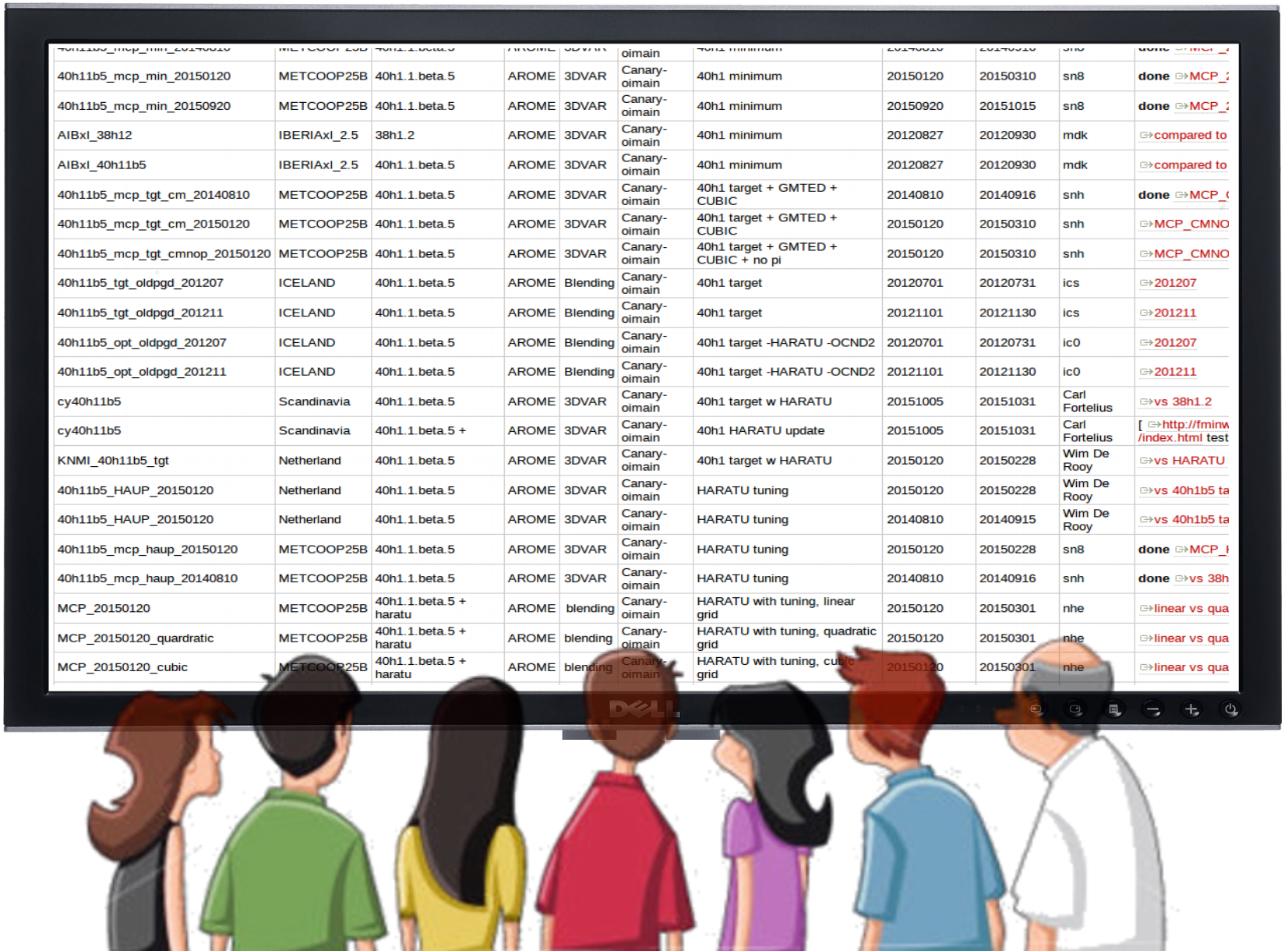
Recent HIRLAM developments in HARMONIE physics/dynamics

Lisa Bengtsson, SMHI

Target 40h1.1



					oimain					
40h11b5_mcp_min_20150120	METCOOP25B	40h1.1.beta.5	AROME	3DVAR	Canary-oimain	40h1 minimum	20150120	20150310	sn8	done ⇨MCP_
40h11b5_mcp_min_20150920	METCOOP25B	40h1.1.beta.5	AROME	3DVAR	Canary-oimain	40h1 minimum	20150920	20151015	sn8	done ⇨MCP_
AIBxl_38h12	IBERIAxl_2.5	38h1.2	AROME	3DVAR	Canary-oimain	40h1 minimum	20120827	20120930	mdk	⇨compared to
AIBxl_40h11b5	IBERIAxl_2.5	40h1.1.beta.5	AROME	3DVAR	Canary-oimain	40h1 minimum	20120827	20120930	mdk	⇨compared to
40h11b5_mcp_tgt_cm_20140810	METCOOP25B	40h1.1.beta.5	AROME	3DVAR	Canary-oimain	40h1 target + GMTED + CUBIC	20140810	20140916	snh	done ⇨MCP_
40h11b5_mcp_tgt_cm_20150120	METCOOP25B	40h1.1.beta.5	AROME	3DVAR	Canary-oimain	40h1 target + GMTED + CUBIC	20150120	20150310	snh	⇨MCP_CMNO
40h11b5_mcp_tgt_cmnop_20150120	METCOOP25B	40h1.1.beta.5	AROME	3DVAR	Canary-oimain	40h1 target + GMTED + CUBIC + no pi	20150120	20150310	snh	⇨MCP_CMNO
40h11b5_tgt_oldpgd_201207	ICELAND	40h1.1.beta.5	AROME	Blending	Canary-oimain	40h1 target	20120701	20120731	ics	⇨201207
40h11b5_tgt_oldpgd_201211	ICELAND	40h1.1.beta.5	AROME	Blending	Canary-oimain	40h1 target	20121101	20121130	ics	⇨201211
40h11b5_opt_oldpgd_201207	ICELAND	40h1.1.beta.5	AROME	Blending	Canary-oimain	40h1 target -HARATU -OCND2	20120701	20120731	ic0	⇨201207
40h11b5_opt_oldpgd_201211	ICELAND	40h1.1.beta.5	AROME	Blending	Canary-oimain	40h1 target -HARATU -OCND2	20121101	20121130	ic0	⇨201211
cy40h11b5	Scandinavia	40h1.1.beta.5	AROME	3DVAR	Canary-oimain	40h1 target w HARATU	20151005	20151031	Carl Fortelius	⇨vs 38h1.2
cy40h11b5	Scandinavia	40h1.1.beta.5 +	AROME	3DVAR	Canary-oimain	40h1 HARATU update	20151005	20151031	Carl Fortelius	[⇨http://fminw /index.html test
KNMI_40h11b5_tgt	Netherland	40h1.1.beta.5	AROME	3DVAR	Canary-oimain	40h1 target w HARATU	20150120	20150228	Wim De Rooy	⇨vs HARATU
40h11b5_HAUP_20150120	Netherland	40h1.1.beta.5	AROME	3DVAR	Canary-oimain	HARATU tuning	20150120	20150228	Wim De Rooy	⇨vs 40h1b5 ta
40h11b5_HAUP_20150120	Netherland	40h1.1.beta.5	AROME	3DVAR	Canary-oimain	HARATU tuning	20140810	20140915	Wim De Rooy	⇨vs 40h1b5 ta
40h11b5_mcp_haup_20150120	METCOOP25B	40h1.1.beta.5	AROME	3DVAR	Canary-oimain	HARATU tuning	20150120	20150228	sn8	done ⇨MCP_
40h11b5_mcp_haup_20140810	METCOOP25B	40h1.1.beta.5	AROME	3DVAR	Canary-oimain	HARATU tuning	20140810	20140916	snh	done ⇨vs 38h
MCP_20150120	METCOOP25B	40h1.1.beta.5 + haratu	AROME	blending	Canary-oimain	HARATU with tuning, linear grid	20150120	20150301	nhe	⇨linear vs qua
MCP_20150120_quardratic	METCOOP25B	40h1.1.beta.5 + haratu	AROME	blending	Canary-oimain	HARATU with tuning, quadratic grid	20150120	20150301	nhe	⇨linear vs qua
MCP_20150120_cubic	METCOOP25B	40h1.1.beta.5 + haratu	AROME	blending	Canary-oimain	HARATU with tuning, cubic grid	20150120	20150301	nhe	⇨linear vs qua

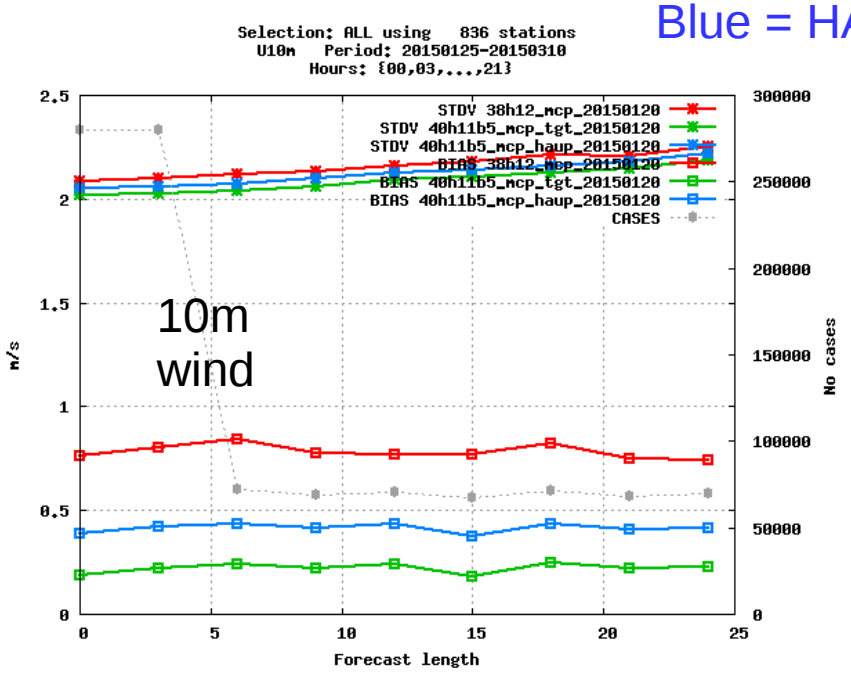
Physics updates for “Target” 40h1.1

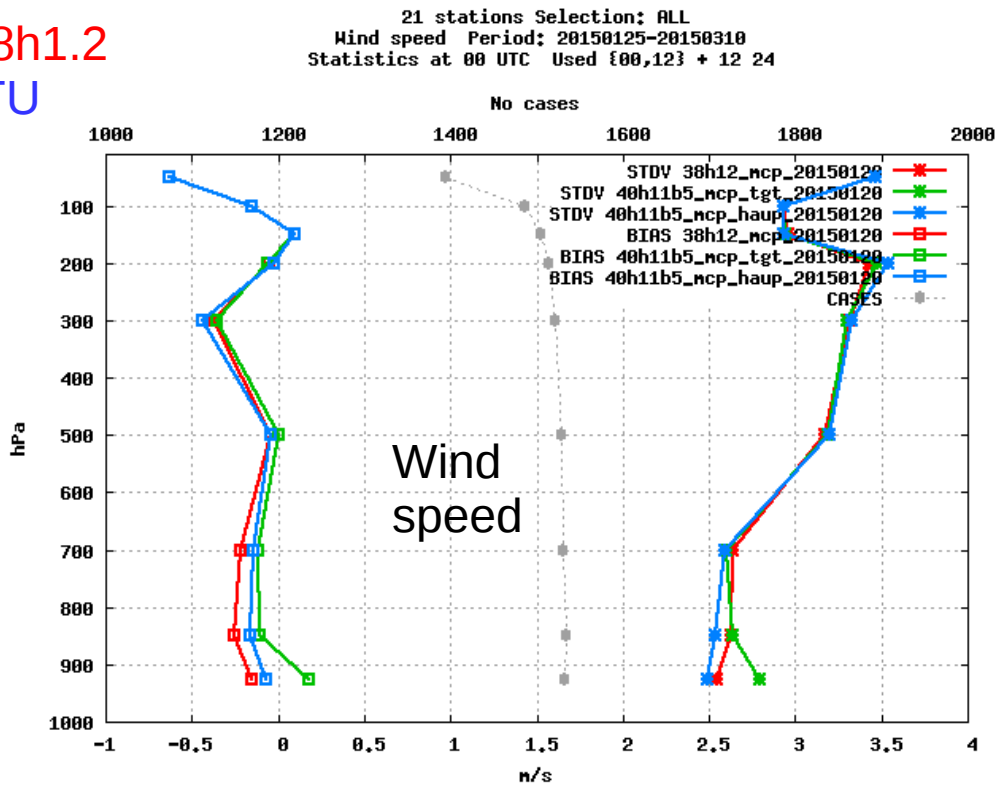
- **Radiation** (*See presentation by Laura Rontu*)
  - Updated cloud liquid optical properties (Nielsen et al. 2014).
  - Updated inhomogeneity factor (from 0.7 to 1.0).
- **Turbulence** (*See presentation by Wim de Rooy*)
  - New scheme; HArmonie RAcmo TUrbulence: HARATU
- **Convection**
  - Updated critical threshold for precipitation generation in shallow convective clouds at cold temperatures. (LCRIT)

HARATU

- The main update in upper air physics between cycle 38h1.2 and the targeted cycle 40h1.1 is the new turbulence scheme; HArmonie with RAcmo Turbulence (HARATU).
- It is based on the Integral length scale formulation for weakly stable to unstable conditions (Lenderink & Holtslag QJRMS 2004). *See presentation by Wim de Rooy.*
- Compared with current “CBR” scheme it yields more top entrainment, slightly more mixing near the surface, considerably more mixing at intermediate heights.

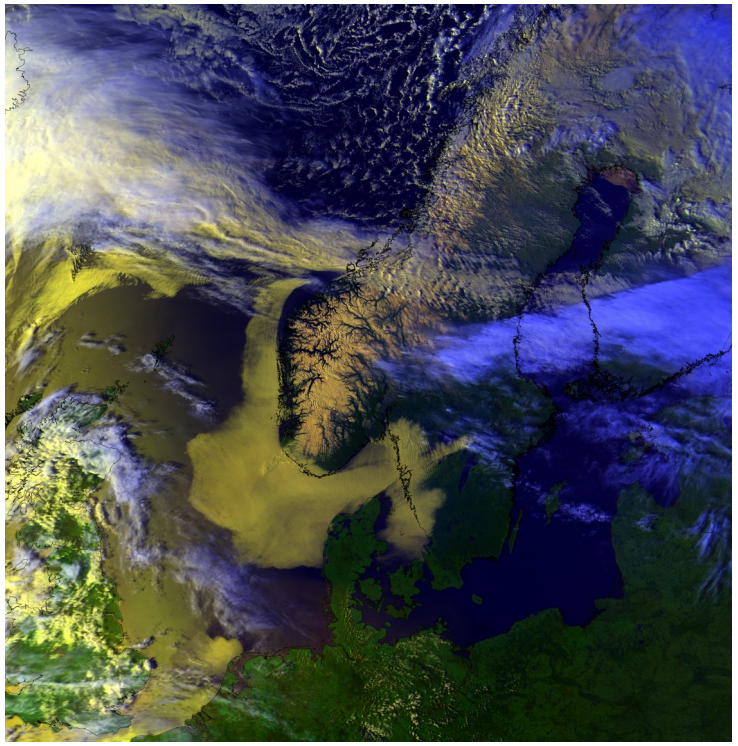
Red = cycle 38h1.2
Blue = HARATU

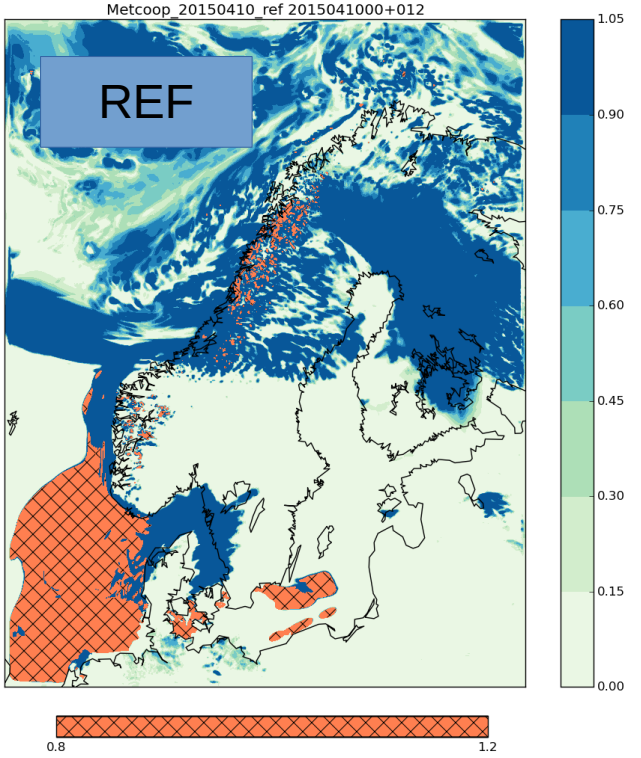


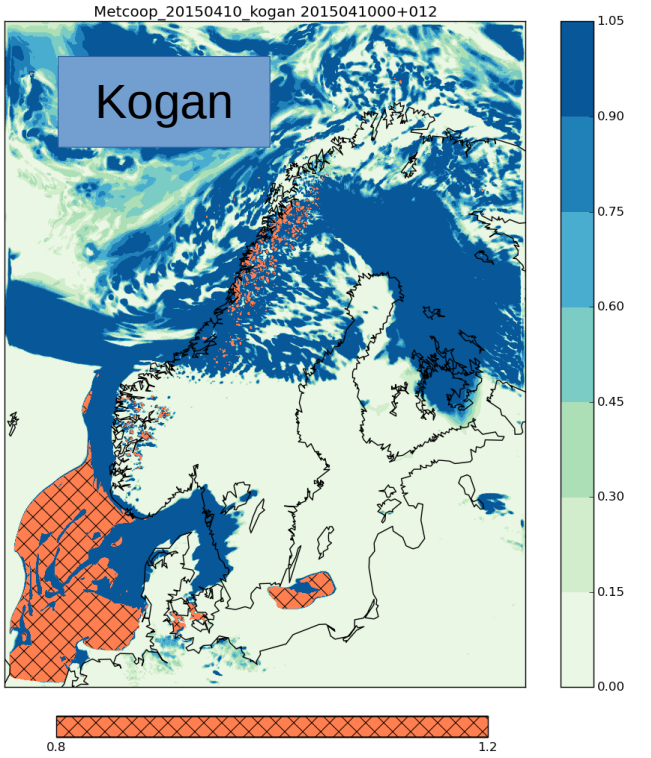


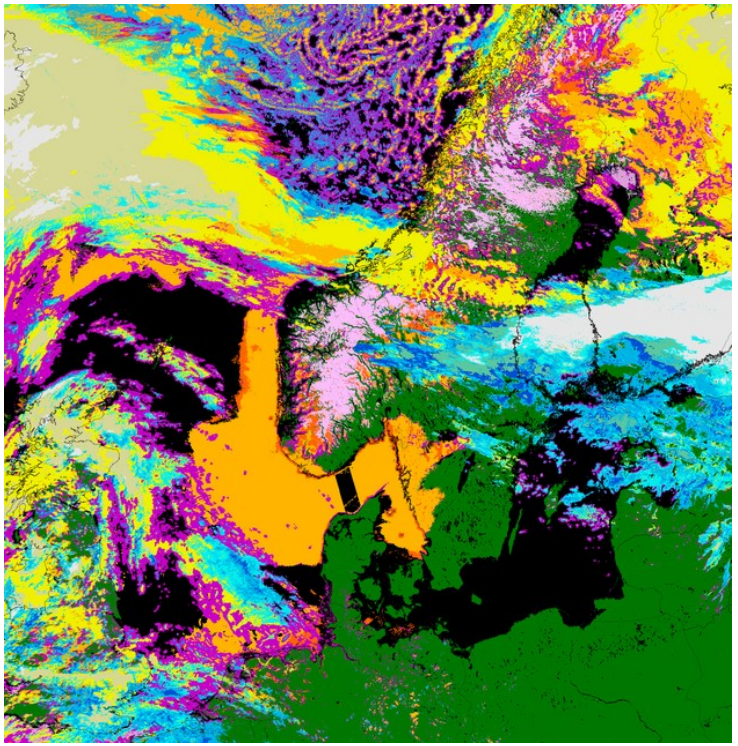
Fog/low level clouds

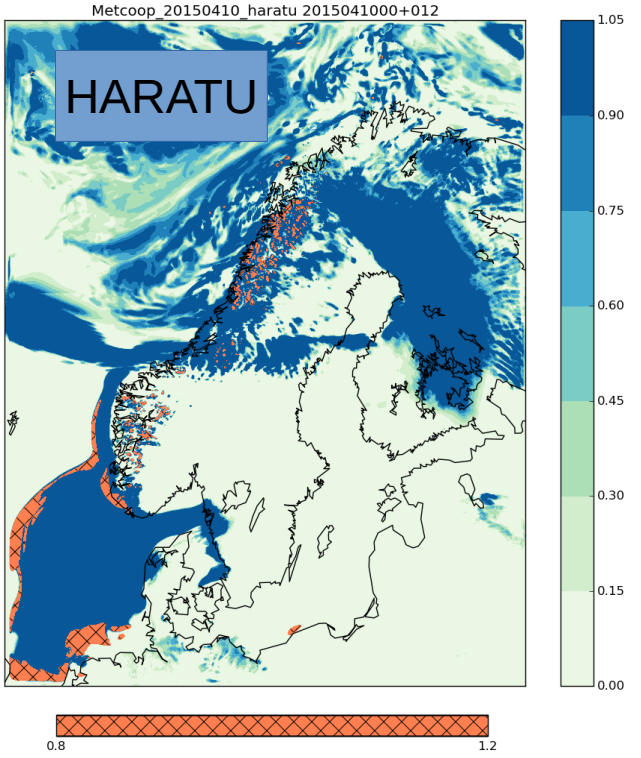
- Fog (especially over Sea) and over-prediction of low level clouds during the winter-time has been a problem in cycle 38h1.2 in all of the domains used. Proposed solutions:
  - More mixing from turbulence (HARATU) (**target cycle 40h1.1**)
  - More cloud condensation nuclei (CCN) at lowest model level(s) to “precipitate out” fog, two solutions (**experimental**):
    - Applied within Kogan autoconversion (Karl-Ivar Ivarsson)
    - Applied within Sundquist autoconversion (Bent Hansen-Sass).
  - In spring, reduce too strong latent heat flux from the surface by using two patches (**experimental**). *(See Patrick Samuelsson's presentation)*

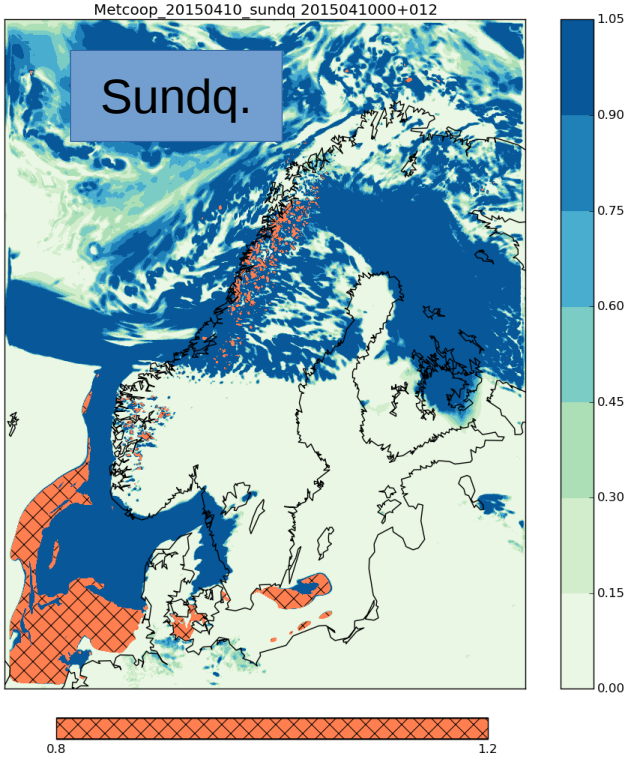




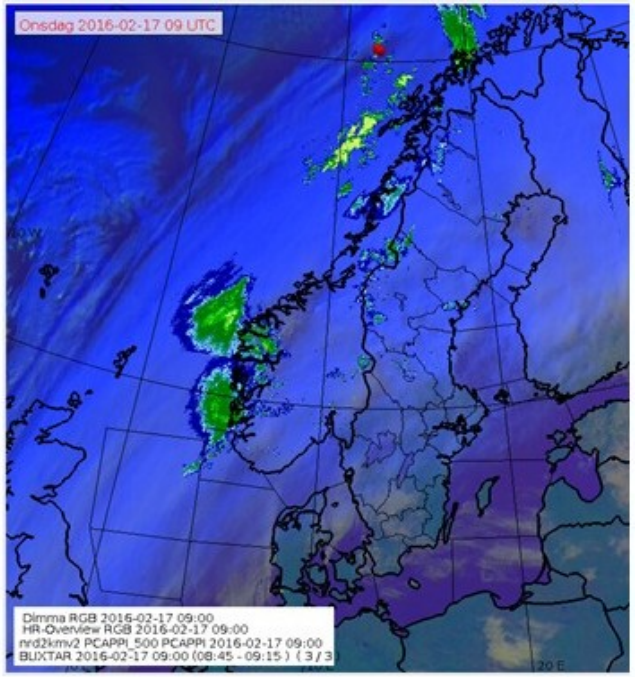


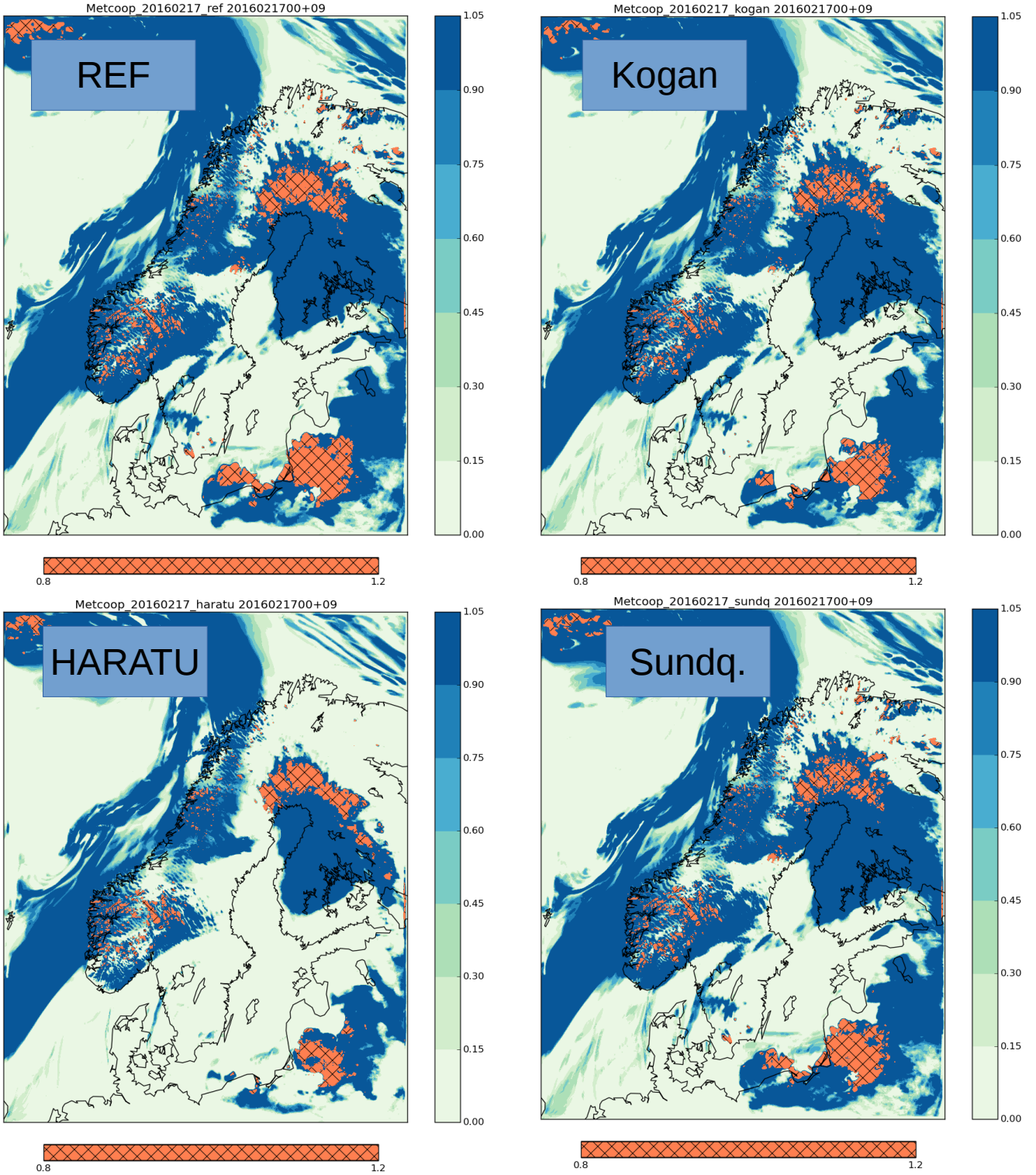




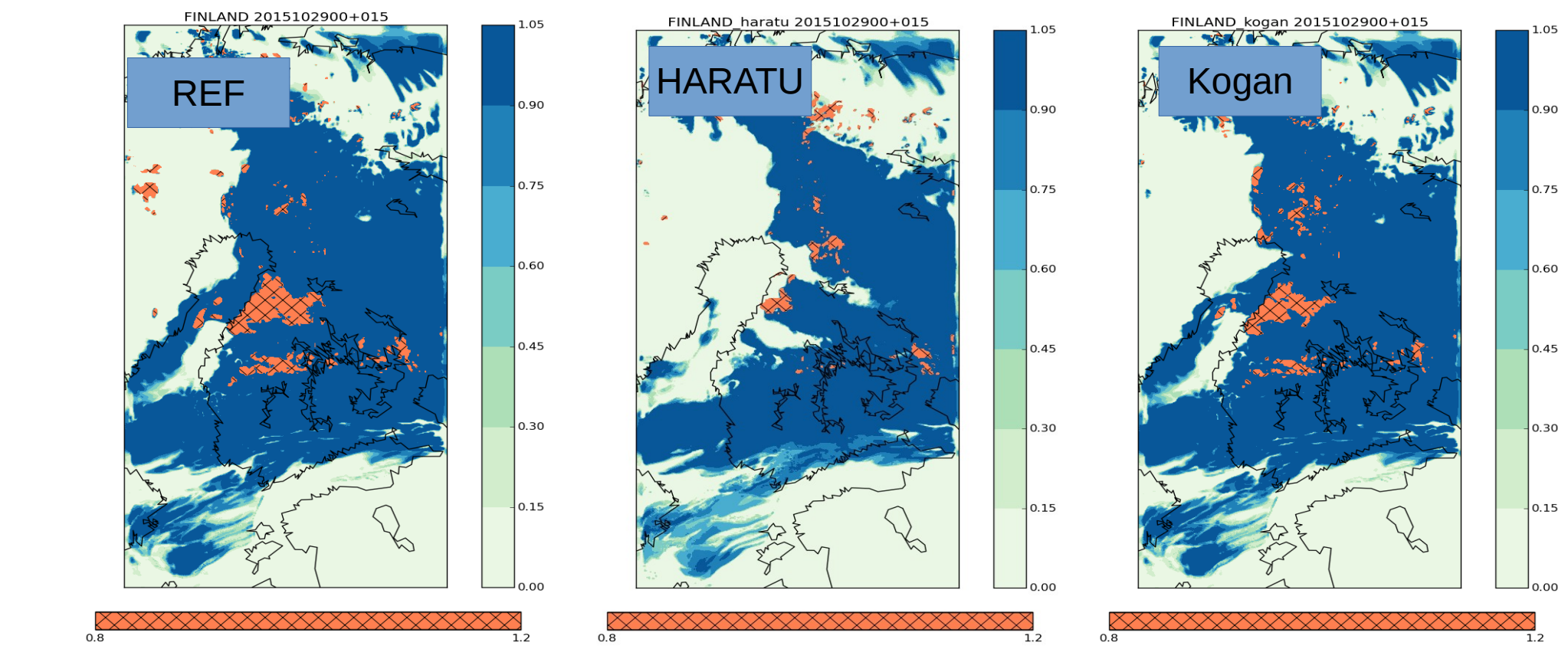


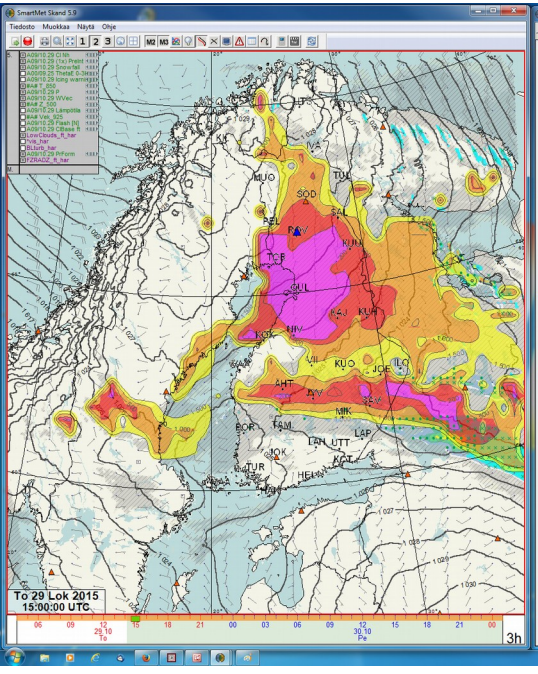
Case reported by Bent Hansen-Sass, DMI

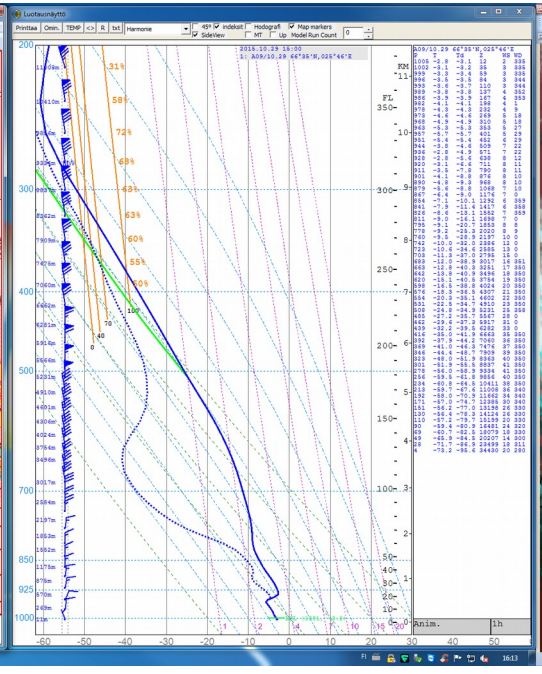


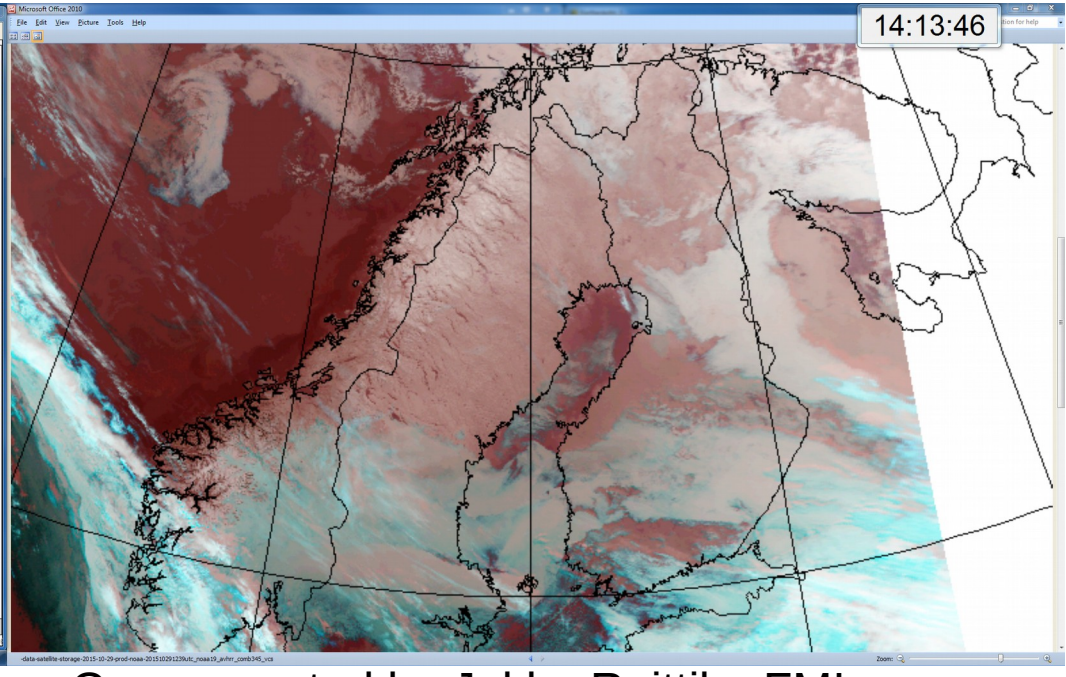


Case reported by Anders Wettergren, SMHI







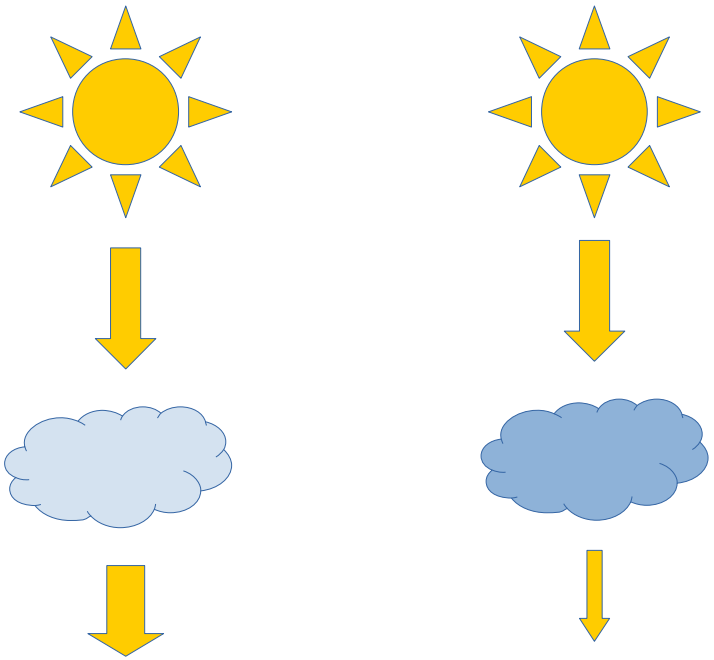


Case reported by Jukka Raittila, FMI

Radiation

Target 40h1.1

- Updated inhomogeneity factor (from 0.7 to 1.0)
- New cloud liquid optical property scheme. (Nielsen et al. 2014).



Both of the updates yields a reduction in downwelling short wave radiation, as the clouds seen by radiation becomes less transparent.

If the cloud liquid is the same in cycle 38h1.2 and cycle 40h1, then this update would act to reduce surface temperatures.

Radiation

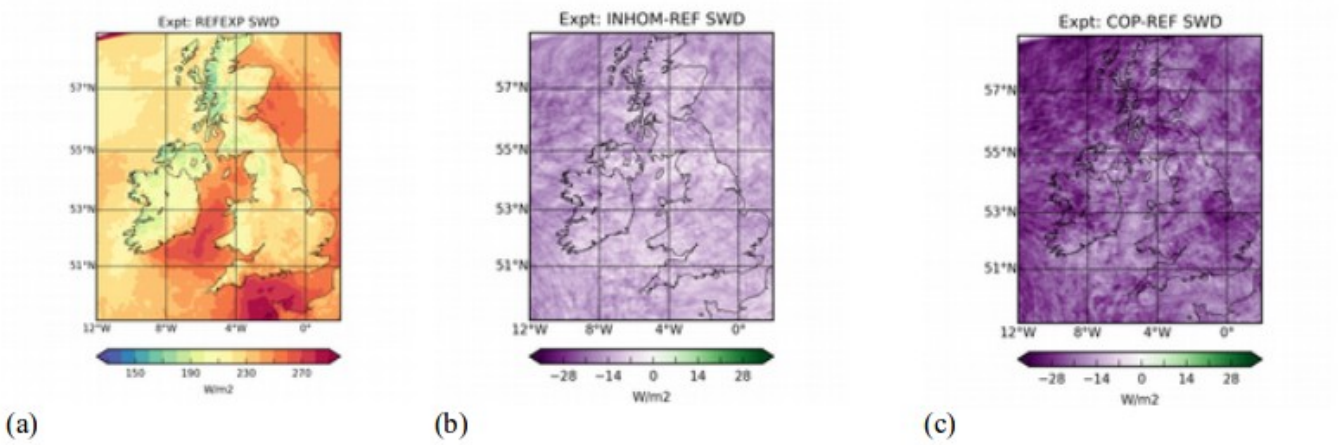


Figure 6. *(a) REFEXP (b) INHOMEXP minus REFEXP and (c) COPEXP minus REFEXP monthly mean of daily mean global SW radiation. In each case the hourly forecasts (up to 24 hours) from the 00UTC cycles were used.*

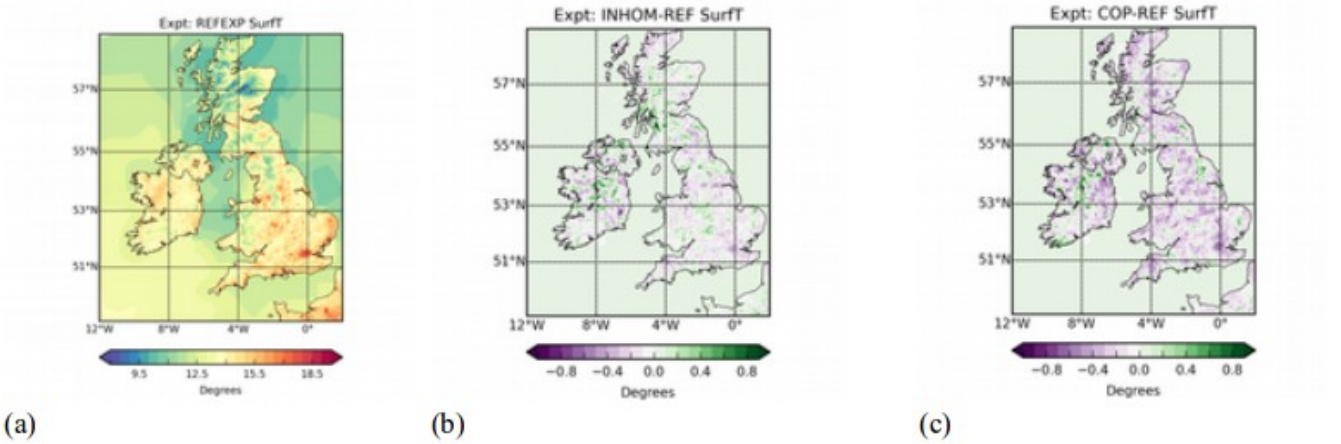


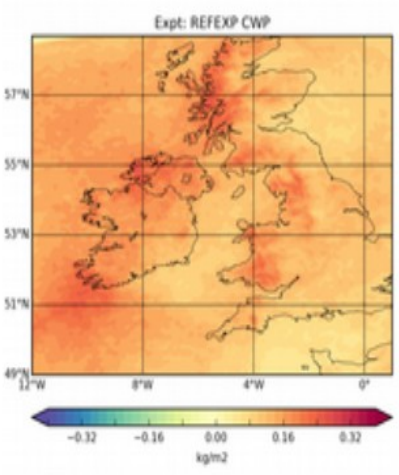
Figure 4. *(a) REFEXP (b) INHOMEXP minus REFEXP and (c) COPEXP minus REFEXP monthly mean surface temperature. In each case the hourly forecasts (up to 24 hours) from the 00UTC cycles were used.*

Gleeson et al. 2015, HIRLAM-ALADIN newsletter, no 5:

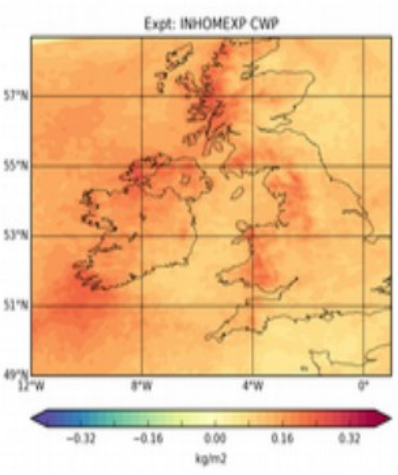
-Less SW radiation down

-Reduced land surface temperatures

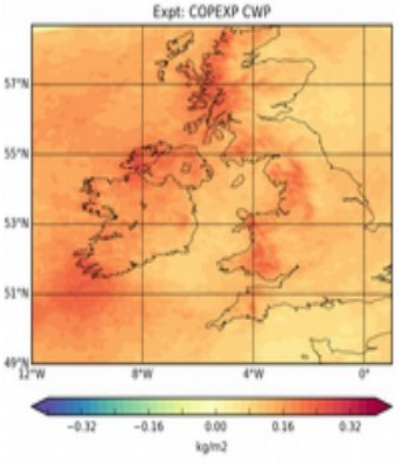
Radiation



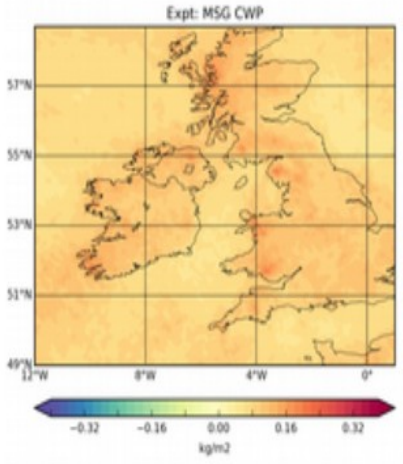
(a)



(b)



(c)



(d)

Using MSG cloud water path product show a positive bias in CWP in HARMONIE cycle 38h1.2.

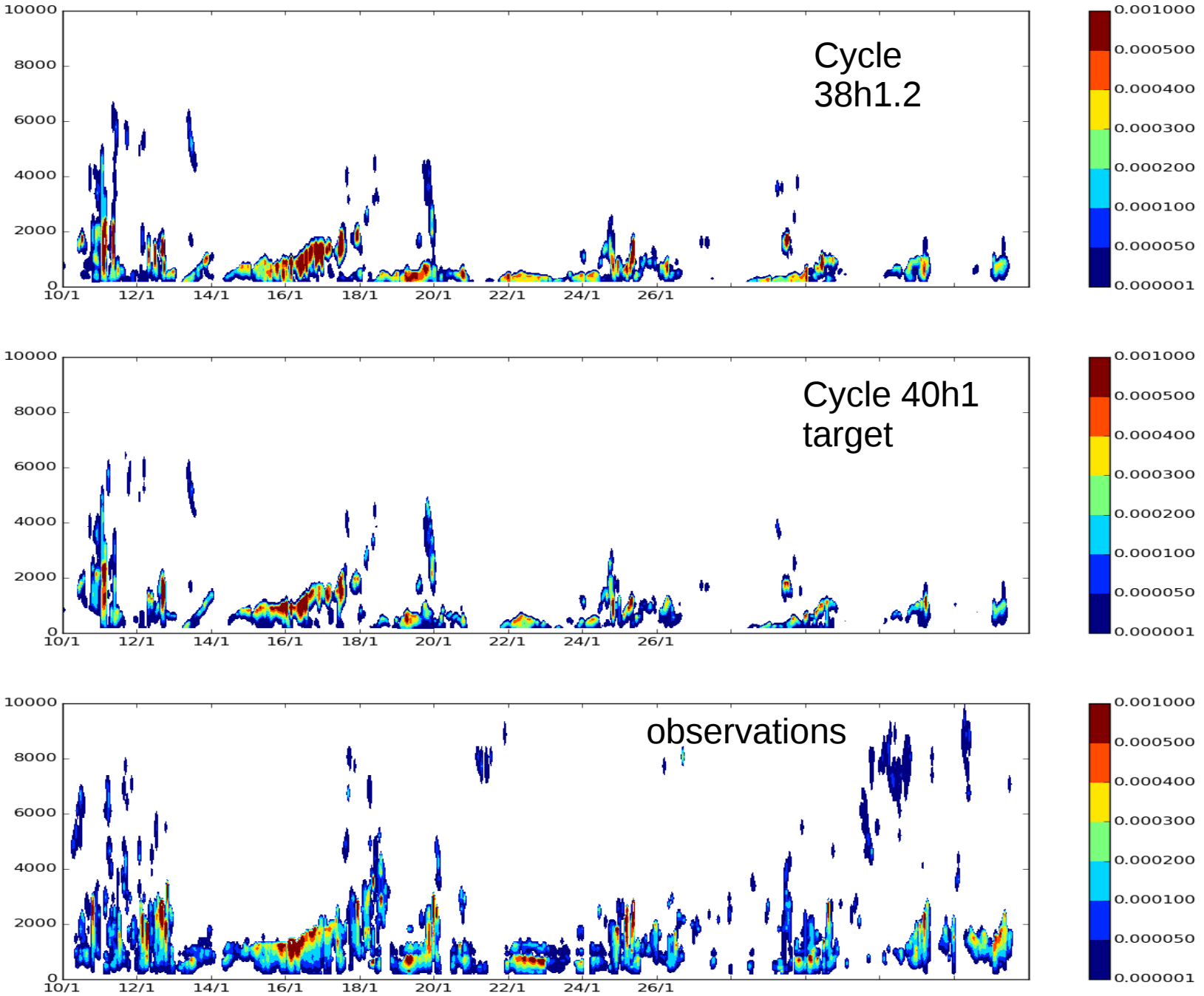
Gleeson et al. 2015, HIRLAM-ALADIN newsletter, no 5:

"In light of the verification of the cloud water path, the cloud inhomogeneity factor offset the effect of the positive bias in cloud water path, by effectively reducing the cloud water and ice loads used by the radiation scheme by 30%."

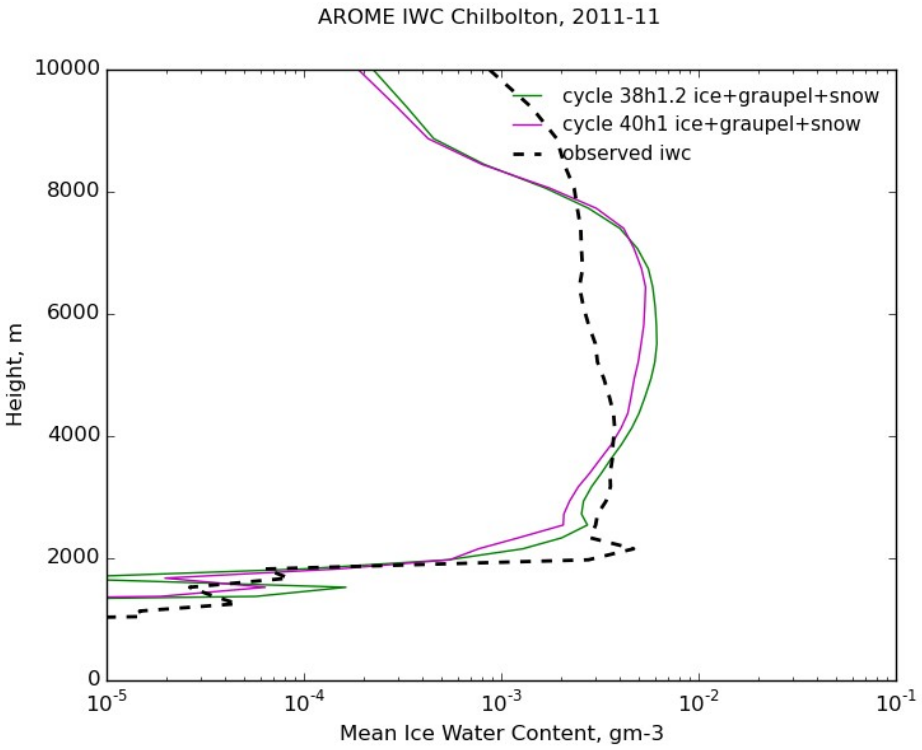
"...cloud water loads are too high in the HARMONIE model... We think that there is too much cloud water in the thickest clouds."

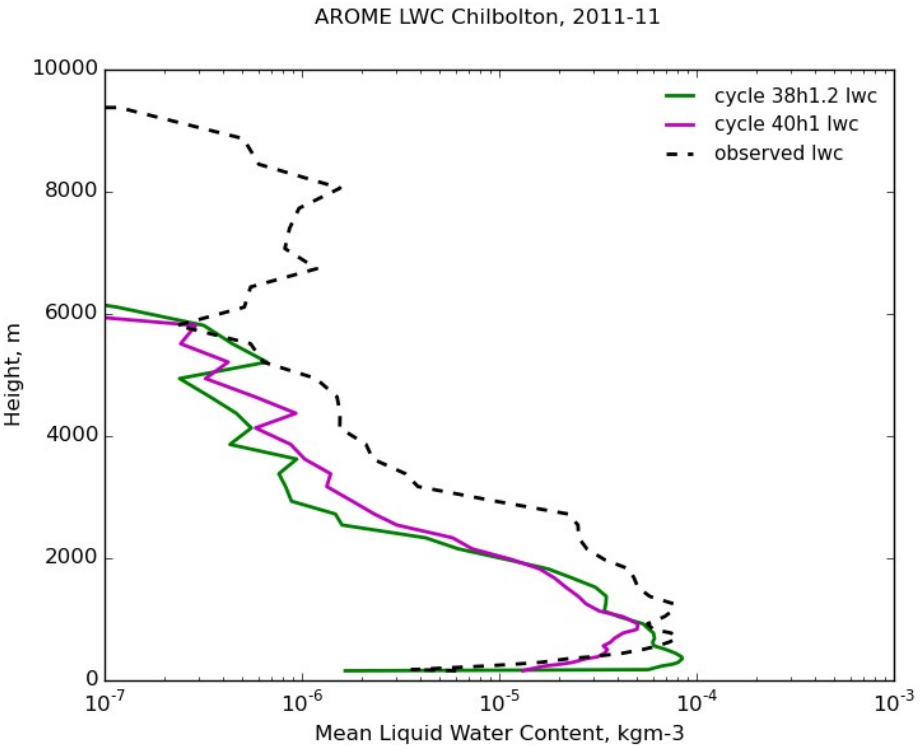
Do we have less water/ice in the clouds in cycle 40?

Clouds: ACTRIS cloud radar obs.



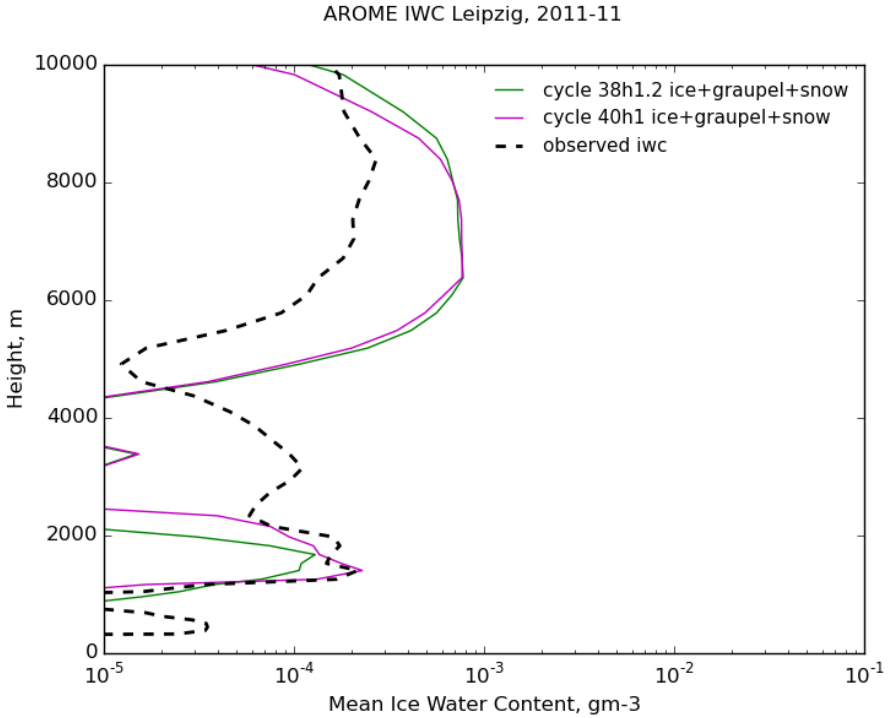
Chilbolton,
2011-11,
LWC

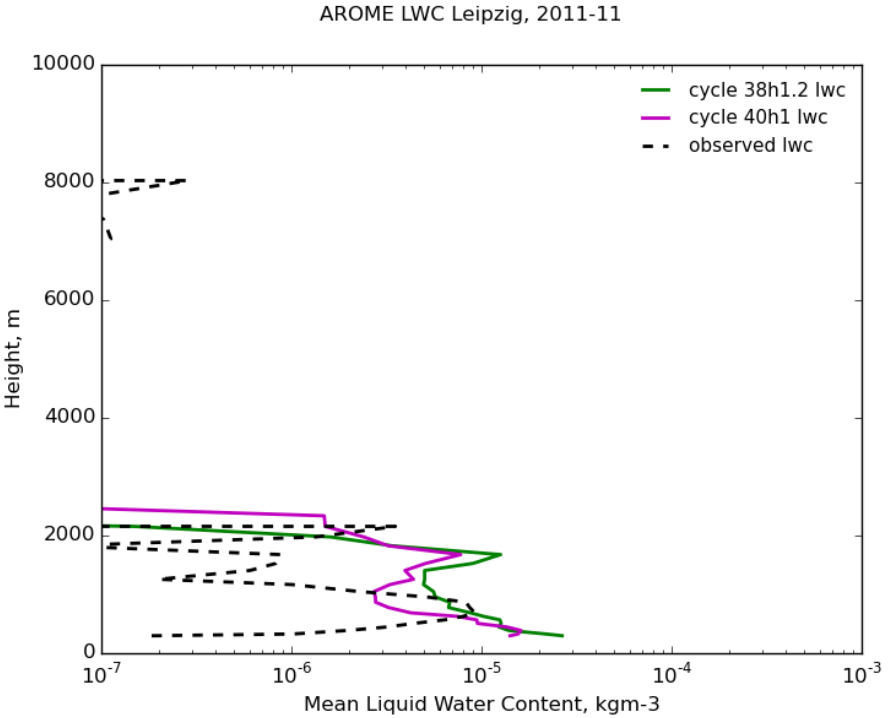




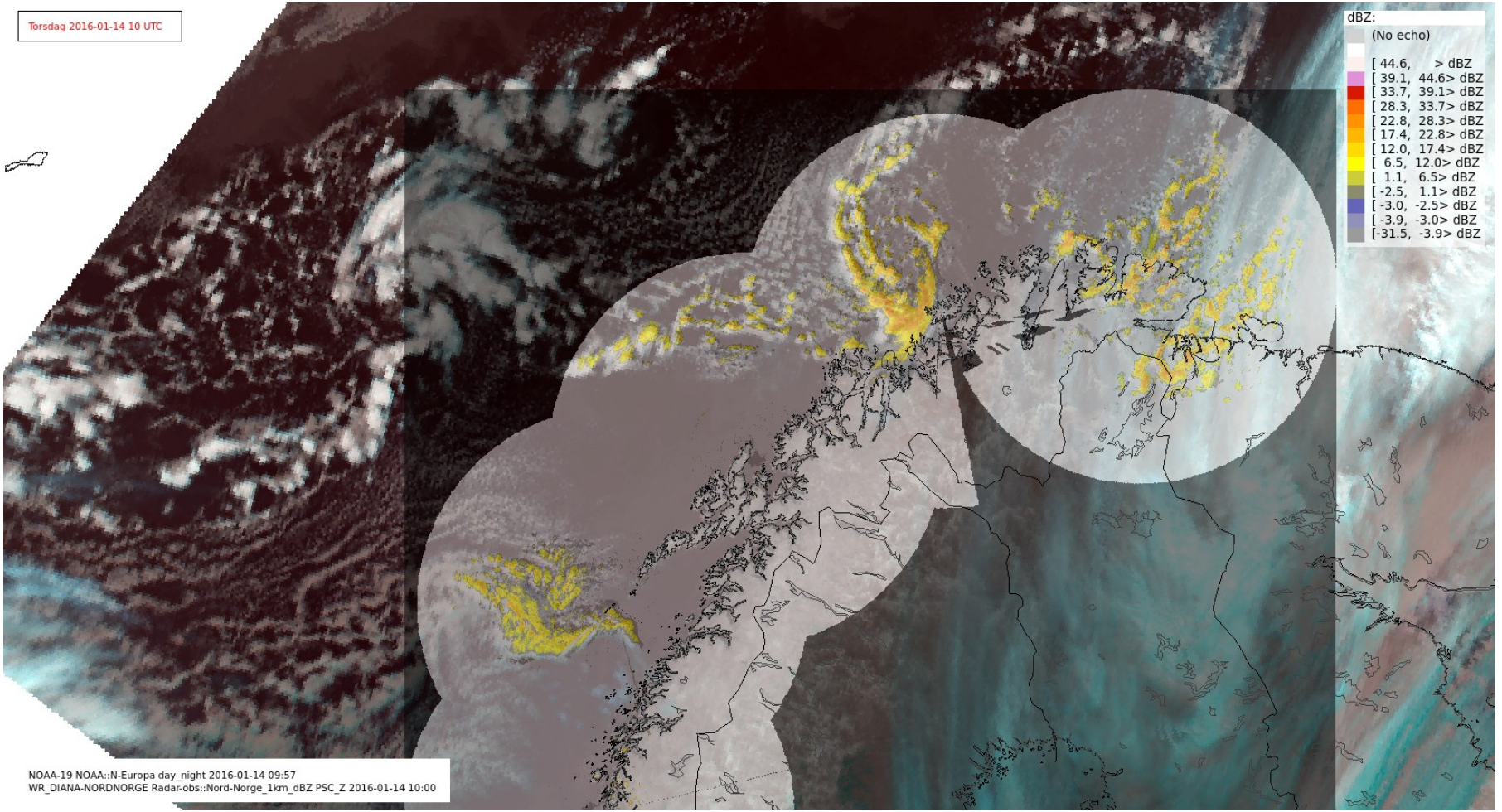
ICE gm-3

WATER kgm-3

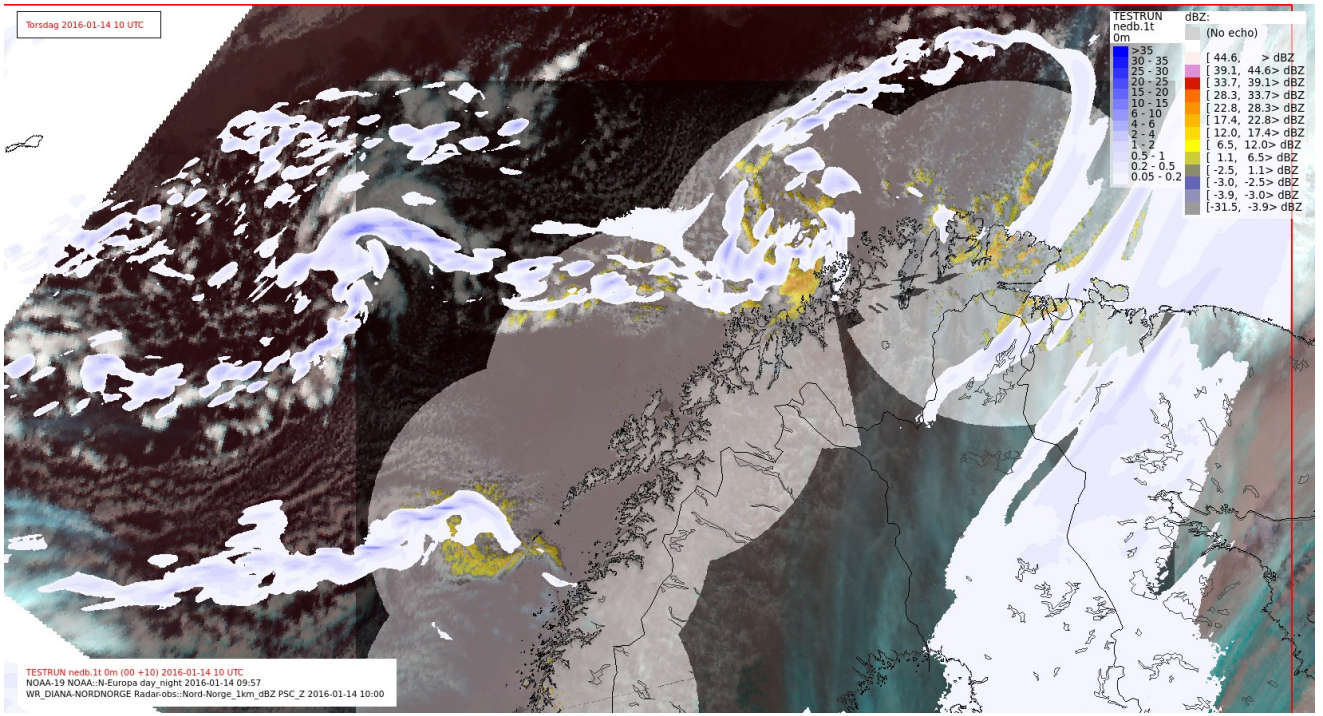


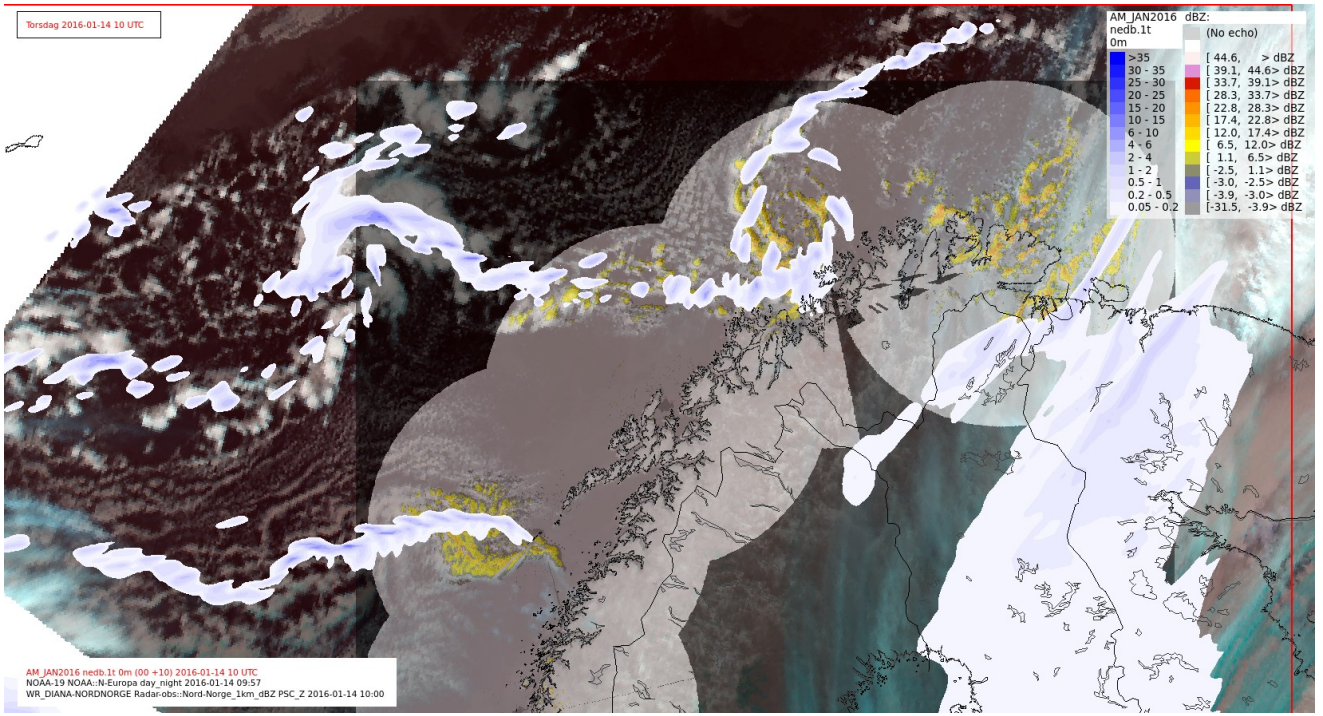


Convection



Case from Morten Køltzow, Met-Norway



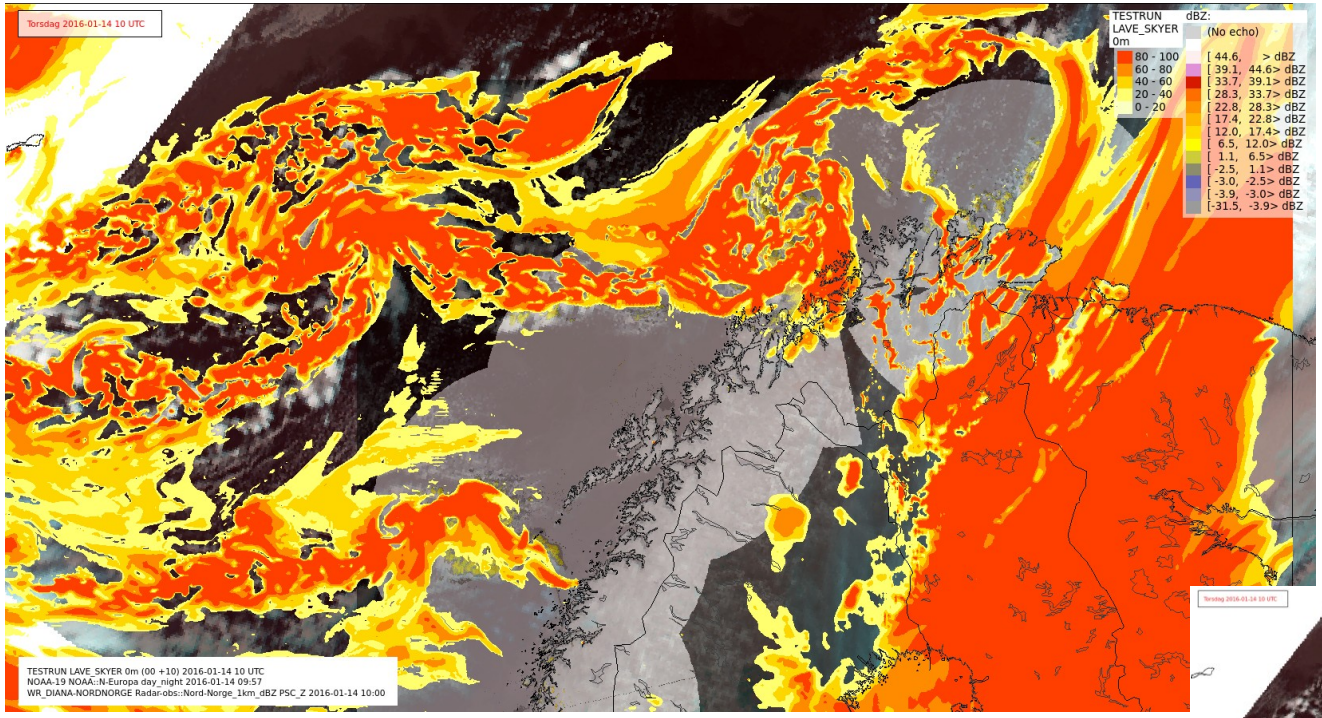


LCRIT

1h precip

Operational metcoop

Slide from Morten Køltzow
05/04/16



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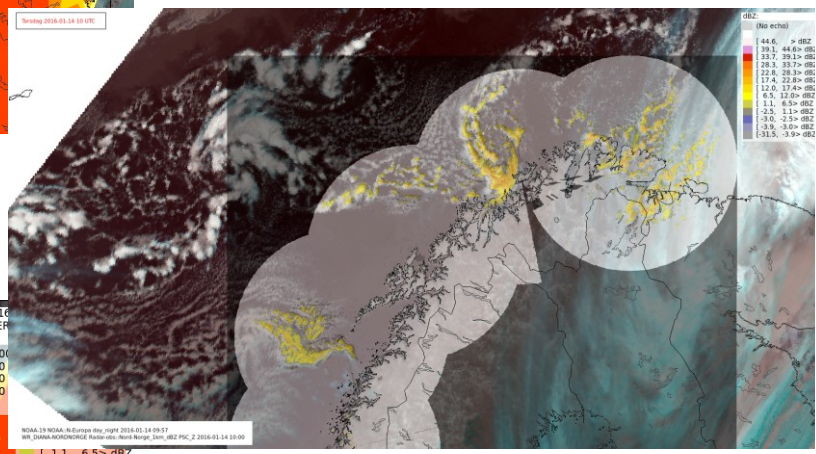
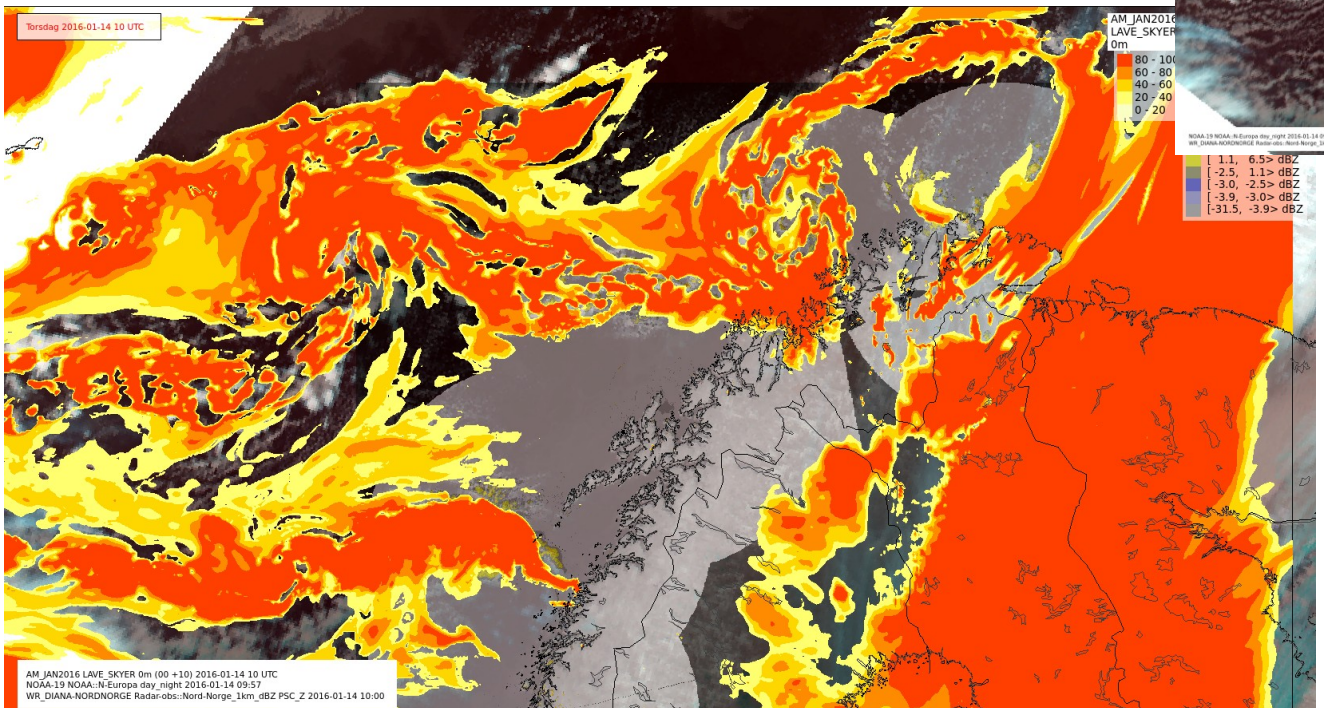


Low level clouds

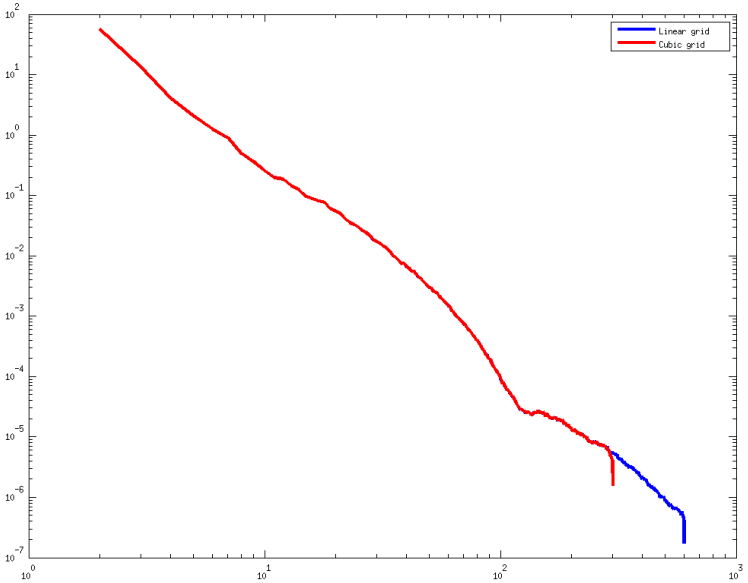


Operational Metcoop

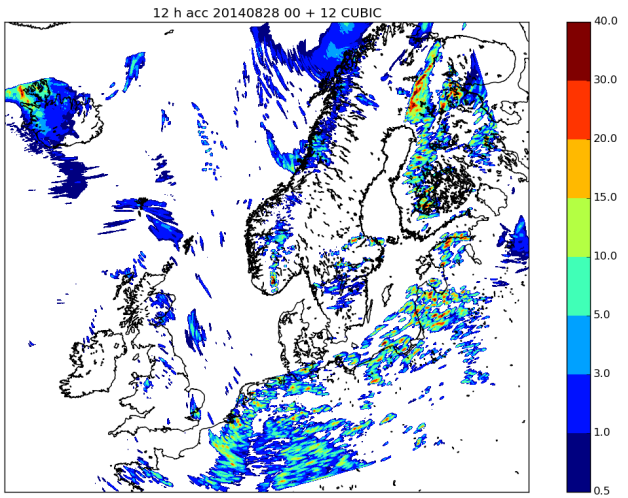
Slide from Morten Køltzow
05/04/16

Ongoing developments (1/3)

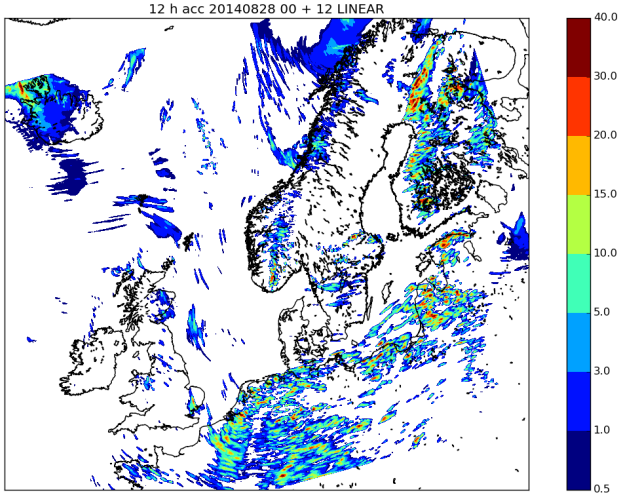
- **Dynamics**
  - Vertical Finite Element's – Good results in mslp with new definition of the 65 vertical levels. Meeting in Prague in June with Alvaro Subias, Juan Simarro, Petra Smolikova and Josef Vivoda. *See Alvaro Subia's poster.*
  - Explore reduced spectral grid option further. Test runs show experiment's with cubic grid to be 15-20% cheaper in CPU (some degradation in wind-speed mostly in steep orography). Option for Ensemble Prediction?



CUBIC grid



LINEAR grid



Ongoing developments (2/3)

- **Microphysics:**
  - Too much graupel *(See Karl-Ivar Ivarsson's presentation)*
  - Freezing rain problem (too quick conversion to ice/snow). *(See Karl-Ivar Ivarsson's presentation, and Sander Tijm's slides in the cloud discussion session)*
  - Consistency between radiation/clouds – pass in fraction of cloud water and fraction of cloud ice to radiation scheme under LOCND2 *(See Karl-Ivar Ivarsson's presentation)*
  - Jenny Engdahl's PhD work, explore Thompson scheme from WRF for slower ice generation in intermediate temperatures.

Ongoing developments (3/3)

- **Radiation:**
  - Long wave radiation and interaction with aerosols
  - HLRADIA scheme → AROME
- **Turbulence:**
  - Explore HARATU in the stable boundary layer further.
- **Clouds/convection:**
  - Double Gaussian PDF for cloud-fraction and cloud water in the statistical cloud-scheme (Daniel Martin, AEMET).
  - Pass precipitation fluxes from EDMFm convection to the ICE3/4 microphysics scheme. (Lisa Bengtsson, SMHI).

Identified problem areas in regards to clouds/convection listed in Iceland meeting, 2013

1) Too persistent fog layer over sea. (Also over-prediction of fog over land).

2) Too “spotty” behavior of deep convection.

3) Dynamically weakly forced deep convection. (Too active).

4) Too low cloud base associated with weak top entrainment in stratocumulus.

5) “on/off” behavior of clouds? (Difficult to compare with observations)

6 a) Too much low level ice clouds and ice fog in cold situations. (generally also too much cirrus year round).

6 b) Too little mixed-phase clouds in cold situations