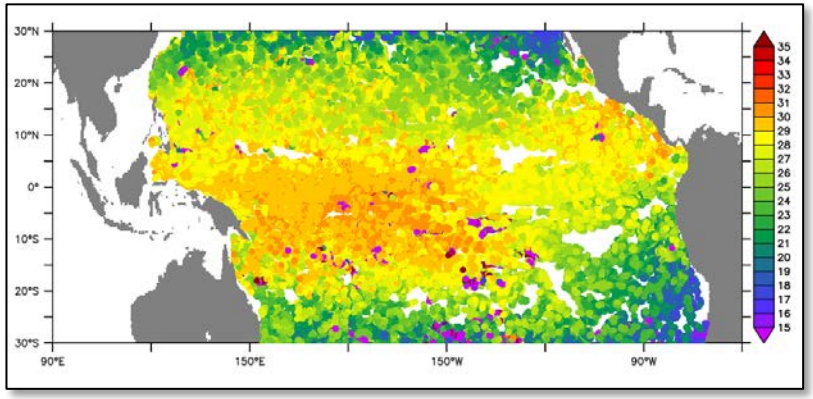
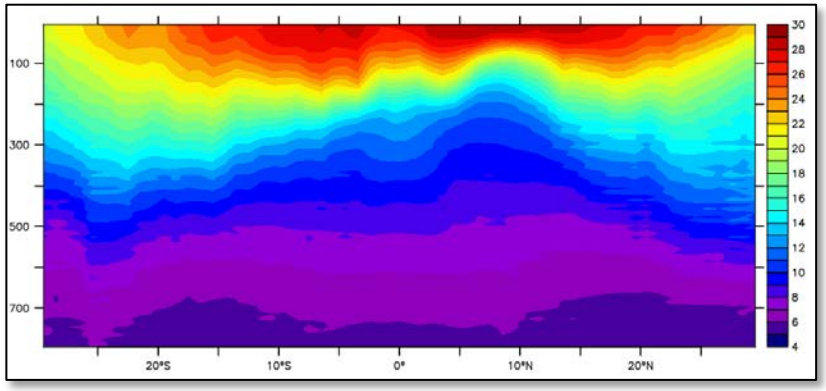
# ERDDAP services for data sharing and integration

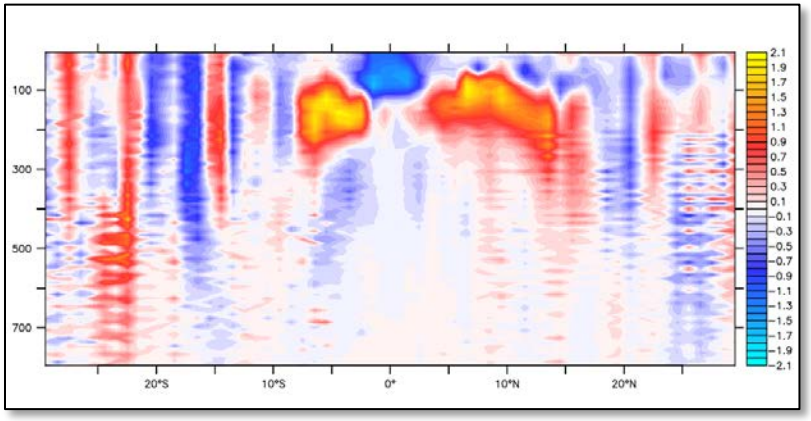
**Harnessing Oceans of Data**
**10th OOMD Community Workshop**





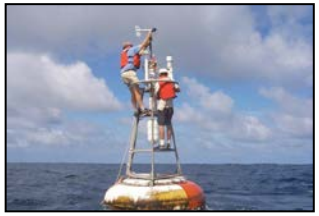
Kevin O'Brien (University of Washington/JISAO)
Kevin Kern (NOAA/NDBC)
Bill Smith (NOAA/NDBC)
Bob Simons (NOAA/NMFS)
Eugene Burger (NOAA/PMEL)

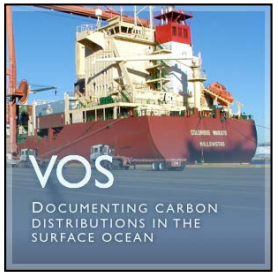



OceanSITES

GO-SHIP

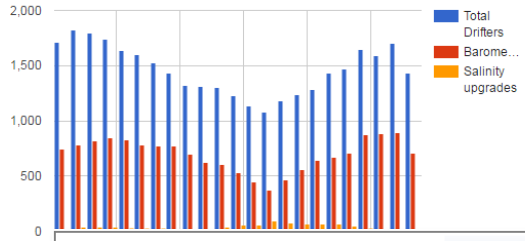





Year: 2016
Quarter: First
Submit

*Counts are limited to platforms reporting

| | Total Drifters | Barometer upgrades | Salinity upgrades |
|---|---|---|---|
| Total | 1,579 | 693 | 15 |
| Goal | 1,250 | 1,250 | 1,250 |
| Additional needed | 0 | 557 | 1,235 |
| Percent of Goal | 126 | 55 | 1 |
| Total Countries Contributing | 10 | | |



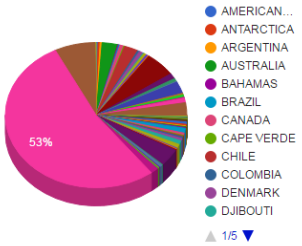

| Country | Total Drifters | With Barometer Upgrade | With Salinity Upgrade |
|---|---|---|---|
| AUSTRALIA | 18 | 18 | 0 |
| CANADA | 11 | 7 | 0 |
| EUROPEAN UNION | 5 | 4 | 0 |
| FRANCE | 3 | 3 | 0 |
| INDIA | 3 | 3 | 0 |
| JAPAN | 6 | 6 | 0 |
| NEW ZEALAND | 6 | 6 | 0 |
| UNITED KINGDOM | 1 | 1 | 0 |
| UNITED | 1,222 | 515 | 10 |
| | | | 5 |

Year: 2016
Quarter: First
Submit

*Counts are limited to platforms reporting

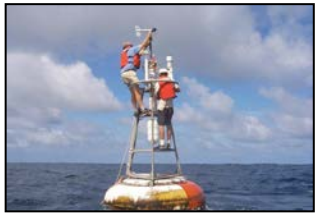
| | Real Time | GLOSS |
|---|---|---|
| Total | 566 | 116 |
| Goal | 3,000 | 300 |
| Additional needed | 2,434 | 184 |
| Percent of Goal | 19 | 39 |
| Total Countries Contributing | 57 | 57 |

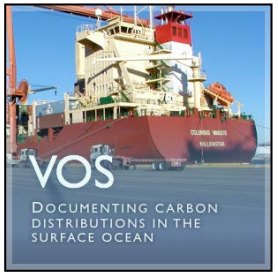
| Country | Tide Gauges on GTS | GLOSS Tide Gauges |
|---|---|---|
| AMERICAN SAMOA | 2 | 2 |
| ANTARCTICA | 2 | 2 |
| ARGENTINA | 2 | 2 |
| AUSTRALIA | 16 | 5 |
| BAHAMAS | 1 | 0 |
| BRAZIL | 1 | 1 |
| CANADA | 4 | 3 |
| CAPE VERDE | 1 | 1 |
| CHILE | 14 | 7 |
| COLOMBIA | 2 | 2 |
| DENMARK | 4 | 0 |
| DJIBOUTI | 1 | 1 |
| DOMINICAN REPUBLIC | 3 | 0 |
| ECUADOR | 2 | 1 |
| EL SALVADOR | 1 | 1 |

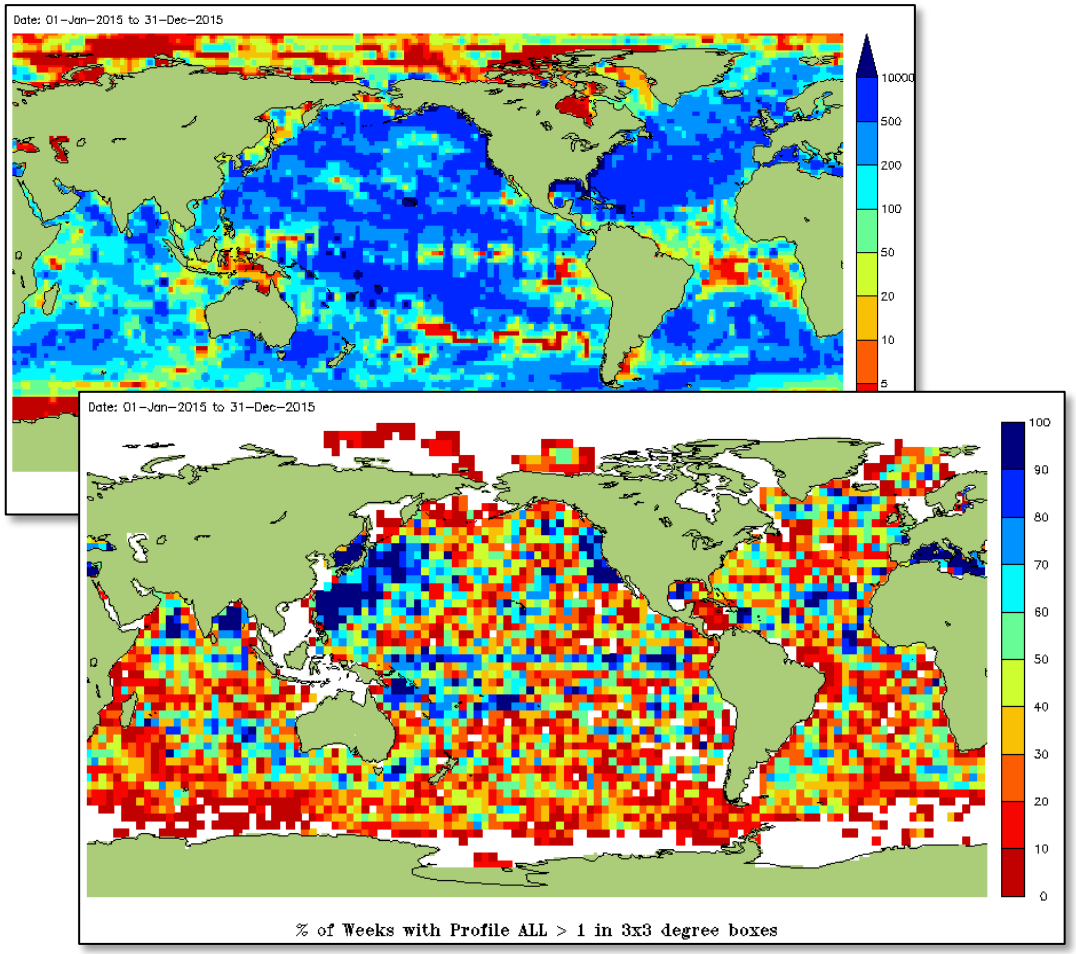


OceanSITES

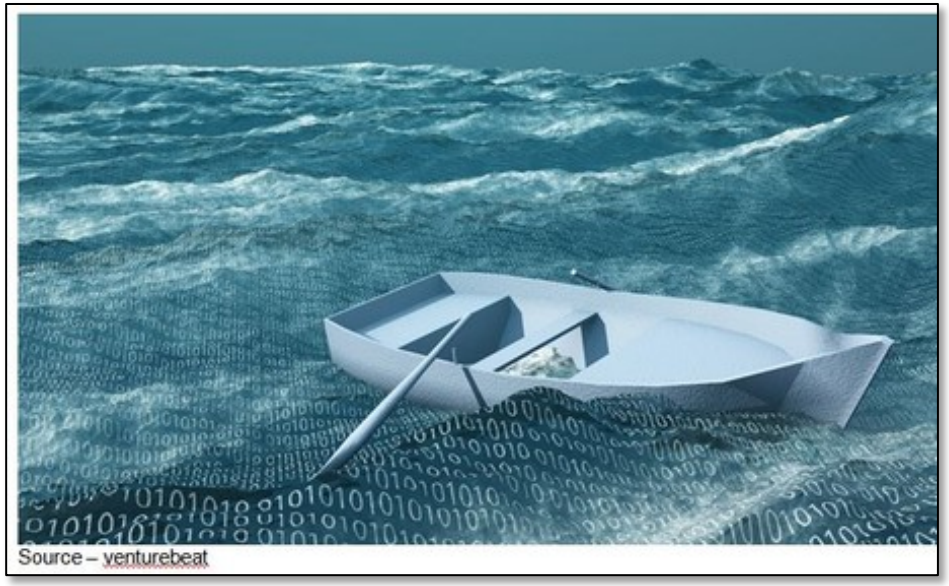
GO-SHIP





# Data as Key Performance Indicator (KPI)


Source – venturebeat

- Data Flow
- Data Availability/Access
- Data Usage and Data Impact

# JCOMM Observations Coordination Group approach

- Provide an interoperable framework for data access
  - Supports easier implementation of (project-specific) data portals
  - Leverage services like DAP, WMS and machine-to-machine services
- Improve data and metadata where possible
  - Aggregation of collections of observations
  - Data quality metadata
- Coordinate with discovery services (NCEI and data.noaa.gov)

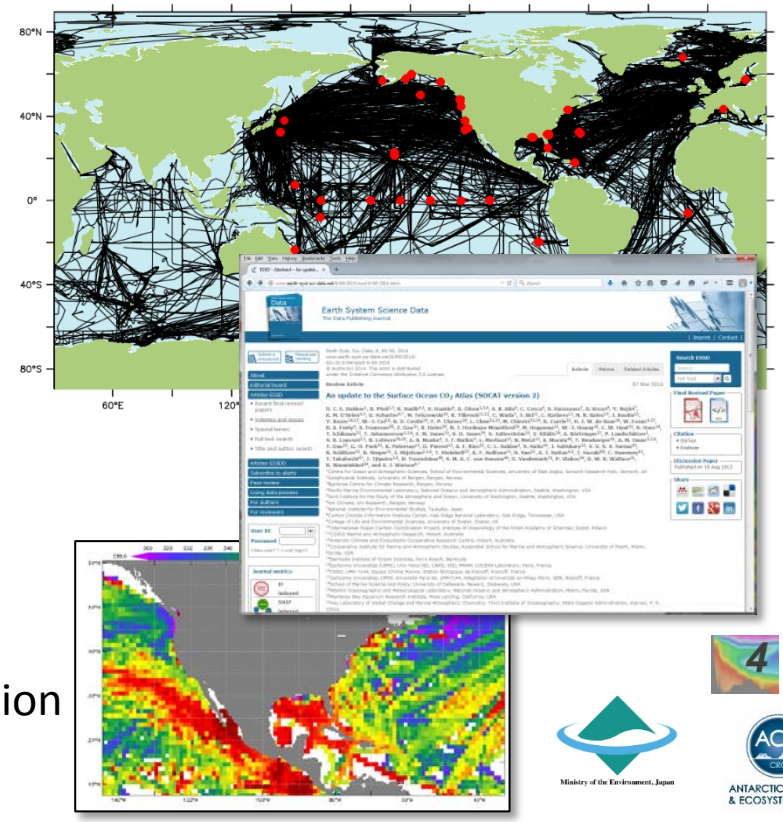
DISCOVER, UNDERSTAND, ACCESS

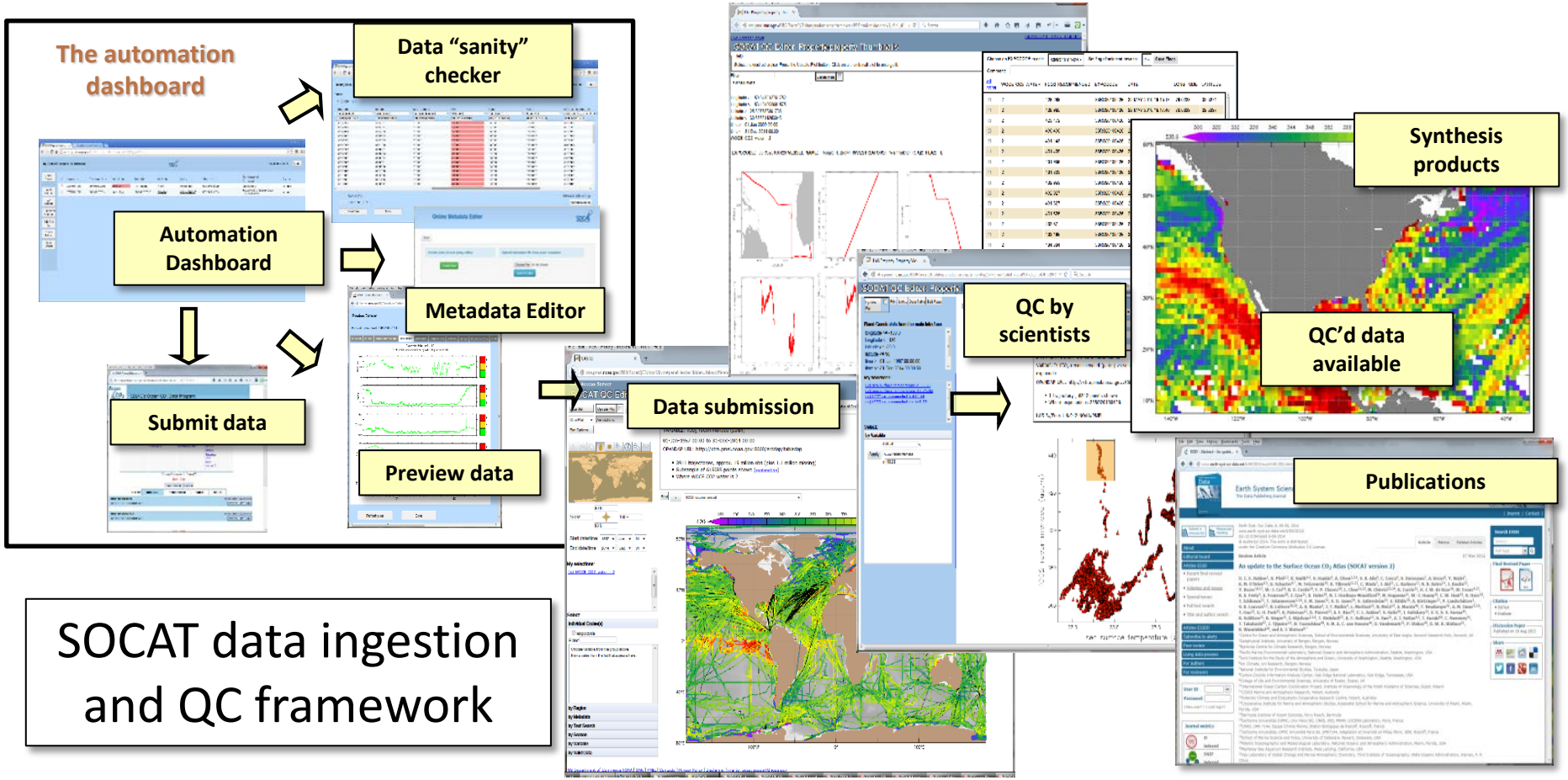
# Surface Ocean $CO_2$ Atlas Project

High Quality, publicly available data set of underway $CO_2$ measurements from ships, moorings and other autonomous ocean platforms

Dates back to 1957

Contains over 21 million observations






# SOCAT data ingestion and QC framework

## Scientific findings and impact of SOCAT:

- Large year-to-year variation in the global ocean carbon sink[b,e,f],
- Models underestimate global ocean carbon sink variability[f],
- SOCAT informs on ocean acidification[c],
- SOCAT enables quantification of land sink (residual, priors)[d,e,f],
- SOCAT is used for model evaluation[d], including CMIP[a].

- 140+ peer-reviewed scientific publications and reports cite or name SOCAT
- SOCAT informs:
  - 10+ mapping products[b,f,g]
  - The Surface Ocean $pCO_2$ Mapping Intercomparison (SOCOM)[f]
  - Global Carbon Project's Annual Carbon Budget[d]

**References** – Eyring et al., 2016[a]; Landschützer et al., 2014[b]; Lauvset et al., 2015[c]; Le Quéré et al., 2015[d]; Rödenbeck et al., 2014[e], 2015[f].

*Slide courtesy of Dorothee Bakker*

# OceanSITES time series

- WHOTS, NTAS, Stratus, KEO, PAPA, RAMA, Pirata moorings
- Significant value in OceanSITES long time series data from the platforms
- BEDI proposal to make the “official” time series data available through interoperable services
- June 2017 completion date

# Using Stratus time series data

stratus_ghrsst - Mozilla Firefox

about:sessionrestore | Home | stratus_ghrsst | stratus_ghrsst

localhost:8888/notebooks/stratus_ghrsst.ipynb

Most Visited | Red Hat, Inc. | Red Hat Network | Support | Shop | Products | Training

jupyter stratus_ghrsst Last Checkpoint: 04/17/2017 (unsaved changes)

File Edit View Insert Cell Kernel Help | Python 2

Markdown | Cell Toolbar: None

```
%matplotlib inline
```

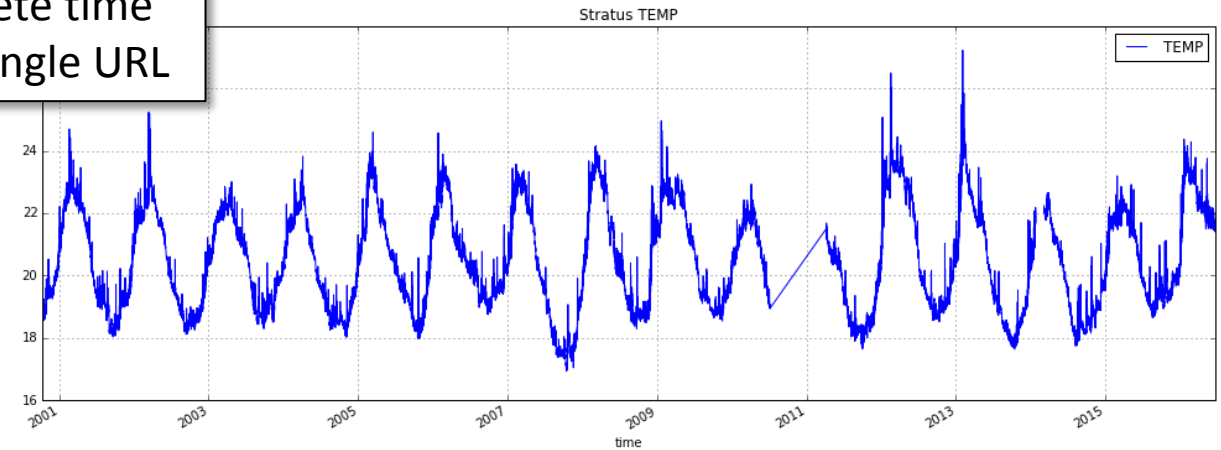
## Grab Stratus temperature data from ERDDAP

In [2]:
```
# Construct URL for CSV data:
# or specify a specific period:

url='http://ferret.pmel.noaa.gov/generic/erddap/tabledap/met_ab43_e62a_5494.csv?time,TEMP'
print url
df = pd.read_csv(url,index_col='time',parse_dates=True,skiprows=[1])
df[['TEMP']].plot(figsize=(17,6), title="Stratus TEMP");
```

oaa.gov/generic/erddap/tabledap/met_ab43_e62a_5494.csv?time,TEMP

Access complete time series with a single URL



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jupyter stratus_ghrsst Last Checkpoint: 04/17/2017 (autosaved)

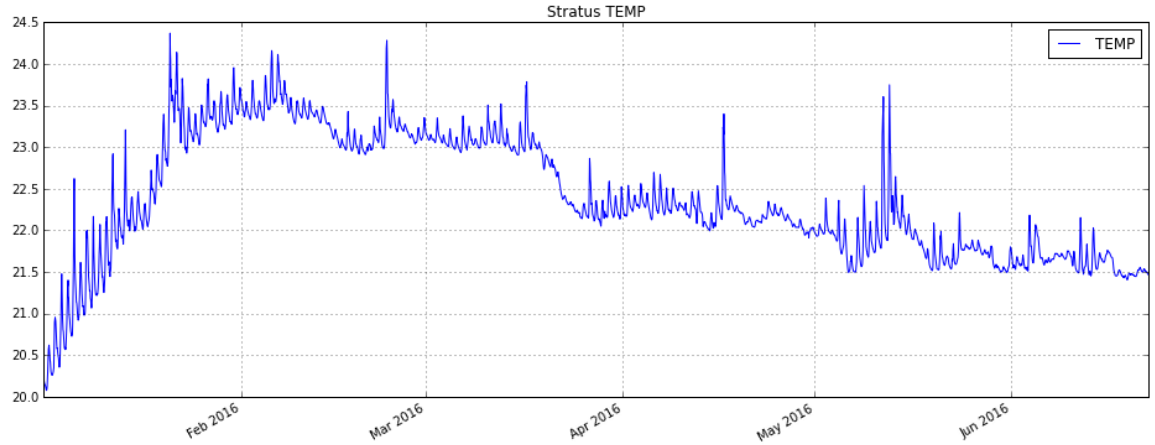
File Edit View Insert Cell Kernel Help Python 2

Markdown Cell Toolbar: None

In [3]:
```
# Construct URL for CSV data:
# or specify a specific period:
start = '2016-01-01T00:00:00Z'
stop =  '2016-12-24T00:00:00Z'
url='http://ferret.pmel.noaa.gov/generic/erddap/tabledap/met_ab43_e62a_5494.csv?time,TEMP\
&time>=%s&time<=%s' % (start,stop)
print url
```

```
http://ferret.pmel.noaa.gov/generic/erddap/tabledap/met_ab43_e62a_5494.csv?time,TEMP&time>=2016-01-01T00:00:00Z&time<=201
6-12-24T00:00:00Z
```

In [9]:
```
# Read data and list last ten records
df = pd.read_csv(url,index_col='time',parse_dates=True,skiprows=[1])  # skip the units row
df[['TEMP']].plot(figsize=(16,6), title="Stratus TEMP");
```



# Using Stratus time series data

stratus_ghrsst - Mozilla Firefox

about:sessionrestore | Home | stratus_ghrsst | stratus_ghrsst

localhost:8888/notebooks/stratus_ghrsst.ipynb

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jupyter stratus_ghrsst Last Checkpoint: 04/17/2017 (autosaved)

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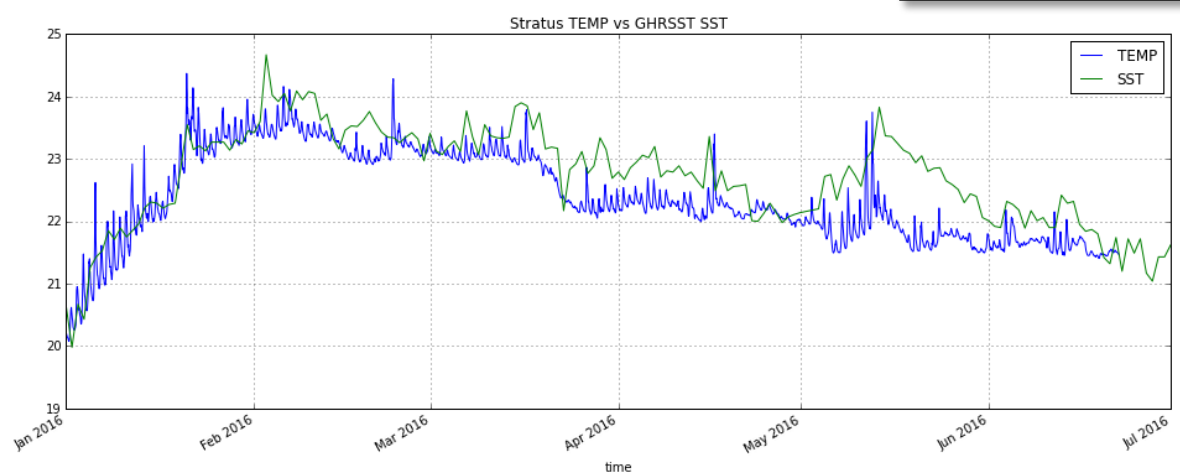
Markdown | Cell Toolbar: None

**Let's compare with GHRSST data (available from different ERDDAP server)**

In [15]:
```
ghrsstURL = 'http://coastwatch.pfeg.noaa.gov/erddap/griddap/jplG1SST.csv\
?SST[(2016-01-01T00:00:00Z):1:(2016-07-01T00:00:00Z)][(-19):1:(-19)][(-85):1:(-85)]'
```

In [16]:
```
df2 = pd.read_csv(ghrsstURL,index_col='time',parse_dates=True,skiprows=[1])  # skip units
ax = df[['TEMP']].plot();
df2[['SST']].plot(ax=ax,figsize=(16,6), title='Stratus TEMP vs GHRSST SST')
```

Out[16]: <matplotlib.axes._subplots.AxesSubplot at 0x7f4ef4710e50>




Compare with GHRSST data – also available through ERDDAP

# Using Stratus time series data

stratus_ghrsst - Mozilla Firefox

about:sessionrestore | Home | stratus_ghrsst | stratus_ghrsst

localhost:8888/notebooks/stratus_ghrsst.ipynb

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jupyter stratus_ghrsst Last Checkpoint: 04/17/2017 (autosaved)

File Edit View Insert Cell Kernel Help Python 2

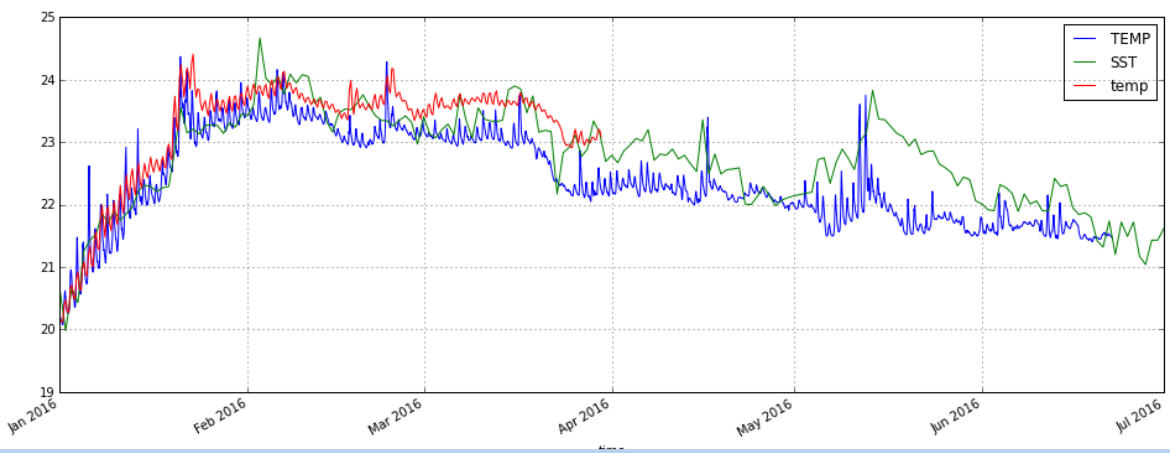
Markdown Cell Toolbar: None

**Now let's include Drifter data from the surrounding area**

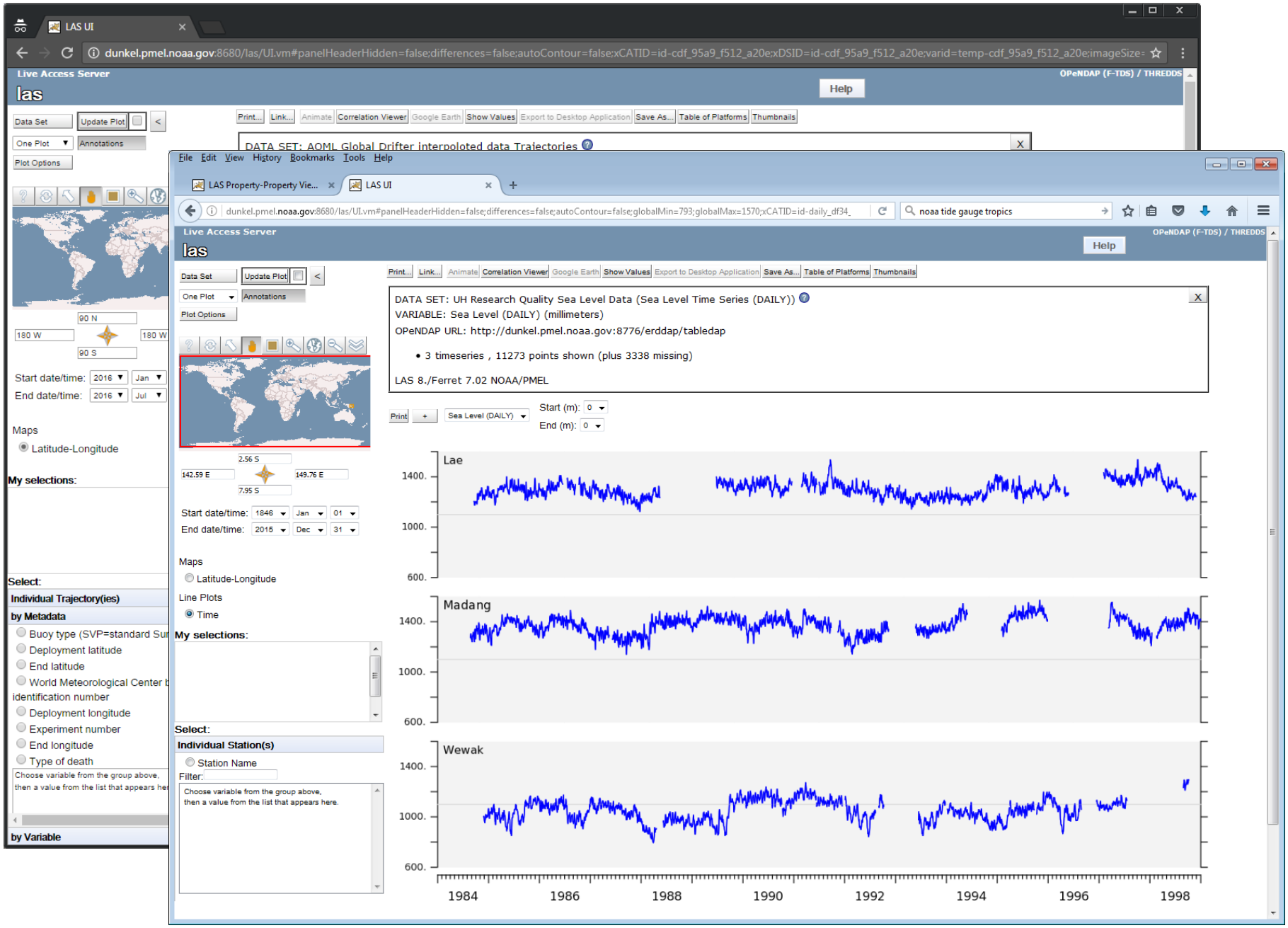
In [13]:
```
drifter_url= 'http://ferret.pmel.noaa.gov/generic/erddap/tabledap/drifter_b617_5548_5f0c.c
?time,temp&time>=2016-01-01T00:00:00Z&time<=2016-04-18T18:00:00Z\
&longitude>=-90&longitude<=-80&latitude>=-23&latitude<=-15'
ddf = pd.read_csv(drifter_url,index_col='time',parse_dates=True,skiprows=[1])  # skip the
```

In [14]:
```
ax = df[['TEMP']].plot();
df2[['SST']].plot(ax=ax,figsize=(16,6));
ddf[['temp']].plot(ax=ax,figsize=(16,6))
```

Out[14]: <matplotlib.axes._subplots.AxesSubplot at 0x7f4ef4775490>




....and Drifter SST as well!


LAS UI
dunkel.pmel.noaa.gov:8680/las/UI.vm#panelHeaderHidden=false;differences=false;autoContour=false;xCATID=id-cdf_95a9_f512_a20e;xDSID=id-cdf_95a9_f512_a20e;varid=temp-cdf_95a9_f512_a20e;imageSize=
Live Access Server
las
Help
OPeNDAP (F-TDS) / THREDDS
Data Set
Update Plot
One Plot
Annotations
Plot Options
Print... Link... Animate Correlation Viewer Google Earth Show Values Export to Desktop Application Save As... Table of Platforms Thumbnails
DATA SET: AOML Global Drifter interpolated data Trajectories
Start date/time: 2016 Jan
End date/time: 2016 Jul
Maps
Latitude-Longitude
My selections:
Select:
Individual Trajectory(ies)
by Metadata
Buoy type (SVP=standard Sur
Deployment latitude
End latitude
World Meteorological Center b
identification number
Deployment longitude
Experiment number
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Type of death
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then a value from the list that appears her
by Variable
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LAS UI
dunkel.pmel.noaa.gov:8680/las/UI.vm#panelHeaderHidden=false;differences=false;autoContour=false;globalMin=793;globalMax=1570;xCATID=id-daily_df34
noaa tide gauge tropics
Live Access Server
las
Help
OPeNDAP (F-TDS) / THREDDS
Data Set
Update Plot
One Plot
Annotations
Plot Options
Print... Link... Animate Correlation Viewer Google Earth Show Values Export to Desktop Application Save As... Table of Platforms Thumbnails
DATA SET: UH Research Quality Sea Level Data (Sea Level Time Series (DAILY))
VARIABLE: Sea Level (DAILY) (millimeters)
OPeNDAP URL: http://dunkel.pmel.noaa.gov:8776/erddap/tabledap
• 3 timeseries , 11273 points shown (plus 3338 missing)
LAS 8./Ferret 7.02 NOAA/PMEL
Print
Sea Level (DAILY)
Start (m): 0
End (m): 0
90 N
180 W
180 W
90 S
2.56 S
142.59 E
149.76 E
7.95 S
Start date/time: 1846 Jan 01
End date/time: 2015 Dec 31
Maps
Latitude-Longitude
Line Plots
Time
My selections:
Select:
Individual Station(s)
Station Name
Filter:
Choose variable from the group above,
then a value from the list that appears here.
Lae
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1400.
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1984
1986
1988
1990
1992
1994
1996
1998

# GOOS and EOVs

- ~20 defined EOVs that cover physical and BGC data
- For greatest understanding, especially at medium to large scales, measurements should be integrated from across disparate observing networks
- Supporting interoperable frameworks for data can help make this a reality

All Data collected and available through ERDDAP server

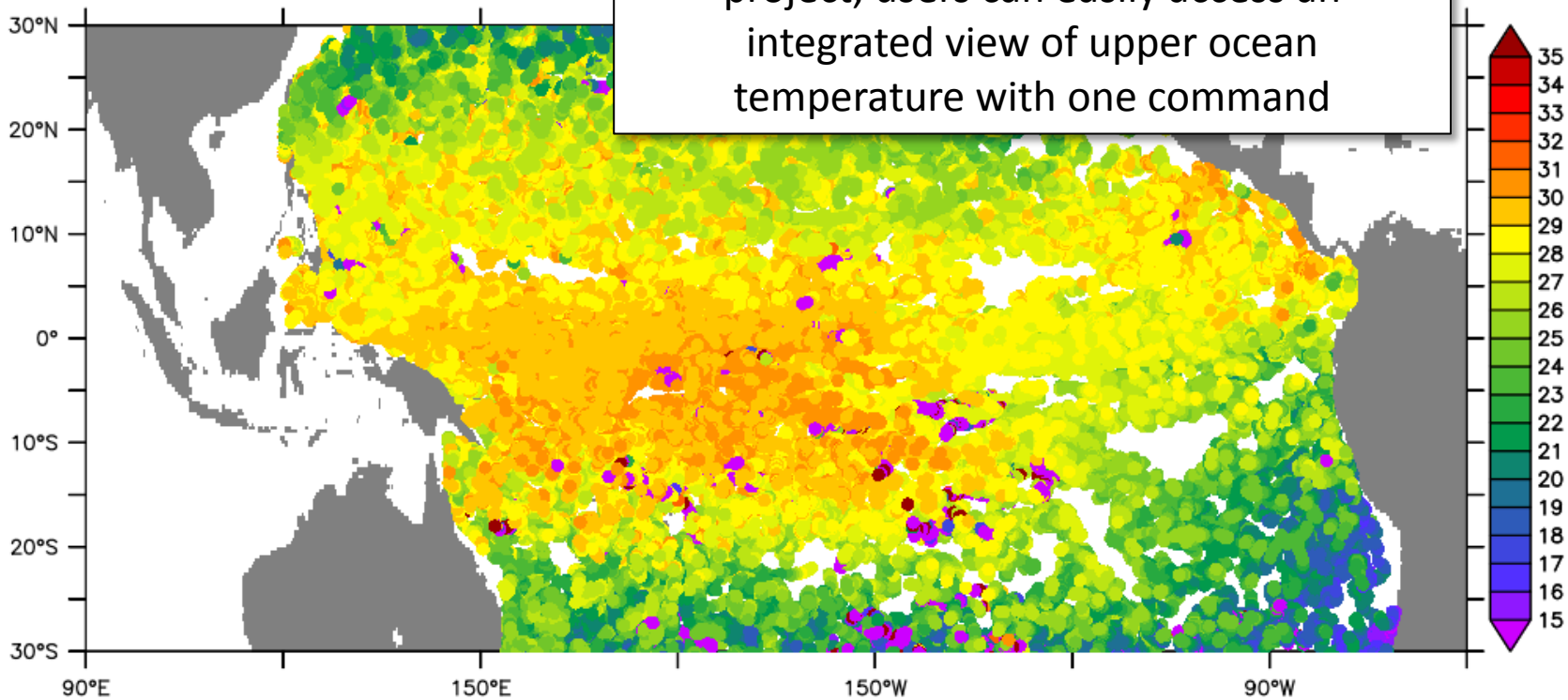
Thanks to uniformity of data in ERDDAP, we can create an "integrated" view of upper ocean temperature

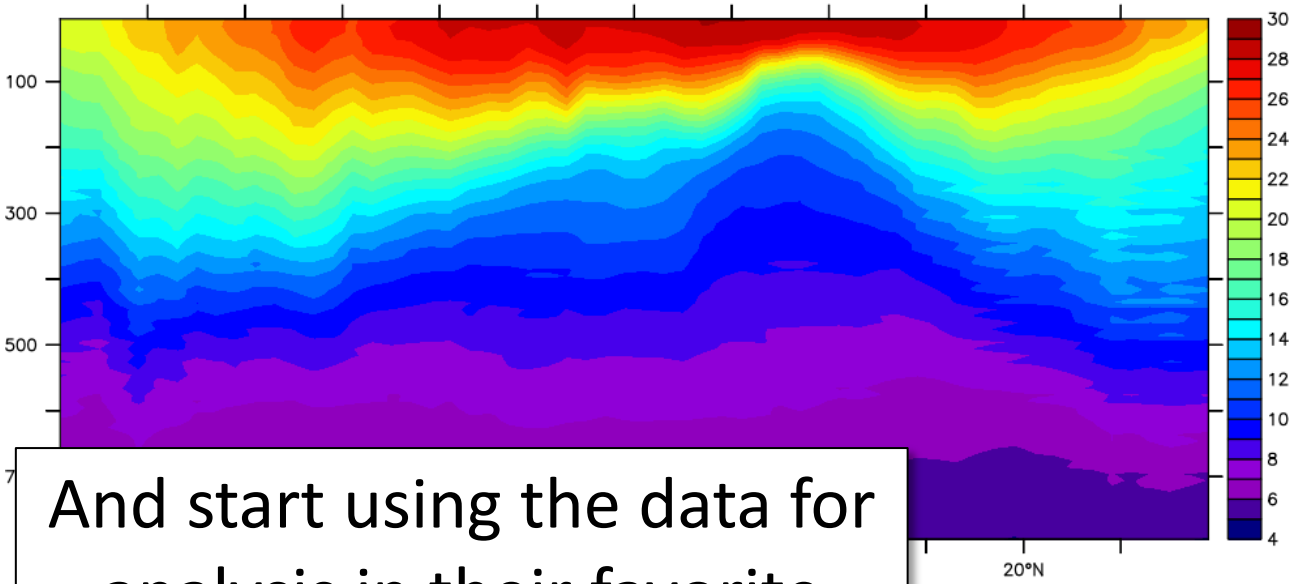
| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | set | data | graph | | | AOML Interpolated Drifter Observations | | | | | | |
| data | | | graph | M | | ARGO gridded Salinity data | | | | | | |
| data | | | graph | M | | ARGO gridded Temperature data | | | | | | |
| | set | data | graph | | | CCHDO CTD FILES | | | | | | |
| | set | data | graph | | | CCHDO Hydrographic data | | | | | | |
| data | | | graph | M | | Gridded upper ocean temperature from delayed mode sources | | F I M | background | RSS | | OSMC |
| | set | data | graph | | | IBI, NRT Algeciras in situ Observations | | | | | | |
| | set | data | graph | | | IBI, NRT Langosteira in situ Observations | | | | | | |
| | set | data | graph | | | IOOS Pacific Glider data | | | | | | |
| | set | data | graph | | | OceanSITES Mooring Temperature (TAO Delayed/Mixed Mode 10 min Data) | | | | | | |
| | set | data | graph | | | OceanSITES NTAS surface mooring fluxes calculated with Coare 3.0 algorithm | | | | | | |
| | set | data | graph | | | OceanSITES NTAS surface mooring MET data | | | | | | |
| | set | data | graph | | | OceanSITES Stratus surface mooring fluxes calculated with Coare 3.0 algorithm | | | | | | |
| | set | data | graph | | | OceanSITES Stratus surface mooring MET data | | F I M | background | RSS | | WHOI |
| | set | data | graph | | | OceanSITES WHOTS surface mooring fluxes calculated with Coare 3.0 algorithm | | F I M | background | RSS | | WHOI |
| | set | data | graph | | | OceanSITES WHOTS surface mooring MET data | | F I M | background | RSS | | WHOI |
| | set | data | graph | | | OSMC integrated upper ocean Temp | | F I M | background | RSS | | OSMC |
| | set | data | graph | | | OceanSITES WHOTS surface mooring MET data | | | | | | serving |
| | set | data | graph | | | OSMC integrated upper ocean Temp | | | | | | |
| | set | data | graph | | | TAO Delayed/Mixed Mode 10 minute Data (OceanSITES Mooring MET data) | | F I M | background | RSS | | OceanSITES |
| | set | data | graph | | | TAO/TRITON, RAMA, and PIRATA Buoys, Daily, 1977-present, Air Temperature | | F I M | background | RSS | | NOAA PMEL, TAO/ |
| | set | data | graph | | | TAO/TRITON, RAMA, and PIRATA Buoys, Daily, 1977-present, Sea Surface Temperature | | F I M | background | RSS | | NOAA PMEL, TAO/ |
| | set | data | graph | | | TAO/TRITON, RAMA, and PIRATA Buoys, Daily, 1977-present, Temperature | | F I M | background | RSS | | NOAA PMEL, TAO/ |
| | set | data | graph | | | TAO/TRITON, RAMA, and PIRATA Buoys, Daily, 1977-present, Wind | | F I M | background | RSS | | NOAA PMEL, TAO/ |
| | set | data | graph | | | TAO/TRITON, RAMA, and PIRATA Buoys, Daily, 1987-present, Salinity | | F I M | background | RSS | | NOAA PMEL, TAO/ |
| | set | data | graph | | | TAO/TRITON, RAMA, and PIRATA Buoys, Daily, 1988-2015, ADCP | | F I M | background | RSS | | NOAA PMEL, TAO/ |
| | set | data | graph | | | TAO/TRITON, RAMA, and PIRATA Buoys, Daily, 1989-present, Wind Stress | | F I M | background | RSS | | NOAA PMEL, TAO/ |
| | set | data | graph | | | TAO/TRITON, RAMA, and PIRATA Buoys, Daily, 1992-present, Sea Surface Salinity | | F I M | background | RSS | | NOAA PMEL, TAO/ |
| | set | data | graph | | | TAO/TRITON, RAMA, and PIRATA Buoys, Daily, 1997-present, Precipitation | | F I M | background | RSS | | NOAA PMEL, TAO/ |
| | set | data | graph | | | UH fast delivery hourly sea level data (Sea Level Time Series (HOURLY)) | | F I M | background | RSS | | University of H |
| | set | data | graph | | | UH fast delivery sea level data (Sea Level Time Series (DAILY)) | | F I M | background | RSS | | University of H |
| | set | data | graph | | | UH research quality hourly sea level data (Sea Level Time Series (HOURLY)) | | F I M | background | RSS | | University of H |
| | set | data | graph | | | UH Research Quality Sea Level Data (Sea Level Time Series (DAILY)) | | F I M | background | RSS | | University of H |

use http://ferret.pmel.noaa.gov/generic/erddap/tabledap/integrated_temp.nc

shade/z=0 temp

As a result, rather than a data management project, users can easily access an integrated view of upper ocean temperature with one command

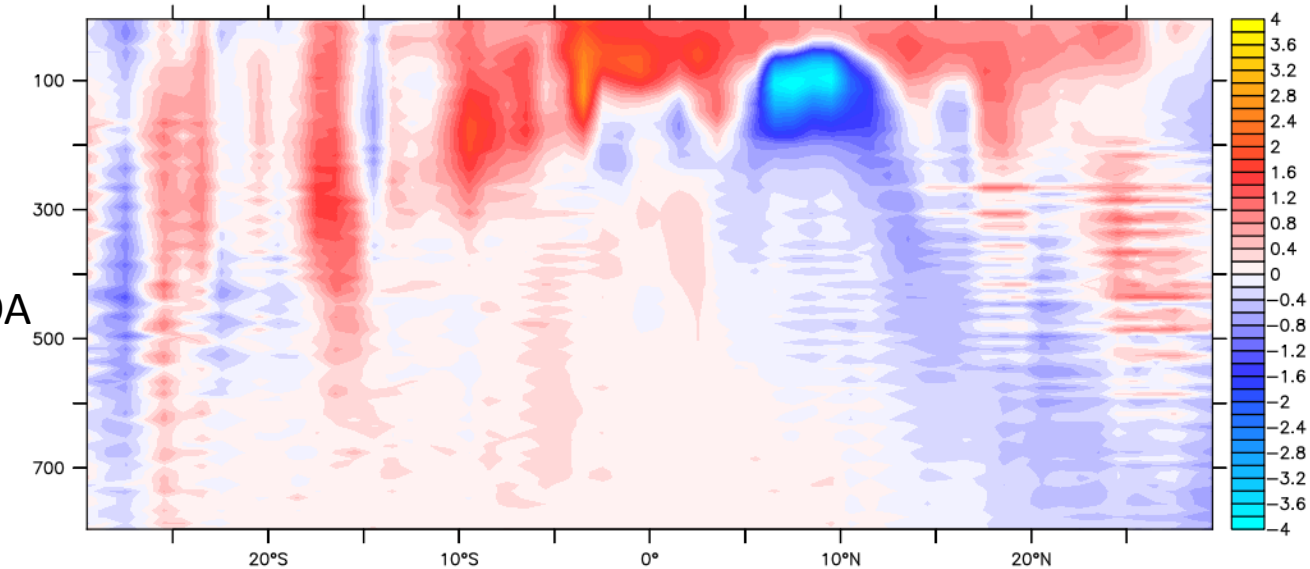





2015 Tropical Pacific temperature, averaged over time and longitude

And start using the data for analysis in their favorite application

2015 TEMP
Anomalies from WOA



# EOVs

- How to harmonize data from heterogeneous sources?
- EOV datasets require very detailed metadata
  - Need quality information to fully understand the value of the observations
  - Example: sea surface temperature
    - From a drifter? From a ship? Was it quality controlled?
- World Ocean Database (WOD), Global Temperature and Salinity Profile Program (GTSPP), etc. are examples of products that attempt to do this
- Are those sufficient? Can we improve them?

# EOVs

- Important to provide both EOV and individual platform network data through interoperable frameworks

- Availability of platform network data in integrated frameworks not only eases creation of EOV datasets/products – it allows for other users to easily create their own versions

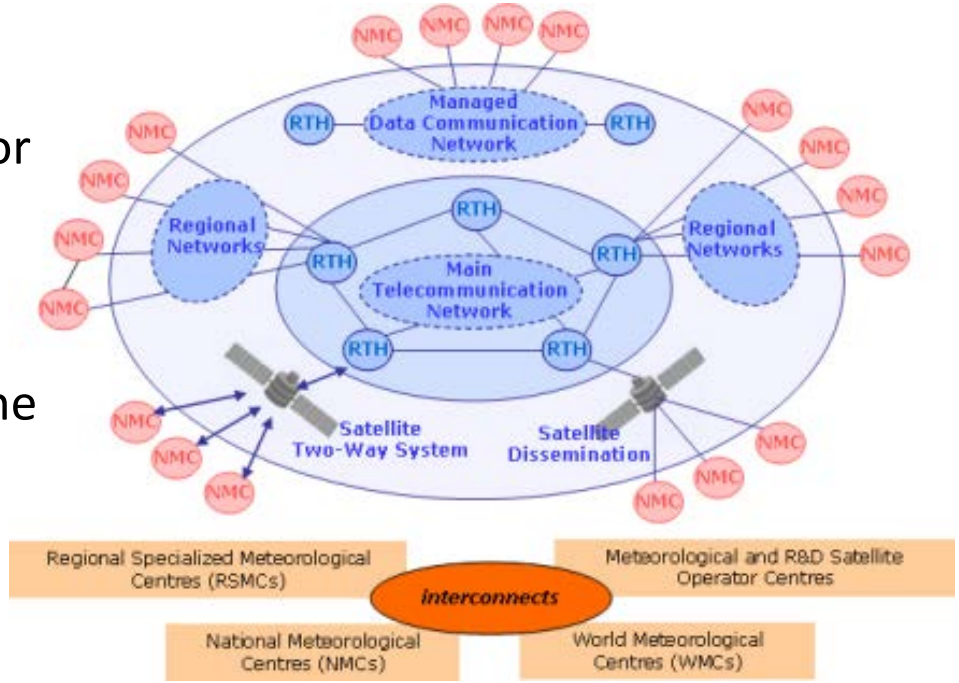
- Users may want to access the original observations that make up a synthesis product

# OpenGTS initiative

Global Telecommunication System (GTS)

- A coordinated global system of telecommunication infrastructure for the rapid collection, exchange and distribution of observations

- GTS is organized into three levels: the Main Telecommunication Network (MTN), six Regional Meteorological Telecommunication Networks (RMTN) and numerous National Meteorological Telecommunication Networks (NMTN).

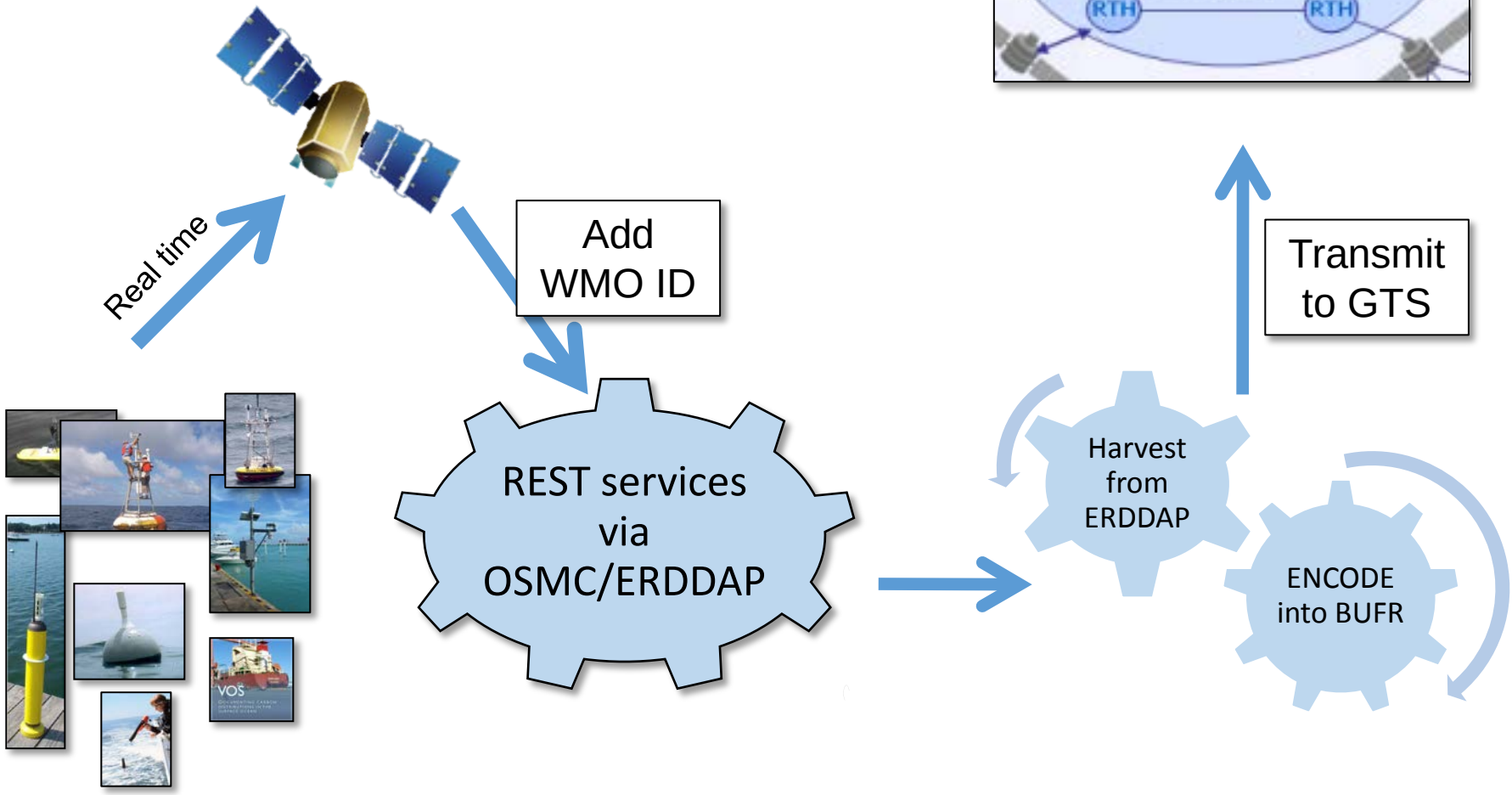


# OpenGTS initiative

- Partners
  - Puertos del Estado, Spain
  - National Institute of Oceanography and Experimental Geophysics (OGS), Italy
  - International Arctic Buoy Program
  - US Integrated Ocean Observing System
- Identify ~12 platforms whose data will be inserted on the GTS
  - Use ERDDAP as the data platform for harvesting of data to be sent to GTS
- Provide ability to access RT data for these platforms
- Demonstration of project slated for JCOMM V in October, 2017

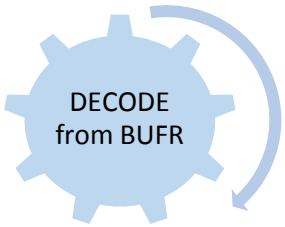
# OpenGTS initiative

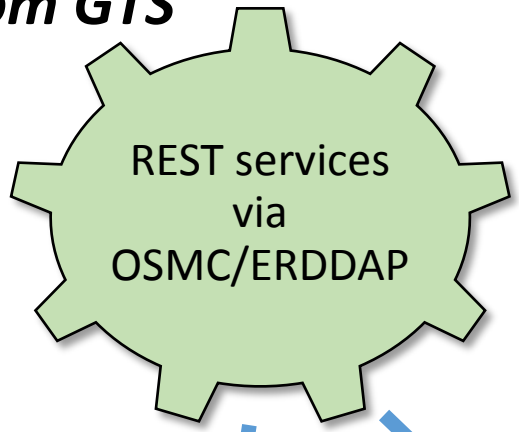
***Insert data onto GTS***

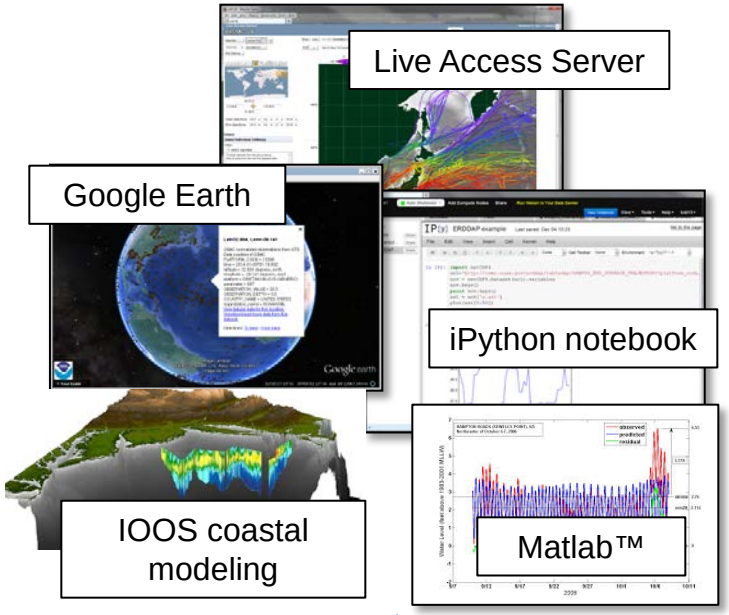


# OpenGTS initiative

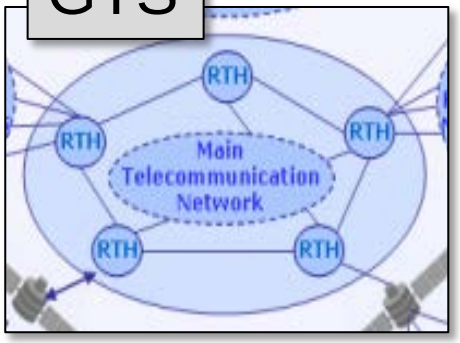
***Retrieve data from GTS***



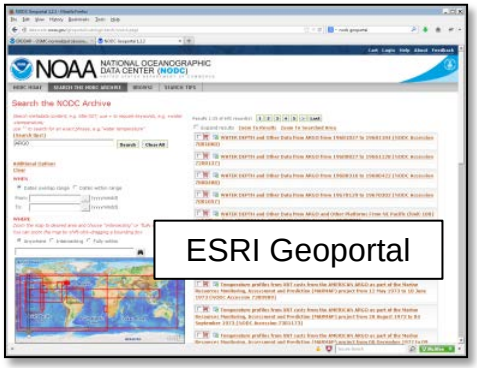



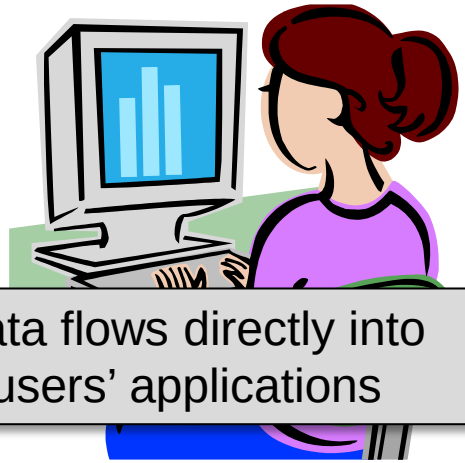




GTS




Metadata available through international standards



Data flows directly into users' applications

# Thank you!

- ERDDAP: coastwatch.pfeg.noaa.gov/erddap/index.html
- OSMC: www.osmc.noaa.gov
- SOCAT: socat.info
- Global drifter program: www.aoml.noaa.gov/phod/dac
- Puertos del Estado: www.puertos.es
- OGS: www.ogs.trieste.it
- US IOOS: ioos.us
- IABP: iabp.apl.washington.edu
- JCOMMOPS: www.jcommops.org

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