

Key New Equations:

$$R_n = a_L (L_{iu} + L_{id}) + a_s S_t (1 + \alpha) - 2L_o$$

$$\sin(\beta) = \cos \phi \cos \omega \cos \delta + \sin \phi \sin \delta$$

$$\delta = 23.5 \cos [2\pi (d - 172) / 365] \quad \text{or}$$

d = day of year, use radians

$$\omega = 15 (t - t_0), \quad t = \text{time in hours,}$$

$$t_0 = 12$$

$$\delta = 23.5 \sin N$$

N = number of days from equinox,
use degrees

$$S_p = I_0 \tau^n, \quad \text{assume } I_0 = 1395 \text{ W/m}^2 \text{ and } P/P_0 = 1.1$$

$$S_b = S_p \sin \beta$$

$$S_t = S_b + S_d$$

$$S_d = 0.5 (1 - \tau^n) I_0 \sin \beta$$

$$\epsilon_{\text{air}} = 0.72 + .005 T_{\text{air}} (\text{°C})$$

ALBEDOS FOR THE SHORTWAVE PORTION OF THE
ELECTROMAGNETIC SPECTRUM
(Wavelengths < 4.0 μ)

A. Water Surfaces		C. Natural Surfaces (cont.)	
Winter— 0° latitude...	6	Forest, coniferous.....	5-15
30° latitude...	9	Tundra.....	15-20
60° latitude...	21	Crops.....	15-25
Summer— 0° latitude...	6	D. Cloud Overcast	
30° latitude...	6	Cumuliform.....	70-90
60° latitude...	7	Stratus (500-1,000' thick)	59-84
B. Bare Areas and Soils		Altostratus.....	39-59
Snow, fresh fallen.....	75-95	Cirrostratus.....	44-50
Snow, several days old..	40-70	E. Planets	
Ice, sea.....	30-40	Earth.....	34-42
Sand dune, dry.....	35-45	Moon.....	6.7
Sand dune, wet.....	20-30	Jupiter.....	73
Soil, dark.....	5-15	Mars.....	16
Soil, moist gray.....	10-20	Mercury.....	5.6
Soil, dry clay or gray...	20-35	Neptune.....	84
Soil, dry light sand.....	25-45	Pluto.....	14
Concrete, dry.....	17-27	Saturn.....	76
Road, black top.....	5-10	Uranus.....	93
C. Natural Surfaces		Venus.....	76
Desert.....	25-30	F. Human Skin	
Savanna, dry season.....	25-30	Blond.....	43-45
Savanna, wet season.....	15-20	Brunette.....	35
Chaparral.....	15-20	Dark.....	16-22
Meadows, green.....	10-20		
Forest, deciduous.....	10-20		

INFRARED EMISSIVITIES
(Percent)

A. Water and Soil Surfaces		C. Vegetation	
Water.....	92-96	Alfalfa, dark green.....	95
Snow, fresh fallen.....	82-99.5	Oak leaves.....	91-95
Snow, ice granules.....	89	Leaves and plants.....	
Ice.....	96	0.8 μ	5-53
Soil, frozen.....	93-94	1.0 μ	5-60
Sand, dry playa.....	84	2.4 μ	70-97
Sand, dry light.....	89-90	10.0 μ	97-98
Sand, wet.....	95	D. Miscellaneous	
Gravel, coarse.....	91-92	Paper, white.....	89-95
Limestone, light gray...	91-92	Glass pane.....	87-94
Concrete, dry.....	71-88	Bricks, red.....	92
Ground, moist, bare....	95-98	Plaster, white.....	91
Ground, dry plowed....	90	Wood, planed oak.....	90
B. Natural Surfaces		Paint, white.....	91-95
Desert.....	90-91	Paint, black.....	88-95
Grass, high dry.....	90	Paint, aluminum.....	43-55
Fields and shrubs.....	90	Aluminum foil.....	1-5
Oak woodland.....	90	Iron, galvanized.....	13-28
Pine forest.....	90	Silver, highly polished...	2
		Skin, human.....	95