Satellite rainfall bias assessment for crop growth simulation – a case study of rainfed maize growth

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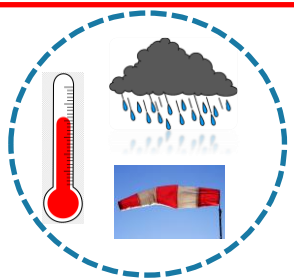
AGENDA

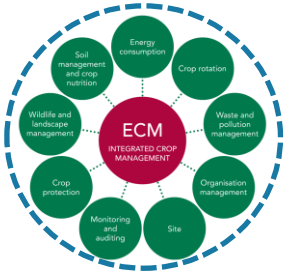
- Role of rainfall data input source in crop growth simulation.
- Limitations of gauge rainfall and outlook of Satellite rainfall products as alternative rainfall data sources.
- Usability of Satellite rainfall products for crop-growth now-casting.
- Contributions and recommendations for the satellite and crop growth simulation community.

ROLE OF RAINFALL IN CROP GROWTH

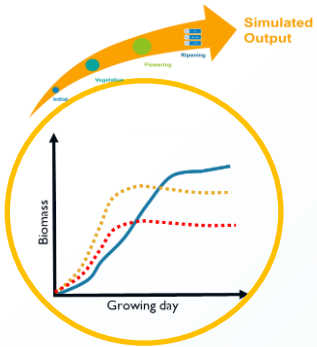
Model parameters incl. soil data



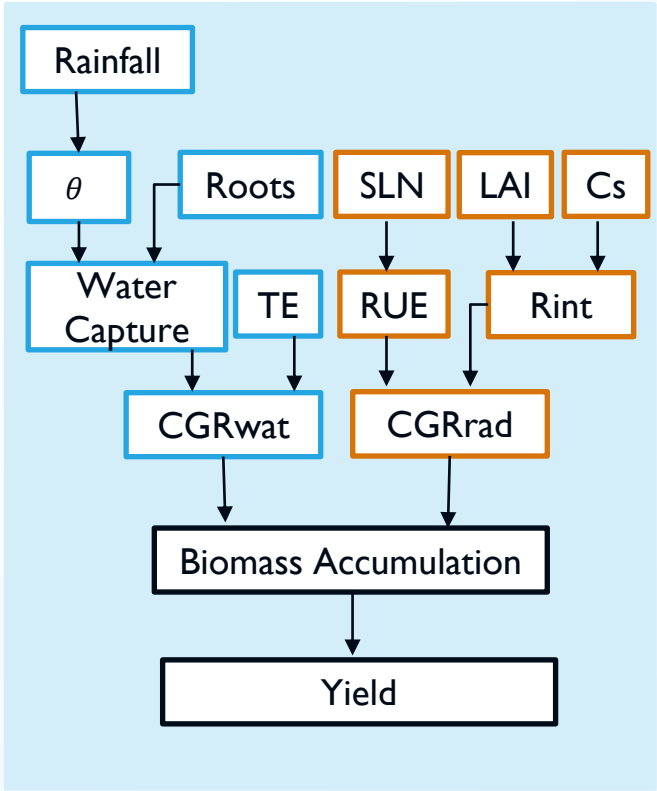
Driving variables incl. weather data



Crop management practice



Crop growth model and analysis



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CONCERNS ON GAUGE RAINFALL

- Concerns on availability and quality of in-situ input data for crop growth models i.e., costly, hard to scale, ignore wealth of spatial and temporal info' from RS data.
- Satellite rainfall estimates (SRE) are an alternative source of rainfall input data but SREs are affected by systematic errors (i.e., bias).
- SREs misrepresent soil water conditions for crop development.
- SREs usability (i.e., bias assessment and correction) in crop growth simulation is essential.

OBJECTIVES

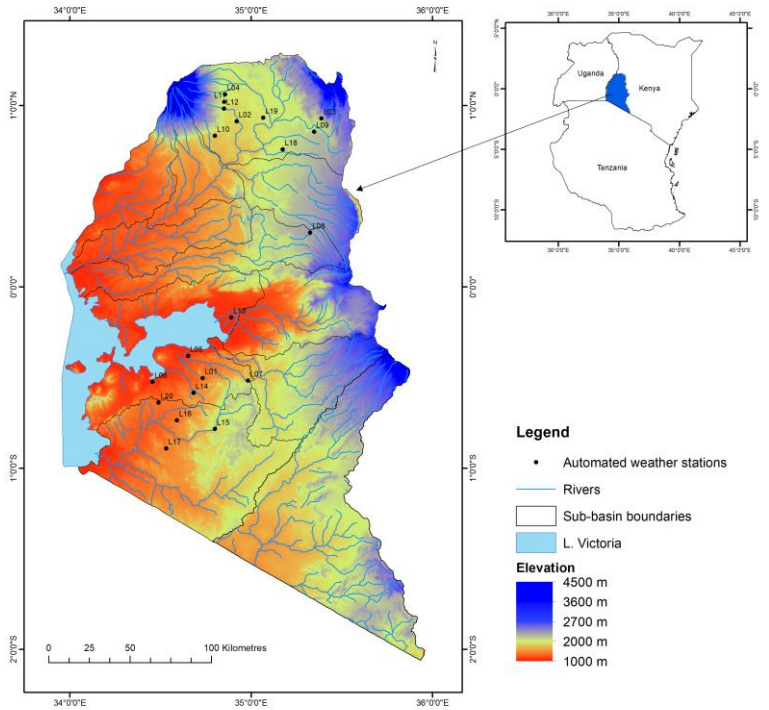
To evaluate if SREs are fit for use in crop growth simulation by assessing SRE bias and bias propagation into crop water requirement satisfaction index (WRSI) on subsequent crop growth stages.

Specific objectives were to:

a. assess the bias of 4 SREs (CHIRPS, CMORPH, MSWEP and RFE2) in representing multi-day timing of rainfall arrival, rainfall depths, prolonged periods of dry days, and rainfall detection occurrence for different crop growth stages.

b. relate SRE errors in rainfall representation to WRSI.

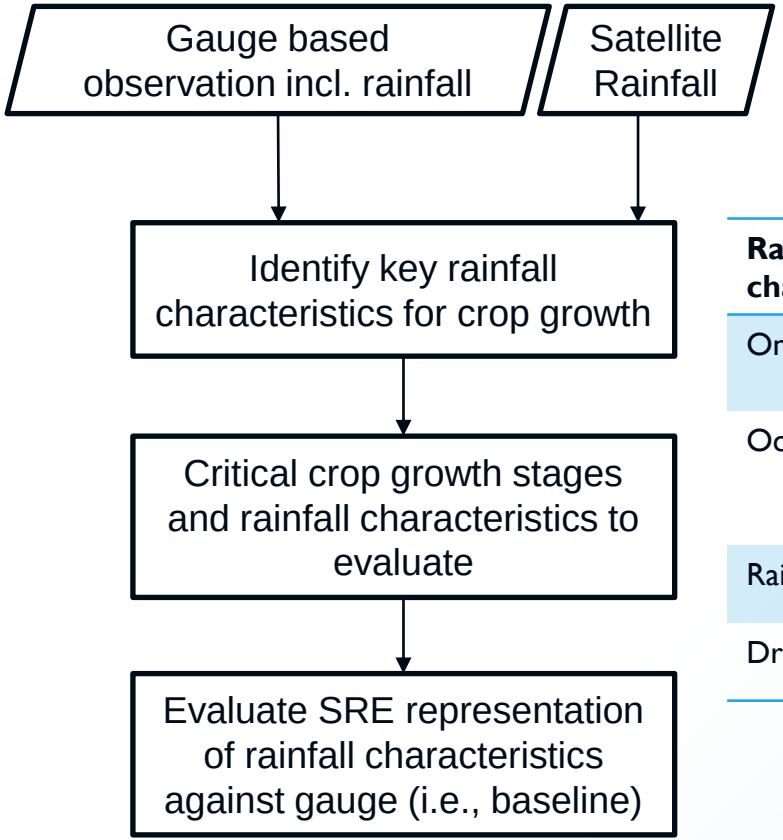
CASE STUDY – MAIZE GROWTH IN LAKE VICTORIA BASIN, KENYA



Data Sources

Product	Spatial coverage	Spatial resolution	Temporal coverage	Temporal resolution	Provider
In-situ	N/A	N/A	2012-2018	d	ACRE-Africa
CHIRPS 2.0	≤50°N/S, land	0,05°	1981-NRT	d	CHG
CMORPH 1.0	60°N/S, global	0,07°	1998-NRT	½-h	NOAA-CPC
MSWEP 2.2	Global	0,1°	1979-2017	3-h	NOAA-CPC
RFE 2.0	40°N/S, 20°W-55°E	0,1°	2001-present	d	NOAA-CPC

RESEARCH FRAMEWORK



Rainfall characteristic	Crop growth stage	Evaluation index
Onset day	Early vegetative	Shifts in rainfall arrival dates
Occurrence	All 4 growth stages (initial, vegetative, reproductive, ripening)	POD, CSI, FAR
Rainfall depth	All 4 growth stages	Relative bias and WRSI
Dry spell	All 4 growth stages	Dry spell length

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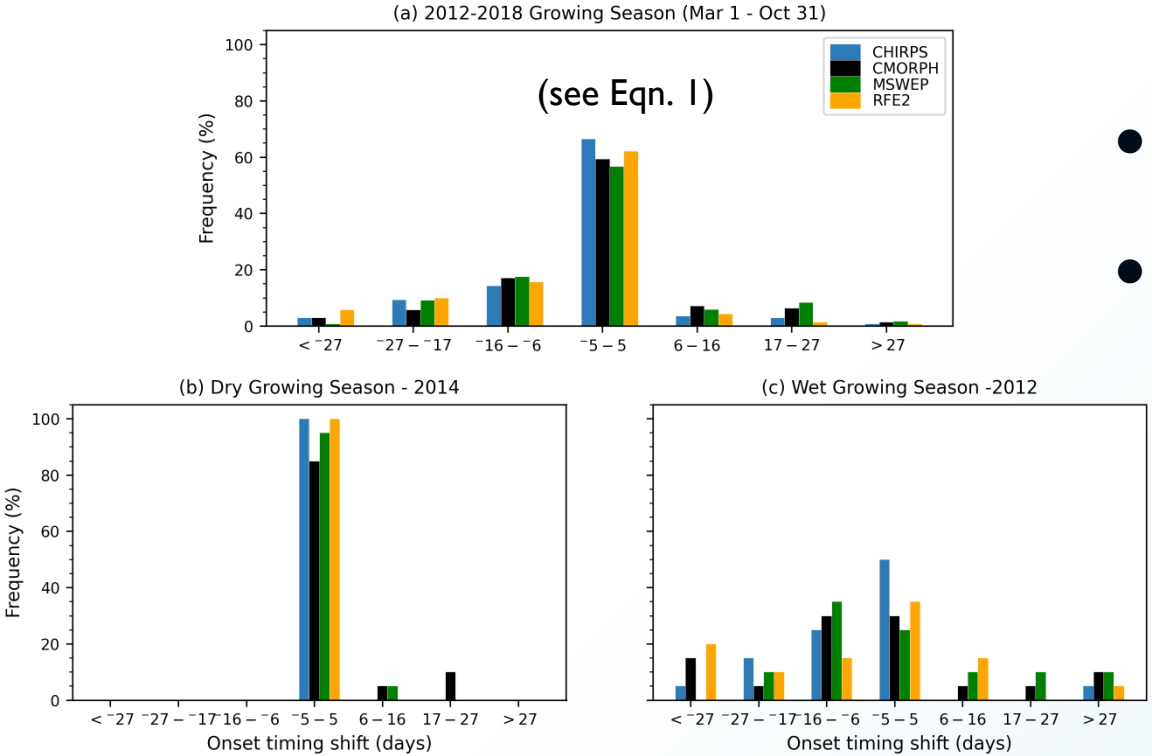
Evaluation index	Definition or Equation	
Onset day [days]	$\left\{\begin{array}{c} 1^{st} \text{ rainfall occurrence centered on March 1} \\ (P_{cum} \geq 20mm \text{ in } 3days) \\ (Dry \text{ days within next } 21 \text{ days } \leq 10 \text{ days}) \end{array}\right\}$	(1)
POD [-]	$POD = \frac{H}{H+M}$, best = 1 & worst = 0	(2)
CSI [-]	$CSI = \frac{H}{H+M+FA}$, best = 1 & worst = 0	(3)
FAR [-]	$FAR = \frac{FA}{H+FA}$, best = 0 & worst = 1	(4)
Dry spell length [days]	Longest number of consecutive days with a rainfall amount below 0.85 mm day^{-1} within a growth stage.	
WRSI [%]	$WRSI = \frac{AET}{WR} x100$	(5)
Relative bias [%]	$Relative\ bias = \frac{\sum_{i=1}^{N}(S_i - G_i)}{\sum_{i=1}^{N} G_i} x100\%$	(6)

Onset day representation results.



- SREs show large variation in timing of rainfall arrival.
- Most difference in marking the onset day by SREs do not exceed 5 days. This suggest their applicability in crop growth simulation.

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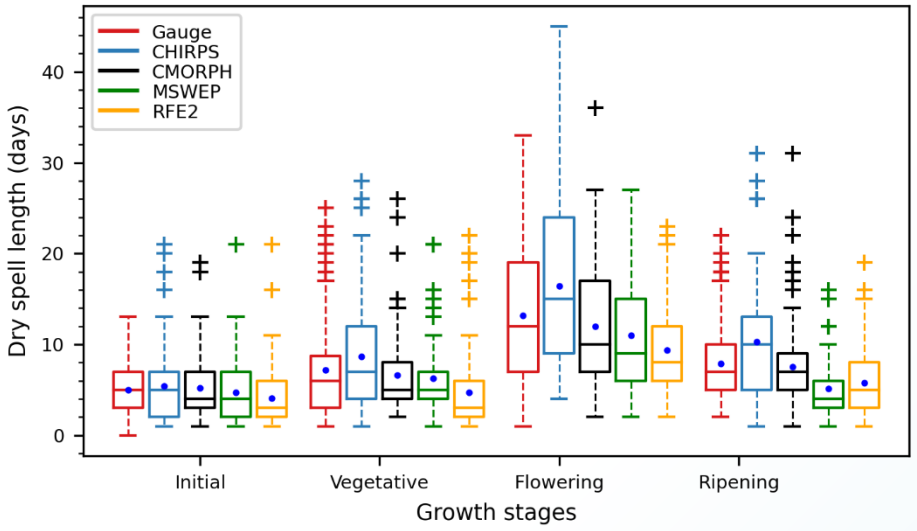
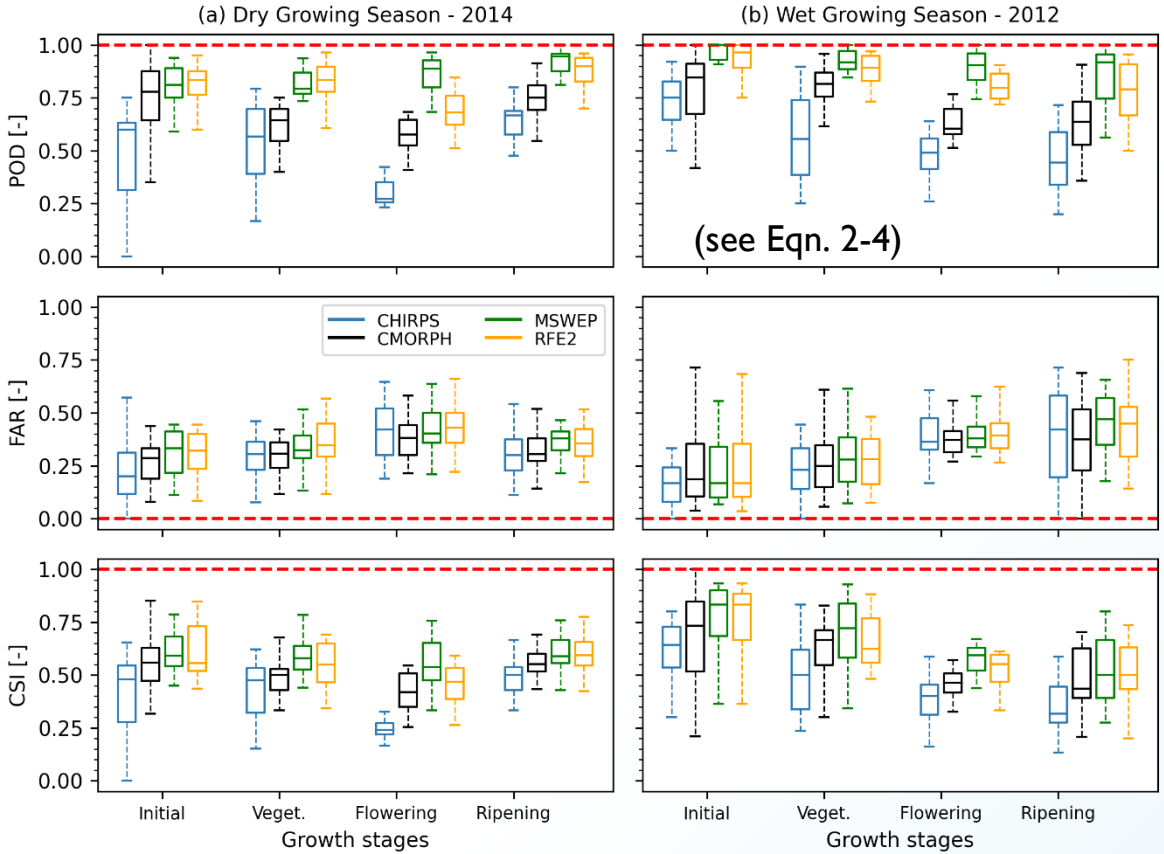
Bias in representing dry spell length results.



- Largest inter-annual and spatial spreads in representing dry spell length during flowering stage.
- CMORPH and CHIRPS showed best and weakest results, respectively.
- Bias in representing dry spell length was smaller during early growth stage.

SRE performance in detecting rainfall occurrence.



- Rainfall occurrence detection by SRE weakened as the growing season progressed.
- MSWEP followed by RFE2 showed best results in detecting rainfall events.
- Falsely detected rainfall was frequent in CHIRPS, especially later growth stages.

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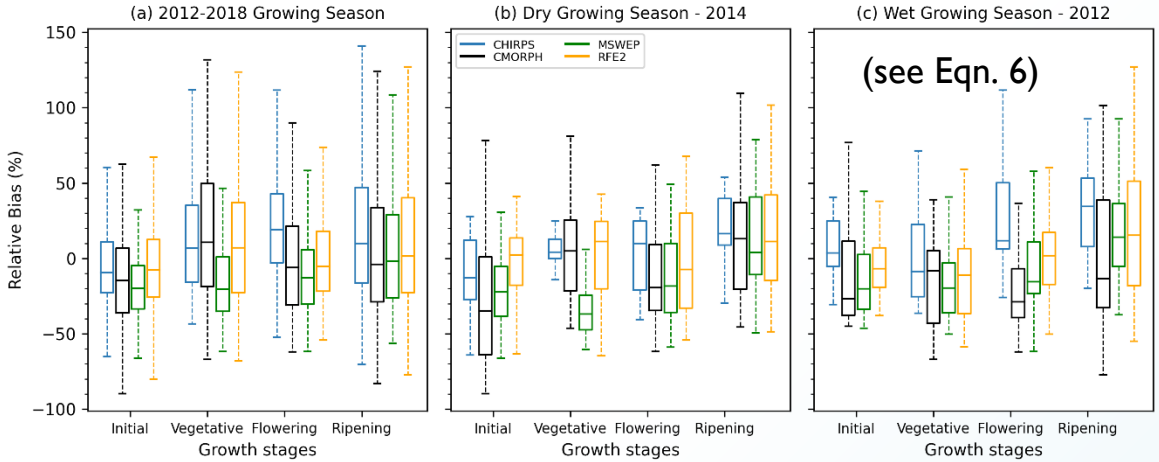
SRE bias in representing rainfall depth.



- SRE showed better performance during cropping season for wet than dry calendar year.
- Less SRE bias in rainfall depth during early stages of crop growth but deteriorated at later stages.
- MSWEP and CMORPH exhibited least and highest interannual spread in relative bias.

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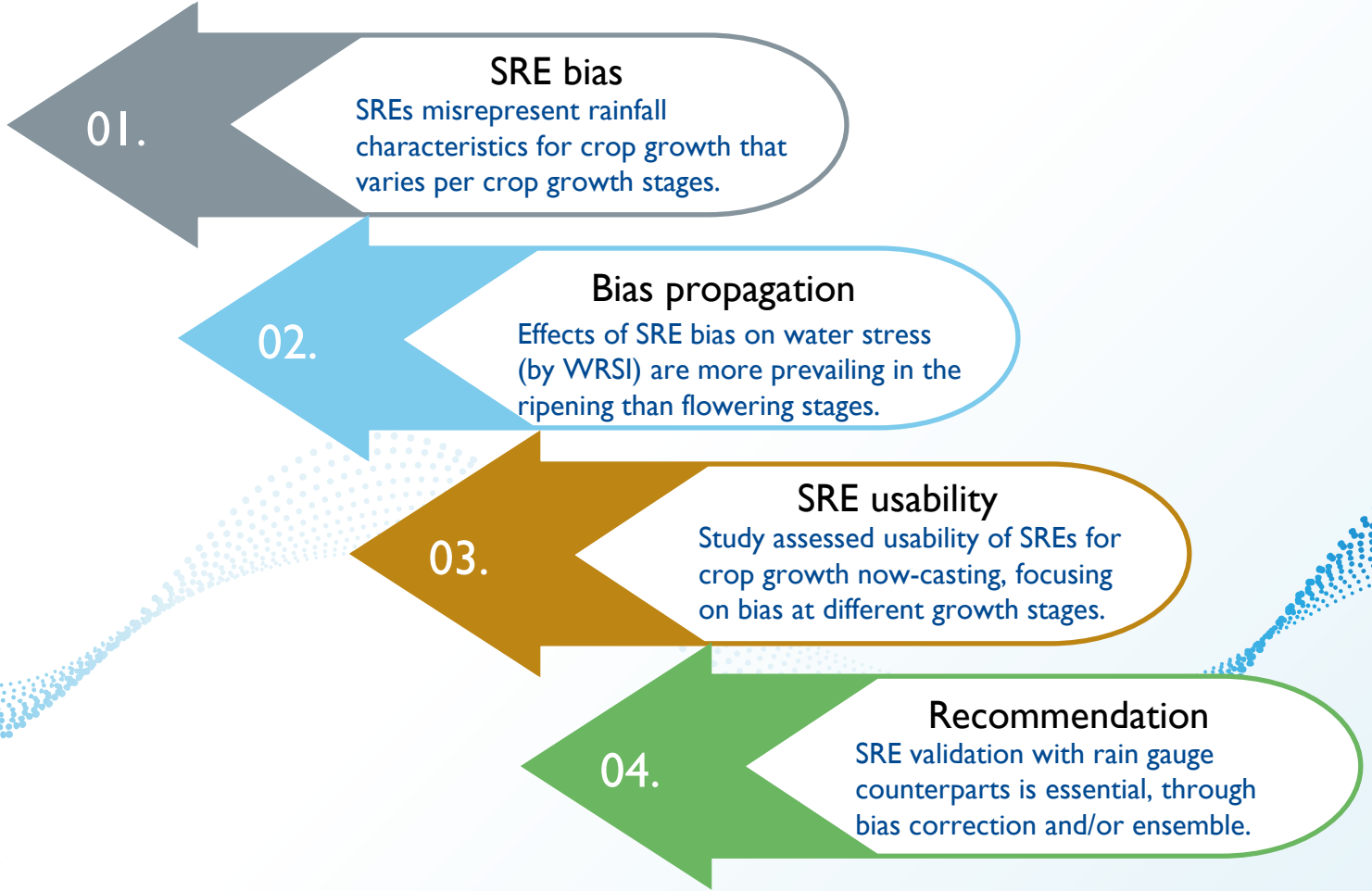
SUMMARY POINTS AND CONTRIBUTIONS



References

Omondi, C.K., Rientjes, T.H.M., Booij, M.J., Nelson, A.D., 2021. Satellite rainfall bias assessment for crop growth simulation – A case study of maize growth in Kenya. Agricultural Water Management 258, 107204. https://doi.org/10.1016/j.agwat.2021.107204

Thank you
Q & A

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