WEATHER CONDITIONS
AIR TEMPERATURE, PRECIPITATIONS
SNOW DEPTH AND SNOW COVER

Marie-Christine Cadieux, Université Laval
Gilles Gauthier, Université Laval

PURPOSE

Climate has a strong impact on arctic wildlife species, either in the short term (e.g. due to strong annual variation in weather conditions) or in the long-term (e.g. due to global warming). In order to better understand theses impacts on wildlife and plants, we recommend the monitoring of a few basic weather variables. In many areas, climatic stations operated by Environment Canada can provide long-term data on weather but these stations are often located at some distance from our field sites. Therefore, it is recommended that some weather parameters are also monitored at the field site itself, at least during the field season, to have a record of local weather. The two most important weather variables to monitor are air temperatures and precipitations. Moreover, other climatic variables important to biological processes such as thawing degree-days, growing degree-days, and the number of frost-free days can be derived from air temperature data. In addition, snow depth and snow cover in spring should also be monitored because the timing of snow-melt in spring can have a considerable impact on the annual phenology of species. In this protocol, we offer two alternatives to collect weather data. The first alternative is to set an automated weather station that can record several weather parameters year round and store them into a data-logger. However, this method will probably be too expensive at most sites. Therefore, we also provide methods to manually record these weather parameters.

TIME PERIOD

If you have an automated weather station, data should be recorded on an annual basis. The recommended frequency of data collection is on an hourly basis, year-round. Data-logger memory can handle this amount of data without problems. If you are recording the weather manually, it should be recorded during the whole field season, from your arrival to the study site until your departure (for snow depth, until the end of snow-melt).

PROCEDURE 1: AUTOMATIC RECORDING

For year-round recording, we recommend setting up *Campbell Scientific* automated stations. On Bylot Island, we have 3 complete automated stations at various sites that have been operated continuously since 1994 in some cases. Here is the recommended list of weather parameters to monitor along with the instruments that should be used to record them. They are organized in decreasing order of priority (i.e. from the most to least important).

Parameter	Instrument
Air temperature and relative humidity (2.5 m above the ground)	Vaisala probe (models HMP35CF or HMP45CF) with radiation shield
Ground temperature (depth of 2 and 10 cm)	Campbell Scientific probe (model 107B)
Wind speed and wind direction (3 m above the ground)	Young Wind Monitor (model 05103-10)
Snow depth	Campbell Scientific sonic ranger (model SR50M)
Total solar radiation	LI-COR Silicon Pyranometer (model Li-200)
PAR (Photosynthetic active radiation)	LI-COR Quantum Sensor (model Li-190)
Net radiation and albedo (alternative to total radiation)	Kipp & Zonen Net Radiometer (model CNR-1)
Precipitation[1]	Geonor T-200

[1] Precipitation will be recorded automatically on Bylot Island only starting in 2007. Automatic recording of precipitation (especially snow) is one of the most difficult parameter

For data storage and as a control module, we suggest the Campbell Scientific CR10X (or equivalent) data logger.

PROCEDURE 2: MANUAL RECORDING

Daily air temperature

Daily air temperature is usually divided into three components: minimum temperature, maximum temperature and mean temperature. Air temperature should be recorded daily using a minimum/maximum thermometer installed inside a Stevenson screen mounted at 1.5 to 2 m above the ground with its door facing north. This louvered box shields the instrument from sunshine and precipitations and permits the free movement of air.

Minimum and maximum air temperatures are recorded twice daily (12 hrs apart) at 8AM and 8PM. These times can be adjusted depending on the latitude of each study sites. Mean air temperature is the average of the two.

Daily precipitations

Precipitations include rain, drizzle, freezing rain, freezing drizzle, hail and snow. All these types of precipitations, *except snow*, can be measured using a standard pluviometer installed at 1.5 to 2 m above the ground. It is important to make sure that it is installed VERTICALLY and that nothing will obstruct the arrival of the rain within a radius of a few meters from the funnel. Hence, care must be taken to locate the pluviometer above the highest point of the structure where it is installed (e.g. roof of a low building or a tent).

Since we want the data to represent the daily accumulation of precipitations, it is recorded only once at the end of the **every day** between 9PM and 10PM. This can be adjusted depending on the latitude of each study sites. Precipitation is recorded in **millimeters**.

Snowfalls are not recorded using a pluviometer. Instead, it should be estimated by measuring the accumulation of snow (in cm) at a few locations on the ground using a ruler. The average of these

measures can then be transform into rain accumulation using the "ten-to-one" rule (1 cm of snow = 1 mm of rain). However, this method is usually less accurate than snowfalls recorded using a Nipher gauge (used on automated weather stations) because of snow accumulations due to wind.

Snow depth during spring

Snow depth measurements are recorded at 50 stations along two 250-m parallel transects at 2-day intervals. Transects should be located in representative lowlands and away from areas that are visited often early in the field season to minimise trampling around the stations, which would accelerate snow melt. Both transects are parallel and ~100 m from each other. Each has 25 stations spaced 10 m apart and individually marked by a permanent wooden stake identified by a number (from 1 to 50). The beginning and end of each transect should be positioned with a GPS. These transects are left in place permanently and are reused annually.

At each station, use a metal rod that you drive firmly in the snow until you reach the ground (put enough pressure on the rod to be sure that you have gone through any ice crust). The rod should be sunk twice at 2 random points between 10 and 100 cm from the stake (not at the stake itself, which may influence snow accumulation). The snow depth is given by how much the rod sunk into the ground. Measure this along the rod using a meter stick (± 1 cm). The average of these 2 values is used as the snow depth of the station.

If your site is reused for many years, an alternative is to buy 50 meter-sticks and to screw them on the transect stakes. Take care to set the "0" of the ruler at the ground lever. During each visit, the snow depth at each station is read directly on the meter-stick. Because the wooden stake can influence snow accumulation or snow melt around the station, it may be useful to carry a 1-m stick that you put on the ground in front of the vertical ruler (position the vertical ruler in the middle of the horizontal stick). Where the horizontal stick will intercept the vertical ruler will provide an average snow depth of the surrounding.

If the ground is partly uncovered around the station, you proceed as follows:

1) if > 50% of the ground is uncovered within a 50-cm radius of the station, the depth recorded is "0"
2) if ≤ 50% of the ground is uncovered within a 50-cm radius of the station, you estimate the depth according to the snow that is still present around the station

The procedure is repeated until all the snow has disappeared.

Snow cover during spring

Snow cover should be evaluated every 2 to 3 days from an elevated vantage point (e.g. small hill or observation tower) starting on the date of your arrival at the study site until the end of snowmelt. The study site should be divided into easily recognizable sectors in the field and identified on a map to facilitate the evaluation of snow cover by different observers year after year. For example, on Bylot Island these sectors are primarily divided by the glacier's river which runs through the valley:

- hills (north and south separately)
- lowlands of the valley towards the glacier (north and south separately)
- lowlands in the middle of the valley (north and south separately)
- lowlands of the valley towards the ocean (north and south separately)
- shores of the glacier's river (north and south separately)

A percentage of snow cover is given for each sector as well as for the overall sectors (e.g. all hills separately, all lowlands separately) and the whole study site (all sectors). In order to compare data among years, a specific date should be chosen for which the snow cover will be evaluated EVERY YEAR. On Bylot Island we have the snow cover on 5 June every year since 1988 as a reference point.

MATERIAL (manual recording)

- Maximum/minimum thermometer and a Stevenson screen
- Pluviometer
- 50 wooden stakes 1.5-m high
- Permanent felt marker
- 1 wooden meter-stick
- Field book
- GPS