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A MODEL TO QUANTIFY SEDIMENT MIXING ACROSS ALLUVIAL PIEDMONTS WITH CYCLES OF AGGRADATION AND INCISION

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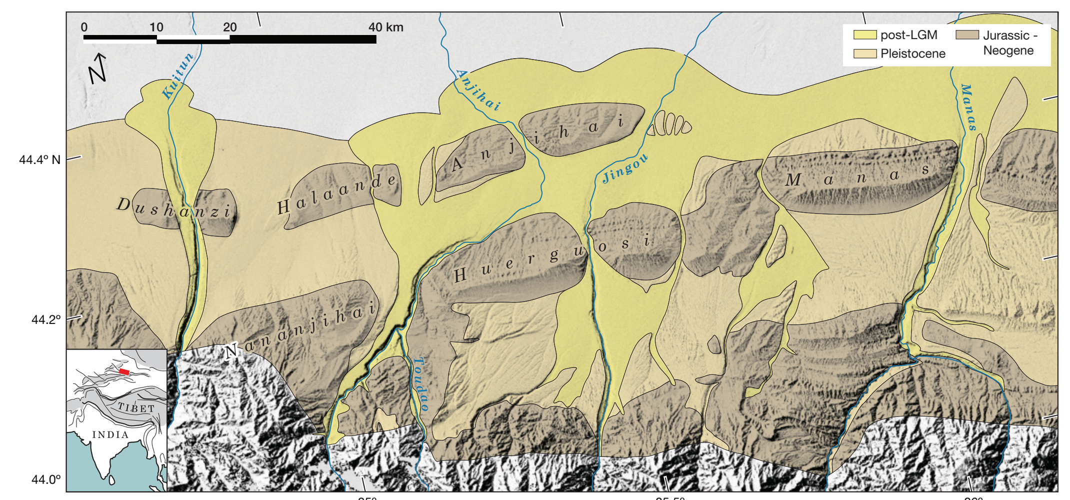
The northern piedmont of the East Tian Shan

Holocene river incision of 100 to 300 m in the N. alluvial piedmont of the East Tian Shan remobilizes a large volume of Pleistocene sediment and inject it in the modern sediment routing system.

The piedmont is built by repeated episodes of aggradation-incision and all the coarse sediment load reaching the basin is modified by mixing across the piedmont[a].

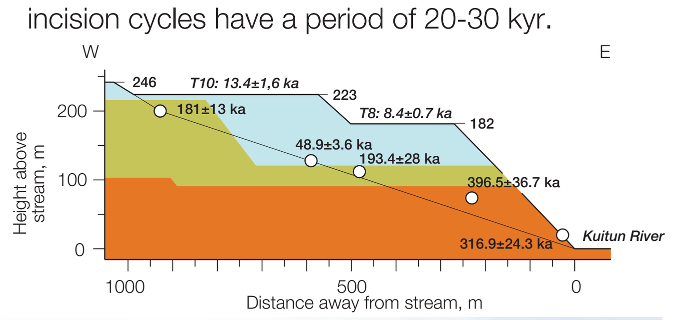
Our goal is to build a model that quantitatively describes, in a probabilistic framework, the degree of signal alteration in alluvial environments that aggrade and incise.

The lateral mobility of the rivers flowing on the piedmont is constrained by piercing points through active anticlines (below).



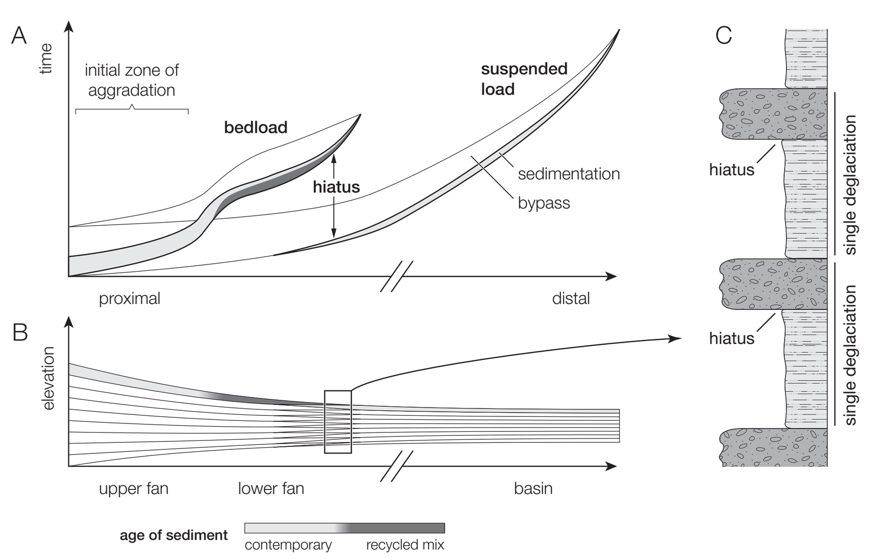
Fieldwork revealed that Middle Pleistocene deposits are currently mined by the incising river[a].

Below: samples in a tributary canyon of the Kuitun River shows at least 3 different generations of aggradation. Complete picture suggests aggradation incision cycles have a period of 20-30 kyr.



Deep sediment mining by a river of the piedmont in the last 5 kyr. The canyon is ca. 200 m deep in the background.

Without lateral constrains such as a bedrock ridge, the river has a near total freedom to migrate laterally on the aggraded fan before incising along a path that randomly changes from cycle to cycle.



Propagation of the bedload and suspended load of a sediment pulse in a time vs. distance space (Wheeler-type diagram).

The suspended load is immediately delivered to the basin. The bedload moves slowly, in two phases, first deposited directly in front of the high range and then remobilized by incision and transported to the foot of the piedmont (current situation in the north piedmont). The darker shade indicates bedload deposit with recycled material.

The sediment flux reaching the basin today is very largely dominated by material recycled from the alluvial fan and from the sediment lined upper valleys[b].

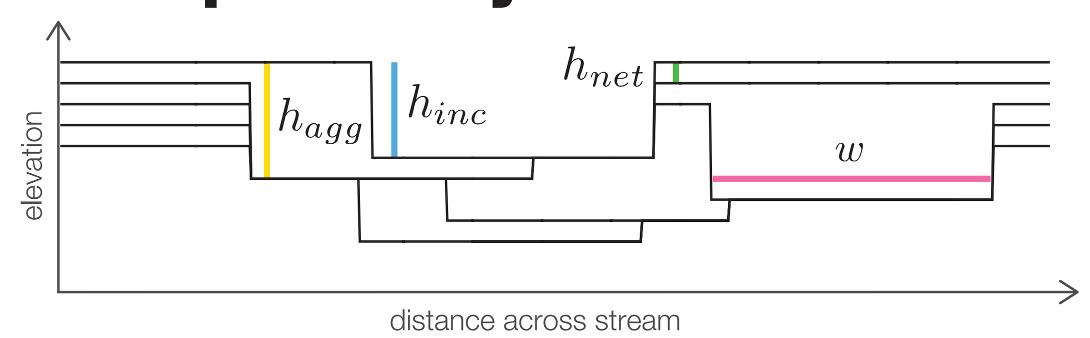
A mixing model to inform probabiltiy distributions

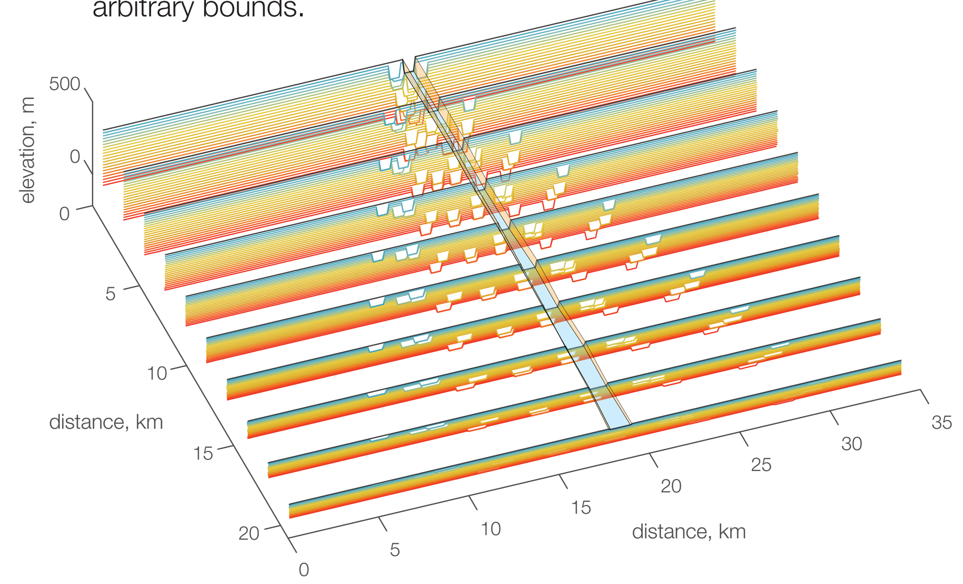
Model setup:

Model for aggradation-incision cycles needs few parameters that can be retrieved from field and remote sensing.

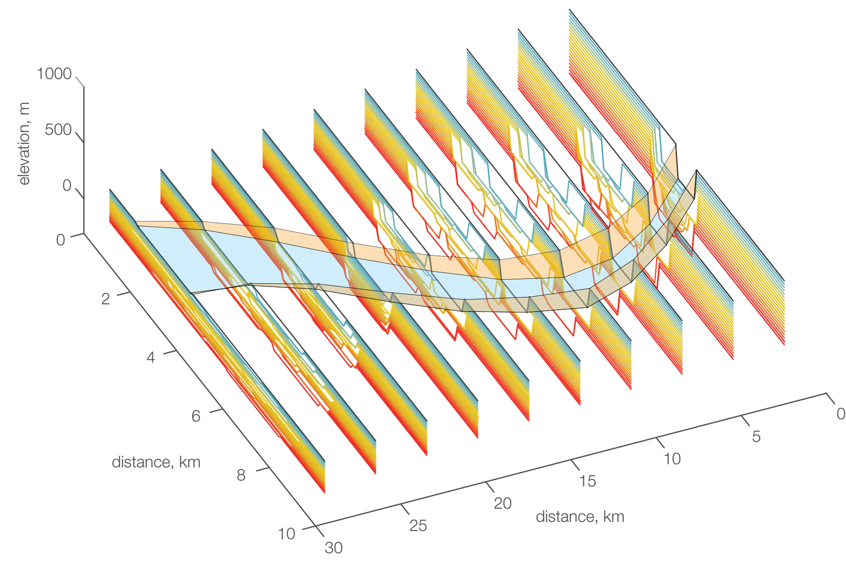
2D cross sections (right) are assembled in series (below) to create alluvial fan geometries.

The position of the river at each incision step is set by a random walk within arbitrary bounds.



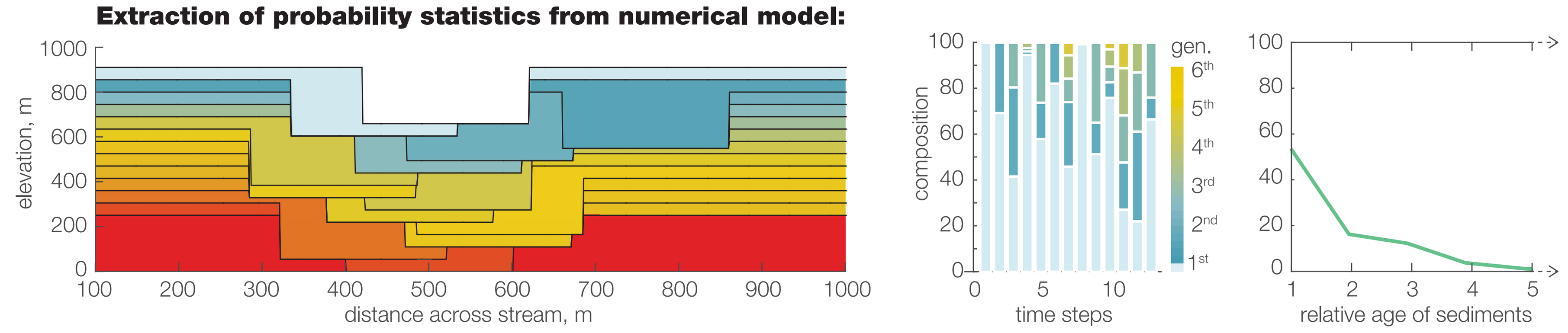


Alluvial fan with the river fanning out from the apex and incising along uniformly distributed paths.

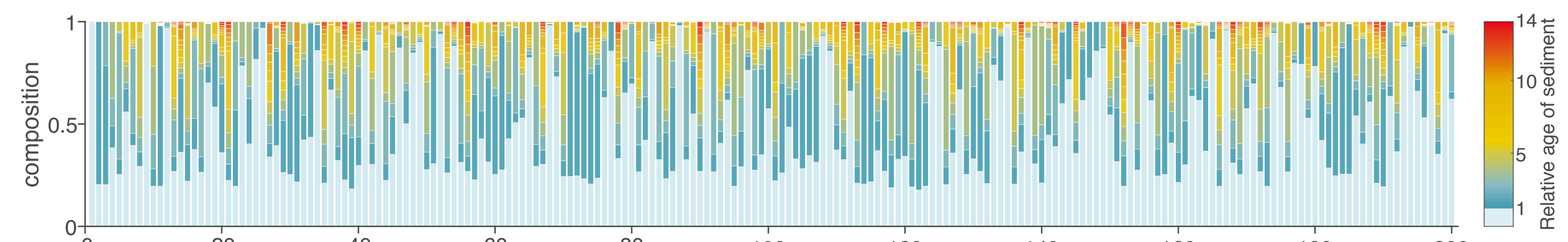


Alluvial fan with piercing point (at 20 km) restricting lateral motion.

Extraction of probability statistics from numerical model:



At every incision step, we track the relative amount of sampled generations in each cross-section (above left) and record it in a histogram that informs the distribution of ages for that run. But every run is unique because of the random migration.



Statistically relevant patterns (variability, min./max. amount of gen. n) emerge over reapeated aggradation-incision cycles.

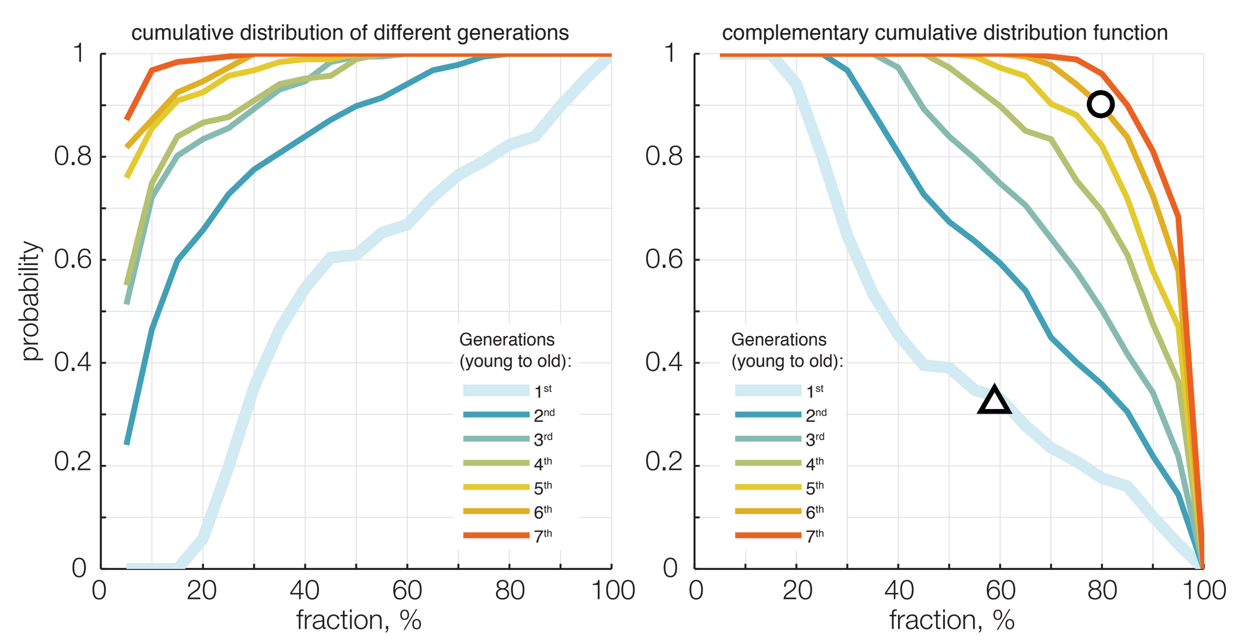
The probabilities of samping each generations are interdependant.

The probability of sampling a given amount of the n^{th} generation depends on the amount of all *non-n* generations already sampled (left).

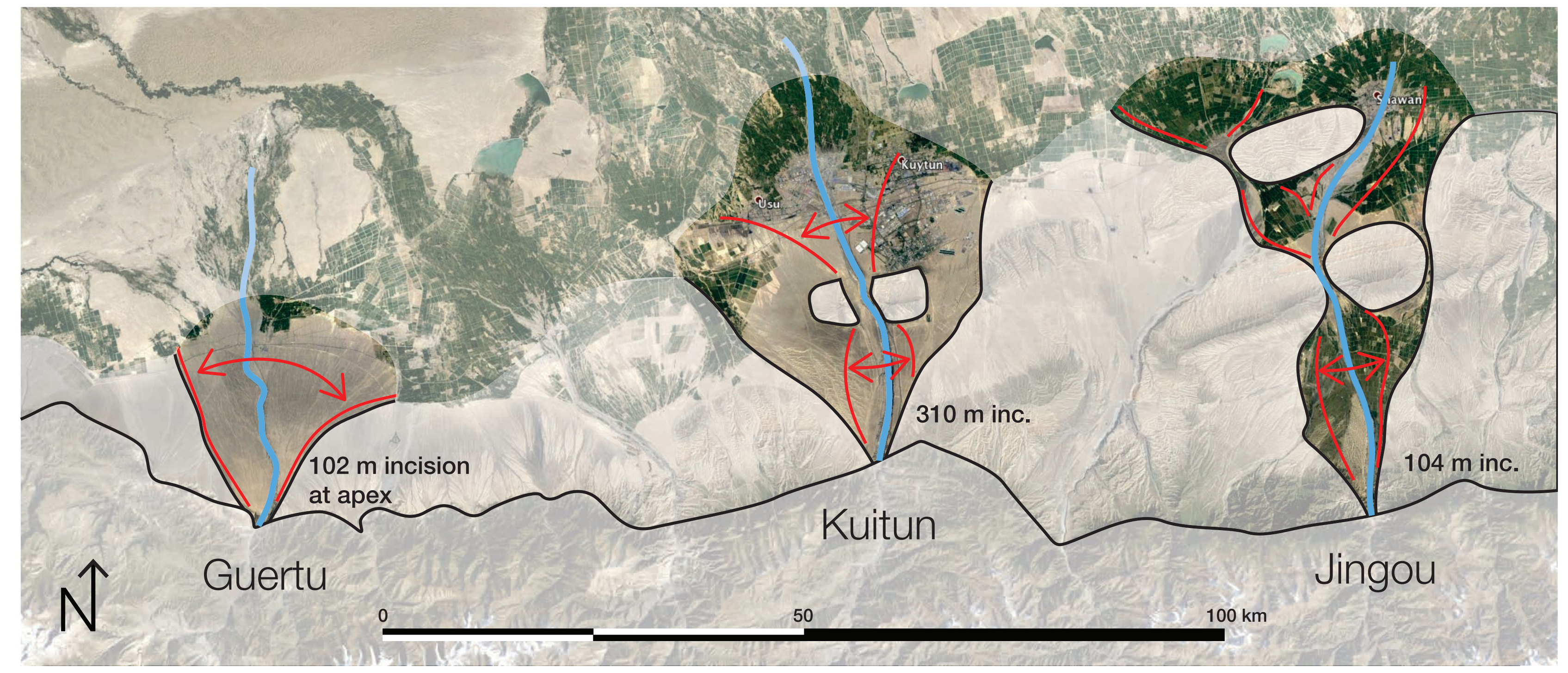
That relationship is contained in a complementary cumulative distribution function **CCDF** (right):

○ There is a 0.9 probability that at least 80% of the outflux is made of generation 6 and younger.

△ There is a 0.68 probability that at least 40% of the output is made of generation 1.



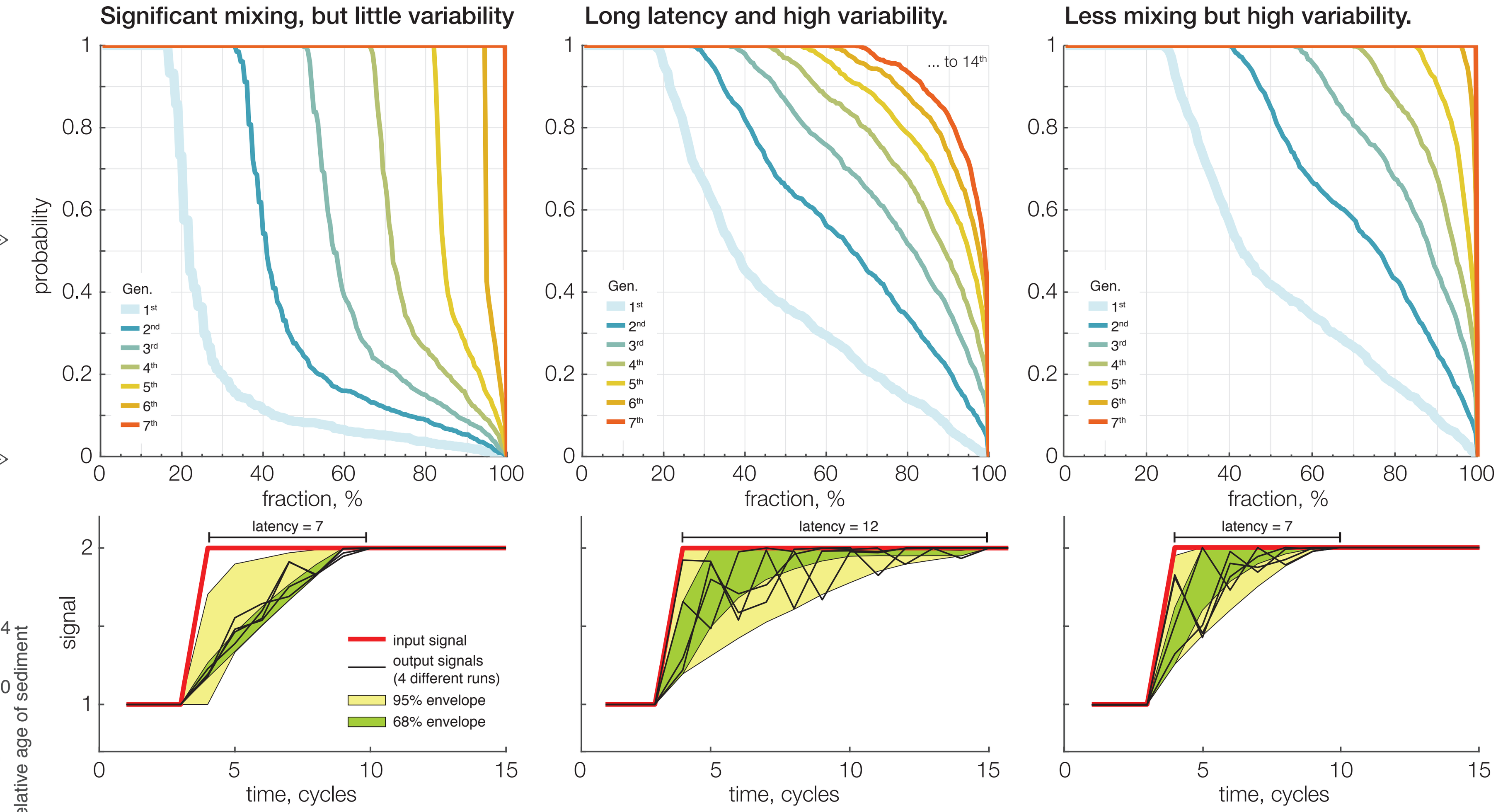
Distribution outputs charaterize local signal transfer



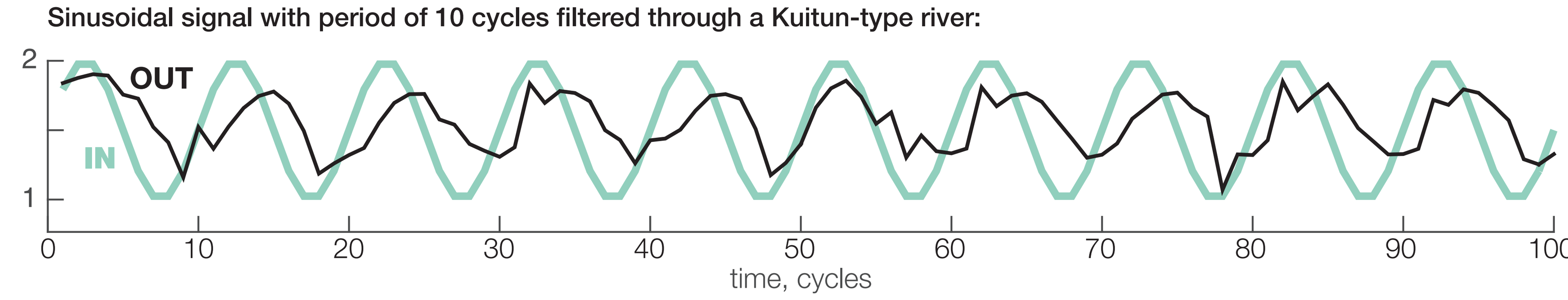
Guertu parameters: 100 m incision and unconstrained lateral motion. **Significant mixing, but little variability**

Kuitun parameters: 300 m incision and constrained lateral motion. **Long latency and high variability.**

Jingou parameters: 100 m incision and constrained lateral motion. **Less mixing but high variability.**



Sinusoidal signal with period of 10 cycles filtered through a Kuitun-type river:



Conclusion

Sediment recycling by aggradation-incision is described by a simple model based on few geometrical parameters that informs probability distributions.

Complementary cumulative distribution functions capture the degree of mixing.

Local degree of mixing and latency of signal transfer for specific field sites can be assessed with the model.

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a Malatesta, Avouac, Brown et al., *in review*.
Repeated cycles of piedmont aggradation and incision driven by climate variability during glacial periods in the Tian Shan. *in review at Basin Research*

b Guerit, et al. (2016).
Denudation intensity and control in the Chinese Tian Shan: new constraints from mass balanceon catchment-alluvial fan systems. *Earth Surface Processes and Landforms, vol. 411*

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