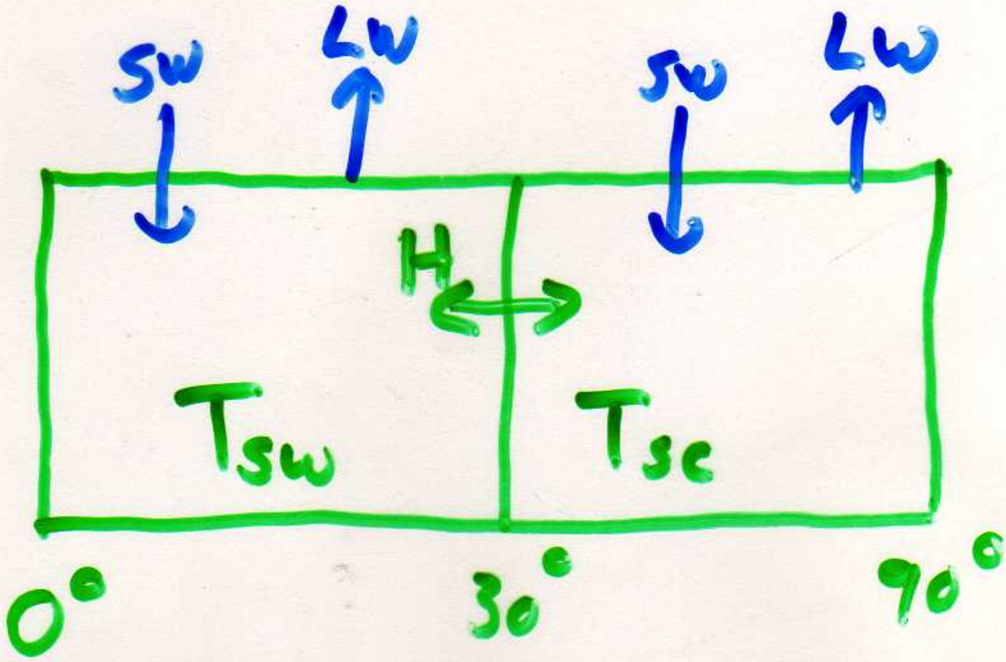
2 Box, Energy Balance Model



For $x = \sin\phi$

$$SW(x,T) = \frac{S_0}{4}\, s(x)\,(1-\alpha(x,T))$$

where $s(x) = 1 - 0.482 \cdot P_2(x)$

and $P_2(x) = \frac{1}{2}(3x^2 - 1)$

Also

$$\alpha(x,T) = \begin{cases} 0.3 + 0.175 \cdot P_2(x), & T > T_i \\ 0.62, & T \le T_i \end{cases}$$

where T_i is the ice line T

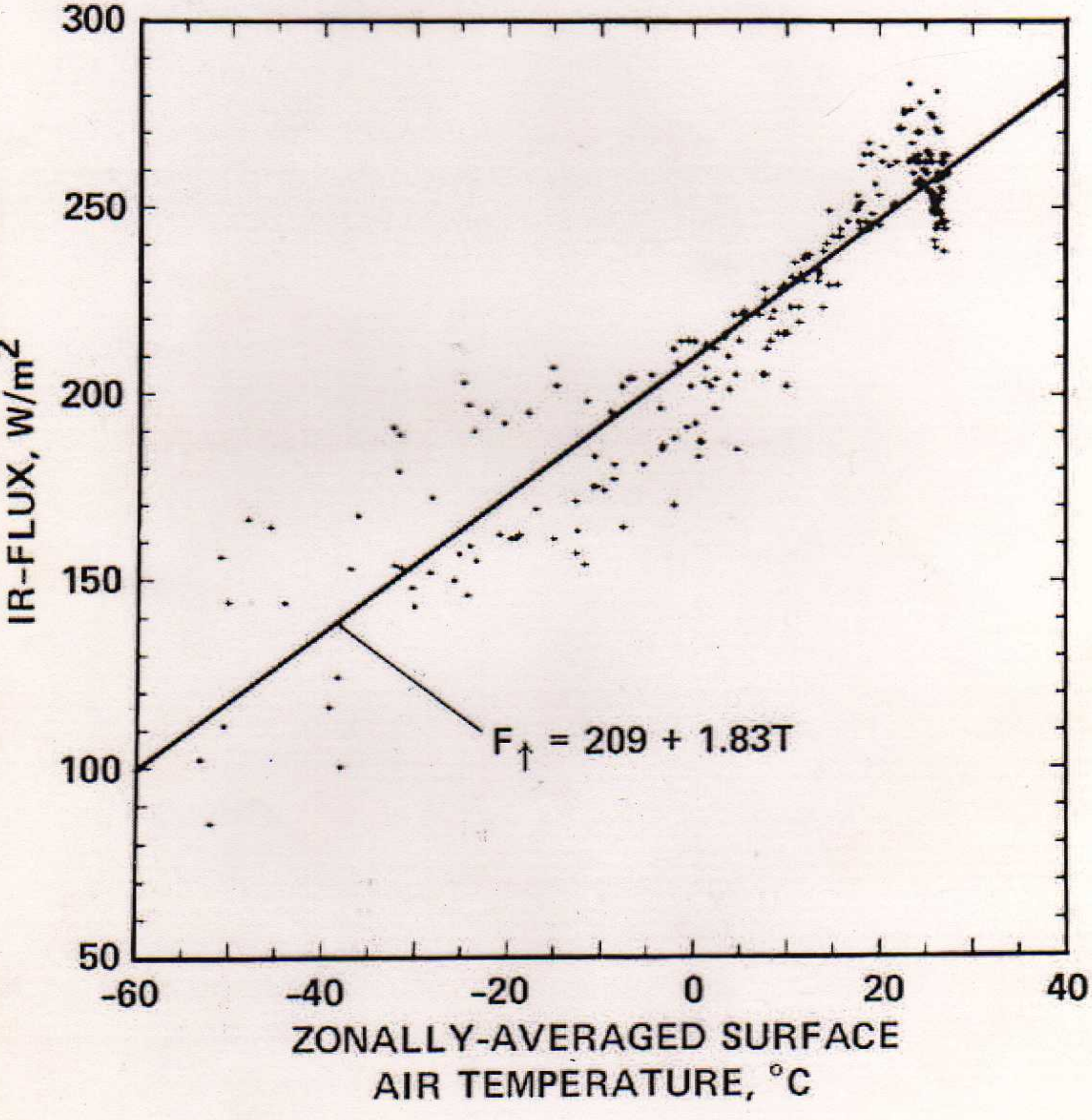
To proceed take

$$T(x) = c_1 + c_2 \cdot P_2(x)$$

where c_1 + c_2 are calculated by requiring that $\overline{T}(x)\big|_w = T_{sw}$

and $\overline{T}(x)\big|_c = T_{se}$

The latitude where $T = T_i$ can then be found and $\alpha(x, T)$ can be calculated


300
250
200
150
100
50
-60
-40
-20
0
20
40
IR-FLUX, W/m^2
ZONALLY-AVERAGED SURFACE AIR TEMPERATURE, °C
$F_\uparrow = 209 + 1.83T$

Furthermore we take

$$LW = A + B \cdot T$$

$$(T \to {}^\circ C)$$

and

$$H = \chi \cdot (T_{sw} - T_{sc})$$

Then we have, for each atmosphere box:

1) $R_w - (A + B \cdot T_{sw}) - \chi \cdot (T_{sw} - T_{sc}) = 0$

2) $R_c - (A + B \cdot T_{sc}) + \chi \cdot (T_{sw} - T_{sc}) = 0$

where $R_w, R_c = \overline{SW}|_w, \overline{SW}|_c$

By adding 1 + 2:

$$R_w + R_c - 2A - B\,(T_{sw} + T_{sc}) = 0$$

or

$$T_m = \frac{T_{sw} + T_{sc}}{2} = \frac{R_w + R_c - 2A}{2B}$$

By subtracting 1 + 2:

$$R_w - R_c - (B + 2X)(T_{sw} - T_{sc}) = 0$$

or

$$\frac{\Delta T}{2} = \frac{T_{sw} - T_{sc}}{2} = \frac{R_w - R_c}{2 \cdot (B + 2X)}$$

$$\Rightarrow \quad T_{sw} = T_m + \frac{\Delta T}{2}$$

$$T_{sc} = T_m - \frac{\Delta T}{2}$$