Atmospheric motion vectors in ECMWF DA System

Iliana Genkova, Niels Bormann, Peter Bauer

- **Operational Status**
- **Research activities**

Many thanks to Regis Borde, Greg Dew, Jörgen Gustafson, Mary Forsythe, Blazej Krzeminski, Joerg Ackerman, Jo Schmetz, Ken Holmlund

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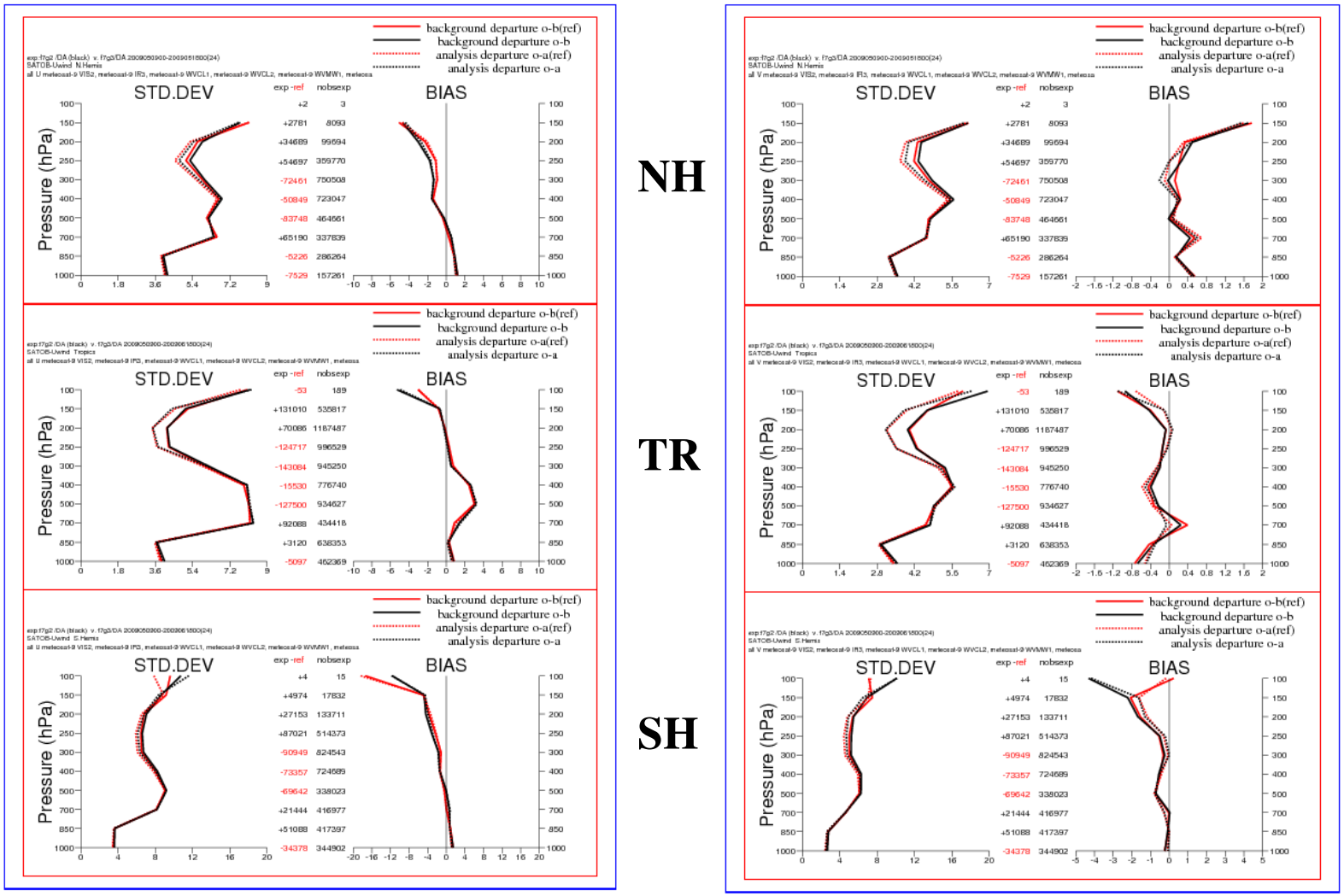
OPERATIONAL STATUS – OVERVIEW

- GOES 11&12 - no algorithmic changes
- CIMSS (MODIS DB and AVHRR)
  - December 2009 - assigned own Generating/Originating Centre code (176)
- FY2-C
  - August 2009 – overall AMV algorithm improvement, new data quality did not show significant statistics improvement;
  - February 2010 – FY2-D and FY2-D replace FY2-C; new data stream is being stored and due quality evaluation
- MTSAT
  - May 2009 – Revised height assignment for High and Middle IR AMVs (CCC), new template size (16pix), expanded derivation region;
  - August 2009 - Adding 03,09,15,21 UTC AMVs over NH, 24 pix template, not assimilated at this time yet;
  - September 2009 – Implemented Improved tracking
- Meteosat-9
  - August 2009 – RTTOV implementation, monthly MODIS emissivity maps, improved cloud detection over ocean

OPERATIONAL STATUS – Meteosat-9 RTTOV
First Guess and Analysis departures STD DEV and BIAS

All AMVs: U V



control (red) and RTTOV experiment (black)

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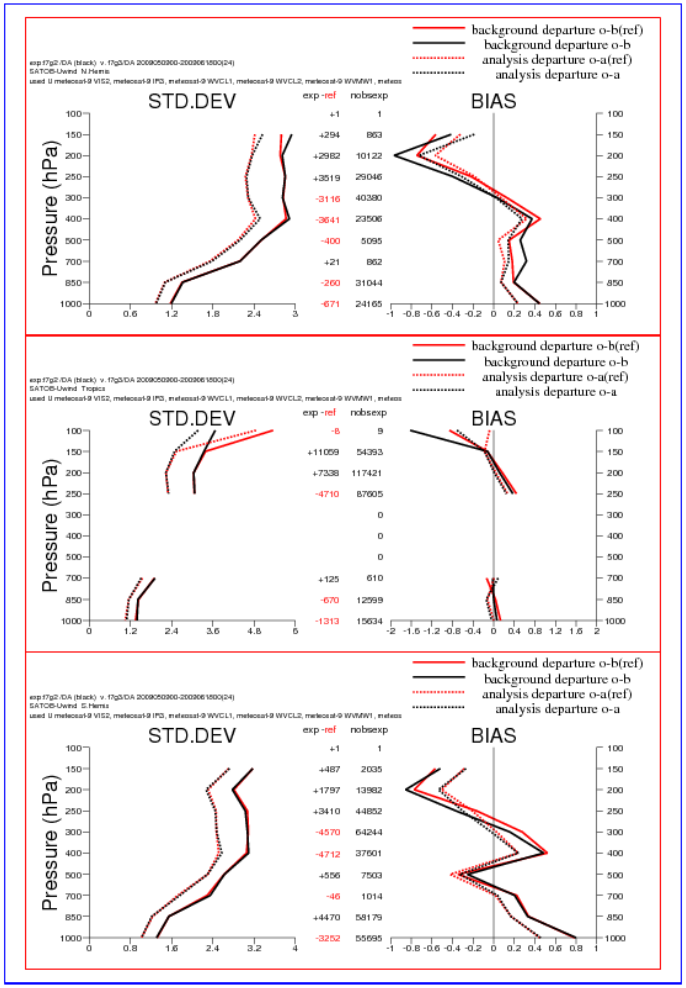
OPERATIONAL STATUS – Meteosat-9 RTTOV
First Guess and Analysis departures STD DEV and BIAS

Used AMVs: U

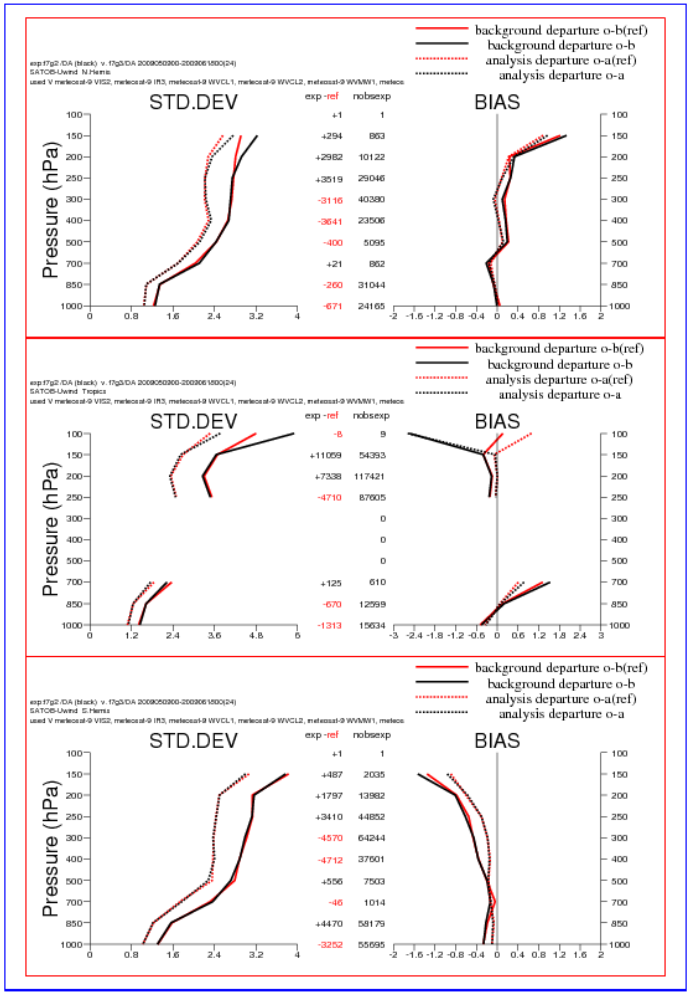


NH

TR

SH

V



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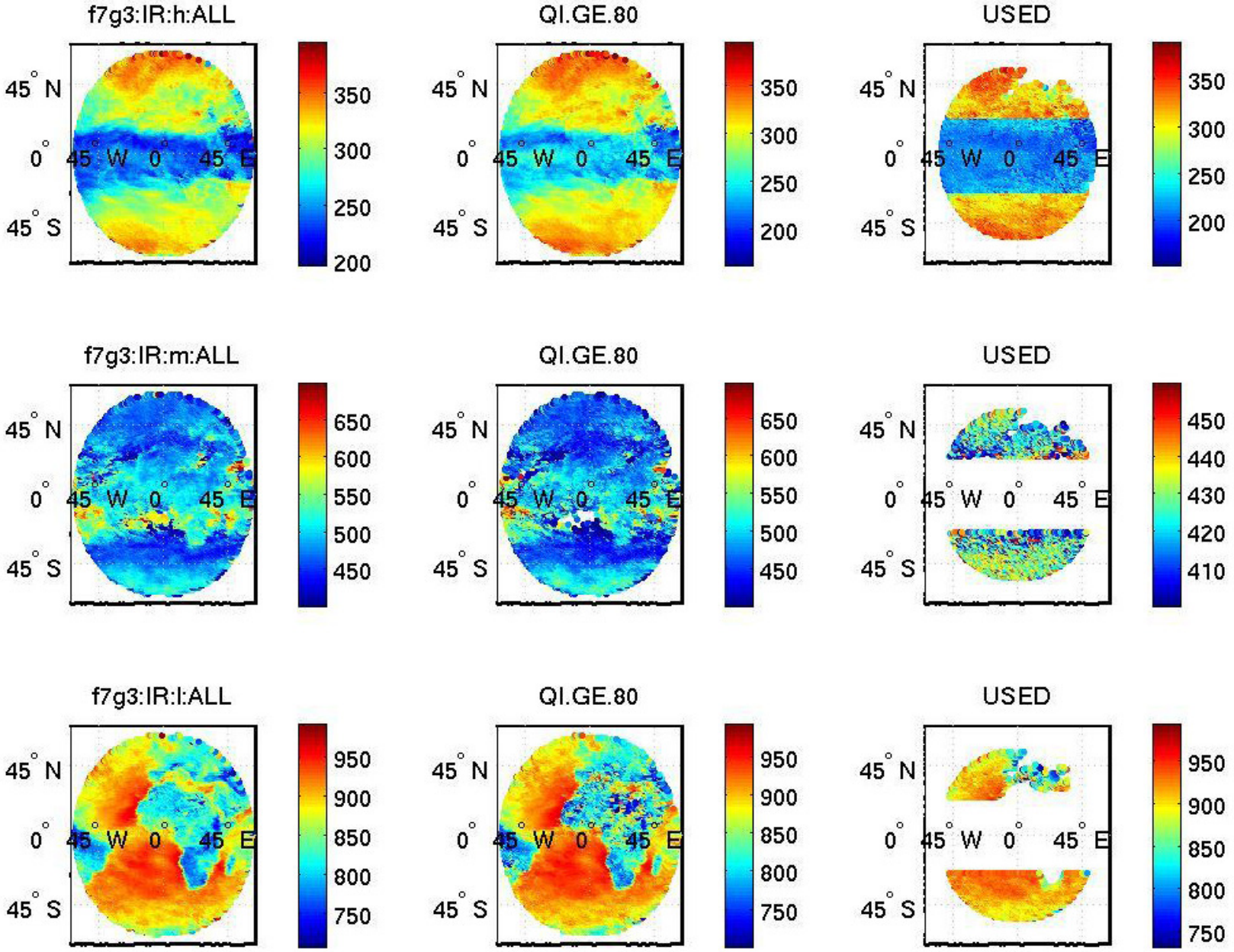
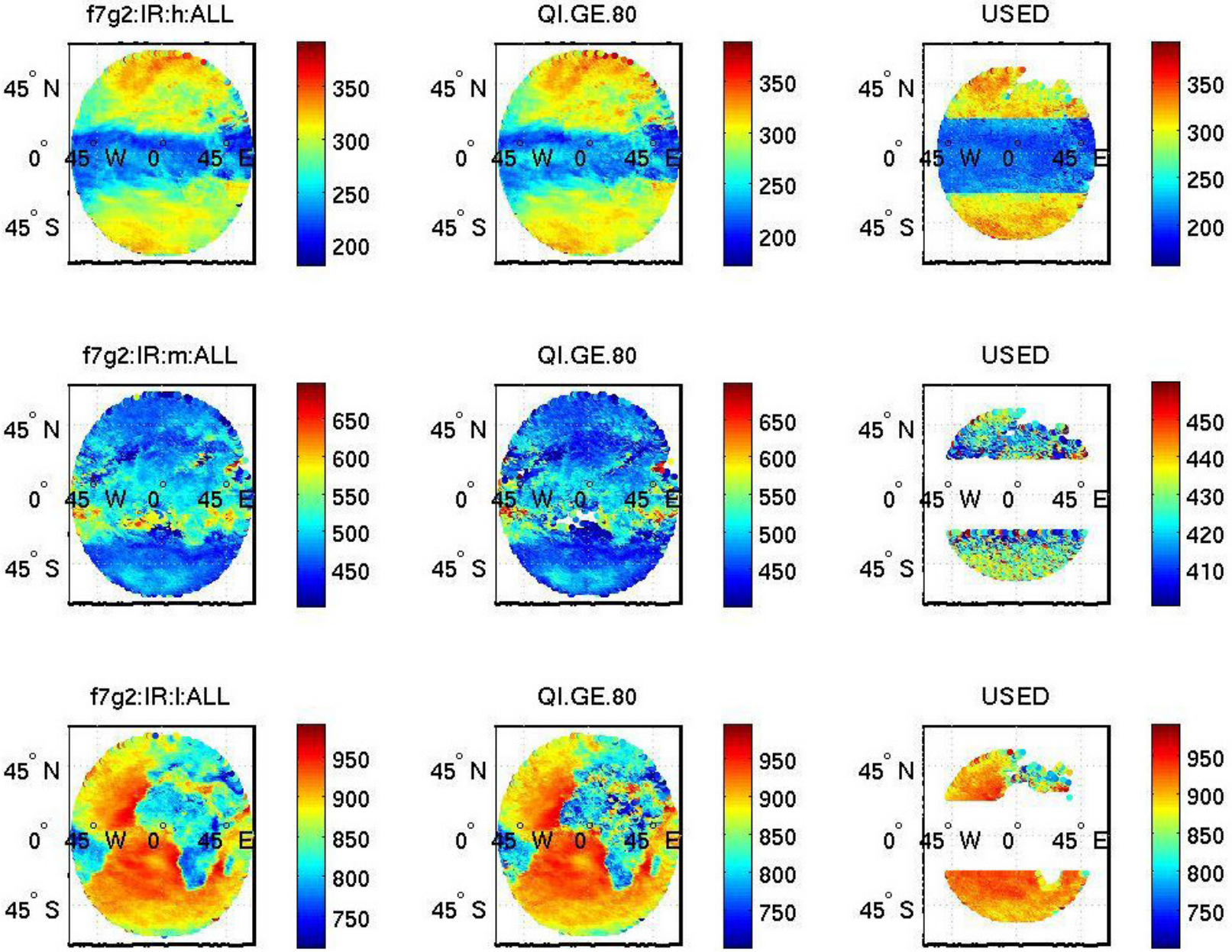
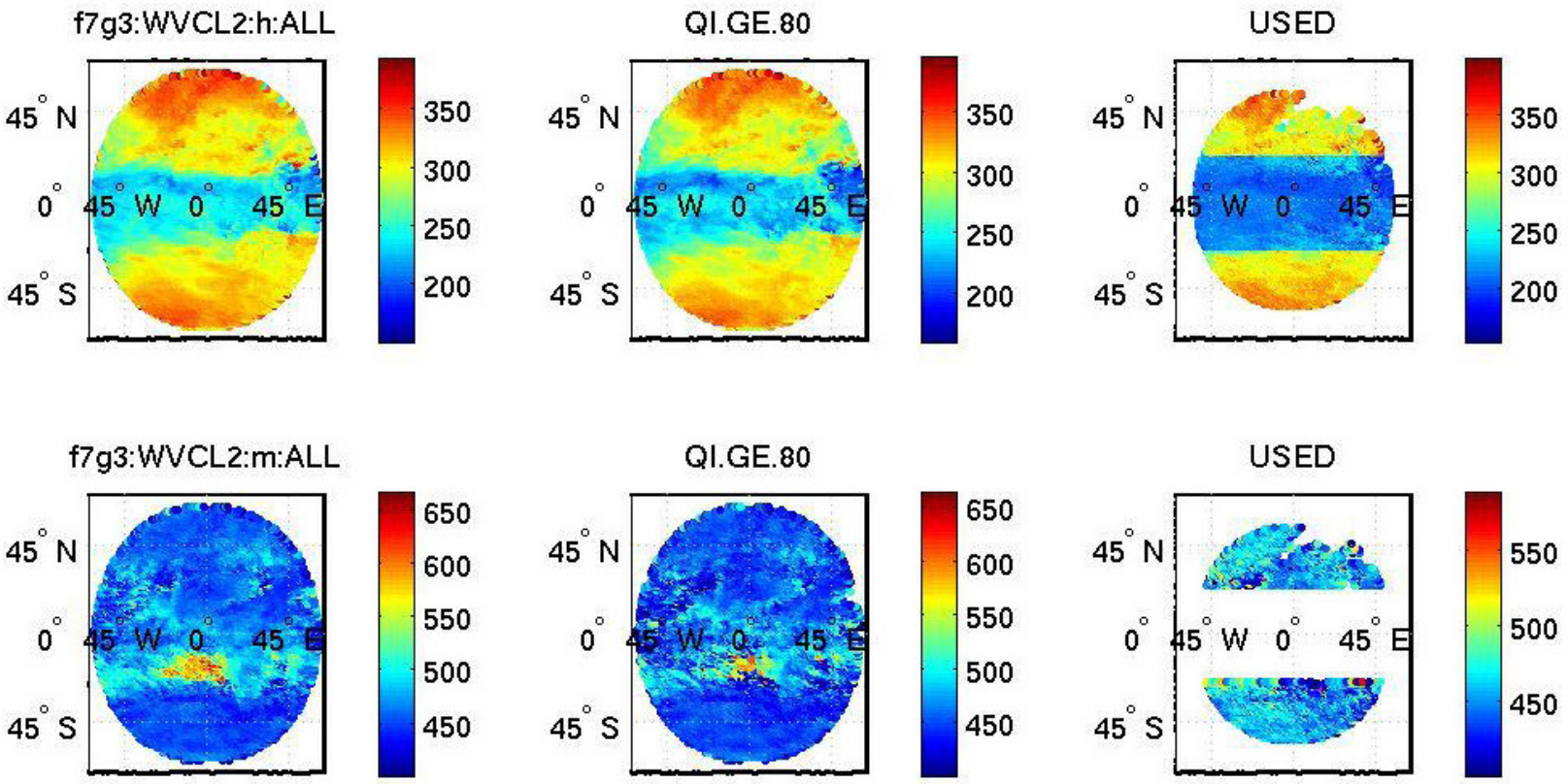
OPERATIONAL STATUS – Meteosat-9 RTTOV
IR AMV mean height map - operations



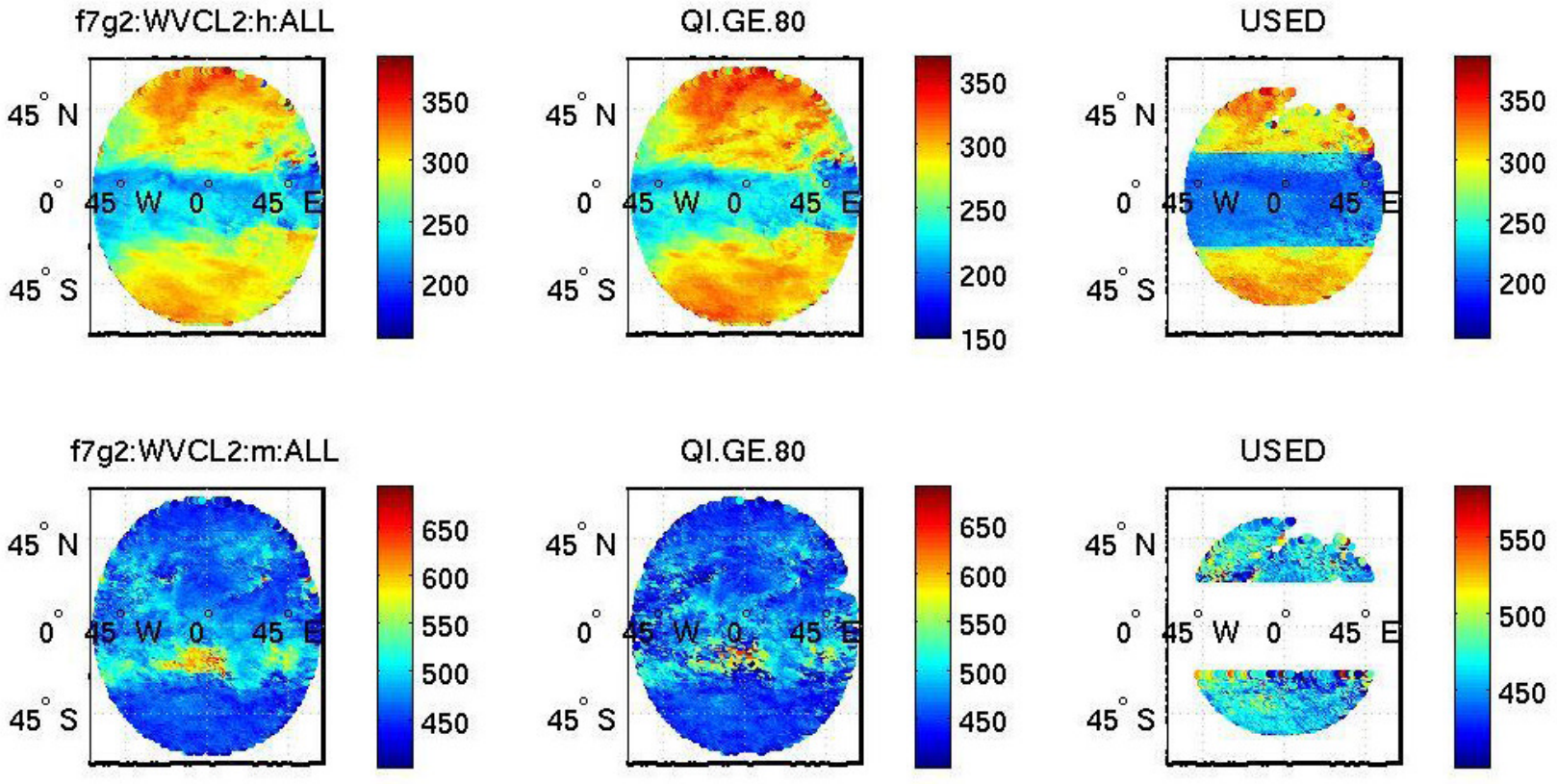
OPERATIONAL STATUS – Meteosat-9 RTTOV
IR AMV mean height map - RTTOV



OPERATIONAL STATUS – Meteosat-9 RTTOV
WV AMV mean height map - operations



OPERATIONAL STATUS – Meteosat-9 RTTOV
WV AMV mean height map - RTTOV



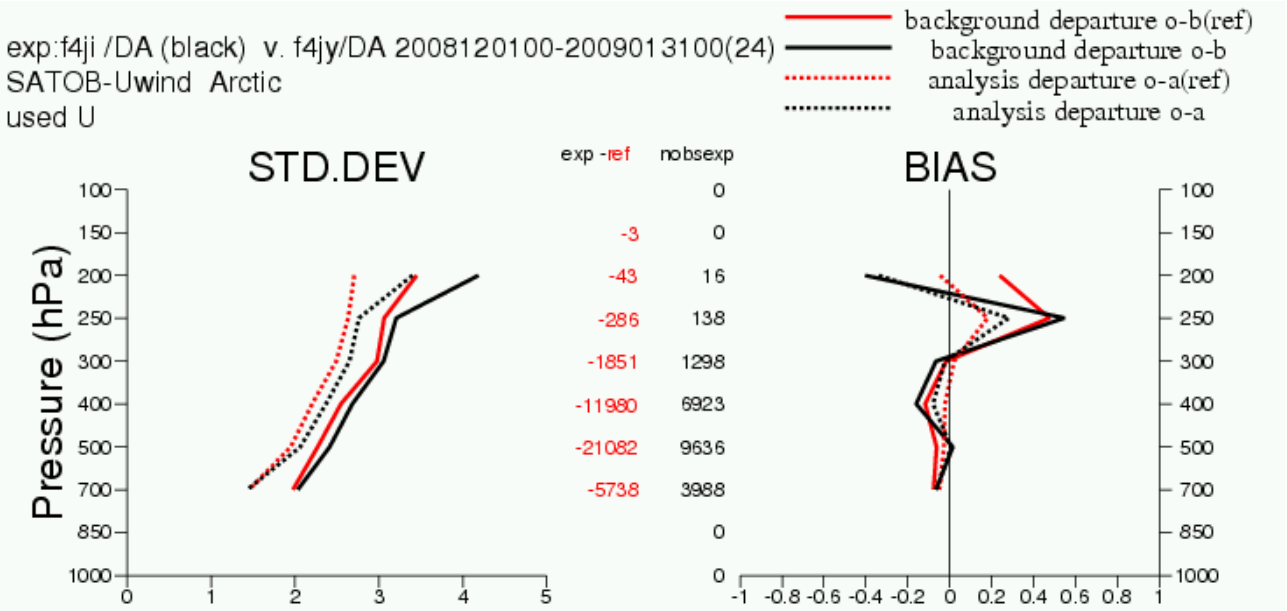
Research activities

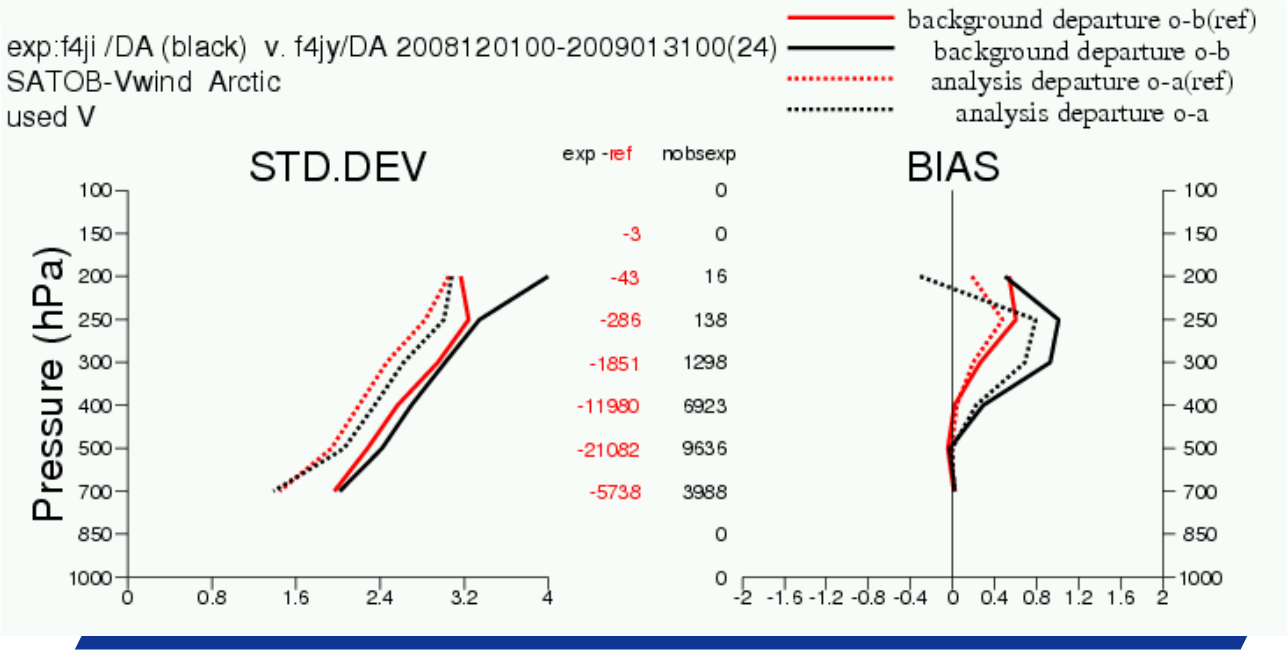
- MODIS Direct Broadcast polar AMV assimilation experiments
- Meteosat-9 Cross-Correlation Contribution Height Assignment AMV Assessment and DA Experiments
- Metop-A AVHRR polar AMV
- Revising Quality Control / Thinning / AMV ObsError
- Heights validation with Calipso (Sabatino Di Michele)
- Experiments with AMMA campaign (Anna Agusti-Panareda)

MODIS Direct Broadcast (DB) polar AMV DA

- Control, Experiment, Experiment with increased OE
- Winter (Dec 2008 - Jan 2009) and Summer (Aug-Sep 2008) runs
- 35R2 e-suite 4D-VAR, TL255, 91 levels
- Winds are screed by QI (forecast dependent) ≥ 50%
- Thinning in 200km by 200km by ~50-175 hPa
- Other AMVs : Meteosat, MTSAT-1R and GOES VIS, IR and WV (cloudy) AMVs; MODIS Global Terra and Aqua (IR and WV); all subject to quality control and thinning
- The experiments use “early delivery” IFS mode (i.e. *DA*)

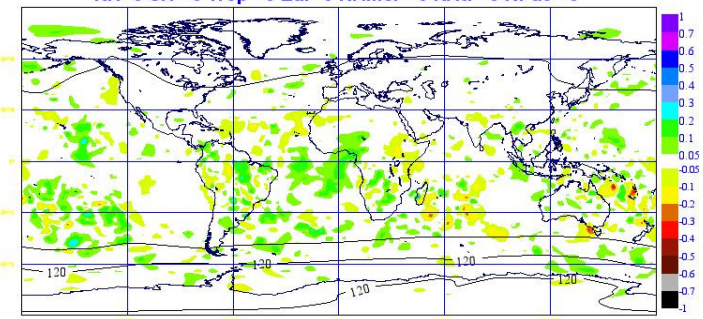
MODIS DB AMV quality (black is control, red is experiment)



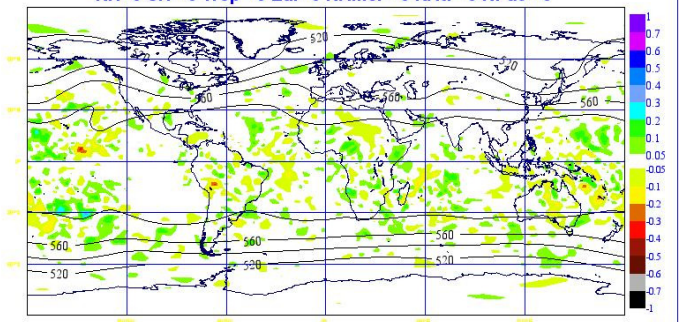


MODIS Direct Broadcast (DB) polar AMV DA

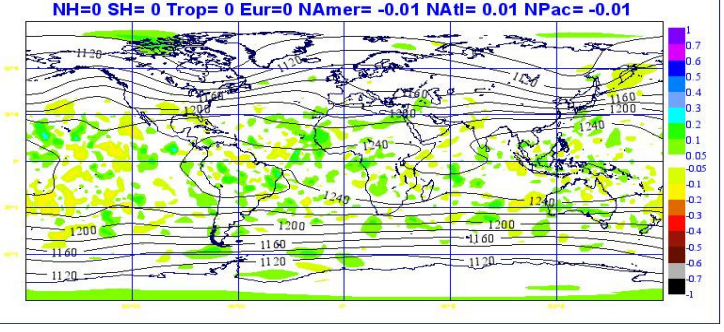
850hPa



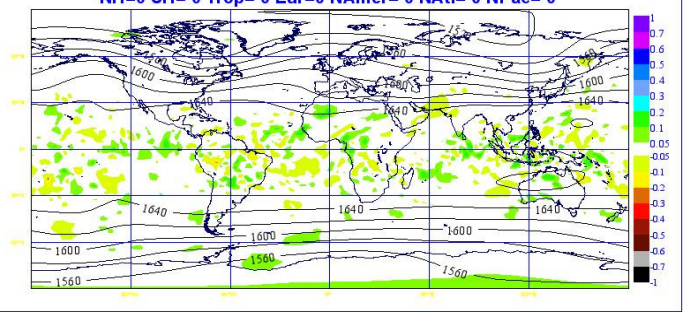
500hPa



200hPa



100hPa



Norm Diff in RMS T+48 FC error, Geopotential Height
yellow/red colouring shows benefit from MODIS DB

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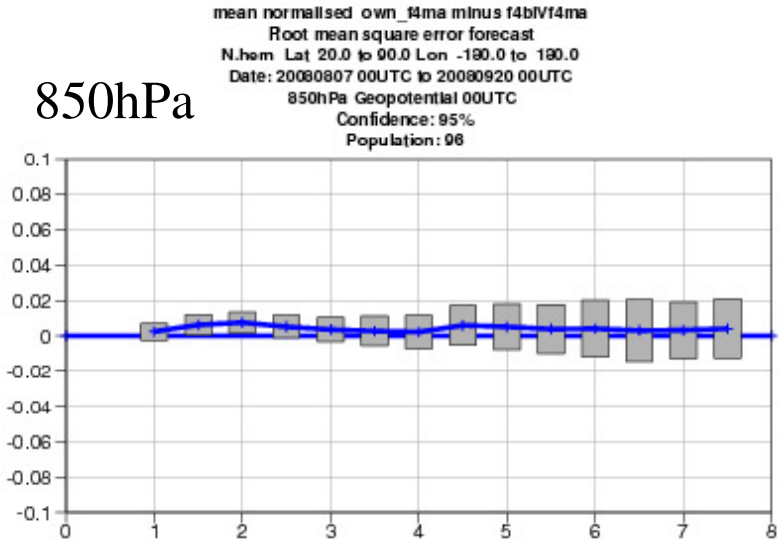
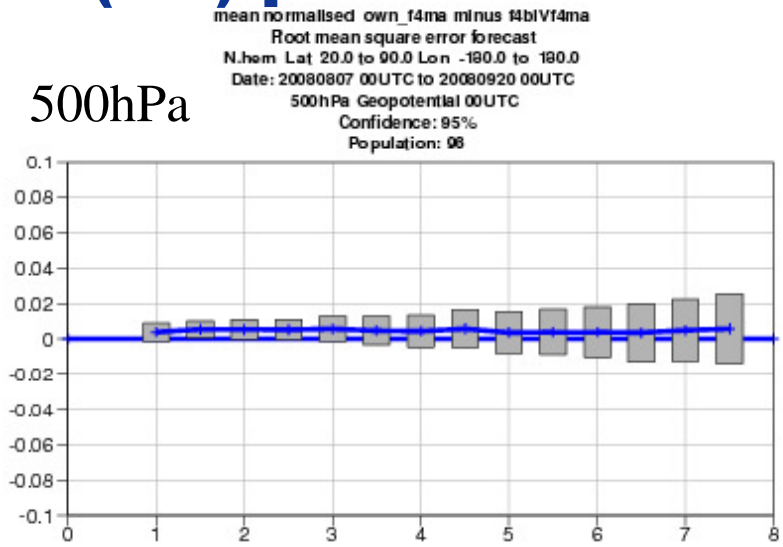
MODIS Direct Broadcast (DB) polar AMV DA

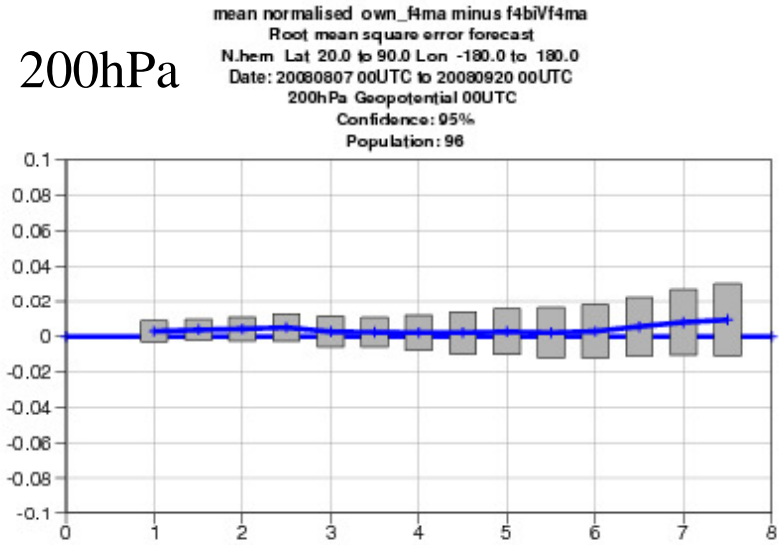
850hPa



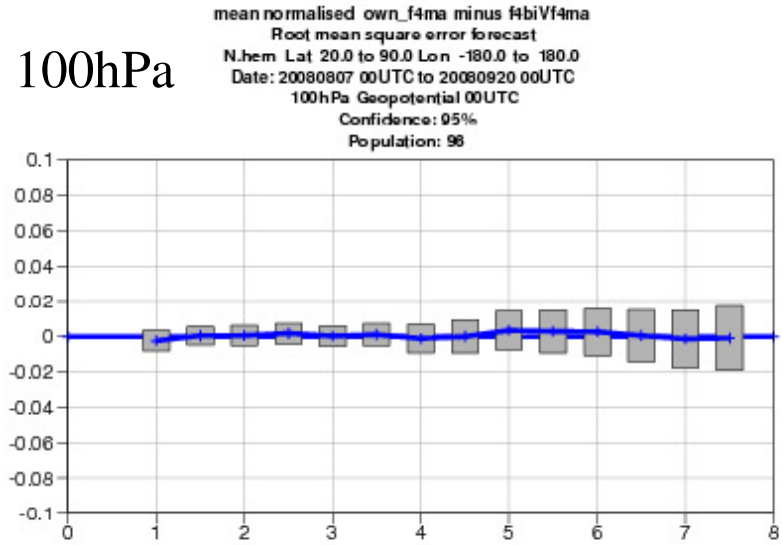
500hPa



200hPa



100hPa



Z norm diff of the RMS of FC Error as a function of forecast range - NH
(Negative difference show positive impact!)

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MODIS Direct Broadcast (DB) polar AMV DA

- Analysis ‘All’ and ‘Used’ MODIS DB AMVs show larger counts and smaller FG/AN departures than the MODIS Global winds
- Slight positive impact on the FC is noticed from day 5 onward, at all pressure levels. Slight negative impact on day 1-3 FC probably due to lack of other observations in the DA system. Altogether global impact map is too noisy, hard to ‘isolate’ areas of positive/negative impact
- Increased OE helps slightly the FC
- Ready to assimilate MODIS DB AMV through a blacklist change, but further discussions with Physical Aspects and Predictability and Diagnostics groups may be beneficial before active DA

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Meteosat-9 Cross-Correlation Contribution (CCC) Height Assignment (HA) AMV Assessment

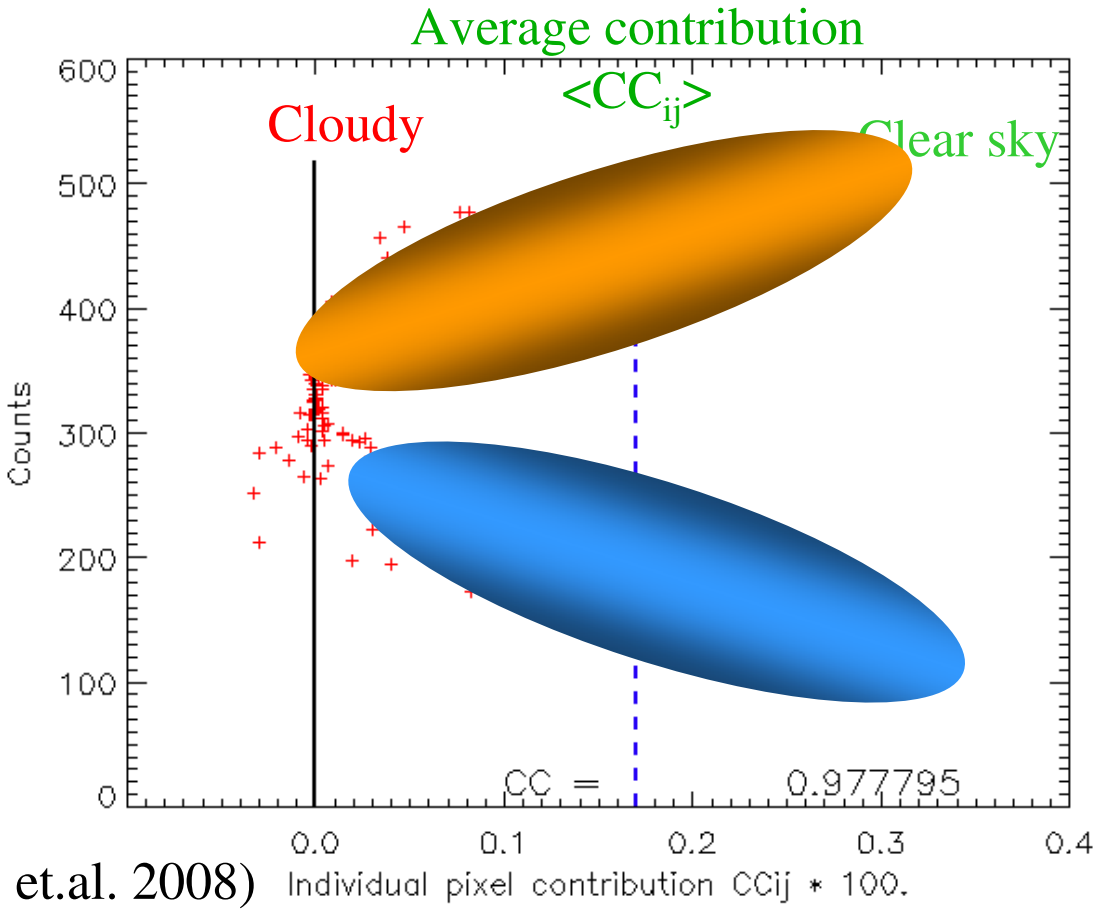
- Current approach – coldest CTP (CLA based) peak pixels
- New approach -

$$CC(m,n) = \frac{1}{MN} \sum_{i=1}^{M} \sum_{j=1}^{N} \frac{a_{i+m,j+n} - \bar{a}(m,n)}{\sigma_a(m,n)} \frac{b_{ij} - \bar{b}}{\sigma_b} = \sum_{i,j}^{M,N} CC_{ij}(m,n)$$

(Büche et.al., 2006)

Meteosat-9 Cross-Correlation Contribution (CCC) Height Assignment (HA) AMV Assessment

- Current approach – coldest CTP (CLA based) peak pixels
- New approach -



Clear sky
ST clouds
Low level
Fractional
Cloud edges
…

Cloud tops
Opaque
Highest

(Borde, et.al. 2008)

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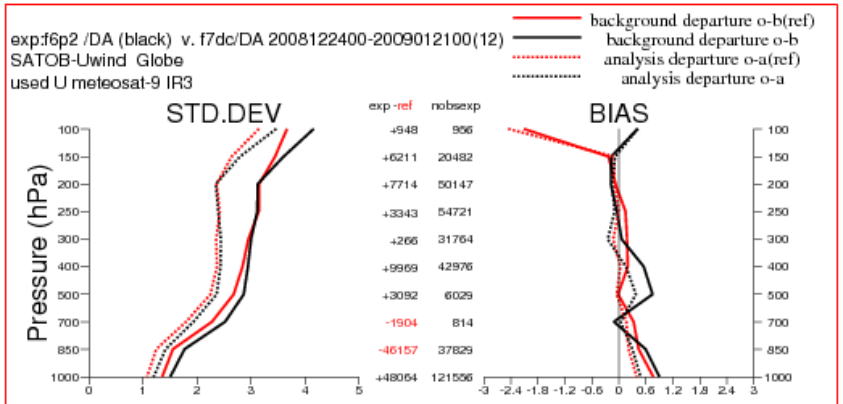
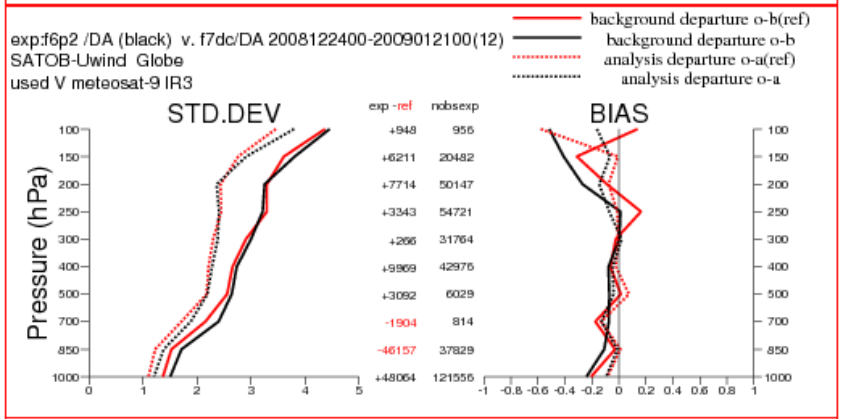
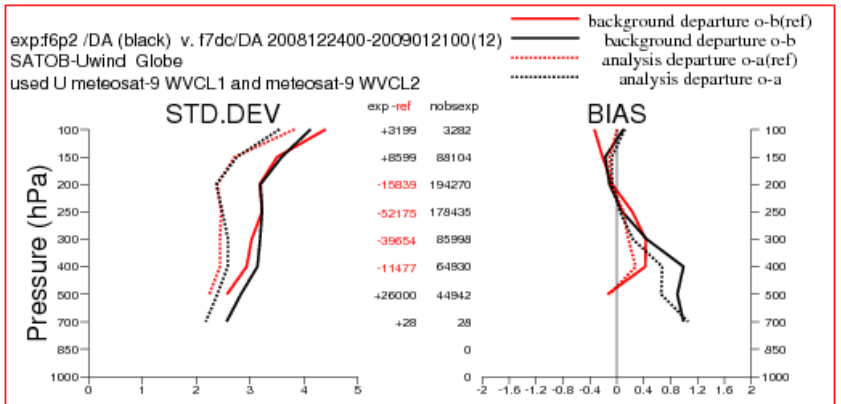
Meteosat-9 Cross-Correlation Contribution (CCC) Height Assignment (HA) AMV Assessment

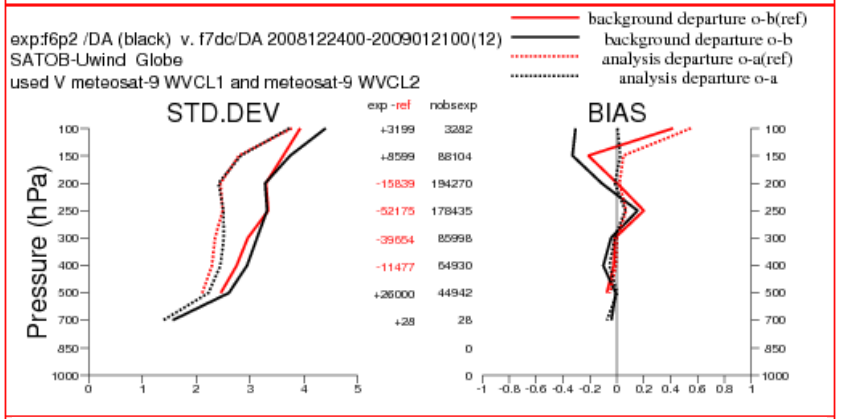
- AMVs redistributed vertically
- Slightly increased FG/AN departures possibly due to:
  - Image Enhancement effects
  - Intermediate product averaging
  - Different HAM in CCC
  - Low level correction effects
  - CLA effects
  - Thinning algorithm
- Further analysis needed



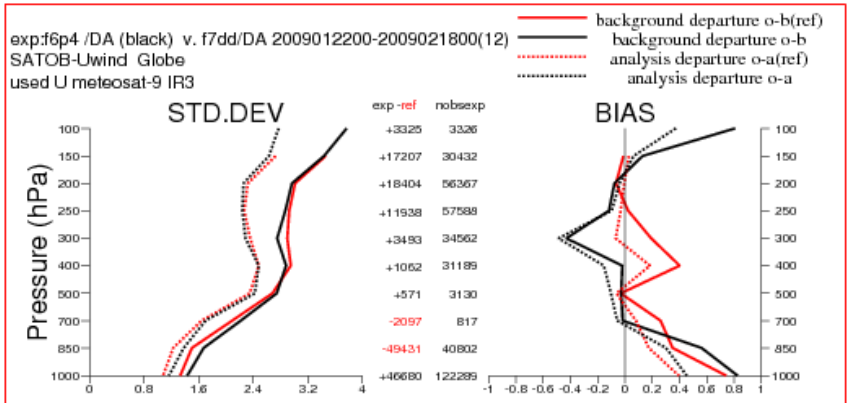


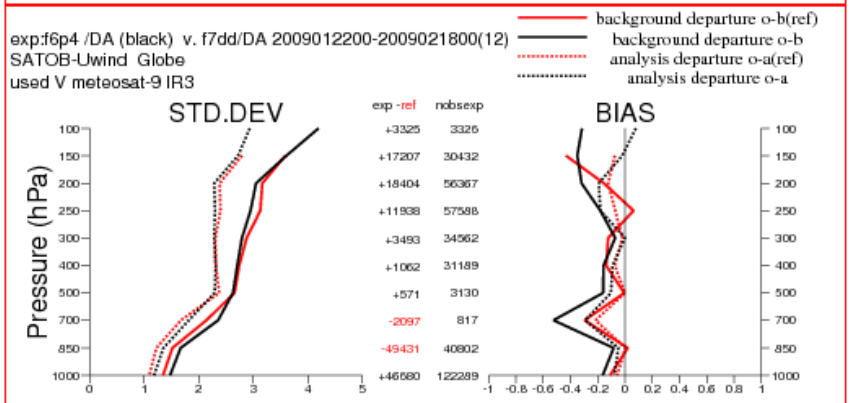
FG (solid) and AN (dotted) departures STD and Bias for the used **IR** winds in the control (red) and the experiment with CCC AMVs, when **operational** CLA is used (black).



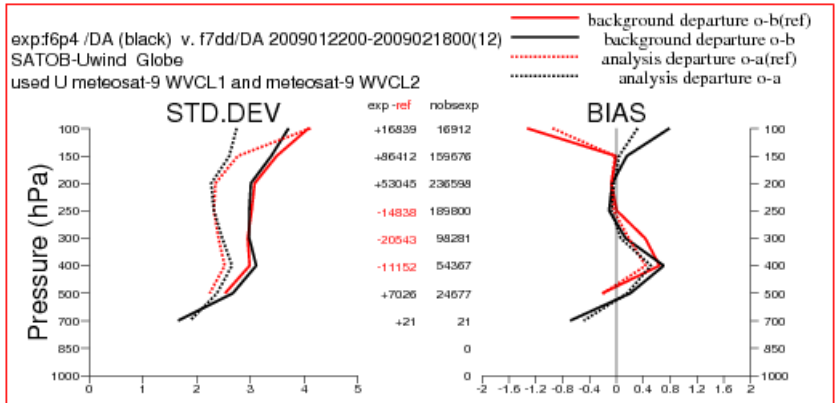


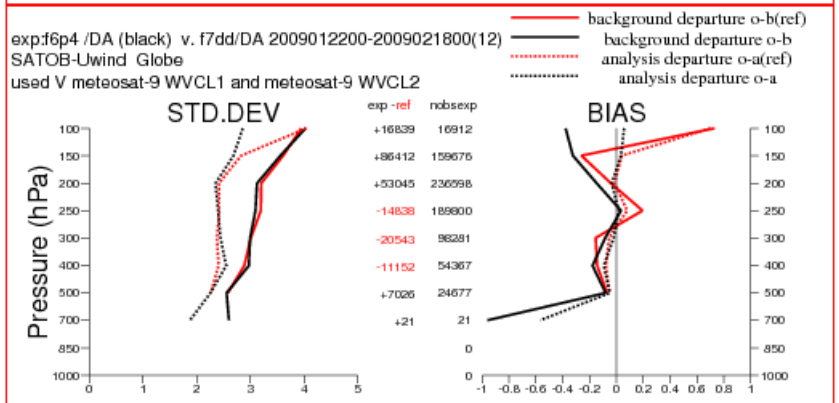
FG (solid) and AN (dotted) departures STD and Bias for the used **WV** winds in the control (red) and the experiment with CCC AMVs, when **operational** CLA is used (black).





FG (solid) and AN (dotted) departures STD and Bias for the used **IR** winds in the control (red) and the experiment with CCC AMVs, when **new** CLA is used (black).





FG (solid) and AN (dotted) departures STD and Bias for the used **WV** winds in the control (red) and the experiment with CCC AMVs, when **new** CLA is used (black).

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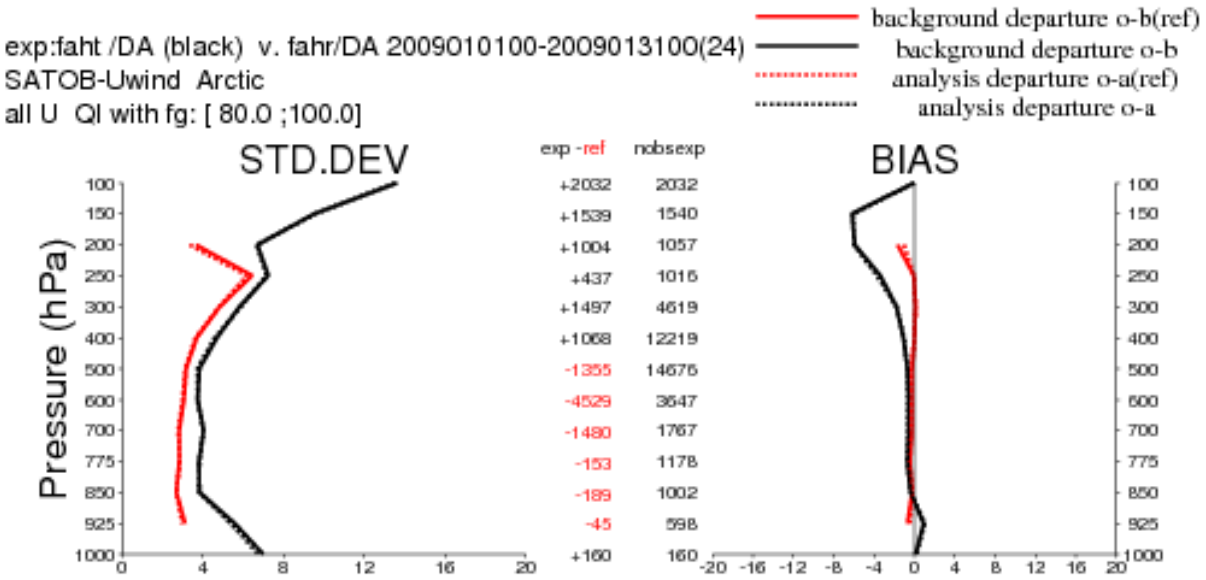
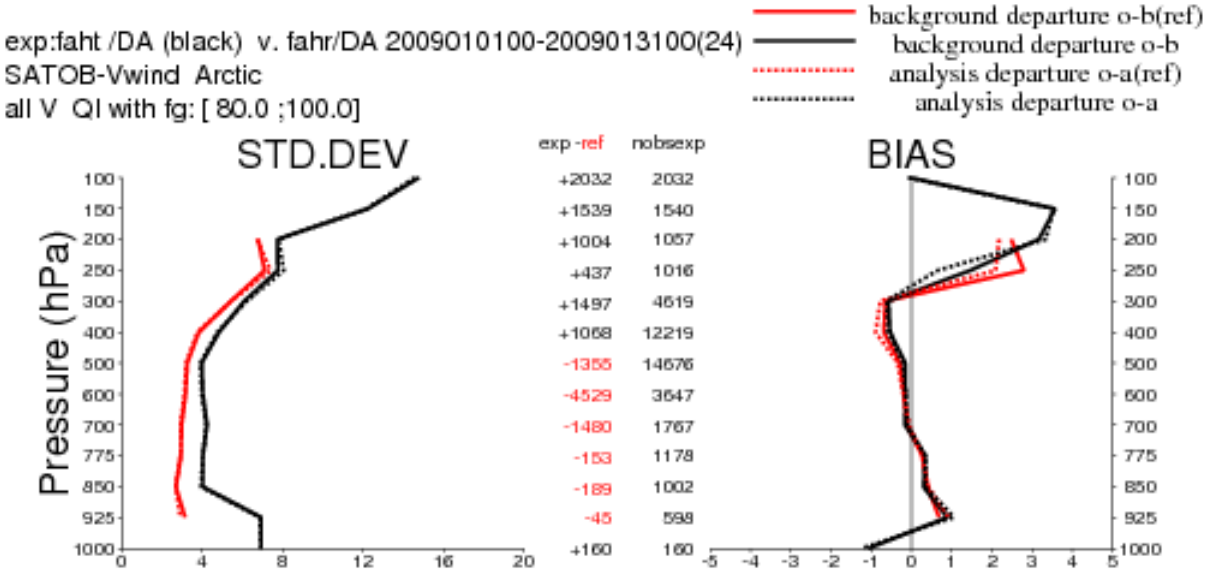
METOP-A AVHRR Winds - First Assessment

- NESDIS/CIMSS polar winds retrieval algorithm used as a prototype
- Two height assignment approaches:

1) passive IR window method;
2) 2) IASI CO2 slicing;

- Increased FG/AN departures with IASI possibly due to:
  - collocation imperfections
  - cloud mask uncertainties
  - faulty algorithm
- New test data and further analysis needed



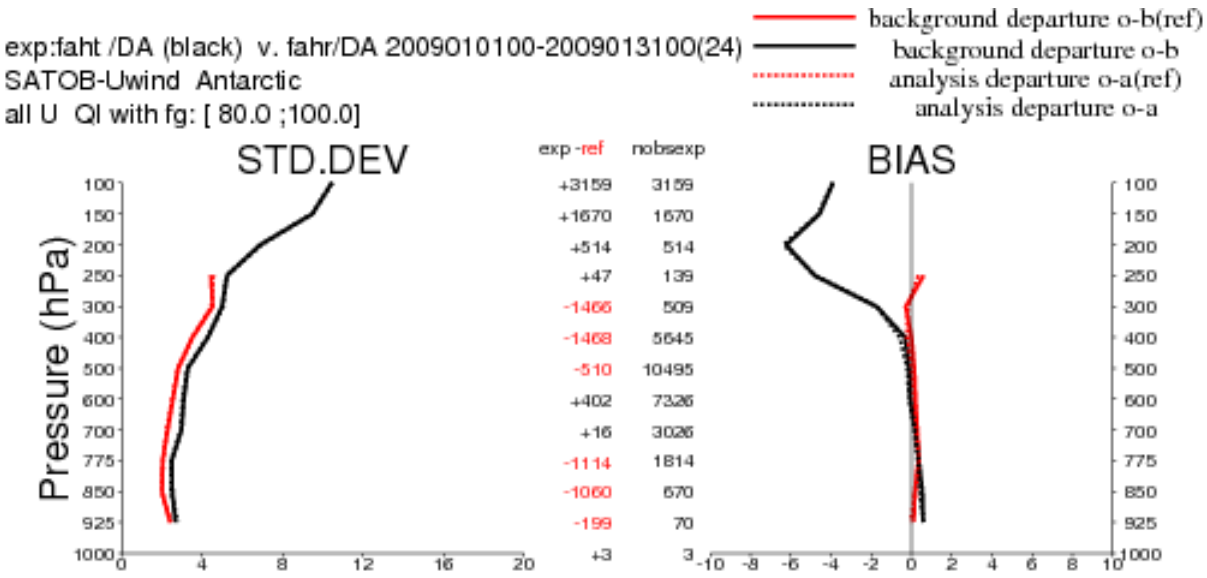


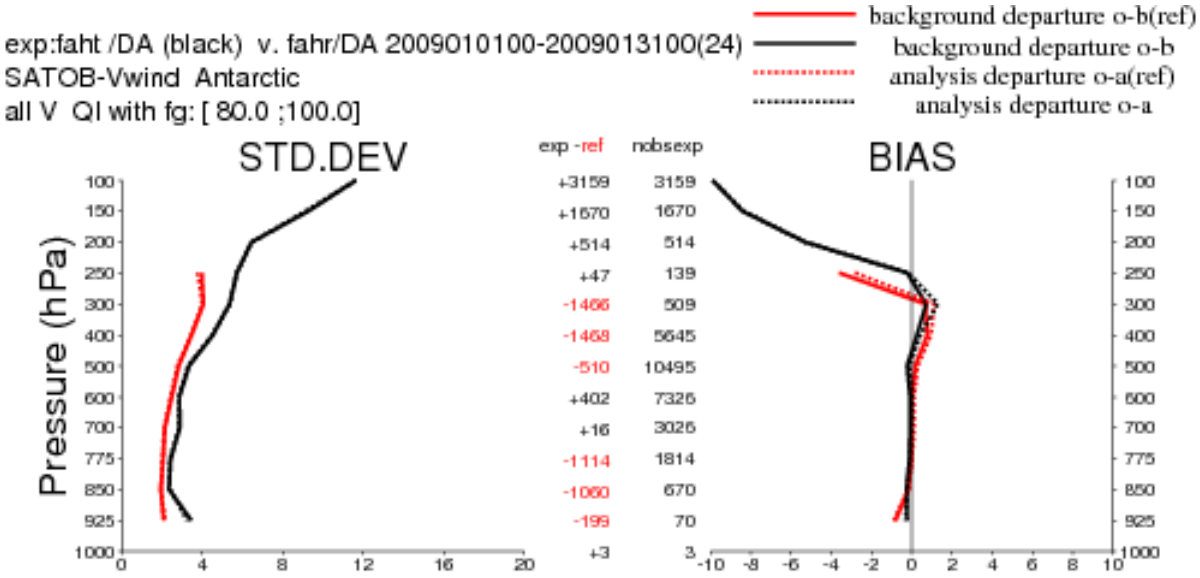
North Pole

All AMVs, QI≥80

CIMSS Heights – red

IASI Heights - black





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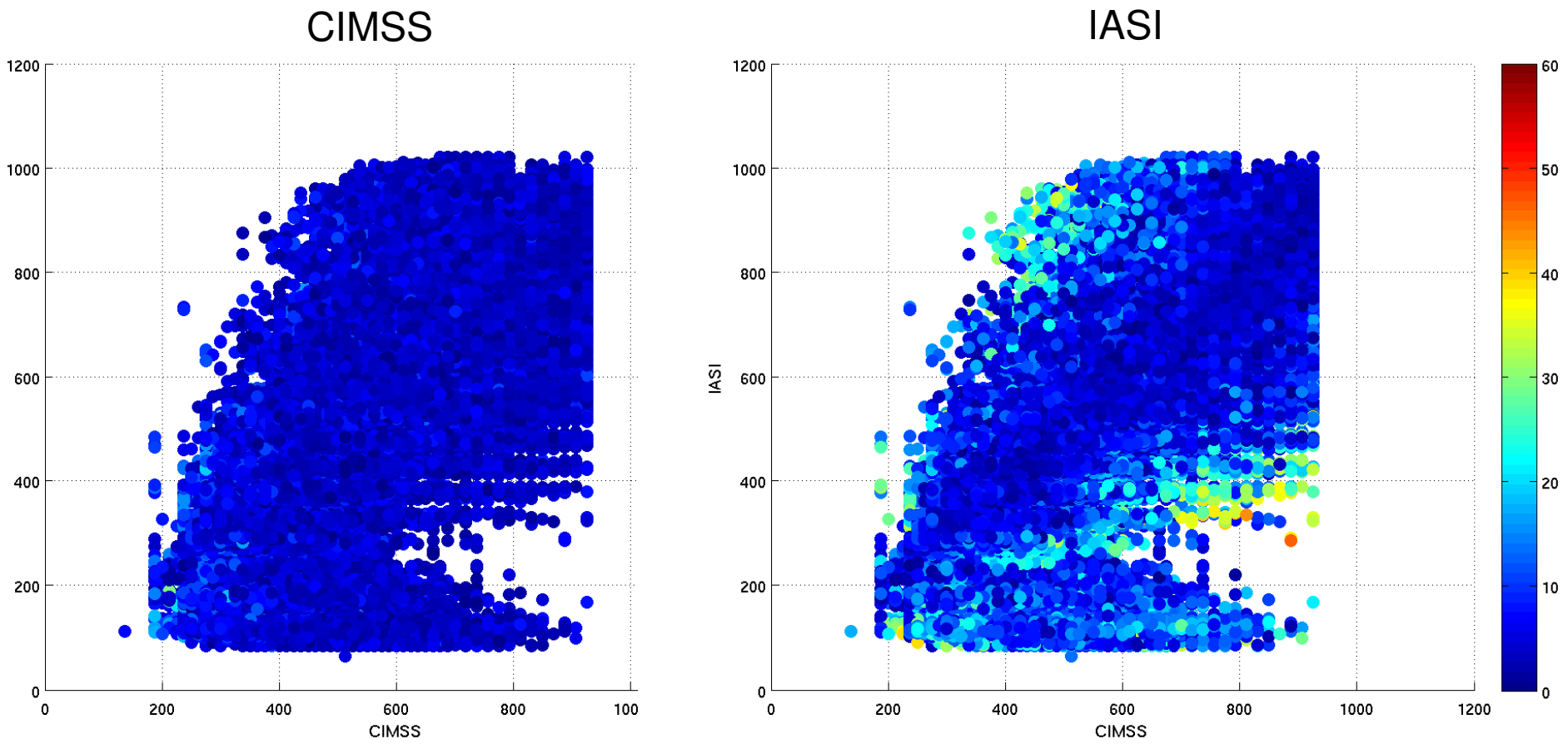
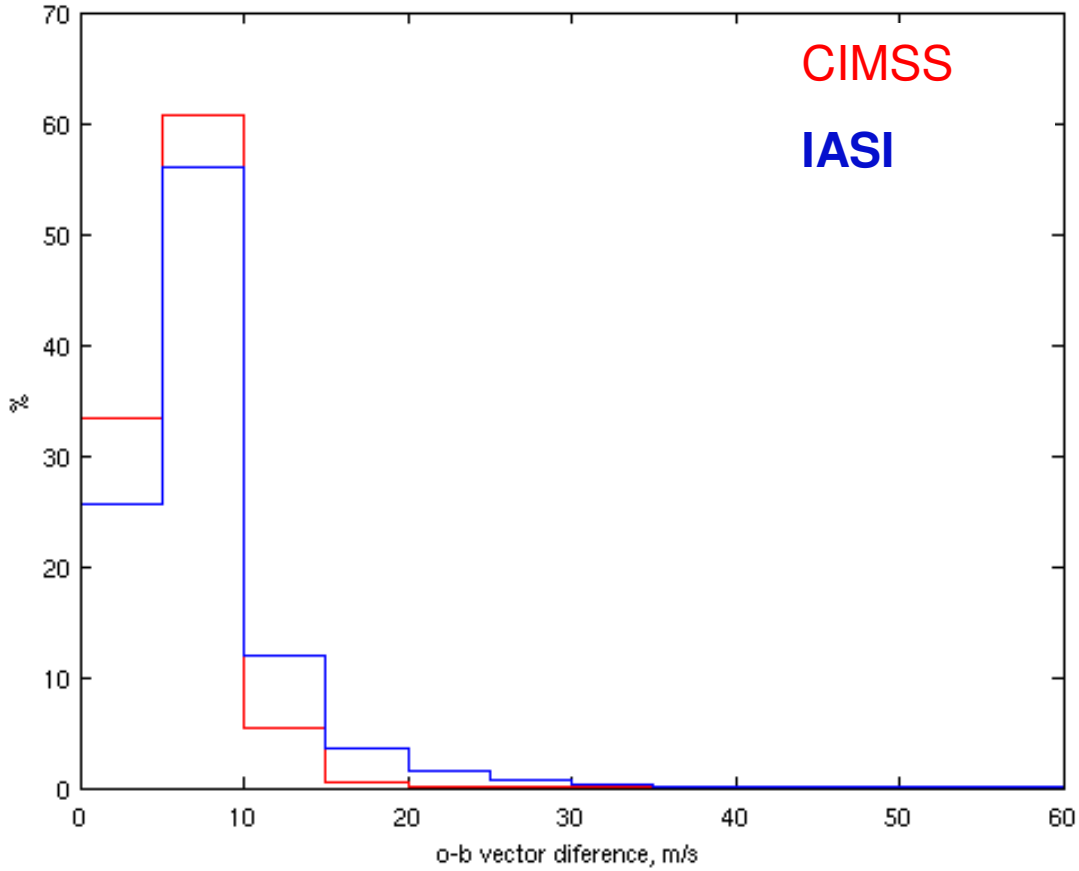
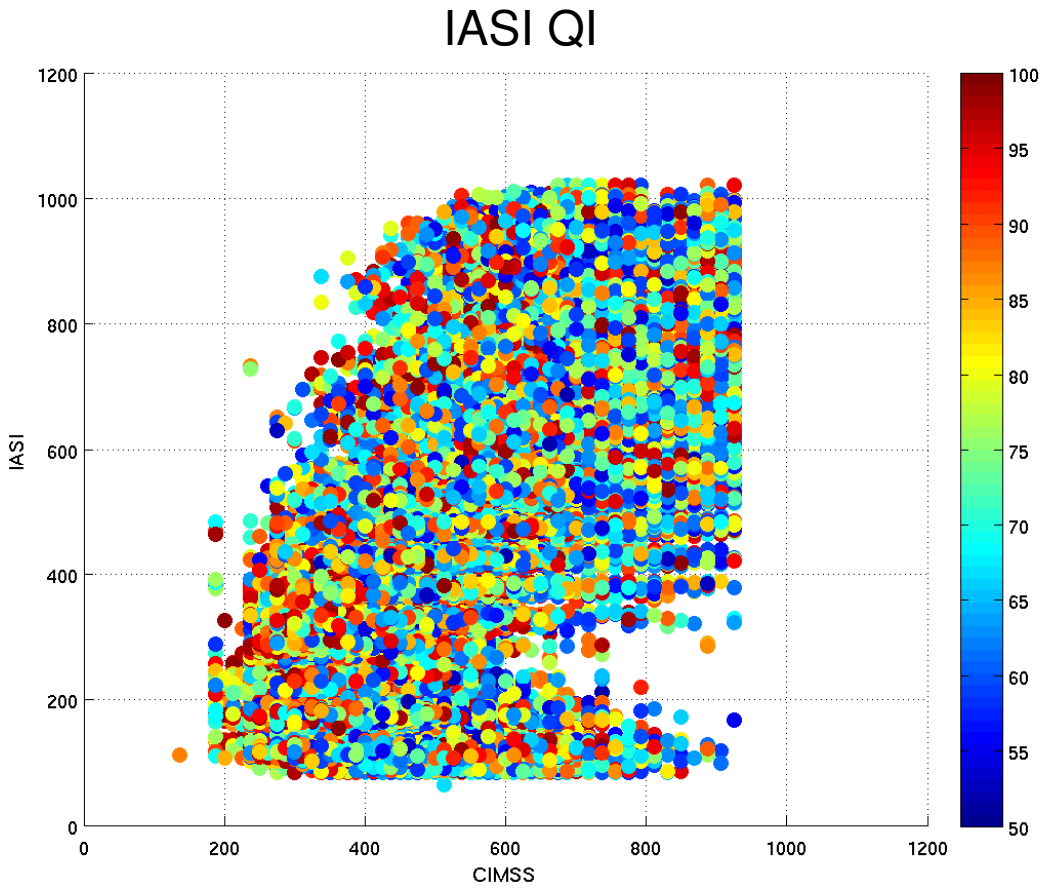


CIMSS (x) vs. IASI (y) AMV_Press

Colour coded by VD=sqrt((Uo-Ub)^2+(Vo-Vb)^2)

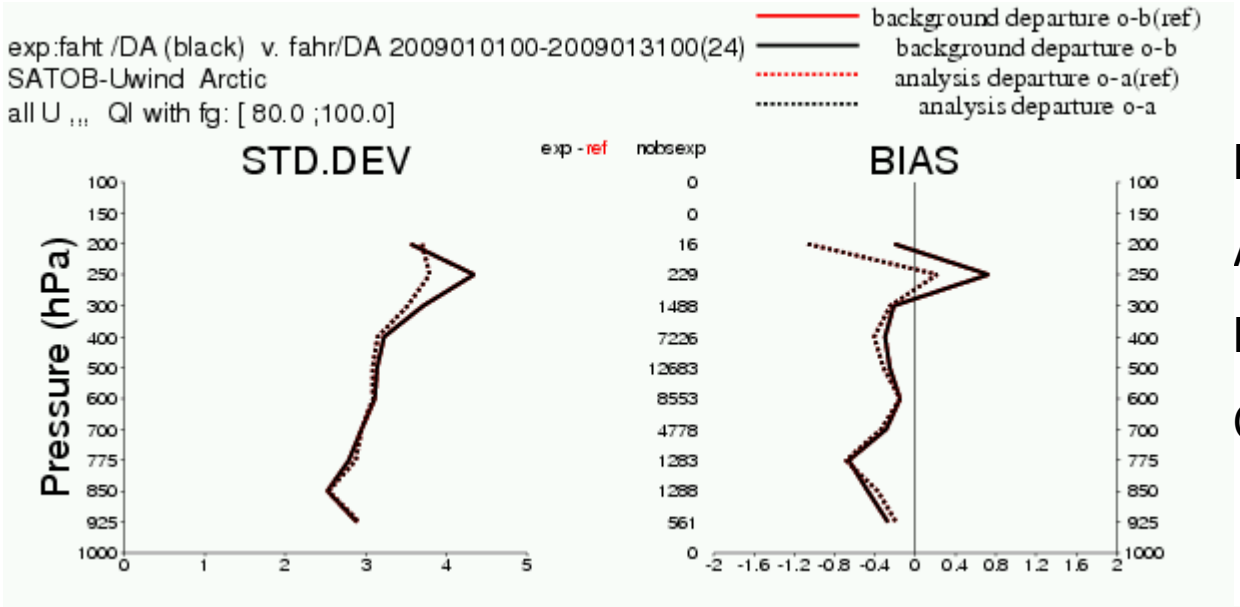


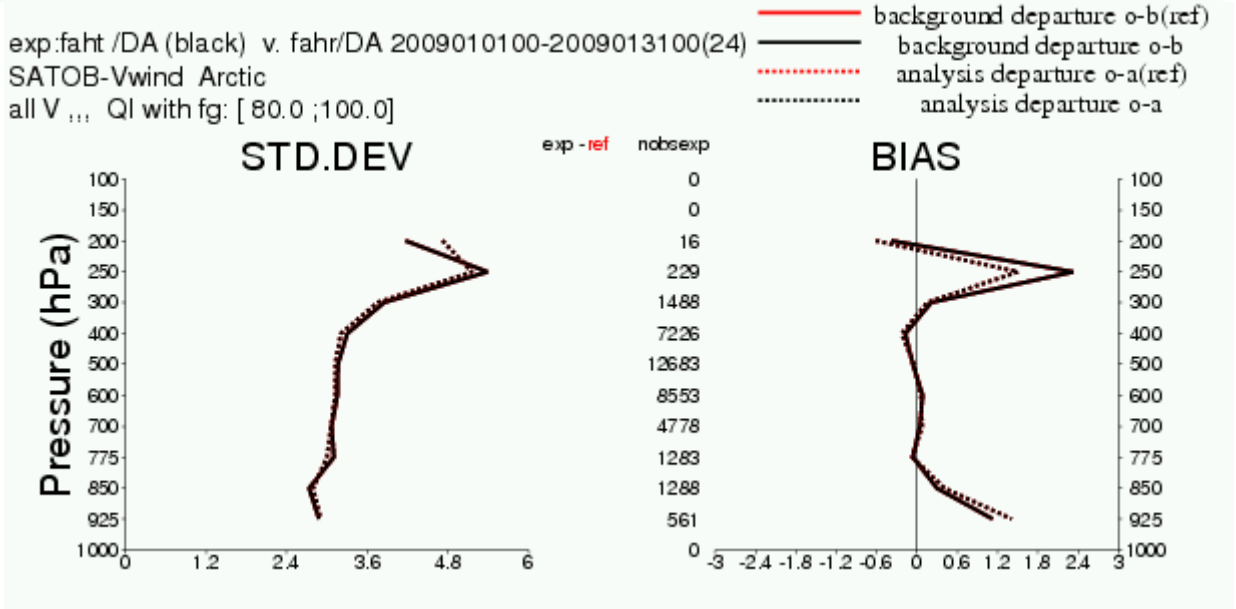
VD=sqrt((Uo-Ub)^2+(Vo-Vb)^2)



CIMSS (x) vs. IASI (y) AMV_Press

Colour coded by Quality Indicator (QI)



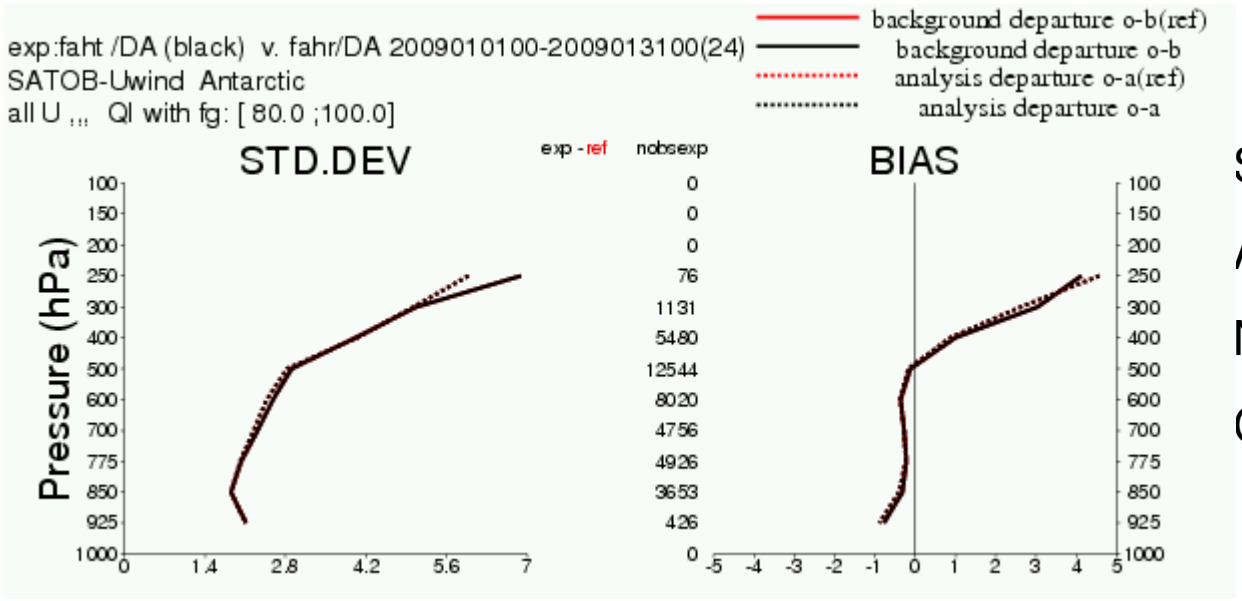


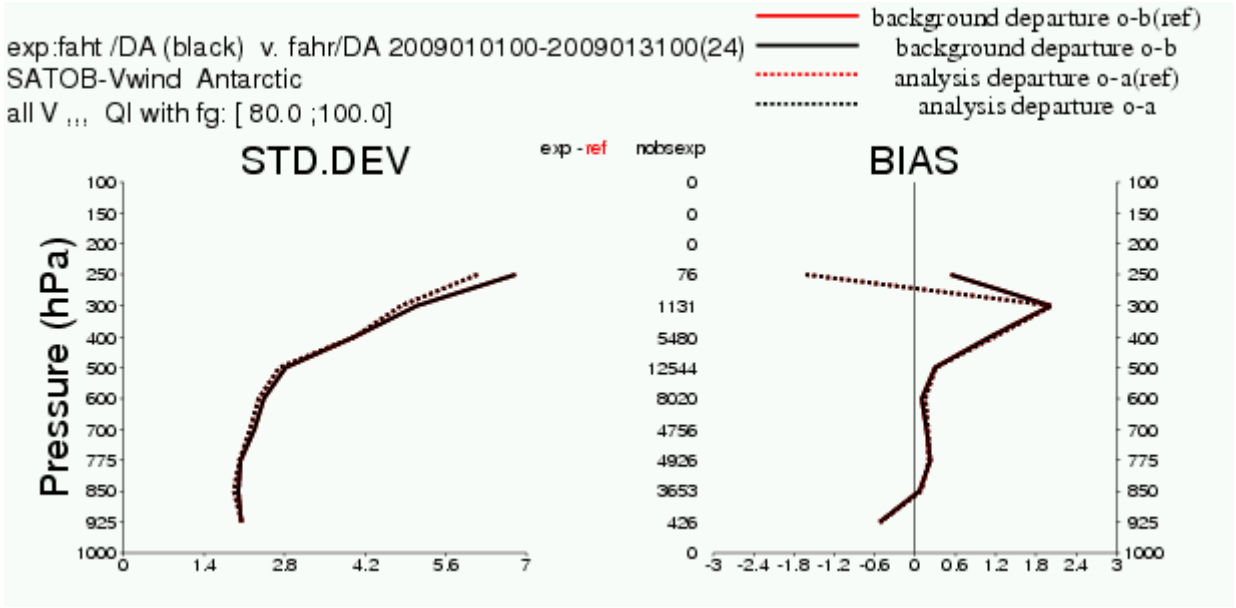
North Pole

All AMVs, QI≥80

NOAA AVHRR AMVs

CIMSS Heights





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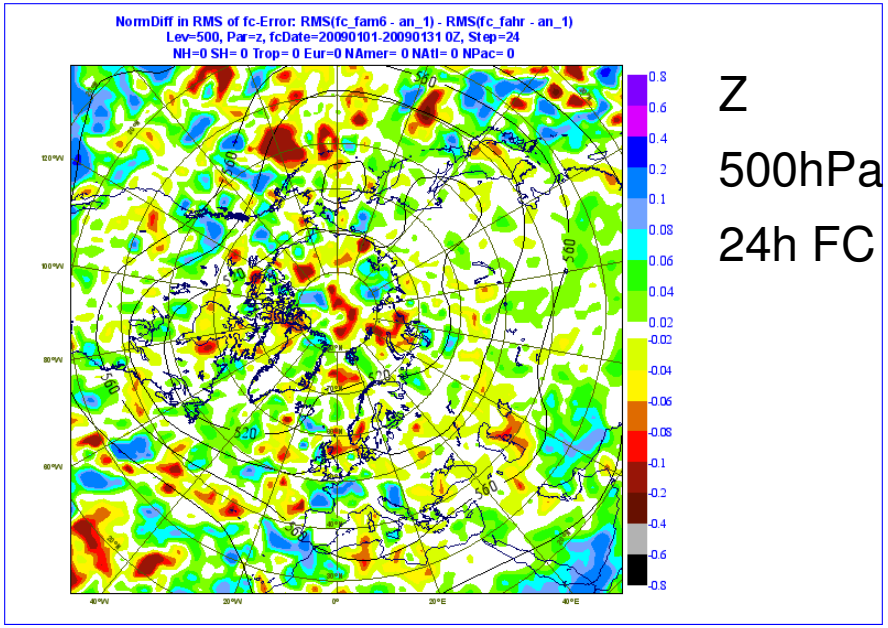
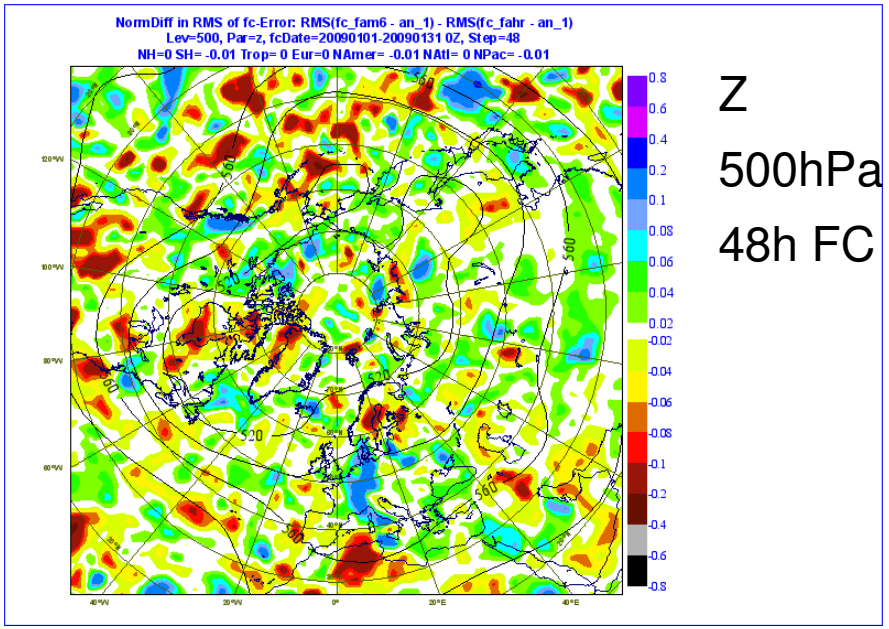


Z

500hPa

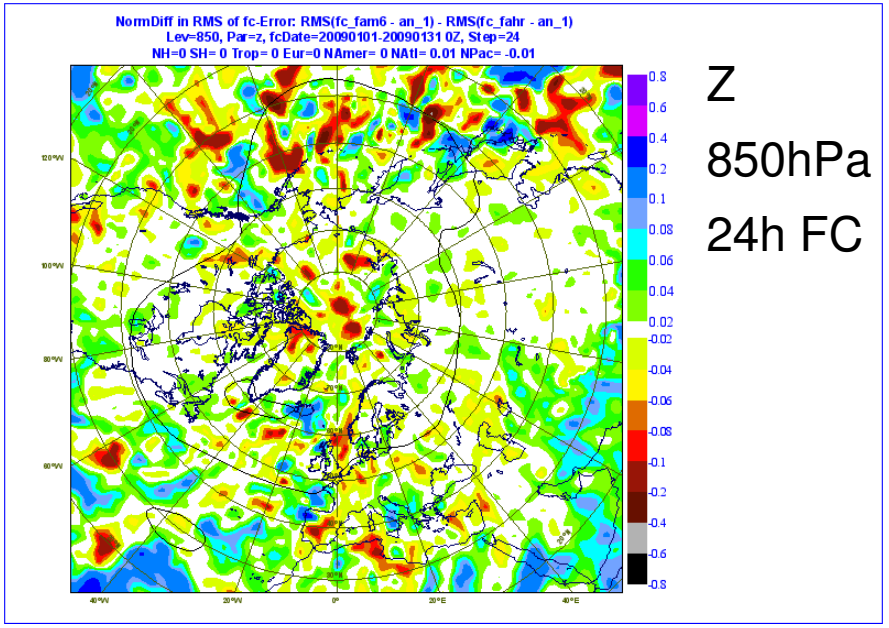
24h FC



Z

500hPa

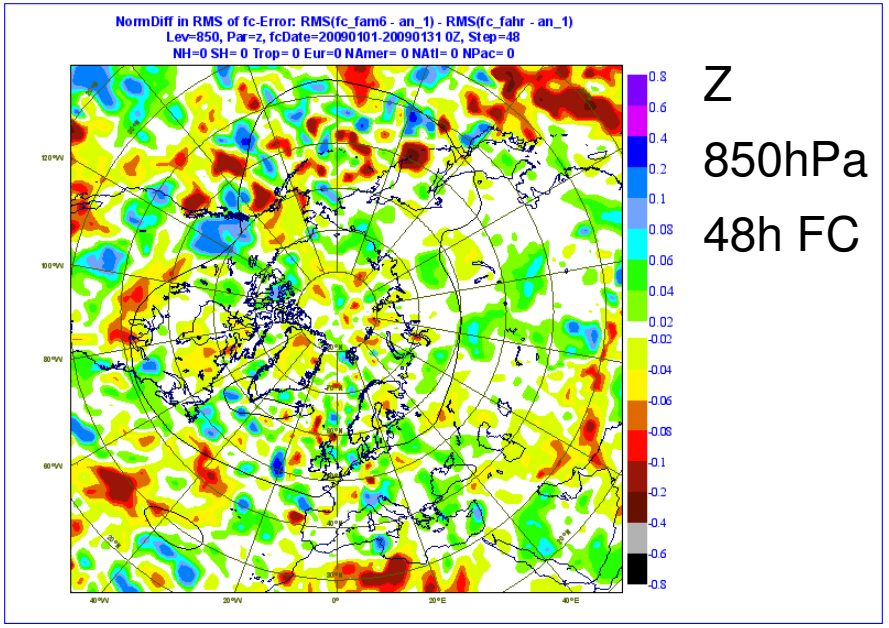
48h FC



Z

850hPa

24h FC

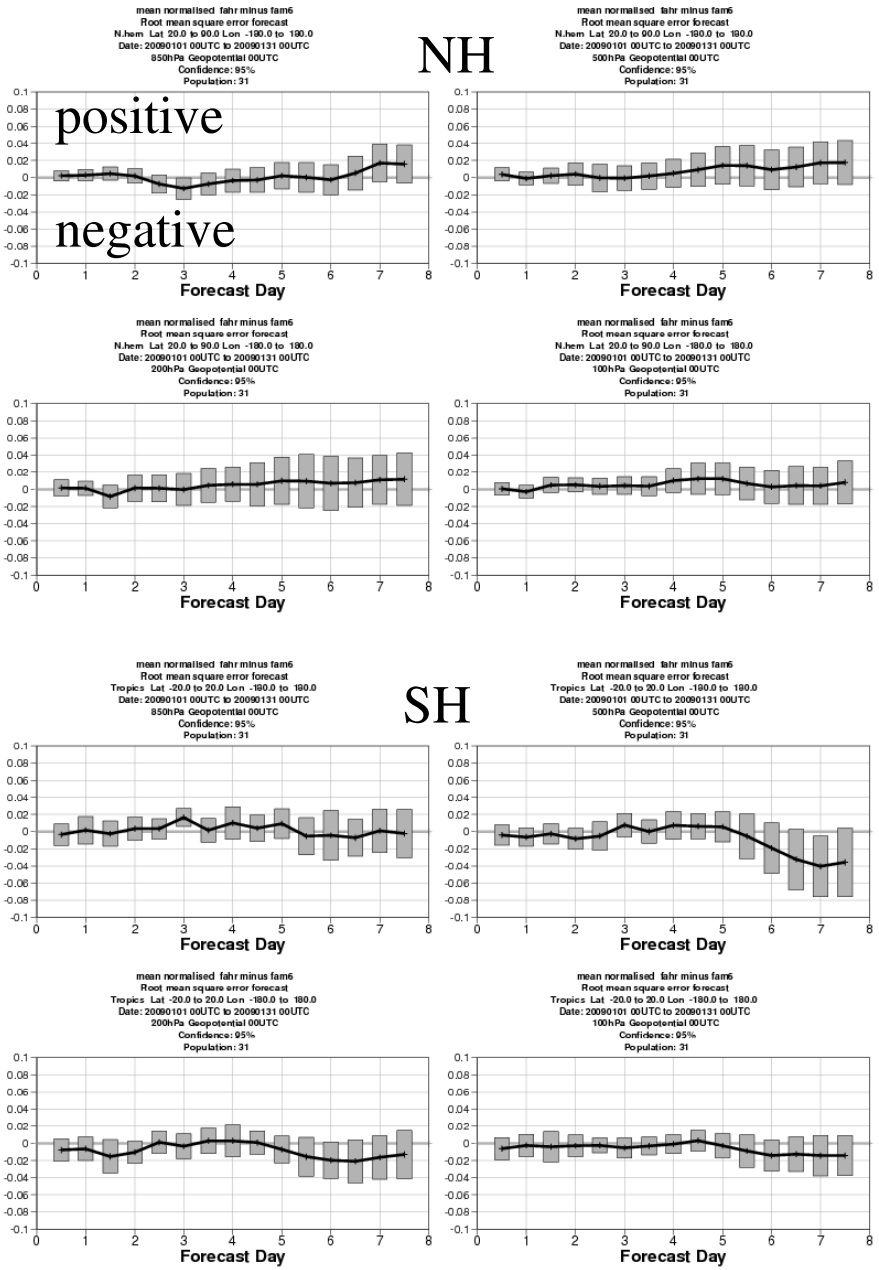


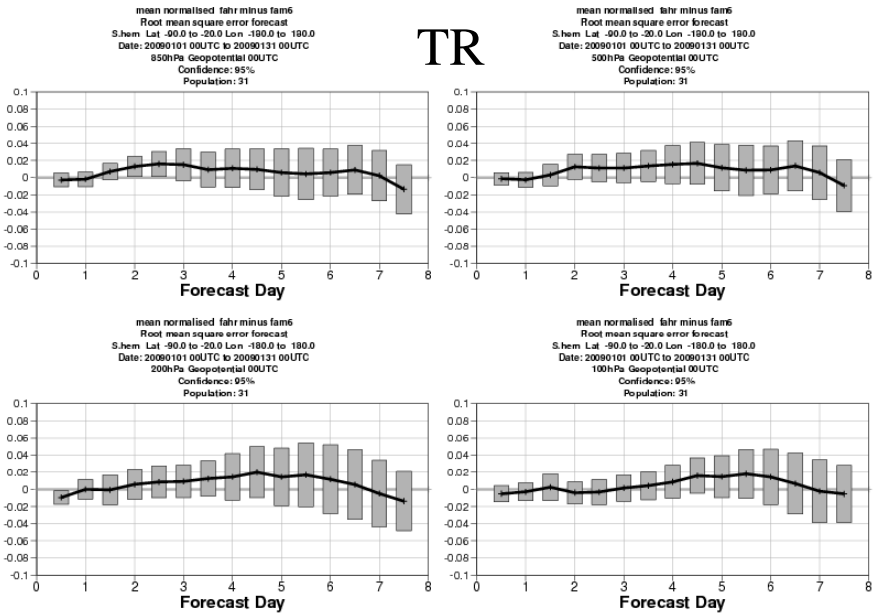
Z

850hPa

48h FC

ECMWF





Mean RMS error FC

Z 500hPa

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Revising Quality Control / Thinning / AMV ObsError

- Added three diagnostics variables to the ODB – height assignment method, tracer correlation method, land-sea flag
- Activated the calculation of FG-based best-fit pressure, shear, t200, t500, etc.
- Implemented new experimental observation operator for AMVs, based on layer averaging using boxcar weighting function – in research mode
- DA experiments are conducted (3 months, TL511, CY36R1) and soon to be analysed

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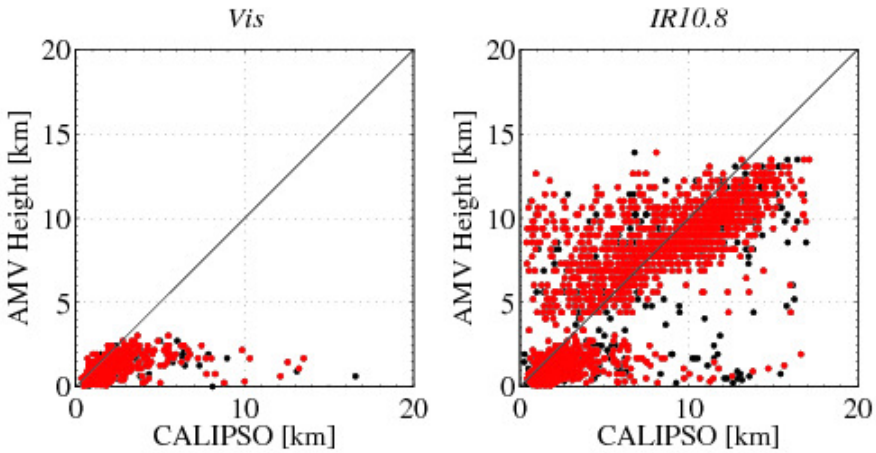
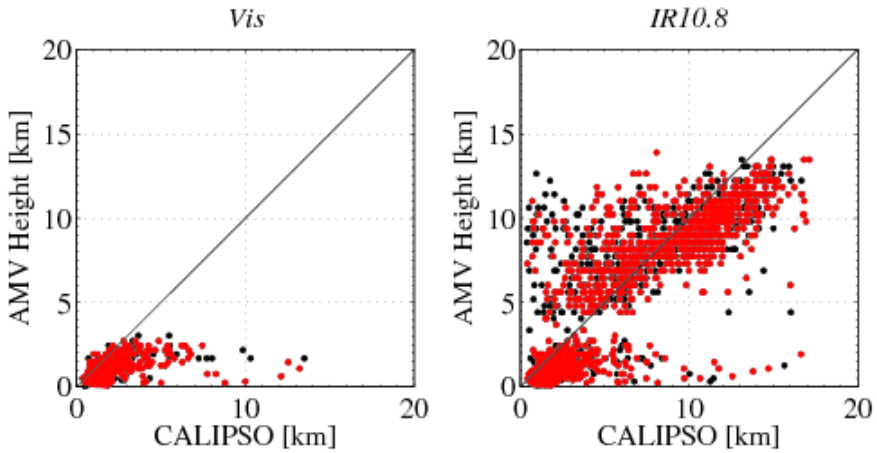
- Heights validation with Calipso (Sabatino Di Michele)
- Experiments with AMMA campaign (Anna Agusti-Panareda)



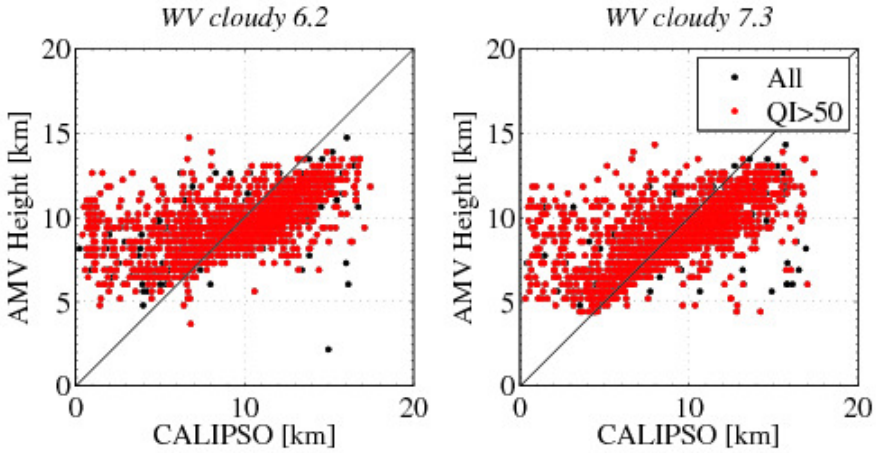
ALL AMVs – black

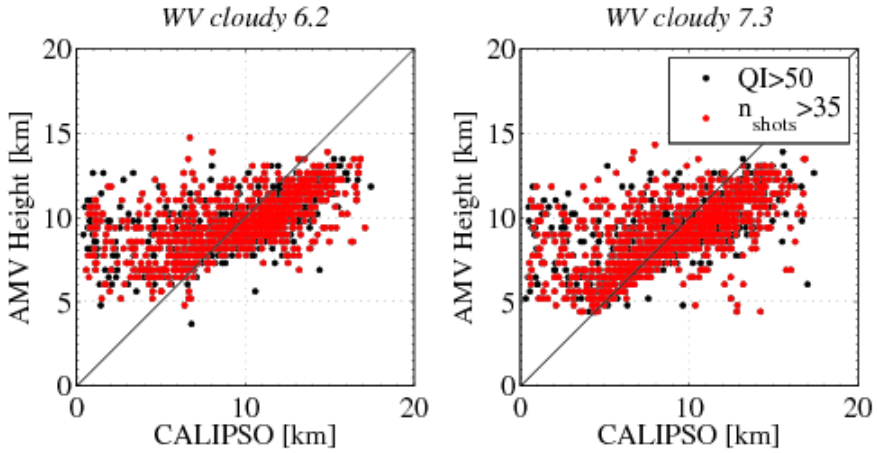
QI>50 - red



QI>50 – black

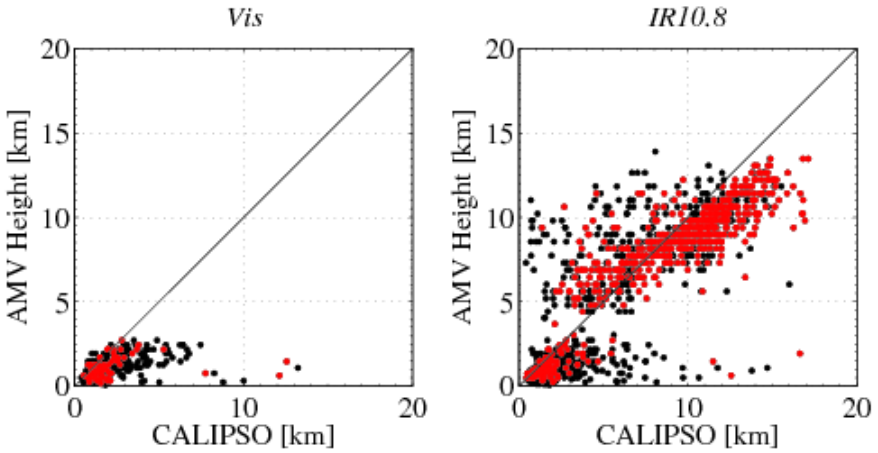
Num Calipso pix > 35 - red





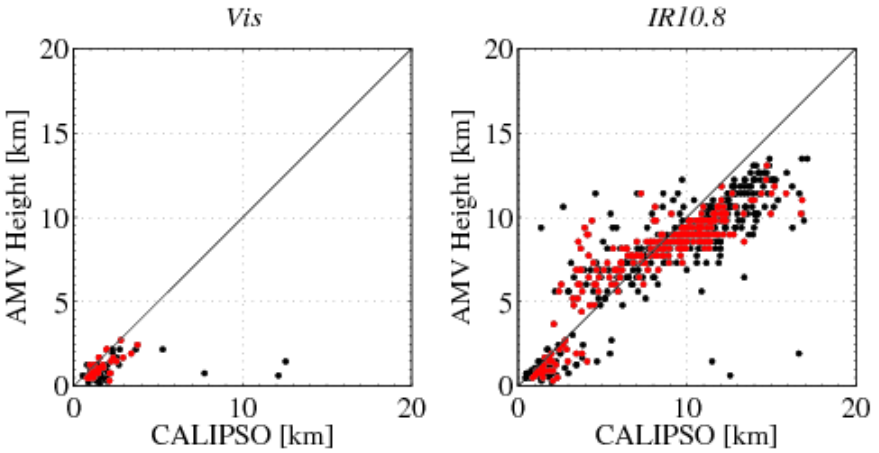
CALIPSO 1km CTH vs MSG AMV Height, 1-10 May 2008

ECMWF



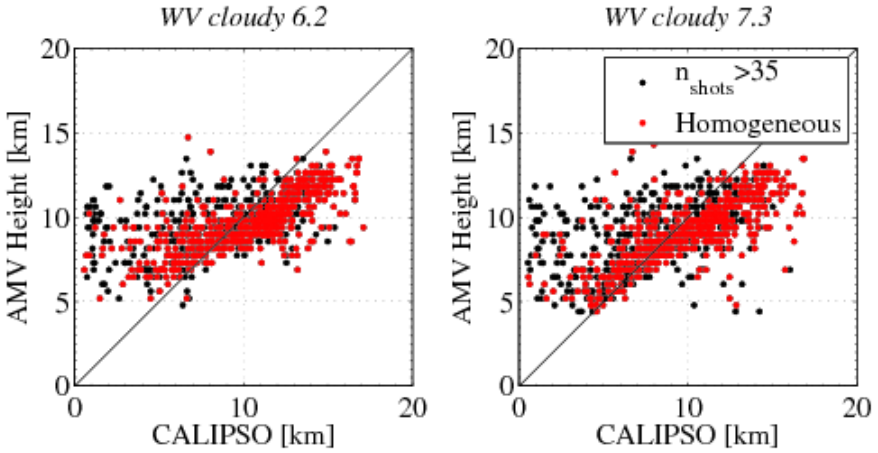
Num Calipso pix > 35 – black

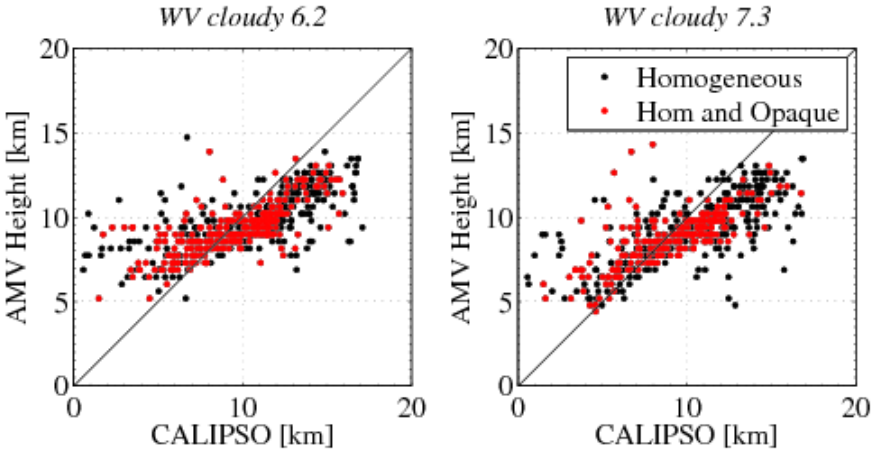
‘Continuous cloud’ - red



Num Calipso pix > 35 – black

‘Continuous cloud’ - red



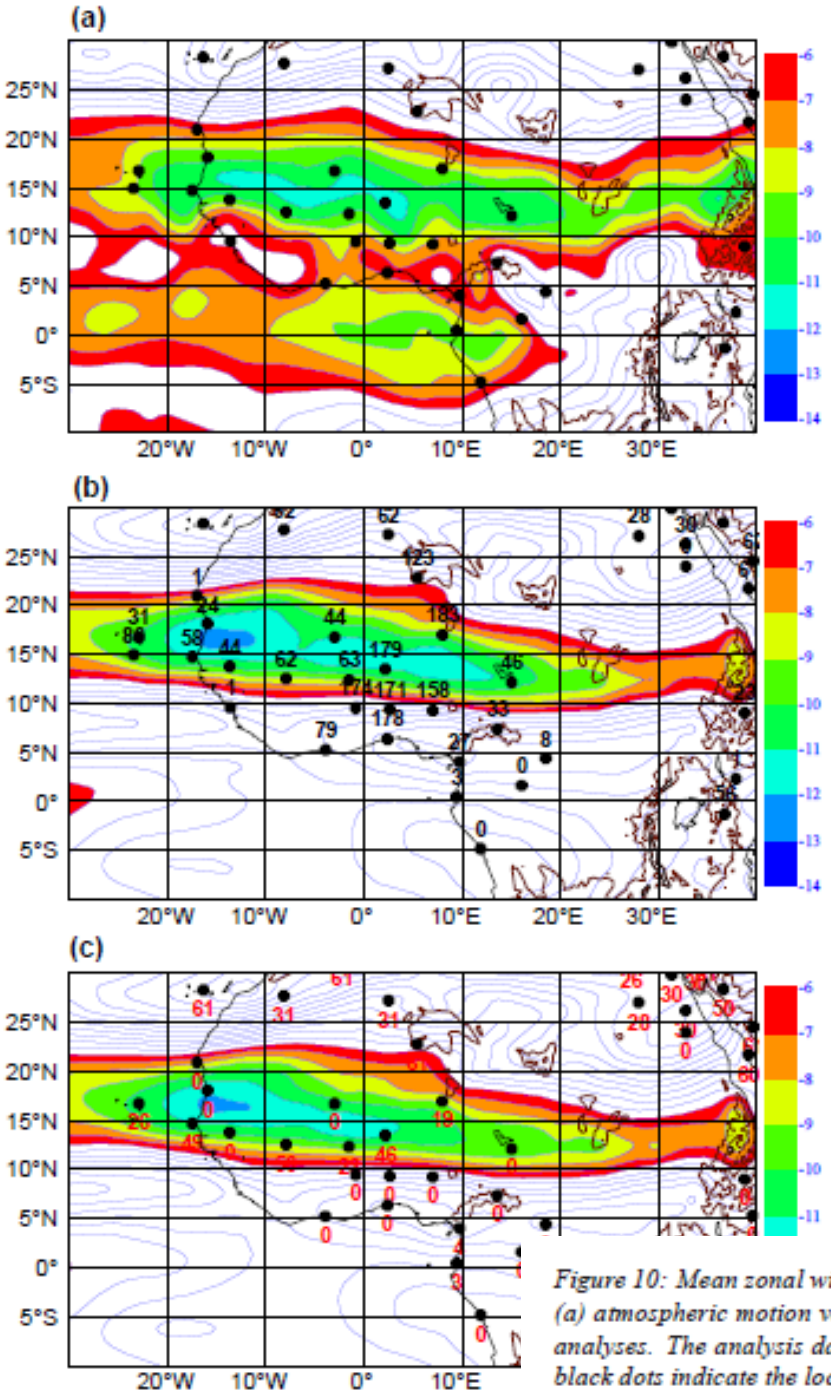


CALIPSO 1km CTH vs MSG AMV Height, 1-10 May 2008

ECMWF

Research activities

- MODIS Direct Broadcast polar AMV assimilation experiments
- Meteosat-9 Cross-Correlation Contribution Height Assignment AMV Assessment and DA Experiments
- Metop-A AVHRR polar AMV
- Revising Quality Control / Thinning / AMV ObsError
- Heights validation with Calipso (Sabatino Di Michele)
- Experiments with AMMA campaign (Anna Agusti-Panareda)



Comparison of 750-500hPa AMVs (top) with experiment assimilating AMMA's campaign RAOBS (middle) and control winds analysis (bottom), for understanding the African Easterly Jet

(Augusti-Panareda, et.al.,2010, Weather and Forecasting, accepted)

Figure 10: Mean zonal wind (1 m s^{-1} contour inverval) within the layer between 750 and 500 hPa for August 2006 from: (a) atmospheric motion vectors from Meteosat-8 gridded with $2^o \times 2^o$ resolution, (b) the AMMA and (c) the pre-AMMA analyses. The analysis data has also been plotted in a grid with 2×2 degrees resolution for comparison purposes. The black dots indicate the location of the AMMA radiosonde stations and the numbers depict the number of soundings used.

Summary and future work

- ❑ All operational winds are in good shape
- ❑ Complete the analysis of MODIS DB winds and decide on active DA
- ❑ Complete the assessment of EUMETSAT Metop-A AVHRR AMVs
- ❑ Active assimilation of CIMSS/NESDIS AVHRR winds
- ❑ Continue with observational operator revision