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Geographic information — Imagery sensor models for geopositioning —

Part 1: Fundamentals

Information géographique — Modèles de capteurs d'images et géopositionnement —

Partie 1: Principes de base

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 211, *Geographic information/Geomatics.*

This first edition of ISO 19130 cancels and replaces ISO/TS 19130:2010, which has been technically revised.

The main changes compared to the previous edition are:

— part number 1 was added to reflect that ISO 19130 is now divided into several parts;

— normative references are updated to reflect revisions;

— Annex B is updated to reference the updated versions of the ISO geographic information standards.

A list of all the parts in the ISO 19130 series, can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

The purpose of this document is to specify the geolocation information that an imagery data provider shall supply in order for the user to be able to find the earth location of the data using a Physical Sensor Model (PSM), a True Replacement Model (TRM) or a Correspondence Model (CM). Detailed PSMs are defined for passive electro-optical visible/ IR sensors (frame, pushbroom and whiskbroom) and for an active microwave sensing system (SAR). A set of components from which models for other sensors can be constructed is also provided. Metadata required for geopositioning using a TRM, a CM, or ground control points (GCPs) are also specified. The intent is to standardize sensor descriptions and specify the minimum geolocation metadata requirements for data providers and geopositioning imagery systems.

Vast amounts of data from imaging systems are collected, processed and distributed by government mapping and remote sensing agencies and commercial data vendors. In order for this data to be useful in extraction of geographic information, it requires further processing. Geopositioning, which determines the ground coordinates of an object from image coordinates, is a fundamental processing step. Because of the diversity of sensor types and the lack of a common sensor model standard, data from different producers can contain different parametric information, lack parameters required to describe the sensor that produces the data, or lack ancillary information necessary for geopositioning and analysing the data. Consequently, a separate software package often has to be developed to deal with data from each individual sensor or data producer. Standard sensor models and geolocation metadata allow agencies or vendors to develop generalized software products that are applicable to data from multiple data producers or from multiple sensors. With such a standard, different producers can describe the geolocation information of their data in the same way, thus promoting interoperability of data between application systems and facilitating data exchange.

This document defines the set of metadata elements specified for providing sensor model and other geopositioning data to users. For the case where a PSM is provided, it includes a location model and metadata relevant to all sensors; it also includes metadata specific to whiskbroom, pushbroom, frame, and SAR sensors. It also includes metadata for functional fit geopositioning, where the function is part of a CM or a TRM. This document also provides a schema for all of these metadata elements.

Geographic information — Imagery sensor models for geopositioning —

Part 1:
Fundamentals

1 Scope

This document identifies the information required to determine the relationship between the position of a remotely sensed pixel in image coordinates and its geoposition. It supports exploitation of remotely sensed images. It defines the metadata to be distributed with the image to enable user determination of geographic position from the observations.

This document specifies several ways in which information in support of geopositioning can be provided.

a) It may be provided as a sensor description with the associated physical and geometric information necessary to rigorously construct a PSM. For the case where precise geoposition information is needed, this document identifies the mathematical equations for rigorously constructing PSMs that relate 2D image space to 3D ground space and the calculation of the associated propagated errors. This document provides detailed information for three types of passive electro-optical/ IR sensors (frame, pushbroom and whiskbroom) and for an active microwave sensing system SAR. It provides a framework by which these sensor models can be extended to other sensor types.

b) It can be provided as a TRM, using functions whose coefficients are based on a PSM so that they provide information for precise geopositioning, including the calculation of errors, as precisely as the PSM they replace.

c) It can be provided as a CM that provides a functional fitting based on observed relationships between the geopositions of a set of GCPs and their image coordinates.

d) It can be provided as a set of GCPs that can be used to develop a CM or to refine a PSM or TRM.

This document does not specify either how users derive geoposition data or the format or content of the data the users generate.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 19103:2015, *Geographic information — Conceptual schema language*

ISO 19107, *Geographic information — Spatial schema*

ISO 19108, *Geographic information — Temporal schema*

ISO 19111:2007, *Geographic information — Spatial referencing by coordinates*

ISO 19115-1:2014, *Geographic information — Metadata — Part 1: Fundamentals*

ISO 19115-2:2009, *Geographic information — Metadata — Part 2: Extensions for imagery and gridded data*

ISO 19123, *Geographic information — Schema for coverage geometry and functions*

ISO 19157:2013, *Geographic information — Data quality*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— IEC Electropedia: available at http://www.electropedia.org/

— ISO Online browsing platform: available at http://www.iso.org/obp

3.1
active sensing system
sensing system that emits energy that the *sensor* (3.79) uses to perform sensing

3.2
adjustable model parameters
model parameters that can be refined using available additional information, such as *ground control points* (3.42), to improve or enhance modelling corrections

3.3
along-track
direction in which the *sensor* (3.79) platform moves

3.4
aperture reference point
APR
3D location of the centre of the synthetic aperture

Note 1 to entry: It is usually expressed in ECEF *coordinates* (3.11) in metres.

3.5
attitude
orientation of a body, described by the angles between the axes of that body's *coordinate system* (3.13) and the axes of an external coordinate system

[SOURCE: ISO 19116:2004, 4.2, modified – NOTE is deleted.]

3.6
attribute
named property of an entity

Note 1 to entry: In this document, the property relates to a geometrical, topological, thematic, or other characteristic of an entity.

[SOURCE: ISO/IEC 2382:2015, 2121440, modified – Note 1 to entry has been added.]

3.7
azimuth resolution
⟨SAR⟩ resolution in the cross-range direction

Note 1 to entry: This is usually measured in terms of the *impulse response* (3.56) of the *SAR* (3.76) *sensor* (3.79) and processing system. It is a function of the size of the synthetic aperture, or alternatively the dwell time (i.e. a larger aperture results in a longer dwell time results in better resolution).

3.8
beam width
⟨SAR⟩ useful angular width of the beam of electromagnetic energy

Note 1 to entry: Beam width is usually measured in radians and as the angular width between two points that have 50 % of the power (3 dB below) of the centre of the beam. It is a property of the antenna. Power emitted outside of this angle is too little to provide a usable return.

3.9
broadside
⟨SAR⟩ direction orthogonal to the velocity vector and parallel to the plane tangent to the Earth's *ellipsoid* (3.21) at the nadir point of the *ARP* (3.4)

3.10
calibrated focal length
distance between the *perspective centre* (3.62) and the *image plane* (3.53) that is the result of balancing positive and negative radial lens distortions during *sensor* (3.79) calibration

3.11
coordinate
one of a sequence of *n* numbers designating the position of a point in *n*-dimensional space

Note 1 to entry: In a *coordinate reference system* (3.12), the coordinate numbers are qualified by units.

[SOURCE: ISO 19111:2007, 4.5]

3.12
coordinate reference system
CRS
coordinate system (3.13) that is related to an object by a *datum* (3.17)

Note 1 to entry: For geodetic and vertical datums, the object will be the Earth.

[SOURCE: ISO 19111:2007, 4.8]

3.13
coordinate system
set of mathematical rules for specifying how *coordinates* (3.11) are to be assigned to points

[SOURCE: ISO 19111:2007, 4.10]

3.14
Correspondence Model
CM
functional relationship between ground and *image* (3.47) *coordinates* (3.11) based on the correlation between a set of *ground control points* (3.42) and their corresponding image coordinates

3.15
cross-track
perpendicular to the direction in which the collection platform moves

3.16
data
reinterpretable representation of information in a formalised manner suitable for communication, interpretation, or processing

[SOURCE: ISO/IEC 2382:2015, 2121272]

3.17
datum
parameter or set of parameters that define the position of the origin, the scale, and the orientation of a *coordinate system* (3.13)

[SOURCE: ISO 19111:2007, 4.14]

3.18
detector
device that generates an output signal in response to an energy input

3.19
Doppler angle
⟨SAR⟩ angle between the velocity vector and the *range vector* (3.72)

3.20
Doppler shift
wavelength change resulting from relative motion of source and *detector* (3.18)

Note 1 to entry: In the *SAR* (3.76) context, it is the frequency shift imposed on a radar signal due to relative motion between the transmitter and the object being illuminated.

3.21
ellipsoid
surface formed by the rotation of an ellipse about a main axis

Note 1 to entry: The Earth ellipsoid is a mathematical ellipsoid figure of the Earth which is used as a reference frame for computations in geodesy, astronomy and the geosciences.

[SOURCE: ISO 19111:2007, 4.17, modified – a new Note 1 to entry replaces NOTE.]

3.22
ellipsoidal coordinate system
geodetic coordinate system
coordinate system (3.13) in which position is specified by *geodetic latitude* (3.30), *geodetic longitude* (3.31) and (in the three-dimensional case) *ellipsoidal height* (3.23)

[SOURCE: ISO 19111:2007, 4.18]

3.23
ellipsoidal height
geodetic height
h
distance of a point from the *ellipsoid* (3.21) measured along the perpendicular from the ellipsoid to this point, positive if upwards or outside of the ellipsoid

Note 1 to entry: Only used as part of a three-dimensional *ellipsoidal coordinate system* (3.22) and never on its own.

[SOURCE: ISO 19111:2007, 4.19]

3.24
error propagation
process of determining the uncertainties of derived quantities from the known uncertainties of the quantities on which the derived quantity is dependent

Note 1 to entry: Error propagation is governed by the mathematical function relating the derived quantity to the quantities from which it was derived.

3.25
external coordinate reference system
coordinate reference system (3.12) whose *datum* (3.17) is independent of the object that is located by it

3.26
fiducial centre
point determined on the basis of the camera *fiducial marks* (3.27)

Note 1 to entry: When there are four fiducial marks, fiducial centre is the intersection of the two lines connecting the pairs of opposite fiducial marks.

3.27
fiducial mark
index marks, typically four or eight rigidly connected with the camera body, which form *images* (3.47) on the film negative and define the *image coordinate reference system* (3.48)

Note 1 to entry: When a camera is calibrated the distances between fiducial marks are precisely measured and assigned *coordinates* (3.11) that assist in correcting for film distortion.

3.28
frame sensor
sensor (3.79) that detects and collects all of the *data* (3.16) for an *image* (3.47) (frame/rectangle) at an instant of time

3.29
geodetic datum
datum (3.17) describing the relationship of a two- or three-dimensional *coordinate system* (3.13) to the Earth

Note 1 to entry: In most cases, the geodetic datum includes an *ellipsoid* (3.21) description.

[SOURCE: ISO 19111:2007, 4.24, modified – Note 1 to entry has been added.]

3.30
geodetic latitude
ellipsoidal latitude

φ
angle from the equatorial plane to the perpendicular to the *ellipsoid* (3.21) through a given point, northwards treated as positive

[SOURCE: ISO 19111:2007, 4.25]

3.31
geodetic longitude
ellipsoidal longitude
λ
angle from the prime meridian plane to the meridian plane of a given point, eastward treated as positive

[SOURCE: ISO 19111:2007, 4.26]

3.32
geoid
equipotential surface of the Earth's gravity field which is everywhere perpendicular to the direction of gravity and which best fits mean sea level either locally or globally

[SOURCE: ISO 19111:2007, 3.27]

3.33
geographic information
information concerning phenomena implicitly or explicitly associated with a location relative to the Earth

[SOURCE: ISO 19101-1:2014, 4.1.18]

3.34
geolocating
geopositioning (3.36) an object using a *Physical Sensor Model* (3.63)or a *True Replacement Model* (3.86)

3.35
geolocation information
information used to determine geographic location corresponding to *image* (3.47) location

[SOURCE: ISO 19115-2:2009, 4.11]

3.36
geopositioning
determination of the geographic position of an object

Note 1 to entry: While there are many methods for geopositioning, this document is focused on geopositioning from *image* (3.47) *coordinates* (3.11).

3.37
georeferencing
geopositioning (3.36) an object using a *Correspondence Model* (3.14)derived from a set of points for which both ground and *image* (3.47) *coordinates* (3.11) are known

3.38
gimbal
mechanical device consisting of two or more rings connected in such a way that each rotates freely around an axis that is a diameter of the next ring toward the outermost ring of the set

Note 1 to entry: An object mounted on a three-ring gimbal will remain horizontally suspended on a plane between the rings regardless as to the stability of the base.

3.39
grazing angle
⟨SAR⟩ vertical angle from the local surface tangent plane to the *slant range direction* (3.70)

3.40
grid
network composed of two or more sets of curves in which the members of each set intersect the members of the other sets in an algorithmic way

Note 1 to entry: The curves partition a space into grid cells.

[SOURCE: ISO 19123:2005, 4.1.23]

3.41
grid coordinates
sequence of two or more numbers specifying a position with respect to its location on a *grid* (3.40)

[SOURCE: ISO 19115-2:2009, 4.16]

3.42
ground control point
GCP
point on the earth that has an accurately known geographic position

[SOURCE: ISO 19115-2:2009, 4.18]

3.43
ground range
⟨SAR⟩ magnitude of the *range vector* (3.72) projected onto the ground

Note 1 to entry: Ground range of an *image* (3.47) is represented by the distance from the nadir point of the antenna to a point in the scene. Usually measured in the horizontal plane, but can also be measured as true distance along the ground, DEM, *geoid* (3.32) or *ellipsoid* (3.21) surface.

3.44
ground reference point
GRP
3D position of a reference point on the ground for a given synthetic aperture

Note 1 to entry: It is usually the centre point of an *image* (3.47) (Spotlight) or an image line (Stripmap). It is usually expressed in ECEF *coordinates* (3.11) in metres.

3.45
ground sampling distance
linear distance between *pixel* (3.64) centres on the ground

Note 1 to entry: This definition also applies for water surfaces.

3.46
gyroscope
device consisting of a spinning rotor mounted in a *gimbal* (3.38) so that its axis of rotation maintains a fixed orientation

Note 1 to entry: The rotor spins on a fixed axis while the structure around it rotates or tilts. In airplanes, the pitch and orientation of the airplane is measured against the steady spin of the gyroscope. In space, where the four compass points are meaningless, the gyroscope's axis of rotation is used as a reference point for navigation. An inertial navigation system includes three gimbal-mounted gyroscopes, used to measure roll, pitch, and yaw.

3.47
image
gridded coverage whose *attribute* (3.6) values are a numerical representation of a physical parameter

Note 1 to entry: The physical parameters are the result of measurement by a *sensor* (3.79) or a prediction from a model.

[SOURCE: ISO 19115-2:2009, 4.19]

3.48
image coordinate reference system
coordinate reference system (3.12) based on an *image datum* (3.49)

[SOURCE: ISO 19111:2007, 4.30]

3.49
image datum
engineering *datum* (3.17) which defines the relationship of a *coordinate system* (3.13) to an *image* (3.47)

[SOURCE: ISO 19111:2007, 4.31]

3.50
image distortion
deviation between the actual location of an *image point* (3.54) and the location that theoretically would result from the geometry of the imaging process without any errors

3.51
image formation
⟨SAR⟩ process by which an *image* (3.47) is generated from collected phase history data in a *SAR* (3.76) system

3.52
image-identifiable ground control point
ground control point (3.42) associated with a marker or other object on the ground that can be recognized in an *image* (3.47)

Note 1 to entry: The ground control point may be marked in the image, or the user may be provided with an unambiguous description of the ground control point so that it can be found in the image.

3.53
image plane
plane behind an imaging lens where *images* (3.47) of objects within the depth of field of the lens are in focus

3.54
image point
point on the *image* (3.47) that uniquely represents an *object point* (3.60)

3.55
imagery
representation of phenomena as *images* (3.47) produced by electronic and/or optical techniques

Note 1 to entry: In this document, it is assumed that the phenomena have been sensed or detected by one or more devices such as radars, cameras, photometers and IR and multispectral scanners.

[SOURCE: ISO 19101-2:2018, 3.14]

3.56
impulse response
IPR
width of the return generated by a small point reflector, which equates to the smallest distance between two point reflectors that can be distinguished as two objects

3.57
incident angle
vertical angle between the line from the detected element to the *sensor* (3.79)and the local surface normal (tangent plane normal)

3.58
internal coordinate reference system
coordinate reference system (3.12) having a *datum* (3.17) specified with reference to the object itself

3.59
metadata
information about a *resource*

[SOURCE: ISO 19115-1:2014, 4.10]

3.60
object point
point in the object space that is imaged by a *sensor* (3.79)

Note 1 to entry: In *remote sensing* (3.74) and aerial photogrammetry an object point is a point defined in an Earth-fixed *coordinate reference system* (3.12).

3.61
passive sensor
sensor (3.79) that detects and collects energy from an independent source

EXAMPLE Many optical sensors collect reflected solar energy.

3.62
perspective centre
projection centre
point located in three dimensions through which all rays between *object points* (3.60) and *image points* (3.54) appear to pass geometrically

3.63
Physical Sensor Model
PSM
sensor model (3.80) based on the physical configuration of a sensing system

3.64
pixel
smallest element of a digital *image* (3.47) to which *attributes* (3.6) are assigned

Note 1 to entry: This term originated as a contraction of “picture element”.

Note 2 to entry: Related to the concept of a *grid* (3.40) cell.

[SOURCE: ISO 19101-2:2018, 3.28]

3.65
platform coordinate reference system
engineering *coordinate reference system* (3.12) fixed to the collection platform within which positions on the collection platform are defined

3.66
principal point of autocollimation
point of intersection between the *image plane* (3.53) and the normal from the *perspective centre* (3.62)

3.67
principal point of best symmetry
centre of the circles of equal distortion of the lens positioned in the *image plane* (3.53)

3.68
pushbroom sensor
sensor (3.79) that collects a single *cross-track* (3.15) *image* (3.47) line at one time and constructs a larger image from a set of adjacent lines resulting from the *along-track* (3.3) motion of the sensor

3.69
range bin
⟨SAR⟩ group of radar returns that all have the same range

3.70
range direction
slant range direction
⟨SAR⟩ direction of the *range vector* (3.72)

3.71
range resolution
spatial **resolution** in the *range direction* (3.70)

Note 1 to entry: For a *SAR (3.76) sensor (3.79)*, it is usually measured in terms of the *impulse response* (3.56) of the *sensor* (3.79) and processing system. It is a function of the bandwidth of the pulse.

3.72
range vector
vector from the antenna to a point in the scene

3.73
rectified grid
grid (3.40) for which there is an affine transformation between the *grid coordinates* (3.41) and the *coordinates* (3.11) of an *external coordinate reference system (3.25)*

Note 1 to entry: If the *coordinate reference system* (3.12) is related to the Earth by a *datum* (3.17), the grid is a georectified grid.

[SOURCE: ISO 19123:2005, 4.1.32]