Bulletin of Glacier Research 11 (1993) *17－22*

Large temperature variations in winter around Svalbard

Hiroyuki ENOMOTO[1], Shuhei TAKAHASHI[1], Shun'ichi KOBAYASHI[2], Kumiko GOTO-AZUMA[3] and Okitsugu WATANABE[4]

1 Kitami Institute of Technology 165 Koen-cho, Kitami 090 Japan

2 Research Institute of Hazards in Snowy Areas, Niigata University, Niigata 950－21 Japan

3 Nagaoka Institute of Snow and Ice Studies, National Research Institute for Earth Science and Disaster Prevention, Science and Technology Agency, Suyoshi, Nagaoka 940 Japan

4 National Institute of Polar Research 9－10 Kaga 1-chome, Itabashi-ku, Tokyo 173 Japan

(Received December 22, 1992 ; Revised manuscript received March 15, 1993)

Abstract

An automatic weather station at Ny-Ålesund in Svalbard observed temperature above 0°C in January, 1992. A synoptic weather map shows that this high temperature was caused by advection of warm air from south over Svalbard. The past temperature data also indicate that remarkable warming sometimes occurs during winter in Svalbard. Such a warm spell is called "warm core". The duration and intensity of the warm core are considered to be important factors for the high variability in winter temperature in Svalbard.

1. Introduction

This study presents remarkable characteristics of seasonal changes of air temperature in Svalbard. Year-to-year fluctuations in winter temperature are great in Svalbard. This is considered to be due to its unique location at the edge of the sea ice area. Although there are many studies regarding the climate of the Arctic (Hanssen-Bauer et al., 1990), the drastic warming in midwinter is little understood. This report focuses on a remarkable increase of air temperature during winter in the Arctic.

2. Data

An automatic weather station (AWS) was established at the terminus of Brøgger Glacier near Ny-Ålesund in Svalbard, in April 1991. The meteorological data are stored at every hour and transferred to the research station of Japanese National Institute of Polar Research (NIPR), which is located in Ny-Ålesund. These data are further transferred to the Arctic Environmental Center in NIPR in Tokyo. This study uses this AWS data set and a world climate data set compiled by NCAR. A hemispheric weather chart produced by the Japanese Meteorological Agency was used for discussion.

3. Variability of Air Temperature

Figure 1 shows the meteorological data obtained by the AWS in winter 1991－92. As shown in the winter temperature of Fig. 1 (a), there were warm periods in December and January ; the temperature was sometimes above 0°C. They lasted about one month.

In order to investigate causes of the warming in 1992, Fig. 1 compares some meteorological conditions. Due to inversions of air temperature by radiative cooling, the air temperature in the Arctic lower troposphere is very low in winter. Those inversions are broken by windy or cloudy weather. The wind speed data in Fig. 1 show that December 1991 and January 1992 were stormy. The temperature rise can be seen corresponding to the peaks of strong wind. In contrast to January, it was calm and cold in February 1992. Changes in humidity are associated with the cloud amounts. There were high cloud amount in the

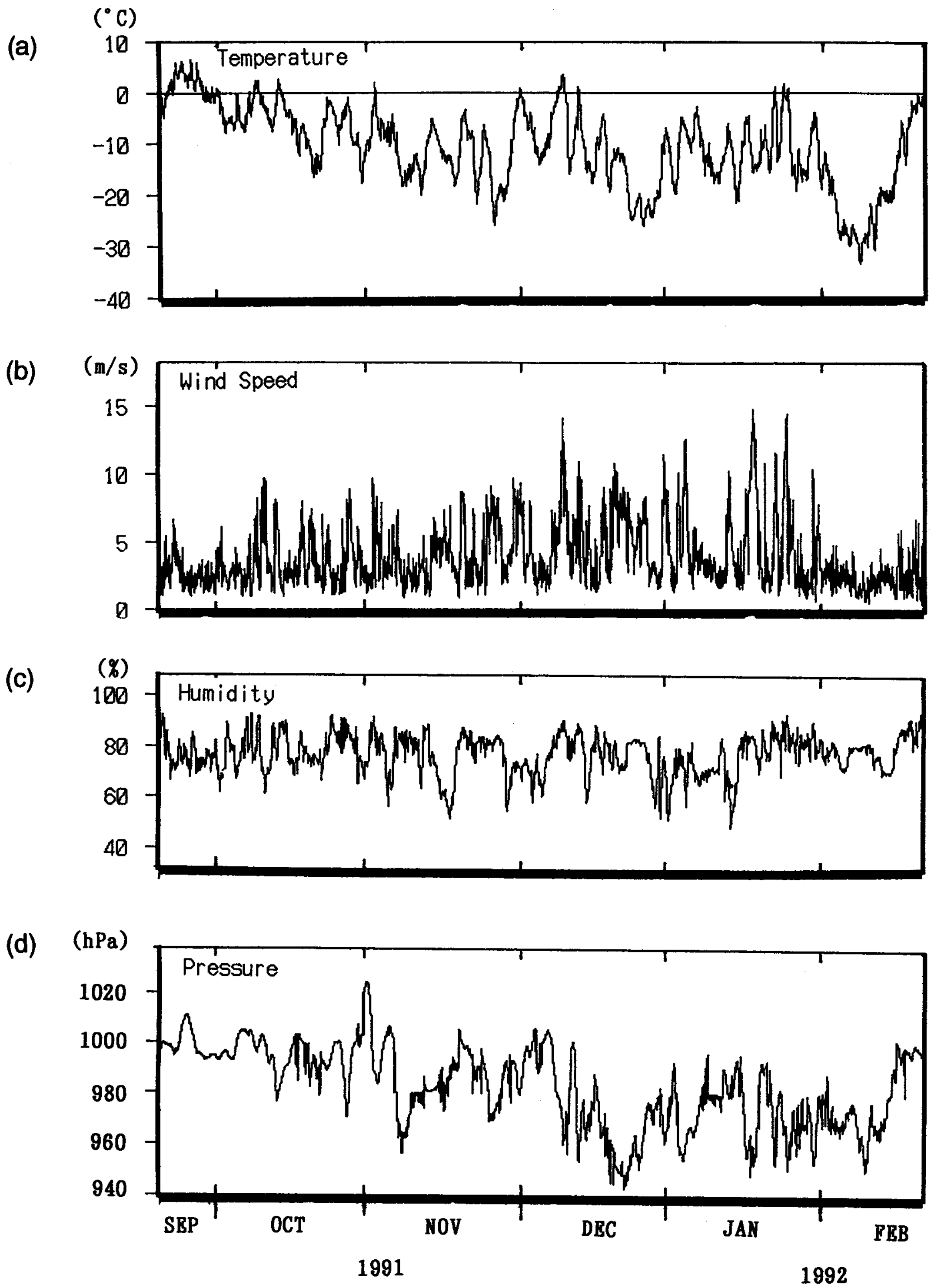

Fig. 1. Meteorological data obtained by AWS at Ny-Ålesund in Svalbard. (a) temperature, (b) wind speed, (c) humidity and (d) pressure. Temperature rises in stormy periods. Windy weather and cloud cover break the inversion of the lower troposphere.

middle of December and the end of January. The cloud cover reduces the radiative cooling and thus the atmospheric inversion. No clear correlation can be seen between temperature and atmospheric pressure.

In the case of the great warming around Alaska during the winter 1988/1989, a drastic increase of atmospheric pressure was observed. The adiabatic heating played an important role in that case (Tanaka and Milkovich, 1990, Colucci, 1985). For the warming around Svalbard in 1992, the advection of warmer air seems to have been important. Figure 2 shows the 5-day mean weather chart at 500 hPa in the Northern Hemisphere (Japan Meteorological Agency, 1992). A strong south wind is noticeable over Svalbard. The center of the polar vortex was located north of Hudson Bay and there was a large positive anomaly over Scandinavia. The zonal air flow was blocked by this high pressure area. The advection from the south brought warm air. It could break the inversion in the lower troposphere.

4. Warm Core

A remarkable characteristic of air temperature in

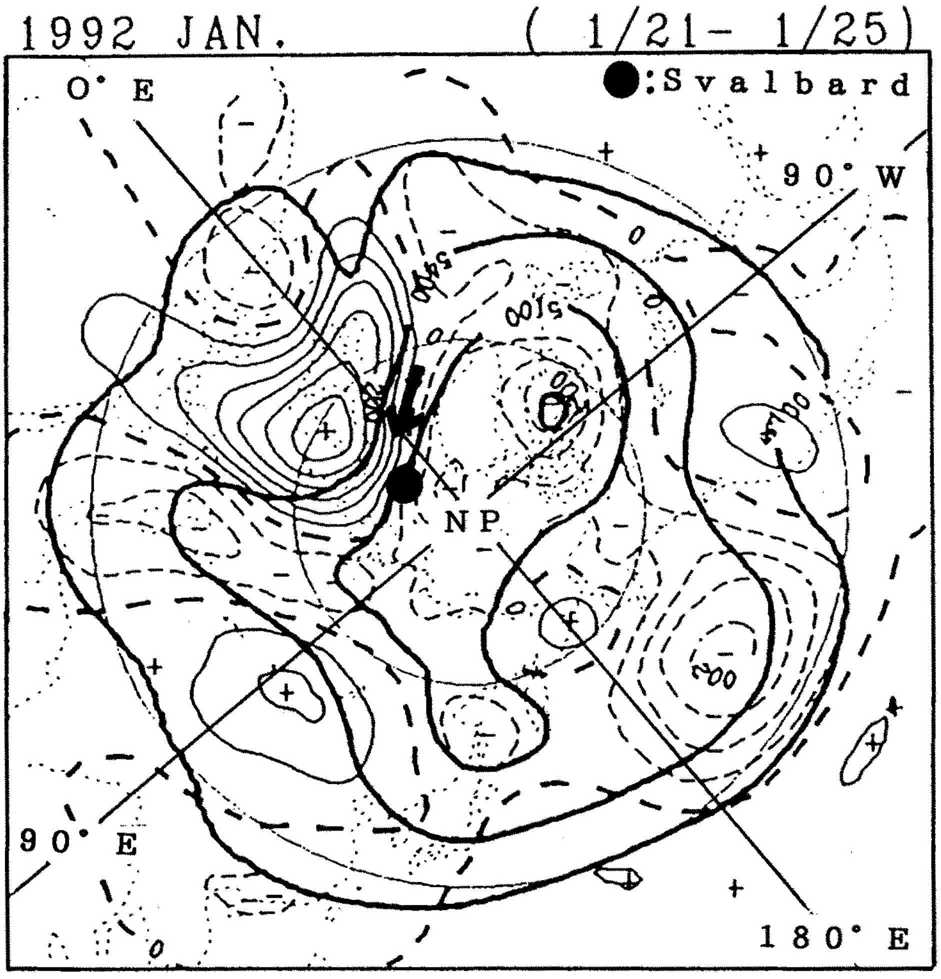

Fig. 2. 5-days mean weather chart at 500 hPa height (Japan Meteorological Agency). Thick line is contour of 500 hPa surface. Thin solid line is contour of positive anomaly of the height from 30 year means, thin broken line is of negative anomaly and thick broken line is of 0 anomaly. Doted line is the coastline. Two circles of thin line are latitude lines of 30°N and 60°N. The air flow was blocked by the high pressure over Scandinavia, resulting in warm air advection to Svalbard.

Svalbard is the large variability in winter. The highest variability of air temperature in the Arctic occurs in winter in Svalbard.

One of the causes of large variability in winter temperature is the occurrence of a warm spell in January. The warming of winter air temperature was observed in winter in many years (Fig. 3). This warm spell has been called the "warm core" (Rubinshteyn, 1962). The monthly mean temperature in January rises about 10°C higher than in December. The warm spikes in Fig. 3 characterize the winter climate in the Arctic.

Figure 4 shows the monthly mean temperature at Isfjord Radio near Longyearbyen, Svalbard. The standard deviations (SD) are obtained from 60 years-long data. The SD in winter is largest among meteorological stations in the Arctic, while the SD in summer is the lowest. Figure 5 shows the maximum and minimum of the monthly-mean temperatures and their range (maximum minus minimum). Variability in temperature in January is great ; its range exceeds 20°C. This range is also the largest among the meteorological stations in the Arctic.

The intensity, length and timing of the winter warming reflect the large year-to-year variations of temperature shown in Figs. 4 and 5. In winter 1989/90, the winter warming occurred in January and February (Shiraiwa and Sawagaki, 1992). It seems to last about two months.

5. Discussion

5.1. Recurring oceanic and continental climates

The climate in Svalbard seems to be influenced greatly by the sea ice extent. Low variability in summer temperature is similar to that in Iceland and Bergen where oceanic climate is dominant. In winter, the temperature variability in Svalbard is great, exceeding that at some inland stations where continental climate is dominant. The climate of Svalbard in winter seems to be caused by its location where ice-covered sea and warm open sea adjoin. Due to recurring changes in wind direction, the climate of Svalbard can be switched from continental to oceanic climate, and vice versa, causing larger variability of air temperature in Svalbard than those of the continental climate.

5.2. Break of winter inversion

The inversion of air temperature can be destroyed by a warm spell in mid-winter. Mixing of air can occur temporarily in the lower troposphere. This

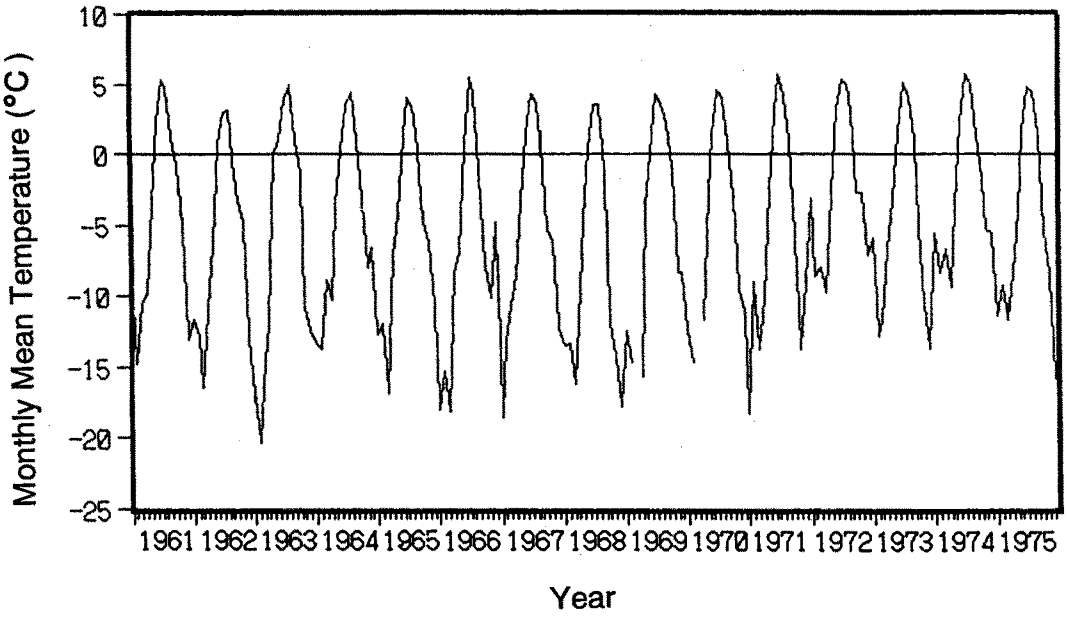

Fig. 3. Time series of air temperature in Isfjord Radio near Longyearbyen, Svalbard, from 1961 to 1975. Warming in winter is remarkable. These temperature increases in winter can be observed over a broad area in the Arctic.

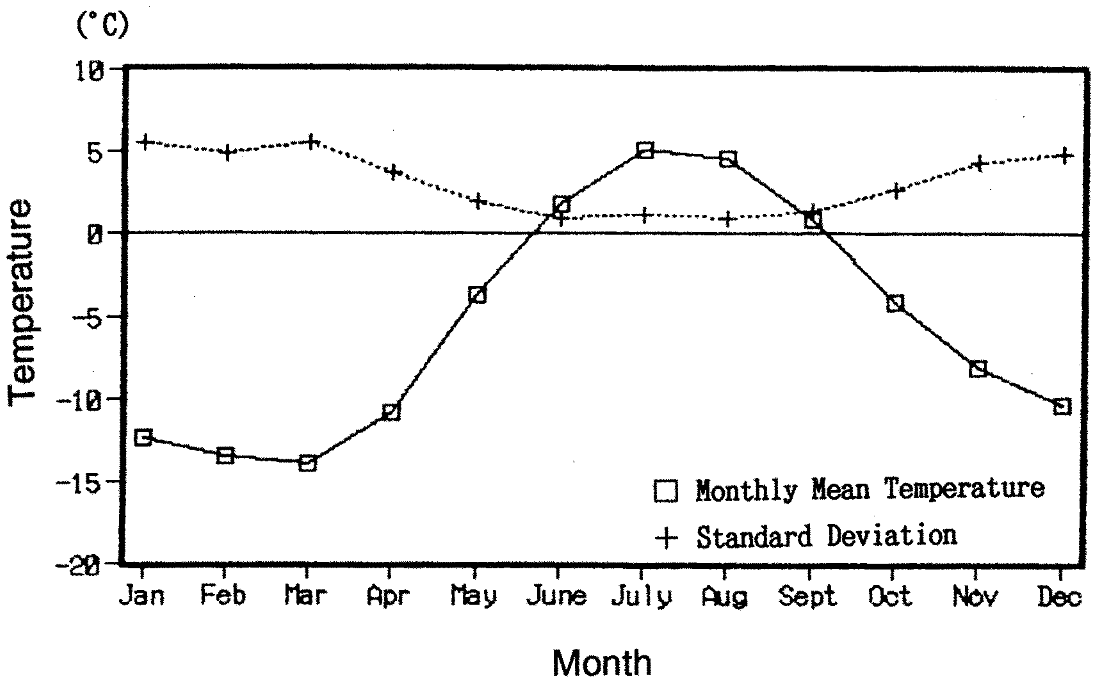

Fig. 4. Monthly mean temperature and its standard deviations (SD) from 60 years -long data in Isfjord Radio, Svalbard. The SD in winter is the largest among the meteorological stations in the Arctic.

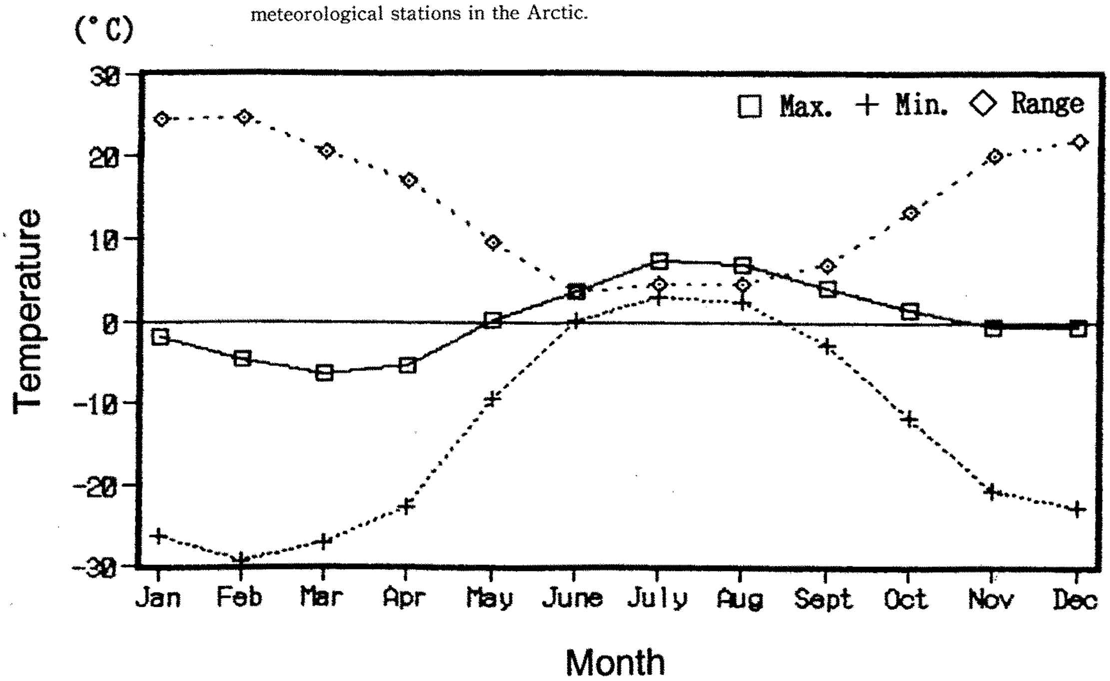

Fig. 5. The maximum and the minimum of the monthly-mean temperature and their range (maximum minus minimum) in Isfjord Radio, Svalbard. Winter temperature in Svalbard shows large year-to-year fluctuations. The range of temperature variation in winter exceeds 20°C.

event may affect the winter, in concentration of polluted air which causes the arctic haze in the following spring. Barrie (1989) reported a time series of sulfate measured at Alert. Sulfate is the major constituent of Arctic haze aerosol. The concentration tends to increase in winter ; however, the tendency of increase stopped temporarily or the concentration even decreased in mid-winter. The winter warming may cause a temporal decrease of aerosol concentration in winter.

5.3. Low variability in summer temperature

The daily-mean air temperature varies little from May to August. The lowest variability of summer temperature in the Arctic was observed in Svalbard. The air in the lower troposphere can be mixed without forming an inversion. During this time, the daily-mean temperature exceeds zero degrees. A large amount of heat would be used for the latent heat to melt ice. Kanno (1991) analyzed characteristics of the polar air mass and pointed out that there are specific periods of changing atmospheric stratification in the Arctic. The beginning and end of the period of snow and ice melting correspond to those periods of change.

Acknowledgments

The Authors are indebted to Dr. H. Kanno of Tokyo Metropolitan University for providing meteorological station data and helpful suggestions. Thanks are also due to Dr. T. Umemoto at Meiji University for kind discussions and comments on the warmcore. Mr. K. Furusawa at Nagoya University and Dr. K. Koshima at Tokyo Institute of Technology helped our observations in Svalbard. The AWS data were provided from the Arctic Environmental Research Center in NIPR, Tokyo. This study was supported by grant No. 03041089 to Prof. Watanabe at NIPR.

References

1. Barrie, L. A. (1989) : The Northern Chemical Environment, in Proc. of the Symp. on the Arctic and Global Change, Climate Institute, Ottawa, 35–38.
2. Colucci, S. J. (1985) : Explosive Cyclogenesis and Large Scale Circulation Changes : Implications for Atmospheric Blocking, J. Atmos. Sci., **42**, 2701–2717.
3. Hanssen-Bauer, I., Kristensen Solas, M. and Steffensen, E. L. (1990) : Climate of Spitsbergen, Norwegian Meteorological Institute Report, 39/90 Klima, 39p.
4. Japan Meteorological Agency (1992) : Monthly Report of Climate System, No. 92–01.
5. Kanno, H. (1991) : Seasonal Variations of Air Masses in the Arctic and in the Middle and HIgh Latitudes of the Eastern Part of the Eurasian Continent (in Japanese), Geographical Review of Japan, **64A-4**, 225-243.
6. Rubinshteyn, Ye. S., (1962) : Warm core and coreless winters, Soviet Geography, **3-Nov.**, 14–29.
7. Shiraiwa, T. and Sawagaki, T. (1992) : A preliminary report on the air temperature in Reindalen, west Spitsbergen, Bulletin of Glacier Research, **10**, 91–97.
8. Tanaka, H. L. and Milkovich, M. F. (1990) : A Heat Budget Analysis of the Polar Troposphere in and around Alaska during the Abnormal Winter of 1988/89, Mon. Wea. Rev., **118**, 1628–1639.