

Assessing Nonlinear Responses of Flash Drought Characteristics to Elevation

in the Western Himalayan Catchment

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1. Introduction

- ❖ A flash drought is the rapid onset or intensification of drought conditions, developing within days or a few weeks rather than months. It causes fast depletion of soil moisture, often resulting in severe agricultural and ecological damage (Otkin et al., 2018).
- ❖ Flash droughts are highly sensitive to local topographical and environmental changes. Existing coarse resolution studies rarely resolve local topographic and climatic gradients specially in highly dynamic and data scarce mountainous regions (Lesinger & Tian, 2022).
- ❖ Studying the elevation dependence of flash drought characteristics and finding threshold elevations is essential for better preparedness, planning and mitigation of flash droughts on agriculture.

3. Methodology

- ❖ ERA-5, GLDAS-2.1, GLDAS-2.2, SMAP, FLDAS daily rootzone soil moisture (RZSM), individual and ensemble, accuracy is checked from NGARI ISMN RZSM.
- ❖ Flash drought events are identified as periods where root-zone soil moisture drops rapidly from ≥40th percentile to ≤20th percentile within 3 octads at a decline rate ≥6.5 percentile/octad, and remains below the threshold for a total duration of ≤11 octads including onset.

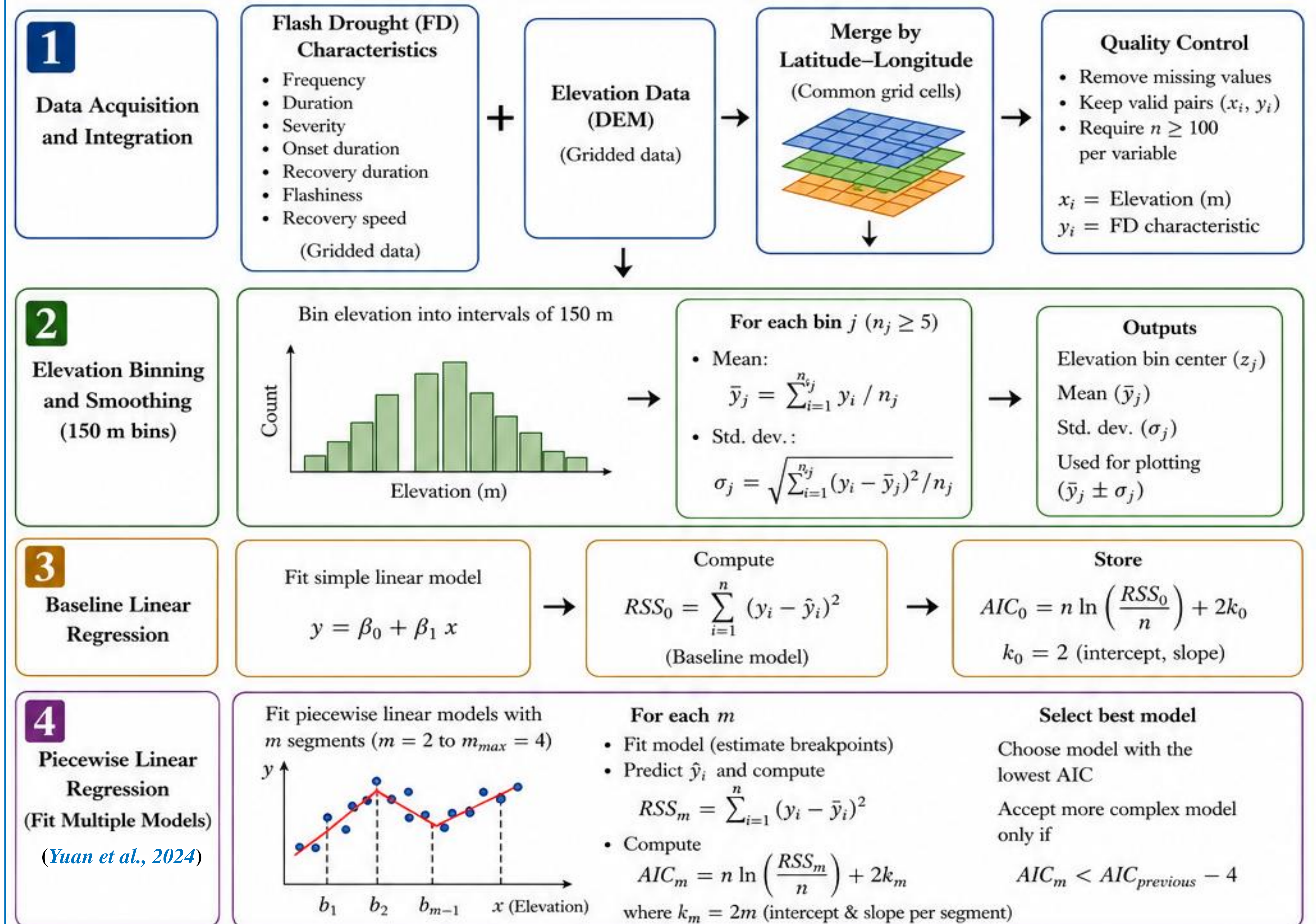


Fig. 2: Data Processing and Methodology

2. Study Area

- ❖ Indian Indus Basin
 - It is highly sensitive to all kinds of hazards due to highly dynamic hydrometeorological processes.

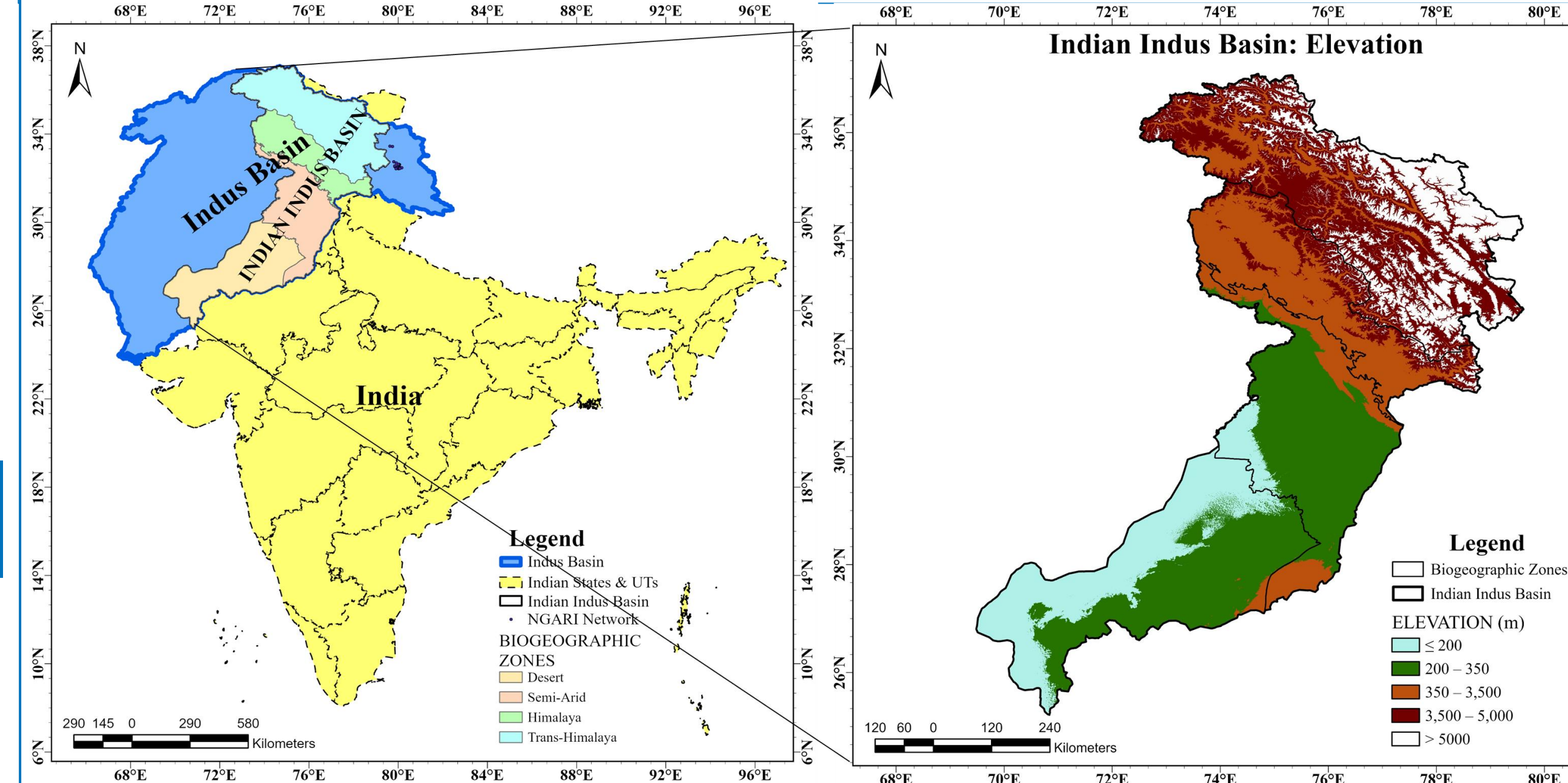


Fig. 1: Study Area Map

(Results)

- ❖ Frequency, severity, and duration events peak at mid-elevations (~1500-2000 m) (Figure 3).
- ❖ High elevations (>4000 m) show declining frequency, severity, and flashiness.
- ❖ Flashiness slightly increases toward mid-high elevations, then declines.
- ❖ Recovery speed decreases with elevation, indicating slower recovery in mountains.

5. Conclusion

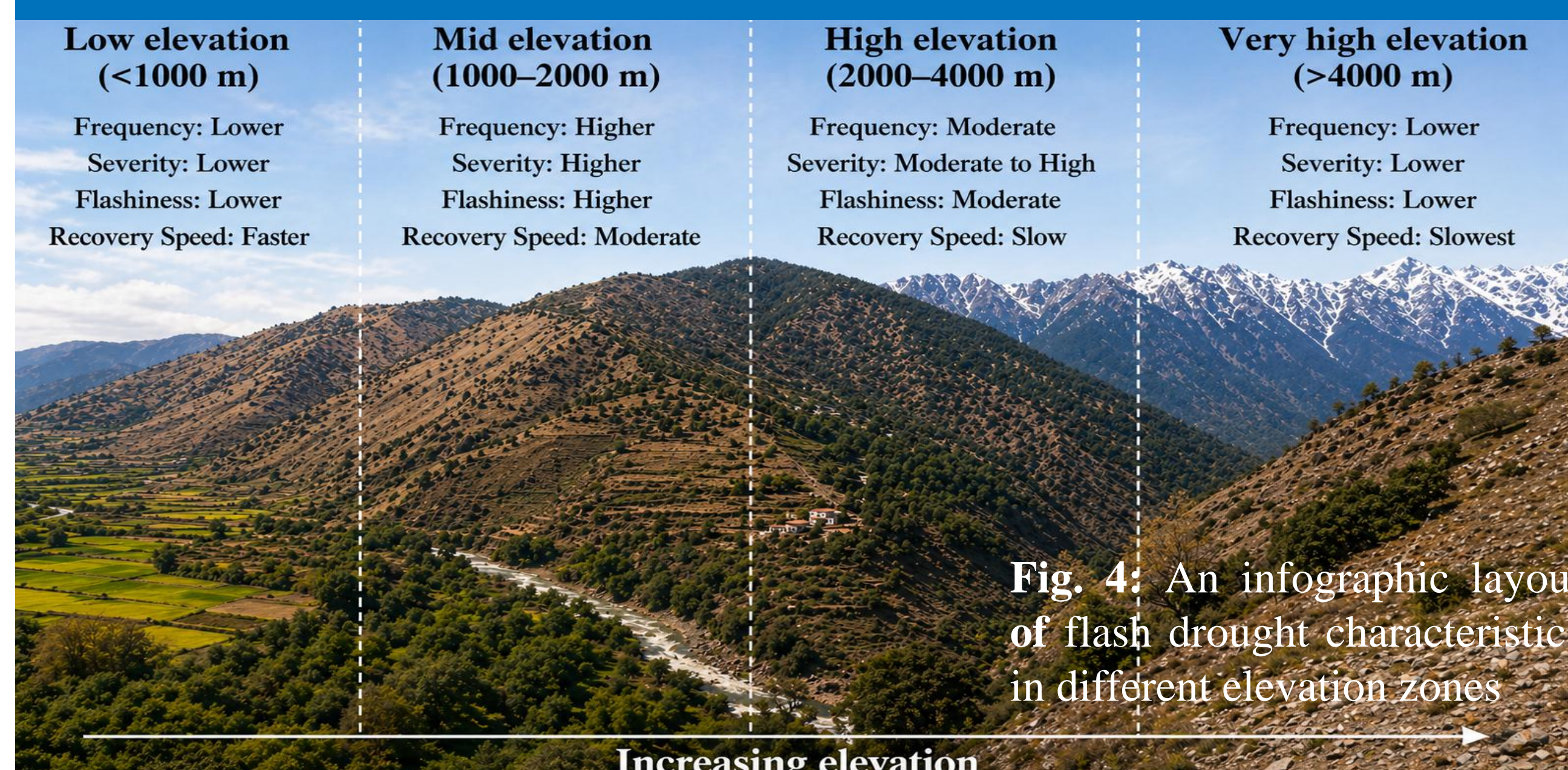


Fig. 4: An infographic layout of flash drought characteristics in different elevation zones

4. Results and Discussion

- ❖ ERA-5 GLDAS-2.1 GLDAS-2.2 (E5G2.1G2.2) ensemble daily RZSM performed best with 0.7 correlation (Table 1).

Table 1: Performance metrics of RZSM products (2001-2025).

Performance Metrics:	GLDAS2.1 (0.1)	GLDAS2.2 (0.1)	ERA5 (0.1)	SMAP (0.1)	FLDAS (0.1)	FLDAS (0.01)	E5G2.1 EM	E5G2.2 EM	G2.1G2.2 EM	E5G2.1G2.2 EM
Correlation:	0.5295	0.6225	0.6325	0.0247	0.0833	0.0587	0.6927	0.6795	0.6155	0.7003
RMSE:	0.047	0.146	0.1	0.0308	0.1135	0.1161	0.0724	0.1225	0.0957	0.0967
CRMSE:	0.0178	0.0162	0.0197	0.0285	0.0334	0.0404	0.0151	0.0155	0.0163	0.0148
MAE:	0.0436	0.1451	0.098	0.025	0.1085	0.1091	0.0708	0.1216	0.0943	0.0956
R ² :	0.2803	0.3875	0.4	0.0006	0.0069	0.0034	0.4799	0.4618	0.3789	0.4904
SD Model:	0.014	0.0122	0.0246	0.0202	0.028	0.0359	0.0166	0.0171	0.0122	0.0146
SD Observed:	0.0207	0.0207	0.0207	0.0206	0.0207	0.0207	0.0207	0.0207	0.0207	0.0207

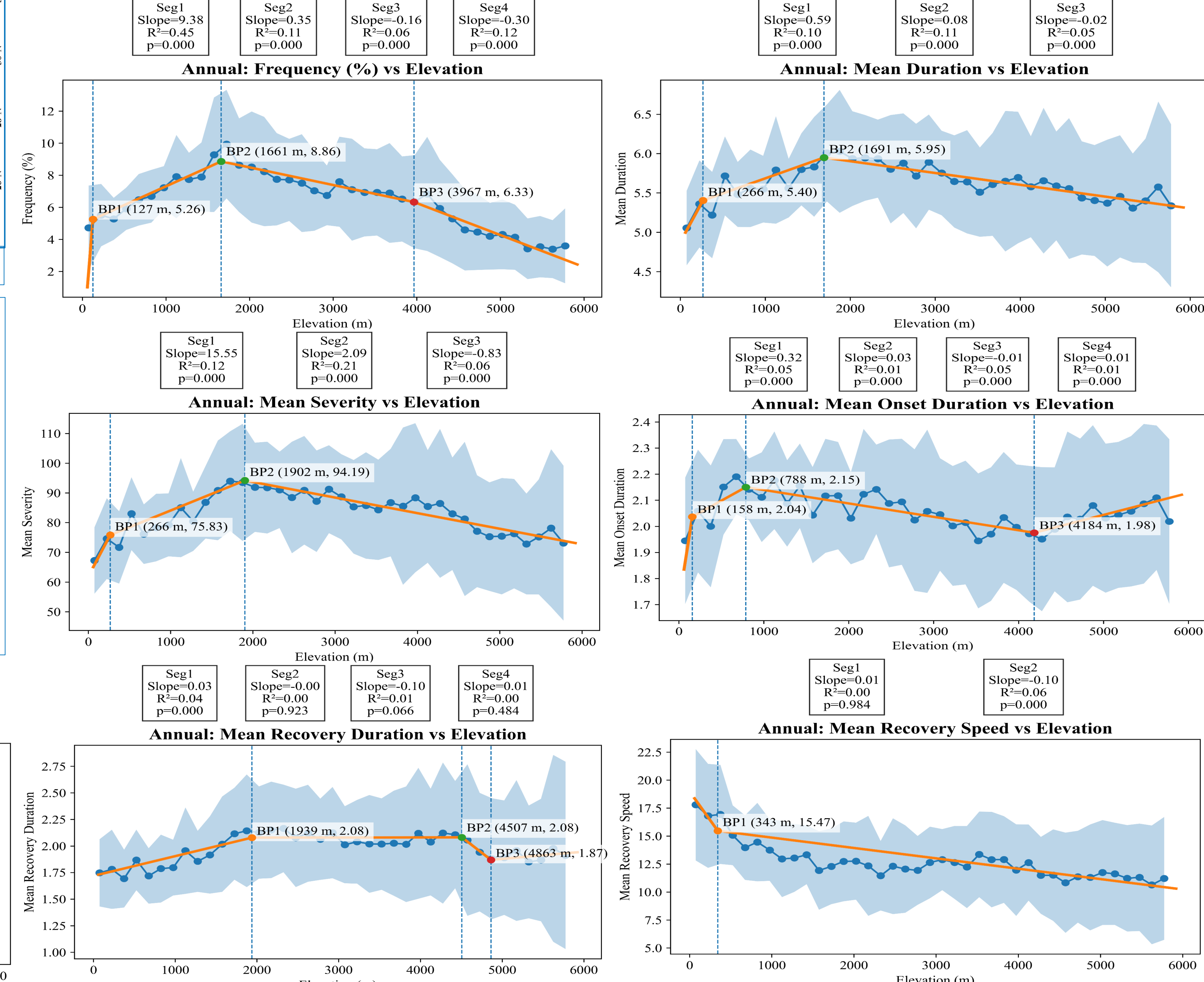


Fig. 3: Elevation breakpoints for annual flash drought characteristics (frequency, duration, severity, onset duration, flashiness, recovery duration and recovery speed).

- ❖ Flash drought behavior shows clear elevation dependence with breakpoints (Figure 4).
- ❖ Overall: mid-elevation zones are most vulnerable to intense and frequent flash droughts.
- ❖ Farmers in mid and high elevations should shift to drought resilient crops to avoid losses.
- ❖ Government needs to make and implement targeted plans for this zone before the situation worsens.

References

Otkin, et al. (2018). Flash droughts: A review and assessment ... in the United States. Bulletin ... Society, 99(5), 911-919. <https://doi.org/10.1175/BAMS-D-17-0149.1>.

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