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The North Atlantic Ocean as a Modulator of Vegetation Greening/Browning in the Northern High Latitudes?

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Vegetation in the northern high latitudes shows a characteristic pattern of persistent changes as documented by multi-decadal satellite observations. The prevailing explanation that these mainly increasing trends (greening) are a consequence of external CO_2 forcing, i.e., due to the ubiquitous effect of CO2-induced fertilization and/or warming of temperature-limited ecosystems, however does not explain why some areas also show decreasing trends of vegetation cover (browning). We propose here to consider the dominant mode of multi-decadal internal climate variability in the north Atlantic region, the Atlantic Multidecadal Variability (AMV), as the missing link in the explanation of greening and browning trend patterns in the northern high latitudes. Such a link would also imply potential for decadal predictions of ecosystem changes in the northern high latitudes.

An analysis of observational and reanalysis data sets for the period 1979-2019 shows that locations characterized by greening trends largely coincide with warming summer temperature and increasing precipitation. Wherever either cooling or decreasing precipitation occurs, browning trends are observed over this period. These precipitation and temperature patterns are significantly correlated with a North Atlantic sea surface temperature index that represents the AMV signal, indicating its role in modulating greening/browning trend patterns in the northern high latitudes.

Using two large ensembles of coupled Earth system model simulations (100 members of MPI-ESM-LR Grand Ensemble and 32 members of the IPSL-CM6A-LR Large Ensemble), we separate the greening/browning pattern caused by external CO_2 forcing from that caused by internal climate variability associated with the AMV. These sets of model simulations enable a clean separation of the externally forced signal from internal variability. While the greening and browning patterns in the simulations do not agree with observations in terms of magnitude and location, we find consistent internally generated greening/browning patterns in both models caused by changes in temperature and precipitation linked to the AMV signal. These greening/browning trend patterns are of the same magnitude as those caused by the external forcing alone. Our work therefore shows that internally-generated changes of vegetation in the northern lands, driven by AMV, are

potentially as large as those caused by external CO_2 forcing. We thus argue that the observed pattern of greening/browning in the northern high latitudes could originate from the combined effect of rising CO_2 as well as the AMV.