



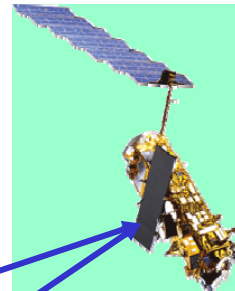
Bestimmung der Biomasse durch Fernerkundung

Kurt P. Günther, Marion Schroedter-Homscheidt, Markus Tum, Markus Niklaus
Deutsches Fernerkundungsdatenzentrum

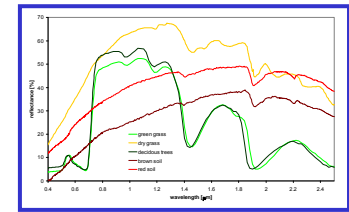


Deutsches Zentrum
für Luft- und Raumfahrt e.V.
in der Helmholtz-Gemeinschaft

DLR-Cluster Angewandte Fernerkundung
Bremerhaven, 6. April 2011



Signal = f(Biomasse)

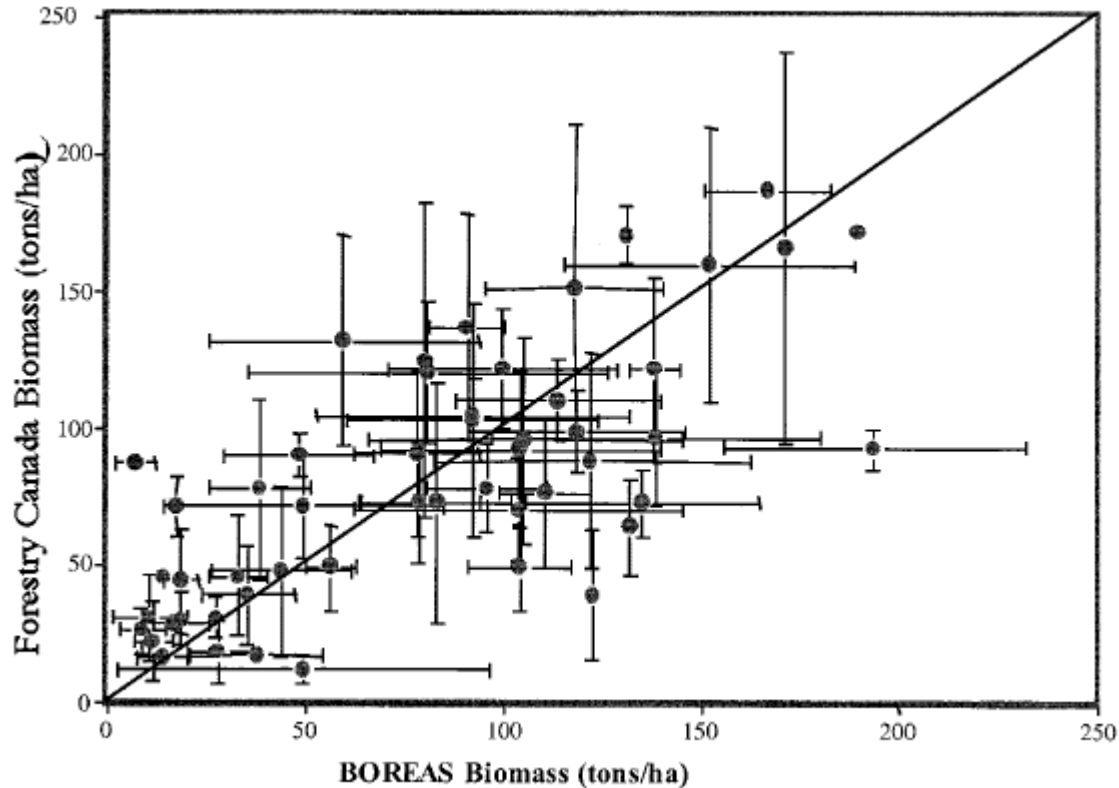


Korrelation von Fernerkundungsdaten mit Biomassedaten

Empirische, statistische Verfahren



Wie gut sind Bodenmessungen der Biomasse?

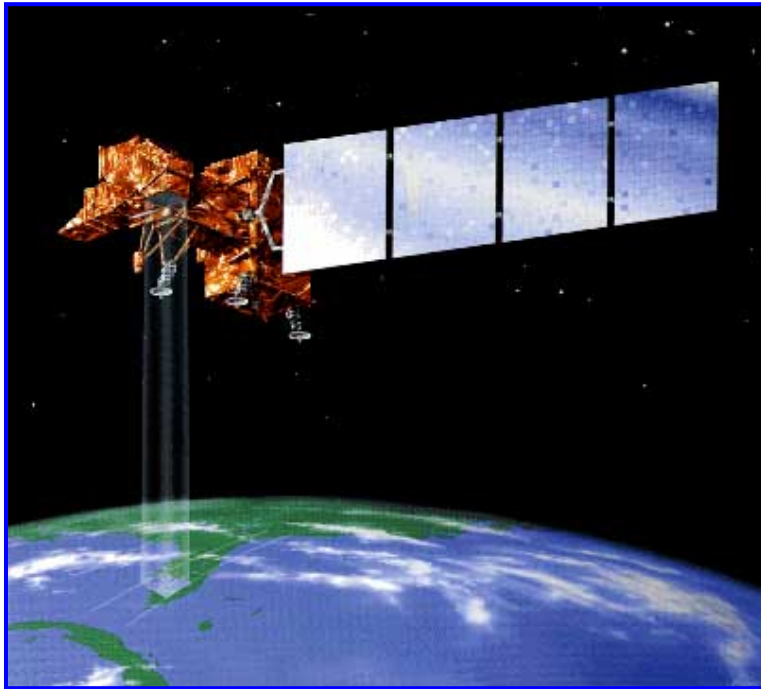


Messung des DBH und der Baumhöhe und Anwendung allometrischer Formeln

Quelle: Saatchi and Moghaddam, IEEE Transactions on Geoscience & Remote Sensing, Vol. 38, No. 2, March 2000



Landsat TM



Landsat-5 (TM) und Landsat-7 (ETM+)

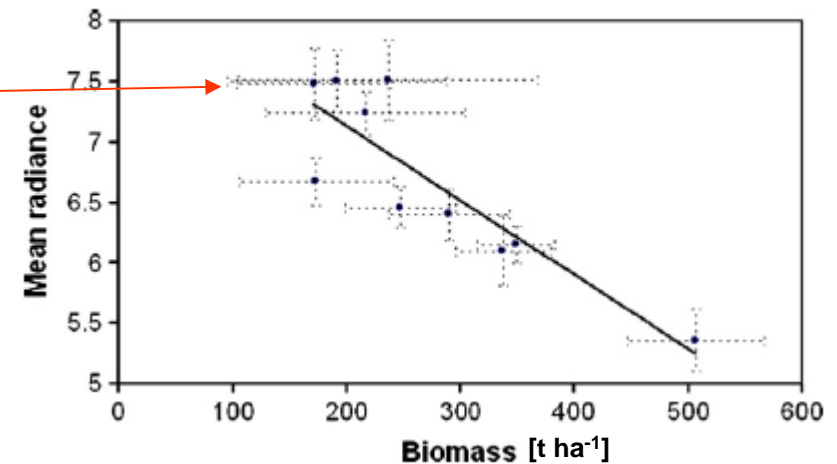
Räumliche Auflösung:	30m x 30m (multi-spektral) 15m x 15m (pan @ETM+)
Spektrale Auflösung:	7 Kanäle 1 Pan-Kanal (bei ETM+)
Szenengröße:	180km x 180km
Zeitraum:	1984 - ~2004 (Landsat-5) 1999 – heute (Landsat-7)

Landsat TM, Malaysian Borneo

➤ Ulu Segama Forest Reserve, Wald

Biomass model, based on Landsat-5 TM bands	r^2
Biomass = 1711.1 – 458.46 × Band 1	0.51
Biomass = 1897.6 – 540.82 × Band 2	0.58
Biomass = 1244.1 – 666.61 × Band 3	0.49
Biomass = 1098.8 – 123.62 × Band 4	0.76
Biomass = 1006.3 – 1171.5 × Band 5	0.76
Biomass = 877.3 – 6144.4 × Band 7	
Biomass = 2914.4 – 4124.1 × NDVI	

Junge Bäume



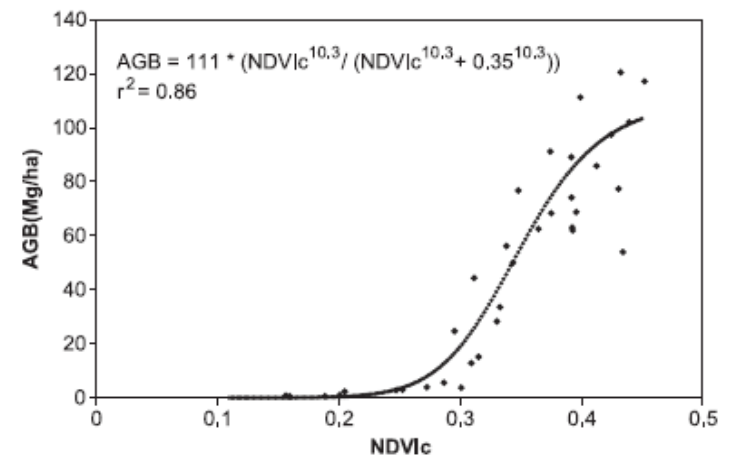
Tangki, H. and Chappelle, N.A., 2008. Biomass variation across selectively logged forest within a 225-km² region of Borneo and its prediction by Landsat TM. Forest Ecology and Management, 256, 1960-1970.

Landsat ETM+, Wisconsin (USA)

➤ Wald

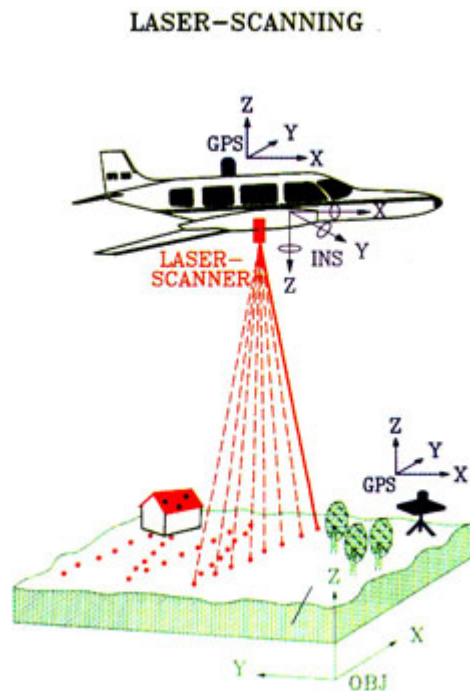
Models	Description	n	r ²
AGB=48.8*(NIR/red)+ 2.3*Age-454*MASVI-38	Overall	55	0.82
AGB=111*(NDVlc ^{10.3} / (NDVlc ^{10.3} +0.35 ^{10.3}))	Pine	35	0.86
AGB=232.5*NIR+2.7*Age-71	Hardwood	20	0.95

$$\text{NDVlc} = \text{NDVI} * (1 - (\text{mir} - \text{mir}_{\min}) / (\text{mir}_{\max} - \text{mir}))$$

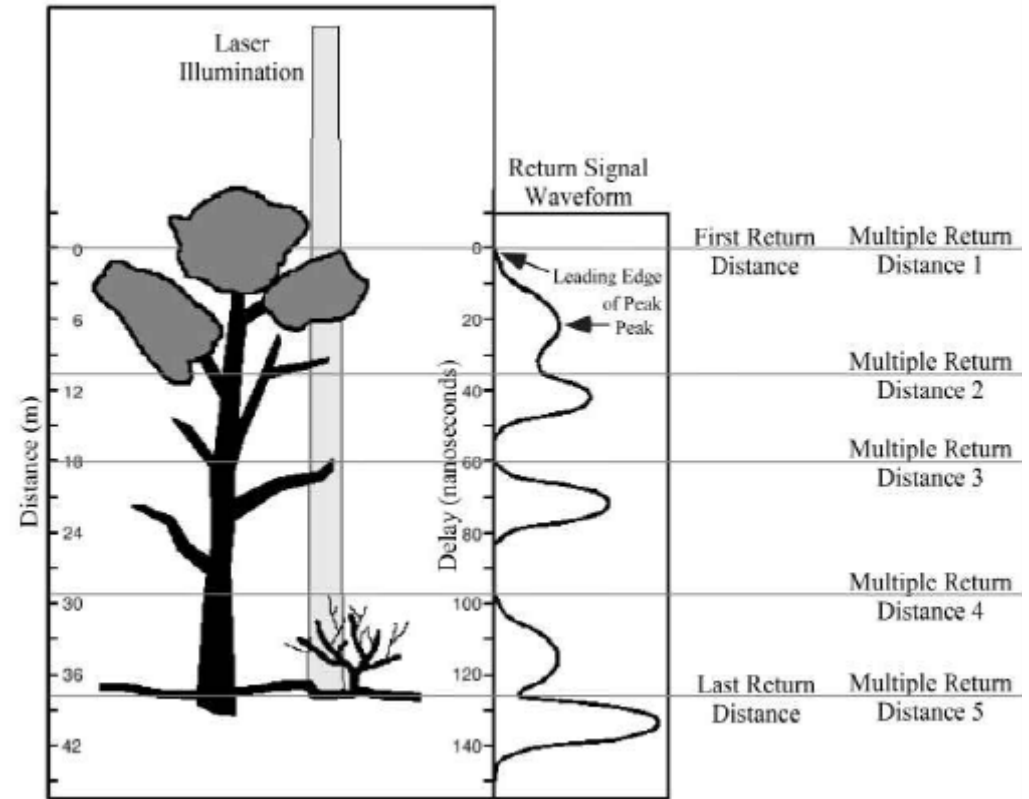


Zheng D., Rademacher J., Chen J., Crow T., Bresee M., Le Moine J. and Ryu S.-R., 2004. Estimating aboveground biomass using Landsat 7 ETM+ data across a managed landscape in northern Wisconsin, USA. Remote Sensing of Environment, 93, 402–411.

Lidarmessungen

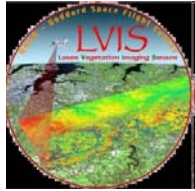


Quelle: <http://www.sbgmaps.com/lidar.htm>

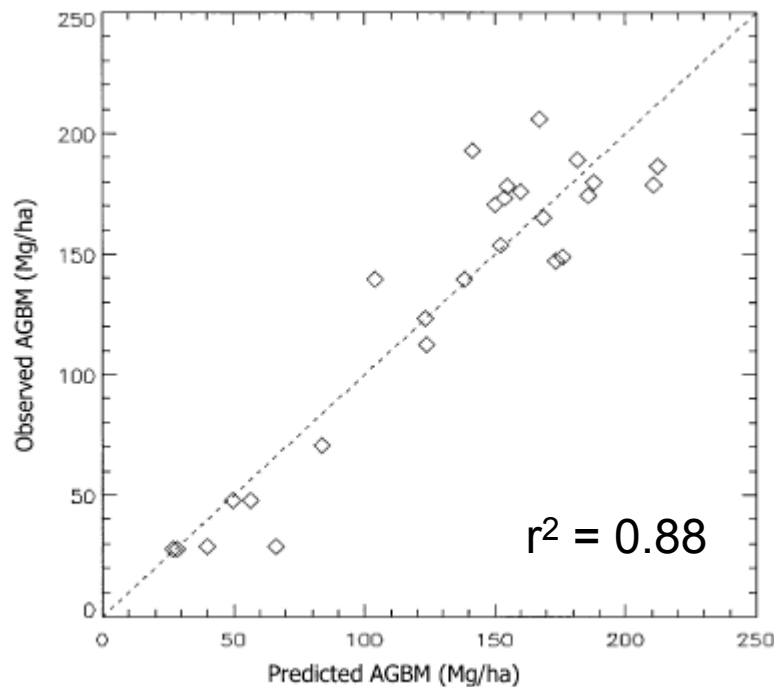


Gemessene Größen:
 Baumhöhe
 Kronendurchmesser
 Struktur der Vegetation

Laser Vegetation Imaging Sensor (LVIS)



➤ Flugzeug, tropischer Wald



LVIS Spezifikationen (full waveform)

Wellenlänge:	1064nm
Pulsenergie:	5mJ
Pulsbreite:	10ns
Rep-Rate:	100-500Hz
Flughöhe:	8km
Φ :	25m
Δx :	25m
Streifenbreite:	1km
Δz :	30cm

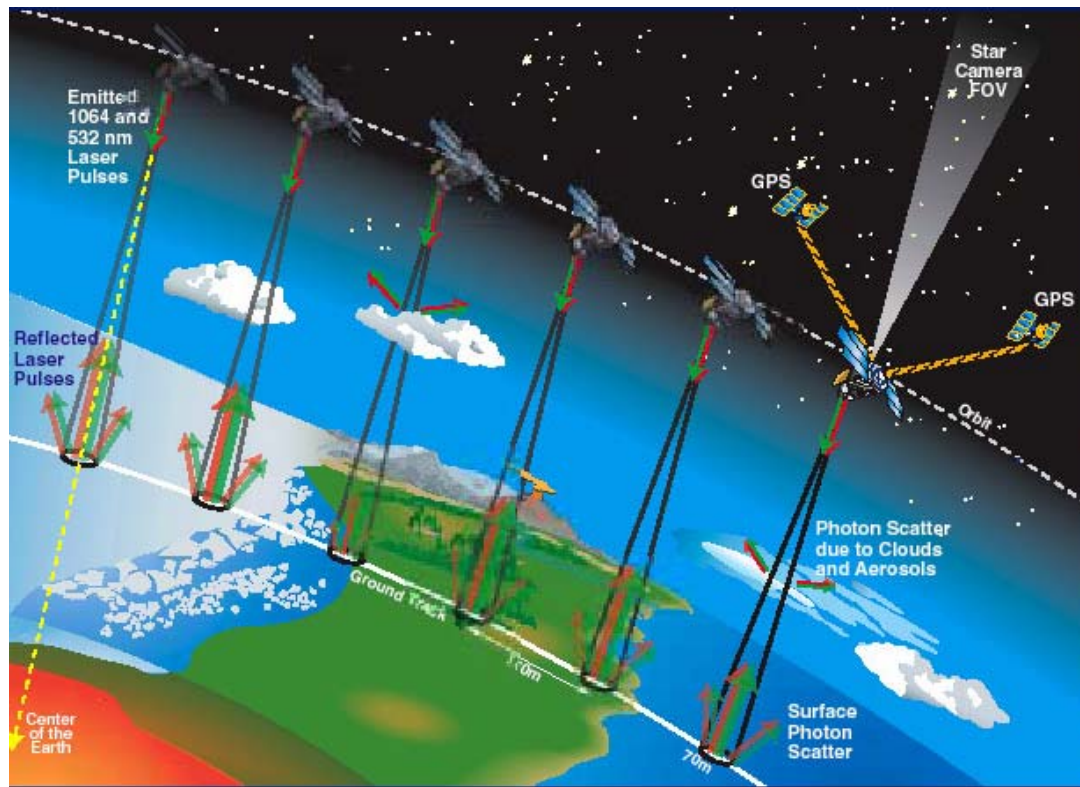
Drake J.B, Dubayah R.O., Knox R.G., Clark D.B. and Blair J.B., 2002. Sensitivity of large-footprint lidar to canopy structure and biomass in a neotropical rainforest. Remote Sensing of Environment, 81, 378– 392.



Geoscience Laser Altimeter System (GLAS)



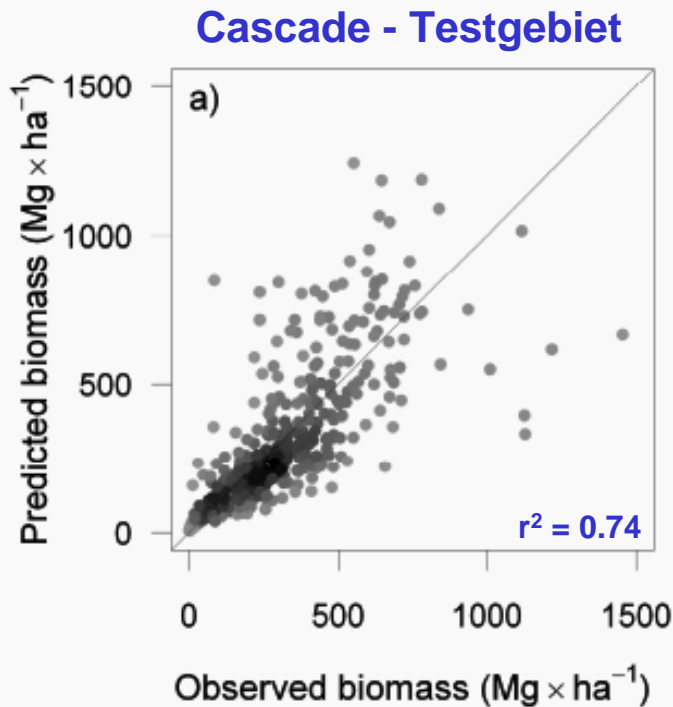
➤ Wald (USA)



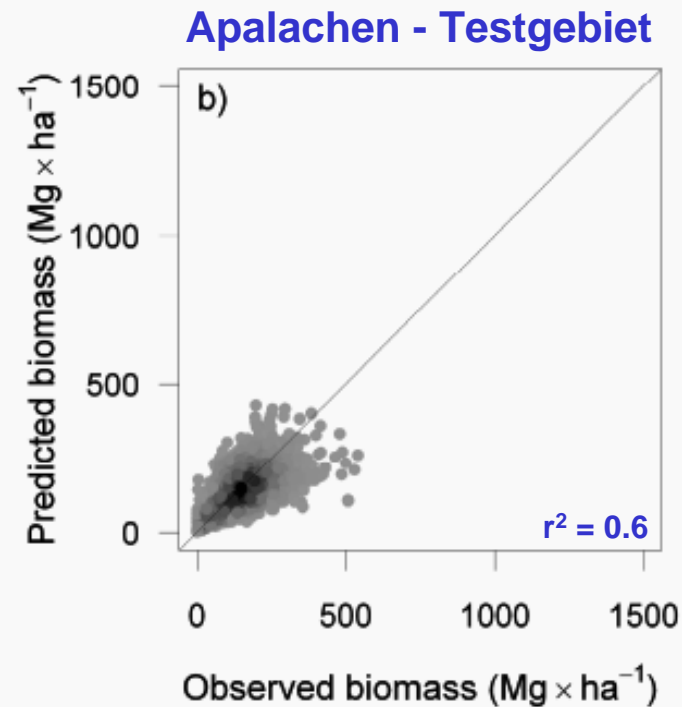
Wellenlänge ₁ :	1064nm
Wellenlänge ₂ :	532nm
Pulsbreite:	4ns
Rep-Rate:	40 Hz
Φ:	70m
Δx:	170m

Pflugmacher D., 2007. Remote Sensing of Forest Aboveground Biomass using the Geoscience Laser Altimeter System. Master thesis, Oregon State University, pp. 88

Geoscience Laser Altimeter System (GLAS)

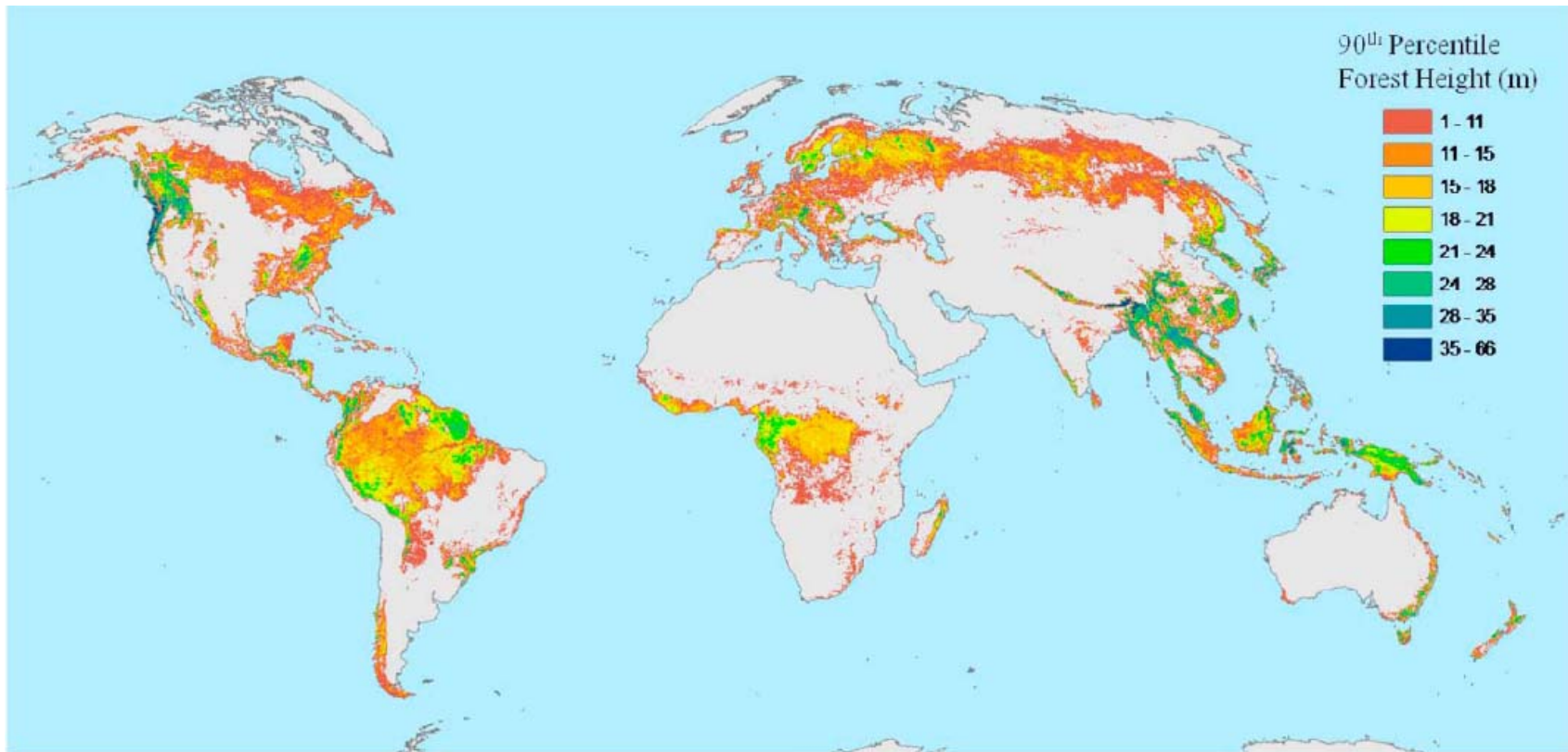


RMSE=174.7 Mg ha⁻¹, n = 362



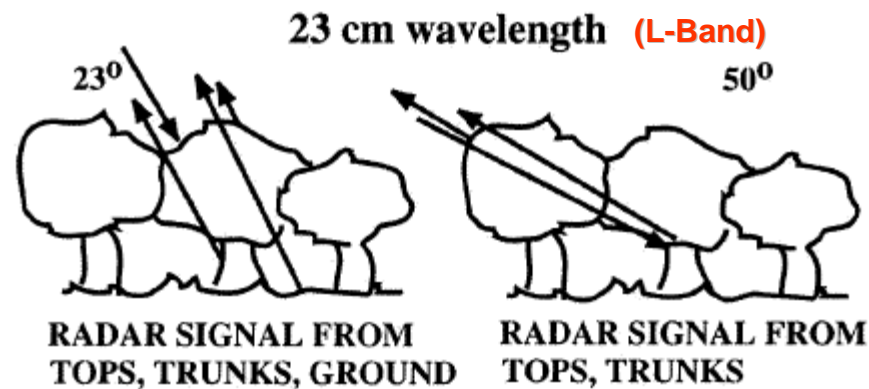
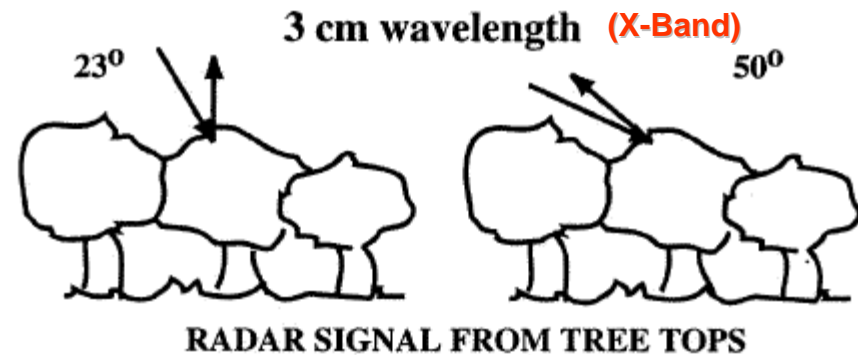
RMSE=60.6 Mg ha⁻¹, n=3054

Global forest height map



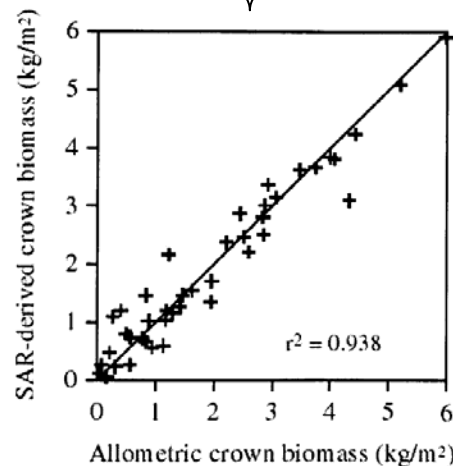
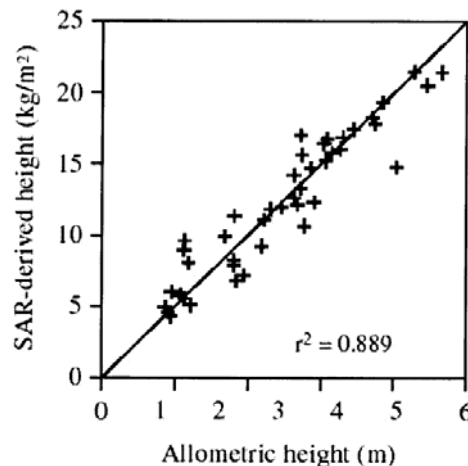
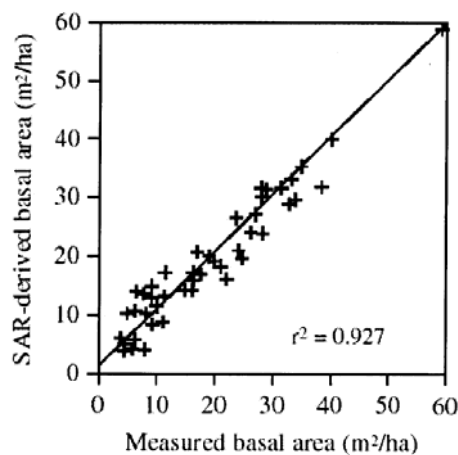
Global forest height map. Heights are the 90th percentile of GLAS height observations within a patch
Quelle: Lefsky, M.A., 2010: A global forest canopy height map from the Moderate Resolution Imaging Spectroradiometer and the Geoscience Laser Altimeter System. GEOPHYSICAL RESEARCH LETTERS, VOL. 37, L15401, doi:10.1029/2010GL043622, 2010.

Aktive Mikrowellen Fernerkundung



Quelle: K.M. Bergen, M.C. Dobson : Ecological Modelling 122 (1999) 257–274

SIR-C, Michigan (USA)



SIR-C-SAR

C-Band: 5.6cm

Polarisation: voll

Räuml. Auflösung: 10-30m

Einfallwinkel: 17 - 63°

Streifenbreite: 15-90km

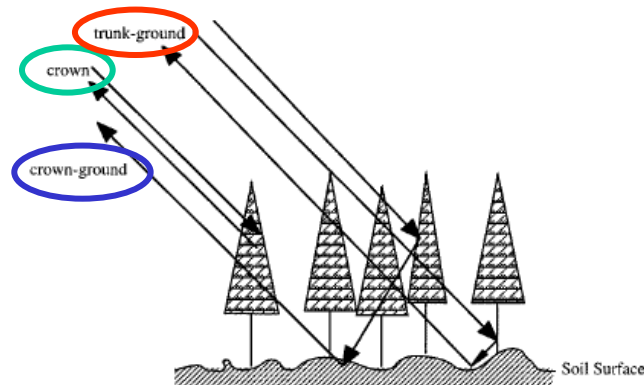
Landbedeckung: Wald

Bergen K.M. and Dobson M.C., 1999. Integration of remotely sensed radar imagery in modelling and mapping of forest biomass and net primary production. Ecological Modelling, 122, 257-274



Multi-Frequenz-SAR, AirSAR

<i>AIRSAR Channels</i>	<i>Crown Biomass Accuracy</i>	<i>Stem Biomass Accuracy</i>	<i>Total Biomass Accuracy</i>
PHH, PHV, LHV, CHV	95%	90%	91%
PHH, PHV, PVV	76%	92%	89%
LHH, LHV, LVV	93%	86%	87%
CHH,CHV,CVV	56%	23%	32%
LHH,CHH,CVV	68%	65%	63%



AirSAR

C-Band: 5.6 cm

L-Band: 24 cm

P-Band: 68 cm

Polarisation: voll

Räuml. Auflösung: 10-30 m

Einfallwinkel: 20 - 60°

Streifenbreite: ~50 km

Saatchi S. and Moghaddam M., 2000. Estimation of Crown and Stem Water Content and Bio-mass of Boreal Forest Using Polarimetric SAR Imagery. IEEE Transaction on Geoscience and Remote Sensing, 38 (2), 697 – 710





Zusammenfassung

- Verschiedene Fernerkundungsmethoden zur Abschätzung des Biomassepotenzials sind mit unterschiedlicher Güte publiziert worden:
 - Optische Verfahren ($r^2 \leq 0.96$)
 - Lidarmessungen ($r^2 \leq 0.89$)
 - Mikrowellenverfahren ($r^2 \leq 0.95$)
 - Bei den meisten Verfahren werden Fernerkundungsdaten mit der forstlichen Biomasse korreliert.