# Recent Changes in Tropospheric Water Vapor over the Arctic as Assessed from Radiosondes and Atmospheric Reanalyses

Mark C. Serreze
National Snow and Ice Data Center, Cooperative Institute for Research in Environmental Sciences, University of Colorado Boulder
Andrew P. Barrett and Julienne Stroeve
National Snow and Ice Data Center, Cooperative Institute for Research in Environmental Sciences, University of Colorado Boulder

The past two decades have seen pronounced rises in surface and lower-tropospheric air temperature over the Arctic, larger than for the Northern Hemisphere as a whole, strongly expressed over the Arctic Ocean during the cold season. Assessment of the satellite data record reveals downward linear trends in Arctic sea ice extent for all months, largest at the end of the melt season in September. Given a warmer atmosphere with more open ocean water, one expects corresponding increases in tropospheric water vapor storage in the Arctic troposphere, acting as a feedback to further the warming. We examine changes in tropospheric water vapor over the Arctic for the period 1979 to 2010 using humidity and temperature data from nine high latitude radiosonde stations north of 70°N with nearly complete records, and from six atmospheric reanalyses, emphasizing the three most modern efforts, MERRA, CFSR and ERA-Interim.

Based on comparisons with the radiosonde profiles, the reanalyses as a group have a positive cold-season humidity bias below the 850 hPa level and an Arctic temperature inversion that is too weak. This suggests that the reanalyses are either not assimilating the radiosonde data at low levels or are giving these data a low weight. Only for August does the spread in the reanalysis estimates below the 850 hPa level clearly straddle the radiosonde values. MERRA has the smallest biases. Trends in column-integrated (surface to 500 hPa) water vapor (precipitable water) computed using data from the radiosondes and from the three modern reanalyses at the radiosonde locations are mostly positive, but magnitudes and statistical significance vary widely between sites and seasons. Positive trends in precipitable water from MERRA, CFSR and ERA-Interim, largest in summer and early autumn, dominate the northern North Atlantic, including the Greenland, Norwegian and Barents seas, the Canadian Arctic Archipelago and (on the Pacific side) the Beaufort and Chukchi seas. This pattern is linked to positive anomalies in air and sea surface temperature and negative anomalies in end-of-summer sea ice extent. Trends from ERA-Interim are weaker than those from either MERRA or CFSR. An interesting feature of September, consistent across the products, is a region of positive trends centered over the Beaufort and Chukchi seas. In MERRA and CSFR these locally exceed 1.5 mm per decade. This feature corresponds with where negative trends in end-of-summer summer sea ice extent have been most pronounced. By September, the solar radiation flux to the surface is small, and there are strong transfers of heat from the anomalous open water to the atmosphere, manifested as strong positive anomalies in lower tropospheric air temperatures and hence a larger vapor carrying capacity of the air.

As assessed for polar cap averages (the region north of 70°N), MERRA, CFSR and ERA-Interim all show increasing surface-500 hPa precipitable over the analysis period encompassing most months, consistent with increases in 850 hPa air temperature and 850 hPa specific humidity. The MERRA record in particular shows evidence of artifacts likely introduced by changes in assimilation data streams. A focus on the most recent decade (2001-2010) reveals large differences between the three reanalyses in the vertical structure of specific humidity and temperature anomalies.

Corresponding Author

Name: Mark C. Serreze
Organization CIRES/NSIDC, University of Colorado
Address Campus Box 449, University of Colorado
Boulder, CO 80309-0449
USA
Email address: Serreze@nsidc.org