Model-data comparison tools using DART and CrocoLake

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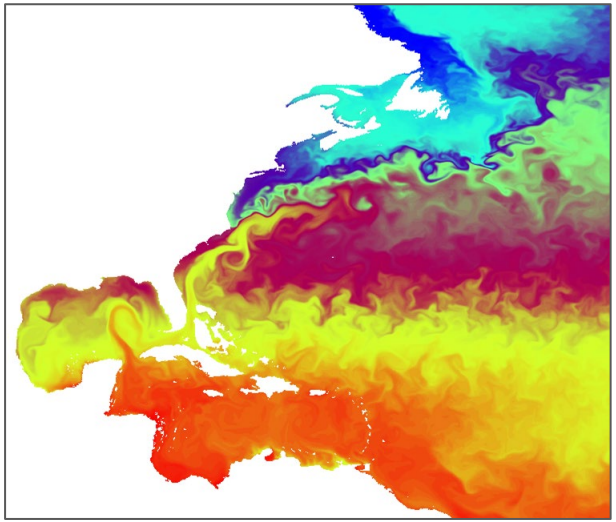
Ocean Model Working Group Meeting 2026

NSF NCAR Mesa Lab, Boulder, CO

February 6, 2025

You just ran your MOM6 simulation



NWA12, sea surface temperature, 2010-05-01

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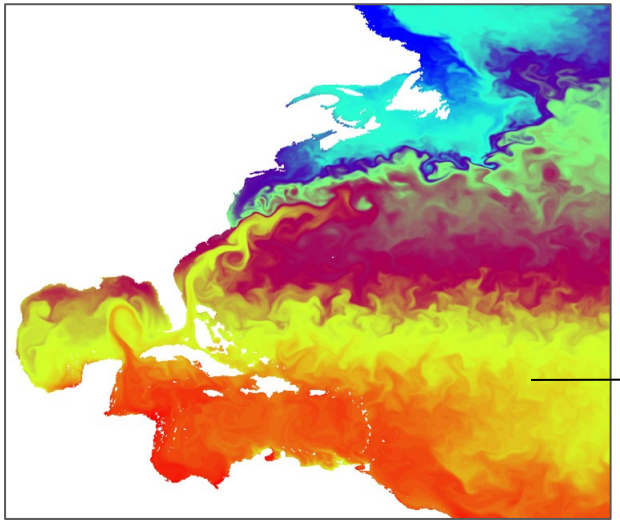


NWA12, sea surface temperature, 2010-05-01

correct?

https://argo.ucsd.edu/
(photo by Adam Ü)

https://anibos.com/

https://bios.asu.edu/oleander

https://spraydata.ucsd.edu/

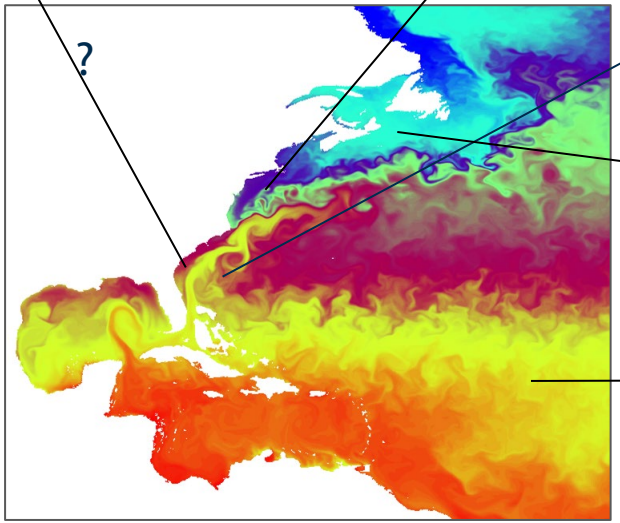
?

?

?

?

?



glodap

NWA12, sea surface temperature, 2010-05-01

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define filters in time, space, variables
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merge them into one structure (table) matching names, etc
[perform QC?]

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need to process one file per float

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download **GLODAP** master file (csv)
load all data into memory (tabular) → csv is inefficient
filter data (tabular)

download **Spray Glider** files (netCDF)
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"TEMP", "temperature", "G2temperature"

merge them into one structure (table) matching names, etc
[perform QC?]

lack of uniform access

bottlenecks:

- both knowledge-related
  (.csv, .netCDF; array vs tabular)
- and technological
  (slow read performance;
  long workflows)

how can we make
your life easier?

CrocoLake: cloud-optimized collection of observations

CrocoLake

CROCODILE's "best and freshest" collection of ocean observations

- maintained by me @ WHOI-NCAR
- ~1.2 billion observations
- both physical and biogeochemical measurements
- it's a collection: Argo (~97% of obs), GLODAP, Spray Gliders, Oleander XBT, OCS Saildrones
- only data *already QCed by provider*
- contains *instrument* errors (where available), not *representation* errors
- updated weekly (Argo, OleanderXBT)
- formats: parquet, (DART's obs sequence)

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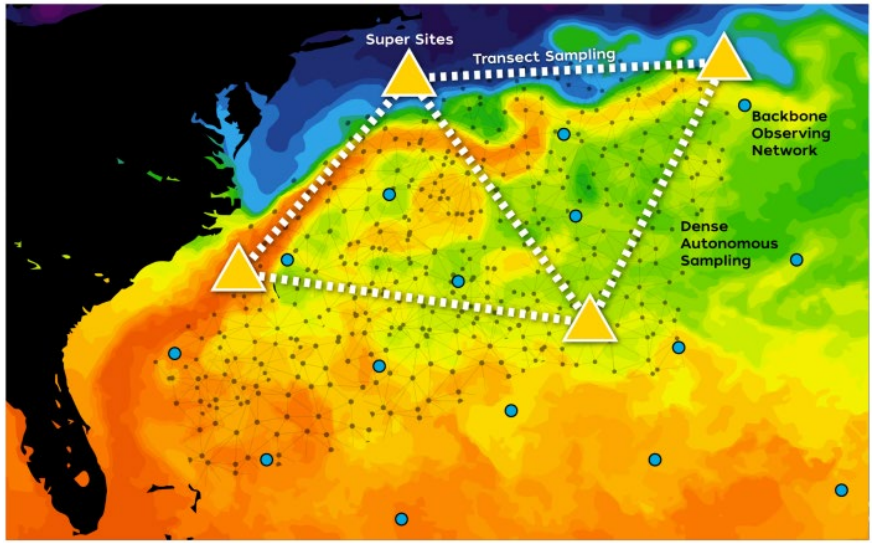
- close collaboration with Susan Wijffels and David Nicholson @WHOI:
  - Argo Core and BGC teams
  - Ocean Vital Signs Network (OVSN)

⇒ special interest in NorthWest Atlantic



CrocoLake: cloud-optimized collection of observations

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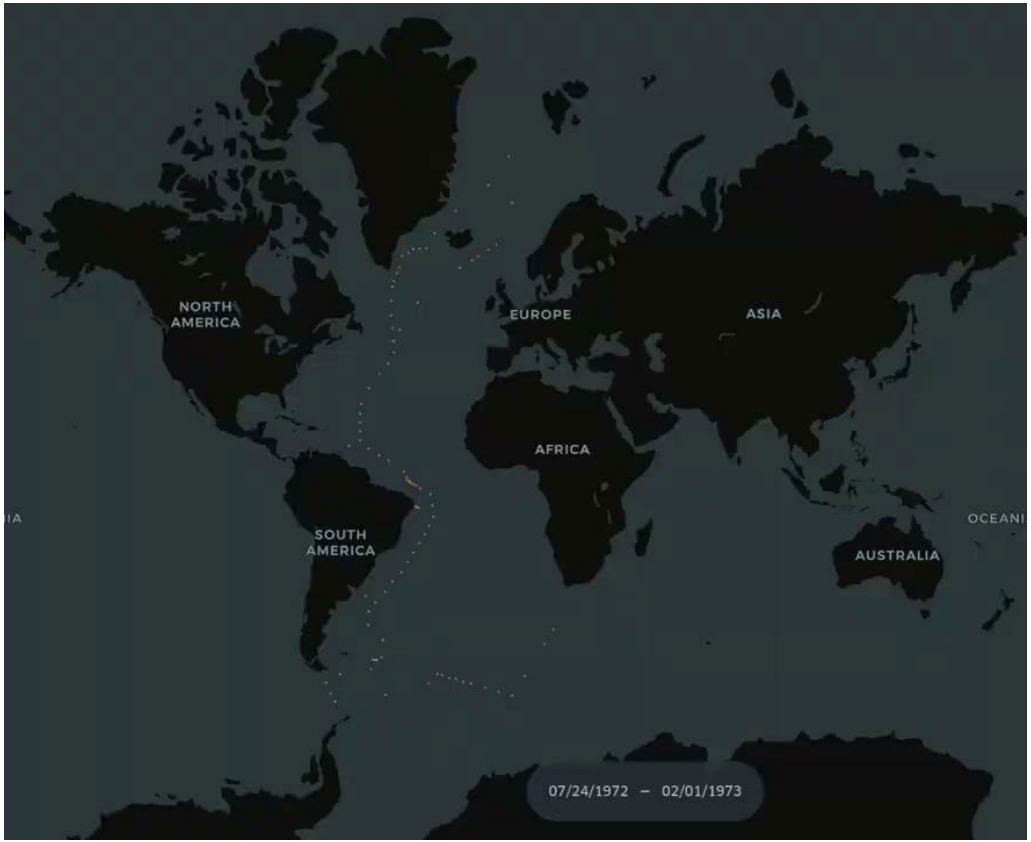
- multi-language support:
  - ✓ crocolake-python
  - ✓ crocolake-matlab
  - ✓ crocolake-julia
- on-disk CrocoLake is the same
- code to access changes with language

CrocoLake: cloud-optimized collection of observations

CrocoLake



CrocoLake: cloud-optimized collection of observations

```
%%time
cols = ["DB_NAME","LATITUDE","LONGITUDE","PRES","JULD","TEMP"]
filter_coords_time_temp = [
    ("LATITUDE",">",lat0), ("LATITUDE","<",lat1),
    ("LONGITUDE",">",lon0), ("LONGITUDE","<",lon1),
    ("JULD",">",date0), ("JULD","<",date1),
    ("TEMP",">=",-1e30),("TEMP","<=",+1e30)
]
ds = pq.ParquetDataset(parquet_dir, schema=crocolake_schema, filters=filter_coords_time_temp)
df = ds.read(columns=cols).to_pandas()
df
```

```
CPU times: user 21.5 s, sys: 894 ms, total: 22.4 s
Wall time: 2.42 s
```

	DB_NAME	LATITUDE	LONGITUDE	PRES	JULD	TEMP
0	ARGO	32.115	-64.427	4.36	2010-01-02 03:16:13.999788544	20.747
1	ARGO	32.115	-64.427	5.96	2010-01-02 03:16:13.999788544	20.747999
2	ARGO	32.115	-64.427	7.96	2010-01-02 03:16:13.999788544	20.747
3	ARGO	32.115	-64.427	10.160001	2010-01-02 03:16:13.999788544	20.740999
4	ARGO	32.115	-64.427	12.160001	2010-01-02 03:16:13.999788544	20.742001
...	...	...	...	...	...	...
8150312	OleanderXBT	32.670734	-64.745903	911.322876	2019-11-04 07:35:04.999995136	9.16
8150313	OleanderXBT	32.670734	-64.745903	911.929749	2019-11-04 07:35:04.999995136	9.15
8150314	OleanderXBT	32.670734	-64.745903	912.546814	2019-11-04 07:35:04.999995136	9.15
8150315	OleanderXBT	32.670734	-64.745903	913.153687	2019-11-04 07:35:04.999995136	9.14
8150316	OleanderXBT	32.670734	-64.745903	913.770691	2019-11-04 07:35:04.999995136	9.13

8150317 rows × 6 columns

CrocoLake: cloud-optimized collection of observations

few lines!
no treatment for each db!

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    ("TEMP",">=",-1e30),("TEMP","<=",+1e30)
]
ds = pq.ParquetDataset(parquet_dir, schema=crocolake_schema, filters=filter_coords_time_temp)
df = ds.read(columns=cols).to_pandas()
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```

filters

load filtered data (similar syntax in Matlab, Julia)

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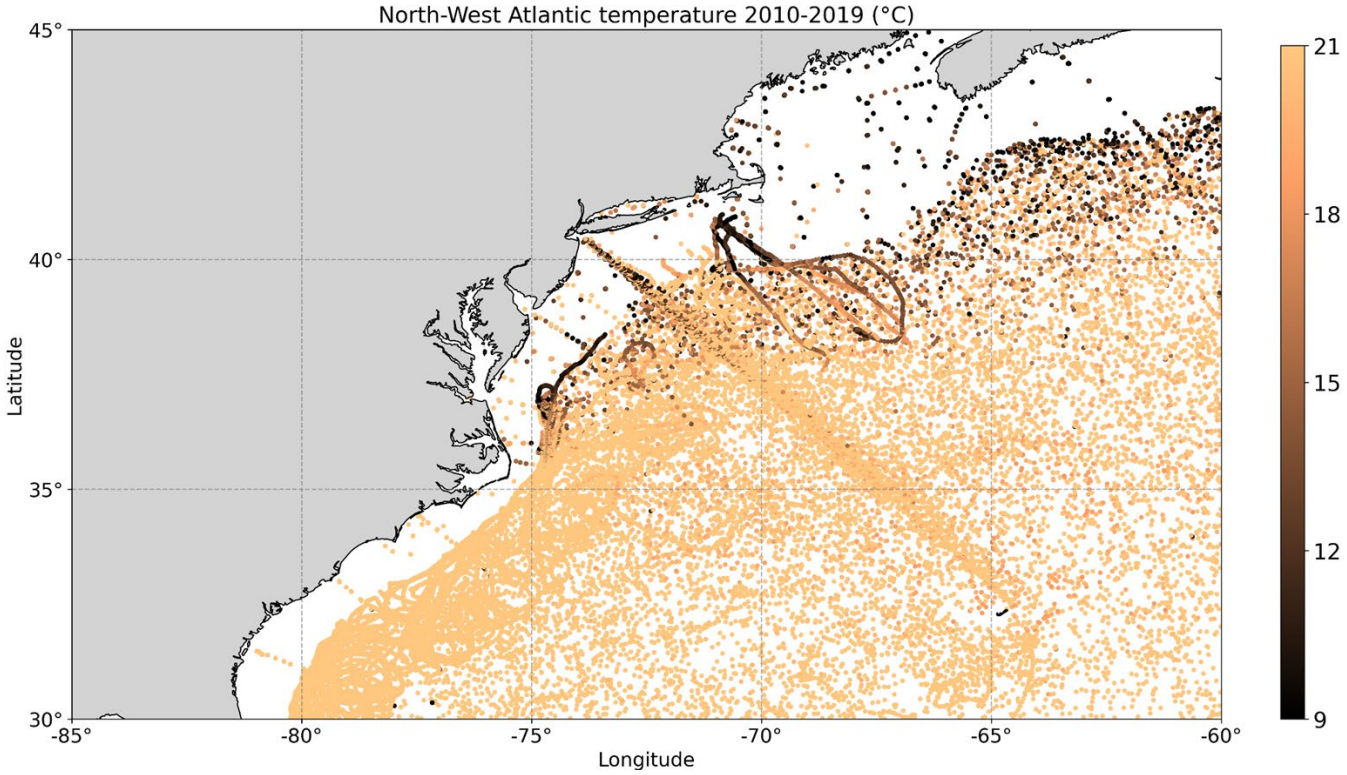
8150317 rows × 6 columns

data in same uniform structure (pandas dataframe)

CrocoLake: cloud-optimized collection of observations



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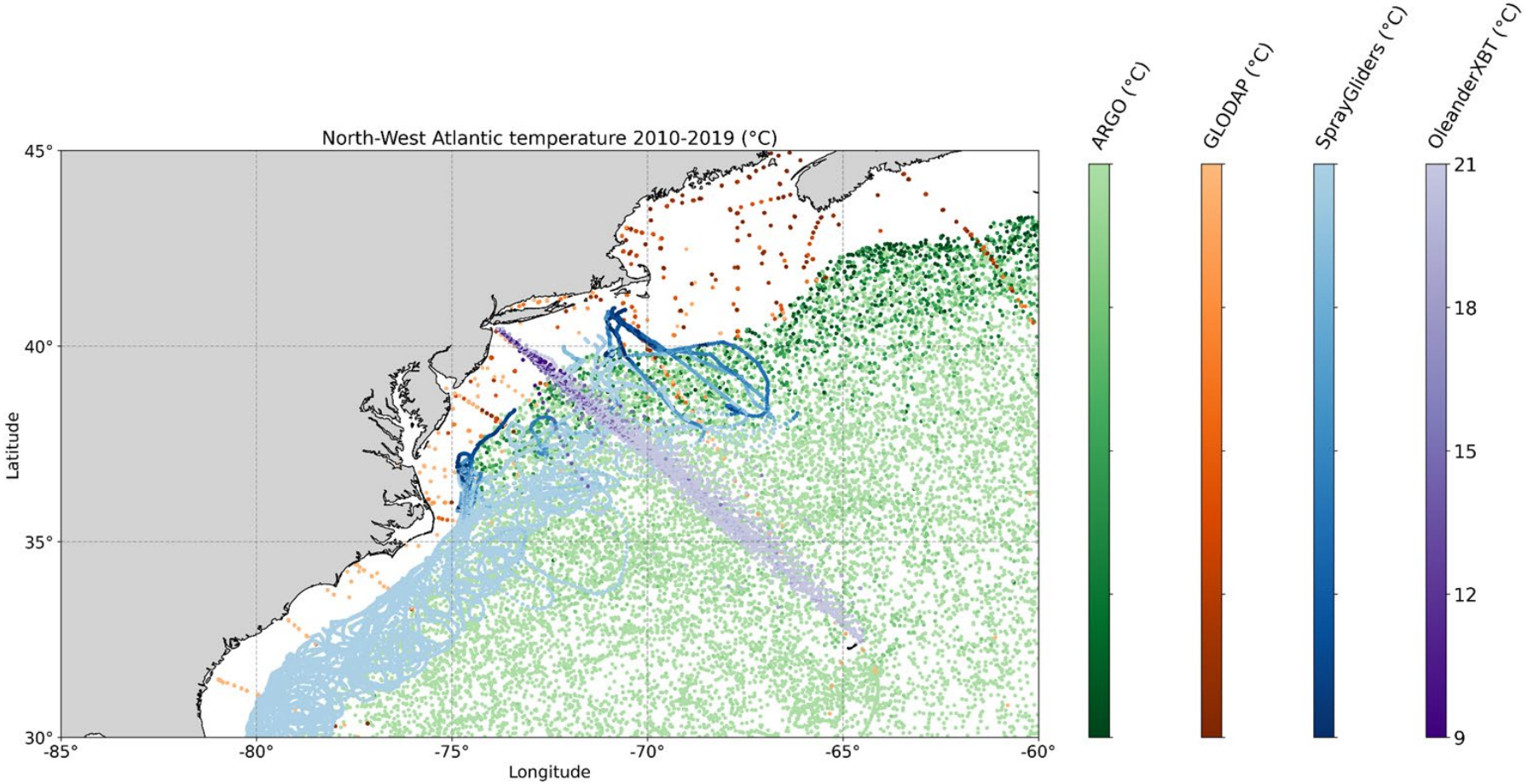

CrocoLake: cloud-optimized collection of observations

World Ocean Database		CrocoLake
○ long established ○ ad hoc QC ○ largest records	*Pros*	○ weekly refreshed ○ download with link ○ fast and cloud -optimized ○ I'm here :) tell me what you need
○ updates every ~5 years (major) or quarterly (minor, Nov '24?) ○ fill in form to download ○ not cloud -optimized	*Cons*	○ fewer metadata (units) ○ fewer observations (for now…?) ○ generally "beta"

Comparing model output to observations (CrocoLake, WOD)

```python
from crococamp.workflows import WorkflowModelObs
from crococamp.viz import InteractiveMapWidget

# interpolate model onto obs space
workflow = WorkflowModelObs.from_config_file("config.yaml")
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# interactive map
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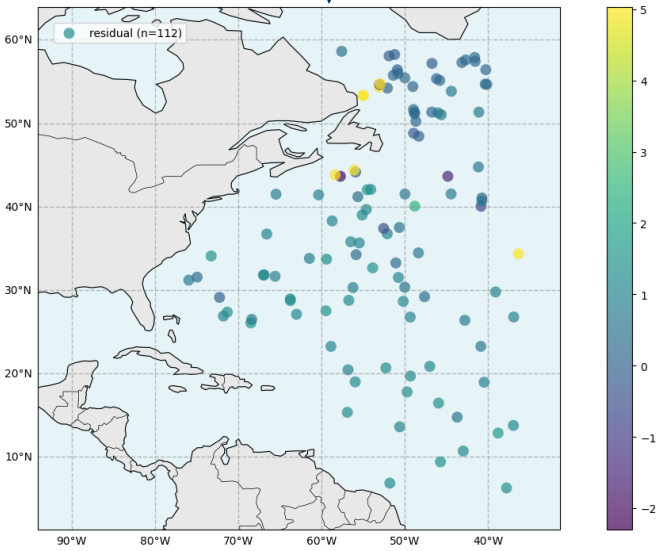
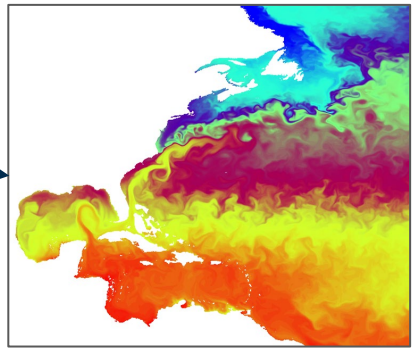
Spray Data

glodap

Argo





Plotted var… residual

Observatio… FLOAT_TEMPERATURE

Window (hrs): 239

Override window: e.g. 4 weeks, 3 days, 48 hour

Center time: 2010-05-05 11:

Colorbar limits: −2.30 – 5.03

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gl◉dap

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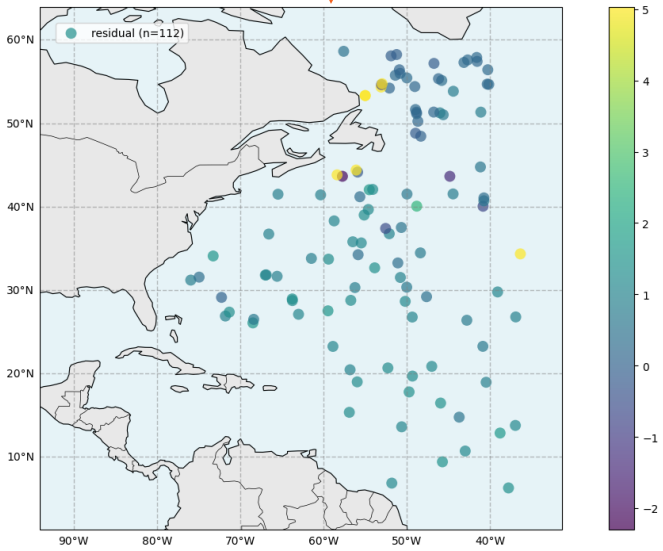
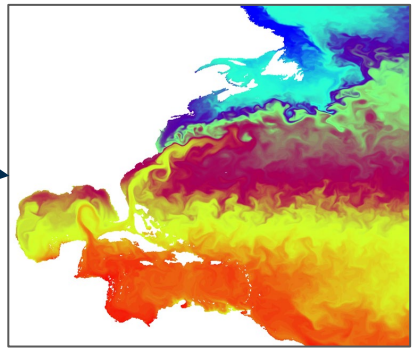
DART tools

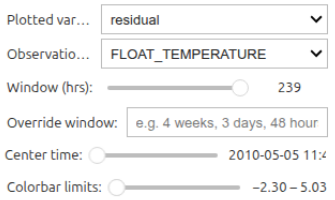
(“perfect_model_obs”)

The Data Assimilation Research Testbed (DART) is an open -source, freely available community facility for ensemble data assimilation (DA).

dev & maintained by NCAR







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CrocoCamp

runs it for you!

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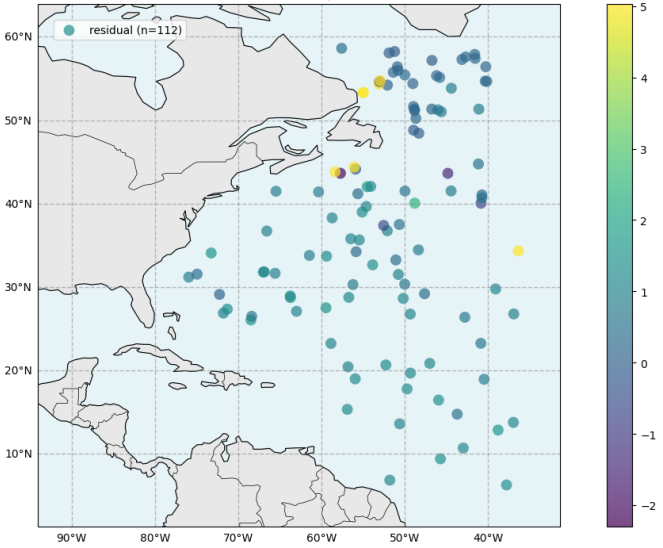

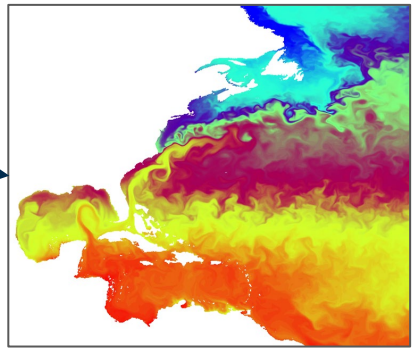

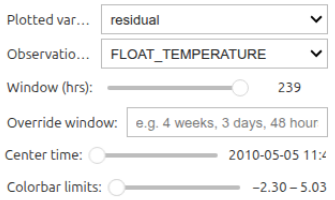

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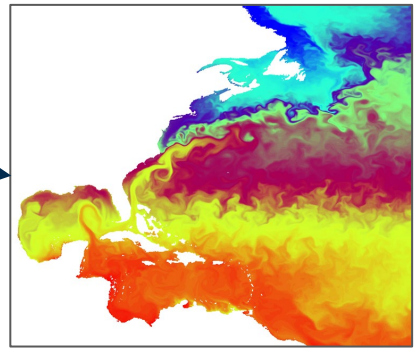

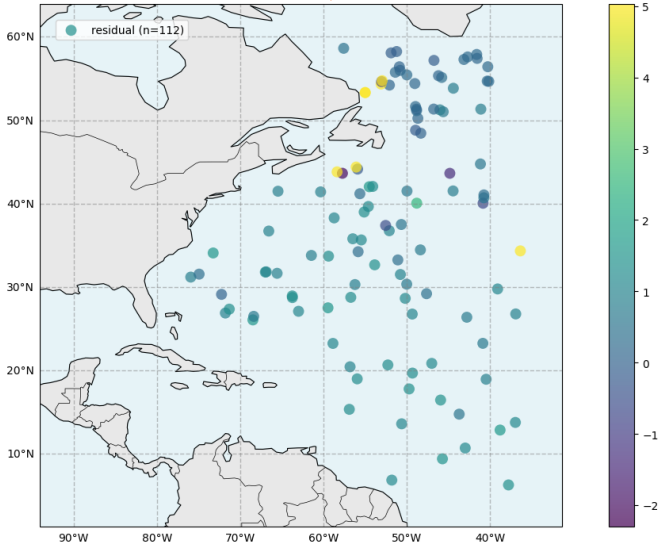

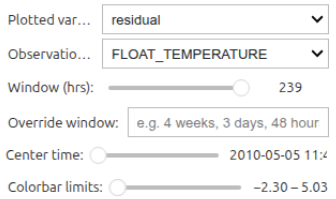

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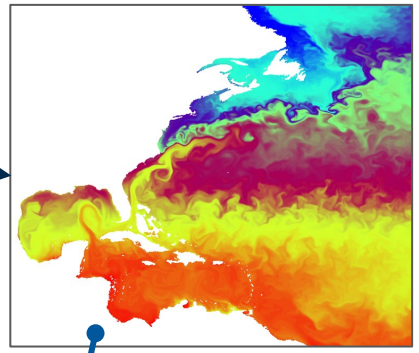

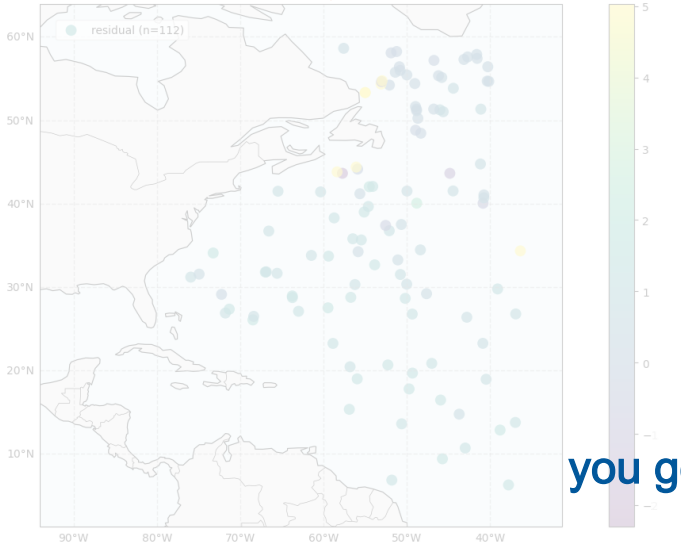

you get this from MOM6

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Spray Data

how about this?

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CrocoCamp

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CrocoCamp

Spray Data

glodap

Argo

how about this?

CrocoLake (or WOD)

Comparing model output to observations (CrocoLake, WOD)

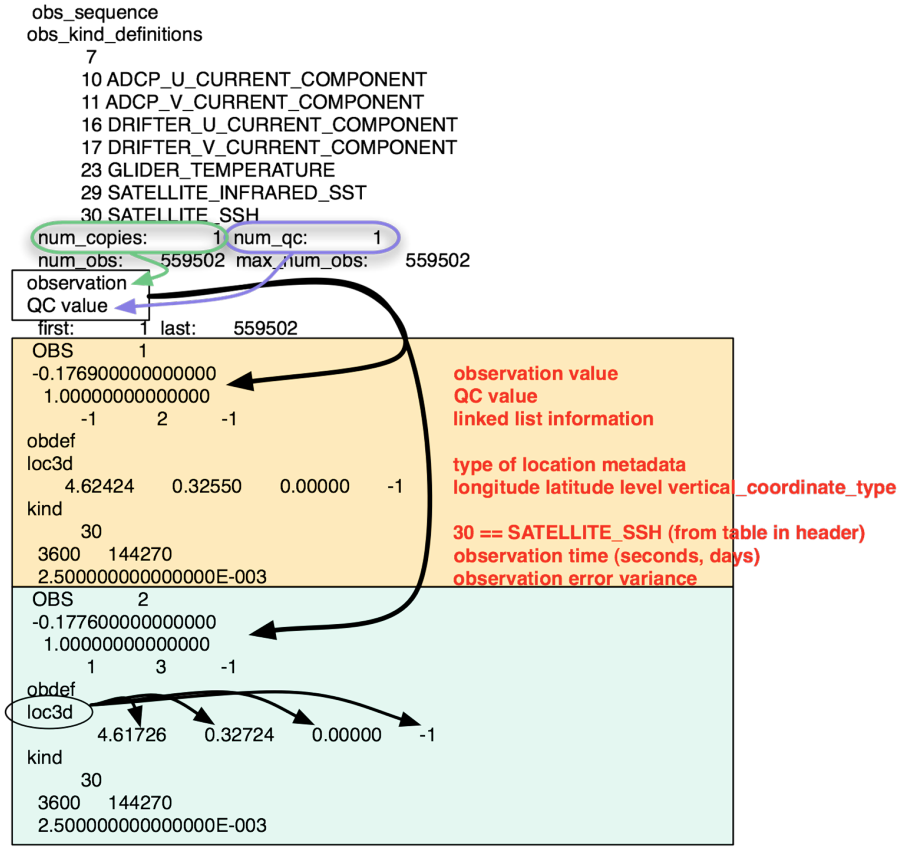
DART (“perfect_model_obs”)

interpolates model

onto obs space

⇒ we need observations in ‘observation sequence’ file format:

- CrocoLake:
  - script to build your own
    - can filter by any variable (e.g. platform number, region, time)



Workflow example #1

model output: one file with a 10-day run, with daily averages

CrocoLake obs_sequence files: 10 files with daily sparse observations

CrocoCamp:

- splits model output along 'time'
- matches snapshots with obs_seq.in files
- interpolates model snapshot to **ALL** obs in corresponding obs_seq.in file
- it does not re-use the same obs_seq.in file (assumes pairing is unique)

⇒ your model-obs "resolution" is your run's averages
⇒ obs_seq.in files must have that "resolution"

Workflow example #2

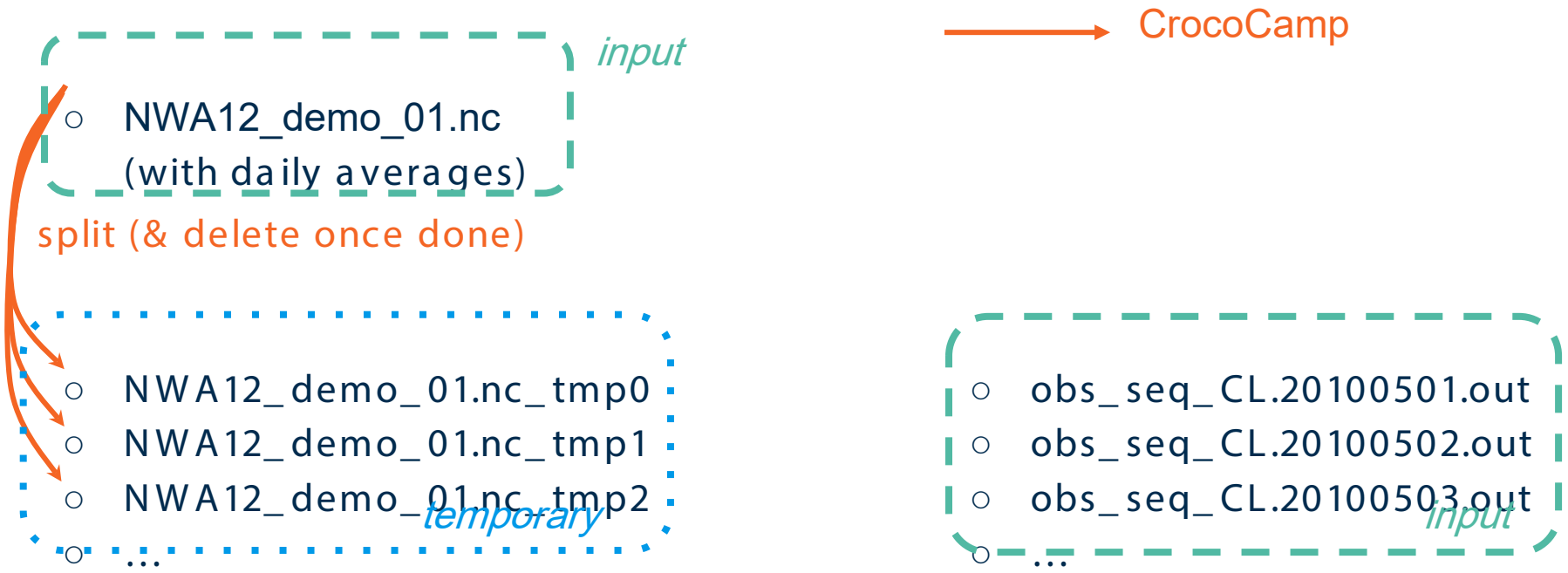
input

- NWA12_demo_01.nc
  (with daily averages)

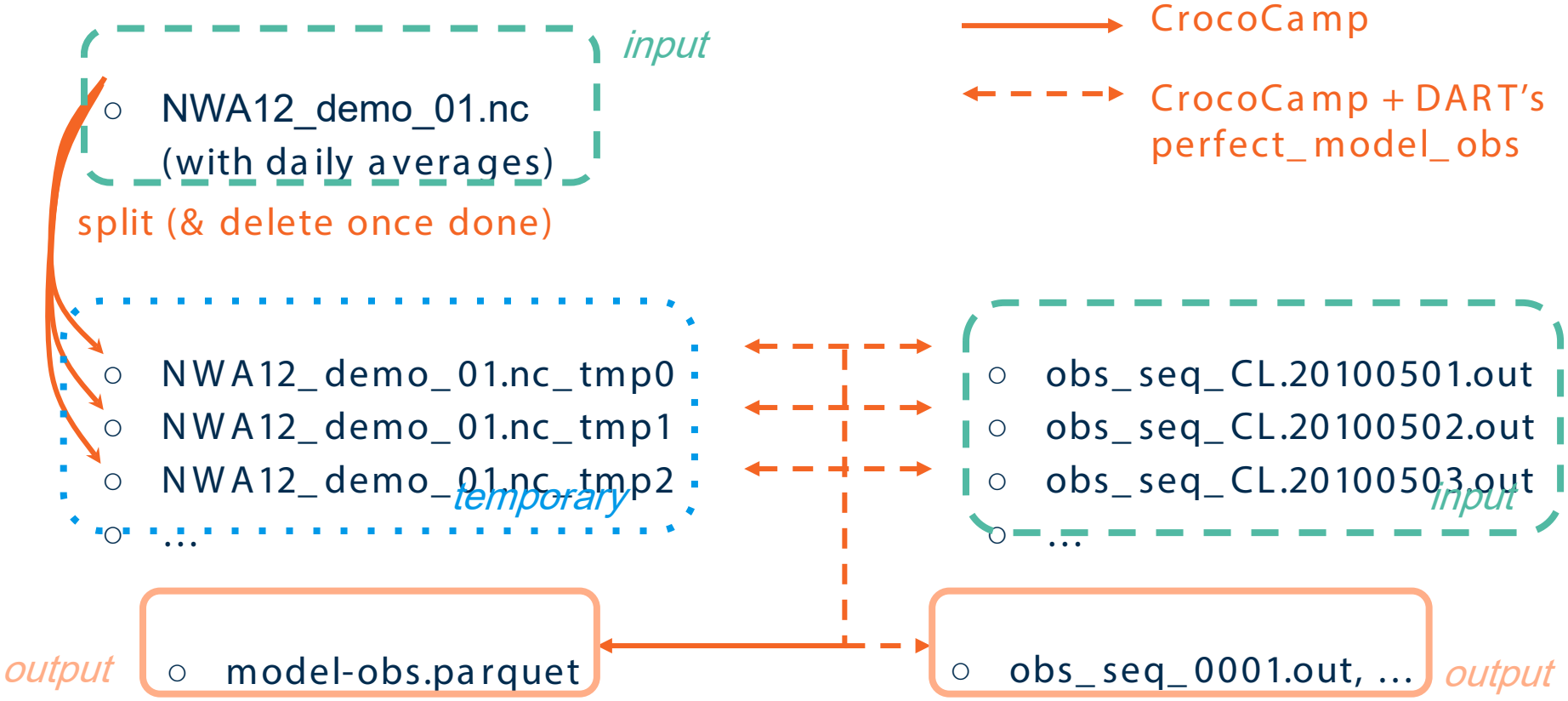
input

- obs_seq_CL.20100501.out
- obs_seq_CL.20100502.out
- obs_seq_CL.20100503.out
- ...

Workflow example #2

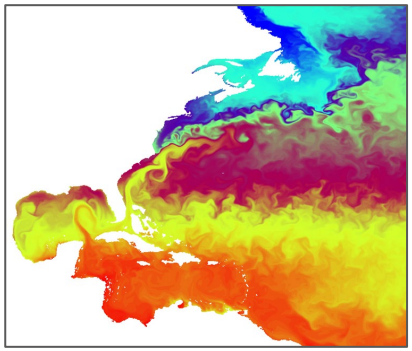


Workflow example #2



Comparing model output to observations (CrocoLake, WOD)

Recap of the ingredients:



1. MOM6/ ROMS model output

2. DART

3. CrocoCamp

4. Observations in

DART'S obs_sequence format:

a. CrocoLake: obs_converter in DART

b. Other: check DART / make your own

Final remarks + outlook

Future plans:

- customizable interpolation windows **without** changing files resolution
- tools for comparisons with **climatologies**
- improved efficiency