

Korelacije in naključno vzorčenje jedrskih podatkov

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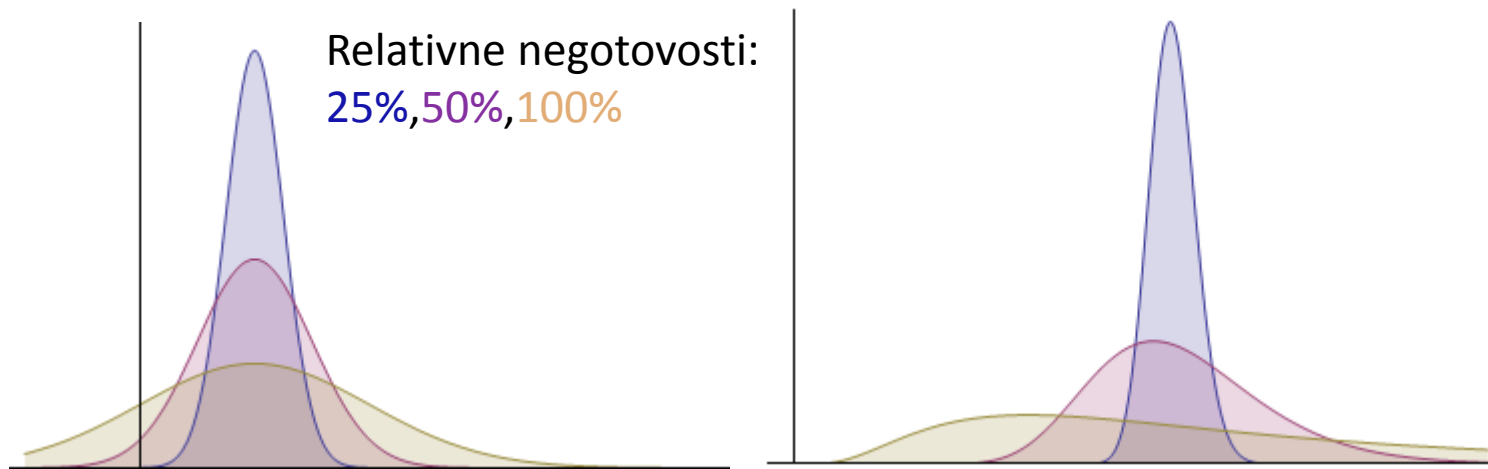
3. konferenca ŠFOSM

Reaktorski center Podgorica, 29. 2. 2016



Jedrski podatki in negotovosti

- Knjižnice: pričakovane vrednosti in kovariančne matrike parametrov.
- Porazdelitev: normalna ali lognormalna.



Generiranje naključnih vzorcev za $N(\mu, \sigma)$ (Box, Muller, 1958)

- v_m in w_m neodvisni vzorci enakomerne porazdelitve na $(0, 1]$
- $u_m = \sqrt{-2 \ln v_m \cos(2\pi w_m)}$
- vzorci $\{\mu + \sigma u_m\}_m$ konvergirajo proti $N(\mu, \sigma)$ za $m \rightarrow \infty$



Generiranje naključnih vzorcev za $LN(\mu, \sigma)$ ($\mu > 0$)

- $\mu' = \ln \frac{\mu}{\sqrt{1 + \left(\frac{\sigma}{\mu}\right)^2}}$
- $\sigma' = \sqrt{\ln \left(1 + \left(\frac{\sigma}{\mu}\right)^2\right)}$
- generiramo vzorec u_m za $N(\mu', \sigma')$
- $\{e^{u_m}\}_m \xrightarrow{m \rightarrow \infty} LN(\mu, \sigma)$



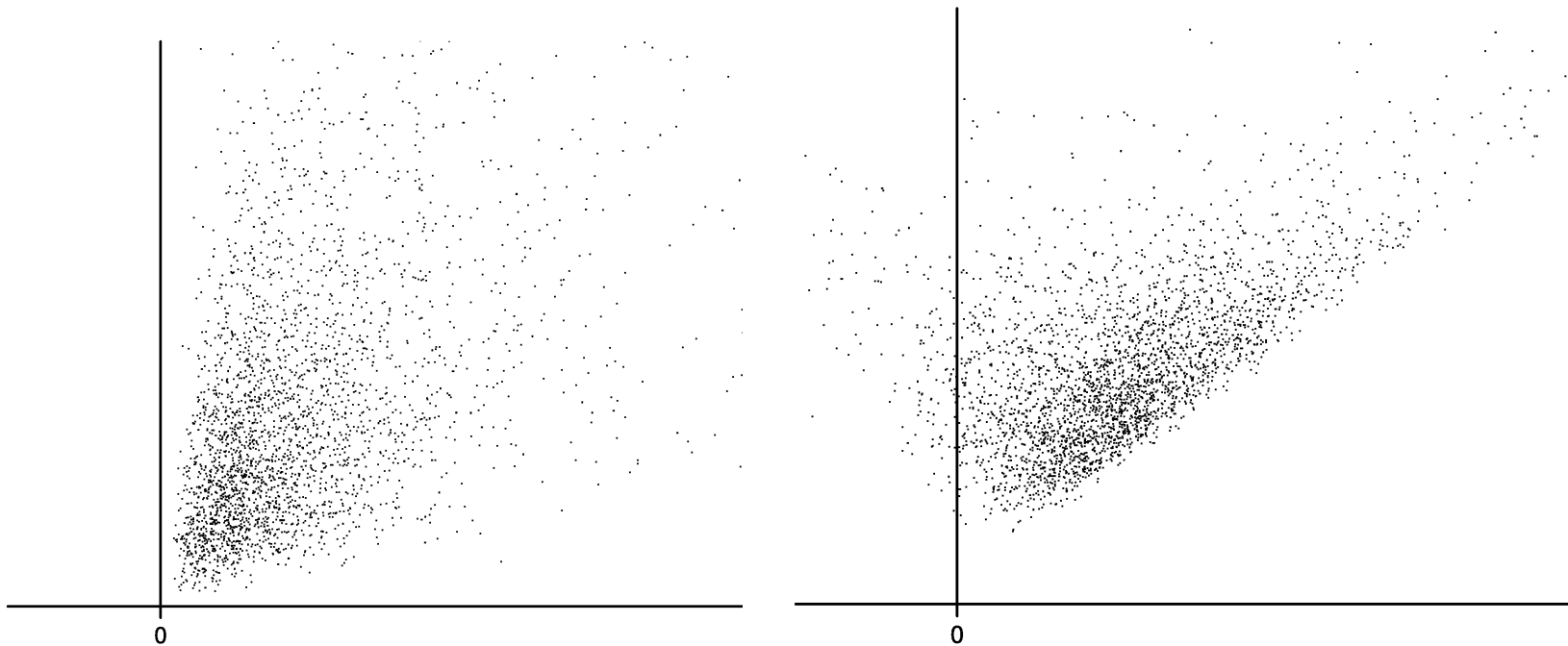
Generiranje naključnih

vektorjev za $N\left(\vec{\mu}, \vec{\sigma}, [c_{ij}]\right)$

- izračunamo naključni vektor u_m za $N(0,1)$ z neodvisnimi komponentami
- izračunamo takšno matriko A , da je $[c_{ij}] = AA^T$
- vzorec je enak $[\mu_i + \sigma_i(Au_m)_i]$



Porazdelitev (log)normalnih vzorcev



Generiranje naključnih vzorcev za kombinacijo N in LN

- $i \sim N$: izračunamo μ_i' in σ_i'

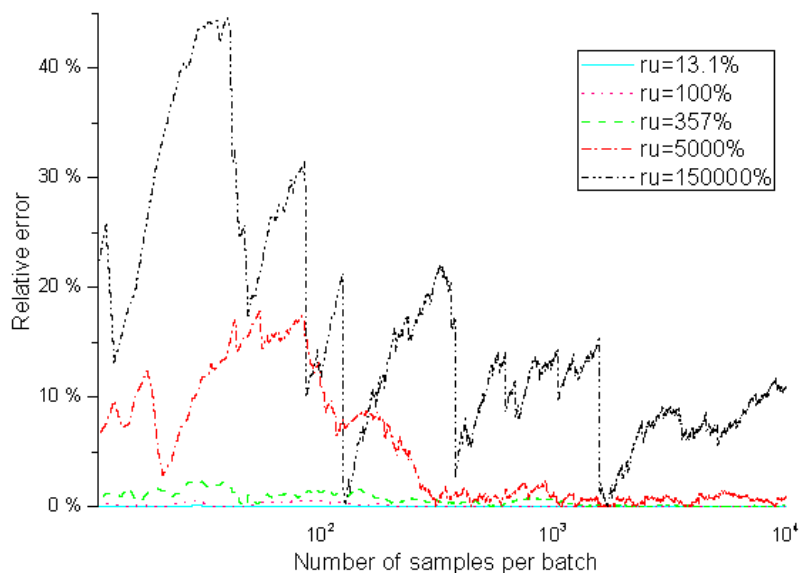
- $i \sim N$ in $j \sim LN$:
$$c'_{ij} = c_{ij} \frac{\frac{\sigma_j}{\mu_j}}{\sqrt{\ln\left(1 + \left(\frac{\sigma_j}{\mu_j}\right)^2\right)}}$$

- $i, j \sim LN$:
$$c'_{ij} = \frac{\ln\left(1 + c_{ij} \frac{\sigma_i \sigma_j}{\mu_i \mu_j}\right)}{\sqrt{\ln\left(1 + \left(\frac{\sigma_i}{\mu_i}\right)^2\right) \ln\left(1 + \left(\frac{\sigma_j}{\mu_j}\right)^2\right)}}$$

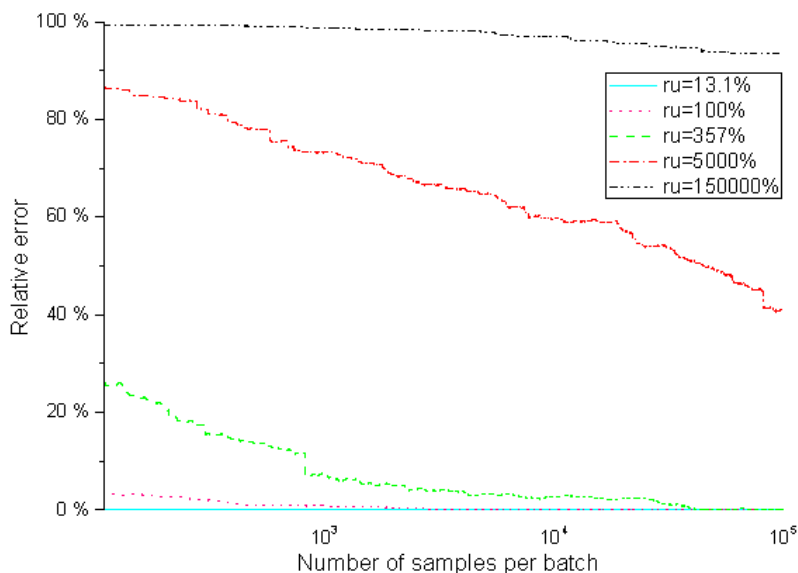


Hitrost konvergence vzorcev

- Povprečja

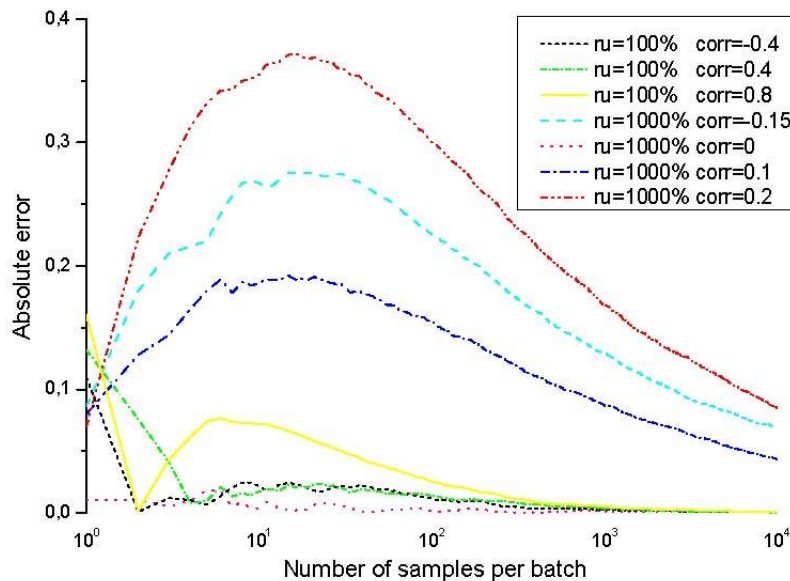


- Deviacije

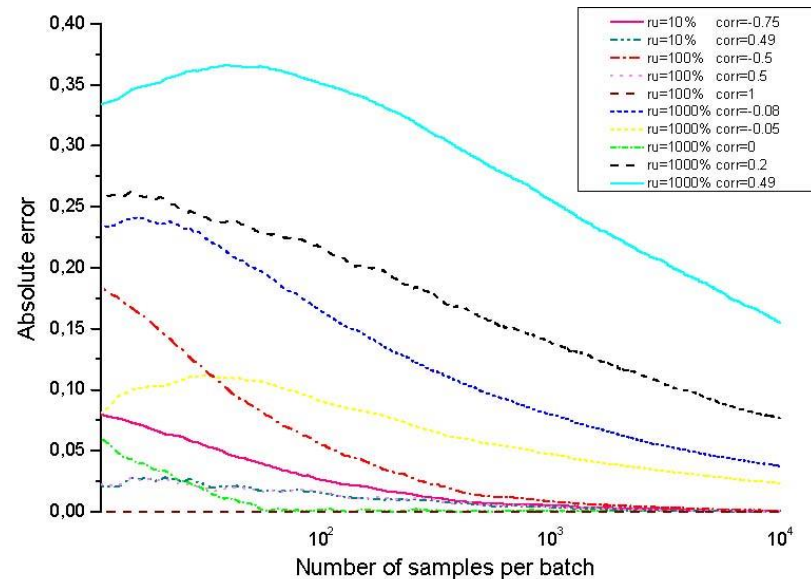


Hitrost konvergence korelacij

- normalen & lognormalen

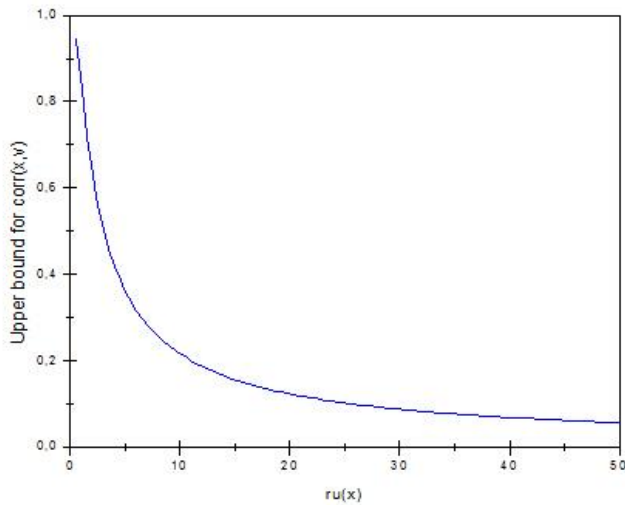


- dva lognormalna

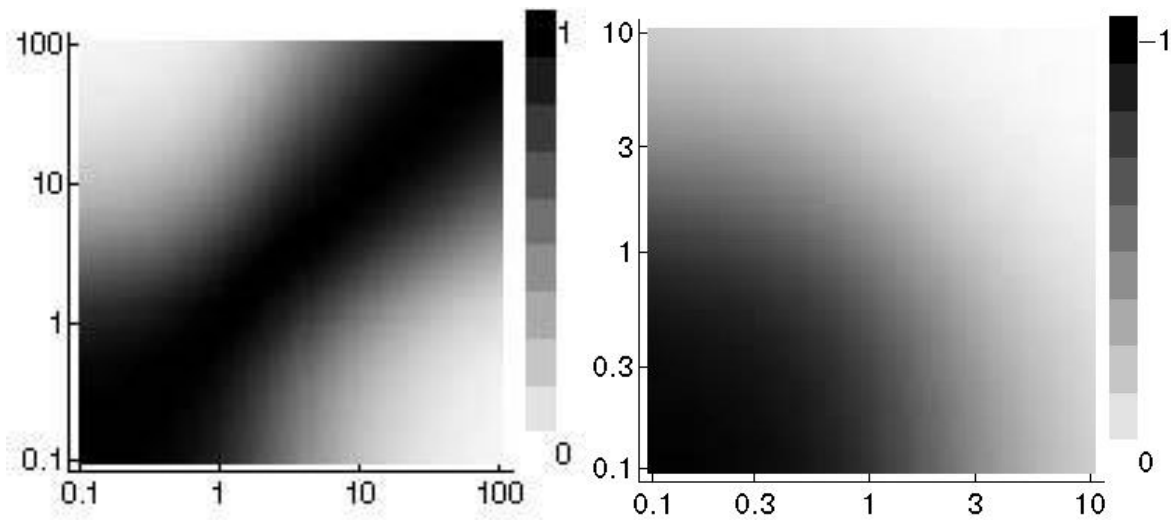


Korelacije lognormalnih parametrov

- z normalnim parametrom



- z lognormalnim parametrom



Problemi

- Lognormalni parametri z velikimi relativnimi negotovostmi konvergirajo počasi.
- Včasih se zgodi, da korelacijske matrice iz knjižnic niso pozitivno definitne.
- Pogosto se zgodi, da korelacijske matrice ne zadoščajo dodatnim zahtevam za korelacije lognormalnih parametrov.



Validacija korelacijskih matrik

| ENDF/B-VII.1 | JEFF 3.2 | JENDL 4.0 |
|--|--|----------------------------------|
| $^{232}\text{Th}, ^{238}\text{Np}$ | $^{34}\text{S}, ^{39}\text{Ar}, ^{66}\text{Zn}, ^{68}\text{Zn}, ^{70}\text{Zn}, ^{69}\text{Ga}, ^{71}\text{Ga}, ^{73}\text{Ge}, ^{75}\text{As}, ^{76}\text{Se}, ^{77}\text{Se}, ^{79}\text{Br}, ^{81}\text{Br}$ | ^{238}Np |
| | $^{85}\text{Rb}, ^{86}\text{Sr}, ^{87}\text{Sr}, ^{122}\text{Te}, ^{148}\text{Gd}, ^{166}\text{Er}, ^{168}\text{Er}, ^{170}\text{Er}, ^{169}\text{Tm}, ^{172}\text{Yb}, ^{176}\text{Yb}, ^{176}\text{Lu}$ | |
| | $^{197}\text{Au}, ^{203}\text{Tl}, ^{204}\text{Pb}, ^{205}\text{Pb}, ^{206}\text{Pb}, ^{207}\text{Pb}, ^{208}\text{Pb}, ^{209}\text{Bi}, ^{232}\text{Th}, ^{231}\text{Pa}, ^{241}\text{Am}$ | |
| $^{35}\text{Cl}, ^{37}\text{Cl}, ^{41}\text{K}, ^{46}\text{Ti}$ | $^{32}\text{S}, ^{34}\text{S}, ^{37}\text{Cl}, ^{39}\text{Ar}, ^{50}\text{Cr}, ^{53}\text{Cr}, ^{63}\text{Cu}, ^{65}\text{Cu}, ^{64}\text{Zn}, ^{66}\text{Zn}, ^{67}\text{Zn}, ^{68}\text{Zn}, ^{70}\text{Zn}, ^{69}\text{Ga}$ | $^{53}\text{Cr}, ^{55}\text{Mn}$ |
| $^{47}\text{Ti}, ^{48}\text{Ti}, ^{49}\text{Ti}, ^{50}\text{Ti}$ | $^{71}\text{Ga}, ^{70}\text{Ge}, ^{73}\text{Ge}, ^{75}\text{As}, ^{76}\text{Se}, ^{77}\text{Se}, ^{80}\text{Se}, ^{79}\text{Br}, ^{81}\text{Br}, ^{86}\text{Kr}, ^{85}\text{Rb}, ^{87}\text{Rb}, ^{86}\text{Sr}$ | ^{236}Np |
| $^{50}\text{Cr}, ^{53}\text{Cr}, ^{152}\text{Gd}$ | $^{87}\text{Sr}, ^{88}\text{Sr}, ^{90}\text{Zr}, ^{94}\text{Zr}, ^{122}\text{Sn}, ^{122}\text{Te}, ^{124}\text{Te}, ^{138}\text{La}, ^{136}\text{Ce}, ^{152}\text{Gd}, ^{153}\text{Gd}, ^{154}\text{Gd}$ | |
| $^{154}\text{Gd}, ^{155}\text{Gd}$ | $^{156}\text{Dy}, ^{158}\text{Dy}, ^{160}\text{Dy}, ^{166}\text{Er}, ^{167}\text{Er}, ^{168}\text{Er}, ^{169}\text{Er}, ^{170}\text{Er}, ^{169}\text{Tm}, ^{170}\text{Yb}, ^{171}\text{Yb}$ | |
| $^{157}\text{Gd}, ^{183}\text{W}, ^{184}\text{W}$ | $^{172}\text{Yb}, ^{173}\text{Yb}, ^{174}\text{Yb}, ^{176}\text{Yb}, ^{175}\text{Lu}, ^{176}\text{Lu}, ^{181}\text{Hf}, ^{185}\text{Re}, ^{187}\text{Re}, ^{186}\text{Os}, ^{187}\text{Os}$ | |
| $^{186}\text{W}, ^{232}\text{Th}, ^{236}\text{Np}$ | $^{188}\text{Os}, ^{189}\text{Os}, ^{195}\text{Pt}, ^{197}\text{Au}, ^{203}\text{Tl}, ^{204}\text{Pb}, ^{205}\text{Pb}, ^{206}\text{Pb}, ^{207}\text{Pb}, ^{208}\text{Pb}, ^{209}\text{Bi}$ | |
| | $^{232}\text{Th}, ^{231}\text{Pa}, ^{241}\text{Am}, ^{242}\text{Cm}, ^{244}\text{Cm}$ | |



Koda ENDSAM

- konsistentno vzorčenje resonančnih parametrov
- implementacija za ENDF-6 format
- validacija kode
- v prihodnosti razširjena na ostale jedrske podatke

