

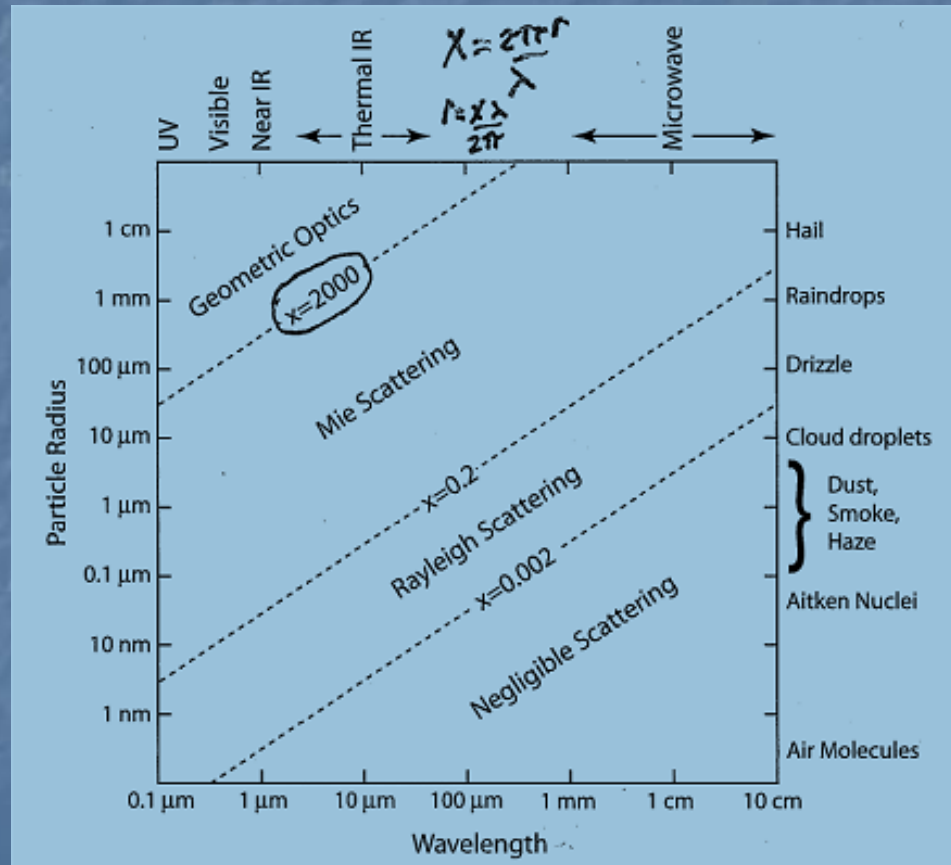
Using Remote Sensing Information on Snow Fraction for Hydrological Applications in the Period of Melting

Appel I.

General approach to MODIS snow cover fraction retrieval

- Based on mostly two bands: band 4 (0.555 μm) and band 6 (1.64 μm)
- Traditional use of NDSI $\text{NDSI} = (b4 - b6) / (b4 + b6)$
- NDSI is used to estimate snow fraction within 500 m cells
- All MODIS data are being reprocessed to provide snow fraction

Scattering regimes

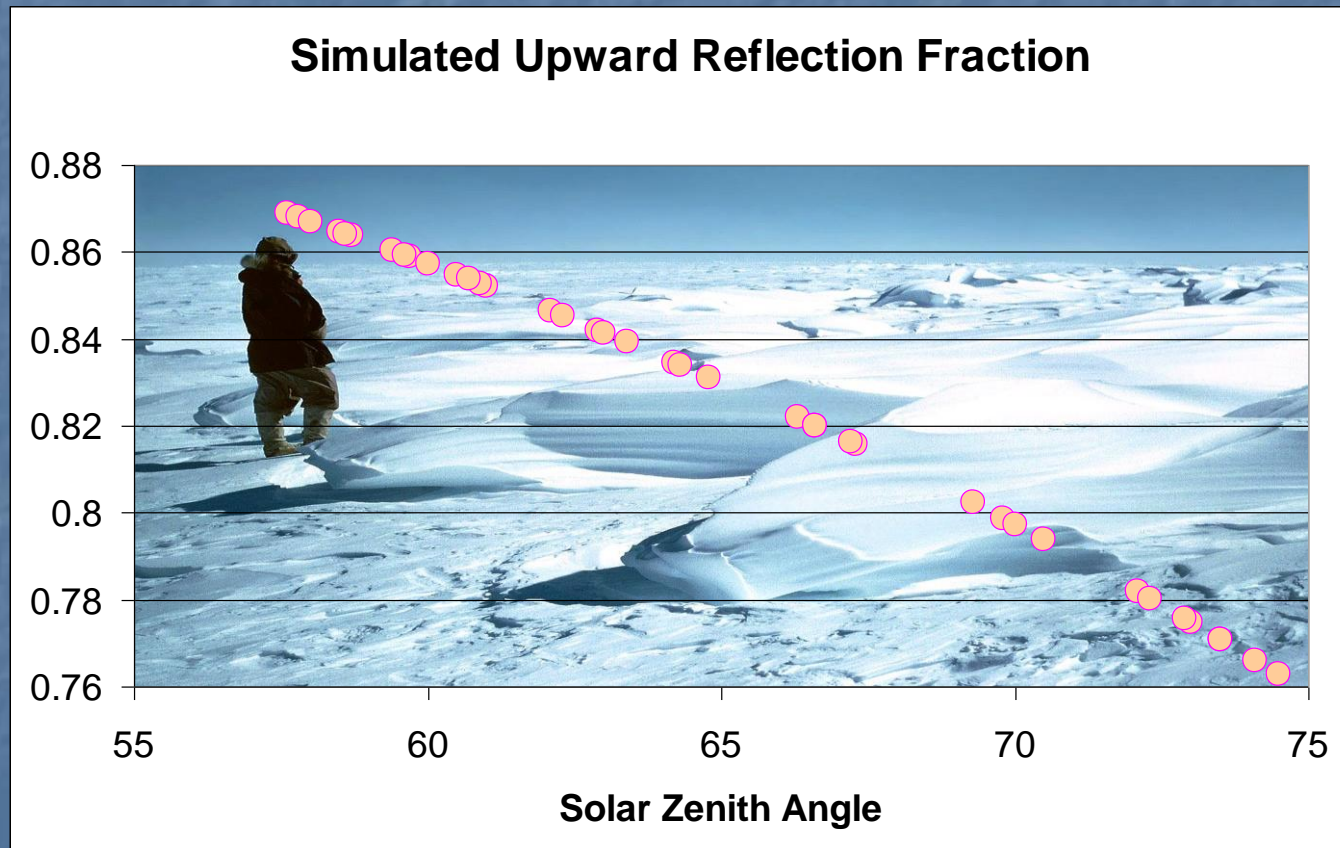


Asymptotic Analytical BRDF model

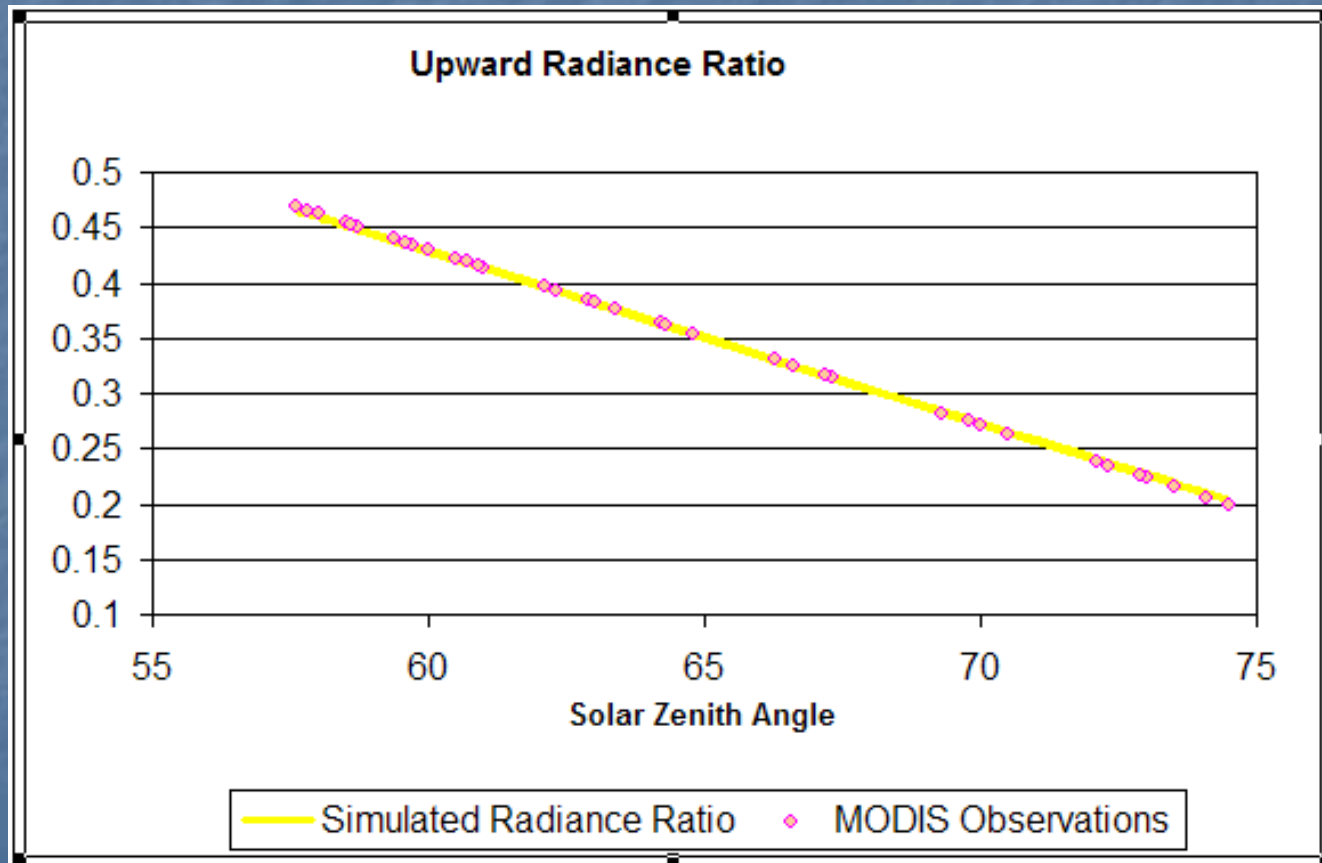
$$R(\mu, \eta, \varphi) = R_0(\mu, \eta, \varphi) \exp[-\gamma f(\mu, \eta, \varphi)],$$

where R is bidirectional reflectance,
 R_0 is bidirectional reflectance for nonabsorbing snow,
 γ is fraction of absorbed energy,
 μ is solar zenith angle,
 η is observation zenith angle,
 φ is relative azimuth.

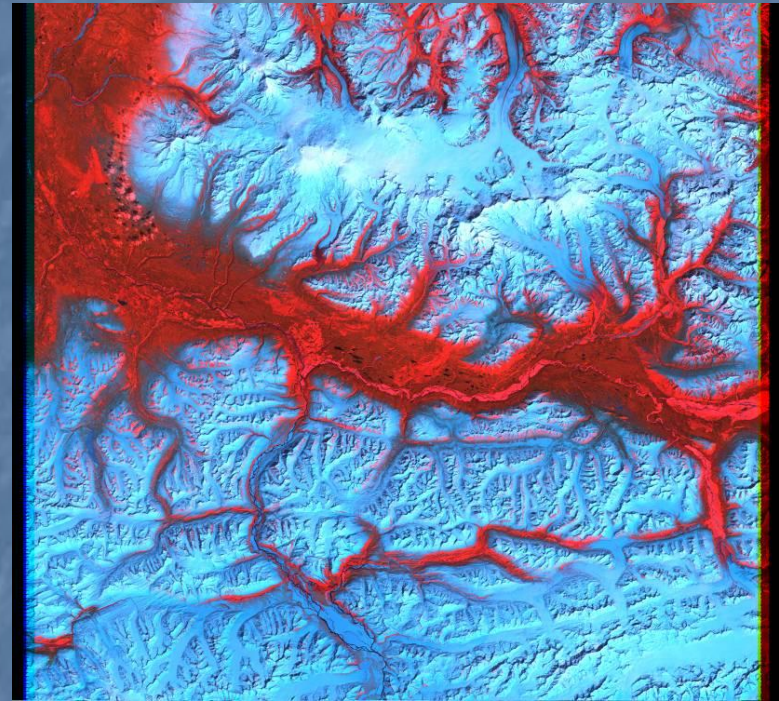
Simulated reflection factor



BRDF model validation



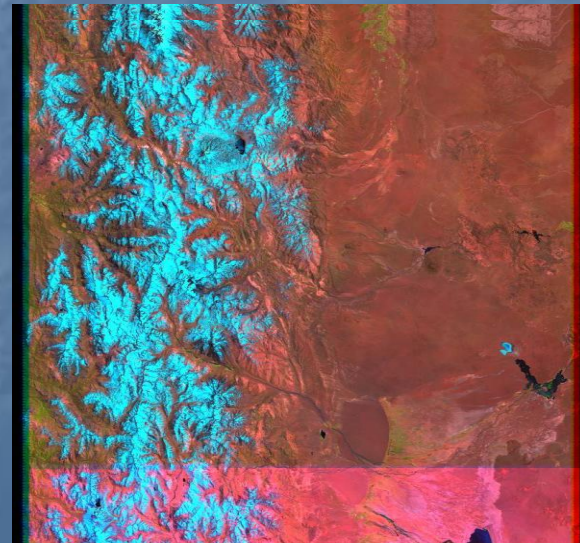
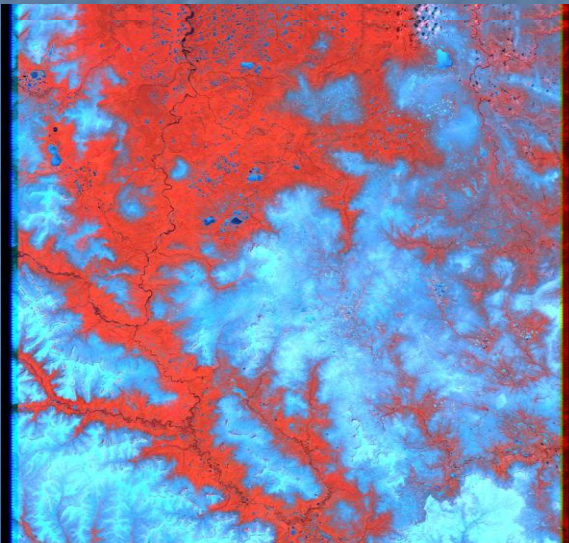
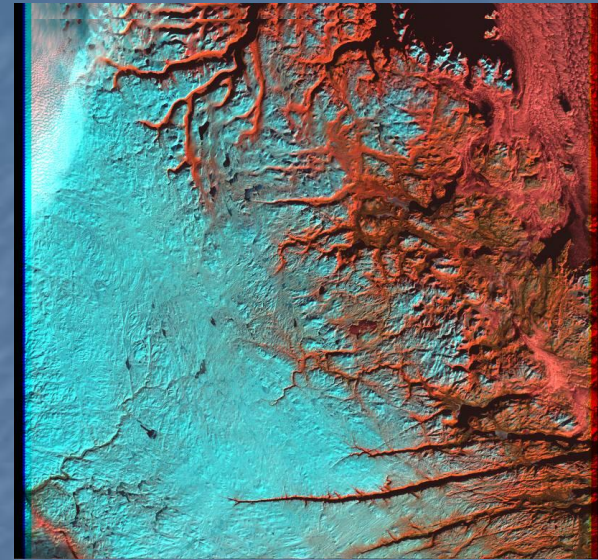
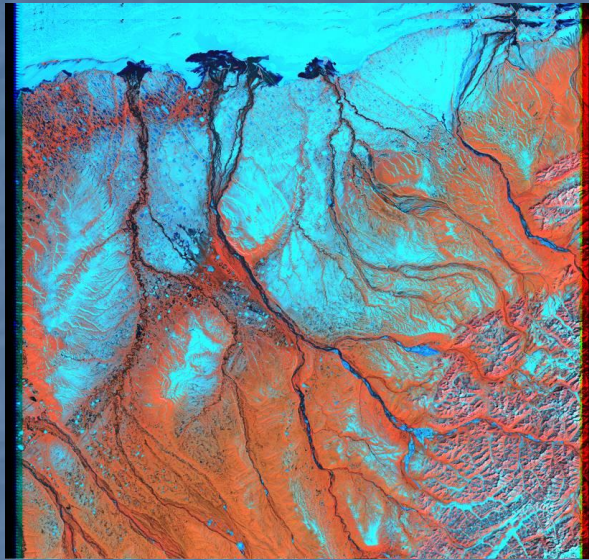
Glaciers in Alaska



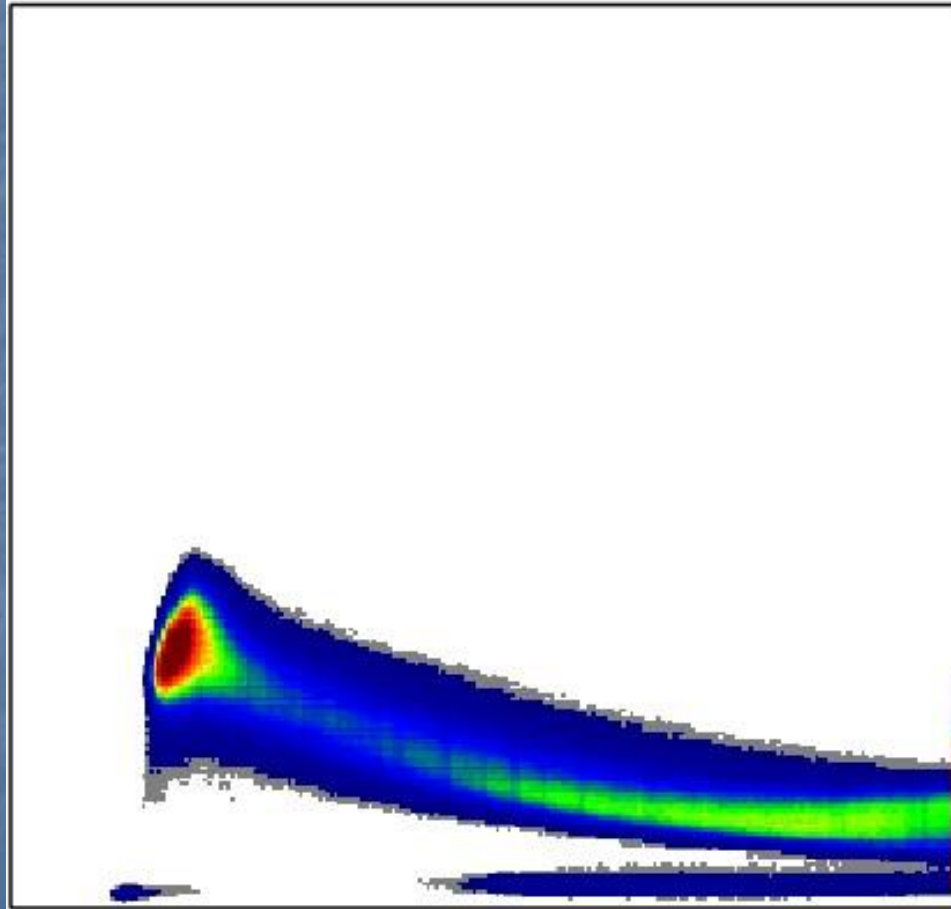
Locations of other scenes



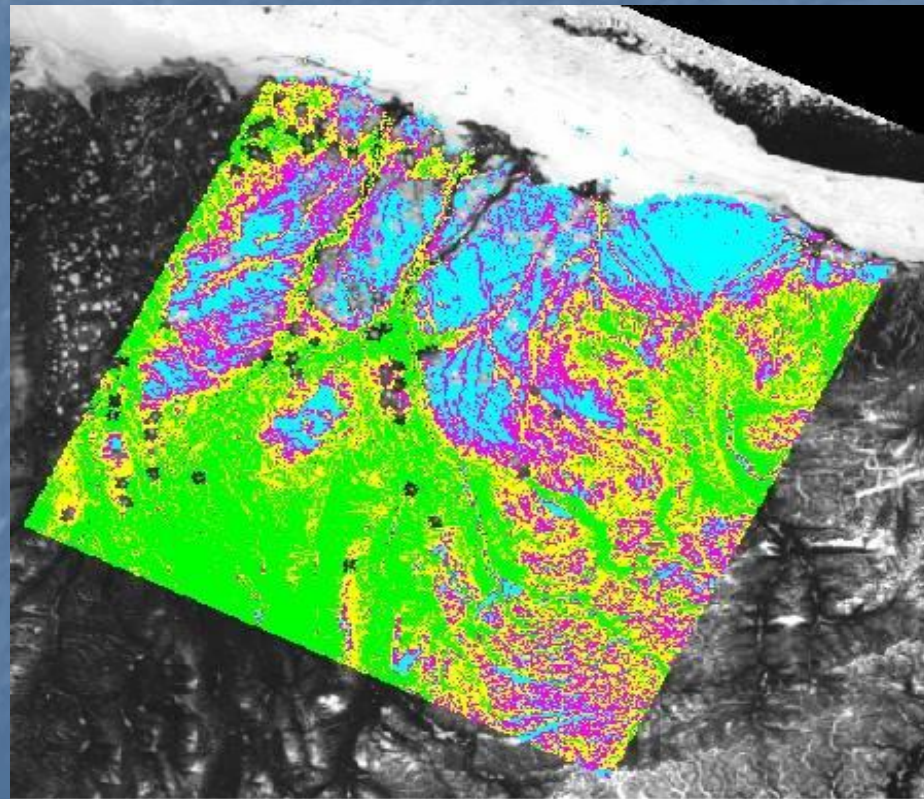
Landsat scenes (false colours)



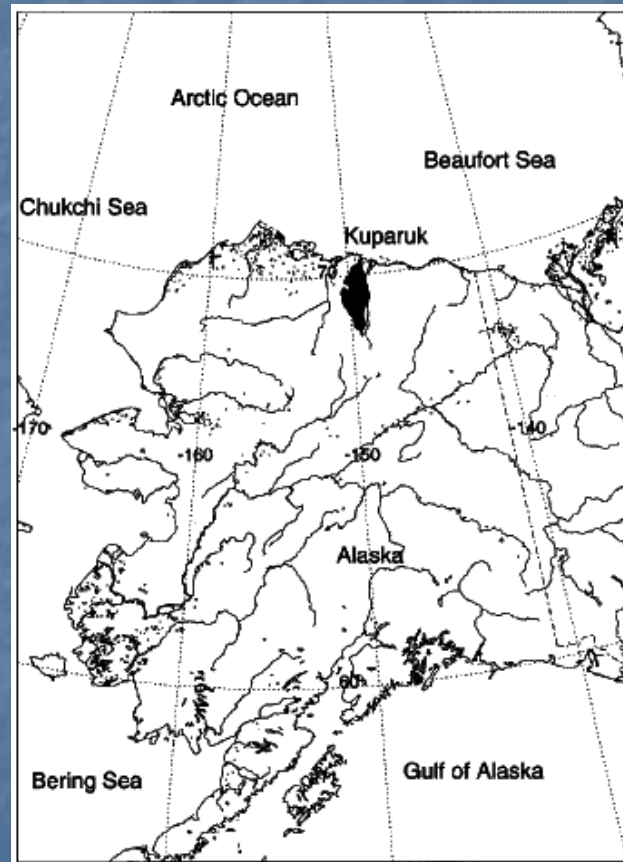
2-D histogram (b2,b5) of Landsat reflectances (Siberia)



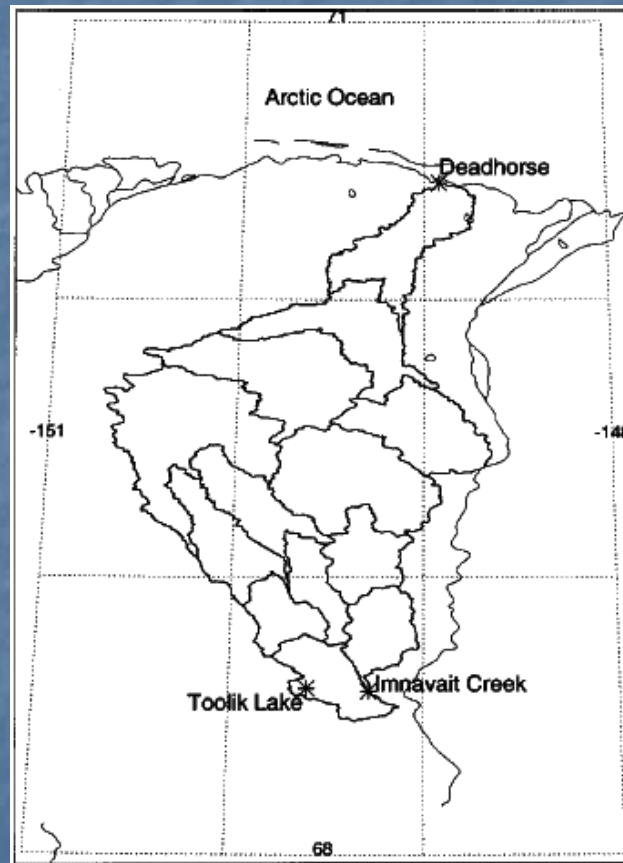
MODIS image of Kuparuk Basin with overlaid snow fraction



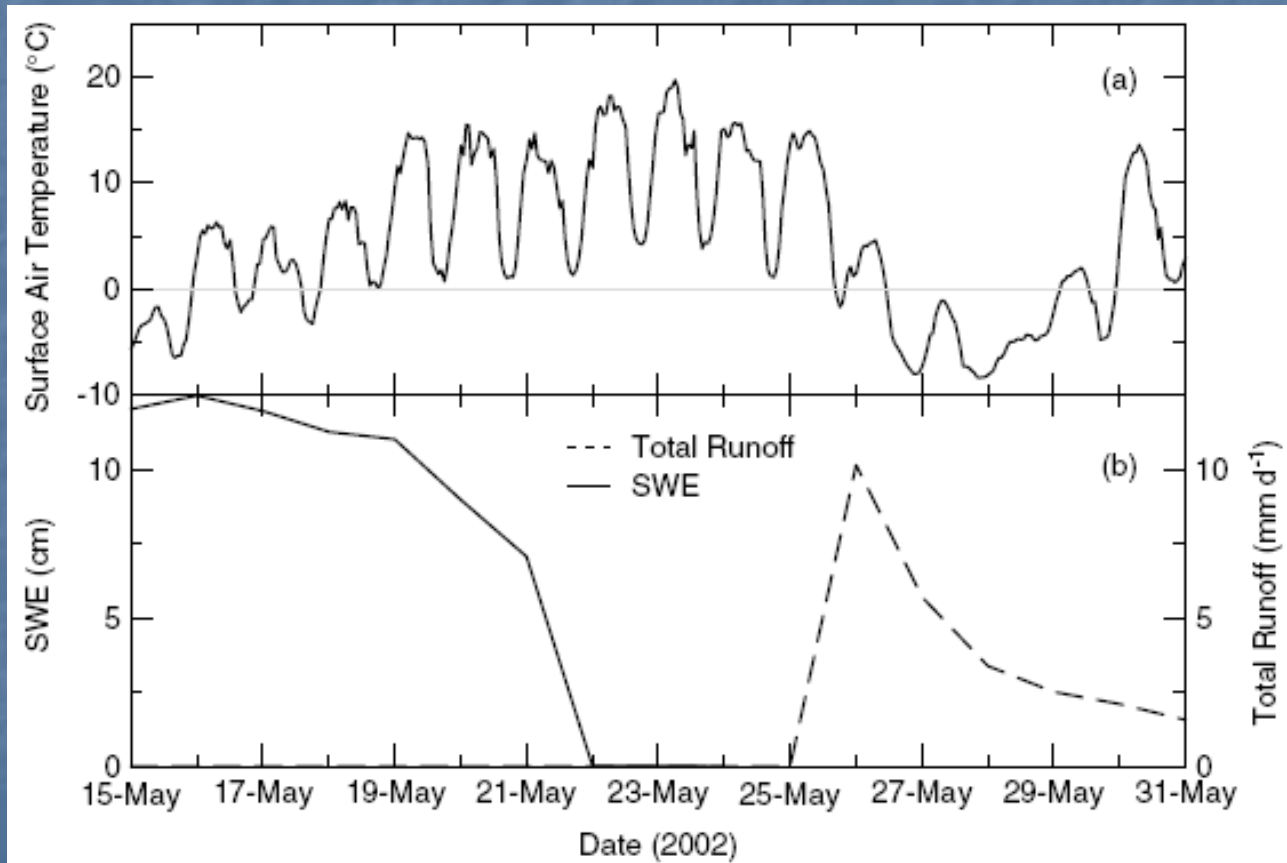
Location of Kuparuk River basin



Kuparuk River basin



Air temperature, SWE at Innnavait Creek, and total runoff

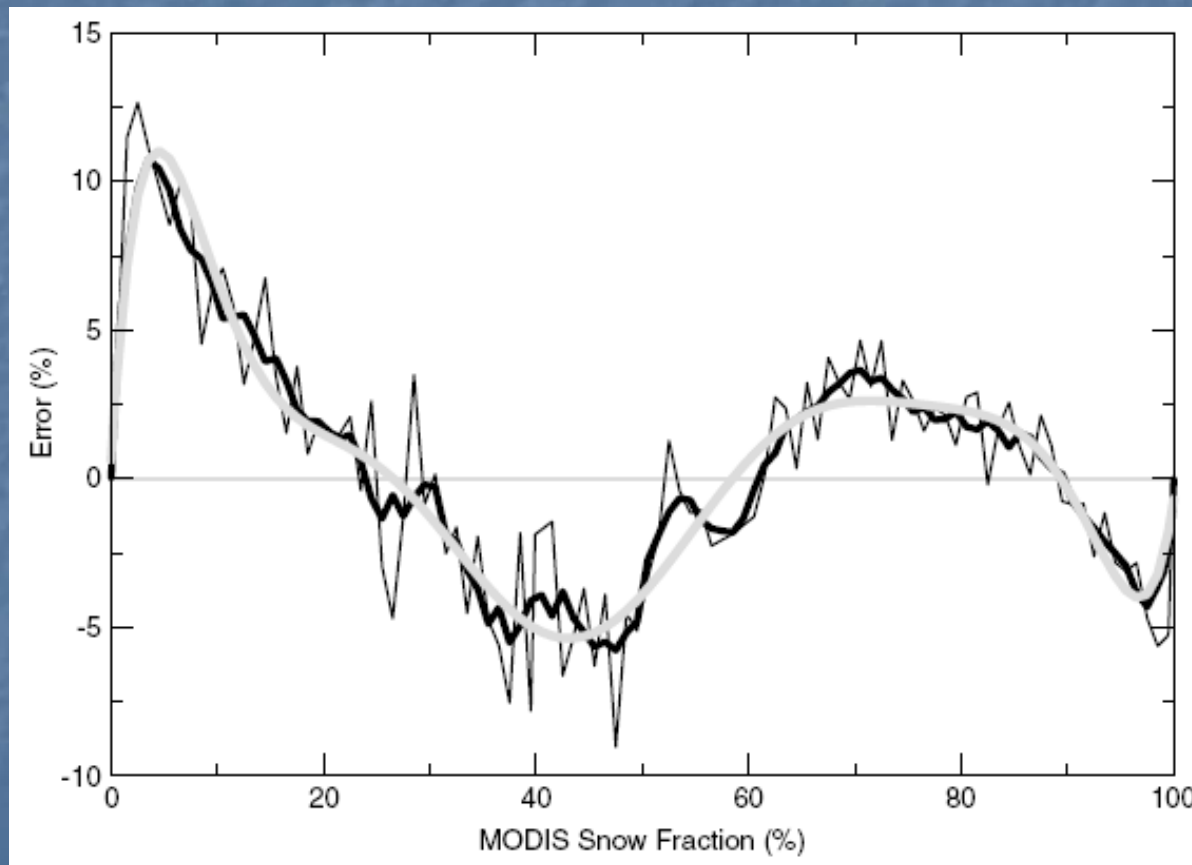


Quality of fraction retrieval

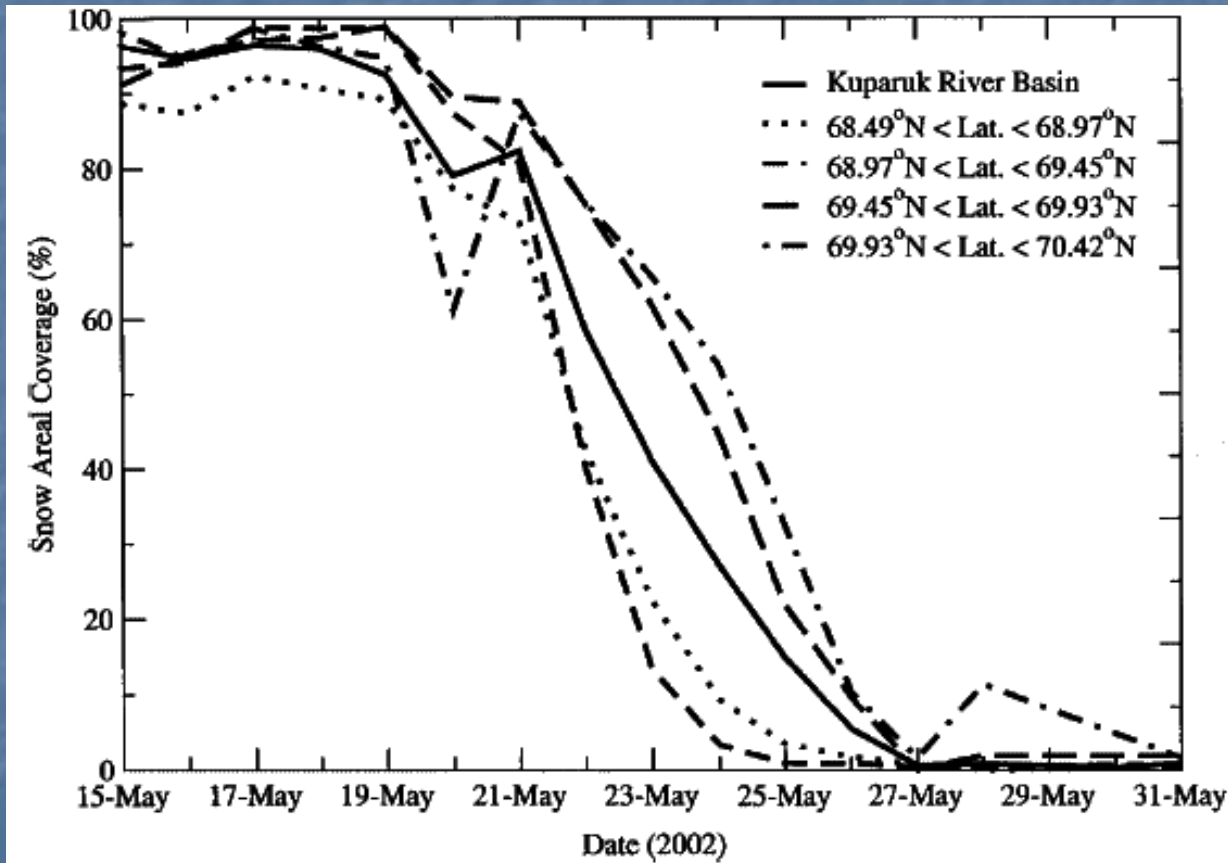
Date	Pixels	R^2	MAE (%)
23 May 2002	35 022	0.89	8.7

RMSE (%)	f_{Landsat} (%)	f_{MODIS} (%)
13.9	40.0	37.6

Error of fraction retrieval (stratified for 100 bins)



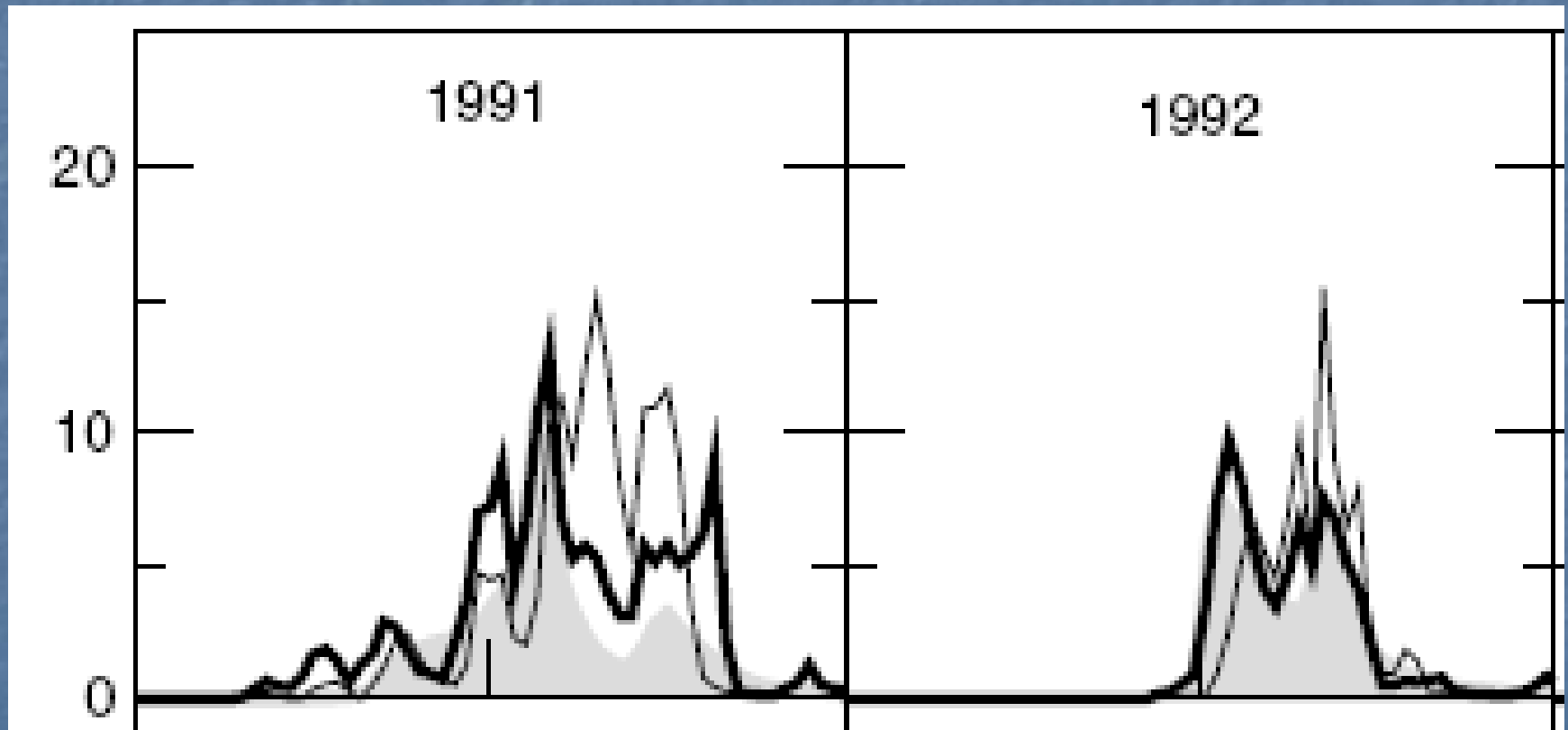
Snow Areal coverage



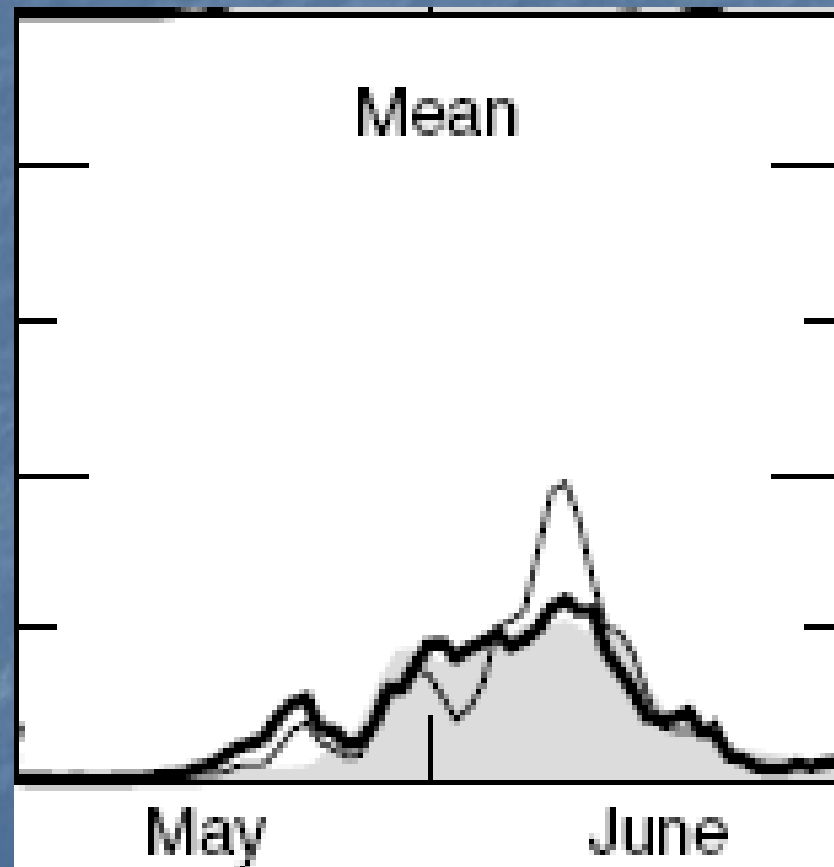
Shallow and deep snow cover fractions in KRB

Latitudinal band	A_{shallow}	A_{deep}
68.49 < Lat. < 68.97 °N	0.73	0.27
68.97 < Lat. < 69.45 °N	0.75	0.25
69.45 < Lat. < 69.93 °N	0.79	0.21
69.93 < Lat. < 70.42 °N	0.80	0.20

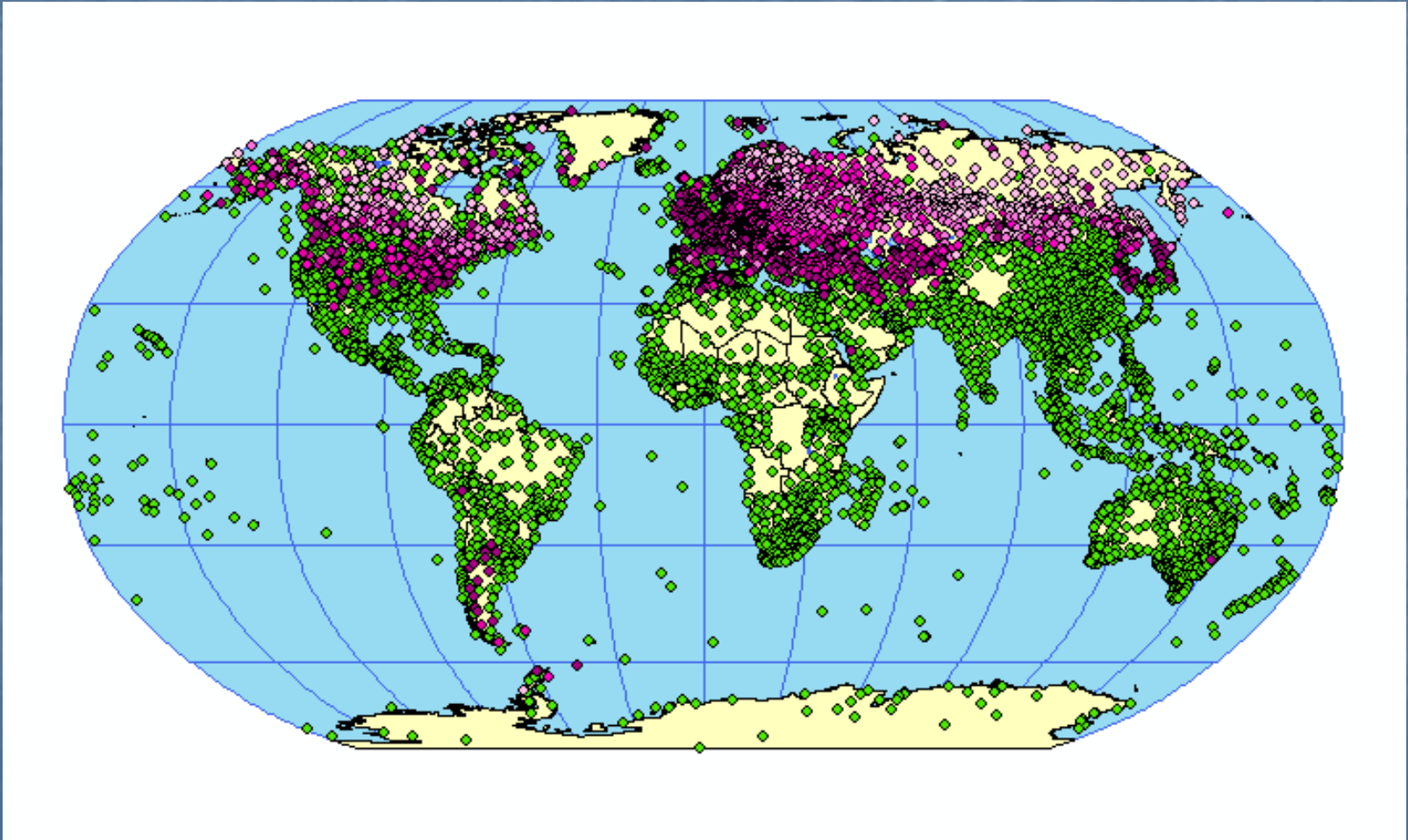
Observed and simulated daily rates of total runoff



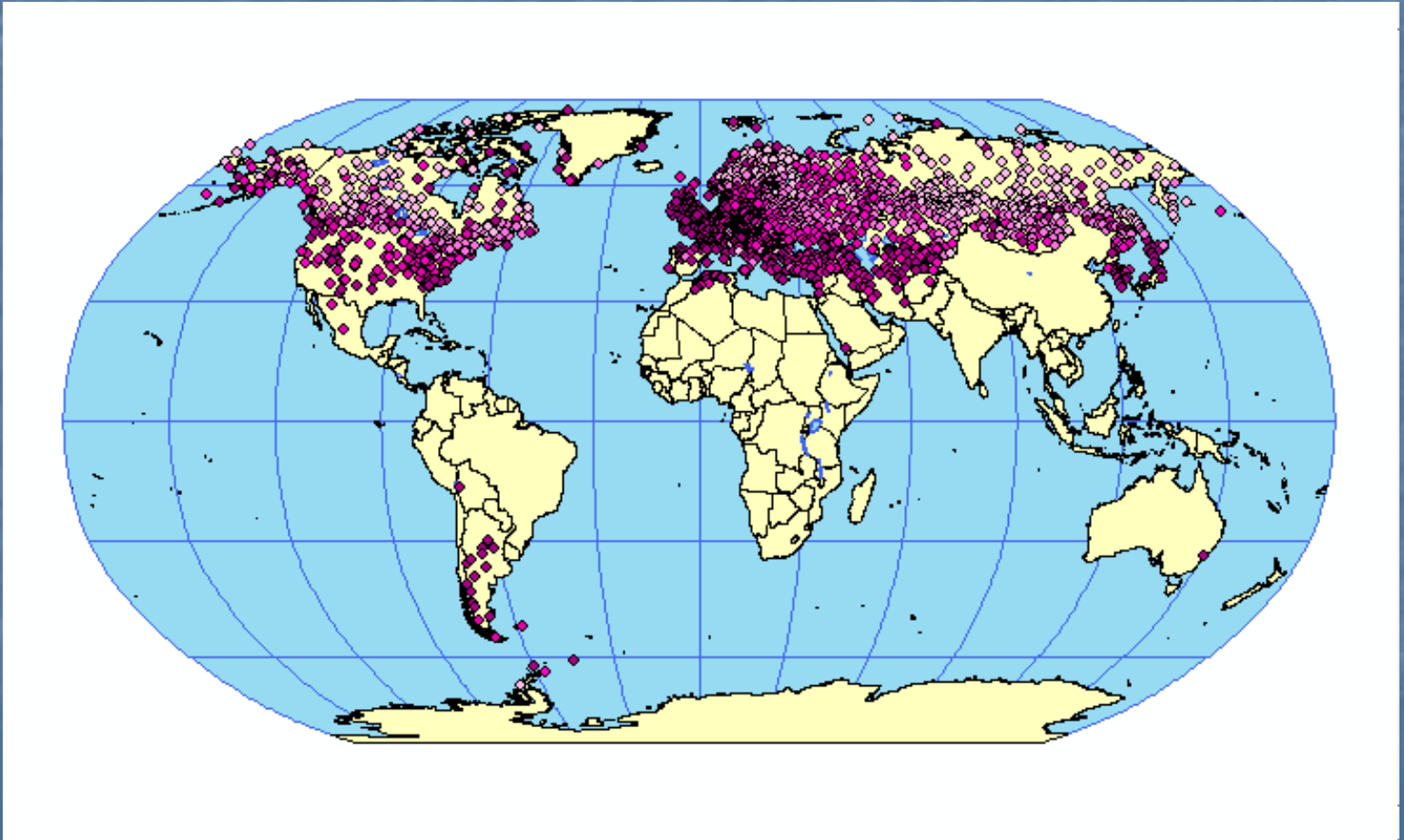
Mean values over the period 1991-2001



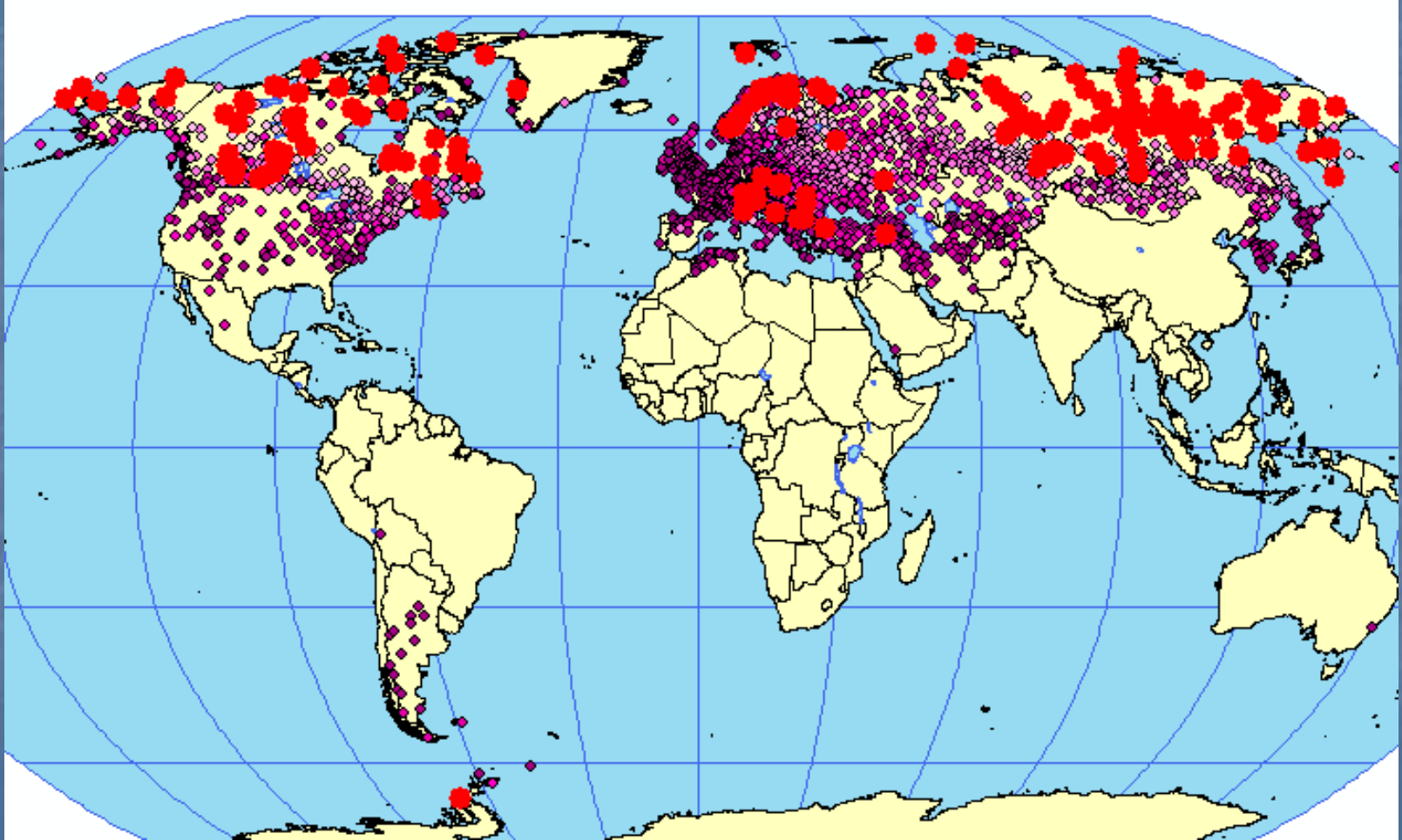
Locations of WMO stations (green) with snow observations (purple)



Probability of snow observations



Locations of observations for $> 50\%$ snow coverage



Locations of WMO stations (green) with snow observations (purple)

