Table DR1. GPS velocities used in the model.

Longitude	Latitude	Velocity east	Sigma east	Velocity north	Sigma north	Site name	Reference
-174.29	52.16	-3.09	0.78	-2.52	0.58	WNDA	Cross and Freymueller, 2008
-174.25	52.18	-3.93	0.61	-3.05	0.47	CHUN	Cross and Freymueller, 2008
-174.24	52.2	-3.41	0.72	-3.01	0.54	PUPA	Cross and Freymueller, 2008
-174.21	52.22	-1.94	0.26	-3.98	0.28	ATKA	Cross and Freymueller, 2008
-174.17	52.23	-2.93	0.84	-3.44	0.51	2-Dec	Cross and Freymueller, 2008
-166.53	53.89	-2.3	0.14	-2.82	0.24	DCH1	Cross and Freymueller, 2008
-166.52	53.92	-2.1	0.35	-3.93	0.33	GUNN	Cross and Freymueller, 2008
-166.52	53.9	-1.66	1.29	-2.42	1.05	SBS2	Cross and Freymueller, 2008
-166.48	53.85	-1.82	0.41	-3.83	0.35	ILIU	Cross and Freymueller, 2008
-165.94	54.14	-0.91	1.02	-3.18	0.67	AKSO	Cross and Freymueller, 2008
-165.87	54.11	-0.62	0.63	-5.24	0.48	BROD	Cross and Freymueller, 2008
-165.85	54.15	0.25	0.43	-3.74	0.37	AKPS	Cross and Freymueller, 2008
-165.73	54.1	-1.84	0.62	-3.72	0.48	AKHB	Cross and Freymueller, 2008
-163.52	55.04	-1.73	0.44	-2.69	0.36	KATY	Cross and Freymueller, 2008
-163.11	54.68	-3.18	0.82	-2.35	0.61	PANK	Cross and Freymueller, 2008
-162.8	54.49	-3.23	0.39	-3.5	0.34	CROW	Cross and Freymueller, 2008
-162.73	55.17	-2.25	0.63	-3.53	0.5	SATT	Cross and Freymueller, 2008
-162.62	54.38	-2.78	0.29	-3.28	0.29	PETE	Cross and Freymueller, 2008
-162.6	54.98	-3.58	1.41	-3.39	1	TELE	Cross and Freymueller, 2008
-162.52	54.86	-2.07	1.97	-2.61	1.45	REEF	Cross and Freymueller, 2008
-162.47	54.74	-2.36	2.31	-0.65	1.62	DAY	Cross and Freymueller, 2008
-162.37	54.63	-4.51	1.4	-3.83	1.02	CHRN	Cross and Freymueller, 2008
-162.36	54.82	0.28	1.98	-4.6	1.41	FAWN	Cross and Freymueller, 2008
-162.3	54.66	-0.1	3.03	-2.44	2.23	LAG	Cross and Freymueller, 2008
-162	54.76	-2.07	2.42	-2.63	1.69	LONE	Cross and Freymueller, 2008
-171.73	63.77	0	0.9	-5.2	1.4	GAMB	Freymueller et al., 2010
-170.25	57.15	-1.2	0.8	-4.4	1.5	SPSW	Freymueller et al., 2010
-166.14	61.52	1.6	2	-3.2	1.7	HOOP	Freymueller et al., 2010
-163.69	64.92	-1.2	1.3	-5.2	1.5	MELS	Freymueller et al., 2010

Longitude	Latitude	Velocity east	Sigma east	Velocity north	Sigma north	Site name	Reference
-162.61	66.89	1.8	1.7	-3.1	1.7	OTZF	Freymueller et al., 2010
-156.65	71.31	1.2	1.4	-1.6	1.5	S123	Freymueller et al., 2010
-156.61	71.32	1.4	0.4	-2.3	1.1	SG27	Freymueller et al., 2010
-151.53	66.91	0.5	3	-5	2.7	BTTA	Freymueller et al., 2010
-141.48	60.01	-21	0.4	27.7	1.2	AMBE	Freymueller et al., 2010
-142.07	60.05	-20.7	0.4	32.1	1.2	WHTU	Freymueller et al., 2010
-143.38	60.06	-20.3	0.4	30.7	1.2	DON	Freymueller et al., 2010
-142.43	60.06	-15.8	2.6	29	2.2	FURR	Freymueller et al., 2010
-142.51	60.08	-18.1	1.2	29.8	1.5	YAKK	Freymueller et al., 2010
-142.49	60.08	-18.5	4	29.7	3.3	G142	Freymueller et al., 2010
-142.49	60.08	-17.4	0.8	29	1.3	VYAK	Freymueller et al., 2010
-142.49	60.08	-12.1	4.5	34.1	4.6	YAK2	Freymueller et al., 2010
-142.49	60.08	-18.9	2	31.4	1.8	YAKR	Freymueller et al., 2010
-150.67	66.82	0.9	2	-6.7	1.9	W152	Freymueller et al., 2010
-149.58	68.08	2.1	1.1	-5.9	1.4	M155	Freymueller et al., 2010
-148.33	70.26	-1.4	0.4	-0.6	1.1	PBOC	Freymueller et al., 2010
-139.65	59.51	-22.5	0.4	42.7	1.2	YKTT	Freymueller et al., 2010
-139.4	59.67	-21.3	1	38.8	1.4	SITU	Freymueller et al., 2010
-139.13	59.88	-19.3	0.9	28.5	1.3	NQ1	Freymueller et al., 2010
-139.03	59.83	-16.5	0.8	28	1.3	NQ4	Freymueller et al., 2010
-138.99	59.57	-21	1.1	35	1.4	MOSR	Freymueller et al., 2010
-138.95	59.71	-19.4	0.6	30.7	1.2	HIDD	Freymueller et al., 2010
-138.86	59.67	-18.2	0.7	28.4	1.3	FLAT	Freymueller et al., 2010
-138.86	59.76	-19	0.7	16.4	1.3	MID	Freymueller et al., 2010
-138.73	59.5	-17.9	0.6	30.4	1.2	YAKU	Freymueller et al., 2010
-138.72	61.22	3.9	0.6	3.2	1.2	DEST	Freymueller et al., 2010
-138.64	59.67	-11.5	0.8	18.8	1.3	COMB	Freymueller et al., 2010
-138.63	59.16	-21.7	0.8	37.9	1.3	CANN	Freymueller et al., 2010
-138.56	59.57	-11.5	1.1	20.6	1.4	NOVA	Freymueller et al., 2010

Longitude	Latitude	Velocity east	Sigma east	Velocity north	Sigma north	Site name	Reference
-138.5	60.99	2.3	0.6	5.7	1.2	NSLM	Freymueller et al., 2010
-138.28	59.06	-15	4	25.2	3.4	HILL	Freymueller et al., 2010
-138.01	58.92	-19	1	32.5	1.4	WARR	Freymueller et al., 2010
-137.74	59.63	1.8	0.6	11.1	1.2	TATS	Freymueller et al., 2010
-135.22	60.75	1.3	0.4	2	1.2	WHIT	Freymueller et al., 2010
-133.71	59.59	2	0.6	3.5	1.2	ATLI	Freymueller et al., 2010
-133.71	59.59	2	0.6	3.5	1.2	ATLI	Freymueller et al., 2010
-130.03	58.44	0.6	0.6	1.3	1.2	DEAS	Freymueller et al., 2010
-117.76	70.74	0.6	0.7	-0.4	0.8	HOLM	Freymueller et al., 2010
-114.48	62.48	0.6	0.6	-1	1	YEL	Freymueller et al., 2010
-101.98	54.73	0.4	0.5	-1.3	1.1	FLIN	Freymueller et al., 2010
-145.85	63.5	-1.2	1.1	-0.7	1.4	ATT	Freymueller et al., 2010
-148.8	63.51	-2.8	1.5	-5.2	1.6	SLIM	Freymueller et al., 2010
-148.81	63.55	-1.1	3.3	-3	2.4	CARL	Freymueller et al., 2010
-148.83	63.65	-2.3	1.2	-0.9	1.5	GRIZ	Freymueller et al., 2010
-142.27	63.66	0.7	5.4	-5.4	4	999	Freymueller et al., 2010
-145.89	63.7	-1.4	0.8	-1.4	1.2	DNLY	Freymueller et al., 2010
-148.92	63.79	-1.7	0.9	-2	1.4	DFLY	Freymueller et al., 2010
-148.98	63.84	0.7	0.4	-2	1.2	GRNR	Freymueller et al., 2010
-145.79	63.91	1.7	0.9	-1.4	1.3	BSB4	Freymueller et al., 2010
-142.08	64.03	3.2	7.1	-16.8	4.9	2999	Freymueller et al., 2010
-145.85	64.15	-0.3	0.8	-2.8	1.3	PPLN	Freymueller et al., 2010
-149.29	64.17	0.3	1.5	-4.7	1.4	BRWN	Freymueller et al., 2010
-146.98	64.48	0.8	0.6	-2.7	1.2	SLCH	Freymueller et al., 2010
-149.08	64.58	-0.8	1.3	-5	1.5	NENA	Freymueller et al., 2010
-147.11	64.69	3.6	0.4	-0.9	1.2	4101	Freymueller et al., 2010
-147.86	64.87	1.4	0.4	-2.7	1.2	CLGO	Freymueller et al., 2010
-147.5	64.98	1.8	0.4	-2.2	1.2	FAIR	Freymueller et al., 2010
-144.68	65.5	1.4	0.4	-1.6	1.1	CENA	Freymueller et al., 2010

Longitude	Latitude	Velocity east	Sigma east	Velocity north	Sigma north	Site name	Reference
-141.77	60.75	-3.6	0.1	6.4	0.1	YESS	Elliott et al., 2008
-142.7	60.77	-5.7	0.1	8.4	0.1	TIME	Elliott et al., 2008
-143.41	61.12	-3.2	0.11	6.6	0.14	FARO	Elliott et al., 2008
-142.92	61.43	-3.7	0.21	5.6	0.18	MCAR	Elliott et al., 2008
219.1375	62.4078	2.8	1.2	4.8	1	BEA2	Leonard et al., 2007
219.1375	62.4078	2.9	1.2	7.4	1	BEA2	Leonard et al., 2007
211.0219	63.8356	1.3	2.1	-1.3	1.5	GRNR	Leonard et al., 2007
212.1399	64.8739	2	1.5	-2.4	1	CLGO	Leonard et al., 2007
212.5008	64.978	2.1	1.5	-2.4	1	FAIR	Leonard et al., 2007
211.9665	70.0256	-1.7	1	0.2	0.9	PBOC	Leonard et al., 2007
220.5654	64.0523	1.6	3.7	-0.9	0.4	DAWS	Leonard et al., 2007
221.2781	61.2169	3.5	2.5	4.1	1.4	DEST	Leonard et al., 2007
221.3056	63.9585	1.8	3	0.1	1.8	FLAT	Leonard et al., 2007
221.5036	60.9927	2.3	2.2	7.1	0.5	NSLM	Leonard et al., 2007
221.9595	60.9577	-0.4	2.4	6.1	1	MOTD	Leonard et al., 2007
222.9372	60.8592	2.7	1.7	2.7	1.3	CANY	Leonard et al., 2007
222.9458	60.3762	0.3	2.5	3	2.3	DEZA	Leonard et al., 2007
223.1811	59.9727	2	0.9	3	1.1	489F	Leonard et al., 2007
223.5346	59.5815	0	2.8	4.7	0.9	BEUT	Leonard et al., 2007
223.8745	67.0978	0.7	0.6	1	2.9	RICH	Leonard et al., 2007
224.0813	63.6567	1.2	0.8	3	0.5	WARE	Leonard et al., 2007
224.303	58.4178	0.2	0.7	3.8	0.7	GUS2	Leonard et al., 2007
224.303	58.4178	-0.3	0.7	6	0.7	GUS2	Leonard et al., 2007
224.7779	60.7505	1.7	0.7	3.1	0.7	WHIT	Leonard et al., 2007
224.7779	60.7505	2.8	0.7	2.1	0.7	WHIT	Leonard et al., 2007
226.2855	59.5895	1.5	0.8	2.5	0.4	ATLI	Leonard et al., 2007
226.4731	68.3062	1.2	0.7	0.6	0.8	INVK	Leonard et al., 2007
226.9072	56.4657	-3	0.8	3.6	0.8	LEV1	Leonard et al., 2007
227.184	60.2103	2.9	1.7	2	2	TSLN	Leonard et al., 2007

Longitude	Latitude	Velocity east	Sigma east	Velocity north	Sigma north	Site name	Reference
227.5125	61.9691	-0.4	1.3	0.9	3	ROSR	Leonard et al., 2007
227.589	61.9011	0	1.9	-0.7	2.5	COLA	Leonard et al., 2007
228.4005	55.0691	0.1	0.7	5.1	0.7	AIS1	Leonard et al., 2007
228.5717	62.4241	1	1	-1	0.4	CARI	Leonard et al., 2007
229.9743	58.4256	1.1	0.9	1.7	0.7	BCDL	Leonard et al., 2007
230.7967	60.7353	-1.1	1.5	0	1.1	SIMP	Leonard et al., 2007
234.7501	71.9903	1	1.1	-0.4	1.5	SACH	Leonard et al., 2007
237.4151	58.8403	0	0.7	-0.9	0.7	BCFN	Leonard et al., 2007
239.2506	56.2462	0.6	0.5	-0.8	0.6	BCFJ	Leonard et al., 2007
242.2388	70.7363	0	0.8	0.3	0.9	HOLM	Leonard et al., 2007
245.5193	62.4809	0.2	5	-0.4	0.4	YELL	Leonard et al., 2007
237.08	50.13	2.3	0.5	1.9	0.7	WSLR	Mazzotti et al., 2003
237.63	47.39	2.8	0.5	4	0.5	RPT1	Mazzotti et al., 2003
237.69	47.65	3.2	0.5	4	0.5	SEAT	Mazzotti et al., 2003
237.78	48.52	2.5	0.5	2.8	0.5	SEDR	Mazzotti et al., 2003
237.83	52.24	-0.6	0.4	0.3	0.5	WILL	Mazzotti et al., 2003
237.99	47.5	2.2	1	4.9	1.3	PUPU	Mazzotti et al., 2003
237.99	49.16	2	0.5	2	0.5	CHWK	Mazzotti et al., 2003
238.17	47.94	3.5	1.1	3.1	1.1	LKCP	Mazzotti et al., 2003
239.46	47	1.3	0.5	2.8	0.5	LIND	Mazzotti et al., 2003
239.9	49.32	0.3	0.2	1.1	0.4	DRAO	Mazzotti et al., 2003
239.9	49.57	0.3	0.5	1.4	0.6	SMLD	Mazzotti et al., 2003
232	51	-0.823	0.1	3.339	0.1	1-Nov	McCaffrey et al., 2007
234.5	53	2.141	0.1	2.718	0.1	sov1	McCaffrey et al., 2007
235	50	1.999	0.1	2.687	0.1	sov2	McCaffrey et al., 2007
237	49	2.013	0.1	2.561	0.1	sov3	McCaffrey et al., 2007
237	47.75	1.842	0.1	3.28	0.1	olym	McCaffrey et al., 2007
191.937875	65.614982	1.7	1.2	-4.8	1.6	AB09	PBO (Nov 2009)
194.626542	64.564497	1.1	0.9	-3.8	1.1	AB11	PBO (Nov 2009)

Longitude	Latitude	Velocity east	Sigma east	Velocity north	Sigma north	Site name	Reference
195.433431	65.55385	1.1	0.7	-3	0.9	AC50	PBO (Nov 2009)
197.760874	64.637977	1.2	0.5	-4.6	0.4	AC31	PBO (Nov 2009)
198.713384	65.961294	0.9	0.9	-4.5	0.6	AC07	PBO (Nov 2009)
200.121639	61.039753	1.3	1.4	-4.6	0.5	AB15	PBO (Nov 2009)
200.908469	59.108167	-2	0.4	-2.1	0.7	AB14	PBO (Nov 2009)
203.095111	67.055887	0.3	0.9	-4.4	0.6	AB27	PBO (Nov 2009)
203.347245	58.681573	-1	0.7	-3	0.5	AC24	PBO (Nov 2009)
214.78737	66.559347	-0.3	2.8	-5.7	2	AB39	PBO (Nov 2009)
209.827457	67.251013	1	0.7	-5	0.4	AB33	PBO (Nov 2009)
214.432099	68.120672	1.3	0.7	-3.5	1.3	AB46	PBO (Nov 2009)
211.128849	68.760495	-0.5	0.9	-3.2	0.8	AB45	PBO (Nov 2009)
297.659536	82.494294	-1.1	0.5	-1.3	0.3	ALRT	PBO (Nov 2009)

Table DR1. GPS velocities used in the model.

Fault	Sense of motion	Published Slip Rates (mm/yr)								Modeled Slip Rates (mm/yr)
		A	B	C	D	E	F	G	H	
Aleutian Megthrust East	Reverse	48	50					35-50		**40.5**
Aleutian Megathrust West	Reverse		62					57-65		**47.2**
Bruin Bay	Reverse	<1								**1.2**
Central Mckenzie Mtns	Reverse			1.8						**0.4**
Castle Mtn	Reverse-dextral	1.3		5.9	2.9					**3.1**
Chatham Strait	Right-lateral							0-4		**0.5**
Totschunda-Fairweather Connector	Right-lateral	7.9							3	**7.0**
Chugach-St. Elias	Reverse	22		17.8				24		**21.5**
Dawson Thrust	Reverse-dextral			1.4						**0.3**
Denali-a	Right-lateral	2.6		2.0-4.5					2	**4.1**
Denali-b	Right-lateral	7		10.2			7.5-10.5	5-8		**4.7**
Denali-c	Right-lateral	11		10.2			7.3-12.1	5-8		**4.9**
Denali-d	Right-lateral	8.8		7			7.5-11.7	5-8		**2.6**
Denali-e	Right-lateral	4.5								**0.9**
Dall City Seismic Zone	Left-lateral					1.3-1.6				**0.4**
Duke River	Reverse-dextral			3.4					3	**5.3**
Fairweather	Right-lateral	39.7	48-58	27.3	48.5-49			36-41	42.9	**34.7**
Fairbanks Seismic Zone	Left-lateral					1.3-1.6				**1.4**
Iditarod-Nixon Fork	Right-lateral									**0.6**
Kaltag-Tanana	Right-lateral									**0.5**
Kayak Island	Reverse	1								**9.5**
Kobuk	Reverse									**0.2**
Medicine Lake-Tintina	Reverse-dextral			0.5						**0.7**
Minto Flats Seismic Zone	Left-lateral					1.3-1.6				**1.4**
North Mckenzie Mtns	Right-lateral			8.2						**1.3**
NE Brooks Range	Normal-sinistral			0.7						**0.6**
Pamplona	Reverse	12	41							**10.3**
Queen Charlotte	Right-lateral	42	22		49			37-46	43.9	**33.7**
Richardson Mtns	Right-lateral			2.1						**0.7**
Rampart Seismic Zone	Left-lateral					1.3-1.6				**0.4**
S Mckenzie Mtns	Reverse			4						**0.9**
Salcha Seismic Zone	Left-lateral					1.3-1.6				**2.0**
Totschunda	Right-lateral	5.8	8		6		4.8-6.8	4.8-6.8	6	**3.6**
Transition	Reverse-dextral	23	10		6				8	**5.7**

Table DR2. Published and modeled fault slip rates.

A - Kalbas et al., 2007; B - Plafker et al., 1994; C - Leonard et al., 2007; D - Wesson et al., 2007; E - Carver et al., 2008; F - Matmon et al., 2006; G - Lundgren et al., 1995; H - Elliott et al., 2010.

Model	Total SSM	Dof	RMS Misfit
Strain rate	135.62	5733	0.15
Velocity	131.78	340	0.63

Table DR3. Misfits for strain rate and velocity field for best-fit model.

Total SSM is the sum of squared misfit between the modeled and observed strain rate and velocity components. Each squared misfit in the summation is weighted by the variance in observed strain rate or velocity component. The number of degrees of freedom (Dof) is three times the total number of grid areas for strain rate and two times the number of grid areas with GPS sites for velocities. RMS misfit is the square root of the quantity total SSM divided by the number of degrees of freedom.

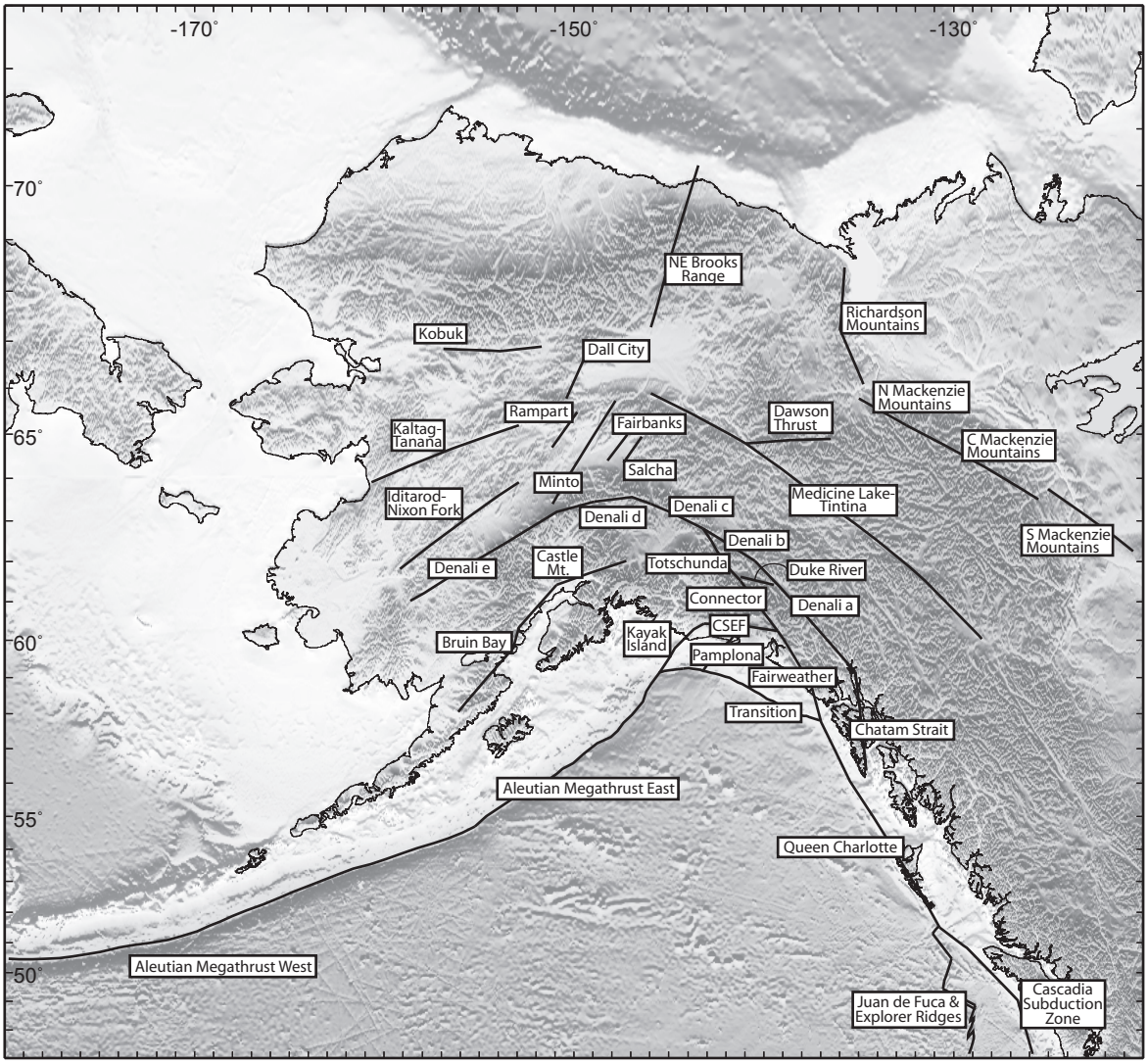

Figure DR1. Map showing the location of modeled faults.

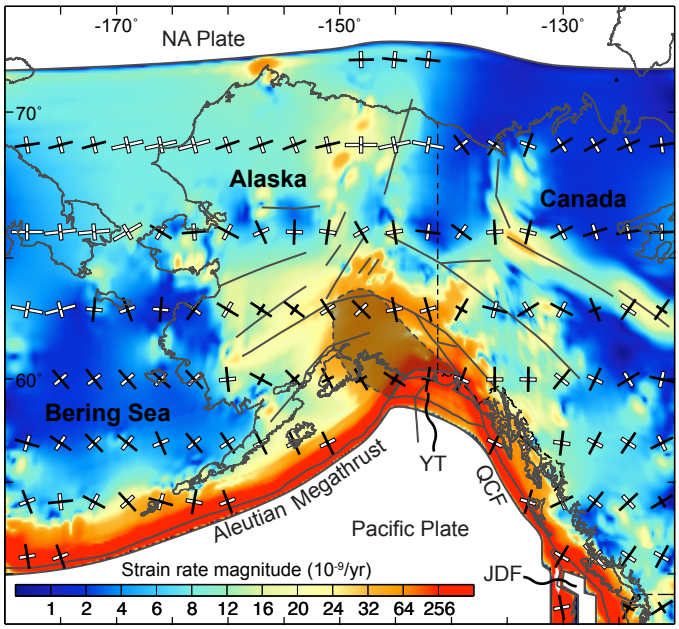

Figure DR2. Modeled continuous strain rate field for a model that uses a constant base level variance and does not use the location of seismicity to increase the variance for the grid areas. The strain rate magnitude is shown in the background grid.

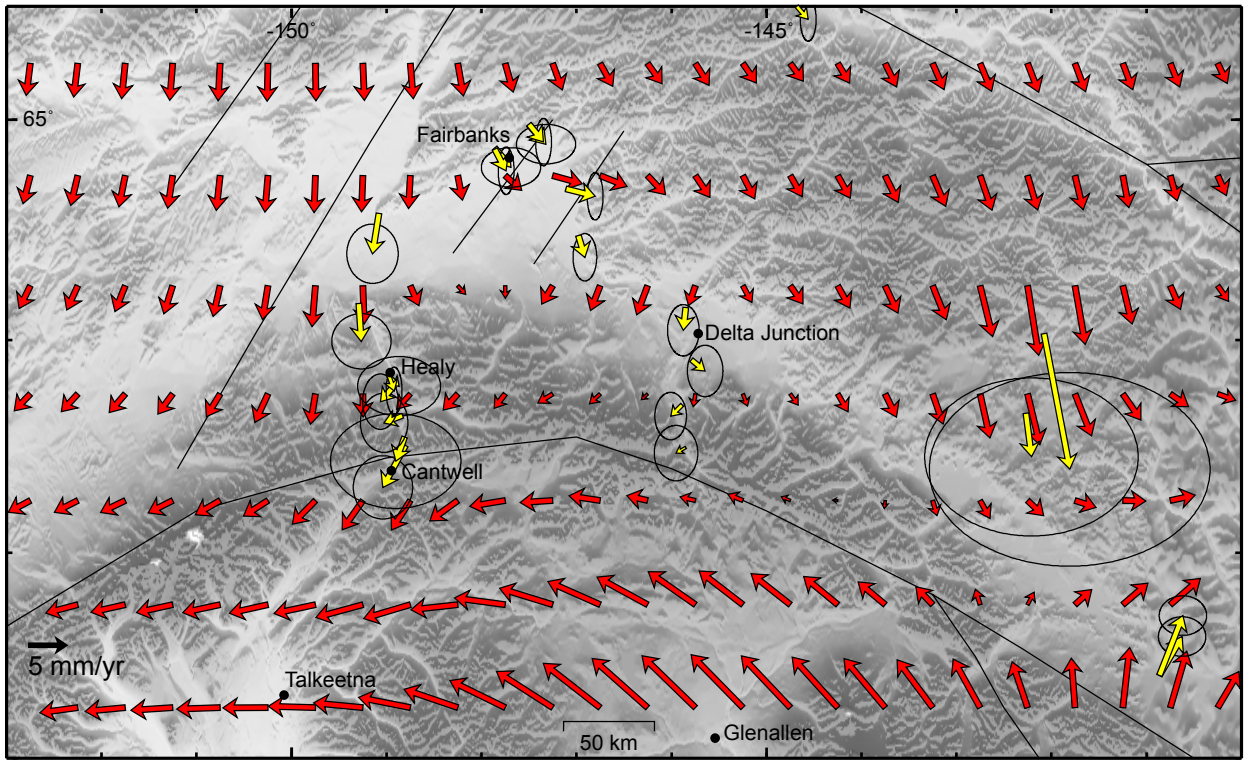

Figure DR3. Modeled continuous horizontal velocity field (red vectors) in the Denali Fault area. Yellow vectors are GPS observations inferred to represent long-term deformation (see Table S2 for sources).

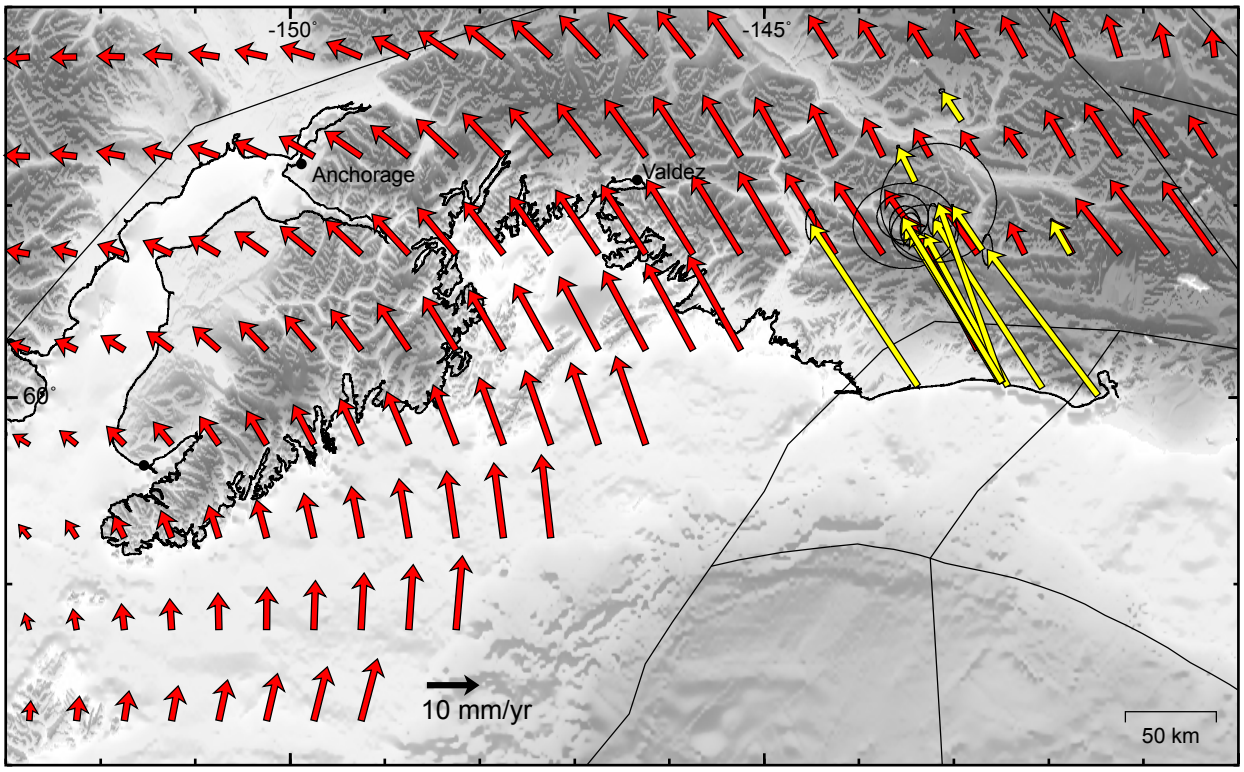

Figure DR4. Modeled continuous horizontal velocity field (red vectors) in the Prince William Sound area. Yellow vectors are GPS observations inferred to represent long-term deformation (see Table S2 for sources).

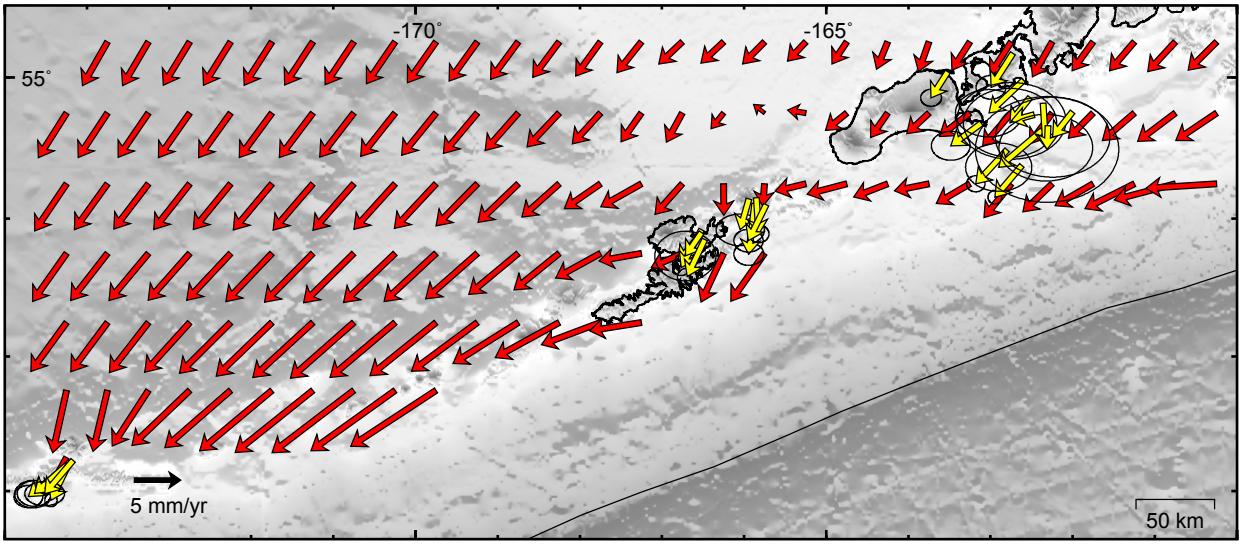

Figure DR5. Modeled continuous horizontal velocity field (red vectors) in the Aleutians Island region. Yellow vectors are GPS observations inferred to represent long-term deformation (see Table S2 for sources).