Legend:
- Triggering
- Triggering from split
- Growing
- Mature
- Decaying
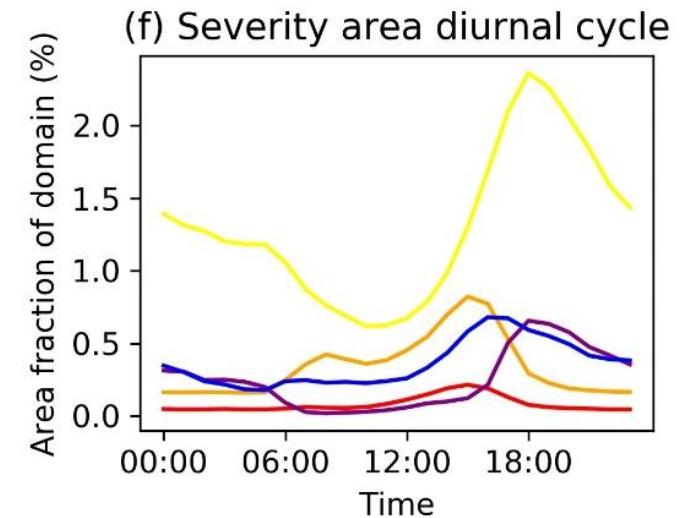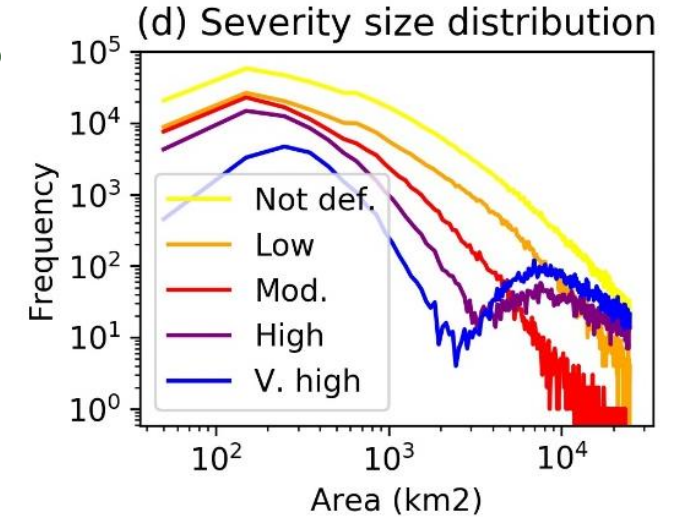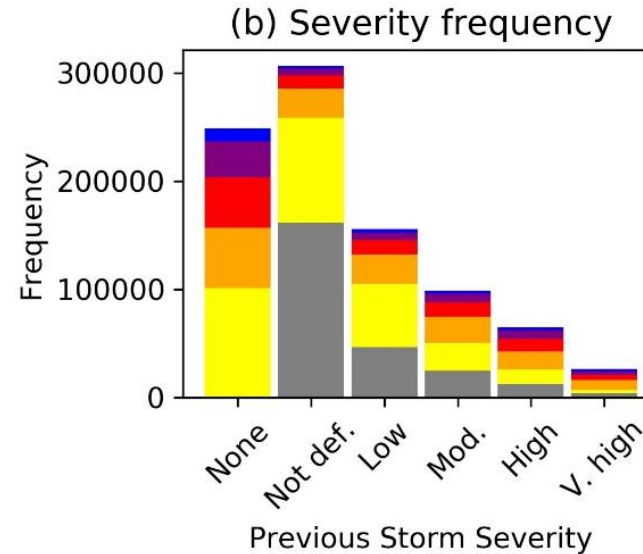
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RDT severity properties

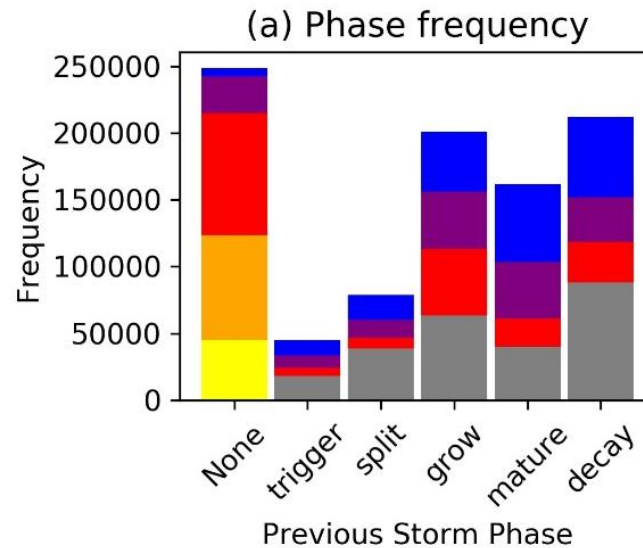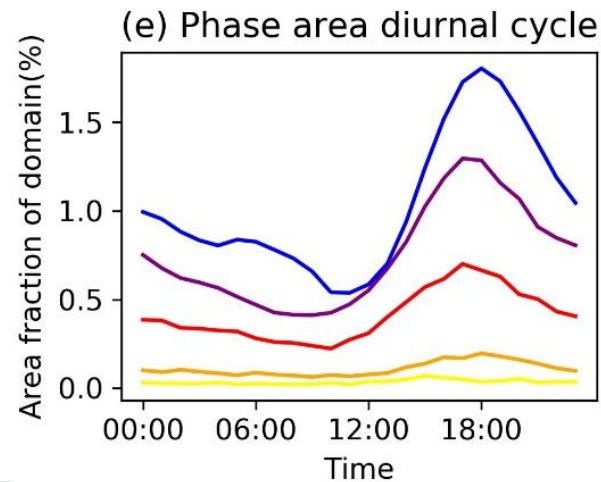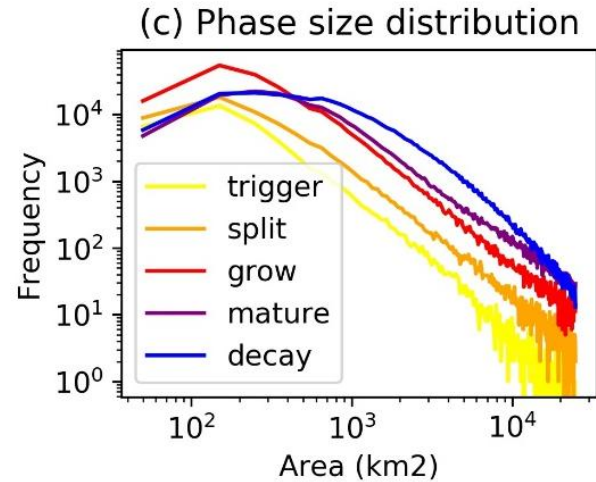Severity dominated by larger number of "not defined" cases.

No obvious pattern between severity at subsequent times.

Most cells are short-lived and small.

Diurnal cycle of cell area matches well-documented diurnal cycle of convective precipitation in tropics.

(d) Severity size distribution

(b) Severity frequency

(f) Severity area diurnal cycle

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RDT phase properties

(c) Phase size distribution

(a) Phase frequency

(e) Phase area diurnal cycle

Phase lifecycle has some of expected traits. E.g.
- New cells start as triggering or growing.
- decaying cells less likely to be identified as mature or growing on subsequent time-step.
- Peak occurrence of decaying cells lags slightly behind that of growing and mature.

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Does RDT capture rain events?

Comparison based on **any** overlap between RDT cell and GPM pixel.

Around 70% of heavy rain coincides with one or more RDT cells, around 60% for 60 minute extrapolated cells.

Increasing rainfall rates are more likely to coincide with very high strength mature storms.

Skill maintained throughout diurnal cycle.

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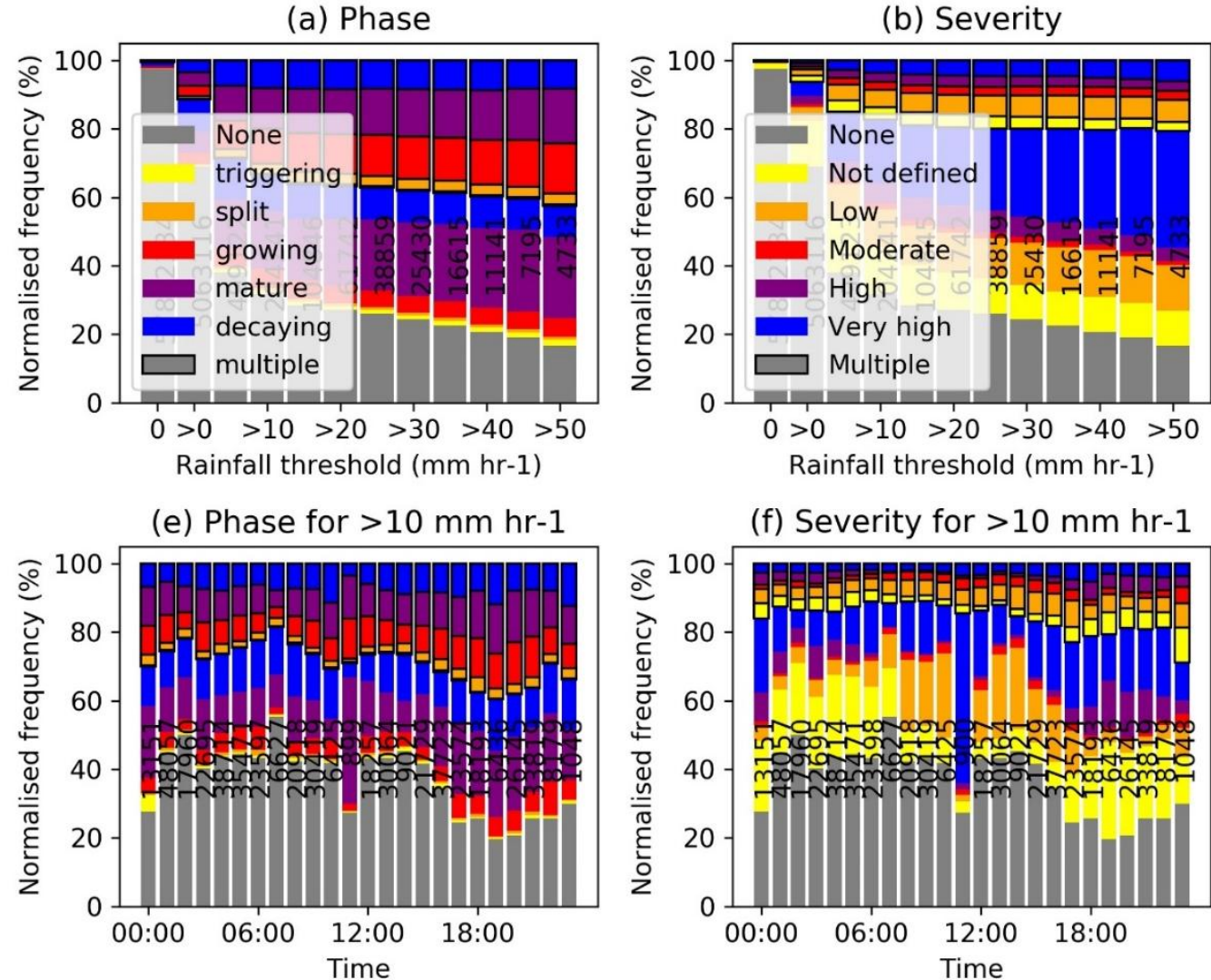
Summary

- NWCSAF products developed for Europe and little evaluation over tropical Africa to date.
- Evaluation required to ensure forecasters in Africa are able to use the products appropriately.
- Comparison with satellite microwave rainfall estimates shows
  - CRR product produces very different rainfall climatologies for day and night. Leads to large differences in the skill of the product between day and night. An indication of which algorithm has been applied would be useful information for users.
  - Around 60% of heavy rainfall events coincide with an RDT cell. Increasing rainfall rates coincide with increasing occurrence of very high severity mature cells.
  - Extrapolation of both the CRR and RDT-CW products maintains useful skill, though limited by underlying retrieval errors.

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Future Work

- Paper to be submitted shortly.

- Possible master's student to work on further evaluation of RDT-CW products against lightning data over tropical Africa.

- Other SWIFT partners to continue work on evaluation of rain rates (e.g. using local gauge data).

- Code to be shared with SWIFT partners so that analysis can re-run for longer periods, different domains, and updated versions of the NWCSAF products.

- If find time: Longer extrapolation periods, comparison to NWP, evaluation at different spatial scales, RDT-like evaluation of CRR.

Thanks for listening!
Questions?