



Exploitation of Satellite Sea-surface Salinity Observations at NOAA

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Ocean Salinity Science Conference 2022

Satellite Salinity Observations

2010

2015

2020

2025

2030



ESA Soil Moisture – Ocean Salinity (SMOS)



NASA Aquarius



NASA Soil Moisture Active Passive (SMAP)



ESA Copernicus Imaging Microwave Radiometer (CIMR)

Operational

SSS Data Acquired

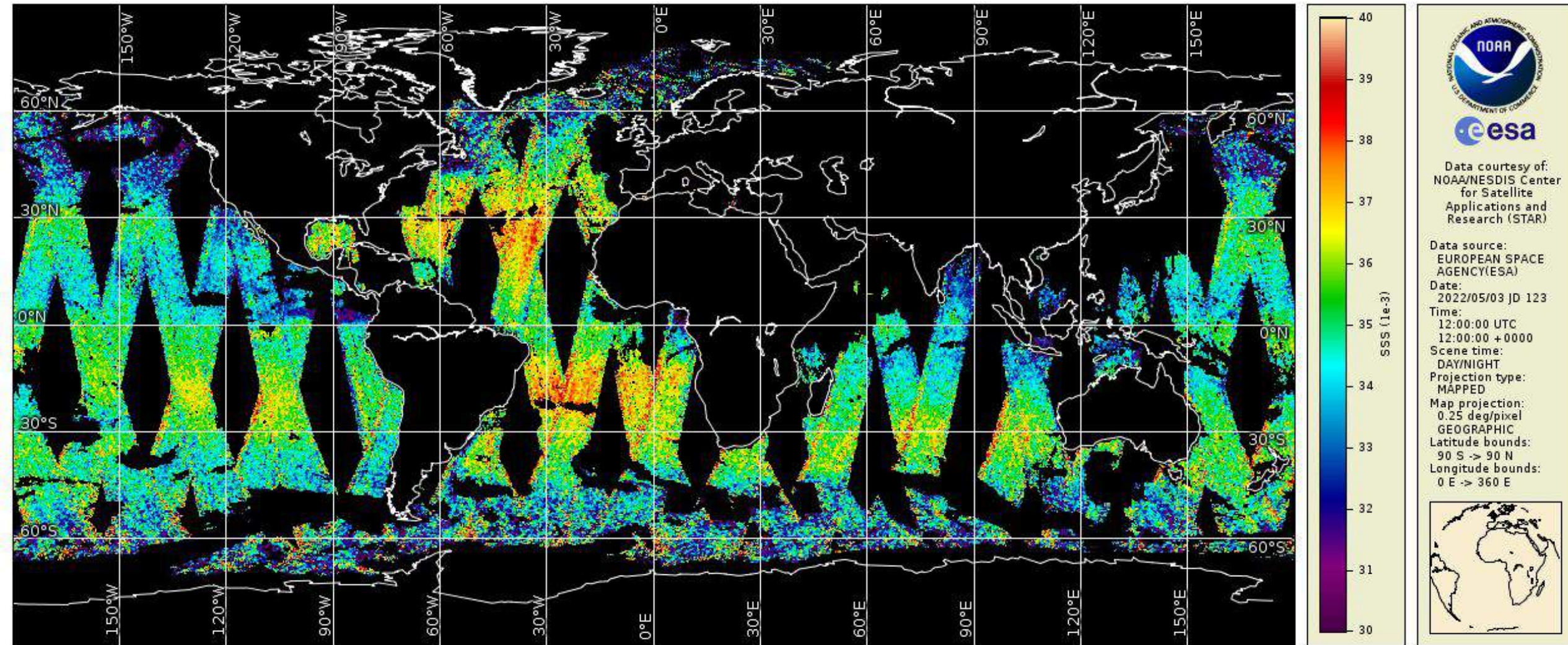
- **ESA: Soil Moisture Ocean Salinity (SMOS) Mission**
 - MIRAS SMOS Level-2 swath
 - Version 7xx
 - Latency ~ 24 hours
 - Format - NetCDF
 - [ESA SMOS Online Dissemination Service](#) (ftps)
- **NASA: Soil Moisture Active Passive (SMAP) Mission**
 - JPL Combined Active Passive (CAP) SMAP Level-2 swath
 - [NRT-delayed Version 5.0 \(SMAP_L2B-SSS_NRT*\)](#)
 - Latency ~ 5 hours
 - Application – operational data assimilation
 - [L2B Version 5.0 \(SMAP_L2B_SSS*\)](#)
 - Latency ~ 3 days
 - Application – scientific analyses, sub-seasonal – climate scale applications
 - Format – HDF5
 - [JPL Oceans SFTP server](#)
- SSS data continuity monitored to support operational exploitation

NOAA SSS Products

NOAA CoastWatch/OceanWatch

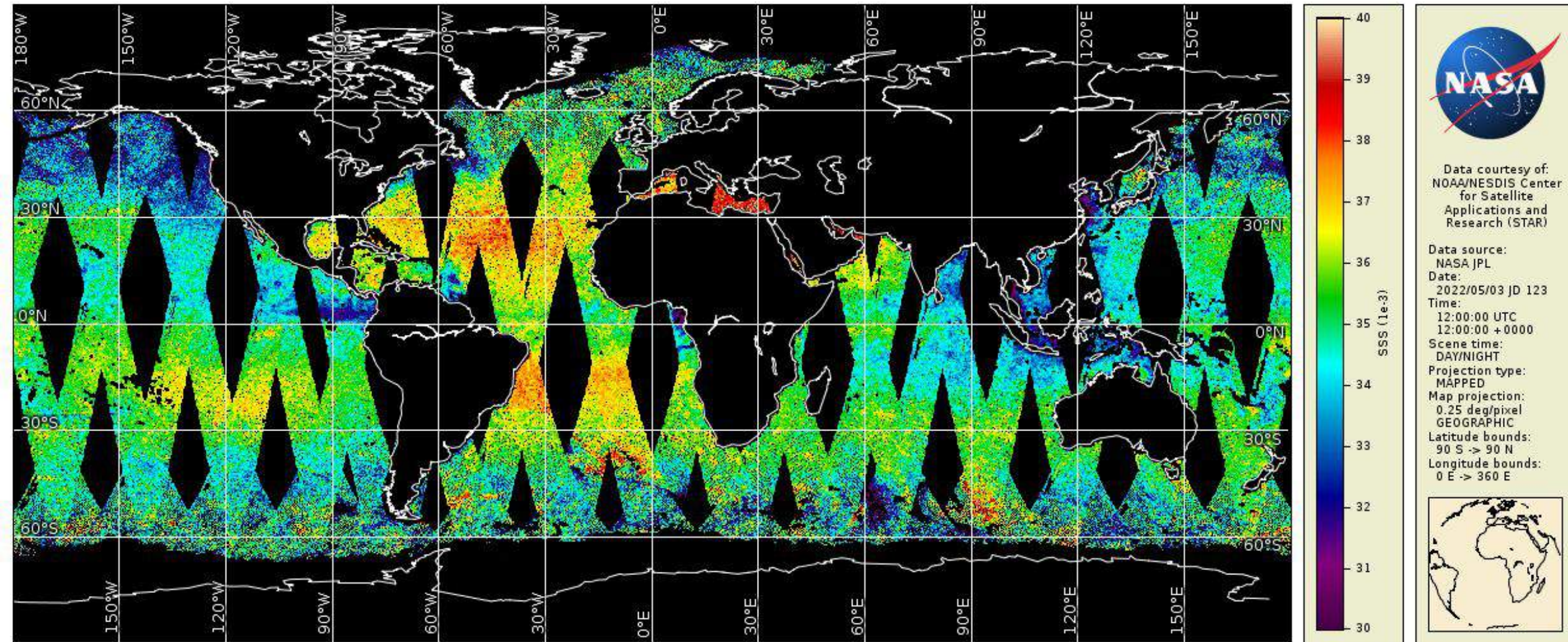
- Level-3 gridded SSS
 - 0.25-degree longitude/latitude resolution
 - box averaging
- SMOS Near-Real Time
 - Global
 - Daily and 3-day Mean
 - Latency – within 24 hours of Level-2 availability
 - Formats – NetCDF, PNG
- SMAP Near-Real Time
 - Global
 - Daily and 3-day Mean
 - Latency – within 24 hours of Level-2 availability
 - Formats – NetCDF, PNG

NOAA CoastWatch/OceanWatch: SMOS SSS



3 May 2022 (Day 123)

NOAA CoastWatch/OceanWatch: SMAP SSS



3 May 2022 (Day 123)

Operational Exploitation: Numerical Prediction

- NOAA recently upgraded its operational ocean and sea ice forecast system — the [Global Real-Time Ocean Forecast System](#) (Global RTOFS) Version 2.0.
 - Global RTOFSv2 provides predictions for up to eight days of ocean currents, salinity, temperature and sea ice conditions
 - Based on an eddy-resolving 1/12° global HYCOM (HYbrid Coordinates Ocean Model), in strong partnership with the U.S. Navy
 - The upgrade enables improved and integrated ocean and sea ice forecasts as a key component of NOAA's fully coupled Unified Forecast System
- Provides the outer context for NOAA's nested operational regional modeling
- Primarily used by:
 - Forecasters at NOAA's [Ocean Prediction Center](#) and [National Hurricane Center](#)
 - [U.S. Coast Guard](#), especially during search and rescue operations

RTOFSv2: Satellite Sea-surface Salinity (SSS)

- **SSS Assimilation**

- SMOS (MIRAS) Level-2 swath
 - Version 7xx (SM_OPER_MIR_OSUDPT_*_700.001.nc)
- JPL Combined Active Passive (CAP) SMAP Level-2 swath
 - NRT-delayed Version 5.0 (SMAP_L2B-SSS_NRT_*_.h5)

- **SSS Verification**

- Class-1 metrics – defined by the GODAE OceanPredict Intercomparison and Validation Task Team (IV-TT) as 2-D and 3-D model fields averaged to daily means and interpolated to common grid resolutions for intercomparison purposes (Hernandez, 2007).
- Surface model fields (SST, SSH, SSS) are compared with Level-3 and Level-4 gridded satellite analyses.
- Model nowcast and forecast fields are interpolated to the observational grids and averaged to match the different time periods of the satellite and analysis products.

- **Satellite SSS observational data sets** used:

- SSS [SMAP via PO.DAAC](#) - Level-3, 8-day mean)
- SSS [SMOS via NESDIS](#) - NOAA CoastWatch/OceanWatch Level-3, 1-day composite

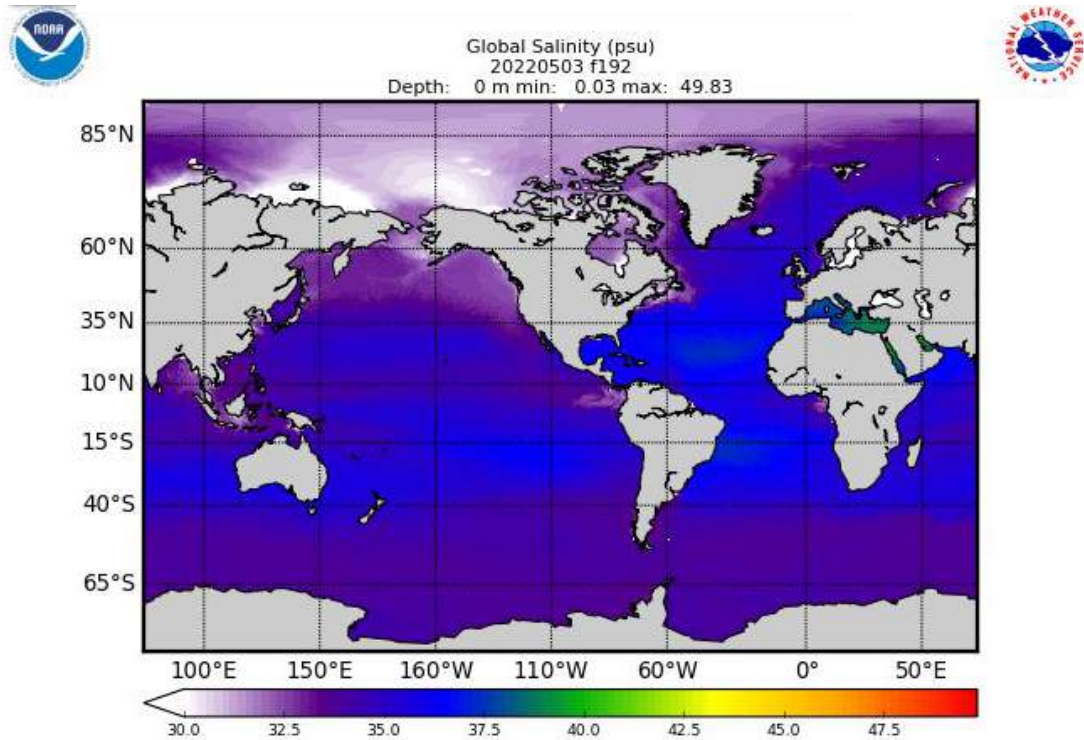
- **Climatology** data set used in computing SSS anomaly statistics:

- [World Ocean Atlas 2013 version 2](#)

NOAA National Weather Service – Environmental Modeling Center

Global Real-Time Ocean Forecast System (RTOFS) v2

RTOFSv2 Sea-surface Salinity Analysis



NCEP/EMC/Verification Post Processing Product Generation Branch

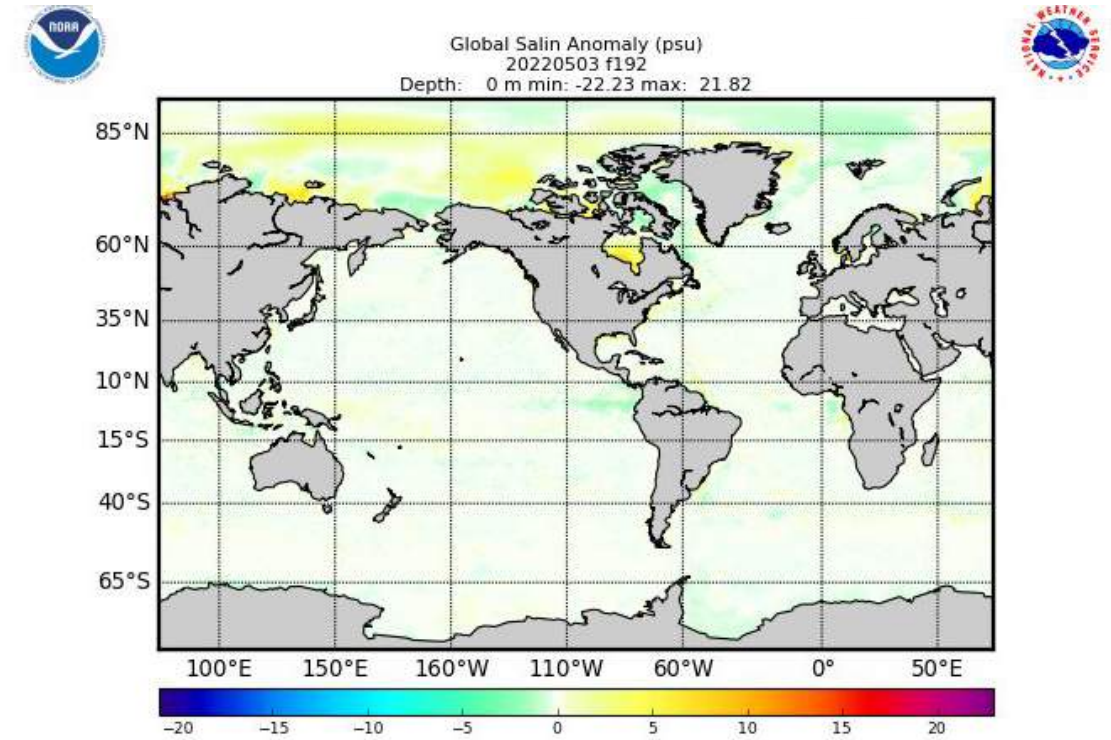
04 May 2022 on Hera

US Dept of Commerce
National Oceanic and Atmospheric Administration
National Weather Service

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RTOFSv2 Sea-surface Salinity Anomaly Analysis



NCEP/EMC/Verification Post Processing Product Generation Branch

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Global Ocean Monitoring: Recent Evolution, Current Status, and Predictions

- **NOAA Climate Prediction Center (CPC)**

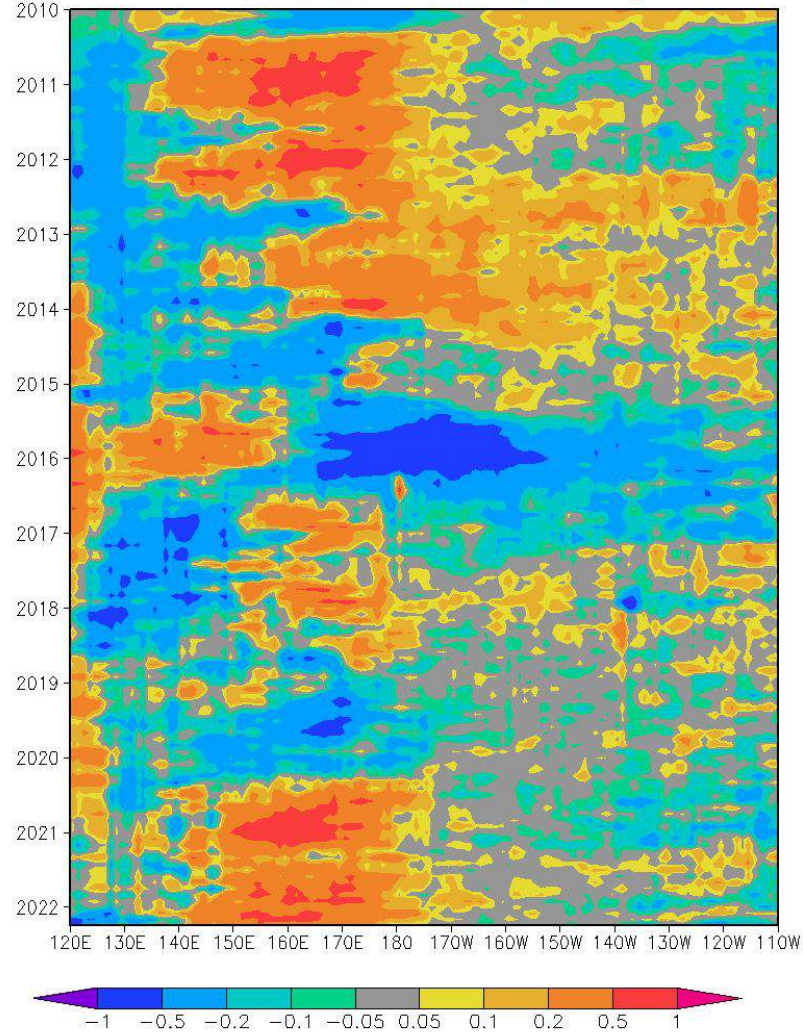
- Delivers real-time ocean monitoring products
 - Monthly Ocean Briefing: <http://www.cpc.ncep.noaa.gov/products/GODAS/>
- Implemented by CPC in cooperation with NOAA's Global Ocean Monitoring and Observing Program (GOMO)

- **Blended Analysis of Surface Salinity (BASS)**

- Xie, P., T. Boyer, E. Bayler, Y. Xue, D. Byrne, J. Reagan, R. Locarnini, F. Sun, R. Joyce, and A. Kumar (2014), [*An in situ-satellite blended analysis of global sea surface salinity*](#), J. Geophys. Res. Oceans, 119, 6140–6160, doi:10.1002/2014JC010046.

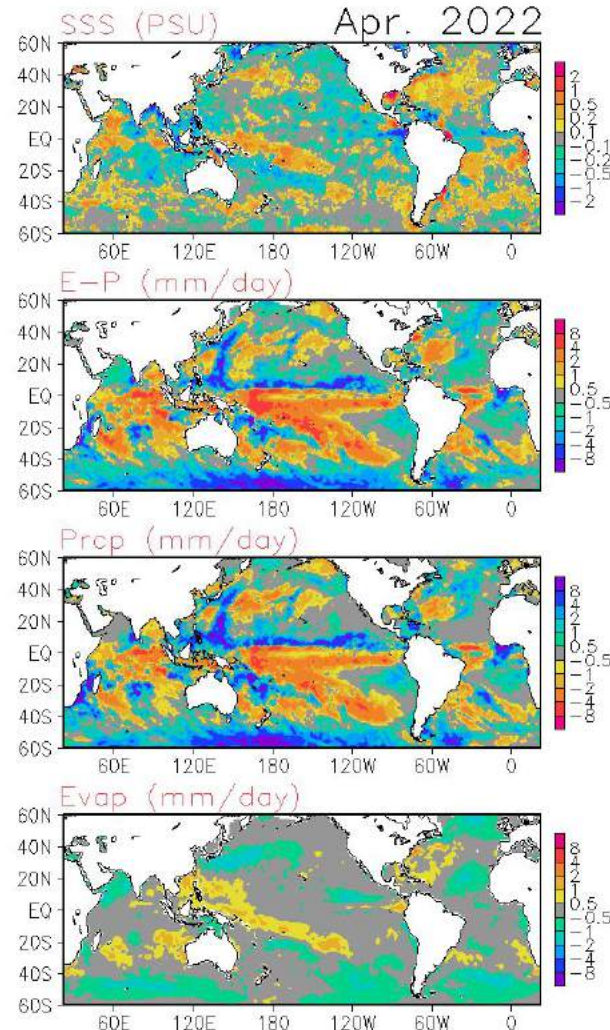
Monthly SSS Anomaly Evolution Equatorial Pacific (5S – 5N)

Sea Surface Salinity

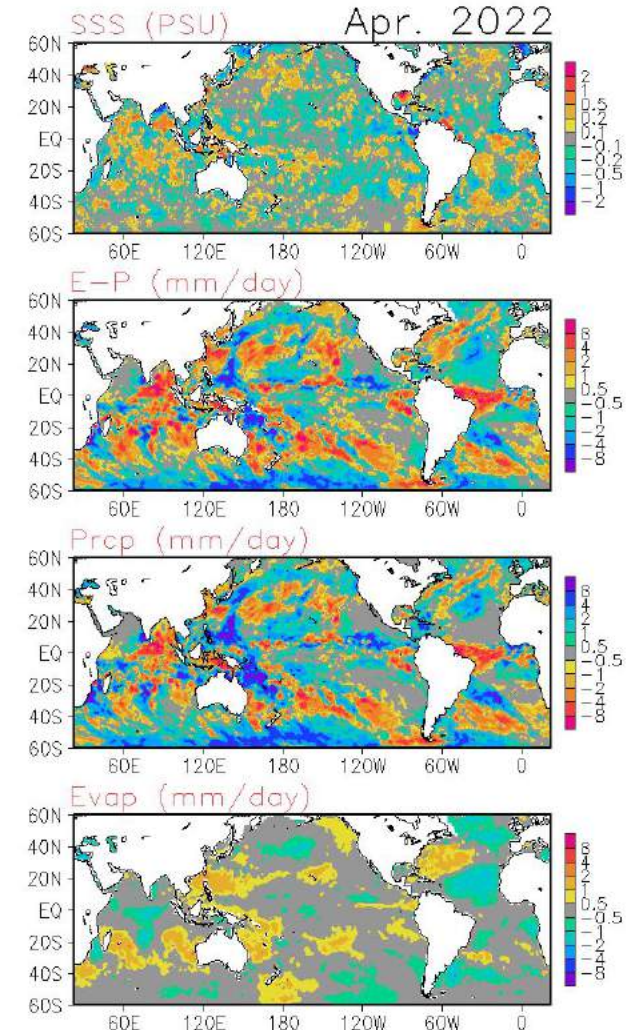


SMOS & Aquarius □ Jun 2015 □ SMOS & SMAP

Global Anomaly (Apr 2022)



Global Tendency (Apr 2022)



SSS : Blended Analysis of Surface Salinity (BASS) V0.Z: <ftp.cpc.ncep.noaa.gov/precip/BASS>
Precipitation: CMORPH adjusted satellite precipitation estimates
Evaporation: Adjusted CFS Reanalysis

Numerical Prediction: Developmental

- **Assimilation of high-latitude satellite SSS**

- Improve global ocean modeling, in particular NOAA's pending operational global coupled (ocean, atmosphere, sea ice) model
- Inform sea-ice modeling and prediction
- Convert to near-surface bulk SSS using AI technique
 - *See poster: Trossman and Bayler*
 - Trossman, D., and E. Bayler, 2022, *An Algorithm to Bias-Correct and Transform Arctic SMAP-Derived Skin Salinities into Bulk Surface Salinities*, Remote Sens, 14, 1418, <https://doi.org/10.3390/rs14061418>

- **Satellite-only sea-surface density (SSD)**

- **Aim:** Exploit satellite SSS to better constrain sea-surface density (SSD) when projecting altimetry observations into the ocean model interior
- **Aim:** Operational model (RTOFSv2) verification
- Satellite-only SSD
 - *See poster: Bayler, Reagan, and Boyer*

Numerical Prediction: Developmental

- **L-band (SSS) radiance assimilation**

- NOAA's Unified Forecast System targets radiance assimilation, where possible
 - [Joint Effort for Data assimilation Integration \(JEDI\)](#)
 - [Joint Center for Satellite Data Assimilation \(JCSDA\)](#)
 - Marine-JEDI component (transition to operations ~3-5 years)
- In discussion with NASA/JPL and Remote Sensing Systems (RSS)
 - Level-1 Top-of-Atmosphere near-real-time data (6-12 hours latency)
 - Level-1 Surface Radiance near-real-time data (6-12 hours latency)
- Operational modeling
 - [Community Radiation Transfer Model \(CRTM\)](#)
 - [Community Surface Emissivity Model \(CSEM\)](#)
 - New fast MW ocean surface emissivity model (NFASTEM): L-band \square 700 GHz
 - Based on machine-learning approximation
 - Provides: V-pol, H-pol, 3rd & 4th Stokes (3rd & 4th Stokes needed at L-band)
 - Improves CSEM frequency range and scattering angle range
 - **Reconstructed the Remote Sensing Systems RTM model in the CSEM**
 - Implemented fully functional tangent-linear (TL) and adjoint (AD) modes
 - Permits use for radiance assimilation; essential for variational data assimilation
 - **Technically readily for SSS radiance data assimilation**
 - **CSEM uses SMAP monthly salinity as the model salinity input, as well as the first guess in the UFS data assimilation**

Numerical Prediction: Developmental

NOAA's West Coast Operational Forecast System (WCOFS)

- Nested within the NOAA RTOFSv2
 - RTOFSv2 assimilates SMOS & SMAP SSS data
- Satellite SSS assimilation challenges:
 - Spatial resolution, particularly with respect to the scale of mesoscale ocean features
 - Observation uncertainty of the same order as the variability
- Exploring potential assimilation of ocean color as proxy for SSS
 - Would employ AI techniques to derive proxy relationship



Questions?