Machine Learning for Extreme Weather Detection: Part II

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Objective: This proposal can be read as an extension to the first one, but here we elaborate more on the detection of aerosols in the atmosphere and their influence on Arctic Amplification and stalling patterns of Rossby waves.

I. INTRODUCTION

A good prediction of extreme weather events is urgently needed, as those become more common due to climate change as a recent study shows [2]. The researchers found that extreme weather events in the Northern Hemisphere are not only characterized by an increase in frequency, but also by a longer duration and size of the affected area. Some scientific studies link this directly to an increase in temperature (e.g.[3, 4]), while other named Arctic amplification (AA) as one of the causes (e.g. [5–8]). But recent studies agree that the persistent episodes of extreme weather in the mid-latitudes are caused by stalling patterns of Rossby waves in the Northern hemisphere jet stream (e.g. [9–14]), which result from quasi-resonant amplification (QRA).

In [14] different CMIP5 models were able to predict an increase of QRA events by on average 50%, but the results varied greatly among the models. The variation in outcome was mainly caused by the inclusion of amplified Arctic warming in some of the models, which lead to a higher increase in QRA events. Moreover the outcome of the models were highly dependent on the predicted changes in radiative forcing due to antropogenic aerosols. Those aerosols have a strong effect on AA warming, and it was shown in [15, 16] that a past reduction in those aerosols in Europe could have increased this effect. On the other side, AA warming also seems to have an effect on the the aerosol optical depth in Northern Europe [17]. However, climate models are often not adequate enough to detect these interactions due to aerosols [16, 18].

II. APPROACH

Machine learning could help to detect the amount of aerosols in the troposphere, such as sulfates, by scanning satellite data of for example the Sentinel5p mission (for SO2). It could also be used to measure the amount of sea-ice in the Arctic, and report changes over a longer period of time. The results can then be compared to each other and help to connect some of the dots that exist on aerosol influence on AA warming/cooling.

Moreover, machine learning can be used to detect the stalling patterns of Rossby waves in the Northern Hemisphere jet stream, that are caused by QRA events. Those can be identified by looking at zonally averaged surface temperature fields [14]. Hence those events can be detected and linked to persistent extreme weather events in the Northern Hemisphere. Again a comparison with CMPIP5 climate models can be performed to quantify the accuracy of such an algorithm.

Both approaches mentioned here need to be worked out further, and a feasibility and more extensive literature study could shed a light on the machine learning techniques that can be used and the expected research outcome.

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