Ocean Surface Current Analyses Real-time (OSCAR) v2.0 User's Handbook

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DATA PRODUCT ABSTRACT

The OSCAR project produces global near-surface current analyses computed from satellite observations: ocean surface topography, ocean vector winds and sea surface temperature. The source gridded fields are obtained from other expert centers using data collected from various satellites and in situ instruments. The model formulation combines geostrophic, Ekman and thermal wind dynamics [1].

The ocean surface velocity files are in NetCDF format and contain total zonal (u) and meridional (v) velocities as well as the zonal (ug) and meridional geostrophic (vg) components. The data is available in three quality levels: final, interim, and near-real-time (nrt). The quality levels are determined by the best available source datasets and are intended to provide users with both the best quality data as well as near-real-time data.

INVESTIGATOR'S NAME AND CREDIT

The OSCAR product is produced by Kathleen Dohan and was originally developed by Gary Lagerloef and Fabrice Bonjean at Earth & Space Research (ESR).

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HOW TO CITE

OSCAR final:
ESR; Dohan, Kathleen. 2021. Ocean Surface Current Analyses Real-time (OSCAR) Surface Currents - Final 0.25 Degree (Version 2.0). Ver. 2.0. PO.DAAC, CA, USA. Dataset accessed [YYYY-MM-DD] at https://doi.org/10.5067/OSCAR-25F20.

OSCAR interim:
ESR; Dohan, Kathleen. 2021. Ocean Surface Current Analyses Real-time (OSCAR) Surface Currents - Interim 0.25 Degree (Version 2.0). Ver. 2.0. PO.DAAC, CA, USA. Dataset accessed [YYYY-MM-DD] at https://doi.org/10.5067/OSCAR-25I20.

OSCAR nrt:

ESR; Dohan, Kathleen. 2021. Ocean Surface Current Analyses Real-time (OSCAR) Surface Currents - Near Real Time 0.25 Degree (Version 2.0). Ver. 2.0. PO.DAAC, CA, USA. Dataset accessed [YYYY-MM-DD] at https://doi.org/10.5067/OSCAR-25N20.

DATA DESCRIPTION

The file names have a naming convention of:

oscar_currents_final_YYYYMMDD.nc

oscar_currents_interim_YYYYMMDD.nc

oscar_currents_nrt_YYYYMMDD.nc

where YYYY, MM, DD denote the year, month, and day of the data.

FILE FORMAT

The data are in netCDF files and have a maximum size of 32 MB.

TEMPORAL COVERAGE AND RESOLUTION

This is a daily product with one file per day consisting of a daily average of data.

SPATIAL COVERAGE AND RESOLUTION

The data covers -89.75° to 89.75° latitude and 0° to 359.75° longitude with a 0.25° x 0.25° spatial resolution. Data is provided as an average over the top 30 m of the upper ocean mixed layer.

LATENCY

OSCAR final has a latency on the order of 1.5 years. OSCAR interim has a latency of approximately 1 month. OSCAR nrt has a latency of 2 days.

DATA PARAMETERS AND FORMAT

Each file consists of daily averaged values for total surface velocity as well as the geostrophic only component. Velocities are provided on a regular 0.25° x 0.25° grid. The sample NetCDF attributes below are from oscar_currents_final_20200101.nc.

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dimensions:
        latitude = 719 ;
        longitude = 1440 ;
        time = 1 ;
variables:
        double lat(latitude) ;
                lat:long_name = "latitude" ;
                lat:standard_name = "latitude" ;
                lat:units = "degrees_north" ;
                lat:axis = "Y" ;
                lat:valid_min = -89.75 ;
                lat:valid_max = 89.75 ;
                lat:bounds = "[-89.75,89.75]" ;
        double lon(longitude) ;
                lon:long_name = "longitude" ;
                lon:standard_name = "longitude" ;
                lon:units = "degrees_east" ;
                lon:axis = "X" ;
                lon:valid_min = 0. ;
                lon:valid_max = 359.75 ;
                lon:bounds = "[0,359.75]" ;
        double time(time) ;
                time:long_name = "time centered on the day" ;
                time:standard_name = "time" ;
                time:units = "days since 1990-1-1" ;
                time:calendar = "julian" ;
                time:axis = "T" ;
                time:time_bounds = "2020-01-01 00:00:00 to 2020-01-01 23:59:59" ;
                time:comment = "Data is averaged over the day" ;
        double u(time, longitude, latitude) ;
                u:_FillValue = -999. ;
                u:long_name = "zonal total surface current" ;
```

u:standard_name = "eastward_sea_water_velocity" ;
u:units = "m s-1" ;
u:coverage_content_type = "modelResult" ;
u:valid_min = -3. ;
u:valid_max = 3. ;
u:coordinates = "lon lat" ;
u:depth = "15m" ;
u:comment = "Velocities are an average over the top 30m of the mixed layer" ;
u:source = "SSH source: CMEMS SSALTO/DUACS SEALEVEL_GLO_PHY_L4_MY_008_047 DOI: 10.48670/moi-00148 ; WIND source: ECMWF ERA5 10m wind DOI: 10.24381/cds.adbb2d47 ; SST source: CMC 0.1 deg SST V3.0 DOI: 10.5067/GHCMC-4FM03" ;
double v(time, longitude, latitude) ;
v:_FillValue = -999. ;
v:long_name = "meridional total surface current" ;
v:standard_name = "northward_sea_water_velocity" ;
v:units = "m s-1" ;
v:coverage_content_type = "modelResult" ;
v:valid_min = -3. ;
v:valid_max = 3. ;
v:coordinates = "lon lat" ;
v:depth = "15m" ;
v:comment = "Velocities are an average over the top 30m of the mixed layer" ;
v:source = "SSH source: CMEMS SSALTO/DUACS SEALEVEL_GLO_PHY_L4_MY_008_047 DOI: 10.48670/moi-00148 ; WIND source: ECMWF ERA5 10m wind DOI: 10.24381/cds.adbb2d47 ; SST source: CMC 0.1 deg SST V3.0 DOI: 10.5067/GHCMC-4FM03" ;
double ug(time, longitude, latitude) ;
ug:_FillValue = -999. ;
ug:long_name = "zonal geostrophic surface current" ;
ug:standard_name = "geostrophic_eastward_sea_water_velocity" ;
ug:units = "m s-1" ;
ug:valid_min = -3. ;
ug:valid_max = 3. ;
ug:coordinates = "lon lat" ;
ug:depth = "15m" ;
ug:comment = "Geostrophic velocities calculated from absolute dynamic topography" ;

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        ug:source = "SSH source: CMEMS SSALTO/DUACS
SEALEVEL_GLO_PHY_L4_MY_008_047 DOI: 10.48670/moi-00148" ;
    double vg(time, longitude, latitude) ;
        vg:_FillValue = -999. ;
        vg:long_name = "meridional geostrophic surface current" ;
        vg:standard_name = "geostrophic_northward_sea_water_velocity" ;
        vg:units = "m s-1" ;
        vg:valid_min = -3. ;
        vg:valid_max = 3. ;
        vg:coordinates = "lon lat" ;
        vg:depth = "15m" ;
        vg:comment = "Geostrophic velocities calculated from absolute dynamic
topography" ;
        vg:source = "SSH source: CMEMS SSALTO/DUACS
SEALEVEL_GLO_PHY_L4_MY_008_047 DOI: 10.48670/moi-00148" ;
```

SAMPLE GLOBAL ATTRIBUTES

These global attributes come from oscar_currents_final_20200101.nc

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:_NCProperties = "version=2,netcdf=4.7.3,hdf5=1.8.12," ;
:title = "Ocean Surface Current Analyses Real-time (OSCAR) Surface Currents - Final 0.25 Degree
(Version 2.0)" ;
:summary = "Global, daily, 0.25 degree geostrophic and total mixed layer currents averaged
over the top 30m. Highest quality OSCAR product." ;
:keywords = "ocean currents,ocean circulation,surface currents,ekman,geostrophic" ;
:Conventions = "CF-1.8 Standard Names v77, ACDD-1.3, netcdf 4.7.3, hdf5 1.8.12" ;
:id = "OSCAR_L4_OC_FINAL_V2.0" ;
:history = "OSCAR 0.25 degree daily version 2.0 replaces OSCAR third degree 5 day" ;
:source = "OSCAR is based on simplified physics using satellite data; SSH source: CMEMS
SSALTO/DUACS SEALEVEL_GLO_PHY_L4_ MY_008_047 DOI: 10.48670/moi-00148 ; WIND
source: ECMWF ERA5 10m wind DOI: 10.24381/cds.adbb2d47 ; SST source: CMC 0.1 deg SST
V3.0 DOI: 10.5067/GHCMC-4FM03" ;
:processing_level = "L4" ;
:standard_name_vocabulary = "NetCDF Climate and Forecast (CF) Metadata Convention" ;
:acknowledgment = "OSCAR products are supported by NASA and may be freely distributed." ;
:product_version = "v2.0" ;
```

:creator_name = "Kathleen Dohan" ;
:creator_email = "kdohan@esr.org" ;
:creator_url = "www.esr.org/research/oscar/" ;
:creator_type = "person" ;
:creator_institution = "ESR" ;
:institution = "Earth & Space Research" ;
:references = "www.esr.org/research/oscar/, PO.DAAC user guide, DOI: 10.5067/OSCAR-25F20" ;
:project = "Ocean Surface Current Analyses Real-time (OSCAR)" ;
:program = "OSCAR" ;
:publisher_name = "NASA Physical Oceanography Distributed Active Archive Center (PO.DAAC)" ;
:publisher_email = "podaac@podaac.jpl.nasa.gov" ;
:publisher_url = "podaac.jpl.nasa.gov" ;
:publisher_type = "institution" ;
:publisher_institution = "PO.DAAC" ;
:geospatial_lat_min = -89.75 ;
:geospatial_lat_max = 89.75 ;
:geospatial_lat_units = "degrees_north" ;
:geospatial_lat_resolution = "0.25 degree" ;
:geospatial_lon_min = 0. ;
:geospatial_lon_max = 359.75 ;
:geospatial_lon_units = "degrees_east" ;
:geospatial_lon_resolution = "0.25 degree" ;
:time_coverage_start = "2020-01-01T00:00:00" ;
:time_coverage_end = "2020-01-01T23:59:59" ;
:date_created = "2021-09-30" ;

OSCAR MODEL OUTLINE

OSCAR surface currents are calculated from satellite datasets using a simplified physical model of an upper ocean turbulent mixed layer. The total velocity is comprised of a geostrophic term, a wind-driven term, and a thermal wind adjustment. The OSCAR model assumes quasi-steady linear flow in a surface layer with turbulent mixing parameterized by an eddy viscosity. Wind stress is related to shear via the eddy viscosity. The geostrophic term is computed from the gradient of sea surface height (SSH) fields and there is a contribution to vertical shear from horizontal sea surface temperature (SST) gradients through the thermal wind relation. OSCAR is an analytical solution to the simplified momentum equation using Stommel boundary conditions - shear goes to zero at depth. The eddy viscosity is constant in depth but depends on wind. The currents are provided as an averaged value over the top 30m of the solution. Over the years, the OSCAR project has evolved from a tropical study [2] to a global near-real-time product [1]. The equations for the basic OSCAR model are:

$$if\mathbf{u} = -\frac{1}{\rho}\nabla p + \frac{1}{\rho}\frac{\partial \tau}{\partial z}$$

$$\frac{\partial p}{\partial z} = -\rho g$$

$$\tau = K\frac{\partial \mathbf{u}}{\partial \mathbf{z}} \qquad K = \mathbf{a}\left(\frac{|\mathbf{W}|}{\mathbf{W_0}}\right)^{\mathbf{b}}$$

$$\frac{\partial \mathbf{u}}{\partial z}(z=0) = \frac{1}{\rho_0 K}\tau_0 \qquad \frac{\partial \mathbf{u}}{\partial z}(z=-H) = 0$$

where: **u**=u+iv, $\boldsymbol{\tau_0}$ is surface wind stress, H=125m, and K is a vertical eddy viscosity, calculated as a function of wind. Optimal choices for a and b are based on a regression against drifter climatology and blend from $a=8\times10^{-5}\ m^2s^{-1}$, b=2.2 at the equator as in [3], to $a=2.85\times10^{-4}\ m^2s^{-1}$, b=2 for the global value.

SOURCE DATASETS

The source datasets used in OSCAR are:

OSCAR final

SSH: SSALTO/DUACS delayed-time absolute dynamic topography (ADT) global gridded product distributed by the Copernicus Marine Environment Monitoring Service (CMEMS) and produced by the DUACS multimission altimeter data processing system. https://resources.marine.copernicus.eu/product-detail/SEALEVEL_GLO_PHY_L4_MY_008_047/INFORMATION https://doi.org/10.48670/moi-00148

WINDS: ERA5 10m reanalysis vector winds produced by ECMWF (Hersbach et al. 2018) downloaded from the Copernicus Climate Change Service (C3S) Climate Data Store [4].

SST from 1993 to 2015: Canada Meteorological Center. 2012. CMC 0.2 deg global sea surface temperature analysis. Ver. 2.0. PO.DAAC, CA, USA. Dataset accessed at https://doi.org/10.5067/GHCMC-4FM02.

SST from 2016 to present: Canada Meteorological Center. 2016. CMC 0.1 deg global sea surface temperature analysis. Ver. 3.0. PO.DAAC, CA, USA. Dataset accessed at https://doi.org/10.5067/GHCMC-4FM03

OSCAR interim

SSH: SSALTO/DUACS near-real-time absolute dynamic topography (ADT) global gridded product distributed by the Copernicus Marine Environment Monitoring Service (CMEMS) and produced by the DUACS multimission altimeter data processing system. https://resources.marine.copernicus.eu/product-detail/SEALEVEL_GLO_PHY_L4_NRT_OBSERVATIONS_008_046/INFORMATION https://doi.org/10.48670/moi-00149

WINDS: ERA5 10m reanalysis vector winds produced by ECMWF (Hersbach et al. 2018) downloaded from the Copernicus Climate Change Service (C3S) Climate Data Store [4].

SST: Canada Meteorological Center. 2016. CMC 0.1 deg global sea surface temperature analysis. Ver. 3.0. PO.DAAC, CA, USA. Dataset accessed at https://doi.org/10.5067/GHCMC-4FM03

OSCAR nrt

SSH: SSALTO/DUACS near-real-time absolute dynamic topography (ADT) global gridded product distributed by the Copernicus Marine Environment Monitoring Service (CMEMS) and produced by the DUACS multimission altimeter data processing system. https://resources.marine.copernicus.eu/product-detail/SEALEVEL_GLO_PHY_L4_NRT_OBSERVATIONS_008_046/INFORMATION https://doi.org/10.48670/moi-00149

WINDS: NCEP/NCAR Reanalysis 1 10m winds from the NOAA-ESRL Physical Sciences Laboratories (PSL) analysis/forecast system data assimilation [5]. https://psl.noaa.gov/data/gridded/data.ncep.reanalysis.html.

SST: Canada Meteorological Center. 2016. CMC 0.1 deg global sea surface temperature analysis. Ver. 3.0. PO.DAAC, CA, USA. Dataset accessed at https://doi.org/10.5067/GHCMC-4FM03

There was an initial complete calculation of the entire dataset in early 2021. Data is now accessed in real-time and the source dataset access dates generally coincide with the creation date of the OSCAR files.

MISSIONS

The time period determines which mission data contributes to the final level 4 source products, according to the duration of each individual mission.
For SSH: ERS-1, ERS-2, TOPEX/Poseidon, Jason-1, OSTM/Jason-2, Jason-3, Envisat, Cryosat-2, Saral/Altika, HY-2A, HY-2B, Sentinel-3A, Sentinel-3B. All available altimeter mission data are used in the calculation of the dynamic topography, along with gravity measurements from GRACE and GOCE and drifting buoy velocities and hydrological profiles for the calculation of the CNES-CLS18 mean dynamic topography (MDT) [6].

For SST: TRMM/TMI, CORIOLIS/WINDS, AVHRR-3 on NOAA-16, NOAA-17, NOAA-19, NOAA-20, METOP-A and METOP-B, Aqua/AMSR-E, ATSR-2 on ERS-1 and ERS-2, ENVISAT/AATSR, SUOMI-NPP/VIIRS, GCOM-W1/AMSR2, and in situ moorings and drifting buoys

The winds used in OSCAR are obtained from reanalysis projects using data assimilation which incorporate data from a wide variety of missions and in situ measurements.
https://confluence.ecmwf.int/display/CKB/ERA5%3A+data+documentation#ERA5:datadocumentation-Observations
https://psl.noaa.gov/data/gridded/data.ncep.reanalysis.html

CALIBRATION INFORMATION

Validation results for the v2.0 product can be found at https://www.esr.org/research/oscar/validation/. Validation information on the OSCAR third degree version of this product can be found in Dohan and Maximenko [7].

KNOWN PROBLEMS

Any inherent errors in the source datasets will impact the quality of the velocities. Examples are high winds, rain, residual orbit errors, optimal interpolation errors, and sparse coverage, to name a few.

These currents are estimated through a simplified diagnostic model of the surface circulation, and as such have some limitations. Notably, local acceleration and non-linearities are not represented, and the geostrophic assumption is not valid at the equator. In addition, the model is not accurate very close to coastlines. It depends on coastlines, but generally OSCAR currents are inaccurate within 100 km of the coast.

Smoothing inevitably occurs in the creation of the regular gridded source data as well as during the calculation of spatial gradients (for geostrophic and thermal wind components only). This sort of indirect smoothing effect is lessened in this v2.0 and was also lessened in the 1/3° OSCAR from the 1° OSCAR product.

The worst performance of OSCAR is in areas where eddies are not the dominant signal, such as in the North Pacific Gyre, or in the meridional component in areas with strong zonal flows such as near the equator.

DIFFERENCES FROM 1/3° AND 1° OSCAR

OSCAR v2.0 is now provided as a daily file on a higher resolution grid with geostrophic velocities in addition to the total velocities. The Maximum Mask velocity (Um, Vm) is no longer used.

The model for equatorial velocities has been changed from [1]. The equatorial solution is now used within +/- 5 degrees of the equator. The turbulence parameterization is modified to blend from equatorial empirical values to global empirical values.

The method for calculating gradients has also been changed to suit the higher resolution data, and produces much better comparisons with in situ data.

A filtered velocity is not available anymore in v2.0.

Velocities over 3m/s are removed without any further processing.

REFERENCES

[1] Bonjean, F., and G. S. E. Lagerloef, 2002. Diagnostic model and analysis of the surface currents in the tropical Pacific Ocean. *J. Phys. Oceanogr.*, vol. 32, pg. 2938-2954.

[2] Lagerloef, G. S., Mitchum, G. T., Lukas, R. B. and P. P. Niiler (1999). Tropical Pacific near-surface currents estimated from altimeter, wind, and drifter data, J. Geophys. Res., 104(C10), 23,313–23,326, doi:10.1029/1999JC900197.

[3] Santiago-Mandujano, F., and E. Firing, 1990: Mixed-layer shear generated by wind stress in the central equatorial Pacific. *J. Phys. Oceanogr.*, 20, 1576–1582.

[4] Hersbach, H., Bell, B., Berrisford, P., Biavati, G., Horányi, A., Muñoz Sabater, J., Nicolas, J., Peubey, C., Radu, R., Rozum, I., Schepers, D., Simmons, A., Soci, C., Dee, D., Thépaut, J-N. (2018): ERA5 hourly data on single levels from 1979 to present. Copernicus Climate Change Service (C3S) Climate Data Store (CDS). 10.24381/cds.adbb2d47

[5] The NCEP/NCAR 40-Year Reanalysis Project: March, 1996 BAMS. https://doi.org/10.1175/1520-0477(1996)077<0437:TNYRP>2.0.CO;2

[6] Mulet, S., Rio, M.-H., Etienne, H., Artana, C., Cancet, M., Dibarboure, G., Feng, H., Husson, R., Picot, N., Provost, C., and Strub, P. T.: The new CNES-CLS18 global mean dynamic topography, Ocean Sci., 17, 789–808, https://doi.org/10.5194/os-17-789-2021, 2021.

[7] Dohan, K., and N. Maximenko, (2010). Monitoring ocean currents with satellite sensors.

CONTACT INFORMATION

Questions or comments about this data product should be directed via email to the Physical Oceanography DAAC: podaac@podaac.jpl.nasa.gov.

DOCUMENT INFORMATION

Kathleen Dohan, ESR
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