Perth, Australia • SkySat

SKYSAT IMAGERY
PRODUCT SPECIFICATION

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COLLECTION TYPES

STANDARD IMAGE

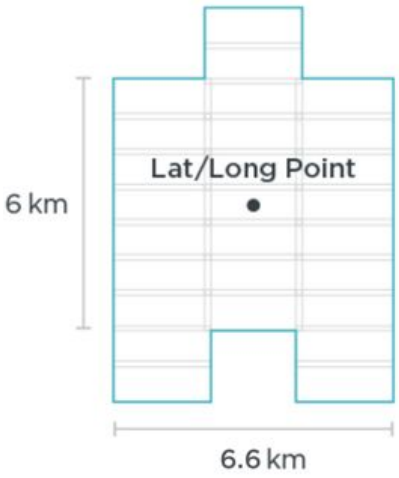


Figure 1: A single "site," or a standard SkySat image deliverable. Image width varies with satellite and collection angle; 6.6 km represents the minimum width.

VIDEO

Full motion videos are collected between 30 and 120 seconds by a single camera from any of the active SkySats. Videos are collected using only the Panchromatic half of the camera, hence all videos are PAN only.

Videos are packaged and delivered with a video mpeg-4 file, plus all image frames with accompanying video metadata and a frame index file (reference Product Types below).

PRODUCT TYPES

SCENES

Basic

The SkySat Basic Scene product includes Analytic, Analytic DN, L1A Panchromatic DN, and Panchromatic imagery that is uncalibrated and in a raw digital number format. The Basic Scene Product is not corrected for any geometric distortions inherent in the imaging process.

Imagery data is accompanied by Rational Polynomial Coefficients (RPCs) to enable orthorectification by the user. This product is designed for users with advanced image processing capabilities and a desire to geometrically correct the product themselves.

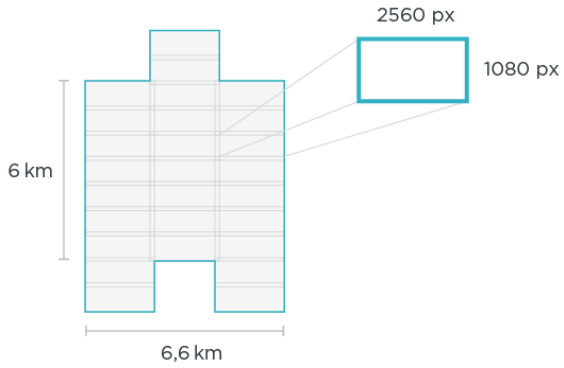
The Basic L1A Panchromatic DN assets (basic_l1a_panchromatic_dn, basic_l1a_panchromatic_dn_rpc) are made available for download immediately after production, before the remaining imagery assets, which may require super-resolution and orthorectification. Hence the L1A Pan browse image will be visible in Explorer and the API before all other image assets are ready for download.

The SkySat Basic Scene Product has a sensor-based framing, and is not mapped to a cartographic projection.

- Analytic - unorthorectified, radiometrically corrected, multispectral BGRN
- Analytic DN - unorthorectified, multispectral BGRN
- Panchromatic - unorthorectified, radiometrically corrected, panchromatic (PAN)
- Panchromatic DN - unorthorectified, panchromatic (PAN)
- L1A Panchromatic DN - unorthorectified, pre-super resolution, panchromatic (PAN)

Table 1: SkySat Basic Scene Product Attributes

SKYSAT BASIC SCENE PRODUCT ATTRIBUTES	
Product Attribute	**Description**
Product Components and Format	Image File – GeoTIFF format Metadata File – JSON format Rational Polynomial Coefficients – Text File UDM File – GeoTIFF format
Information Content	
Image Configurations	4-band Analytic DN Image (Blue, Green, Red, NIR)
	1-band Panchromatic DN Image (Pan)
Product Orientation	Spacecraft/Sensor Orientation
Product Framing	Scene based:

	 SkySat Satellites have three cameras per satellite, which capture overlapping strips. Each of these strips contain overlapping scenes. One scene is approximately 2560px x 1080px.
Sensor Type	CMOS Frame Camera with Panchromatic and Multispectral halves
Spectral Bands	Blue: 450 - 515 nm Green: 515 - 595 nm Red: 605 - 695 nm NIR: 740 - 900 nm Pan: 450 - 900 nm
Processing	**Basic Scene**
Radiometric Corrections	Cross-Sensor Non Uniformity Correction (1%) Conversion to absolute radiometric values based on calibration coefficients Calibration coefficients regularly monitored and updated with on-orbit calibration techniques
Geometric Corrections	Idealized sensor model and Rational Polynomial Coefficients (RPC) Bands are co-registered
Horizontal Datum	WGS84
Map Projection	N/A
Resampling Kernel	Resampling of Analytic Multispectral Data to > 1.0m GSD
Ground Sample Distance	[SkySat-1, SkySat-2] Panchromatic: 0.86m Multispectral: 1.0m
	[SkySat-3 - SkySat-13] Panchromatic: 0.72m Multispectral: 1.0m
Geometric Accuracy	<50m RMSE

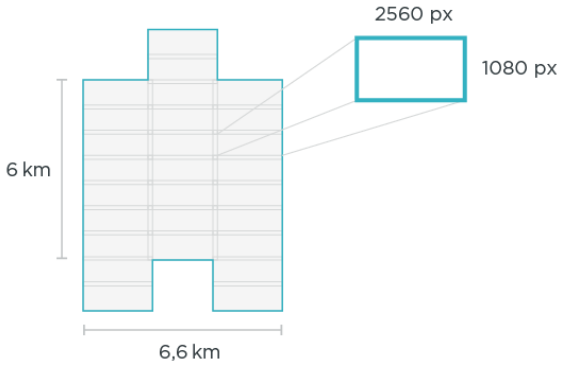
Ortho

The SkySat Ortho Scene product includes Visual, Analytic DN, Analytic, Panchromatic, and Pansharpened Multispectral imagery. The Ortho Scene product is sensor- and geometrically-corrected, and is projected to a cartographic map projection. The geometric correction uses fine Digital Elevation Models (DEMs) with a post spacing of between 30 and 90 meters.

Ground Control Points (GCPs) are used in the creation of every image and the accuracy of the product will vary from region to region based on available GCPs. Also note, ortho accuracy is not guaranteed for collections with view angle greater than 30 degrees.

- Visual - orthorectified, pansharpened, and color-corrected (using a color curve) 3-band RGB Imagery
- Pansharpened Multispectral - orthorectified, pansharpened 4-band BGRN Imagery
- Analytic - orthorectified, multispectral BGRN. Radiometric corrections applied to correct for any sensor artifacts and transformation to top-of-atmosphere radiance
- Analytic DN - orthorectified, multispectral BGRN, uncalibrated digital number imagery product Radiometric corrections applied to correct for any sensor artifacts
- Panchromatic - orthorectified, radiometrically correct, panchromatic (PAN)
- Panchromatic DN - orthorectified, panchromatic (PAN), uncalibrated digital number imagery product

Table 2: SkySat Ortho Scene Product Attributes

SKYSAT ORTHO SCENE PRODUCT ATTRIBUTES	
Product Attribute	**Description**
Product Components and Format	Image File – GeoTIFF format Metadata File – JSON format Rational Polynomial Coefficients – Text File UDM File – GeoTIFF format
Information Content	
Product Framing	Scene Based:  SkySat Satellites have three cameras per satellite, which capture overlapping strips. Each of these strips contain overlapping scenes. One scene is approximately 2560px x 1080px.
Sensor Type	CMOS Frame Camera with Panchromatic and Multispectral halves
Spectral Bands	Blue: 450 - 515 nm Green: 515 - 595 nm Red: 605 - 695 nm NIR: 740 - 900 nm

	Pan: 450 - 900 nm
Processing	
Radiometric Corrections	Cross-Sensor Non Uniformity Correction (1%) Conversion to absolute radiometric values based on calibration coefficients Calibration coefficients regularly monitored and updated with on-orbit calibration techniques
Geometric Corrections	Sensor-related effects are corrected using sensor telemetry and a sensor model. Orthorectification uses GCPs and fine DEMs (30 m to 90 m posting).
Horizontal Datum	WGS84
Map Projection	UTM
Resampling Kernel	Cubic Convolution
Geometric Accuracy	<10 m RMSE

Table 3: SkySat Ortho Scene Asset Attributes

SKYSAT ORTHO SCENE ASSET ATTRIBUTES

Product Attribute	Description
Bands	Visual: 3-band Pansharpened (PS Red, PS Green, PS Blue)
	Pansharpened Multispectral: 4-band Pansharpened (PS Blue, PS Green, PS Red, PS NIR)
	Analytic, Analytic DN: 4-band Multispectral (B, G, R, N)
	Panchromatic, Panchromatic DN: 1-band Panchromatic
Pixel Size (Orthorectified)	Pansharpened Multispectral, Analytic, Analytic DN: 1.0 m
	Visual, Panchromatic, Panchromatic DN: 0.72 m
Bit Depth	Visual: 8-bit Unsigned Integer Pansharpened Multispectral, Analytic, Analytic DN, Panchromatic, Panchromatic DN: 16 Unsigned Integer
Geometric Corrections	Sensor-related effects are corrected using sensor telemetry and a sensor model. Orthorectification uses GCPs and fine DEMs (30m to 90m posting).
Radiometric Calibration Accuracy	Visual, Pansharpened Multispectral, Analytic DN, Panchromatic DN: • No correction applied, pixel values are digital numbers Analytic, Panchromatic: • Absolute Radiance derived using vicarious calibration methods • Product is radiometrically calibrated to radiance units [W/(µm * m^2 * str)], and scaled by 100 to reduce quantization errors • Calibration regularly monitored and updated with on-orbit calibration techniques.
Radiometric Accuracy (Analytic, Panchromatic)	+/- 5% Relative accuracy at < 10 degrees off-nadir angle

Color Enhancements (Visual)	Enhanced for visual use

Scene Metadata

Basic Scene GeoJSON metadata

Table 4: Skysat Basic Scene Geojson Metadata Schema

SKYSAT BASIC SCENE GEOJSON METADATA SCHEMA

Parameter	Description	Type
acquired	The RFC 3339 acquisition time of the image.	string
camera_id	The specific detector used to capture the scene.	String (e.g. “d1”, “d2”)
cloud_cover	The estimated percentage of the scene covered by clouds.	number (0-100)
ground_control	If the image meets the positional accuracy specifications this value will be true. If the image has uncertain positional accuracy, this value will be false.	boolean
gsd	The ground sampling distance of the image acquisition.	number
item_type	The name of the item type that models shared imagery data schema.	string (e.g. “PSScene3Band”, ”SkySatScene”)
provider	Name of the imagery provider.	string ("planetscope","rapideye", “skysat”)
published	The RFC 3339 timestamp at which this item was added to the API.	string
quality_category	Metric for image quality. To qualify for “standard” image quality an image must meet a variety of quality standards, for example: PAN motion blur less than 1.15 pixels, compression bits per pixel less than 3. If the image does not meet these criteria it is considered “test” quality.	string (“standard”, “test”)
satellite_azimuth	Angle from true north to the satellite vector at the time of imaging, projected on the horizontal plane in degrees.	number (0 - 360)
satellite_id	Globally unique identifier of the satellite that acquired the underlying imagery.	string

strip_id	Globally unique identifier of the image strip this scene was collected against	string
sun_azimuth	Angle from true north to the sun vector projected on the horizontal plane in degrees.	number (0 - 360)
sun_elevation	Elevation angle of the sun in degrees.	number (0 - 90)
updated	The RFC 3339 timestamp at which this item was updated in the API.	string
view_angle	Spacecraft across-track off-nadir viewing angle used for imaging, in degrees with + being east and - being west.	number (-90 - +90)

Basic Scene RPC metadata

Table 5: Skysat Basic Scene Text file Metadata Schema

Parameter	Description	Sample
LINE_OFF	Row offset of center point	534.896219421794
SAMP_OFF	Column offset of center point	1267.3960612691
LAT_OFF	Latitude coordinate of center point	-18.1132
LONG_OFF	Longitude coordinate of center point	178.4441
HEIGHT_OFF	Altitude of center point	123
LINE_SCALE	Scaling factor for row coordinate	534.896219421794
SAMP_SCALE	Scaling factor for column coordinate	1267.39606126914
LAT_SCALE	Scaling factor for latitude coordinates	-0.0264
LONG_SCALE	Scaling factor for longitude coordinates	0.0331
HEIGHT_SCALE	Scaling factor for altitude coordinates	77
LINE_NUM_COEFF_	Numerator coefficient in row RPC equation (1-20)	4.27902854674
LINE_DEN_COEFF_	Denominator Coefficient in row RPC equation(1-20)	0.00174493132019
SAMP_NUM_COEFF_	Numerator coefficient in column RPC equation(1-20)	0.0110620153979
SAMP_DEN_COEFF_	Denominator coefficient in column RPC equation (1-20)	0.00174477677906

Ortho Scene GeoJSON metadata

Table 6: Skysat Ortho Scene Geojson Metadata Schema

SKYSAT ORTHO SCENE GEOJSON METADATA SCHEMA

Parameter	Description	Type
acquired	The RFC 3339 acquisition time of the image.	string
camera_id	The specific detector used to capture the scene.	String (e.g. “d1”, “d2”)
cloud_cover	The estimated percentage of the scene covered by clouds.	number (0-100)
ground_control	If the image meets the positional accuracy specifications this value will be true. If the image has uncertain positional accuracy, this value will be false.	boolean
gsd	The ground sampling distance of the image acquisition.	number
item_type	The name of the item type that models shared imagery data schema.	string (e.g. “PSScene3Band”, ”SkySatScene”)
provider	Name of the imagery provider.	string ("planetscope","rapideye", “skysat”)
published	The RFC 3339 timestamp at which this item was added to the API.	string
quality_category	Metric for image quality. To qualify for “standard” image quality an image must meet a variety of quality standards, for example: PAN motion blur less than 1.15 pixels, compression bits per pixel less than 3. If the image does not meet these criteria it is considered “test” quality.	string (“standard”, “test”)
satellite_azimuth	Angle from true north to the satellite vector at the time of imaging, projected on the horizontal plane in degrees.	number (0 - 360)
satellite_id	Globally unique identifier of the satellite that acquired the underlying imagery.	string
strip_id	Globally unique identifier of the image strip this scene was collected against	string

sun_azimuth	Angle from true north to the sun vector projected on the horizontal plane in degrees.	number (0 - 360)
sun_elevation	Elevation angle of the sun in degrees.	number (0 - 90)
updated	The RFC 3339 timestamp at which this item was updated in the API.	string
view_angle	Spacecraft across-track off-nadir viewing angle used for imaging, in degrees with + being east and - being west.	number (-90 - +90)

Analytic Ortho Scene Product Specifications

To convert the pixel values of the Analytic products to radiance, it is necessary to multiply the DN value by the radiometric scale factor, as follows:

RAD(i) = DN(i) * radiometric_scale_factor(i), where radiometric_scale_factor(i) = 0.01

The resulting value is the Top of Atmosphere Radiance of that pixel in watts per steradian per square meter ($W/m^2*sr*\mu m$).

To convert the pixel values of the Analytic products to Top of Atmosphere Reflectance, it is necessary to multiply the DN value by the reflectance coefficient found in the GeoTiff header. This makes the complete conversion from DN to Top of Atmosphere Reflectance to be as follows:

REF(i) = DN(i) * reflectance_coefficient(i)

Alternatively, the customer may perform the TOA Reflectance conversion on their own using the following equation, with the ESUN values given below in Table 3.

$$TOAR = \frac{(\pi \times Radiance \times d^2)}{ESUN \times cos(90 - sun\ elevation)}$$

d = Earth to sun distance in astronomical units

Table 7: Skysat Analytic Ortho Scene ESUN values, resampled from Thuillier irradiance spectra

	PAN	BLUE	GREEN	RED	NIR
SkySat-1	1587.94	1984.85	1812.88	1565.83	1127
SkySat-2	1587.94	1984.85	1812.88	1565.83	1127
SkySat-3	1585.89	2000.7	1821.8	1584.13	1120.33
SkySat-4	1585.89	2000.7	1821.8	1584.13	1120.33
SkySat-5	1573.42	2009.23	1820.33	1584.84	1104.96
SkySat-6	1573.42	2009.23	1820.33	1584.84	1104.96

SkySat-7	1573.42	2009.23	1820.33	1584.84	1104.96
SkySat-8	1582.79	2009.28	1820.25	1583.3	1114.22
SkySat-9	1583.61	2009.29	1821.04	1583.83	1109.44
SkySat-10	1583.88	2008.61	1820.87	1583.5	1112.3
SkySat-11	1586.89	2009.26	1821.14	1583.66	1113.77
SkySat-12	1581.65	2009.5	1821.24	1584.91	1109.01
SkySat-13	1580.89	2009.43	1821.7	1583.77	1108.74
SkySat-14	1581.65	2009.5	1821.24	1584.91	1109.01
SkySat-15	1580.89	2009.43	1821.7	1583.77	1108.74

SkySat Analytic Scene GeoTIFF Properties

Table 8: Properties included in the GeoTIFF Header, under 'TIFFTAG_IMAGEDESCRIPTION'

Field	Value	Sample
radiometric_scale_factor	Provides the parameter to convert the scaled radiance pixel value to radiance. Multiplying the scaled radiance pixel values by the scale factor, derives the Top of Atmosphere Radiance product. This value is a constant, set to 0.01	0.01
reflectance_coefficients	The value is a multiplicative, when multiplied with the DN values, provides the Top of Atmosphere Reflectance values, in watts per steradian per square meter ($W/m^2*sr*\mu m$)	[0.0019093447035360626, 0.0021074819723268657, 0.002420630889355243, 0.003471901841411239]
satellite_azimuth	Angle from true north to the satellite vector at the time of imaging, projected on the horizontal plane in degrees.	103.22169693
satellite_elevation	Angle between the satellite pointing direction and the local horizontal plane in degrees.	61.32334041
sun_azimuth	Angle from true north to the sun vector projected on the horizontal plane in degrees.	136.7200917
sun_elevation	Elevation angle of the sun in degrees.	56.98039498

COLLECTS

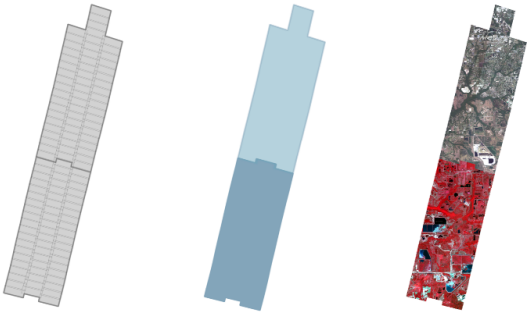
Ortho

The Ortho Collect product is created by composing SkySat Ortho Scenes along an imaging strip into segments typically unifying ~60 SkySat Ortho Scenes. The product may contain artifacts resulting from the composing process, particular offsets in areas of stitched source scenes. In a next version artifacts caused by scene misalignment will be hidden by cutlines. This is particularly important for the appearance of objects in built-up areas and their accurate extraction.

- Visual - pansharpened, orthorectified, color corrected RGB
- Pansharpened Multispectral - pansharpened, orthorectified, color corrected BGRN
- Analytic - orthorectified, radiometrically corrected, multispectral BGRN
- Analytic DN - orthorectified, multispectral BGRN
- Panchromatic - orthorectified, radiometrically correct, panchromatic (PAN)
- Panchromatic DN - orthorectified, panchromatic (PAN)

*Asset attributes match those of the Scene counterparts listed above

Table 9: Skysat Ortho Collect Attributes

SKYSAT ORTHO COLLECT ATTRIBUTES	
Attribute	**Description**
Product Framing	Strip Based  SkySat Satellites have three cameras per satellite, which capture overlapping strips. Each of these strips contain overlapping scenes. One Collect product composes up to 60 scenes (up to 20 per camera) and is approximately 20km x 6.6km.
Assets	Visual: 3-band Pansharpened Image (8-bit Unsigned Integer) Multispectral: 4-band Pansharpened Image (16-bit Unsigned Integer) 4-band Analytic DN Image (B, G, R, N) (16-bit Unsigned Integer) 1-band Panchromatic Image (16-bit Unsigned Integer)

Projection	UTM WGS84
Geometric Corrections	Sensor-related effects are corrected using sensor telemetry and a sensor model. Orthorectification uses GCPs and fine DEMs (30m to 90m posting).
Positional Accuracy	Less than 10 m RMSE
Radiometric Corrections	Cross-Sensor Non Uniformity Correction (1%) Conversion to absolute radiometric values based on calibration coefficients Calibration coefficients regularly monitored and updated with on-orbit calibration techniques

Collect Metadata

Ortho Collect GeoJSON metadata

Table 10: Skysat Ortho Collect Geojson Metadata Schema

SKYSAT ORTHO COLLECT GEOJSON METADATA SCHEMA

Parameter	Description	Type
acquired	The RFC 3339 acquisition time of the image.	string
camera_id	The specific detector used to capture the scene.	String (e.g. “d1”, “d2”)
cloud_cover	The estimated percentage of the scene covered by clouds.	number (0-100)
ground_control	If the image meets the positional accuracy specifications this value will be true. If the image has uncertain positional accuracy, this value will be false.	boolean
gsd	The ground sampling distance of the image acquisition.	number
item_type	The name of the item type that models shared imagery data schema.	string (e.g. “PSScene3Band”, ”SkySatCollect”)
provider	Name of the imagery provider.	string ("planetscope","rapideye", “skysat”)
published	The RFC 3339 timestamp at which this item was added to the API.	string
quality_category	Metric for image quality. To qualify for “standard” image quality an image must meet a variety of quality standards, for example: PAN motion blur less than 1.15 pixels, compression bits per pixel less than 3.	string (“standard”, “test”)

	If the image does not meet these criteria it is considered “test” quality.	
satellite_azimuth	Angle from true north to the satellite vector at the time of imaging, projected on the horizontal plane in degrees.	number (0 - 360)
satellite_id	Globally unique identifier of the satellite that acquired the underlying imagery.	string
strip_id	Globally unique identifier of the image strip this scene was collected against	string
sun_azimuth	Angle from true north to the sun vector projected on the horizontal plane in degrees.	number (0 - 360)
sun_elevation	Elevation angle of the sun in degrees.	number (0 - 90)
updated	The RFC 3339 timestamp at which this item was updated in the API.	string
view_angle	Spacecraft across-track off-nadir viewing angle used for imaging, in degrees with + being east and - being west.	number (-90 - +90)

BASEMAP

All basemaps can be viewed at full resolution within the Planet graphical user interface (up to Zoom Level 18 in the Web Mercator Projection), giving a resolution of 0.597 m at the Equator. The projection used in Planet basemaps has been selected to match what is typically used in web mapping applications. The resolution improves at higher and lower latitudes. The Alpha Mask indicates areas of the quad where there is no imagery data available.

Table 11: Individual Quad Specifications

INDIVIDUAL QUAD SPECIFICATIONS	
Attribute	**Description**
Sensors	SkySat
Pixel Size (resolution)	.597m
Image Bit Depth	8 bits per pixel
Bands	Red, Green, Blue
Projection	WGS84 Web Mercator (EPSG:3857)
Size	4096 x 4096 pixels

Processing	Pansharpened. Geometrically aligned. Seam lines are minimized with tonal balancing. Cutlines to minimize visual breaks

VIDEO

Table 12: Video Product Metadata

VIDEO PRODUCT METADATA		
Field	**Value**	**Sample**
Satellite	Satellite ID	00110
Camera	Camera used for imaging	2
Time		
Start	Start time of video capture	2018-04-10T21:43:07
End	End time of video capture	2018-04-10T21:44:07
Duration (s)	Duration of video in seconds	59.976592063903809
Angle		
Start	Satellite collection elevation of first frame in video	55.476973516035933
End	Satellite collection elevation of last frame in video	61.410026752389307
Convergence	Convergence angle between first and last frames	5.9330532363533734
Azimuth		
Start	Satellite azimuth angle of first frame in video	48.316762122631033
End	Satellite azimuth angle of last frame in video	143.12580513942621
Delta	Difference between start and end satellite azimuth angle	94.809043016795172

Table 13: Frame Index (csv)

FRAME INDEX (CSV)

Field	Value	Sample
name	Frame image filename(w/o file extension)	1207431805.69566202_sc00110_c2_PAN
datetime	Time of frame capture	2018-04-10T21:43:07Z
gsd	Ground Sample Distance	0.964506
sat_az	Avg satellite azimuth for frame	48.3168
sat_elev	Avg satellite elevation for frame	55.477
x_sat_eci	X-axis aligned ECI coordinate	3074.73
y_sat_eci	Y-axis aligned ECI coordinate	3057.87
z_sat_eci	Z-axis aligned ECI coordinate	5338.56
q0	First quaternion coefficient	-0.246954
q1	Second quaternion coefficient	-0.887421
q2	Third quaternion coefficient	-0.385464
q3	Fourth quaternion coefficient	0.0539912
bit_depth	Pixel bit depth of frame	16
geom	Frame dimensions	POLYGON((-123.132 49.2933,-123.089 49.294,-123.092 49.2825,-123.135 49.2818))