



NOS S-111/S-104 Encoding Update

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5th Tides, Water Level and Currents Working Group (TWCWG5)

Remote VTC

16-18 March 2021

In memory of Kurt Hess





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NOAA PRECISION NAVIGATION PROGRAM



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Objective

In support of NOAA's Precision Navigation Program, increase utility of NOS Operational Forecast Systems (OFS) for mariners by encoding & disseminating Hydrodynamic Model Guidance in IHO standardized S-100 Formats

Overview

- In support of NOAA's Precision Navigation Program, Office of Coast Survey (OCS), Coast Survey Development Lab (CSDL) has developed a prototype processing and dissemination service for prototype S-111 HDF5 files available through NOAA Big Data AWS s3 bucket for testing by commercial manufactures of Electronic Chart Systems such as Electronic Chart Display and Information Systems (ECDIS), portable pilot units (PPU), and electronic charting systems (ECS).
- The Precision Navigation Processing and Dissemination System is deployed using cloud infrastructure, open source software and NOS's suite of open source python packages developed to encode and deliver standardized, water current forecasts for use in navigation systems according to IHO S-100/S-111 HDF5 standards.
- Current Data Source : NOAA/NOS Operational Forecast Systems (OFS)
 - NOAA/NOS Operational Forecast Systems(OFS), consisting of an automated integration of near-real-time data from observing systems and hydrodynamic modelling systems, provides near nowcasts and short-term oceanographic forecast guidance for a distinct coastal or lake region throughout the U.S.



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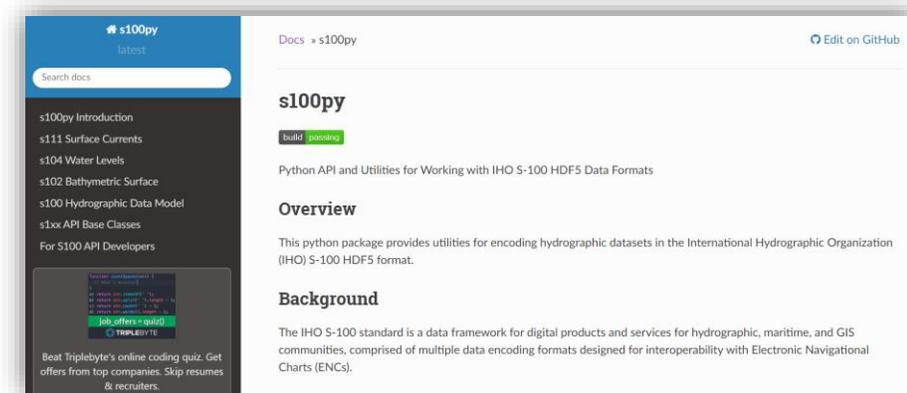
NOAA/NOS/OCS/CSDL UPDATES



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Released s100py v1.0.0-rc.1 on February 11, 2021, this replaces s100py v0.5.1

- This is a major release candidate, which includes a new API that encapsulates the data specifications to allow introspection with Python
- A consistent API for S100 data structures was added and is used to encode S102, S104, and S111
- Support for s102 (bathymetry) and s104 (water levels) has been added
- Convenience utility functions are available to convert data into S102/S104/S111 so detailed knowledge of the S100 specs and APIs is not required in most cases
- The previous S111 library has been migrated to this general S100 API and therefore any code written against the previous s100py library will no longer work
- thyme python package is no longer a required dependency



<https://s100py.readthedocs.io/en/latest/>

<https://github.com/noaa-ocs-s100/s100py>



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NOAA/NOS/OCS/CSDL UPDATES



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• CSDL has built a precision navigation processing and dissemination system for prototype S-111 operations using AWS cloud infrastructure and open source software

• Migrated production of S-111 files for all 15 NOS OFS to AWS cloud infrastructure and Dockerize python framework for easier deployment in the cloud

• Migrated s100py metadata database and NOAA REST API to AWS cloud infrastructure to automatically generate S-111 Exchange Catalogues for each OFS forecast cycle and disseminate via S3 bucket for discoverability

• Produced sample S-104 files using forecast guidance of water levels from NOAA’s Global Extratropical Surge and Tide Operational Forecast System (G-ESTOFS)

• Sample S-104 files were produced for reschemed ENC Band 2 cells located in Palau, Marianas, Guam, and American Samoa Pacific Islands

• Sample S-104 files match S-104 Product Specification v0.0.7 - Proposed Configurations and water level heights are relative to a global Mean Sea Level defined by the EGM2008 geoid

Sample S-104 file

	waterLevelHeight	waterLevelTrend
0	0.32	3
1	0.32	3
2	0.32	3
3	0.32	3
4	0.32	3
5	0.32	3

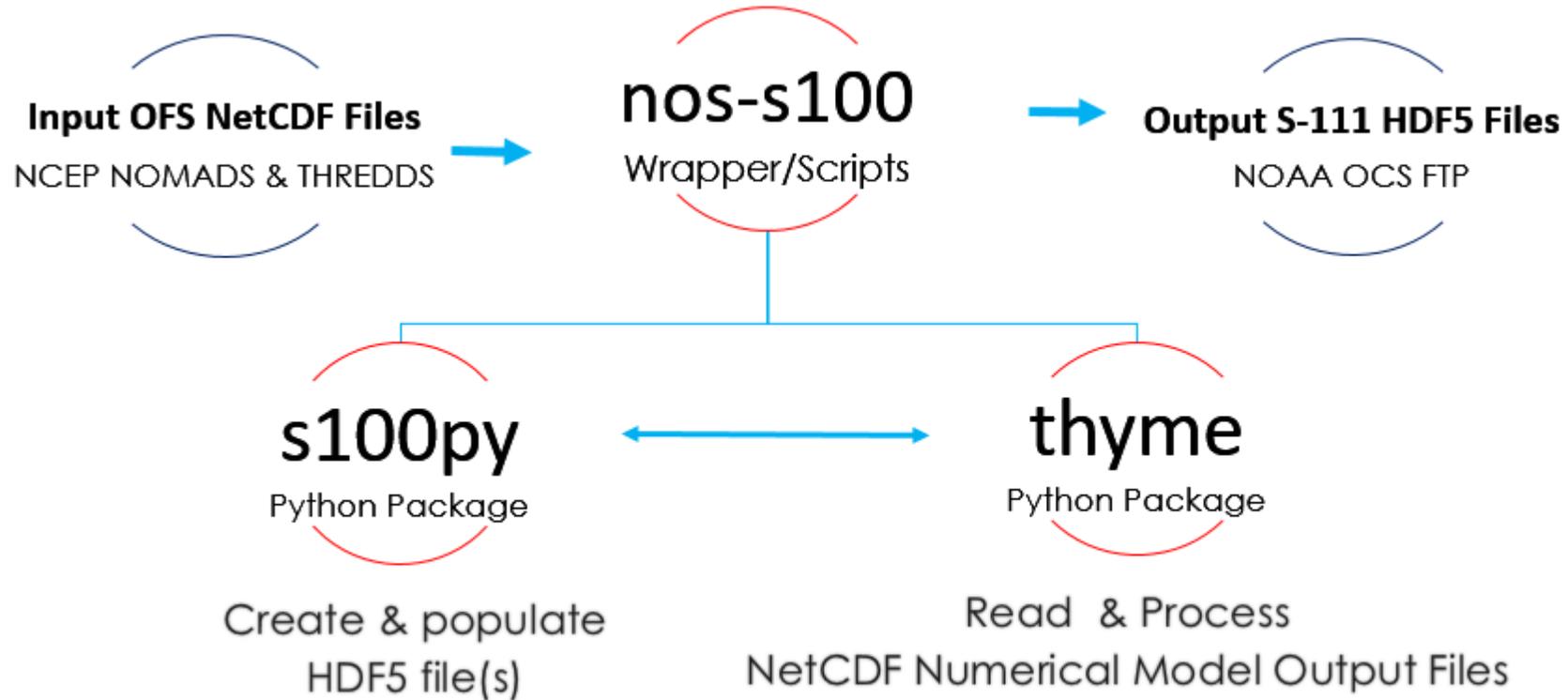


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PREVIOUS S-111 ENCODING OPERATIONS

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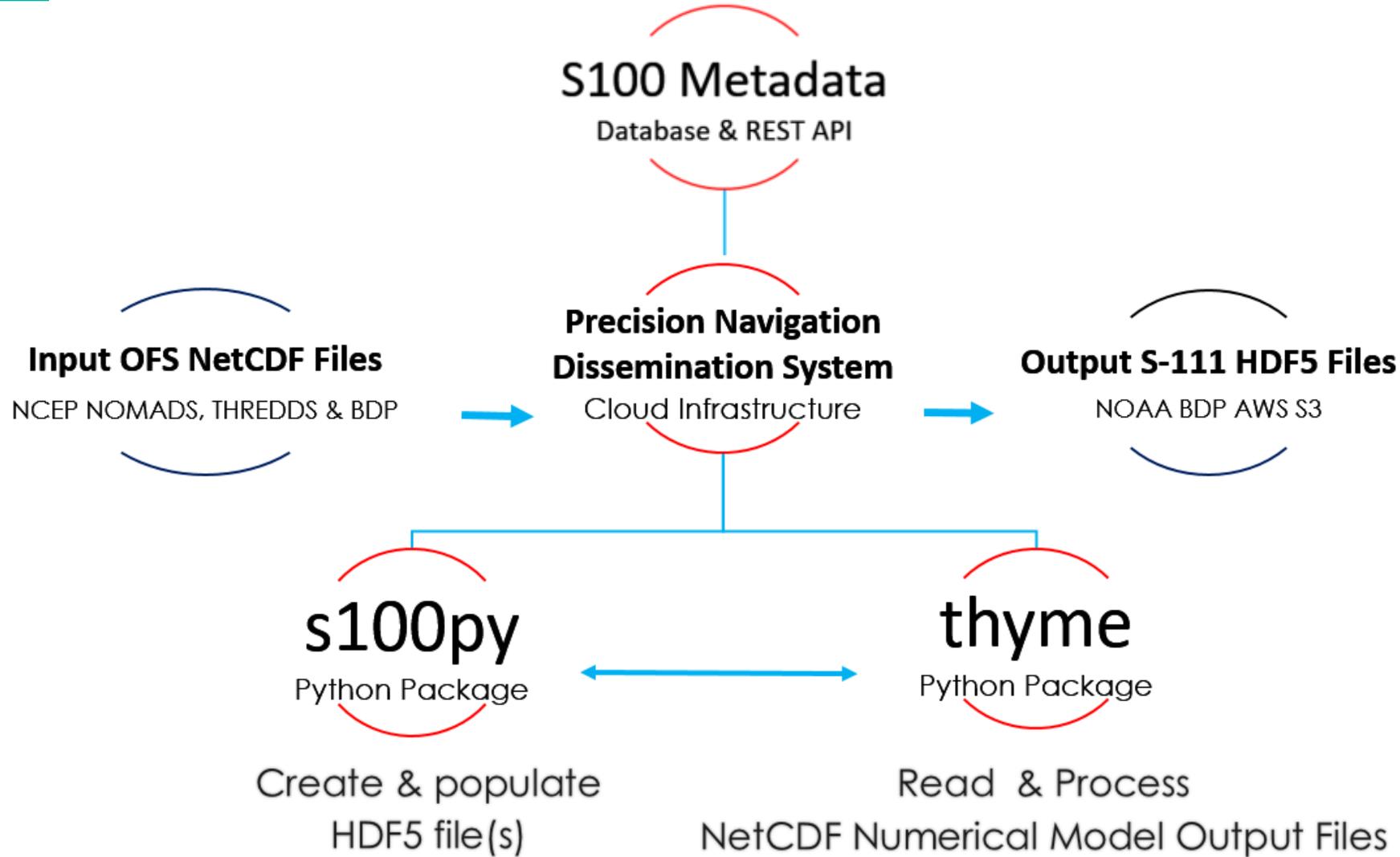


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CURRENT S-111 ENCODING OPERATIONS

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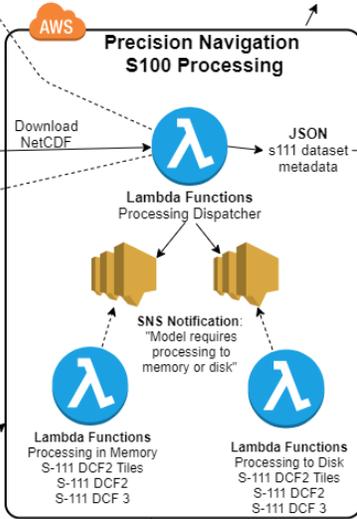
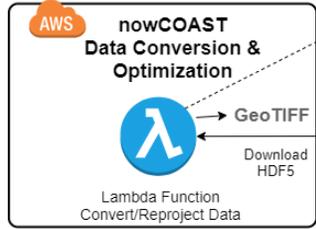
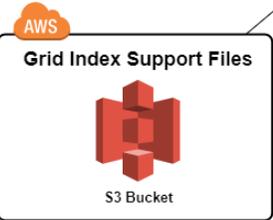
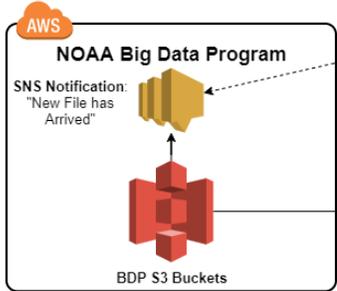
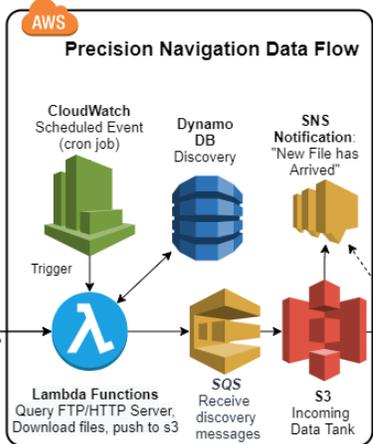




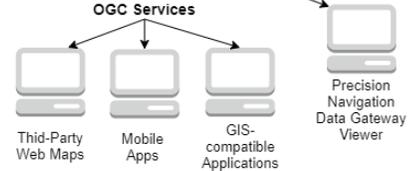
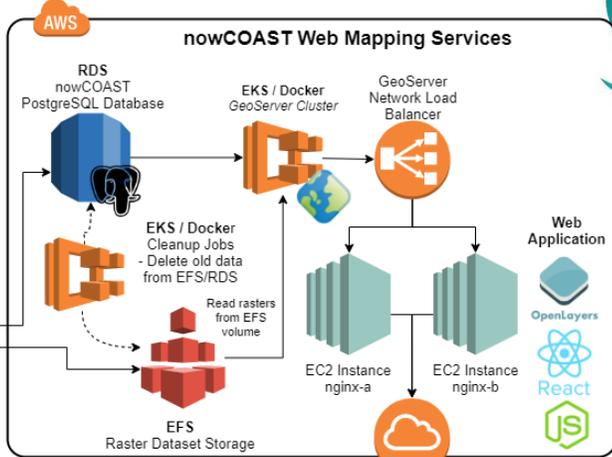
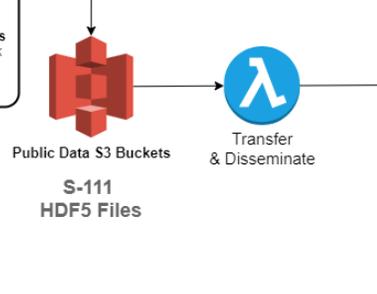
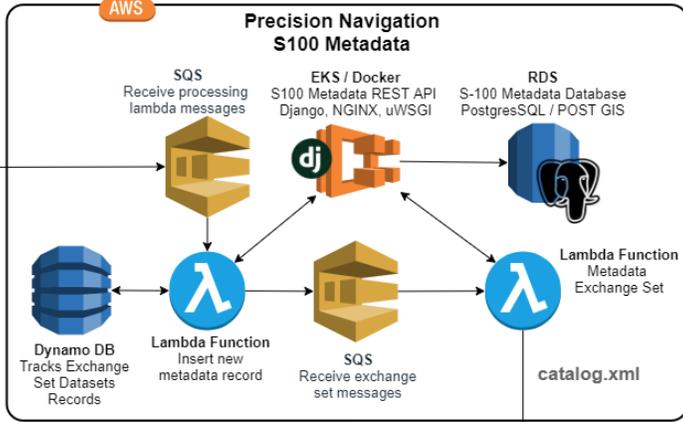
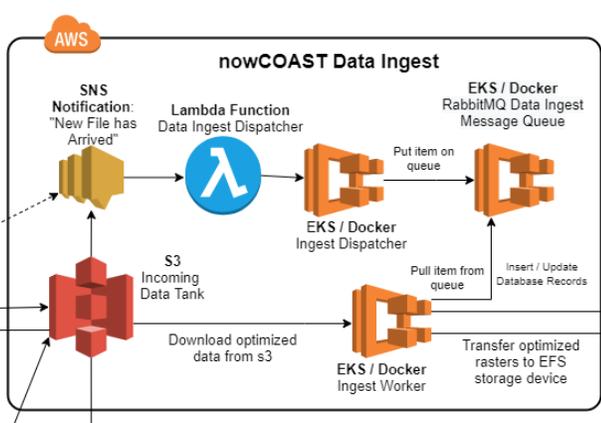
Precision Navigation & nowCOAST Cloud-Based Data Processing, Ingest, and Dissemination



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```
s100py thyme
gdal numpy
scipy shapely
netCDF4 h5py
```



AWS Acronyms
 AWS = Amazon Web Services
 EFS = Elastic File System
 EKS = Elastic Kubernetes Service
 S3 = Simple Storage Service
 SNS = Simple Notification Service
 SQS = Simple Queue Service
 RDS = Relational Database Service





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PRECISION NAVIGATION SYSTEM S100 METADATA

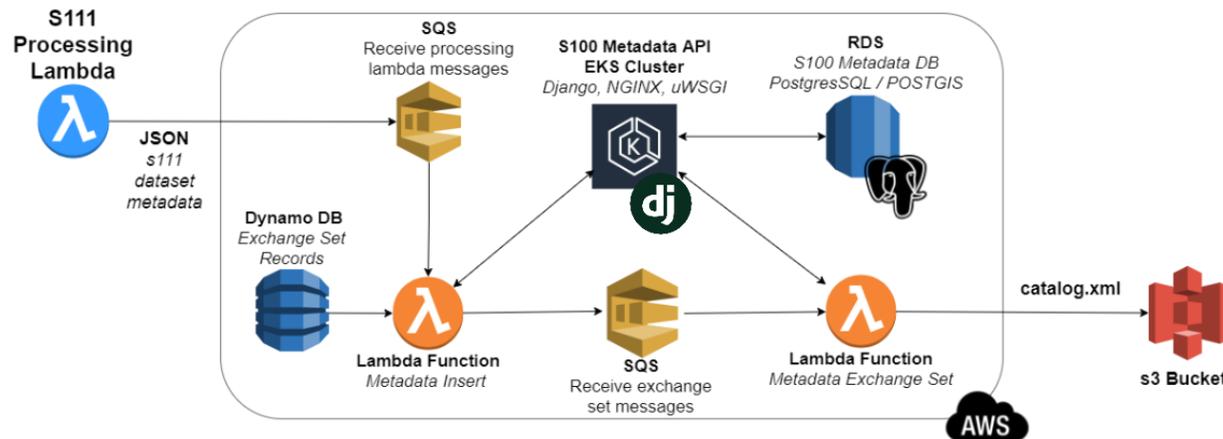


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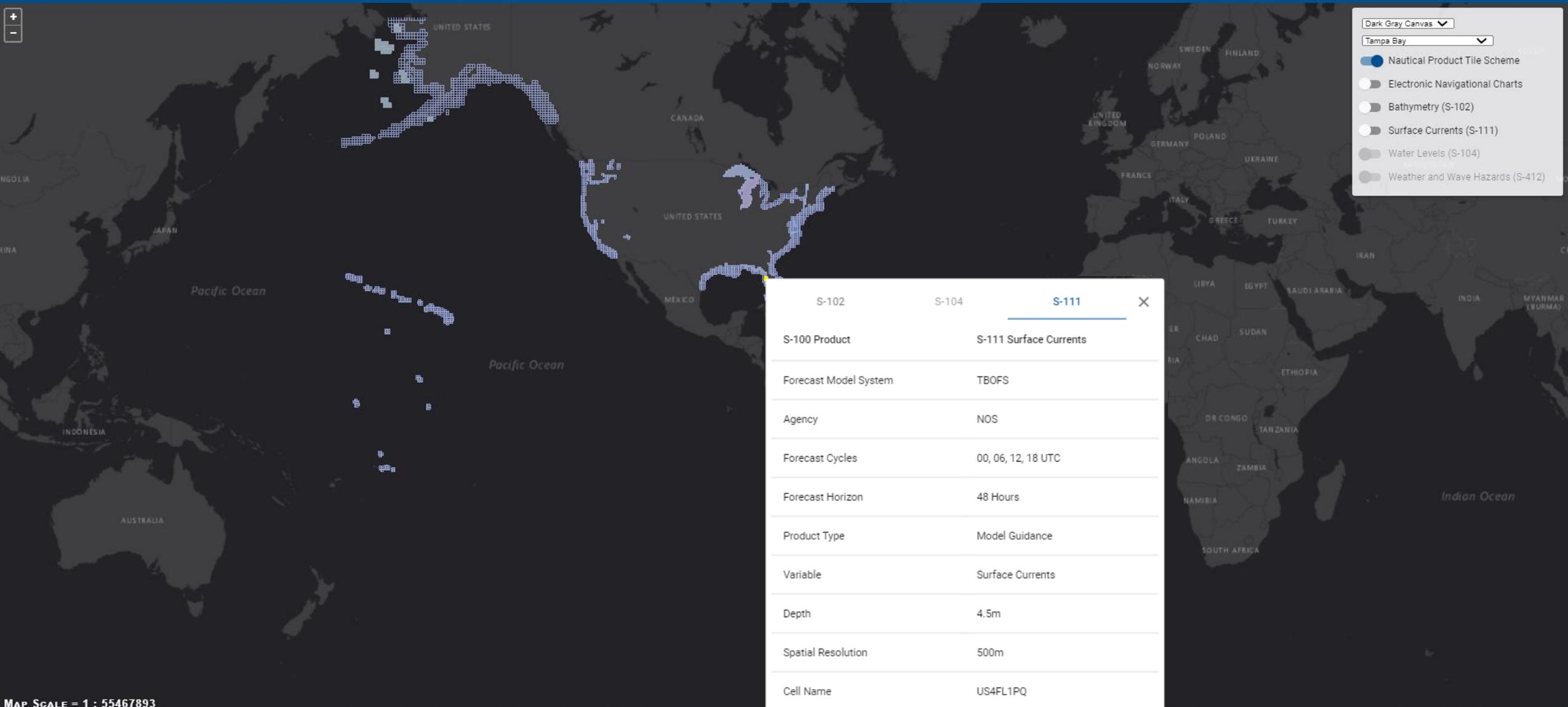
- Provides S-111 Exchange Catalog Metadata containing:
 - When new data is released
 - Where the data is stored
 - Where the data is geographically located
 - What type of data it is
 - Who produced the data
- S100 relational database tables developed by Raphael Malyankar and modeled after S-100 Edition 4.0.0 metadata
- NOAA REST API developed by IIC Technologies Inc based on NOAA requirements and built using Django
- Initialized and migrated to AWS by Precision Navigation Team using docker container that houses Django NOAA REST API, NGINX, uWSGI and works with external PostgreSQL (AWS RDS) S100 Metadata DB
- Additional S-100 products have been added and include S101, S102, and S104, metadata will be generated as additional products become available

Precision Navigation S100 Metadata



Example S-111 Exchange Set Endpoints

POST	/exchangeSets/111	Adds S-111 exchange set record
PUT	/exchangeSets/111{exchangeSetId}	Updates specific S-111 exchange set record
GET	/exchangeSets	Retrieves all exchange set record IDs
GET	/exchangeSets/?Identifier=	Retrieves exchange set record matching specified identifier
GET	/exchangeSets/?ProductType=	Retrieves exchange set records matching specified product type
GET	/exchangeSets/{exchangeSetId}/export	Validates and exports specific exchange set record as XML
POST	/exchangeSets/{exchangeSetId}/datasets	Adds dataset associations to specific exchange set record
PUT	/exchangeSets/{exchangeSetId}/datasets	Updates dataset associations for specific exchange set record
GET	/exchangeSets/{exchangeSetId}/datasets	Retrieves dataset associations for specific exchange set record
DELETE	/exchangeSets/{exchangeSetId}/datasets	Deletes dataset associations from specific exchange set record



Dark Gray Canvas

Tampa Bay

- Nautical Product Tile Scheme
- Electronic Navigational Charts
- Bathymetry (S-102)
- Surface Currents (S-111)
- Water Levels (S-104)
- Weather and Wave Hazards (S-412)

S-102	S-104	S-111	X
S-100 Product		S-111 Surface Currents	
Forecast Model System		TBOFS	
Agency		NOS	
Forecast Cycles		00, 06, 12, 18 UTC	
Forecast Horizon		48 Hours	
Product Type		Model Guidance	
Variable		Surface Currents	
Depth		4.5m	
Spatial Resolution		500m	
Cell Name		US4FL1PQ	
Band Number		4	
Get Data		S-111 HDF-5 Files	

MAP SCALE = 1 : 55467893

<https://beta.marinenavigation.noaa.gov/gateway/>

DISCOVER



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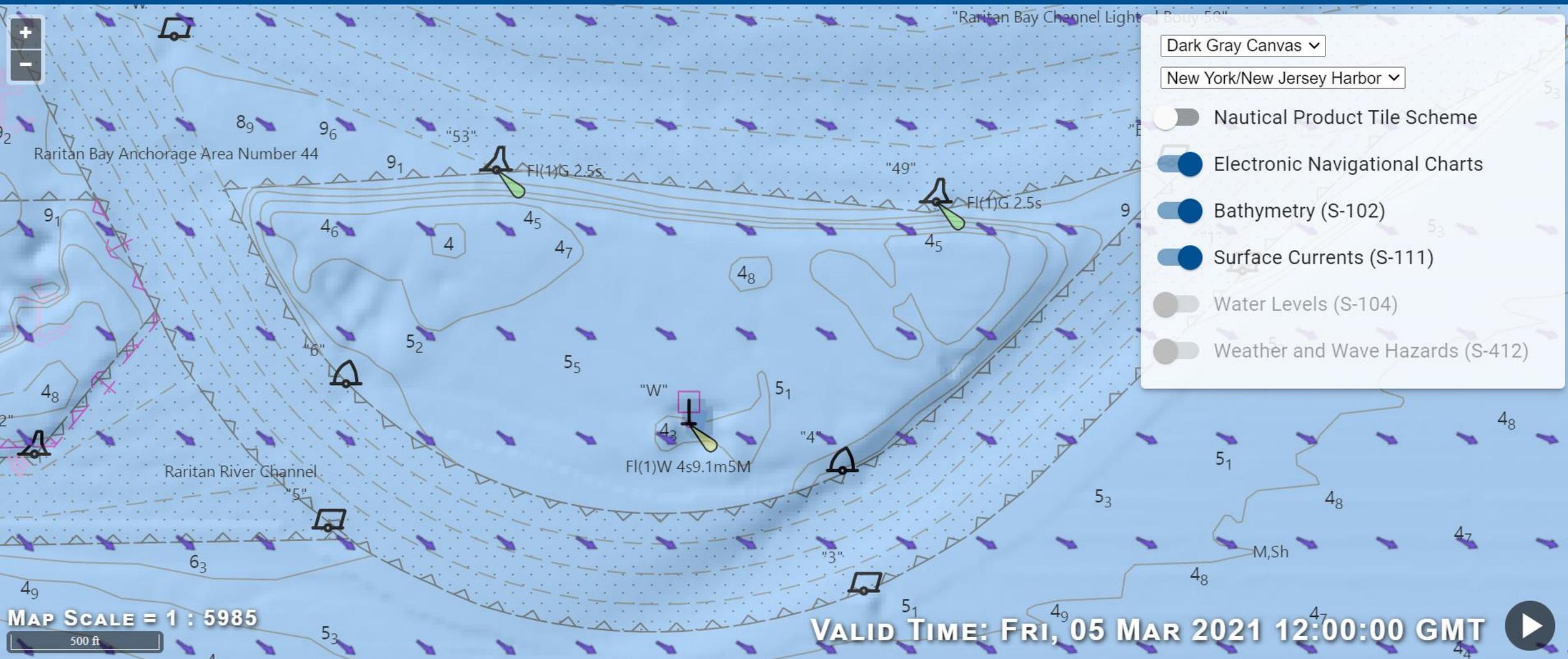
VISUALIZE

<https://beta.marinenavigation.noaa.gov/gateway/>



Precision Navigation Data Gateway *Prototype*

Discover → Visualize → Download





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ACCESSING NOAA S-111 DATA ON AWS



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- Access to the datasets is being provided on Amazon Web Services (AWS) via Simple Storage Service (S3). Files can be downloaded via the native AWS S3 API using tools such as the [AWS CLI](#) or AWS SDK libraries such as the [Python boto3 package](#).
- AWS S3 also provides direct HTTP access to the files, so datasets can be downloaded using any HTTP client such as a web browser. The Amazon Resource Name (ARN) for the S3 Bucket is: **arn:aws:s3:::noaa-s111-pds**
- Additionally, an AWS Simple Notification Service (SNS) Topic has also been created to provide automated notifications when new files are added to the S3 Bucket. Users who operate their own infrastructure on AWS can integrate directly with this SNS Topic to trigger automated workflows using AWS Lambda or other services.
- The Amazon Resource Name (ARN) for the SNS Topic is: **arn:aws:sns:us-east-1:123901341784:NewS111Object**
- To make discovering and accessing the data easier, a simple [AWS bucket explorer](#) web app is also provided which allows you to navigate through the object key structure and download files using a web browser.

<https://noaa-s111-pds.s3.amazonaws.com/README.html>

Object	Last Modified	Timestamp	Size
111USA1_TBOFS_20210304T12Z_US4FL1NP.h5	9 hours ago	2021-03-04 08:35:42	363 KB
111USA1_TBOFS_20210304T12Z_US4FL1NQ.h5	9 hours ago	2021-03-04 08:35:42	516 KB
111USA1_TBOFS_20210304T12Z_US4FL1NR.h5	9 hours ago	2021-03-04 08:35:41	230 KB
111USA1_TBOFS_20210304T12Z_US4FL1OO.h5	9 hours ago	2021-03-04 08:35:42	298 KB
111USA1_TBOFS_20210304T12Z_US4FL1OP.h5	9 hours ago	2021-03-04 08:35:42	637 KB
111USA1_TBOFS_20210304T12Z_US4FL1OQ.h5	9 hours ago	2021-03-04 08:35:43	587 KB
111USA1_TBOFS_20210304T12Z_US4FL1PO.h5	9 hours ago	2021-03-04 08:35:42	310 KB
111USA1_TBOFS_20210304T12Z_US4FL1PP.h5	9 hours ago	2021-03-04 08:35:41	653 KB
111USA1_TBOFS_20210304T12Z_US4FL1PQ.h5	9 hours ago	2021-03-04 08:35:41	585 KB
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111USA1_TBOFS_20210304T12Z_US4FL1QQ.h5	9 hours ago	2021-03-04 08:35:42	334 KB
111USA1_TBOFS_20210304T12Z_US4FL1QR.h5	9 hours ago	2021-03-04 08:35:43	242 KB
catalog.xml	9 hours ago	2021-03-04 08:35:52	76 KB

https://noaa-s111-pds.s3.amazonaws.com/index.html#ed1.0.1/model_forecast_guidance/

DOWNLOAD



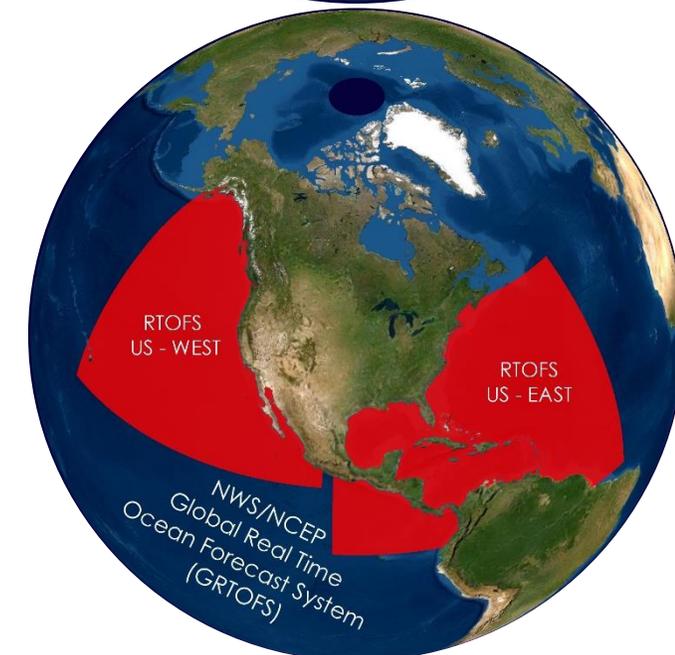
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PRECISION NAVIGATION S-111 DISSEMINATION

Automatically generating prototype S-111 HDF5 Type 2 tiles and exchange catalogs, Type 2 regional, and Type 3 regional files compliant with S-111 Edition 1.0.1 & S-100 Edition 4.0.0 for the following NOAA operational forecast systems :



Region	Horizontal Resolution	S-111 Tiles Per Exchange Set	Exchange Set Per Day	ENC Band
CBOFS	500 m	62	4	4
DBOFS	500 m	26	4	4
NYOFS	300 m	5	4	4
TBOFS	500 m	13	4	4
LEOFS	500 m	37	4	4
LOOFS	500 m	23	4	4
LSOFS	500 m	103	4	4
LMHOFS	500 m	154	4	4
NEGOFS	500 m	150	4	4
NWGOFS	500 m	19	4	4
NGOFS	1000 m	50	4	4
SFBOFS	300 m	15	4	4
GOMOFS	700 m	84	4	4
RTOFS – US EAST	8.5 km	32	1	2
ROTFS- US WEST	8.5 km	27	1	2





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CHALLENGES IN WORKING WITH NOS OFS OUTPUTS



- NOS ocean forecast system metadata is not standardized by framework, region, or model version, CF Metadata attributes mitigate some of the issues, but not all, thyme python module is developed specifically for each numerical ocean modeling framework and customized to support nuances specific to U.S. NOS numerical operational forecast systems
- Presently, the BAND4 S-111/HDF5 tiles are only generated at one spatial resolution for each OFS (e.g. 500 m for XXOFS) which does not match native model grid resolution and is not sufficient for nearshore navigation
- NOS ocean models do not contain spatial indexing and require horizontal and vertical interpolation
- Initial regular grid masking solutions are not ideal for global grids and time varying masks (e.g. wetting and drying)
- Water Level predictions from saltwater OFSs can be referenced to localized “Model Sea Level” rather than Mean Sea Level (MSL) and require vertical transformation
- NOS OFS model output can contain different units , dimensionality, fill values, vertical/horizontal coordinate systems, and variable naming conventions
- Water level, bathymetry, temperature, salinity, u/v, etc. may not be located at same grid points, implications on horizontal/vertical transformations, interpolation, and rotation
- Output files often contain variables not applicable to most users and a collection of all native output files for full forecast run can be huge (> 4GB for some models)



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NEXT STEPS



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- Refactor and optimize thyme python package
- Upgrade to latest S100 Metadata API repository and add to GitHub
- Add support for S-104/S-111 DCF 1, 4, 7, 8 in S100 API
- Develop S-104 test files from NOS OFS forecast guidance using new S100 API
- Improve S-111 map services , use u/v instead of speed/direction
- Need S100 test bed with interoperability and portrayal and feature catalogs to test S-111 datasets feasibility
- Need data quality checks and data structure validation

Required product specification component	(TRL5) Level 1 v1.0.0	(TRL6) Level 2 v1-2.0.0	(TRL7) Level 3 >v2.0.0	(TRL8) Level 4 >v2.0.0	(TRL9) Level 5 >v2.0.0
Main Document (Defines the relevant parts of S-100 that are required for the product specification)	X	X	X	X	X
A Default Encoding	X	X	X	X	X
S-100 Compliant Feature Catalogue	X	X	X	X	X
<i>DCEG</i>	X	X	X	X	X
S-100 Compliant Portrayal Catalogue NOTE: Not every specification will need a portrayal catalogue – this should be determined as part of the development process and stakeholder feedback		X	X	X	X
Data Quality Checks		X	X	X	X
Test Data Sets		X	X	X	X
<i>Data Validation (and test datasets)</i>		X	X	X	X
Exchange Catalogue		X	X	X	X
Encryption / Digital Signatures			X	X	X
Interoperability				X	X
Alerts and Indications				X	X
Operational data					X



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Acknowledgements



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- Precision Navigation Team

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- NOAA/NOS/CSDL

Barry Gallagher, Greg Seroka

- NOAA/NOS nowCOAST Project

- <https://nowcoast.noaa.gov>

- Contact: marinenav.team@noaa.gov

