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FEASIBILITY STUDY FOR GEO-LOCATION ASSESSMENT OF OPTICAL SENSORS GEOACCA

**Auxiliary Data Survey on existing reference (or a priori)
geographic information**

Deliverable D03

Prepared by

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<p>ABSTRACT:</p> <p>This report studies the availability of suitable reference data for assessing the geo-location accuracy of medium resolution optical satellite data like AATSR and MERIS. The basis for generating the set of ground control points (GCPs) as reference data are terrain corrected Landsat data (L1T products, 30 meters resolution).</p> <p>GCPs are isolated lakes and islands of a certain extent, stable in time, and clearly identifiable in medium resolution optical data. For the selection of the GCPs, Shuttle Radar Topography Mission (SRTM) Water Body Data have been used. The set of GCPs was adapted, depending on their performance during the matching procedure. Version 1.1.0 of the GCP database includes 363 GCPs around the world.</p> <p>An automatic procedure has been implemented to extract the data window (bands 1-5) covering each GCP from the Landsat scenes. Additionally, reprojection to the UTM map projection is done.</p>			
<p>The work described in this report was done under ESA Contract. Responsibility for the contents resides in the authors or organisation that prepared it.</p>			
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TABLE OF CONTENT

1. Introduction	9
1.1 Purpose	9
1.2 Outline.....	9
1.3 Acronyms.....	9
2. Reference Data	10
2.1 Landsat L1T Products	11
2.2 SRTM Water Body Data (SWBD)	11
2.3 Global Self-consistent, Hierarchical, High-Resolution Shoreline Database (GSHHG)	12
2.4 Water mask from GLOBCOVER.....	12
2.5 LC_CCI SAR Water Bodies product.....	13
3. Generation of Database of Ground Control Points	14
3.1 Selection of Ground Control Points	14
3.2 Automatic extraction of Reference Image Chips (GCPs).....	15
4. GCP Database.....	18
5. References	30

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1. INTRODUCTION

1.1 Purpose

The purpose of this document is to identify and describe the reference data set and the selected Ground Control Points (GCPs) used for the assessment of the geo-location accuracy of optical sensors.

1.2 Outline

The report is organized into 4 sections:

- Section 2 describes the reference data which are used to assess the geo-location accuracy of EO data.
- In Section 3, the selection of the Ground Control Points and the preparation of the Landsat image chips are explained.
- Section 4 provides the coordinates and type of selected GCPs (Version 1.1.0 of GCP database includes 363 GCPs around the world).

1.3 Acronyms

AATSR	Advanced Along-Track Scanning Radiometer
GCP	Ground Control Point
MERIS	MEdium Resolution Imaging Spectrometer
SPOT	Satellite Pour l'Observation de la Terre
SRTM	Shuttle Radar Topography Mission
SWBD	Shuttle Radar Topography Mission Water Body Data
TM	Thematic Mapper
WRS	Worldwide Reference System for Landsat data

2. REFERENCE DATA

Reference data are the basis to generate a set of ground control points (GCPs) for determining the local geolocation accuracy of rectified satellite images. GCPs are extended targets like lakes and island which can be clearly identified in satellite images.

The requirements for the reference data are:

- Global coverage
- Resolution: better than 1/3 of a pixel of medium resolution optical sensor (AATR: 1 km; MERIS 300m)
- Public or freely available data

The proposed algorithm for estimation of the geolocation accuracy applies cross-correlation on the GCPs, which are image chips (raster data), and medium resolution satellite data. Therefore accurately rectified high resolution satellite data are the primary data source for reference data. The selection of suitable GCPs is supported by independent information in order to check visually the geolocation accuracy of the raster data itself and the temporal stability in the extent of the GCP.

The following data sets are identified:

Dataset of orthorectified high Resolution Satellite data:

- Landsat TM / ETM+ / OLI data set (processed to Level L1T; Terrain corrected), freely available at NASA

Available vector data of water bodies:

- Shuttle Radar Topography Mission Water Body Data: SRTM SWBD (vector files)
- NOAA National Geophysical Data Center Global Self-consistent, Hierarchical, High-Resolution Shoreline Database: NGDC GSHHS (vector files)
- Water mask from GLOBCOVER (raster file, water bodies are digitized from classification)
- LC_CCI SAR Water Bodies product

At the Preliminary Design Review Meeting, it was decided to use Landsat TM / ETM+ / OLI images with a resolution of 30 meters as reference data for the assessment of the geo-location accuracy of AATSR and MERIS data. Only images processed as L1T (Terrain Corrected Images) are used.

Additionally, for identifying water bodies we used the SRTM SWBD data sets.

In the following sub-sections the datasets are shortly described.

2.1 Landsat L1T Products

The L1T correction process utilizes both ground control points (GCP) and digital elevation models (DEM) to attain absolute geodetic accuracy. The WGS84 ellipsoid is employed as the Earth model for the Universal Transverse Mercator (UTM) coordinate transformation. The L1T Product is geometrically rectified, free from distortions related to the sensor (e.g. jitter, view angle effects), satellite (e.g. attitude deviations from nominal) and Earth (e.g. rotation, curvature, relief). Geodetic accuracy of the product depends on the accuracy of the ground control points and the resolution of the DEM used. Ground control points used for Level 1T correction come from the Global Land Survey 2000 (GLS2000) data set. DEM sources include SRTM, NED, CDED, DTED, and GTOPO 30. (Landsat 7 – Science data User Handbook).

Specifications of L1T products:

- Data Resolution (Reflective bands 1-5): 30 m
- Data Format: GeoTIFF
- Resampling: Cubic Convolution
- Projection: Universal Transverse Mercator (UTM)
- Datum: WGS84

2.2 SRTM Water Body Data (SWBD)

The SRTM Water Body Data (SWBD) is a geographical dataset encoding high-resolution worldwide coastline outlines in a vector format, published by NASA. It was created by BAE Systems ADR for the US National Geospatial-Intelligence Agency (NGA) as a complementary product during editing of the digital elevation model database of the Shuttle Radar Topography Mission (SRTM). SWBD data covers the Earth's surface between 56° southern latitude and 60° northern latitude. It is distributed in ESRI shapefile format, divided into 12229 files, each covering one 1°-by-1° tile of the Earth's surface. SWBD data is in the public domain and is made available online for free download by NASA. (SRTM Water Body Data Product Specific Guidance, 2003).

Specifications of SWBD:

- The horizontal datum is the World Geodetic System (WGS84 1984).
- The vertical datum is WGS84 Earth Gravitational Model 1996 (EGM 96) geoid.
- Absolute Horizontal Accuracy equivalent to SRTM DTED 2 is 20 m circular error, 90% confidence.

- Absolute Vertical Accuracy equivalent to SRTM DTED 2 is 16 m linear error, 90% confidence.

2.3 Global Self-consistent, Hierarchical, High-Resolution Shoreline Database (GSHHG)

The GSHHG (Wessel and Smith, 1996) is a high-resolution geography data set, amalgamated from two databases in the public domain: World Vector Shorelines (WVS) and CIA World Data Bank II (WDBII). The former is the basis for shorelines while the latter is the basis for lakes, although there are instances where differences in coastline representations necessitated adding WDBII islands to GSHHG. GSHHG data have undergone extensive processing and should be free of internal inconsistencies such as erratic points and crossing segments. The shorelines are constructed entirely from hierarchically arranged closed polygons.

GSHHG combines the older GSHHS shoreline database with WDBII rivers and borders, available for file download in either ESRI shapefile format or in a native binary format. The GSHHG geography data come in five different resolutions: crude(c), low(l), intermediate(i), high(h), and full(f). Shorelines are further organized into 4 hierarchical levels: boundary between land and ocean (L1), boundary between lake and land (L2), boundary between island-in-lake and lake (L3), and boundary between pond-in-island and island (L4).

The latest version of GSHHG has been released Feb 1, 2014, as version 2.3.0 (see <http://www.soest.hawaii.edu/pwessel/gshhg/index.html>).

2.4 Water mask from GLOBCOVER

GlobCover is an ESA initiative which began in 2005 in partnership with JRC, EEA, FAO, UNEP, GOC-GOLD and IGBP. The GlobCover product offers a global land cover map at 300m resolution, using the MERIS sensor on-board ENVISAT satellite as main source of data. The GlobCover products have been validated with high spatial resolution satellite image data like LANDSAT, SPOT and ASTER.

From the raster file containing the land cover classification, the water bodies are digitized. Therefore, a global data set of water bodies at 300m resolution is available.

Due to the coarse resolution this data set is not used.

2.5 LC_CCI SAR Water Bodies product

The LC_CCI SAR WB product gives the repartition of open and permanent water bodies (inland water and oceans) at 300m spatial resolution at global scale. Its Coordinate Reference System (CRS) is a Geographic Coordinate System (GCS) based on the World Geodetic System 84 (WGS84) reference ellipsoid. (ESA, 2013).

The ASAR WSM data set (150m) for the time period 2005-2010 was used at the main source of imagery. As the quantity of WSM was insufficient in some places, imagery in IMM (75m) and GMM (500m) were used in complement. A water/land classification scheme relied first on the Temporal Variability (TV) of the SAR backscatter and a measure of the Minimum Backscatter. Refinements were then applied based on visual and inconsistency assessments. The product is finally resampled to the 300m spatial resolution to be in line with the LC_CCI maps.

Due to the coarse resolution this data set is not used.

3. GENERATION OF DATABASE OF GROUND CONTROL POINTS

3.1 Selection of Ground Control Points

Several test runs revealed that isolated lakes and islands serve best as GCPs for the matching procedure between reference images and EO input data images (Deliverable D04, section 2.4). For the creation of the GCP database, the SRTM water body data (SWBD), which have an approximate resolution of 30 meters, has been used. From these water outlines, lakes and islands with a certain dimension have been selected automatically.

In a next step, the selected features have been manually checked for their shape, distribution and surroundings. Thereby, some inappropriate GCPs were rejected, whereas other, suitable features which had not been selected during the automatic procedure were added. It is intended to continuously adapt the set of GCPs in dependence on their performance during the matching procedure of a longer time series of satellite data from different sensors.

One important issue is to identify and exclude lakes or islands, which exhibit significant changes in their extent. This can be done by overlaying independent data sets of water bodies. Figure 3.1 shows two examples of GCPs. We used Landsat TM raster data and the SWBD vector data of open water. As the data sets were acquired at different dates, GCPs with temporarily variable extent (e.g. Figure 3.2) can be easily identified.

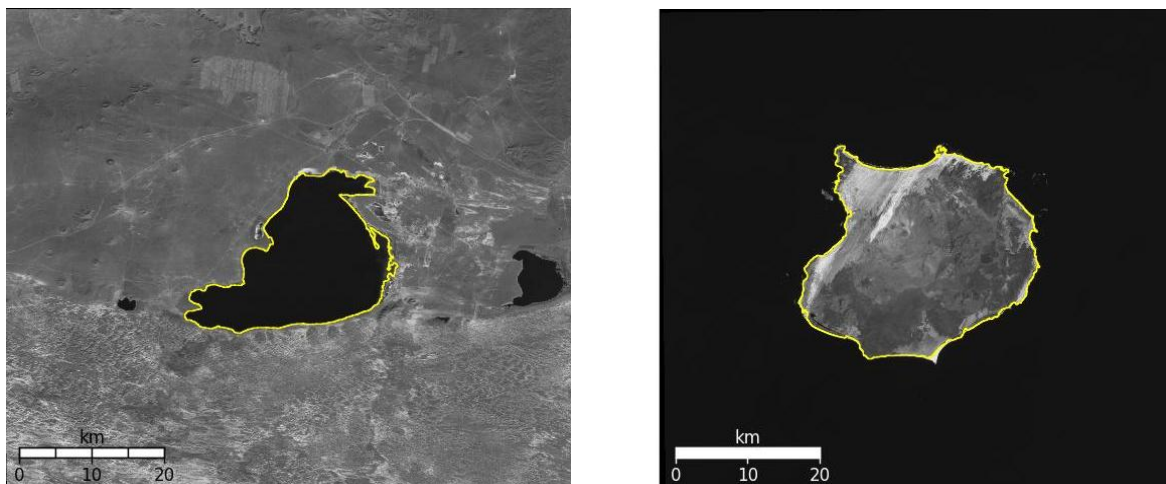


Figure 3.1: Examples of Ground Control Points, displayed by the SWBD water outlines laid over the Landsat band 4 (NIR) raster files: The lake Dali Nuoyer in China (left), and the island Ilha da Boa Vista in Cap Verde, Africa (right).

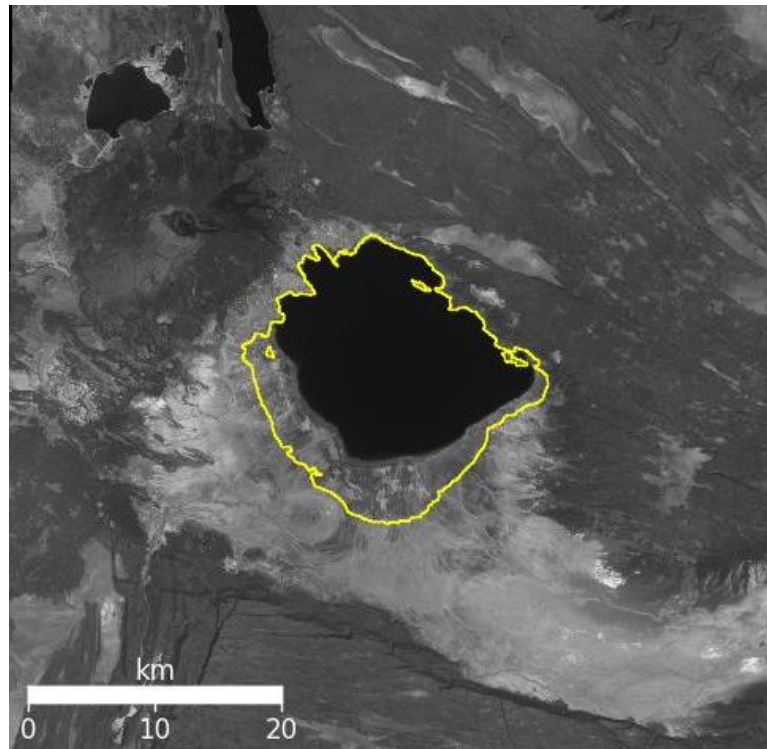


Figure 3.2: Example of lake with temporarily changing extent: Lake Abhe, Ethiopia. This type of GCP is not useful as GCP

3.2 Automatic extraction of Reference Image Chips (GCPs)

The automatic retrieval of the appropriate Landsat scene for each GCP, and the preparation of the Landsat image chips is outlined in Figure 3.3. The procedure utilizes Landsat L1T data, but can be also adapted for other orthorectified data sets. For automatic pre-selection of GCPs the SWBD data set was screened for suitable targets according to their size. The GCP selection was then manually refined by taking the spatial density of points into account. For the selected shapesfiles the center coordinates and the maximum extent in East and West direction are specified. The center points in latitude and longitude are also used for creating the GCP id and filename, which makes sure that only unique IDs and GCP filenames are created. Based on the center coordinates the Landsat WRS Scene ID is calculated and the full coverage of the reference image chip by the LANDSAT scene is derived. If the image chip of the GCP is only partly covered by the Landsat image (e.g. the GCP is located at the border of the Landsat Scene) the GCP is rejected. Otherwise it is checked if the scenes have already been downloaded (e.g. by a previous GCP) from the GFSC server and stored in the basic data set at ENVEO. Finally the visible bands of the Landsat Scene are extended for the specified image window

and stored in the reference image chip data base using the GCP id as filenames. The extracted Landsat TM image chips are overlaid with the outline of the lake / island form the SWBD in order to manually assess the accuracy and temporal stability of the GCP.

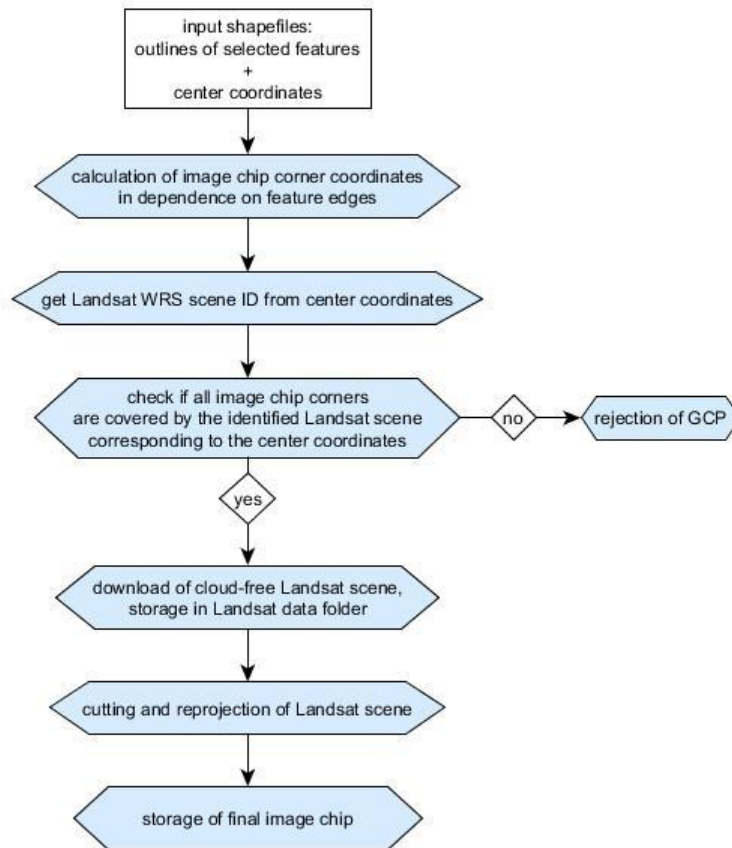


Figure 3.3: Procedure for automatic extraction of Landsat image chips (bands 1-5) using centre coordinates of identified GCP.

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4. GCP DATABASE

In this section the GCP data set version 1.1.0 is listed. Figure 4.1 and Figure 4.2 show the location of the selected GCPs. The coordinates and type of the selected GCPs are listed in Table 4.1.

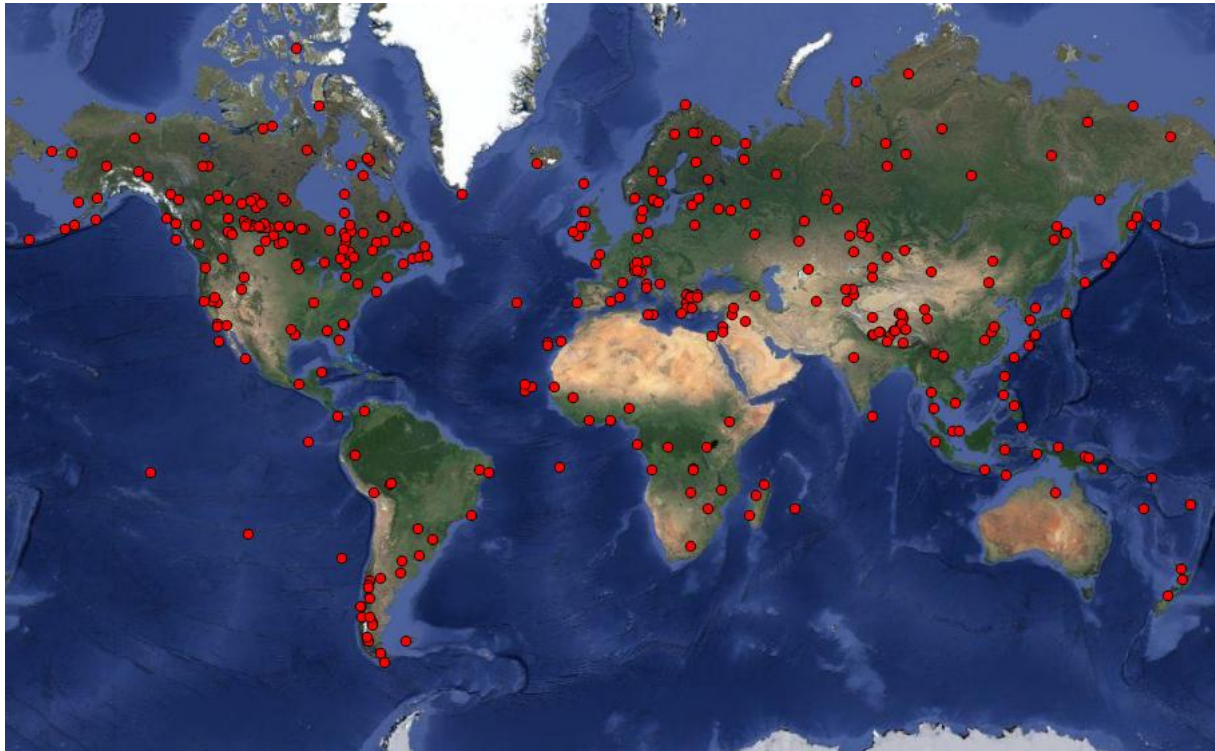


Figure 4.1: Location of GCPs of database version 1.1.0.

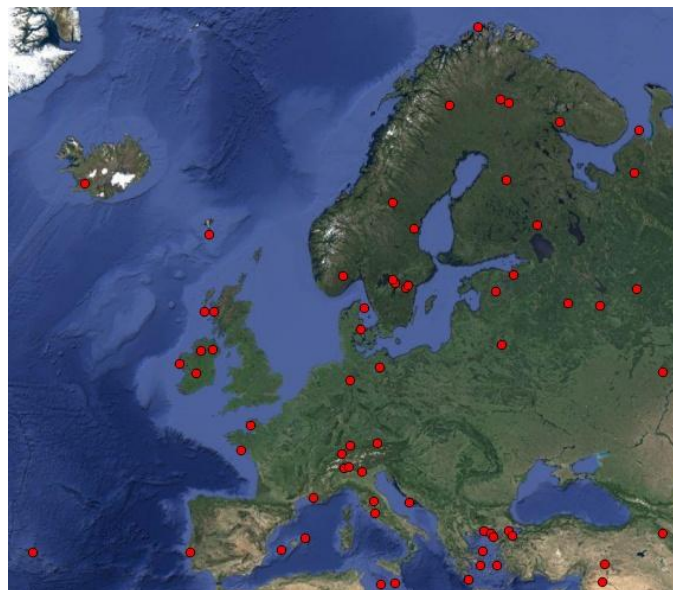


Figure 4.2: Location of GCPs in Europe of database version 1.1.0.

Table 4.1
List of GCPs, Version 1.1.0. ID, coordinates, name, country, continent and type.

ID	Longitude [deg]	Latitude [deg]	Name	Country	Continent	Type
N02935_E105754	105.754693	2.935630	Pulau Jemaja	Indonesia	Asia	island
N02999_E107777	107.777577	2.999953	Mida	Indonesia	Asia	island
N04270_E126770	126.770821	4.270967	Pulau Karakelong	Indonesia	Asia	island
N05845_E037549	37.549300	5.845779	Chamo Lake	Ethiopia	Africa	lake
N06244_W005109	-5.109859	6.244283	nn	Cote dlvoire	Africa	lake
N06245_E001438	1.438207	6.245455	Lac Togo	Togo	Africa	lake
N07471_W081746	-81.746776	7.471479	Isla de Coiba	Panama	North America	island
N07582_E081193	81.193834	7.582362	Maduru Oya Reservoir	Sri Lanka	Asia	lake
N09143_W073817	-73.817717	9.143491	Cienaga de Zapatosa	Colombia	South America	lake
N09742_E100031	100.031657	9.742086	Ko Pha Ngan	Thailand	Asia	island
N09987_E006918	6.918574	9.987914	Shiroro	Nigeria	Africa	lake
N10652_E124386	124.386538	10.652249	San Francisco Island	Philippines	Asia	island
N11463_E106328	106.328617	11.463065	Ho Dau Tieng	Viet Nam	Asia	lake
N13095_W010324	-10.324771	13.095076	Bamafele	Mali	Africa	lake
N14008_E121010	121.010929	14.008183	Lake Taal	Philippines	Asia	lake
N14709_E099077	99.077656	14.709506	Sinakharin	Thailand	Asia	lake
N14851_W024704	-24.704545	14.851848	Brava	Cape Verde	Africa	island
N16050_W015874	-15.874087	16.050969	Lac de Guiers	Senegal	Africa	lake
N16112_W022815	-22.815474	16.112000	Ilha da Boa Vista	Cape Verde	Africa	island
N16854_W024971	-24.971462	16.854582	Sao Vicente	Cape Verde	Africa	island
N17124_W093587	-93.587517	17.124402	Presa Nezahualcyotl	Mexico	North America	lake
N19324_E121455	121.455321	19.324245	Calayan Island	Philippines	Asia	island
N20462_W086875	-86.875728	20.462313	Cozumel	Mexico	North America	island
N24245_W109877	-109.877445	24.245220	Isla Ceralvo	Mexico	North America	island
N24457_E124204	124.204713	24.457257	Ishigaki	Philippines	Asia	island
N24500_E102883	102.883913	24.500965	Fuxian Hu	China	Asia	lake
N24794_E075526	75.526270	24.794826	Rana Pratap Sagar	India	Asia	lake
N24849_E102670	102.670162	24.849850	Dian Chi	China	Asia	lake
N25788_E100196	100.196660	25.788588	Er Hai	China	Asia	lake
N27748_W018005	-18.005294	27.748612	El Hierro	Spain	Africa	island
N27789_E128944	128.944089	27.789053	Tokunoshima	Japan	Asia	island
N28563_E090395	90.395931	28.563365	Puma Yumco	China	Asia	lake
N28675_W017857	-17.857552	28.675840	Isla de la Palma	Spain	Africa	island
N28889_E085581	85.581598	28.889560	Paiku Co	China	Asia	lake
N29035_W013631	-13.631557	29.035331	Lanzarote	Spain	Africa	island
N29056_W118291	-118.291795	29.056751	Isla de Guadalupe	Mexico	North America	island

ID	Longitude [deg]	Latitude [deg]	Name	Country	Continent	Type
N29271_E115326	115.326792	29.271971	Zhelin Shuiku	China	Asia	lake
N29311_W081615	-81.615098	29.311908	Lake George	United States	North America	lake
N30280_E086414	86.414282	30.280104	Xuru Co	China	Asia	lake
N30288_E032449	32.449572	30.288612	Great Bitter Lake	Egypt	Africa	lake
N30343_E130514	130.514930	30.343742	Yakushima	Japan	Asia	island
N30582_E130977	130.977630	30.582582	Tanegashima	Japan	Asia	island
N30668_E081491	81.491913	30.668931	Mapam Yumco	China	Asia	lake
N30688_E081219	81.219638	30.688307	Langa Co	China	Asia	lake
N30718_W095097	-95.097933	30.718278	Lake Livingston	United States	North America	lake
N31277_E083426	83.426211	31.277762	Rinqin Xubco	China	Asia	lake
N31510_E035489	35.489597	31.510699	Dead Sea	Jordan	Asia	lake
N31542_E083097	83.097161	31.542746	Ngangla Ringeo	China	Asia	lake
N31579_E117556	117.556825	31.579098	Chao Hu	China	Asia	lake
N31717_E088012	88.012678	31.717268	Urru Co	China	Asia	lake
N31815_W085107	-85.107807	31.815951	Walter F George Reservoir	United States	North America	lake
N31895_E087527	87.527701	31.895937	Dagze Co	China	Asia	lake
N31997_W096258	-96.258131	31.997827	Richland Chambers Reservoir	United States	North America	lake
N32028_E091484	91.484518	32.028056	Conag	China	Asia	lake
N32069_E090856	90.856412	32.069835	Zige Tangco	China	Asia	lake
N32804_E035588	35.588597	32.804802	Sea of Galilee	Israel	Asia	lake
N32909_W118491	-118.491173	32.909226	San Clemente Island	United States	North America	island
N32937_E118141	118.141642	32.937960	Nvshan River	China	Asia	lake
N33301_W115790	-115.790198	33.301534	Salton Sea	United States	North America	lake
N33312_W080052	-80.052487	33.312986	Lake Moultrie	United States	North America	lake
N33398_W118457	-118.457237	33.398004	Santa Catalina Island	United States	North America	island
N33399_E089824	89.824769	33.399853	Dorsoidong Co	China	Asia	lake
N33449_E090233	90.233943	33.449810	Chibzhang Co	China	Asia	lake
N33473_W080262	-80.262657	33.473946	Lake Marion	United States	North America	lake
N34310_E042259	42.259104	34.310232	Hadithah Dam Lake	Iraq	Asia	lake
N34391_E129333	129.333246	34.391398	Tsushima	Japan	Asia	island
N34827_E090429	90.429534	34.827968	Ulan Ul Hu	China	Asia	lake
N34900_E097696	97.696231	34.900330	Ngoring Hu	China	Asia	lake
N35030_E081086	81.086410	35.030592	Gozha Co	China	Asia	lake
N35751_E090199	90.199499	35.751697	Lixioidain Co	China	Asia	lake
N35864_E012866	12.866998	35.864761	Linosa	Italy	Europe	island
N35899_E014451	14.451296	35.899195	Malta	Malta	Europe	island
N36008_E038270	38.270378	36.008634	Al Assad	Syrian Arab Republic	Asia	lake

ID	Longitude [deg]	Latitude [deg]	Name	Country	Continent	Type
N36053_E140357	140.357611	36.053789	Kasumiga Ura	Japan	Asia	lake
N36244_E022983	22.983323	36.244441	Potamos	Greece	Europe	island
N36351_E089400	89.400437	36.351073	Jingyu Nu	China	Asia	lake
N37144_E096930	96.930405	37.144928	Toson Hu	China	Asia	lake
N37501_E130857	130.857859	37.501922	Ulleungdo	Korea	Asia	island
N37600_E026159	26.159678	37.600671	Ikaria	Greece	Europe	island
N37614_E024328	24.328284	37.614591	Kea	Greece	Europe	island
N37635_E038640	38.640339	37.635942	Ataturk Barajt	Turkey	Asia	lake
N38696_W089276	-89.276757	38.696505	Carlyle Reservoir	United States	North America	lake
N38700_W118713	-118.713769	38.700367	Walker Lake	United States	North America	lake
N38721_W027194	-27.194508	38.721482	Terceira	Portugal	Europe	island
N38767_W009036	-9.036982	38.767962	Rio Tejo	Morocco	Africa	lake
N38859_E024550	24.550022	38.859377	Skiros	Greece	Europe	island
N38977_E001408	1.408779	38.977409	Ibiza	Spain	Europe	island
N39017_W122759	-122.759501	39.017532	Clear Lake	United States	North America	lake
N39023_E073396	73.396025	39.023440	Ozero Karakul	Tajikistan	Asia	lake
N39094_W120032	-120.032849	39.094696	Lake Tahoe	United States	North America	lake
N39139_E064085	64.085228	39.139809	Dengizkul	Uzbekistan	Asia	lake
N39971_E004095	4.095610	39.971942	Menorca	Spain	Europe	island
N40004_W119537	-119.537854	40.004821	Pyramid Lake	United States	North America	lake
N40161_E025857	25.857996	40.161356	Gokceada	Turkey	Asia	island
N40186_E027960	27.960897	40.186319	Kus Golu	Turkey	Asia	lake
N40404_E045271	45.271646	40.404759	Lake Sevana	Armenia	Asia	lake
N40451_E025574	25.574515	40.451331	Samothraki	Greece	Europe	island
N40626_E027626	27.626380	40.626747	Marmara	Turkey	Asia	island
N40633_E075287	75.287609	40.633050	Ozero Chatyr-kel	Kyrgyzstan	Asia	lake
N40678_E024666	24.666490	40.678388	Limenas	Greece	Europe	island
N41296_W070078	-70.078633	41.296952	Nantucket Island	United States	North America	island
N41782_E072860	72.860521	41.782832	Toktogul Suu Saktagychy	Kyrgyzstan	Asia	lake
N41837_E075161	75.161727	41.837417	Ozero Song-kel	Kyrgyzstan	Asia	lake
N41985_W111332	-111.332569	41.985390	Bear Lake	United States	North America	lake
N42123_E012229	12.229952	42.123248	Lago di Bracciano	Italy	Europe	lake
N43046_E016162	16.162668	43.046781	Otok Vis	Croatia	Europe	island
N43141_E012108	12.108325	43.141696	Lago Trasimeno	Italy	Europe	lake
N43209_W075953	-75.953874	43.209600	Oneida Lake	United States	North America	lake
N43304_E116645	116.645010	43.304316	Dalai Nur	China	Asia	lake
N43471_E005113	5.113626	43.471281	Etang de Barre	France	Europe	lake

ID	Longitude [deg]	Latitude [deg]	Name	Country	Continent	Type
N43508_E146134	146.134126	43.508825	nn	Russia	Asia	island
N44412_W110365	-110.365277	44.412294	Yellowstone Lake	United States	North America	lake
N44462_W079394	-79.394341	44.462631	Lake Simcoe	Canada	North America	lake
N44603_E081184	81.184594	44.603953	Sayram Hu	China	Asia	lake
N44694_W066793	-66.793945	44.694289	Grand Manan Island	Canada	North America	island
N45592_E099101	99.101241	45.592881	Boontsagaan Nuur	Mongolia	Asia	lake
N45644_E010694	10.694319	45.644966	Lago di Garda	Italy	Europe	lake
N45930_E008648	8.648282	45.930459	Lago Maggiore	Italy	Europe	lake
N45964_E009268	9.268012	45.964357	Lago di Como	Italy	Europe	lake
N46193_E061766	61.766831	46.193830	Ozero Kamyslybas	Kazakhstan	Asia	lake
N46216_W093626	-93.626444	46.216792	Mille Lacs Lake	United States	North America	lake
N46437_E081275	81.275582	46.437085	Qoshqarkol	Kazakhstan	Asia	lake
N46492_W122292	-122.292673	46.492403	Riffe Lake	United States	North America	lake
N46992_E008446	8.446785	46.992597	Vierwaldstaettersee	Switzerland	Europe	lake
N47163_W094417	-94.417038	47.163062	Leech Lake	United States	North America	lake
N47328_W003179	-3.179683	47.328434	Belle-ile	France	Europe	island
N47329_E152470	152.470954	47.329246	nn	Russia	Asia	island
N47434_W079533	-79.533967	47.434402	Lake Timiskaming	Canada	North America	lake
N47445_W061735	-61.735489	47.445976	Iles de la Madeleine	Greenland	North America	island
N47472_W094161	-94.161044	47.472607	Lake Winnibigoshish	United States	North America	lake
N47643_E009271	9.271697	47.643735	Bodensee	Switzerland	Europe	lake
N47741_W085779	-85.779449	47.741829	Michipicoten Island	Canada	North America	island
N47803_E117684	117.684669	47.803745	Buyr Nuur	Mongolia	Asia	lake
N47874_E012434	12.434333	47.874816	Chiemsee	Germany	Europe	lake
N48426_W080975	-80.975609	48.426053	Night Hawk Lake	Canada	North America	lake
N48593_W058949	-58.949538	48.593829	nn	Canada	North America	island
N48598_W116863	-116.863129	48.598899	Priest Lake	United States	North America	lake
N48633_W077067	-77.067883	48.633034	Lac Parent	Canada	North America	lake
N48695_W056873	-56.873723	48.695198	Red Indian Lake	Canada	North America	lake
N48757_E085803	85.803166	48.757161	Marqakl	Kazakhstan	Asia	lake
N48812_E154101	154.101869	48.812313	nn	Russia	Asia	island
N48906_W054737	-54.737492	48.906578	Gander Lake	Canada	North America	lake
N49208_W002136	-2.136424	49.208838	Jersey	Jersey	Europe	island
N49866_E075384	75.384076	49.866387	Qarasar Kli	Kazakhstan	Asia	lake

ID	Longitude [deg]	Latitude [deg]	Name	Country	Continent	Type
N49941_W078150	-78.150012	49.941649	Lac Grasset	Canada	North America	lake
N50099_W105973	-105.973785	50.099299	Old Wives Lake	Canada	North America	lake
N50145_E091004	91.004244	50.145889	Reg Nuur	Mongolia	Asia	lake
N50145_W071275	-71.275565	50.145525	Lake Peribonca	Canada	North America	lake
N50315_W080221	-80.221683	50.315175	Kesagami Lake	Canada	North America	lake
N50752_W055552	-55.552802	50.752634	Bell Island	Canada	North America	island
N51273_W099788	-99.788054	51.273110	Dauphin Lake	Canada	North America	lake
N51341_W124113	-124.113723	51.341671	Chilko Lake	Canada	North America	lake
N51677_W098424	-98.424741	51.677542	Lake St Martin	Canada	North America	lake
N51707_W070135	-70.135137	51.707261	Lake Plitipi	Canada	North America	lake
N51856_E058852	58.852911	51.856904	Irkilinskoye	Russia	Europe	lake
N51868_W067688	-67.688232	51.868384	Petit Lac Manicougan	Canada	North America	lake
N51909_W104039	-104.039319	51.909898	Little Quill Lake	Canada	North America	lake
N51997_W079460	-79.460924	51.997129	Charlton Island	Canada	North America	island
N52028_E136554	136.554131	52.028507	Ozero Chukchagirskoye	Russia	Asia	lake
N52037_W176084	-176.084148	52.037124	Great Sitkin Island	United States	North America	island
N52056_W131041	-131.041751	52.056719	Kunghit Island	Canada	North America	island
N52473_E009332	9.332665	52.473840	Steinhuder Meer	Germany	Europe	lake
N52557_W079602	-79.602409	52.557151	Weston	Canada	North America	island
N52704_E079774	79.774991	52.704053	Ozero Kuchukskoye	Russia	Asia	lake
N52864_E074126	74.126182	52.864208	Zhalauly Kli	Kazakhstan	Asia	lake
N52942_W101387	-101.387045	52.942798	Red Deer Lake	Canada	North America	lake
N52957_W008341	-8.341301	52.957680	Lough Derg	Ireland	Europe	lake
N53024_W114060	-114.060118	53.024138	Pigeon Lake	Canada	North America	lake
N53029_E045297	45.297037	53.029377	Surskoye	Russia	Europe	lake
N53120_W079854	-79.854542	53.120959	South Twin Island	Canada	North America	island
N53308_W080018	-80.018098	53.308489	North Twin Island	Canada	North America	island
N53318_E077985	77.985373	53.318182	Ozero Bolshoye Topolnoye	Russia	Asia	lake
N53396_W073986	-73.986135	53.396519	Lac de la Corvette	Canada	North America	lake
N53403_E012681	12.681863	53.403199	Mritz	Germany	Europe	lake
N53446_E139777	139.777046	53.446676	Ozero Orel	Russia	Asia	lake
N53460_E140098	140.098308	53.460782	Ozero Chlya	Russia	Asia	lake

<i>ID</i>	<i>Longitude [deg]</i>	<i>Latitude [deg]</i>	<i>Name</i>	<i>Country</i>	<i>Continent</i>	<i>Type</i>
N53496_W077907	-77.907931	53.496264	Lac Duncan	Canada	North America	lake
N53539_W114566	-114.566501	53.539845	Wabamun Lake	Canada	North America	lake
N53603_W064062	-64.062918	53.603021	Churchill River	Canada	North America	lake
N53622_W010218	-10.218795	53.622784	Inisbofin	Ireland	Europe	island
N53654_W115400	-115.400506	53.654463	Chip Lake	Canada	North America	lake
N53915_W084375	-84.375812	53.915274	Opinnagau Lake	Canada	North America	lake
N54102_W165066	-165.066437	54.102637	Tigalda Island	United States	North America	island
N54146_W092185	-92.185251	54.146569	Little Sachigo Lake	Canada	North America	lake
N54151_W092990	-92.990294	54.151408	Pierce Lake	Canada	North America	lake
N54213_W060761	-60.761014	54.213171	Nipishish Lake	Canada	North America	lake
N54225_W096779	-96.779595	54.225336	Molson Lake	Canada	North America	lake
N54314_W105694	-105.694527	54.314014	Montreal Lake	Canada	North America	lake
N54360_W102784	-102.784873	54.360293	Suggi Lake	Canada	North America	lake
N54434_W104097	-104.097970	54.434614	Big Sandy Lake	Canada	North America	lake
N54458_E137608	137.608997	54.458029	Proliv Lindgolma	Russia	Asia	island
N54466_W007796	-7.796485	54.466480	Lower Lough Erne	United Kingdom	Europe	lake
N54475_W099677	-99.677173	54.475242	Hargrave Lake	Canada	North America	lake
N54480_W108394	-108.394717	54.480830	Waterhen Lake	Canada	North America	lake
N54489_W105998	-105.998736	54.489877	Weyakwin Lake	Canada	North America	lake
N54505_W096670	-96.670859	54.505117	Lawford Lake	Canada	North America	lake
N54525_W110058	-110.058186	54.525490	Cold Lake	Canada	North America	lake
N54549_W061473	-61.473467	54.549146	Snegamook Lake	Canada	North America	lake
N54550_E078500	78.500143	54.550657	Ozero Uryum	Russia	Asia	lake
N54589_E078019	78.019228	54.589584	Ozero Malyve Chany	Russia	Asia	lake
N54606_W006408	-6.408609	54.606438	Lough Neagh	United Kingdom	Europe	lake
N54691_E167758	167.758782	54.691646	Medny Island	Russia	Asia	island
N54773_W078346	-78.346266	54.773035	Burton Lake	Canada	North America	lake
N54798_E160201	160.201640	54.798625	Ozero Kronotskoye	Russia	Asia	lake
N54813_W125193	-125.193092	54.813266	Trembleur Lake	Canada	North America	lake
N54858_E026766	26.766291	54.858372	Narac	Belarus	Europe	lake
N54889_W108124	-108.124338	54.889470	Keeley Lake	Canada	North America	lake

ID	Longitude [deg]	Latitude [deg]	Name	Country	Continent	Type
N54909_W162330	-162.330018	54.909892	Deer Island	United States	North America	island
N54914_W109765	-109.765395	54.914450	Primrose Lake	Canada	North America	lake
N54927_W131330	-131.330885	54.927014	Duke Island	United States	North America	island
N54938_W104407	-104.407607	54.938274	Wapawekka Lake	Canada	North America	lake
N54974_E078550	78.550790	54.974538	Ozero Sartlan	Russia	Asia	lake
N55395_E060374	60.374218	55.395838	Argazinskoye	Russia	Asia	lake
N55502_W110542	-110.542555	55.502486	Windfred Lake	Canada	North America	lake
N55835_W155641	-155.641870	55.835011	Chirikof Island	United States	North America	island
N55870_W115432	-115.432201	55.870259	Utikuma Lake	Canada	North America	lake
N55884_E010595	10.595512	55.884219	Samso	Denmark	Europe	island
N55888_W134264	-134.264478	55.888783	Coronation Island	United States	North America	island
N56145_W068230	-68.230007	56.145321	Lac Otelnuc	Canada	North America	lake
N56151_E161835	161.835939	56.151646	Ozero Azhabachye	Russia	Asia	lake
N56259_W067701	-67.701366	56.259325	Lac Romanet	Canada	North America	lake
N56331_W068612	-68.612982	56.331180	Lac Castignon	Canada	North America	lake
N56857_W079863	-79.863453	56.857608	Split Island	Canada	North America	island
N56992_W007458	-7.458772	56.992344	Barra	United Kingdom	Europe	island
N57003_W006342	-6.342137	57.003860	Isle of Rum	United Kingdom	Europe	island
N57270_E011030	11.030742	57.270349	Laeso	Denmark	Europe	island
N57351_E038024	38.024884	57.351425	Uglich Reservoir	Russia	Europe	lake
N57533_E070478	70.478075	57.533209	Ozero Bolshoy Uvat	Russia	Asia	lake
N57560_E034437	34.437635	57.560839	Vyshnevolotskoye	Russia	Europe	lake
N57689_W106723	-106.723788	57.689958	Weitzel Lake	Canada	North America	lake
N58254_E026047	26.047423	58.254748	Vortsjaerv	Estonia	Europe	lake
N58385_W105294	-105.294477	58.385021	Pasfield Lake	Canada	North America	lake
N58401_W111078	-111.078110	58.401112	Richardson Lake	Canada	North America	lake
N58408_E042297	42.297023	58.408307	Galichskoye Ozero	Russia	Europe	lake
N58502_E015732	15.732848	58.502523	Roxen	Sweden	Europe	lake
N58624_E015964	15.964672	58.624895	Glan	Sweden	Europe	lake
N58685_W160864	-160.864847	58.685257	Hagemeister Island	United States	North America	island
N58775_E014461	14.461021	58.775887	Unden	Sweden	Europe	lake
N58799_W097824	-97.824247	58.799970	Seal River	Canada	North America	lake
N58860_W108302	-108.302475	58.860818	Davy Lake	Canada	North America	lake

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N58916_E066908	66.908133	58.916678	Ozero Andreyevskoye	Russia	Asia	lake
N58961_W115404	-115.404427	58.961326	Margaret Lake	Canada	North America	lake
N58992_E014243	14.243800	58.992913	Skagem	Sweden	Europe	lake
N59070_E150640	150.640111	59.070798	Bukhta Rassvet	Russia	Asia	island
N59074_W130580	-130.580542	59.074135	Tuya Lake	Canada	North America	lake
N59078_W121143	-121.143755	59.078137	Kotcho Lake	Canada	North America	lake
N59166_W155287	-155.287216	59.166110	Kukaklek Lake	United States	North America	lake
N59168_W107168	-107.168914	59.168859	Richards Lake	Canada	North America	lake
N59172_E008494	8.494829	59.172730	Nisser	Norway	Europe	lake
N59225_W098533	-98.533322	59.225314	Monroe Lake	Canada	North America	lake
N59277_E028191	28.191035	59.277186	Narvskoye	Russia	Europe	lake
N59734_W118694	-118.694565	59.734161	Bistcho Lake	Canada	North America	lake
N59763_E067242	67.242268	59.763974	Ozero Yakh-Tur	Russia	Asia	lake
N59812_W080066	-80.066252	59.812709	Gilmour Island	Canada	North America	island
N59862_W043890	-43.890715	59.862790	Ostrov Zavyalova	Greenland	North America	island
N59871_W132937	-132.937779	59.871106	Gladys Lake	Canada	North America	lake
N61529_W006834	-6.834176	61.529711	Suduroy	Faroe Islands	Europe	island
N61839_E016700	16.700220	61.839920	Norra Dellen	Sweden	Europe	lake
N62014_E030907	30.907511	62.014498	Ozero Yanisyarvi	Russia	Europe	lake
N62342_W139822	-139.822856	62.342414	Wellesley Lake	Canada	North America	lake
N62624_E111240	111.240687	62.624044	Vilyuyskoye Vodokhranilishche	Russia	Asia	lake
N62660_W074279	-74.279525	62.660173	Charles Island	Canada	North America	island
N62749_E051933	51.933997	62.749063	Ozero Sindorskoye	Russia	Europe	lake
N63098_W142747	-142.747352	63.098886	Tetlin Lake	United States	North America	lake
N63220_E014205	14.205904	63.220318	Storsjoen	Sweden	Europe	lake
N63809_E085810	85.810966	63.809670	Ozero Nalimye	Russia	Asia	lake
N63885_W152242	-152.242178	63.885981	Lake Minchumina	United States	North America	lake
N63942_W123051	-123.051036	63.942783	Blackwater Lake	Canada	North America	lake
N63944_W121585	-121.585999	63.944134	Keller Lake	Canada	North America	lake
N63988_W077754	-77.754688	63.988603	Mill Island	Canada	North America	island
N64185_W021131	-21.131070	64.185799	Pingvallavatn	Iceland	Europe	lake
N64348_E027311	27.311022	64.348356	Oulujarvi	Finland	Europe	lake
N64596_W072111	-72.111026	64.596347	nn	Canada	North America	lake

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N64753_E041976	41.976202	64.753180	Ozero Teldozero	Russia	Europe	lake
N64874_W072989	-72.989389	64.874367	nn	Canada	North America	lake
N65282_E135781	135.781376	65.282866	Ozero Emanda	Russia	Asia	lake
N65497_E091248	91.248275	65.497280	Ozero Oneko	Russia	Asia	lake
N65599_W163202	-163.202298	65.599306	Imuruk Lake	United States	North America	lake
N65786_W169060	-169.060405	65.786392	Big Diomedes Island	Russia	Asia	island
N65899_W091203	-91.203362	65.899491	nn	Canada	North America	lake
N66725_E042562	42.562462	66.725502	nn	Russia	Europe	island
N66827_E085323	85.323807	66.827677	Ozero Makovskoye	Russia	Asia	lake
N67093_E033412	33.412894	67.093488	Ozero Tiksha	Russia	Europe	lake
N67364_W143831	-143.831687	67.364058	Vundik Lake	United States	North America	lake
N67474_W122507	-122.507575	67.474014	Horton Lake	Canada	North America	lake
N67492_E172077	172.077204	67.492957	Ozero Elgygytyn	Russia	Asia	lake
N67862_E020709	20.709236	67.862765	Tornetraesk	Sweden	Europe	lake
N67969_E027602	27.602071	67.969586	Lokan Tekojarvi	Finland	Europe	lake
N68081_E026610	26.610220	68.081602	Porttipahta Reservoir	Finland	Europe	lake
N68441_E102378	102.378849	68.441186	Ozero Essey	Russia	Asia	lake
N68500_W104736	-104.736345	68.500565	Melbourne Island	Canada	North America	island
N68709_W101928	-101.928586	68.709715	Jenny Lind Island	Canada	North America	island
N69261_E146665	146.665812	69.261785	Ozero Ozhogino	Russia	Asia	lake
N69578_W139126	-139.126592	69.578548	Herschel Island	Canada	North America	island
N70823_W087772	-87.772114	70.823282	nn	Canada	North America	lake
N70854_E160592	160.592027	70.854228	Krestovskiy	Russia	Asia	island
N71011_E024040	24.040397	71.011912	Rolvsoya	Norway	Europe	island
N73159_E076391	76.391311	73.159428	nn	Russia	Asia	island
N73858_E092083	92.083275	73.858540	Ozero Ayaturku	Russia	Asia	lake
N75873_W094590	-94.590038	75.873921	Baillie-Hamilton Island	Canada	North America	island
S00266_W090715	-90.715041	-0.266623	Santiago	Ecuador	South America	island
S00325_E100191	100.191102	-0.325058	Danau Maninjau	Indonesia	Asia	lake
S01133_E009478	9.478484	-1.133004	Lac Anengue	Gabon	Africa	lake
S01733_E018835	18.835289	-1.733660	Crique dObeke	Democratic Republic of the Congo	Africa	lake
S01862_E137894	137.894286	-1.862012	Danau Rombebai	Indonesia	Asia	lake
S01886_E030766	30.766261	-1.886231	Lac Ihema	Rwanda	Africa	lake
S02773_E121504	121.504689	-2.773350	Danau Towuti	Indonesia	Asia	lake
S04014_E131225	131.225873	-4.014508	Pulau Panjang	Indonesia	Asia	island

ID	Longitude [deg]	Latitude [deg]	Name	Country	Continent	Type
S04418_W076704	-76.704330	-4.418847	Lago Rimachi	Peru	South America	lake
S04651_E145963	145.963992	-4.651580	Kar Kar	Papua New Guinea	Asia	island
S05324_E147108	147.108042	-5.324407	Long Island	Papua New Guinea	Asia	island
S07944_W014363	-14.363360	-7.944881	Ascension	Saint Helena	Africa	island
S08266_E026490	26.490455	-8.266093	Lac Kisale	Democratic Republic of the Congo	Africa	lake
S08592_E151090	151.090035	-8.592497	Kiriwina	Papua New Guinea	Oceania	island
S08640_E026385	26.385515	-8.640206	Lac Upemba	Democratic Republic of the Congo	Africa	lake
S08746_E115537	115.537679	-8.746275	Nusa Penida	Indonesia	Asia	island
S08898_W038561	-38.561972	-8.898787	Rio Sao Francisco	Brazil	South America	lake
S08963_E013967	13.967316	-8.963628	nn	Angola	Africa	lake
S09624_W035780	-35.780250	-9.624139	Lagoa Mundau	Brazil	South America	lake
S09777_W138986	-138.986293	-9.777019	Hiva Oa	French Polynesia	Oceania	island
S10536_E121854	121.854914	-10.536799	Sawu	Indonesia	Asia	island
S11260_E166526	166.526864	-11.260572	Utupua	Solomon Islands	Oceania	island
S12905_W065526	-65.526016	-12.905214	Laguna Ragaguado	Bolivia	South America	lake
S13023_W065937	-65.937096	-13.023771	Laguna Huaitunas	Bolivia	South America	lake
S13313_E048268	48.268047	-13.313391	Nosy Be	Madagascar	Africa	island
S14636_E035253	35.253178	-14.636882	Lake Malombe	Malawi	Africa	lake
S15714_E137007	137.007728	-15.714177	Vanderlin Island	Australia	Australia	island
S15726_W070740	-70.740609	-15.726360	Laguna Lagunillas	Peru	South America	lake
S15748_E025923	25.923612	-15.748398	Itezhi Tezhi Dam	Zambia	Africa	lake
S16165_E045842	45.842380	-16.165690	Kinkony	Madagascar	Africa	lake
S19051_E178227	178.227974	-19.051410	Kadavu Island	Vanuatu	Oceania	island
S20046_E163970	163.970718	-20.046764	Ile Baaba	New Caledonia	Oceania	island
S20197_E031009	31.009050	-20.197120	Lake Mutirikwi	Zimbabwe	Africa	lake
S20267_E057585	57.585871	-20.267883	Mauritius	Mauritius	Africa	island
S21948_E043679	43.679793	-21.948424	Lake Ihotry	Madagascar	Africa	lake
S22020_W041337	-41.337818	-22.020516	Lagoa Feia	Brazil	South America	lake
S25922_W057436	-57.436958	-25.922602	Lago Ypoa	Paraguay	South America	lake
S27129_W109350	-109.350485	-27.129252	Easter Island	Chile	Oceania	island
S28886_W053148	-53.148763	-28.886476	Rio Jacui	Brazil	South America	lake
S30629_E025725	25.725258	-30.629376	Gariep Dam	South Africa	Africa	lake

ID	Longitude [deg]	Latitude [deg]	Name	Country	Continent	Type
S33082_W057190	-57.190836	-33.082028	Embalse de Rincon de Baygorria	Uruguay	South America	lake
S33766_W080795	-80.795674	-33.766360	Selkirk	Chile	South America	island
S34337_W062281	-62.281923	-34.337118	nn	Argentina	South America	lake
S36195_E175410	175.410952	-36.195750	Great Barrier Island	New Zealand	Oceania	island
S37123_W062852	-62.852004	-37.123040	Lago Epecuen	Argentina	South America	lake
S38572_W068754	-68.754935	-38.572289	Embalse Los Barreales	Argentina	South America	lake
S38792_E175888	175.888947	-38.792629	Lake Taupo	New Zealand	Oceania	lake
S39259_W072090	-72.090494	-39.259123	Lago Villarrica	Chile	South America	lake
S40233_W072375	-72.375581	-40.233498	Lago Ranco	Chile	South America	lake
S40672_W072450	-72.450228	-40.672362	Lago Puyehue	Chile	South America	lake
S40844_W072432	-72.432575	-40.844772	Lago Rupanco	Chile	South America	lake
S42615_E171453	171.453989	-42.615984	Lake Brunner	New Zealand	Oceania	lake
S43299_W072301	-72.301082	-43.299291	Lago Yelcho	Chile	South America	lake
S44849_W075117	-75.117588	-44.849814	Isla Guambelin	Chile	South America	island
S47093_W074364	-74.364334	-47.093236	Isla Javier	Chile	South America	island
S47264_W072142	-72.142803	-47.264732	Lago Pueyrredon	Chile	South America	lake
S48433_W071192	-71.192612	-48.433477	Lago Strobel	Argentina	South America	lake
S48912_W071229	-71.229352	-48.912213	Lago Cardiel	Argentina	South America	lake
S51215_W072757	-72.757614	-51.215921	Lago del Toro	Chile	South America	lake
S51861_W060997	-60.997487	-51.861548	Weddell Island	Falkland Islands	South America	island
S52027_W072469	-72.469698	-52.027739	Lago Anibal Pinto	Chile	South America	lake
S54079_W069050	-69.050180	-54.079542	Lago Blanco	Chile	South America	lake
S55853_W067688	-67.688656	-55.853712	Isla Hermite	Trinidad and Tobago	North America	island

5. REFERENCES

ESA 2013. Quick user guide of the LC_CCI SAR Water Bodies product. Version 27.July 2013. ESA Landcover CCI.

NASA, 2003. SRTM Water Body Data Product Specific Guidance. Version 2.0. 4pp.

Technical Note on adopted geolocation validation methods (GeoAcca Deliverable D04, 2014).

Wessel, P., and W. H. F. Smith, A Global Self-consistent, Hierarchical, High-resolution Shoreline Database, *J. Geophys. Res.*, 101, #B4, pp. 8741-8743, 1996.