An new height assignment scheme for low level cloud motion winds using temperature inversion information from high resolution forecast data.

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January 25, 1999

1 Introduction

It has been recognised for many years that the height assignment of low level winds in subsidence areas in the Atlantic is not realistic. The problem was early identified to be caused by the poor vertical resolution of the used forecast data.

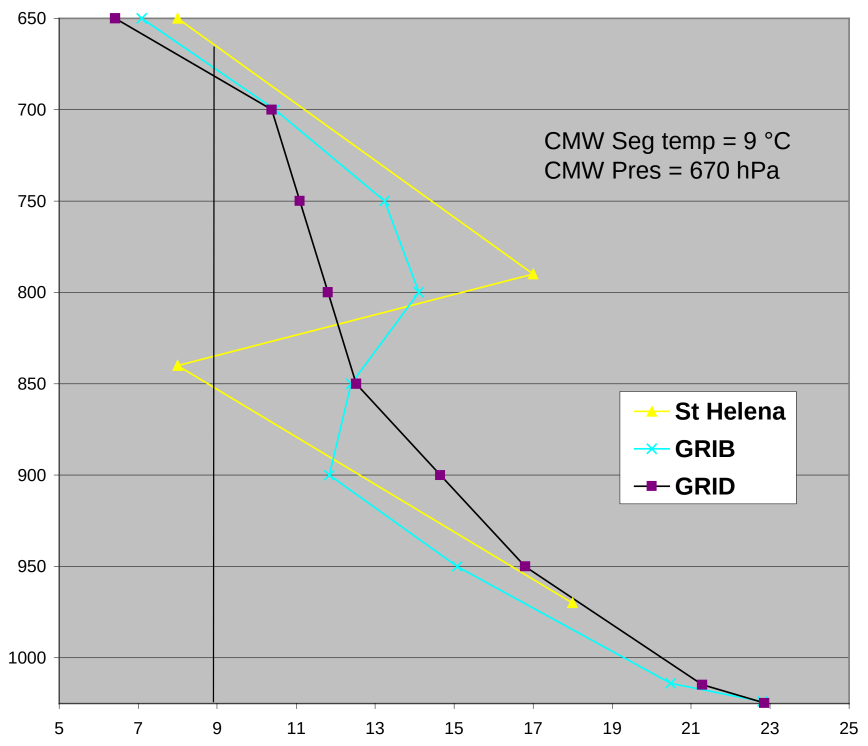
The approach for the SATOB product has so far been to remove those winds with manual intervention, for the ELW product they are disseminated "as is" and the problem has been left to the user.

The replacement of the low resolution forecast data (GRID data) with high resolution forecast data (GRIB data) in June 1998 has drastically improved the quality of the forecast data, but this has not affected the quality of the CMW height assignment in these areas. An investigation has showed that the extremely strong temperature inversion in these areas is still not enough recognised in the GRIB data.

Since manual quality control has stopped since beginning of September 1998, and it is generally unsatisfactory to distribute data with doubtful quality, we have taken the action to improve the height assignment by forcing the CMW height to the level of the temperature inversion in the GRIB data.

2 Formulation.

The introduction of high resolution forecast data (GRIB) has drastically improved the quality of the forecasted vertical temperature profile used by MPEF. Nevertheless, in the cases where the temperature inversion is extremely strong, the forecast model is still unable to describe the strength of the inversion good enough (picture below), and the CMW will be processed at a far too high level. A way of using the improved GRIB data is to apply a completely different height assignment for CMW:s in segments where a inversion is present in the forecast temperature profile.



By forcing the CMW height to the level of cold extreme in the temperature inversion, the CMW in picture 1 would be assigned to a more realistic height of 900 hPa, instead of 670 hPa.

The first step is to decide in which segments this should be applied (inversion segment), which is based on the following:

- Height (pressure) of cold extreme temperature in the inversion > $\mathbf{P_l}$, to exclude ground inversions.
- Height (pressure) of warm extreme temperature in the inversion < $\mathbf{P_h}$, to exclude high/medium levels.
- Vertical extension (hPa) of the temperature inversion **H**. Since the vertical resolution of the MPEF segmented forecast is 50 hPa, this is the minimum value.
- Strength of the temperature inversion (°K) **S**, within the vertical extension H.

The second step is to decide for which winds the height should be reassigned:

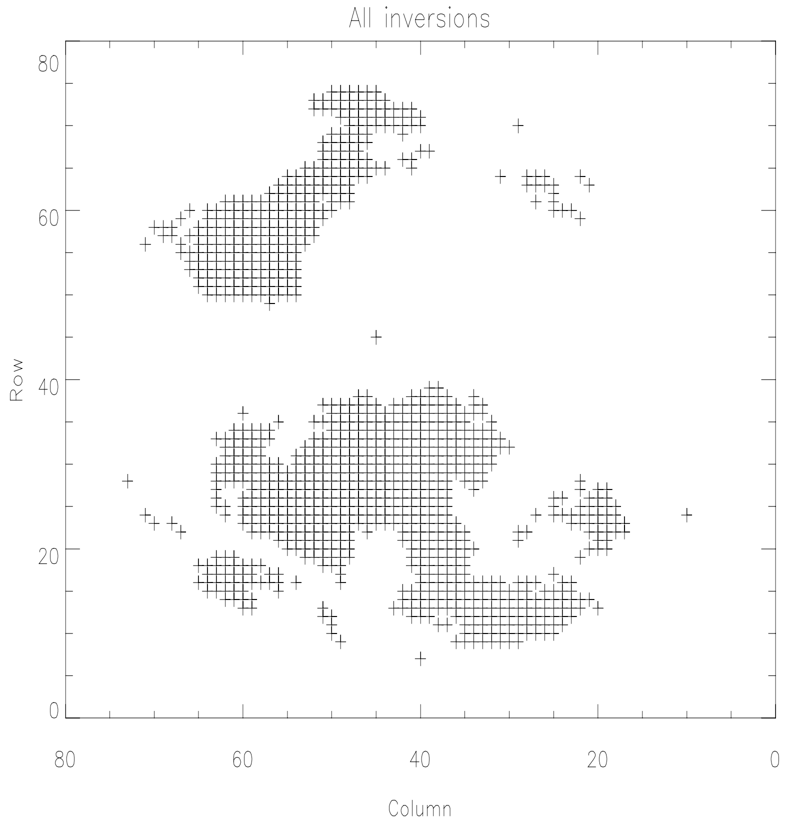
- From the manual quality control it is experienced that clouds in these subsidence areas are frequently processed on heights up to 600 hPa, where the real height should be below 800 hPa.
- In these subsidence areas are real clouds above the inversion and below 600 hPa very rare.

Based on the empirical reasons above, the height of all clouds processed at levels below 600 hPa <u>and in an inversion segment</u>, should be reassigned.

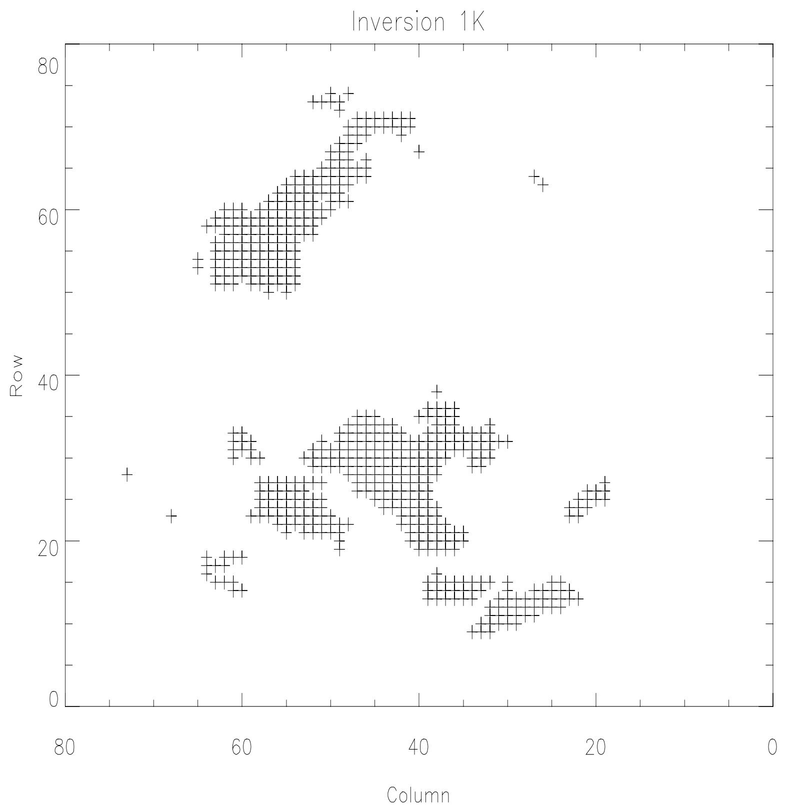
3 Sensitivity analysis.

In order to be able to select the appropriate values for an "inversion segment" some familiarity with the GRIB data inversion strength and depth, and the geographic extension of the same is essential.

P_l was set to 50 hPa, which effectively will prevent any ground inversions from being used. P_h was set to 700 hPa to limit the reassignment to low levels.



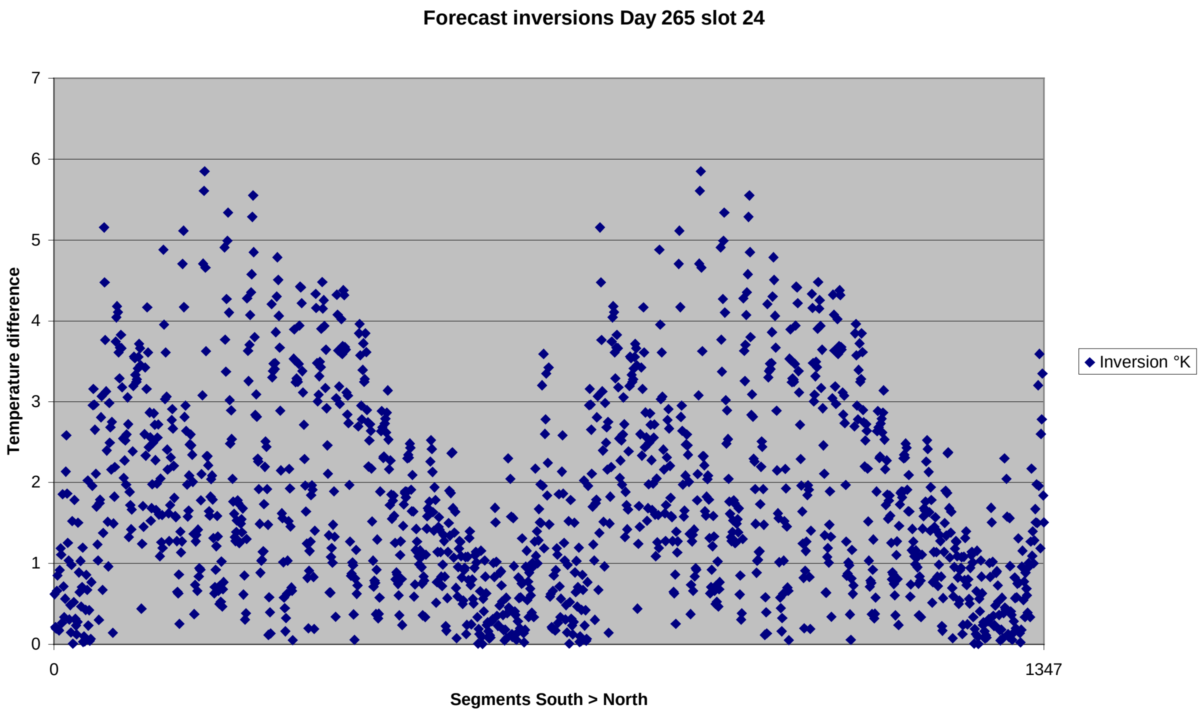
The picture to the left illustrates the geographical presence of inversions of any strength (The upper level temperature is warmer than the lower level) over a minimum inversion depth of 50 hPa. We can see that there is an inversion present in the subsidence areas, and that it is a quite unified field.



This picture illustrates the same but for inversions of strength at least 1°K over minimum 50 hPa. The number of segments affected is about 50% compared to the picture above.

It was also tested to restrict the inversion to be at least 100 hPa deep, but then only about 25 % of the segments remained. This corresponds with reality, the extreme inversions in the Atlantic are normally not very deep, frequently less than 50 hPa.

Even if in reality inversions of 10 - 15° K is quite common, and 20° K is not rare, we can not expect this in the forecast. The picture below illustrates the distribution of "inversion strength" in the forecast. We can see that the maximum strength is 5 - 6 degrees, and the subsidence areas and the ITCZ are easily recognised. (South to the left). A general experience is that the real inversion is 5 - 10° K stronger than the forecast inversion.



- Setting the parameter S to 1° K gives satisfying results in the centre of the subsidence are in the south Atlantic, but winds from the outer regions of this area (where we definitely still have inversion clouds) are unaffected. Also winds from the Canary Isles region are mostly unaffected, and still assigned a far to high level.
- Setting the parameter S to 0° K increases the affected area considerably, and now only winds processed from scattered clouds at the real edges of the subsidence areas are unaffected. The present CMW height reassignment scheme will remain for segments without inversion in the forecast data, and will positively affect segments with scattered clouds.
- No cases where a wind originally processed at a correct height has been reassigned to a clearly false height has been identified for any of the above settings. A few cases where a doubtful wind has been reassigned to an even worse height has been found, in most cases a failing semitransparency correction is the assumed reason.

As a result of our analysis above the following values for the parameters used for the definition of an inversion segment will be used:

- P_l = 50 hPa.
- P_h = 700 hPa.
- H = 50 hPa.
- S = 0.0° K.

These settings has proved to give a good coverage without any appearing negative effects.

After several discussions on where (vertically) in the forecast inversion to assign the wind, it was decided to use the height of the coldest level in the segmented forecast inversion (See picture 1). It was discussed to use the corresponding level from the raw ECMWF forecast, or to improve the interpolation to MPEF levels, but the improvement in height assignment isrelatively small. If the number of levels in the ECMWF forecast increases further, this may motivate another decision.

Since the segmented forecast has values every 50 hPa only, this means that winds affected of the inversion heigth correction, always will have a height beeing a multiple of 50 hPa.

4 Results.

In the beginning of January 1999, GRIB forecast data was finally implemented also on the operational chain, allowing comparisons with and without IHC applied.

The figures below are based on 24 hours of data, 16 CMW-products, from slot 25, 10. January, to slot 22 11. of January.

	Oper chain	**Test chain**
Total winds	80808	79628
Winds below 600 hPa	23175	22090
Winds affected by IHC		8598 (mean 537/slot)
Mean pressure for affected winds	751	883
Mean FC-consistency for affected winds	0.43	0.60

Another data set from the 13-14 January, slots 01, 13, 25, 37 was also tested:

	Oper chain	**Test chain**
Total winds	20711	20787
Winds below 600 hPa	6177	6255
Winds affected by IHC		2092 (mean 523/slot)
Mean pressure for affected winds	757	870
Mean FC-consistency for affected winds	0.49	0.62

It is noticeable that the number of VIS winds had increased on test chain. The reason is that some winds are moved down from above 700 hPa to a level below 700 hPa, and thereby accepted.

To filter out random effects winds with AQC-score < 0.3 was filtered out:

Mean pressure for affected winds	759	866
Mean FC-consistency for affected winds	0.51	0.66

And finally this dataset was divided in winds moved down resp. up:

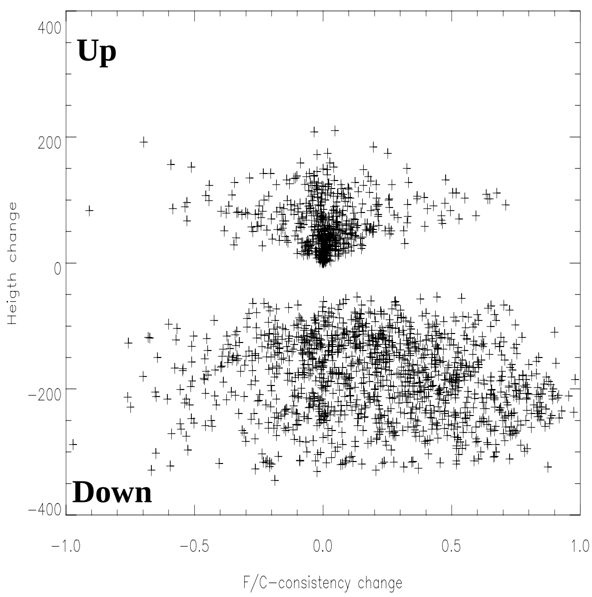
Mean pressure for winds moved down	699	881
Mean FC-cons. for winds moved down	0.43	0.64
Mean pressure for winds moved up	892	832
Mean FC-cons. for winds moved up	0.70	0.71

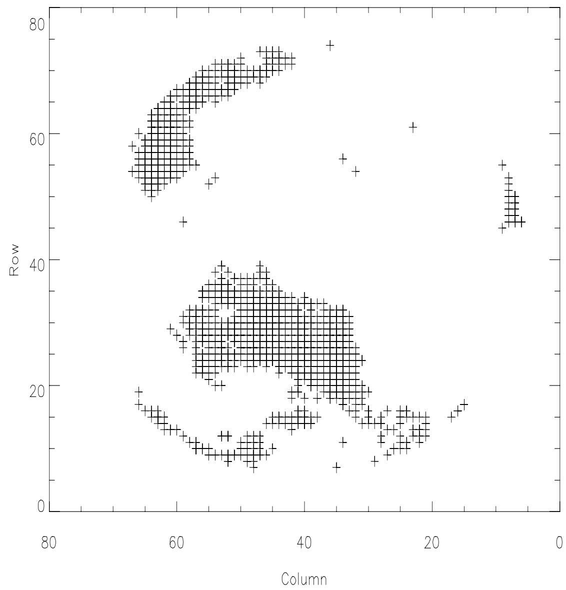
It is clear from the figures above that moving winds from a lower level up to the base of the inversion doesn't have any positive impact. This is also visible in the picture below to the left, and conforms with the theory that the vertical gradient for the wind should be small below the inversion, assuming mixing within the cloud. Since a move upwards indicates a cloud top well below the inversion, there are surprisingly many winds moved upwards. One situation where this can occur is if there are many small inversions not resolved by the forecast.

We can also see that a number of winds have a worse F/C consistency after correction. A study showed that these winds often have a large vertical wind shear in the forecast. A small vertical error in the CMW pressure will result in a very different F/C-consistency. Theoretically the major vertical wind shear should be located within the inversion, i.e. above the coldest point where we assign the wind, which was one of the reasons to assign the wind to that point. Below the inversion the vertical wind shear is expected to be smaller, as mentioned above. The wind below the inversion is also expected to be representative for the cloud movement.

The winds concerned also looks very good with relation to neighbouring winds and images, and would have past any manual quality control.

The conclusion for both the large number of winds moved upwards and winds having a worse F/C consistency after correction, is that this depends on limitations in the CMW processing, and/or the representativeness of the forecast, especially the vertical interpolation within MPEF.





F/C consistency change versus height change. Geographical distribution.

The gap in the vertical change, indicating a minimum down movement of 50 hPa, is explained by the height assignment method used in MPEF. The F/C profile is searched (upwards) for a temperature matching the cluster temperature, with the consequence that no wind is assigned a height within the inversion, which is minimum 50 hPa.

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