Geophysical Research Abstracts,
Vol. 11, EGU2009-11692-4, 2009
EGU General Assembly 2009

Spatio-temporal characteristics of the diurnal precipitation cycle over Sweden and the linkage to large-scale circulation

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Rainfall events exhibit diurnal cycle in both frequency and amount, of which phase and amplitude show substantial geographic and seasonal variation. Although the diurnal cycle of precipitation is one of the fundamental characteristics to determine local weather and climate, most of sophisticated climate models still have great deficiencies in reproducing it. Thus more exact understanding of the diurnal precipitation cycle and its mechanisms is thought to be very important to improve climate models and their prediction results.

In this work we investigate the diurnal cycle of precipitation in Sweden using ground based hourly observations for 1996-2008. For the precipitation amount and frequency, mean diurnal cycles are computed, and the peak timing and amplitude of the diurnal and semi-diurnal cycle of precipitation are estimated by the harmonic analysis method. Clear mean diurnal precipitation cycles as well as distinct spatial patterns for all seasons are derived. In summer, showing the most distinct pattern, the majority of the stations show a clear rainfall maximum in the afternoon (12-18 LST) except for the coastal part of Central Sweden where we see an early-morning peak (00-06 LST) and the east coast of southern Sweden where we find a morning peak (06-12 LST). The clear afternoon peak may be due to high insolation accumulated during the day time in summer leading to a local convection activity later on that day. These coastal bands mostly consist of the stations closest to the Baltic Sea. Meso-scale convection connected to temperature differences between sea and land combined with a favorable wind pattern seems to play a role here. In the transition seasons, spring and autumn, the amplitude is weaker and the spatial pattern of peak timing is less distinct than in summer. In spring the westcoast stations have a morning peak and stations in southeastern Sweden show an afternoon peak. In autumn we see a zonal division with a clear afternoon peak in southern Sweden. This might be due to a steeply decreasing energy input from the solar insolation in the northern parts causing less convection activity but still enough insolation to cause an afternoon peak in southern Sweden. In both seasons, spring and autumn, north of 60 degrees the pattern is mixed showing early-morning, morning and afternoon peaks. The winter pattern is characterized by afternoon peaks along the eastcoast and central South Sweden and morning peaks over the most of the other parts of the country. However, the amplitude of the diurnal cycle is much weaker compared to that in summer or autumn.

In order to examine the large scale circulation which might modulate the diurnal cycle, the Lamb weather types are computed based on sea level pressure fields from the NCEP/NCAR reanalysis 2 dataset with daily and 6-hourly resolution, respectively. The Lamb types based on 6-hourly SLP underline the high temporal variability of atmospheric conditions over the research area. Throughout all seasons, on about 45% of the days two or more circulation classes are different. In 6.3% (JJA) to 8.4% (DJF) of the days can observe 4 different Lamb classes. Using Lamb types with 6-hourly resolution leads to a somewhat finer classification. On average, for about one third of the days with precipitation the daily Lamb type and the appropriate 6-hourly one are different. The most frequent large-scale circulation classes coupled to precipitation events are of cyclonic or directional type. The atmospheric circulation patterns do not follow a diurnal cycle, whereas the local observed precipitation does. Knowledge about the timing of the rainfall is important in order to assign the right underlying circulation patterns to precipitation events.