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Harmonie – Cloud DA

Experiments with ingest of MSG-NWCSAF cloud information

Finnish Meteorological Institute
Erik Gregow

Harmonie – Cloud (MSG-NWCSAF) Data Assimilation (DA)

Goal:

- Improve the cloudiness and radiation forecast, out to +48h fc.

Method:

- Original method based on the work done by Siebe Van der Veen, KNMI (within Hirlam model)
  Reference: http://journals.ametsoc.org/doi/pdf/10.1175/MWR-D-12-00021.1

→ **Correcting the humidity field, between detected cloud-base and height (MSG-NWCSAF)**

- SMHI (Magnus Lindskog and Tomas Landelius) implemented the method into Harmonie c38h12. This code has been shared with FMI
- FMI is closely cooperating with KNMI and SMHI in this development

Setup:

- Harmonie version c38h12, modified ingest routines and micro-physics
- Run at the ECMWF HPC-facilities; MetCoOP-area and with 3h cycling (+48h fc at 00 and 12Z)
- Completed experiments for July 2016 (1 full month):
  - Reference run (hereafter Ref)
  - Experiment 1: NWCSAF cloud- mask and -top temperature, cloud-base from interpolated Synop stations (hereafter MSG)
  - Experiment 2: Same as 1) but with cloud-base derieved from NWCSAF cloud-type and climatological/estimated values (hereafter MSG_SWE)

Results:

- Results from the three above experiments are shown... Focus: Radiation and Clouds

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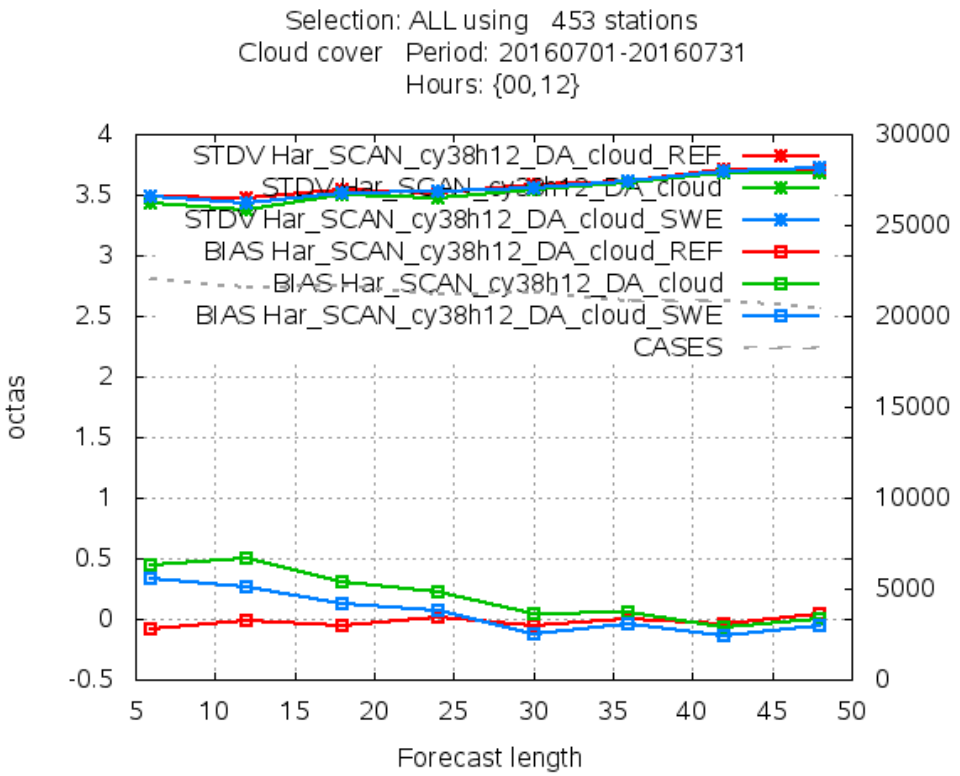
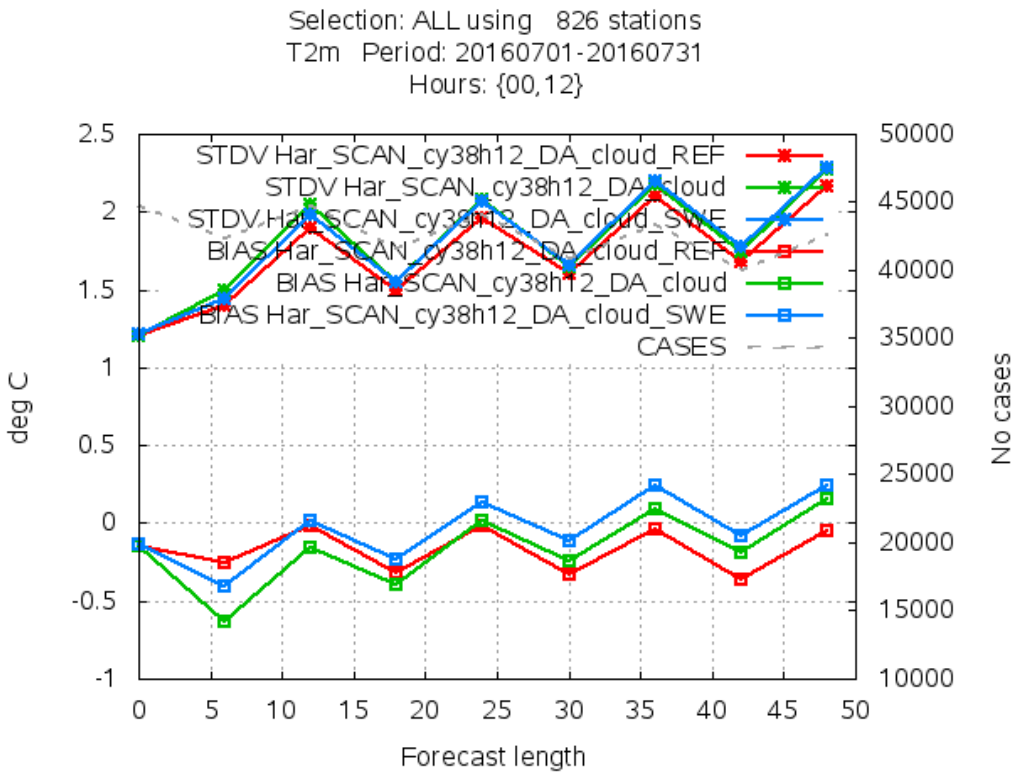
Harmonie Exp: DA of cloud (MSG-NWCSAF) – WebGraf verification tool

- There is a positive cloud-cover bias for MSG (green) and MSG_SWE (blue), Ref (red) slightly neg. The effect persists out to approximately +25-35h forecast step
- The 2 meter temperature have a negative bias (too low temperature) in the beginning (first 12-22h), then it turns to become slightly positive/neutral

Cloud cover



Temperature, 2m



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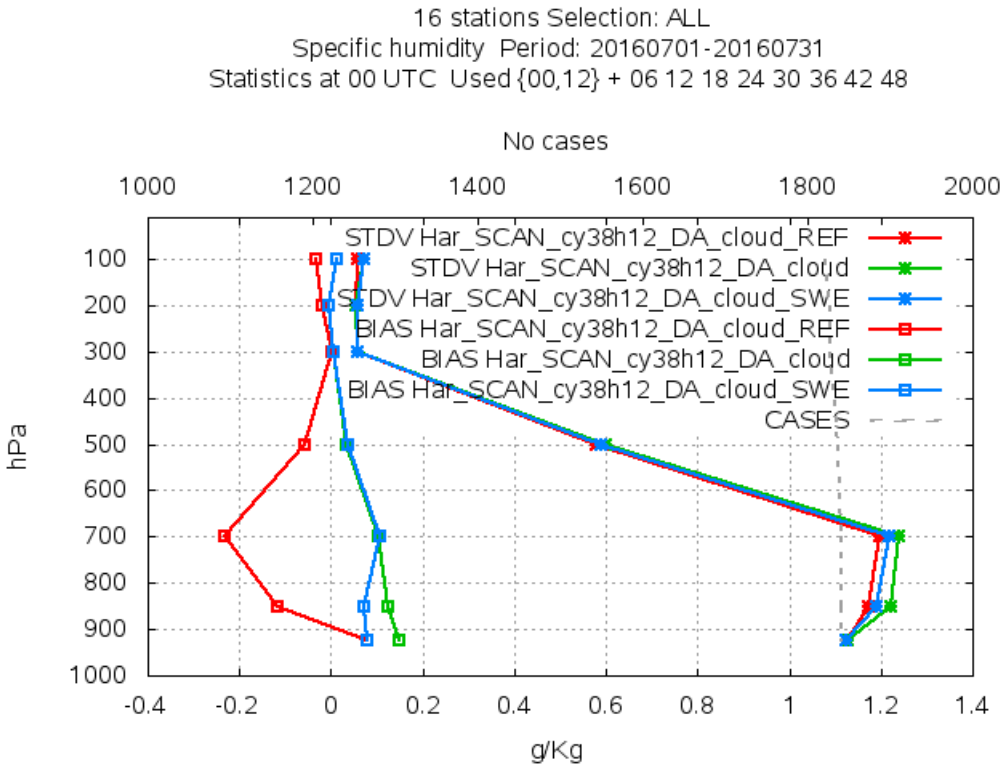
Harmonie Exp: DA of cloud (MSG-NWCSAF) – WebGraf verification tool

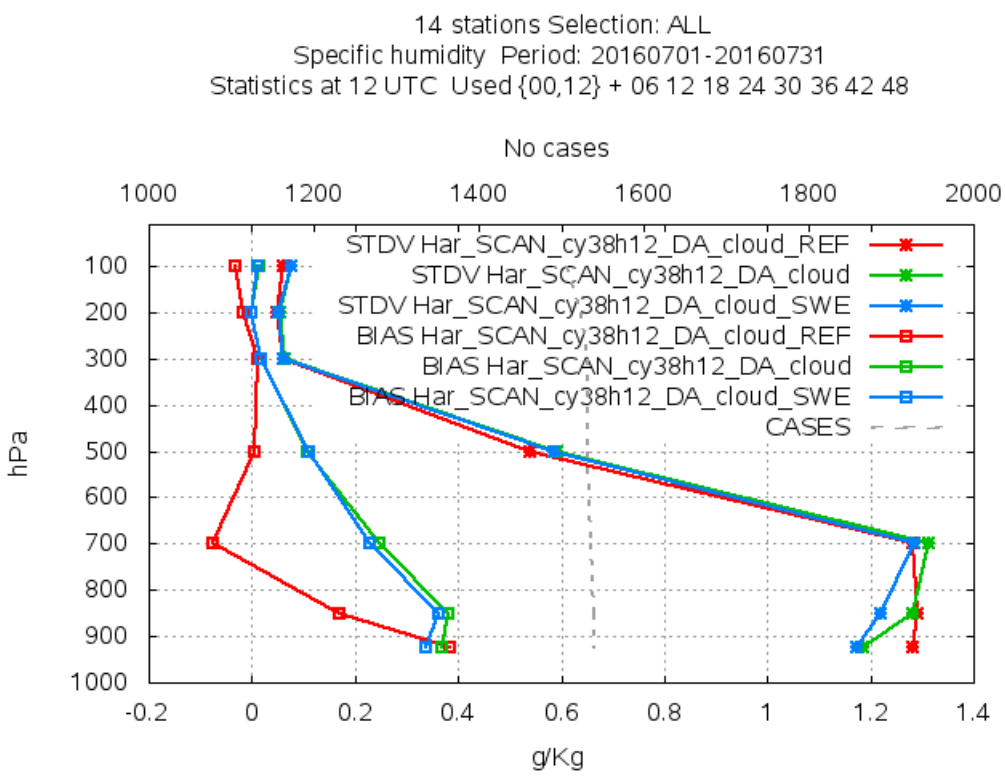
Verification of upper-air parameters:

- At 00Z MSG (green) and MSG_SWE (blue) scores are slightly better (positive bias), compared to Ref (red) But for the 12Z run the scores are worse (positive bias, too hight Spec. hum.)
- Indication that we add clouds and that we add too much (seen especially in 12Z)

Specific Humidity, 00Z



Specific Humidity, 12Z



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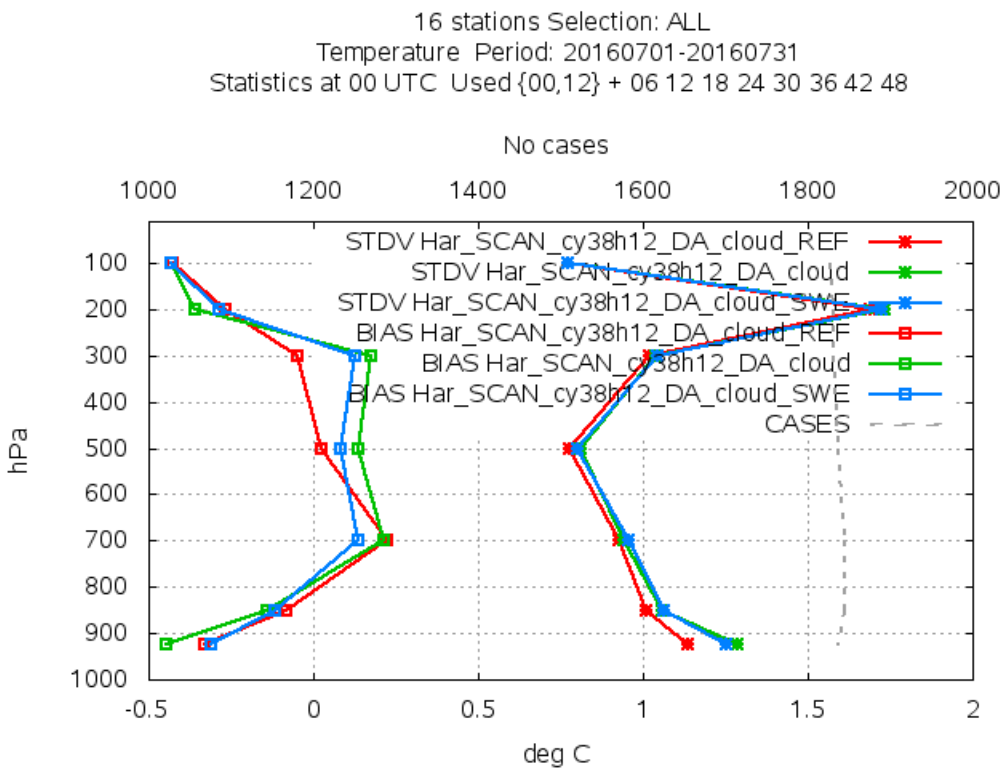
Harmonie Exp: DA of cloud (MSG-NWCSAF) – WebGraf verification tool

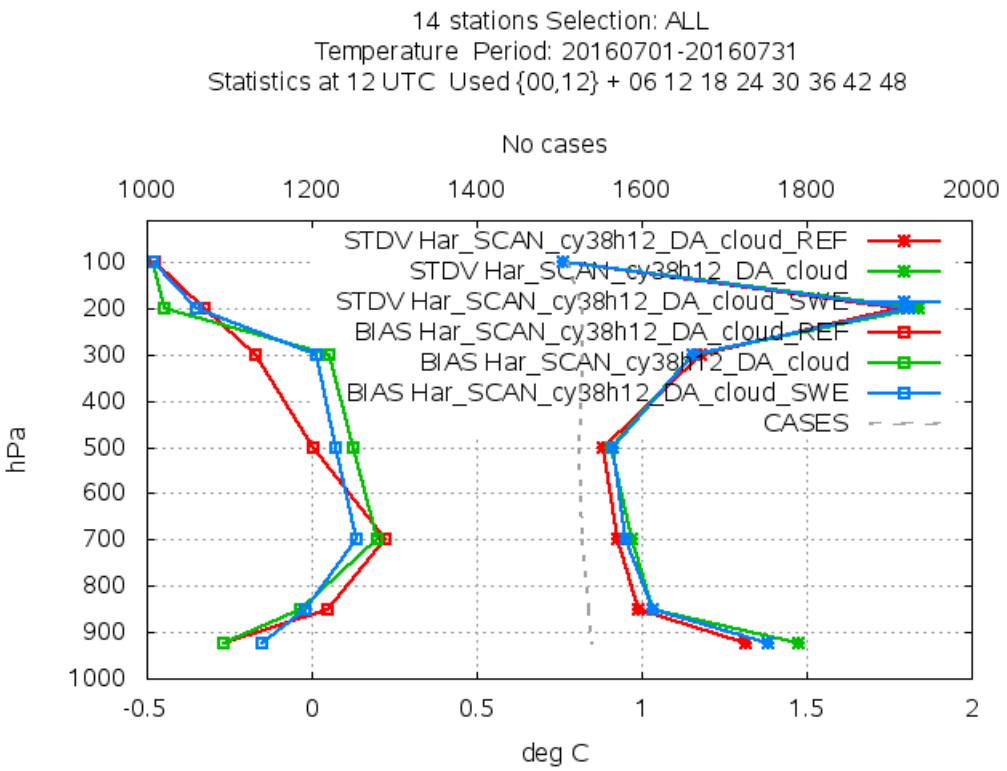
Verification of upper-air parameters:

- The temperature becomes slightly worse with the MSG (green), especially btw levels 300-700 hPa
  But MSG_SWE (blue) give better or equal scores compared to Ref (red), except levels 300-500 hPa.

Temperature, 00Z



Temperature, 12Z



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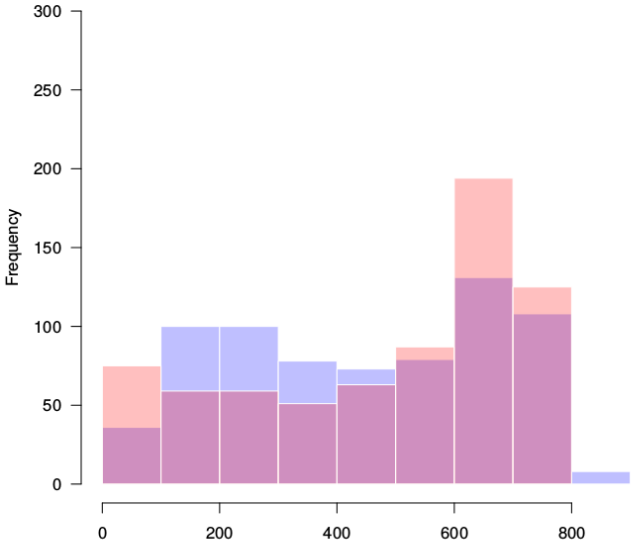
Harmonie Exp: MSG-NWCSAF DA of cloud – Impact on Radiation (SW global)

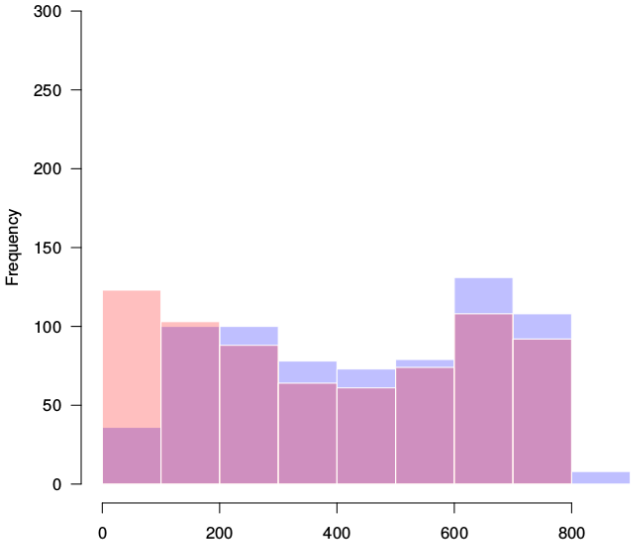
- First verification results with observations: July 2016

Representative results shown for ~25 stations at 10Z (similar results seen also for other timestamps!)
Corresponding Harmonie output forecast: 09Z+1h fc (accumulated)

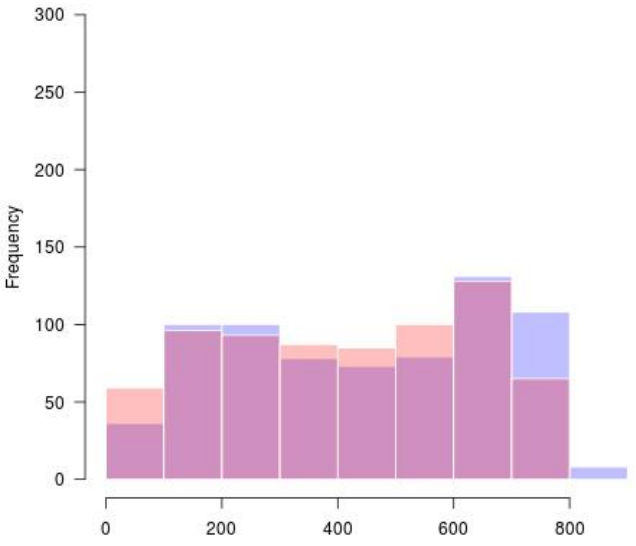
Obs (blue) vs Ref (red)



Obs (blue) vs MSG (red)



Obs (blue) vs MSG_SWE (red)



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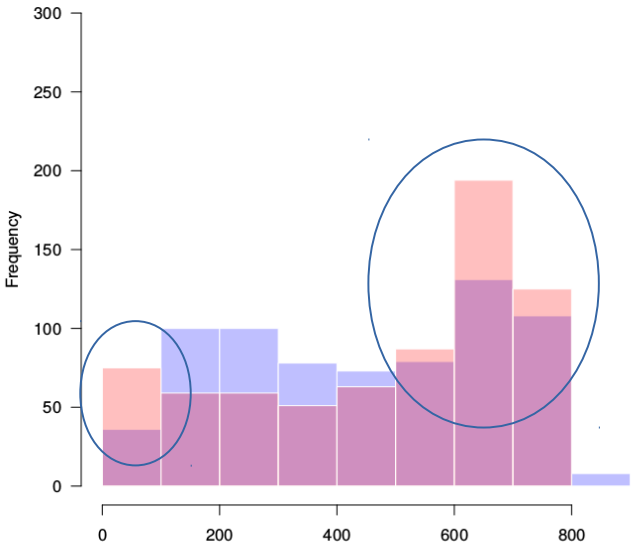
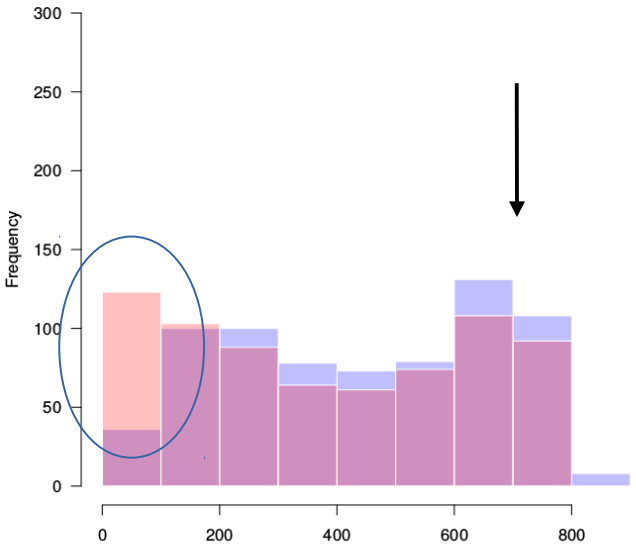


Ref:

RMSE = 185.6
BIAS = -27.9

Generally too few clouds, i.e. too much high radiation!
Some cases with too much clouds, underestimationg the radiation

Obs (blue) vs MSG (red)

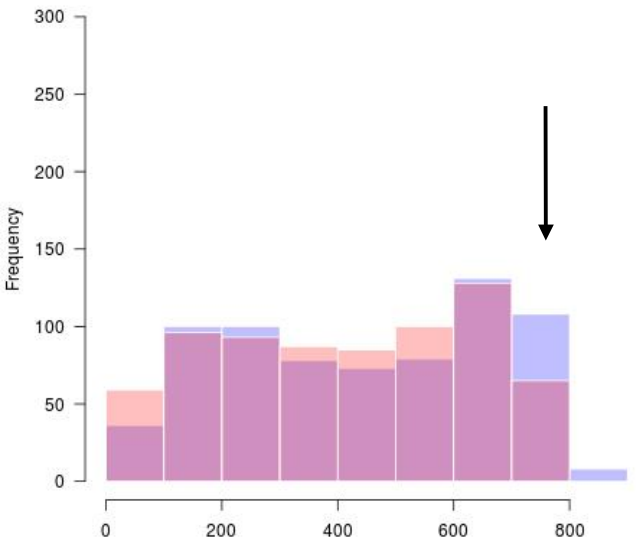


MSG:

RMSE = 224.0
BIAS = 67.6

Too much clouds → Mainly underestimation of radiation

Obs (blue) vs MSG_SWE (red)



MSG_SWE:

RMSE = 191.4
BIAS = 33.6

Better than MSG but underestimating the high radiation cases, still too much clouds!

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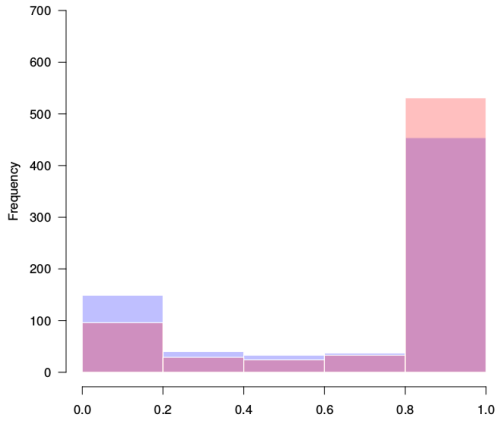
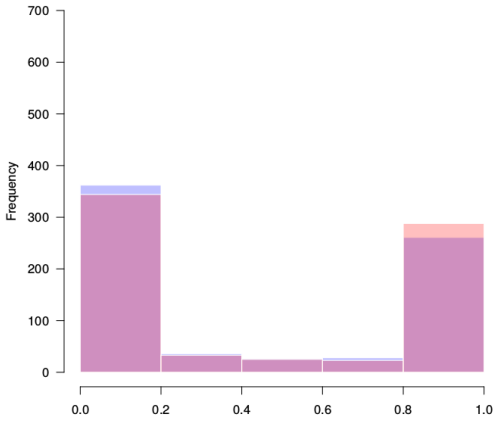
Harmonie Exp: MSG-NWCSAF DA of cloud – Impact on cloud/layers

- Representative results shown for 10Z (fc +1h) during July 2016

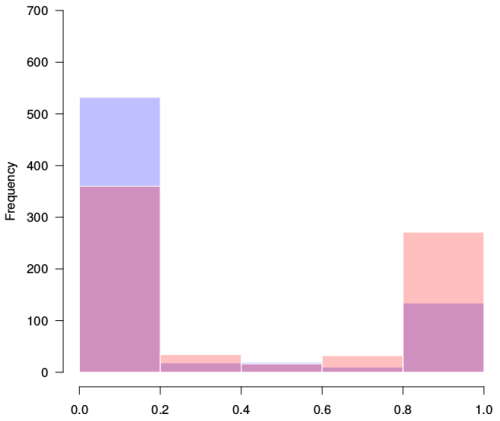
Ref (blue) vs MSG (red)



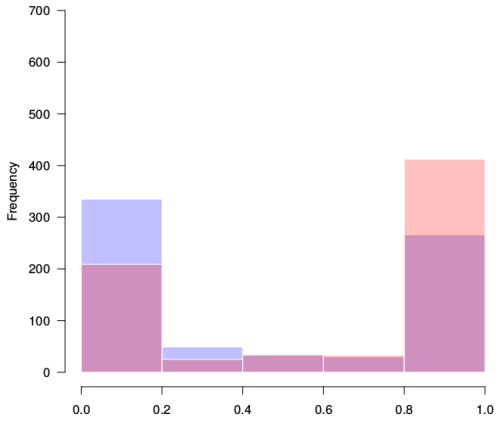
Cld Frac/Tot Cld



Low Cld

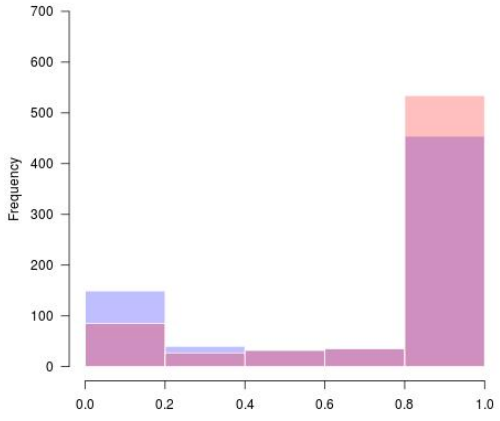


Middle Cld



High Cld

Ref (blue) vs MSG_SWE (red)



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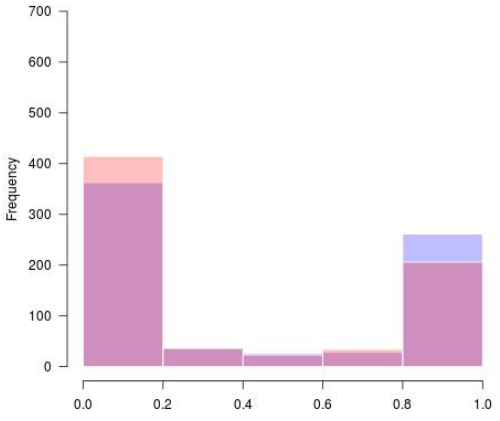
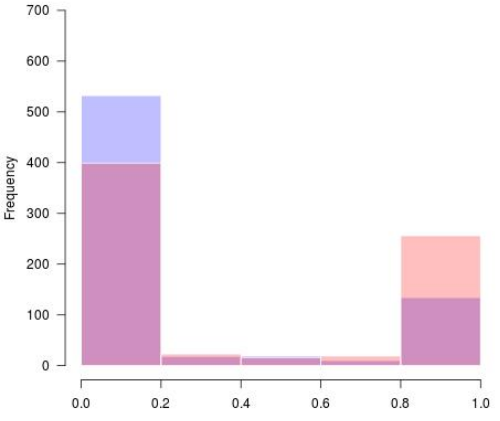
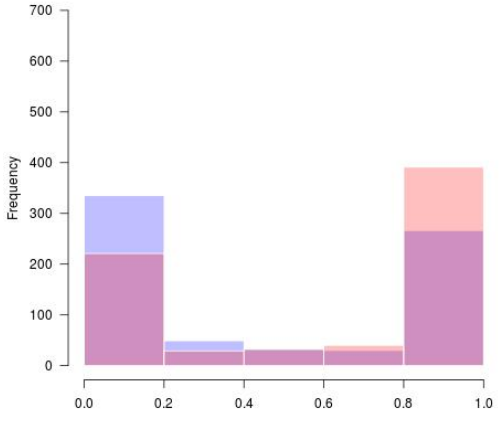


Low Cld



Middle Cld



High Cld

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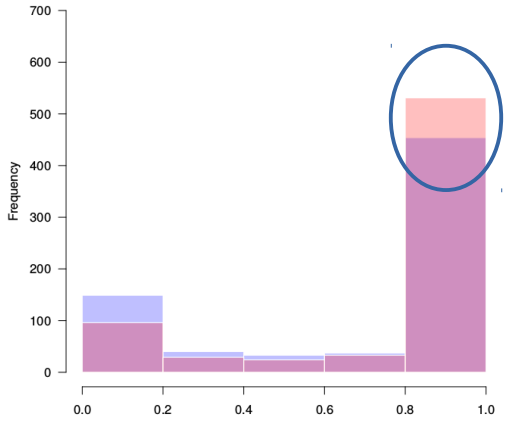
Harmonie Exp: MSG-NWCSAF DA of cloud – Impact on cloud/layers

- Representative results shown for 10Z (fc +1h) during July 2016

Ref (blue) vs MSG (red)



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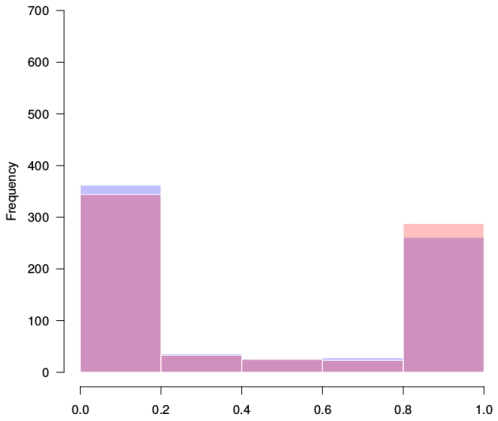
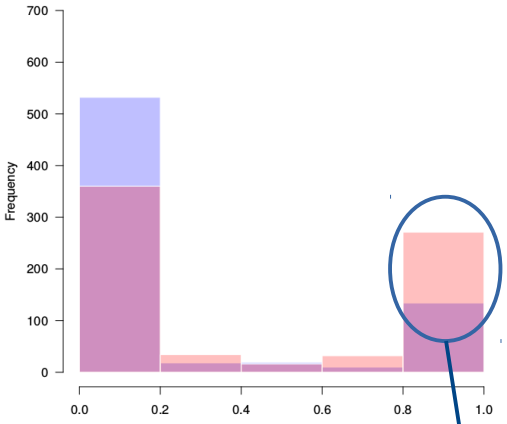
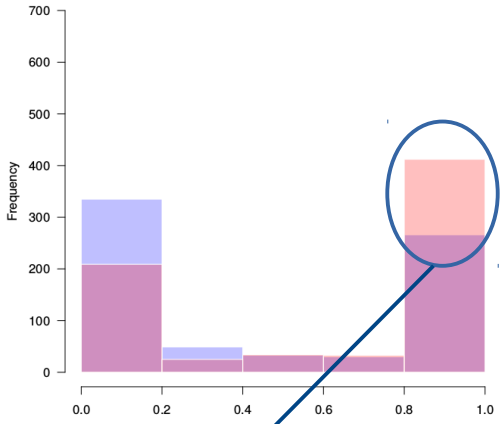


Low Cld

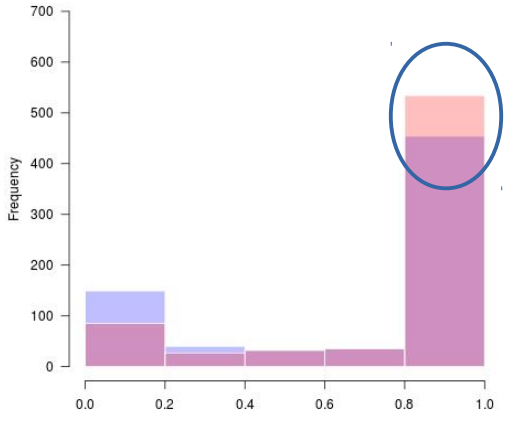


Middle Cld

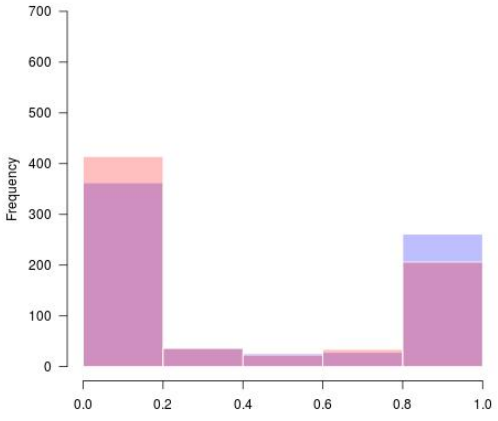


High Cld

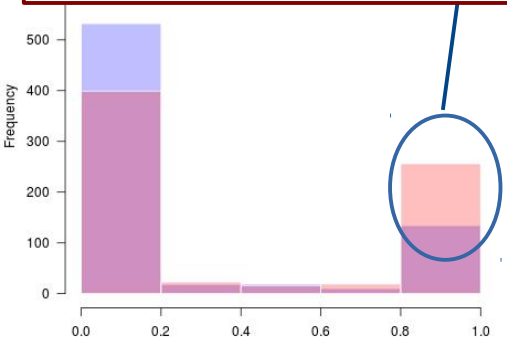
Ref (blue) vs MSG_SWE (red)



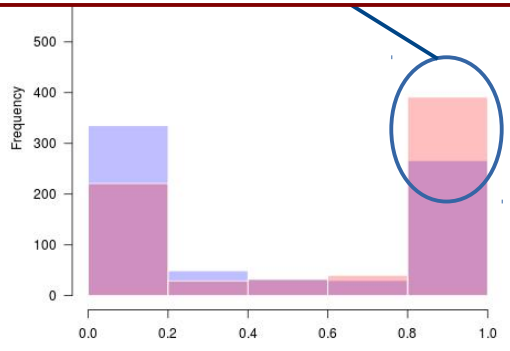
Cld Frac/Tot Cld



Low Cld



Middle Cld



High Cld

High- and middle Clouds are added by MSG and MSG_SWE, compared with Ref

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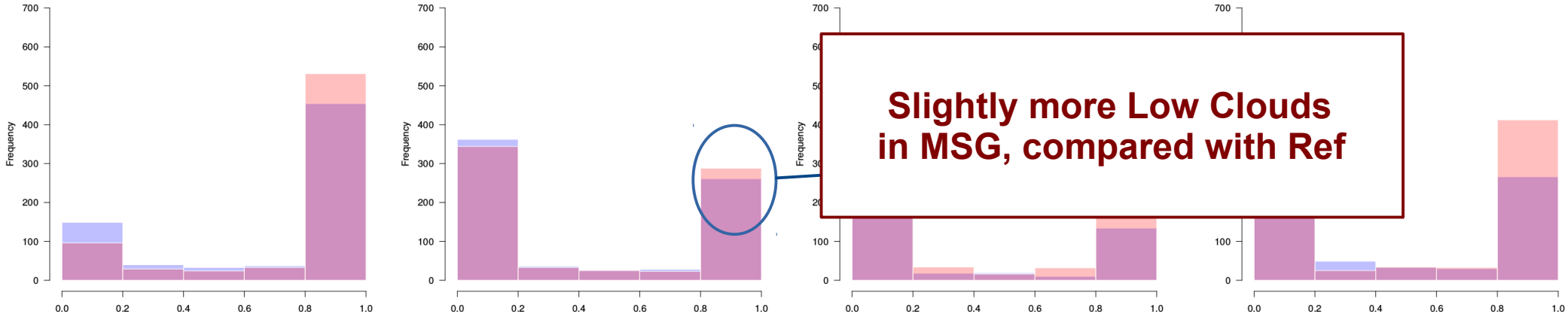
Harmonie Exp: MSG-NWCSAF DA of cloud – Impact on cloud/layers

- Representative results shown for 10Z (fc +1h) during July 2016

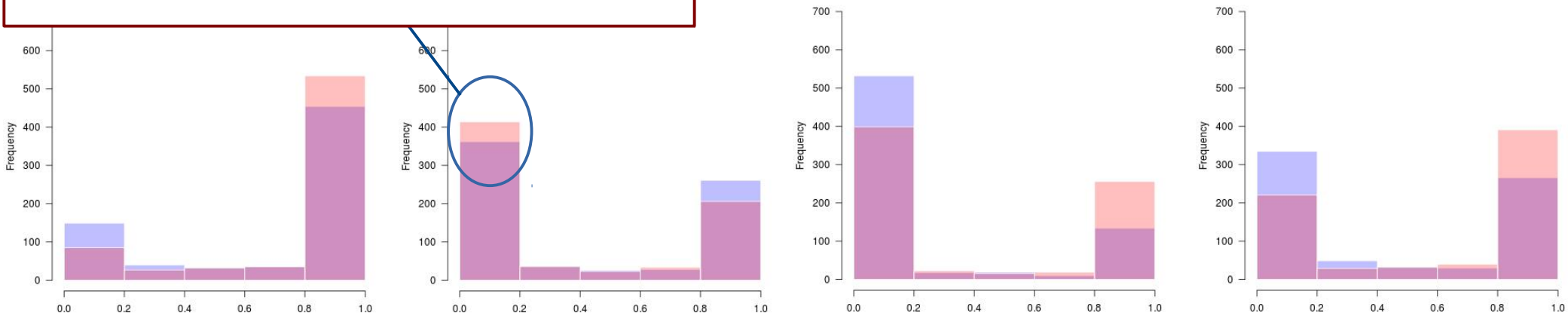
Ref (blue) vs MSG (red)



Slightly more Low Clouds in MSG, compared with Ref

Less Low Clouds in MSG_SWE, compared with Ref

e) vs MSG_SWE (red)



Harmonie Exp: MSG-NWCSAF DA of cloud

Experiments:

- **Reference (Ref)**: Normal run with Harmonie v38c1.2
- **MSG**: NWCSAF cloud-mask and -top temperature, with Sibbo's Synop derived cloud base
- **MSG-SWE**: Same as MSG but with cloud-base from SMHI static values (derived from MESAN/climatological and first-guess estimate)

Conclusions

Radiation:

- Reference (Ref) mainly overestimate the high radiation values (e.g. too few clouds), to some extent/few cases with too low radiation
- MSG clearly underestimate the radiation, too many cases with low radiation (e.g. too much clouds)
- MSG-SWE also generally underestimate the radiation BUT results are better than MSG!

Clouds and cloud-layers:

- MSG and MSG-SWE overestimate the cloud-fraction, especially the middle- and high-clouds
- From case-studies, it is seen that MSG is sensitive to Synop station placement, which in some cases removed areas with low clouds!
- MSG-SWE underestimate the low-clouds (e.g. too few low-clouds). Problem since method uses cloud-type to determine cloud-base, and only the highest cloud-layer is detected and not what is beneath!

Harmonie – Cloud (MSG-NWCSAF) Data Assimilation (DA)

- **Detection of problems and defining possible solutions → New developments**

  - Input from NWCSAF: Cloud-Type classes → cloud-mask & cloud-base MSG_SWE
    - Too much clouds (especially high-clouds)
    - Which Cloud-Type classes to use - Exclude certain classes

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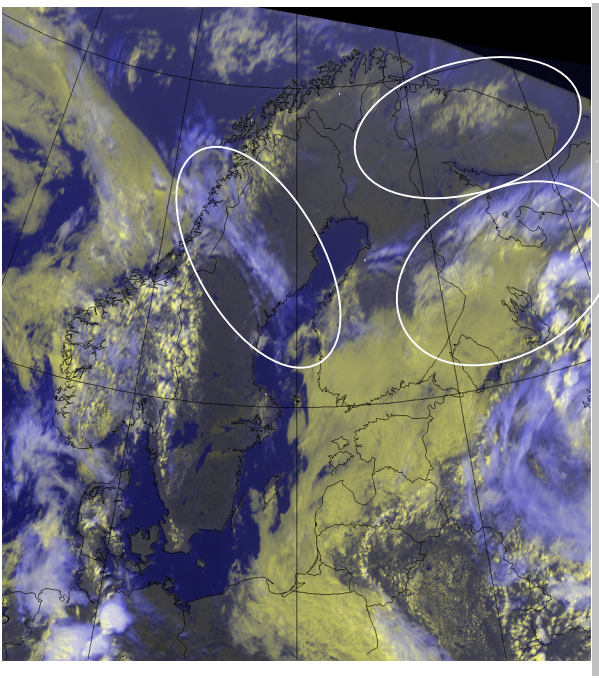
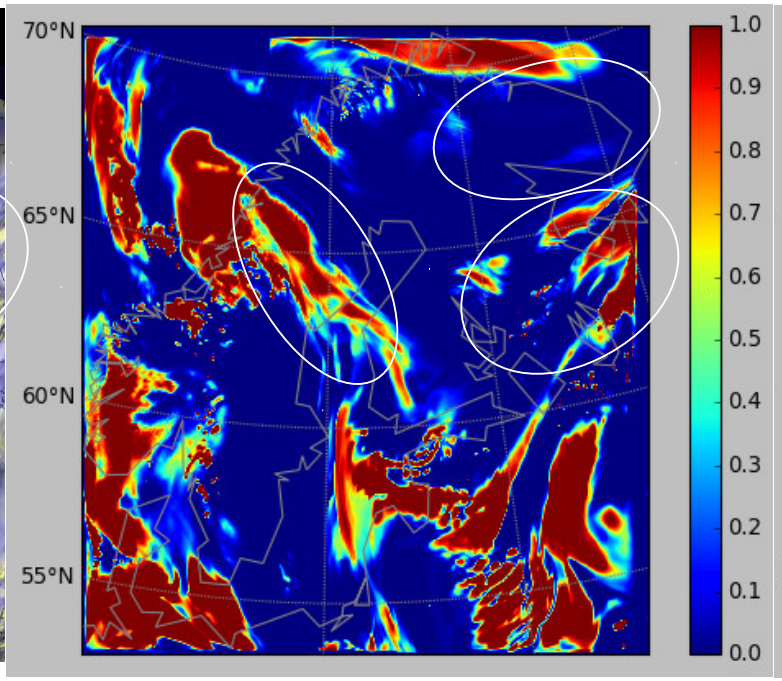
  - Input from NWCSAF: Cloud-Type classes → cloud-mask & cloud-base MSG_SWE
    - Too much clouds (especially high-clouds)
    - Which Cloud-Type classes to use - Exclude certain classes

Example from date: 2016-07-22, at 12Z + 00h fc - **High clouds:**

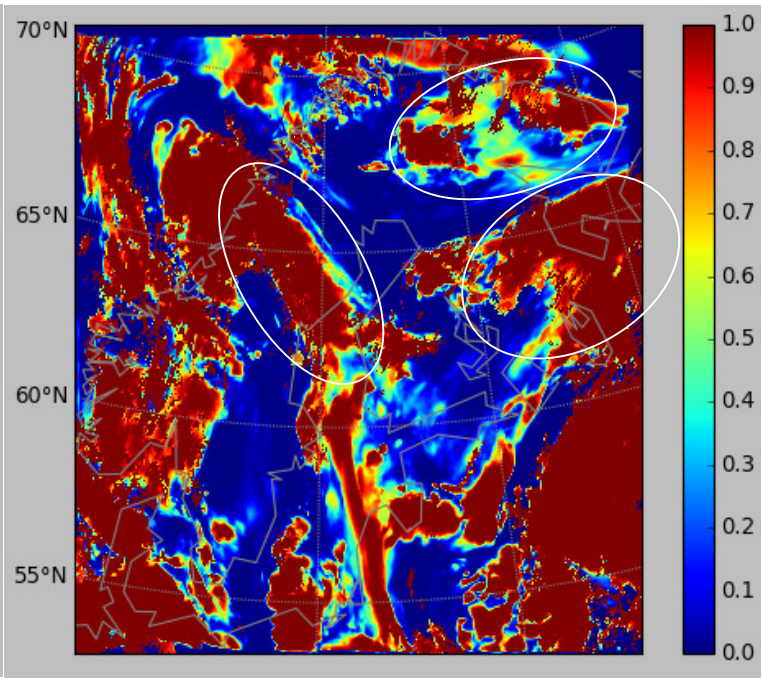
Satellite



Har. Reference



Har. MSG-NWCSAF



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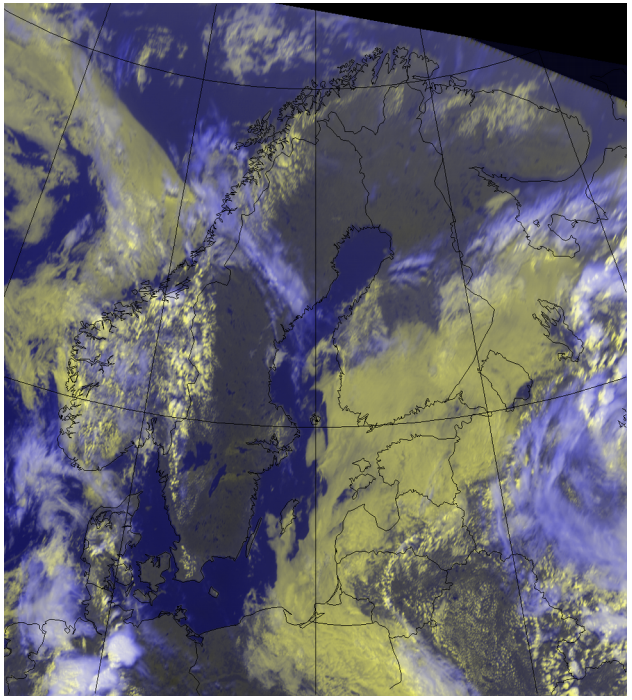
MSG-NWCSAF DA of cloud – Input from NWCSAF: Cloud-Type classes

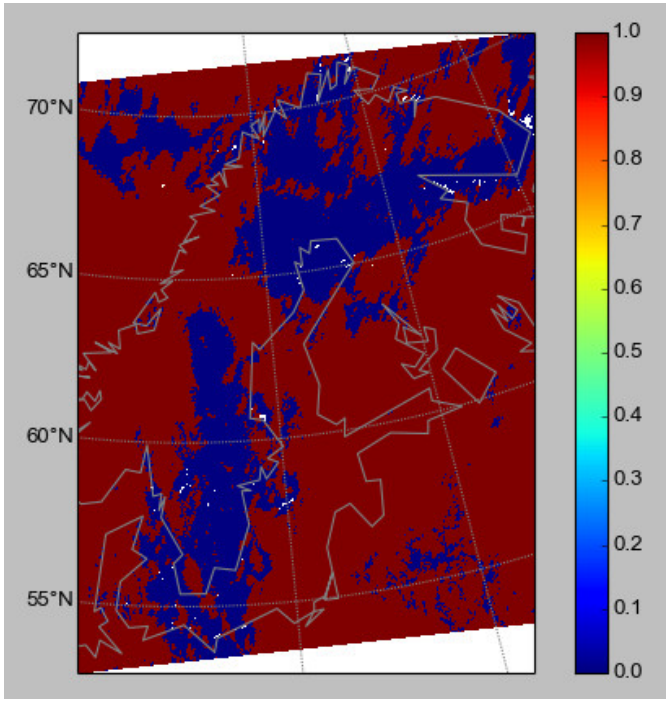
- In order to solve the problem:
  - Which Cloud-Type classes to use as input from NWCSAF?
  - Test: Exclude *"Fractional clouds"* and *"High, very thin Cirrus"*
  - **Future Experiment run will exclude Cloud-Type classes: 19 and 15**

Date: 22 July 2016, 12Z - **Cloud-mask:**

Satellite

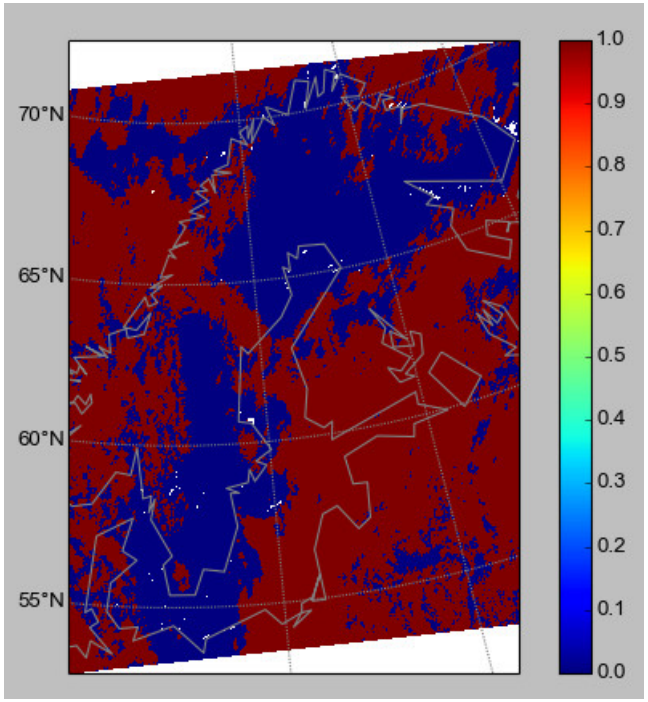


Original



Too much clouds!

Exclude CT=19,15



Reduced clouds
Looks better!

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MSG-NWCSAF DA of cloud – Input from NWCSAF: Cloud-Type classes

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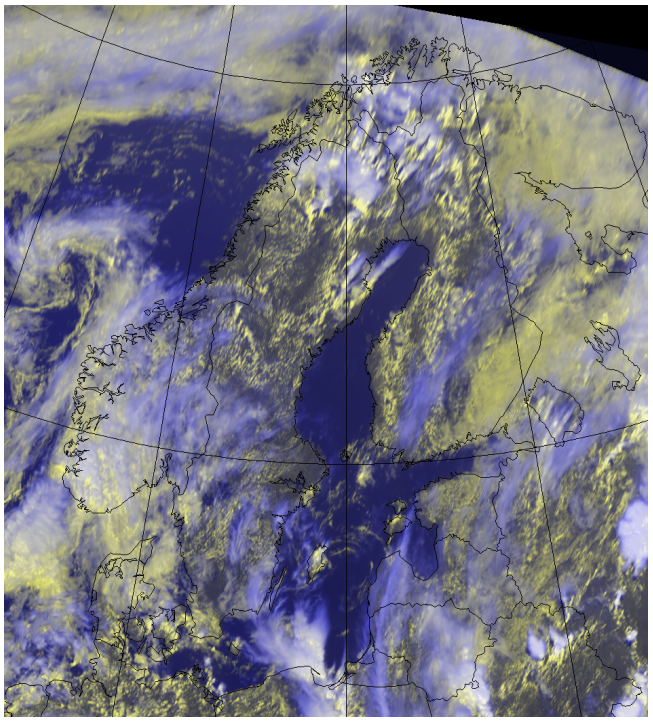
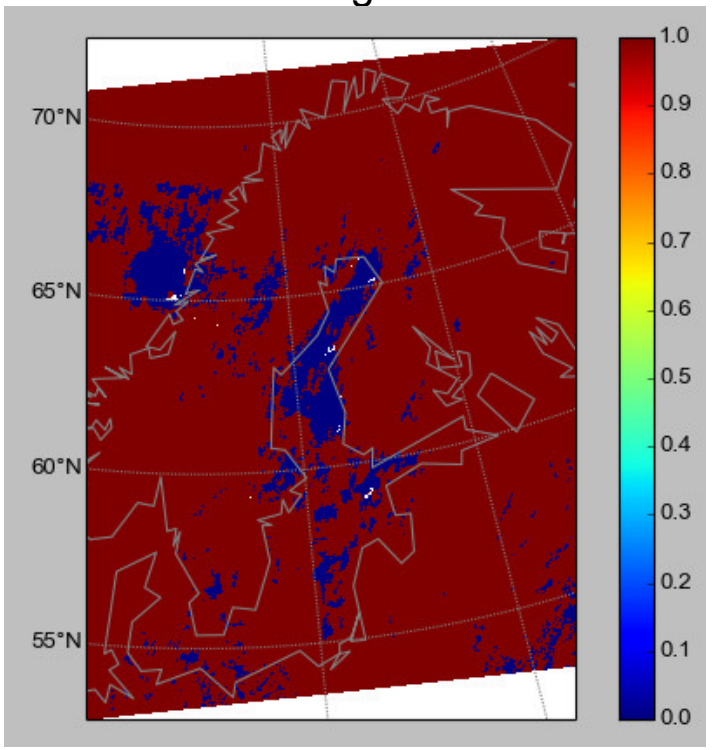
  - Test: Exclude *"Fractional clouds"* and *"High, very thin Cirrus"*
  - Next Experiment run will exclude Cloud-Type classes: 19 and 15

Date: 29 July 2016, 12Z - **Cloud-mask:**

Satellite

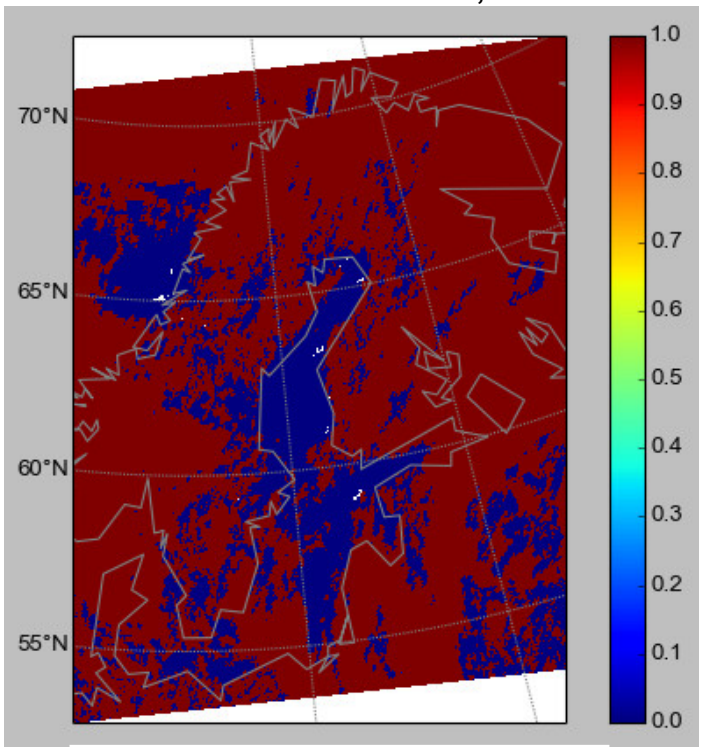


Original



Too much clouds!

Exclude CT=19,15



Reduced clouds
Looks better!

Harmonie – Cloud (MSG-NWCSAF) Data Assimilation (DA)

- **Detection of problems and defining possible solutions → New developments**

  - Input from NWCSAF: Cloud-Type classes
    - Too much clouds (especially high-clouds)
    - Which Cloud-Type classes to use - Exclude certain classes

  - Cloud-base estimation, 2 versions: Related to low-clouds
    - MSG – Synop based
    - MSG_SWE – Climatological estimates, “first-guess”

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MSG-NWCSAF DA of cloud – Cloud-base estimation

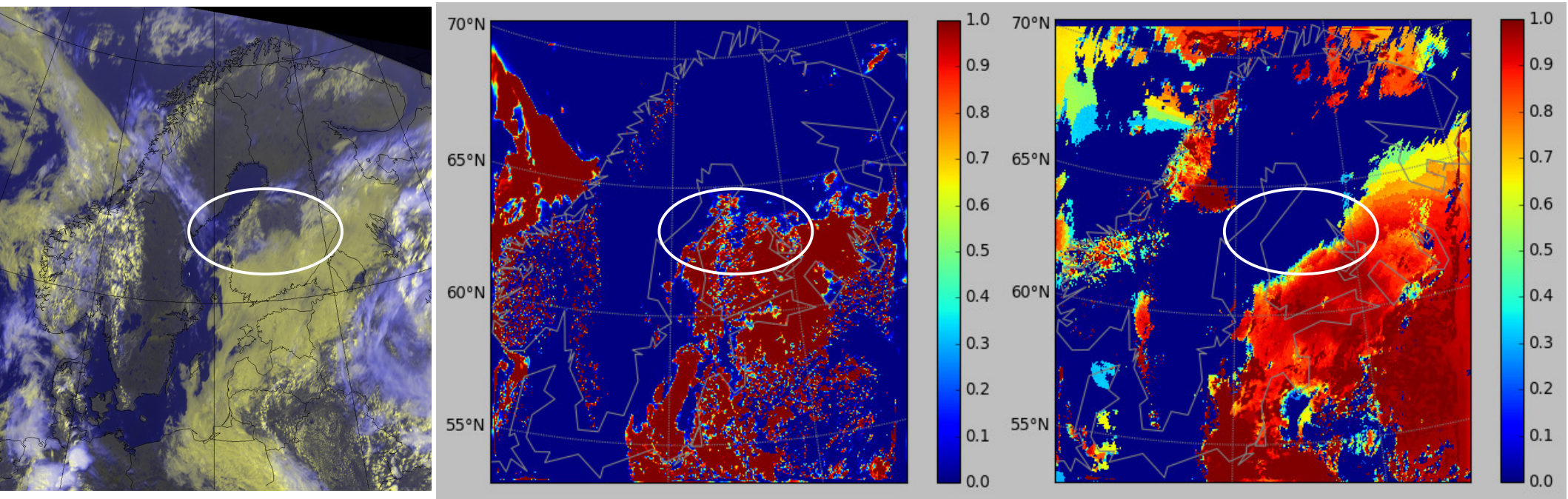
- MSG cloud-base uses Synop data, e.g. interpolated field from stations
- Can create problems in areas where there are few Synop stations and/or the stations are not representative for area

Low clouds – Replacing/relocating the low clouds according to MSG-NWCSAF cloud-mask

– Sensitive to Synop station location and the edges of clouds → can cause error like removing low cloud layers (as example below)

Example from date: 2016-07-22, at 12Z + 00h fc

Satellite | Har. Reference | Har. MSG-NWCSAF



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MSG-NWCSAF DA of cloud – Cloud-base estimation

- MSG cloud-base uses Synop data, e.g. interpolated field from stations
- Can create problems in areas where there are few Synop stations and/or the stations are not representative for area

Low clouds – Replacing/relocating the low clouds according to MSG-NWCSAF cloud-mask

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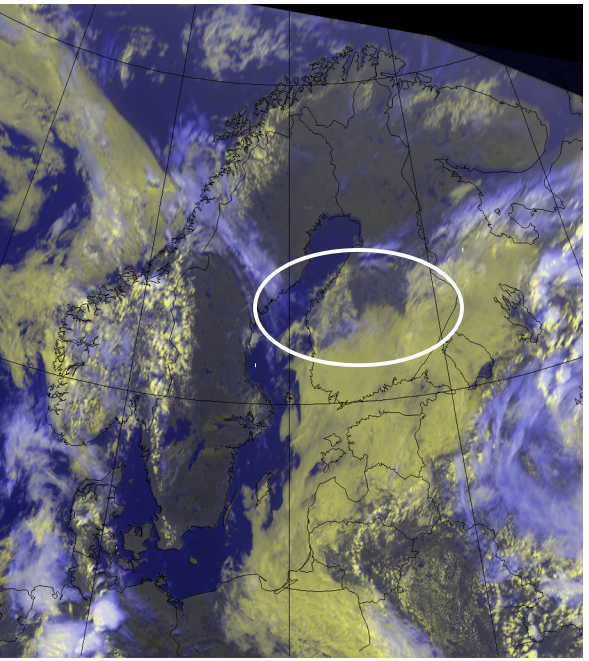
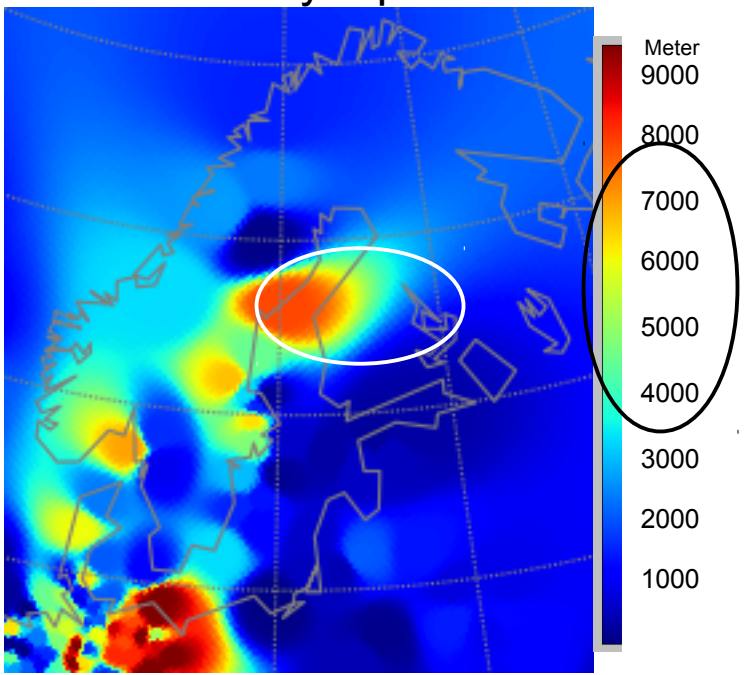
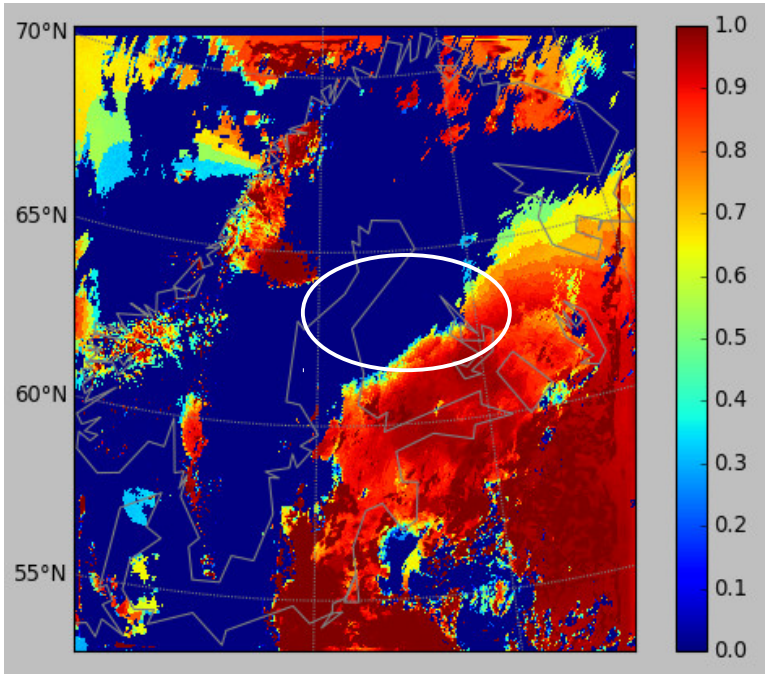


Interpolated Cld Base from Synop's



Har. MSG-NWCSAF



MSG-NWCSAF DA of cloud – Cloud-base estimation

- MSG_SWE use Cloud-Type classes (NWCSAF) to determine the cloud-mask and cloud-base
  - Each class has a “climatological” first-guess cloud-base associated to it
  - **Can create problems when high-clouds shelter the low-clouds beneath**

	Cloud-base:	Cloud-type:	
No used	-999	0	Non-processed
	-999	1	Cloud free land
	-999	2	Cloud free sea
	-999	3	Land contaminated by snow
	-999	4	Sea contaminated by snow/ice
	550	5	Very low cumuliform clouds
	550	6	Very low stratiform clouds
	1230	7	Low cumuliform clouds
	1230	8	Low stratiform clouds
	2215	9	Medium level cumuliform clouds
	2215	10	Medium level stratiform clouds
	3015	11	High cumuliform clouds
	3015	12	High stratiform clouds
	1470	13	Very high cumuliform clouds
	1470	14	Very high stratiform clouds
Exclude →	5595	15	High semi-transparent very thin cirrus
	5595	16	High semi-transparent thin cirrus
	5595	17	High semi-transparent thick cirrus
	2216	18	High semi-transparent cirrus above low or medium level clouds
Exclude →	-999	19	Fractional clouds (sub-pixel water clouds
		20	Unclassified (due to known separability problems)

Harmonie – Cloud (MSG-NWCSAF) Data Assimilation (DA)

- **Detection of problems and defining possible solutions → New developments**

  - Input from NWCSAF: Cloud-Type classes
    - Too much clouds (especially high-clouds)
    - Which Cloud-Type classes to use - Exclude certain classes

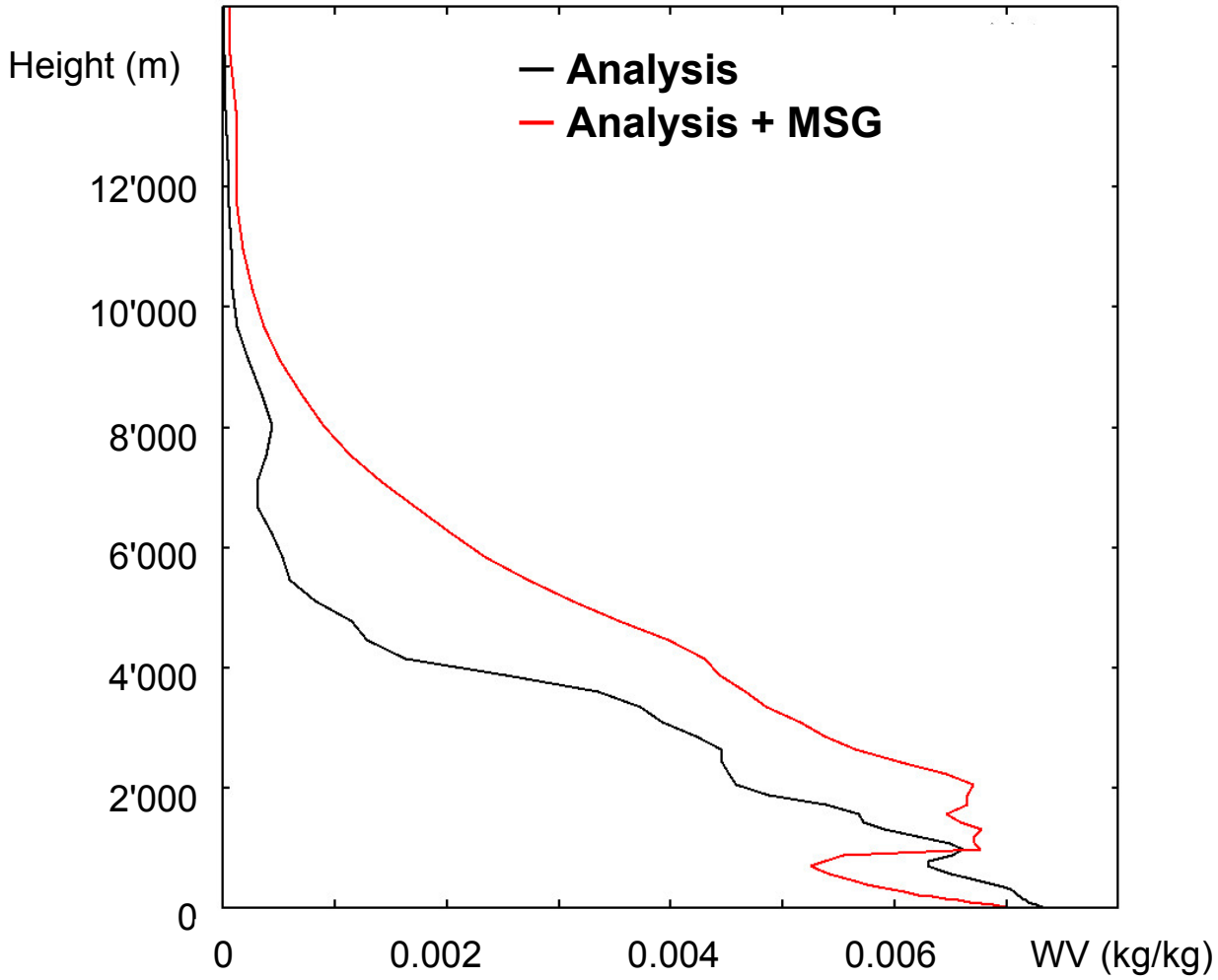
  - Cloud-base estimation: Related to low-clouds
    - MSG – Synop based
    - MSG_SWE – Climatological estimates, “first-guess”

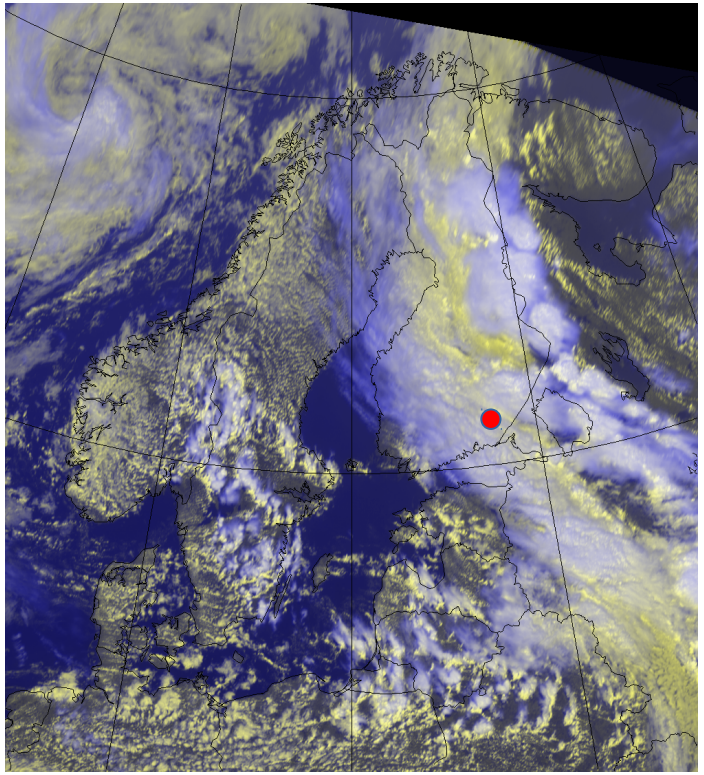
  - Saturation water vapor only to water: Related to too much high-clouds
    - Include new code to calculate the saturation water vapor
    - In upper levels calculate saturation WV against ice
    - Study the impact with 1D-msgInit model

MSG-NWCSAF DA of cloud –Saturation water vapor only to water

Results with 1D-MSGinit model:

- Looking at one gridpoint-profile and run the 1D_MSG-model to adjust the humidity in column





Date: 4 July 2016, 12Z

MSG-NWCSAF DA of cloud –Saturation water vapor only to water

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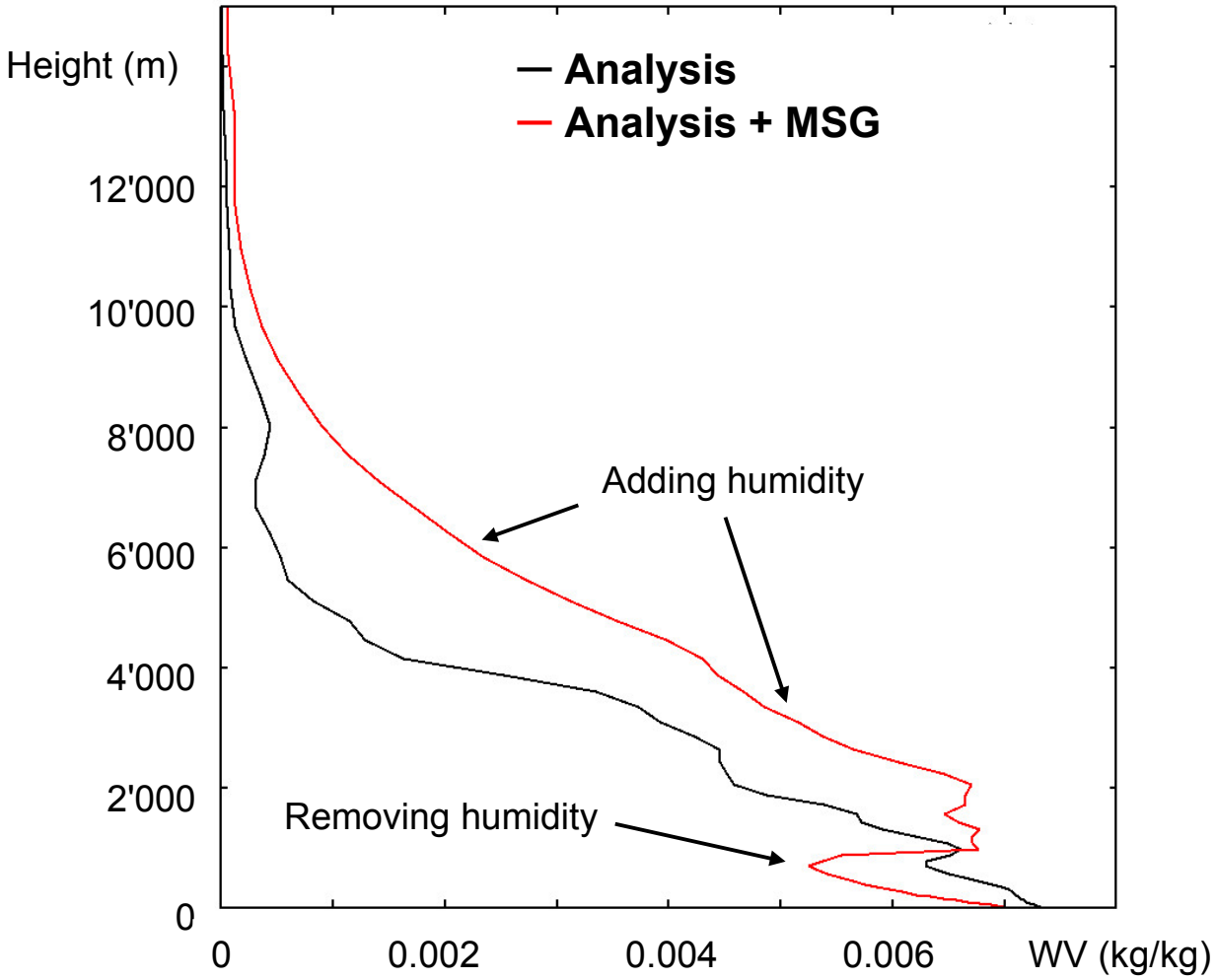

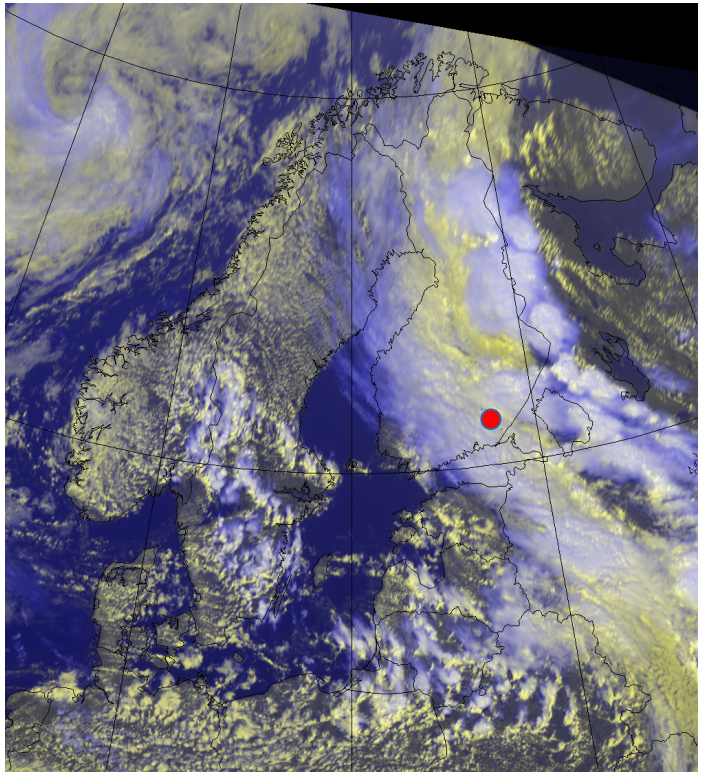

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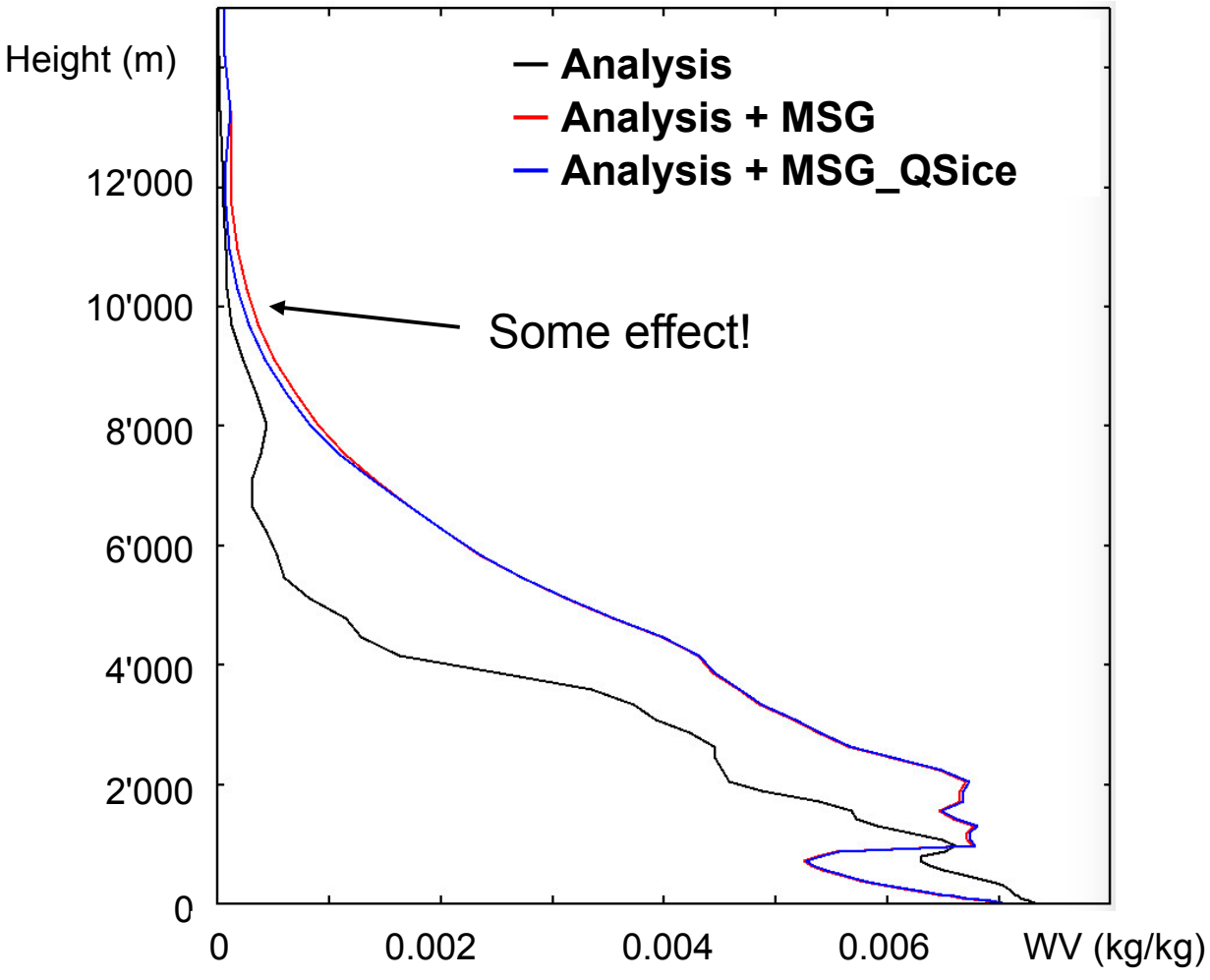
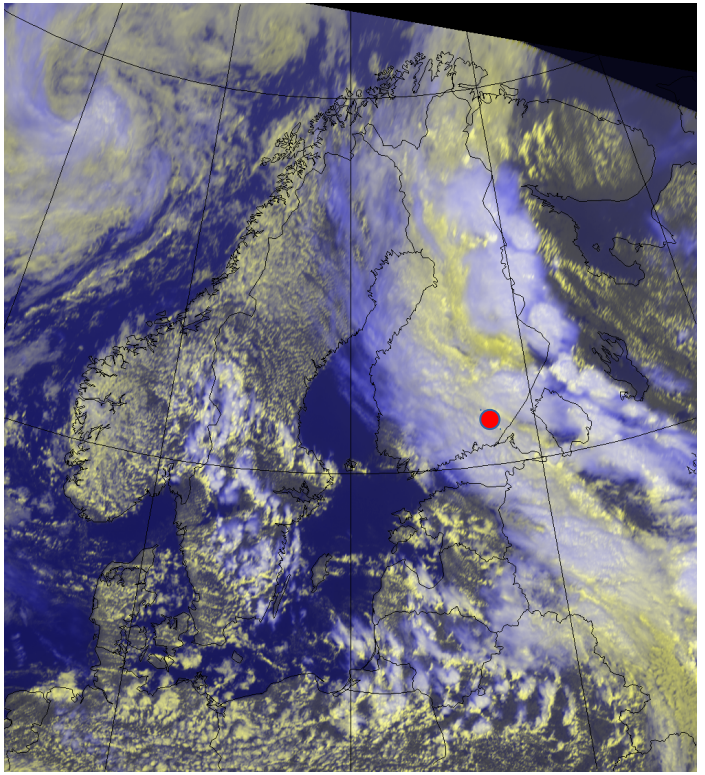
MSG-NWCSAF DA of cloud –Saturation water vapor only to water

Results with 1D-msginit model:

- Looking at one profile and run the MSG-ingest to adjust the humidity in column
- Effects from new saturation code, which use saturation with respect to water **and ice**





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Harmonie – Cloud (MSG-NWCSAF) Data Assimilation (DA)

- **Detection of problems and defining possible solutions → New developments**

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    - In upper levels calculate saturation WV against ice
    - Study the impact with 1D-msgInit model

  - Thresholds effecting the humudity profiles: Related to whole vertical profile of cloud
    - Tune the impact humidity adjustment in code
    - Set limiting thresholds according to KNMI suggestion, in code:

```
! LIMIT CHANGE IN SPECIFIC HUMIDITY:
        IF ( QM(JX,JK) > (1.+CLIMIT)*QM0) QM(JX,JK)=(1.+CLIMIT)*QM0
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Where CLIMIT = 0.2 → change to 0.1 (e.g. maximum effect is 10% to the water vapor)

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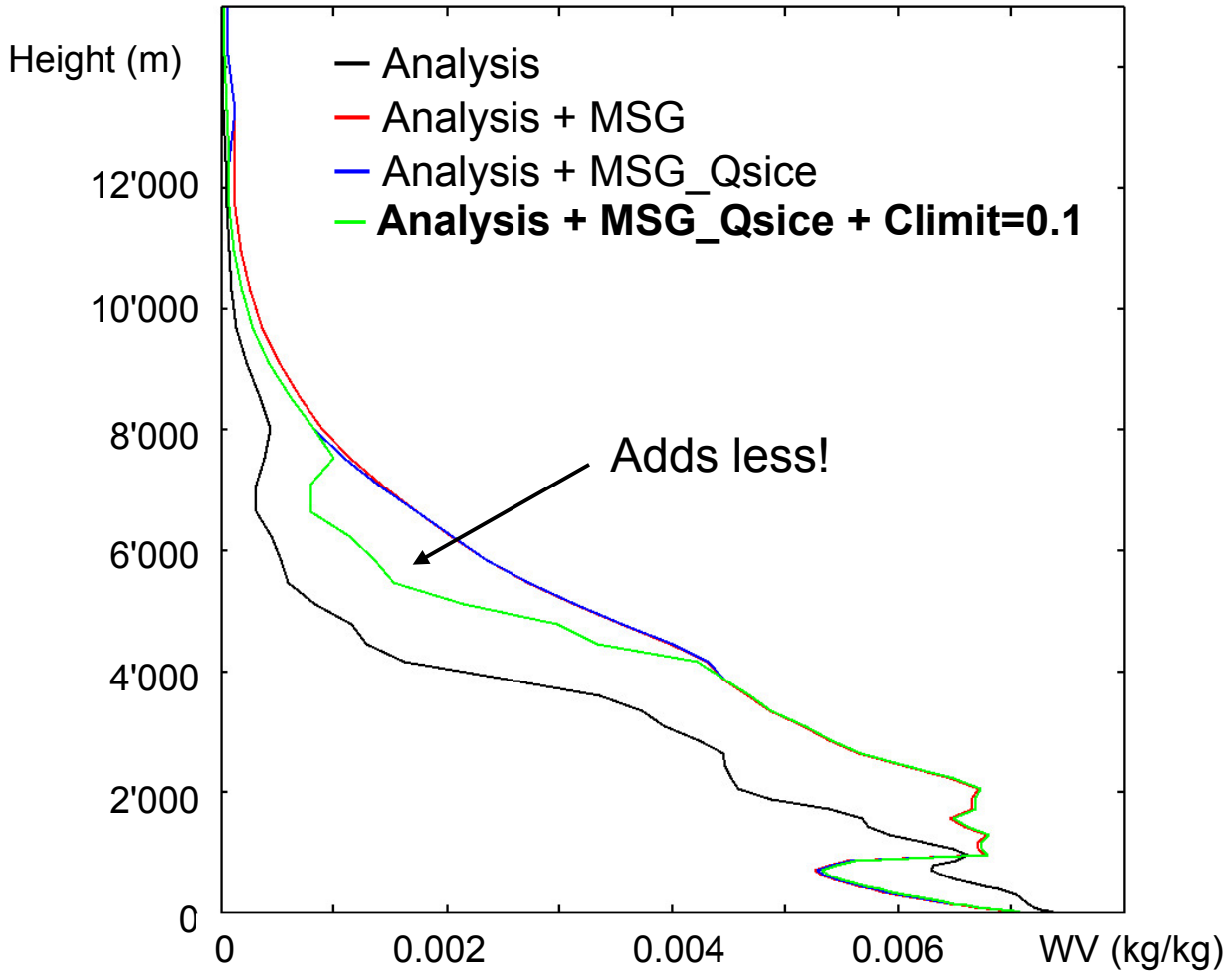

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Harmonie – Cloud DA

Experiments with ingest of MSG-NWCSAF cloud information

Finnish Meteorological Institute
Erik Gregow