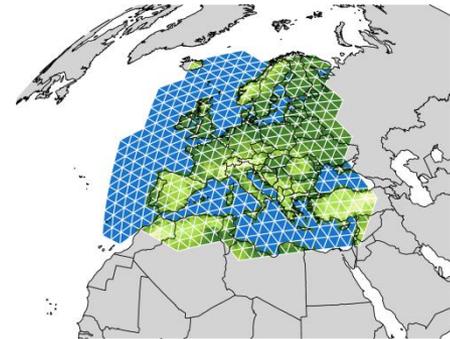# ICON

Current status, ongoing developments, and future plans

Günther Zängl, on behalf of the ICON development team

COSMO General Meeting, Wroclaw, 10.09.2015

Outline

➔ **ICON's steps towards operational production at DWD**

➔ **Comparison of scores against GME and COSMO-EU**

➔ **Ongoing developments and future plans**

Steps towards operational production

➔ **Aug 12, 2014: Start of preoperational ICON forecasts; mesh size 13 km with 90 levels up to 75 km**

➔ **3D-Var data assimilation scheme and surface analyses adapted to ICON; digital filter initialization used in GME is replaced by incremental analysis update and enhanced divergence damping during the assimilation cycle**

➔ **Jan 20, 2015: Start of operational production with ICON; GME was turned off about one month later**

➔ **March 2015: Start of experimental forecasts with nested domain (6.5 km, 60 levels up to 22.5 km) over Europe, gradual introduction of surface analysis schemes on nested domain**

Steps towards operational production (cont'd)

➔ **Jun 10, 2015: Start of preoperational forecast suite with nested domain over Europe and full set of surface analyses**

➔ **For the time being, the 3D-Var data assimilation scheme runs on the global domain only, and the assimilation increments are interpolated onto the nested grid**

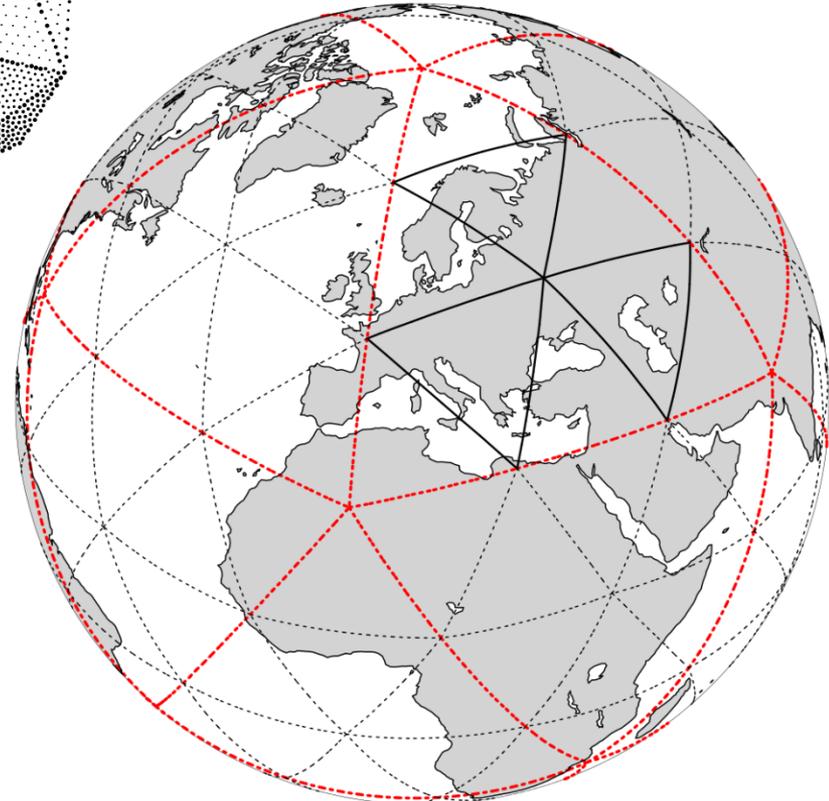➔ **Jul 21, 2015: Start of operational production with nested domain over Europe ("ICON-EU")**

Grid structure

Icosahedral grid similar to GME, but unstructured triangular C-grid

R2B00
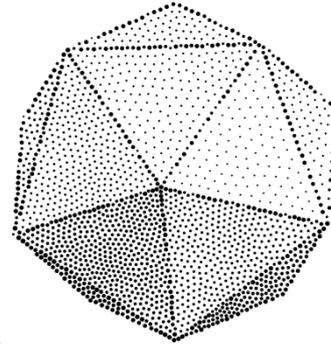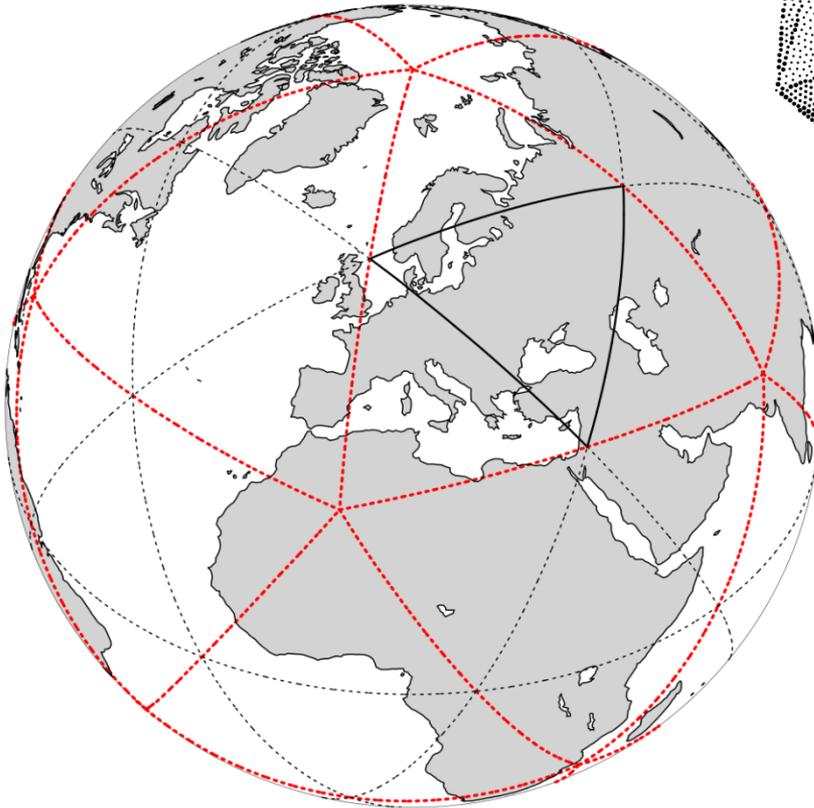
R3B00

Grid structure with refinement

Rule-of-thumb for average mesh size:

$\Delta x \approx 5050 / (\ n\ 2^k\ )$ [km]

Example:

R3B7: root division $n = 3$, number of bisections $k = 7$

Mesh size: 13 km; 2.95 Mio grid points in global domain

The nested domain over Europe (replacing COSMO-EU) has a mesh size of 6.5 km

Global domain

Regional domain

Physics parameterizations
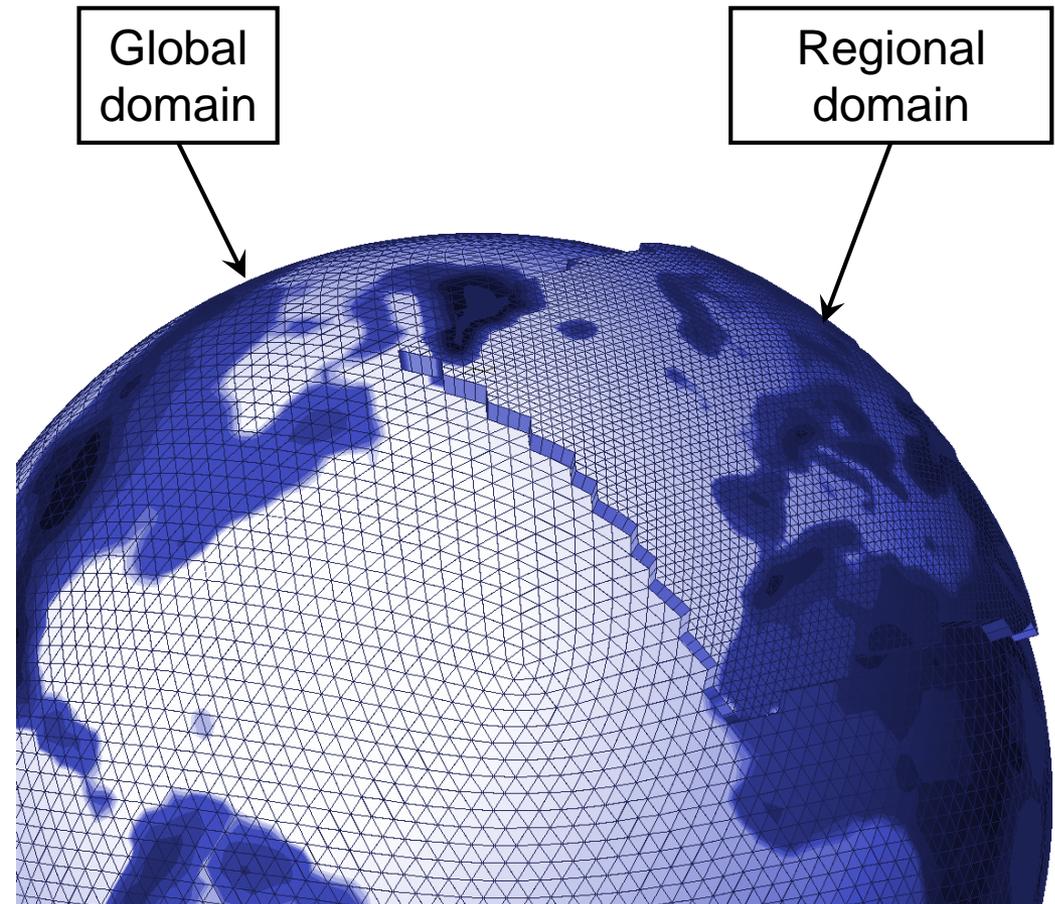
Process	Authors	Scheme	Origin
Radiation	Mlawer et al. (1997) Barker et al. (2002)	RRTM (later with McICA & McSI)	AER Inc. (via IFS)
	Ritter and Geleyn (1992)	δ two-stream	GME/COSMO
Non-orographic gravity wave drag	Scinocca (2003) Orr, Bechtold et al. (2010)	wave dissipation at critical level	IFS
Sub-grid scale orographic drag	Lott and Miller (1997)	blocking, GWD	IFS
Cloud cover	Doms and Schättler (2004)	sub-grid diagnostic	GME/COSMO
	Köhler et al. (new development)	diagnostic (later prognostic) PDF	ICON
Microphysics	Doms and Schättler (2004) Seifert (2010)	prognostic: water vapor, cloud water, cloud ice, rain and snow	GME/COSMO
Convection	Tiedtke (1989) Bechthold et al. (2008)	mass-flux shallow and deep	IFS
Turbulent transfer	Raschendorfer (2001)	prognostic TKE	COSMO
	Brinkop and Roeckner (1995)	prognostic TKE	ECHAM6/IFS
	Neggers, Köhler, Beljaars (2010)	EDMF-DUALM	IFS
Land	Heise and Schrodin (2002), Helmert, Mironov (2008, lake)	tiled TERRA + FLAKE + multi-layer snow	GME/COSMO
	Raddatz, Knorr	JSBACH	ECHAM6

Verification against GME, December 2014
(i.e. the last full month of the preoperational phase)

a) analysis verification

- **WMO standard verification against own analyses on 1.5°x1.5° lat-lon grid**

b) radiosonde verification

- **Verification against radiosondes that passed the quality check of the data assimilation scheme**

c) surface verification

- **Verification against SYNOP observations**

Many thanks to Uli Damrath and Uli Pflüger!

Analysis verification

Mean sea-level pressure, RMSE in hPa

blue: GME, red: ICON; RV: reduction of variance
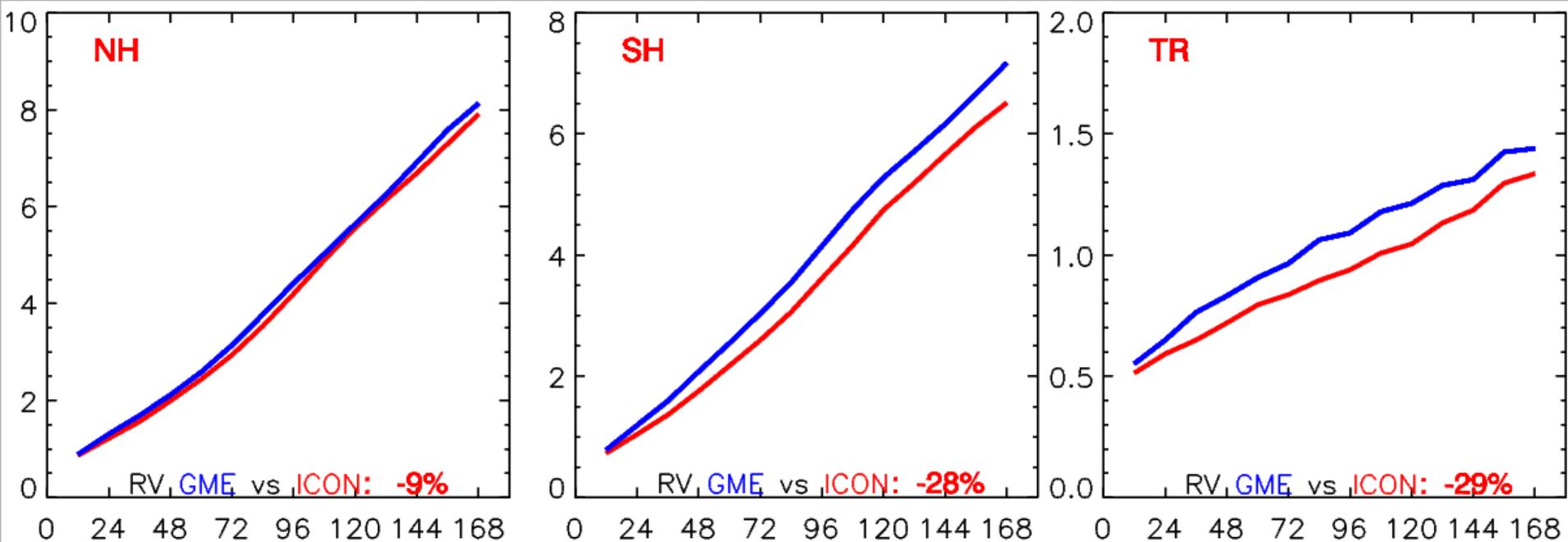
Geopotential height at 500 hPa, RMSE in m

blue: GME, red: ICON; RV: reduction of variance
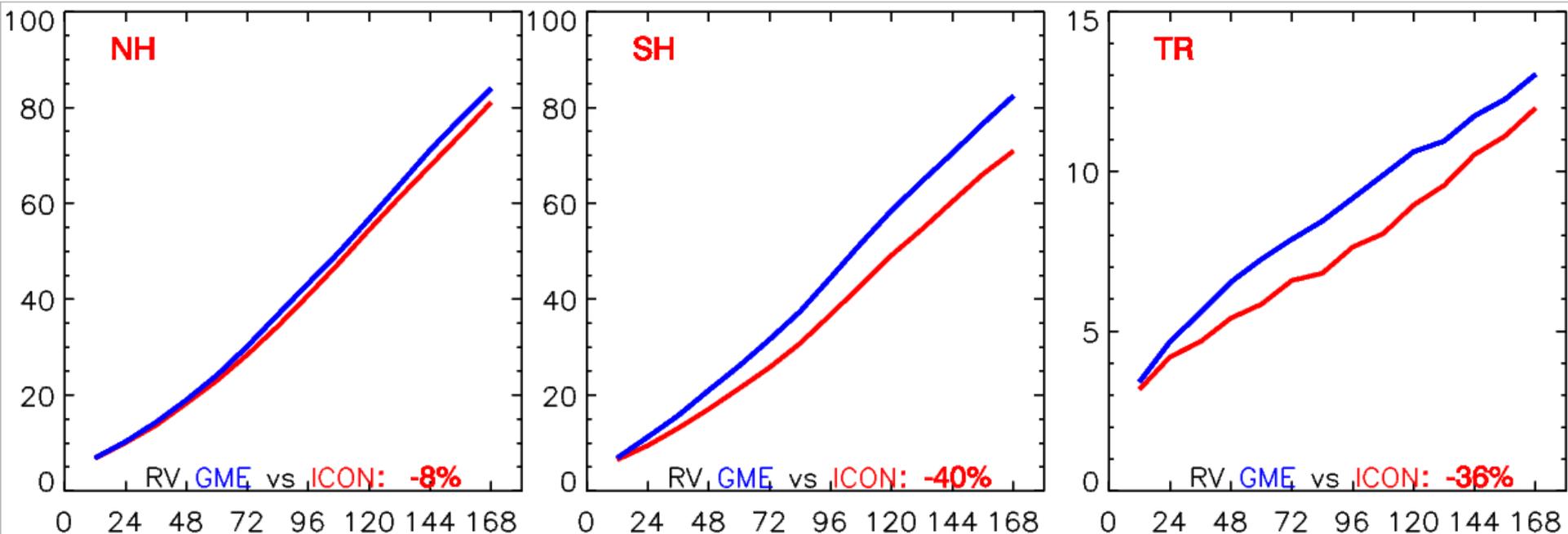
RMSE results for Antarctica

blue: GME, red: ICON; RV: reduction of variance

PMSL (hPa)　　　Geopot. 500 hPa (m)　　　Temp. 700 hPa (K)
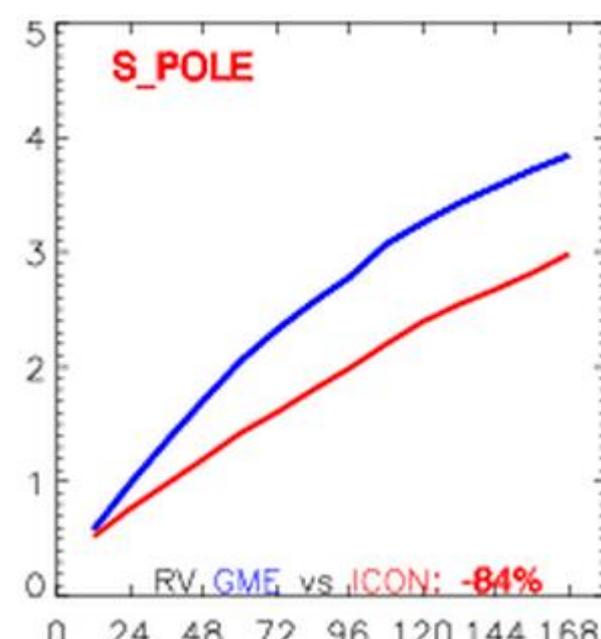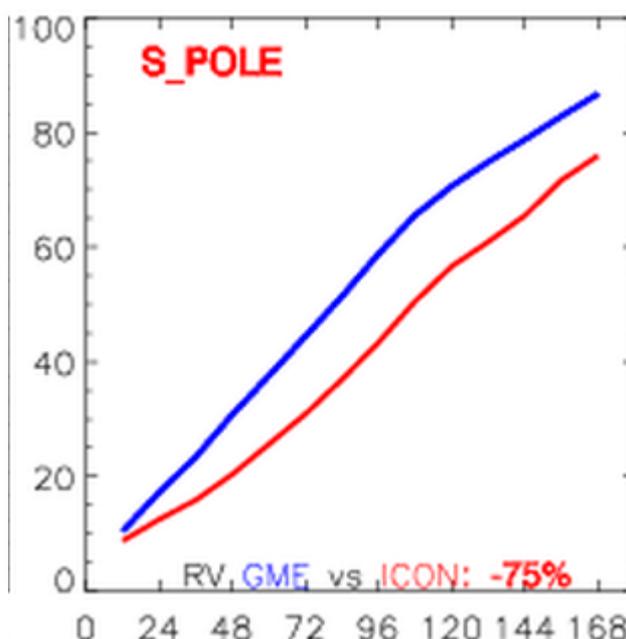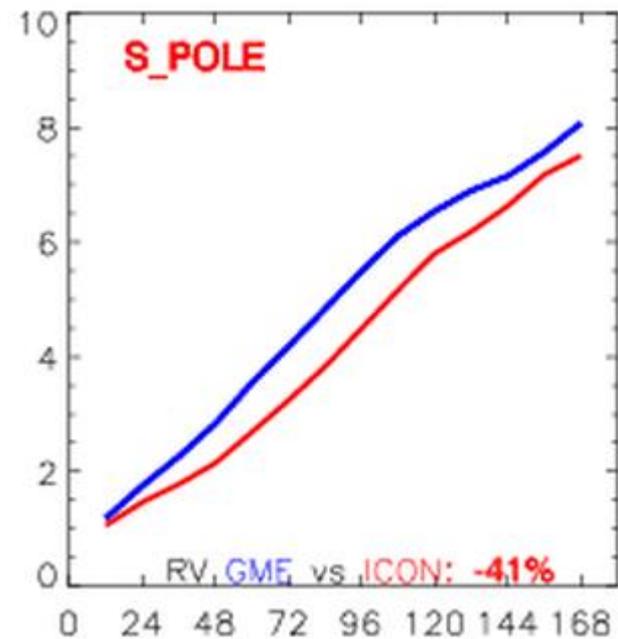
Radiosonde verification for Antarctica (Dec 2014)

dashed: ICON
solid: GME
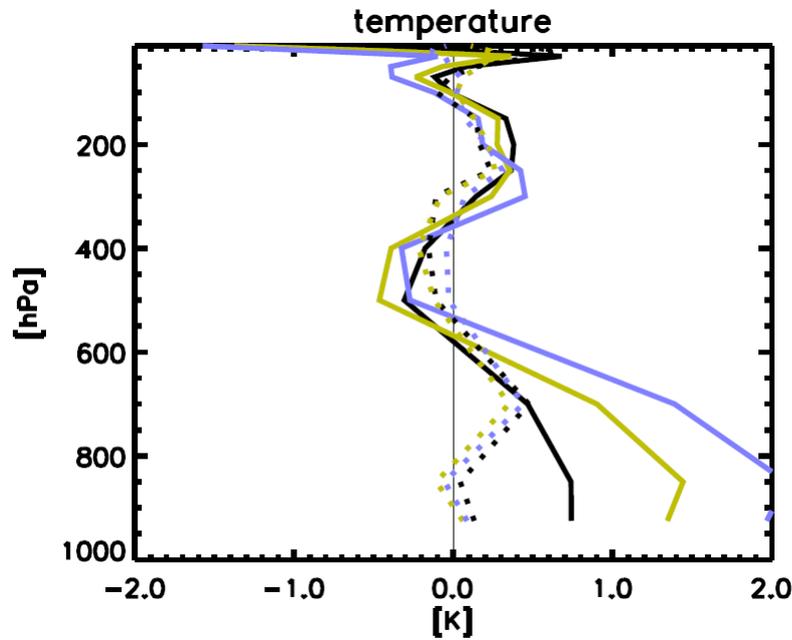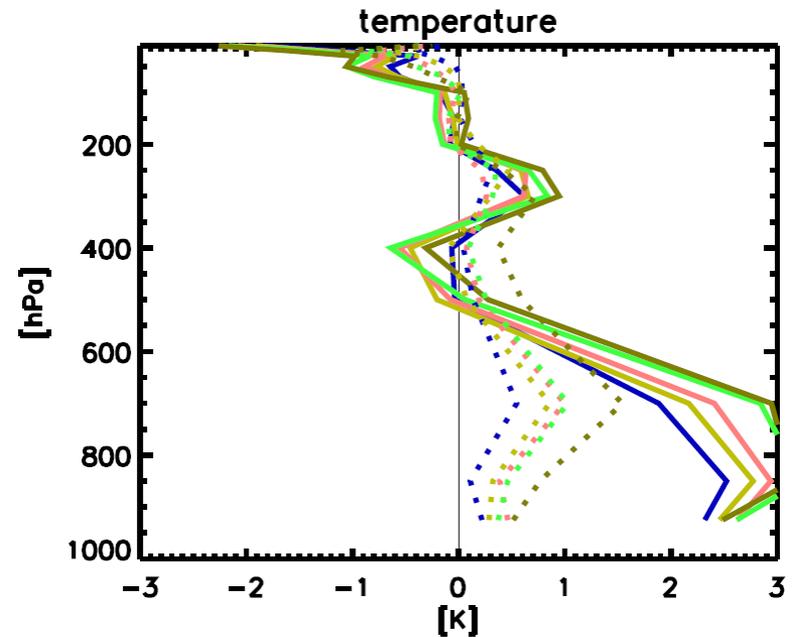
Surface verification Antarctica; blue: GME, red: ICON

temperature   dew point depression   minimum temperature
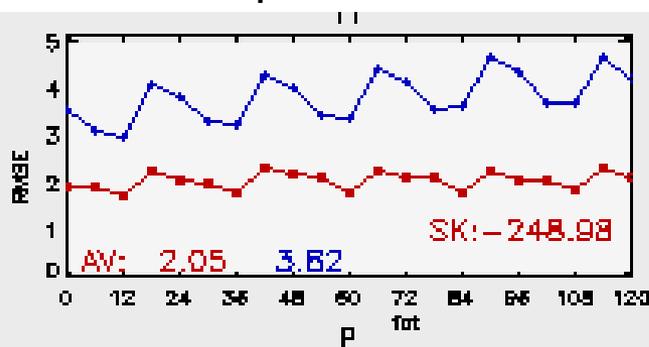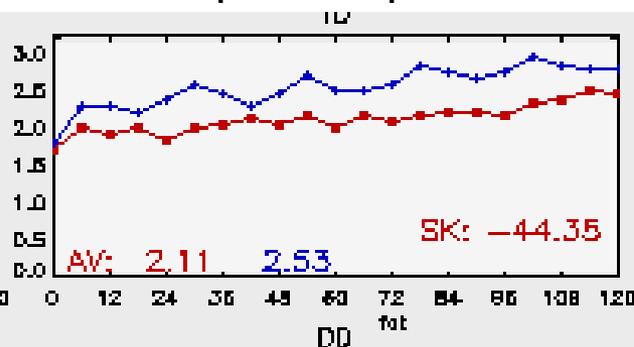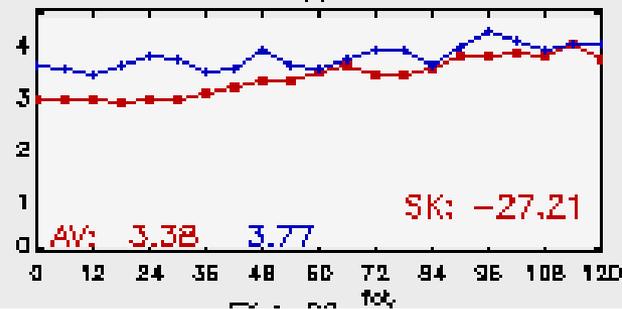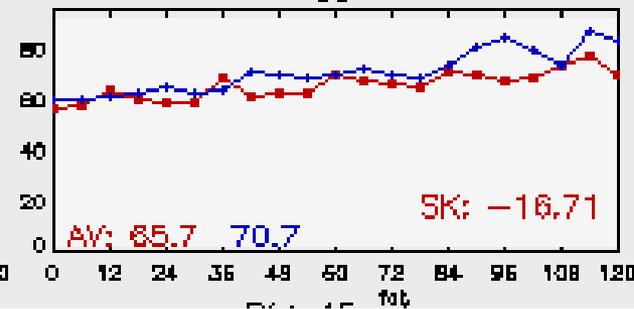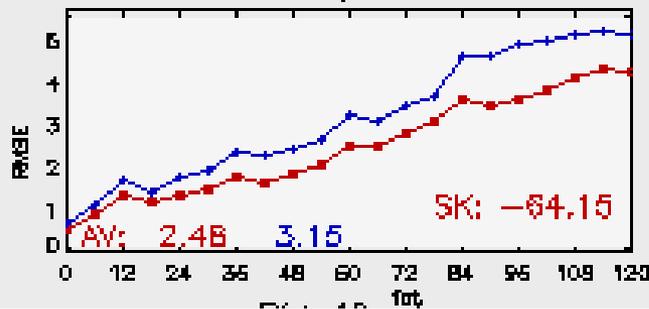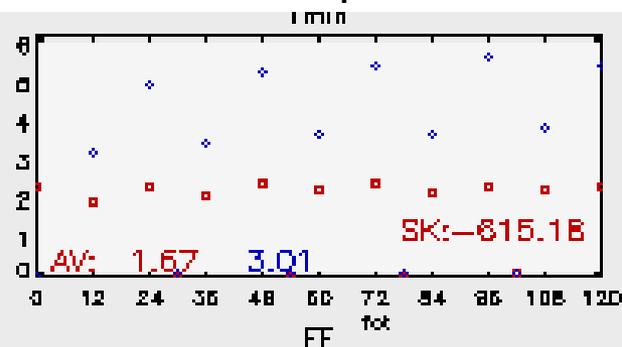
pressure   wind direction   wind speed

Surface verification Europe; blue: GME, red: ICON
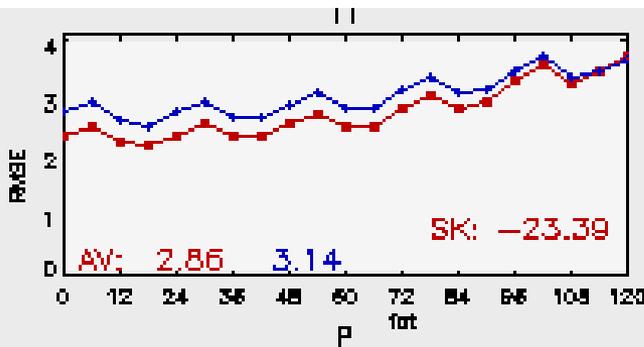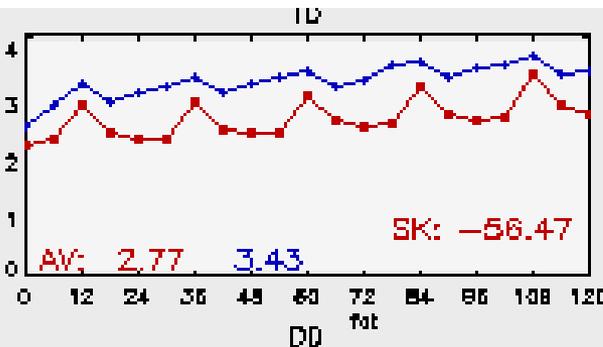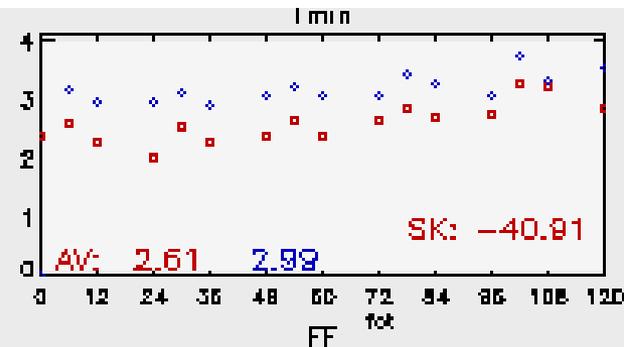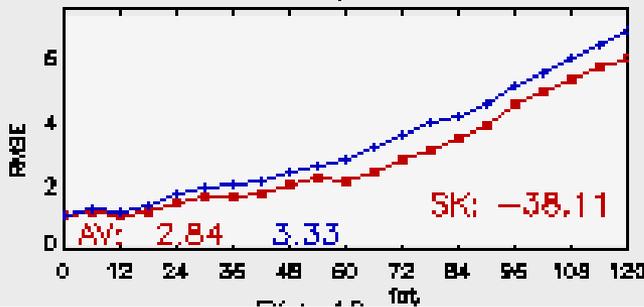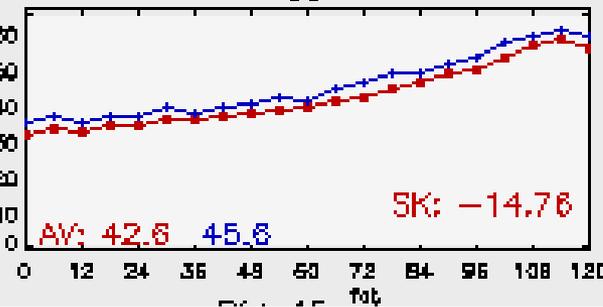
temperature · dew point depression · minimum temperature · pressure · wind direction · wind speed
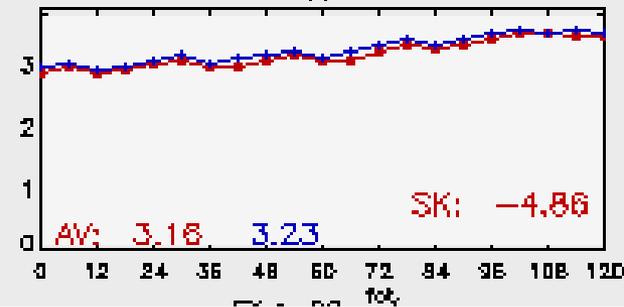
Gusts > 25 m/s Europe, 00 UTC, mountain stations above 750 m, Jan 2015   blue: ICON, red: GME
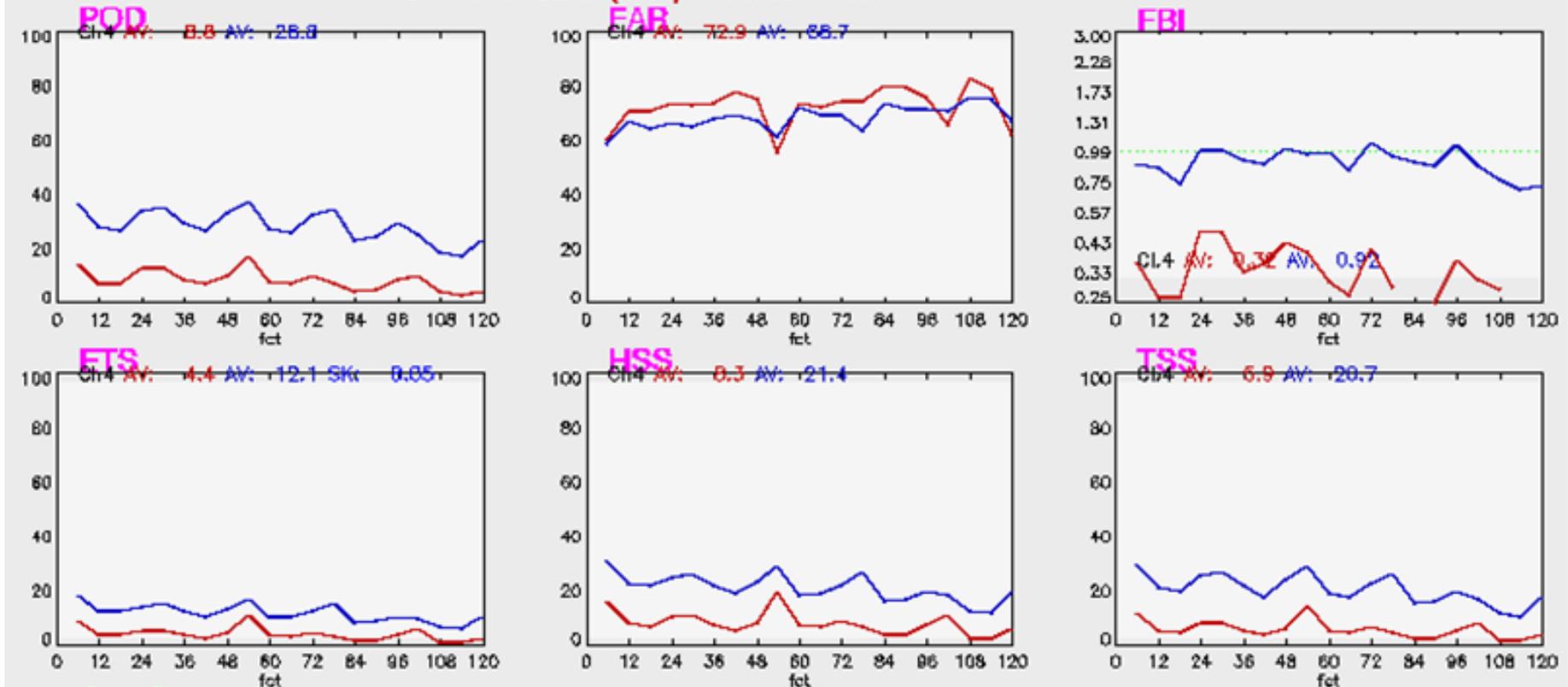
Surface verification COSMO-EU vs. ICON-EU, Jun 10 – Jul 20, 2015

DWD
Deutscher Wetterdienst
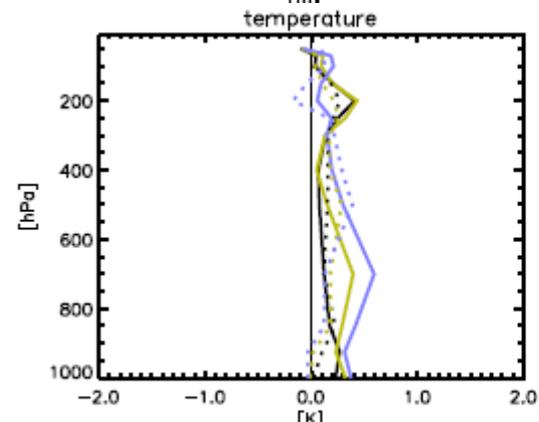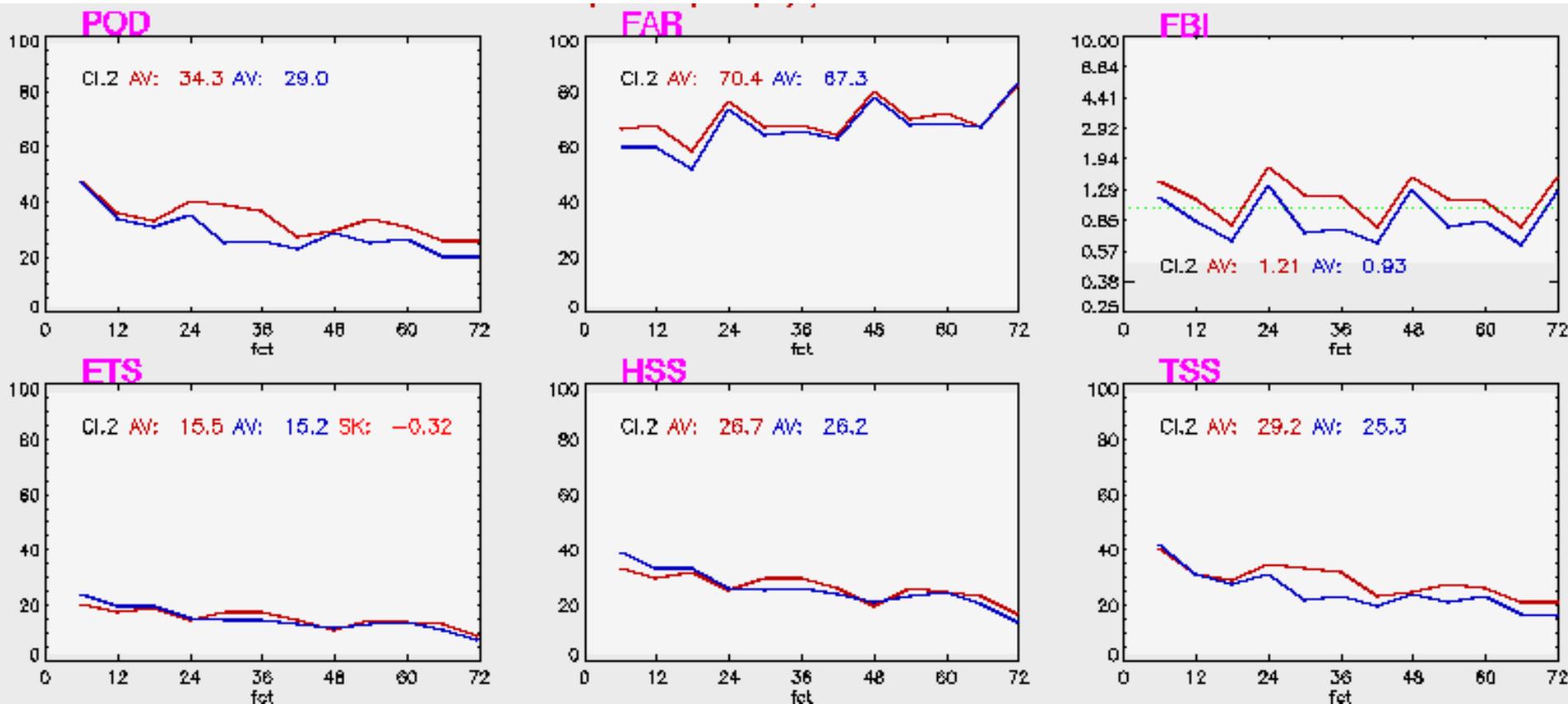Wetter und Klima aus einer Hand

2m-temperature, 00 and 12 UTC runs
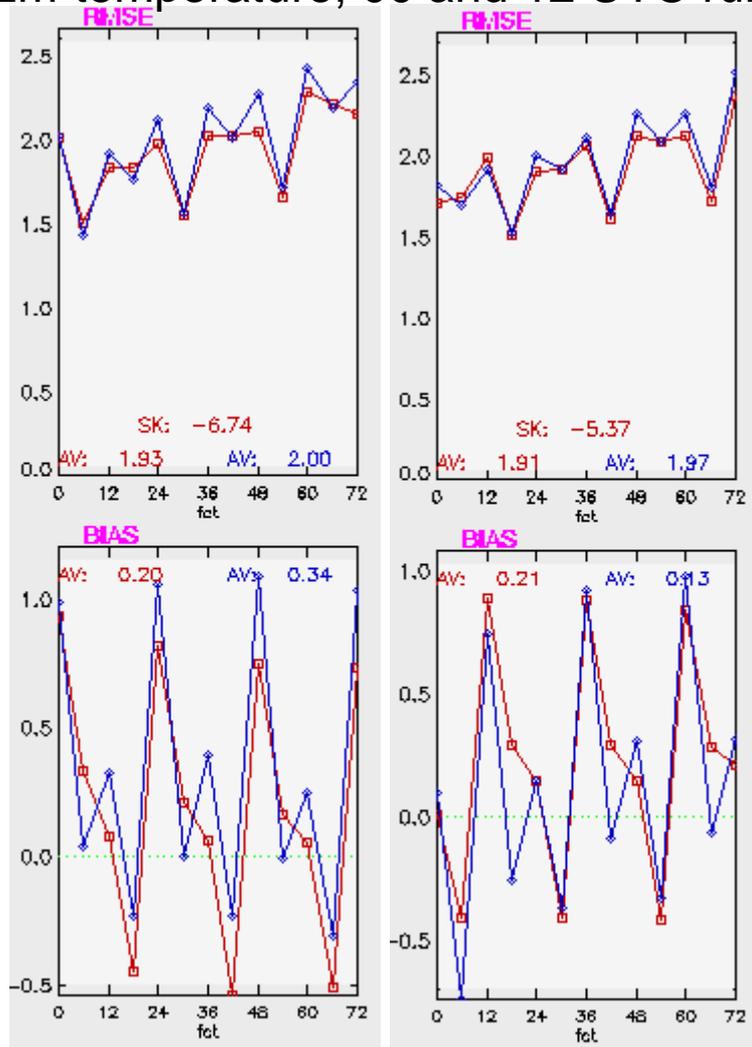
Surface pressure, 00 and 12 UTC runs
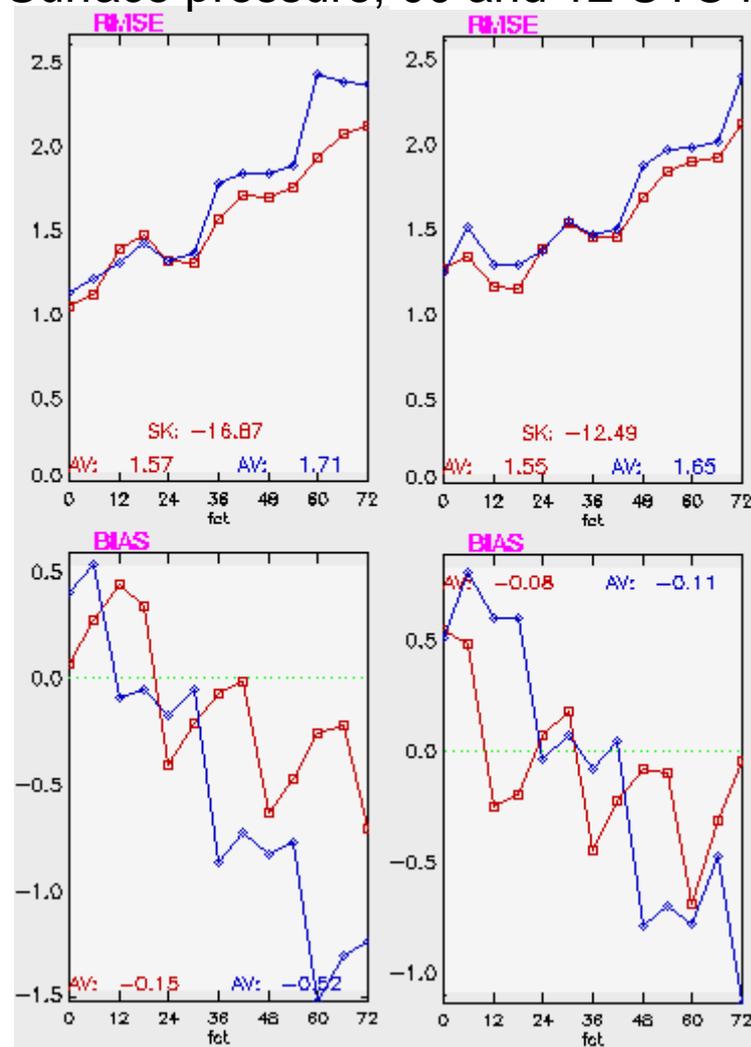
blue: COSMO-EU, red: ICON-EU
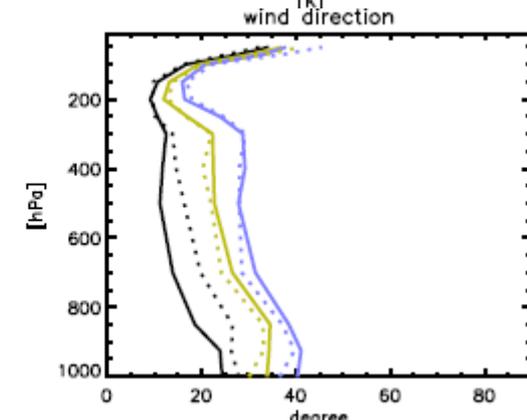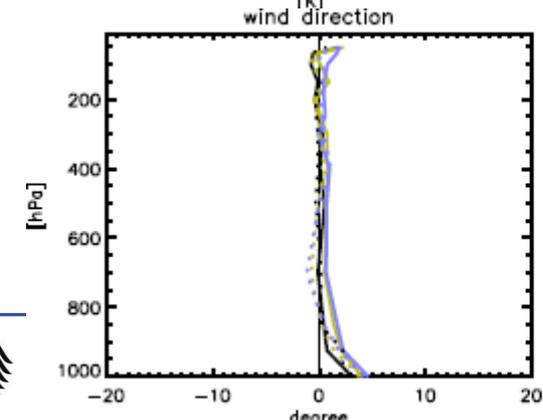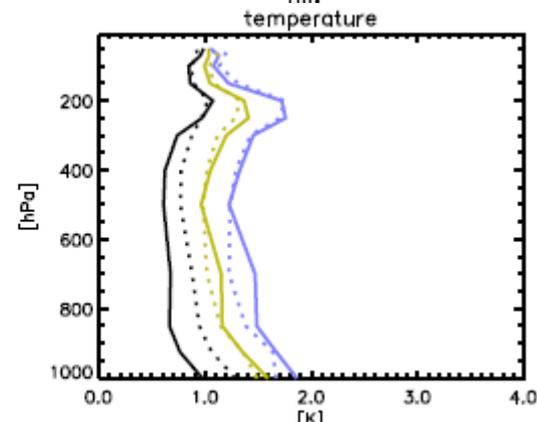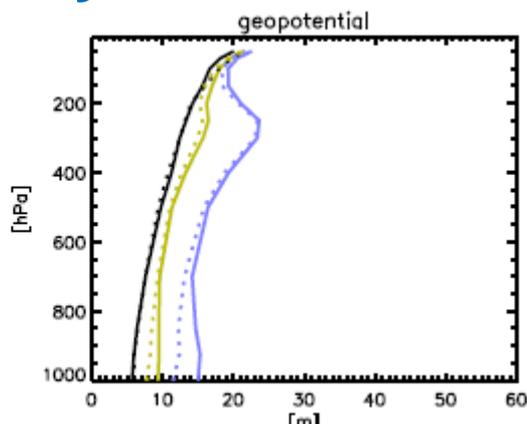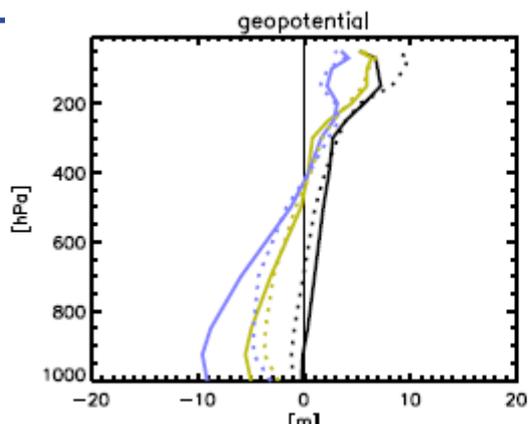
Bias (left) and RMSE (right) for analysis, 24h and 48h forecasts

**dashed: ICON-EU
solid: COSMO-EU**

Surface verification COSMO-EU vs. ICON-EU, Jun 10 – Jul 20, 2015

DWD
Deutscher Wetterdienst
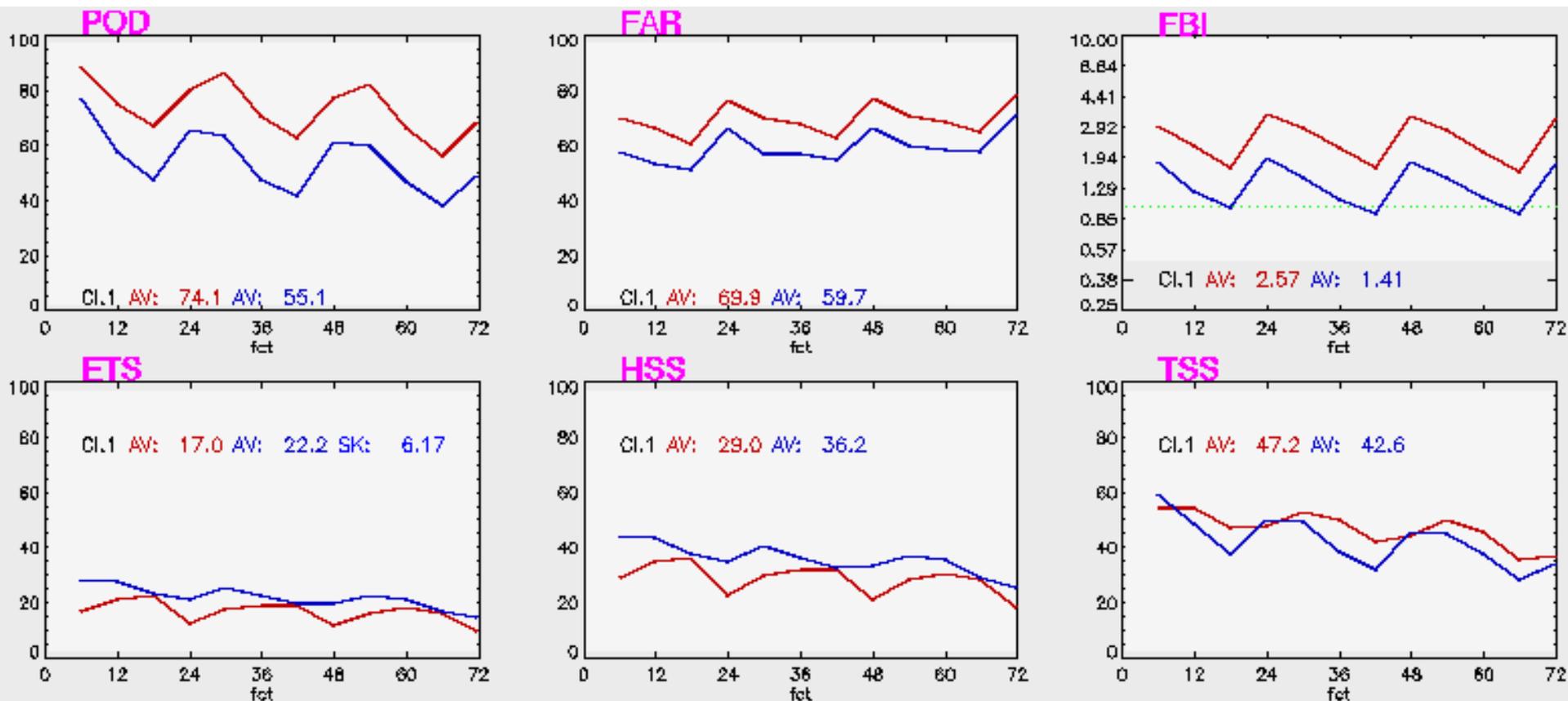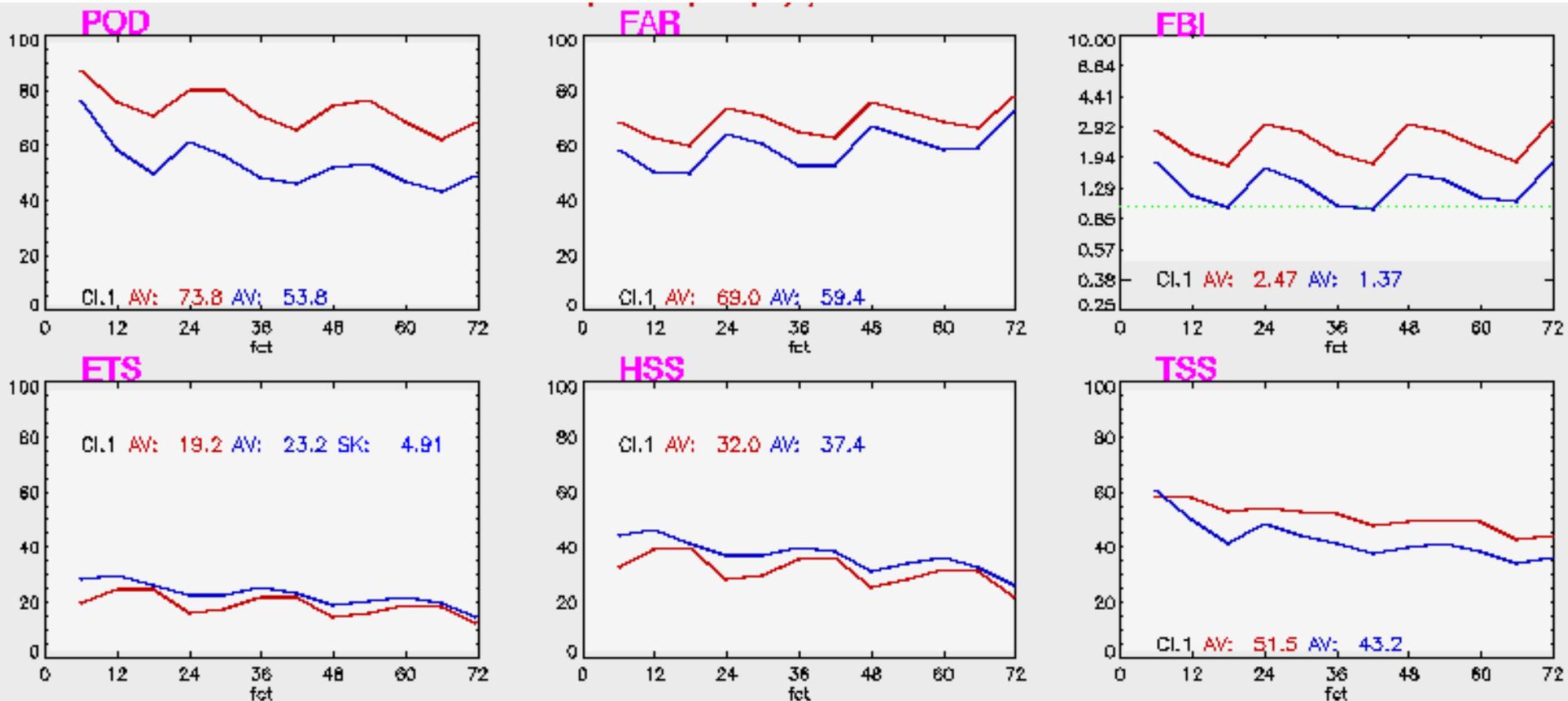Wetter und Klima aus einer Hand

Precipitation > 2 mm / 6h

Precipitation > 0.1 mm / 6h

Surface verification COSMO-EU vs. ICON-EU,
Jul 27 – Aug 28, 2015

DWD
Deutscher Wetterdienst
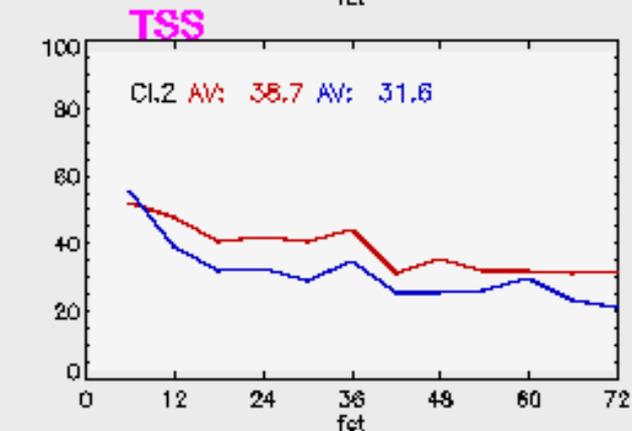Wetter und Klima aus einer Hand
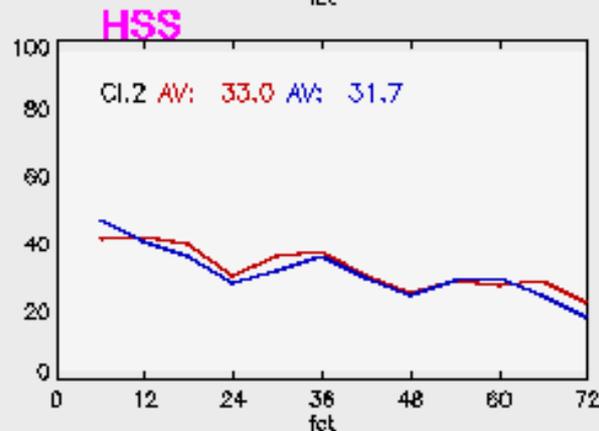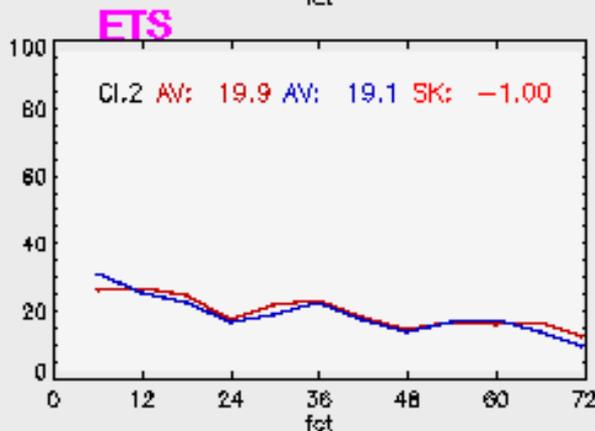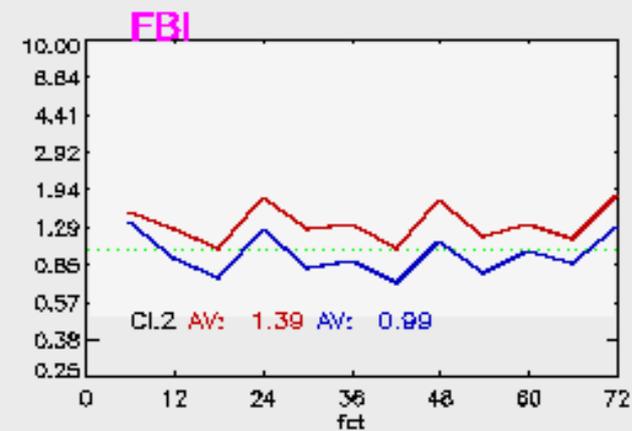
Precipitation > 0.1 mm / 6h

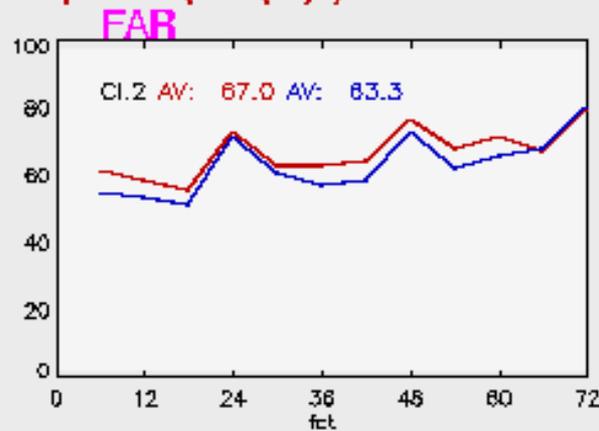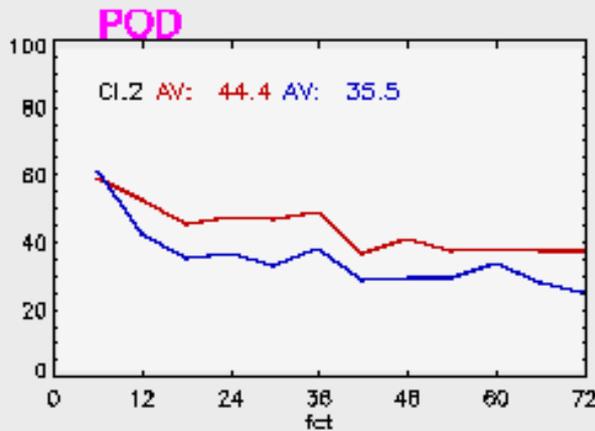# Surface verification COSMO-EU vs. ICON-EU, Jul 27 – Aug 28, 2015

DWD
Deutscher Wetterdienst
Wetter und Klima aus einer Hand

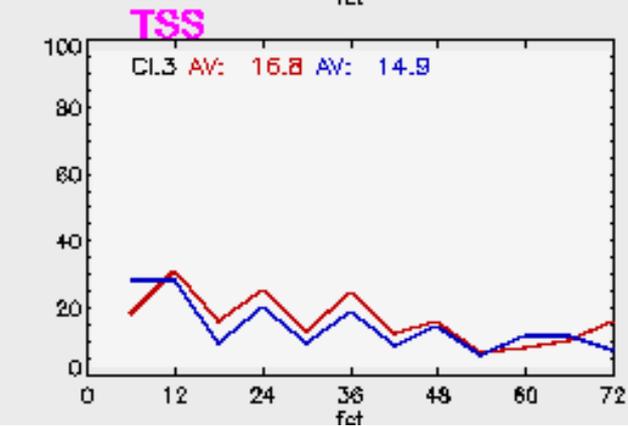## Precipitation > 2 mm / 6h
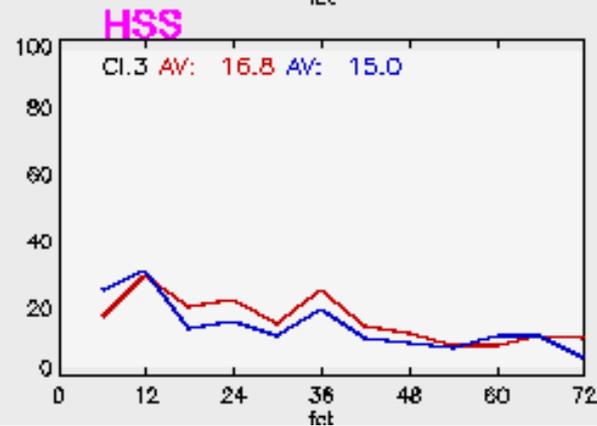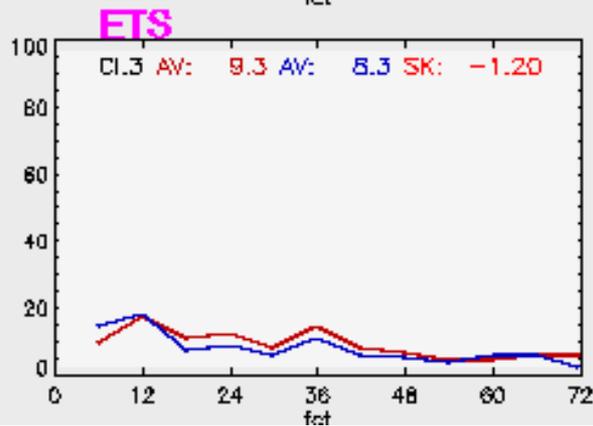
Surface verification COSMO-EU vs. ICON-EU, Jul 27 – Aug 28, 2015

DWD
Deutscher Wetterdienst
Wetter und Klima aus einer Hand

Precipitation > 10 mm / 6h
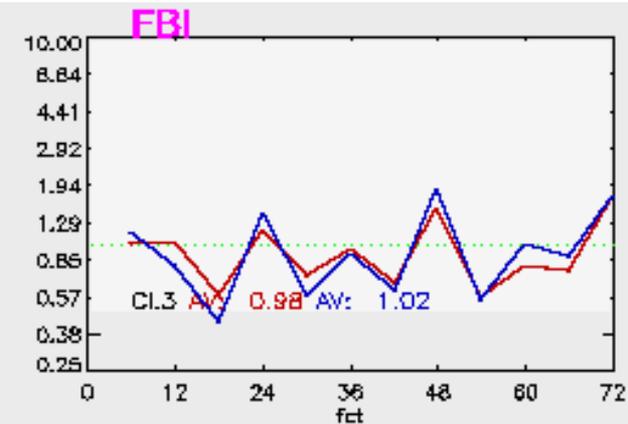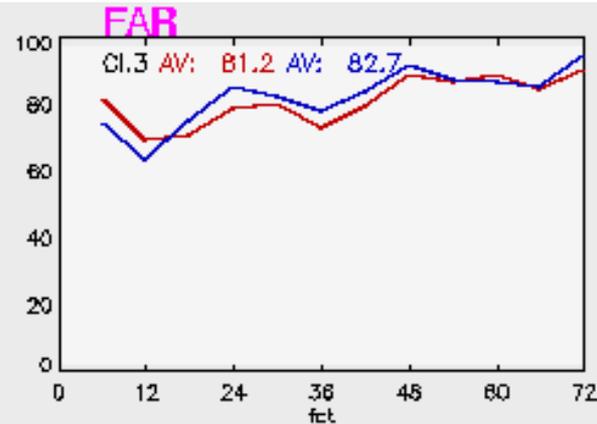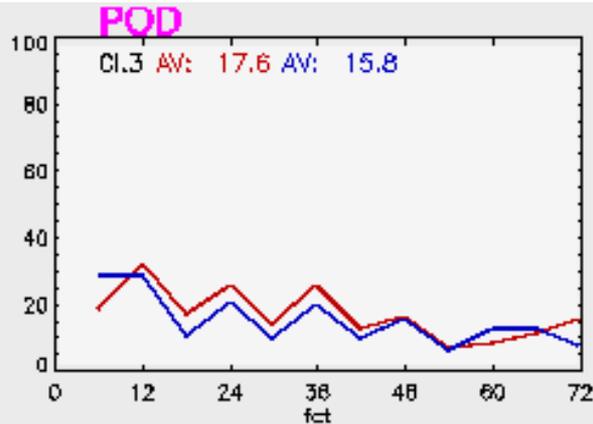
Ongoing developments and future plans

➔ **Ensemble data assimilation (hybrid 3D-Var- LETKF); corresponding forecasts will provide boundary conditions for KENDA**

➔ **Radar data assimilation (latent heat nudging) on Europe domain**

➔ **Extensions of 3D-Var system (FGAT, increased usage of remote-sensing data)**

➔ **Limited-area mode: further forward operators for data assimilation, optimization of boundary condition treatment, maybe quadrilateral grid for higher convergence order**