Wind tracing from SEVIRI clear and overcast radiance assimilation

Cristina Lupu and Tony McNally
ECMWF, Reading, UK

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Outline

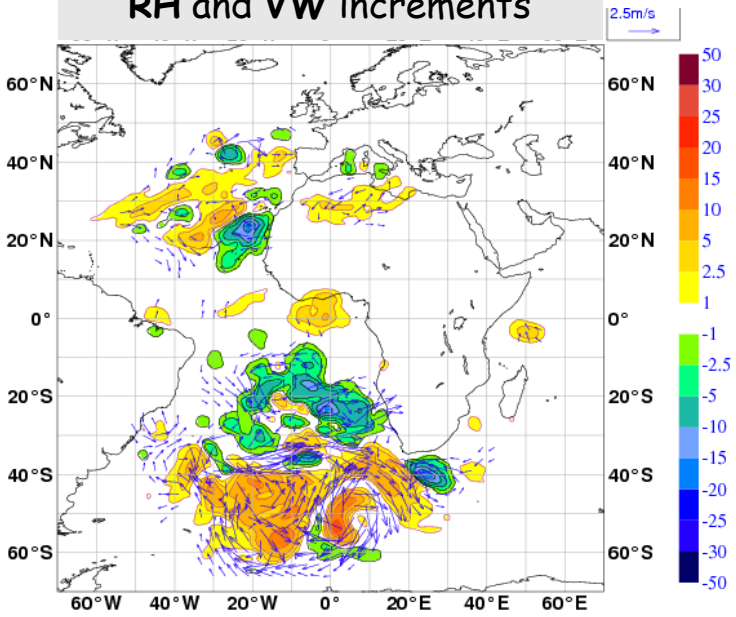
- Motivation & Objective
- Analysis impact of SEVIRI radiances and cloudy AMVs
  - 4D-Var relative-humidity and wind adjustments with CSR, Overcast, CSR+OV and AMVs;
- Impact of SEVIRI CSR and Overcast in ECMWF operations
  - Forecast scores
- Summary

Motivation

- WV Clear-sky radiances (CSR) from geostationary satellites provide humidity information in the middle and upper troposphere;

- CSR influence the wind fields via *humidity tracer advection* induced by 4D-Var (Peubey and McNally, 2009);

RH and **VW** increments



In 4D-Var, a humidity increment due to the assimilation of humidity sensitive radiances will be accompanied by an increment in temperature and wind;

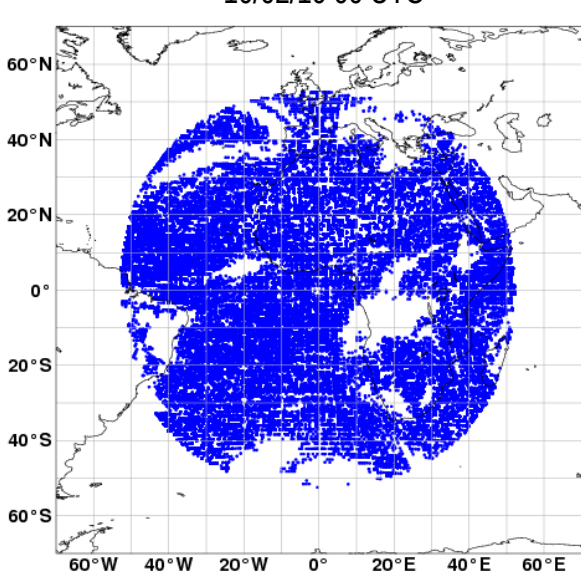
Any changes to the humidity field, will result in the adjustements to other variables (for example, the wind field can be changed to advect humidity to and from other areas).

SEVIRI CSR leads to an improvement in ECMWF's 4D-Var wind analyses throughout the troposphere, with the strongest signal at 300 hPa and 500 hPa.

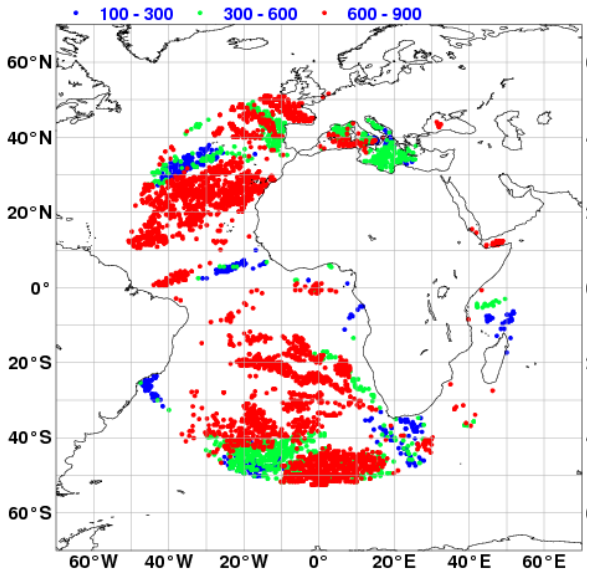
Objective

- Extend the humidity tracing capability to cloudy regions - to obtain an all-sky constraint on the atmospheric wind field with geostationary radiances.
  - Quantify the magnitude of each of the CSR, overcast (OV) and CSR+OV wind impact on isolation and compare results with the cloudy AMVs wind impact.

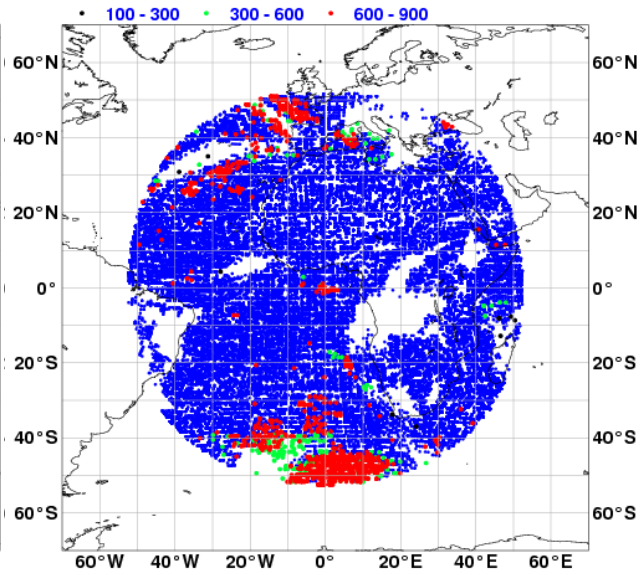
Met-9 CSR
10/02/10 00 UTC



Met-9 Overcast



Met-9 CSR+OV



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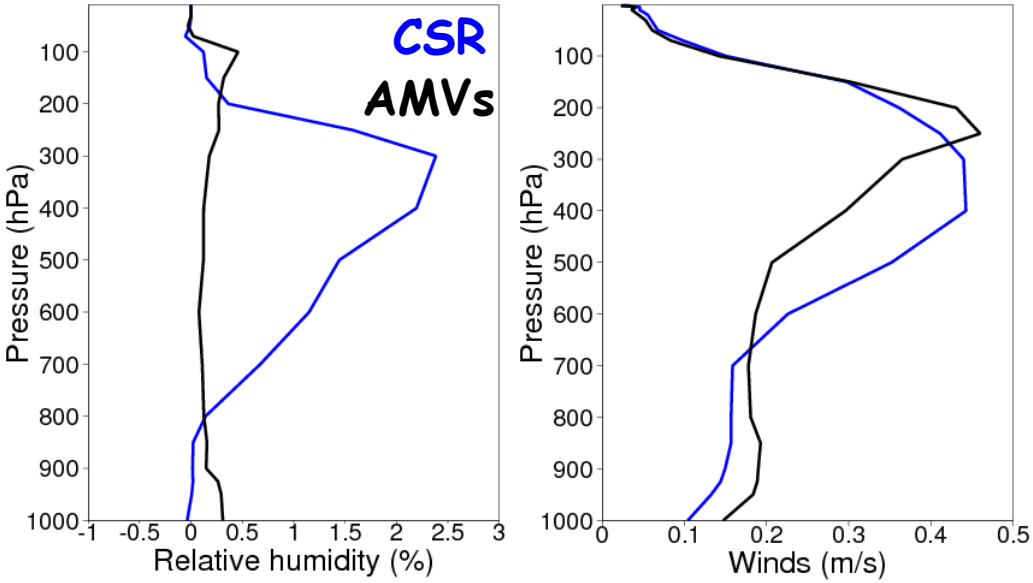
Assimilation experiments

- CSR, OV, CSR+OV and AMVs from SEVIRI were each added to a Base experiment which uses a depleted observing system. All experiments were run at T511L91 (12-hour 4D-Var) , 10th February – 10th March 2010;

- The analysis impact of each of the CSR, OV, CSR+OV and AMVs is shown in terms of the root-mean-square (RMS) of relative-humidity and wind speed increments differences with respect to the Base, averaged inside Meteosat-9 disc over 1-month period;

Analysis impact of SEVIRI Clear-sky radiances and AMVs



Met-9 WV CSR

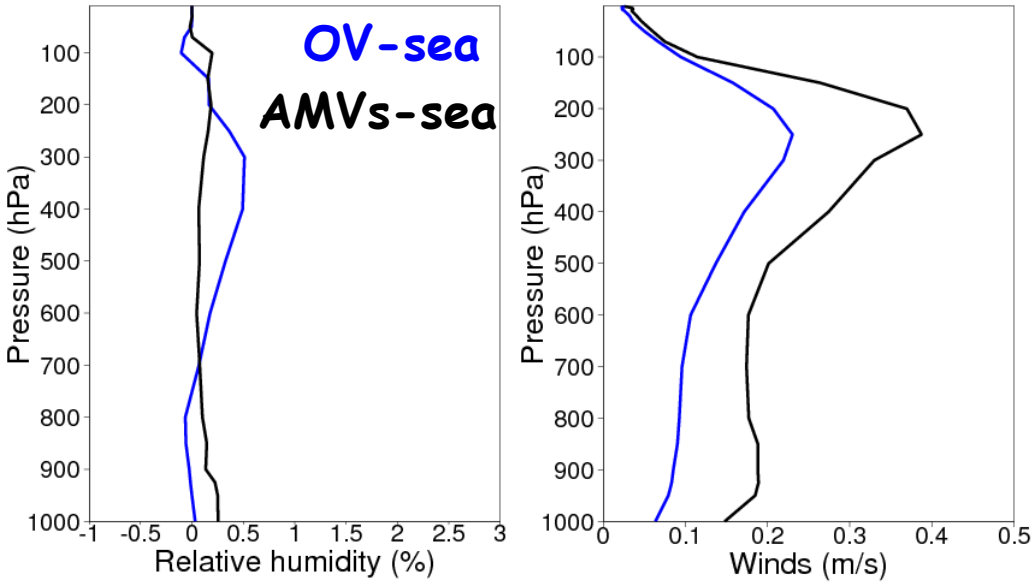
- The vertical extent of the relative humidity increments, from WV CSR, typically between 100 and 800 hPa, and their peak, typically at 300 to 400 hPa, reflect the sensitivity of the WV channels;
- When the WV CSR are assimilated, the 4D-Var tracing mechanism fits the CSR by advecting deep layers of humidity and this leads to deeper layer adjustements of the wind field.

Met-9 cloudy AMVs

- The wind information is provided as a single level wind information and the structure functions of the background covariance matrix control the spread of this information on the vertical.
- SEVIRI AMVs does not have important impact on the humidity field.

SEVIRI CSR and AMVs impact is complementary with respect to the magnitude of wind increments and the altitude range at which each observation type has maximum impact.

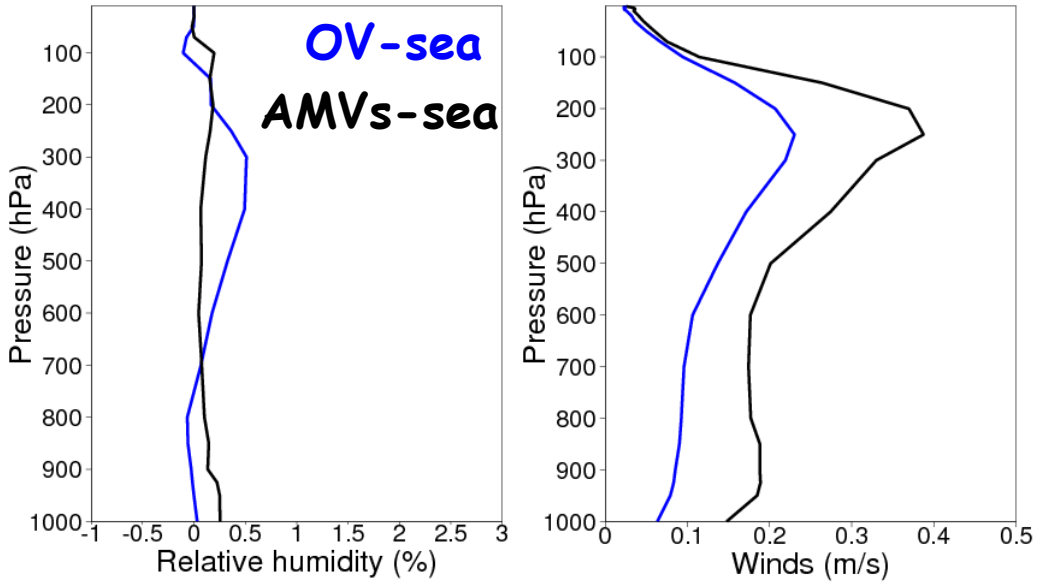
Analysis impact of SEVIRI overcast radiances and AMVs



Met-9 overcast and AMVs (over sea)

- Wind speed vertical profiles from overcast radiances and AMVs assimilated over sea, are very similar in shape, showing a main peak at 250-300 hPa.
- Larger impact of AMVs owing to the large number of AMVs assimilated.
- Relative-humidity changes are only restricted to above the cloud top.

Analysis impact of SEVIRI overcast radiances and AMVs



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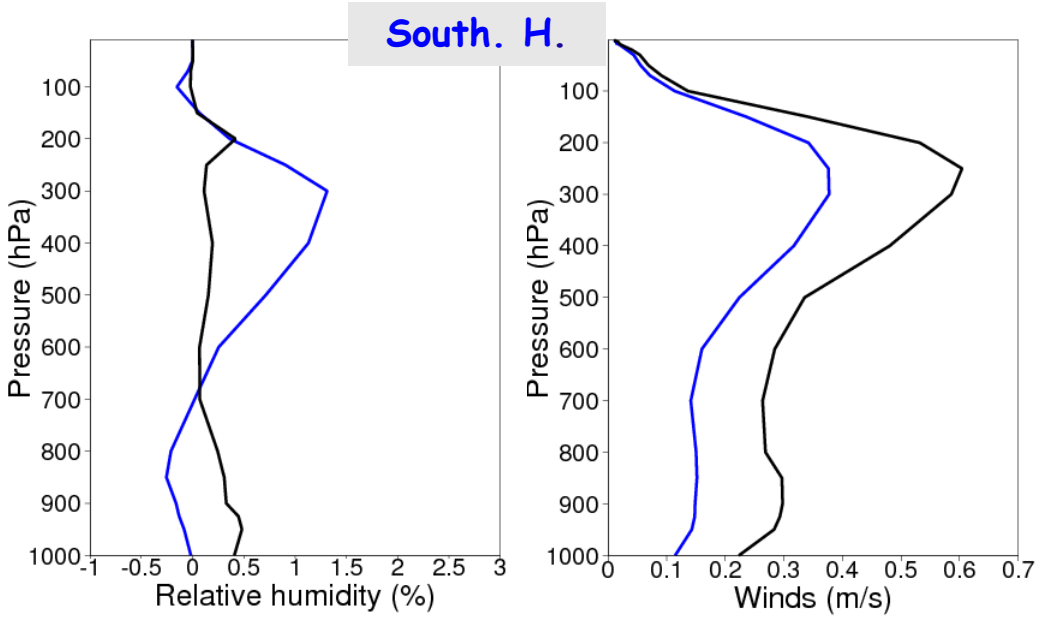
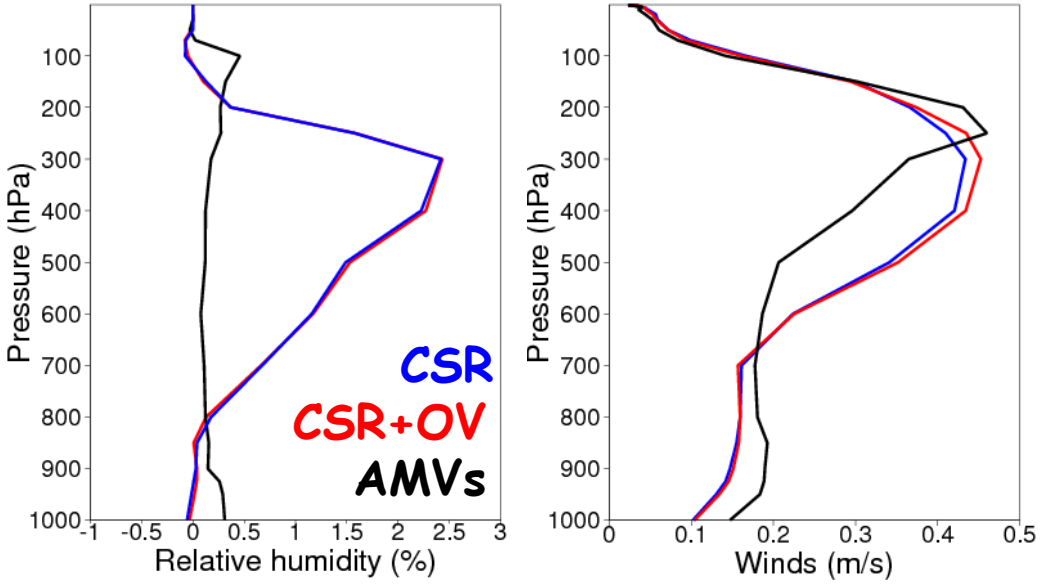


- The vertical composite of relative-humidity changes is constrained to within 1.5% in the Southern Hemisphere where changes above low level clouds are observed from the use of overcast data.

Analysis impact : extend SEVIRI CSR to CSR+OV usage



- The use of clear-sky and overcast data (CSR+OV) from Meteosat-9 improves the wind analysis via tracing.

- CSR+OV and CSR wind speed increments are very similar in structure; a larger magnitude with a maximum at 300 hPa is obtained from CSR+OV;

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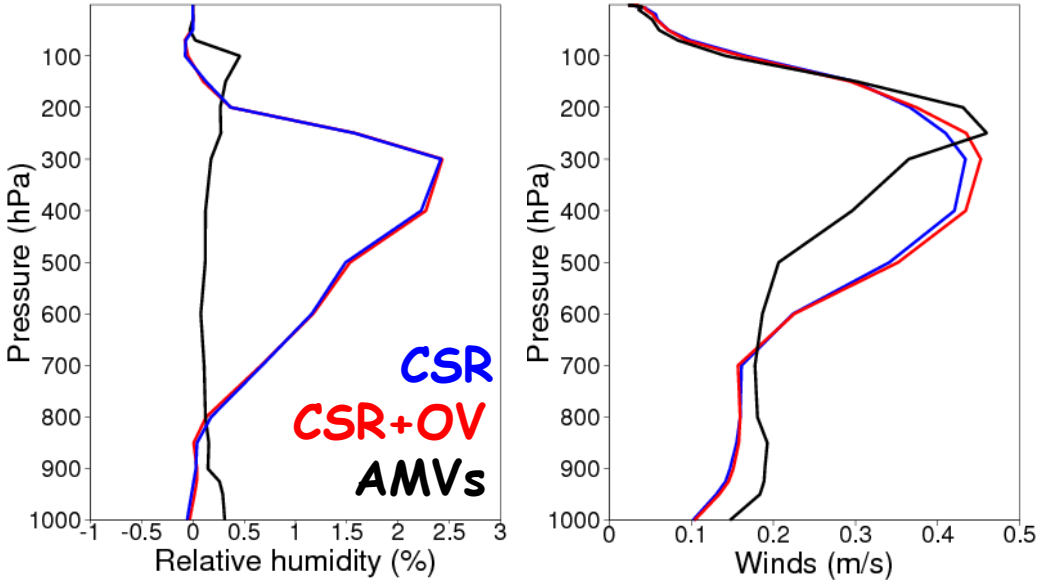

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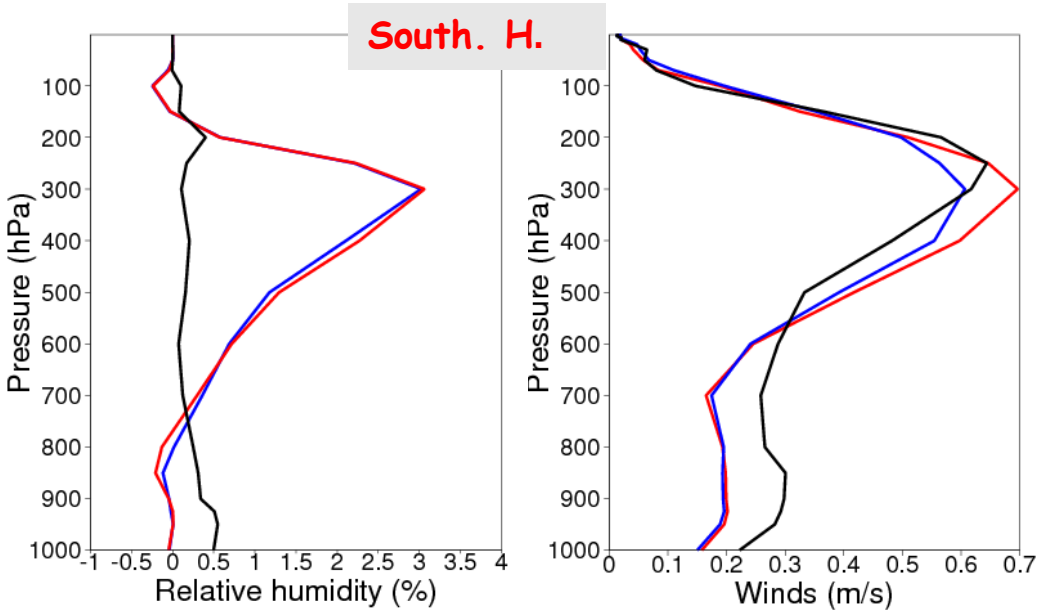


- This benefit can be clearly seen through the upper-troposphere over the South. H. when Meteosat-9 radiances are the only satellite observations in the system.

Wind analysis scores from SEVIRI observations

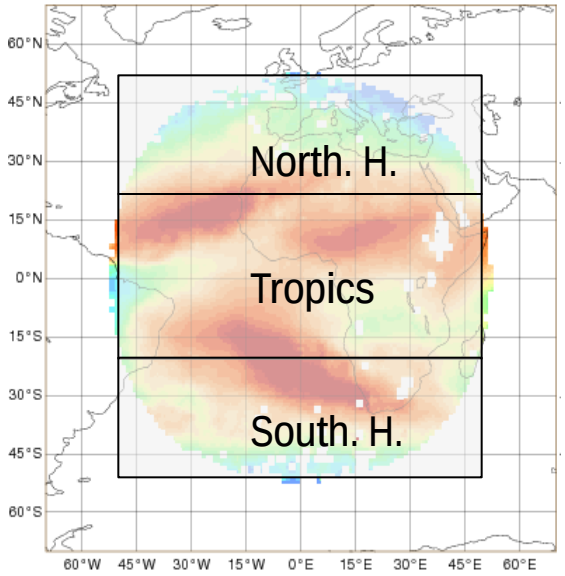
• Wind analysis errors are calculated as departures from the ECMWF operational analysis (T1279L91, full observing system), considered as the best estimate of the true wind field:

$$RMSE_j = \sqrt{\frac{1}{n}\sum_{i=1}^{n}\left[\left(u_i - u_i^r\right)^2 + \left(v_i - v_i^r\right)^2\right]}$$

• For each experiment (e.g., CSR, CSR+OV and AMVs) the analysis error is compared to that of Base to provide an "Wind analysis score":

$$\Delta RMSE = \frac{\sum_{j=1}^{m}\left(RMSE_j - RMSE_j^{Base}\right)}{\sum_{j=1}^{m} RMSE_j^{Base}}$$

• An analysis score equal to zero means no improvement over the base, while a value of 100% correspond to an analysis that has no error with respect to the high resolution oper. analysis;



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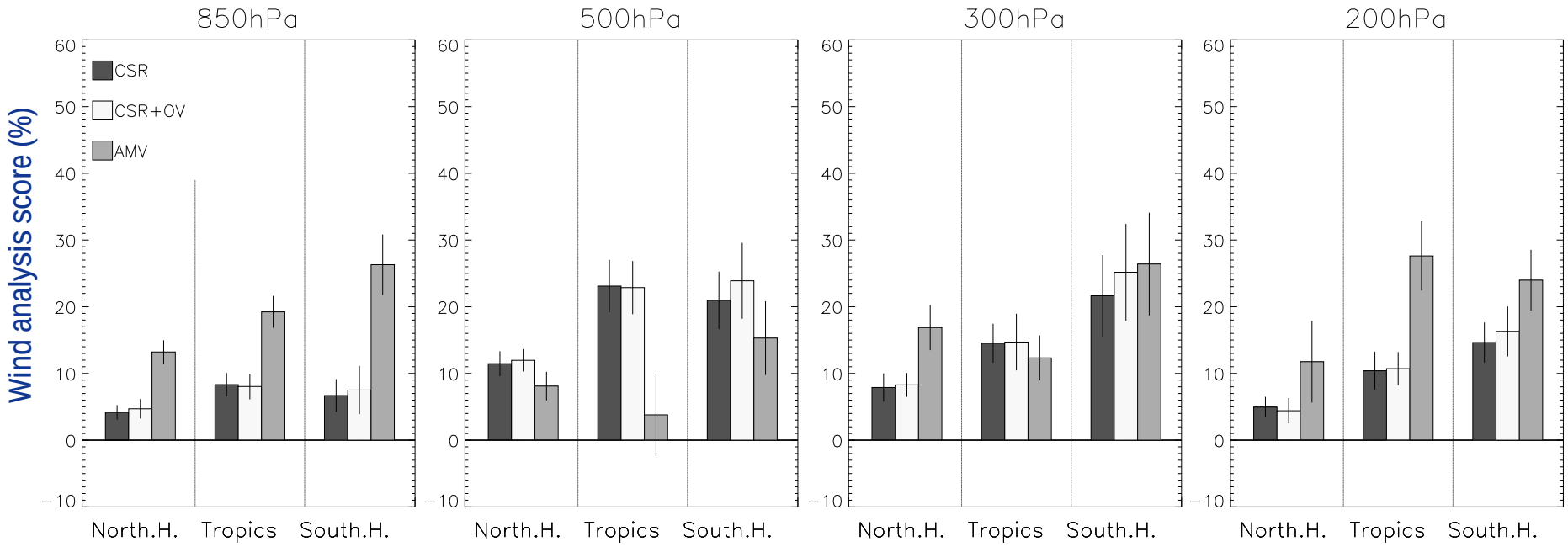

- CSR+OV have a large positive impact on wind analyses than CSR over the South. H.;
- Over North. H. and Tropics, the number of overcast scenes assimilated is limited and wind analyses only get benefits from the CSR assimilation;

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Impact of SEVIRI CSR and overcast in ECMWF operations

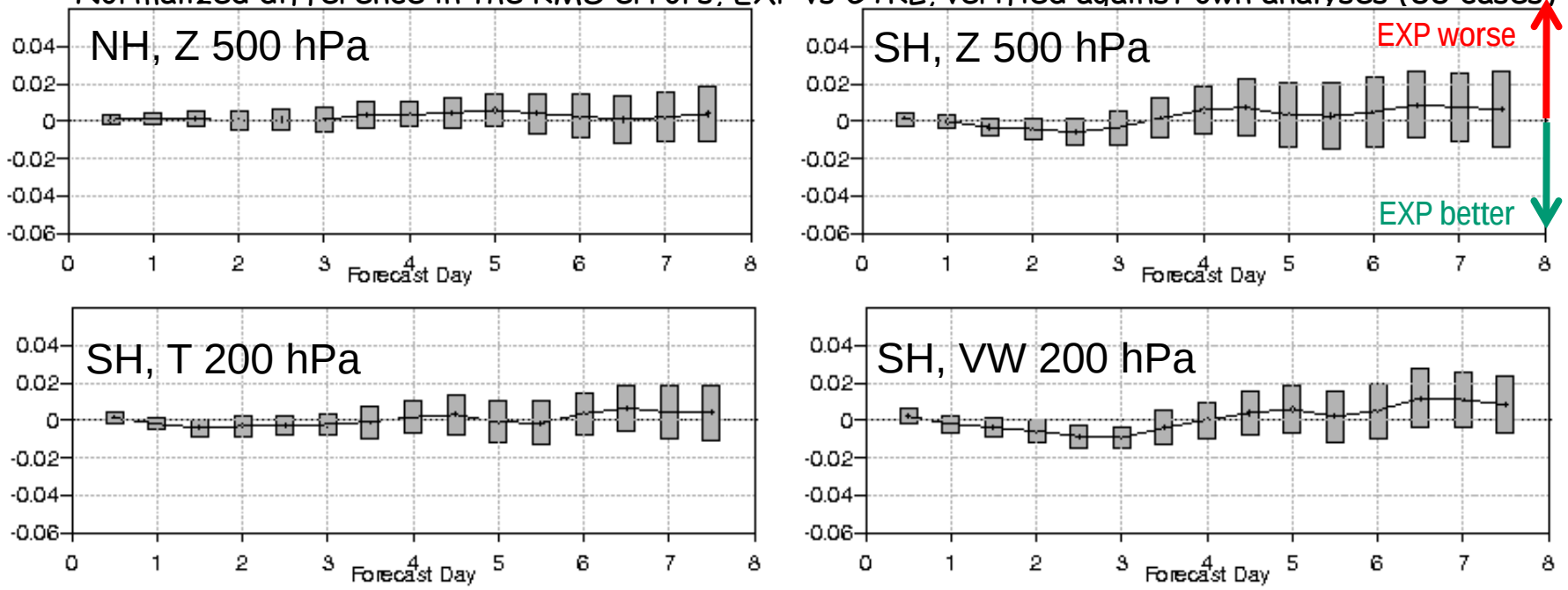
Full System Experiments: T511L91, 1 January – 29 March 2011

CTRL : CY37R3 full operational system with Met-9 WV CSR

EXP : CY37R3 full system with Met-9 WV Clear-sky and Overcast Radiances

The forecast impact on the Z 500 hPa is neutral with Meteosat-9 CSR+OV ;
The VW forecast error in the upper troposphere in the SH are reduced;

Normalized difference in the RMS errors, EXP vs CTRL, verified against own analyses (88 cases)



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Summary

- A 4D-Var assimilation system can derive useful tropospheric wind information from geostationary humidity-sensitive SEVIRI radiances by advecting humidity features to improve the analysis fit to observations.

  - SEVIRI CSR and AMVs impact is complementary with respect to the magnitude of wind increments and the altitude range at which each observation type has maximum impact (CSR@500hPa; AMVs@200, 850hPa).

  - SEVIRI OV and AMVs impact show a very good agreement with a maximum impact in the upper troposphere (250-300 hPa). Larger impact is obtained from AMVs as the number of completely overcast scenes is reduced comparatively with the number of cloudy AMVs.

  - The additional use of overcast data in CSR+OV experiment improves the wind analysis via tracing (maximum impact 300hPa).

Summary

- **Wind analyses scores**
  - **In the context of no-satellite baseline experiment, CSR+OV have a positive impact on wind analyses through the troposphere, with better performance than CSR over the Southern Hemisphere.**

- **WV CSR+OV from Meteosat-9 will be operational assimilated at ECMWF with CY38R1 (Spring 2012)**
  - **Overall the impact of CSR+OV is close to neutral, with some positive impacts in the SH for forecast ranges up to day 3.**

Thank you !

Questions ?