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N87-17628

MESOCALE WAVES AS A PROBE OF JUPITER'S DEEP ATMOSPHERE

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The presentation by Flasar and Gierasch is largely contained in a paper submitted to *The Journal of the Atmospheric Sciences*. The abstract of their presentation for the conference is reproduced here:

Images from the Voyager north/south mapping sequences have been searched for waves. A remarkable class of mesoscale waves has been identified, with the following features: 1) The wavetrains are usually aligned zonally, i.e., wavecrests are north-south. 2) The average wavelength is 300 km with a standard deviation of only 20%. 3) The wavetrains are long, ~20 crests. 4) The waves occur within 25 degrees of the equator, the bulk being at the equator itself. 5) The waves are centered at the extrema (in latitude) of the zonal flow. 6) The meridional extent of the waves is typically 1 degree of latitude.

We interpret these observations as evidence of gravity waves propagating vertically within a leaky duct. We assume a three-level model composed of a stable duct which extends up to the base of the NH_3 cloud deck near 600 mb. Above this is a thin wave-trapping region characterized by a Richardson number $Ri < 1/4$ and containing a critical level, where the local value of the zonal flow velocity equals the phase speed of the wave. This in turn is overlain by a stable region, representing the tropopause region and stratosphere. We search for the "almost free" modes of the model. The critical level ensures that the upward propagating waves are totally or over-reflected back into the duct and naturally explains (3) above. The requirement that only one "almost free" mode be observable ((2) above) constrains the Richardson number of the duct itself. We conclude that just below the NH_3 cloud deck, $Ri \approx 1$. The requirement that the frequencies of vertically propagating inertial-gravity waves exceed the Coriolis frequency explains the tropical confinement of the waves (4), and implies wave frequencies, relative to the mean flow, $\sim 10^{-4}\ s^{-1}$. A meridional waveguide which results from the north-south shear in the background flow effects the meridional trapping ((5) and (6)) and zonal alignment (1) of the waves. The contribution to trapping from the variation of the Coriolis frequency with latitude is secondary.

DR. READ: Have you looked at the momentum fluxes in terms of the superrotation problem?

DR. FLASAR: Actually, the only thing I really looked at before was the $\overline{w'\phi'}$, which is the vertical energy flux, and that turns out to be about 1000-fold below the σT^4 flux, the internal flux of the planet. Energywise, it seems to be small potatoes. I probably should look at $\overline{u'w'}$ a little more closely.

DR. LEOVY: Just to comment on that again, the waves you're looking at are trapped waves, so they'll have relatively little momentum flux. On the other hand, one expects that the trapped waves are the signatures of wave forcing, so you very likely, in those regions and times, have an ample amount of propagating waves, whose signature is just harder to see.

DR. INGERSOLL: With a Richardson's number of one in the ammonia cloud, I'm wondering what happens when you plug in some numbers? Let's say the shear of the zonal wind is given by the difference between its measured value and zero over two scale heights. Let's say the static stability is what you might get from the latent heat associated with evaporating ammonia. What do you get?

DR. FLASAR: The easy thing to do is to use the static stability values given by the ortho-para mixing theory that Barney and Peter did. That gave a Brunt frequency of 2×10^{-3} s^{-1}. This is a working number. That corresponds to $\partial u/\partial z$ of about 2 m s^{-1} km^{-1}, which I think is 40 m s^{-1} per scale height. And they scale linearly with each other.

DR. INGERSOLL: You're in the right ballpark. Big shear?

DR. FLASAR: They could be small shears, but then the Brunt frequency would have to go down to keep track of it. There's a lower limit on the Brunt frequency given by the fact that it has to exceed the Coriolis frequency of about 10^{-4} s^{-1}, so you have constraints there, although I don't think you can distinguish between big or small $\partial u/\partial z$ yet.

DR. STONE: Mike, I wasn't too clear about your middle region there. What you had to assume; you said it wasn't too sensitive to conditions there, but you did assume it was a small Richardson number...

DR. FLASAR: I need a Richardson number less than 1/4 to trap the waves. I need a quantum mechanical tunneling problem basically...

DR. STONE: Yeah, but won't that give you lots of instability there?

DR. FLASAR: I assume that region is maintained below a Richardson number of 1/4 by all kinds of convective instabilities and that this won't be affected by the waves. In other words, the waves aren't going to drive the Richardson number up or anything like that.

DR. STONE: The waves, you are saying, will survive any small scale instabilities too?

DR. FLASAR: Well, I still think that they'll be reflected back down if the conditions are right. But you're correct. I'm not treating in detail the interaction between the gravity waves and the convective instabilities. I'm treating the middle, wave-trapping region as a homogeneous medium with a small index of refraction.