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Interseasonal impact of Siberian snow cover formation rate on the baroclinicity and wave activity over Northern Eurasia

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Introduction

or "What do we know about the connection between autumn snow cover and winter atmospheric dynamics modulation?"

I Foster J. et al., 1983:

Snow cover: NOAA satellite data,

T: observations (6 stations in Eurasia and 7 stations in N.America)

Period: 1970-1982

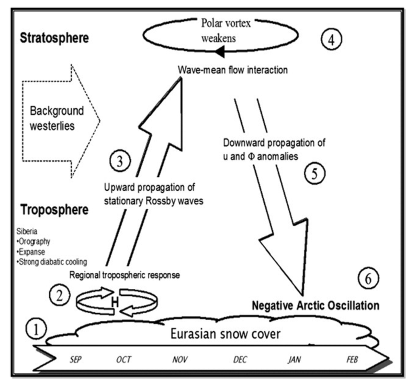
Result: ***significant relationship***

II Cohen J. et al., 2007:

NCEP/NCAR 1948-2004

Result:

The mechanism is:



III Popova V.V. et al., 2014:

Observations, 1950-2008

15-years sliding correlation coefficients

Result: ***not for all time periods***

IV Furtado J.C. et al., 2015:

ERA-Interim, NCEP/NCAR, MERRA, CMIP5 piControl

Ensemble average

Time periods: 30, 40, 50 years

Result: ***the most of models don't catch the relationship***

V Douville H et al., 2017:

Reanalysis: 20CR, 1851–2014; ERA-20C, 1900–2010

Result: ***stochastic manifestation***

VI Henderson G R et al., 2018:

Observations and models output

Result: ***a lot of uncertainties in data and models; mechanism is still enigmatic***

The aim of the study:

to assess the response of the troposphere and lower stratosphere over Northern Eurasia during the autumn-winter period to a rate of the snow cover formation in Siberia

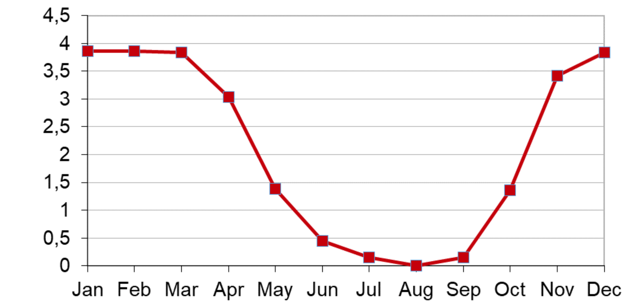
Data and Methods

Data

- *NOAA weekly satellite data on snow cover from the Rutgers University Global Snow Lab (GSL) (Robinson, 2012)*
- *ERA-Interim reanalysis: atmospheric data (Dee et al., 2011)*

Region

Western Siberia (60E-90E 50N-70N)



Climatological S_{snow}, GSL, 1979-2016.

Baroclinicity Index

$$BI = BI_x\mathbf{i} + BI_y\mathbf{j}$$

(Nakamura and Yamane, 2009)

$$BI_x = -\frac{g}{\theta N}\frac{\partial\theta}{\partial y};\ BI_y = \frac{g}{\theta N}\frac{\partial\theta}{\partial x},$$

$$N^2 = \frac{g}{\theta}\frac{d\theta}{dz}$$

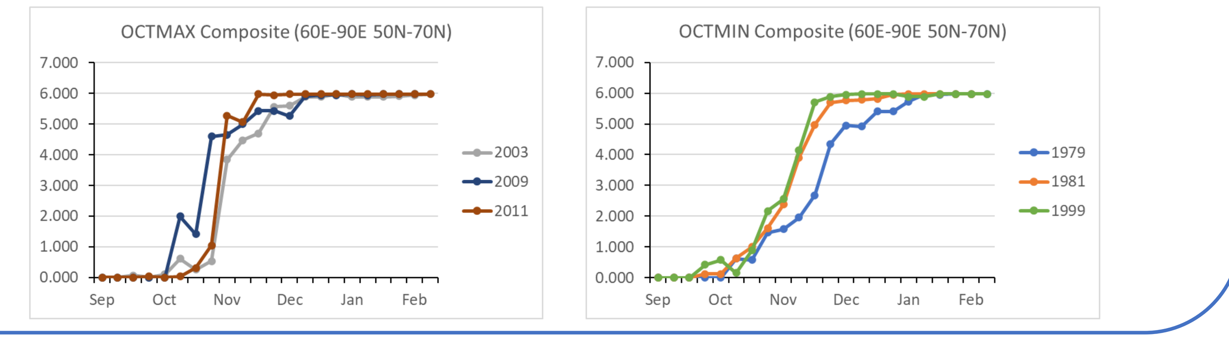
Eliassen-Palm flux (wave activity)

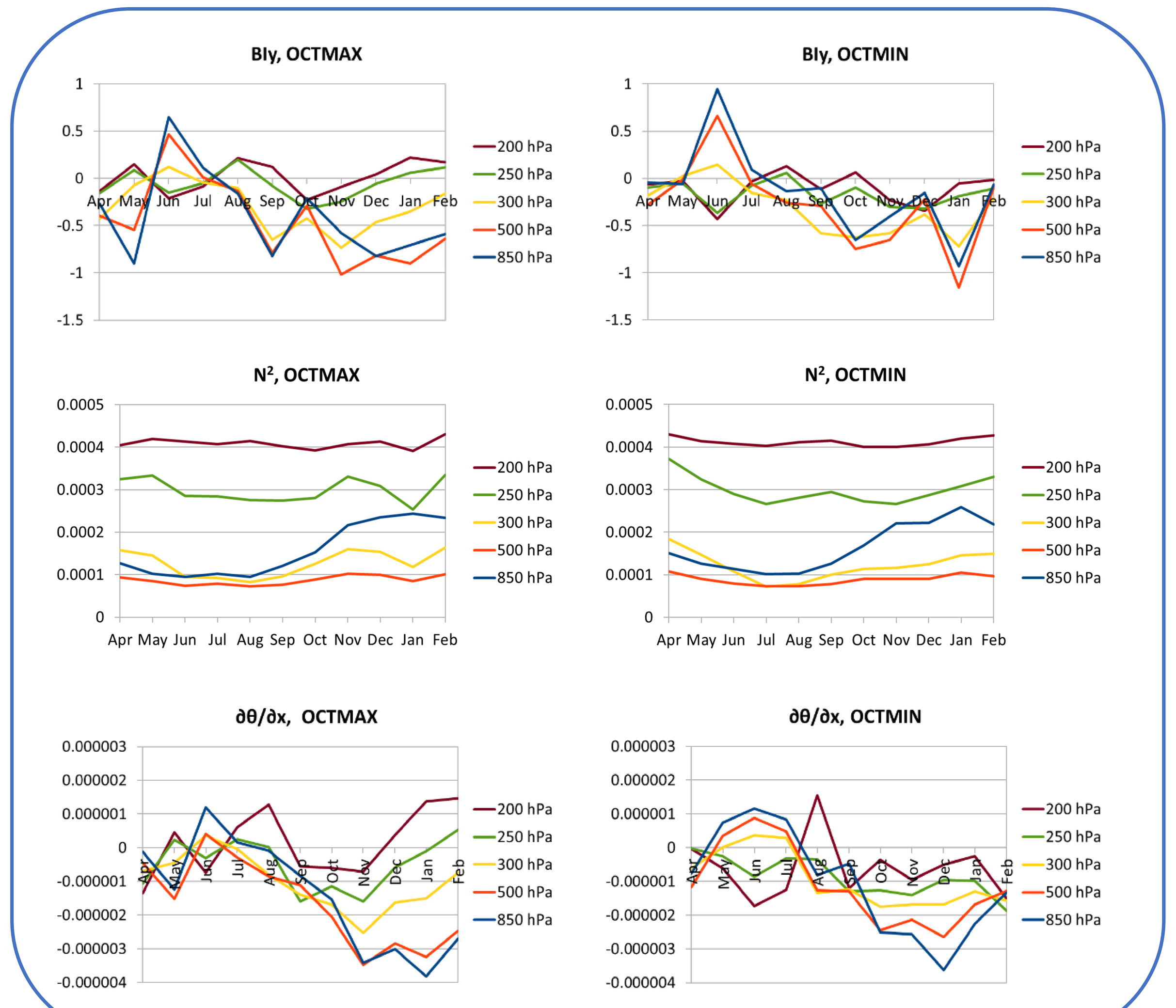
$$F = (F_y, F_p)$$

$$F_y = -\langle\overline{u'v'}\rangle;\ F_p = f\frac{\langle\overline{u'\theta'}\rangle}{\partial\langle\theta\rangle/\partial p}$$

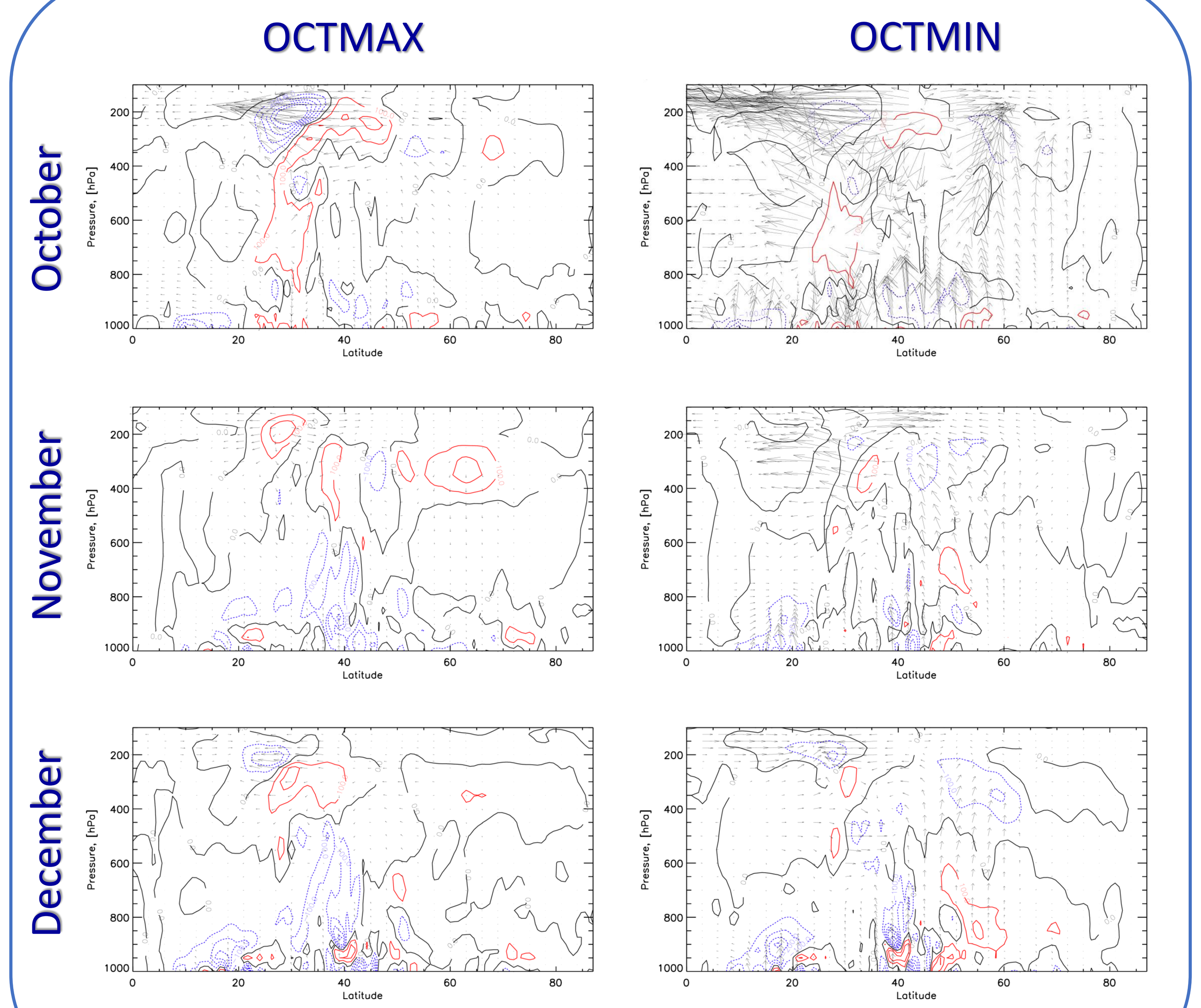
Composites

- *OCTMAX - with fast and sharp snow cover formation. Most of the area forms during one week in October*
- *OCTMIN - with slow and smooth snow cover formation. The week with the highest formation rate is not in October*





Differences in the behavior of the baroclinicity index (BI) and its components between composites begin to appear long before the snow cover formation. The most considerable differences are demonstrated by the BI_y, starting in September. Moreover, such variability is largely determined by the zonal gradient of the potential temperature ($\partial\theta/\partial x$), and not by the vertical atmospheric instability (N^2).



Arrows: $F = (F_y, F_p)$; isolines: $div(F)$; red color: $div(F) > 0$; blue color: $div(F) < 0$

Wave activity showed significant differences between OCTMAX and OCTMIN composites. These differences are especially pronounced in October and persist, but gradually weakening, until February. From October to December, the OCTMIN exhibits significantly more intense (especially in October and November) wave activity than the OCTMAX.

Besides, the presence of differences between composites for a more extensive territory (Western + Eastern Siberia) manifests itself even in September, when snow cover has not yet begun to form.

In conclusion, we can assume that anomalies in the snow cover formation, atmospheric wave activity and baroclinicity are manifested independently due to anomalies in atmospheric circulation already existing at the time of the snow cover formation.

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