AIS Big Data Introductory Training

UNSD | May 2023

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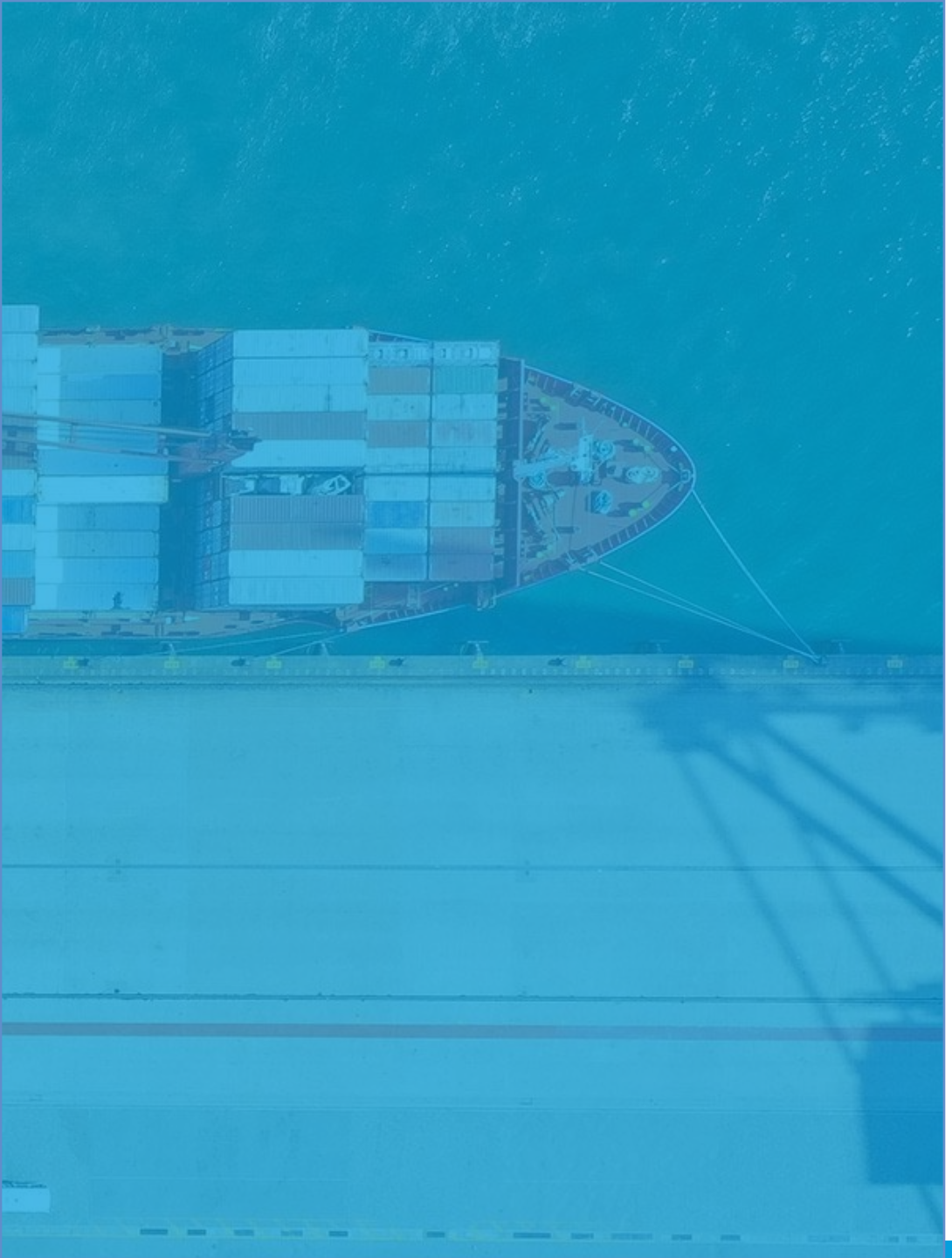

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Outline

- Overview
  - What is AIS Data
  - AIS Data generation
  - Accessibility of AIS data
- AIS Data Use Cases
- Acquiring AIS Data
- Useful recourse and learning opportunities

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Overview

About AIS

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- The Automatic Identification System (AIS) is an automated, autonomous tracking system which can be used for the exchange of navigational information between AIS-equipped terminals.
- It allows vessels like cargo ship, tanker, fishing vessel or passenger ship to periodically broadcast their information.
- AIS was originally developed by IMO (International Maritime Organization) in 2004, solely for collision avoidance among large vessels at sea that are not within range of shore-based systems.
- Now, AIS data provides a big data source of unrivaled quality above and beyond its original application for collision avoidance.

About AIS Big Data

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- The system stores more than 11 million AIS messages a day
- There are 27 different AIS messages containing different types of information
- AIS data mainly comprised of 3 information categories, which are Static data, dynamic data, and voyage-related data.

Static data	Dynamic data	Voyage-related data
information on ship characteristics	information on ship position and movements	information on a current voyage
MMSI, IMO number, call sign, ship name, type, dimensions	Ship's position (long, lat), speed over ground (SOG), course over ground (COG), navigation status	Destination, estimated time of arrival, drought (Time does not exist in AIS frames. It is added by receivers)

AIS Data example

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FID	mmsi	imo	vessel_name	callsign	vessel_type	vessel_type_code	vessel_type_cargo	vessel_class	length	width	flag_country	flag_code
null	440503000	8815724	55 SHIN YUNG	6MWP	Fishing	30	null	A	55	9	South Korea	440
null	366557000	8419142	MATSON ANCHORAGE	KGTX	Cargo	70	null	A	216	24	USA	366
null	440055000	9019509	ORYONG 325	6MNZ	Fishing	30	null	A	56	10	South Korea	440
null	367542320	null	WALTER L GIBBS	WDG5004	Towing	31	null	A	27	10	USA	367
null	538008215	9844277	OLYMPIC LIFE	V7A2092	Tanker	80	null	A	333	60	Marshall Islands	538
null	345070040	9242106	DONA BLANCA	XCDC	Passenger	60	null	A	22	5	Mexico	345
null	735057514	null	DARWIN	HC2113	Passenger	60	null	A	20	5	Ecuador	735
null	367651380	440	ELK	WDH7758	Cargo	70	null	A	58	15	USA	367
null	366998130	null	TAYLOR MARIE	WDC2822	Tug	52	null	A	22	8	USA	366
null	218791000	9612997	ANTWERPEN EXPRESS	DJCE2	Cargo	79	No Additional Inf...	A	366	48	Germany	218
null	735059299	null	JOLINDA	HC56O1	Fishing	30	null	A	45	5	Ecuador	735
null	636016940	9238789	MSC MANU	A8CF3	Cargo	70	null	A	260	32	Liberia	636
null	338392816	null	COOL BREEZE	null	Pleasure Craft	37	null	B	13	5	USA	338
null	636018346	9797187	POLAR CHILE	D5PH8	Cargo	72	Carrying DG,HS or...	A	230	37	Liberia	636
null	563063700	9833541	STI MAGISTER	9V8891	Tanker	80	null	A	183	32	Singapore	563
null	636010032	9018658	SOL DO BRASIL	ELQQ4	Cargo	70	null	A	172	26	Liberia	636
null	338125000	9670339	RUSSELL ADAMS	WDG9047	WIG	20	null	A	81	18	USA	338
null	224559000	8802363	PLAYA DE RODAS	EHQQ	Fishing	30	null	A	55	10	Spain	224
null	316266000	9175298	PLACENTIA PRIDE	VCWB	Tug	52	null	A	38	13	Canada	316
null	710003110	null	PELAGIUS	PR 6983	Tug	52	null	A	30	10	Brazil	710

Vessel ID

Vessel name

Vessels Type

Vessels Size

Vessels Flag

AIS Data example

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destination	eta	draught	position	longitude	latitude	sog	cog	rot	heading	nav_status	nav_status_code
null	null	0.0	POINT (13.1726333...	-164.43488333	13.17263333	3.7	116.8	0.0	0	Under Way Using E...	0
TACOMA WA	null	9.0	POINT (53.9401883...	-164.57464667	53.94018833	19.3	86.8	16.11514409	86	Under Way Using E...	0
null	null	3.7	POINT (1.6708 -15...	-153.56116667	1.6708	4.0	152.6	0.0	0	Under Way Using E...	0
HOUSTON	null	2.9	POINT (29.7433333...	-94.08	29.74333333	5.0	230.0	0.0	0	Unknown	16
GALVESTON	null	11.0	POINT (28.3352133...	-93.05576667	28.33521333	11.5	303.8	0.0	302	Under Way Using E...	0
null	null	0.0	POINT (18.6533333...	-91.84166667	18.65333333	0.0	212.0	0.0	0	Not Defined	15
CRUCEROS INTERISLAS	null	0.0	POINT (-0.75 -90.31)	-90.31	-0.75	0.0	276.0	0.0	0	At Anchor	1
FOURCHON	null	4.0	POINT (28.35 -90....	-90.66666667	28.35	0.0	26.0	0.0	0	Under Way Using E...	0
US^0EW8>0E70	null	2.8	POINT (30.0466666...	-90.6	30.04666667	0.0	173.0	0.0	0	Unknown	16
KRPUS	null	12.9	POINT (8.24166666...	-86.84666667	8.24166667	19.0	284.0	0.0	0	Under Way Using E...	0
FAENA D PESCA	null	0.0	POINT (-11.474056...	-84.07834	-11.47405667	0.0	0.0	0.0	129	Engaged In Fishing	7
PAROD	null	8.8	POINT (-0.11949 -...	-81.113605	-0.11949	17.9	13.5	0.0	13	Under Way Using E...	0
null	null	0.0	POINT (26.16917 -...	-80.10563	26.16917	0.0	0.0	0.0	0	Unknown	16
BALBOA	null	10.2	POINT (-33.592733...	-71.61748333	-33.59273333	0.0	222.2	0.0	181	Moored	5
BR SLZ	null	12.2	POINT (14.603895 ...	-68.09905	14.603895	11.3	114.2	0.0	116	Under Way Using E...	0
US ILG	null	9.4	POINT (26.2783333...	-64.30666667	26.27833333	17.0	312.0	0.0	0	Under Way Using E...	0
GT GUY	null	4.2	POINT (6.78647833...	-58.17381333	6.78647833	0.0	46.0	0.0	13	Moored	5
FISHING GROUND	null	7.2	POINT (-35.757288...	-55.027085	-35.75728833	10.6	131.1	0.0	131	Moored	5
null	null	0.0	POINT (47.7732133...	-54.01134167	47.77321333	0.0	49.0	0.0	8	Not Defined	15
SAO LUIS	null	4.0	POINT (-2.59382 -...	-44.36726833	-2.59382	0.1	208.6	0.0	0	Underway Sailing	8

Destination

Geospatial location

Speed

Navigation Status

AIS Data example

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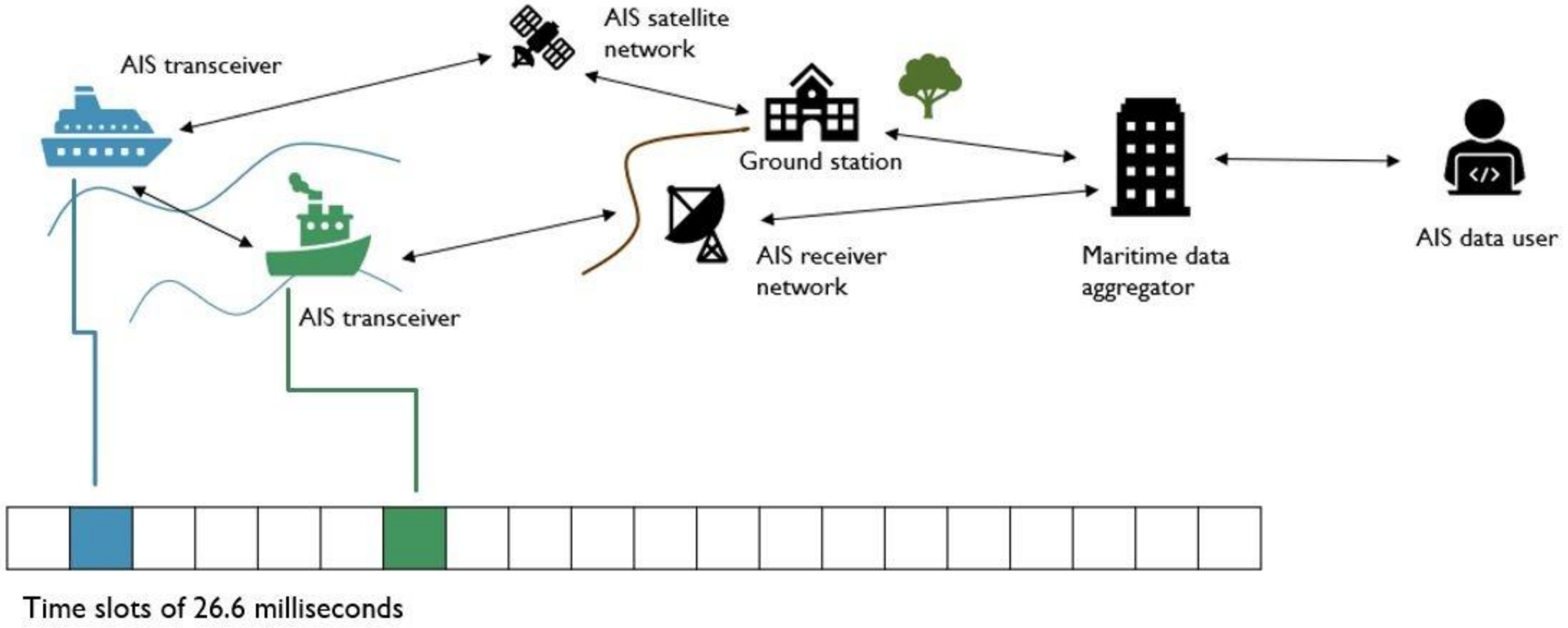
source	ts_pos_utc	ts_static_utc	ts_insert_utc	dt_pos_utc	dt_static_utc	dt_insert_utc	vessel_type_main	vessel_type_sub	message_type	eeid	dayIndex
S-AIS	null	null	null	2021-05-08 05:43:34	2021-05-08 05:36:10	2021-05-08 05:43:52	Fishing Vessel	null	1	null	739814
S-AIS	null	null	null	2021-05-08 05:43:20	2021-05-08 05:31:08	2021-05-08 05:43:30	Container Ship	null	1	null	739814
S-AIS	null	null	null	2021-05-08 05:43:11	2021-05-08 05:36:02	2021-05-08 05:43:30	Fishing Vessel	null	1	null	739814
S-AIS	null	null	null	2021-05-08 05:42:59	2021-05-08 05:39:05	2021-05-08 05:43:11	null	null	27	null	739814
S-AIS	null	null	null	2021-05-08 05:43:40	2021-05-08 05:31:50	2021-05-08 05:43:53	null	null	1	null	739814
S-AIS	null	null	null	2021-05-08 05:43:28	2021-05-08 05:03:28	2021-05-08 05:43:43	Offshore Vessel	Offshore Tug Supp...	27	null	739814
S-AIS	null	null	null	2021-05-08 05:42:52	2021-05-07 18:08:02	2021-05-08 05:43:11	null	null	27	null	739814
S-AIS	null	null	null	2021-05-08 05:43:13	2021-04-30 02:47:14	2021-05-08 05:43:28	Offshore Vessel	Offshore Support ...	27	null	739814
S-AIS	null	null	null	2021-05-08 05:43:02	2021-05-07 13:09:21	2021-05-08 05:43:21	Service Ship	null	27	null	739814
S-AIS	null	null	null	2021-05-08 05:43:19	2021-05-08 00:27:04	2021-05-08 05:43:43	Container Ship	null	27	null	739814
S-AIS	null	null	null	2021-05-08 05:43:02	2021-05-08 05:33:22	2021-05-08 05:43:20	null	null	1	null	739814
S-AIS	null	null	null	2021-05-08 05:43:02	2021-05-08 04:47:33	2021-05-08 05:43:20	Container Ship	null	1	null	739814
T-AIS	null	null	null	2021-05-08 05:43:44	2021-05-08 05:41:45	2021-05-08 05:43:55	null	null	18	null	739814
S-AIS	null	null	null	2021-05-08 05:42:38	2021-05-08 05:32:08	2021-05-08 05:43:08	null	null	3	null	739814
S-AIS	null	null	null	2021-05-08 05:43:00	2021-05-08 04:24:31	2021-05-08 05:43:12	null	null	1	null	739814
S-AIS	null	null	null	2021-05-08 05:43:34	2021-05-07 23:01:02	2021-05-08 05:43:53	Other Tanker	Fruit Juice Tanker	27	null	739814
S-AIS	null	null	null	2021-05-08 05:43:16	2021-05-08 05:10:17	2021-05-08 05:43:42	Offshore Vessel	Offshore Tug Supp...	3	null	739814
S-AIS	null	null	null	2021-05-08 05:42:59	2021-05-08 04:40:45	2021-05-08 05:43:12	Fishing Vessel	null	1	null	739814
S-AIS	null	null	null	2021-05-08 05:43:34	2021-05-08 05:40:51	2021-05-08 05:43:53	Tug	null	1	null	739814
S-AIS	null	null	null	2021-05-08 05:42:50	2021-05-08 05:35:54	2021-05-08 05:43:08	null	null	1	null	739814

Source

Time

How it works



- **Static information & voyage related information**: are provided by the crew of the vessel and is transmitted every 6 minutes
- **Dynamic information**: is automatically transmitted depending on the vessels' speed and course while underway every 2 to 10 seconds and while a vessel is at anchor every 3 minutes

Accessibility of AIS Data

How to get the data?

- As the use and demand of AIS data have increased, this enabled the rise of AIS data provider(s) that collect, store, analyze and disseminate AIS data.
- Commercial data providers offer access to AIS data that they have collected and enriched, but the costs could be significant

UN Global Platform:

- UNSD acquires AIS data from commercial data providers
- Makes it available via the **UN Global Platform**
- It is free for experimental and official statistics use and it is accessible around the globe
- UN Global Platform provides the storage and computing functionality that required to work with big data

Other AIS data providers

AIS data community:

- AIS Data Exchange Hub (https://www.aishub.net/)

Government:

- Norwegian Coastal Administration (https://kystverket.no/)
- US Coast Guard: (https://marinecadastre.gov/ais/)

Commercial Providers:

- MarineTraffic (https://www.marinetraffic.com)
- ExactEarth (https://www.exactearth.com/)

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AIS Data Use Cases

General uses of AIS data

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AIS data can be used for:

- Maritime applications: Navigation at sea, collision avoidance at sea, search and rescue, accident investigation,
- Tracking and monitoring: Port monitoring, fleet and cargo tracking
- International trade: International trade estimation, economic trend discovery
- Environmental statistics: Shipping greenhouse gas emission estimation, ocean currents estimation
- …

slido

Which field are you interested in?

ⓘ Start presenting to display the poll results on this slide.

IMF Trade volume estimates

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Research question: if the AIS data can be used for trade volume estimation. Enable statistical agencies to complement existing data sources on trade and introduce more timely (real-time) new statistics that measure trade flows.

Research uses Malta as a benchmark

A) Cargo number indicator:

- Number of cargo ships visiting a port (filtered)
- Comparable with official number of ships

B) Cargo load indicator:

- Volume of cargo loaded/unloaded at a port
- Highly correlated with the official trade in volume

Conclusion: trade in goods, trade volume, gross trade, and trade by broad groups can be measured with the AIS data.

UK ONS Faster economic indicators

Research question: Can we use AIS data to create faster economic indicators, enabling Policy makers to act more quickly?

Research undertaken: Three economic/trade indicators have been developed:

1. Time-in-port – aggregated time in seconds spent by ships in UK ports
2. Port traffic – number of unique ships (MMSI) entering port
3. Number of visits/port calls, e.g. to capture multiple sailing, e.g. ferry route

Future research:

- Disaggregate Time-in-port by duration of stay
- Anchorage or holding area outside port might contain information, e.g. holding pattern indicating port congestion, increasing oil prices, etc.

Office for National Statistics

Greenhouse Gas Study (Fourth IMO)

- Uses AIS data to track and calculate a ship's emissions:
  a) Movement of ships
  b) Port calls
  c) Speed
  d) Ships characteristics

- Merged with other data on engine type, fuel oil consumption and power demand

- ➢ Can provide an estimate of a ship's emissions
- ➢ Can distinguish between domestic and international emissions -> more accurate international shipping emissions
- ➢ Resulting emissions estimates for each ship are aggregated into annual statistics, broken down by domestic and international voyage, vessel types, and size categories

IMO INTERNATIONAL MARITIME ORGANIZATION

Port monitoring: PORTWATCH

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[Port Monitor | PortWatch (arcgis.com)]

Environmental statistics: Panama Canal case

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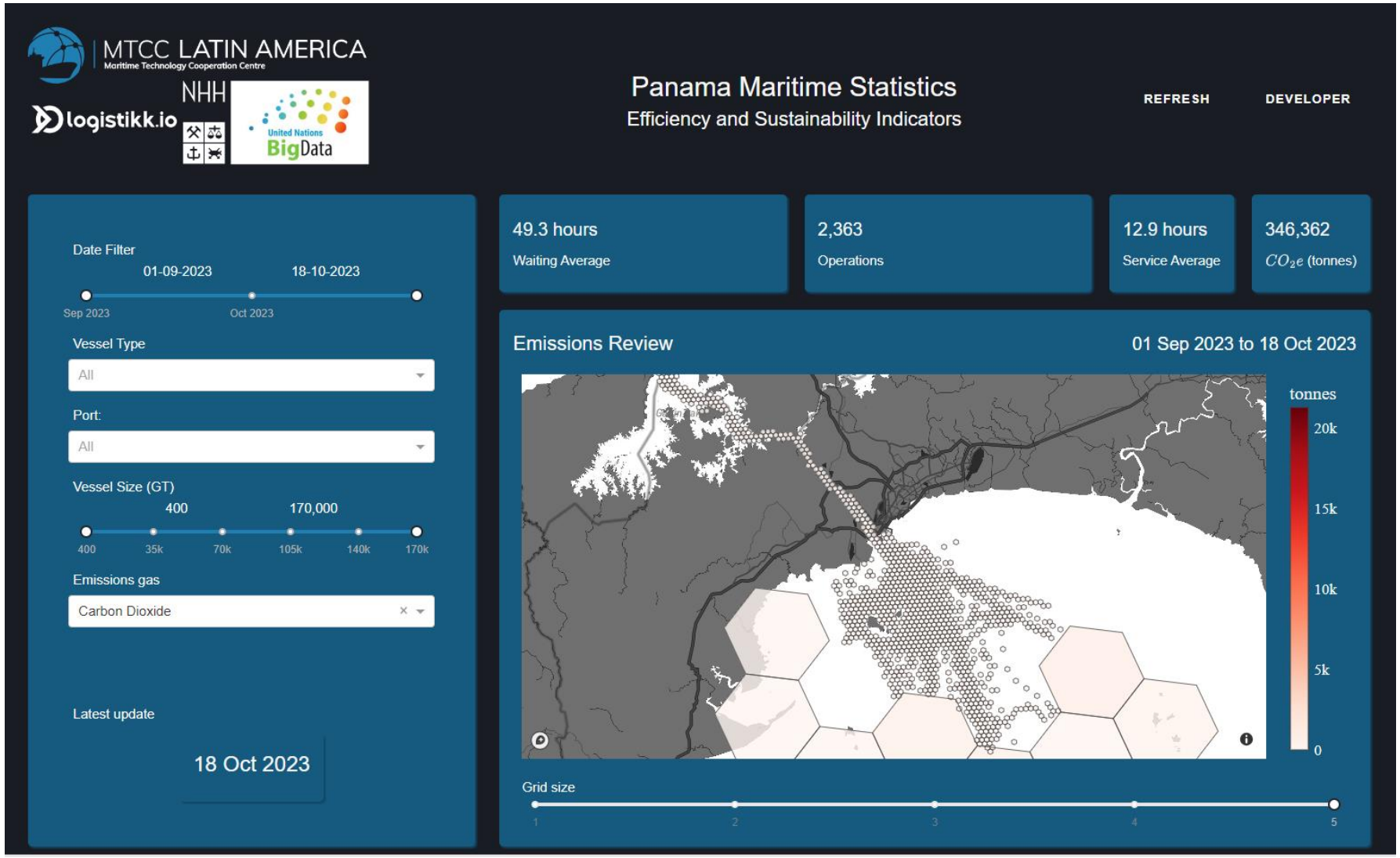

stats.mtcclatinamerica.com

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Acquiring AIS data

UN Global Platform for AIS

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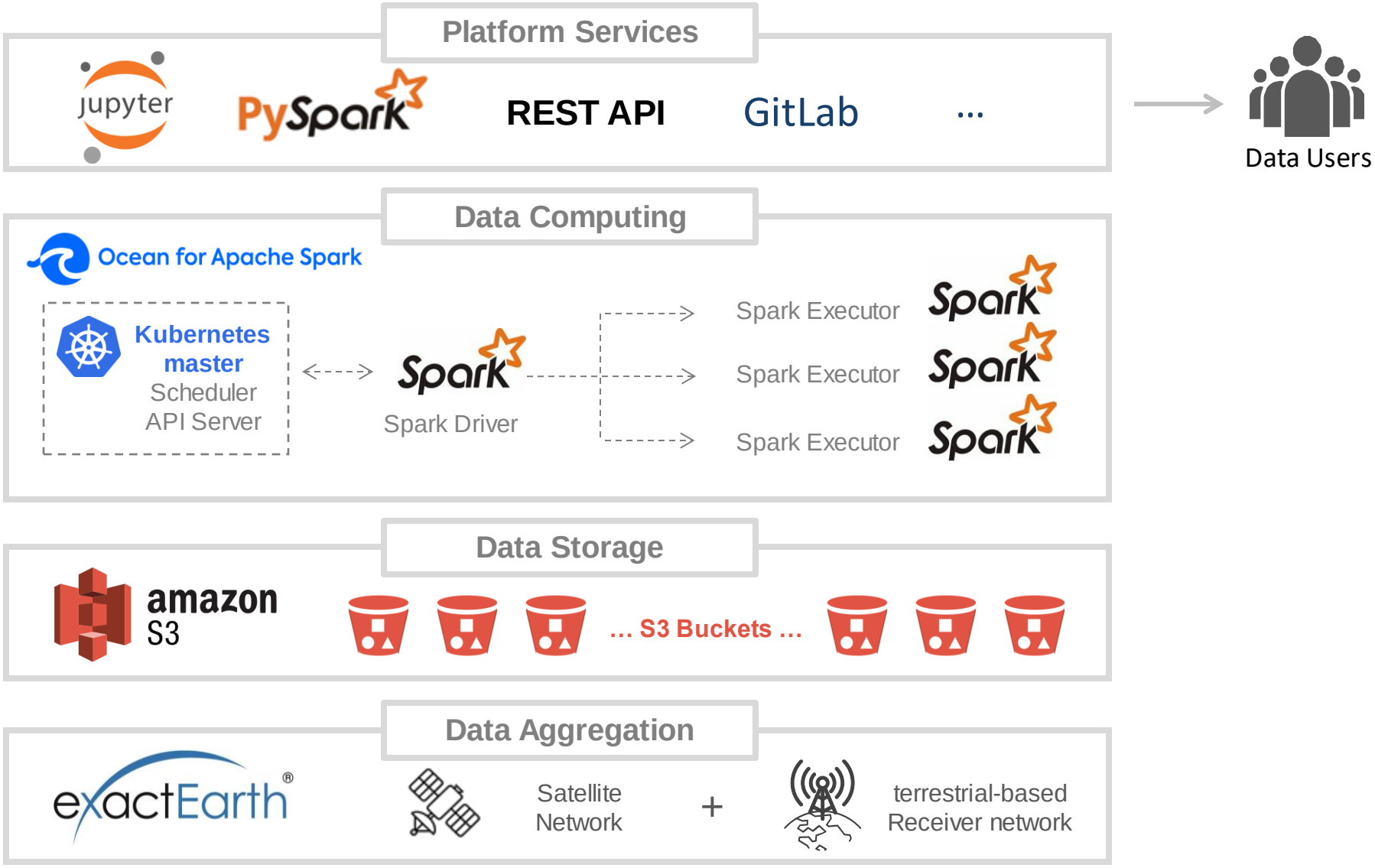

UN Global Platform Overview

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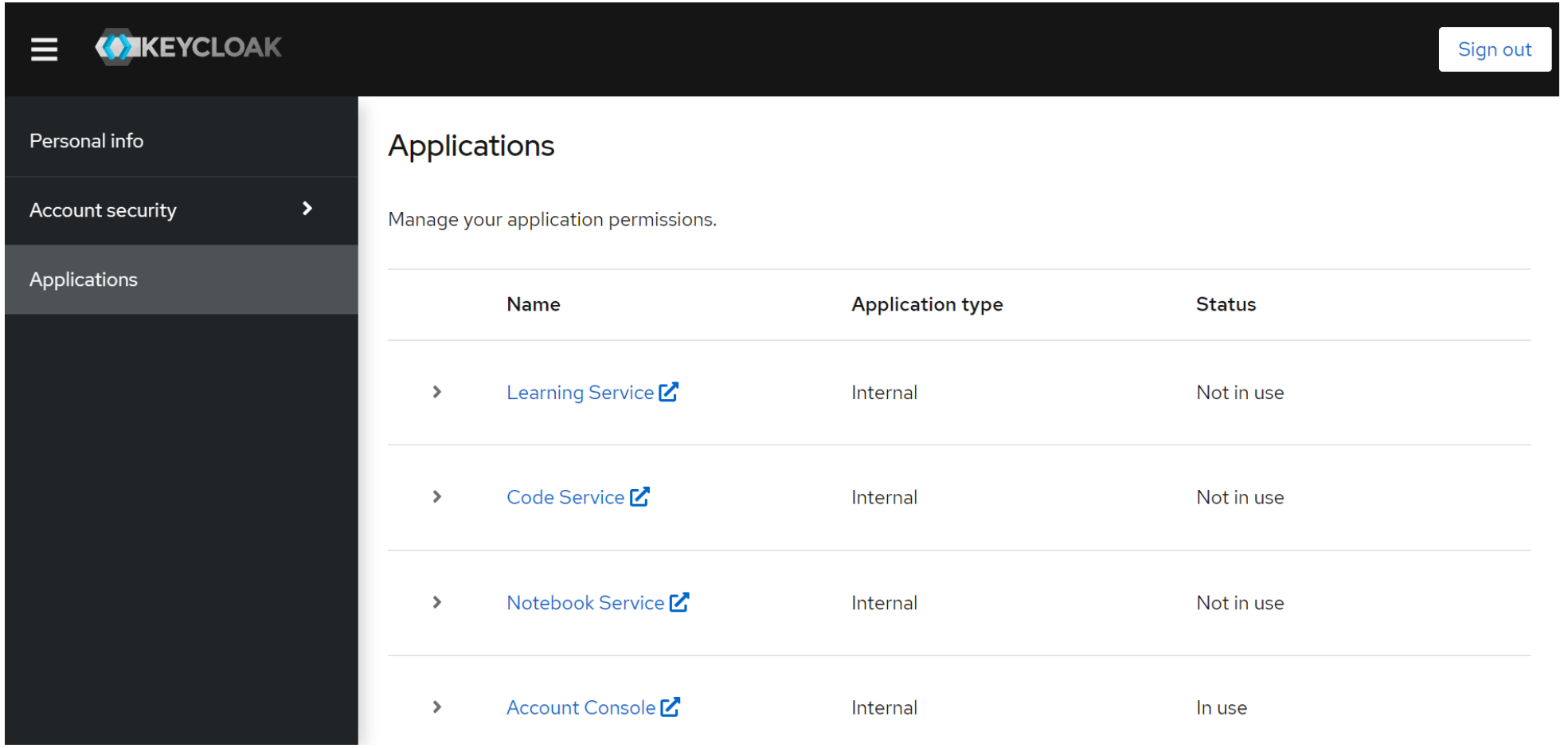
- Link: https://id.officialstatistics.org/



UN Global Platform: Code Service

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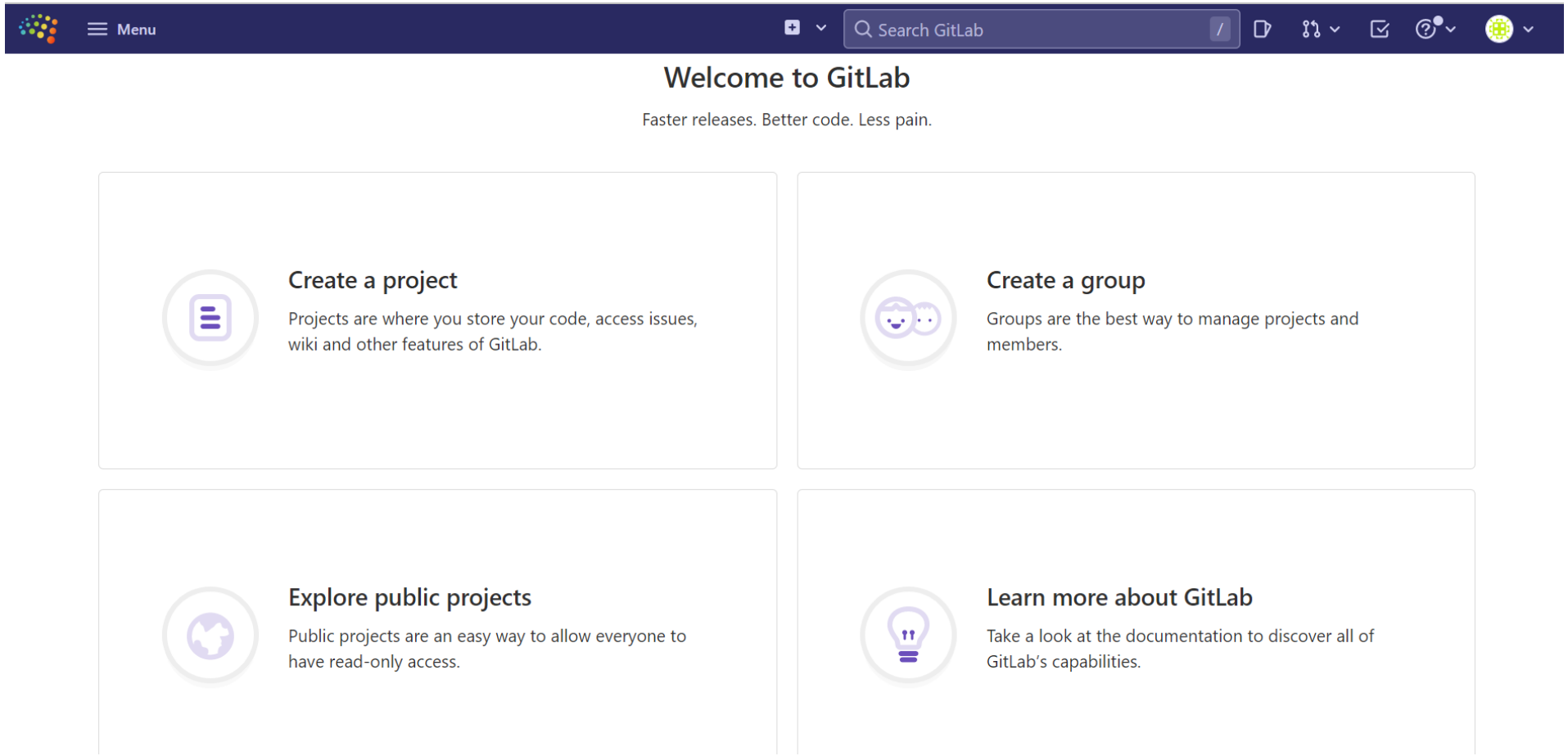
- Link: https://code.officialstatistics.org/



UN Global Platform: Notebook Service

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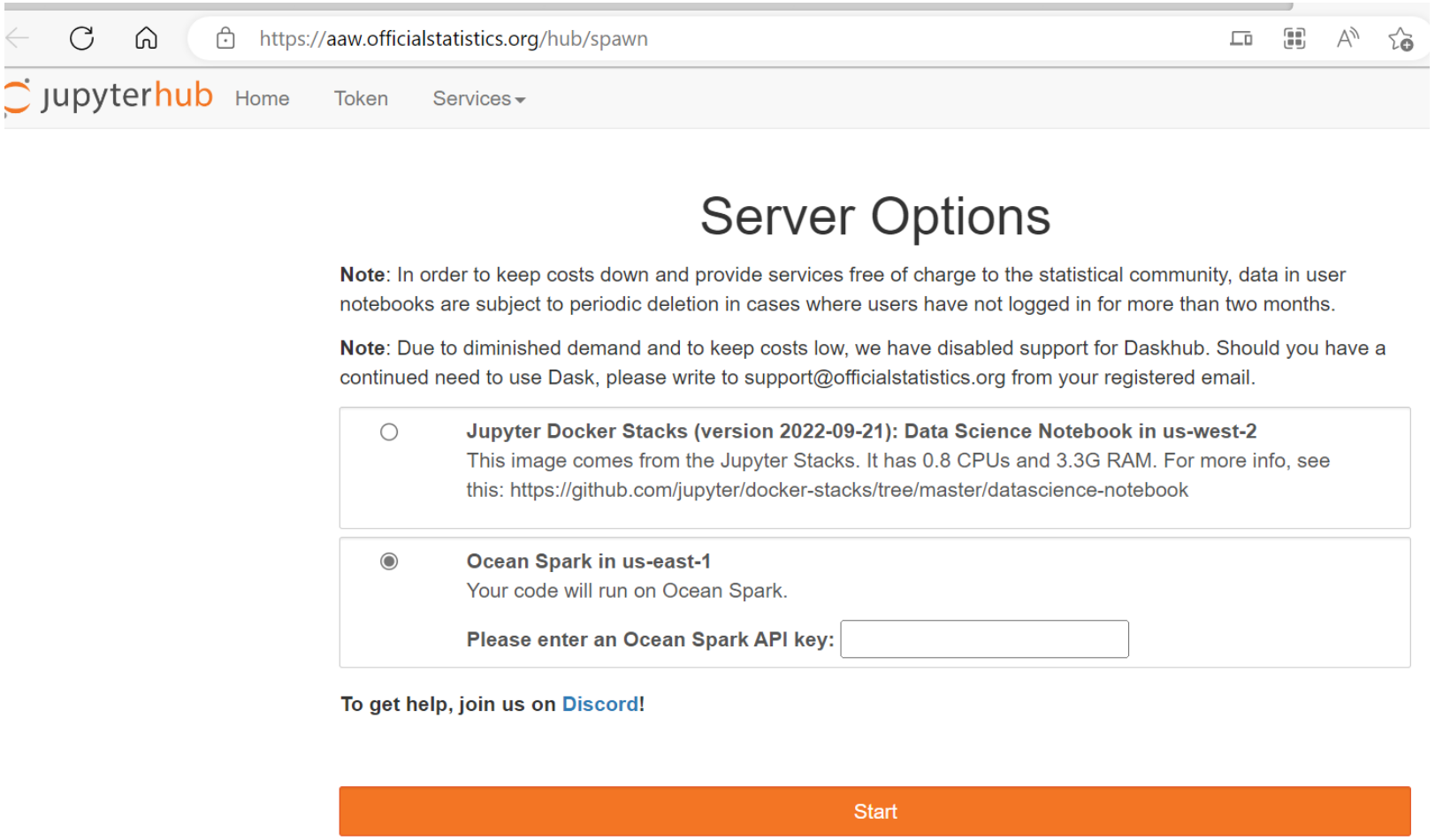
- Link: https://aaw.officialstatistics.org/hub/spawn



*Jupyterhub: a browser-based remote computing environment.

Example of acquiring AIS data

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jupyter AIS Big Data Demo for SACU Last Checkpoint: Last Friday at 6:41 PM (autosaved) Logout

File Edit View Insert Cell Kernel Widgets Help Not Trusted Config template ais-tt-dev

Run Markdown

1. AIS Data Structure

- Data is stored in amazon S3 bucket *ungp-ais-data-historical-backup*.
- Data is converted to *parquet* format
- The parquet files are partitioned according to *H3index_0* (H3 index resolution 0)

In [1]:
```
import pandas as pd
import h3
```

2. Read AIS Data

In [2]:
```
basepath = "s3a://ungp-ais-data-historical-backup/exact-earth-data/transformed/prod/"
```

2.1 Read AIS data of certain a day

In [3]:
```
#Read Data January 1 2022
rawDF = spark.read.parquet(basepath+ "year=2022/month=01/day=01")
```

In [4]:
```
rawDF.limit(1).show(vertical=True, truncate=False)
```

```
-RECORD 0-----------------------------------------------------------------------------------------------------------------------------------
-----
```

JupyterHub (officialstatistics.org)

AIS Data format

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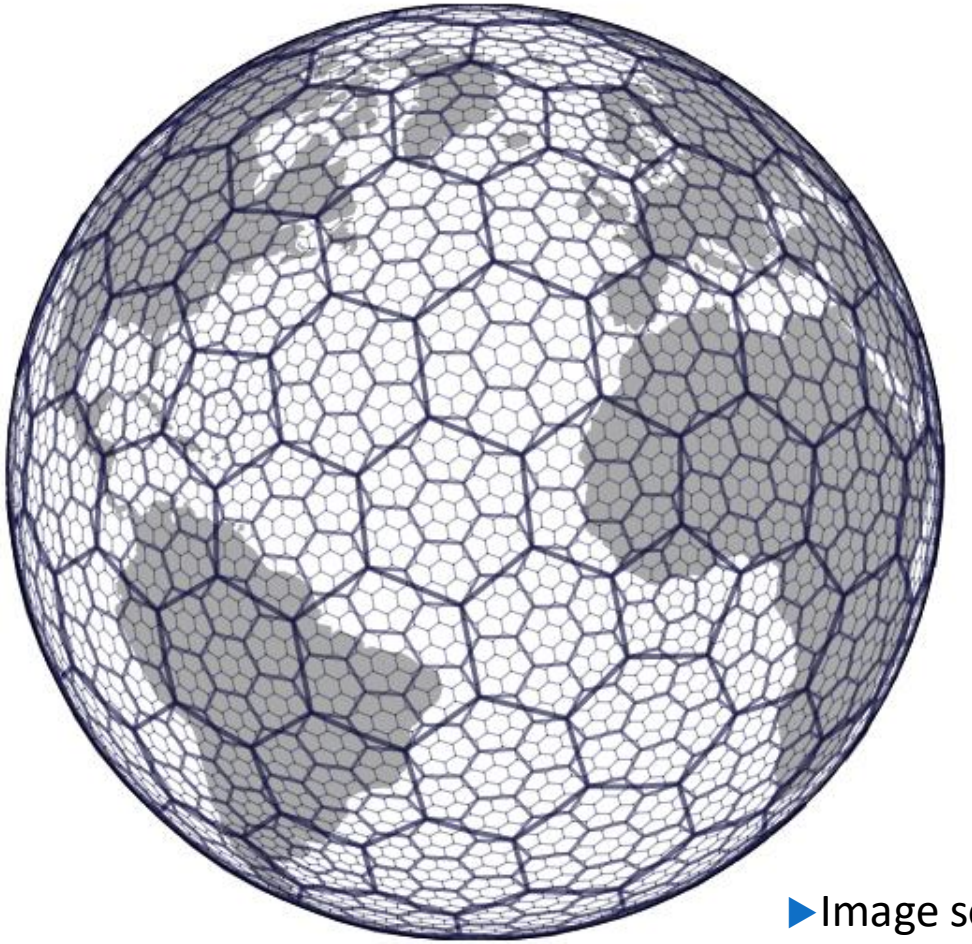
Format: Data is converted to parquet format. Every parquet is partitioned by H3 index resolution 0.

H3 index : Hexagonal hierarchal spatial index

- Global grid system developed by Uber Engineering
- Each latitude and longitude pair is transformed to a 64-bit H3 index identifying a grid cell
- Resolution 0:
  - Ave. area of ~4.2Mn sq.km
  - Ave. hexagon edge length ~1,107km
  - 122 unique indices
- Resolution 15
  - Ave. area of 9xe-7 sq. km
  - Ave. hexagon edge length 0.5m
  - 569 trillion unique indices



▶Image source: Uber

Example of plotting AIS data

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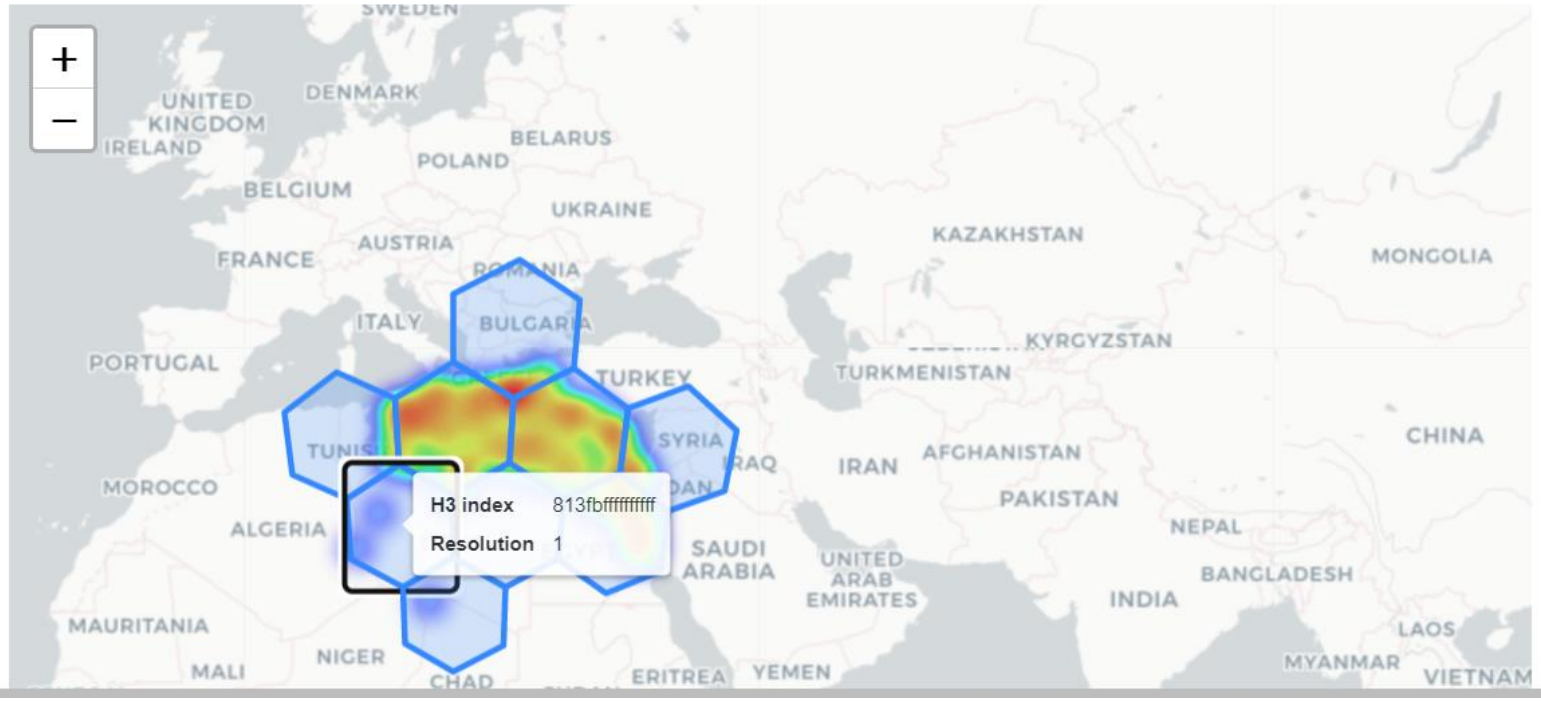
AIS Data Extract Demo.ipynb | aisDataExtractionDemo2023. | AIS Big Data Demo for SACU

Code | Config template ais-tt-dev

03:27:11

[23]:
```
a = folium.GeoJson(create_geojson(df["h3_1"].unique().tolist()),
                   tooltip = folium.GeoJsonTooltip(fields=['H3 index','Resolution']),
                   name='H3 Resolution 1', show=False).add_to(m)
m
```

[23]:



AIS Data Strength & Weaknesses

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Strengths

- Timely statistics can be generated
- Aggregated data can be filtered
- High frequency data

Weaknesses

- Not consistent in some areas and from some vessel sizes (missing data)
- Vessels can switch off the device e.g. in piracy areas
- Manually input data is based on crew proactivity in timely updating

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Useful Resources and Learning Opportunities

Learning Opportunities

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- AIS handbook:
  - https://unstats.un.org/wiki/display/AIS/AIS+Handbook
- AIS E-learning course:
  - https://learning.officialstatistics.org/course/index.php?categoryid=8
- AIS Online Sprint:
  - 1 week training in September

Useful Resources

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- Official website:
  - https://unstats.un.org/bigdata/task-teams/ais/index.cshtml
- Use cases:
  - Fourth Greenhouse Gas Study 2020 (imo.org)
  - Big Data on Vessel Traffic: Nowcasting Trade Flows in Real Time (imf.org)
  - Faster indicators of UK economic activity: more timely and relevant shipping indicators | Data Science Campus (ons.gov.uk)
- AIS Big Data Hackathon:
  - Winning project: AIS Hackathon — UN-CEBD
- Apache Spark: https://spark.apache.org/

How to request access

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USER emails support@officialstatistics.org to request for AIS Data Platform access through UNGP. User must provide the following information:

- Full name:
- Email address:
- Nationality:
- Details on your use of AIS:

SUPPORT TEAM receives and reviews request

SUPPORT TEAM creates accounts on UNGP and send invitation to the user to join AIS Task Team

USER receive a welcome email and activation link. User activate the account

SUPPORT TEAM requests USER to fill-out the form at: https://forms.office.com/r/0k1QBZunKe for tracking

Start

Finish

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Q&A

Do you have additional questions?