29 September 2020

Expert Team on Data Requirements for Climate Services (ET-DRC)

WMO Services Commission (Sercom)

Metadata needed for the DAYCLI message

The future DAYCLI message should contain the following daily variables, with all values for one month:

- Daily maximum temperature **TX**
- Daily minimum temperature **TN**
- Daily mean temperature **T**
- Total daily precipitation **RR**
- Depth of fresh snow **F_SNOW**
- Depth of total snow on the ground **T_SNOW**

Issues:

- **STANDARD TIME** : day and time should be based on UTC;
- **LOCATION** : Do we need lat, lon, and altitude as the CLIMAT message does not have such fields?
- **SNOW DEFINITION** : depth of fresh snow (0 13 012) and total snow depth (0 13 013) are instantaneous measurements and not an accumulation over a period of time; This has to be confirmed and definition of the parameters well specified;
- **CLIMATOLOGICAL DAY DEFINITION**, due to different worldwide climatological practices on daily values (e.g. max and min temperatures not over 24h period) the beginning and ending times for a period of time is required;
- **QUALITY CODE**, so far, there is no WMO standard to precise the quality of the data, but it is wise to let the DAYCLI having such possibility in the near future. One of the works of ET-DRC is also to prepare such quality information;
- **STATION QUALITY** : Siting Classification and Maintained Performance Classification
- **MONITORING** of the DAYCLI message : WIGOS Data Quality Monitoring System (WDQMS)
- **ASSISTING** : software, tutor, manual, training

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Definitions of the climatological day and date-time of snow measurements

For each station present in the DAYCLI message such information is needed:

Daily maximum temperature TX

- DAY that corresponds to the TIME of the beginning of the period of the climatological day for **TX** (previous/current/next day)
- TIME-Begin in UTC of the beginning of the period for the climatological day of the
- TIME-End in UTC of the end of the period for the climatological day of the TX

Daily minimum temperature TN

- DAY that corresponds to the TIME of the beginning of the period of the climatological day for **TN** (previous/current/next day)
- TIME-Begin in UTC of the beginning of the period for the climatological day of the TN
- TIME-End in UTC of the end of the period for the climatological day of the TN

For Daily average temperature T

- DAY that corresponds to the TIME of the beginning of the period of the climatological day for **T** (previous/current/next day)
- TIME-Begin in UTC of the beginning of the period for the climatological day of the T
- TIME-End in UTC of the end of the period for the climatological day of the T

For Total precipitation RR

- DAY that corresponds to the TIME of the beginning of the period of the climatological day for **RR** (previous/current/next day)
- TIME-Begin in UTC of the beginning of the period for the climatological day of the RR
- TIME-End in UTC of the end of the period for the climatological day of the RR

For Depth of fresh snowl F_SNOW

- Time of the measurements of F_SNOW

For Total snow depth T_SNOW

- Time of the measurements of T_SNOW

Variables values for each day of the month:

- Value of the Daily maximum temperature **TX**
- Time when occurs the Daily maximum temperature TX
- Quality of the TX (empty field)

- Value of the Daily minimum temperature **TN**
- Time when occurs the Daily minimum temperature TN
- Quality of the TN (empty field)

- Value of the Daily mean temperature **T**
- Quality of the T (empty field)

- Value of the Total daily precipitation **RR**
- Quality of the RR (empty field)

- Value of the Depth of new snowfall **F_SNOW**
- Quality of the F_SNOW (empty field)

- Value of the Depth of total snow on the ground **T_SNOW**
- Quality of the T_SNOW (empty field)

E.g. Météo-France for the PARIS station

Time zone : UTC+1

Local Time: UTC+2 / UTC+3 (Daylight Saving Time)

DAYCLI message	PARIS station	Comments
DAY (UTC) that corresponds of the TIME (UTC) of the beginning of the period of the climatological day for TX	0	From Day D at 06:01 to Day D+1 at 06:00
TIME-Begin in UTC of the beginning of the period for the climatological day of the TX (TIME-End = TIME-Begin + 24h)	06:01	
Time-End	06:00	
DAY (UTC) that corresponds of the TIME (UTC) of the beginning of the period of the climatological day for TN	-1	From Day D-1 at 18:01 to Day D at 18:00
TIME-Begin in UTC of the beginning of the period for the climatological day of the TN (TIME-End = TIME-Begin + 24h)	18:01	
TIME-End	18:00	
DAY (UTC) that corresponds of the TIME (UTC) of the beginning of the period of the climatological day for T	0	From Day D at 00:01 to Day D+1 at 00:00
TIME-Begin in UTC of the beginning of the period for the climatological day of the T (TIME-End = TIME-Begin + 24h)	00:01	
TIME-End	00:00	
DAY (UTC) that corresponds of the TIME (UTC) of the beginning of the period of the climatological day for RR	0	From Day D at 06:01 to Day D+1 at 06:00
TIME-Begin in UTC of the beginning of the period for the climatological day of the RR (TIME-End = TIME-Begin + 24h)	06:01	
TIME-End	06:00	

E.g. Météo-France for the Nouméa station (in New Caledonia)

Time zone : UTC+11

DAYCLI message	PARIS station	Comments
DAY (UTC) that corresponds of the TIME (UTC) of the beginning of the period of the climatological day for TX	0	From Day D at 18:01 UTC to Day D+1 at 18:00 UTC *(From Day D at 05:01 Time Zone to Day D+1 at 05:00 Time Zone)*
TIME-Begin in UTC of the beginning of the period for the climatological day of the TX (TIME-End = TIME-Begin + 24h)	18:01	
TIME-End	18:01	
DAY (UTC) that corresponds of the TIME (UTC) of the beginning of the period of the climatological day for TN	-1	From Day D-1 at 06:01 UTC to Day D at 06:00 UTC *(From Day D-1 at 17:01 Time Zone to Day D at 17:00 Time Zone)*
TIME-Begin in UTC of the beginning of the period for the climatological day of the TN (TIME-End = TIME-Begin + 24h)	06:01	
Time-End	06:00	
DAY (UTC) that corresponds of the TIME (UTC) of the beginning of the period of the climatological day for T	0	From Day D-1 at 13:01 UTC to Day D at 13:00 UTC *(From Day D-1 at 00:01 Time Zone to Day D at 00:00 Time Zone)*
TIME-Begin in UTC of the beginning of the period for the climatological day of the T (TIME-End = TIME-Begin + 24h)	13:01	
	13:00	
DAY (UTC) that corresponds of the TIME (UTC) of the beginning of the period of the climatological day for RR	0	From Day D at 18:01 UTC to Day D+1 at 18:00 UTC *(From Day D at 05:01 Time Zone to Day D+1 at 05:00 Time Zone)*
TIME-Begin in UTC of the beginning of the period for the climatological day of the RR (TIME-End = TIME-Begin + 24h)	18:01	
TIME-End	18:00	

Annexe 1: WMO Secretariat Proposition

Draft **requirement for new BUFR template 3 07 074** (for information; request will be channeled through SERCOM ET-DRC)

A trial phase for the monthly reporting of daily climate data (DAYCLI) has been started in January 2019 (cf. WMO of 30 July 2018, ref.: 20824/2018/CLW/CLPA/DMA/BUFR307074_1). BUFR template 3 07 074 has been published to facilitate the international exchange via GTS of DAYCLI messages. An assessment report of the trial phase has been published in May 2020. EC-72/INF. 4.2(1) is attached for reference.

The key benefit of DAYCLI messages emerges from its consistency with national climate records, thereby allowing for better comparability of regional and global climate data analyses and products with national climate analyses and products. The above assessment also confirmed different national climate observing and climate data management practices, which have been established historically in the absence of global coordination. The assessment, therefore, revealed the need to attach information on the hour of observation and the period of observation to each of the climate variables reported.

A new BUFR template is requested, which allows provision of additional metadata as per below schema:

Day (local time; need to reflect shifts in local time such as daylight-saving time)

Hour

Time period

Daily maximum temperature

Hour

Time period

Daily minimum temperature

Hour

Time period

Daily mean temperature

Hour

Time period

Total accumulated precipitation

Hour

Time period

Depth of fresh snow

Hour

Time period

Total snow depth

Annexe 2: Extension of the trial phase of the international exchange of the DAYCLI message

Extension of the trial phase of the international exchange of daily climate data with the aim of recommending its operational implementation in 2021

1. Background, history and reasoning for the reporting of daily climate observations

The development of the principal measure of the state of the climate – the global temperature record – has extensively depended on monthly CLIMAT data provided by National Meteorological and Hydrological Services (NMHSs). Over the last 20 years, there has been a growing demand for indices and measures of the climate that also consider extremes. For many extreme measures, monthly data are insufficient and there is a need for operationally exchanged daily climate data. This need is not just for timeliness, but principally for data that is compatible with long historical daily series developed and made available by NMHSs. Attempts have been made to use SYNOP data for this purpose (e.g. by the European Climate Assessment and Dataset (ECA&D)) but there are serious issues of incompatibility of SYNOP data with traditional methods of climate measurement within NMHSs. Daily summaries in SYNOP messages are based on measurements that occur between synoptic reporting times and often over a period of less than 24 hours. For instance, in Europe, minimum temperatures are recorded usually over the 18 to 06 UTC 12-hour period and maximum temperatures during the 06 to 18 UTC 12-hour period. Measured in this way, the true daily minimum and maximum temperatures may not be reported because they may have occurred outside those particular 12-hour periods. As a result, SYNOP reports have been shown to significantly underestimate extremes: minimum temperatures measured in this way may be higher than the true daily minimum temperature, and maximum temperatures reported may be lower than the true daily maximum temperature reported as 24-hour climate observation. Similar problems occur for precipitation. In other regions of the world, SYNOP reporting practices can differ, but problems remain.

The Commission for Basic Systems (CBS) Open Programme Area Group on Integrated Observing Systems (OPAG-IOS), Implementation/Coordination Team on Integrated Observing Systems (ICT-IOS), recommended in 2012 that daily climate observations be included in monthly CLIMAT reports as a means of addressing the gap in the quality of daily climate observations. The U.S. National Oceanic and Atmospheric Administration (NOAA) National Centers for Environmental Information (NCEI), in cooperation with WMO Inter-programme Expert Team on Data Representation Maintenance and Monitoring (IPET-DRMM) and NOAA National Centers for Environmental Prediction (NCEP), developed a BUFR template for transmission of daily climate observations in BUFR format. This template was approved by CBS for implementation in May 2015. It was subsequently tested in the United States, with the cooperation of the UK Met Office. A one-year trial phase for the monthly reporting of daily climate observations was accepted by delegates to the seventeenth session of the Commission for Climatology in April 2018 (see Recommendation 5 (CCl-17)). NOAA/NCEI, in cooperation with IPET-DRMM (taken over by the Inter-programme Expert Team on Codes Maintenance (IPET-CM) in 2016) and NOAA/NCEP, developed a BUFR template, 3 07 074 – Supplemental daily temperature and precipitation values, for daily climate observations in BUFR format, for monthly reporting. Please note that this does not replace the existing CLIMAT BUFR templates but offers complementary reporting of daily observations once per month.

BUFR template 3 07 074 enables NMHSs to provide 31 daily observations consistent with national climate databases for the following elements:

- Time of observation for temperature
- Daily maximum temperature
- Daily minimum temperature
- Daily mean temperature (if it differs from (Tmax+Tmin)/2)
- Time of observation for precipitation
- Total daily precipitation

- Depth of new snowfall
- Depth of total snow on the ground

It was suggested, for the trial phase, to report daily climate data from those observing stations that prepare the traditional CLIMAT report.

2. Trial phase for the monthly reporting of daily climate data: Assessment report of March 2020

Notes:

- *Key conclusions and recommendations of the assessment are highlighted in **bold.***
- *DAYCLI (daily climate data) is used as working title for the message exchanging daily climate data through GTS.*

2.1. Introduction

Members have been invited to participate, on a voluntary basis, in the trial phase for the monthly reporting of daily climate data via GTS (WMO letter of 30 July 2018, ref.: 20824/2018/CLW/CLPA/DMA/BUFR307074_1). This report provides an interim assessment of the trial phase, which started in February 2019 and lasted for one year.

2.2. Assessment of February 2019 to January 2020 trial phase

Following the above mentioned WMO call of July 2018, 20 Members expressed intent to participate in the trial phase (see table below). A quickly upcoming request from Members concerned the provision of software to encode the DAYCLI message. In response, NOAA/NCEI kindly provided – on a voluntary basis - access to its DAYCLI software demonstration package, noting that it will require some expertise on the part of the country using it, mainly to make some modifications specific to their input data formats.

In the course of the trial, several countries shared their observations and challenges of methodological and technical nature with the Secretariat:

<u>Methodological:</u>

The current BUFR sequence suggests that

- ‘Daily maximum temperature’, ‘Daily minimum temperature’ and ‘Daily average temperature’ refer to the same observational time period, and
- Measurements of ‘Total accumulated precipitation’, ‘Depth of fresh snow’ and ‘Total snow depth’ refer to the same observational time period.

National observing practices, however, observe different time periods for the above temperature variables, assigned to different days. Also, snow depth measurements do not typically represent a time period such as accumulated precipitation.

Note: When introducing the new BUFR template, it has been recommended to use it for those stations that submit CLIMAT messages already. According to ‘Handbook on CLIMAT and CLIMAT TEMP reporting’ (WMO/TD-No. 1188), daily maximum and minimum temperatures are defined to reflect the 0000-2359 local time period.

The challenge of nationally differing definitions of ‘climatological days’ is well known including the fact that there is no easy solution to overcome these methodological differences. The implementation of the exchange of daily climate data may trigger discussions about scenarios for future solutions. For the time being, however, **it is suggested to reflect the differing observing practices in a new BUFR template by introducing additional metadata information regarding variable-specific observing times and/or observing periods, where appropriate.**

<u>Technical (including organizational):</u>

- A majority of NMHSs reported difficulties in determining the correct GTS header including its area designator, and few reported on difficulties in registering the new message in the WMO publication *Weather Reporting* (WMO-No. 9) and updating WIS discovery metadata; these issues can normally be solved at NMHS level itself by contacting the NMHS's internal telecommunication team;
- Various Members requested the provision of encoding software as well as a technical guidance document such as the *Handbook on CLIMAT and CLIMAT TEMP reporting* (WMO/TD-No. 1188) (WMO 2009) including samples of correctly formatted DAYCLI messages. Some Members requested consideration of providing general BUFR training;
- Guidance has been requested for data quality control requirements as well as rules for sending corrections to DAYCLI messages via GTS including potentially attached time limits;
- NOAA/NCEI intends to collect the data submitted through DAYCLI and make them available and to integrate them eventually by adding these data specifically to their Global Historical Climatology Network (GHCN) datasets. It is not yet specified, however, how RCCs can access and efficiently use DAYCLI data in quasi real time mode. Moreover, QC/QA procedures at regional (RCC) level and relevant interactions with NOAA/NCEI have not been addressed so far;
- Members may wish to receive information on the use of their data submitted through DAYCLI.

It is suggested to explore ways to draft further WMO guidance on DAYCLI, which addresses the above observations and requests.

The below table shows that 20 Members submitted written intents to participate in the trial phase February 2019 - January 2020 (first column). In February 2020, a test done at NOAA/NCEP Central Operations (USA) revealed that data from only six Members have been received through GTS.

A technical analysis is needed to fully understand the situation and to outline a process ensuring that DAYCLI messages submitted by Members are available through WIS/GTS globally.

The following Members submitted interest and/or written intents to the Secretariat to participate in the trial

Argentina
Australia (will join later)
Brazil
Chile
Egypt
Estonia
France
Hong Kong, China
Indonesia
Ireland
Japan
Kazakhstan
Korea
Latvia
Mexico
Norway
Pakistan
Russian Federation
Spain
Switzerland

Benefits:

An analysis of recent data received at NOAA/NCEI compared to data in its GHCN-Daily dataset showed the benefit of the DAYCLI messages. For the stations received, in comparison to summary of the day observations previously collected in near real-time via FM12 SYNOP messages, the DAYCLI daily climate observations are able to fill in previously missing values for approximately thirty percent of the observations and update with more accurate measurements another thirty percent of the observations. These improvements highlight the value of the DAYCLI messages and the importance of expanding the list of participating countries so that the benefits can be extended across all regions in the global climate record.

3. Way forward

Aim at initiation of the DAYCLI pre-operational phase in 2021.

Before initiating the start of the pre-operational phase,

- Strive to implement a basic GTS monitoring process for the exchange of DAYCLI messages,
- Establish a repository of DAYCLI use cases to promote Member participation in the exchange of DAYCLI messages and to inform the need for and specifications of a new BUFR template for DAYCLI messages, and consider options to provide a user-friendly encoding tool including guidance for Members.

Annexe 3: First attempt for a BUFR Template

Reporting of daily climate data

Point of contact: Peer HECHLER, Scientific Officer, WMO Secretariat; wcdmp@wmo.int

Background, history and reasoning for the reporting of daily climate observations

The development of the principal measure of the state of the climate – the global temperature record – has extensively depended on monthly CLIMAT data provided by National Meteorological and Hydrological Services (NMHSs). Over the last 20 years, there has been a growing demand for indices and measures of the climate that also consider extremes (Jones et al., 2012). For many extreme measures, monthly data are insufficient and there is a need for operationally exchanged daily climate data. This need is not just for timeliness, but principally for data that is compatible with long historical daily series developed and made available by NMHSs.

Attempts have been made to use SYNOP data for this purpose (e.g. by the European Climate Assessment and Dataset (ECA&D)) but there are serious issues of incompatibility of SYNOP data with traditional methods of climate measurement within NMHSs (see van den Besselaar et al., 2012). Daily summaries in SYNOP messages are based on measurements that occur between synoptic reporting times and often over a period of less than 24 hours. For instance, in Europe, minimum temperatures are recorded usually over the 18 to 06 UTC 12-hour period and maximum temperatures during the 06 to 18 UTC 12-hour period. Measured in this way, the true daily minimum and maximum temperatures may not be reported because they may have occurred outside those particular 12-hour periods. As a result, SYNOP reports have been shown to significantly underestimate extremes: minimum temperatures measured in this way may be higher than the true daily minimum temperature, and maximum temperatures reported may be lower than the true daily maximum temperature reported as 24-hour climate observation. Similar problems occur for precipitation. In other regions of the world, SYNOP reporting practices can differ but problems remain.

The Commission for Basic Systems (CBS) Open Programme Area Group on Integrated Observing Systems (OPAG-IOS), Implementation/Coordination Team on Integrated Observing Systems (ICT-IOS), recommended in 2012 that daily climate observations be included in monthly CLIMAT reports as a means of addressing the gap in the quality of daily climate observations. The U.S. National Oceanic and Atmospheric Administration (NOAA) National Centers for Environmental Information (NCEI), in cooperation with WMO Inter-programme Expert Team on Data Representation Maintenance and Monitoring (IPET-DRMM) and NOAA National Centers for Environmental Prediction (NCEP), developed a BUFR template for transmission of daily climate observations in BUFR format. This template was approved by CBS for implementation in May 2015. It was subsequently tested in the United States, with the cooperation of the UK Met Office. A one-year trial phase for the monthly reporting of daily climate observations was accepted by delegates to the seventeenth session of the Commission for Climatology in April 2018 (see Recommendation 5 (CCl-17)).

Reporting daily climate observations: Technical solution

NOAA/NCEI, in cooperation with IPET-DRMM (taken over by the Inter-programme

Expert Team on Codes Maintenance (IPET-CM) in 2016) and NOAA/NCEP, developed a BUFR template,
3 07 074 – Supplemental daily temperature and precipitation values, for daily climate observations in BUFR format, for monthly reporting. **Please note that this does not replace the existing CLIMAT BUFR templates but offers complementary reporting of daily observations once per month.**

BUFR template 3 07 074 enables NMHSs to provide 31 daily observations consistent with national climate databases for the following elements:

- Time of observation for temperature
- Daily maximum temperature
- Daily minimum temperature
- Daily mean temperature (if it differs from (Tmax+Tmin)/2)
- Time of observation for precipitation
- Total daily precipitation
- Depth of new snowfall
- Depth of total snow on the ground

Each of these observations should be recorded at the observing time consistent with the climate reporting practices of the NMHS and should reflect conditions over the previous 24-hour period. The climate convention varies from country to country; each country should retain its traditional observing practice in reporting daily climate summaries.

For example, while in the U.S. the reporting time is local midnight, in Australia it is 9 a.m. local, and in Canada it is 06 UTC. These observations can be efficiently provided via daily CLIMAT reports or other methods specifically designed for climate purposes.

It is suggested, for the trial phase, to report daily climate data from those observing stations that prepare the traditional CLIMAT report.

The following sub-sections summarize relevant procedures.

Encoding in FM 94 BUFR

(a) The BUFR template 3 07 074 (section 3) for daily climate data is defined in the BUFR Table D as follows.

3 07 074 – Supplemental daily temperature and precipitation values for monthly climate report

3 01 001	WMO block and station numbers	
0 04 001	Year	
0 04 002	Month	
3 01 021	Latitude/longitude (high accuracy)	
0 07 030	Height of station ground above mean sea level	
0 07 032	Height of sensor above local ground (or deck of marine platform)	
1 12 000	Delayed replication of 12 descriptors	

0 31 001	Delayed descriptor replication factor	Set to the number of days in the particular month for which data are being reported
0 04 003	Day	
0 04 004	Hour	
0 04 024	Time period or displacement	Typically set to -24 to denote the time to period beginning 24 hours prior to and ending at the specified time
1 02 003	Replicate 2 descriptors 3 times	

0 08 023	First-order statistics	= 2 Daily maximum temperature, = 3 Daily minimum temperature, = 4 Daily average temperature
0 12 101	Temperature/air temperature	
0 08 023	First-order statistics	Set to missing (cancel)
0 04 004	Hour	
0 04 024	Time period or displacement	
0 13 060	Total accumulated precipitation	
0 13 012	Depth of fresh snow	
0 13 013	Total snow depth	

(b) Data category and sub-category (section 1) shall be specified.

Octet No. 11: Data category **000** = surface data – land

Octet No. 12: An international data sub-category for daily climate data will be adopted and Members will be notified through the World Weather Watch Operational Newsletter well in advance of the trial phase.

Global Telecommunication System abbreviated heading

A Global Telecommunication System (GTS) heading ($T_1T_2A_1A_2ii$) for daily climate data will be adopted and Members will be notified through the World Weather Watch Operational Newsletter well in advance of the trial phase.

A_2 will be a geographic designator indicating the area where the observing station is located.

Instructions for the proper application of the geographical area designator

(a) The designators specified in the following table should be used to the greatest extent possible to indicate the geographical area of the data contained within (the text of) the bulletin.

(b) Where the geographical area of the data does not correspond exactly to the designator, the designator for the area closest to that of the data may be used.

(c) If the table does not contain a suitable designator for the geographical area, an alphabetic designator which is not assigned in the table should be introduced and the WMO Secretariat should be notified.

Designator	*Geographical area*		*Designator*	*Geographical area*	
A	0° – 90°W	northern hemisphere	I	0° – 90°W	southern hemisphere
B	90°W –180°	northern hemisphere	J	90°W – 180°	southern hemisphere
C	180° – 90°E	northern hemisphere	K	180° – 90°E	southern hemisphere
D	90°E – 0°	northern hemisphere	L	90°E – 0°	southern hemisphere
E	0° – 90°W	tropical belt	N	Northern hemisphere	
F	90°W – 180°	tropical belt	S	Southern hemisphere	
G	180° – 90°E	tropical belt	T	45°W – 180°	northern hemisphere
H	90°E – 0°	tropical belt	X	Global area (area not definable)	

The international exchange of daily climate data in practice

(a) Notification to the WMO Secretariat

In accordance with the regulations on the responsibility of World Meteorological Centres (WMCs) and Regional Telecommunication Hubs (RTHs) (see the *Manual on the Global Telecommunication System* (WMO-No. 386), Part I, 2.1 (h), and Part II, 5.1) NMHSs make arrangements within their organization and consult with their responsible RTH, which shall notify the WMO Secretariat of the change to *Weather Reporting* (WMO-No. 9), Volume C1, at least two months in advance of the effective date of the change.

NMHSs update and make their WMO Information System (WIS) discovery metadata available to their responsible WIS centre (see the *Technical Regulations* (WMO-No. 49), Volume I, Part II, 1.2.8).

(b) METNO message

The WMO Secretariat will issue a METNO message (see the *Manual on the Global Telecommunication System* (WMO-No. 386), Part II, 5.2) to notify other NMHSs of the change.

References

Jones, P.D., Lister, D.H., Osborn, T.J., Harpham, C., Salmon, M., Morice, C.P., 2012: Hemispheric and large-scale land-surface air temperature variations: An extensive revision and an update to 2010. *Journal of Geophysical Research*, 117, D05127, doi:10.1029/2011JD017139.

Van den Besselaar, E.J.M., Klein Tank, A.M.G, van der Schrier, G. and Jones, P.D., 2012: Synoptic messages to extend climate data records. *Journal of Geophysical Research*, 117, D07101, doi:10.1029/2011JD1688.