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Editorial

Svalbard Meteorology

Igor Esau,[1] Stefania Argentini,[2] Rajmund Przybylak,[3] Irina Repina,[4] and Anna Sjöblom[5]

[1] *Nansen Environmental and Remote Sensing Centre (NERSC), Thormohlensgt. 47, 5006 Bergen, Norway*
[2] *Istituto di Scienze dell' Atmosfera e del Clima (ISAC), Consiglio Nazionale delle Ricerche (CNR), Via Fosso del Cavaliere 100, 00133 Roma, Italy*
[3] *Department of Climatology, Nicolaus Copernicus University, ul. Gagarina 11, 87-100 Torun, Poland*
[4] *A. M. Obukhov Institute for Atmospheric Physics, Russian Academy of Science, Pyzhevsky 3, 119017 Moscow, Russia*
[5] *University Centre in Svalbard, 9171 Longyearbyen, Norway*

Correspondence should be addressed to Igor Esau, igore@nersc.no

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The Svalbard archipelago (Spitsbergen is the name of the main island, whereas Svalbard is the official name of the whole archipelago between 76°26′N (Bjørnøya) and 80°50′N (Sjuøyane) and 10°30′E and 28°10′E) is one of the most remote places on the Earth with the North Pole located just a thousand kilometers away. The total land area of the archipelago is 62,450 km^2, about 60% of which is covered by ice. The islands' coastline is very complex with many *fjords*—long, narrow inlets with steep sides or cliffs, created in a valley carved by glacial activity. Svalbard's location and topography create its unique polar-maritime climate, which is shaped by continuous fight between open water of the North Atlantic Ocean, Arctic sea ice, and mountain glaciers. Winters here are less cold than they are at any other location on these latitudes. The required heating is delivered by both the meridional atmospheric circulation and the ocean currents. It makes the climate strongly sensitive to the global scale variability. Locally, the West Spitsbergen current is the primary source of heat and moisture along Spitsbergen's west coast. This makes the climate of western and northern coasts relatively mild, with little sea ice. Eastern parts of Svalbard are influenced by a cold current coming from the northeast. This current brings cold polar water masses and a lot of drifting sea ice from the polar ocean even in the summer.

At present, inhospitable land and waters of the archipelago witness tremendous climate change and therefore attract considerable attention of the international research community. Distinct to other places in the Arctic, a significant share of the Svalbard research is driven not as episodic expeditions or field experiments but using permanent research stations. Moreover, the Svalbard research is truly international, for example, the international research station situated at Ny Ålesund (78°55′N, 11°56′E) is operated by about 150 Norwegian, German, Japanese, Italian, French, and UK researchers and open for researchers of other nations. This station is included into the International Arctic System for Observing the Atmosphere (http://iasoa.org). The University Centre in Svalbard (UNIS) is the world's northernmost institution for higher education and research, located in Longyearbyen, Spitsbergen at 78°N.

The combination of the challenging research problems and opportunities to drive the high quality research on the archipelago has already resulted in extensive scientific production. Figure 1 shows historical development of the number of publications (according to ISI Web of Science) discussing one or another aspect of the Svalbard meteorology. In total, more than 1500 publications appeared since 1980. The recent International Polar Year has brought more research results to be reported. This development and importance of the polar research to humanity motivated us to organize this special issue.

Regular meteorological observations on Svalbard are known since the period of the first International Polar Year (1882-1883). Since 1911, observations were regularly conducted in the area of Isfjorden on the west coast. This long observational record in the high latitude region with large natural variability makes Svalbard particularly interesting and important for climate studies. Therefore it is not surprising that a large part of contributions to this issue is dealing with the analysis of the temperature record from Isfjorden

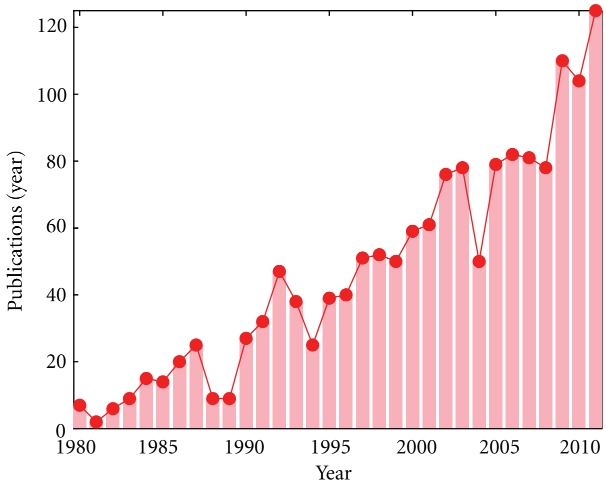

Figure 1: Number of publications by years dealing with one or another aspect of Svalbard meteorology according to ISI Web of Science data base.

(see Figure 2). Many authors have analyzed temperature and precipitation development, variability and trends. For all temperature series, positive linear trends were found for annual values as well as spring, summer, and autumn series. A very strong winter warming was identified for the latest decades. Significant changes were also observed in other essential climate variables, for example, in the total cloudiness, aerosols, and precipitation. Mean annual total nitrogen deposition was 74 mg N/(m^2 yr) but exhibited large interannual variability and was dominated by highly episodic "strong" events. Trends of reactive nitrogen emissions from Europe are uncertain, and increasing cyclonic activity over the North Atlantic caused by a changing climate might lead to more strong deposition events in Svalbard.

Although the temperature trends are clearly identified in observations, attribution of specific climate change causes remains less certain in the region due to the mentioned large impact of nonlocal advective processes, teleconnections, and long-term variability. This makes the attribution of the regional climate records distinct to the attribution on the larger continental and global scales published elsewhere. Temperature trends downscaled from global climate models forced with observed greenhouse gas emissions span the observation-based trends at Svalbard Airport 1912–2010. Novel projections focusing on the Svalbard region indicate a future warming rate for winter months up to year 2100 three times stronger than that observed during the latest 100 years. The average winter temperature in the Longyearbyen area at the end of this century is projected to be around 10°C higher than in present climate. Also for precipitation, the long-term observational series indicate an increase and the projections indicate a further increase up to year 2100. At the same time, natural variability is also strongly decreasing the signal-to-noise ratio in attribution studies. It was found that temperature at Svalbard is negatively correlated with the length of the solar cycle. The strongest negative correlation is found with lags of 10–12 years. The relations between the length of a solar cycle and the mean temperature in the following cycle are used to model Svalbard annual mean temperature and seasonal temperature variations. These models show that 60 per cent of the annual and winter temperature variations are explained by solar activity. XXIst century temperature prediction by a statistical model is rather opposite to the prediction of the green-house gas forcing driven models. The statistical model predicts an annual mean temperature decrease for Svalbard from solar cycle 23 to solar cycle 24 (2009–20) and a decrease in the winter temperature could be as large as −6°C. As Figure 2 shows, there is no clear signal yet.

It is worth to emphasize that the Svalbard surface layer climate is significantly modified by the specific climate conditions of fjords and mountain valleys. Hence, interpretation of numerical simulation results where those specific conditions are not properly reproduced, such as in the state-of-the-art climate models, must be done with care. Similarly, the statistical relationships could depend on dominant circulation patterns in the region and therefore must be also extrapolated with care. Chapman and Walsh [2] and Alexeev et al. [3] disclosed particularly large discrepancies between different reanalyses and models in the Svalbard–Barents Sea region. Fine-resolution regional simulations by Kilpeläinen et al. [1, 4] demonstrated that climate conditions in the fjords could be significantly different from those over open areas. Moreover, the modeled temperature can differ by several degrees depending on model resolution and weather conditions.

Observational studies in Svalbard fjords (e.g., Isfjorden and Kongsfjorden) are now done using the most advanced instrumentation, for example, applying three tethersonde systems and a new lidar system (MULID). The inversion strength and depth were strongly affected by weather conditions at the 850 hPa level. Strong inversions were deep with a highly elevated base, and the strongest ones occurred in warm air mass. Unexpectedly, downward longwave radiation measured at the sounding site did not correlate with the inversion properties. Most low-level jets were related to katabatic winds. Over the ice-covered Kongsfjorden, jets were lifted above a cold-air pool on the fjord; the jet core was located highest when the snow surface was coldest. At the ice-free Isfjorden, jets were located lower. The conclusions that most jets are of katabatic origin are challenged with turbulence-resolving simulations. This work suggested the leading roles of the thermal land-sea breeze circulation and the mechanical wind channeling in the modulation of the valley winds. The characteristic signatures of the developed down-slope gravity accelerated flow, that is, the katabatic wind, were found to be of lesser significance under typical meteorological conditions. Modellers simulated the atmospheric conditions over three Svalbard glaciers using the ERA-Interim reanalysis for boundary forcing and three nested model grids with 24 km, 8 km, and 2.7 km resolutions. They concluded that the choice of different physics schemes only slightly changed the model results. The polar-optimized microphysics scheme outperformed a slightly simpler microphysics scheme, but the two alternative and more sophisticated planetary boundary layer (PBL) schemes

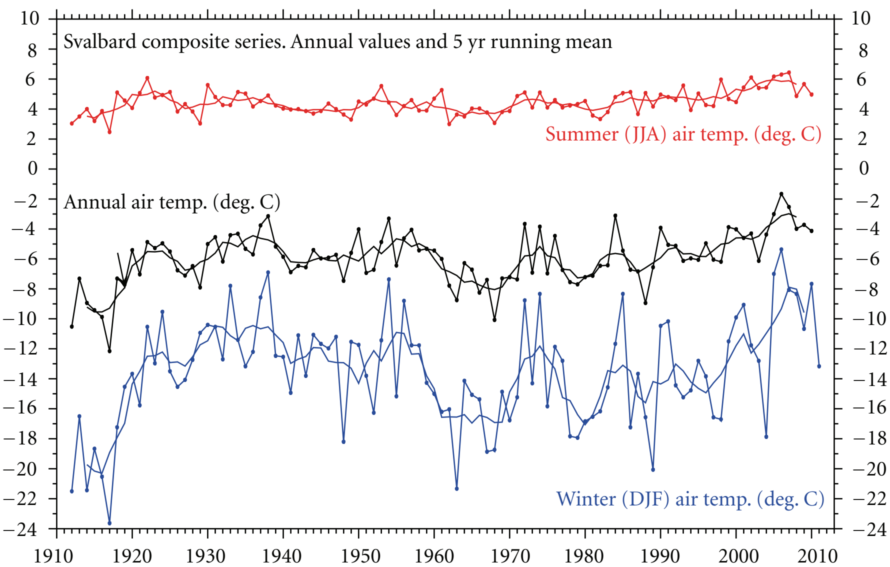

FIGURE 2: The Svalbard temperature record 1912–2010, showing the mean annual air temperature (MAAT), the average summer temperature (JJA), and the average winter temperature (DJF). Thin lines show annual values, and thick lines show the simple 5 yr average (extracted from [1]).

improved the model score. It should be noted that the polar PBL is rather different from its low- and midlatitude counterparts as the horizontal heat advection and negative surface radiation balance maintain temperature inversions over long periods of time.

The Svalbard meteorology is considerably affected by processes in the ocean surrounding the archipelago. Studies of the Arctic Ocean between Svalbard and Franz Joseph Land elucidate the possible role of Atlantic water (AW) inflow in shaping ice conditions. Ice conditions substantially affect the temperature regime of the Spitsbergen archipelago, particularly in winter. The hypothesis is that intensive vertical mixing at the upper AW boundary releases substantial heat upwards that eventually reaches the underice water layer, thinning the ice cover. Analysis of 1979–2011 ice properties revealed a general tendency of decreasing ice concentration that commenced after the mid-1990s. AW temperature time series in Fram Strait feature a monotonic increase after the mid-1990s, consistent with shrinking ice cover.

The contributions to this special issue present not only diversity of the research activity at Svalbard but also complexity of the specific high-latitude environmental phenomena to be studied. They also indicate the need for better integration of research in different scientific fields and disciplines. Unfortunately, the large amount of meteorological observations and other research data remains unavailable for broader research community. Many datasets need careful quality control and homogenization. The discrepancies between model results and observations are to be better attributed and need to be significantly reduced. Recently, these needs were finally met and addressed in European and national research programs, for example, the Norwegian Polar Program (http://www.forskningsradet.no/prognett-polarforskning/Home_page/1231229969357).

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Igor Esau
Stefania Argentini
Rajmund Przybylak
Irina Repina
Anna Sjöblom

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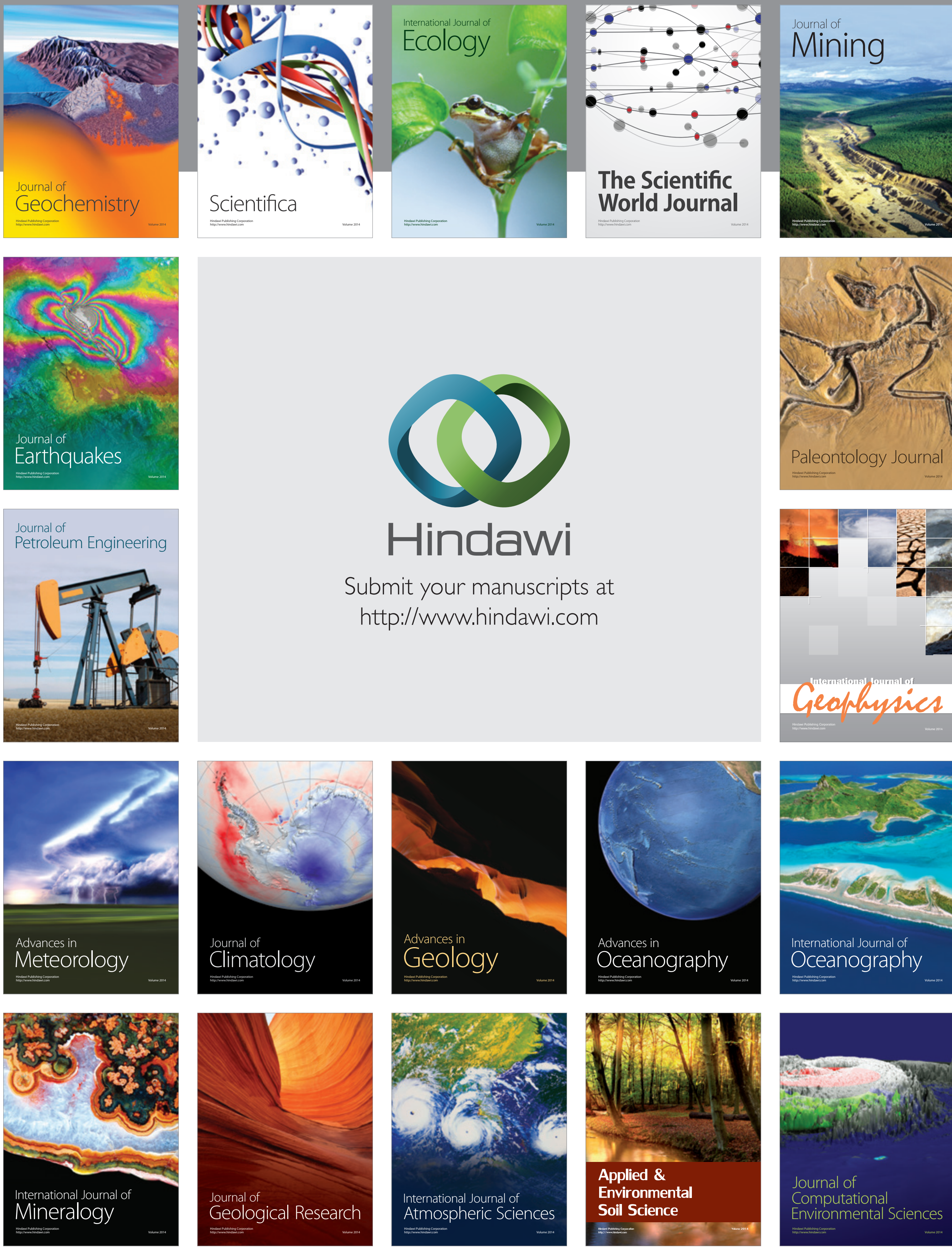
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