

Generating ocean climatologies from in situ observations

 gher-ulg

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**Collect once,
Use many times
And create products with DIVA**

Conclusions

1. `DIVA` is a software tool written in Fortran
2. `DIVAnd` is a software tool written in Julia
3. Both are designed for the spatial interpolation of data

Methodology: spatial interpolation

Gridding problem

Constraints

1. **Closer** observations have a **stronger** influence
2. Different **confidence** in some measurements
3. **Physical** barriers and currents
4. Deal with up to **millions** of points
5. Many sources of **errors** on observations
6. Need an associated **error field**



DIVA

Data-Interpolating Variational Analysis
<https://github.com/gher-ulg/DIVA>

DOI: [10.5281/zenodo.1407062](https://doi.org/10.5281/zenodo.1407062)




DIVAnd

n-dimensional generalisation of DIVA
<https://github.com/gher-ulg/DIVAnd.jl>

DOI [10.5281/zenodo.1466985](https://doi.org/10.5281/zenodo.1466985)

README.md

DIVAnd

build passing  build passing

coverage 82% codecov 84%

docs latest

DIVAnd performs an n-dimensional variational analysis of arbitrarily located observations. Observations will be interpolated on a curvilinear grid in 2, 3 or more dimensions.

Please cite this paper as follows if you use DIVAnd in a publication:

Barth, A., Beckers, J.-M., Troupin, C., Alvera-Azcárate, A., and Vandenbulcke, L.: DIVAnd-1.0: n-dimensional variational data analysis for ocean observations, Geosci. Model Dev., 7, 225-241, doi:[10.5194/gmd-7-225-2014](https://doi.org/10.5194/gmd-7-225-2014), 2014.

Geosci. Model Dev., 7, 225–241, 2014
www.geosci-model-dev.net/7/225/2014/
doi:10.5194/gmd-7-225-2014
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Geoscientific
Model Development

Open Access

The logo for Geoscientific Model Development, featuring a stylized globe with a grid pattern and a large letter 'G' overlaid on it.

divand-1.0: n -dimensional variational data analysis for ocean observations

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* *Invited contribution by A. Barth, recipient of the EGU Arne Richter Award for Outstanding Young Scientists 2010.*

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How to use it?

Jupyter notebooks as a guideline for the climatologies

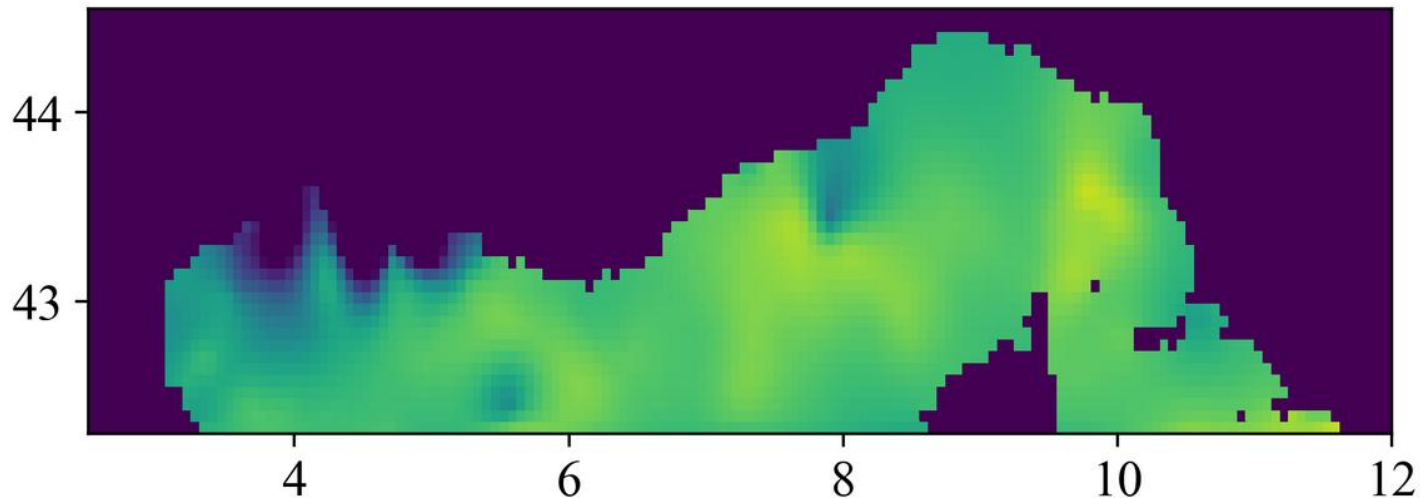
Analysis `fi` using mean data as background.

Structure `s` is stored for later use in error calculation.

```
In [10]: fi,s = DIVAndrun(mask,(pm,pn),(xi,yi),(obslon,obslat),obsval.-mean(obsval),len,epsilon2);
```

Create a simple plot of the analysis

```
In [11]: pcolor(xi,yi,fi.+mean(obsval),vmin=37,vmax=38.5);  
colorbar(orientation="horizontal")  
gca()[:set_aspect](1/cos(mean([ylim()...]) * pi/180))
```



<https://github.com/gher-ulg/Diva-Workshops>

Fortran - MATLAB - Julia...



Creation: 2012

1.0.0 released: Aug 9, 2018

Simplicity of Python + speed of C or Fortran

<http://julialang.org/>

<https://github.com/JuliaLang/julia>

Who is Julia?

Julia Child (1912-2004)



By Lynn Gilbert - Own work, CC BY-SA 4.0, <https://commons.wikimedia.org/w/index.php?curid=51678880>

Why did we chose Julia?



Source: <http://daftpunk.wikia.com>, No copyright infringement is intended

Better...

Multiple dispatch

Math-friendly syntax

Unicode support: π , η , $\int \in \alpha$

```
julia> 🐦 = 1.  
julia> 🐢 = 2.  
julia> N = 🐦 + 🐢  
3.0
```

Faster

Just-in-time (JIT) compiled Parallelism

```
function fib(n::Int)
  f=Vector{Int}(undef, n+1)
  f[1]=f[2]=1;
  for i=3:n+1
    f[i]=f[i-1]+f[i-2]
  end
  return f
end
ff = @time fib(400000000);
1.158971 seconds (18.52 k allocations: 2.981 GiB, 0.84% gc time)
```

Stronger

Metaprogramming:

Julia programs can read, analyse, generate other Julia programs

"Easy" interfacing: R, Python, ...

```
@pyimport numpy.random as nr  
nr.rand(3,4)
```


Harder

Learning a new and evolving language
Transition from 0.6 to 1.0

Here is the latest from Julia Computing



Julia 1.0 Released

10 Aug 2018 | Andrew Claster

London, UK – Julia 1.0 was [released](#) today during [JuliaCon 2018](#).

Today's Julia 1.0 release is the most important Julia milestone since Julia was introduced in February 2012.

Julia 1.0 is the first complete, reliable, stable and forward-compatible Julia release. More information about Julia 1.0 is available [here](#).

RECENT POSTS

[Call for Proposals to Increase Diversity and Inclusion Within the Julia Community](#)

31 Oct 2018 | Jane E. Herriman

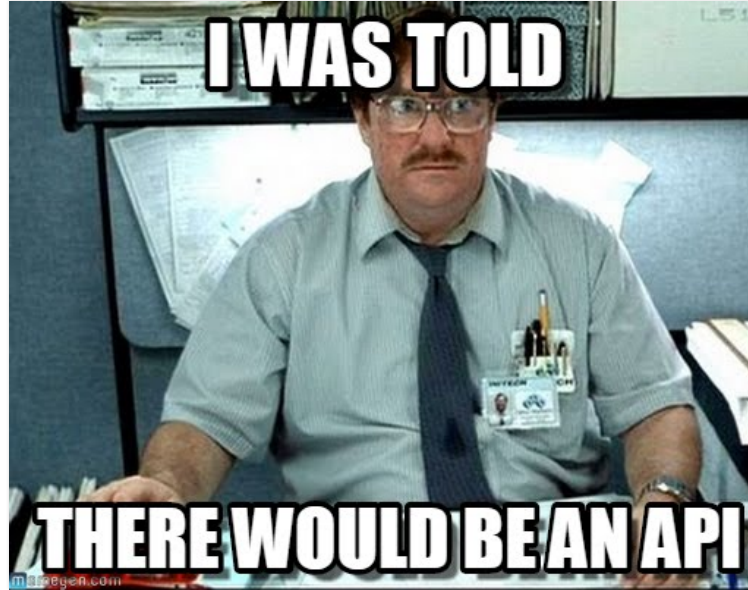
[The New JuliaPro](#)

16 Oct 2018 | Julia Computing

DIVAnd in the VRE

In short...

1. Ingest data from webODV (netCDF)
2. Set the analysis parameters
3. Apply DIVAnd interpolation
4. Export the results in a new netCDF
5. Visualise using Deltares toolbox



Implementation

1. Julia using HTTP and JSON modules
2. Deployment as a Docker container

The screenshot shows the GitHub repository page for `gher-ulg / DIVAnd-REST`. The repository is currently on the `master` branch. It has 76 commits, 2 branches, 0 releases, 1 contributor, and is licensed under GPL-2.0. The repository is categorized under several topics: `api`, `api-rest`, `spatial-analysis`, `interpolation`, `seadatacloud`, `search`, `virtual-research-environment`, and `oceanography`. The repository is currently being watched by 3 people, has 0 stars, and 0 forks. The repository is currently being watched by 3 people, has 0 stars, and 0 forks. The repository is currently being watched by 3 people, has 0 stars, and 0 forks.

REST API for DIVAnd

76 commits 2 branches 0 releases 1 contributor GPL-2.0

Branch: `master` [New pull request](#) [Create new file](#) [Upload files](#) [Find file](#) [Clone or download](#)

URL of the observay to force

Name of the variable

Bounding box (east, south, w
degrees)

Comma separated list of depth levels (meters)

Correlation length in zonal and meridional
direction (meters)

Error voariance of observation (relative to the
error variance of the background field)

Resolution in zonal and meridional direction (in
degrees)

Start and end year

Month of every season

URL of the bathymetry file

<input type="text" value="1,2,3"/>	<input type="text" value="4,5,6"/>
<input type="text" value="7,8,9"/>	<input type="text" value="10,11,12"/>

Metadata ▶

[Run DIVAnd](#)

[Download results](#)

Applications

SeaDataCloud climatologies

SeaDataNet PAN-EUROPEAN INFRASTRUCTURE FOR OCEAN & MARINE DATA MANAGEMENT

ABOUT US METADATA DATA ACCESS STANDARDS SOFTWARE PRODUCTS EVENTS PUBLICATIONS

Home > Products > Climatologies

CLIMATOLOGIES

[ACCESS TO AGGREGATED DATASETS & CLIMATOLOGIES](#)

SeaDataNet gridded climatologies are based on the [aggregated datasets](#) v1.1. The preparation of the products has also improved the quality, the consistency and the overall coherence of the data made available by SeaDataNet. They have been computed using [DIVA](#) software.

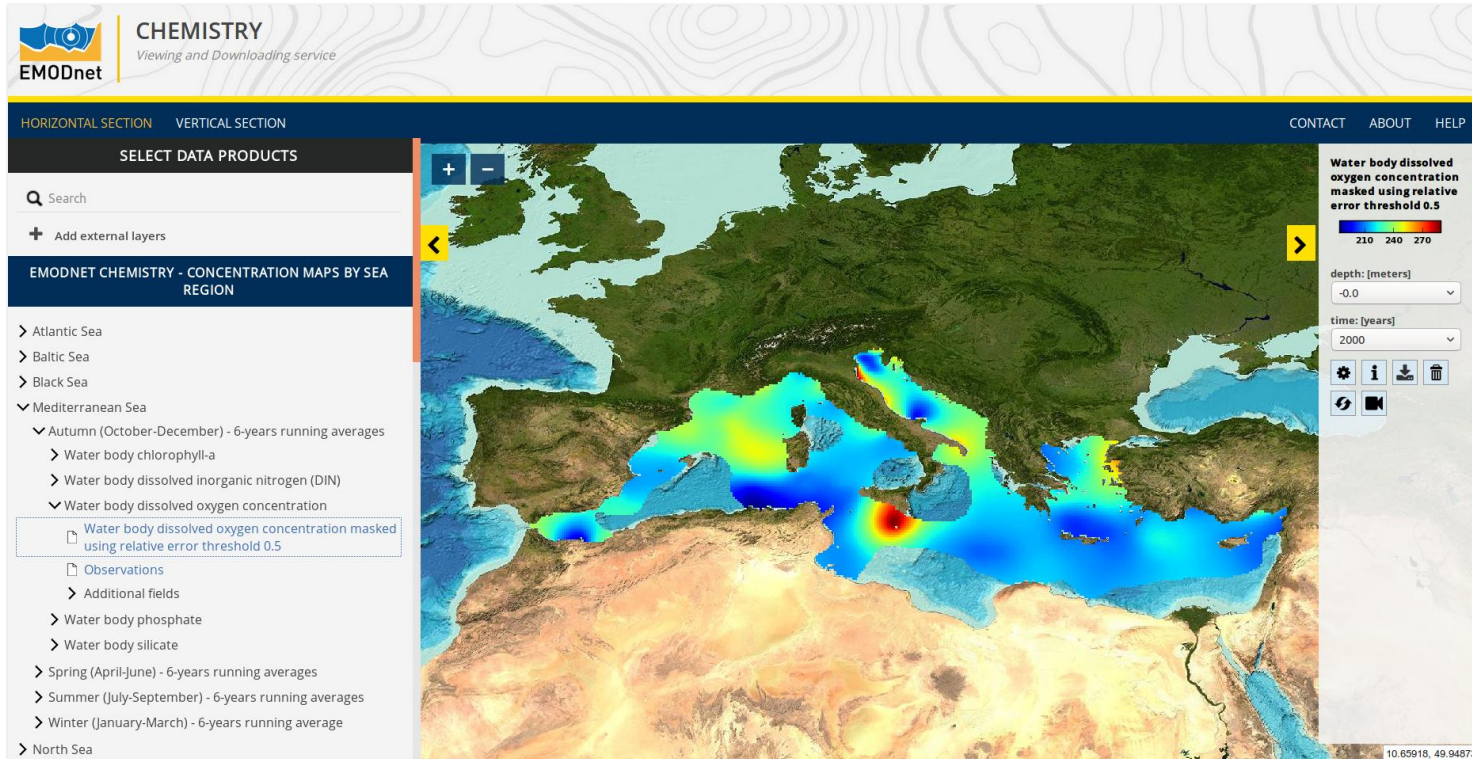
INFOS

Last modified on 25/04/2018

The figure displays five maps of the Mediterranean and Atlantic regions, each showing a different climate parameter. The maps use a color scale from blue (cooler) to red (warmer). The first map shows sea surface temperature in the Mediterranean. The second map shows sea surface temperature in the Atlantic. The third map shows sea surface temperature at 0m depth in the Mediterranean. The fourth map shows SDN Temperature Out at 0m in the Mediterranean. The fifth map shows sea surface temperature in the Atlantic.

<https://www.seadatanet.org/Products/Climatologies>

EMODnet Chemistry gridded fields



<http://www.emodnet-chemistry.eu/products>

EMODnet Biology products

EMODnet | **BIOLOGY**
Dive into data on Europe's marine life

Search ...
CONTACT US
SUBMIT DATA

Home | Data Catalog | Data Download | Map Viewer | **Data Products** | Project | Contribute | Help-desk

Data products

Benthos (19) | Birds (10) | EMODnet Biology use cases (8) | Fish (6)

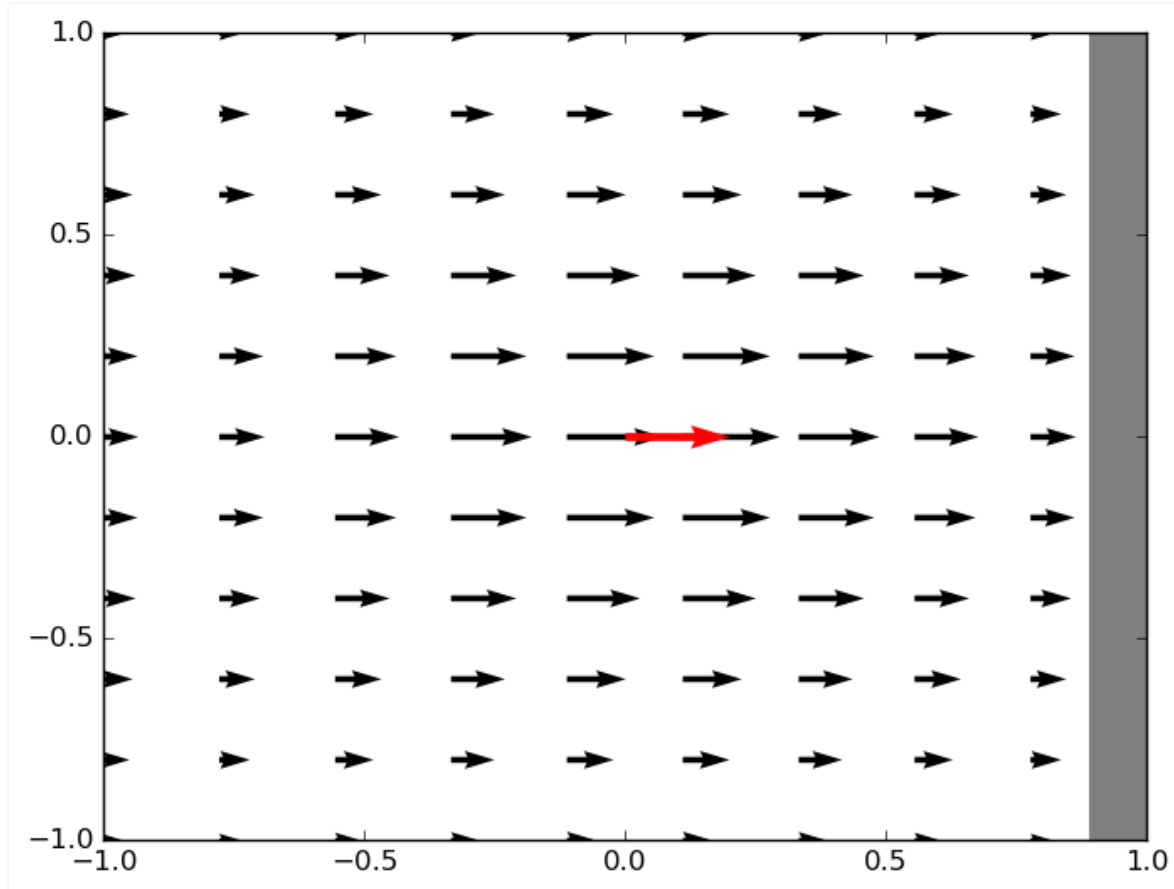
Mammals (8) | Microorganisms (5) | Phytoplankton (24) | Reptiles (1)

<http://www.emodnet-biology.eu/data-products>

#Innovations

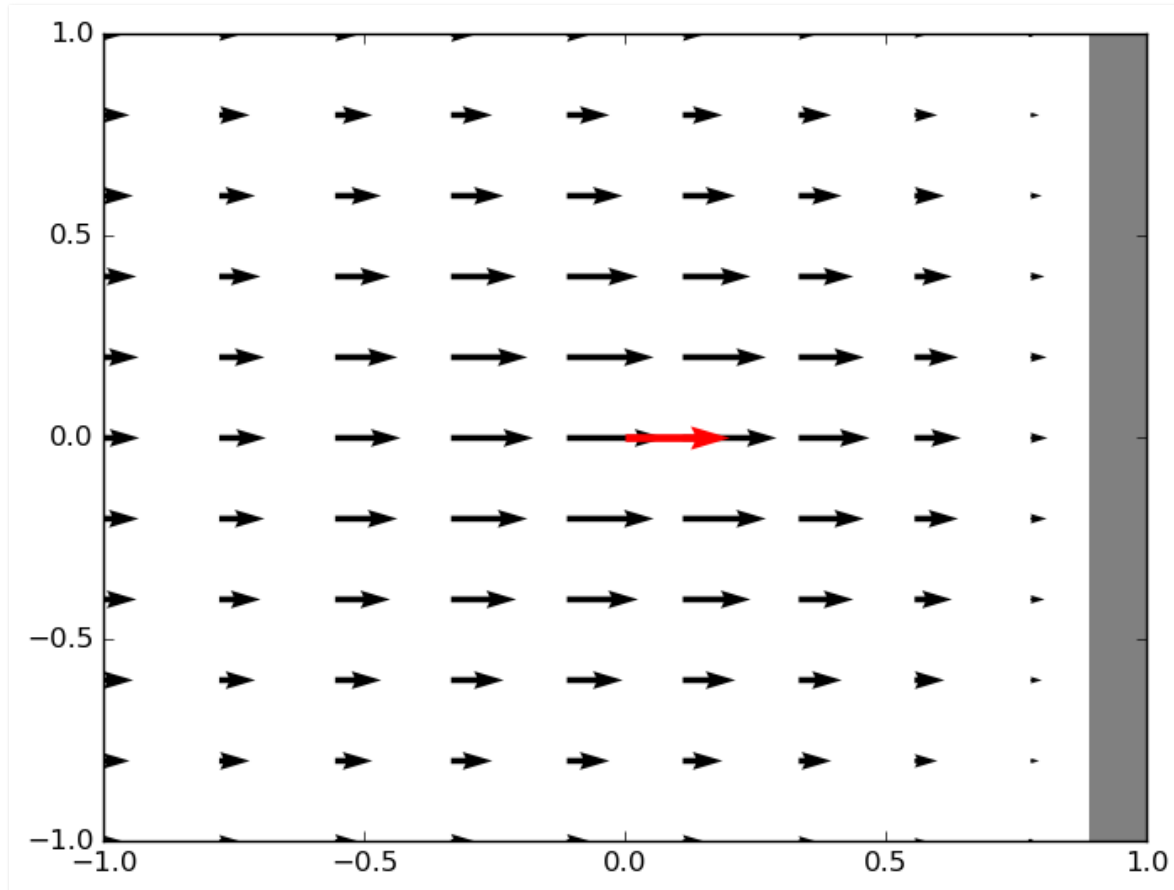
High-frequency radar interpolation

Synthetic velocity field, red arrow = measurement



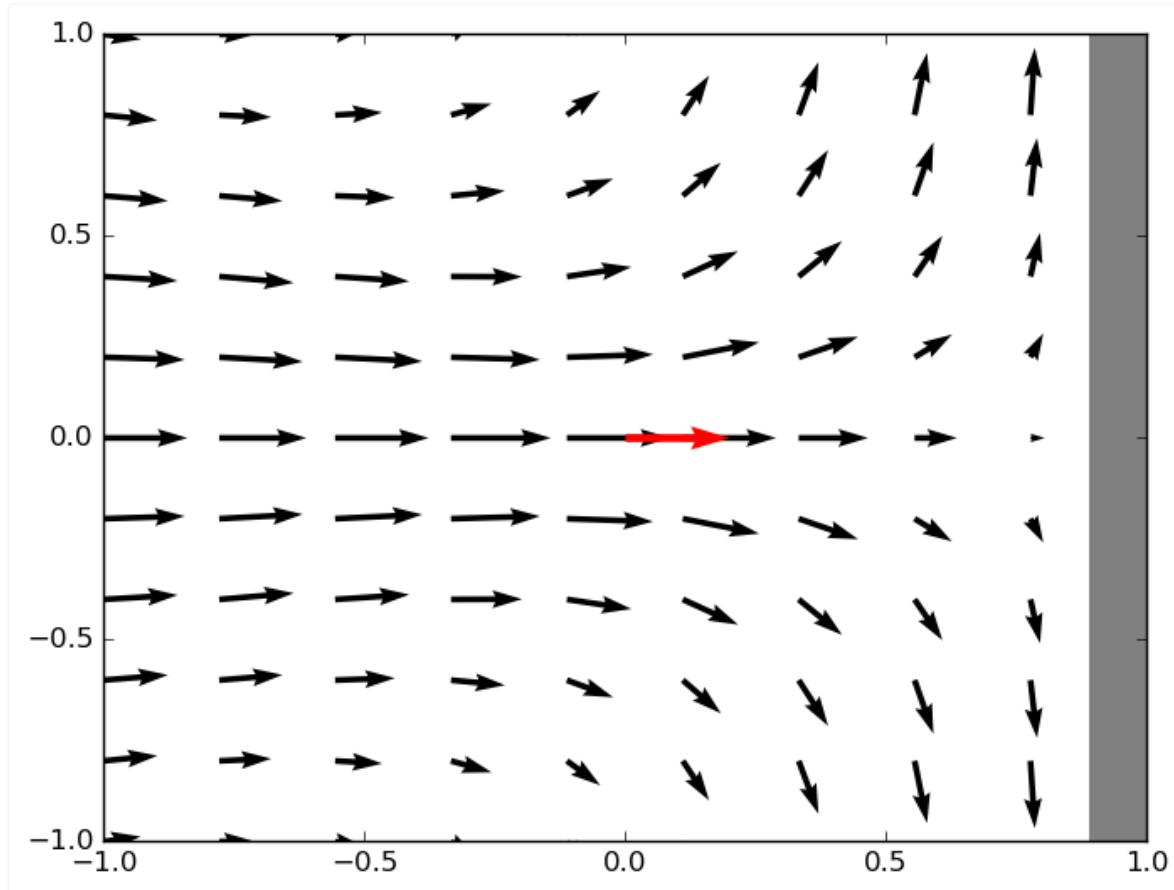
High-frequency radar interpolation

Adding the influence of the coast



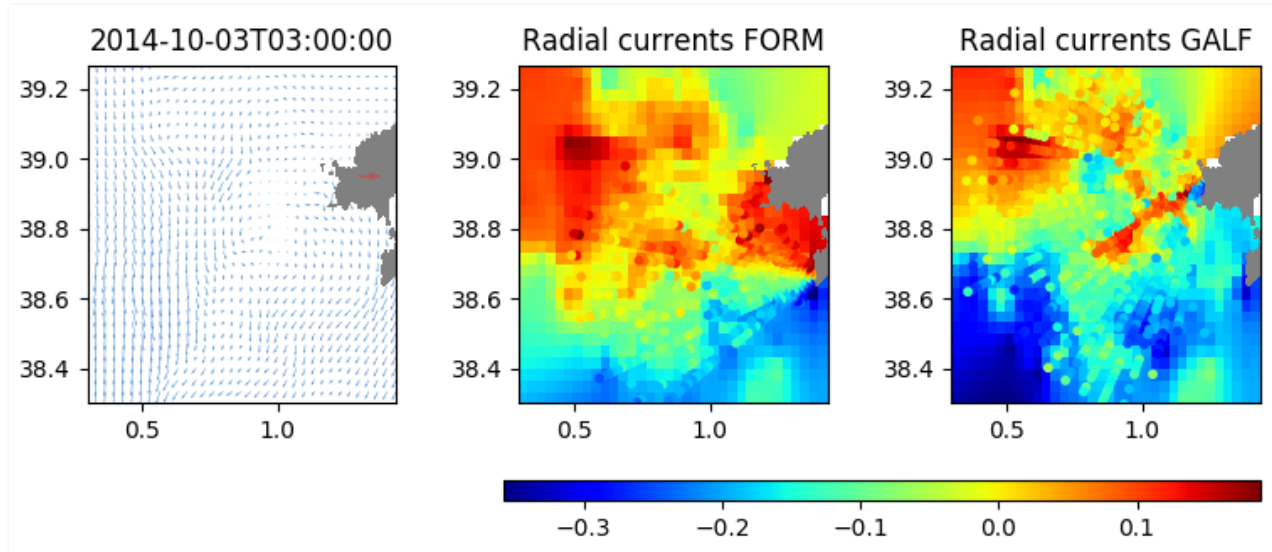
High-frequency radar interpolation

Low horizontal divergence of currents



High-frequency radar interpolation

Including Coriolis force and geostrophically balanced mean flow



Test areas: Ibiza Channel, Gulf of Trieste

Neural network



Baron Schwartz ✓
@xaprb



When you're fundraising, it's AI
When you're hiring, it's ML
When you're implementing, it's linear regression
When you're debugging, it's printf()

♡ 12.7K 6:52 AM - Nov 15, 2017



💬 5,642 people are talking about this



Neural network

From univariate to multivariate...

Principle:

Use other co-variables to improve the interpolation

Use neural network to derive the relationships between the variables

Application: zooplankton count in the Baltic Sea

Covariables:

- Dissolved oxygen → EMODnet Chemistry
- Salinity → SeaDataCloud
- Temperature → SeaDataCloud
- Chlorophyll concentration → MODIS-Aqua from NASA
- Bathymetry → EMODnet Bathymetry, GEBCO
- Distance from coast → GSFC, NASA

Application: zooplankton count in the Baltic Sea

Conclusions

1. `DIVA` is a software tool written in Fortran
2. `DIVAnd` is a software tool written in Julia
3. Both are designed for the spatial interpolation of data
4. We are open and willing to improve and adapt the code for different data types

Thanks for your attention

(and use `DIVA{nd}` many times)