Letters to the Editor

Readers are encouraged to submit letters by e-mail to: weather@royalmetsoc.org. Letters sent by post should be typed on one side of the page only. The Editor reserves the right to edit any letter to conform to house style and/or to fit available space.

The Coriolis force and the subtropical jet stream

In the November 2002 issue Juan Carlos Bergmann (2002) points out that I did not make it sufficiently clear that it is only in climatological averages that the subtropical high pressure belt is located underneath the subtropical jet stream (STJ). This is true, but in trying to keep the text short there was no opportunity to go into detail as to how the internal dynamics and thermodynamics of the STJ, together with interaction with the midlatitudes, modify the picture. See Persson (2002a) for a broader exposure of the general circulation.

Bergmann also found my explanation of the subtropical high pressure belt 'naive' and 'obscure'. Firstly, it is not really 'mine'. A colleague made me aware that an almost identical explanation is to be found in a classical standard work on jet streams (Reiter 1963, p. 155; further elaborated in Reiter 1967, pp. 103–105).

Secondly, Holton's (1992) explanation of the sinking motions (subsidence) in the subtropics, which Bergmann refers to, goes back to an observational study by Blackmon *et al.* (1977). They point to a substantial outgoing long-wave radiation and cooling at the subtropical latitudes due to cloud-free conditions caused by a dominant sinking motion. I have not been quite satisfied with this circular argument and therefore suggested the obstructing effect of the earth's rotation (Persson 2002b). It provides a mechanism which limits the poleward upper-tropospheric flow by an upper-level zone of strong convergence, leading to subsidence.

Thirdly, this model also suggests that with a faster rotation of the earth the STJ (and the subsidence) would be closer to the equator, with a slower rotation further away from the equator. This is what comes out in a series of very interesting and illuminating computer simulations by the British–American meteorologist Gareth P. Williams (1988a,b, 2002). I have summarised this part of Williams's work in Figs. 1–3. Those who are familiar with the planetary atmospheres of the slowly rotating Venus and the rapidly rotating Jupiter may notice some striking similarities.

Trying to find easily understood explanations of seemingly complex phenomena is, of course, risky; the originator might be ridiculed as naive and 'hissed off the stage'. However, on reading certain textbooks on dynamical meteorology and the general circulation, I occasionally feel an affinity with the Spanish king Alphonso X (1221–84) who, on being introduced to the geocentric 40-wheeled Ptolemaic system of the Medieval universe, muttered: "If only the Lord Almighty had consulted me before embarking upon the Creation I should have recommended something

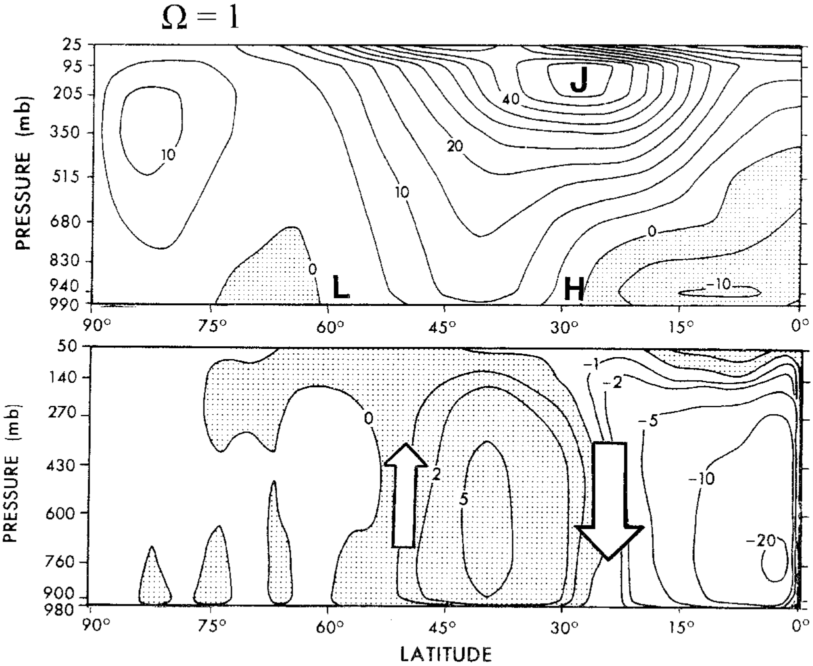

Fig. 1 Variation of westerly and meridional flow for different rotation rates (Ω) of the earth according to Williams's (1988a,b, 2002) simulations. Upper image shows the westerly wind component averaged around the longitudes, lower image the stream functions. The distance between the isolines in the stream function defines the strength of the circulation, the inserted arrows define the direction. 'L' and 'H' indicate cyclonic and anticyclonic surface circulation respectively. The westerly wind component for the earth rotation rate (Ω=1) shows the subtropical jet stream (STJ) of 50 m s^{-1} near 30° latitude. There is an area of strong subsidence and high pressure areas between 25 and 30° latitude, just beneath the STJ.

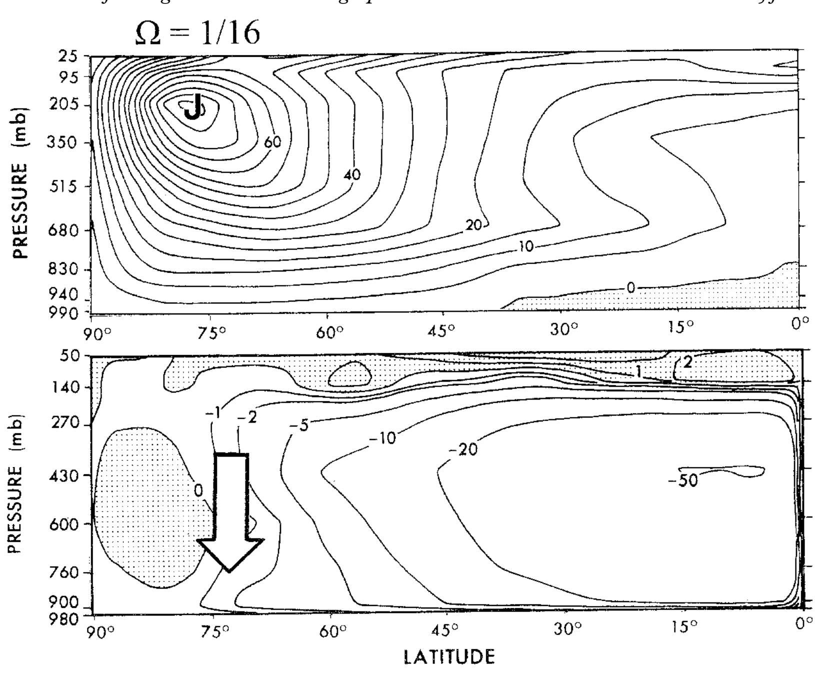

Fig. 2 As Fig. 1 but for slow rotation rate (Ω=1/16). The poleward-moving air will be able to progress further away from the equator before it is halted by the effect of the rotation, and have time to acquire a higher speed. The main jet stream is located at 75° latitude with a maximum speed of 80 m s^{-1} and the strongest subsidence again just below the jet maximum.

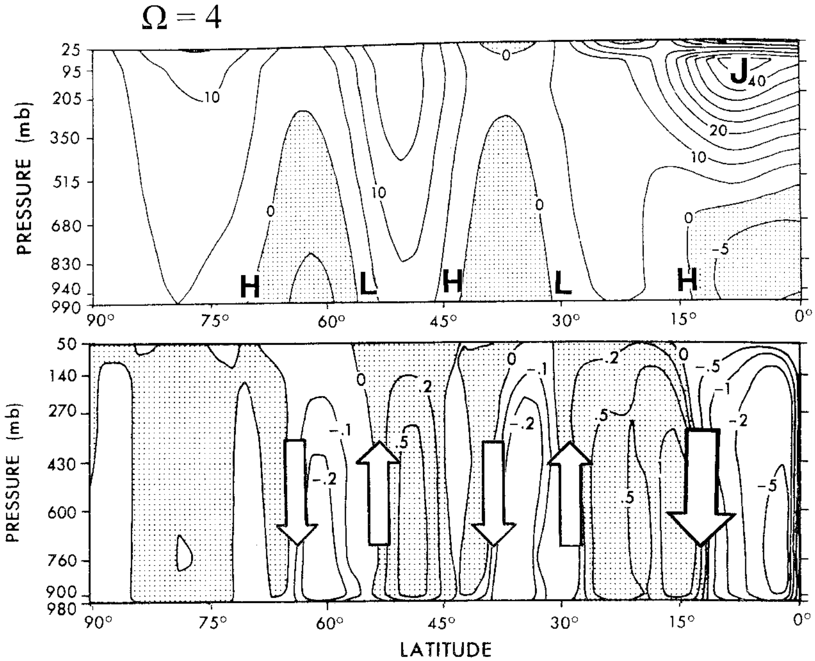

Fig. 3 As Fig. 1 but for high rotation rate (Ω=4). The air has difficulty in moving any considerable distance from the equator. We find the main jet stream at 10° latitude with a speed of 45 m s^{-1}, with the subsidence and high pressure underneath. The effect of the earth's rotation in confining the air and thus limiting the acceleration is counterbalanced by another mechanism. The obstruction of meridional exchange will increase the thermal contrasts and thus the acceleration of the winds. For Ω=8 (not shown here) the simulations show an almost equatorial jet stream of 80 m s^{-1}. Poleward of the jet stream the meridional flow is divided into several cells with their own jet streams.

simpler". My ambition is only to show that the Lord Almighty may be subtle, but not malicious. This seems, in the end, to be the case with the Coriolis effect, and why should it not also be for other atmospheric features such as the subtropical jet stream, blocking high pressure systems and Atlantic depressions?

References

Bergmann, J. C. (2002) The Coriolis force and the subtropical jet stream. *Weather*, **57**, pp. 425–426

Blackmon, M. L., Wallace, J. M., Lau, N.-C. and Mullen, S. L. (1977) An observational study of the Northern Hemisphere wintertime circulation. *J. Atmos. Sci.*, **34**, pp. 1040–1053

Holton, J. R. (1992) *An introduction to dynamic meteorology*, third edition. Academic Press

Persson, A. (2002a) Atmospheric motions. In: Munn, T. (Ed.) *Encyclopedia of global environment change, Vol. 1, The earth system: physical and chemical dimensions of global environment change*, Wiley, Chichester, pp. 221–242

—— (2002b) The Coriolis force and the subtropical jet stream (Coriolis Part 8). *Weather*, **57**, pp. 53-59

Reiter, E. R. (1963) *Jet stream meteorology*. University of Chicago Press, Chicago

—— (1967) *Jet stream*. Doubleday & Co, New York (a Science Study Series book sponsored by the American Meteorological Society)

Williams, G. P. (1988a) The dynamical range of global circulations – I. *Clim. Dyn.*, **2**, pp. 205–260

—— (1988b) The dynamical range of global circulations – II. *Clim. Dyn.*, **3**, pp. 45–84

—— (2002) http://www.gfdl.gov/~gw/global/figs/figs00/g88fig02.gif

Söderköping, Sweden **Anders Persson**
doi:10.1256/wea.272.02