OSDYN: a new python tool for the analysis of high-volume ocean outputs.

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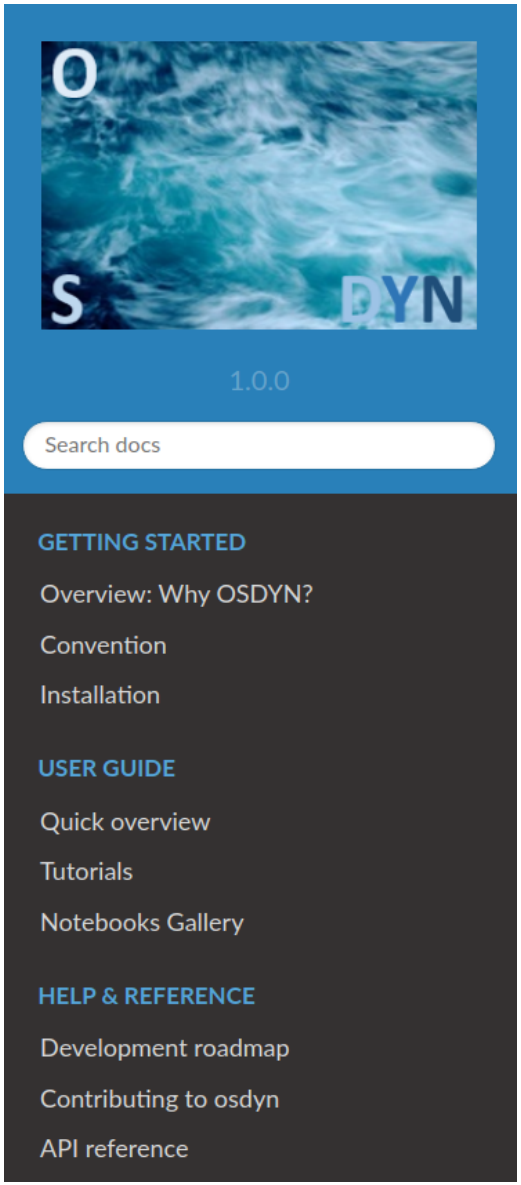
June 9, 2022

Observations and Simulations of the DYNamics



Scientific analyses of data from atmospheric, oceanic, wave models and remote or in-situ observations.

- large datasets (hourly, years, 100 meters)
- easily
- quickly

- (auto-)kerchunk package
- Osdyn readers
- Pangeo ecosystem (xarray, dask, xgcm, xesmf...)

https://osdyn.ifremer.fr/osdyn

auto-kerchunk package: pre-reading

This step is done once for good for each dataset.

- metadata of netCDF files gathered (.json)
- description file (.yaml) called by intake to get the dataset
- requires netcdf4 (hdf5) + chunks

```yaml
metadata:
    model:  mars
    positive:  up
name: marc_f2_1200_sn_T1Z60Y462X1100
sources:
  marc_f2_1200_sn_T1Z60Y462X1100:
    args:
      consolidated: false
      storage_options:
        fo: file:///home/datawork-lops-siam-moawi/PROJECTS/OSDYN/DATA/CATALOG/KERCHUNK/marc_f2_1200_sn_T1Z60Y462X1100.json.zst
        target_options:
          compression: zstd
        target_protocol: file
      urlpath: reference://
    description: description
    driver: zarr
    name: marc_f2_1200_sn_T1Z60Y462X1100
    parameters: {}

  marc_f2_1200_sn_T1Z60Y462X1100_grid:
    args:
      urlpath: /home/datawork-lops-siam-moawi/PROJECTS/COTACOT/DATA/MODELS/MARS/F2_1200_SN/SUBSET/grid_SUB_MARC_F2-MARS3D-MENOR1200
    description: description
    driver: netcdf
    name: marc_f2_1200_sn_T1Z60Y462X1100_grid
```

auto-kerchunk package: pre-reading

MEDRYS, a Mediterranean Sea reanalysis over the period 1992–2013 (Hamon et al., 2016)

```yaml
metadata:
    model:  nemo
    parameters:
        cgrid:
            description: data stored according to their location on the Arakawa c-grid
            type: str
            default: "gridT"
            allowed: ["grid2D", "gridT", "gridS", "gridU", "gridV"]
    positive:  down
name: medrys_T1Z75Y264X567
sources:
  medrys_T1Z75Y264X567:
    args:
      consolidated: false
      storage_options:
        fo: file:///home/datawork-lops-siam-moawi/PROJECTS/OSDYN/DATA/CATALOG/KERCHUNK/medrys_T1Z75Y264X567.json.zst/{{ cgrid }}.json.zst
        target_options:
          compression: zstd
        target_protocol: file
      urlpath: reference://
    description: description
    driver: zarr
    name: medrys_T1Z75Y264X567
    parameters: {}

  medrys_T1Z75Y264X567_grid:
    args:
      urlpath: /home/datawork-lops-siam-moawi/PROJECTS/COTACOT/DATA/MODELS/NEMO/MEDRYS1V2/medrys_grid_osdyn.nc
    description: description
    driver: netcdf
    name: medrys_T1Z75Y264X567_grid
~
```

read yaml from intake

Mars f2_sn

```
[4]: from intake import open_catalog
     yaml = "/home/datawork-lops-siam-moawi/PROJECTS/OSDYN/DATA/CATALOG/INTAKE/marc_f2_1200_sn_T
     cat = open_catalog(yaml)
     cat
```

```
marc_f2_1200_sn_T1Z60Y462X1100:
  args:
    path: /home/datawork-lops-siam-moawi/PROJECTS/OSDYN/DATA/CATALOG/INTAKE/marc_f2_1200_sn
  description: ''
  driver: intake.catalog.local.YAMLFileCatalog
  metadata:
    model: mars
    positive: up
```

Nemo Medrys

```
[8]: from intake import open_catalog
     yaml = "/home/datawork-lops-siam-moawi/PROJECTS/OSDYN/DATA/CATALOG/INTAKE/medrys_T1Z75Y264X
     cat = open_catalog(yaml)
     cat
```

```
medrys_T1Z75Y264X567:
  args:
    path: /home/datawork-lops-siam-moawi/PROJECTS/OSDYN/DATA/CATALOG/INTAKE/medrys_T1Z75Y26
  description: ''
  driver: intake.catalog.local.YAMLFileCatalog
  metadata:
    model: nemo
    parameters:
      cgrid:
        allowed:
        - grid2D
        - gridT
        - gridS
        - gridU
        - gridV
        default: gridT
        description: data stored according to their location on the Arakawa c-grid
        type: str
    positive: down
```

read yaml from intake

Mars f2_sn

```
%%time
ds = getattr(cat, cat.name).to_dask()
ds
```

```
CPU times: user 308 ms, sys: 12 ms, total: 320 ms
Wall time: 381 ms
```

▸ Dimensions: (**level**: 60, **nj**: 462, **ni**: 1100, **nj_u**: 462, **ni_u**: 1100, **nj_v**: 462, **ni_v**: 1100, **time**: 20407, **ni_f**: 1100, **nj_f**: 462)

nj	(nj)	float32	1.0 2.0 3.0 ... 460.0 46...
nj_f	(nj_f)	float32	1.5 2.5 3.5 ... 460.5 46...
nj_u	(nj_u)	float32	1.0 2.0 3.0 ... 460.0 46...
nj_v	(nj_v)	float32	1.5 2.5 3.5 ... 460.5 46...
time	(time)	datetime64[us]	2015-01-01 ... 2021-1...

▾ Data variables:

Csu_sig	(level)	float32	dask.array<chunksize=...
H0	(nj, ni)	float32	dask.array<chunksize=...
HX	(nj_u, ni_u)	float32	dask.array<chunksize=...
HY	(nj_v, ni_v)	float32	dask.array<chunksize=...
SAL	(time, level, nj, ni)	float32	dask.array<chunksize=...
SIG	(level)	float32	dask.array<chunksize=...
TAUX	(time, nj_u, ni_u)	float32	dask.array<chunksize=...
TAUY	(time, nj_v, ni_v)	float32	dask.array<chunksize=...
TEMP	(time, level, nj, ni)	float32	dask.array<chunksize=...

Nemo Medrys

▸ Dimensions: (**deptht**: 75, **y**: 264, **x**: 567, **time_counter**: 6752)

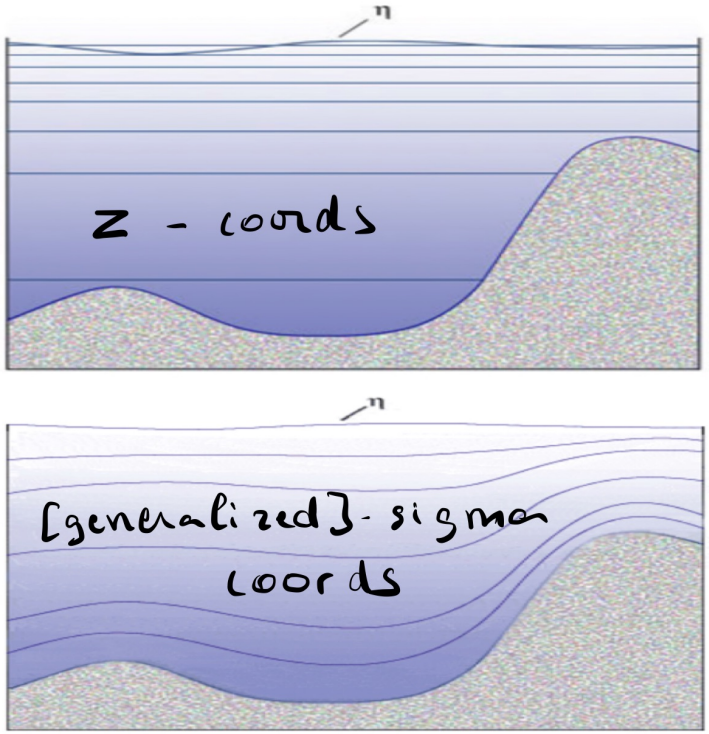
▾ Coordinates:

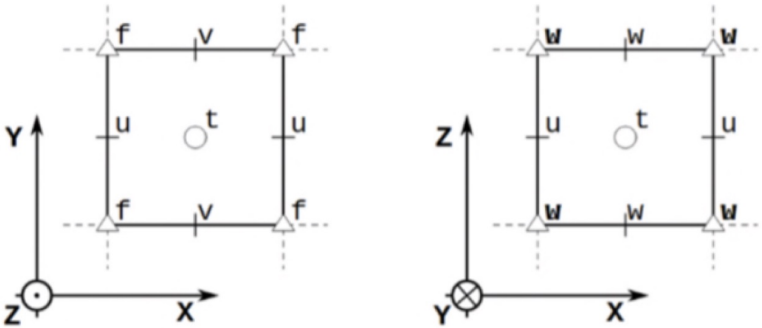
deptht	(deptht)	float32	0.5165 1.622 ... 4.
nav_lat	(y, x)	float32	dask.array<chunk..
nav_lon	(y, x)	float32	dask.array<chunk..
time_counter	(time_counter)	datetime64[us]	1995-01-01T12:...
x	(x)	float64	1.0 2.0 3.0 ... 565..
y	(y)	float64	1.0 2.0 3.0 ... 262..

▾ Data variables:

vodensity	(time_counter, deptht, y, x)	float32	dask.array<chunk..
votemper	(time_counter, deptht, y, x)	float32	dask.array<chunk..

Osdyn readers: example for model outputs



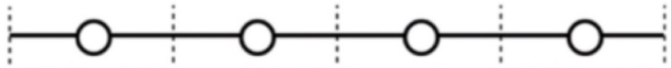


C-grid — horizontal view

C-grid — vertical view

Image from the pycomodo project

XGCM grid convention



center		f[0]	f[1]	…	f[n-1]
left	f[0]	f[1]	…	f[n-1]	
right		f[0]	f[1]	…	f[n-1]
inner		f[0]	…	f[n-2]	
outer	f[0]	f[1]	…	f[n-1]	f[n]

The different possible positions of a variable `f` along an axis.

OSDYN name convention

[medium_] [axe] **name**_adjectif [_niveau] [_direction] [_location]

oce	x	**temp**_insitu	_sfc	_down	_t _u _v _f, _w [_wu...]
atm	y	**cur**_btrope	_bot	_from	
wav	z	**wnd**_bcline	_10m		
obs		**cur**_geos	_top		
ice		**h**_smooth	...		
lake		X_wet			
town		X_tcrit002			
		X_dcrit003			
		X_net			
		X_flx			
		X_along (parallèle à trace)			
		X_cross (perpendiculaire à trace)			
		...			

auto-kerchunk + osdyn reader

Read yaml from intake

```
yaml = os.path.join(path,"marc_f2_1200_sn_T1Z60Y463X1101.yaml")
```

and get the dataset

```
%%time
mc = moawi(yaml)
```

```
Wall time: 3.45 s
```

in

```
%%time
mc.ds
```

Xarray dataset

```
CPU times: user 0 ns, sys: 0 ns, total: 0 ns
Wall time: 5.48 µs
```

xarray.Dataset

▸ Dimensions: (nz_g: 61, nz_c: 60, ny_g: 462, ny_c: 462, nx_g: 1100, nx_c: 1100, nt: 20407)

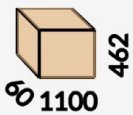
▾ Coordinates:

nz_g	(nz_g)	float64	0.5 1.5 2.5 3.5 ... 58.5 59.5 60.5
lat_t	(ny_c, nx_c)	float64	dask.array<chunksize=(462, 110...
lon_v	(ny_g, nx_c)	float64	dask.array<chunksize=(...
time	(nt)	datetime64[ns]	2015-01-01 ... 2021-12...

▾ Data variables:

salt	(nt, nz_c, ny_c, nx_c)	float32	dask.array<chunksize=(...
temp	(nt, nz_c, ny_c, nx_c)	float32	dask.array<chunksize=(...
xcur	(nt, nz_c, ny_c, nx_g)	float32	dask.array<chunksize=(...
ycur	(nt, nz_c, ny_g, nx_c)	float32	dask.array<chunksize=(...
z_sfc	(nt, ny_c, nx_c)	float32	dask.array<chunksize=(...
sc_cs_t			

Array	Chunk
2.26 TiB	116.32 MiB
(20407, 60, 462, 1100)	(1, 60, 462, 1100)
20408 Tasks	20407 Chunks



Application: 7-year average of sea surface temperature

```
mc.ds["temp"]
```

xarray.DataArray 'temp' (nt: 20407, nz_c: 60, ny_c: 462, nx_c: 1100)

	Array	Chunk
Bytes	2.26 TiB	116.32 MiB
Shape	(20407, 60, 462, 1100)	(1, 60, 462, 1100)
Count	20408 Tasks	20407 Chunks
Type	float32	numpy.ndarray

SST

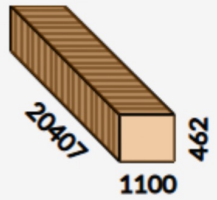
```
# index of the sea surface
ksurf = mc.get_surface_index()
ksurf
```

```
59
```

```
sst = mc.ds["temp"].isel(nz_c=ksurf)
sst
```

xarray.DataArray 'temp' (nt: 20407, ny_c: 462, nx_c: 1100)

	Array	Chunk
Bytes	38.63 GiB	1.94 MiB
Shape	(20407, 462, 1100)	(1, 462, 1100)
Count	40815 Tasks	20407 Chunks
Type	float32	numpy.ndarray



LocalCluster

dask-worker-local

Dashboard: http://127.0.0.1:8787/status	**Workers:** 8
Total threads: 56	**Total memory:** 115.00 GiB
Status: running	**Using processes:** True

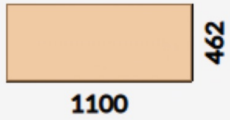
Application: 7-year average of sea surface temperature

```
%%time
surf_tmean = mc.ds["temp"].isel(nz_c=ksurf).mean(dim="nt")
surf_tmean
```

```
CPU times: user 108 ms, sys: 8 ms, total: 116 ms
Wall time: 112 ms
```

xarray.DataArray 'temp' (ny_c: 462, nx_c: 1100)

	Array	Chunk
Bytes	1.94 MiB	1.94 MiB
Shape	(462, 1100)	(462, 1100)
Count	68027 Tasks	1 Chunks
Type	float32	numpy.ndarray




```
%%time
mc.ds["temp"].isel(nz_c=ksurf).mean(dim=["ny_c", "nx_c"])
```

```
CPU times: user 148 ms, sys: 4 ms, total: 152 ms
Wall time: 150 ms
```

xarray.DataArray 'temp' (nt: 20407)

	Array	Chunk
Bytes	79.71 kiB	4 B
Shape	(20407,)	(1,)
Count	81629 Tasks	20407 Chunks
Type	float32	numpy.ndarray


```
%%time
sst_tmean = surf_tmean.compute()
```

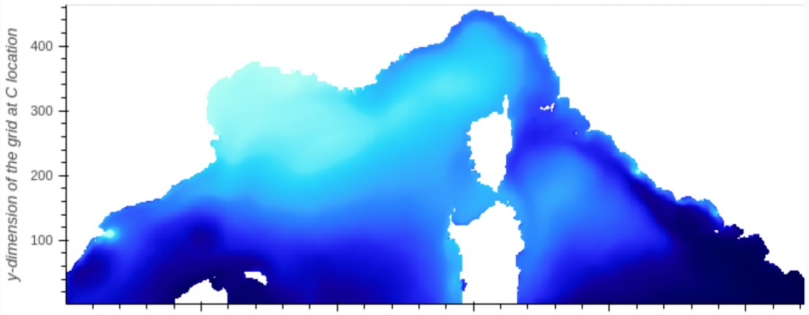
```
CPU times: user 1min 45s, sys: 6.62 s, total: 1min 51s
Wall time: 5min 40s
```

```
%%time
sst_xymean = mc.ds["temp"].isel(nz_c=ksurf).mean(dim=["ny_c", "nx_c"]).compute()
```

```
CPU times: user 1min 51s, sys: 5.87 s, total: 1min 56s
Wall time: 5min 43s
```

```
%%time
sst_tmean.hvplot(datashade=True)
```

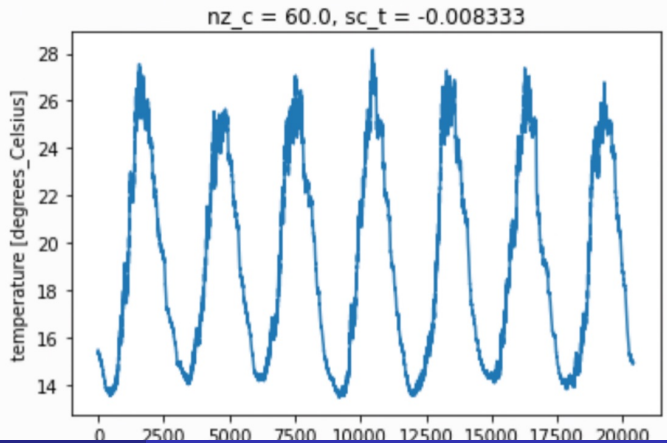
```
CPU times: user 3.04 s, sys: 116 ms, total: 3.15 s
Wall time: 10.7 s
```




```
sst_xymean.plot()
```

```
CPU times: user 28 ms, sys: 8 ms, total: 36 ms
Wall time: 189 ms
```

```
[<matplotlib.lines.Line2D at 0x2aac4b656850>]
```



Application: 7-year average of kinetic energy at 200m

```
yaml = os.path.join(path,"marc_f2_1200_sn_noon_T1Z60Y463X1101.yaml")
```

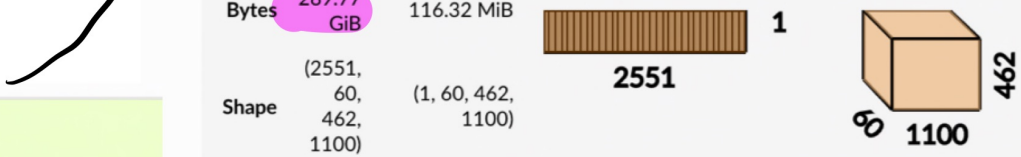
```
%%time
mc = moawi(yaml)
```

```
[WARNING]:  cf.py in name2key - line: 1289
 No osdyn key for this variable : sc_t
[WARNING]:  cf.py in name2key - line: 1289
 No osdyn key for this variable : sc_w
CPU times: user 716 ms, sys: 44 ms, total: 760 ms
Wall time: 1.35 s
```

```
mc.ds.z_t
```

xarray.DataArray 'z_t' (nt: 2551, nz_c: 60, ny_c: 462, nx_c: 1

	Array	Chunk
Bytes	289.77 GiB	116.32 MiB
Shape	(2551, 60, 462, 1100)	(1, 60, 462, 1100)
Count	7670 Tasks	2551 Chunks
Type	float32	numpy.ndarray

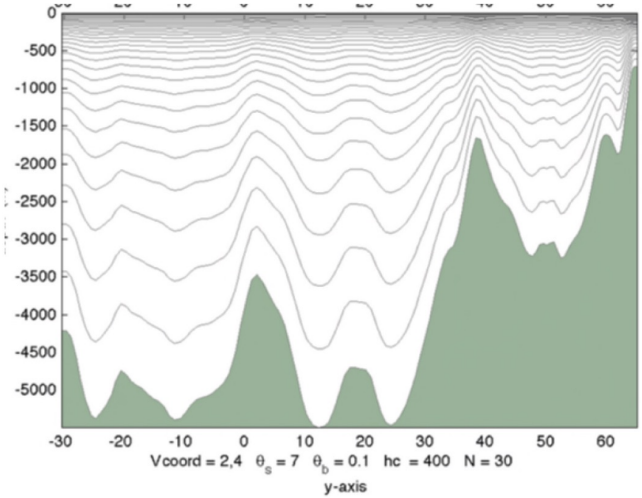


4D variables

```
%%time
mc.set_z(at="t")
# does nothing if depths are already in the dataset
```

for genericity

```
CPU times: user 376 ms, sys: 4 ms, total: 380 ms
Wall time: 374 ms
```



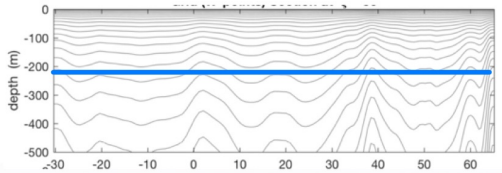

```
mc.ds.xcur
```

xarray.DataArray 'xcur' (nt: 2551, nz_c: 60, ny_c: 462, nx_g:

	Array	Chunk
Bytes	289.77 GiB	116.32 MiB
Shape	(2551, 60, 462, 1100)	(1, 60, 462, 1100)
Count	2552 Tasks	2551 Chunks
Type	float32	numpy.ndarray

Application: 7-year average of kinetic energy at 200m

Projection to -200 m

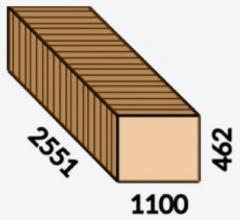



```
%%time
mc.set_var_at_z("xcur", [-200])
mc.ds.xcur_200m
```

```
CPU times: user 2.48 s, sys: 32 ms, total: 2.52 s
Wall time: 2.5 s
```

xarray.DataArray 'xcur_200m' (nt: 2551, ny_c: 462,

	Array	Chunk
Bytes	4.83 GiB	1.94 MiB
Shape	(2551, 462, 1100)	(1, 462, 1099)
Count	58692 Tasks	5102 Chunks
Type	float32	numpy.ndarray




```
mc.ds.z_t
```

xarray.DataArray 'z_t' (nt: 2551, nz_c: 60, ny_c: 462, nx_c: 1

	Array	Chunk
Bytes	289.77 GiB	116.32 MiB
Shape	(2551, 60, 462, 1100)	(1, 60, 462, 1100)
Count	7670 Tasks	2551 Chunks
Type	float32	numpy.ndarray

4D variables

6 nodes 115 GiB

2 workers / nodes

PBSCluster

dask-worker-datarmor

Dashboard: /user/jfleroux/proxy/8787/status	**Workers:** 12
Total threads: 12	**Total memory:** 670.56 GiB

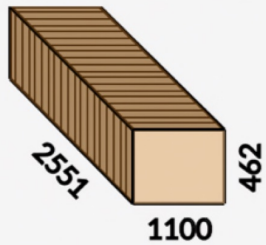
Application: 7-year average of kinetic energy at 200m

```
%%time
ke = kinetic_energy(mc.ds, mc.xgcmgrid, u="xcur_200m", v="ycur_200m")
ke
```

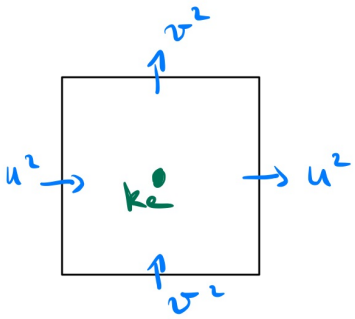
```
CPU times: user 12.4 s, sys: 284 ms, total: 12.7 s
Wall time: 12.6 s
```

xarray.DataArray 'ke_200m' (nt: 2551, ny_c: 462, nx_c: 1100)

	Array	Chunk
Bytes	4.83 GiB	1.93 MiB
Shape	(2551, 462, 1100)	(1, 460, 1098)
Count	316344 Tasks	22959 Chunks
Type	float32	numpy.ndarray



$$ke = \frac{\overline{u^2}^x + \overline{v^2}^y}{2}$$

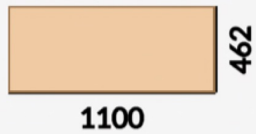



```
%%time
ke_tmean = ke.mean(dim="nt")
ke_tmean
```

```
CPU times: user 88 ms, sys: 0 ns, total: 88 ms
Wall time: 88.9 ms
```

xarray.DataArray 'ke_200m' (ny_c: 462, nx_c: 1100)

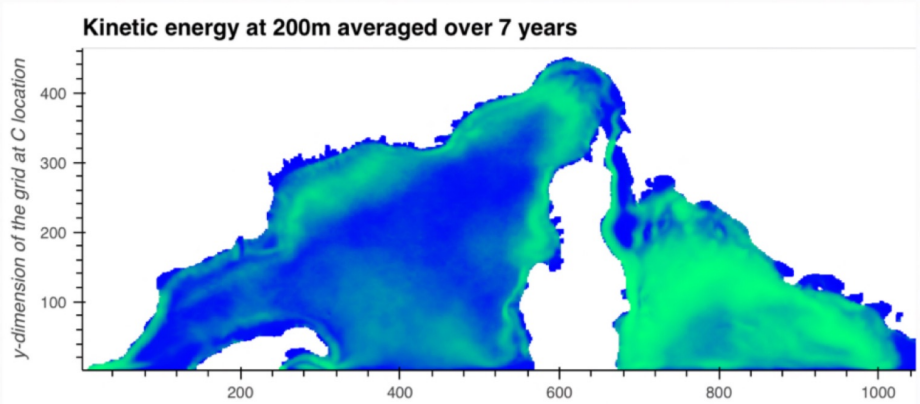
	Array	Chunk
Bytes	1.94 MiB	1.93 MiB
Shape	(462, 1100)	(460, 1098)
Count	346971 Tasks	9 Chunks
Type	float32	numpy.ndarray




```
%%time
ke_tmean_np = ke_tmean.compute()
```

```
CPU times: user 7min 52s, sys: 14.8 s, total: 8min 6s
Wall time: 19min 40s
```

```
ke_tmean_np.hvplot(datashade=True, title="Kinetic energy at 200m averaged over 7 years", cr
```



Summary

auto-kerchunk + intake

Fast access to huge dataset of netcdf files.

osdyn readers

- get rid of specificities in model outputs
- available for NEMO, MARS, Symphonie, CROCO (ocean), MesoNH (atmosphere), WW3 (wave) and any file gridded over a simple grid.

osdyn convention

- genericity of the diagnostics
- bank of diagnostics

osdyn

Takes benefit of pangeo ecosystem (xarray, xgcm, xesmf... and dask parallelization).

A dream ?

[auto]-kerchunk / intake

- Change the chunks when creating the dataset?

dask

- Cluster according to the memory.
- Balance between the numbers of tasks and the size of the chunks.
- Keep track of the fields of the same record?

MERCI A VOUS TOUS POUR VOTRE ATTENTION