Measurements of Aerosol Hygroscopic Growth

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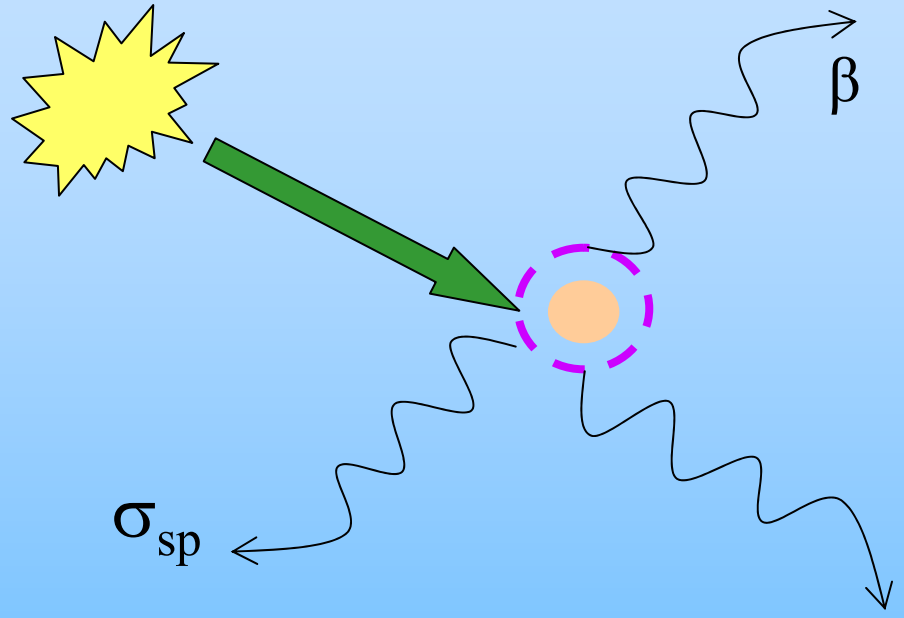
http://www.cmdl.noaa.gov/aero

Change in aerosol scattering with water uptake



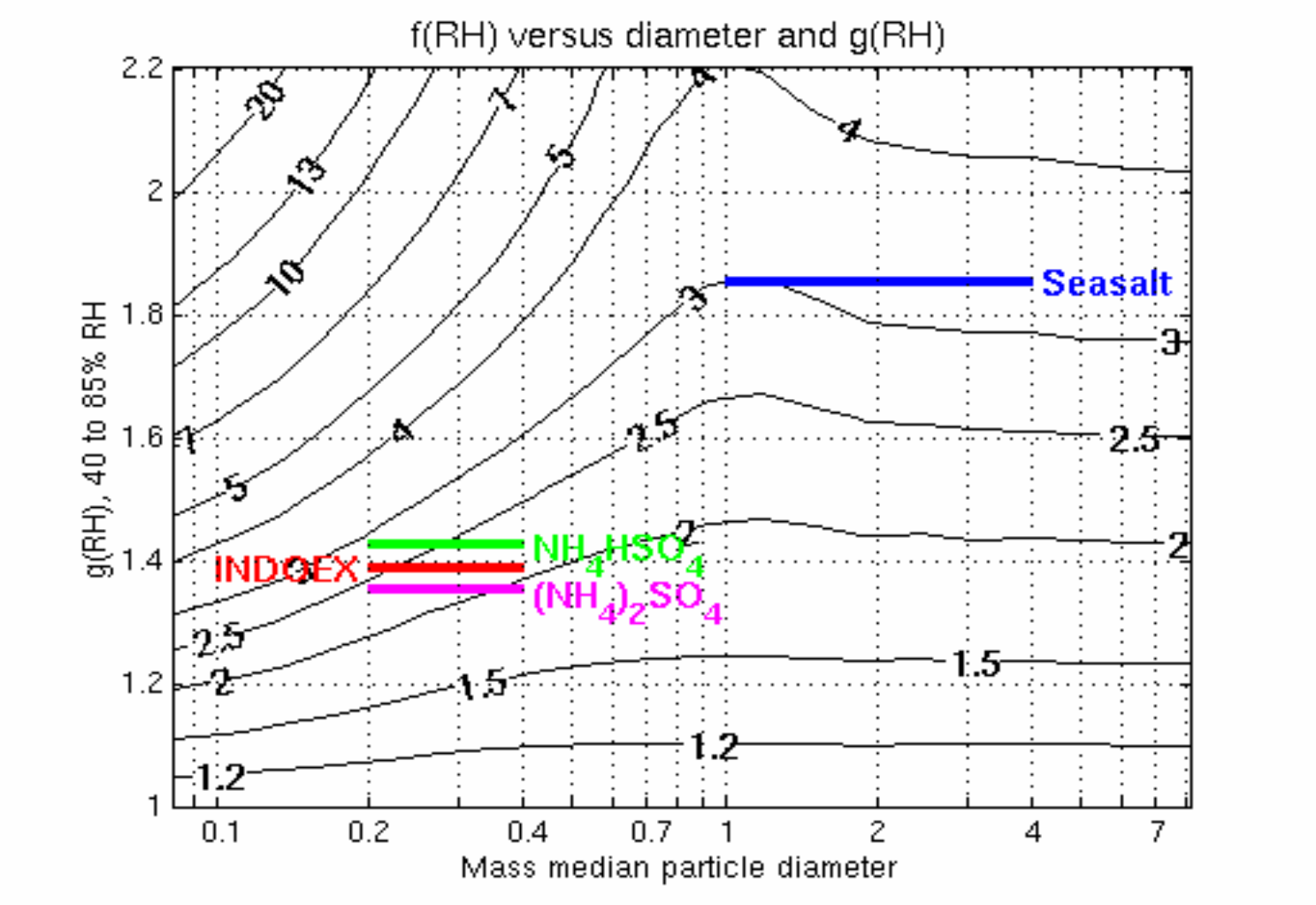
increase in total scattering, σ_{sp}

decrease in hemispheric backscatter fraction, β

Aerosol hygroscopic growth factor:

$$f(RH) = \sigma sp(85\%\ RH) / \sigma sp(40\%RH)$$

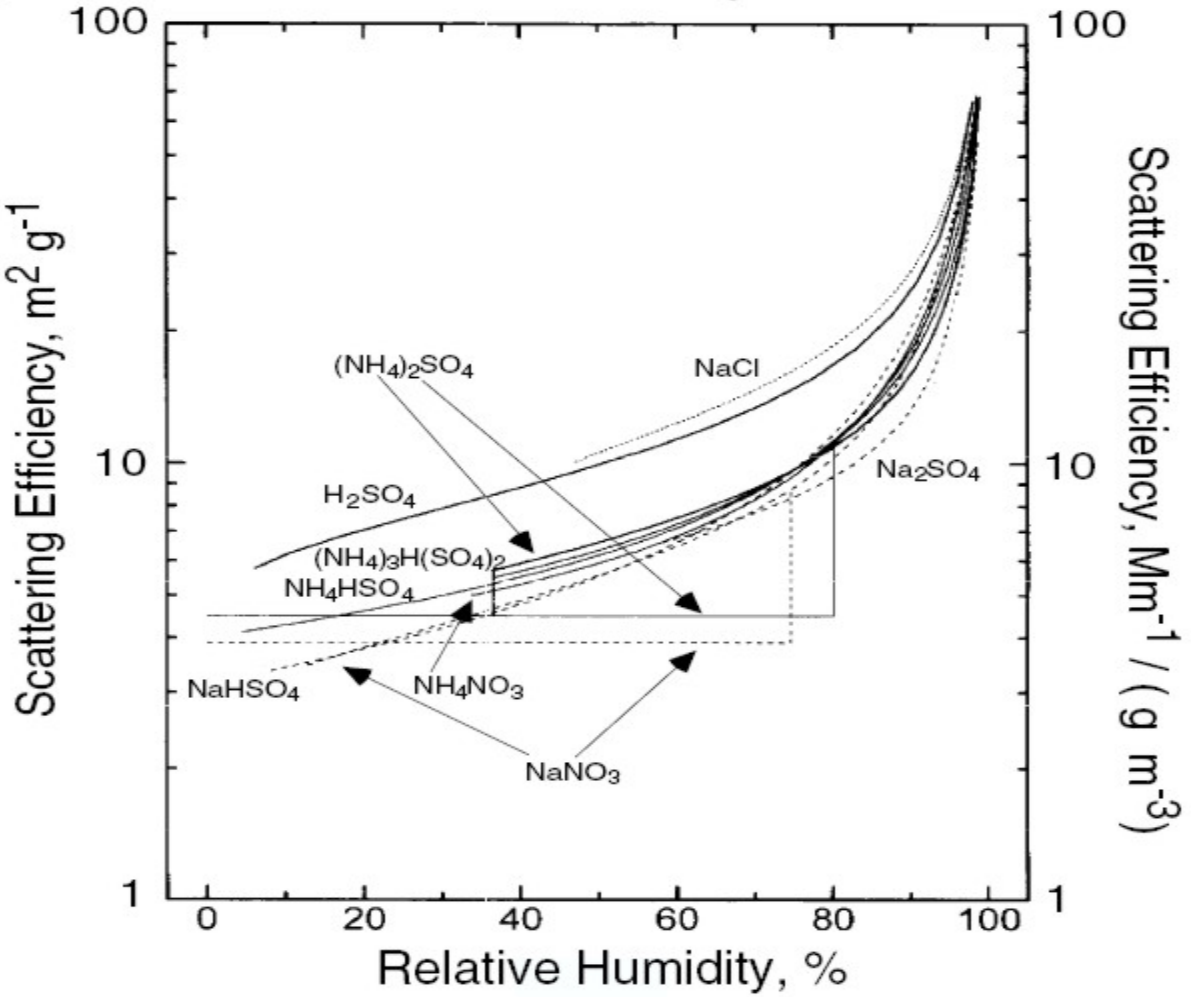
Increase in scattering with RH in relation to particle size



Mie calculations and plot courtesy of Steve Howell. Calculations are for dry lognormal size distributions with a geometric stdev. of 1.5. The refractive index of the dry aerosol is 1.55 and that of the wet aerosol is 1.33

WATER UPTAKE AND LIGHT SCATTERING COEFFICIENT

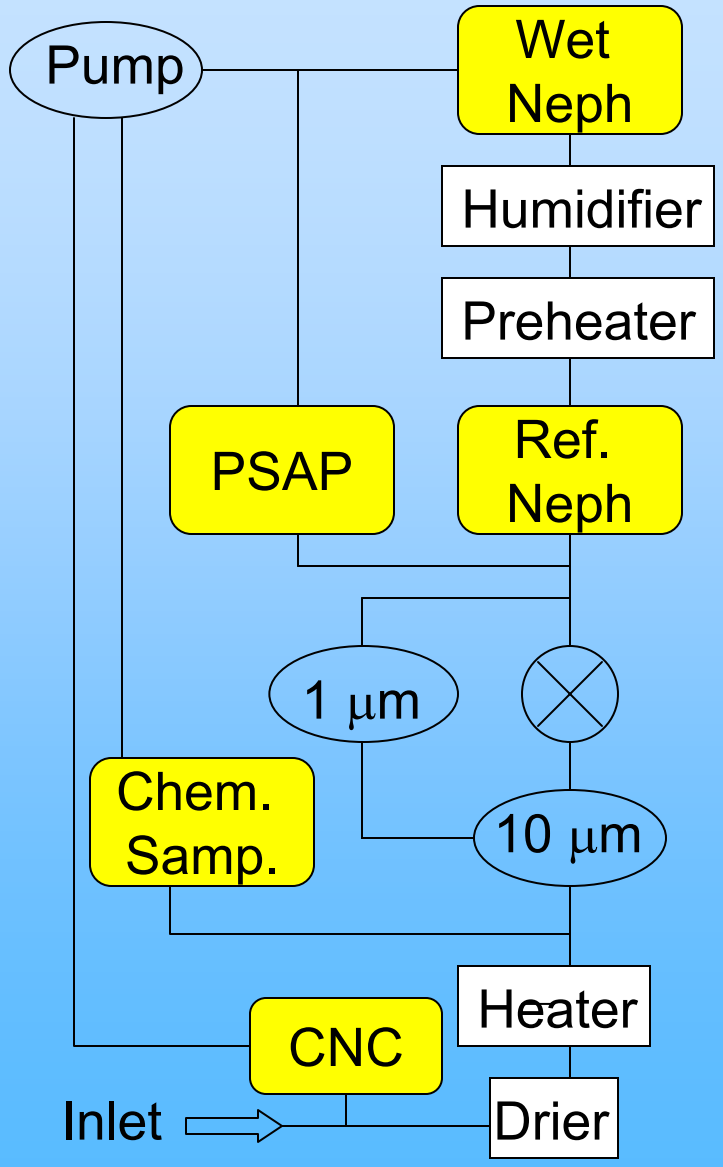
Dependence on relative humidity for various substances

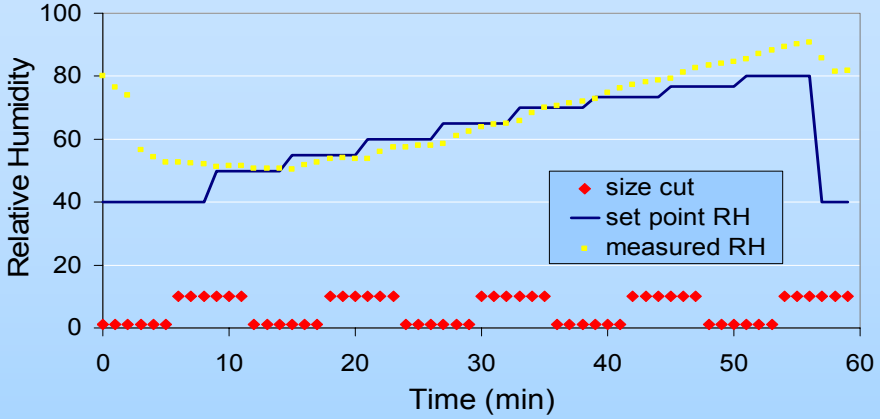


Lognormal, D_g = 0.3 μm; σ_g = 1.5; I. Tang, JGR, 1996

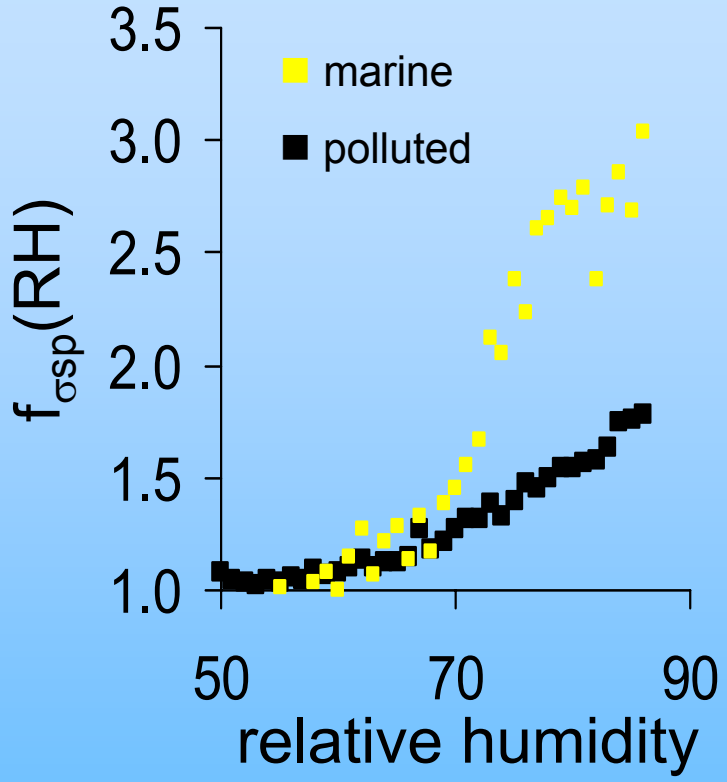
NOAA/CMDL Aerosol Network

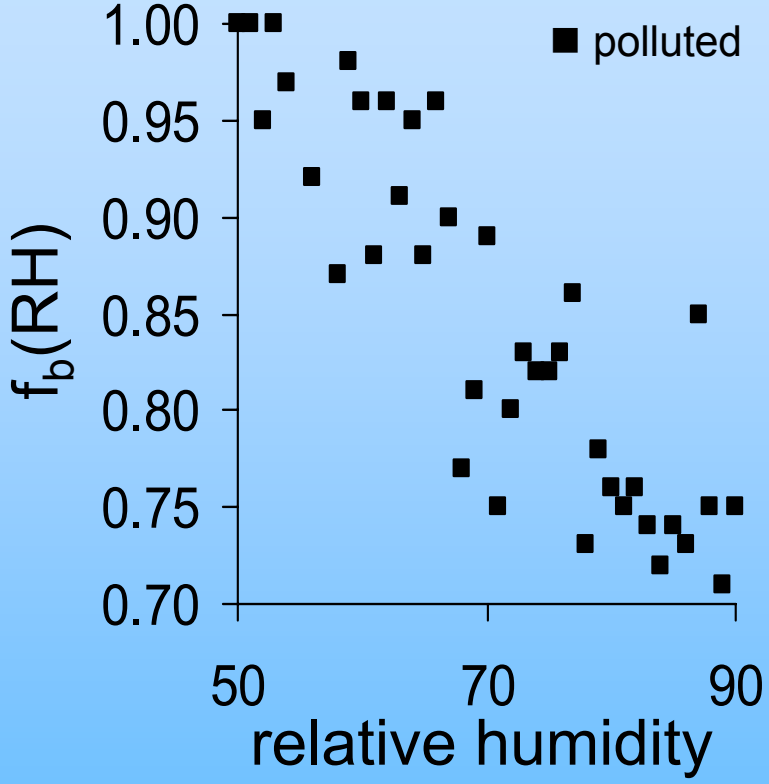
CMDL Humidograph System





Hygroscopic growth at Sable Island

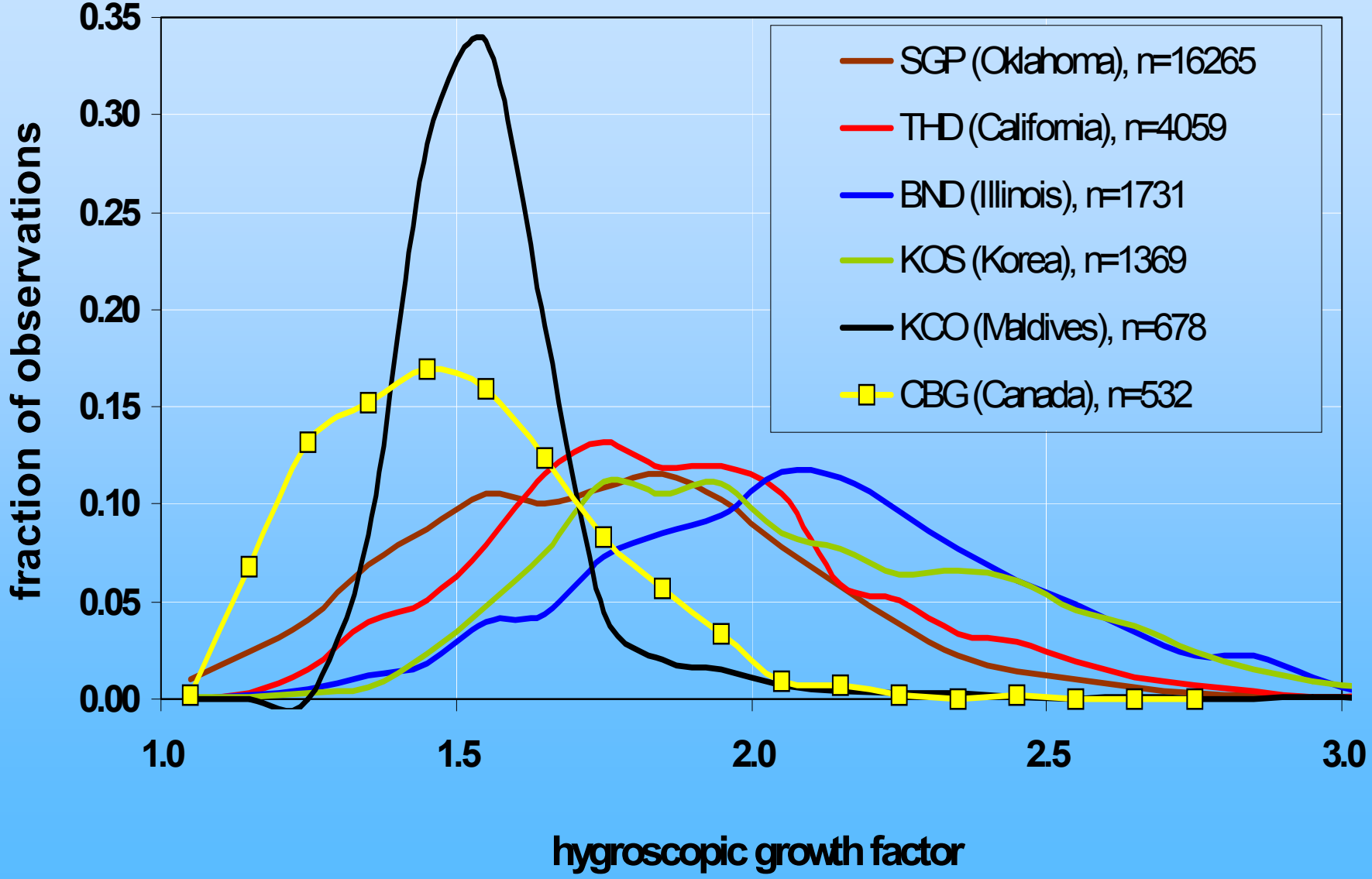




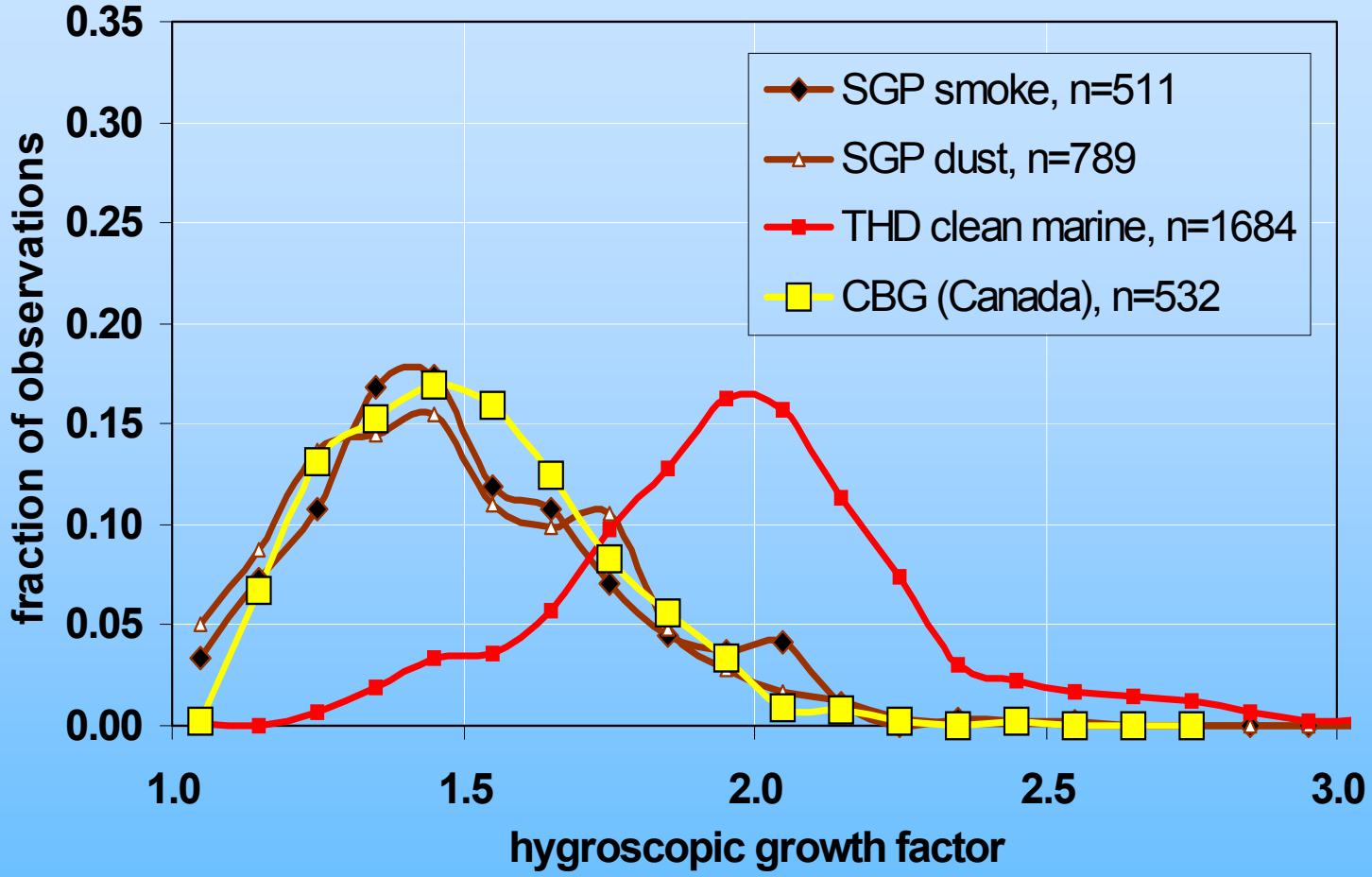
1. Chemical composition controls hygroscopic growth.

2. Backscatter fraction decreases with increasing RH.

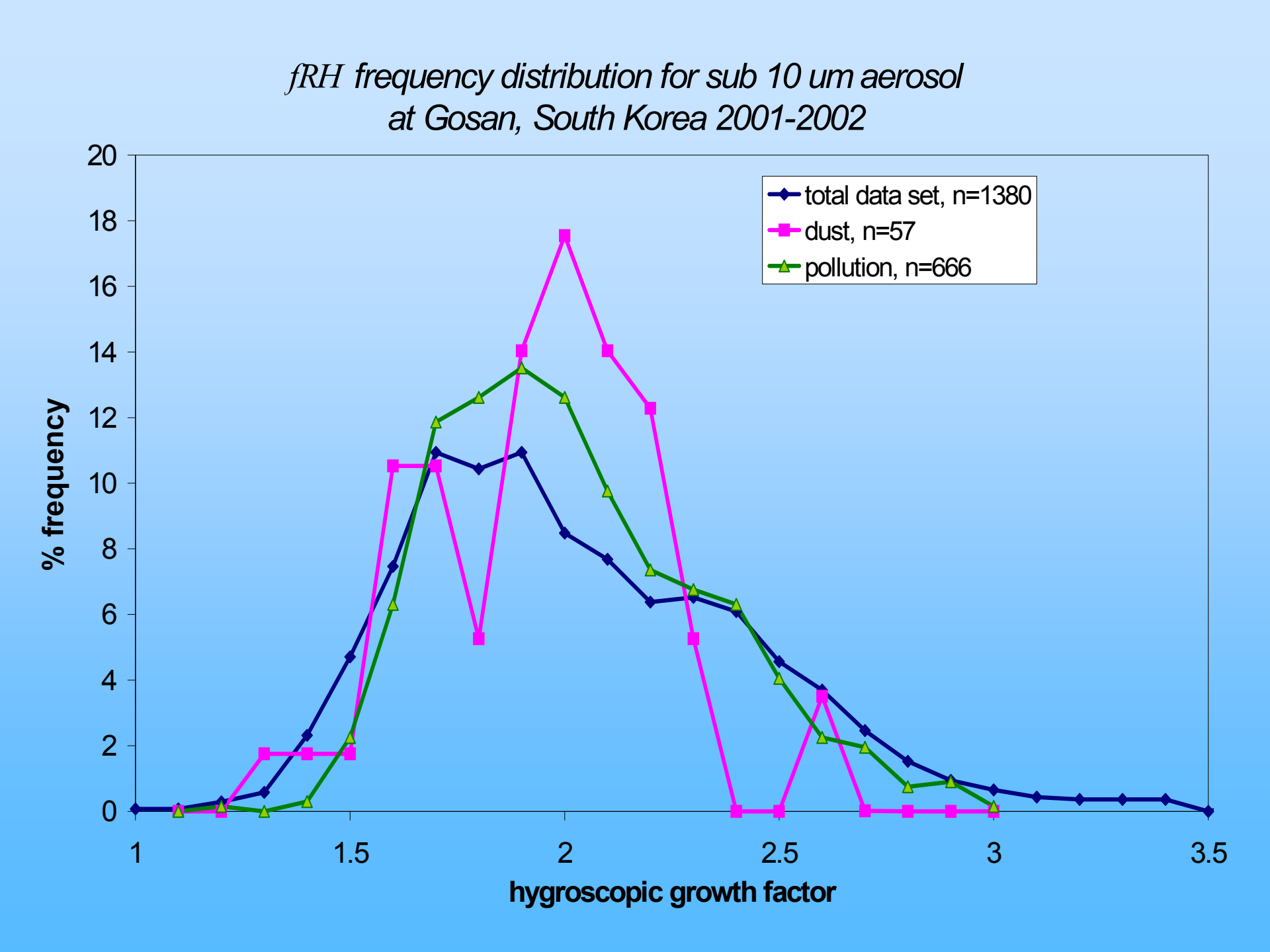
fRH frequency distribution



fRH frequency distribution for different aerosol types in North America



Aerosol hygroscopic growth factors are low for smoke, dust at SGP and interstitial fog aerosol at CBG and high for marine sea salt aerosol at THD.


fRH frequency distribution for sub 10 um aerosol
at Gosan, South Korea 2001-2002
total data set, n=1380
dust, n=57
pollution, n=666
% frequency
hygroscopic growth factor
0
2
4
6
8
10
12
14
16
18
20
1
1.5
2
2.5
3
3.5

Variance of *fRH* with air mass source region

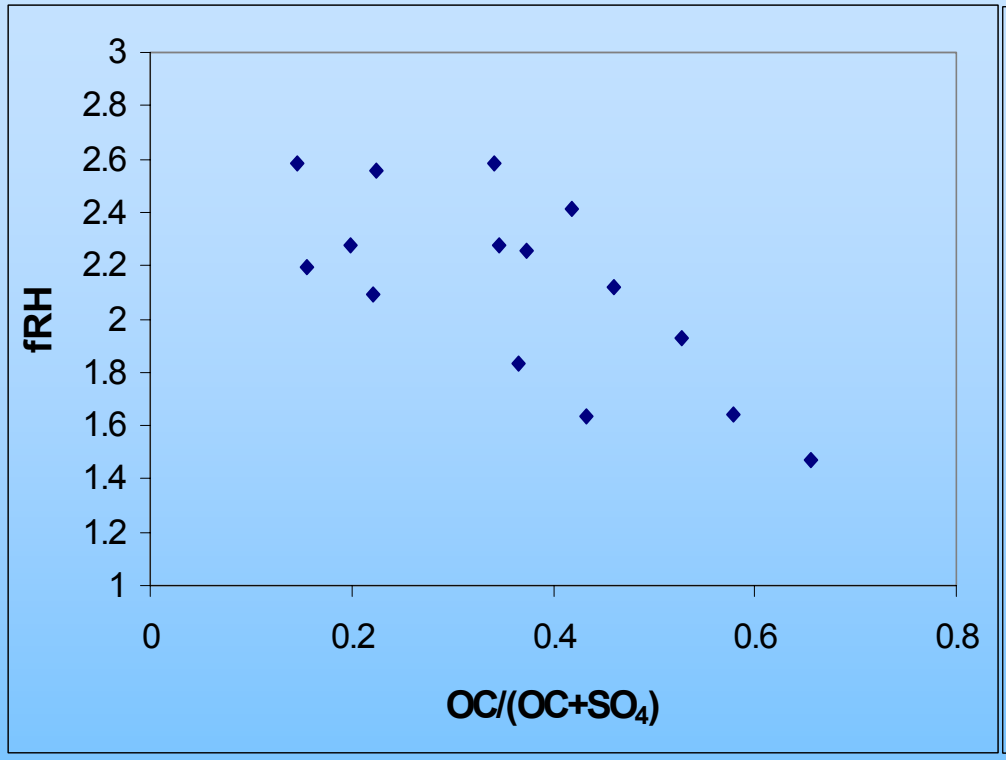
Table 1.0 In-situ Aerosol properties measured at Gosan, South Korea

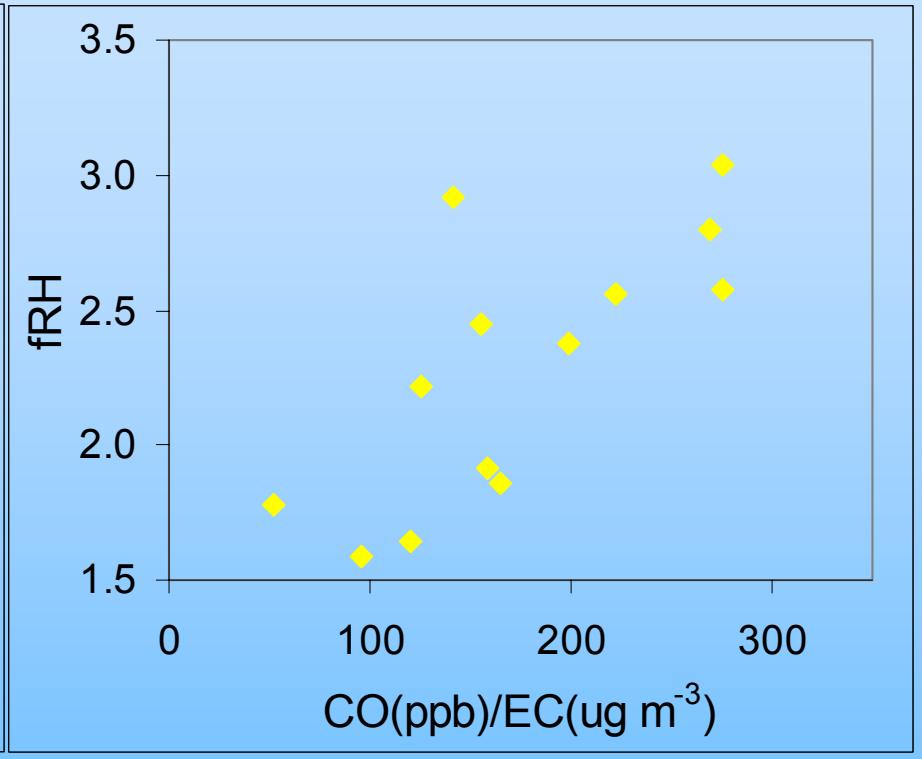
Region	Extinction	Albedo	Ångström	*fRH*	# days
Korea	100.84	0.88	1.45	1.89	61
China	112.56	0.89	1.26	2.10	111
Japan	69.73	0.89	1.55	2.32	25
Marine	44.88	0.88	1.17	2.49	40
SOJ	69.53	0.86	1.38	2.03	29
Local	73.14	0.89	1.57	2.40	20
Total	87.45	0.88	1.37	2.10	310

Extinction is for 550 nm radiation in units of Mm-1. The Ångström exponent was measured for the the 450/700 nm wavelength pair. All data is for sub 10 micron size particles. "Albedo" refers to the single scattering albedo measured at 550 nm.

- *fRH* values are relatively high for a polluted site.
- fRH values are highest for marine (sea salt) and lowest in air masses with relatively fresh emissions from the Korean Peninsula.
- Variance of *fRH* with absorbing fraction, size and wind speed is weak (not shown)

Variance of *fRH* at Gosan on composition and air mass age

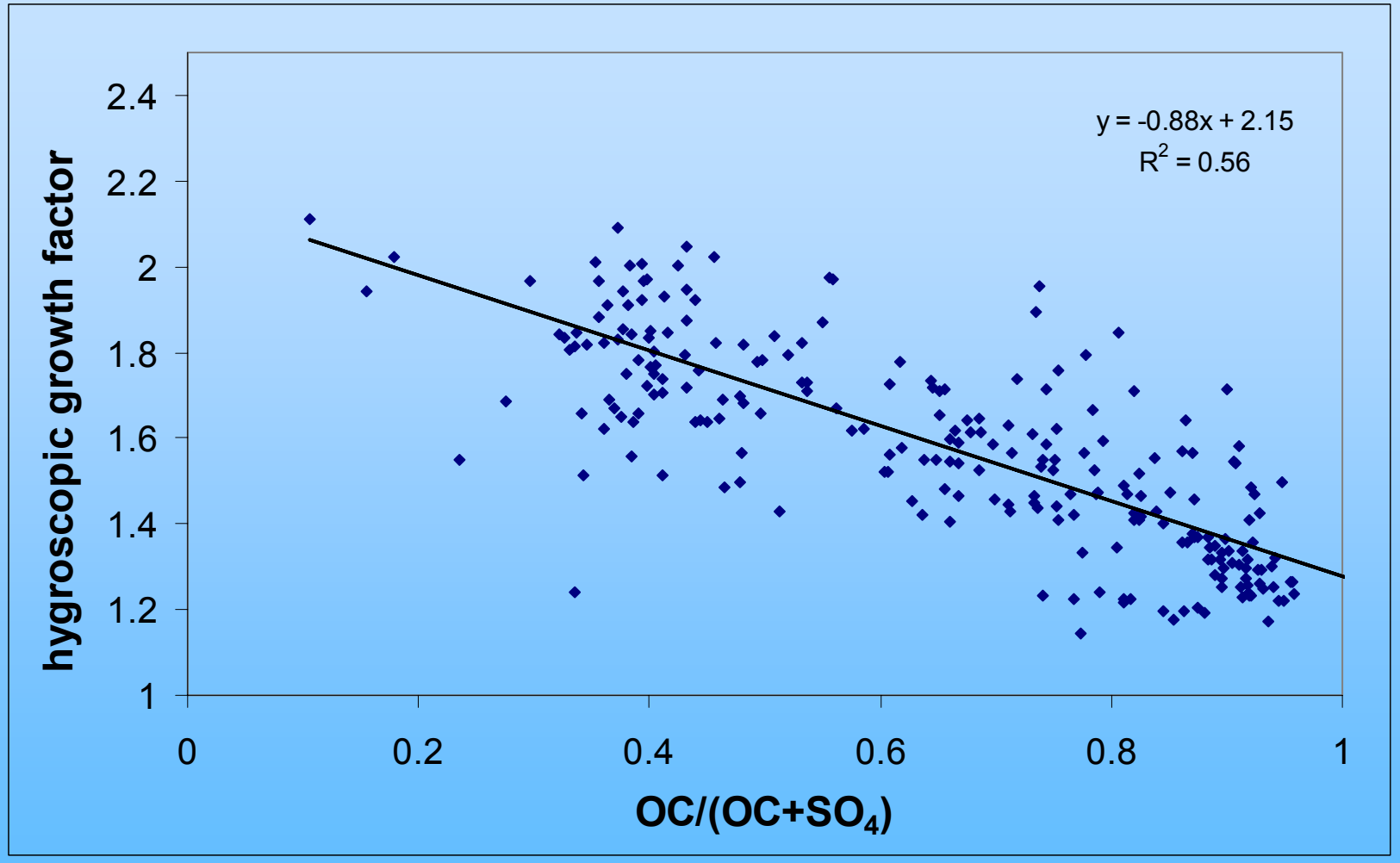




OC and EC data from J. Yu and H. Yang of HKUST. SO_4^- data from J. Schauer of U. of Wisconsin. CO data from UMIST. Data are 24 hr averages for sub 10 micron sized aerosol.

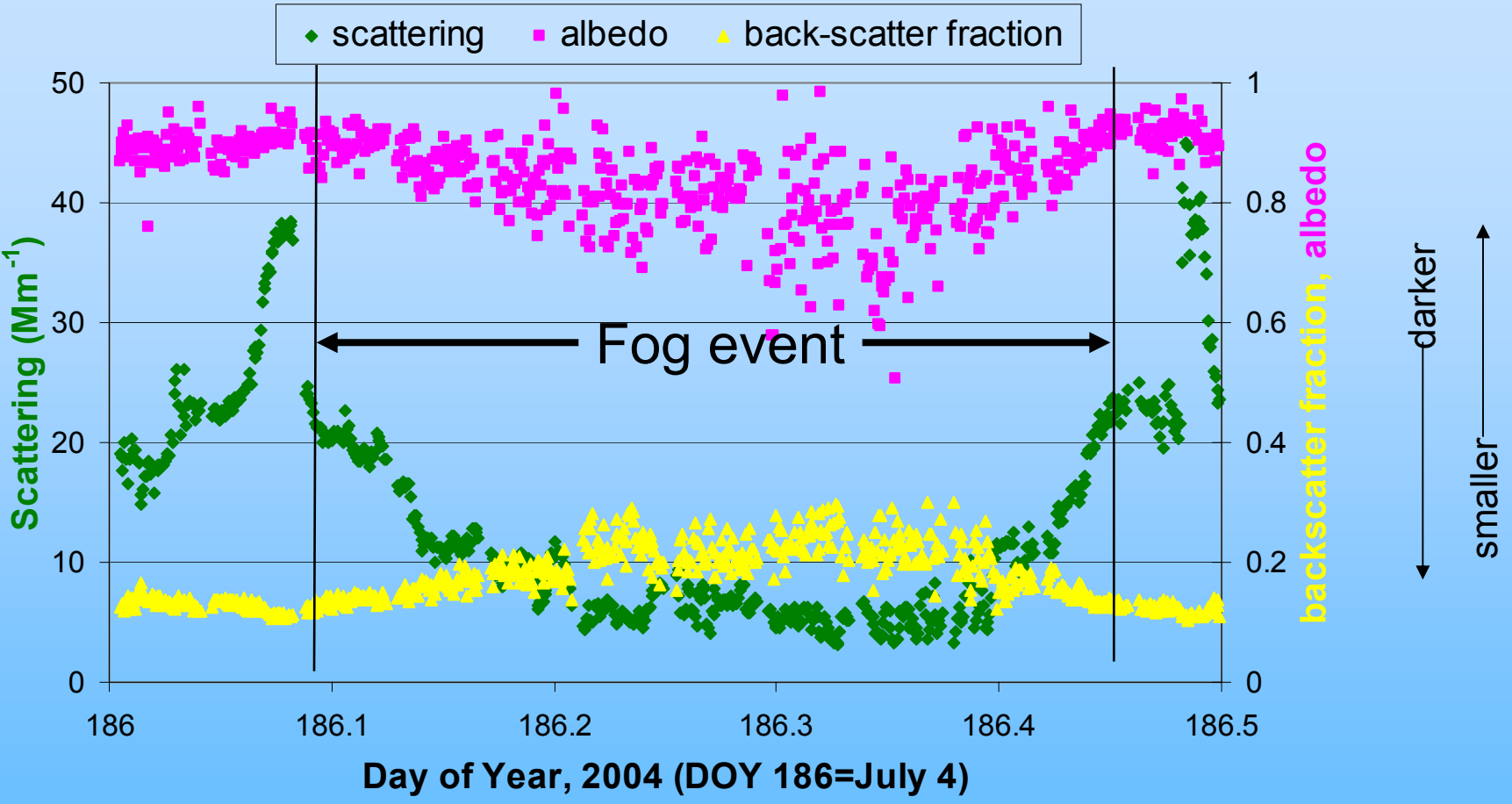
- *fRH* shows a strong variance on the fraction of OC composition as well as the air mass "age".
- The CO/EC ratio might serve as a rough indicator of the amount of aerosol oxidation.

Variance of hygroscopic growth with particle composition



Data from ICARTT campaign at Chebogue Point, N.S. 2004. OC and SO_4 data from UMIST

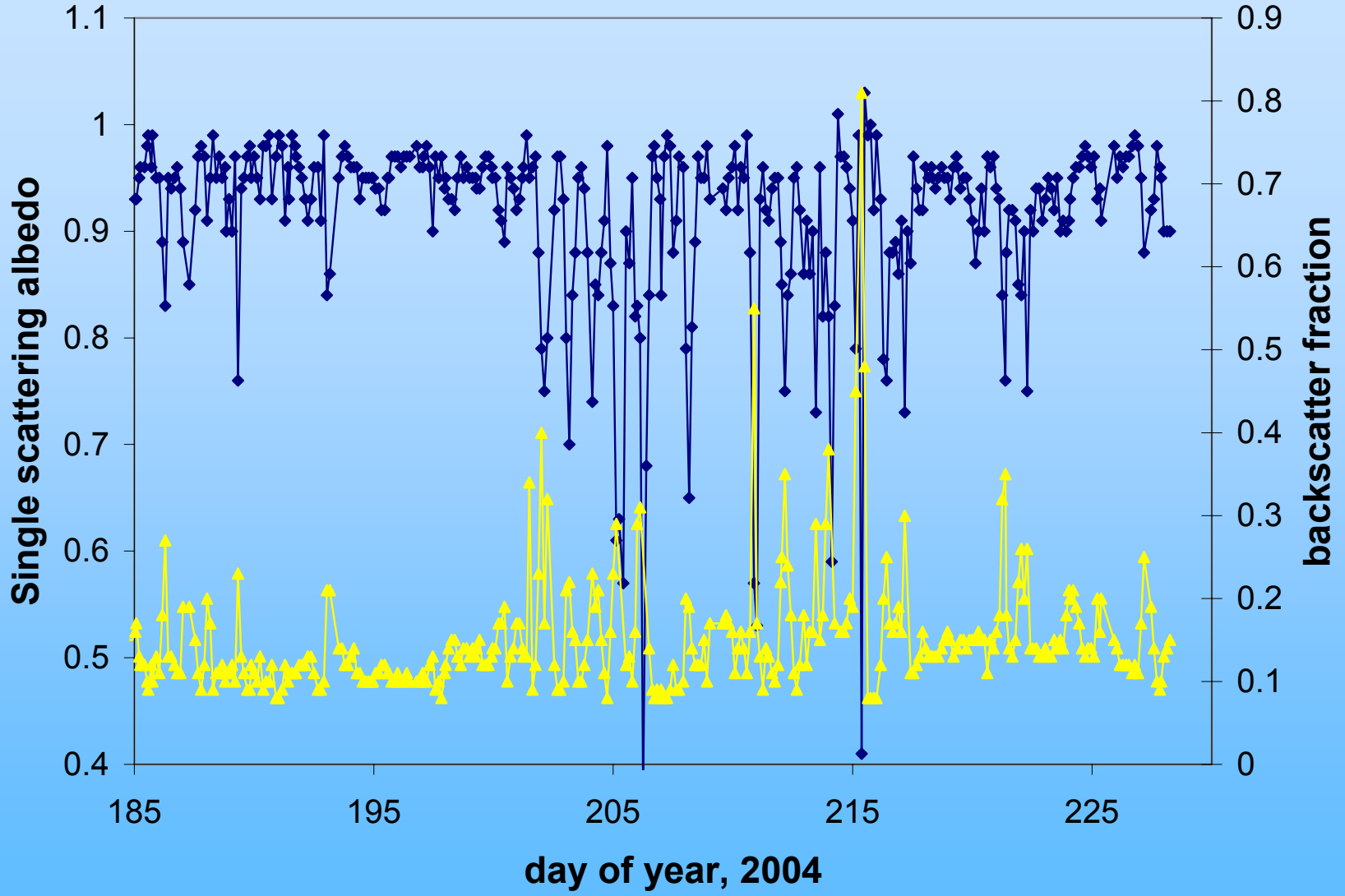
Effect of fog on interstitial aerosol optical properties at Chebogue Point, N.S.



Onset of fog causes:

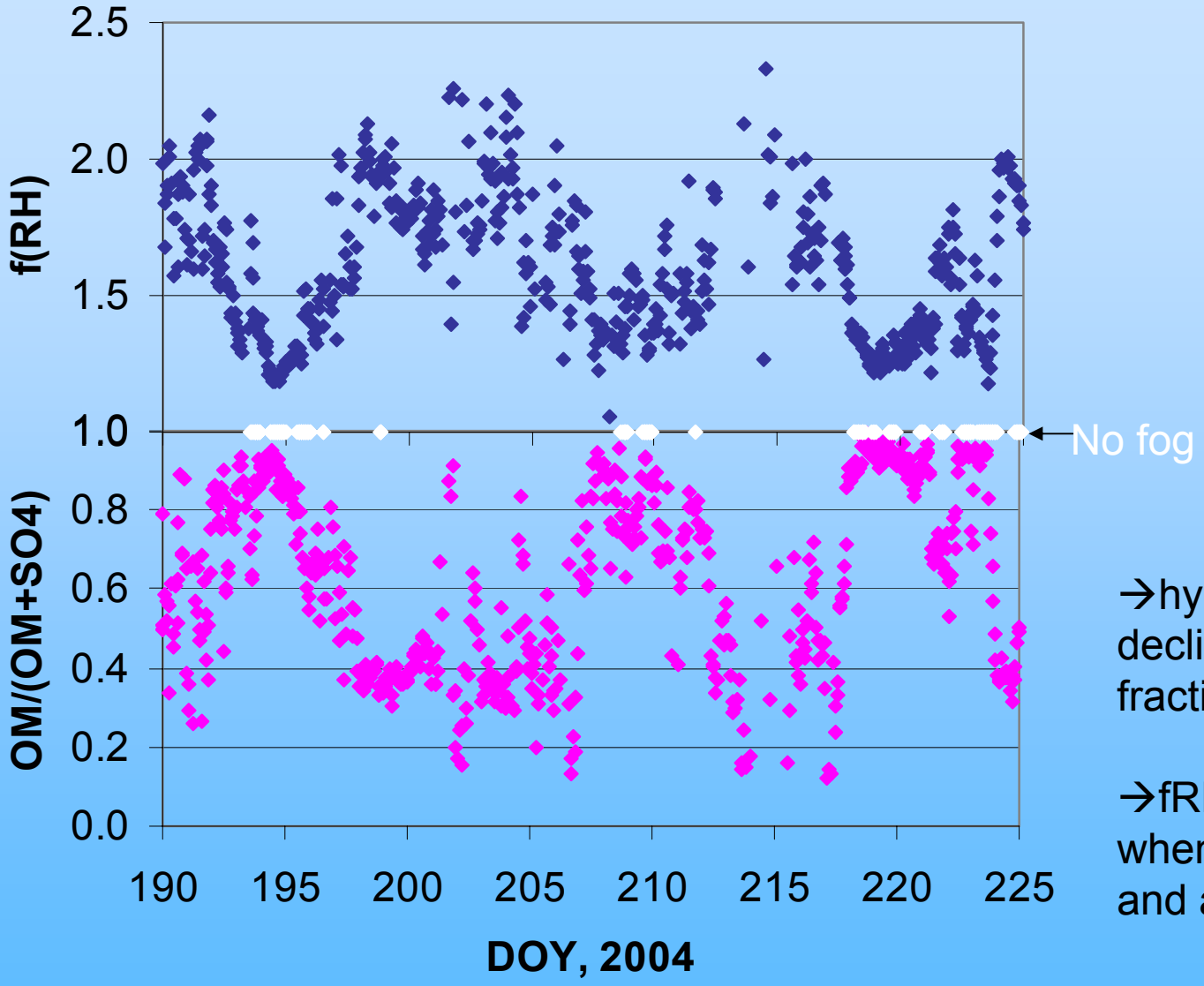
- Decrease in light scattering
- Decrease in single scattering albedo
- Increase in back-scatter fraction

Aerosol intensive properties in fog at Chebogue Pt, N.S.



Foggy periods were characterized by increases in hemispheric backscatter fraction and decreases in the single scattering albedo. Measurements at λ=550 nm, Dp<5 *u*m

Chemistry and hygroscopic growth in interstitial particles



→hygroscopicity declines with organic fraction

→fRH is higher in fog when albedo is low and aerosol is small

OM=organic material, SO4= sulfate
SO_4&OM data from Aerodyne/UMIST
[OM] > 0.25 ug/m^3, f(RH) for dp<1 um

Summary

- *fRH* exhibits a strong covariance with fraction of OC composition
- *fRH* is low for smoke and dust aerosol at a continental US site but relatively high at an East Asian marine site
- aerosol size and single scattering albedo decline in fog