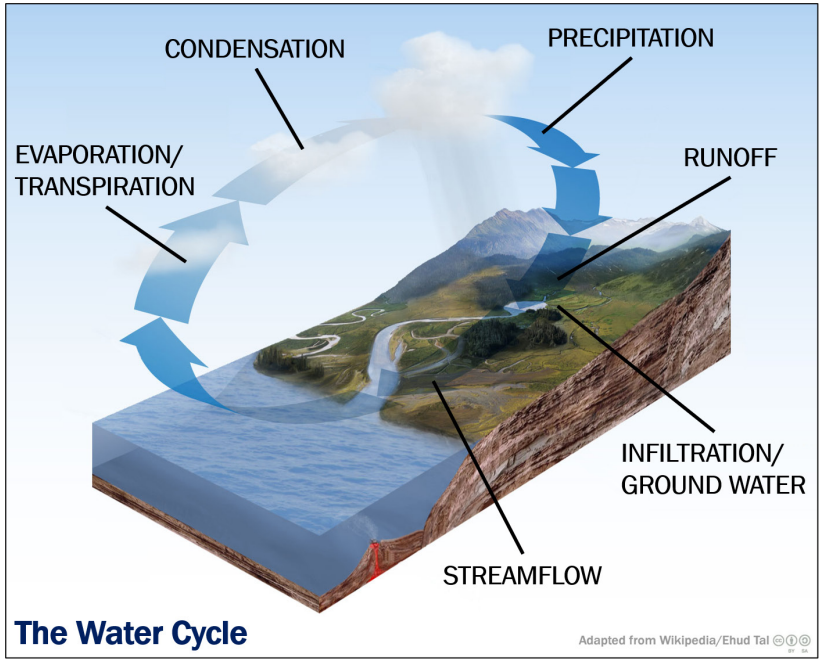
Hydrology

AOSC 680

Ross Salawitch

Class Web Sites:

http://www2.atmos.umd.edu/~rjs/class/fall2024
https://umd.instructure.com/courses/1367293



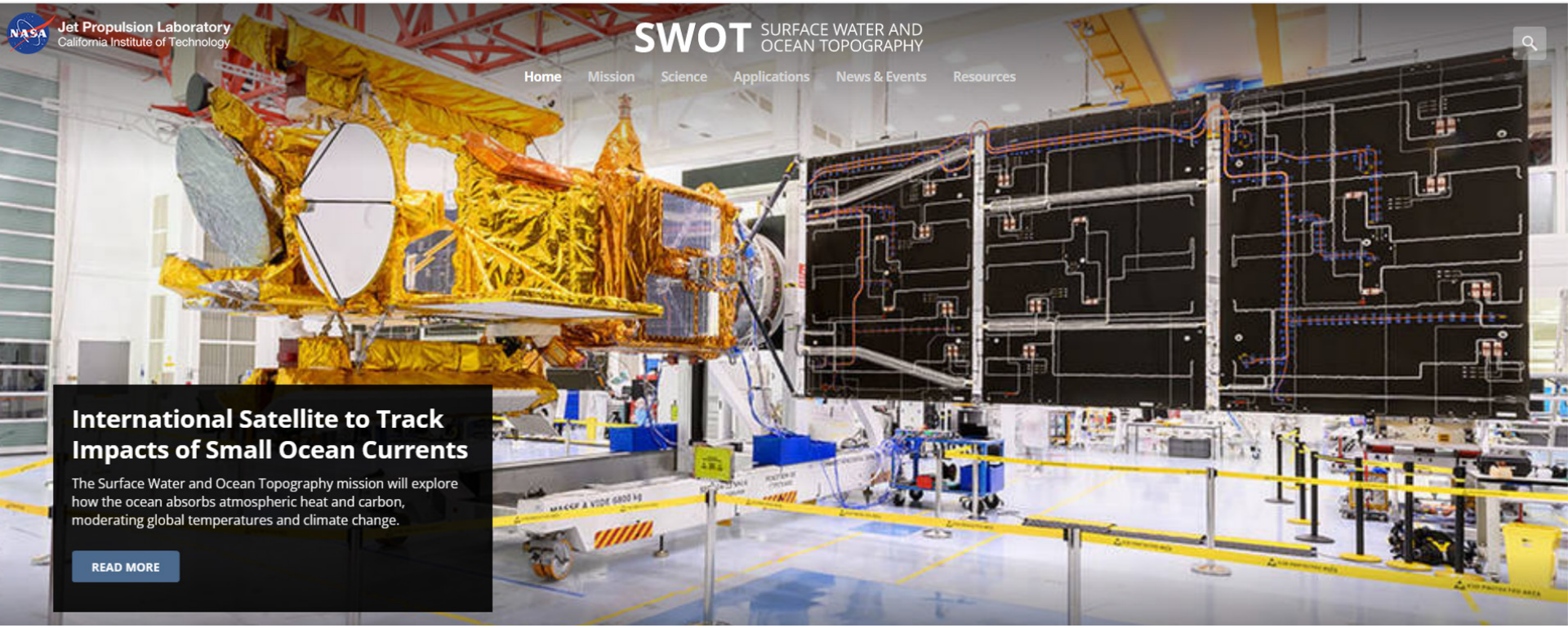
https://www.weather.gov/lot/hydrology_education_watercycle

Lecture 18

5 November 2024

SWOT: Surface Water and Ocean Topography Mission

Launch :16 December 2022

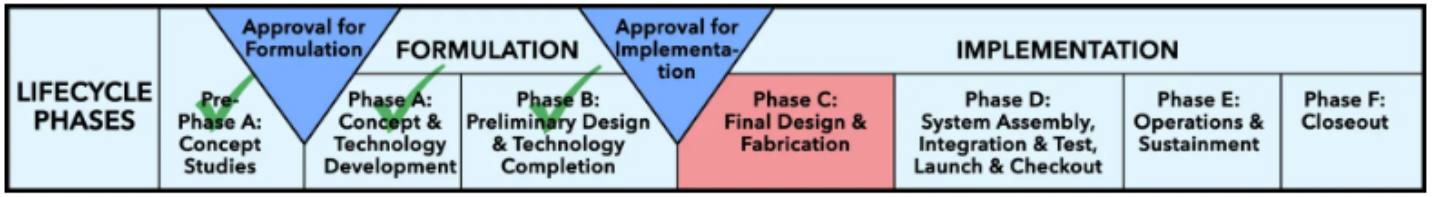


https://swot.jpl.nasa.gov/resources/171/swot-nasa-cnes-satellite-to-survey-the-worlds-water-mission-overview
https://www.youtube.com/watch?v=1Rr2L2rVvdc
https://swot.jpl.nasa.gov/mission/flight-systems

SWOT: Surface Water and Ocean Topography Mission

Mission Development Timeline

SWOT was one of 15 missions listed in the 2007 National Research Council Decadal Survey of Earth science missions that NASA should implement in the subsequent decade (full report available here). In its earliest stages, the mission underwent *Concept Studies* (Pre-Phase A) and *Concept & Technology Development* (Phase A).



Mission lifecycle phases.

In early 2015, SWOT entered Phase B, *Preliminary Design & Technology Completion*. In 2016, SWOT was approved for implementation and thus entered Phase C *(Final Design & Fabrication)*.

https://swot.jpl.nasa.gov/mission/overview/

https://swot.jpl.nasa.gov/resources/171/swot-nasa-cnes-satellite-to-survey-the-worlds-water-mission-overview
https://www.youtube.com/watch?v=1Rr2L2rVvdc
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SWOT: Surface Water and Ocean Topography Mission

Instruments

Payload

SWOT's payload is comprised of the following instruments:

- **KaRIn**
  - Using JPL-developed instrument technology, radar interferometry, KaRIn will measure ocean and surface water levels over a 120-km (75-mi) wide swath with a ~20 km (~12 mi) gap along nadir. It will operate in two modes:
    - Low-Resolution over the ocean with significant onboard processing to reduce data volume.
    - High-Resolution over broad, primarily continental, regions defined by the SWOT Science Team, focusing on hydrology studies.
- **Jason-class Altimeter** will collect data in the gap between the KaRIn swaths. It will send and receive signals that travel straight up and down. Each pulse's round-trip travel time will be used to determine Sea Surface height.
- **DORIS Antenna** will pick up signals from 50-60 ground-based radio beacons, equally distributed over Earth to ensure good coverage.
- **Microwave Radiometer** will measure the amount of water vapor between SWOT and Earth's surface. More water vapor means slower radar signals.

The Payload has components contributed by NASA, CNES, and CSA. The primary payload is the Ka-band Radar Interferometer (KaRIn) that is being developed by JPL. The Canadian Space Agency will provide a high-power assembly component for KaRIn. CNES will build the Doppler Orbitography and Radiopositioning Integrated by Satellite (DORIS) Antenna and Nadir Altimeter.

https://swot.jpl.nasa.gov/resources/171/swot-nasa-cnes-satellite-to-survey-the-worlds-water-mission-overview
https://www.youtube.com/watch?v=1Rr2L2rVvdc
https://swot.jpl.nasa.gov/mission/flight-systems

SWOT: Surface Water and Ocean Topography Mission

Data Product Overview

In March 2024, the SWOT mission team released a suite of pre-validated Level 1 and Level 2 hydrology and oceanography datasets offering terrestrial water surface elevation, slope, width, area, sea surface height, significant wave height and wind speed measurements, and more. Information about these new datasets will follow a brief overview of the SWOT mission, how these data are acquired, and data

In brief, SWOT data will allow hydrologists and oceanographers to:

- Estimate river flow as well as lake and reservoir volume changes around the globe, track how much water is flowing through hundreds of thousands of river reaches wider than 330 feet (100 meters), and keep a close watch on the levels of more than a million lakes larger than 15 acres (6 hectares)
- Create detailed maps of rivers, lakes, and reservoirs that will enable accurate monitoring to provide a view of freshwater resources, even in remote locations
- Provide derived volumetric measurements of rivers, lakes, and reservoirs to help hydrologists better track droughts and floods
- View the ocean with unprecedented clarity, allowing scientists to detect features such as fronts, eddies, and waves as small as a few kilometers, and — for the first time — provide information that will improve physics models and forecasts
- Better understand the role the ocean plays in climate change by inferring how much heat and carbon the ocean absorbs from the atmosphere
- Monitor sea level, tides, and coastal sea level variations all the way into estuaries for the first time, at a resolution that will contribute to the understanding of local coastal changes

https://www.earthdata.nasa.gov/news/feature-articles/nasas-surface-water-ocean-topography-swot-mission-data-release

SWOT: Surface Water and Ocean Topography Mission

22 Hydrology Science Investigations Currently Supported

Towards a better understanding of the global hydrological cycle with SWOT

SUBJECT

Global Modeling & Remote Sensing

PRINCIPAL INVESTIGATOR(S)

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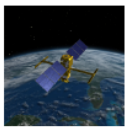
Munier, Simon ›
CNRM, MeteoFrance

Ottlé, Catherine ›
Laboratoire des Sciences du Climat et de l'Environnement (LSCE)



Estimation of River Discharges from SWOT Observations using Data Assimilation and Hydraulic Models

SUBJECT

Discharge Algorithms

PRINCIPAL INVESTIGATOR(S)

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https://www.youtube.com/watch?v=1Rr2L2rVvdc
https://swot.jpl.nasa.gov/mission/flight-systems

SWOT: Surface Water and Ocean Topography Mission

One Early Result

SWOT Science Team Meeting – Toulouse – from 19th to 22nd September 2023

Towards a better understanding of the global hydrological cycle with SWOT

Simon Munier[1], Aaron Boone[1], Patrick Le Moigne[1], Marylin Uchasara[2], Jan Polcher[2], Catherine Ottle[3]
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There is an urgent need to be able to better predict the impacts of climate change on the planetary-scale fresh water resources. The interest of the SWOT mission on the continental / global scale is to be able to observe all major watersheds and lakes, especially those still poorly observed in situ, making SWOT a particularly good tool, suitable for the study of the continental and global hydrological cycle. Such information would go a long way in improving understanding of the role of the spatio-temporal variability of river flows and wetlands within the global water cycle. Currently, no model system exists which is able to produce reliable global estimates of discharge and river and lake water storage, mostly owing to a lack of data with sufficient spatial and temporal coverage. The main objective of this project, therefore, is to further refine methodologies (notably data assimilation) which have been developed over the past decade in preparation of the mission for using SWOT data to improve the input parameters and the physics of the hydrological and hydrodynamic parameterizations in Earth System Models (ESMs).

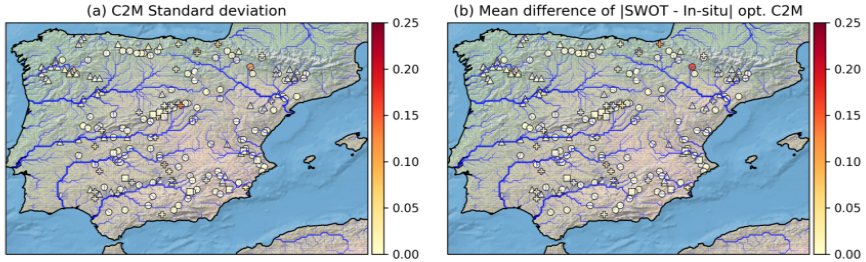
d. Using SWOT to calibrate the DROP reservoir model

The DROP (Dam-Reservoir Operation model) has been recently developed and integrated to the CTRIP model to represent the effect of dam-reservoirs on the river flow dynamics (Sadki et al., 2022).

The model has been implemented and validated over 215 dam-reservoirs in Spain.

Simulated SWOT-derived volume variations with various types of error have been used to calibrate the DROP model.

The efficiency of the calibration is compared to the best calibration results that could be obtained from daily observed data (volume variations and reservoir release).



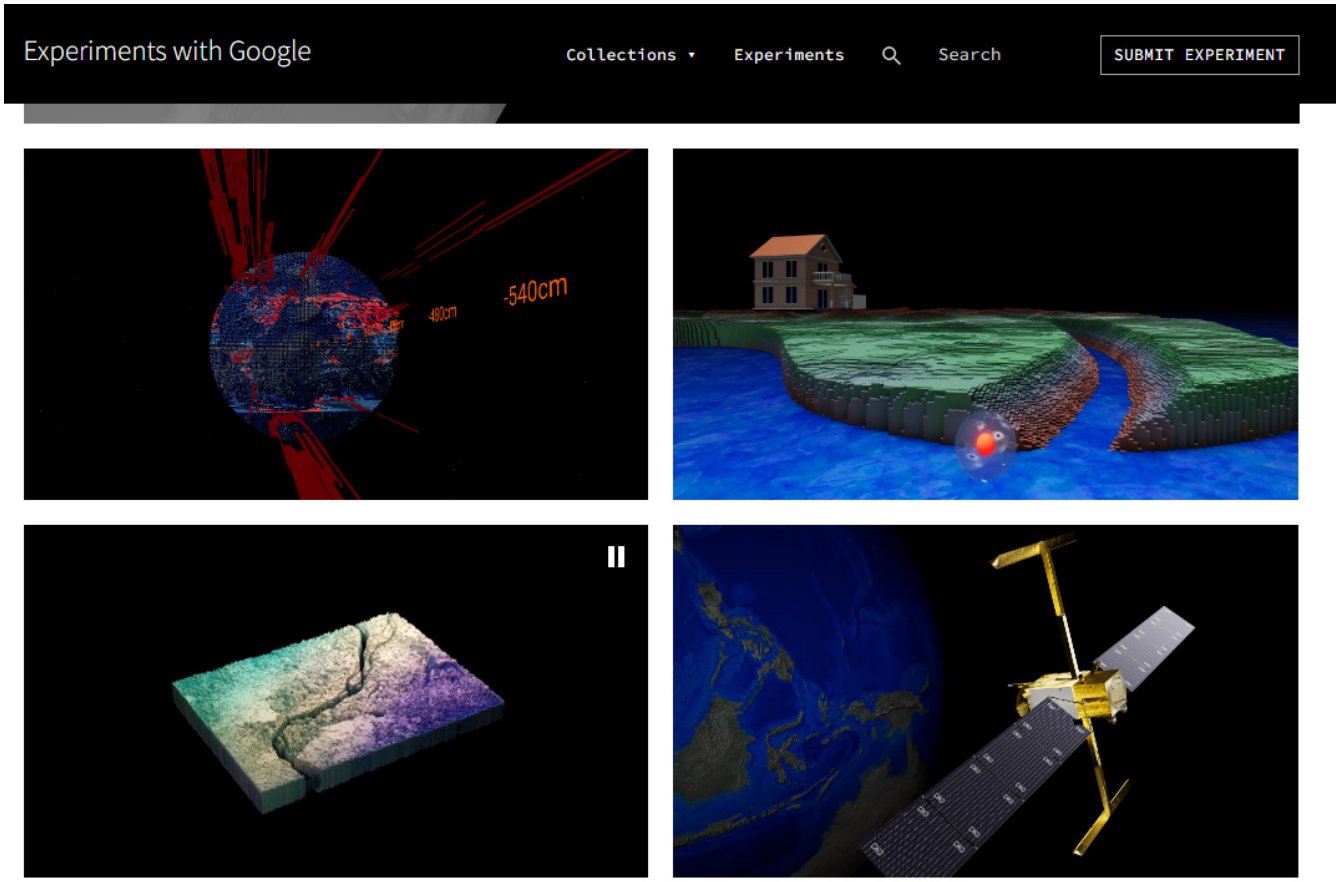
(a) For each reservoir, standard deviation of the optimal C2M score with varying random errors on SWOT observations of water elevation and surface area. (b) Average of absolute biases between the calibration efficiency of the reference (daily in situ data) and the calibration efficiency with varying errors on SWOT observations.

Results show that despite errors in SWOT observations and coarser time sampling, the calibration efficiency using SWOT data is almost as good as the one using real daily data.

This demonstrates the huge potential of SWOT to calibrate the DROP model for all dam-reservoirs of the globe observed by SWOT.

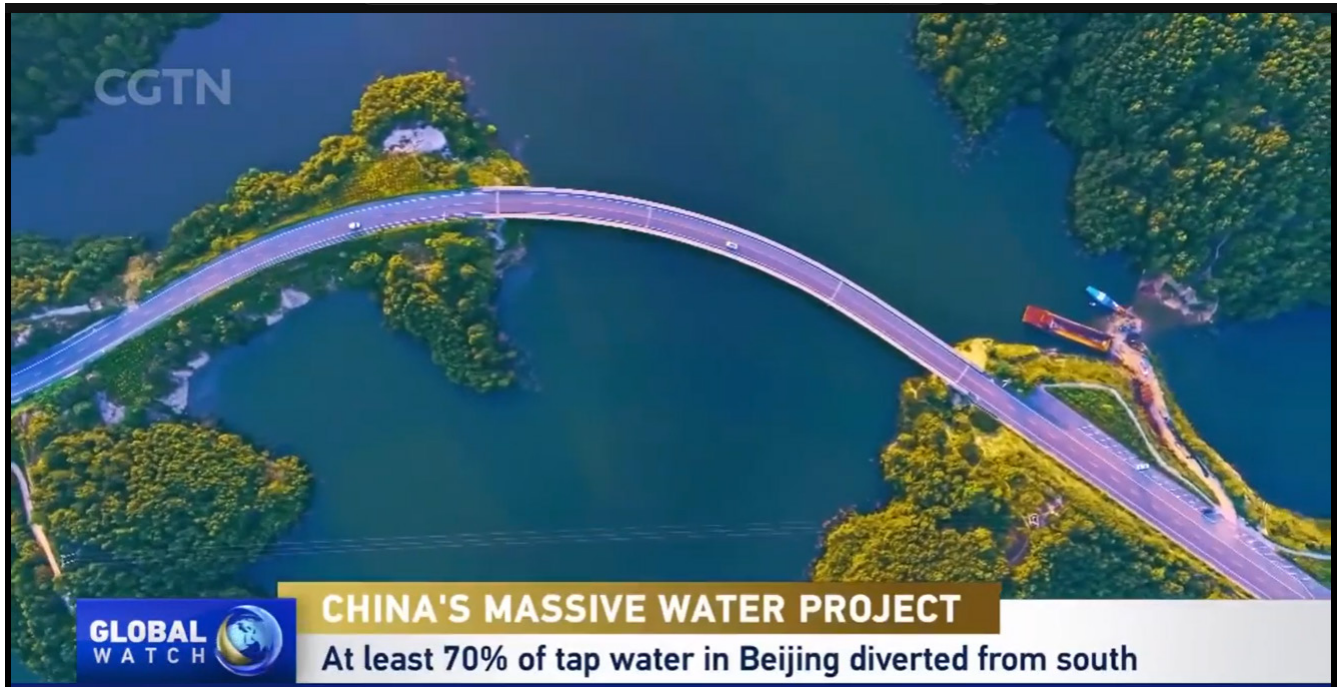
https://swotst.aviso.altimetry.fr/fileadmin/user_upload/SWOTST2023/postersPI/munier_hydro_global_pi.pdf

Passage of Water:
Immersive Experience That Combines Data From SWOT and GRACE



https://climate.nasa.gov/news/3293/googles-a-passage-of-water-brings-nasas-water-data-to-life
https://experiments.withgoogle.com/passage-of-water

China’s Massive South-North Water Diversion Project



China's massive South-North water diversion project serves 120 million people

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China says its ambitious South-to-North Water Diversion Project is now serving more than 120 million people. On the fifth anniversary of the opening of the east and middle routes, China's Water Resources Ministry said it's working hard to complete the project in full. The south-to-north water diversion project is the world's largest of its kind. In China, water is abundant in the south, but scarce in the north – so this massive infrastructure project aims to resolve water shortage issues in cities like Beijing. Here are some more facts about the project.
Video:

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LAND SUBSIDENCE

Land subsidence is the lowering of the land-surface elevation due to changes that take place underground.

Throughout California, subsidence has damaged buildings, aqueducts, well casings, bridges and highways. Common causes include pumping water, oil or gas, dissolution of limestone aquifers known as sinkholes, drainage of organic soils and initial wetting of dry soils, according to the U.S. Geological Survey.

As the land sinks, flooding problems are aggravated. Subtle changes in land gradient can adversely impact sewer lines and storm drainage. In all, subsidence has resulted in millions of dollars in damage.

Land Subsidence Hot Spots

The most severely affected areas were in southern and western portions of the San Joaquin Valley as irrigated agriculture expanded. Between 1925 and 1977, land near Mendota sank by nearly 30 feet. By the 1950s a broad area down the west side of the valley to Kettleman City in Kings County sank by up to 25 feet, and on the eastern side of the valley, Tulare and Wasco area farms sank 12 feet. At the extreme southern end of the valley, the ground sank 8 feet. Even in the wetter Sacramento Valley, in the Zamora and Knights Landing areas of Yolo County, the land sank by 4 to 6 feet. Portions of the Antelope Valley near Lancaster, northeast of Los Angeles, have sunk by 6 to 8 feet from 1930, according to USGS.

https://www.watereducation.org/aquapedia/land-subsidence

Meanwhile, back in the USA

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19 MARCH 2019

Western droughts caused permanent loss to major California groundwater source

By Joshua Rapp Learn

California's Central Valley aquifer, the major source of groundwater in the region, suffered permanent loss of capacity during the drought experienced in the area from 2012 to 2015.

California has been afflicted by a number of droughts in recent decades, including one between 2007 and 2009, and the millennium drought that plagued the state from 2012 to 2015. Due to lack of water resources, the state drew heavily on its underground aquifer reserves during these periods.

According to new research, the San Joaquin Valley aquifer in the Central Valley shrank permanently by up to 3 percent due to excess pumping during the sustained dry spell. Combined with the loss from the 2007 to 2009 drought, the aquifer may have lost up to 5 percent of its storage capacity during the first two decades of the 21st Century, according to Manoochehr Shirzaei, an assistant professor of earth sciences at Arizona State University in Tempe and one of the co-authors of a new study published in AGU's *Journal of Geophysical Research: Solid Earth*.

Measures of land Subsidence in San Joaquin Valley. Credit: USGS

https://blogs.agu.org/geospace/2019/03/19/western-droughts-caused-permanent-loss-to-major-california-groundwater-source/