Determination of cloud flags on water vapour -sensitive channels

Reima Eresmaa and Anthony P. McNally
European Centre for Medium-range Weather Forecasts
Shinfield Park, Reading RG2 9AX, United Kingdom
R.Eresmaa@ecmwf.int

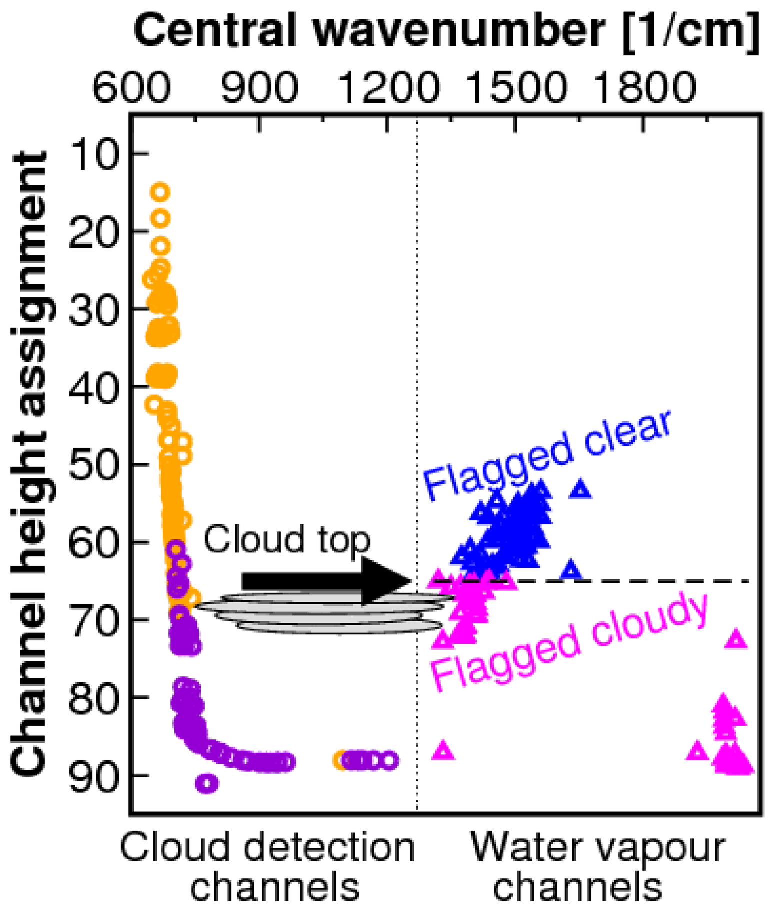

Figure 1. The cross-band option of the ECMWF cloud detection scheme.

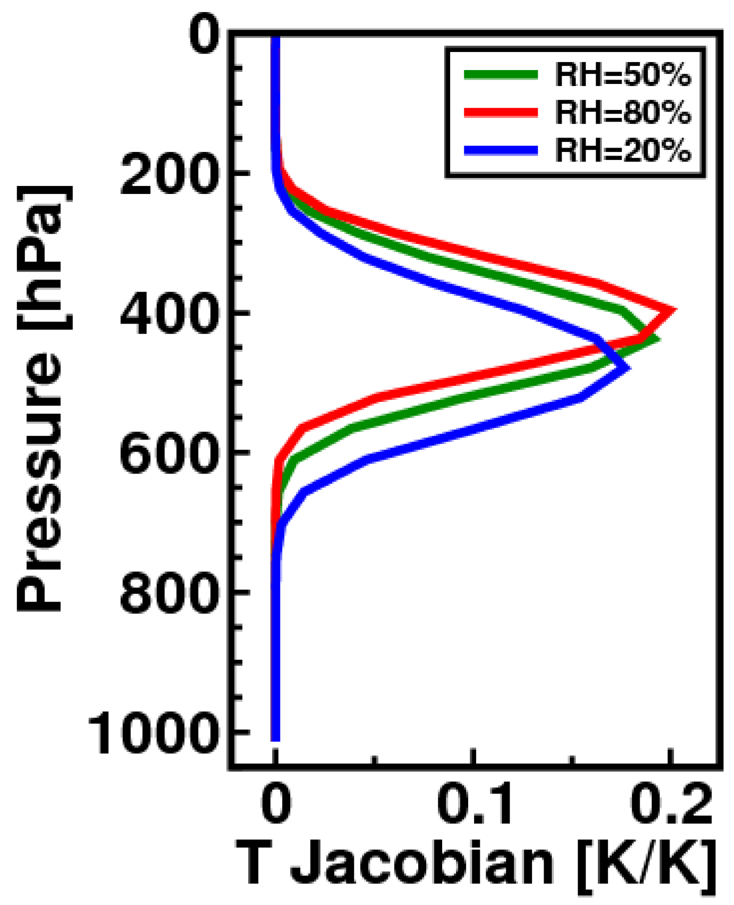

Figure 2. Temperature jacobians of a WV channel in different (tropical) humidity profiles.

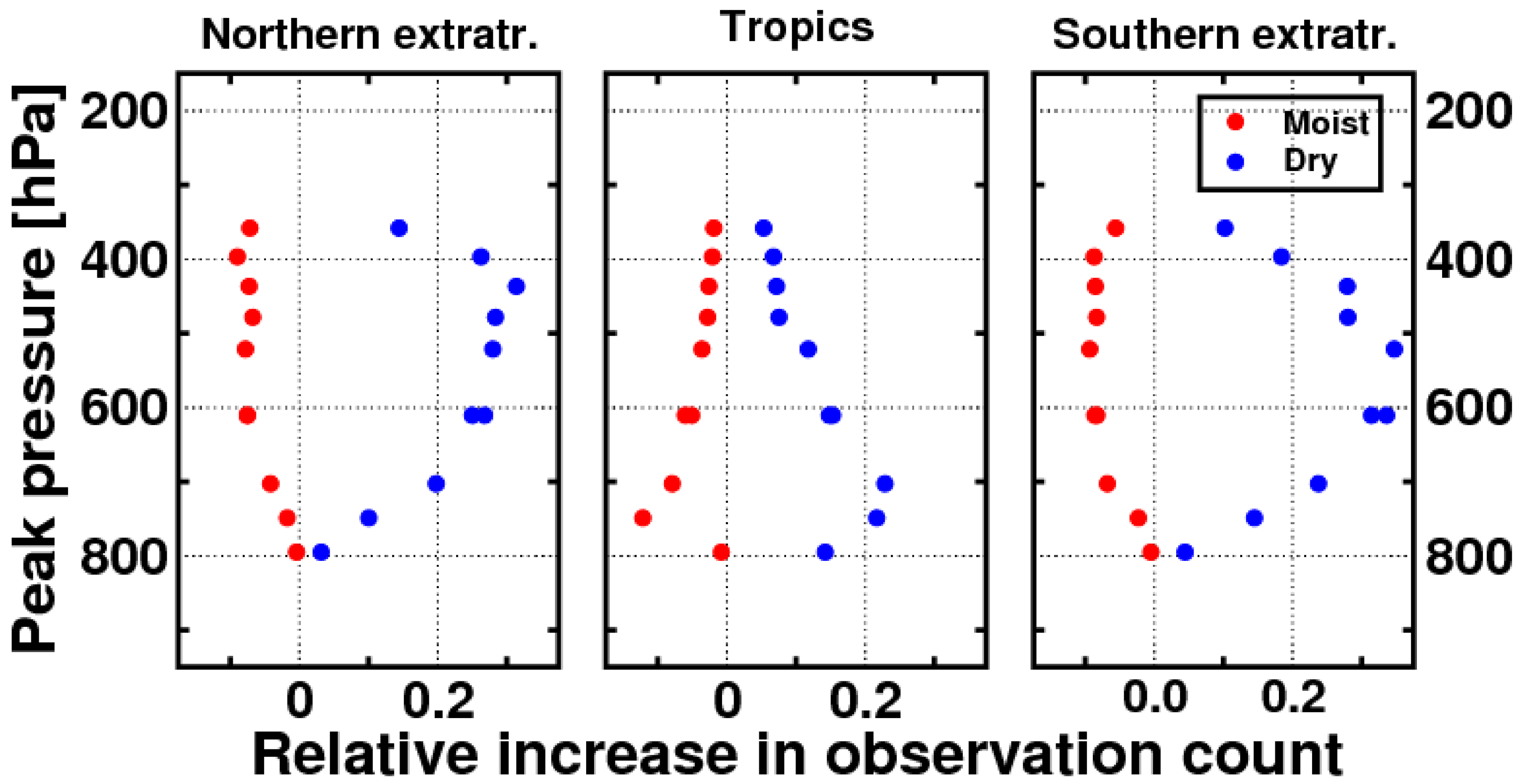

Figure 3. Relative count of active data on WV channels of IASI in experiments accounting for either moist (red) or dry (blue) background errors. The experiment covers 62 days in Northern-hemispheric winter.

Introduction

Use of IASI data in operational Numerical Weather Prediction (NWP) is almost exclusively restricted to clear channels. Incoming radiance data is screened in cloud detection, that is based primarily on background departure information. Setup of the cloud detection at ECMWF includes a set of long-wave channels for diagnosing the cloud top height and a cross-band option for extending the diagnosis to water vapour –sensitive channels (hereafter WV channels). In the cross-band option, situation-dependent height assignments of WV channels are compared with the diagnosed cloud top height as illustrated in *Figure 1*.

Reasoning of a potential problem

Weighting functions of WV channels depend strongly on atmospheric humidity profiles (see *Figure 2*). Weighting functions (and hence the channel height assignments) corresponding to the background can realistically differ from those representing the true atmospheric state to such extent that determination of cloud flags becomes suboptimal. Depending on the sign of the background error, there is a risk of either assimilating cloud-contaminated WV channels or unnecessarily rejecting useful clear WV channels.

Conservative approach: Accounting for a moist background error

In case of a moist background error WV channels are sensitive to deeper atmospheric layers than would be expected on the basis of background information. There is an increased risk of assimilating cloud-contaminated WV channels. One can reduce the risk by artificially reducing humidity while computing the channel height assignments. Some implications from taking such an approach are illustrated in *Figures 3* and *4*. The downward-shifted jacobians mean that count of active data on WV channels is decreased (red dots in *Figure 3*), but there is no consistent improvement in the fit of analysis to Microwave Humidity Sounder (MHS) data (red vs. green lines in *Figure 4*).

Aggressive approach: Accounting for a dry background error

In case of a dry background error WV channels are sensitive to higher atmospheric layers than would be expected on the basis of background information. Consequently, it is possible that some WV channels are unnecessarily declared cloudy, making the use of WV channels overly cautious. The risk of being overly cautious can be reduced by computing the channel height assignments assuming a saturated humidity profile, thus shifting jacobians upwards. This makes the use of WV channels increasingly aggressive (blue dots in *Figure 3*). A consistent improvement in the analysis fit to MHS data is found in all verification domains (blue vs. green lines in *Figure 4*). The improvement comes together with cooling and associated moistening in tropical boundary layer over Pacific and Atlantic Oceans (see *Figures 5* and *6*).

Discussion

The two approaches described above are opposite to each other and they cannot be adopted simultaneously. Impact on the analysis fit to MHS data suggests that accounting for dry background errors is the more beneficial approach of the two. This result can be understood by recalling that cloud only exists in state of saturation (with respect to either water or ice). As background humidity profile is rarely significantly super-saturated, existence of cloud is more often associated with dry than with moist background errors. The aggressive approach increases count of assimilated data immediately above cloud top, indicating towards potential for improving model description in cloudy regions.

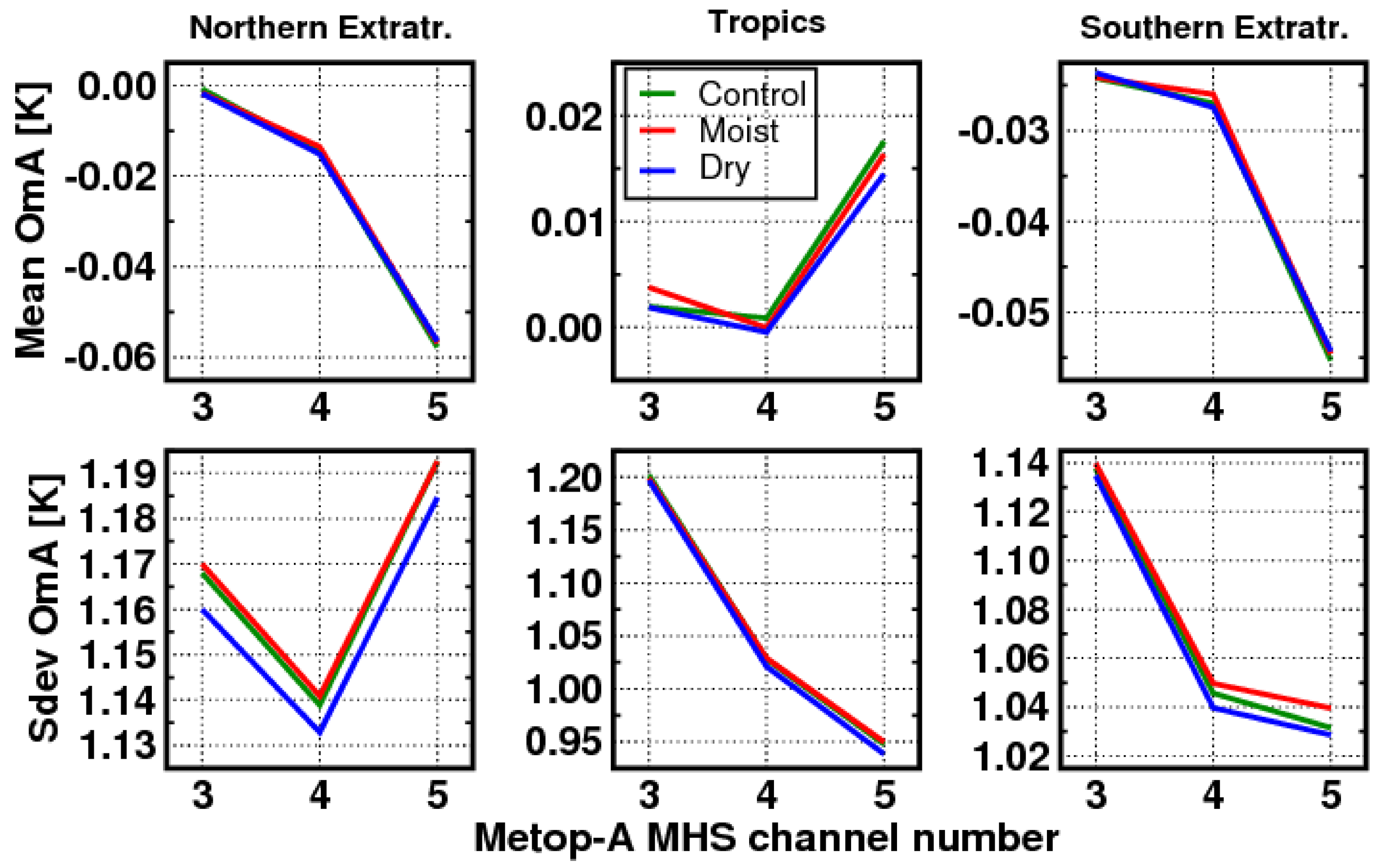

Figure 4. Analysis departure statistics for Microwave Humidity Sounder (MHS) on Metop-A satellite in a control run (green) and in experiments accounting for either moist (red) or dry (blue) background errors.

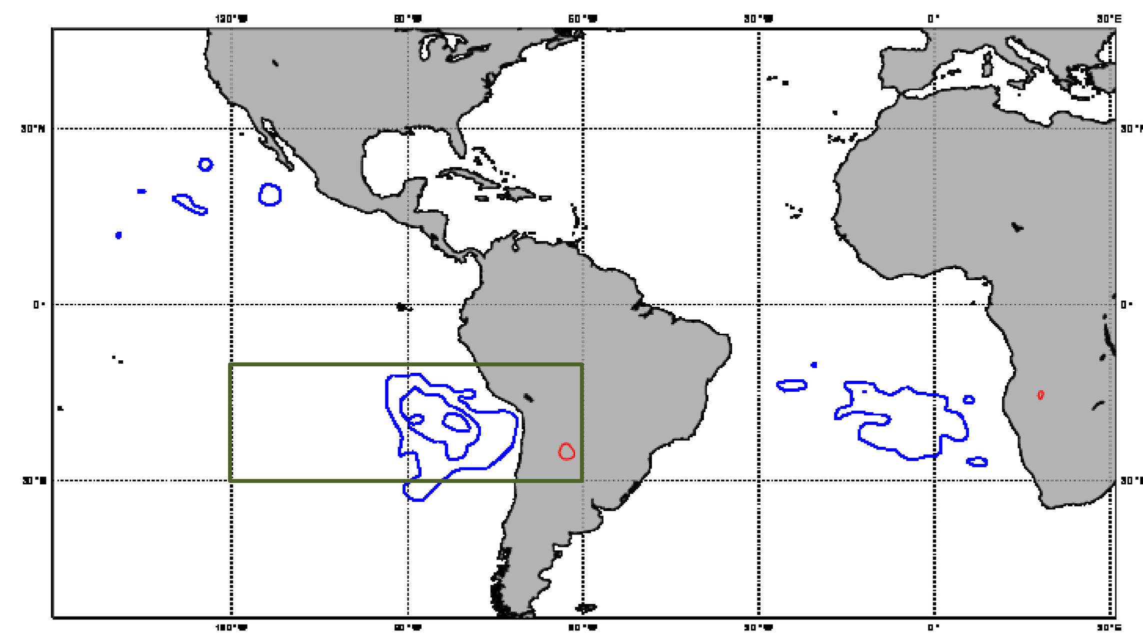

Figure 5. Impact of accounting for dry background errors on mean T850 analysis. Blue contours indicate cooling. Contour interval is 0.2K.

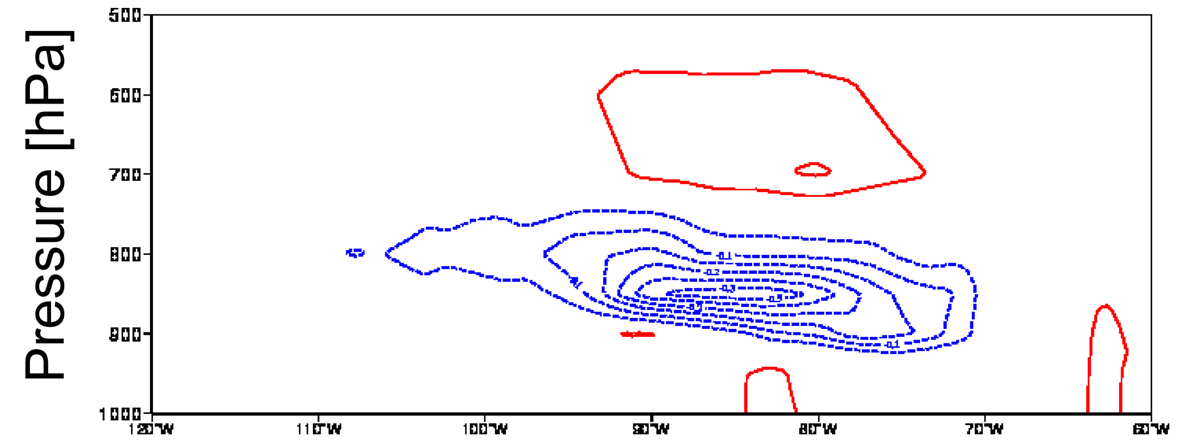

Figure 6. Impact of accounting for dry background errors on lower-tropospheric temperature within the rectangle shown in Figure 5. Contour interval is 0.05K.