

# The Glacial Geomorphology of the Altai and Western Sayan mountains, Central Asia - Supplementary material

## Data

All geographic data that was used as a basis for the mapping or as background data in the final map was downloaded from USGS' Earth Explorer platform ([www.usgs.earthexplorer.com](http://www.usgs.earthexplorer.com)) or the Global Land Ice Measurements from Space (GLIMS) website (<http://www.glims.org/RGI/andolph.html>) Table S1, S2, S3 and S4 summarize the data sets and their respective entities. The authors have also supplied the acquired glacial geomorphological data (as a series of shp- and kml files, Table S5) used in the production of the map.

*Table S1. Landsat 7 ETM+ imagery used in this study to map the glacial geomorphology of the Altai and Western Sayan mountains. All images were downloaded from USGS - Earth Explorer (2012-13). The images are originally fixed to the Universal Transverse Mercator (UTM) map projection and coordinate system and the World Geodetic System 1984 (WGS84) datum. All image bands have been individually resampled, using a nearest neighbour algorithm. WRS = World Reference System.*

Entity ID	WRS Path	WRS Row	Acquisition date	Satellite	Sensor
p139r026_7t20010823	139	026	2001-08-23	Landsat 7	ETM+
p139r028_7t20000905	139	028	2000-09-05	Landsat 7	ETM+
p140r023_7t19990708	140	023	1999-07-08	Landsat 7	ETM+
p140r024_7t20020716	140	024	2002-07-16	Landsat 7	ETM+
p140r027_7t20000827	140	027	2000-08-27	Landsat 7	ETM+

p140r028_7t20000827	140	028	2000-08-27	Landsat 7	ETM+
p141r023_7t19990917	141	023	1999-09-17	Landsat 7	ETM+
p141r024_7t20020808	141	024	2002-08-08	Landsat 7	ETM+
p141r026_7t20020808	141	026	2002-08-08	Landsat 7	ETM+
p141r027_7t20020808	141	027	2002-08-08	Landsat 7	ETM+
p141r028_7t20020808	141	028	2002-08-08	Landsat 7	ETM+
p142r023_7t20000910	142	023	2000-09-10	Landsat 7	ETM+
p142r024_7t20000910	142	024	2000-09-10	Landsat 7	ETM+
p142r025_7t20000910	142	025	2000-09-10	Landsat 7	ETM+
p142r026_7t20020714	142	026	2002-07-14	Landsat 7	ETM+
p142r027_7t20020714	142	027	2002-07-14	Landsat 7	ETM+
p143r024_7t20010904	143	024	2001-09-04	Landsat 7	ETM+
p143r025_7t20010904	143	025	2001-09-04	Landsat 7	ETM+
p143r026_7t20010904	143	026	2001-09-04	Landsat 7	ETM+
p143r027_7t19991017	143	027	1999-10-17	Landsat 7	ETM+
p144r024_7t20010927	144	024	2001-09-27	Landsat 7	ETM+
p144r025_7t20000722	144	025	2000-07-22	Landsat 7	ETM+
p144r026_7t20000807	144	026	2000-08-07	Landsat 7	ETM+
p145r024_7t20010817	145	024	2001-08-17	Landsat 7	ETM+
p145r025_7t20000627	145	025	2000-06-27	Landsat 7	ETM+
p145r026_7t20000627	145	026	2000-06-27	Landsat 7	ETM+
p146r025_7t20000906	146	025	2000-09-06	Landsat 7	ETM+

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*Table S2. The Shuttle radar topographic mission Water Body dataset (SWBD) was used as background data on the final map product. All SWDB datasets were downloaded from USGS - Earth Explorer (2012-13). The individual shp-files have a resolution of one arc second (approx. 30-meter). The SRTM Water Body Data files are a by-product of the data editing performed by the National Geospatial-Intelligence Agency (NGA) to produce the finished SRTM Digital Terrain Elevation Data Level 2 (DTED® 2) (Arendt et al., 2012).*

Entity ID	Acquisition date	Entity ID	Acquisition date
SWBDE082N49E	2000-02-01	SWBDE089N48E	2000-02-01
SWBDE082N50E	2000-02-01	SWBDE089N49E	2000-02-01
SWBDE083N48E	2000-02-01	SWBDE089N50E	2000-02-01
SWBDE083N49E	2000-02-01	SWBDE089N51E	2000-02-01
SWBDE083N50E	2000-02-01	SWBDE089N52E	2000-02-01
SWBDE083N51E	2000-02-01	SWBDE082N53E	2000-02-01
SWBDE084N48E	2000-02-01	SWBDE089N54E	2000-02-01
SWBDE084N49E	2000-02-01	SWBDE089N55E	2000-02-01
SWBDE084N50E	2000-02-01	SWBDE090N46E	2000-02-01
SWBDE084N51E	2000-02-01	SWBDE090N47E	2000-02-01
SWBDE084N52E	2000-02-01	SWBDE090N48E	2000-02-01
SWBDE085N48E	2000-02-01	SWBDE090N49E	2000-02-01
SWBDE085N49E	2000-02-01	SWBDE090N50E	2000-02-01
SWBDE085N50E	2000-02-01	SWBDE090N51E	2000-02-01
SWBDE085N51E	2000-02-01	SWBDE090N52E	2000-02-01
SWBDE085N52E	2000-02-01	SWBDE090N53E	2000-02-01
SWBDE086N47E	2000-02-01	SWBDE090N54E	2000-02-01

SWBDE086N48E	2000-02-01	SWBDE091N46E	2000-02-01
SWBDE086N49E	2000-02-01	SWBDE091N47E	2000-02-01
SWBDE086N51E	2000-02-01	SWBDE091N48E	2000-02-01
SWBDE086N52E	2000-02-01	SWBDE091N49E	2000-02-01
SWBDE086N53E	2000-02-01	SWBDE091N50E	2000-02-01
SWBDE086N54E	2000-02-01	SWBDE091N51E	2000-02-01
SWBDE086N55E	2000-02-01	SWBDE091N52E	2000-02-01
SWBDE086N56E	2000-02-01	SWBDE091N53E	2000-02-01
SWBDE087N47E	2000-02-01	SWBDE092N46E	2000-02-01
SWBDE087N48E	2000-02-01	SWBDE092N47E	2000-02-01
SWBDE087N49E	2000-02-01	SWBDE092N48E	2000-02-01
SWBDE087N50E	2000-02-01	SWBDE092N49E	2000-02-01
SWBDE087N51E	2000-02-01	SWBDE092N50E	2000-02-01
SWBDE087N52E	2000-02-01	SWBDE092N51E	2000-02-01
SWBDE087N53E	2000-02-01	SWBDE092N52E	2000-02-01
SWBDE087N54E	2000-02-01	SWBDE092N53E	2000-02-01
SWBDE087N55E	2000-02-01	SWBDE093N46E	2000-02-01
SWBDE087N56E	2000-02-01	SWBDE093N47E	2000-02-01
SWBDE088N46E	2000-02-01	SWBDE093N50E	2000-02-01
SWBDE088N47E	2000-02-01	SWBDE093N51E	2000-02-01
SWBDE088N48E	2000-02-01	SWBDE093N52E	2000-02-01
SWBDE088N49E	2000-02-01	SWBDE093N53E	2000-02-01
SWBDE088N50E	2000-02-01	SWBDE094N50E	2000-02-01

SWBDE088N51E	2000-02-01	SWBDE094N51E	2000-02-01
SWBDE088N52E	2000-02-01	SWBDE094N52E	2000-02-01
SWBDE088N53E	2000-02-01	SWBDE094N53E	2000-02-01
SWBDE088N54E	2000-02-01	SWBDE095N51E	2000-02-01
SWBDE088N55E	2000-02-01	SWBDE095N52E	2000-02-01
SWBDE089N46E	2000-02-01	SWBDE095N53E	2000-02-01
SWBDE089N47E	2000-02-01		

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*Table S3. The Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) Global Digital Elevation Model (AGDEM) was used to aid mapping of glacial geomorphology in the Altai and Western Sayan mountains and is also used as background data on the final map product. All AGDEM datasets were downloaded from USGS - Earth Explorer (2012-13). The AGDEM data is posted on a 1 arc-second (approximately 30 m at the equator) grid and referenced to the 1984 World Geodetic System (WGS84)/ 1996 Earth Gravitational Model (EGM96) geoid. The U.S. National Aeronautics and Space Administration (NASA) and Japan's Ministry of Economy, Trade, and Industry (METI) developed the AGDEM data jointly. A single-scene (60 x 60 km) digital elevation model (DEM) has a vertical (RMSE) accuracy generally between 10- and 25 m (Arendt et al., 2012).*

Entity ID	Acquisition date	Entity ID	Acquisition date
ASTGDEM2_0N46E087	2011-10-17	ASTGDEM2_0N50E089	2011-10-17
ASTGDEM2_0N46E088	2011-10-17	ASTGDEM2_0N50E090	2011-10-17
ASTGDEM2_0N46E089	2011-10-17	ASTGDEM2_0N50E091	2011-10-17
ASTGDEM2_0N46E090	2011-10-17	ASTGDEM2_0N50E092	2011-10-17
ASTGDEM2_0N46E091	2011-10-17	ASTGDEM2_0N50E093	2011-10-17
ASTGDEM2_0N46E092	2011-10-17	ASTGDEM2_0N50E094	2011-10-17

ASTGDEM2_0N46E093	2011-10-17	ASTGDEM2_0N50E095	2011-10-17
ASTGDEM2_0N46E094	2011-10-17	ASTGDEM2_0N51E083	2011-10-17
ASTGDEM2_0N46E095	2011-10-17	ASTGDEM2_0N51E084	2011-10-17
ASTGDEM2_0N47E085	2011-10-17	ASTGDEM2_0N51E085	2011-10-17
ASTGDEM2_0N47E086	2011-10-17	ASTGDEM2_0N51E086	2011-10-17
ASTGDEM2_0N47E087	2011-10-17	ASTGDEM2_0N51E087	2011-10-17
ASTGDEM2_0N47E088	2011-10-17	ASTGDEM2_0N51E088	2011-10-17
ASTGDEM2_0N47E089	2011-10-17	ASTGDEM2_0N51E089	2011-10-17
ASTGDEM2_0N47E090	2011-10-17	ASTGDEM2_0N51E090	2011-10-17
ASTGDEM2_0N47E091	2011-10-17	ASTGDEM2_0N51E091	2011-10-17
ASTGDEM2_0N47E092	2011-10-17	ASTGDEM2_0N51E092	2011-10-17
ASTGDEM2_0N47E093	2011-10-17	ASTGDEM2_0N51E093	2011-10-17
ASTGDEM2_0N47E094	2011-10-17	ASTGDEM2_0N51E094	2011-10-17
ASTGDEM2_0N47E095	2011-10-17	ASTGDEM2_0N51E095	2011-10-17
ASTGDEM2_0N48E083	2011-10-17	ASTGDEM2_0N52E083	2011-10-17
ASTGDEM2_0N48E084	2011-10-17	ASTGDEM2_0N52E084	2011-10-17
ASTGDEM2_0N48E085	2011-10-17	ASTGDEM2_0N52E085	2011-10-17
ASTGDEM2_0N48E086	2011-10-17	ASTGDEM2_0N52E086	2011-10-17
ASTGDEM2_0N48E087	2011-10-17	ASTGDEM2_0N52E087	2011-10-17
ASTGDEM2_0N48E088	2011-10-17	ASTGDEM2_0N52E088	2011-10-17
ASTGDEM2_0N48E089	2011-10-17	ASTGDEM2_0N52E089	2011-10-17
ASTGDEM2_0N48E090	2011-10-17	ASTGDEM2_0N52E090	2011-10-17
ASTGDEM2_0N48E091	2011-10-17	ASTGDEM2_0N52E091	2011-10-17

ASTGDEM2_0N48E092	2011-10-17	ASTGDEM2_0N52E092	2011-10-17
ASTGDEM2_0N48E093	2011-10-17	ASTGDEM2_0N52E093	2011-10-17
ASTGDEM2_0N48E094	2011-10-17	ASTGDEM2_0N52E094	2011-10-17
ASTGDEM2_0N48E095	2011-10-17	ASTGDEM2_0N52E095	2011-10-17
ASTGDEM2_0N49E082	2011-10-17	ASTGDEM2_0N53E086	2011-10-17
ASTGDEM2_0N49E083	2011-10-17	ASTGDEM2_0N53E087	2011-10-17
ASTGDEM2_0N49E084	2011-10-17	ASTGDEM2_0N53E088	2011-10-17
ASTGDEM2_0N49E085	2011-10-17	ASTGDEM2_0N53E089	2011-10-17
ASTGDEM2_0N49E086	2011-10-17	ASTGDEM2_0N53E090	2011-10-17
ASTGDEM2_0N49E087	2011-10-17	ASTGDEM2_0N53E091	2011-10-17
ASTGDEM2_0N49E088	2011-10-17	ASTGDEM2_0N53E092	2011-10-17
ASTGDEM2_0N49E089	2011-10-17	ASTGDEM2_0N53E093	2011-10-17
ASTGDEM2_0N49E090	2011-10-17	ASTGDEM2_0N53E094	2011-10-17
ASTGDEM2_0N49E091	2011-10-17	ASTGDEM2_0N53E095	2011-10-17
ASTGDEM2_0N49E092	2011-10-17	ASTGDEM2_0N54E086	2011-10-17
ASTGDEM2_0N49E093	2011-10-17	ASTGDEM2_0N54E087	2011-10-17
ASTGDEM2_0N49E094	2011-10-17	ASTGDEM2_0N54E088	2011-10-17
ASTGDEM2_0N49E095	2011-10-17	ASTGDEM2_0N54E089	2011-10-17
ASTGDEM2_0N50E082	2011-10-17	ASTGDEM2_0N54E090	2011-10-17
ASTGDEM2_0N50E083	2011-10-17	ASTGDEM2_0N55E086	2011-10-17
ASTGDEM2_0N50E084	2011-10-17	ASTGDEM2_0N55E087	2011-10-17
ASTGDEM2_0N50E085	2011-10-17	ASTGDEM2_0N55E088	2011-10-17
ASTGDEM2_0N50E086	2011-10-17	ASTGDEM2_0N55E089	2011-10-17

ASTGDEM2_0N50E087	2011-10-17	ASTGDEM2_0N55E090	2011-10-17
ASTGDEM2_0N50E088	2011-10-17	ASTGDEM2_0N55E091	2011-10-17

*Table S4. The Randolph Glacier Inventory (RGI) is a globally complete inventory of glacier outlines (Arendt et al., 2012). It is supplemental to the Global Land Ice Measurements from Space initiative (GLIMS). This dataset was used as background data on the final map product.*

Entity ID	1st-	2nd-Order-	Name
	Order- Region	Region Code	
10_RGI30_NorthAsia	10	10-01	North Asia (North)
		10-02	North Asia (East)
		10-03	Chukotka
		10-04	Altay and Sayan
13_RGI30_CentralAsia	13	13-02	Hissar Alay
			Pamir (Safed Khirs/W
		13-03	Tarim)
		13-04	W Tien Shan
		13-05	E Tien Shan (Dzhungaria)
		13-06	W Kun Lun
		13-07	E Kun Lun (Altyn Tagh)
		13-08	Qilian Shan
		13-09	Inner Tibet
		13-10	S and E Tibet



*Table S5. Summary of datasets accompanying this paper. The data is compatible with ESRI ArcGIS and Google Earth©.*

Name	Extension	Type	Comment
altai_map_extent	dbf	polygon	Extent of map
altai_map_extent	prj	polygon	"
altai_map_extent	sbn	polygon	"
altai_map_extent	sbx	polygon	"
altai_map_extent	shp	polygon	"
altai_map_extent	shx	polygon	"
altai_marginal_moraine	dbf	polygon	Distribution of moraines
altai_marginal_moraine	prj	polygon	"
altai_marginal_moraine	sbn	polygon	"
altai_marginal_moraine	sbx	polygon	"
altai_marginal_moraine	shp	polygon	"
altai_marginal_moraine	shp.xml	polygon	"
altai_marginal_moraine	shx	polygon	"
			Distribution of glacial
altai_glacial_lineations	dbf	polyline	lineations
altai_glacial_lineations	prj	polyline	"
altai_glacial_lineations	sbn	polyline	"
altai_glacial_lineations	sbx	polyline	"

altai_glacial_lineations	shp	polyline	"
altai_glacial_lineations	shp.xml	polyline	"
altai_glacial_lineations	shx	polyline	"

#### Distribution of hummocky

altai_hummocky_terrain	dbf	polygon	terrain
altai_hummocky_terrain	prj	polygon	"
altai_hummocky_terrain	sbn	polygon	"
altai_hummocky_terrain	sbx	polygon	"
altai_hummocky_terrain	shp	polygon	"
altai_hummocky_terrain	shp.xml	polygon	"
altai_hummocky_terrain	shx	polygon	"

#### Distribution of glacial

altai_glacial_valley	dbf	polygon	valleys
altai_glacial_valley	prj	polygon	"
altai_glacial_valley	sbn	polygon	"
altai_glacial_valley	sbx	polygon	"
altai_glacial_valley	shp	polygon	"
altai_glacial_valley	shp.xml	polygon	"
altai_glacial_valley	shx	polygon	"

## References

Arendt, A., Bolch, T., Cogley, J.G., Gardner, A., Hagen, J.-O., Hock, R., Kaser, G.,  
Pfeffer, W.T., Moholdt, G., Paul, F., Radić, V., Andreassen, L., Bajracharya, S.,  
Barrand, N., Beedle, M., Berthier, E., Bhambri, R., Bliss, A., Brown, I., Burgess,  
D., Burgess, E., Cawkwell, F., Chinn, T., Copland, L., Davies, B., De Angelis, H.,  
Dolgova, E., Filbert, K., Forester, R.R., Fountain, A., Frey, H., Giffen, B.,  
Glasser, N., Gurney, S., Hagg, W., Hall, D., Haritashya, U.K., Hartmann, G.,  
Helm, C., Herreid, S., Howat, I., Kapustin, G., Khromova, T., Kienholz, C.,  
Köönig, M., Kohler, J., Kriegel, D., Kutuzov, S., Lavrentiev, I., Le Bris, R., Lund,  
J., Manley, W., Mayer, C., Miles, E., Li, X., Menounos, B., Mercer, A., Mölg, N.,  
Mool, P., Nosenko, G., Negrete, A., Nuth, C., Pettersson, R., Racoviteanu, A.,  
Ranzi, R., Rastner, P., Rau, F., Raup, B., Rich, J., Rott, H., Schneider, C.,  
Seliverstov, Y., Sharp, M., Sigurðsson, O., Stokes, C., Wheate, R., Winsvold, S.,  
Wolken, G., Wyatt, F., & Zheltyhina, N. (2012). Randolph Glacier Inventory – a  
dataset of global glacier outlines: Version 3.2. Global Land Ice Measurements  
from Space, Boulder Colorado, USA. Digital Media.