



*Meteorologisk
institutt
met.no*

**Radar data assimilation in
Hirlam/Aladin/Arome models**

Martin S. Grønsleth, PhD
R&D, met.no, Norway
OMSZ, Hungary, 2011-04-18

- 1 Meso-scale data assimilation
 - High resolution NWP \Rightarrow new observation types
 - HIRLAM and ALADIN
 - Experiences from Météo-France
 - Method: Humidity profile pseudo-observations
- 2 Quality control of radar data observations
 - Filtering of radar observation at met.no
- 3 Collaboration on radar data assimilation
 - CONRAD: CONversion of RADar data
- 4 Results on reflectivity assimilation, south of Norway

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- Numerical weather prediction (NWP) systems evolving:
 - Increased computing power \Rightarrow **higher resolution models**
 - Also for global models (ECMWF 16 km)
- Meso-scale models:
 - Very high resolution (2.5 km, 1 km, 0.5 km?)

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Higher resolution/more sophisticated physics requires
observations of high **temporal frequency** and **horizontal resolution**

High resolution NWP \Rightarrow new observation types

Observations from weather radars!



Wind and reflectivity
(precipitation)

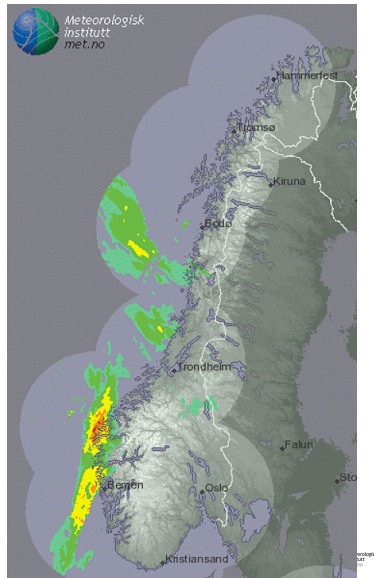


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Models used at met.no/Norway

- HIRLAM 8 km, 4 km, hydrostatic
- Unified Model (UM) 4km, non-hydrostatic physics, even 1 km for small domains

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- HIRLAM 8 km, 4 km, hydrostatic
- Unified Model (UM) 4km, non-hydrostatic physics, even 1 km for small domains
- Replace HIRLAM with:
 - Harmonie 5.5 km, ALARO, 3DVAR and surface data assimilation
 - Harmonie 2.5 km, AROME, 3DVAR and surface data assimilation

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- Successor of the HIRLAM system: **Harmonie**
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Météo-France already have support for radar data in Harmonie:

- Assimilation of
 - Radar reflectivity (precipitation)
 - Radar radial winds

HIRLAM and ALADIN

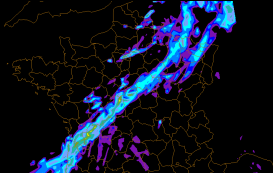
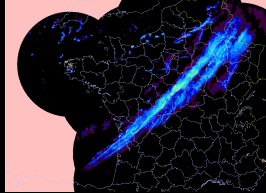
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Next slides taken from Eric Wattrelot's presentation at the radar meeting in Oslo, Norway, March 2010.

Implementation of the radar reflectivity assimilation method in Arome



Eric Wattrelot

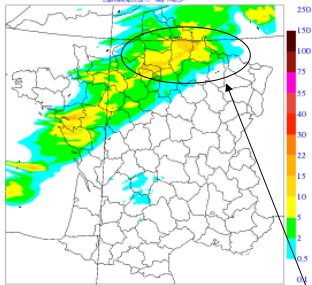
3h - cumulated rain - P3-P0

r00 - 3 cycling

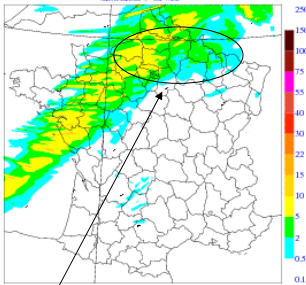
REFL

CTRL

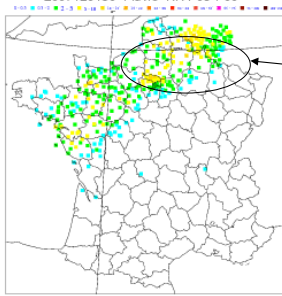
2007120100 73BL / RR P03-P00



2007120100 61Z / RR P03-P00



2007120100 Pluvio RR P03-P00



Capability to shift the cold front (well located on the 3-hour forecast from the analysis with reflectivities)

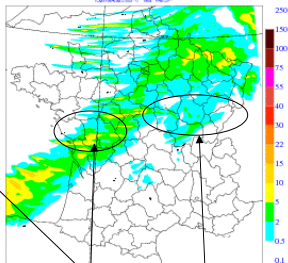
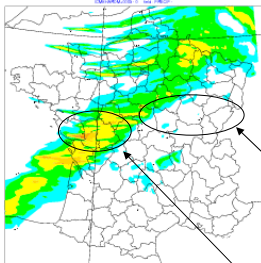
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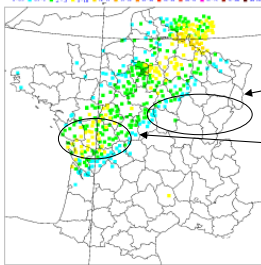
CTRL

2007120103 73BL / RR P03-P00

2007120103 61Z7 / RR P03-P00



2007120103 Pluvio RR P03-P00

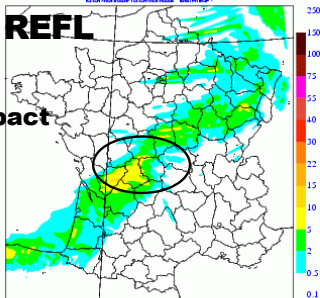


Good drying up on the front of the main rainfalls with reflectivities assimilated

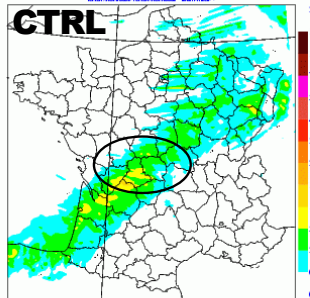
Good quantity of rainfalls on this area with reflectivities assimilated

**Positive impact
on longer
forecast**

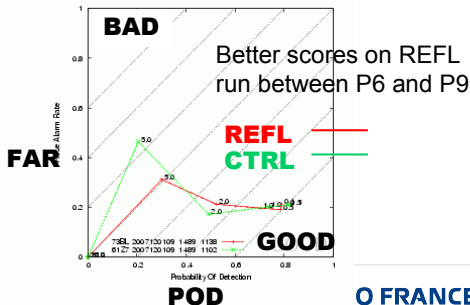
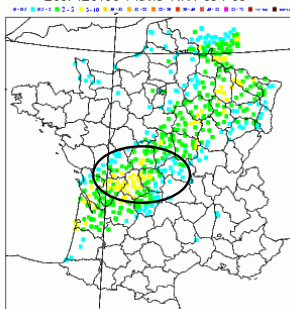
2007120100 73BL / RR P09-P06



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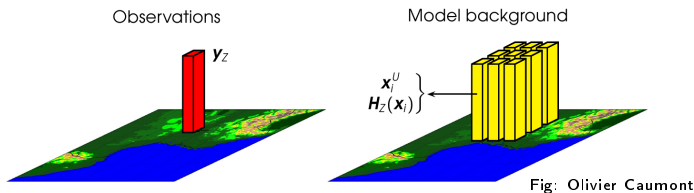
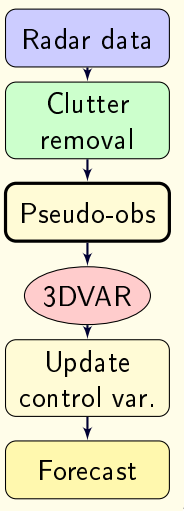
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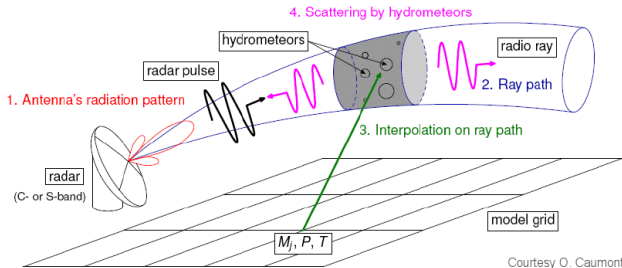
Assimilation of radar reflectivity

- **Reflectivity** is not a control variable in the model
- Method from Météo-France: 1D Bayesian + 3DVAR
- Generate pseudo-observations from model background: **Humidity profiles**



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Courtesy O. Caumont

M_j hydrometeor contents (rain water, snow, graupel, pristine ice)

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(No WMO standard tables for radar images)

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- Improve **Quality control** of radar data
- Pre-processing, **data conversion**, prepare for NWP
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Financed by Energy Norway/The Research Council of Norway

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Quality control of radar data observations

Radar data observations are not perfect:

- Clutter: Unwanted echoes
 - **Sea-clutter**: Waves on water pass through Doppler-filter
 - **Ground-clutter** (buildings, etc.)
 - **Traffic noise** (boats, planes)
 - **Sun flare**
 - Other: Birds, insects, chaff, ...
- Static maps of **beam blockage** (mountains)

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*Absolutely essential to **remove/flag** pixels of
non-meteorological echoes
in order to get **positive impact** on forecast*

Filtering of radar data

Identification and correction: Seaclutter/groundclutter

No filter

Filtered

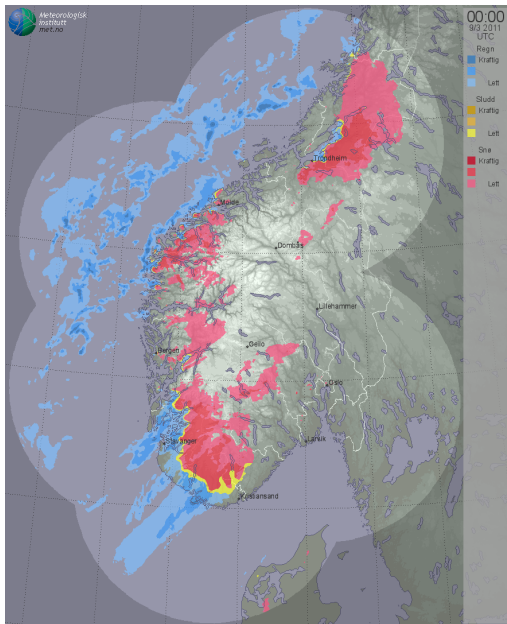
Radar Bømlo in Norway.

Christoffer A. Elo and Morten Salomonsen, met.no



Classification of precipitation at met.no

- 2011-03-10 1000
- Rain/sleet/snow



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- Observation handling in Harmonie (BATOR) reads **Météo-France BUFR** files
- \Rightarrow Need for **conversion** \Rightarrow CONRAD

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 - Currently supports Norwegian reflectivity observations
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- Will probably be used by Sweden, Denmark, The Netherlands, Ireland, Spain, Croatia, Hungary(?), ...

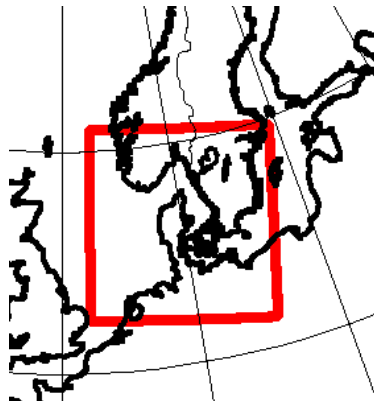
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Diverse data formats, versatile tool, common domain

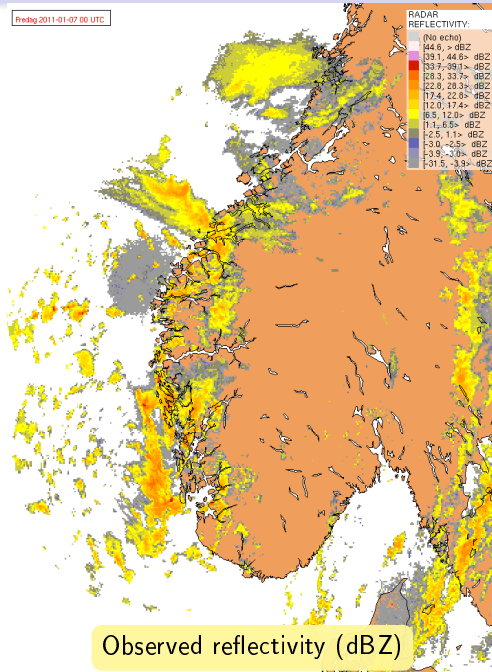
- Different local formats
- Common tool (CONRAD \Rightarrow Météo-France BUFR)
- Common NWP system (Harmonie/AROME)
- Common domain for testing: Denmark
- Radar data from various different formats inside same domain



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Results

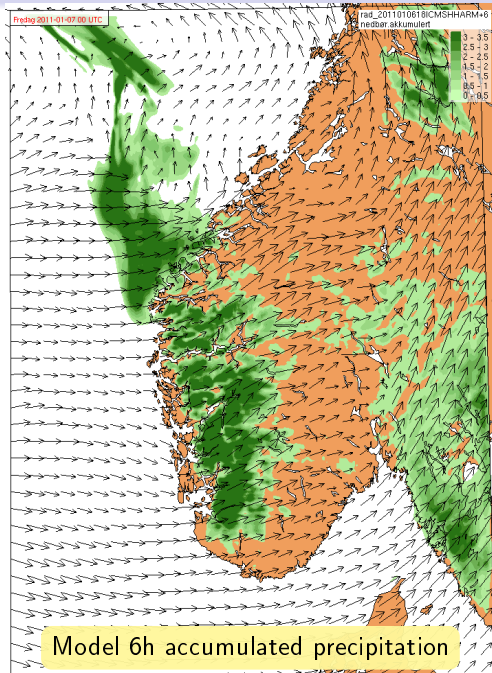
Friday 2011-01-07 00 UTC



Observed reflectivity (dBZ)

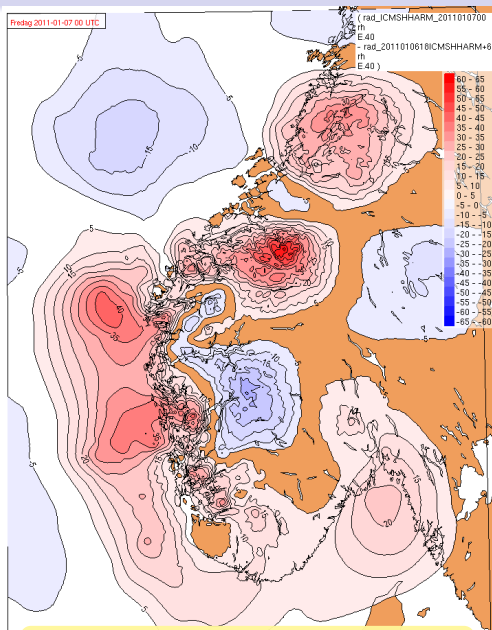
Observed reflectivity at
analysis time (Pseudo
CAPPI $\sim 500\text{-}700$ m)

Results



Model precipitation: +6h
forecast, 6h accumulated
precip. and wind (level
40), valid at analysis time

Results

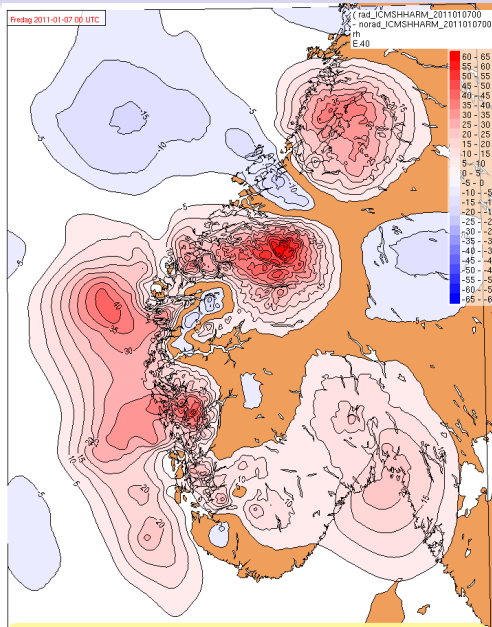


Analysis increment $x_a^{\text{radar}} - x_b^{\text{radar}}$ (RH)

Analysis increment

$x_a^{\text{radar}} - x_b^{\text{radar}}$, relative
humidity (RH), when radar
reflectivity is assimilated
(level 40)

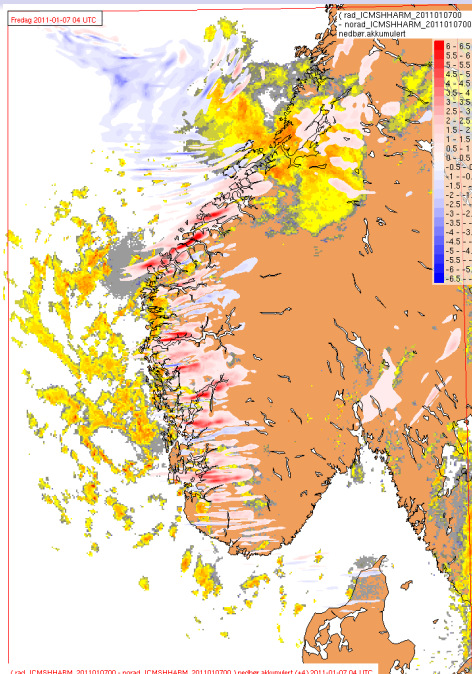
Results



Analysis differences

$x_a^{\text{radar}} - x_a^{\text{noradar}}$ (RH) with
and without radar
reflectivity assimilation
(level 40)

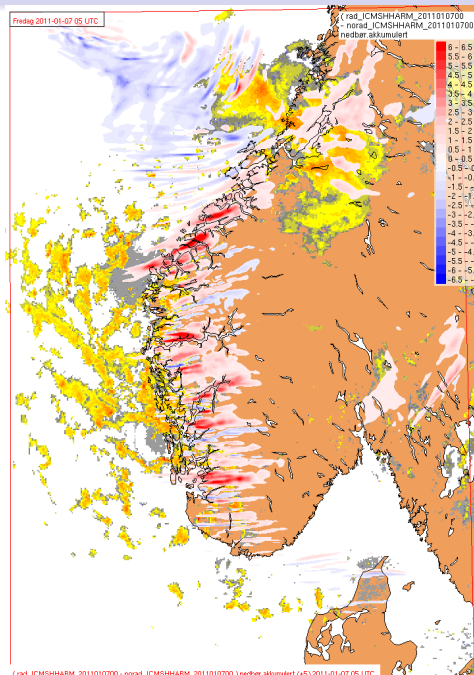
Results



Differences in forecasted
accumulated precipitation

+4h

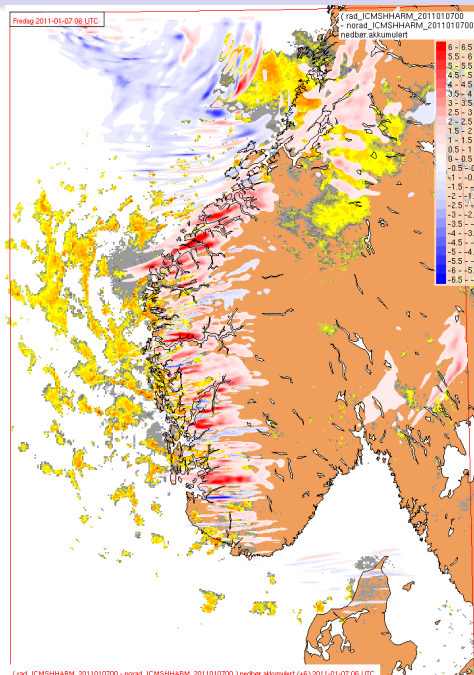
Results



Differences in forecasted
accumulated precipitation

+5h

Results



Differences in forecasted
accumulated precipitation

+6h

Differences in forecasted
accumulated precipitation

(animation)

Acknowledgments

- Energy Norway
- The Research Council of Norway (RCN/193048)
- ECMWF (SPNOHARM)
- Météo-France
(Thibaut Montmerle,
Eric Wattrelot)
- Radar producers at met.no
(M. Salomonsen, C. A. Elo)
- Colleagues at met.no R&D
dept., especially my former
office roommate
Roger Randriamampianina

Thank you!

martin.s.gronsleth@met.no

