Description of the single-column stable boundary layer intercomparison case study for the second GABLS study

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Introduction.

This case is based on the simulations performed by Steeneveld et al. (2005) for the period of 23-Oct 1999, 1900 UTC – 26 Oct 1999, 1900 UTC (DOY = 296-299) for the CASES-99 campaign (Poulos et al, 2002). The area is covered with prairie grassland (roughness length z0 = 0.03 m). The area is relatively flat with some minor topography. A heavily instrumented 60 m mast (thermocouples, sonic anemometers), surrounded by several 10 m masts formed the heart of the campaign. In addition radio soundings were launched. See http://www.joss.ucar.edu/cases99/ for all the measurements and http://www.atd.ucar.edu/rtf/projects/cases99/asciiDownload.jsp for ascii download of the tower data).

Instead of the first GABLS intercomparison, this case is more complicated, since the subject deals with three nights that differ in their character according to the relative impact of mechanical and radiative forcing. The advantage is this case study is that we can make use of real observations to compare the different model output. We will briefly summarize the basic character of the three nights (See Figure 1 and Table 1)

The first night (23/24 Oct) is of intermittent character, with a mean friction velocity of 0.067 m/s

The second night is characterized as an upside down boundary layer with a strong jet. This night is fully turbulent with a mean friction velocity of 0.3 ms^{-1}.

The third night has weak or absence of turbulence (U10 = 2.0 ms^{-1}), and is thus mainly driven by radiation (mean friction velocity 0.02 ms^{-1}).

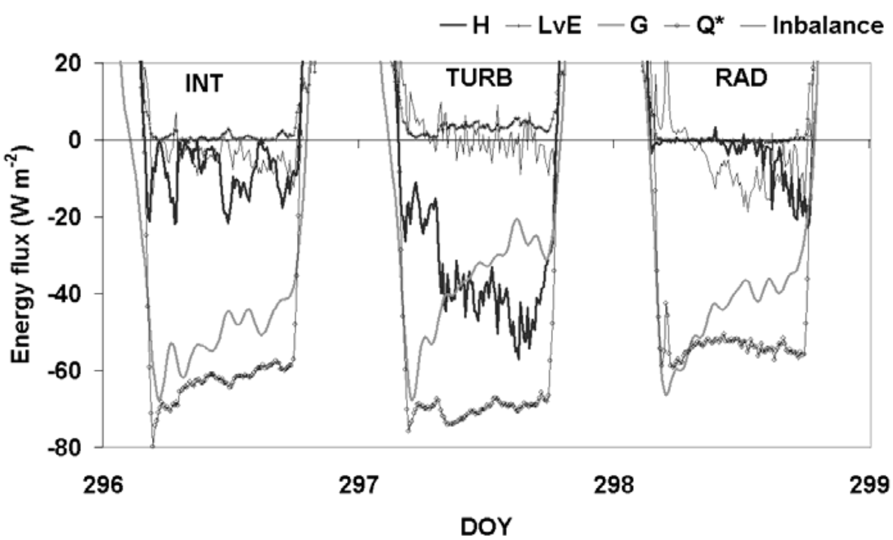

Figure 1: Observed components of the surface energy balance for the three nights.

Table 1: Main characteristics of proposed nights from CASES-99.

Date	Type	u_* (m s^{-1})	Q^* (W m^{-2})	H (W m^{-2})	L_vE (W m^{-2})	G (W m^{-2})	U_{10} (m s^{-1})	T_{10} (K)
297	Int	0.067	-61.2	-4.8	0.5	-48.3	2.9	275.02
298	Turb	0.296	-69.6	-34.5	3.9	-29.5	6.28	282.11
299	Rad	0.018	-53.4	-1.7	-0.3	-39.6	2.02	285.29

Description.

We propose to do three simulations:

I. Prescribed vegetation temperature (T_{veg}, Figure 2), radiation scheme switched off.

II. Free vegetation temperature, radiation scheme switched off. (Moet Ts hier vastgehouden of voorgeschreven?)

III. Free vegetation temperature, radiation scheme switched on. Moet Ts hier vastgehouden of voorgeschreven?)

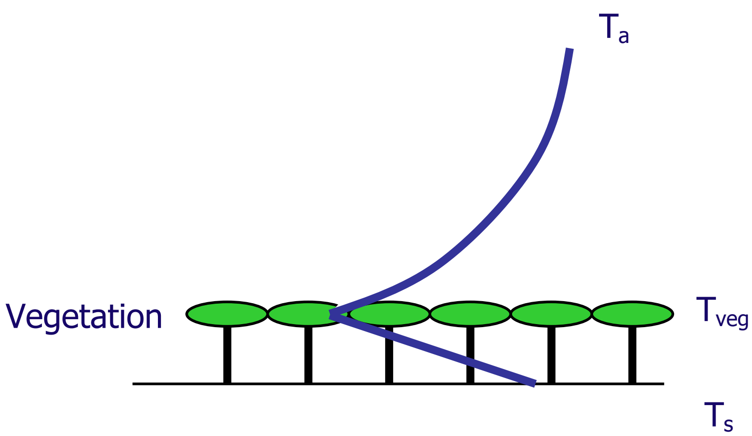

Figure 2: Definitions of the vegetation temperature and upper soil temperature (Ts).

Vertical domain: 1800 m.
Location: 37.6486º N, -96.7351º E, 436 m ASL.
Other constants: g =9.81 ms^{-1}, reference potential temperature 298 K, and reference density 1.2 kg m^{-3}.

Grid spacing.

We prefer a logarithmically spaced grid. The grid spacing can be distributed according to:

$$Z = \frac{z}{A} + \ln\left(\frac{z+B}{B}\right)$$

With A = 200 and B = 1. How many layers? I used 40.
Other configurations are welcome as well when it is unable to use the logaritmic grid structure as proposed above.

Time step.
Time step should set to 10 sec.

Radiation scheme.
What to do with this? I propose everyone uses his/her own radiation scheme. As an alternative we can use the radiation scheme in the D91 model

Initial and boundary conditions.

- **What to do with TKE? Kan niemand hier een begin profile voor verzinnen? Tke is about 3 J/kg aan het oppervlak.**

Files with initial condition are found on ftp://metair@hp1.met.wau.nl/Gert-Jan. of de toekomstige website. There you find seven files (all files use **UTC** for the time format):

-*InitialprofilesUVT_231900UTC.prn* contains the initial profiles of wind speed (U,V), temperature (T), specific humidity (Q)

```
POINT    Z        U         V         T      Q
```

-*Geowindforc.prn* contains the time evolution of the geostrophic wind speed (speed, direction) on hourly intervals.

```
DOY_UTC         HH_UTC          MIN_UTC         Ugeo            DIR
```

-*Fluxes_surfGABLS.prn* contains the evolution of the surface fluxes (sensible heat flux, sensible heat flux uncertainty, latent heat flux, latent heat flux uncertainty, soil heat flux, components of the radiation budget, soil temperatures at 0 cm, 3 cm and 8 cm depth, surface temperature, 5m relative humidity. The surface temperature (TVE_veg) that present in this file should be used for exercises I and II.

```
DOY        HH         MM   H(Sonic)  Tol(HSonic      LvE       dLvE
UStar    dUStar        Tau      dTau       S_in      S_out       L_in
L_out      Rnet        IRT   Tsoil3cm  Tsoil8cm  Tsoil0cm SoilHeatfl
TVE_veg       RH5.
```

For verification the following files are available

-*tempprof_mast.prn* contains the temperature profiles along the 60 m. mast.
-*windprof_mast.prn* contains the wind profiles along the 60 m. mast.
-*TKEprof_mast.prn* contains the TKE profiles along the 60 m. mast.

-*soundings_time_UTC.zip* contains raw radio soundings launched at the CASES-99 mean site.

Subsidence (*during first 48 hours only*).

Subsidence W should be prescribed during the first 48 hours:

$W = -0.5.10^{-3}\ ms^{-1}$ $z > 1000$ m

$W = -0.5.10^{-3}\ ms^{-1} * (z / 1000)$ $z < 1000$ m, to ensure $w = 0$ at the surface

After 48 hours W=0.

Advection *(for the period between t = 24 h and t = 48 h only!)*

$dT/dt|_{adv} = 5E\text{-}5\ K\ s^{-1}$

$dq/dt|_{adv} = +1.3E\text{-}8\ kg\ kg^{-1}\ s^{-1}$ $z < 1000$ m

$dq/dt|_{adv} = -1.3E\text{-}9\ kg\ kg^{-1}\ s^{-1}$ $z > 1000$ m

Between $0 < z < 100$: $dX/dt|_{adv} = dX/dt|_{adv}\ (z = 100)*(z/100)$, to make sure advection is 0 at the surface.

Relaxation: above z = 1000 m, temperature is relaxed to the observations. Wind speed is U = Ugeo and V = Vgeo above z =1000 m.

Soil/Surface

The initial vegetation temperature $T_{veg} = 296.1$ K.

Surface soil temperature $T_s = 292.6$ K.

Roughness length

For momentum: z0 = 0.03 m

For heat: z0h = z0/10.

Canopy resistance: 1400 s m^{-1}. formulations for humidity transfer differ among models (what to do)?

Surface resistance: 5.9 W m^{-2} K^{-1} (for Case III)

Output required.

The total simulation takes 72 hours (259200 seconds). With datasets A, B, C, D and E. Data sets A-D contains profiles of quantities and their fluxes. Dataset E contains the time series of the whole run. The boundary layer height is diagnosed as the height at which the total stress falls to 5% of the surface value (u_*^2) divided by 0.95.

Set A: mean profiles

Mean profiles should be sampled every 2 hours??? What do we want?

1. Height (m)
2. x- velocity (m s^{-1})
3. y velocity (m s^{-1})
4. Potential temperature (K)

Set A_2: mean profiles for radio soundings

This set is specially meant to compare with the available radio soundings observations. There are 13 profiles available in total.

```
TPRT(1)=0*3.6E3
TPRT(2)=8*3.6E3
TPRT(3)=11.00*3.6E3
TPRT(4)=15.00*3.6E3
TPRT(5)=24.00*3.6E3
TPRT(6)=32.00*3.6E3
```

TPRT(7)=36.00*3.6E3
TPRT(8)=40.00*3.6E3
TPRT(9)=48.00*3.6E3
TPRT(10)=56.00*3.6E3
TPRT(11)=60.00*3.6E3
TPRT(12)=64.25*3.6E3
TPRT(13)=72.00*3.6E3

1. Height (m)
2. x- velocity (m s^{-1})
3. y velocity (m s^{-1})
4. Potential temperature (K)

Set B: Turbulence variances

Mean profiles should be sampled every 2 hours???

1. Height (m)
2. TKE (m^2 s^{-2})
3. Potential temperature variance (K^2)
4. u-variance (m^2 s^{-2})
5. v-variance (m^2 s^{-2})
6. v-variance (m^2 s^{-2})
7. skewness $\overline{w'^3} / \overline{w'^2}^{2/3}$ (-)

Set C: Flux profiles

1. Height (m)
2. x momentum flux $\overline{u'w'}$
3. y momentum flux $\overline{v'w'}$

4. Potential temperature flux $\overline{\theta' w'}$

5. Specific humidity flux $\overline{q' w'}$

6. Longwave downward (LWD, Wm^{-2})

7. Longwave upward (LWU, Wm^{-2})

Set D TKE budget

1. Height (m)

2. Shear production

3. Buoyancy production

4. Total transport

5. Dissipation

6. Storage of TKE

Set E: Time series (sampled every 10 minutes)

1. Time

2. Boundary layer height (m)

3. Surface potential temperature flux $\overline{\theta' w'}_0$ (W m^{-2})

4. Surface latent heat flux $\overline{q' w'}_0$ (W m^{-2})

5. Ground surface heatflux G (W m^{-2})

6. Friction velocity u_* (m s^{-1})

7. Surface temperature (K)

8. Shortwave surface incoming radiation (W m^{-2}).

9. Shortwave surface outgoing radiation (W m^{-2}).

10. Longwave surface incoming radiation (W m^{-2}).

11. Longwave surface outgoing radiation (W m^{-2}).

12. Monin-Obukov length (m).