Atmos. Chem. Phys. Discuss., 5, S4549–S4553, 2005
www.atmos-chem-phys.org/acpd/5/S4549/
European Geosciences Union

Atmospheric Chemistry and Physics Discussions

Interactive comment on "Small-scale gravity waves in ER-2 MMS/MTP wind and temperature measurements during CRYSTAL-FACE" *by* L. Wang et al.

L. Wang

lwang@cora.nwra.com

Received and published: 17 December 2005

Reply to Anonymous Referee # 2

1. Major Comments

1. As far as we know, the CRYSTAL-FACE campaign was the first time when both ER2 MMS and MTP data were obtained on flights designed to sample the envi-

Full Screen / Esc
Print Version
Interactive Discussion
Discussion Paper
EGU

ronment above convection. The STEP campaign in 1987 was an exception, but the height information for the MTP vertical scans is lost (Bruce Gary, personal communication).

2. First, as a general note, the Denning et al. (1989) paper is nearly 17 years old, so it is not current. One of us (M. J. Mahoney) is preparing an up-to-date paper on the MTP instrument. Below are our response to each question raised in this comment.

   200 ms^{-1} is the ER2 air speed, but the ground speed varies with winds and this determines the horizontal resolution. Consequently, the horizontal resolution of the MTP data is $\sim$ 1.3-2.5 km. The instrument view is perpendicular to the flight direction, so the line-of-sight weighting function does not affect the horizontal resolution.

   In this study, we use the MTP temperatures only to derive GWs' vertical wavelengths. Other parameters, such as horizontal wavelengths, propagation directions, etc., are derived from the MMS winds and temperatures, which have a much better horizontal resolution ($\sim$ 0.2 km). We believe GWs with horizontal wavelengths of $\sim$ 10-20 km can be resolved using the MMS data.

   The vertical resolution of the MTP data has been improved since Denning et al. (1989). The vertical resolution is $\sim$ 100 m at the flight level.

3. We use only the MTP temperature gradient information at the flight level in the analysis. The vertical resolution of the MTP data is much better at the flight level than other altitudes, which explains why sloping phase is hard to observe at altitudes $>$ 2 km from the flight level.

4. We find that the values of δ generally cluster around 0° or 180°. A histogram plot of δ will be included in the formal replies. We think most readers are interested in the physical wave properties rather than intermediate quantities like δ, hence we did not show δ in the paper.

ACPD

5, S4549–S4553, 2005

Interactive Comment

Full Screen / Esc

Print Version

Interactive Discussion

Discussion Paper

EGU

We will include the simplified discussion on how to derive horizontal propagation directions using the additional temperature information in the revised draft, as suggested by the reviewer. There are typos in Eqns. (12) and (13) in the manuscript. They should have been

$$F_{px} = \frac{1}{2}\overline{\rho}\left(1 - f^2/\hat{\omega}^2\right)\tilde{u}\tilde{w}\cos\left(\Phi_w - \Phi_u\right) \tag{1}$$

$$F_{py} = \frac{1}{2}\overline{\rho}\left(1 - f^2/\hat{\omega}^2\right)\tilde{v}\tilde{w}\cos\left(\Phi_w - \Phi_v\right) \tag{2}$$

We thank the reviewer for calling this error to our attention. We will clarify on the usage of “coherence” in the revised paper.

5. The original wording on describing the ray-tracing algorithm is misleading, and needs to be modified. For example, what we meant by the intrinsic frequency being smaller than f or larger than N in the original text actually refer to the cases of a GW approaching its critical level or it approaching its turning point, respectively. We never allow the ray-tracing to violate the $f^2 < \hat{\omega}^2 < N^2$ limits. We used the time-varying NCEP data as the background fields. Since the temporal resolution of the NCEP data is 6 hours and we only ray-traced each ray for up to 3 hours, we assumed that the ground-based frequency was constant during the ray-tracing.

6. We speculated in the paper that those were likely trapped waves because they had high intrinsic frequencies and short horizontal wavelengths. The trapping mechanism is high $\hat{\omega}$ reflection. The uncertainty in our calculations does not warrant further detailed analysis of wave trapping.

ACPD

5, S4549–S4553, 2005

Full Screen / Esc

Print Version

Interactive Discussion

Discussion Paper

EGU

2. Minor Comments

Below are replies to some selected minor comments. For comments not listed below, we will revise the paper as suggested by the reviewer.

- Page 11378 L8 : The relevant sentence in the abstract will be changed to "The vertical temperature gradient was used to determine the vertical wavelengths of the events."
- Page 11380 L8: Bregman et al. (2002) examine mid-latitude cirrus clouds and their effects on the stratospheric chemistry at similar latitudes. Of more relevance to our study are subtropical-tropical cirrus clouds, which can influence the polar stratospheric chemistry indirectly by affecting the stratospheric humidity through the Brewer-Dobson circulation (Solomon, 1999). For the revised paper, we will use Solomon (1999) instead of Solomon et al. (1986) as the reference.
- Page 11381 L10: The relevant sentence will be changed to "The original sampling rate of MMS was $\sim$ 10 Hz, but the 1 Hz version was used in this study as it had a better signal-to-noise ratio."
- Page 11383 L4: i is indeed commonly referred to as the "imaginary unit".
- Page 11386 L14-15: The frequencies are in radians per second.
- Page 11386 L24-25: The vertical resolution of the MTP data at the flight level was $\sim$ 100 m, so GWs with $\lambda_z \geq 0.2$ km can be detected.
- Page 11386 L27: Yes, they are *horizontal* speeds.
- Page 11389 L12: We will provide the units and range of the NEXRAD data in the revised paper.

ACPD

5, S4549–S4553, 2005

- Page 11389 L26: Visual inspection of individual plots similar to Fig. 8 was applied to examine whether a given event can be traced to a convective source. If a line similar to the dashed red line in Fig. 8 crossed a region with base reflectivity larger than $\sim$ 40 dBz, the event was considered to be traceable to a convective source.
- Page 11390 L3: Yes, this means that a turning point occurred.
- Page 11390 L6-7: The relevant sentence should be changed to "The source to event direction was defined as the direction from the convective sources we identified to the mid-point of each event."
- Page 11378 L24, Page 11392 L20, L23 : We share the reviewer's concern about the wording used in the text. Nevertheless, we think it should be clear to ice cloud modelers if we change the wording of $\hat{\omega}\tilde{T}$ to the "local wave-induced cooling rate" in the revised text. To avoid any confusion, we will also change the wording in the figure capation of Fig. 12 to "The probability of observing a GW event with local wave-induced cooling rate, $\hat{\omega}\tilde{T}$, within a given range from the ER-2 aircraft during CRYSTAL-FACE. See text for details."

Interactive comment on Atmos. Chem. Phys. Discuss., 5, 11377, 2005.