Limpet Heat Budget Model Overview

1. What limpetheatbudgetmodel.R does

Block	Purpose	Key outputs
Clear workspace & set meteorological inputs	Fixes one set of conditions (solar irradiance = 1 W m^{-2}, Ta = 25 °C, etc.).	*Isw, Ta, Tw, u, ϕ*
Limpet geometry & heat capacity	Treats the shell as a right cone frustum, stores radius (R), height (H), lateral area (Al), conductive contact area (Acd), and calculates the heat capacity of a seawater-filled limpet body (*J per °C*).	*Ap* (projected area to sun), *JperC*
Optical & radiative constants	Short-wave absorptivity, long-wave emissivity/absorptivity, Stefan-Boltzmann σ.	–
Air & rock properties	Gives kinematic viscosity, thermal conductivity of air; granite thermal conductivity, density, specific heat; sky view factor *Vs*.	–
Convective heat tools	Calculates Reynolds (Re), Nusselt (Nu), and the convective heat-transfer coefficient *h_c*.	*h_c*
Energy-balance coefficients (q1 – q5)	Pre-computes constant factors for the energy-balance equation: *q1* = short-wave gain *q2, q3* = linearised long-wave terms *q4* = convective term *q5* = conduction into rock	–
Iterative loop (10 000 × 30 s ≈ 3.5 d)	Initializes rock as an isothermal column (ocean temp) then steps forward, updating: • temperature gradient in rock (finite-difference) • limpet body temperature *T_b* (solves linear energy-balance eqn each step).	Final body temperature *Tb* and rock profile *Tr*.
Flux bookkeeping	After equilibrium, recomputes each heat-flux term so you can see the relative magnitudes (W sw, W lw, W cv, W cd).	Printed values.

Essentially this is a **steady-state finder**: it cranks through enough 30-second steps that the limpet–rock system stops changing, then reports the equilibrium body temperature and flux partitioning for a single micro-climate.

---

2. What limpetheatbudgetmodel_dynamic.R does

Block	Purpose	Key outputs
Synthetic time series	Builds 30-s data for 6 days (3-day burn-in, 3-day output) with: • sinusoidal solar irradiance (Isw) • sinusoidal air temperature (Ta) • corresponding sun angle ϕ.	Vectors SignalIsw, SignalTa, Signal.phi.
Rock initialization	Starts the rock column at ocean temp (Tw) just like script 1.	Tr (length = TidalRange/Δz = 200 cells).
hot_limpets()	A **single-time-step solver** – it is the guts of script 1 wrapped in a function. Returns 12 values: *Tb*, *Tr[2]*, each flux term, projected area pieces, etc.	Vector of length 12.
hot_rocks()	Updates the rock column one time step forward (explicit finite-difference). Uses Δt = 30 s (hard-coded).	New Tr vector.
Main loop over all 30-s steps	For each time step *i*: 1. Call hot_limpets() with the current meteorological inputs. 2. Record its return values in a growing data frame df. 3. Over-write the surface rock cell with the newly computed body temperature. 4. Diffuse heat through the rock with hot_rocks().	Time series of body temp, rock surface temp, and each flux term.
Quick-look plots	Simple base-graphics plots and histograms.	Visual QC only.

So this script delivers a **dynamic simulation**—a moving body temperature that responds to diurnal forcing—and exposes every state variable for plotting or statistical analysis.

---

3. Key differences side-by-side

Theme	**limpetheatbudgetmodel.R (static)**	**limpetheatbudgetmodel_dynamic.R (dynamic)**
Purpose	Finds equilibrium under one micro-climate.	Simulates transient response over many days.
Forcing	Single, hard-coded set of environmental drivers.	Periodic (sinusoidal) drivers; sun angle moves.
Structure	Monolithic script; uses a single long for -loop to converge.	Modularised into two functions; outer loop over time.
Rock conduction	Updates rock every iteration inside equilibrium loop.	Updates rock **after** solving limpet step, using explicit finite-difference with fixed 30 s Δt.
Projected area (Ap) logic	Original formula only; can sometimes return a negative additive term ah which shrinks Ap.	Adds a safety check if(Ap < Acd*abs(cos ϕ)) to avoid impossible negative area.
Outputs	Just prints final values and fluxes.	Returns a full data frame; quick base R plots included.
Run-time	10 000 iterations regardless of convergence.	Δt = 30 s fixed; total iterations = days × 2880.
Extensibility	Hard to vary parameters.	Easier: inputs are function arguments, but most constants still hard-coded.