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Precipitation, weather, low frequency weather and the emergence of the climate

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A basic feature of fluid systems is that the larger the structure (L), the longer the lifetime (τ). Over "weather" time scales, we show starting from the solar forcing and backed by extensive empirical evidence - that this is controlled by the energy flux ε so that from dimensional analysis, $\tau \approx \varepsilon^{-1/3}L^{2/3}$. The observed tropospheric mean $\varepsilon \approx 10^{-3}\ m^2/s^3$ implies that planetary structures ($L \approx 20000$ *km*) live for $\tau_w \approx 10$ days at which scale, the temporal scaling undergoes a drastic "dimensional transition". In the strongly variable high frequency "weather" regime, fluctuations in a field f vary as $\Delta f \approx \tau^H$ where H a scaling exponent generally >0 so that fluctuations generally grow with scale. However, for "low frequency weather" $\tau > \tau_w$, we find (theoretically, empirically), that $H <0$ so that fluctuations no longer grow but diminish with scale. In spectral terms (and ignoring the intermittency corrections) this implies $E(\omega) \approx \omega^{-\beta}$with β=1+2H so that at high frequencies $\omega > \omega_w = \tau_w^{-1}$, $\beta >1$ whereas at low frequencies $\omega < \omega_w = \tau_w^{-1}$, $\beta <1$ so that the spectra are much flatter: the resulting "low frequency weather" regimes have been called "spectral plateaus". For the oceans, the turbulent dynamics are very similar but the mean surface $\varepsilon \approx 10^{-8}\ m^2/s^3$ so that the critical time scale is $\tau_o \approx 1$ *yr*.

In spite of their differences, the low and high frequency regimes can be considered "weather" since both have statistical scaling properties that are well modeled by conventional atmospheric (weather and climate) models as well by stochastic cascade models. However at a new scale τ_c – if only because of the large glacial to interglacial fluctuation in temperature, precipitation and other fields – low frequency weather must eventually give way to the emergence of a qualitatively new "climate" regime in which once again fluctuations grow with scale ($H >0$). We present evidence that while this scale varies somewhat from region to region that although globally, $\tau_c \approx 10$ *yrs* that in the Mediterranean region it is somewhat larger ($\tau_c \approx 100$ *yrs*) and we discuss the consequences. We show how this scaling picture can unify our understanding of precipitation, weather and climate – including the extremes - and we discuss the ability of current GCM's to model the very low frequency climate regimes at scales $\tau > \tau_c$.