GABLS 3 SCM intercomparison and evaluation
What did we learn?

Fred Bosveld and Peter Baas (KNMI),
Gert-Jan Steeneveld and Bert Holtslag (WUR)

With contributions of:

Wayne Angevine, Eric Bazile, Martin Koehler, Cisco de Bruijn, John Edward, Gunilla Svensson, Michael Ek, Frank Freedman, Vincent Larson, Geert Lenderink, Jocelyn Mailhot, Jon Pleim, Matthias Raschendorfer, Juergen Helmert, Sander Tijm, Joshua Fasching, Sukanta Basu, Daniel Deca, Jocelyn Mailhot.

GABLS 3 SCM intercomparison and evaluation

What did we learn?

Content

1. Case set-up
2. Model Results
3. Alternatives in case designs

(1) Case requirements.

- Single Column Model and LES case
- "Ideal case"
- Evening and morning transition
- Well defined inertial oscillation
- Flat and homogeneous terrain
- Atmosphere-Land surface-Radiation interaction
- Accurate prescription of forcings to allow for direct evaluation with observations

Cabauw Observational Program.

1986-1996 and 2001-2011

CESAR consortium (8 Institutes)

Land-Atmosphere observations

- Flat terrain
- Dominated by grassland (10 km scale)
- Tower profiles of wind, temperature and humidity
- Wind profiler
- Surface radiation components
- Surface energy budget components
- Soil thermal and water
- Tower turbulent fluxes
- Radio sounding De Bilt (25 km) from Cabauw

www.cesar-observatory.nl

including data portal

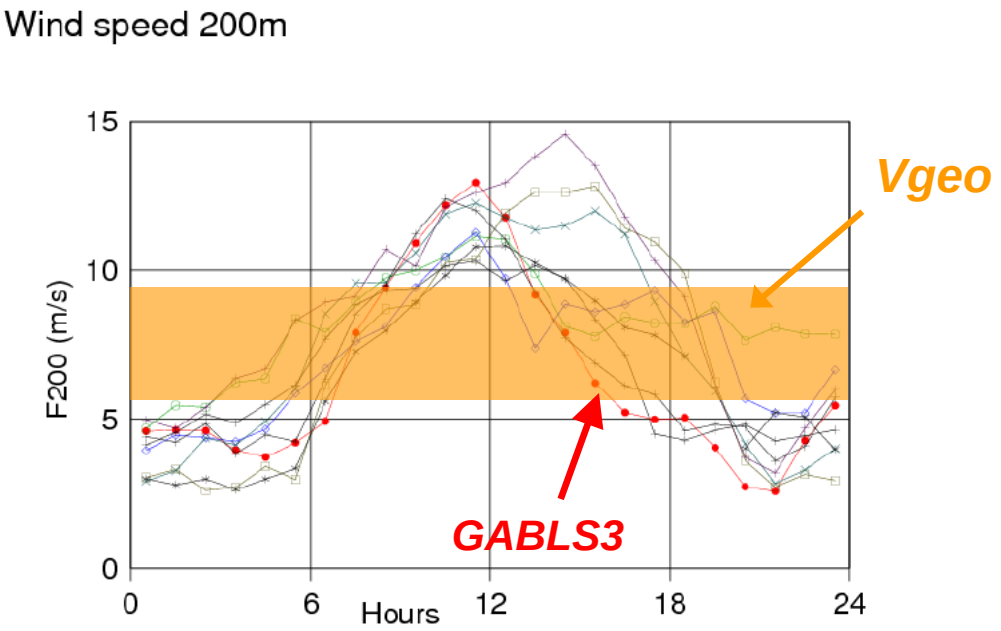
Case selection

- Simulation period
- 1-2 July 2006, 12 – 12 UTC (24 h)

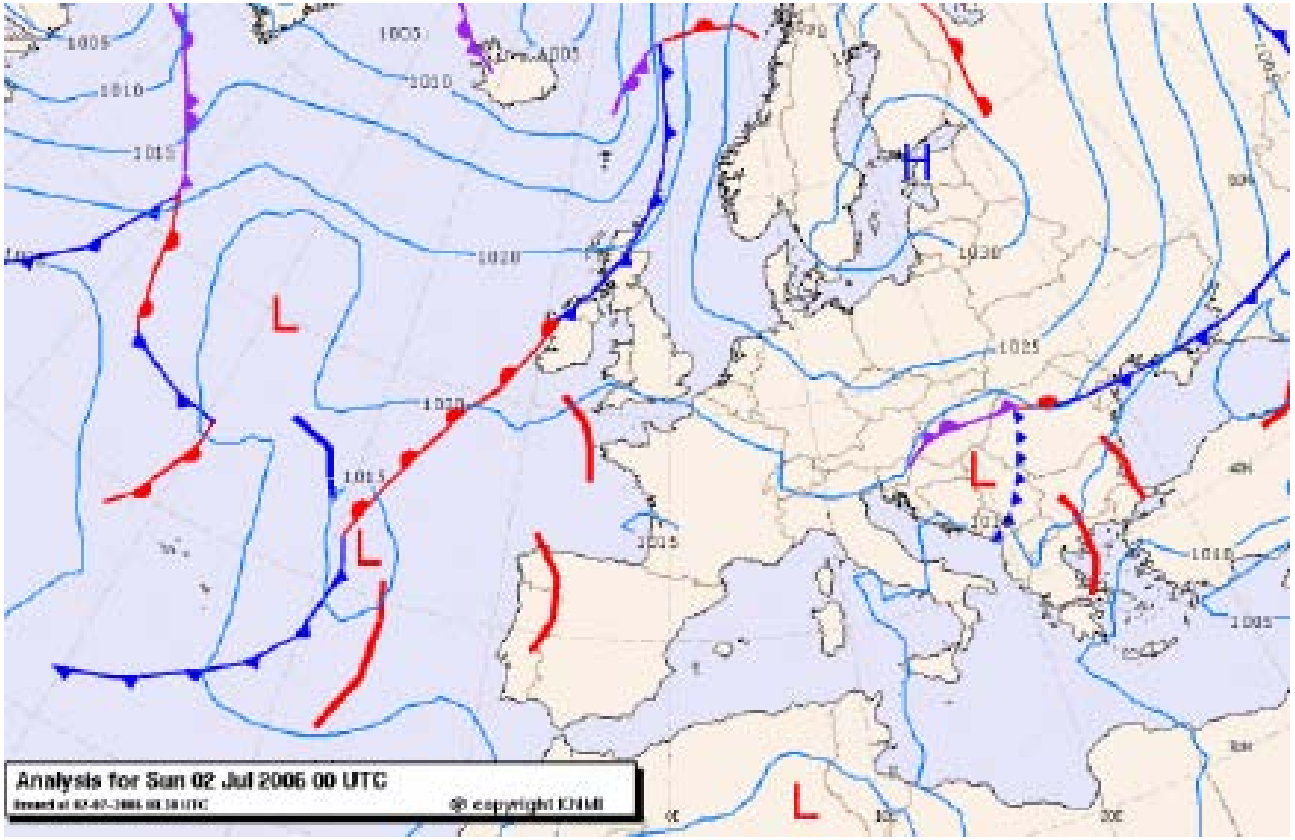
- To do
- Initial Conditions
- Soil / vegetation specifications
- Atmospheric forcings.

- Tools
- 12 hourly soundings from De Bilt
- Observations from the site
- Various 3D NWP models

Wind speed 200 m for 9 selected nights



Synoptical situation



Initial and boundary conditions

Initial conditions:

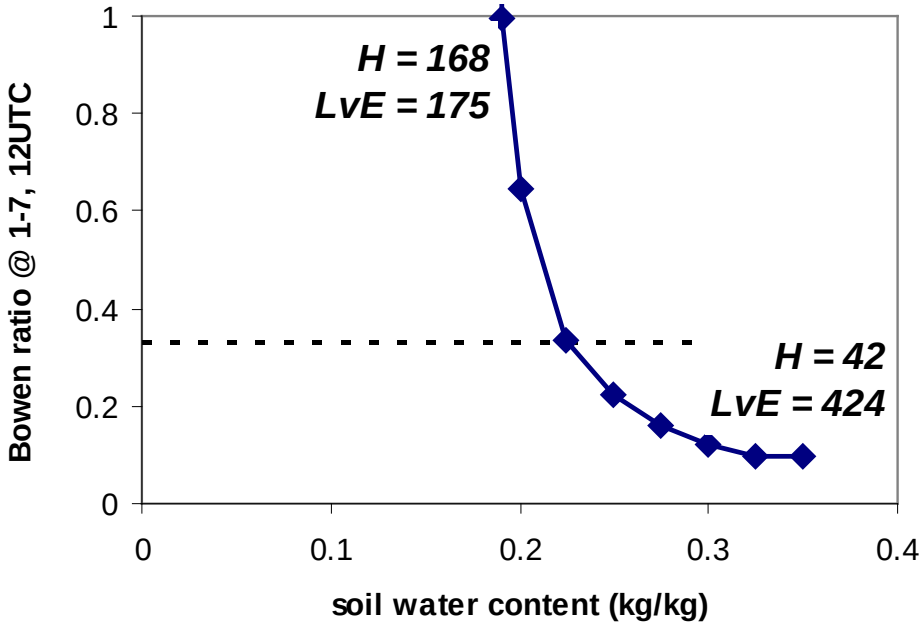
from tower, radiosonde and soil observations

Land Surface parameters:

Albedo = 0.23 (observed)
Emissivity =0.99 (literature)
z0m = 0.15 m (meso-scale, observed)
z0h = 0.0015 m (5% of local scale z0m=0.03m, observed)
Vegetation fraction: 100% grass
Leaf area index: LAI = 2.
soil type = clay. 45% clay, 8% organic matter, no sand.
soil water content at field capacity is 0.47 m3/m3

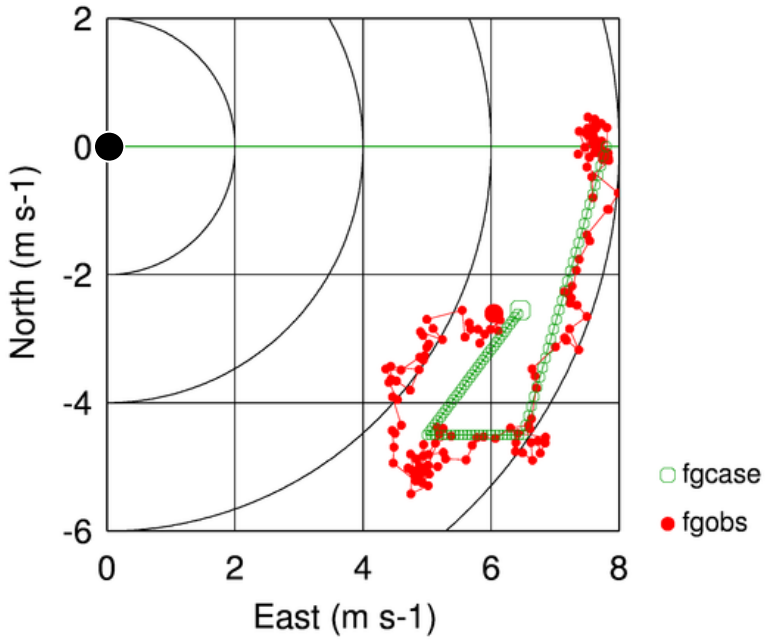
What about *soil moisture?*

Tuning parameter to get correct sensible and latent heat fluxes at start of simulation (Bow = 0.33).

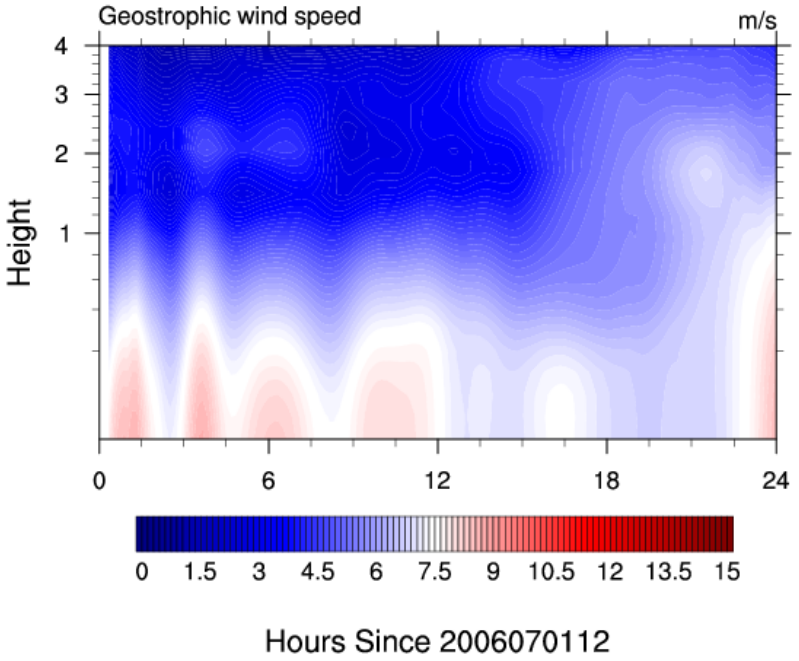


Geostrophic wind

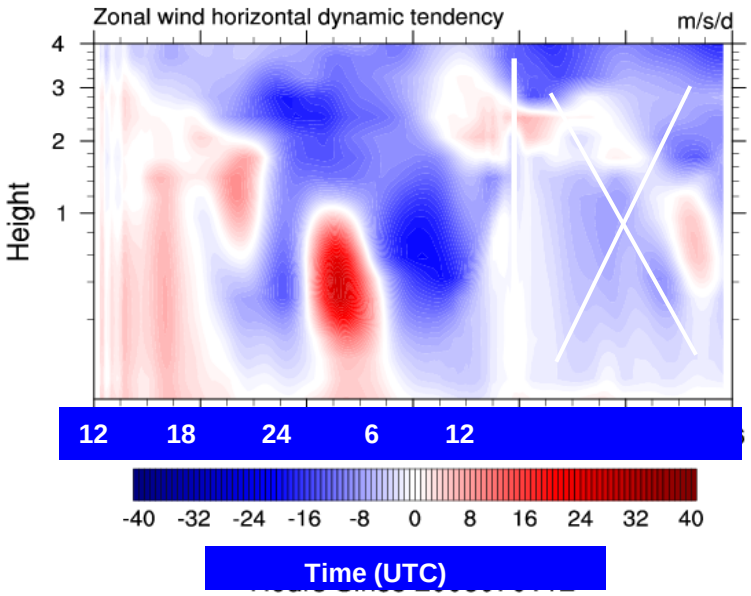
Surface geostrophic forcing from surface pressure network the Netherlands



Geostrophic forcing from 3D NWP (RACMO)



Derivation of momentum advection



Assume full decoupling of 200 m level from the surface from sunset to sunrise.

$$\frac{du}{dt} = \vec{v} \bullet \vec{\nabla} u + f(v - v_G)$$

$$\frac{dv}{dt} = \vec{v} \bullet \vec{\nabla} v - f(u - u_G)$$

Derivation of momentum advection

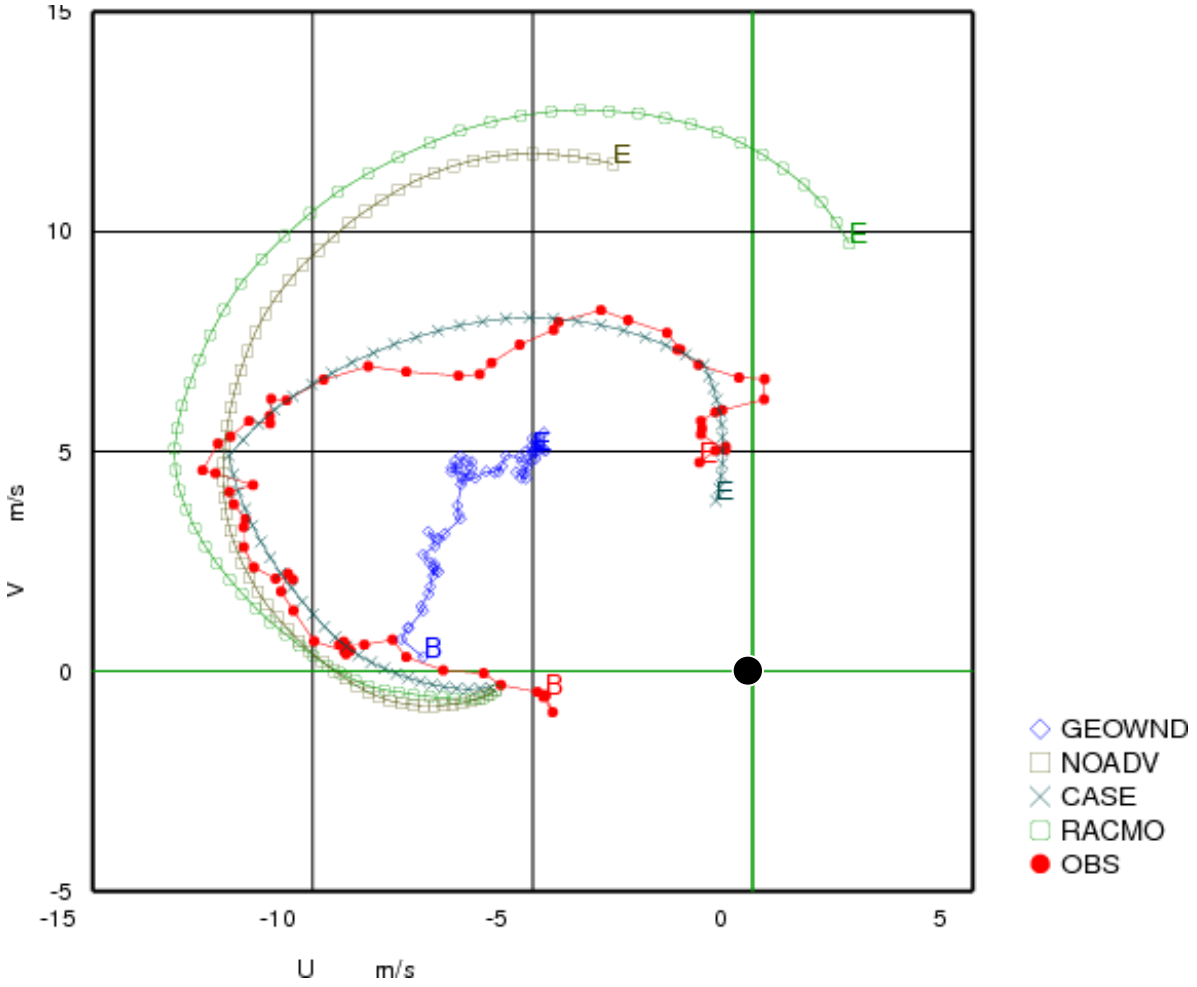
Evolution of Horizontal wind at 200 m.

Observations (OBS) and when RACMO-3D and CASE advection is applied on sunset wind vector.

Also shown is evolution when no advection is applied (NOADV)

and shown is the Geostrophic wind evolution (GEOWND).

B indicates begin of time series (sunset) and E indicates end of time series (11 hours later).



Conclusions on case set-up

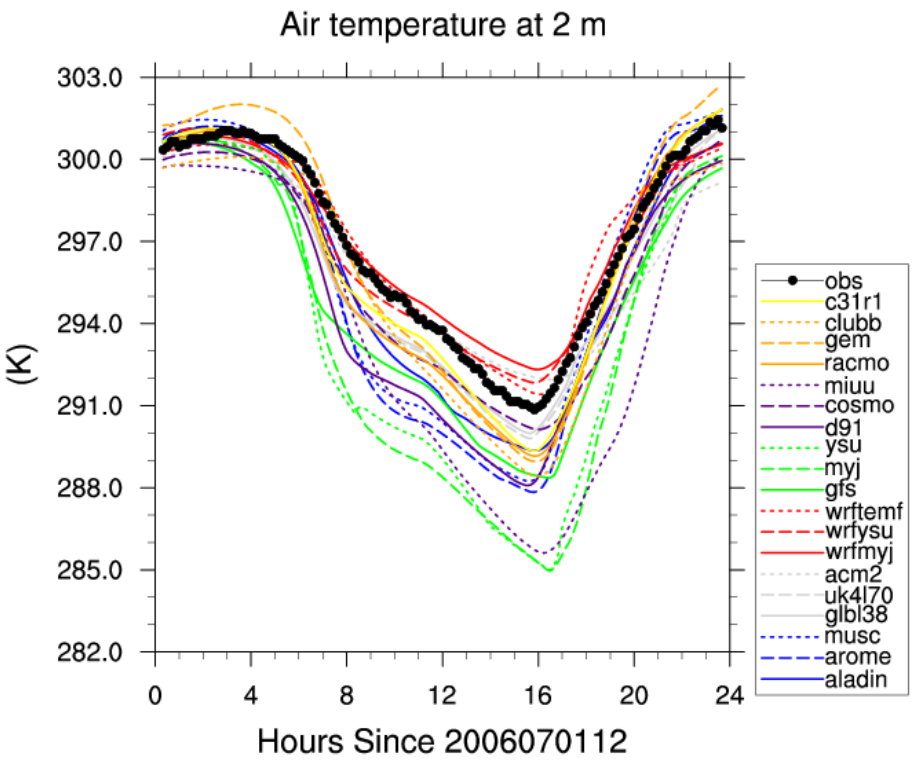
- A moderately stable case is defined
- Allow for SCM runs in full interaction with surface
- Special care for atmospheric forces
- to allow for a direct evaluation with observations

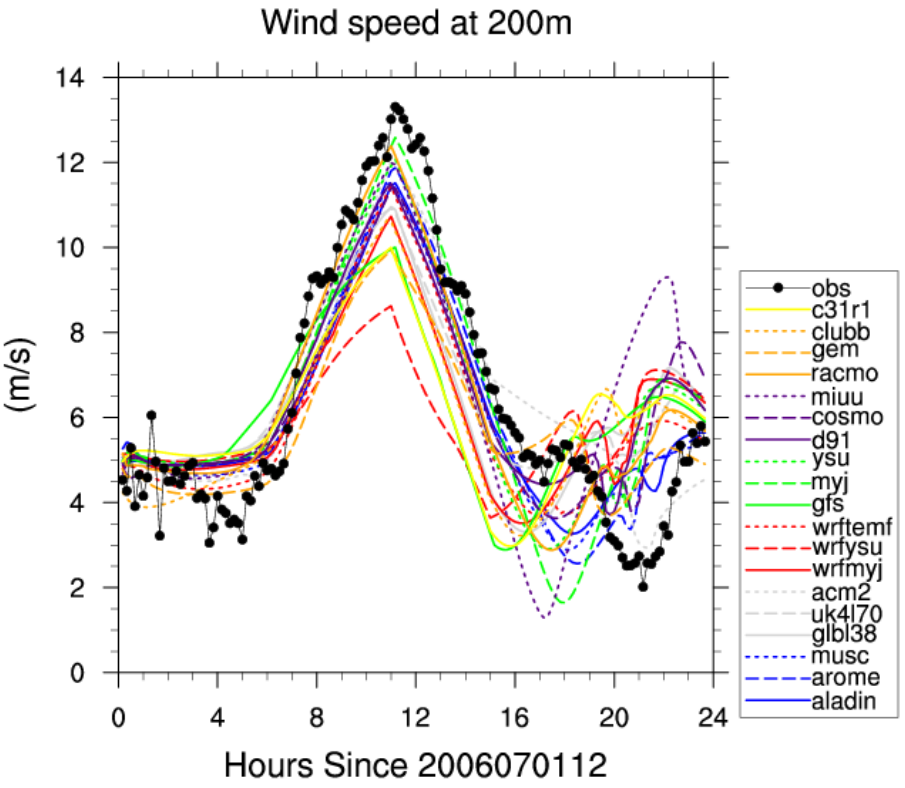
(2) Model intercomparison and evaluation

Participating models

Name	*Institute*	*PI*	*Nlev*	*BL.Scheme*	*Skin*
ALADIN	Meteo France	Bazile	41	TKE-l	No
AROME	Meteo France	Bazile	41	TKE-l	No
GLBL38	Met Office	Edwards	38	K (long tail)	Yes
UK4L70	Met Office	Edwards	70	K (short tail)	Yes
D91	WUR	Steeneveld	91	K	Yes
GEM	Env. Canada	Mailhot	89	TKE-l	No
ACM2	UCEPA	Pleim	155	K+non-local	No
WRF YSU	CIRES	Angevine	61	K	No
WRF MYJ	CIRES	Angevine	61	TKE-l	No
WRFTEMF	CIRES	Angevine	61	Total E-l	No
COSMO	DWD	Helmert	41	K	No
GFS	NCEP	Freedman	57	K	Yes
WRF MYJ	NCEP	Freedman	57	TKE-l	Yes
WRF YSU	NCEP	Freedman	57	K	Yes
MIUU	MISU	Svensson	65	2nd order	No
MUSC	KNMI	De Bruijn	41	TKE-l	No
RACMO	KNMI	Baas	80	TKE-l	Yes
C31R1	ECMWF	Beljaars	80	K	Yes
CLUBB	UWM	Fasching	250	Higher order	No

State and structure of SBL

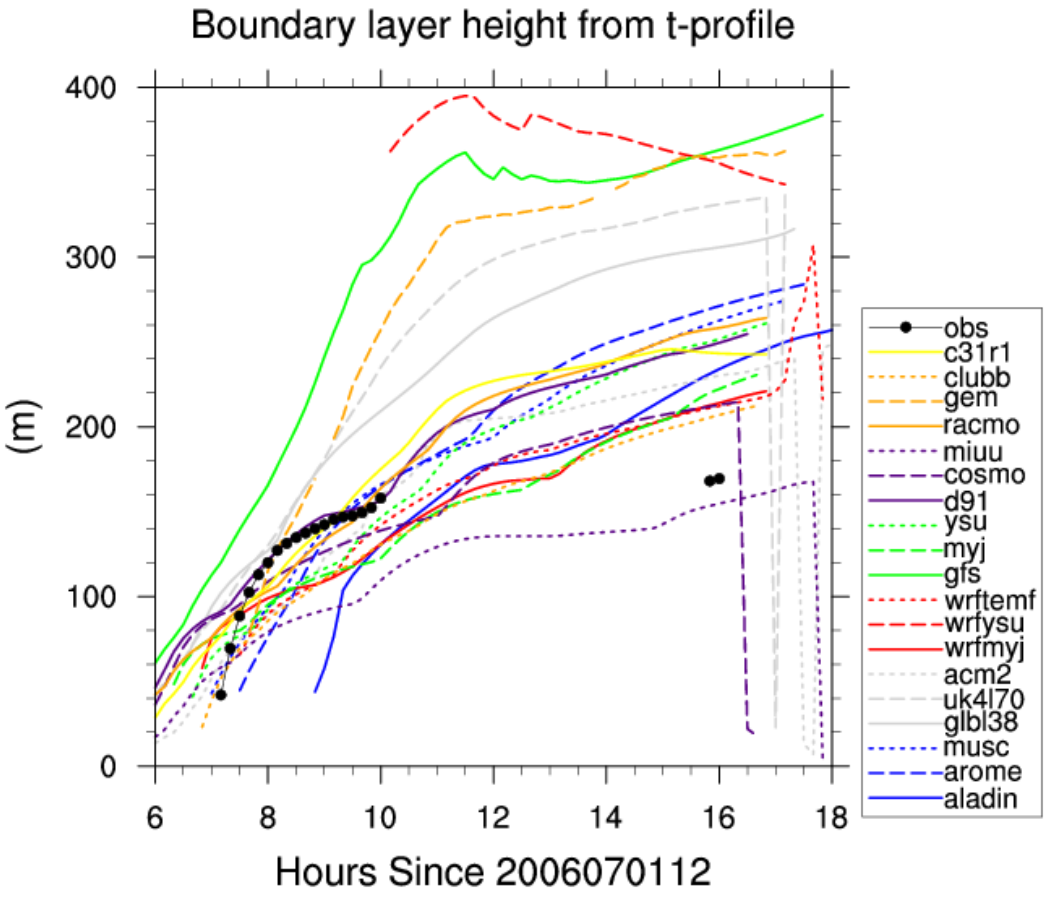




State and structure of SBL

Boundary layer height determined from:

Air temperature profile where dT(z)/dz = 0



Method of Evaluation

1) Identifying the relevant processes that characterise the SBL

2) Discrimate between "wrong physics" and "wrong parameters" (simulating the wrong site).

3) Use state of the art models to estimate sensitivity to parameter variations.

4) Use observations to judge quality of the models

Sensitivity runs with SCM (RACMO) on the dominating processes

mixing

varying the TKE-l parameters that relates turbulent length scale to the properties of the flow

[ch,cp] = [0.1,0.0] -> [0.2,1.0] -> [0.4,1.0]

coupling:

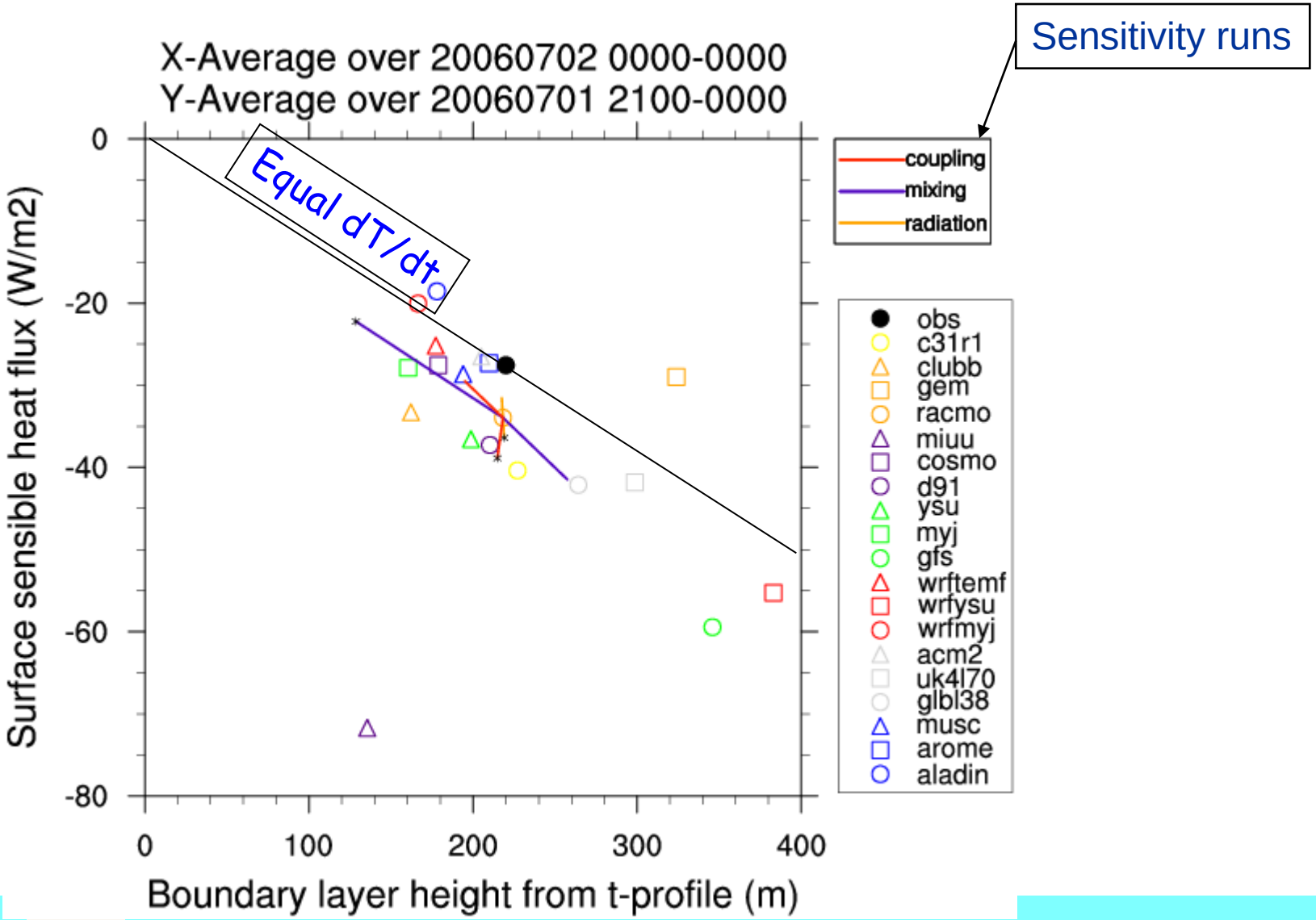
varying the thermal conductance between the skin layer and the soil Λ = 0.5 -> 5 -> 50 W/m2/K

radiation

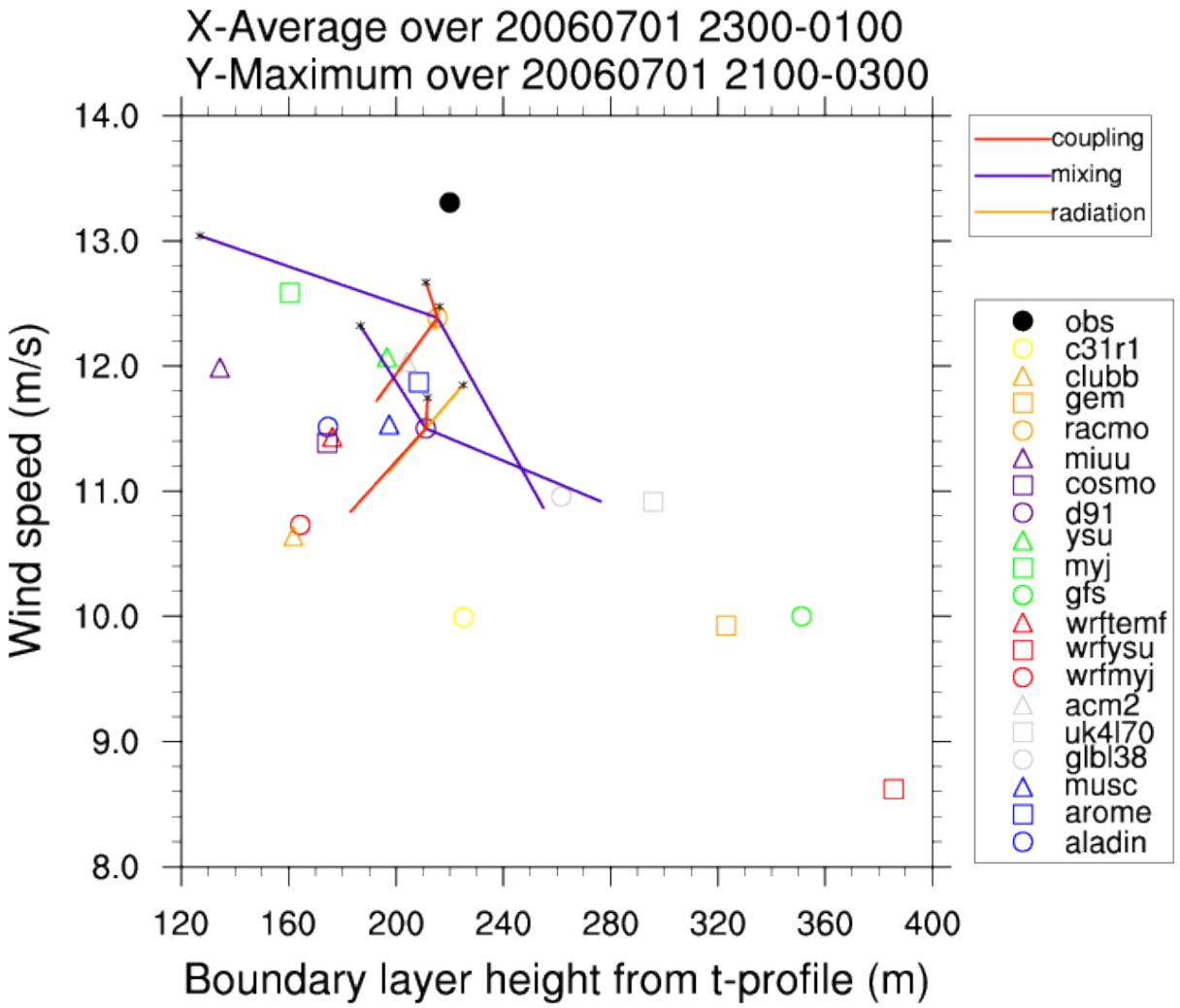
varying specific humidity to affect long wave incoming radiation. $L\downarrow$ 15 W/m^2

All have approx. the same effect on sensible heat flux

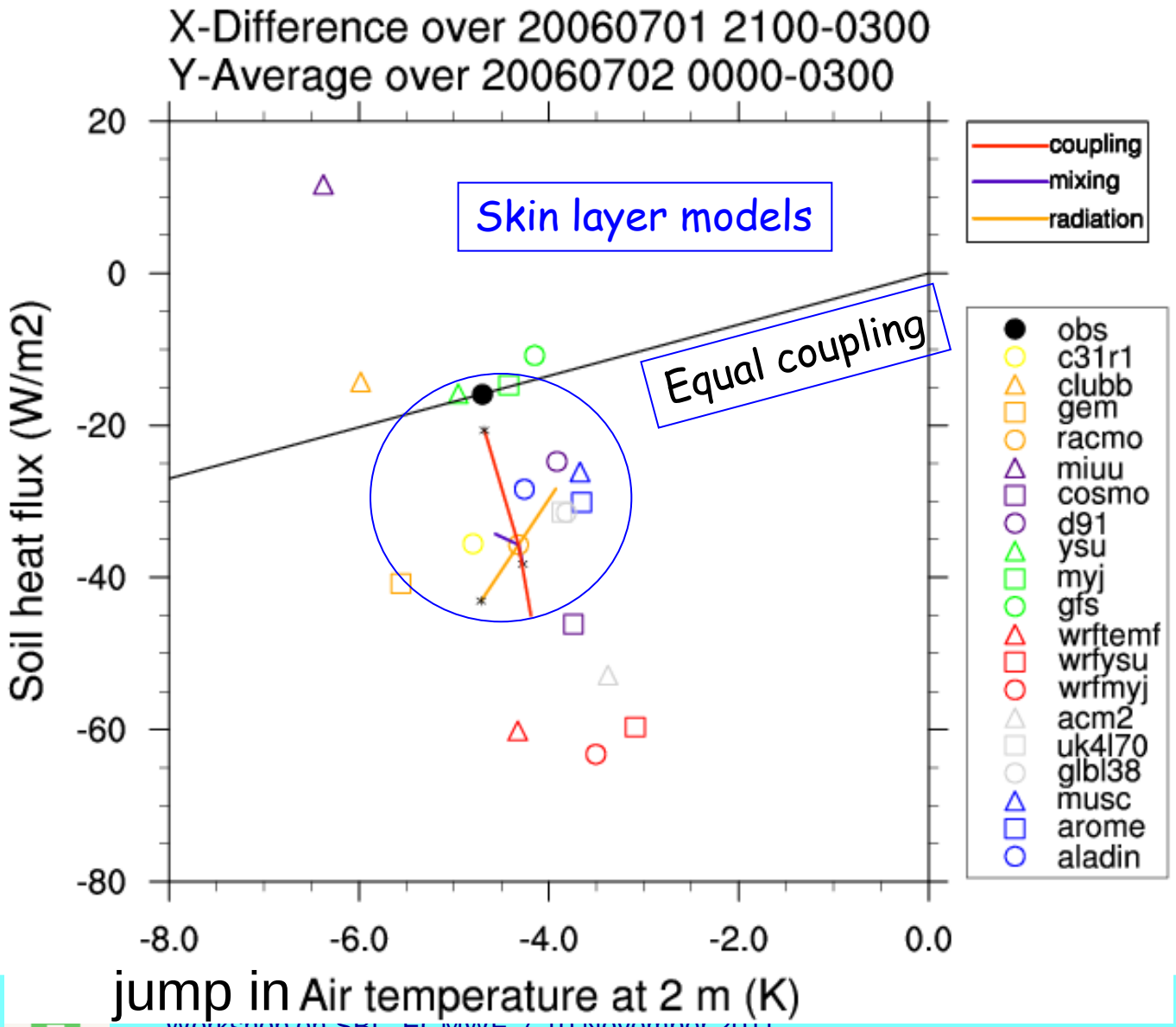
Influence of mixing



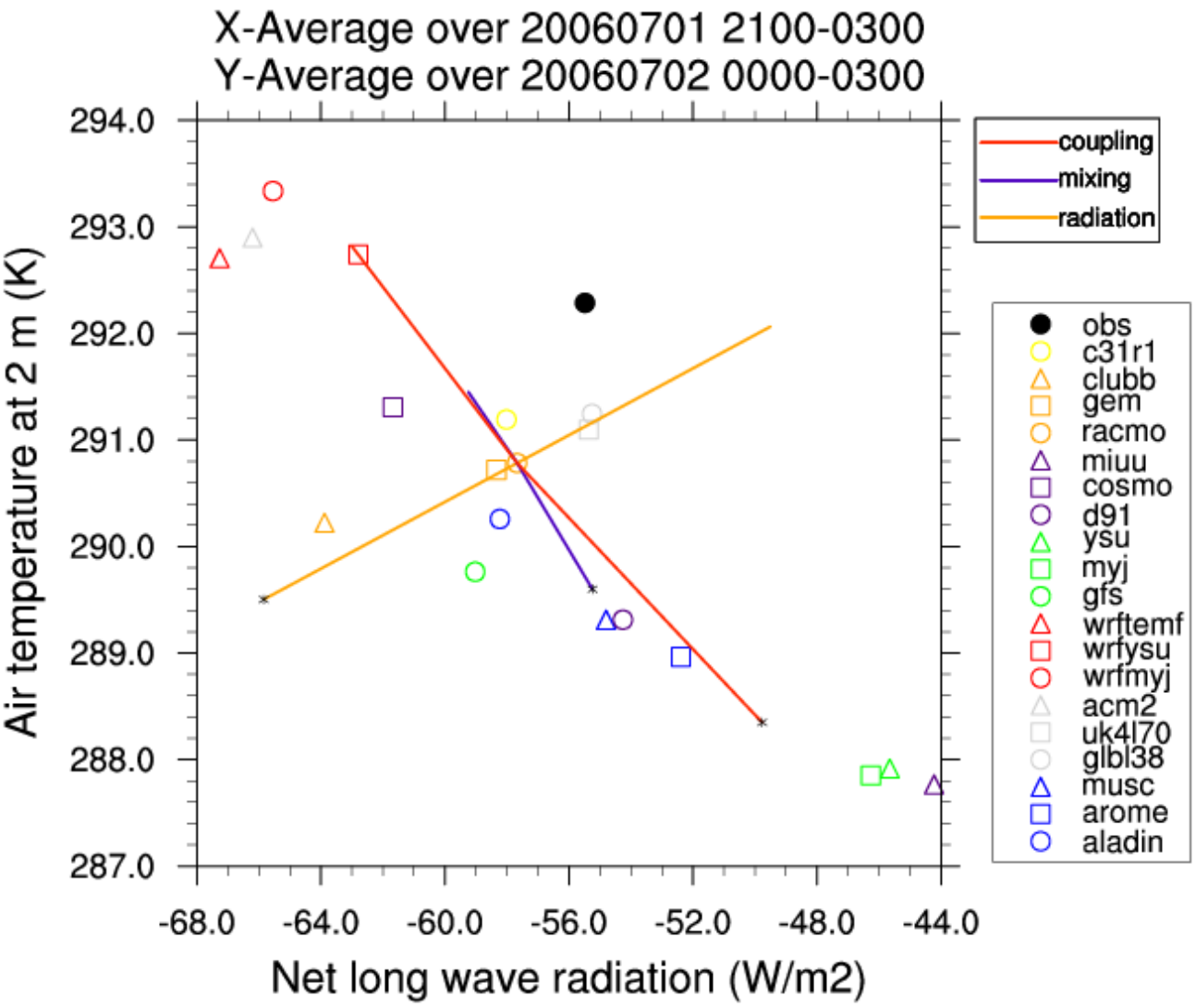
Influence of mixing
Jet speed versus BLH



Coupling to the soil



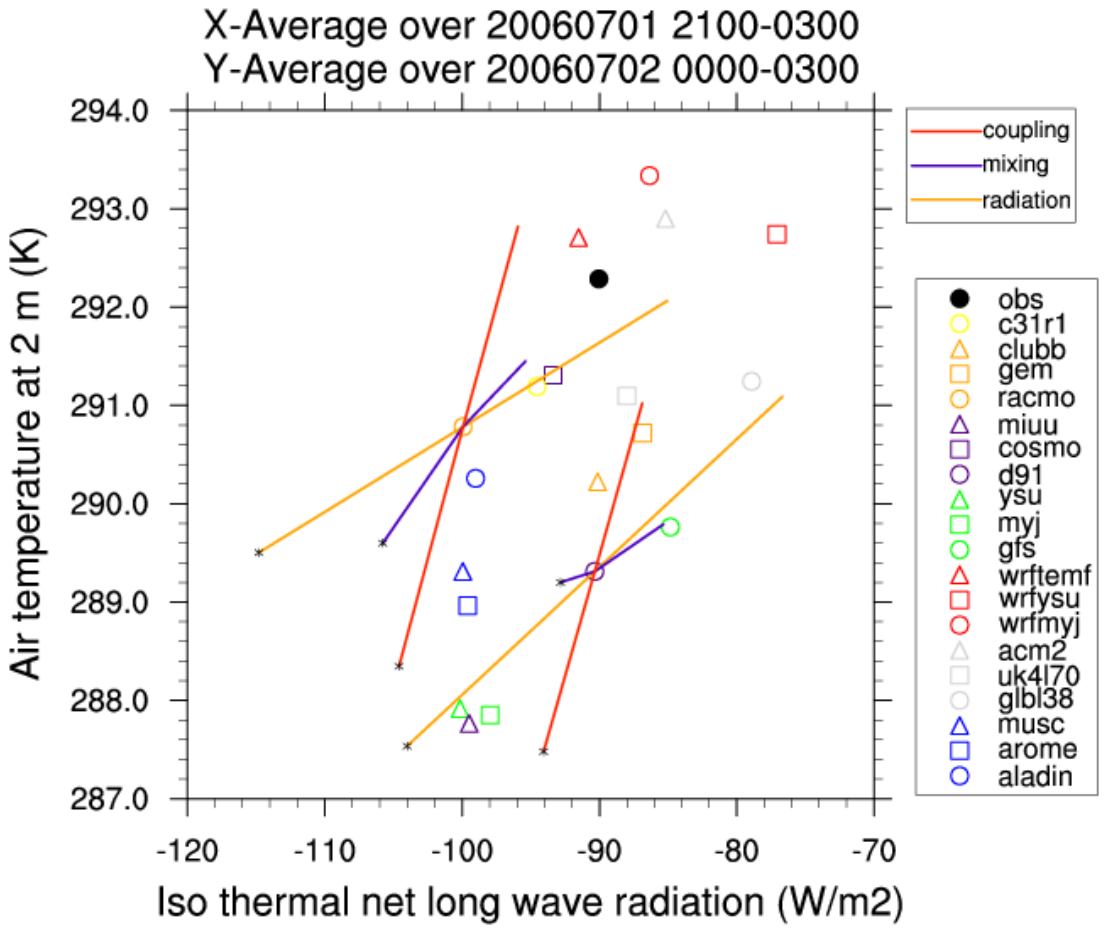
Influence of surface radiation



L↑ is strong function of surface temperature

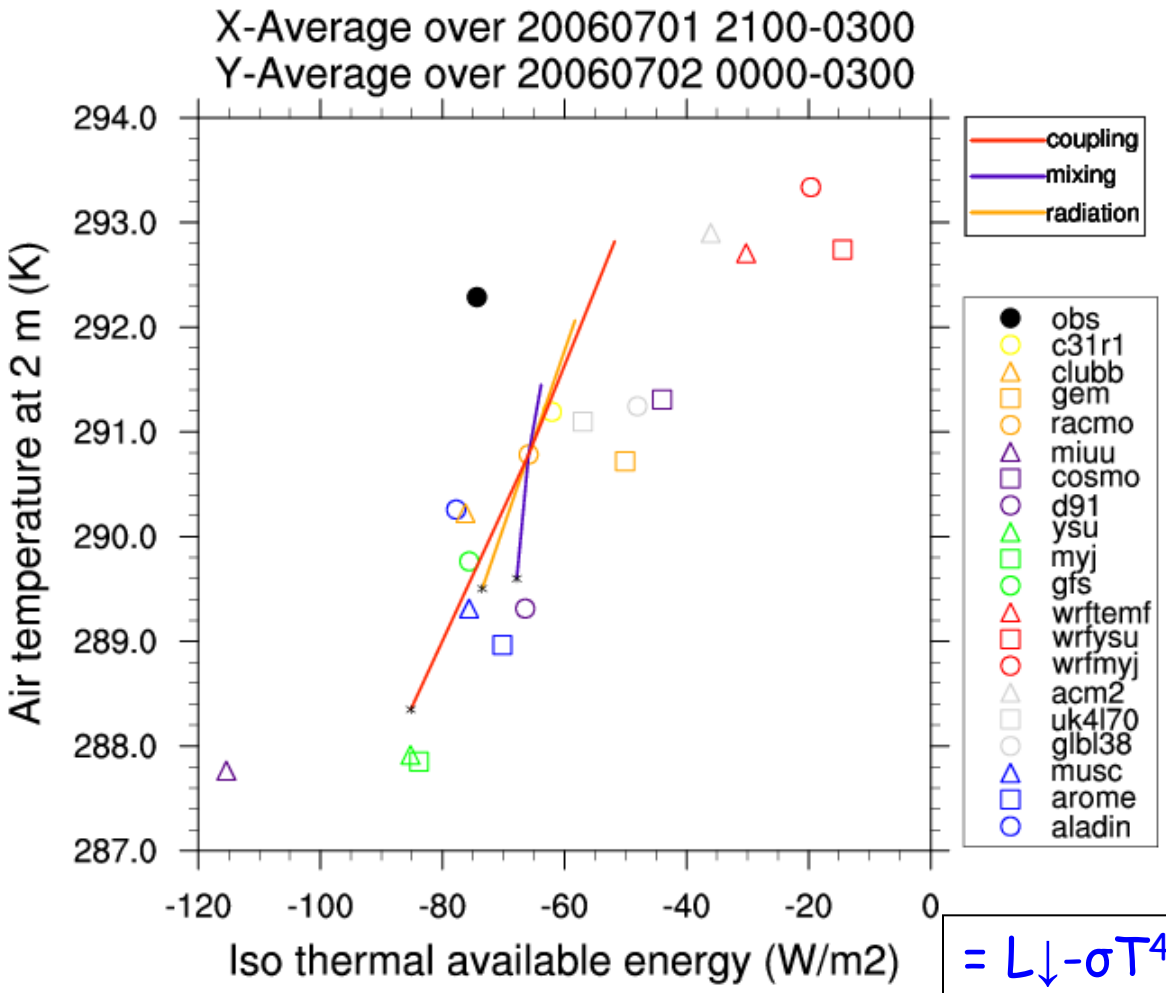
=L↓-L↑

Combined influence of radiation and coupling



$= L\downarrow - \sigma T^4(z=200m)$

Combined influence of radiation and coupling



$= L\downarrow - \sigma T^4(z=200m) - Gsoil$

Conclusions on model intercomparison and evaluation

- Significant variation in all aspects of the SBL are observed among models which can be coupled to relevant processes.

- Using sensitivity runs facilitate the interpretation of deviations among SCM runs and between models and observations.

- Significant mixing differences cause variation in sensible heat flux and boundary layer height. But variation in temperature rate of change is relatively small

- Miss representation of the thermal coupling to the soil/vegetation is significant in explaining differences in T2m.

- Careful prescribing the atmospheric forcings enabled a direct comparison between models and observations.

- In general models with skin layers perform better

(3) Alternative ways in case designs

Baas et al. (2010). QJRMS

Exploit long term datasets and select similar cases

Use 3D NWP to get atmospheric forcings for SCM

Currently this does not work for individual cases
To much noise (non-deterministic mesoscale variations)

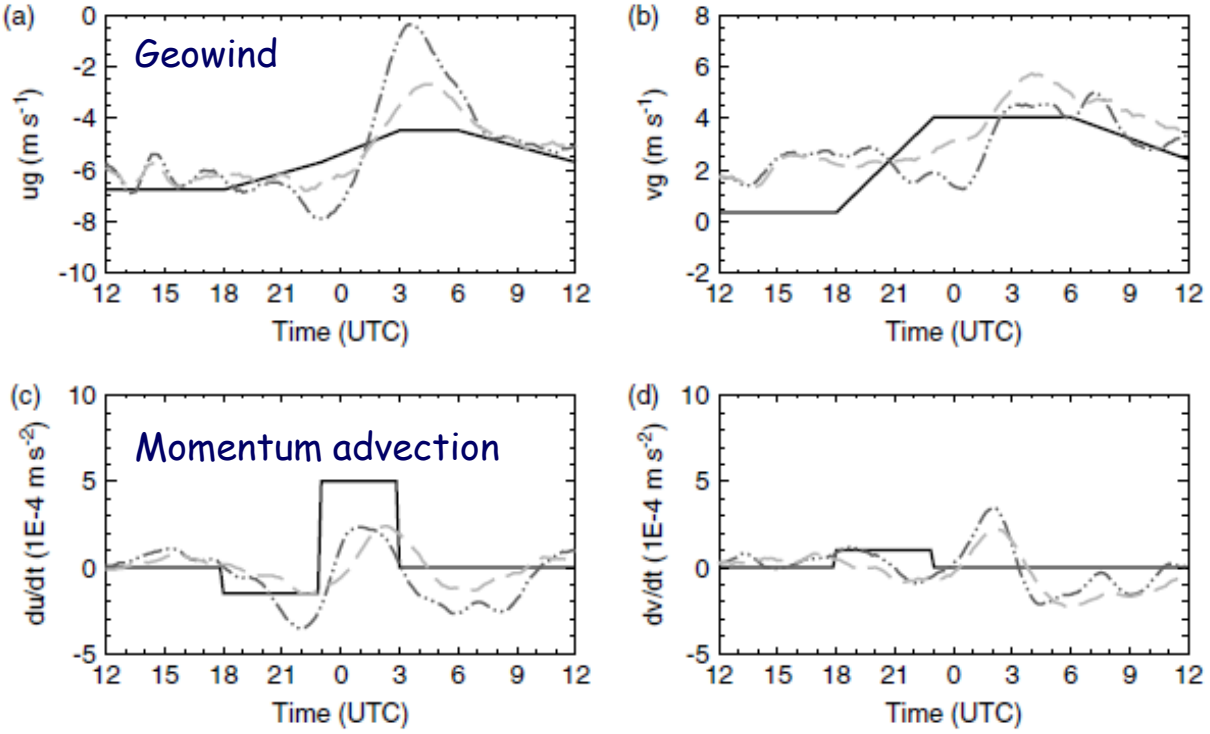
Two approaches:

1) Run an ensemble of similar cases and evaluate ensemble mean

2) Make a single composite case and evaluate outcome

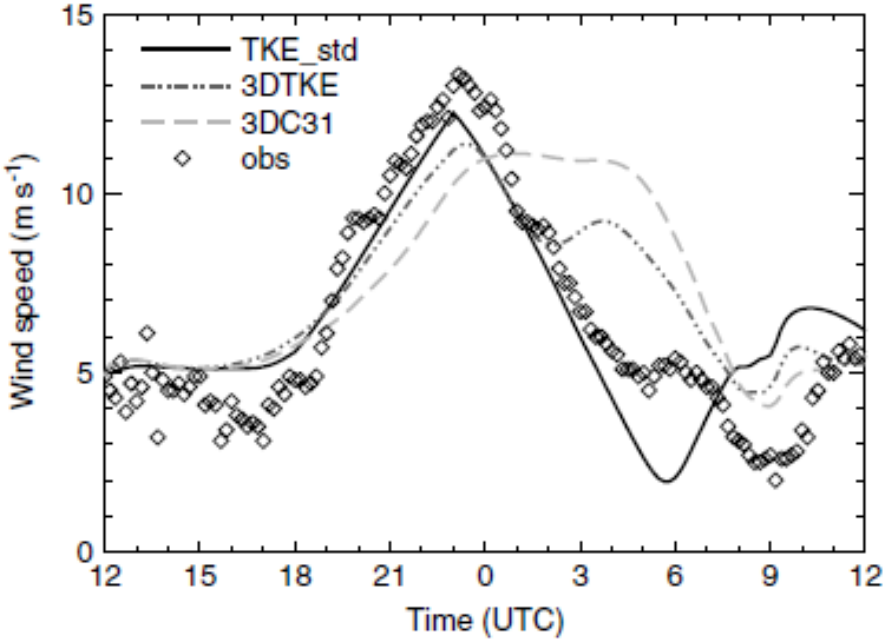
Individual GABLS3 case

Geowind and advection from:
- GABLS3 case
- 3D RACMO TKE
- 3D RACMO C31

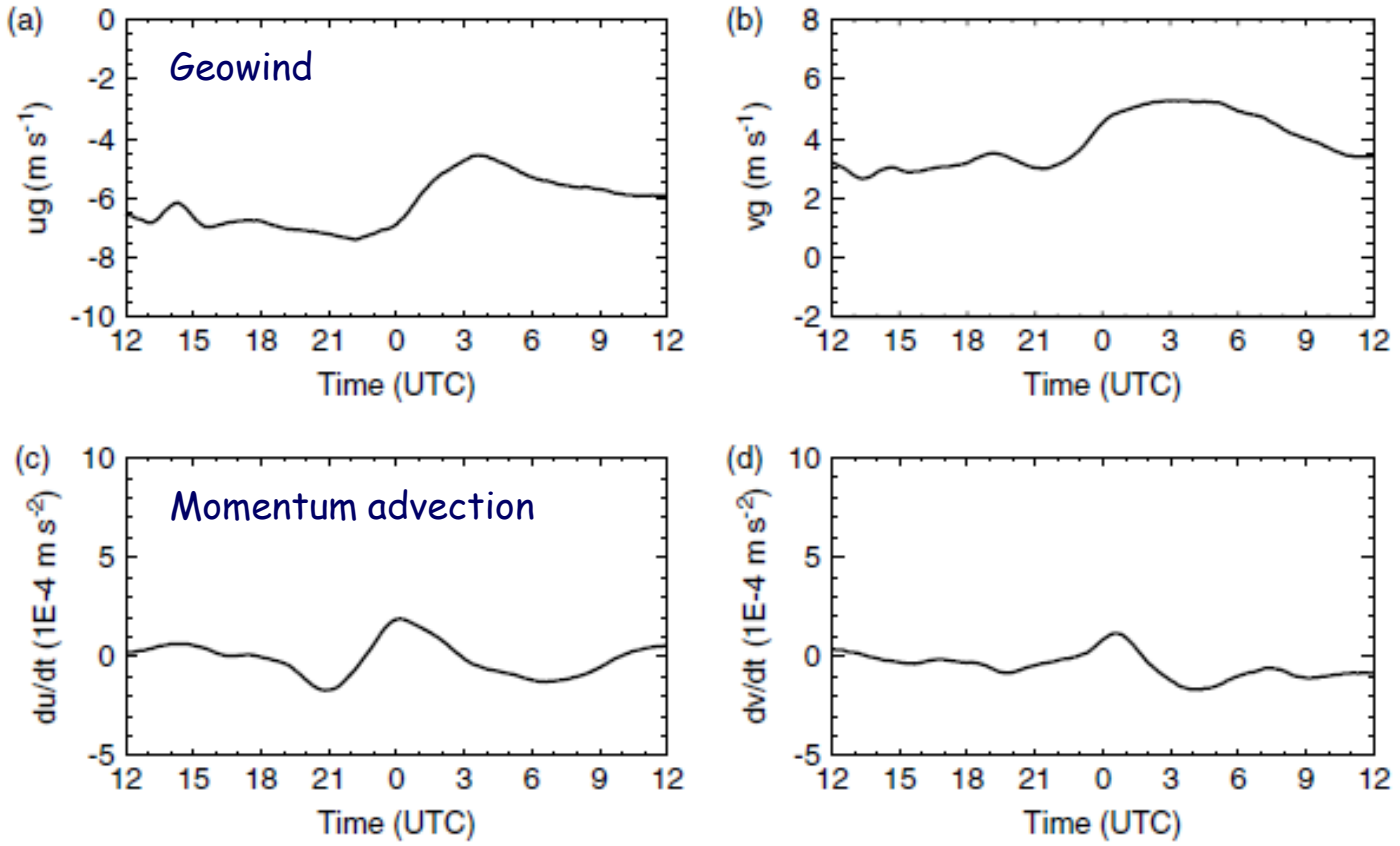


RACMO SCM runs with forcings from:
- GABLS3 case
- 3D RACMO TKE
-3D RACMO c31

And observations

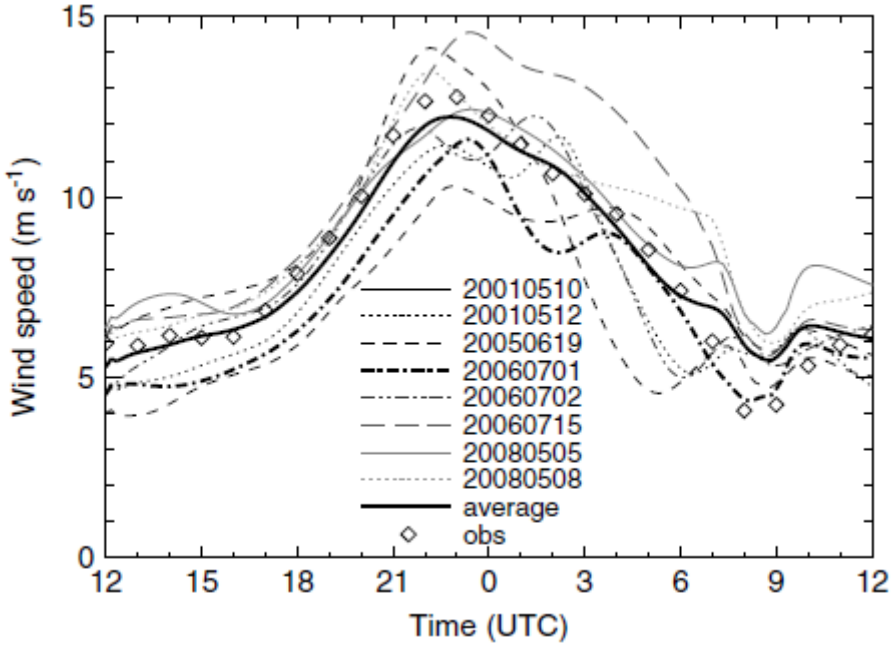


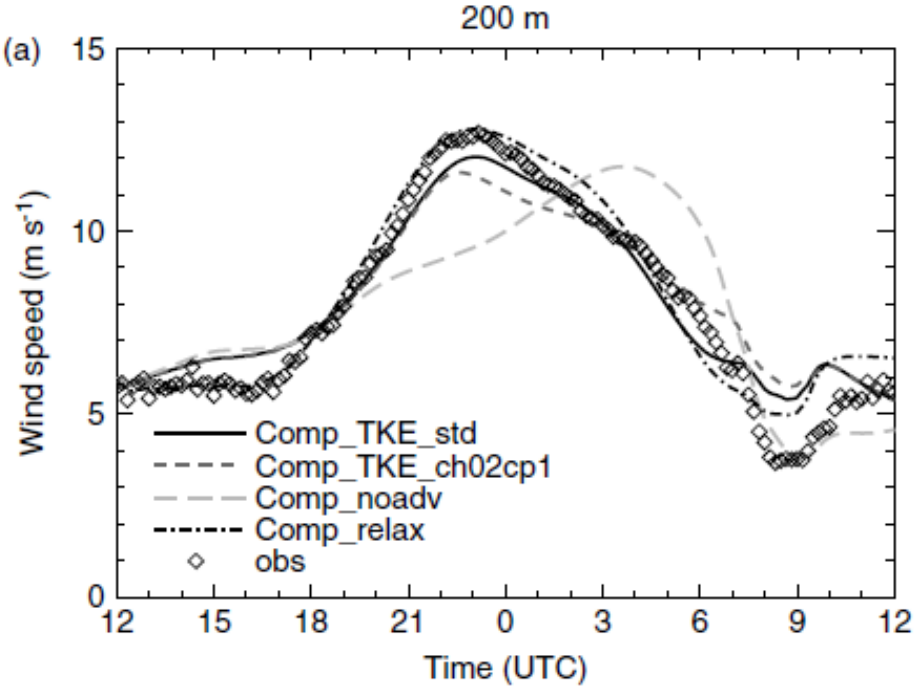
Average atmospheric forcings for 8 similar cases



Ensemble case

Composite case

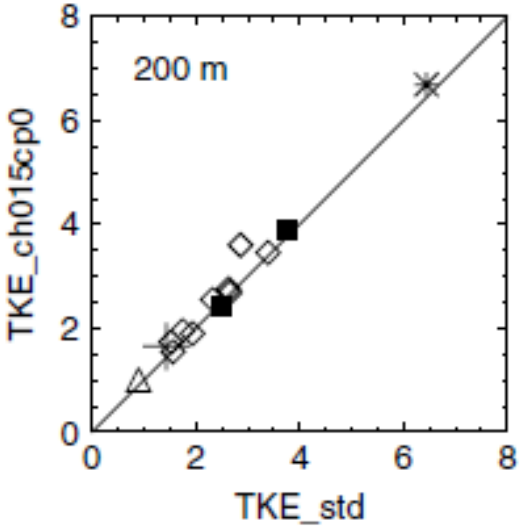


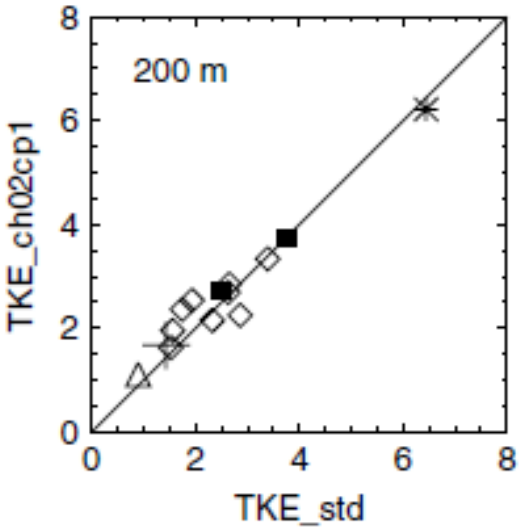


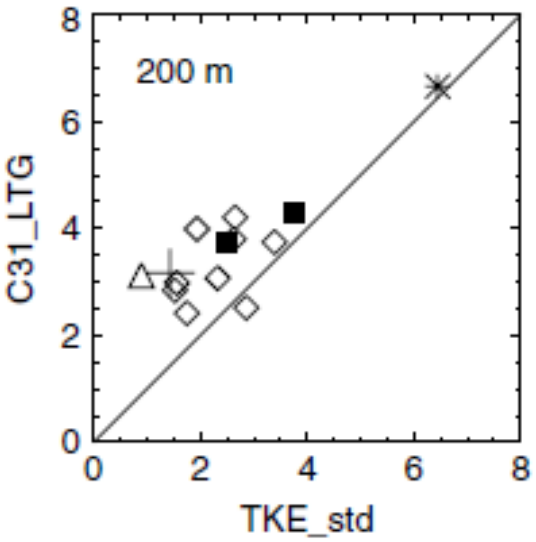
Conclusions on case designs

- When long time series are available similar cases can be selected
- 3D NWP atmospheric forcings are not (yet) good enough to be used for a single case.
- Non-deterministic meso-scale effects deteriorate the run.
- When long observational time series are available similar cases can be selected.
- Averaging over many similar cases reduces non-deterministic noise in the 3D NWP forcings.
- The current compositing case gave slightly better results then the ensemble case.

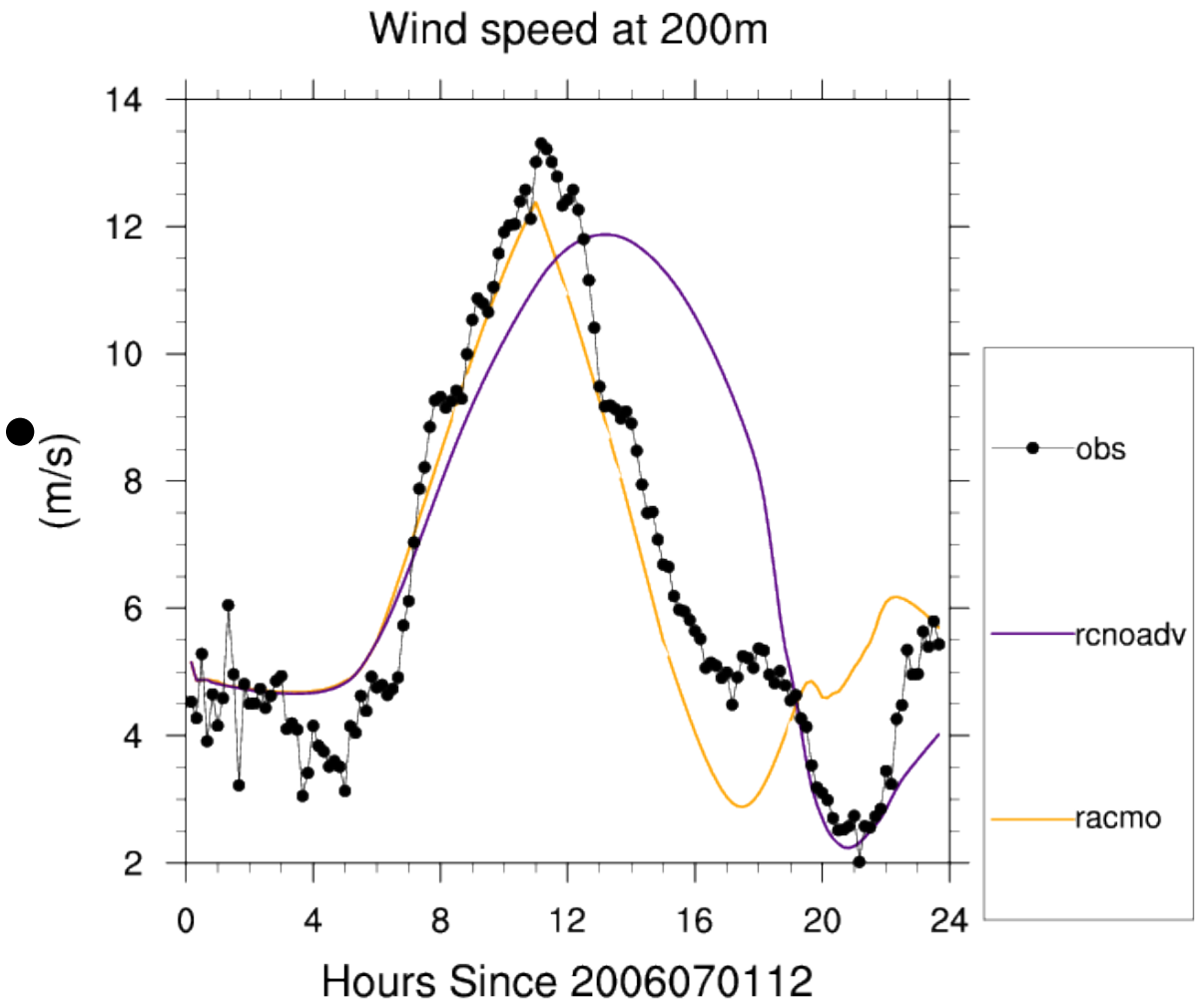
Ensemble of cases







Effect of momentum advection on 200 m wind

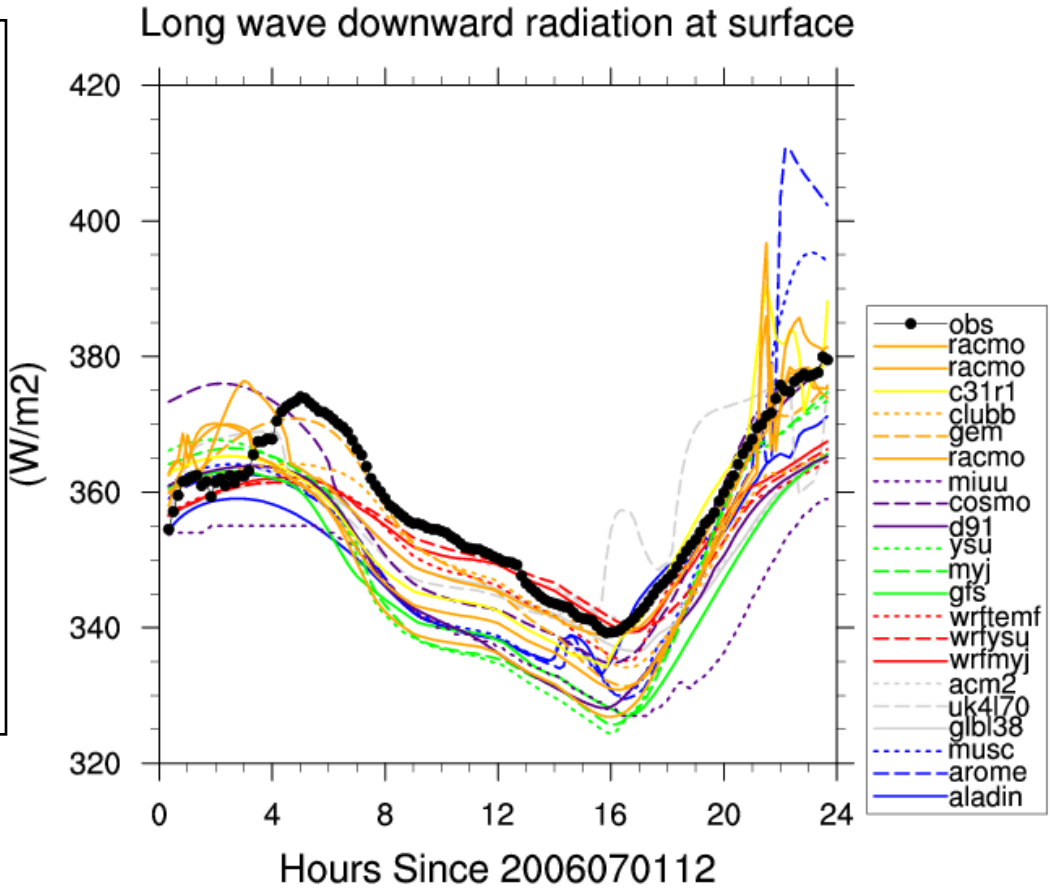


State and structure of SBL

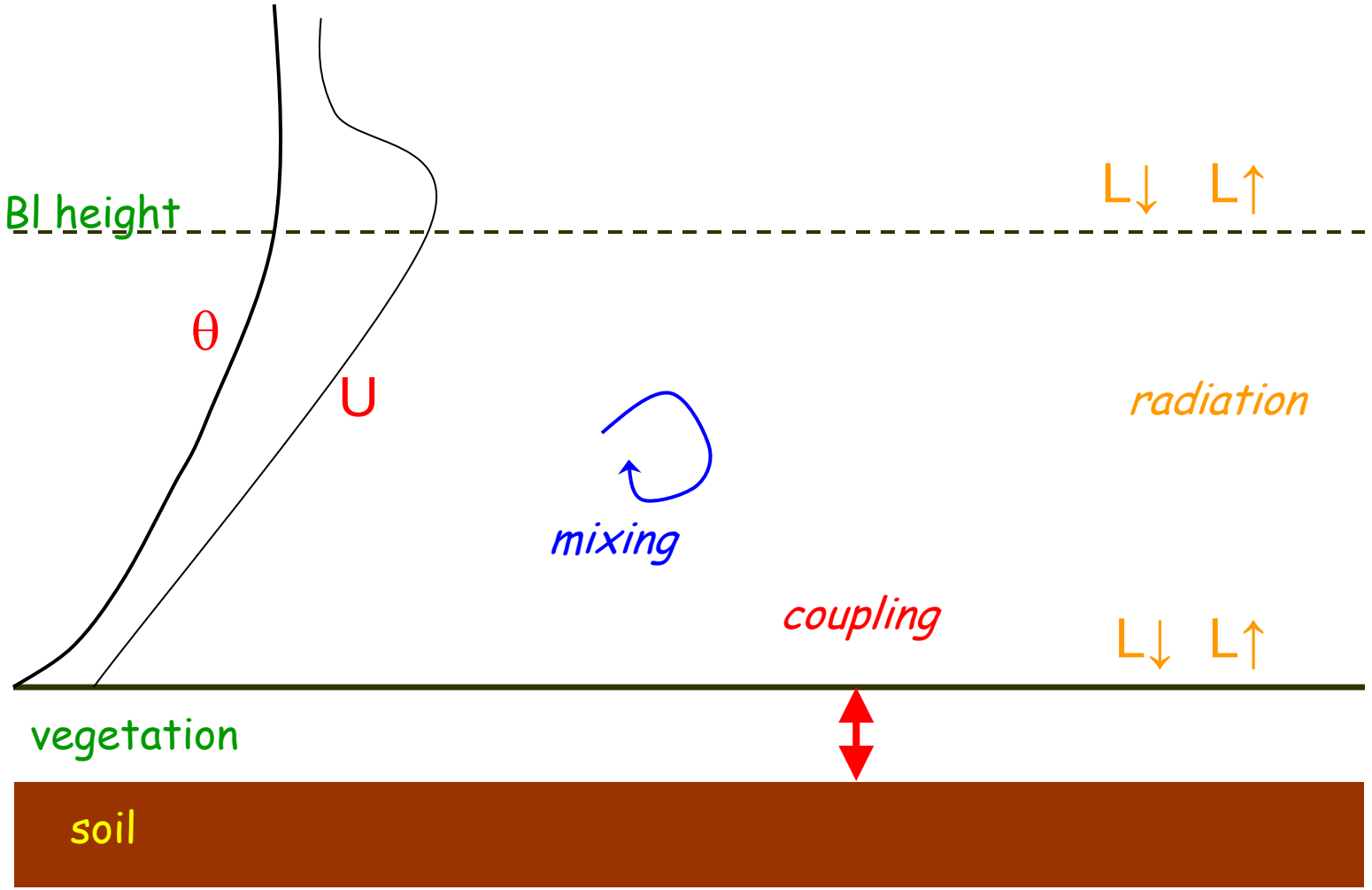
Long wave incoming radiation is:

- to a large extend determined by temperature of the lowest atmospheric layers.

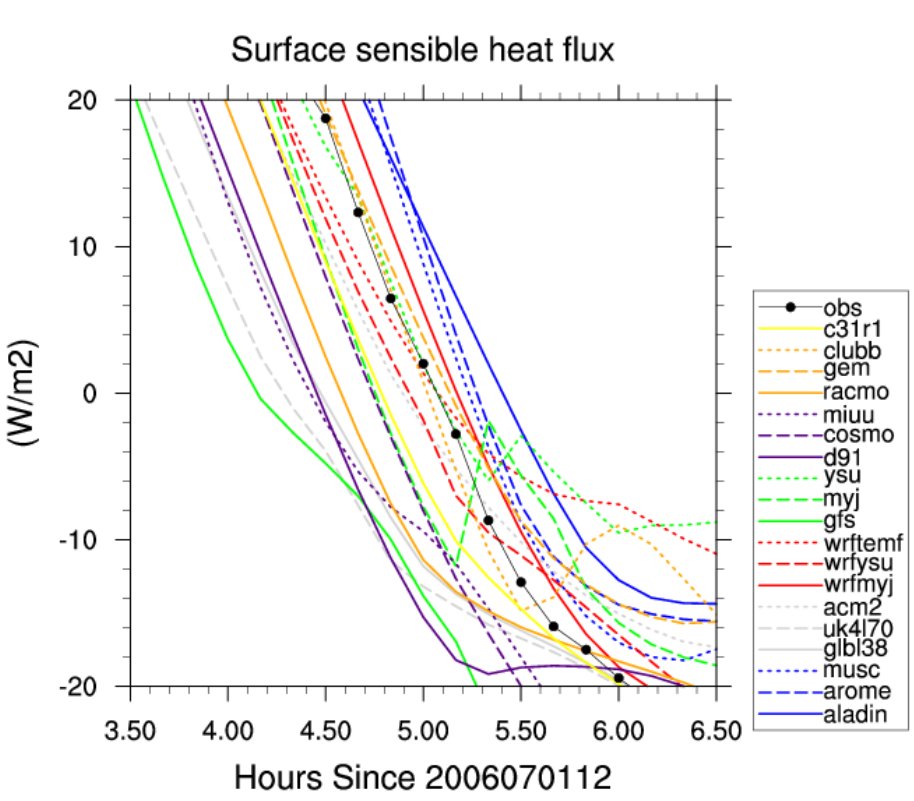
- is an internal (coupled) parameter of the stable boundary layer

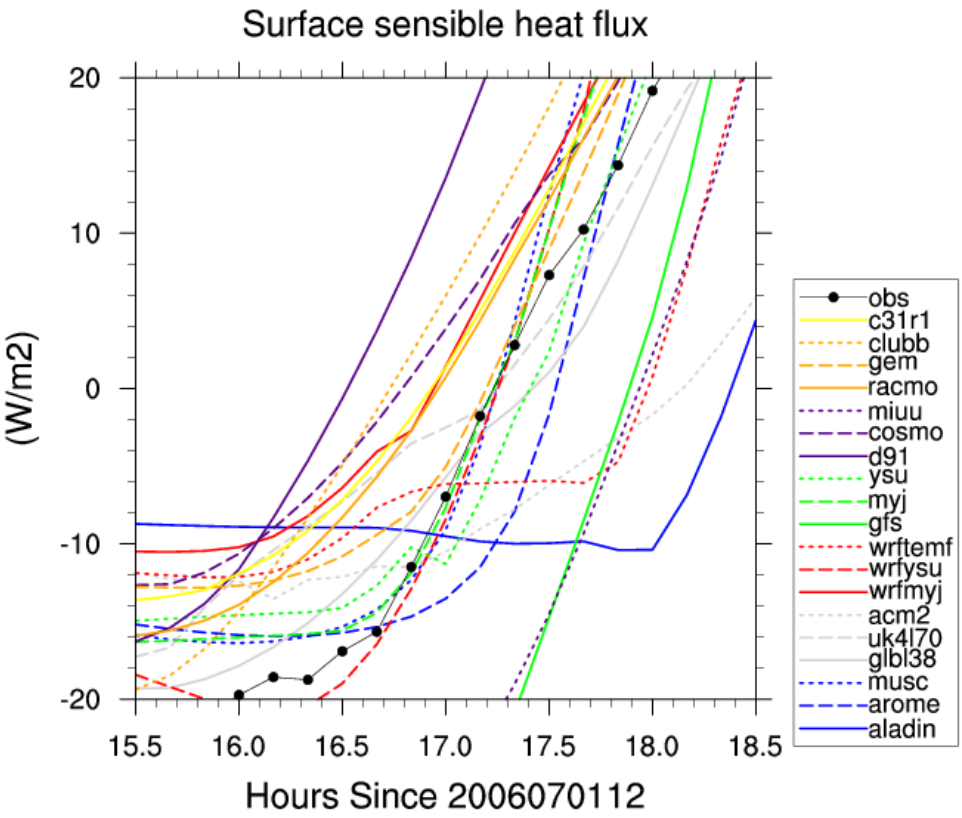


Dominant processes in moderately stable SBL

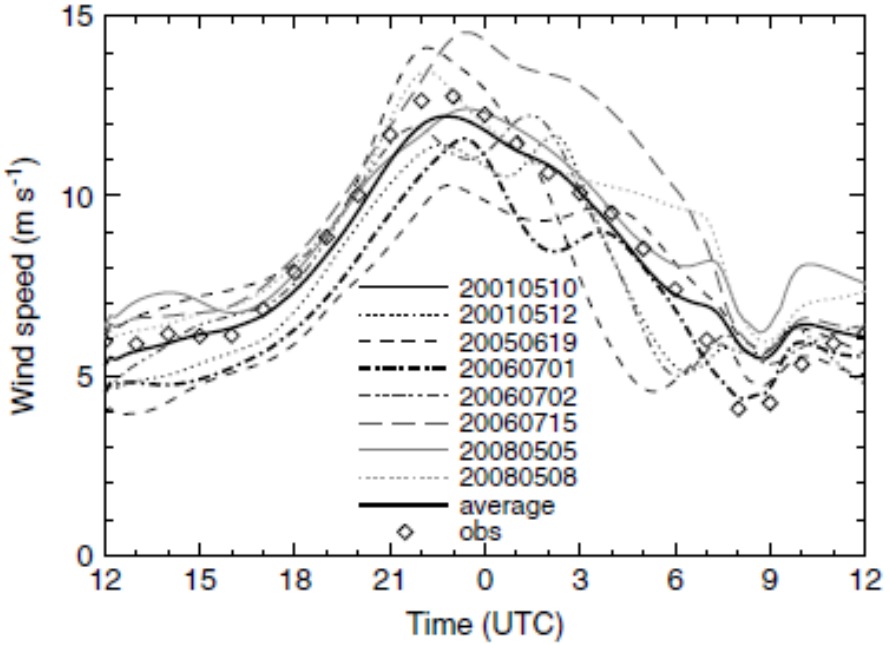


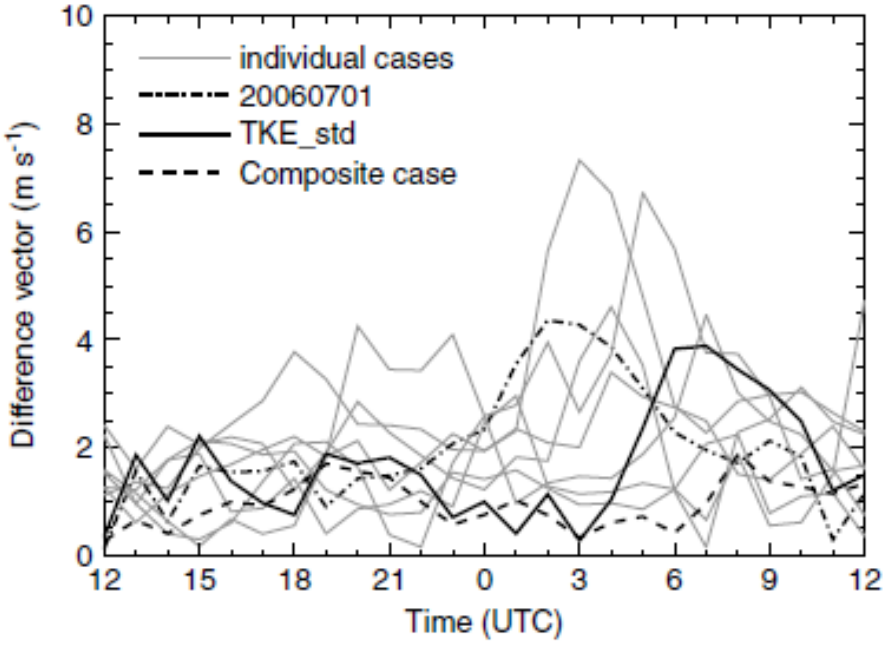
Transition around sun-set and sun-rise





Ensemble case





Composite case