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Towards an improved representation of fog and low stratus in COSMO-1

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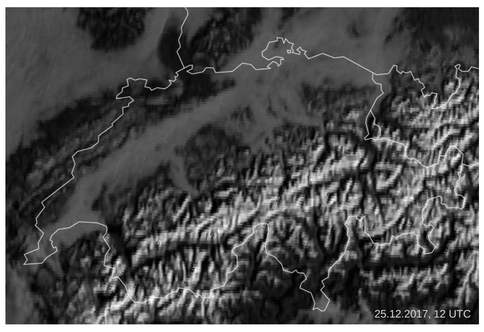
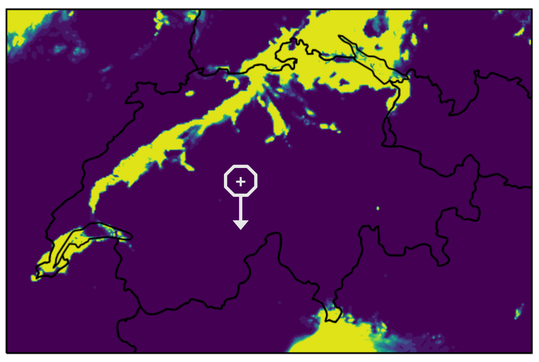
1. Introduction

- At MeteoSwiss, forecasters rely on COSMO-1 for predicting **fog and low stratus (FLS)** occurrence in the short-range. Their feedback states that COSMO-1 overall has difficulties initialising FLS on the day before its occurrence and that often FLS are dissipated too fast.
- Visibility reduction due to fog occurrence poses a threat for safety at airports (eg Gultepe et al., 2007).
- Low stratus affects PV power generation. Day-ahead forecasts can exhibit large errors (Köhler et al., 2017).

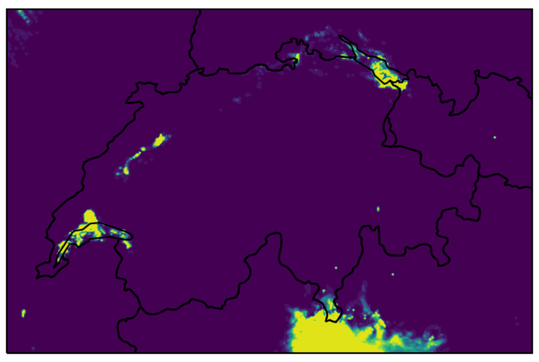
Our goal is to understand which processes are responsible for the poor FLS forecasts and to come up with ideas how to improve them.

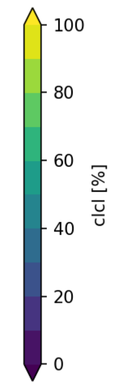


COSMO-1 CLCL fcst: 2017 12 25 00: **+09h**



COSMO-1 CLCL fcst: 2017 12 25 00: **+12h**





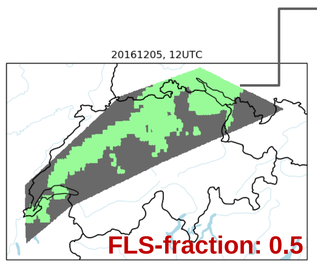
Webcam and satellite imagery (left) show that December 25, 2017 was dominated by low stratus clouds on the north side of the alps. COSMO-1 (above) was not able to simulate the full extent at 09UTC and erroneously dissipated the clouds by 12UTC although the stratus layer persisted for the whole day.

2. Systematic FLS verification

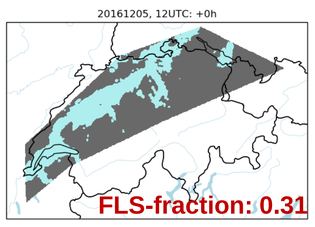
Comparing COSMO-1 forecasts with satellite imagery, we can show that COSMO-1 generally

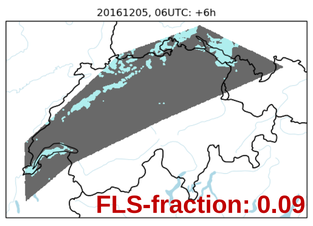
- **underestimates fog and low stratus clouds and**
- **dissipates them too fast.**

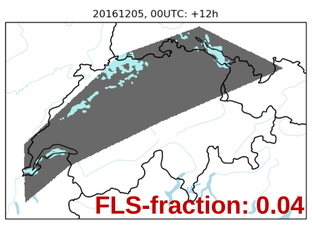
Swiss Plateau («Schweizer Mittelland»): A region prone to fog and low stratus during winter



a) Fraction of cloudy pixels in Swiss Plateau is determined in satellite imagery (MSG SEVIRI, data from Jan Cermak) and in COSMO-1 forecasts (liquid water path > 0.2g/m2).



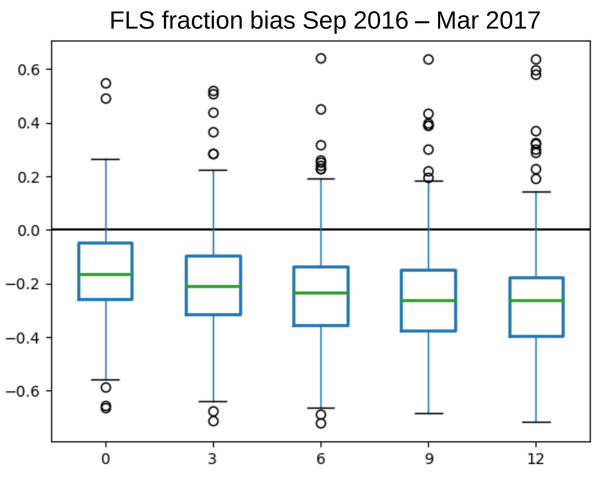




Increasing FLS underestimation with increasing leadtime!

b) Calculate **fraction bias** = FLS fraction fcst – FLS fraction satellite

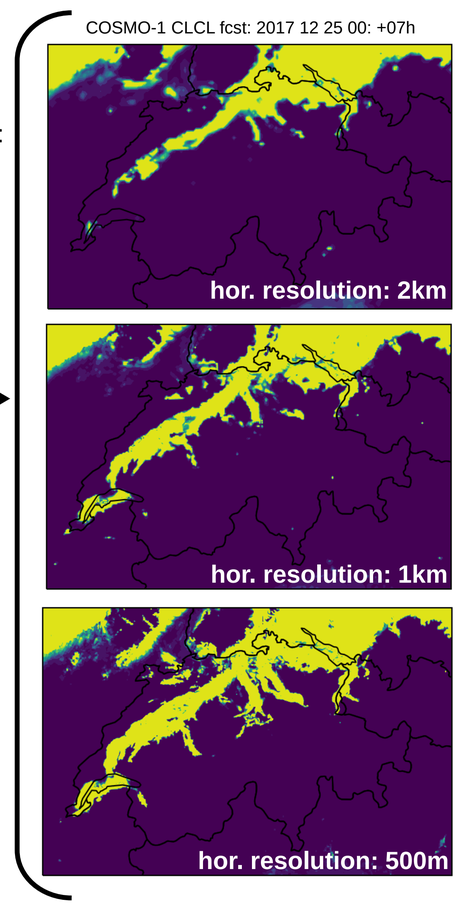
- don't care about location of FLS
- exclude pixels with high clouds
- exclude days with more than 5% of area covered with high clouds (this way, also rainy days are excluded)
- stratify by leadtimes

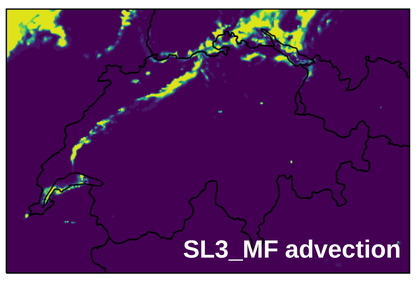


3. Case study: December 25, 2017

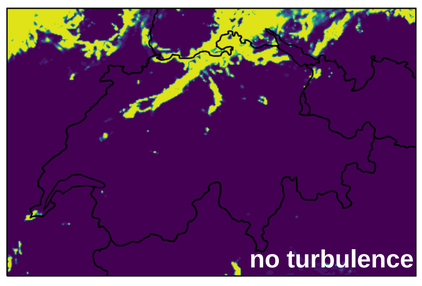
To find out what is responsible for the incorrect dissipation of FLS, we conducted several sensitivity studies (of which none solved our problem):

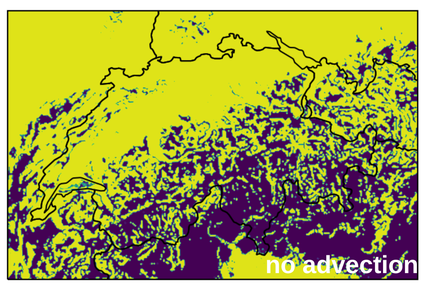
- PAFOG microphysics scheme (Bott and Trautmann, 2002)
- double soil moisture content (W_SO) 24h prior to start
- reducing tkhmin/tkmmin from 0.4 to 0.1, 0.01
- 5.05 turbulence parameterisation
- increased vertical resolution
- **increased horizontal resolution** →
- flat topography in Swiss Plateau (550m)
- '**SL3_MF**' instead of 'Bott_2Strang'-advection scheme





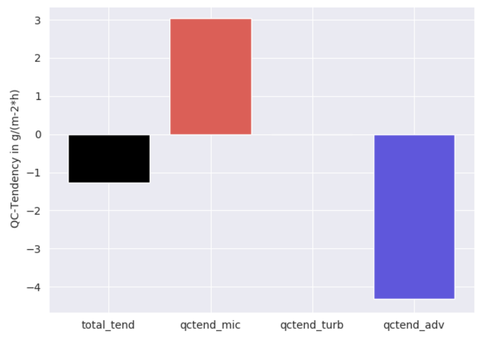
- **no turbulence/advection parameterisation for humidity-tracers**

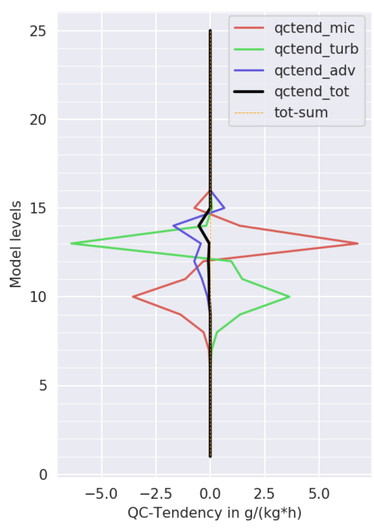




The budget tool (Langhans et al., 2012) reveals that (horizontal) **advection is the main driver for the reduction in liquid water content** → see 15min QC-tendencies (left: profile and below: integrated vertically) above KLO on 2017 12 25 00: +02:15h

BUT: WHY?





4. Summary & Outlook

COSMO-1 often fails to give accurate forecasts of fog and low stratus. Comparison with FLS signals derived from satellite imagery shows that the extent of the clouds is already underestimated in the analysis and then dissipated too fast. The underestimation of FLS becomes more severe at longer leadtimes. Advection is a driving process in this.

- ➢ Do similar models have similar problems? Try **intercomparison** (IFS, COSMO-DE, AROME?).
- ➢ What does the **resolution dependence** tell us? Test effect of increased resolution when effective resolution remains constant.
- ➢ Investigate advection by implementing additional **'xyz'-tracers**.

5. Literature

Bott, Andreas, and Thomas Trautmann. "PAFOG—A new efficient forecast model of radiation fog and low-level stratiform clouds." *Atmospheric Research* 64.1-4 (2002): 191-203.
Gultepe, Ismail, et al. "Fog research: A review of past achievements and future perspectives." *Pure and Applied Geophysics* 164.6-7 (2007): 1121-1159.
Köhler, Carmen, et al. "Critical weather situations for renewable energies–Part B: Low stratus risk for solar power." *Renewable energy* 101 (2017): 794-803.
Langhans, Wolfgang, Oliver Fuhrer, and Jürg Schmidli. "Description and application of a budget-diagnosis tool in COSMO." *COSMO Newsletter* 12 (2012): 43-51.

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