(Supplementary material for HW4 Prob 3)

The following is the "observed" long-term mean of the vertical velocity in p-coordinate, ω, at 500-mb level, over Africa. The map was produced by the online composite/analysis tool provided by Physical Science Division/NOAA Earth Systems Research Laboratory (www.esrl.noaa.gov/psd), using data from "NCEP Reanalysis" (detail available from the instructor). While vertical velocity is not routinely observed, the global 3-D field of ω is routinely (at least twice daily) constructed from other observed fields (or produced by a numerical model) and archived. The map shown is the long-term mean of ω over a 20 yr period (1990-2009), all seasons included. Note that the vertical "velocity" in p-coordinate, ω, is related to the vertical velocity in z-coordinate, w, by

$$\omega \equiv \frac{dp}{dt} = \frac{dp}{dz}\frac{dz}{dt} \approx -\rho g w \quad ,$$

where w ≡ dz/dt. (We have invoked hydrostatic approximation, which is usually very accurate.) We can estimate w as w ≈ − ω/(ρg), where ρ ≈ 0.7 kg m⁻³ at 500 mb. Note that the unit of ω in the map is Pa s⁻¹; Positive value of ω means *downward* motion.