PROBABILISTIC FAULT DISPLACEMENT HAZARD ANALYSIS
IMPROVED METHODOLOGY AND APPLICATIONS

SCEC WORKSHOP ON PROBABILISTIC FAULT DISPLACEMENT: CRITICAL ISSUES, DATA NEEDS, AND INTERFACE PLANS
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OBJECTIVES OF THE PhD PROJECT

- Completing the dataset of distributed surface rupturing
- Model with updated empirical attenuation relationships
- Applicating the model to various rupturing kinematics

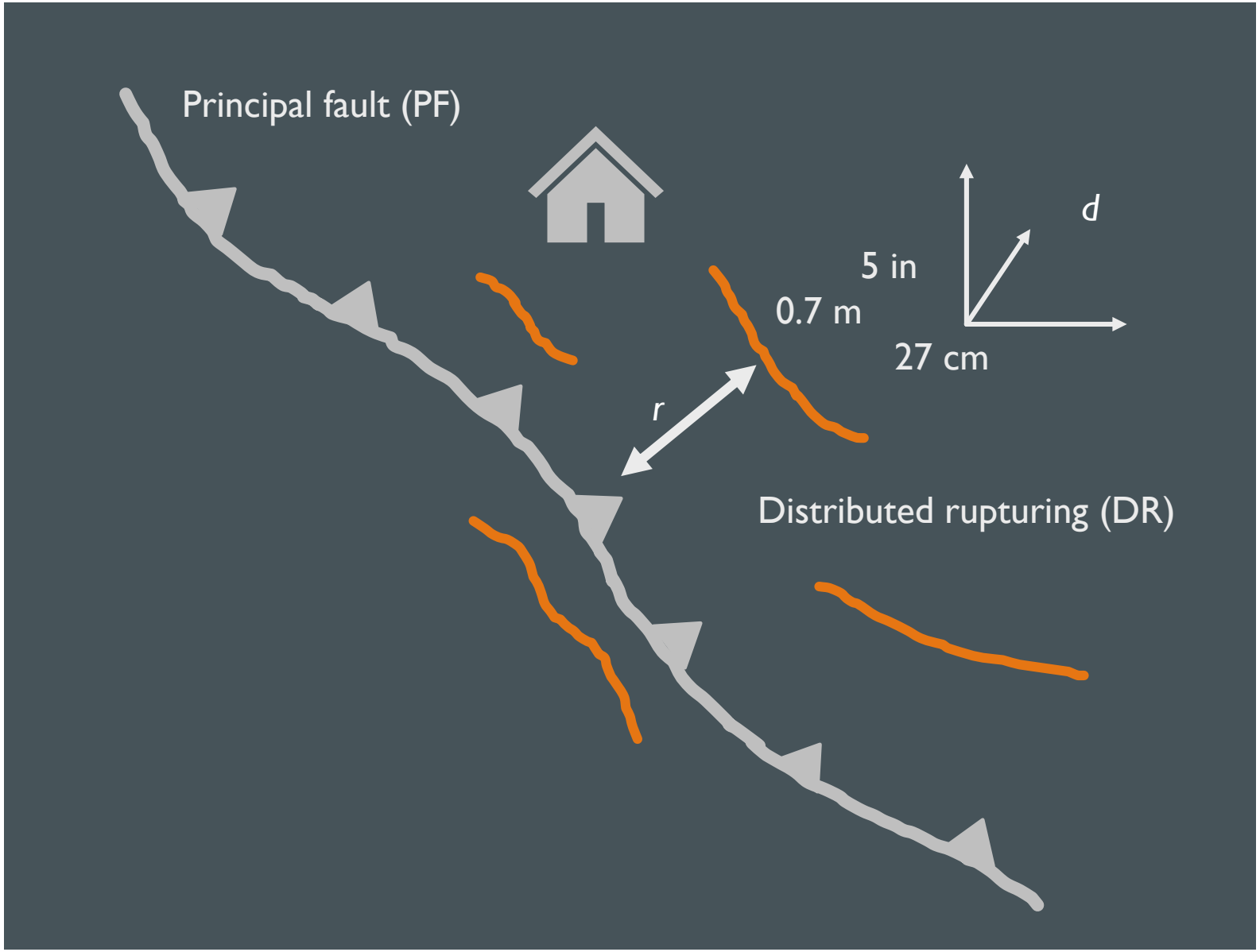
PFDHA?

I. Probability of surface faulting on PF

II. Displacement distribution along PF

III. Probability of DR at a distance *r* from PF

IV. Probability of exceeding a displacement *d* on DR



EMPIRICAL APPROACH: DATASET OF MODERN EARTHQUAKES

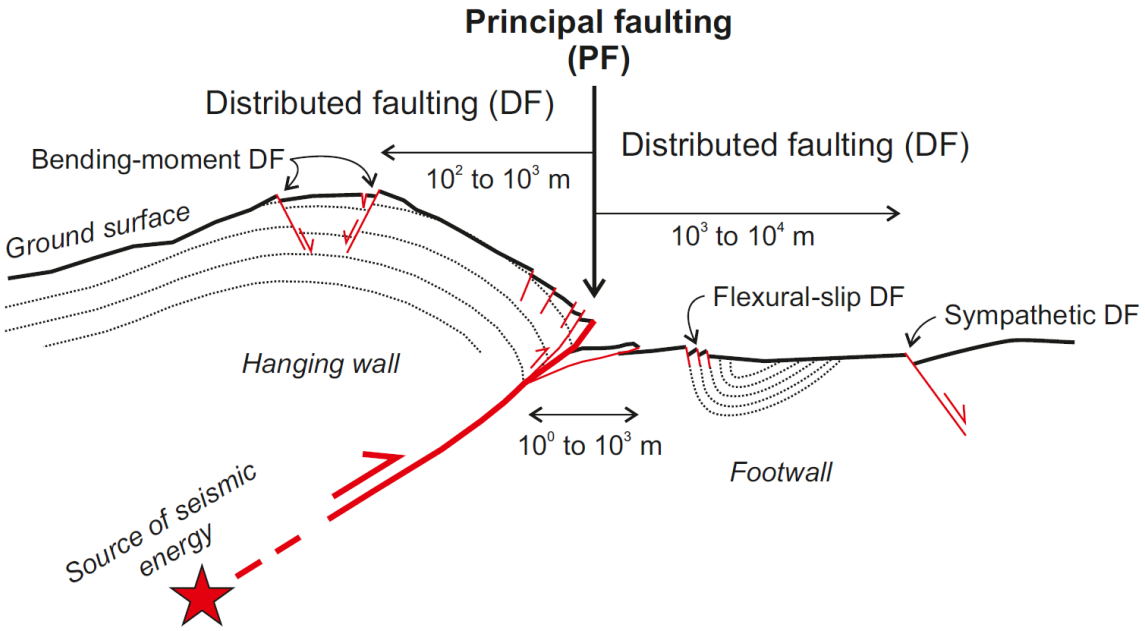
- Data
  - Boncio et al., 2018: Thrust: 12 earthquakes (M_w 5.4 – 7.9)
  - Baize et al., 2019 – *Seismological Research Letters*
    A Worldwide and Unified Database of Surface Ruptures (SURE) for Fault Displacement Hazard Analyses *(completed)*
  - Combined dataset soon in fault2sha.net
- Distributed rupturing analysis
  - Nurminen et al., *in prep*: rupture ranking and metrics

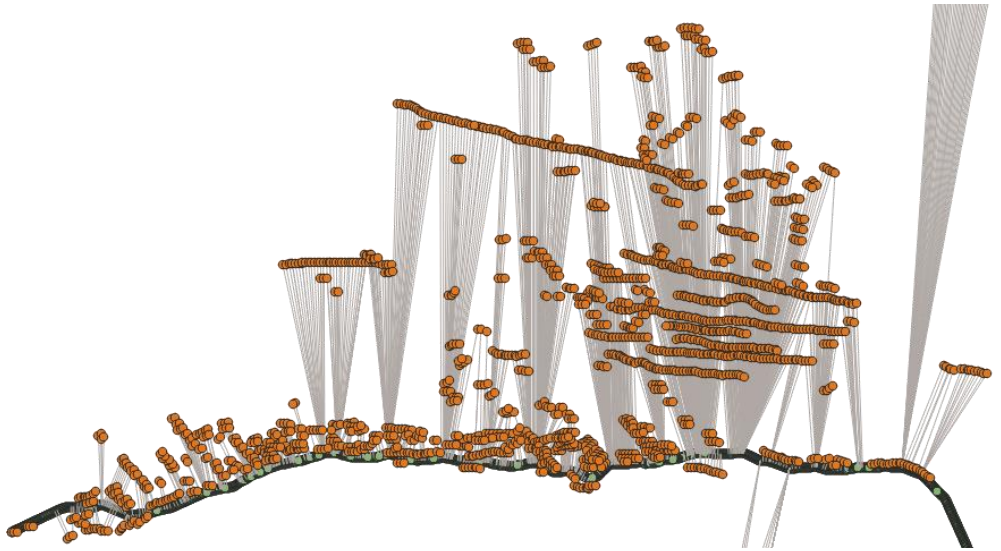
Earthquake	M_w	Kine-matics	SRL [km]	MD_v [m]	MD_n [m]	Types of DR
San Fernando 1971	6.6	R—LL	16	1.39	2.5	Simple, B-M, Sy
El Asnam 1980	7.1	R	31	5	6.5	Simple, B-M, F-S, Sy
Coalinga (Nunez) 1983	5.4	R	3.3	0.58	0.64	Simple
Marryat Creek 1986	5.8	R—LL	13	0.9	1.3	Simple
Tennant Creek 1988 (3 events)	6.3 6.4 6.6	R R—LL R	10.2 6.7 16		1.3 1.17 1.9	Simple Simple, Sy Simple
Spitak 1988	6.8	R—RL	25	1.6	2.0	Simple
Killari 1993	6.2	R	5.5	0.7	1.2	Simple
Chi-Chi 1999	7.6	R—LL	72	12.7	16.4	Simple, Sy
Kashmir 2005	7.6	R	70	3.4	7.05	Simple, B-M
Wenchuan 2008	7.9	R—RL	312	4.9	6.5	Simple
Nagano 2014	6.2	R	9.34	0.8	1.6	Simple
Petermann 2016	6.1	R-LL	20	0.9		Simple

Kinematics: R = reverse, LL = left-lateral, RL = right-lateral
SRL = surface rupture length of the principal fault (PF)

MD_v = maximum vertical dislocation along the PF
MD_n = maximum net dislocation along the PF
Types of DR: B-M = bending-moment, F-S = flexural-slip, Sy = sympathetic

III. IMPROVED METHODOLOGY: PROBABILITY OF DR OCCURRENCE



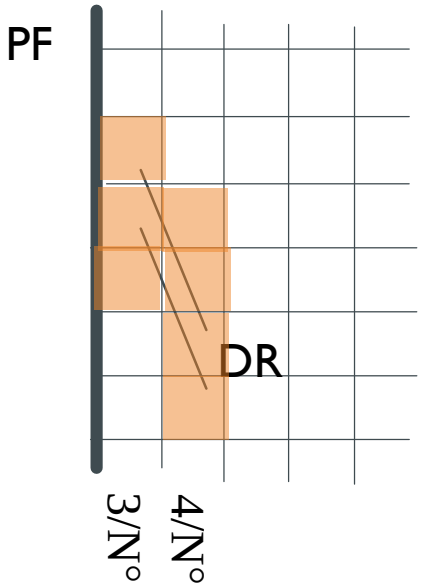


Principal fault defined based on continuity of trace and amount of slip San Fernando eq (1971)

- Distance DR → PF is measured within an interval ≤ chosen bin size (10 m)
  - Nearest distance between the points
  - Binning r and counting the bins containing *at least one* DR avoids over measuring

III. IMPROVED METHODOLOGY: PROBABILITY OF DR OCCURRENCE

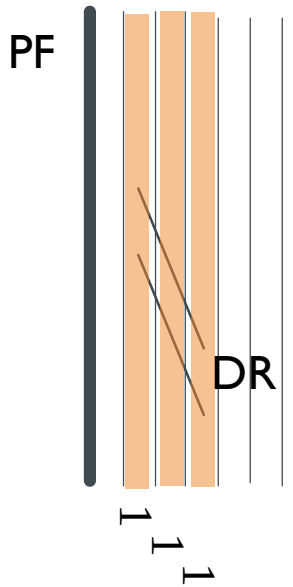
Gridding [e.g. Petersen et al., 2011]



Grid size ≥ 25 x 25 m

- Various grid pixel sizes tested; minimum 25 x 25 m
- 2D view: assumption of the completeness of the database

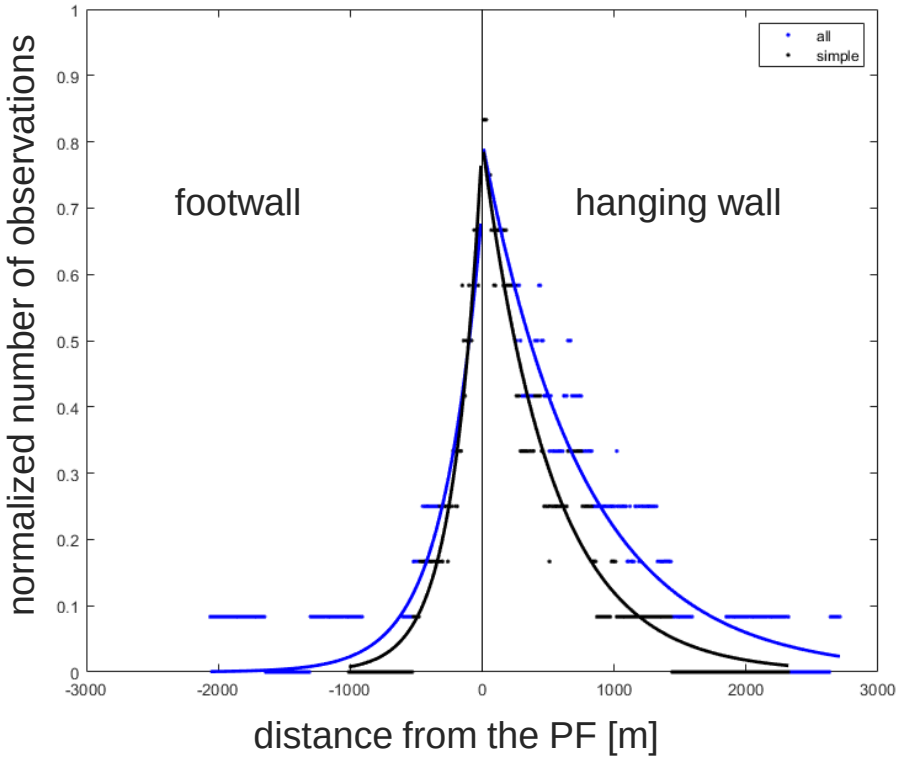
Slicing [Nurminen et al., *in prep.*]

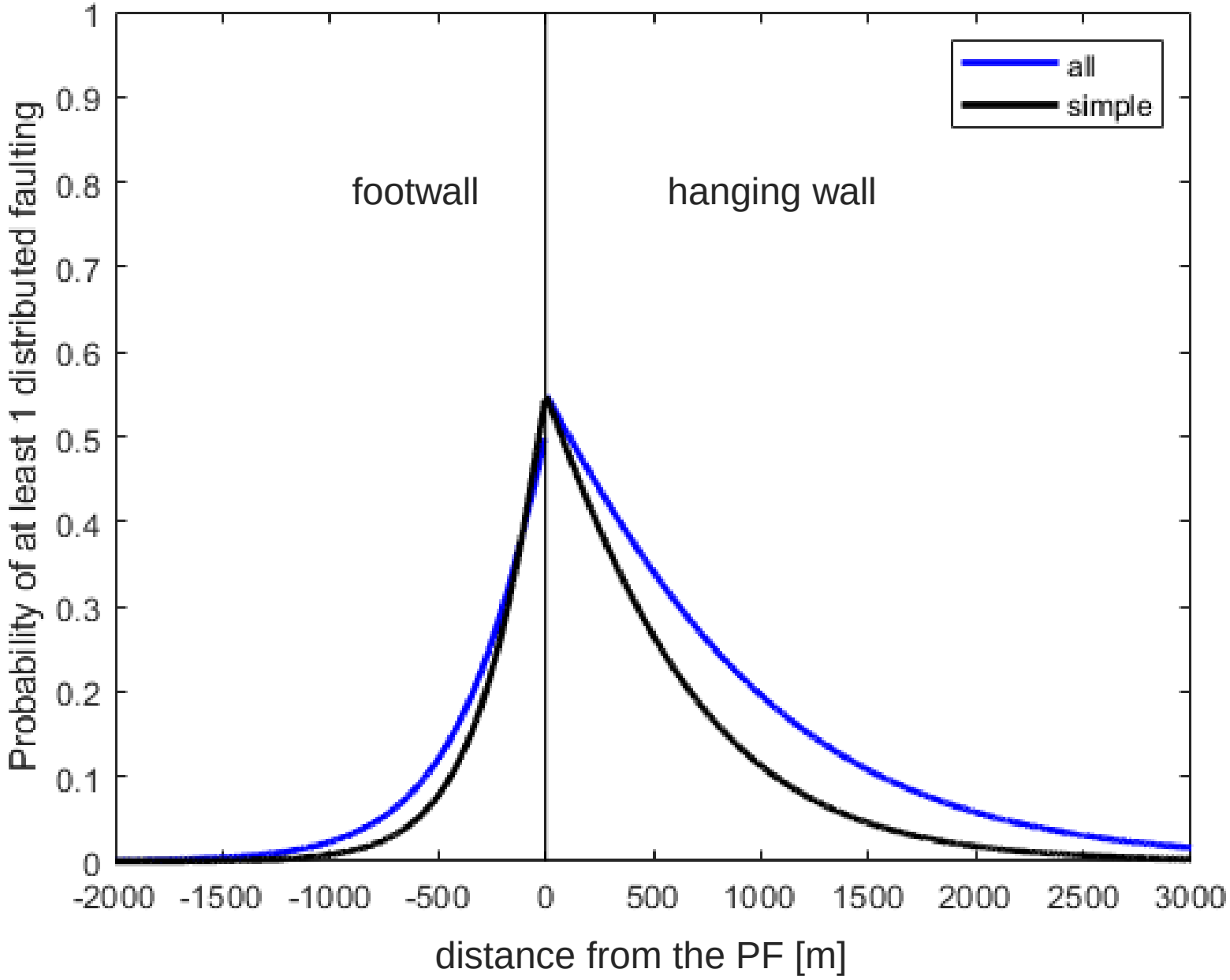


Bin width 10 m

- Measuring the distances from DR to PF allows testing variable bin sizes (when measure interval along DR strike ≤ bin width)
- 1D view: generalizing the probability along the PF strike

III. PROBABILITY OF DR OCCURRENCE





IV. PROBABILITY OF EXCEEDING A DISPLACEMENT LEVEL *d*

The amount of displacement is analysed using the

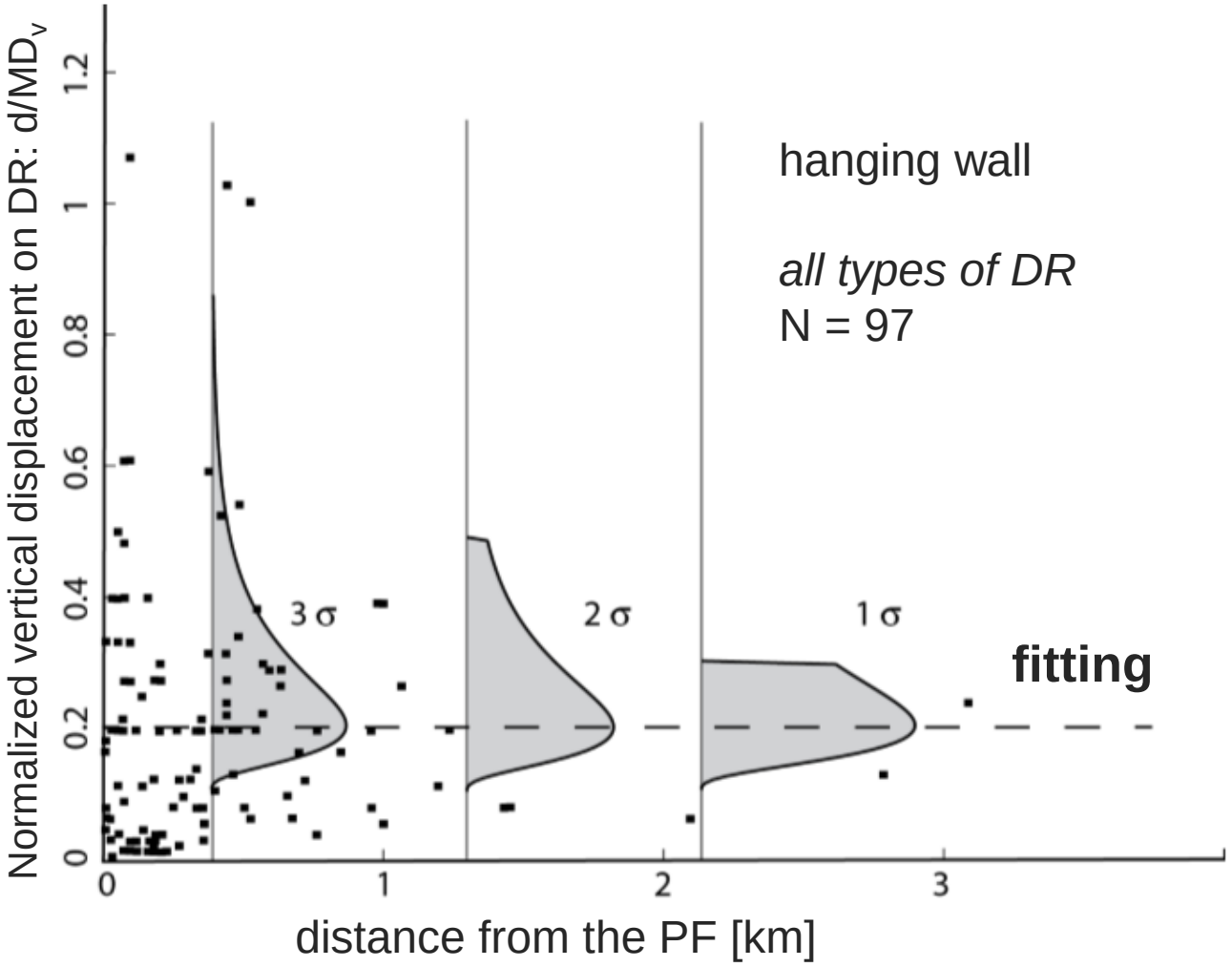
vertical slip parameter on DR,

normalized to the **maximum vertical displacement** on PF.

The observations suggest a decrease in the probability of exceedance levels of displacement higher than the median (dashed line) with the distance

two arbitrarily chosen truncation levels of the upper ends of the **probability curves**:

2 stand. dev. (1-2 km from the PF), and
1 stand. dev. (> 2 km from the PF)



NEXT STEPS

- Approach for DR analysis to normal and strike-slip earthquakes (SURE database)
- PF parameters (probability of occurrence and slip distribution: e.g. Lavrentiadis & Abrahamson 2019)
- User-friendly, open-source computing code for FDH (2021 - 2022)