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Interactive Comment

Interactive comment on "Analysis of a jet stream induced gravity wave associated with an observed ice cloud over Greenland" *by* S. Buss et al.

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The paper investigates the meteorological origin of an observed polar stratospheric ice cloud (I would add the term "stratospheric" in the title) above Greenland. The cloud was observed close to the steep eastern coastline of Greenland during the SOLVE winter 1999/2000. The authors describe the very complex synoptic situation by means of ECMWF operational analyses and mesoscale model simulations. The meteorological situation does not allow an easy conclusion in favour of an vertically propagating mountain wave. Therefore, arguments are accumulated to describe the observed cloud as an inertia gravity waves excited by an strongly curved and, therefore, unbalanced jet stream. The analysis is well written and most of the results are presented clearly. There are two major points concerning the validity of the arguments:

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(1) In their discussion of mountain waves the authors only refer to a vertically propagating hydrostatic gravity waves; mountain waves also disperse horizontally and influence the temperature field far away from their origin. Especially, nonhydrostatic mountain waves (which are not considered in the paper due to the use of an hydrostatic mesoscale model) and inertia gravity waves (induced by mountains) have significant horizontal components of their group velocity. The possibility of such waves causing the observed ice cloud is not considered in the paper (see special remarks 18 and 20).

(2) The validity of the ray tracing techniques is restricted to stationary environments. A discussion of the applicability of this technique in the present strongly instationary meteorological situation should be discussed in more detail. The apparent period of the wave packet was calculated to be ˜10h - how does this time scale relate to the temporal change of the background profiles?

The authors express uncertainty about their own analysis in the Conclusions: "The issue that remains is whether this wave (the non-orographic gravity wave) has suffucient amplitude to explain the ˜8K mesoscale cooling or if a superimposed orographic wave also contibuted to the temperature minimum responsible for the PSC formation." As a reader I was extremely confused: Is there something missing in the presented analysis which would appear in forthcoming studies (e.g. by using higher resolved simulations,....)?

These major and a number of special points listed below shouldn't prevent the publication of results after revisions have been made.

Minor points:

INTRODUCTION

(1) The first sentences is too restrictive: also other gravity as "inertio gravity waves" can be effective in inducing PSCs.

(2) In the review of previous work on gravity waves the authors should give specific

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values of wavelength, frequency and amplitude of the observed/simulated jet stream-induced gravity waves. A comparison with similar quantities of observed/simulated mountain waves is useful to evaluate the difference between both sources of stratospheric temperature fluctuations.

(3) The quotation Leutbecher etal 2000 must be Leutbecher and Volkert 2000.

METEOROLOGICAL MODEL

(4) I was surprised that the authors smooth the digitalized orography. In this way, they restrict possible solutions of the numerical solver drastically as contributions with horizontal wavelengths less than 50 km have no chance to survive. The observed cloud is only 50km wide. This needs explanation.

(5) The vertical resolution is also rather poor (with 700m only 3 levels are in the simulated temperature anomaly) and the strong sensitivity of the results to changes in the vertical resolution raises the question: what would happen if one increases the number of vertical levels? In my own numerical simulation of inertia gravity waves excited by jet streams I try to keep a ratio dz/dx=f/N˜1/100, i.e. dz about 200m would be required in the present case.

ICE CLOUD ABOVE GREENLAND

(6) I don't understand the meaning of the 1st sentence last para in 3.1; what means "disposal of ..."?

(7) It is possible to draw the unsmoothed orography below the panels in Fig. 1?

(8) Last paragraph 3.1: I understand the arguments. However, I still have strong doubts whether the scale restriction is physically really justified: the cloud shows signatures of smaller waves as well (as stated in the text) and could well be the result of superposition/interaction of a broader spectrum of atmospheric waves than finally simulated in the paper.

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(9) Last sentence, 2nd paragraph in 3.2 and Fig 2a): What is the conclusion in terms of gravity wave properties?

(10) First sentence 3.3: writing and meaning of "monthes ..."

(11) Fig.3: How does the length of the vector arrows corresponds to their magnitude in m/s?

(12) The discussion in the last two paragraphs in 3.3 is uncomplete: with the northward propagation of the anticyclone strong westerly surface winds occur on its northern edge. These winds are aligned with the midtropospheric and stratospheric winds (according to the statements in the text) giving favourable conditions for mountain wave excitation and propagation due to the minimum directional shear just above the location where the PSC was observed. The authors only mention the flow favourable for mountain waves near the southern tip of Greenland.

(13) There is no quantification of the unstationarity of the evolving situation: a table/graph displaying the change of key parameters (wind speed, wind direction at the surface, 850hPa, ...) could be helpful

WAVE SIGNATURES IN THE HRM SIMULATIONS

(14) Figure Caption of Fig 4.: the reference to Fig. 4 should be changed to Fig. 6.

(15) paragraph 4.1, sentence starting with "Vertical sections ...": I don't understand the meaning of the sentence. Do you mean that each stratospheric cold anomaly has its own mountain underneath producing it?? You mix waves with wave sources. Please, clarify!

(16) In section 4.1 and 4.2 you should characterize the simulated wave parameters (l_x, l_z, amplitude) quantitatively. I see, there is more wave parameters in the next section but some numbers here would help to compare the simulations with previous ones.

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INTERPRETATION OF HRM WAVE SIGNATURES

(17) 2nd sentence: I would replace "waves' divergence" by "horizontal divergence of the wind field" .

(18) Section 5.1 (wind profiles): I have strong doubts about the averaged vertical profiles as the lowermost levels are certainly influenced by local and strongly inhomegeneous terrain features. It is therefore inadequate to conclude that there is a critical layer for mountain waves to propagate vertically. Furthermore, this is contrast to the wave signitures inside the observed cloud itself which the authors believe (Section 3.1) "are associated with vertically propagating GWs triggered by the complex structure of the underlying topography". There is a contradiction: on the one hand they claim that mountain waves propagate vertically on the other they don't. This needs to be resolved carefully! The definition of a critical level should be written more exactly, especially considering possible instationary effects. At the end, I still see strong arguments that the cloud be produced by orography as the conditions are quite favourable for excitation and propagation at least for a certain period of time.

(19) Could you specify what you mean with "quasi-vertically propagating" (last sentence, 1st paragraph 5.1)

(20) The divergence field repeats the arguments in the text before; the fact that the structure does not extend to the surface can also mean: the mountain wave source can be south/north of the section. Furthermore, instationary conditions can lead to a display of the remnants of a wave excited hours before.

(21) I'm not a specialist in ray tracing. My only concern is formulated in major point (2).

(22) Table 1: The vertical wavelength is rather large for an inertia-gravity wave; in previous studies, values with l_z˜2..4km have been found. How do you explain this? Could you discuss this discrepancy?

(23) Figure 9: Why the phase relationship for intertia gravity waves appears only above

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z=22km? It is suggested that the waves originate from the jet stream at 370hPa. Why is there no signature below 22km?

(24) 4th paragraph 5.3.2: Where the number Ric=2 comes from. I know 0.25 or 1 as critical Richardson number.

POTENTIAL FOR JET-INDUCED GW IN WINTER CLIMATOLOGY

(25) I would hardly call this climatology when only one winter is considered! It's just a statistics of the SOLVE winter.

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