3rd International Conference on Earth System Modelling
Vol. , 3ICESM-57, 2012
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Initialisation and predictability of the AMOC over the last 50 years in a climate model

D Swingedouw (1), J Mignot (2), and E Guilyardi (2)

(1) LSCE - IPSL, CEA/CNRS/UVSQ, Gif-sur-Yvette, France (didier.swingedouw@lsce.ipsl.fr), (2) LOCEAN - IPSL, Paris, France

The mechanisms involved in Atlantic Meridional Overturning Circulation (AMOC) decadal variability and predictability over the last 50 years are analysed in the IPSLCM5A-LR model using historical and initialised simulations. The initialisation procedure only uses Sea Surface Temperature (SST) anomalies nudging with a physically based restoring coefficient. When compared to two independent AMOC reconstructions, both the historical and nudged ensemble simulations exhibit skill at reproducing AMOC variations from 1977 onwards, and in particular two maxima occurring respectively around 1978 and 1997. We argue that one source of skill is related to the large 1963 Agung volcanic eruption, which reset an internal 20-year variability cycle in the North Atlantic in the model. This cycle involves sea-ice cover, atmospheric circulation, East Greenland Current intensity, and advection along the subpolar gyre. The increased sea-ice cover in the Nordic Seas following the Agung eruption leads to the 1978 AMOC maximum around 15 years later. The 1997 maximum occurs approximately 20 years after this initial excitation of the cycle. The nudged simulations have better skill than the historical simulations at reproducing this second maximum. This is due to the initialisation of a cooling of the convection sites in the 1980s due to a persistent North Atlantic Oscillation (NAO) positive phase, a featured not captured in the historical simulations. Hence we argue that the 20-year cycle excited by the 1963 Agung eruption together with the NAO forcing both contributed to the 1990s AMOC maximum. These results further support the existence of a 20-year cycle in the North Atlantic in the observations. Hindcasts following the CMIP5 protocol are launched from a nudged simulation every 5 years for the 1960-2005 period. They exhibit significant correlation skill score as compared to an independent reconstruction of the AMOC from 4-year lead-time average. This encouraging result is also accompanied by increased correlation skills in reproducing the observed 2-meter air temperature in the bordering regions of the North Atlantic and to a lesser extent the nudged simulation precipitation in the tropical Atlantic. We argue that this skill is due to the initialisation and predictability of the AMOC in the present prediction system. The mechanisms evidenced here support the idea of volcanic eruptions as a pacemaker for internal variability of the AMOC. Together with the existence of a 20-year cycle in the North Atlantic they propose a novel and complementary explanation for the AMOC variations over the last 50 years.