ERA-5 and MERRA-2 Temperature Trends in the Stratosphere

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Introduction

Homogeneity of time series is a necessary condition for the proper trend analysis. Reanalysis provide the global coverage with equal space data. On the other hand, the time series from the reanalysis are not homogeneous which has great impact on the trend results. The aim of this poster is to find the occurrence of breakpoints in the temperature time series from the MERRA 2 and ERA 5 reanalysis and their temporal and spatial distribution with the help of the Pettit homogeneity test. This research was done for the winter months of the Northern Hemisphere for all layers above 500 hPa in the period 1980-2018.

Results

In fig. 1 we see climatology for period 1980-2018 in January at several pressure levels. This figure shows very good agreement for both reanalyses.

Figs. 2 and 3 display geographical distribution and histograms of jumps for MERRA 2 and ERA 5 at different pressure levels (1, 10, 50, 100 hPa) for January. Significant cases mean application of variance condition (see next paragraph). Red means grid point with identified jumps. It is obvious that ERA 5 has significantly lees jumps than MERRA 2 reanalysis.

The vertical profile of the percentage of grids with breaks is given in fig. 5. These profiles are similar in all months with absolute maximum at 0.1 hPa (top layer), minimum at 0.7 hPa and secondary maximum at 3 hPa and secondary minima at 100 hPa. The number of breaks is generally lower in the lower stratosphere and upper troposphere than in the upper stratosphere. The different situation is for significant cases where minimum occurs at 10 hPa especially for ERA 5.

Significant and insignificant breaks

•We have time series with the length N. Let k is the year when the break occurs. We compute the average from all years before the break (1…k-1) and after the break (k+1…N). If the difference between the average before and after the break is greater than variance of the series, we consider this break as significant. If the opposite is true we consider this break as insignificant. We employ this procedure for distinguishing between the significant and insignificant breaks. The temporal distribution of all breaks at 10 hPa is given in the significant cases panels of figs. 2 and 3. We see the distribution of significant breaks is narrower and the number of significant breaks is lower than that of all breaks. The vertical profile of the percentage of all grids with breaks and the percentage of grids with significant breaks is shown in fig. 5. In each month and layer, the number of significant breaks is lower than that of all breaks and the shape of vertical profile of significant breaks is similar to that of all breaks. The difference between the number of all breaks and the number of the significant breaks are monthly dependent especially in the lower stratosphere and upper troposphere (fig. 5).

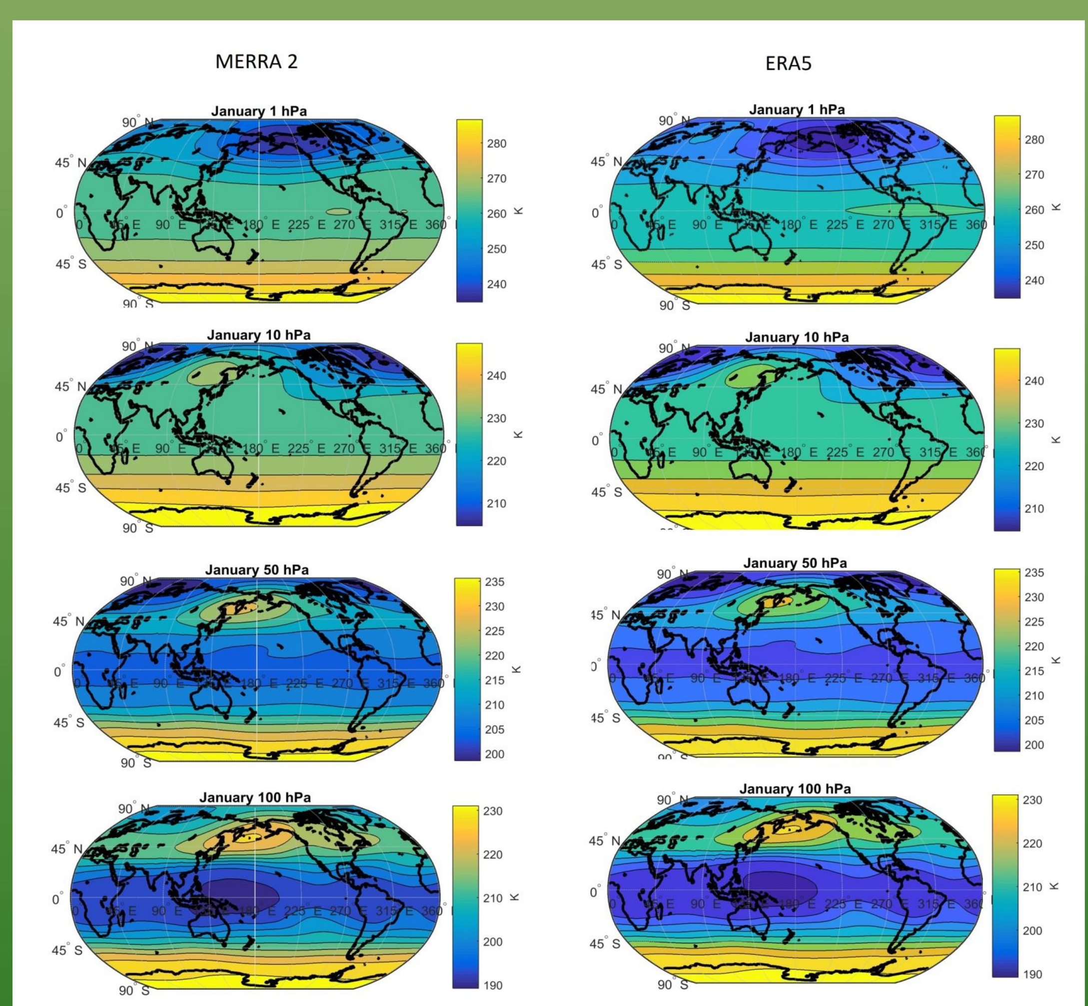

Figure 1: Climatology for period 1980-2018. ERA 5 reanalysis on the right panels MERRA 2 on the left panels for pressure levels 1, 10, 50, 100 hPa.

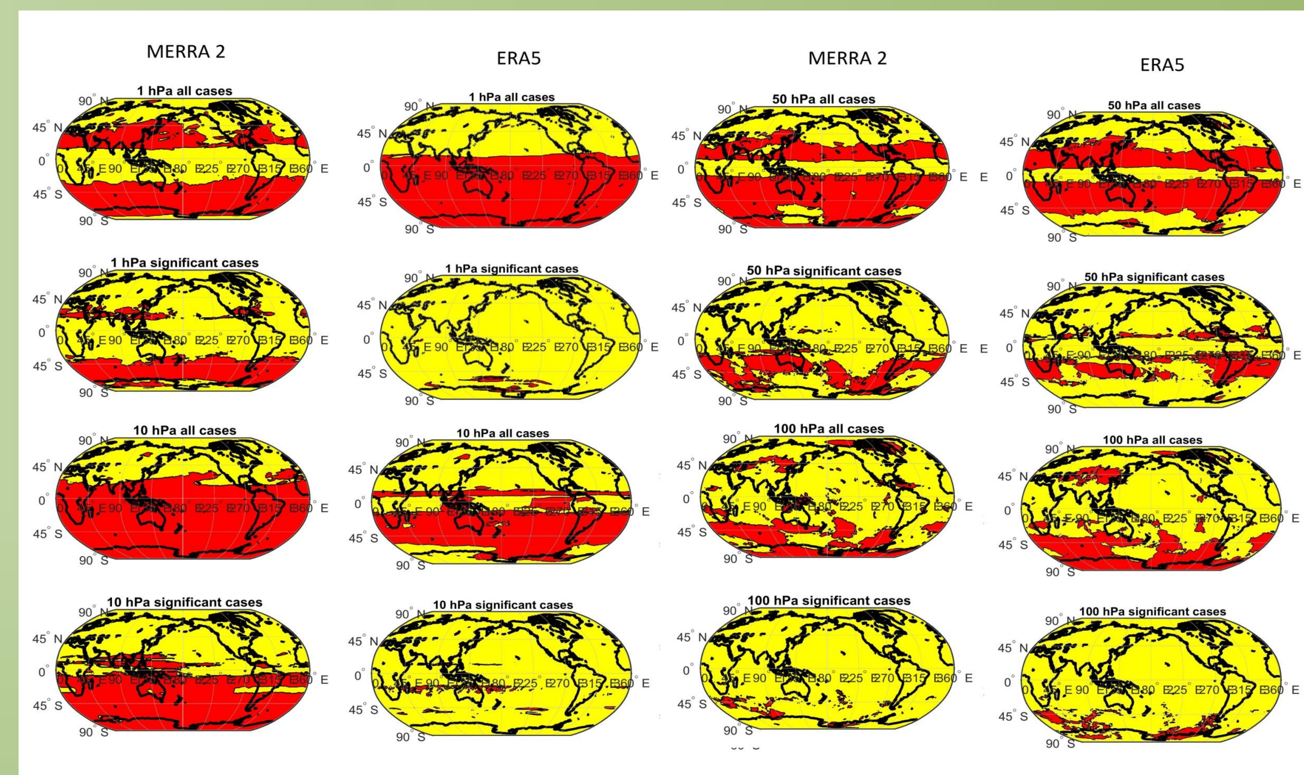

Figure 2: Geographical distribution of jumps for MERRA 2 and ERA 5 at different pressure levels (1, 10, 50, 100 hPa) for January. Significant cases mean application of variance condition. Red means grid point with identified jump

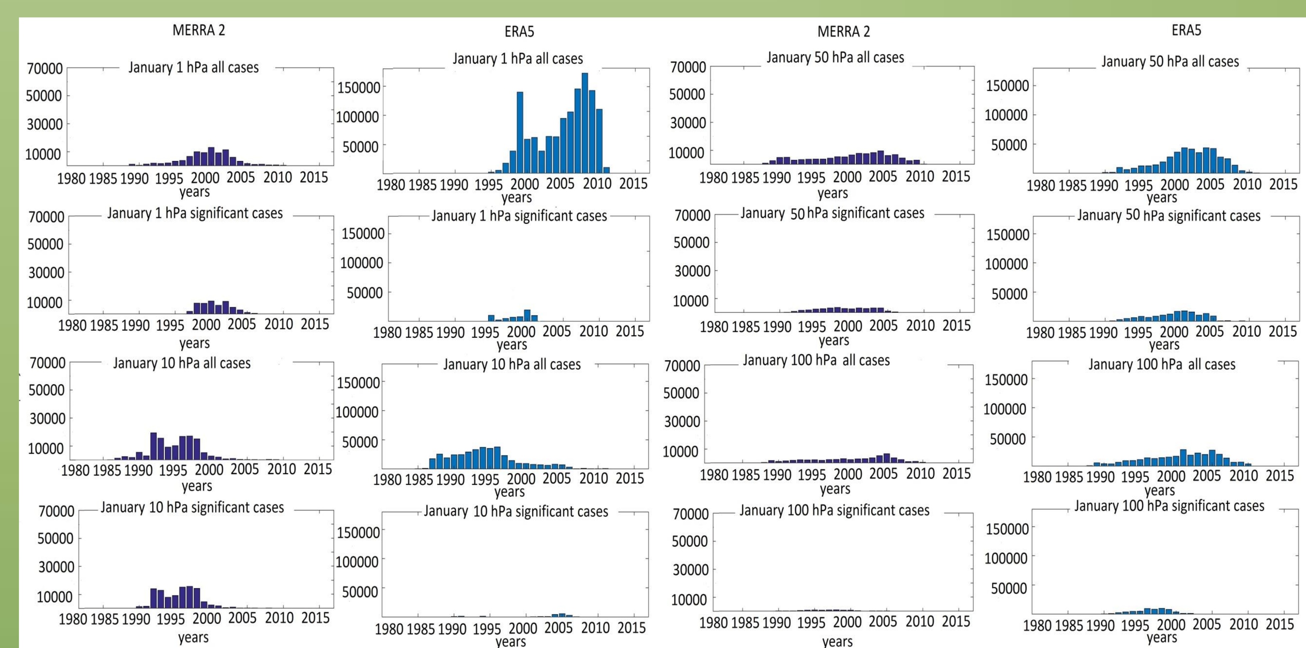

Figure 3: Number of grid points with jumps during period 1980-2018 for several pressure levels (1, 10, 50, 100 hPa) in January of MERRA 2 and ERA 5 reanalyses. Significant cases mean application of variance condition

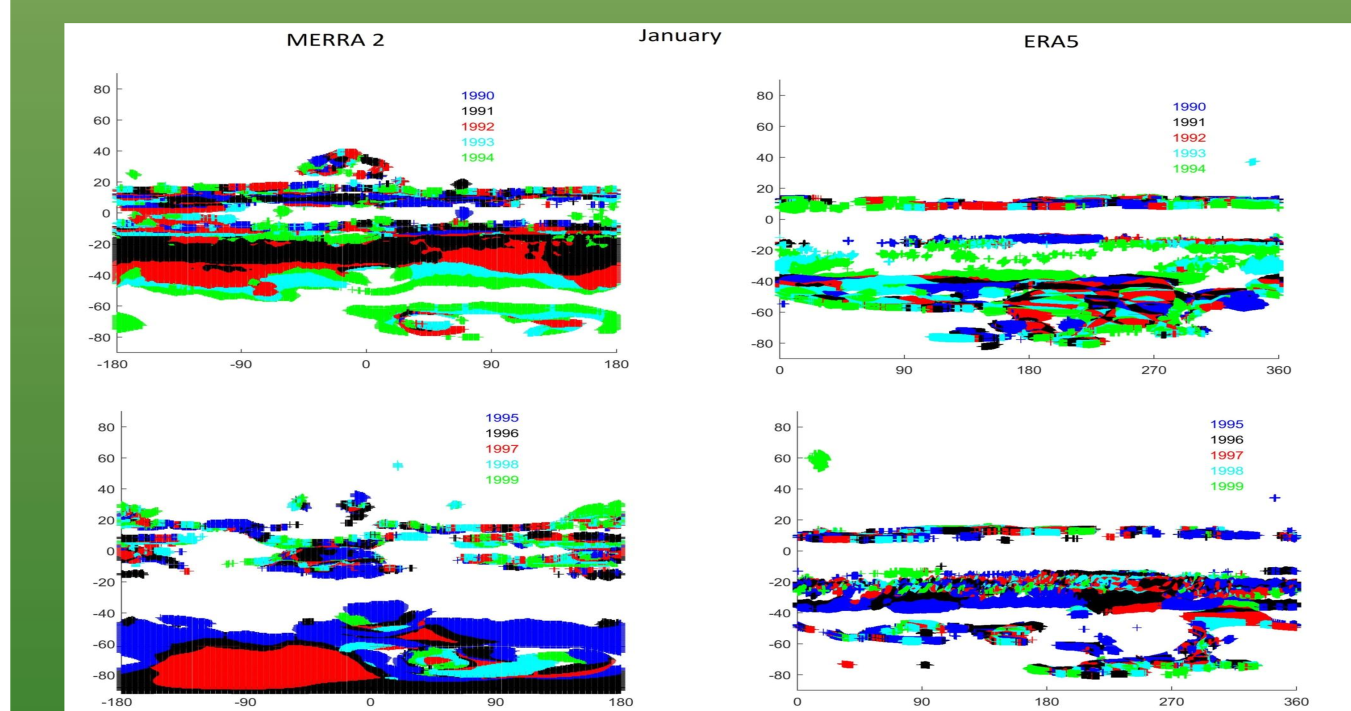

Figure 4: Geographical distribution of significant jumps for MERRA 2 and ERA 5 at 10 hPa in January for specific years.

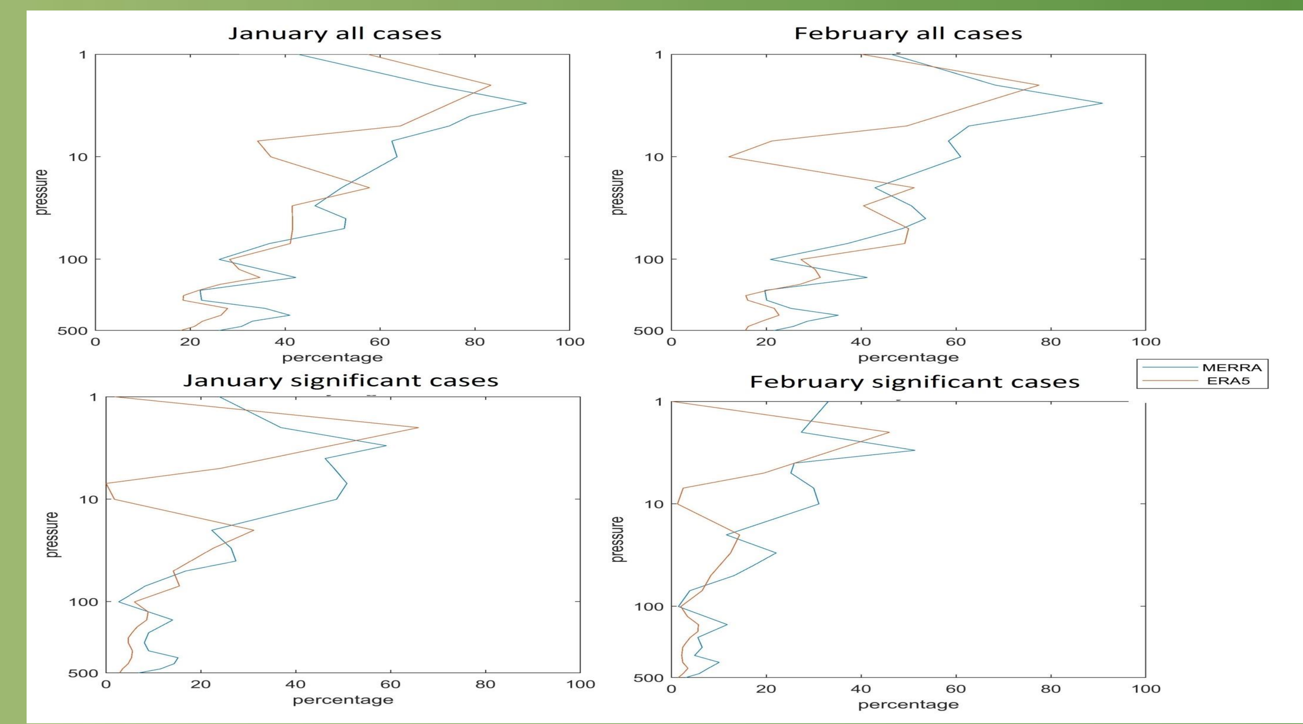

Figure 5: Vertical profile number of grid points (in percent) for ERA 5 and MERRA 2 in January (left panels) and February (right panels). Significant cases mean application of variance condition.

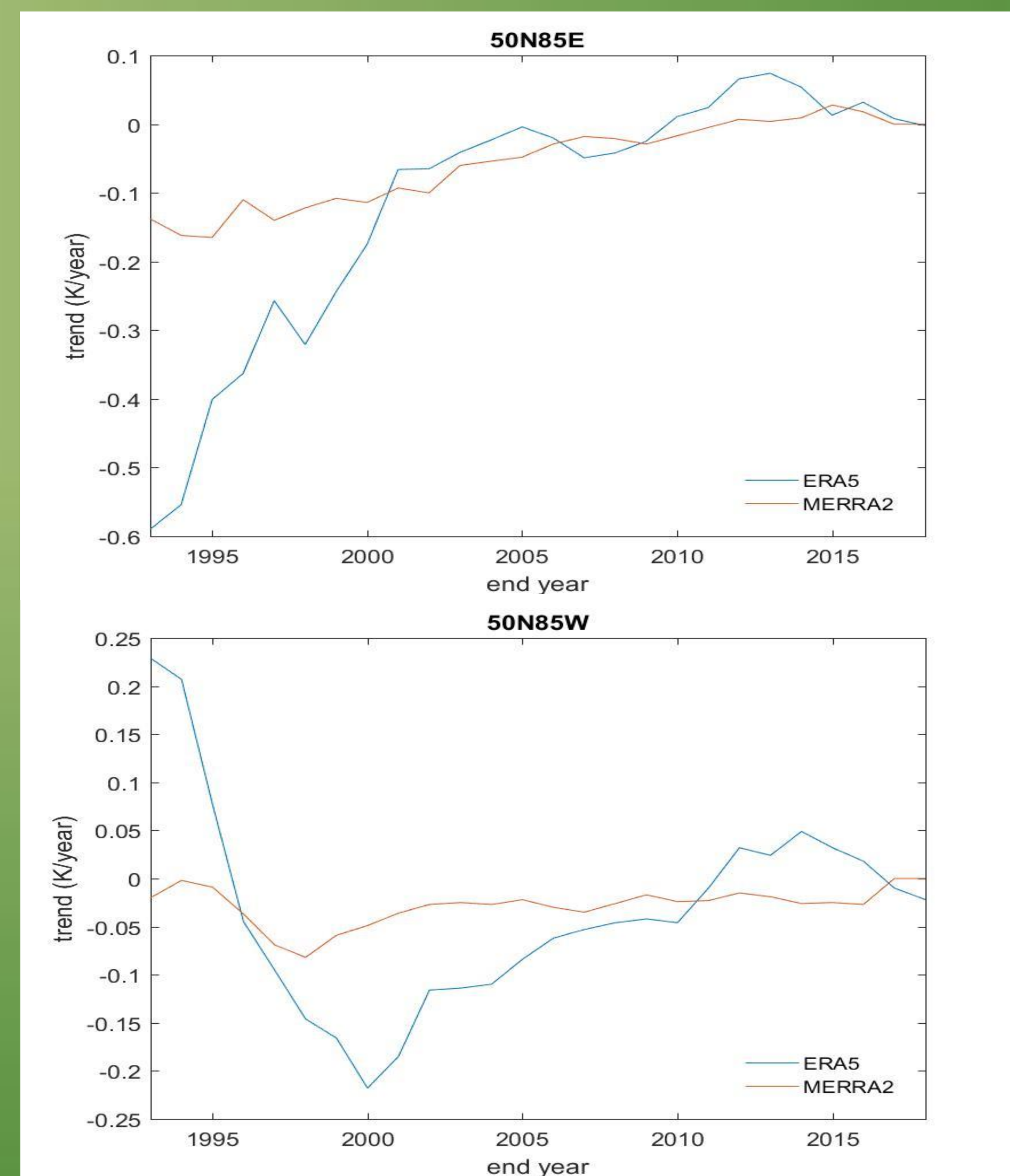

Figure 6: Temperature trend (K/yr) for MERRA and ERA5 reanalysis in January for grid point 50°N and 85°E or W. Trend is calculated for period from 1980 to 1993-2018 (lenght of the period vary).

Trend analysis

Figures 6 and 7 show temperature trend for different periods (starts in 1980 end in 1993-2018). This analysis can also identify jumps especially during the final year of the period.

In January we identify jumps during late 90s which correspond with the change from the MSU to AMSU in ECMWF reanalysis. MERRA 2 does not show any significant jumps during whole period. In February we can see the similar feature for ERA 5 but we also identify jumps for MERRA 2 (70°N85°W) in 1998 and 2004. This again coresponds with using MLS dataset in MERRA 2 from 2004.

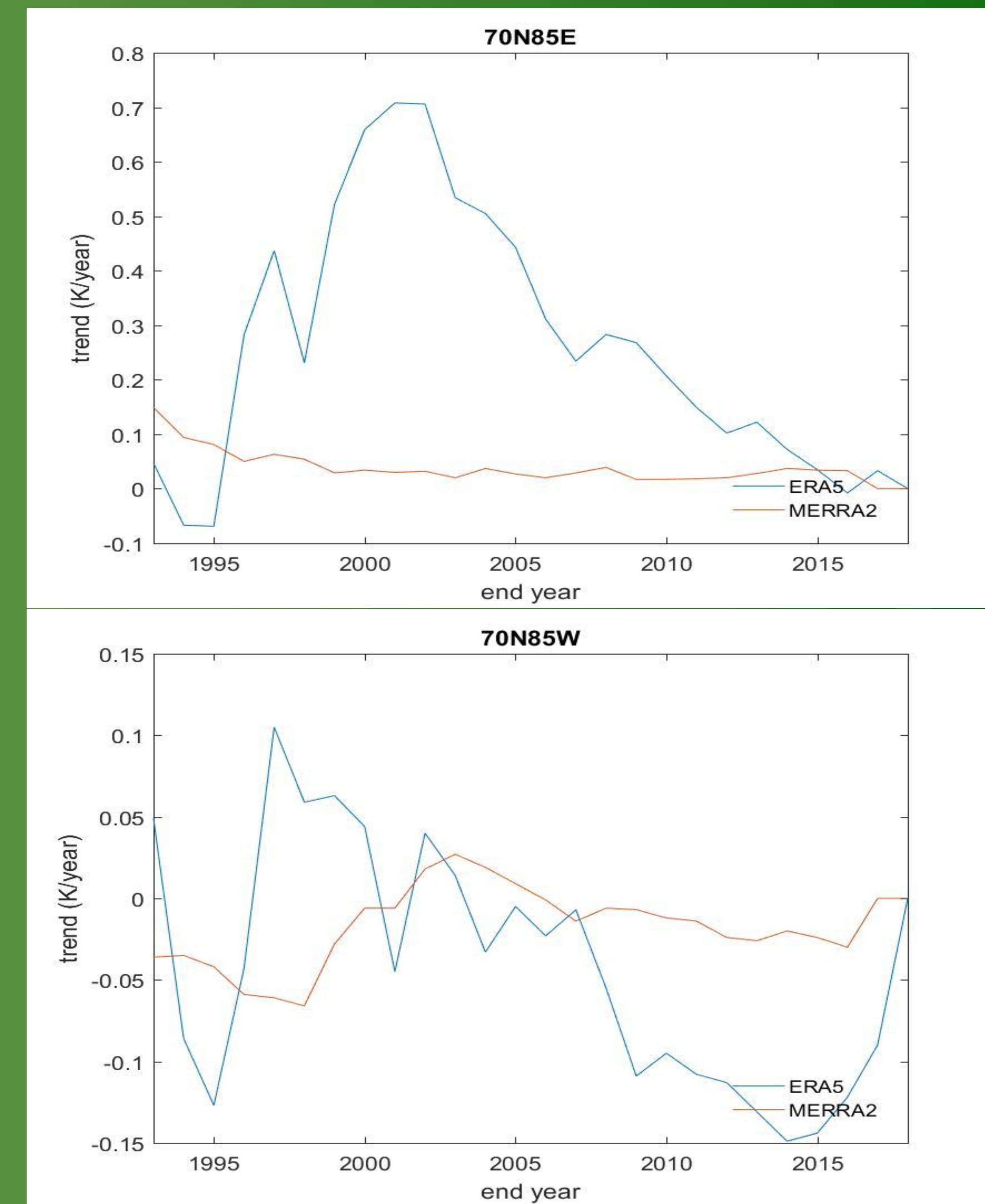

Figure 7: The same as fig. 6 but for February and grid point 70°N and 85°E or W.

5. Conclusions

The main results are:

•Climatology generally agrees well for both reanalyses for the main features and amplitude especially at lower altitudes.

•The main problem with homogeneity (significant cases) occurs on the Southern Hemisphere at 1 - 10 hPa for MERRA 2 reanalysis.

•Very low number of significant cases (less than 20% up to 5 hPa) occurs especially for ERA 5.

•The trend analysis coresponds with changes of assimilated datsets.

Acknowledgement

Support by the Grant Agency of the Czech Republic via Grant 18-01625S is acknowledged.