Retrieval of tropospheric specific humidity profiles with high vertical resolution from Radio Occultations

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ROM SAF

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Outline

Introduction to RO
- Example profiles

Applications
- NWP

EUMETSAT context

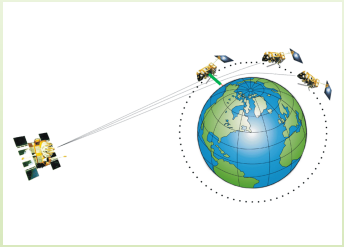
Retrieval method
- 1D-Var
- Sensitivity

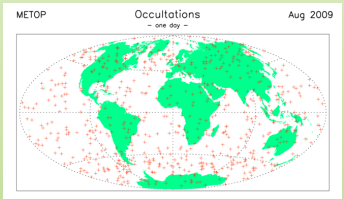
Comparison to model and radiosondes

ROM SAF Reprocessing # 2

Summary

The RO technique





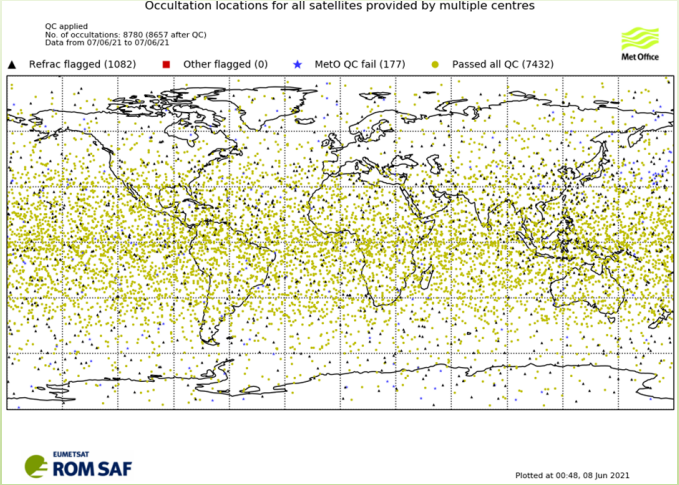
Bending angle $\rightarrow$ Refractivity

$$N = k_1 \frac{P_{\text{dry air}}}{T} + k_2 \frac{P_{\text{water}}}{T} + k_3 \frac{P_{\text{water}}}{T^2}$$

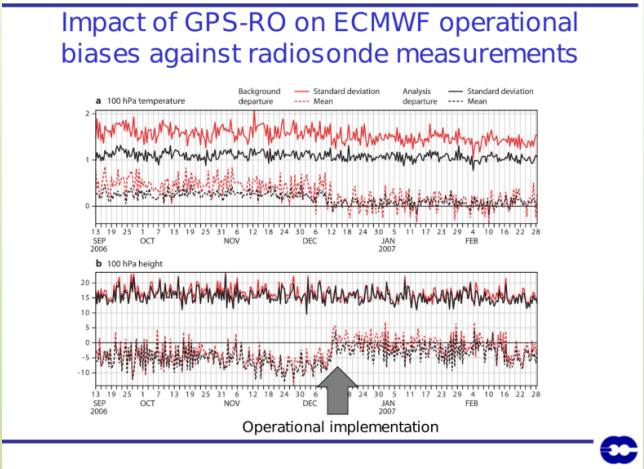
600-700 daily profiles per LEO

- Vertical resolution < 250 m
- Horizontal resolution < 300 km

Combined daily coverage



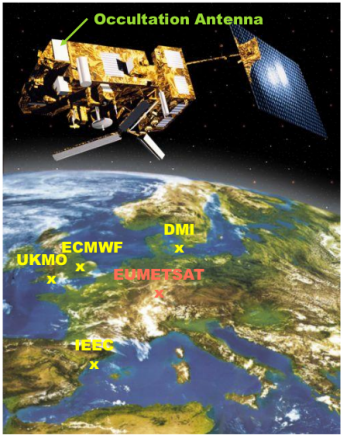
Anchoring the model



(Sean Healy 2015, ECMWF)

EUMETSAT context

CDOP-3 Konsortium



Leading Entity:

(DMI, Copenhagen, DK)

Partners:

(ECMWF, Reading, UK)

(Institute d'Estudis Espacials de Catalunya, IEEC, Barcelona, Spain)

(Met Office, Exeter, UK)

1D variational retrieval of tropospheric humidity:

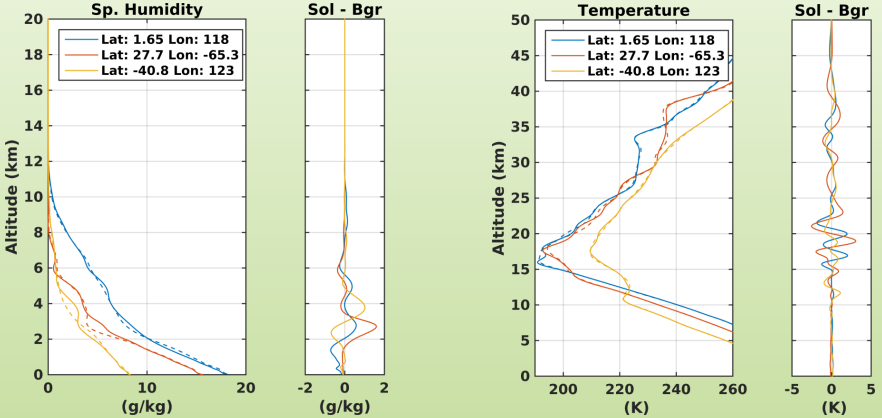
$\mathbf{x}$ = (temperature, sp.humidity, sfc. pressure), $\mathbf{x}^b$ = model background
$\mathbf{y}$ = refractivity profile
$\mathbf{H}$ = forward model
Minimize this by varying $\mathbf{x}$:

$$J(\mathbf{x}) = \frac{1}{2}(\mathbf{x} - \mathbf{x}^b)^T \mathbf{B}^{-1}(\mathbf{x} - \mathbf{x}^b) + \frac{1}{2}(\mathbf{y} - \mathbf{H}(\mathbf{x}))^T \mathbf{O}^{-1}(\mathbf{y} - \mathbf{H}(\mathbf{x}))$$

Estimation of $\mathbf{O}$ and $\mathbf{B}$ matrices is crucial

Example of retrieved T/q profiles

3 random occultations



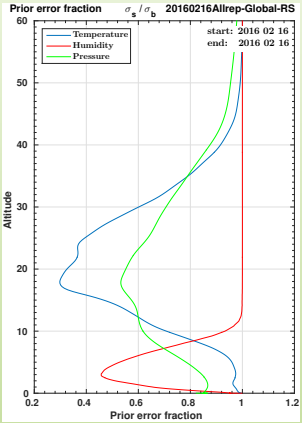
Full curves: Retrieval - Dashed curves: Background

Sensitivity

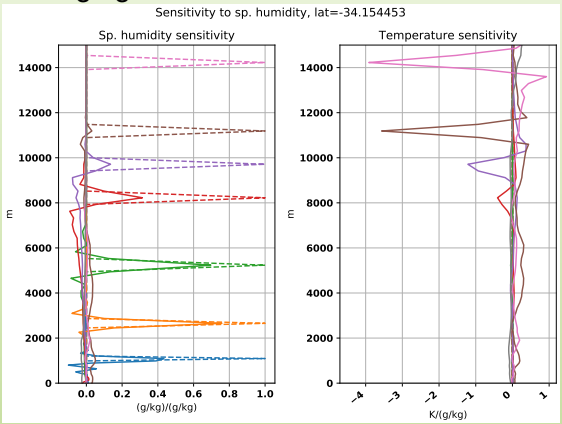
Prior fraction:

$\sigma / \sigma_{\text{background}}$

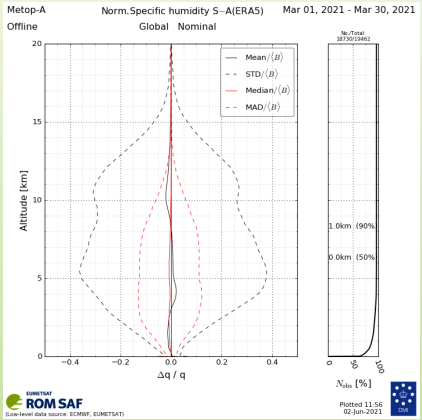
$\rightarrow$

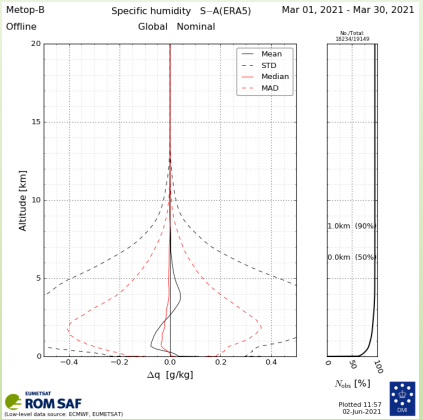


Averaging Kernels



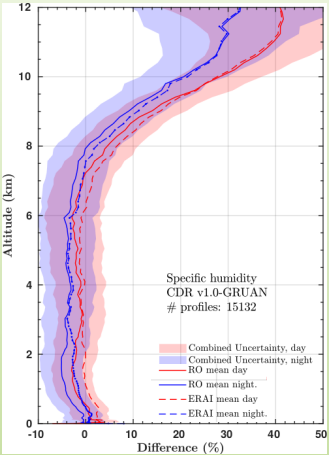
Comparison against ECMWF analysis (one month)

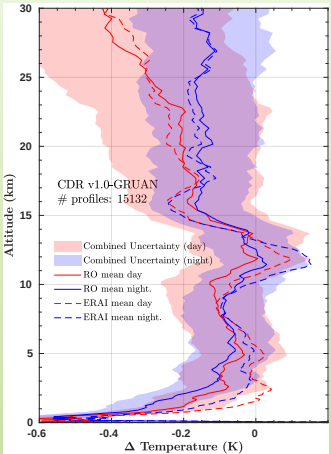




Aavailable at https://www.romsaf.org

Comparison to GRUAN radiosondes

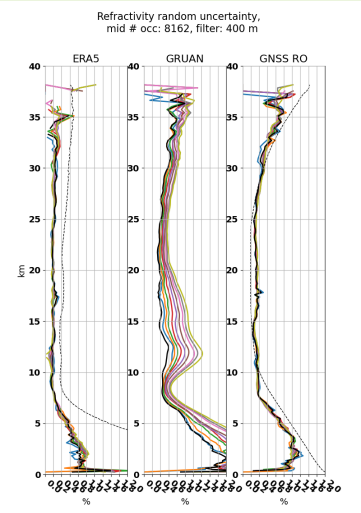




Estimated uncertainty dominated by systematic GRUAN uncertainty.

ROM SAF Reprocessing # 2

- In preparation
- Top down estimate of error covariances →
- Based on ERA5



←
3 cornered hat estimate of observation error.
Model, RS and RO
Colors correspond to different collocation criteria 300-100km.

Summary

- RO complements conventional satellite retrievals
- Good humidity accuracy and good vertical resolution in mid troposphere
- ROM SAF Reprocessing #2 will contain improved uncertainty characterization