ILMATIETEEN LAITOS
METEOROLOGISKA INSTITUTET
FINNISH METEOROLOGICAL INSTITUTE

ABL structures and processes at Sodankylä

Carl Fortelius

HIRLAM All Staff Meeting,
Cracow,
13-16 April 2010

Contents...

- Intercomparison of measurements and two weather forecasting models, HIRLAM 7.2 and 7.3beta2
- Descriptive approach: looking for differences and similarities

Contents...

- **ABL structures**
  - Surface layer temperature gradient
    - winter-time cold spells, summer-time diurnal cycle
  - Surface layer wind shear
    - too few cases of low wind speed at 10 m (0-2 m/s, say), e.g winter and night time summer
- and ***processes***
  - Radiative and turbulent heat fluxes
- *At sodankylä*
  - Sodankylä (67 N, 26 E)
  - Sparse Scots pine forest, 10-15 m tall
  - July 2009, Dec 2009-Jan2010

Contents...

- ***Models***
  - HIRLAM operational reference runs (RCR)
    - HIRLAM 7.2
  - HIRLAM 7.3 beta 2
    - Dec 2009-Jan 2010: RCR-parallel run at FMI
    - July 2009: as RCR, but with 3D-VAR and without LSMIX
  - state at h+6, fluxes during hours 0...6

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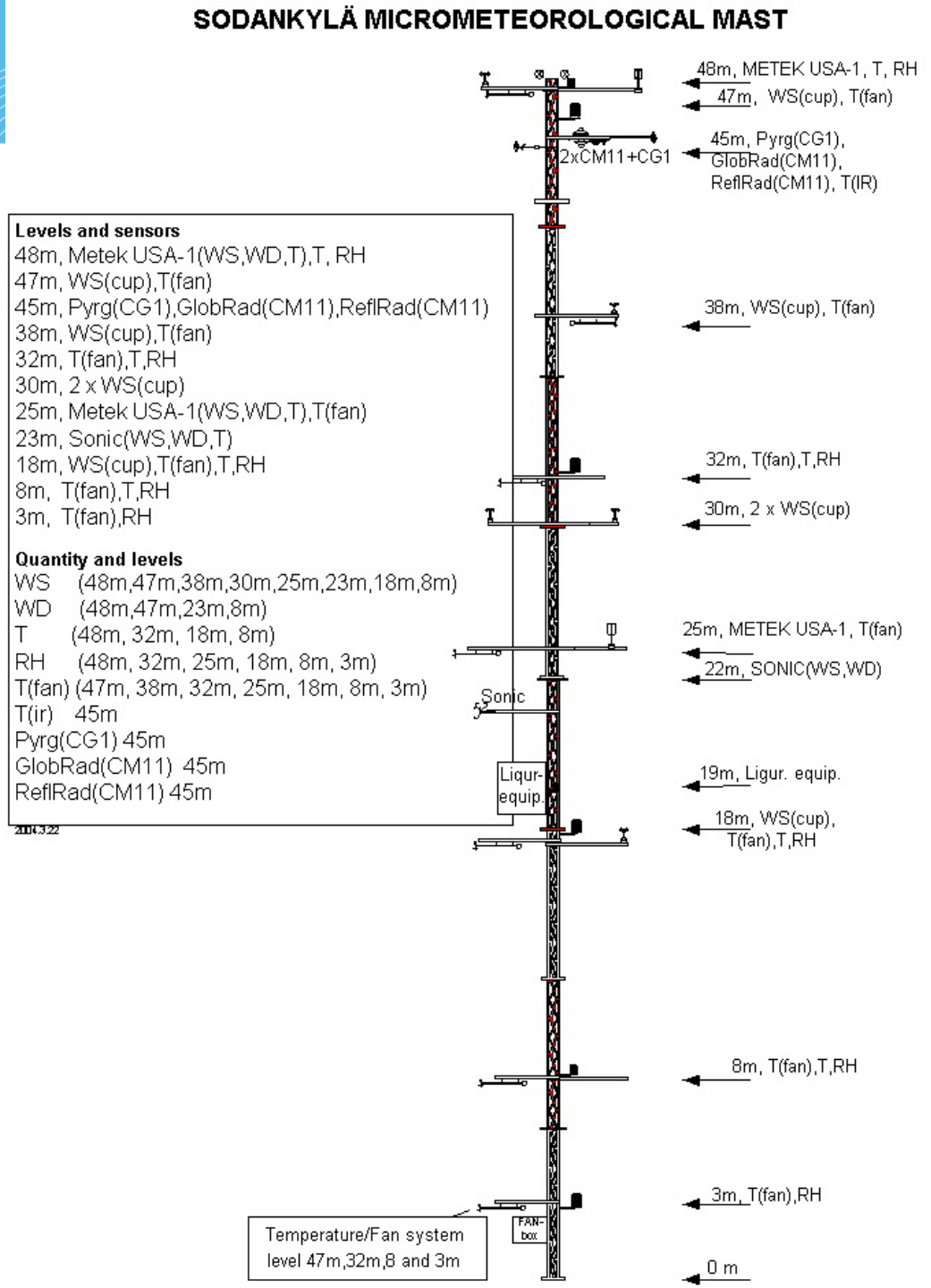
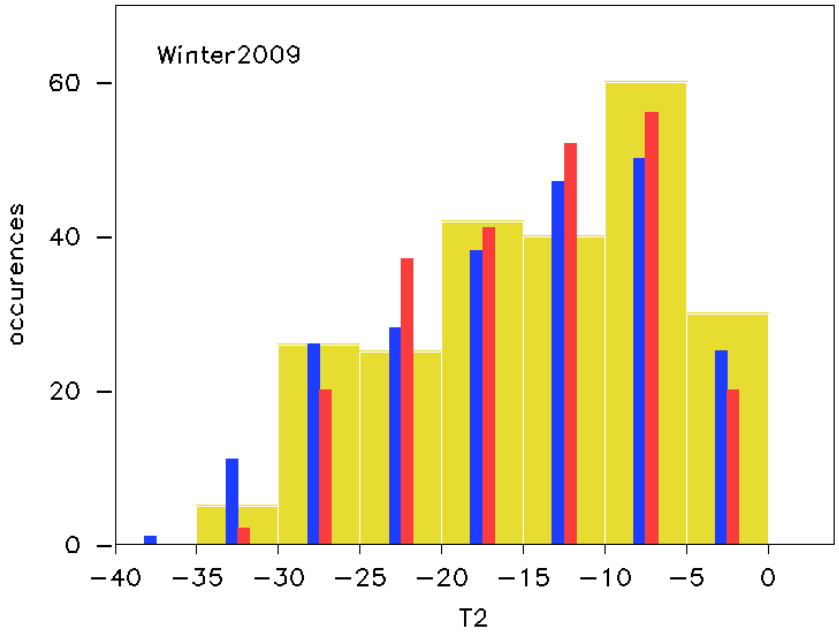
Contents...

- ***Data***
  - The Arctic Research Centre of the Finnish Meteorological Institute (FMI-ARC)
    - T: 3 m, 30 m
    - V: 18m, 38m
    - Rad: 18 m
    - SHF, LHF: 22m
    - Soil heat flux: -7 cm

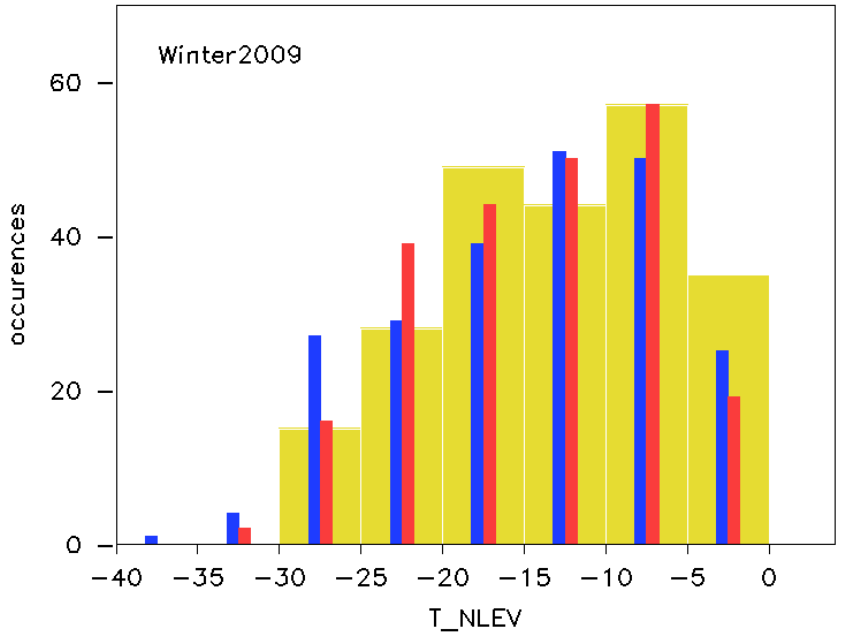


Temperature

Sodankylä
Dec 2009-Jan2010
Yellow: Obs
Red: RCR
Blue: 7.3beta2



more cold cases in new model

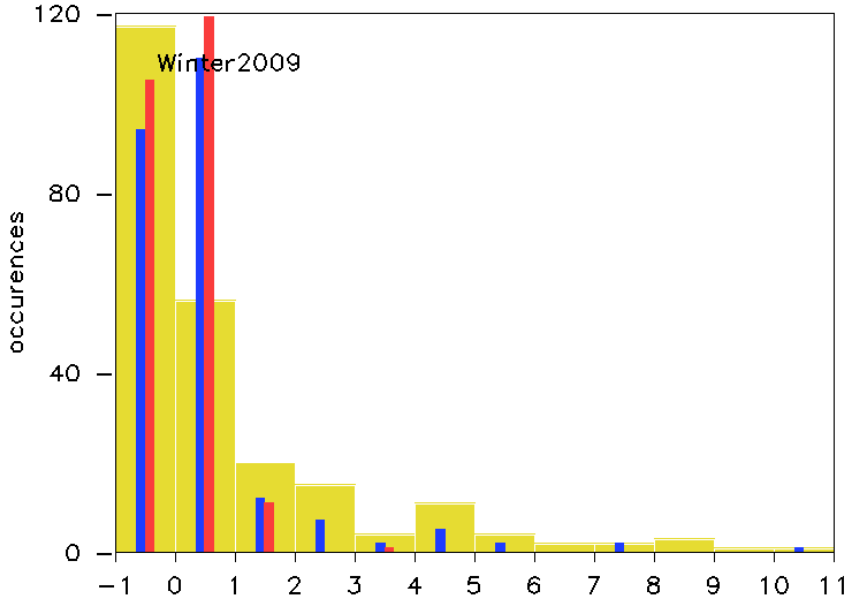


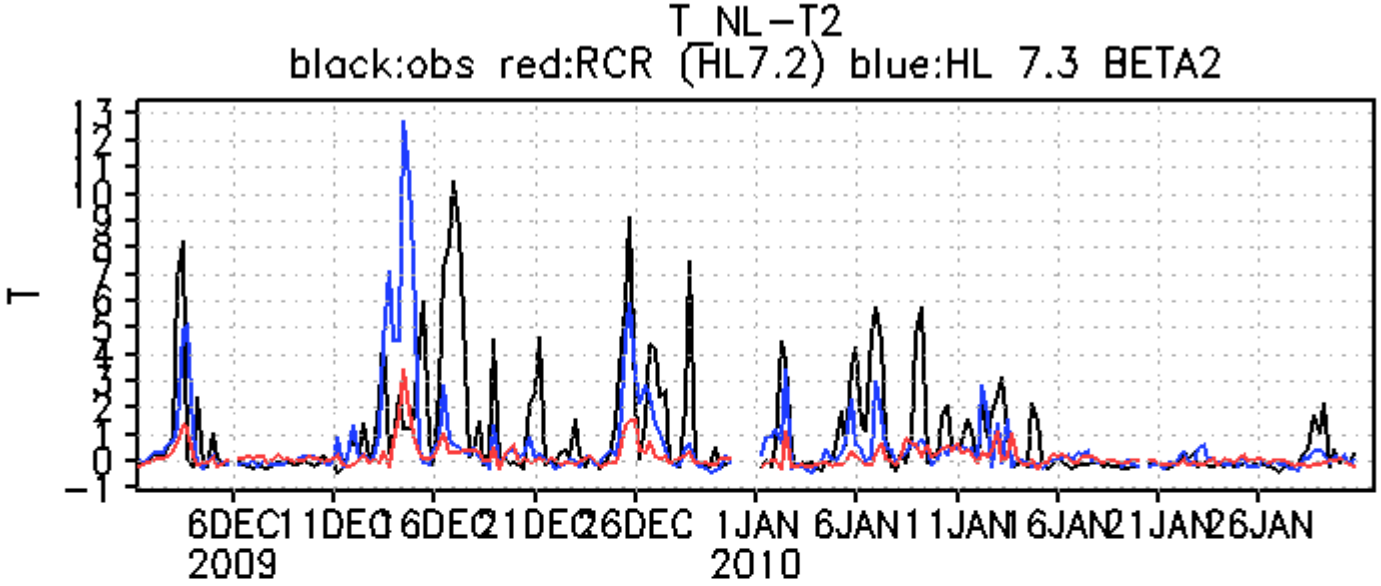
more cold bias in new model

Surface layer temperature gradient

WINTER

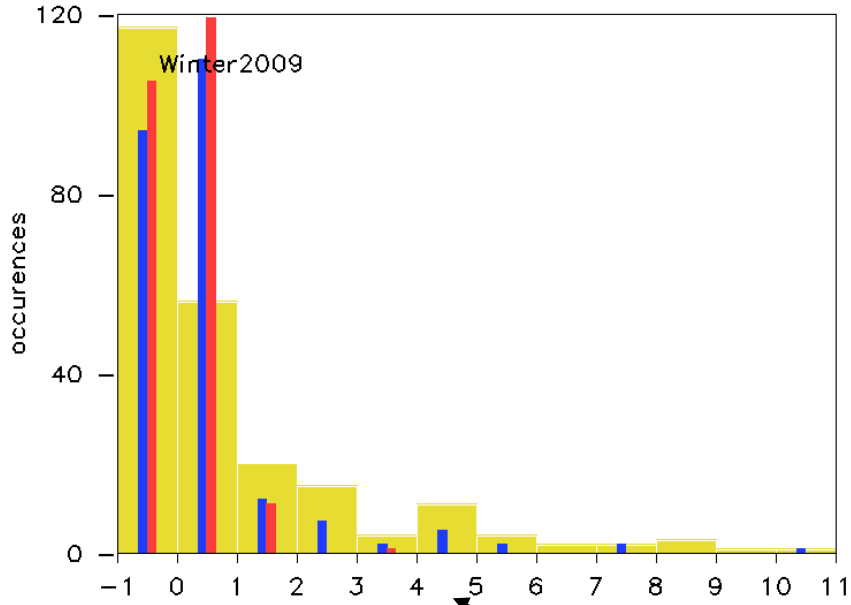
Sodankylä
Dec 2009-Jan2010
Black: Obs
Red: RCR
Blue: 7.3beta2

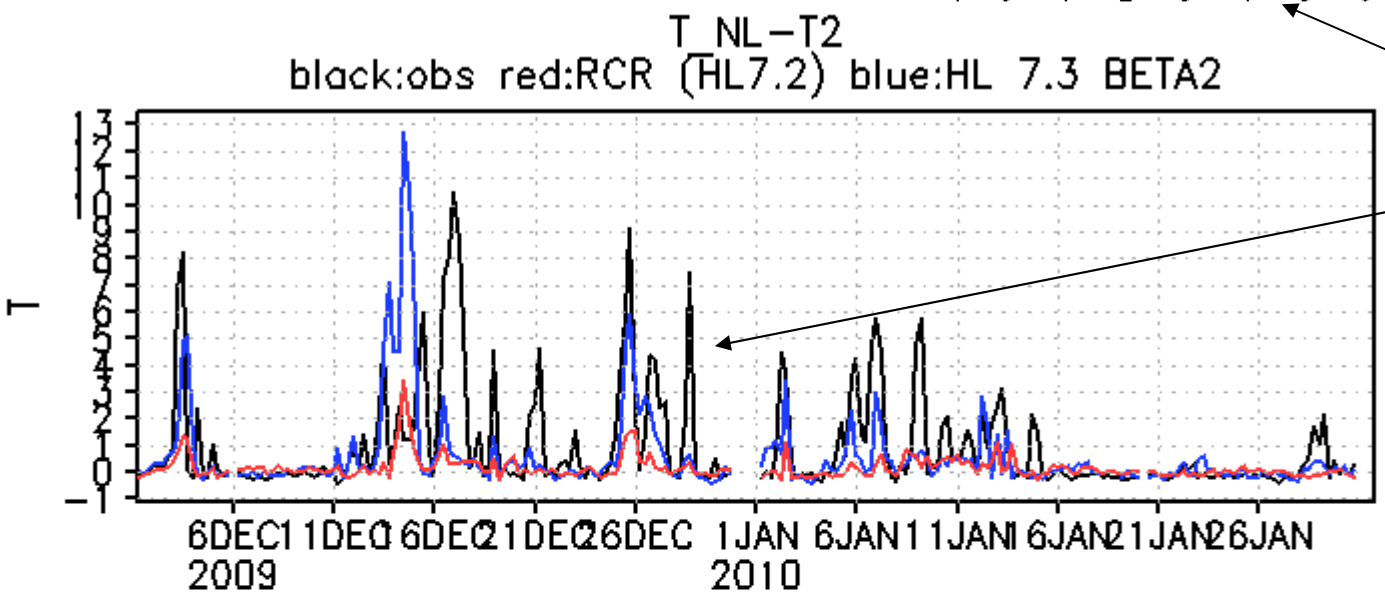




Surface layer temperature gradient

Sodankylä
Dec 2009-Jan2010
Black: Obs
Red: RCR
Blue: 7.3beta2

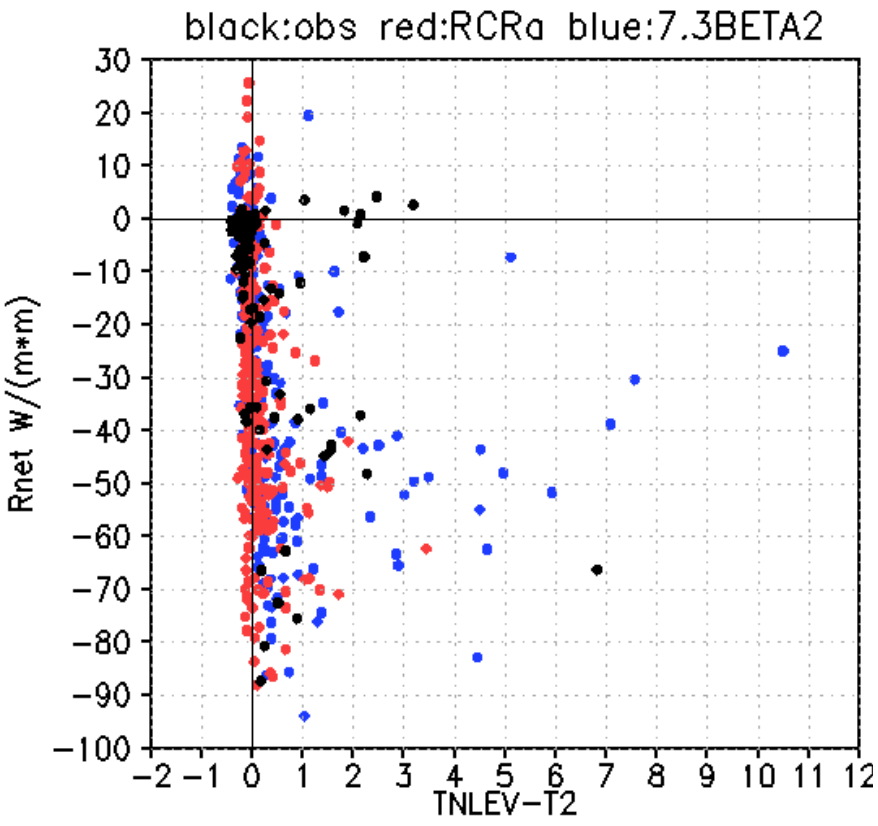




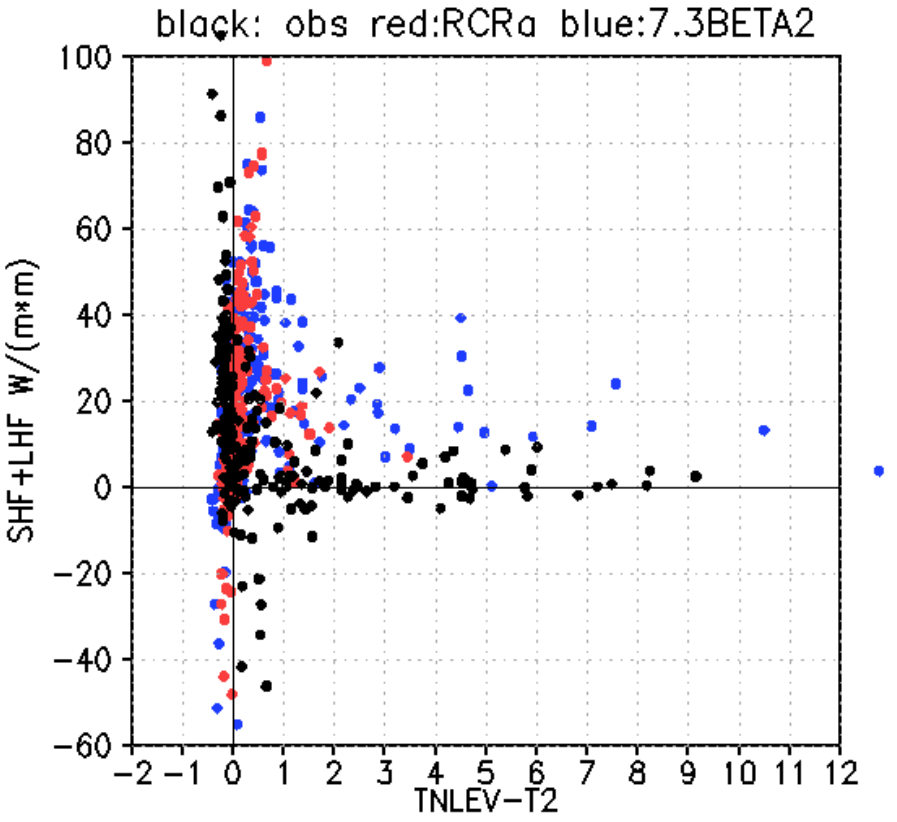
Inversions

Inversions and surface fluxes

Net radiatin vs. stability

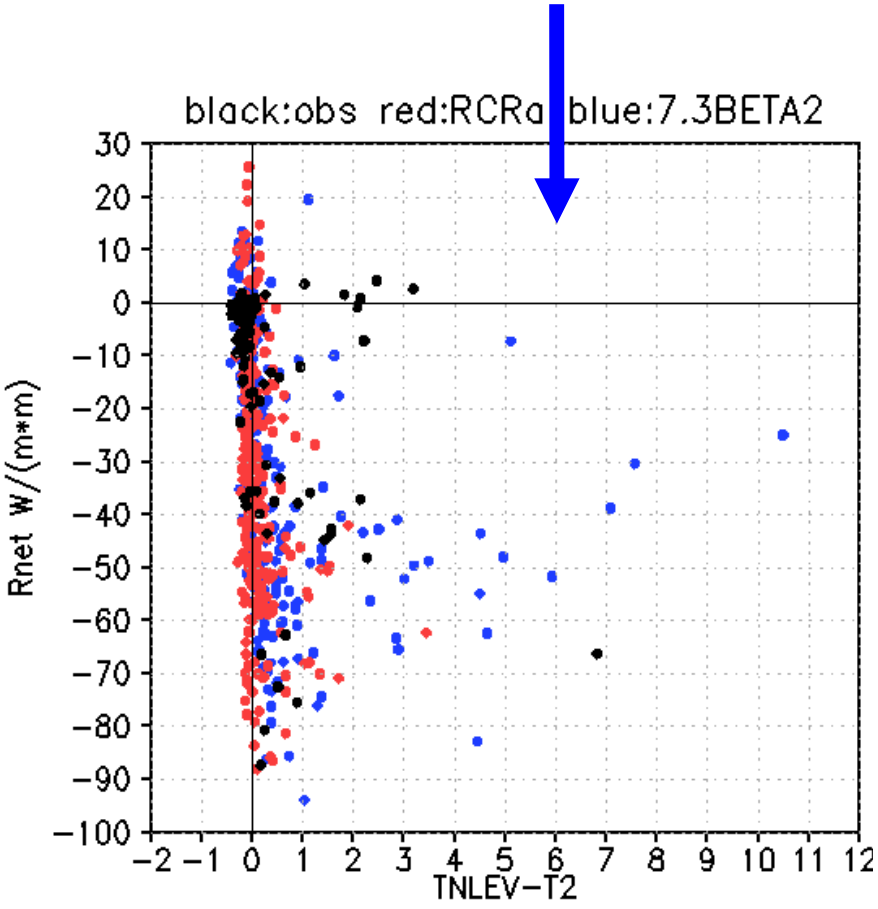


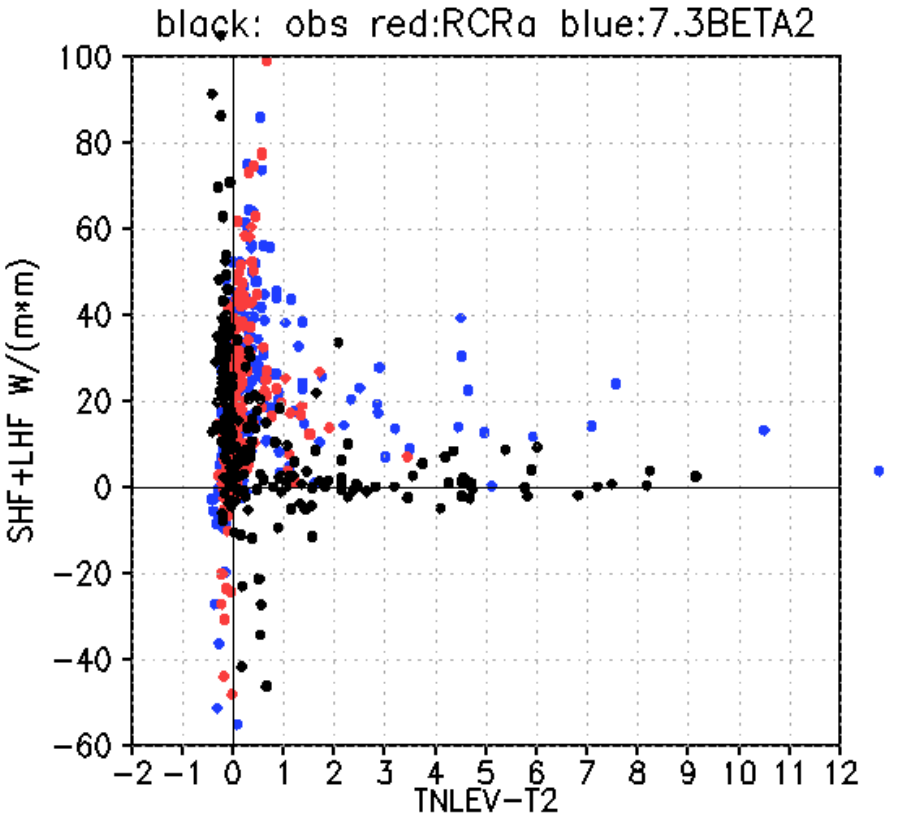
Turbulent heat flux vs stability



Inversions and surface fluxes

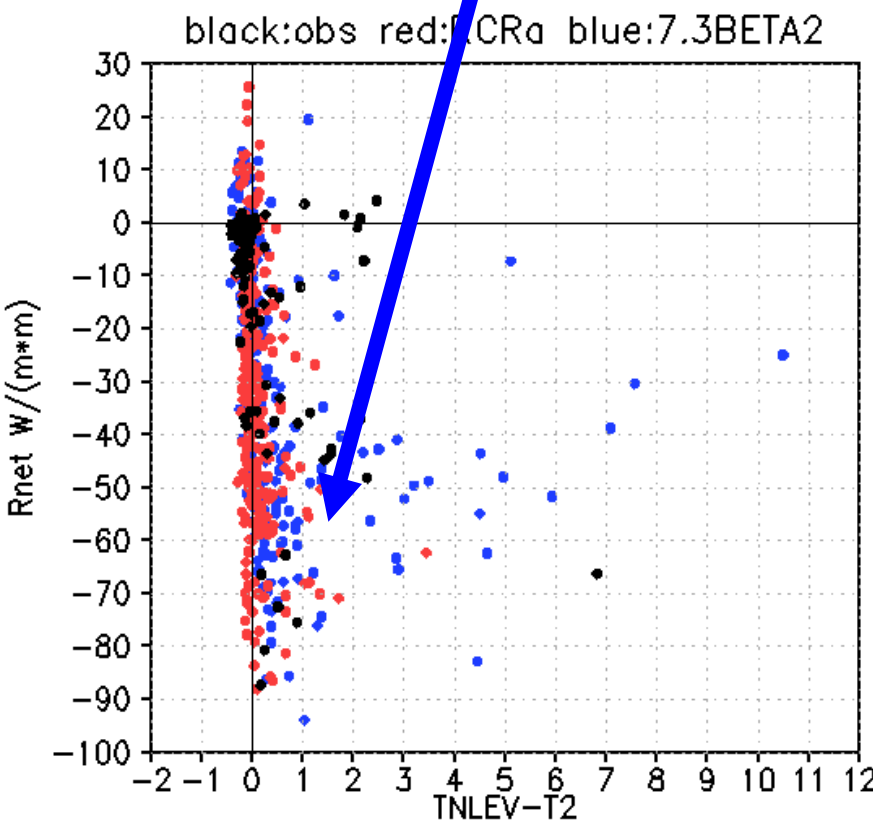
few good inversion cases covered by the observations

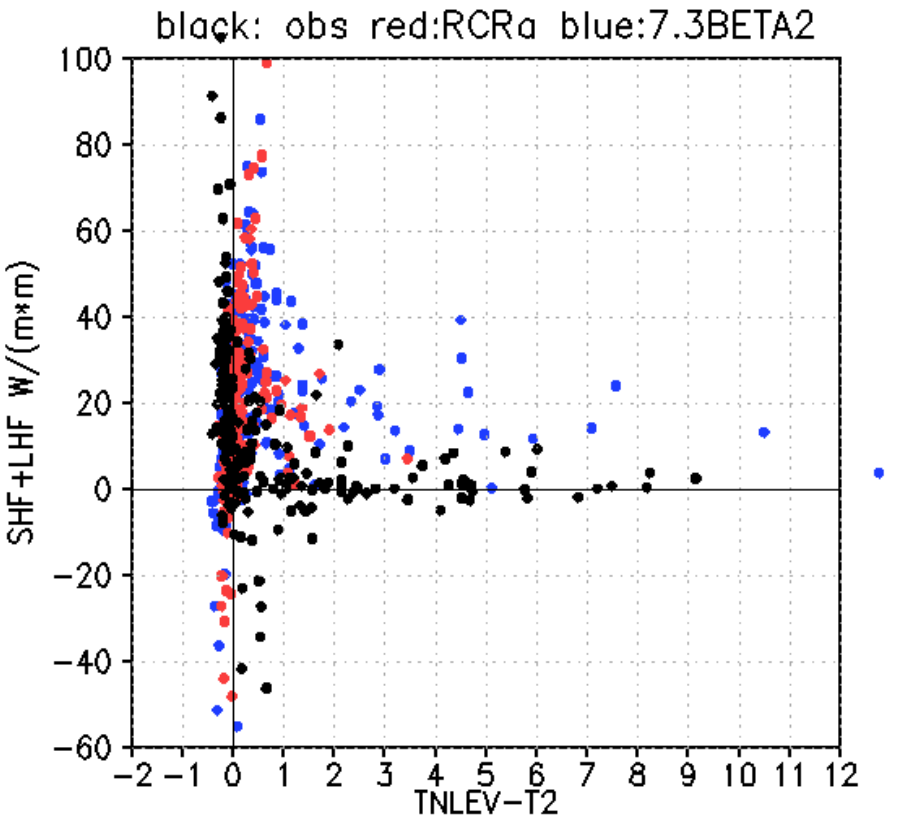




Inversions and surface fluxes

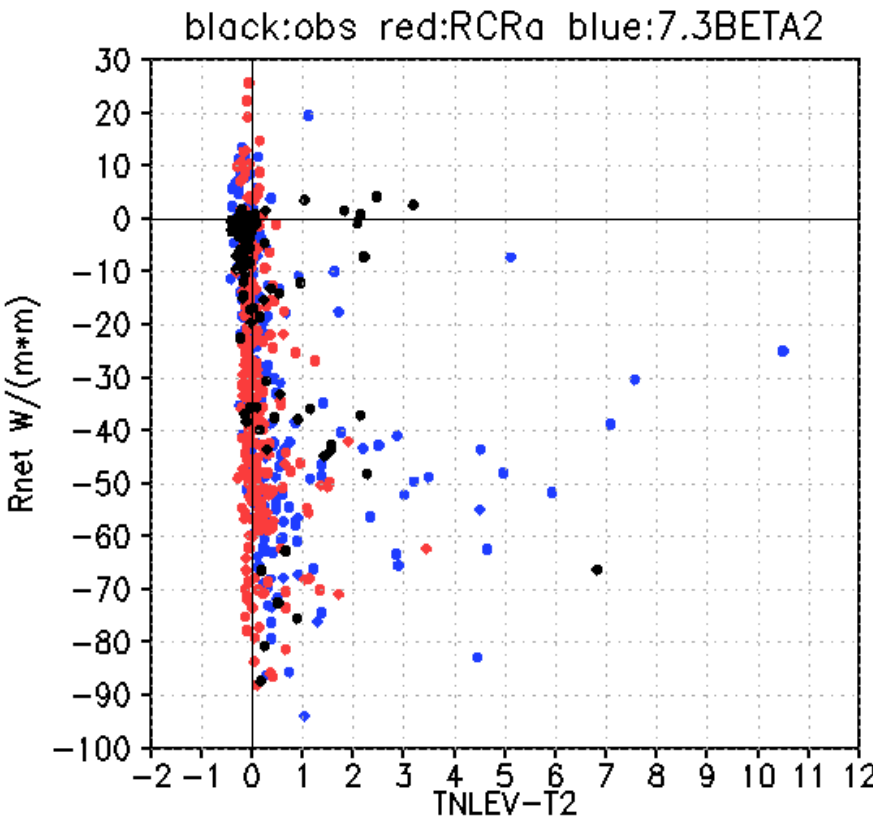
both models produce negative net radiation
but only 7.3 generates inversions

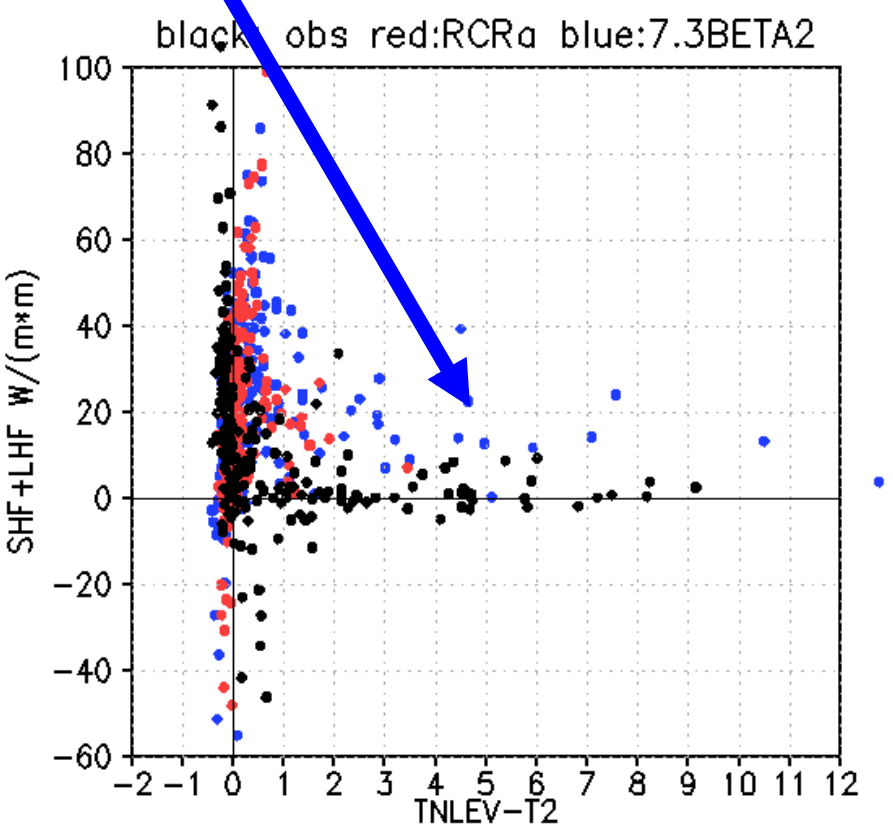




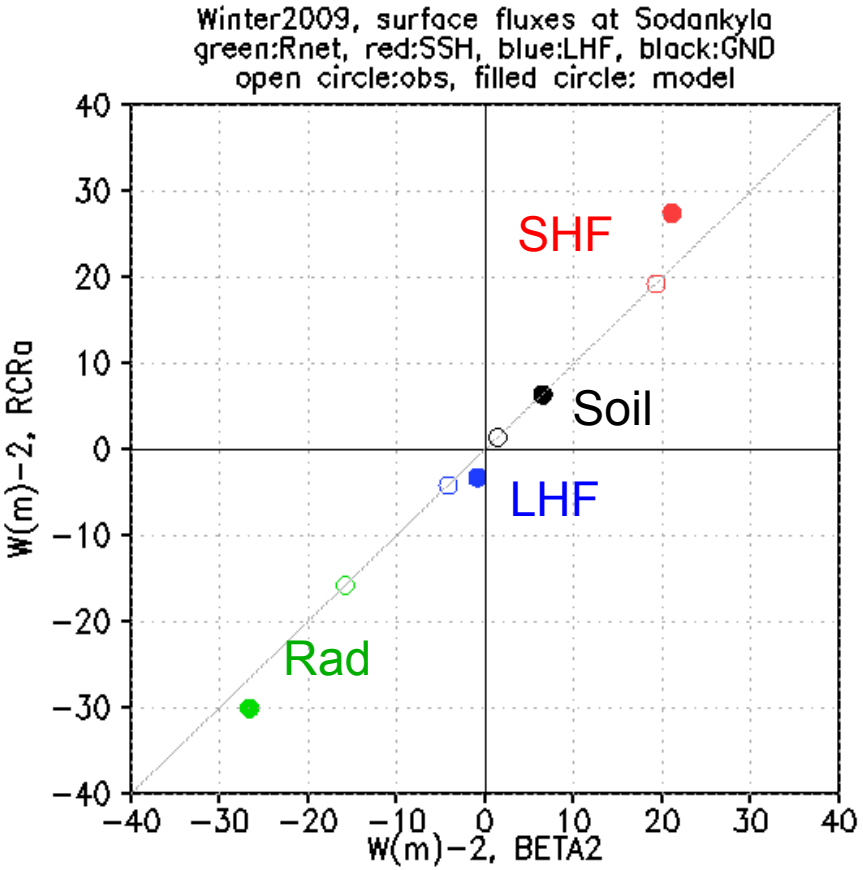
Inversions and surface fluxes

too much downward turbulent heat fluxes during inversions

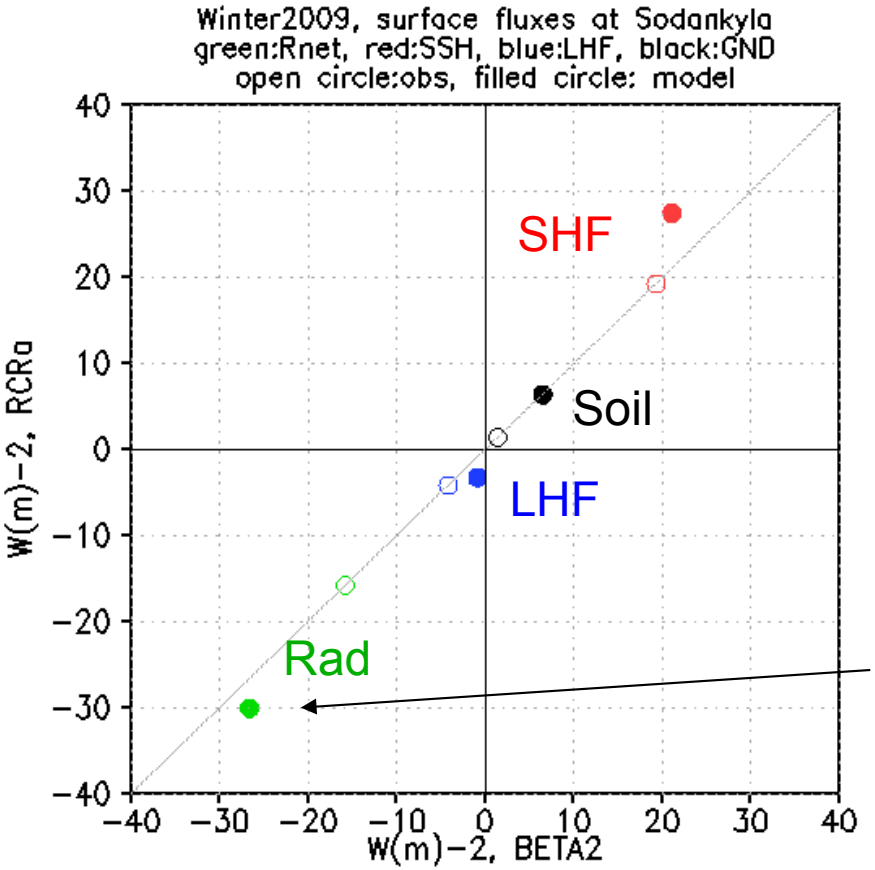




Ensemble mean surface heat fluxes

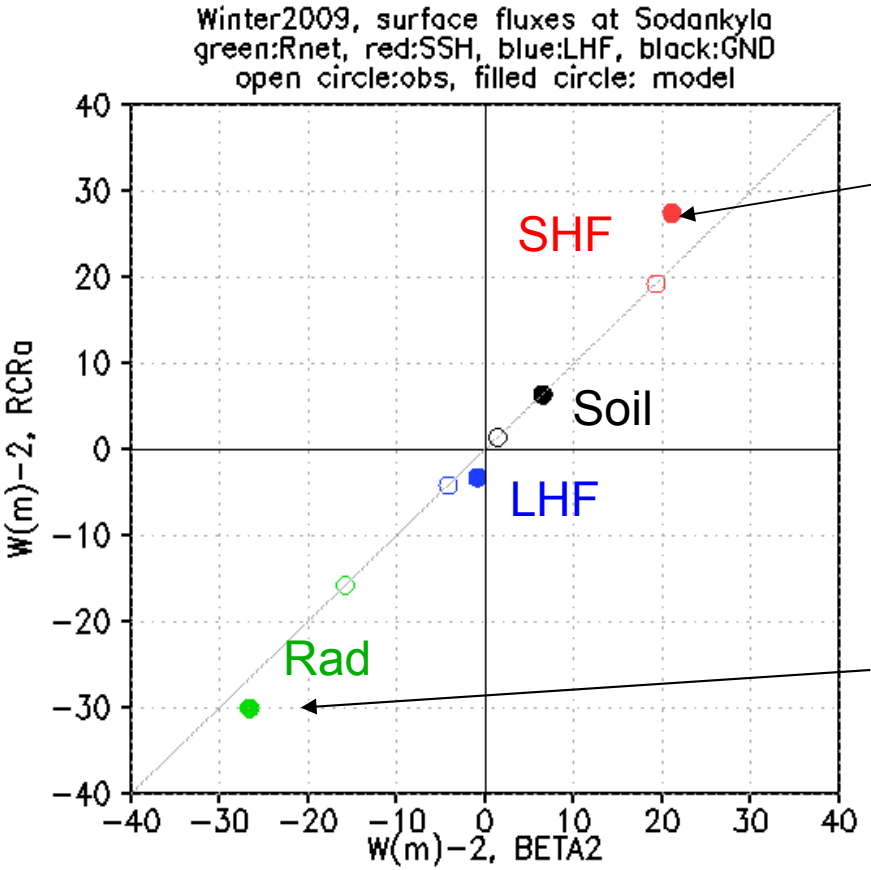


Ensemble mean surface heat fluxes



Too much radiative cooling

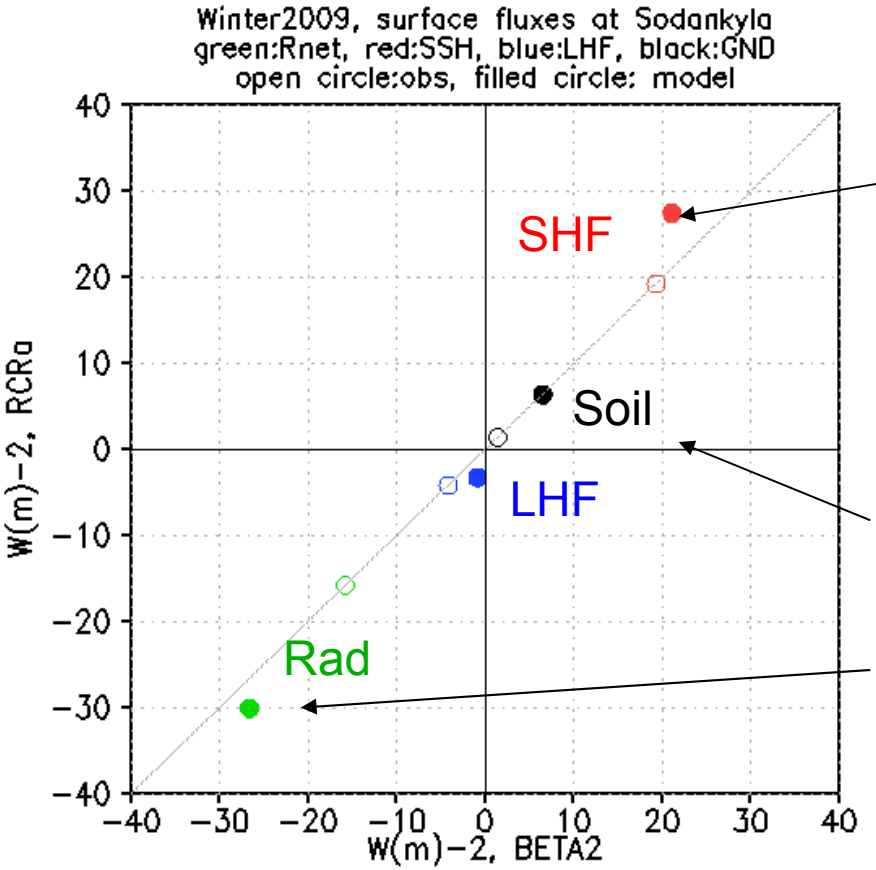
Ensemble mean surface heat fluxes



Too much downward sensible heat flux in RCR, better in 7.3

Too much radiative cooling

Ensemble mean surface heat fluxes



Too much downward sensible heat flux in RCR, better in 7.3

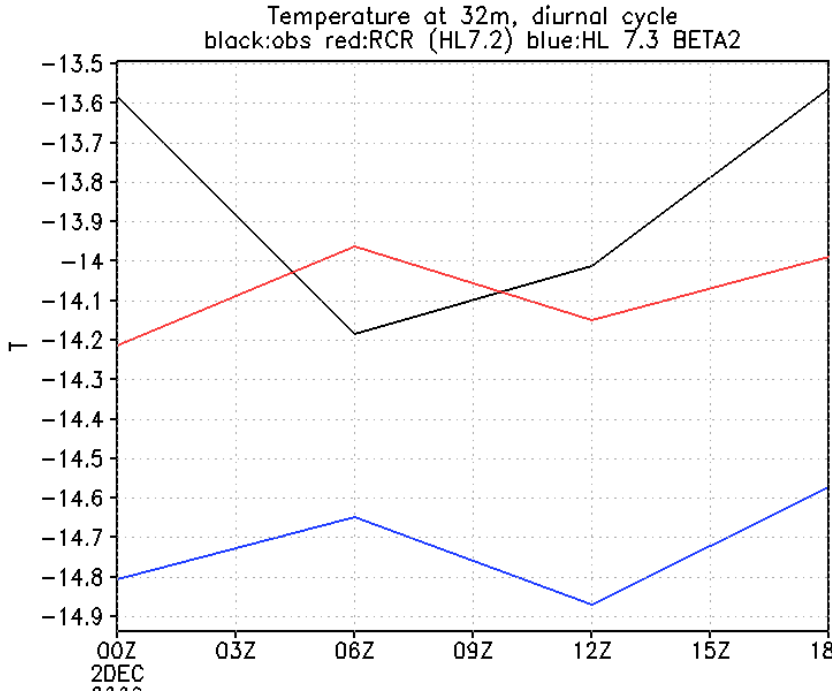
Too much heat release from the soil (residual term)

Too much radiative cooling

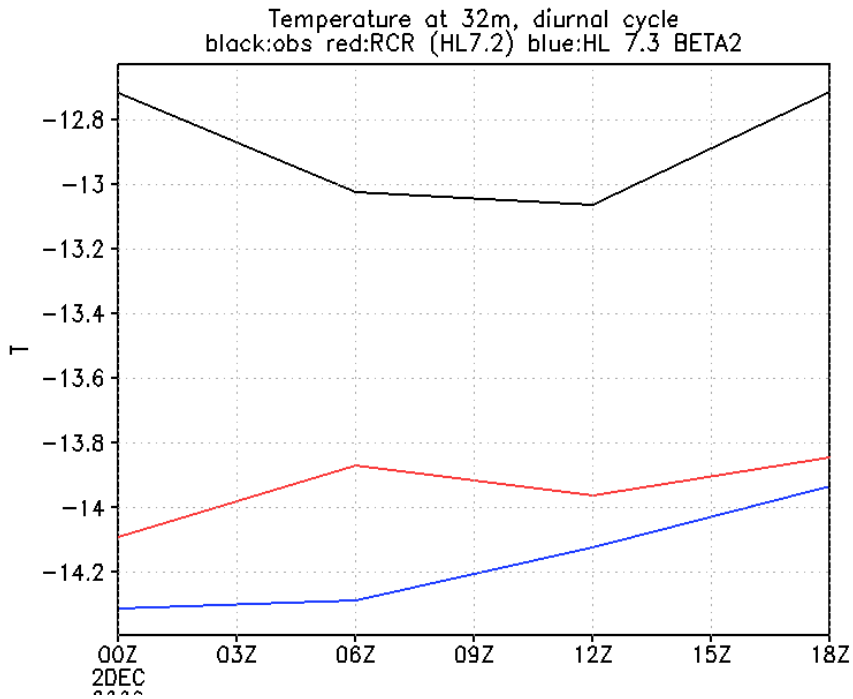
Average temperature Dec2009-Jan2010

(diurnal cycle)

screen



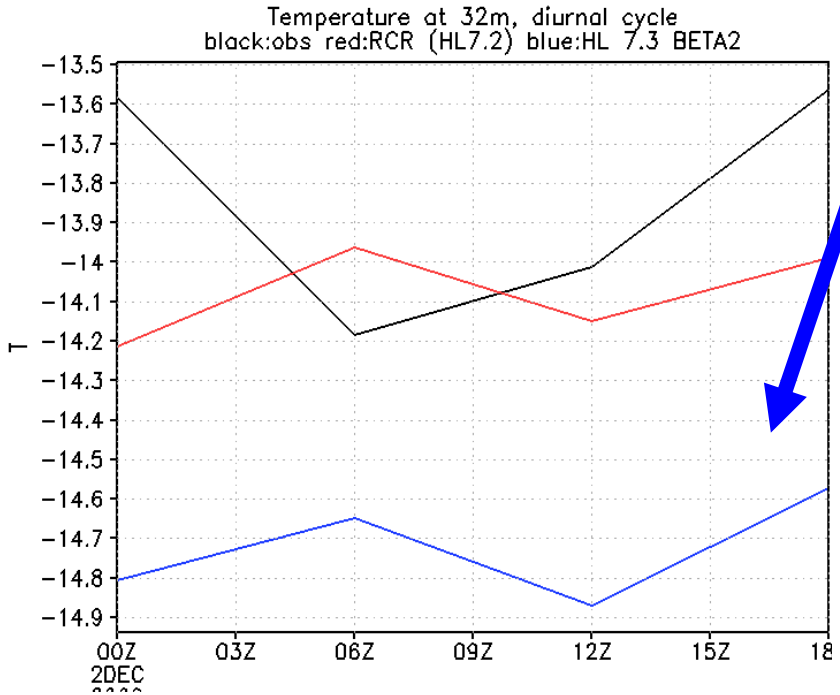
30m



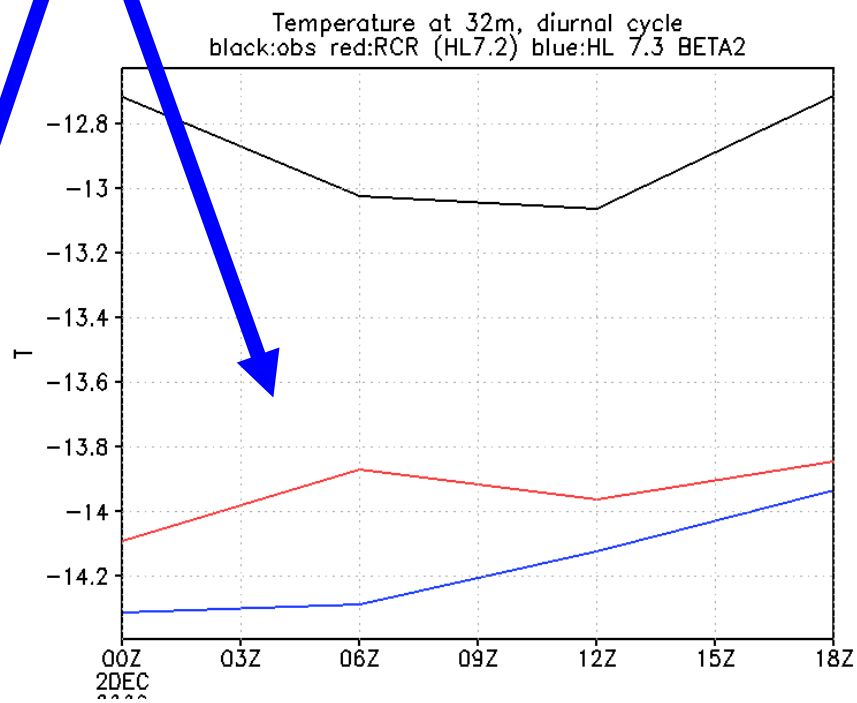
Average temperature Dec2009-Jan2010

cold bias,

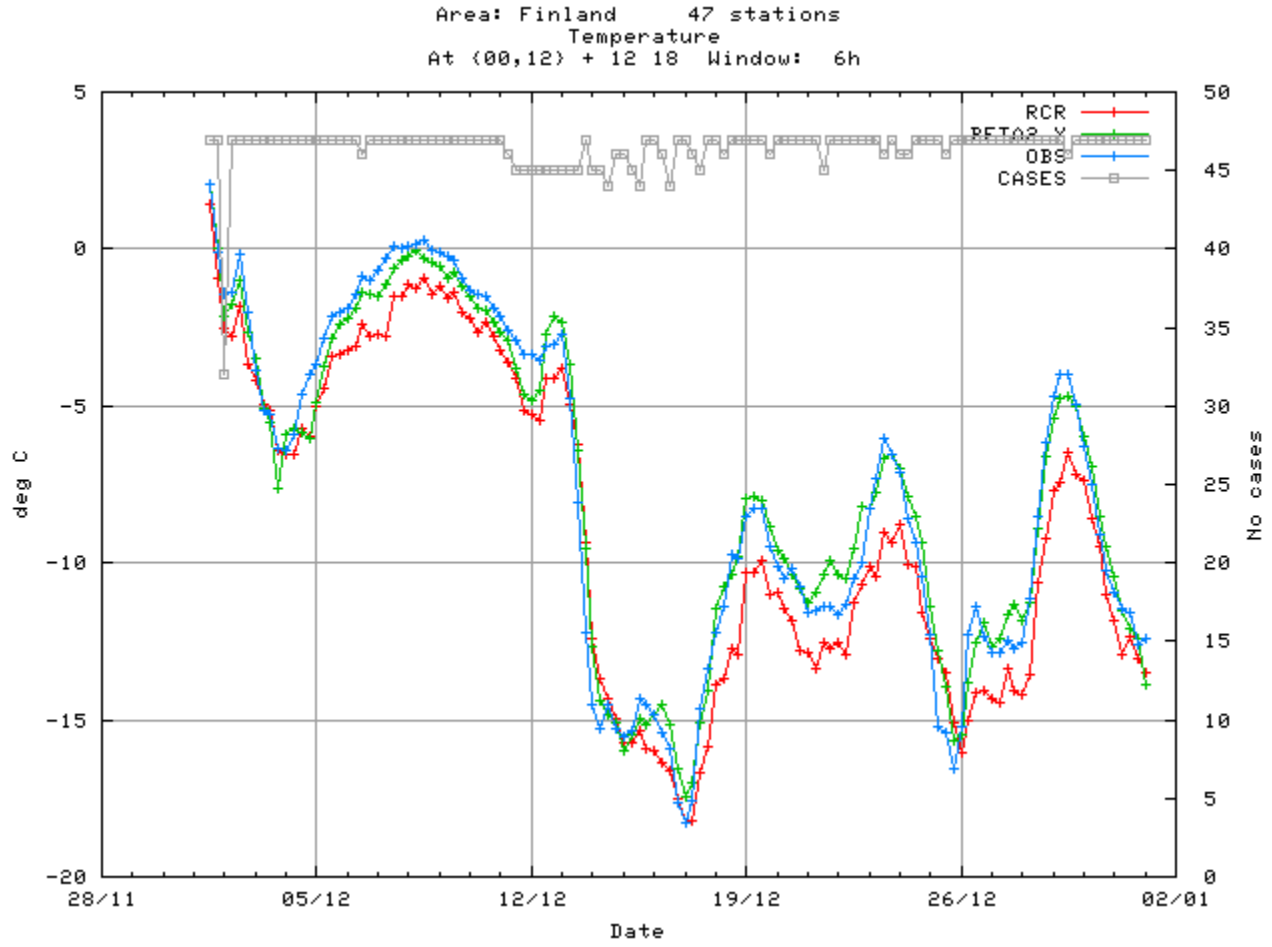
screen



30m



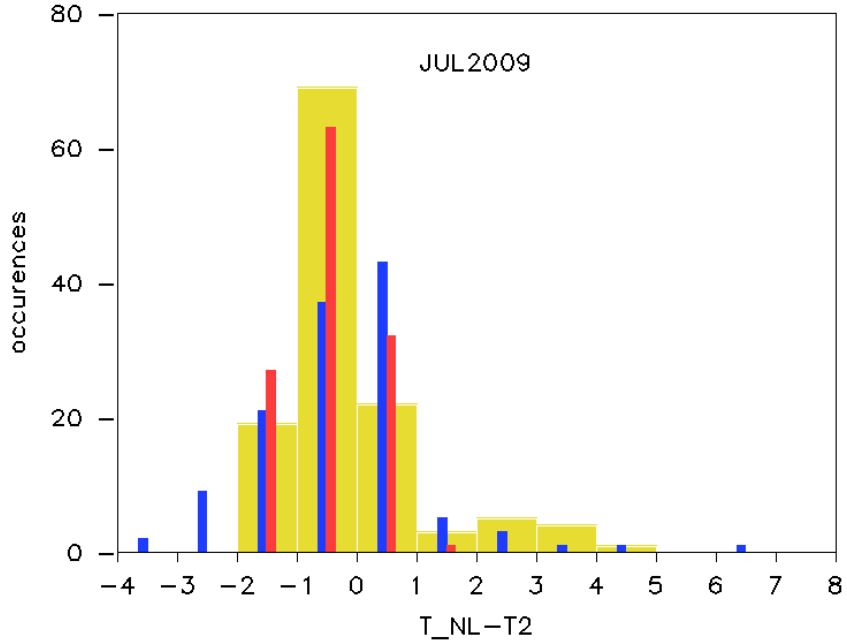
But, for whole Finland, 7.2 is cold at screen level, 7.3 is ok

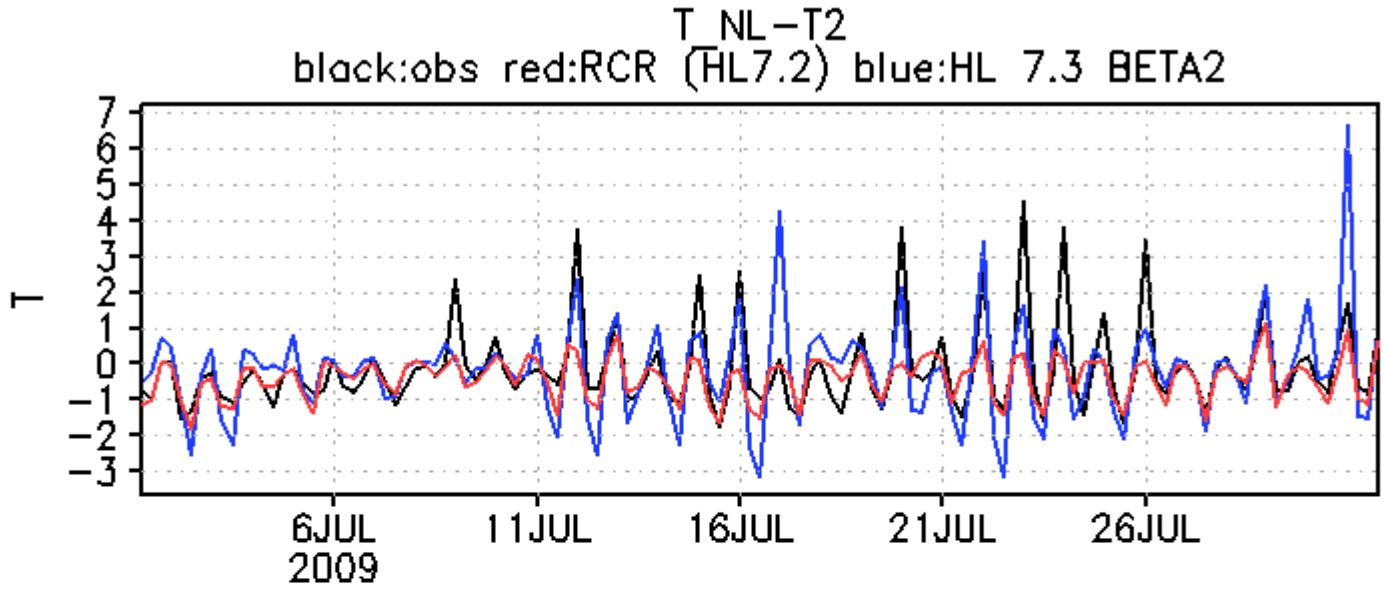


Surface layer temperature gradient

SUMMER

Sodankylä
July 2009
Black: Obs
Red: RCR
Blue: 7.3beta2





Surface layer temperature gradient

SUMMER

Sodankylä
July 2009
Black: Obs
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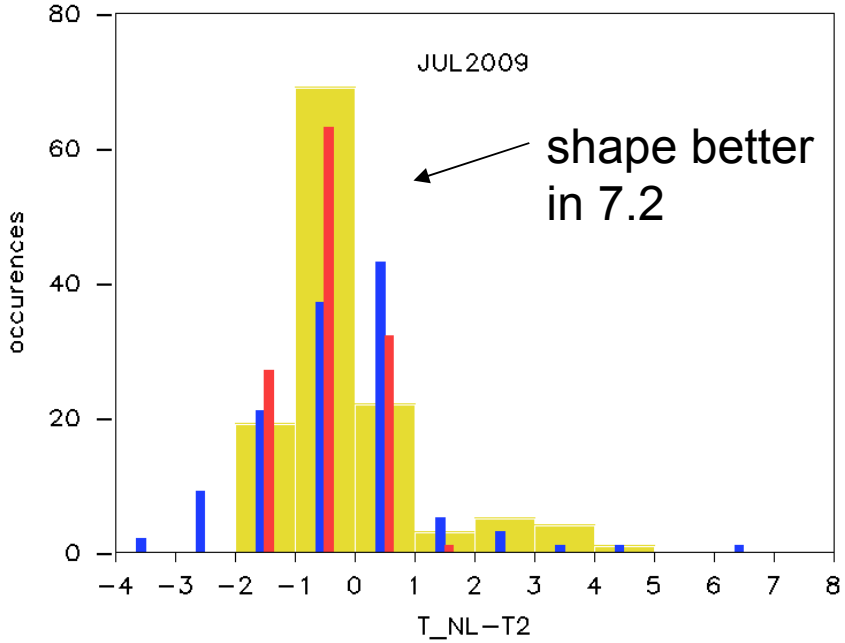
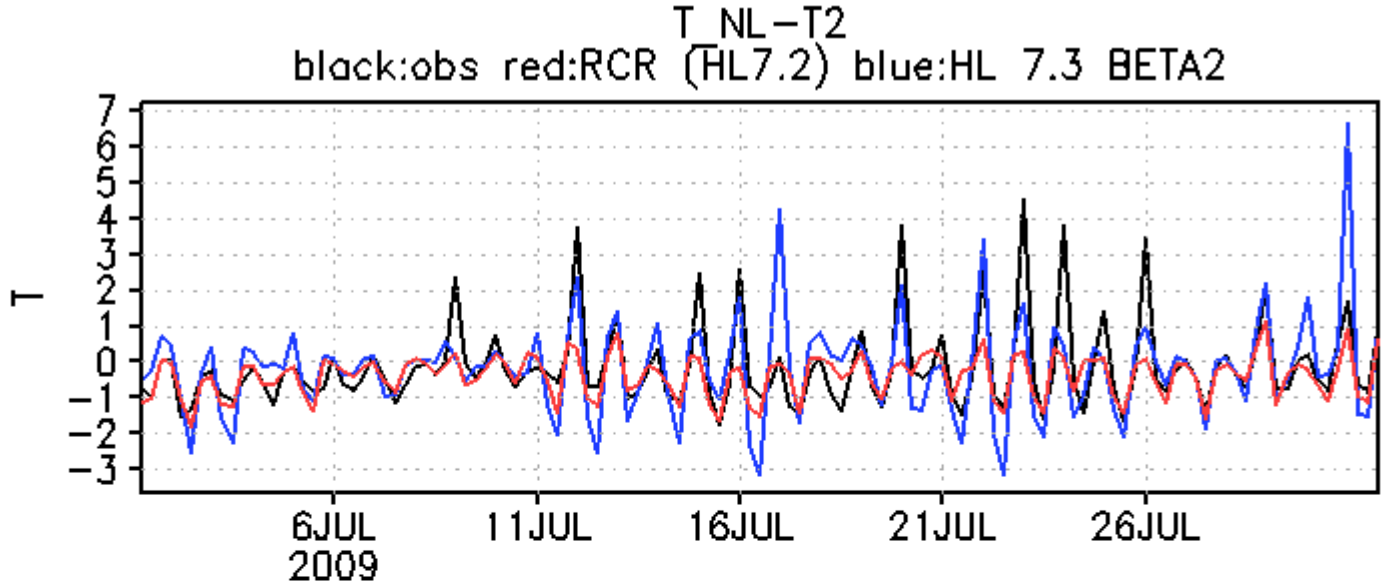
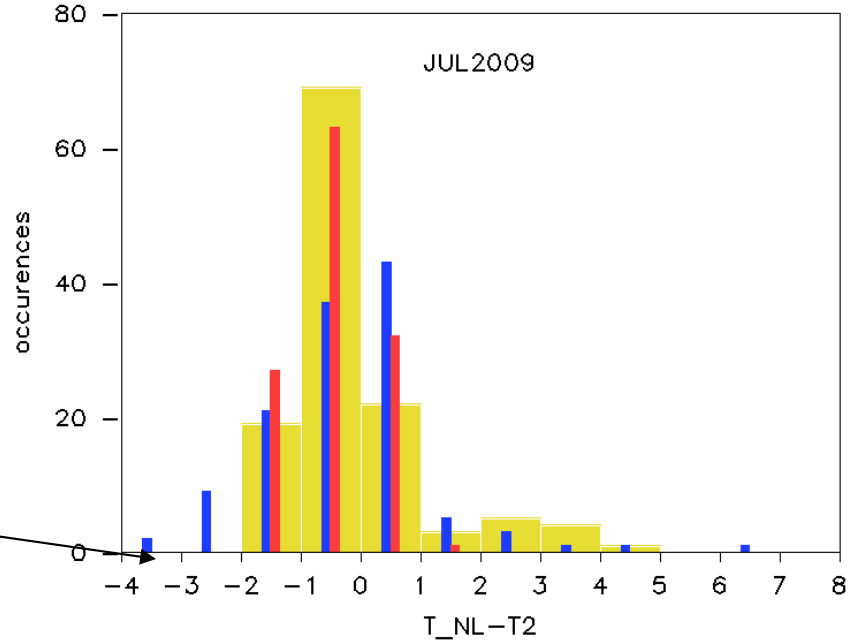


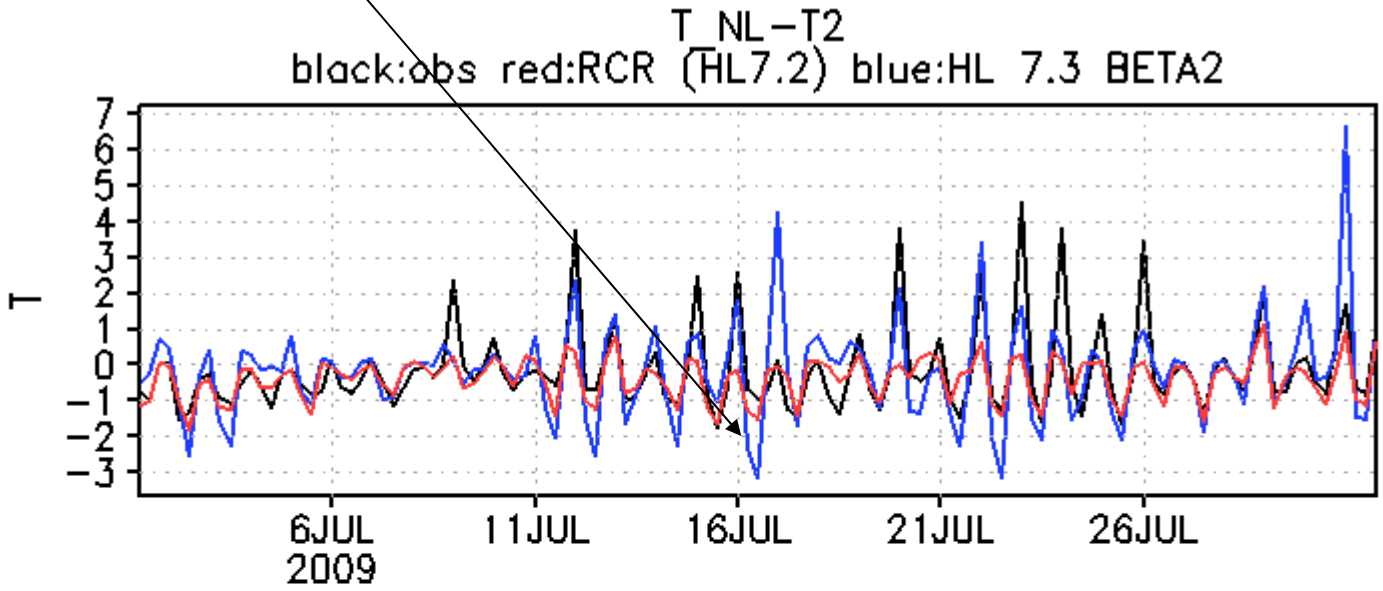


Surface layer temperature gradient

Sodankylä
July 2009
Black: Obs
Red: RCR
Blue: 7.3beta2

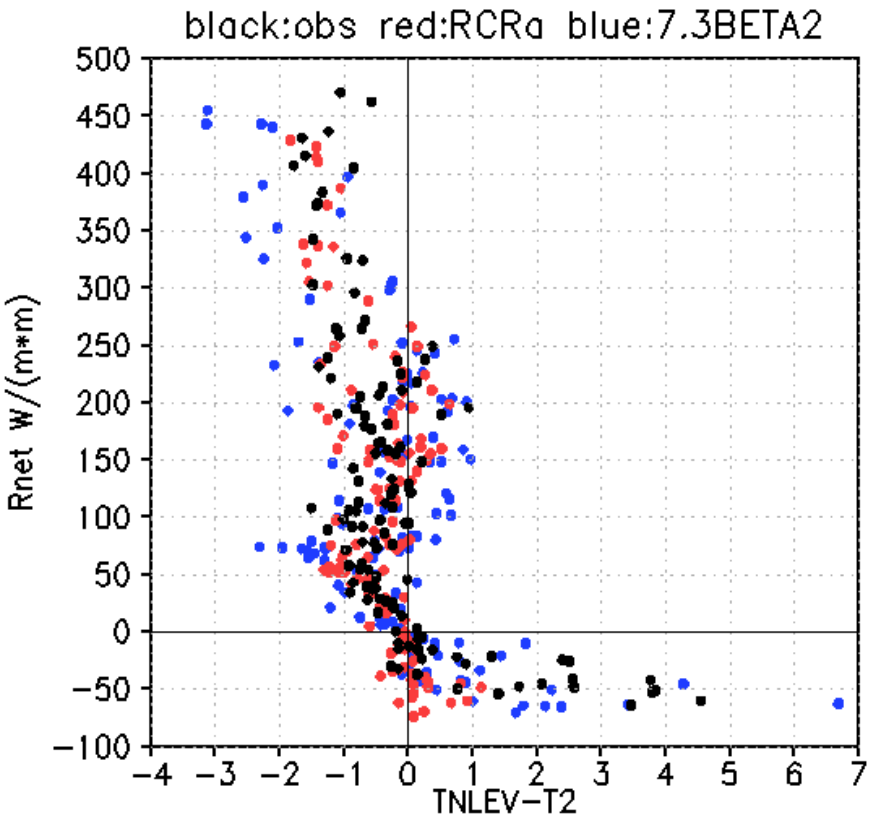


very unstable

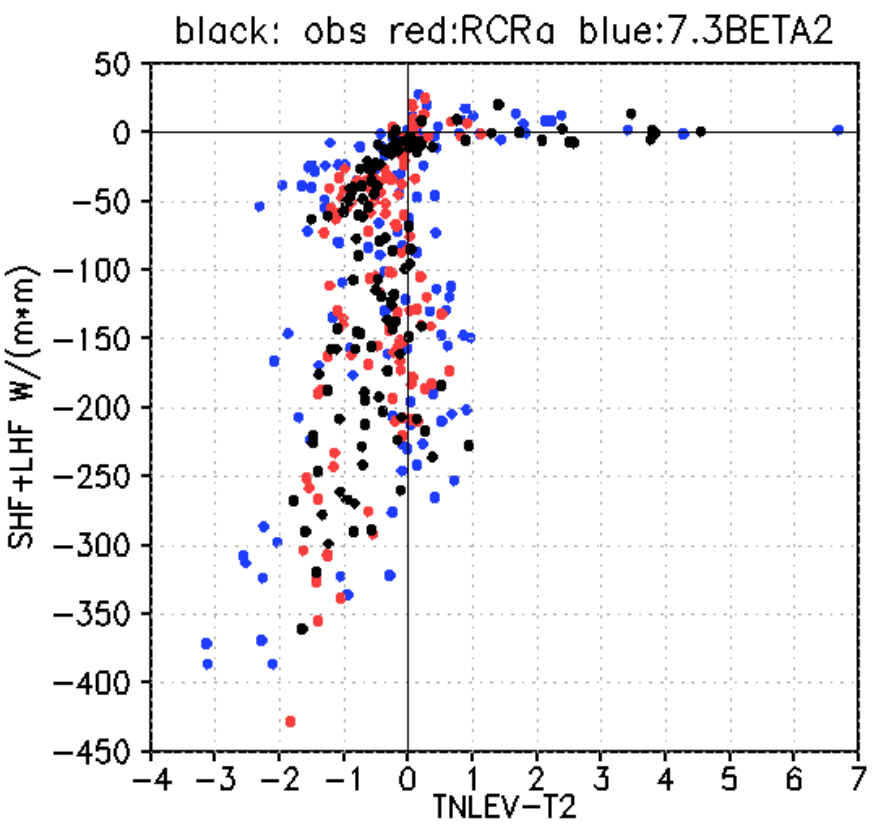


Temperature gradient and heat fluxes

Net radiation vs stability



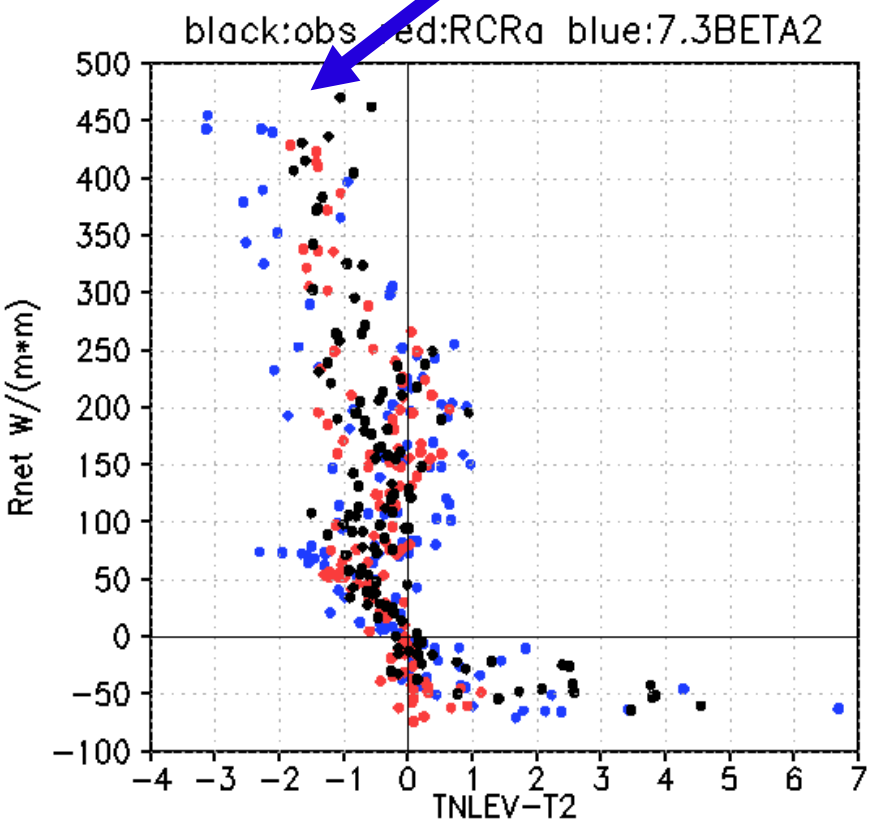
Turbulent fluxes vs, stability



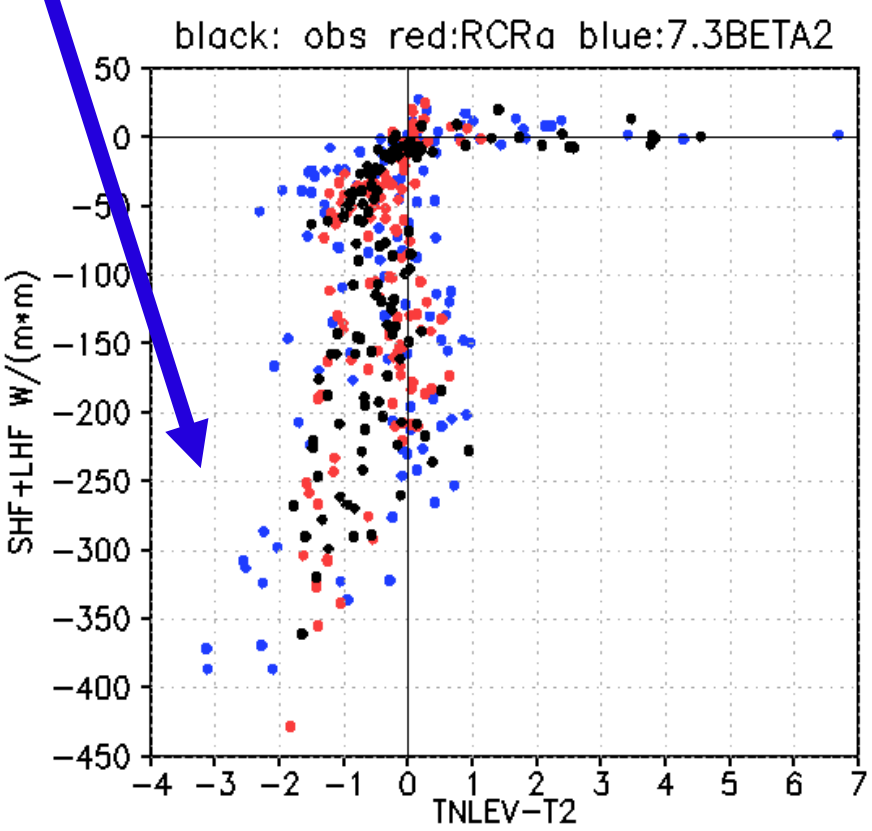
Temperature gradient and heat fluxes

similar fluxes, stronger gradient

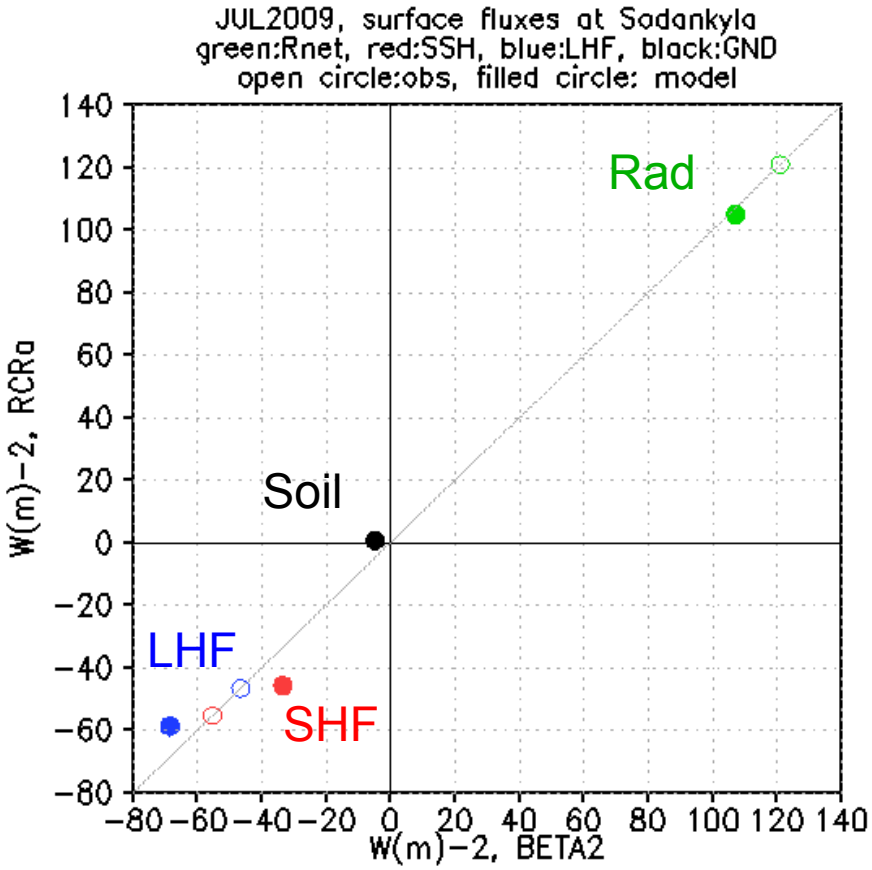
Net radiation vs stability



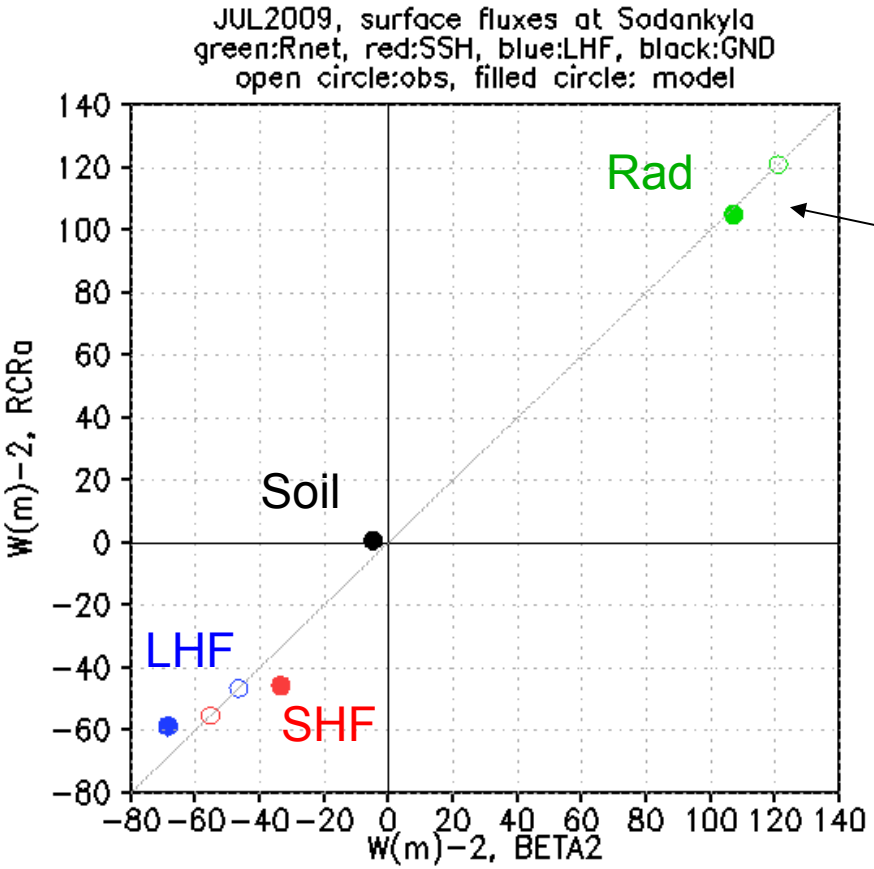
Turbulent fluxes vs, stability



Ensemble mean surface heat fluxes

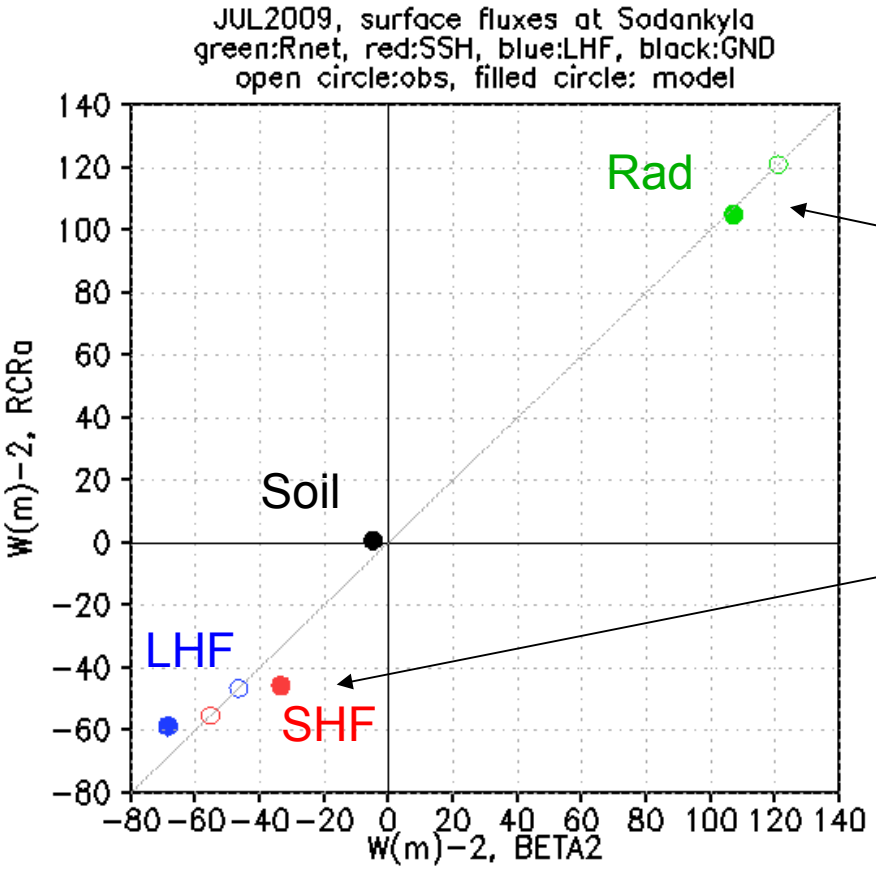


Ensemble mean surface heat fluxes



Less radiative heating

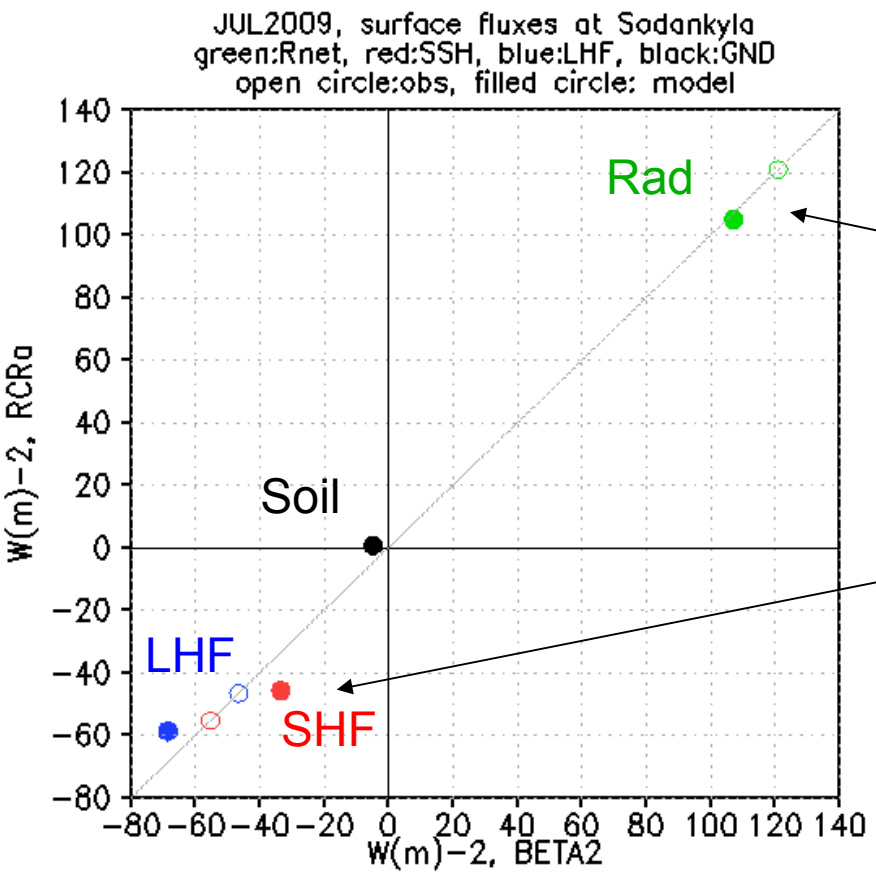
Ensemble mean surface heat fluxes



Less radiative heating

Opposite relative partitioning into SHF and LHF

Ensemble mean surface heat fluxes



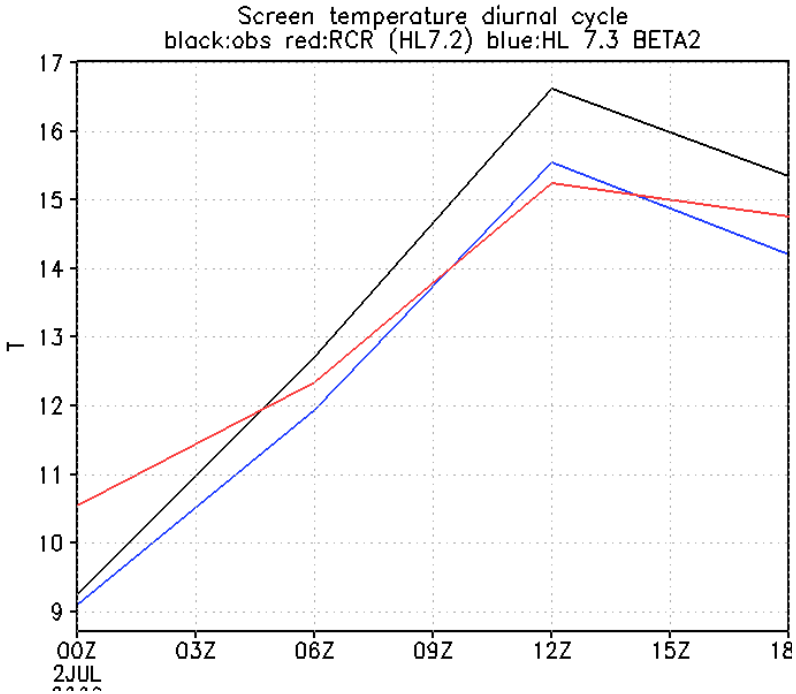
Observed budget not closed:
Rad+SHF+LHF = 20 W/m2
soil?

Less radiative heating

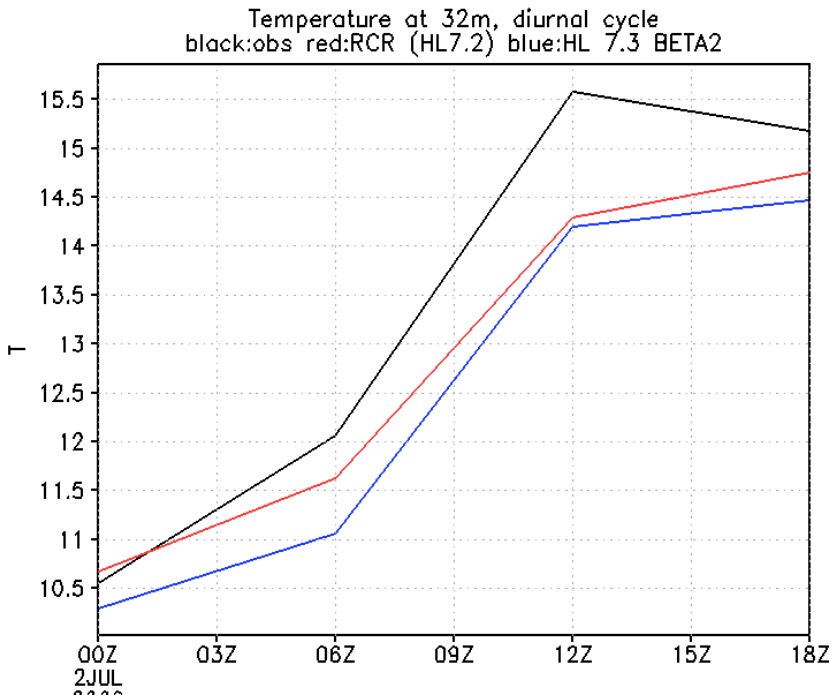
Opposite relative partitioning into SHF and LHF

Temperature diurnal cycle

screen



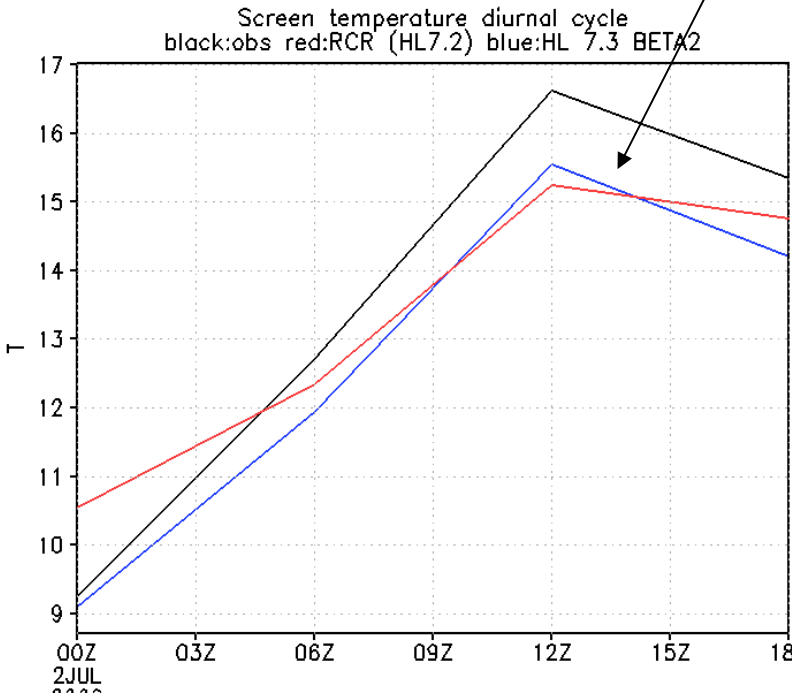
30m



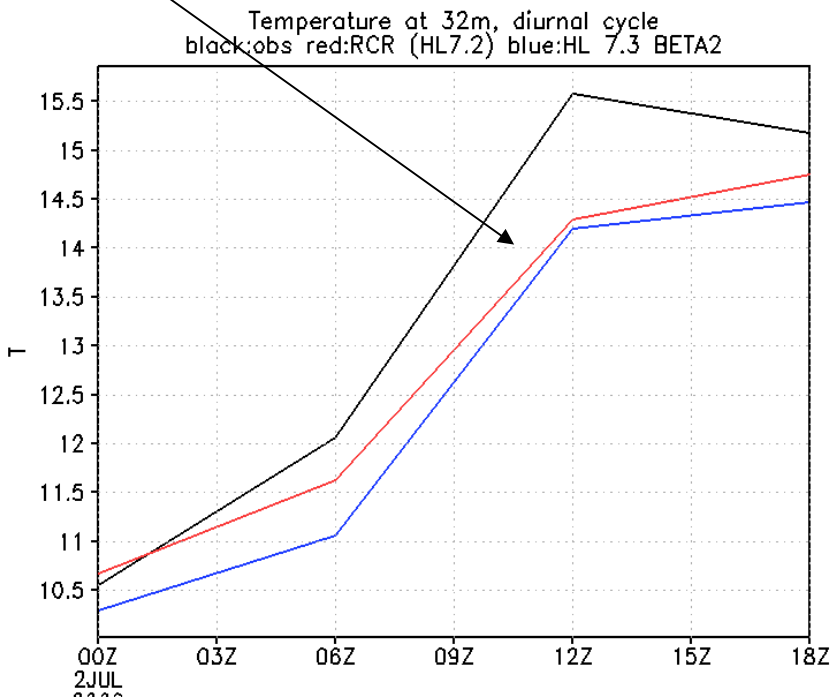
Temperature diurnal cycle

cold bias

screen



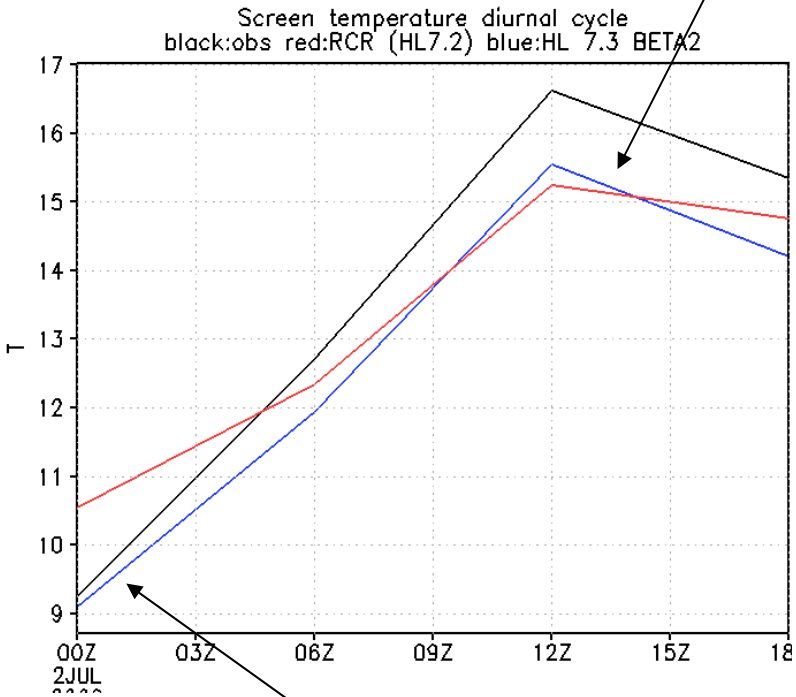
30m



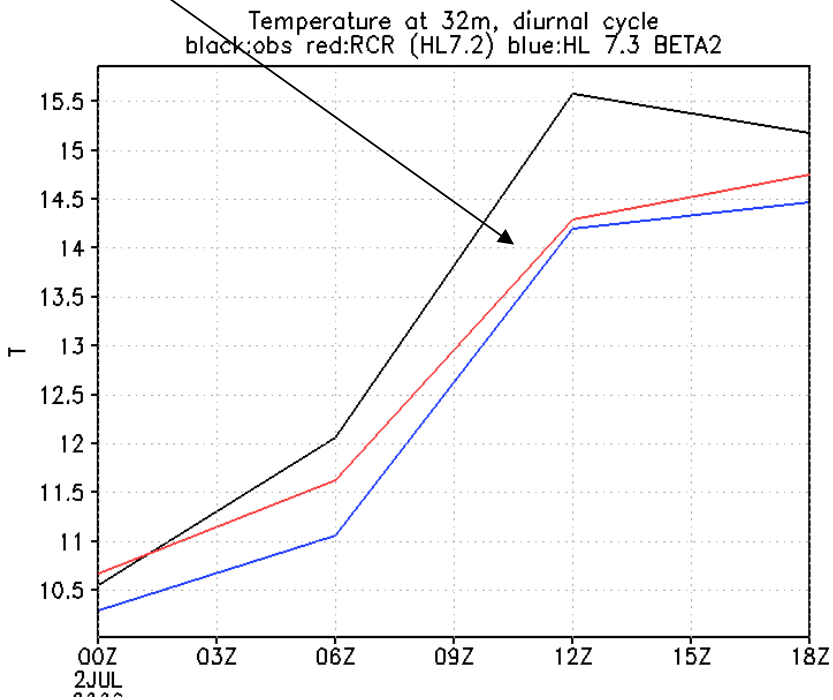
Temperature diurnal cycle

cold bias

screen

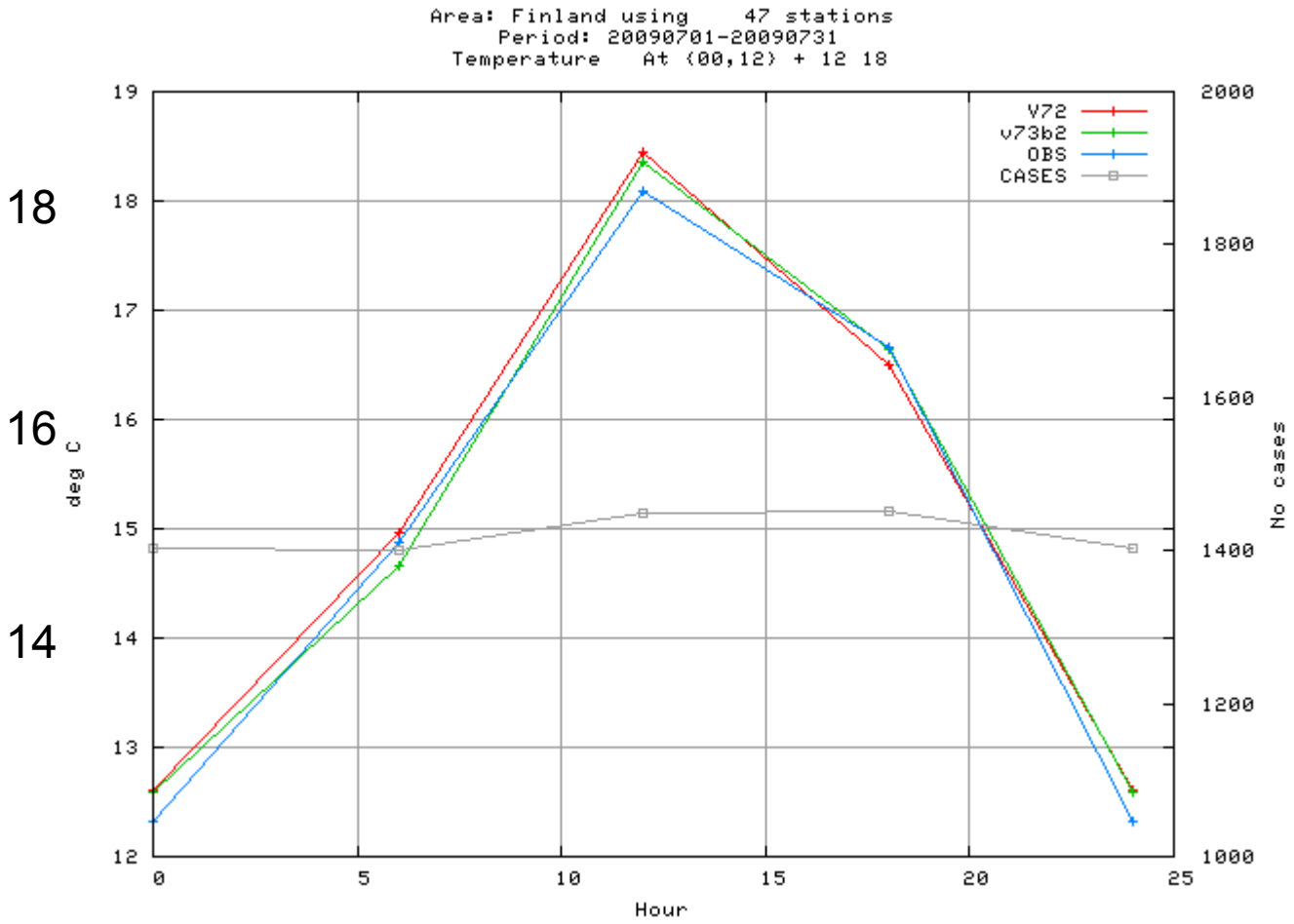


30m



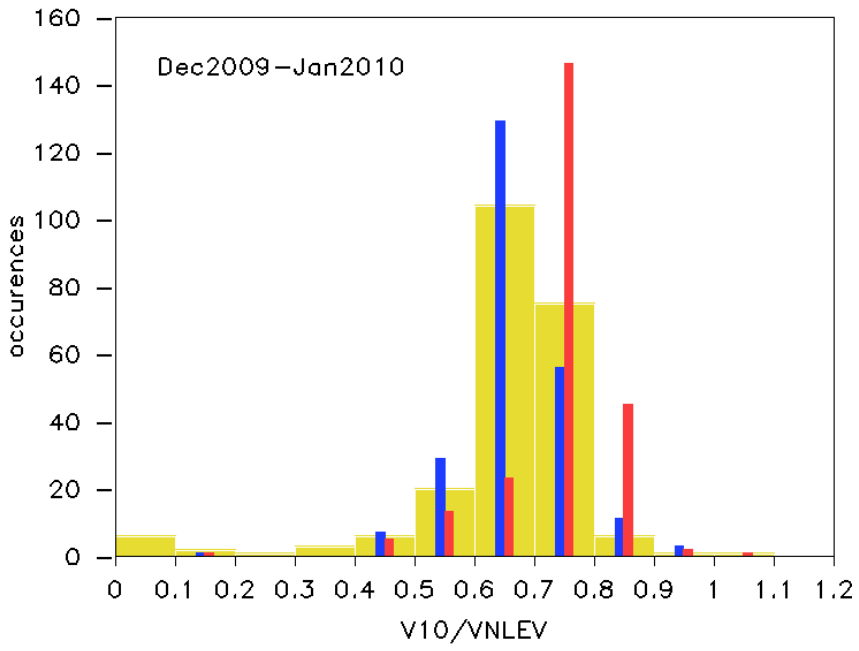
no night time bias

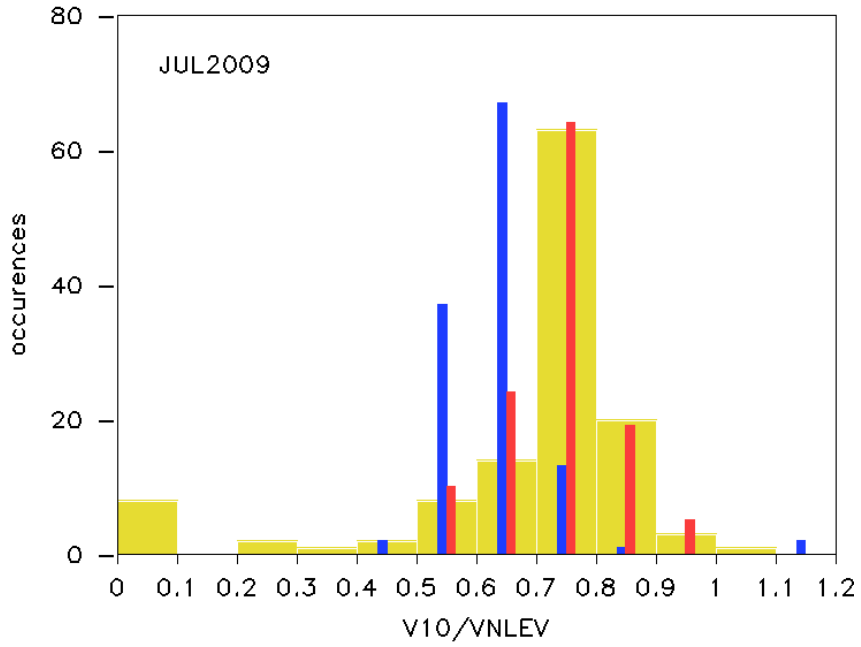
But, for whole Finland, biases are small:



Surface layer wind shear

Yellow:obs Red:RCR Blue:7.3beta2

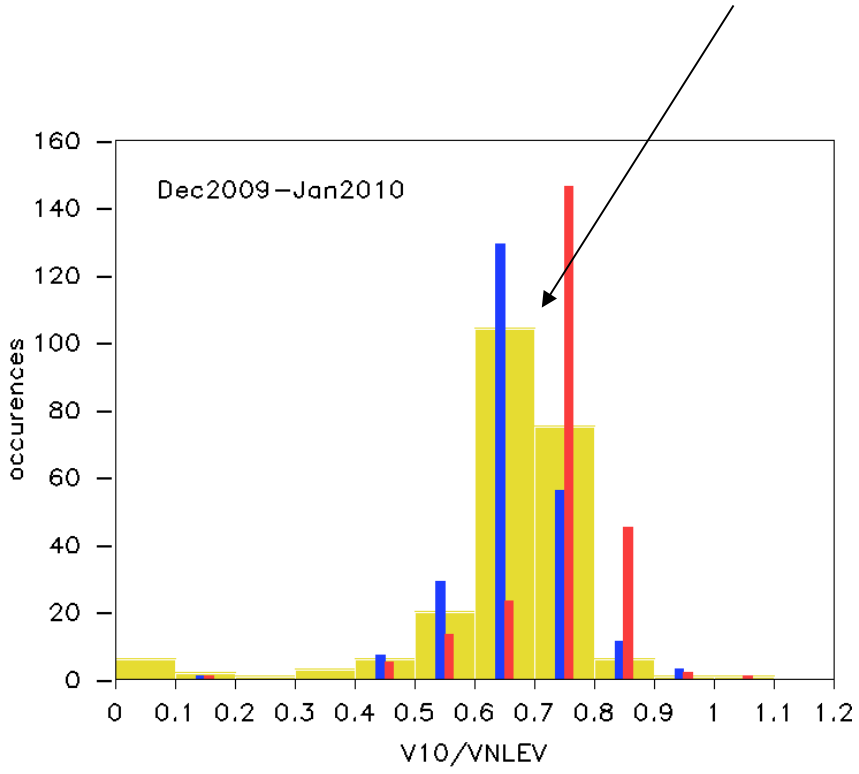


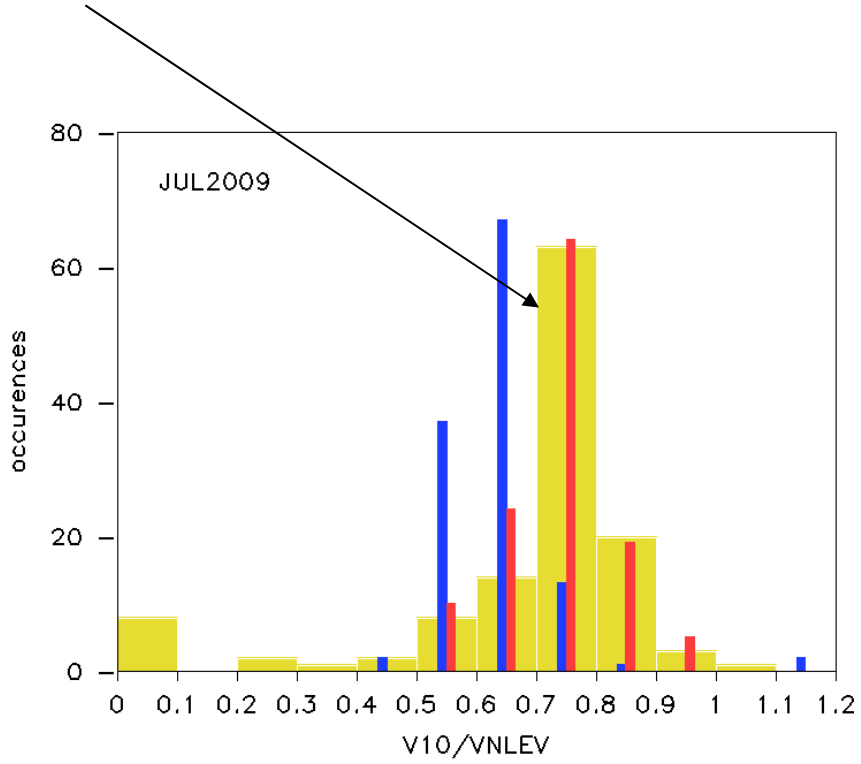


Surface layer wind shear

Yellow:obs Red:RCR Blue:7.3beta2

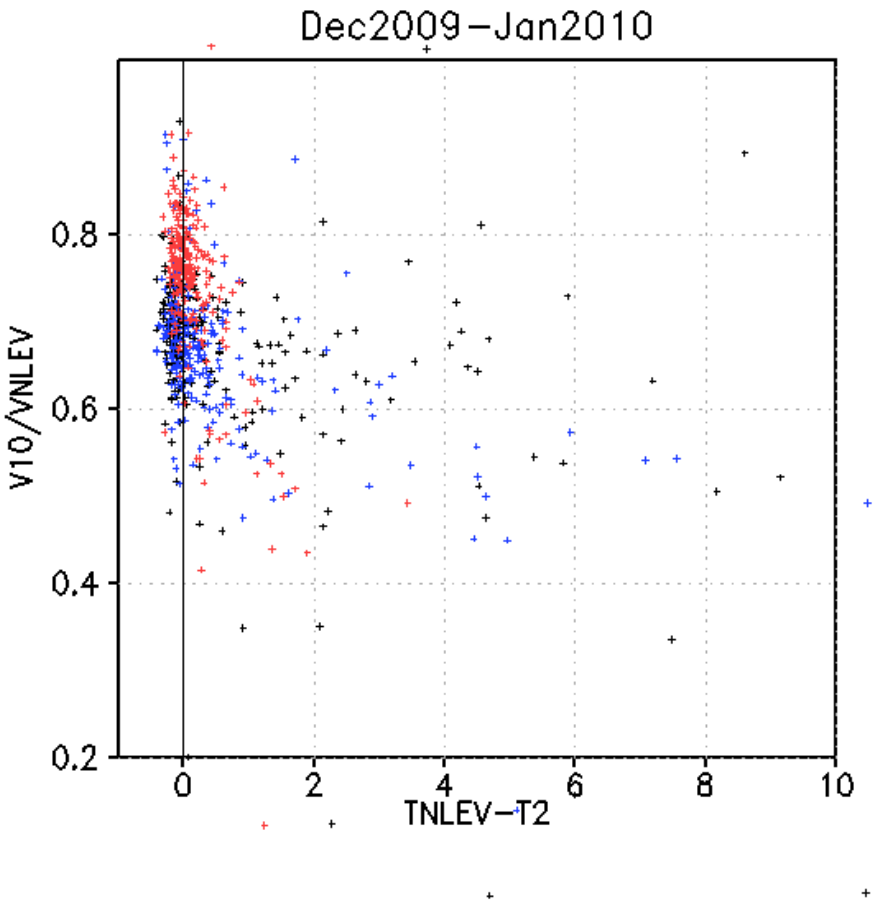
”Data shift, models stay the same”

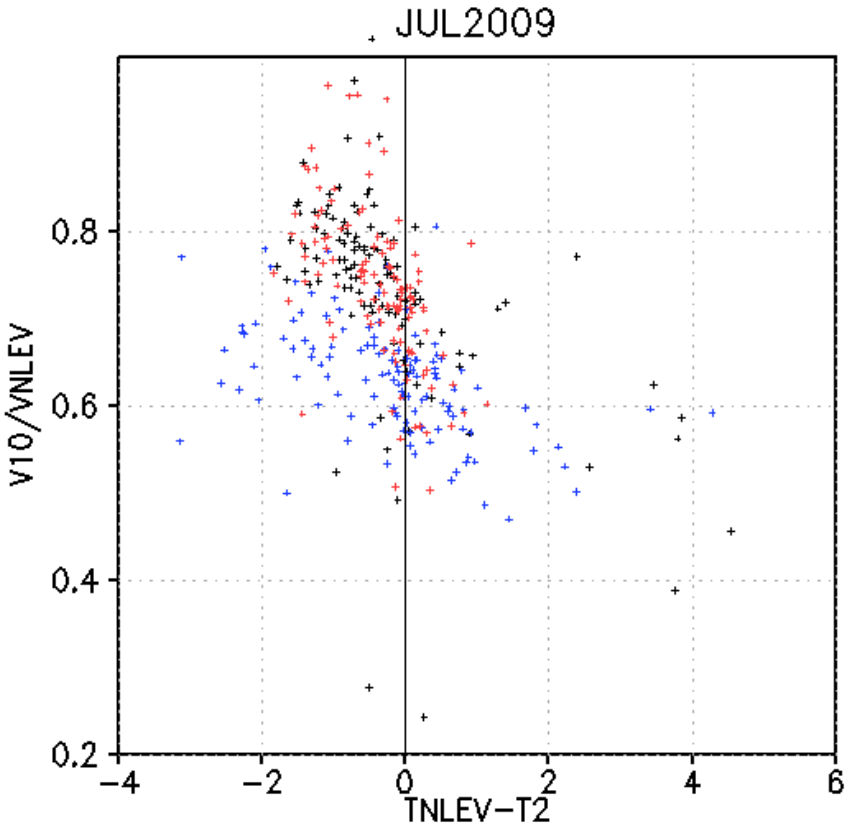




Surface layer wind shear vs stability

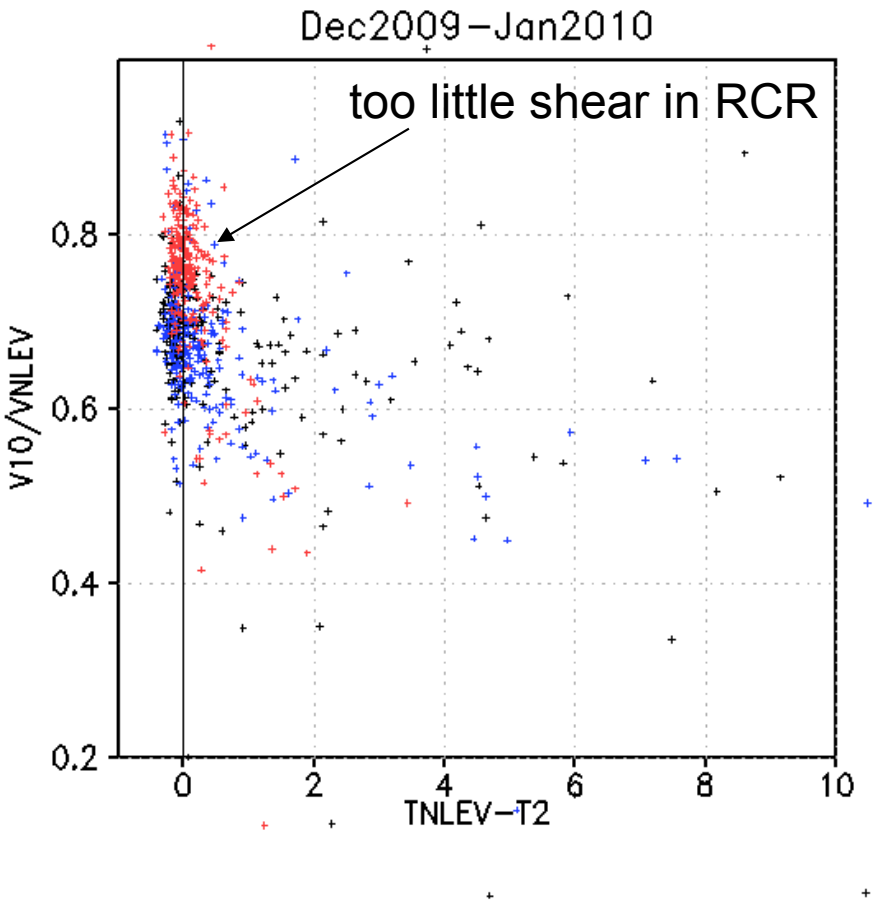
Black:obs Red:RCR Blue:7.3beta2

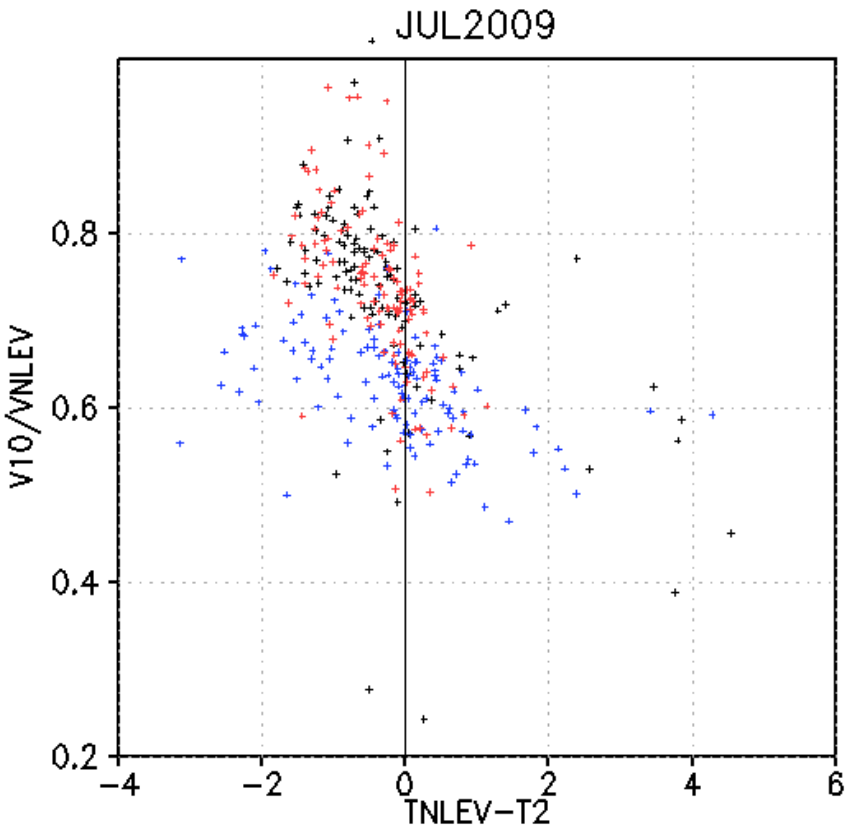




Surface layer wind shear vs stability

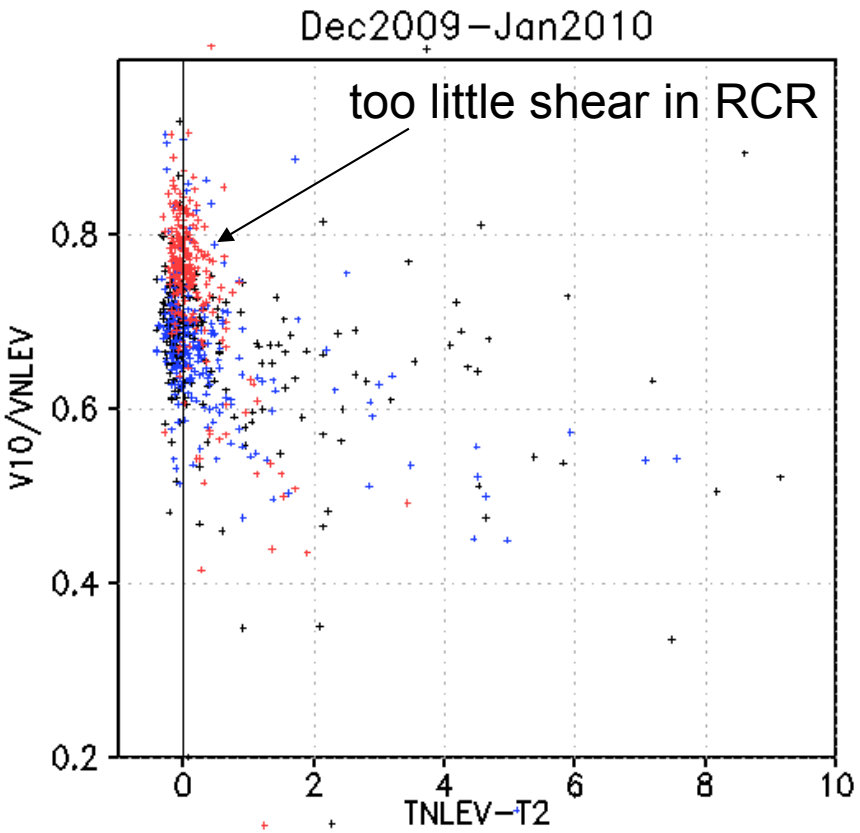
Black:obs Red:RCR Blue:7.3beta2

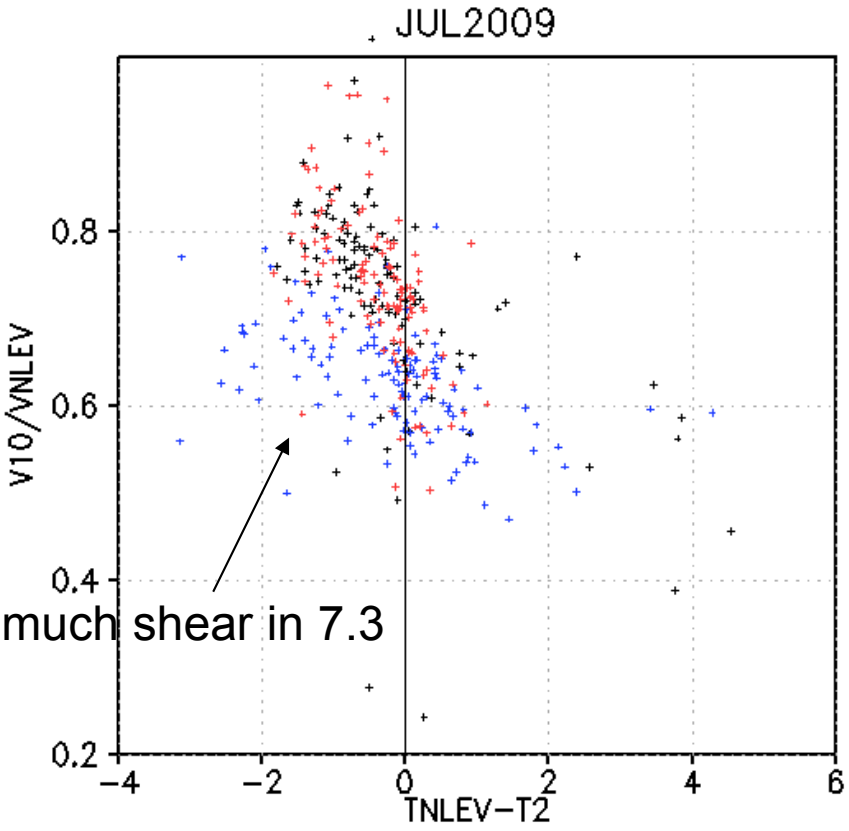




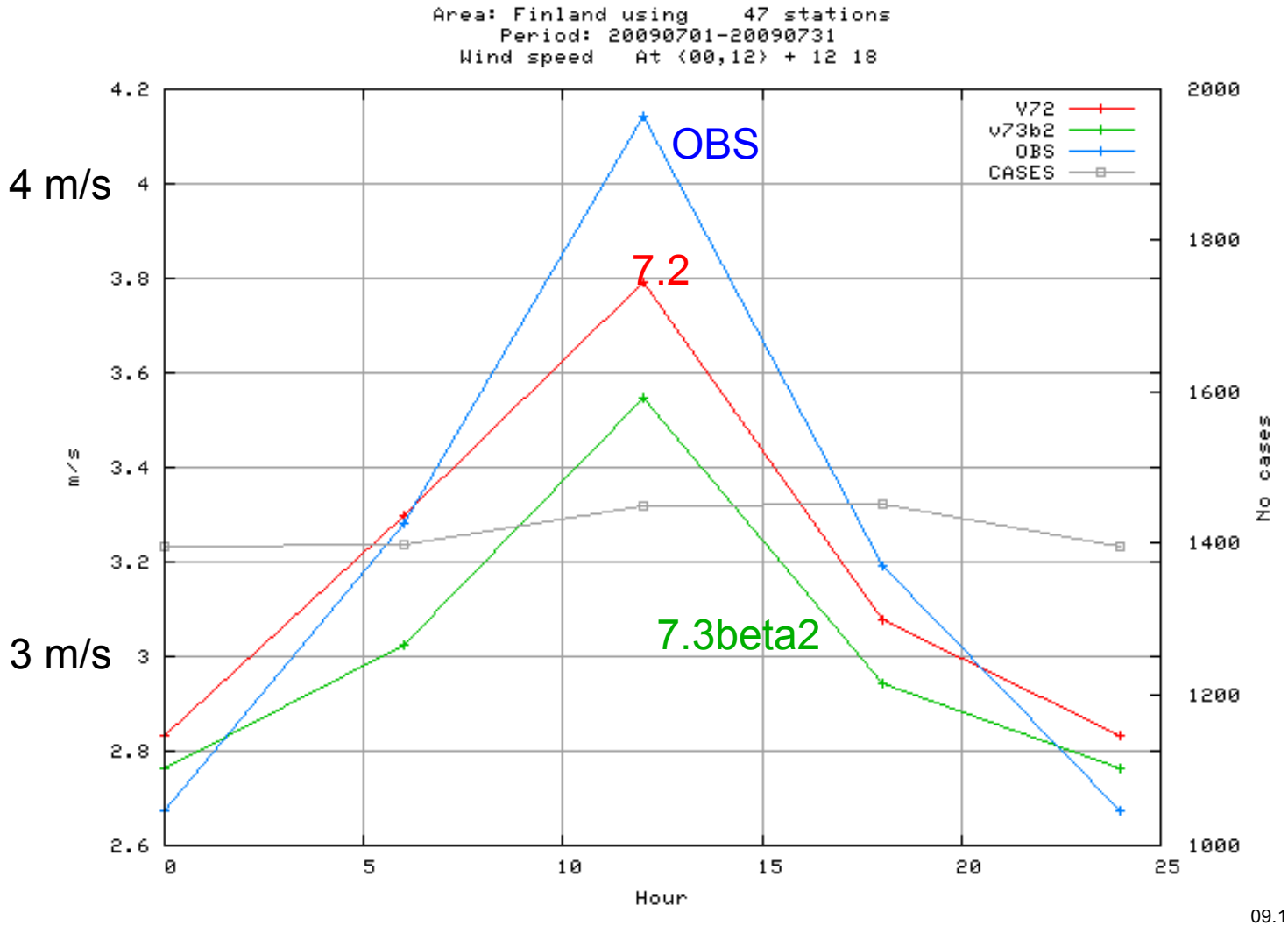
Surface layer wind shear vs stability

Black:obs Red:RCR Blue:7.3beta2





U10m, diurnal cycle, July 2009, Finland



Summary 1: temperature and energy cycle

- **Winter**
  - New HIRLAM: more frequent and more intense surface incersions
  - New HIRLAM: Increased cold bias at the top of the surface layer
  - Both 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.
- **Summer**
  - Both versions underestimate the radiative heating
  - Observed SHF exceeds observed LHF in magnitude, the opposite is true for both models
  - Both models show a cold day-time bias throughot the sfc layer

Summary 2: wind

- **The ratio V(10m)/V(NLEV)**
  - HIRLAM 7.3 overestimates shear in unstable situations
  - HIRLAM 7.2 underestimates shear in neutral to stable situations
  - The observed distribution shows stronger annual cycle than either of the model versions

Distributions of wind speed