Global estimates of the horizontal variability of total cloud optical thickness from MODIS Level-3 data

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From July 2003 and January 2004 MODIS Terra and Aqua Level-3 data we have built a climatology of the following quantities:

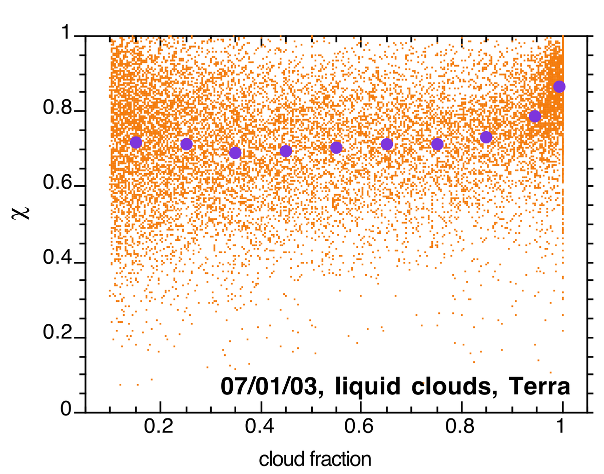
$$\chi = \frac{e^{\overline{\ln q}}}{\overline{q}} \qquad \nu_{MOM} = \left(\frac{\overline{q}}{\sigma_q}\right)^2 \qquad \nu_{MLE} = \frac{1+\sqrt{1+4y/3}}{4y} \quad (y = \ln\overline{q} - \overline{\ln q})$$

q is either the total optical thickness τ or the total water path W. These quantities are measures of cloud horizontal inhomogeneity: the smaller they are, the larger cloud inhomogeneity is. χ is the scaling factor in the "effective thickness approximation" of Cahalan et al. (JAS, 1994), while ν is the shape parameter of the gamma distribution (observed PDFs of q have been found to resemble gamma PDFs).

The figures in this poster show results in terms of χ which is probably more intuitive: if the mean q of a region is scaled by χ and used to calculate the albedo, the outcome is often pretty good, i.e., close to the Independent Pixel Approximation (IPA) albedo.

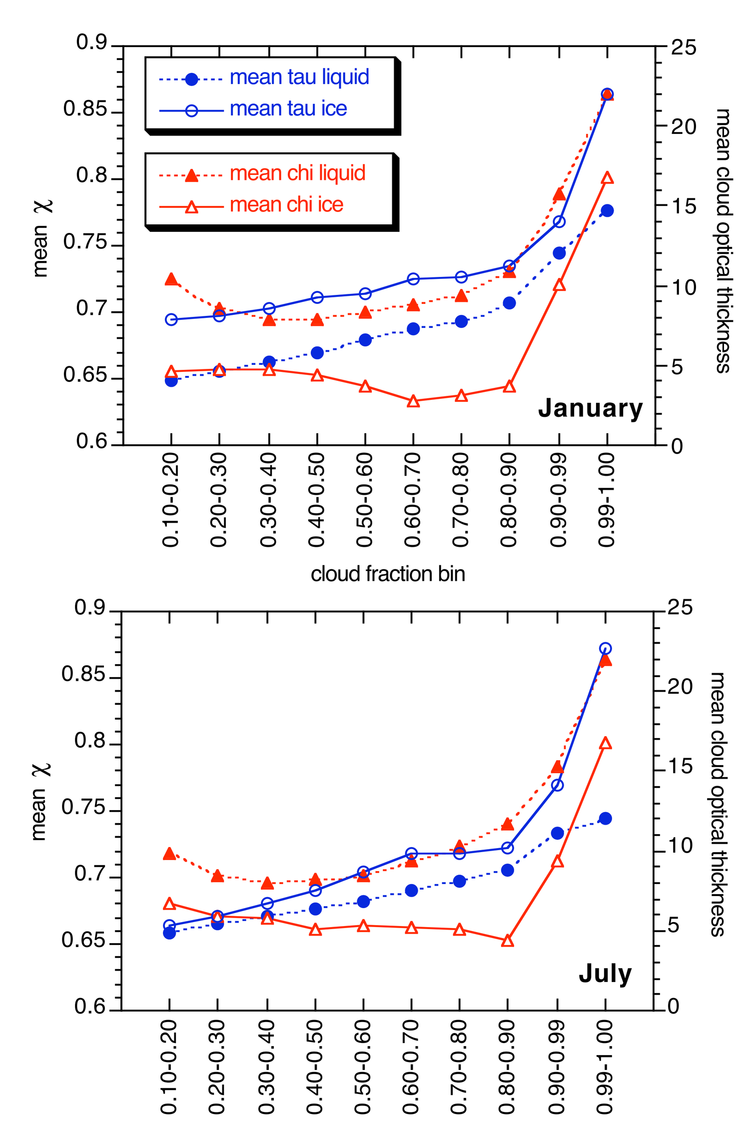
The inhomogeneity parameters are calculated for each day of the month for each 1°x1° gridpoint (we use D3 data). Then they are averaged in time (monthly averages) and/or space (zonal, hemispheric, global averages) using cloud fraction as weight. The calculations are performed separately for the "ice" and "liquid" phase as identified by the cloud phase algorithm.

Dependence on cloud fraction

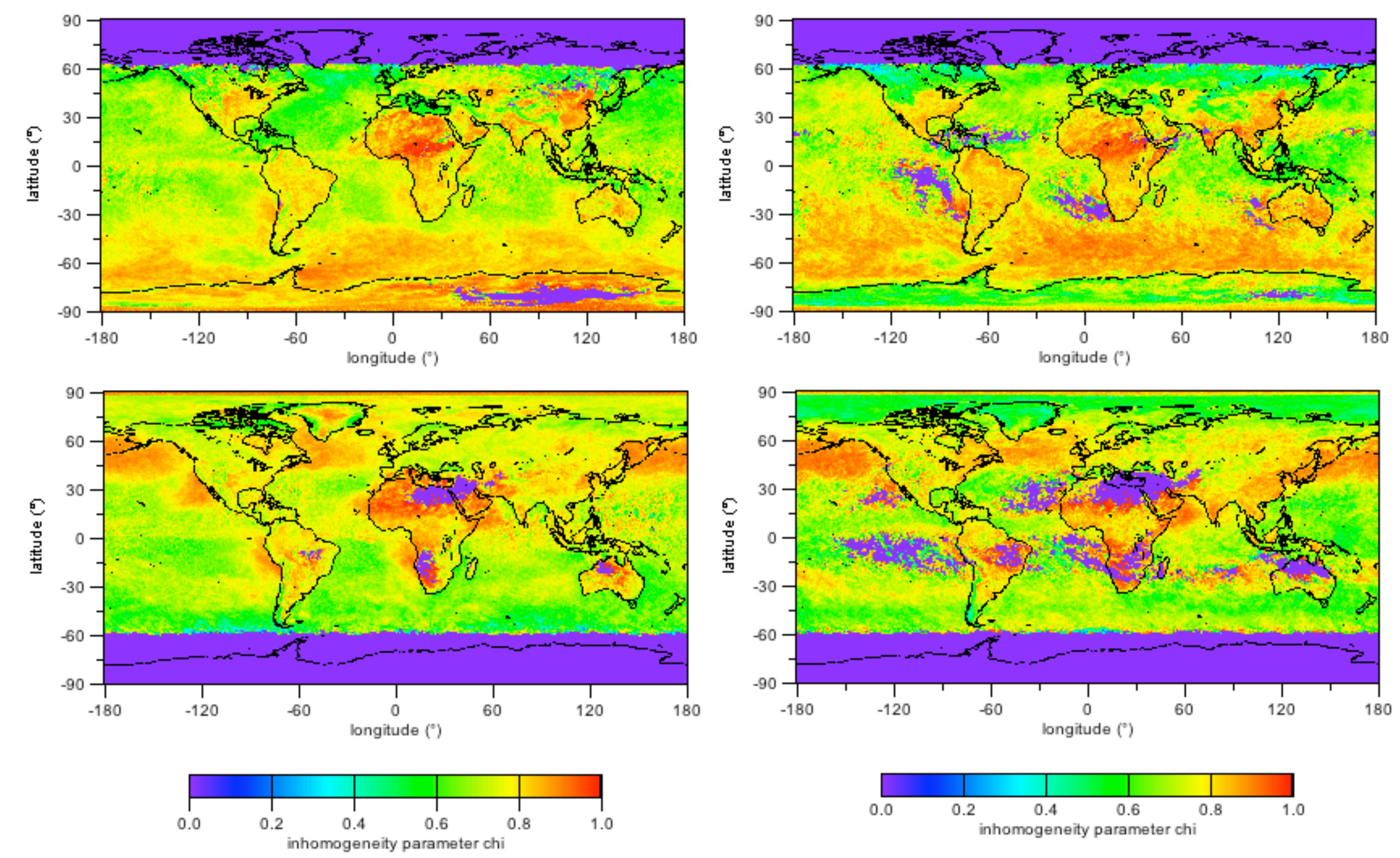


Is χ related to cloud fraction? The figure in the left reveals that when the values of all gridpoints on a particular day are plotted (orange points) no clear relationship can be discerned. But when χ is averaged within cloud fraction bins, a tendency emerges for near overcast regions to be more homogeneous *on average*.

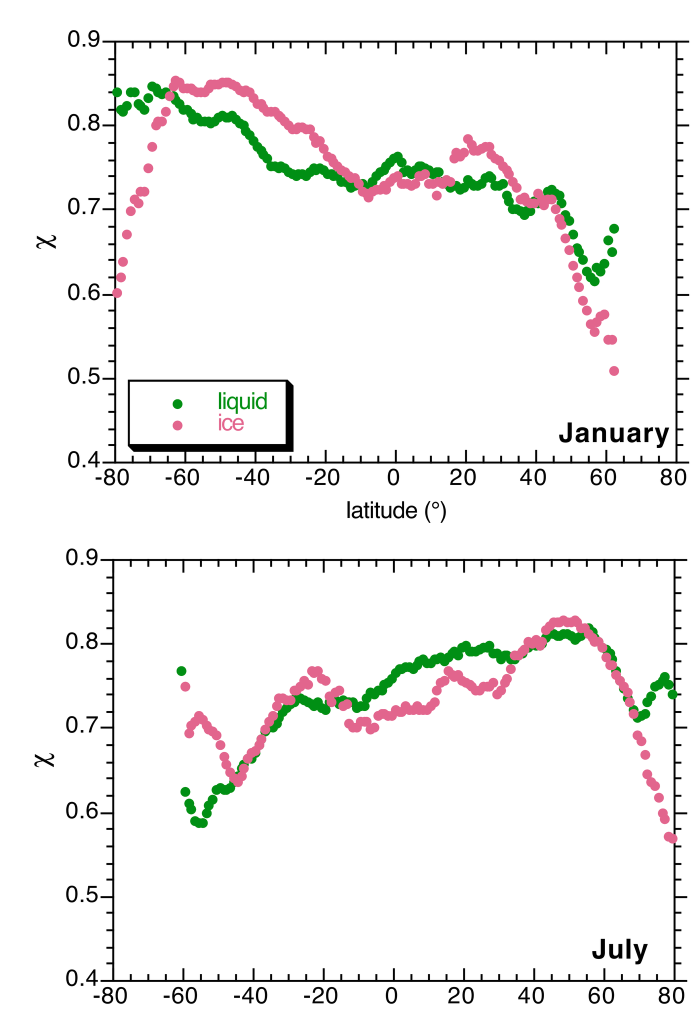
The figure in the right generalizes the above result for the entire months of January and July and for the two cloud phases (Terra). Optical thickness increases with cloud fraction on average, but χ remains relatively constant before rising sharply for the last two cloud fraction bins. Note that overcast is noticeably different than almost overcast.

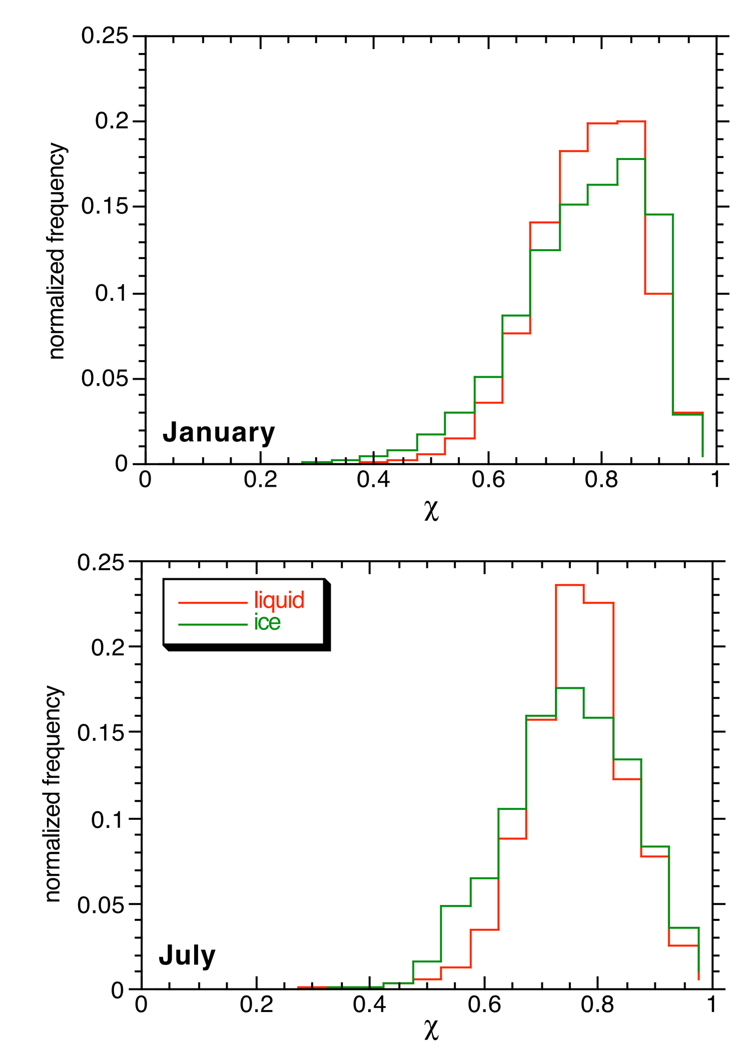


Dependence on phase and season



The figure above shows the geographical distribution of monthly-averaged χ. The left two panels are for liquid phase clouds, the right two panels for ice phase clouds. Top is January and bottom is July

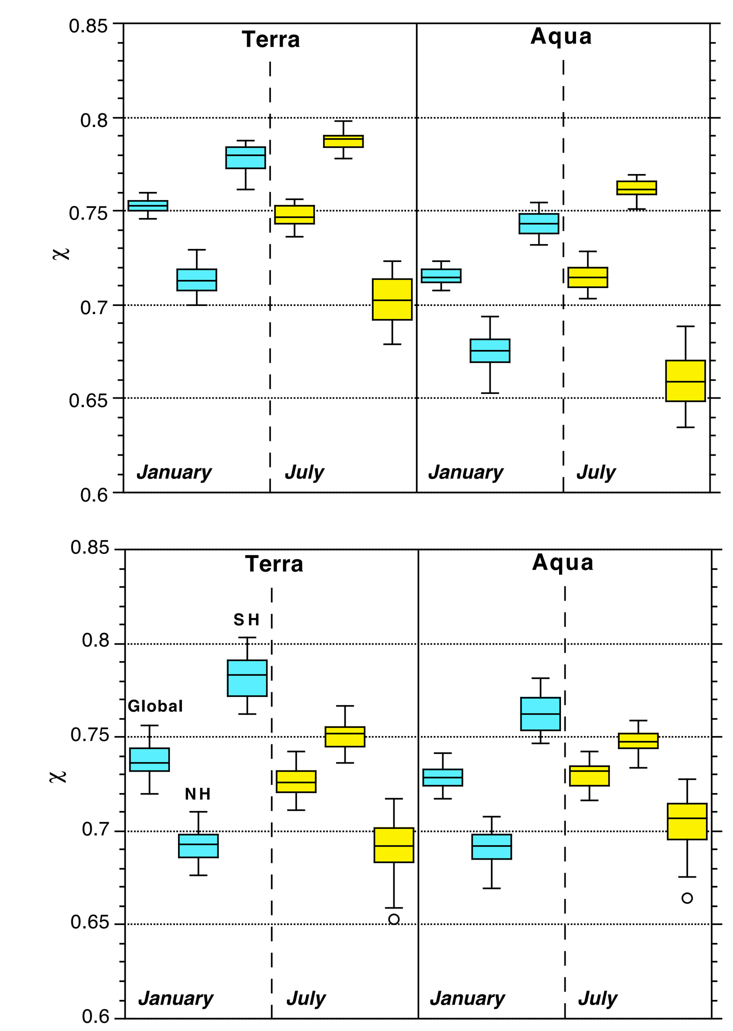




This is the monthly zonal distribution of χ for Terra. One can see liquid and ice phase differences and their seasonal changes. Note the large changes in the midlatitudes.

While the Terra global χ values for the liquid and ice phase are similar (see the tables) the histograms of χ derived from all available gridpoint values are wider for the ice phase.

Global scale details



The figure above is a standard boxplot constructed from the 31 global daily values of χ for each month. Top is for liquid phase, bottom for ice phase. The plot summarizes day to day variability, seasonal and platform differences.

	Liquid					Ice				
	τ_1	τ_2	τ_1 QA	W_1	W_2	τ_1	τ_2	τ_1 QA	W_1	W_2
χ	0.745	0.742	0.771	N/A	0.731	0.735	0.735	0.780	N/A	0.747
ν_{MLE}	2.87	2.76	3.19	N/A	2.66	2.91	2.89	3.40	N/A	2.85
ν_{MOM}	2.62	2.55	2.96	2.63	2.37	2.71	2.69	3.09	3.00	2.61

These tables are for those who love details. The table above shows dependence of global values on method of calculation (Terra). "1" means that the inhomogeneity parameters were derived from moment SDSs and "2" that that they were derived from histogram SDSs. The tables below are almost self-explanatory

Liquid

	TERRA						AQUA					
	January			*July*			*January*			*July*		
	χ	ν_{MLE}	ν_{MOM}	χ	ν_{MLE}	ν_{MOM}	χ	ν_{MLE}	ν_{MOM}	χ	ν_{MLE}	ν_{MOM}
Global	0.748	2.96	2.74	0.745	2.87	2.62	0.711	2.58	2.42	0.710	2.57	2.38
NH	0.716	2.64	2.36	0.786	3.35	3.07	0.682	2.34	2.13	0.759	3.10	2.87
SH	0.774	3.23	3.04	0.700	2.34	2.14	0.736	2.79	2.66	0.658	1.99	1.85
Land	0.788	3.66	3.33	0.796	3.39	3.04	0.750	3.16	2.82	0.759	2.95	2.58
Ocean	0.736	2.76	2.56	0.727	2.70	2.49	0.700	2.41	2.31	0.694	2.45	2.32

Ice

	TERRA						AQUA					
	January			*July*			*January*			*July*		
	χ	ν_{MLE}	ν_{MOM}	χ	ν_{MLE}	ν_{MOM}	χ	ν_{MLE}	ν_{MOM}	χ	ν_{MLE}	ν_{MOM}
Global	0.748	3.18	3.00	0.735	2.91	2.71	0.739	3.09	2.95	0.737	2.87	2.67
NH	0.710	2.64	2.43	0.757	3.21	3.06	0.707	2.60	2.40	0.753	3.11	2.99
SH	0.784	3.68	3.54	0.709	2.54	2.27	0.770	3.54	3.46	0.718	2.58	2.29
Land	0.748	3.34	3.11	0.798	3.70	3.41	0.716	2.90	2.67	0.748	3.00	2.72
Ocean	0.750	3.15	2.99	0.716	2.68	2.50	0.750	3.19	3.08	0.735	2.84	2.67