



The Assimilation of Clear-Sky Infrared Radiances in the HIRLAM model at SMHI

Martin Stengel

SMHI, Swedish Meteorological and Hydrological Institute

ITSC-XVI: Angra dos Reis, Brazil, 7-13 May 2008

The Assimilation of Clear-Sky Infrared Radiances in the HIRLAM Model

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The potential use of spatially and temporal high resolved SEVIRI observations in the environment using the two water vapour channels (WV6.2, WV7.3), located at 6.2 and 7.3 μm, the impact on the analysis are illustrated for one case study. Secondly, we present upper air parameters during the summer period. In the winter period, the impact of

Data Preparation

The SEVIRI observations undergo various data preparation steps which are listed below. Usually 300 to 400 pixels (two observations each) at approx. 90km resolution are then kept in each observation window. (6 obs. windows per 4D-Var analysis)

- Processing of BTs and FGBs using the SAF-MHC software (for SEVIRI segments 7 and 8)
- Selecting 1 pixel out of a 10x10 pixel box
- Rejecting out-of-domain pixels (and scan angles > 70°)
- Rejecting cloudy pixels (GOES1/OMA, cloud mask)
- Applying flat IRACS correction to WV6.2 obs. (2.6K)
- First guess check
- Spatial thinning (thinning box size = 90km)

As demonstrated in the middle and right panels, the whole area seen here.



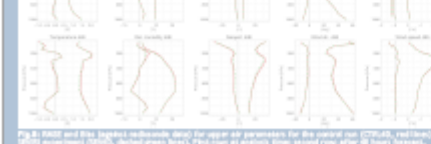
Current use of satellite data in HIRLAM/SMHI:

- AMSU-A
- NOAA 15, NOAA 16
- Channels 5 to 10
- 4D-Var
(Per Dahlgren)

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SEVIRI IR radiances have been introduced successfully as a new observation type in summer month and one winter month. With the chosen experimental specifications, mid- and upper-tropospheric humidity fields. A positive impact can be seen in the with forecast length. Small positive effects are also found for the temperature, geopotential height and surface wind. The impact of the temperature, geopotential height and surface wind variables is found to be very small and rather neutral during the winter period. "Superobbing" will be addressed in the near future.

Keywords:

- HIRLAM/SMHI (limited area model)
- 4D-Var
- SEVIRI water vapour channels (data from 6 time slots used)
- not operational yet

The Assimilation of Clear-Sky Infrared Radiances in the HIRLAM Model

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Abstract

The potential use of spatially and temporal high resolved SEVIRI observations in the HIRLAM model VAR analysis is currently investigated at SMHI. Especially, the extended utilization of the three dimension in HIRLAM 4D-Var is appropriate to make full use of SEVIRI's fast imaging cycle. Currently, we carry out observation impact studies in a pre-operational environment using the two water vapor channels (WV6.2, WV7.3), located at 6.2µm and 7.3µm, to find an optimal assimilation setup. Firstly, the data preparation steps as well as the impact on the analysis are illustrated for one case study. Secondly, we present on this poster two impact studies, which show a positive impact of SEVIRI observations on the upper air parameters during the summer period. In the winter period, the impact on moisture is less pronounced and rather neutral for the other variables.

Data Preparation

The SEVIRI observations undergo various data preparation steps which are listed below. Usually 500 to 1200 pixels (two observations each) at approx. 90km resolution are then kept in each observation window. (6 obs.-windows per 4D-Var analysis)

- Processing of BTs and PGEs using the SAF NWC software (for SEVIRI-segments 7 and 8)
- Selecting 1 pixel out of a 10x10 pixel box
- Rejecting out-of-domain pixels (and scan angles $.gt. 70^\circ$)
- Rejecting cloudy pixels (PGE01/CMa, cloud mask)
- Applying flat BIAS correction to WV6.2 obs. (2.6K)
- First guess check
- Spatial thinning (thinning box size = 90km)

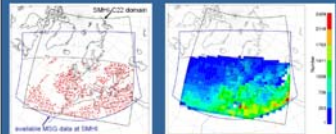


Fig.1: Example of thinned SEVIRI observations (red dots) after applying all data preparation steps.

Fig.2: Spatial distribution of used SEVIRI pixels for a one month period with 4D-Var.

Impact on HIRLAM 4D-Var Analysis - Case Study

As demonstrated in this case study, the impact of assimilating the middle and upper troposphere (Figure 3). The larger impact seen here, is due to a systematic deviation in the background state.

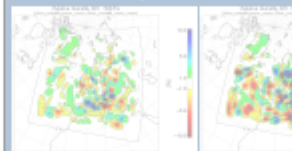


Fig.3: Increase in Relative Humidity at 3 isobaric levels (200hPa, 300hPa, 400hPa) with conventional observations only.



Fig.4: Frequency distribution of background state observation departures.

Observation Impact Study I - Summer Period

Experiment description

- Time period : 06/24/2009 - 07/21/2009
- Control run (CTRL4D) : 4D-Var analysis with conventional observations only
- Experiment (SEV4D) : 4D-Var analysis with conventional and SEVIRI observations; SEVIRI observations are taken from six time slots (the slot closest to the respective observation window centre)
- Cycle : 6 hour assimilation cycle / forecast up to 48 hours
- Verification : ENIGLAM radiances and synops



Fig.5: Time series of all four generalized brightness temperature errors (BT errors) used in the cost function.

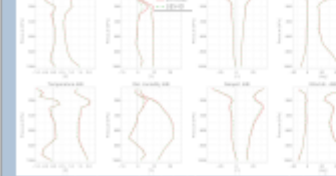


Fig.6: BT errors and their impact on radiances (BT error) for upper air parameters for the control run (CTRL4D, red line) and the experiment (SEV4D, blue line). The plot shows the time series of all four BT errors.

Observation

Experiment description

- Time period : 12/9/2008 - 12/16/2008
- Control run (CTRL4D) : 4D-Var analysis with conventional observations only
- Experiment (SEV4D) : 4D-Var analysis with conventional and SEVIRI observations; SEVIRI observations are taken from six time slots (the slot closest to the respective observation window centre)
- Cycle : 6 hour assimilation cycle / forecast up to 48 hours
- Verification : ENIGLAM radiances and synops

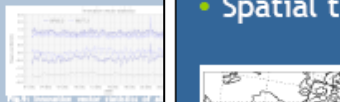


Fig.7: Time series of all four generalized brightness temperature errors (BT errors) used in the cost function.

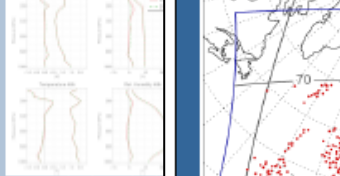


Fig.8: BT errors and their impact on radiances (BT error) for upper air parameters for the control run (CTRL4D, red line) and the experiment (SEV4D, blue line). The plot shows the time series of all four BT errors.

Summary

SEVIRI IR radiances have been introduced successfully as a new observation type in the HIRLAM assimilation system. As in the summer and one winter month. With the chosen experimental specifications, the assimilation of SEVIRI's water vapor mid- and upper-tropospheric humidity fields. A positive impact can be seen in the upper troposphere for all experiments with long forecast length. Small positive effects are also found for the temperature, geopotential height and wind fields after 48 h variables is found to be very small and rather neutral during the winter period. Changes in the data preparation step "thinning", will be addressed in the near future.

Acknowledgements

This poster is presenting research results with contributions from: Martin Stengel, Per Dalgaard, Magnus Lövberg, Per Uden, Håkan and others. This work is supported by EUMETSAT within the EUMETSAT Fellowship program.

Data Preparation

The SEVIRI observations undergo various data preparation steps which are listed below. Usually 500 to 1200 pixels (two observations each) at approx. 90km resolution are then kept in each observation window. (6 obs.-windows per 4D-Var analysis)

- Processing of BTs and PGEs using the SAF NWC software (for SEVIRI-segments 7 and 8)
- Selecting 1 pixel out of a 10x10 pixel box
- Rejecting out-of-domain pixels (and scan angles $.gt. 70^\circ$)
- Rejecting cloudy pixels (PGE01/CMa, cloud mask)
- Applying flat BIAS correction to WV6.2 obs. (2.6K)
- First guess check
- Spatial thinning (thinning box size = 90km)

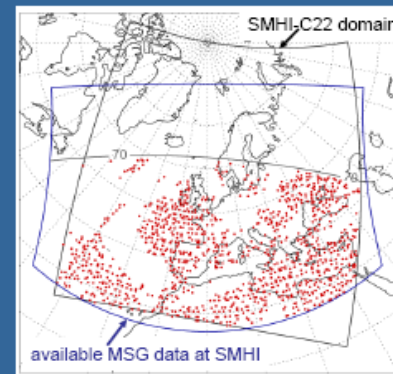


Fig.1: Example of thinned SEVIRI observations (red dots) after applying all data preparation steps.

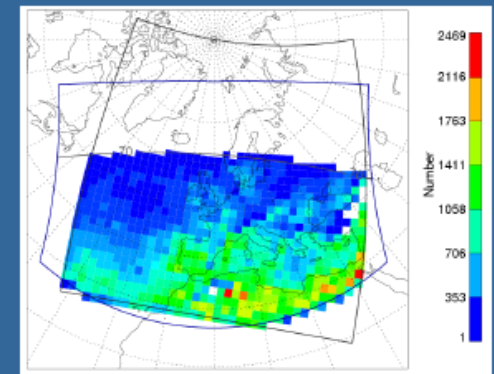


Fig.2: Spatial distribution of used SEVIRI pixels for a one month period with 4D-Var.

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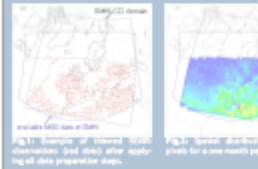
Abstract

The potential use of spatially and temporal high resolved SEVIRI observations in the HIRLAM model VAR analysis is currently investigated at SMHI. Especially, the extended utilization of the three dimension in HIRLAM 4D-Var is appropriate to make full use of SEVIRI's fast imaging cycle. Currently, we carry out observation impact studies in a pre-operational environment using the two water vapour channels (WV6.2, WV7.3), located at 6.2µm and 7.3µm, to fit an optimal assimilation setup. Firstly, the data preparation steps as well as the impact on the analysis are illustrated for one case study. Secondly, we present on this poster two impact studies, which show a positive impact of SEVIRI observations on the upper air parameters during the summer period. In the winter period, the impact on moisture is less pronounced and rather neutral for the other variables.

Data Preparation

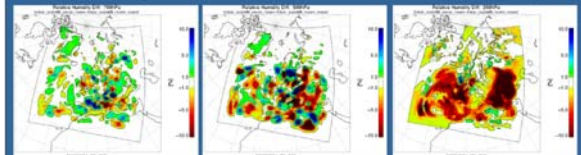
The SEVIRI observations undergo various data preparation steps which are listed below, usually 300 to 600 pixels (two observations each) at approx. 90km resolution are then kept in each observation window. (8 obs. windows per 4D-Var analysis)

- Processing of BTs and FGBs using the SAF IMC software (for SEVIRI-segments 7 and 8)
- Selecting 1 pixel out of a 10x10 pixel box
- Rejecting out-of-domain pixels (and scan angles > 70°)
- Rejecting cloudy pixels (QCE01/QCA, cloud mask)
- Applying flat IRACS correction to WV6.2 obs. (2.4K)
- First guess check
- Spatial thinning (thinning box size = 92km)



Impact on HIRLAM 4D-Var Analysis - Case Study

As demonstrated in this case study, the impact of assimilated SEVIRI radiances is mainly in the moisture fields of the middle and upper troposphere (Figure 3). The large-scale drying in the upper-tropospheric layers, which can be seen here, is due to a systematic deviation in the background minus observation departures (Figure 4).

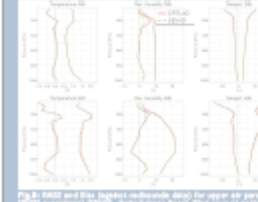


Impact on HIRLAM 4D-Var Analysis - Case Study

As demonstrated in this case study, the impact of assimilated SEVIRI radiances is mainly in the moisture fields of the middle and upper troposphere (Figure 3). The large-scale drying in the upper-tropospheric layers, which can be seen here, is due to a systematic deviation in the background minus observation departures (Figure 4).

Observation Impact Study I

- Experiment description
- Time period : 08/24/2009 - 07/21/2010
 - Control run (CTRL4D) : 4D-Var analysis with con
 - Experiment (SEV4D) : 4D-Var analysis with con + SEVIRI observations are closest to the respective
 - Cycle : 6 hour assimilation cycle
 - Verification : ECHAM5 radiocoster



SEVIRI IR radiances have been introduced success summer month and one winter month. With the c mid- and upper-tropospheric humidity fields. A p with forecast length. Small positive effects are sta variables is found to be very small and rather "superfluous", will be addressed in the near future

This poster is presenting research results with con SMHI) and others. This work is supported by EUHCT

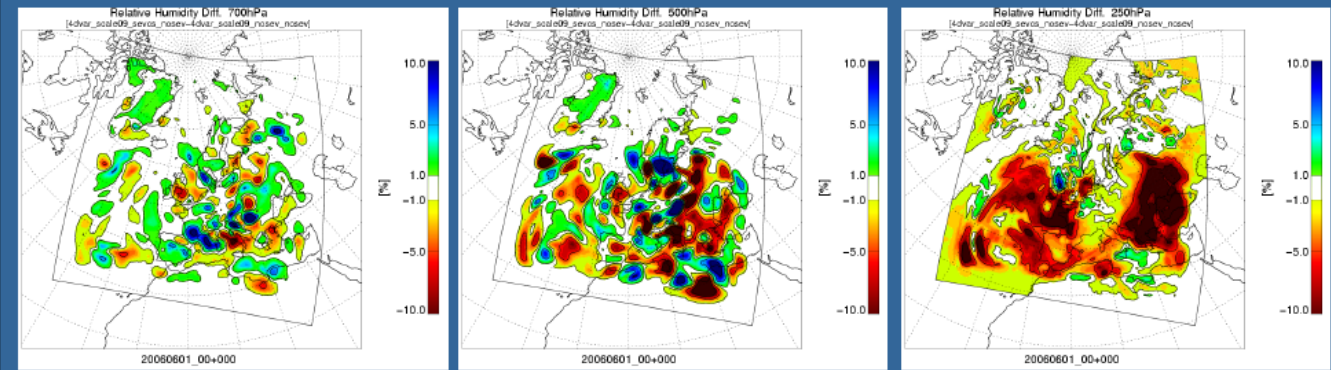


Fig. 3: Increments in Relative Humidity at 3 atmospheric levels (700hPa:left, 500hPa:middle, 250hPa right), calculated with respect to a control analysis with conventional observations only.

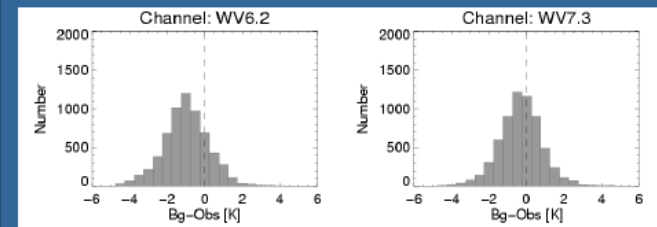


Fig. 4: Frequency distribution of background minus observation departures.

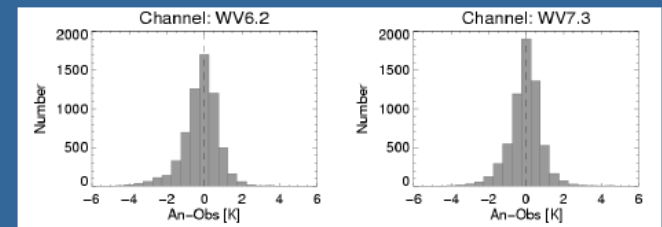


Fig. 5: Frequency distribution of analysis minus observation departures.

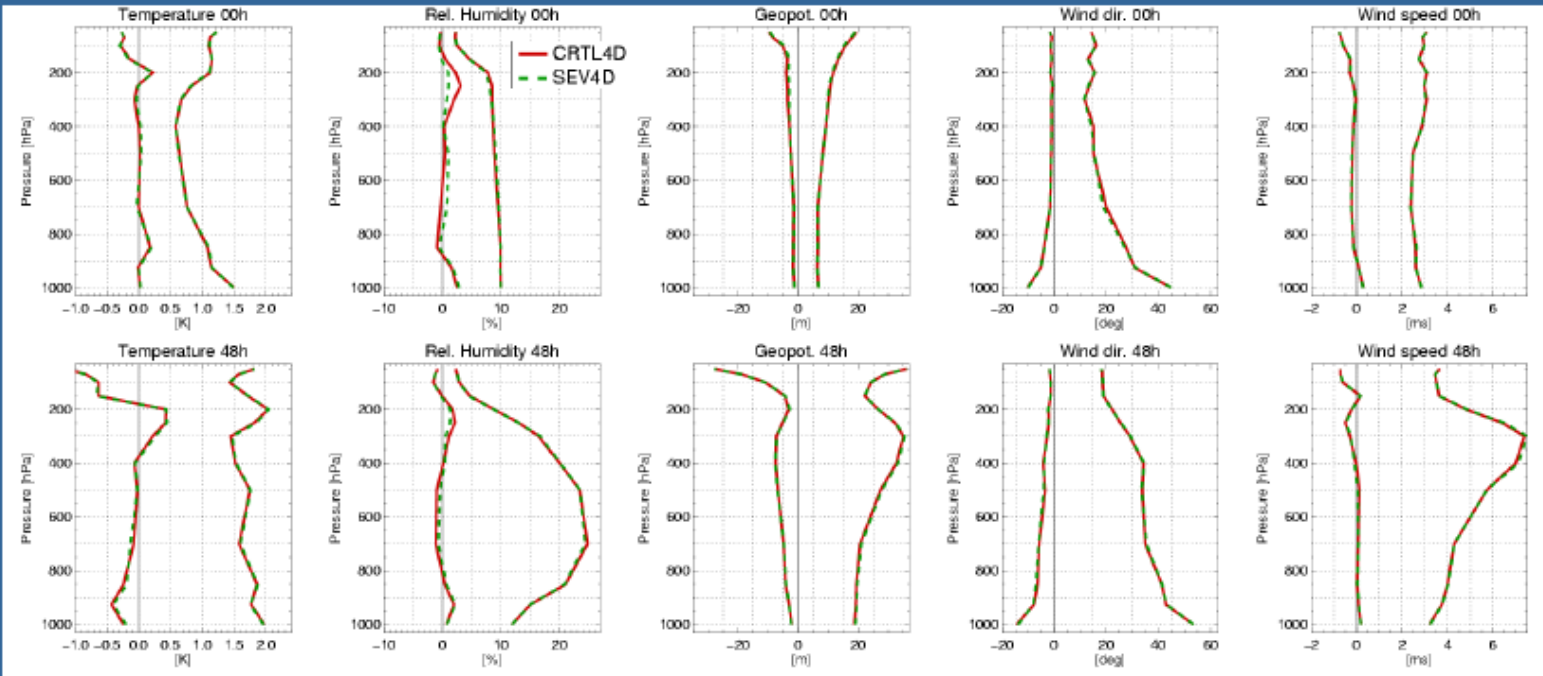


Fig. 11: RMSE and Bias (against radiosonde data) for upper air parameters for the control run (CTRL4D, red lines) and SEVIRI experiment (SEV4D, dashed green lines). First row: at analysis time; second row: after 48 hours forecast.

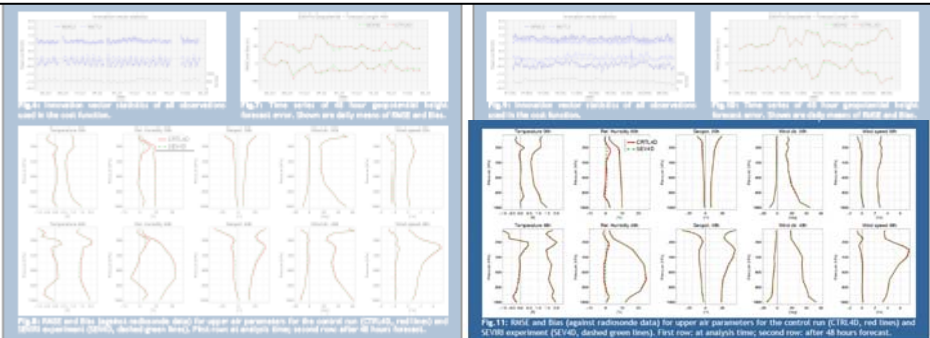


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Summary

SEVIRI IR radiances have been introduced successfully as a new observation type in the IIRAW assimilation system. Assimilation experiments shown in this presentation cover one summer month and one winter month. With the chosen experimental specifications, the assimilation of SEVIRI's water vapour channels primarily affects the analyzed and forecasted mid- and upper-tropospheric humidity fields. A positive impact can be seen in the upper troposphere for all experiments when comparing to radiosondes. This impact is decreasing with forecast length. Small positive effects are also found for the temperature, geopotential height and wind fields after 48 hours in the summer period. The impact on those upper air variables is found to be very small and rather neutral during the winter period. Changes in the data preparation steps, as for example better file correction and postfilter "superobbing", will be addressed in the near future.

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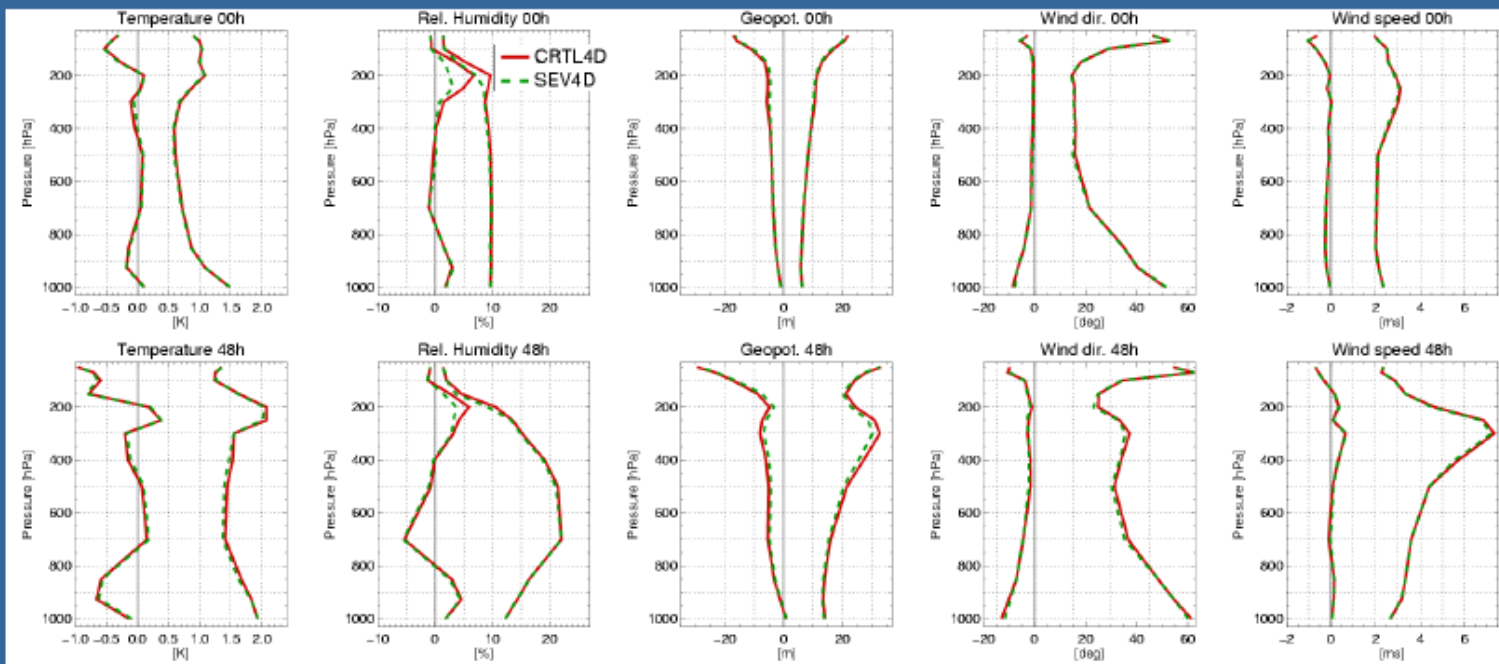


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- Cycle : 6 hour assimilation cycle / forecast up to 48 hours
- Verification : DWGLAM radiosondes and synops

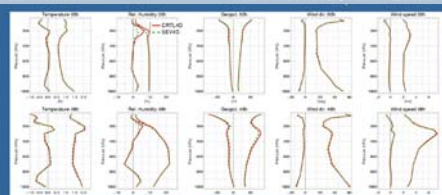
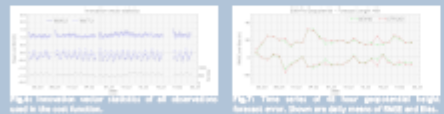


Fig. 9: RMSE and Bias (against radiosonde data) for upper air parameters for the control run (CTRL4D, red lines) and SEV4D experiment (SEV4D, dashed green lines). First row: at analysis time; second row: after 48 hours forecast.

- Cycle : 6 hour assimilation cycle / forecast up to 48 hours
- Verification : DWGLAM radiosondes and synops

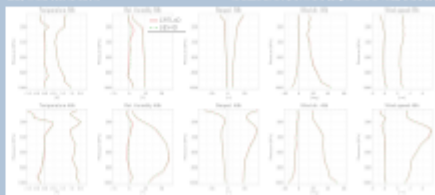
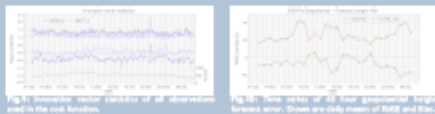


Fig. 11: RMSE and Bias (against radiosonde data) for upper air parameters for the control run (CTRL4D, red lines) and SEV4D experiment (SEV4D, dashed green lines). First row: at analysis time; second row: after 48 hours forecast.

Summary

SEVIRI IR radiances have been introduced successfully as a new observation type in the IIRLAM assimilation system. Assimilation experiments shown in this presentation cover one summer month and one winter month. With the chosen experimental specifications, the assimilation of SEVIRI's water vapour channels primarily affects the analysed and forecasted mid- and upper-tropospheric humidity fields. A positive impact can be seen in the upper troposphere for all experiments when comparing to radiosondes. This impact is decreasing with forecast length. Small positive effects are also found for the temperature, geopotential height and wind fields after 48 hours in the summer period. The impact on those upper air variables is found to be very small and rather neutral during the winter period. Changes in the data preparation steps, as for example better file connection and possibly "superobbing", will be addressed in the near future.

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Abstract

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Data Preparation

The SEVIRI observations undergo various data preparation steps which are listed below. Usually 500 to 1000 pixels (two observations each) at approx. 900m resolution are then kept in each observation window. (6 obs. windows per 4D-Var analysis)

- Processing of BTs and FGBs using the SAF-MWC software (for SEVIRI-segments 7 and 8)
- Selecting 1 pixel out of a 10x10 pixel box
- Rejecting out-of-domain pixels (and scan angles > 70°)
- Rejecting cloudy pixels (COE1/OMA, cloud mask)
- Applying flat-BIAS correction to WV6.2 obs. (2.6K)
- First guess check
- Spatial thinning (thinning box size = 92km)

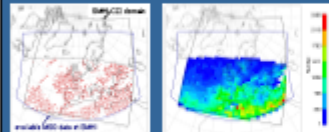


Fig.1: Examples of selected observation (2nd obs) after applying all data preparation steps.

Impact on HIRLAM 4D-Var Analysis - Case Study

As demonstrated in this case study, the impact of assimilated SEVIRI radiances is mainly in the moisture fields of the middle and upper troposphere (Figure 2). The large-scale drying in the upper-tropospheric layers, which can be seen here, is due to a systematic deviation in the background minus observation departures (Figure 4).

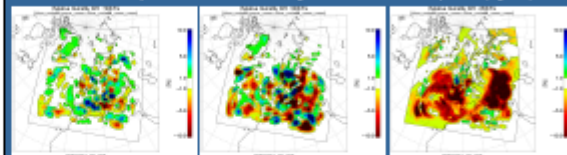


Fig.2: Increases in Relative Humidity at 300hPa level, 500hPa level, 700hPa level, calculated with respect to a control analysis with conventional observations only.

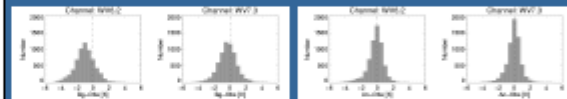


Fig.3: Frequency distribution of background minus observation departures. Fig.4: Frequency distribution of analysis minus observation departures.

Observation Impact Study I - Summer Period

Experiment description

- Time period : 06/24/2005 - 07/21/2005
- Control run (CTRL4D) : 4D-Var analysis with conventional observations only
- Experiment (SEV4D) : 4D-Var analysis with conventional and SEVIRI observations; SEVIRI observations are taken from six time slots (the slot closest to the respective observation window centre)
- Cycle : 6 hour assimilation cycle / forecast up to 48 hours
- Verification : ENIGLAM radiosondes and synops

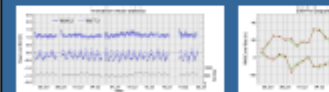


Fig.5: Time series of all four generalized brightness error. Shown are daily means of BSE and BSE.

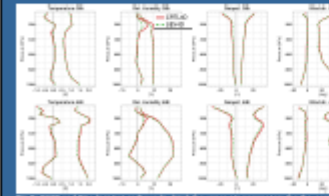


Fig.6: Moist and dry brightness radiances (BR) for upper air parameters for the control run (CTRL4D, red lines) and SEV4D experiment (SEV4D, dashed green lines). Plots from all analysis times, averaged over all 48-hour forecasts.

Observation Impact Study II - Winter Period

Experiment description

- Time period : 12/01/2005 - 02/31/2006
- Control run (CTRL4D) : 4D-Var analysis with conventional observations only
- Experiment (SEV4D) : 4D-Var analysis with conventional and SEVIRI observations; SEVIRI observations are taken from six time slots (the slot closest to the respective observation window centre)
- Cycle : 6 hour assimilation cycle / forecast up to 48 hours
- Verification : ENIGLAM radiosondes and synops

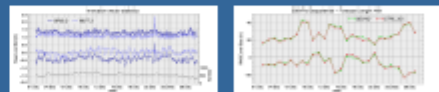


Fig.7: Time series of all four generalized brightness error. Shown are daily means of BSE and BSE.

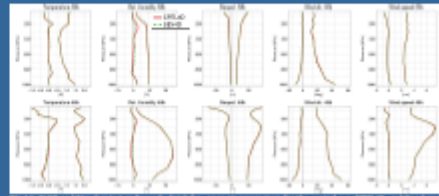


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Summary

SEVIRI IR radiances have been introduced successfully as a new observation type in the HIRLAM assimilation system. Assimilation experiments shown in this presentation cover one summer month and one winter month. With the chosen experimental specifications, the assimilation of SEVIRI's water vapour channels primarily affects the analyzed and forecasted mid- and upper-tropospheric humidity fields. A positive impact can be seen in the upper troposphere for all experiments when comparing to radioondes. This impact is decreasing with forecast length. Small positive effects are also found for the temperature, geopotential height and wind fields after 48 hours in the summer period. The impact on those upper air variables is found to be very small and rather neutral during the winter period. Changes in the data preparation steps, as for example better bias correction and possibly "superobbing", will be addressed in the near future.

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Presentation number: 6.12

The logo for SMHI, consisting of the letters 'SMHI' in a bold, white, sans-serif font.

Swedish Meteorological and Hydrological Institute

Thank you