planet.

Fully Automated Earth Observation Imagery Quality Assurance

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Lake Okeechobee, Florida, USA • July 1, 2016

Overview

LONDON ARRAY WIND FARM • United Kingdom • April 17, 2016

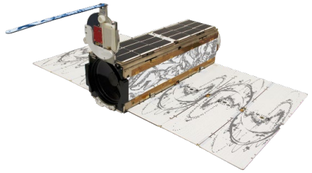
Introduction

Singapore Strait • Singapore • July 29, 2016

Agile Aerospace

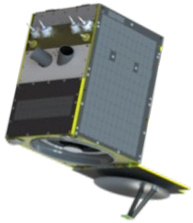
Through our agile aerospace approach, we've created a unique data set

CURRENT CONSTELLATIONS



SuperDove

- ~180 satellites
- Up to 300 million km^2 / day
- 8-band
- Unique scanning



SkySat

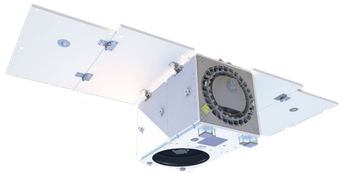
- ~20 satellites
- 50cm resolution
- RGB, NIR, and Pan bands
- Sub-daily tasking

PLANNED HIGH RESOLUTION UPGRADE

PLANNED FUTURE CONSTELLATIONS

Tanager

- 400 - 2500 nm
- ~400 5nm bands
- Technical demo planned to launch in 2024



Pelican

- Initial constellation of up to 30 satellites[1]
- Up to 30cm resolution
- Pan + 6 RGB+NIR bands
- Up to 30 revisits/day

[1] *Does not include initial 2 demonstration satellites planned.*

Overview

- **Automated quality assurance** is important due to the amount of imagery produced at Planet
- The metrics and algorithms used Planet need to be valid on **all the different types of satellites** that Planet launches
    - Currently there are only **push frame payloads** operating
    - Soon there will be **line-scanner payloads** (Pelican and Tanager)
    - The **architecture** of the any automated quality assurance pipeline needs to handle the nuances of these different types of payload
- The satellite constellations operate at **different resolutions** and have different spectral bands
    - PlanetScope imagery is processed at 3m and SkySat imagery is processed at 0.5m
- The main **metrics** that are automatically tracked are
    - **Geolocation metrics**
    - **Sharpness metrics**
- The **geolocation accuracy is continuously monitored** over a global distribution of test sites
    - This is reported **quarterly** in the **Data Quality** reports

Methodology

LAKE TUBORG • Canada • May 30, 2015

Metrics

- A sample selection runs **automatically** every day selecting **100 to 600 products** from the pipeline for geolocation metrics
    - Number of geolocation **test sites** (recently increased) is ~800

- The **rectification_accuracy program** runs every **two hours** for a configurable amount of products in **different assessment modes**
    - The rectification_accuracy program is implementing an **independent methodology** based on **Catalyst** tools

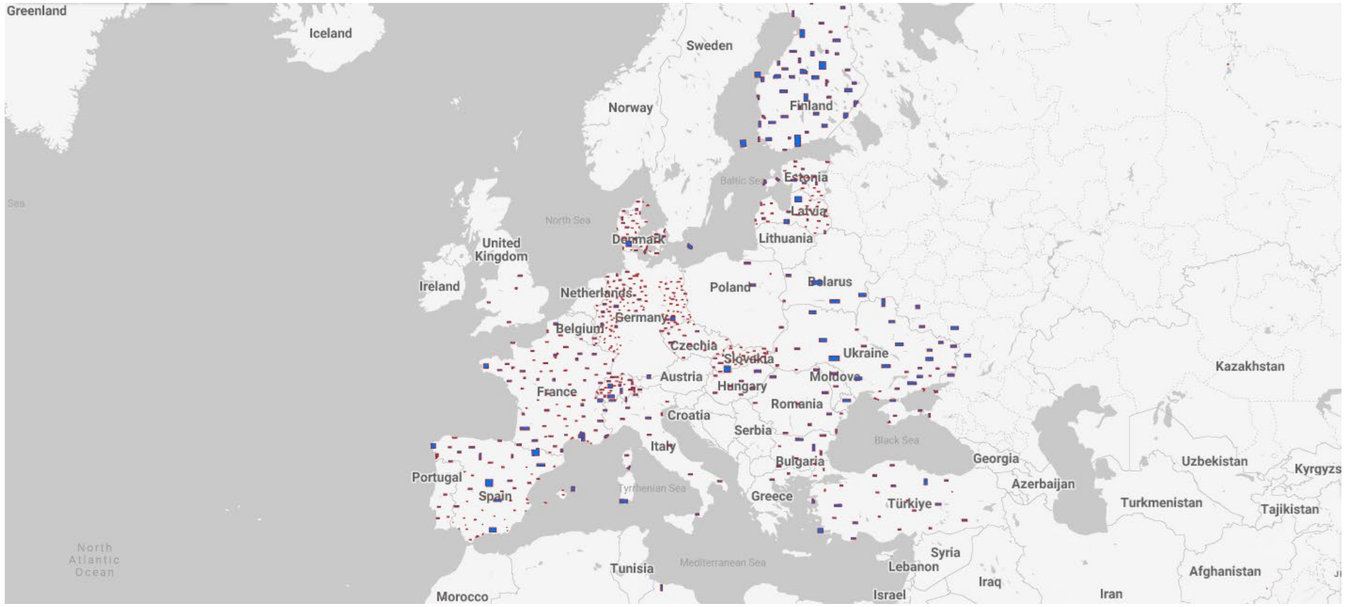
- A **sharpness** metric, **Relative Edge Response (RER)**, is also calculated on scenes that overlap **RER test sites**
    - The test sites are a collection of **airports with known edges**

- All accuracy assessments results are automatically stored in **Google BigQuery** which feeds **Google Looker Studio Dashboards** so that there are up to date reports.

Metrics

Distribution of RER Sharpness Test Sites

Closeup of new Europe Test Sites



Reporting

- Each quarter, Planet publishes a **Data Quality report** on its support website
  - This contains the **latest results** from radiometric validations, SNR measurements and others
  - It also includes an update on **changes** to the data products and pipeline
- The **Geometric Performance** section is based on the **automated quality assurance tools**
  - This includes subsections on Absolute Geolocation, Band Registration, Temporal Registration and Relative Geolocation
  - Any updates on **reference data** will also be reported on:

Table: Ground control data sources.

GCP source	Region	Resolution (m)	Accuracy
VHR aerial imagery	Continental USA	1.0	< 6.5 m RMSE
VHR aerial imagery	Poland	0.1 - 0.25	RMSE_xy <= 3 pixel size
Airbus OneAtlas	Bahrain, Kuwait, Lebanon, North Korea, Qatar, Syria, Ukraine	0.3 - 1.5	< 6 m CE90 for slopes less than 20%
ALOS Satellite imagery	Rest of the world	2.5	5.0 m RMSE
RapidEye (based on ALOS/Landsat)	Gap filling	5.0	< 7.0 m RMSE
Landsat	Antarctica and Greenland	15.0	20.0 m RMSE

Table: Digital elevation models used in Planet product orthorectification.

DEM source	Region	Post Spacing (m)	Vertical Accuracy (RMSE, m)
USG NED	Continental USA	10	< 3
LINZ	New Zealand	25	6
INEGI CEM 3.0	Mexico	15	7
SRTM	Australia (released by GeoScience Australia)	30	7
PlanetObserver90	Antarctica	90	7
Intermap World30	Rest of the world	30	7

Tables are taken from the Planet L1 Data Quality Q4 2023 Report for PlanetScope

Results

AGRICULTURE • North Caucasus, Russia • June 27, 2016

Quarterly Data Quality Report

SuperDove absolute geolocation

Absolute Geolocation

The absolute geolocation of PSScene Ortho Analytic products has been evaluated over known locations where independent reference from different sources (aerial imagery, DG satellite imagery, SPOT satellite imagery, etc.) are available. These test sites are of higher positional accuracy, have a good distribution around the world and contain different land cover (urban, forest, bare ground, agriculture, ...) and terrain types (flat, hilly, mountainous).

The absolute geolocation has been evaluated on a sample of PSScene Ortho Analytic for SuperDove acquired in the first quarter of 2024. Following table shows the results for this period of time:

	Sample Size	PCTL90 of RMSE [m]	CE90 empirical [m]
SuperDove	21126	6.47	6.34

Taken from the Planet L1 Data Quality Q4 2023 Report for PlanetScope

Quarterly Data Quality Report

SuperDove band registration

Band Registration

The SuperDove sensor plane consists of eight horizontal stripes that capture eight different spectral bands, Coastal Blue, Blue, Green_i, Green_ii, Red, Yellow, Red Edge and NIR.

To form one multi-band composite of SuperDove imagery at least 24 individual frames are combined via a prior-less registration technique.

For SuperDove, Band-to-Band registration has been evaluated for a sample of Ortho Analytic products acquired in the first quarter of 2024 demonstrating following overall results:

Constellation	Sample Size	PCTL90 of RMSEs [pixels]
SUPER_DOVE	50444	0.22

Taken from the Planet L1 Data Quality Q4 2023 Report for PlanetScope

Quarterly Data Quality Report

SuperDove band registration (continued)

Band alignment of SuperDove by individual band combination:

Sample Size
(PCTL90 of RMSEs [pixels], Standard deviation of RMSEs)

	BLUE	COASTAL_BLUE	GREEN_I	GREEN_II	RED	REDEDGE	YELLOW
COASTAL_BLUE	50419 (0.26, 0.09)						
GREEN_I	50424 (0.11, 0.08)	50415 (0.14, 0.07)					
GREEN_II	50422 (0.11, 0.08)	50415 (0.13, 0.07)	50416 (0.10, 0.09)				
RED	50424 (0.11, 0.09)	50396 (0.25, 0.08)	50413 (0.11, 0.07)	50408 (0.11, 0.06)			
REDEDGE	50396 (0.12, 0.05)	50245 (0.12, 0.05)	50382 (0.10, 0.05)	50385 (0.09, 0.04)	50364 (0.12, 0.05)		
YELLOW	50416 (0.27, 0.08)	50397 (0.13, 0.07)	50408 (0.12, 0.07)	50398 (0.12, 0.07)	50381 (0.27, 0.09)	50364 (0.11, 0.08)	
NIR	49875 (0.30, 0.12)	47385 (0.22, 0.08)	50270 (0.35, 0.13)	50286 (0.35, 0.13)	49096 (0.32, 0.13)	50142 (0.24, 0.11)	49859 (0.26, 0.10)

Taken from the Planet L1 Data Quality Q4 2023 Report for PlanetScope

Quarterly Data Quality Report

SuperDove temporal registration

Temporal Registration

A stack of PSScene Ortho Analytic products over defined test sites has been used to evaluate the temporal registration. The process selects a more recently acquired product and compares its location against older products that belong to the same test site. Check points are collected on the red band of both products, target and reference.

For SuperDove, the temporal registration has been evaluated for a sample of Ortho Analytic products acquired in the first quarter of 2024 showing following results:

Constellation	Sample Size	PCTL90 of RMSEs [m]
SuperDove	50010	4.76

Taken from the Planet L1 Data Quality Q4 2023 Report for PlanetScope

Quarterly Data Quality Report

SuperDove relative geolocation

Relative Geolocation

The relative geolocation evaluates the scene-to-scene alignment of scenes that belong to the same strip. The process selects a target ortho scene and compares its location against the adjacent scenes in the strip. Check points are collected on the red band.

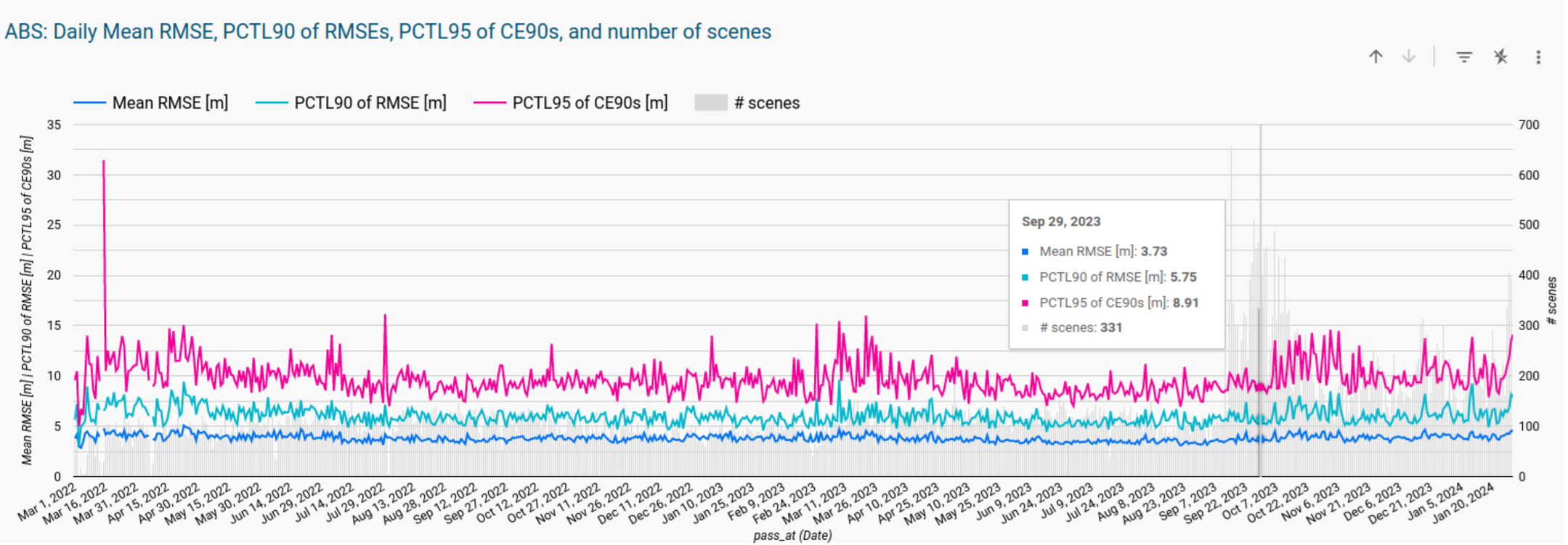
For SuperDove, the relative geo-location has been evaluated for a sample of Ortho Analytic products acquired in the first quarter of 2024 showing following results:

Constellation	Sample Size	PCTL90 of RMSEs [m]
SuperDove	189244	4.49

Taken from the Planet L1 Data Quality Q4 2023 Report for PlanetScope

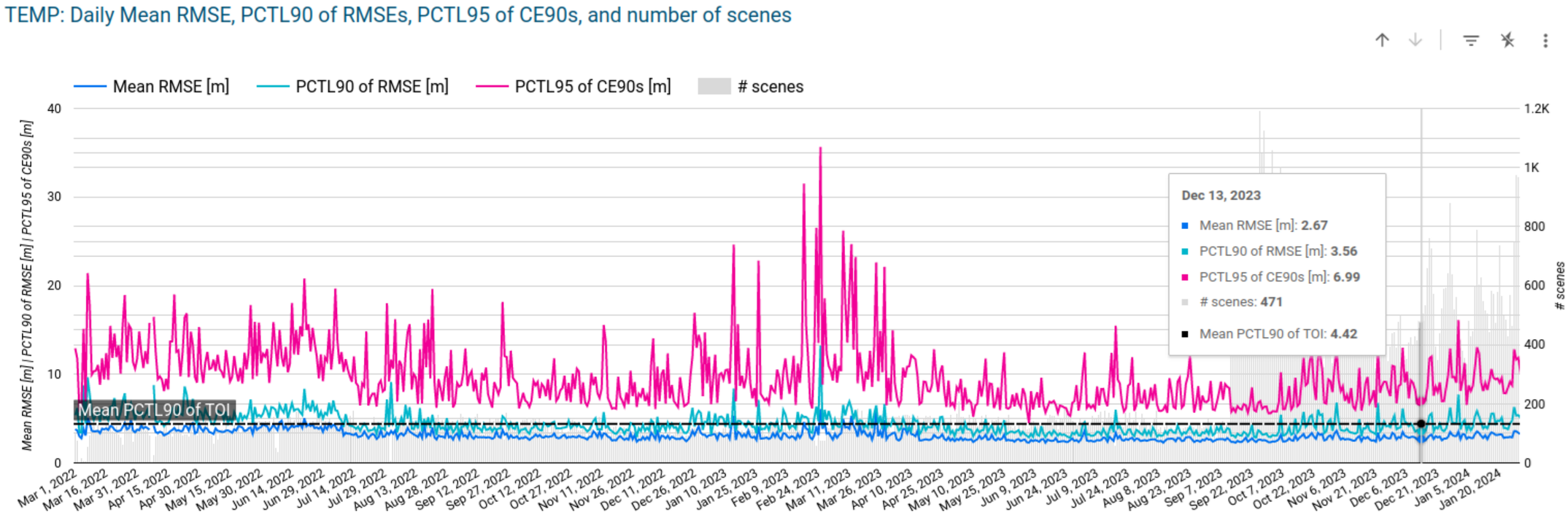
Automated quality assurance dashboard

SuperDove absolute geolocation measurement



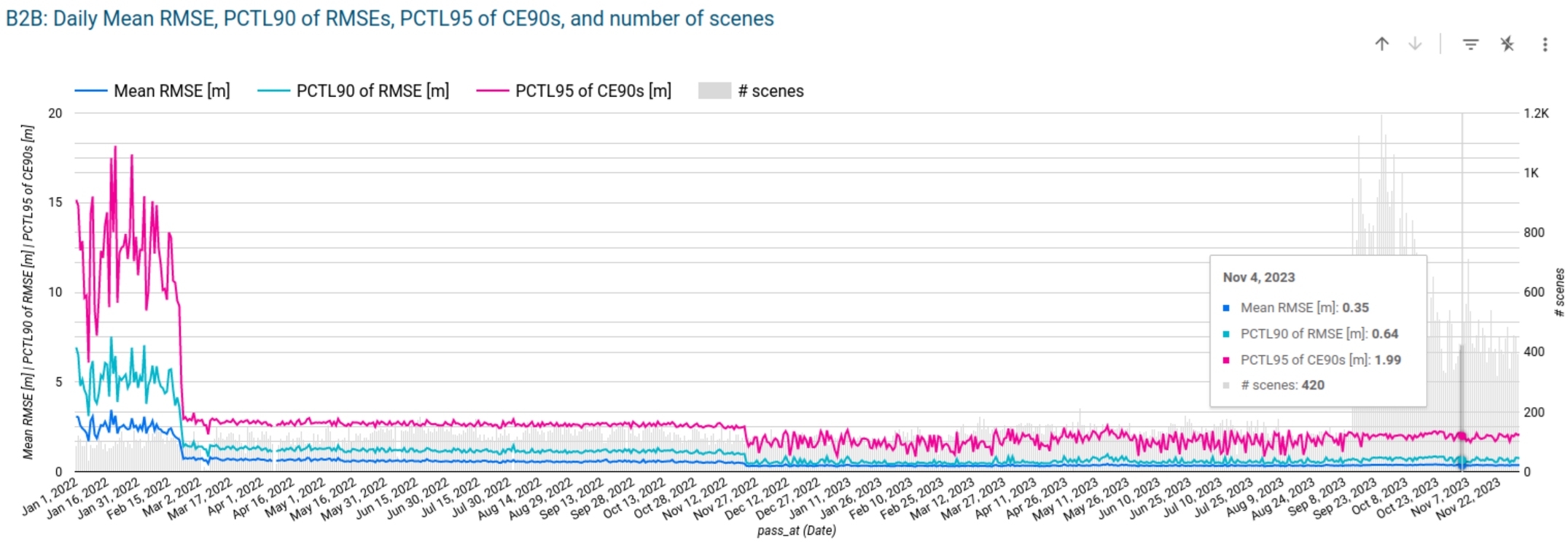
Automated quality assurance dashboard

SuperDove temporal geolocation measurement



Automated quality assurance dashboard

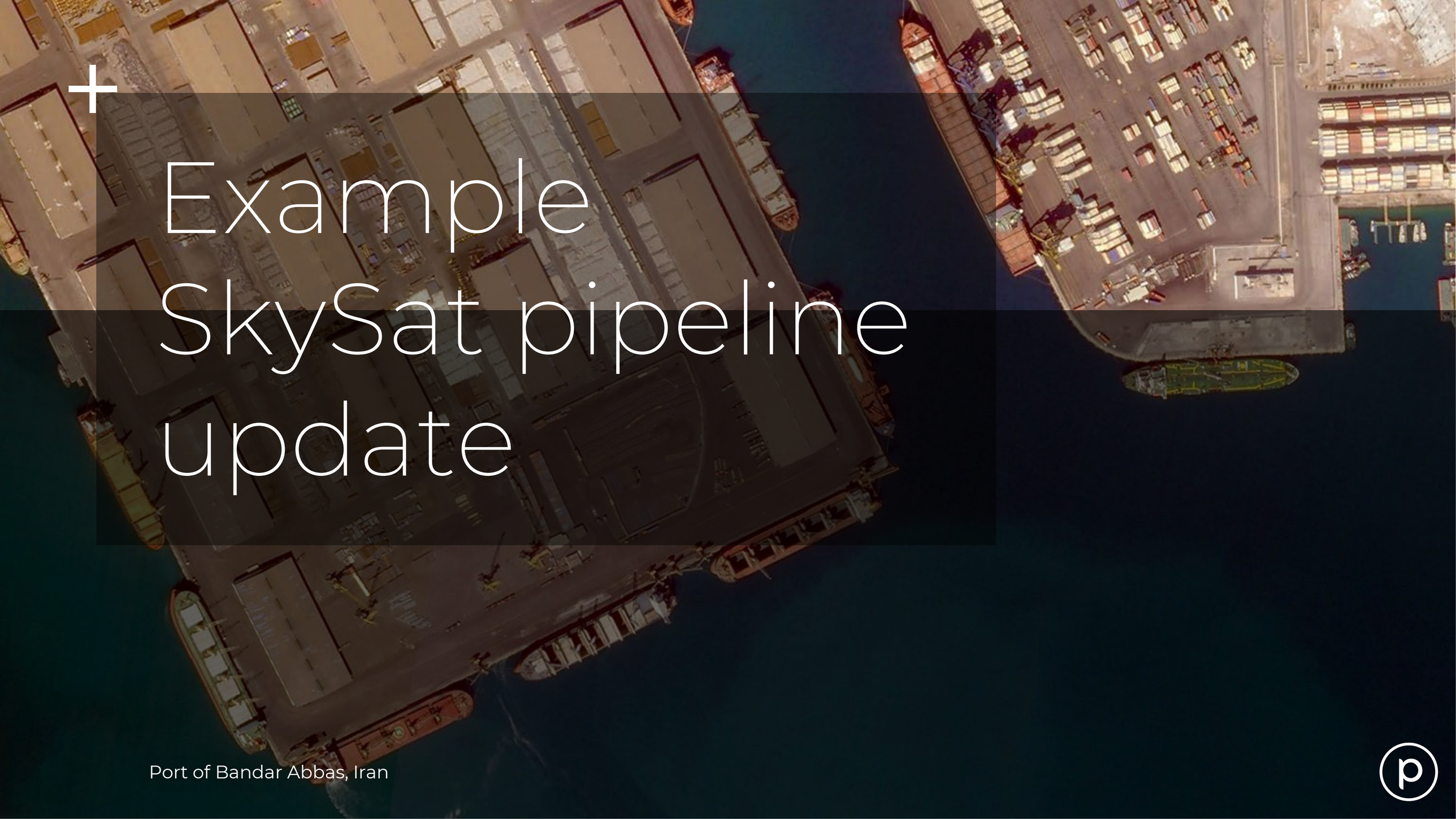
SuperDove band to band measurement



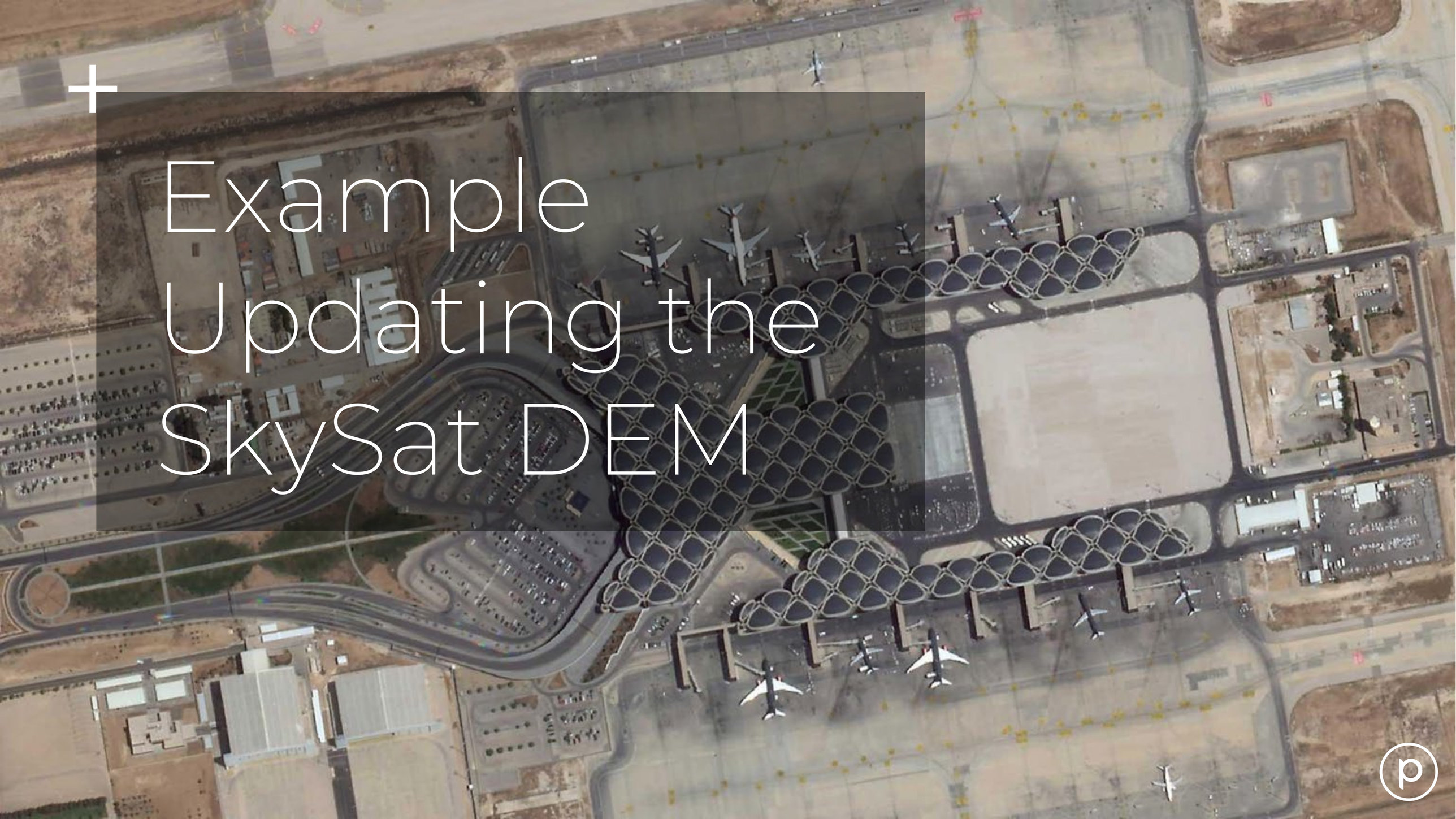
Example studies

CORAL REEF • Belize • April 14, 2019

Example SkySat pipeline update



Port of Bandar Abbas, Iran



Example Updating the SkySat DEM

SkySat DEM Update

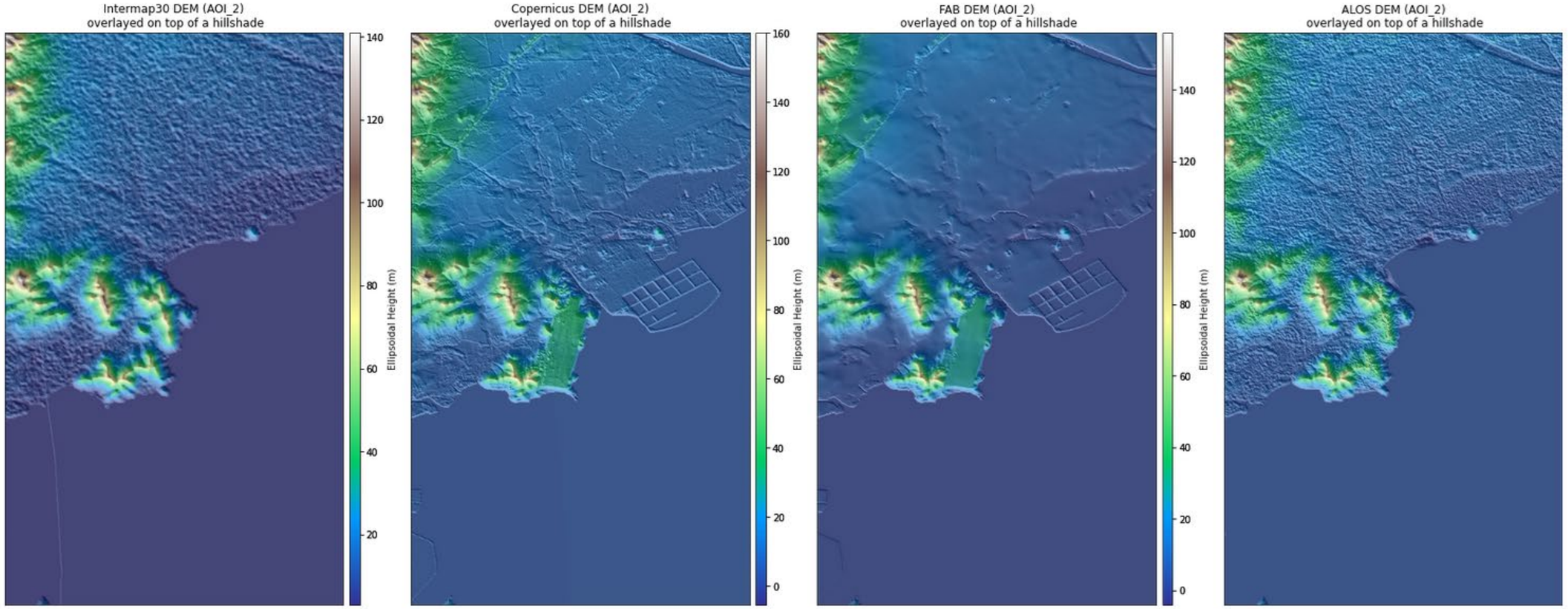
- Late last year, the **digital elevation model (DEM)** that is used in the **ortho-rectification process** was updated

- The DEM that was used previously was the **InterMap 30 DEM**
  - There are places where it is now **outdated**
  - For example, **new airports** that were built after the InterMap 30 DEM was produced is not reflected in the data, resulting in **artifacts** like the example shown where the **runway appears wavy**

- A study was made into the effect of alternative DEMs
  - This used the **automated quality assurance tools extensively** to test the effect of different DEMs **at scale**

SkySat DEM Update

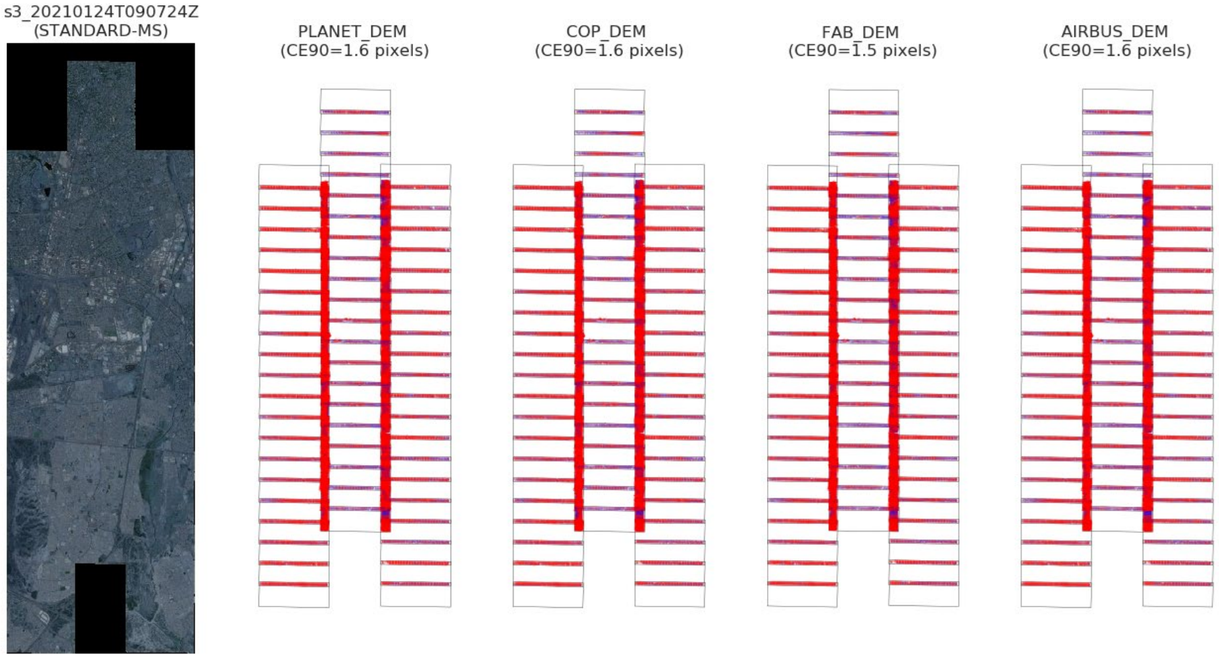
This shows how different DEMs can be



SkySat DEM Update

The automated quality assurance tools were used to test the effect of different DEMs on a **large dataset of SkySat images**

- In general, the differences were **subtle**
- The tools could be used to confirm this

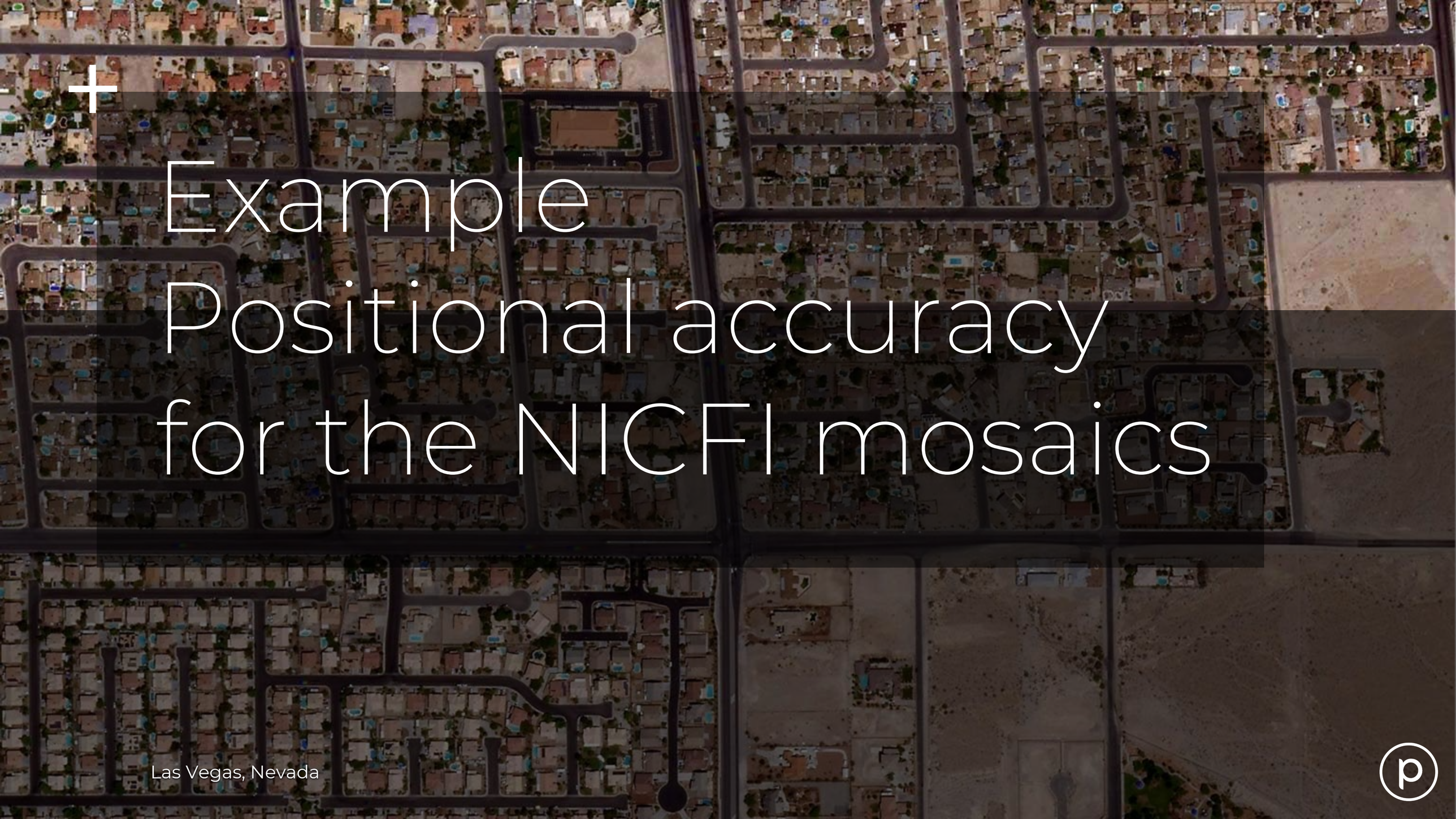


SkySat DEM Update

- At the end of 2023, the DEM used for SkySat ortho rectification started the transition to using **ESA's Copernicus GLO30 DEM**
    - This was finalized in production in **April 2024**

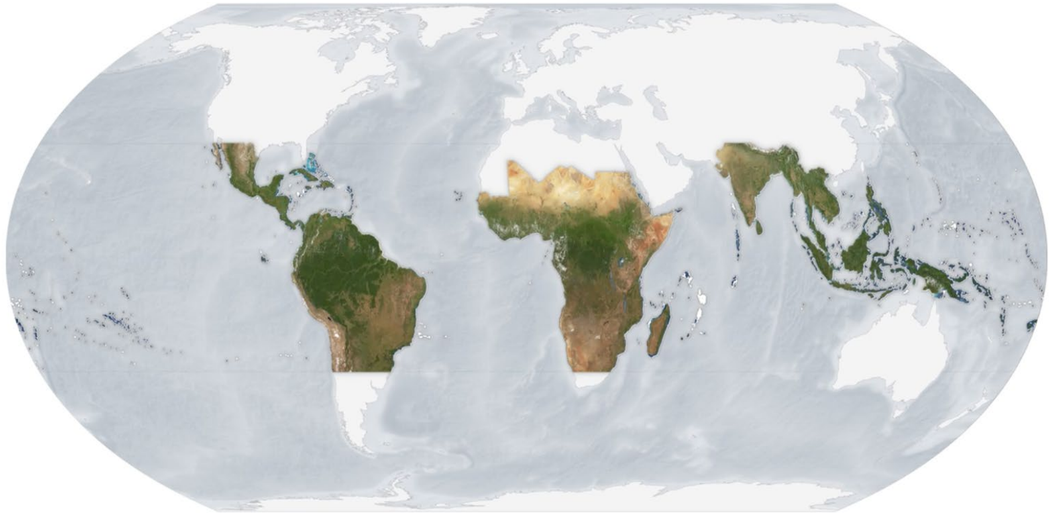
- The animations on the left show some of the **differences** from the previously used InterMap 30 DEM and the GLO30 DEM

Example Positional accuracy for the NICFI mosaics



Positional Accuracy Report for the NICFI Mosaics

- In partnership with **Norway's International Climate & Forests Initiative (NICFI)**, Planet produces analysis-ready **mosaics of the world's tropics** in order to help reduce and reverse the loss of tropical forests, combat climate change, conserve biodiversity, and facilitate **sustainable development** for non commercial uses.
    - More information can be found at https://www.planet.com/nicfi/



This shows the extent of the NICFI dataset (from https://www.planet.com/nicfi/)

- In order to help support this effort, a **study of positional accuracy** within the mosaic was undertaken
    - This study was **done in 2020** so the results shown **does not reflect current data**
    - The study is just being used as **an example of an in depth analysis** that the automated assessment tools routinely help with

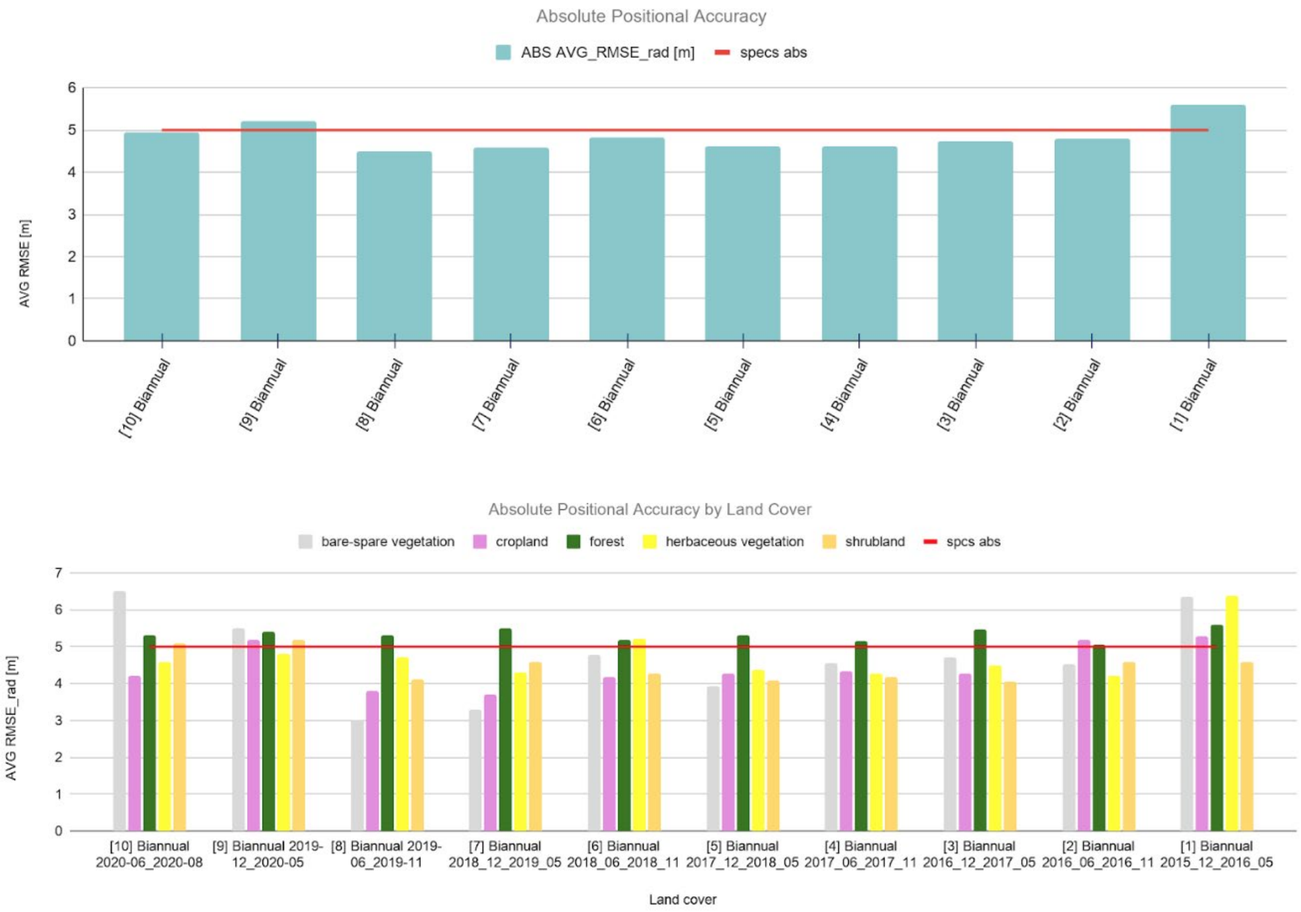
Positional Accuracy Report for the NICFI Mosaics

The **absolute positional accuracy**, **temporal registration** and **band to band registration** measurements were done

- These were all done on all the **monthly mosaics** as well as **biannual mosaics**

For simplicity, only the **absolute positional accuracy results** for the biannual mosaics are shown to the right

- The top shows the absolute positional accuracy throughout the biannual mosaics
- The bottom shows the results broken down by land cover



Summary

GULF OF OMAN • Iran • June 3, 2021

Overview

Current State of Planet's Automated Quality Assurance

The **details of Planet's automated quality assurance tools** have been presented

- These **results** are updated quarterly in the **Data Quality Report** for each constellation
- The Data Quality Reports also contain detailed information on the **methodology** of how each measurement is calculated and the **dataset** involved

Examples of where the automated quality assurance tools were used to **make decisions** and **monitor changes to the pipeline** were also presented

- These tools are used across **all of Planet's constellations** to make **informed decisions**

Currently **geometric measurements** have been the focus of the tools

- There is also a **sharpness measurement**, Relative Edge Response, but this is still being productionized

There are plans for **future quality assurance tools**, which include:

- Automatic **SNR measurements** over homogeneous test sites; these can be a range of test sites across the dynamic range
- Further automatic sharpness measurements like a **Point Spread Function estimation** over a test site like Baotou

For More Information, You May Find Us Here:

Official Website

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