Sea ice outlook in 2011: Dynamical contributions to fall sea ice extent

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Estimate for sea ice extent for September, 2011; slightly greater than the 2007 record minimum in sea ice extent, or approximately 4.4 – 4.5 · 10^6 km^2.

Rationale

Increased spatial variability in springtime sea ice drift in 2011 relative to 2007, the absence of a persistent SLP high over the Arctic in July, 2011 relative to July, 2007, in addition to record loss of sea ice at the beginning of July, 2011 (http://www.nsidc.org/arcticseaicenews/) suggest that a continued decline in sea ice cover will be an artifact of increased temperatures and thermodynamic forcing, in contrast to considerable dynamical contributions encountered in the summer of 2007, and that sea ice extent may be comparable to or slightly greater than that for September, 2007.

Methods

Atmospheric dynamical contributions to summertime sea ice extent were examined in the context of surface winds and SLP, obtained from the NCEP reanalysis dataset provided by the NOAA/ESRL Physical Sciences Division. Investigated also is AMSR-E sea ice motion in April, 2007 and 2011 obtained from the Institut Francais de recherche pour l'exploitation de la mer, in addition to sea ice concentrations for April and June in 2007 and 2011 and obtained from the University of Bremen.

Discussion

July SLP fields highlight differences in spatial patterns between July, 2007 and July 2011. Noteworthy is the prevalence of the Beaufort High in July, 2007 that contributed significantly to the record minimum in sea ice extent of that year (Kwok, 2008), in contrast to the presence of a SLP low over the Beaufort Sea region in July, 2011 (Figure 1). Also of interest is the presence of strong gradients in SLP in the vicinity of Fram Strait in July, 2007, suggesting increased ice export due to advection; in 2011, strong gradients separate the Eurasian and Canadian sectors of the Arctic, suggesting reduced influence of associated surface winds on ice drift and export due to advection. Surface wind anomalies provide further evidence of the contrast between atmospheric dynamical contributions in July, 2007 and 2011; strong wind anomalies are observed over Fram Strait in 2007, with implications for increased ice export from the Arctic Ocean to the

Atlantic, whereas wind anomalies in 2011 exist in a band extending from the Kara Sea to the Canadian Archipelago, with implications for ridging and internal ice stress due to interactions with coastlines yet little implication for ice export (Figure 2).

Sea ice drift data for the last available ice motion data from spring, 2011 also illustrates an absence of coherence in ice motion fields in 2011 relative to 2007 (Figure 3). Of particular interest is the existence of a well-defined Beaufort Gyre and transpolar drift stream characteristic of strong advection and conducive to ice export through Fram Strait in 2007. By contrast in spring, 2010 (provided for comparison), sea ice drift is characterized by a weaker Beaufort Gyre, a cyclonic gyre to the north of the Barents Sea, and a corresponding weakened transport drift and advection through Fram Strait. A more distinctive contrast between ice drift regimes is presented in spring, 2011 relative to 2007, with an absence of spatial coherence in ice motion and significantly weaker advection relative to 2007.

AMSR-E sea ice concentration maps for July, 2007, 2010, and 2011 demonstrate comparable extents in 2007 and 2011, relative to 2010 (in disagreement with previous assertions that the September, 2011 sea ice extent would be comparable to that for September, 2010). However, increased heterogeneity in the sea ice cover, attributed to increased melt pond development, sensitivity to increased temperatures, and rapid loss of sea ice in July, 2011 (http://www.nsidc.org/arcticseaicenews/), may also influence sea ice drift response to surface winds, with increased potential for ice accumulation and ridging, and increased internal stress in response to surface winds that may establish barriers to transport and inhibit ice export from the Pacific to the Atlantic sectors of the Arctic. The absence of a strong and persistent SLP high over the Beaufort Sea in summer, in addition to the absence of spatial homogeneity in the springtime sea ice drift fields suggest that the continued loss of sea ice in the Arctic in 2011 may be an artifact of thermodynamic forcing and increased temperatures rather than dynamical preconditioning events such as were encountered in the summer of 2007. The rate of continued ice loss will be a consequence of the interplay between thermodynamic forcing and ice deformation characteristics resulting from the response of an increasingly fractured ice cover to regional wind-driven forcing in the marginal ice zone over timescales of several weeks.

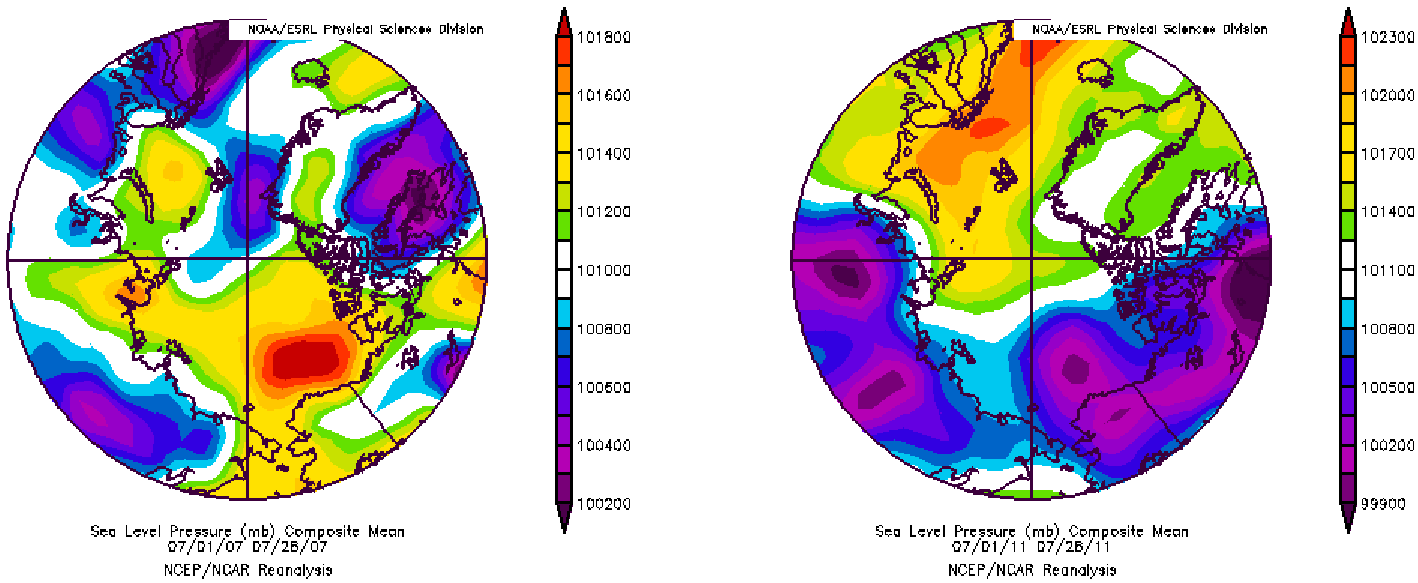

Figure 1. Sea level pressure fields for July, 2007 (left) and July 2007 (right). Image provided by the NOAA/ESRL Physical Sciences Division, Boulder Colorado from their Web site at http://www.esrl.noaa.gov/psd/.

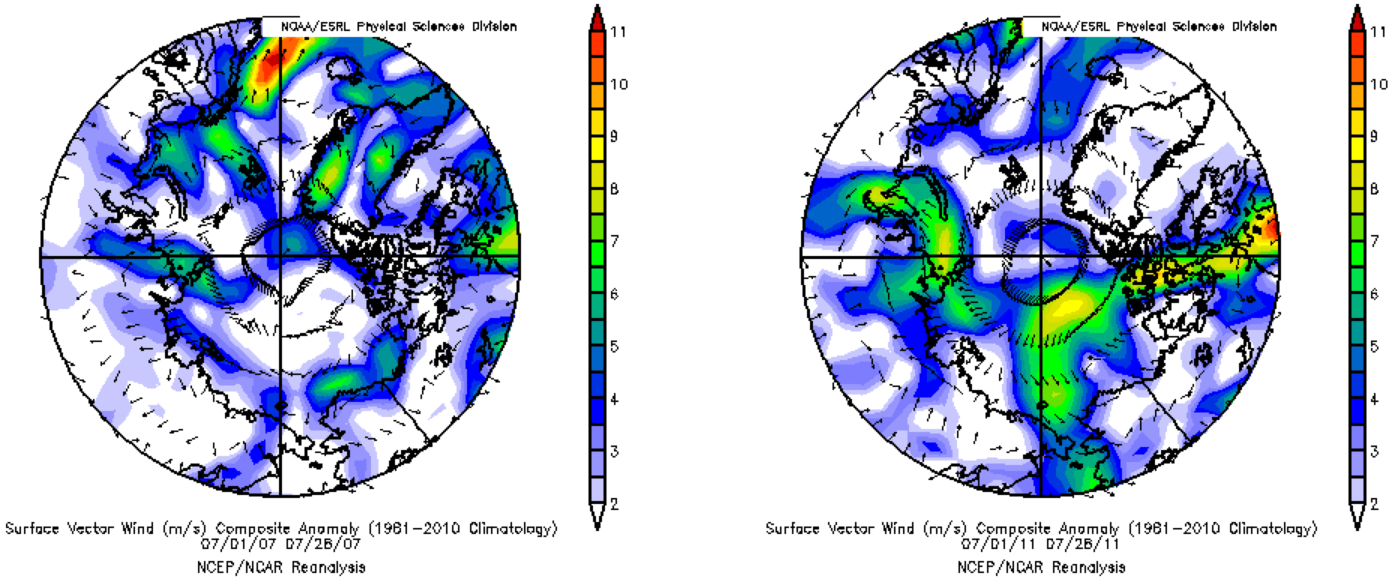

Figure 1. Surface vector winds for July, 2007 (left) and July 2007 (right). Image provided by the NOAA/ESRL Physical Sciences Division, Boulder Colorado from their web site at http://www.esrl.noaa.gov/psd/.

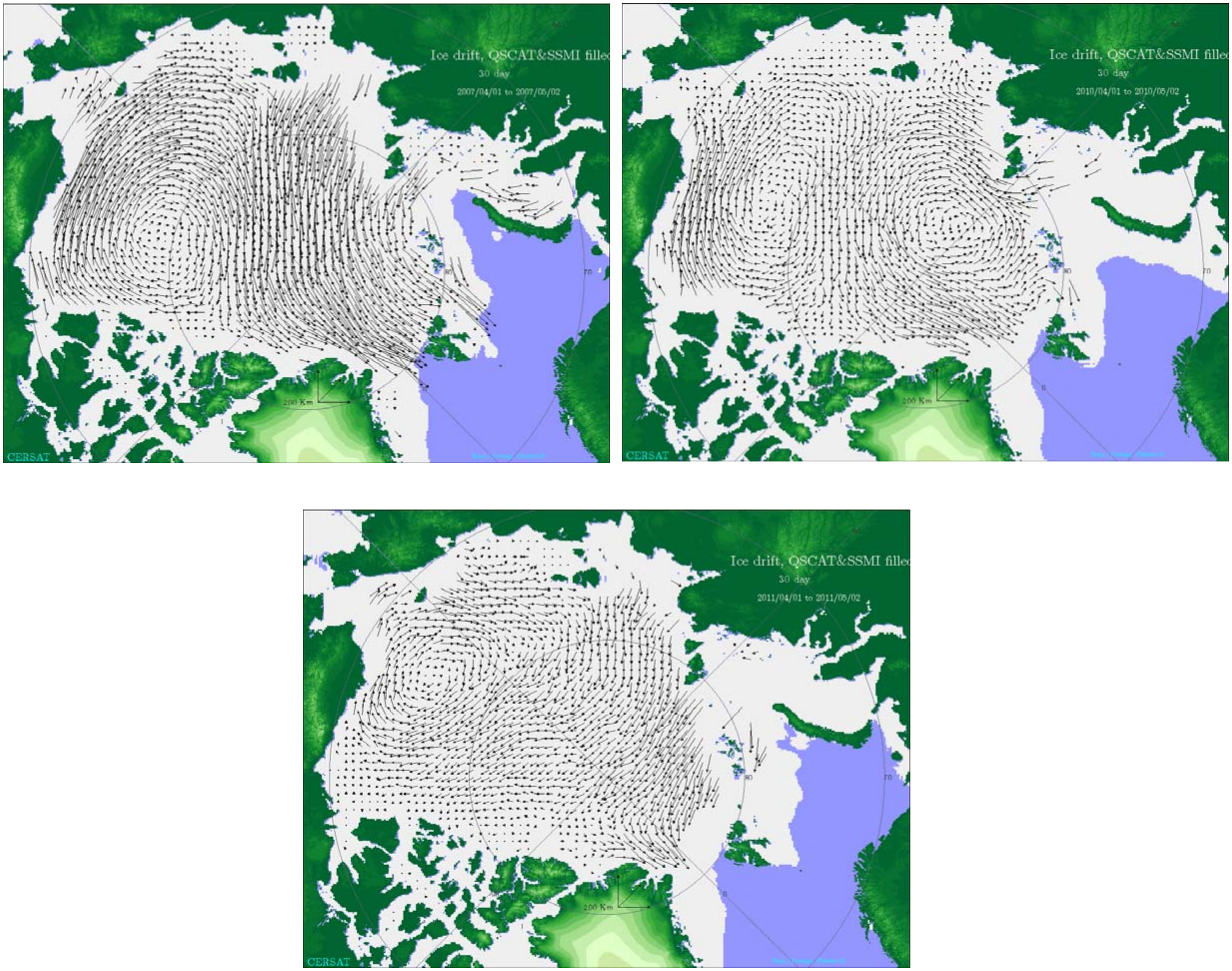

Figure 3. AMSR-E maps of sea ice drift for May, 2007, 2010, and 2011. Sea ice drift image provided by Institut Francais de recherche pour l'exploitation de la mer at ftp://ftp.ifremer.fr/ifremer/cersat/products/gridded/psi-drift/quicklooks/arctic/.

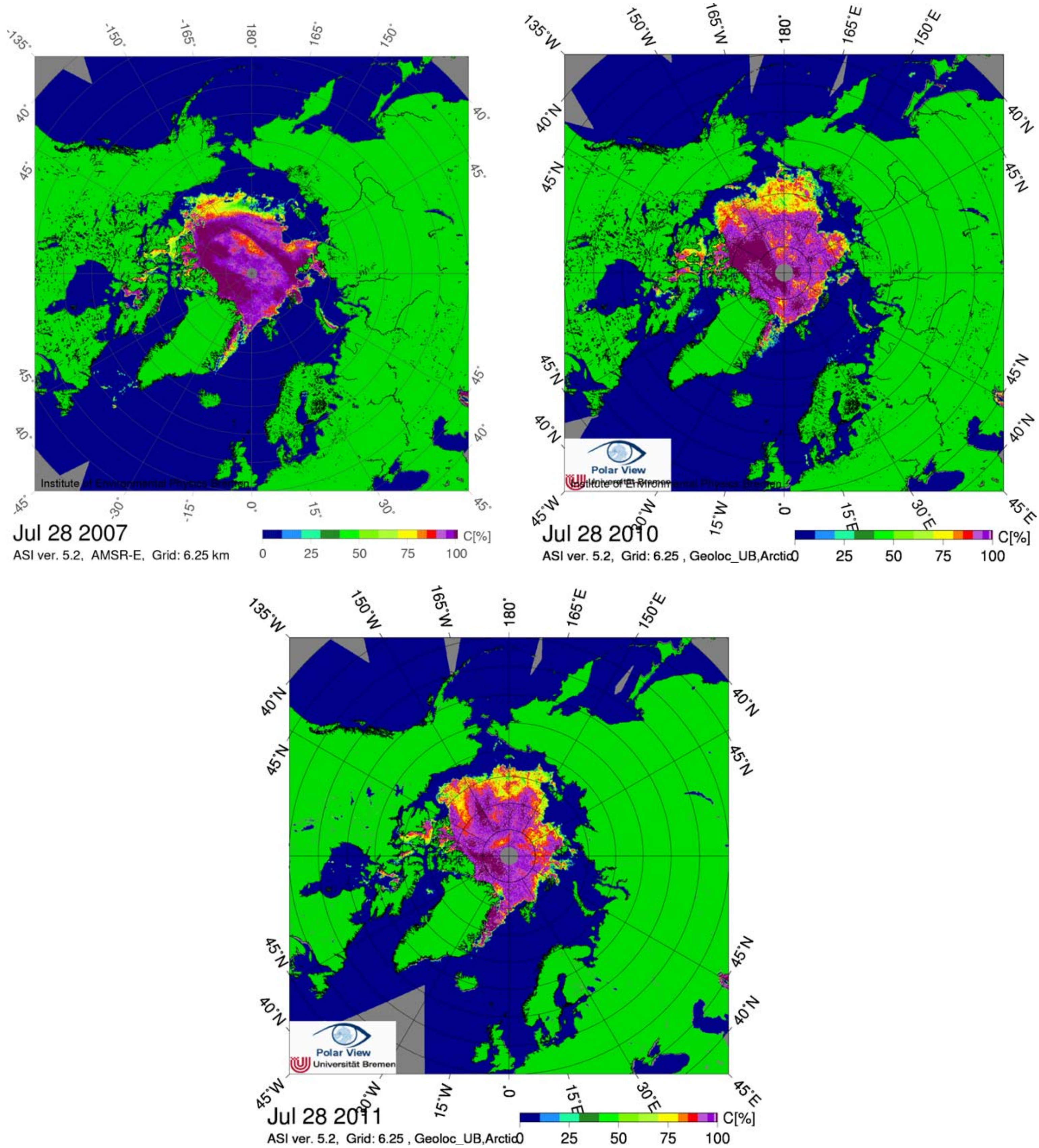

Figure 4. AMSR-E sea ice maps of sea ice concentrations in the Arctic for July 28, 2007, July 29, 2010, and July 28, 2011. Image provided by the University of Bremen at http://www.iup.uni-bremen.de:8084/amsr/.