P1.1 CO2 MIXING RATIOS FLUCTUATIONS AND ATMOSPHERIC CIRCULATION

Valery N. Khokhlov * and Alexander V. Glushkov
Odessa State Ecological University, Ukraine

1. INTRODUCTION

The impact of greenhouse gases including carbon dioxide (CO_2) on the modeled climatic characteristics is well known (e.g., Kothalava et al., 1999). On the other hand, the atmospheric circulation have influence onto atmosphere constituents as ozone (e.g., Brönnimann et al., 2000) and other. Nevertheless, in contrast to the one-or-two-year modelling the numerous feedbacks will be essential at long-term period simulation. In this work the impact of atmospheric circulation on seasonal fluctuations of carbon dioxide mixing ratios is investigated

2. DATA

The CDIAC monthly mean dataset was used for analysis of the CO_2 mixing ratios fluctuations during 1985-1992 years (Conway et al., 1994). The teleconnection patterns was used for investigations of the atmospheric circulation features (available from http://www.cpc.ncep.noaa.gov/data/teledoc/telecontents.html)

3. RESULTS

For the period 1985-1992 years on average the mixing ratio has increased on 10 ppm approximately and has exceeded 357 ppm for high latitudes of Northern Hemisphere. All sites can be divided into two groups on a degree of CO_2 mixing ratio variability during year.

The first group includes sites with small annual variability and on some of them (e.g., Samoa or South Pole; Fig. 1) the annual fluctuations almost are absent. The increase of carbon dioxide mixing ratios at sites of this group during above period is associated mainly to the anthropogenic influence.

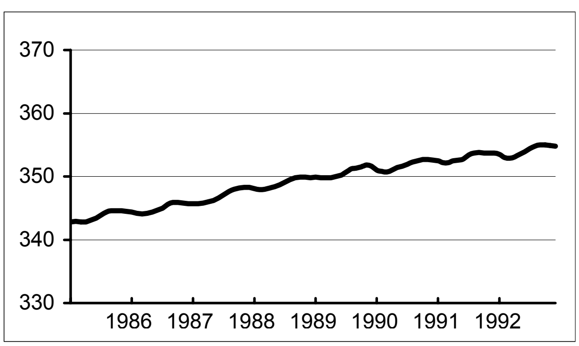

Fig. 1. Concentration of atmospheric CO_2 (ppm) at South Pole.

* *Corresponding author address:* Valery N. Khokhlov, Odessa State Ecological Univ., Dept. of Theoretical Meteorology, Lvovskaya 15, Odessa, 65016, Ukraine; e-mail: valerijnkhokhlov@ukr.net.

The sites of other group are characterized by large annual variability of CO_2 mixing ratios and are located in middle and high latitudes of Northern Hemisphere. The large annual fluctuations may be accounted by three main seasonal factors - anthropogenic, variability of vegetation absorbing CO_2, and features of atmospheric circulation providing accumulation or dispersion of CO_2. It is possible to consider first of these factors working irrespective of a season. The second factor in high latitudes subjects to the large fluctuations during year as in winter the vegetation is less than in summer, and CO_2 is absorbed less also. Confirmation of it can be trend at Alert, Mould Bay or Barrow (Fig. 2) where the increased values of CO_2 mixing ratios are kept during cold months.

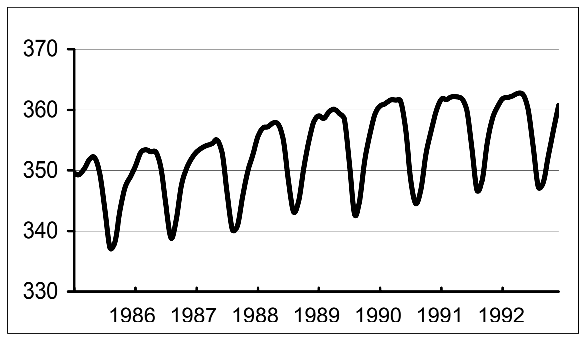

Fig. 2. Concentration of atmospheric CO_2 (ppm) at Barrow.

However, in winter of some years at these sites the two maximums of CO_2 mixing ratios are registered and at the neighboring stations they are observed in the same years. It can be associated with features of atmospheric circulation, which are convenient for analyzing using a teleconnection patterns (Barnston and Livezey, 1987). As an example we have considered the trends since August 1988 till July 1989 at Barrow and Cape Mears (Fig. 3). These stations are under influence of teleconnection pattern known as East Pacific (EP).

The EP pattern is evident in all months except August and September, and reflects a north-south dipole of height anomalies over the eastern North Pacific. The northern center is located in the vicinity of Alaska and the west coast of Canada, while the southern center is of opposite sign and is found near, or east of, Hawaii. During strong positive phases of the EP pattern, a deeper than normal trough is located in the vicinity of the Gulf of Alaska / western North America, and positive height anomalies are observed farther south. This phase of the pattern is associated with a pronounced northeastward extension of the Pacific jet stream toward western North America, and with enhanced westerlies over the Pacific Northwest States, northern California, and sometimes southwestern British Columbia.

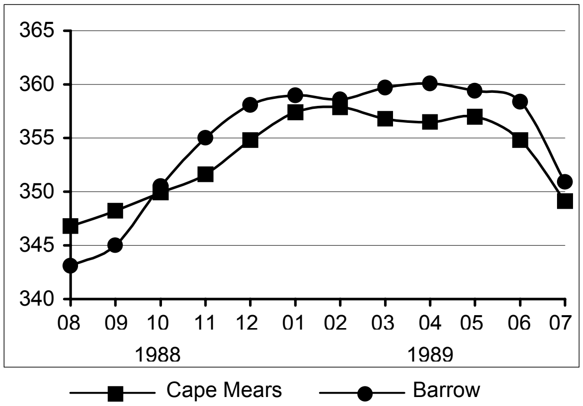

Fig. 3. Concentration of atmospheric CO_2 (ppm) at Cape Mears and Barrow since August 1988 till July 1989.

In contrast, strong negative phases of the EP pattern are associated with a pronounced split-flow configuration over the eastern North Pacific, and with reduced westerlies throughout the region. This circulation is accompanied by a confinement of the climatological mean Pacific trough to the western North Pacific, and possibly with a blocking flow configuration farther east.

The considered cold season was characterized by strong positive phases in November 1988 – January 1989 and in April – May 1989 and strong negative phase in January 1989 (Fig. 4). In our opinion such circulating conditions have resulted that in February 1989 maximum of CO_2 mixing ratio at Cape Mears corresponded to a minimum at Barrow; the reverse was observed in April 1989 (see Fig. 3).

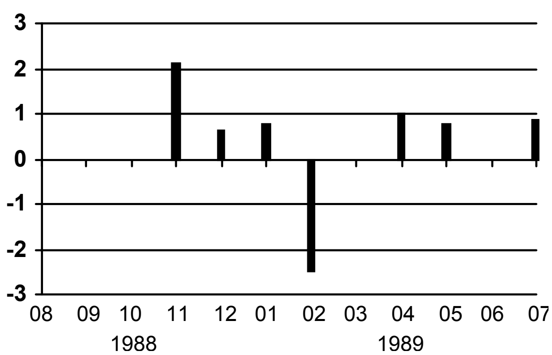

Fig. 4. EP pattern indices since August 1988 till July 1989.

The modelling with NCAR CCM3 (Kiehl et al., 1996) has shown that under compulsory strong positive and negative phases of the above teleconnection pattern at considered sites it is possible to obtain two maximums of the CO_2 mixing ratio in the cold period. The simulations with CCM3 were carried out for two cases: compulsory strong (the index is equal to 3.5 in December, January and April and to –3.5 in February) and weak positive and negative phases of the EP pattern. Fig. 5 shows result of these computations for Barrow during August 1987 – July 1989. Let's note that the strong negative phase of the PE pattern was not marked in February 1988.

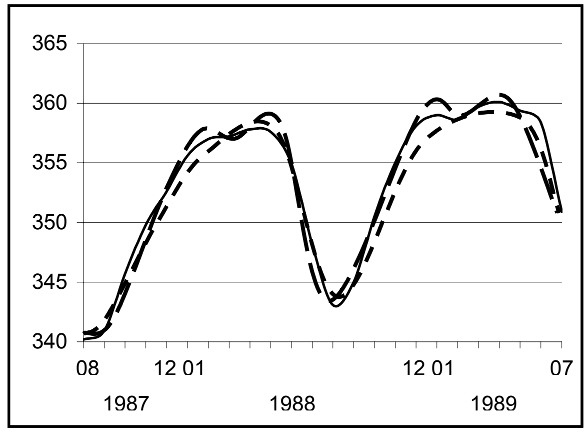

Fig. 5. Concentration of atmospheric CO_2 (ppm) at Barrow since August 1987 till July 1989 (solid line – observations, short dotted line – weak EP pattern indices, long dotted line – strong EP pattern indices).

4. CONCLUSIONS

Our results reveal a relation between CO_2 mixing ratio and important atmospheric circulation indices. And the strong phases of the teleconnection patterns correspond to the considerable intra-seasonal fluctuations of CO_2.

We also consider that other teleconnection patterns as the North Atlantic Oscillation (NAO), Pacific / North American (PNA) and Polar / Eurasia (PE) patterns have an influence on the cold period trends for the stations at middle and high latitudes.

REFERENCES

Barnston, A. G., and R. E. Livezey, 1987: Classification, seasonality and persistence of low-frequency atmospheric circulation patterns. *Mon. Wea. Rev.*, **115**, 1083-1126.

Brönnimann, S., J. Luterbacher, C. Scmutz, H. Wanner, and J. Staehelin, 2000: Variability of total ozone at Arosa, Switzerland, since 1931 related to atmospheric circulation indices. *Geophys. Res. Lett.*, **27**, 2213-2216.

Conway, T.J., P. P. Tans, and L. S. Waternan, 1994: CO_2 records from sites in NOAA/CMDL air sampling network. *Trends'93: A compendium of data on global change*. T. A. Boden, D. P. Kaiser, R. J. Sepanski and F. W. Stoss, Eds., ORNL/CDIAC-65, 41-119.

Kiehl, J. T., J. J. Hack, G. B. Bonan, B. A. Boville, B. P. Briegleb, D. L. Williamson, and P. J. Rasch, 1996: Description of the NCAR Community Climate Model (CCM3). NCAR Technical Note, NCAR/TN-420+STR, National Center for Atmospheric Research, Boulder, Colo., 152 pp.

Kothavala, Z., R. J. Ogleaby, and B. Saltzman, 1999: Sensitivity of Equilibrium Surface Temperature of CCM3 to Systematic Changes in Atmospheric CO_2. *Geophys. Res. Lett.*, **26**, 209-212.