KENDAscope: KENDA from Surface to Cloud Observations Progressive Extension
(Sept. 2020 – Aug. 2025)

- Task 1: algorithmic developments
  - 1.1 refinements of reference KENDA (currently LETKF)
  - 1.2 Variational DA (EnVar , CEnVar, 4D-EnVar)
  - 1.3 Particle Filter
- Task 2: observations (from surface to clouds)
  - 2.1 Radar (Z + Vr)
  - 2.2 ground-based GNSS ZTD + STD
  - 2.3 all-sky IR + VIS radiances
  - 2.4 MTG IRS
  - 2.5 screen-level obs (T2M, RH2M)
  - 2.6 PBL profiling obs (wind lidar, MW radiometer, Raman lidar, drones, towers)
- Task 3: soil / surface (satellite soil moisture, SST, …)

christoph.schraff@dwd.de

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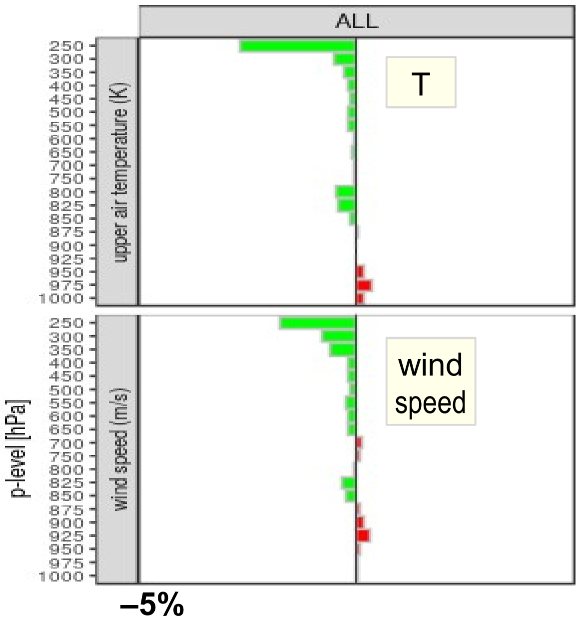
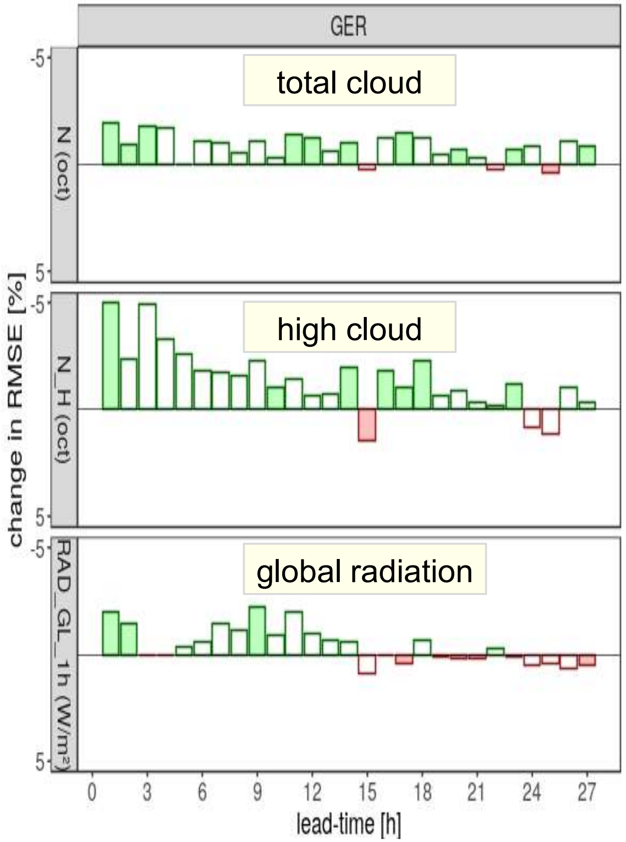
- Task 1: algorithmic developments
  - 1.1 refinements of reference KENDA (currently LETKF)
  - 1) 1.2 Variational DA (EnVar , CEnVar, 4D-EnVar)
  - 1.3 Particle Filter → success at improving ens. spread, tests with ICON-D2
- Task 2: observations (from surface to clouds)
  - 2.1 Radar (Z + Vr) → DWD: e.g. adjust for 2-mom. microphysics
  - 2.2 ground-b. GNSS ZTD + STD → tech. work tbd. before ICON-D2 impact exp. (limited resources)
  - 3) → 2.3 <u>**all-sky IR + VIS radiances**</u>
  - 2.4 MTG IRS → project started on 15 March 2021
  - 2) → 2.5 <u>**screen-level obs (T2M, RH2M)**</u> → e.g. in context of fog / low stratus
  - 4) → 2.6 PBL profiling obs (wind lidar, MW radiometer, Raman lidar, drones, towers)
- Task 3: soil / surface (satellite soil moisture, SST, …)

DWD *(Hendrik Reich, Christoph Schraff, Klaus Stephan Elisabeth Bauernschubert, Christine Sgoff et al.)*

- main changes in parallel suite for ICON-D2:
  - Nov. 2020 : use of obs located up to 200 hPa (instead of 300 hPa)
    - positive impact on wind + temperature in upper troposphere (200 – 300 hPa)





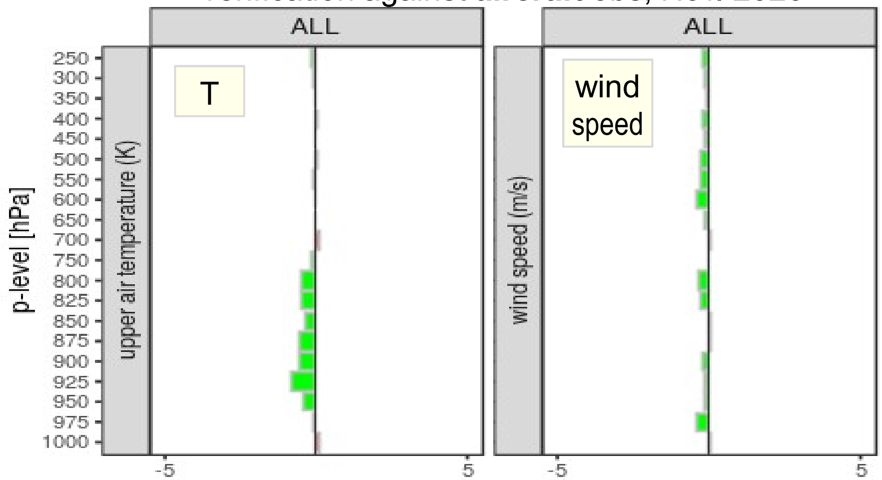
(some) positive impact mainly on high cloud in summer

DWD *(Hendrik Reich, Christoph Schraff, Klaus Stephan Elisabeth Bauernschubert, Christine Sgoff et al.)*

- main changes in parallel suite for ICON-D2:
  - Nov. 2020 : use of obs located up to 200 hPa (instead of 300 hPa)
  - Jan. 2021 : **assimilation of T2M + RH2M obs without bias correction**
  - Feb. 2020 : ICON-D2 operational
  - Apr. 2021 : LHN re-tuned to increase precip in ICON w. cp/cv bug fix + ecRad
  - Sept 2021 : use of superobbed high-resolution radiosonde ascents

- experiments with physics + LHN parameter perturbations in DA cycle

verification against **aircraft** obs, Nov. 2020

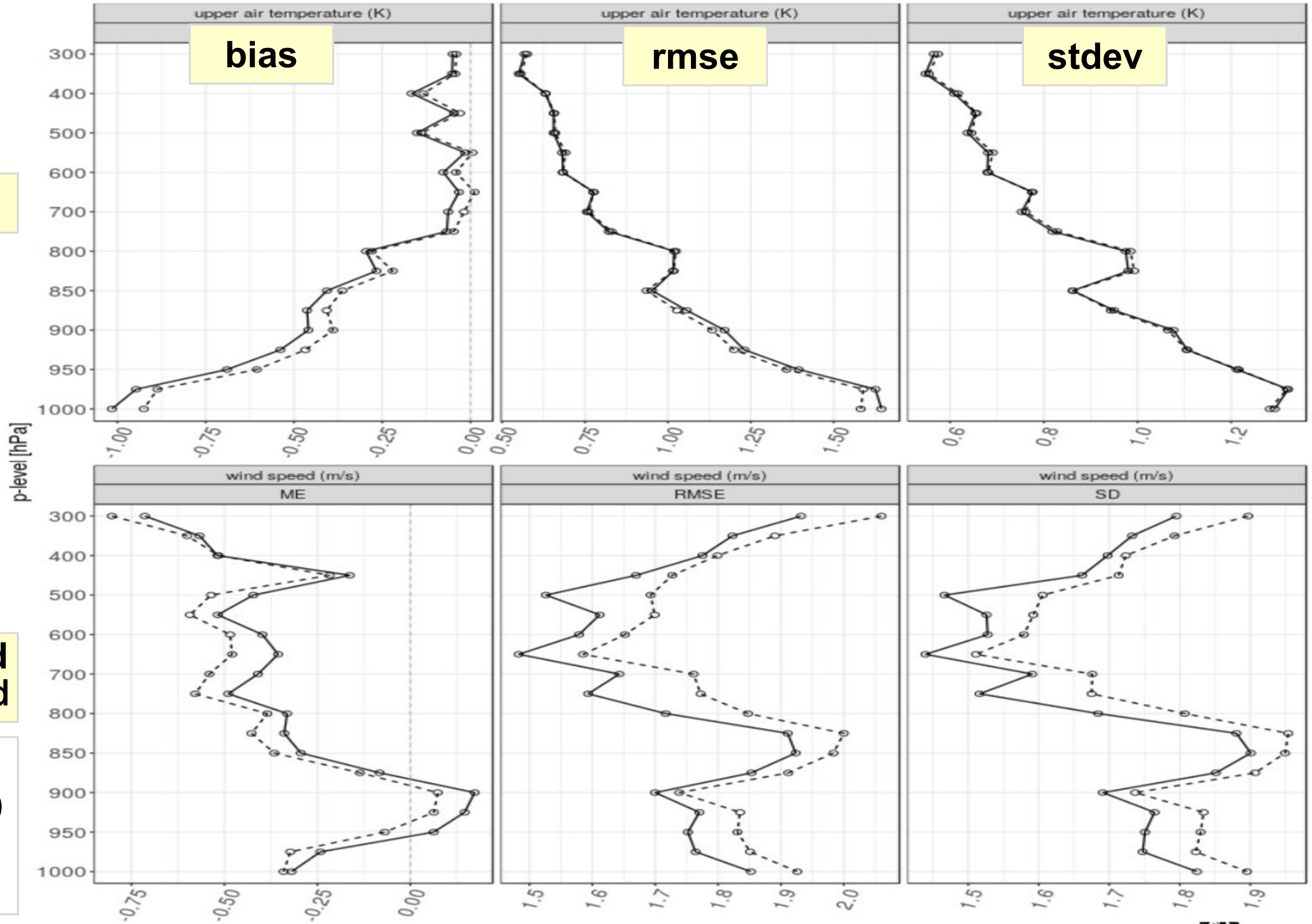


- **EnVar**: runs technically in a preliminary version (with DACE obs operators);
  (Mareike Burba et al.) for testing and comparing to LETKF, need to use similar set of obs
  → careful study obs processing chains & checks to reject obs (no VarQC, thinning, FG check..)
  → using aircraft T obs only: differences in 1-step analysis exp. (mostly) understood

experiment:
- 1 day,
- 4 24-hr forecasts

T

wind speed



EnVar
LETKF

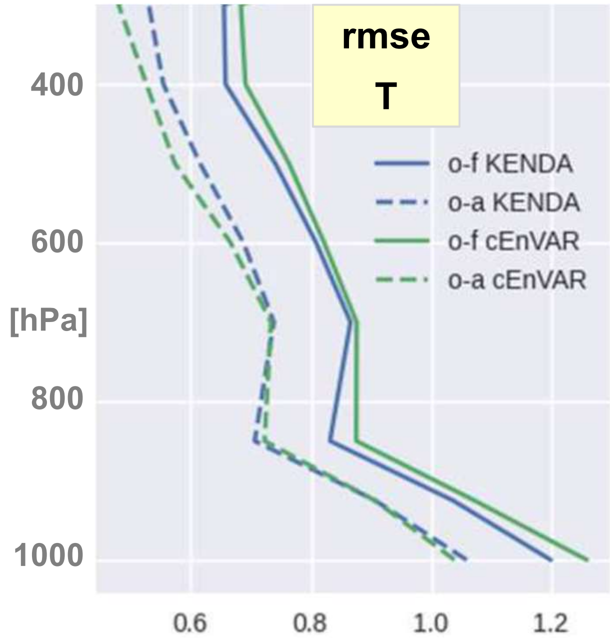
EnVar vs. LETKF
- T slightly worse (bias)
- wind clearly better
  → cross-covariances!

DWD: (C-)EnVar for ILAM

Deutscher Wetterdienst

- **CEnVar**: runs technically in a preliminary version
  (with ensemble-B from ICON-EU; with B from ICON-global yet to be checked)

  next: use cropped ICON-EU ensemble fields for B-matrix



- (C)EnVar: still uses DACE observation operators developed for global DA

  → include required properties of KENDA operators (based on COSMO routines) into the 'global' DACE routines (needed for TL + adjoint operator)

  → implemented / being tested for aircraft obs (as a first obs type)

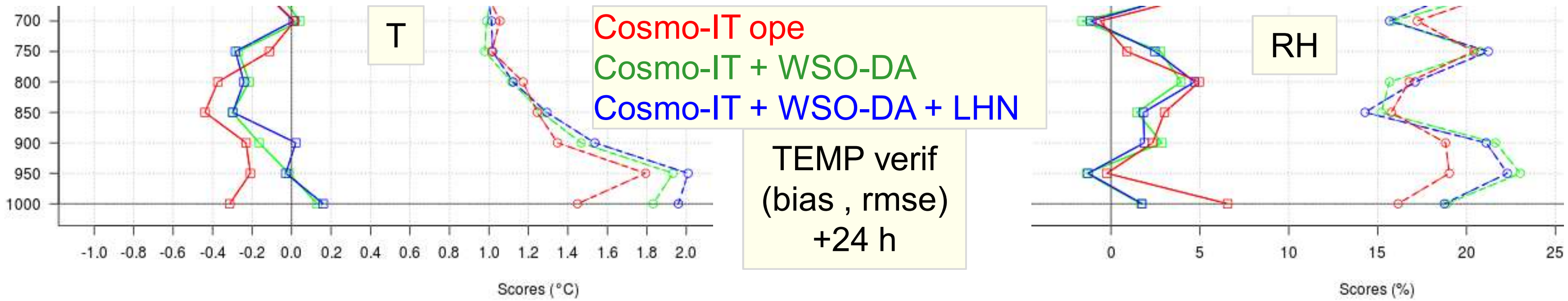
- **Hybrid EnVar / 3DVar**, i.e. with additional use of **climatological B-matrix**:
  - **global** climatological B-matrix is applicable
  - aim to develop **regional** clim. B-matrix: required very well-trained resources currently not available (due to other high-priority work, e.g. 4D-EnVar)

KENDA at COMET: **COSMO**-IT

(*Francesca Marcucci, Valerio Cardinali*)

impact experiments (convective summer periods):

- assimilation of satellite-derived soil moisture (WSO-DA)
  (WSO + T2M + RH2M obs influence both soil + low-level atmosphere in LETKF step)
- LHN (latent heat nudging)



status + next steps:

- WSO-DA: negative impact on low-level T, humidity
  otherwise neutral – negative impact on surface verif; precip overestimated by LHN $\leq$ 12 h;
  COSMO-IT vs. obs: soil too wet, but RH2M too dry …
- WSO-DA: decouple soil & atmosphere: no influence of T2m + RH2m on wsoil ana.
  of WSO obs on atmosphere

  WSO-DA: compute CDF coeff. for COSMO-IT (calibration of obs) ; bias correction?

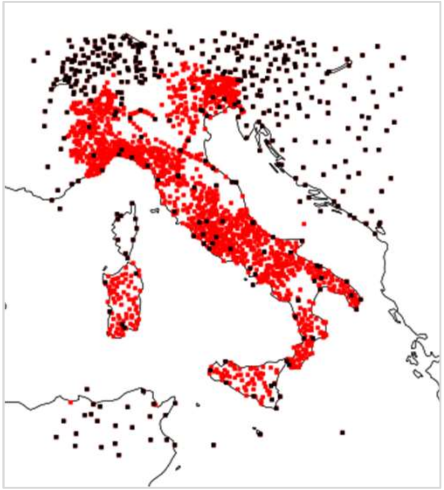
KENDA at COMET: **ICON**-IT

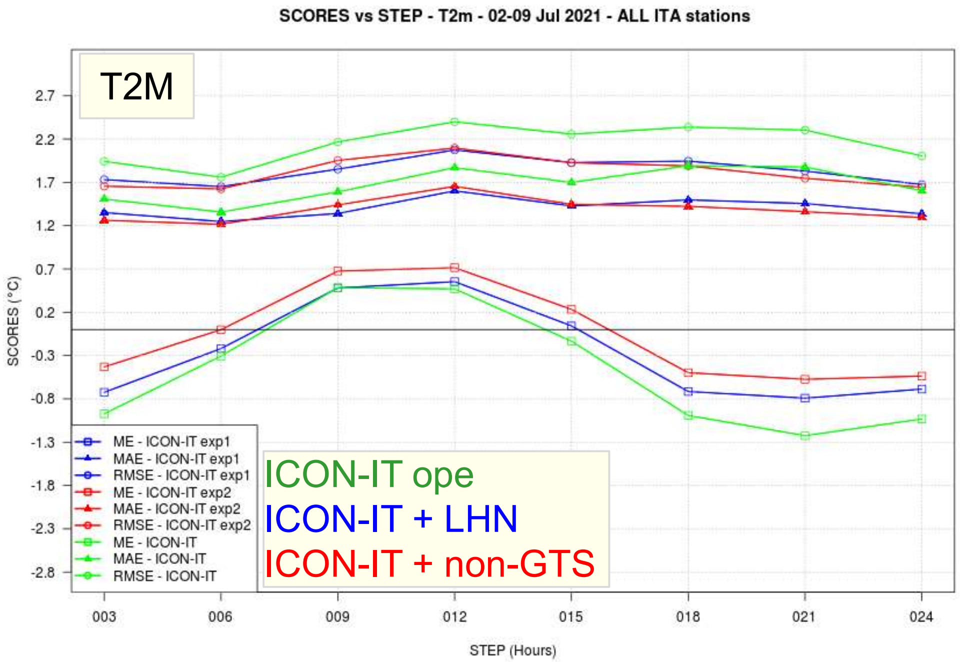
(Francesca Marcucci, Valerio Cardinali)

Deutscher Wetterdienst

impact exp:
(convective)

- LHN
- non-GTS surface stations:
  many: T2M →
  few sta.: PS, UV10M, RH2M





status + next steps:

- soil too dry up to now → add soil moisture nudging towards ICON-EU (4 UTC)
- further tests with LHN
- assimilation of 3-D radar reflectivity (+ radial winds)

Radar reflectivity & radial wind at arpae emilia-romagna

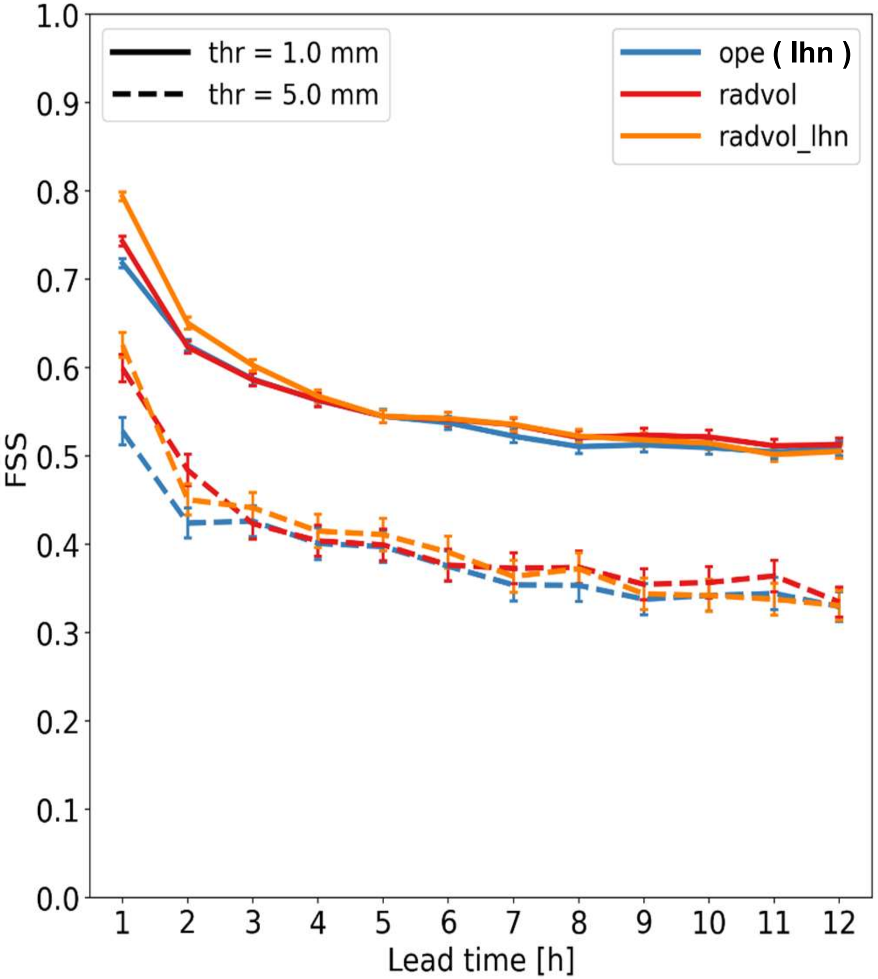
Thomas Gastaldo, Virginia Poli

Deutscher Wetterdienst DWD

- 3-D Reflectivity Z in LETKF:
  - Radar Z + LHN > Radar Z > LHN
  - precip improved up to +3 h (significant) resp. + 9 h (not significant)
  - other variables ~ neutral
  - w/o LHN: less precip, drying of soil
  - introduced operationally in spring 2021
  - (further experiments:
    - discarding lowest elevation (ground clutter)
    - use further (regional) radars,
    - precipitate excluded in control vector)
- 3-D Radial winds in LETKF:
  - impact experiment:

    positive impact on tropospheric wind and temperature in first 4 – 6 h, neutral otherwise

FSS 22 km against rain-gauge adjusted radar 18/09 – 19/10/2020



2-m temperature + humidity obs: BC + **assimilation**

Elisabeth Bauernschubert, C. Sgoff, C. Schraff, K. Stephan

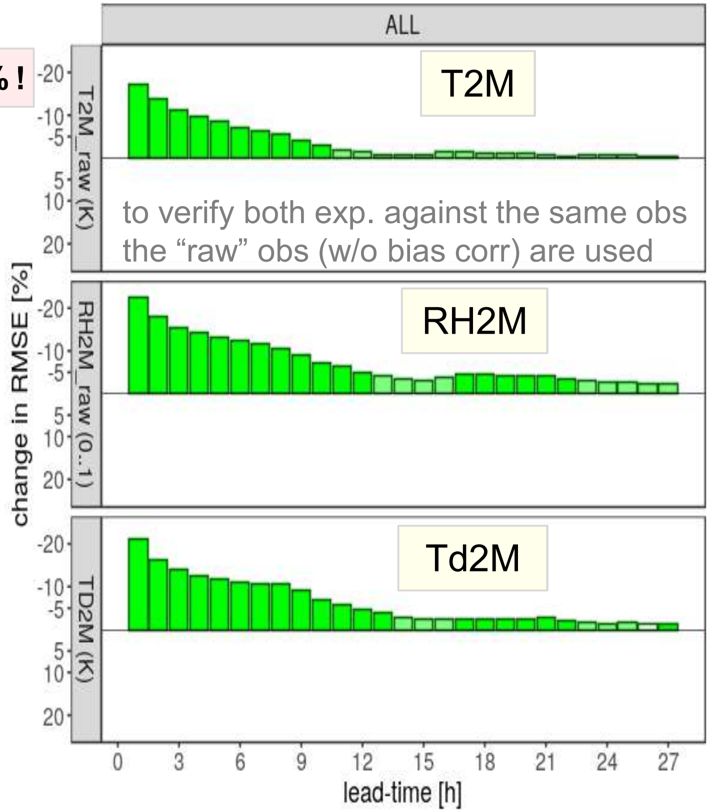
Deutscher Wetterdienst DWD

winter 21/12/19 – 08/01/20

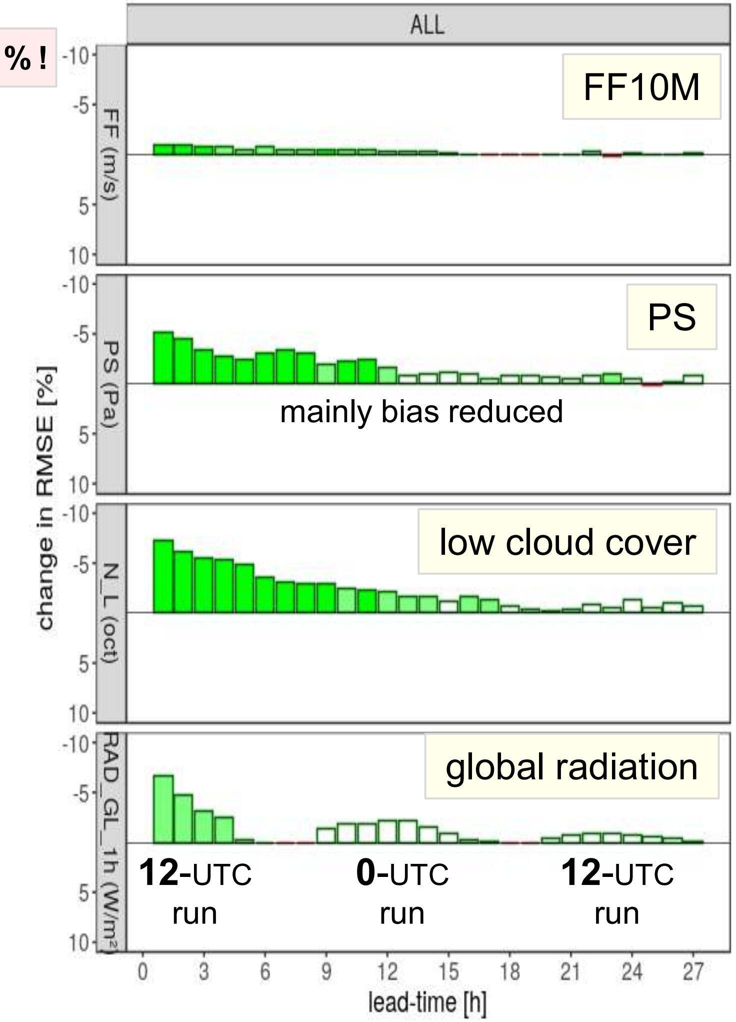
change [%] of RMSE against synop

ICON-D2
with RH2M + T2M better
w/o RH2M + T2M better

20 % !



10 % !

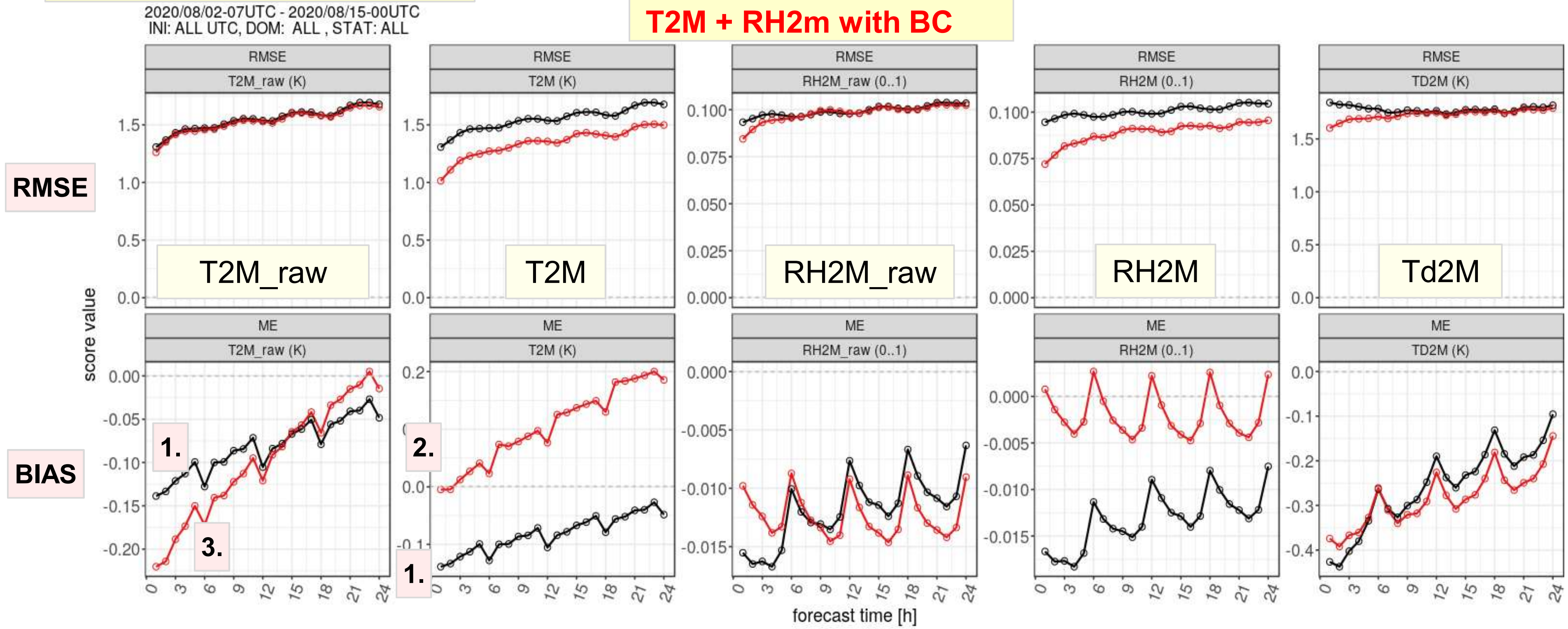


2-m temperature + humidity obs:
bias correction (BC) + assimilation

Deutscher Wetterdienst DWD

summer 02 – 15/08/20

ICON-D2 **REF**
T2M + RH2m with BC



1. model (at +1h) has cold bias

2. T2M model bias at + 1h against bias-corrected T2M obs ≈ 0 → BC works ok, i.e. it adjusts the obs to the cold bias of the model by making the obs colder

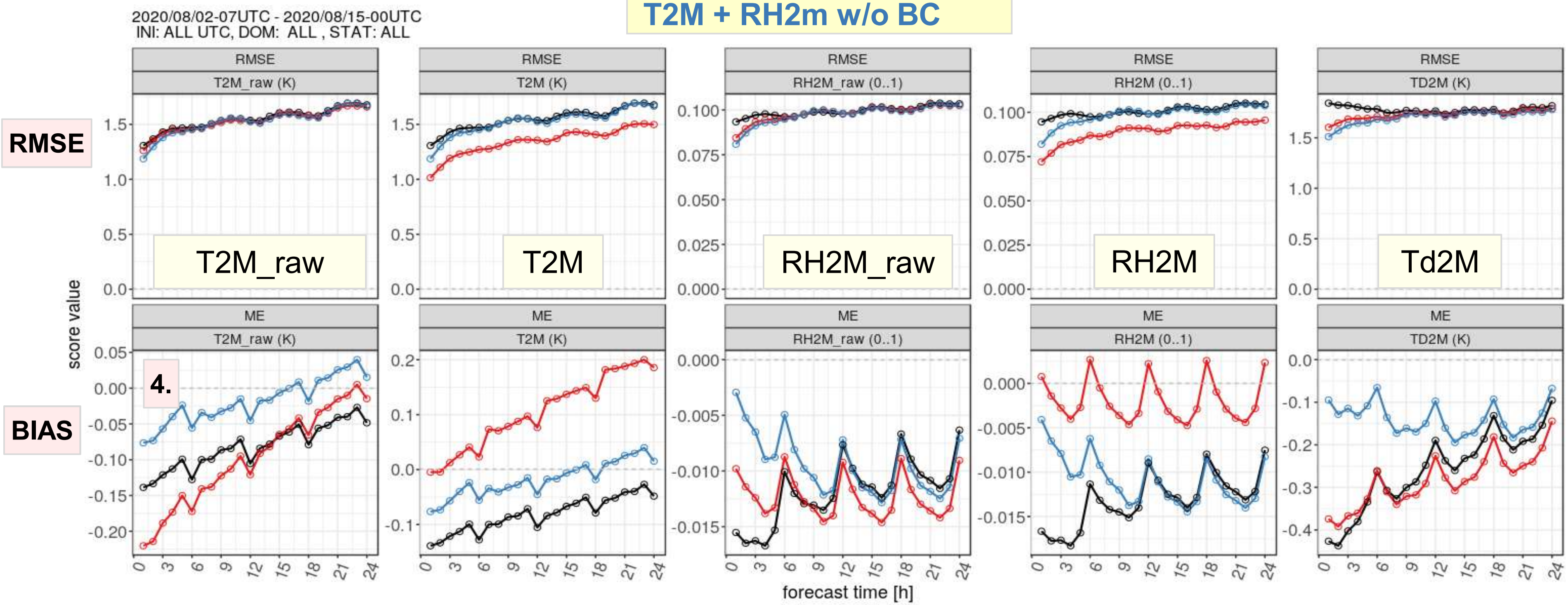
3. **assimilating the bias-corrected cold T2M obs increases cold bias of model** (FG) if verified against raw T2M obs or radiosonde / aircraft obs → undesired positive feedback

2-m temperature + humidity obs:
bias correction (BC) + assimilation

Deutscher Wetterdienst DWD

summer 02 – 15/08/20

ICON-D2 **REF**
T2M + RH2m with BC
T2M + RH2m w/o BC



assimilation of T2M + RH2M without bias correction:

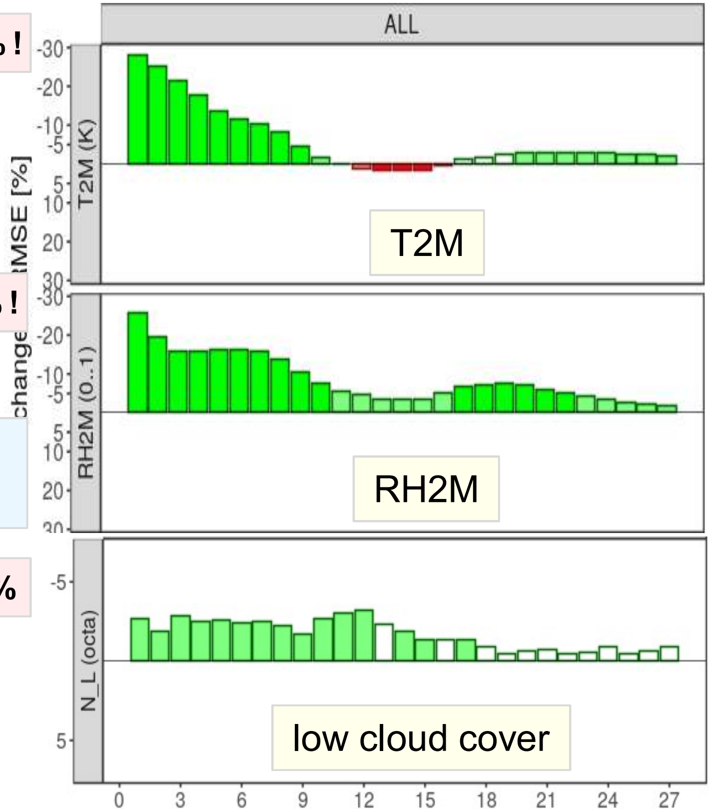
- avoids increase of cold bias and even decreases T2M bias (averaged over all stations!!)
- still improves T2M + RH2M forecasts (against raw obs)
  (but loses small positive impact on low cloud / precip)

assimilation of T2M + RH2M without bias correction:

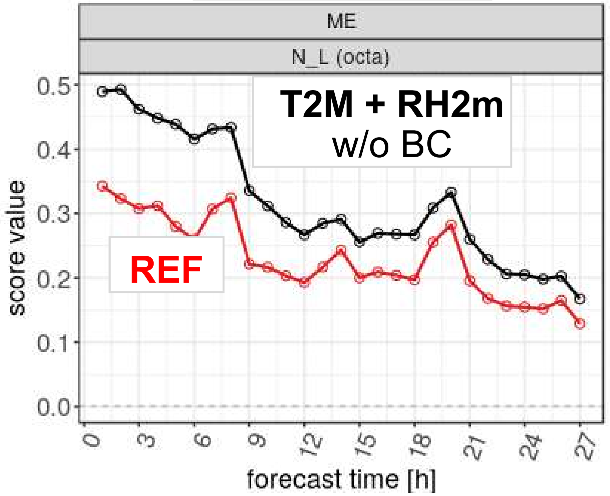
- test in winter / for low stratus (Nov. 2020)
- assimilation of T2M + RH2M w/o BC **introduced** (pre-/)**operationally in ICON-D2 (Q1/21)**
- working on revised bias correction (by relaxing area-averaged BC towards zero)

winter 3 – 22/11/20

change [%] of RMSE against synop



low cloud cover bias



→ impact on low cloud:
improves RMSE
but increases overestimation

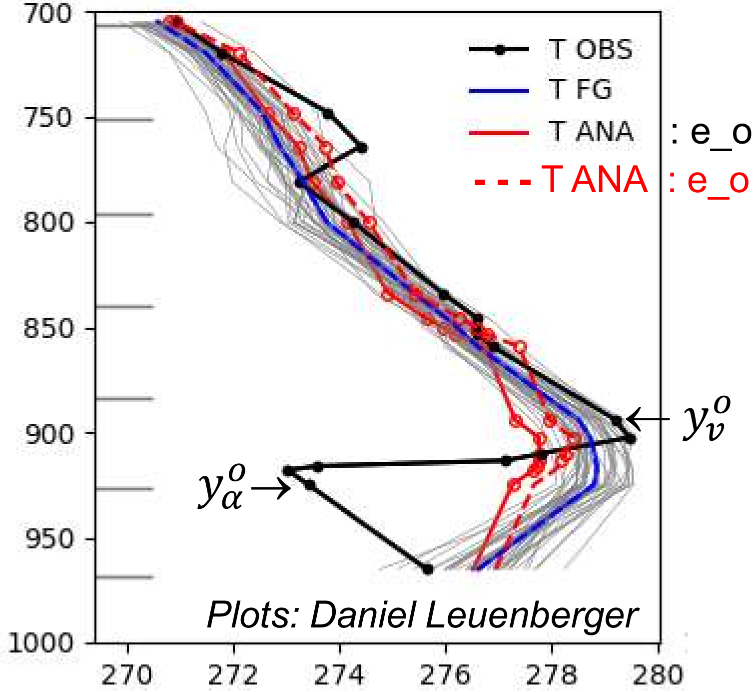
- assimilation of T2M + RH2M w/o BC also **operational at COMET**

Low stratus, inversions
and the role of **ensemble covariances**

Deutscher Wetterdienst

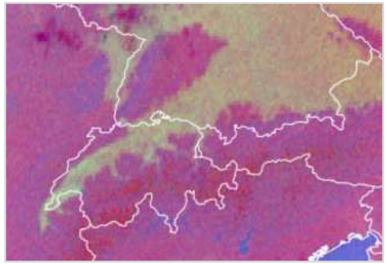
LETKF: problems in case of strong vertical gradients, missing low stratus in Swiss Plat.
seen as serious problem at MeteoSwiss after introducing KENDA-1 / COSMO1(E)

temperature inversion
at radiosonde Payerne

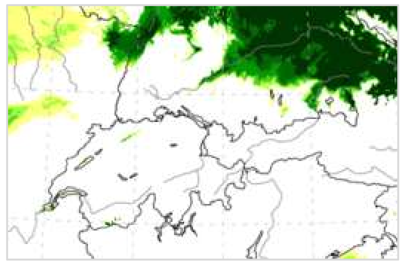


: e_o = e_o(oper)
: e_o = e_o(oper) / 4.

Meteosat



KENDA-1 ana.: low cloud



- decreasing obs errors by factor 4 should have fairly similar effect as increasing ensemble spread by 4
- does not help very much to improve analysis here, i.e. inversion not much enhanced – why?
- reason: across-inversion ensemble covariances $P^{b,\,loc}_{ens(\alpha,v)}$ (> 0) contradict f.g. error 'correlation' $(y_v^o - y_v^b)(y_\alpha^o - y_\alpha^b)$ (< 0)

new diagnostics ←
developed by Olaf Stiller

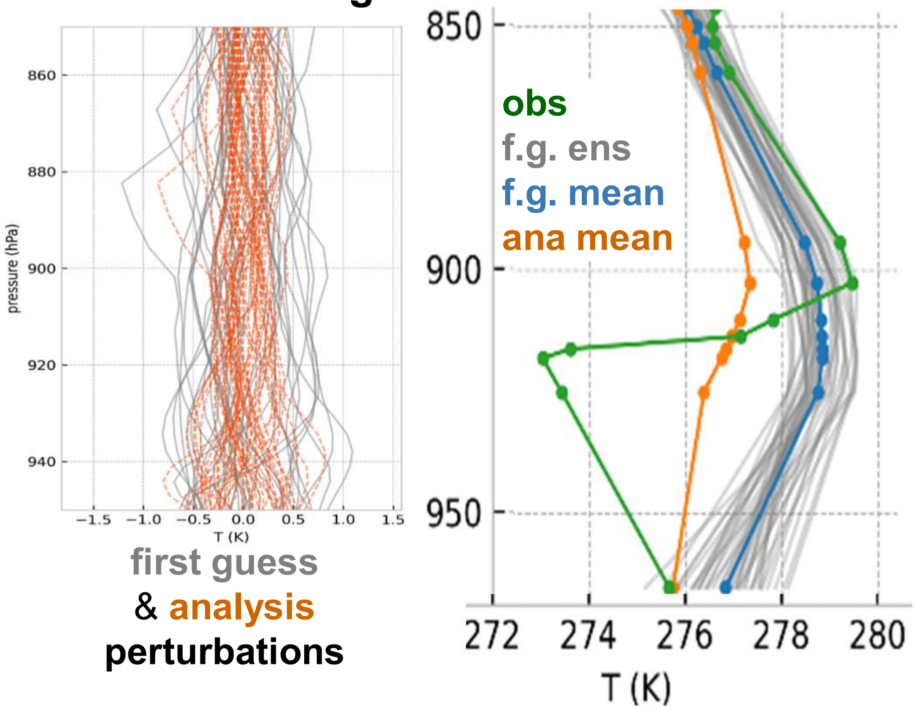
$$J^b_{\alpha,v} = P^{b,\,loc}_{ens(\ ,v)}\,(y_v^o - y_v^b)(y_\alpha^o - y_\alpha^b)\; s^{-1} < 0$$

Low stratus, inversions
and the role of **ensemble covariances**

Deutscher Wetterdienst
DWD

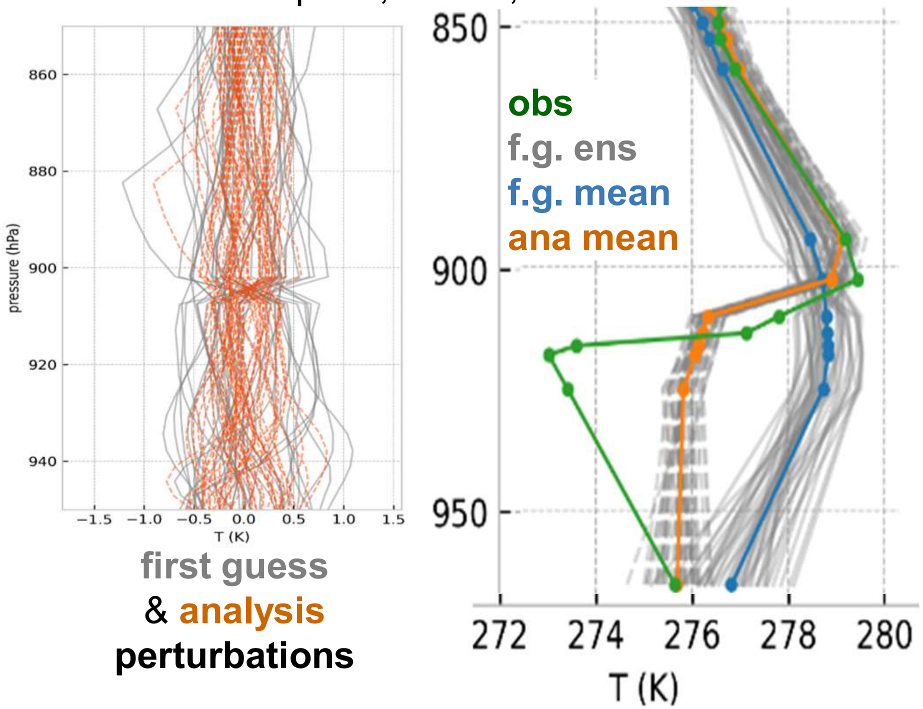
temperature inversion *plots by Claire Merker, MeteoSwiss* (toy ETKF tool, only 1 model profile)

original ensemble



first guess
& **analysis**
perturbations

shuffled ensemble (idealized experiment):
dissect ensemble members at inversion height
into 2 parts, shuffle, reassemble



first guess
& **analysis**
perturbations

- across-inversion covariances of shuffled ensemble (~ zero) do not contradict f.g. error ‘correl.’ (negative) → obs below and above do not work against each other → improved analysis
- ensemble covariances crucial in DA → motivates to investigate how PPP + LHNP affect them

Daniel Leuenberger, Claire Merker, Marco Arpagaus

Findings of sensitivity studies on DA (with KENDA-1 / COSMO-1(E)):

- LETKF: problems in case of strong vertical gradients & bad first guess ensembles
- virtually no improvement with increasing FG spread, relaxsing RH QC, etc.
- some improvement of analysis with
  - improving FG structure (→ better representation of gradients in analysis)
  - assimilation of more frequent T/RH profiles

→ need for better first guess

- improved model (e.g. ICON ☺)
- and … ⇒ assimilation of more observations in the PBL

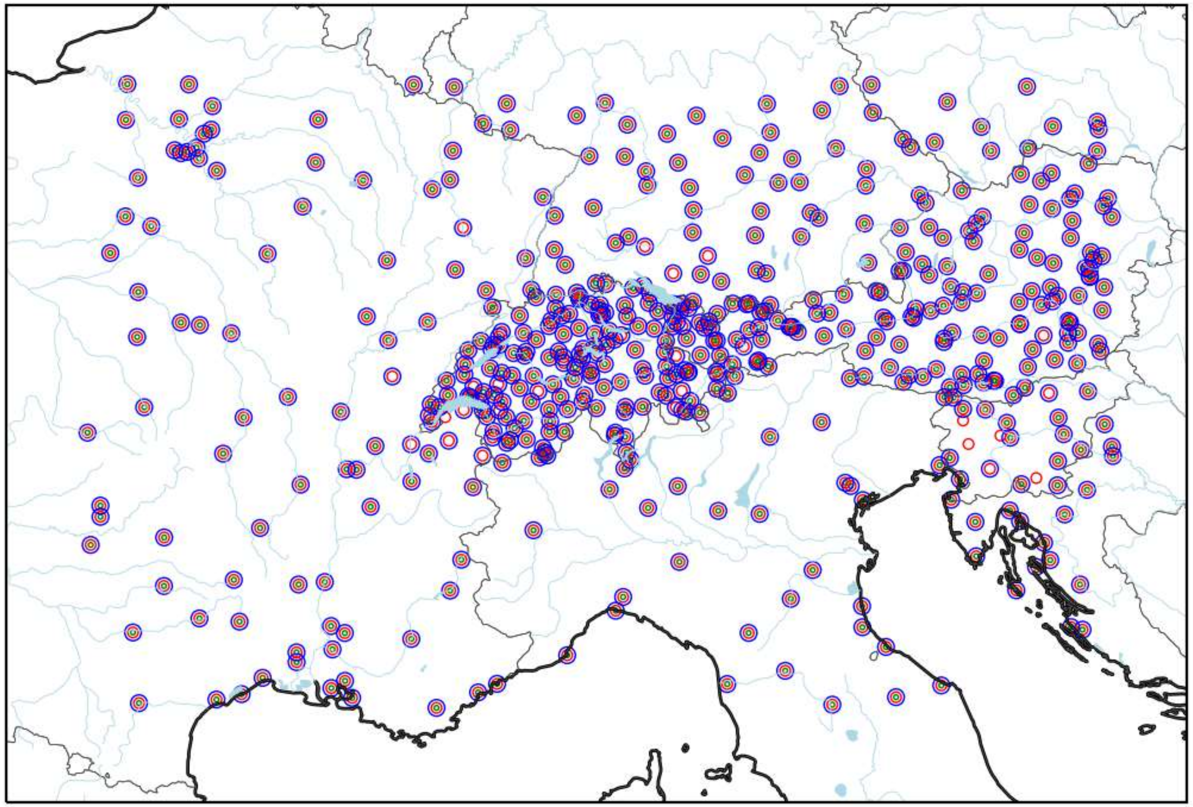
MeteoSwiss

Daniel Leuenberger, Claire Merker, Marco Arpagaus

assimilation of T2M + RH2M obs

- Period: 21. – 30.11.2020 (10d)
- e-suite KENDA-1 and COSMO-1E (00 and 12UTC)
- settings according to DWD
- relaxation of COSMO QC threshold for RH: qcvf(4) = 1.5
- **exp**: with T2M + RH2M assim.
  ref : operational

locations of active observations



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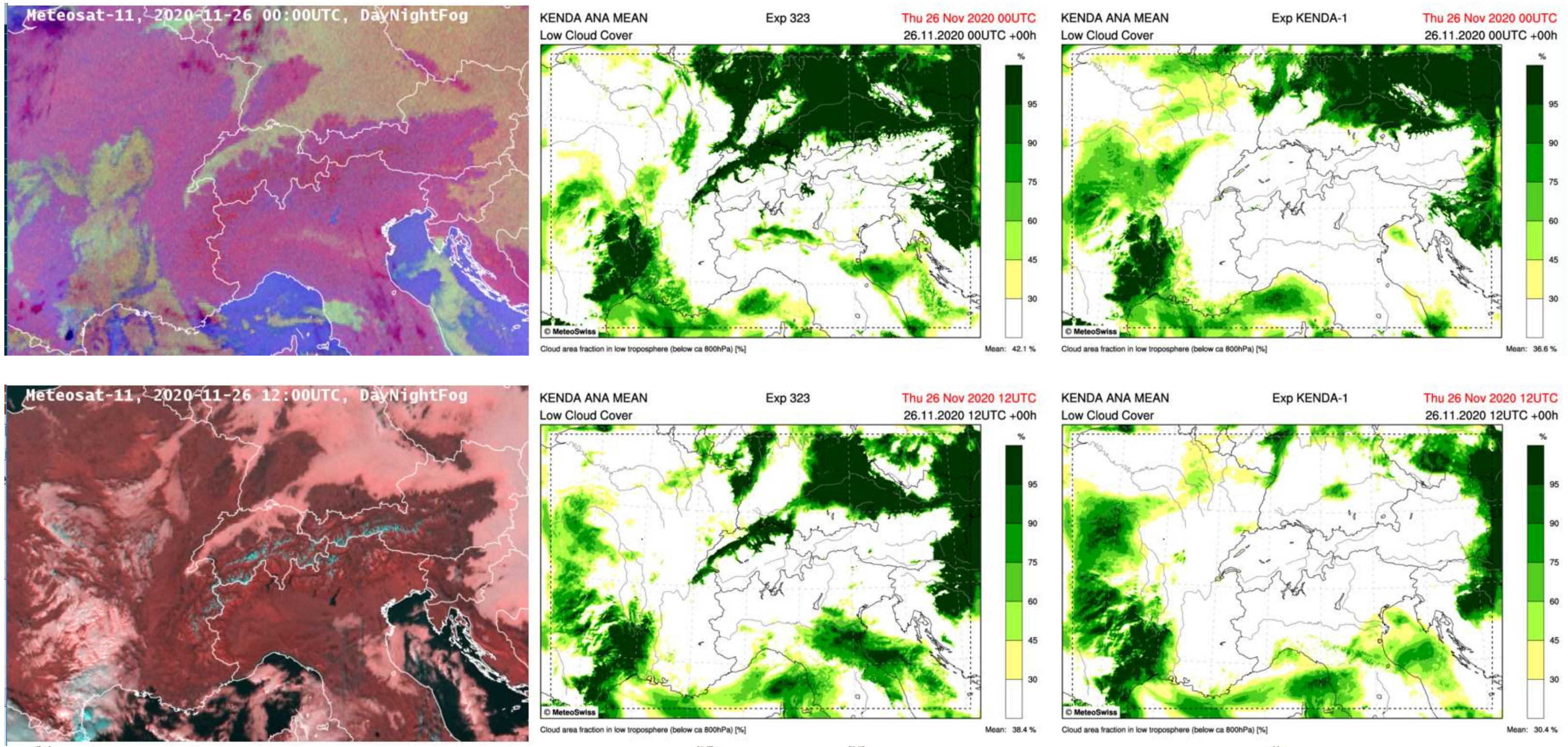
impact on KENDA-1 **analysis** (low clouds)

	Satellite	Exp	Opr
26.11.2020 00 UTC			
26.11.2020 12 UTC			

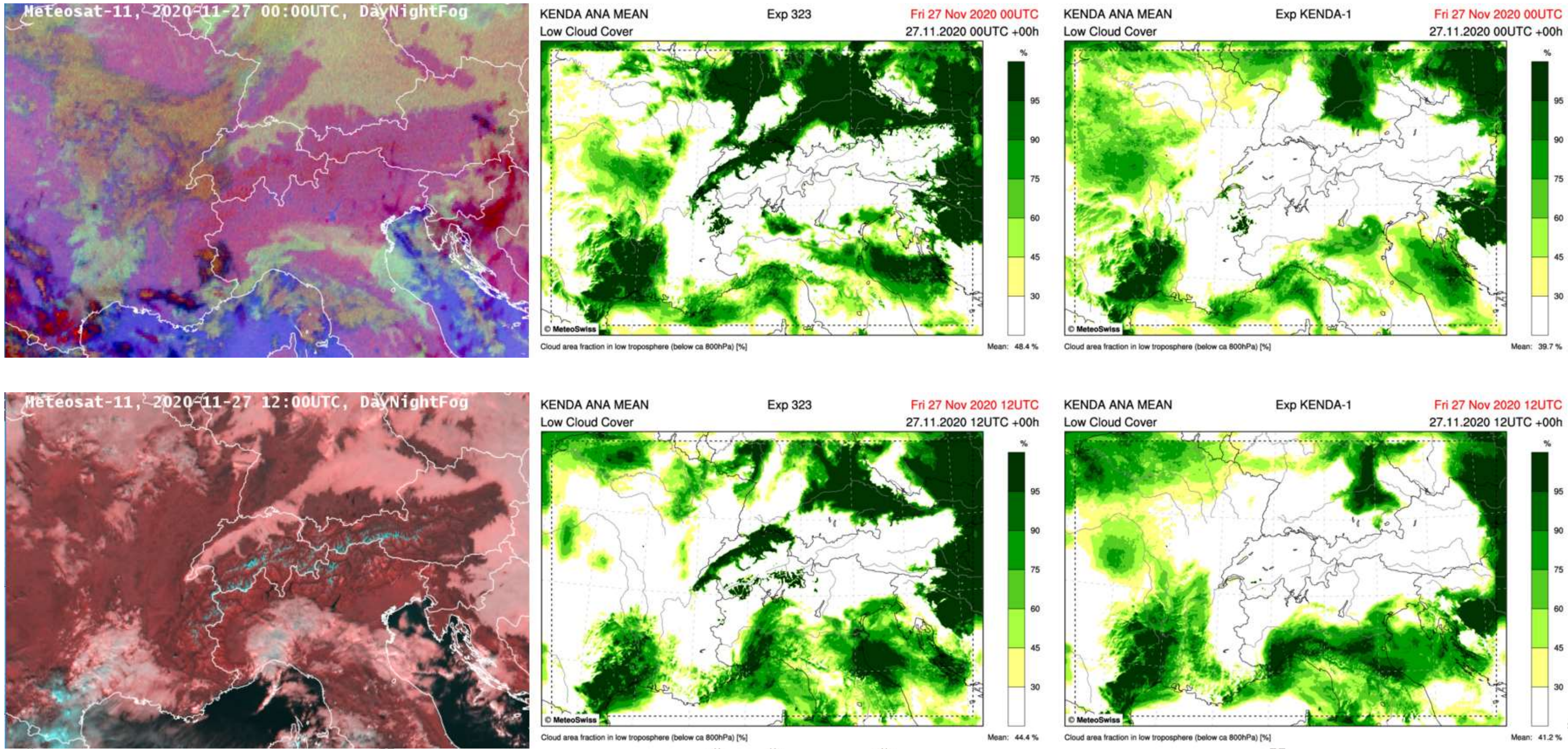


Assimilation of T2M + RH2M obs in case of strong inversion / low stratus

Deutscher Wetterdienst

impact on KENDA-1 **analysis** (low clouds)

	Satellite	Exp	Opr
27.11.2020 00 UTC			
27.11.2020 12 UTC			



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Assimilation of T2M + RH2M obs in case of strong inversion / low stratus

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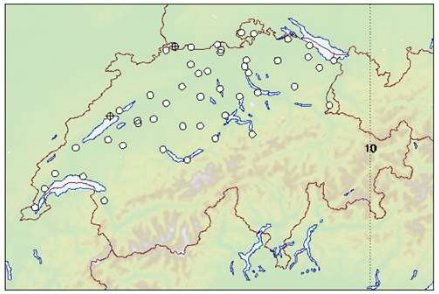
impact on KENDA-1 **first guess** (surface stations)



45 Swiss Plateau Stations

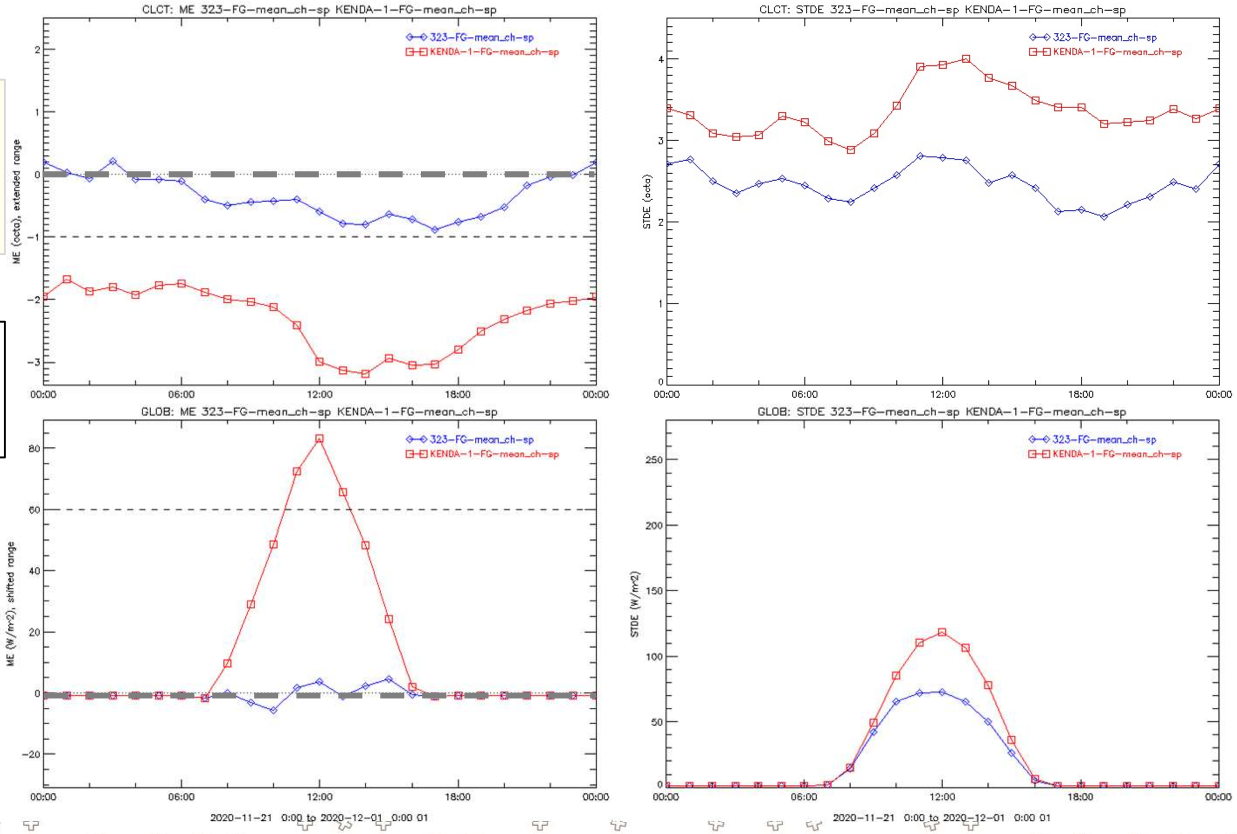
total cloud cover

global radiation

opr
exp

BIAS

STDEV



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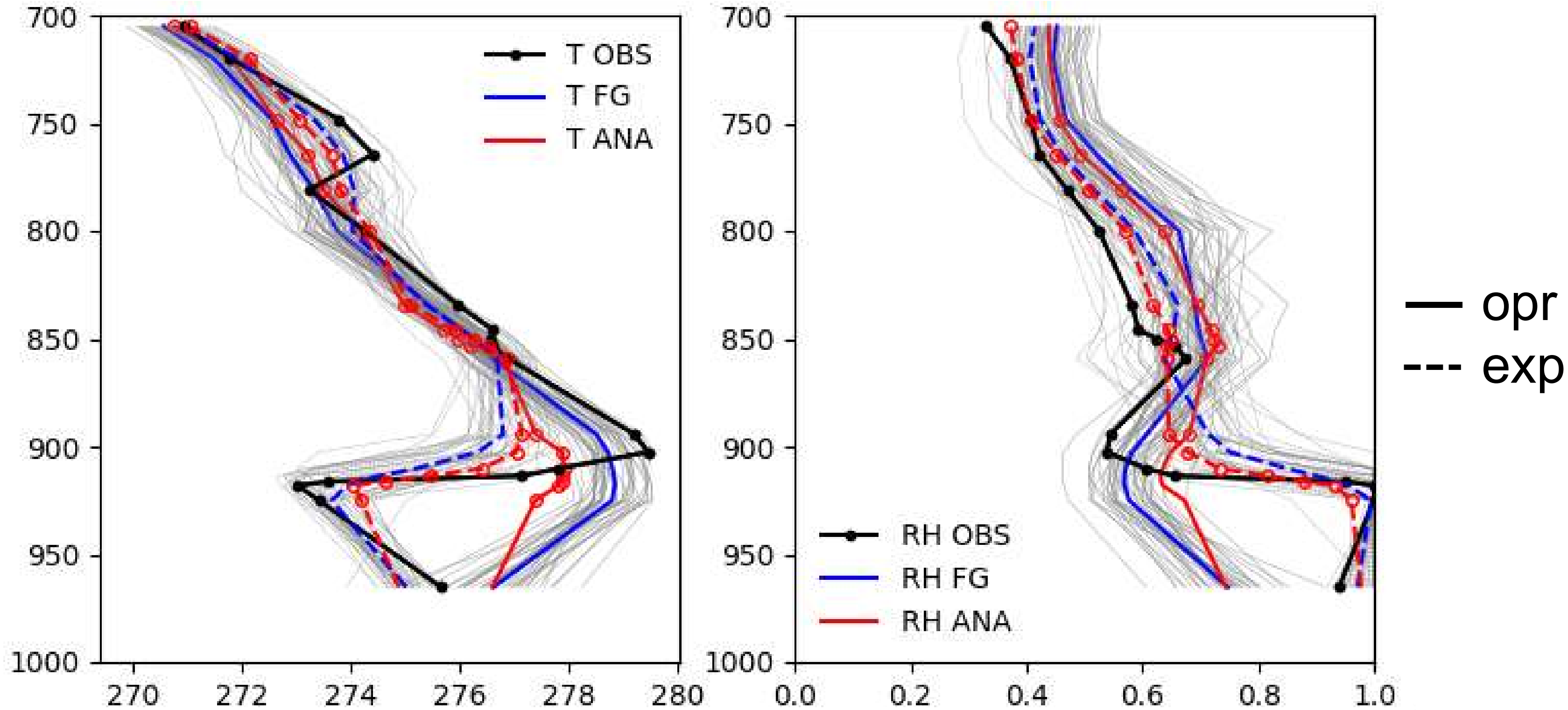
impact on KENDA-1: **vertical structure**

Radiosonde Payerne, 26.11.2020 00UTC



impact on forecasts (surface stations)

Probabilistic Results

Parameter	Spread/Error	RPSS	BSS (low thr.)	BSS (high thr.)
Precipitation (6h)	similar	slightly worse	slightly worse	slightly better
Cloud amount	better	much better	much better	much better
Temperature	better	much better	much better	similar
Dewpoint	better	much better	much better	much better
Wind speed	similar	slightly better	slightly better	similar
Gusts	similar	slightly better	slightly better	better

Virtually no rain in this period

Control

Parameter	RMSE	Bias	STDE
Precipitation	similar	similar	similar
Cloud Cover	better	better	better
Global Radiation	slightly better	better	slightly better
Sunshine Duration	better	better	better
Temperature	better	slightly better	better
Dewpoint	better	better	better
Relative Humidity	much better	much better	much better
Wind Speed	similar	similar	similar
Wind Gusts	similar	similar	similar
Wind Direction	similar	similar	similar
Station Pressure	similar	similar	similar
Sea Level Pressure	slightly better	slightly better	slightly better
Parameter	**Freq. Bias**	**POD**	**FAR**
Precipitation > 0.2 mm/6h	slightly worse	similar	slightly worse
Precipitation > 5 mm/6h	worse	better	slightly better
Cloud Cover > 2.5 okta	worse	better	similar
Cloud Cover > 6.5 okta	better	better	slightly better
Wind Gusts > 12.5 m/s	similar	similar	similar

virtually no rain in this period

MeteoSwiss

Assimilation of T2M + RH2M obs in case of strong inversion / low stratus

Deutscher Wetterdienst

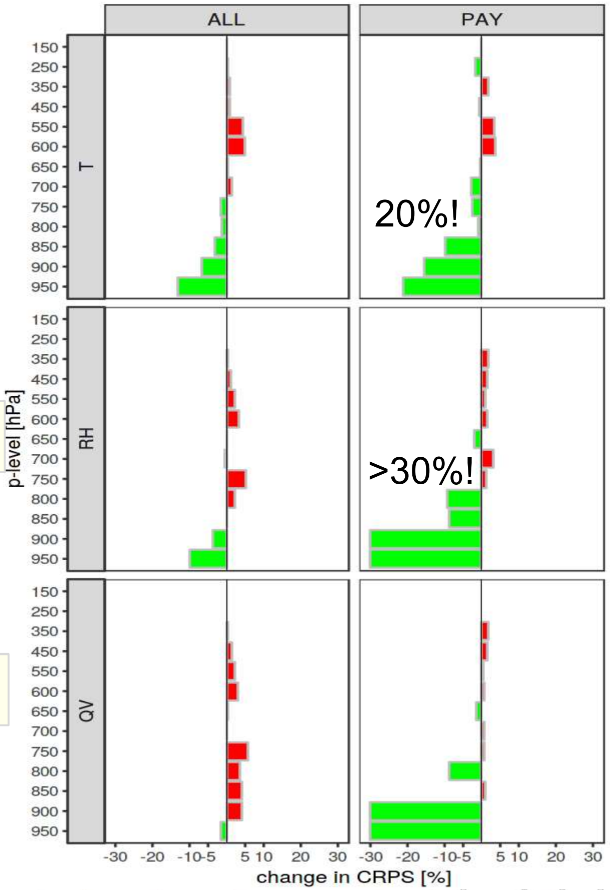
impact on EPS forecasts (radiosondes)

ALL PAY

T

RH

QV



% change of CRPS (all lead times)

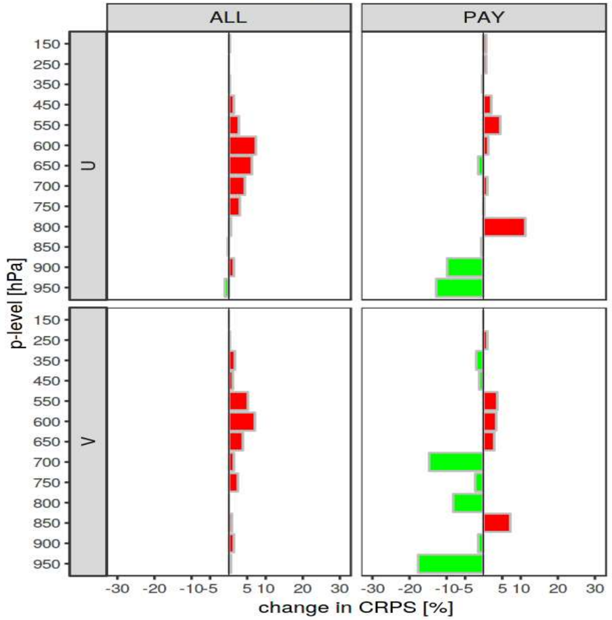
Exp better

Exp worse

ALL PAY

U

V



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Assimilation of T2M + RH2M obs summary

Deutscher Wetterdienst

- strong vertical gradients: challenge for the model & DA system → bad FG + ana
- assimilation of T2m + RH2m a game changer
  - better representation of T2m + RH2m, better FG for assimilation of radiosonde
  - fog much better represented in analysis
  - positive impact up to +24h (in investigated 10-day period)
  - no clear negative side effects so far, potential problems with surface inversions … and cloud overestimation ?

outlook

- assimilation of T2m + RH2m
  - extended tests for autumn / winter, operationalize in autumn if successful
  - tests in other season, deploy operationally in all seasons if successful
  - put more efforts on station selection + quality control
- use more obs: wind lidar, Raman lidar, MWR, meteodrones, RAOB descents
- ICON

Task 2.3: **All-sky** assimilation of **SEVIRI** satellite data

Clear-sky data assimilation → (mainly) info on temperature, humidity

All-sky data assimilation (as developed for ICON-KENDA) → (mainly) info on cloud

- Infrared (**IR**) water vapour (**WV**) radiance (as brightness temperature BT)

  Annika Schomburg,

  Liselotte Bach, Christina Stumpf, Christoph Schraff, Roland Potthast, Robin Faulwetter,

  Christina Köpken-Watts, Thorsten Steinert, Hendrik Reich, Thomas Deppisch, Felix Fundel, et al.

- Visible (**VIS**) reflectance

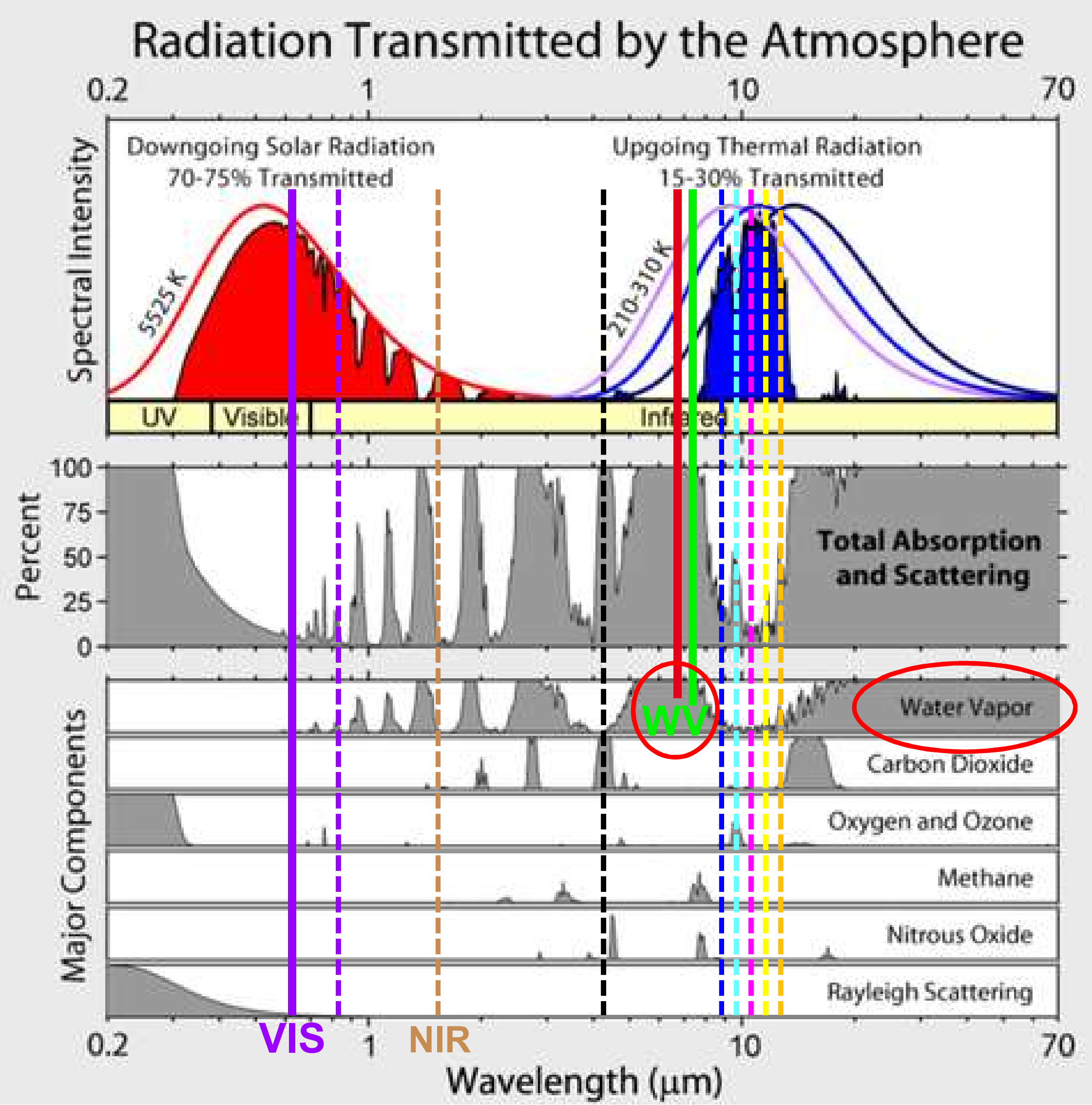
  Lilo Bach, Thomas Deppisch,

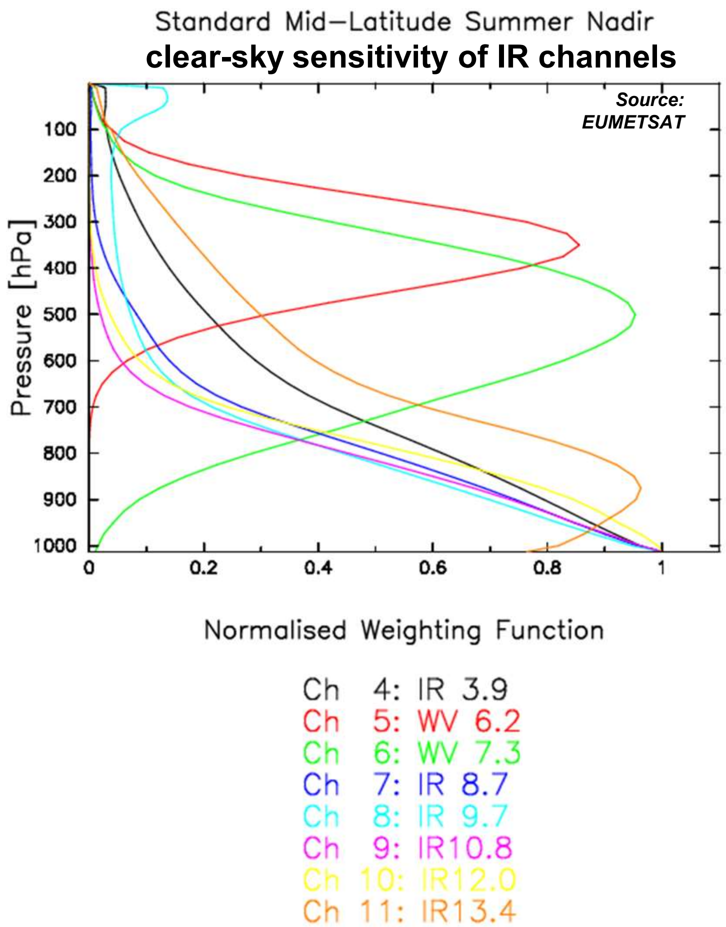
  Christina Stumpf, Leonhard Scheck, Robin Faulwetter, Michael Bender, Annika Schomburg,

  Christina Köpken-Watts, Christoph Schraff, Alberto de Lozar, Thomas Kratzsch, Roland Potthast,…

All-sky assimilation of SEVIRI data:
Available channels (on Meteosat MSG)

Deutscher Wetterdienst
DWD





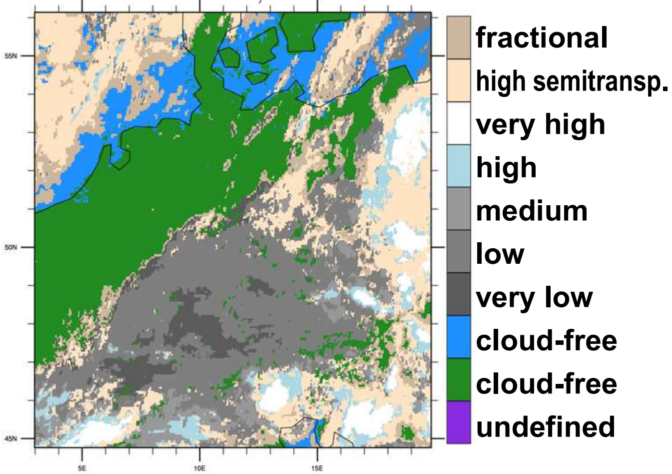
All-sky assimilation of SEVIRI IR **WV** radiances: Available channels

Deutscher Wetterdienst

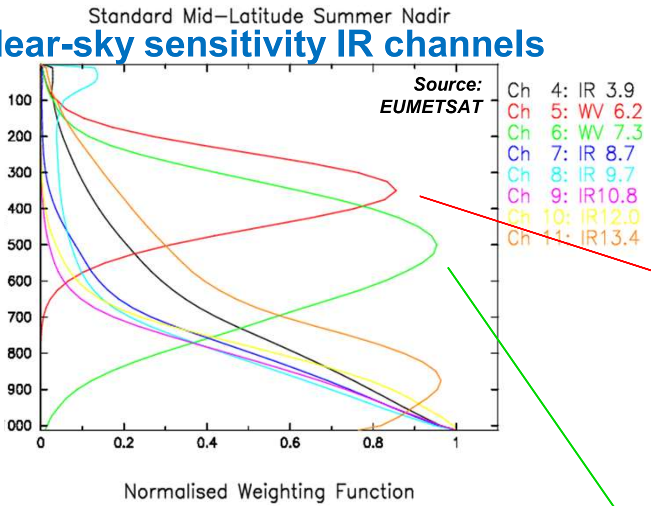
DWD

cloud classification

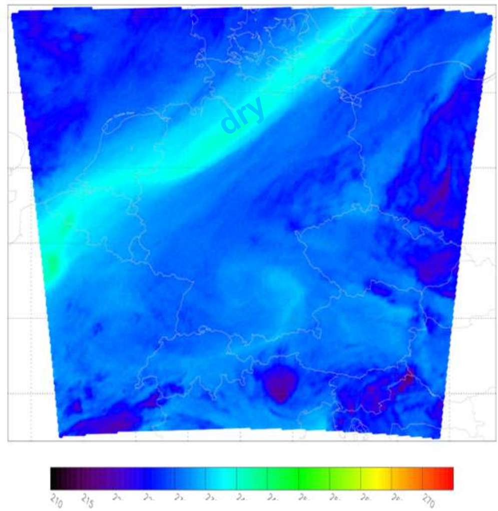
at 1 June 2011, 18:00 UTC



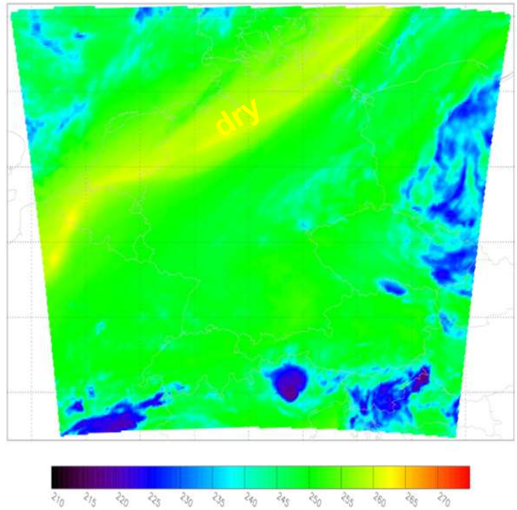
clear-sky sensitivity IR channels



WV6.2



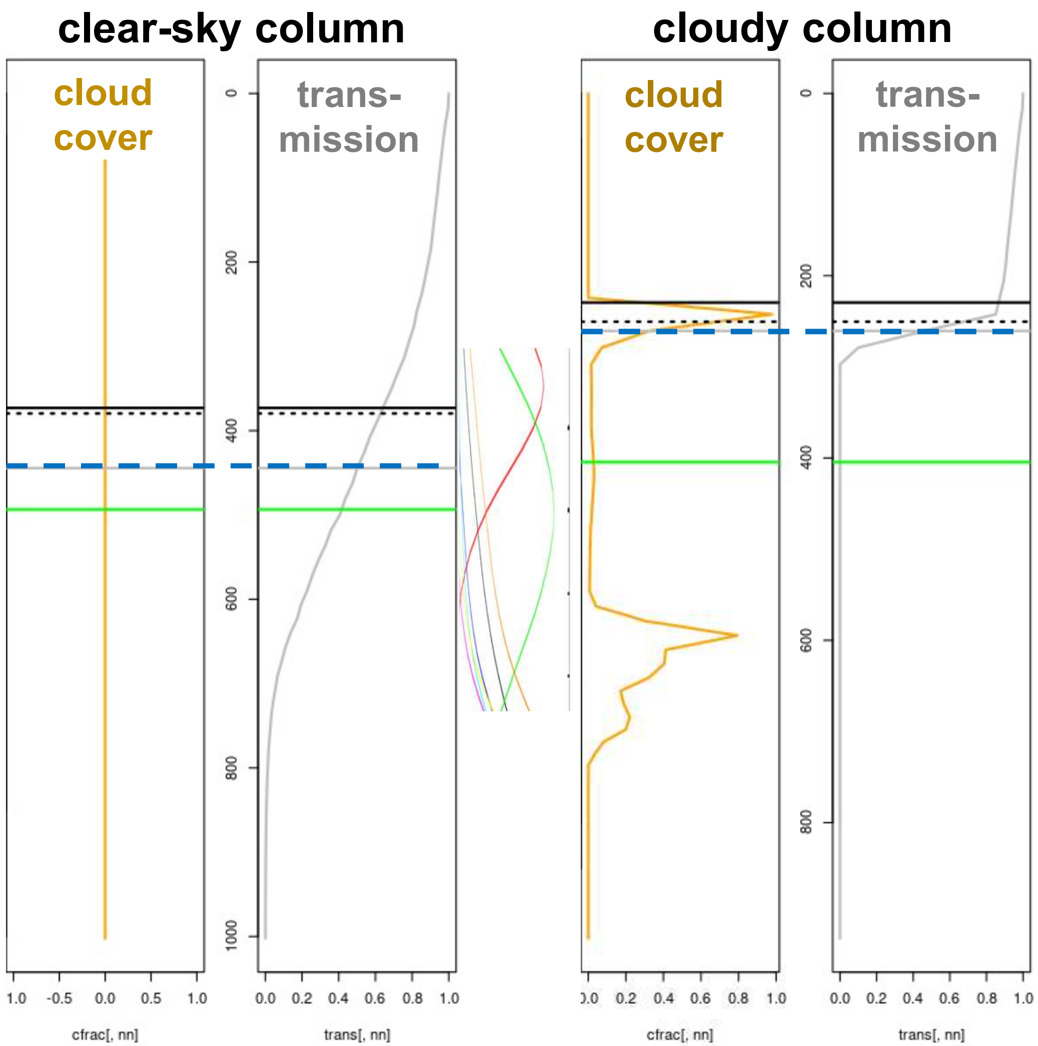
WV7.3



IR WV channels mainly sensitive to:

- high + mid-level cloud : large obs increments (up to ~20 K)
- water vapour : smaller observation increments (few K)
  (above cloud, upper / middle troposphere)
- available day + night

vertical height assignment: examples (WV7.3)



- assigned height where transmission = 0.5
- by this approach, assigned height is different for each ensemble member
- in LETKF, choose max. height from all members
  (→ highest cloud, max. sensitivity, max. obs. increment)
- in experiments so far, slightly different height assignment applied

All-sky assimilation of SEVIRI IR WV radiances: Impact experiments

experimental setup

- all-sky
- no bias correction
- observation error: constant 6 K for both channels
  $\rightarrow$ very small influence of clear-sky WV info
- thinning: every 4th pixel (in both horiz. directions) ; 1 scan per hour
- 3 – 25 August 2020 (23 days)
- **REF** : like operational ICON-D2 (obs incl. 3-D radar, T2M + RH2M, LHN)
  seviriWV : REF + all-sky WV

All-sky assimilation of SEVIRI IR **WV** radiances: Impact experiments

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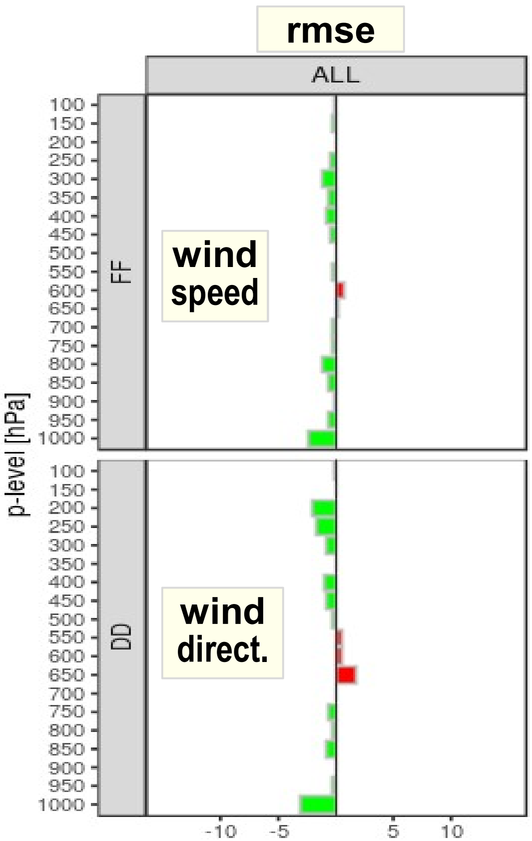
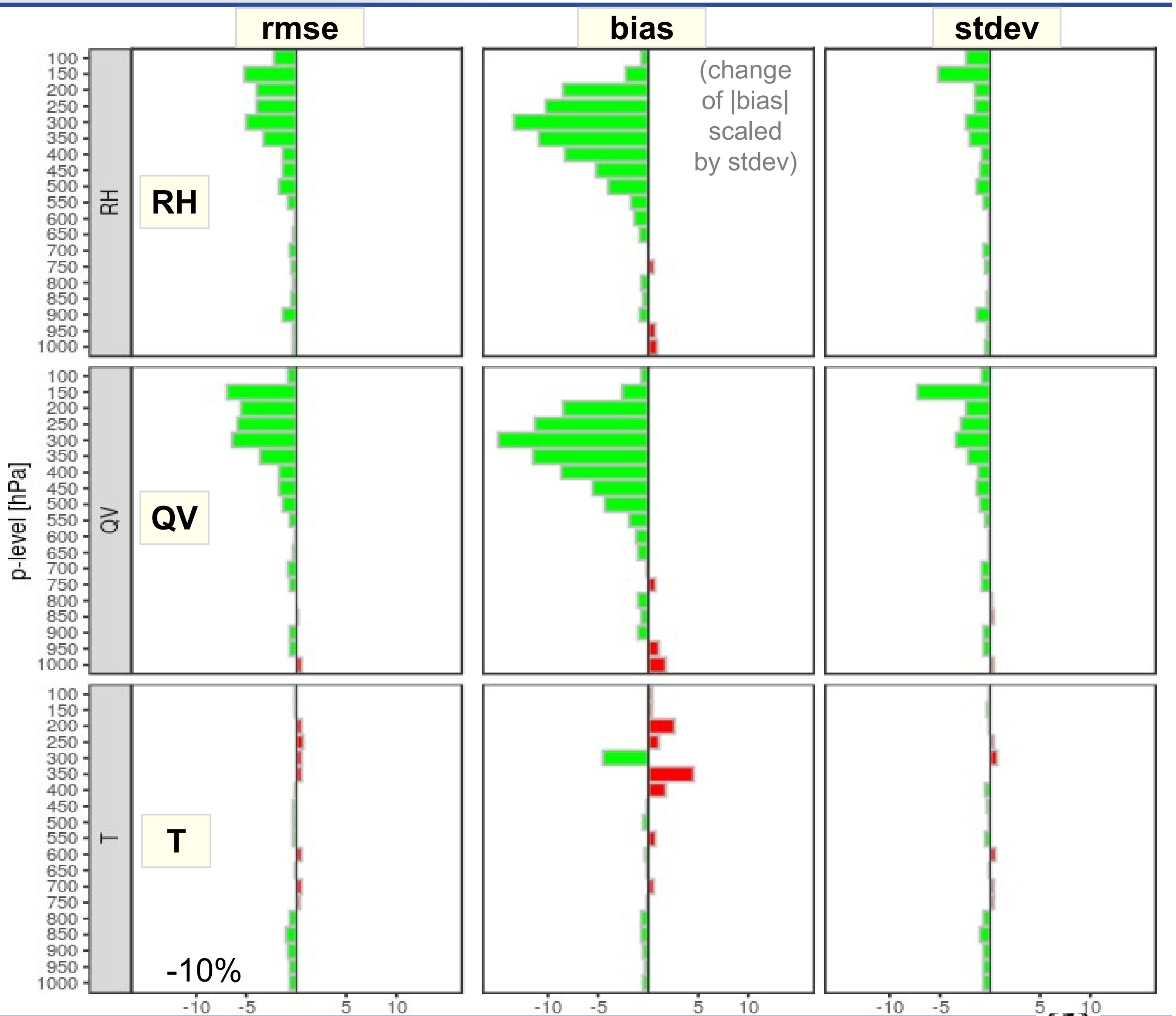
radiosonde verification:
% change

REF better
seviriWV better





All-sky assimilation of SEVIRI IR WV radiances: Impact experiments

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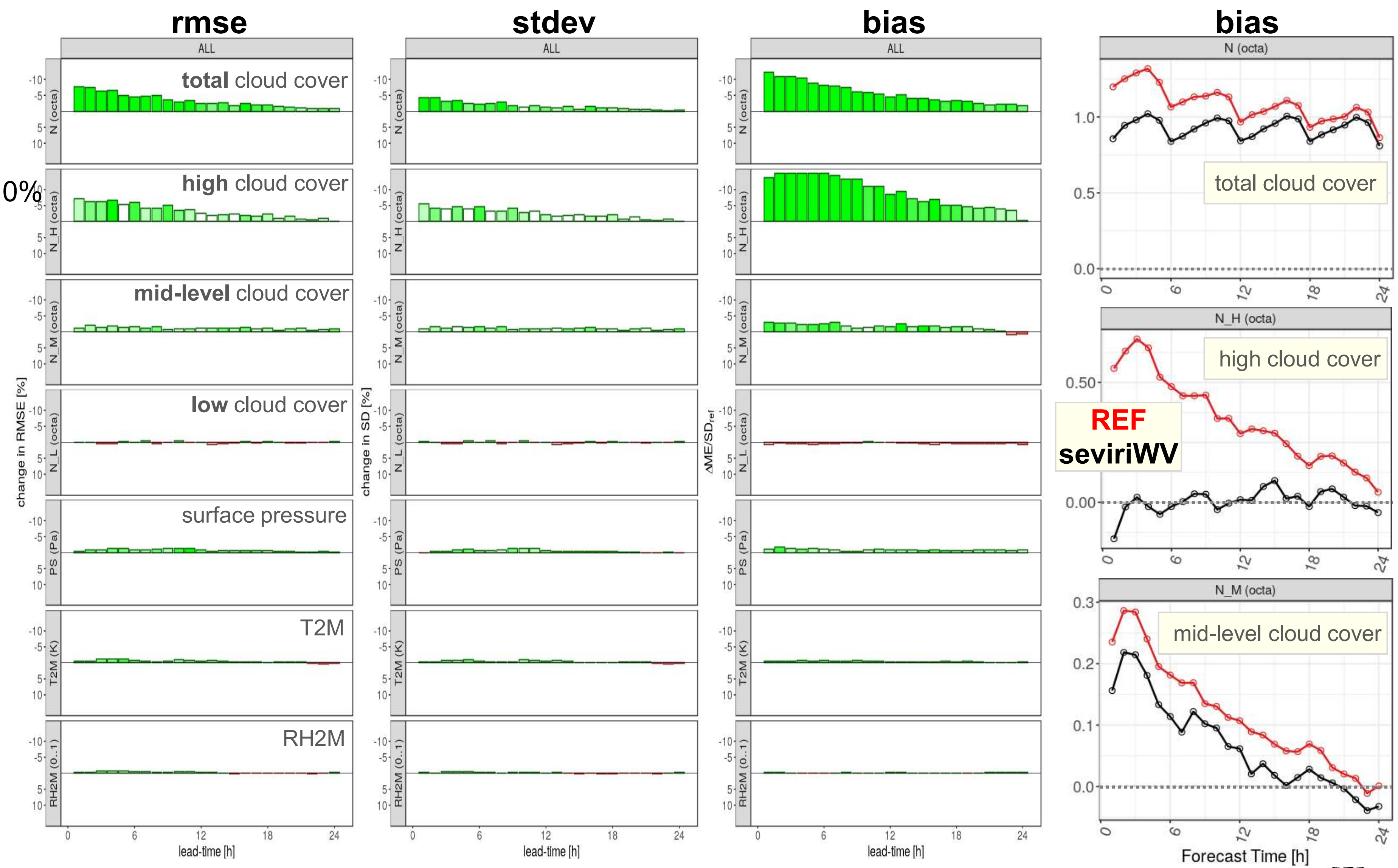

All-sky assimilation of SEVIRI IR WV radiances: Status & next steps

assimilation of all-sky SEVIRI WV brightness temperature in ICON-D2:

- strong positive impact on upper-level humidity + high cloud (mid-level cloud),
  mostly due to a systematic overestimation of high-cloud in first forecast hours,
  which is corrected by SEVIRI radiances
- small positive impact also on other variables (incl. precip), no show stopper
- recent experiment with revised specification of observation error
  (smaller for cloud-free, larger for large cloud impact, i.e. better matching mean |O – FG|) :
  further slight improvement, to be further revised
- bias correction
- observation operator: slant path, super'modding'
- test further periods, combination with SEVIRI VIS

All-sky assimilation of SEVIRI **VIS** reflectance: Introduction

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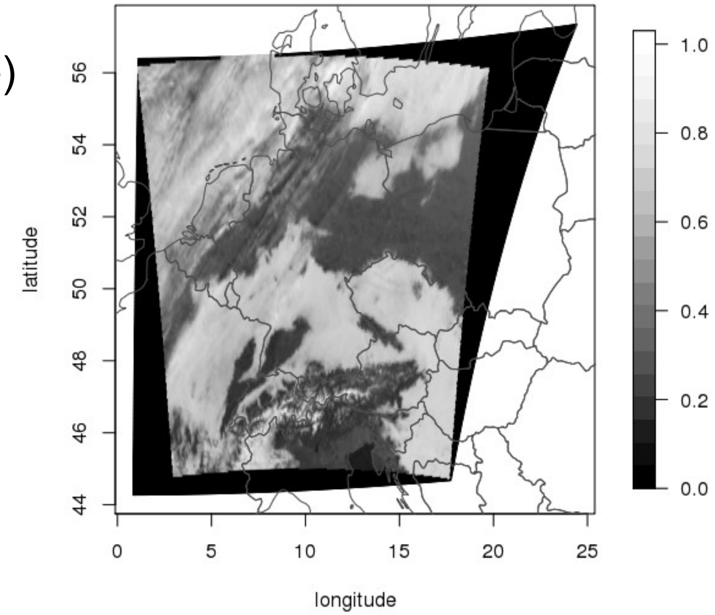
- Observations
  - imager channel in the visible spectral range (0.6 µm)
  - SEVIRI instrument on geostationary MSG (0°/0°)
    horizontal resolution: 6 km x 3 km (Central Europe)



- What is reflectance?
  - percentage of solar irradiation that is reflected by clouds and the earth‘s surface
- Important characteristics
  - availability limited to day time
  - also sensitive to (surface albedo →) snow cover (Alps!), volcanic ash, Saharan dust

All-sky assimilation of SEVIRI **VIS** reflectance: Motivation

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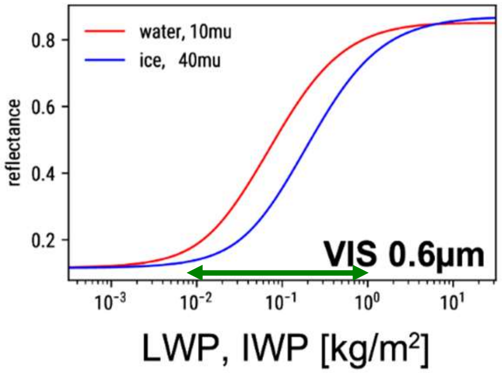
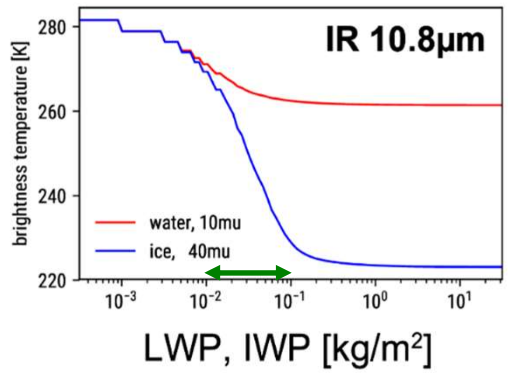
- Why assimilate VIS – how does **VIS** differ from **IR**?
  - sensitive also to low cloud / boundary layer clouds (convective initiation, low stratus)
  - sensitive to a much larger range of LWP / IWP than IR
    except for very small LWP / IWP
    (thin cirrus)
  - sensitive to cloud properties (VIS)
    - cloud water mass
    - cloud optical properties

    … and cloud positions,
    water vapour, surface albedo

    rather than to temperature-humidity mixture / cloud top temperature (IR)
  - no (direct) info on cloud top height; available only at daytime





- Which forecast impact can we expect / hope for?
  - cloud positions → convective initiation, precipitation; low stratus
  - cloud optical depth → solar radiation at surface → e.g. solar power forecasting
  - processes related to solar radiation, e.g. surface fluxes

- RTTOV-MFASIS observation operator
  - **fast** & accurate radiative transfer method MFASIS (Scheck, 2016)
    → DA in operations conceivable for the first time
  - Look-Up Table (LUT) approach; **vertical integrals** instead of vertical distribution

model variables

temperature
pressure / density
specific humidity
cloud ice
cloud water
cloud cover

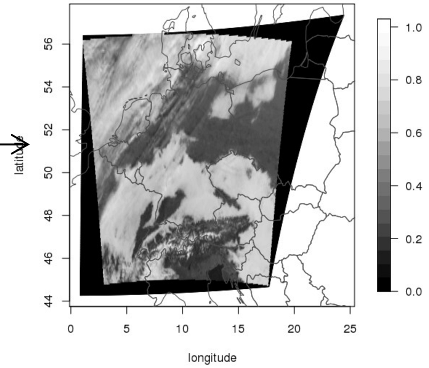
interface → **derive**

input for MFASIS

integrated optical thickness
effective particle radius
albedo (BRDF)
sun zenith angle
satellite zenith angle
scattering angle

RTTOV-MFASIS → **LUT**

simulated obs



  - treatment of cloud variables: avoid interpolation (nearest neighbor)
  - ongoing developments:
    - NIR channel,
    - aerosol (to be accounted for)
    - neural networks (instead of LUT)

All-sky assimilation of SEVIRI **VIS** reflectance: Bias issues

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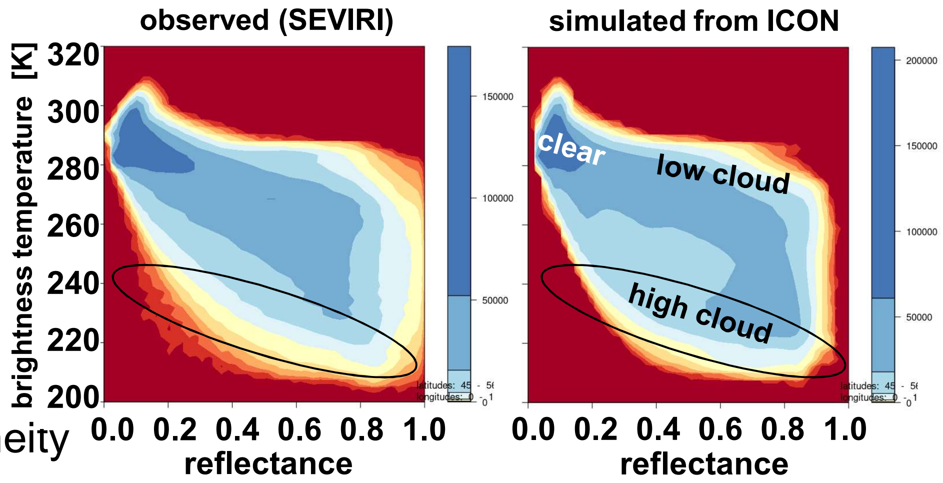
bias → differences in frequency distributions →



- inconsistencies (in climatologies) betw. observed and simulated reflectances

  e.g. due to inconsistent microphysical assumptions in ICON resp. MFASIS
  - vertical cloud overlap, horiz. heteorogeneity
  - effective radii (of cloud particles)

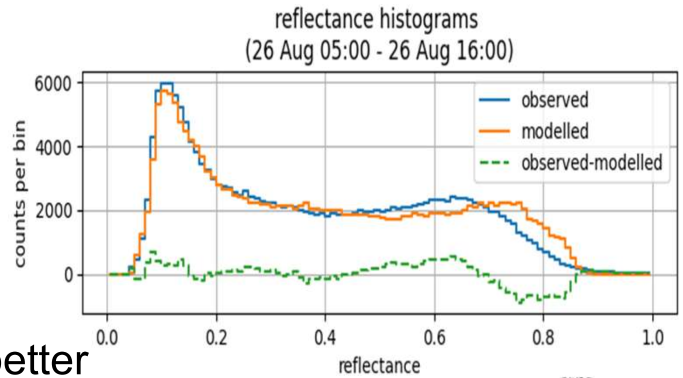
→ **consistence**: adapt ICON + MFASIS so effective radii from ICON microphysics (param in 1-mom. / predicted in 2-mom.) also used in ICON radiation + MFASIS

→ **adapt / tune ICON** vs. satellite obs, to get better cloud frequency distrib.

close (!) collab. w. physics experts

→ **calibration** (SEVIRI VIS 8 % too dark MODIS (ag. moon)
→ scale obs by 1.08

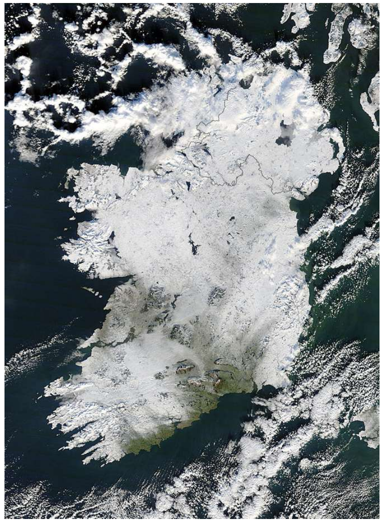
→ **bias correction** for conditional bias, polynomial in reflectance (weighted by sun zenith angle)
→ apply small correction to every single simulated obs such that simulated and observed histograms match better



All-sky assimilation of SEVIRI VIS reflectance:
Impact experiments (all-sky) : setup

- quality control, e.g.:
  - sun zenith angle > 75°, obs > 1.5 rejected (missing 3-D effects)
  - snow cover, Saharan dust, volcanic ash flagged by NWC-SAF cloud mask (misinterpretation as cloud)

mixture of snow & clouds

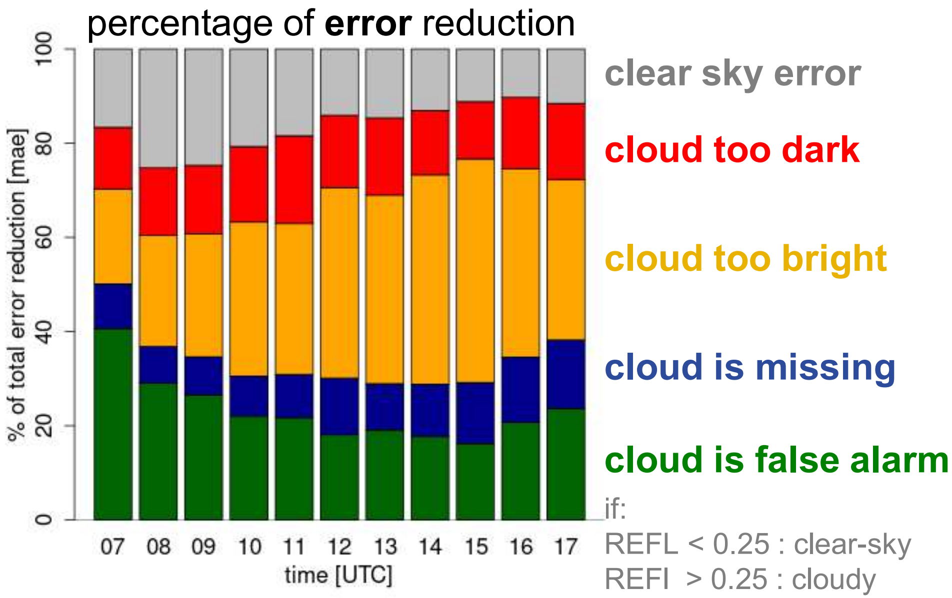


- calibration, no bias correction
- observation error: 0.2 (fixed)
- 1 scan per hour
- superobbing to 12 km (to balance number of remote sensing and conventional obs + to reduce representativity error & double penalty issues)
- no vertical localization (because no info on vertical position / extent of cloud from VIS)
- 3 – 26 August 2020 (24 days)
- **REF** : like operational ICON-D2 (w. cp/cv bug fix, ecRad; obs incl. 3-D radar, T2M + RH2M, LHN)

  seviriVIS : REF + all-sky VIS

first guess reflectance

→ MAE reduced by ~ 30 %

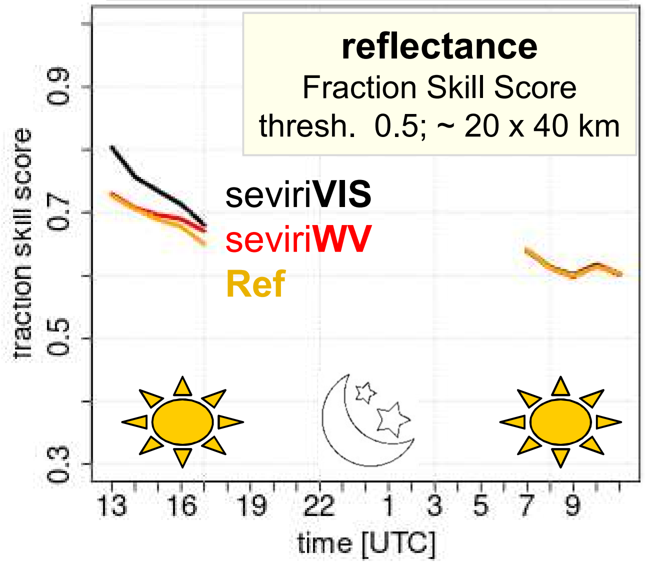


→ ambiguous reasons for errors,

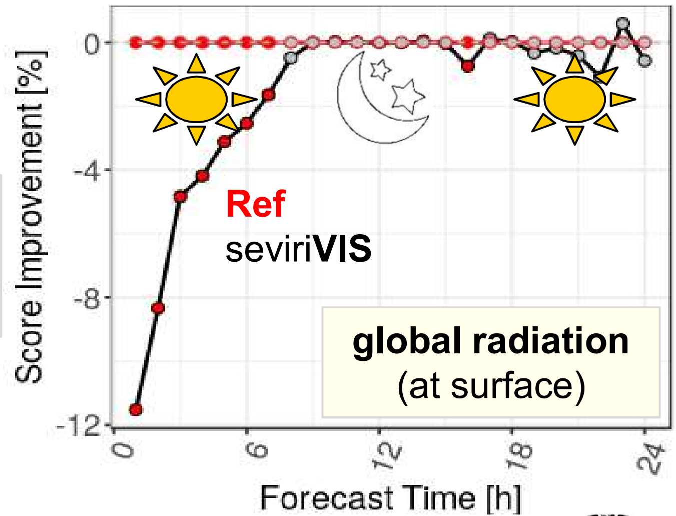
e.g. cloud too bright:
- wrong water phase (water)
- too much water mass
- too small particles
- too many particles

12-UTC forecast runs

FSS REFL



RMSE change [%]



All-sky assimilation of SEVIRI **VIS** reflectance:
Impact experiments (all-sky) : results

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summer 03 – 26/08/20

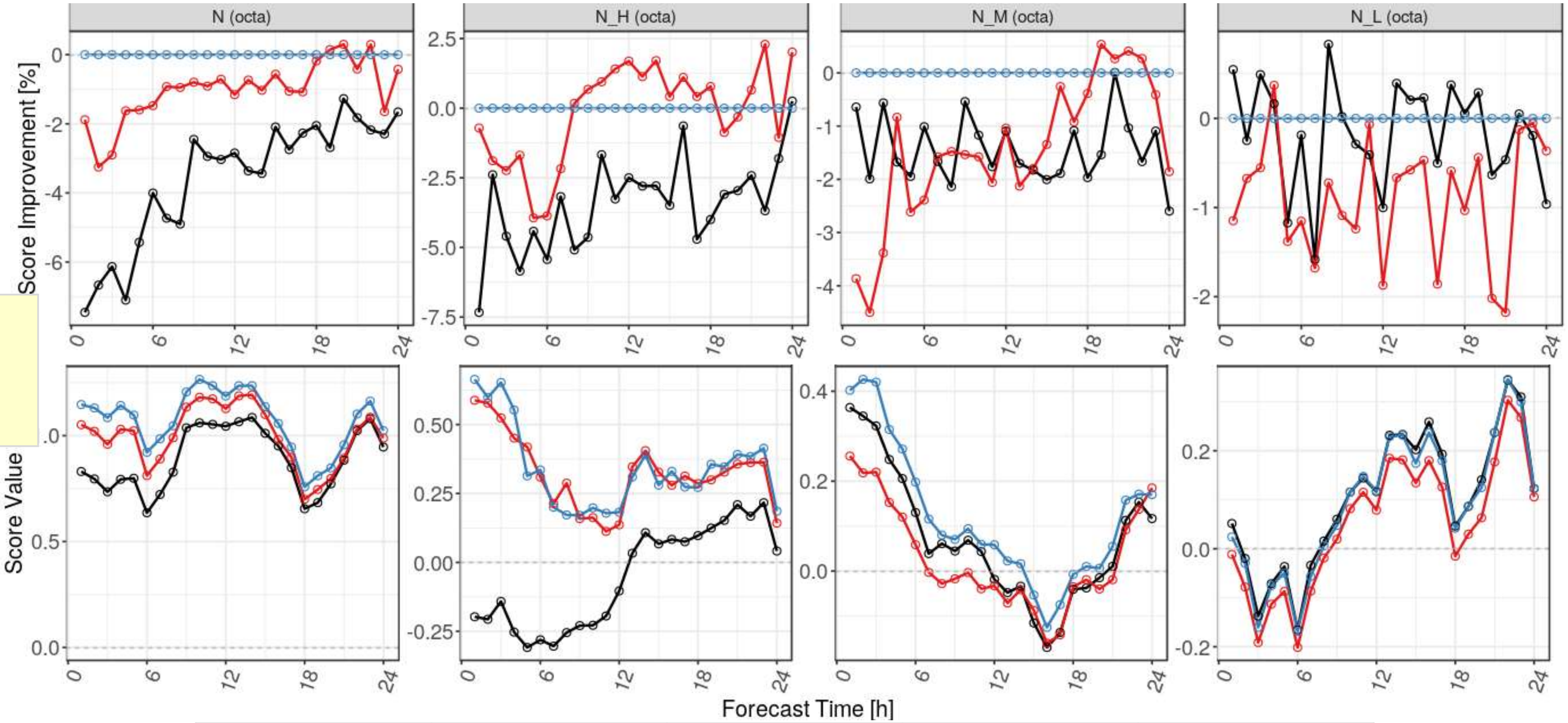
12-UTC forecast runs

total cloud cover	**high** cloud cover	**mid-level** cloud c.	**low** cloud cover

RMSE change [%]

I-D2 **Ref**
seviri**WV**
seviri**VIS**

BIAS



cloud	total	high	mid-level	low
VIS	+	(+)	+	(+)
IR-**WV**	++	++	(+)	0

assimilation of all-sky SEVIRI VIS reflectance in ICON-D2:

- positive impact on reflectance, (mid-level + low) cloud, global radiation + other surface variables (T2M, RH2M) in 12-UTC forecast runs

- little impact on other variables (incl. precip) and in 0-, 6-, 18-UTC forecast runs

- results depend highly on consistency betw. simulated and observed reflectance histograms and on model version

  → further work on bias correction, tuning, experiments …

- introduction in SINFONY-RUC & ICON-D2 parallel suites pursued in near future

Task 2.6: Ground-based remote sensing: **Microwave Radiometer (MWR)**

Deutscher Wetterdienst

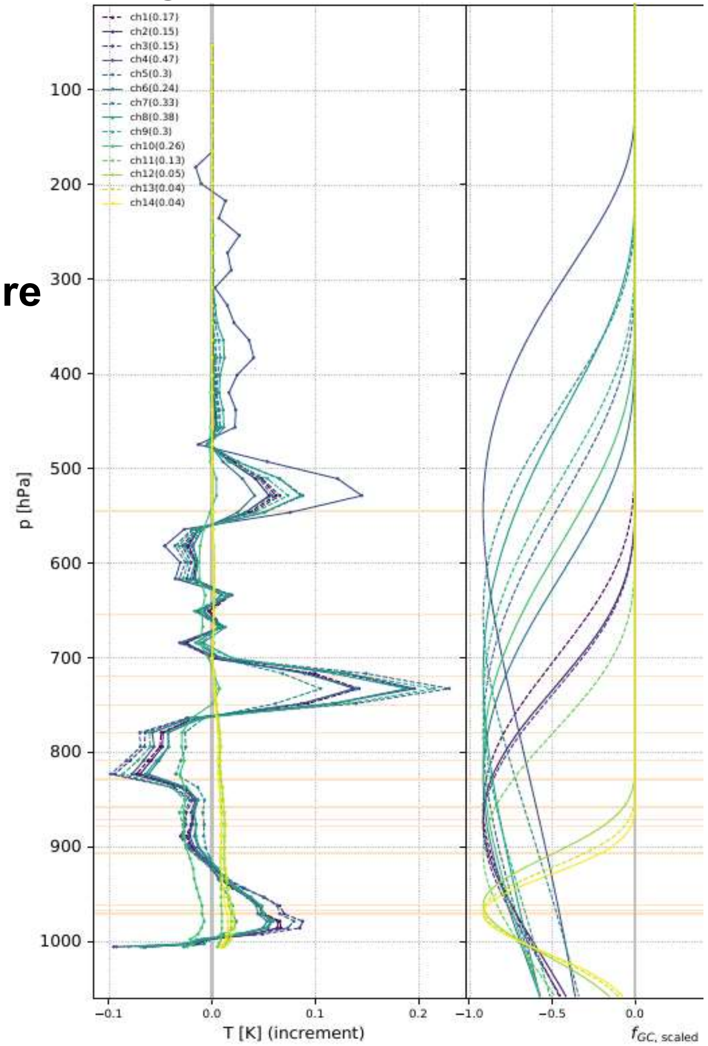
DWD

MeteoSwiss: ***Claire Merker,*** *Daniel Leuenberger, Alexander Haefele, Maxime Hervo, Marco Arpagaus*

DWD: ***Jasmin Vural,*** *Moritz Löffler, Christine Knist, Annika Schomburg*

- 3 MWR in Swiss Plateau, 1 at Lindenberg (DE)
- passive remote sensing instrument
- **brightness temperature**, directly assimilated:
  - **7** V-band channels (51.26 - 58.0 GHz): mainly **temperature**
    7 K-band channels (22.24 - 31.4 GHz): mainly **humidity**

  in **low – mid troposphere**



status

- assimilation experiments ongoing
- errors partly reduced in observation space (vs. MWR) but impact in synop / radiosonde verif mixed – negative

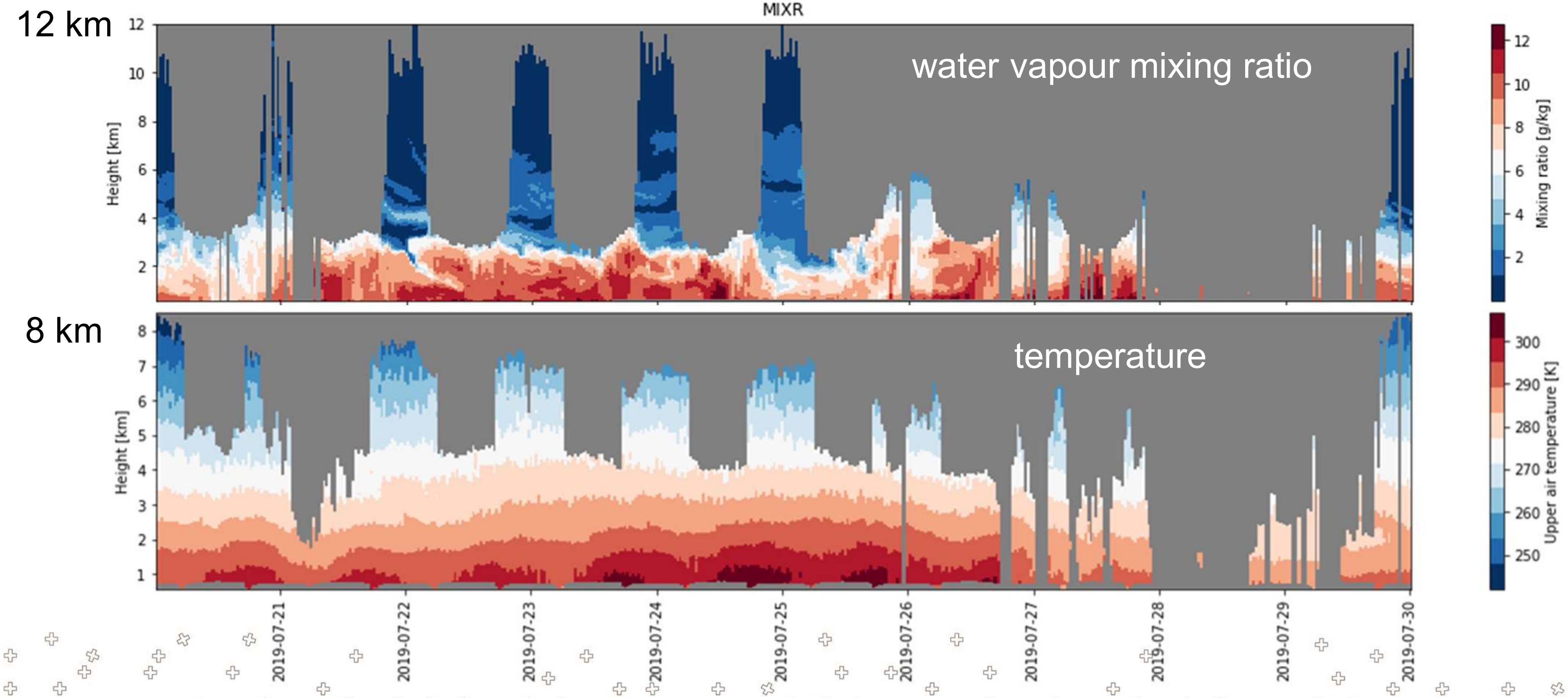
→ tune observation error variances

→ use less channels (← interchannel obs error correlations)

→ use new instruments with better quality

Bas Crezee, *Daniel Leuenberger, Giovanni Martucci, Alexander Haefele, Marco Arpagaus*

- vertical profiles of temperature + WV mixing ratio, averages over 30 min
- almost bias-free, only up to cloud base



Task 2.6: Ground-based remote sensing: **Raman Lidar** (at Payerne)

Deutscher Wetterdienst

DWD

Bas Crezee, *Daniel Leuenberger, Giovanni Martucci, Alexander Haefele, Marco Arpagaus*

forecast impact in trial 20 – 30 July 2019 (obs error: 1 K ; 1 g/kg)

	First Guess (FG)		**Forecast**
	Surface	Profile (PAY only)	Surface
Temperature	neutral	better	neutral
RH / TD	better	better < 600hPa	better
Radiation / Cloud Cover	worse	-	worse
Brightness Temperature	-	Moisture-sensitive channels better	-
Precip	-	-	better

next steps:

- obs error tuning (Desroziers stats)
- further tests / seasons