Improving Satellite Derived Rainfall Products: Bayesian Approach

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Raingauges are direct measurements of rainfall but spatially limited (Kidd, Bauer et al. 2012).

Satellite derived rainfall products have good coverage (Joyce, Janowiak et al. 2004).

Have errors (Feidas, Lagouvardos et al. 2005) arising from their indirect estimates.

Improvements and characterisation of their errors is crucial.
Objective

To improve the satellite derived rainfall estimates by correcting the bias errors using Bayesian methods.
Study Area

- Bimodal Rainfall (March – May) and October-December
- Complex topography as shown by the Digital elevation Model (DEM).
- Gridded raingauges over Greater horn of Africa.

(Funk CC, Nicholson SE et al. 2015)
Data and Methodology

TARCAT 0.0375°

TRMM-3B43 0.25°

CMORPH 0.25°

PERSIANN-CDR 0.25°

CMAP 2.5°

CHIRPS 0.05°

Resampled

Gauge 0.05°


Errors

Validation monthly averages (2008-2012)

Bias correction pixel by pixel monthly averages (2008-2012) in the absence of raingauges
Bayesian approach

- Combine data from different sources to get optimal result (Bayes 1763) while accounting for their uncertainties.

\[ P(s|g) = \frac{P(s)P(g|s)}{P(g)} \quad \Rightarrow \quad s_c = \alpha_1 s + \alpha_2 g, \text{ P-> probability density function.} \]

- \( \alpha = \text{weight}, \ g=\text{gauge}, \ s=\text{satellite}, \ s_c=\text{s corrected}, \ \sigma \text{ variance} \)

\[ s_c = s + \frac{\sigma_1^2}{\sigma_1^2+\sigma_2^2} (g - s) \quad \Rightarrow \quad \sigma_2(g) >> \sigma_1(s) \quad s_c \rightarrow s, \ \sigma_2(g) << \sigma_1(s) \quad s_c > g \]
High resolution products (0.0375°, 0.05°)

- Increased correspondence after corrections.
- CHIRPS slight over corrections in October
Spatial maps indicating topographic influence

TARCAT: Underestimates on high ground areas before corrections.
Moderate resolution products (0.25°)

- Increased correspondence after bias corrections.
Moderate resolution products

PERSIANN: Underestimates on high ground areas before corrections.
Coarse resolution products (2.5\(^\circ\))

- Close correspondence after bias corrections.

![Graphs showing correlation between satellite estimates and raingauge measurements for April and October, with R\(^2\) values of 0.10, 0.69, 0.22, and 0.63.]
Moderate resolution products

CMAP and GPCP: Underestimates on high ground areas before corrections.
After bias corrections CHIRPS: C and PERSIANN: F show increased standard deviations in October

Error statistics

B: TARCAT
C: CHIRPS
D: TRMM-3B43
E: CMORPH
F: PERSIANN-CDR
G: CMAP
H: GPCP
## Conclusions

- The approach corrected systematic errors related to rainfall intensities and topography.
- The random errors were related to temporal and spatial sampling caused by rainfall variabilities.
- TRMM outperformed other products is recommended for climate studies over East Africa region.
- Approach is recommended for other regions to correct systematic errors and detection of random errors.