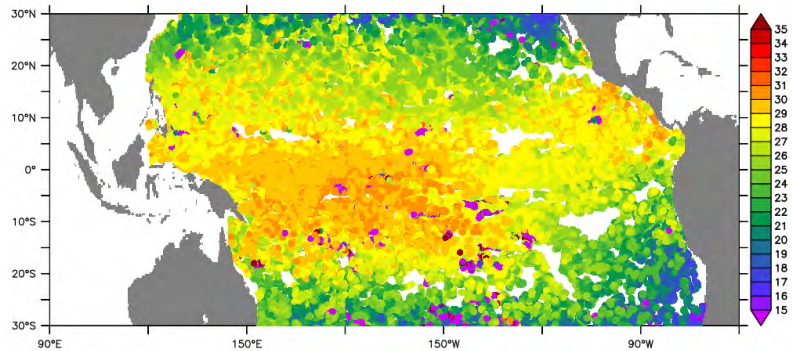
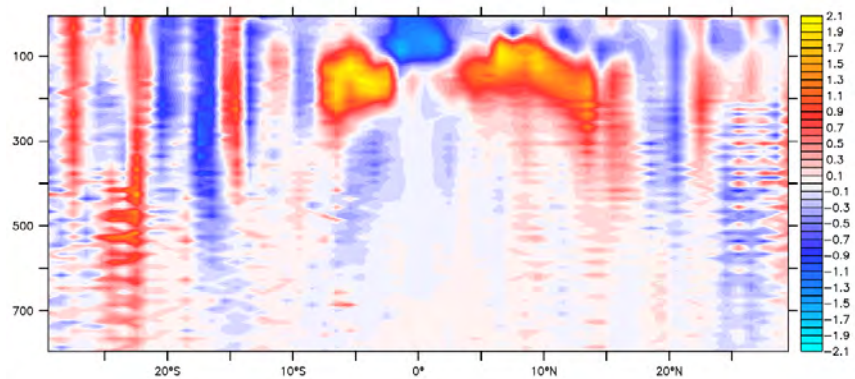
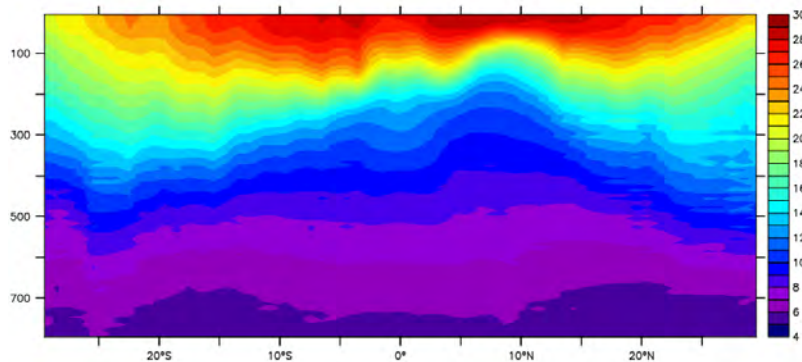


# Integrating Data and Information Across Observing Systems



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Steven Worley: UCAR, CO, USA  
Bob Simons: NOAA Southwest Fisheries, CA, USA  
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# Integration and Interoperability, what is it?

Three broad categories of integration by example:

1. Collecting single observing system observations
  - All data from the Surface Ocean CO<sub>2</sub> Atlas (SOCAT) project in a common data and metadata format
2. Multiple observing systems, across an EOV/ECV (Temperature)
  - Surface Temp from moored and drifting buoys, ARGO, and hydrographic stations
3. Cross-system, multi-variable reference collections
  - World Ocean Database (WOD), International Comprehensive Ocean-Atmosphere Data Set (ICOADS), Surface Ocean CO<sub>2</sub> Atlas (SOCAT)

## Interoperability – definition<sup>1</sup>

The ability of data or tools from non-cooperating resources to integrate or work together with minimal effort.

<sup>1</sup> Wilkinson, M. D. et al. *The FAIR Guiding Principles for scientific data management and stewardship*. *Sci. Data* 3:160018 doi: 10.1038/sdata.2016.18 (2016).

FAIR = Findable, Accessible, Interoperable, Reusable

- Example – Expedia.com: “Find me a cheap flight”
  - Poll many systems in real time
  - Using known protocols, i.e. access mechanism

# Surface Ocean CO2 Atlas (SOCAT) v3

traditi

Name	Last modified	Size	Description
Parent Directory			
Fair Data Use Statement for SOCAT.pdf	29-Jan-2016 15:35	85K	
Read SOCATv3.m	15-Sep-2015 08:21	18K	
SOCAT_cat_logo.jpg	25-Aug-2015 15:10	835K	
SOCATv3.zip	29-Oct-2015 11:27	330M	
SOCATv3_Arctic.zip	29-Oct-2015 11:20	14M	
SOCATv3_Coastal.zip	29-Oct-2015 11:23	127M	
SOCATv3_FlagE.zip	29-Oct-2015 11:29	5.3M	
SOCATv3_Gridded_Dat/	02-Mar-2016 09:22	-	
SOCATv3_Indian.zip	29-Oct-2015 11:20	4.2M	
SOCATv3_NorthAtlantic.zip	29-Oct-2015 11:21	35M	
SOCATv3_NorthPacific.zip	29-Oct-2015 11:22	13M	

Or available via FTP grouped by ocean basin

Though downloadable, the user will have to:

- Download all 4K files
- Somehow knit them together in order to look at the entire “collection”
- Format the data to work in application of choice

3. Bakker

Specifically, in regional studies invite large data providers, who frequently possess valuable expert knowledge on data and region, to collaborate at an level which may lead to an invitation of co-authorship.

We recognize that co-authorship is only justified in case of a significant scientific contribution to a publication and that provision of data on its own does not warrant co-authorship.

2) Cite SOCAT and its data products as:  
Version 3: Bakker et al. (2016, in prep.) and Bakker et al. (2014) (cite both papers until the version 3 publication has been published in ESSD);

# Surface Ocean CO2 Atlas (SOCAT) v3 *interoperable* data access

ERDDAP - List of All Datasets

ferret.pmel.noaa.gov/socat/erddap/info/index.html?page=1&itemsPerPage=1000

ERDDAP  
Easier access to scientific data

Brought to you by [NOAA NMFS SWFSC ERD](#)

[ERDDAP](#) > List of All Datasets

Or, Do a Full Text Search for Datasets:

Or, Search for Datasets by Category:  
[cdm\\_data\\_type](#), [institution](#), [ioos\\_category](#), [keywords](#),  
[long\\_name](#), [standard\\_name](#), [variableName](#)

Or, Search for Datasets with [Advanced Search](#)

Pick a Dataset

7 matching datasets

Grid DAP Data	Sub-set	Table DAP Data		Background Info	RSS	E mail	Institution	Dataset ID
	<a href="#">set</a>	<a href="#">data</a>	* The List of All Active Datasets in this ERDDAP	<a href="#">background</a>			NOAA/PMEL	allDatasets
	<a href="#">set</a>	<a href="#">data</a>	SOCAT v3 Data Collection	<a href="#">background</a>	<a href="#">RSS</a>	<a href="#">E mail</a>	PMEL	socat_v3_fulldata
	<a href="#">set</a>	<a href="#">data</a>		<a href="#">background</a>	<a href="#">RSS</a>	<a href="#">E mail</a>	PMEL	socat_v2_decimated

Because data are available through ERDDAP framework

- No Download necessary (DAP access available)
- User can look at whole "collection" of data as a single dataset
- Many applications can directly access and use data from ERDDAP
- Easy to leverage existing tools to visualize and analyze data

# Surface Ocean CO2 Atlas (SOCAT) v3 interoperable data access

Using Live Access Server to visualize SOCAT collection

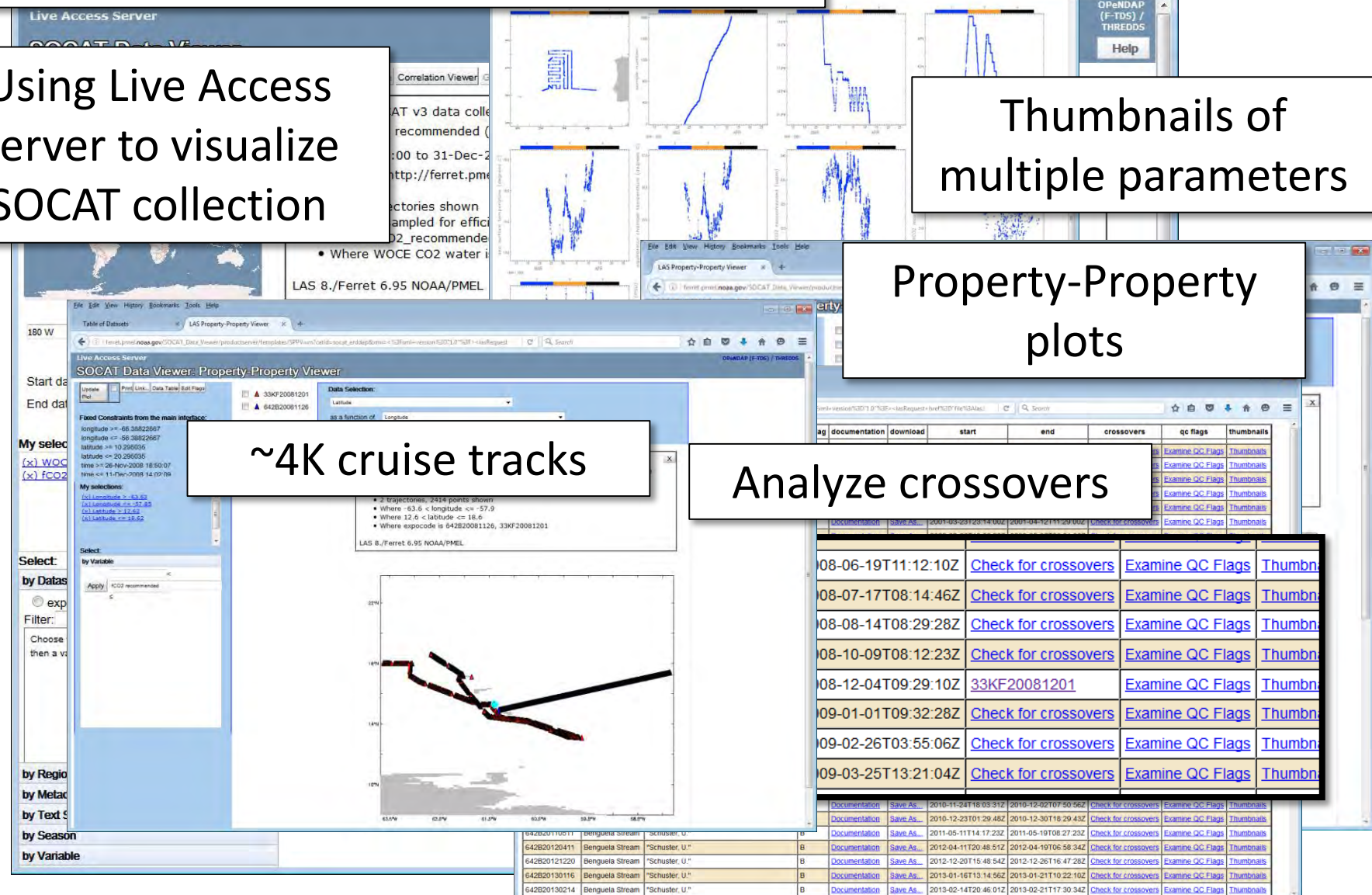
Thumbnails of multiple parameters

Property-Property plots

~4K cruise tracks

Analyze crossovers

Documentation	Save As...	start	end	crossovers	qc flags	thumbnails
<a href="#">Documentation</a>	<a href="#">Save As...</a>	2007-04-26T12:14:06Z	2007-04-26T11:29:06Z	<a href="#">Check for crossovers</a>	<a href="#">Examine QC Flags</a>	<a href="#">Thumbnail</a>
<a href="#">Documentation</a>	<a href="#">Save As...</a>	2010-11-24T16:03:31Z	2010-12-02T07:50:56Z	<a href="#">Check for crossovers</a>	<a href="#">Examine QC Flags</a>	<a href="#">Thumbnail</a>
<a href="#">Documentation</a>	<a href="#">Save As...</a>	2010-12-23T01:29:48Z	2010-12-30T18:29:43Z	<a href="#">Check for crossovers</a>	<a href="#">Examine QC Flags</a>	<a href="#">Thumbnail</a>
<a href="#">Documentation</a>	<a href="#">Save As...</a>	2011-05-11T14:17:23Z	2011-05-19T08:27:23Z	<a href="#">Check for crossovers</a>	<a href="#">Examine QC Flags</a>	<a href="#">Thumbnail</a>
<a href="#">Documentation</a>	<a href="#">Save As...</a>	2012-04-11T20:48:51Z	2012-04-19T06:58:34Z	<a href="#">Check for crossovers</a>	<a href="#">Examine QC Flags</a>	<a href="#">Thumbnail</a>
<a href="#">Documentation</a>	<a href="#">Save As...</a>	2012-12-20T15:48:54Z	2012-12-26T16:47:28Z	<a href="#">Check for crossovers</a>	<a href="#">Examine QC Flags</a>	<a href="#">Thumbnail</a>
<a href="#">Documentation</a>	<a href="#">Save As...</a>	2013-01-16T13:14:56Z	2013-01-21T10:22:10Z	<a href="#">Check for crossovers</a>	<a href="#">Examine QC Flags</a>	<a href="#">Thumbnail</a>
<a href="#">Documentation</a>	<a href="#">Save As...</a>	2013-02-14T20:46:01Z	2013-02-21T17:30:34Z	<a href="#">Check for crossovers</a>	<a href="#">Examine QC Flags</a>	<a href="#">Thumbnail</a>



Excel spreadsheet showing a table of data with columns: expocode, dataset\_name, vessel\_name, organizati, geospatia, time\_cov, time\_con, investigat, socat\_ver, all\_region, socat\_doi, qc\_flag, sample\_n, year, month, day, hour, minute, second, longitude, latitude.

expocode	dataset_name	vessel_name	organizati	geospatia	geospatia	geospatia	geospatia	time_cov	time_con	investigat	socat_ver	all_region	socat_doi	qc_flag	sample_n	year	month	day	hour	minute	second	longitude	latitude
77CN20140928	com14_16	Atlantic Companion		301.4381	354.0999	44.9816	52.4034	2014-09-2i	2014-10-0i	Steinhoff, 3.0N	AC	10.1594/P/B		1	2014	9	28	9	51	38	-5.9001	52.40	
77CN20140928	com14_16	Atlantic Companion		301.4381	354.0999	44.9816	52.4034	2014-09-2i	2014-10-0i	Steinhoff, 3.0N	AC	10.1594/P/B		2	2014	9	28	9	53	2	-5.9032	52.40	
77CN20140928	com14_16	Atlantic Companion		301.4381	354.0999	44.9816	52.4034	2014-09-2i	2014-10-0i	Steinhoff, 3.0N	AC	10.1594/P/B		3	2014	9	28	9	53	45	-5.9064	52.3	
77CN20140928	com14_16	Atlantic Companion		301.4381	354.0999	44.9816	52.4034	2014-09-2i	2014-10-0i	Steinhoff, 3.0N	AC	10.1594/P/B		4	2014	9	28	9	55	9	-5.9096	52.39	
77CN20140928	com14_16	Atlantic Companion		301.4381	354.0999	44.9816	52.4034	2014-09-2i	2014-10-0i	Steinhoff, 3.0N	AC	10.1594/P/B		5	2014	9	28	9	55	52	-5.9127	52.39	
77CN20140928	com14_16	Atlantic Companion		301.4381	354.0999	44.9816	52.4034	2014-09-2i	2014-10-0i	Steinhoff, 3.0N	AC	10.1594/P/B		6	2014	9	28	9	57	59	-5.9191	52.38	
77CN20140928	com14_16	Atlantic Companion		301.4381	354.0999	44.9816	52.4034	2014-09-2i	2014-10-0i	Steinhoff, 3.0N	AC	10.1594/P/B		7	2014	9	28	9	58	41	-5.9222	52.3	
77CN20140928	com14_16	Atlantic Companion		301.4381	354.0999	44.9816	52.4034	2014-09-2i	2014-10-0i	Steinhoff, 3.0N	AC	10.1594/P/B		8	2014	9	28	10	0	18	-5.9254	52.37	
77CN20140928	com14_16	Atlantic Companion		301.4381	354.0999	44.9816	52.4034	2014-09-2i	2014-10-0i	Steinhoff, 3.0N	AC	10.1594/P/B		9	2014	9	28	10	1	5	-5.9286	52.37	
77CN20140928	com14_16	Atlantic Companion		301.4381	354.0999	44.9816	52.4034	2014-09-2i	2014-10-0i	Steinhoff, 3.0N	AC	10.1594/P/B		10	2014	9	28	10	1	52	-5.9317	52.37	

Google Earth interface showing a map of the ocean with a data popup window.

**Lat=0, Lon=-155**

OceanSITES Mooring Temperature (TAO Delayed/Mixed Mode 10 min Data)  
 Data courtesy of oceansites  
 TEMP = 27.237 degree\_Celsius  
 longitude = -155.0 degrees\_east  
 latitude = 0.0 degrees\_north  
[View tabular data for this location.](#)  
[View/download more data from this dataset.](#)

Directions: [To here](#) - [From here](#)

Other clients (Excel, Google Earth, Matlab®, Jupyter, Notebooks, R, etc) can also directly access data from ERDDAP

# Digression: DAP in the *modeling* community

Data Access Protocol (DAP) (originally Distributed Oceanographic Data System (DODS)), revolutionized how data was accessed

- User could use familiar applications and not worry about data formats
- Users could access complete model runs with a single command (time series analysis, etc)
- Allows for access of heterogeneous datasets in a highly distributed environment

OPeNDAP servers (Hyrax, THREDDS data server) are now the de facto way to serve such data.

Many barriers to interoperable access of gridded/model data have been removed thanks to DAP

- See Unified Access Framework project which offers access to 6K+ datasets in a uniform way



# Digression: DAP for the ocean observation community

## ERDDAP is DAP, but for in situ data!

- ERDDAP can also revolutionize how people serve, access and use observational data
- ERDDAP is NOT a portal - it's a framework upon which portals can easily be built
- From Provider standpoint:
  - Can ingest many existing formats and make available through interoperable web services – flexible!
- From user standpoint
  - Can access and use observations and “collections” of observations with familiar clients without worrying about data format
  - Provides machine to machine access with RESTful web services

# Digression: DAP for the ocean observation community

## ERDDAP is DAP, but for in situ data!

- Reducing the time required to deal with data management allows more time for scientific productivity
- Does it solve all the problems?
  - No. But can significantly improve integration of many types of data already.
  - Leveraging existing standards, conventions and frameworks, such as ERDDAP, allows us to solve many of these issues at significantly reduced costs.

# JCOMM Observations Coordination Group (OCG) ACTION: to develop vision for integration of data across observing systems.

## A Piloting (prototyping) Activity to Address Key Challenges of the JCOMM OCG Task Team on Integrated Data Access

- Chose to focus on Tropical Pacific in support of TPOS 2020
- Build an integrated framework of ocean observation data from multiple platform networks or data sources:
  - Drifting Buoys
  - Argo Floats
  - SOT/VOS data (CCHDO)
  - SOCAT underway data
  - IOOS Glider data
  - OceanSITES stations
    - Tropical Moorings, Stratus, WHOTS, CCE1, CCE2
  - Real Time data from OSMC GTS
- Selected ERDDAP as data framework for integrating the observations

JCOMM Observations Coordination Group (OCG) ACTION: to develop vision for integration of data across observing systems.

## Further possibilities

- Integrating across EOVS – Temperature example

# JCOMM OCG ACTION: to develop vision for integration of data across observing systems.

All Data collected and available through a single ERDDAP server

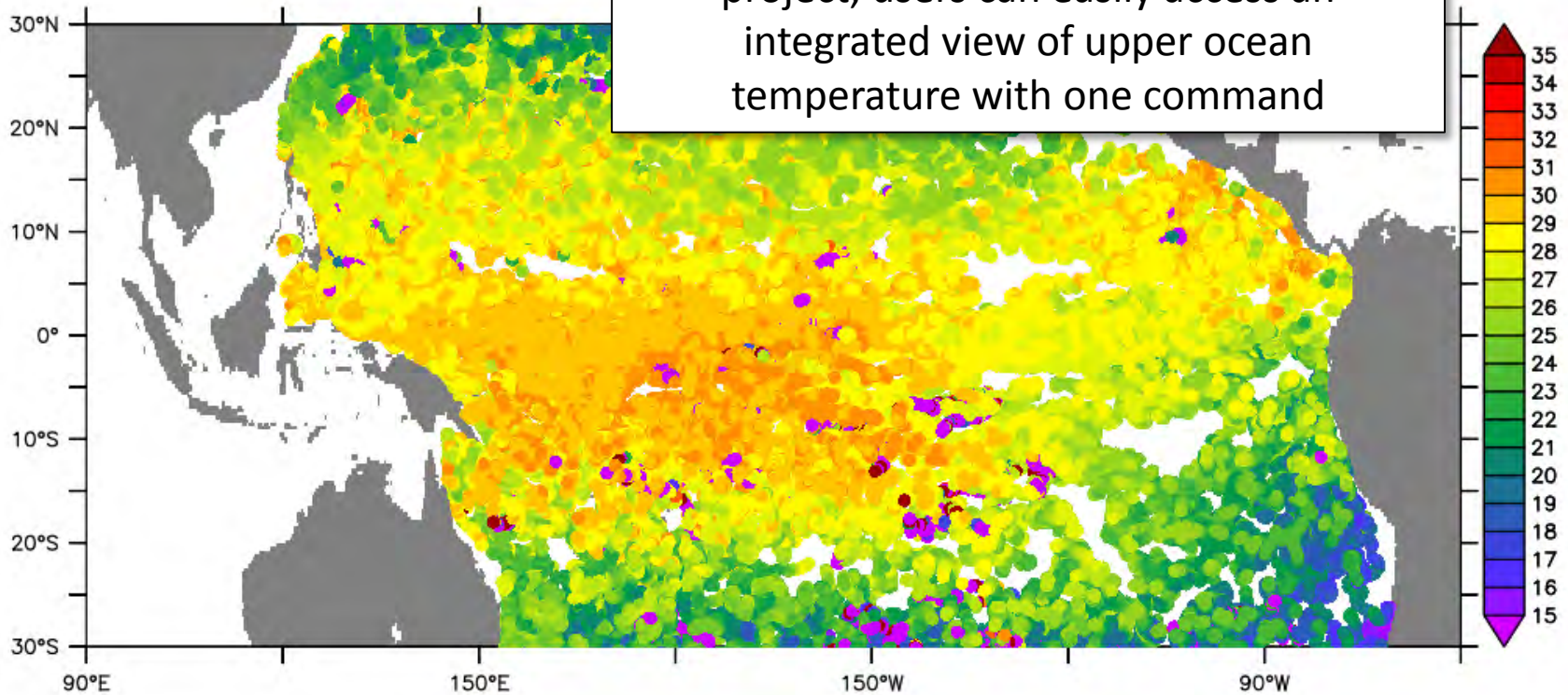
ERDDAP, we can create an "integrated" view of upper ocean temperature

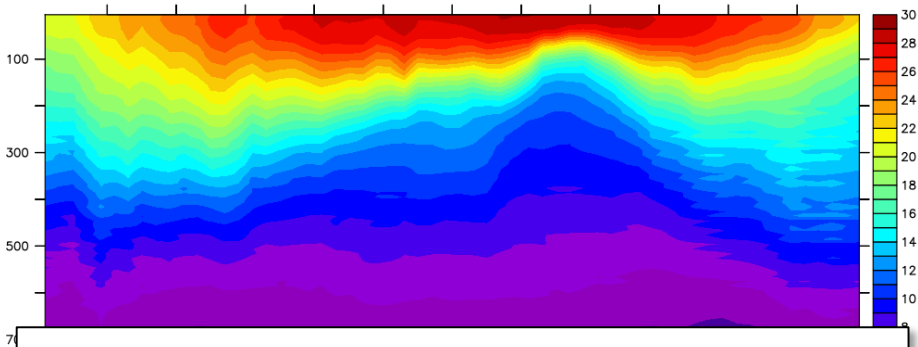
Grid DAP Data	Sub-set	Table DAP Data	Make A Graph	W M S	Source Data Files	Title								
	<a href="#">set</a>	<a href="#">data</a>	<a href="#">graph</a>			* The List of All Active Datasets in this ERDDAP *								
	<a href="#">set</a>	<a href="#">data</a>	<a href="#">graph</a>			AOML Interpolated Drifter Observations								
	<a href="#">set</a>	<a href="#">data</a>	<a href="#">graph</a>			Argo float vertical profile (ARGO delayed mode data)								
	<a href="#">set</a>	<a href="#">data</a>	<a href="#">graph</a>			CCHDO CTD FILES								
	<a href="#">set</a>	<a href="#">data</a>	<a href="#">graph</a>			CCHDO Hydrographic data								
<a href="#">data</a>			<a href="#">graph</a>	M		Gridded upper ocean temperature from delayed mode sources								
	<a href="#">set</a>	<a href="#">data</a>	<a href="#">graph</a>			IOOS Pacific Glider data								
<a href="#">data</a>			<a href="#">graph</a>	M		March Real Time Gridded Temperature data								
	<a href="#">set</a>	<a href="#">data</a>	<a href="#">graph</a>			OceanSITES CCE1 Mooring data	<a href="#">?</a>	<a href="#">F</a>	<a href="#">I</a>	<a href="#">M</a>	<a href="#">background</a>	<a href="#">RSS</a>	<a href="#">✉</a>	OSMC
	<a href="#">set</a>	<a href="#">data</a>	<a href="#">graph</a>			OceanSITES CCE2 Mooring data from the California Current	<a href="#">?</a>	<a href="#">F</a>	<a href="#">I</a>	<a href="#">M</a>	<a href="#">background</a>	<a href="#">RSS</a>	<a href="#">✉</a>	OceanSITES/UCSD/SIO
	<a href="#">set</a>	<a href="#">data</a>	<a href="#">graph</a>			OceanSITES CCE2 Mooring data from the California Current	<a href="#">?</a>	<a href="#">F</a>	<a href="#">I</a>	<a href="#">M</a>	<a href="#">background</a>	<a href="#">RSS</a>	<a href="#">✉</a>	USCD
	<a href="#">set</a>	<a href="#">data</a>	<a href="#">graph</a>			OceanSITES Mooring Temperature (TAO Delayed/Mixed Mode 10 min Data)	<a href="#">?</a>	<a href="#">F</a>	<a href="#">I</a>	<a href="#">M</a>	<a href="#">background</a>	<a href="#">RSS</a>	<a href="#">✉</a>	oceansites
	<a href="#">set</a>	<a href="#">data</a>	<a href="#">graph</a>			OSMC Real Time GIS Ocean observations (OSMC flattened observations from GIS)	<a href="#">?</a>	<a href="#">F</a>	<a href="#">I</a>	<a href="#">M</a>				
	<a href="#">set</a>	<a href="#">data</a>	<a href="#">graph</a>			OSMC Upper Ocean Temperature from the Pacific	<a href="#">?</a>	<a href="#">F</a>	<a href="#">I</a>	<a href="#">M</a>				
	<a href="#">set</a>	<a href="#">data</a>	<a href="#">graph</a>			SOCAT v3 data collection	<a href="#">?</a>	<a href="#">F</a>	<a href="#">I</a>	<a href="#">M</a>				
	<a href="#">set</a>	<a href="#">data</a>	<a href="#">graph</a>			SOCAT v3 data collection	<a href="#">?</a>	<a href="#">F</a>	<a href="#">I</a>	<a href="#">M</a>	<a href="#">background</a>	<a href="#">RSS</a>	<a href="#">✉</a>	PMEL
	<a href="#">set</a>	<a href="#">data</a>	<a href="#">graph</a>			TAO Delayed/Mixed Mode 10 minute Data (OceanSITES Mooring MET data)	<a href="#">?</a>	<a href="#">F</a>	<a href="#">I</a>	<a href="#">M</a>	<a href="#">background</a>	<a href="#">RSS</a>	<a href="#">✉</a>	OceanSITES
	<a href="#">set</a>	<a href="#">data</a>	<a href="#">graph</a>			TAO/TRITON, RAMA, and PIRATA Buoys, Daily, ADCP	<a href="#">?</a>	<a href="#">F</a>	<a href="#">I</a>	<a href="#">M</a>	<a href="#">background</a>	<a href="#">RSS</a>	<a href="#">✉</a>	NOAA PMEL, TAO/ ...
	<a href="#">set</a>	<a href="#">data</a>	<a href="#">graph</a>			TAO/TRITON, RAMA, and PIRATA Buoys, Daily, Air Temperature	<a href="#">?</a>	<a href="#">F</a>	<a href="#">I</a>	<a href="#">M</a>	<a href="#">background</a>	<a href="#">RSS</a>	<a href="#">✉</a>	NOAA PMEL, TAO/ ...
	<a href="#">set</a>	<a href="#">data</a>	<a href="#">graph</a>			TAO/TRITON, RAMA, and PIRATA Buoys, Daily, Precipitation	<a href="#">?</a>	<a href="#">F</a>	<a href="#">I</a>	<a href="#">M</a>	<a href="#">background</a>	<a href="#">RSS</a>	<a href="#">✉</a>	NOAA PMEL, TAO/ ...
	<a href="#">set</a>	<a href="#">data</a>	<a href="#">graph</a>			TAO/TRITON, RAMA, and PIRATA Buoys, Daily, Salinity	<a href="#">?</a>	<a href="#">F</a>	<a href="#">I</a>	<a href="#">M</a>	<a href="#">background</a>	<a href="#">RSS</a>	<a href="#">✉</a>	NOAA PMEL, TAO/ ...
	<a href="#">set</a>	<a href="#">data</a>	<a href="#">graph</a>			TAO/TRITON, RAMA, and PIRATA Buoys, Daily, Sea Surface Salinity	<a href="#">?</a>	<a href="#">F</a>	<a href="#">I</a>	<a href="#">M</a>	<a href="#">background</a>	<a href="#">RSS</a>	<a href="#">✉</a>	NOAA PMEL, TAO/ ...
	<a href="#">set</a>	<a href="#">data</a>	<a href="#">graph</a>			TAO/TRITON, RAMA, and PIRATA Buoys, Daily, Sea Surface Temperature	<a href="#">?</a>	<a href="#">F</a>	<a href="#">I</a>	<a href="#">M</a>	<a href="#">background</a>	<a href="#">RSS</a>	<a href="#">✉</a>	NOAA PMEL, TAO/ ...
	<a href="#">set</a>	<a href="#">data</a>	<a href="#">graph</a>			TAO/TRITON, RAMA, and PIRATA Buoys, Daily, Temperature	<a href="#">?</a>	<a href="#">F</a>	<a href="#">I</a>	<a href="#">M</a>	<a href="#">background</a>	<a href="#">RSS</a>	<a href="#">✉</a>	NOAA PMEL, TAO/ ...

use [http://ferret.pmel.noaa.gov/generic/erddap/taledap/integrated\\_temp.nc](http://ferret.pmel.noaa.gov/generic/erddap/taledap/integrated_temp.nc)

shade/z=0 temp

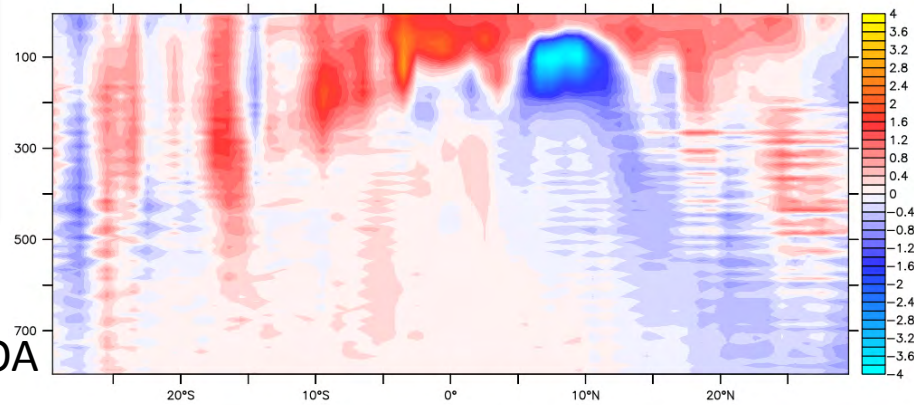
As a result, rather than a data management project, users can easily access an integrated view of upper ocean temperature with one command



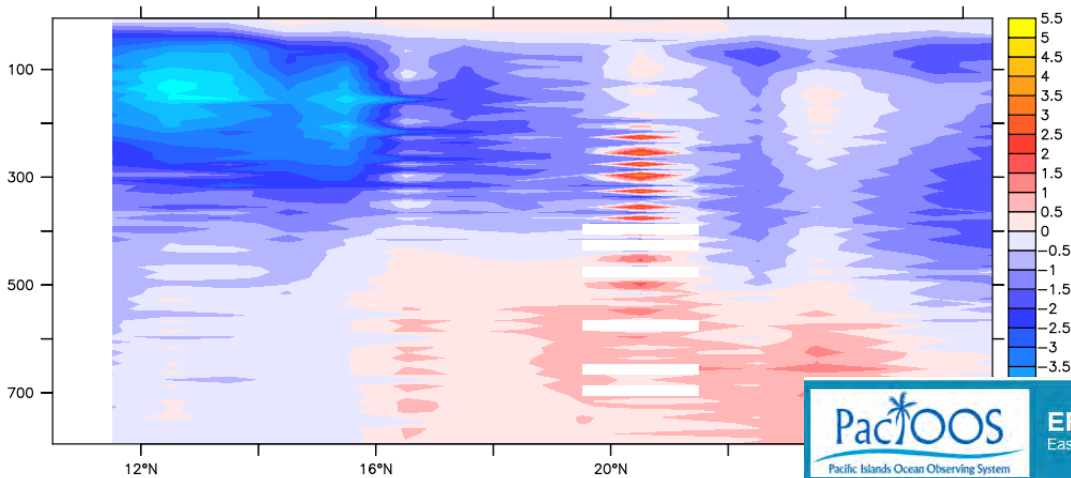


2015 Tropical Pacific temperature, averaged over time and longitude

And start using the data for analysis in their favorite application



2015 TEMP Anomalies from WOA



Oct 2015 TEMP Anomalies from PacIOOS ROMS CNMI

# Moving Forward.....

## JCOMM Data Management Coordination Group (DMCG) recommendations:

- Observation Coordination Group continue working with global observing networks to implement data interoperability framework in close consultation with DMCG
- Welcomed proposed OCG pilot project to demonstrate integration by EOV
- Requested OCG refine the vision of EOV pilot project and consult with observing networks to determine interest
- OCG to engage with GOOS Regional Alliances (GRA) to provide data framework in support of GRA data portals and ODP



# Thank you!

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Benjamin Pfeil: benjamin.pfeil@uib.no

- ERDDAP: <https://coastwatch.pfeg.noaa.gov/erddap/index.html>
- OSMC: [www.osmc.noaa.gov](http://www.osmc.noaa.gov)

*Poster 102: Global Data Assembly Centre for Marine Biogeochemistry will be build services on ERDDAP!*