ON THE USE OF OBSERVATION DATA SETS FOR THE VALIDATION OF SRNWP SURFACE SCHEMES

Jean-François Mahfouf (Météo-France/CNRM)

and the SRNWP ET on surface processes

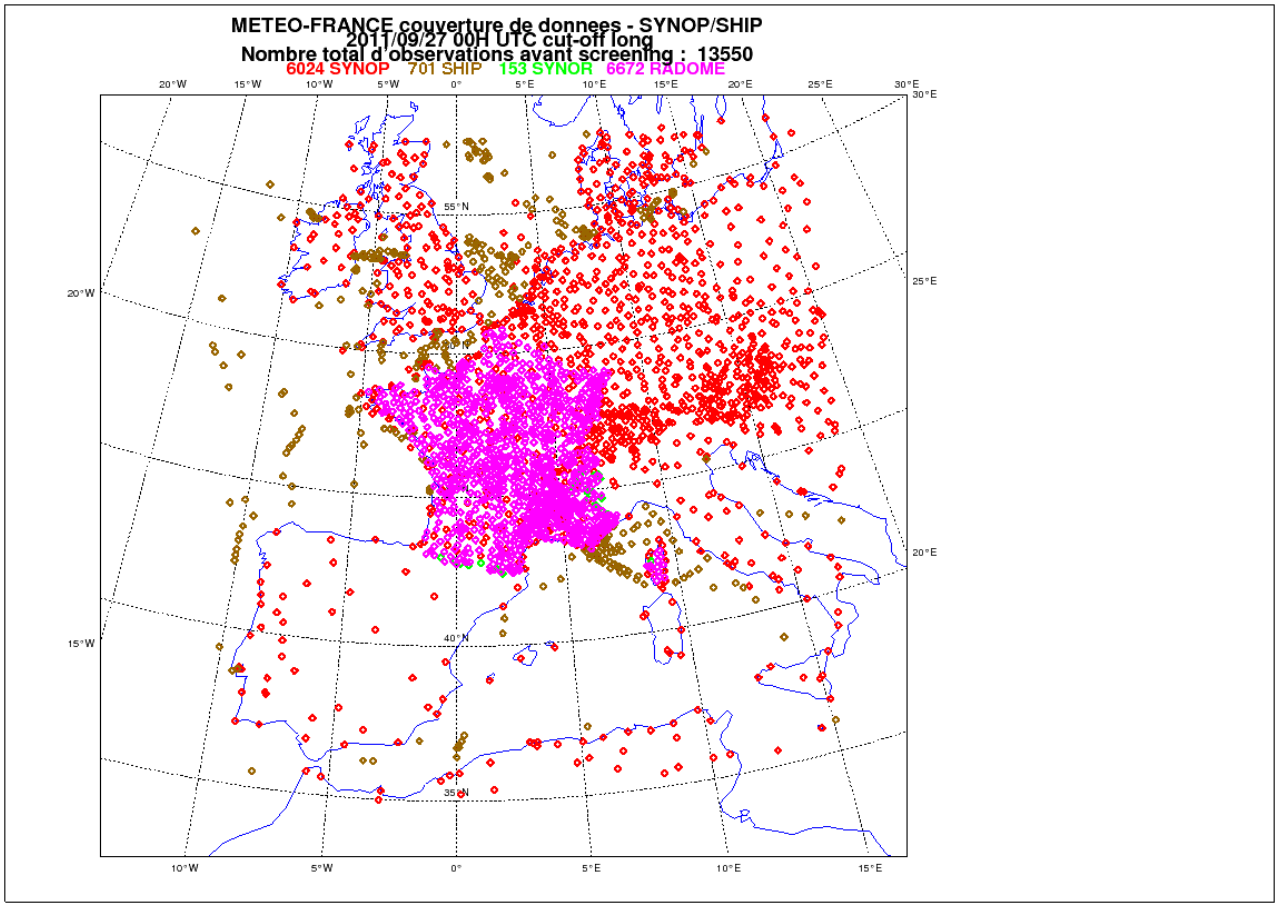
Outline

- Current operational practice for the evaluation of surface schemes in NWP models
- Interest for local validation datasets
- The SRNWP initiative : the COSMO/COLOBOC data pool
- Examples of evaluations
- Conclusions and perspectives

Current operational practice

- Surface schemes describe (turbulent) exchanges of momentum, energy, and water at the interface => impact on PBL development, initiation of convection, and also cloud cover (including fog)
- Meteorological parameters affected by low level processes and measured in routine are (from SYNOP reports) :
  - Screen-level temperature and humidity
  - 10 m wind speed and direction
  - Cloudiness (cloud cover, visibility)
  - Surface precipitation

Surface network over Europe

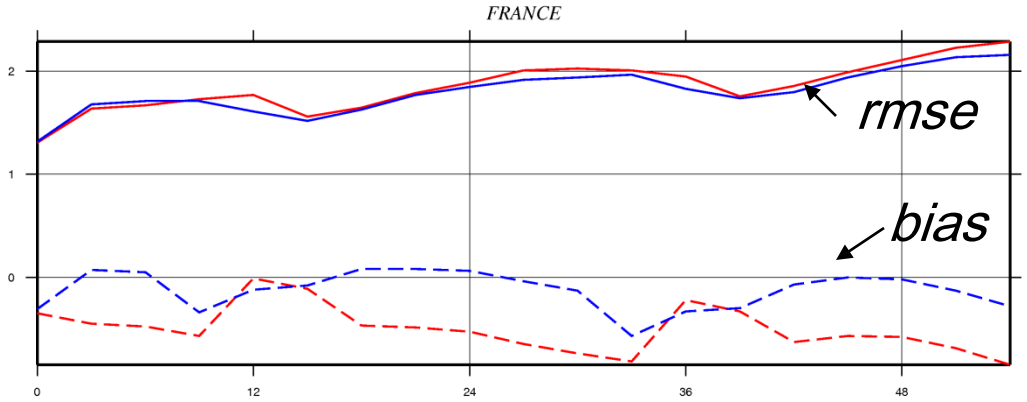


Evaluation of surface boundary layer scheme CANOPY in ALADIN model

Winter period

01/12/2010 -> 02/01/2011

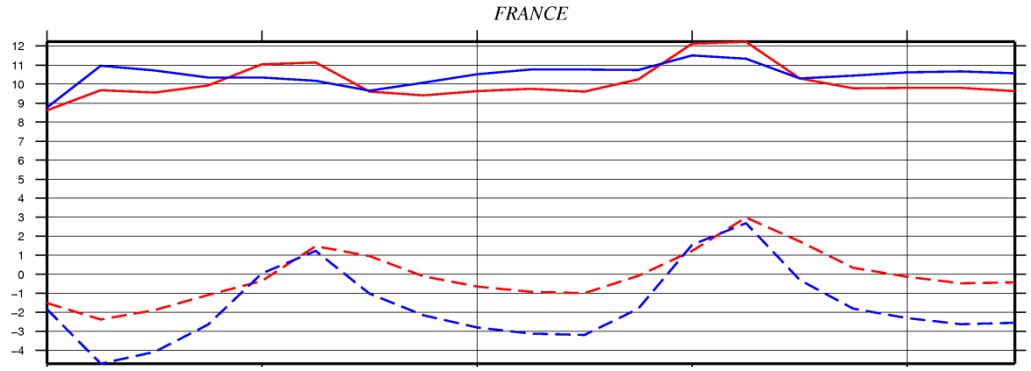
T2m



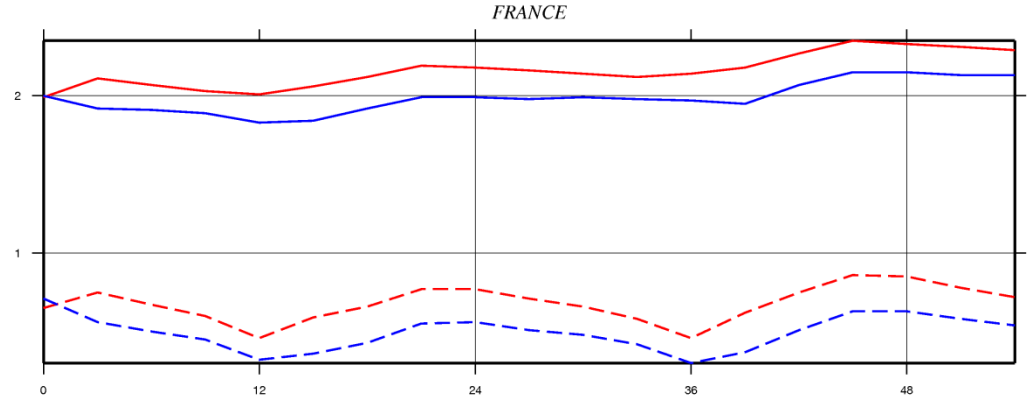
Without CANOPY

With CANOPY

RH2m

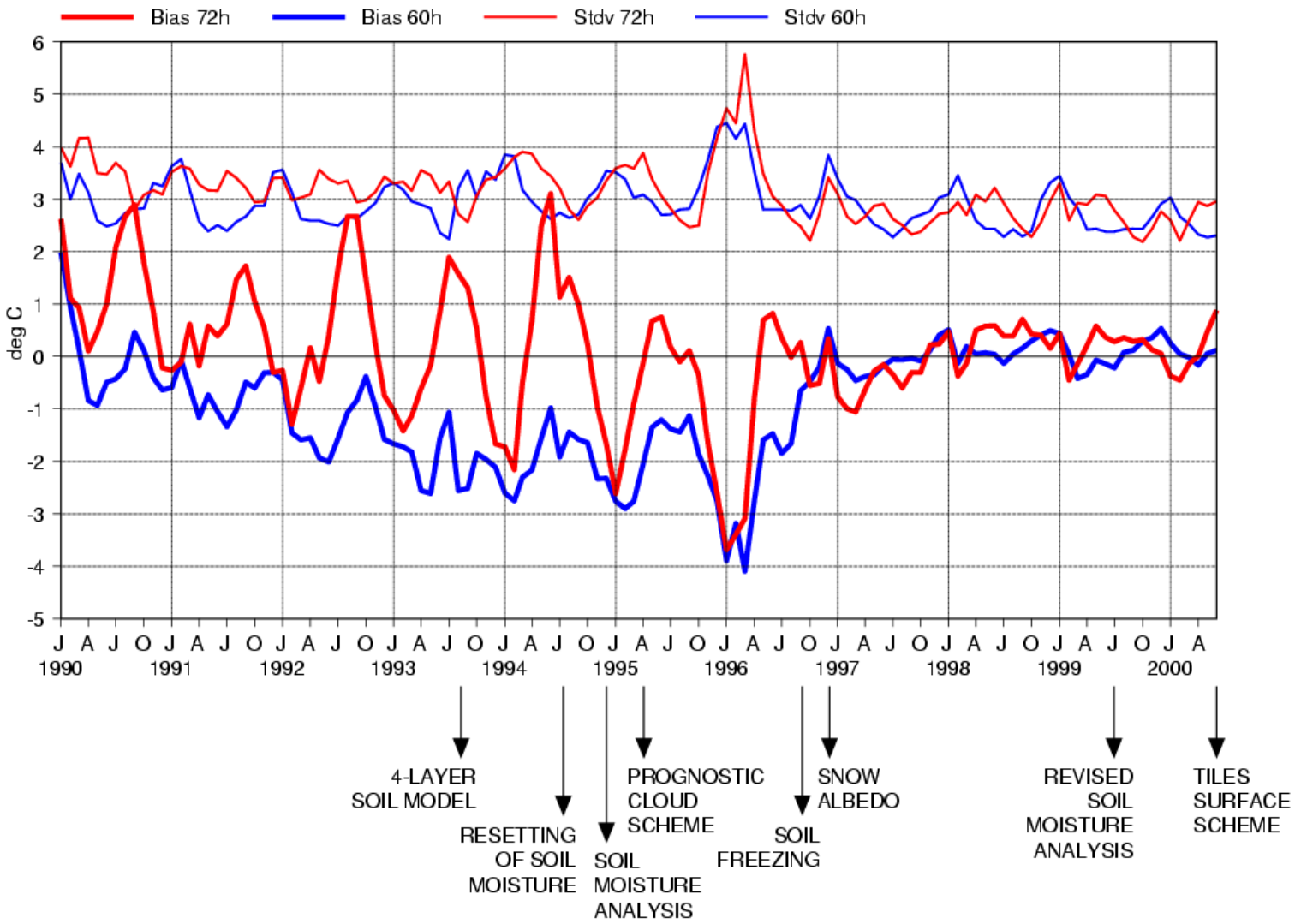


Wind speed



Surface observations (RADOME+SYNOP) over France

T2m forecast scores at ECMWF over Europe



Importance of additional parameters

- Turbulent fluxes : sensible and latent heat fluxes
- Radiative fluxes : net surface radiation, downward longwave and shorwave fluxes (satellite)
- Ground heat flux (to close the energy budget)
- Surface temperature (satellite)
- Soil moisture contents (at various levels in the root zone)
- Soil temperatures (at various levels) (climatological networks)

Validation of soil hydrology at ECMWF

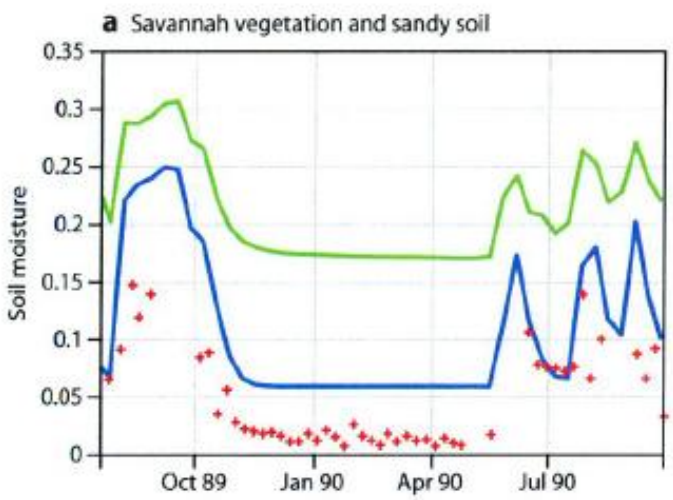
- **H**ydrology-**TESSEL**

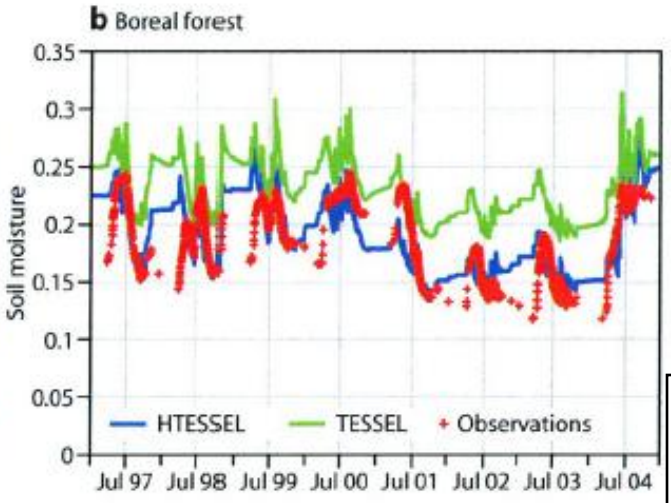
Balsamo et al. (2009)
van den Hurk and Viterbo (2003)

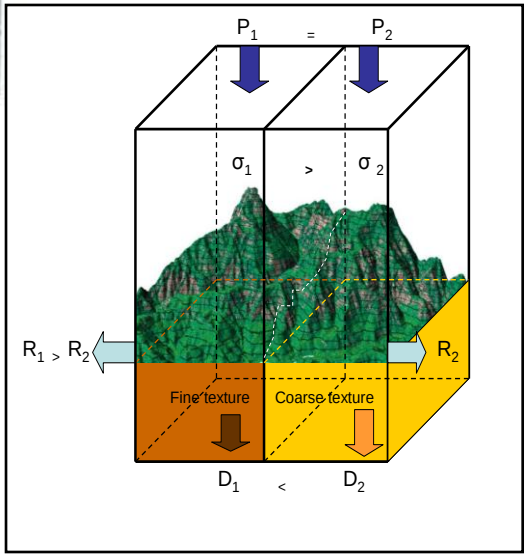
Global Soil Texture (FAO)

Van Genuchten hydraulic properties

Variable Infiltration capacity & surface runoff revision







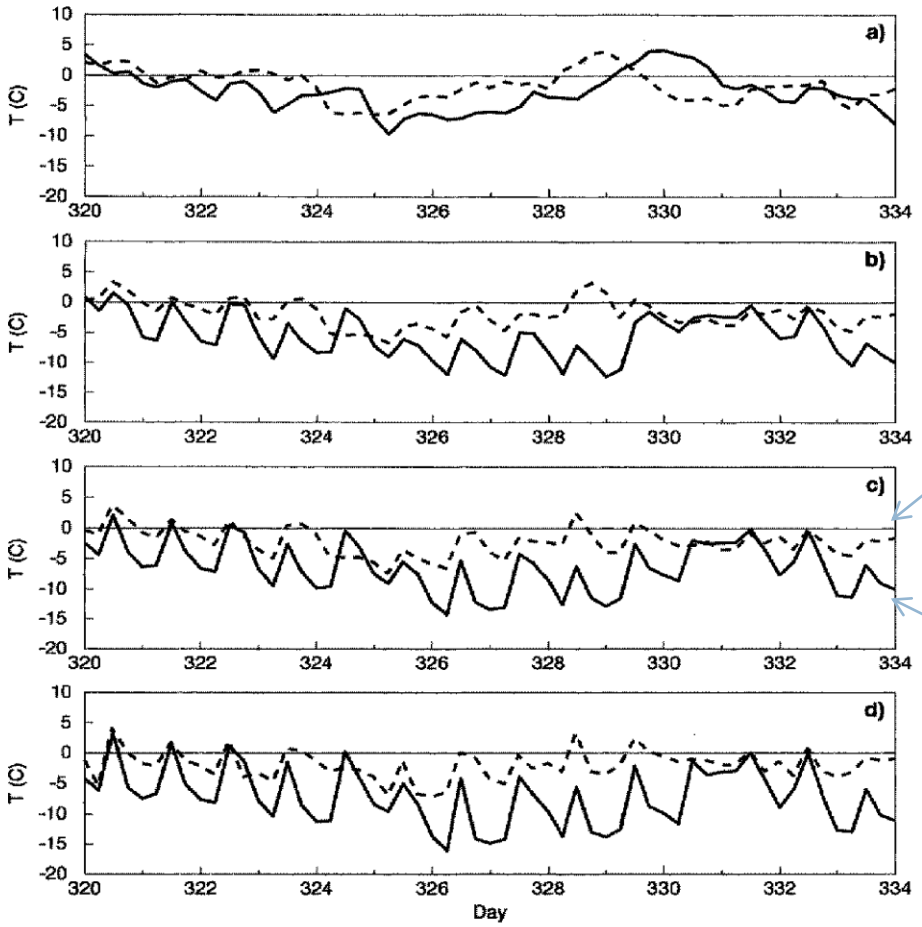
Developments on soil moisture freezing (1)

140 m

40 m

2 m

0 m



Observations

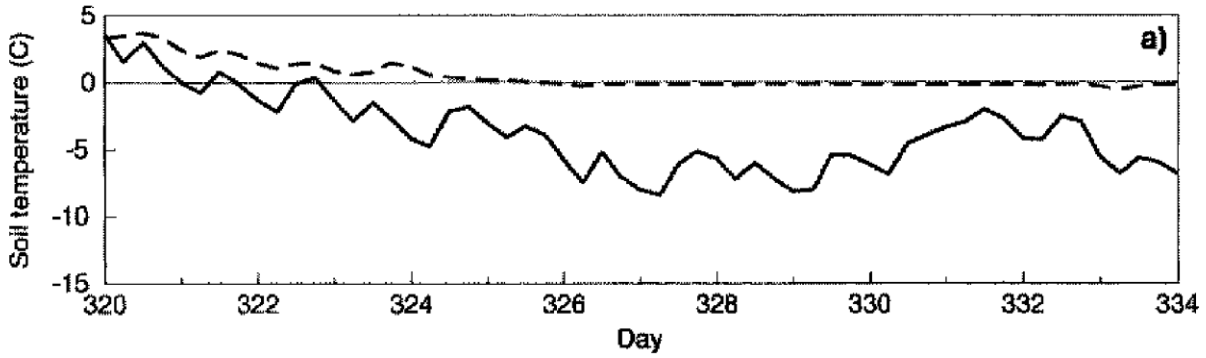
ECMWF model

Cabauw, Nov 1993

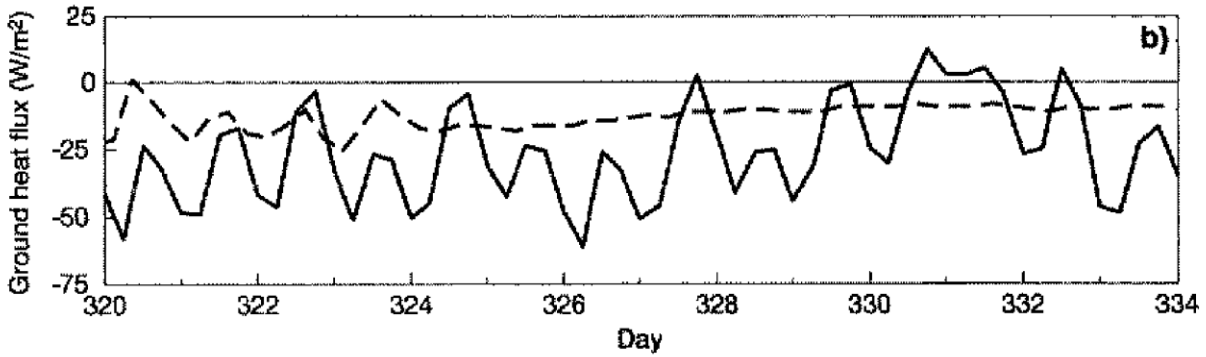
Viterbo et al. (1999)

Developments on soil moisture freezing (2)

Soil temperature



Soil heat flux



Viterbo et al. (1999)

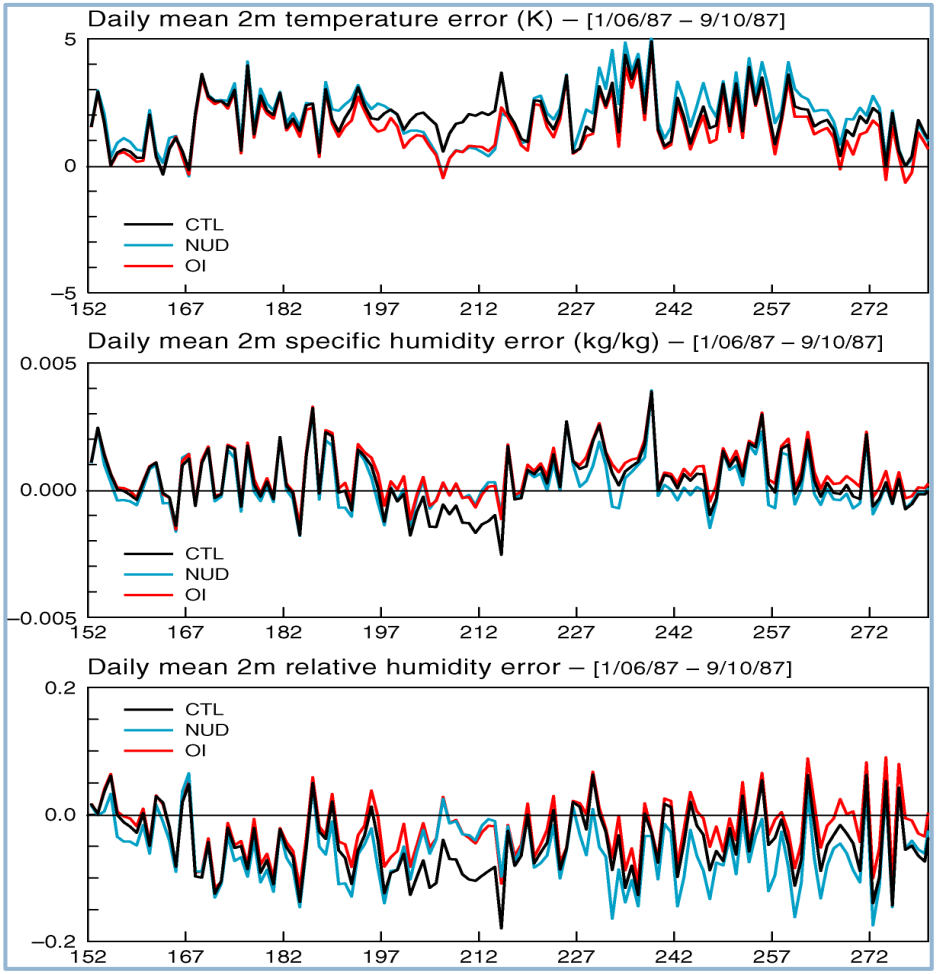
Soil analysis from 2m parameters (1)

FIFE 1987 (Douville et al., 2000)

T2m

q2m

RH2m

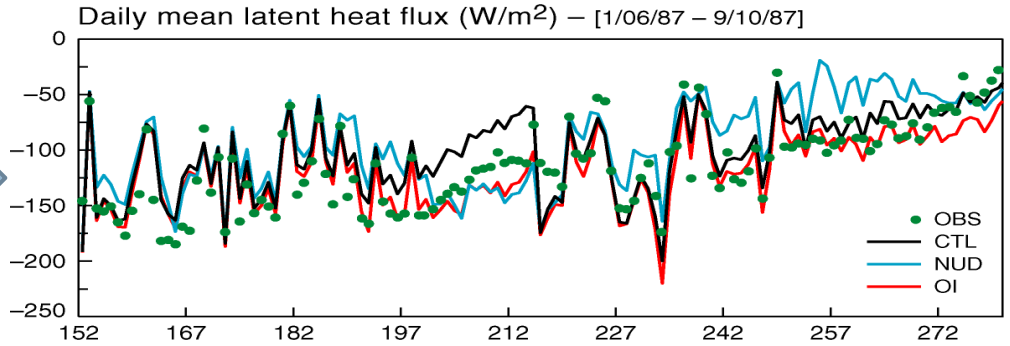


OPEN LOOP NUDGING ($\Delta w = D\Delta q$) OPTIMUM INTERPOLATION ($\Delta w = a\Delta T + b\Delta RH$)

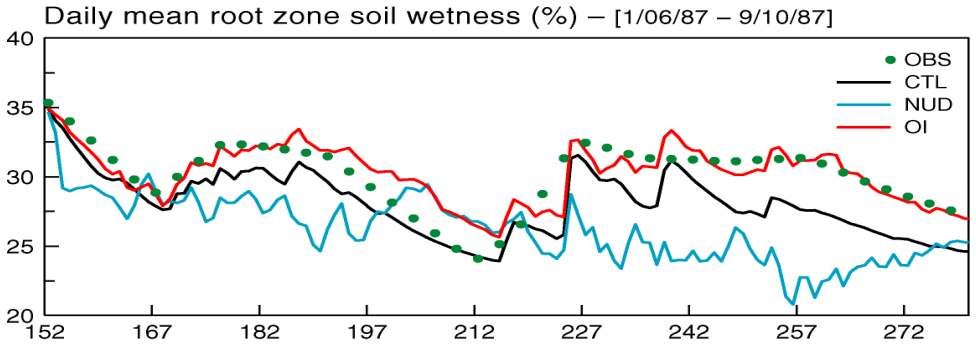
Soil analysis from 2m parameters (2)

FIFE 1987 (Douville et al., 2000)

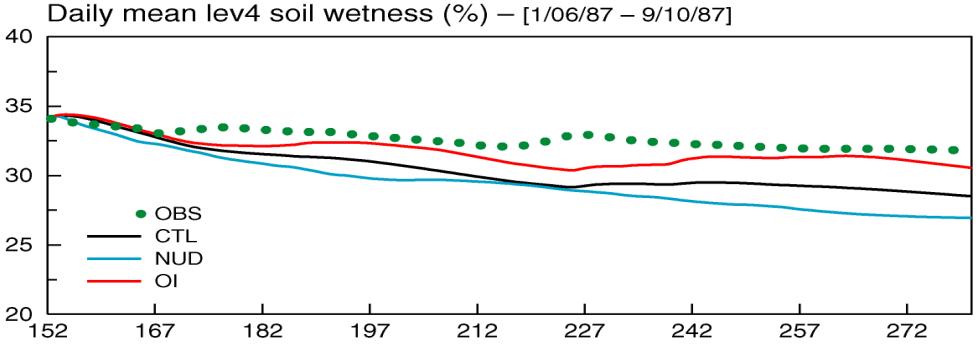
Latent heat flux



Root zone soil moisture



Deep soil moisture



Consistency in forecast improvements

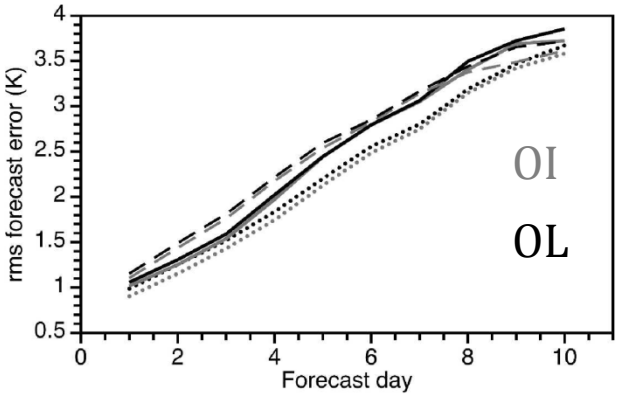


FIG. 6. Rms forecast errors for temperature at 1000 hPa as computed from the CTRL OI experiment (gray lines) and the open loop run (black lines). Results for Europe, North America, and East Asia are presented in dotted, solid, and dashed lines, respectively.

TABLE 2. Significance levels for the *t* test (first value) and sign test (second value). CTRL and OL experiment are compared based on rms forecast errors of temperature. The numbers represent cases where the CTRL experiment is better than the OL experiment. Dashes indicate cases for which no significant difference has been found.

		Forecast time (h)				
Area	Height (hPa)	24	72	120	168	216
Northern Hemisphere	1000	0.1/0.1%	0.1/0.1%	0.1/0.5%	2.0/10.0%	—/1.0%
	850	0.1/0.1%	0.1/0.1%	0.1/5.0%	—/—%	—/5.0%
	700	—/5.0%	2.0/1.0%	—/—%	—/—%	—/10.0%
Europe	1000	0.1/0.1%	0.1/0.1%	0.2/0.1%	—/—%	—/—%
	850	0.1/0.1%	0.1/0.1%	5.0/5.0%	—/—%	—/—%
	700	—/—%	—/10.0%	—/—%	—/—%	—/—%
East Asia	1000	0.1/0.1%	0.1/0.1%	5.0/0.1%	—/5.0%	0.5/0.5%
	850	0.1/0.1%	5.0/0.1%	2.0/5.0%	—/—%	0.1/0.2%
	700	2.0/—%	—/—%	—/—%	—/—%	—/5.0%
Northern America	1000	0.1/0.1%	1.0/0.1%	—/—%	—/—%	—/—%
	850	0.1/0.1%	0.2/0.1%	—/—%	—/—%	—/—%
	700	—/5.0%	—/—%	—/—%	—/—%	—/—%

T 1000hpa

Soil moisture

0-5cm soil moisture

0-1 m soil moisture

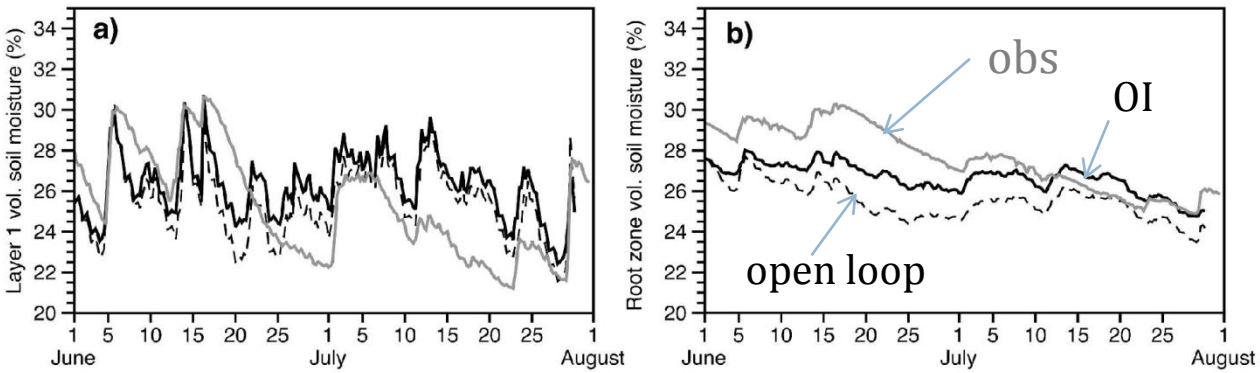
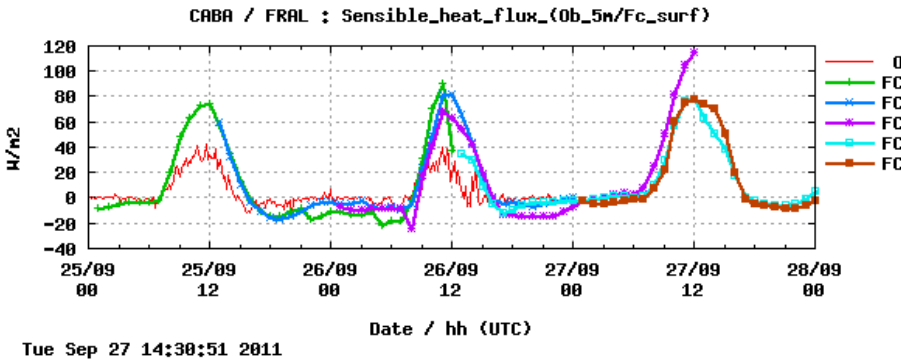


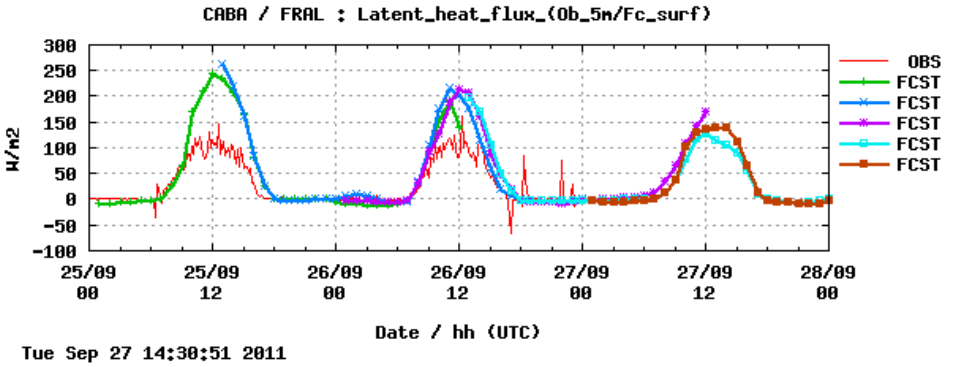
FIG. 8. Analyzed and observed (dash–dotted gray line) soil moisture (a) for the top soil layer and at 5 cm depth, respectively, and (b) for the root zone (1 m depth) for the Oklahoma area. Results from the CTRL OI and OL experiments are shown as solid and dash–dotted lines, respectively, at 6-hourly resolution.

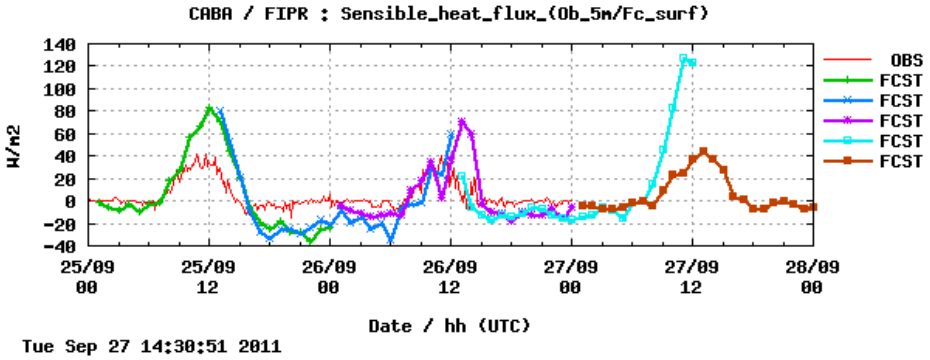
Drusch et al. (2007)

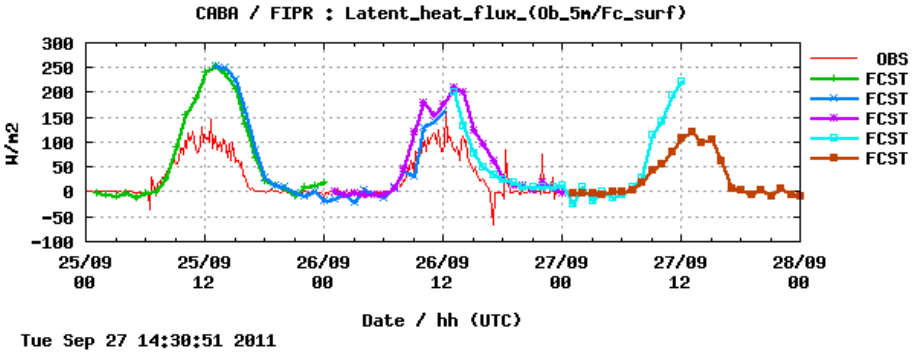
Real-time evaluations from FMI

http://fminwp.fmi.fi/mastverif/mastverif.html









Validation sites : Cabauw, Sodankyla, Lindenberg, Kuopio, Kivenlahti, Valladolid, Rovaniemi

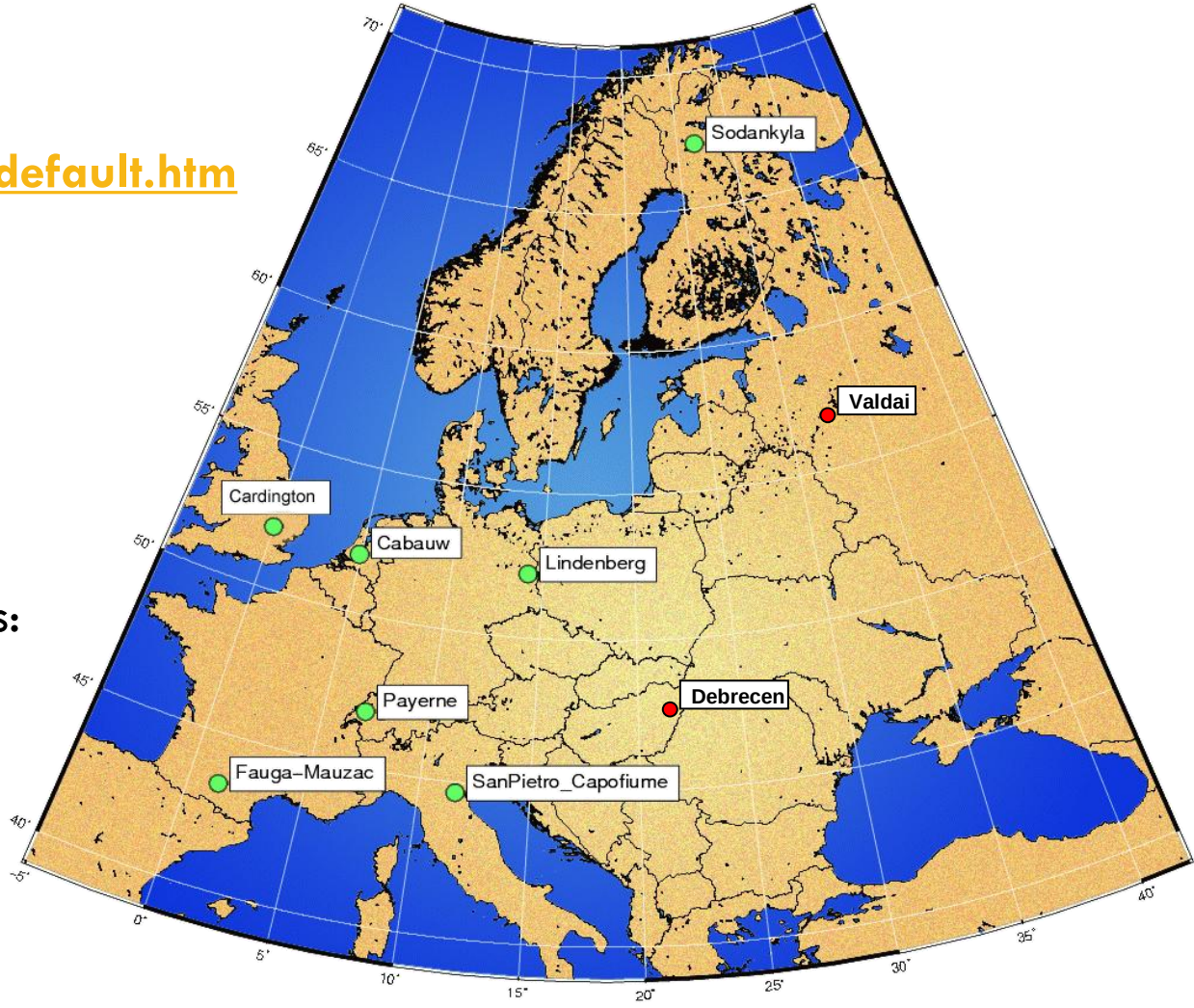
Models :ARPEGE, ALADIN, AROME, HIRLAM, HARMONIE, IFS

The SRNWP data pool

- **Goal**: convenient access to **recent operational high quality** observations, representative of **different climate and soil/vegetation properties**
- **Action** started in October 2009 with an official letter sent to a selection of NMS directors.
- **Agreement** within the C-SRNWP Programme of EUMETNET :
  *"I would like to emphasise that the data would be provided ONLY for the **C-SRNWP members** (particularly to the Expert Team members) with a significant **time-lag** after the observational time and for **research purposes** only."*
- **Resources** from DWD (C.Heret, F. Beyrich), HNMS (T. Andreadis) and MCH (J.-M.Bettems) as contribution to the COLOBOC project.
- **Support** from C-SRNWP coordinator (András Horányi) and from chair of SRNWP ET Soil and Surface (J.-F. Mahfouf)

Data sets

- Access from COSMO web, password protected http://www.cosmo-model.org/srnwp/content/default.htm
- Currently **7 sites**, data from **2006-2010**, in a **common ASCII format**
- **Soil**, **surface** and **BL** observations
- Agreement for two new sites: **Debrecen** (Hu), **Valdai** (Ru)



Example of data sets

Monthly CSV tables, for each site, with all parameters, incl. qc when available
Missing values are flagged with -9999.00

CAB_200705.txt.gz

#SRNWP data exchange action
#Cabauw 51.971° N 4.927° E 20070501 00:10 - 20070601 00:00 UTC
DATE;P0;Q_P0;RAIN;Q_RAIN;TAIR002;Q_TAIR002;TD002;Q_TD002;TAIR010;Q_TAIR010;TD010;Q_TD010;WSPEED010;Q_WSPEED010;WDIR010;Q_WDIR010;TAIR020;Q_TAIR020;TD020;Q_TD020;WSPEED020;Q_WSPEED020;WDIR020;Q_WDIR020;TAIR040;Q_TAIR040;TD040;Q_TD040;WSPEED040;Q_WSPEED040;WDIR040;Q_WDIR040;TAIR080;Q_TAIR080;TD080;Q_TD080;WSPEED080;Q_WSPEED080;WDIR080;Q_WDIR080;TAIR140;Q_TAIR140;TD140;Q_TD140;WSPEED140;Q_WSPEED140;WDIR140;Q_WDIR140;TAIR200;Q_TAIR200;TD200;Q_TD200;WSPEED200;Q_WSPEED200;WDIR200;Q_WDIR200;RSWD;Q_RSWD;RSWU;Q_RSWU;RLWD;Q_RLWD;RLWU;Q_RLWU;CLC;Q_CLC;USTAR;Q_USTAR;MOM;Q_MOM;HS;Q_HS;LE;Q_LE;TSOIL000;Q_TSOIL000;TSOIL002;Q_TSOIL002;TSOIL004;Q_TSOIL004;TSOIL006;Q_TSOIL006;TSOIL008;Q_TSOIL008;TSOIL012;Q_TSOIL012;TSOIL020;Q_TSOIL020;TSOIL030;Q_TSOIL030;TSOIL050;Q_TSOIL050;MSOIL008;Q_MSOIL008;G00;Q_G00;G005;Q_G005;G010;Q_G010
yyyyMMddhhmm;hPa;-;mm;-;° C;-;° C;-;° C;-;° C;-;ms-1;-;degree;-;° C;-;° C;-;ms-1;-;degree;-;° C;-;° C;-;ms-1;-;degree;-;° C;-;° C;-;ms-1;-;degree;-;° C;-;° C;-;ms-1;-;degree;-;° C;-;° C;-;ms-1;-;degree;-;Wm-2;-;Wm-2;-;Wm-2;-;Wm-2;-;%;-;ms-1;-;Nm-2;-;Wm-2;-;Wm-2;-;° C;-;° C;-;° C;-;° C;-;° C;-;° C;-;° C;-;° C;-;° C;-;-;-;Wm-2;-;Wm-2;-;Wm-2;-
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Data sets
Availability: nbr. available tables, status 08.2011

	2006	2007	2008	2009	2010
Sodankyla	0	2	12	12	12
SP Capofiume	12	12	12	12	12
Payerne	12	12	12	12	12
Lindenberg	12	12	12	12	12
Toulouse	12	12	12	12	12
Cardington	8	11	7	6	0
Cabauw	12	12	12	12	12

Data sets
Parameters availability, Lindenberg, status 08.2011

LIN

Availability [%]

= 100
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>= 60 && < 90
>= 30 && < 60
>= 10 && < 30
>= 0 && < 10
= 0

	2006	2007	2008	2009	2010
P0	99.9	99.9	100.0	100.0	100.0
RAIN	100.0	99.6	99.6	98.5	100.0
TAIR002	99.9	99.9	100.0	100.0	100.0
RH002	99.9	99.9	100.0	100.0	100.0
TD002	99.9	99.9	100.0	100.0	100.0
TAIR010	99.9	99.9	100.0	100.0	100.0
RH010	99.9	99.9	100.0	100.0	100.0
TD010	99.9	99.9	100.0	100.0	100.0
WSPEED010	98.4	99.8	99.9	99.1	97.6
WDIR010	99.2	99.9	100.0	100.0	100.0
TAIR020	99.9	99.7	100.0	99.9	100.0
RH020	99.4	99.7	100.0	97.5	100.0
TD020	99.4	99.7	100.0	97.5	100.0
TAIR040	99.9	99.9	100.0	100.0	100.0
RH040	99.9	99.9	100.0	100.0	100.0
TD040	99.9	99.9	100.0	100.0	100.0
WSPEED040	99.9	99.9	100.0	100.0	100.0
WDIR040	99.9	99.9	100.0	100.0	100.0
TAIR060	99.9	99.9	100.0	100.0	100.0
RH060	95.4	99.9	100.0	99.9	100.0
TD060	95.4	99.9	100.0	99.9	100.0
TAIR080	99.9	99.9	100.0	100.0	100.0
RH080	99.9	99.9	99.9	100.0	100.0
TD080	99.9	99.9	99.9	100.0	100.0
TAIR098	99.9	99.2	97.9	100.0	99.9
RH098	99.9	99.2	97.9	100.0	99.9
TD098	99.9	99.2	97.9	100.0	99.9
WSPEED098	99.9	99.9	99.8	100.0	99.9
WDIR098	99.9	99.9	100.0	100.0	100.0
RSWD	99.9	99.9	100.0	100.0	100.0
RSWU	99.9	99.9	100.0	100.0	100.0
RLWD	99.9	99.9	100.0	100.0	100.0
RLWU	99.9	99.9	100.0	100.0	100.0
CLC*2	100.0	100.0	100.0	100.0	100.0
USTAR*1	90.5	93.1	89.5	92.6	89.6
MOM*1	90.5	93.1	89.5	92.6	89.5
HS*1	96.9	98.5	94.9	98.4	95.3
LE*1	75.8	80.6	71.7	78.8	74.7
TSOIL005	99.9	99.9	100.0	100.0	99.8
TSOIL010	99.9	99.9	100.0	100.0	99.8
TSOIL015	99.9	99.9	100.0	100.0	99.8
TSOIL020	99.9	99.9	100.0	100.0	99.8
TSOIL030	99.9	99.9	100.0	100.0	99.8
TSOIL045	99.9	99.9	100.0	100.0	99.6
TSOIL050	99.9	99.9	100.0	100.0	99.8
TSOIL060	99.9	99.9	100.0	100.0	99.8
TSOIL090	99.9	99.9	100.0	100.0	99.8
TSOIL100	99.9	99.9	100.0	100.0	99.8
TSOIL120	99.9	99.9	100.0	100.0	99.8
TSOIL150	99.9	99.9	100.0	100.0	99.8
MSOIL008	99.9	99.9	100.0	100.0	100.0
MSOIL015	99.9	99.9	100.0	100.0	99.5
MSOIL030	99.9	99.9	100.0	100.0	71.1
MSOIL045	99.9	99.9	100.0	100.0	97.2
MSOIL060	99.9	99.9	100.0	100.0	98.1
MSOIL090	99.9	99.9	100.0	100.0	68.7
G005	99.9	99.9	100.0	100.0	99.2
G010	99.9	99.9	100.0	100.0	99.2
SNOW*4	21.5	4.6	3.5	14.3	25.8
SNOWN*4	6.2	3.9	0.0	0.0	0.0

different time resolution
*1 30 min
*2 60 min
*4 24 h **if snow exists**

Data sets
Parameters availability, SP Capofiume, status 08.2011

Availability [%]

= 100
>= 90 && < 100
>= 60 && < 90
>= 30 && < 60
>= 10 && < 30
>= 0 && < 10
= 0

SPC

	2006	2007	2008	2009	2010
P0	38.6	60.8	99.1	99.8	99.9
RAIN	38.6	39.2	83.5	99.8	98.5
TAIR002	38.6	56.8	99.1	99.8	99.9
RH002	38.6	56.8	99.1	99.8	99.9
TD002	38.6	56.8	99.1	99.8	99.9
WSPEED010	38.6	56.4	99.1	99.8	98.8
WDIR010	38.6	56.4	99.1	99.8	99.9
RSWD	0.0	56.4	99.1	84.5	99.9
RSWU	0.0	56.4	99.1	99.8	99.8
RLWD	0.0	56.4	66.7	99.8	99.9
RLWU	0.0	56.4	99.1	99.8	99.9
CLC	0.0	0.0	0.0	0.0	0.0
USTAR	0.0	0.0	0.0	0.0	0.0
MOM	0.0	0.0	0.0	0.0	0.0
HS	0.0	0.0	0.0	0.0	0.0
LE	0.0	0.0	0.0	0.0	0.0
TSOIL010	50.2	48.1	88.5	61.3	100.0
TSOIL025	50.3	48.3	88.5	61.3	100.0
TSOIL045	50.3	48.3	88.5	61.3	100.0
TSOIL070	50.2	48.3	88.5	61.3	100.0
TSOIL100	50.2	48.3	88.5	61.3	100.0
TSOIL135	50.3	48.3	88.5	9.9	0.0
TSOIL180	50.3	48.3	88.5	61.3	100.0
MSOIL010	0.0	23.1	44.0	49.0	95.8
MSOIL025	0.0	23.2	44.0	50.0	94.8
MSOIL045	0.0	23.2	46.3	50.0	96.7
MSOIL070	0.0	23.2	39.4	49.8	94.7
MSOIL100	0.0	0.0	0.0	31.2	48.0
MSOIL135	0.0	0.0	0.0	36.9	66.6
MSOIL180	0.0	0.0	0.0	41.8	79.1

Data set documentation

Parameter names

unified parameter names and units for all sites

standard time resolution 10 min

quality flags for all parameters
Q_
if provided with the data
g good quality
i interpolated or simulated value or replaced by other systems
d dubious value
u unchecked value
b bad
m missing
9 quality flag not available

	parameter		unit
profiles between 10 m and 200 m <height in m>	TAIR<hhh>	temperature	°C
	TD<hhh>	dew point	°C
	additionally: humidity (relative humidity RH [%], specific humidity Q [gkg-1])		
	WSPEED<hhh>	wind speed	ms-1
	WDIR<hhh>	wind direction	degree
(near-)surface	TAIR002	temperature 2 m	°C
	TD002	relative humidity 2 m	°C
	additionally: humidity in 2 m (relative humidity RH [%], specific humidity Q [gkg-1])		
	WSPEED010	wind speed 10 m	ms-1
	WDIR010	wind direction 10 m	degree
	P0	surface pressure	hPa
	RR	hourly precipitation sum	mm
	SNOW	accumulated snow height	cm
	SNOWN	new snow height	cm
	CLC	total cloud cover	%
radiation and energy	RSWD	incoming solar radiation	Wm-2
	RSWU	reflected solar radiation	Wm-2
	RLWD	incoming thermal radiation	Wm-2
	RLWU	outgoing thermal radiation	Wm-2
	RN	or - if components are not available - net radiation	Wm-2
	HS	sensible heat flux	Wm-2
	LE	latent heat flux	Wm-2
	MOM	momentum flux	Nm-2
	USTAR	friction velocity	ms-1
	T0	radiative surface temperature	°C
soil quantities <depth in cm>	TSOIL<hhh>	soil temperature	°C
	MSOIL<hhh>	soil moisture content	-
	G0<hhh>	soil heat flux	Wm-2

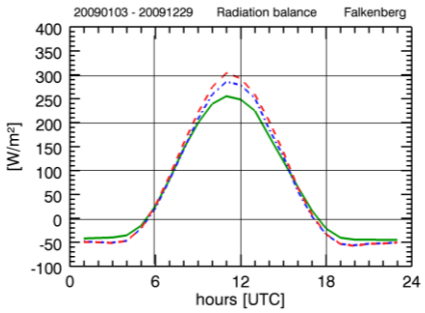
Site documentation

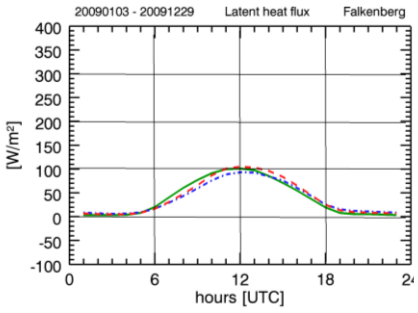
	site		description of instruments	mNN	soil type	local land use	land use (10 km)
LIN	Lindenberg Meteorological Observatory - Richard Aßmann Observatory (MOL-RAO)	http://www.dwd.de/mol	*v*	73	loamy sand Eutric Podzoluvisol	grass	60 % grassland/cropland, 30 % pine forest, 5% settlement, 5 % water
CAB	Cabauw Experimental Site for Atmospheric Research (CESAR)	http://www.cesar-observatory.nl/	*v*	-0.7	clay	open pasture for at least 400 m	
PAY	MeteoSwiss aerological station Payerne	http://www.meteoswiss.admin.ch/		490			82 % grassland/cropland, 10 % forest, 5 % settlement, 3 % water
CFM	Office National d'Etudes et des Recherches Aérospatiales (ONERA)	http://www.onera.fr/fauga-mauzac/index.php		186	loamy sand	grassland	grassland
SPC	Meteorological Site of San Pietro Capofiume		*v*	11	loamy sand CalcariFluvicCambisols	grassland, surrounded by crop	
SOD	Finnish Meteorological Institute Arctic Research Centre (FMI-ARC)	http://fmiarc.fmi.fi/		179			28.2 % coniferous, 23.6 % transitional woodland/shrub, 17.2 % mixed forest, 12.9 % bog, 8.1 % broadleaved forest, 4.8 % water, 5.2 % other
CAR	UK Met Office Cardington	http://badc.nerc.ac.uk/data/cardington/instr_v7/index.html	available at BADC web site	29		grassland	

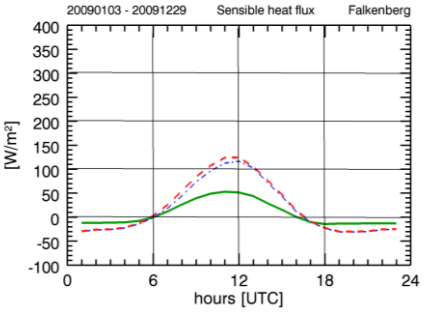
Energy budget evaluation in COSMO

Radiation balance **Latent heat flux** **Sensible heat flux**

LGS 2009



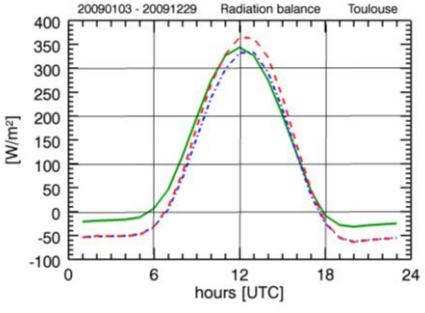


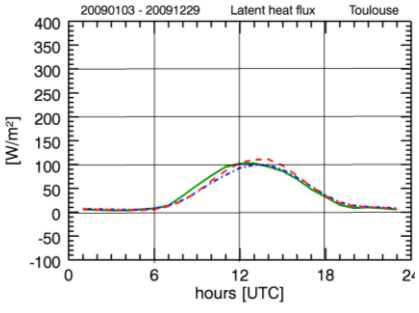


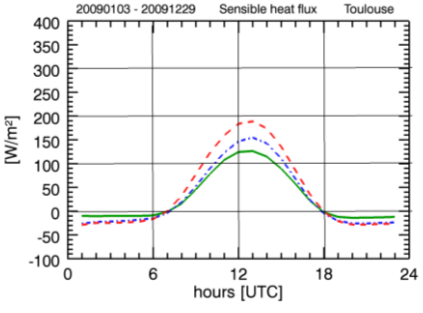
Bowen ratio

0.45 1.08 1.04

TOU 2009



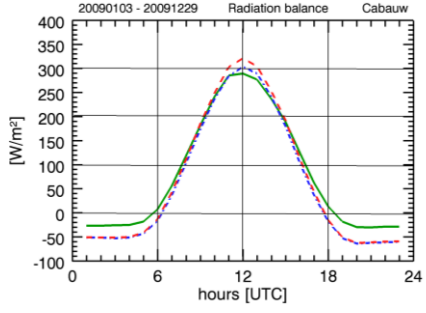


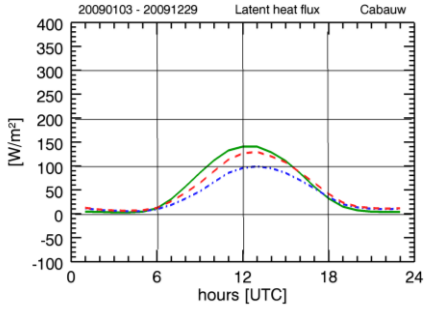


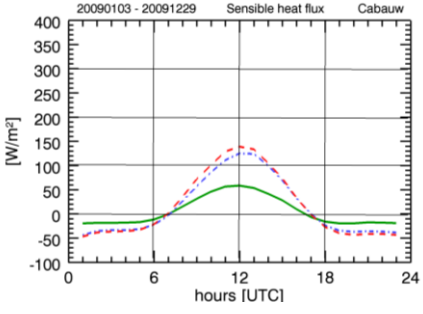
Bowen ratio

1.12 1.46 1.69

CAB 2009







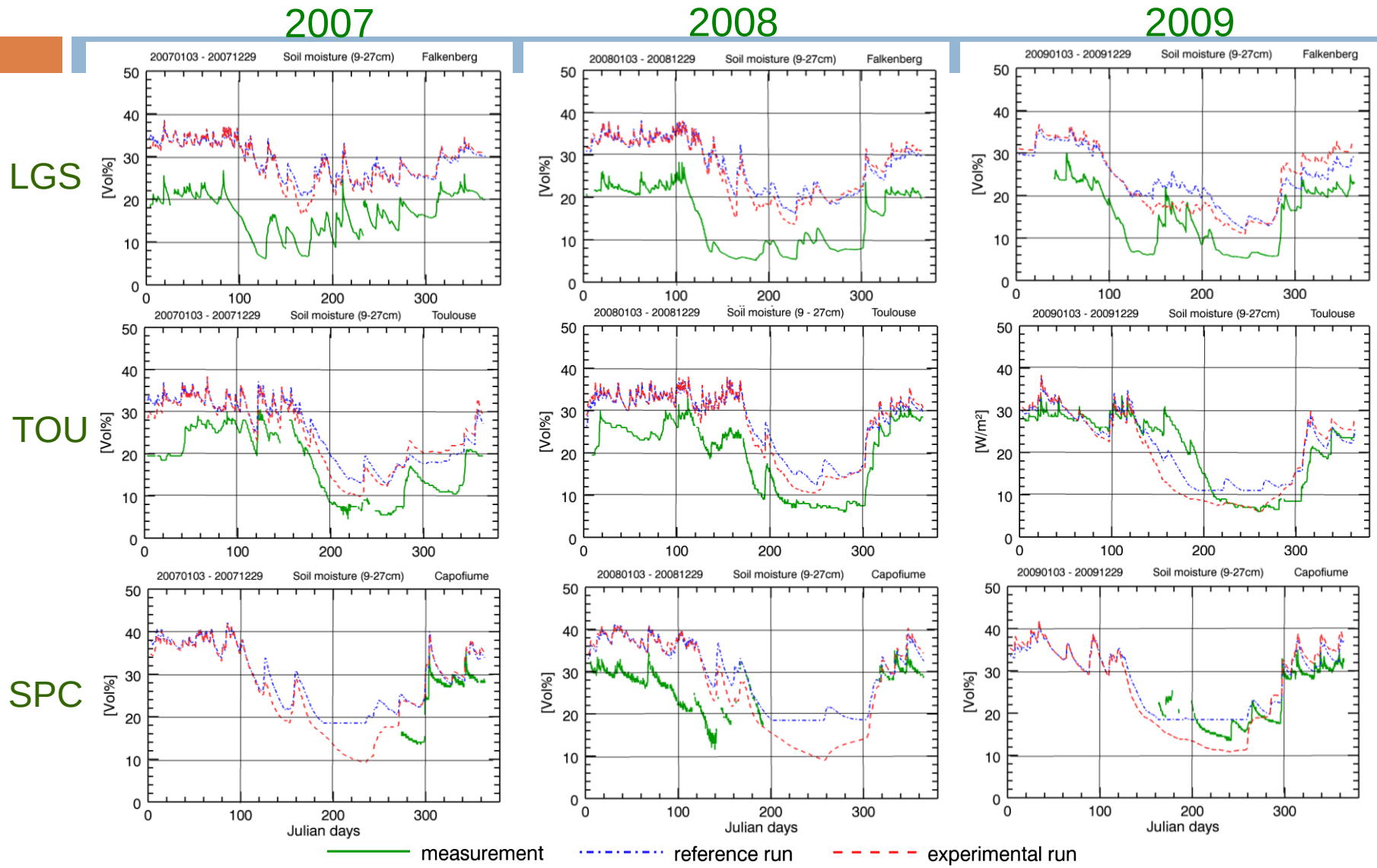
Bowen ratio

0.37 1.17 1.01

measurement reference run experimental run

G. Voegel (2011)

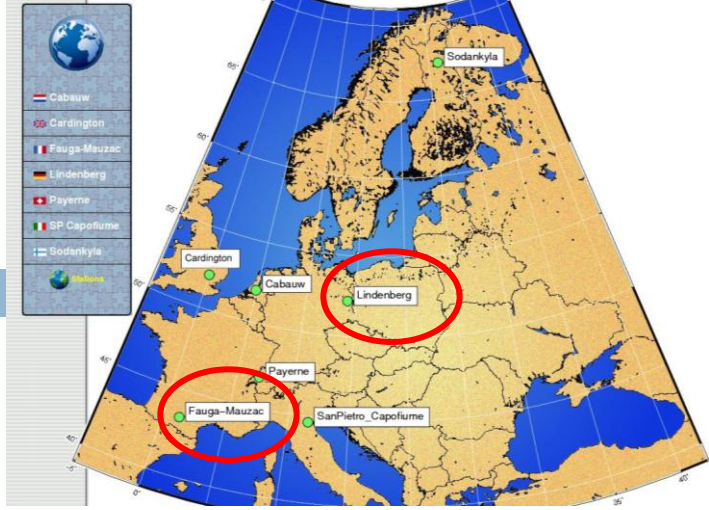
Soil moisture evaluation in COSMO



Soil layer 9cm – 27cm

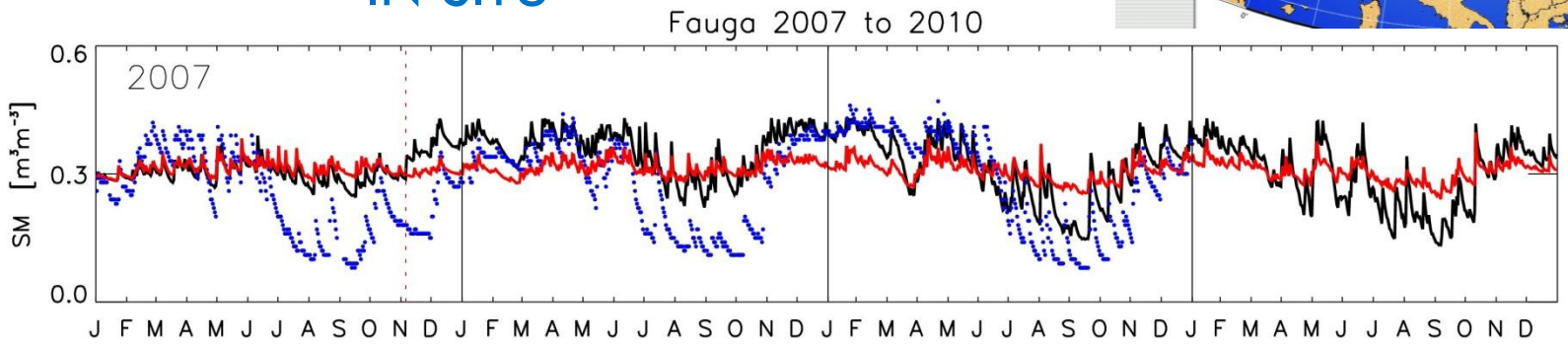
G. Voegel (2011)

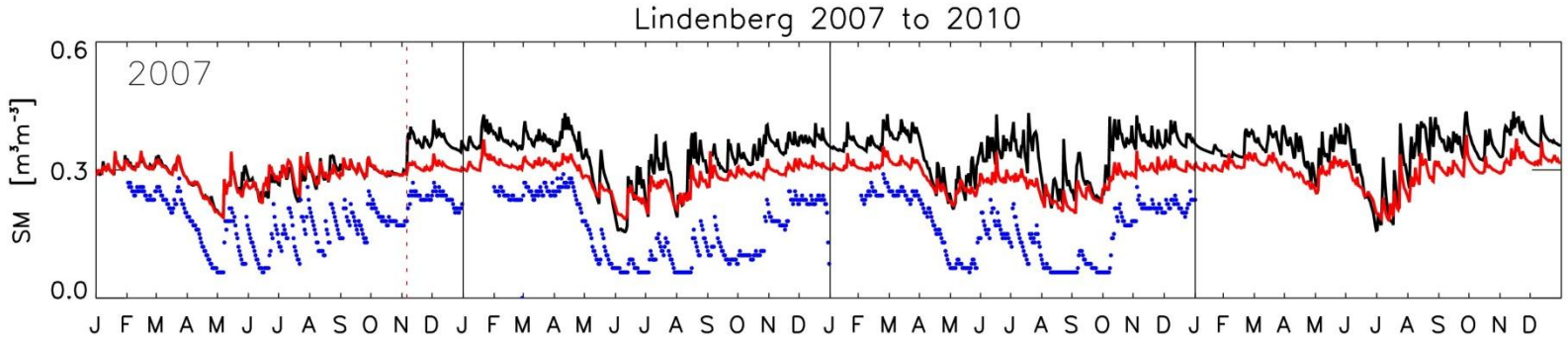
Soil moisture time series evaluation at ECMWF



Operational product ERA-INTERIM

IN SITU

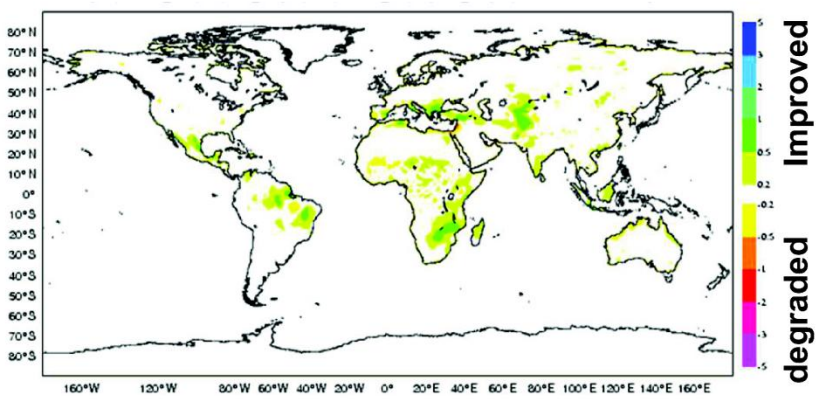




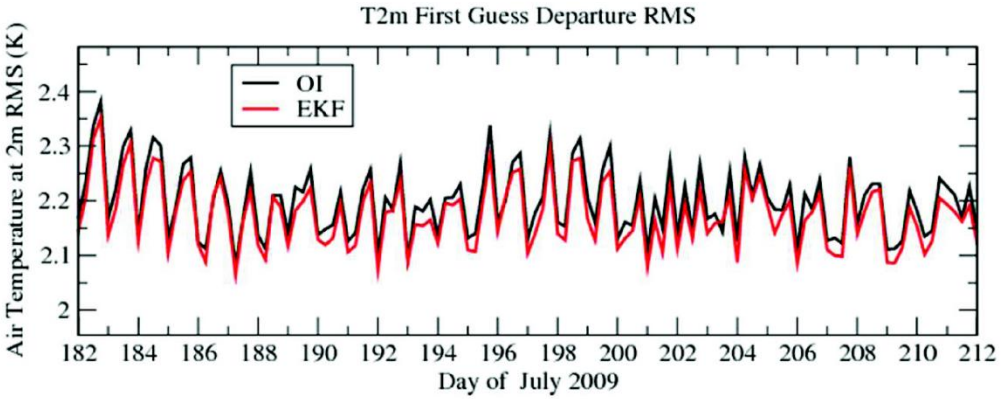
Impact of EKF vs OI soil analysis (1)

Compared to the OI, the SEKF consistently improves T2m

T2m error (OI-SEKF) 48h fc
→ EKF improves T2m



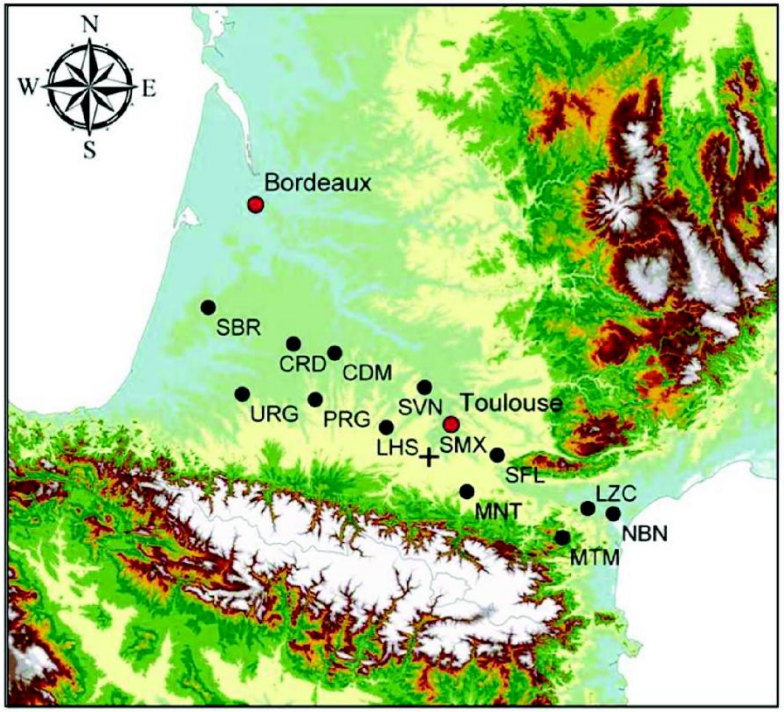
Global mean RMS (against SYNOP)

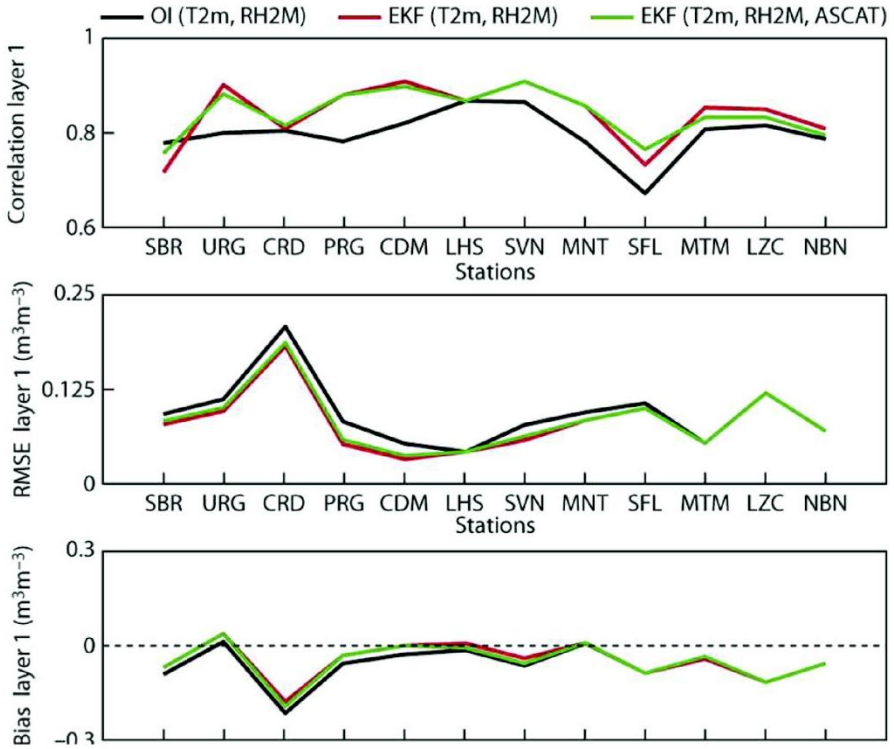


De Rosnay et al. (2011) ECMWF Newsletter

Impact of EKF vs OI soil analysis (2)

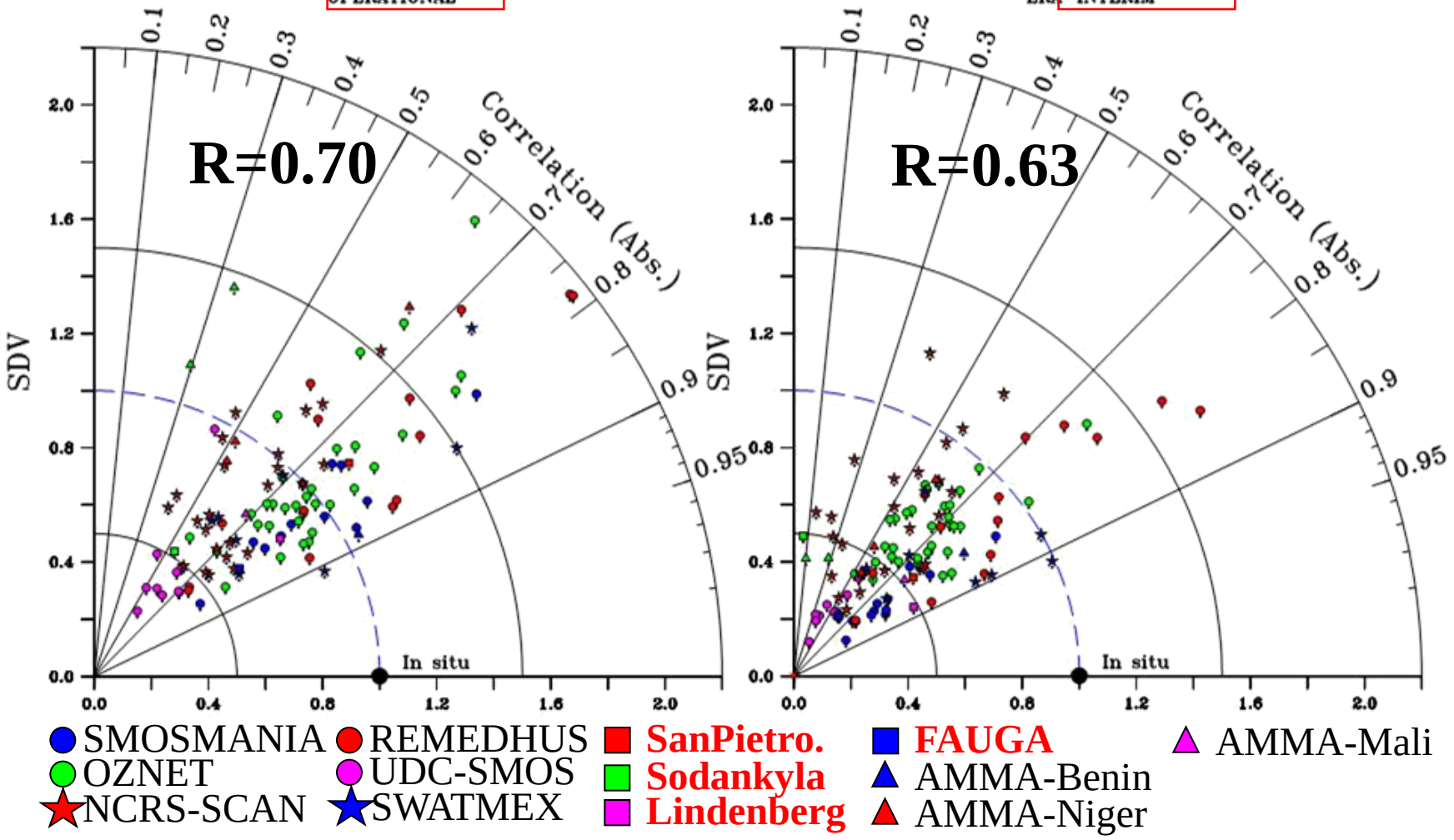
Verification of ECMWF SM over the SMOSMANIA Network





Albergel et al. (2011) J. Hydromet. (submitted)

In situ SSM vs ECMWF (0-7cm) : operational product + ERA-Interim



Users : Status 07.2011

jean-marie.bettems@meteoswiss.ch	Test data pool / Development of TERRA.
guy.demorsier@meteoswiss.ch	For testing of TERRA standalone and also to verify the COSMO model (incl. the snow)
Ekaterina.Machulskaya@dwd.de	Verification of the performance and component testing of the COSMO-model (soil module, sub-grid turbulence scheme)
jan-peter.schulz@dwd.de	Research on land surface parameterizations
gerd.vogel@dwd.de	The data are needed for model validation of COSMO_7 and COSMO-EU.
gbonafe@arpa.emr.it	To check if San Pietro Capofiume uploaded data are ok COSMO (I7,I2 operational or high res. runs) diagnostic
jean-francois.mahfouf@meteo.fr	Validation of the land surface scheme ISBA used in the Météo-France NWP models
calvet@meteo.fr	Check the Fauga-Mauzac data format. Use other sites for model verification.
mike.bush@metoffice.gov.uk	Use the observational data to validate the Unified Model.
markku.kangas@fmi.fi Patrick.Samuelsson@smhi.se	Weather model verification
rafiq.hamdi@meteo.be	Model verification
clement.albergel@ecmwf.int	Model verification

Ongoing activities (1)

- Consolidate **sites documentation**
  (climate, soil type and horizon, vegetation, instruments)
- Consolidate data set **Cardington**
  (list of errors in received data has been communicated,
  waiting for corrected data)
- Collect data from **Debrecen** observatory
  (agreement has been reached,
  contact persons have been named,
  waiting for first data)
- Collect data from **Valdai** observatory
  (agreement has been reached,
  contact persons have been named)

Ongoing activities (2)

- **Make this effort sustainable in the COSMO consortium**

  → transfer responsibility for this actions from the COLOBOC project to the new COSMO Working Group 3b (soil and surface aspects)

  → F.Beyrich / DWD has agreed *"… continuation of the management of the data streams for the data pool as well as long as this is possible with reasonable efforts."*

- **Promote usage within the SRNWP Community**

  → expert team soil&surface

- **Open this initiative to academic institutions ?**

  → this would drastically extend the set of potential users

  → … but a re-formulation of the agreement is necessary, and NMS directors have to be convinced …

Conclusions

- Routine surface observations are useful to assess the quality of NWP surface schemes
- Without additionnal information such evaluations can be difficult to interpret and misleading
- Importance of comprehensive in-situ observational data sets (soil, surface, boundary layer)
- Existence of already many initiatives (e.g. FLUXNET)
- Interest for the SRNWP initiative (common validation dataset among european consortia, common database format, temporal continuity)
- Data pool already used by a number of SRNWP users and found useful