# Моделирование влияния океана и явления Эль-Ниньо – Южной осцилляции на структуру и состав атмосферы
# Simulation of influence of ocean and El-Nino – South oscillation phenomenon on structure and composition of atmosphere

Russian State Hydrometeorological University

**A. Jakovlev, S. Smyshlyaev**

Russian State Hydrometeorology University, St. Petersburg, RUSSIA

Рассматривается влияние явления Эль-Ниньо – Южная осцилляция на стратосферу Арктики. Проанализированы данные ре-анализа по температуре поверхности океана, потенциальному вихрю, температуры воздуха, отношения смеси для озона и общего содержания озона. Изучается влияние Эль-Ниньо и Ла-Нинья на циркумполярный вихрь, температуру воздуха в стратосфере и озоновый слой. Показано, что Эль-Ниньо приводит к неустойчивости циркумполярного вихря, вызывает внезапные стратосферные потепления и увеличивают содержание озона. Также проанализированы результаты численных экспериментов и данных ре-анализа за период с 1980 по 2015 годы и оценено влияние ТПО и уровня $CO_2$ на атмосферу. По результатам моделирования наблюдается увеличение температуры в приземном слое и уменьшение температуры и отношения смеси для озона в стратосфере. Данные ре-анализа не противоречат результатам моделирования в тропосфере, но в стратосфере значительно расходятся.

Influence of the phenomenon the El-Nino - Southern oscillation on a stratosphere of Arctic regions is considered. Data of the reanalysis on temperature of a surface of ocean, a potential vorticity, temperatures of air, the ozone mixed ratio and the total column of ozone are analyzed. Influence the El-Nino and La-Nina on circumpolar vortex, temperature of air in a stratosphere and an ozone cloud is studied. It is shown, that the El-Nino leads to instability circumpolar vortex, causes sudden stratospheric warming and increase the maintenance of ozone. Also results of numerical experiments and data of the reanalysis for the period with 1980 for 2015 are analyzed and influence SST and $CO_2$ level on an atmosphere is estimated. By results of simulation the increase in temperature in a ground layer and reduction of temperature and the ozone mixed ratio in a stratosphere is observed. Data of the reanalysis do not contradict results of simulation in troposphere, but in a stratosphere considerably miss.

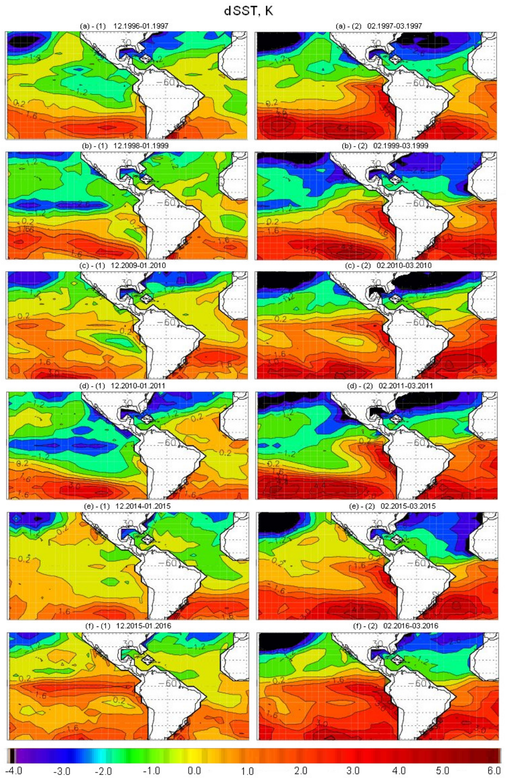


Figure 1 - Distribution of averages for two months of anomalies of temperature of a surface of ocean in K on area $40^0$ S - $40^0$ N latitudes and $180^0$ W - $0^0$ longitudes according to ERA Interim for 1996-1997 (line (a), 1998-1999 (line (b)), 2009-2010 (line (c)), 2010-2011 (line (d)), 2014-2015 (line (e)), 2015-2016 (line (f)) for December-January (column (1)) and February-March (column (2)).

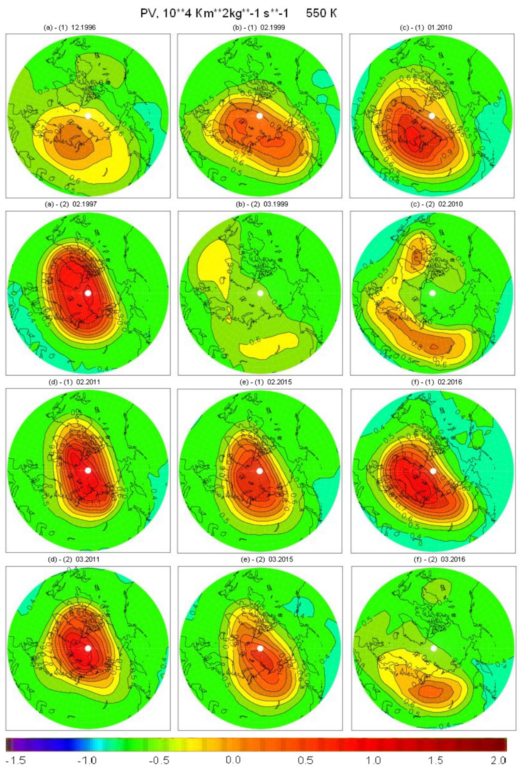


Figure 2 - Monthly average distribution of a potential whirlwind to northern hemisphere in $10^4$ K $m^2$ $kg^{-1}$ $s^{-2}$ on area $40^0$ N - $90^0$ N and height of 24.5 km (30 gPa) according to ERA Interim for December and February, 1996-1997 (column (a), February and March, 1999 (column (b)), January and February, 2010 (column (c)), February and March, 2011 (column (d)), 2015 (column (e)), 2016 (column (f)).

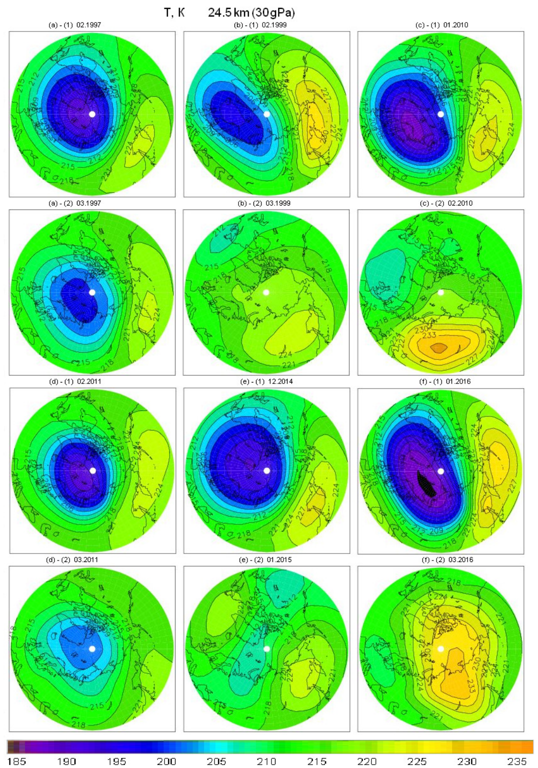


Figure 3 - Monthly average distribution of temperature of air to northern hemisphere in K on area $40^0$ N - $90^0$ N and height of 24.5 km (30 gPa) according to ERA Interim for February and March, 1997 (column (a), 1999 (column (b)), January and February, 2010 (column (c)), February and March, 2011 (column (d)), December and January, 2014-2015 (column (e)), January and March, 2016 (column (f)).

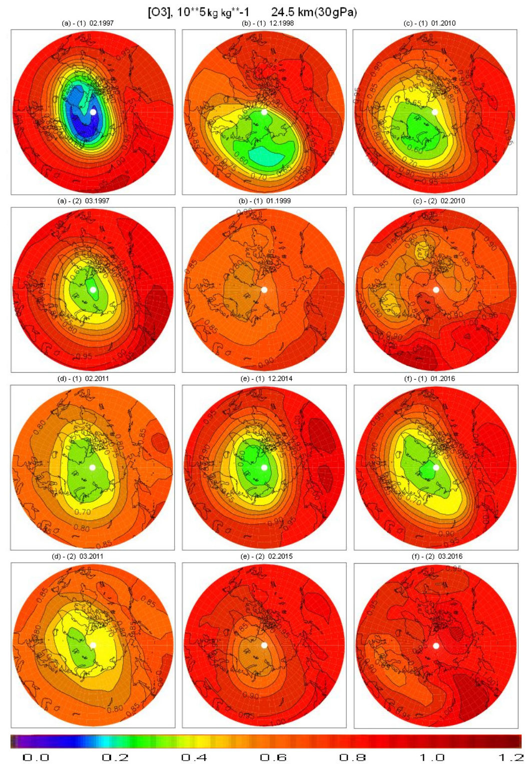


Figure 4 - Monthly average distribution of the ozone mixed ratio on northern hemisphere in $10^5$ kg/kg on area $40^0$ N - $90^0$ N and height of 24.5 km (30 gPa) according to ERA Interim for February and March, 1997 (column (a), December and January, 1998-1999 (column (b)), January and February, 2010 (column (c)), February and March, 2011 (column (d)), December and February, 2014-2015 (column (e)), January and March, 2016 (column (f)).

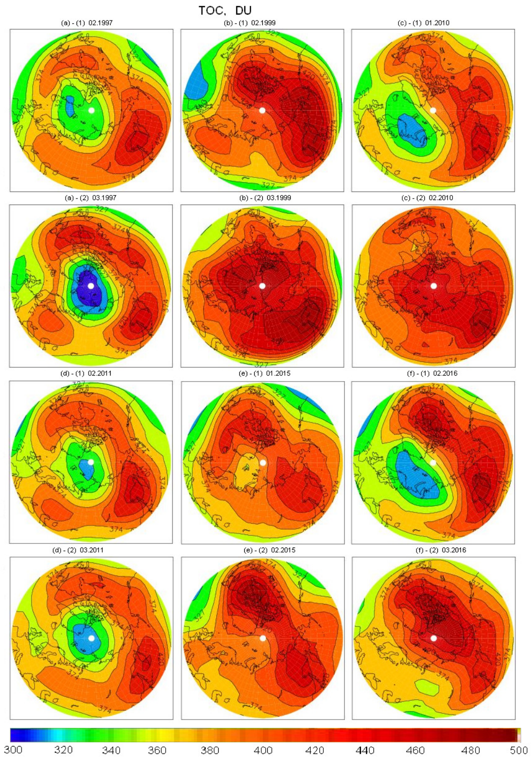


Figure 8 - Monthly average distribution of the total column of ozone to northern hemisphere in DU on area $40^0$ N - $90^0$ N according to ERA Interim for February and March, 1997 (column (a), 1999 (column (b)), January and February, 2010 (column (c)), February and March, 2011 (column (d)), January and February, 2015 (column (e)), February and March, 2016 (column (f)).

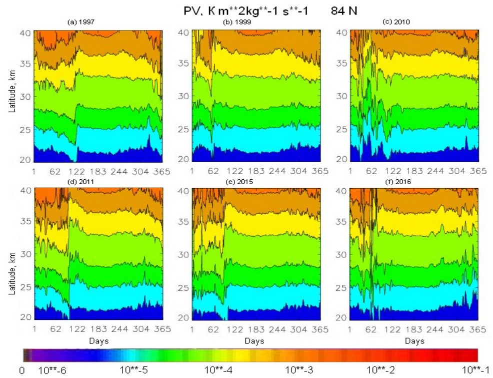


Figure 5 - Vertical annual profiles of a potential vorticity in K $m^2$ $kg^{-1}$ $s^{-2}$ on daily average data ERA Interim at latitude $84^0$ N for 1997 (a), 1999 (b), 2010 (c), 2011 (d), 2015 (e), 2016 (f).

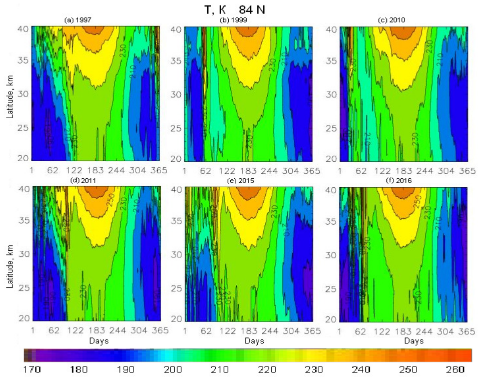


Figure 6 - Vertical annual profiles of temperature of air in K on daily average data ERA Interim at latitude $84^0$ N for 1997 (a), 1999 (b), 2010 (c), 2011 (d), 2015 (e), 2016 (f).

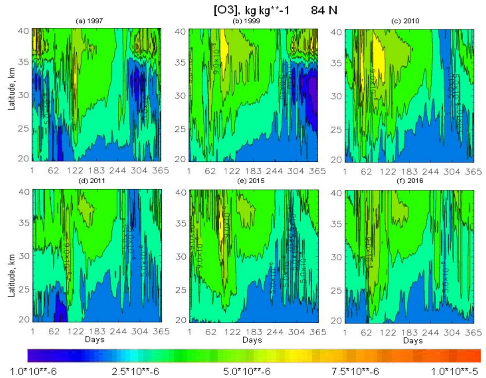


Figure 7 - Vertical annual structures of the ozone mixed ratio in kg/kg on daily average data ERA Interim at latitude $84^0$ N for 1997 (a), 1999 (b), 2010 (c), 2011 (d), 2015 (e), 2016 (f).

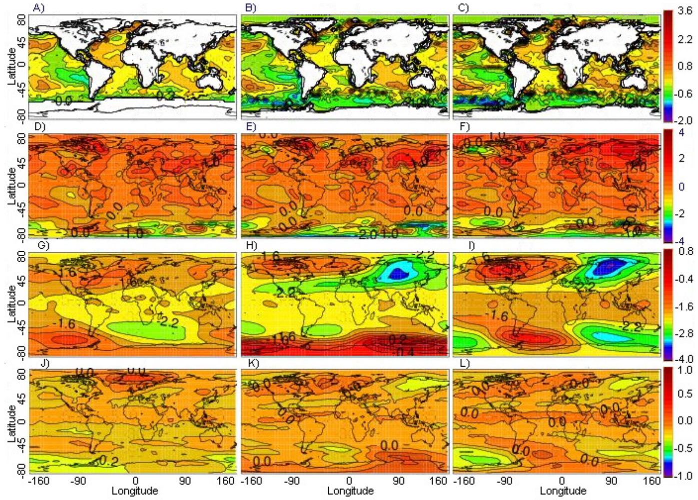


Figure 9 - Difference of average sizes for 2010-2015 and 1980-1985 temperatures of a surface of ocean (K) according to Met Office (A), ERA Interim (B), ERA20Century and ERA5 (C), results of simulation of temperature of air (K) at a level 925 gPa with use of SST data Met Office (D), ERA Interim (E), ERA20Century and ERA5 (F), temperatures of air at a level 20 gPa with use of SST data Met Office (G), ERA Interim (H), ERA20Century and ERA5 (I), maintenances of ozone (kg/kg) at a level 20 gPa with use of SST data Met Office (J), ERA Interim (K), ERA20Century and ERA5 (L).

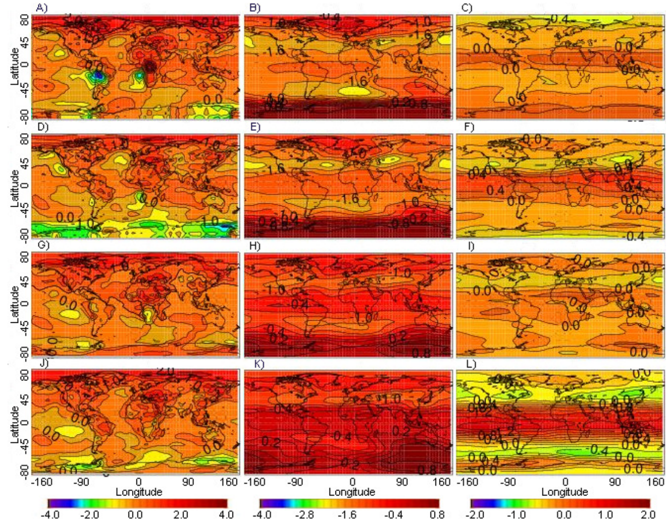


Figure 10 - Difference of reanalysis data, averaged for the periods with 2010 on 2015 and with 1980 on 1985 MERRA (the first line), MERRA2 (second line), JRA (third line), ERA Interim (fourth line). The left column - temperature of air (K) at a level 925 gPa, an average column - temperature of air (K) at a level 20 gPa, the right column - the ozone mixed ratio (kg/kg) at a level 20 gPa.

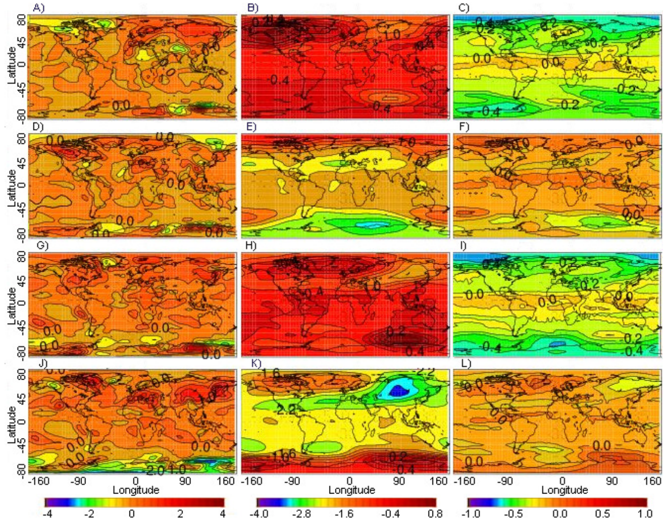


Figure 11 - Difference of results of simulation, averaged for the periods with 2010 on 2015 and with 1980 on 1985 in experiments with fixed SST, SIC and $CO_2$ values at a level 1979 (first line), with fixed SST and SIC at a level 1979 (second line), with fixed $CO_2$ at a level 1979 (third line) and base (bottom line). The left column - temperature of air (K) at a level 925 gPa, an average column - temperature of air (K) at a level 20 gPa, the right column - the ozone mixed ratio (kg/kg) at a level 20 gPa.

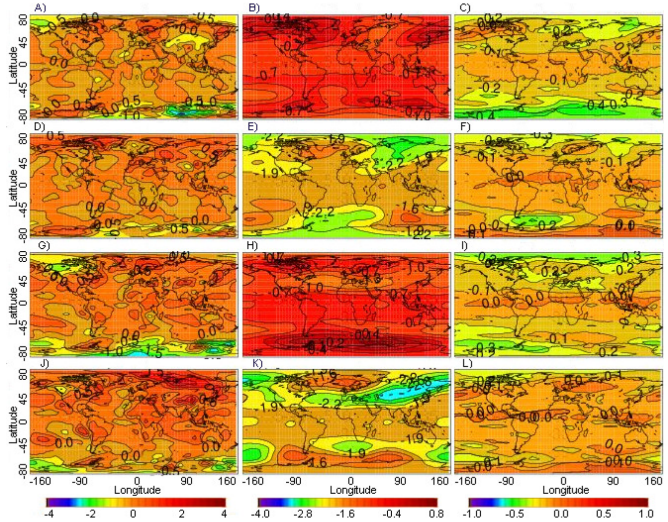


Figure 12 - Difference of results of simulation in view of influence of return influence of ozone, averaged for the periods with 2010 on 2015 and with 1980 on 1985 in experiments with fixed SST, SIC and $CO_2$ values at a level 1979 (first line), with fixed SST and SIC at a level 1979 (second line), with fixed $CO_2$ at a level 1979 (third line) and base (bottom line). The left column - temperature of air (K) at a level 925 gPa, an average column - temperature of air (K) at a level 20 gPa, the right column - the ozone mixed ratio (kg/kg) at a level 20 gPa.

# Conclusions:

1. The phenomenon the El-Nino was in 2010, 2015 and 2016, and in 2011 - La-Nina. SST in 2010, 2015 and 2016 was above 27 $^0$C in all tropical region of Pacific ocean, whereas in 2011 - only in its western part.

2. Steady CPV, as a rule, precede the El-Nino, and unstable to be its consequence. In 1997 CPV was the steadiest, thus the El-Nino 1997-1998 was very powerful. In 1999 after that the El-Nino, CPV was the most unstable.

3. A consequence the El-Nino can be SSW which lead to instability connected with CPV the center of a cold (temperature less than 200 K). Within about the El-Nino (2010, 2015 and 2016), and also after the El-Nino (1999) series SSW which caused instability of the center of a cold were observed.

4. The El-Nino can lead to increase in the maintenance of ozone that is visible on 2010, 2015 and to 2016 when the zone of the low maintenance of ozone after February starts to decrease quickly (the ozone mixed ratio increases with 3.6 on 4.8 ppm).

5. The El-Nino can result and in increase in the total column of ozone above North Pole that is visible on 2010, 2015 and to 2016 (value of the maintenance of ozone increases with 280 on 374 DU within February-March).

6. Change of temperature of air above oceans and coastal areas, as a whole, corresponds to variability of SST though both the increase in maintenance $CO_2$ and other influences at an atmosphere render essential influence on ground temperature. By results of the lead simulation experiments it is possible to draw a conclusion that global warming is caused, substantially, set of influences on an atmosphere and amplifies increase in maintenance $CO_2$ whereas changes of SST, mainly, influence a geographic distribution of changes of temperature.

7. Results of simulation calculations have shown, that if to not consider change $CO_2$ that temperature of air in a stratosphere will vary a little. Thus, carried out research has shown, that for observable cooling a stratosphere by the significant factor changes of maintenance $CO_2$ which fixation does temperature of a stratosphere almost constant within 1980-2015 are, and change of SST renders on it only insignificant influence

8. Results of simulation, as a whole, show decrease in the mixed ratio of stratospheric ozone in polar regions and increase in tropics. Thus as a whole on a planet there is an increase in the ozone mixed ratio. As well as in case of with temperature of air in a stratosphere, distribution of changes of the maintenance of ozone slightly depends on changes of SST that does this factor poorly significant. Greater value for the maintenance of ozone has level $CO_2$ influencing temperature of a stratosphere, substantially defining speed of destruction of ozone.