Progress in long-term trends in the MLT region

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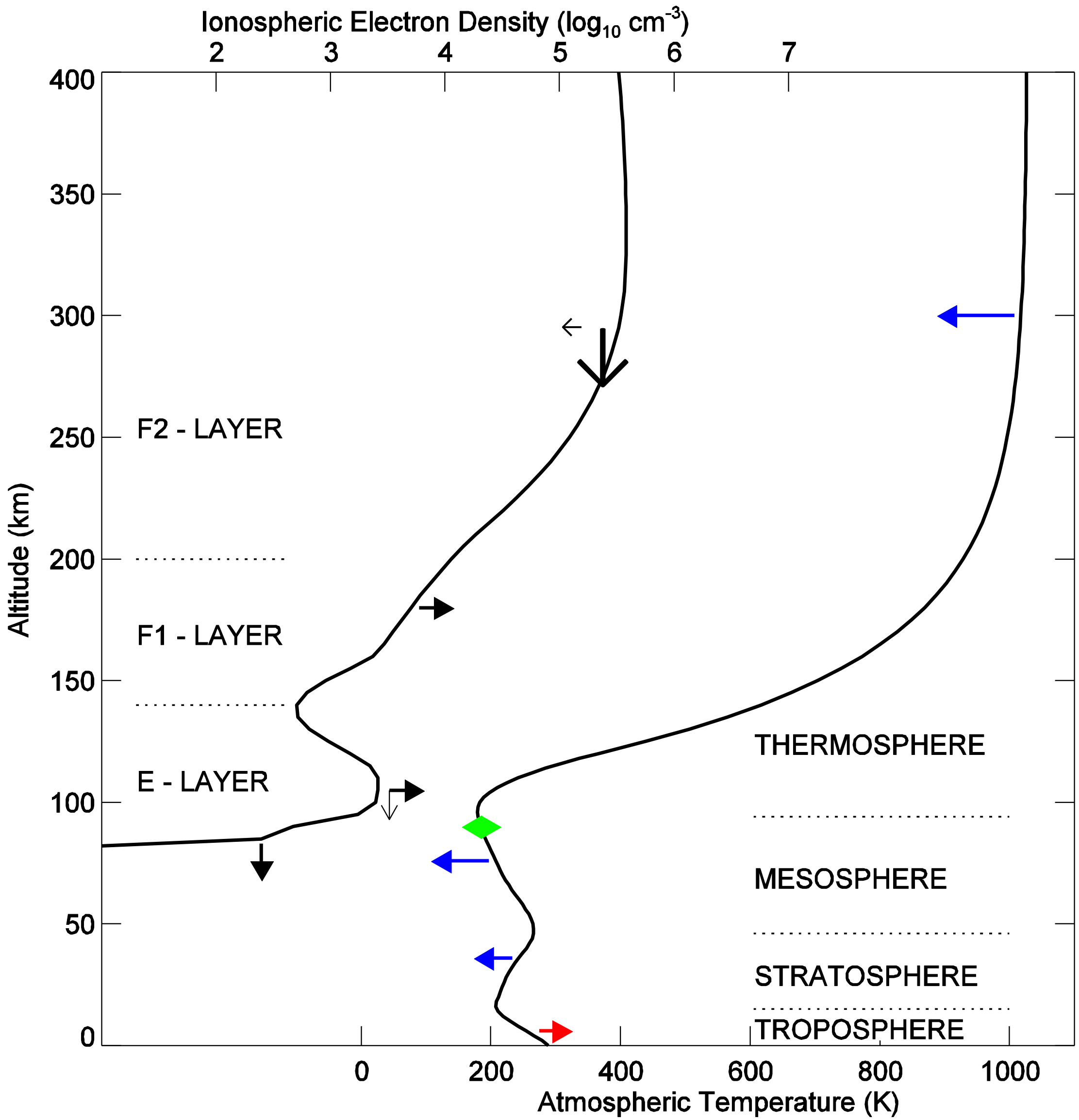
Results reached by the VarSITI ROSMIC WG-3

Working group 3 of ROSMIC VarSITI has been dealing with long-term trends in the mesosphere and lower thermosphere (MLT region). Some important findings concerning trends in the MLT region will be treated in this presentation.

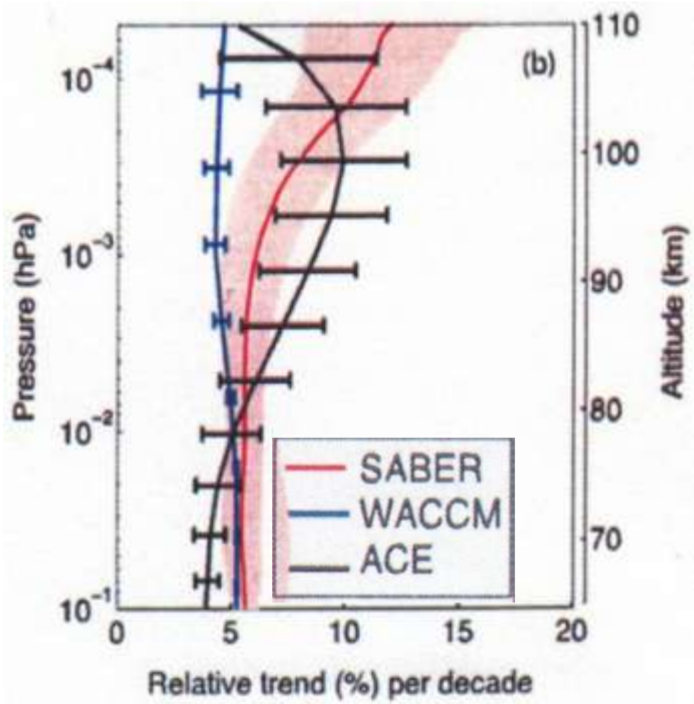
Global trend scenario

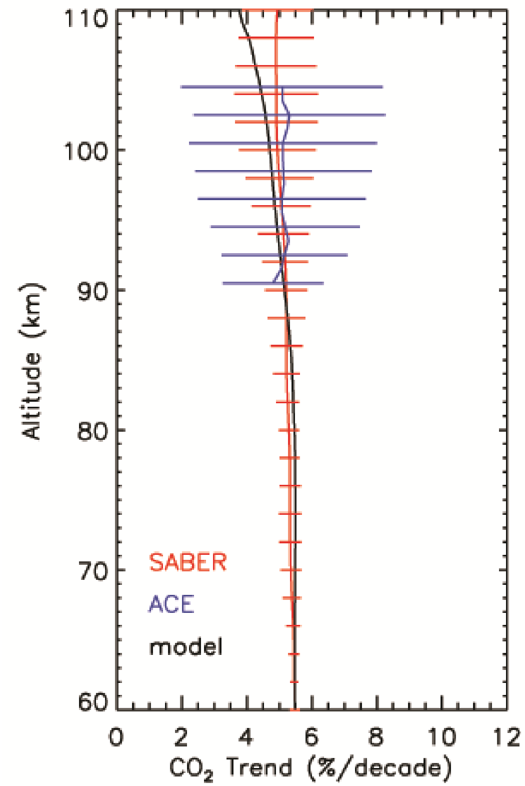


Summary of consistent mesospheric, thermospheric and ionospheric trends, which form the global pattern/scenario – in terms of temperature and electron density.

Carbon dioxide CO_2

CO_2 volume mixing ratio (VMR) in the mesosphere and lower thermosphere





Original CO_2 retrievals summarized by Yue et al. (2015) – observed values in the MLT region are significantly larger than model values.

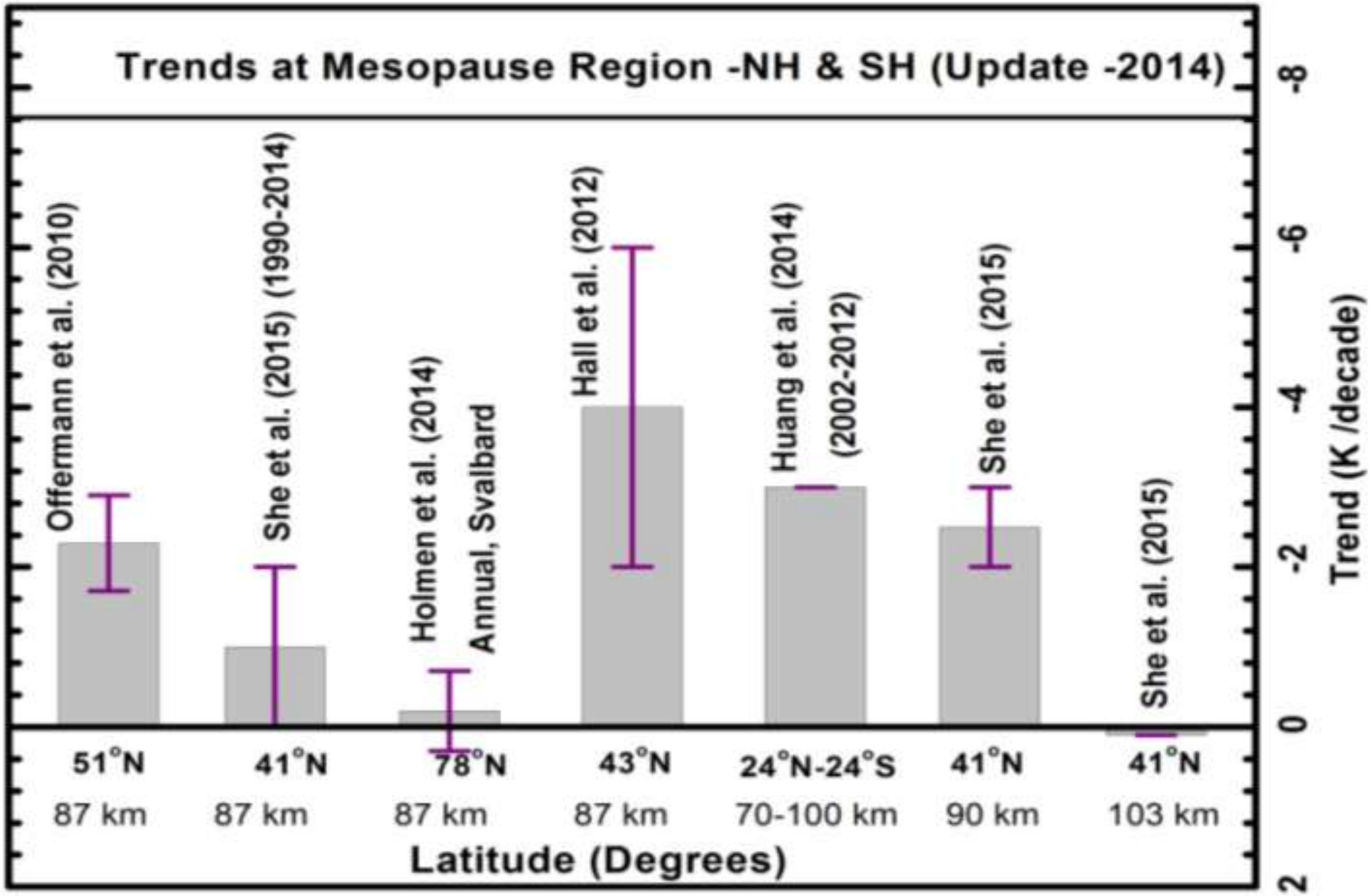
Rezac et al. (2018) **confirm statistically insignificant difference** between CO_2 observational and simulated trends.

Qian et al. (2017) corrected issues with methodologies used to derive CO_2 trends – observed values now agree with model values.

Temperature

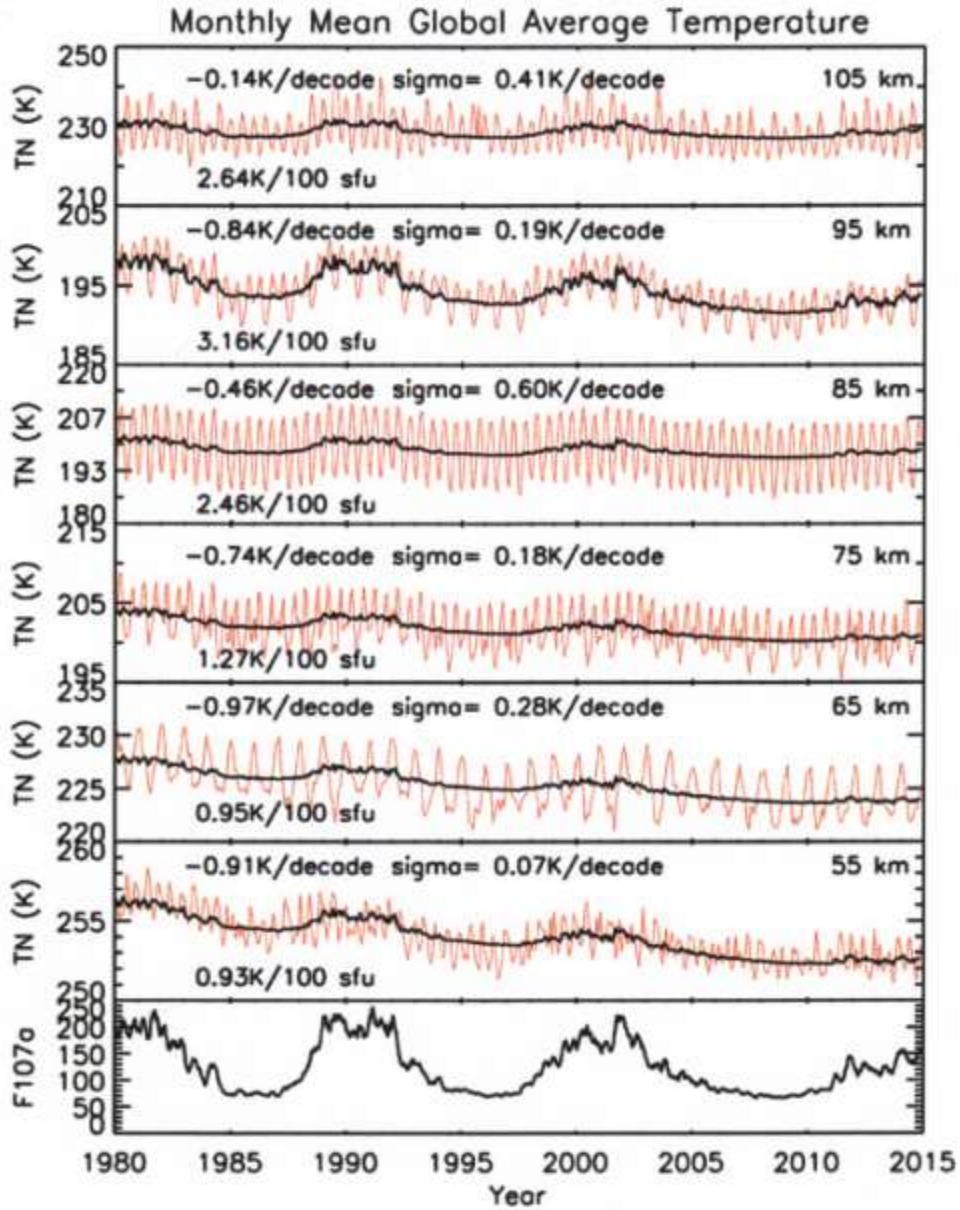
BEYOND 2010 TO PRESENT……

G. Beig (2016)



Faster cooling is supported by model LIMA calculations

Garcia (2018): WACCM4 simulations confirm that temperature trends in the mesosphere are clearly different in 1975-1995 versus 1995-2015.



Monthly mean global average temperatures (red lines), their multiple linear regression fittings (black lines), temperature trends (K per decade) and the standard deviations (sigma, K/decade), and solar activity dependence of temperatures (K/100 sfu), at six different altitudes from 105 to 55 km – WACCM-X model, 1980–2014. The bottom panel - 81-day average F10.7. Qian et al. (2019).

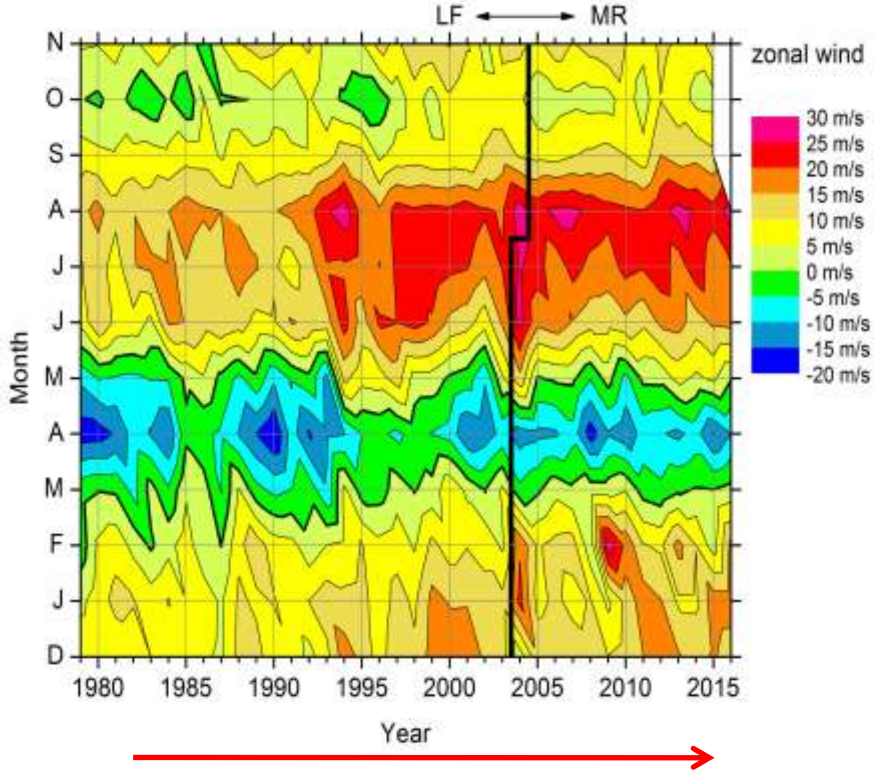
Simulated temperature trends are everywhere negative. They peak in the lower-middle mesosphere, are weak in the mesospause region and become very weak above 100 km due to effect of shrinking.

MLT dynamics

Combined LF and Meteor Radar time series at Collm

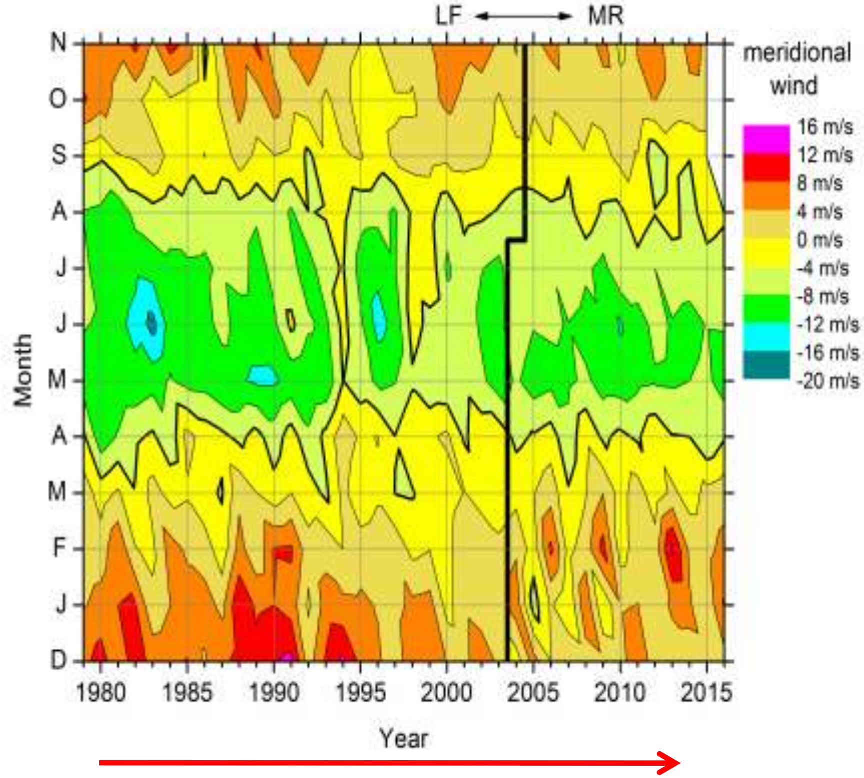
1979-2016 - attributed to ~90 km

Zonal wind



increase towards more westerly winds

Meridional

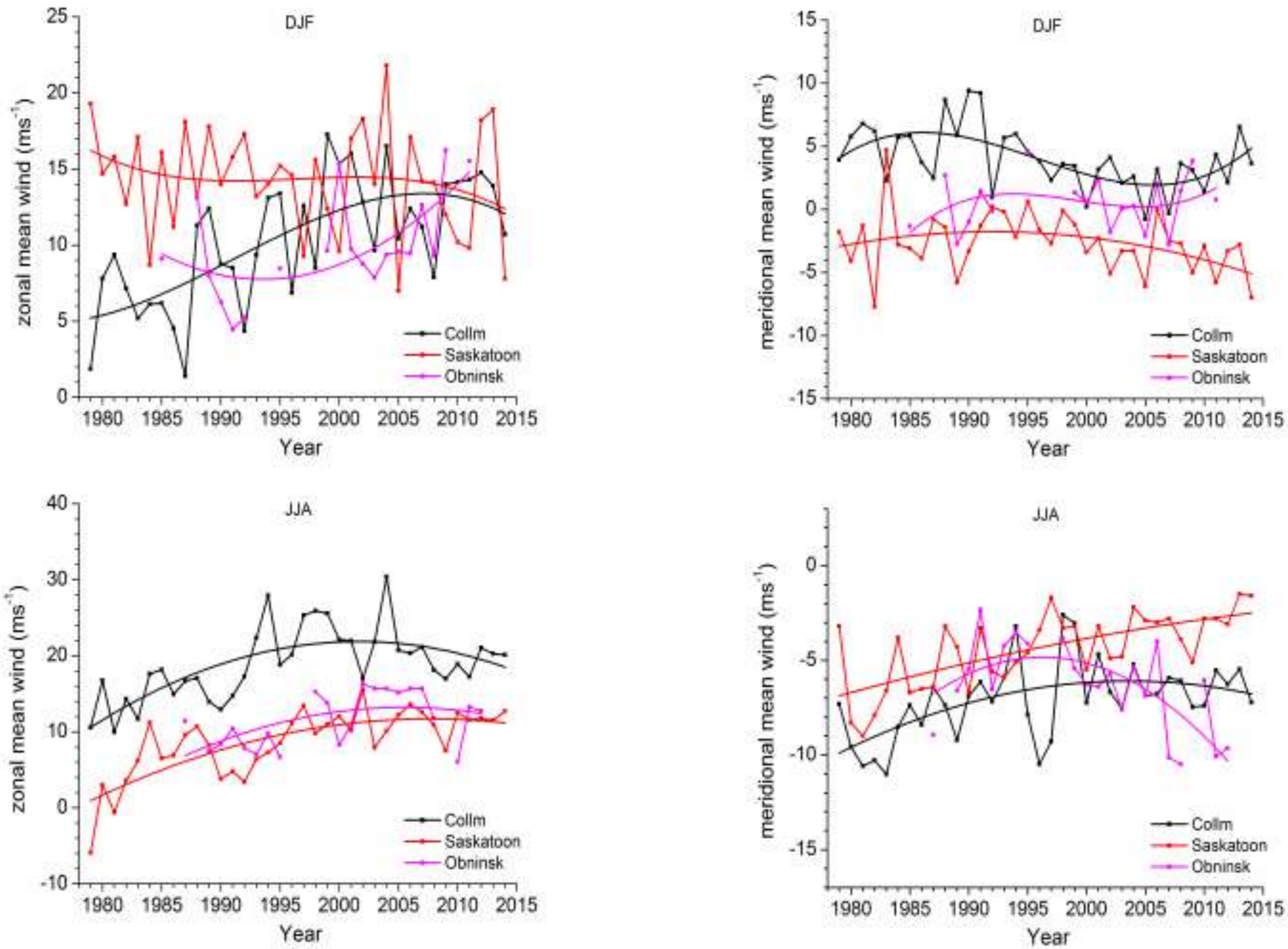


decrease of the magnitude

Jacobi

Saskatoon (52N, 107W), Collm (51N, 13E), Obninsk (55N, 37E)

Zonal wind



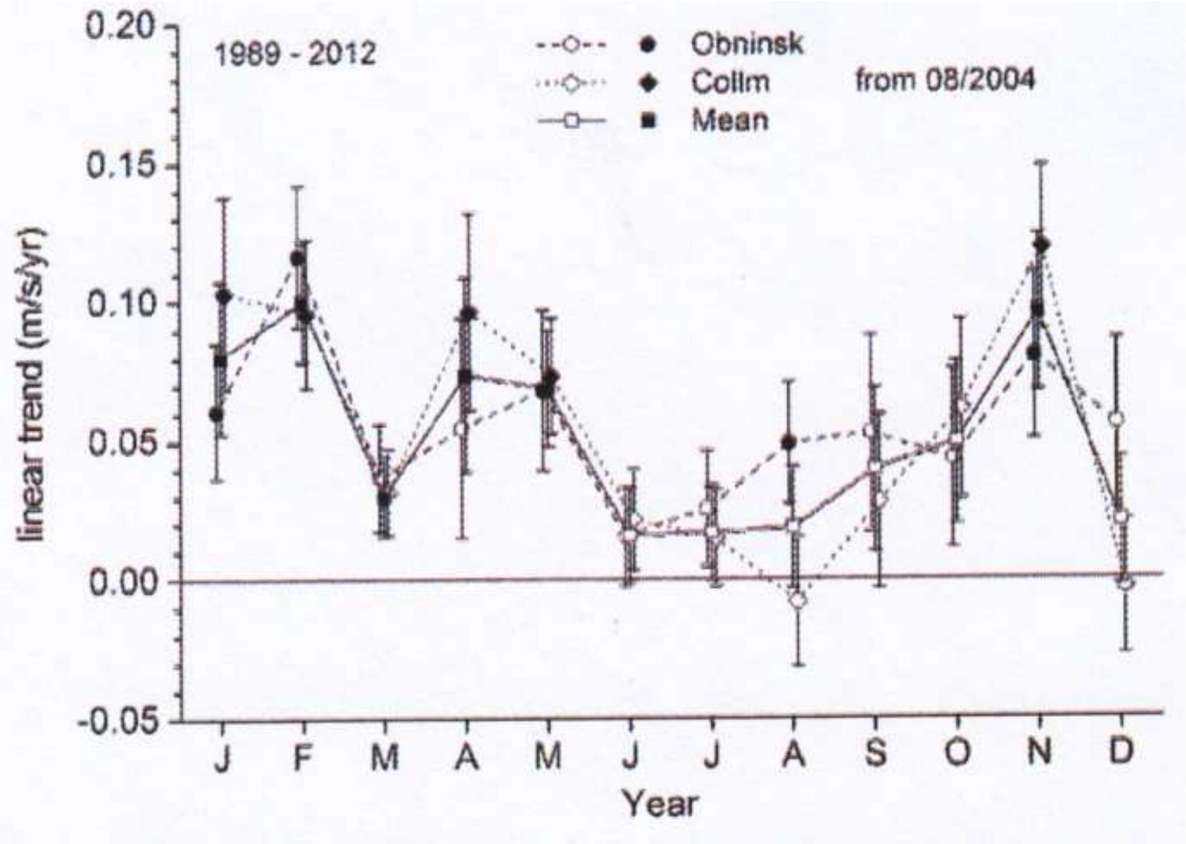
Merid wind

Winter zonal winds behave differently at different longitudes. ?effect of PW.

Summer zonal winds reveal similar tendencies. **Jacobi**

Quarterdiurnal tide (6 h) at midlatitudes (Collm and Obninsk)

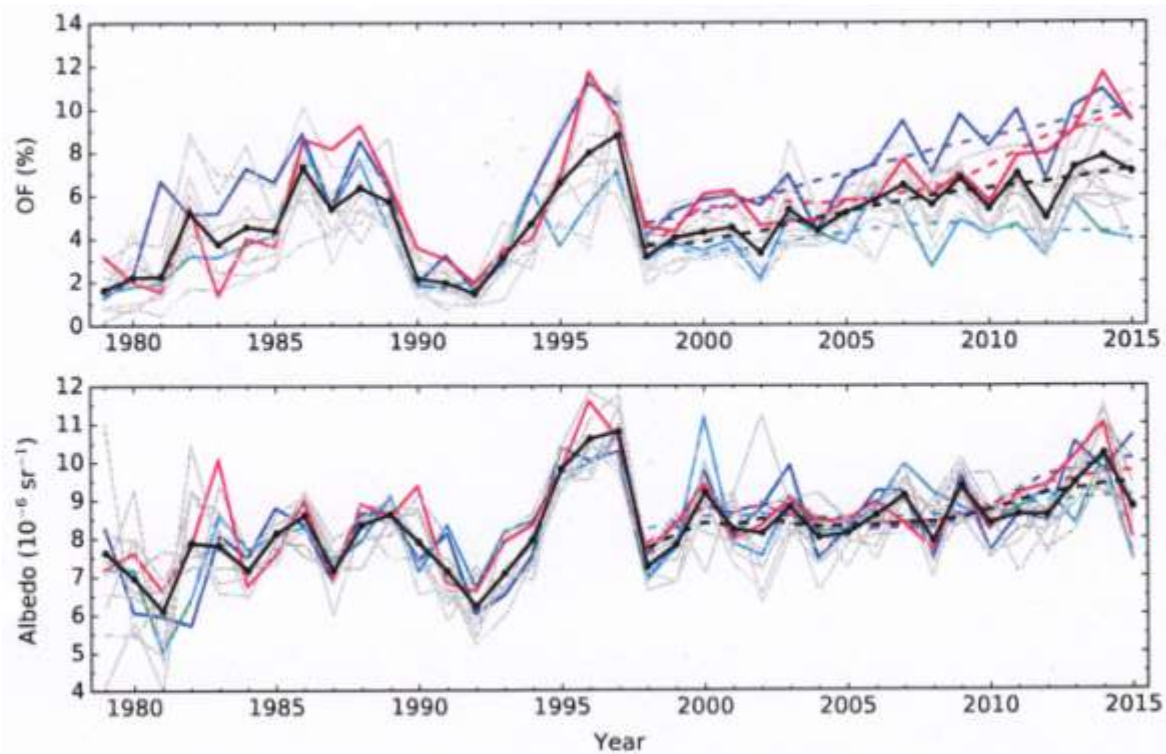
Linear trend coefficients and their standard errors of QDT monthly amplitudes in wind, 1989–2012. Only Obninsk until July 2004, after that time the data used are Obninsk (circles), Collm (diamonds), or Obninsk/Collm mean (squares). Solid symbols - significant trends at the 5% level (t-test). Jacobi et al. (2017).



The long-term trends are positive throughout the year, but they are small in summer.

Noctilucent clouds and water vapor

SBUV time series of noctilucent cloud (NLC) occurrence frequency (top) and brightness (bottom) for 64-74^{o}N – Alaska (blue), Greenland (blue-green), Norway (red), zonal mean (black). Dashed lines – fits starting in 1998.

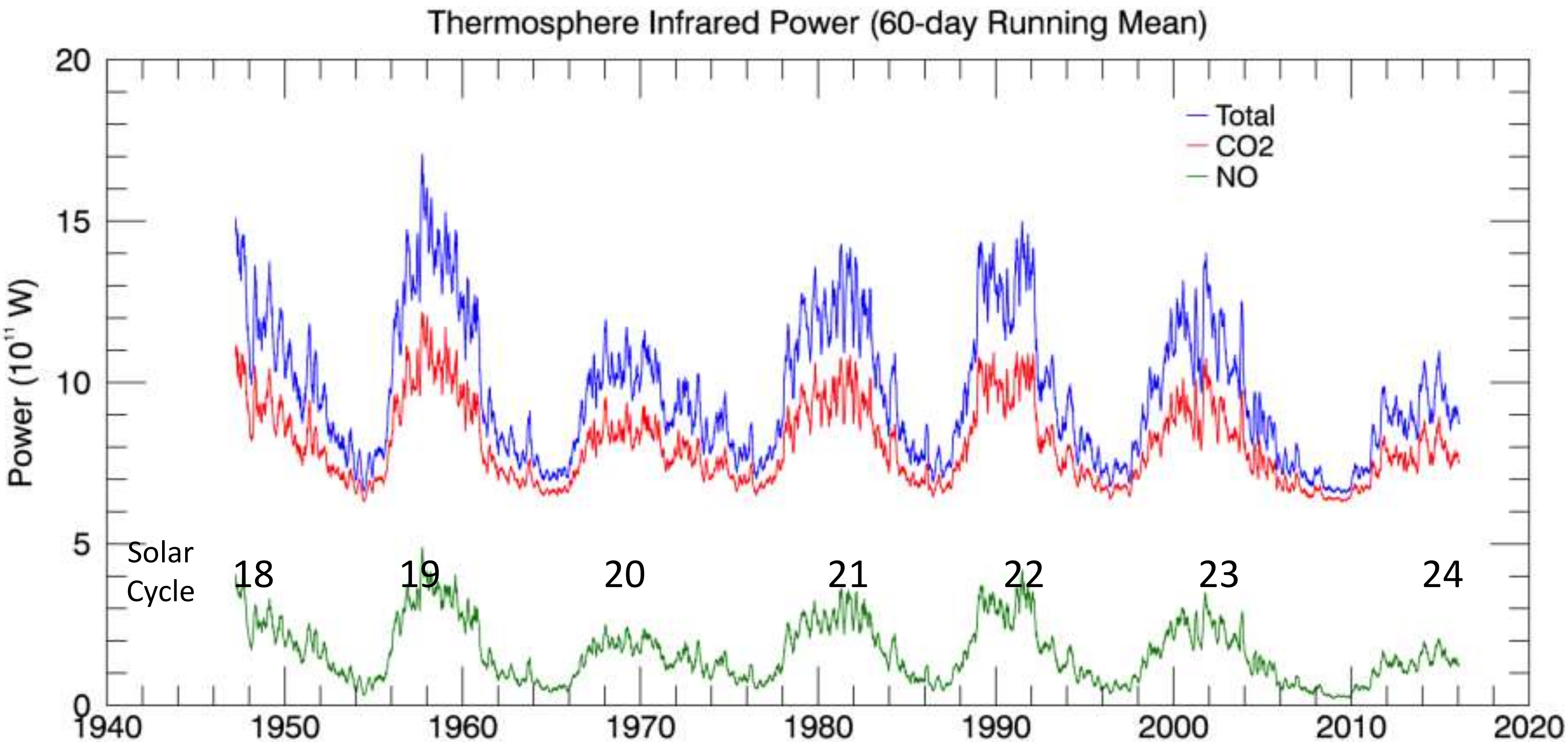


Longitudinal variation – NLC trends are strongest in Norway followed by Alaska and weakest in Greenland.

Lübken et al. (2018): Simulations of NLC with LIMA/MIMAS model. NLC trends are essentially from increasing water vapor concentration (due to increasing methane concentration), temperature plays minor role.

Infrared cooling of the lower thermosphere

Reconstruction of Thermosphere Infrared Power



Reconstructed cooling time series back to 1947 using extant F10.7, Ap, Dst

CO_2 cooling depends less on solar activity than NO coling

CO_2 cooling dominates in the lower thermosphere.

M. Mlynczak

Integrated IR power over solar cycle is rather stable

foE and solar correction

Is solar correction for trend studies stable? No.

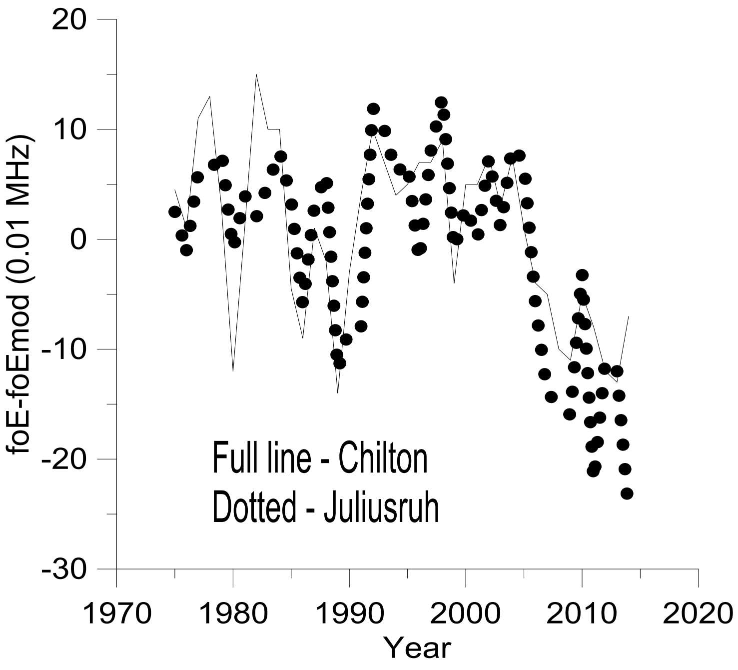
	F10.7	Fα
1975-2014	0.88/0.91	0.89/0.92
1975-1990	0.96/0.91	0.93/0.92
1990-2005	0.94/0.98	0.93/0.95
2006-2014	0.79/0.96	0.86/0.96

foE = A + B * solar

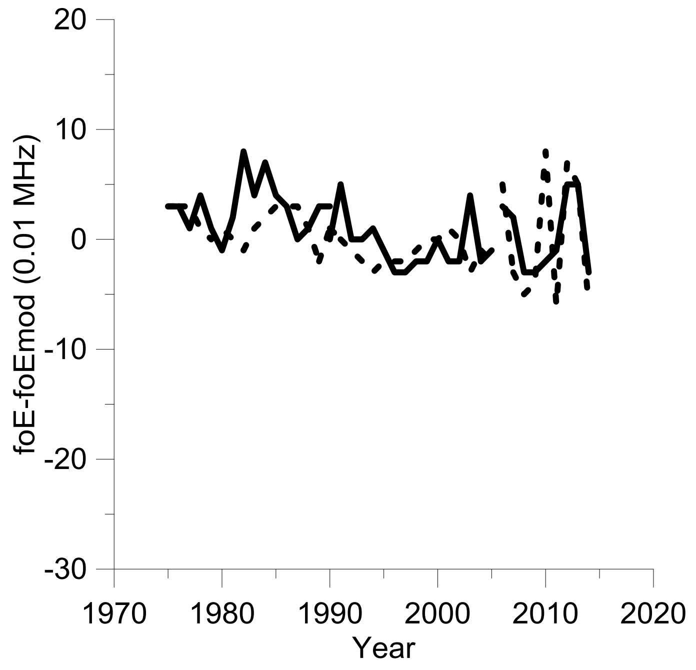
Percentage of total variance of **foE** explained by eq. foE = A + B*solar for **Juliusruh/Chilton**, yearly values, and solar proxies F10.7 and Fα. **Clearly better for three separate corrections.**

Laštovička et al. (2016)

One solar correction



Three solar corrections



Future investigations of trends in MLT

Filling in gaps in scenario of trends in the upper atmosphere and removal/explanation of controversies.

Particular points:

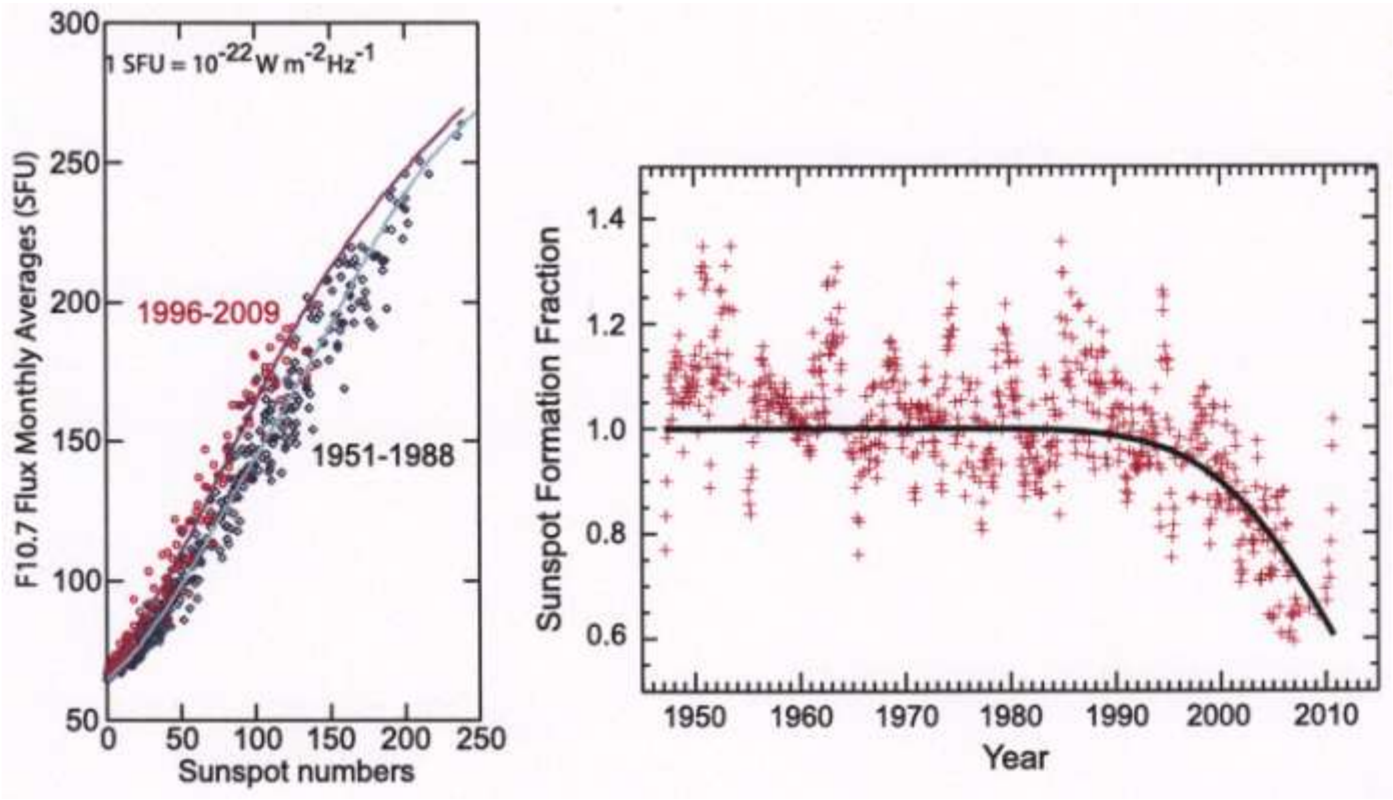
1. Investigations of trends in atmospheric wave activity – key problem of trends in MLT region.

2. Further development and improvement of complex models.

3. Monitoring and investigations of changes of secondary (= non-CO_2) trend drivers and their impacts on trends.

Something is happening with the Sun

Left panel: F10.7 plotted vs. sunspot numbers. Relationship between them has changed significantly during solar cycle 23. Right panel: The sunspot formation fraction parameter changed remarkably during solar cycle 23. Balogh et al. (2014).



Compared to previous solar cycles, the Sun has changed its behavior in cycles 23 and 24 (present).

Membership of WG-3

Chairman: J. Laštovička (Czechia)
Co-chairman: D.R. Marsh (USA)

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WG-3 co-organized the 9^{th} (Kühlungsborn, Germany, Sept. 2016) and 10^{th} (Hefei, China, May 2018) workshops "Long-term Changes and Trends in the Atmosphere"