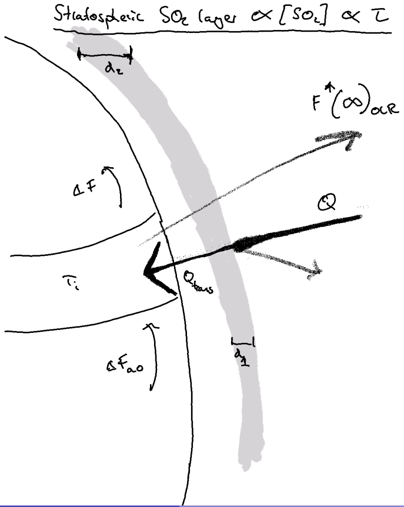
Volcanic activity to Snowball Earth?

$$\frac{Q_{trans}}{4} S(x)(1-\alpha(x)) = A + BT(x) + C(T(x) - \bar{T})$$


Stratospheric SO₂ layer ∝ [SO₂] ∝ τ
d_2
$F^{\uparrow}(\infty)_{OLR}$
Q
ΔF
T_i
Q_{trans}
ΔF_{ao}
d_1

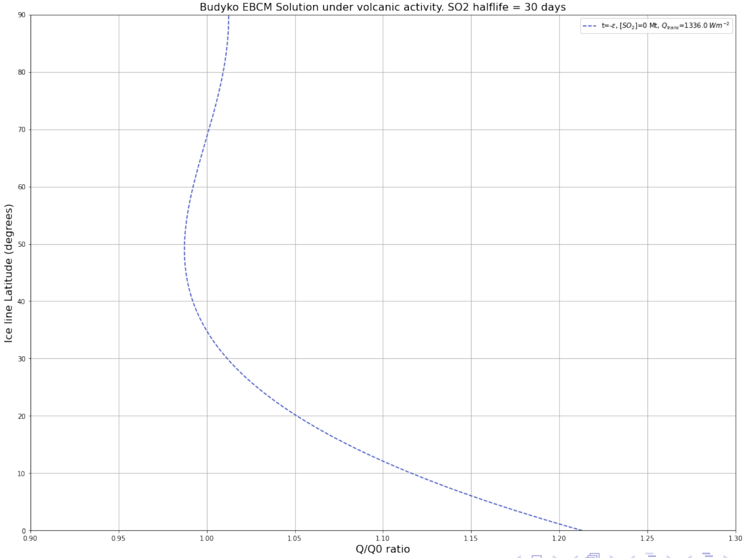
Optical Depth

$$\tau := \ln\left(\frac{Q_{trans}}{Q}\right)$$

Assumption:
Layer is thin, so
$d_1 \approx d_2$.

Pinatubo (Self et al 1999)
- 20 Mt [SO₂]
- $\tau_{max} = 0.4$
- $\bar{\tau} = 0.1 \sim 0.15$

EBCM Results



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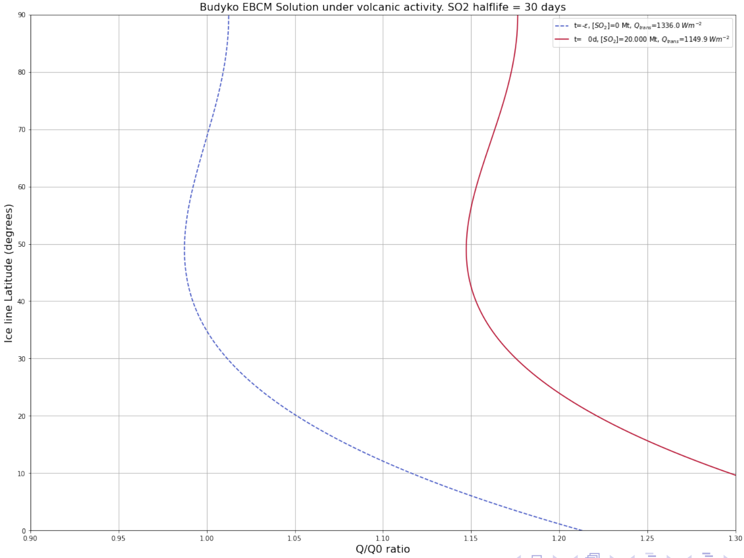

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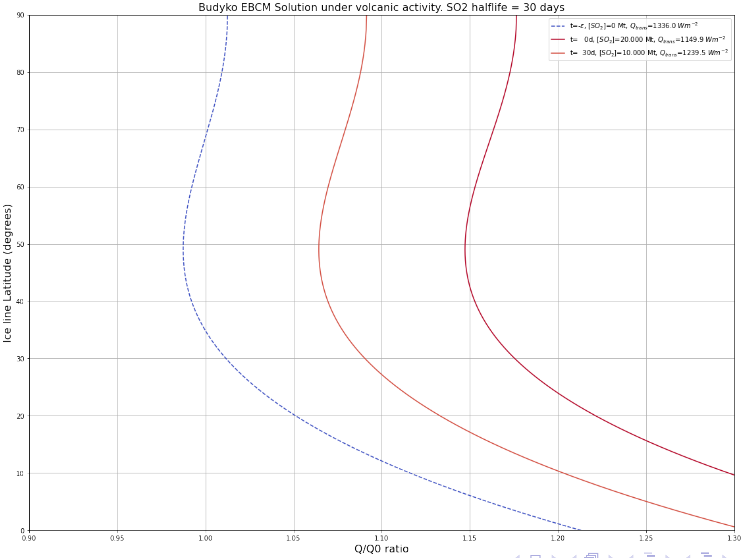

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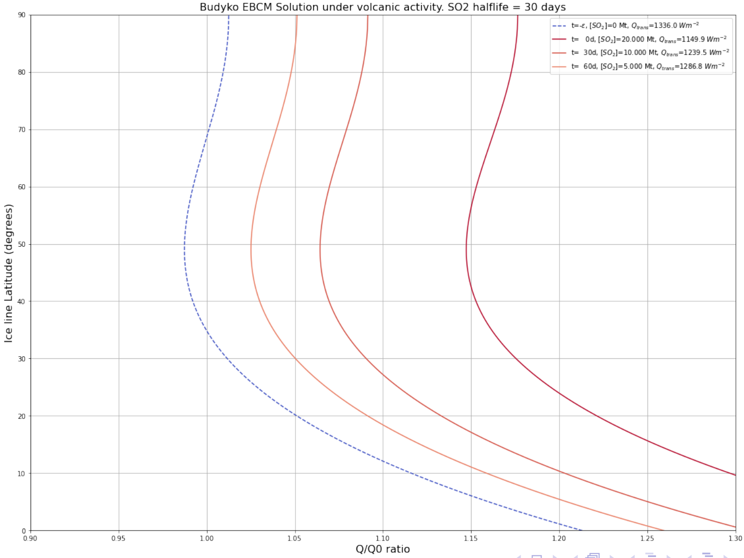

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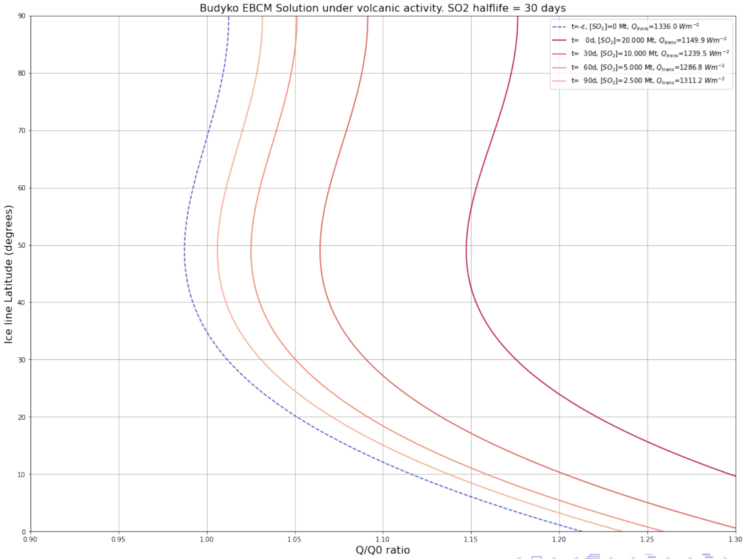

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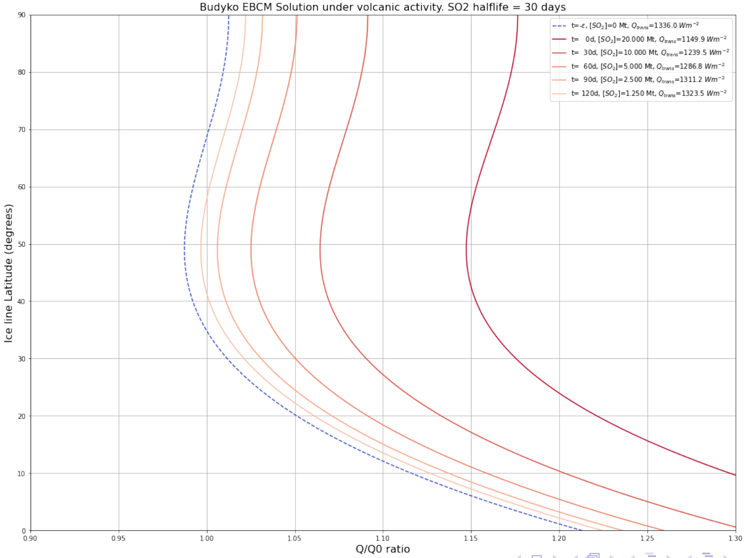

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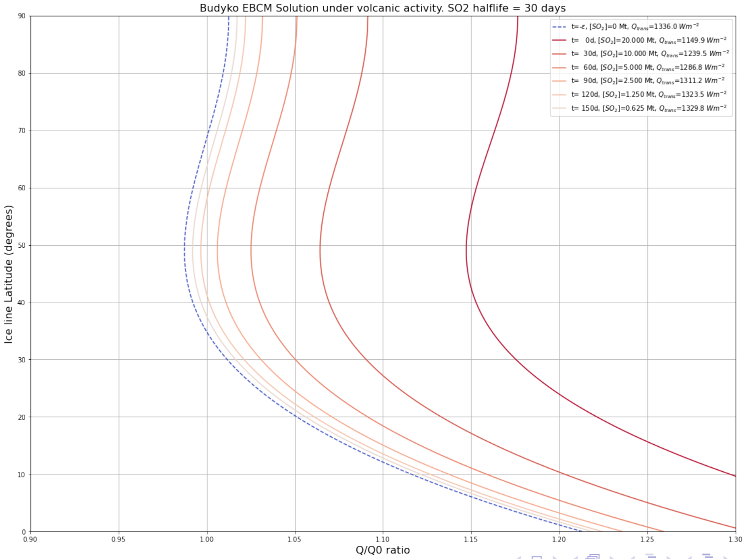
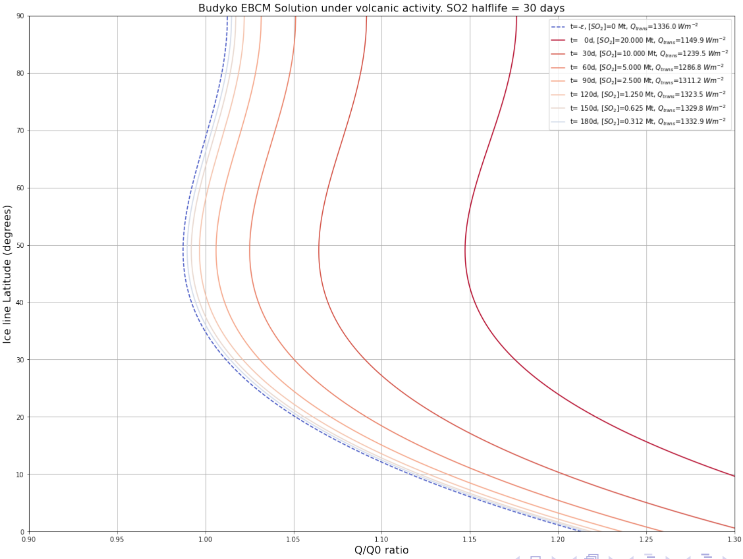


Budyko EBCM Solution under volcanic activity. SO2 halflife = 30 days

EBCM Results



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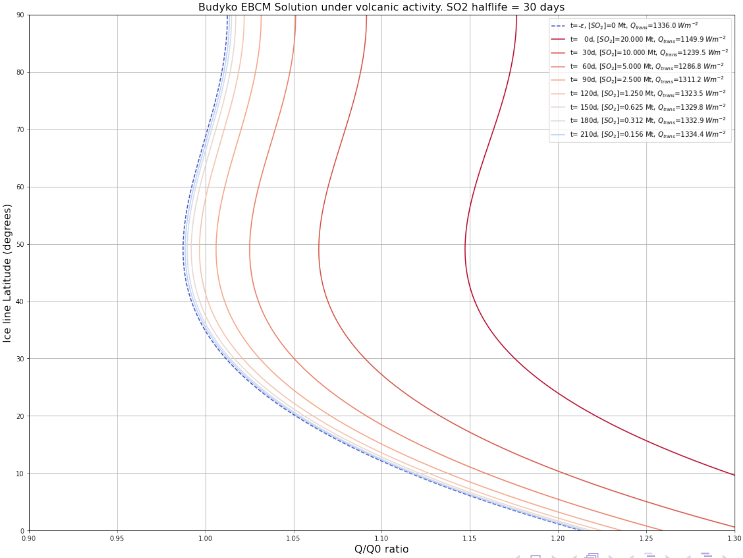

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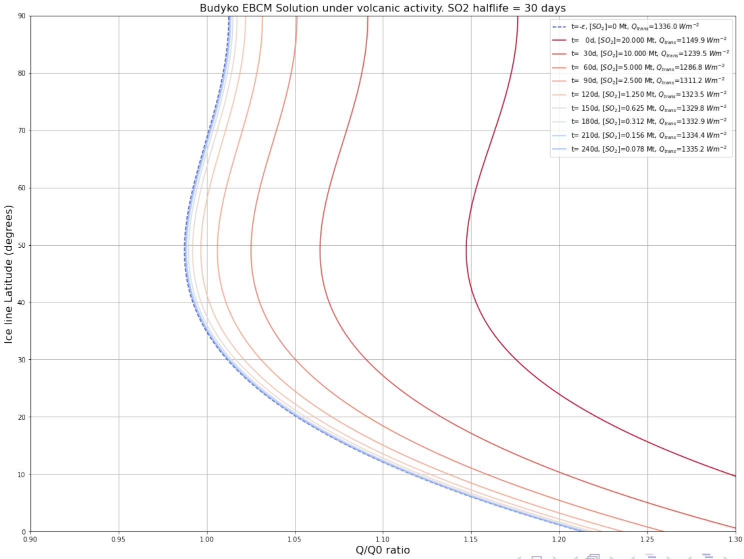

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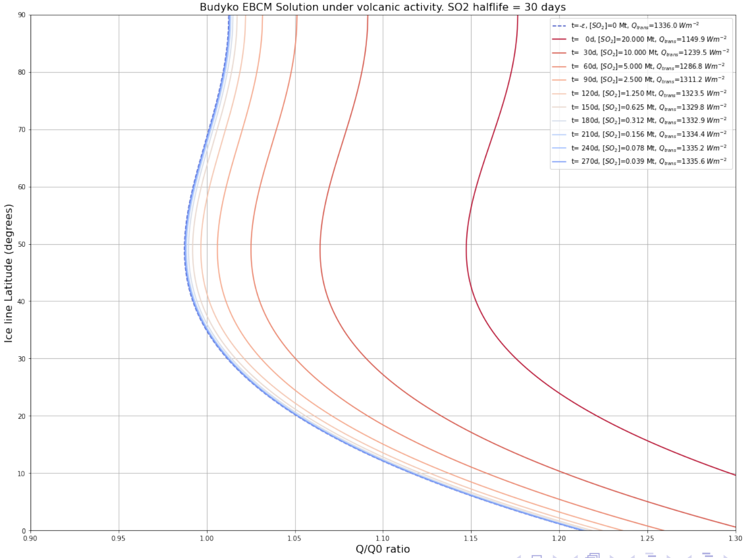

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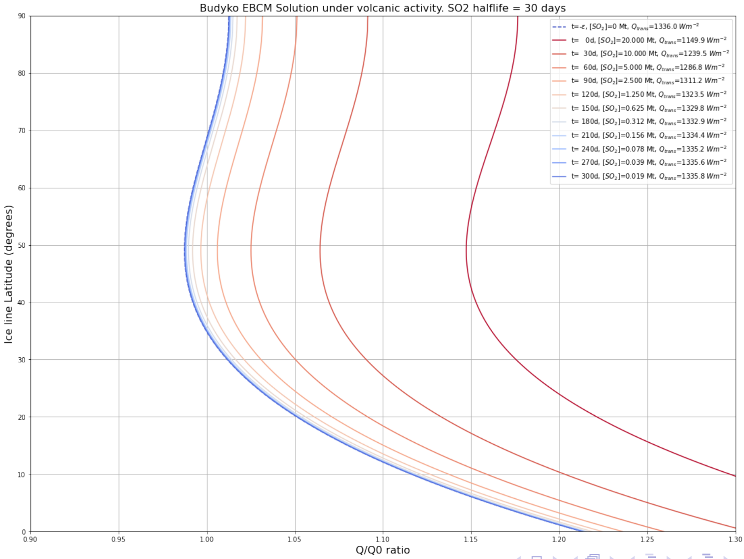

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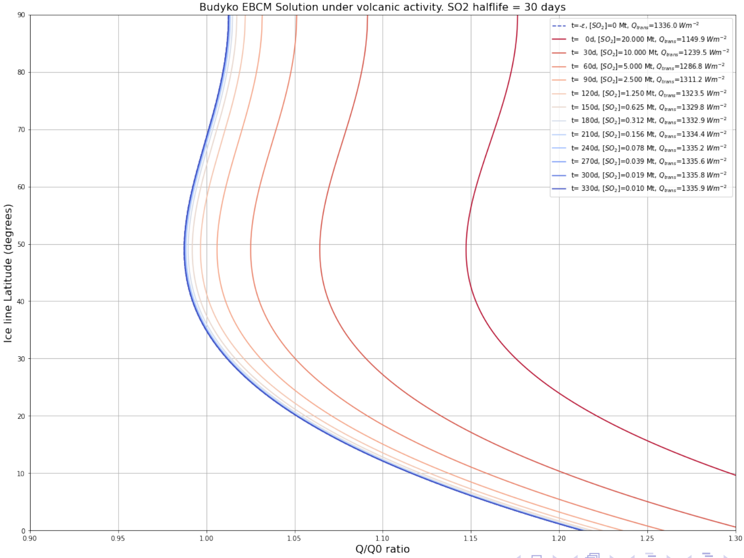
Budyko EBCM Solution under volcanic activity. SO2 halflife = 30 days
Ice line Latitude (degrees)
Q/Q0 ratio
0
10
20
30
40
50
60
70
80
90
0.90
0.95
1.00
1.05
1.10
1.15
1.20
1.25
1.30
t=-ϵ, [SO_2]=0 Mt, Q_{trans}=1336.0 Wm^{-2}
t= 0d, [SO_2]=20.000 Mt, Q_{trans}=1149.9 Wm^{-2}
t= 30d, [SO_2]=10.000 Mt, Q_{trans}=1239.5 Wm^{-2}
t= 60d, [SO_2]=5.000 Mt, Q_{trans}=1286.8 Wm^{-2}
t= 90d, [SO_2]=2.500 Mt, Q_{trans}=1311.2 Wm^{-2}
t= 120d, [SO_2]=1.250 Mt, Q_{trans}=1323.5 Wm^{-2}
t= 150d, [SO_2]=0.625 Mt, Q_{trans}=1329.8 Wm^{-2}
t= 180d, [SO_2]=0.312 Mt, Q_{trans}=1332.9 Wm^{-2}
t= 210d, [SO_2]=0.156 Mt, Q_{trans}=1334.4 Wm^{-2}
t= 240d, [SO_2]=0.078 Mt, Q_{trans}=1335.2 Wm^{-2}
t= 270d, [SO_2]=0.039 Mt, Q_{trans}=1335.6 Wm^{-2}
t= 300d, [SO_2]=0.019 Mt, Q_{trans}=1335.8 Wm^{-2}
t= 330d, [SO_2]=0.010 Mt, Q_{trans}=1335.9 Wm^{-2}