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НАУЧНЫЙ РЕФЕРИРУЕМЫЙ СБОРНИК ТРУДОВ ИНСТИТУТА ГИДРОМЕТЕОРОЛОГИИ ГТУ, Т. 131. 2021
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Influence of atmospheric circulation anomalies on weather and climate in Georgia.

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The North Atlantic Oscillation (NAO) index is based on the surface sea-level pressure difference between the Subtropical (Azores) High and the Subpolar - Low. The positive phase of the NAO reflects below-normal heights and pressure across the high latitudes of the North Atlantic and above-normal heights and pressure over the central North Atlantic, the eastern United States and Western Europe. The negative phase reflects an opposite pattern of height and pressure anomalies over these regions. Both phases of the NAO are associated with basin-wide changes in the intensity and location of the North Atlantic jet stream and storm track, and in large-scale modulations of the normal patterns of zonal and meridional heat and moisture transport, which in turn results in changes in temperature and precipitation patterns often extending from eastern North America to western and central Europe.

Strong positive phases of the NAO tend to be associated with above-normal temperatures in the eastern United States and across northern Europe and below-normal temperatures in Greenland and oftentimes across southern Europe and the Middle East [1,6]. They are also associated with above-normal precipitation over northern Europe and Scandinavia and below-normal precipitation over southern and central Europe. Opposite patterns of temperature and precipitation anomalies are typically observed during strong negative phases of the NAO. During particularly prolonged periods dominated by one particular phase of the NAO, abnormal height and temperature patterns are also often seen extending well into central Russia and north-central Siberia. The NAO exhibits considerable interseasonal and interannual variability, and prolonged periods (several months) of both positive and negative phases of the pattern are common.

The NAO index is obtained by projecting the NAO loading pattern to the daily anomaly 500 millibar height field over 0-90°N. The NAO loading pattern has been chosen as the first mode of a Rotated Empirical Orthogonal Function (EOF) analysis using monthly mean 500 millibar height anomaly data from 1950 to 2000 over 0-90°N latitude.

The NAO has been linked with a variety of meteorological and non-meteorological effects across a wide spatial and multiple temporal scales, and only a selection of these impacts can be mentioned here. For example, Nesje, Lie, and Dahl (2000) showed a strong relationship between the mass balance of Scandinavian glaciers and the NAO due to the controlling influence of the storm tracks by the NAO, which influenced precipitation amounts, and glacier mass balance as a result. Coincidentally, the NAO has been shown to explain a large amount of the variance in Norwegian streamflow (55%) and hydropower output (30%), influencing electricity consumption and prices (Cherry et al., 2005). Baltic sea-ice extent is also strongly related to NAO changes (Karpechko, Peterson, Scaife, Vainiko, & Gregow, 2015). Cropper, Hanna, and Bigg (2014) found an influence of the NAO as far south as 20°N in coastal upwelling-inducing winds along the northwest African coastline. The great-circle distance between northwest Africa and Scandinavia is ~5,700 km, indicating the great spatial extent of the NAO influence. Recent NAO–climate linkages literature includes a strong signal of the (non-summer) NAO on precipitation in Iraq (Khidher & Pilesjö, 2015), an influence on sea-ice breakup date in south-central Ontario (Fu & Yao, 2015) and even a Southern Hemisphere influence, via a decadal-scale mechanism, on subtropical eastern Australian rainfall (Sun, Feng, & Xie, 2015).

Table 1. Five lowest and five highest NAO years for each calendar month and season, based on the Hurrell PC NAO index and the January 1899–February 2016 period, updated from Hanna et al. (2015).

Month	5 lowest	5 highest
Jan	1966, 1969, 1940, 1963, 1945	1993, 1989, 1983, 1928, 1990
Feb	1947, 2010, 1978, 1942, 1960	1990, 1989, 1997, 2000, 1959
Mar	2013, 1962, 1958, 1931, 1952	1986, 1990, 1913, 1920, 1994
Apr	1966, 1978, 1988, 1979, 2008	1947, 2011, 1943, 1990, 1904
May	1993, 2008, 1954, 1952, 1909	1956, 1963, 2009, 1914, 2015
Jun	1902, 1903, 2009, 1982, 2011/2012	1994, 1961, 1967, 1922, 1919
Jul	2015, 1907, 1962, 2009, 1918,	1964, 1920, 1946, 1935, 1975
Aug	1943, 1964, 1958, 2011, 1966	1991, 1971, 1983, 1961, 2013
Sep	1998, 1930, 1968, 1939, 1915	1975, 1947, 2009, 1917, 1950
Oct	2006, 1960, 2012, 1966, 1968	1986, 1957, 1983, 1938, 1935
Nov	1910, 1947, 1955, 1915, 1965	1978, 1982, 1992, 1953, 1913
Dec	2010, 2009, 1961, 1995, 1978	2011, 2006, 1951/1982, 2004

Particular increase in the NAO between the 1960s and 1990s was widely noted in previous work and was thought to be related to human-induced greenhouse gas forcing. However, since then this trend has reversed, with a significant decrease in the summer NAO since the 1990s and a striking increase in variability of the winter especially December—NAO that has resulted in four of the six highest and two of the five lowest NAO Decembers occurring during 2004–2015 in the 116-year record, with accompanying more variable year-to-year winter weather conditions over the United Kingdom. These NAO changes are related to an increasing trend in the Greenland Blocking Index (GBI; equals high pressure over Greenland) in summer and a significantly more variable GBI in December. Such NAO and related jet stream and blocking changes are not generally present in the current generation of global climate models, although recent process studies offer insights into their possible causes. Several plausible climate forcing and feedbacks, including changes in the sun's energy output and the Arctic amplification of global warming with accompanying reductions in sea ice, may help explain the recent NAO changes. Recent research also suggests significant skill in being able to make seasonal NAO predictions and therefore long-range weather forecasts for up to several months ahead for northwest Europe [2,3]. However, global climate models remain unclear on longer-term NAO predictions for the remainder of the 21st century.

Climate phenomena subject to MJO influences include the monsoons and several climate modes such as ENSO, the North Atlantic Oscillation (NAO), the AO and Antarctic Oscillation (AAO), the Pacific North American (PNA) pattern, and the Indian Ocean Dipole (IOD). While these climate modes all feed back to the MJO, discussions in this section focus on MJO effects on them.

During winter, the positive (negative) phase of the AO, also known as the Northern Annular Mode (NAM), is twice as likely to occur as the opposite phase when MJO convection is enhanced (suppressed) over the Indian Ocean. When MJO convection is enhanced (suppressed) in the Eastern Hemisphere, especially over the Maritime Continent, the number of days of positive (negative) AO phase becomes large. In November–March, 18–21% of the variance in extratropical 1000-hPa geopotential height is related to the MJO. The MJO influence on the AO is also through Rossby wave trains excited by MJO convection and propagating from the tropical Pacific into the extratropics.

The southern hemispheric counterparts of the NAM and AO are the Southern Annular Mode (SAM) and AAO. They are also influenced by the MJO. Negative (positive) phases of the AAO in austral winter tend to occur when MJO convection is enhanced (suppressed) over the central Pacific. The SAM reaches its maximum positive phase immediately after MJO convection peaks over the equatorial Indian Ocean. The Antarctic circumpolar transport can be accelerated by MJO-enhanced surface westerly wind associated with the SAM that covers almost the entire latitude circle at 60° S.

The NAO/NAM pattern is a result of the eddy-driven extratropical atmospheric circulation: specifically, the transport of heat and momentum by stationary eddies (longwaves or planetary waves in the northern polar jet stream) and transient eddies (cyclones and anticyclones forming within or along the jet stream) (e.g., Kaspi & Schneider, 2013). The polar jet stream is directly related to NAO changes and has a mean latitude somewhere between 50°N and 60°N over the eastern North Atlantic. The strongest westerly winds (of up to about 200 km/hr in the core of the jet near the tropopause) are typically experienced at these latitudes, and there is a clear clustering of extratropical storm tracks along the polar jet stream. The prevailing direction is westerly due to the Coriolis Effect of earth's rotation, which deflects air masses to the right of their direction of motion in the Northern Hemisphere. Longwaves develop in the jet stream because of orographic obstacles (e.g., the Rocky Mountains over North America) or east–west heating contrasts between land and sea, or variations in latent heating due to condensation and rainfall. Low- and high-pressure systems form due to strong horizontal contrasts in temperature, typically where cold polar air meets relatively warm tropical air masses. These transient eddies are very important in providing energy for maintaining the polar jet stream flow and mid-latitude westerlies, otherwise friction with the surface would slow and eventually halt the winds. However, a significant contribution to maintaining the westerlies—greater than in the Southern Hemisphere—comes from the stationary eddies: this is due to the much stronger land–ocean contrast effects in northern mid-latitudes [4,5] .

Being linked with the jet stream, there is a deep and pronounced vertical structure to the AO and NAO, which extends up into the stratosphere; this is most notable for the AO, which lies further north and is more directly linked with the polar vortex. What happens in the stratosphere in polar winter can also have a big bearing on conditions in the troposphere: for example, stratospheric sudden warming are associated with a weakening and sometimes reversal of the polar vortex and development of negative NAO/ AO that sometimes occurs in mid- to late winter (e.g., Cohen et al., 2014; Marshall & Scaife, 2010). Stratosphere–troposphere interaction and coupling is not very well understood, yet is important for NAO dynamics (Kidston et al., 2015). It appears from theory and observations that planetary-scale Rossby waves can propagate upwards from the troposphere into the stratosphere under conditions of moderate westerly flow during boreal winter; the stratosphere is effectively decoupled from the troposphere in other seasons. If the wintertime polar vortex is weak (strong), the upward-propagating waves can (cannot readily) interact with and slow the upper-level westerly flow. There is also a kind of reverse effect where airflow anomalies in the stratosphere can propagate down to affect the near-surface circulation (Baldwin & Dunkerton, 2001). The time of operation of these changes is typically 2–3 weeks, although dynamical couplings range over timescales from daily to multidecadal (Kidston et al., 2015).

Between the 1960s and 1990s the NAO was becoming more positive, but since then this trend has tended to reverse. Recently updated observational records and reanalyses showed increasing variability of winter NAO and AO, which is a feature not just of the 2000ts and early 2010ts but has been ongoing during the 20th century.

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ატმოსფეროს ცირკულაციური ანომალიების გავლენა ამინდზე და კლიმატზე საქართველოში მ. ტატიშვილი,ზ.ხვედელიძე, ი. სამხარაძე, ა.ფალავანდიშვილი./ სტუ-ის ჰმი-ს სამეცნ. რეფ. შრ. კრებ. – 2021- - ტ.131. - გვ.56-58. - ინგლ.; რეზ.: ქართ., ინგლ., რუს.

სტატიაში განხილულია ჩრდილოატლანტიკური ოსილაციის ინდექსი (NAO), რომელიც ეფუძნება ზედაპირული ზღვის წნევის დონეების სხვაობას სუბტროპიკულ (აზორის) მაღალსა და სუბპოლარულ დაბალს შორის. NAO– ს პოზიტიური ფაზა ასახავს სიმაღლეებს და წნევას ნორმის ქვემოთ ჩრდილო ატლანტიკის მაღალ განედებზე და და წნევას ცენტრალურ ჩრდილო – ატლანტიკურზე, აღმოსავლეთ შეერთებულ შტატებსა და დასავლეთ ევროპაზე. NAO ასახავს ჩრდილოატლანტიკური პოლარული ციკლონის რეაქტიული ნაკადის მდებარეობასა და წნევის ცვლილებებს და დაკავშირებულია ატლანტიკის შუა და მაღალ გრძედის ამინდსა და კლიმატზე გავლენაზე. უფრო პოზიტიური (უარყოფითი) NAO / AO ინდექსი წარმოადგენს ძლიერ (სუსტ) ჰაერის ნაკადს ჩრდილოეთ ნახევარსფეროს გარშემო და ციკლონური ნაკადის გადაადგილებას ჩრდილოეთ ატლანტიკის ჩრდილოეთით (სამხრეთით).

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The North Atlantic Oscillation (NAO) index has been discussed in presented article, which is based on the surface sea-level pressure difference between the Subtropical (Azores) High and the Subpolar Low. The positive phase of the NAO reflects below-normal heights and pressure across the high latitudes of the North Atlantic and above-normal heights and pressure over the central North Atlantic, the eastern United States and Western Europe. The NAO reflects changes in the position and strength of the North Atlantic polar front jet stream and has associated effects on the weather and climate of mid-to-high latitudes within and around the Atlantic. The more positive (negative) NAO/AO index represents stronger (weaker) airflow around the Northern Hemisphere and a jet stream that is shifted further north (south) over the North Atlantic.

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Влияние аномалий атмосферной циркуляции на погоду и климат Грузии. /Татишвили М.Р., Хведелидзе З.В., Самхарадзе И.Н., Палавандишвили А.М../ Сб. Трудов ИГМ, ГТУ. - 2021. - вып.131. - с.56-58. - Анг .;Рез. Груз., Анг., Рус В представленной статье рассматривается Индекс Североатлантического колебания (NAO) которая основана на разнице давления на уровне моря между субтропическим (Азорскими) максимумом и субполярным минимумом. Положительная фаза NAO отражает высоты и давление ниже нормы в высоких широтах Северной Атлантики и высоты и давление выше нормы в центральной части Северной Атлантики, восточной части Соединенных Штатов и Западной Европе. NAO отражает изменения в положении и силе струйного течения на полярном фронте в Северной Атлантике и оказывает связанное с этим влияние на погоду и климат в средних и высоких широтах в Атлантике и вокруг нее. Более положительный (отрицательный) индекс NAO / AO представляет более сильный (более слабый) воздушный поток вокруг Северного полушария и струйный поток, который смещается дальше на север (юг) над Северной Атлантикой