

Interactive comment on “High temporal resolution VHF radar observations of stratospheric air intrusions in to the upper troposphere during the passage of a mesoscale convective system over Gadanki (13.5° N, 79.2° E)” by K. K. Kumar and K. N. Uma

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We are very much thankful to the reviewer for evaluating our manuscript and providing comments. The responses to the reviewer’s comments are typed in bold letters.

Comment: While the authors show some interesting data (in Figure 1), the level of the analysis detailed in this paper is cursory. In particular, I am concerned that the event they focus on around 20:34 on 19th June 2006 is actually related to a MCS. Satellite

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observations or some extra supporting evidence are required. Note that the convective plumes at around 18:00 also look a little suspicious. Work detailed in Hooper et al. (2005) suggests confined enhancements in the vertical velocity and signal power from the surface to the top of the plume. So could these be areas of moist air unrelated to convection?

Reply: Most of referee's comments are very vague like 'more analysis, more research, more evidence'. We might have appreciated if comments are specific. We suppose referee think that we have reported these results prematurely. This is not the case, we did a very exhaustive analysis, looked for all other available measurements including geo-stationary satellites and NCEP/NCAR data. Right form radar experiment, spectral estimation, spurious echoes elimination, GPS sonde ascents from the radar site, rainfall measurements needs some efforts. We do have carried out studies on stratosphere-troposphere exchange in the past [Kumar 2006, Rao, Uma et al, 2008] and this study is continuation of these efforts. What we want to convey is, considerable efforts, planning and analysis went into the present study.

Coming to the referee's specific questions, now we are providing the Geostationary Operational Environmental Satellite (GOES 9) (Miyakawa and Satomura 2006) Tbb (brightness temperature) maps, which are generated for every hour; around the time of appearance of convective core in the Indian MST radar. Please refer to the response to reviewer#1's (figure 1 and figure 2 of reply) comments for Tbb maps along with water vapor imageries during the passage of MCS over radar site. We have not provided these images in earlier version of manuscript as we thought that the rainfall measurements at the radar site were enough to prove the passage of convective system. Now we include satellite images in the revised manuscript. One more point to be noted here is that VHF radar can observe only those parts of the convective systems, which passes over the radar volume. We don't know why referee is suspicious about the plumes at 18:00 hrs. It is not mandatory that enhanced signal should always accompanied by enhanced vertical velocity. For example in most of the tropical mesoscale convective

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systems we observe a updraft and downdraft couplet in height-time section of vertical velocity. Both up and downdraft areas will have enhanced signal power. Moreover, the rainfall measurements show precipitation at 18:00 Hrs confirming the passage of the cloud and thus rules out the possibility of moist air unrelated to convection.

Comment: The introduction is also cursory and requires more research. This work should not be published at present and the authors should provide significantly more evidence for their hypothesis before re-submitting this work to a journal again.

Reply: As we mentioned earlier, more research and more evidence are very vague terms and we will appreciate if referee can provide some specific comments. Coming to the evidence part of it, VHF radar observations are more than two decade old and these radars provided a wealth of information on atmospheric processes in finer details. By now, most of the processes responsible for VHF radar back-scattering are well-established. In the present study we observe slanted enhanced echoes in the 13-16 km region. The enhancement in the SNR is attributed to the gradients in refractive index of air, which is a function of temperature and humidity in the lower atmosphere. In the present study, the echoes observed in the 13-16 km altitude are not due to deep cloud, which is obvious from height-time section of SNR. The only reason we find for this localized enhancement in the SNR is the mixing of two air masses of different refractive index. The downdraft observed during the same period substantiates our interpretation of stratospheric air intrusion in to the troposphere. At this juncture, where VHF radar applications are extending to operation meteorology, what we believe is VHF radar measurements can be used as an independent tool for understanding some of the atmospheric processes in finer details. By now, it is showed by several researches across the globe that VHF radar observations can be independently used to study the stratosphere-troposphere exchange [e.g., Hocking et al., 2007]. We are herewith providing one more event in figure 3 in which the slanted echoes are observed during the passage of a deep convective system over Gadanki.

Narayana Rao, K. N. Uma, D. Narayana Rao and S. Fukao (2008): Understanding

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the Transportation Process of Tropospheric Air Entering the Stratosphere from Direct Vertical Air Motion Measurements over Gadanki and Kototabang , Geophys. Res. Lett., 35, doi : 10.1029/2008GL034220

Interactive comment on Atmos. Chem. Phys. Discuss., 9, 13843, 2009.

ACPD

9, C6813–C6819, 2009

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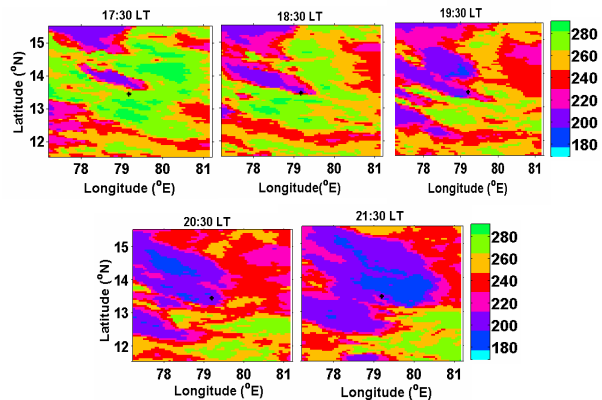
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Figure 1: T_{bb} maps generated from GOES 9 observations over Gadanki

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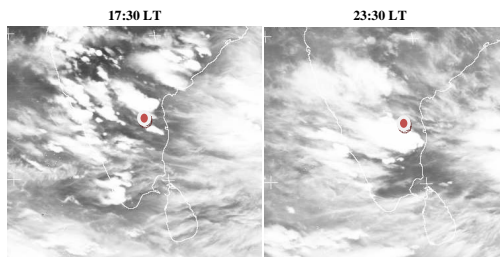


Figure 2: Water vapor imagery from Meteosat observations

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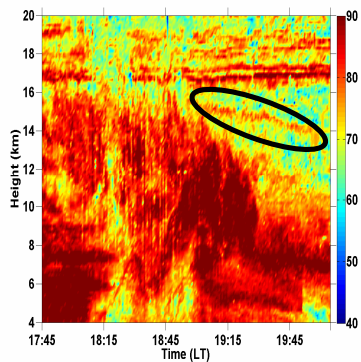
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Figure 3 : Height time section of range corrected SNR (dB) during the passage of a deep convective system over Gadanki on 31 July 2001

Fig. 3. Height time section of range corrected SNR (dB) during the passage of a deep convective system over Gadanki on 31 July 2001

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