Boundary-layer ozone loss near the poles - why spring and not autumn?

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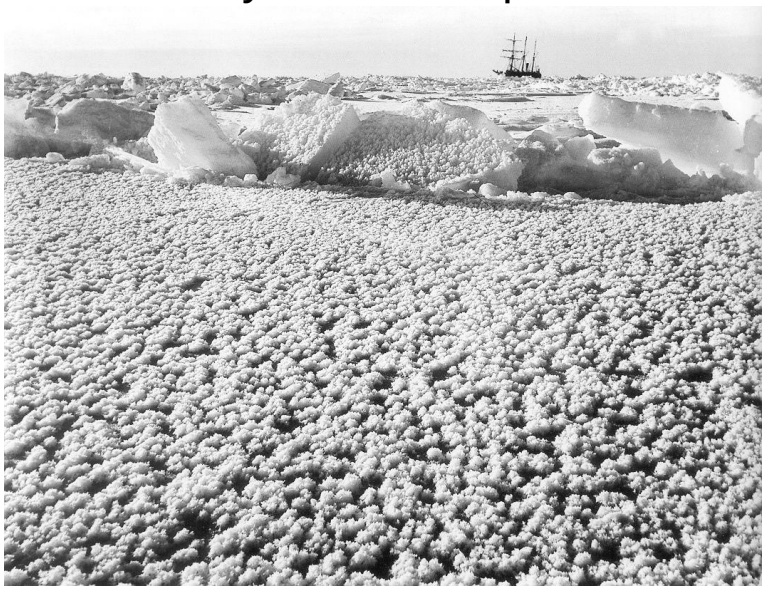
28. April 2005, General Assembly of the European Geosciences Union, Vienna



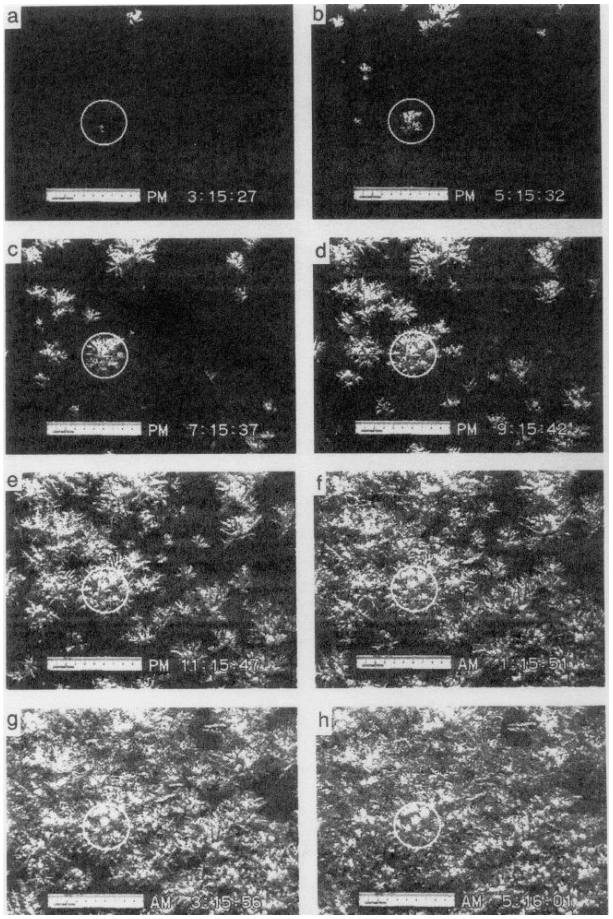
Hypothesis: Frost flowers are the halogen reservoir for the bromine explosion and the source of sea salt aerosol in the polar regions

Courtesy of Stefan Kern (Univ. Hamburg)

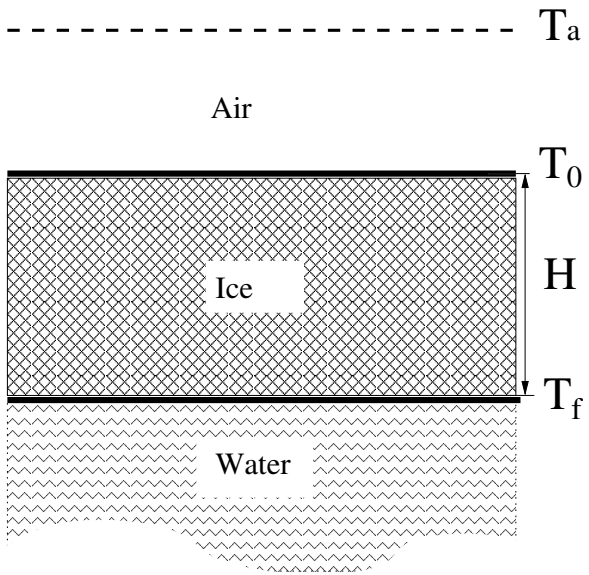
- Grow on thin ice at cold temperatures
- Very salty
- Large specific surface area
- Fragile crystals + wind $\rightarrow$ aerosol

Rankin *et al.*, *JGR*, 2002

Frost Flowers in the Laboratory



Martin *et al*, *JGR*, 1996



Area growth rate g depends on temperature gradient $\Delta T = T_0 - T_a$:

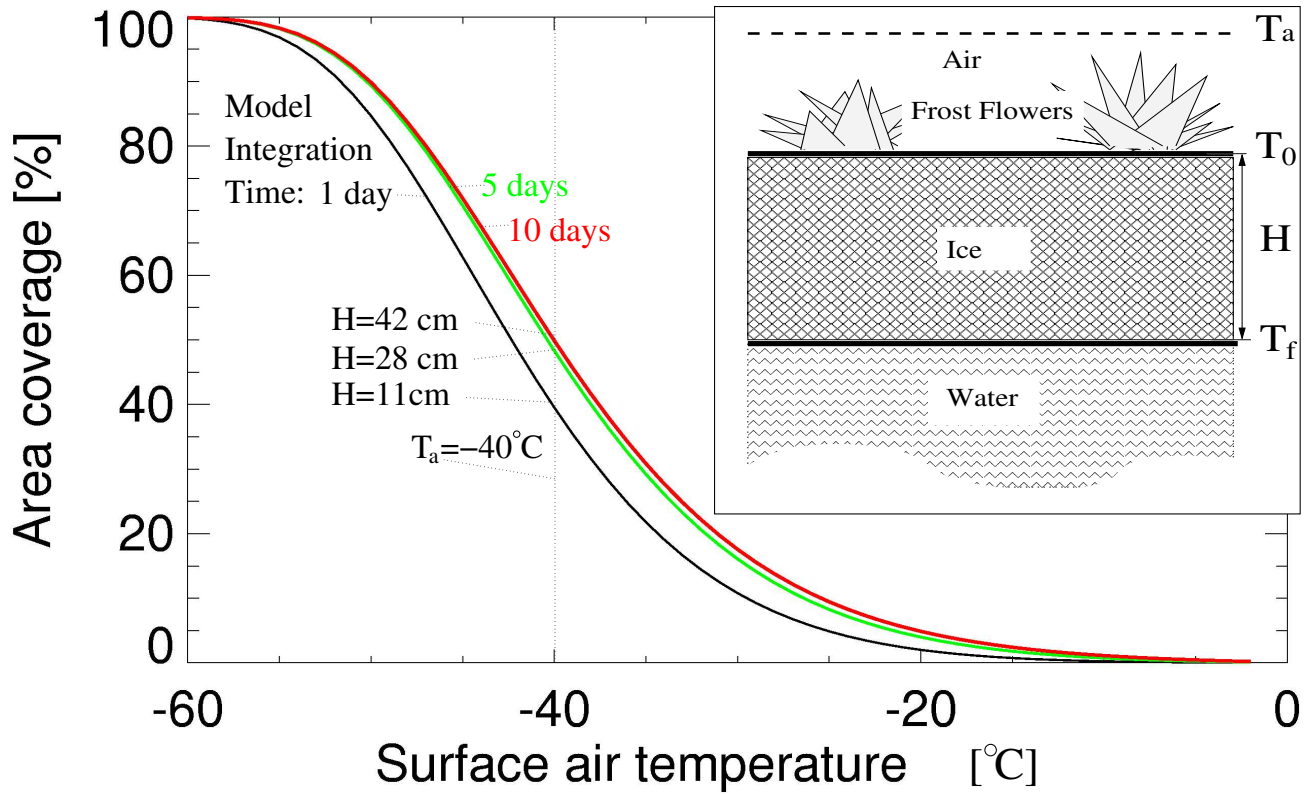
$$g = Be^{A\Delta T}$$

Frost Flower Model

- Input parameters
  - Open water area= 1 - sea ice concentration
  - Air temperature at the surface T_a
- Sea ice thickness $H(T_a)$
- Ice surface temperature $T_0(H, T_a)$
- Area growth rate $g = Be^{A(T_0 - T_a)}$
- Frost flower coverage

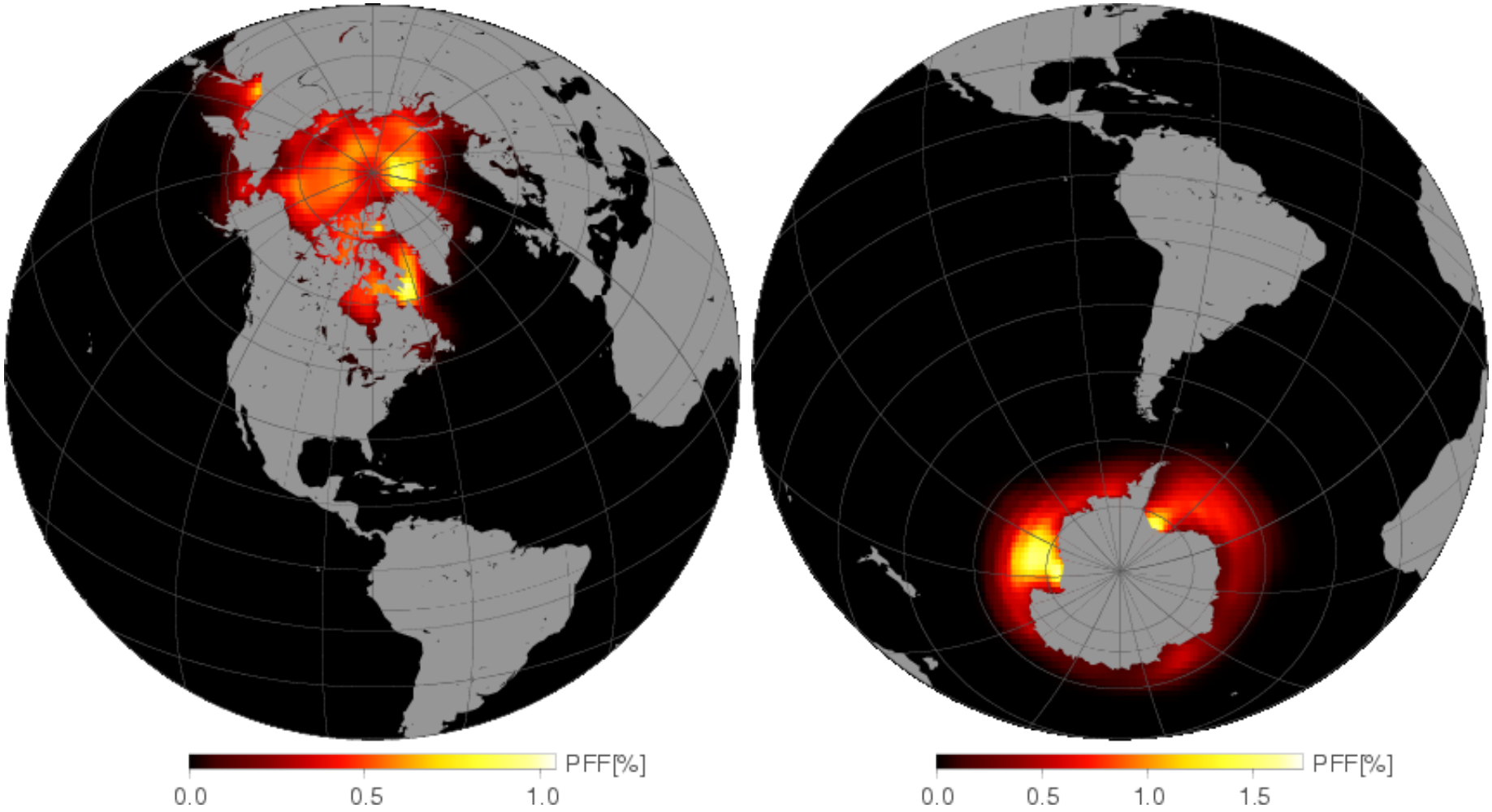
Kaleschke *et al., GRL*, 2004

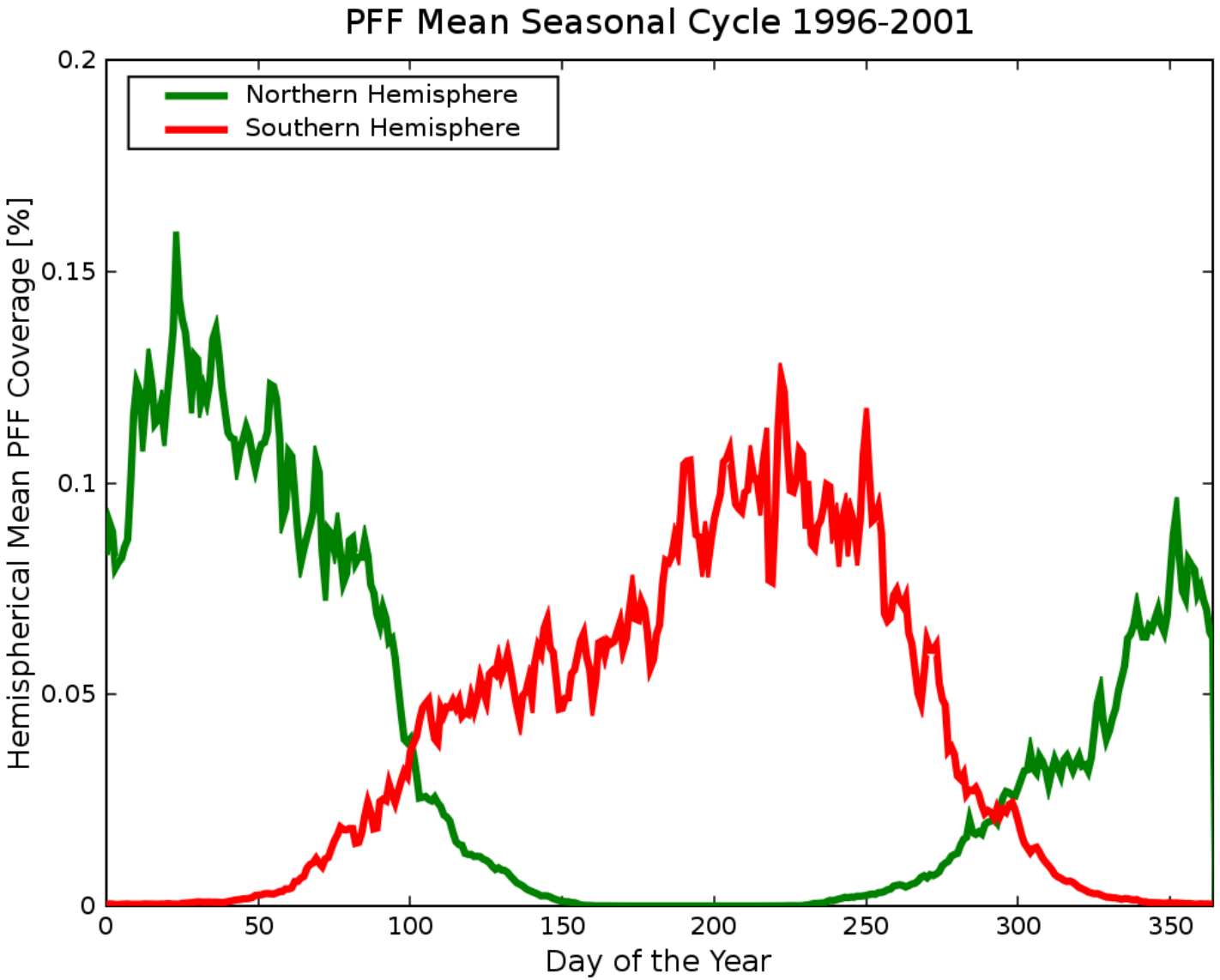
Model Result



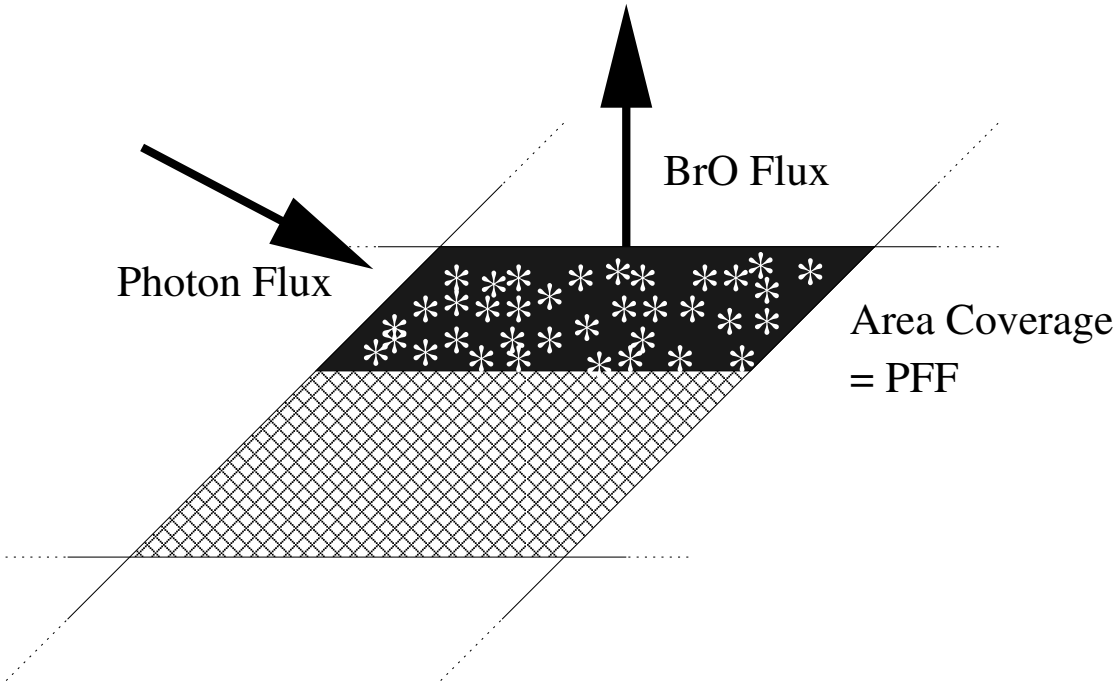
Upper limit (≈10 days): *Potential Frost Flower (PFF) coverage on new ice*

Global Potential Frost Flower Distribution (1996-2001)

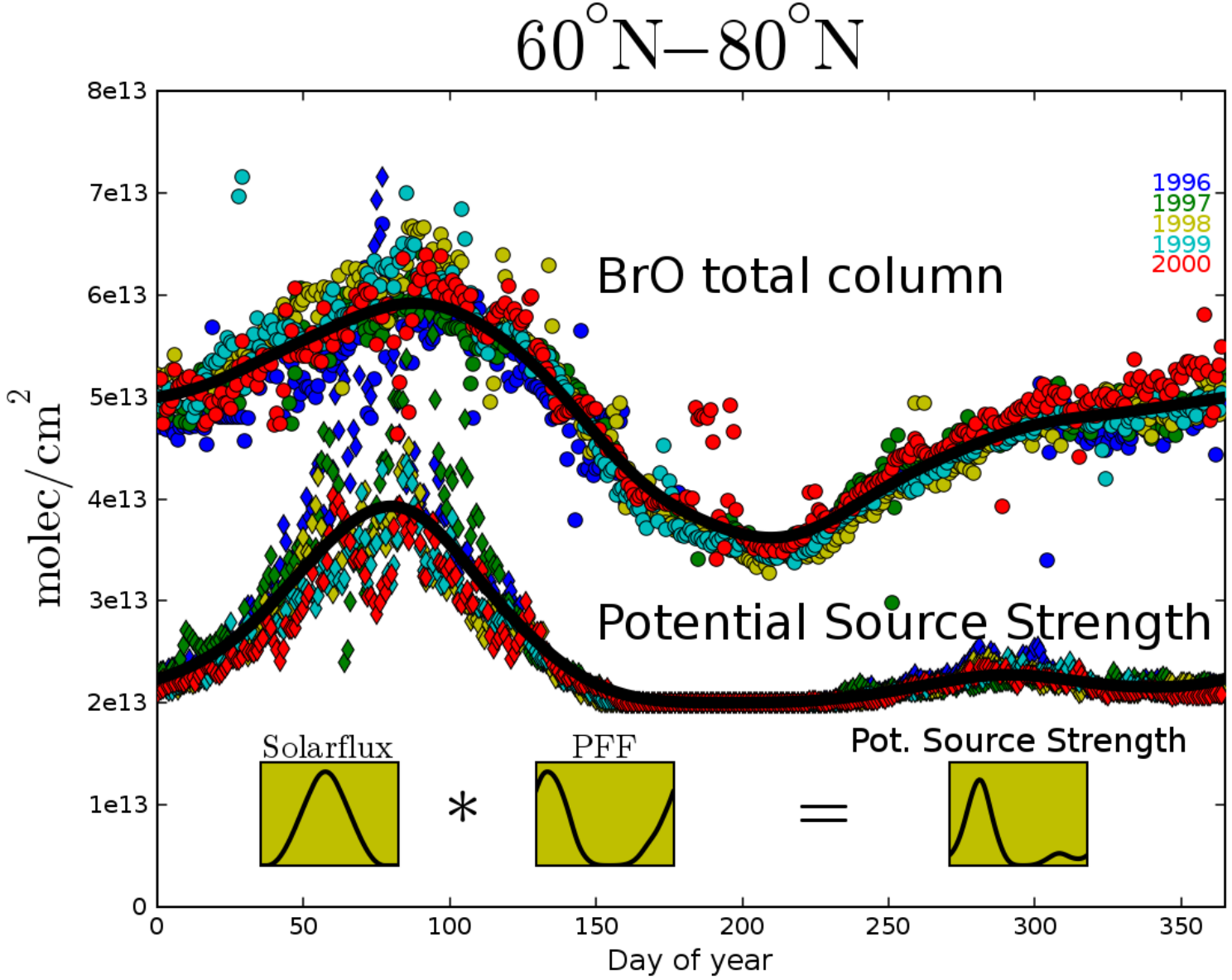


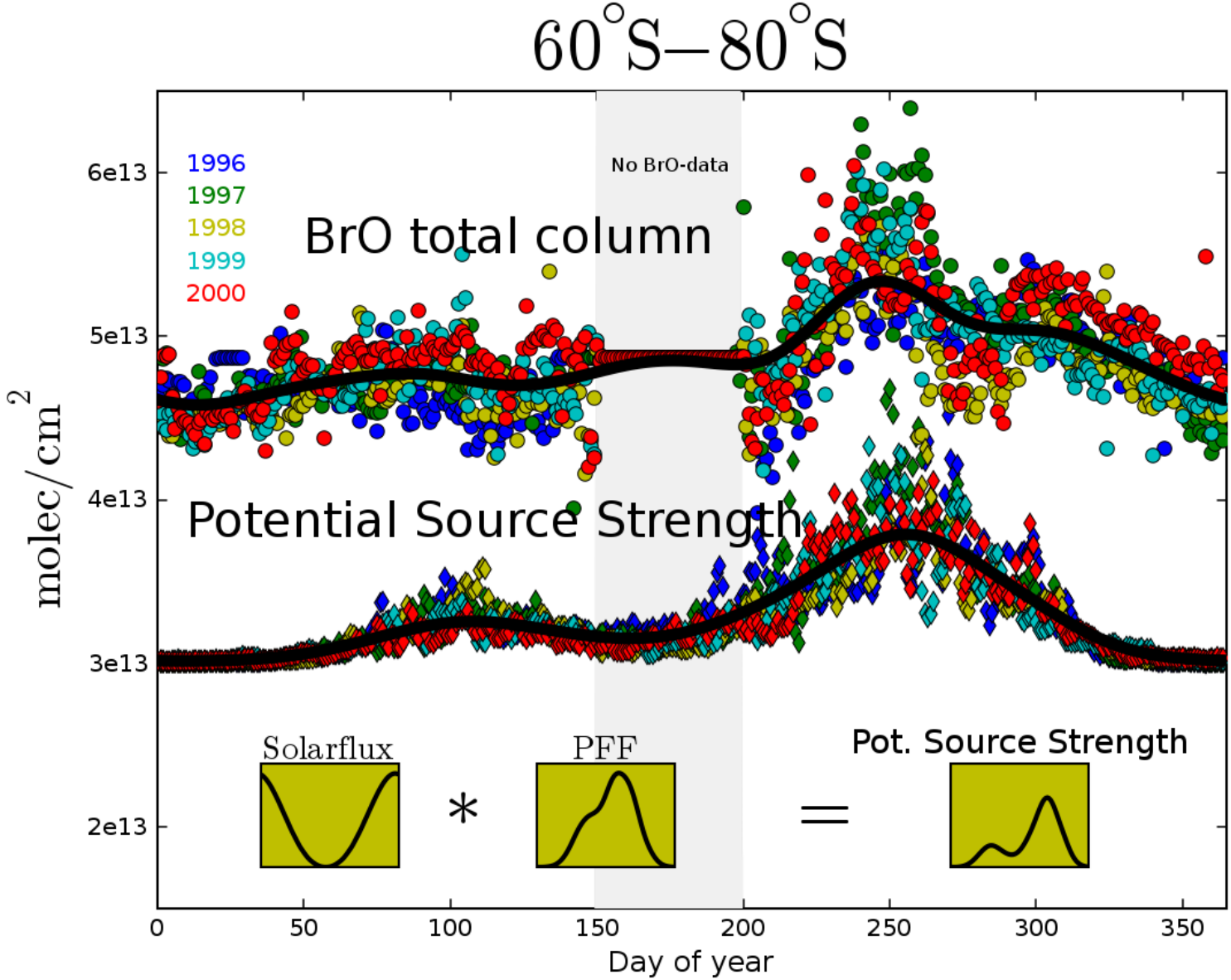

PFF Mean Seasonal Cycle 1996-2001
Northern Hemisphere
Southern Hemisphere
Hemispherical Mean PFF Coverage [%]
0.2
0.15
0.1
0.05
0
0
50
100
150
200
250
300
350
Day of the Year

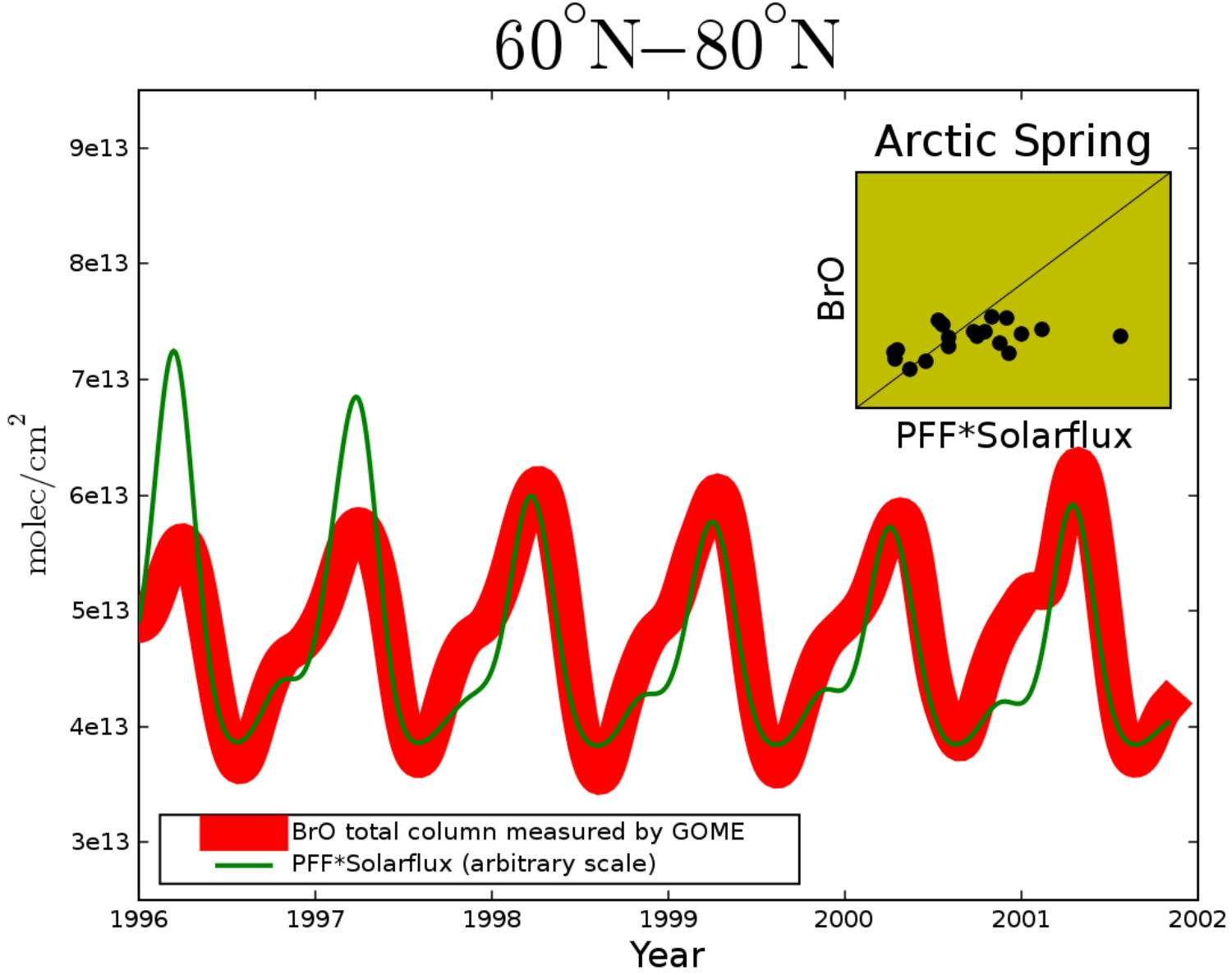
Potential Bromine Source Strength

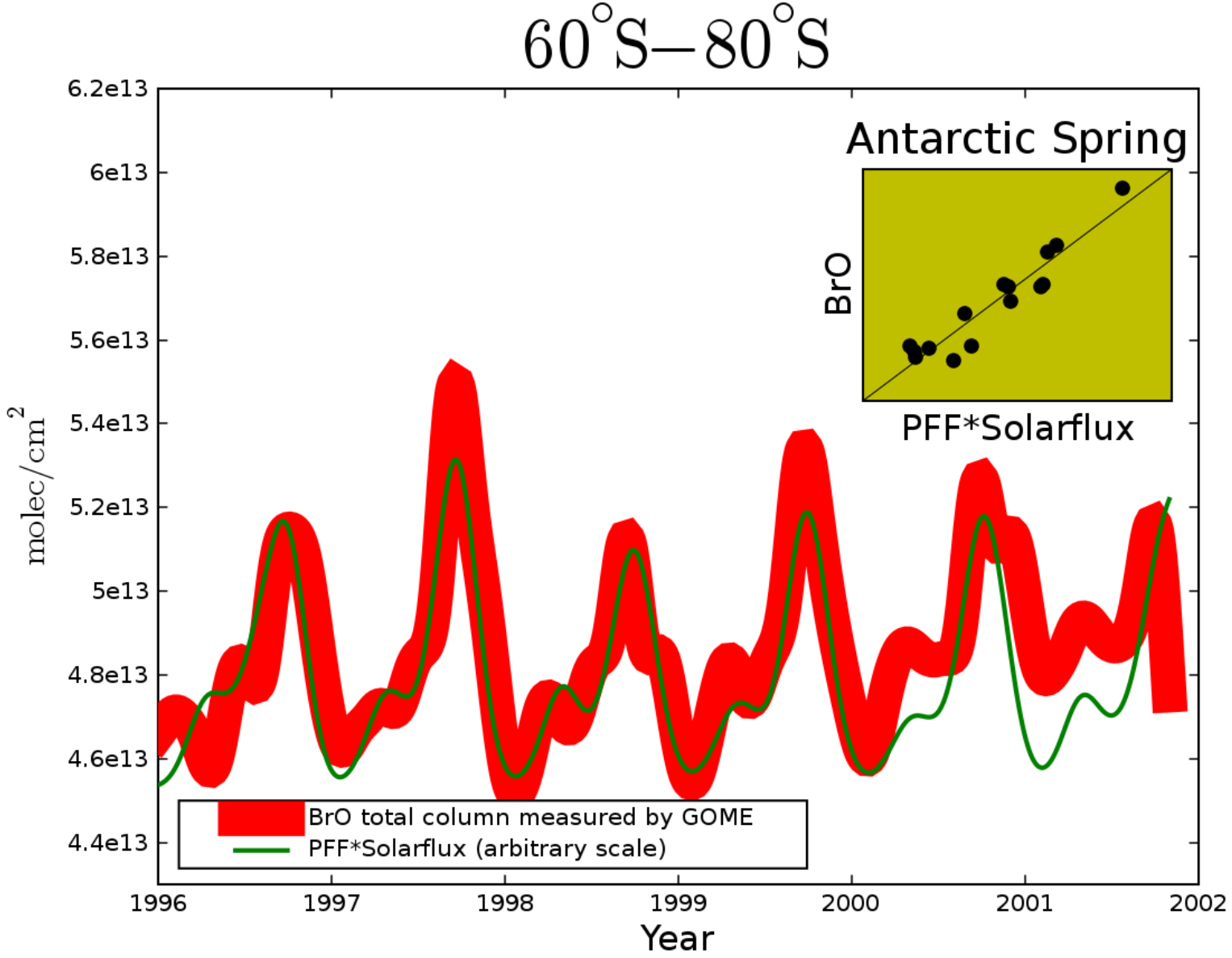


Potential Bromine Source Strength $\sim$ Potential Frost Flowers $\times$ Photon Flux


60°N–80°N
8e13
7e13
6e13
5e13
4e13
3e13
2e13
1e13
0
molec/cm 2
1996
1997
1998
1999
2000
BrO total column
Potential Source Strength
Solarflux
PFF
Pot. Source Strength
0
50
100
150
200
250
300
350
Day of year


60°S–80°S
1996
1997
1998
1999
2000
No BrO-data
BrO total column
Potential Source Strength
molec/cm 2
6e13
5e13
4e13
3e13
2e13
0
50
100
150
200
250
300
350
Day of year
Solarflux
PFF
Pot. Source Strength


60°N–80°N
Arctic Spring
BrO
PFF*Solarflux
9e13
8e13
7e13
6e13
5e13
4e13
3e13
molec/cm^2
1996
1997
1998
1999
2000
2001
2002
Year
BrO total column measured by GOME
PFF*Solarflux (arbitrary scale)


60°S–80°S
Antarctic Spring
BrO
PFF*Solarflux
molec/cm^2
6.2e13
6e13
5.8e13
5.6e13
5.4e13
5.2e13
5e13
4.8e13
4.6e13
4.4e13
1996
1997
1998
1999
2000
2001
2002
Year
BrO total column measured by GOME
PFF*Solarflux (arbitrary scale)

Summary

- Frost flower model
- Potential bromine source strength
- The model explains:
  - BrO spatial variability (not shown here)
  - BrO seasonal cycle:
    Springtime maximum and seconday maximum in autumn
  - BrO interannual variability for the Antarctic
- Discrepancies in the interannual variability for the Arctic
  Additional forcing parameters needed?

Thank you for your attention!

Arved Fuchs, Northern Searoute 2002