

The North Atlantic Oscillation
Climatic Significance and Environmental Impact

James W. Hurrell
Yochanan Kushnir
Geir Ottersen
Martin Visbeck
Editors

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Preface

James W. Hurrell, Yochanan Kushnir, Geir Ottersen, and Martin Visbeck vii

An Overview of the North Atlantic Oscillation

James W. Hurrell, Yochanan Kushnir, Geir Ottersen, and Martin Visbeck 1

The History of Scientific Research on the North Atlantic Oscillation

David B. Stephenson, Heinz Wanner, Stefan Brönnimann, and Jürg Luterbacher 37

Pressure-Based Measures of the North Atlantic Oscillation (NAO): A Comparison and an Assessment of Changes in the Strength of the NAO and in Its Influence on Surface Climate Parameters

Philip D. Jones, Timothy J. Osborn, and Keith R. Briffa 51

Multi-Proxy Reconstructions of the North Atlantic Oscillation (NAO) Index: A Critical Review and a New Well-Verified Winter NAO Index Reconstruction Back to AD 1400

Edward R. Cook 63

Atmospheric Processes Governing the Northern Hemisphere Annular Mode/North Atlantic Oscillation

David W. J. Thompson, Sukyoung Lee, and Mark P. Baldwin 81

The Ocean's Response to North Atlantic Oscillation Variability

Martin Visbeck, Eric P. Chassignet, Ruth G. Curry, Thomas L. Delworth, Robert R. Dickson, and Gerd Krahnmann 113

The Role of Atlantic Ocean-Atmosphere Coupling in Affecting North Atlantic Oscillation Variability

Arnaud Czaja, Andrew W. Robertson, and Thierry Huck 147

On the Predictability of North Atlantic Climate

Mark J. Rodwell 173

Climate Change and the North Atlantic Oscillation

Nathan P. Gillett, Hans F. Graf, and Tim J. Osborn 193

The Response of Marine Ecosystems to Climate Variability Associated With the North Atlantic Oscillation

Kenneth F. Drinkwater, Andrea Belgrano, Angel Borja, Alessandra Conversi, Martin Edwards, Charles H. Greene, Geir Ottersen, Andrew J. Pershing, and Henry Walker 211

The Response of Terrestrial Ecosystems to Climate Variability Associated With the North Atlantic Oscillation

Atle Mysterud, Nils Chr. Stenseth, Nigel G. Yoccoz, Geir Ottersen, and Rolf Langvatn 235

The Response of Freshwater Ecosystems to Climate Variability Associated With the North Atlantic Oscillation

Dietmar Straile, David M. Livingstone, Gesa A. Weyhenmeyer, and D. Glen George 263

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This volume represents a current and authoritative survey of the ever-growing body of literature on the North Atlantic Oscillation. It is unique: no other such volume exists. As such, we, the editors, hope it is a valuable resource for students and researchers alike.

PREFACE

Over the middle and high latitudes of the Northern Hemisphere the most prominent and recurrent pattern of atmospheric variability is the North Atlantic Oscillation (NAO). The NAO refers to swings in the atmospheric sea level pressure difference between the Arctic and the subtropical Atlantic that are most noticeable during the boreal cold season (November–April) and are associated with changes in the mean wind speed and direction. Such changes alter the seasonal mean heat and moisture transport between the Atlantic and the neighboring continents, as well as the intensity and number of storms, their paths, and their weather. Significant changes in ocean surface temperature and heat content, ocean currents and their related heat transport, and sea ice cover in the Arctic and sub-Arctic regions are also induced by changes in the NAO. Such climatic fluctuations affect agricultural harvests, water management, energy supply and demand, and fisheries yields. All these effects have led to many studies of the phenomenon; yet, despite this interest, unanswered questions remain regarding the climatic processes that govern NAO variability, how the phenomenon has varied in the past or will vary in the future, and whether it is at all predictable.

Focusing exclusively on the NAO and its impacts, this monograph brings together for the first time atmospheric scientists, oceanographers, paleoclimatologists, and biologists to present a state-of-the-art assessment of the current understanding of this important climate phenomenon and its environmental and societal consequences. Indeed, the outstanding feature of the monograph is its multidisciplinary content presented in 12 papers thematically organized. Each paper provides a thorough overview of different facets of the NAO phenomenon and contains new research as well.

The NAO is one of the oldest known world weather patterns, as some of the earliest descriptions of it were from seafaring Scandinavians several centuries ago. The monograph presents a stimulating account of the major scientific landmarks of NAO research through time while also stressing the present renewed interest in the phenomenon. The NAO and its time dependence, for instance, appear central to the current global climate change debate. The

monograph assesses whether recent changes in the atmospheric circulation of the North Atlantic are beyond natural variability by synthesizing a diverse body of literature dealing with how the NAO might change in response to increasing concentrations of greenhouse gases. The relationship between the NAO and anthropogenic climate change has also made it critical to better understand how the NAO and its influence on surface climate have varied in the past. These issues are addressed in separate papers using long instrumental records and paleoclimate proxies.

Another reason for recent invigorated interest in the NAO is that the richly complex and differential responses of the surface-, intermediate- and deep-layers of the ocean to NAO-induced forcing are becoming better documented and understood. The state of knowledge about the oceanic response to changes in NAO forcing is reviewed from theoretical, numerical experimentation and observational perspectives.

That the ocean may play an active role in determining the evolution of the NAO is one of the most debated aspects of this climatic phenomenon, and it is thoroughly investigated in the monograph. If such a role can be delineated and understood, it may also provide one pathway to predictability. New statistical analyses have revealed patterns in North Atlantic sea surface temperatures that precede specific phases of the NAO by 6–9 months, a link that most likely involves the remarkable tendency of the extratropical ocean to preserve its thermal state throughout the year. These results are reviewed and evaluated in a separate paper using observations and global ocean-atmosphere model data.

A second pathway that offers hope for NAO predictions involves links to the stratosphere. A wintertime statistical connection between the month-to-month variability of the strength of the stratospheric polar vortex and the NAO was established several years ago; more recently, it has been argued that large amplitude anomalies in the former precede anomalous behavior of the NAO by 1–2 weeks. The monograph describes these results together with the general state of knowledge on the complex dynamical processes within the atmosphere necessary to understand the NAO behavior.

Renewed interest in the NAO has also come from the biological community. Variations in climate have a profound influence on a variety of ecological processes and, consequently, patterns of species abundance and dynamics. Fluctuations in temperature and salinity, vertical mixing, circulation patterns and ice formation of the North Atlantic Ocean influenced by variations in the NAO have a demonstrated effect on marine biology and fish stocks through both direct and indirect pathways. Responses of terrestrial ecosystems to NAO fluctuations have also been documented. Likewise, the NAO affects lake temperature profiles, lake ice phenology, river runoff, lake water levels, and ultimately the population dynamics of freshwater organisms.

The monograph derives from the American Geophysical Union Chapman Conference on the NAO convened in Ourense, Spain, in the fall of 2000. Each paper was subjected to critical peer review and was revised accordingly. A total of 42 specialists participated in writing the material for the book, and 36 expert referees made substantial contributions to the overall quality and content of the mono-

graph. It is the first time that the NAO phenomenon is addressed in such a comprehensive manner, providing a current and authoritative survey of the ever-growing body of literature on the NAO. The monograph offers extensive information on different levels that can be useful to the students and scientists of climate and environmental studies as well as to non-scientists who are interested in this topic.

James W. Hurrell
National Center for Atmospheric Research

Yochanan Kushnir
Lamont-Doherty Earth Observatory

Geir Ottersen
Institute of Marine Research

Martin Visbeck
Lamont-Doherty Earth Observatory