P1G.1 DATA DENIAL EXPERIMENTS DURING EXTRATROPICAL TRANSITION

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1. INTRODUCTION

Extratropical transition (ET) of tropical cyclones presents a significant challange to numerical weather forecasts. Small uncertainties in sensitive regions around ET events can lead to large forecast errors. An important source of such uncertainties lies in the insufficient data coverage. Introducing targeted observations made in sensitive regions into the data assimilation procedure may have a notable value for a numerical forecast.
In recent data denial studies at the ECMWF the sensitivity of forecasts of the atmospheric flow over Europe to targeted observations taken in the Atlantic has been investigated (Cardinali et al., 2007). The sensitive regions were calculated with singular vectors (SV) verifying over Europe. For ET cases an average forecast degradation of 13% in terms of the root-mean-squared error (RMSE) of the 500 hPa geopotential height over Europe has been found. It is supposed that the data denial experiments in sensitive regions give an upper bound of the expected impact that extra observations released in targeting campains would have.
In this paper data denial experiments conducted with the ECMWF model IFS are presented. They are designed to investigate the value of additional observations for historical ET cases in regions around the ET event itself. The degradation of the forecast over Europe due to data denial in SV regions and due to data denial in the ET region are compared.

2. EXPERIMENTS

The analysis from which the forecast is initialized is produced every 12 hours at the ECMWF. The latest short range forecast initialized 12 hours before this analysis time represents the background. Observations are introduced and assimilated within a window of 6 hours, 3 hours before and 3 hours after the analysis time.

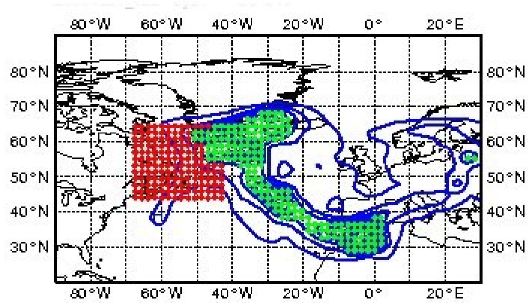

Fig. 1: Schematic of data denial areas for ETout (red) and SVout (green). SV1 optimizes over Europe.

Data denial regions around the selected historical ET events have been chosen in which none ofl the observations that are usually introduced into the assimilation are used. These regions are rectangular boxes placed around the relative vorticity maximum. The boxes extend 5° outwards from the outermost closed surface isobar of the tropical cyclone (TC) (Fig. 1). The maximum extension of the box is 30° in the zonal and 20° in the meridional direction. In a further experiment data denial regions are calculated from the leading extratropical SV optimized over Europe, i. e. 10°W-30°E, 35°-75°N (Fig. 1). New forecast runs using the T511L60 resolution have been calculated denying observations in the ET regions (ETout) and in the SV regions (SVout). Both were compared to runs with all observations (control).
To evaluate the experiments the RMSE of ETout and SVout of the 500 hPa geopotential have been compared to the RMSE of the control forecast.

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3. IMPACT OF DATA DENIAL

Eight historical TCs which either underwent ET or interacted with a frontal system have been chosen for the experiments (Table 1).
The forecast degradation due to ETout of the ET events is shown in Fig. 2. For each denial case only the highest deviation from the control forecast, showing degradation or improvement respectively, is presented. The associated forecast times for each denial case after which the degradation is most are given in Table 1. The deviation is calculated from [RMSE(control) – RMSE(ETout)] / RMSE(control) and expressed in percent.

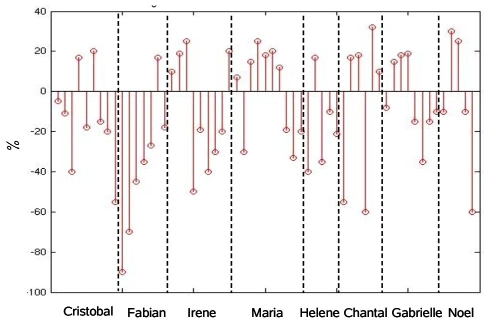

Fig. 2: Deviation of the RMSE of ETout from the RMSE of the conrol forecast. For each denial case the highest deviation in percent is shown. The associated forecast times are given in Table 1. Cases are numbered from the left for each event.

For every ET event positive (improvement) and negative values are seen. The number of negative values is higher and the degradation is stronger in these cases.

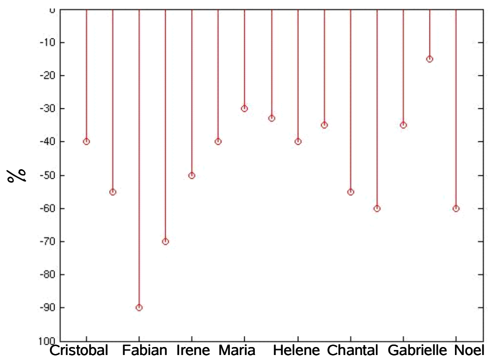

Fig. 3: Deviation of the RMSE of ETout from the RMSE of the conrol forecast for the denial cases with strongest degradation. For each case the highest degradation in percent is shown.

To obtain information about in which region and at what stage of ET additional observations are most useful we investigate the denial cases which show the strongest degradation. For ETout (Fig. 3) the degradation extends from 15 % for one denial case for Gabrielle (2007) up to 90 % for one denial case of Fabian (2003). In a lot of cases degradations of about 45 % can be found.
For the 4 cases of SVout (Fig. 4) the strongest degradations extend from 10 % in one case of Helene (2006) up to 40 % in one case of Chantal (2007). Most of the cases show degradations of around 20 %.

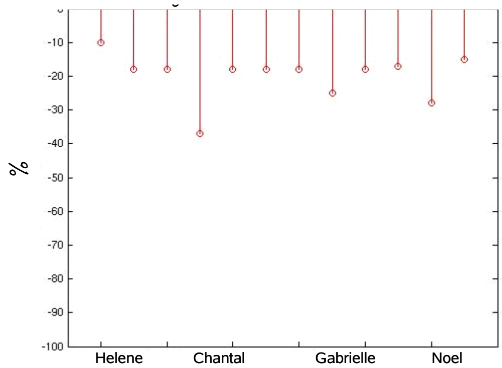

Fig. 4: Deviation of the RMSE of SVout from the RMSE of the conrol forecast for the denial cases with strongest degradation. For each case the highest degradation in percent is shown.

For a fair assessment of the utility of SVs to determine the region where targeted observations are made ETout and SVout must be compared at the SV optimization time, i. e. after 48 hours. In this case the highest degradation due to SVout is larger (between 10 and 20 %) than for ETout (between 0 and 10 %).
In about half of the data denial times for which the degradation is shown in Fig. 3 the TC is in its stage of recurvature and has not begun to transform yet. These cases show the strongest degradation over Europe after a rather long forecast time, i. e. in many cases after about 5 days. Five of the 15 cases (Fig. 3) are in their ET stage and only three had re-intensified already when the observations were denied.
From these results it can be said that the early stages of ET are important for targeted observations.

4. CASE STUDY

Hurricane Helene developed to a category 3 hurricane in the North Atlantic on 18 September 2006. On 20 September, Helene turned northward ahead of a large trough

situated over the east coast of the United States. After turning north-eastwards over the Atlantic it retained hurricane strength again and completed ET by 18 UTC 24 September northwest of the Azores. One day later a trough downstream of Helene deepens over Europe due to the modification of the Rossby wave train by Helene. On 28 September ex-Helene merged with a larger extratropical deep pressure system. The track of ex-Helene was forecast correctly only in the deterministic forecast two days before the merger.
For the data denial time 21 September 00 UTC for Helene the forecast degradation was 40 % after 4 ½ days and for the 23 September 00 UTC it was 35 % after 3 ½ days. At 21 September Helene was still in the stage of recurvature and on 23 September it started to become embedded in the midlatitude flow.

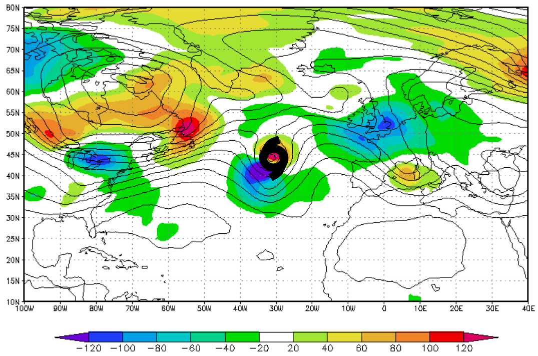

Fig. 5: Difference of 500hPa geopotential between analysis and control forecast for 21 September 00 UTC (shaded). Analyzed surface pressure (contours). Helene is marked by a hurricane symbol.

The differences between the analysis and the control forecast at 500 hPa are shown in Fig. 5. A couplet of positive and negative values is seen at the location of Helene indicating a shift in the central pressure of Helene to the southwest in the analysis compared to the control forecast. A trough is situated over Europe. The differences in this trough are smaller than around Helene. They indicate a shift of the trough to the north in the analysis compared to the control forecast.
Comparing the impact due to SVout (Fig. 6) to the control forecast yields about the same values in the region of the ET event but slightly larger and higher values in the downstream trough.

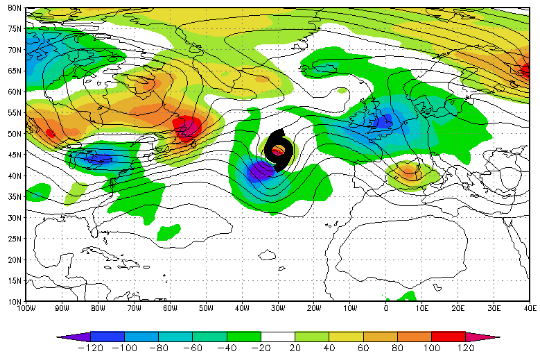

Fig. 6: As Fig. 5 for SVout.

For ETout (Fig. 7) the values in this downstream trough are much higher than in the control and also than in SVout. In contrast the differences around Helene are about the same as in the control forecast.

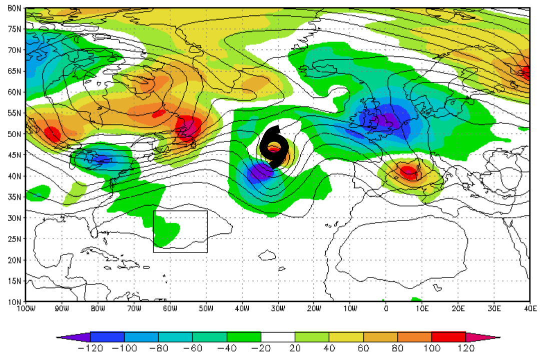

Fig. 7: As Fig. 5 for ETout.

Hence, for Helene the degradation due to the experiments affect the synoptic flow downstream over Europe and not in the direct environment of the ET system.

5. OUTLOOK

The synoptic charts of the other ET events investigated will be examined with regard to the regions of highest degradation. Other experiments will be conducted with the aim to deny data only in several layers, for example in the outflow of the ET event. Further experiments will be designed for SVs targeted on the ET event.

6. REFERENCES

Cardinali, C., R. Buizza, G. Kelly, M. Shapiro, and J.-N. Thepaut, 2007: The value of targeted observations. Part III: Influence of different weather regimes. ECMWF technical memorandum.

ACKNOWLEDGEMENTS

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Table 1: Forecast times (in hours) of highest deviation from the control forecast as in Fig. 2

	Cristobal	Fabian	Irene	Maria	Helene	Chantal	Gabrielle	Noel
1	120	120	108	84	108	120	84	96
2	96	120	84	120	96	24	96	84
3	84	72	60	84	96	60	120	84
4	120	84	96	72	84	72	108	60
5	12	72	108	120	72	96	120	12
6	72	48	120	120		72	120	
7	24	60	72	48			36	
8	36		120	60			72	
9	12		108	120				
10				84				