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# On different response of mesopause region characteristics to long-term and short-term solar variability

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**Long-term variability**

Periods > 2 years.

The strongest spectral peak in many solar characteristics –

~ 11 years

**Short-term variability**

2 days < periods< 30 days

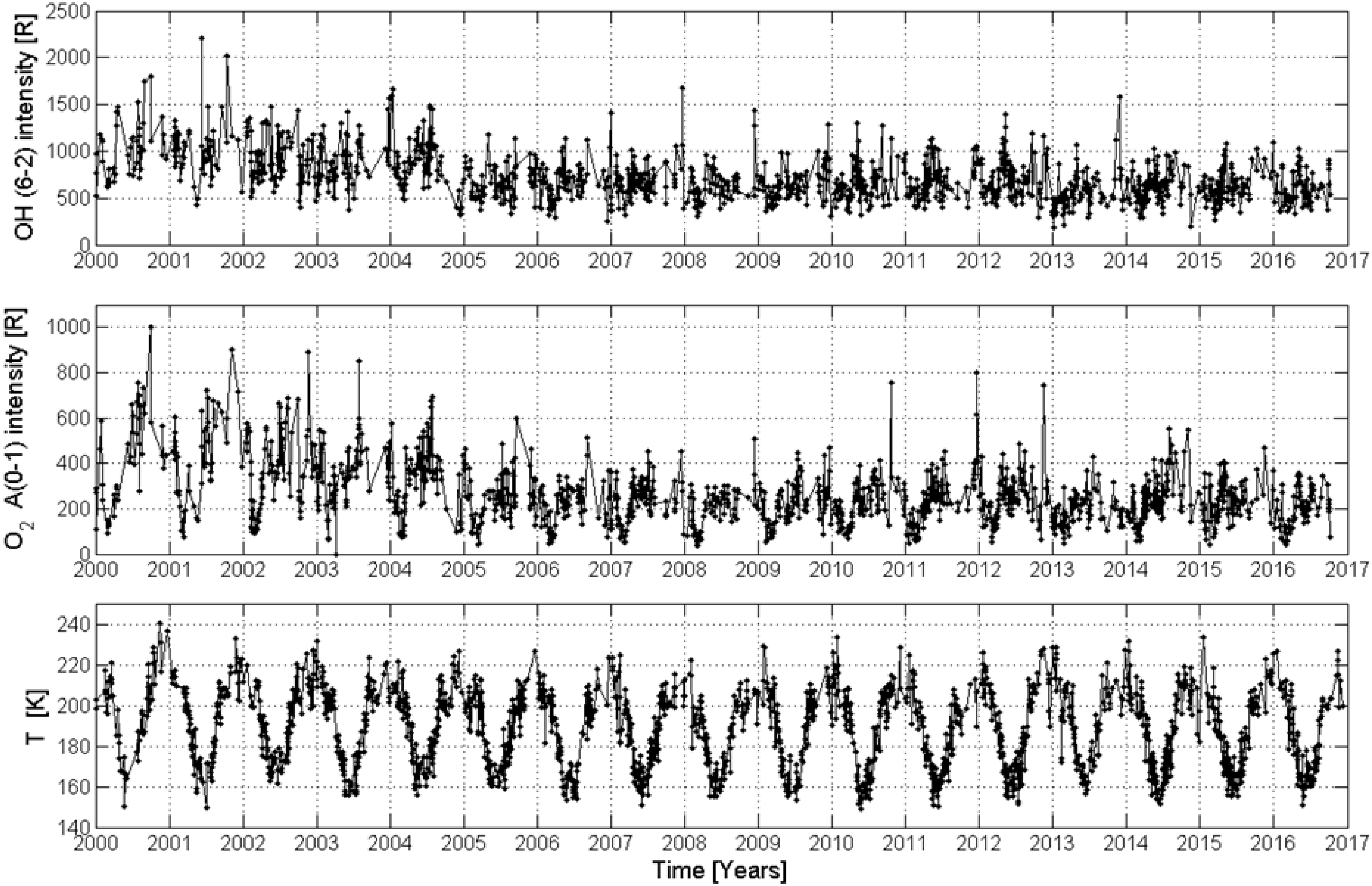
The strongest spectral peak in many solar characteristics –

~ 27 days

**Analysis of atmospheric response:**

Seasonally and yearly averaging of data are estimated

Slowly varying mean values over 35 day-window are excluded




OH* (6-2) and $O_2$* 865 nm airglow measurements in Zvenigorod (56 N 36 E) are analyzed in order to extract the influence of solar activity

## Besides, the 1962-2016 data on ground-based estimations of NLC brightness were examined

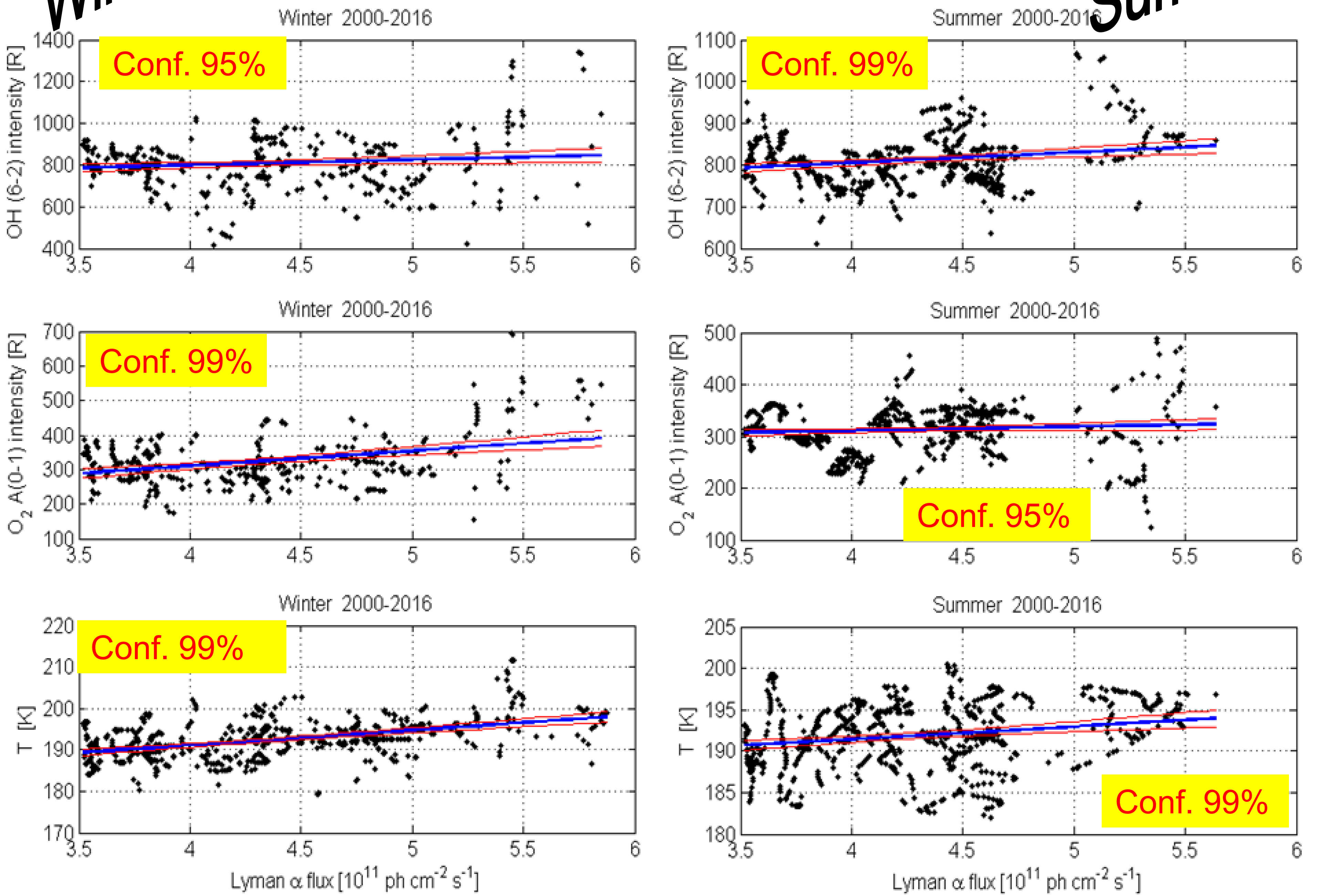
### Technique of the analysis:

**Multiple regression analysis with averaging long-term (1 year) or subtracting short-term (35 days) mean values**

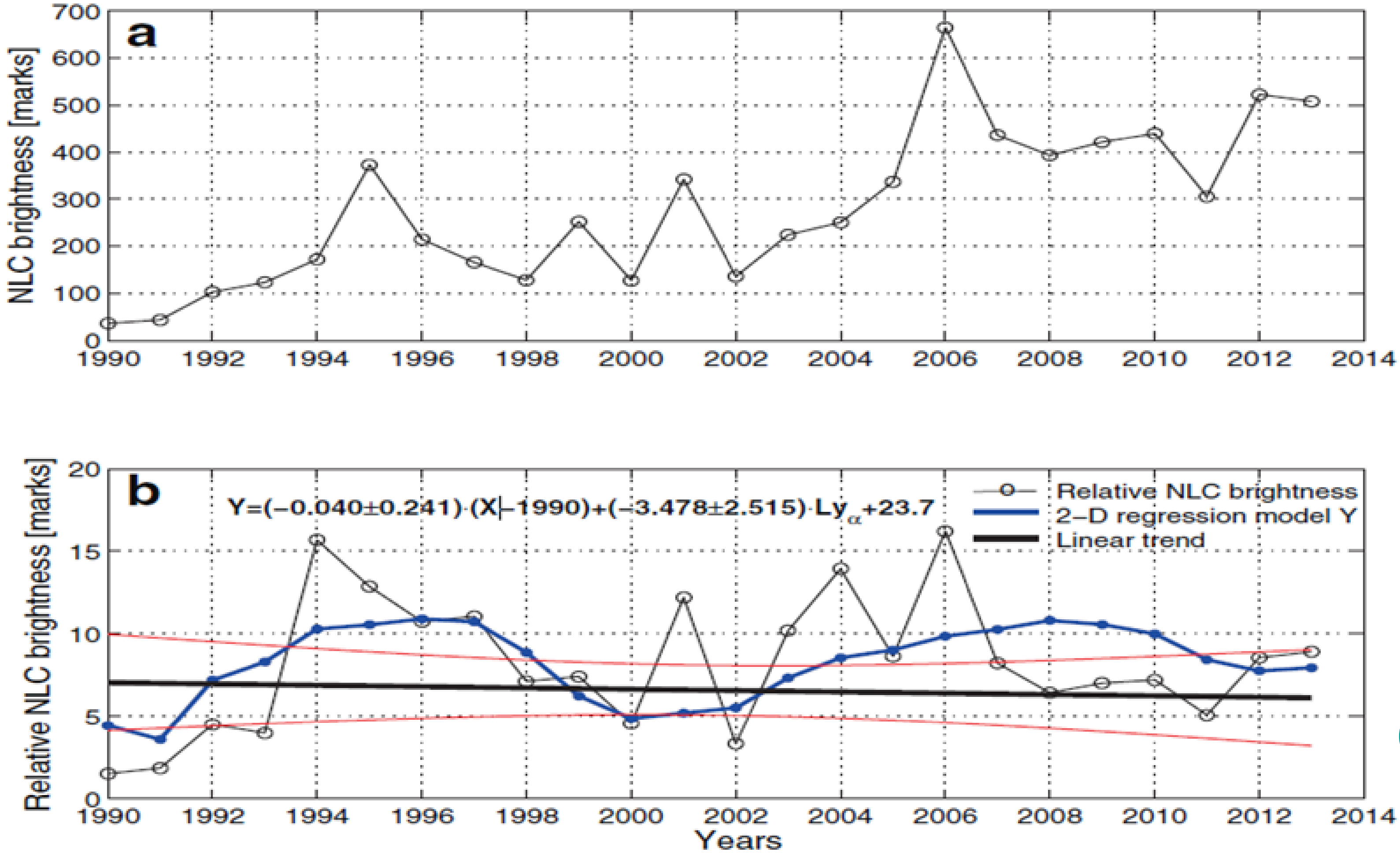
Winter

# Long-term solar influence

Summer



# Noctilucent clouds' brightness by visual ground–based estimations 1990-2014




**Best**

**Fitting**

**Lag =**

**0 y-rs**

**Statistically significant negative regression with seasonally averaged Ly alpha flux (Moscow database, Pertsev et al., 2014)**

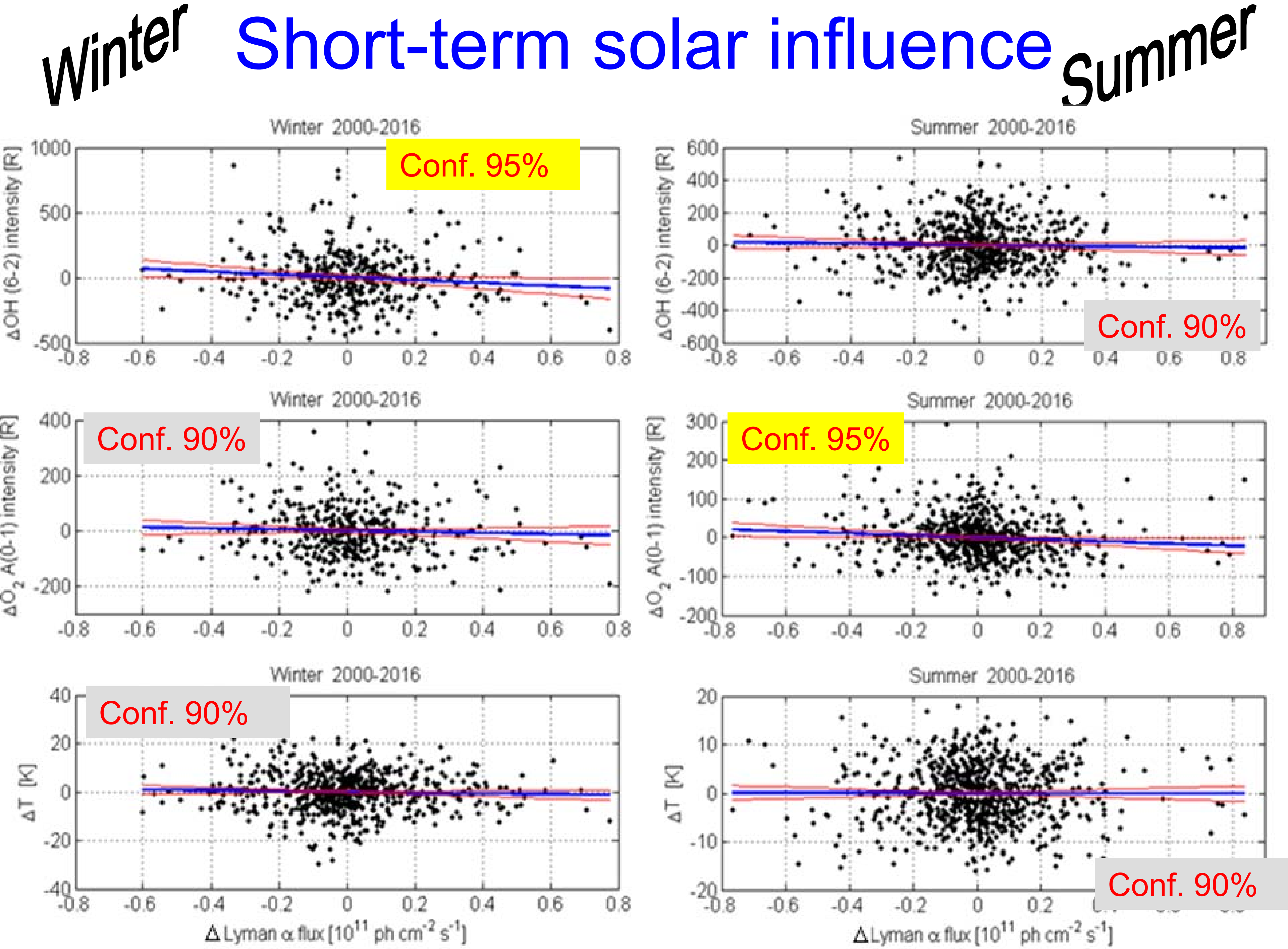
# Main probable mechanisms of long-term solar influence

- Higher solar UV → higher $O_2$ dissociation → more O→more $OH^*$ and $O_2^*$

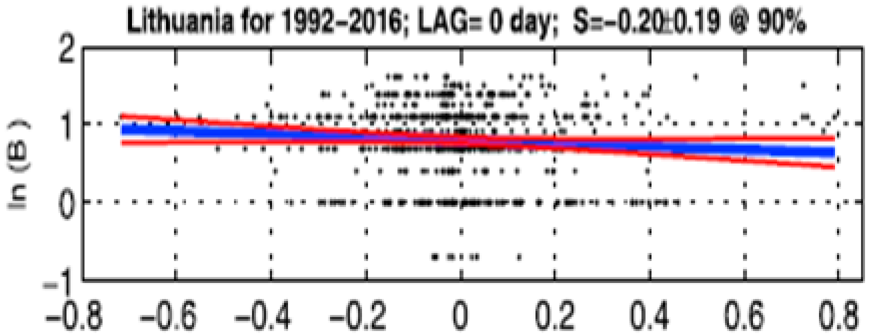
- Higher solar UV → higher $O_2$ dissociation → more heat flux from relevant exothermic reactions →higher temperature

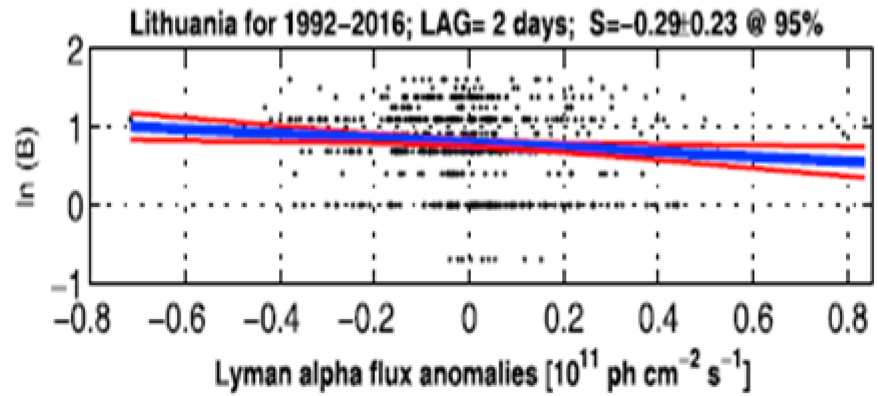
- Higher solar UV → higher $H_2O$ dissociation → lesser $H_2O$ vapour →less frequent and bright NLC

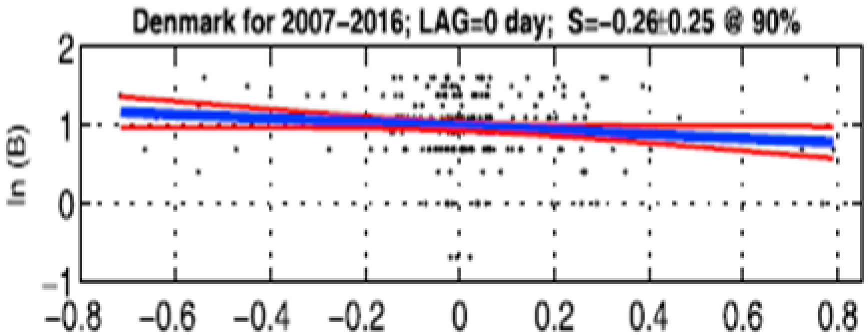
# Short-term solar influence

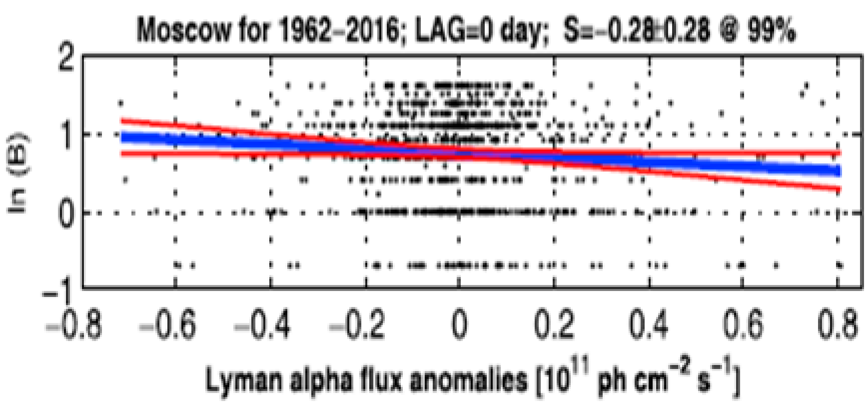


# Noctilucent clouds' brightness by visual ground–based estimations 1962-2016




**ln (NLC brightness) vs. short-time component of solar Ly-alpha flux.**

Different observing sites show negative statistically significant (90 to 99 % probability) dependencies with lags from 0 to 3 days (Dalin et al., 2018)

# Main difference in regression coef-s for **long-term** and **short-term** Ly-α flux variations

| | | |
|---|---|---|
| **Winter intensity of OH* airglow** | >0 | <0 |
| **Summer intensity of OH*airglow** | >0 | ~0 |
| **Winter intensity of $O_2$* emission** | >0 | ~0 |
| **Summer intensity of $O_2$* emission** | >0 | <0 |
| **Winter OH* rotational temperature** | >0 | ~0 |
| **Summer OH* rotational temperature** | >0 | <0 |

# Probable mechanism of solar short-term influence

Perhaps one of strongest players in the competition of different physical mechanisms is vertical advection mechanism that is effectively governed by solar activity on the short-term scale (Thomas et al., 2015).

- Higher solar UV → changes in meridional-vertical circulation → increase in upward vertical velocity
  - →decreased [O]→less OH* and $O_2$*
  - → adiabatic decrease of temperature

Competition of the vertical advection mechanism and the dissociative mechanism on the short-term scale <u>may give different signs for different physical variables</u>

# Summary

1. The analysis of mesopause region infrared emissions OH* and $O_2$* measurements shows different responses of their intensity and OH* layer temperature to solar activity variations on the long-term (year-to-year) and short-term (day-to-day) scales. It means that different physical mechanisms of the solar influence are involved on these two scales.

# Summary

2. On the long-term scale the most probable mechanism of the solar influence is through the $O_2$ and $H_2O$ dissociation by solar UV radiation.

# Summary

3. On the short-term scale one may guess a strong competition between the dissociative mechanism and some opposite mechanism. We support an idea of Thomas et al., 2015 that this mechanism is implemented through the vertical advection. The short-term increase in solar activity must be accompanied by the increase in the upward motion at midlatitude mesopause region in summer and attenuation of the downward motion in winter.

**Thank you for attention**

# References


- **Dalin, P. et al. (2018).** Response of noctilucent cloud brightness to daily solar variations// J. Atmos. Sol. Terr. Phys. 169, 83–90.
- **Pertsev N. et al. (2014).** Noctilucent clouds observed from the ground: sensitivity to mesospheric parameters and long-term time series// Earth, Planets and Space. 66, 98.
- **Thomas, G. et al. (2015).** Solar induced 27-day variations of mesospheric temperature and water vapor from the AIM SOFIE experiment: drivers of polar mesospheric cloud variability. J. Atmos. Sol. Terr. Phys. 134, 56–68.