

Data DOI Task Force Report on “Present Status of Data Publication and Data Citation of Geomagnetic Data/Indices”

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Denmark (by Anna Willer (anna@space.dtu.dk))

Data Publication

DTU Space has minted a DOI for the definitive PCN index on July 5, 2019 ([doi:10.11581/DTU:00000057](https://doi.org/10.11581/DTU:00000057)). The metadata include for example the creator, the license for the index, the geolocation, abstract and subjects. DTU Space is planning to mint DOIs for quality-controlled data sets from magnetometer stations (variometer stations and observatories) in Greenland, Faroe Islands and Denmark.

France (by Vincent Lesur (lesur@ipgp.fr))

Data Publication

The “Bureau Central de Magnétisme terrestre” (BCMT) has mint a Digital Object Identifier (DOI) and set a licence (Creative Commons BY NC) for the definitive and variometer data it generates. One single DOI ([doi:10.18715/BCMT.MAG.DEF](https://doi.org/10.18715/BCMT.MAG.DEF)) has been set for all definitive data derived from the BCMT observatories where agreement of partner institutions contributing to the data collection has been granted. In the same way a single DOI has been set for variometer data ([doi:10.18715/BCMT.MAG.VAR](https://doi.org/10.18715/BCMT.MAG.VAR)). The landing page describing the involved observatories and giving access to the data is hosted by the data centre of the “Institut de Physique du Globe de Paris” (IPGP).

Germany (by Jürgen Matzka (jmat@gfz-potsdam.de))

Data Publication and Citation

In 2021, a DOI was given to the IAGA-endorsed Kp index provided as:

- Yearly files of definitive Kp , ap , Ap , Cp , $C9$ in WDC format.
- Yearly files of nowcast Kp , ap , Ap , Cp , $C9$ in WDC format.
- Yearly ASCII tables of quiet and disturbed days since 1932.

In this context, a comprehensive description of the Kp index was published in the AGU journal Space Weather (Matzka et al., 2021).

A new, Kp -like but opened ended index, the Hpo index, was developed and also published with a DOI, which includes the Hpo and apo indices in versions of 30 and 60 minutes time resolution.

All these indices grow in time and are monthly updated in the DOI archive. Most recent access to the data files is provided via the usual links at GFZ.

Name of Database	Aurhor of Database	Data DOI	Article DOI Citing Data DOI	Author
Geomagnetic Kp index	Matzka, et al. [2021]	10.5880/Kp.0001	10.1029/2020sw002641	Matzka et al. [2021, Space Weather]
Geomagnetic Hpo index. V. 1.0.	Matzka et al. [2021]	10.5880/Hpo.0001		

At GFZ, DOIs are also assigned to clearly defined datasets that are used in a specific publication. Support through data curation experts and software tools from GFZ Data Services allow the scientists to get DOIs and publish their data in a very easy way. Here are examples of such data publications for 2018.

Name of Database	Aurhor of Database	Data DOI	Article DOI Citing Data DOI	Author
Preliminary minute means Geomagnetic Observatory Tatuoca (TTB), 2008 to 2017	Soares, et al. [2018]	10.5880/GFZ.2.3.2018.005	10.1029/2018JA025968	Soares et al. [2018, J. Geophys. Res.]
Preliminary minute mean values of geomagnetic observatory Villa Remedios, Bolivia, for January 2013	Matzka et al. [2018]	10.5880/GFZ.2.3.2018.001	10.1029/2017JA025165	Yamazaki et al. [2018, J. Geophys. Res.]
Hourly mean values of the horizontal component at the geomagnetic observatory Huancayo (HUA), 1958 to 2013	Matzka et al. [2018]	10.5880/GFZ.2.3.2018.003	10.1029/2018GL077510	Siddiqui et al. 2018, J. Geophys. Res.]
Preliminary minute mean values of geomagnetic observatory Villa Remedios, Bolivia, August 2010	Matzka et al. [2018]	10.5880/GFZ.2.3.2018.004	10.1029/2018JA025365	Yamazaki et al. [2018, J. Geophys. Res.]

We have plans to give a DOI for GFZ Observatory data. This would be very rewarding, but it is a bit more complex, since data sets are growing and potentially the data has to be changed in the future if errors are detected and new versions of the DOI are required.

Intermagnet (by Simon Flower (smf@bgs.ac.uk) and Kirsten Elger (kelger@gfz-potsdam.de))

Data Publication

Since the previous report, Intermagnet has published a further 4 DOIs, bringing the total created to 5:

Title of Dataset	DOI
Global magnetic observatory data 2013	doi:10.5880/INTERMAGNET.2013
Global magnetic observatory data 2014	doi:10.5880/INTERMAGNET.2014
Global magnetic observatory data 1991 - 2015	doi:10.5880/INTERMAGNET.1991.2015

Intermagnet Reference Data Set (IRDS) 2016 – Definitive Magnetic Observatory Data	doi:10.5880/INTERMAGNET.1991.2016
Intermagnet Reference Data Set (IRDS) 2017 – Definitive Magnetic Observatory Data	doi:10.5880/INTERMAGNET.1991.2017

Intermagnet has published definitive geomagnetic data for its network of observatory members since 1991. The original publications were on CD-ROM, followed by DVD and latterly USB stick. The publication of data for the year 2013 was the first for which Intermagnet created a DOI. The DOIs for the 2013 and 2014 data sets contain a single year of data for the entire network and contain identical copies of the physical publications. The publication for 2015 data was special in two ways, being the last data set to be published on a physical medium, and the first year in which the entire definitive data set was published, for all 25 years (1991 to 2015) from all observatories. Subsequent data sets in 2016 and 2017 are published only online with DOIs. They also contain the entire data set, from 1991, updated with a new year of data each year. Each new DOI also includes any corrections that Intermagnet members have made to their data from previous years. From 2016 onwards this data set has been named the “Intermagnet Reference Data Set”.

All data associated with each DOI is available for download from the DOI’s landing page. A convention for naming individual versions of annual data within the data set has been introduced which uses both the year in which the data was recorded as well as the year in which this version is published. This ensures that corrections can be made to previously published data from an observatory when a new DOI is published, but that the data from previous DOI publications will not be altered.

The DOI landing pages and data are hosted at GFZ. INTERMAGNET gratefully acknowledges the work of GFZ Data Services to publish these DOIs.

World Data Centre, Edinburgh (by Simon Flower (smf@bgs.ac.uk))

Data Publication

The World Data Centre, Edinburgh, are not currently creating any DOIs, but have applied for Core Trust Seal (<https://www.coretrustseal.org>) certification for the data centre. As part of this application the WDC has made a commitment to investigate the use of persistent identifiers for data held at the data centre. This is a more complex problem than the Intermagnet use of DOIs, since Intermagnet has a periodic publication process for definitive data, whereas the WDC adds data into its database as it is received, so the issue of repeatability of the overall data set arises.

Japan (by Masahito Nosé (nose.masahito@isee.nagoya-u.ac.jp) and Seiki Asari (asari@kakioka-jma.go.jp))

Data Publication

Recognizing the importance of data publication and data citation, solar-terrestrial physics (STP) data centers in Japan have been working to mint DOI to their data collections. We participated from October 2014 in a 1-year pilot program for DOI-minting to scientific data launched by Japan Link Center, which is one of the DOI registration agencies. In the pilot program, a procedure for the DOI-minting for STP data was established. As a result of the close collaboration with the Japan Link Center, the first case of data-DOI in Japan ([doi:10.17591/55838dbd6c0ad](https://doi.org/10.17591/55838dbd6c0ad)) was created in June 2015. As of August 2021, there are 19 data-DOIs for the STP data in Japan. Five out of these are DOIs for the geomagnetic indices and geomagnetic field data, as shown below.

Name of Database	DOI	Date of Minting
Dst Index	10.17593/14515-74000	2015/12/30
Wp index	10.17593/13437-46800	2016/08/10
Magnetotelluric Data at Muroto, Japan	10.17593/13882-05900	2017/02/14
AE index	10.17593/15031-54800	2017/08/20
Fluxgate magnetometer data at Inabu, Japan	10.48673/16281-75600	2021/08/06

Kakoika Magnetic Observatory (KMO) has recently been engaged in assigning DOIs to its original data that have been released on its official webpage. The DOI registration for KMO database is undertaken by Japan Link Center. By the end of August 2021, the sixteen DOIs in the table below will be minted to the datasets of the geoelectric and atmospheric electric observations, which were all finally terminated in February 2021. All the data contents of KMO will be given DOI in the near future, including magnetic data, historical data from analogue records, and data for magnetic phenomena. The DOIs registered for the KMO database will then increase to more than seventy.

Title of Dataset	DOI
Geoelectric data at Kakioka (1-hour)	doi:10.48682/129bd.2b000
Geoelectric data at Kakioka (1-minute)	doi:10.48682/129bd.3f000
Geoelectric data at Kakioka (1-second)	doi:10.48682/129bd.58000
Geoelectric data at Kakioka (0.1-second)	doi:10.48682/129bd.ed000
Geoelectric data at Memambetsu (1-hour)	doi:10.48682/129d7.2b000
Geoelectric data at Memambetsu (1-minute)	doi:10.48682/129d7.3f000
Geoelectric data at Memambetsu (1-second)	doi:10.48682/129d7.58000
Geoelectric data at Memambetsu (0.1-second)	doi:10.48682/129d7.ed000
Geoelectric data at Kanoya (1-hour)	doi:10.48682/129fd.2b000
Geoelectric data at Kanoya (1-minute)	doi:10.48682/129fd.3f000
Geoelectric data at Kanoya (1-second)	doi:10.48682/129fd.58000
Geoelectric data at Kanoya (0.1-second)	doi:10.48682/129fd.ed000
Atmospheric electric data at Kakioka (1-hour)	doi:10.48682/1f5bd.2b000
Atmospheric electric data at Kakioka (1-minute)	doi:10.48682/1f5bd.3f000
Atmospheric electric data at Memambetsu (1-hour)	doi:10.48682/1f5d7.2b000
Atmospheric electric data at Memambetsu (1-minute)	doi:10.48682/1f5d7.3f000

Data Citation

Data citation becomes gradually popular in these years. According to the analysis results of “Web of Science”, the Dst index and the AE index are cited 20–30 times in international journal articles (as of August 15, 2021).

(Left) Citation report of the Dst index (doi:10.17593/14515-74000). (Right) Citation report of the AE index (10.17593/15031-54800).

Russia (by Anatoly Soloviev (a.soloviev@gcras.ru) and Michael Nisilevich (m.nisilevich@gcras.ru))

Data Publication

“Earth Science DataBase” (ESDB) project was initiated by the Geophysical Center RAS in 2014 on the basis of the World Data Center for Solar-Terrestrial Physics (WDC for STP), a regular member of ICSU-WDS. The focus is on creation of the modern system of geophysical data registration, publication and DOI assignment through the Crossref registration agency, used for unique identification of intellectual property. Since 2014, the following data sets have been registered in the ESDB system: database including 6 catalogues of Solar proton events over 1970-2008, database on historical recordings from 22 geomagnetic observatories in USSR/Russia over 1983-2009, database on continuous recordings from “Klimovskaya” geomagnetic observatory and “Saint-Petersburg” INTERMAGNET observatory since 2012, and seismotectonics map of Eastern Siberia. It also includes 26 individual data sets, including 2015 definitive data from INTERMAGNET observatory “Saint-Petersburg”.

Since August 2017, the following data sets have been registered in the ESDB system: 5 catalogues of solar proton events included in the database of Solar Proton Events (1970–2008) registered earlier in 2016, database of ULF wave power index (new geomagnetic index) and 17 data sets included in this database, database of virtual magnetograms 1994–2017, database and 2 data sets of solar flare events, database of magnetic storms and magnetic storm families 1908-2010 with 7 data sets, dataset of quality flag varies from 0 for doubtful to 2 for high quality events, uranium isotope composition of kimberlites, the enclosing and overburden deposits of the Zolotitskoye ore field, geomagnetic data recorded at geomagnetic observatory “White Sea” (IGA code: WSE), and seismic activity and syzygies data.

Each data set, catalogue and database is accompanied with individual response page, located in the central repository of ESDB: <http://esdb.gcras.ru/>. Russian-Ukrainian Geomagnetic Data Center (RUGDC) is also indexed in re3data (<http://www.re3data.org/>) with [doi:10.17616/R39344](https://doi.org/10.17616/R39344). World Data Center for Solar-Terrestrial Physics in Moscow (WDC for STP) is also indexed in re3data with [doi:10.17616/R3DC7Z](https://doi.org/10.17616/R3DC7Z).

For the time since 2017 several data sets registered with DOI have been cited, as well as the articles with DOI referring to data sets. In 2020–2021, we have added 2 datasets for the geomagnetic observatory Saint Petersburg (IAGA code: SPG) (10.2205/SPG2017 and 10.2205/SPG2017min-def) these are definitive minute data, which are time variations of the full values of geomagnetic field elements X (North), Y (East), Z (Down) and its total intensity F. We also have added 2 datasets for the geomagnetic observatory Gyulagarak (IAGA code: GLK) these are recorded geomagnetic data and minute values of time variations of the geomagnetic field.

Title of Database	DOI
Geomagnetic data recorded at Geomagnetic Observatory Vostok (VOS) – Variational Minute Values (1993-2000)	10.2205/Mag-VOS-minute-values
Geomagnetic data recorded at Geomagnetic Observatory Tixie Bay (TIK) – Variational Minute Values (1984-1998)	10.2205/Mag-TIK-minute-values
Geomagnetic data recorded at Geomagnetic Observatory Seykha (SEY) – Variational Minute Values (1988-1993)	10.2205/Mag-SEY-minute-values
Geomagnetic data recorded at Geomagnetic Observatory Sabetta (SBT) – Variational Minute Values (1987-1990)	10.2205/Mag-SBT-minute-values
Geomagnetic data recorded at Geomagnetic Observatory Salekhard (SAL) – Variational Minute Values (1987-1990)	10.2205/Mag-SAL-minute-values
Geomagnetic data recorded at Geomagnetic Observatory Moscow (MSK) – Variational Minute Values (1997-1999)	10.2205/Mag-MSK-minute-values
Geomagnetic data recorded at Geomagnetic Observatory Moscow (MOS) – Variational Minute Values (1985-2009)	10.2205/Mag-MOS-minute-values
Geomagnetic data recorded at Geomagnetic Observatory Mirny (MIR) – Variational Minute Values (1987-1998)	10.2205/Mag-MIR-minute-values
Geomagnetic data recorded at Geomagnetic Observatory Lovozero (LOZ) – Variational Minute Values (1997-2000)	10.2205/Mag-LOZ-minute-values
Geomagnetic data recorded at Geomagnetic Observatory Loparskaya (LOP) – Variational Minute Values (1993-1998)	10.2205/Mag-LOP-minute-values
Geomagnetic data recorded at Geomagnetic Observatory Komsomolskaya (KMS) – Variational Minute Values (1990)	10.2205/Mag-KMS-minute-values
Geomagnetic data recorded at Geomagnetic Observatory Kharasavey (KHS) – Variational Minute Values (1986)	10.2205/Mag-KHS-minute-values
Geomagnetic data recorded at Geomagnetic Observatory Yugorsky Shar (JSH) – Variational Minute Values (1983-1984)	10.2205/Mag-JSH-minute-values
Geomagnetic data recorded at Geomagnetic Observatory Irkutsk (IRT) – Variational Minute Values (1997-2003)	10.2205/Mag-IRT-minute-values
Geomagnetic data recorded at Geomagnetic Observatory Dixon Island (DIK) – Variational Minute Values (1983-1998)	10.2205/Mag-DIK-minute-values
Geomagnetic data recorded at Geomagnetic Observatory Cape Schmidt (CPS) – Variational Minute Values (1984-2000)	10.2205/Mag-CPS-minute-values
Geomagnetic data recorded at Geomagnetic Observatory Cape Kamenniy (CKA) – Variational Minute Values (1988-1998)	10.2205/Mag-CKA-minute-values
Geomagnetic data recorded at Geomagnetic Observatory Cape Chelyuskin (CCS) – Variational Minute Values (1997-1998)	10.2205/Mag-CCS-minute-values
Geomagnetic data recorded at Geomagnetic Observatory Beliy Island (BEY) – Variational Minute Values (1988-1990)	10.2205/Mag-BEY-minute-values
Geomagnetic data recorded at Geomagnetic Observatory Arti (ARS) – Variational Minute Values (1994-1996)	10.2205/Mag-ARS-minute-values
Geomagnetic data recorded at Geomagnetic Observatory Amderma (AMD) – Variational Minute Values (1984-1998)	10.2205/Mag-AMD-minute-values
Geomagnetic data recorded at Geomagnetic Observatory Heiss Island (HIS) – Variational Minute Values (1997-1998)	10.2205/Mag-HIS-minute-values
Geomagnetic data recorded at Geomagnetic Observatory Klimovskaya (IAGA code: KLI)	10.2205/KLI2011

Geomagnetic data recorded at Geomagnetic Observatory Saint Petersburg (IAGA code: SPG)	10.2205/SPG2012
Geomagnetic data recorded at Geomagnetic Observatory Saint Petersburg (SPG) - Minute Definitive Values (2015)	10.2205/SPG2015min-def
Seismotectonics map of Eastern Siberia	10.2205/ESDB-VONZ-125-map
Geomagnetic data recorded at Geomagnetic Observatory Klimovskaya (KLI) - Minute Values	10.2205/KLI2011min
Geomagnetic data recorded at Geomagnetic Observatory Saint Petersburg (SPG) - Minute Values (2012)	10.2205/SPG2012min
The Earth's Magnetic Field Variations Database (the Database of the Russian magnetic observatories for the variational minute values of E, H, Z elements of the Earth's magnetic field, 1983-2009)	10.2205/Mag-Variations-Database
Database of Solar Proton Events (1970–2008)	10.2205/ESDB-SAD-P
Catalog of Solar Proton Events in the 23rd Cycle of Solar Activity (1996–2008)	10.2205/ESDB-SAD-P-001
Catalog of Solar Proton Events in the 23rd Cycle of Solar Activity (1996–2008) (in Russian)	10.2205/ESDB-SAD-P-001-RU
Registered after August 2017	
Catalog of Solar Proton Events (1970-1979)	10.2205/ESDB-SAD-P-002
Catalog of Energy Spectra of Solar Proton Events (1970-1979)	10.2205/ESDB-SAD-P-003
Solar Proton Events Catalogue (1980-1986). Plots of the time profiles and energetic spectra of protons, ...	10.2205/ESDB-SAD-P-004
Solar Proton Events Catalogue (1980-1986). Data on particles and electromagnetic emissions.	10.2205/ESDB-SAD-P-005
Catalogue of Solar Proton Events (1987-1996)	10.2205/ESDB-SAD-P-006
Geomagnetic data recorded at Geomagnetic Observatory Saint Petersburg (SPG) - Minute Definitive Values (2016)	10.2205/SPG2016min-def
ULF wave index database	10.2205/ULF-index
ULF wave index 1991 dataset	10.2205/ULF-index-1991
ULF wave index 1992 dataset	10.2205/ULF-index-1992
ULF wave power index 1993 dataset	10.2205/ULF-index-1993
ULF wave power index 1994 dataset	10.2205/ULF-index-1994
ULF wave power index 1995 dataset	10.2205/ULF-index-1995
ULF wave power index 1996 dataset	10.2205/ULF-index-1996
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ULF wave power index 2004 dataset	10.2205/ULF-index-2004
ULF wave power index 2005 dataset	10.2205/ULF-index-2005
ULF wave power index 2006 dataset	10.2205/ULF-index-2006
ULF wave power index 2007 dataset	10.2205/ULF-index-2007
Dataset of quality flag varies from 0 for doubtful to 2 for high quality events	10.2205/RJES-data-646
Virtual Magnetograms Database	10.2205/vm-database

Database of Solar Flare Events	10.2205/ESDB-SAD-FE
Catalog of Solar Flare Events with X-ray Class M1 - X>17.5. XXIII cycle of Solar Activity (1996-2008)	10.2205/ESDB-SAD-FE-01
Preliminary Current Catalog of Solar Flare Events with X-ray Classes M1 - X>17.5. XXIV Cycle of Solar Activity (2009-2017)	10.2205/ESDB-SAD-FE-02
Database of Magnetic Storms and Magnetic Storm Families 1908-2010	10.2205/Mag-St
Combined Catalogue of Magnetic Storms for 1938-1948	10.2205/Mag-St-01
Combined Catalogue of Magnetic Storms for 1949-1958	10.2205/Mag-St-02
Catalogue of Magnetic Storm Families for the period of 1957-1964	10.2205/Mag-St-03
Catalogue of Geomagnetic Storm Families for the Period of 1965-1975 and Statistical Regularities of Geomagnetic Activity	10.2205/Mag-St-04
Catalogue of Magnetic Storms	10.2205/Mag-St-05
Magnetic Storms from the Observations in Irkutsk for 1908-1959	10.2205/Mag-St-06
Catalogue of Magnetic Storms of the Ulan-Bator Observatory for 1966-1984	10.2205/Mag-St-07
Uranium isotope composition of kimberlites, the enclosing and overburden deposits of the Zolotitskoye ore field	10.2205/RJES-data-622
Geomagnetic data recorded at Geomagnetic Observatory White Sea (IAGA code: WSE)	10.2205/WSE-database
Seismic Activity and Syzygies Data	10.2205/rjes-data-650
Geomagnetic data recorded at Geomagnetic Observatory Saint Petersburg (IAGA code: SPG)	10.2205/SPG2017
2017 definitive data from geomagnetic observatory Saint Petersburg (IAGA code: SPG): minute values of X, Y, Z components and total intensity F of the Earth's magnetic field	10.2205/SPG2017min-def
Geomagnetic data recorded at Geomagnetic Observatory Gyulagarak (IAGA code: GLK)	10.2205/GLK2020
Minute values of X, Y, Z components and total intensity F of the Earth's magnetic field from Geomagnetic Observatory Gyulagarak (IAGA code: GLK) (Dataset)	10.2205/GLK2020min

Data Citation

The table below shows which of the registered DOI data has been cited, as well as the DOI of the articles referring to them.

DOI	Citation
10.2205/kli2011	https://doi.org/10.2139/ssrn.1731828
10.2205/ESDB-SAD-P-001-RU	https://doi.org/10.1134/S0010952519010106
10.2205/ESDB-SAD-P	https://doi.org/10.1134/S0016793217060044
10.2205/SPG2012	https://doi.org/10.5194/gi-6-473-2017
10.2205/SPG2015min-def	https://doi.org/10.5194/gi-6-473-2017 ; https://doi.org/10.1186/s40623-018-0786-8
10.2205/SPG2012min	https://doi.org/10.5194/gi-6-473-2017
10.2205/RJES-data-646	https://doi.org/10.2205/2018ES000646
10.2205/RJES-data-622	https://doi.org/10.2205/2018ES000622
10.2205/RJES-data-650	https://doi.org/10.2205/2019ES000650
10.2205/ESDB-SAD-P-007	https://doi.org/10.1029/2021JA029572

United States (by Brian Meyer (brian.meyer@noaa.gov))

Data Publication

The National Centers for Environmental Information (NCEI) mints Digital Object Identifiers (DOI) for definitive data products, technical reports, and data collections. Since 2013, all products produced at NCEI for public consumption have an associated DOI. Since the previous report, NCEI geomagnetism team has released the World Magnetic Model (WMM) for the 2020-2025 time period. We have minted a DOI to represent the entire airborne magnetic and the marine trackline data holdings of NCEI. This is due to the nature of the data collection, where NCEI does not own these data, so it would be inappropriate for NCEI to mint survey level DOI, but we do control the distribution system. Collection level DOI were minted so that users are able to cite the source of these diverse source data.

Product/Database Title	DOI
EMAG2: A 2-arc min resolution Earth Magnetic Anomaly Grid compiled from satellite, airborne, and marine magnetic measurements	10.1029/2009GC002471
EMAG2: Earth Magnetic Anomaly Grid (2-arc-minute resolution) Version 3	10.7289/V5H70CVX
Enhanced Magnetic Model 2010	10.7289/V5HH6H0D
The Enhanced Magnetic Model 2015-2020	10.7289/V56971HV
The US/UK World Magnetic Model for 2015-2020	10.7289/V5TH8JNW
The US/UK World Magnetic Model for 2015-2020: Technical Report	10.7289/V5TB14V7
The US/UK World Magnetic Model for 2020-2025	10.25921/11v3-da71
The US/UK World Magnetic Model for 2020-2025: Technical Report	10.25923/ytk1-yx35
Out-of-Cycle Update of the US/UK World Magnetic Model for 2015-2020: Technical Note	10.25921/xhr3-0t19
Airborne Magnetic Trackline Database	10.7289/V5862DPB
Marine Trackline Geophysical Database	10.7289/V5CZ35DR