NOAA In Situ – Satellite Blended Analysis of Surface Salinity: Preliminary Results for 2010 - 2012

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Objective:

- **To develop an objective analysis of sea surface salinity (SSS) through blending information from *in situ* measurements as well as retrievals from Aquarius and SMOS satellite passive microwave observations.**

- **NOAA Blended Analysis of Surface Salinity (BASS)**
  - Covering the entire global oceans on a 1^{o}lat/lon grid
  - Starting from (at least) January 2010 on a time resolution of monthly or finer
  - Quantitative consistency with *in situ* based analysis for longer period

The Blending Algorithm [1]

In Situ and Satellite Inputs

- **In situ**
  - Grid box mean SSS from all measurements collected from Argo and other buoy arrays (e.g. TAO/TRITON, PIRATA, RAMA)
  - Monthly mean SSS
  - Number of profiles
  - Monthly climatology on a 1^{o} lat/lon global grid
- **SMOS**
  - Level 2 retrievals (Version 5.50) at ~50km pixels averaged into 1^{o}lat/lon grid
  - Number of pixels in each monthly / 1^{o}lat/lon grid box counted and used in defining random error
- **Aquarius**
  - Level 2 retrievals (Version 1.3) at ~100km pixels averaged into 1^{o}lat/lon grid
  - Number of pixels in each monthly / 1^{o}lat/lon grid box computed and used in defining random error

The Blending Algorithm [2]

Blending Strategy

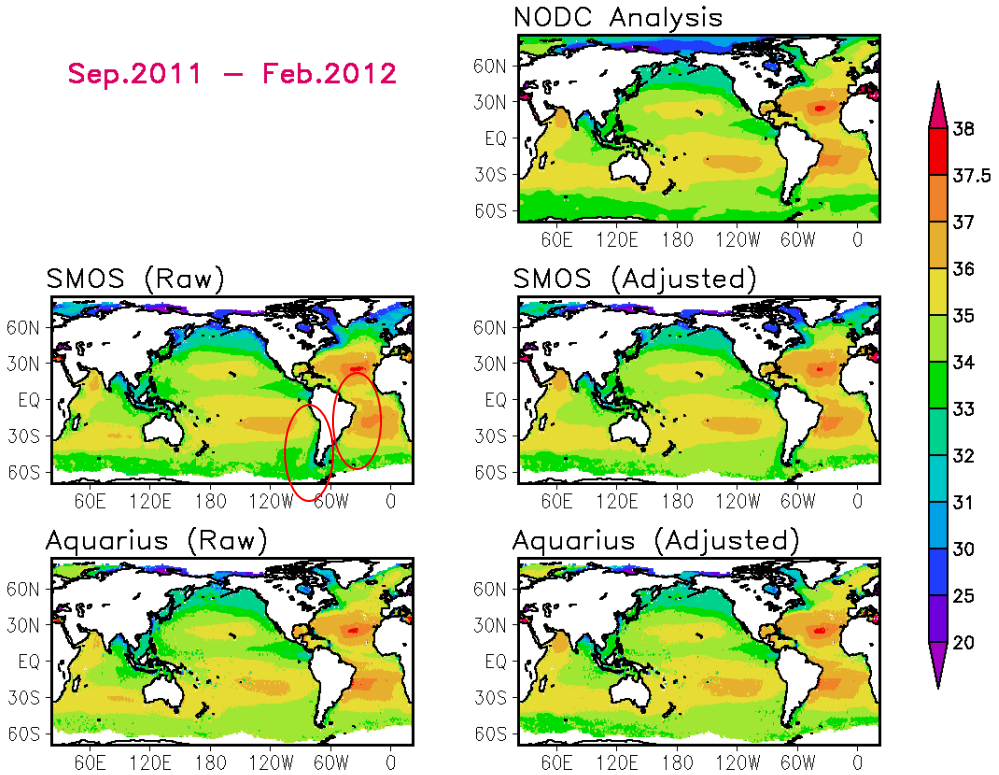
- Basic assumption:
  - *Resulting blended analysis representing bulk SSS at 5m depth*
  - *In situ measurements accurate but sparse*
  - *Satellite observations provide spatial coverage but biased*
  - *Both in situ measurements and satellite retrievals contain random error*

- A Two-Step Approach
  - Bias correction for satellite retrievals
    - *PDF tables are constructed using co-located satellite and in situ data covering a 5-month period centering at the target month and over a spatial domain centering at the target grid box*
    - *The spatial domain is expended until sufficient number of data pairs are collected*
  - Blending in situ measurements and bias corrected satellite retrievals
    - *Optimal Interpolation*
    - *First Guess :* *Analysis for the previous time step*
    - *Observations:* *In situ, satellite retrievals*

The Blending Algorithm [3]

Bias Correction Results

- After the bias correction, both the spatial pattern and the magnitude of SSS match closely with those in the in situ measurements
- Artificial band of large SSS over SE Pacific in the raw SMOS retrieval is removed
- Positions of the maxima SSS over Atlantic in SMOS close to those in the in situ analysis and the Aquarius retrievals



The Blending Algorithm [4]

Crs-Val Results for Bias Correction

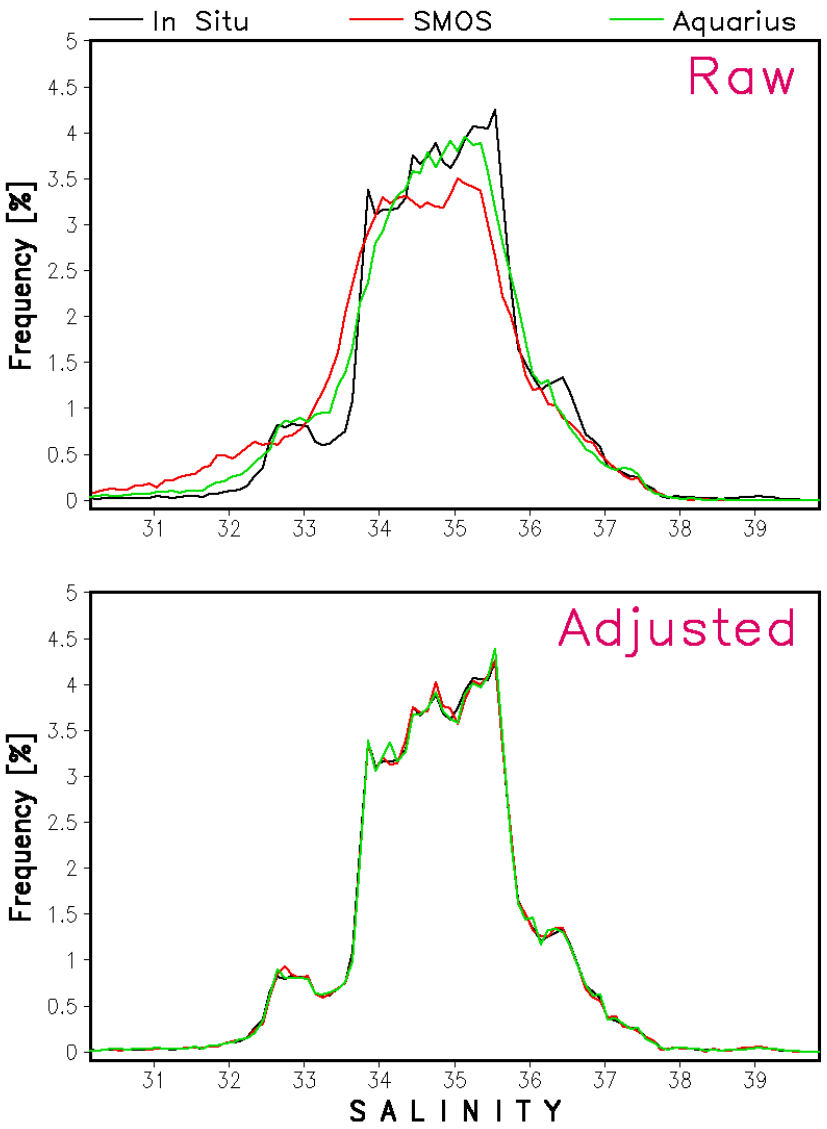
Statistics	SMOS -1 Raw	SMOS-1 Adjusted	Aquarius Raw	Aquarius Adjusted
BIAS	-0.232	0.012	-0.082	0.020
RMS Error	0.502	0.303	0.406	0.268
Correlation	0.903	0.960	0.926	0.970

- Cross-validation tests were done for withdrawing in situ data at 10% randomly selected grid boxes and perform the bias correction using the in situ data at the 90% remaining grid boxes
- After the PDF bias correction, the bias in the raw satellite retrievals is removed almost completely while pattern correlation is improved

The Blending Algorithm [5]

PDF Before and After the Bias Correction

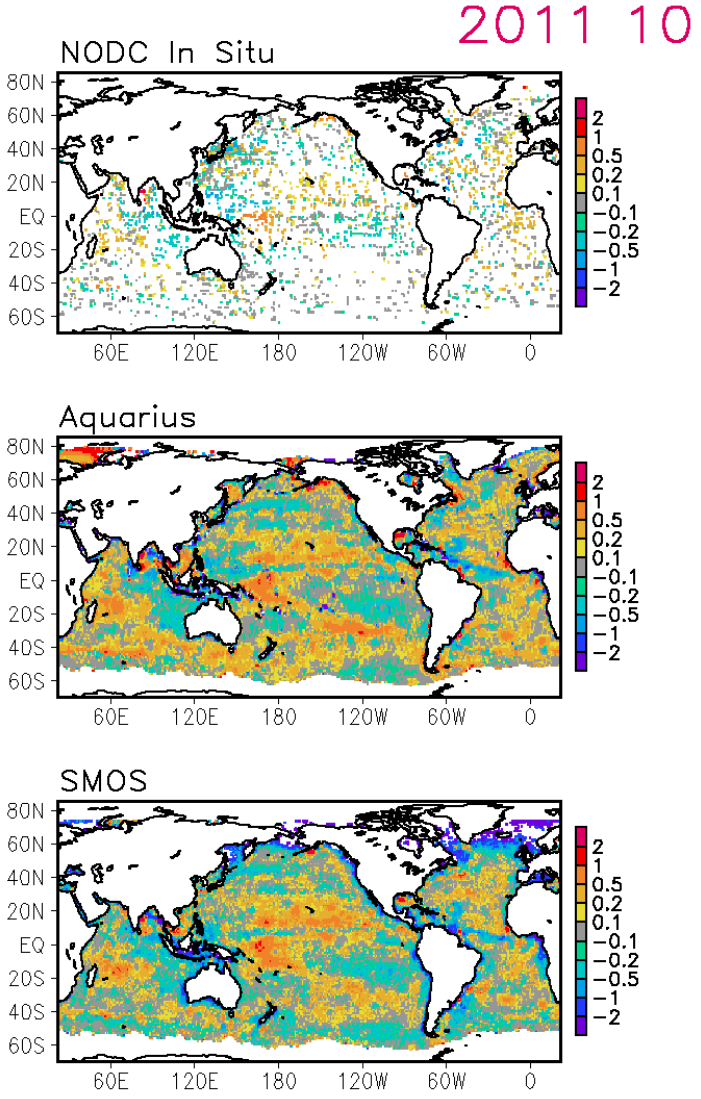
- Results based on cross-validation tests
- After the bias correction, PDF for the SMOS and Aquarius matches closely with that for the in situ measurements



The Blending Algorithm [6]

Sample Inputs to the OI for Oct.'11

- The bias corrected SMOS and Aquarius SSS retrievals are further combined with in the NODC in situ measurement (not the analysis) through OI
- OI operates for the monthly anomaly relative to the Levitus climatology
- Similar patterns of SSS anomaly from the in situ measurements and the two satellite retrievals
- Differences observed over high latitudes and along the coasts

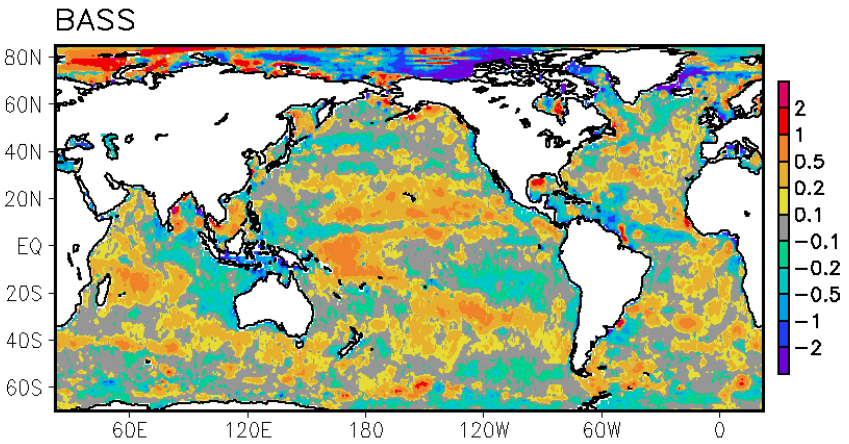


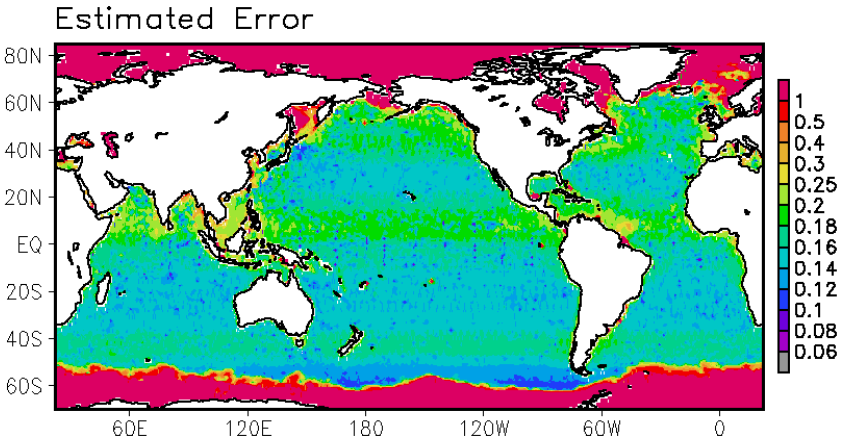
The Blending Algorithm [7]

Sample Blended Analysis for Oct.'11

2011 10

- Analysis looks reasonable over most of the global ocean
- In addition to the analyzed fields of SSS, the OI algorithm also generates estimation of error for the SSS analysis
- Estimated analysis error is on the order of ~0.2PSU over most of the open oceans and reaches more than 1PSU over high latitudes





The Blending Algorithm [8]

Crs-Val Results for the OI Combining

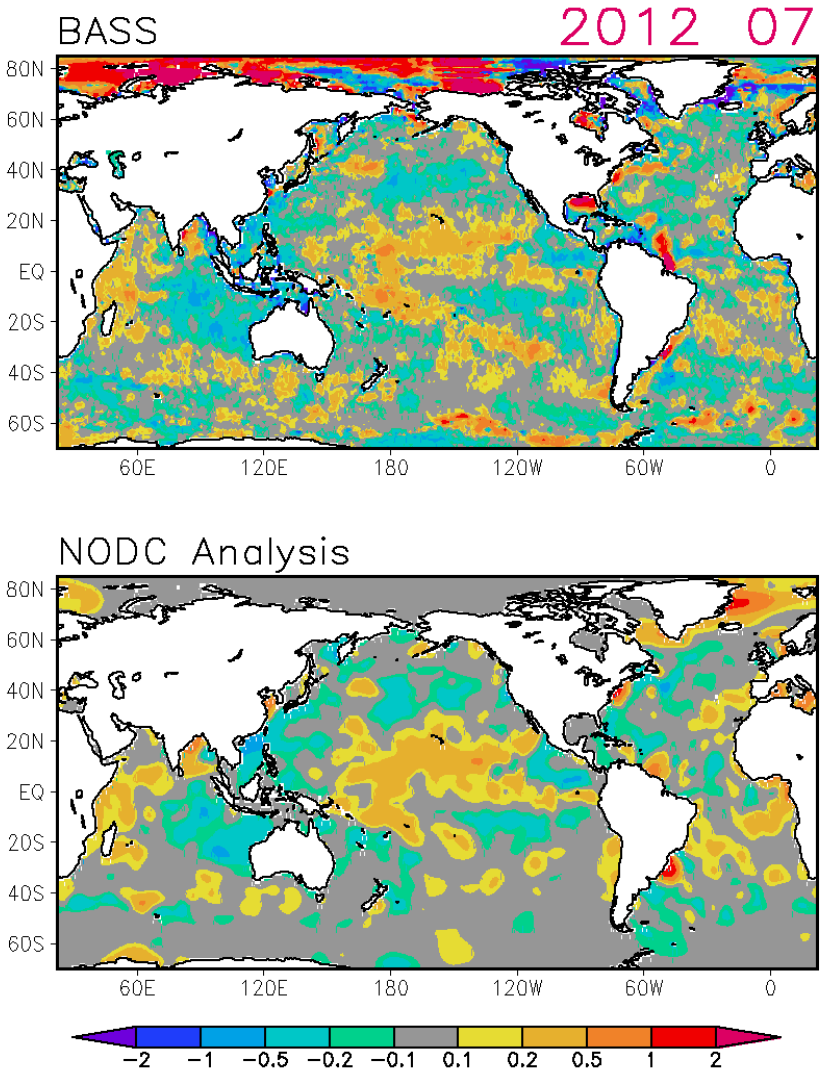
Tropics (20°S-20°N)	SMOS	Aquarius	Blended
BIAS	0.005	0.014	0.008
RMS Error	0.323	0.289	0.216
Correlation	0.507	0.586	0.686

Globe (90°S-90°N)	SMOS	Aquarius	Blended
BIAS	-0.001	0.010	0.006
RMS Error	0.315	0.290	0.205
Correlation	0.407	0.495	0.628

Comparison with NODC Analysis [1]

Example for July 2012

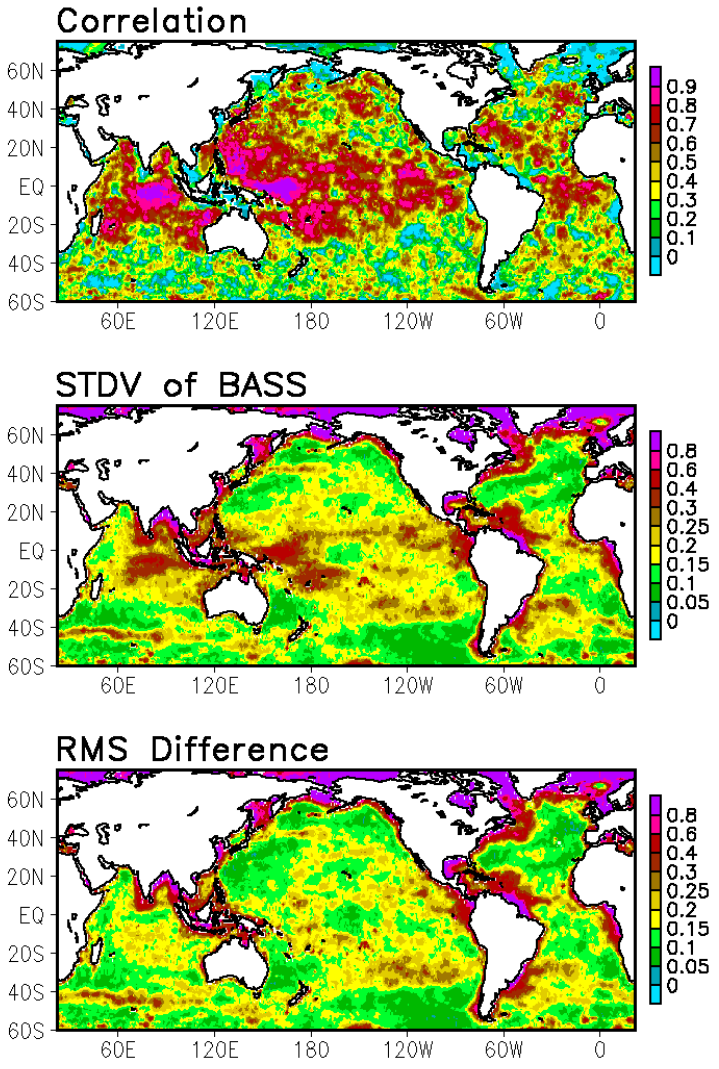
- NODC analysis defined by interpolating in situ measurements within 770km through a distance-weighting technique
- Overall similar anomaly patterns
- BASS presents more details
- Differences over costal regions and high-latitude oceans



Comparison with NODC Analysis [2]

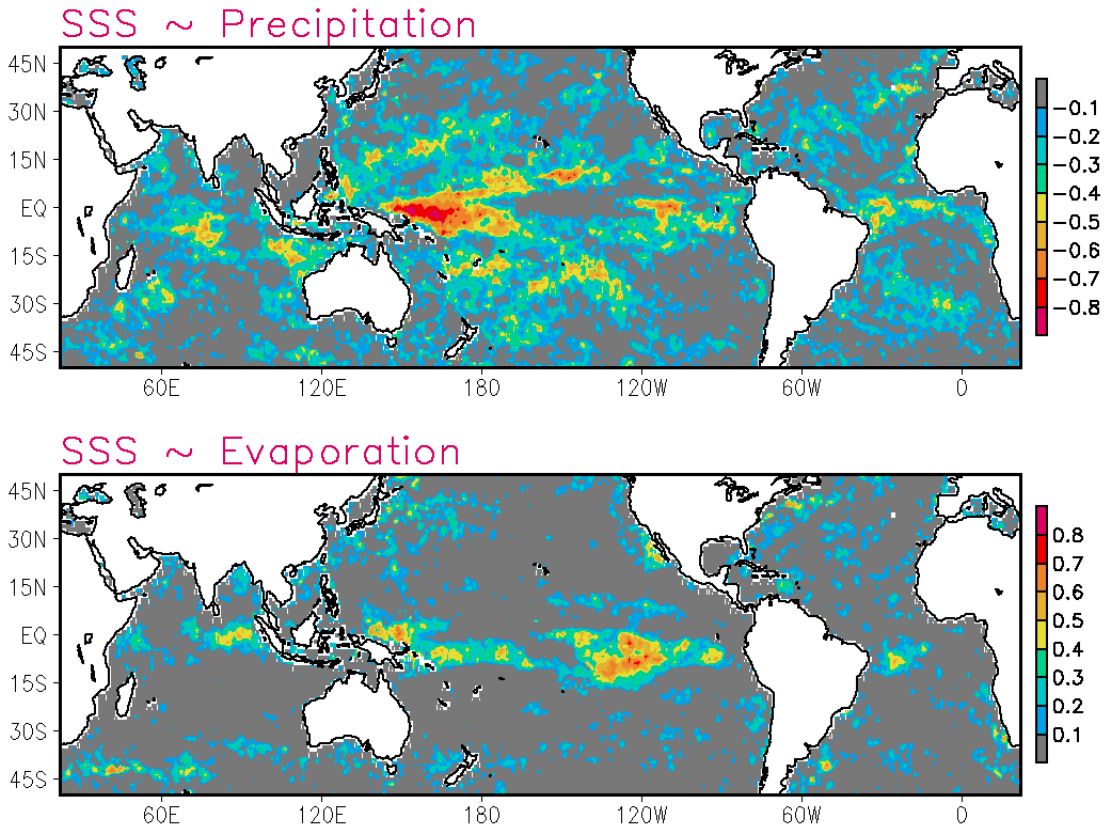
Comparison Statistics for 2010-2012

- Good agreements between BASS and the NODC in situ analysis over majority of the tropical oceans, with high correlation and low RMS differences
- Poor agreements over high latitude oceans with RMS differences on the order of the signal indicated by the standard deviation of the BASS
- Differences are also large over coastal regions



Applications of the SSS Analysis [1]

Anomaly Correlation with P and E

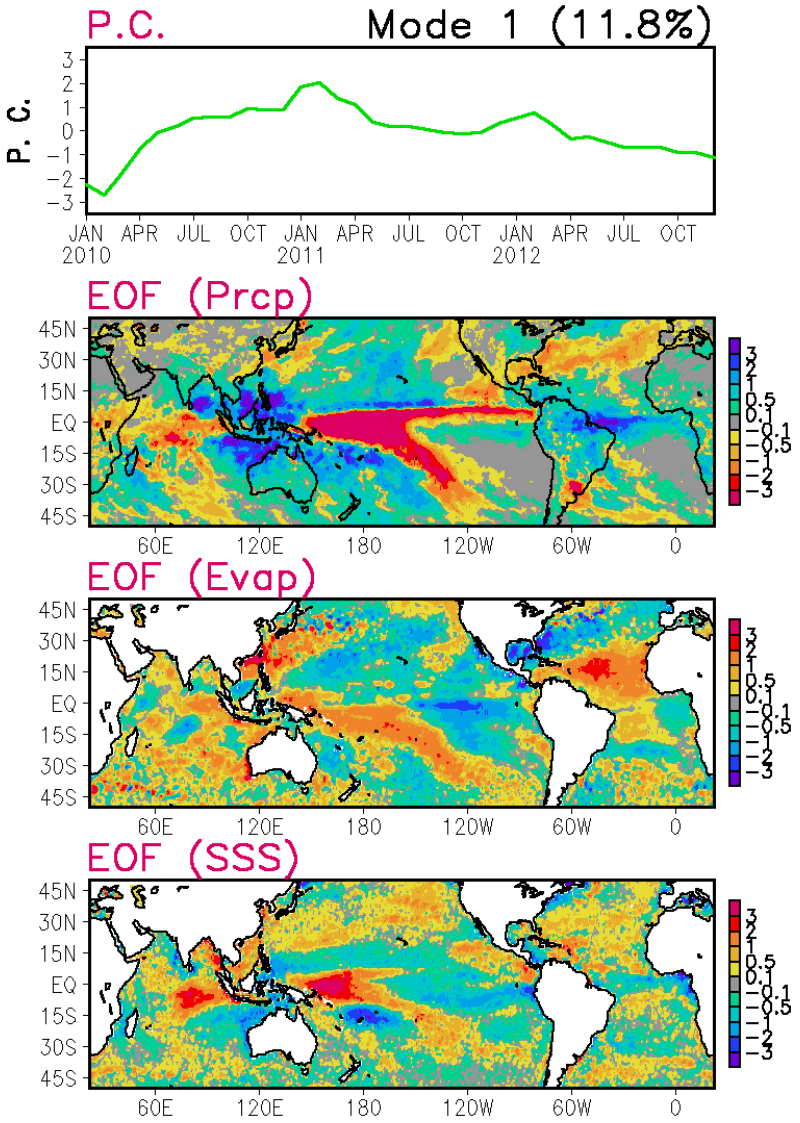


- P from CMORPH, E from OIFlux
- Precip presents high correlation with SSS over tropics
- Evaporation exhibits correlation over parts of tropical ocean with strong evaporations

Applications of the SSS Analysis [2]

Combined EOF with P and E

- Combined EOF Model 1 shows coherent variation patterns of SSS, P, and E in association with the evolution of ENSO
- Positive precipitation yields reduced SSS over tropical open oceans with strong convective activities (ITCZ, SPCZ et al)
- Enhanced evaporation is related to increased SSS when/where precipitation is absent or weak



SUMMARY

- A prototype algorithm has been developed to construct a global analysis of monthly SSS through blending information from in situ measurements and satellite retrievals from multiple platforms
- Called ***NOAA Blended Analysis of Surface Salinity (BASS)***, the SSS analysis is defined by first removing the bias in the satellite retrievals through **PDF matching** against the in situ data and then combining the bias-removed retrievals with in situ measurements under the **OI framework**
- Cross validation tests demonstrated the effectiveness of the technique in removing the bias in the input satellite retrievals and generate blended analysis with reduced random error and improved correlation compared to those for the input fields
- The blended analysis presents more details in the global SSS distribution compared to the NODC in situ based analysis
- The blended analysis provides important information for the diagnostics of the SSS variability and its association with the oceanic fresh water flux