SMHI

Bias Correction Issues in Limited Area Models:

Strategy for HIRLAM

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Brief Introduction To HIRLAM

- HIRLAM, HIgh Resolution Limited Area Model

- Joint project between:
  Sweden, Denmark, Finland, Norway, Ireland,
  The Netherlands, Iceland and Spain.
  Research cooperation with Météo-France

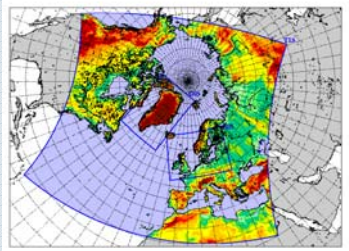
- Started in 1985

- Exists in both grid-point and spectral versions

- Most applications use the grid-point model, except:
  1: the background error constraint in 3DVAR
  2: the inner loop of the upcoming 4DVAR

Sweden

Norway



Denmark

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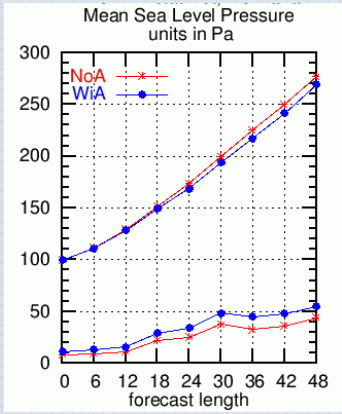
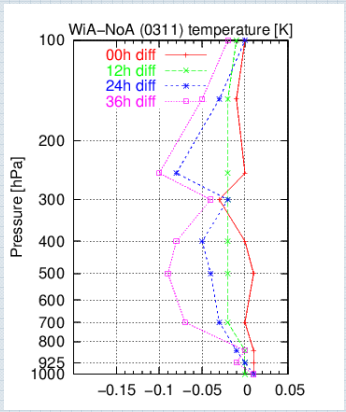
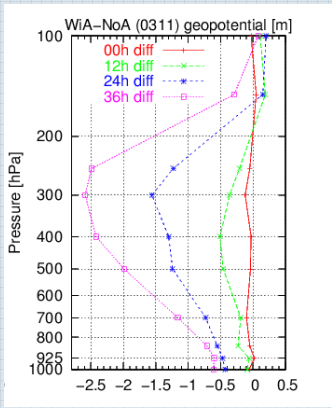
Use Of ATOVS In HIRLAM

Plots from DMI, Denmark
Nov 2003

- When 3DVAR was developed for HIRLAM (around 2000) direct assimilation of ATOVS AMSU-A became possible
- With EARS, operational use with good data coverage became feasible
- Today Denmark, Norway, Sweden and Spain use AMSU-A operationally
- Its positive impact on e.g. MSLP and T has been seen in most impact studies

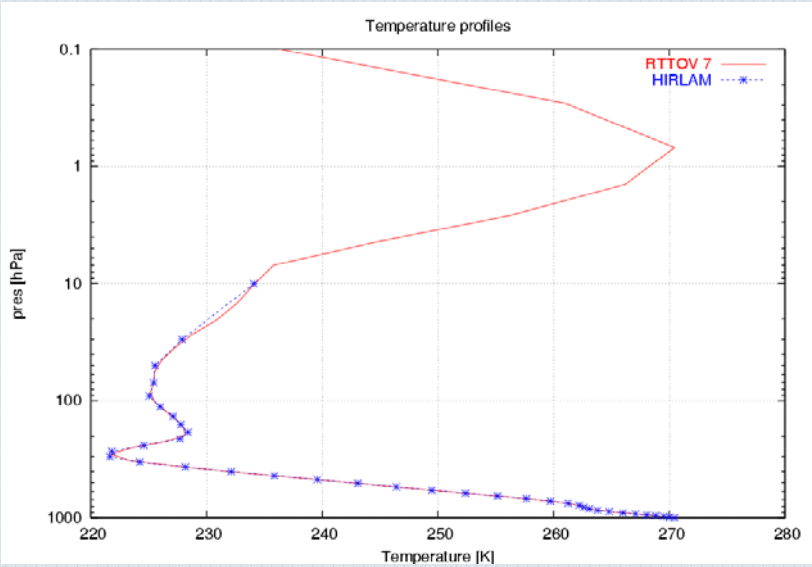






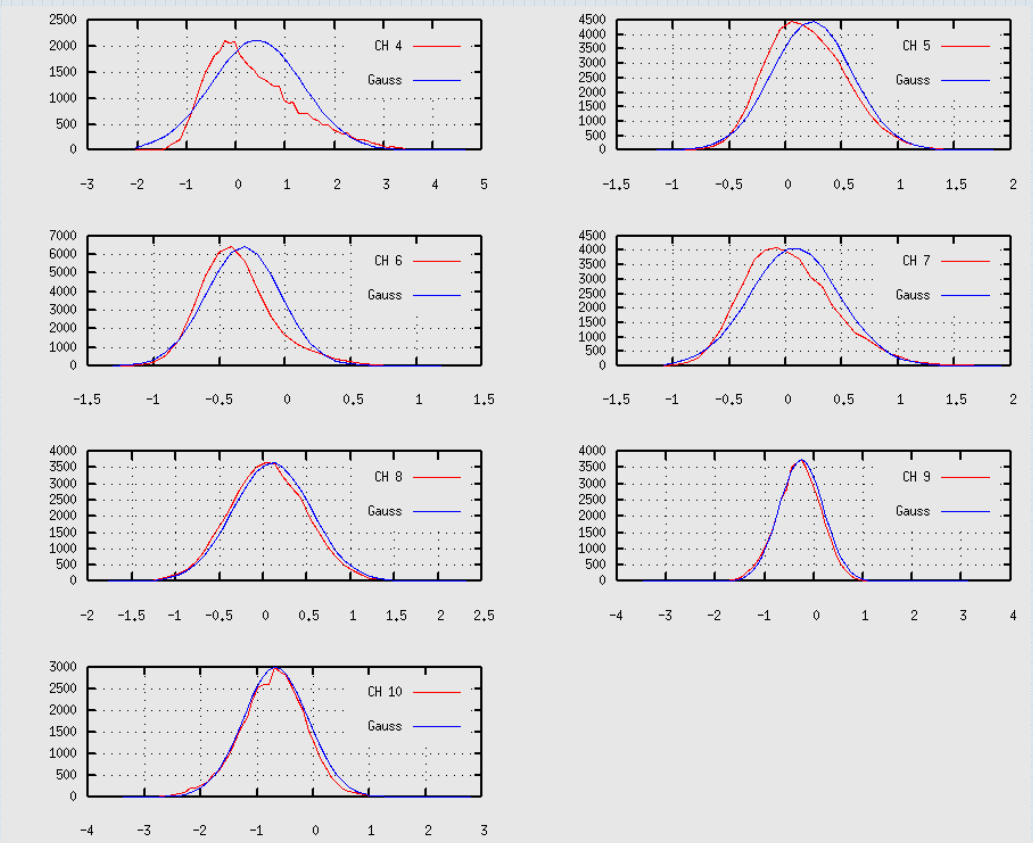
Use Of ATOVS In HIRLAM cont.

- Observation operator (H): RTTOV
  Most common is RTTOV-7 but RTTOV-8 is being tested at DMI, Denmark
- Cloud-cleared radiances over sea are used
- Channels 5-10 are assimilated
  (ch11-14 are above the model top)
- The HIRLAM top is at 10hPa
  Above 10hPa, climate-profiles are used
- Use of high peaking channels over ice and land is being tested in Norway and Denmark



AMSU-A Statistics In HIRLAM: Biases Revealed

- A sample of (y-Hx_b) statistics should ideally be Gaussian distributed around zero
- This is not the case for AMSU-A however
- Most channels are shifted ~0.1-0.5K and some are also skewed, ch5 and 6 e.g.
- We therefore need a bias correction procedure



Y-axis: Number of observations
X-axis: (y-Hx_b) [K] 0.1 K slots
Sample from March 2005 SMHI operational suite
NOAA16

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Bias Correction Of AMSU-A

- No research on bias reduction has been done in HIRLAM

- We have adopted the Harris/Kelly scheme with the following predictors:

  1: Constant shift
  2: Mean temperature between 1000-300hPa
  3: Mean temperature between 200-50hPa
  4: Surface temperature
  5: Integrated water vapor content
  6: Square of observation scan angle
  7: The observation scan angle

- It may be important to study which predictors that are most important and remove the others

- In tests with AMSU-B, at SMHI, the same scheme is used but predictors 4 and 5 are removed

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The Bias Correction Regression Formula

$$BiasCorrection_i = \sum_{j=1}^{No\,Pred} c_j P_j \left(x_b, y^i_{raw} \right)$$

x_b=first guess
y=observation

Coefficients determined from a reference dataset

The Predictors
Unique for each observation

Calculating the coefficients

How many observations should be in the reference dataset?

Regional model problem:

To get a reference dataset that is big ‘enough’.

Is there consensus on how much ‘enough’ is?

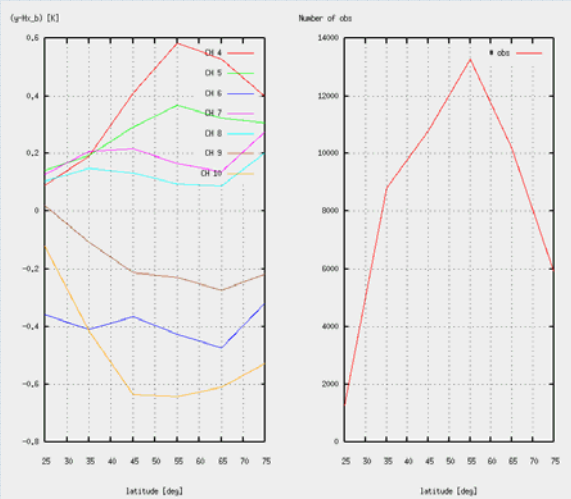
Calculating The Coefficients

Reference datasets, NOAA16, from some HIRLAM countries:

- Sweden
  Period: Jan-June (2004)
  Number of observations: ~500.000
  Latitude bands: 00-60N , 60-90N

- Denmark
  Period: Jan-May 2005
  Number of observations: ~10^6
  Latitude bands: 00-45N, 45-60N,60-90N

- Norway
  Period: Nov 2003-Feb 2004
  Number of observations: ~300.000
  Latitude bands:25-65N, 65-90N



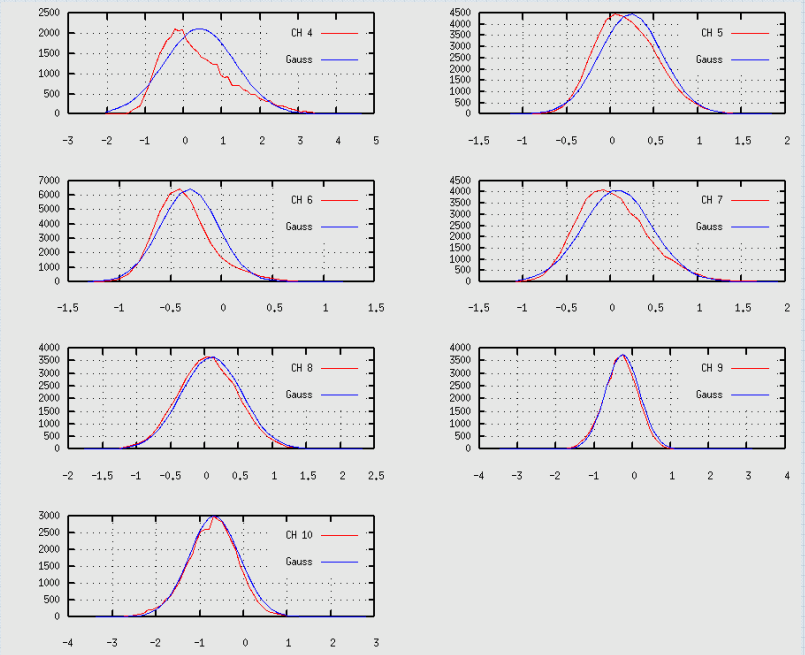
Sample from March 2005 SMHI operational suite NOAA16

The choice of latitude bands is a compromise between:

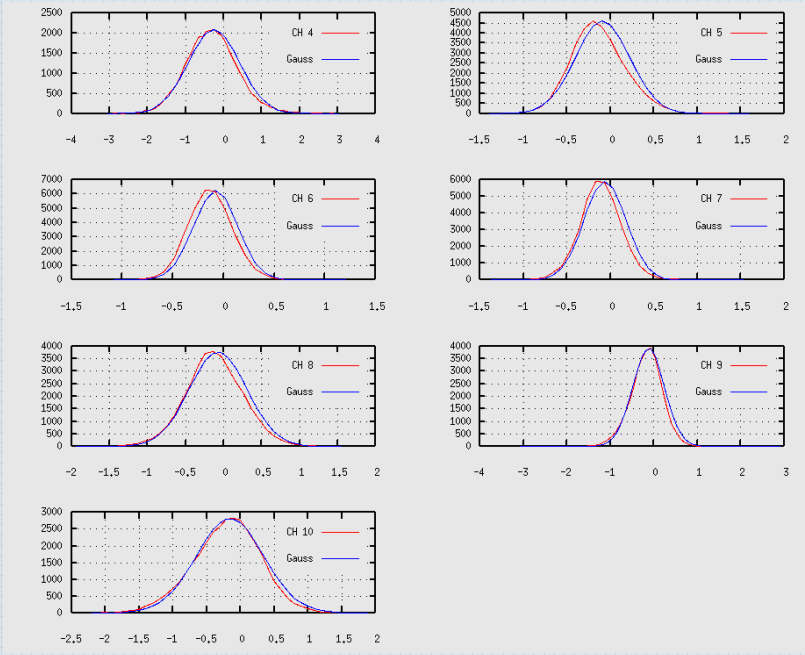
1: The model area
2: The actual latitude dependency

Apply the Bias Correction

Raw data (again)



Bias corrected



Y-axis: Number of observations
X-axis: (y-Hx_b) [K] 0.1 K slots
Sample from March 2005 SMHI operational suite
NOAA16

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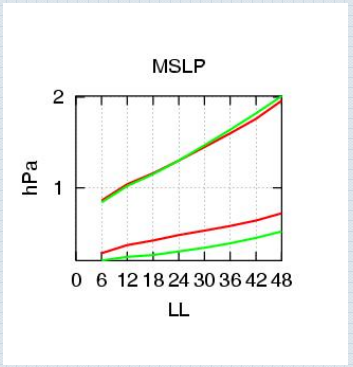
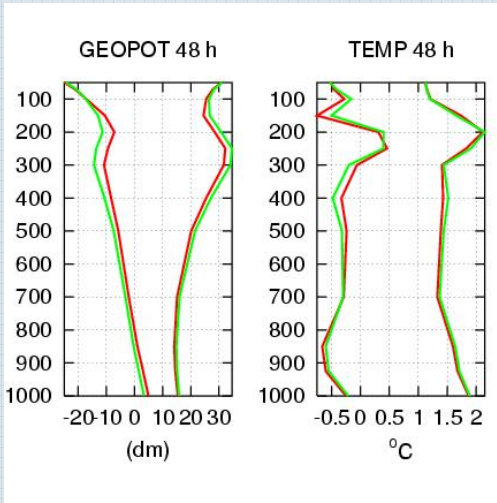
Bias Correction and Forecast Impact

- The bias correction improves the statistics
- It also important to test what effect it has on the forecasts
- At SMHI, an impact experiment has been performed where AMSU-A radiances were assimilated with and without bias-correction
- If the radiances are used without bias-correction, the errors (especially RMSE) for MSLP, GEOPOT and TEMPERATURE becomes larger

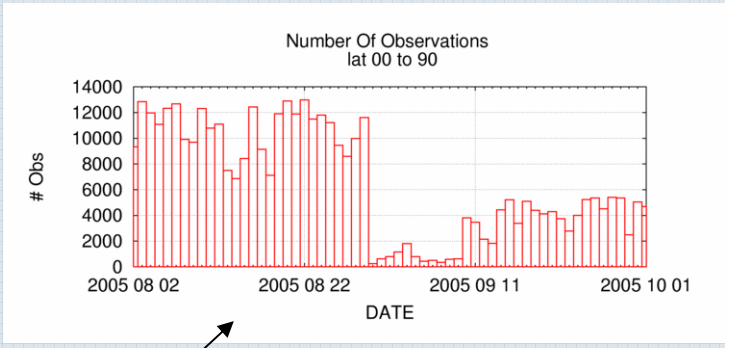


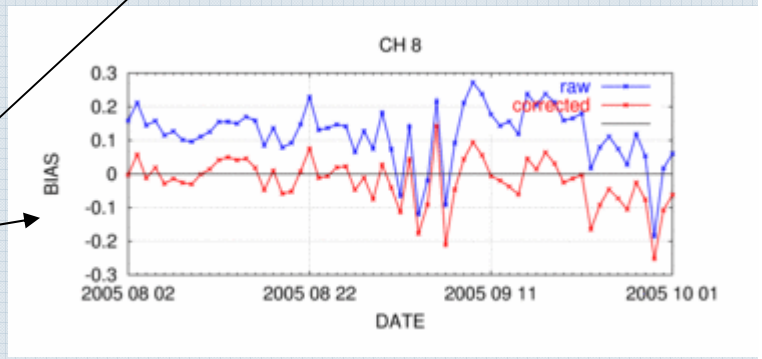


Red: Bias corrected radiances used
Green: Uncorrected radiances used
Period: 10:th Aug to 11:th Sep 2004

Monitoring

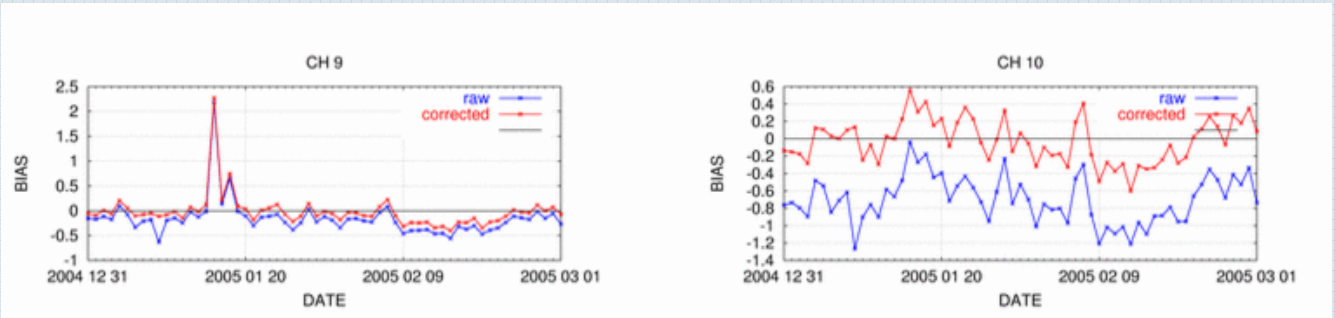
- At SMHI, (y-Hx_b) statistics are routinely plotted as time-series
- The statistics have been very stable the last year
- However, it is dependent on a steady inflow of observations
- The unstable behavior in this example is due to that the data-sample has drastically been reduced





Monitoring II

- In January 2005 NOAA16 CH9-14 were having problems
- The signal could be seen for channel 9 in the SMHI monitoring
- With aid from the monitoring plots and some mail-correspondence on the ITWG mail-list, channels 9 and 10 were taken out of operations at SMHI



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Summary

- Our bias-correction procedure seems to work quite well:
  1: It improves innovation statistics
  2: We get positive impact on forecasts if bias-corrected radiances are used

- In HIRLAM we calculate our coefficients once, and then use those as long as the monitoring looks okay

- Monitoring can be a bit problematic in a regional model:
  1: The amount of observations fluctuate from run to run and from day to day
  2: The monitoring statistics fluctuate as a consequence of varying data-samples
  This may conceal fluctuations due to e.g. instrument failures