Deutscher Wetterdienst
Wetter und Klima aus einer Hand

SEVIRI cloud product assimilation in KENDA: Current status

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Outline

- Short repetition of assimilation concept
- Full domain experiments
  - Experimental setup: 3 different settings
  - Results
  - Conclusion/Outlook
- EWeLiNE

Brand new!

Assimilation concept

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Variables assimilated

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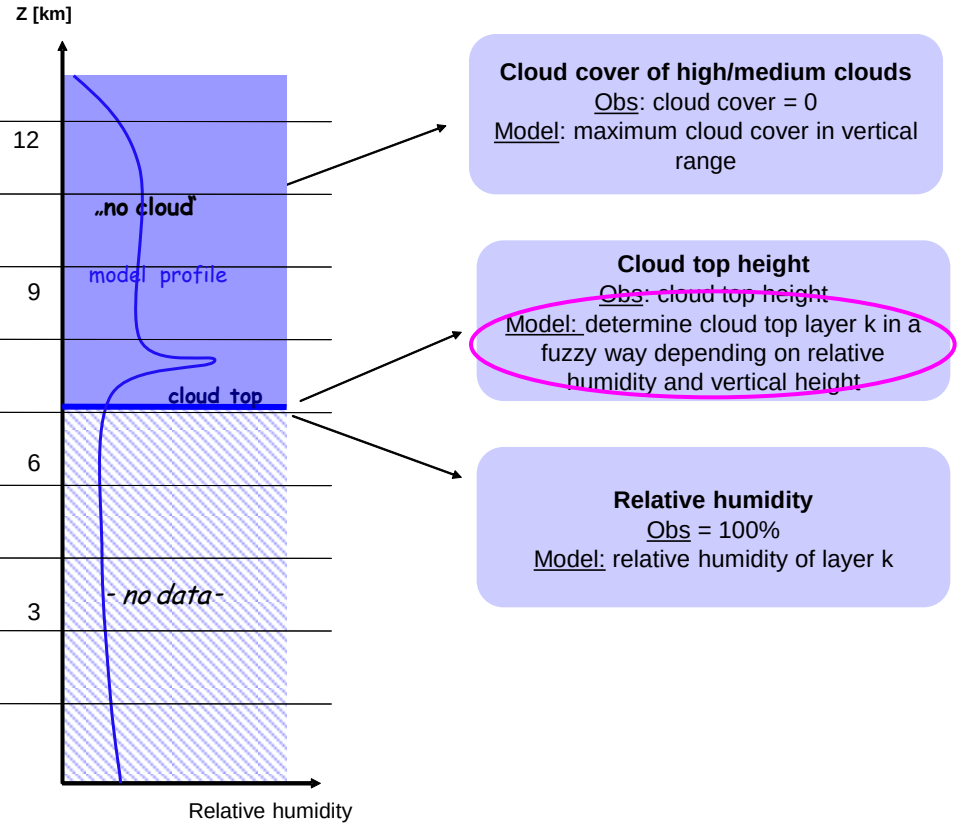
From one observation of **cloud top height** several variables are extracted and used to weight the ensemble members in the LETKF (observation $\mathbf{y}_i$ and model equivalent $\mathbf{H}(\mathbf{x}_i)$)

Cloudy pixel:

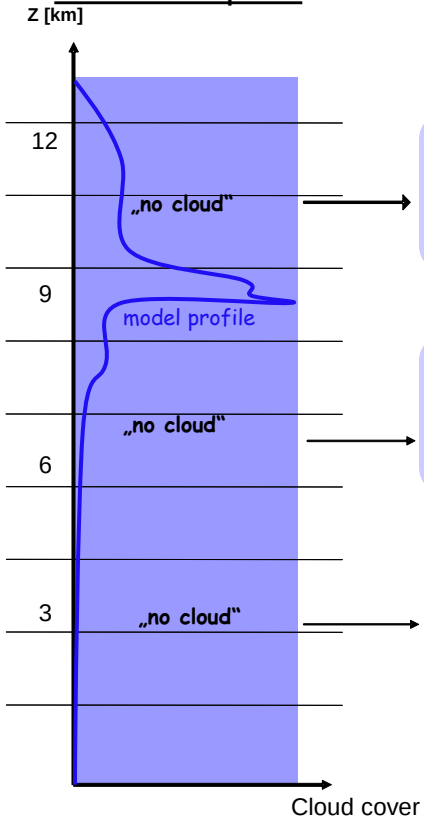


Cloud cover of high/medium clouds
Obs: cloud cover = 0
Model: maximum cloud cover in vertical range

Cloud top height
Obs: cloud top height
Model: determine cloud top layer k in a fuzzy way depending on relative humidity and vertical height

Relative humidity
Obs = 100%
Model: relative humidity of layer k

Cloudfree pixel:

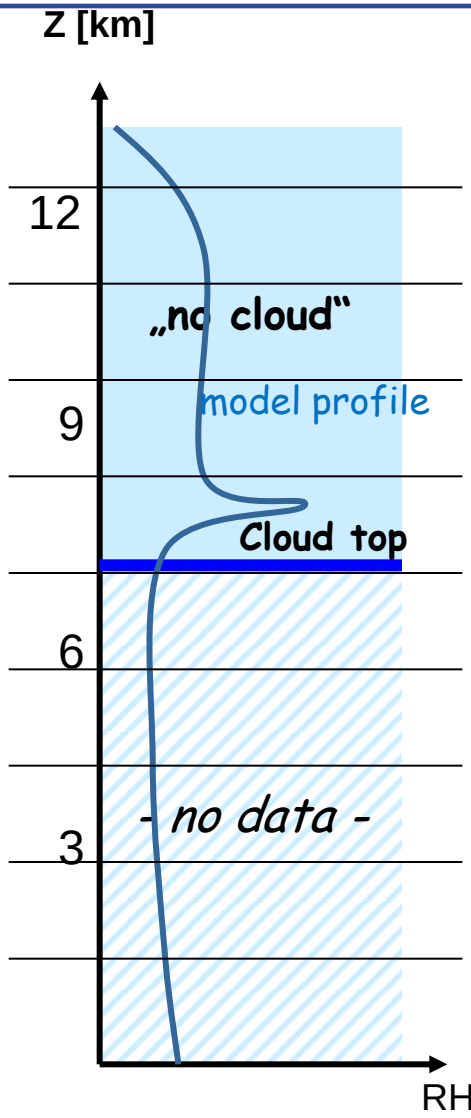


Cloud cover of high clouds
Obs: cloud cover = 0
Model: maximum cloud cover in high cloud range

Cloud cover of medium clouds
Obs: cloud cover = 0
Model: maximum cloud cover in medium cloud range

Cloud cover of low clouds
Obs: cloud cover = 0
Model: maximum cloud cover in low cloud range

Find cloud top height model equivalent



- If using a fixed threshold to define cloud top, one might penalize close members
- Therefore: find model layer optimally fitting the observed cloud top height:

$$d = \min_k \sqrt{(f(\rho_k) - f(\rho_o))^2 + \frac{1}{\Delta h_{\max}}(h_k - h_o)^2}$$

ρ: Relative humidity h: height

  - Search for the minimum in a vertical range (e.g. +/-2500m of the observed cloud top)
  - If above a layer exceeds the cloud coverage of the chosen layer or exceeds 70%, then chose the top of that layer

Example for 40 single profiles

red: observed cloud top

green: model equiv. cloud top

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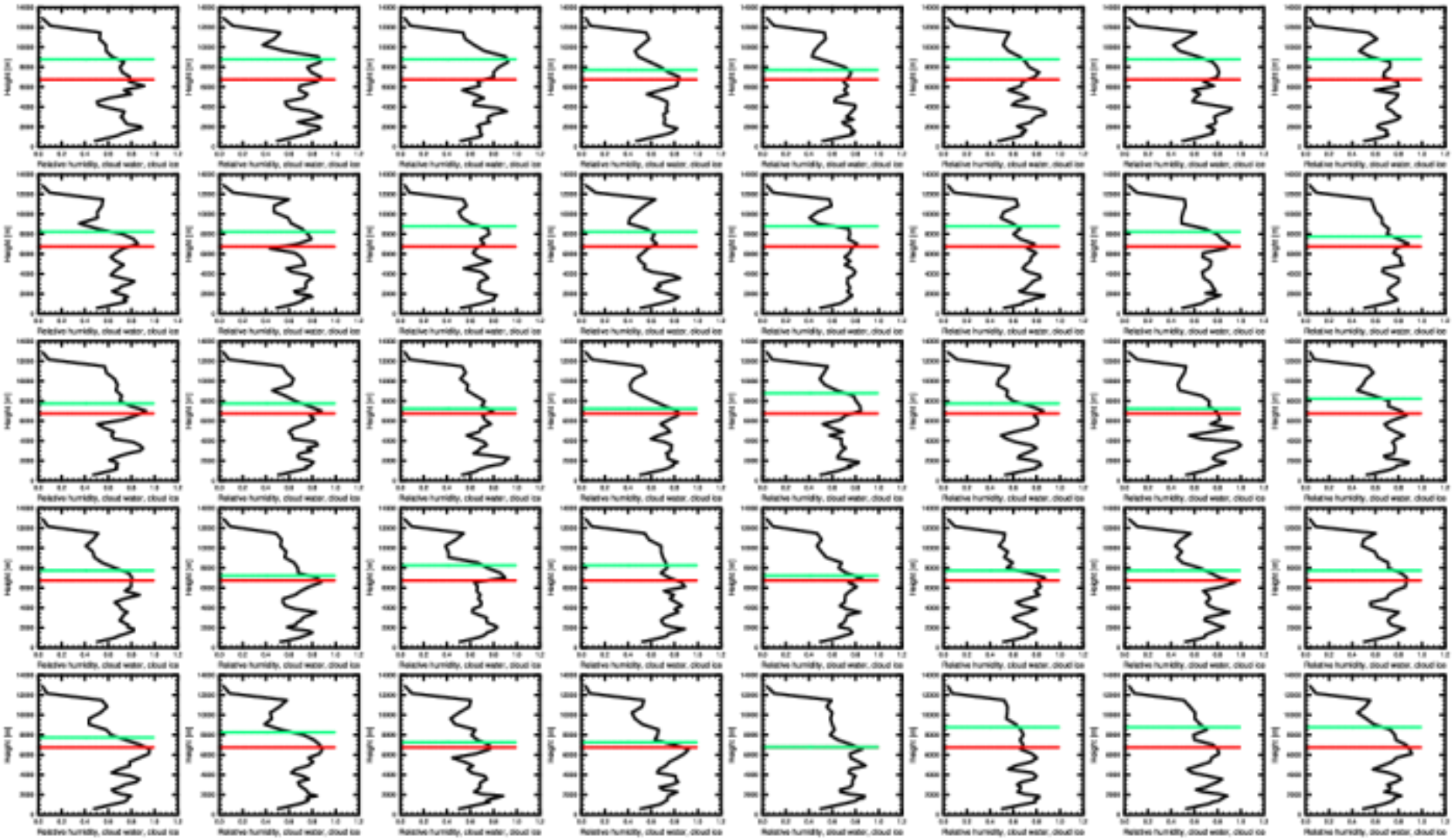

Model equivalents for cloudy column

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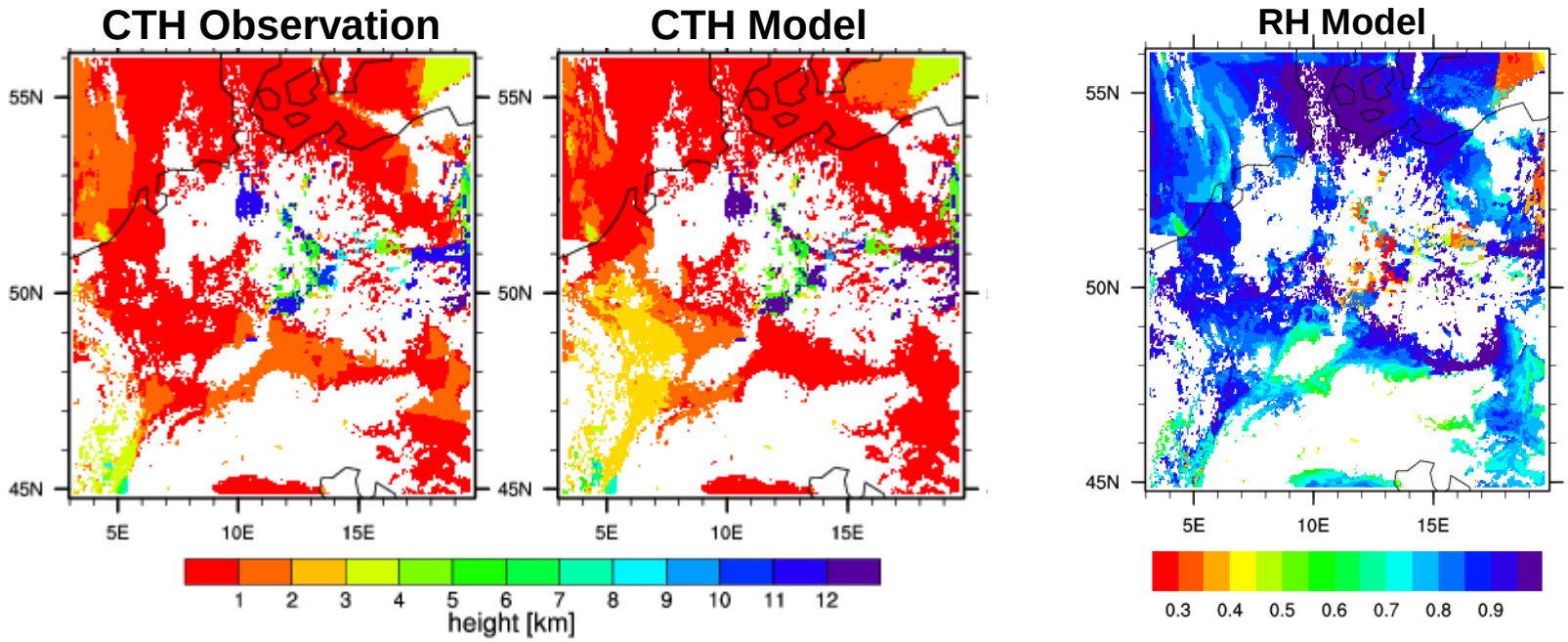
Assimilated variables: Cloud top height and relative humidity



Model equivalents for cloud-free column

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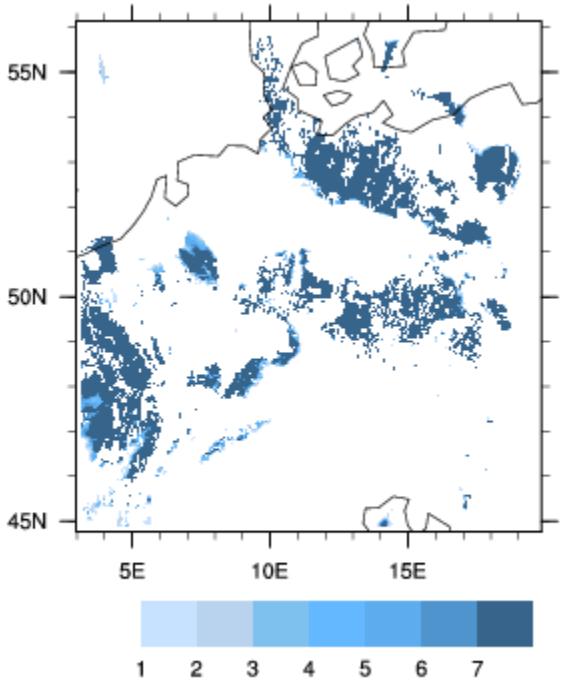
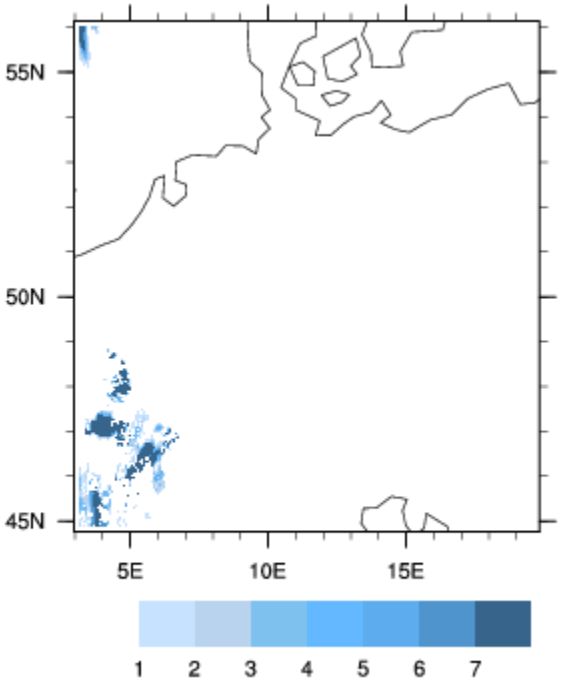
Assimilated variables: Cloud cover

- COSMO cloud cover where observations “cloudfree”

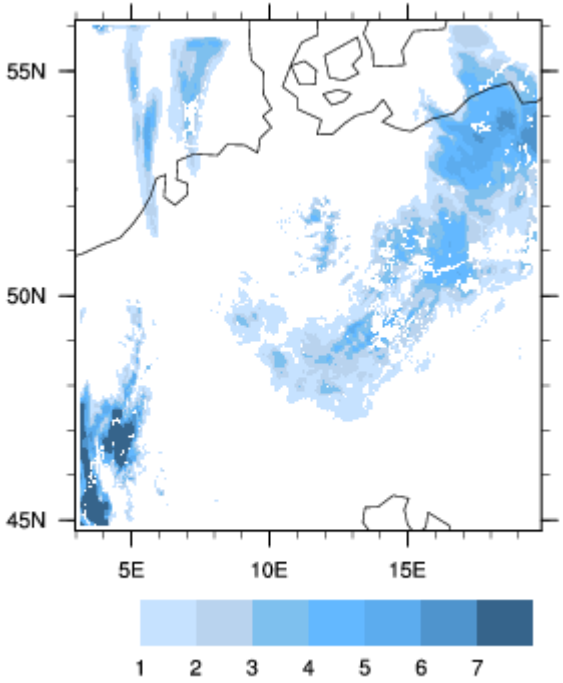
Low clouds (oktas)



Medium clouds (oktas)



High clouds (oktas)



Results

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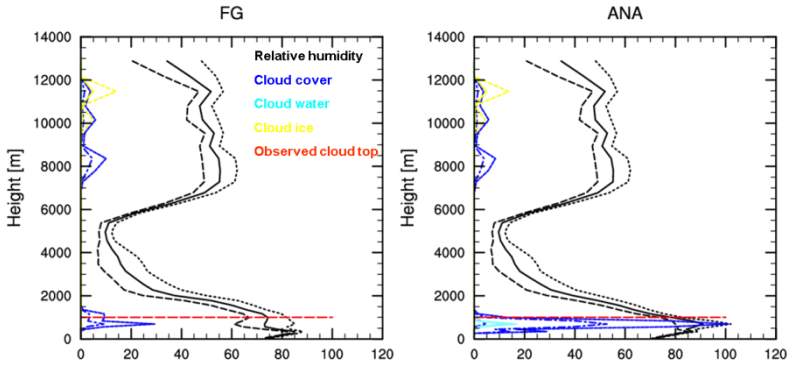
Experimental setup

- Before: Single observation experiments. Objective:
  - Objective: Understand in detail what the filter does with this special observation type



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

- Now: full domain experiments
  - Hourly cycling
  - Horizontal localization: adaptive
  - 3 Experiments:
    1. Assimilate every 5th grid point
    2. Assimilate every 3rd grid point
    3. Control: no assimilation (realized by increasing the observation errors by a factor 1000.)

Synoptic situation 15h cycling

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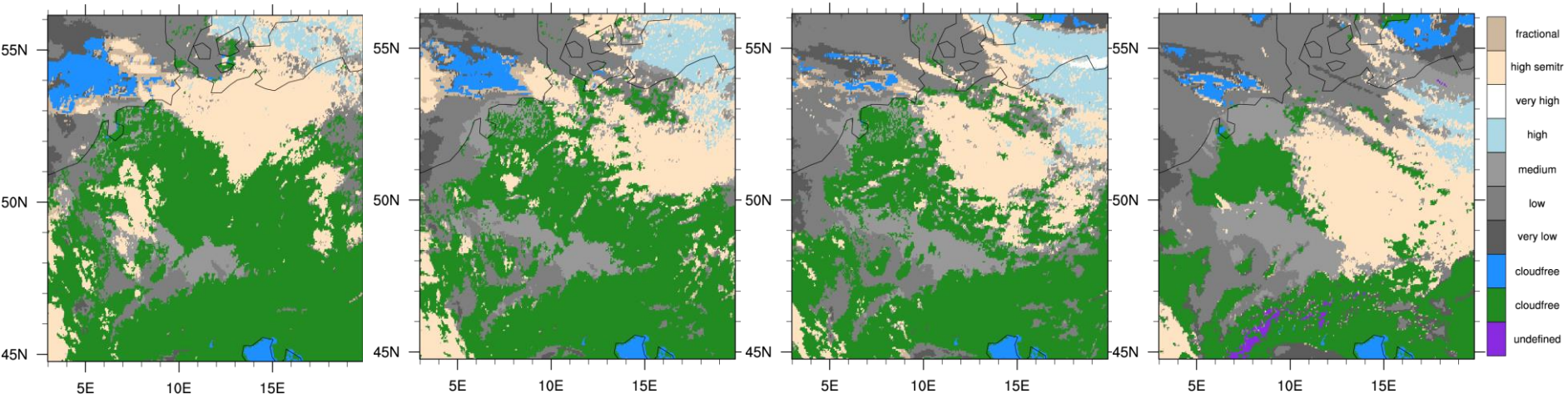
Stable high pressure situation

13 Nov 2011, 21:00 UTC - 14 Nov 12:00 UTC



0:00 UTC | 3:00 UTC | 6:00 UTC | 9:00 UTC

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Low cloud cover „false alarms“ at end of experiments

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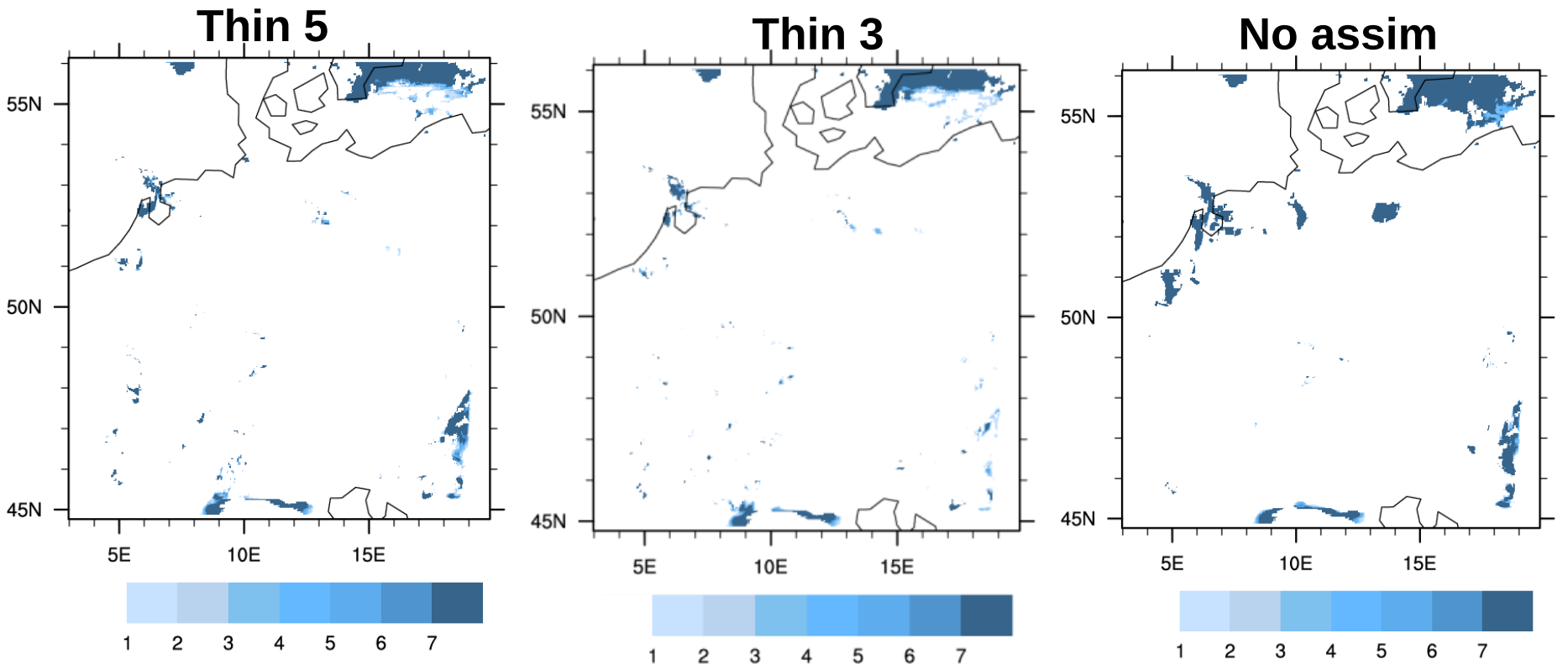

Medium cloud cover „false alarms“ at end of experiments

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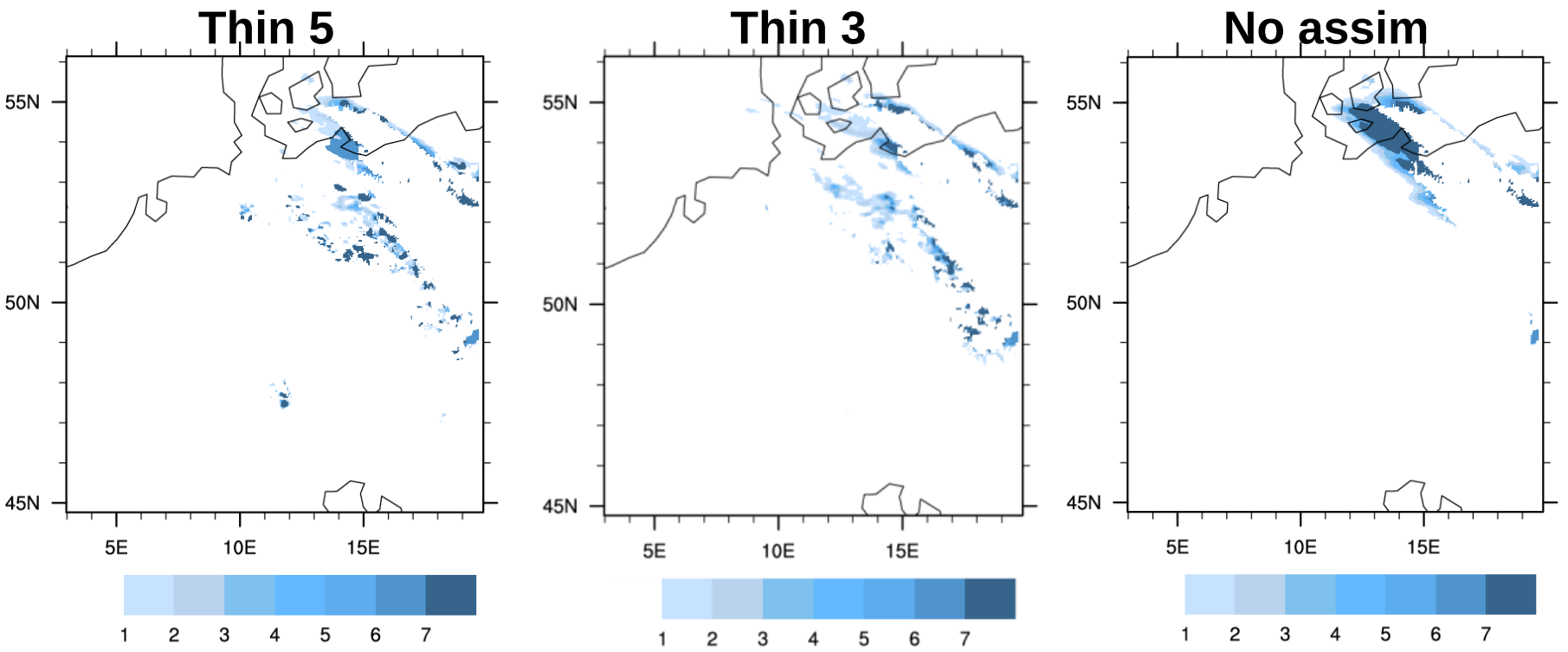

High cloud cover „false alarms“ at end of experiments

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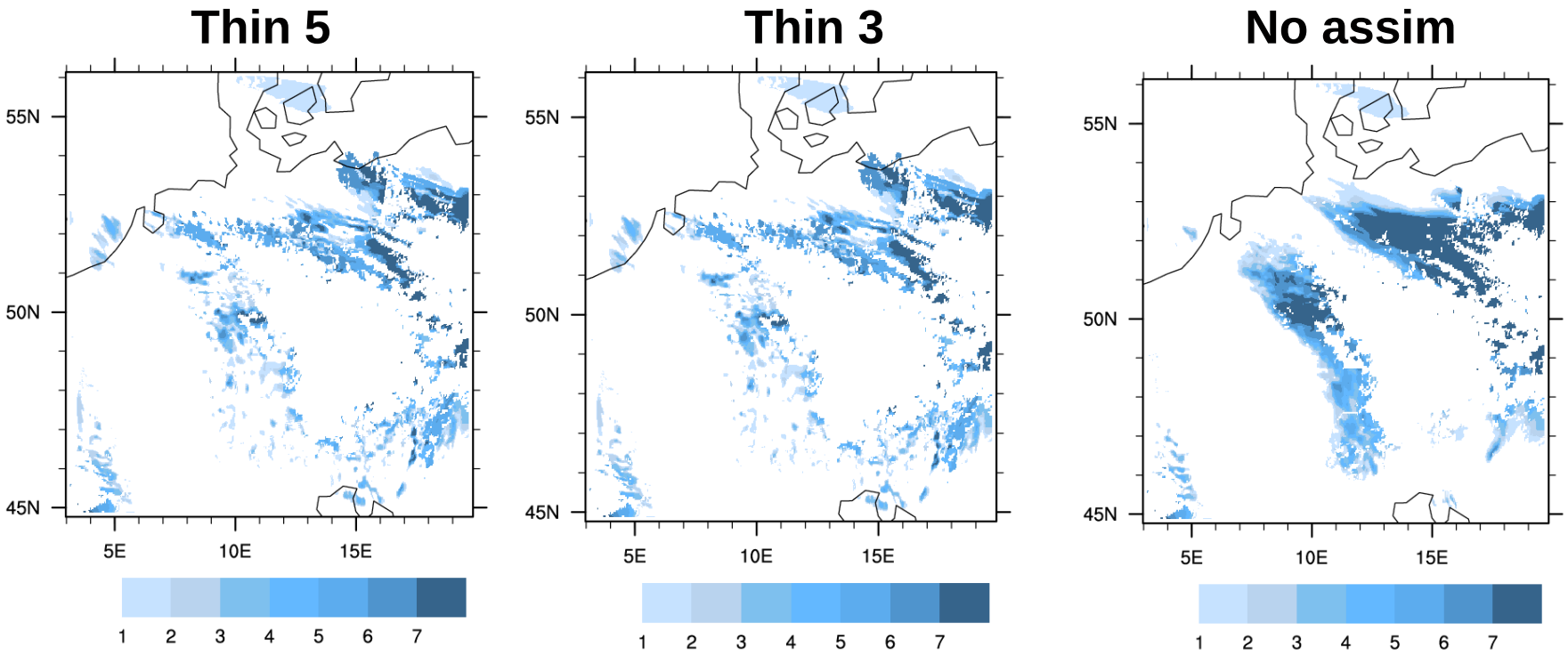

High cloud cover change

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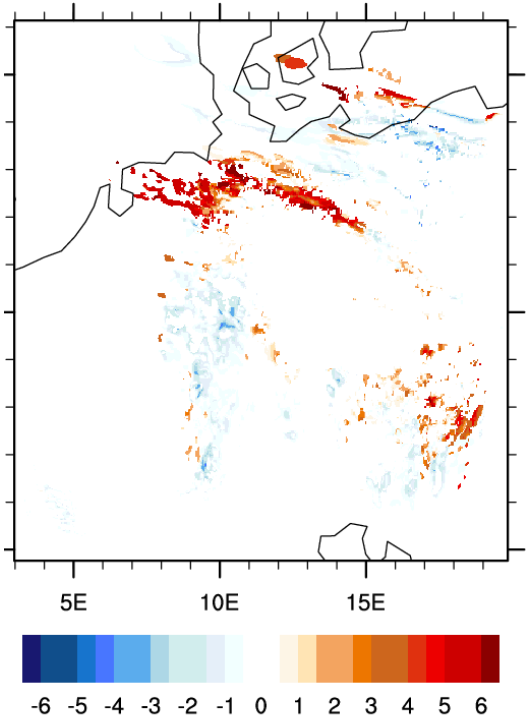
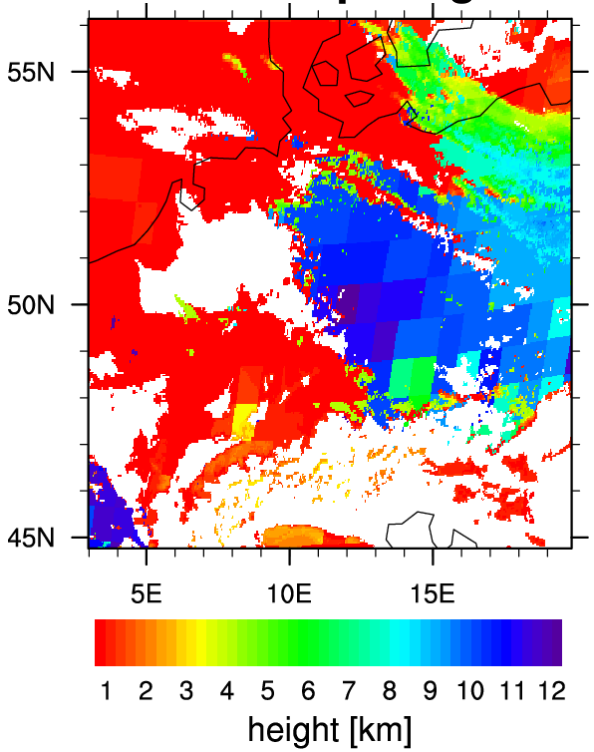
Cloud cover change high clouds during analysis



Cloud top height



9:00 UTC

Statistics: Mean absolute increment

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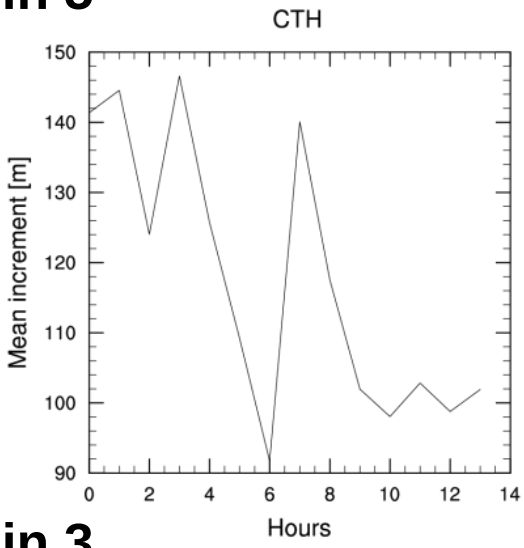
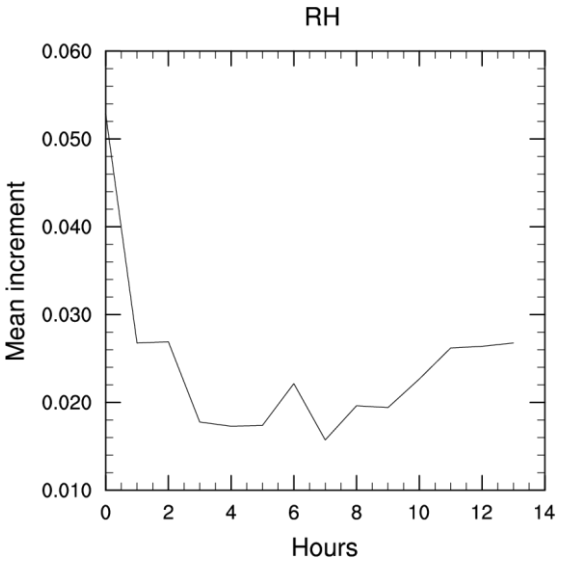
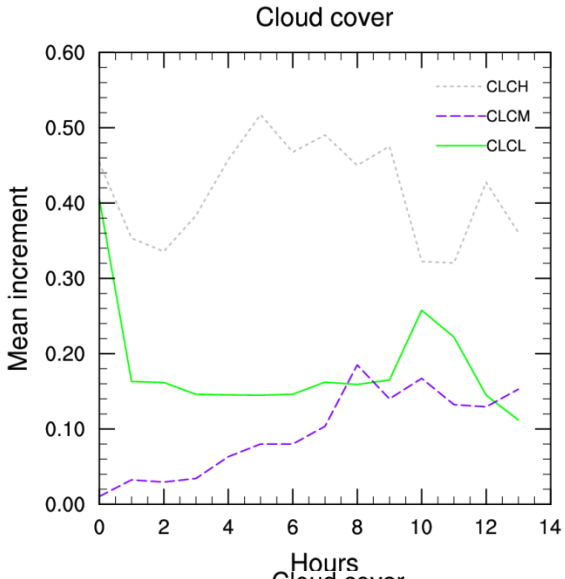
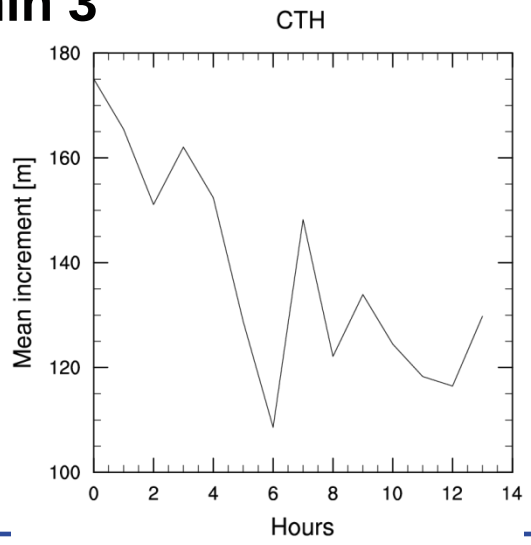
Thin 5

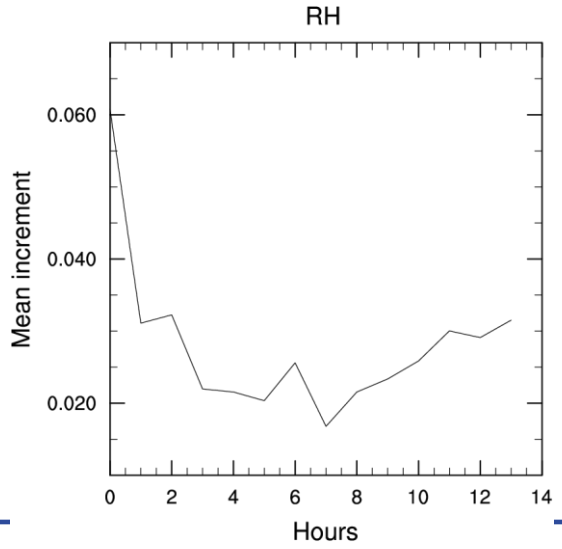


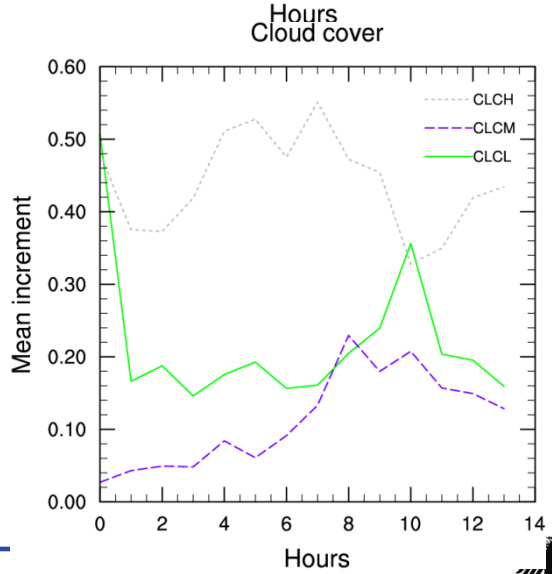




Thin 3







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RMSE and Bias

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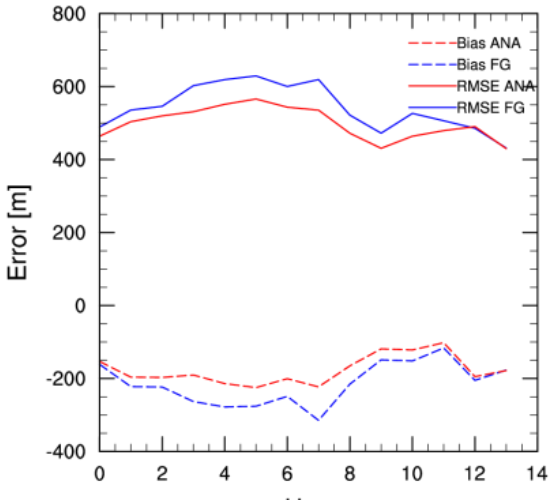
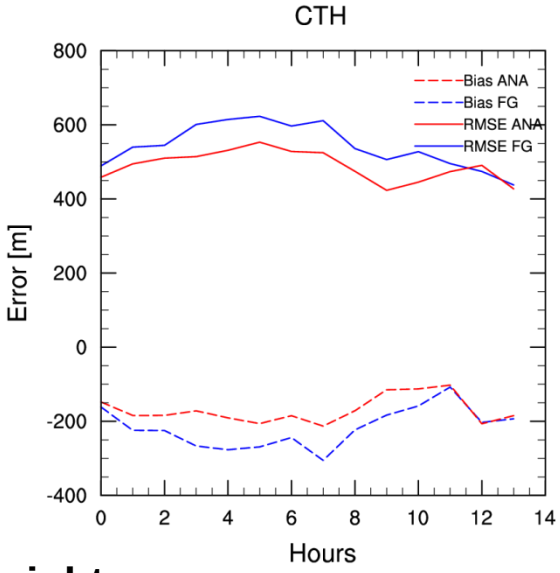
Thin 5

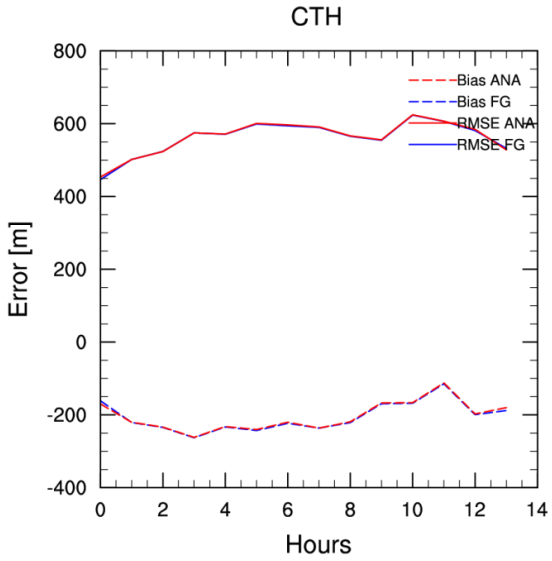
Thin 3

No Assim

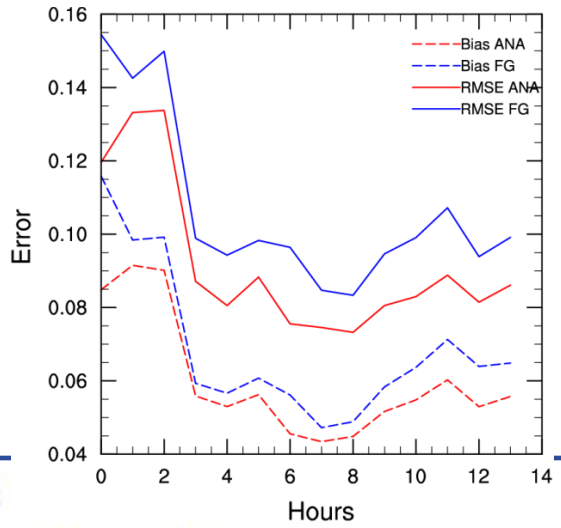
Cloud top height

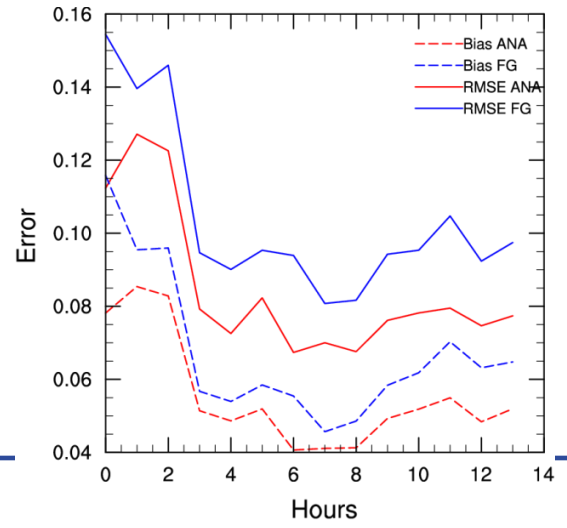


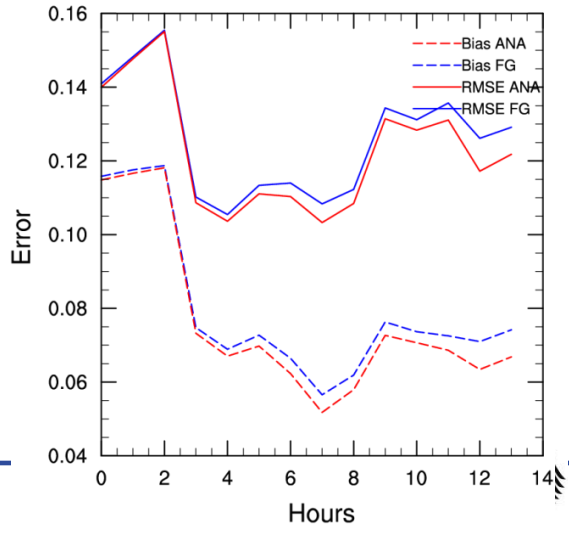




Relative humidity at cloud top height







RMSE and Bias for different cloud levels

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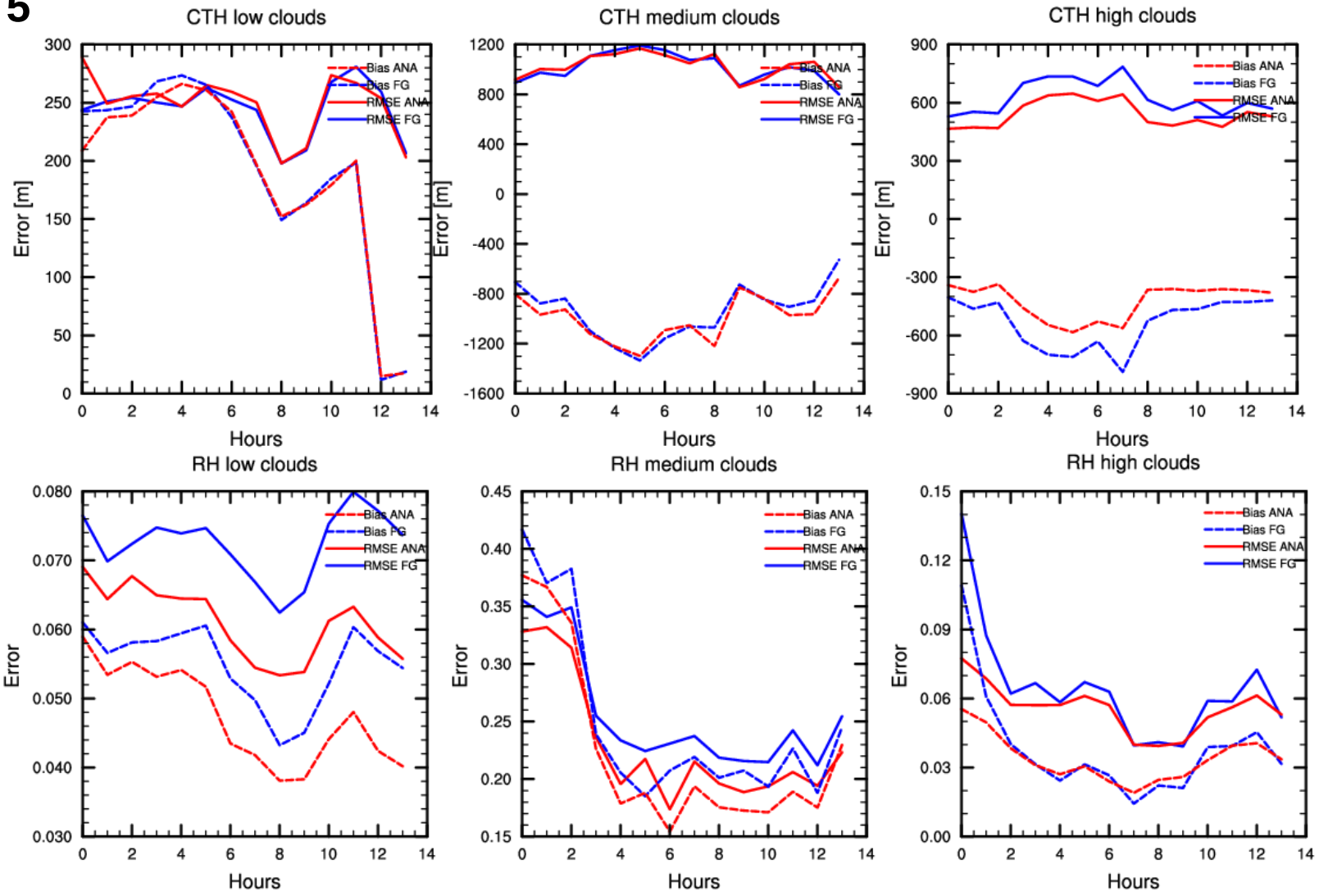
Thin 5



Brier scores

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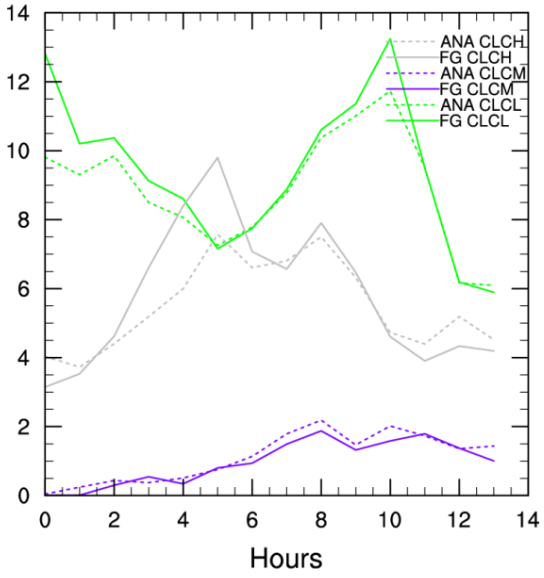
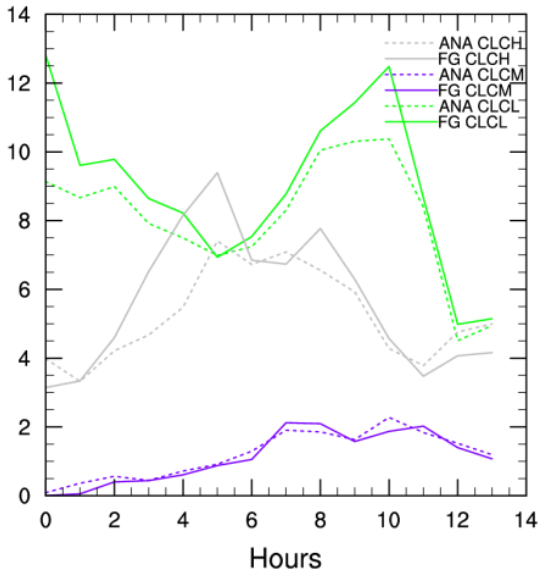
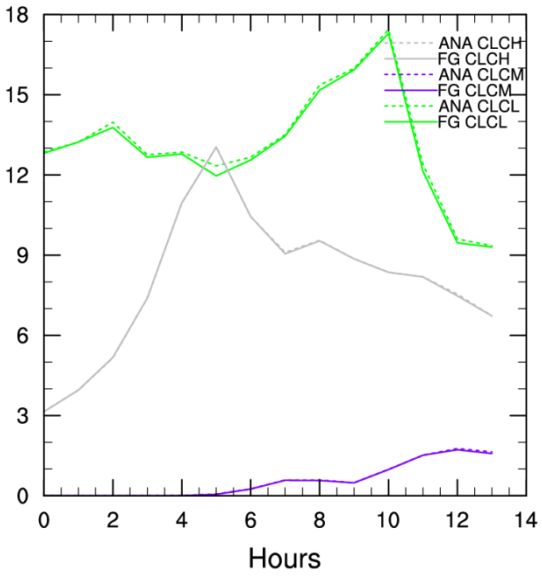
Thin 5



Thin 3

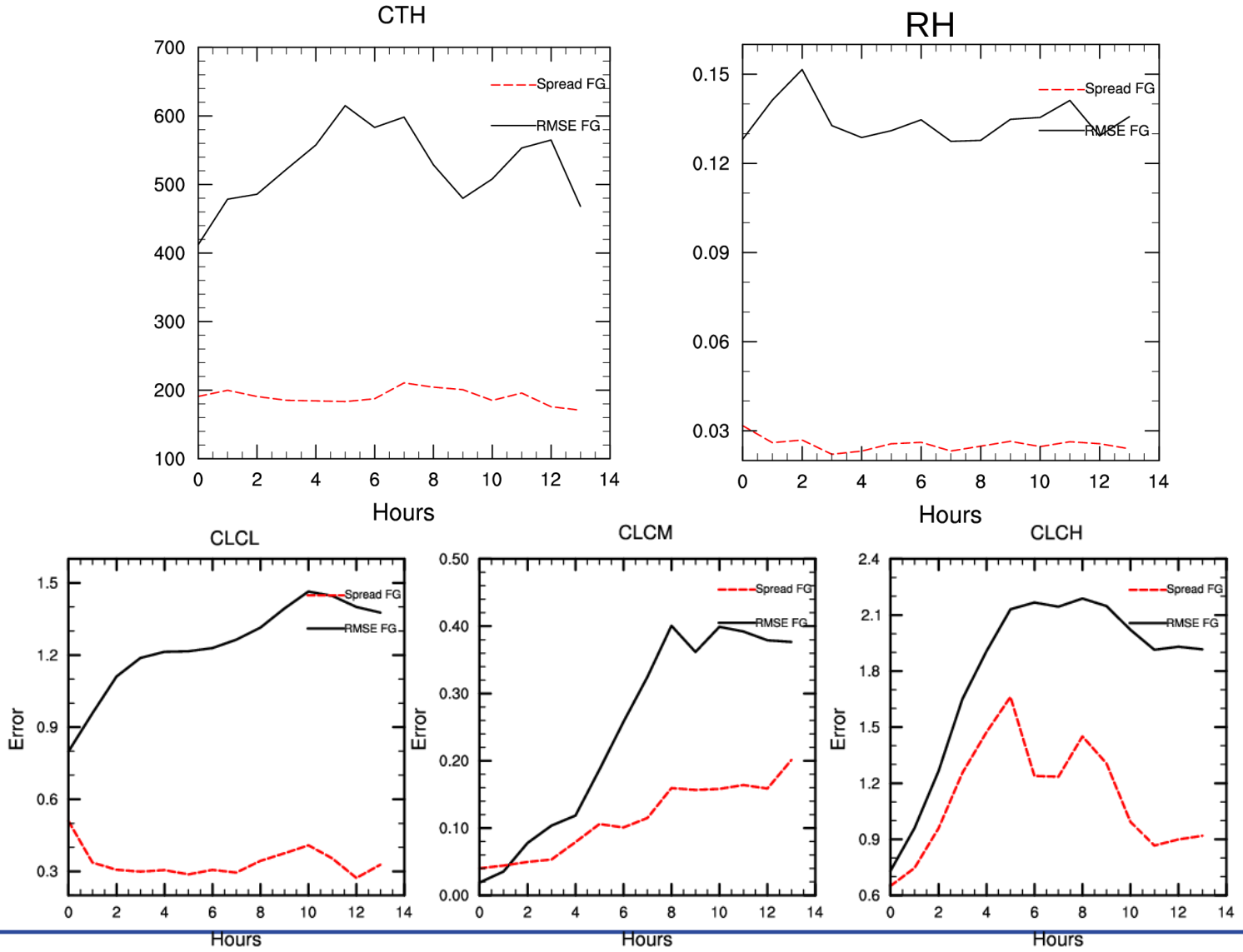


No Assim



$$BS = \frac{1}{N}\sum_{n=1}^{N}(H(x_n) - y_n)^2$$

Spread vs RMSE for assimilated variables



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Conclusion/Outlook

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Conclusion

- Analysis shows improved cloud characteristics compared to first guess
- Assimilate every 3rd instead of every 5th grid point leads to larger increments
- Considerable improvements of cloud characteristics compared to a control experiment without any assimilation

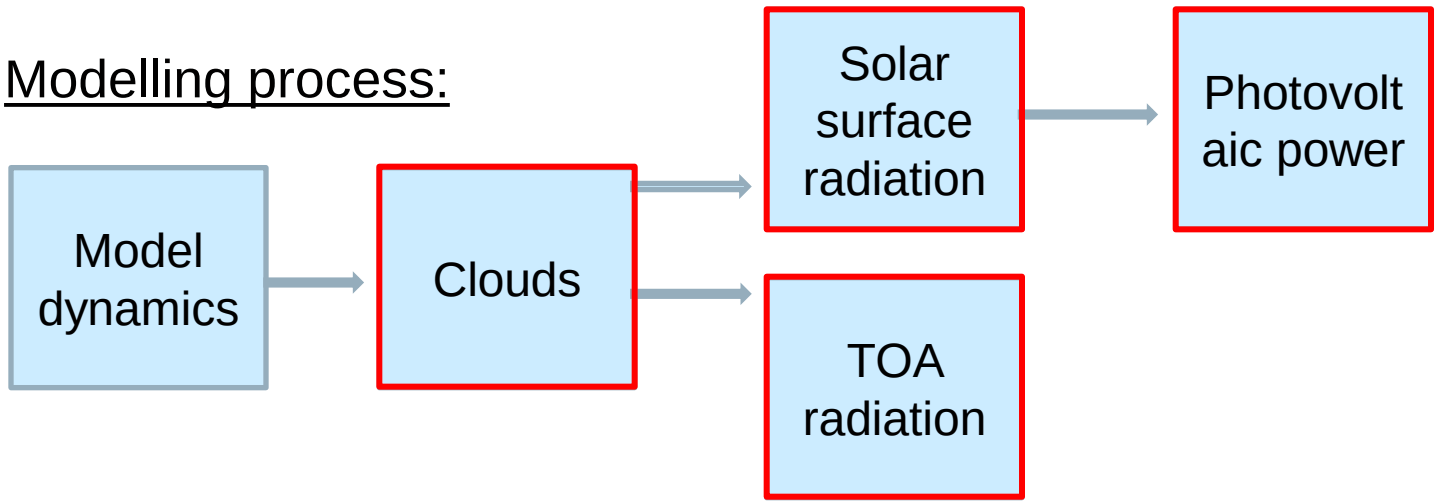
Outlook

- Run forecast

- Verification to other data: How does the cloud assimilation affect other model variables?
  - Conventional
  - IR-SEVIRI-Radiances
  - Solar surface net radiation

- Simulate convective case
- Combination with conventional observations

Aim: improve photovoltaic (and wind) power predictions



- To this end assimilate either
  - NWCSAF SEVIRI cloud products
  - Solar surface radiation (CMSAF SEVIRI satellite product)
  - Top of atmosphere radiation (CMSAF SEVIRI satellite product)
  - Photovoltaic power production