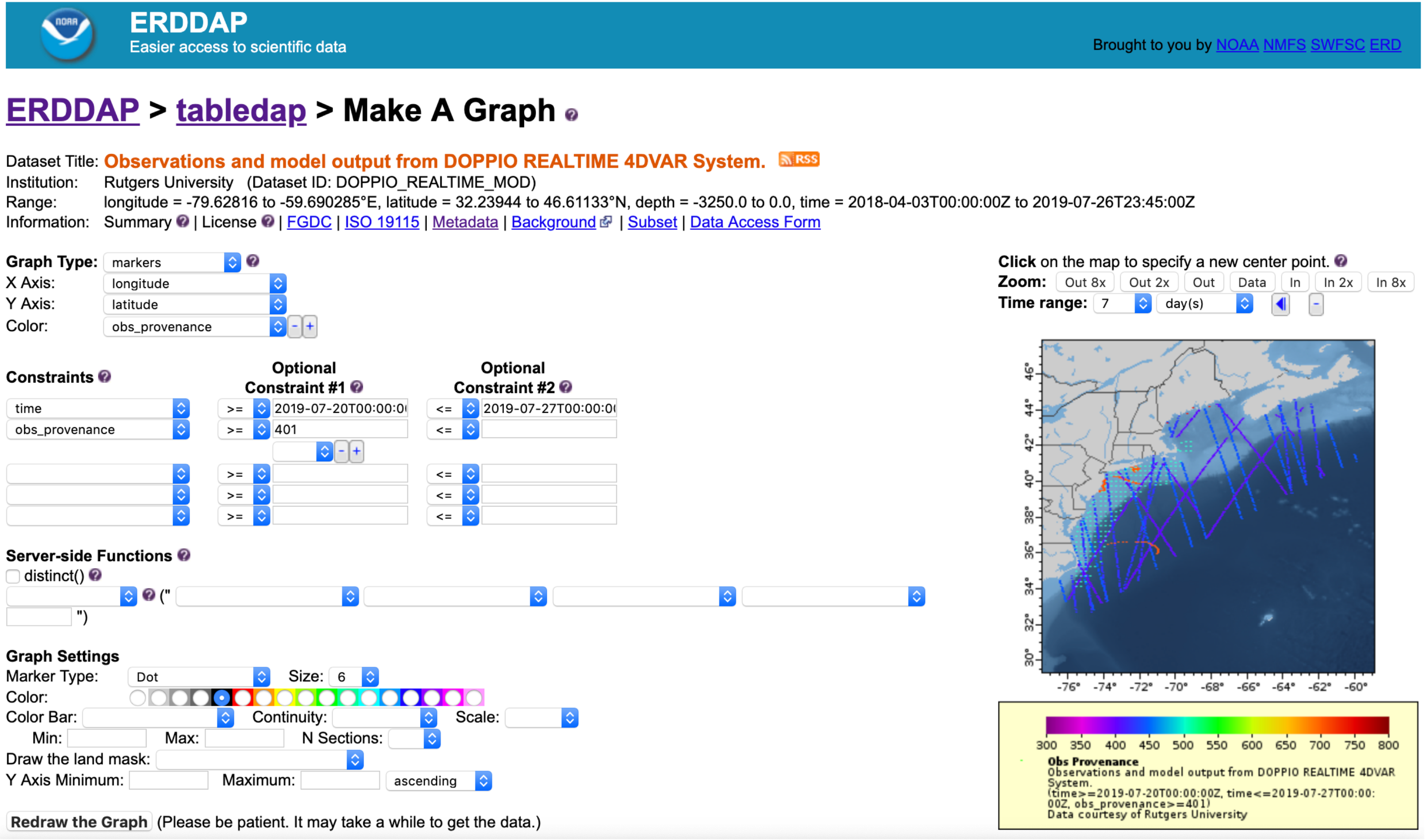
Using ERDDAP to monitor and analyze DA systems performance



ERDDAP
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ERDDAP > tabledap > Make A Graph

Dataset Title: Observations and model output from DOPPIO REALTIME 4DVAR System.
Institution: Rutgers University (Dataset ID: DOPPIO_REALTIME_MOD)
Range: longitude = -79.62816 to -59.690285°E, latitude = 32.23944 to 46.61133°N, depth = -3250.0 to 0.0, time = 2018-04-03T00:00:00Z to 2019-07-26T23:45:00Z
Information: Summary | License | FGDC | ISO 19115 | Metadata | Background | Subset | Data Access Form

Graph Type: markers
X Axis: longitude
Y Axis: latitude
Color: obs_provenance

Constraints	Optional Constraint #1		Optional Constraint #2	
time	>=	2019-07-20T00:00:0	<=	2019-07-27T00:00:0
obs_provenance	>=	401	<=	
	>=		<=	
	>=		<=	
	>=		<=	

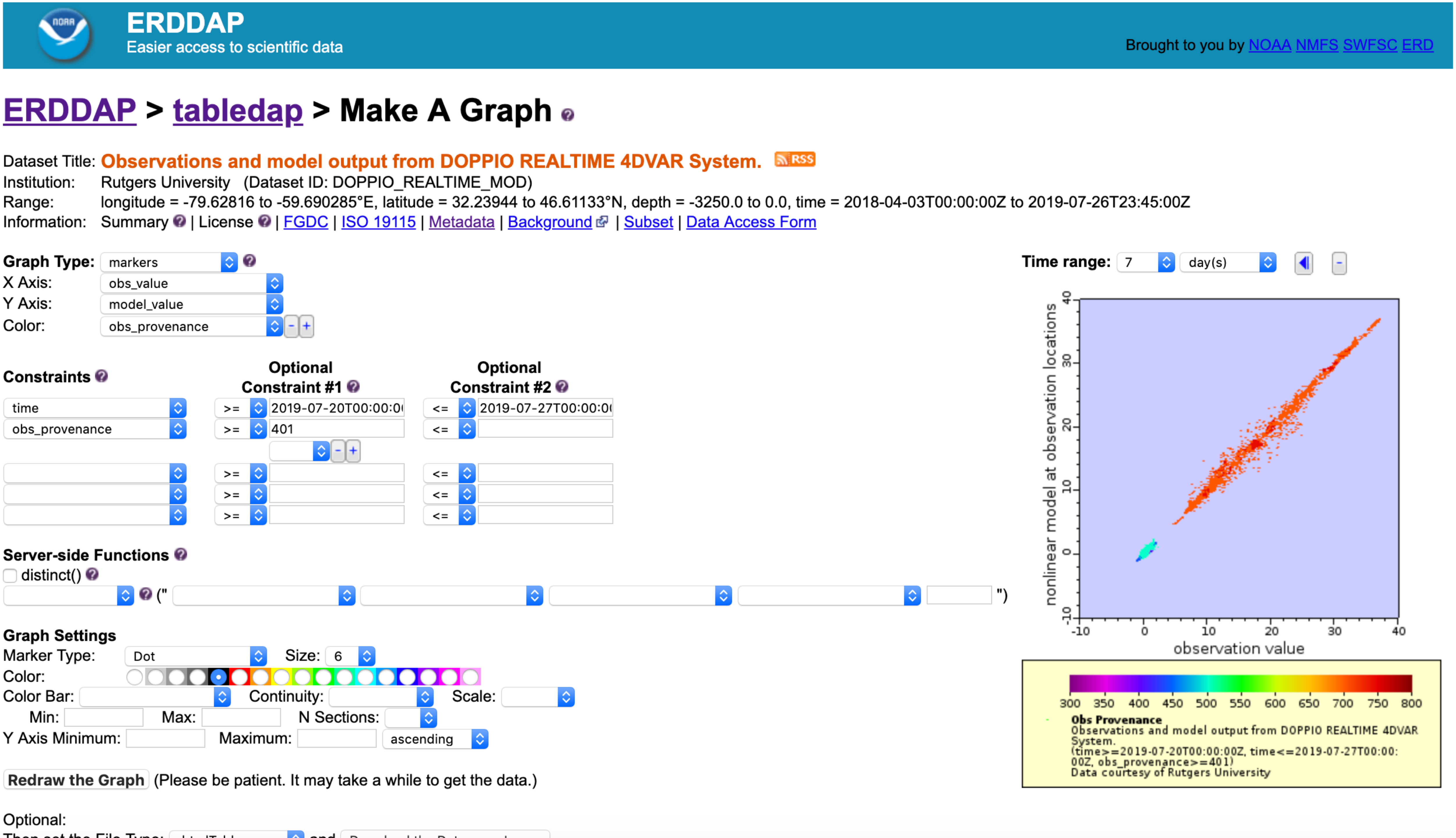
Server-side Functions
□ distinct()
(" ")

Graph Settings
Marker Type: Dot Size: 6
Color:
Color Bar: Continuity: Scale:
Min: Max: N Sections:
Draw the land mask:
Y Axis Minimum: Maximum: ascending

Redraw the Graph (Please be patient. It may take a while to get the data.)

Click on the map to specify a new center point.
Zoom: Out 8x Out 2x Out Data In In 2x In 8x
Time range: 7 day(s)

Obs Provenance
Observations and model output from DOPPIO REALTIME 4DVAR System.
(time>=2019-07-20T00:00:00Z, time<=2019-07-27T00:00:00Z, obs_provenance>=401)
Data courtesy of Rutgers University



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Information: Summary | License | FGDC | ISO 19115 | Metadata | Background | Subset | Data Access Form

Graph Type: markers
X Axis: obs_value
Y Axis: model_value
Color: obs_provenance

Time range: 7 day(s)

Constraints	Optional Constraint #1		Optional Constraint #2	
time	>=	2019-07-20T00:00:0(	<=	2019-07-27T00:00:0(
obs_provenance	>=	401	<=	
	>=		<=	
	>=		<=	
	>=		<=	

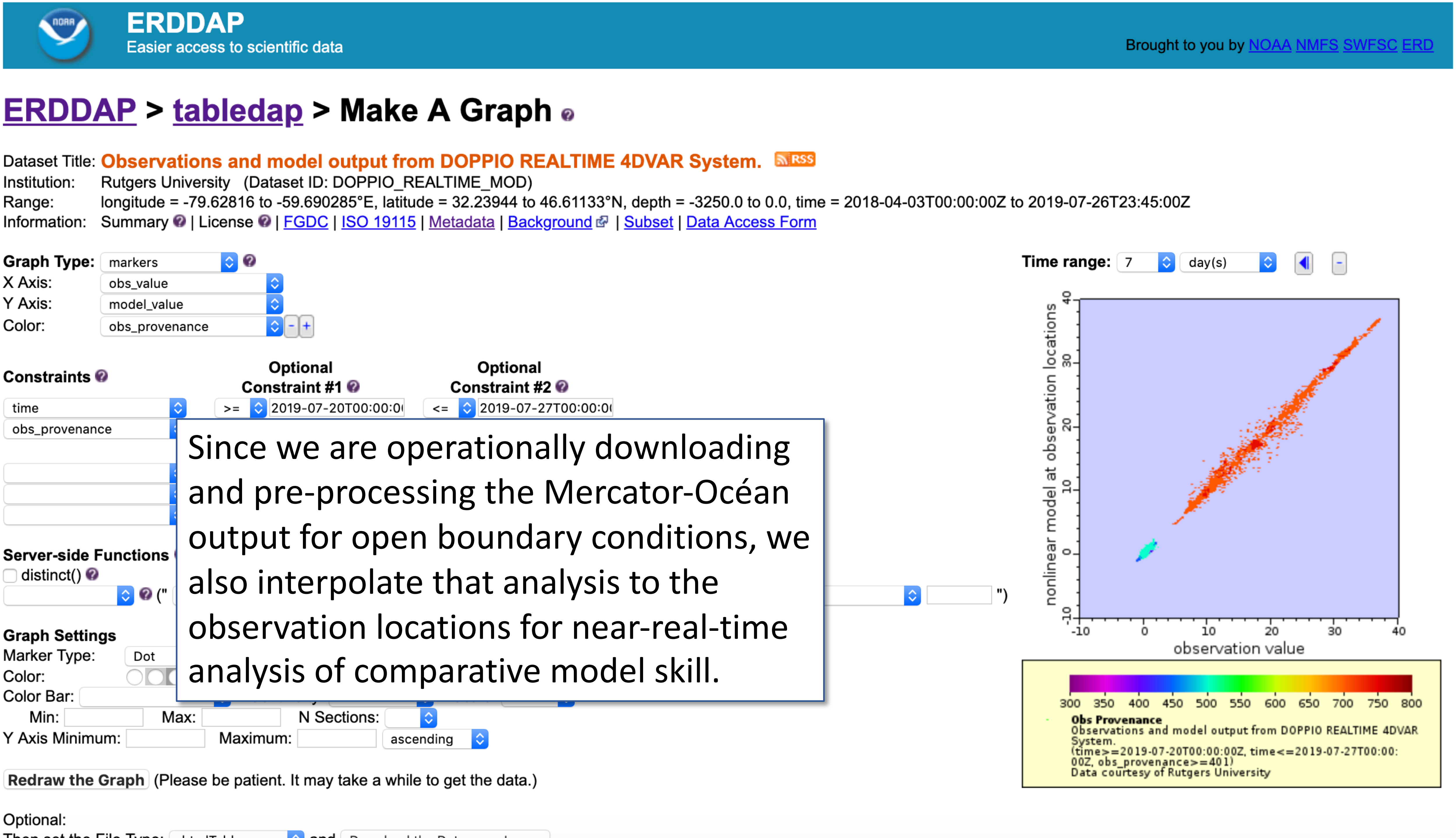
Server-side Functions
□ distinct()
(" ")

Graph Settings
Marker Type: Dot Size: 6
Color:
Color Bar: Continuity: Scale:
Min: Max: N Sections:
Y Axis Minimum: Maximum: ascending

Redraw the Graph (Please be patient. It may take a while to get the data.)

Optional:
Then set the File Type: and

Obs Provenance
Observations and model output from DOPPIO REALTIME 4DVAR System.
(time>=2019-07-20T00:00:00Z, time<=2019-07-27T00:00:00Z, obs_provenance>=401)
Data courtesy of Rutgers University



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Information: Summary | License | FGDC | ISO 19115 | Metadata | Background | Subset | Data Access Form

Graph Type: markers
X Axis: obs_value
Y Axis: model_value
Color: obs_provenance

Time range: 7 day(s)

Constraints

	Optional Constraint #1	Optional Constraint #2
time	>= 2019-07-20T00:00:0	<= 2019-07-27T00:00:0
obs_provenance		

Server-side Functions
□ distinct()

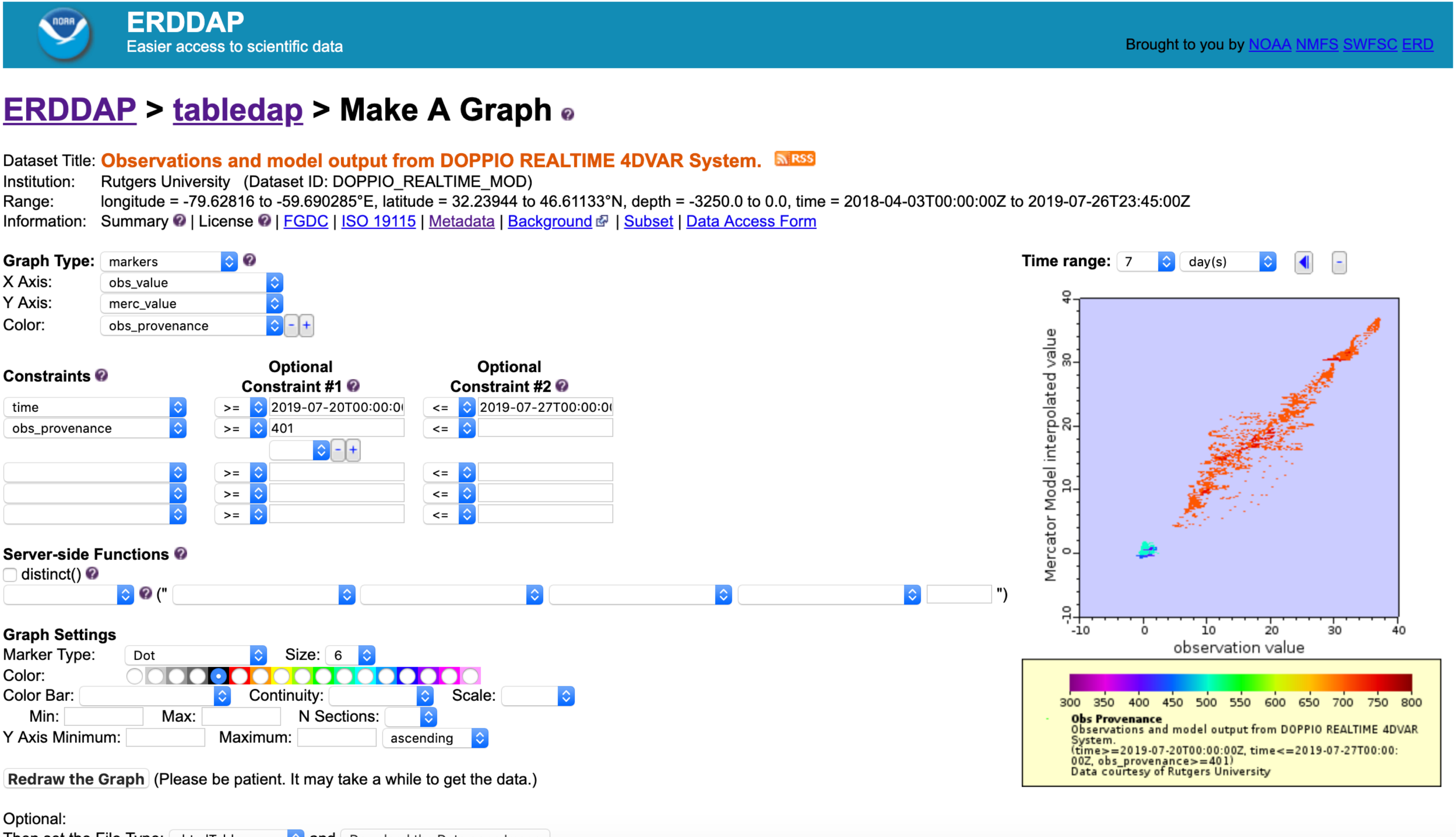
Graph Settings
Marker Type: Dot
Color:
Color Bar:
Min: Max: N Sections:
Y Axis Minimum: Maximum: ascending

Redraw the Graph (Please be patient. It may take a while to get the data.)

Optional:
Then set the File Type:

Observations and model output from DOPPIO REALTIME 4DVAR System.
(time>=2019-07-20T00:00:00Z, time<=2019-07-27T00:00:00Z, obs_provenance>=401)
Data courtesy of Rutgers University

Since we are operationally downloading and pre-processing the Mercator-Océan output for open boundary conditions, we also interpolate that analysis to the observation locations for near-real-time analysis of comparative model skill.



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Information: Summary | License | FGDC | ISO 19115 | Metadata | Background | Subset | Data Access Form

Graph Type: markers
X Axis: obs_value
Y Axis: merc_value
Color: obs_provenance

Constraints		**Optional Constraint #1**		**Optional Constraint #2**
time	>=	2019-07-20T00:00:0(	<=	2019-07-27T00:00:0(
obs_provenance	>=	401	<=	
	>=		<=	
	>=		<=	
	>=		<=	

Server-side Functions
□ distinct()
(" ")

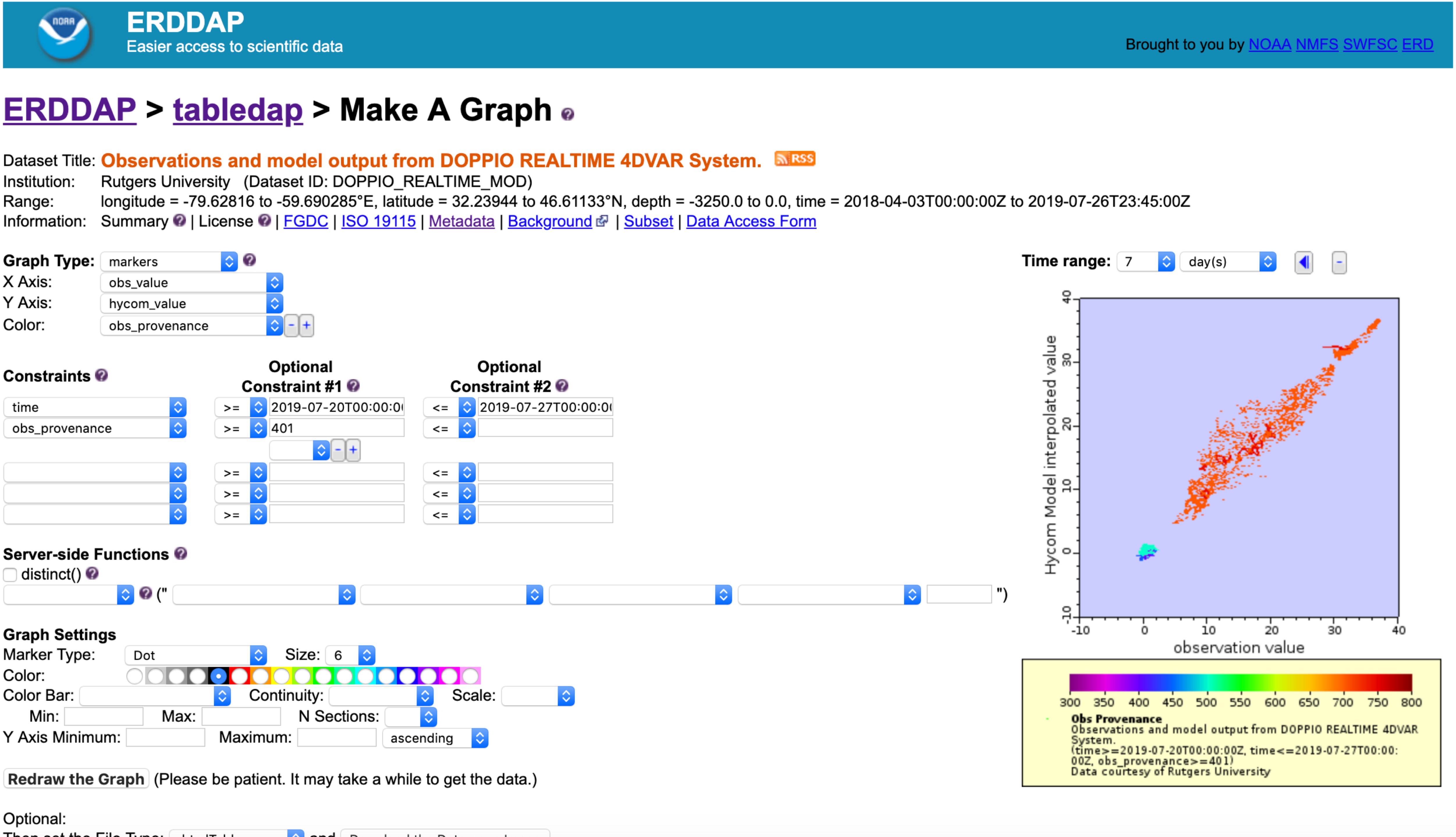
Graph Settings
Marker Type: Dot Size: 6
Color:
Color Bar: Continuity: Scale:
Min: Max: N Sections:
Y Axis Minimum: Maximum: ascending

Redraw the Graph (Please be patient. It may take a while to get the data.)

Optional:
Then set the File Type: and

Time range: 7 day(s)

Obs Provenance
Observations and model output from DOPPIO REALTIME 4DVAR System.
(time>=2019-07-20T00:00:00Z, time<=2019-07-27T00:00:00Z, obs_provenance>=401)
Data courtesy of Rutgers University



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Graph Type: markers
X Axis: obs_value
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Time range: 7 day(s)

Constraints	Optional Constraint #1		Optional Constraint #2	
time	>=	2019-07-20T00:00:0(	<=	2019-07-27T00:00:0(
obs_provenance	>=	401	<=	
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Server-side Functions
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Graph Settings
Marker Type: Dot Size: 6
Color:
Color Bar: Continuity: Scale:
Min: Max: N Sections:
Y Axis Minimum: Maximum: ascending

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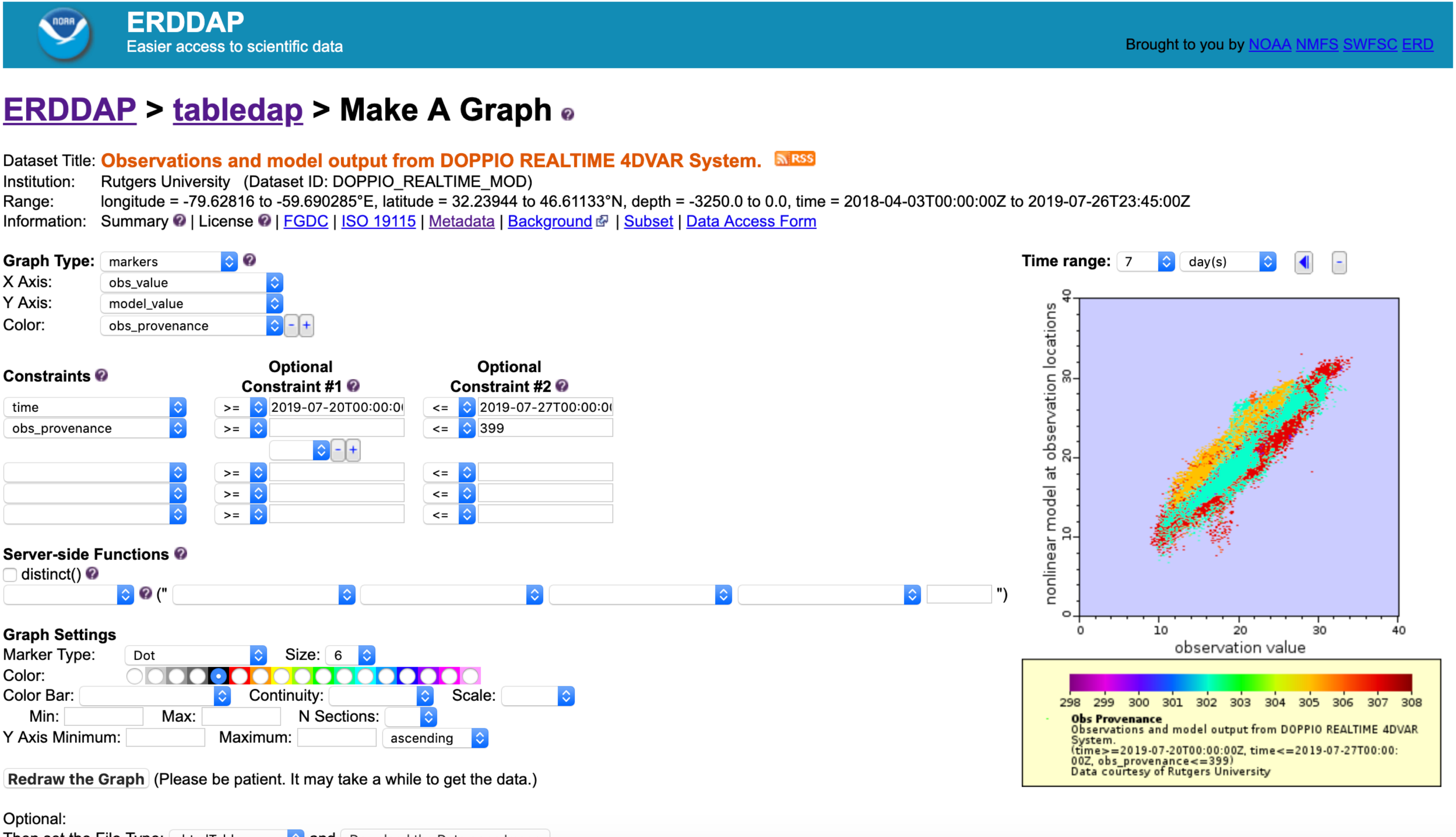
(time>=2019-07-20T00:00:00Z, time<=2019-07-27T00:00:00Z, obs_provenance>=401)
Data courtesy of Rutgers University

Optional:
Then set the File Type:



ERDDAP
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Information: Summary | License | FGDC | ISO 19115 | Metadata | Background | Subset | Data Access Form

Graph Type: markers
X Axis: obs_value
Y Axis: model_value
Color: obs_provenance

Constraints	Optional Constraint #1		Optional Constraint #2	
time	>=	2019-07-20T00:00:0(	<=	2019-07-27T00:00:0(
obs_provenance	>=		<=	399
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Server-side Functions
□ distinct()
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Graph Settings
Marker Type: Dot Size: 6
Color:
Color Bar: Continuity: Scale:
Min: Max: N Sections:
Y Axis Minimum: Maximum: ascending

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Optional:

Time range: 7 day(s)

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Observations and model output from DOPPIO REALTIME 4DVAR System.
(time>=2019-07-20T00:00:00Z, time<=2019-07-27T00:00:00Z, obs_provenance<=399)
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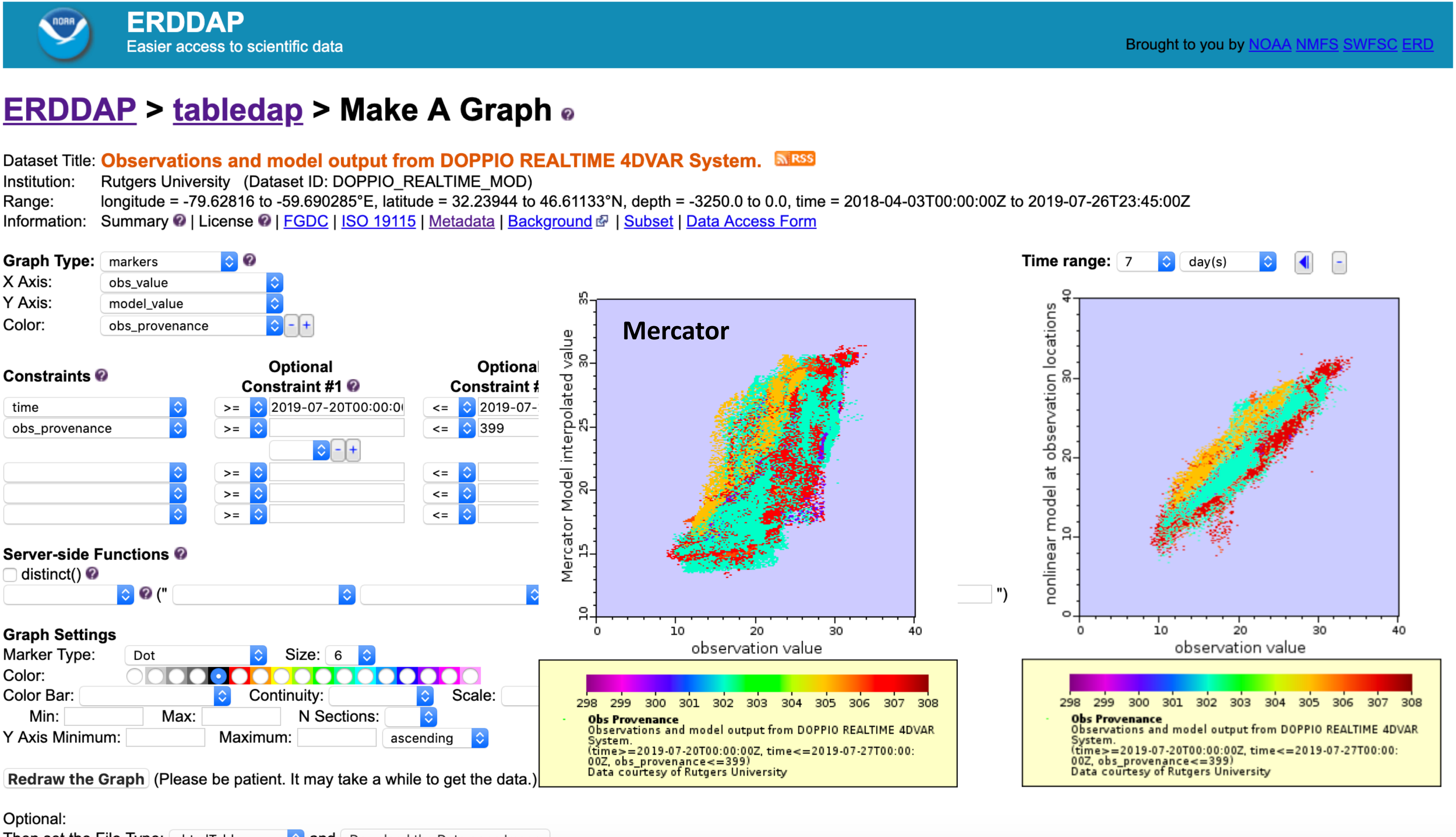

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Information: Summary | License | FGDC | ISO 19115 | Metadata | Background | Subset | Data Access Form

Graph Type: markers
X Axis: obs_value
Y Axis: model_value
Color: obs_provenance

Time range: 7 day(s)

Constraints | Optional Constraint #1 | Optional Constraint #
time | >= 2019-07-20T00:00:0 | <= 2019-07-
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Server-side Functions
□ distinct()

Graph Settings
Marker Type: Dot Size: 6
Color:
Color Bar: Continuity: Scale:
Min: Max: N Sections:
Y Axis Minimum: Maximum: ascending

Redraw the Graph (Please be patient. It may take a while to get the data.)

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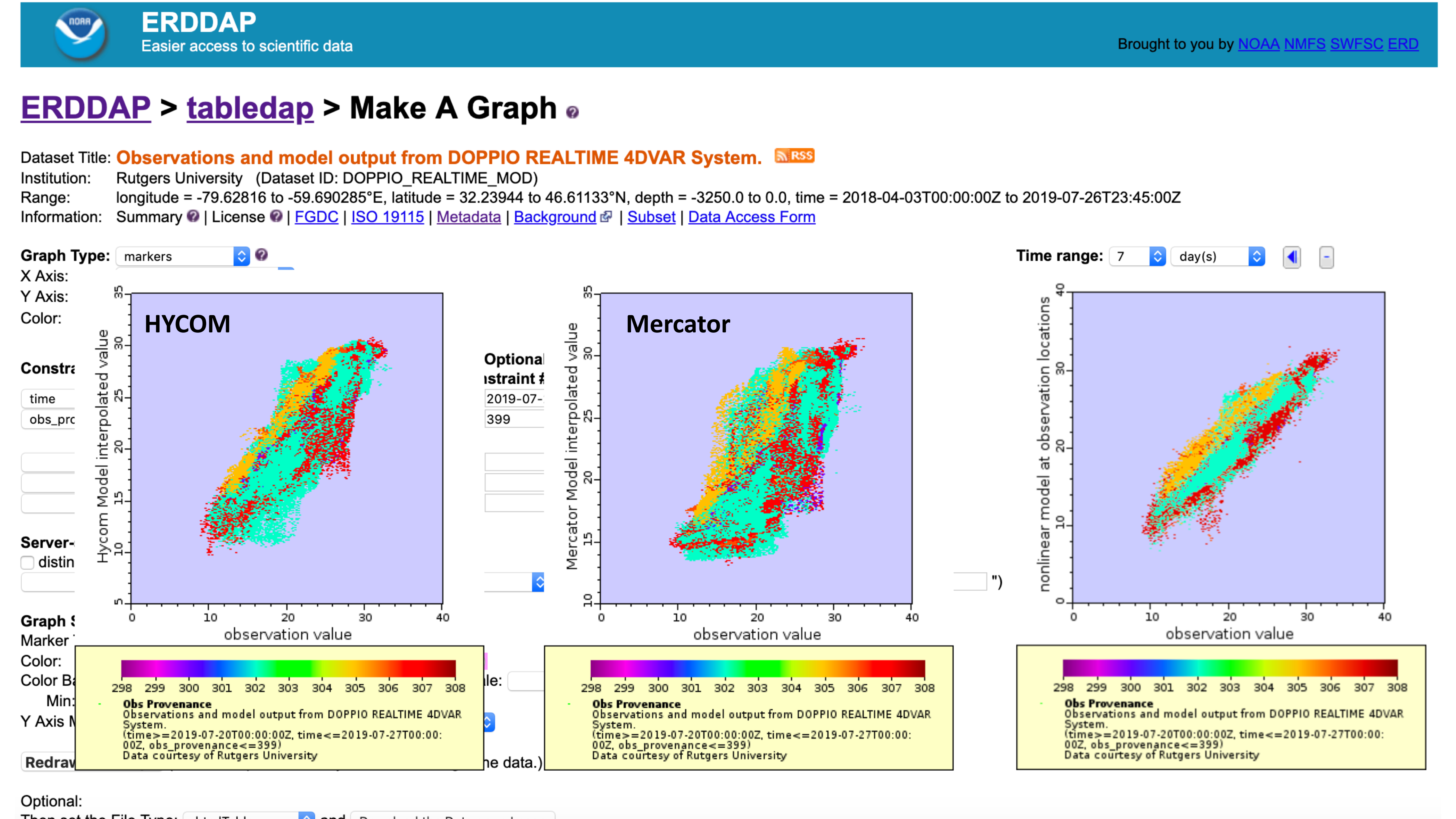
Observations and model output from DOPPIO REALTIME 4DVAR System.
(time>=2019-07-20T00:00:00Z, time<=2019-07-27T00:00:00Z, obs_provenance<=399)
Data courtesy of Rutgers University

Obs Provenance
Observations and model output from DOPPIO REALTIME 4DVAR System.
(time>=2019-07-20T00:00:00Z, time<=2019-07-27T00:00:00Z, obs_provenance<=399)
Data courtesy of Rutgers University



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Information: Summary | License | FGDC | ISO 19115 | Metadata | Background | Subset | Data Access Form

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Time range: 7 day(s)

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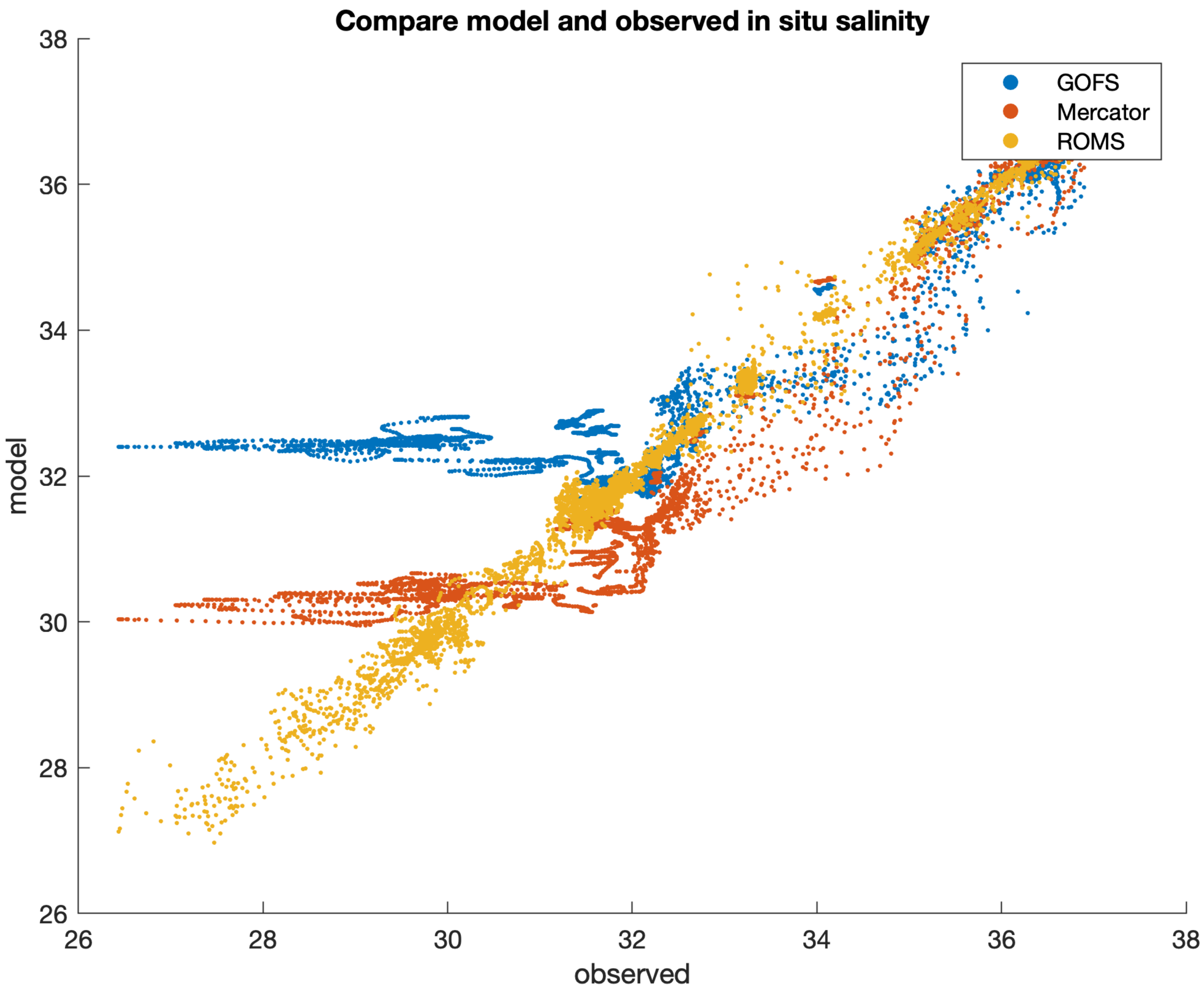
Obs Provenance
Observations and model output from DOPPIO REALTIME 4DVAR System.
(time>=2019-07-20T00:00:00Z, time<=2019-07-27T00:00:00Z, obs_provenance<=399)
Data courtesy of Rutgers University

Obs Provenance
Observations and model output from DOPPIO REALTIME 4DVAR System.
(time>=2019-07-20T00:00:00Z, time<=2019-07-27T00:00:00Z, obs_provenance<=399)
Data courtesy of Rutgers University

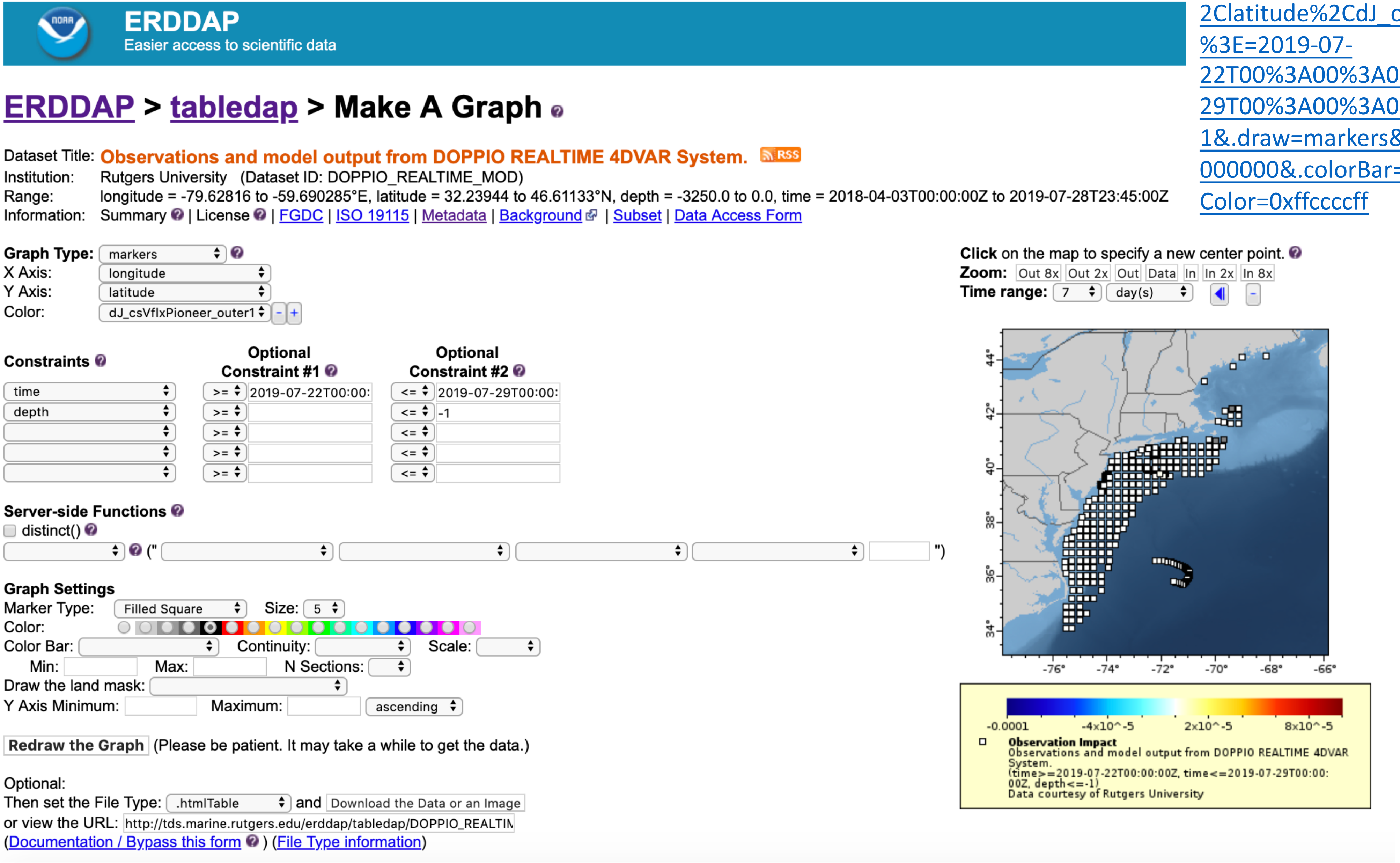
Obs Provenance
Observations and model output from DOPPIO REALTIME 4DVAR System.
(time>=2019-07-20T00:00:00Z, time<=2019-07-27T00:00:00Z, obs_provenance<=399)
Data courtesy of Rutgers University

Using ERDDAP to monitor and analyze DA systems performance



Using ERDDAP to monitor and analyze DA systems performance

http://tds.marine.rutgers.edu/erddap/tabledap/DOPPIO_REALTIME_MOD.graph?longitude%2Clatitude%2CdJ_csVflxPioneer_outer1&time%3E=2019-07-22T00%3A00%3A00Z&time%3C=2019-07-29T00%3A00%3A00Z&depth%3C=-1&.draw=markers&.marker=5%7C5&.color=0x000000&.colorBar=%7C%7C%7C%7C%7C&.bgColor=0xffccccff



ERDDAP
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Information: Summary | License | FGDC | ISO 19115 | Metadata | Background | Subset | Data Access Form

Graph Type: markers
X Axis: longitude
Y Axis: latitude
Color: dJ_csVflxPioneer_outer1

Constraints	Optional Constraint #1		Optional Constraint #2	
time	>=	2019-07-22T00:00:	<=	2019-07-29T00:00:
depth	>=		<=	-1
	>=		<=	
	>=		<=	
	>=		<=	

Server-side Functions
□ distinct()
(" ")

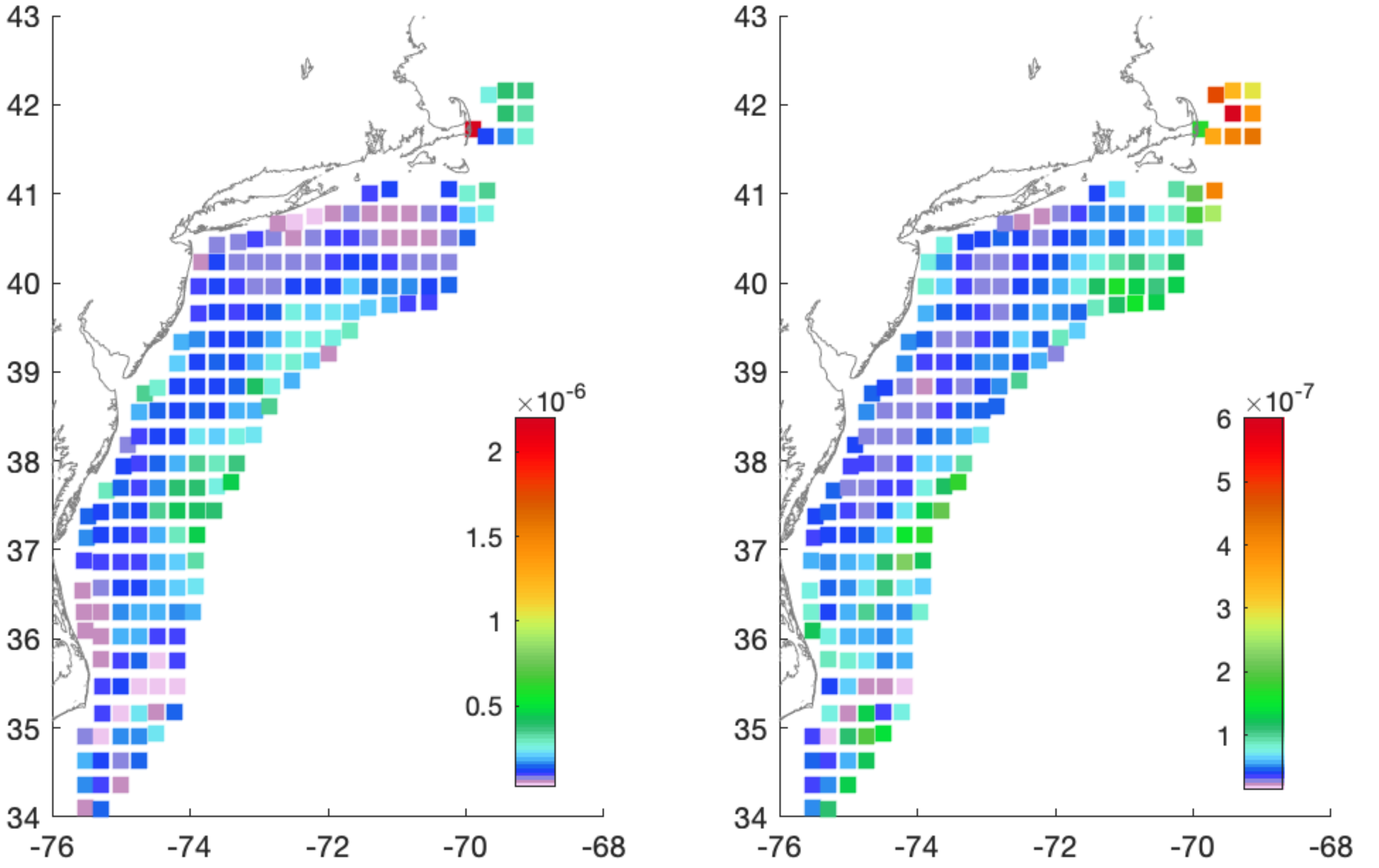
Graph Settings
Marker Type: Filled Square Size: 5
Color:
Color Bar: Continuity: Scale:
Min: Max: N Sections:
Draw the land mask:
Y Axis Minimum: Maximum: ascending

Redraw the Graph (Please be patient. It may take a while to get the data.)

Optional:
Then set the File Type: .htmlTable and Download the Data or an Image
or view the URL: http://tds.marine.rutgers.edu/erddap/tabledap/DOPPIO_REALTIN
(Documentation / Bypass this form) (File Type information)

Click on the map to specify a new center point.
Zoom: Out 8x Out 2x Out Data In In 2x In 8x
Time range: 7 day(s)

□ Observation Impact
Observations and model output from DOPPIO REALTIME 4DVAR System.
(time>=2019-07-22T00:00:00Z, time<=2019-07-29T00:00:00Z, depth<=-1)
Data courtesy of Rutgers University



Standard deviation of MARACOOS cross-shelf transport observation impact metric computed for 3 months of output (Oct-Dec, 2018) from the real-time system. Impacts are for (left) u- and (right) v-component of vector total velocity measured by the MARACOOS HF-radar network.

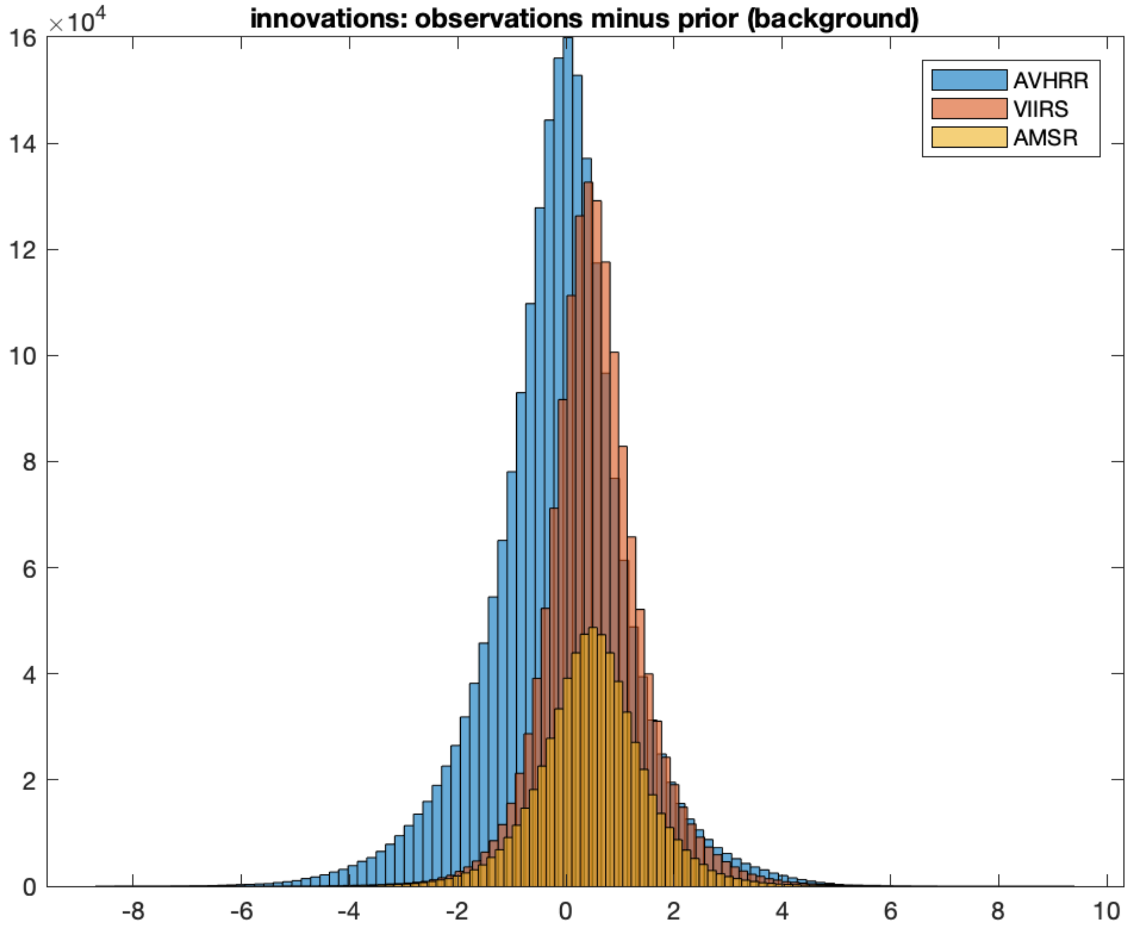
Using ERDDAP to monitor and analyze DA systems performance

We post-process the *obs, fwd* and *mod* files to assemble the:

- **innovation**
- **increment**
- **residual**
- **observation error**
- **background error**
- **obs. impact (from first outer loop)**

which are all in the observation space and with the same *datum* dimension

Using ERDDAP we can easily download subsets of the data from different observing platforms and contrast prior and posterior data-model misfit.



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- **observation error**
- **background error**
- **obs. impact (from first outer loop)**

which are all in the observation space and with the same *datum* dimension

We've done this for the WC13 test case:

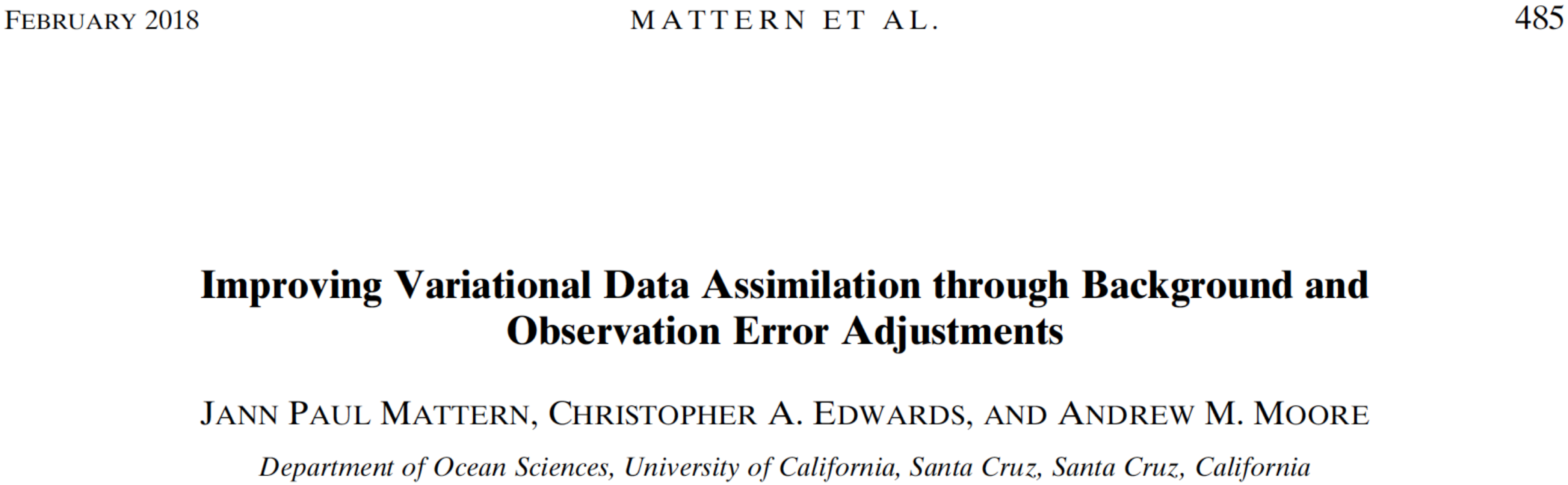
http://tds.marine.rutgers.edu/erddap/tabledap/wc13_mod_i4dvar.graph

http://tds.marine.rutgers.edu/erddap/tabledap/wc13_mod_psas.graph

(Only PSAS has observation impacts.)

Original WC13 outputs are here:
http://tds.marine.rutgers.edu/thredds/catalog/projects/wilkin/wc13/catalog.html

Statistics of prior and posterior errors inform us about the validity of the assumed observation and background error hypotheses



FEBRUARY 2018 MATTERN ET AL. 485

Improving Variational Data Assimilation through Background and Observation Error Adjustments

JANN PAUL MATTERN, CHRISTOPHER A. EDWARDS, AND ANDREW M. MOORE

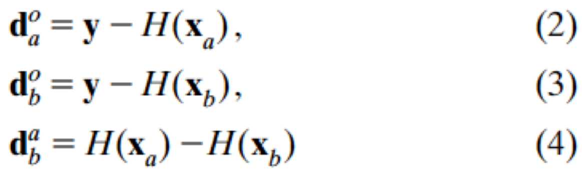
Department of Ocean Sciences, University of California, Santa Cruz, Santa Cruz, California

Mattern, J. Paul, C. A. Edwards, and A. M. Moore, 2018, "Improving variational data assimilation through background and observation error adjustments." Monthly Weather Review 146.2: 485-501.

Desroziers, G, L. Berre, B. Chapnik, and P. Poli, 2005: Diagnosis of observation, background and analysis-error statistics in observation space. Quart. J. Roy. Meteor. Soc., 131, 3385–3396, https://doi.org/10.1256/qj.05.108.

Objective adjustment of 4D-Var observation and background error assumptions

residual ->



$$\mathbf{d}_a^o = \mathbf{y} - H(\mathbf{x}_a), \quad (2)$$

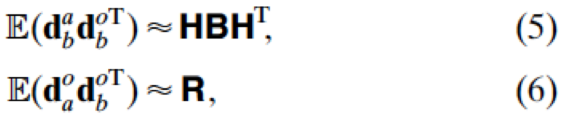
innovation ->

$$\mathbf{d}_b^o = \mathbf{y} - H(\mathbf{x}_b), \quad (3)$$

increment ->

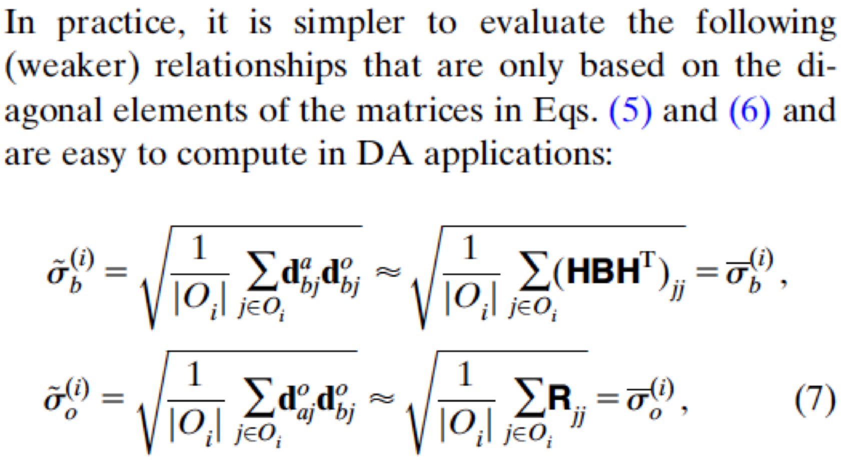
$$\mathbf{d}_b^a = H(\mathbf{x}_a) - H(\mathbf{x}_b) \quad (4)$$

For a linearized observation operator, Desroziers et al. (2005) show that the following relationships should approximately hold for correctly specified variational DA systems:



$$\mathbb{E}(\mathbf{d}_b^a \mathbf{d}_b^{o\mathrm{T}}) \approx \mathbf{HBH}^{\mathrm{T}}, \quad (5)$$

$$\mathbb{E}(\mathbf{d}_a^o \mathbf{d}_b^{o\mathrm{T}}) \approx \mathbf{R}, \quad (6)$$

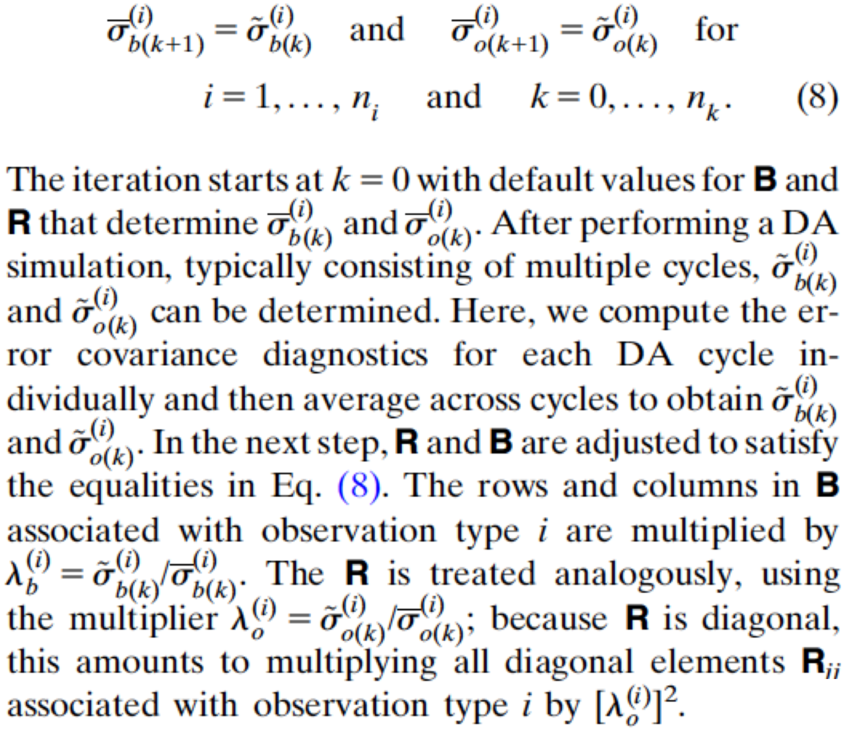


In practice, it is simpler to evaluate the following (weaker) relationships that are only based on the diagonal elements of the matrices in Eqs. (5) and (6) and are easy to compute in DA applications:

$$\tilde{\sigma}_b^{(i)} = \sqrt{\frac{1}{|O_i|} \sum_{j \in O_i} \mathbf{d}_{bj}^a \mathbf{d}_{bj}^o} \approx \sqrt{\frac{1}{|O_i|} \sum_{j \in O_i} (\mathbf{HBH}^{\mathrm{T}})_{jj}} = \bar{\sigma}_b^{(i)},$$

$$\tilde{\sigma}_o^{(i)} = \sqrt{\frac{1}{|O_i|} \sum_{j \in O_i} \mathbf{d}_{aj}^o \mathbf{d}_{bj}^o} \approx \sqrt{\frac{1}{|O_i|} \sum_{j \in O_i} \mathbf{R}_{jj}} = \bar{\sigma}_o^{(i)}, \quad (7)$$

Building on ideas of Desroziers and others, Mattern et al. (2018) construct a Fixed Point Iteration to adjust background and observation errors to improve the consistency of the DA system error statistics.



$$\bar{\sigma}_{b(k+1)}^{(i)} = \tilde{\sigma}_{b(k)}^{(i)} \quad \text{and} \quad \bar{\sigma}_{o(k+1)}^{(i)} = \tilde{\sigma}_{o(k)}^{(i)} \quad \text{for}$$
$$i = 1, \ldots, n_i \quad \text{and} \quad k = 0, \ldots, n_k. \quad (8)$$

The iteration starts at $k = 0$ with default values for **B** and **R** that determine $\bar{\sigma}_{b(k)}^{(i)}$ and $\bar{\sigma}_{o(k)}^{(i)}$. After performing a DA simulation, typically consisting of multiple cycles, $\tilde{\sigma}_{b(k)}^{(i)}$ and $\tilde{\sigma}_{o(k)}^{(i)}$ can be determined. Here, we compute the error covariance diagnostics for each DA cycle individually and then average across cycles to obtain $\tilde{\sigma}_{b(k)}^{(i)}$ and $\tilde{\sigma}_{o(k)}^{(i)}$. In the next step, **R** and **B** are adjusted to satisfy the equalities in Eq. (8). The rows and columns in **B** associated with observation type i are multiplied by $\lambda_b^{(i)} = \tilde{\sigma}_{b(k)}^{(i)} / \bar{\sigma}_{b(k)}^{(i)}$. The **R** is treated analogously, using the multiplier $\lambda_o^{(i)} = \tilde{\sigma}_{o(k)}^{(i)} / \bar{\sigma}_{o(k)}^{(i)}$; because **R** is diagonal, this amounts to multiplying all diagonal elements $\mathbf{R}_{ii}$ associated with observation type i by $[\lambda_o^{(i)}]^2$.

Mattern, J. Paul, C. A. Edwards, and A. M. Moore, 2018, "Improving variational data assimilation through background and observation error adjustments." Monthly Weather Review 146.2: 485-501.

Desroziers, G, L. Berre, B. Chapnik, and P. Poli, 2005: Diagnosis of observation, background and analysis-error statistics in observation space. Quart. J. Roy. Meteor. Soc., 131, 3385–3396, https://doi.org/10.1256/qj.05.108.

Extract these data from ERDDAP obs/mod file browser

residual -> $$\mathbf{d}_a^o = \mathbf{y} - H(\mathbf{x}_a), \qquad (2)$$

innovation -> $$\mathbf{d}_b^o = \mathbf{y} - H(\mathbf{x}_b), \qquad (3)$$

increment -> $$\mathbf{d}_b^a = H(\mathbf{x}_a) - H(\mathbf{x}_b) \qquad (4)$$

Compute

$$\tilde{\sigma}_b^{(i)} = \sqrt{\frac{1}{|O_i|} \sum_{j \in O_i} \mathbf{d}_{bj}^a \mathbf{d}_{bj}^o} \approx \sqrt{\frac{1}{|O_i|} \sum_{j \in O_i} (\mathbf{HBH}^{\mathrm{T}})_{jj}} = \overline{\sigma}_b^{(i)},$$

$$\tilde{\sigma}_o^{(i)} = \sqrt{\frac{1}{|O_i|} \sum_{j \in O_i} \mathbf{d}_{aj}^o \mathbf{d}_{bj}^o} \approx \sqrt{\frac{1}{|O_i|} \sum_{j \in O_i} \mathbf{R}_{jj}} = \overline{\sigma}_o^{(i)}, \qquad (7)$$

Extract these data from ERDDAP obs/mod file browser

residual -> $$\mathbf{d}_a^o = \mathbf{y} - H(\mathbf{x}_a), \tag{2}$$

innovation -> $$\mathbf{d}_b^o = \mathbf{y} - H(\mathbf{x}_b), \tag{3}$$

increment -> $$\mathbf{d}_b^a = H(\mathbf{x}_a) - H(\mathbf{x}_b) \tag{4}$$

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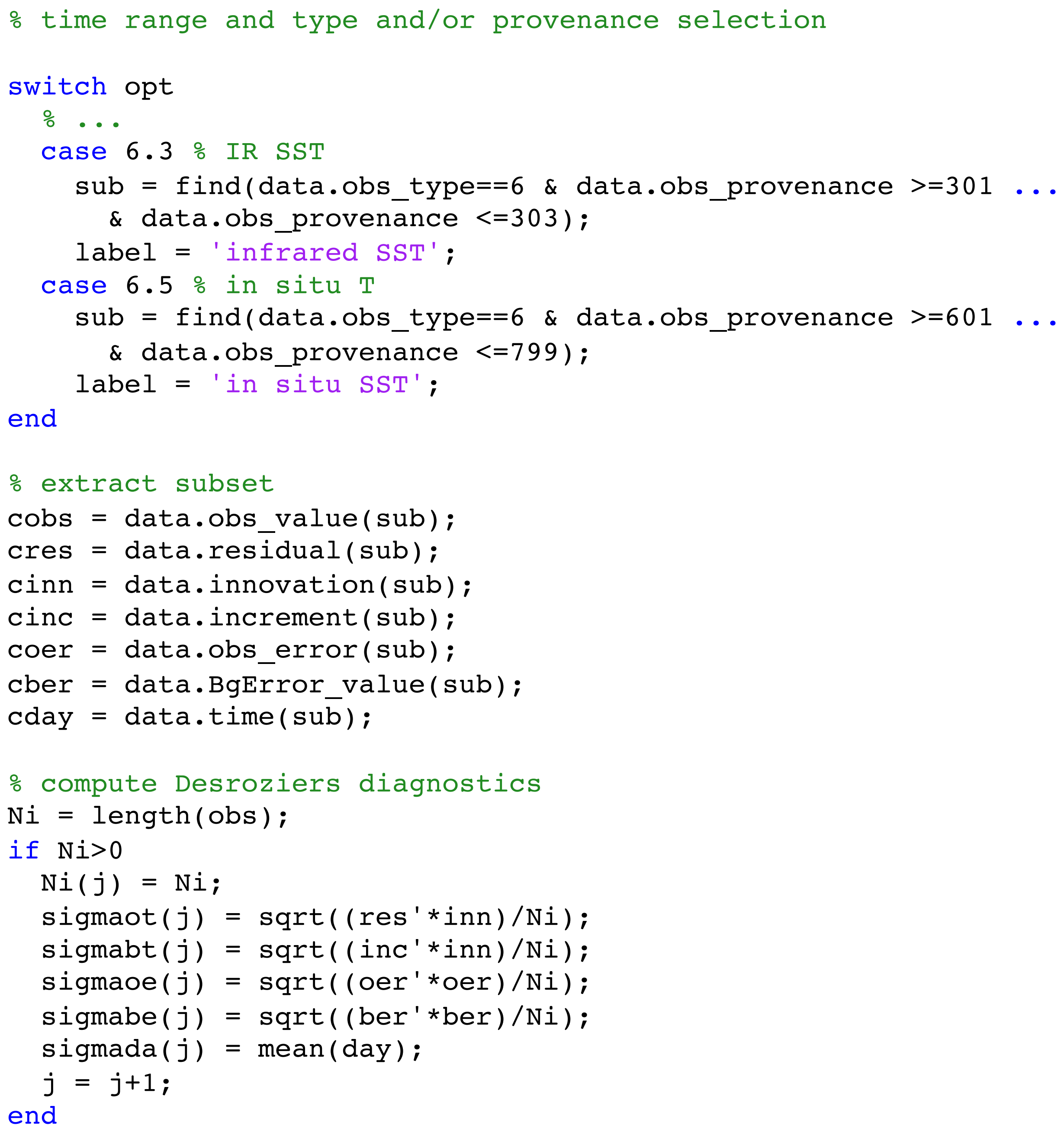
$$\tilde{\sigma}_o^{(i)} = \sqrt{\frac{1}{|O_i|}\sum_{j\in O_i}\mathbf{d}_{aj}^o\mathbf{d}_{bj}^o} \approx \sqrt{\frac{1}{|O_i|}\sum_{j\in O_i}\mathbf{R}_{jj}} = \bar{\sigma}_o^{(i)}, \tag{7}$$



```
% time range and type and/or provenance selection

switch opt
  % ...
  case 6.3 % IR SST
    sub = find(data.obs_type==6 & data.obs_provenance >=301 ...
      & data.obs_provenance <=303);
    label = 'infrared SST';
  case 6.5 % in situ T
    sub = find(data.obs_type==6 & data.obs_provenance >=601 ...
      & data.obs_provenance <=799);
    label = 'in situ SST';
end

% extract subset
cobs = data.obs_value(sub);
cres = data.residual(sub);
cinn = data.innovation(sub);
cinc = data.increment(sub);
coer = data.obs_error(sub);
cber = data.BgError_value(sub);
cday = data.time(sub);

% compute Desroziers diagnostics
Ni = length(obs);
if Ni>0
  Ni(j) = Ni;
  sigmaot(j) = sqrt((res'*inn)/Ni);
  sigmabt(j) = sqrt((inc'*inn)/Ni);
  sigmaoe(j) = sqrt((oer'*oer)/Ni);
  sigmabe(j) = sqrt((ber'*ber)/Ni);
  sigmada(j) = mean(day);
  j = j+1;
end
```

Extract these data from ERDDAP obs/mod file browser

$$\text{residual ->} \quad \mathbf{d}_a^o = \mathbf{y} - H(\mathbf{x}_a), \qquad (2)$$

$$\text{innovation ->} \quad \mathbf{d}_b^o = \mathbf{y} - H(\mathbf{x}_b), \qquad (3)$$

$$\text{increment ->} \quad \mathbf{d}_b^a = H(\mathbf{x}_a) - H(\mathbf{x}_b) \qquad (4)$$

Compute

$$\tilde{\sigma}_b^{(i)} = \sqrt{\frac{1}{|O_i|}\sum_{j\in O_i}\mathbf{d}_{bj}^a\mathbf{d}_{bj}^o} \approx \sqrt{\frac{1}{|O_i|}\sum_{j\in O_i}(\mathbf{HBH}^{\mathrm{T}})_{jj}} = \overline{\sigma}_b^{(i)},$$

$$\tilde{\sigma}_o^{(i)} = \sqrt{\frac{1}{|O_i|}\sum_{j\in O_i}\mathbf{d}_{aj}^o\mathbf{d}_{bj}^o} \approx \sqrt{\frac{1}{|O_i|}\sum_{j\in O_i}\mathbf{R}_{jj}} = \overline{\sigma}_o^{(i)}, \qquad (7)$$

Revise estimated background and observation error and repeat the analysis

$$\overline{\sigma}_{b(k+1)}^{(i)} = \tilde{\sigma}_{b(k)}^{(i)} \quad \text{and} \quad \overline{\sigma}_{o(k+1)}^{(i)} = \tilde{\sigma}_{o(k)}^{(i)} \quad \text{for}$$

$$i = 1, \ldots, n_i \quad \text{and} \quad k = 0, \ldots, n_k. \qquad (8)$$

```
% time range and type and/or provenance selection

switch opt
  % ...
  case 6.3 % IR SST
    sub = find(data.obs_type==6 & data.obs_provenance >=301 ...
      & data.obs_provenance <=303);
    label = 'infrared SST';
  case 6.5 % in situ T
    sub = find(data.obs_type==6 & data.obs_provenance >=601 ...
      & data.obs_provenance <=799);
    label = 'in situ SST';
end

% extract subset
cobs = data.obs_value(sub);
cres = data.residual(sub);
cinn = data.innovation(sub);
cinc = data.increment(sub);
coer = data.obs_error(sub);
cber = data.BgError_value(sub);
cday = data.time(sub);

% compute Desroziers diagnostics
Ni = length(obs);
if Ni>0
  Ni(j) = Ni;
  sigmaot(j) = sqrt((res'*inn)/Ni);
  sigmabt(j) = sqrt((inc'*inn)/Ni);
  sigmaoe(j) = sqrt((oer'*oer)/Ni);
  sigmabe(j) = sqrt((ber'*ber)/Ni);
  sigmada(j) = mean(day);
  j = j+1;
end
```

Objective adjustment of 4D-Var observation and background error assumptions

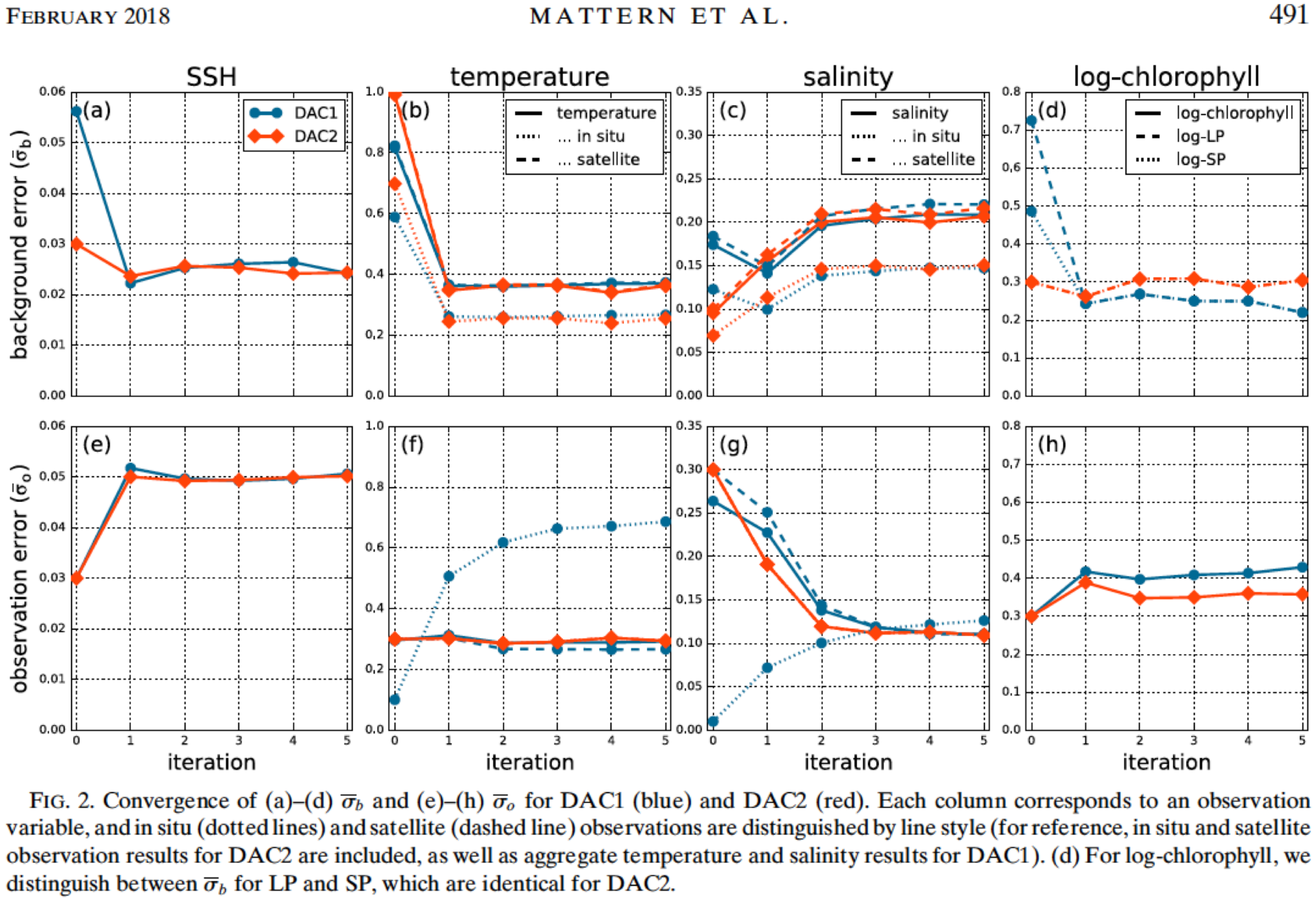


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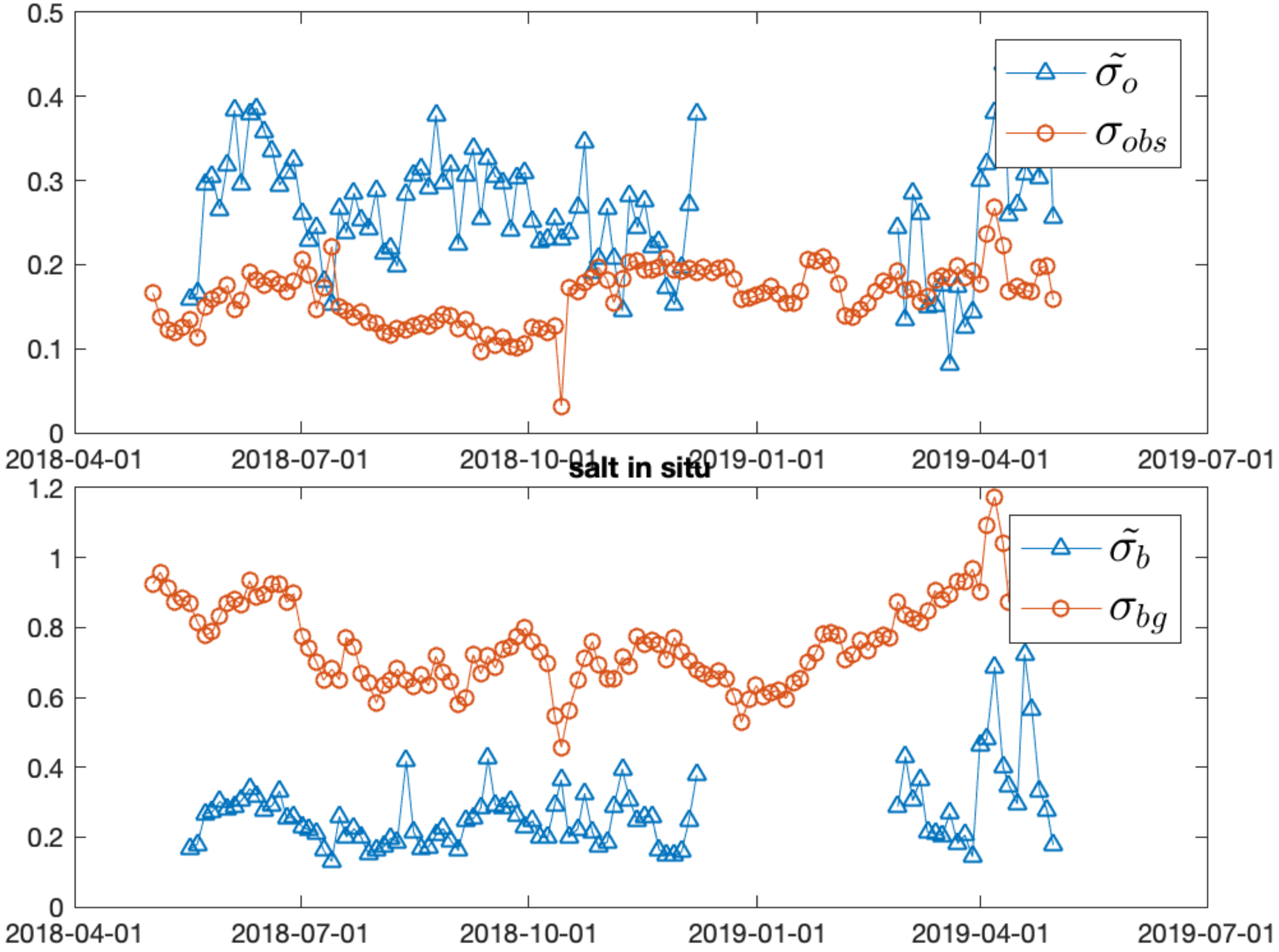
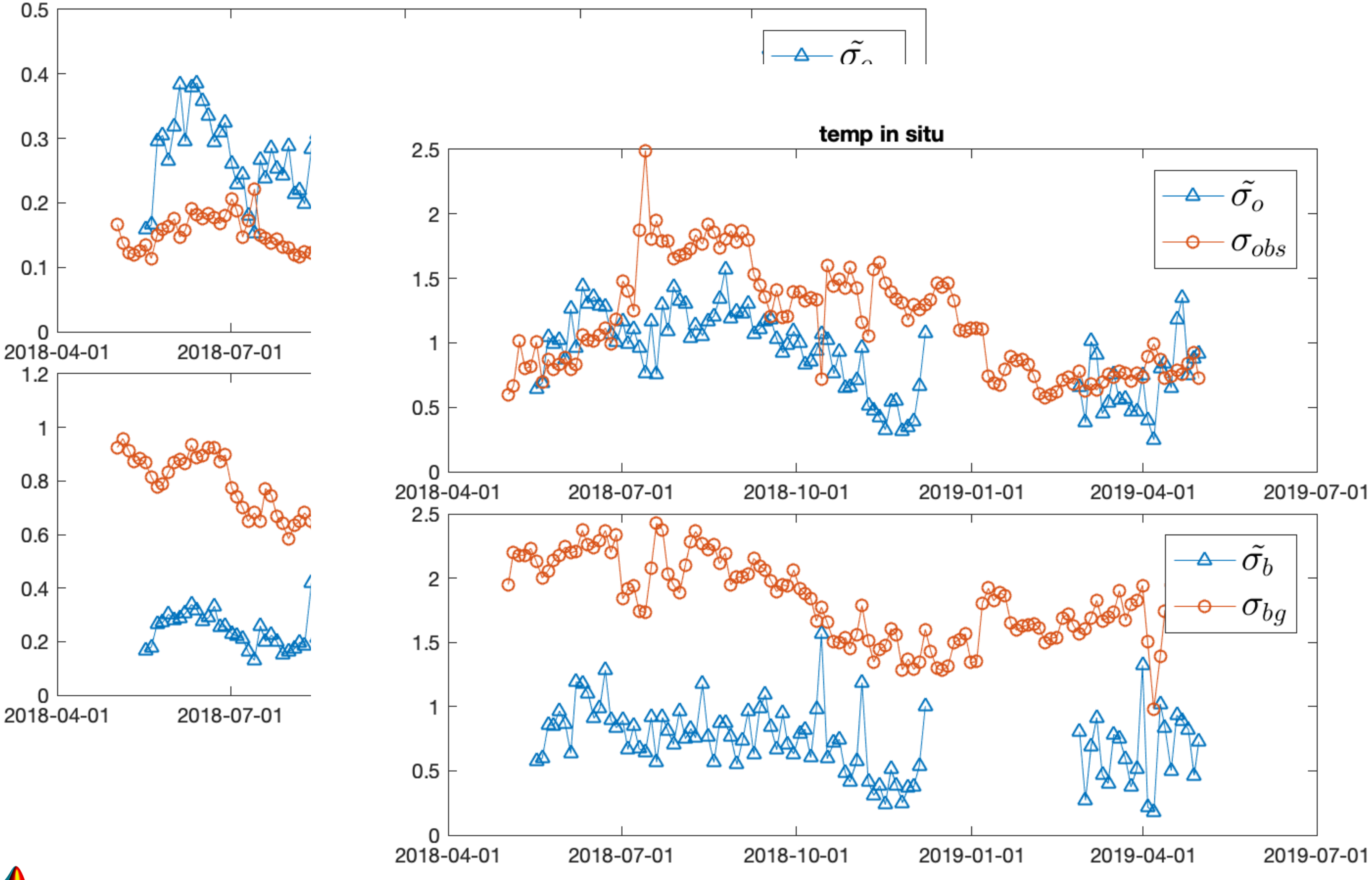
FIG. 2. Convergence of (a)–(d) $\overline{\sigma}_b$ and (e)–(h) $\overline{\sigma}_o$ for DAC1 (blue) and DAC2 (red). Each column corresponds to an observation variable, and in situ (dotted lines) and satellite (dashed line) observations are distinguished by line style (for reference, in situ and satellite observation results for DAC2 are included, as well as aggregate temperature and salinity results for DAC1). (d) For log-chlorophyll, we distinguish between $\overline{\sigma}_b$ for LP and SP, which are identical for DAC2.

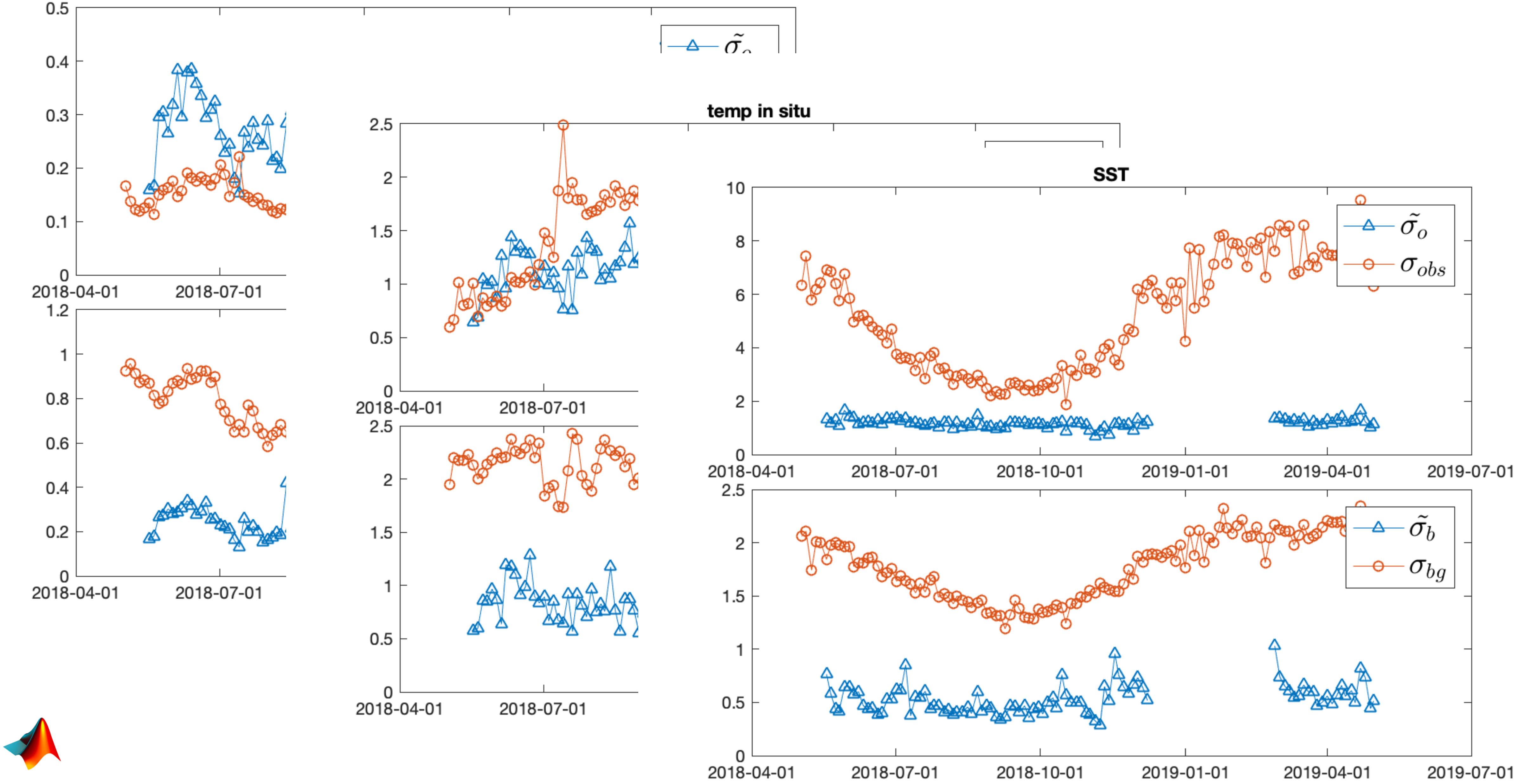
Objective adjustment of 4D-Var observation and background error assumptions

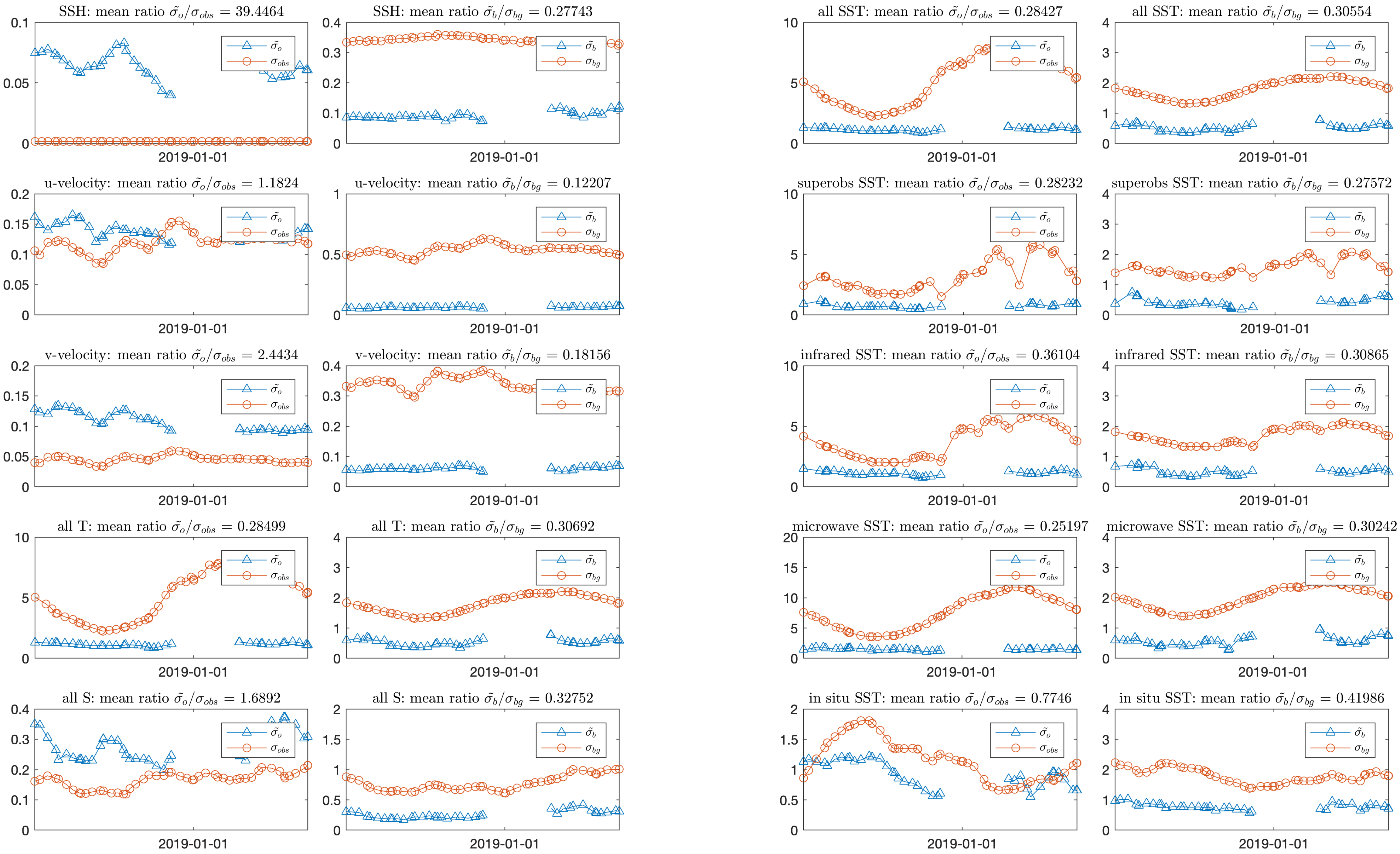


Objective adjustment of 4D-Var observation and background error assumptions



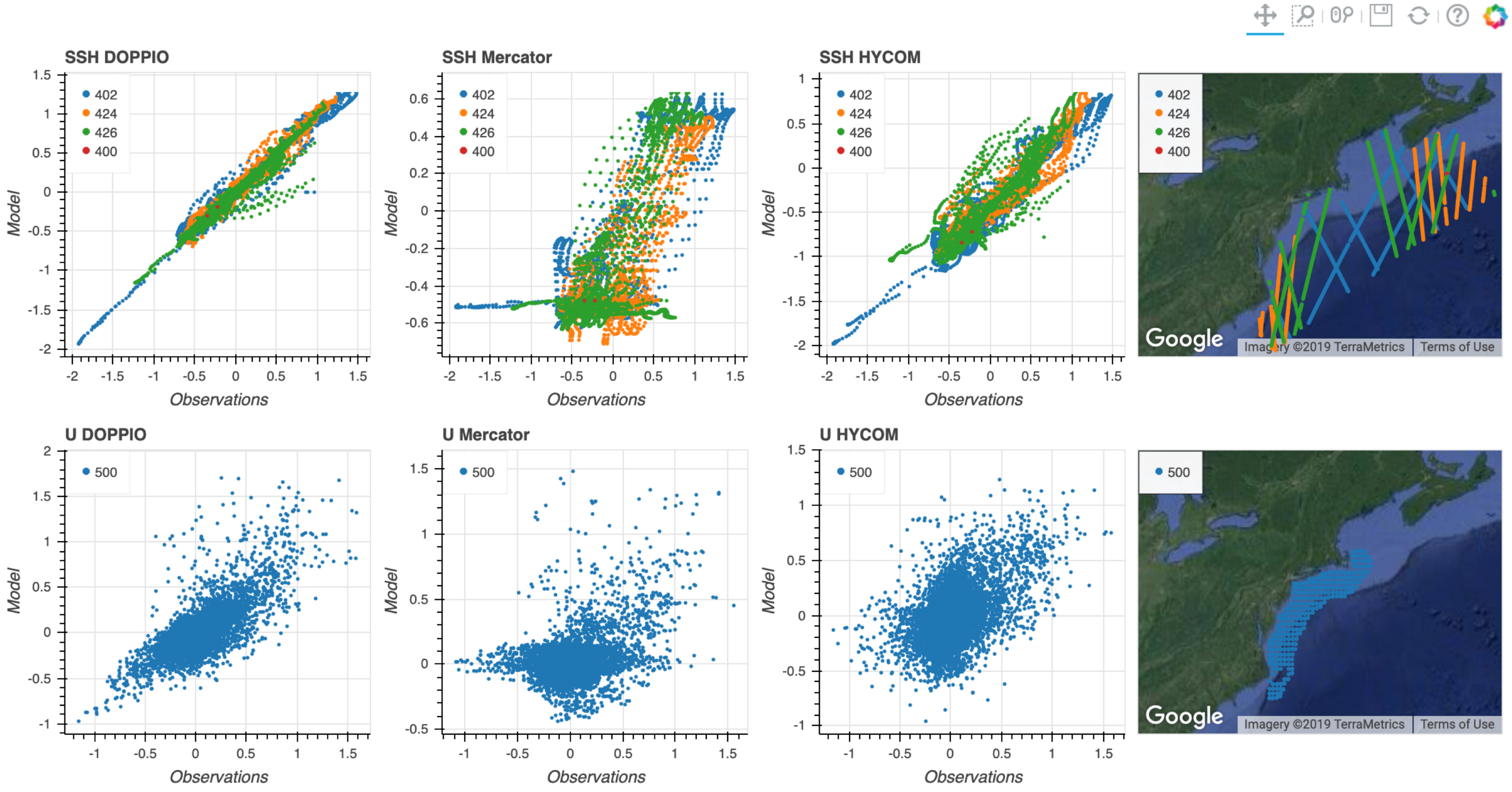
Objective adjustment of 4D-Var observation and background error assumptions




SSH: mean ratio $\tilde{\sigma}_o/\sigma_{obs} = 39.4464$
SSH: mean ratio $\tilde{\sigma}_b/\sigma_{bg} = 0.27743$
all SST: mean ratio $\tilde{\sigma}_o/\sigma_{obs} = 0.28427$
all SST: mean ratio $\tilde{\sigma}_b/\sigma_{bg} = 0.30554$
u-velocity: mean ratio $\tilde{\sigma}_o/\sigma_{obs} = 1.1824$
u-velocity: mean ratio $\tilde{\sigma}_b/\sigma_{bg} = 0.12207$
superobs SST: mean ratio $\tilde{\sigma}_o/\sigma_{obs} = 0.28232$
superobs SST: mean ratio $\tilde{\sigma}_b/\sigma_{bg} = 0.27572$
v-velocity: mean ratio $\tilde{\sigma}_o/\sigma_{obs} = 2.4434$
v-velocity: mean ratio $\tilde{\sigma}_b/\sigma_{bg} = 0.18156$
infrared SST: mean ratio $\tilde{\sigma}_o/\sigma_{obs} = 0.36104$
infrared SST: mean ratio $\tilde{\sigma}_b/\sigma_{bg} = 0.30865$
all T: mean ratio $\tilde{\sigma}_o/\sigma_{obs} = 0.28499$
all T: mean ratio $\tilde{\sigma}_b/\sigma_{bg} = 0.30692$
microwave SST: mean ratio $\tilde{\sigma}_o/\sigma_{obs} = 0.25197$
microwave SST: mean ratio $\tilde{\sigma}_b/\sigma_{bg} = 0.30242$
all S: mean ratio $\tilde{\sigma}_o/\sigma_{obs} = 1.6892$
all S: mean ratio $\tilde{\sigma}_b/\sigma_{bg} = 0.32752$
in situ SST: mean ratio $\tilde{\sigma}_o/\sigma_{obs} = 0.7746$
in situ SST: mean ratio $\tilde{\sigma}_b/\sigma_{bg} = 0.41986$
$\tilde{\sigma}_o$
σ_{obs}
$\tilde{\sigma}_b$
σ_{bg}
2019-01-01
0
0.05
0.1
0.15
0.2
0.3
0.4
0.5
1
1.5
2
3
4
5
10
15
20

Using ERDDAP as a back-end to web-based graphical displays

https://marine.rutgers.edu/~hunter/bokeh/DOPPIO_SCATTER.html



Using ERDDAP as a back-end to web-based graphical displays

https://marine.rutgers.edu/~hunter/stuff/DOPPIO+Skill+update.html

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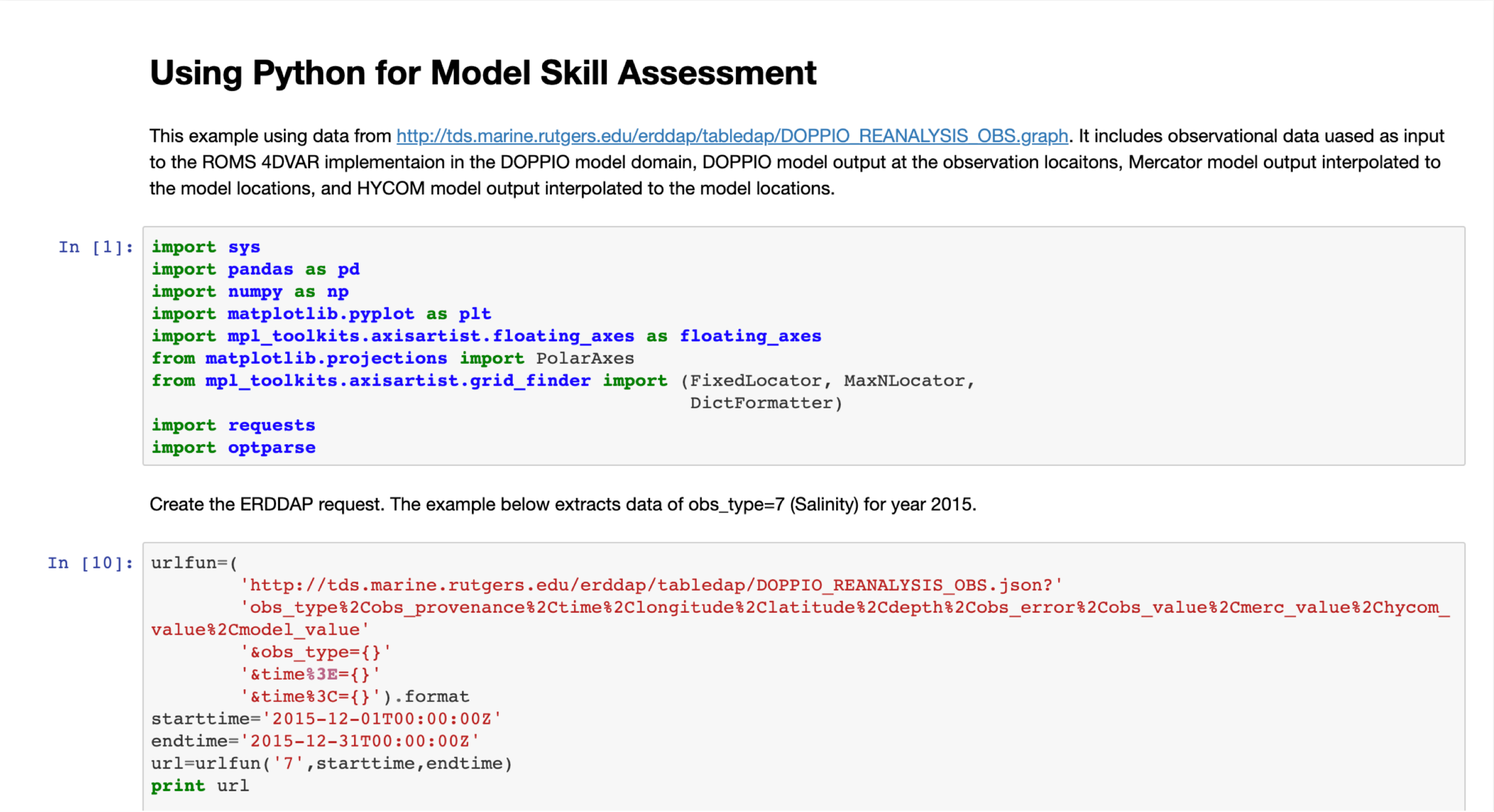


Using Python for Model Skill Assessment

This example using data from http://tds.marine.rutgers.edu/erddap/tabledap/DOPPIO_REANALYSIS_OBS.graph. It includes observational data uased as input to the ROMS 4DVAR implementaion in the DOPPIO model domain, DOPPIO model output at the observation locaitons, Mercator model output interpolated to the model locations, and HYCOM model output interpolated to the model locations.

In [1]:

```
import sys
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import mpl_toolkits.axisartist.floating_axes as floating_axes
from matplotlib.projections import PolarAxes
from mpl_toolkits.axisartist.grid_finder import (FixedLocator, MaxNLocator,
                                                 DictFormatter)
import requests
import optparse
```

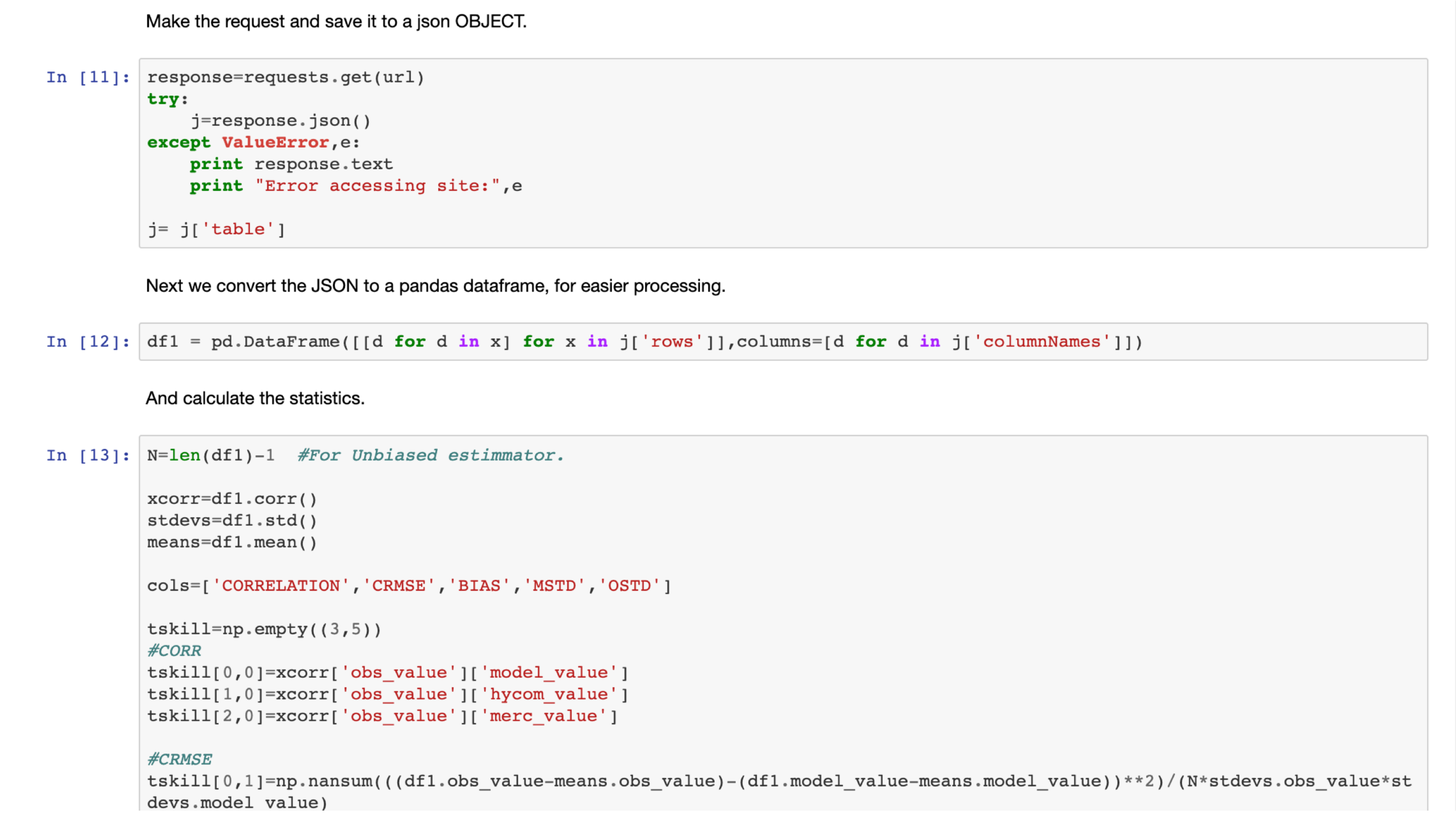
Create the ERDDAP request. The example below extracts data of obs_type=7 (Salinity) for year 2015.

In [10]:

```
urlfun=(
        'http://tds.marine.rutgers.edu/erddap/tabledap/DOPPIO_REANALYSIS_OBS.json?'
        'obs_type%2Cobs_provenance%2Ctime%2Clongitude%2Clatitude%2Cdepth%2Cobs_error%2Cobs_value%2Cmerc_value%2Chycom_
value%2Cmodel_value'
        '&obs_type={}'
        '&time%3E={}'
        '&time%3C={}').format
starttime='2015-12-01T00:00:00Z'
endtime='2015-12-31T00:00:00Z'
url=urlfun('7',starttime,endtime)
print url
```

Using ERDDAP as a back-end to web-based graphical displays

https://marine.rutgers.edu/~hunter/stuff/DOPPIO+Skill+update.html



Make the request and save it to a json OBJECT.

In [11]:
```
response=requests.get(url)
try:
    j=response.json()
except ValueError,e:
    print response.text
    print "Error accessing site:",e

j= j['table']
```

Next we convert the JSON to a pandas dataframe, for easier processing.

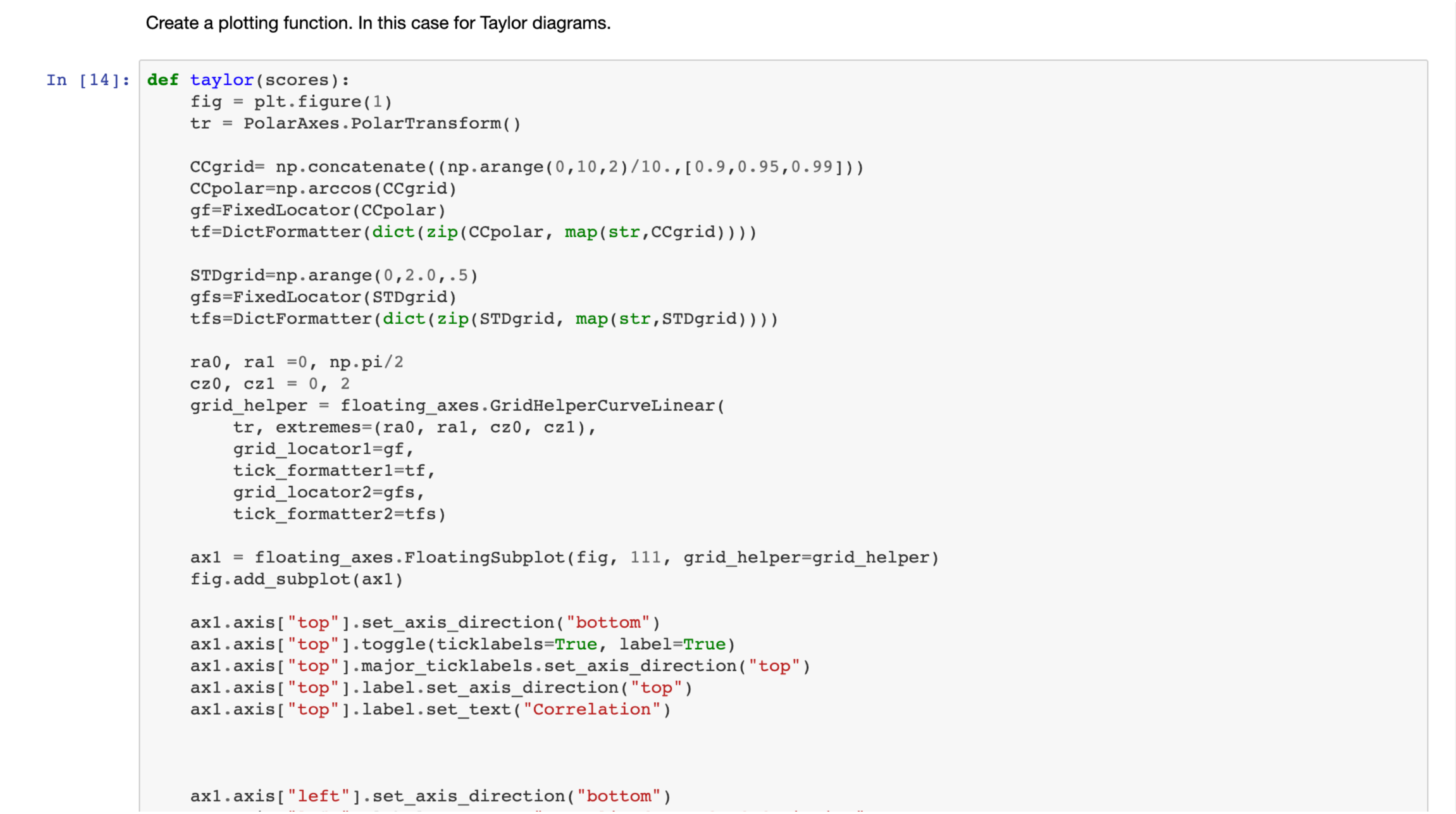
In [12]:
```
df1 = pd.DataFrame([[d for d in x] for x in j['rows']],columns=[d for d in j['columnNames']])
```

And calculate the statistics.

In [13]:
```
N=len(df1)-1  #For Unbiased estimmator.

xcorr=df1.corr()
stdevs=df1.std()
means=df1.mean()

cols=['CORRELATION','CRMSE','BIAS','MSTD','OSTD']

tskill=np.empty((3,5))
#CORR
tskill[0,0]=xcorr['obs_value']['model_value']
tskill[1,0]=xcorr['obs_value']['hycom_value']
tskill[2,0]=xcorr['obs_value']['merc_value']

#CRMSE
tskill[0,1]=np.nansum(((df1.obs_value-means.obs_value)-(df1.model_value-means.model_value))**2)/(N*stdevs.obs_value*st
devs.model_value)
```

Using ERDDAP as a back-end to web-based graphical displays

https://marine.rutgers.edu/~hunter/stuff/DOPPIO+Skill+update.html



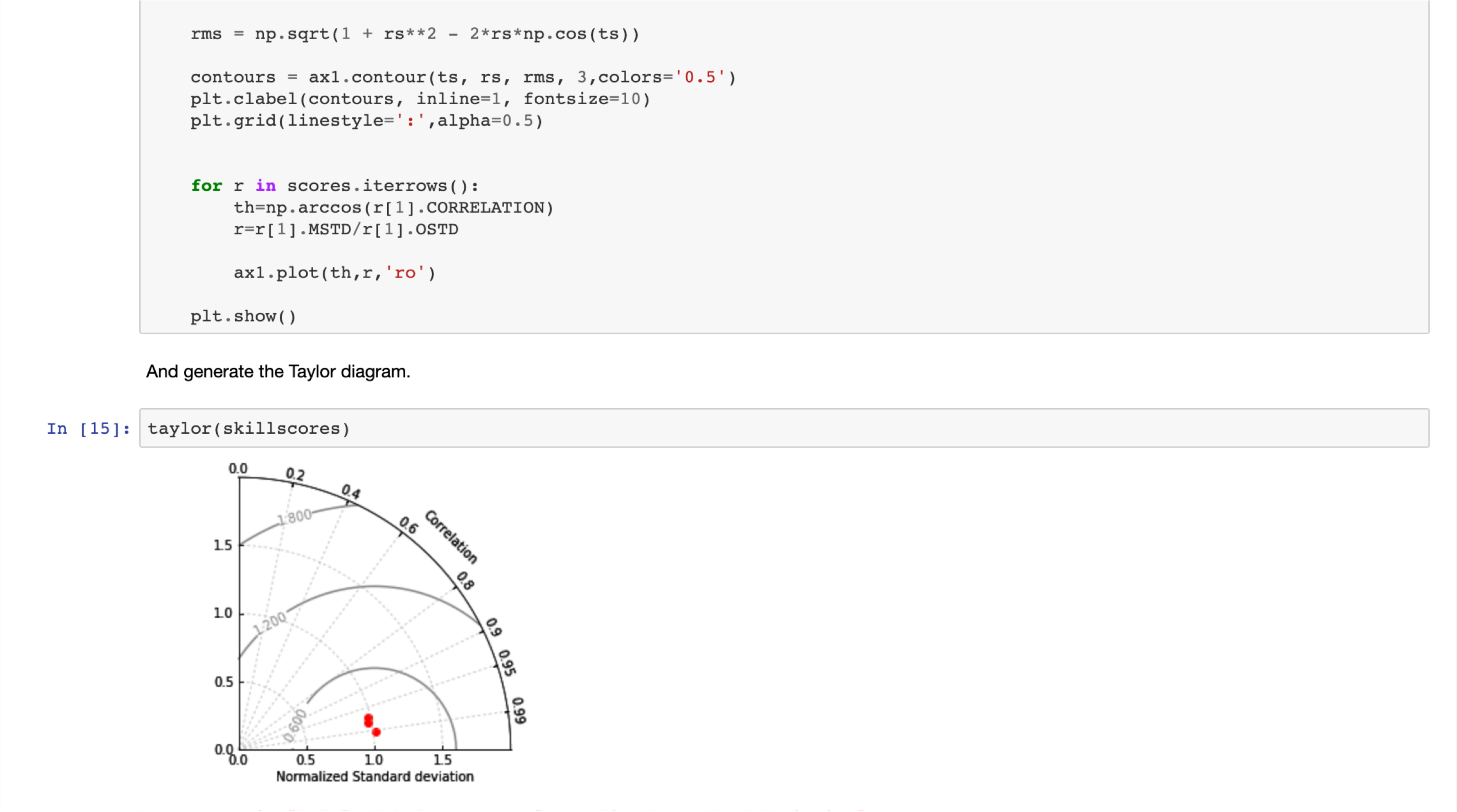
Create a plotting function. In this case for Taylor diagrams.

In [14]:

```
def taylor(scores):
    fig = plt.figure(1)
    tr = PolarAxes.PolarTransform()

    CCgrid= np.concatenate((np.arange(0,10,2)/10.,[0.9,0.95,0.99]))
    CCpolar=np.arccos(CCgrid)
    gf=FixedLocator(CCpolar)
    tf=DictFormatter(dict(zip(CCpolar, map(str,CCgrid))))

    STDgrid=np.arange(0,2.0,.5)
    gfs=FixedLocator(STDgrid)
    tfs=DictFormatter(dict(zip(STDgrid, map(str,STDgrid))))

    ra0, ra1 =0, np.pi/2
    cz0, cz1 = 0, 2
    grid_helper = floating_axes.GridHelperCurveLinear(
        tr, extremes=(ra0, ra1, cz0, cz1),
        grid_locator1=gf,
        tick_formatter1=tf,
        grid_locator2=gfs,
        tick_formatter2=tfs)

    ax1 = floating_axes.FloatingSubplot(fig, 111, grid_helper=grid_helper)
    fig.add_subplot(ax1)

    ax1.axis["top"].set_axis_direction("bottom")
    ax1.axis["top"].toggle(ticklabels=True, label=True)
    ax1.axis["top"].major_ticklabels.set_axis_direction("top")
    ax1.axis["top"].label.set_axis_direction("top")
    ax1.axis["top"].label.set_text("Correlation")



    ax1.axis["left"].set_axis_direction("bottom")
```

Using ERDDAP as a back-end to web-based graphical displays

https://marine.rutgers.edu/~hunter/stuff/DOPPIO+Skill+update.html



```
    rms = np.sqrt(1 + rs**2 - 2*rs*np.cos(ts))

    contours = ax1.contour(ts, rs, rms, 3,colors='0.5')
    plt.clabel(contours, inline=1, fontsize=10)
    plt.grid(linestyle=':',alpha=0.5)


    for r in scores.iterrows():
        th=np.arccos(r[1].CORRELATION)
        r=r[1].MSTD/r[1].OSTD

        ax1.plot(th,r,'ro')

    plt.show()
```

And generate the Taylor diagram.

```
In [15]: taylor(skillscores)
```