Coupling Vegetation Responses and Shallow Cumulus through Direct and Diffuse Radiation

> X. Pedruzo Bagazgoitia , H.G. Ouwersloot, M. Sikma, C. M. J. Jacobs, J.Vila-Guerau de Arellano

> > xabier.pedruzobagazgoitia@wur.nl



Increased carbon absorption in cloudy days



Adapted from Freedman et al. (2001)

> Higher CO₂ absorption on days with shallow cumulus or reduced transmittance

 Does this affect evapotranspiration?

Global relevance of Shallow Cumulus



van Stratum et al. (2013)

Global relevance of Shallow Cumulus



Is **diffuse** radiation influencing **CO₂ absorption** and **evapotranspiration**?

What is the impact at the **BL**? and for low **clouds**?



van Stratum et al. (2013)

A bi-directional interaction

Direct & Diffuse

1. Impact of clouds at vegetated surface

Direct & Diffuse

Photo: Bob Small Photography

A bi-directional interaction

Direct & Diffuse

1. Impact of clouds at vegetated surface

2. Impact of vegetated surface on BL and clouds

Direct & Diffuse

Photo: Bob Small Photography

Methods and set up

- Dutch Atmospheric Large Eddy Simulation (DALES)
- Domain: 24km x 24km x 5.4km
- Gridbox size: 50m x 50m x 12m
- Experiment time: 7:00 -17:00 UTC
- LAI=2
- Clear atmosphere
- No wind, CBL
- Typical summer day in The Netherlands:
 - Max cloud cover ≈ 0.2
 - SH_{max} ≈ 155 W/m2
 - LE_{max} ≈ 140 W/m2
 - BL height ≈ 2000 m



Direct/diffuse in clouds



Direct/diffuse in clouds



Direct/diffuse in canopy



Two leaf A-gs :

- Plant physiological model
- Similar to ECMWF
- Sunlit and shaded leaves
- Direct/diffuse radiation at 3 levels
- T_eff for all canopy

Conditional averaging criteria



Because of localized effects:

Conditional averaging criteria



Conditional averaging criteria



Results

Direct & Diffuse

1. Impact of clouds at vegetated surface

2. Impact of vegetated surface on BL and clouds

Direct & Diffuse

Photo: Bob Small Photography















Two thickness-dependent regimes



Disruption of SEB:

Under optimal cloud thickness, An and LE are larger than under clear sky

Two thickness-dependent regimes



Disruption of SEB:

Under optimal cloud thickness, An and LE are larger than under clear sky

Results

Direct & Diffuse

. Impact of clouds at vegetated surface

2. Impact of vegetated surface on BL and clouds

Direct & Diffuse

Photo: Bob Small Photography



Domain averages: Similar surface fluxes and BL



Domain averages: Similar surface fluxes and BL



Conditional average on clouds

Average profiles at 14:00-14:20 UTC

• Cloud core:
$$q_1 > 0$$
, $\theta_v > \theta_{v avg}$

Conditional average on clouds

Average profiles at 14:00-14:20 UTC



Conditional average on clouds

Average profiles at 14:00-14:20 UTC



1. Diffuse radiation plays a critical role on enhancing photosynthesis and LE

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2. Two regimes for An and LE for thick/thin clouds: optimal cloud thickness for vegetation

 Diffuse radiation plays a critical role on enhancing photosynthesis and LE

3. Character of light does not affect cloud and BL dynamics significantly (only **local** effects)

2. Two regimes for An and LE for thick/thin clouds: optimal cloud thickness for vegetation

 Diffuse radiation plays a critical role on enhancing photosynthesis and LE

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3. Character of light does not affect cloud and BL dynamics significantly (only **local** effects)

2. Two regimes for An and LE for thick/thin clouds: optimal cloud thickness for vegetation

xabier.pedruzobagazgoitia@wur.nl

BACK-up slides



Day average





Background diffuse



Background diffuse



DIR



15min plant response lag





In-canopy scheme



In-canopy scheme



2 types of leaves:

Sunlit: Receive direct and diffuse light

Shaded: Receive diffuse light only

Canopy radiative transfer: Validation



Baldocchi et al. (1985)

Conclusions



Challenge in the local

- SCu are rooted in the surface
- Shading changes surface fluxes

Canopy sensitive to direct/diffuse