Global mapping of foliage clumping index using POLDER-1, POLDER-3 multi-angle satellite data

J. Pisek[1], J.M. Chen[1], C. Menges, S.G. Leblanc[2], R.Lacaze[3], J-L. Roujean[4]

[1] Department of Geography and Program in Planning, University of Toronto

[2] Earth Observation Applications and Advisory Section , CCRS

[3] Medias France

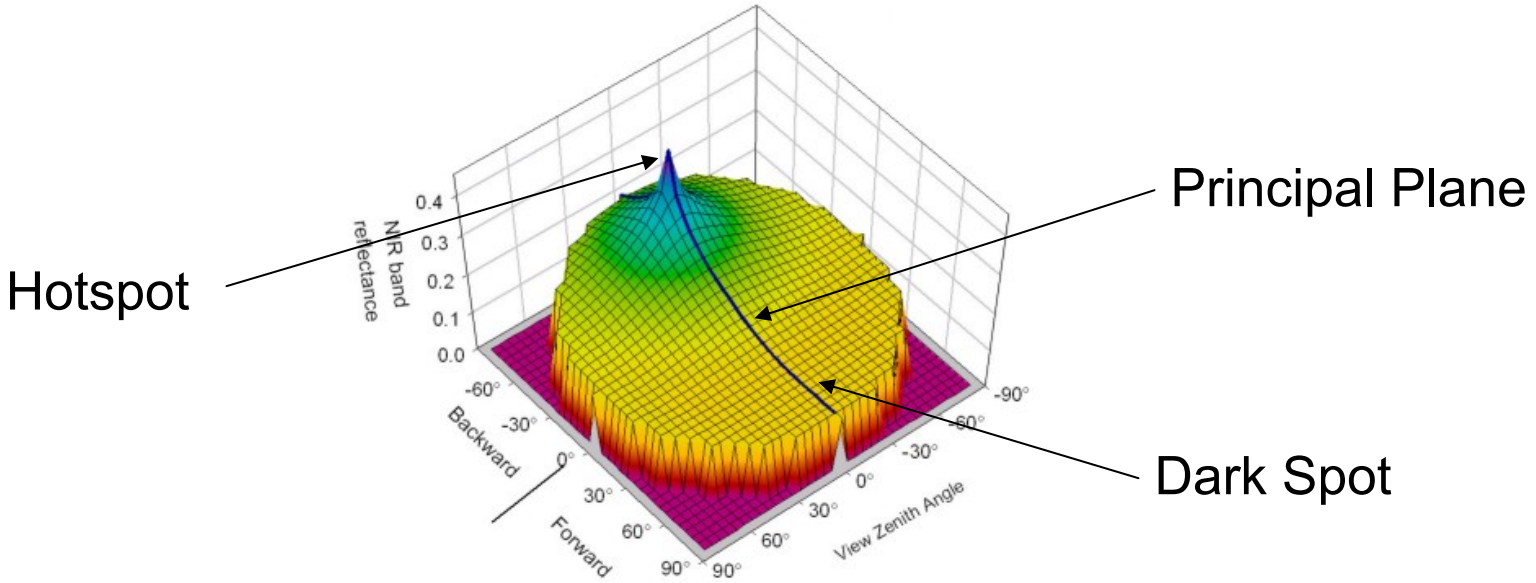
[4] Meteo France

CEOS/LPV-VALERI workshop, Davos, March 15 2007

The Clumping Index

- Reflectance measurements are obtained from a single observation at a given direction (usually Nadir)
- The total reflected solar radiance results mostly from sunlit leaves (Chen et al., 2003)
- Shaded foliage contributes significantly to the total photosynthesis (Lacaze et al., 2002)
- Multi-angle remote sensing allows the determination of structural parameters
- The clumping index (Ω) quantifies the effect of canopy structure on radiation interception

Bidirectional Reflectance Distribution function (BRDF)

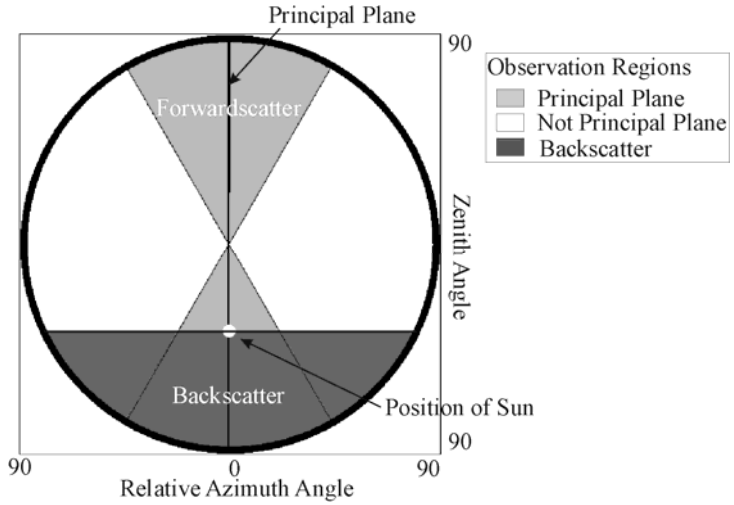


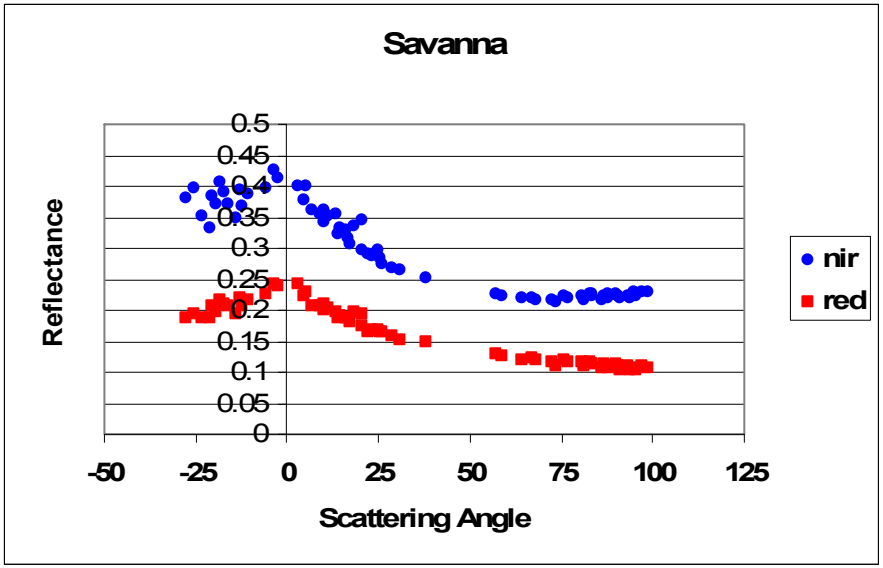
The anisotropy index (NDHD) = (HS – DS)/(HS + DS)

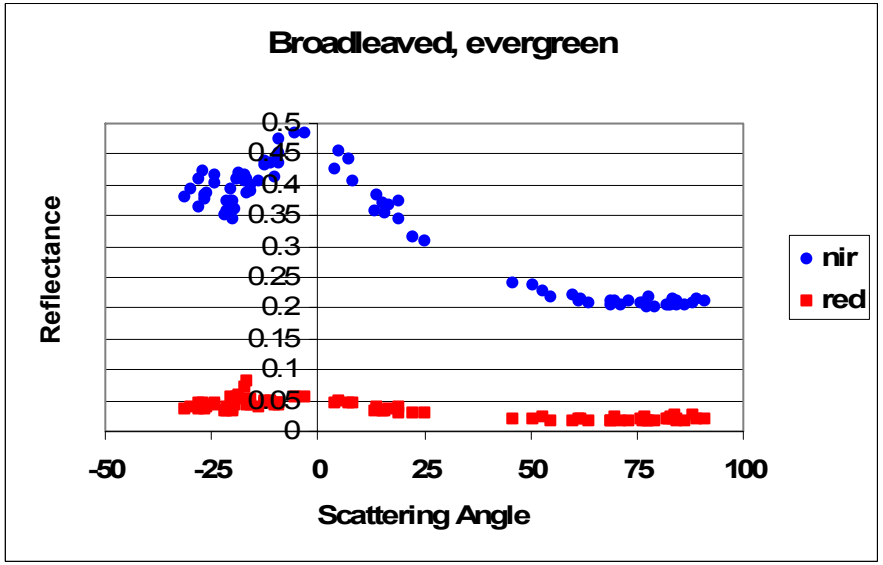
Interpolation of the hotspot reflectance: $F(\xi) = C_1 e^{-C_2 \xi/\pi}$

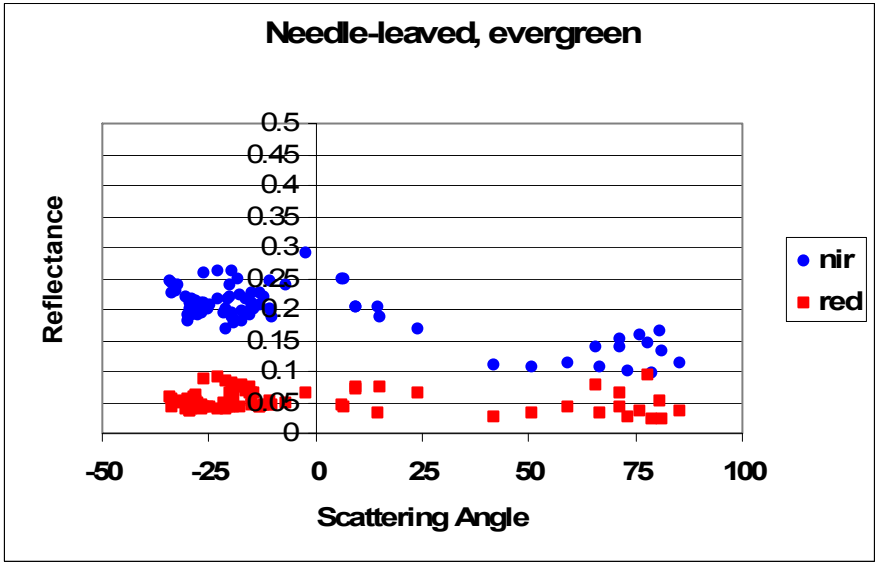
Bidirectional Reflectance Distribution function (BRDF)

POLDER Observations along the Principal Plane for 3 samples



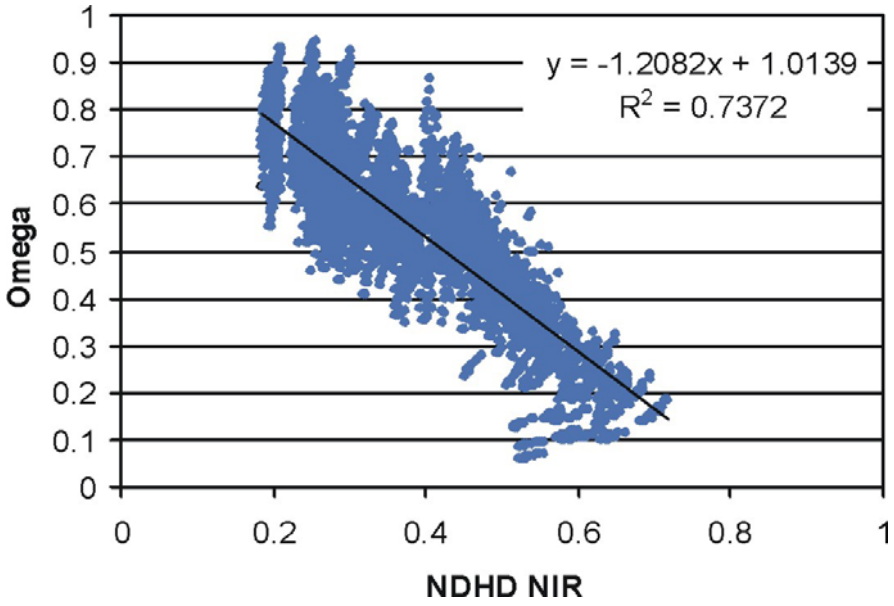


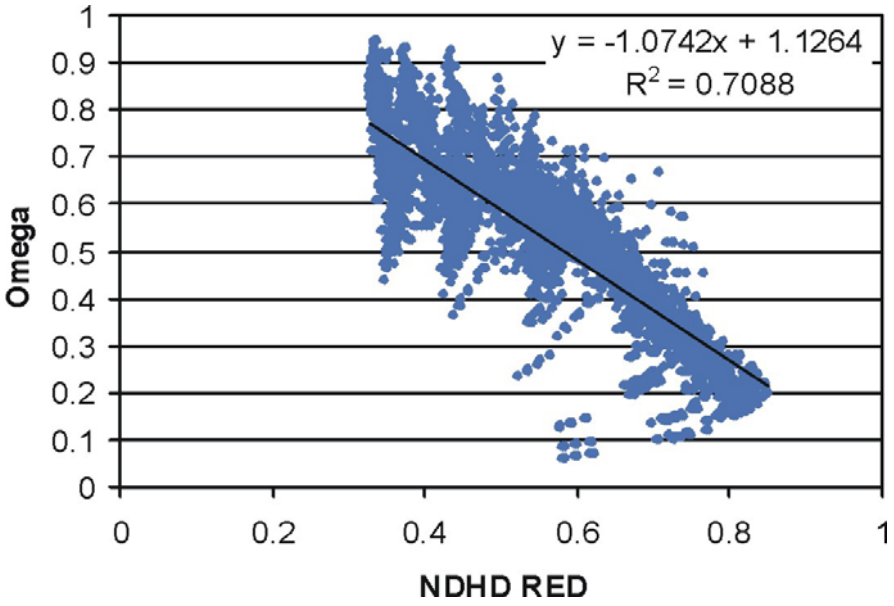




Four-Scale Model Simulation Results - NDHD vs. clumping index

Overall correlation for 10000 simulations
with canopy cover above 25%





Four-Scale Model Simulation Results - NDHD vs. clumping index

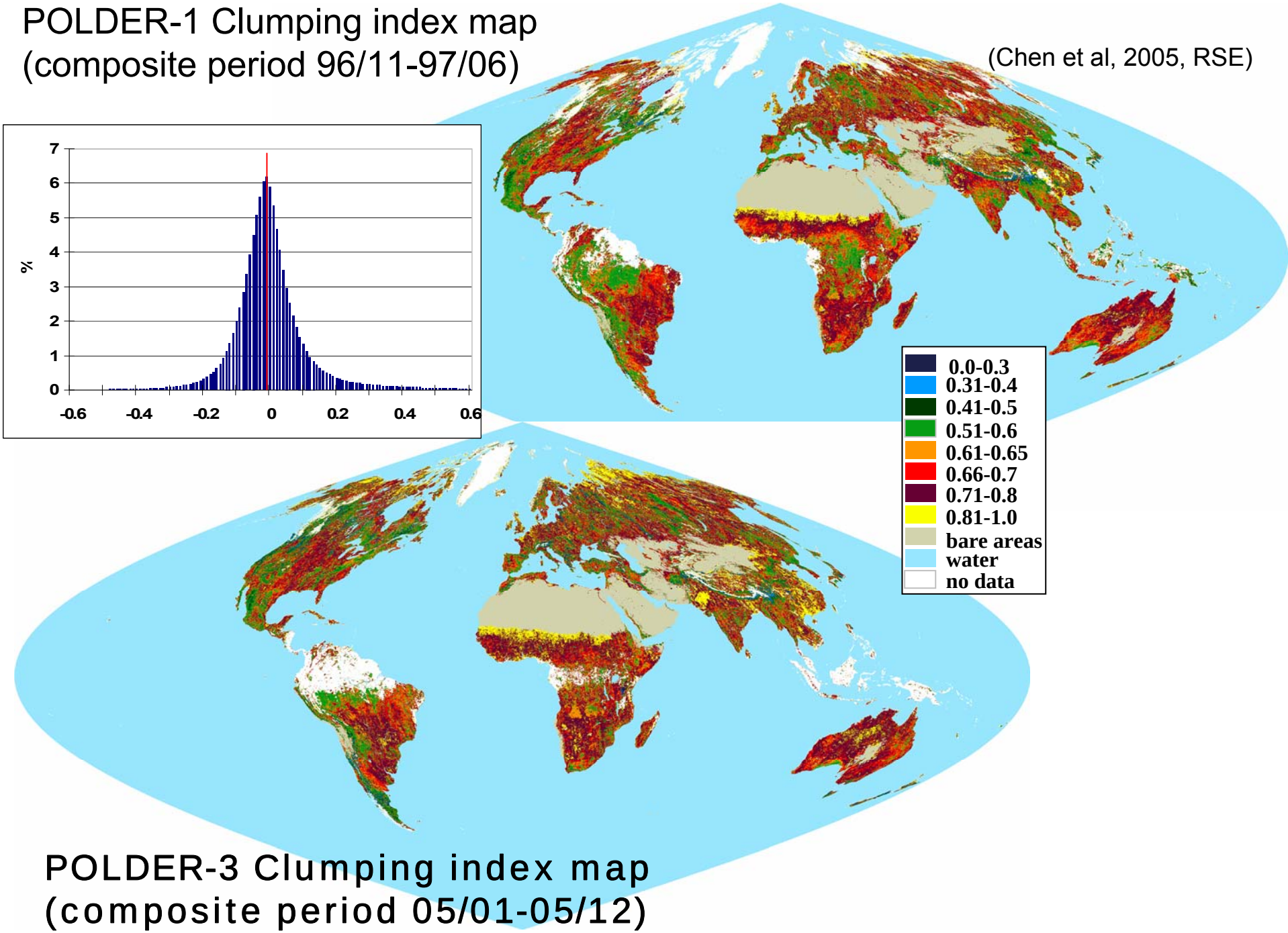
Solar Zenith Angle and Tree Shape

The coefficients of the line of best fit for NDHD vs Omega
(Ω = A*NDHD + B) for sun angle / shape (NIR=865 nm)

NIR	Cone/Cylinder			Ellipsoid			Half Ellipsoid		
SZA [deg]	A	B	R^2	A	B	R^2	A	B	R^2
10	-1.14	0.76	0.67	-1.63	1.01	0.84	-1.62	0.97	0.81
15	-0.93	0.76	0.66	-1.42	1.00	0.84	-1.45	0.95	0.82
20	-0.82	0.77	0.64	-1.32	1.02	0.84	-1.34	0.96	0.83
25	-0.75	0.79	0.62	-1.28	1.06	0.83	-1.28	0.98	0.84
30	-0.71	0.81	0.59	-1.29	1.11	0.82	-1.27	1.01	0.84
35	-0.68	0.83	0.56	-1.31	1.17	0.80	-1.27	1.06	0.84
40	-0.66	0.85	0.53	-1.35	1.25	0.79	-1.29	1.11	0.85
45	-0.66	0.88	0.50	-1.42	1.33	0.78	-1.34	1.18	0.86
50	-0.67	0.91	0.47	-1.52	1.44	0.76	-1.41	1.27	0.86
55	-0.68	0.94	0.42	-1.67	1.58	0.75	-1.50	1.37	0.87
60	-0.71	0.98	0.37	-1.89	1.78	0.72	-1.63	1.50	0.87

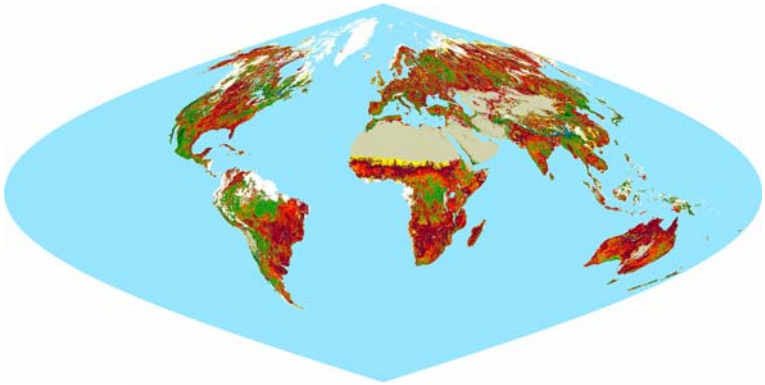
POLDER-1 Clumping index map (composite period 96/11-97/06)

(Chen et al, 2005, RSE)

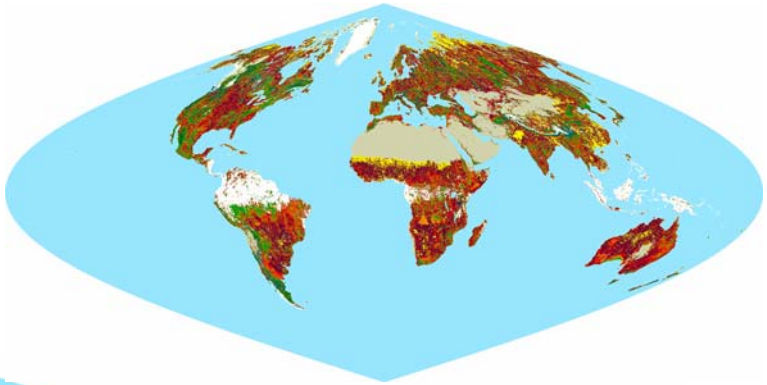


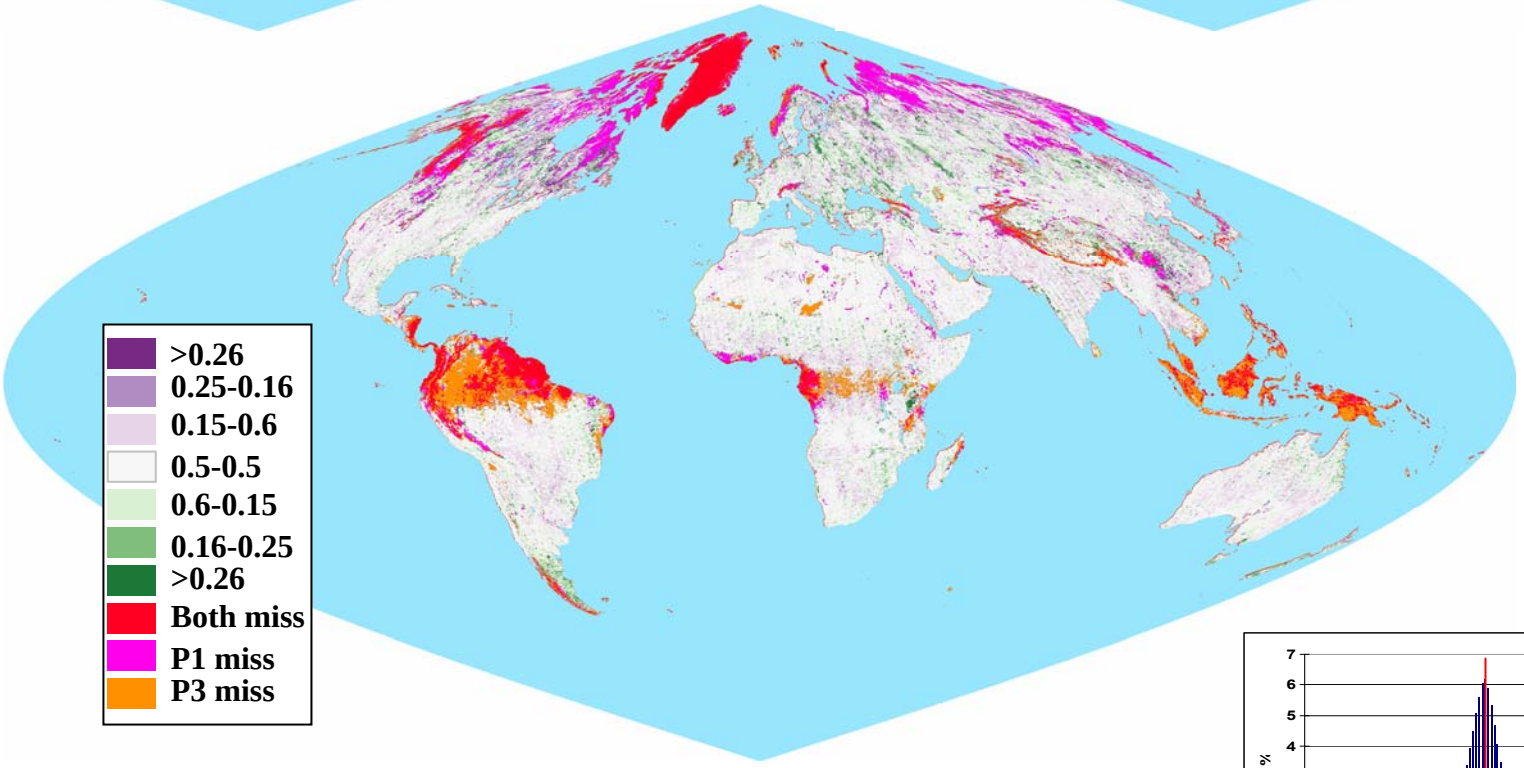
POLDER-3 Clumping index map (composite period 05/01-05/12)

POLDER-1 Ω map

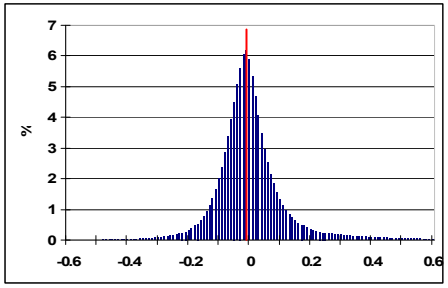


POLDER-3 Ω map



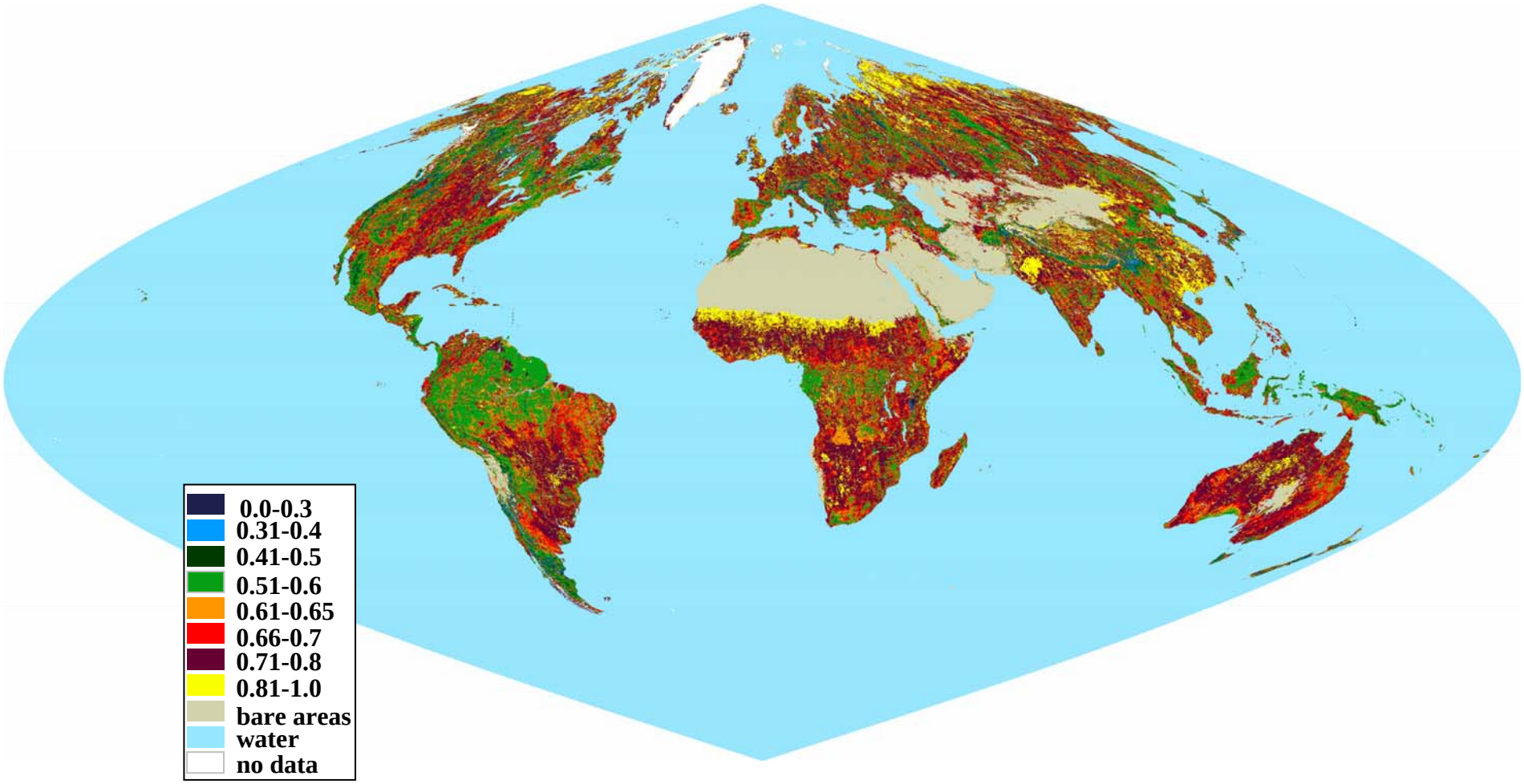


POLDER-1 – POLDER-3 Ω difference



POLDER-3 Global Clumping index map

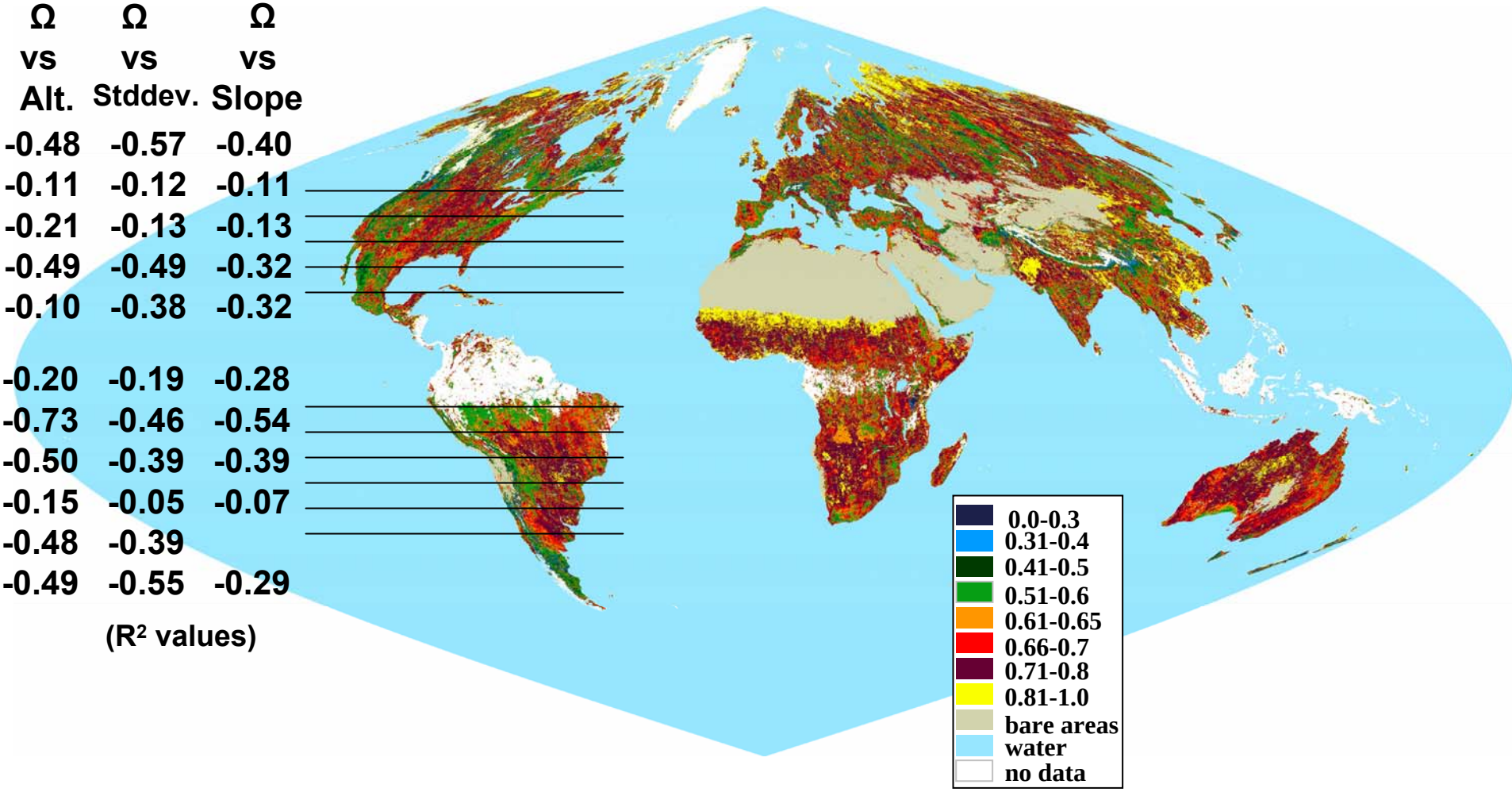
(missing areas filled with POLDER-1 estimates or averages for given land cover type)



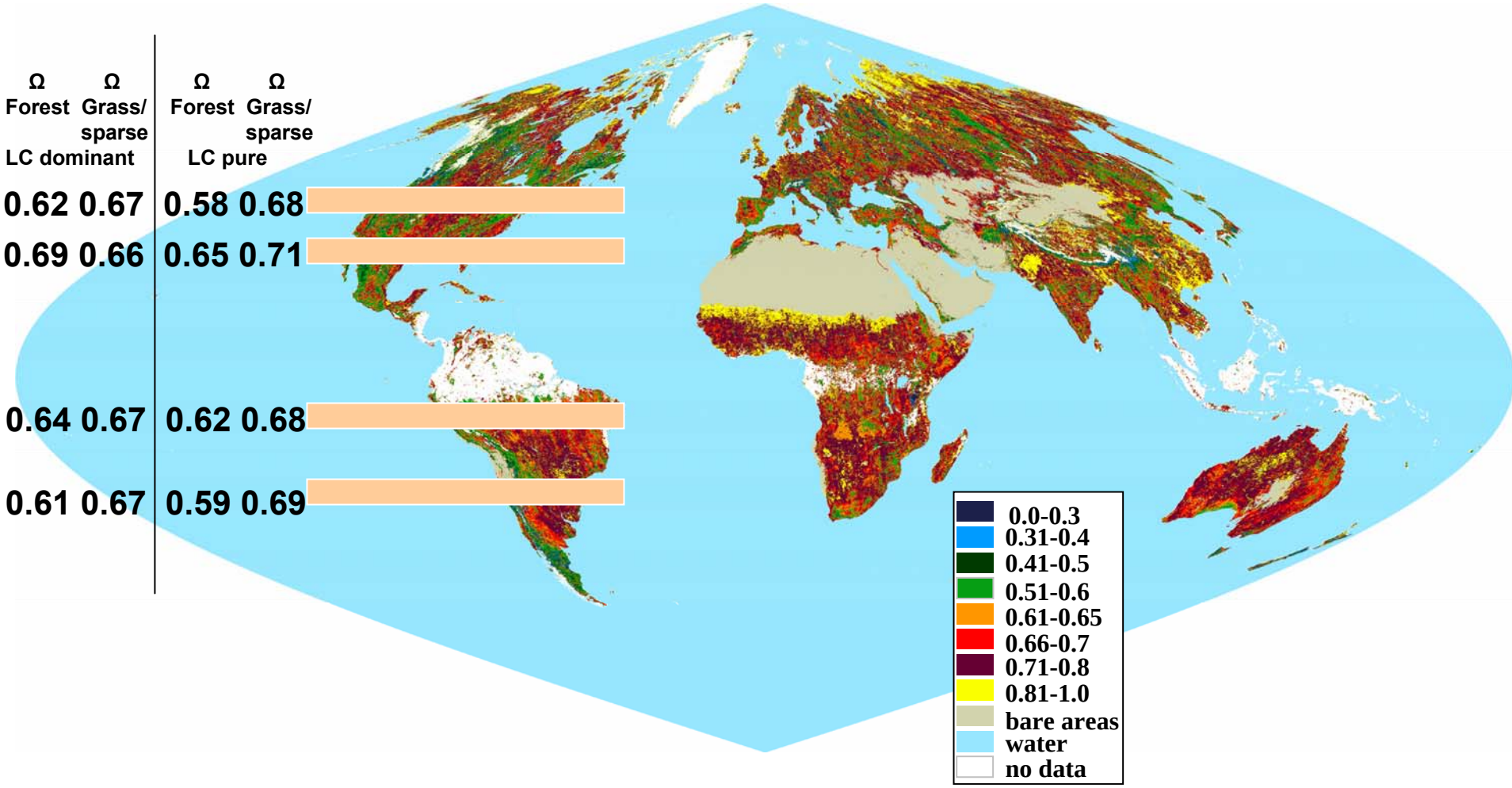
Topographic effects in POLDER-3 Clumping index map

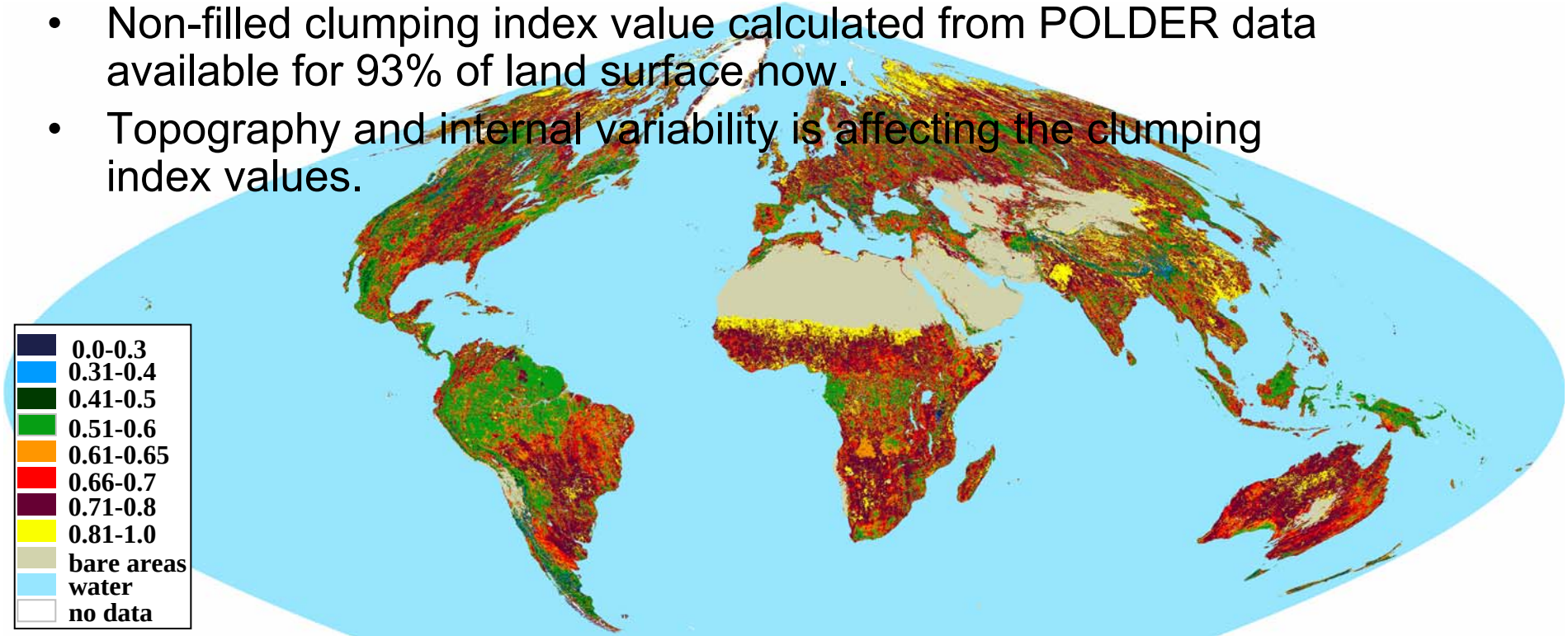
Ω vs Alt.	Ω vs Stddev.	Ω vs Slope
-0.48	-0.57	-0.40
-0.11	-0.12	-0.11
-0.21	-0.13	-0.13
-0.49	-0.49	-0.32
-0.10	-0.38	-0.32
-0.20	-0.19	-0.28
-0.73	-0.46	-0.54
-0.50	-0.39	-0.39
-0.15	-0.05	-0.07
-0.48	-0.39	
-0.49	-0.55	-0.29

(R^2 values)



Purity pixel issue in POLDER-3 Clumping index map



Conclusions

- The relationship between the angular index NDHD and the vegetation clumping index has been tested using a wide range of parameters in the Four Scale model.
- The relationship is significant for a crown coverage of more than 25% and there is a dependence on solar zenith angles (below 50 degrees).
- A simplified Hotspot equation can be used to derive the Hotspot magnitude after subtraction of the Dark Spot.
- Non-filled clumping index value calculated from POLDER data available for 93% of land surface now.
- Topography and internal variability is affecting the clumping index values.