SEVENTH FRAMEWORK PROGRAMME

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MONARCH - A

MONitoring and Assessing Regional Climate change

in High latitudes and the Arctic

Working paper:

Deliverables No. 1.1.1 and 1.1.3:

Monthly and 5-day fields of snow extent

Start and end dates of snow cover

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1. Introduction

The aim of this working paper is to provide a description for the a) Monthly and 5-day fields of snow extent and b) start and end dates of snow cover files, provided as deliverables 1.1.1 and 1.1.3. These data are a contribution to the Work Package 1.1 "Decadal snow dynamics and their consequences for GHGs and climate".

2. Source data

We have used passive microwave data set from the SSM/I (Special Sensor Microwave/Imager) instrument onboard the DMSP (Defense Meteorological Satellite Program) series (since 1987). These radiometers with incidence angle from 50.2 to 52.8 degrees provided measurements of brightness temperature at different frequencies and at different (vertical or horizontal) polarisations. We have used the data from the 19 and 37 GHz channels at horizontal polarisation.

The National Snow and Ice Data Center (NSIDC, www.nsidc.org) provide the SSM/I data mapped to the Equal Area (625 km2 resolution) SSM/I Earth Grid (EASE-Grid) projection. An overview of the EASE-Grid projection can be found at the http://nsidc.org/data/ease/, and more detailed information at the http://nsidc.org/data/ease/ease_grid.html. We have used data in the global projection, that has 1383 pixels in X direction (values range from 0 to 1282) covering from -180 to 180° in longitude, and 120 values in Y direction (values range from 0 to 119) covering from 36°N to 90°N in latitude. Corresponding latitude and longitude for each EASE-Grid pixel (X,Y) center are provided in the file EASE-Grid119.txt

(directory EASE-Grid info). In order to perform the processing only on land, only pixels falling at least 10 km from the coastline have been considered. Moreover, pixels covering large lakes and rivers, as well as glaciated regions (e.g. Greenland) have also been excluded. File EASE-Grid119.txt contains code for each pixel (0 - ocean or excluded, 9 - land).

To minimise the effects of ice and snow melting, only night brightness temperatures were used (thus affecting the choice of ascending or descending passes). The initial data were averaged to obtain the pentad (5 days) mean values in order to get continuous spatial coverage. Each year has 73 pentads, pentad number for each days of the year provided in the file Day2pentad.txt (directory EASE-Grid info). We have used this dataset, which is available at the LEGOS/CTOH (Center for the Topography of the Oceans and Hydrology). Dataset spans from pentad 46 on year 1987 and ends by pentad 36 of the year 2008. Some data gaps (data for the whole pentad are missing) are presented in this dataset (Table 1). For other pentads some data gaps may occur for selected regions, due to missing orbits.

Table 1. Periods when the SSM/I data for the whole pentad are missing

Year	**Missing pentad(s)**	**Total missing pentads**
1987	69 to 73	5
1988	1 to 2, 38	3
1990	72	1
1996	20	1
1998	60	1
1999	25	1
2003	58-62	5
2007	16	1
Total		**18**

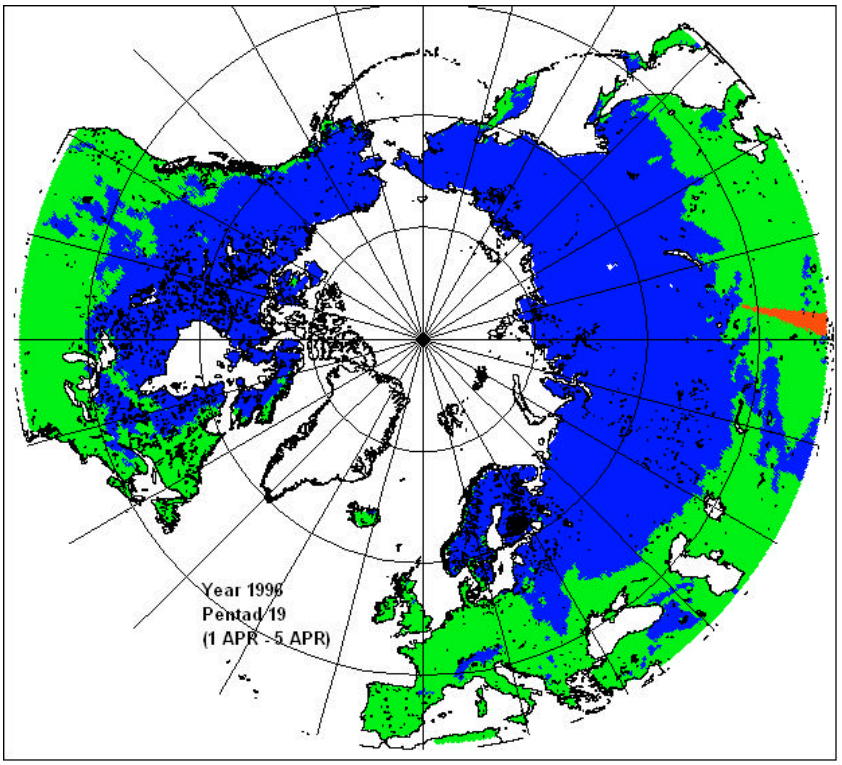
3. Monthly and five-days fields of snow extent

The whole dataset has been processed to produce monthly and five-days field of snow extent. The methodology is based on calculating the spectral gradient (SG):

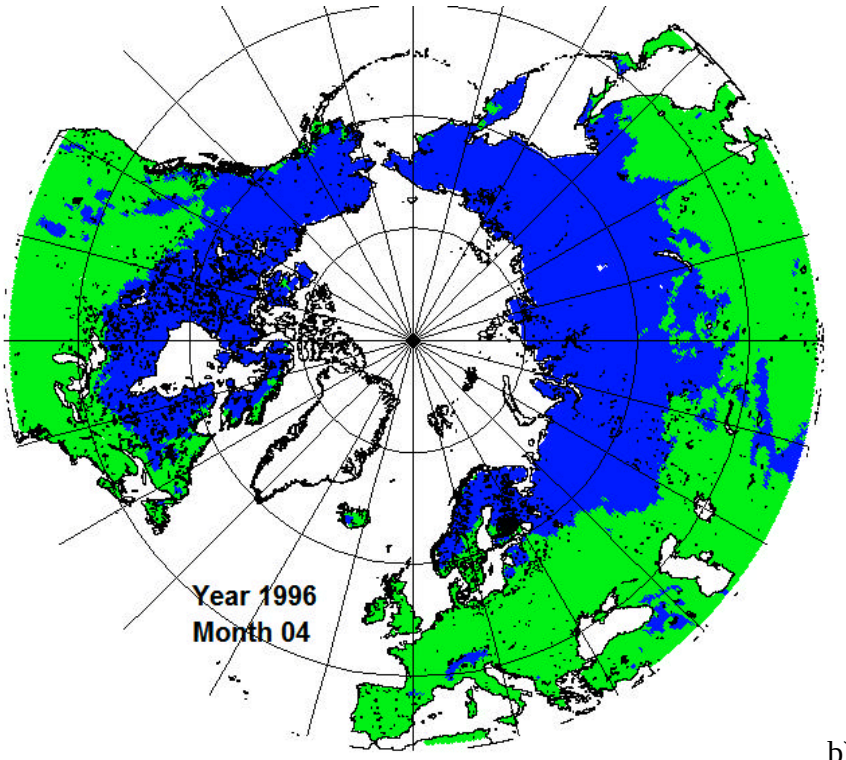
$$SG= (TB19H-6°K)-(TB37H-1°K)$$

where TB19H and TB37H are brightness temperatures at horizontal polarisation for 19 and 37 GHz, correspondingly. For monthly values, an average of all SG values for pentads corresponding to the specific month has been used. Pentads used for each month are listed in the file Month2pentad.txt (Directory EASE-Grid info).

When SG is larger than 3°K, it was considered that the pixel is snow-covered. Five-days fields are presented in the directory Snow_Extent as files sns_pXXX.YY where XXX - pentad number, and YY - year. Monthly fields are presented in the directory Snow_Extent_Monthly as files sns_pXX.YY where XX - month number, and YY - year. Each file represents a matrix of 1383 by 199 (order: first X and then Y) byte values (1 byte, Windows format), that are coded as follows:: 0 - no snow; 1 - snow; 9 - ocean/excluded/data gaps. Examples are presented in Figure 1.



a)



b)

Figure 1. Snow extent for a) pentad 19 (1-5 April) of 1996 and b) April 1996. Green color - land, blue - snow, red - no data, white - ocean/excluded pixels.

4. Start and end dates of snow cover

The ground is considered to be snow-free when SG < 3°K. The timing of the snow appearance and disappearance has been calculated based on the temporal variability of the SG coefficient. In order to account for the data gaps (whole pentads missing or data missing for some regions) a procedure of re-calculating the SG for each pixel with missing data has been performed. If the SG value is missing for current pentad but exists for the previous and the next one, then a linear interpolation has been performed and a new SG value is assigned for the current pentad for this pixel. For period with large gaps (1987-1888 and 2003) a linear interpolation between SG values before and after the gap has been done.

The resulting dataset has been then analysed and timing (in pentads) of the start and end of the snow cover has been defined as follows: when the pixel was snow-free (pentad -1) and for three consecutive pentads (this and the two next pentads) it was snow-covered, then the start of the snow appearance (current pentad) has been attributed for this pixel for this year (and vice-versa for the snow disappearance).

When referring to the year, we use the notion of "winter year", i.e. 1988 means winter 1988/1989, with snow usually appearing in autumn 1988 and disappearing in spring 1989. In order to account for year change, timing is expressed in number of pentads elapsed after pentad 42 (25-29 July), thus pentad 43=1 and so on. Pentad 42 has been chosen as the one that has the lowest possible snow extent for the whole timespan of the dataset. Examples of maps showing the start and the end of snow cover are presented in figures 2 and 3.

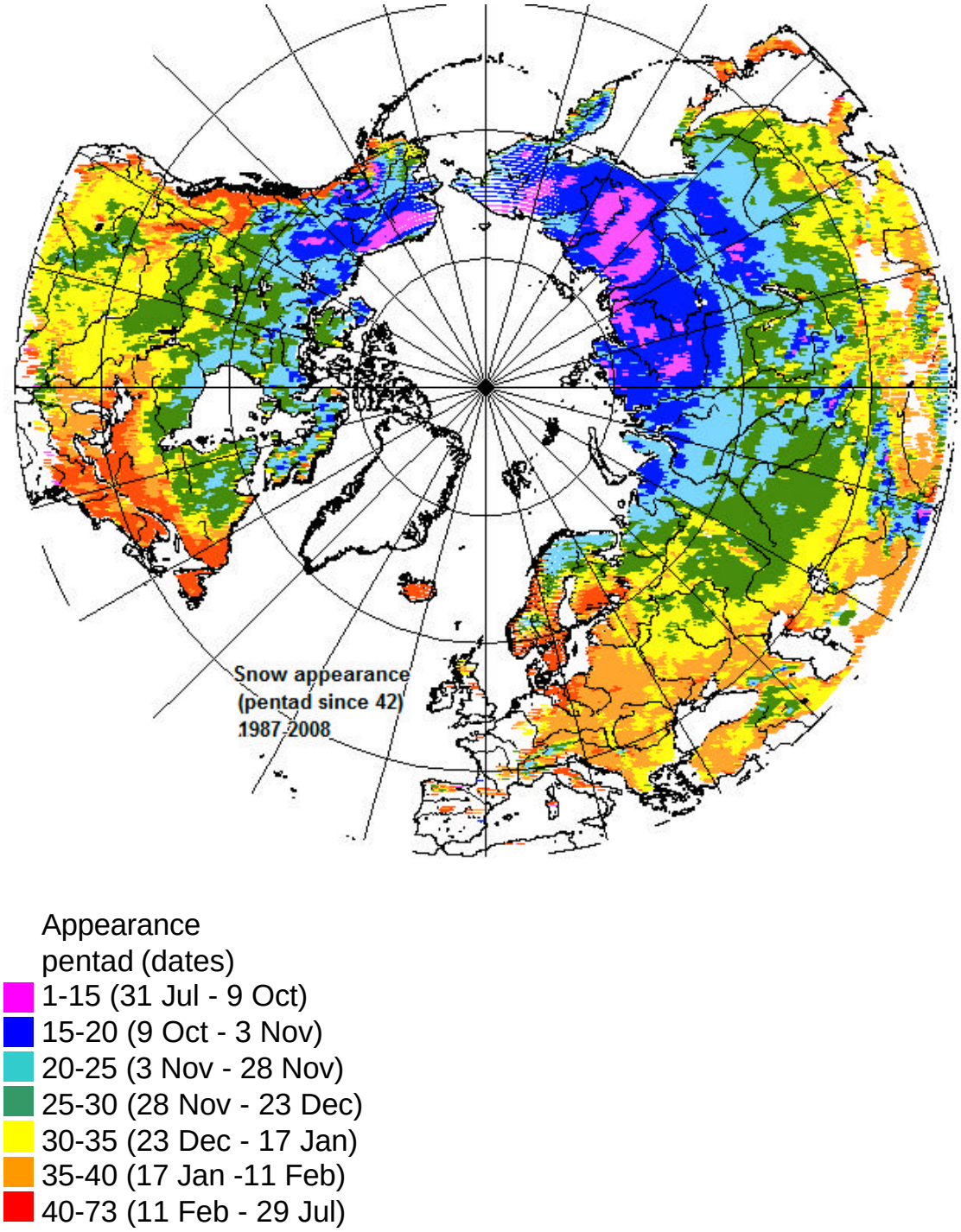


Figure 2. Average (1987-2008) dates (in pentads since pentad 42, July 29) of snow appearance.

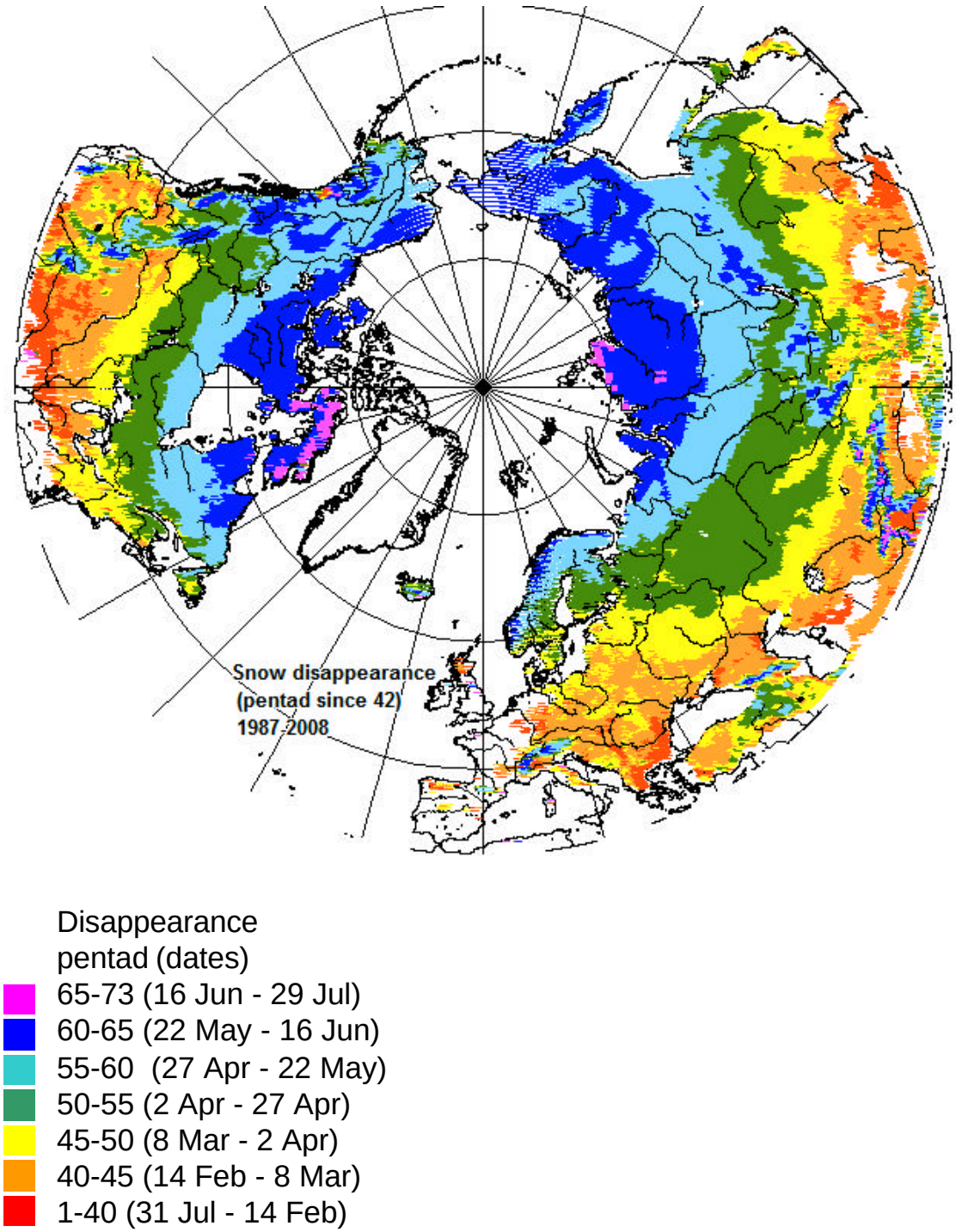


Figure 3. Average (1987-2008) dates (in pentads since pentad 42, 29 July) of snow disappearance.

Annual fields are presented in the directory Snow_Timing as files Start_YYYY or End_YYYY where YYYY - year number. Also average start and end timing for

1987-2008 are presented as files Start_all_1987_2008 and End_all_1987_2008. Each file represents a matrix of 1383 by 199 (order: first X and then Y) byte values (1 byte, Windows format).