Measuring Subsidence in California from Space

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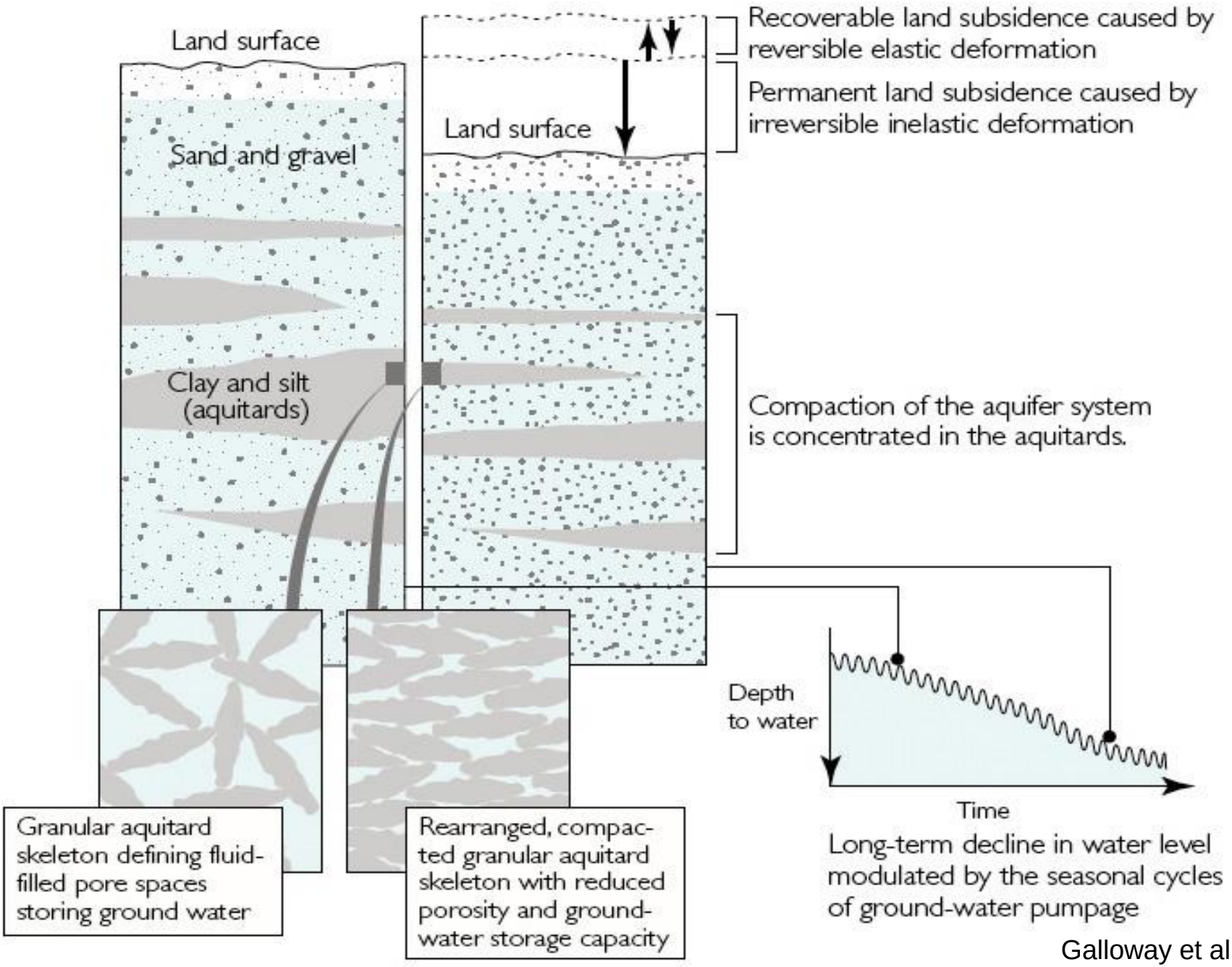
Subsidence from Space

- Groundwater is becoming a more important part of water resources
- But knowledge of the groundwater level is not uniformly available
- Wells provide some monitoring capability, but there are political and practical difficulties
- Interferometric Synthetic Aperture Radar (InSAR) can provide information on groundwater levels by measuring surface deformation caused by withdrawal and recharge of aquifers
- Subsidence also causes problems for infrastructure such as roads, aqueducts, and trains
- We are developing information products for water managers, the public, and hydrologists including animations, maps of ‘hot spots’, pixel histories, and regional maps of subsidence
- Most of the work has been done for the Central Valley and LA basin, but we are beginning to process data for other basins of California

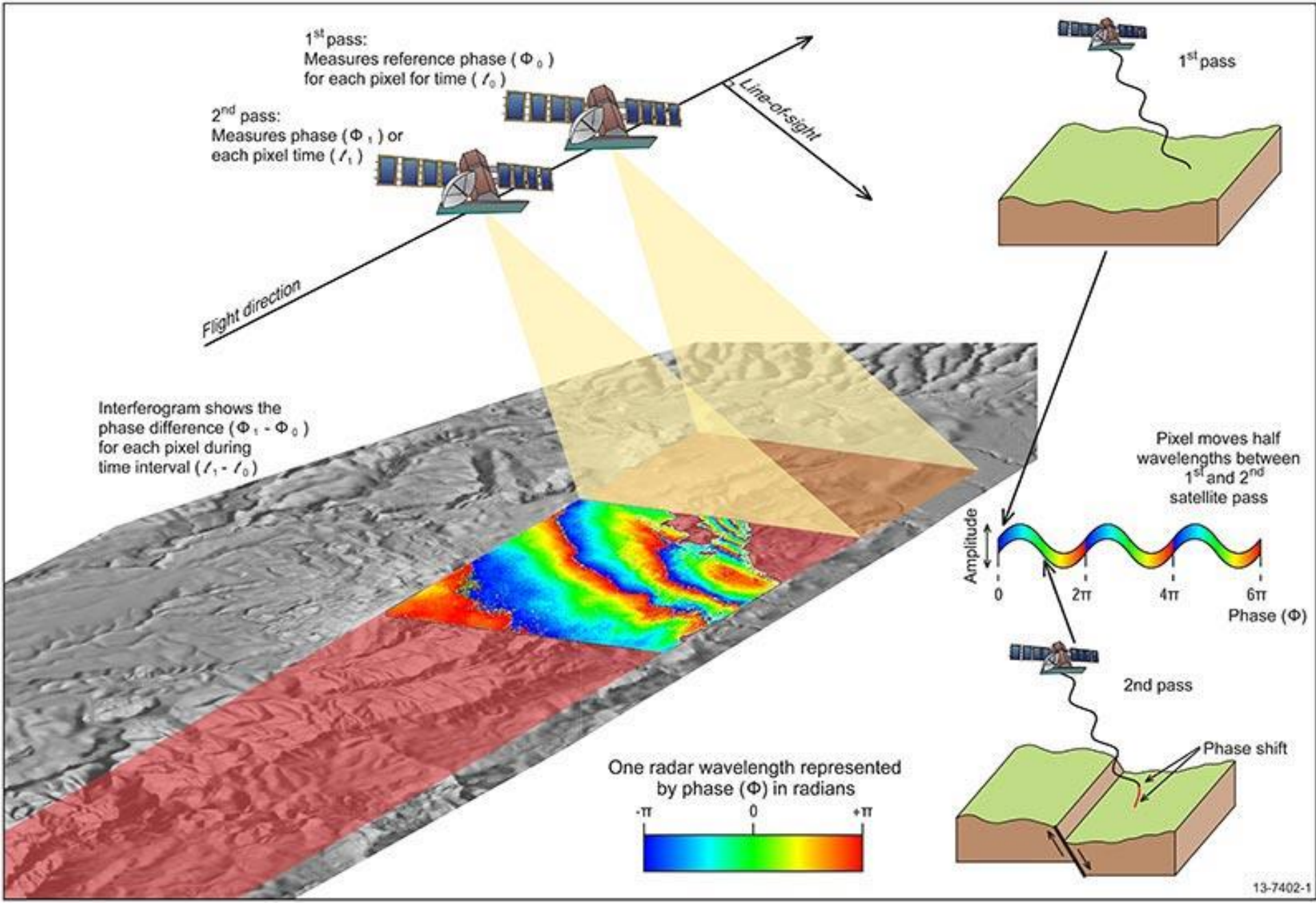
Hydrology 101: Aquifer compaction



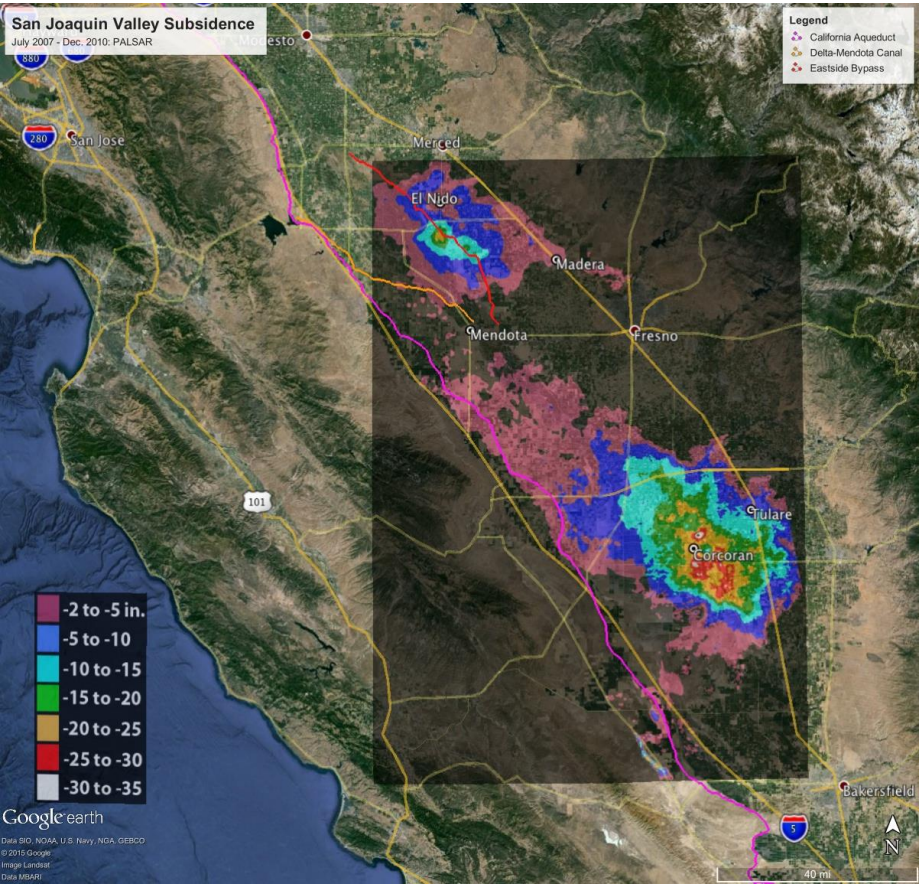
Galloway et al., 1999

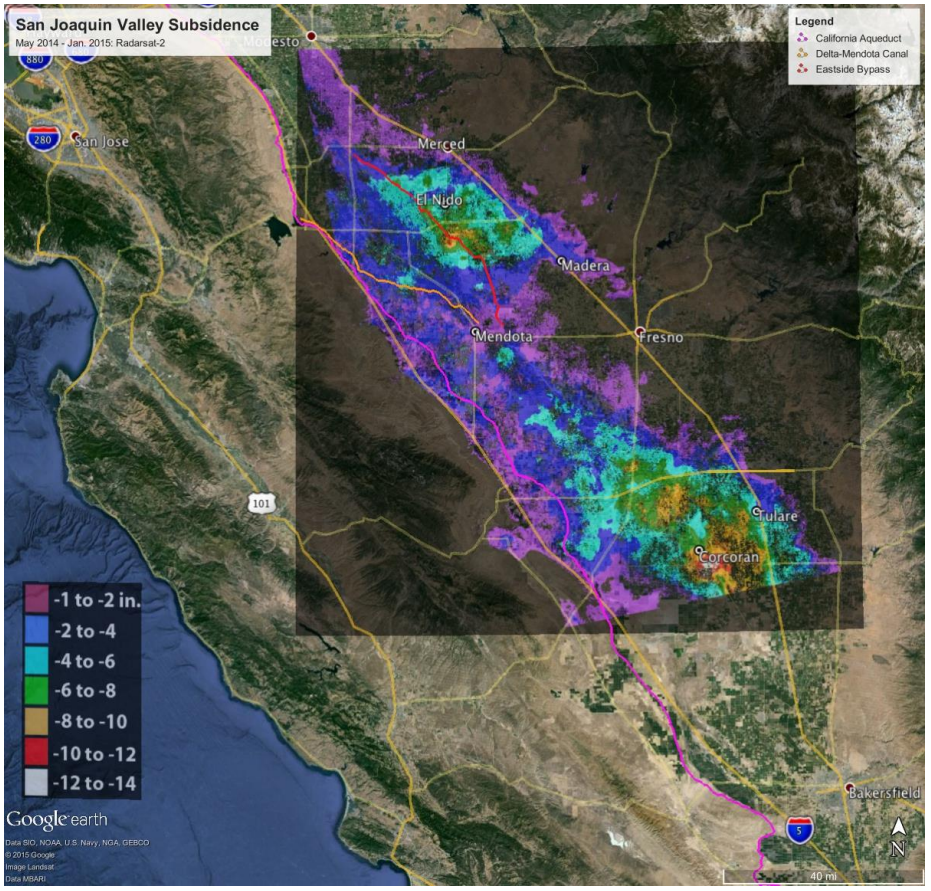

1925
1955
SAN JOAQUIN VALLEY
CALIFORNIA
BM.S661
SUBSIDENCE 9M
1925-1977
1977

How InSAR Works

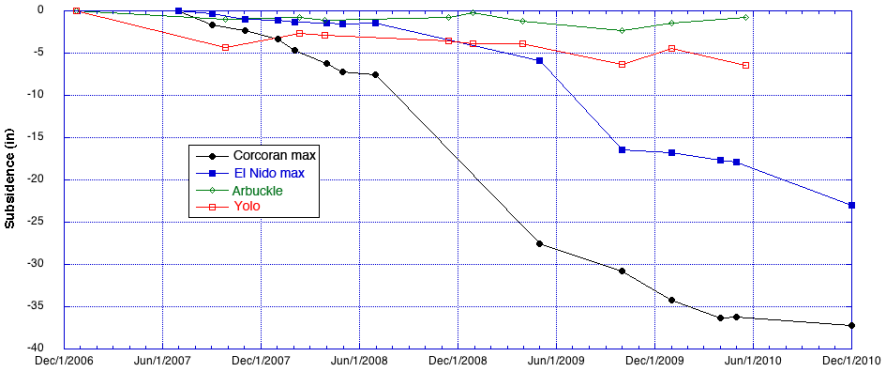


San Joaquin Valley Subsidence

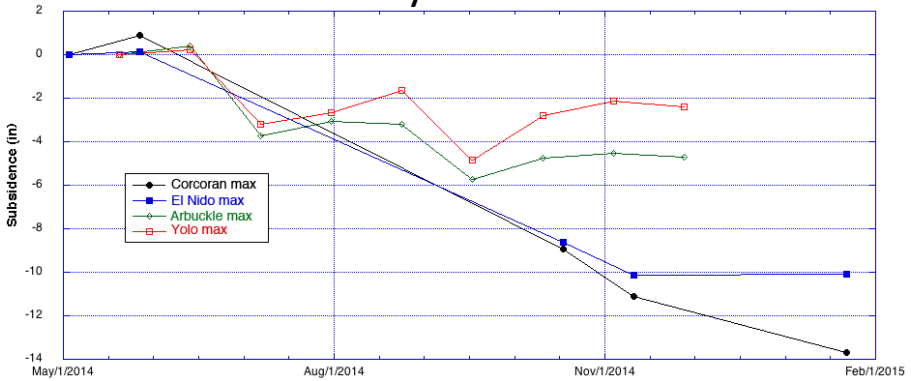


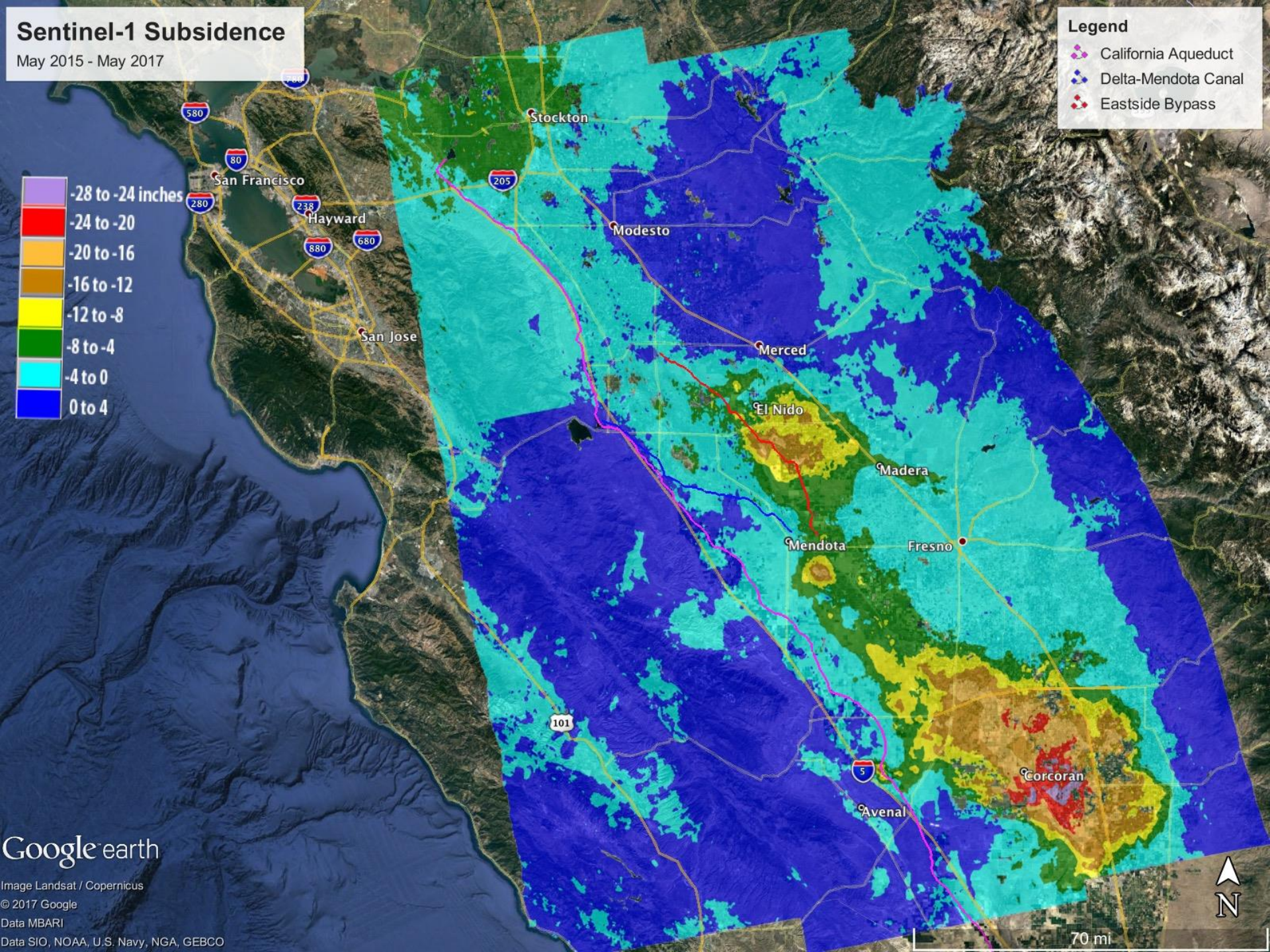


2007 - 2011



May-Dec. 2014




Sentinel-1 Subsidence
May 2015 - May 2017
Legend
California Aqueduct
Delta-Mendota Canal
Eastside Bypass
-28 to -24 inches
-24 to -20
-20 to -16
-16 to -12
-12 to -8
-8 to -4
-4 to 0
0 to 4
Stockton
San Francisco
Hayward
San Jose
Modesto
Merced
El Nido
Madera
Mendota
Fresno
Corcoran
Avenal
580
80
280
238
880
680
205
101
5
Google earth
Image Landsat / Copernicus
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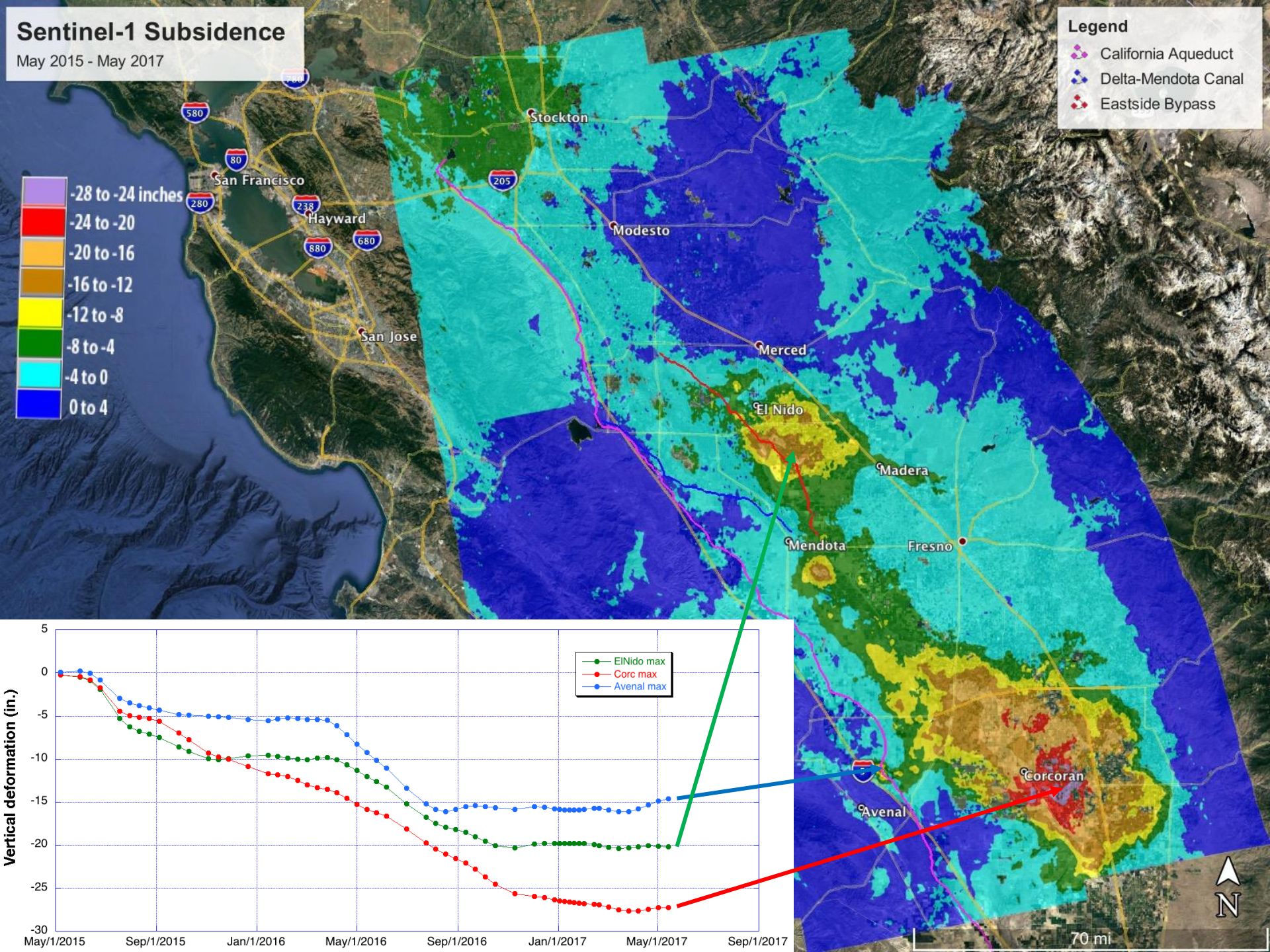
Data MBARI
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
N
70 mi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Delta-Mendota Canal
Eastside Bypass
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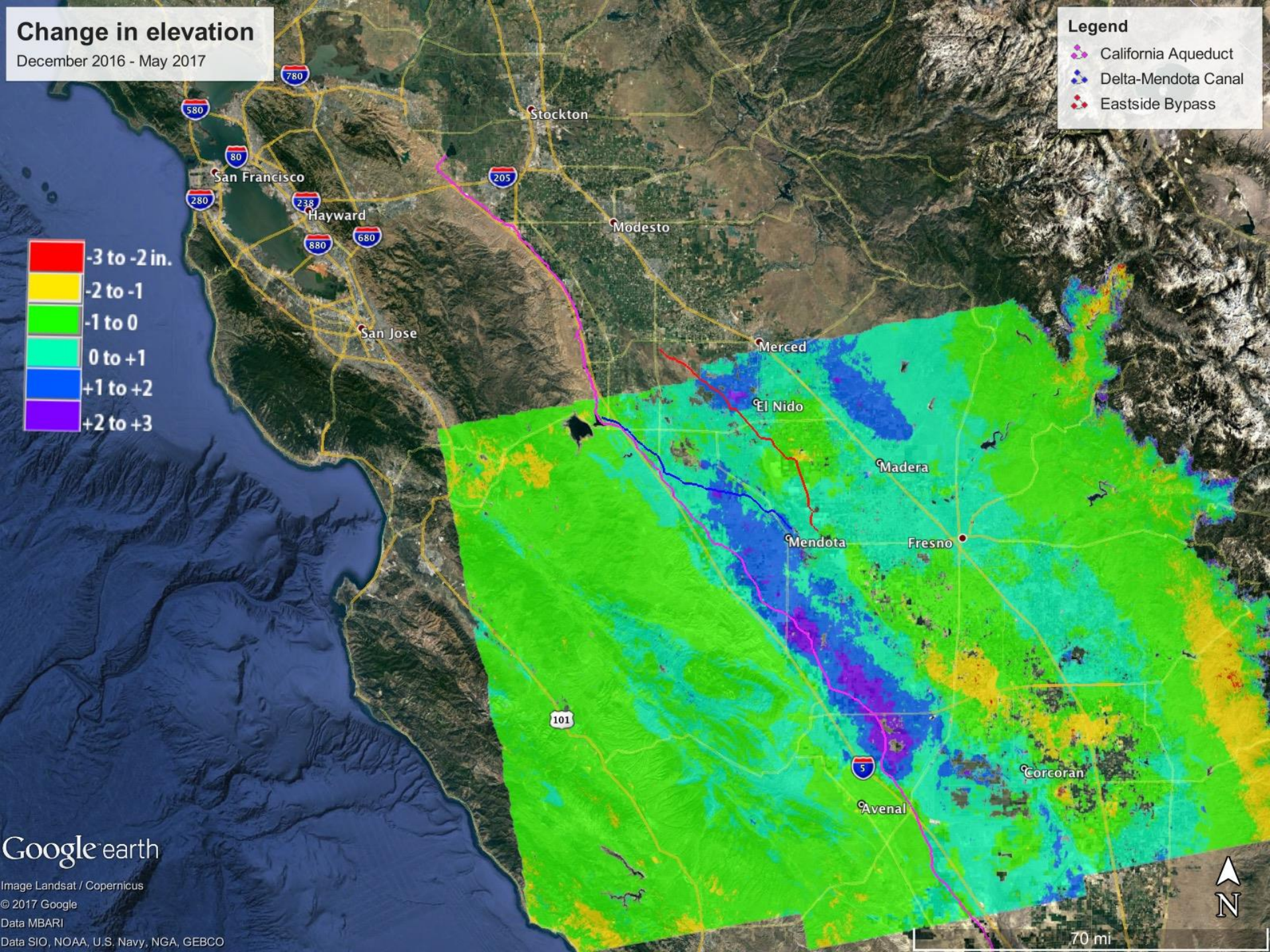
-16 to -12
-12 to -8
-8 to -4
-4 to 0
0 to 4
Stockton
San Francisco
Hayward
San Jose
Modesto
Merced
El Nido
Madera
Mendota
Fresno
Corcoran
Avenal
580
80
205
280
238
880
680
N
70 mi
Vertical deformation (in.)
5
0
-5
-10
-15
-20
-25
-30
May/1/2015
Sep/1/2015
Jan/1/2016
May/1/2016
Sep/1/2016
Jan/1/2017
May/1/2017
Sep/1/2017
ElNido max
Corc max
Avenal max


Change in elevation
December 2016 - May 2017
Legend
California Aqueduct
Delta-Mendota Canal
Eastside Bypass
-3 to -2 in.
-2 to -1
-1 to 0
0 to +1
+1 to +2
+2 to +3
Stockton
San Francisco
Hayward
Modesto
San Jose
Merced
El Nido
Madera
Mendota
Fresno
Corcoran
Avenal
780
580
80
205
280
238
880
680
101
5
Google earth
Image Landsat / Copernicus
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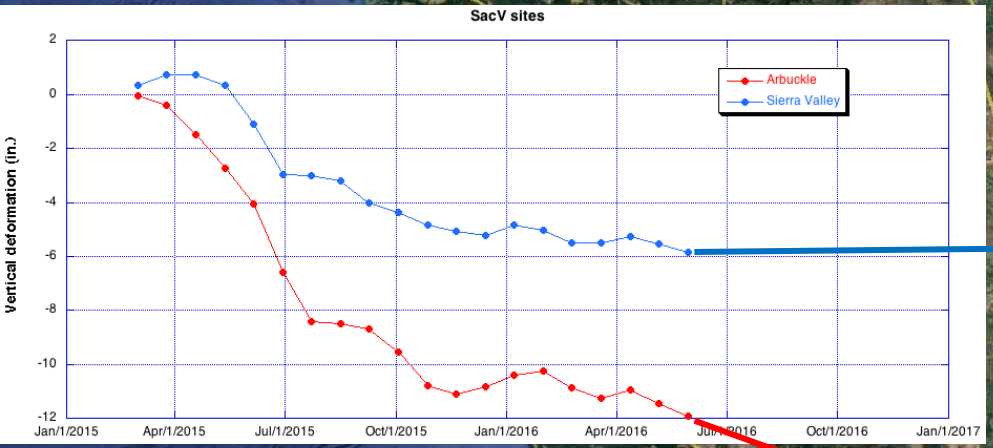
Data MBARI
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
N
70 mi

Sentinel-1 Subsidence

March 2015 - May 2016



-7 to -6 in.
-6 to -5
-5 to -4
-4 to -3
-3 to -2
-2 to -1
-1 to +1

Redding
Chico
Reno
Carson City
Sacramento
Santa Rosa
Stockton
San Francisco
Hayward
Modesto
San Jose
Merced
El Nido
80
505
50
780
580
280
238
880
205
395

Google earth

Image Landsat / Copernicus
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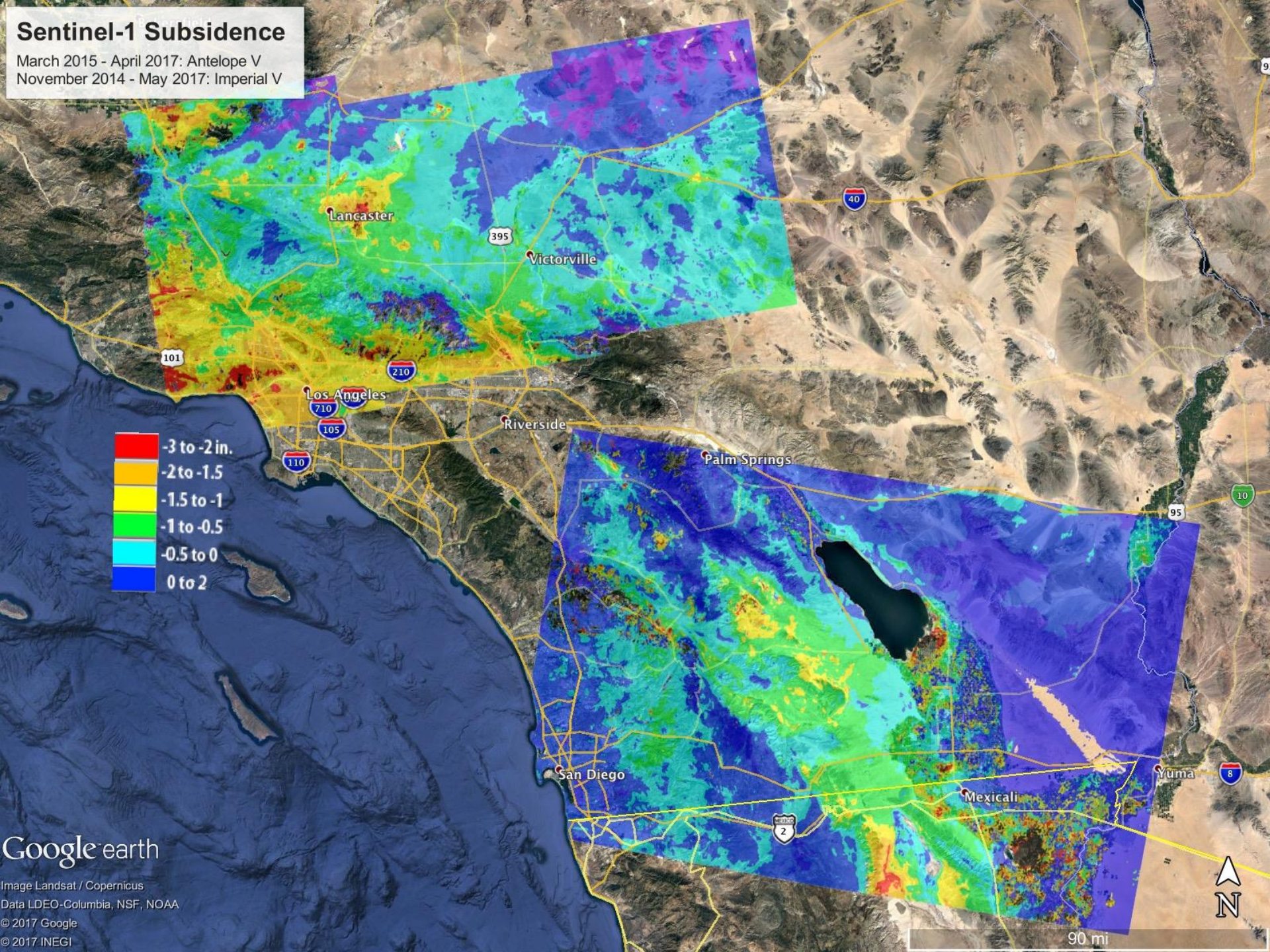
Data LDEO-Columbia, NSF, NOAA
Data SIO, NOAA, U.S. Navy, NGA, GEBCO

N

100 mi


Sentinel-1 Subsidence
March 2015 - April 2017: Antelope V
November 2014 - May 2017: Imperial V
-3 to -2 in.
-2 to -1.5
-1.5 to -1
-1 to -0.5
-0.5 to 0
0 to 2
Lancaster
Victorville
Los Angeles
Riverside
Palm Springs
San Diego
Mexicali
Yuma
Google earth
Image Landsat / Copernicus
Data LDEO-Columbia, NSF, NOAA
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90 mi
N