User Guide
NASA-SSH Sea Surface Height Indicators

Josh Willis, Severine Fournier, Kevin Marlis, Emmy Killett
Jet Propulsion Laboratory, California Institute of Technology

These files contain regularly updated sea level indicators in the form of time series, based on the NASA-SSH data products. Indicators for global mean sea level (GMSL), the El Niño Southern Oscillation (ENSO), the Indian Ocean Dipole (IOD), and the Pacific Decadal Oscillation (PDO) are included. Details for each can be found below.

GMSL

NASA-SSH Global Mean Sea Level from Simple Gridded Sea Surface Height

This file contains a time series of globally-averaged sea level change, or "global mean sea level" (GMSL) in units of centimeters. The estimate is based on satellite observations of sea surface height anomaly, measured by reference radar altimeter missions such as TOPEX/Poseidon, the Jason series, and Sentinel-6. The indicator values were calculated using NASA-SSH Simple Gridded Sea Surface Height from Standardized Reference Missions Only Version 1
https://podaac.jpl.nasa.gov/dataset/NASA_SSH_REF_SIMPLE_GRID_V1 .

GMSL was calculated as the area-weighted average over each map in the time series of Simple Gridded Sea Surface Height. Because maps are computed using 10-days of observations, but are computed once every 7 days, there is a small amount of overlap between data used to compute successive time steps. A version of the estimate smoothed over 60 days is also provided.

Expert users, please note that this estimate has NOT been adjusted for Glacial Isostatic Adjustment, to account for the slight long-term depression of the sea floor. Users who study the sea level budget will need to account for this effect in order to properly evaluate closure of the budget.

If you use these data please cite:

NASA-SSH. 2025. SSH Global Mean Sea Level from Simple Gridded Sea Surface Height. PO.DAAC, CA, USA. Dataset accessed [YYYY-MM-DD] at https://doi.org/10.5067/NSIND-GMSV1.

ENSO

NASA-SSH ENSO Sea Surface Height Indicator

This file contains an indicator for the El Nino-Southern Oscillation (ENSO), based on satellite observations of sea surface height anomaly, measured by radar altimeter missions such as TOPEX/Poseidon, the Jason series, and Sentinel-6. The indicator values were calculated using NASA-SSH Simple Gridded Sea Surface Height from Standardized Reference Missions Only Version 1 https://podaac.jpl.nasa.gov/dataset/NASA_SSH_REF_SIMPLE_GRID_V1 .

Indicator values were calculated using cyclostationary empirical orthogonal functions (CSEOFs; Kim et al., 2015) computed by decomposing the gridded sea surface height anomalies over the time period from 1993 to 2019. After removing the linear trend from each individual gridded location, three sets of regional CSEOFs were generated, one each for ENSO, the Pacific Decadal Oscillation (PDO) and Indian Ocean Diode (IOD). In each case, the dominant statistical mode represents the seasonal cycle. The second most dominant mode represents the variability explained by each respective indicator and is referred to as the "indicator mode". The seasonal mode and indicator mode are then projected onto the along-track sea surface height anomalies to produce the indicator time series through the most current date. In this case, the ENSO mode was used to produce the time series contained in this file.

For more information on how the data were generated please refer to:

K.Y. Kim, B. Hamlington, H. Na, "Theoretical foundation of cyclostationary EOF analysis for geophysical and climatic variables: concepts and examples", 2015. Earth-science reviews, 150, 201-218.

P. Kumar, B. Hamlington, S. Cheon, W. Han, and P. Thompson, "20th Century Multivariate Indian Ocean Regional Sea Level Reconstruction," J. Geophys. Res. Oceans, vol. 125, no. 10, Oct. 2020, doi: 10.1029/2020jc016270.

B. D. Hamlington et al., "The Dominant Global Modes of Recent Internal Sea Level Variability," J. Geophys. Res. Oceans, vol. 124, no. 4, pp. 2750–2768, Apr. 2019, doi: 10.1029/2018jc014635.

IOD

NASA-SSH IOD Sea Surface Height Indicator

This file contains an indicator for the Indian Ocean Dipole (IOD), based on satellite observations of sea surface height anomaly, measured by radar altimeter missions such as TOPEX/Poseidon, the Jason series, and Sentinel-6. The indicator values were calculated using NASA-SSH Simple Gridded Sea Surface Height from Standardized Reference Missions Only Version 1 https://podaac.jpl.nasa.gov/dataset/NASA_SSH_REF_SIMPLE_GRID_V1 .

Indicator values were calculated using cyclostationary empirical orthogonal functions (CSEOFs; Kim et al., 2015) computed by decomposing the gridded sea surface height anomalies over the time period from 1993 to 2019. After removing the linear trend from each individual gridded location, three sets of regional CSEOFs were generated, one each for the El Nino-Southern Oscillation (ENSO), the Pacific Decadal Oscillation (PDO) and (IOD). In each case, the dominant statistical mode represents the seasonal cycle. The second most dominant mode represents the variability explained by each respective indicator and is referred to as the “indicator mode”. The seasonal mode and indicator mode are then projected onto the along-track sea surface height anomalies to produce the indicator time series through the most current date. In this case, the IOD mode was used to produce the time series contained in this file.

For more information on how the data were generated please refer to:

K.Y. Kim, B. Hamlington, H. Na, “Theoretical foundation of cyclostationary EOF analysis for geophysical and climatic variables: concepts and examples”, 2015. Earth-science reviews, 150, 201-218.

P. Kumar, B. Hamlington, S. Cheon, W. Han, and P. Thompson, “20th Century Multivariate Indian Ocean Regional Sea Level Reconstruction,” J. Geophys. Res. Oceans, vol. 125, no. 10, Oct. 2020, doi: 10.1029/2020jc016270.

B. D. Hamlington et al., “The Dominant Global Modes of Recent Internal Sea Level Variability,” J. Geophys. Res. Oceans, vol. 124, no. 4, pp. 2750–2768, Apr. 2019, doi: 10.1029/2018jc014635.

PDO

NASA-SSH PDO Sea Surface Height Indicator

This file contains an indicator for the Pacific Decadal Oscillation (PDO), based on satellite observations of sea surface height anomaly, measured by radar altimeter missions such as TOPEX/Poseidon, the Jason series, and Sentinel-6. The indicator values were calculated using NASA-SSH Simple Gridded Sea Surface Height from Standardized Reference Missions Only Version 1 https://podaac.jpl.nasa.gov/dataset/NASA_SSH_REF_SIMPLE_GRID_V1 .

Indicator values were calculated using cyclostationary empirical orthogonal functions (CSEOFs; Kim et al., 2015) computed by decomposing the gridded sea surface height anomalies over the time period from 1993 to 2019. After removing the linear trend from each individual gridded location, three sets of regional CSEOFs were generated, one each for El Nino-Southern Oscillation (ENSO), the PDO and Indian Ocean Diode (IOD). In each case, the dominant statistical mode represents the seasonal cycle. The second most dominant mode represents the variability explained by each respective indicator and is referred to as the "indicator mode". The seasonal mode and indicator mode are then projected onto the along-track sea surface height anomalies to produce the indicator time series through the most current date. In this case, the PDO mode was used to produce the time series contained in this file.

For more information on how the data were generated please refer to:

K.Y. Kim, B. Hamlington, H. Na, "Theoretical foundation of cyclostationary EOF analysis for geophysical and climatic variables: concepts and examples", 2015. Earth-science reviews, 150, 201-218.

P. Kumar, B. Hamlington, S. Cheon, W. Han, and P. Thompson, "20th Century Multivariate Indian Ocean Regional Sea Level Reconstruction," J. Geophys. Res. Oceans, vol. 125, no. 10, Oct. 2020, doi: 10.1029/2020jc016270.

B. D. Hamlington et al., "The Dominant Global Modes of Recent Internal Sea Level Variability," J. Geophys. Res. Oceans, vol. 124, no. 4, pp. 2750–2768, Apr. 2019, doi: 10.1029/2018jc014635.

Acknowledgement

The preparation of this document and the data it describes was carried in part out at the Jet Propulsion Laboratory, California Institute of Technology, under a contract with the National Aeronautics and Space Administration (80NM0018D0004).