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The impact of horizontal radiation transport on canopy absorption at multiple scales

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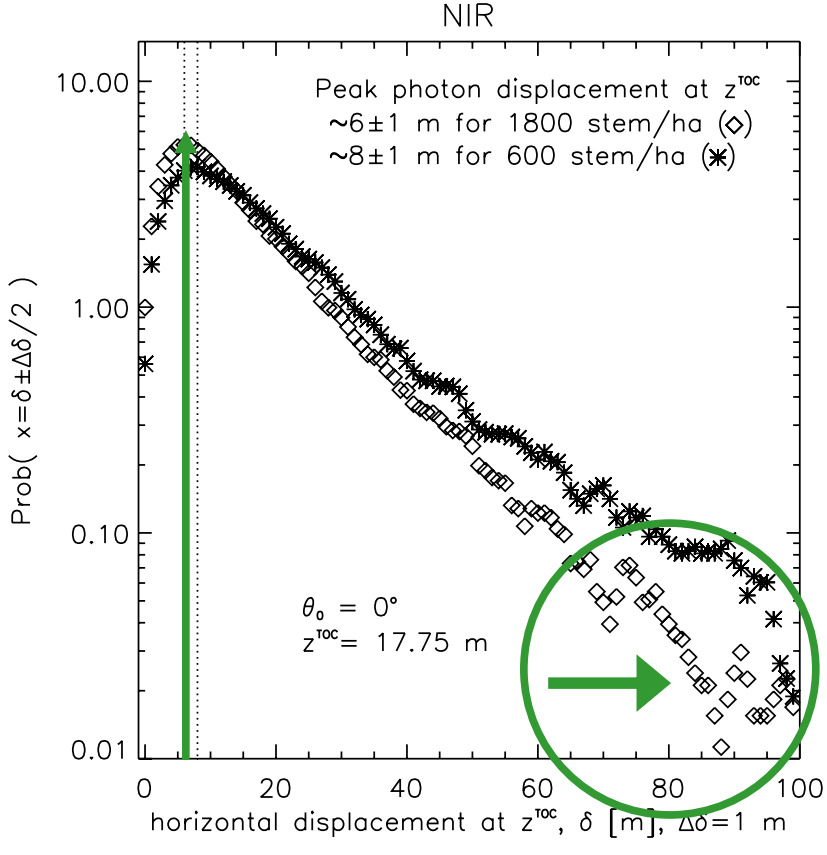
Institute for Environment and Sustainability

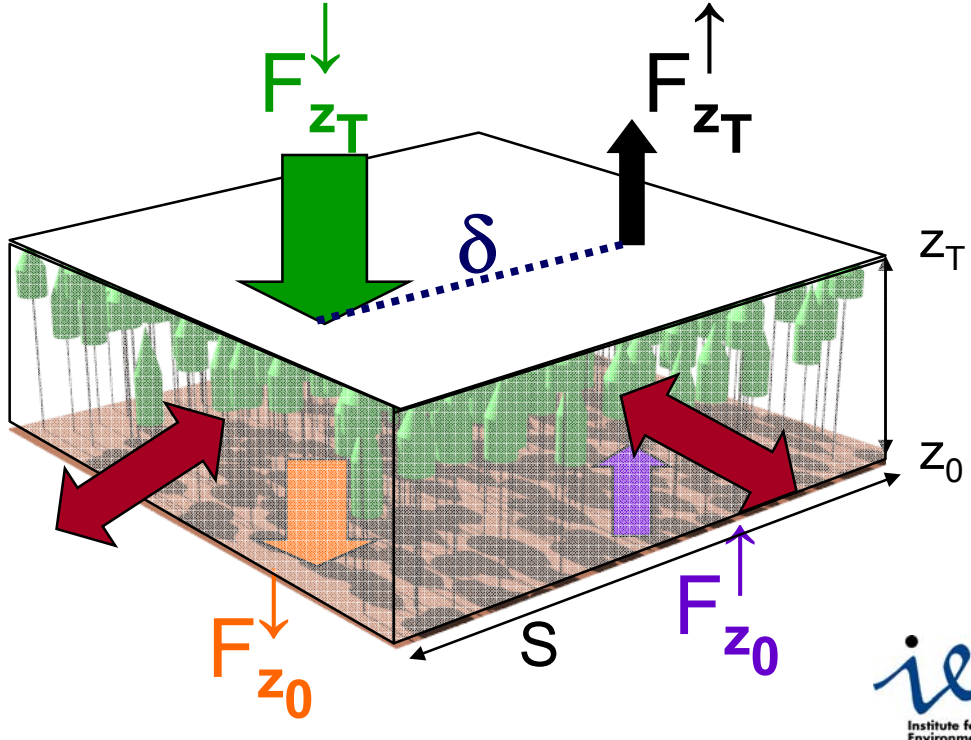
Horizontal Radiation Transport

Does horizontal radiation transport affect the local energy balance within some canopy volume of dimension, S ?



Widlowski et al., 2005, RSE

$$A = 1 - T + \alpha T - R + H$$



background albedo = α

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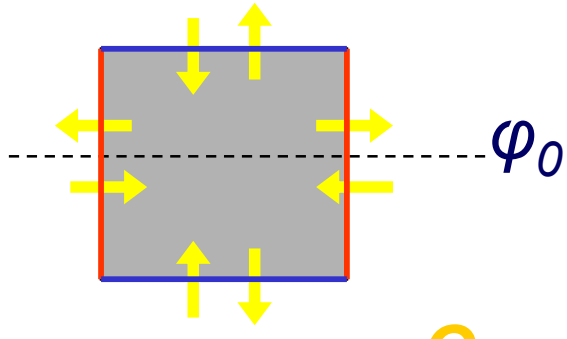
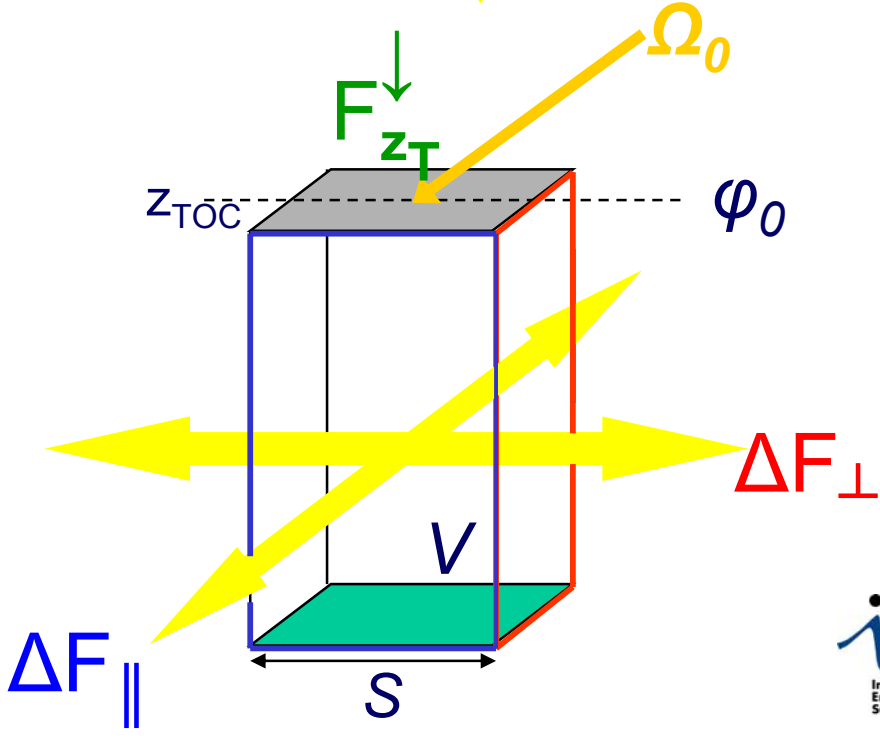
The Net Horizontal Flux Term, H(S)

H(S) is the sum of entering and exiting flux densities across the lateral sides of a canopy volume, *V* at a spatial resolution *S* normalised by the total incident flux at the top-of-canopy, F_{zT}.



- $\Delta F_{\perp}$ = fluxes across sides that are *perpendicular* to the solar azimuth, φ_0
- $\Delta F_{\parallel}$ = fluxes across sides that are *parallel* to φ_0

$$H(S) = (\Delta F_{\parallel} + \Delta F_{\perp}) / F^{\downarrow}_{z_T}$$



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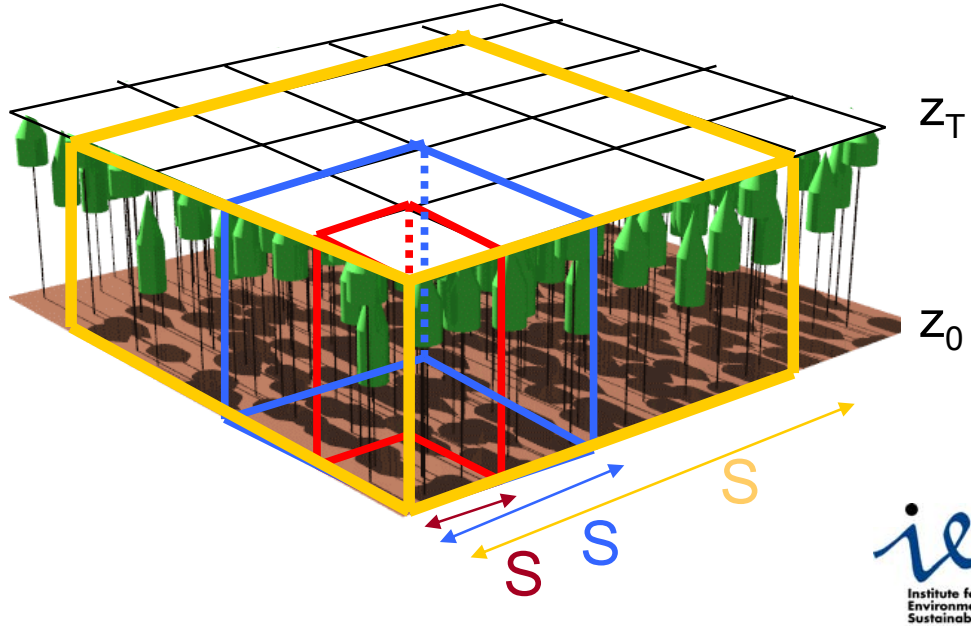
Magnitude of Net Horizontal Flux Components

Experimental set-up

- Within large overall forest domain (900x900 m^2) cover a region of 500x500m^2 by a regular array of fine resolution (1x1m^2) voxels.
- Determine maximum and minimum net horizontal flux term within 500x500m^2 area.
- Coarse grain voxel size and repeat.
- Plot H_{max} and H_{min} versus voxel scale, S



Widlowski et al., 2005, RSE

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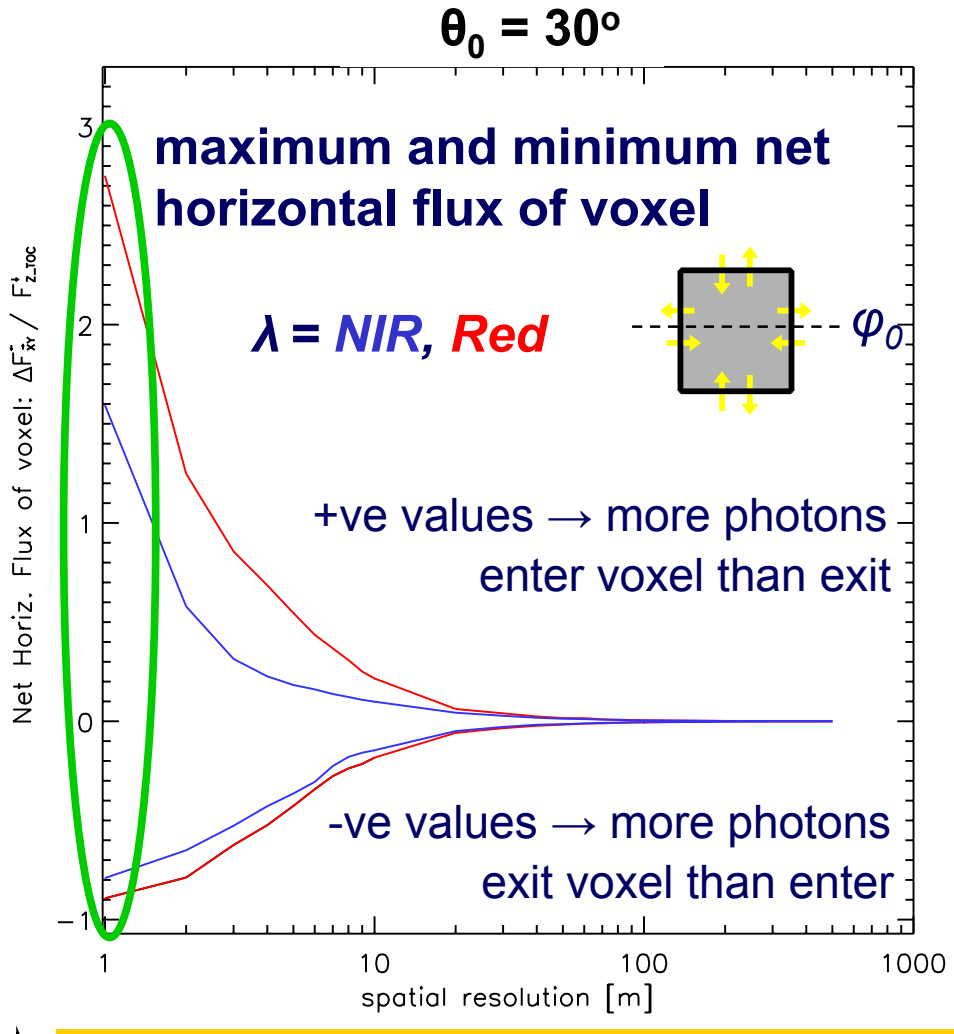
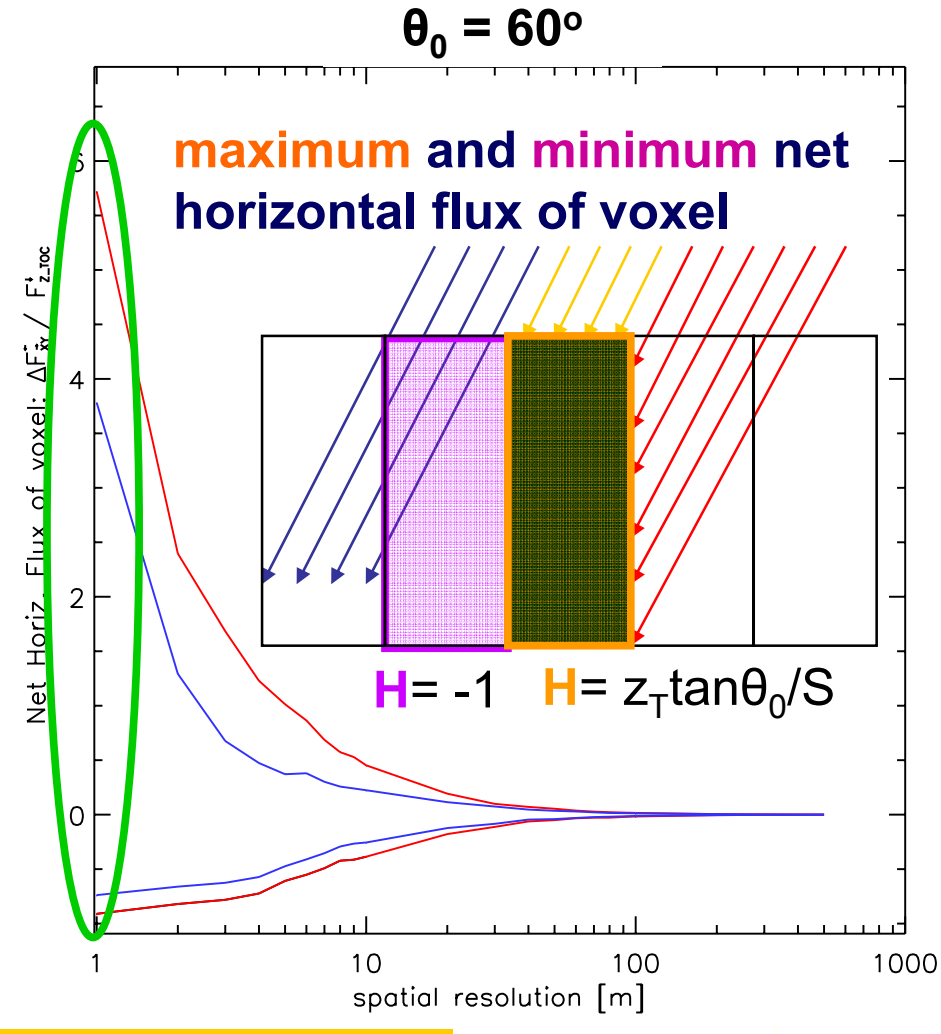
Magnitude of Total Net Horizontal Flux





What is impact of H(S) on **in-situ** measurements?

Widlowski et al., 2006, RSE

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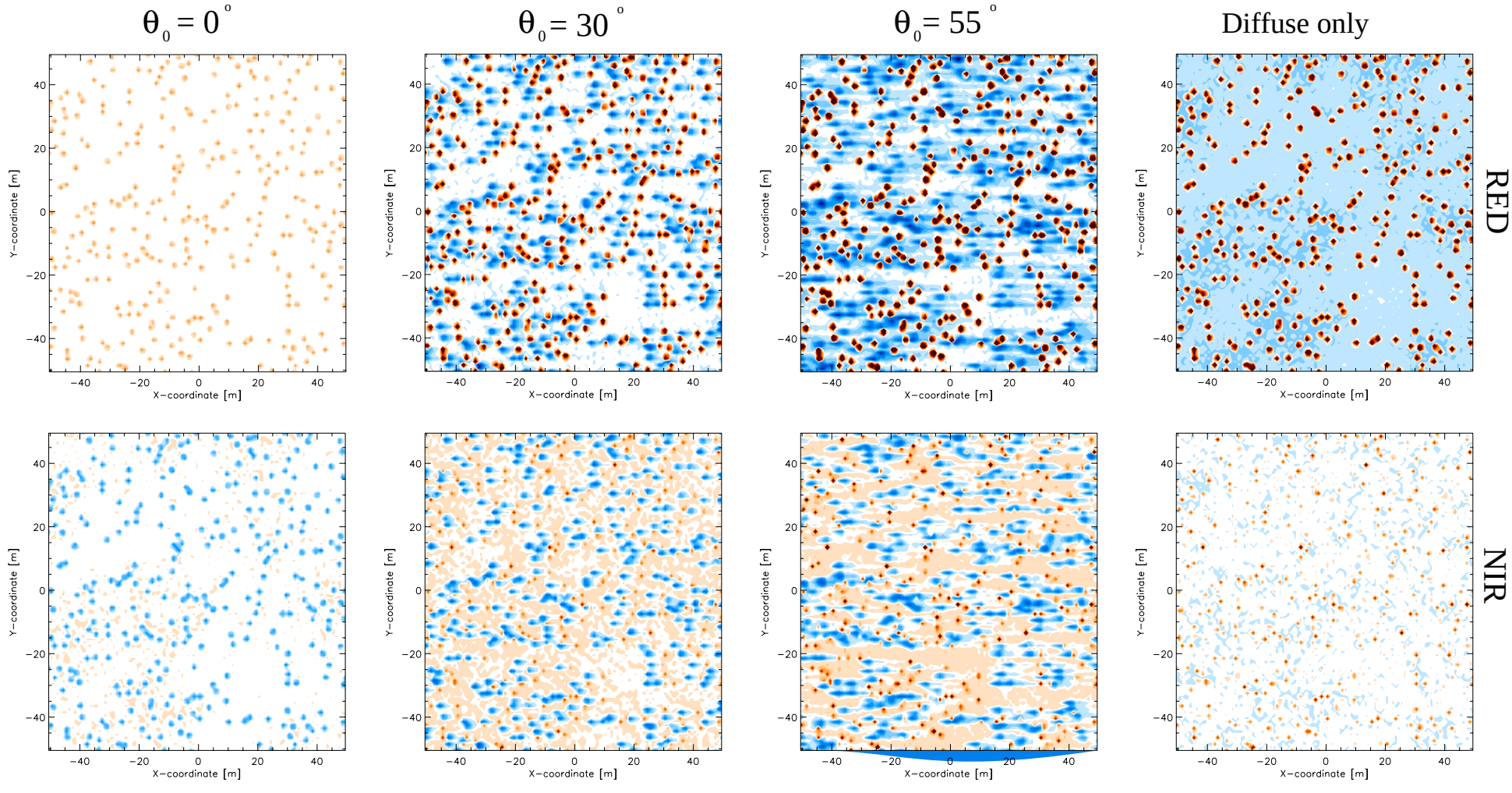
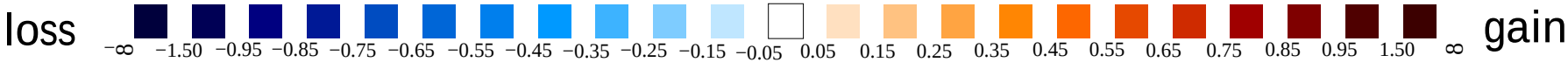
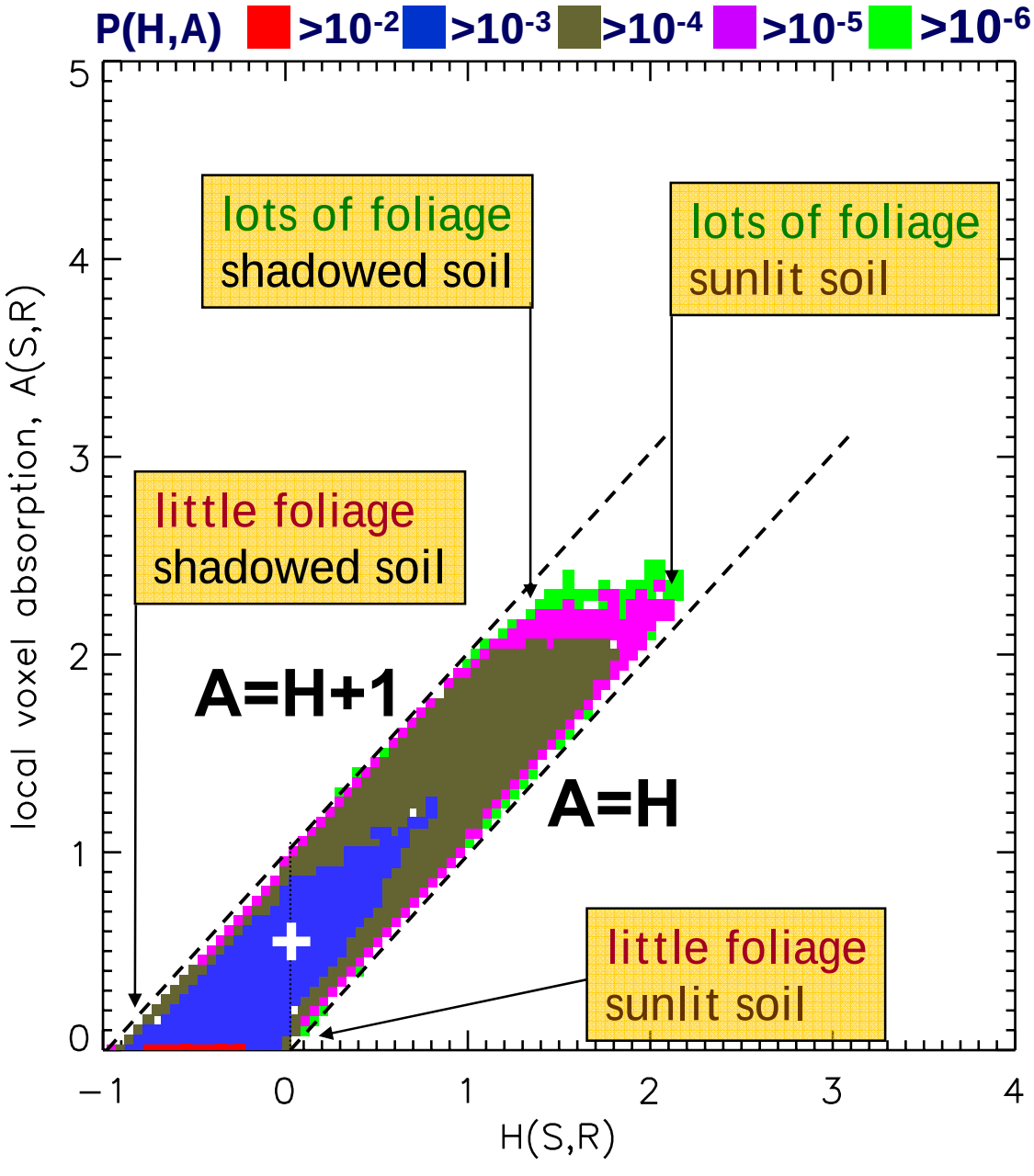
Net Horizontal Radiation Transport (S=1m)

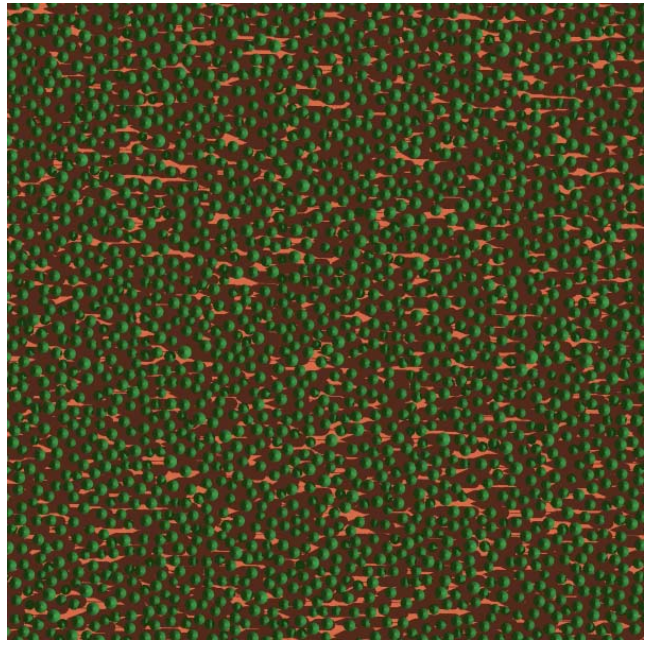


Net horizontal power / Incident power at TOC, H(S=1m)

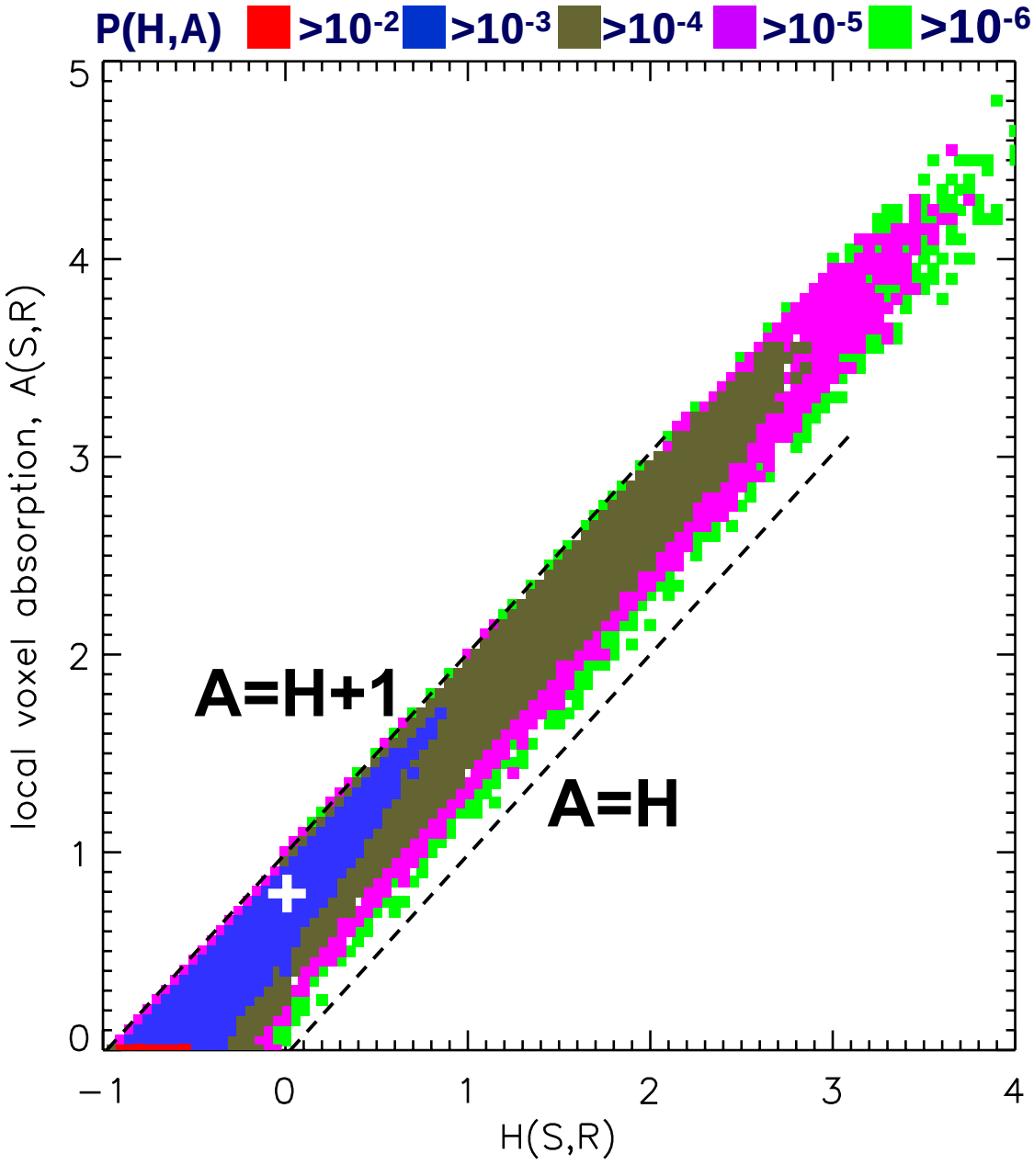




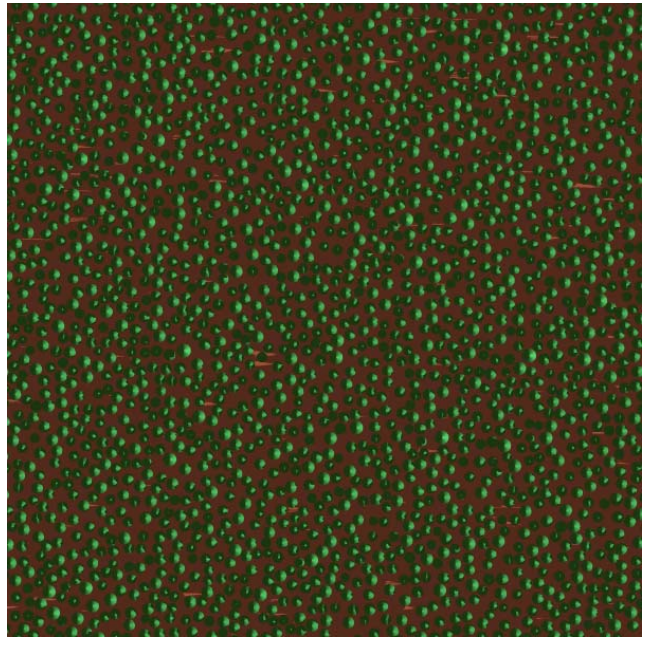
λ = red
$\theta_0 = 30^o$
δ = 1800 stem/ha
α = medium bright soil



domain average of canopy absorption falls on H=0 line



λ = red
$\theta_0 = 60^o$
δ = 1800 stem/ha
α = medium bright soil



- more shadowing of ground leads to shift towards A=H+1 line
- more interception due to elongated crowns

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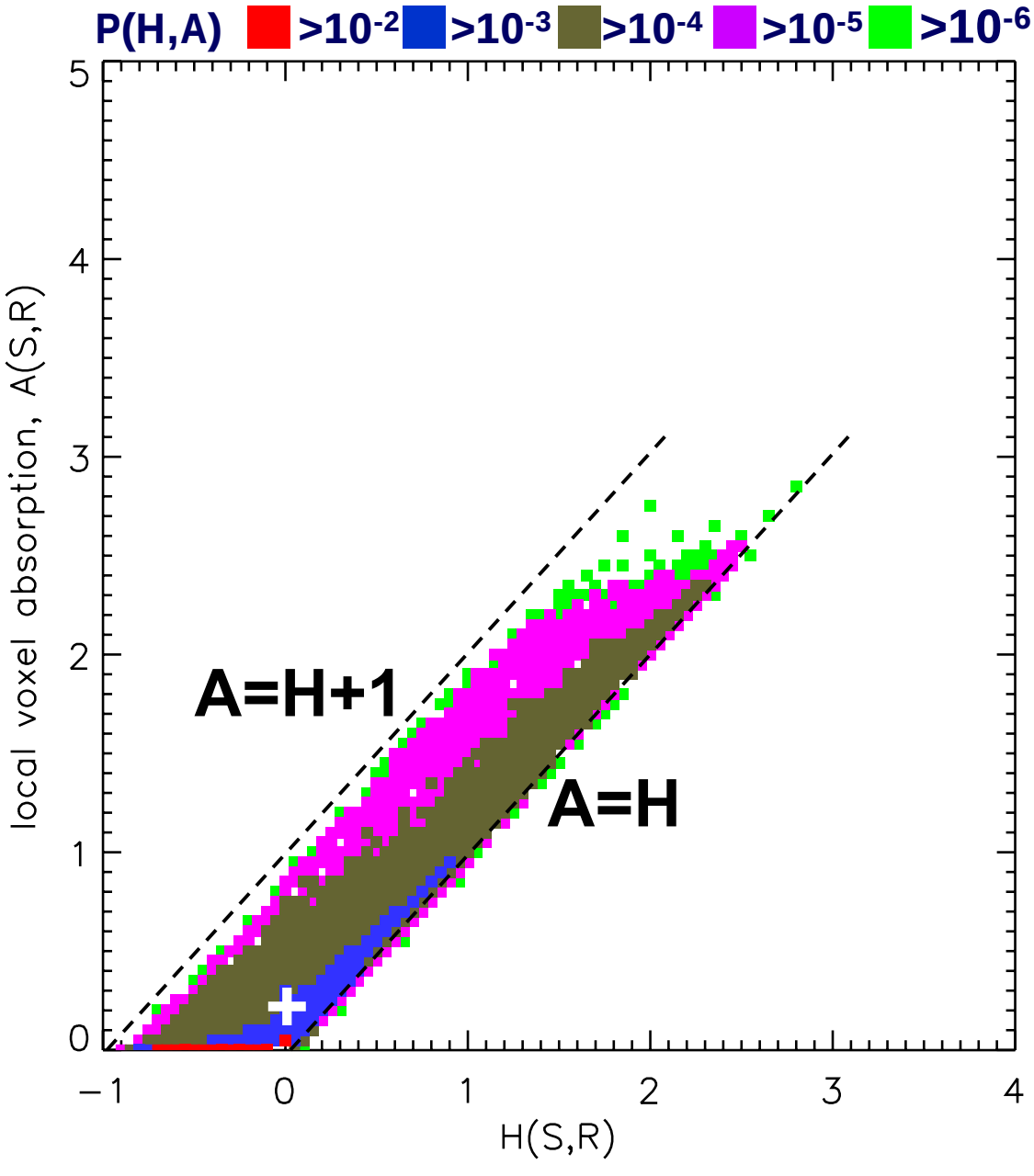
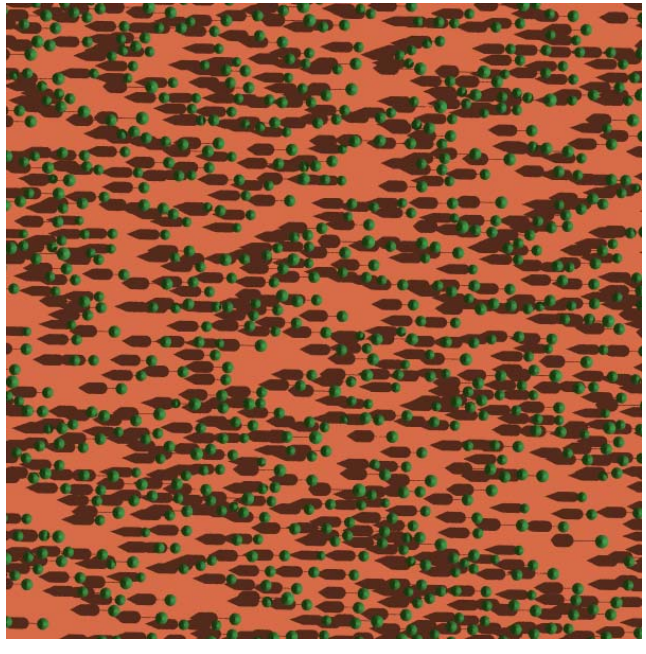


λ = red
θ_0 = 30°
δ = 600 stem/ha
α = medium bright soil



- less shadowing of ground leads to shift towards A=H line

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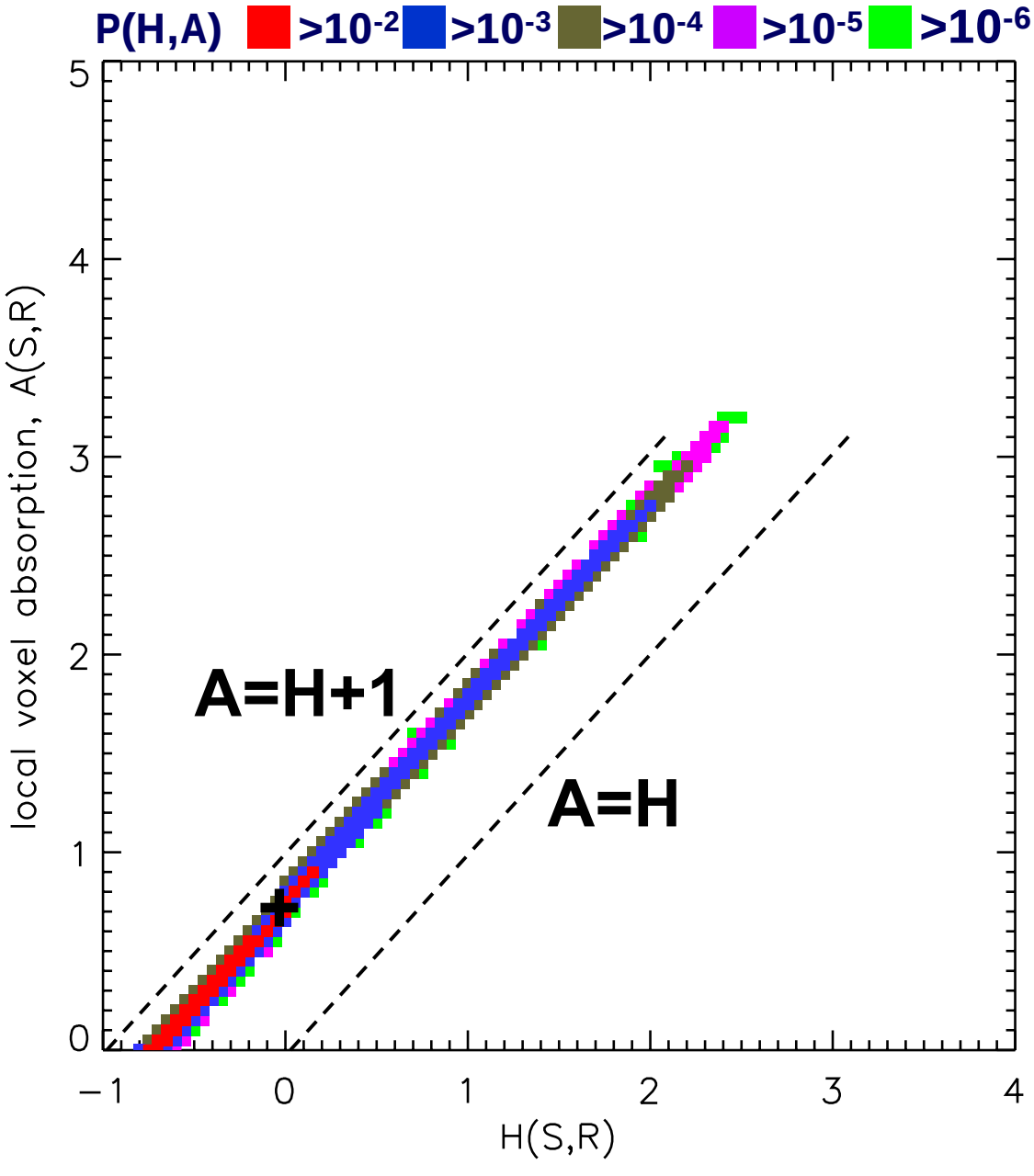
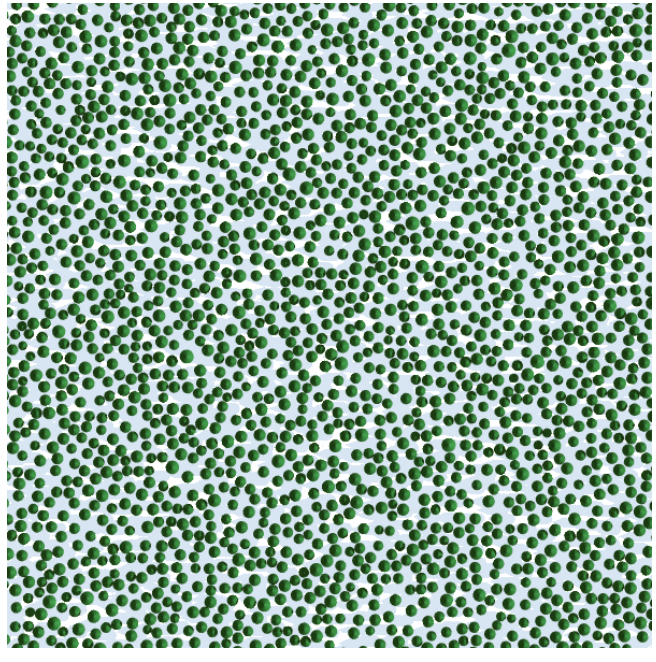


λ = red
$\theta_0 = 30^o$
δ = 1800 stem/ha
α = snow



scattering from snow will:

- reduce H and shift data pairs away from A=H line
- weaken shadows
- increase interception

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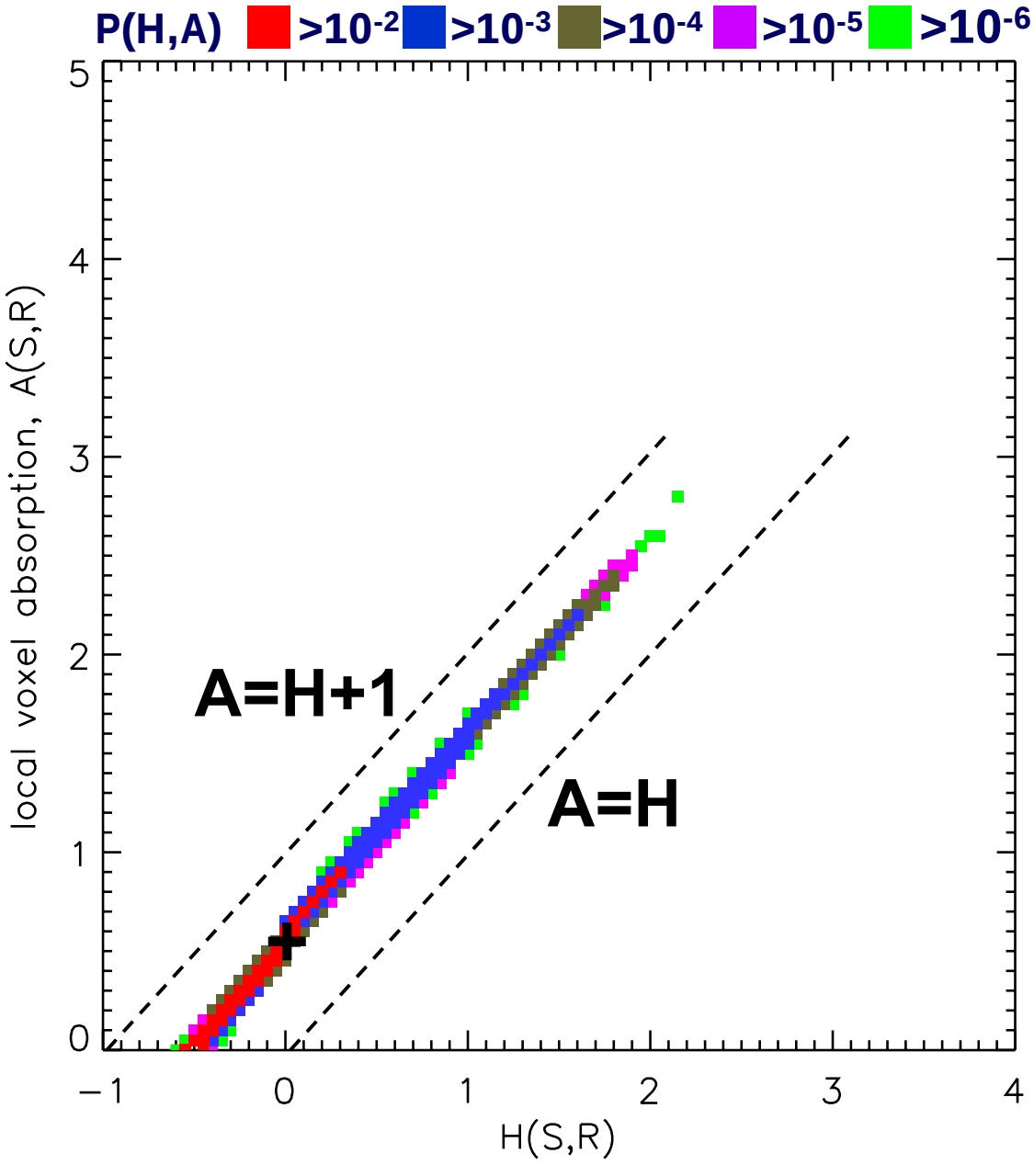
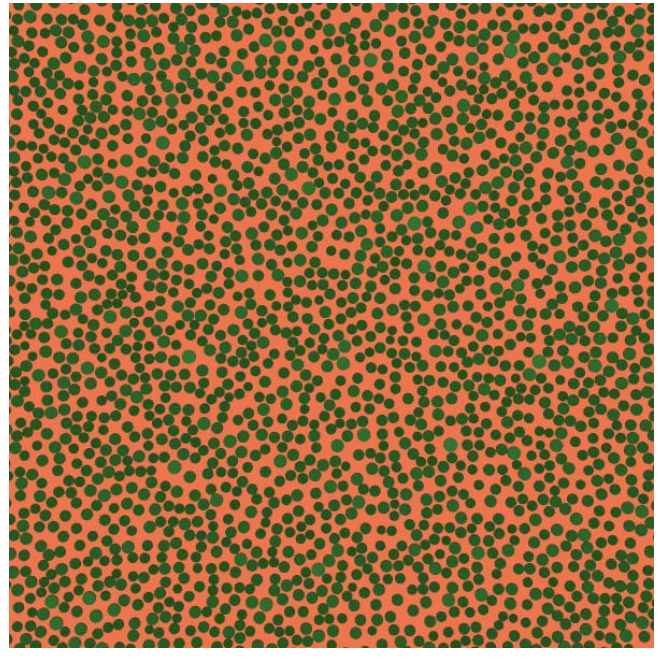


λ = red
θ_0 = diffuse illumination
δ = 1800 stem/ha
α = medium bright soil



diffuse illumination will:

- soften both shadows and direct illumination data pairs shift to middle of A=H and A=H+1 lines

Measuring absorption in coniferous canopies

Local canopy absorption measured as: $A^{\updownarrow}(S) = 1 - R(S) - (1-\alpha)T(S)$

$A^{*}(S) = 1 - T(S)$ since $R(S) \approx \alpha T(S)$

BUT, true canopy absorption is

$$A(S) = A^{\updownarrow}(S) + H(S)$$

$$A(S) \approx A^{*}(S) + H(S)$$

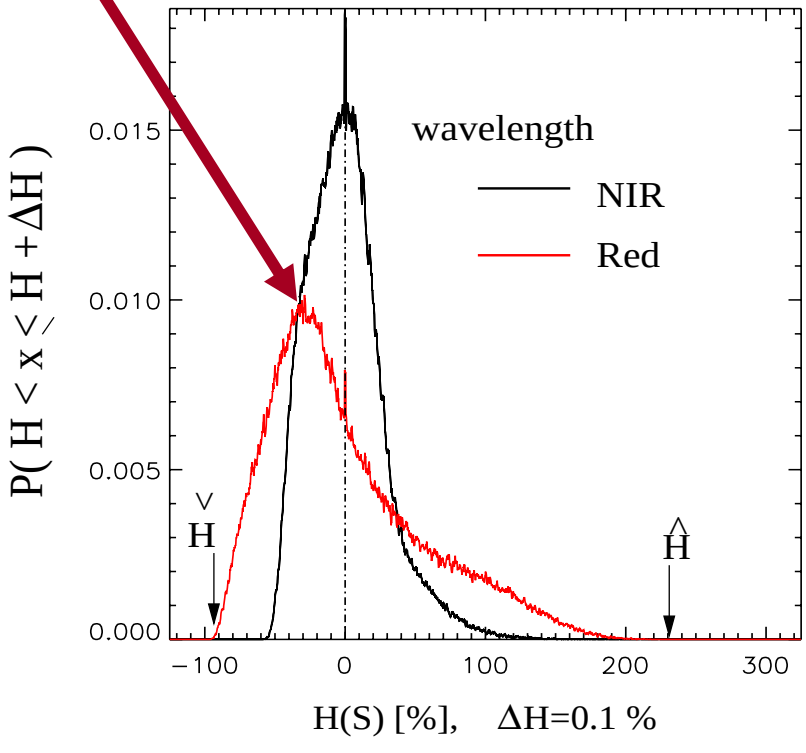
Thus most local absorption estimates:

$$A(S,R) < A^{\updownarrow}(S,R)$$

$$A(S) < A^{*}(S)$$

Inappropriate or insufficient sampling thus may lead to an overestimation of the domain-averaged absorption in complex 3D canopies.

- Domain average of H(S) is 0
- Most likely value of H(S) is < 0



At such sites (correctly derived) absorption estimates from EO data may be smaller than in-situ estimates but not vice versa.

S=1x1m^2 R=location of canopy volumes (voxels)

Widlowski et al. (2006), RSE

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Thank you!