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Progress in DA and implementation of the AROME-Arctic

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Outline

- ~~Use of the IASI humidity sensitive channels~~
- Implementation of the AROME-Arctic DA and forecasting system (ACCESS Project)
- Studies/speculations on the background error statistics
- Evaluation of the observations error statistics
- Concluding remarks and further plans

Implementation of the AROME-Arctic DA and forecasting system

The ACCESS project tasks are:

1. Describe the present *short-range* monitoring and forecasting capabilities in the Arctic
2. Identify key factors limiting the monitoring and forecasting capabilities, and give recommendations for key areas to improve the capabilities

The Arctic DA and forecasting challenge

Some physical processes:

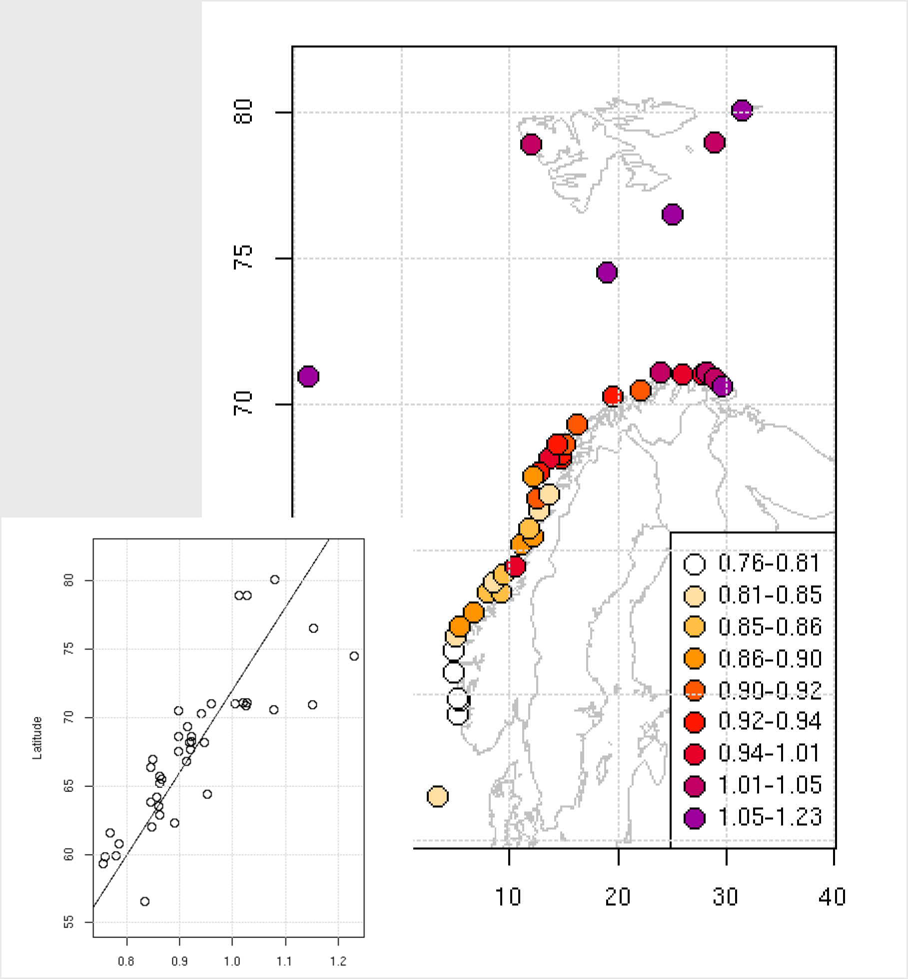
- The presence of sea ice surfaces with varying ice concentrations and properties and their influence on the surface heat and moisture fluxes
- Very stable boundary layers connected to strong surface cooling
- Convection over leads and over outbreaks of air masses moving from the sea ice or cold land to the open ocean

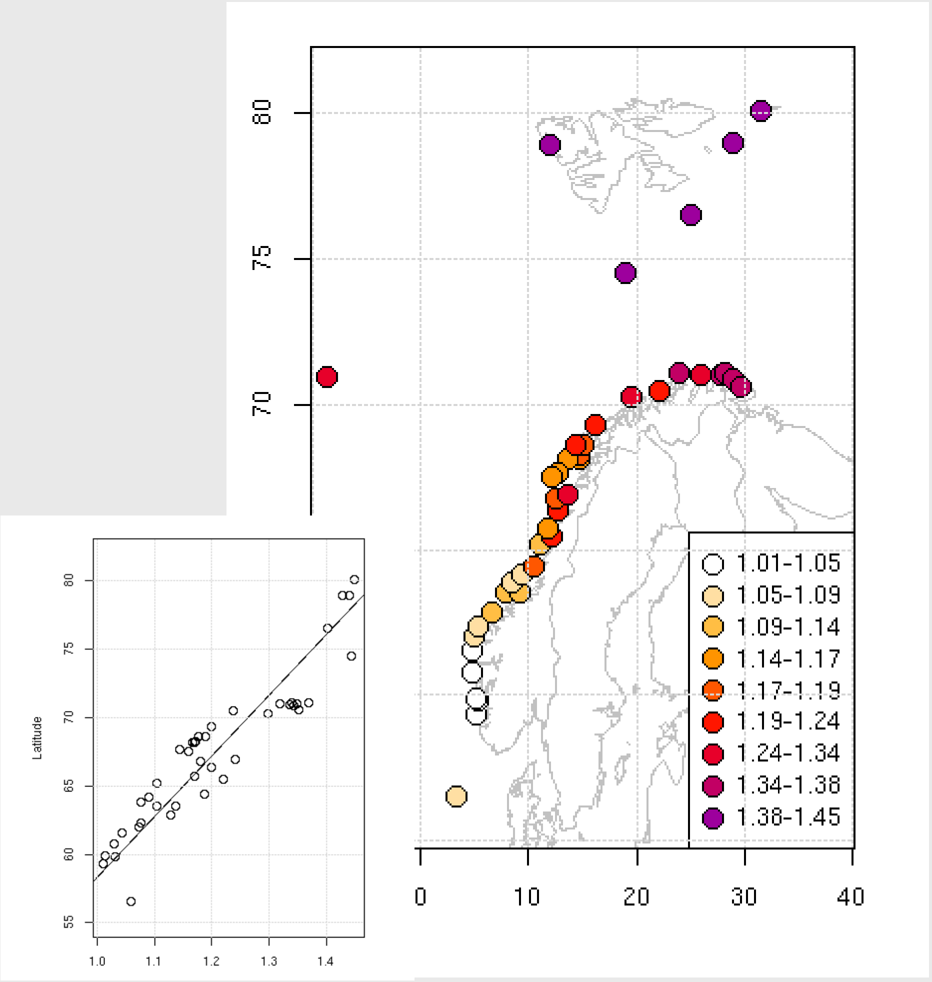
The Arctic observing system:

- Small density of conventional observations
- Satellite systems give coverage

How does this translate to model quality/model verification?

Model accuracy decreases towards the pole

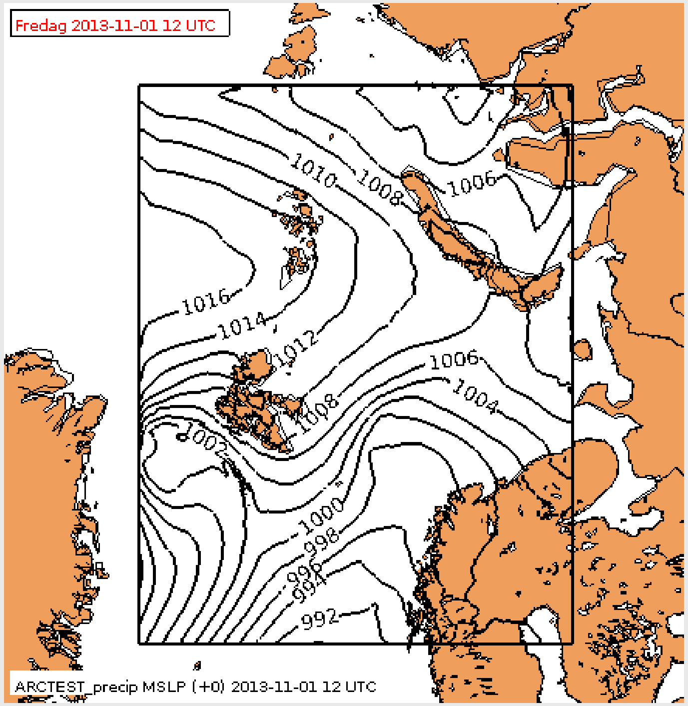




The figures shows the RMS errors in pressure (vs observations) for forecasts in the range from <u>18 to 42 hours</u>

- Left: Operational ECMWF global model (~16 km resolution)
- Right: Operational HIRLAM 12 km regional model

AROME-Arctic



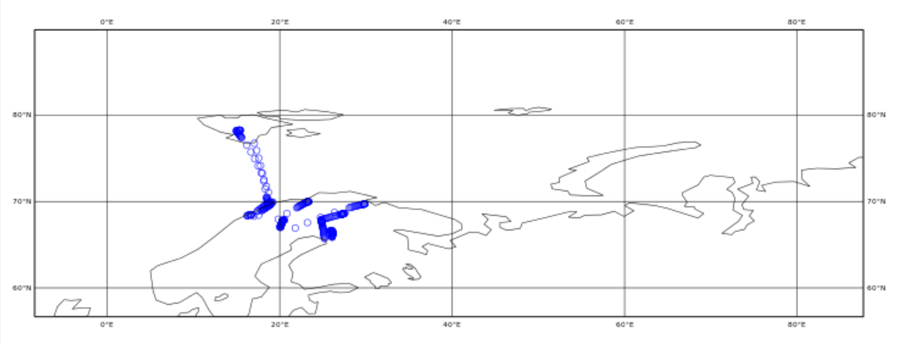
System setup:

- ➔ Harmonie cycle 38h1.1
- ➔ Domain: Same size as METCOOP (750x960)
- ➔ Model level definition: 65
- ➔ 3-hourly cycling
- ➔ Using all observations from MARS archive
- ➔ Background error statistics computed as mean over 4 seasons

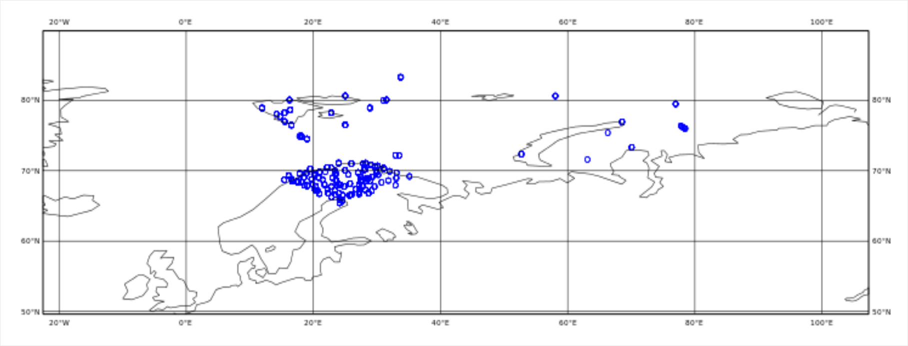
Tasks:

- ➔ Perform OSEs on the existing observing systems
- ➔ Perform OSSEs with the aim to provide guidance and recommendations for key observing networks over key areas to improve the monitoring and forecasting capabilities

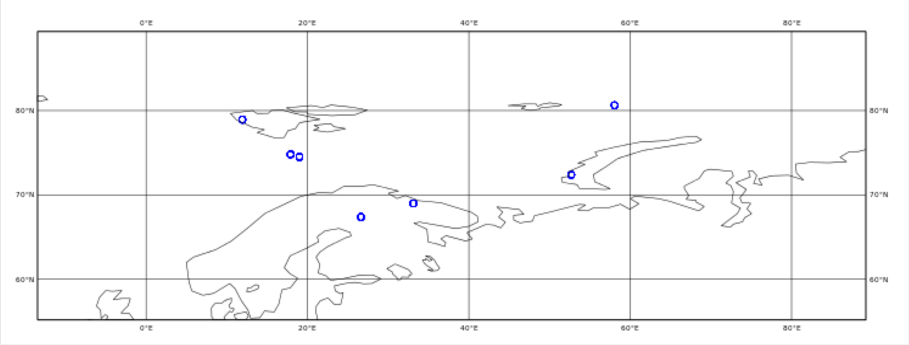
On the observations availability at 12 UTC over the domain



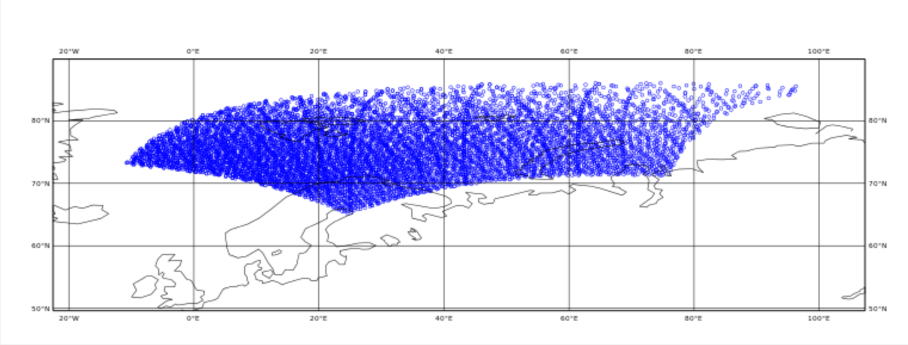
Aircraft observations



Surface observations

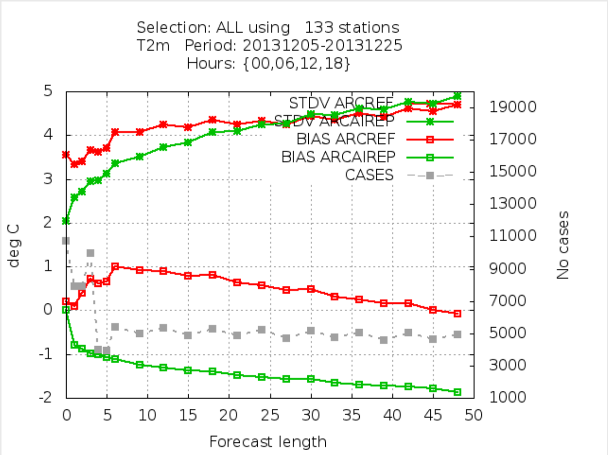


Radiosonde observations

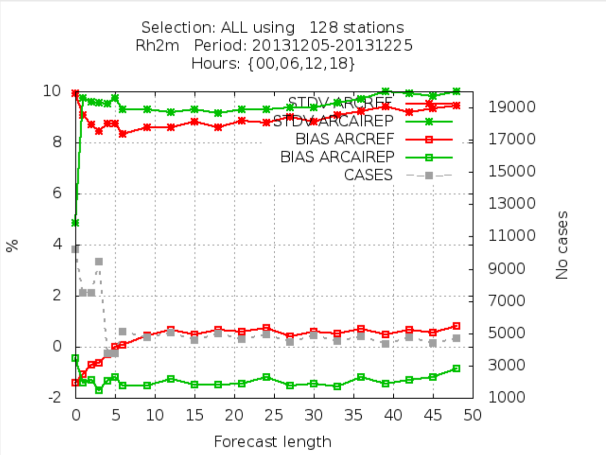


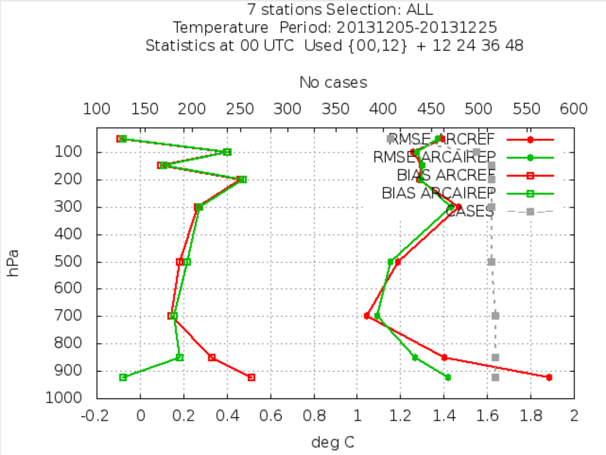
Satellite observations

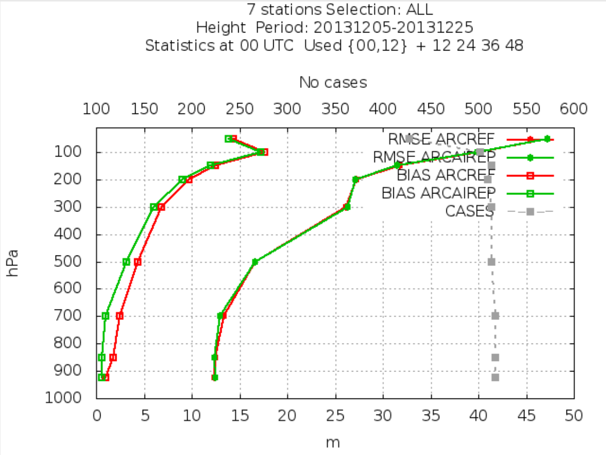
Testing the DA system: Study period Dec. 1-25, 2013
Reference: Run without DA – ARCREF;
DA test: Run with conv. data only, but no aircraft ARCAIREP;

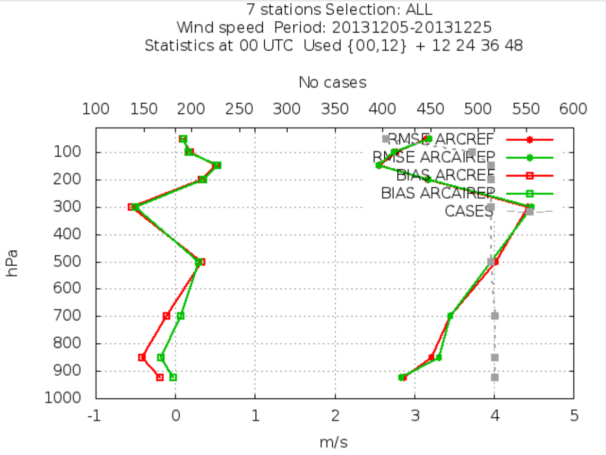


The assimilation system have the ability to improve the analyses and forecasts performance









Studies/speculations on the background error statistics

We know that:

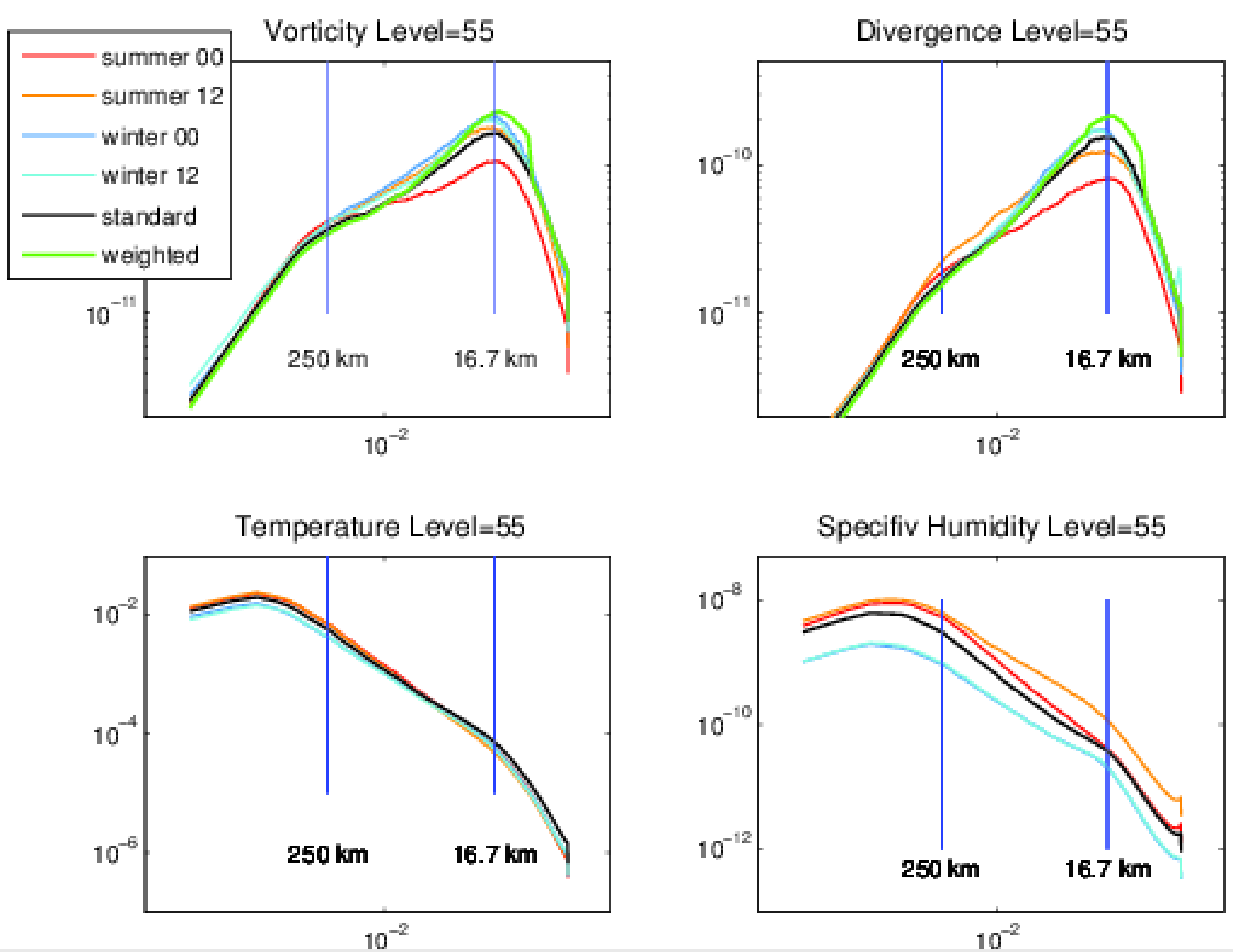
- ✓ The background error statistics have seasonal and even diurnal dependency (Storto and Randriamampianina (2010), Bölöni (2012), Zhuang (2013), … and more Aladin/Hirlam papers;
- ✓ Gert-Jan Marseille discussed the problem of lack of energy represented in the Harmonie B matrix, especially at small scale;
- ✓ We learned that "large jump" between model resolutions from the EC EPS to 2.5 km is influenced by spin-up problem (Gustafsson et al, 2014);
- ✓ We observe a relatively smaller impact of observations in the AROME-Norway system with DA compared to 11-km hydrostatic system.

The performed experiments

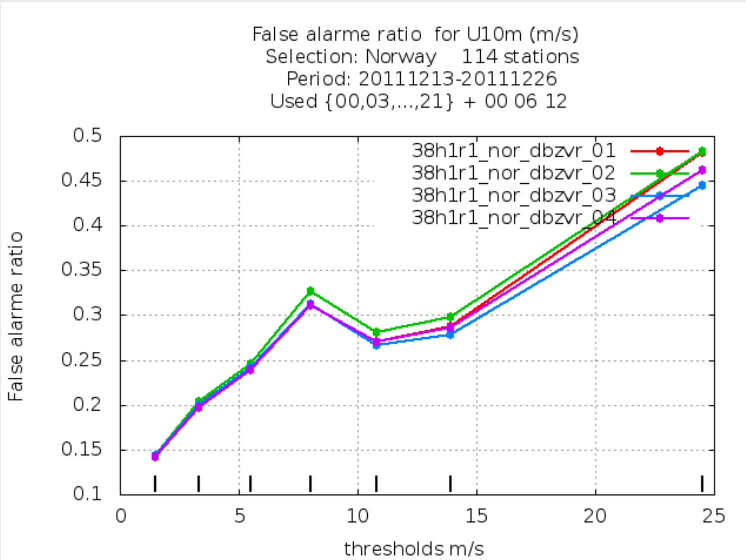
The following experiments were performed:

- 38h1r1_nor_dbzvr_01 - REDNMC=0.6 conv data and Norwegian radar reflectivity and wind
- 38h1r1_nor_dbzvr_02 - same as 01 with REDNMC=1.5;
- 38h1r1_nor_dbzvr_03 - same as 01 but with day/night B;
- 38h1r1_nor_dbzvr_04 - same as 01 but with weighted B;

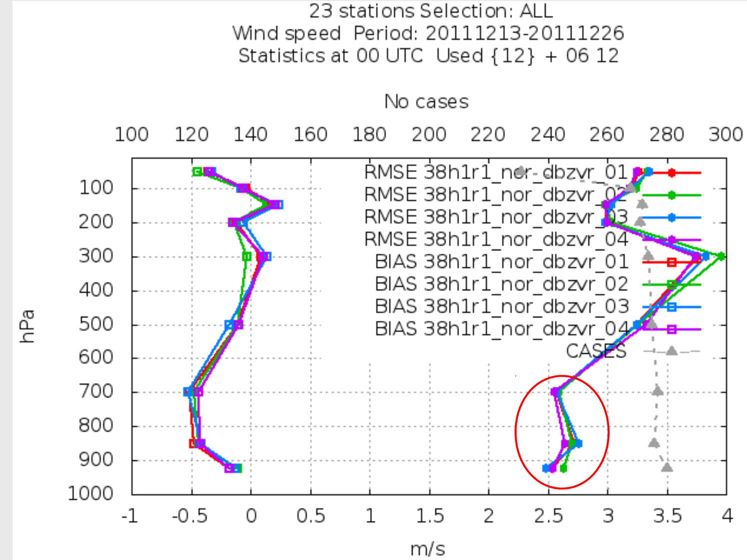
Inflating/weighting the spectral energy represented in B



Results on wind forecasts

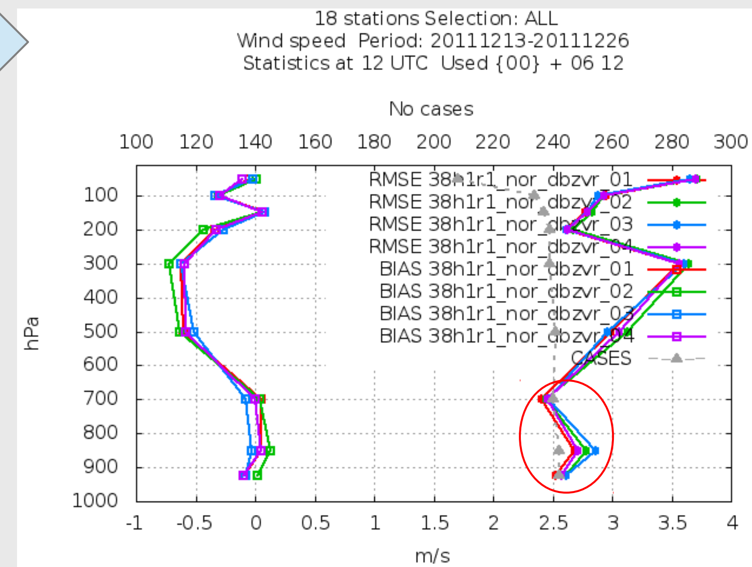


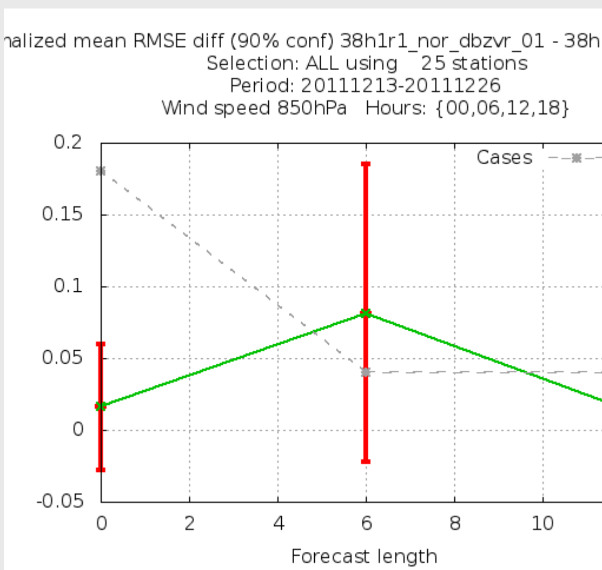
Day/night and weighted Bs good for intense wind forecast (?)



weighted B provides accurate wind forecast at lower troposphere (?)

also





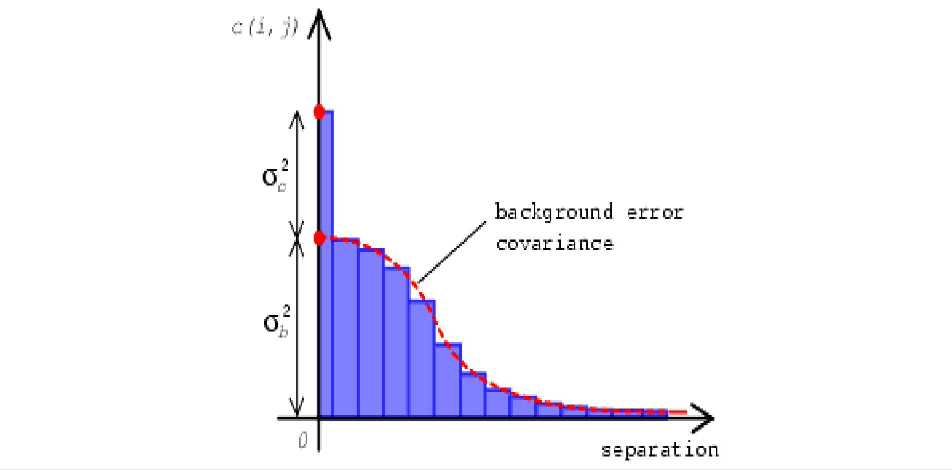
(01-04)

Evaluation of the observation error statistics

Hollingsworth & Lönnberg (1986) method

- **Assumptions**
  - Observation and background errors are uncorrelated
  - Observation errors are spatially uncorrelated
  - Background errors are spatially correlated

- **Diagnostics:**
  - if i=j : $var(d_b^o(i)) = \sigma_o^2 + \sigma_b^2$
  - If i -> j: $\lim_{i \to j} cov(d_b^o(i) d_b^o(j)) = \sigma_b^2$



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Desroziers et al. (2005) method

- **Assumptions**
  - Observation and background errors are uncorrelated
  - Observation and background covariances are exactly specified

- **Diagnostics:**

$$\sigma_o^2 = cov(d_a^o(i) d_b^o(i))$$
$$\sigma_b^2 = cov(d_b^a(i) d_b^o(i))$$

with

$$\mathbf{d}_b^a = \mathbf{H}\delta\mathbf{x}^a$$
$$\mathbf{d}_a^o = (\mathbf{y} - \mathbf{H}(\mathbf{x}^b + \delta\mathbf{x}^a))$$

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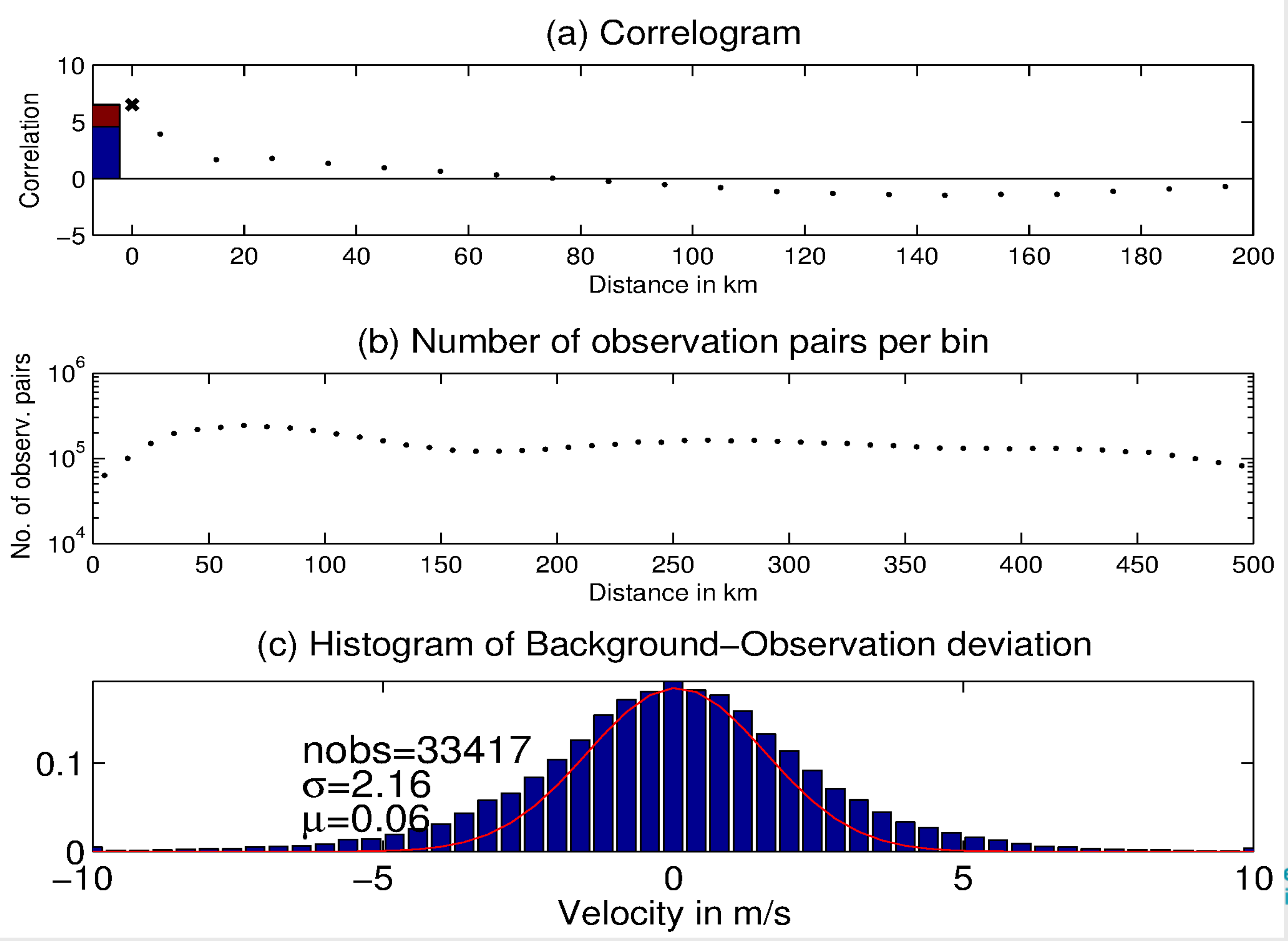
Radar radial wind observations

2 week summer period – all Norwegian radars



Radar radial wind observations

Hollings.-Lönn.

$$var(d_b^o(i)) = \sigma_o^2 + \sigma_b^2$$

Hollings.-Lönn.

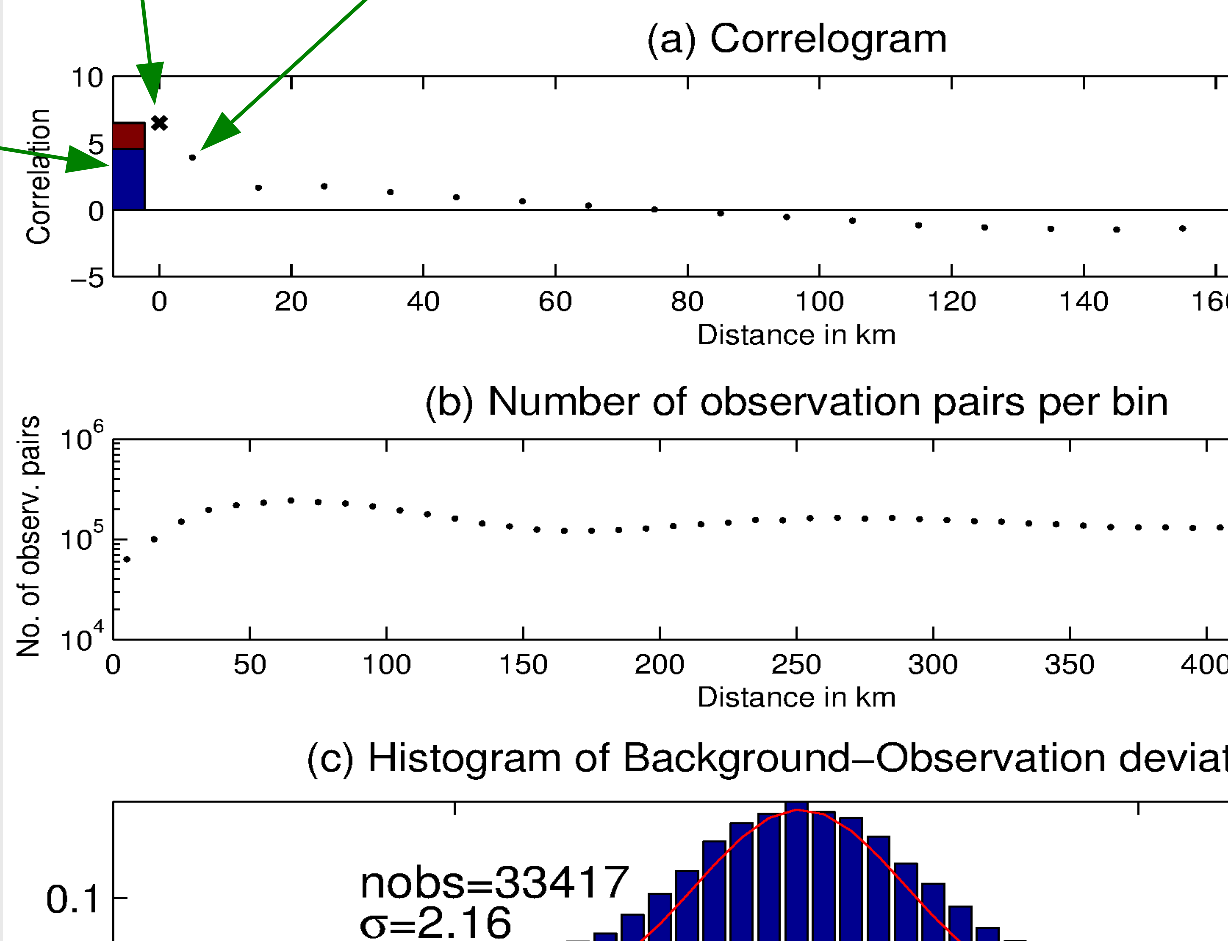
$$\lim_{i \to j} cov(d_b^o(i) d_b^o(j)) = \sigma_b^2$$

Desroziers

$$\sigma_o^2 = cov(d_a^o(i) d_b^o(i))$$

$$\sigma_b^2 = cov(d_b^a(i) d_b^o(i))$$

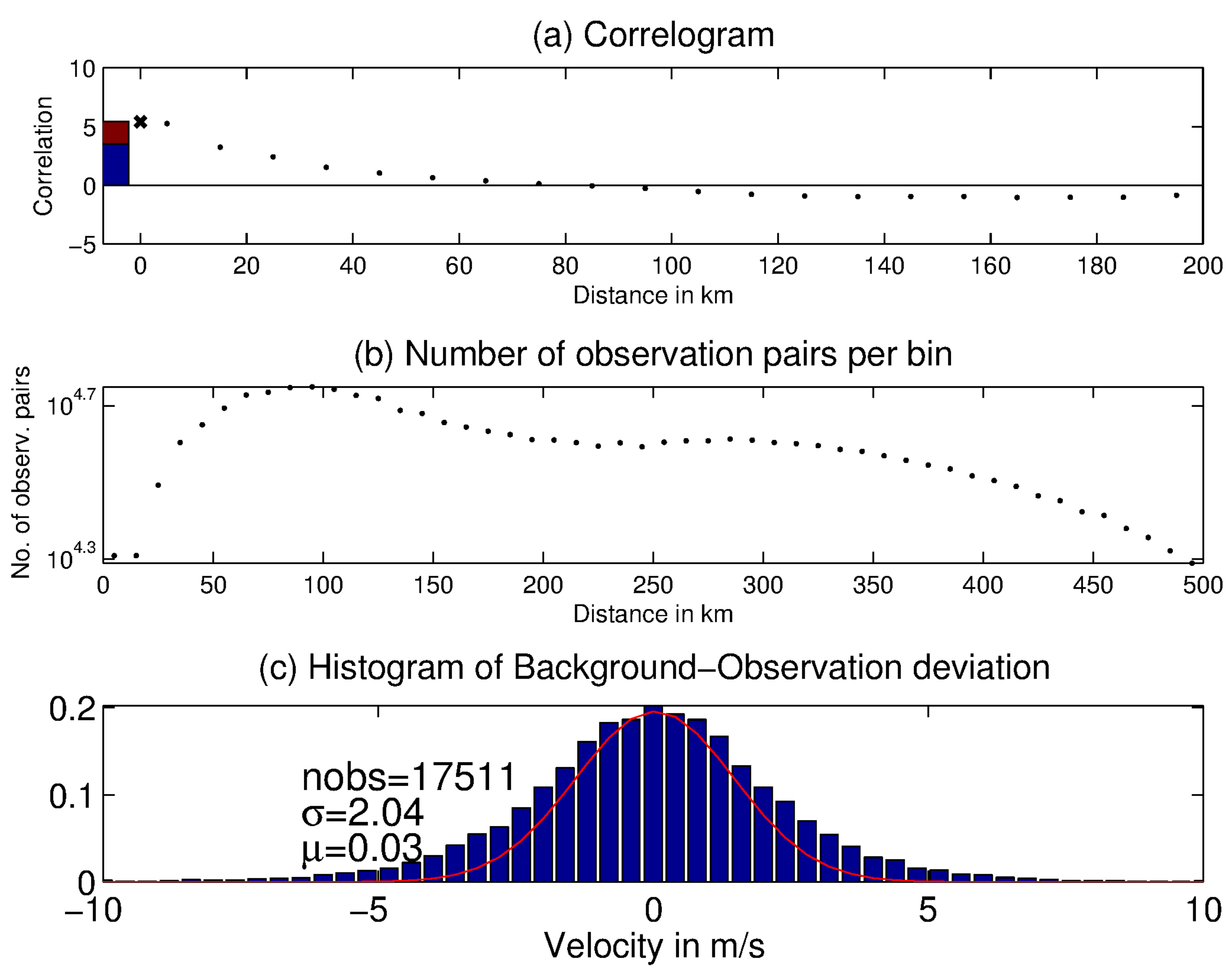
	H.-L.	Desr.
sig_o	1.61	1.40
sig_b	1.98	2.14



Radar radial wind observations

2 week summer period – all Norwegian radars -elevations lower than 3 degree

	H.-L.	Desr.
sig_o	0.40	1.38
sig_b	2.29	1.87



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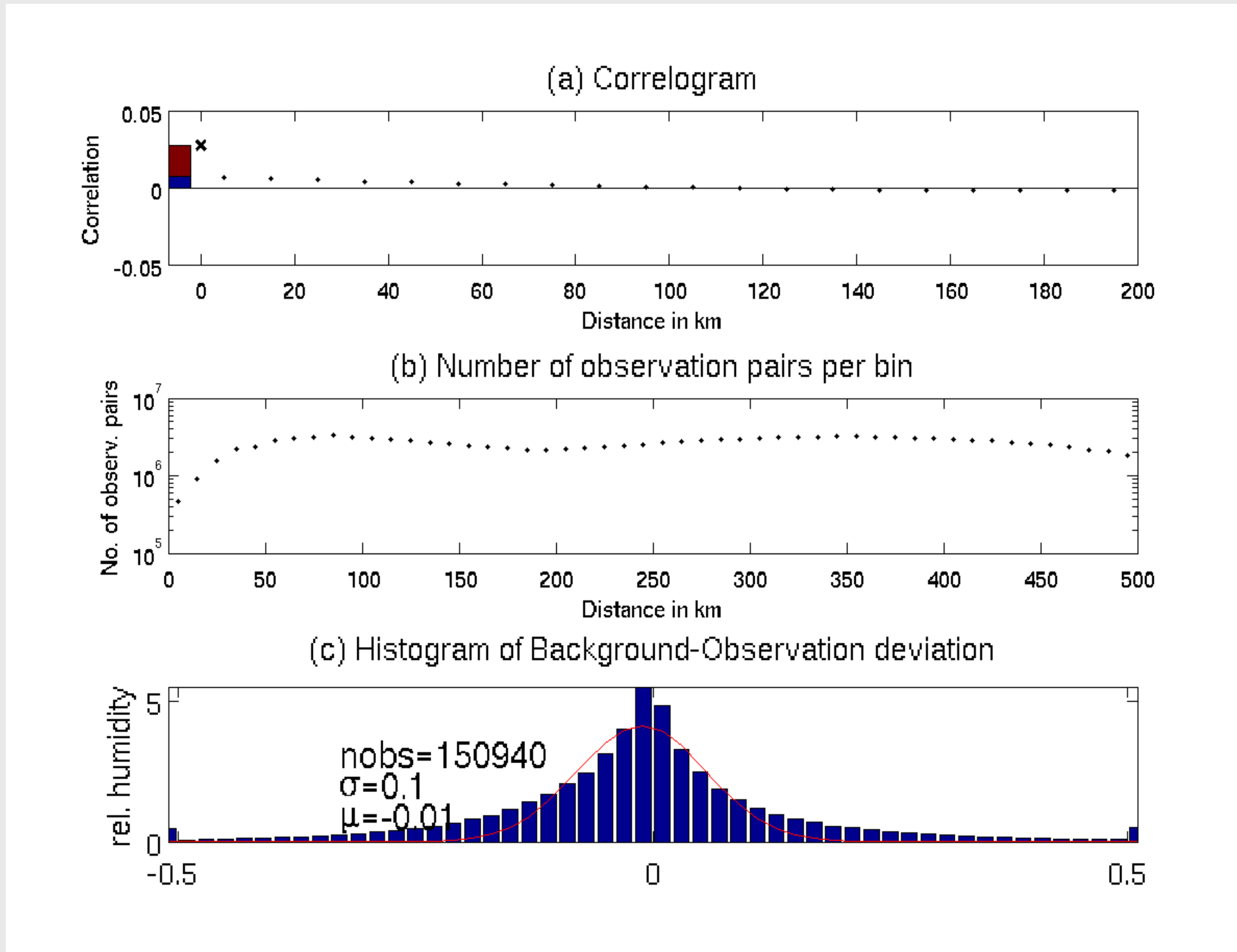
Radar reflectivity (rel. humidity) observations

2 week summer period – all Norwegian radars

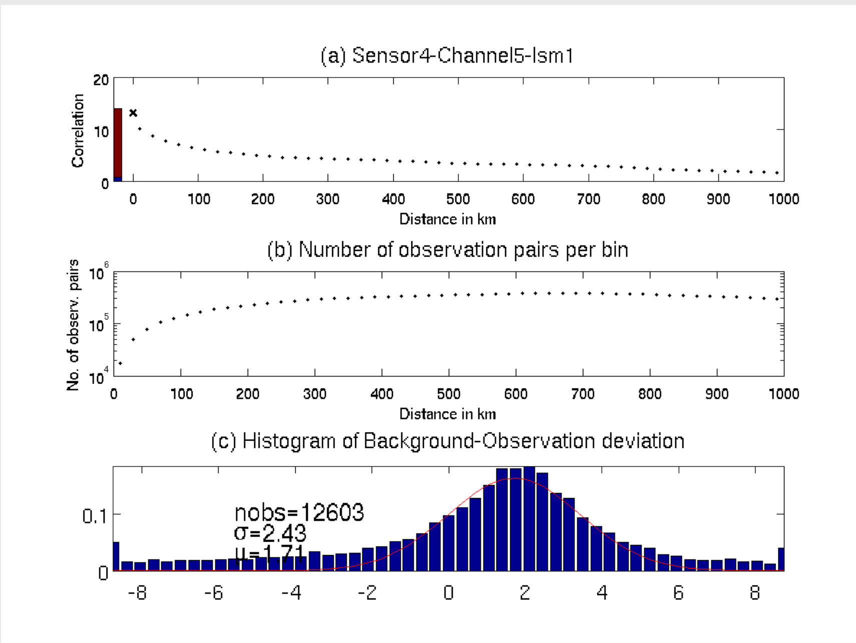
	H.-L.	Desr.
sig_o	0.145	0.141
sig_b	0.080	0.086



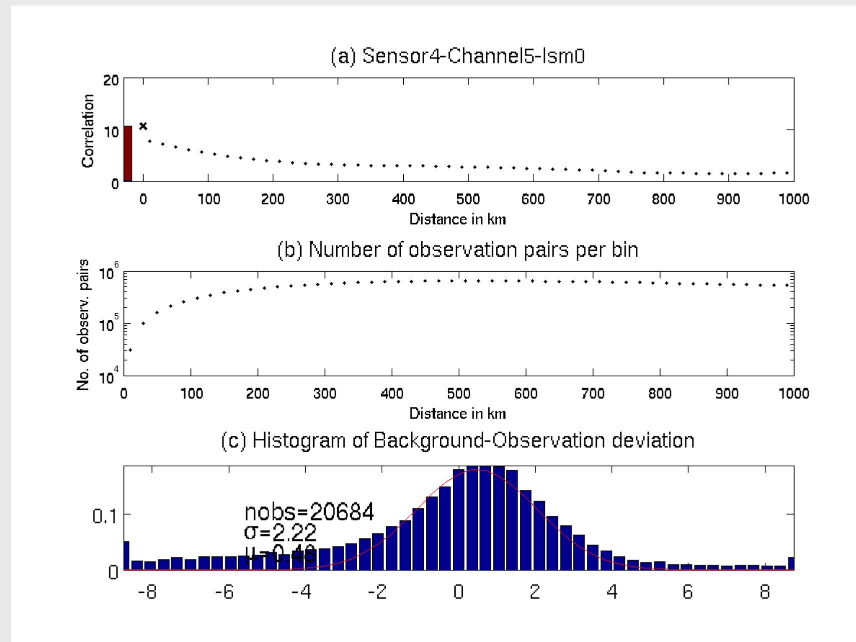
... possible to do the same with other observation types, e.g. ATOVS, ASCAT ...

From passive radiance assimilation:
AMSU-B Channel 5

Land



Sea



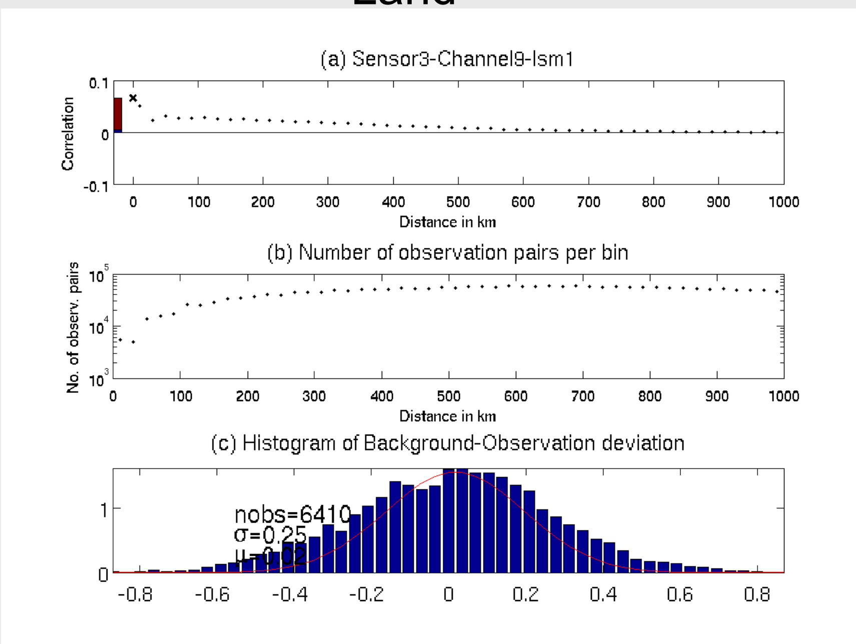
	H.-L.	Desr.
sig_o	1.73	3.63
sig_b	3.17	0.88

	H.-L.	Desr.
sig_o	1.67	3.22
sig_b	2.78	0.49

... possible to do the same with other observation types, e.g. ATOVS, ASCAT ...

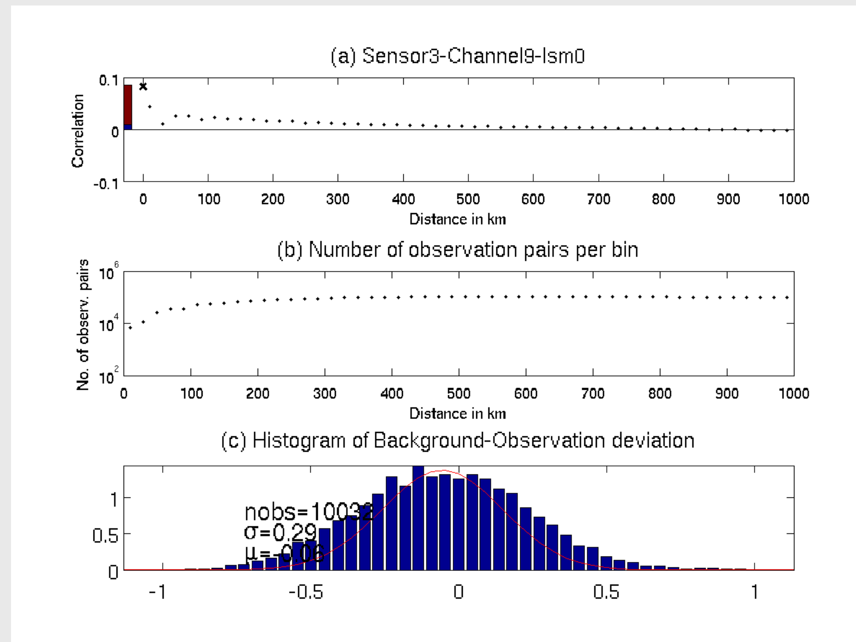
From passive radiance assimilation:
AMSU-A Channel 9

Land



	H.-L.	Desr.
sig_o	0.13	0.25
sig_b	0.23	0.07

Sea



	H.-L.	Desr.
sig_o	0.20	0.28
sig_b	0.21	0.09

Concluding remarks and future plans - 1

- ✓ We found 21 useful humidity sensitive IASI channels, which will be candidate for the operational use together with temperature sensitive channels;

- ✓ The implementation of the AROME-Arctic with DA is well in progress, where we found that the DA works well, but needs to be tuned together with the physics parametrization.
  - We observed the following (technical) issues so far:
    - – In CANARI the system aborted with Lat-north < Lat-south. This is due to the choice of strong rotation of the domain;
    - – The system suggests the use of polar stereographic projection instead of the Lambert one. We have experience of implementing such a system. This option will be tested later.

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Concluding remarks and future plans - 2

- ✓ The Harmonie system showed somehow sensitivity to the tested 3 versions of background error statistics.
  - – Spectral weighting can be option for tuning the static B.
  - – Accounting for the French experiences, we would like to use an AROME EDA to compute the B matrix.

- ✓ With respect to the estimation of the sigma-O (obs error) and sigma-B (background error), good agreement between the tested techniques was found. But, for some cases, we observe some disagreement, more probably when the assumptions are not fully respected.
  - – More thorough computations should be done for separate observing networks (for ex. for each radar and for each satellite) for a more comprehensive conclusions.