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SEASONAL DEPENDENCE OF THE NORTH-SOUTH ASYMMETRY IN THE NEUTRAL UPPER-ATMOSPHERE

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ABSTRACT

In an earlier paper (Illés-Almár and Almár, 2006) it was demonstrated that there is a **North-South asymmetry in the density of the upper-atmosphere** with higher density over the Northern hemisphere in average. Looking for the origin of this asymmetry an investigation is carried out on its seasonal dependence on the basis of the same data base. The origin of the North-South asymmetry could not be cleared by this analysis, but serendipitously a discrepancy has been found in existing models, namely a **Sun-Earth distance effect is not correctly taken into account in the atmospheric models**.

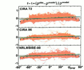

Fig. 1

Reason for reanalyzing an old observational material from the 1970's:

The data base in our previous investigations[1] was restricted to the equatorial region, because of the small inclination of these satellites. -In order to enlarge the latitudinal interval we have reanalyzed our old observational material from the 1970's. A serendipitous result of that investigation was the discovery of a North-South asymmetry in the neutral upper atmosphere (*Fig. 1;* Illés-Almár and Almár, 2006): the model-residuals decrease continuously and evenly from $\varphi = +60°$ to $\varphi = -60°$ – the Northern hemisphere being warmer.

[1] in situ CASTOR/CACTUS and San Marco V accelerometric measurements in modeling the geomagnetic effect of the upper-atmospheric density (Almár and Illés-Almár, 2004 and Illés-Almár, 2004 and the references therein).

What mechanism can cause such a hemispheric asymmetry?

1.) the different configuration of the **geomagnetic field** on the two hemispheres (*Fig. 2*)
2.) the significantly **different distribution of oceans** on the two hemispheres (*Fig. 3*)
3.) **the different dust-content[2] in the atmosphere** on the two hemispheres as a consequence of the dust-aerosol lifted up from desert-areas by winds (*Fig. 4*)

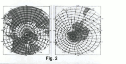

Fig. 2

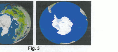

Fig. 3

[2] The working hypothesis behind the dust content is the following.
The dust from the deserts is lifted up into the troposphere by the zonal winds producing a larger dust content over the Northern hemisphere and during spring as it was suggested by the CALIPSO lidar measurements (Liu et al., 2007).
In this case an increase would be expected in the steepness of the North-South asymmetry during springs.
This lifted dust layer, namely, as a heat source may disturb the temperature profile and as a consequence an upward expansion of the atmosphere can occur – similarly to the diurnal bulge. But since the prevailing winds are zonal, the expansion may be restricted to the latitudinal zones of the large deserts. The upward expansion of the atmosphere may reach the heights where the satellites are orbiting and therefore they might record higher densities there.

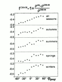

Fig. 5

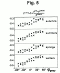

Fig. 6

INVESTIGATION OF A POSSIBLE SEASONAL DEPENDENCE OF THE NORTH-SOUTH ASYMMETRY

The original topic of the present paper was the seasonal dependence of this North-South asymmetry – based on the same observational material.

Observational Material:

Number of total neutral air density (ρ) data based on drag decay of 20 artificial satellites: 15999 (with $e > 0.01$, where the position of the perigee is well determined)
Height interval: 260 – 450 km
Time interval: May. 1965 – Sep. 1977.
Time resolution: 1 – 2 days
Inclination of the selected satellites: 3° – 96°
For comparison at this seasonal analysis the CIRA'86 upper atmospheric model has been used: $f = \rho_{observed} / \rho_{CIRA'86}$ and the model residuals (f-1) have been plotted as a function of geographic latitudes (φ_{geogr}).

Method to control the working hypothesis in connection with dust-content:

We divided and plotted *(Fig. 5)* the density data according to real seasons[3]. It is clear that the North-South asymmetry is present during all seasons as well, but the steepness in spring is not larger as it would be awaited if the dust content is the cause of the North-South asymmetry.

A problem is emerging, however, as the time and space dependence is mixed in *Fig. 5* as the same season occurs half a year later on the other hemisphere.

To consider this time dependence we have investigated the North-South asymmetry during the Northern seasons[4] for the *whole globe* (**crosses**) and during the Southern seasons[4] for the *whole globe* (**dots**) separately and plotted on the same figure *(Fig. 6)*.

Results:

On the basis of this figure it is clear that the steepness of the North-South asymmetry is also the same during the Northern and the Southern seasons, similarly, as during the real seasons[3] (*Fig. 5*).

A further discrepancy is emerging, however, namely: during the Northern winter and Northern spring the whole globe is warmer (not only at the Northern, but at the Southern hemisphere as well!)[5].

We suggest that this observational fact (i.e. that the whole globe is warmer) is the consequence of an incorrect model-representation[6] of the changing Sun-Earth distance due to the eccentricity of the orbit of the Earth – with a certain time delay.

The determination of this time delay with respect to the time of perihelium:

A correlation analysis has been carried out on the mean North-South asymmetry curves for 3 months periods – centered on perihelium and aphelium respectively – with several time delay intervals.

The difference was maximal (approximately 4%) with a 2 months time delay *(Fig. 7)*: that is the effect of a larger insulation (as a consequence of the Earth's orbital eccentricity) appears with a 2 months time delay in the upper atmosphere.

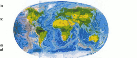

Fig. 4

3 that is, for example, the real spring means March, April, May on the Northern and Sept., Oct., Nov. on the Southern hemisphere.

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5 Northern wintertime (Dec., Jan., Feb.) and Northern springtime (March, April, May).

6 Very probably at the time of the first attempts to construct a model the philosophy was that $S_{10.7}$ is able to represent correctly the **EUV** solar effect in the upper atmospheric models with changing Sun-Earth distance as $S_{10.7}$ is continuously measured on the surface of the Earth, (i.e. in changing distance from the Sun).
Our results illustrated on *Fig. 6* demonstrate that
either this assumption is not correct, that is the correlation between $S_{10.7}$ and EUV is not adequate neither in this respect,
or another mechanism acts in the atmosphere that is dependent on the Sun-Earth distance.

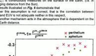

Fig. 7

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CONCLUSIONS

The seasonal investigation proved that

1.) similarly to the mean annual effect the same **North-South asymmetry exists during the different seasons as well,**
2.) as the **steepness of the asymmetry does not change with seasons,** this observational fact **rejects the wind-blown dust explanation of the North-South asymmetry,**
3.) but **favors the ocean/continent cover-difference explanation** (probably through the different specific heat of the surface materials) **and/or the geomagnetic field asymmetry explanation.**
4.) A further discrepancy in the upper atmospheric models has been **discovered**: there is an **annual effect in model residuals**, **as the average atmospheric density is globally higher near perihelium time[7] by roughly 4%** than near aphelium time following the distance extrema with roughly two months time delay.

7 It is surprising that such an evident effect has been discovered only many decades after the first modeling effort (L. Jacchia) even on the basis of such old and inaccurate measurements.
Regrettably the same input indices are used unaltered until today in modern atmospheric models.

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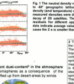

Fig. 1 The neutral density residuals (f-1) decrease from +60° to -60° geographic latitude (φgeogr) hinting at a larger density (and temperature) on the Northern hemisphere. The measured densities were determined on the basis of orbital decay of 20 satellites. The different panels show density residuals for different upper atmospheric models. Heavy dots indicate average values in 10o latitude intervals. In all cases the 2 s is smaller than the diameter of the dots.

What mechanism can cause such a hemispheric asymmetry?

1.) the different configuration of the **geomagnetic field** on the two hemispheres

Fig. 2 The geomagnetic and the geographic coordinate systems (viewed from the two poles) demonstrate the distortion of the Earth's magnetic field from a bipolar one that can cause different geomagnetic heating on the two auroral ovals.

2.) the significantly **different distribution of oceans** on the two hemispheres

Fig. 3 The distribution of the continents and oceans on the surface of the Earth (the Northern hemisphere is dominated by large continents, while the Southern by big ocean surfaces).

3.) **the different dust-content[2] in the atmosphere** on the two hemispheres as a consequence of the dust-aerosol lifted up from desert-areas by winds

Fig. 4 The distribution of the large deserts on the surface of the Earth is conspicuous on this map.

2 The working hypothesis behind the dust content is the following.
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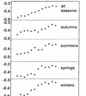

Fig. 5 Averaged density residual (f-1) values in 10o geographic latitude intervals (φgeogr). The observational material is separated according to real seasons3. The same North-South asymmetry is apparent during all seasons, as it is demonstrated by Fig. 1 for the yearly averaged values.

A problem is emerging, however, as the time and space dependence is mixed in *Fig. 5* as the same season occurs half a year later on the other hemisphere.

To consider this time dependence we have investigated the North-South asymmetry during the Northern seasons[3] for the whole globe (**crosses**) and during the Southern seasons[3] for the *whole globe* (**dots**) separately and plotted on the same figure (*Fig. 6*).

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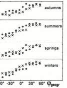

Fig. 6 The same as in *Fig. 5*, but the observational material is separated according to the seasons of the Northern hemisphere4 (crosses) and of the Southern hemisphere4 (dots). It is clearly visible that there is no difference in steepness between Northern and Southern seasons. Consequently, this analysis did not prove the connection of the warmer Northern hemisphere with the higher dust-content over the Northern hemisphere during spring time. Accordingly we have to reject the dust-content working hypothesis. It is also clearly visible that the densities are higher on the whole globe (that is on both hemispheres) during the Northern winter and Northern spring than during the Northern summers and autumns.

The determination of this time delay with respect to the time of perihelium:

A correlation analysis has been carried out on the mean North-South asymmetry curves for 3 months periods – centered on perihelium and aphelium respectively – with several time delay intervals.

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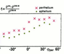

Fig. 7 The same as in *Fig. 5*, but the observational material is selected and plotted for 3 months time intervals centered to the times of the perihelium and aphelium respectively – with a 2 months time delay. The density is about 4% higher over the whole globe after perihelium than after aphelium.

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