Online Training Course
On

Visualization of data, Generation of gridded products, Introduction to open source S/Ws

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'Fundamental of Ocean Data Management' 23-27, Aug 2021

INCOIS as Data Centre

- The central repository for marine data in the country, receives voluminous oceanographic data
- Data provides information on physical, chemical, biological and geological parameters
- Spatial, temporal data and data products at different resolutions, and levels
- Data pre-processing, post-processing, quality control, dissemination and archives

Affiliations:

- Designated as the National Oceanographic Data Centre by the International Oceanographic Data Exchange Programme (IODE) of International Oceanographic Commission (IOC)
- Indian Ocean Global Ocean Observing System (IOGOOS)

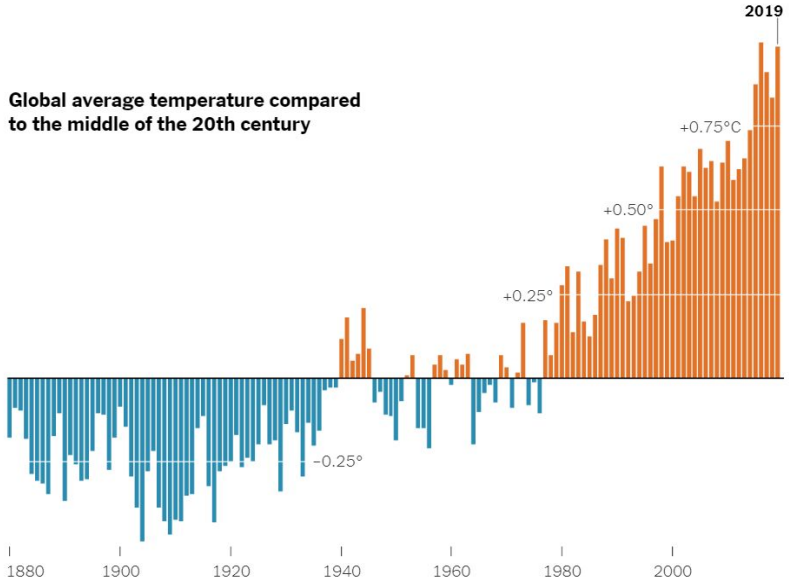
http://www.iocperth.org/iogoos

Data types	Parameters
Remote sensing	
• MODIS/Terra and Aqua	• air/sea/ice surface temperature, cloud cover
• OCM-1&2/Oceansat-2	• chlorophyll, wind fields over ocean surface
• TMI	• sea level, rainfall, SST
• Quicksat & ASCAT	• wind, sea level pressure, ice
In-situ	
• Argo, Bio-Argo	• temperature/salinity/oxygen/pH
• Moored buoy(OMNI)	• air pressure/temp, humidity, current, SST
• Drifting buoy	• wind speed/direction, surface current
• Tide gauge	• tide heights, air/water temperature
• Bottom pressure recorder	• water column height
• Current meter	• near-surface current
• HF Radar	• surface currents, ocean waves
• Wave Rider Buoy	• wave/tide height, ocean currents
• CTD	• conductivity, temperature, depth
• XBT	• water column temperature

Model data: SST, MLD, SSH, etc. (Upon request)

Data Visualization

- Data visualization is the representation of data in a pictorial or graphical format (plot, map, chart, etc.)
- Data visualization means implementing an easy way to observe and interpret trends, outliers, patterns in data
- It enables decision makers to see analytics presented visually, so they can grasp difficult concepts or identify new patterns



- Interactive data visualization can take the concept a step further by using technology to drill down into charts and graphs for more detail, interactively changing what data you see and how it's processed

Importance of Data Visualization

- Owing to the way human brain processes informations:
  - Using charts or graphs to visualize large amounts of complex data is easier than poring over spreadsheets or reports
  - Data visualization is a quick, easy way to convey concepts in a universal manner
  - One can experiment with different scenarios by making slight adjustments
- Data visualizations can also:
  - Identify areas that need attention and improvement
  - Clarify the factors that influence the observed behavior

Software’s

Commercial S/W’s

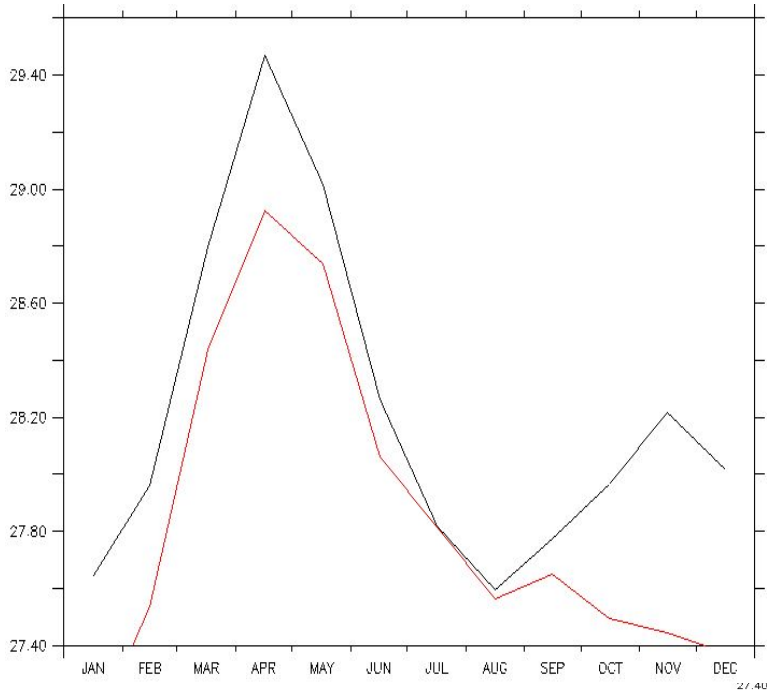
- ArcGIS
- Origin
- Surfer
- Grafer
- Xplenty

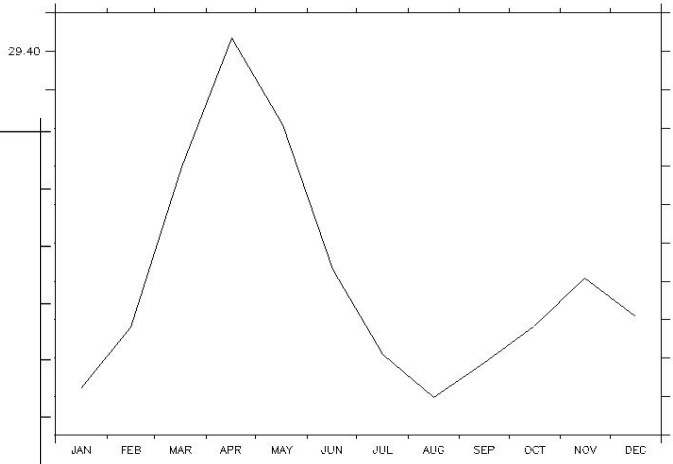
Open S/W’s

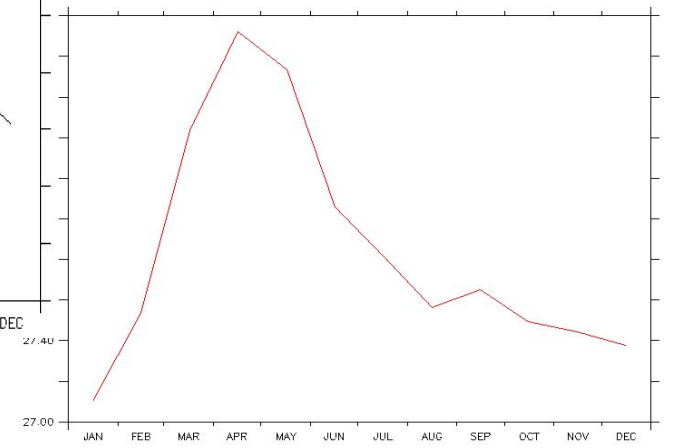
- FERRET
- ODV
- DIVA
- Generic Mapping Tools(GMT)
- Climate Data Operator (CDO)
- NcBrowse, NcView
- Google Sheets, etc.

Examples

MONTH	SST	AIRT
16-JAN	27.64	27.1
15-FEB	27.96	27.53
17-MAR	28.8	28.44
16-APR	29.47	28.92
16-MAY	29.02	28.74
16-JUN	28.26	28.06
16-JUL	27.82	27.82
16-AUG	27.6	27.56
15-SEP	27.77	27.65
16-OCT	27.97	27.49
15-NOV	28.22	27.44
16-DEC	28.02	27.38







Lon	Lat
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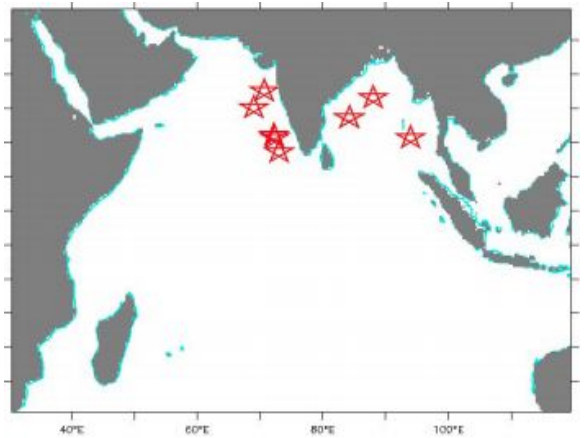
73	8.5
72.3	10.6
72.2	10.9
70.7	17.4
94	10.5
84.2	13.5
88	16.4



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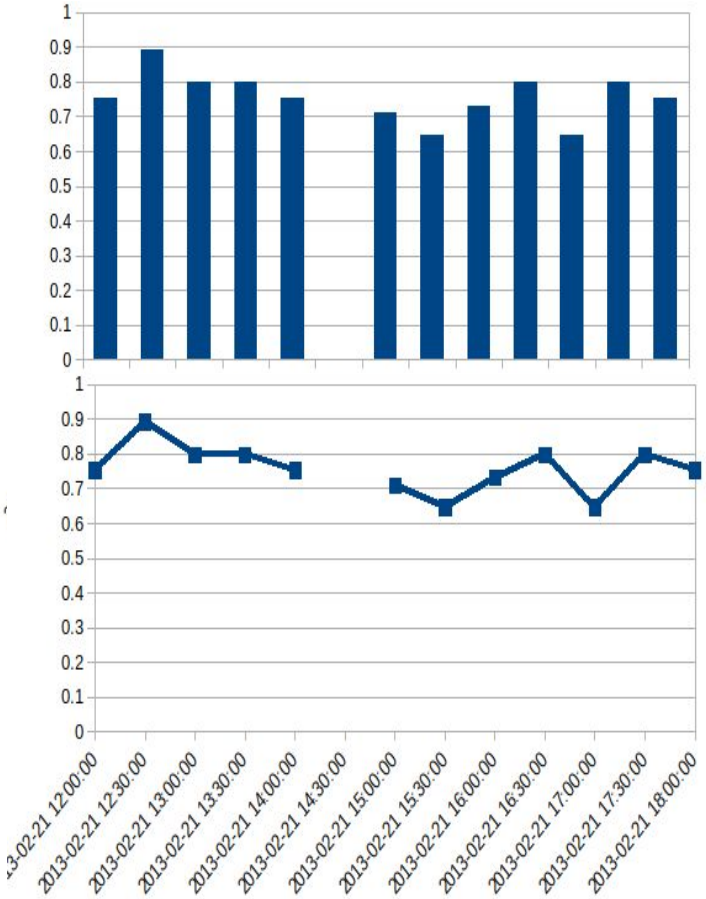
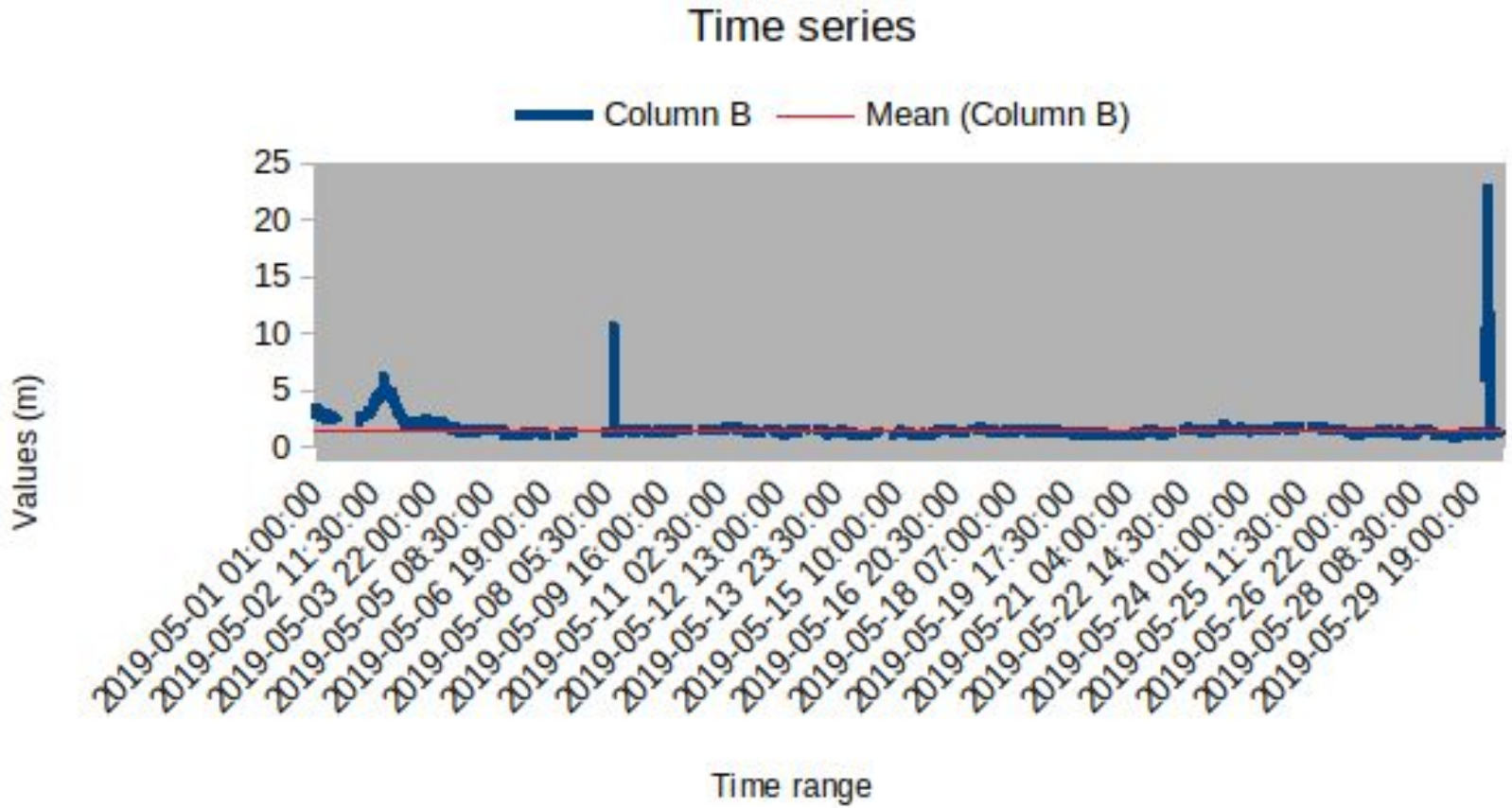
2013-02-21 12:30:00	0.892
2013-02-21 13:00:00	0.798
2013-02-21 13:30:00	0.798
2013-02-21 14:00:00	0.753
2013-02-21 14:30:00	
2013-02-21 15:00:00	0.71
2013-02-21 15:30:00	0.647
2013-02-21 16:00:00	0.731
2013-02-21 16:30:00	0.798
2013-02-21 17:00:00	0.647
2013-02-21 17:30:00	0.798
2013-02-21 18:00:00	0.753




Time series
Column B
Mean (Column B)
25
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Values (m)
2019-05-01 01:00:00
2019-05-02 11:30:00
2019-05-03 22:00:00
2019-05-05 08:30:00
2019-05-06 19:00:00
2019-05-08 05:30:00
2019-05-09 16:00:00
2019-05-11 02:30:00
2019-05-12 13:00:00
2019-05-13 23:30:00
2019-05-15 10:00:00
2019-05-16 20:30:00
2019-05-18 07:00:00
2019-05-19 17:30:00
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2019-05-24 01:00:00
2019-05-25 11:30:00
2019-05-26 22:00:00
2019-05-28 08:30:00
2019-05-29 19:00:00
Time range

Ex:Rainfall

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Jun-05 3.1 Jul-05 7.8 Aug-05 3.9 Sep-05 ??
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Jun-10 8.3 July-10 6.2 Aug-10 6.0 Sep-10 ??
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Jun-15 5.8 July-15 11.7 Aug-15 3.8 Sep-15 ??
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Jun-20 3.8 July-10 11.8 Aug-20 8.5 Sep-20 ??
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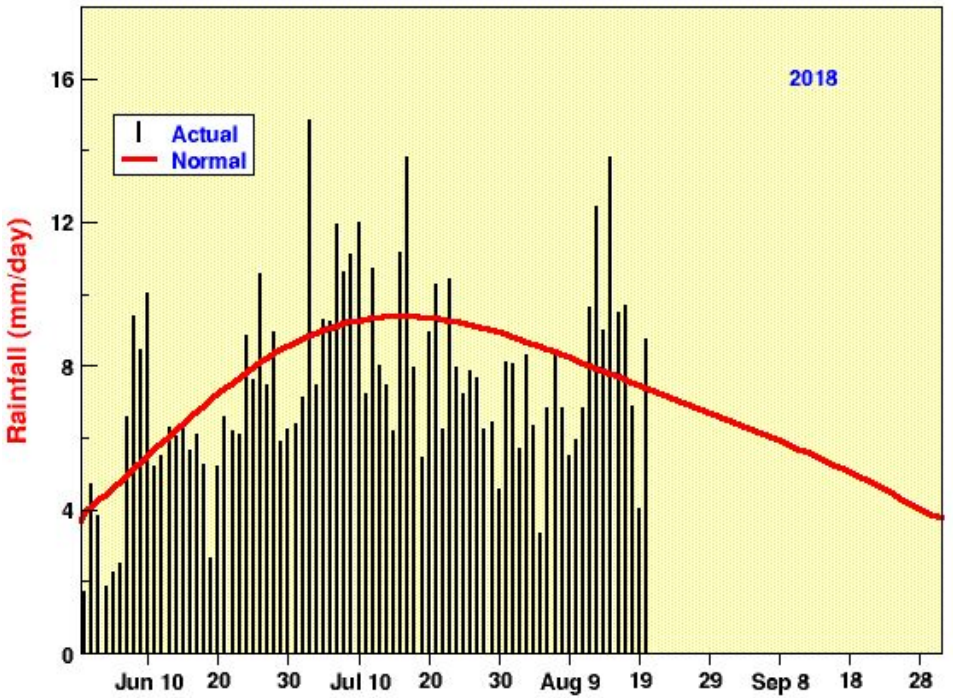
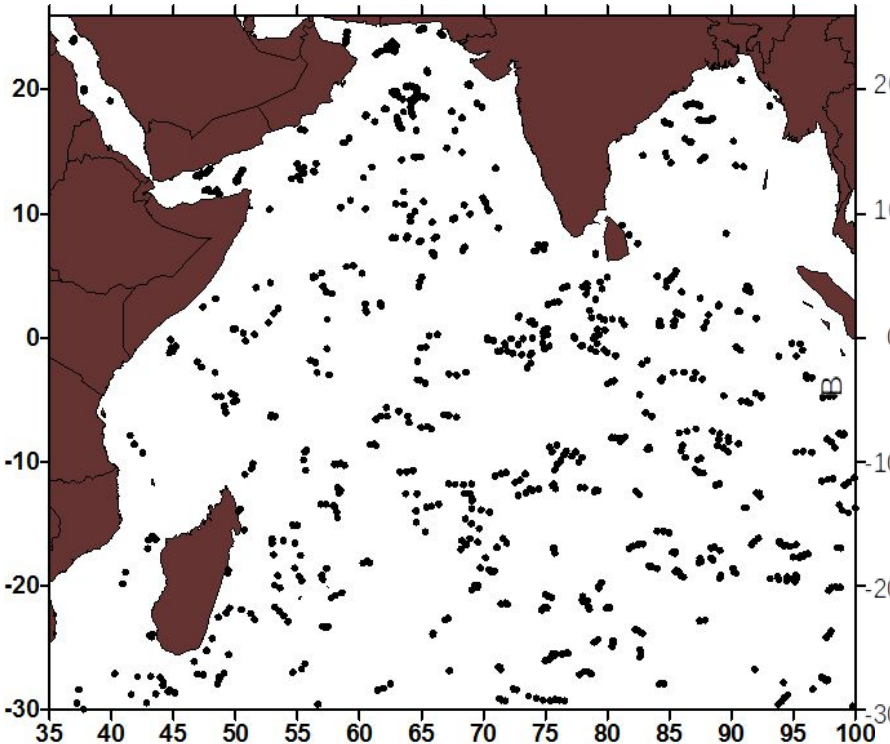
Jun-30 6.2 July-20 8.8 Aug-30 ?? Sep-30 ??



Ex cntd...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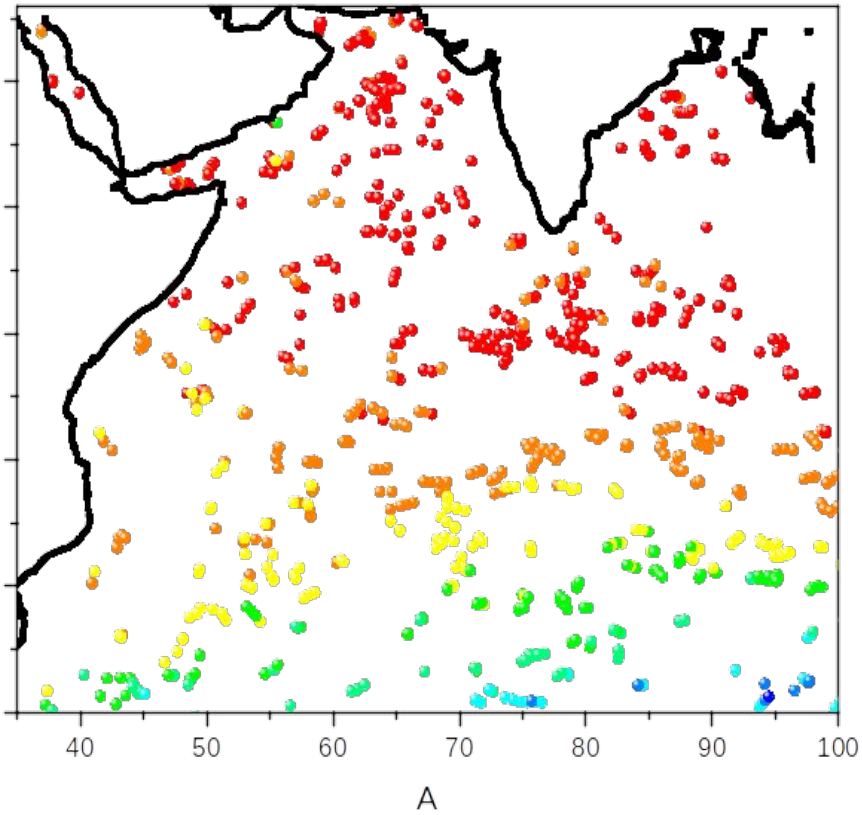
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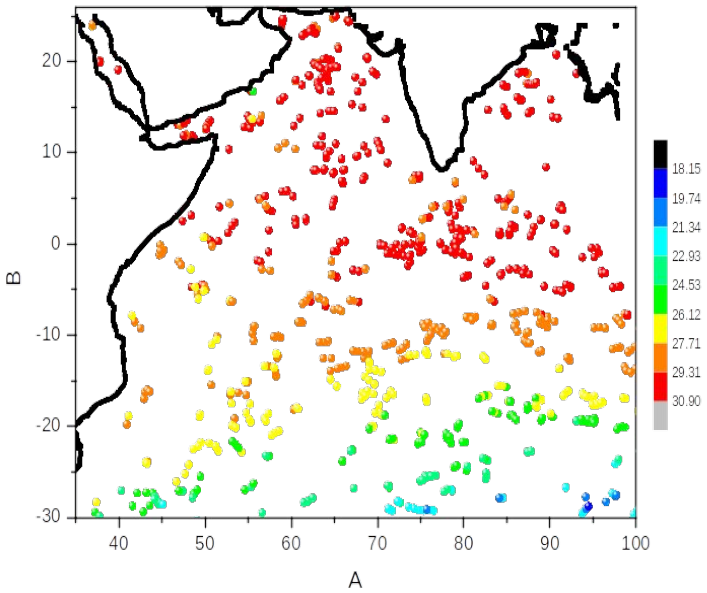
Gridding Problem

- *In Situ* observations in Oceanography are usually sparse, and inhomogeneously distributed over time and space
- Fixing such sparse observations on uniform or non-uniform grid positions is called Gridding problems
- Gridding can be performed through Interpolations, Numerical Methods, Moving Average, Variational Analysis, etc.
- Outcome is useful for many applications such as data analysis, graphical display, initialization of models, etc.
- Many useful products can be generated through *in-situ data*, *satellite data*, and blend of *in-situ & satellite*
- No such BEST Method known, depends on data and requirements to get most satisfying interpretation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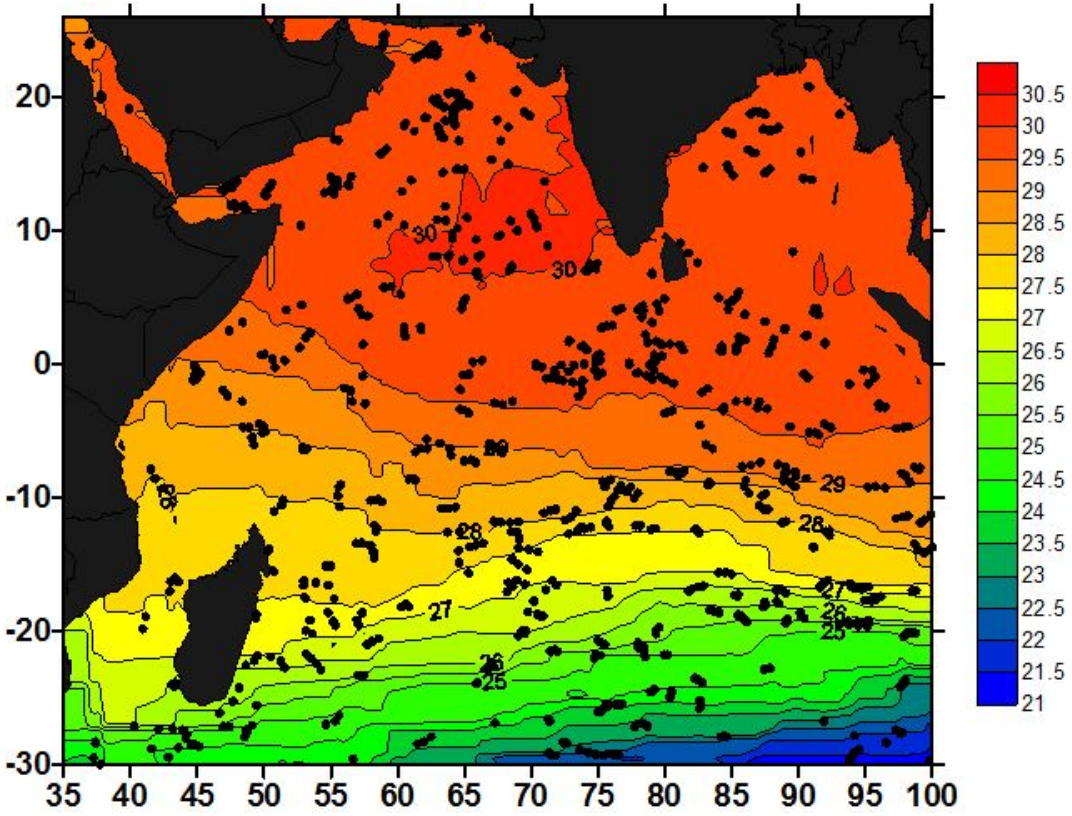
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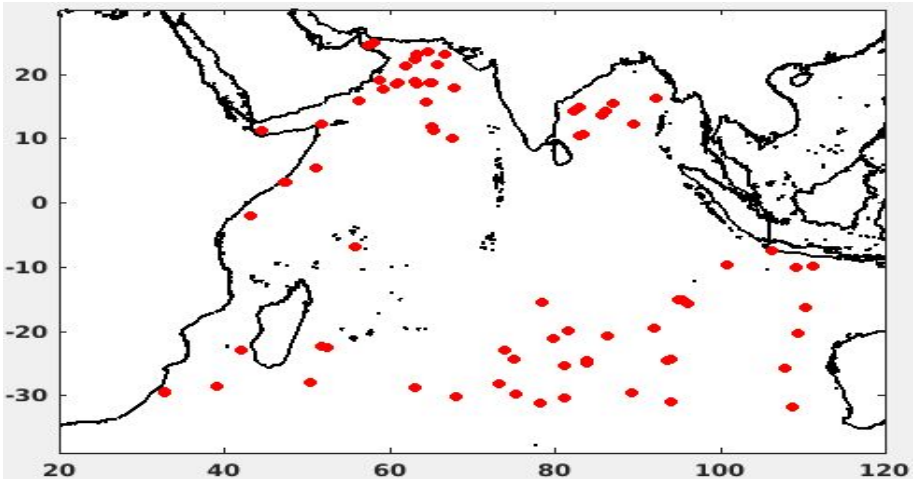
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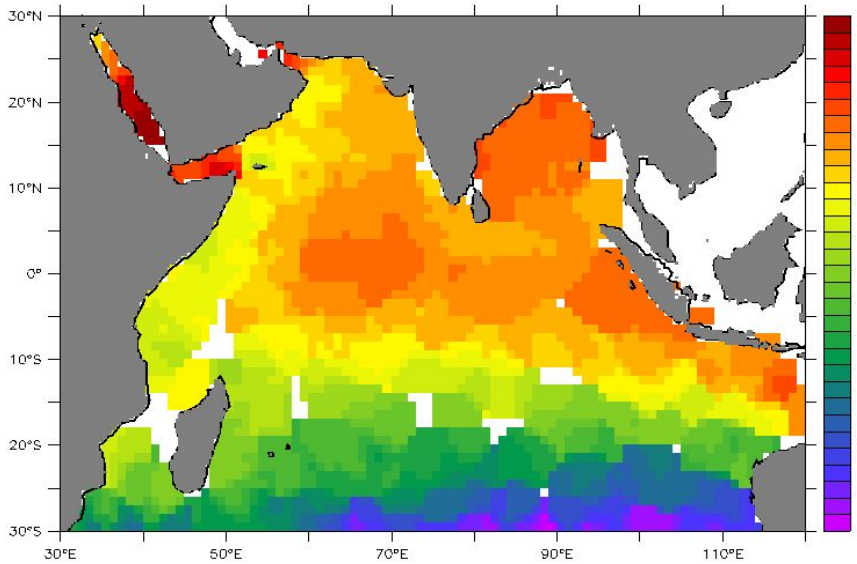
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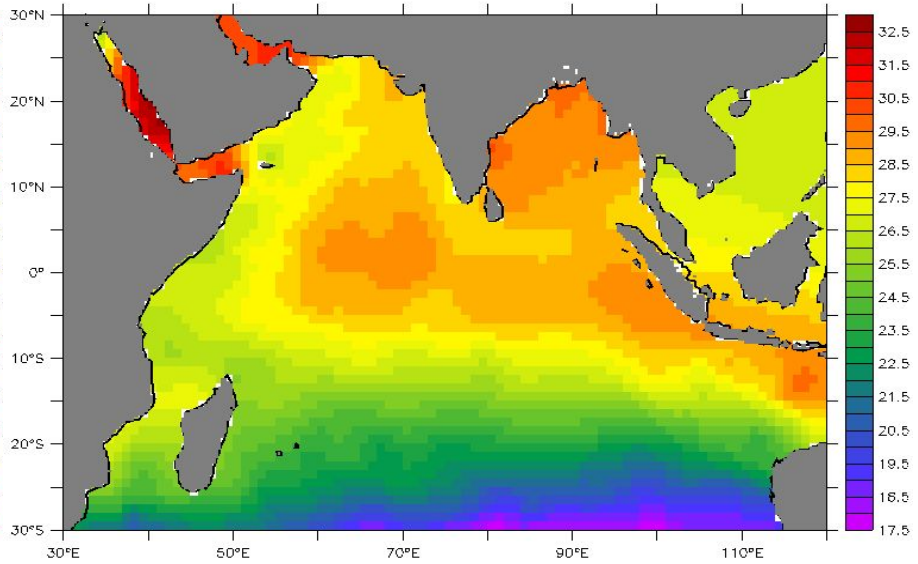
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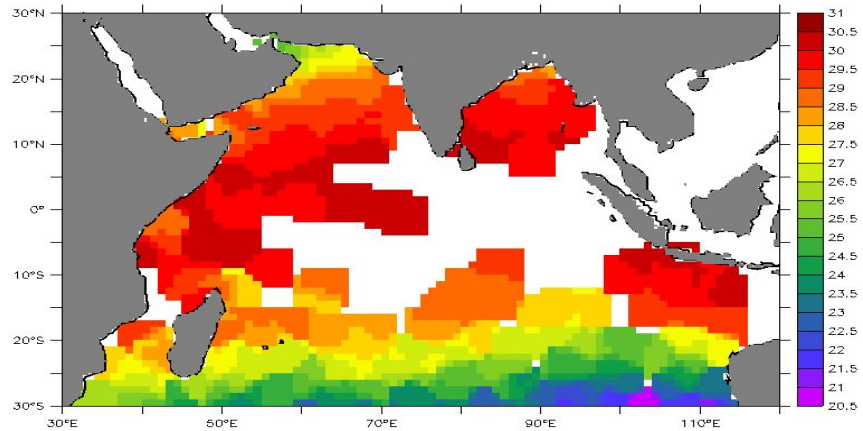
Popular Gridding Methods In Oceanography

- Kriging Method
- Nearest Neighbor
- Objective Analysis
- Optimal Interpolation
- Variational Analysis

- The differences between gridding methods varies with the mathematical algorithms
- Some of the popular mesh grids used in gridding
    - Finite Difference Method
    - Finite Element Method
    - Finite Volume Method
    - Spline Techniques
    - Metrics Method
    - Linear and Curvilinear functions

Objective Analysis

- Transform datasets from irregularly spaced to regularly arranged grid
- Also known as statistical interpolation or Gauss-Markov interpolation
- A simple OA scheme, the background values would not be used and the analysis would be based solely on new observations
- Weight, for instance, is proportional to the distance of the data from the grid point



The analysis value at the grid point = $\sum_{\text{sum}}$ (weights × new observations)

The analysis value at the grid point = The background (or first guess) value at the grid point + A correction

where

correction = $\sum_{\text{sum}}$ (weights × new information (based on observations))

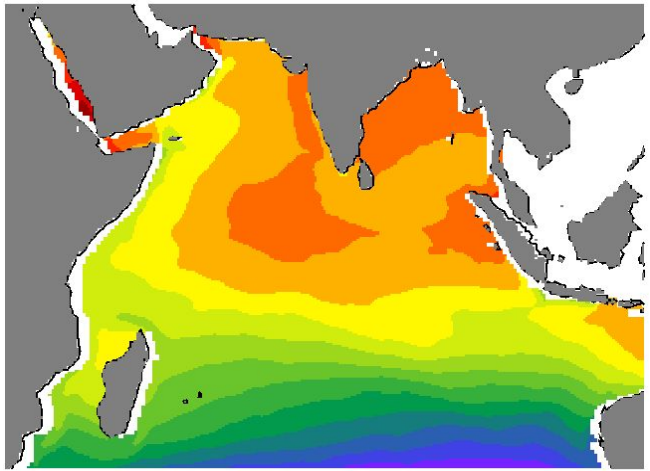
in other words

correction = a weighted average of a set of observations taken from sites surrounding the grid point

Bhaskar et al. 2007

Optimal Interpolation

- OI requires a background field (initial observations), and observations to generate grid values
- OI uses ‘n’ closest data points for calculating values for grid points
- Based on the distance between the points, their distances from the grid point, each sampled data point is assigned a weight
- The background field at each data point is then subtracted from each data value. These new values are multiplied by their alpha weights and then added together (weighted average)
- Weights plus background fields provide final grids, associated with error field



$$X_a = X_b + W[y_0 - H(X_b)] = X_b + Wd, \quad \varepsilon_a = X_a - X_t$$

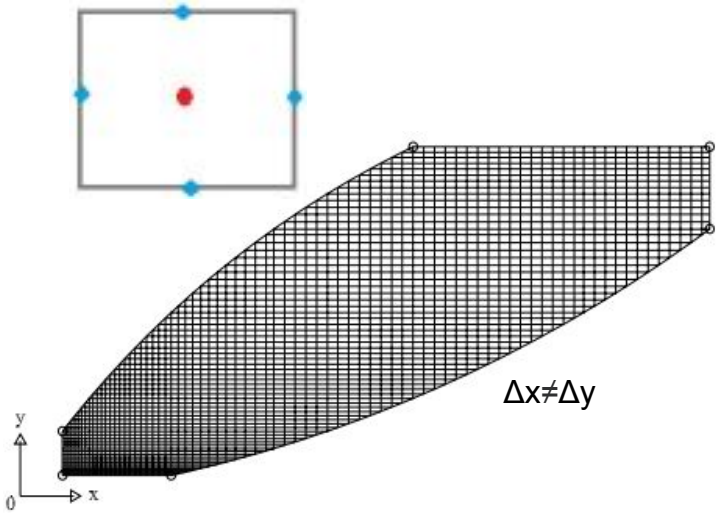
Gandin (1963)

Finite Difference grid

- FD partitions the domain of computation into smaller grids to approximate the differential operator
- Derivatives are approximated by differences equations,between neighboring points on grids
- 1st & 2nd order FD schemes
- Square or rectangular grid formulations
- Boundary values at outer grid known, and subsequently interior grid values obtained using the FD scheme
- Δx=Δy or Δx≠Δy
- Oceanography, problem domains are often complex, FD scheme near boundary requires further work done

$$\left(\frac{\partial u}{\partial x}\right) \approx \frac{u_{i+1} - u_{i-1}}{2\Delta x}$$

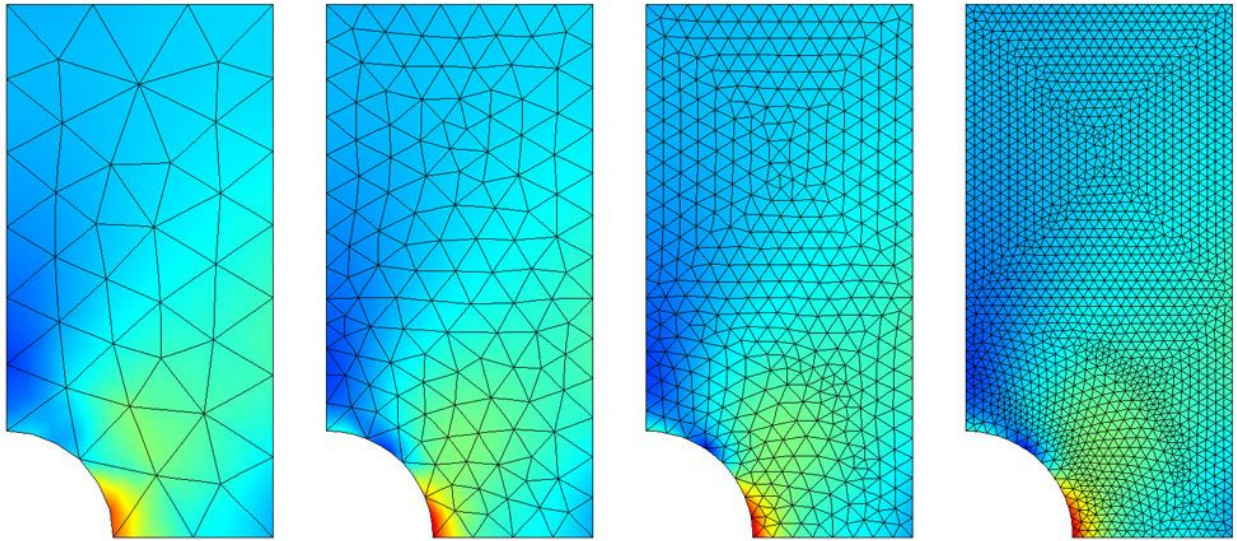
$$\left(\frac{\partial^2 u}{\partial x^2}\right)_i = \frac{u_{i+1} - 2u_i + u_{i-1}}{(\Delta x)^2} + \mathcal{O}(\Delta x)^2$$



Sanmiguel et al. 2005; Jha et al. 2018

Finite Element grid

- FE create triangular mesh splitting the problem domain into a discrete number of elements, datasets are interpolated across the whole domain
- A well-sampled require finer mesh to achieve the better accuracy of the solution
- *Mesh refinement* is the process of resolving the model with successively finer and finer meshes



Variational method

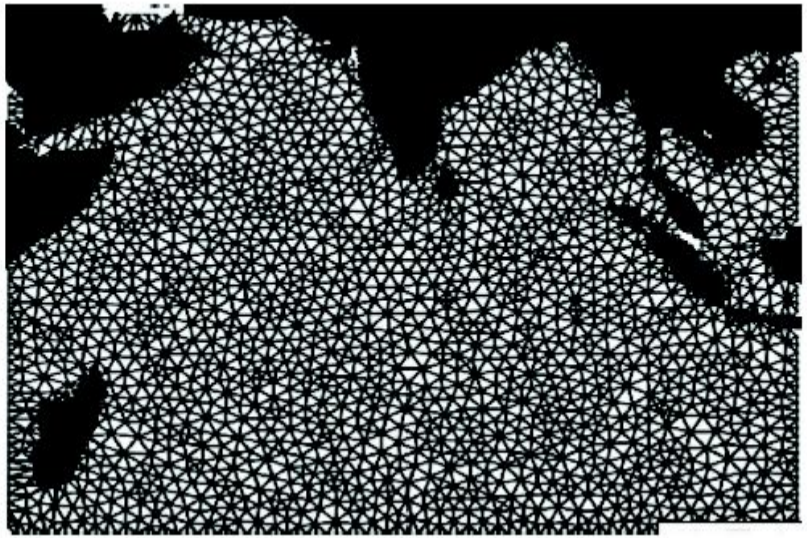
- *Variational Method* is a procedure that minimizes a cost function *J* defined as the distance between the analysis and the observations at the data points
- Observations can be added easily to the minimization procedure either as a weak or a strong constraint
- Method incurs low computational cost and is compatible with operational purposes

- *DIVA:* Data-Interpolating Variational Analysis, is a Variational method where a cost function is to be minimized
- Aim is to get the value of φ sufficiently close to the observation such that variation can be minimized

$$J[\varphi]=\sum_{i=1}^{N}\mu_i[d_i-\varphi(x_i,y_i)]^2+\int_{\Omega}(\nabla\nabla\varphi:\nabla\nabla\varphi+\alpha_1\nabla\varphi.\nabla\varphi+\alpha_0\varphi^2)d\Omega$$

Open Software's

- DIVA uses a finite element approach that provides triangular mesh through the region and has features to make a coarser grid near the boundary
- DIVA efficiently handles the noise in the observations while processing the analysis
- DIVA requires large memory to execute the analysis for finer resolutions, and time varies with the choice of parameters
- DIVA parameters: Correlation length and Signal-to-noise ratio
- DIVA generates adaptive Finite element mesh throughout the domain
- Derives gridded products from in situ observations



DIVA User Guide

DIVA on Web

http://ec.oceanbrowser.net/emodnet/diva.html

- Must: ASCII file with three columns [Lon, Lat, observation]
- Upload input file, specify the Grid coordinates
- Analysis: Divafit provide the optimal parameter value of L & λ
- Proceed with the analysis, download output (*.nc; png; .mat)

Analysis with Diva

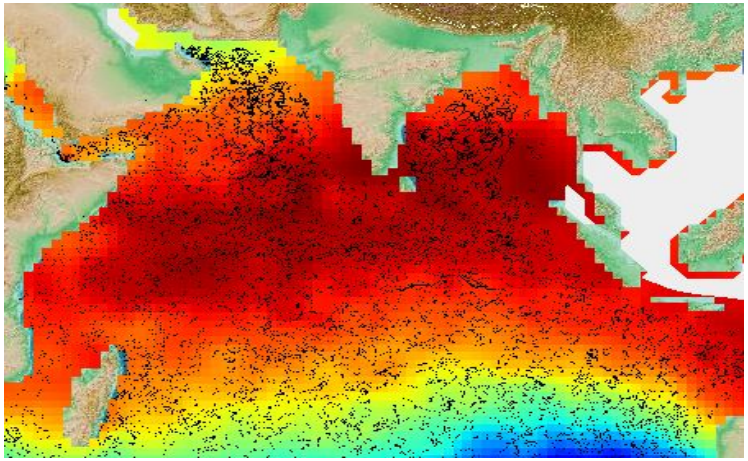
Correlation length [deg]: 7.920137
Signal to noise ratio: 2.63513

divafit
Quality of the fit (0: bad 1: good): 0.929269

Advanced settings

Optional parameters

Maximum rel. error (from 0 to 1): 0.3



Barth et al. 2010

webODV

- webODV provides a suite of online services based on ODV software
- webODV is designed to interactively perform analysis, exploration and visualization of ocean data
- webODV allows users to aggregate large numbers of SeaDataNet data files and perform quality control
- ODV being a part of SeaDataNet, DIVA method has been integrated into ODV
- ODV/DIVA integration provide proper treatment of domain separation due to land masses and undersea ridges or seamounts, etc.

- webODV is associated with the free VRE (Virtual Research Environment)*

https://www.seadatanet.org/Software/VRE

(*Login required)

DATA REQUISITION FORM

INCOIS

DATA REQUISITION FORM

1. Institution / Dept. Address:
2. Name & designation of the officer requiring data:
3. Details of data requirement:

Parameters	Platform / Instrument	Period

4. Project for which the above data is required and the project cost:
5. Please indicate whether the data is required for:
   a. Own research
   b. Sponsored & consultancy projects *
6. If it is for consultancy project, whether the project has obtained the approval from Central/State Government, if so, please provide the details:

7. **CERTIFICATE OF UNDERTAKING:**
   a. Data supplied are exclusively for the use of the organization only.
   b. The data will be used only for the purpose for which it is supplied.
   c. These data shall not be passed on to any other party or agency (India/abroad) either in part, in full or in any form. If needed, prior approval should be taken from Indian National Centre for Ocean Information Services for the same under special circumstances.
   d. Due acknowledgement shall be given to Indian National Centre for Ocean Information Services for the source of data in all reports / publications etc. made by you.

Signature of the Officer (Requisite) Signature of the Head of the Institution

Station:
Date & office seal:

Note:
* For sponsored and consultancy projects, INCOIS will be charging for the data to be supplied as per INCOIS norms.

https://incois.gov.in/portal/datainfo/drform.jsp


THANK YOU!!