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CONSORTIUM FOR SMALL SCALE MODELING
COSMO

WG3b
Activity Review

Jean-Marie Bettems / MeteoSwiss

COSMO General Meeting
Eretria, September 9th , 2014

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Science Plan

Science Plan
WG3b related aspects

The following sections are available

- **Land surface** scheme
- Parameterisation of **sea ice**
- Parameterisation of **lakes**
- **External parameters**

The following **strategic decisions** have been taken

- **TERRA** is further chosen as basis for COSMO NWP
- Coupling with other SVAT models (CLM, Veg3D) supports the further development of TERRA, through inter-comparison studies.

Science Plan
Land surface scheme

Short to medium term actions (2015 – 2017)

•Revision of the **surface energy budget**: consideration of the role of vegetation (shading effect, additional vegetation layer – the latter topic is coordinated by WG3a) (P1);

•Revision of **plant water uptake** : impact of vegetation properties (P2);

•Implementation of advanced **soil properties** data sets: Harmonized World Soil Database, new formulation of soil water transport (P2);

•Identification of processes to be used in **stochastic physics** approach (P1), (in cooperation with WG7),

•**Assimilation** of soil moisture, and maybe soil temperature, (remote) observations, or other approaches improving the initial state of the soil (this work is coordinated by WG1) (P1);

•**Model inter-comparison** and validation studies (SRNWP data pool) to identify future fields of development activities (P1).

Long term actions (2018 – 2020)

•Improve the simplified treatment of **infiltration, interception, and run-off** from surface and ground; due to numerical problems a revised approach should be considered and extended to possible stream flow routing. This requires the consideration of horizontal transports, implementation of soil water interflow, base flow, and ground table (P1).

•Improve the **multi-layer snow model**, in particular in complex topography, and the related assimilation techniques (this latter task is coordinated by WG1) (P1)

Science Plan
Reviewers feedback

- No **fundamental** criticisms specifically aimed at the WG3b sections
- All **specific** comments have been taken into account, and the document modified accordingly
- **My** main comment: the document should be shorter

- Recent input from USAM to incorporate the development of a **coupled atmosphere / wave model**

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Activities

WG3b Activities
Summary (1/4)

- **Permanent activities**
  - **Data pool** action (data base of soil & surface observations)
  - Coordination of **EXTPAR** development (generation of external parameters)
  - Link with **SOILVEG** (CLM community)

- **PT and PP**
  - PP **CALMO** (calibration of COSMO model)
  - PT **SNOWE** (snow water equivalent for analysis)

- **Recent developments ready for operations, available in EXTPAR 2.0 / INT2LM 2.0 / COSMO 5.0**
  - Soil moisture dependent **thermal conductivity** (bug fix in 5.1!)
  - **Flake** (lake model)
  - EXTPAR: GLOBCOVER (**land use**), HWSD (**soil texture**), ASTER (**topography**)
  - EXTPAR: MODIS based surface **albedo** (climatology, annual cycle)
  - EXTPAR: NDVI based **vegetation climatology**

WG3b Activities
Summary (2/4)

- **Recent developments, not yet finalized**
  - Revised **bare soil evaporation**, both at DWD and IMGW
    - Systematically overestimated (Observations at Falkenberg)
    - IMGW: Hour of day and temperature dependent formulation
      Fit to reduce error of near surface parameters
  - Revised parameterization of **water infiltration**
    - Depth dependent, higher values at top (soil defaults)
    - Large sensitivity observed in CLM simulation (O. Bellprat / ETHZ)
  - Revised **soil water transport**
    - Brooks and Corey, support soil vertical heterogeneities as available in HWSD
  - **Phenology** model to catch vegetation inter-annual variability
    - Workshop at MeteoSwiss planned in 2014Q4 (Jan-Peter, Reto, Andreas)
  - Exponential **root profile**

WG3b Activities
Summary (3/4)

- **Recent developments, not yet finalized (ctn'd)**
  - **Tile** approach
    - Available in ICON, incl. dynamic snow tile (partial snow cover)
    - Still some technical issues (GRIB coding…)
  - Multi-layers **snow** model
    - Available in ICON
    - Still stability issue (coarse resolution only), coupling with analysis missing
  - ➢ **Urban** module
  - **Mire** parameterization

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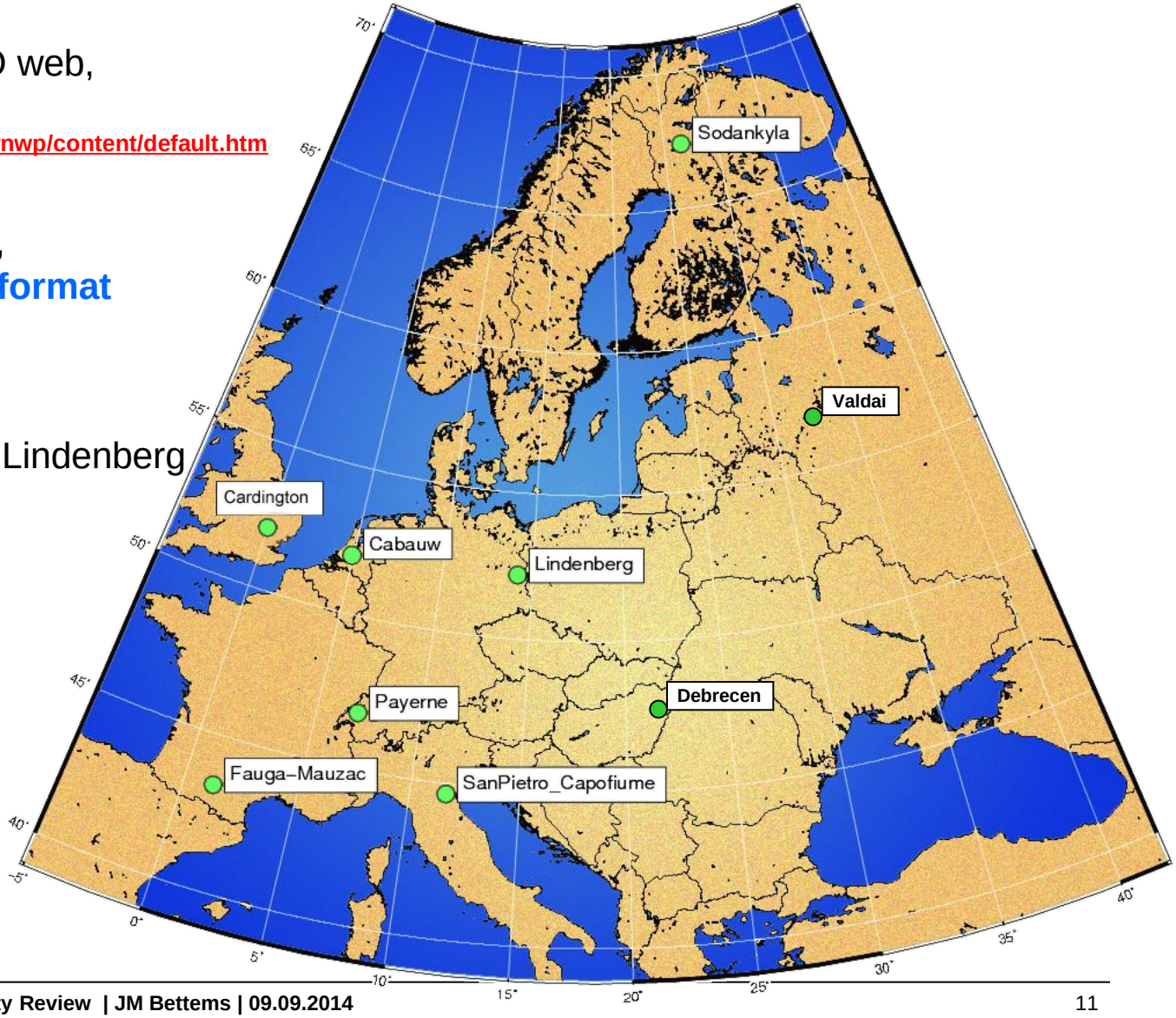
SRNWP data pool

Data pool action

- Access from COSMO web, password protected
  http://www.cosmo-model.org/srnwp/content/default.htm
- Currently **9 sites**, data from **2006-2013**, in a **common ASCII format**
- **Soil**, **surface** and **BL** observations
- Work done at DWD / Lindenberg (C.Heret)



Data pool action
Status

- Data available from start of the action to end 2013 from
  Cabauw (NL), **Capofiume** (IT), **Lindenberg** (DE),
  Payerne (CH), **Sodankyla** (FI)
- Sites not updated since 2012
  Fauga-Mauzac (FR), **Cardington** (GB)
- Almost no data for
  Debrecen (HU)
- New site **Valdai** (RU)
  … but no fluxes measurements, no deep soil measurements …

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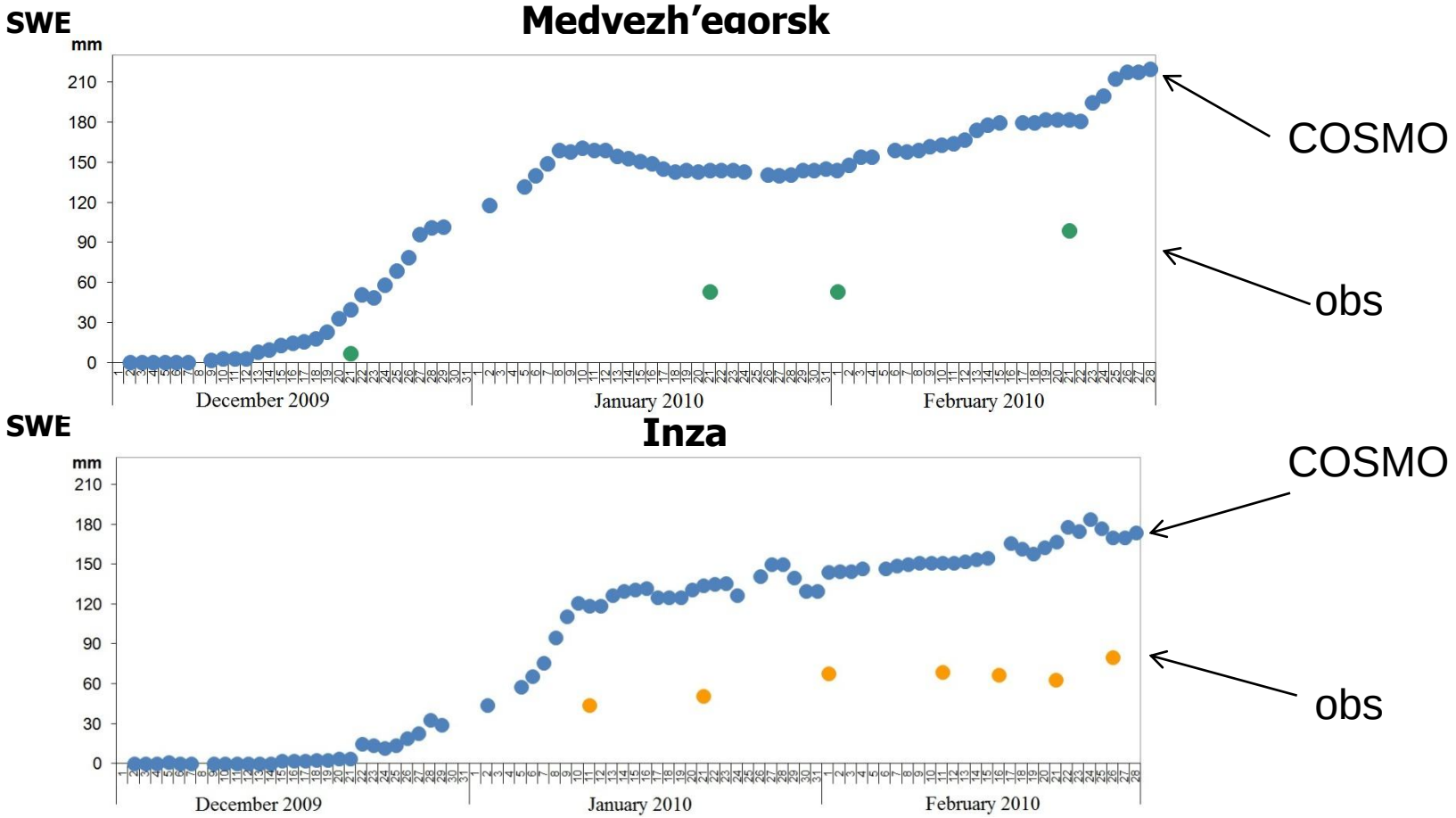
PT SNOWE

Snow water equivalent for snow analysis

Motivation

- Initial GME-fields of snow water equivalent (SWE) may have significant errors when compared with hydrological measurements
- This has a detrimental impact on T2m through the parameterization of partial snow cover, in particular in spring



Method

1D multi-layers snow model, observation driven

- Computed at each SYNOP location
- Computed through the whole snow season
- Provide snow density and snow water equivalent at SYNOP locations

Combine this information with satellite derived snow mask and model first guess

- Interpolation of snow density and snow water equivalent

Integrate in current COSMO snow analysis

- Combine model first guess, snow depth observation and snow mask
- Coordinate with M. Lange / DWD

New **PT** at Roshdromet, starting now (StC agreed ?)

Impact of improved snow analysis

Station	10 April 2013, 12 UTC			11 April 2013, 00 UTC		
	Obs, t◦C	Oper, t◦C	Ex, t◦C	Obs, t◦C	Oper, t◦C	Ex, t◦C
Efremov	8,0	4,3	6,6	-0,4	-0,5	-0,6
Volovo	6,9	0,6	5,8	-1,1	-3,6	-1,7
Verhov'e	7,0	1,2	6,0	0,8	-1,2	-0,2
Temnikov	7,2	6,2	5,6	0,2	0,7	-3,0
Unecha	7,1	6,6	5,4	1,0	0,4	0,7
Fatezh	8,1	5,6	6,7	-1,5	-3,0	0,3
	Mean abs. error	3,3	1,37		1,2	1,11

Improved ground heat flux

Evaluation of the ground heat flux simulated by a multi-layer land surface scheme using high-quality observations

Jan-Peter Schulz[1,3,*], Gerd Vogel[2], Claudia Becker[2] and Bodo Ahrens[3]

[1]Biodiversity and Climate Research Centre (BiK-F), Frankfurt
[2]Deutscher Wetterdienst, Lindenberg
[3]Goethe University Frankfurt

*Affiliation now: Deutscher Wetterdienst, Offenbach

COSMO General Meeting, 8 - 11 Sep. 2014, Eretria, Greece

The problem …

- The ground heat flux in the COSMO land surface scheme TERRA is systematically overestimated under dry conditions.
- Since this flux is part of the surface energy balance it affects the other components like the turbulent heat fluxes or the surface temperature.
- An overestimation of the ground heat flux during daytime leads to an underestimation of the other surface fluxes and a reduced surface warming.
- During afternoon and night this behaviour is reversed.

Hypothesis

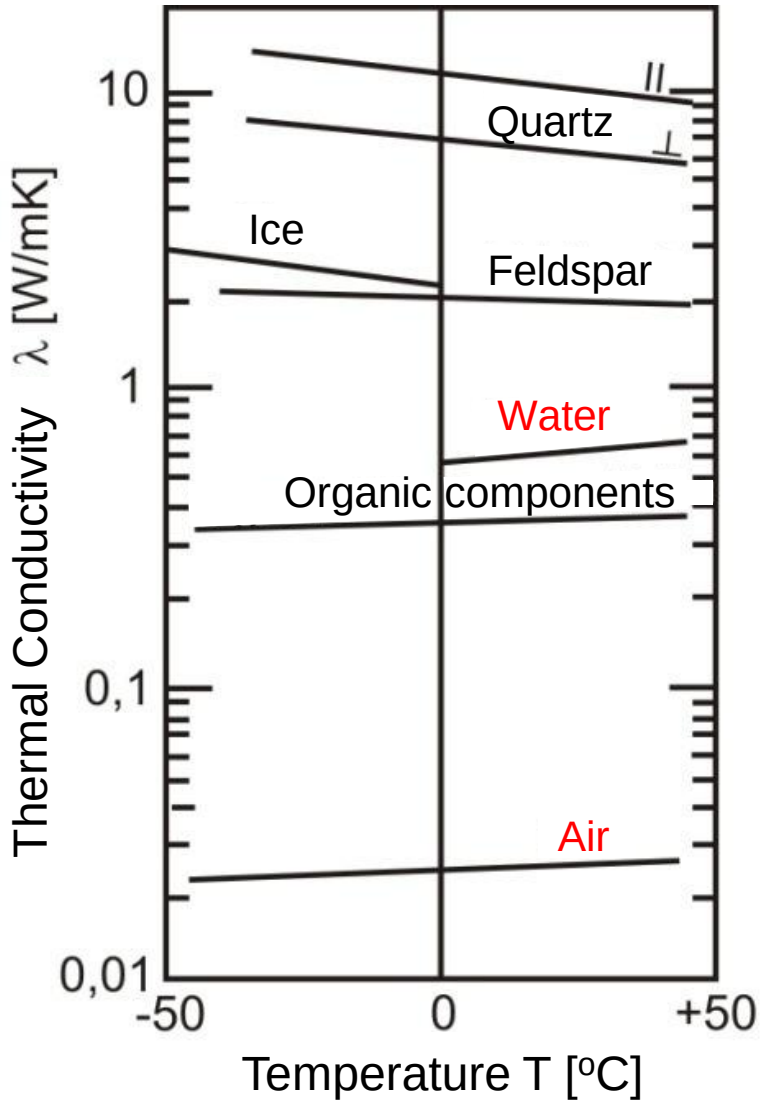
The ground heat flux in the COSMO model is systematically overestimated in summer. Main reasons:

- The shading effect of the vegetation is not represented in the model
- The thermal conductivity of the soil is too large in summer

Methodology

- Focus on thermal conductivity first
- Reduce the thermal conductivity of the soil in summer, by introducing its strong dependence on the soil water content

Thermal Conductivity



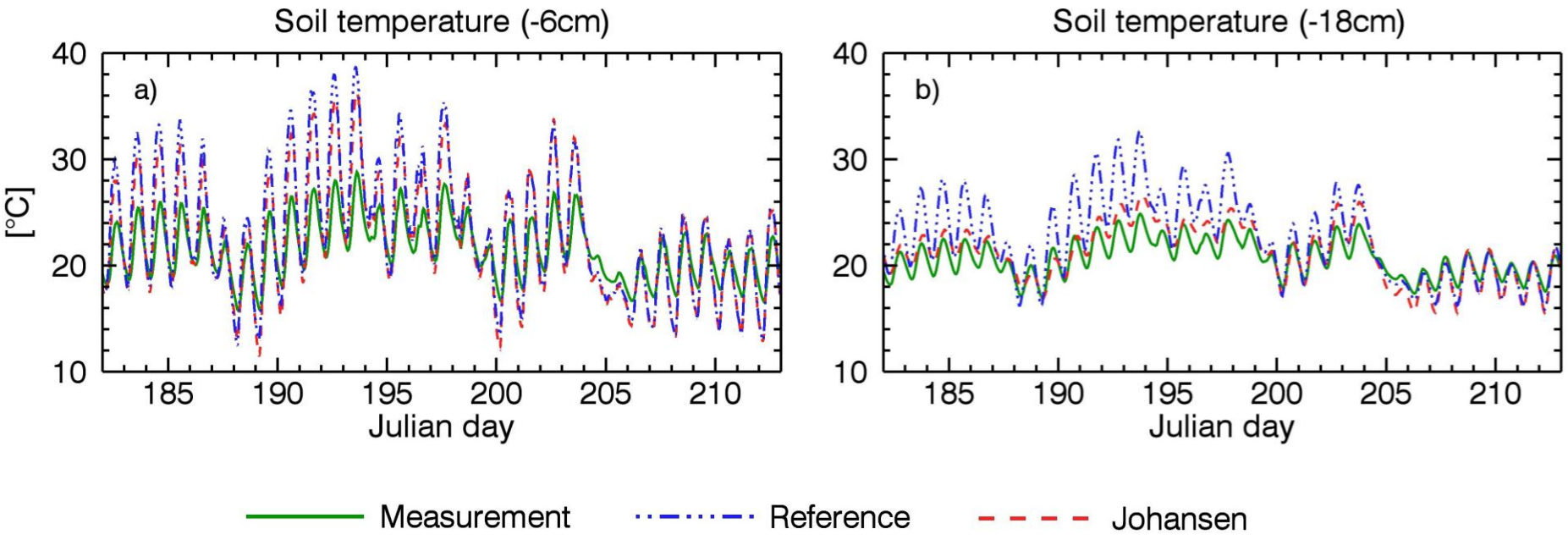
The thermal conductivity of water is about a factor of 25 larger than that of air!

This means, replacing the air in the pores of a soil by water increases the thermal conductivity of the soil system dramatically.

In other words:
A wet soil (in winter) has a much larger thermal conductivity than a dry soil (in summer).

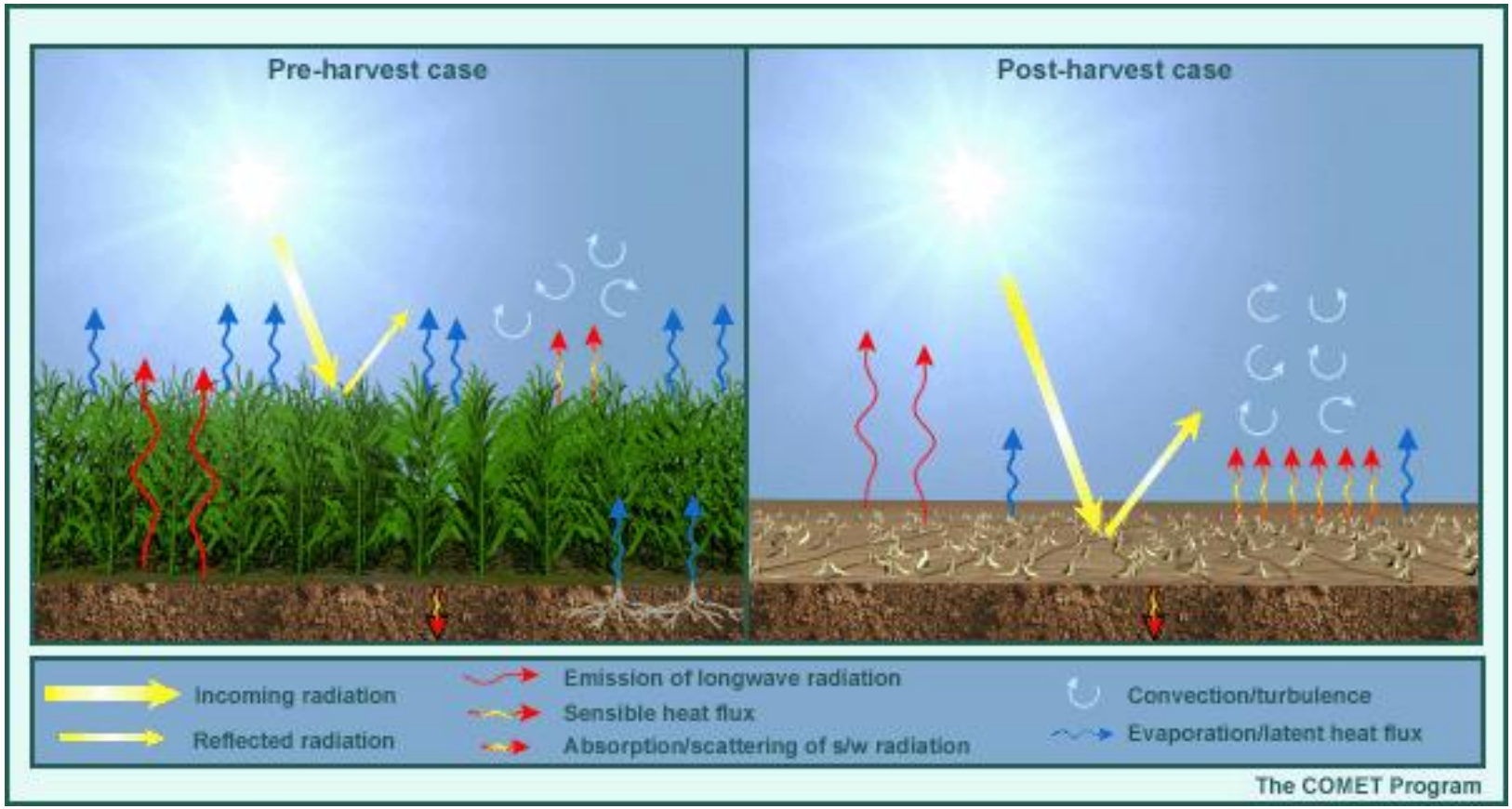
Baier (2008), after Frivik (1981)

Offline TERRA: Falkenberg July 2010
Thermal conductivity: Johansen
Grass land



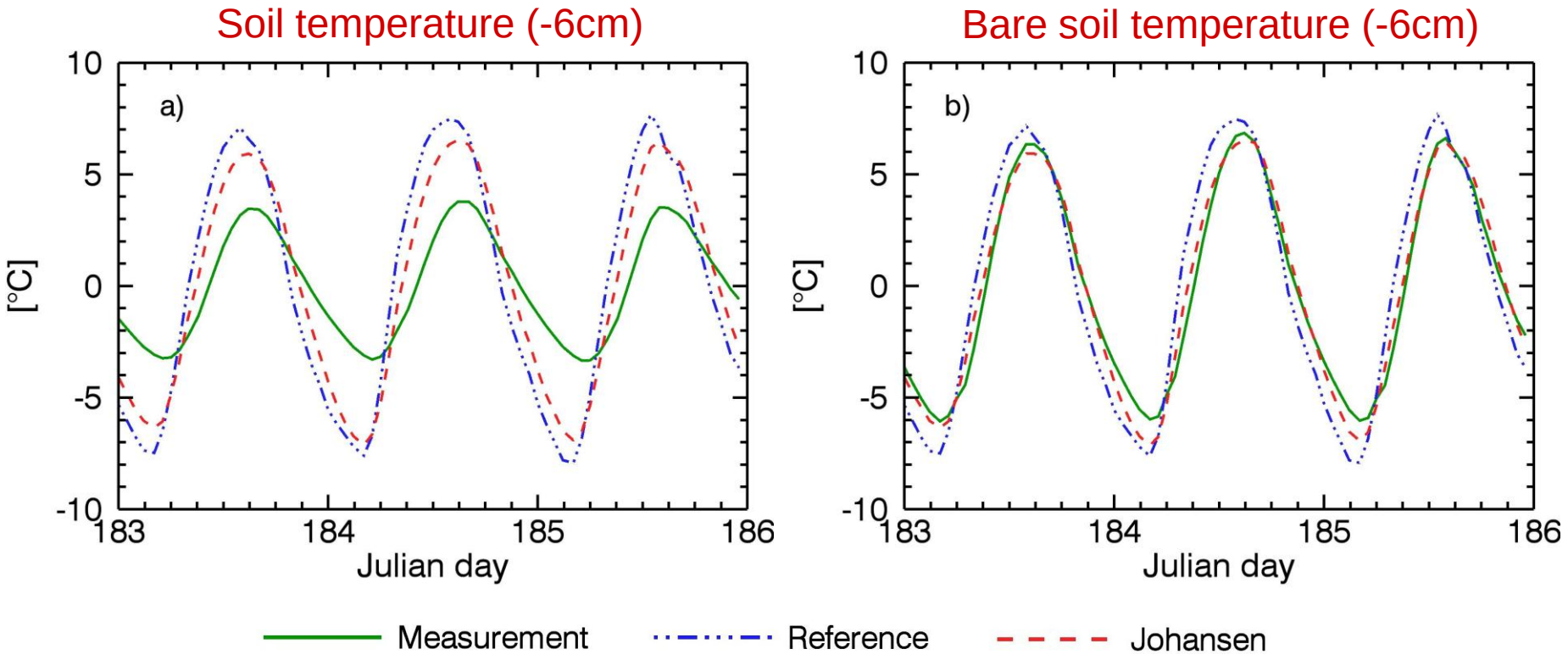
The diurnal cycles of the soil temperature are reduced by Johansen under dry conditions.

Shading



In TERRA the effects of shading of the sub-canopy land surface by the vegetation is not represented. The incoming solar radiation is directly used in the surface energy balance, modifying the other energy terms in an unrealistic way.

Offline TERRA: Falkenberg 2 - 4 July 2010
Thermal conductivity: Johansen



- Diurnal temperature range reduced by Johansen by about 2°C
- Compared to bare soil measurements this is very good
- Shading (even by grass) has a huge effect

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New external parameters ASTER, GLOBCOVER, HWSD

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Accuracy of simulated diurnal valley winds in the Swiss Alps: Influence of grid resolution and land surface characteristics

J. Schmidli[1], S. Böing[1], and O. Fuhrer[2]

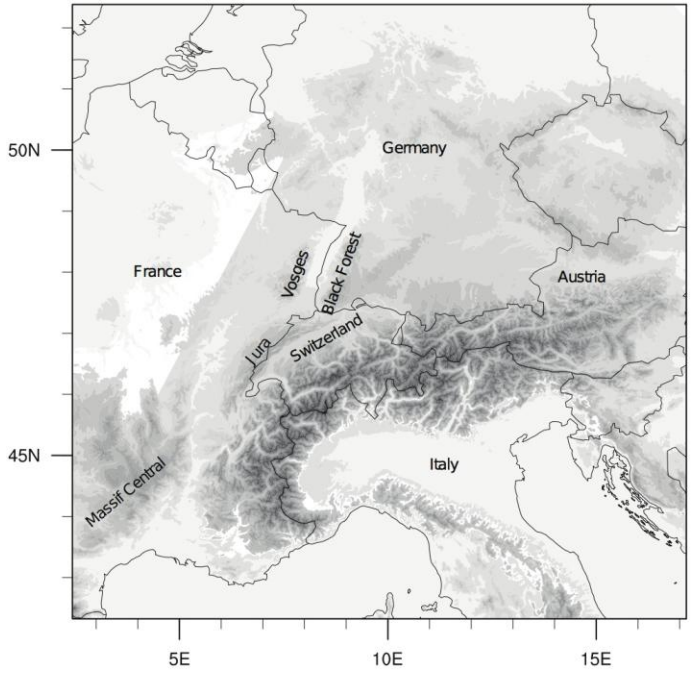
[1]ETH and [2]MeteoSwiss

Acknowledgments:
D. Lüthi, W. Langhans, C. Schär and the COSMO-1 team

Experimental setup

Basic setup

- COSMO v5 @ 2.2 and 1.1 km
- Initialized with and driven by ECMWF analysis (25km)
- **Soil initialized** from 10-yr climate run with 2km resolution (N. Ban)
- Standard physics options (MY-PBL scheme, no horiz. diffusion)



High-resolution surface data

- ASTER topography (30 m)
- GC2009 land cover (300 m)
- HWSD soil type (1 km)
- Raymond filter for topography (def: cutoff ~5 dx)

→ C2_ref, **C1_ref**

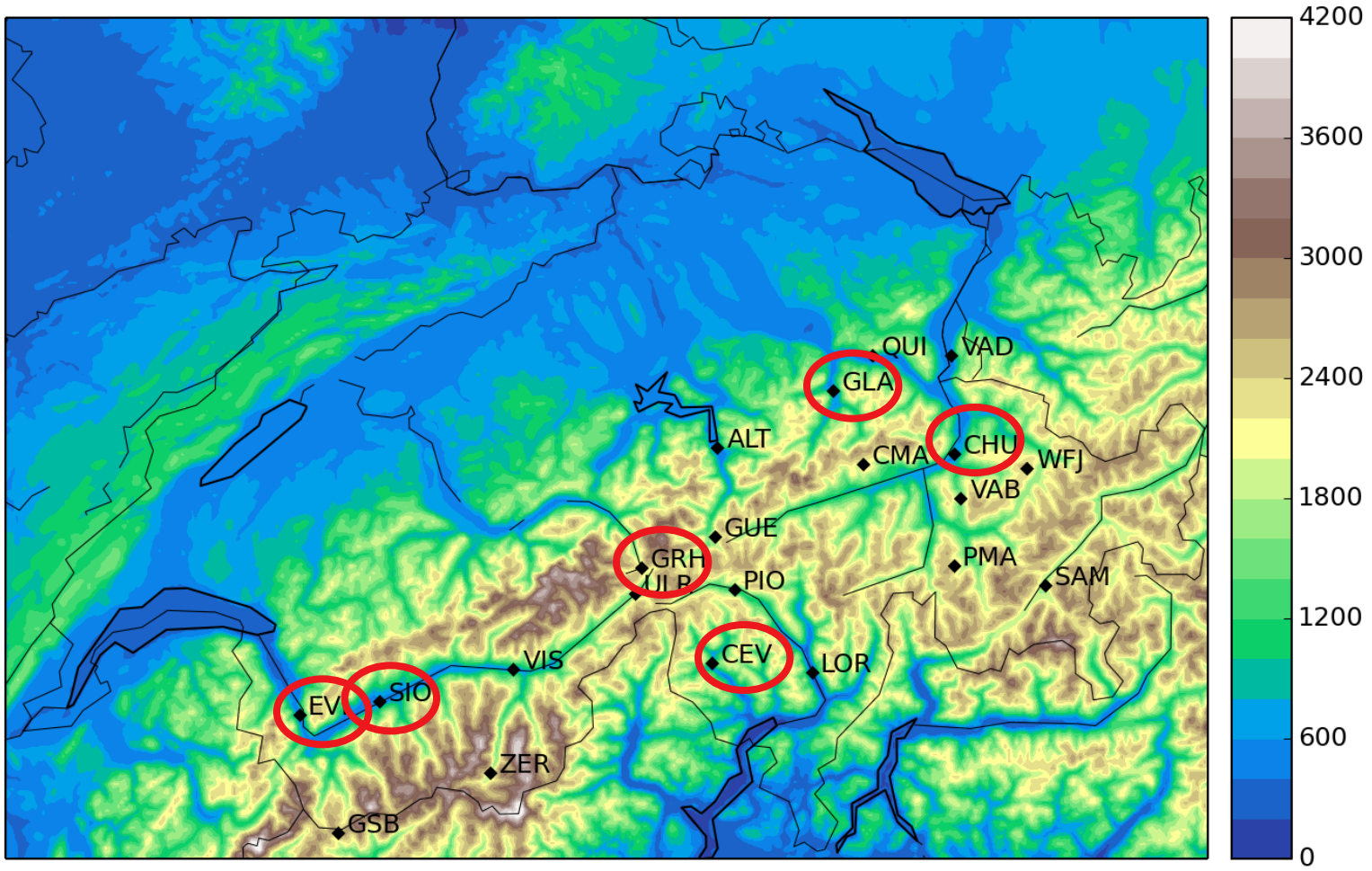
Low-resolution surface data

- GLOBE topography (1 km)
- GLC2000 land cover (1 km)
- FAO DSMW (10 km)
- Raymond filter for topography (def: cutoff ~5 dx)

→ **C2_sfc**, C1_sfc

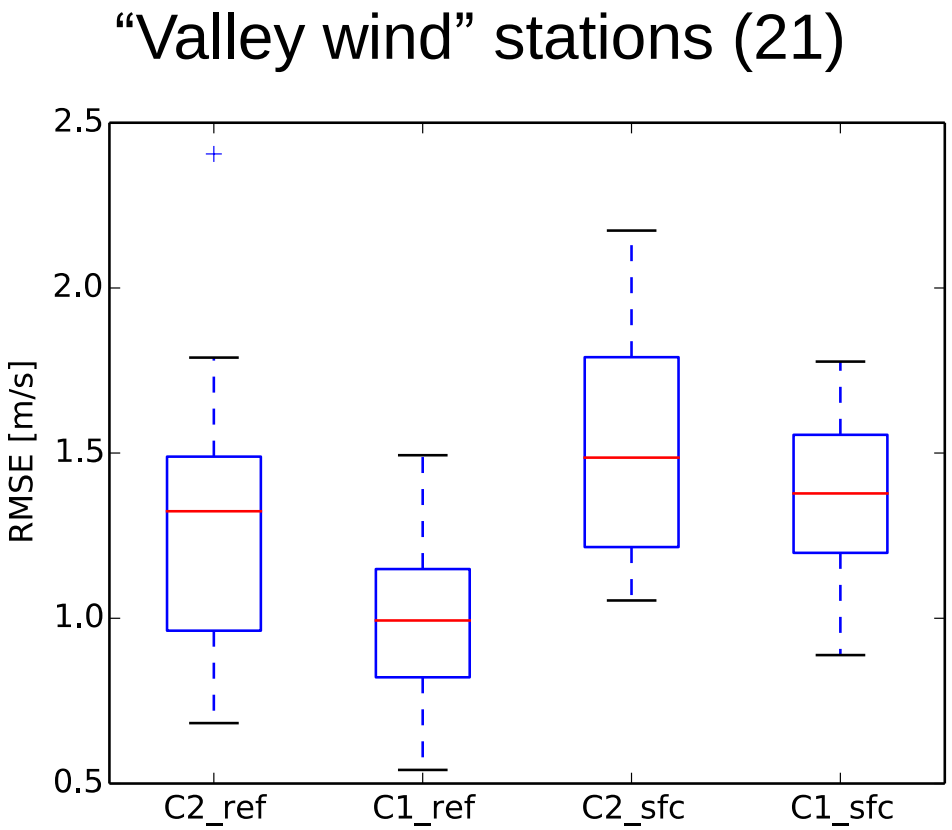
“Valley wind” stations

“Top-six” stations



Mean maximum wind > 4 m/s → 21 stations

Influence of surface data

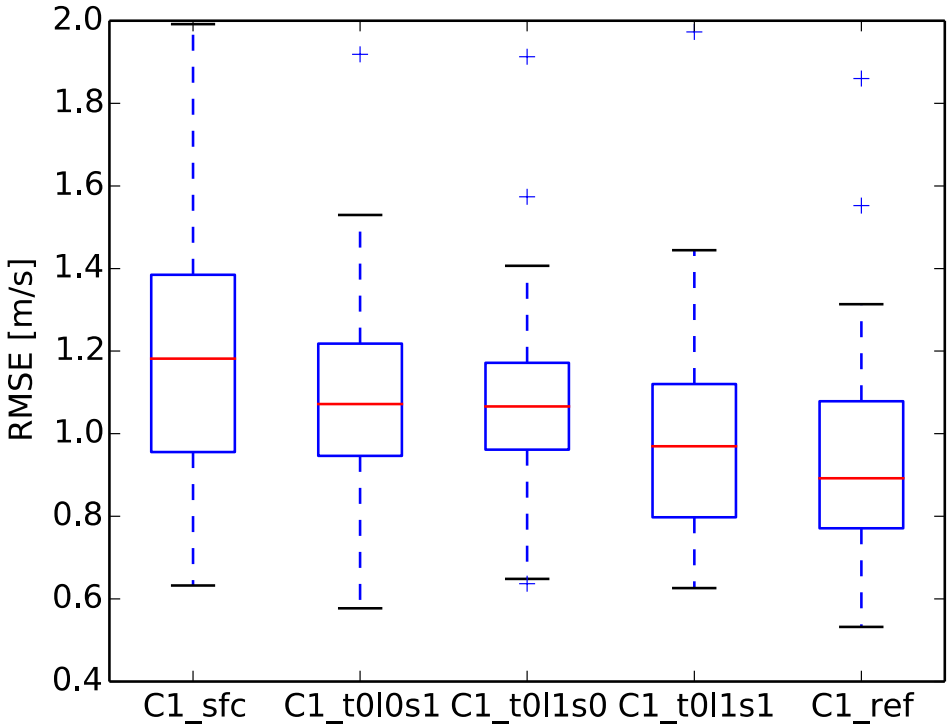


→ coarse surface data: Only minor improvement for 1km!

→ need high-resolution surface data for 1km simulation!

Influence of surface data
(soil, land cover, topography)

“Valley wind” stations (21)



→ **All** three components (soil, land cover, topography) important

→ Similar contribution to improvement

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Urban parameterization

Urban parameterization

Three urban models available in COSMO-CLM

URBMIP – Inter-comparison study performed by the CLM community

Name	TEB alongside TERRA_ML	TERRA-URB	TERRA-ML / BEP
Responsability	Kristina Trusilova	Hendrik Wouters	Sebastian Schubert
Features	inner building temperature snow model, water skin layer roofs/walls/roods, tiled urban fraction	Direct representation of the urban landcover in TERR-ML using a tile approach, new surface-layer transfer coefficients, thermal capacity, anthropogenic heat and impervious surface interception distribution	Street canyon model advanced double-canyon radiation scheme, shadows, radiation trapping, roof/wall/ground fluxes; coupled with the PBL scheme not only through surface fluxes but also by means of energy and momentum fluxes in layers above the surface
Input		Urban fraction (EEA), annual mean anthropogenic heat (NCAR)	Full 3D cityGML
References	Trusilova et al 2008, Masson 2001	Wouters et al. 2013, Wouters et al. 2012, Flanner 2010, Demuzere et al. 2008, De Ridder, 2012	Schubert et al. 2012, Martilli et al. 2002,Gröger et al. 2008
Aims	Urban climate of Europe and Germany	urban climate and its impact on Air-quality simulations Flanders Belgium	Urban climate of Berlin and Basel

TERRA-URB (H. Wouters)

Findings

- Urban parameterization in COSMO-CLM/TERRA-ML was successfully implemented and tested on 1km resolution over Belgium
- The temporal and spatial variatiability of the UHI intensity are very well reproduced
- Additional computational cost was negligible (+3% CPU-time)
- Number of needed extra parameters is small and readily available globally

➢ TERRA-URB is the best candidate for NWP applications

➢ Visit of H. Wouters at Offenbach in 2014Q4 to discuss code implementation issues (coupling with TKE, external parameters)

Open issues

WG3b Activities
Open issues

- **Common** COSMO / ICON library
  - Terra developments available in ICON only
  - When will it be available ?
- **Vegetation shading**
  - Important impact on diurnal cycle of near surface parameters
  - Resources, planning ?
  - Coordination with J. Schmidli / ETHZ ?
- **TERRA standalone**
  - Useful tool to bring the soil in equilibrium for a new configuration
  - Will ICON framework support this mode ?
- **SRNWP data pool**
  - Missing resources ?

Thank you for your attention!