Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Confederation

Federal Department of Home Affairs FDHA
Federal Office of Meteorology and Climatology MeteoSwiss

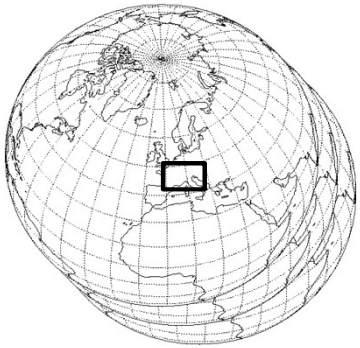
Benefit and challenges in assimilating near-surface temperature and humidity observations in complex terrain

Claire Merker, Daniel Leuenberger, Bas Crezee, Daniel Regenass and Marco Arpagaus
MeteoSwiss, Zurich, Switzerland

MeteoSwiss NWP system (since 2020)

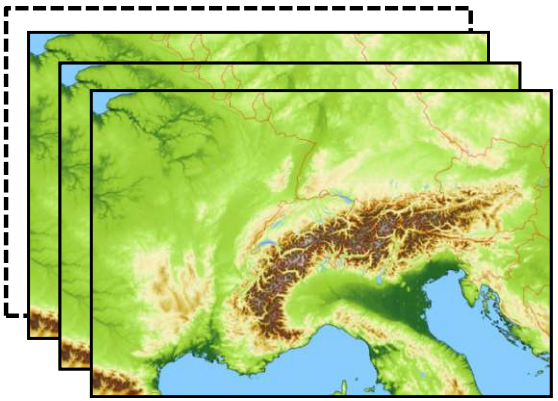
Lateral boundary conditions

IFS ENS 18km
4x per day



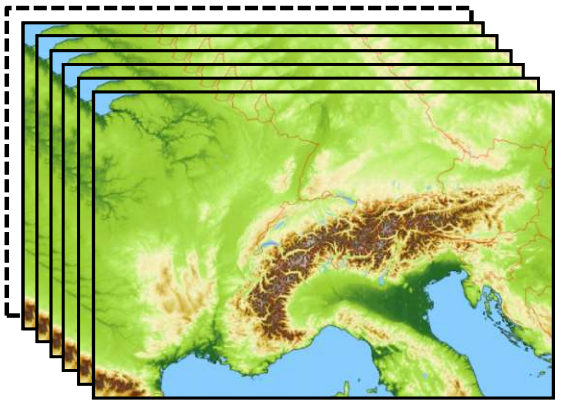
COSMO-1E

33 hour forecasts, 8x per day
1.1 km grid size
11 ensemble members



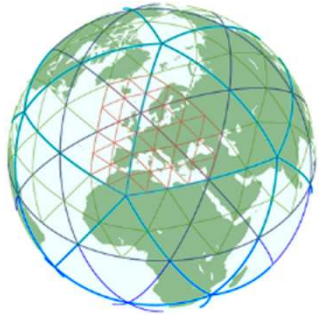
COSMO-2E

5 day forecasts, 4x per day
2.2 km grid size
21 ensemble members

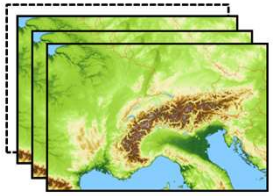


KENDA ensemble data assimilation system (Schraff et al. 2016):
LETKF (Hunt et al. 2007), 40+1 members at 1.1km, hourly cycling

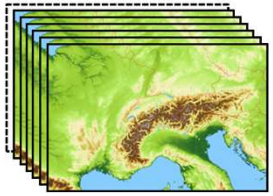
Current project ICON-22



COSMO-1E
33 hour forecasts, 8x per day
1.1 km grid size
11 ensemble members

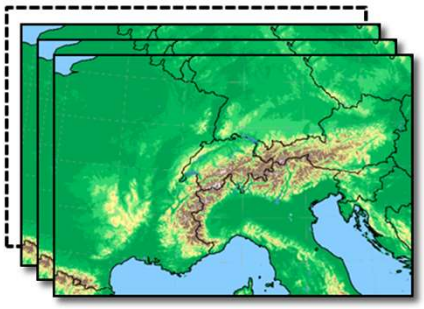


COSMO-2E
5 day forecasts, 4x per day
2.2 km grid size
21 ensemble members

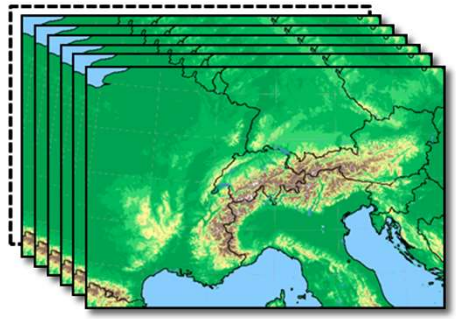


New model systems:
ICON-CH1-EPS and **ICON-CH2-EPS**

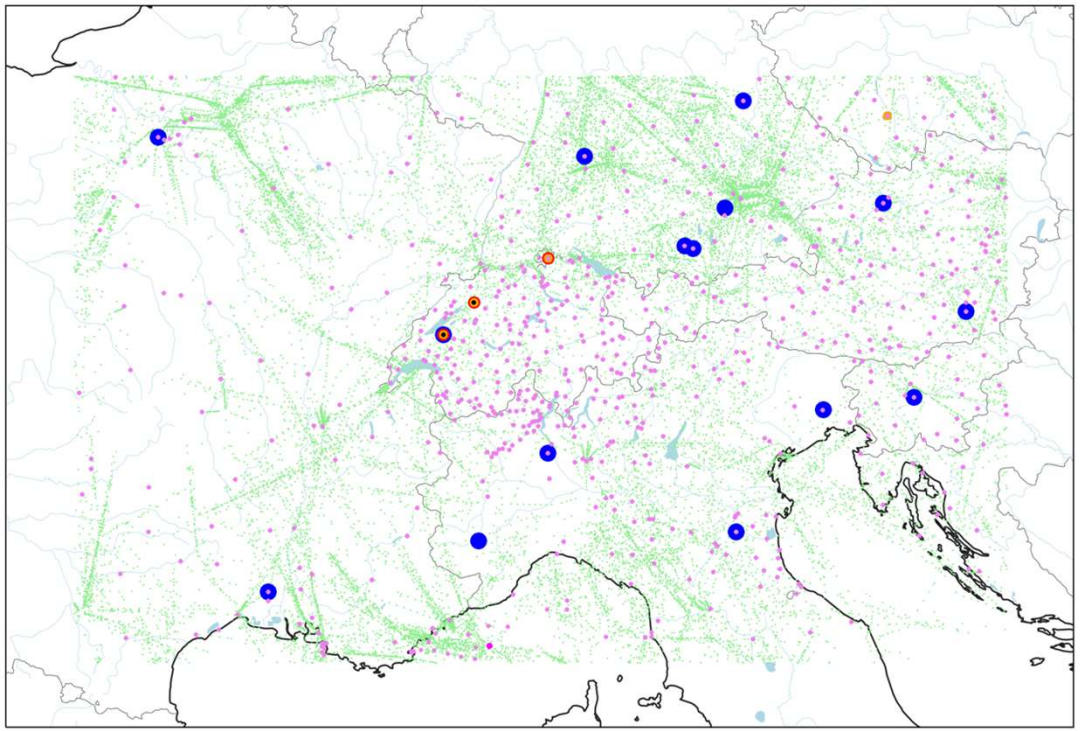
ICON-CH1-EPS
33 hour forecasts, 8x per day
1.1 km grid size
11 ensemble members



ICON-CH2-EPS
5 day forecasts, 4x per day
2.2 km grid size
21 ensemble members



Assimilated observations (current state)



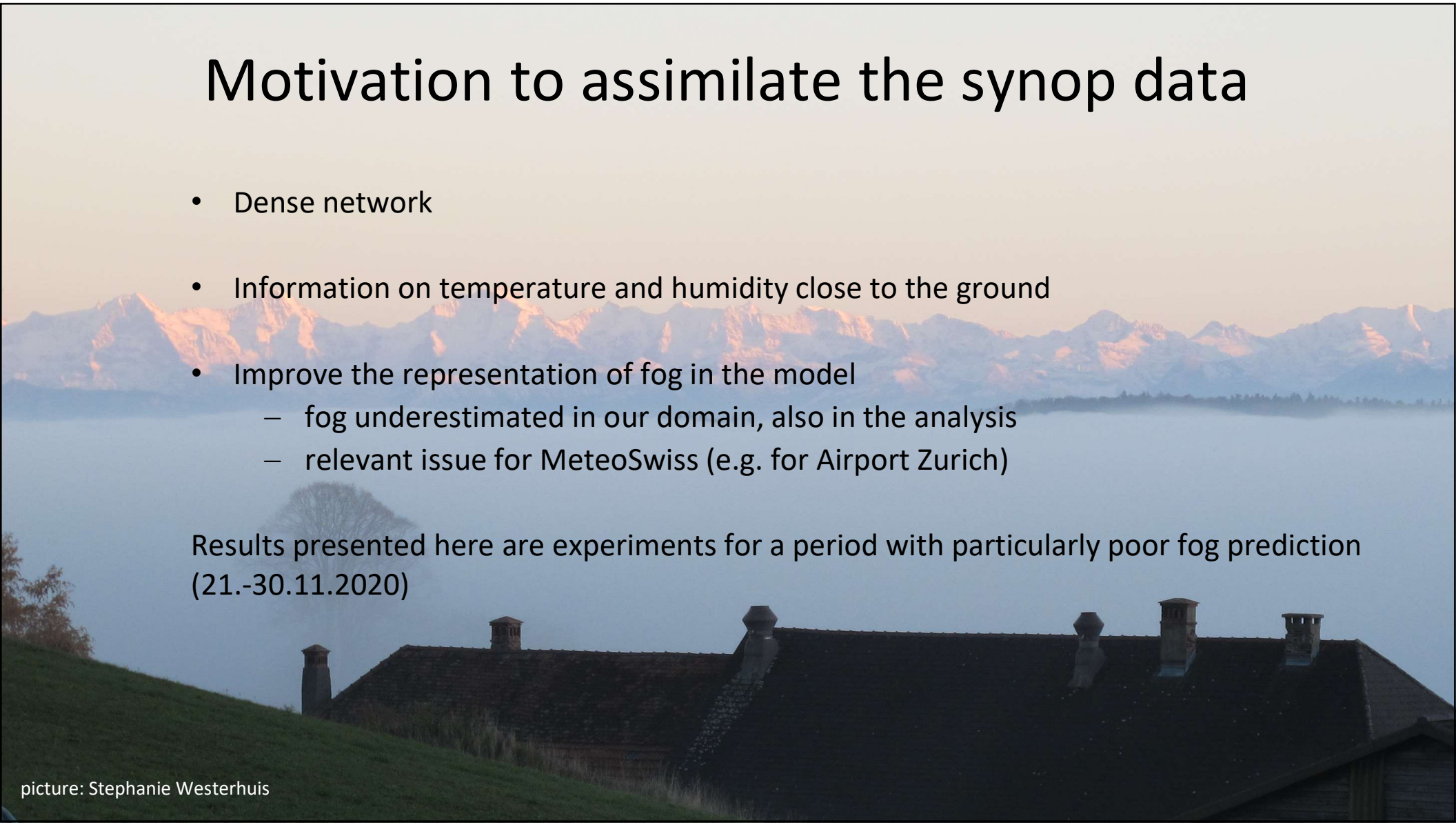
- Aircraft
- Radiosondes
- Wind Lidar
- Wind Radar
- Land Surface Stations
- Ship Surface Stations
- Buoys
- MWR

+ Radar QPE with
  Latent Heat Nudging

Motivation to assimilate the synop data

- Dense network
- Information on temperature and humidity close to the ground
- Improve the representation of fog in the model
  - fog underestimated in our domain, also in the analysis
  - relevant issue for MeteoSwiss (e.g. for Airport Zurich)

Results presented here are experiments for a period with particularly poor fog prediction (21.-30.11.2020)



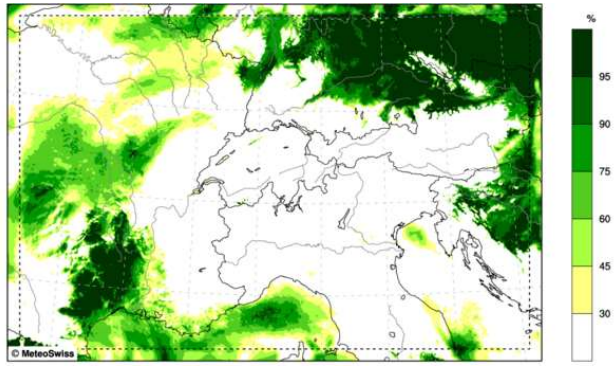
picture: Stephanie Westerhuis

Operational analysis at that time

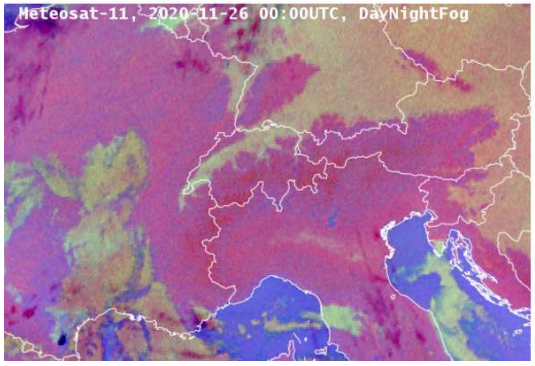
Nearly **no fog in the analysis, extended fog in the observations.**

26.11.2020 00 UTC

COSMO analysis



Satellite fog product

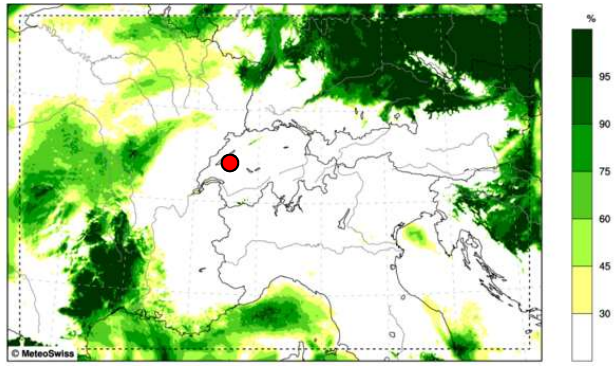


Operational analysis at that time

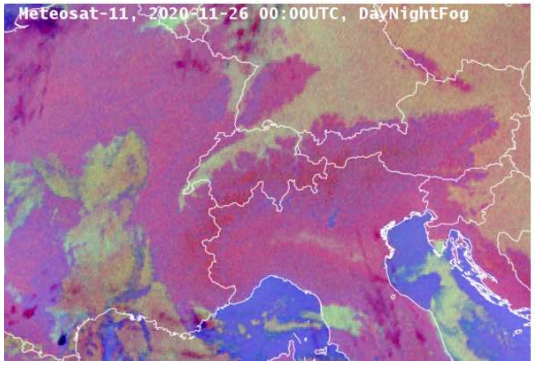
Nearly **no fog in the analysis, extended fog in the observations.**

26.11.2020 00 UTC

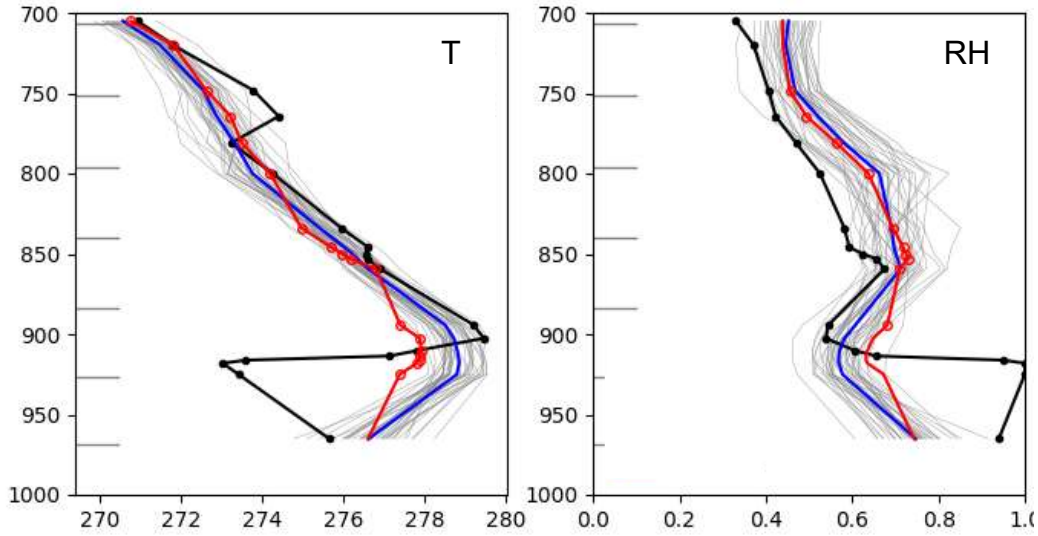
COSMO analysis



Satellite fog product



Sounding in Payerne, 26.11.2020 00UTC

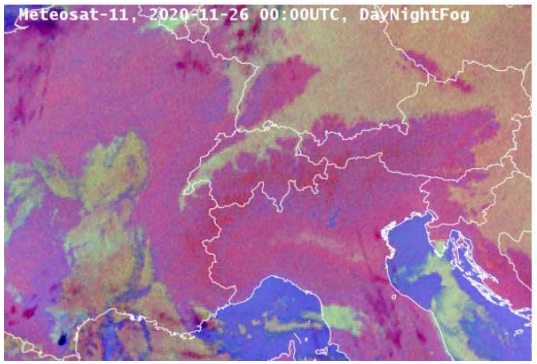
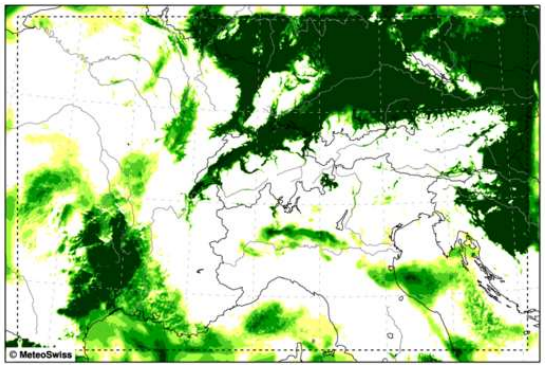
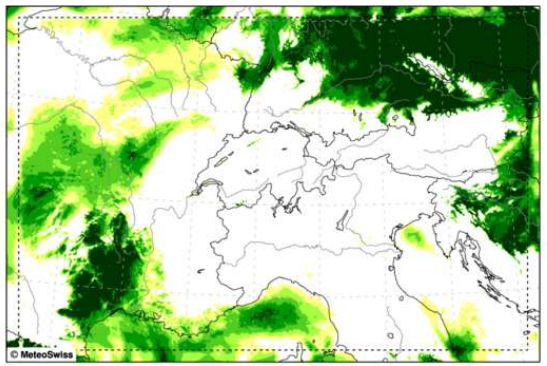
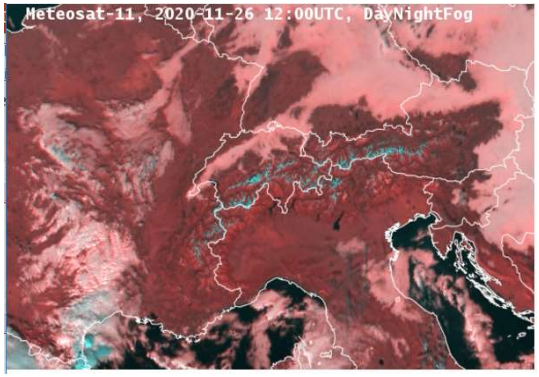
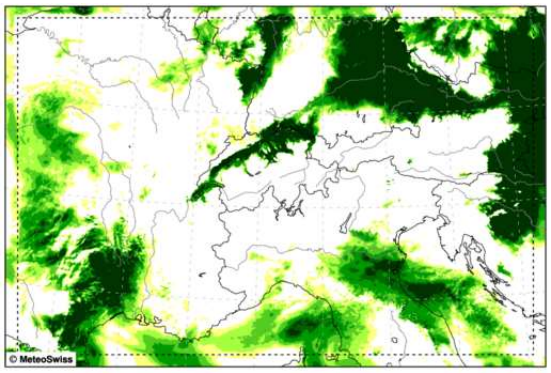
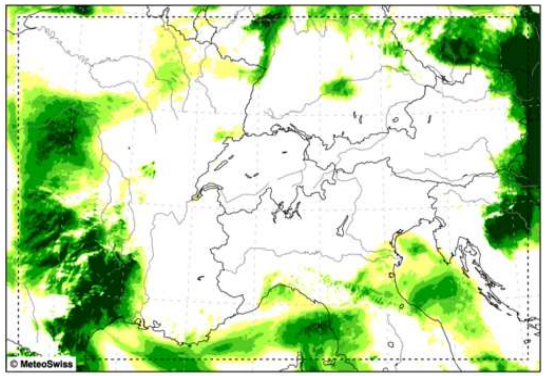


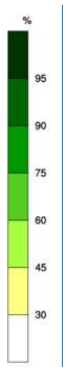
First guess members Observations

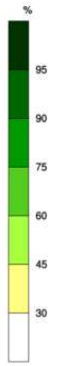
First guess mean Analysis mean

Impact on model low clouds

Improvement of the fog representation in the analysis.

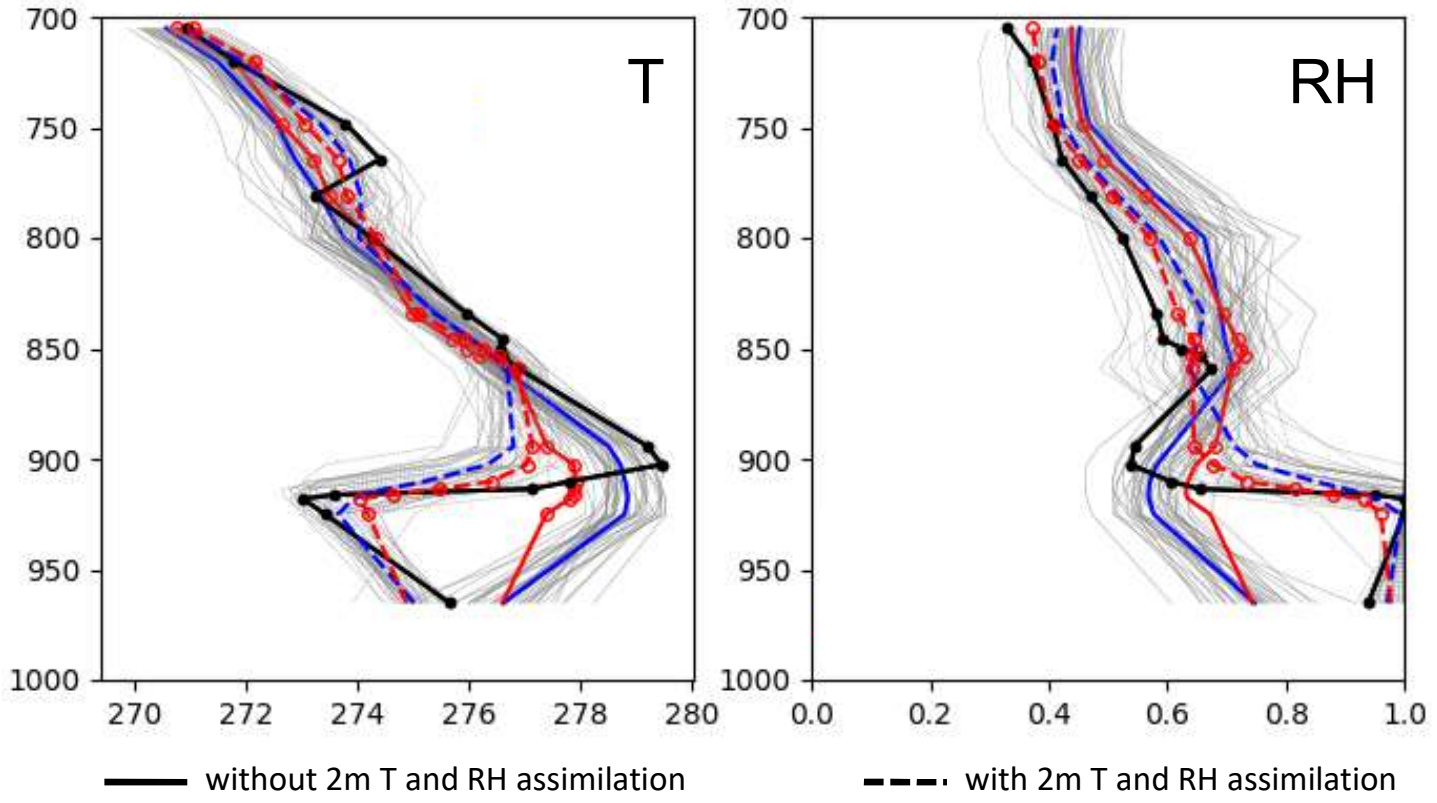
	satellite	with 2m T and RH assimilation	w/o 2m T and RH assimilation
26.11.2020 00UTC			
26.11.2020 12UTC			





Impact on model PBL

Improvement of the inversion representation in the analysis and the first guess.



Sounding in Payerne,
26.11.2020 00UTC

Observations
First guess mean
First guess members
Analysis mean

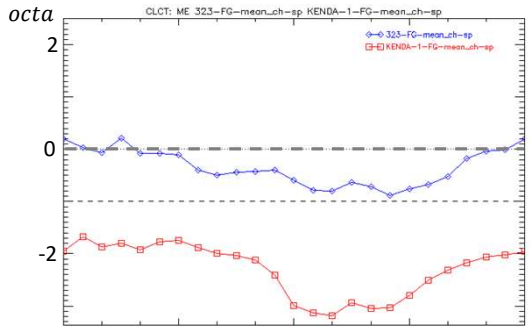
Model verification

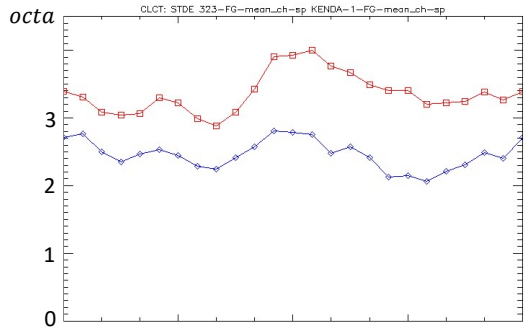
Overall improvement of the model scores (here diurnal cycle over the period).

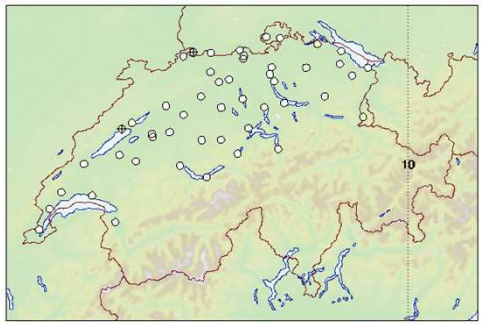
Bias

Standard deviation

Total clouds

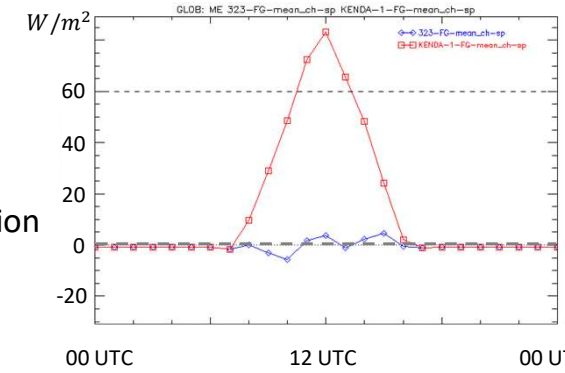


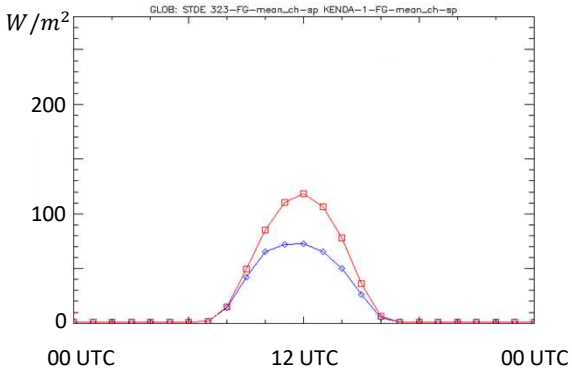




45 Swiss Plateau Stations

Global radiation





without 2m T and RH assimilation
with 2m T and RH assimilation

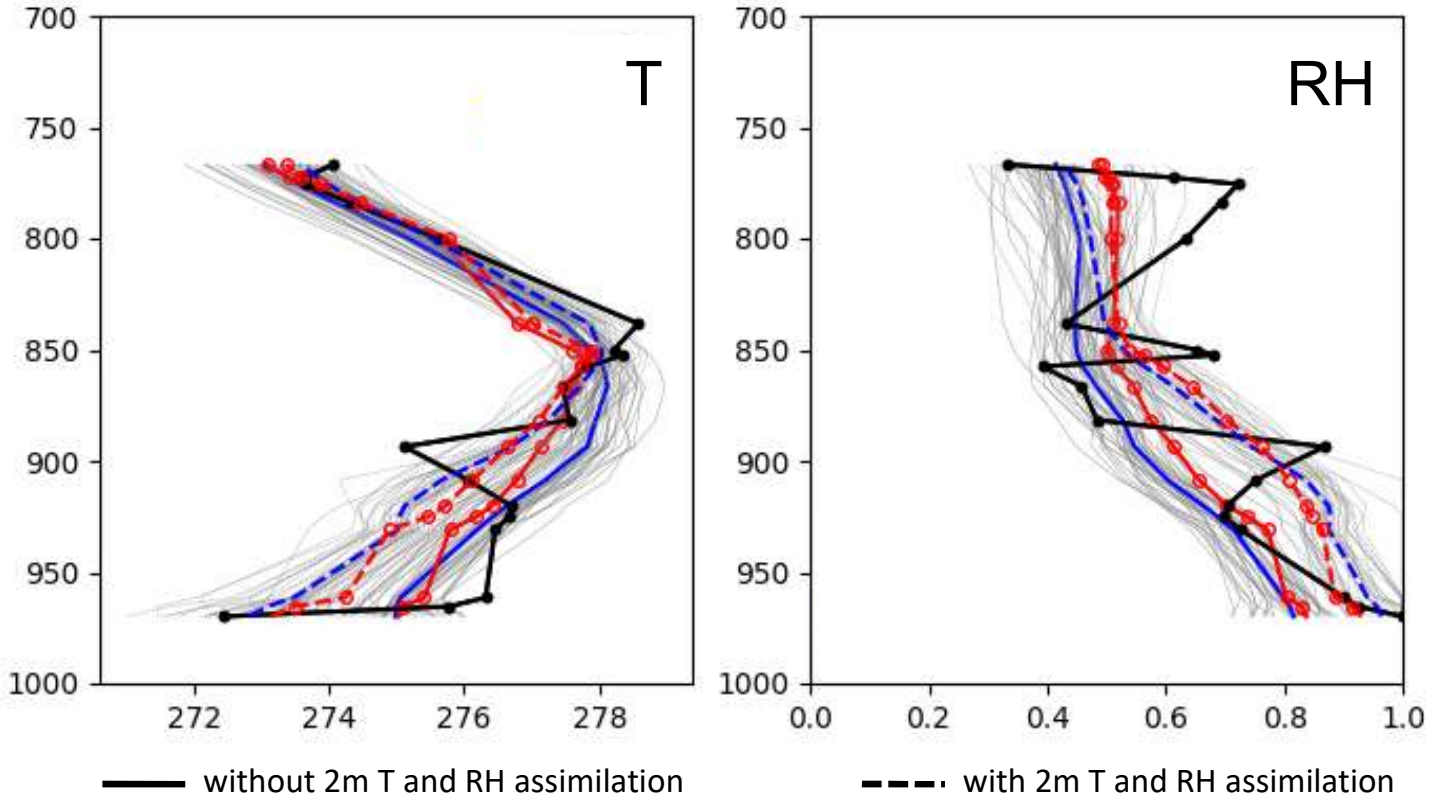
Challenge: observation representativity

- **Topography mismatch**
  - Model topography and station height can differ a lot in complex topography (height difference Δz)
  - Mitigation
    - Stations with $|\Delta z| > 150\ m$ are rejected
    - Observation error proportional to $|\Delta z|$

- **Horizontal variability**
  - can be large due to topographic effects in stable boundary layer (local pools of cold air, small fog patches)

Representativity: very shallow inversion

Deterioration of the PBL representation in the analysis and the first guess.

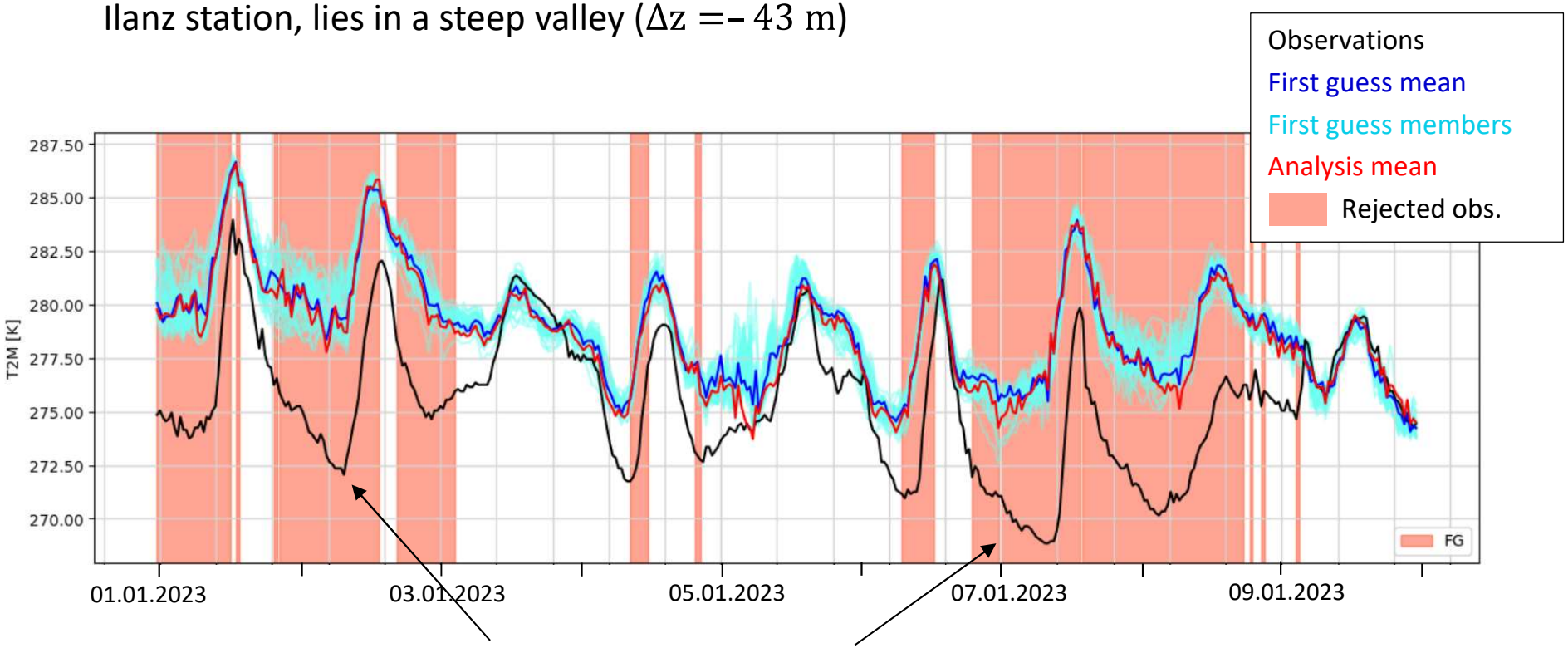


Sounding in Payerne,
24.11.2020 00UTC

Observations
First guess mean
First guess members
Analysis mean

Challenge: systematic model error

Ilanz station, lies in a steep valley ($\Delta z = -43$ m)



Large temperature deviations at night, model underestimates the valley cooling.

Summary

- The assimilation of T2m and RH2m has turned out to be a game changer
  - Better representation of T2m and RH2m
  - Better first guess for the assimilation of upper-air obs, e.g. radiosondes
  - Much better fog representation in the analysis
- Positive impact out to +24h into forecast time
- No long-lasting negative side effects have been observed so far, possible problems in case of strong vertical low-level gradients of T and/or RH

Possible future investigations

- Tune horizontal localisation radius
- Station selection based on statistics of obs. minus first guess instead of only Δz
- Improved observation rejection (e.g. for very shallow inversions)

Thank you for your attention!