Update on the KENDA project

Deutscher Wetterdienst DWD

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… and many colleagues from CH, D, I, ROM, RU

- **K**m-scale **EN**semble-based **D**ata **A**ssimilation : COSMO priority project
- Local Ensemble Transform Kalman Filter (LETKF) system being developed

This talk:

- brief overview on status of KENDA
- assimilation of SEVIRI-derived cloud top height in LETKF (Annika Schomburg)

KENDA: brief overview

experiment chain in NUMEX set up

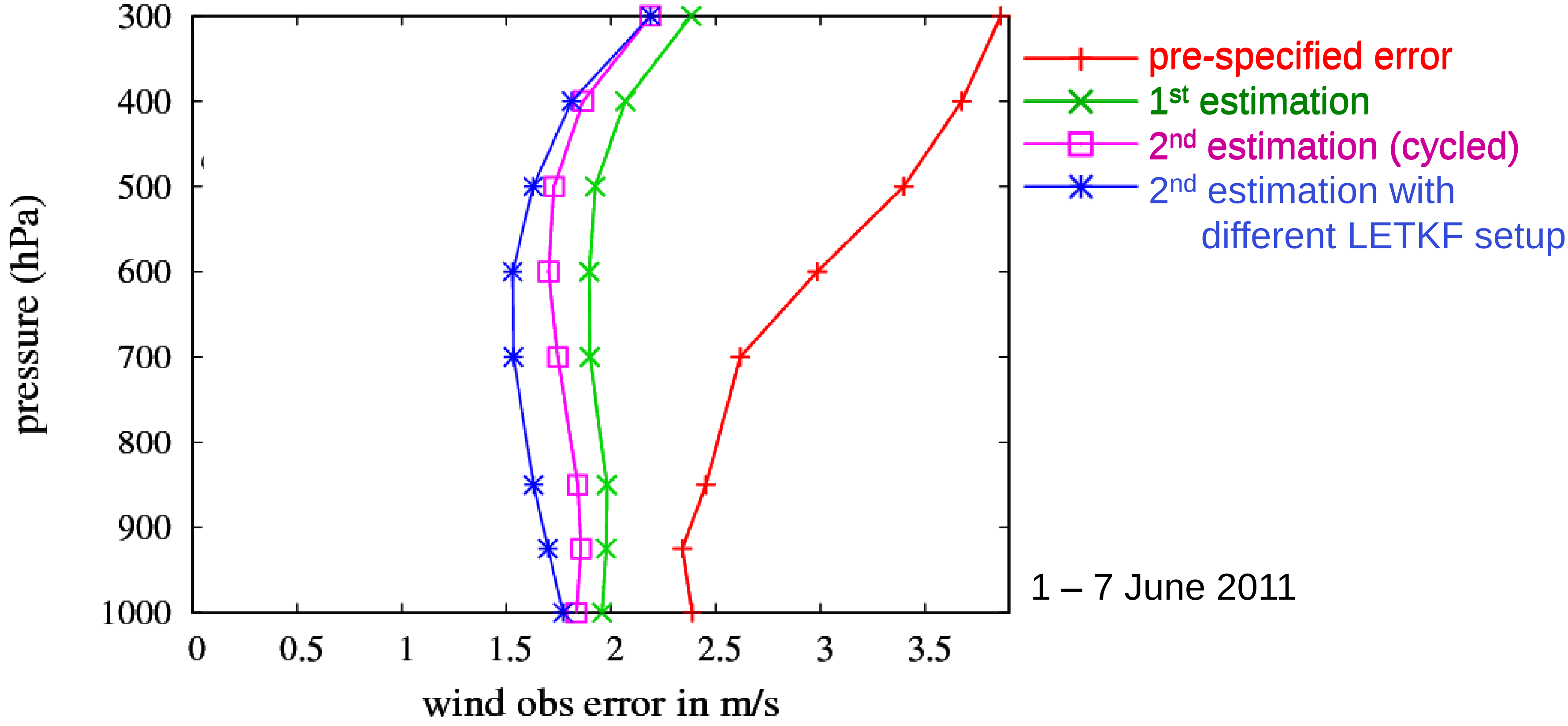
- Δx = 2.8 km ; perturbed lateral BC from GME LETKF experiment
- 1-hourly cycling, radiosonde, aircraft, wind profiler, synop;   40 ens. members
- assimilation only,   should take ~ 1 real day for 1 day of assimilation,
  but in fact: ~ 1 – 4 real months for 1 week of assimilation !
  (without forecasts !!)   (← slow archive)
  → only 3 experiments so far

→ new flexible stand-alone scripts to run LETKF experiments without using NUMEX / archive
  → 1 real day for 1 day of LETKF assimilation
  → but very limited disk space

- being implemented: evaluation / verification tools in script suite
- may become very suitable tool for users outside DWD (academia)

→ (almost) no interesting new results yet to show

- offline **adaptive** estimation of **obs errors** in observation space



→ fairly good convergence

→ fairly weak dependence on LETKF setup

KENDA:
brief overview

- testing of LETKF started at MeteoSwiss, ARPA-SIM (Bologna)
- stochastic perturbation of physics tendencies (SPPT) :
  $\rightarrow$ small, but consistent positive impact on LETKF assimilation cycle

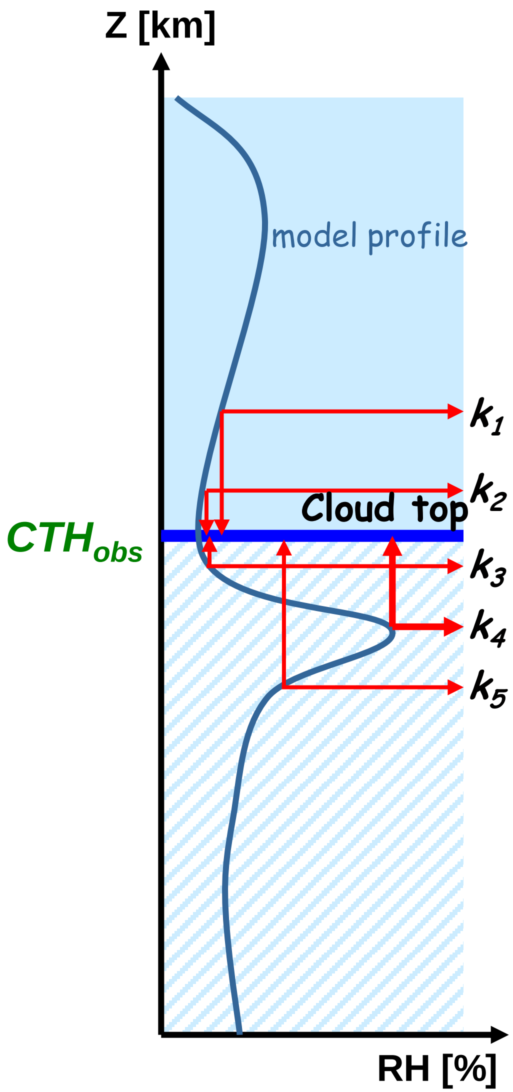
LETKF: high-resolution obs

- **Radar :** direct use of 3-D radial winds v_r and reflectivity Z
  - obs operators finished, assimilation works technically
  - need to test thinning / superobbing strategies

- **direct assimilation of SEVIRI radiances (window channels for cloud info)**
  - technically implemented (obs operator (RTTOV), reading / writing)
  - work on monitoring / assimilation start in Nov. 2013

- **(SEVIRI-based, radiosonde-corrected) cloud top height (CTH) product (NWC-SAF) :** → see next slides (Annika Schomburg)

use of (SEVIRI-based) cloud top height (CTH) 'observations' in LETKF: method



if cloud observed with cloud top height ***CTH_{obs}***,
what is the appropriate type of obs increment ?

- avoid too strong penalizing of members with high humidity but no cloud
- avoid strong penalizing of members which are dry at $\boldsymbol{CTH_{obs}}$ but have a cloud or even only high humidity close to $\boldsymbol{CTH_{obs}}$

→ search in a vertical range Δh_{max} around $\boldsymbol{CTH_{obs}}$ for a 'best fitting' model level *k*, i.e. with minimum 'distance' *d*:

$$d = \min_k \sqrt{(f(RH_k) - f(RH_{obs}))^2 + \frac{1}{\Delta h_{\max}} (h_k - CTH_{obs})^2}$$

function of relative humidity

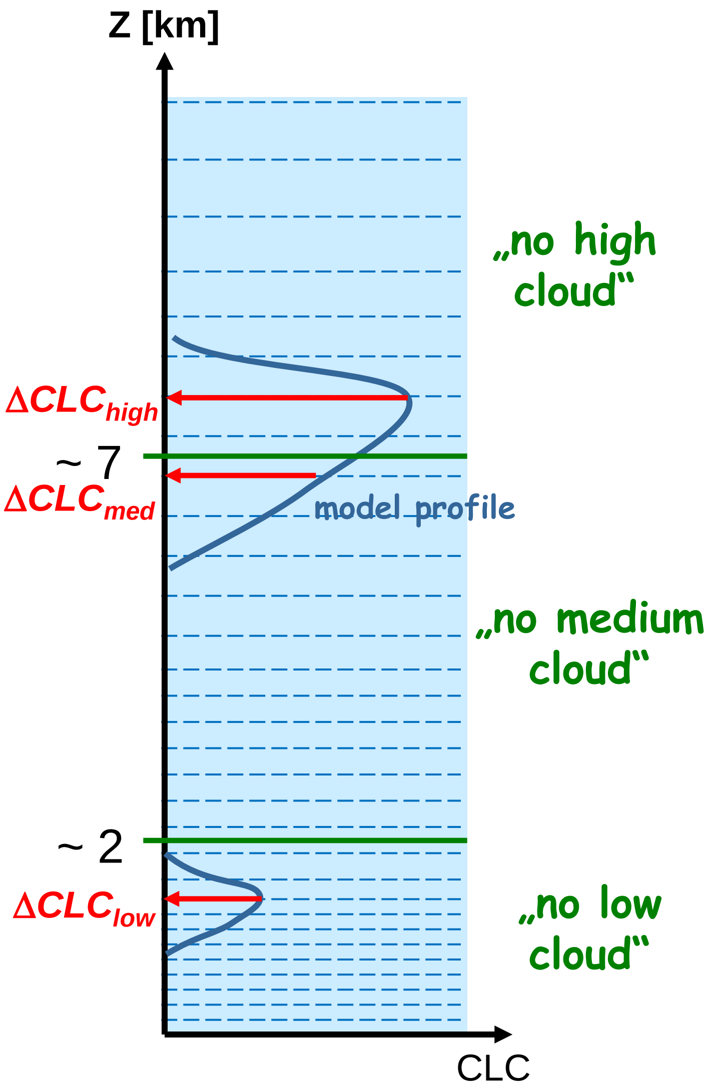
= 1

height of model level *k*

(if above a layer with cloud fraction > 70 %, then choose top of that layer)

- use $f(RH_{obs}{=}1) - f(RH_k)$ and $CTH_{obs} - h_k$ as 2 separate obs increments in LETKF

use of (SEVIRI-based) cloud top height (CTH) ‘observations’ in LETKF: method



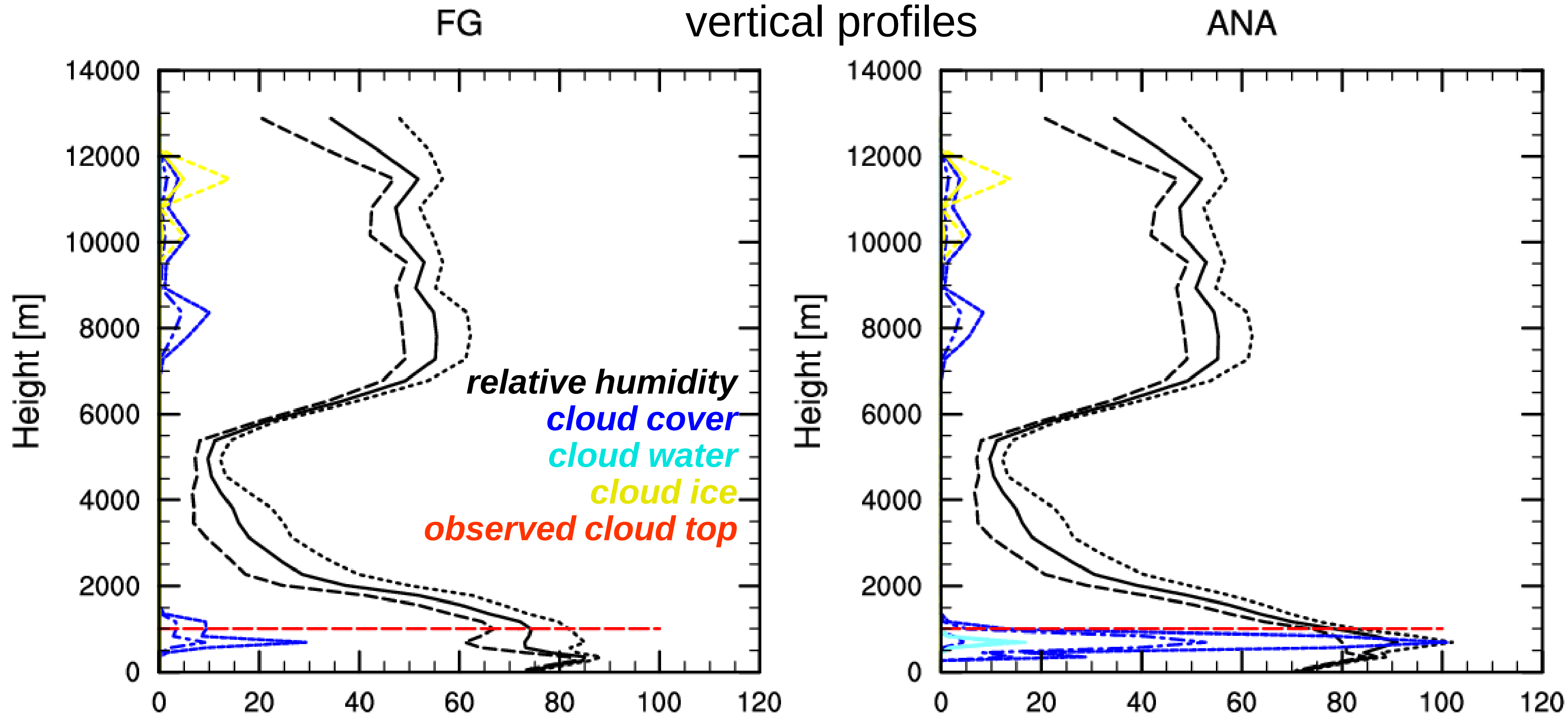
type of obs increment ,
if **no cloud** observed ?

- assimilate cloud fraction ***CLC_{obs}* = 0** separately for high, medium, low clouds
- model equivalent: maximum CLC within vertical range

CTH single-observation experiments

- 1 analysis step ,   17 Nov. 2011, 6 UTC (wintertime low stratus)
- example: missed cloud event

vertical profiles

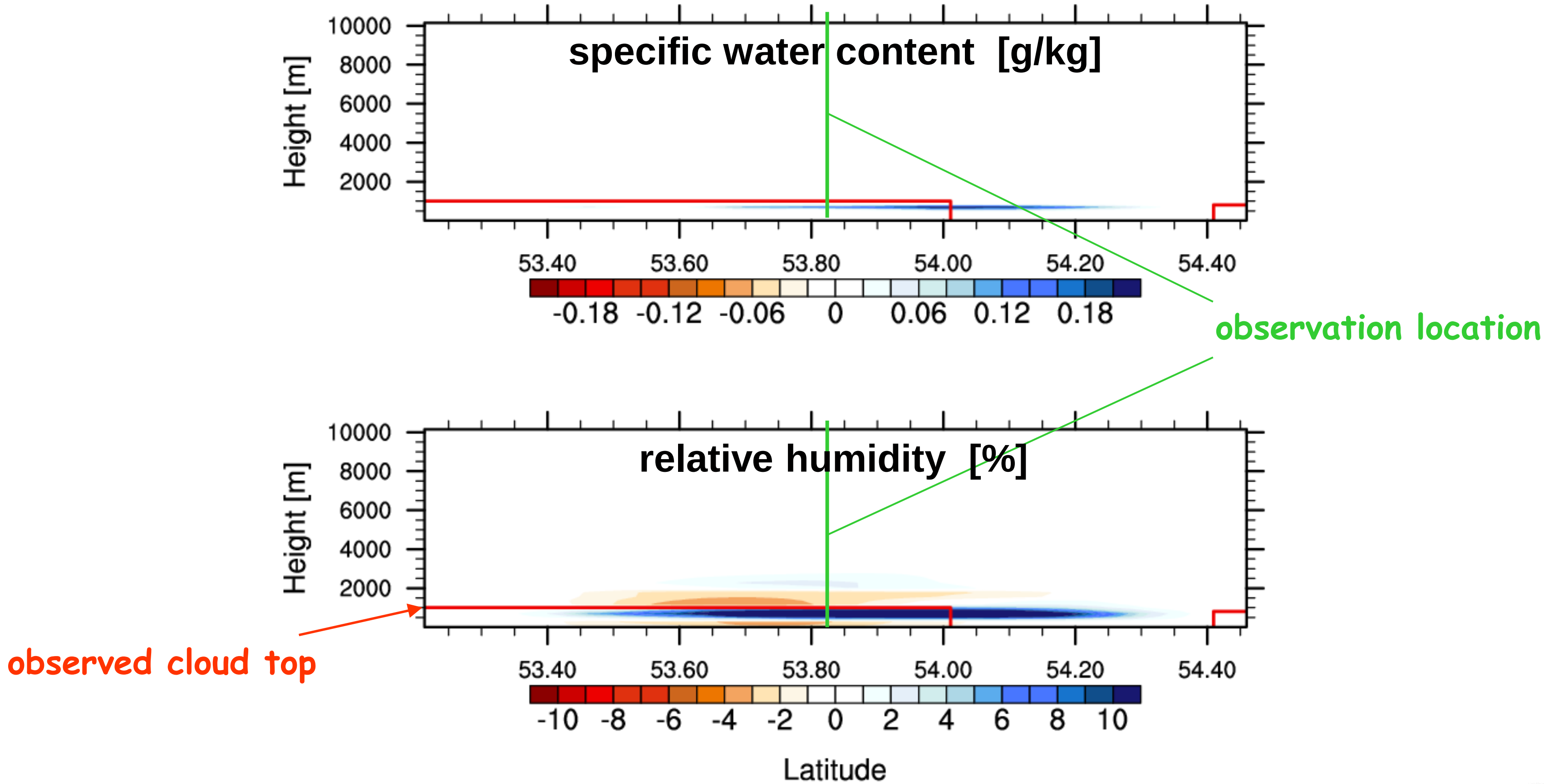


3 lines on one colour indicate ensemble mean and mean +/- spread

CTH single-observation experiments

- example: missed cloud event

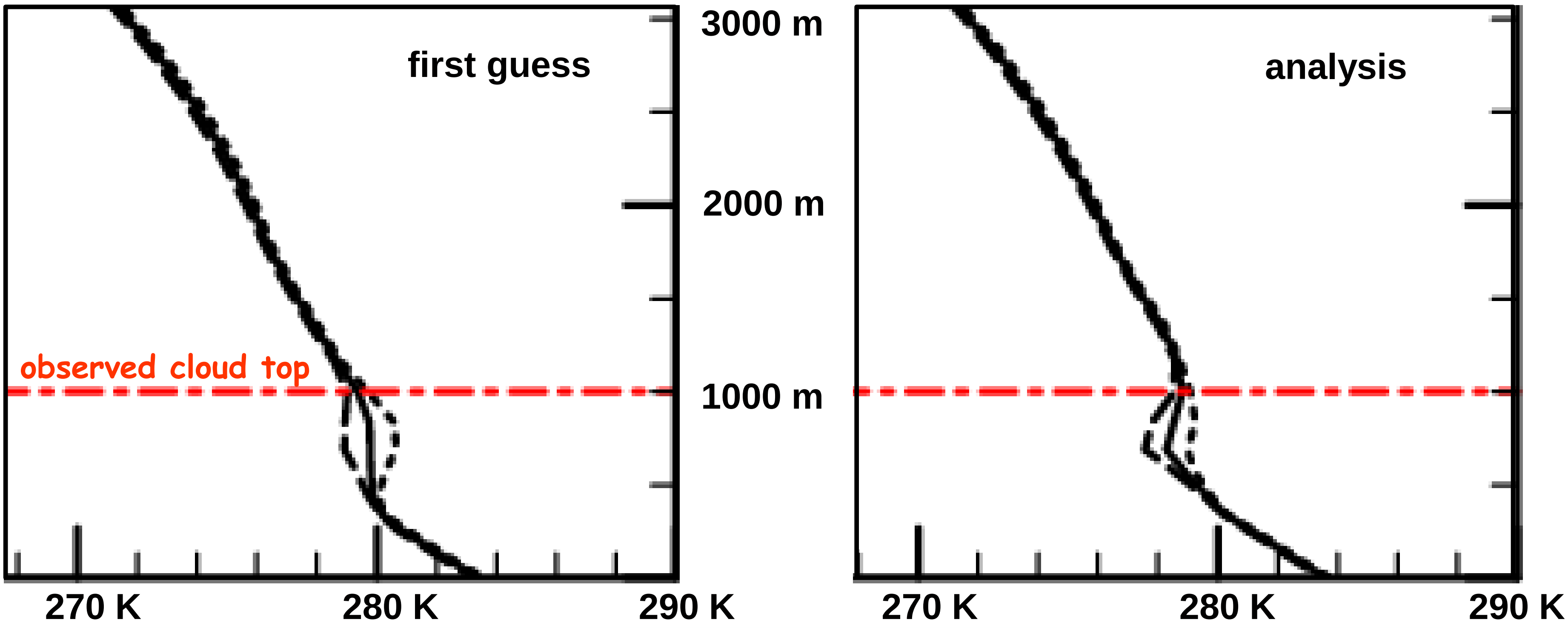
cross section of analysis increments for ensemble mean



CTH single-observation experiments

- example: missed cloud event

temperature profile (mean +/- spread)

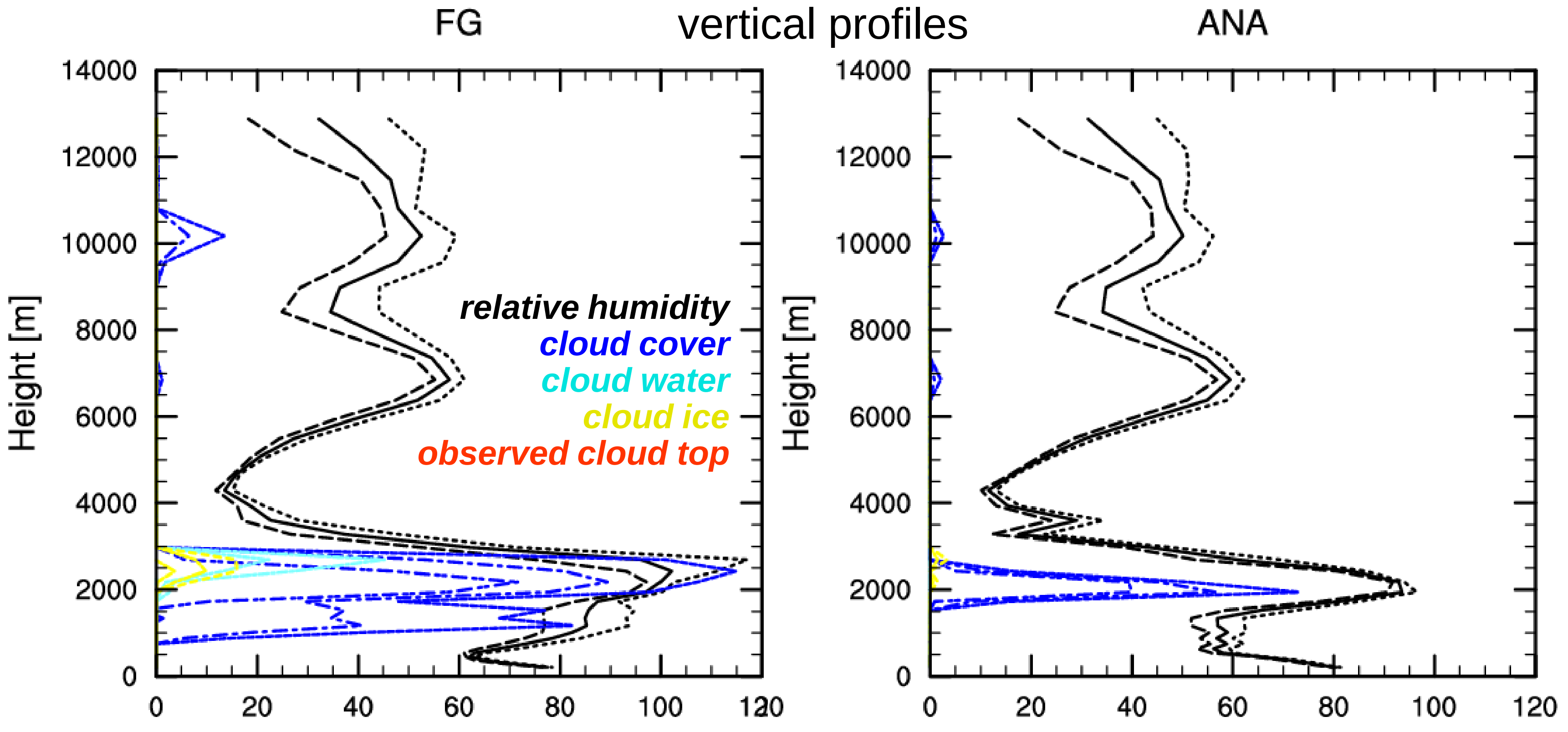


→ LETKF introduces inversion due to **RH(CTH) – T** cross correlations in first guess ensemble perturbations

CTH single-observation experiments

- example: false alarm cloud → assimilated quantity: cloud fraction (= 0)

vertical profiles

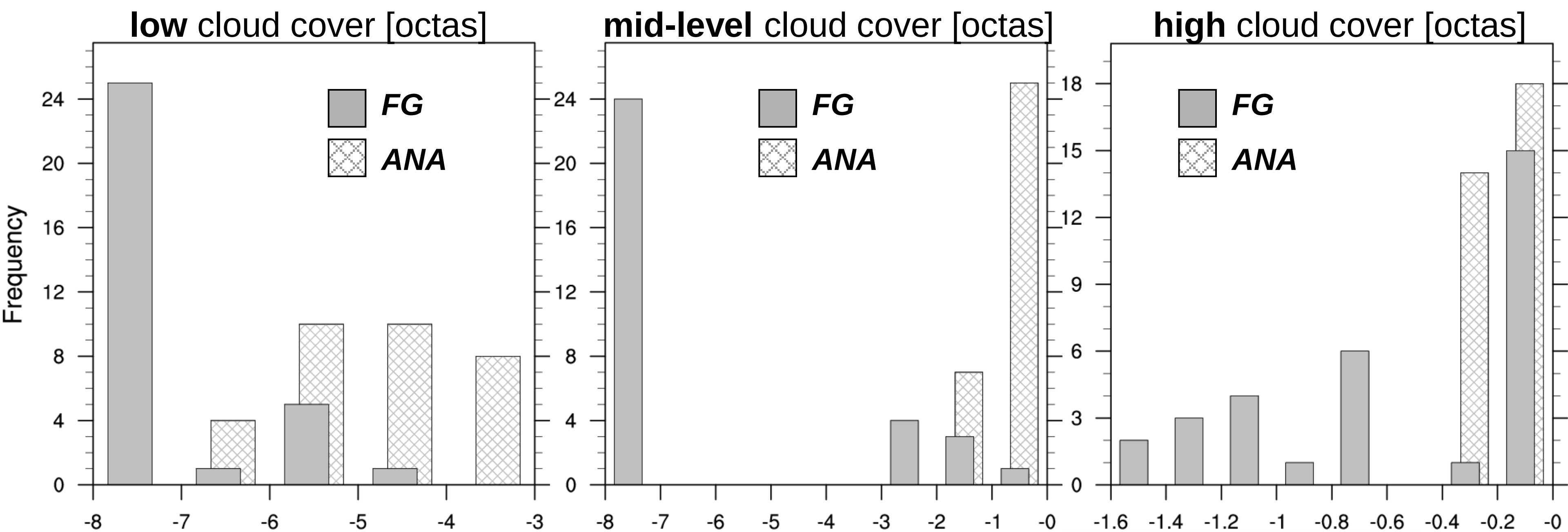


3 lines on one colour indicate ensemble mean and mean +/- spread

CTH single-observation experiments

- example: false alarm cloud → assimilated quantity: cloud fraction (= 0)

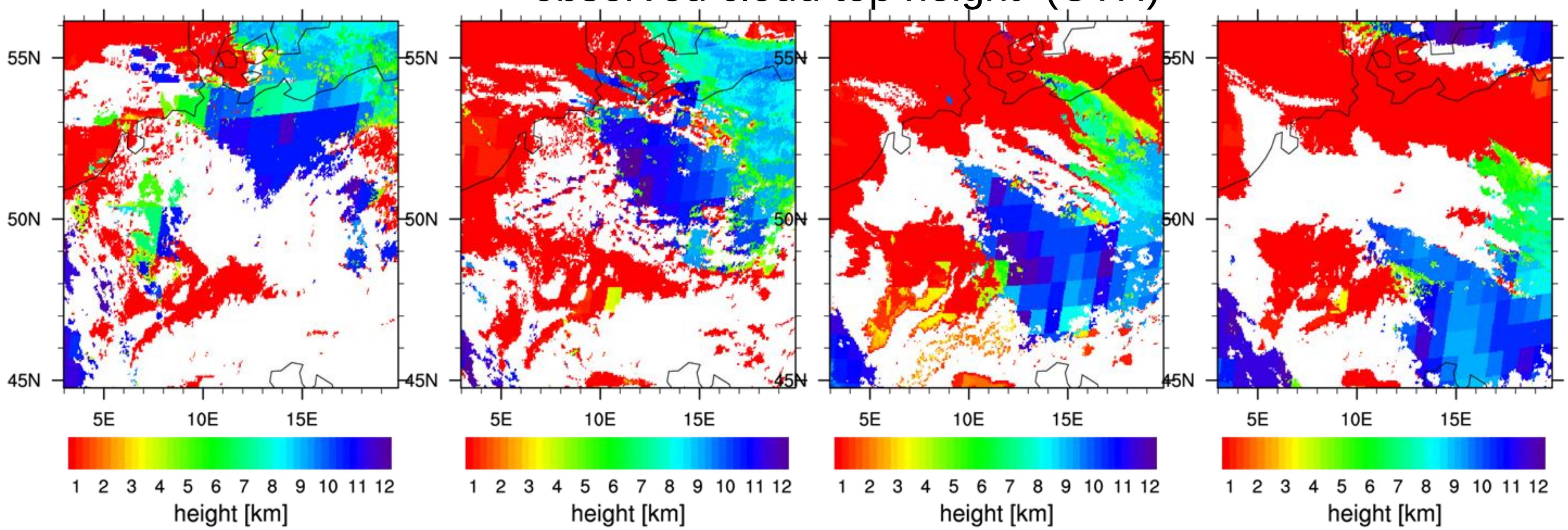
observation increments - histogram over ensemble members



→ LETKF decreases erroneous cloud cover despite very non-Gaussian distributions

1-hourly cycle over 21 hours, 13 Nov., 21 UTC – 14 Nov. 2011, 18 UTC
(wintertime low stratus)

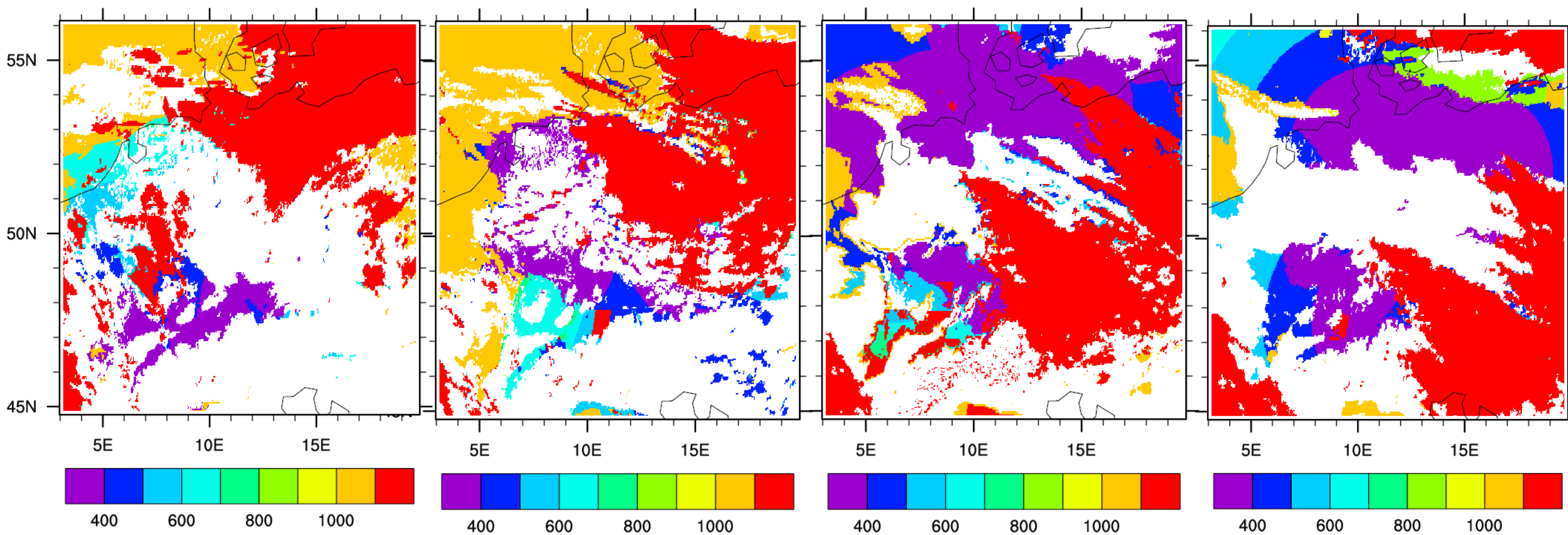
observed cloud top height (CTH)



0:00 UTC **6:00** UTC **12:00** UTC **17:00** UTC

cycled assimilation of dense CTH obs : LETKF setup

- thinning: use obs at every 5th grid pt.
- adaptive covariance inflation, adaptive localisation scale ($\rightarrow s_{loc}$ ~ 35 km)
- Observation error variances : relative humidity = 10 %
  cloud cover = 3.2 octa
  cloud top height [m] : ↓

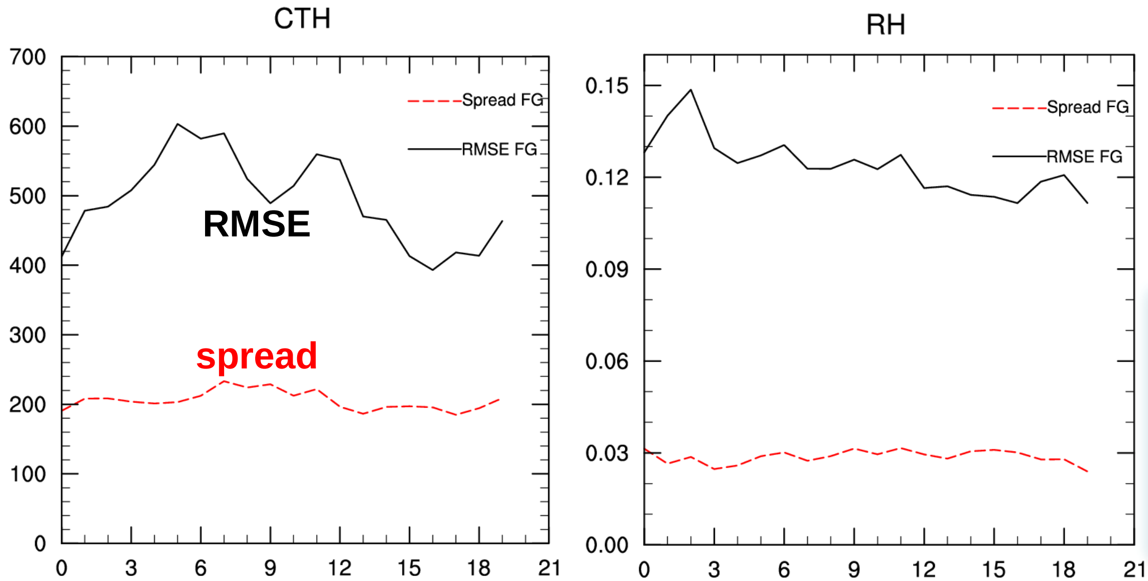


0:00 UTC **6:00** UTC **12:00** UTC **17:00** UTC

cycled assimilation of dense CTH obs

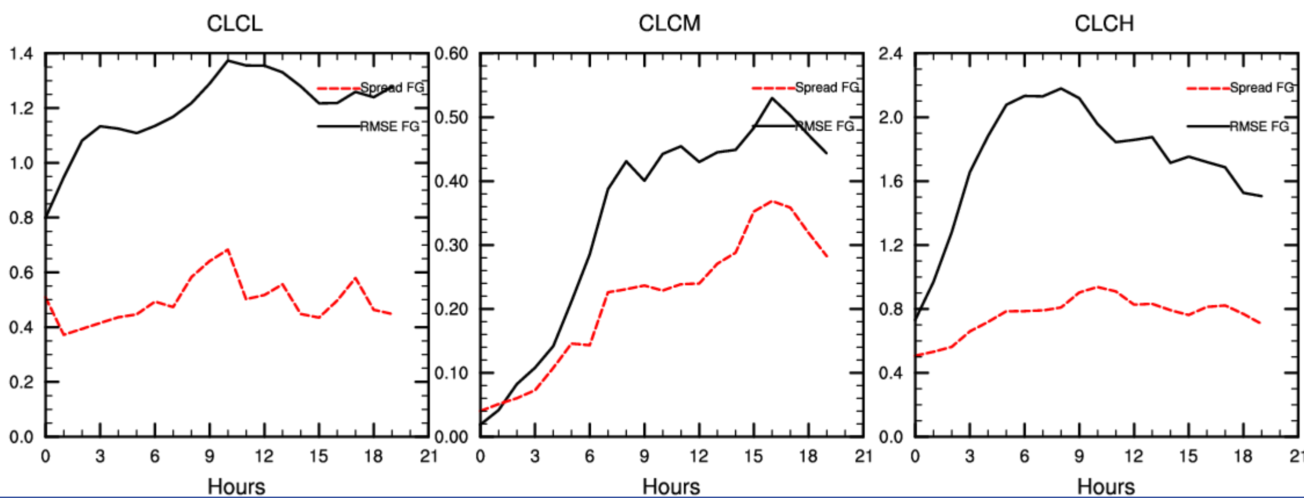
time series of first guess errors of ensemble mean / spread of ensemble

averaged over **cloudy** obs locations



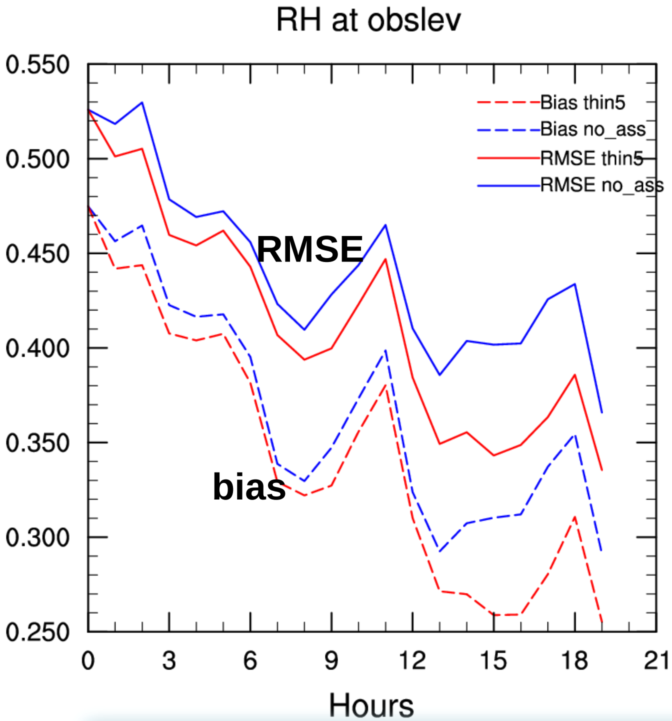
→ underdispersive but no trend for reduction of spread

averaged over **cloud-free** obs locations



time series of first guess errors of RH at observed CTH (det. run), averaged over **cloudy** obs locations

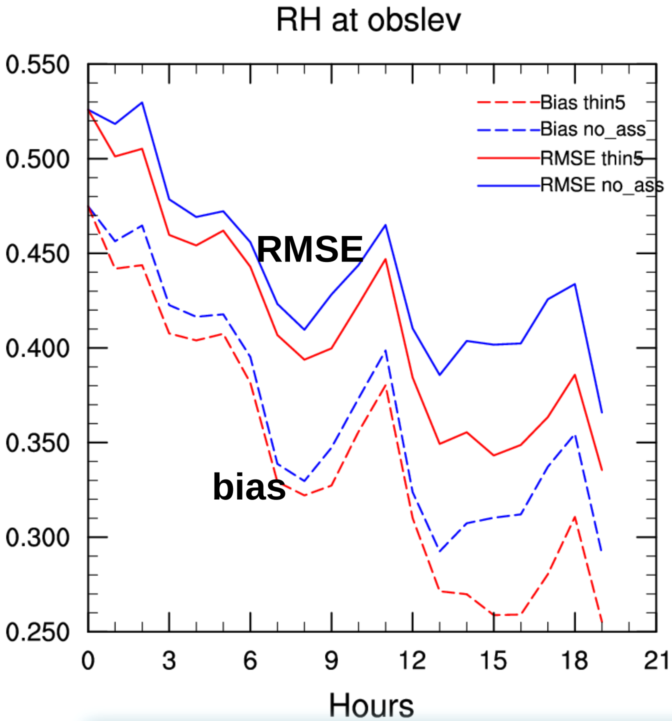
no assimilation
with cloud assimilation

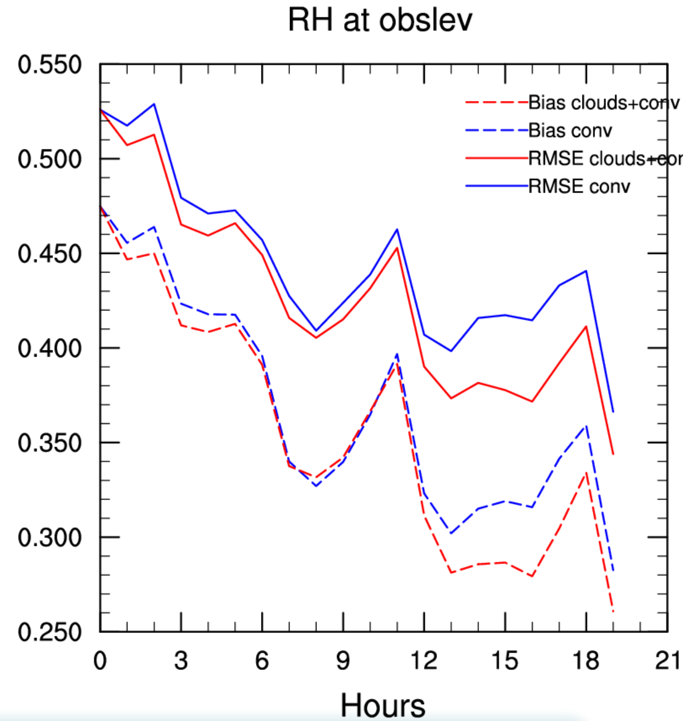


→ CTH assimilation : reduces RH (1-hour forecast) errors time series of first guess errors of RH at observed CTH (det. run), averaged over **cloudy** obs locations

no assimilation
with cloud assimilation

assimilation of conventional obs only
assimilation of conventional + cloud obs
localization scale s_{loc} : adaptive / 20 km

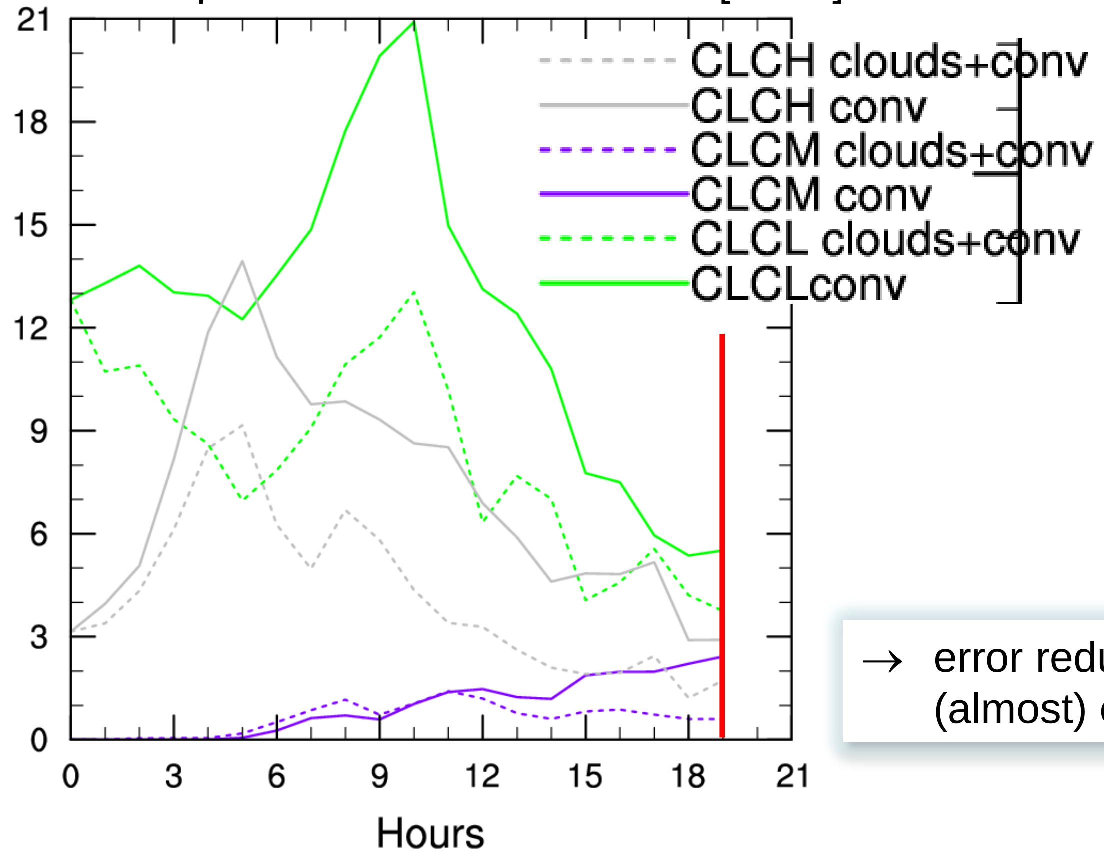




→ CTH assimilation : reduces RH (1-hour forecast) errors

time series of first guess errors, averaged over **cloud-free** obs locations
(errors are due to false alarm cloud)

mean square error of cloud fraction [octas]



→ error reduced (almost) everywhere

cycled assimilation of dense CTH obs

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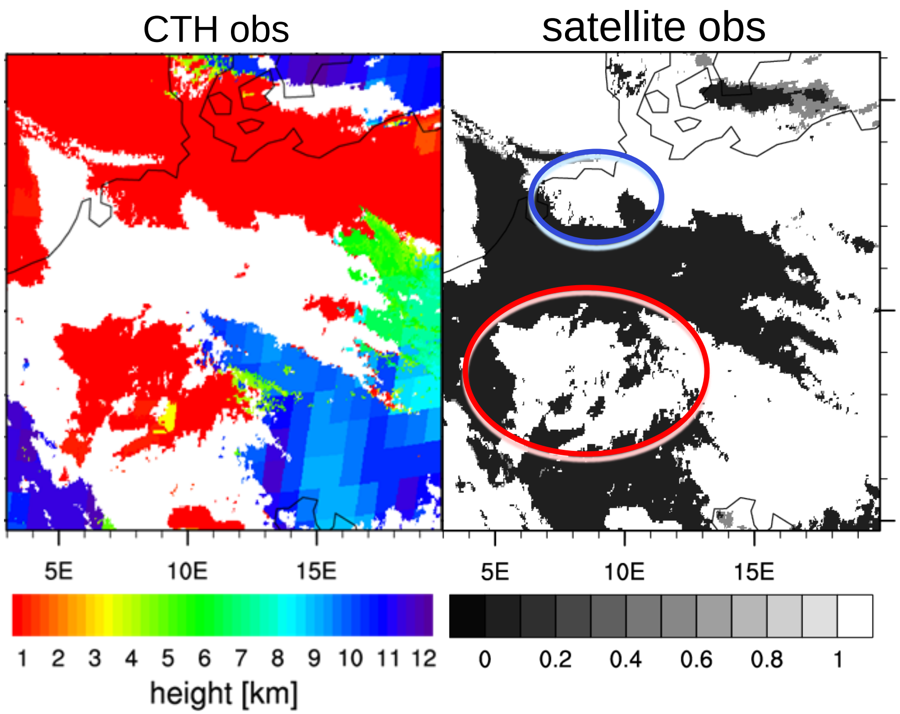
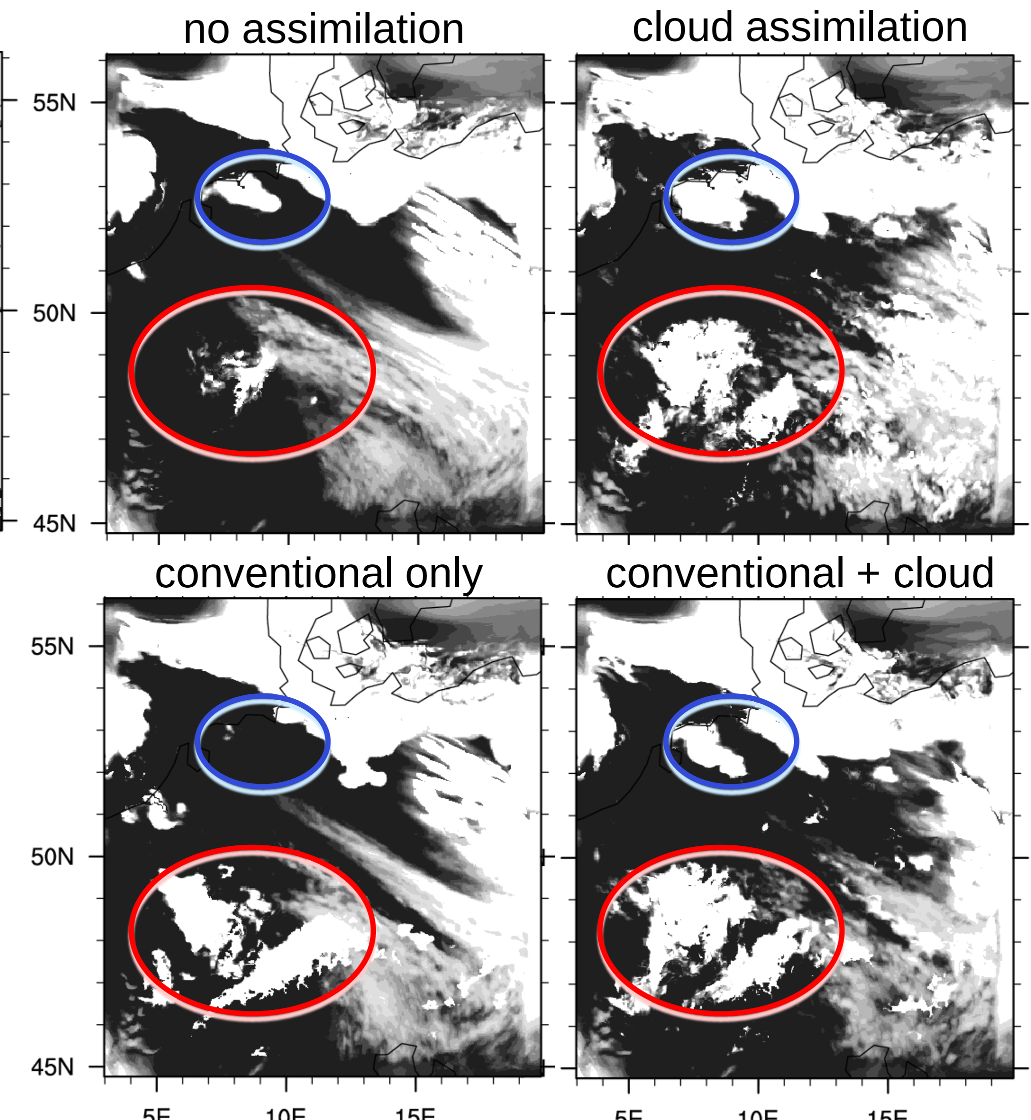
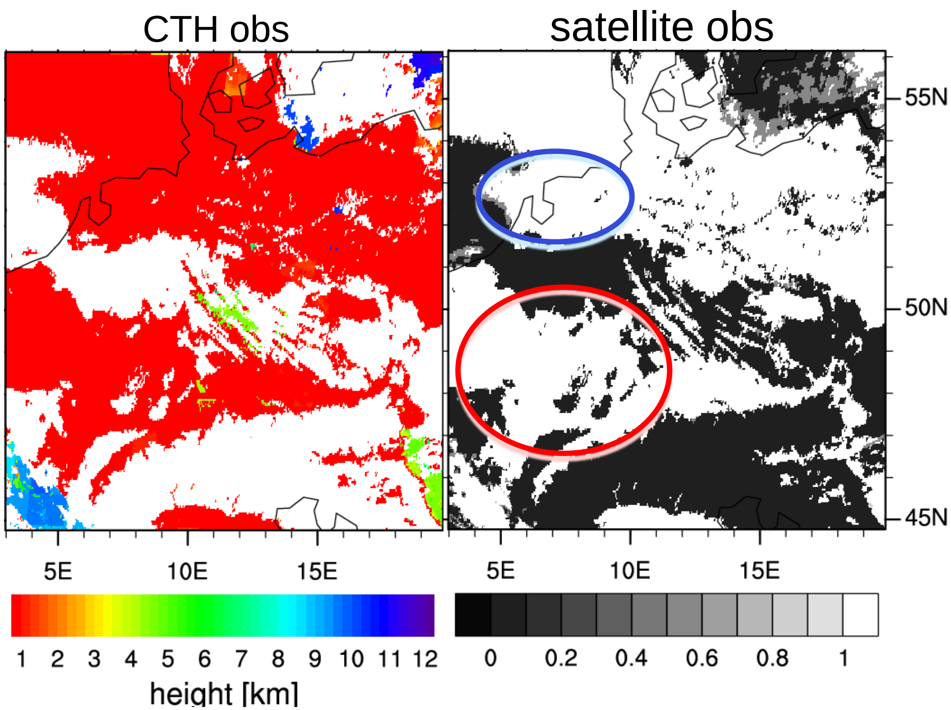




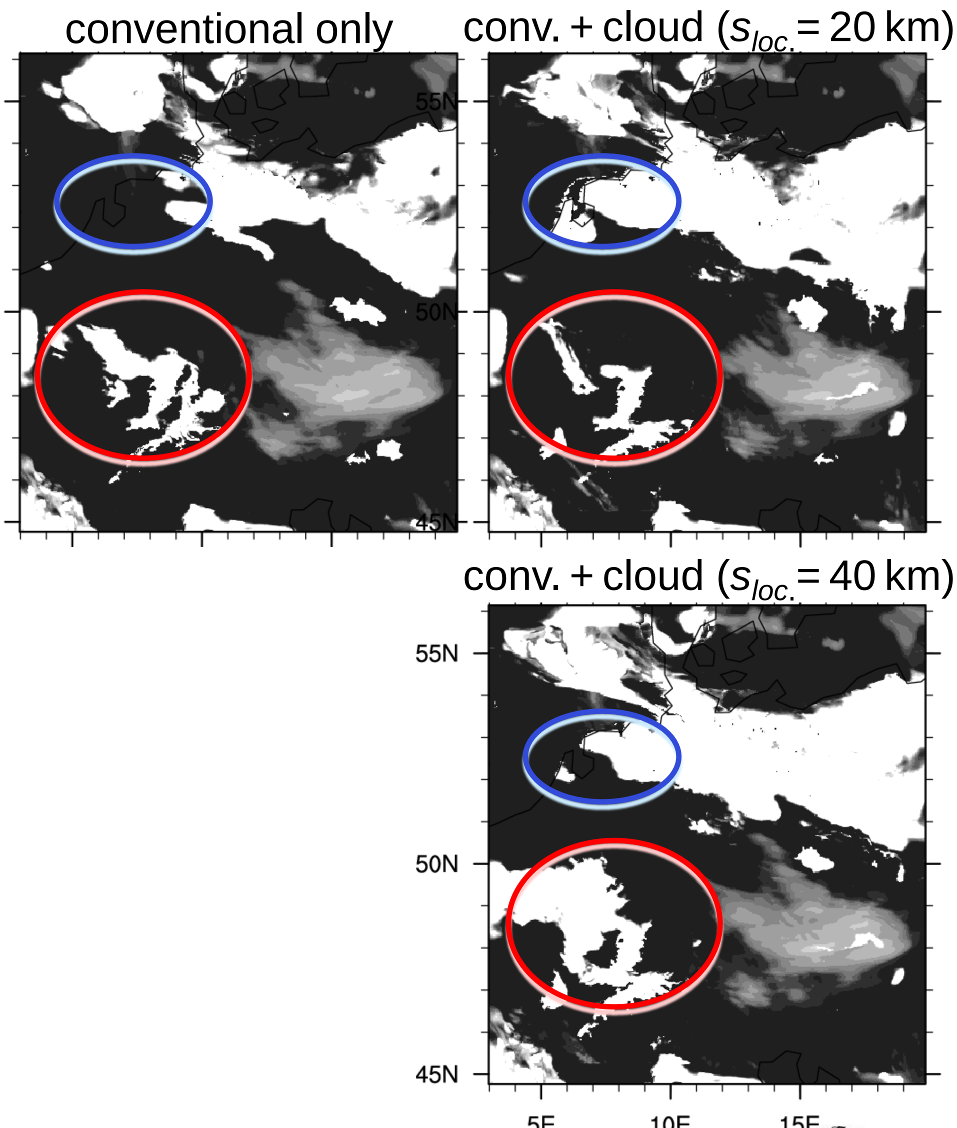
total cloud cover
of first guess
fields after
20 hours of cycling
(14 Nov. 2011, 17 UTC)

cycled assimilation of dense CTH obs : forecast impact



total cloud cover of **12-h** forecast

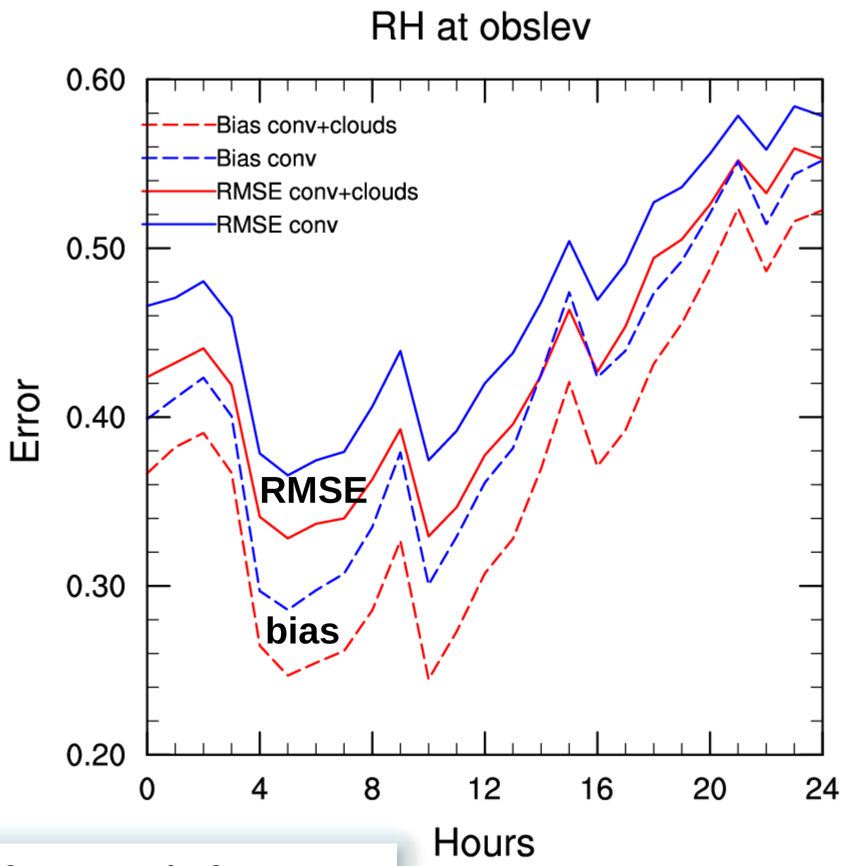
(forecast starting 14 Nov. 2011, 18 UTC)



errors of RH at observed CTH (det. run) as function of forecast lead time,
averaged over **cloudy** obs locations

assimilation of conventional obs only
assimilation of conventional + cloud obs

localization scale s_{loc} : adaptive / 20 km



→ CTH assimilation impact lasts throughout free 24-h forecast

conclusions (1 case study → preliminary) :
use of dense CTH ‘obs’ in LETKF

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(for low stratus conditions:)

✓ tends to introduce humidity / cloud where it should (+ temperature inversion)

✓ tends to reduce ‘false-alarm’ clouds

✓ despite non-Gaussian pdf’s

✓ no sign of filter collapse (no decrease of spread)

✓ first results of free forecast impact look promising

- better understand forecast impact, evaluate other variables
- test multi-step analysis option (for conventional / cloud top height data)
  (→ adaptive localisation scale also for CTH data)
- other cases, also convective ones

Thank you for your attention!

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Questions ?

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cycled assimilation of dense CTH obs

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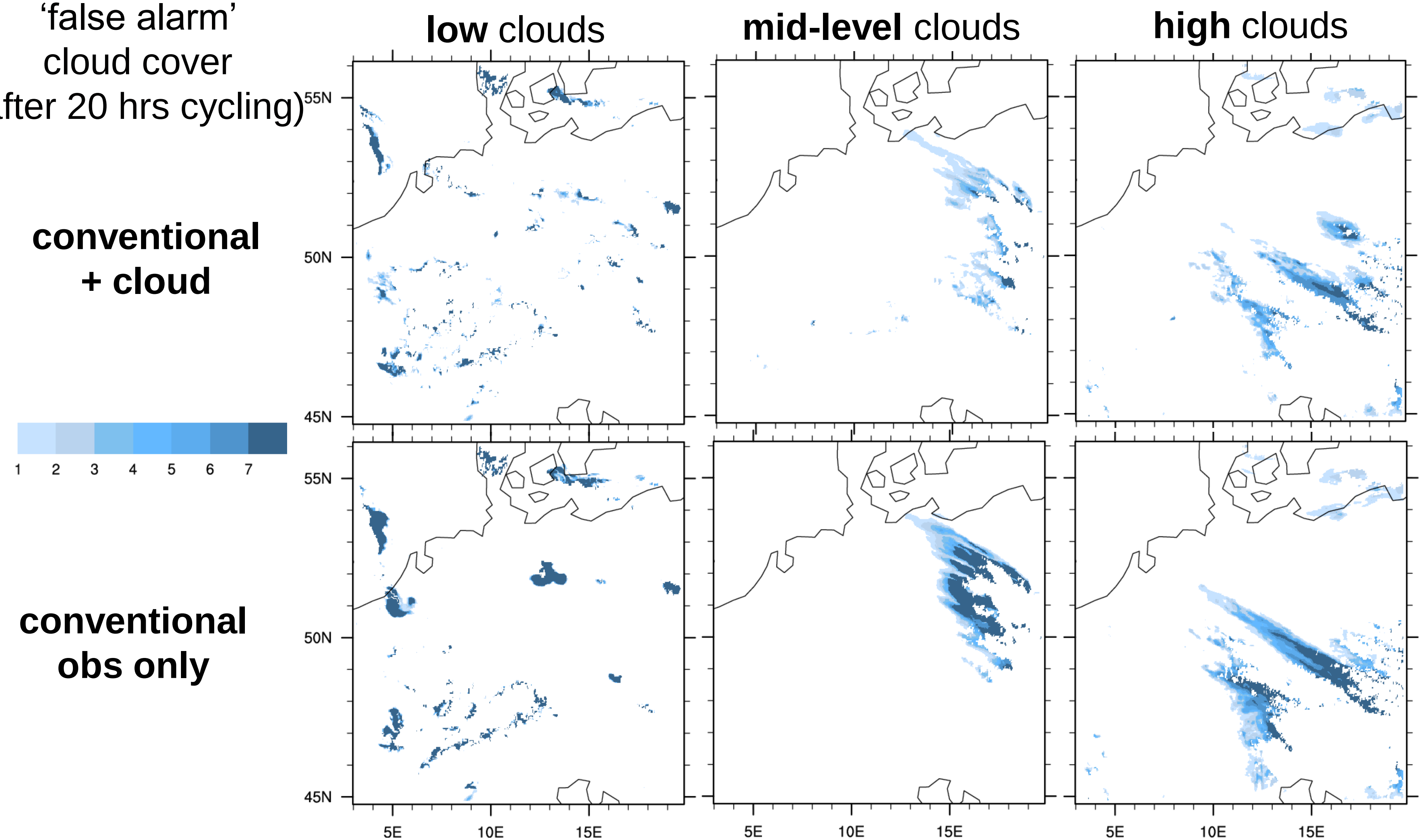
‘false alarm’
cloud cover
(after 20 hrs cycling)

conventional + cloud

conventional obs only



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Low cloud cover (COSMO)

17:00 UTC

No assim

Cloud assim

conv

Cloud +conv