Application of Grain-Size End-Member Modelling in Bed Sediments of the Brahmaputra River

Abhishek Dixit[1], sourav kumar[1], Chandan Mahanta[1], Sumantra Chaudhari[1], and Manish singh Rana[1]

[1]IIT Guwahati

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Abstract

Superimposed signatures of grain size effect, lithology and chemical processes on fluvial sediments need to be resolved to answer the profound research questions related to sediment provenance and processes. Hydraulic forces sort the sediments into different grain size classes in the river water column. The finest fraction is transported as the suspended sediments which have different sediment composition than the bed sediments. Thus, suspended sediment may provide additional information about earth surface processes, such as chemical weathering. Hydraulically sorted river bed sediments may or may not provide this information, as bulk sample may be depleted in finer grains by hydraulic processes. Bed sediments that are easily sampled from the sand bars and river banks are often investigated to study the weathering intensity and sediment provenance. It is thus crucial to identify and quantify the specific grain size classes in the bulk sample to be investigated for the research question at hand. End Member Modelling Algorithms (EMMA) for grain size distribution is a useful tool to unmix the grain size population into geological meaningful end members. We applied Hierarchical alternating least squares nonnegative matrix factorization (HALS-NMF) algorithm to unmix the grain size data (62 samples) of river bed sediments collected from the freshly exposed sand bars of the Brahmaputra river over a stretch of 550km. The grain size distribution of the finest end member (mean=18μm) is closely approximated to be of the surface sediment grain size distribution reported previously for the Brahmaputra river. Thus, we were able to quantify the relative contribution of suspended sediment to the bed sediment of the Brahmaputra trunk. Results show that the contribution of the suspended sediments in the bed sediment is higher at the lower reaches of the river near floodplain outlet, possibly due to the reduced flow energy in downstream regions. The findings may also be used to select samples and grain size classes for additional geochemical and mineralogical study in order to interpret signals of weathering, provenance and physical processes in the Brahmaputra's large dynamic floodplains at a finer spatial scale.

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Indian Institute of Technology Guwahati, India

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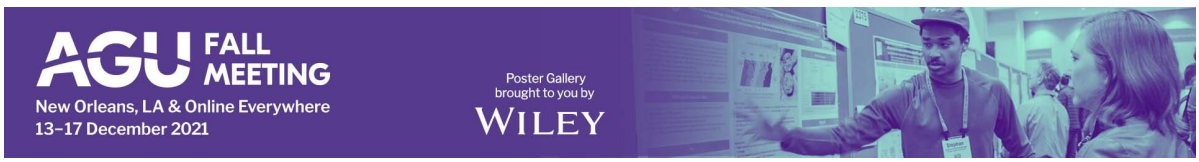
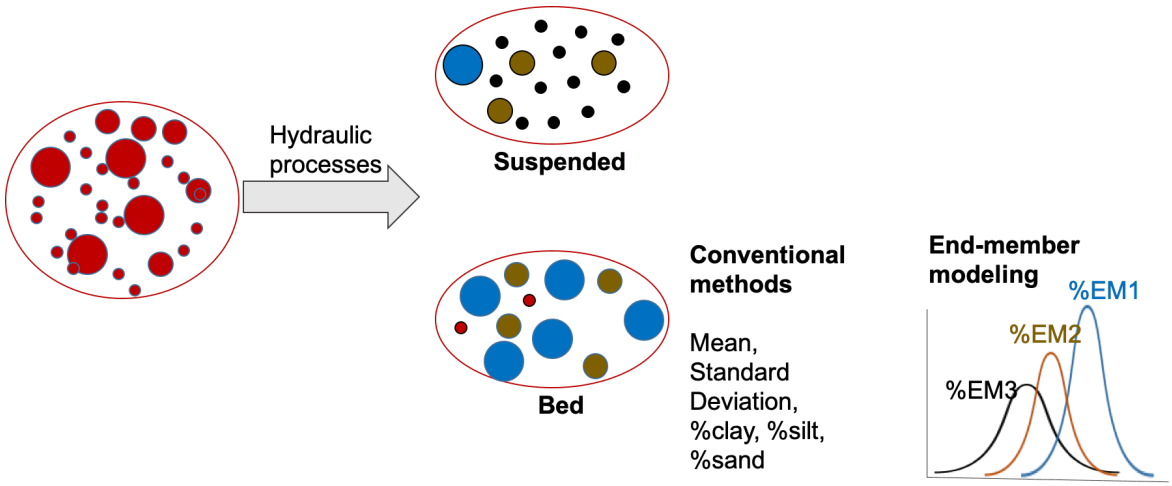
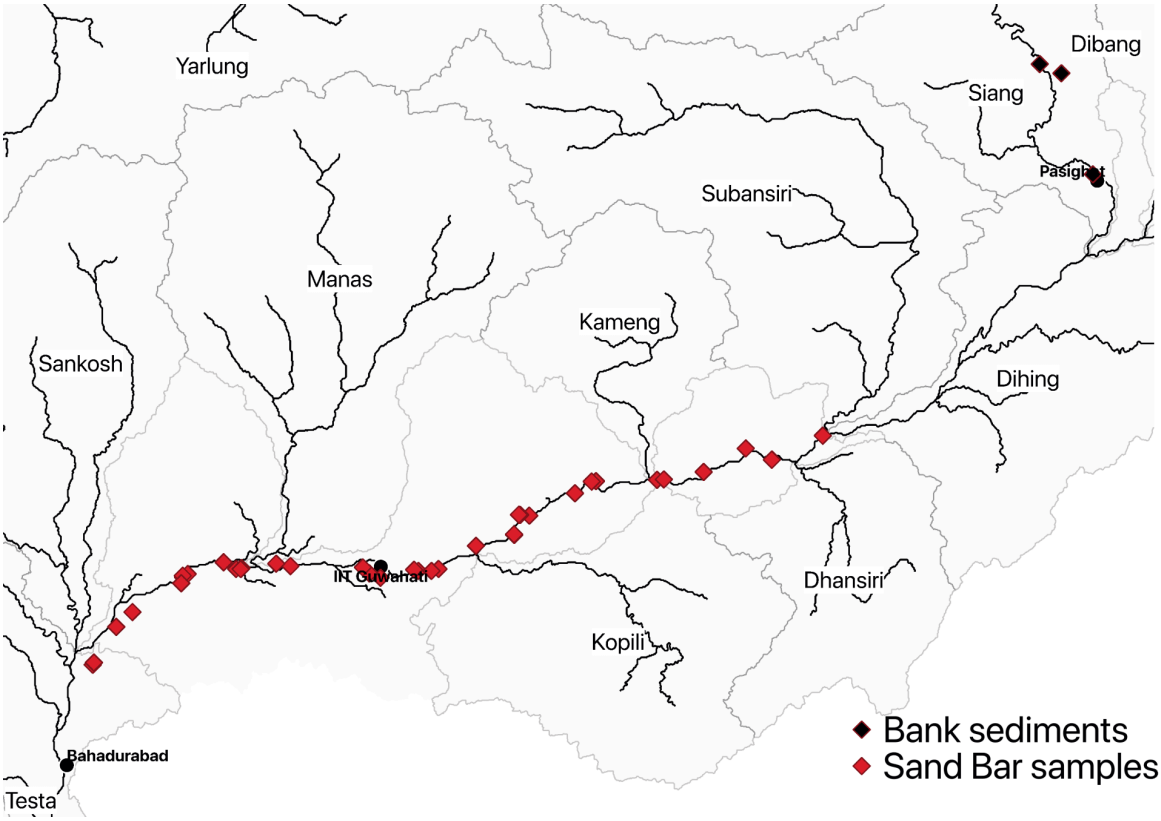


MOTIVATION



- Observed sediment composition in large floodplains is majorly controlled by the grain size effect which in turn is affected by the hydraulic processes.
- While the conventional grain size analysis statistics provide useful information, end-member modeling used to unmix the grain size data into geologically meaningful endmembers may be a better tool to resolve the grain size variability.

STUDY AREA

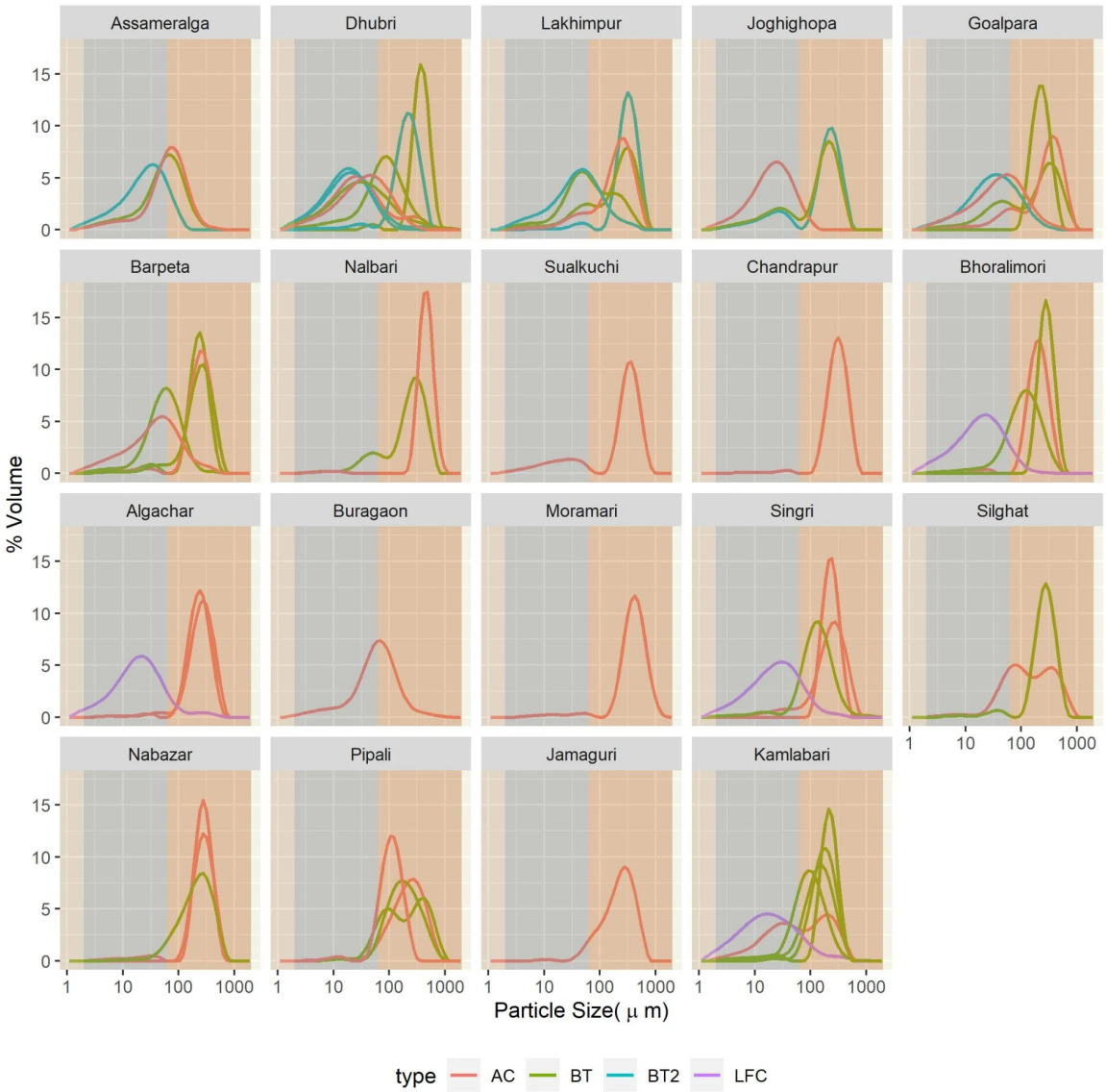


- Brahmaputra basin is the major basin of the Eastern Himalayas
- The Brahmaputra in floodplains flows through braided channels in non-monsoon (sampling period) having different hydrodynamic conditions.
- We sampled the freshly exposed sand bars along the 550km stretch in main truck on the river

RESULTS

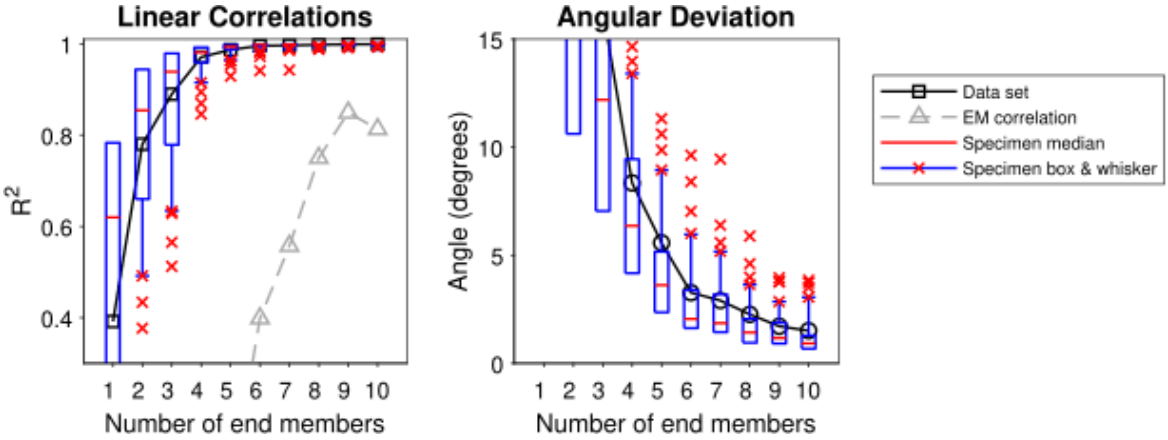
Grain size distributions

Bed sediments of the Brahmaputra are primarily sand-sized.



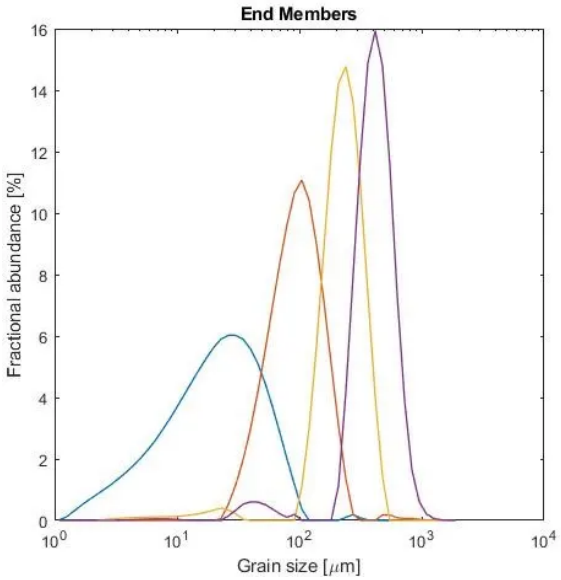
Goodness of fit

Goodness of fit statistics show that the four end-members model is best optimized (linear coefficient of determination >.9 for all samples)

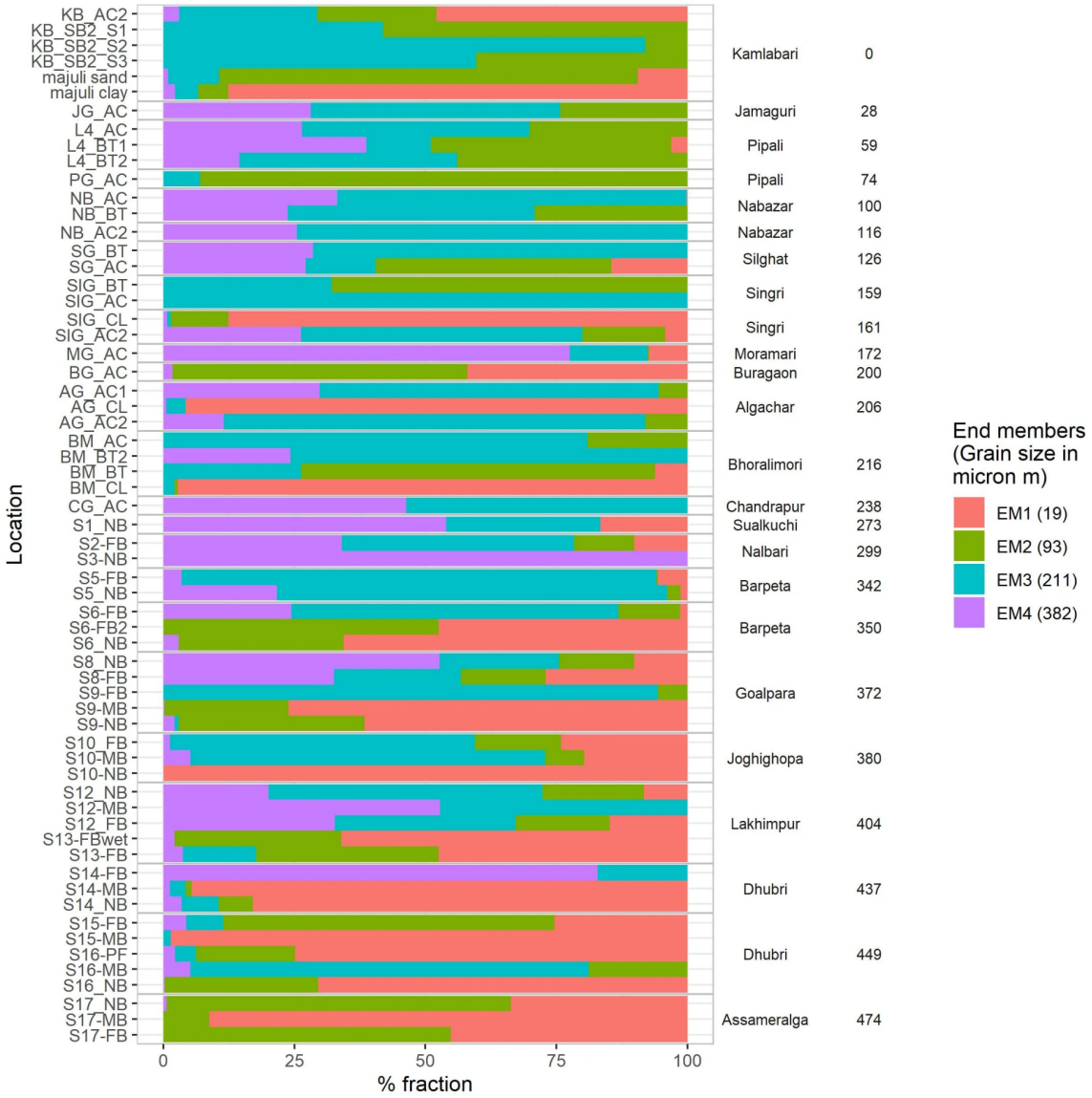


End-Members

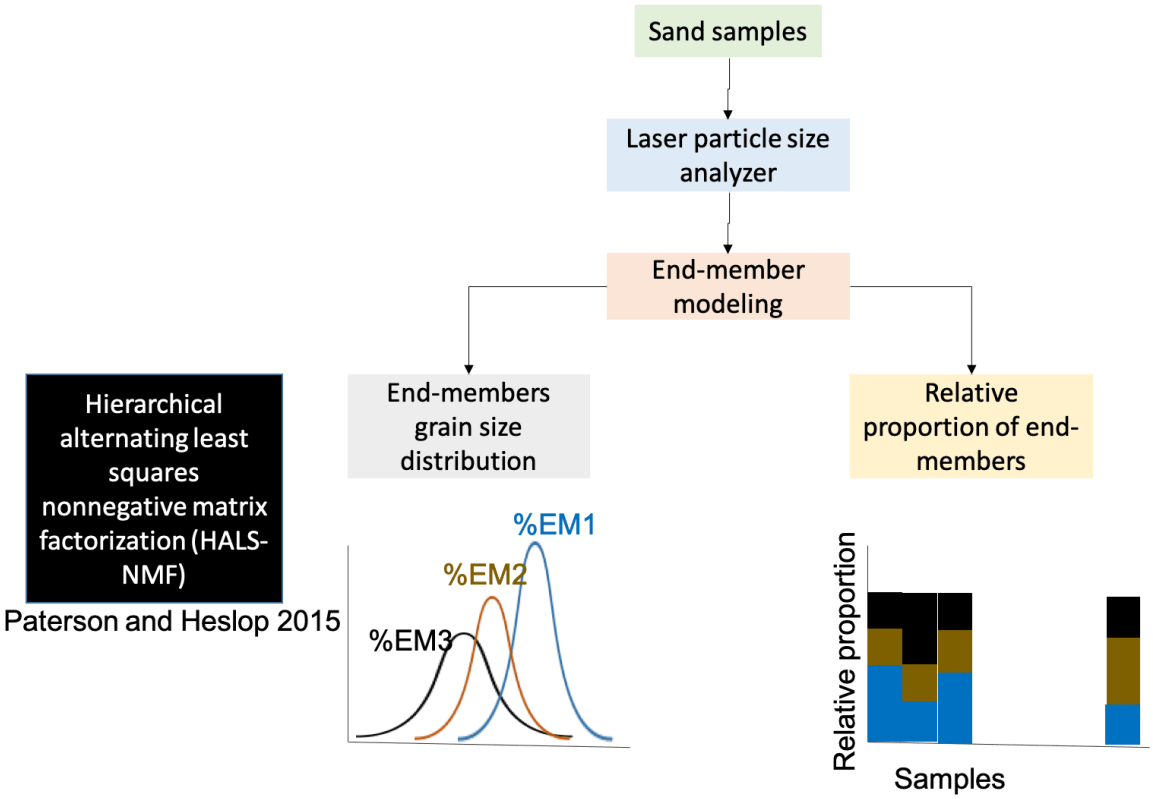
End-member model contains grain-size mean of ~19, ~93, ~211 and ~382 µm for end-members EM1, EM2, EM3 and EM4, respectively.



End-members quantification


KB_AC2
KB_SB2_S1
KB_SB2_S2
KB_SB2_S3
majuli sand
majuli clay
JG_AC
L4_AC
L4_BT1
L4_BT2
PG_AC
NB_AC
NB_BT
NB_AC2
SG_BT
SG_AC
SIG_BT
SIG_AC
SIG_CL
SIG_AC2
MG_AC
BG_AC
AG_AC1
AG_CL
AG_AC2
BM_AC
BM_BT2
BM_BT
BM_CL
CG_AC
S1_NB
S2-FB
S3-NB
S5-FB
S5_NB
S6-FB
S6-FB2
S6_NB
S8_NB
S8-FB
S9-FB
S9-MB
S9-NB
S10_FB
S10-MB
S10-NB
S12_NB
S12-MB
S12_FB
S13-FBwet
S13-FB
S14-FB
S14-MB
S14_NB
S15-FB
S15-MB
S16-PF
S16-MB
S16_NB
S17_NB
S17-MB
S17-FB
Location
0
25
50
75
100
% fraction
Kamlabari 0
Jamaguri 28
Pipali 59
Pipali 74
Nabazar 100
Nabazar 116
Silghat 126
Singri 159
Singri 161
Moramari 172
Buragaon 200
Algachar 206
Bhoralimori 216
Chandrapur 238
Sualkuchi 273
Nalbari 299
Barpeta 342
Barpeta 350
Goalpara 372
Joghighopa 380
Lakhimpur 404
Dhubri 437
Dhubri 449
Assameralga 474
End members (Grain size in micron m)
EM1 (19)
EM2 (93)
EM3 (211)
EM4 (382)

METHODOLOGY



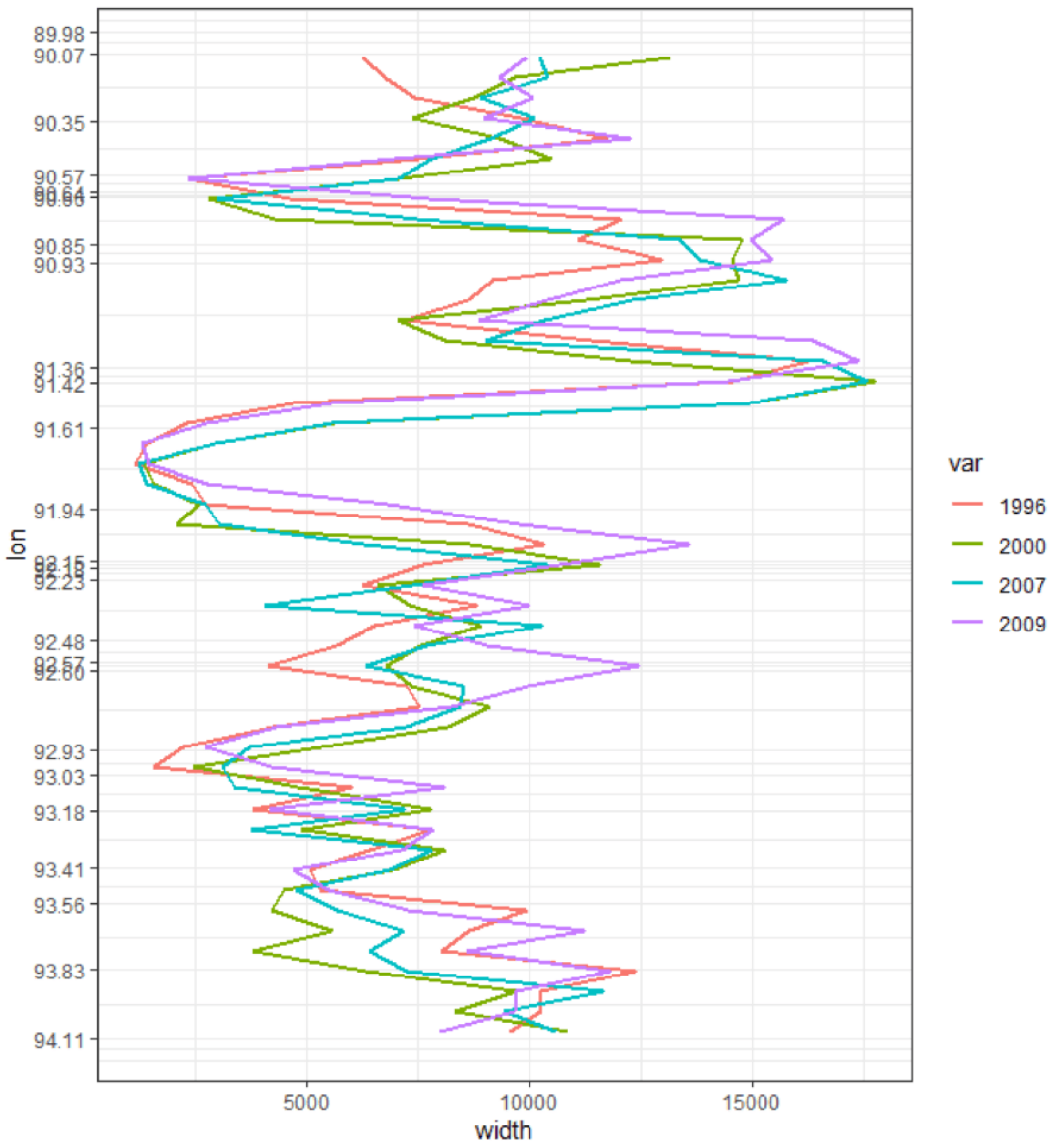
- We applied Hierarchical alternating least squares nonnegative matrix factorization (HALS-NMF) algorithm (Paterson and Heslop 2015) to unmix the grain size data of samples collected from the sand bars.

INTERPRETATION AND IMPLICATIONS

- The grain size distribution of the finest end member (EM1) is closely approximated to be of the surface sediment grain size distribution reported previously for the Brahmaputra river (Garzanti et al., 2011).

Grain size distribution	Mean	StDev	Skewness	Kurtosis
Suspended sediment (Garzanti et al., 2011)	18	1.7	0.3	3
EM1	18.74	2.55	-0.45	2.84
EM2	93.21	1.65	0.12	3.8
EM3	210.68	1.83	-3.37	18.93
EM4	382.38	1.76	-2.98	16.54

- We are indirectly able to estimate the proportion of suspended sediments in bed sediments.
- The proportion of finest end member (EM1) is variable along the main trunk which may be a function of the river's morphology and hydrodynamic conditions. The following figures show the variable width along the main trunk (Data from Karmarker et al., 2017).



- River when emerges from the low width section, the proportion of EM1 increases.

- But overall, sediments are getting finer at the downstream sections possibly due to the reduced flow energy in downstream regions.
- The findings may also be used to select samples and grain size classes for additional geochemical and mineralogical study in order to interpret signals of weathering, provenance and physical processes in the Brahmaputra's large dynamic floodplains at a finer spatial scale.

ABSTRACT

Superimposed signatures of grain size effect, lithology and chemical processes on fluvial sediments need to be resolved to answer the profound research questions related to sediment provenance and processes. Hydraulic forces sort the sediments into different grain size classes in the river water column. The finest fraction is transported as the suspended sediments which have different sediment composition than the bed sediments. Thus, suspended sediment may provide additional information about earth surface processes, such as chemical weathering. Hydraulically sorted river bed sediments may or may not provide this information, as bulk sample may be depleted in finer grains by hydraulic processes. Bed sediments that are easily sampled from the sand bars and river banks are often investigated to study the weathering intensity and sediment provenance. It is thus crucial to identify and quantify the specific grain size classes in the bulk sample to be investigated for the research question at hand.

End Member Modelling Algorithms (EMMA) for grain size distribution is a useful tool to unmix the grain size population into geological meaningful end members. We applied non-hierarchical alternating least squares nonnegative matrix factorization (HALS-NMF) algorithm to unmix the grain size data (62 samples) of river bed sediments collected from the freshly exposed sand bars of the Brahmaputra river over a stretch of 550km. The grain size distribution of the finest end member (mean=18μm) is closely approximated to be of the surface sediment grain size distribution reported previously for the Brahmaputra river. Thus, we were able to quantify the relative contribution of suspended sediment to the bed sediment of the Brahmaputra trunk. Results show that the contribution of the suspended sediments in the bed sediment is higher at the lower reaches of the river near floodplain outlet, possibly due to the reduced flow energy in downstream regions. The findings may also be used to select samples and grain size classes for additional geochemical and mineralogical study in order to interpret signals of weathering, provenance and physical processes in the Brahmaputra's large dynamic floodplains at a finer spatial scale.

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