Response to Referee Comments on egusphere-2022-126, "Responses of CIPS/AIM Noctilucent Clouds to the Interplanetary Magnetic Field"

The manuscript describes an analysis of space based observations of Noctilucent Clouds, also called Polar Mesospheric Clouds.
Observations between 2007 and 2017 are used and a correlation study with the IMF is performed on a day-to-day basis. The paper is well structured and reads in most parts well.

We thank the anonymous referee #1 for the valuable comments. The suggestions are very constructive and have been taken into accounts in the revised paper. In the following the remarks are responded point by point.

The analysis has a couple of major flaws that make the results questionable:

Tides and observational effects:

Tides at the cloud altitude are known to have a large effect on cloud occurrence and brightness, and other properties. Orbit changes and changes in the local time of the ascending and descending node might affect the correlation coefficients. A discussion is needed.

We are appreciated for this comment and agreed that the tide effects are very important in NLC variations. We have investigated and confirmed that the correlation coefficients will not be affected when the tide effects are taken into consideration. The relevant results have been discussed in the revised manuscript and listed here:

NLCs are dominantly influenced by the solar tides with the diurnal variation, and the NLCs occurrences are usually more frequent at the local time of morning (Fiedler & Baumgarten, 2018; Stevens et al., 2017). In addition, the NLCs can also be affected by the lunar tides, and the longitudinal variations in NLCs attributed to the non-migrating lunar tides have been found (Liu et al., 2016; von Savigny et al., 2017). To check whether the local time differences between the descending and ascending branches of the AIM satellite will affect the results, we separate the CIPS data of the descending and ascending branches into two groups. Similarly, in order to check the longitudinal variations, the CIPS data are divided into two groups in term of the longitude ranges of (-180°,0°) and (0°,180°). The correlation coefficients for the above two scenarios have been calculated and listed in Table 1, and the results for all of them are consistent with the results shown in Fig.2. In summary, the correlations coefficients are found not affected by the local time variations and longitudinal variations in the CIPS data caused by the tide effects, this further proves that our results are robust.

Table 1. The correlation coefficient of NLC properties with *IMF* B_y under different data selections of satellite branches and longitudinal ranges.

Data selections	r_m (SH)	r_m (NH)	Alb_m (SH)	Alb_m (NH)	IWC_m (SH)	IWC_m (NH)	*FO* (SH)	*FO* (NH)
All	0.25±0.04	-0.13±0.04	0.16±0.08	-0.10±0.07	0.11±0.08	-0.05±0.07	0.12±0.08	-0.03±0.07
Ascending	0.23±0.04	-0.09±0.04	0.14±0.07	-0.07±0.06	0.10±0.07	-0.05±0.06	0.09±0.07	-0.00±0.07
Descending	0.19±0.06	-0.15±0.06	0.15±0.08	-0.10±0.07	0.09±0.08	-0.04±0.07	0.13±0.09	-0.05±0.06
(-180°~0°)	0.19±0.07	-0.08±0.04	0.15±0.06	-0.09±0.07	0.08±0.07	-0.05±0.07	0.06±0.07	-0.03±0.05
(0°~180°)	0.24±0.05	-0.13±0.04	0.12±0.08	-0.08±0.05	0.09±0.09	-0.03±0.06	0.13±0.08	-0.12±0.06

Microphysics:

The authors provide no detailed discussion about microphysical aspects that are well elaborated in literature (e.g., Rapp and Thomas, 2006 and references therein). Instead, they mention “coagulation”, which is less relevant (unimportant) for mesospheric clouds. For example, IWC, brightness, and radius have a strong relation to each other. Since the detection threshold of CIPS depends on the particle size, it should be discussed how this affects the small particle size cutoff and its changes (e.g. Fig. 6).

Coincidently, the Referee #2 was also very concerned about the microphysical mechanism. We have proposed a new microphysical mechanism, which emphasizes the role of the charged meteoric smoke particles (MSPs) and the nucleation process, as stated in the reply to Referee #2.

As pointed out by the reviewer that the ‘coagulation’ is unimportant in NLCs, we decide to remove the relevant discussion.

With regards to the relationship between NLC properties, we noticed that the detection threshold of CIPS for ice particles with 10-15 nm radii has been used to explain the opposite changes of the ice particle radius and ice particle concentration in NLCs during gravity waves (Gao et al., 2018). Meanwhile, simulations also confirm the opposite variations of ice particle radius and concentration from the view of the nucleation process in NLCs (Wilms et al., 2016). Both the above two explanations have been applied in the revised manuscript to discuss the relation between NLC properties.

Electron densities:

A discussion about the state of knowledge on IMF effects on the electron density at cloud altitudes is needed. E.g. in case IMF effects are longitude dependent, the results may be different for ascending and descending nodes. Since the electron density is relevant for particle charging in the dusty plasma environment, it is a key parameter.

We are fully agreed with the reviewer that the electron density plays a key role in the link between *IMF* B_y and NLCs, especially for the charging process of MSPs. A new microphysical mechanism involving the electron density has been proposed. Please find the new mechanism in the Discussion part of the revised paper.

The results of correlation coefficients for different branches as well as different longitudinal regions have been investigated in the previous responses to the tide effects. As shown in Table 1, the longitudinal effect of *IMF* B_y on ionospheric potential caused by the dipole tilt of geomagnetic field is insignificant or too small to be observed. In fact, studies usually concern more about the latitude variations of the ionospheric potential changes induced by the *IMF* B_y, which are confirmed in our Fig. 4 and Fig. 5.

PMSE

A discussion of radar echoes associated with icy particles (PMSE) is completely missing. These radar echoes are caused/affected by electron density fluctuations and icy particles. Following the authors “*IMF* B_y - ionospheric potential - NLCs microphysics - NLCs brightness’”, they are likely more directly affected than NLCs.

We thank for the useful comment. The PMSE are well known to be closely related with the charged ice particles in NLCs. In the revised manuscript the PMSE have been discussed as follows:

"Polar mesosphere summer echoes (PMSE) are very strong radar echoes scattered by the electron number density irregularities at the polar summer mesopause altitudes of about 75-100 km, and the electron structures are thought to be caused by the neutral air turbulence in combination with the charged ice particles in the NLCs (Rapp and Lübken, 2004). Note that the NLCs are absent in the winter hemisphere, whereas polar mesosphere winter echoes (PMWE) were still observed at much lower altitudes of 55- 85 km. PMWE are suggested to be caused by the neutral air turbulence together with the charged MSPs (Strelnikov et al., 2021). A possible link is expected to exist between PMSE/PMWE with the *IMF* B_y for two reasons: First, the PMSE is sensitive to ice particle radius and concentration, due to the ice particle can affect the diffusion of electrons (Rapp and Lübken, 2004). Our results show that the ice particle radius is sensitive to solar wind, thus it is necessary to check whether this response has further influence on the PMSE. Second, as mentioned in the above microphysical process, the *IMF* B_y is supposed to have a major effect on the charging process of MSPs, and the latter play a more direct role in PMSE/PMWE. In conclusion, to investigate the response of PMSE/PMWE to *IMF* B_y will be helpful for understanding the link between solar wind and mesosphere, while the relevant work is beyond the scope of this paper."

Specific comments:

Line 106: Due to the large number of noisy lines in Figure 1, a correlation is not visible. A more convincing display would help.

Agreed. A new figure for the 2008/2009 summer season in SH has been plotted to make the correlation more visible.

Line 112: Figure 2 does not provide uncertainties. How significant are the year-to-year changes shown?

Done. The uncertainties have been shown by adding the error bar for the standard deviation of the mean in Fig. 2.

Line 126: It may be more convincing if negative lag days are also shown in Fig. 3.

Agreed. The results for negative lag days have been added in Fig. 3.

Line 127: *"In previous studies of the link between Ly-α and NLCs, the proposed mechanism involving photodissociation, heating, or circulation all required longer time"*: What causes the *"longer time"*, for example, for photodissociation? A more detailed discussion/references may help.

Done. We have cited the reference of Shapiro et al. (2012) to describe the time lag of photodissociation, the references of Thomas et al. (2015) and Thurairajah et al. (2017) to present the observed lag time for the responses of NLCs to the *Ly-α* solar irradiance.

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