Boundary Layer Resistance ($r_a$) Describes resistance to the flow of vapor or heat

Aerodynamic Resistance ($r_a$) – Canopy scale resistance:

$$r_a = \frac{\ln \left( \frac{z_m - d}{z_{om}} \right) \times \ln \left( \frac{z_h - d}{z_{oh}} \right)}{k^2 \times u_z}$$

- $z_m$ = height of wind measurement
- $d$ = zero plane displacement height
- $z_{om}$ = roughness length to momentum
- $z_h$ = height of humidity measure
- $z_{oh}$ = roughness length to moisture
- $k = 0.41$ (Von Karman’s constant)
- $u_z$ = wind speed at height $z$

Bulk surface resistance ($r_s$)
Combined resistance of soil and plants

$$r_s = \frac{rl}{LAI} \cdot rl = stomatal \ resistance$$

$LAI = Leaf \ Area \ Index \ (cm^2/cm^2) = 0.5 \cdot 24 \cdot h$
Potential terrestrial niches for thermosynthesizers

The driving force for the evolution from PTS/MTS by PS0 to BPS is increasing power, the free energy generated per unit time. This power is inversely proportional to the characteristic cycle time, which is for

- PTS/MTS: the cycle time of the convection current: estimated lower limit, a few seconds, but in general much larger, \( \sim 10^2 \) s;
- PS0: the cycle time of light fluctuations beneath surface waves: 0.1 - 10 s;
- BPS: the diffusion time of the quinone across the membrane: \( \sim 10 \) ms

The power of BPS will therefore be \( \sim 100 \) times the power of PS0, which in turn will be \( \sim 100 \) times the power of PTS/MTS. One expects any BPS organism to outcompete any PS0 or PTS/MTS organism.

PTS/MTS can, however, work in dark niches: at night, during the polar night, and in subsurface conditions or at great depths in natural waters. It can occur in convection cells, as well as in thermal gradients where an organism can thermally cycle its membranes. An illustrative example is given by chloroplasts in a leaf (which is of course not in the dark!).

Leaves contain a thermal gradient, as the leaf is warmed at the sunny side and cooled at the shadow side by transpiration. The palisade cells span the leaf-and the thermal gradient-and the protoplasm stream circulates all cellorganelles such as chloroplasts and mitochondria in this thermal gradient, which would permit thermosynthesis in these organelles.

More generally, the protoplasm stream can thermally cycle the cellorganelles in any organism/cell placed in a thermal gradient. The world around us contains many thermal gradients, with a conspicuous organism presence:

- thermal cycling by passive movement: hot springs, convecting natural waters, Langmuir circulations in the ocean, meteoric waters, industrial cooling water systems (where 'biofouling' is a nuisance), hot water tanks, air conditioning systems;
- thermal cycling by active movement: many natural waters contain thermoclines: the ocean, lakes, saline ponds, hot springs, and migrate through these thermoclines. Many organisms are found at interfaces: algae at ground/air, snow/air, sea/air, sea/sea-ice interfaces, interfaces at industrial heat transfer systems.