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Modelled and observed ABL structure and processes in a snow-covered forest

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Joint MUSCATEN and NetICE Workshop on Modelling of snow-ice-atmosphere interactions

Kuopio, Finland, 24-26 March 2010

Contents...

- *Modelled and observed ABL structures and processes in a snow-covered forest*
- Intercomparison of measurements and two weather forecasting models
- Descriptive approach: looking for differences and similarities

Contents...

- ***Modelled***
  - HIRLAM operational reference runs (RCR)
    - version 7.2 (and 6.4.4)
    - Monin-Obukhov surface layer with stability-dependent exchange coefficients, simplistic treatment of snow cover
    - Warm bias in screen temperature associated with failure to predict strong wintertime surface inversions
  - HIRLAM 7.3 candidates
    - version 7.3 Beta2 (and earlier “NS0630”)
    - Double energy balance forest scheme, advanced treatment of snow cover (*see the presentation by Stefan Gollvik*)
    - Reduced warm bias during cold episodes
  - Forecast step 0...6 hrs
- *and observed ABL structures and Processes in a snow-covered forest*

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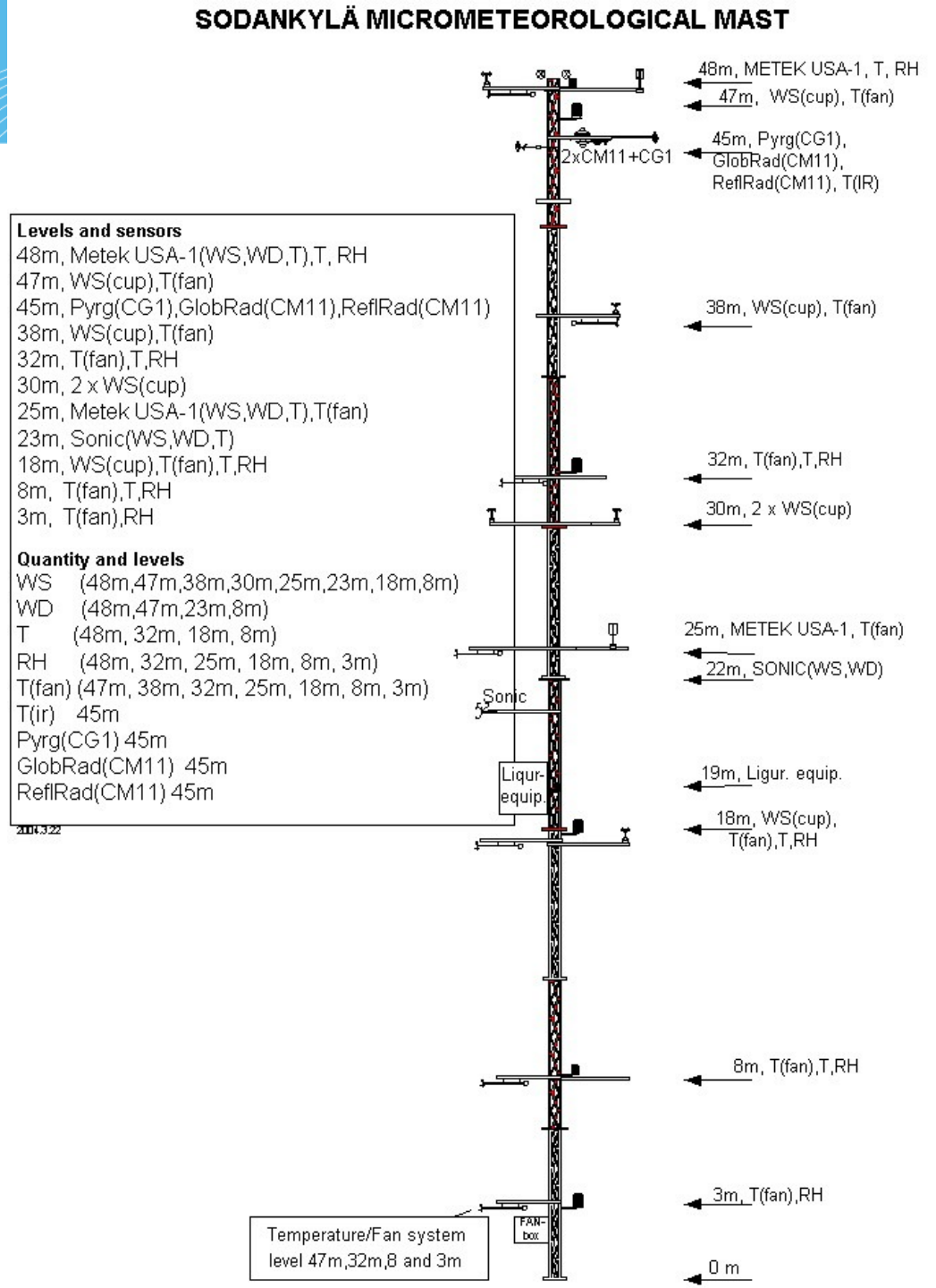
Contents...

- *Modelled and **observed***
  - The Arctic Research Centre of the Finnish Meteorological Institute (FMI-ARC)
    - T: 3 m, 30 m
    - Rad: 18 m
    - SHF, LHF: 22m
    - Soil heat flux: -7 cm
- *ABL structures and Processes in a snow-covered forest*

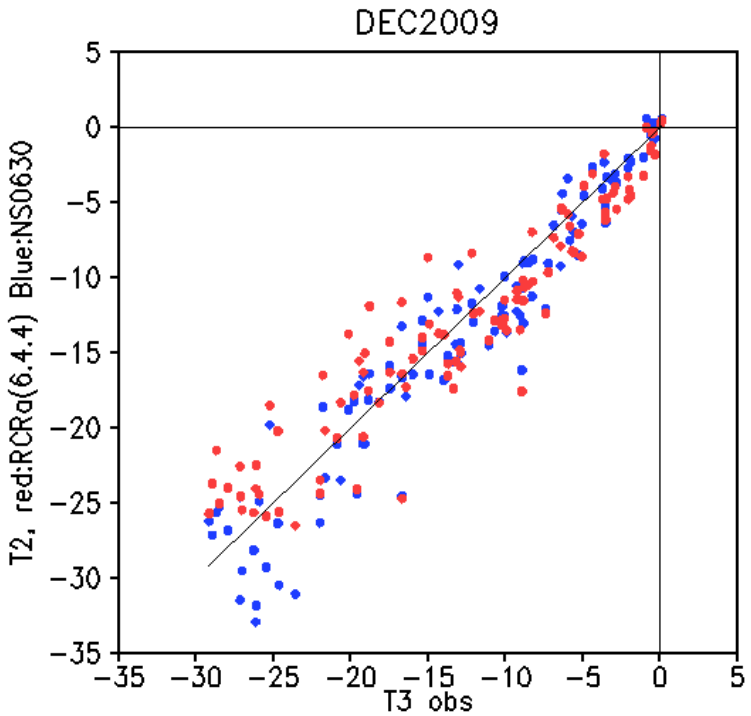


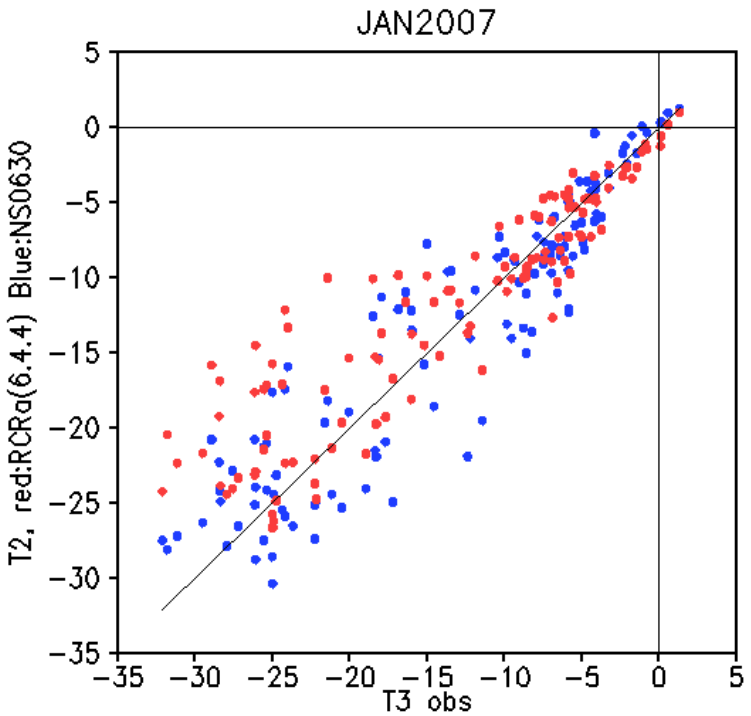
Contents...

- *Modelled and observed* **ABL structures**
  - Surface layer temperature gradient
- and ***processes***
  - Radiative and turbulent heat fluxes
- *in a* ***snow-covered forest***
  - Sodankylä (67 N, 26 E)
  - Sparse Scots pine forest, 10-15 m tall
  - Jan 2007, Dec 2009

Sodankylä temperature at screen level

Red: RCR (7.2) , Blue: 7.3 BETA2





Sodankylä temperature at screen level

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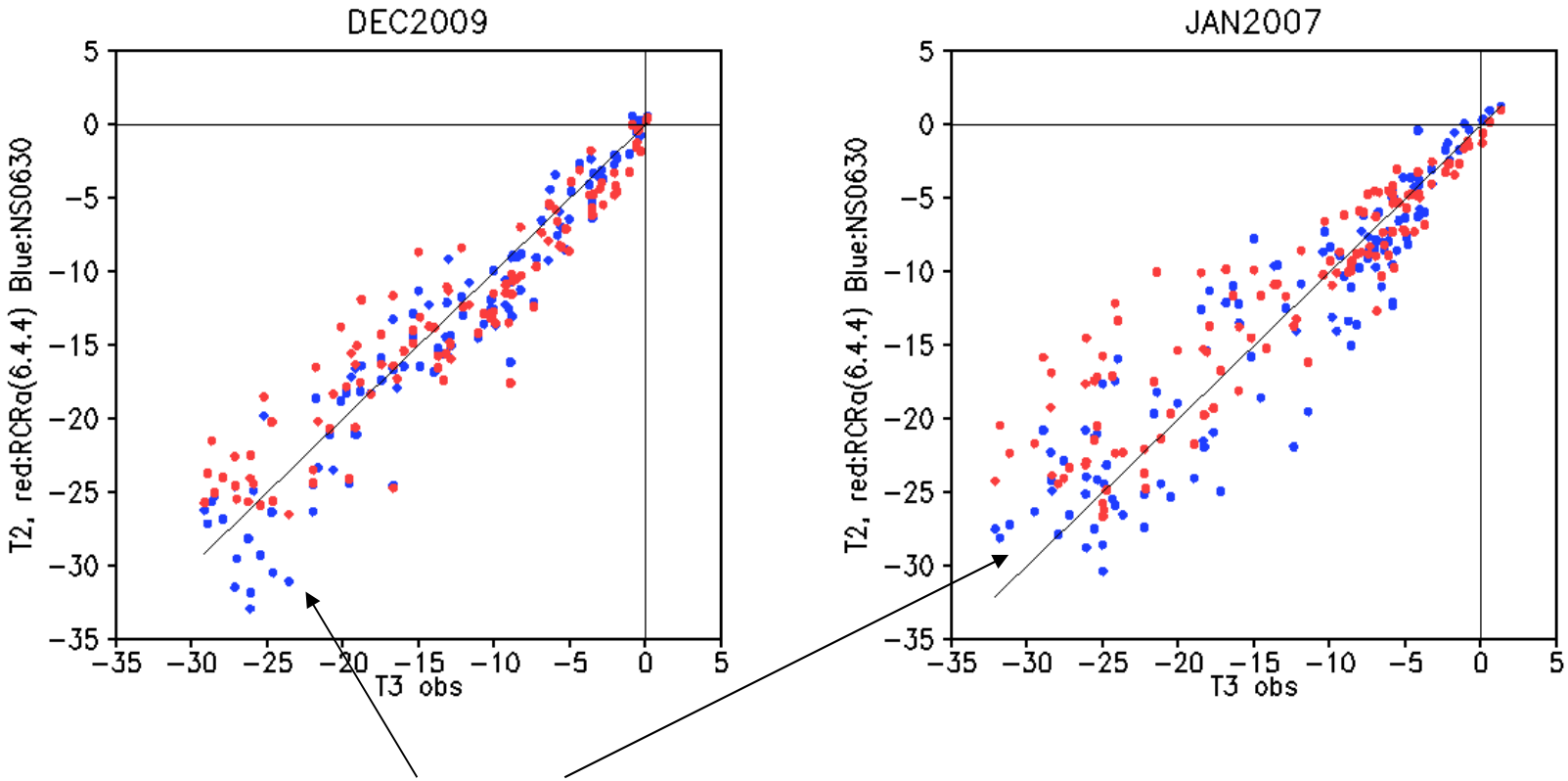

Cold temperatures get colder.

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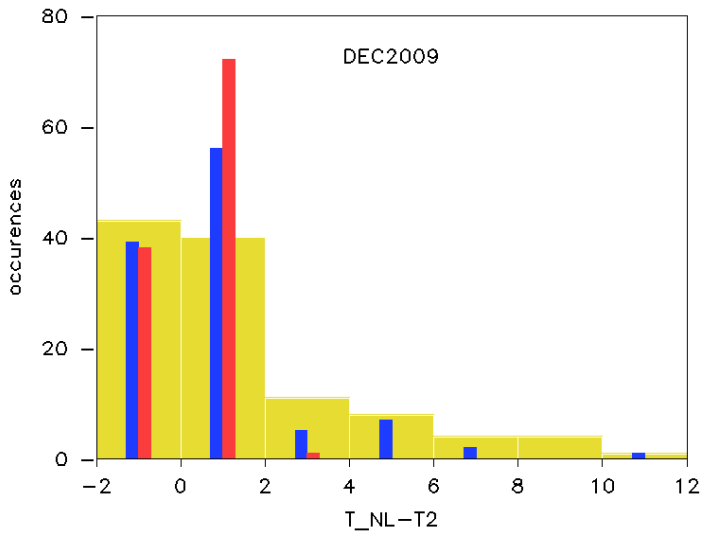
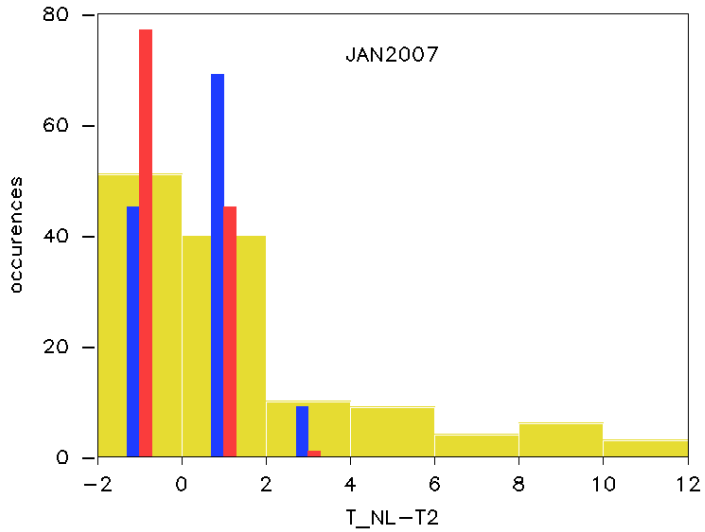
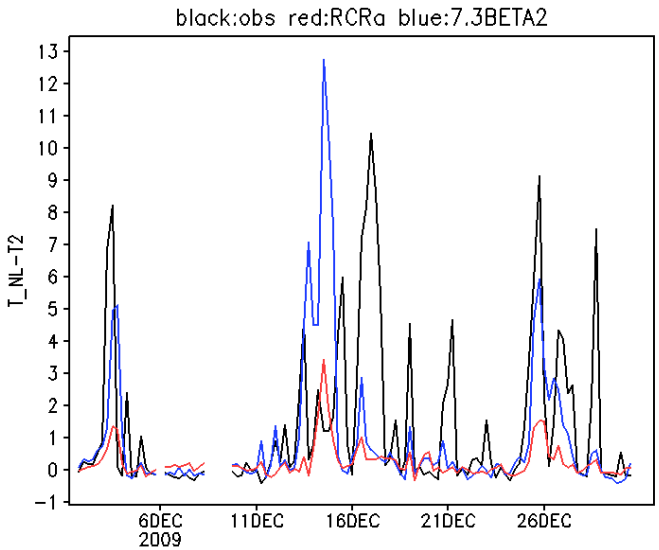
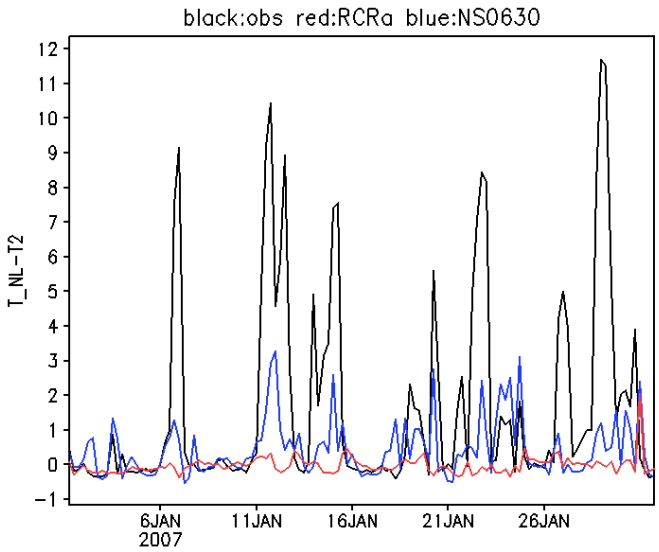
Surface layer temperature gradient

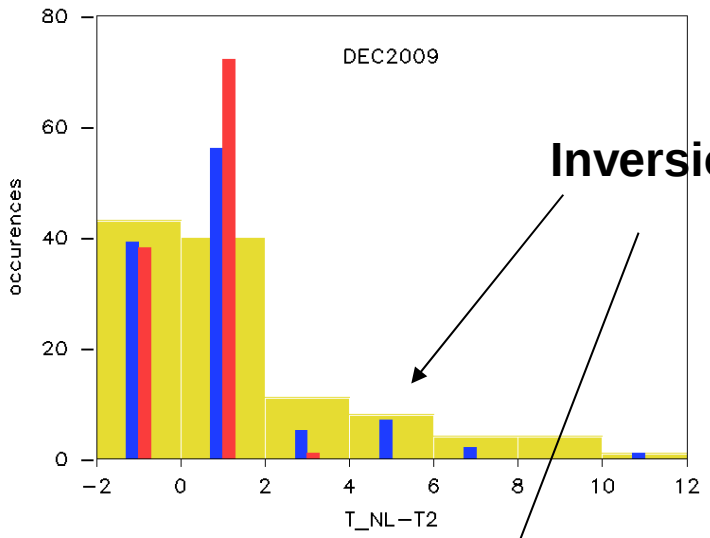




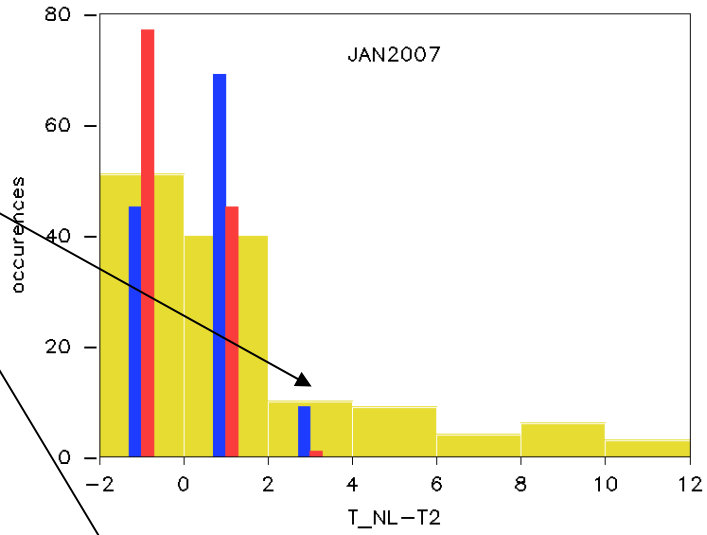


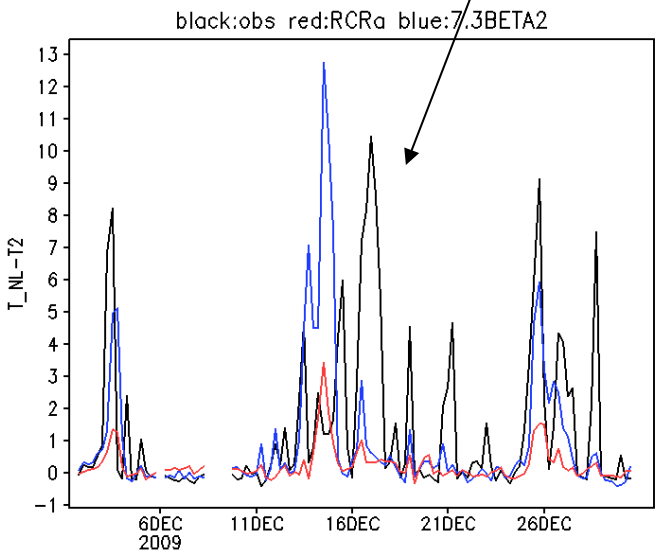


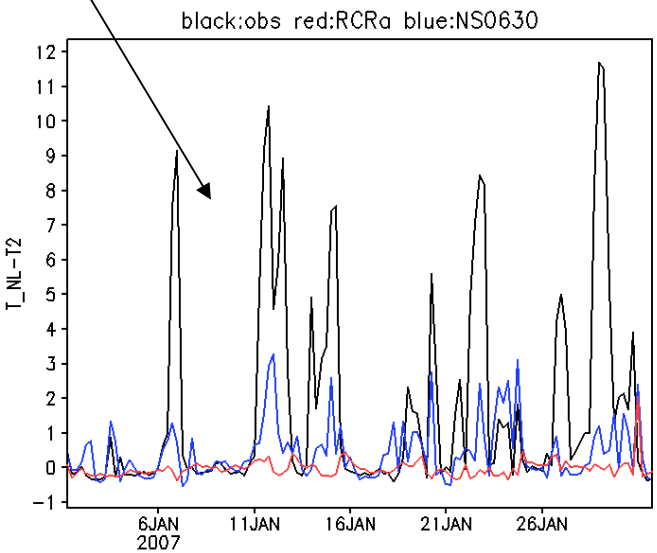
Surface layer temperature gradient



Inversions

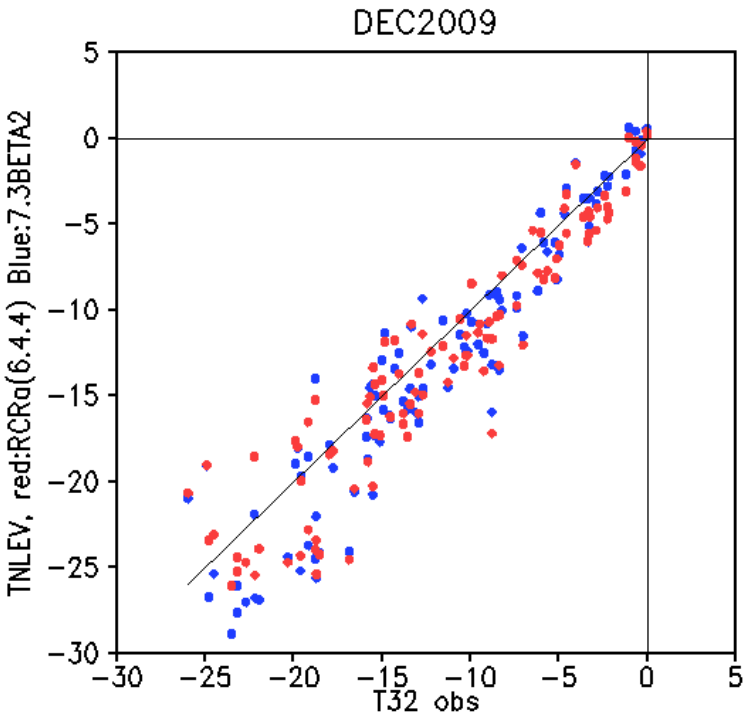


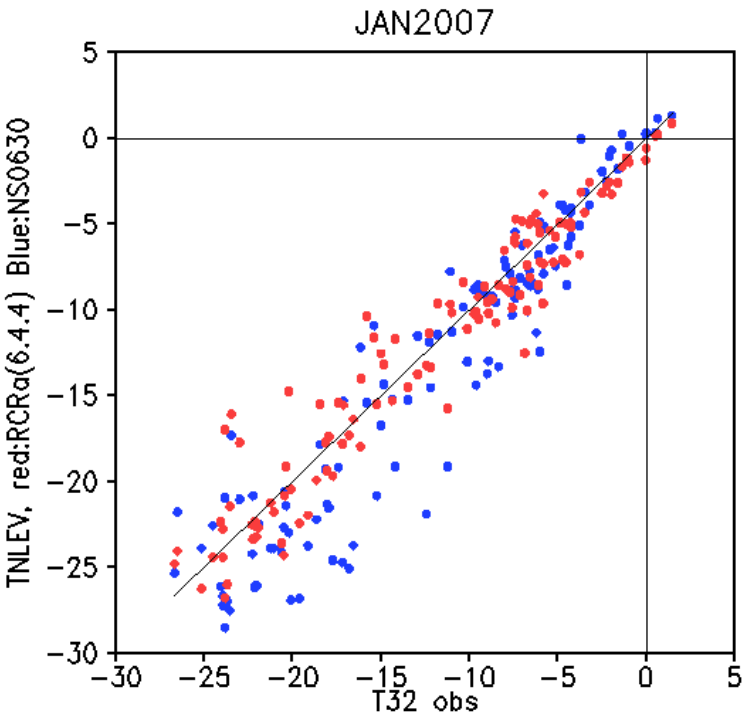




Temperature at 30m

Red: RCR (7.2) , Blue: 7.3 BETA2





Temperature at 30m

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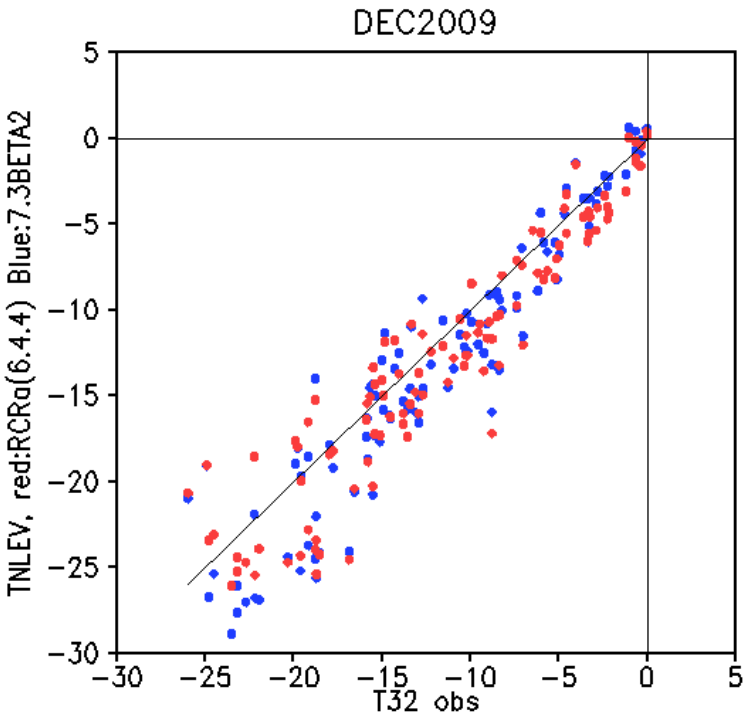
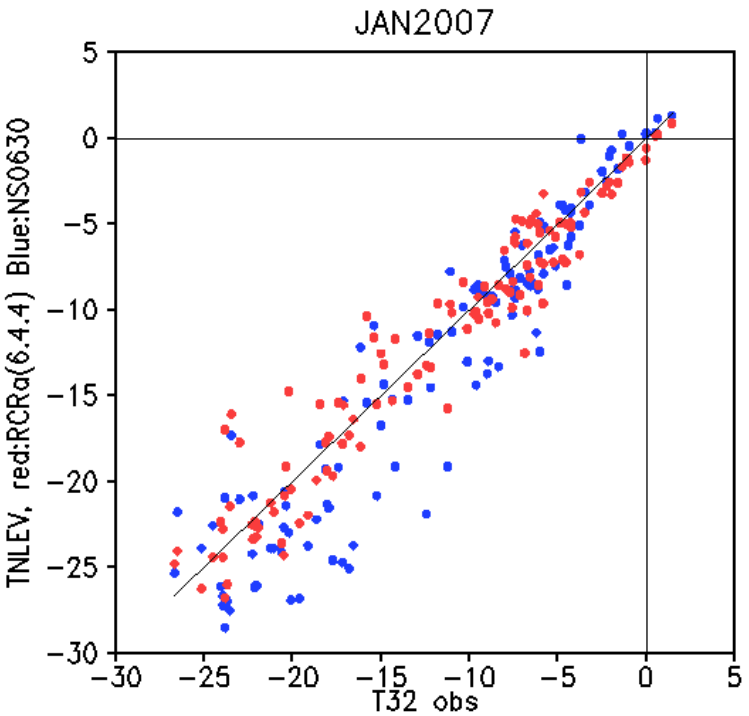
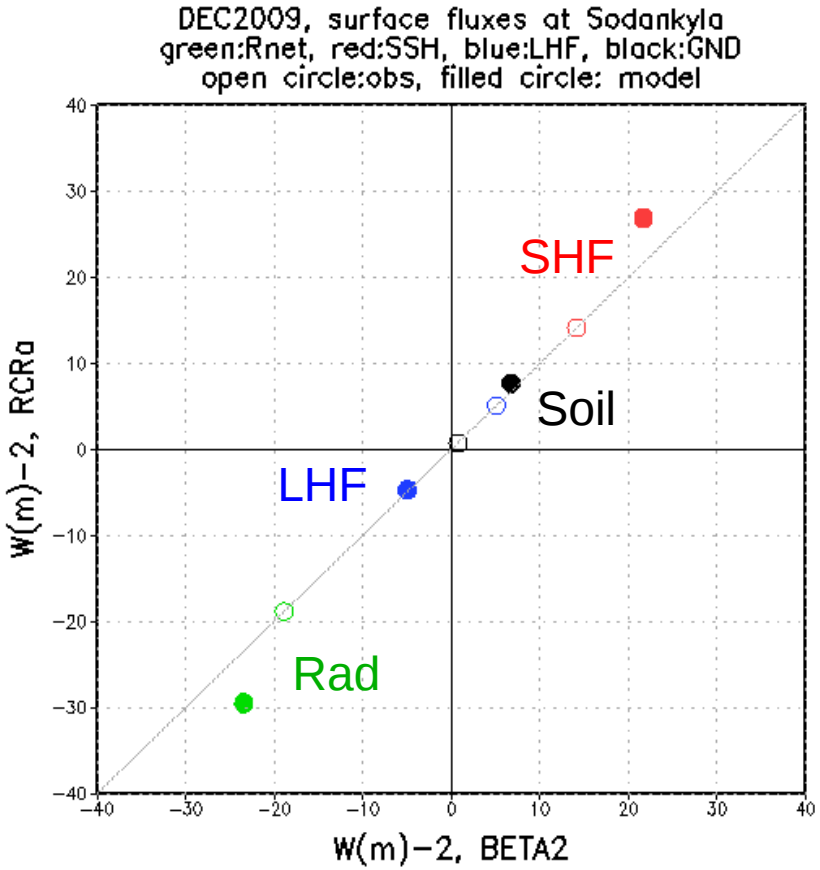




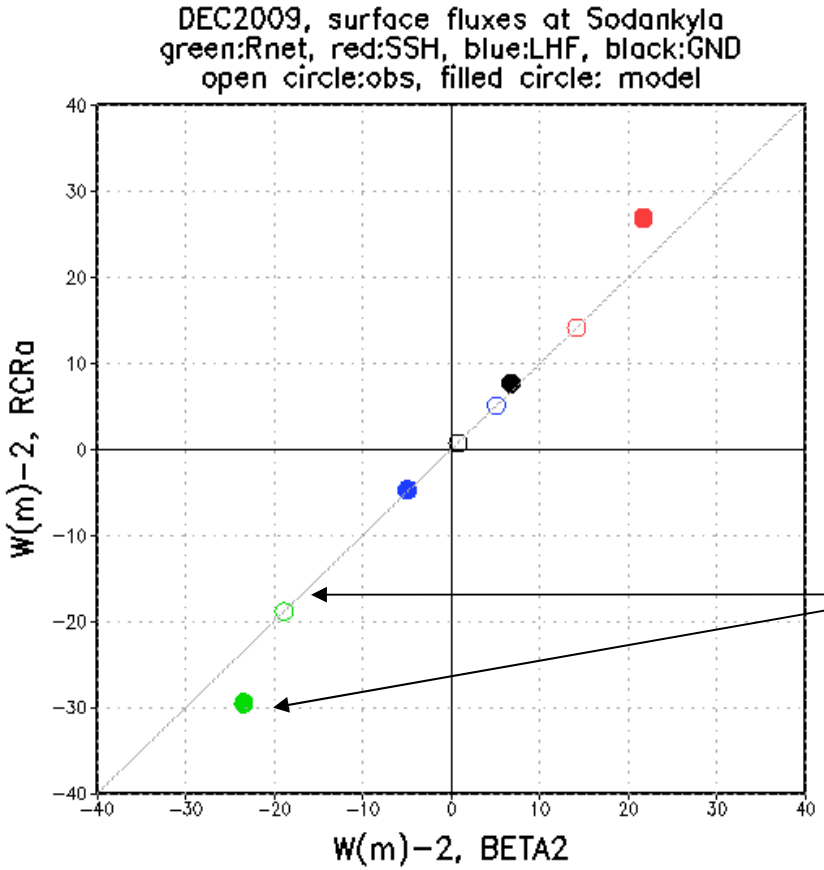
Cold bias, worse in 7.3 BETA2

- **Reduced warm bias of screen temperature in the new model HL 7.3**
  - \+ more frequent and more intense surface inversions
  - − increased cold bias at the top of the surface layer

Ensemble mean surface heat fluxes, DEC 2009

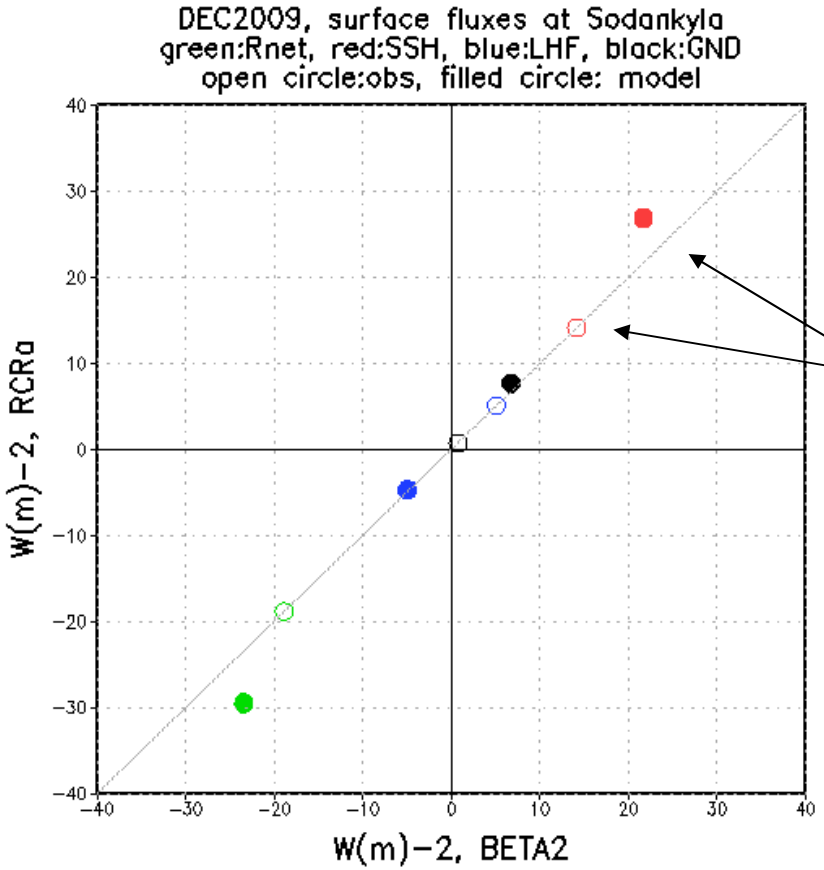


Ensemble mean surface heat fluxes



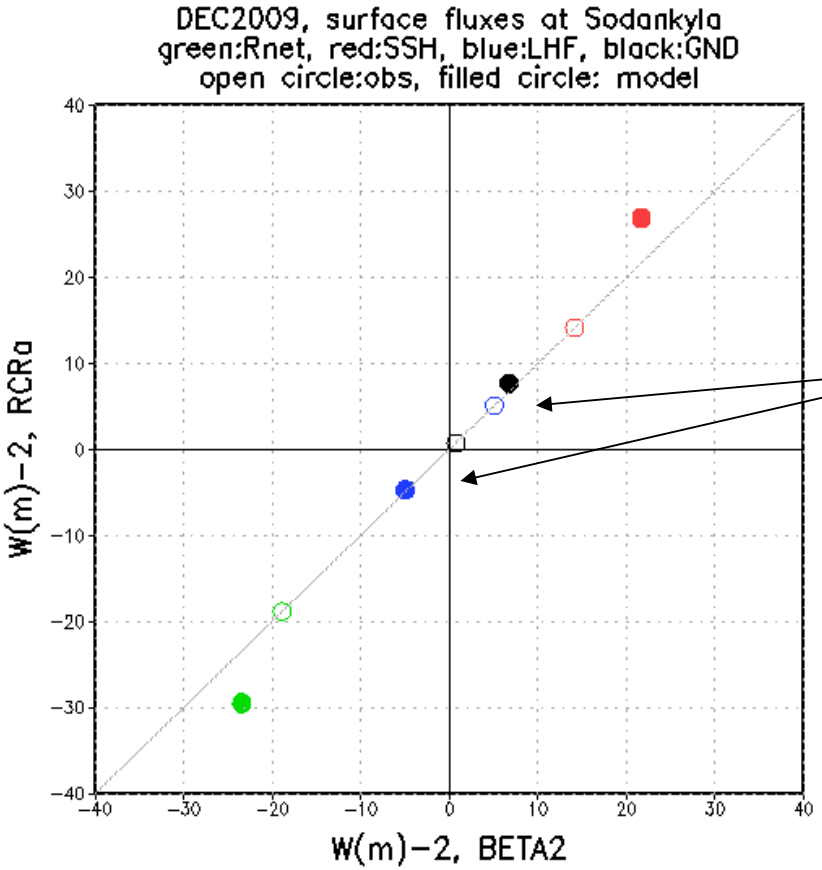
Net radiation too negative, improved in HL 7.3

Ensemble mean surface heat fluxes



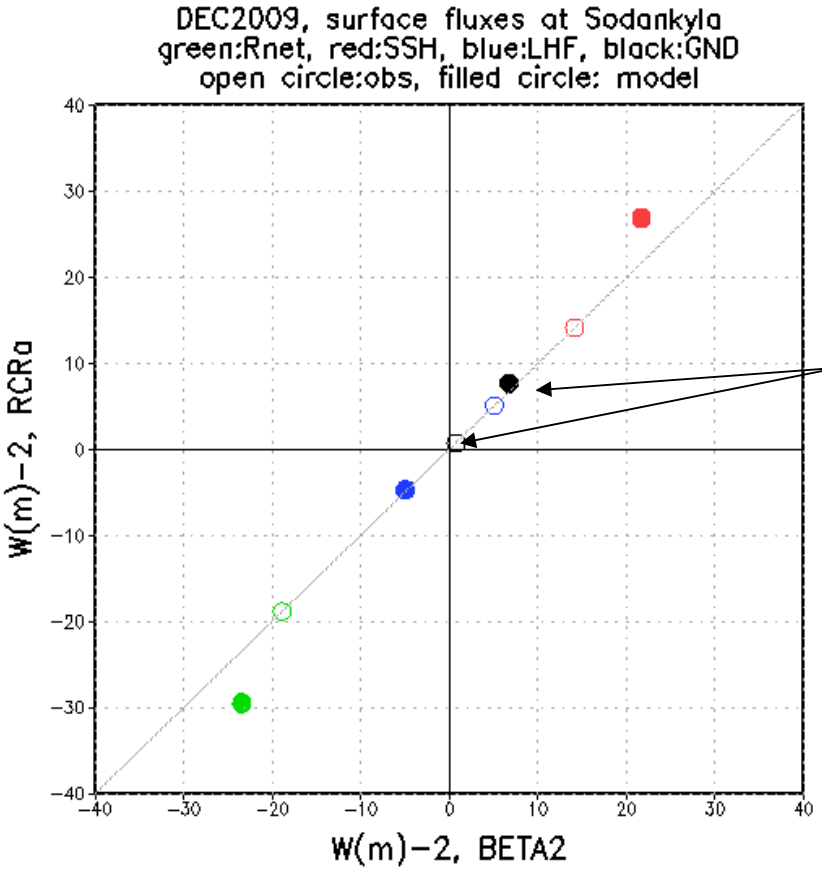
too much downward sensible heat flux, improved in HL 7.3

Ensemble mean surface heat fluxes



wrong sign of latent heat flux,
identical in the two model versions

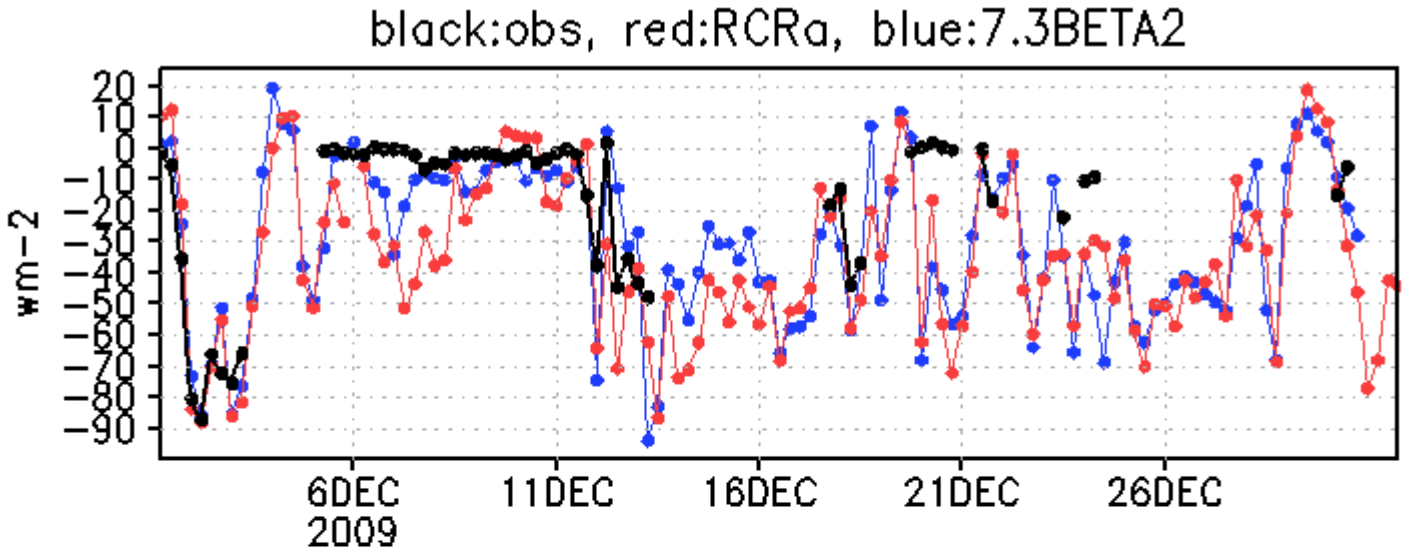
Ensemble mean surface heat fluxes

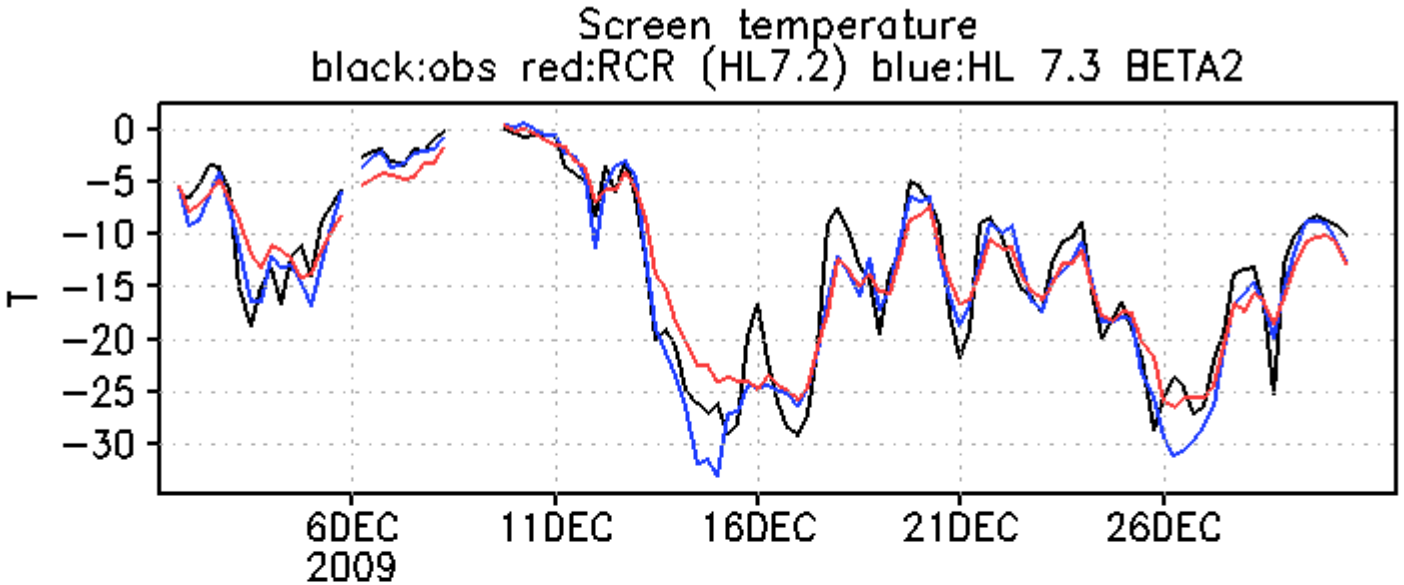


too much heat release from the soil
(*residual between R,SHF,LHF*)

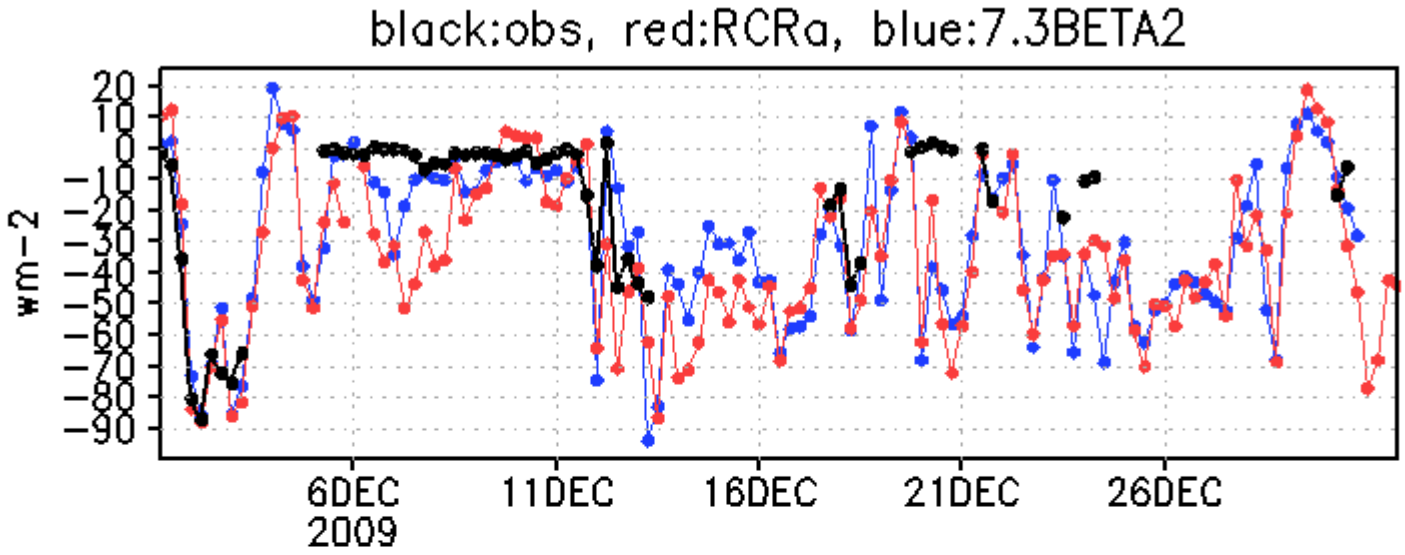
Time sequencies...

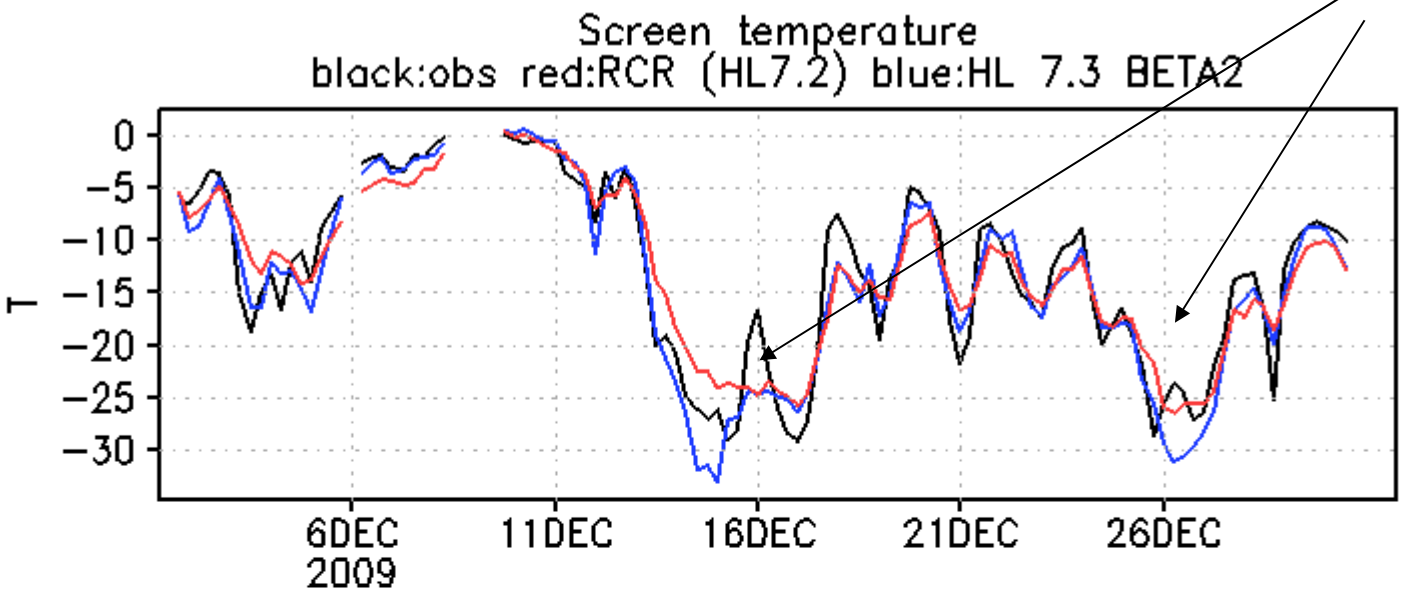
Net radiation



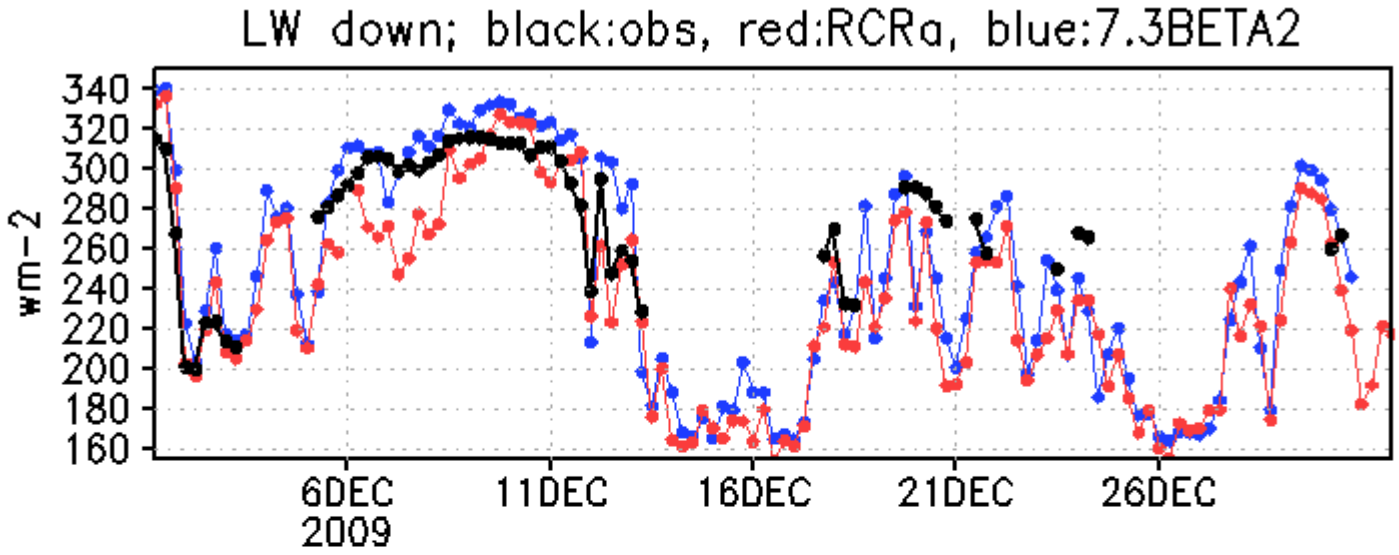


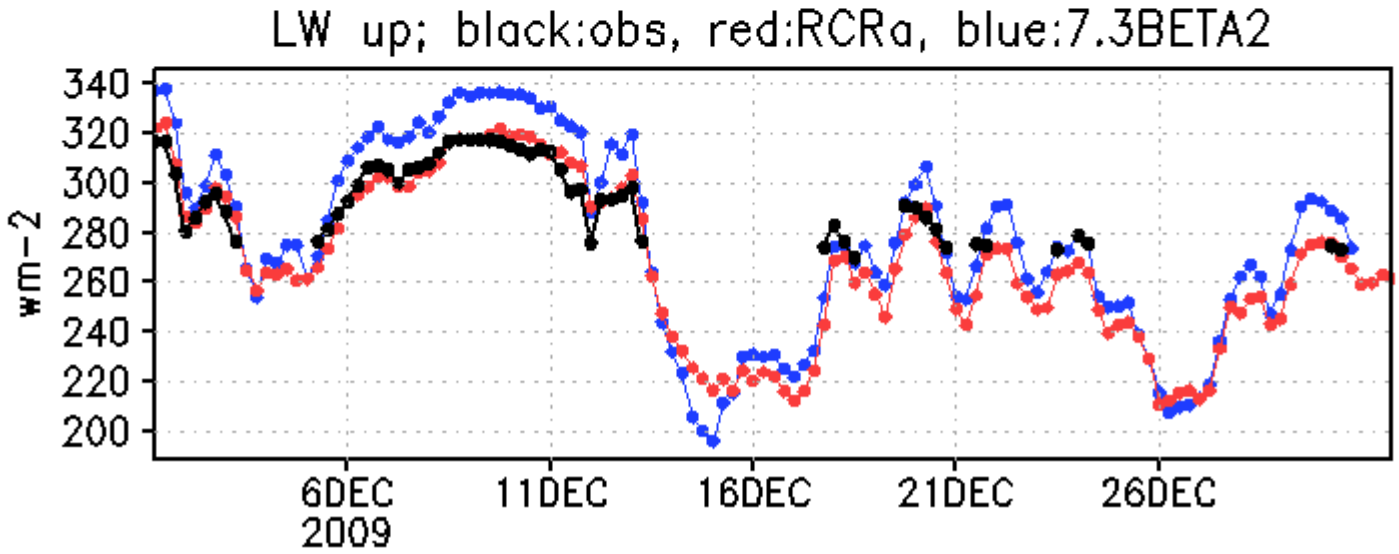
Net radiation





inversion episodes not covered by measurements!


LW down; black:obs, red:RCRa, blue:7.3BETA2
wm-2
340
320
300
280
260
240
220
200
180
160
6DEC
2009
11DEC
16DEC
21DEC
26DEC


LW up; black:obs, red:RCRa, blue:7.3BETA2
wm-2
340
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2009
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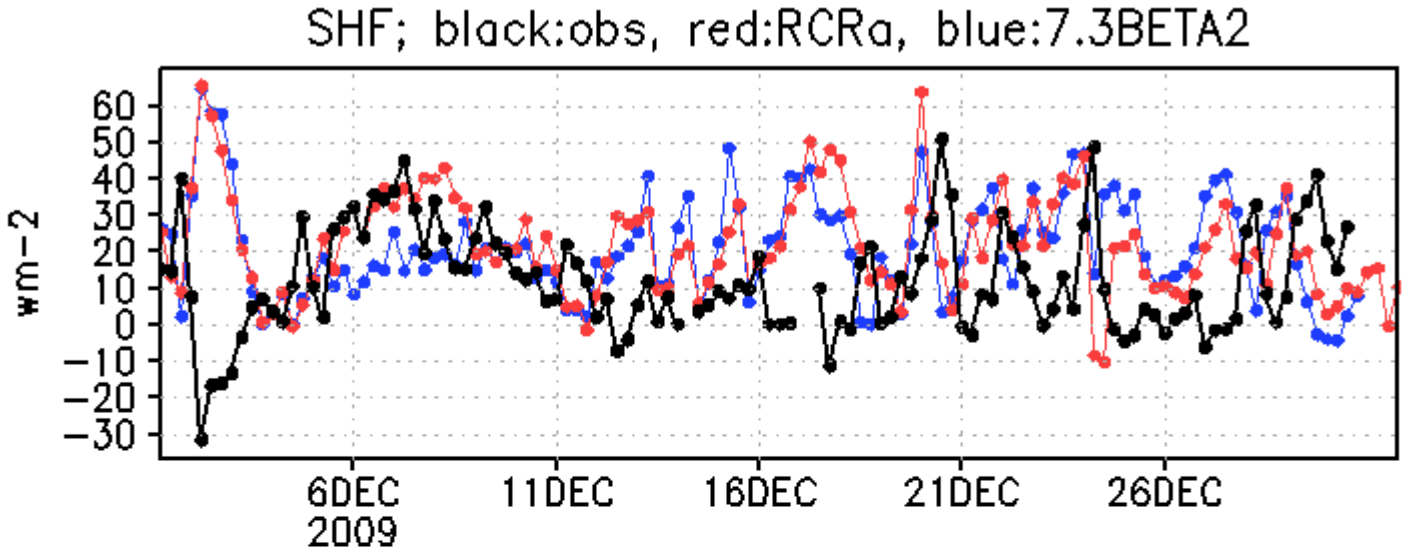
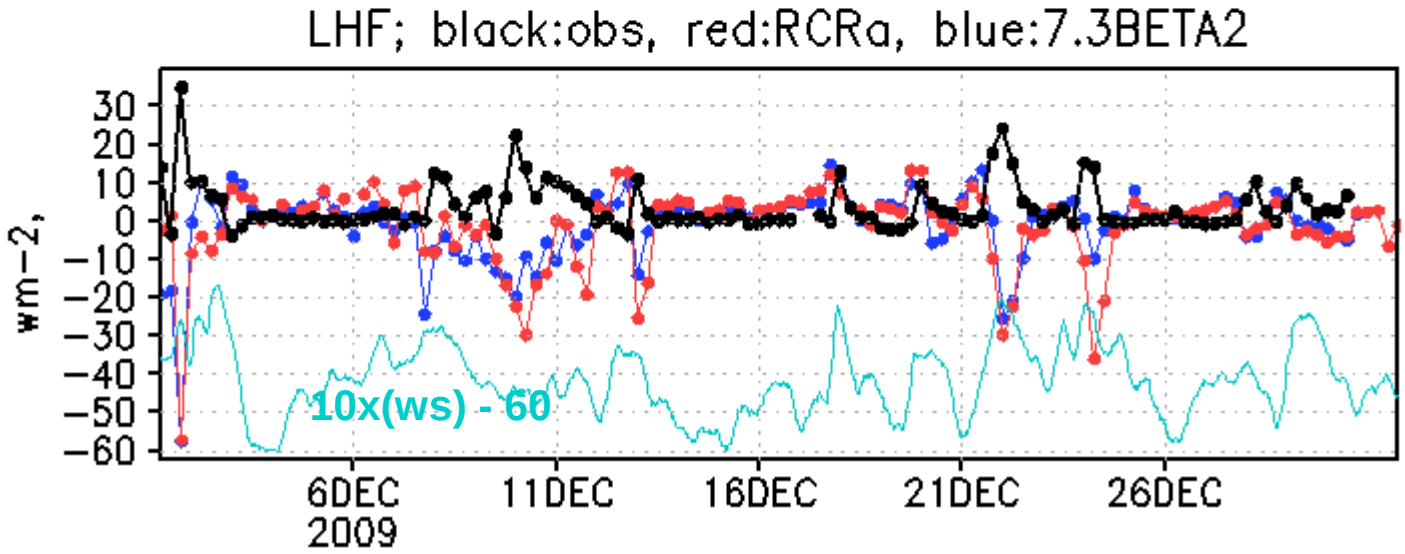
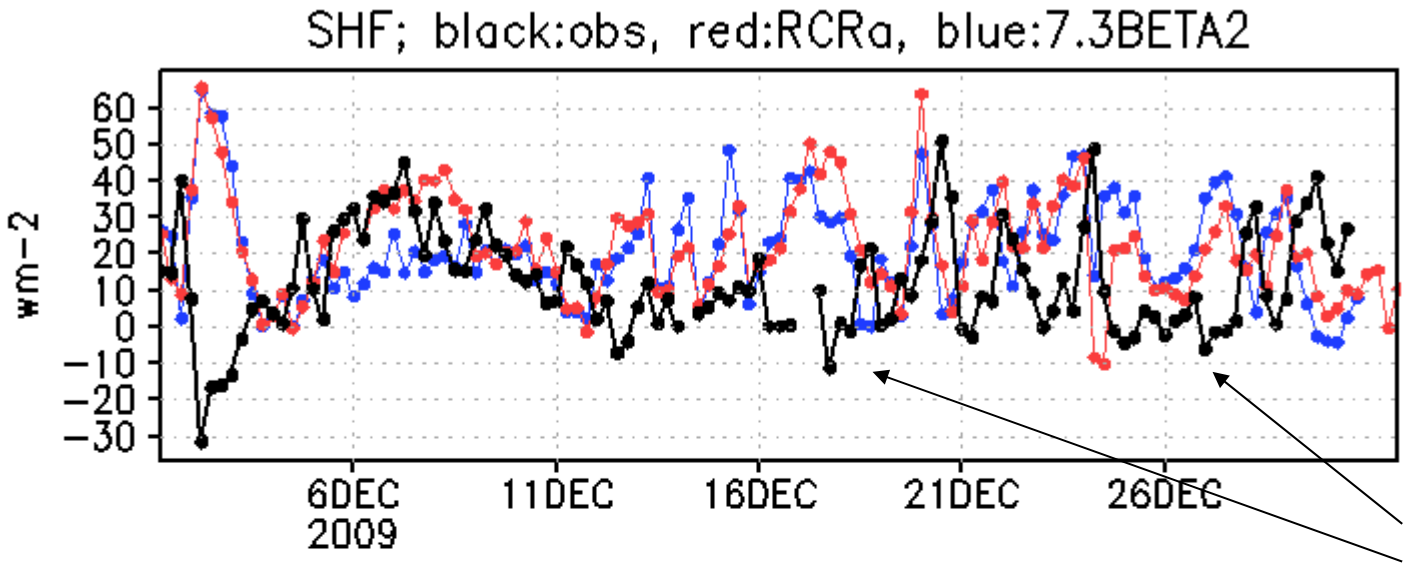
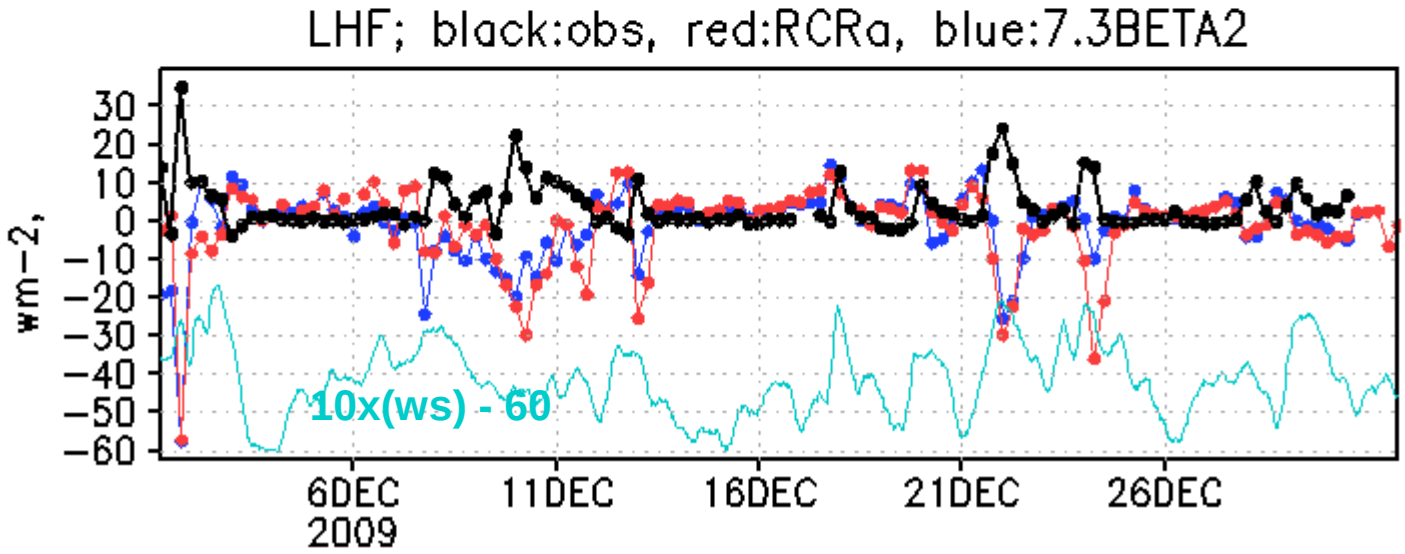
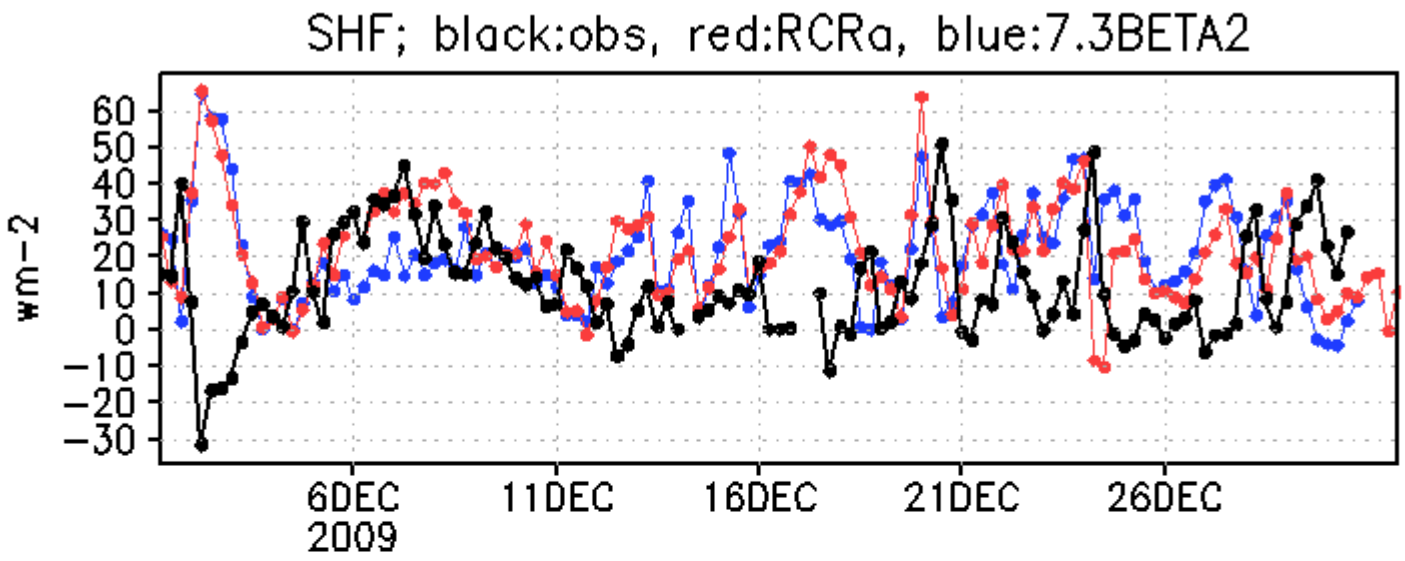

SHF; black:obs, red:RCRa, blue:7.3BETA2
wm-2
60
50
40
30
20
10
0
−10
−20
−30
6DEC
2009
11DEC
16DEC
21DEC
26DEC

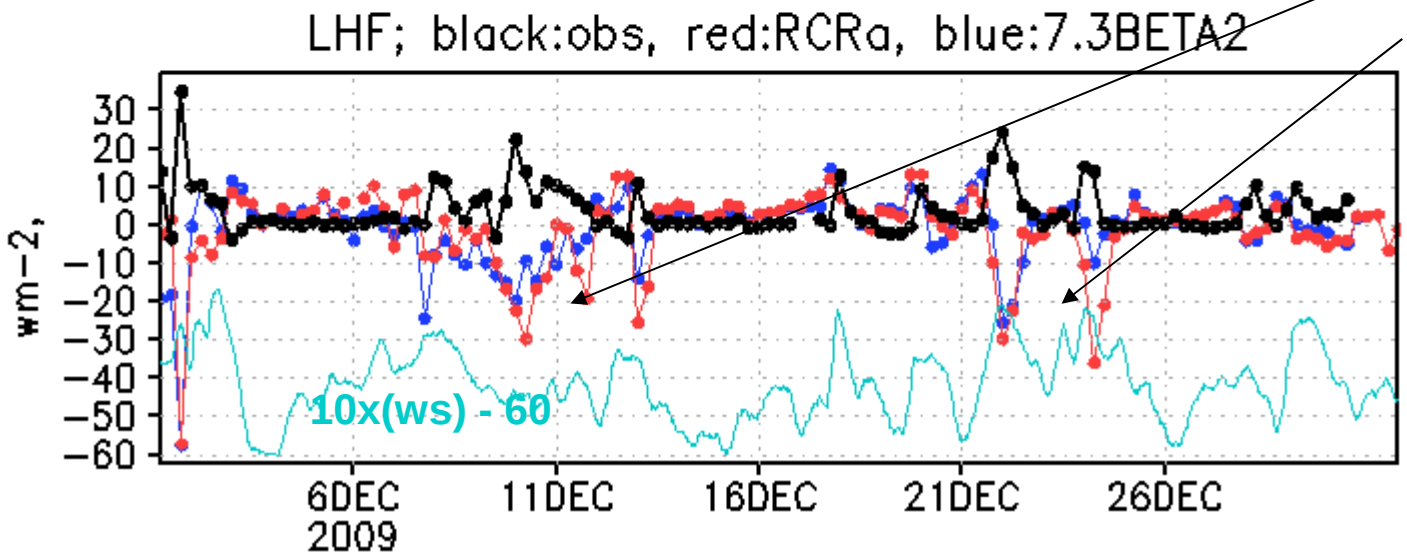

LHF; black:obs, red:RCRa, blue:7.3BETA2
wm-2,
30
20
10
0
−10
−20
−30
−40
−50
−60
10x(ws) - 60
6DEC
2009
11DEC
16DEC
21DEC
26DEC



too strong fluxes during inversion episodes

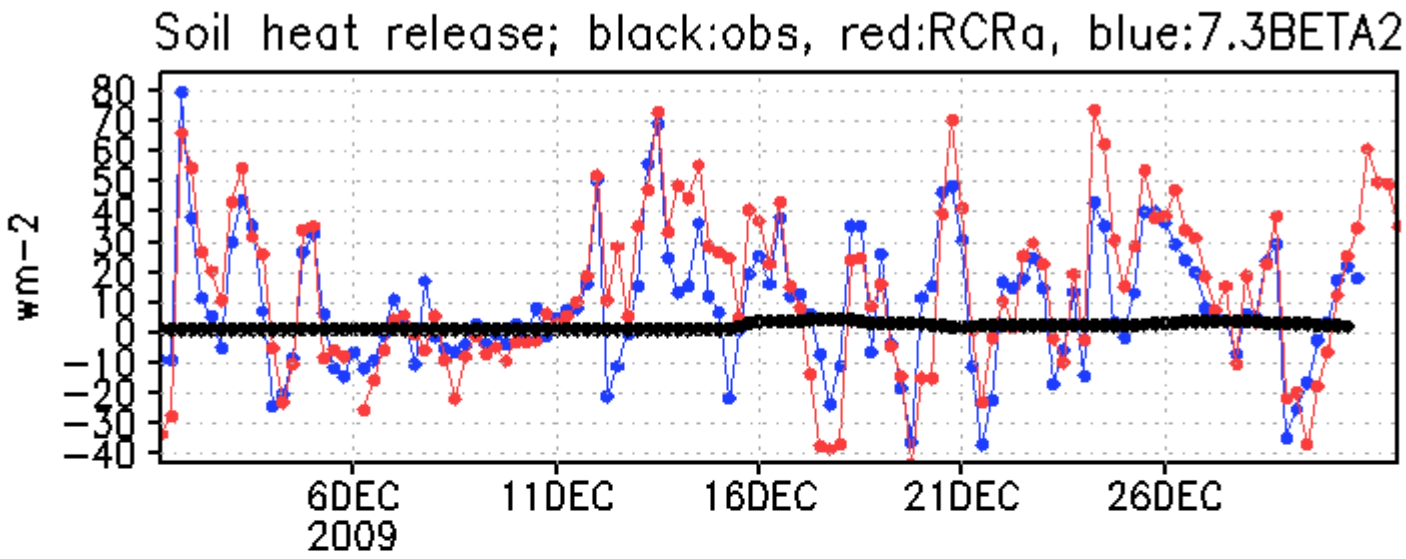


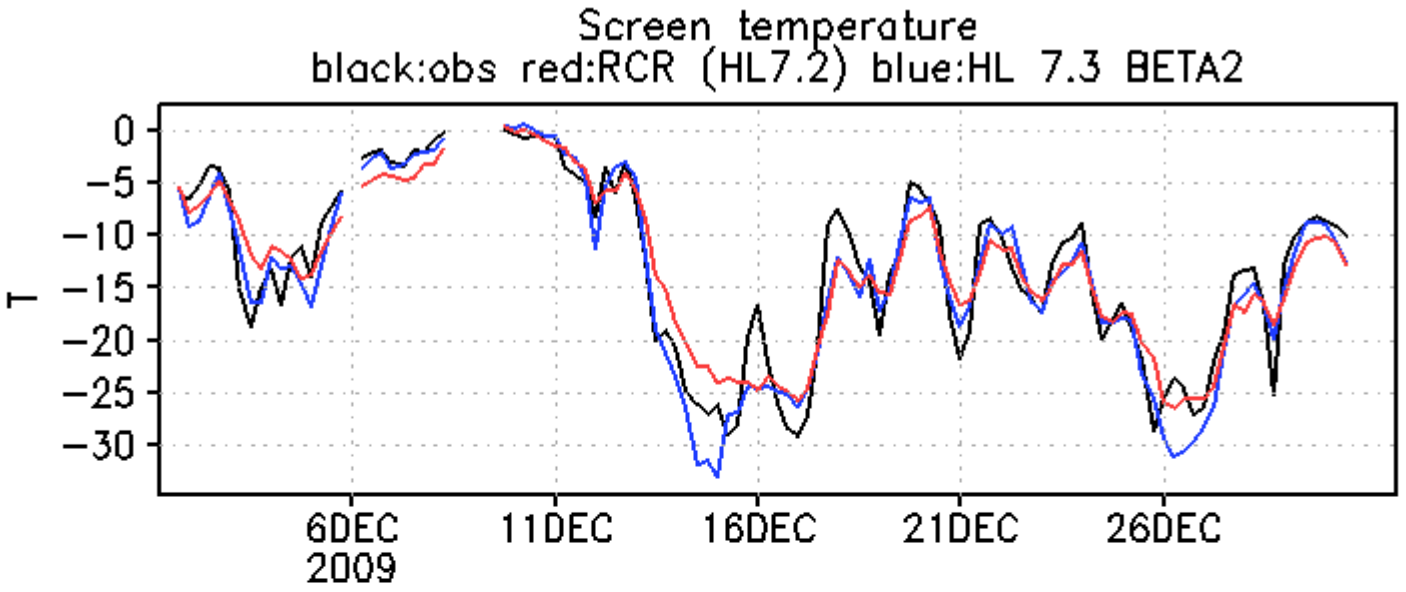




unobserved upward latent heat flux

Soil heat release

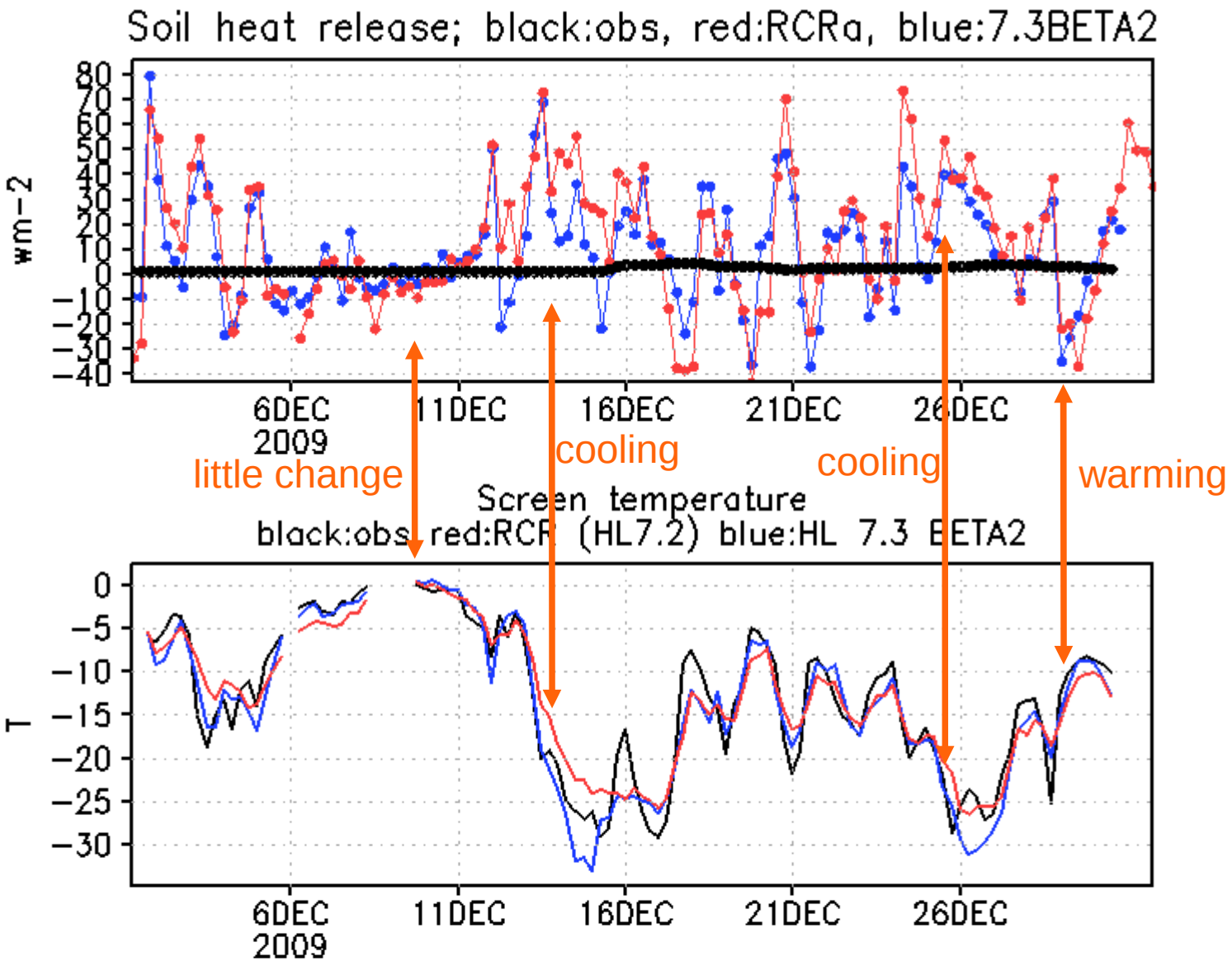




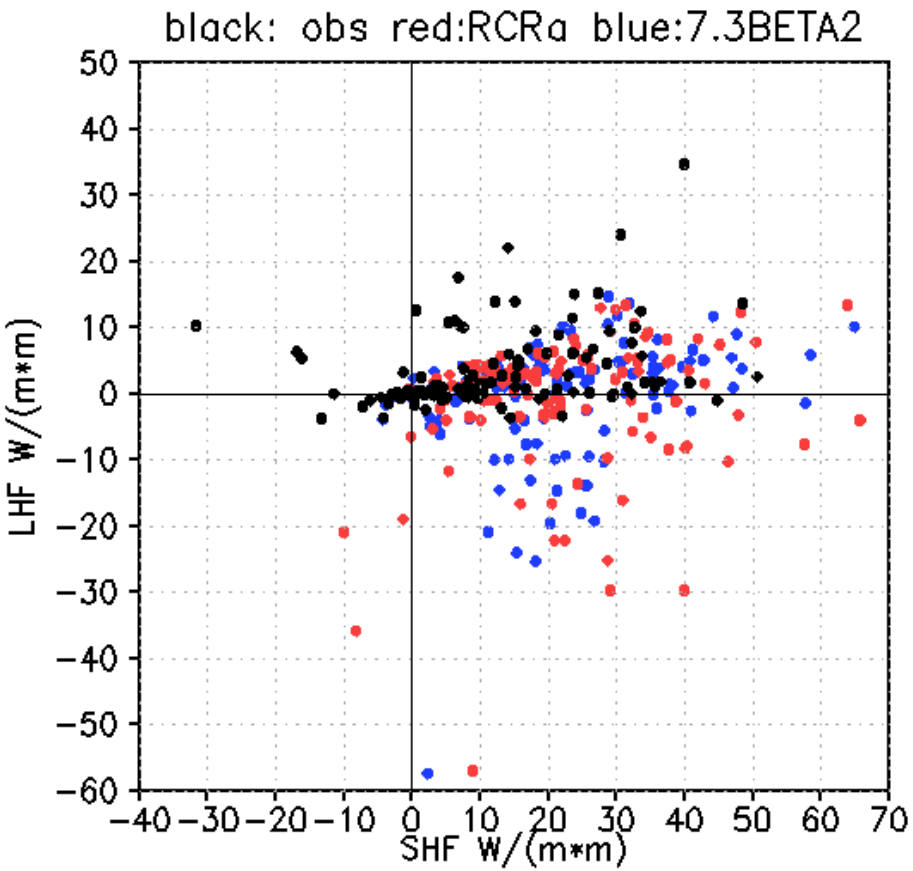
Models: *residual of Rad,SHF,LHF*

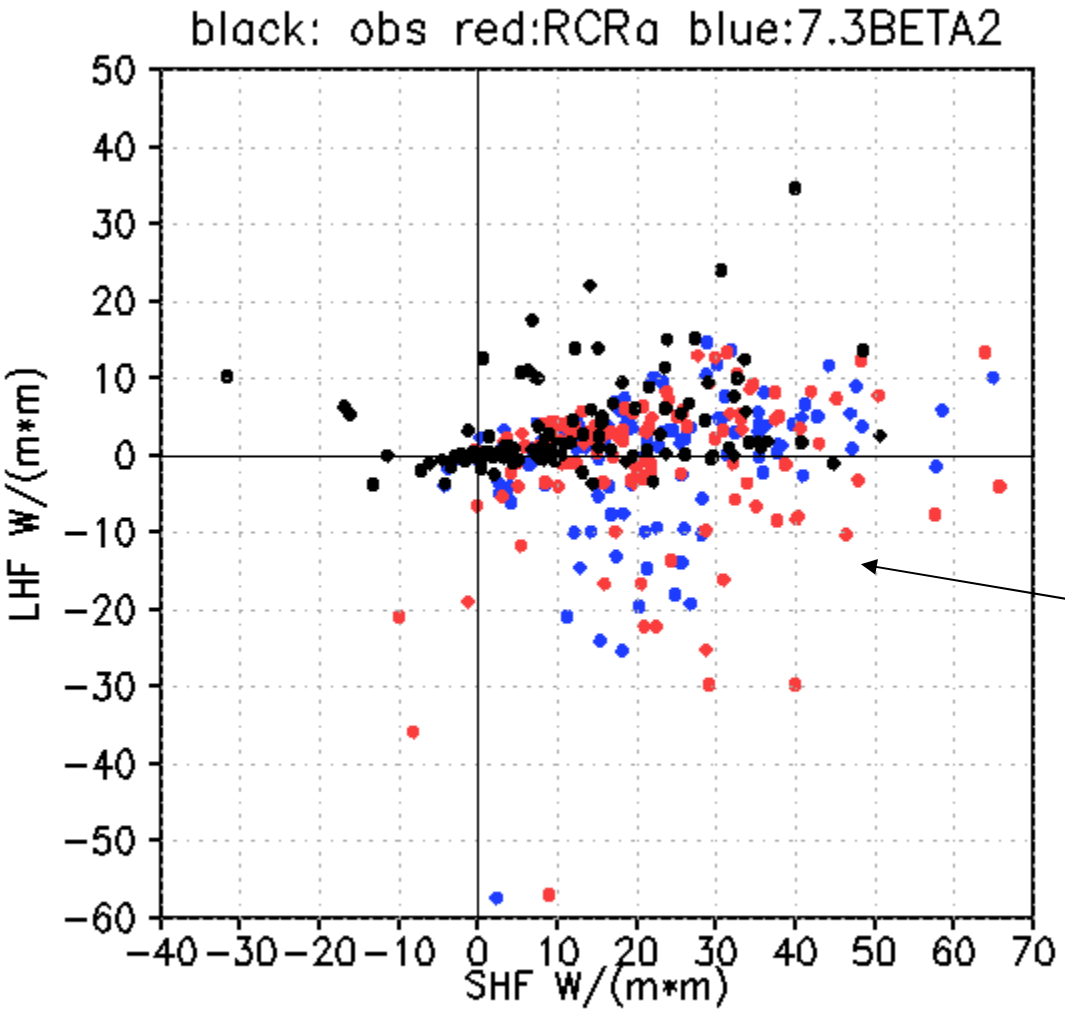
Obs: *flux at 7 cm in the soil*

Soil heat release

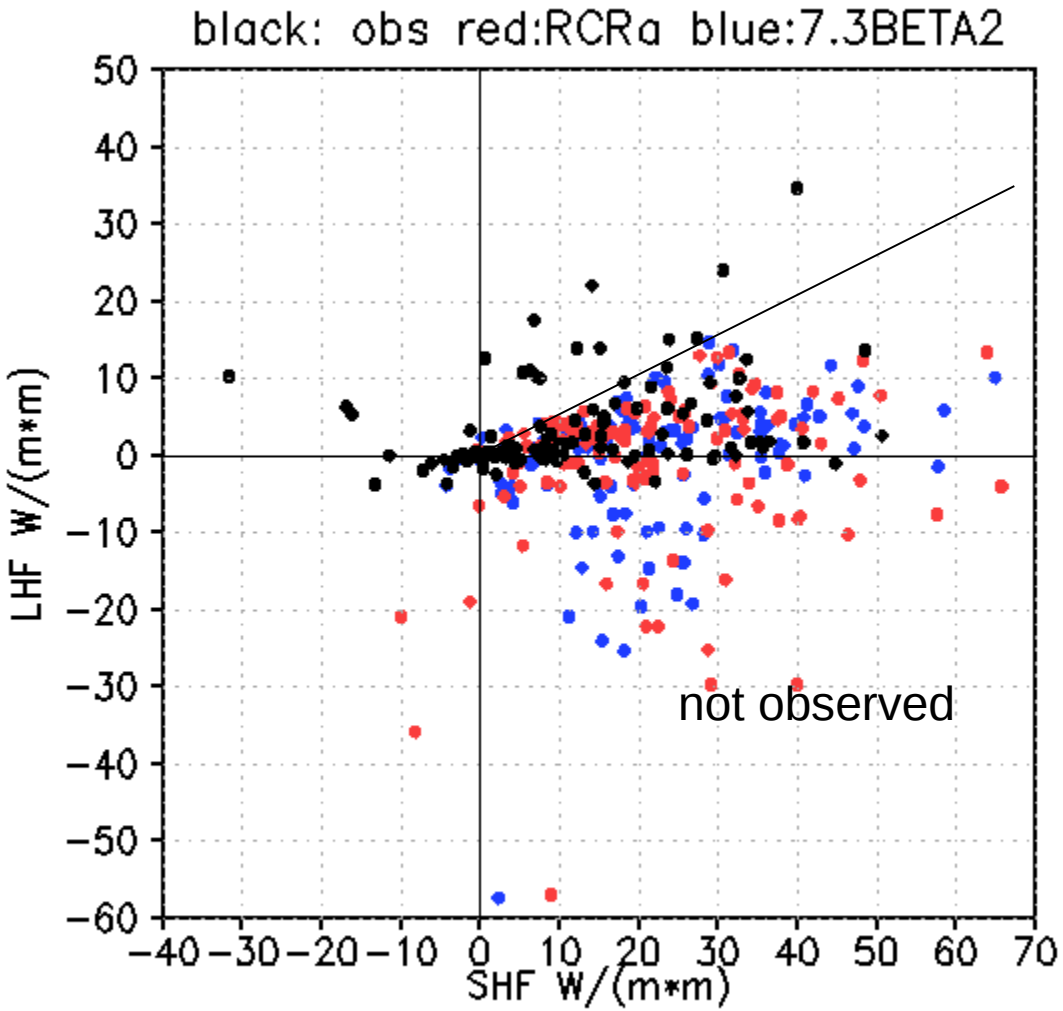


LHF vs. SHF, Dec 2009

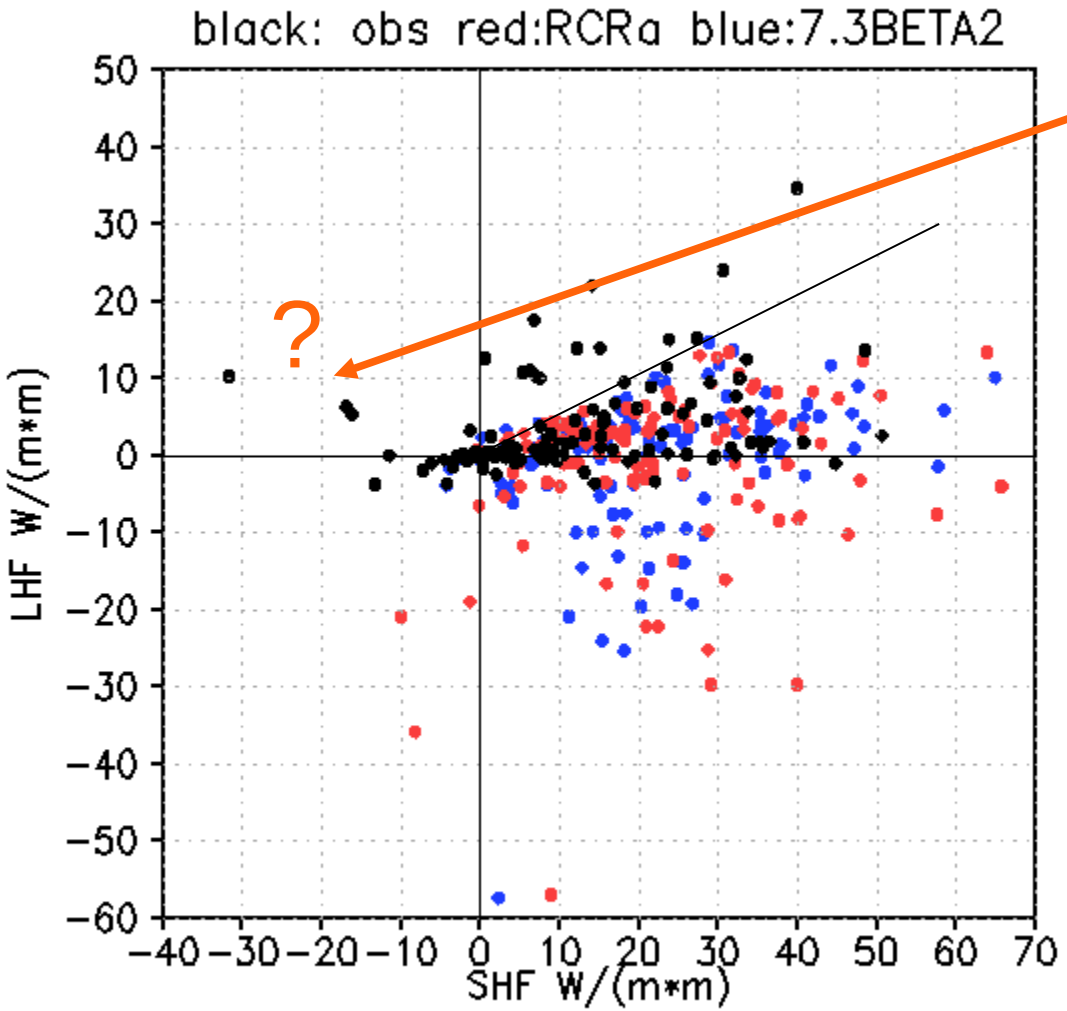




strong upward latent heat flux associated with downward sensible heat flux: not observed



cut-off at
LHF=0.5xSHF:
not observed



Measurement error?

Summary

- **Reduced warm bias of screen temperature in the new model**
  - \+ more frequent and more intense surface inversions
  - − increased cold bias at the top of the surface layer
- **Both model versions overestimate the intensity of the surface energy cycle (too much radiative loss, too much downward sensible heat flux, too much heat release from the soil). Some improvement in the new version.**
- **(failures to forecast) surface inversions coincident with overestimated downward sensible heat flux in both model versions.**
- **Both model versions display unobserved peaks of upward latent heat flux, leading to wrong sign on the average.**