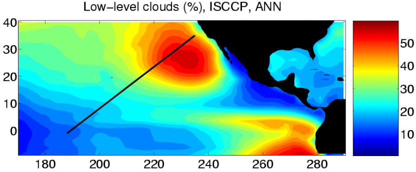
EUCLIPSE radiation intercomparison study for stratocumulus

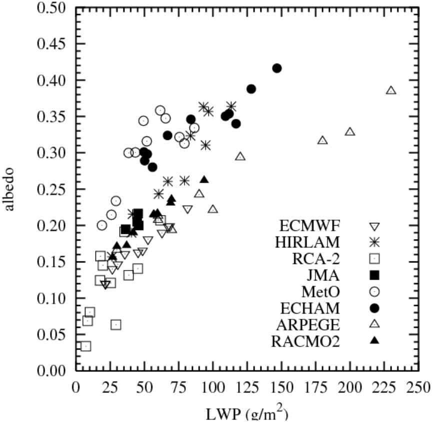
S. Dal Gesso, P. Siebesma, R. Neggers, S. de Roode
KNMI, Royal Netherlands Meteorological Institute
TUD, Delft University of Technology

I. Beau, P.Blossey, A. Cheng, J. van der Dussen, A. Lock, J. Manners, P. Wang

9 June 2011
EUCLIPSE/CFMIP/GCSS meeting

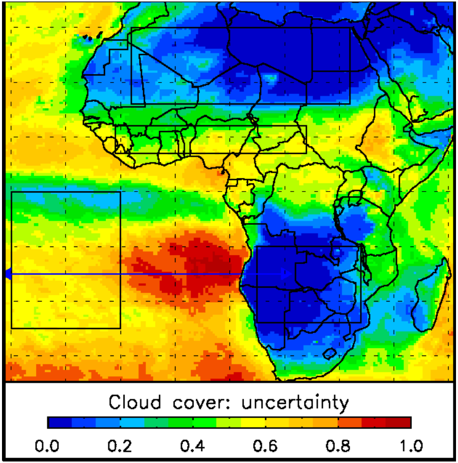
Introduction and motivations





Siebesma et al. 2004

From Pacific to Atlantic ocean



Greuell et al. 2011

Scientific questions

1. How large is the spread in broadband shortwave albedo calculated by the different radiation codes for the marine stratocumulus topped boundary layer?
2. Do more sophisticated radiation codes provide albedos closer to the observations?
3. How critical are the assumptions on the internal microphysics for the radiative properties of stratocumulus clouds?

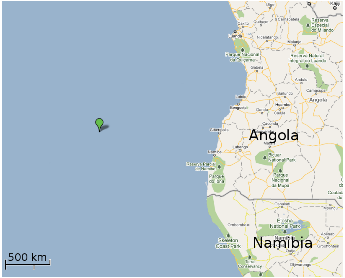
Outline

- models simulations set-up;
- description of the dataset;
- results;
- conclusions and outlook.

Simulations set-up

For further details:
http://www.euclipse.nl/wp3/Radiation_Intercomparison/Introduction.shtml
gesso@knmi.nl

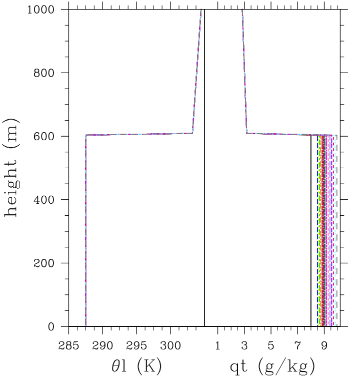
Simulations set-up



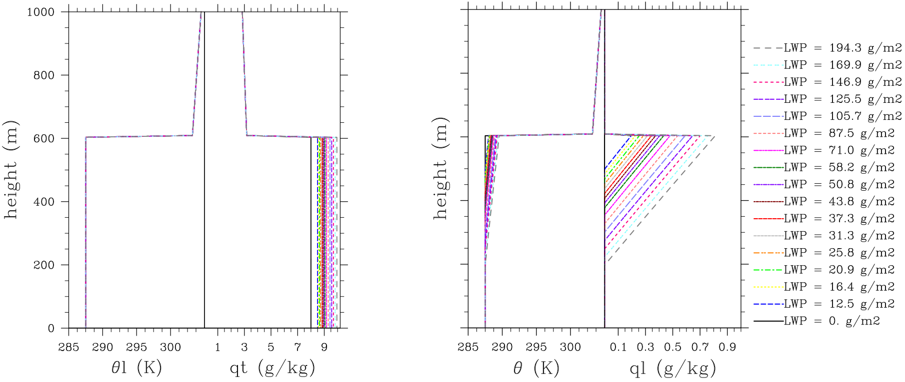
Position: LAT=14.S
LON=6.5E
Duration: one time step 11.30 UTC (local noon)
Date: 15 July 2006

solar constant (W/m^2)	1325.8
cos zenith angle	0.813
albedo (-)	0.026
p_s (hPa)	1017.
SST (K)	288.4

Initial conditions



Initial conditions



Microphysics

- SET A: operational set-up

Microphysics

- SET A: operational set-up
- SET B: constant effective radius: $r_e = 9\mu m$ (according to SEVIRI)

$$\tau = \frac{3}{2}\frac{1}{\rho_l r_e}\int_0^{+\infty}\rho_a(z)q_l(z)dz$$

no inhomogeneity

Microphysics

- SET A: operational set-up
- SET B: constant effective radius: $r_e = 9\mu m$ (according to SEVIRI)

$$\tau = \frac{3}{2}\frac{1}{\rho_l r_e}\int_0^{+\infty} \rho_a(z) q_l(z) dz$$

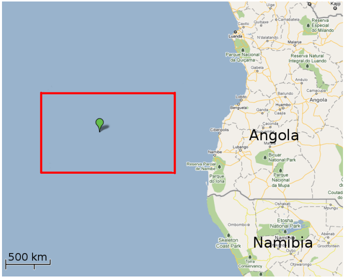
no inhomogeneity

- SET C: constant cloud droplet number concentration: $N_c = 200.\mathrm{cm}^{-3}$ (so that $r_e = 9\mu m$ at cloud top)

$$\tau = \left(\frac{9}{2}\pi N_c \rho_l^{-2}\right)^{1/3} \int_0^{+\infty} (\rho_a(z) q_l(z))^{2/3} dz$$

no inhomogeneity

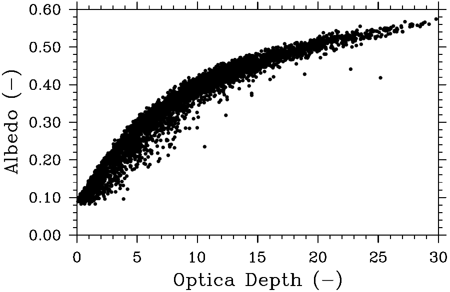
Dataset description



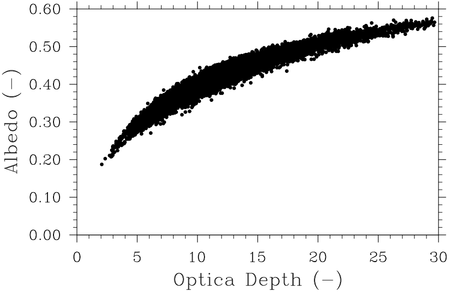
Area: 3-10 E and 12-16 S divided in 50×50 km^2.
Time: 4 measurements between 11.00 - 12.00 UTC.
Date: July 2006.

- GERB: radiative fluxes and albedo;
- SEVIRI: cloud cover, optical thickness and effective radius;
- OMI: aerosol index.

Conditional sampling

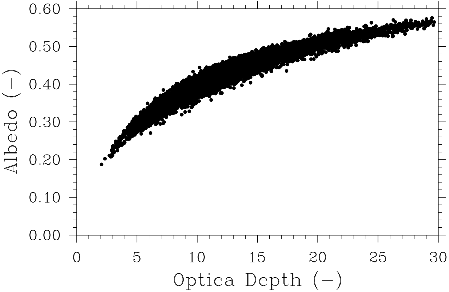


Conditional sampling



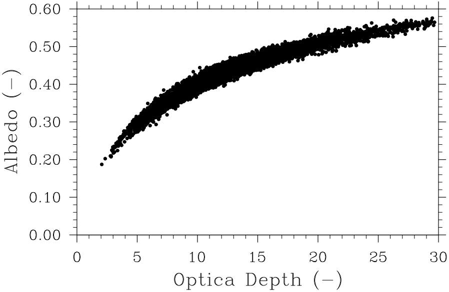
- just stratocumulus clouds: CC = 1.

Conditional sampling



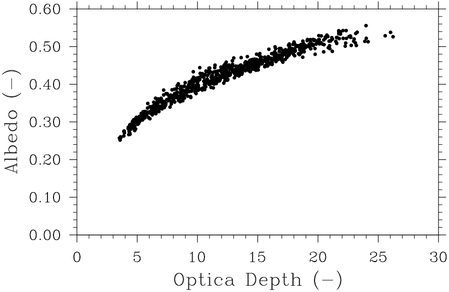
- just stratocumulus clouds: CC = 1.
- to exclude icy clouds: phase = 1.

Conditional sampling



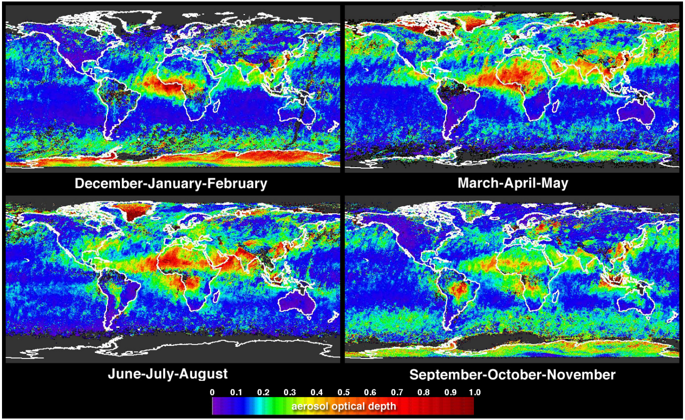
- just stratocumulus clouds: CC = 1.
- to exclude icy clouds: phase = 1.
- in order to reduce horizontal inhomogeneity: $\sigma_\tau/\overline{\tau} \leq 0.3$ and $\sigma_{LWP}/\overline{LWP} \leq 0.3$

Conditional sampling



- just stratocumulus clouds: CC = 1.
- to exclude icy clouds: phase = 1.
- in order to reduce horizontal inhomogeneity: $\sigma_\tau/\overline{\tau} \leq 0.3$ and $\sigma_{LWP}/\overline{LWP} \leq 0.3$
- in order to minimize the absorbing aerosol amount: aerosol index ≤ 0.5

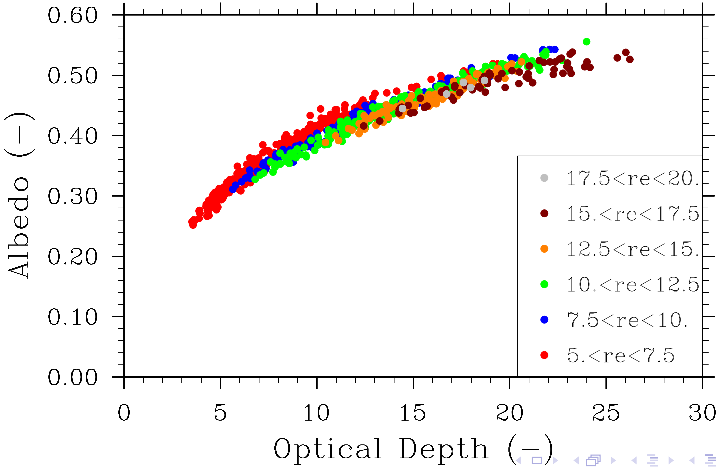
Aerosol optical thickness



Global summaries of aerosol optical thickness from the Multi-angle Imaging SpectroRadiometer (MISR)

NASA Langley Atmospheric Sciences Data Center

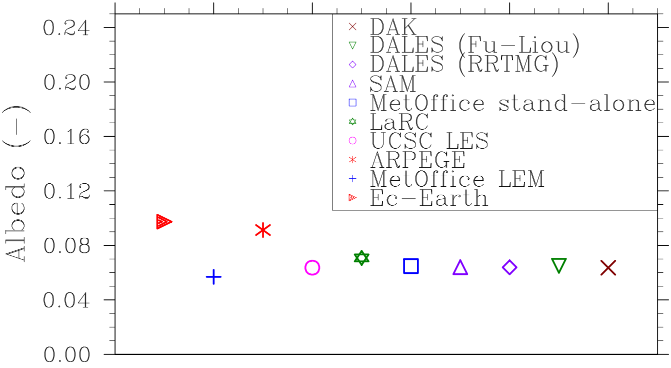
Effective radius effect



Participants

Participant	Model	Scheme
I. Beau (Meteo France)	ARPEGE (SCM)	Fouquart-Morcrette
P. Blossey (Washington University)	SAM (LES)	RRTMG
A. Cheng (SSAI, Inc./ LaRC, NASA)	LaRC (SCM)	Fu-Liou
S. Dal Gesso (KNMI)	Ec-Earth (SCM)	Fouquart-Morcrette
J. van der Dussen (TUD)	DALES (LES)	RRTMG
J. van der Dussen (TUD)	DALES (LES)	Fu-Liou
A. Lock (Met Office)	Met Office LEM (LES)	Edwards-Slingo
J. Manners (Met Office)	stand-alone (HadGEM3)	Edwards-Slingo
J. Petters (UCSC)	UCSC LES (LES)	CKD
P. Wang (KNMI)	stand-alone	DAK
W. Grabowski (NCAR) D. Klocke (ECMWF-MPI) M. Lefrebvre (LMDZ) R. Pincus (NOAA) B. Stevens (MPI)	(SCM) (SCM) (LES) (LES)	

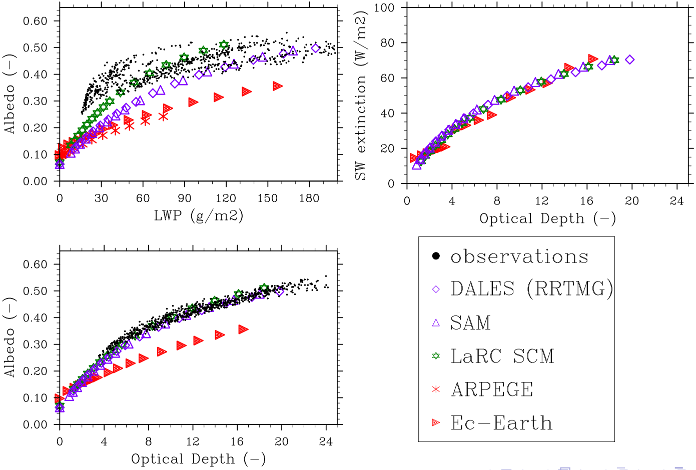
Albedo for clear sky case



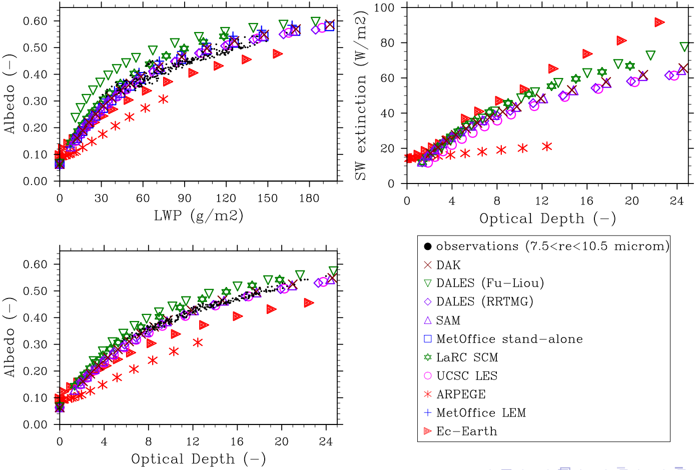
Set A: operational set-up

Participant	Scheme	$r_e(\mu m)$	inhomogeneity factor
ARPEGE (SCM)	Fouquart-Morcrette	*Martin et al. 1994*	0.7
SAM (LES)	RRTMG	14.	-
LaRC (SCM)	Fu-Liou	10.	0.7
Ec-Earth (SCM)	Fouquart-Morcrette	*Martin et al. 1994*	0.7
DALES (LES)	RRTMG	14.	-

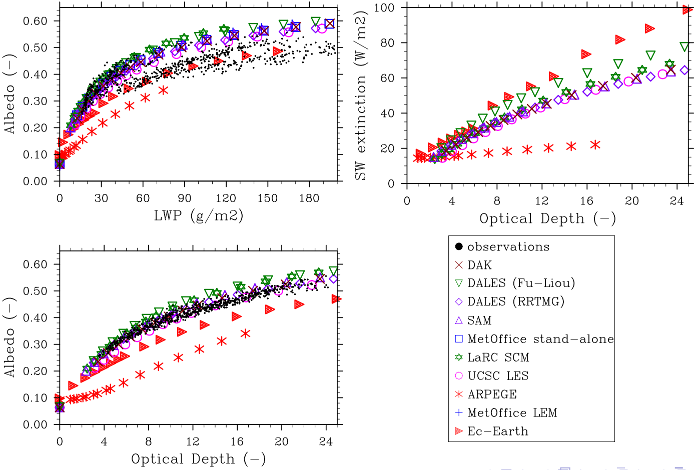
Set A: operational set-up



Set B: constant $r_e = 9\mu m$ (no inhomogeneity)



Set C: constant $N_c = 200.\mathrm{cm}^{-3}$ (no inhomogeneity)



Conclusions and outlook

Comments:

- ✔ spread in broadband albedo due to two factors:
  - ✓ set A: conversion from physical properties to optical properties
  - ✓ set B and C: difference in parametrization factors (single scattering albedo, asymmetry factor,...)
- ✔ CDK, RRTMG and DAK give similar results
- ✔ Fu-Liou gives higher albedo with respect to RRTMG
- ✔ Ec-Earth underestimates the albedo...

Conclusions and outlook

Comments:

- ✔ spread in broadband albedo due to two factors:
  - ✓ set A: conversion from physical properties to optical properties
  - ✓ set B and C: difference in parametrization factors (single scattering albedo, asymmetry factor,...)
- ✔ CDK, RRTMG and DAK give similar results
- ✔ Fu-Liou gives higher albedo with respect to RRTMG
- ✔ Ec-Earth underestimates the albedo...

Open questions and outlook:

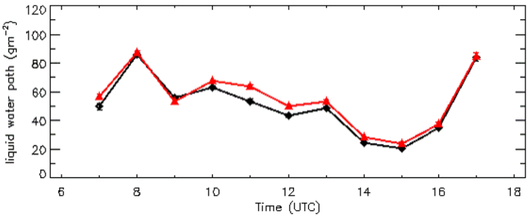
- ⇛ in order to compare observations and model results: which are the best constraints?
- ⇛ what about inhomogeneity? Is it necessary a set D?

For further informations:
http://www.euclipse.nl/wp3/Radiation_Intercomparison/Introduction.shtml
gesso@knmi.nl

Acknowledgements

Wouter Gruell's and Jan Fokke Meirink's help in setting up the case and providing the satellite data is gratefully acknowledged.

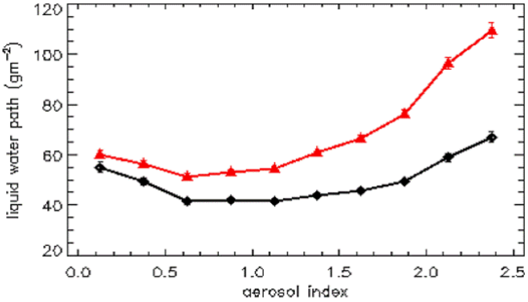
Sensitivity to vertical resolution



Diurnal cycle of Liquid Water Path over the stratocumulus [10oS-20oS, 0-10oE] domain, in Feb 2009. The Red line represents observations from the TMI instrument and the black line retrievals from SEVIRI with the CPP algorithm.

Courtesy of Seethala Chellappan (MPI)

Sensitivity to vertical resolution



Relationship between OMI aerosol index versus Liquid Water Path Aug 2008. The Red line represents observations from the TMI instrument and the black line retrievals from SEVIRI with the CPP algorithm.

Courtesy of Seethala Chellappan (MPI)

Sensitivity to vertical resolution