18 December 2015
Global Environment and Marine Department
Japan Meteorological Agency

Bugs in JRA-55 snow depth analysis

Bugs were recently found in the snow depth analysis (i.e., the snow depth data generation process) of the Japanese 55-year Reanalysis (JRA-55). This has affected the quality of certain variables as follows:

- For some areas within 600 km of the coast, snow depth values (and those for the water equivalent of accumulated snow depth) were found to be unrealistically high (Section 1), and snow was not shown as being present where it should have been (Section 2).
- For places where snow was not shown as being present (Section 2), sensible heat flux was found to be excessive and upward solar radiation flux at the surface was insufficient (Section 3).

More detailed information regarding the locations can be found in JRA-55_snow_bugs_list1.en.txt for grid points where snow depth values were found to be unrealistically high and in JRA-55_snow_bugs_list2_en.txt for grid points where snow was not shown as being present.

Users are advised to check whether quality is sufficient for their applications when these data are used. For further details of the issue's cause, see Section 4.

JMA sincerely apologizes for any inconvenience caused by this problem, and remains committed to implementing all necessary measures for the prevention of any recurrence.

Questions regarding this matter can be directed to jra@met.kishou.go.jp.

Section 1. Areas and periods shown with unrealistically deep snow

This section summarizes typical snow distributions for areas where snow was shown as being unrealistically deep due to snow depth analysis bugs. It also includes tabulation of periods during which a significant impact is seen for each of these areas.

For more detailed information regarding the grid points where snow was shown as being unrealistically deep, please see JRA-55_snow_hist1_en.txt.

1.1. Europe

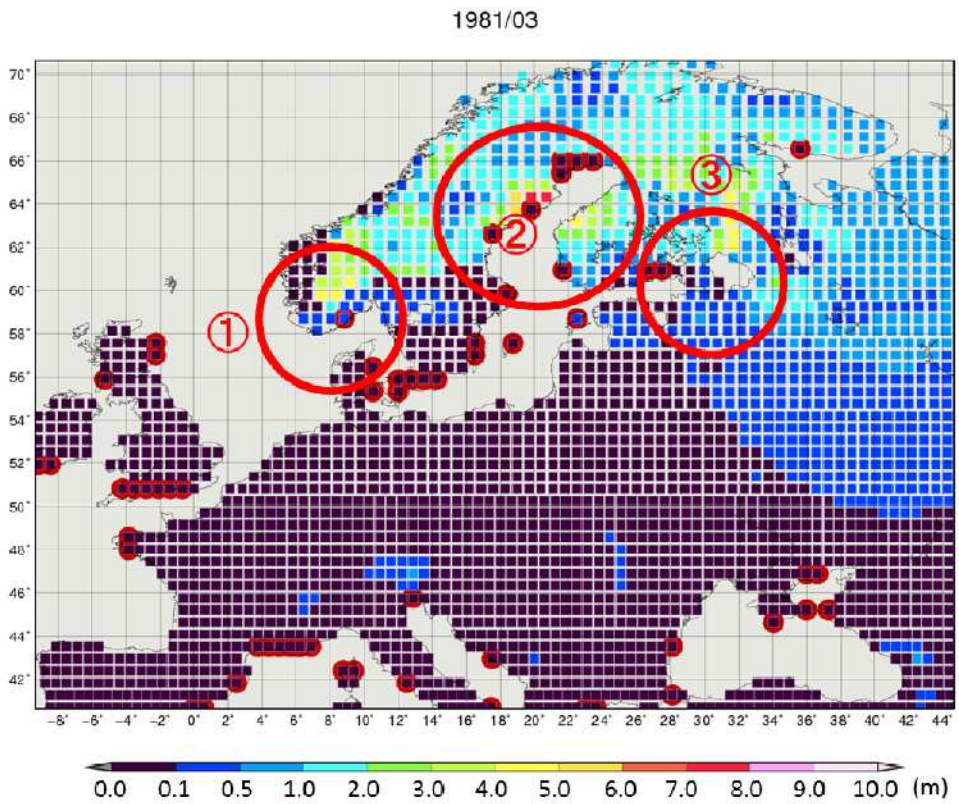


Fig. 1.1. Areas shown with unrealistically deep snow in Europe for March 1981

Shading shows monthly mean snow depth, red dots represent grid points in which the interpolation error occurred, and red circles indicate areas where snow is shown as being unrealistically deep due to an error in snow cover climatology interpolation.

Table 1.1. Periods during which a significant impact is seen in Europe

Area	Period of significant impact (boreal winter only)
1	1980/1981 to 1985/1986
2	1979/1980 to 1986/1987
3	1958 to 1986/1987

1.2. Western Siberia

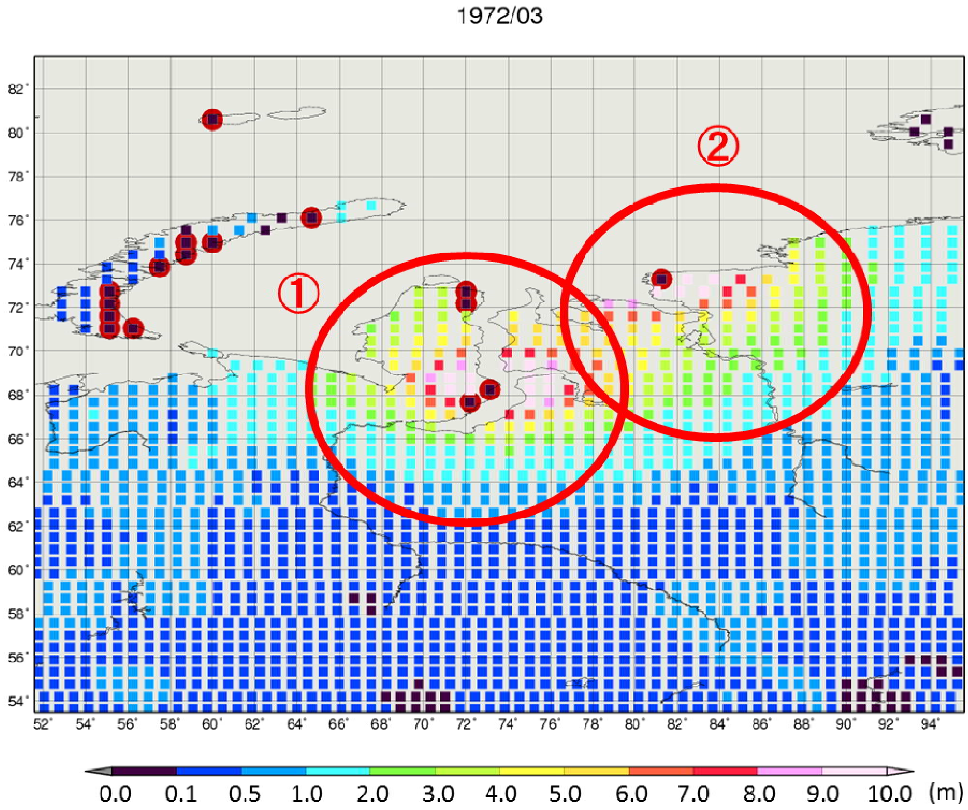


Fig. 1.2. Areas shown with unrealistically deep snow in Western Siberia for March 1972
Shading, red dots and red circles are as per Fig. 1.1.

Table 1.2. Periods during which a significant impact is seen in Western Siberia.

Area	Period of significant impact (boreal winter only)
1	1958/1959 to 1985/1986
2	1966/1967 to 1979/1980, 1987/1988

1.3. East Asia

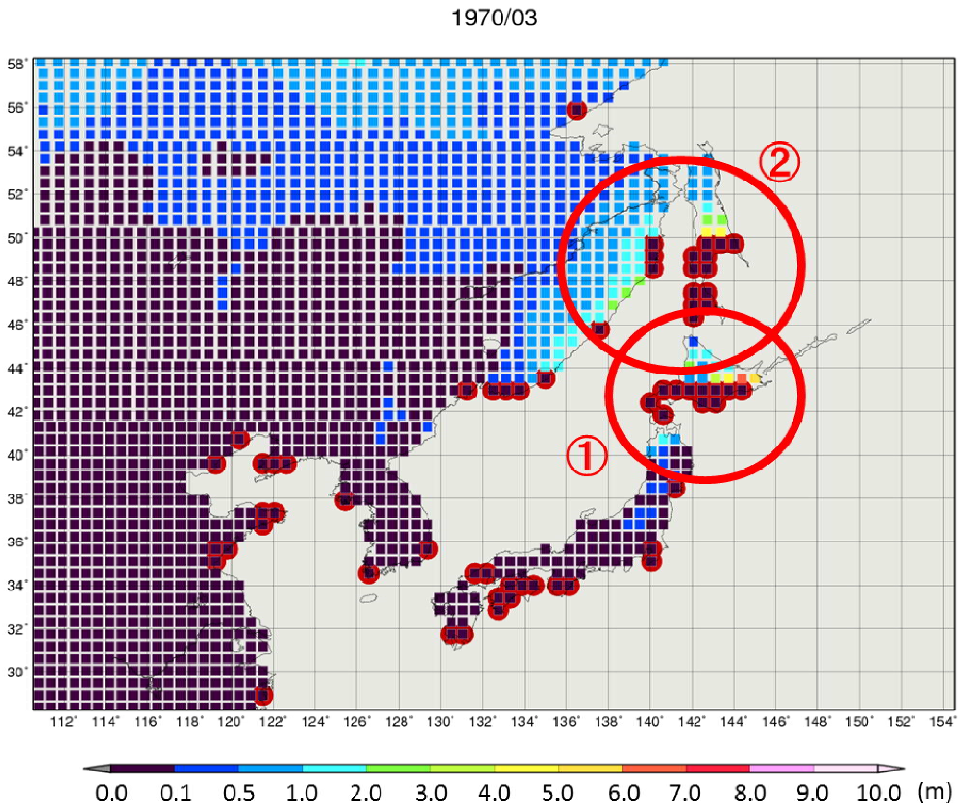


Fig. 1.3. Areas shown with unrealistically deep snow in East Asia for March 1970.
Shading, red dots and red circles are as per Fig. 1.1.

Table 1.3. Periods during which a significant impact is seen in East Asia.

Area	Period of significant impact (boreal winter only)
1	1959/1960 to 1986/1987
2	1966/1967, 1968/1969 to 1970/1971, 1973/1974 to 1980/1981, 1985/1986, 1987/1988 to 1989/1990, 1991/1992 to 1999/2000, 2001/2002, 2002/2003, 2005/2006

1.4. Eastern Siberia

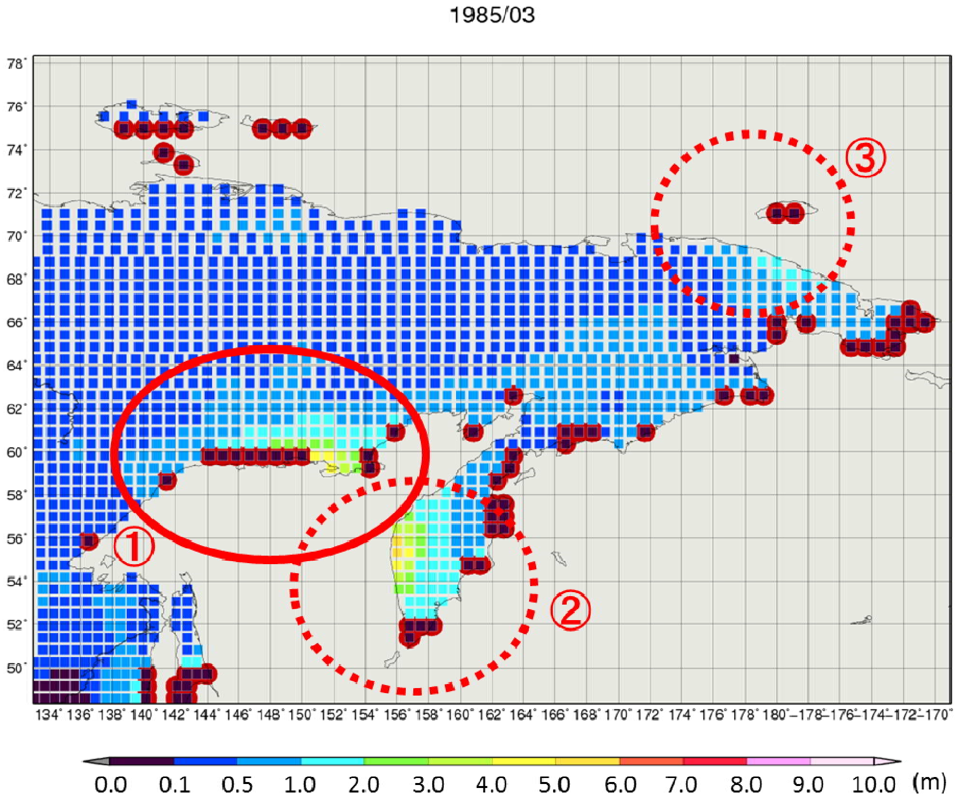


Fig. 1.4. Areas shown with unrealistically deep snow in Eastern Siberia for March 1985
Shading, red dots and red circles are as per Fig. 1.1. Dotted red circles indicate areas where snow is shown as being unrealistically deep due to an error in the handling of coastal-area snow depth observation data.

Table 1.4. Periods during which a significant impact is seen in Eastern Siberia.

Area	Period of significant impact (boreal winter only)
1	1962/1963, 1965/1966, 1966/1967, 1970/1971 to 1973/1974, 1980/1981 to 1982/1983, 1984/1985 to 1987/1988
2	1958/1959 to 1962/1963, 1965/1966, 1980/1981, 1984/1985, 1985/1986, 1987/1988, 1988/1989, 1993/1994, 1995/1996, 1996/1997, 1998/1999, 2004/2005, 2006/2007 to 2011/2012
3	2009/2010, 2010/2011

1.5. Northwestern North America

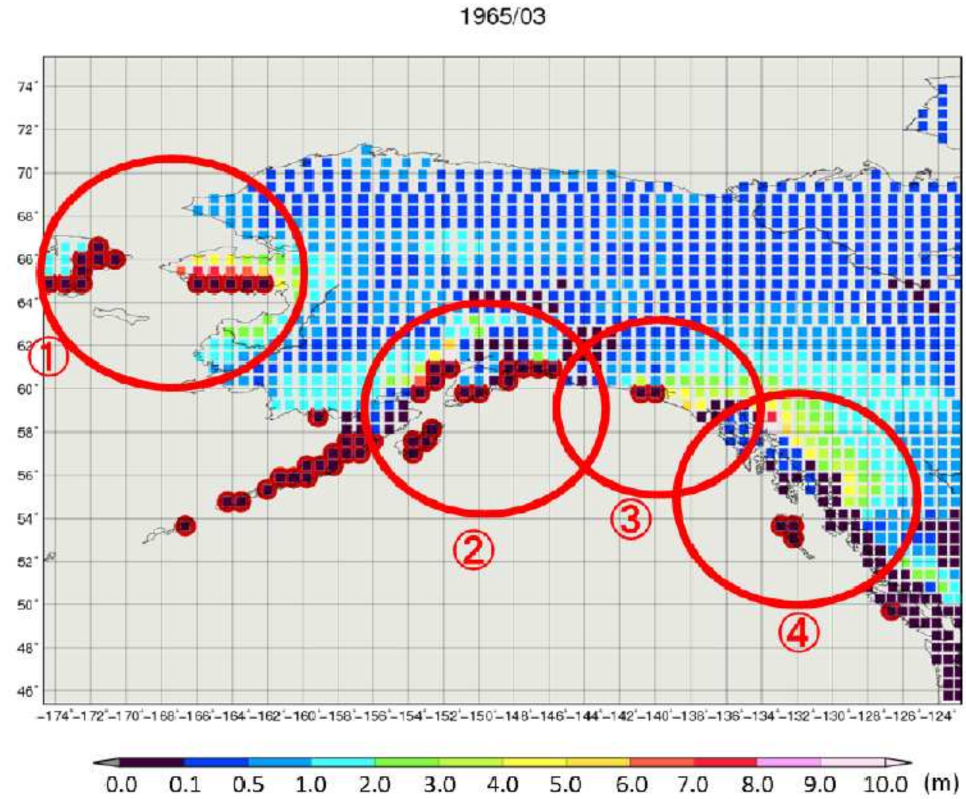


Fig. 1.5. Areas shown with unrealistically deep snow in northwestern North America for March 1965.

Shading, red dots and red circles are as per Fig. 1.1.

Table 1.5. Periods during which a significant impact is seen in northwestern North America.

Area	Period of significant impact (boreal winter only)
1	1958/1959, 1964/1965 to 1966/1967, 1972/1973, 1973/1974, 1976/1977, 1980/1981, 1983/1984 to 1990/1991, 1992/1993 to 1994/1995, 2008/2009, 2011/2012
2	1958/1959 to 1961/1962, 1964/1965 to 1966/1967, 1971/1972 to 1989/1990, 1994/1995 to 1996/1997, 1998/1999, 2008/2009, 2009/2010
3	1958/1959, 1964/1965 to 1985/1986, 2011/2012
4	1958/1959 to 1961/1962, 1964/1965 to 1966/1967, 1968/1969, 1970/1971 to 1975/1976, 1977/1978, 1978/1979, 1981/1982 to 1984/1985, 2006/2007 to 2008/2009

1.6. Northern Canada

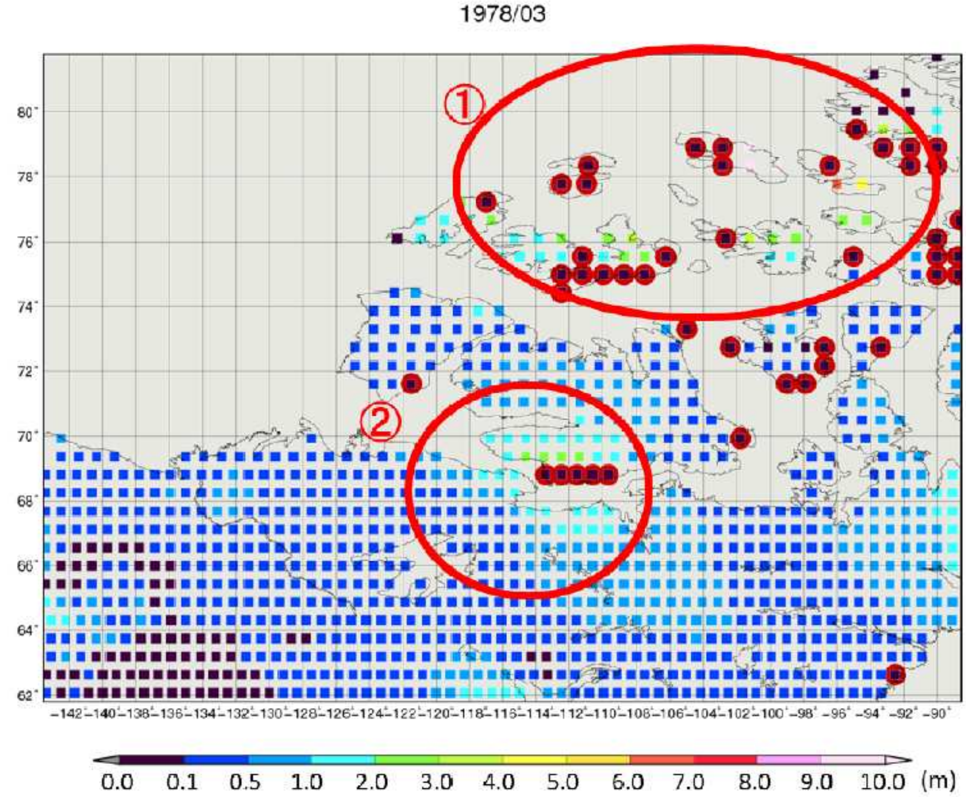


Fig. 1.6. Areas shown with unrealistically deep snow in northern Canada for March 1978.

Shading, red dots and red circles are as per Fig. 1.1.

Table 1.6. Periods during which a significant impact is seen in northern Canada.

Area	Period of significant impact (boreal winter only)
1	1976/1977
2	1977/1978, 1980/1981 to 1982/1983, 1984/1985 to 1987/1988

1.7. Northeastern Canada

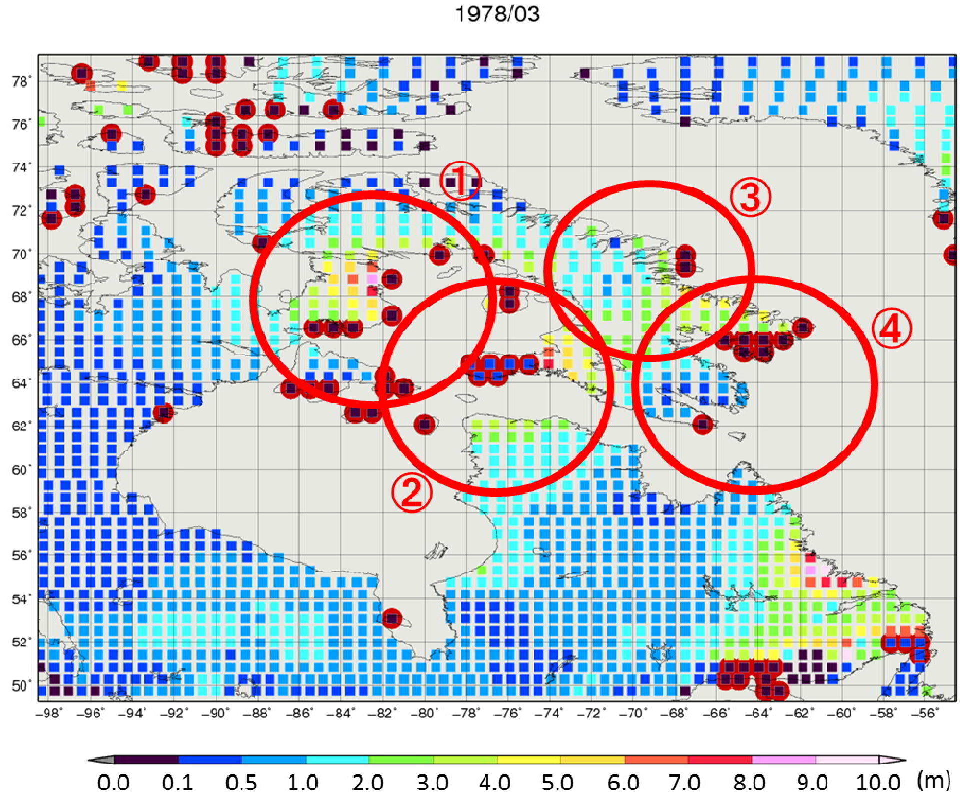


Fig. 1.7. Areas shown with unrealistically deep snow in northeastern Canada for March 1978.

Shading, red dots and red circles are as per Fig. 1.1.

Table 1.7. Periods during which a significant impact is seen in northeastern Canada.

Area	Period of significant impact (boreal winter only)
1	1977/1978, 1978/1979, 1980/1981 to 1990/1991, 1992/1993, 1993/1994
2	1977/1978, 1978/1979, 1987/1988
3	1977/1978, 1985/1986, 1987/1988 to 1990/1991, 1993/1994
4	1977/1978, 1978/1979, 1980/1981 to 1983/1984, 1985/1986 to 1990/1991

1.8. Northeastern North America

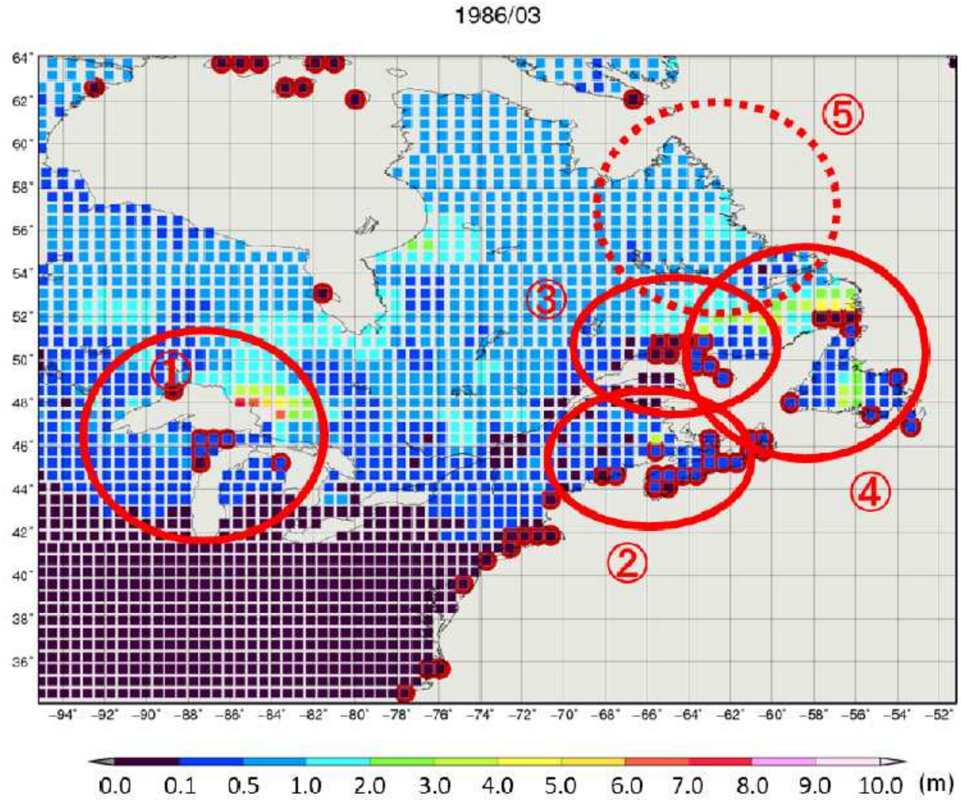


Fig. 1.8. Areas shown with unrealistically deep snow in northeastern North America for March 1986.

Shading, red dots and red circles are as per Fig. 1.1. Dotted red circles indicate areas where snow is shown as being unrealistically deep due to an error in the handing of coastal-area snow depth observation data.

Table 1.8. Periods during which a significant impact is seen in northeastern North America.

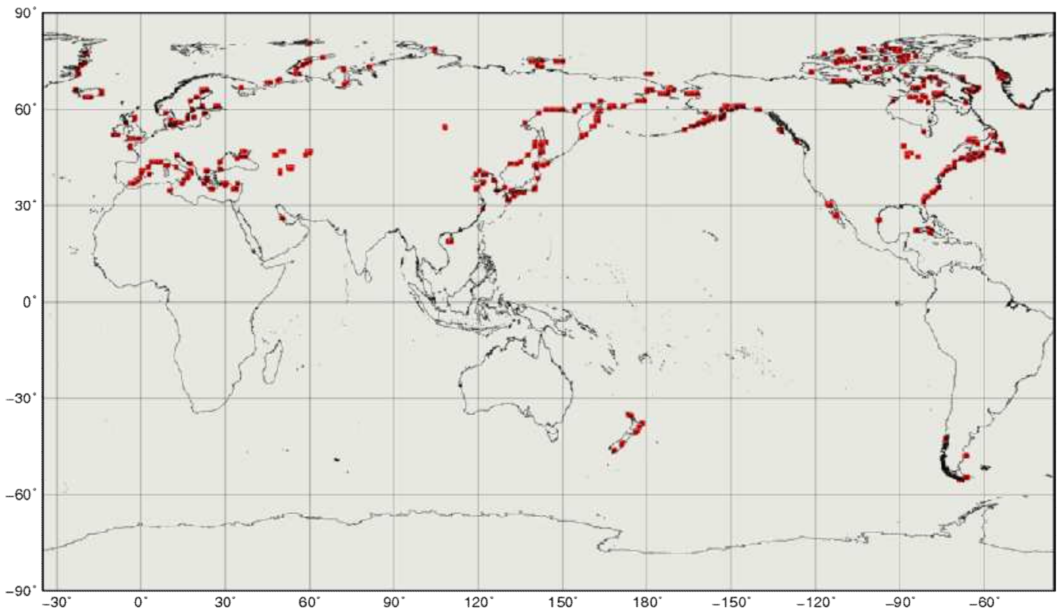
Area	Period of significant impact (boreal winter only)
1	1958/1959 to 1990/1991, 1995/1996 to 1998/1999, 2003/2004 to 2005/2006
2	1977/1978, 1980/1981, 1982/1983 to 1986/1987, 1992/1993, 1993/1994
3	1977/1978, 2002/2003 to 2005/2006
4	1977/1978, 1979/1980 to 1990/1991, 1992/1993 to 1994/1995, 2005/2006, 2006/2007
5	1977/1978, 1981/1982 to 1983/1984, 1998/1999, 2001/2002, 2002/2003, 2004/2005

Section 2. Grid points with errors in snow cover climatology interpolation

The following maps show grid points for which no value was set due to an error in snow cover climatology interpolation from the 1-degree latitude/longitude grid to the TL319 analysis grid.

For more detailed information regarding the location of these grid points, please see JRA-55_snow_bugs_list2_en.txt.

(a)



(b)

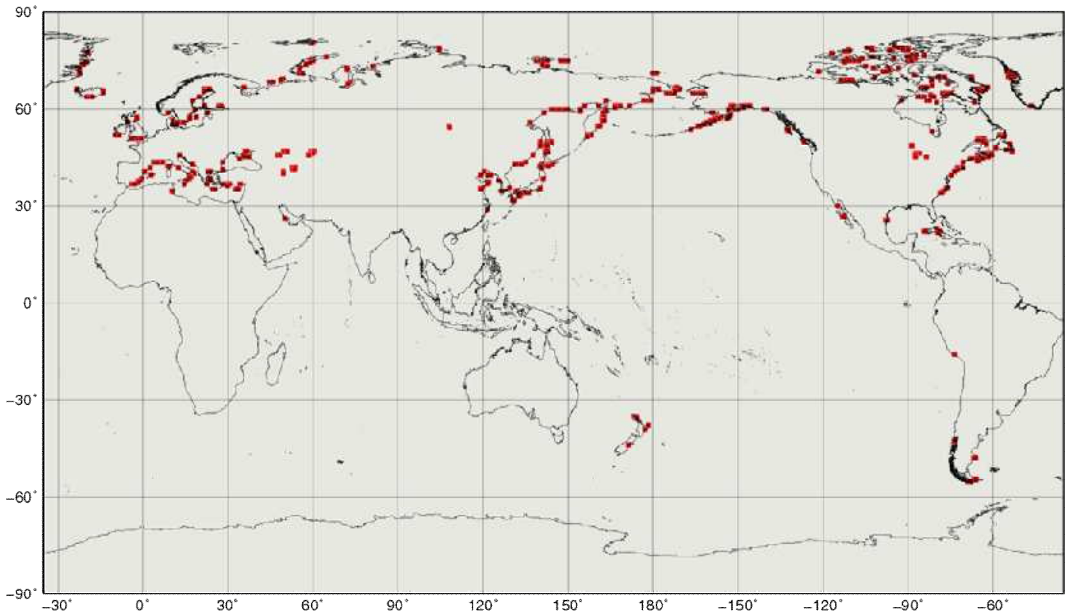
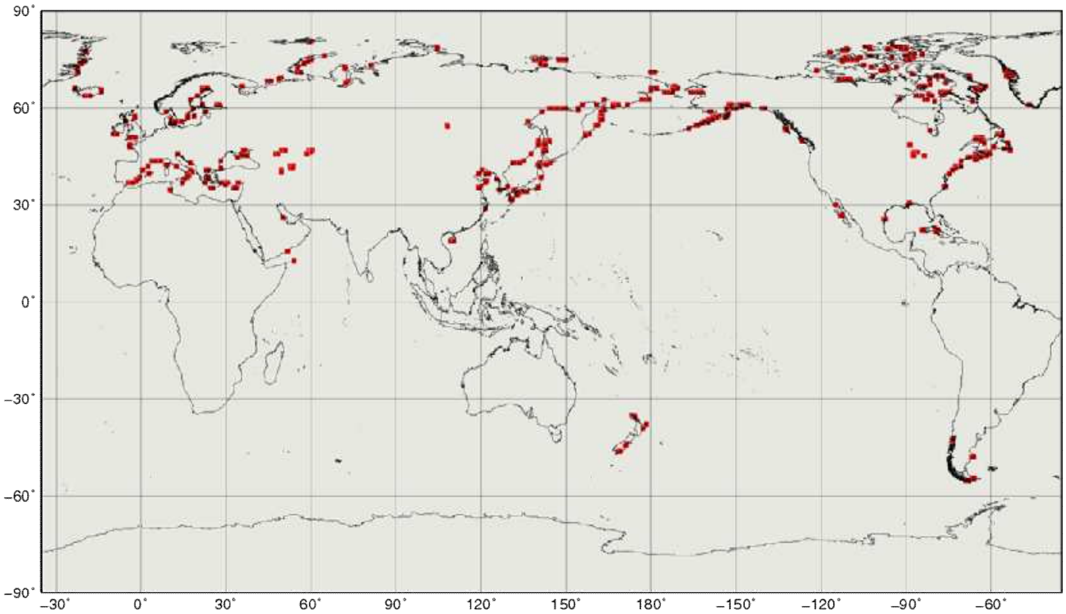


Fig. 2.1. Grid points with errors in snow cover climatology interpolation (red dots)

(a) January, (b) February

(c)



(d)

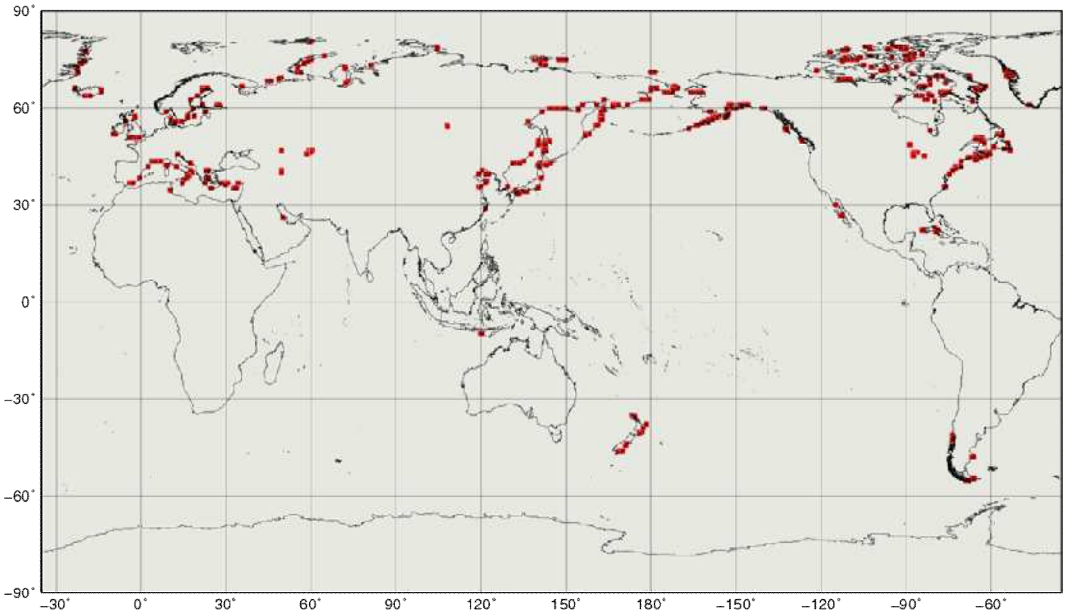
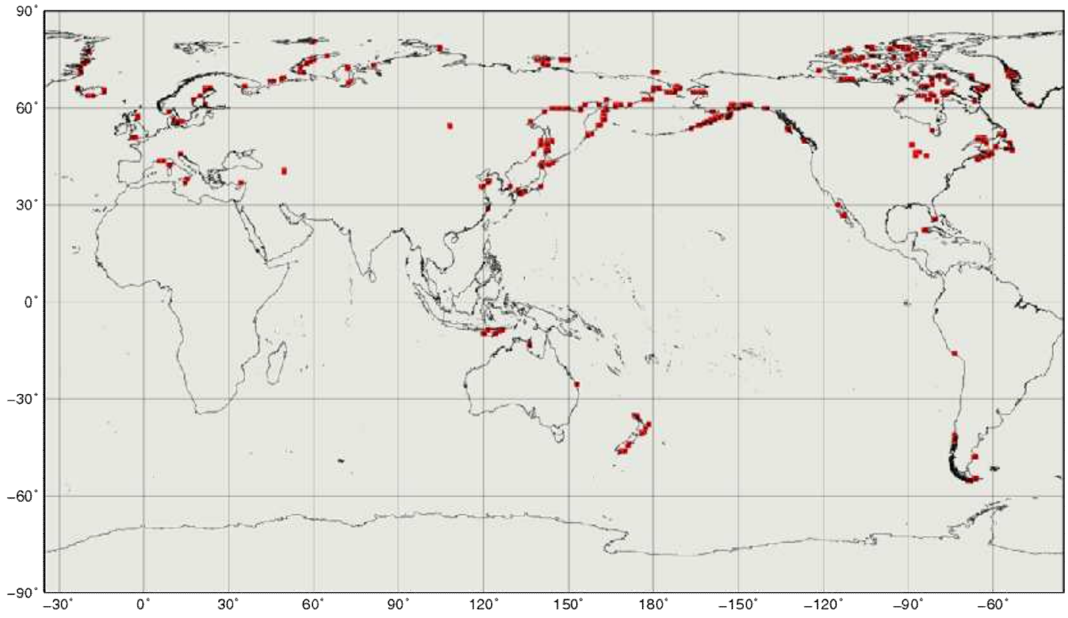


Fig. 2.1. Grid points with errors in snow cover climatology interpolation (red dots) (continued)

(c) March, (d) April

(e)



(f)

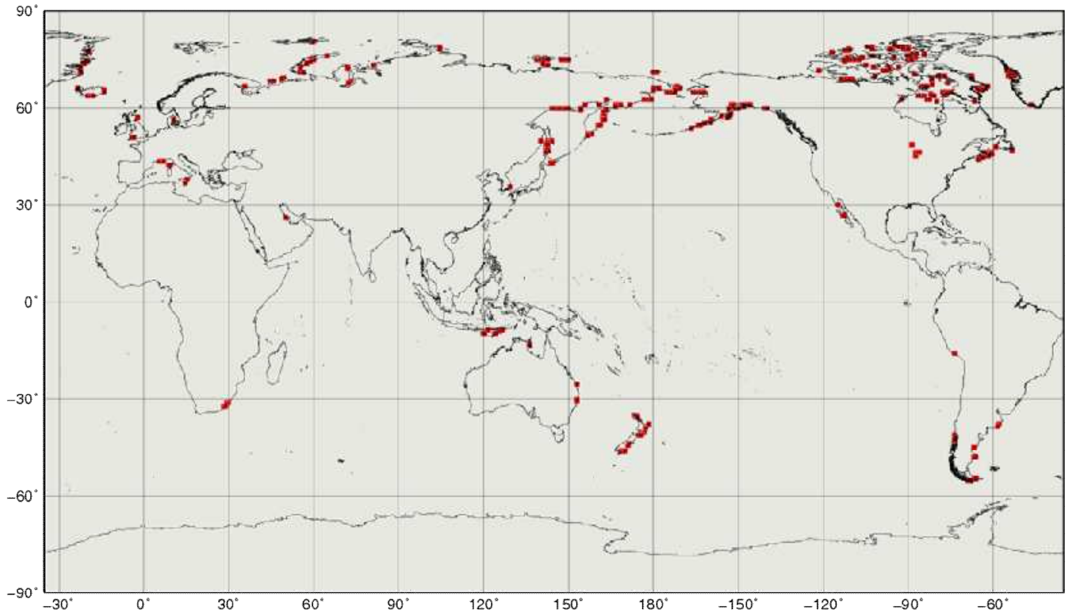
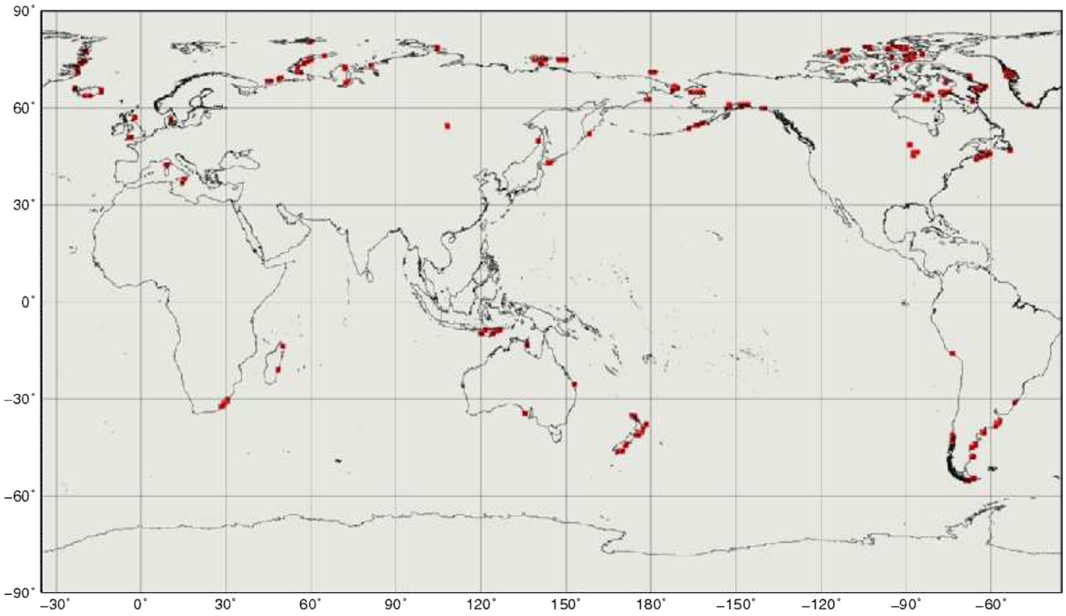


Fig. 2.1. Grid points with errors in snow cover climatology interpolation (red dots) (continued).

(e) May, (f) June

(g)



(h)

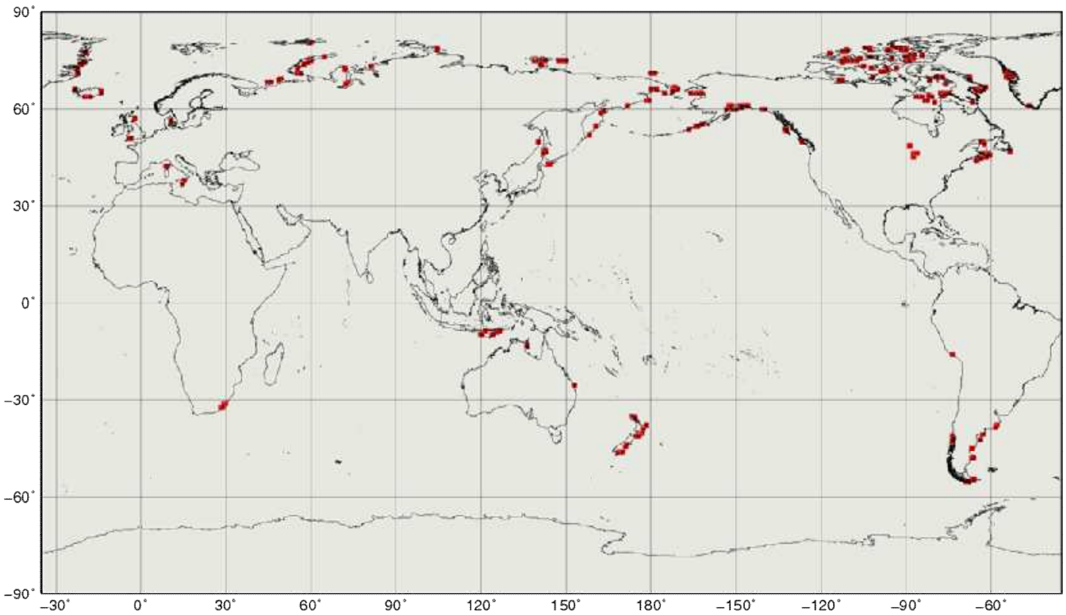
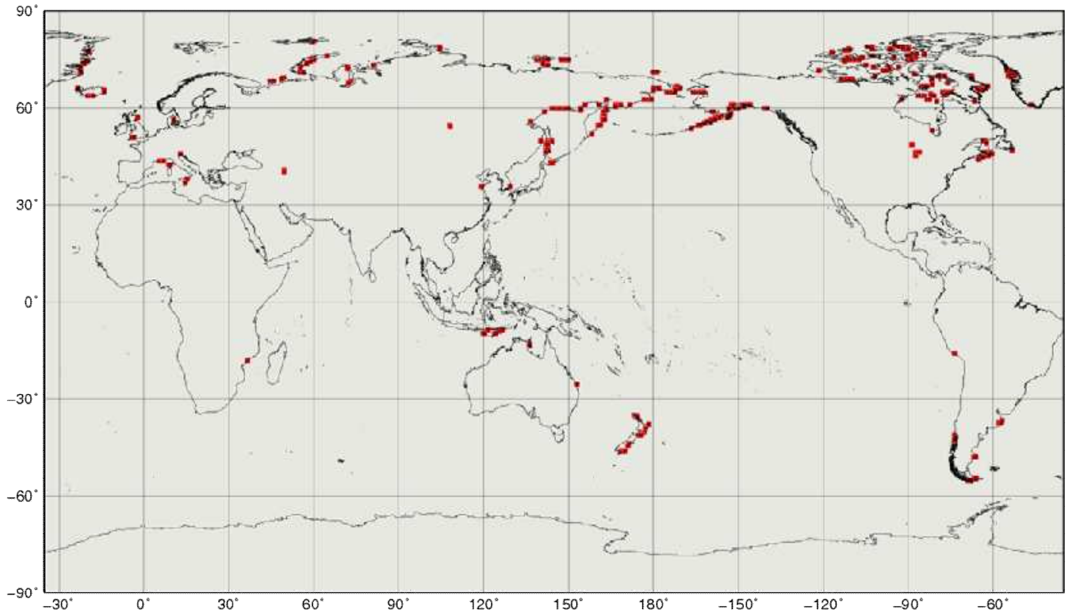


Fig. 2.1. Grid points with errors in snow cover climatology interpolation (red dots) (continued).

(g) July, (h) August

(i)



(j)

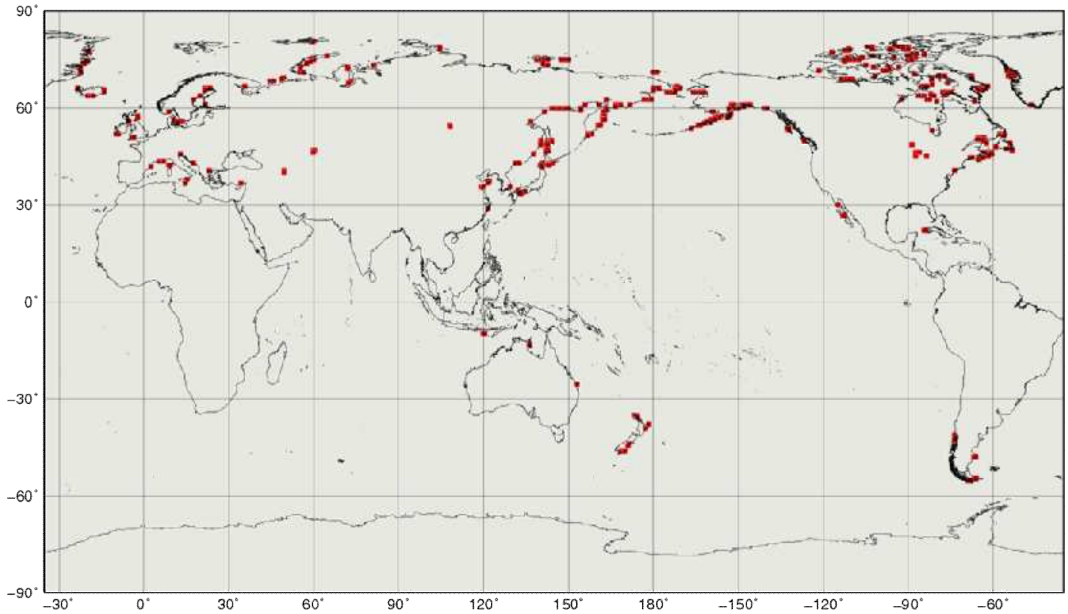
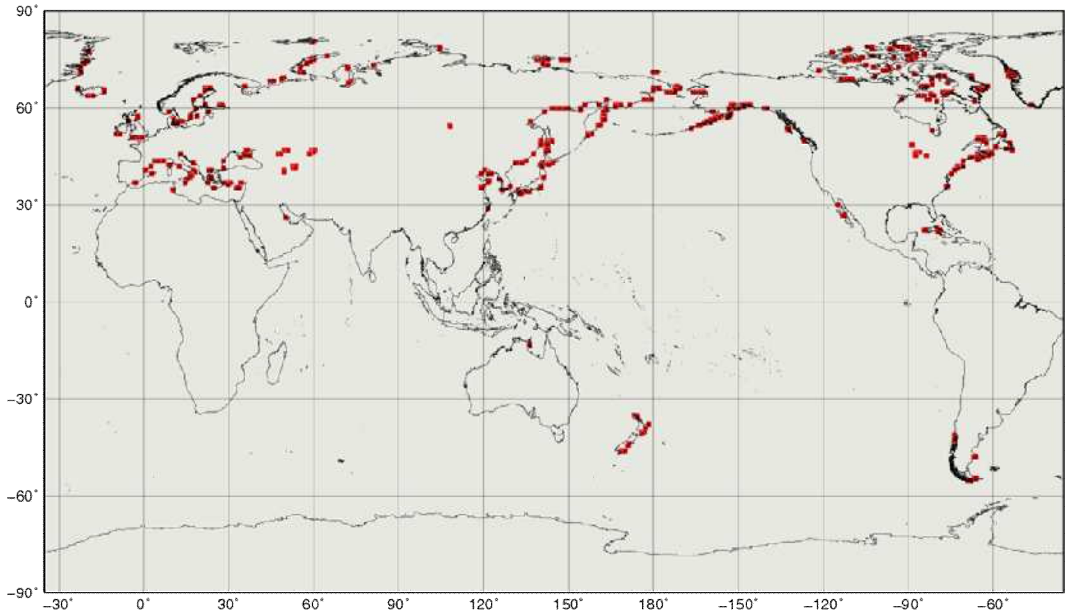


Fig. 2.1. Grid points with errors in snow cover climatology interpolation (red dots) (continued).

(i) September, (j) October

(k)



(l)

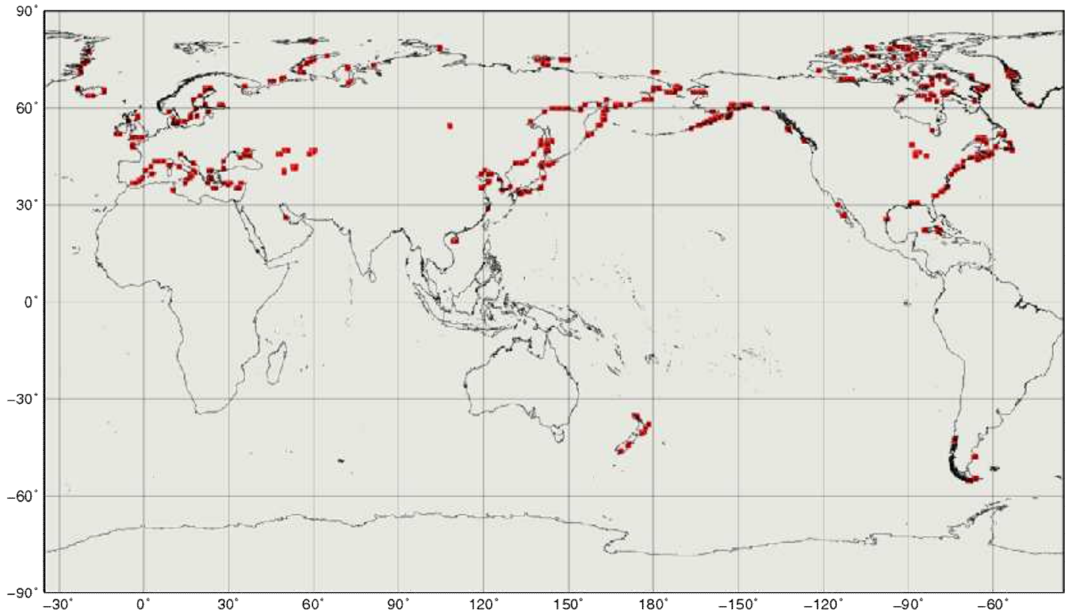


Fig. 2.1. Grid points with errors in snow cover climatology interpolation (red dots) (continued).

(k) November, (l) December

Section 3. Impacts in locations of missing snow data

As examples of impacts in locations where snow was actually present but not shown, this section includes time-series representations of snow depth analysis data, sensible heat flux anomalies and surface upward solar radiation flux anomalies at the grid point 73.291°N, 81.25°E, where an error occurred in snow cover climatology interpolation in Western Siberia (area #2) as described in Subsection 0.

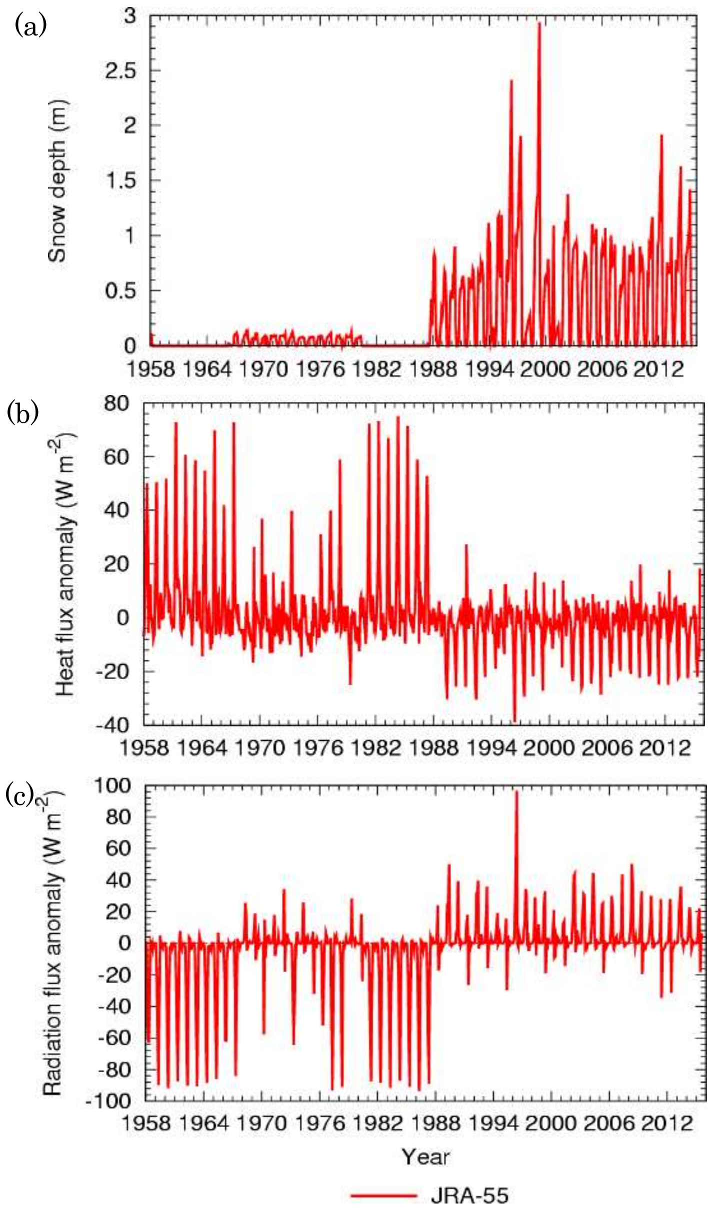


Fig. 3.1. (a) Snow depth analysis data, (b) sensible heat flux anomalies and (c) surface upward solar radiation flux anomalies at the grid point 73.291°N, 81.25°E

Anomalies are defined relative to climatological monthly means for the period 1981 – 2010.

Section 4. Causes of snow depth analysis bugs

4.1. Overview of snow depth analysis

JRA-55 snow depth analysis fields are generated once a day based on correction of snow depth estimates (first-guess values; details will be given later) of a target day with snow depth observations. Long-term snow depth data are generated through the daily implementation of this analysis process. The flow of snow depth analysis is outlined below.

I. Snow depth estimates (first-guess values) of a target day are derived from snow depths for the previous day and other data. Further details are given in Subsection 0.
II. First-guess values are interpolated to observation stations, and observations minus interpolated first-guess values (known as *departures*) are computed.
III. On the assumption that errors at the grid points surrounding an observation station are correlated, departures are interpolated to the surrounding grid points (optimal interpolation).
IV. Snow depth analysis fields are generated based on the correction of first-guess fields with departures interpolated to each grid point.

4.2. First-guess field generation

First-guess fields in snow depth analysis are derived from (A) snow depth forecasts for a target day based on snow depth analysis fields for the previous day as the initial condition, and from (B) snow cover data representing the percentage of snow coverage within each grid square. Details are as follows:

- If there is snow in both (A) and (B), (A) is assigned for the first guess.
- If there is snow only in (B), the first guess is a snow depth that would bring the ground temperature down to freezing point through melting (up to 2.1 cm).
- If there is snow only in (A), the first guess is 0 cm.
- If there is no snow in (A) or (B), the analysis value is 0 cm and the optimal interpolation analysis process is not performed.

There are two types of snow cover data: daily snow cover retrievals from satellite microwave imagers for the period after 25 June 1987, and snow cover climatologies for the period before 24 June 1987. However, snow cover climatology data are used where daily snow cover retrievals from satellite microwave imagers are missing for the period after 25 June 1987.

4.3. Causes of bugs

4.3.1. Error in snow cover climatology interpolation

As the snow cover climatology grid differs from the model grid used in snow depth analysis, the snow cover climatologies are interpolated to the model grid. However, an error in the interpolation process resulted in a failure to set values for some coastal-area grid points, which were consequently rendered as 0% (see Section 2 for details). As a result, snow depths at these grid points show a negative bias because first-guess snow depths were reset to 0 cm in every analysis process regardless of the presence of snow in forecast fields.

Conversely, where snow depth observation data existed for areas close to grid points in which interpolation errors occurred, departures were overestimated. As a result, these overestimations were interpolated to surrounding grid points. The overestimated correction amount accumulated with every snow depth analysis process, resulting in unrealistically deep snow data in analysis for the surrounding grid points.

4.3.2. Errors in the handling of coastal-area snow depth observation data

Unlike grid points, observation stations are not spaced uniformly. Accordingly, first-guess values are interpolated from the four surrounding grid points to observation stations before departures are computed. In this interpolation process, marine grid points were not handled appropriately when first-guess values were interpolated to coastal-area observation stations. As there is no snow cover at sea, differences between observations and first-guess values were overestimated at coastal-area observation stations, producing data that showed unrealistically deep snow in analysis for the surrounding grid points.

4.4. Impact

4.4.1. At grid points where analysis data showed unrealistically deep snow

Since snow depth analysis fields are used as the initial condition for the forecast model in JRA-55, errors in snow depth analysis could adversely affect forecasting of other variables. However, in regard to data showing unrealistically deep snow (Section 1), no serious effects are seen in variables other than snow depth as outlined below.

Forecasts performed in the JRA-55 production have a forecast length of nine hours. On this relatively short time scale, snow depth errors do not have as large an impact on forecasts as errors in the status of snow presence/absence. Although data showing unrealistically deep snow could cause errors in the status of snow presence/absence by suggesting delayed thawing, this did not occur because snow depth observation is not available after thawing and there is no snow in satellite daily snow cover retrievals and snow cover climatologies. Accordingly, it can be concluded that effects on variables other than snow depth are limited.

4.4.2. At grid points where first-guess snow depths were reset to 0 cm

At grid points where first-guess snow depths were reset to 0 cm (Section 2), as detailed in Subsection 0, snow depth analysis values were also set to 0 cm when there were no snow depth observations nearby. This resulted in excessive sensible heat fluxes and insufficient surface upward solar radiation fluxes at those grid points (Section 3).