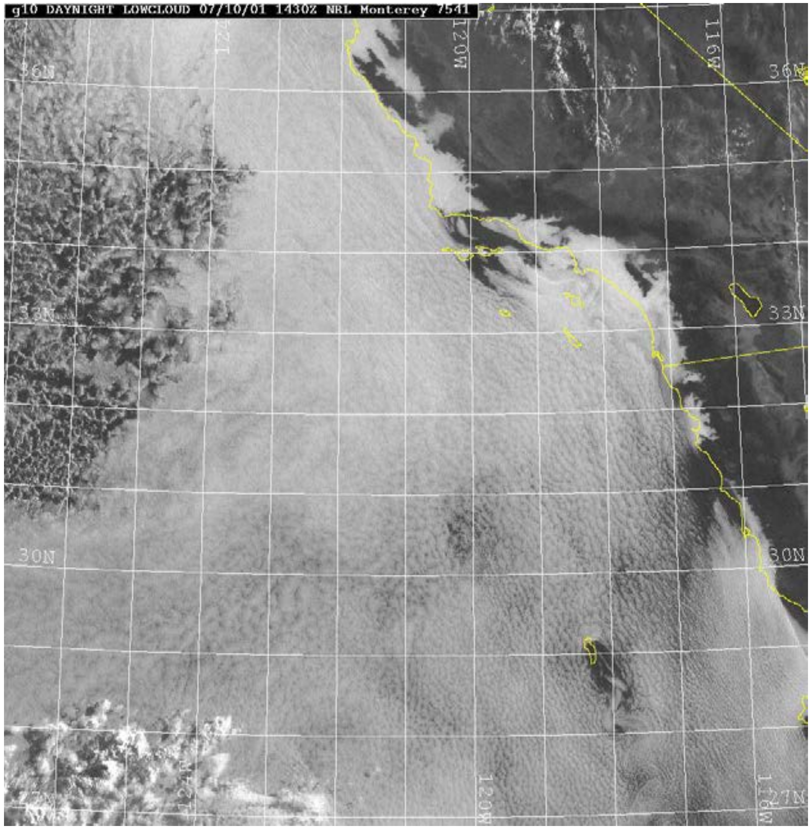
Update WP3: Process level evaluation



Results from observations, conceptual, single-column and large-eddy models

Deliverables

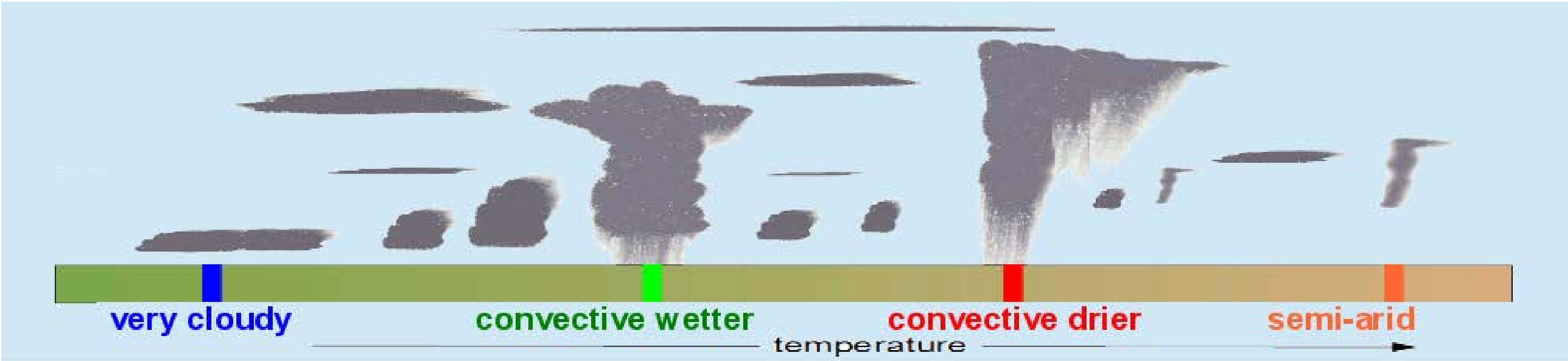
Interpretation of the spread of cloud and precipiation responses among models, in interaction with WP3 and WP4	D2.8	Jan. 2014	Report
Description of the set-up for the ASTEX, the GPCI stratocumulus and shallow cumulus, and the SCM equilibrium state cases	D3.1	July 2011	Description of Work
Storage of instantaneous 3D LES fields and key statistical variables in a public archive	D3.2	Feb. 2012	Report
Detailed analyses of the LES and SCM results for ASTEX and the two GPCI columns	D3.3	Jan. 2013	Report
Identifcation and comparison of the key quantities used in ESM parameterization schemes with LES results and observations	D3.4	Jan. 2013	Report
SCM equilibrium states in the Hadley circulation	D3.5	Jan. 2013	Report
Results at selected grid points (GCPI/CloudNet/ARM/AMMA)	D3.6	--	--
Comparison of the hydrological and energy balance and the cloud amount as computed by ESMs	D3.7	Aug. 2013	Article
Development and application of methods to exploit high frequency for understanding cloud feedbacks	D3.8	Jan. 2013	Report
Quantification of the cloud-climate feedback and its uncertainty for prescribed large-sale conditions	D3.9	Jan. 2013	Report

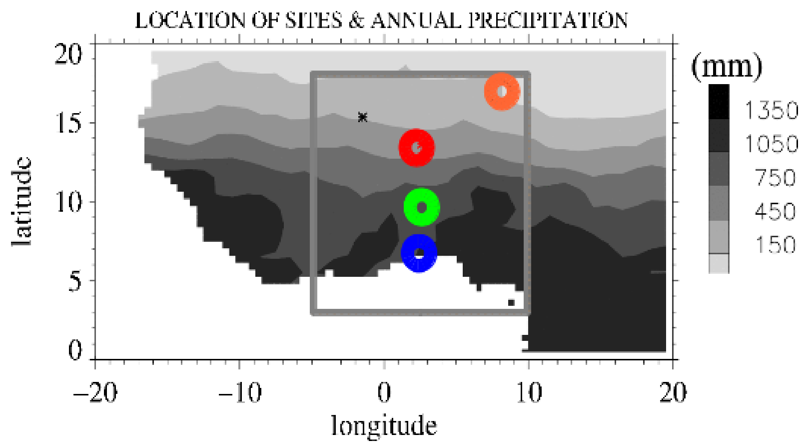
D3.6: Report will be submitted mid-July

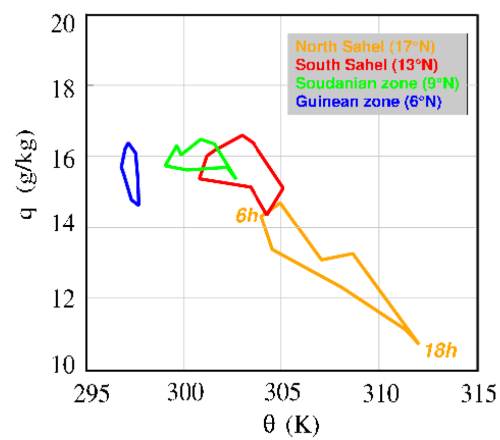
Dal Gesso, S., J. J. van der Dussen, A. P. Siebesma, S. R. de Roode, I. Boutle, H. Kamae, R. Roehrig, J. Vial, 2014b. A Single-Column Model intercomparison on the stratocumulus representation in present-day and future climate. To be submitted.

Neggers, R.A.J., and A. P. Siebesma, 2013: Constraining a system of interacting parameterizations through multiple-parameter evaluation: tracing a compensating error between cloud vertical structure and cloud overlap. *J. Clim.*, 26, 6698-6715.

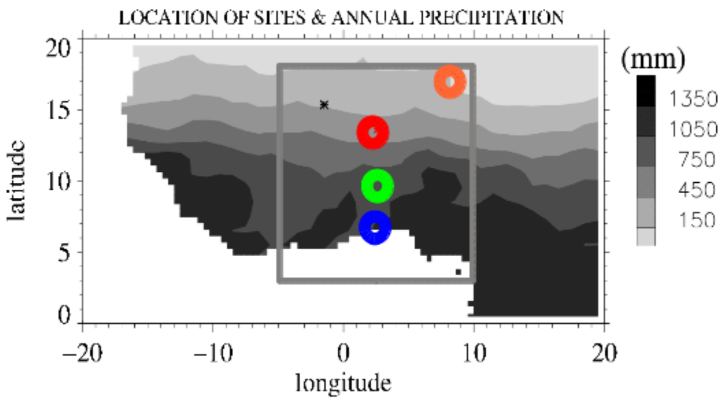
New results on AMMA (Francoise Guichard and colleagues)

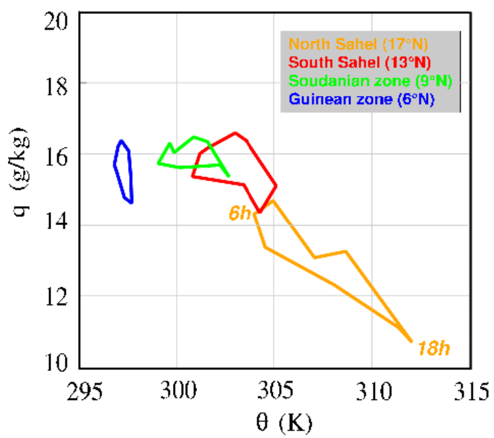


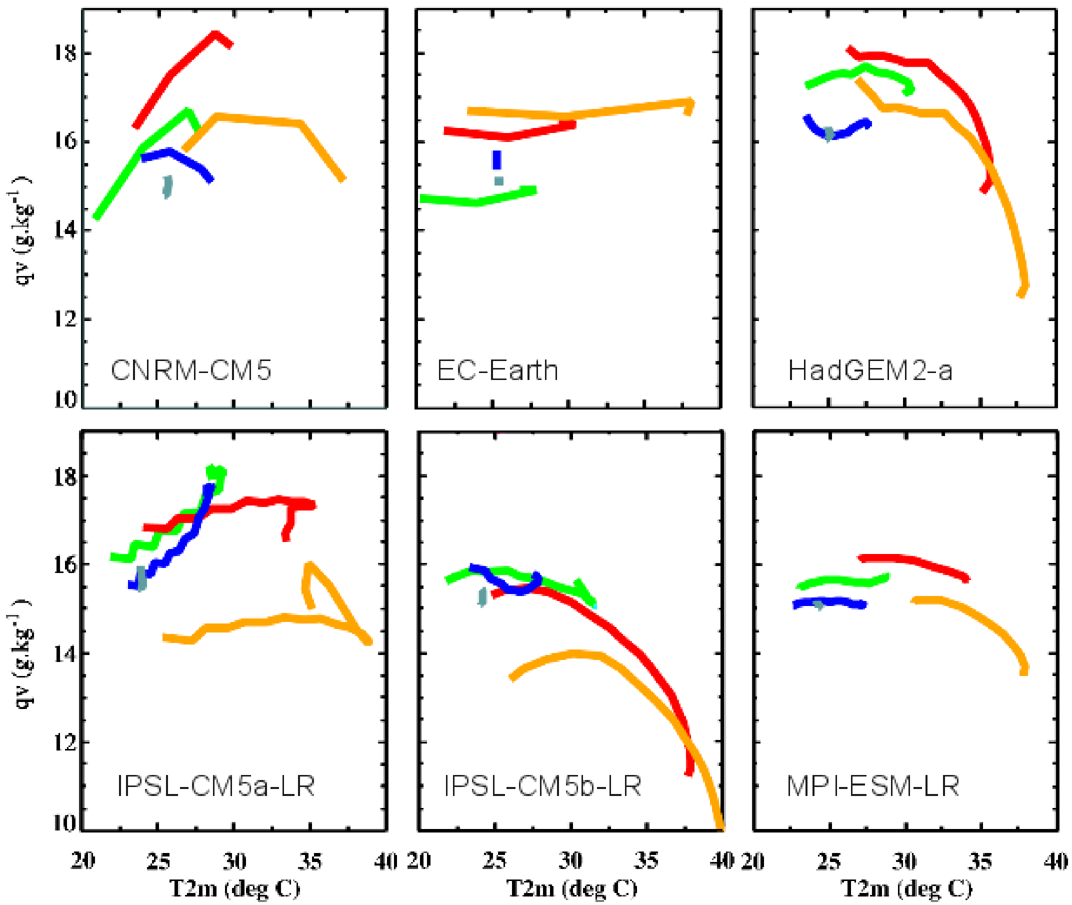




AMMA: *Observed joint diurnal fluctuations of potential temperature and water vapour mixing ratio in the lower atmosphere (0-500 m average), 10-day mean values at the four different types of location during the monsoon (Guichard and colleagues)*



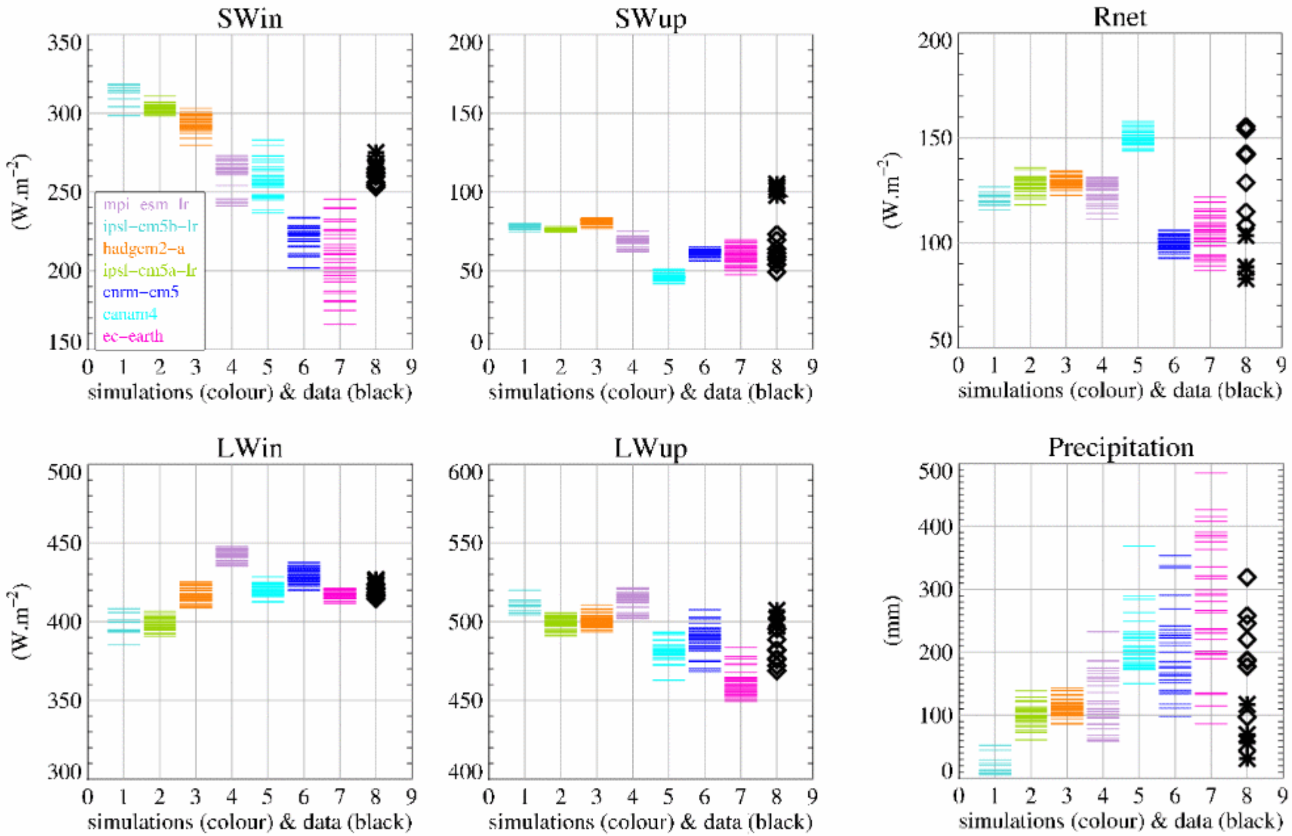




AMMA: *CMIP5 AMIP simulations and august-mean of 30-year series of T2m and q2m. Here, only daytime trajectories, from morning to afternoon are displayed, for clarity.*

IPSL-CM5b-lr, HadGEM2-a show a qualitative agreement with observations, in terms of daytime fluctuations

AMMA: *Each color identifies a model, and each horizontal segment corresponds to a different year. The values correspond to a 2-month average, spanning mid-July to mid-September (monsoon, Sahel region).*



1. model Rnet fall within same range as observations
2. Only 2 out of 6 models give right range for SWin
3. Larger SWin -> larger LWup
4. large variation in SWin for clear skies (not shown)

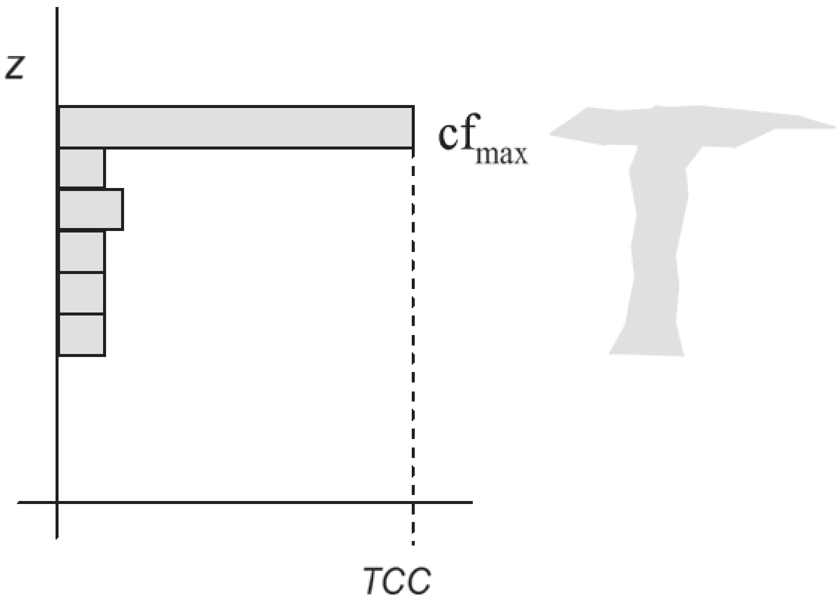
Results at selected grid points: example from CloudNet

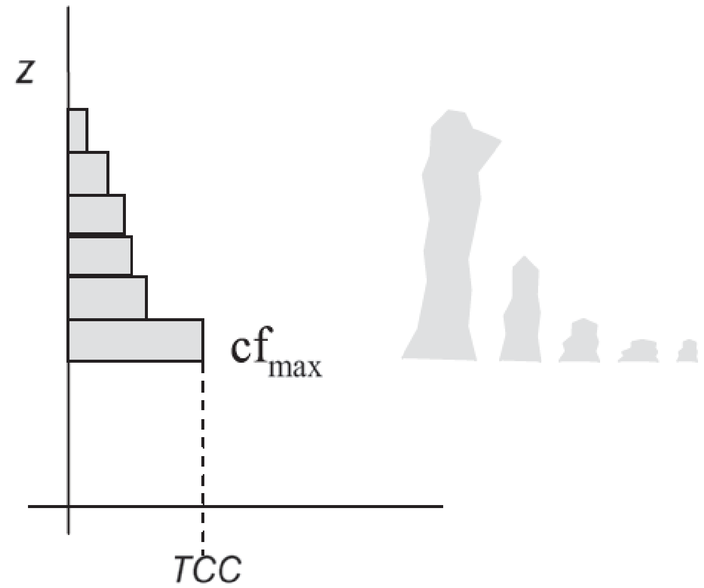
TABLE 1. Set of observed and LES-diagnosed parameters at Cabauw used in the SCM evaluation. sfc: surface; BSRN: Baseline Surface Radiation Network.

	Parameter	Abbreviation	Units	Instrument
1	Total cloud cover	TCC	%	CloudNet
2	Downward shortwave radiative flux at sfc	SW_d	$W m^{-2}$	BSRN
3	Downward longwave radiative flux at sfc	LW_d	$W m^{-2}$	BSRN
4	Sensible heat flux at 5 m	SHF	$W m^{-2}$	Sonic anemometer and thermometer
5	Latent heat flux at 5 m	LHF	$W m^{-2}$	Sonic anemometer and optical open-path sensor
6	Soil temperature at 0 cm	T_{soil}	K	KNMI nickel-wired needles
7	Air temperature at 2 m	T_{2m}	K	KNMI Pt500
8	Air temperature at 200 m	T_{200m}	K	KNMI Pt500
9	Lowest cloud-base height	z_{base}	m	LD40 ceilometer and LES
10	Maximum cloud fraction within BL	cf_{max}	%	LES
11	Height of maximum cloud fraction	z_{cfmax}	m	LES
12	Cloud overlap ratio	$r_{overlap}$	—	LES

Neggers and Siebesma (2013)

Observations and LES results for Cabauw point at importance of appropriate cloud overlap function used in RACMO





old scheme

* too few clouds but too large cloud cover

* compensating errors give about right surface radiation

new scheme

* better cloud amount

* no improvement in surface radiation (random maximum overlap in radiation scheme gives too large cloud cover)

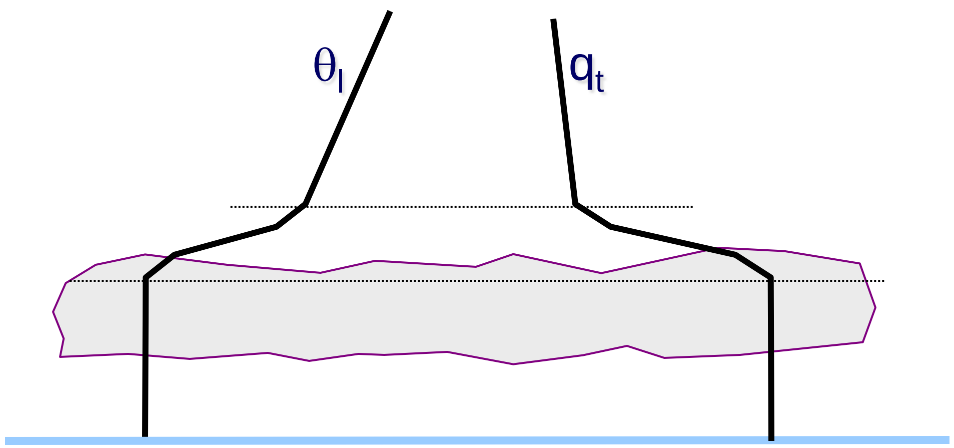
Inversion structure and stratocumulus break up

Kappa-TCC space

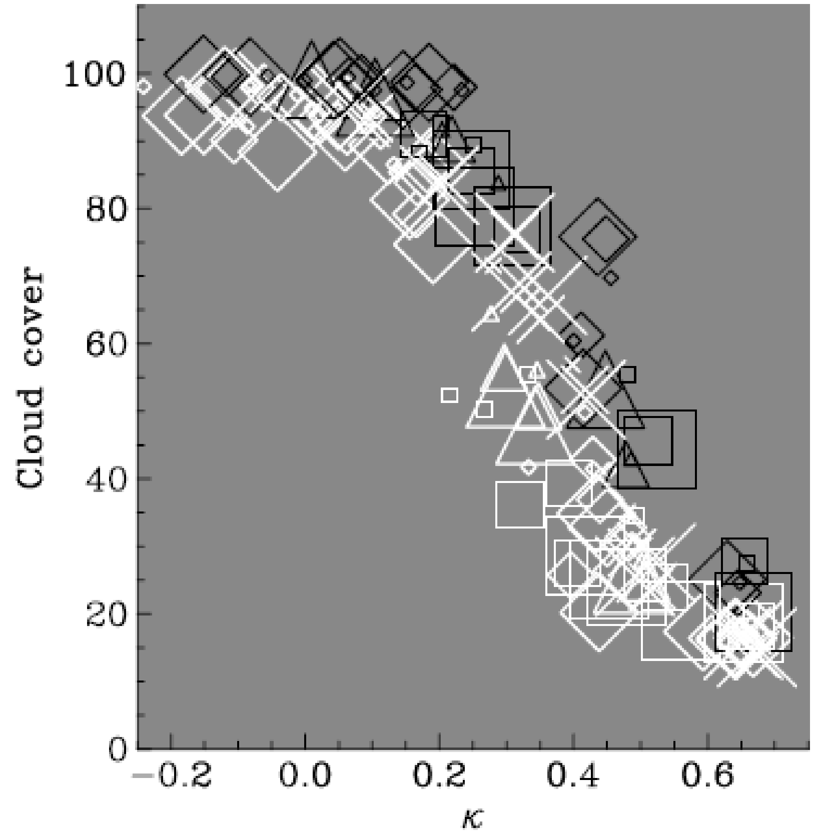
CTEI parameter

Kuo and Schubert (QJRMS, 1988)
Moeng (JAS, 2000)

$$\kappa = \frac{\Delta\theta_e}{(L/c_p)\Delta q_t} = 1 + \frac{\Delta\theta_\ell}{(L/c_p)\Delta q_t}$$



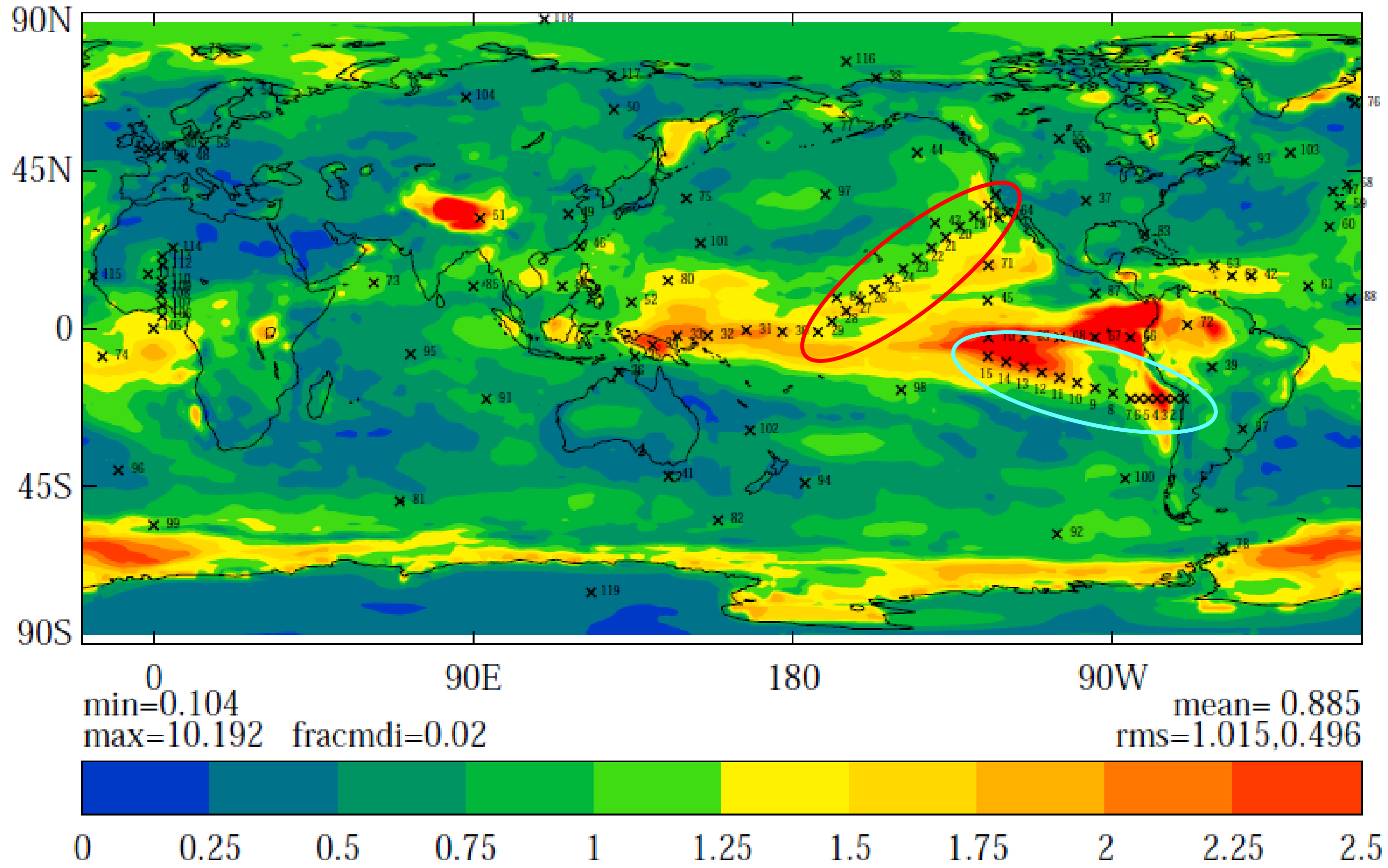
LES results *Lock (QJRMS, 2009)*



→ drier inversion layer

Moving up the model hierarchy: GCM

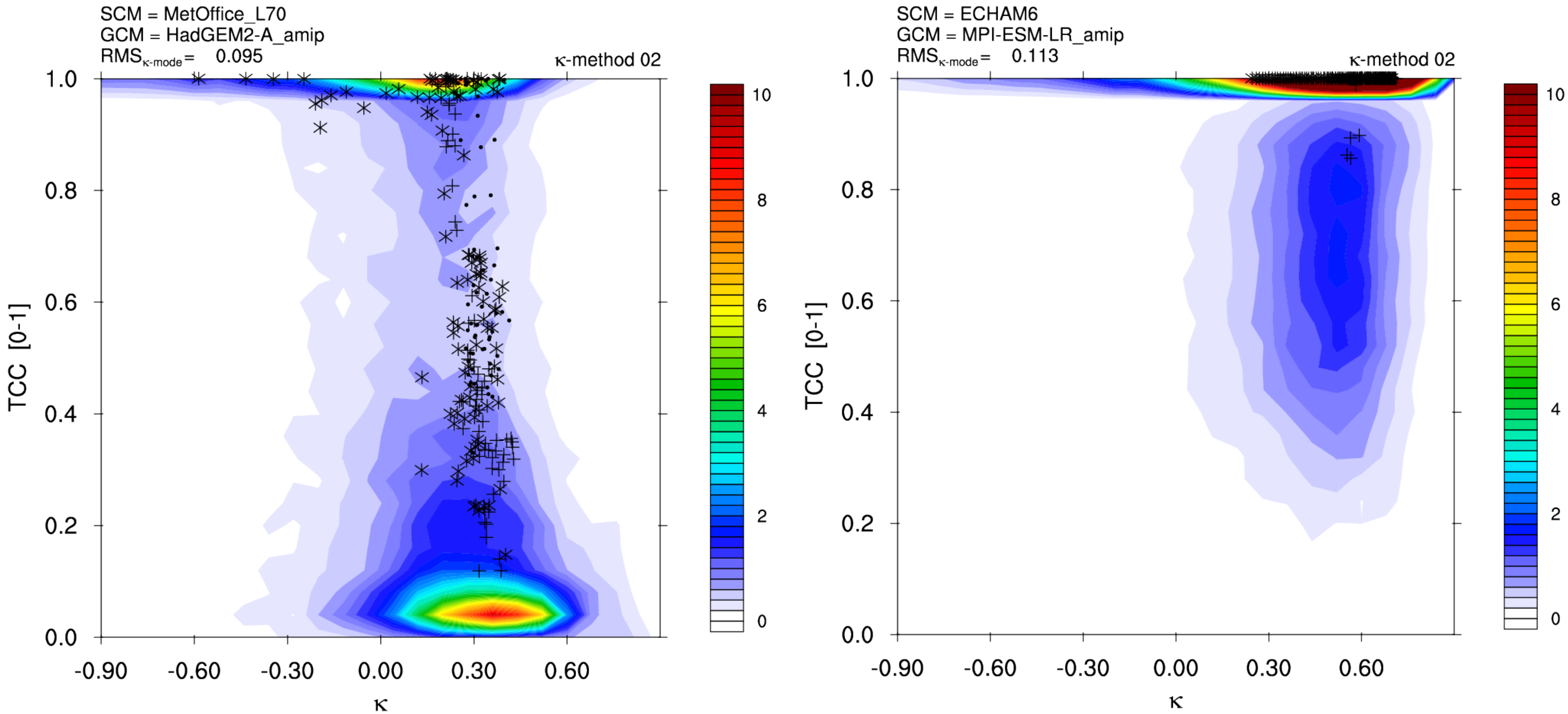
ESM output at selected gridpoints (CMIP5 AMIP)



CMIP5 AMIP

Location : Eastern Pacific (cfSites 1-29)

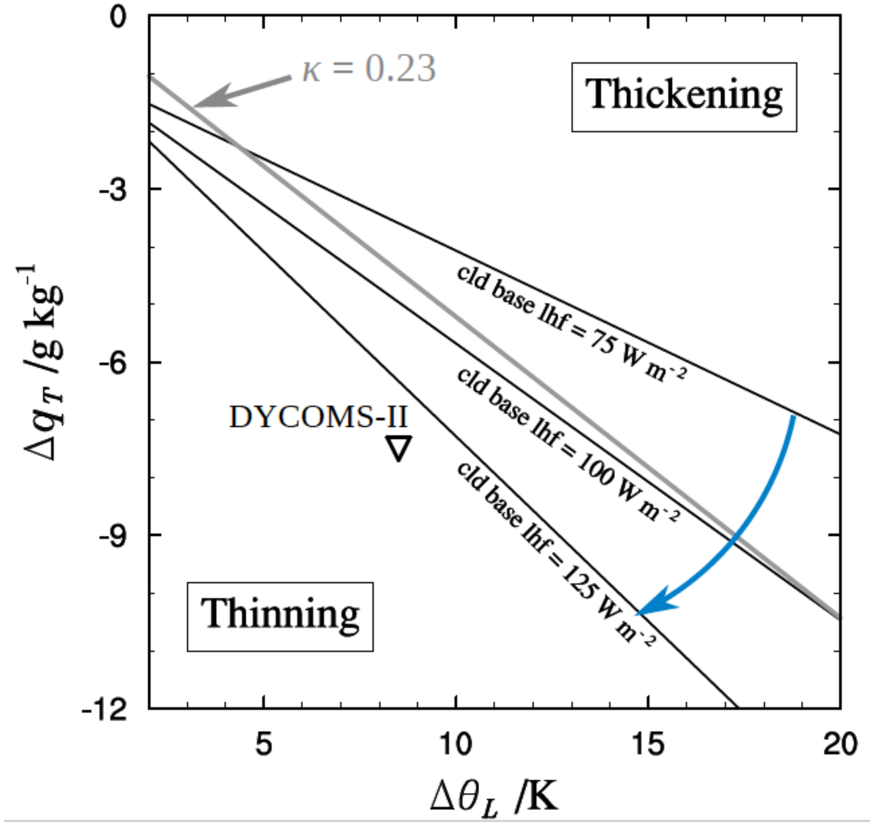
Period : 200509 - 200608



results are similar to SCM results from SCM Lagrangian transitions (crosses)

cloud thins for different values of κ

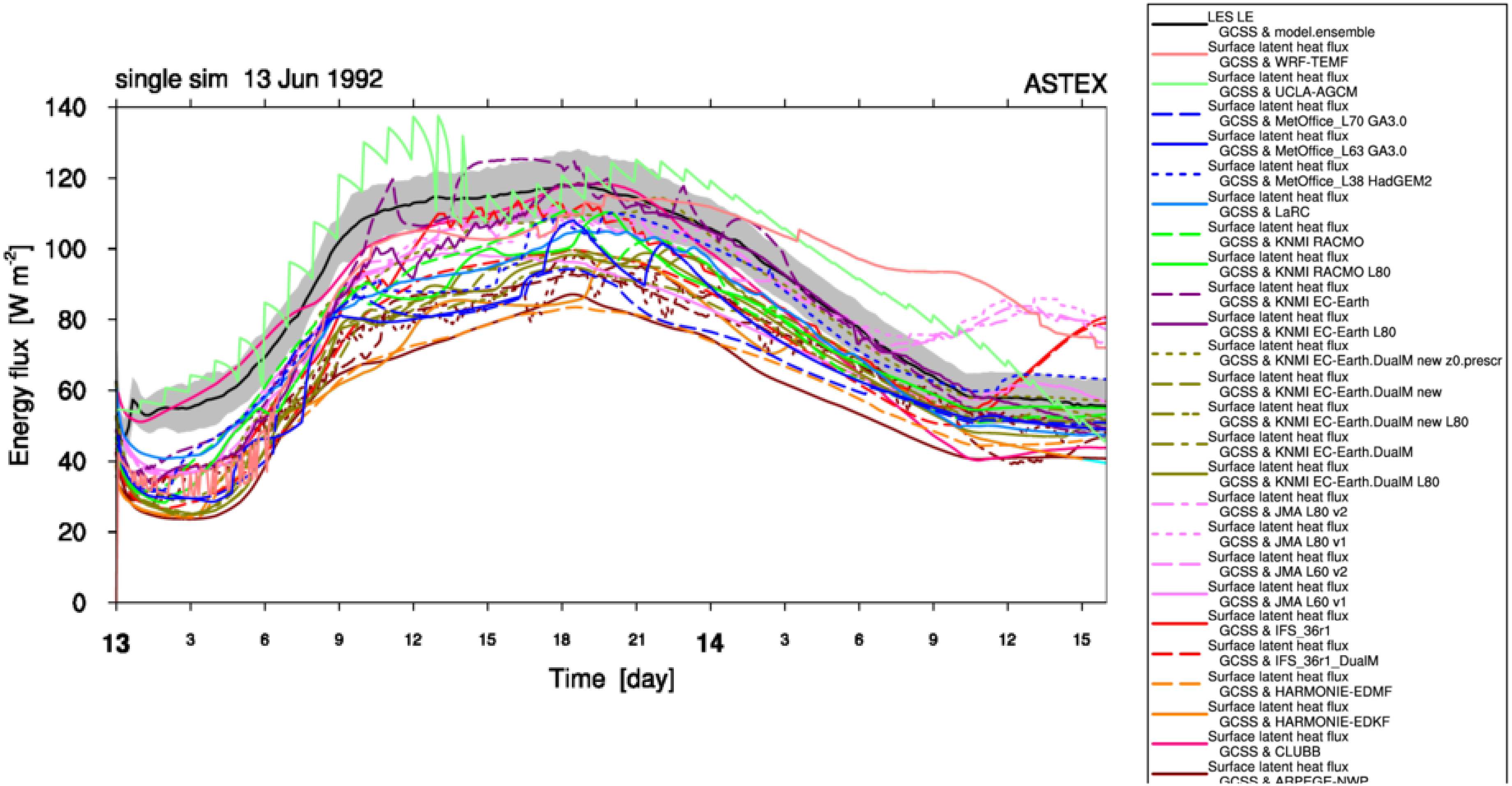
Example: larger cloud base moisture flux requires larger κ value



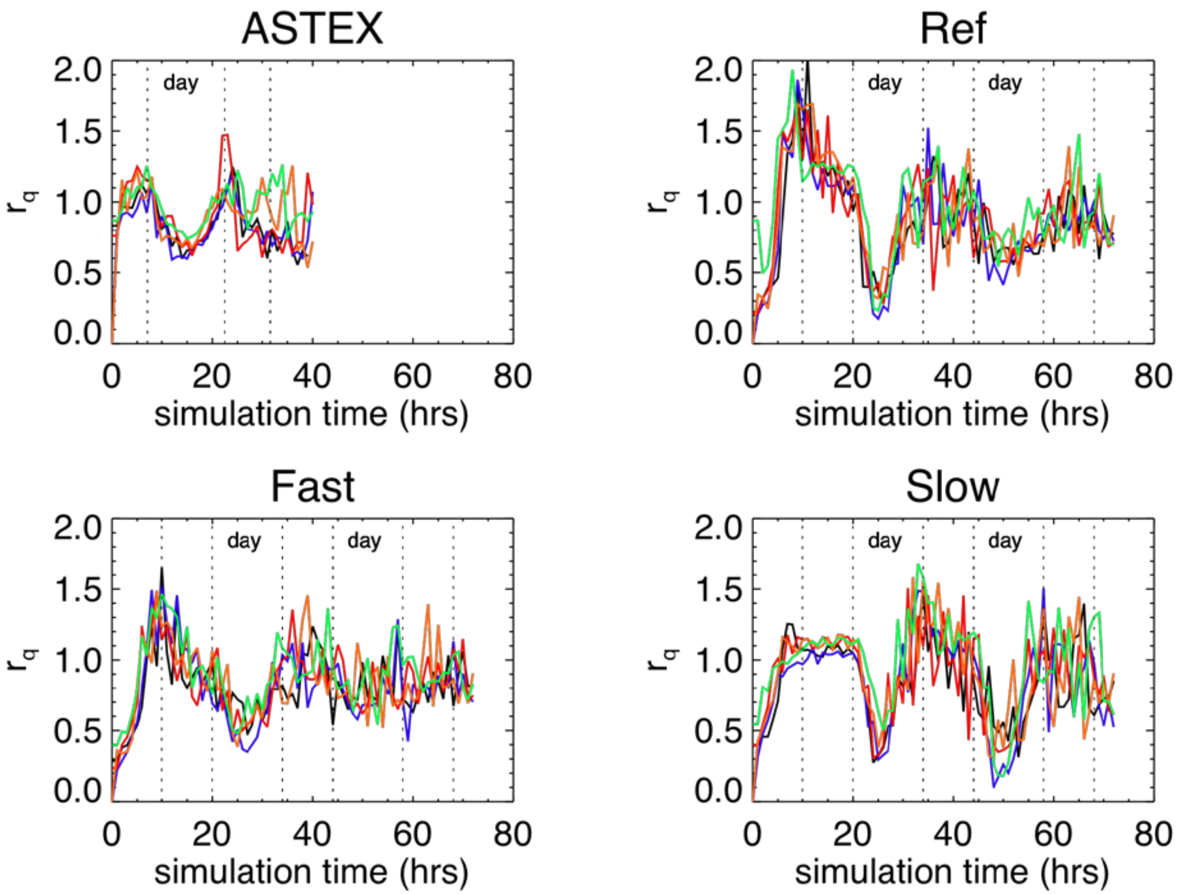
van der Dussen et al. (2014)

Latent heat flux during ASTEX

Spinup effects in surface evaporation as produced by most SCMs



Diurnal cycle of moisture flux at the top of the subcloud layer



$$r_q = \frac{\overline{w'q_T'}_{cb}}{\overline{w'q_T'}_{sfc}}$$

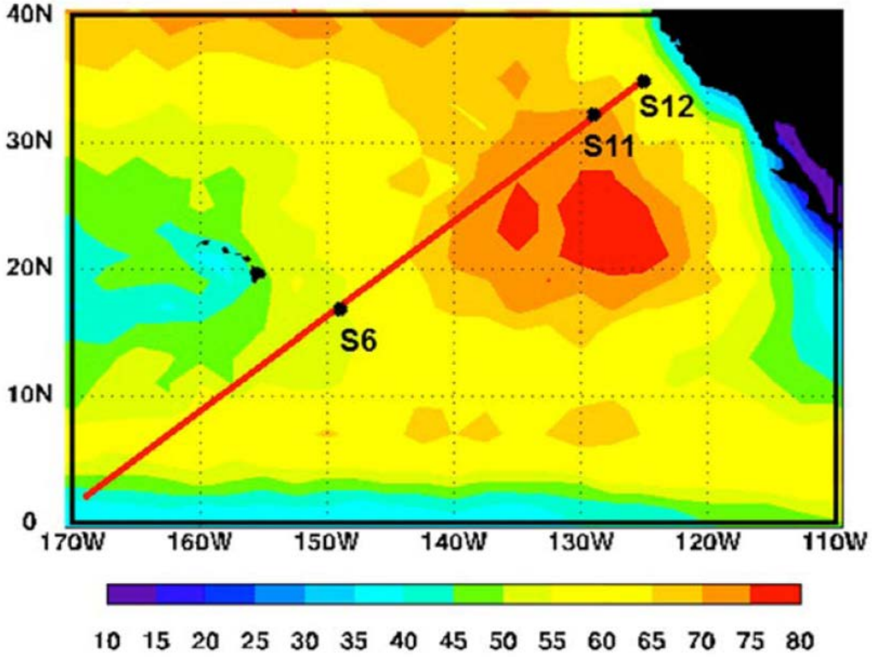
* Weakening of moisture transport at cumulus cloud base during day-time

* During the night cumulus are more actively removing moisture from subcloud layer

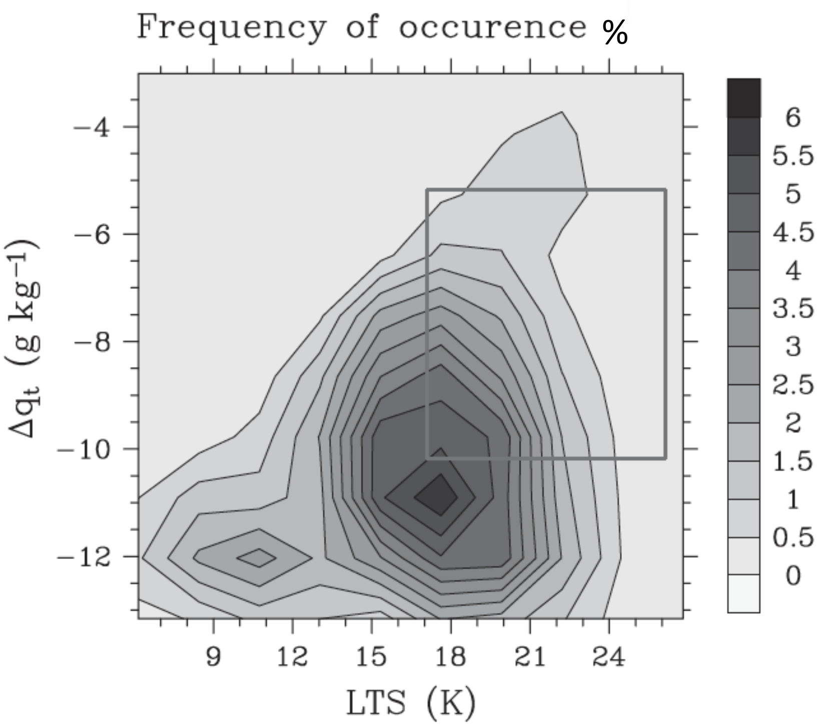
* Mean value r_q slightly smaller than 1

Past and ongoing activities: Phase space experiments

average summer low cloud amount

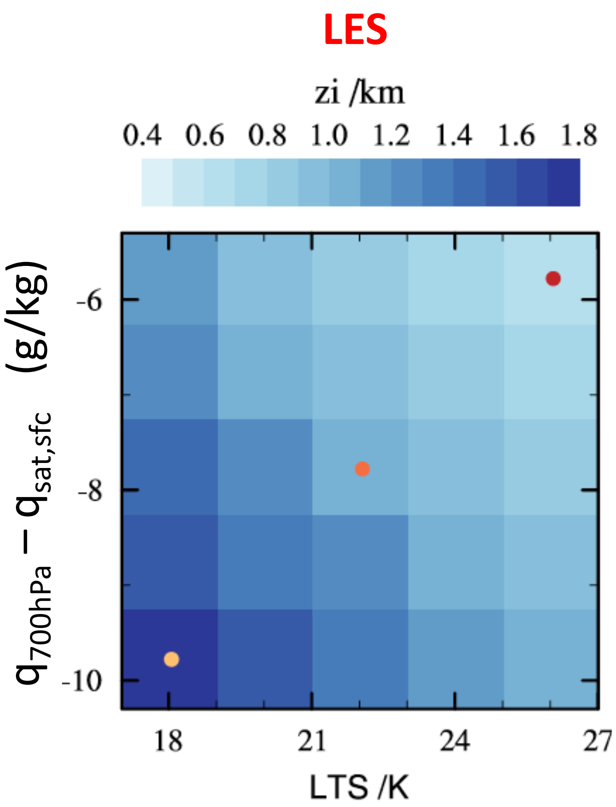


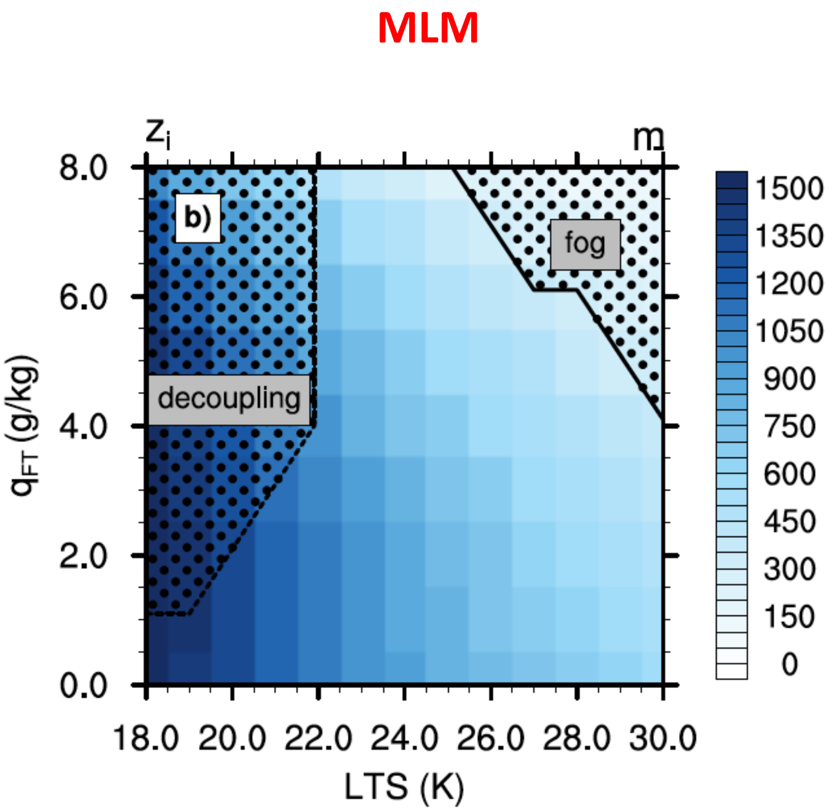
Zhang et al., 2013



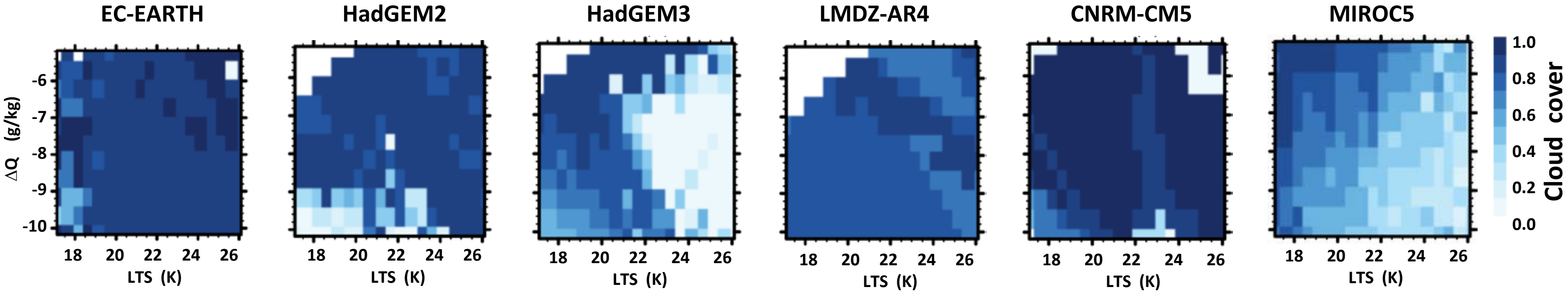
Gesso et al. (2013)

LES and Mixed-Layer Model (MLM) results in the LTS, q_{ft} phase space

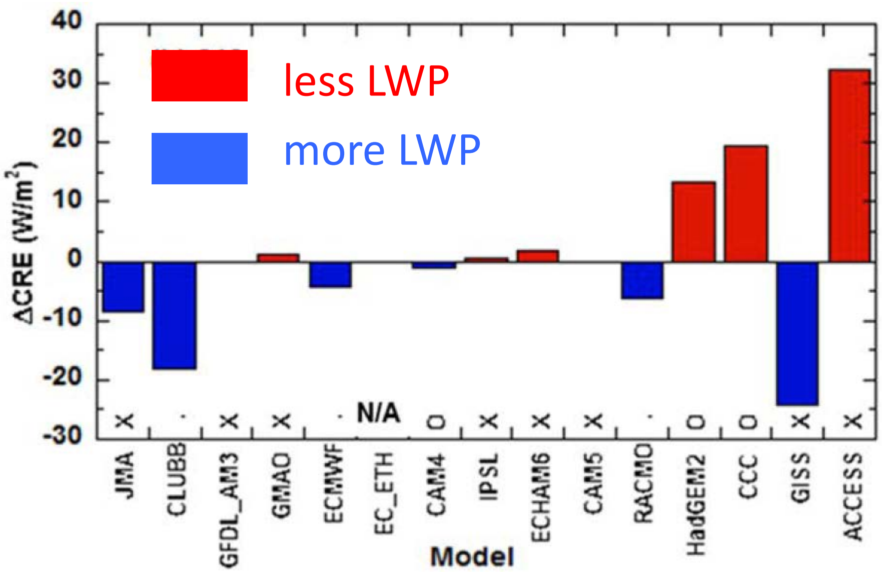




SCM cloud cover results in the LTS, q_{ft} phase space



CGILS SCM results at stratocumulus location ("S12")



Zhang et al., 2013

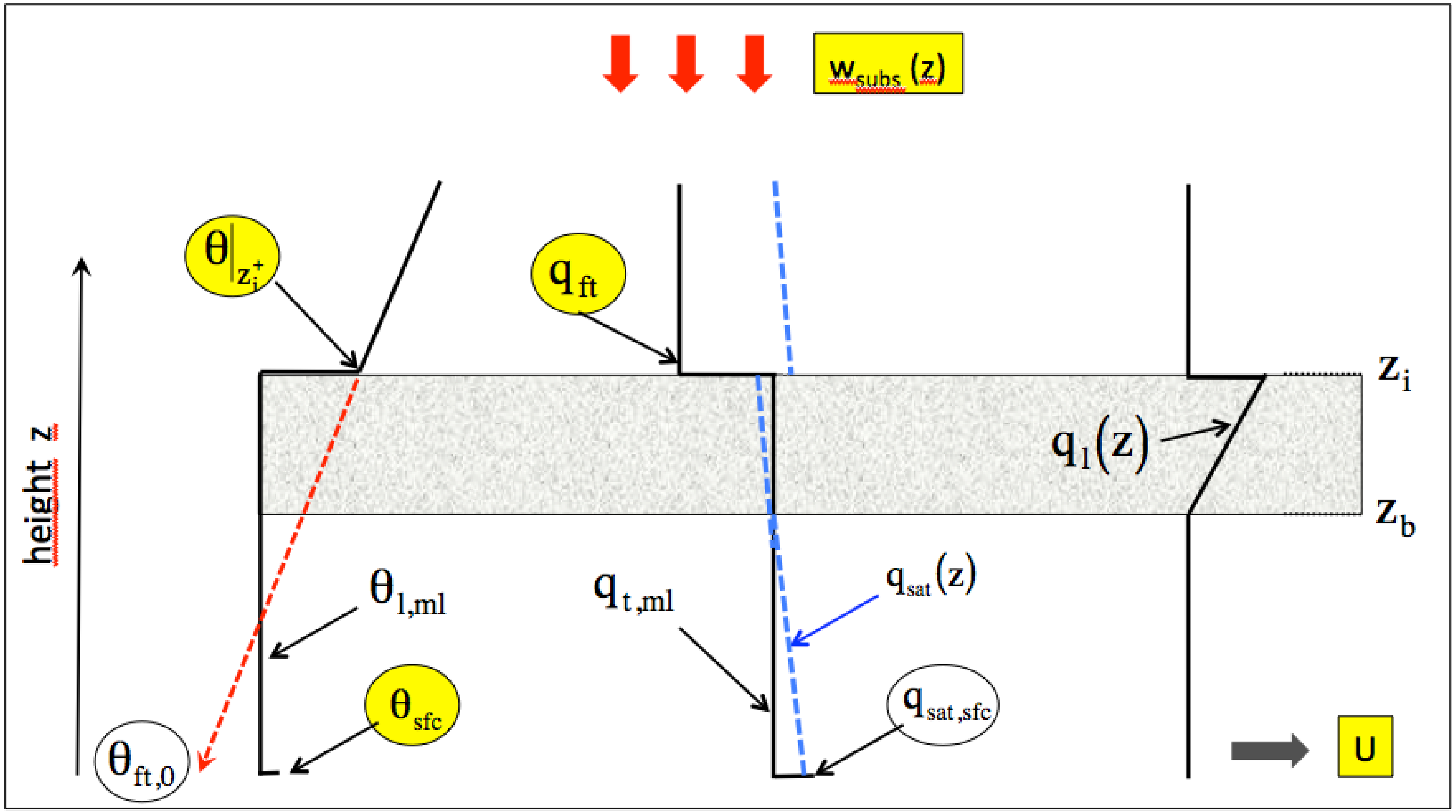
Model_ID	SH	LH
ACCESS	13.8 (−5.8)	58.9 (−2.8)
CAM4	24.7 (−0.6)	48.3 (4.6)
CAMS	−6.0 (0.2)	2.9 (0.3)
CCC	26.6 (−3.6)	54.4 (13.1)
CLUBB	25.8 (−1.6)	64.7 (11.4)
ECHAM6	−22.8 (1.9)	62.2 (2.9)
ECMWF	10.1 (−3.7)	68.1 (15.4)
EC_ETH*	−27.9 (43.7)	1.5 (32.8)
GFDL_AM3	−4.8 (1.1)	18.9 (2.6)
GISS	11.3 (−0.5)	59.9 (10.7)
GMAO	1.3 (0.2)	35.5 (2.1)
HadGEM2	17.0 (−1.8)	61.2 (7.2)
IPSL	25.0 (−1.6)	66.4 (5.4)
JMA	27.0 (−0.4)	62.3 (4.9)
RACMO	20.2 (−3.5)	68.2 (11.9)

changes for perturbed climate

Perturbed climate in SCMs:

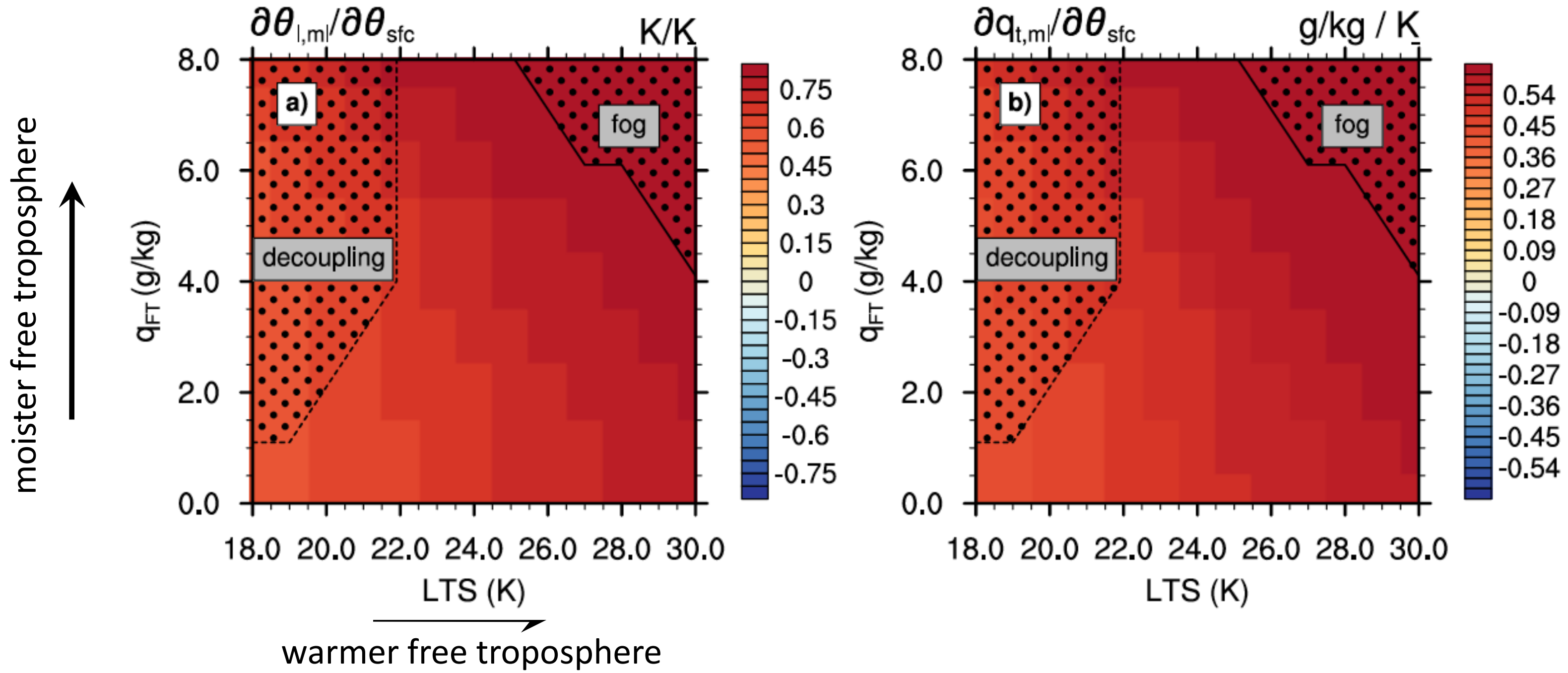
* LWP:	both larger and smaller results
* Sensible heat flux:	mainly smaller
* Latent heat flux:	increase

Stratocumulus representation in a mixed layer model



Boundary layer thermodynamic response to increase in SST (θ_{sfc})

entrainment fixed to control case value



$$\frac{\partial\theta_{l,ml}}{\partial\theta_{sfc}} = \frac{C_d U}{w_e + C_d U} < 1$$

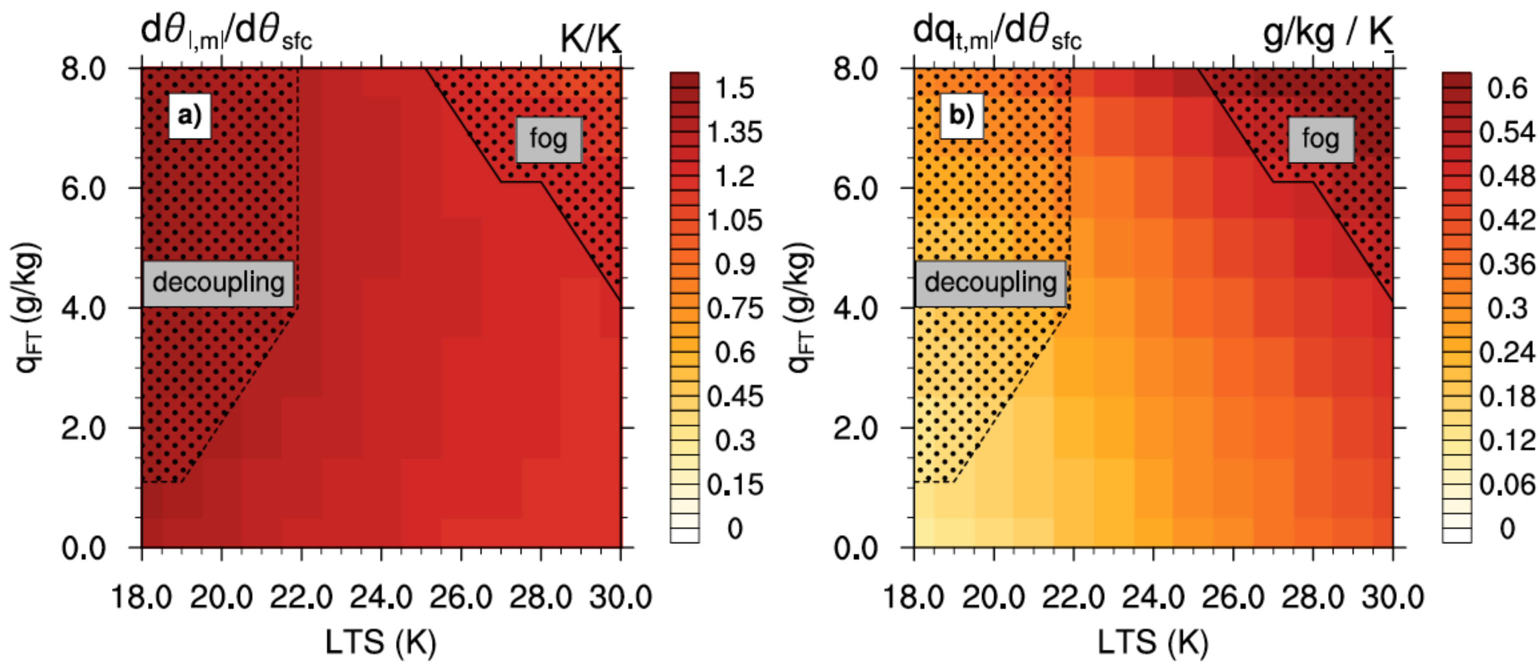
SHF increase

$$\frac{\partial q_{sat,sfc}}{\partial\theta_{sfc}} = 0.76 \quad g/kg/K$$

LHF increase

Boundary-layer and surface flux response to SST increase

(including entrainment response)



BL warms more than SST,
so **SHF will decrease**

BL moistening less than at surface,
so **LHF will increase**

D2.8: Interpretation of the spread of cloud and precipiation responses among models, in interaction with WP3 and WP4

Conclusions

Lagrangians

* LES results compare well with observations (ASTEX)
* distinct diurnal cycle in moisture flux at cumulus cloud base height
* cloud break up interplay between surface-based (moisture) fluxes and entrainment

CGILS and its spin-off results

* we better understand the effect of entrainment/convection scheme on sign feedback of LWP, surface heat fluxes

Observations have helped to identify weaknesses in parameterizations

* AMMA: surface energy balance, surface-boundary layer coupling, radiation and precipitation
* CloudNet/Testbed: e.g. cloud fraction and cloud overlap