Identification of biases in the modelling of high-peaking water vapour channels from IASI

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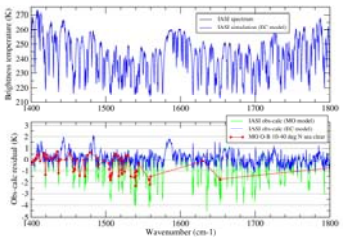
The modelling of strong water vapour emission lines from the Infrared Atmospheric Sounding Interferometer (IASI) on MetOp has been investigated. Studies from international research aircraft campaigns have been used to validate IASI radiances and identify sources of error in the radiative transfer modelling. In this poster, biases for high-peaking water vapour lines identified in the research aircraft case studies are analysed for consistency with operational biases from the Met Office and ECMWF. Differences in the observed biases for the two operational centres are explored in relation to differing schemes for the treatment of upper atmospheric humidity.

1. JAIVEx case study over Gulf of Mexico

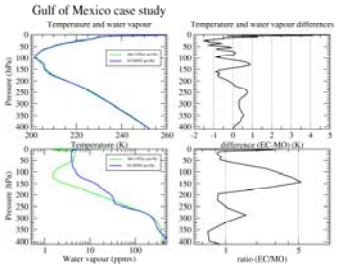
The **J**oint **A**irborne **I**ASI **V**alidation **Ex**periment (JAIVEx) was based in Houston, Texas during April and May 2007, combining in-situ and remote measurements from two instrumented aircraft (FAAM BAe 146 and NASA WB-57), radiosondes, dropsondes and ground based observations from the ARM Southern Great Plains facility, Oklahoma. For this work the "true" profile for the lower atmosphere is derived from dropsonde observations, with Met Office and ECMWF model fields used for upper atmosphere information.

FAAM flight B290 on 30 April 2007 was conducted over the Gulf of Mexico, with a coincident MetOp overpass at 1529 UTC. The figure below shows results from the strong water vapour band 1400-1800 cm^{-1}, where IASI observations are compared with line-by-line simulations.



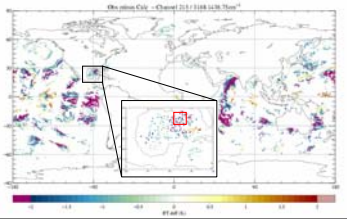
The residual brightness temperature differences across the water vapour band differ depending on the model fields used for the upper atmosphere; ECMWF fields produce a slight positive bias, whereas Met Office fields produce a negative bias. The latter is well matched by the observed-background (O-B) residual in red, generated from Met Office assimilated IASI fields of view over a larger area (10-40° N clear sky over sea for 30 April 2007).

The figure below compares the Met Office and ECMWF temperature and water vapour fields, matched to the case study location and time. The temperatures do not differ greatly, but the Met Office water vapour field exhibits a distinct dry bias relative to ECMWF, leading to the observed negative brightness temperature bias for IASI.

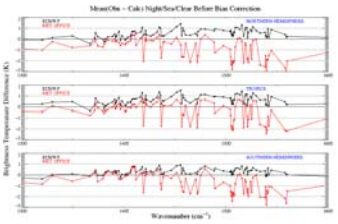


2. How globally representative is the JAIVEx case study?

The bias of the Met Office model in the area of the JAIVEx case study is not atypical. The plot below shows 18 hours of Observation – Calculation difference for the Met Office model on 30/04/07: most of the globe shows a negative bias. The JAIVEx study area is indicated with a red box in the inset plot.

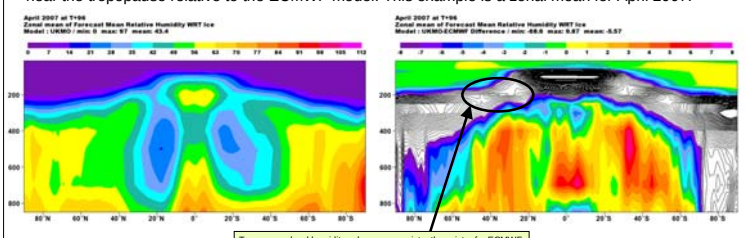


This plot compares IASI-model bias between the Met Office and ECMWF for all clear, night-time, sea observations on 30/04/07. Unlike ECMWF, the Met Office model has a large negative bias for the high-peaking channels for all latitude bands. The ECMWF data shows a small positive bias for most channels.



3. Can we see any bias in the global model water vapour fields?

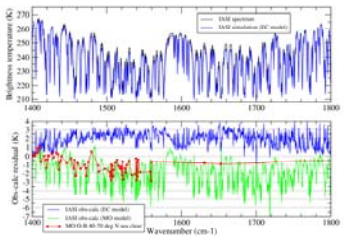
Comparisons of the model fields themselves show that the Met Office Unified Model is extremely dry near the tropopause relative to the ECMWF model. This example is a zonal mean for April 2007.

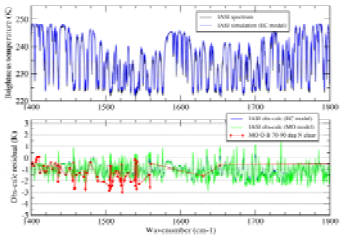


4. Midlatitude winter and Arctic winter case studies

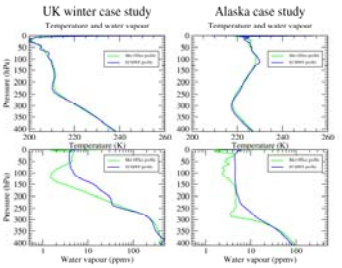
The FAAM BAe 146 has also underflown MetOp in other, contrasting climatological zones. FAAM flight B332 on 12 December 2007 was conducted off the northwest coast of Scotland, while flight B350 occurred during the CLPX-II campaign in Alaska on 26 February 2008. These cases are useful for analysing whether the results from JAIVEx are globally representative and whether there is any seasonal variability in the results.

Observed and modelled clear sky IASI brightness temperatures for the UK midlatitude winter case are shown below. The residuals diverge markedly depending on the upper atmosphere profile used in the line-by-line simulations; once again a slight positive bias is observed for ECMWF fields, with a negative bias for Met Office fields (corroborated by 40-70° N clear sky over sea Met Office O-B residual in red).

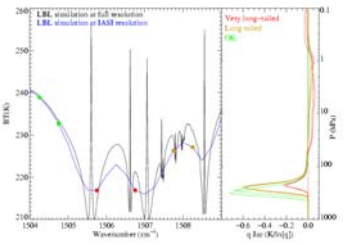




While the residuals for the Met Office and ECMWF fields do not differ greatly for the Alaska case (above), the Met Office O-B negative bias persists. A comparison of model fields (below) shows a consistent Met Office dry bias around the tropopause level.



5. High-peaking channels in operational assimilation



The channels which show the worst bias are typically close to water vapour line centres.

Although assimilation of IASI data could help to correct the model bias, these channels cause problems for operational assimilation. Their Jacobians show that they are sensitive to water vapour throughout the atmospheric column.

A large model bias in the stratosphere leading to an observation-background difference can result in an erroneous humidity increment in the mid-troposphere.

6. Summary

Comparisons between IASI data and Met Office and ECMWF model profiles have helped to identify a large and previously unrecognised dry bias in the Met Office global model near the tropopause. This bias is present all year round and across all latitude ranges. In contrast, the ECMWF model tends to show a small moist bias.

It is likely that the Met Office dry bias arises because the data assimilation scheme constrains the stratospheric water vapour to be between 1 and 3 mg/kg. The stratosphere has a simple definition in the scheme, identified by a globally constant value of potential vorticity. This definition can lead to increments in the upper troposphere which tend to dry the model, particularly in the extra-tropics (David Jackson, 2008, pers. comm.).

A new project aims to address the upper-tropospheric/lower-stratospheric humidity increments by introducing a new moist control variable in 4D-Var which is normalised by the variance of the relative humidity at each model level.

7. Acknowledgements

This work has been partially funded under EUMETSAT contract Eum/CO/06/1596/PS. The FAAM BAe 146 is jointly funded by the Met Office and the Natural Environment Research Council. The US team was sponsored by the National Polar-orbiting Operational Environmental Satellite System (NPOESS) Integrated Program Office (IPO) and NASA.

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