Supplementary Material for InSAR+GNSS Time Series Integration:

Supplementary List S1: List of 250 descending Sentinel-1 A/B SLC image IDs used in this study from Path 87 Frame 526 between November 23, 2015 – April 13, 2021.

S1A_IW_SLC__1SDV_20210413T161621_20210413T161648_037434_0469A3_AD8B-SLC
S1B_IW_SLC__1SDV_20210407T161539_20210407T161606_026363_0325AE_8117-SLC
S1B_IW_SLC__1SDV_20210326T161539_20210326T161606_026188_032020_A2A0-SLC
S1A_IW_SLC__1SDV_20210320T161621_20210320T161648_037084_045D8C_C34C-SLC
S1B_IW_SLC__1SDV_20210314T161539_20210314T161606_026013_031A91_0025-SLC
S1A_IW_SLC__1SDV_20210308T161621_20210308T161648_036909_04576F_1D1F-SLC
S1B_IW_SLC__1SDV_20210302T161539_20210302T161606_025838_0314E4_C6CC-SLC
S1A_IW_SLC__1SDV_20210224T161621_20210224T161648_036734_045152_035E-SLC
S1B_IW_SLC__1SDV_20210218T161539_20210218T161606_025663_030F29_6B49-SLC
S1A_IW_SLC__1SDV_20210212T161621_20210212T161648_036559_044B3D_C4F1-SLC
S1B_IW_SLC__1SDV_20210206T161539_20210206T161606_025488_030973_EAF9-SLC
S1A_IW_SLC__1SDV_20210131T161621_20210131T161648_036384_044526_9861-SLC
S1B_IW_SLC__1SDV_20210125T161540_20210125T161607_025313_0303C9_2092-SLC
S1A_IW_SLC__1SDV_20210119T161622_20210119T161648_036209_043F19_7AB5-SLC
S1B_IW_SLC__1SDV_20210113T161540_20210113T161607_025138_02FE3B_A0E6-SLC
S1A_IW_SLC__1SDV_20210107T161622_20210107T161649_036034_0438F1_97A4-SLC
S1B_IW_SLC__1SDV_20210101T161541_20210101T161608_024963_02F899_751A-SLC
S1A_IW_SLC__1SDV_20201226T161623_20201226T161650_035859_0432E0_C868-SLC
S1B_IW_SLC__1SDV_20201220T161541_20201220T161608_024788_02F2F7_CCBE-SLC
S1A_IW_SLC__1SDV_20201214T161623_20201214T161650_035684_042CCF_259B-SLC
S1B_IW_SLC__1SDV_20201208T161542_20201208T161609_024613_02ED45_2955-SLC
S1A_IW_SLC__1SDV_20201202T161624_20201202T161651_035509_0426D2_8FEA-SLC
S1B_IW_SLC__1SDV_20201126T161542_20201126T161609_024438_02E7AB_80D6-SLC
S1A_IW_SLC__1SDV_20201120T161624_20201120T161651_035334_0420BD_F007-SLC
S1B_IW_SLC__1SDV_20201114T161543_20201114T161609_024263_02E22A_52DA-SLC
S1A_IW_SLC__1SDV_20201108T161624_20201108T161651_035159_041AA3_1A68-SLC
S1B_IW_SLC__1SDV_20201102T161543_20201102T161610_024088_02DCA9_DD1A-SLC
S1A_IW_SLC__1SDV_20201027T161625_20201027T161652_034984_04149F_A5E0-SLC
S1B_IW_SLC__1SDV_20201021T161542_20201021T161609_023913_02D73C_66A0-SLC
S1A_IW_SLC__1SDV_20201015T161625_20201015T161652_034809_040E95_0967-SLC
S1B_IW_SLC__1SDV_20201009T161543_20201009T161610_023738_02D1C3_C5C0-SLC
S1A_IW_SLC__1SDV_20201003T161625_20201003T161651_034634_04087E_2FD4-SLC
S1B_IW_SLC__1SDV_20200927T161542_20200927T161609_023563_02CC58_C487-SLC
S1A_IW_SLC__1SDV_20200921T161624_20200921T161651_034459_04025D_BC16-SLC
S1B_IW_SLC__1SDV_20200915T161542_20200915T161609_023388_02C6DA_82E7-SLC
S1A_IW_SLC__1SDV_20200909T161624_20200909T161651_034284_03FC1A_99BF-SLC
S1B_IW_SLC__1SDV_20200903T161542_20200903T161609_023213_02C156_CD05-SLC
S1A_IW_SLC__1SDV_20200828T161623_20200828T161650_034109_03F5F8_CC8E-SLC
S1B_IW_SLC__1SDV_20200822T161541_20200822T161608_023038_02BBE8_2C27-SLC
S1A_IW_SLC__1SDV_20200816T161623_20200816T161650_033934_03EFCE_20F0-SLC
S1B_IW_SLC__1SDV_20200810T161540_20200810T161607_022863_02B66A_1C00-SLC
S1A_IW_SLC__1SDV_20200804T161622_20200804T161649_033759_03E9B6_BDDA-SLC
S1B_IW_SLC__1SDV_20200729T161540_20200729T161607_022688_02B106_C974-SLC
S1A_IW_SLC__1SDV_20200723T161621_20200723T161648_033584_03E461_3CAE-SLC
S1B_IW_SLC__1SDV_20200717T161539_20200717T161606_022513_02ABB2_FF9A-SLC
S1B_IW_SLC__1SDV_20200705T161538_20200705T161605_022338_02A665_EAD0-SLC
S1A_IW_SLC__1SDV_20200629T161620_20200629T161647_033234_03D9B0_B784-SLC
S1B_IW_SLC__1SDV_20200623T161538_20200623T161604_022163_02A10F_4D32-SLC

S1A_IW_SLC__1SDV_20200617T161619_20200617T161646_033059_03D45F_3801-SLC
S1B_IW_SLC__1SDV_20200611T161537_20200611T161604_021988_029BBA_099F-SLC
S1A_IW_SLC__1SDV_20200605T161618_20200605T161645_032884_03CF1B_D34B-SLC
S1A_IW_SLC__1SDV_20200524T161618_20200524T161645_032709_03C9EE_1C76-SLC
S1B_IW_SLC__1SDV_20200518T161535_20200518T161602_021638_029146_2FFC-SLC
S1A_IW_SLC__1SDV_20200512T161617_20200512T161644_032534_03C49F_004C-SLC
S1B_IW_SLC__1SDV_20200506T161535_20200506T161602_021463_028C11_C502-SLC
S1A_IW_SLC__1SDV_20200430T161616_20200430T161643_032359_03BEE1_879C-SLC
S1B_IW_SLC__1SDV_20200424T161534_20200424T161601_021288_028688_1D1E-SLC
S1A_IW_SLC__1SDV_20200418T161616_20200418T161643_032184_03B8BF_F8B2-SLC
S1B_IW_SLC__1SDV_20200412T161534_20200412T161601_021113_028103_CC2C-SLC
S1A_IW_SLC__1SDV_20200406T161615_20200406T161642_032009_03B293_CAC1-SLC
S1B_IW_SLC__1SDV_20200331T161533_20200331T161600_020938_027B76_F80E-SLC
S1A_IW_SLC__1SDV_20200325T161615_20200325T161642_031834_03AC6C_0152-SLC
S1B_IW_SLC__1SDV_20200319T161533_20200319T161600_020763_0275EF_7E45-SLC
S1A_IW_SLC__1SDV_20200313T161615_20200313T161642_031659_03A63C_DEC8-SLC
S1B_IW_SLC__1SDV_20200307T161533_20200307T161600_020588_027062_CC4B-SLC
S1A_IW_SLC__1SDV_20200301T161615_20200301T161642_031484_03A028_0039-SLC
S1B_IW_SLC__1SDV_20200224T161533_20200224T161600_020413_026AD4_4AC9-SLC
S1A_IW_SLC__1SDV_20200218T161615_20200218T161642_031309_039A29_36D8-SLC
S1B_IW_SLC__1SDV_20200212T161533_20200212T161600_020238_026532_0EB2-SLC
S1A_IW_SLC__1SDV_20200206T161615_20200206T161642_031134_03941A_B825-SLC
S1B_IW_SLC__1SDV_20200131T161533_20200131T161600_020063_025F88_ED24-SLC
S1A_IW_SLC__1SDV_20200125T161615_20200125T161642_030959_038E00_F6F0-SLC
S1B_IW_SLC__1SDV_20200119T161534_20200119T161601_019888_0259E8_E6E5-SLC
S1A_IW_SLC__1SDV_20200113T161616_20200113T161643_030784_0387D6_01CE-SLC
S1B_IW_SLC__1SDV_20200107T161534_20200107T161601_019713_025456_B62E-SLC
S1A_IW_SLC__1SDV_20200101T161616_20200101T161643_030609_0381C0_FBCE-SLC
S1B_IW_SLC__1SDV_20191226T161535_20191226T161602_019538_024EC2_C998-SLC
S1A_IW_SLC__1SDV_20191220T161617_20191220T161644_030434_037BB6_D0CD-SLC
S1B_IW_SLC__1SDV_20191214T161535_20191214T161602_019363_024934_BBEA-SLC
S1A_IW_SLC__1SDV_20191208T161617_20191208T161644_030259_0375A4_84A0-SLC
S1B_IW_SLC__1SDV_20191202T161536_20191202T161603_019188_0243A3_08A9-SLC
S1A_IW_SLC__1SDV_20191126T161618_20191126T161645_030084_036FA3_3F49-SLC
S1B_IW_SLC__1SDV_20191120T161536_20191120T161603_019013_023E15_D5A6-SLC
S1A_IW_SLC__1SDV_20191114T161618_20191114T161645_029909_036991_BB3C-SLC
S1B_IW_SLC__1SDV_20191108T161536_20191108T161603_018838_02386D_53B1-SLC
S1A_IW_SLC__1SDV_20191102T161618_20191102T161645_029734_03636D_018F-SLC
S1B_IW_SLC__1SDV_20191027T161536_20191027T161603_018663_0232C3_946E-SLC
S1A_IW_SLC__1SDV_20191021T161618_20191021T161645_029559_035D59_D964-SLC
S1B_IW_SLC__1SDV_20191015T161536_20191015T161603_018488_022D65_8C28-SLC
S1A_IW_SLC__1SDV_20191009T161618_20191009T161645_029384_03574D_1787-SLC
S1B_IW_SLC__1SDV_20191003T161536_20191003T161603_018313_0227F9_4F4D-SLC
S1A_IW_SLC__1SDV_20190927T161618_20190927T161645_029209_035145_DD78-SLC
S1B_IW_SLC__1SDV_20190921T161536_20190921T161603_018138_022287_7B38-SLC
S1A_IW_SLC__1SDV_20190915T161617_20190915T161644_029034_034B50_853C-SLC
S1B_IW_SLC__1SDV_20190909T161536_20190909T161603_017963_021D1D_0940-SLC
S1A_IW_SLC__1SDV_20190903T161617_20190903T161644_028859_034539_4E57-SLC
S1B_IW_SLC__1SDV_20190828T161535_20190828T161602_017788_02179E_A3C4-SLC
S1A_IW_SLC__1SDV_20190822T161617_20190822T161643_028684_033F1E_9AF3-SLC
S1B_IW_SLC__1SDV_20190816T161534_20190816T161601_017613_021230_1723-SLC
S1A_IW_SLC__1SDV_20190810T161616_20190810T161643_028509_033911_7640-SLC
S1B_IW_SLC__1SDV_20190804T161534_20190804T161601_017438_020CC8_40F7-SLC

S1A_IW_SLC__1SDV_20190729T161615_20190729T161642_028334_033397_E1A6-SLC
S1B_IW_SLC__1SDV_20190723T161533_20190723T161600_017263_020785_7D6A-SLC
S1A_IW_SLC__1SDV_20190717T161614_20190717T161641_028159_032E3F_2630-SLC
S1B_IW_SLC__1SDV_20190711T161532_20190711T161559_017088_02026E_184C-SLC
S1A_IW_SLC__1SDV_20190705T161613_20190705T161640_027984_0328F2_A172-SLC
S1B_IW_SLC__1SDV_20190629T161531_20190629T161558_016913_01FD48_96B5-SLC
S1A_IW_SLC__1SDV_20190623T161613_20190623T161640_027809_0323A9_E521-SLC
S1B_IW_SLC__1SDV_20190617T161531_20190617T161558_016738_01F819_112C-SLC
S1A_IW_SLC__1SDV_20190611T161612_20190611T161639_027634_031E71_9925-SLC
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S1A_IW_SLC__1SDV_20190530T161611_20190530T161638_027459_031916_4797-SLC
S1B_IW_SLC__1SDV_20190524T161529_20190524T161556_016388_01EDA2_21C4-SLC
S1A_IW_SLC__1SDV_20190518T161611_20190518T161638_027284_0313A1_AE8A-SLC
S1B_IW_SLC__1SDV_20190512T161529_20190512T161556_016213_01E839_26B7-SLC
S1A_IW_SLC__1SDV_20190506T161610_20190506T161637_027109_030E29_5A71-SLC
S1B_IW_SLC__1SDV_20190430T161528_20190430T161555_016038_01E295_8D96-SLC
S1A_IW_SLC__1SDV_20190424T161610_20190424T161637_026934_0307C6_C173-SLC
S1B_IW_SLC__1SDV_20190418T161528_20190418T161555_015863_01DCBB_C128-SLC
S1A_IW_SLC__1SDV_20190412T161609_20190412T161636_026759_030170_0C87-SLC
S1B_IW_SLC__1SDV_20190406T161527_20190406T161554_015688_01D6F3_6288-SLC
S1A_IW_SLC__1SDV_20190331T161609_20190331T161636_026584_02FB08_E9DE-SLC
S1B_IW_SLC__1SDV_20190325T161527_20190325T161554_015513_01D128_9198-SLC
S1A_IW_SLC__1SDV_20190319T161609_20190319T161635_026409_02F499_30DE-SLC
S1B_IW_SLC__1SDV_20190313T161527_20190313T161554_015338_01CB78_2D1E-SLC
S1A_IW_SLC__1SDV_20190307T161609_20190307T161636_026234_02EE1E_3DB6-SLC
S1B_IW_SLC__1SDV_20190301T161527_20190301T161554_015163_01C5BB_648F-SLC
S1A_IW_SLC__1SDV_20190223T161609_20190223T161635_026059_02E7DA_651E-SLC
S1B_IW_SLC__1SDV_20190217T161527_20190217T161554_014988_01C003_3A21-SLC
S1A_IW_SLC__1SDV_20190211T161609_20190211T161636_025884_02E1A0_FE75-SLC
S1B_IW_SLC__1SDV_20190205T161527_20190205T161554_014813_01BA44_34FF-SLC
S1A_IW_SLC__1SDV_20190130T161609_20190130T161636_025709_02DB5D_5555-SLC
S1B_IW_SLC__1SDV_20190124T161527_20190124T161554_014638_01B482_A1A0-SLC
S1A_IW_SLC__1SDV_20190118T161609_20190118T161636_025534_02D4F7_4F67-SLC
S1B_IW_SLC__1SDV_20190112T161528_20190112T161555_014463_01AEEC_3C72-SLC
S1A_IW_SLC__1SDV_20190106T161610_20190106T161637_025359_02CEA7_7B38-SLC
S1B_IW_SLC__1SDV_20181231T161528_20181231T161555_014288_01A94A_47EF-SLC
S1A_IW_SLC__1SDV_20181225T161610_20181225T161637_025184_02C858_98D2-SLC
S1B_IW_SLC__1SDV_20181219T161529_20181219T161556_014113_01A37C_3463-SLC
S1A_IW_SLC__1SDV_20181213T161610_20181213T161637_025009_02C200_5C85-SLC
S1B_IW_SLC__1SDV_20181207T161529_20181207T161556_013938_019DBF_5D98-SLC
S1A_IW_SLC__1SDV_20181201T161611_20181201T161638_024834_02BBEE_6EF4-SLC
S1A_IW_SLC__1SDV_20181119T161612_20181119T161638_024659_02B5BA_44ED-SLC
S1B_IW_SLC__1SDV_20181113T161530_20181113T161557_013588_01927D_7383-SLC
S1A_IW_SLC__1SDV_20181107T161608_20181107T161643_024484_02AF45_24C2-SLC
S1B_IW_SLC__1SDV_20181101T161530_20181101T161557_013413_018D11_5076-SLC
S1A_IW_SLC__1SDV_20181026T161608_20181026T161644_024309_02A937_D893-SLC
S1B_IW_SLC__1SDV_20181020T161533_20181020T161600_013238_018791_C42B-SLC
S1A_IW_SLC__1SDV_20181014T161608_20181014T161644_024134_02A394_79B2-SLC
S1B_IW_SLC__1SDV_20181008T161533_20181008T161600_013063_018228_5452-SLC
S1A_IW_SLC__1SDV_20181002T161608_20181002T161643_023959_029DD7_03E1-SLC
S1B_IW_SLC__1SDV_20180926T161532_20180926T161559_012888_017CD1_7657-SLC
S1A_IW_SLC__1SDV_20180920T161608_20180920T161643_023784_029822_52BC-SLC
S1B_IW_SLC__1SDV_20180914T161532_20180914T161559_012713_01776E_0076-SLC

S1A_IW_SLC__1SDV_20180908T161607_20180908T161643_023609_029284_32AE-SLC
S1B_IW_SLC__1SDV_20180902T161532_20180902T161559_012538_017218_2664-SLC
S1A_IW_SLC__1SDV_20180827T161607_20180827T161642_023434_028CEA_210F-SLC
S1B_IW_SLC__1SDV_20180821T161531_20180821T161558_012363_016CAF_CC74-SLC
S1A_IW_SLC__1SDV_20180815T161606_20180815T161642_023259_02874A_79C7-SLC
S1B_IW_SLC__1SDV_20180809T161530_20180809T161557_012188_01673B_569C-SLC
S1A_IW_SLC__1SDV_20180803T161605_20180803T161641_023084_0281AA_A677-SLC
S1B_IW_SLC__1SDV_20180728T161530_20180728T161557_012013_0161DF_09AF-SLC
S1A_IW_SLC__1SDV_20180722T161605_20180722T161640_022909_027C2D_6BA8-SLC
S1B_IW_SLC__1SDV_20180716T161529_20180716T161556_011838_015C9C_9CFC-SLC
S1A_IW_SLC__1SDV_20180710T161604_20180710T161639_022734_0276BD_7F8C-SLC
S1B_IW_SLC__1SDV_20180704T161528_20180704T161555_011663_01573A_ABD3-SLC
S1A_IW_SLC__1SDV_20180628T161603_20180628T161639_022559_027193_CF3A-SLC
S1B_IW_SLC__1SDV_20180622T161528_20180622T161554_011488_0151C5_C29B-SLC
S1A_IW_SLC__1SDV_20180616T161603_20180616T161638_022384_026C76_4F43-SLC
S1B_IW_SLC__1SDV_20180610T161527_20180610T161554_011313_014C5B_3DBD-SLC
S1A_IW_SLC__1SDV_20180604T161602_20180604T161637_022209_026711_A413-SLC
S1B_IW_SLC__1SDV_20180529T161526_20180529T161553_011138_0146D9_8CBE-SLC
S1B_IW_SLC__1SDV_20180517T161525_20180517T161552_010963_01411F_59D5-SLC
S1B_IW_SLC__1SDV_20180505T161525_20180505T161552_010788_013B7D_25D2-SLC
S1B_IW_SLC__1SDV_20180423T161524_20180423T161551_010613_0135DD_33F0-SLC
S1B_IW_SLC__1SDV_20180411T161524_20180411T161551_010438_013047_51DB-SLC
S1B_IW_SLC__1SDV_20180330T161523_20180330T161550_010263_012A95_0FF0-SLC
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S1B_IW_SLC__1SDV_20180210T161523_20180210T161550_009563_011395_5129-SLC
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S1A_IW_SLC__1SDV_20160203T161550_20160203T161617_009784_00E4F0_2209-SLC
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S1A_IW_SLC__1SDV_20151217T161551_20151217T161618_009084_00D0C5_CD08-SLC
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S1A_IW_SLC__1SDV_20151111T161552_20151111T161619_008559_00C21C_709F-SLC

Supplementary List S2: List of 694 (671 successful) interferometric image date pairs created from List S1 during this study using GMTSAR software and allowing a maximum of 35 days between images.

20151111_20151205	20151205_20151217	20151217_20160122	20160110_20160203
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20151123_20151217	20151217_20151229	20151229_20160203	20160122_20160215
20151123_20151229	20151217_20160110	20160110_20160122	20160122_20160227

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GNSS Reference Frame Comparison of Plotted Time Series:

In the main paper, we present results using the 24-hour final GNSS solutions from NGL, which are provided in three components (east, north, up) and aligned to the fixed, Pacific Plate reference frame to minimize linear trends from tectonic plate motions. NGL also provides GNSS solutions aligned to the International GNSS Service-14 (IGS14) reference frame. IGS14 is based on the International Terrestrial Reference Frame (ITRF) and holds a no-net-rotation (NNR), by which the motion of each tectonic plate is held fixed with respect to the weighted average of all the world's plate velocities. Here we present plotted time series from CRIM, MKEA, and BLBP stations (Supplementary Figures S1-S3, respectively), for comparison. Westward and northward motions are seen in Figures S1-S3, corresponding to the motion of the Pacific Plate in the NNR IGS14 reference frame. This motion is less obvious in Figure S1 because it is superimposed on the effects of the volcanic activity at CRIM station. Motions in the up direction should remain unaffected, regardless of reference frame used. These supplementary figures can be compared with Figures 8, 10, and 11, respectively, in the main manuscript.

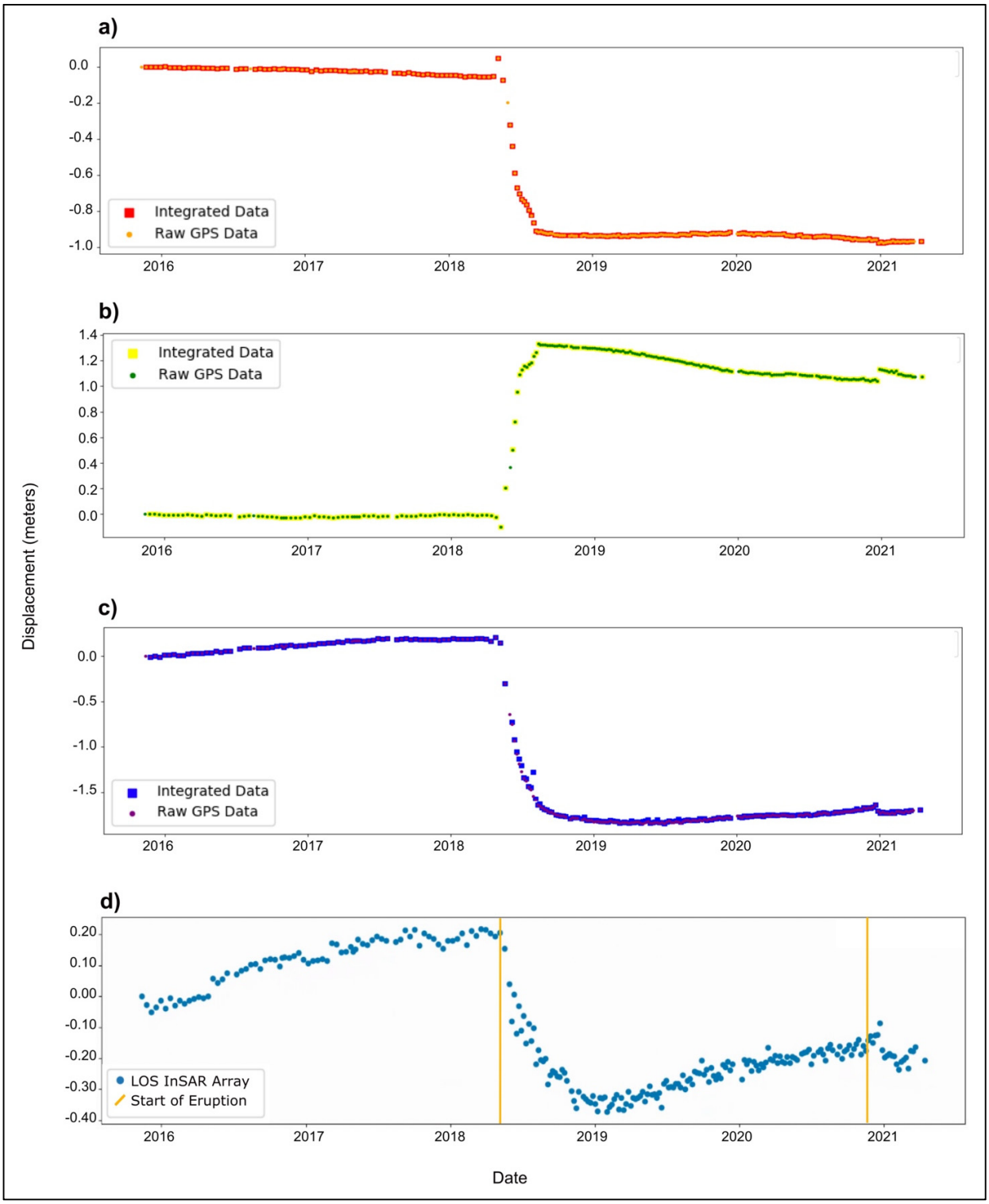

Figure S1: Integrated results compared to original, raw GNSS time series aligned to the ITRF-14 reference frame in **the a)** east-, **b)** north-, and **c)** up-components of motion at CRIM GNSS station (19.395ºN, -155.274ºW). **d)** DInSAR LOS time series at the same pixel, over CRIM station.

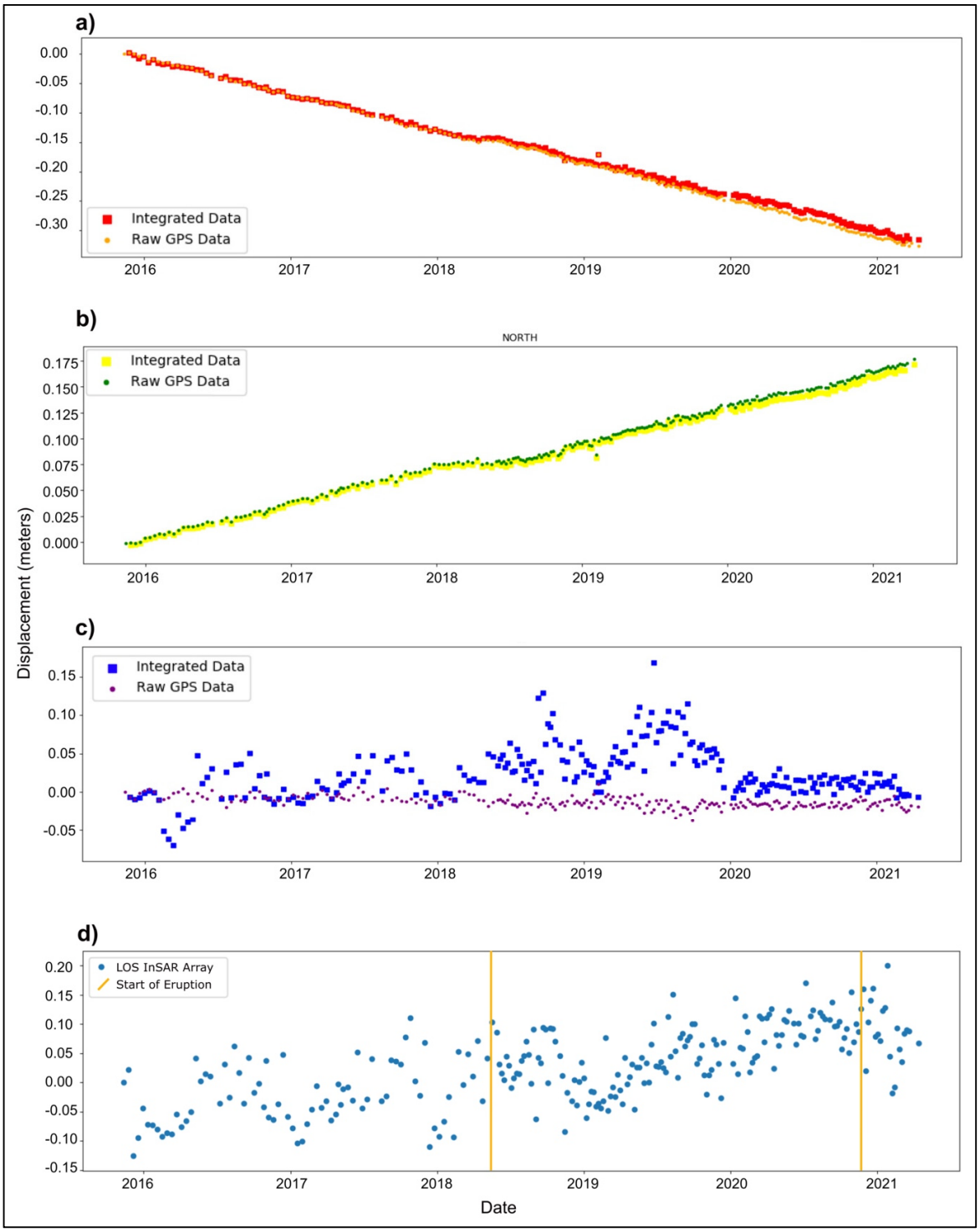

Figure S2: Integrated results compared to original, raw GNSS time series aligned to the ITRF-14 reference frame in the **a)** east-, **b)** north-, and **c)** up-components of motion at MKEA GNSS station (19.801ºN, -155.456ºW). Motion in the east-west and north-south directions are slightly more constrained, while motion in the up-down direction is significantly transformed after combining the DInSAR and GNSS datasets together. **d)** DInSAR LOS time series at the same pixel, MKEA station.

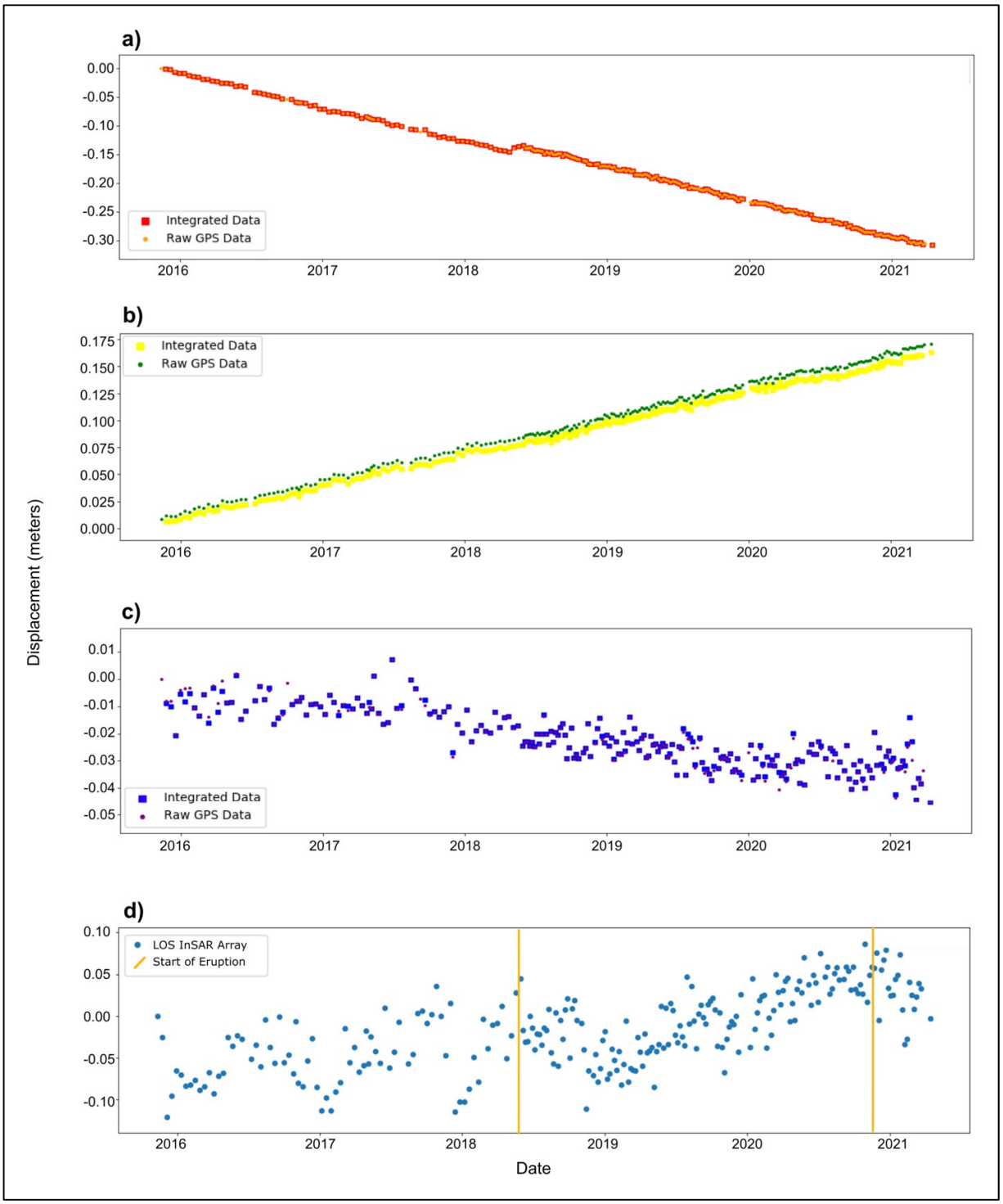

Figure S3: Integrated results compared to original, raw GNSS time series aligned to the ITRF-14 reference frame in the **a)** east-, **b)** north-, and **c)** up-components of motion at BLBP GNSS station (19.355ºN, -155.711ºW). **d)** DInSAR LOS time series at the same pixel, BLBP station.

Supplementary Equations:

The energy function is as follows:

$$U(b/a) = \sum_{i=1}^{N} \frac{(b_i - a_i)^2}{2\sigma_i^2} \quad \text{(S1)}$$

where $U\left(\frac{a}{b}\right)$ is the likelihood energy, b is the observation with uncertainty, σ, a is the unknown parameter, and N is the number of observations, or pixels within the acquisition. The resulting adaptation of Equation S1 to our geodetic displacement datasets is:

$$\begin{aligned} U(d^{LOS}, d_x^{GPS}, d_y^{GPS}, d_z^{GPS}/d_x, d_y, d_z) = \\ \sum_{i=1}^{N} C^{LOS}(d^{LOS} - S_x^{LOS} d_x - S_y^{LOS} d_y - S_z^{LOS} d_z)^2 \\ + C_x^{GPS}(d_x^{GPS} - d_x)^2 + C_y^{GPS}(d_y^{GPS} - d_y)^2 + C_z^{GPS}(d_z^{GPS} - d_z)^2 \end{aligned} \quad \text{(S2)}$$

with coefficients

$$\begin{aligned} C^{LOS} = \frac{1}{2(\sigma^{LOS})^2}, \\ C_x^{GPS} = \frac{1}{2(\sigma_x^{GPS})^2}, \quad C_y^{GPS} = \frac{1}{2(\sigma_y^{GPS})^2}, \quad C_z^{GPS} = \frac{1}{2(\sigma_z^{GPS})^2} \end{aligned} \quad \text{(S3)}$$

where σ is the standard deviation for the measurements, d^{LOS} is the cumulative LOS displacement, $[S_x^{LOS}, S_y^{LOS}, S_z^{LOS}]$ are the unit vectors pointing from the ground to the satellite, and $[d_x^{GPS}, d_y^{GPS}, d_z^{GPS}]$ are the 3D displacements from the kriging interpolated GNSS data.

The global minimum of equation S2 is achieved when the first partial derivatives, $[\frac{\partial U}{\partial d_x}, \frac{\partial U}{\partial d_y}, \frac{\partial U}{\partial d_z}]$, are equal to zero.

$$\begin{aligned} \frac{\partial U}{\partial d_x} = -2C^{LOS} S_x^{LOS}(d^{LOS} - S_x^{LOS} d_x - S_y^{LOS} d_y - S_z^{LOS} d_z) \\ -2C_x^{GPS}(d_x^{GPS} - d_x) \\ = 0 \\ \frac{\partial U}{\partial d_y} = -2C^{LOS} S_y^{LOS}(d^{LOS} - S_x^{LOS} d_x - S_y^{LOS} d_y - S_z^{LOS} d_z) \\ -2C_y^{GPS}(d_y^{PO} - d_y) \\ = 0 \\ \frac{\partial U}{\partial d_z} = -2C^{LOS} S_z^{LOS}(d^{LOS} - S_x^{LOS} d_x - S_y^{LOS} d_y - S_z^{LOS} d_z) \\ -2C_z^{GPS}(d_z^{GPS} - d_z) \\ = 0 \end{aligned} \quad \text{(S4)}$$

Rewritten in matrix notation, these partial derivatives take the following form:

$$\begin{vmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{vmatrix} \begin{vmatrix} d_x \\ d_y \\ d_z \end{vmatrix} = \begin{vmatrix} D_x \\ D_y \\ D_z \end{vmatrix} \quad \text{(S5)}$$

In order to solve for the DInSAR+GNSS integrated data, $[d_x, d_y, d_z]$, we perform an inversion of equation S5. Error estimates, $[\sigma_x, \sigma_y, \sigma_z]$, also are calculated for the 3D surface displacements as in Samsonov et al. [2006].

$$\begin{aligned}
\sigma_{d_x}^2 &= \left(\frac{\partial d_x}{\partial d^{LOS}}\right)^2 (\sigma^{LOS})^2 \\
&+ \left(\frac{\partial d_x}{\partial d_x^{GPS}}\right)^2 (\sigma_x^{GPS})^2 + \left(\frac{\partial d_x}{\partial d_y^{GPS}}\right)^2 (\sigma_y^{GPS})^2 + \left(\frac{\partial d_x}{\partial d_z^{GPS}}\right)^2 (\sigma_z^{GPS})^2 \\
\sigma_{d_y}^2 &= \left(\frac{\partial d_y}{\partial d^{LOS}}\right)^2 (\sigma^{LOS})^2 \\
&+ \left(\frac{\partial d_y}{\partial d_x^{GPS}}\right)^2 (\sigma_x^{GPS})^2 + \left(\frac{\partial d_y}{\partial d_y^{GPS}}\right)^2 (\sigma_y^{GPS})^2 + \left(\frac{\partial d_y}{\partial d_z^{GPS}}\right)^2 (\sigma_z^{GPS})^2 \\
\sigma_{d_z}^2 &= \left(\frac{\partial d_z}{\partial d^{LOS}}\right)^2 (\sigma^{LOS})^2 \\
&+ \left(\frac{\partial d_z}{\partial d_x^{GPS}}\right)^2 (\sigma_x^{GPS})^2 + \left(\frac{\partial d_z}{\partial d_y^{GPS}}\right)^2 (\sigma_y^{GPS})^2 + \left(\frac{\partial d_z}{\partial d_z^{GPS}}\right)^2 (\sigma_z^{GPS})^2
\end{aligned} \quad \text{(S6)}$$

where

$$\begin{aligned}
\frac{\partial d_x}{\partial d^{LOS}} &= \frac{C^{LOS}}{|A|}(S_x^{LOS} b_{11} + S_y^{LOS} b_{12} + S_z^{LOS} b_{13}), \\
\frac{\partial d_x}{\partial d_x^{GPS}} &= \frac{C_x^{GPS} b_{11}}{|A|},\ \frac{\partial d_x}{\partial d_y^{GPS}} = \frac{C_y^{GPS} b_{12}}{|A|},\ \frac{\partial d_x}{\partial d_z^{GPS}} = \frac{C_z^{GPS} b_{13}}{|A|} \\
\frac{\partial d_y}{\partial d^{LOS}} &= \frac{C^{LOS}}{|A|}(S_x^{LOS} b_{21} + S_y^{LOS} b_{22} + S_z^{LOS} b_{23}) \\
\frac{\partial d_y}{\partial d_x^{GPS}} &= \frac{C_x^{GPS} b_{21}}{|A|},\ \frac{\partial d_y}{\partial d_y^{GPS}} = \frac{C_y^{GPS} b_{22}}{|A|},\ \frac{\partial d_y}{\partial d_z^{GPS}} = \frac{C_z^{GPS} b_{23}}{|A|} \\
\frac{\partial d_z}{\partial d^{LOS}} &= \frac{C^{LOS}}{|A|}(S_x^{LOS} b_{31} + S_y^{LOS} b_{32} + S_z^{LOS} b_{33}) \\
\frac{\partial d_z}{\partial d_x^{GPS}} &= \frac{C_x^{GPS} b_{31}}{|A|},\ \frac{\partial d_z}{\partial d_y^{GPS}} = \frac{C_y^{GPS} b_{32}}{|A|},\ \frac{\partial d_z}{\partial d_z^{GPS}} = \frac{C_z^{GPS} b_{33}}{|A|}
\end{aligned} \quad \text{(S7)}$$

and

$$B = \begin{vmatrix} b_{11} & b_{12} & b_{13} \\ b_{21} & b_{22} & b_{23} \\ b_{31} & b_{32} & b_{33} \end{vmatrix} = A^{-1}|A| \quad \text{(S8)}$$

Uncertainties of GNSS time series results:

24-Hour final solution GNSS time series data from 48 different stations and aligned to the local, fixed, Pacific Plate reference frame, were obtained from the Nevada Geodetic Laboratory (NGL), University of Nevada Reno (http://geodesy.unr.edu/), and decimated to match the sampling rate of the InSAR time series. Figure S4 shows the uncertainty results for the GNSS displacement data. Uncertainty values in the vertical direction at MKEA GNSS station are a magnitude higher (10^{-3} versus 10^{-4}) than other stations between November 2015 and December 2019, shown in the northern part of the island in subplots a-c, below. Figure S4, subplots d-e, show the highest uncertainties, which reach up to 7.63 mm in the east-component of motion, 3.28 mm in the north-component, and 9.66 mm in the up-direction of motion. Median errors for the raw GNSS data in the east, north, and up directions are 0.81 mm, 0.74 mm, and 3.27 mm.

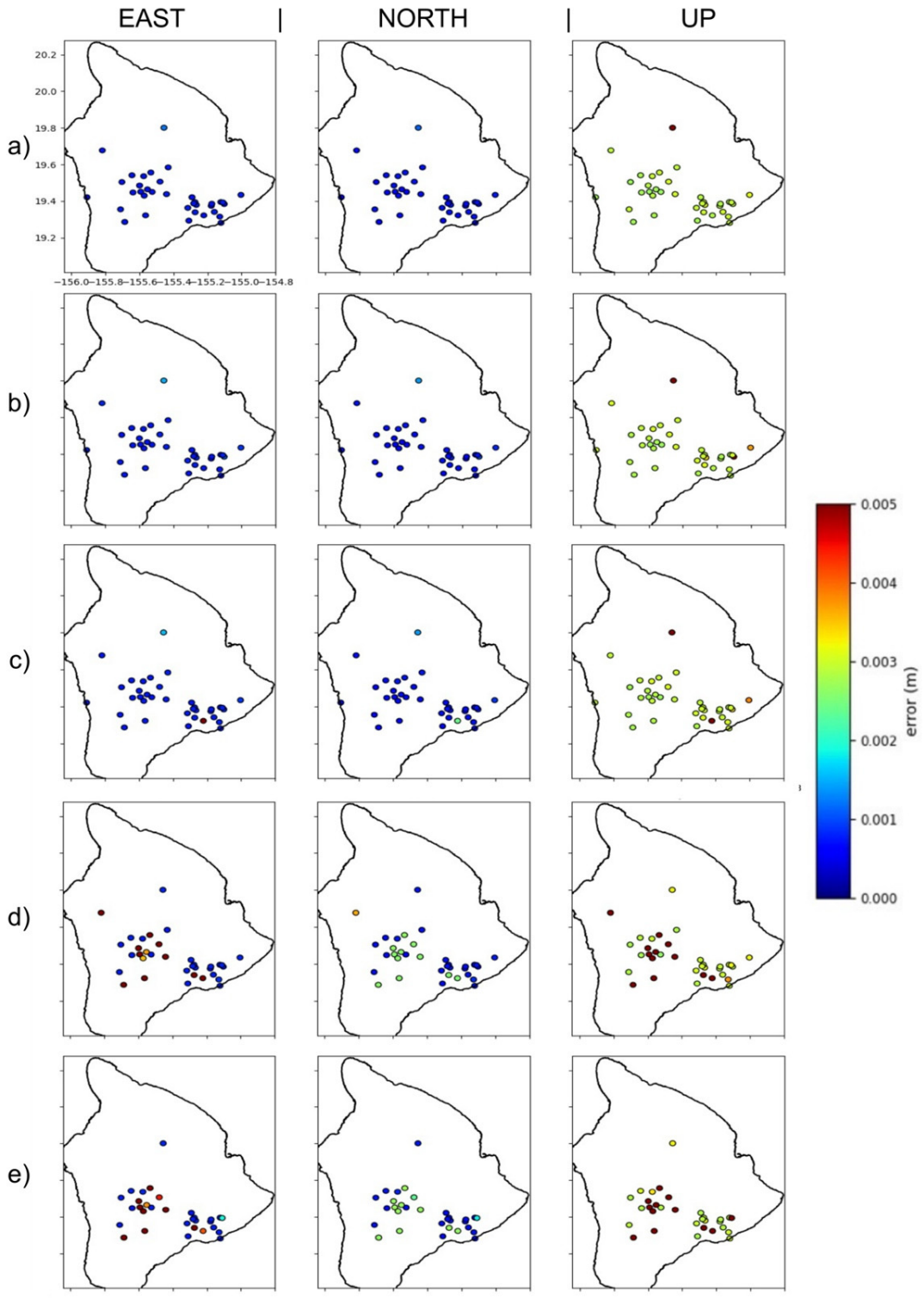

Figure S4: Raw GNSS uncertainty results shown at 48 GNSS stations used in this study from **a**) November 18, 2017**, b)** November 07, 2018**, c)** November 14, 2019, **d)** November 08, 2020, and **e)** April 13, 2021. Maximum GNSS station data error measures up to 9.65 millimeters in the up direction of motion.

For the 3D displacement maps, an additional error is introduced when we interpolate data from the 48 GNSS stations into a variogram using the ordinary kriging algorithm. Figure S5 shows the isolated, total variance distribution of the GNSS 3D displacement maps as a direct result of interpolating undefined points across the spatial field. Error measurements are minimal at the location of the individual GNSS stations, where data is provided, and as the algorithm interpolates the measurements between the stations, more variance is produced (reaching up to 4.5 mm^2).

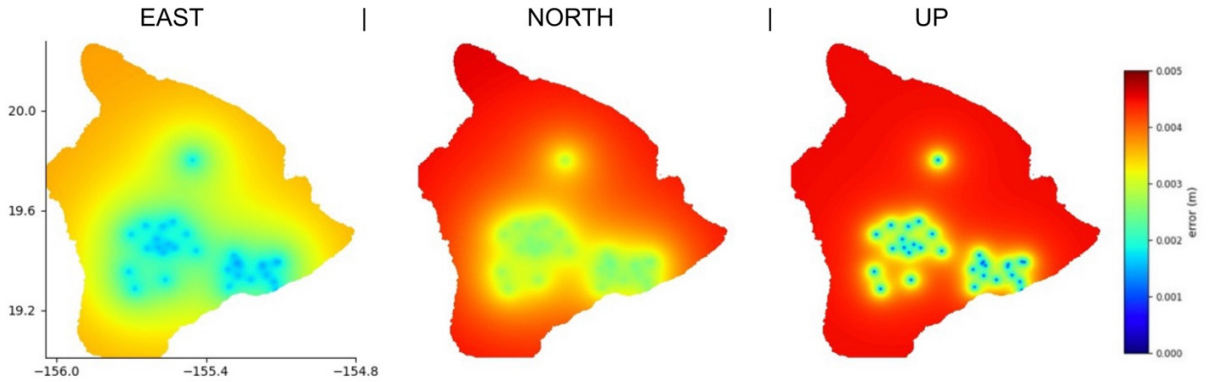

Figure S5: Variance associated with the Kriging interpolation used to generate the GNSS displacement map from the final time slice in our time series on April 13, 2021.

Uncertainties of integrated time series results:

Uncertainties associated with the final, integrated 3D displacement maps and the plotted time series are automatically generated with the corresponding time series products. Individual uncertainties from the DInSAR and GNSS data are combined using the same methodology as the real data (See Supplementary Equations 6-8). This process combines errors from the individual DInSAR time series, the GNSS datasets, and additional error introduced from applying the kriging algorithm to interpolate the GNSS data. As a result of the interpolation method, uncertainties associated with the integrated, cumulative 3D displacement maps are greater than the uncertainties calculated at a single pixel. Figure S6 shows the final, integrated uncertainty distribution for the 3D displacement maps. Maximum uncertainties in the east, north, and up directions are 7.07 cm, 5.82 cm, and 5.72 cm, respectively.

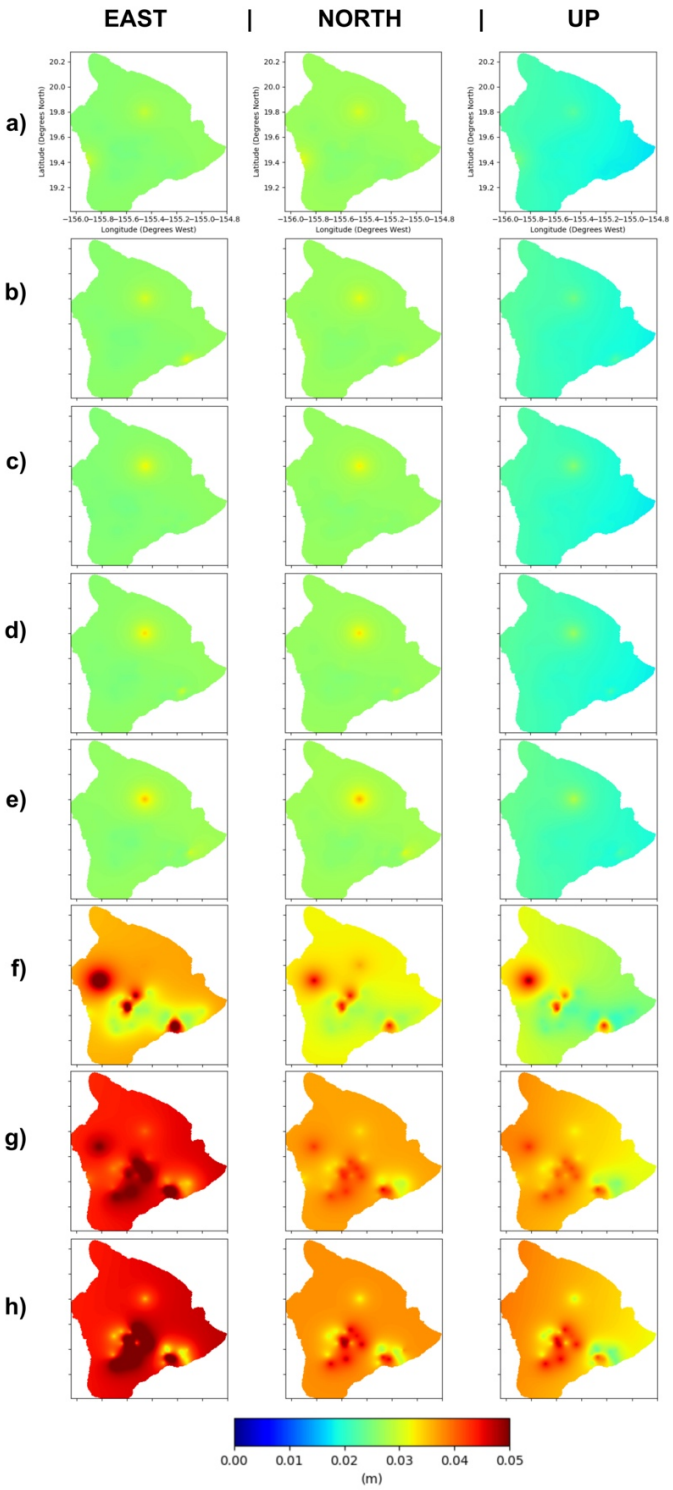

Figure S6: Final, cumulative uncertainty distribution for the 3D integrated displacement maps. Uncertainty results are combined from errors associated with the raw DInSAR and GNSS time series data and additional error introduced from applying the kriging algorithm to interpolate the GNSS data and produce variograms. Subplots show the uncertainty from a) December 29, 2015; b) December 23, 2016; c) November 18, 2017; d) May 5, 2018; e) November 7, 2018; f) December 14, 2019; g) May 12, 2020; and h) April 13, 2021.

At a single pixel, error estimates are more constrained than the original, raw GNSS or DInSAR errors alone. The north component of motion from the raw GNSS dataset consistently has the lowest error bounds compared to the east and up directions of motion, as well as the LOS DInSAR time series data. In most cases, uncertainty in the east and up directions of motion are significantly improved, while the north component of motion remains constant or is slightly reduced.

For CRIM GNSS station (Figure S7), the median uncertainties for the raw GNSS time series data in the east, north, and up directions of motion are 0.77 mm, 0.70 mm, and 3.06 mm, respectively. By combining the GNSS data with DInSAR time series, the fused data set has improved the median uncertainty of 0.76 mm, 0.70 mm, and 1.95 mm in the east, north, and up directions.

For NUPM GNSS station, (Figure S8), the median uncertainties for the raw GNSS time series data in the east, north, and up directions of motion are 0.73 mm, 0.67 mm, and 2.87 mm, respectively. By combining the GNSS data with DInSAR time series, the fused data set has improved median uncertainty of 0.73 mm, 0.67 mm, and 1.85 mm in the east, north, and up directions.

For MKEA GNSS station, (Figure S9), the median uncertainties for the raw GNSS time series data in the east, north, and up directions of motion are 1.34 mm, 1.21 mm, and 6.24 mm. By combining the GNSS data with DInSAR time series, the fused data set has improved median uncertainty of 1.23 mm, 1.13 mm, and 2.88 mm in the east, north, and up directions.

For BLBP GNSS station, (Figure S10), the median uncertainties for the raw GNSS time series data in the east, north, and up directions of motion are 0.74 mm, 0.68 mm, and 2.87 mm. By combining the GNSS data with DInSAR time series, the fused data set has improved median uncertainty of 0.74 mm, 0.68 mm, and 1.90 mm in the east, north, and up directions.

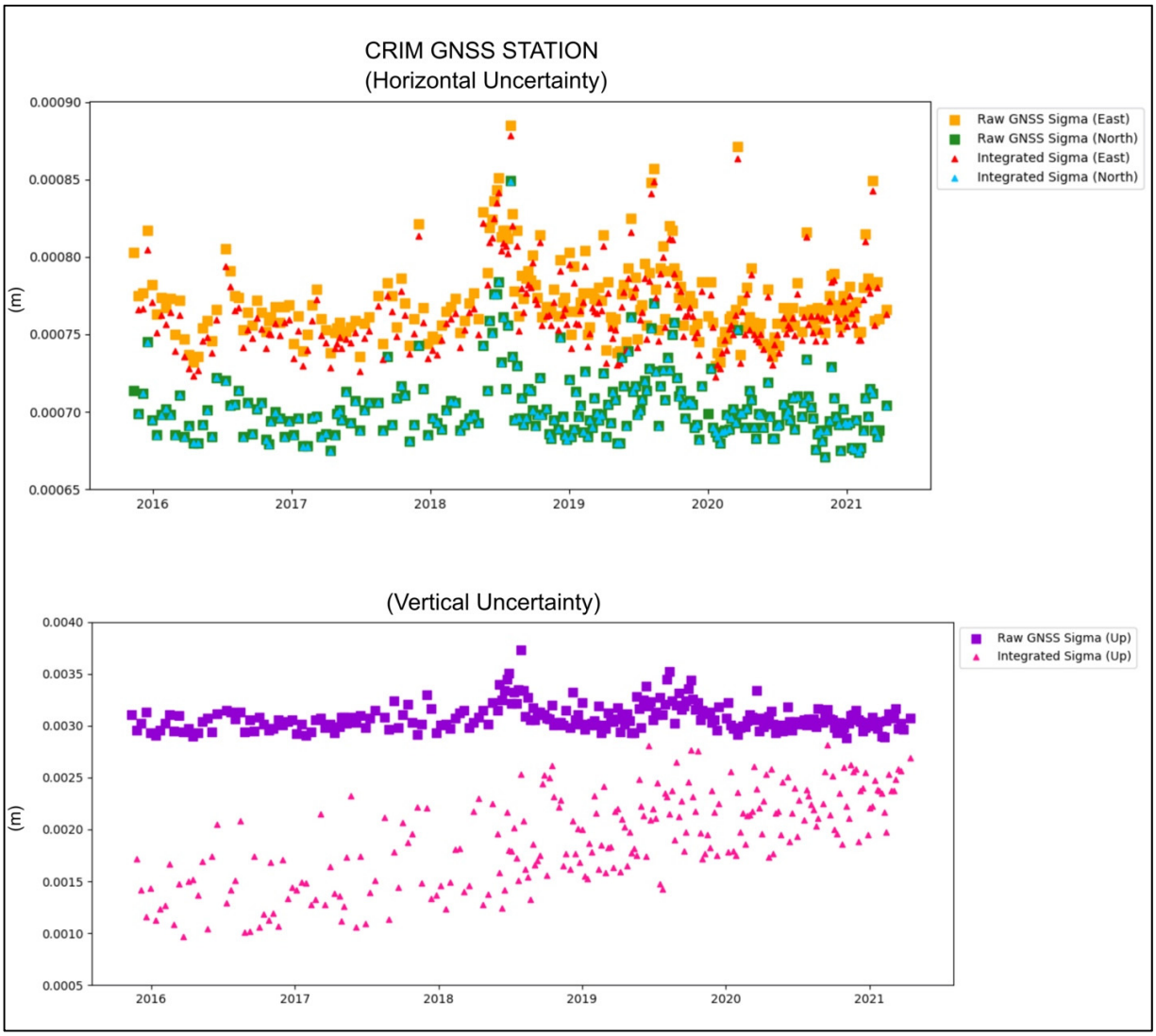

Figure S7: Integrated uncertainty for the plotted time series at the overlapping pixel location for CRIM GNSS station.

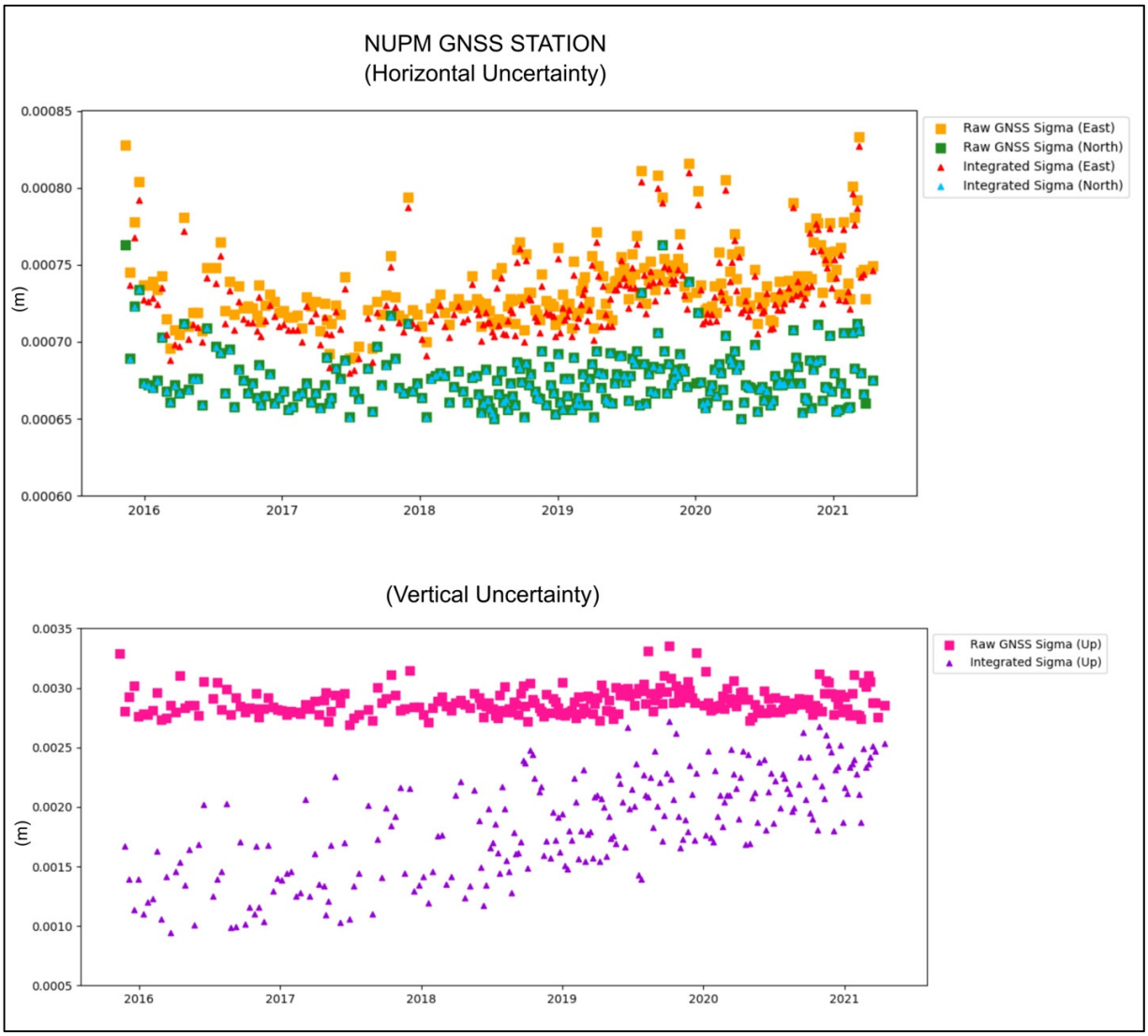

Figure S8: Integrated uncertainty for the plotted time series at the overlapping pixel location for NUPM GNSS station.

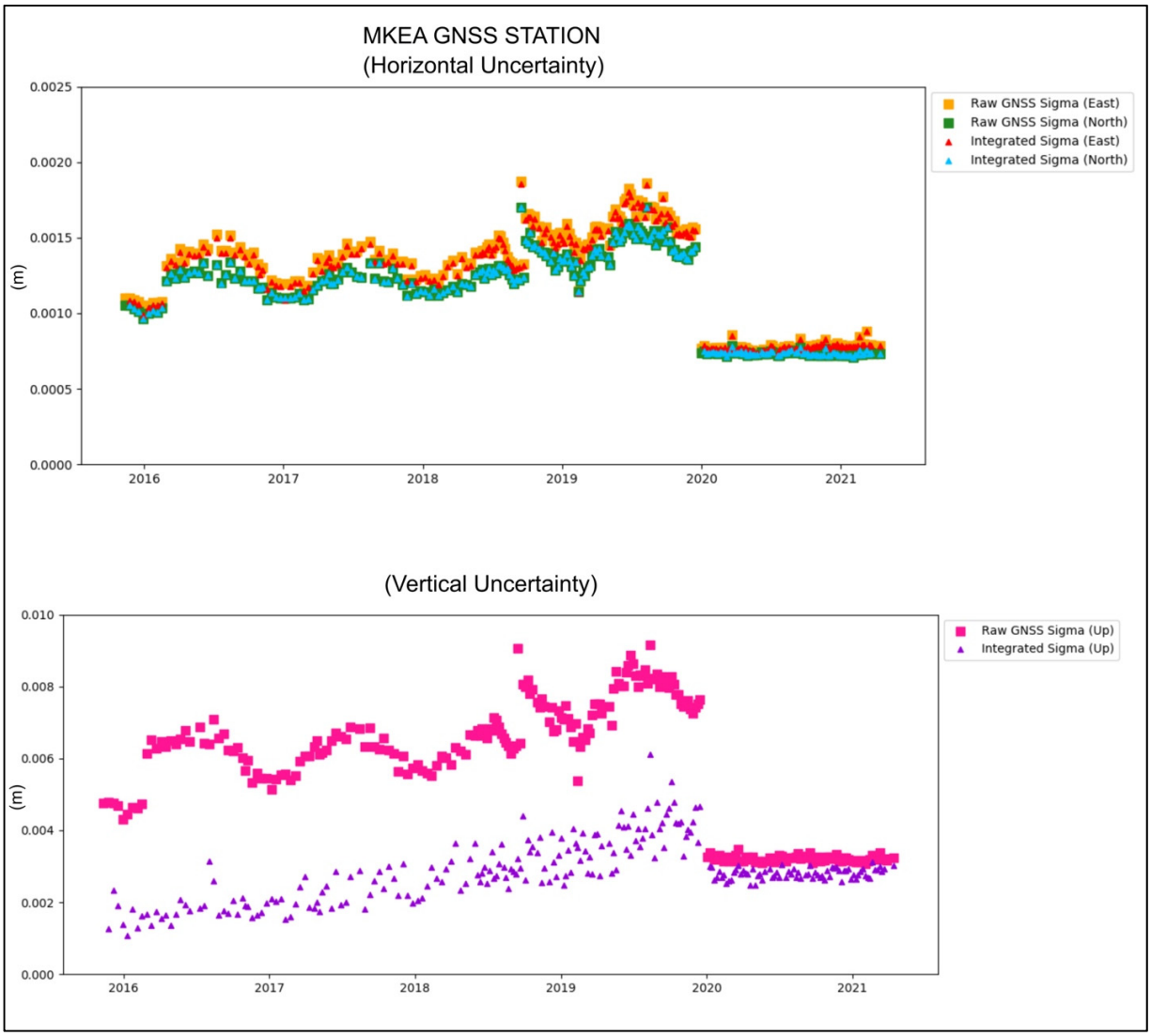

Figure S9: Integrated uncertainty for the plotted time series at the overlapping pixel location for MKEA GNSS station.

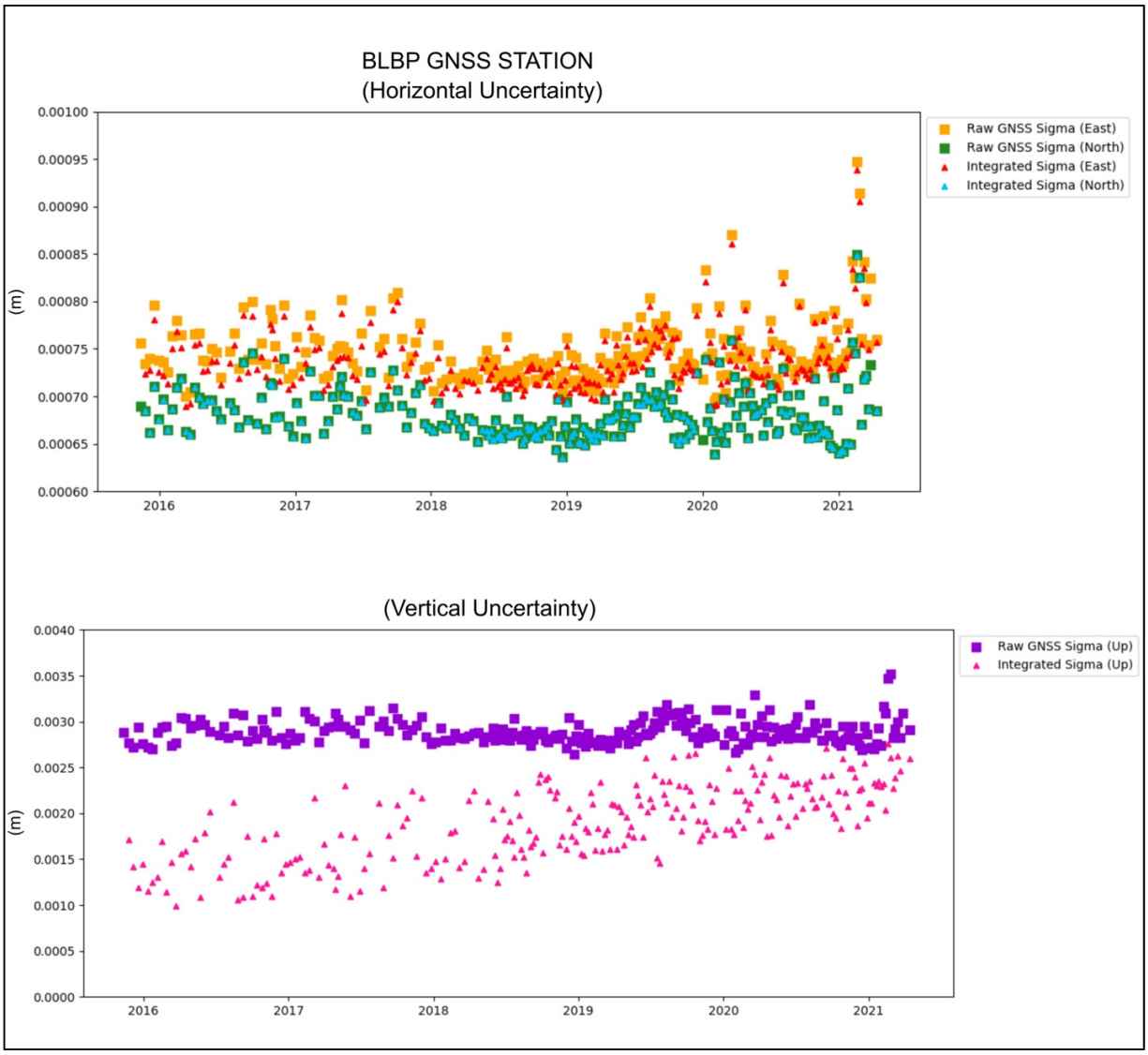

Figure S10: Integrated uncertainty for the plotted time series at the overlapping pixel location for BLBP GNSS station.