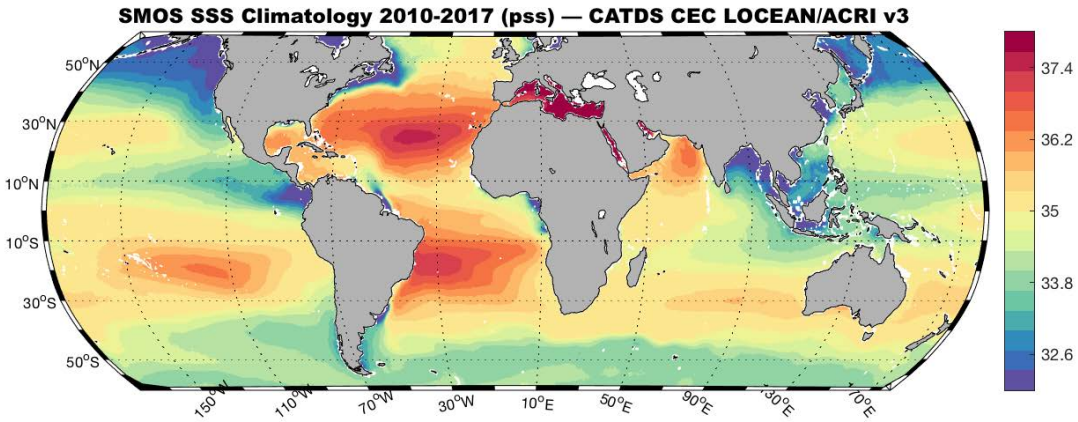
Sea Surface Salinity : let's see what we can do !

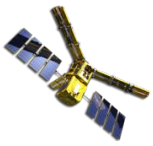
Practical Sessions

Audrey Hasson (LOCEAN, Paris) and Lucile Gaultier (ODL, Brest)



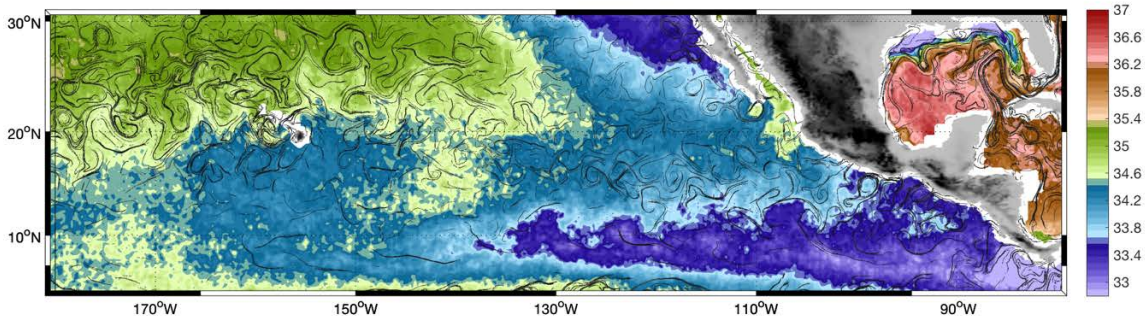
We will investigate sea surface salinity (SSS) signals from one of the largest variability of the global ocean: El Nino to much smaller features such as eddies. The main objective is to understand the strength and weaknesses of satellite SSS and its synergy with other datasets such as SSS from moorings or ISAS floats but also with sea surface temperature (SST), surface currents etc…

I recommend that you read this paper to get a broad overview of the most recent state of satellite SSS observations: Vinogradova et al., 2019 Front. Mar. Sci. https://doi.org/10.3389/fmars.2019.00243



Interactive Lecture 12

SSS Fronts and Eddies: Satellite SSS in synergy with satellite derived currents, temperature, precipitation and/or Chlorophyll



Salinity in July 2017 from L4 monthly CCI (satellite-blend SSS product) and FSLE from Aviso on top

STEP 1. Explore salinity and ocean current stream functions of 2018

Navigate on Seascope with satellite salinity and identify the following regions:

A. The Gulf of Mexico in August
B. The Costa Rica Dome in March
C. The Gulf Stream in September
D. Pacific Tropical Instability Waves in May

What do you see on seascope ?

Can you see some coherence between SSS and surface currents (stream functions)?
How are the salinity differences generated? (river plume, ocean dynamics, air-sea interaction …)
Can you find other regions/other processes where similar coherence can be found?

STEP 2. How do salinity structures affect density?

2.1 Select and Load data from Seascope to the Python notebook

choose one of the regions of interest described above (could be one of your own choosing)

Select the region by drawing a polygon. Extract the data and load them on your python notebook.

2.2 How do salinity and temperature structures affect density?

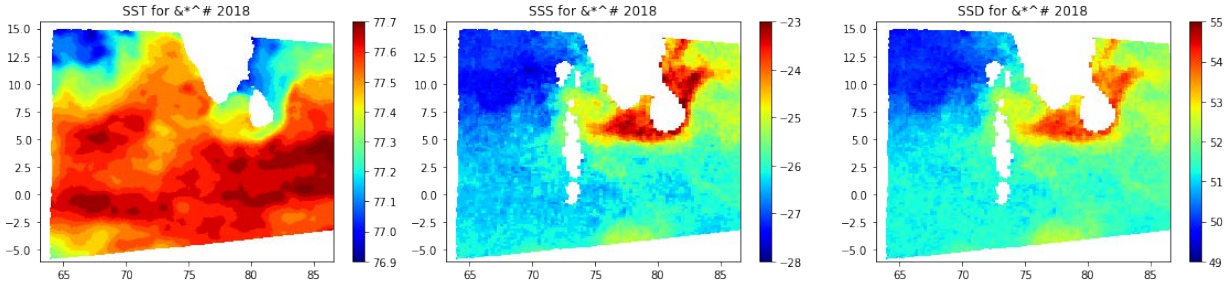
Compute sea surface density (SSD) based on satellite observations using the simplified formula:

$$SSD = Alpha*SST - Beta*SSS$$

Where Alpha=0.257 kg m^{-3} K^{-1} and Beta=0.744 kg m^{-3}

You can (and must) read about absolute salinity and how to compute accurate density on this website http://www.teos-10.org/index.htm

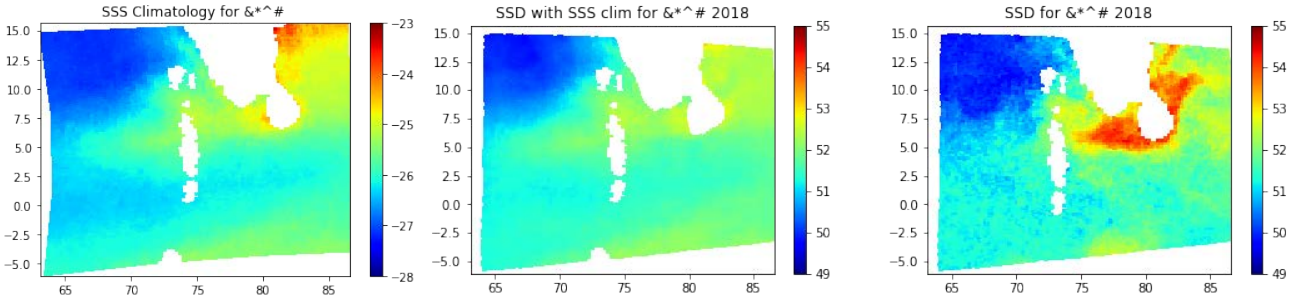
Plot maps of SSS, SST and SSD in the region of your choice



2.3 What is the effect of the unprecedented weekly SSS from the satellite SMOS?

Compute SSD using climatology SSS and weekly SST using the formula stated above.

Plot maps SSS, SST and SSD for the same region but with climatological SSS, i.e. SSS_{clim} and SSD(SST, SSS_{clim}).



What do you see on your maps?

Can you see the contribution of both SSS and SST to the surface density?

Are there zones where SSS or SST dominated the surface density?
What is the difference between SSD and SSD based on climatological SSS?

STEP 3. What synergy of the density patterns do we observe?

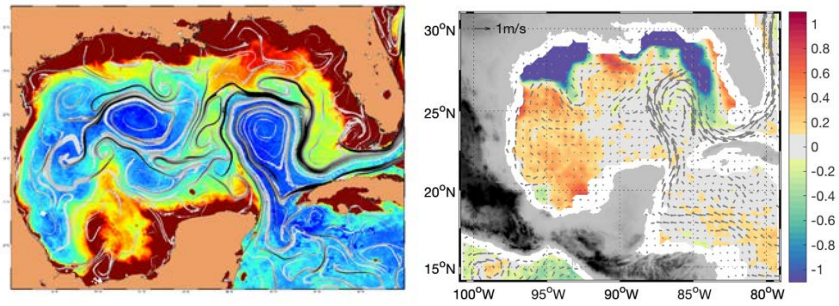
3.1 Export ssd from Python notebook to SEAScope

3.1 What synergy of the density patterns do we observe?

From the maps you have produced before, choose one or more parameters that could have some coherence with the SSS structures.

- We have already looked at the synergy between SSS and currents.

Possible parameters: SST, Precipitation, Evaporation, Chlorophyll



July 2017

Left: Chl-a (CCI) and FLSE (Aviso) – Right: Salinity anomlies (SMOS) and Currents (CMEMS)

What do you see on your maps?

Do all parameters have a signal in the features you are interested in?
Do you see any shift in the possible observed patterns?
Can you explain why the structures are different amongst datasets?
What does this teach you on the ocean dynamics of the area?
Is that consistent with what you know of this region?

FURTHER WORK and CONCLUDING QUESTIONS

1. Plot the time-mean gradients of SSS, SST and SSD along a chosen set of latitudes or longitudes. Is the density gradient solely driven by SSS, SST or both ? For the entire section?
2. What would be the difference in using L2 of L3 SSS ?

Interactive Lecture 13 :

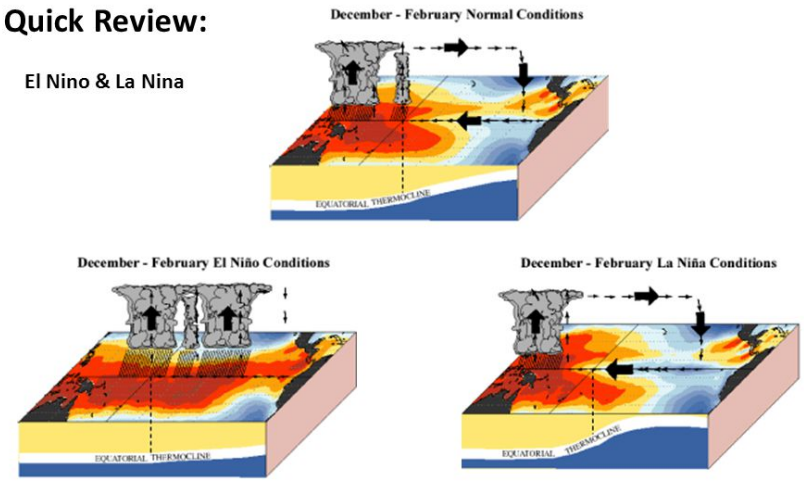
El Nino - Southern Oscillation (ENSO): Satellite SSS in synergy with in situ observations from moorings and ISAS floats.

We have seen during the lecture different technologies from which we derive salinity and the differences amongst them. This practical session will give you a sense of how and why use one or several SSS dataset to answer your scientific questions.

We will focus on the salinity and temperature signals associated with ENSO in the Tropical Pacific Ocean.

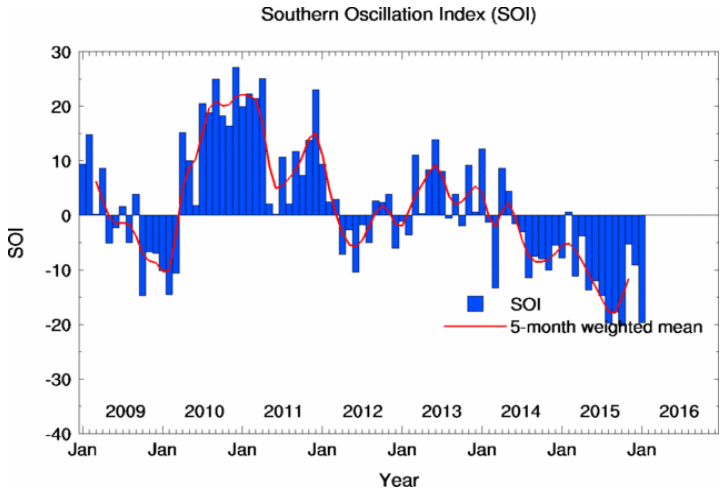
Introduction. What is ENSO?

I recommend that we start by watching this youtube video : https://bit.ly/1QADpS8



Schematic view of sea surface temperature and tropical rainfall in the equatorial Pacific Ocean during normal, El Niño, and La Niña conditions.

The ENSO phase is tracked by the Southern Oscillation Index (SOI) - http://www.bom.gov.au/climate/glossary/soi.shtml



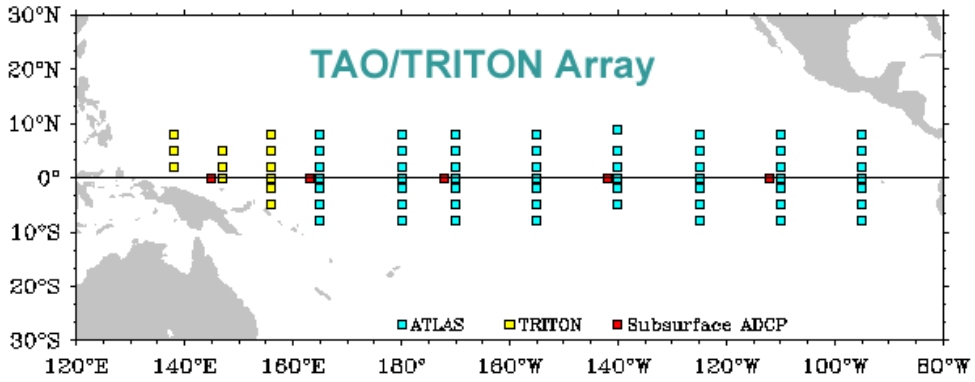
STEP 1. Comparison of SSS at one TAO Location

1.1 Choose/load all SSS data

3 datasets of salinity and temperature will be used in this session:

	MOORING	IN SITU OPTIMAL INTERPOLATION	SATELLITE
SALINITY	TAO	ISAS	L4-CCI
TEMPERATURE	TAO	ISAS	L4-Ifremer

On the TAO website (https://www.pmel.noaa.gov/tao/drupal/disdel/) you can see the distribution of the TAO moorings in the tropical Pacific Ocean.



From what you know/just learned from the video, pick one mooring. – There are no good/bad answers, the idea is to choose different moorings from your neighbours. – choose the location (longitude, latitude) of the mooring of your choice and modify the python notebook accordingly

```
sss2s125w_5day.cdf sss5s156e_5day.cdf sss0n110w_5day.cdf sss2s140w_5day.cdf
sss5s165e_5day.cdf sss0n125w_5day.cdf sss2s155w_5day.cdf sss5s170w_5day.cdf
sss0n140w_5day.cdf sss2s156e_5day.cdf sss5s180w_5day.cdf sss0n147e_5day.cdf
sss2s165e_5day.cdf sss5s95w_5day.cdf  sss0n155w_5day.cdf sss2s170w_5day.cdf
sss8n110w_5day.cdf sss0n156e_5day.cdf sss2s180w_5day.cdf sss8n125w_5day.cdf
sss0n165e_5day.cdf sss2s95w_5day.cdf  sss8n137e_5day.cdf sss0n170w_5day.cdf
sss5n110w_5day.cdf sss8n155w_5day.cdf sss0n180w_5day.cdf sss5n125w_5day.cdf
sss8n156e_5day.cdf sss0n95w_5day.cdf  sss5n137e_5day.cdf sss8n165e_5day.cdf
sss2n110w_5day.cdf sss5n140w_5day.cdf sss8n170w_5day.cdf sss2n125w_5day.cdf
sss5n147e_5day.cdf sss8n180w_5day.cdf sss2n137e_5day.cdf sss5n155w_5day.cdf
sss8n95w_5day.cdf  sss2n140w_5day.cdf sss5n156e_5day.cdf sss8s110w_5day.cdf
sss2n147e_5day.cdf sss5n165e_5day.cdf sss8s125w_5day.cdf sss2n155w_5day.cdf
sss5n170w_5day.cdf sss8s155w_5day.cdf sss2n156e_5day.cdf sss5n180w_5day.cdf
sss8s165e_5day.cdf sss2n165e_5day.cdf sss5n95w_5day.cdf  sss8s170w_5day.cdf
sss2n170w_5day.cdf sss5s110w_5day.cdf sss8s180w_5day.cdf sss2n180w_5day.cdf
sss5s125w_5day.cdf sss8s95w_5day.cdf  sss2n95w_5day.cdf  sss5s140w_5day.cdf
sss9n140w_5day.cdf sss2s110w_5day.cdf sss5s155w_5day.cdf
```

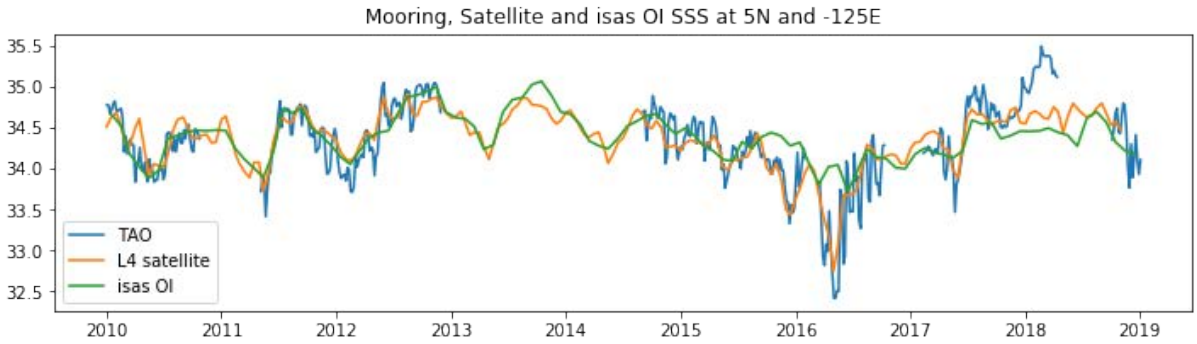
1.2 Plot SSS and SST at one TAO Location

Plot the time series of SSS and SST observed by the 3 datasets at the location of the mooring of your choice.

+ Make sure the y-axis limits are wisely chosen i.e. we can see the entire time series.

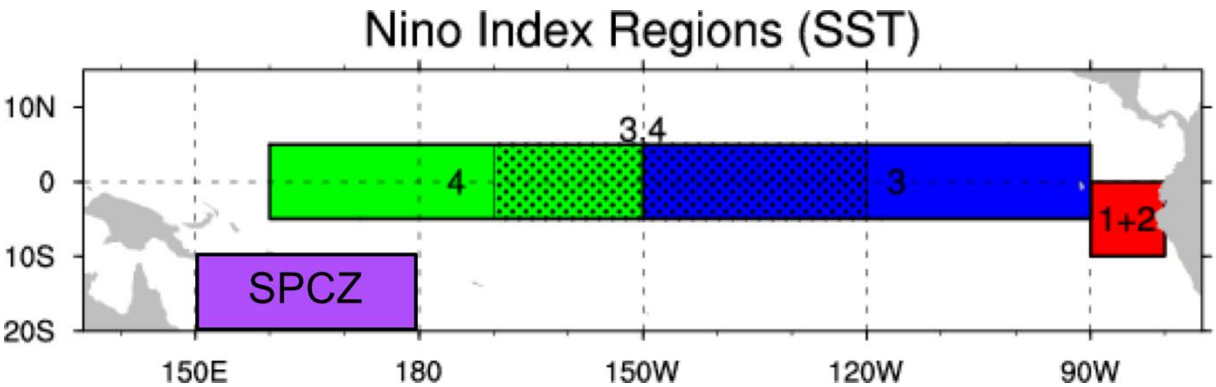
What do you see on your plot?

What kind of variability do you see?
Are the SSS and SST plot the same?
Are there any differences amongst the products?
Are the products independent?
What is the most accurate dataset?
Does what you see make sense with the dynamics of ENSO?



STEP 2. Capturing some ENSO-related signal

2.1 Choose the box you wish to plot



Some regions have been established in the literature as key areas to track ENSO. I have added one in the south. Choose the region you wish to investigate and modify the python notebook accordingly

2.2 Compute and plot mean SSS from L4 satellite and ISAS data over specified box:

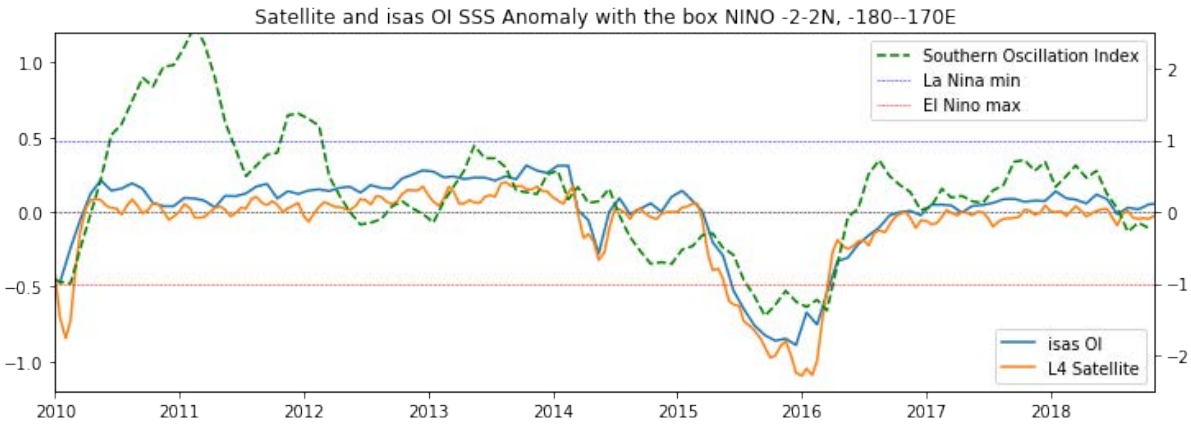
Compute the time series of SSS averaged within the box of your choice with ISAS OI and satellites only.

- Remove the seasonal cycle from your time series.

+ How do you choose the period to compute the climatology over?

+ Make sure the y-axis limits are wisely chosen i.e. we can see the entire time series.

- Add to this plot the SOI



What do you see on your plot?

Is there variability associated with ENSO in SSS?
Can you single out El Nino and La Nina events in SOI? In SSS?
Are the differences amongst the products coherent with what was found earlier? Why?
Does what you see make sense with the dynamics of ENSO?

STEP 3. Exploring one event of El Nino or La Nina

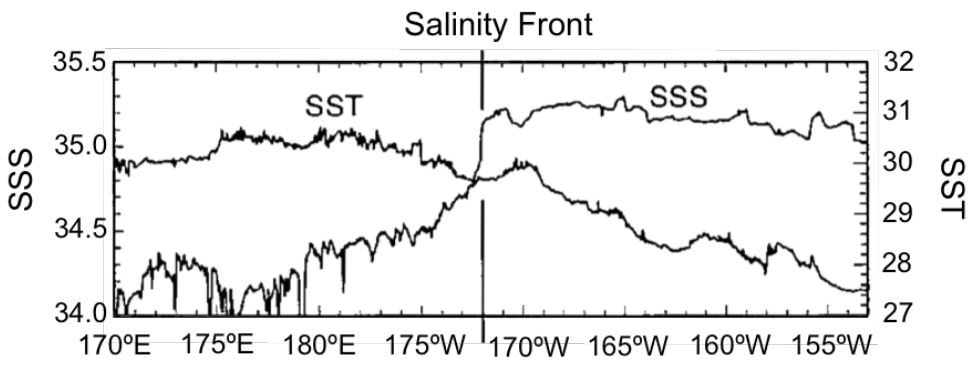
3.1 From STEP 2, decide what ENSO event ou would like to focus on and modify the python notebook accordingly

3.2 Zonal gradient associated with ENSO

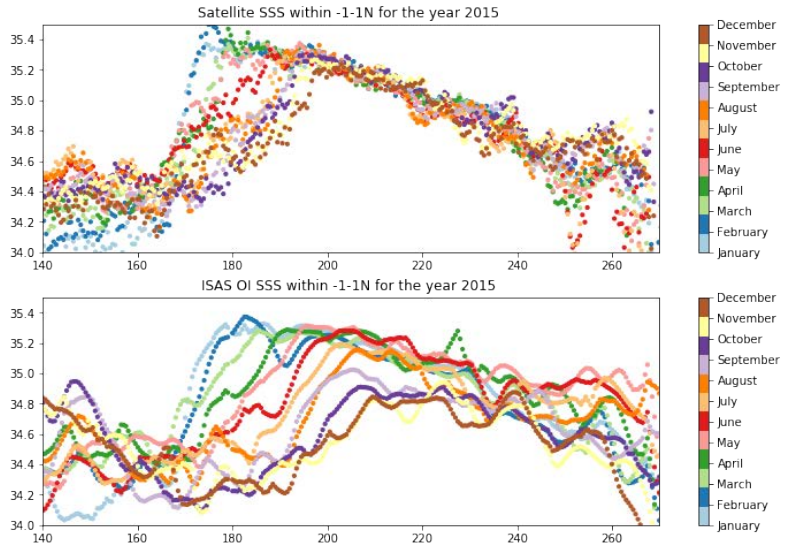
Plot SSS along the latitude of your choice averaged for each month of the chosen event, with ISAS OI and satellites only. The figure below shows SSS and SST measured in situ during the **cruise** FLUPAC in Sept./Oct. 1994.

+ The cycle usually starts in April of one year and dies out in April the second year. Don't be fooled by the Gregorian calendar, you might want to try out 2 different years

+ Make sure the x-axis (longitudes) and y-axis (SSS) are wisely chosen.



Zonal distribution of high-resolution SST and SSS data collected from a TSG instrument during the September-October 1994 FLUPAC cruise along the equator (From Rodier et al., 2000).



What do you see on your plots?

Is there variability associated with ENSO in SSS? In SST?
What are the differences between SSS and SST?
Are the differences amongst the products coherent with what was found earlier? Why?
Is what you see in agreement with the previous plots?
Does what you see make sense with the dynamics of ENSO?

STEP 4 Mapping one event of El Nino or La Nina

4.1 From STEPS 2 and 3, decide what ENSO event and what month you would like to focus on

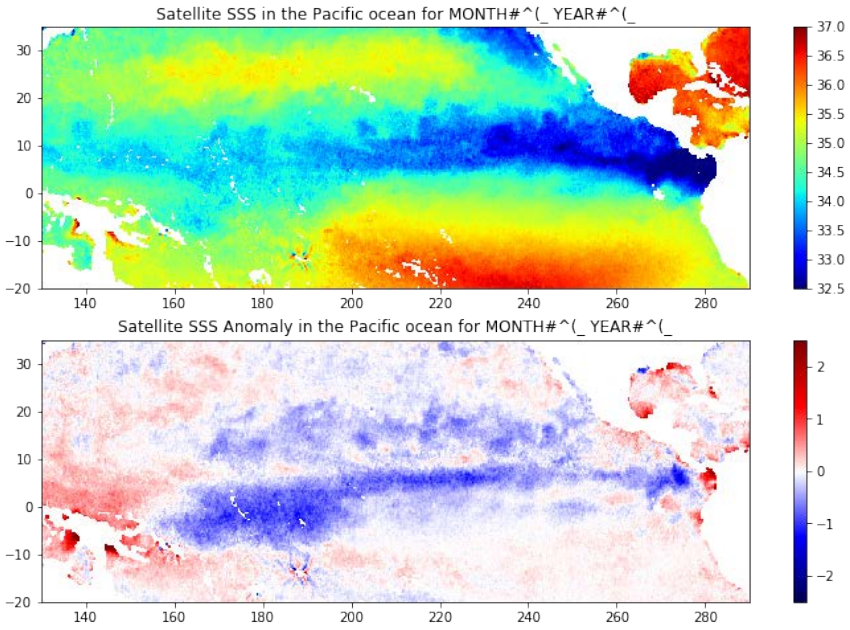
Choose either the 2010-2011 La Nina or the 2015-2016 El Nino as they were both historically strong and fully captured by SMOS. Choose also one month, you find especially interesting from the plots made during STEP 3.

modify the python notebook accordingly

4.2 Map the SSS of the Pacific Ocean for the month/year you have chosen from the satellite L4 dataset

Make a map of the monthly anomalies of SSS and SST over the tropical Pacific Ocean defined here by [40ºN-40ºS] and [140ºE-70ºW], with ISAS OI and satellites only.

- remove the seasonal cycle from your map



What do you see on your maps?

Is there a large scale pattern associated with ENSO in SSS? In SST?
What are the differences between SSS and SST?
Are the differences amongst the products coherent with what was found earlier? Why?
Is what you see in agreement with the previous plots?
Does what you see make sense with the dynamics of ENSO?

FURTHER WORK and CONCLUDING QUESTIONS

1. Can you make an ENSO index based on SSS solely?
2. If you were to design a new TAO array with only 50% of the moorings, what would be the most critical location for each mooring and why? (check TPOS2020.org to see if your findings are consistent with what has been decided)
3. Can you list the + and – of each of the SSS datasets?
4. What SSS datasets would you use to answer your scientific question?