Website for interacting with oceanographic data and numerical model output

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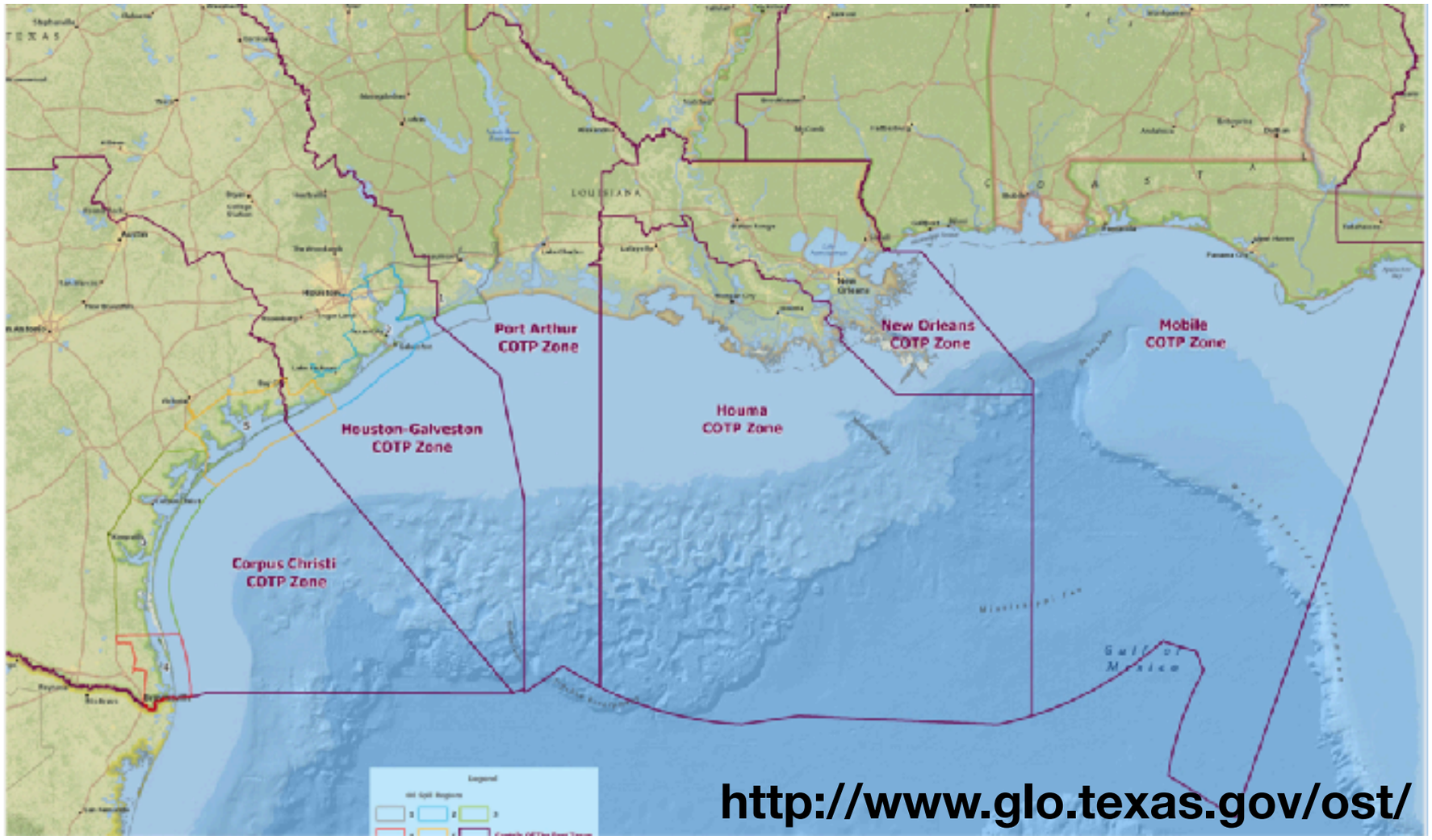
Motivation

- 20+ years of buoy data
- Has been served online for decades
- Website needs revamp
- Numerical model output also supported by Texas General Land Office (TGLO)
- Want to make all available on modern website
- Users: non-scientific and scientific both

Texas General Land Office

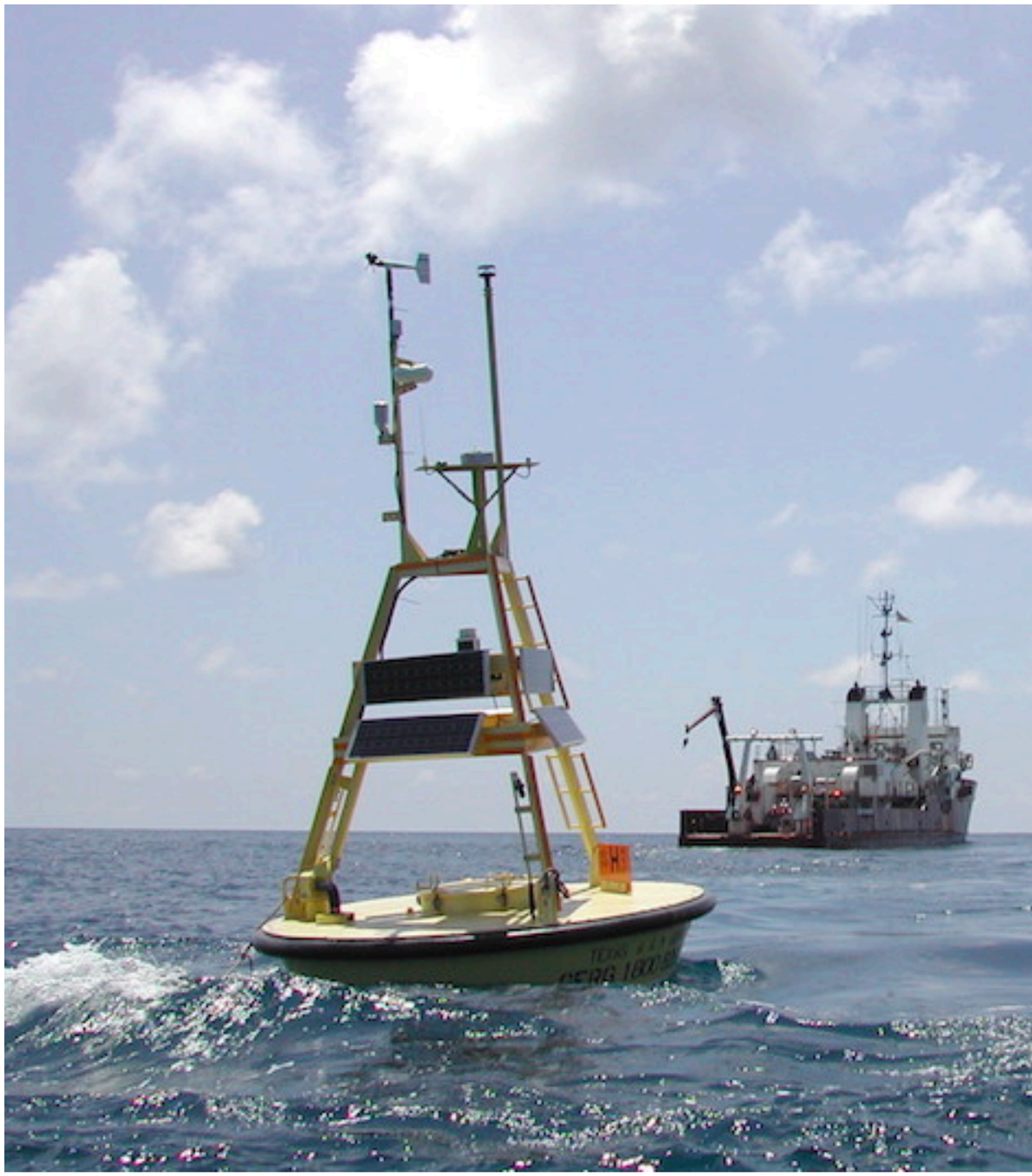


- Oil Spill Prevention & Response Research & Development
- Run oil spill tracking models to respond to oil spills in Texas

Geochemical and Environmental Research Group (Texas A&M)

- Develops and maintains buoys in Texas waters to support TGLO oil spill response

- TABS buoys: measure surface velocity and more



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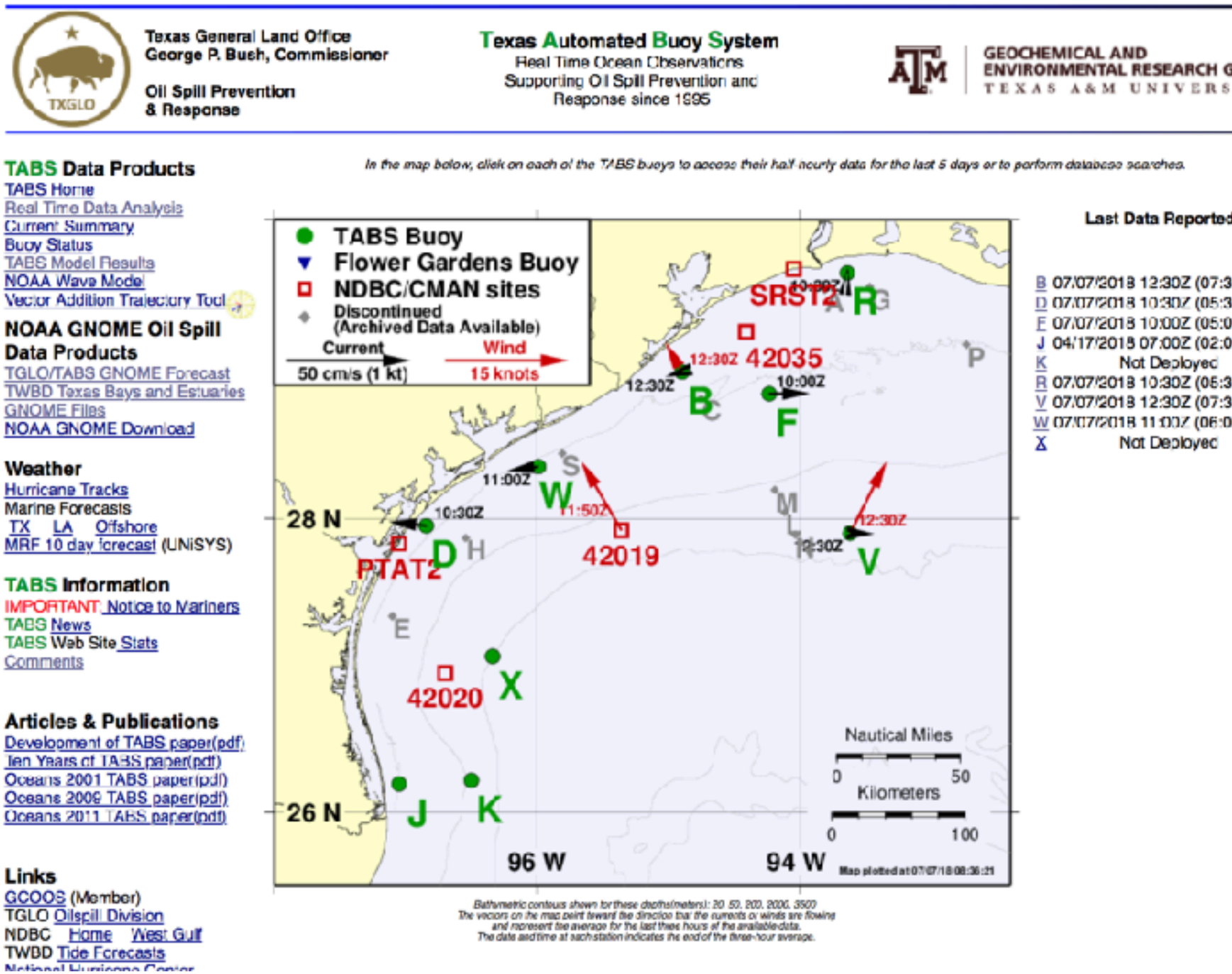
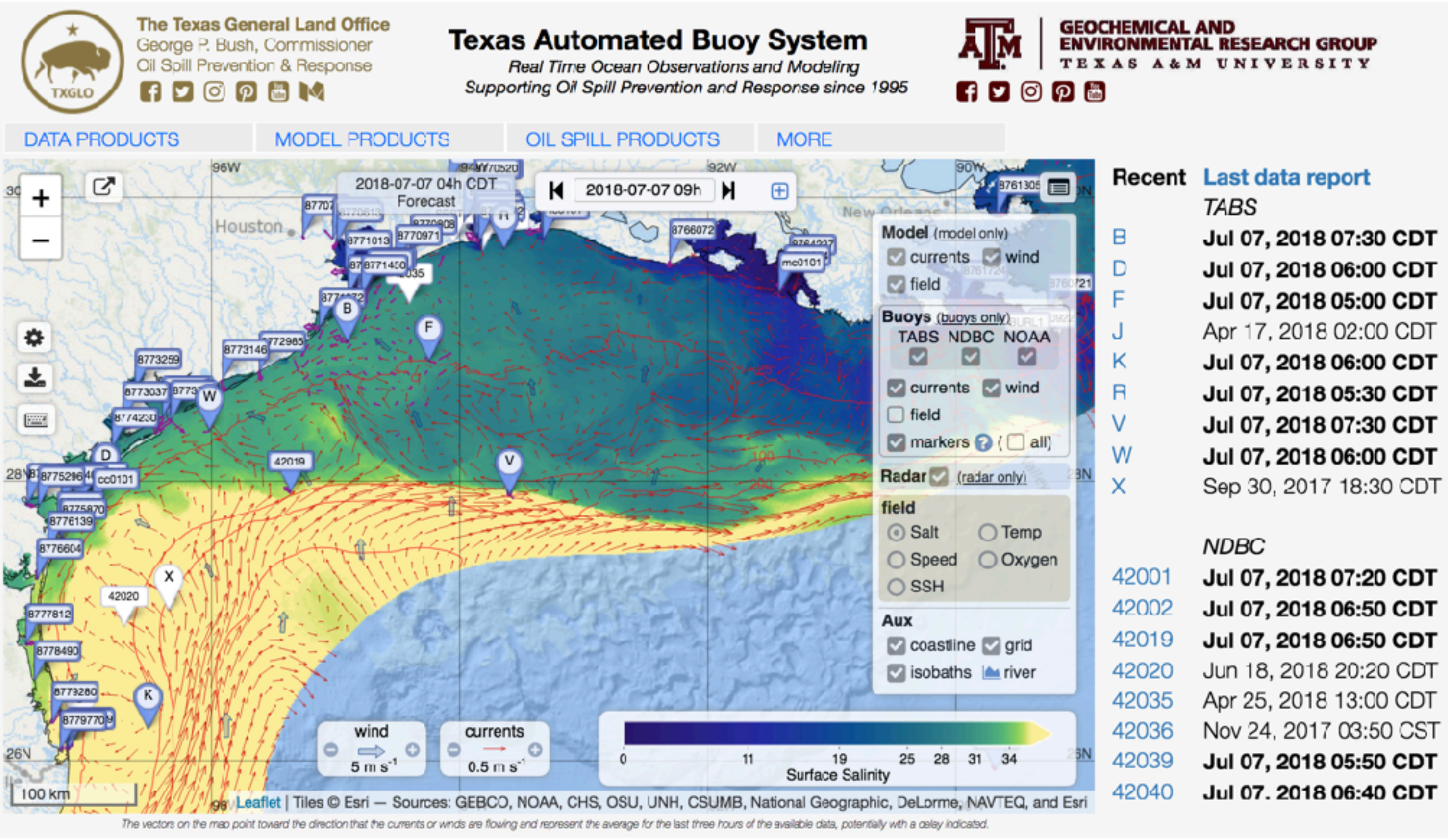
Existing site

- Pros:
  - fast
  - straight-forward
- Cons:
  - difficulty in accessing over 60 days of data
  - no model output
  - old style



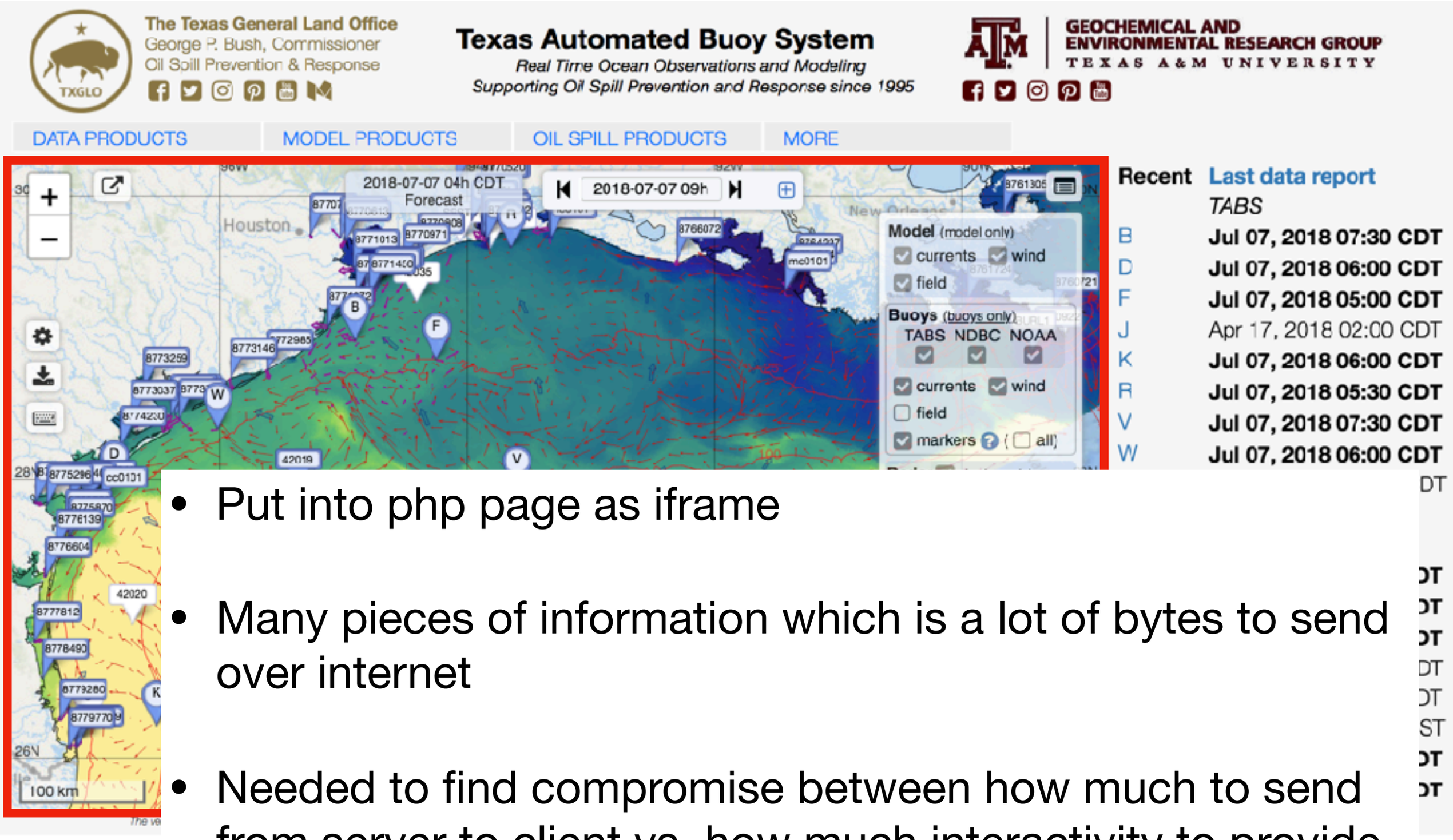
tabs.gerg.tamu.edu

New site!



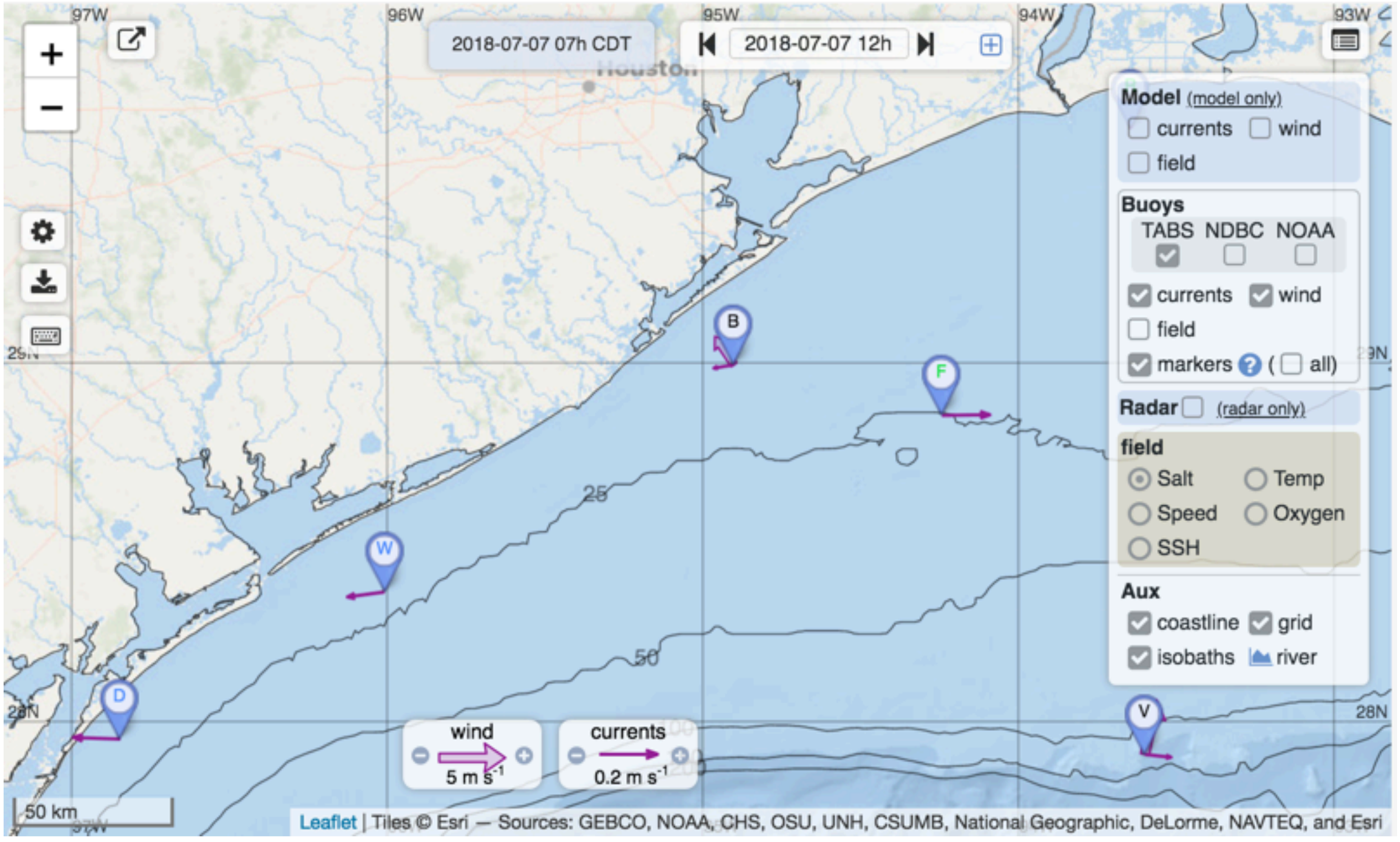
currently: pong.tamu.edu/tabswebsite

Map display

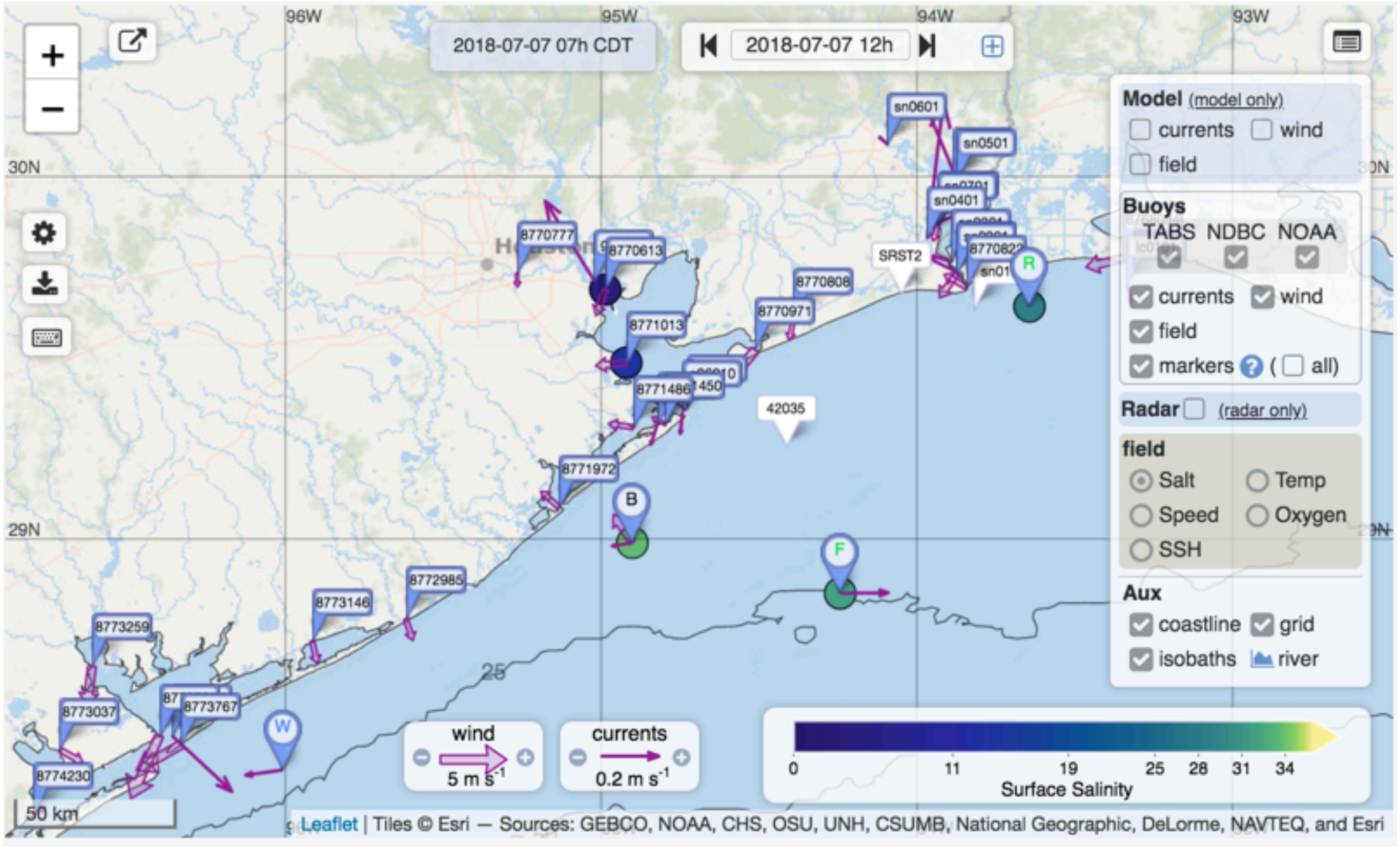


- Put into php page as iframe
- Many pieces of information which is a lot of bytes to send over internet
- Needed to find compromise between how much to send from server to client vs. how much interactivity to provide

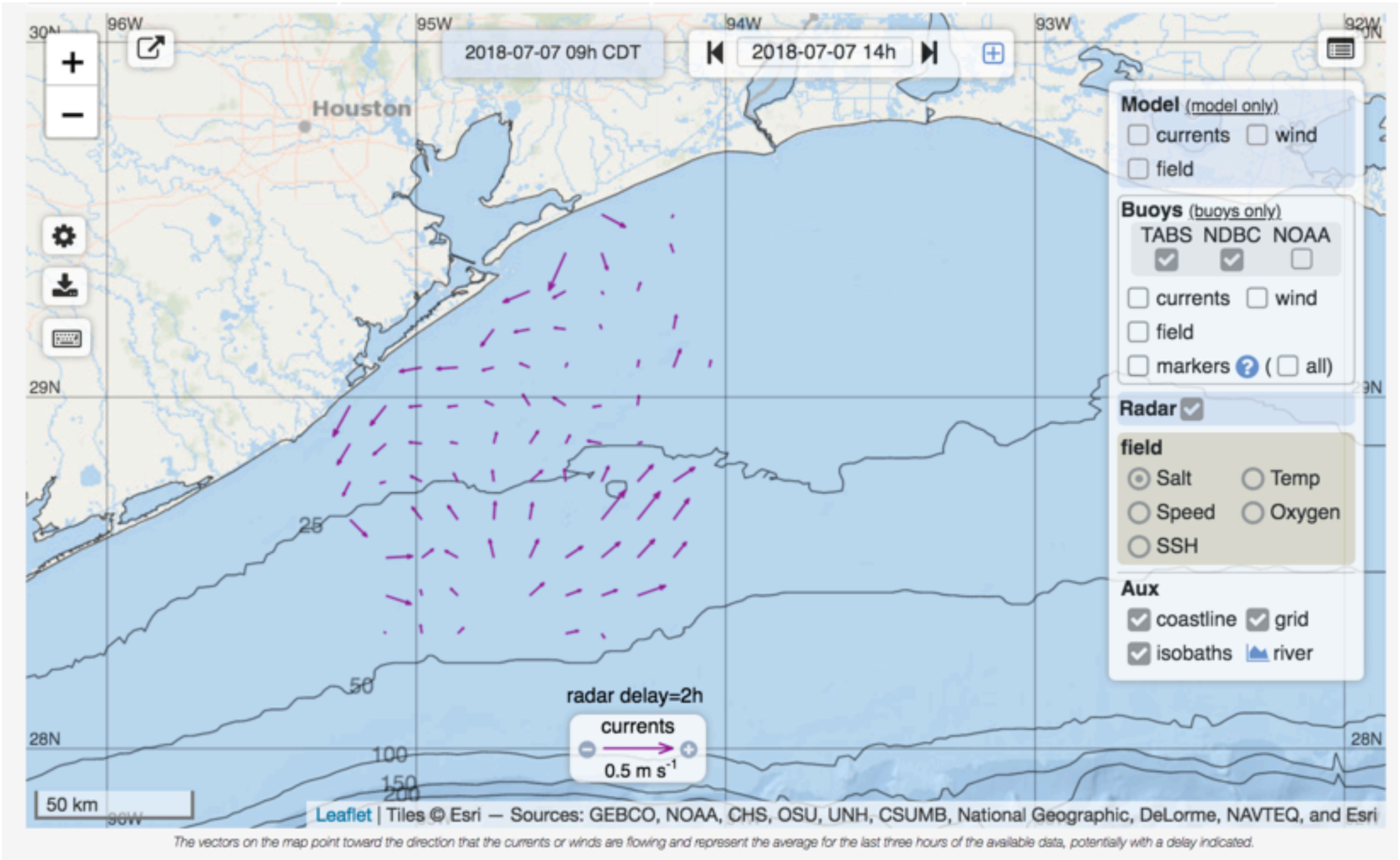
TABS Buoys


97W
96W
95W
94W
93W
2018-07-07 07h CDT
2018-07-07 12h
Houston
Model (model only)
currents
wind
field
Buoys
TABS NDBC NOAA
currents
wind
field
markers (all)
Radar (radar only)
field
Salt
Temp
Speed
Oxygen
SSH
Aux
coastline
grid
isobaths
river
B
F
W
D
V
25
50
29N
28N
wind
5 m s-1
currents
0.2 m s-1
50 km
Leaflet | Tiles © Esri — Sources: GEBCO, NOAA, CHS, OSU, UNH, CSUMB, National Geographic, DeLorme, NAVTEQ, and Esri

Also other stations



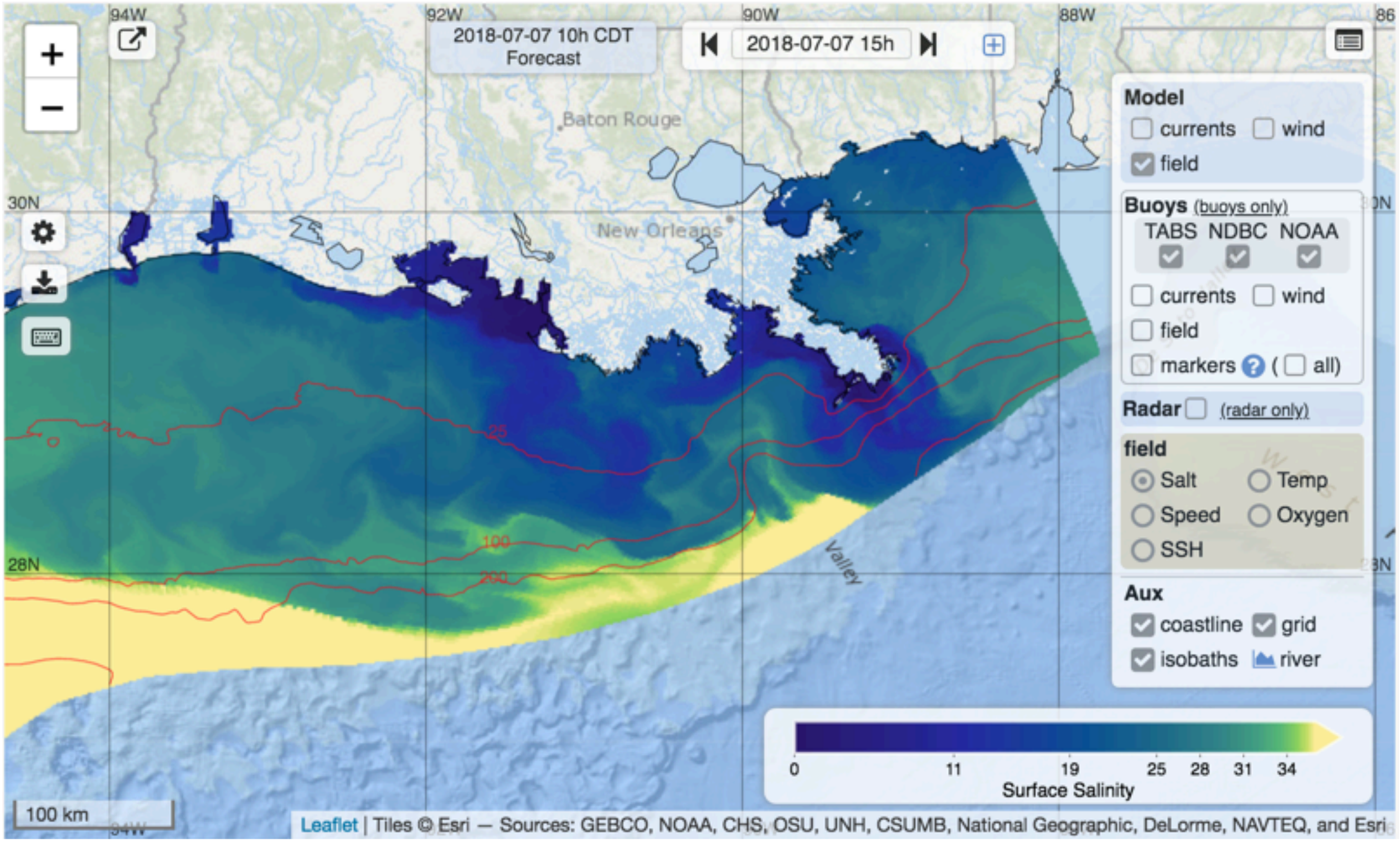
HF Radar



The vectors on the map point toward the direction that the currents or winds are flowing and represent the average for the last three hours of the available data, potentially with a delay indicated.

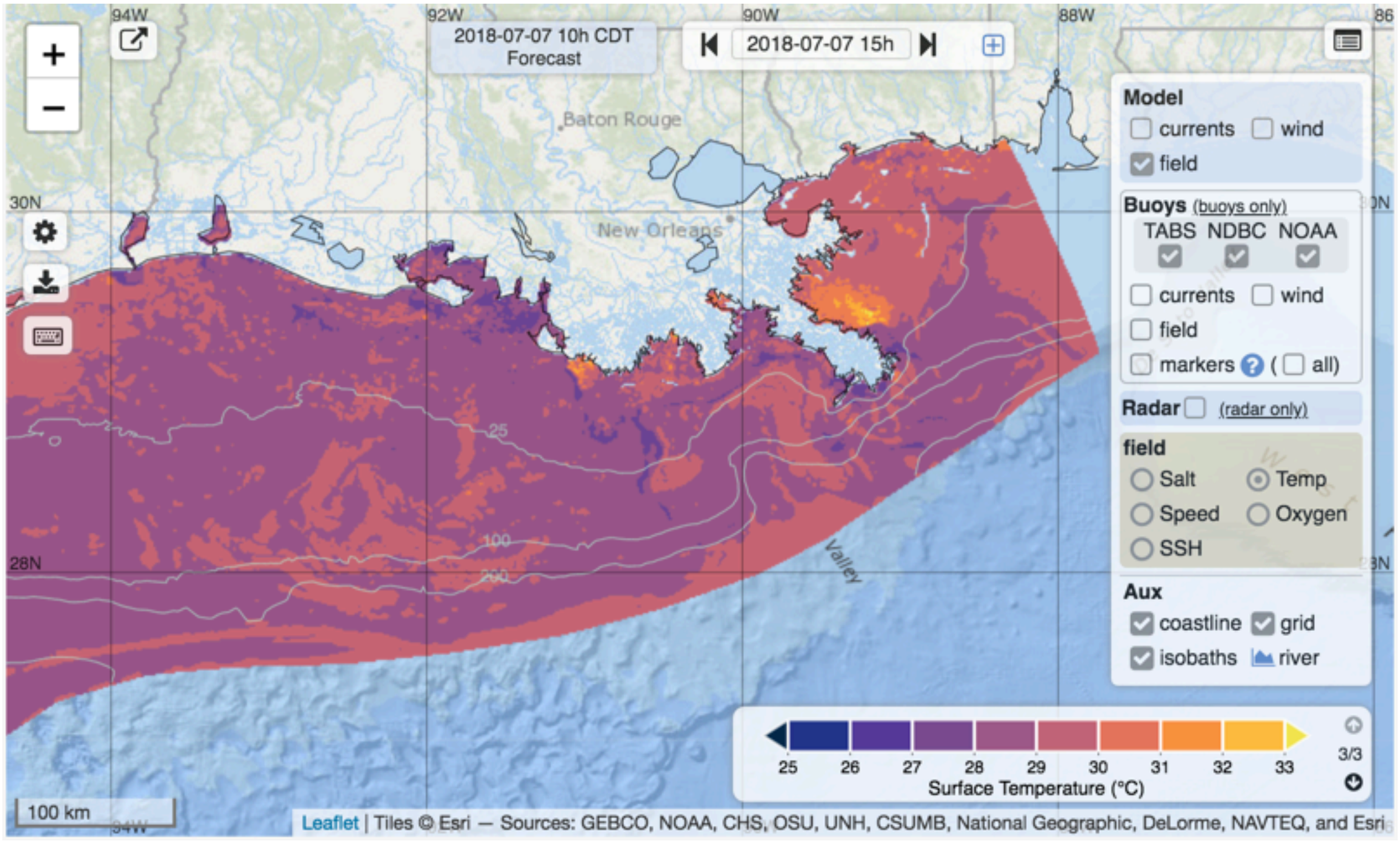
Surface currents as measured from land

Numerical model



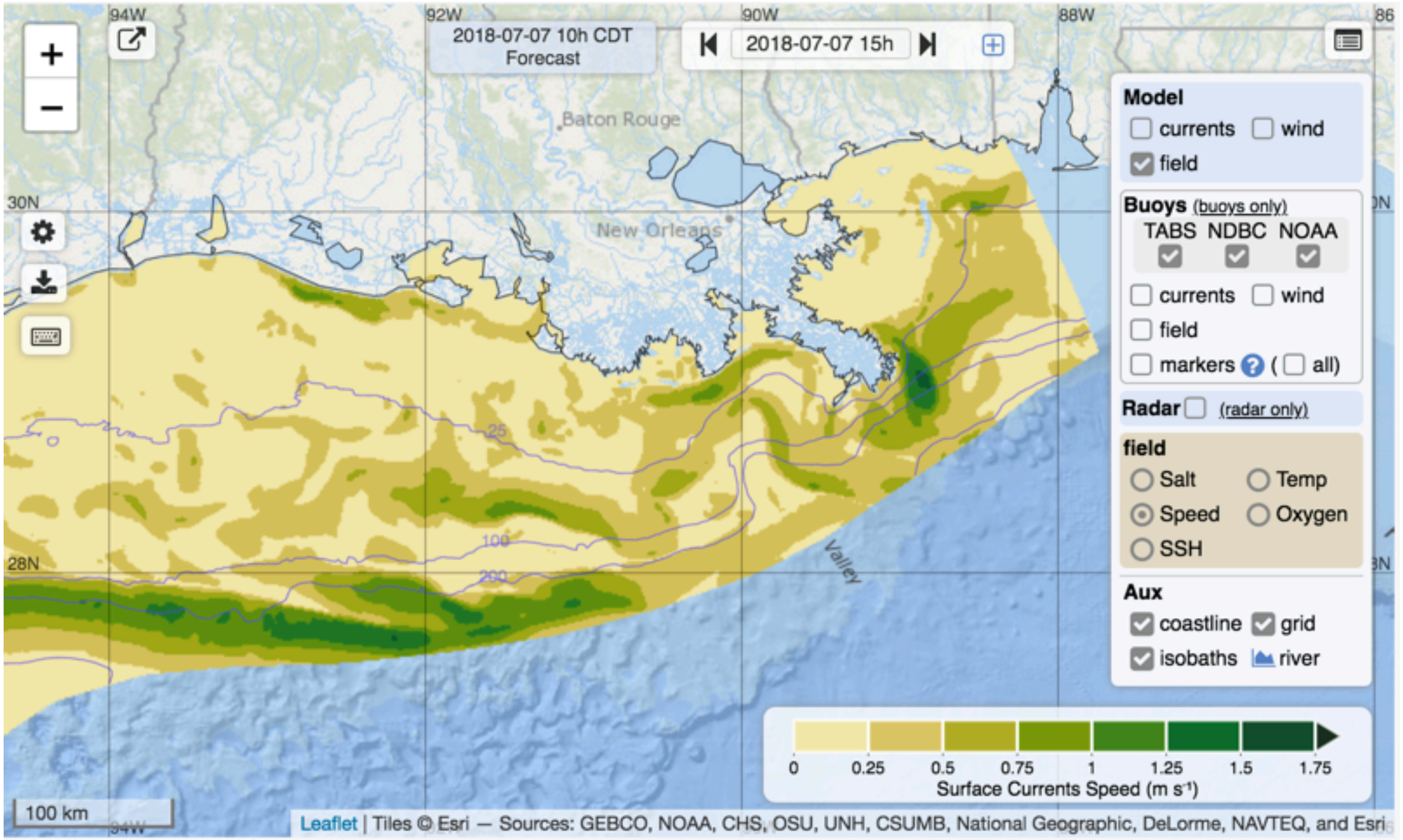
Surface salinity

Numerical model



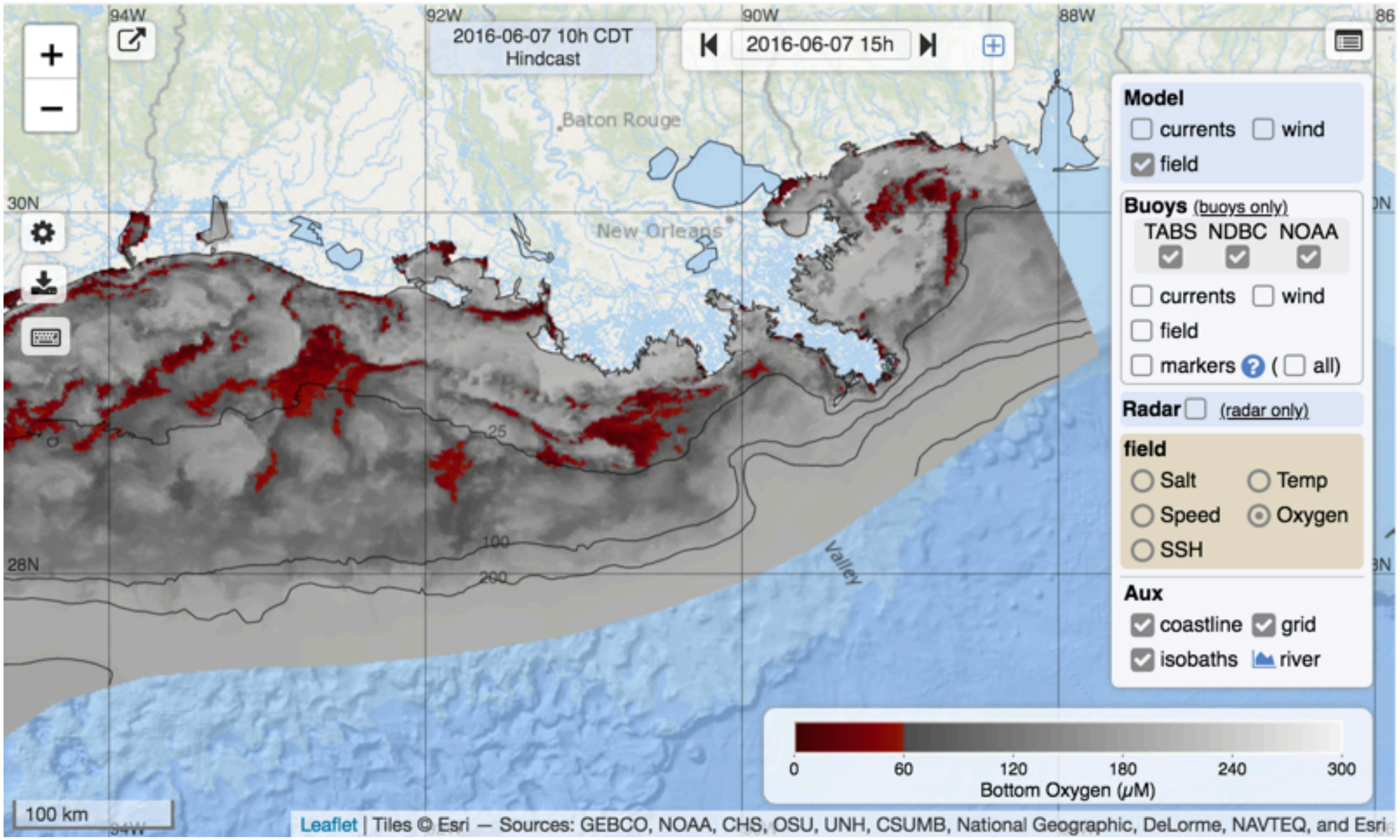
Surface temperature

Numerical model



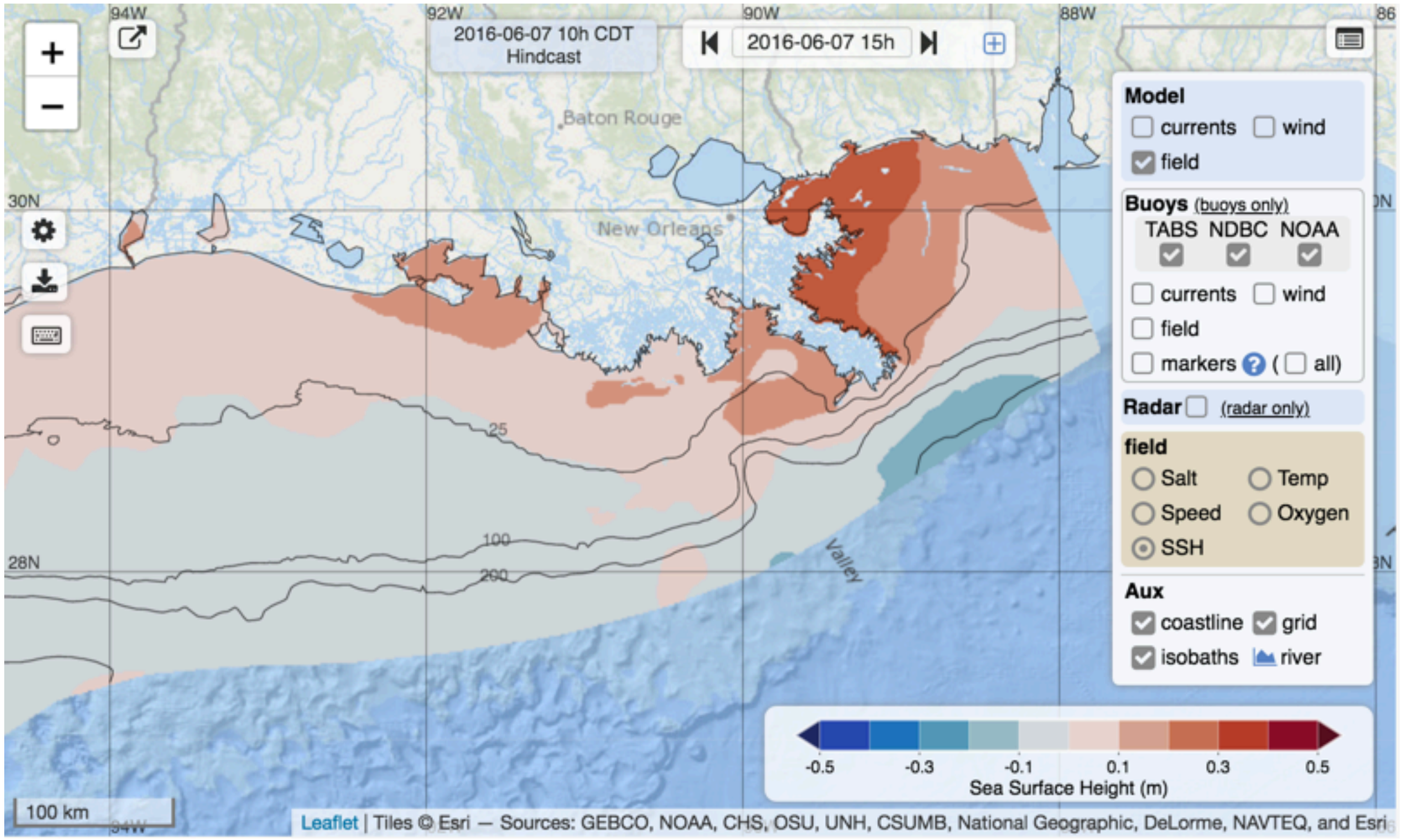
Surface speed

Numerical model



Bottom oxygen

Numerical model

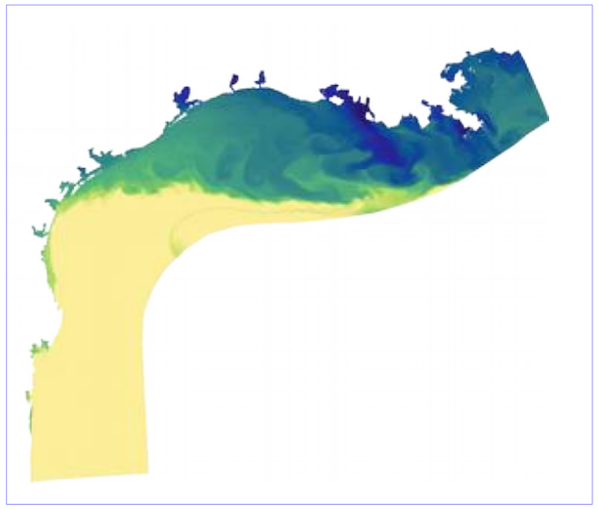


Sea surface height

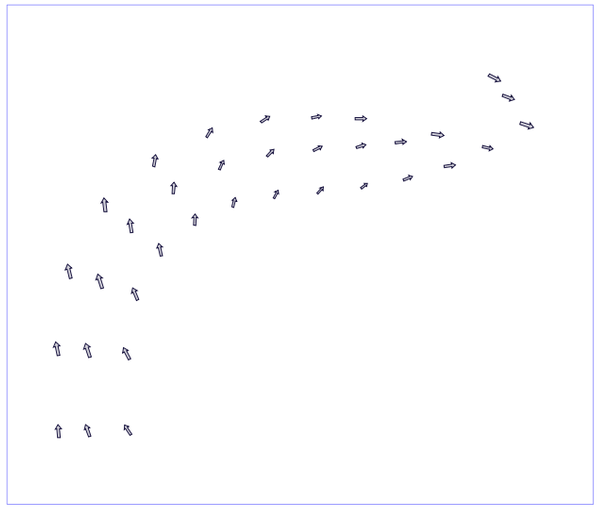
How to display everything: Static images for complex plots and client makes simple plots

- Server provides the complex plots — the model field like salinity as png's
- Client draws wind, currents, etc
- New buoys or additional model output can be added in a structured way

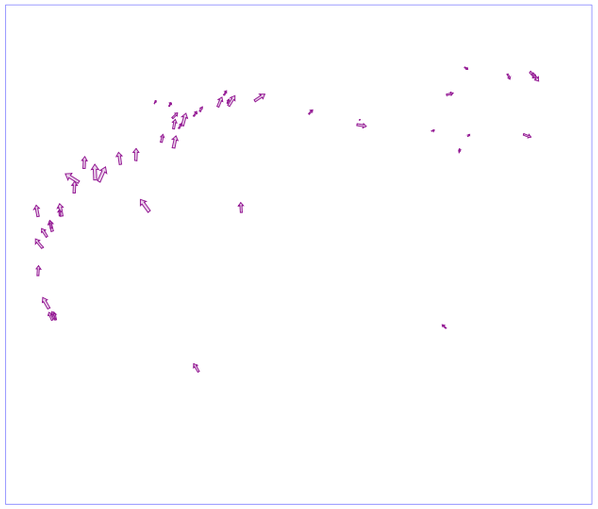
Model field



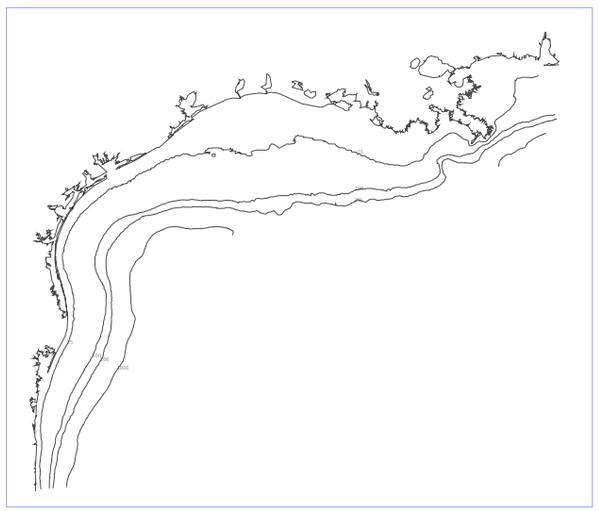
Model wind



Buoys wind

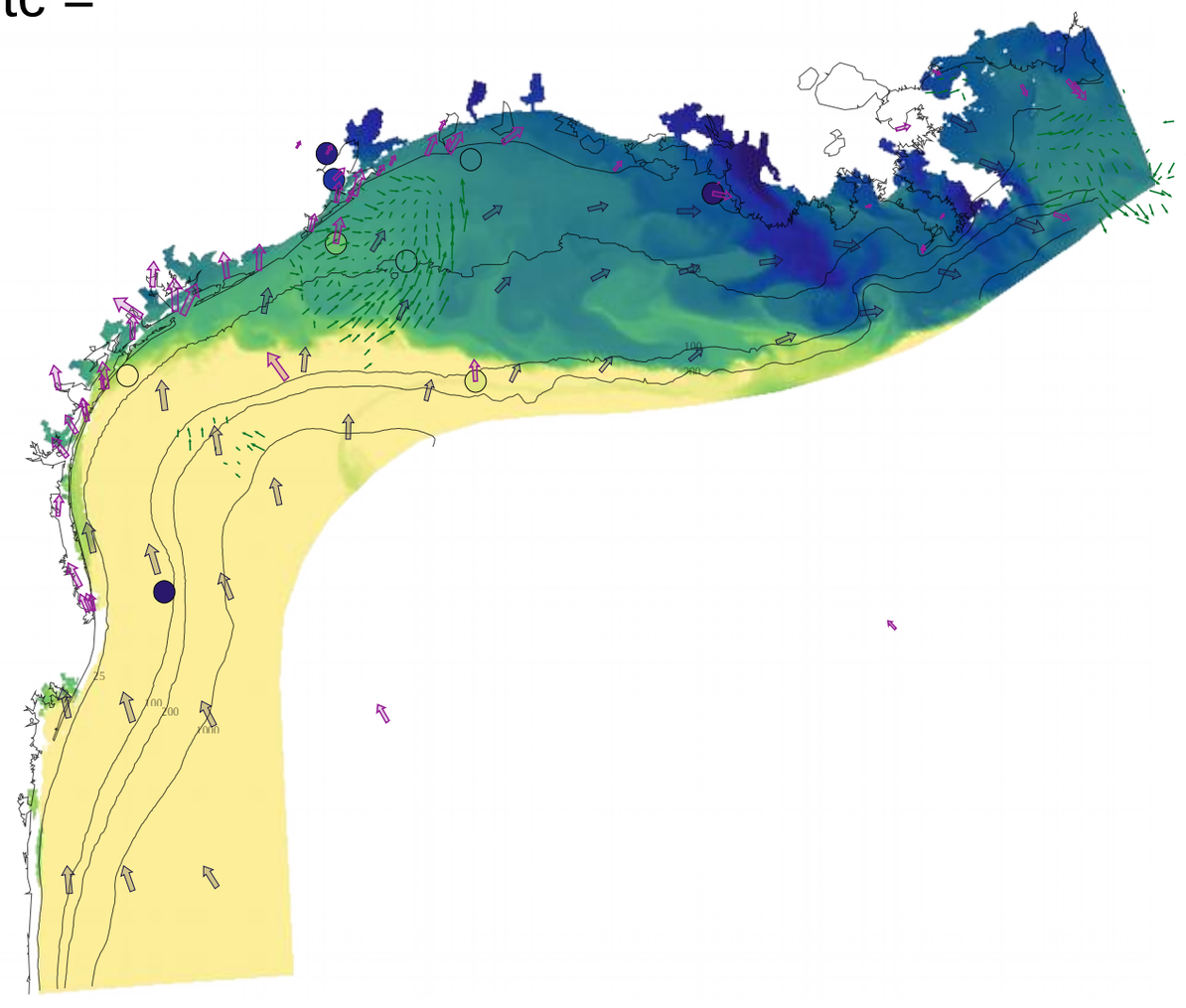


Isobaths, ...



Radar currents, ...

\+ etc =



Overlays to static model field:

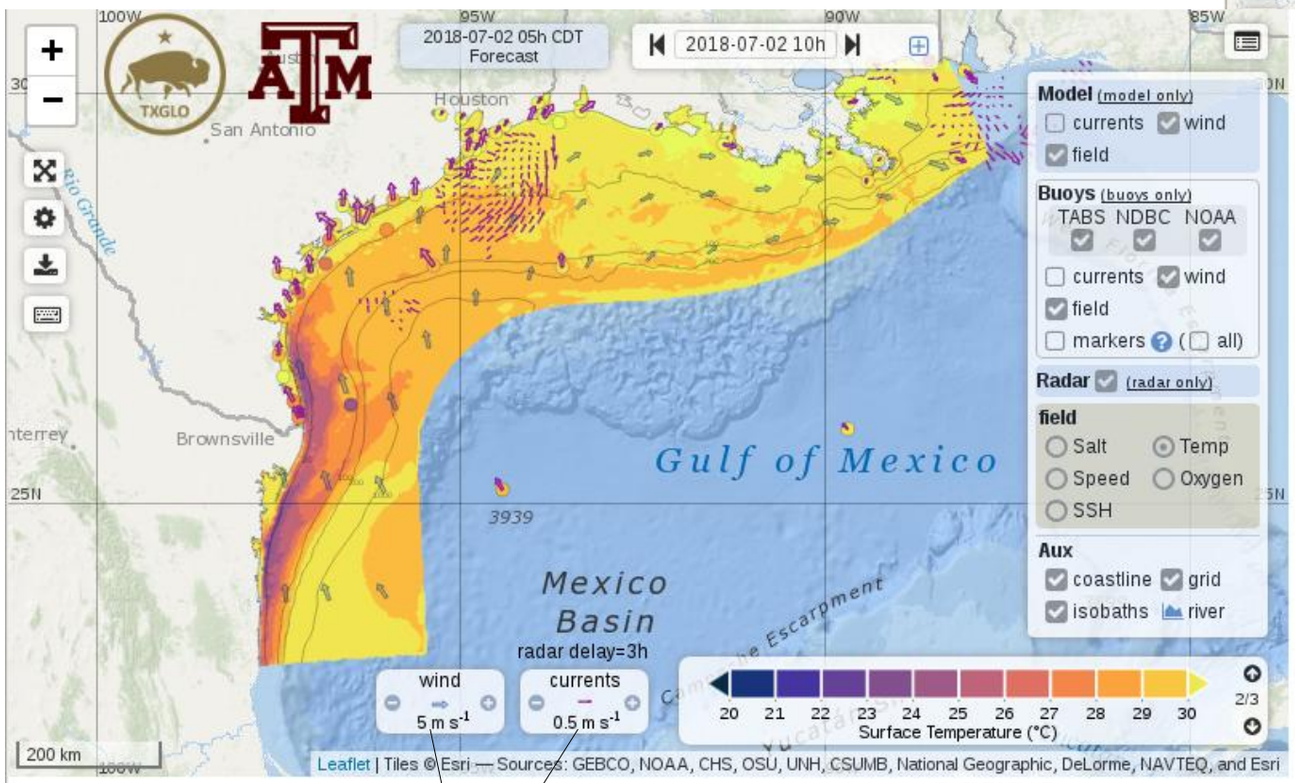
- server provides data
- browser draws the arrow, circles, etc
- any set of objects to display

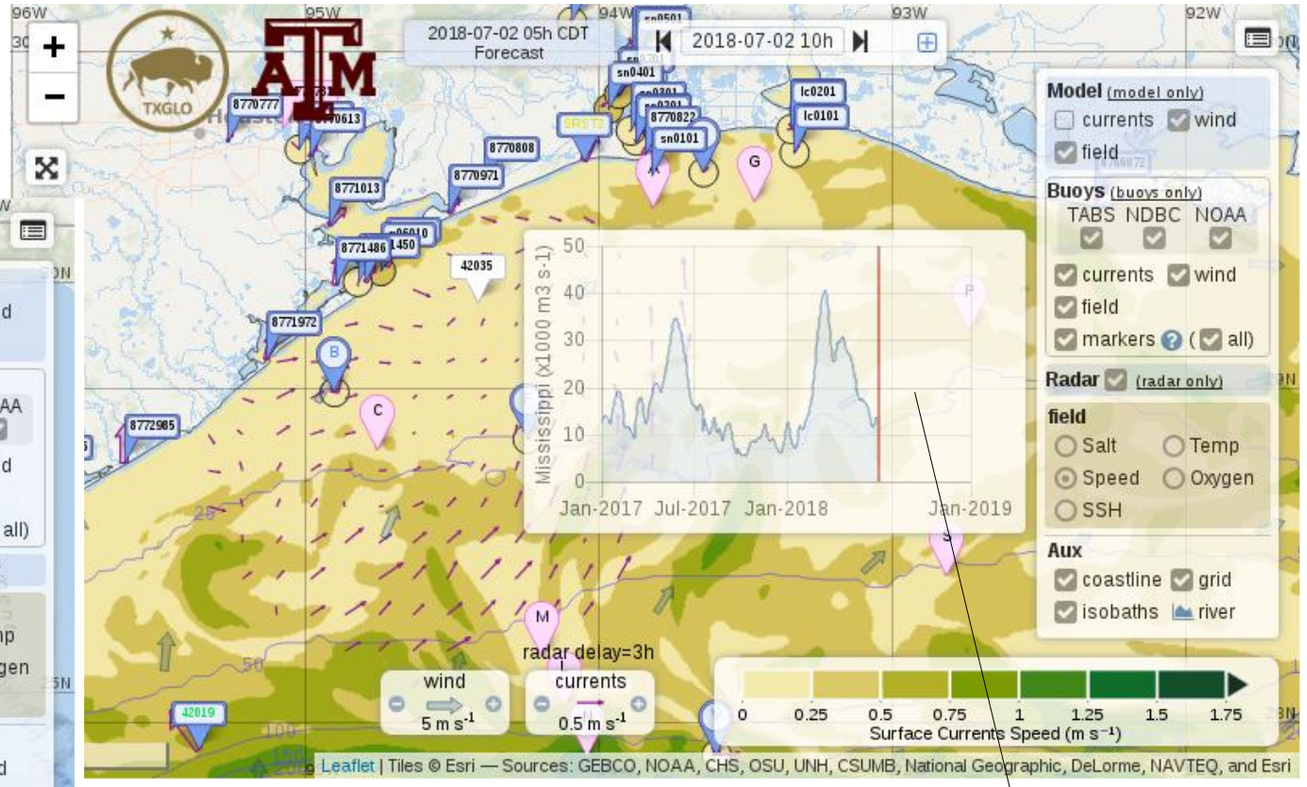
  can be easily combined

Draw the client side using SVG

Keep it simple! No fancy frameworks, just clean javascript

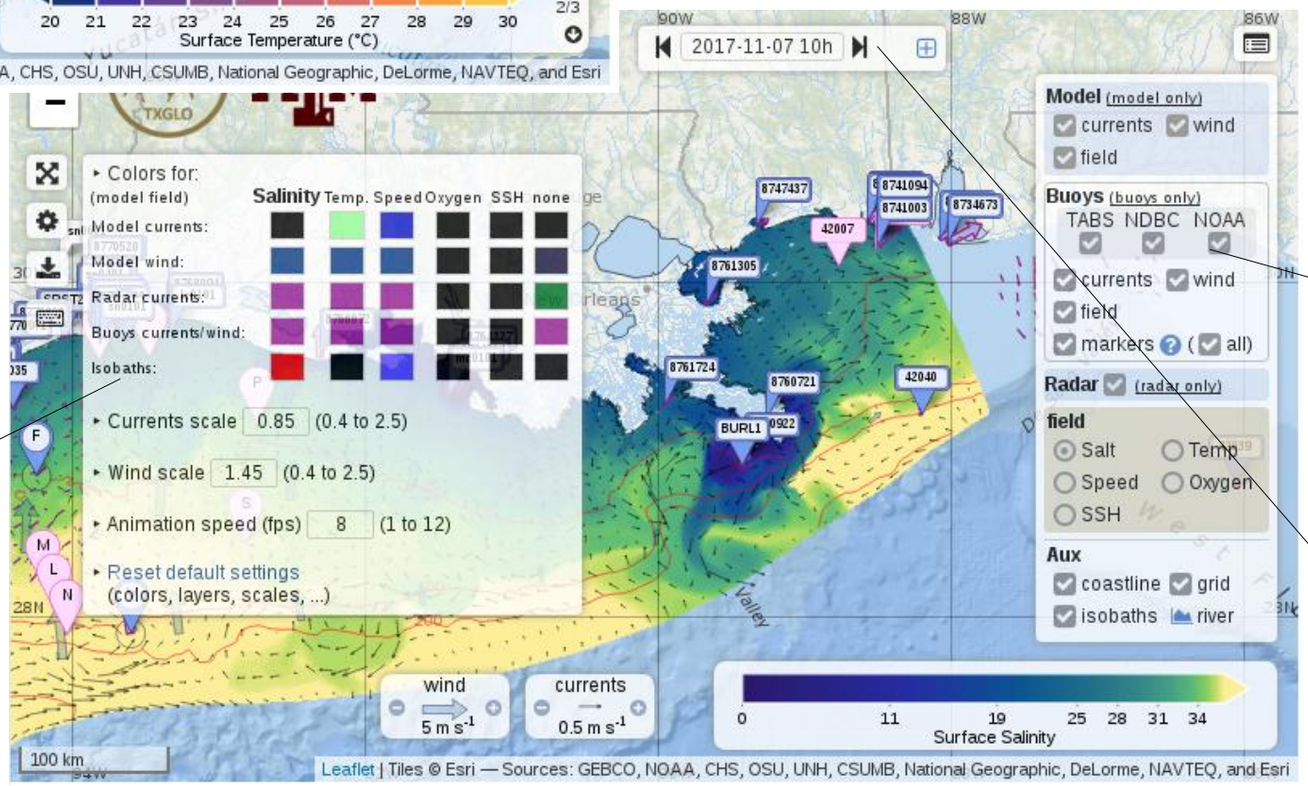
Putting all together





Mississippi time series

Wind and currents scale (easily adjustable)

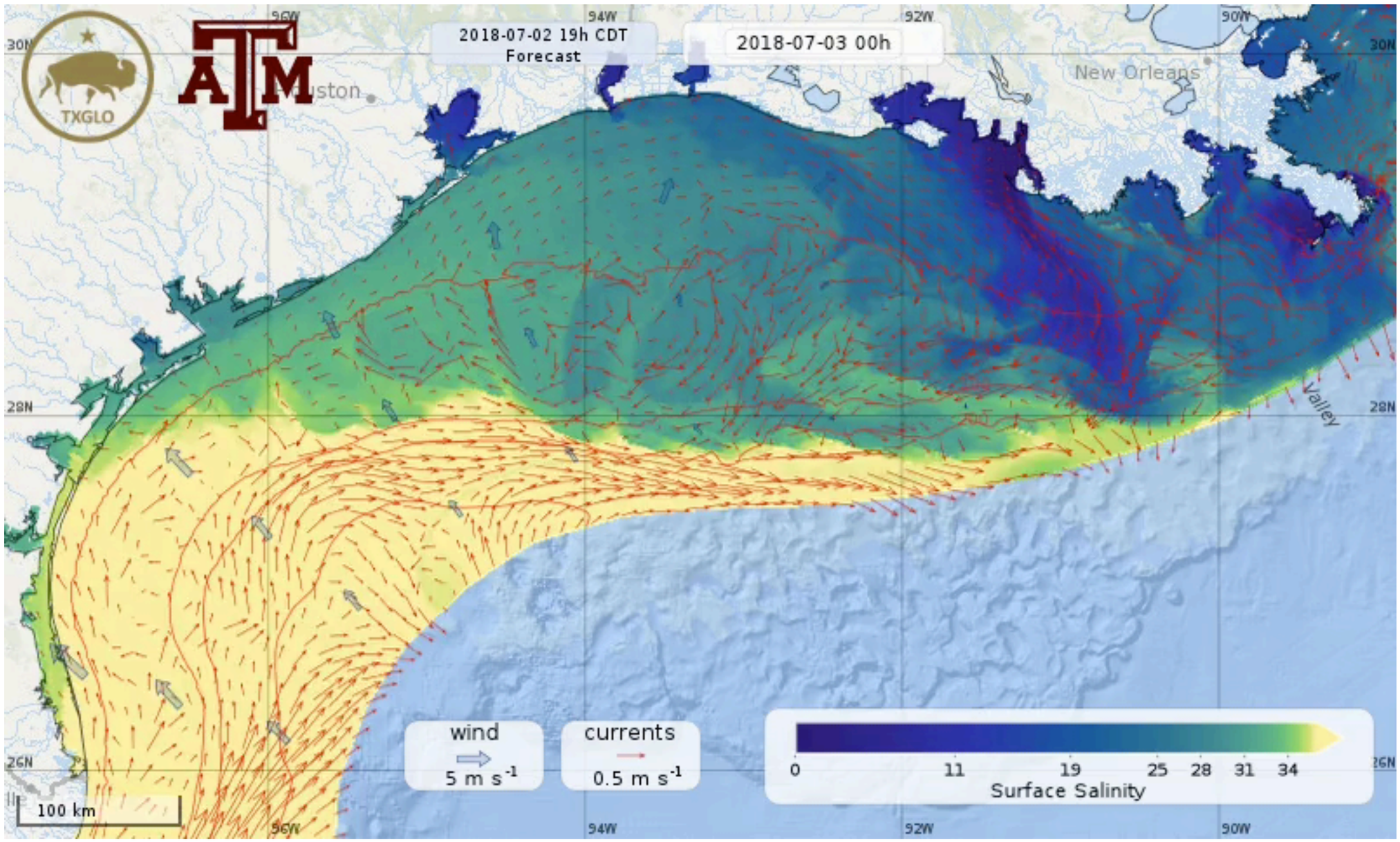


Customizable options

Choose Variables to display

- Change date
- Make animations

Animation



Can save both images and animations

Animation

- User can select a date range and time between images
- Each type of data required is extracted at once (not one request per frame)
- Images are stored; SVG objects are created and stored
- Each frame or the whole animation can be downloaded as png/mp4.

Data Management

- numpy/scipy with python multiprocessing library
- **Model**
  - Local files/opendap server
  - Stored in server as png files with different dpi for zoom levels
    - 94 Mb /day: 676 files, 5 fields, 5 dpis, 3 color limits for temp
- Wind and currents stored as npz files
  - 2 Mb /day: 168 files, 3 strides for currents, 4 strides for wind

Data Management

- **Radar**: Extracted from remote opendap server and stored as npz files
  - 13 Mb /day: 48 files, 2 strides
- **Buoys**: Fields (temp, salt, etc), wind and currents are extracted via web service and stored as npz files
  - 32 Mb /day: 78 buoys, several variables, thousands values per day (1 txt file each)
- **Mississippi river**: Extracted via web service and stored as netCDF file, 0.2 Mb /year

Server and data transfer

- Server: Flask
  - Clean web framework written in Python
  - Does not require particular tools or libraries
  - Easily integrated with Apache via WSGI

Rest of website

The Texas General Land Office
George P. Bush, Commissioner
Oil Spill Prevention & Response

Texas Automated Buoy System

Real Time Ocean Observations and Modeling
Supporting Oil Spill Prevention and Response since 1995

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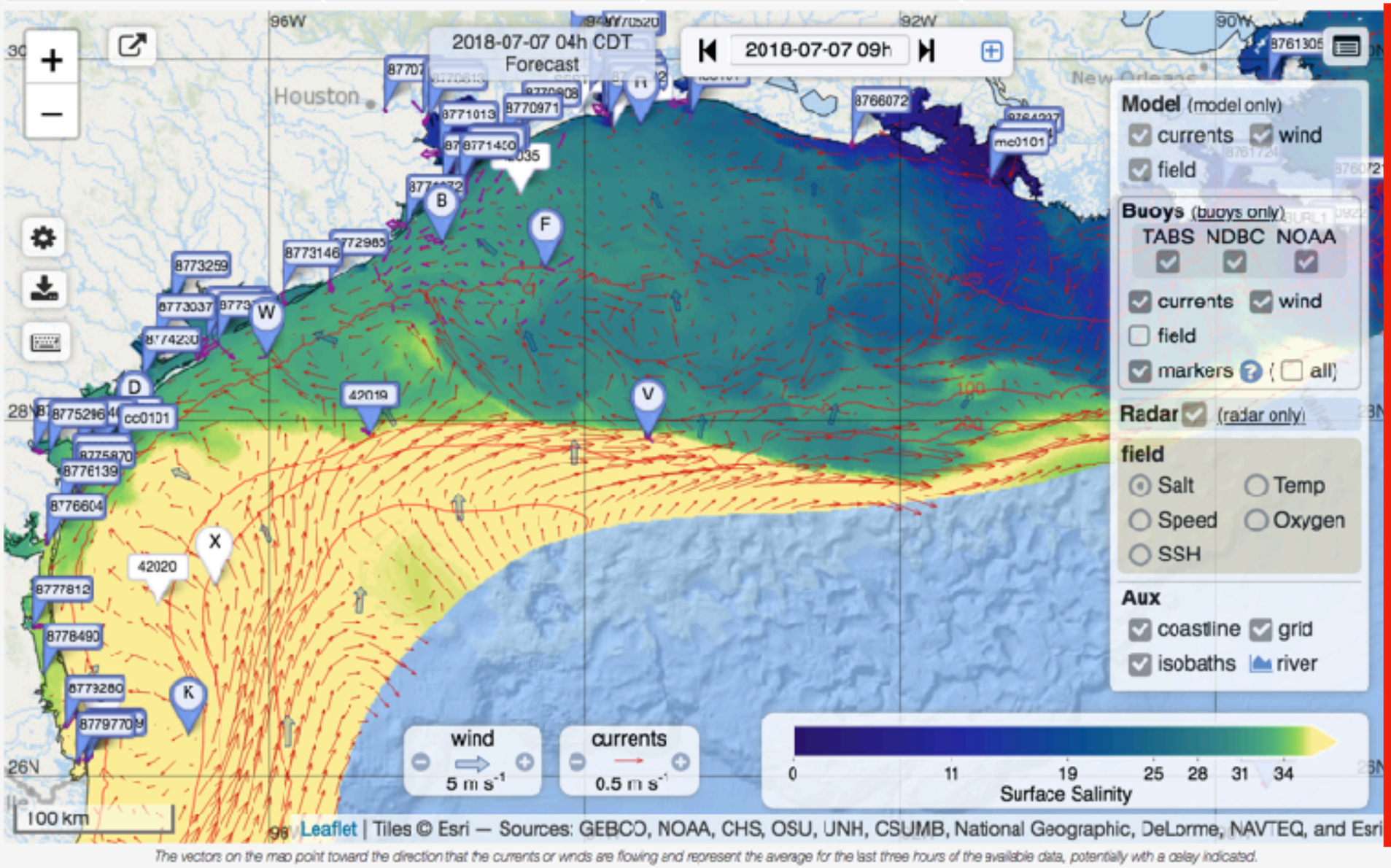
DATA PRODUCTS | MODEL PRODUCTS | OIL SPILL PRODUCTS | MORE



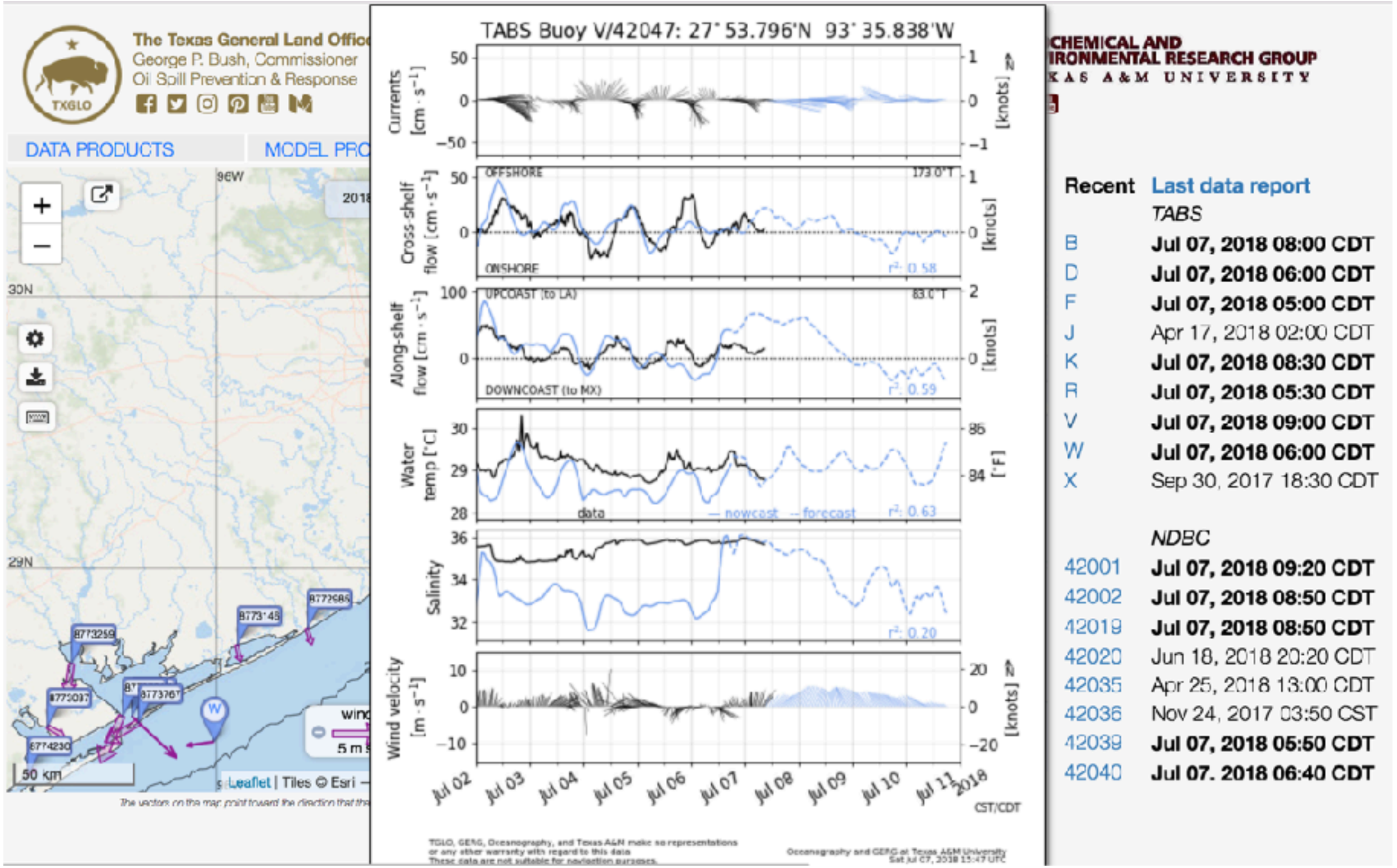
The vectors on the map point toward the direction that the currents or winds are flowing and represent the average for the last three hours of the available data, potentially with a delay indicated.

Recent	Last data report
	TABS
B	**Jul 07, 2018 07:30 CDT**
D	**Jul 07, 2018 06:00 CDT**
F	**Jul 07, 2018 05:00 CDT**
J	Apr 17, 2018 02:00 CDT
K	**Jul 07, 2018 06:00 CDT**
R	**Jul 07, 2018 05:30 CDT**
V	**Jul 07, 2018 07:30 CDT**
W	**Jul 07, 2018 06:00 CDT**
X	Sep 30, 2017 18:30 CDT
	NDBC
42001	**Jul 07, 2018 07:20 CDT**
42002	**Jul 07, 2018 06:50 CDT**
42019	**Jul 07, 2018 06:50 CDT**
42020	Jun 18, 2018 20:20 CDT
42035	Apr 25, 2018 13:00 CDT
42036	Nov 24, 2017 03:50 CST
42039	**Jul 07, 2018 05:50 CDT**
42040	**Jul 07, 2018 06:40 CDT**

Website and data access

- Pages are PHP and HTML, bits of jQuery
- Call Python when accessing data or plotting
- Station data
    - TABS buoys send their data back, stored in mySQL database, accessed by website
    - Regional buoy data is accessed from NDBC, NOAA, and PORTS portals and stored locally
- Model output
    - Model output (from Rob Hetland, TAMU) is available on THREDDS server
    - http://barataria.tamu.edu:8080/thredds/catalog.html
    - Time series for stations quickly accessible in smaller files

Data access: recent



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Recent	Last data report
	TABS
B	**Jul 07, 2018 08:00 CDT**
D	**Jul 07, 2018 06:00 CDT**
F	**Jul 07, 2018 05:00 CDT**
J	Apr 17, 2018 02:00 CDT
K	**Jul 07, 2018 08:30 CDT**
R	**Jul 07, 2018 05:30 CDT**
V	**Jul 07, 2018 09:00 CDT**
W	**Jul 07, 2018 06:00 CDT**
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42035	Apr 25, 2018 13:00 CDT
42036	Nov 24, 2017 03:50 CST
42039	**Jul 07, 2018 05:50 CDT**
42040	**Jul 07. 2018 06:40 CDT**

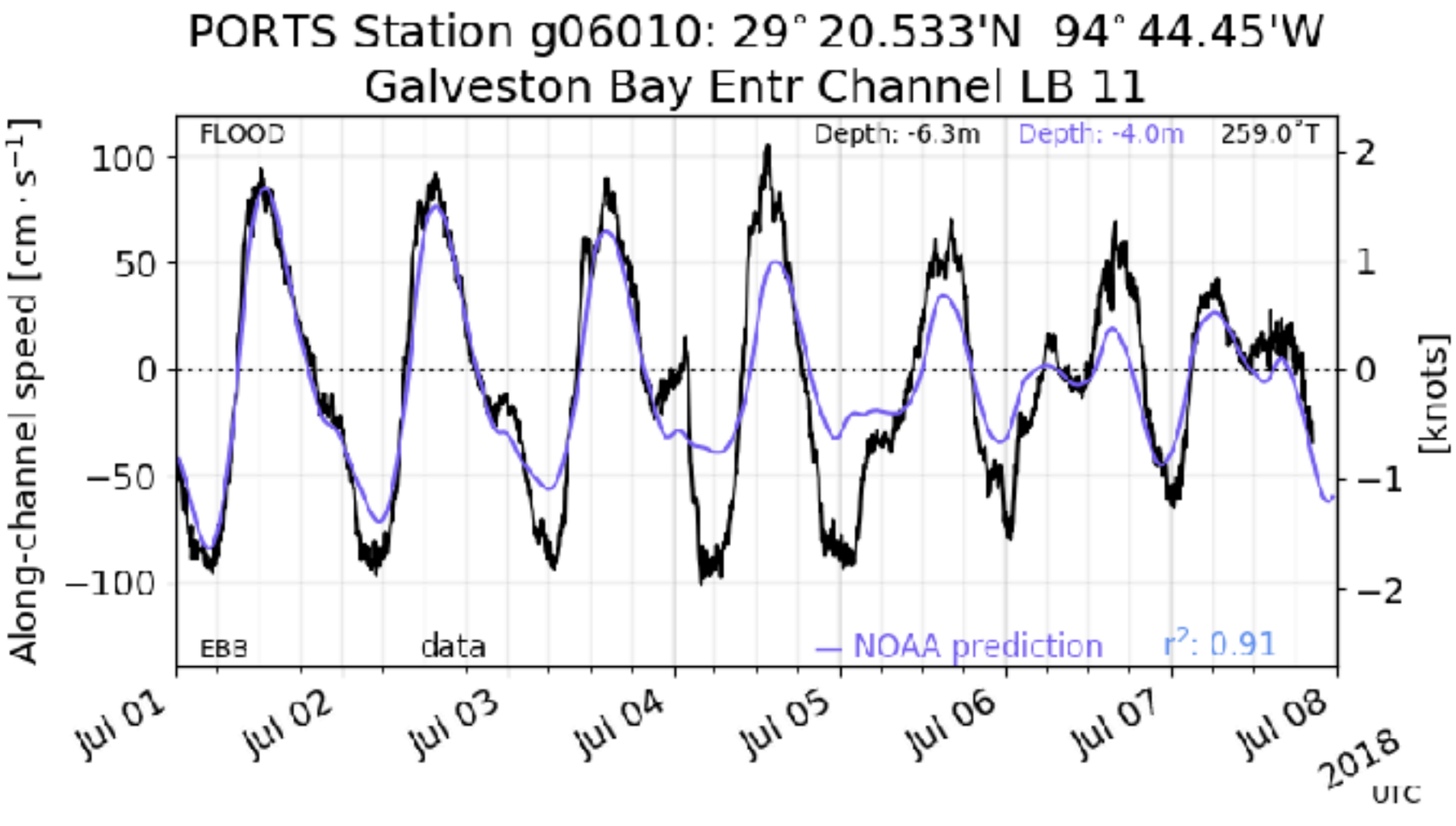
Right hand side shows recent data and model output along with forecast

Time Series Plotting

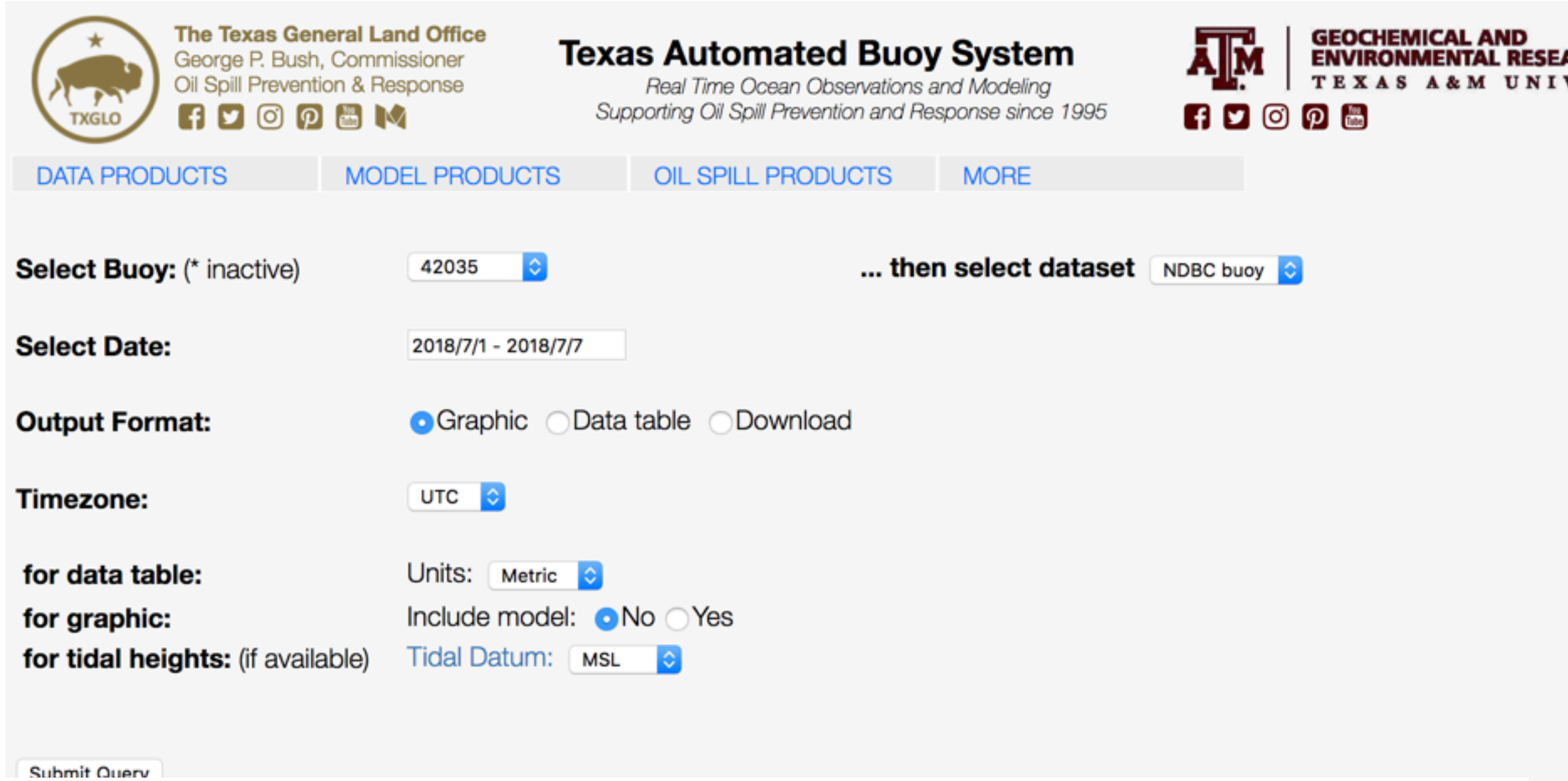
- Recent time series (front RHS panels) created every 30 minutes with updated data and forecast model output

- Time series plots called from user are made on the fly by server

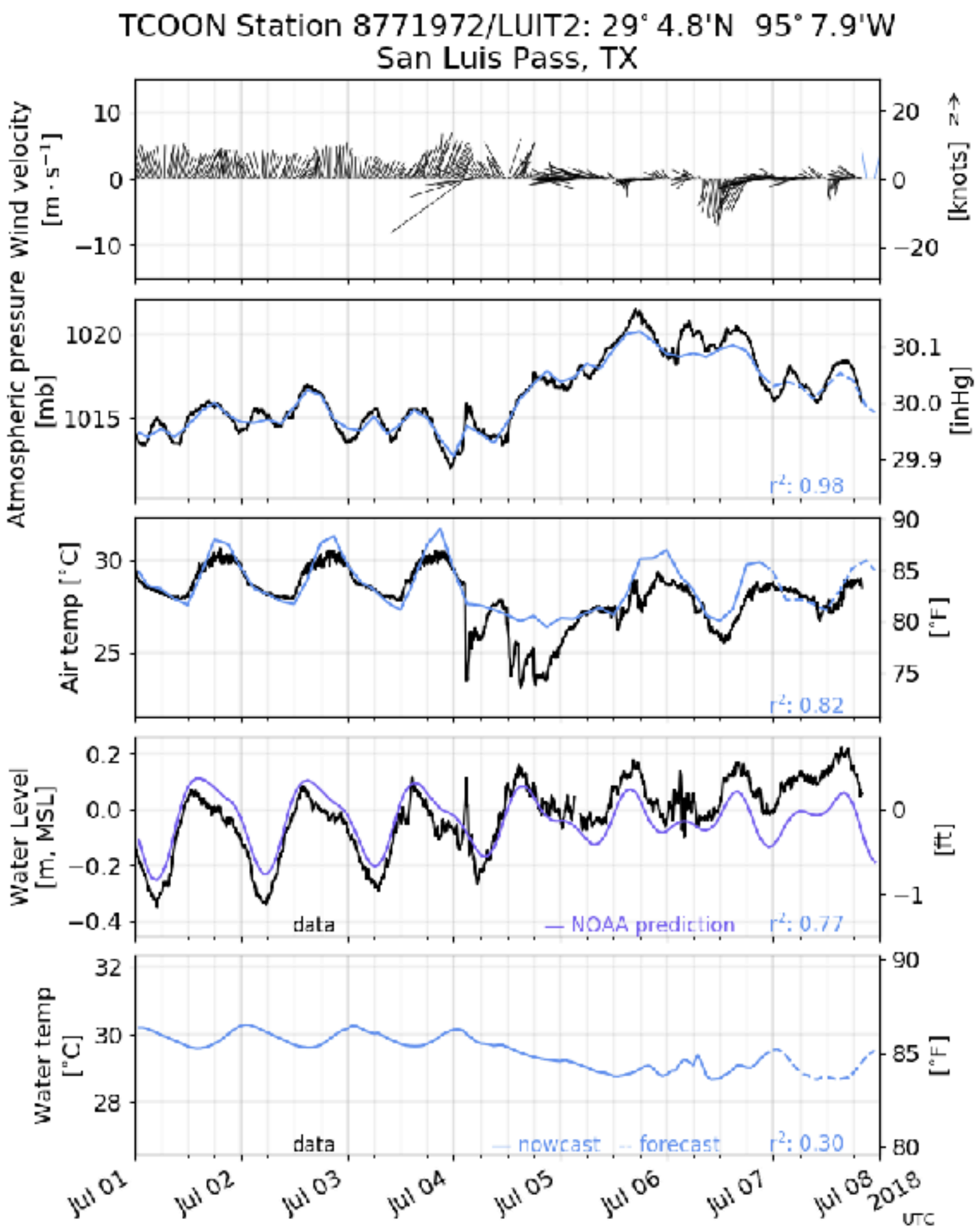
- Data managed by pandas, plots made using matplotlib



Data access: database



Select buoy data from any available time; can change units, time zone, etc. Can also download directly.



- Saves to png and pdf
- Computes r^2 between data and model time series
- forecast shown as dashed line

Data access: full files

DATA PRODUCTS | MODEL PRODUCTS | OIL SPILL PRODUCTS | MORE

Station W

TABS
28.3507,-96.0058

Status: In Service. Buoy redeployed on 06/05/2017

Depth: 21 [meters]
Flood tide rotation angle: 173 [° True]

Data types available:
- Currents
- Water temperature, Salinity

Complete Archives (download)
uncompressed text, hdf
uncompressed text, hdf

Can download available station data directly
Can edit search query

Data access: TABS package

- Easy access to the time series data and model output available through the website

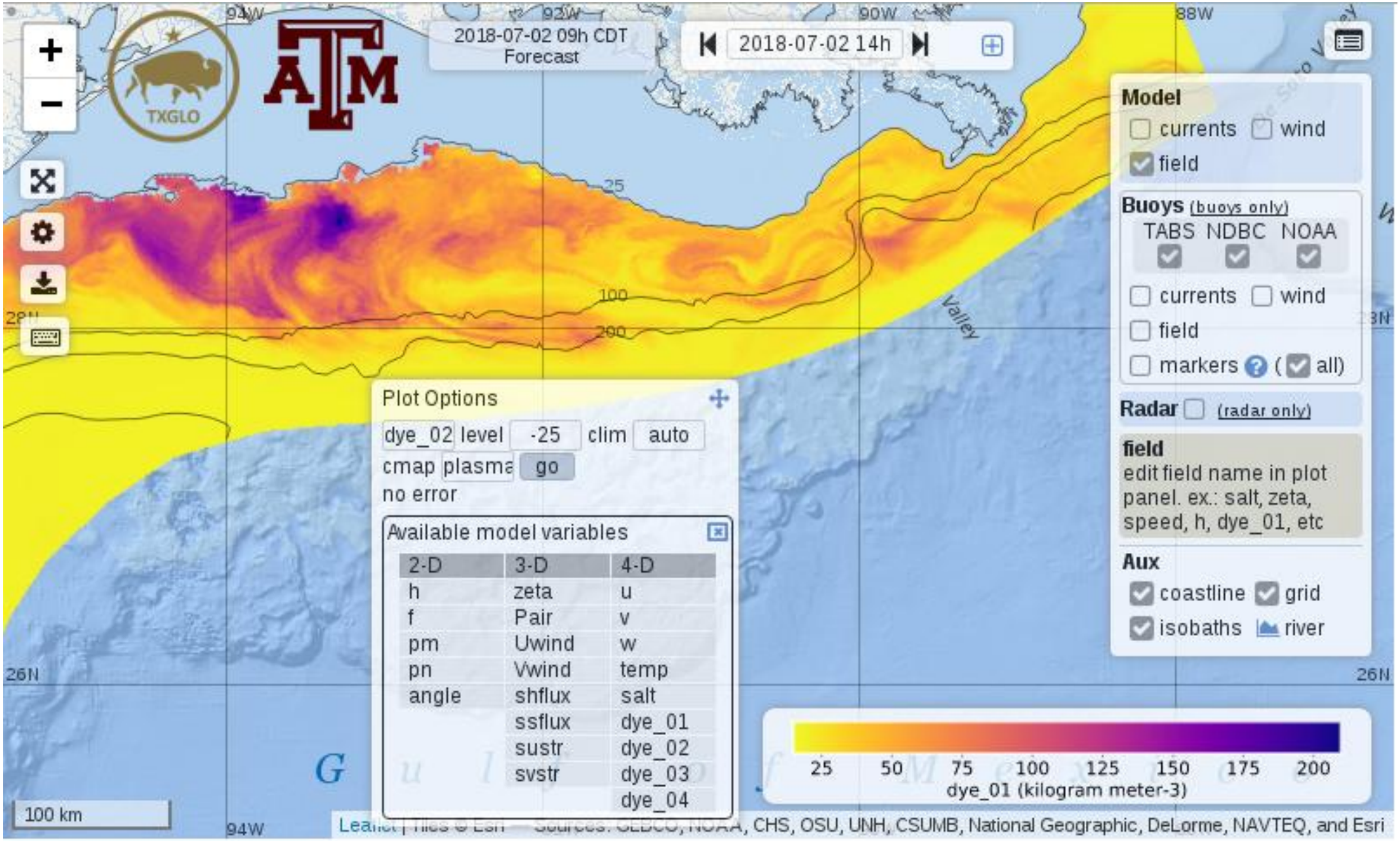
- df = tabs.read('buoyname', '2017-1-1', '2017-1-7')

- https://github.com/kthyng/tabs

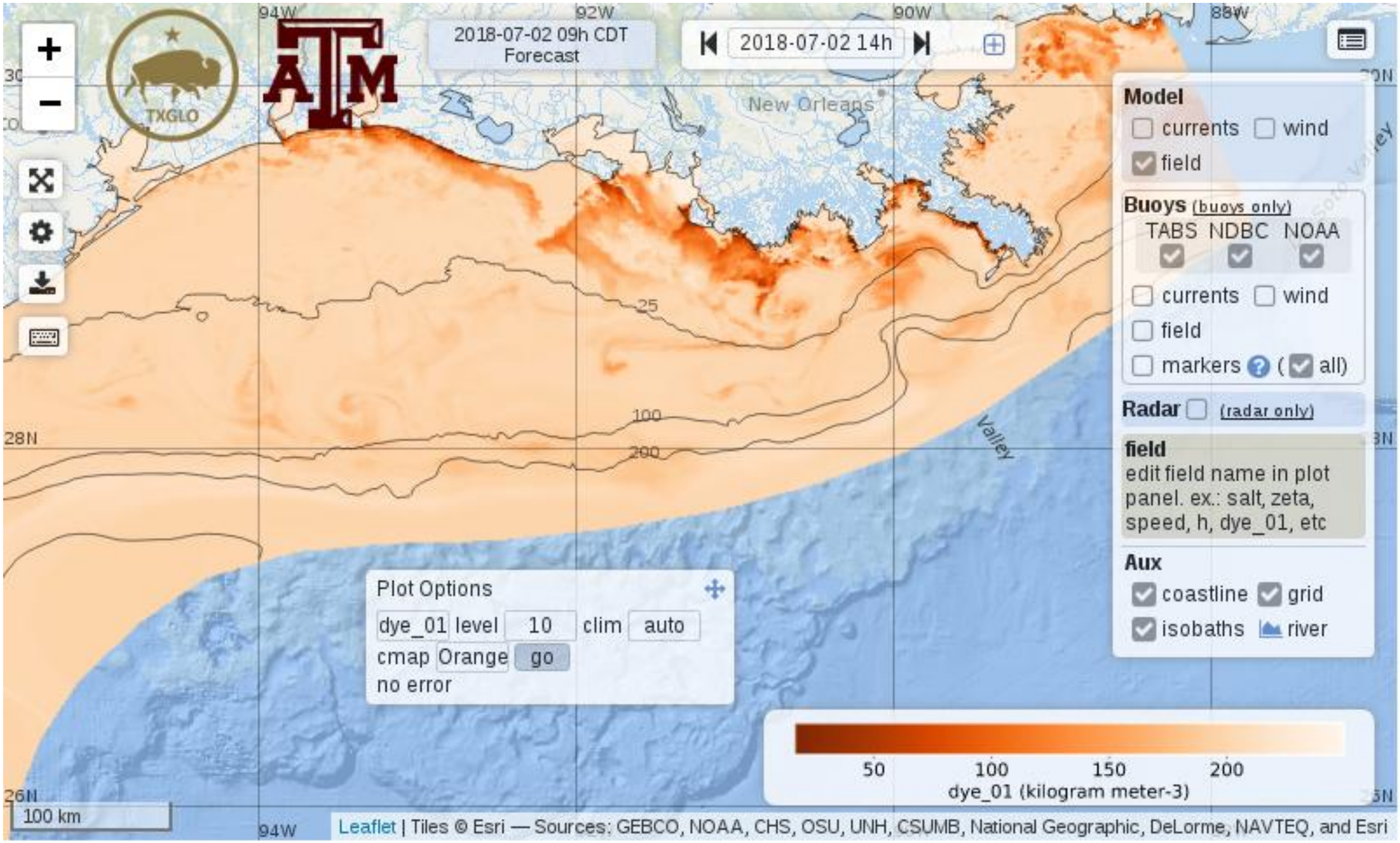
Bonus stuff!
Interactive model output mode

- Uses okean (github.com/martalmeida/okean)
  - uses numpy/scipy/matplotlib for ocean modeling data analysis and visualization
  - any 2D slice, profile or time series from the 4D dataset
  - slice at constant depth
    - requires conversion of vertical coordinates
    - uses spline or linear vertical interpolation (done in fortran via f2py)

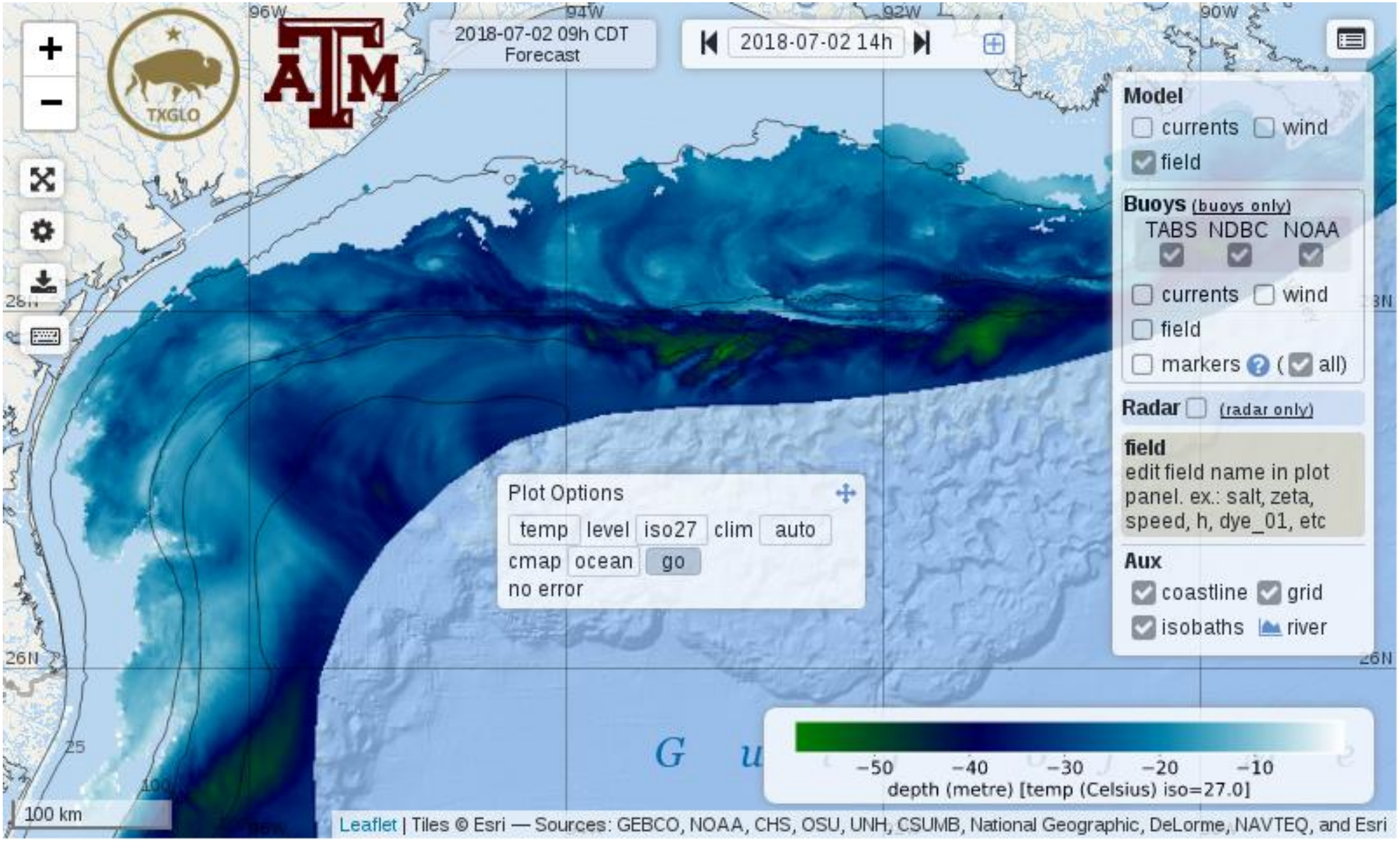
Slice at constant depth



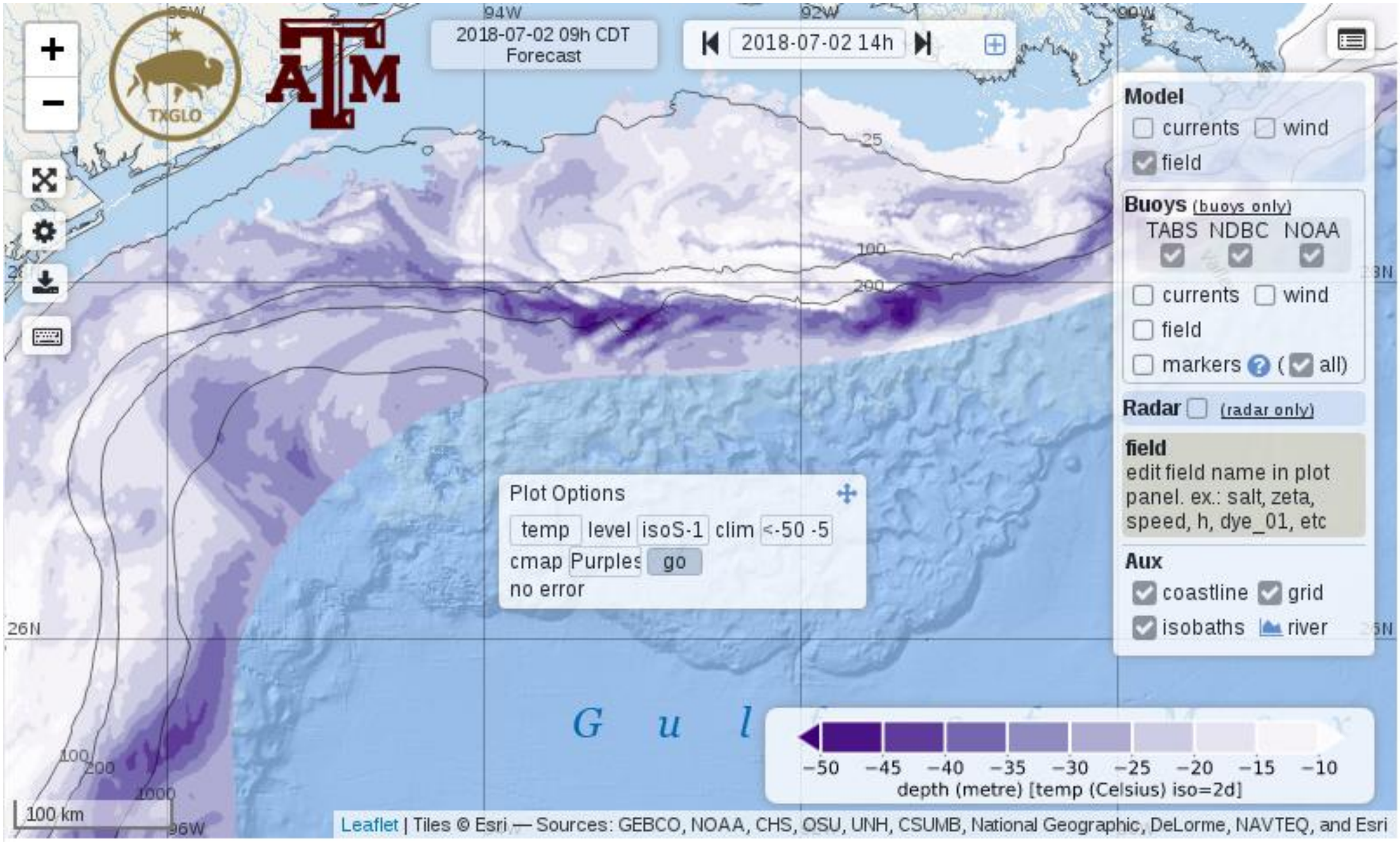
Slice at s-level



Constant-Iso-slice - 1st depth where temperature is a some fixed value)



Variable-Iso-slice - 1st depth where temperature is some 2d array (surface temp-1ºC in this case)



Challenges

- Deciding best way to accommodate data vs. user options was a development over time
- Website pulls from many sources, which break, so many contingencies are built into the system
- Same problem with forecast model, but needs to be reliable
- Making time series plots generalized for the many combinations of variables
- Small thing: quiver plots don’t seem to work with date times as coordinates

Thanks!

Site currently at
pong.tamu.edu/tabswebsite

Thanks to numpy, scipy, matplotlib, pandas, netCDF, xarray

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