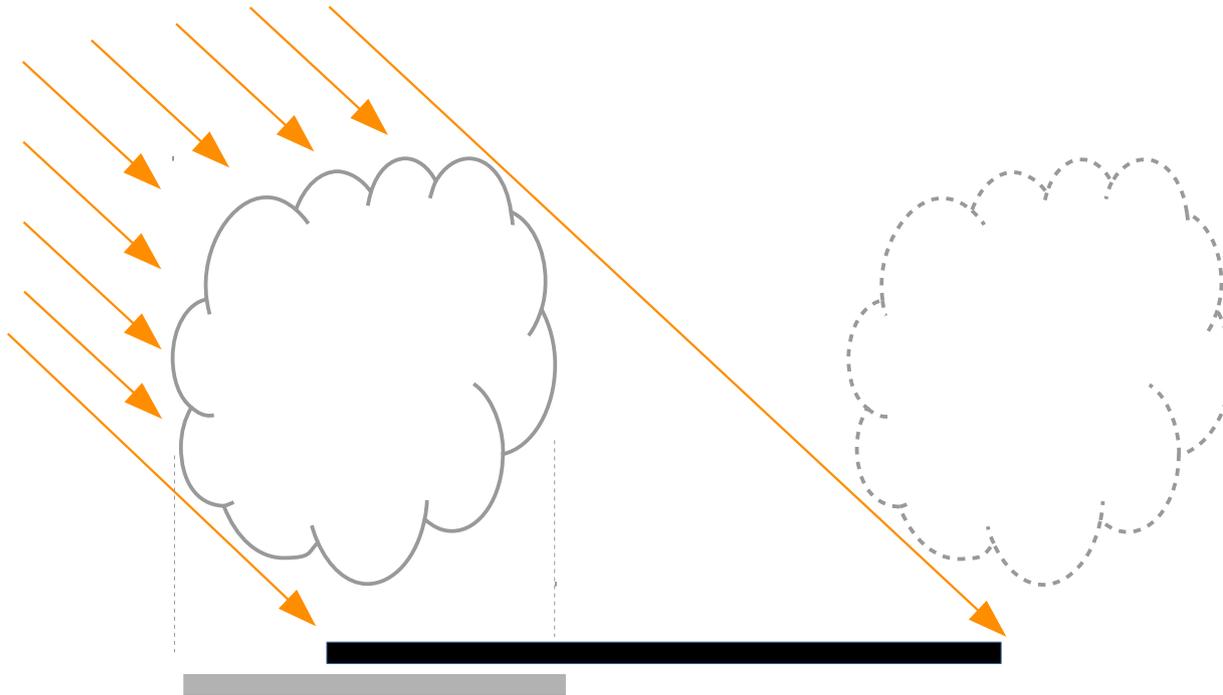
A landscape photograph showing a field of tall grass in the foreground, a line of trees in the middle ground, and a bright blue sky with scattered white clouds. The text is overlaid on a semi-transparent grey box in the lower half of the image.

# Comment prendre en compte les effets radiatifs 3-D des nuages dans un modèle colonne?

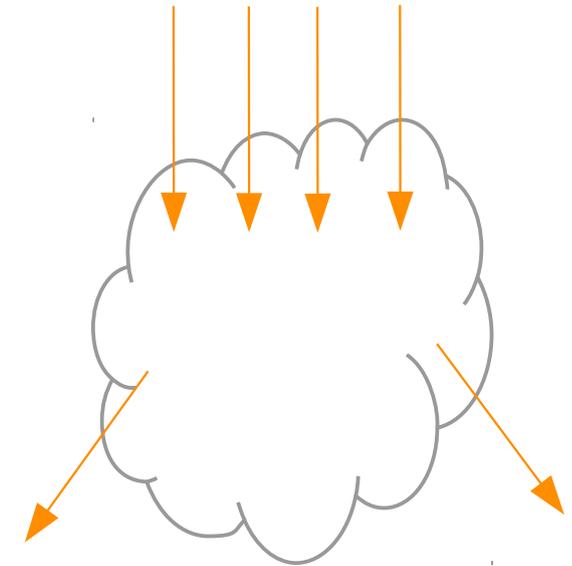
Quentin Libois, CNRM-GAME, GMME, Meso-NH

# 3-D radiative effects in clouds : why should we care ? (SW)

Side illumination  
(increased cloud reflectance)



Side leaks  
(reduced cloud reflectance)



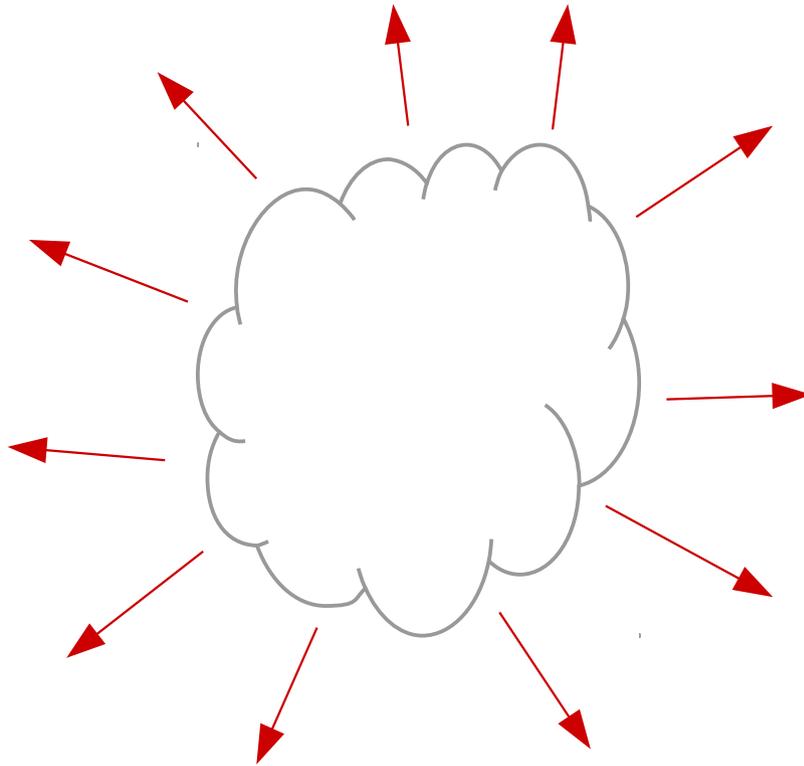
3-D effects can change TOA CRE from -25 % to 100 % (Hogan and Shonk, 2012)

Larger effects for contrails, cumulus and convective towers, clouds which have « sides »

Larger errors than those resulting from coarse spectral resolution,  
choice of correlated-k distribution, spatial heterogeneities etc.

# 3-D radiative effects in clouds : why should we care ? (LW)

Side emission  
(increased downward LW radiation)



For an optically thick cloud in a non absorbing atmosphere, downward LW radiation is 3 times more and more evenly distributed below the cloud  
(Schäfer et al., 2016)

# How to account for 3D effects ?

## In GCMs

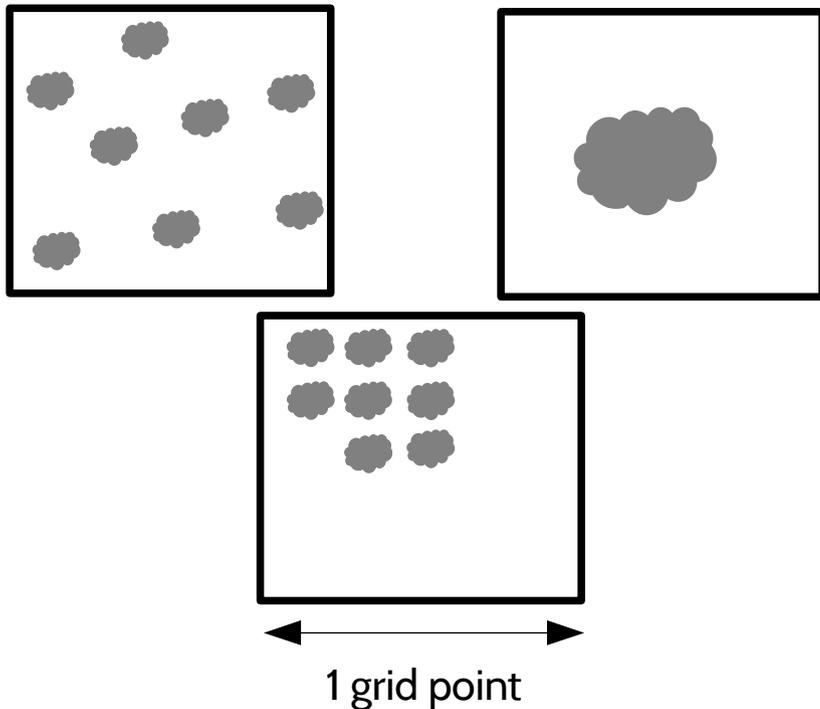
(ECRAD ; Hogan et al., 2016)

Addition of side contributions  
to the 2-stream equations  $\neq$  ICA

Side contributions proportional to the length  
of the interfaces (not only cloud fraction)

Impact of clustering

Need for observations to constrain  
these parameters



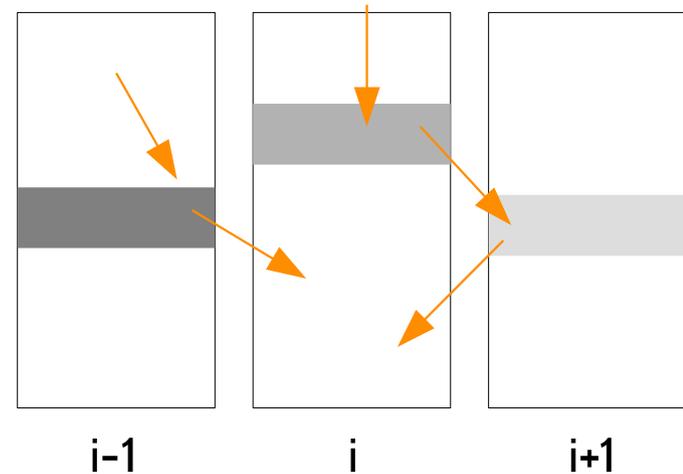
## In LES simulations

Clouds are resolved  
(no assumptions on cloud overlap, edge length, clustering)

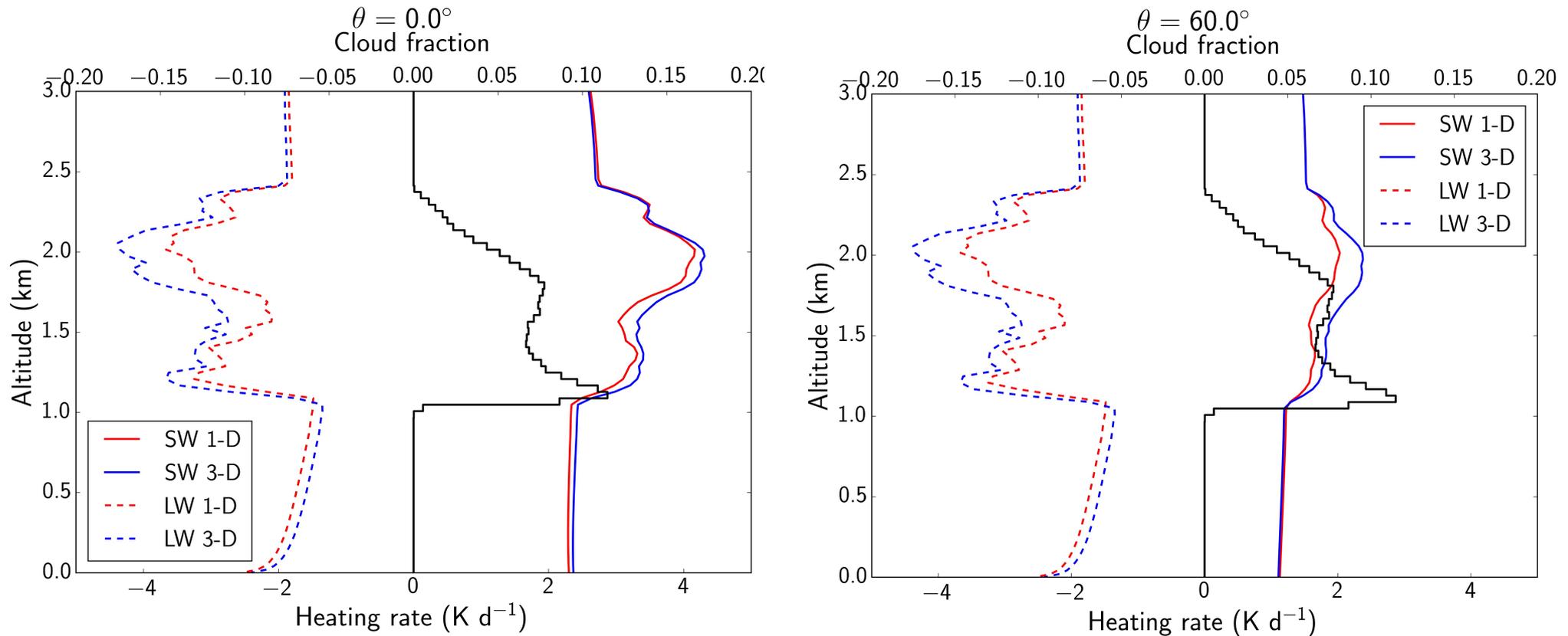
Average fluxes can be estimated, but not local fluxes

Explicit inter columns lateral transfer  
(TenStream ; Jakub and Mayer, 2015)

Communication between neighbouring columns only  
(NCA ; Klinger and Mayer, 2016)



# ECRAD on a LES simulation of cumulus



$$F_{\text{SW},3\text{D}}^{\downarrow} - F_{\text{SW},1\text{D}}^{\downarrow} = 0,15 \text{ (23,8) } \text{ W m}^{-2} \text{ for } \theta = 60^\circ \text{ (} 0^\circ \text{)}$$

$$F_{\text{LW},3\text{D}}^{\downarrow} - F_{\text{LW},1\text{D}}^{\downarrow} = 4,6 \text{ W m}^{-2}$$

# Perspectives



Implementation of ECRAD in *Meso-NH*

Coupling with microphysics (LIMA)

Impact of the update on the physics  
(+ Sensitivity to unbiased/biase errors)

Quantification of 3D effects

Impact of spatial and temporal sampling  
of the radiative computations