Initial assessment of GNSS-RO data from Spire

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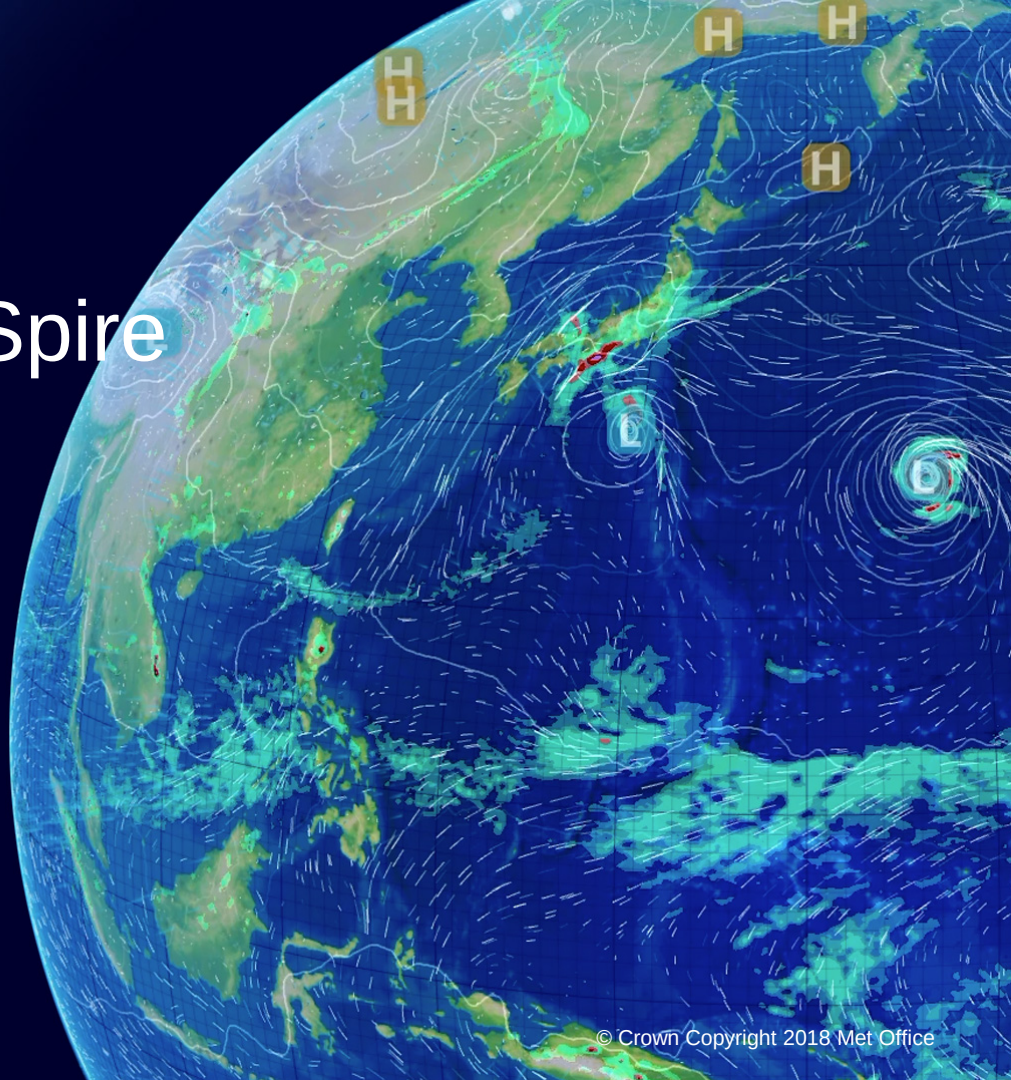
Met Office

(following discussions with Vladimir Irisov, Dallas Masters and Tim Duly)



Funding

- ESA ARTES program
- Pioneer project – Space as a Service
- Funding for Spire to build up to providing 5,000 observations per day over a sustained period (and 10,000 obs/day for a short period)
- Met Office making quality assessments using comparisons with Met Office short-range forecasts
- Work began in early June 2018

Met Office

Contents

- Issues in early data assessment
- Current assessment
  - Data volumes and timeliness
  - Comparisons with other satellites
  - GNSS constellation
- Conclusions

Data Processing

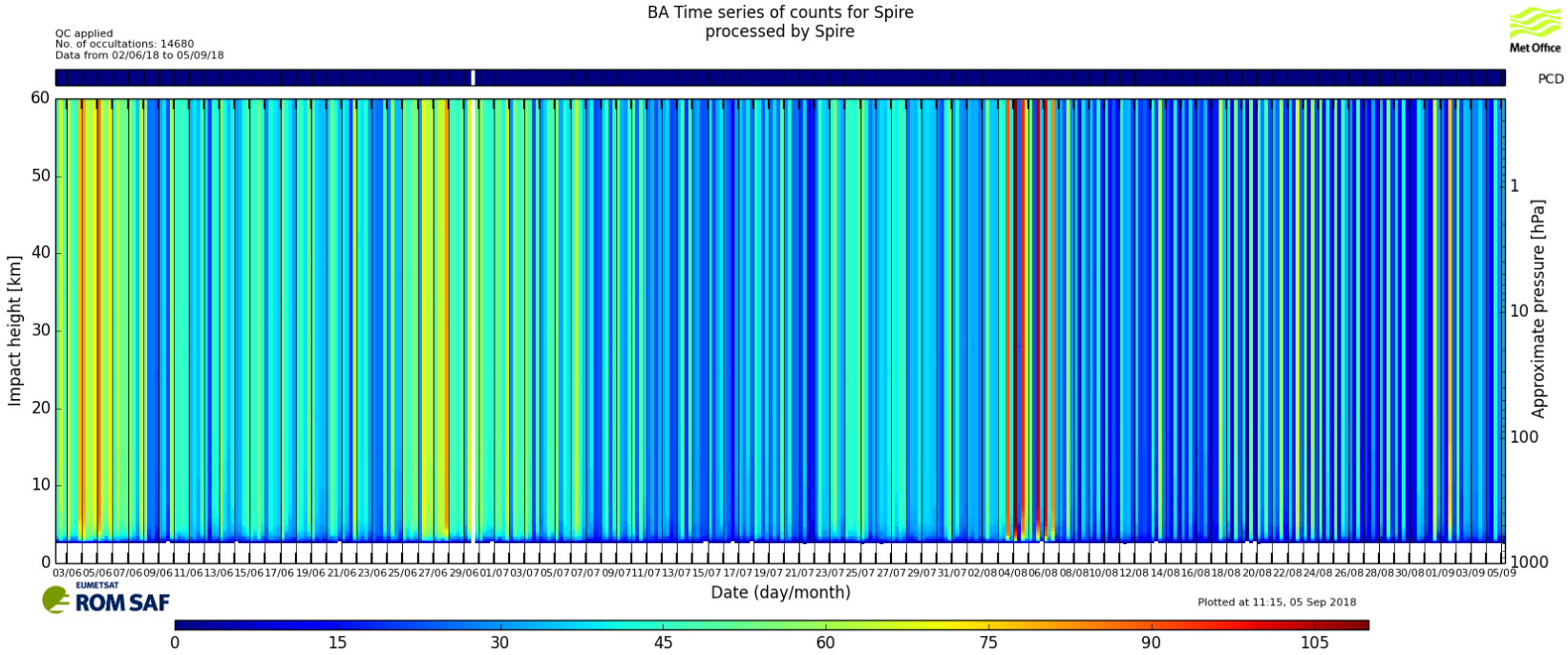
- Extract observations and operational short-range forecast (between 3-9h)
- Calculate refractivity and bending angle from model
- Compare
- Accumulate stats: typically (O-B)/B

- Using the same software as for ROM SAF website
- Focus here on bending angle

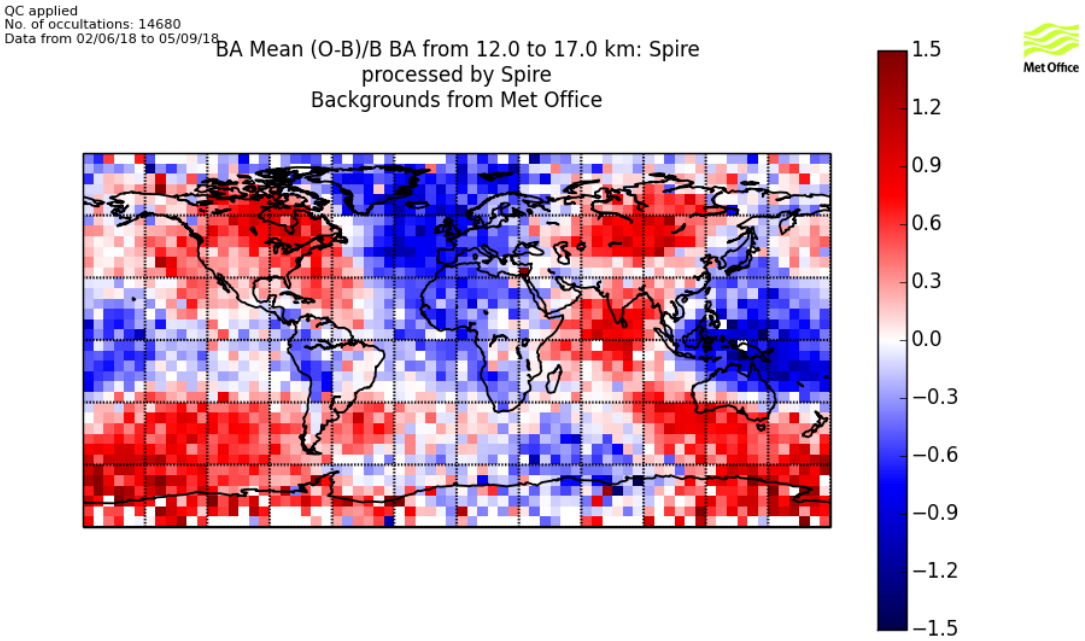
Early assessment

Data volumes

- 154 occultations per day
- Compared with Metop (~670) FY-3C (~415)
- Cycle to cycle variation less than ideal

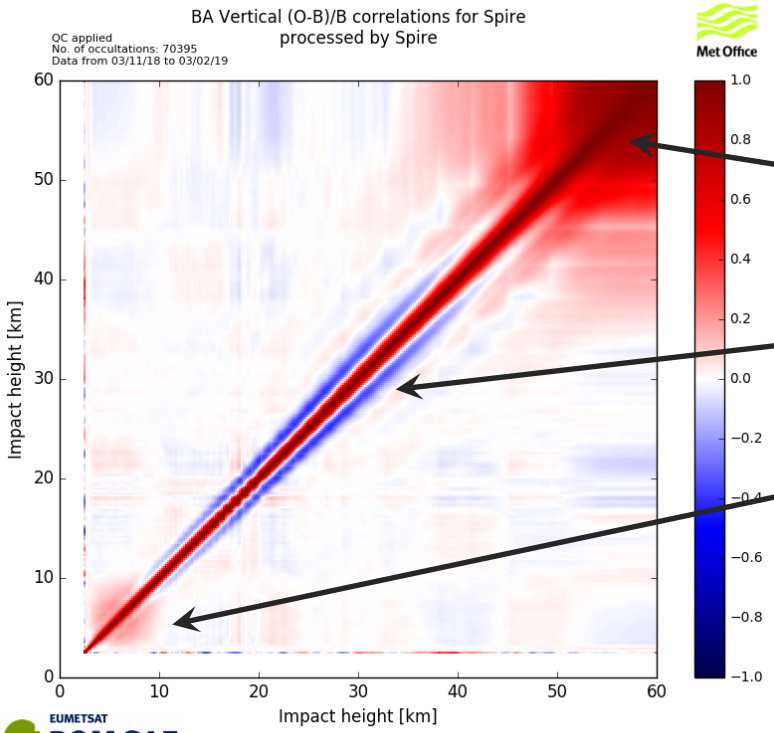


Mean departure (O-B)/B – Spire



- 3-month average of the mean departure
- Curious pattern in the bias
- Undulation?
- Related to differences in the definition of radius of curvature

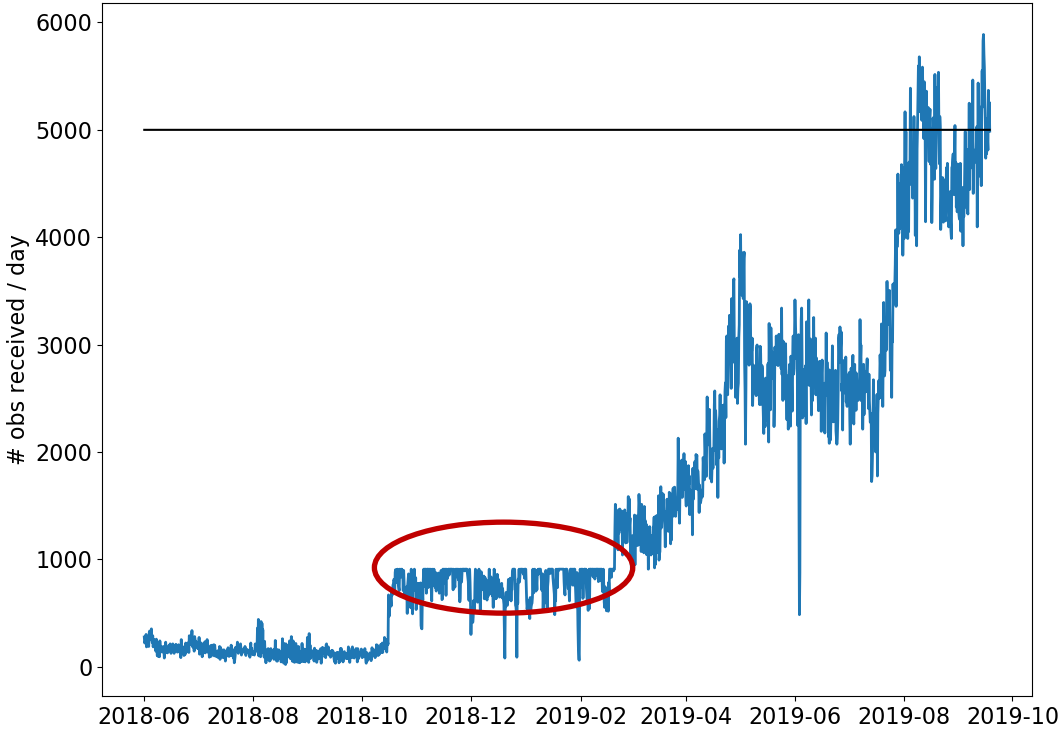
Vertical correlations – Spire (second iteration)



- Looking for small vertical correlations in (O-B)/B
- Long-range correlations above 40km
- Comparable correlations to COSMIC around 30km
- Longer-range correlations in troposphere

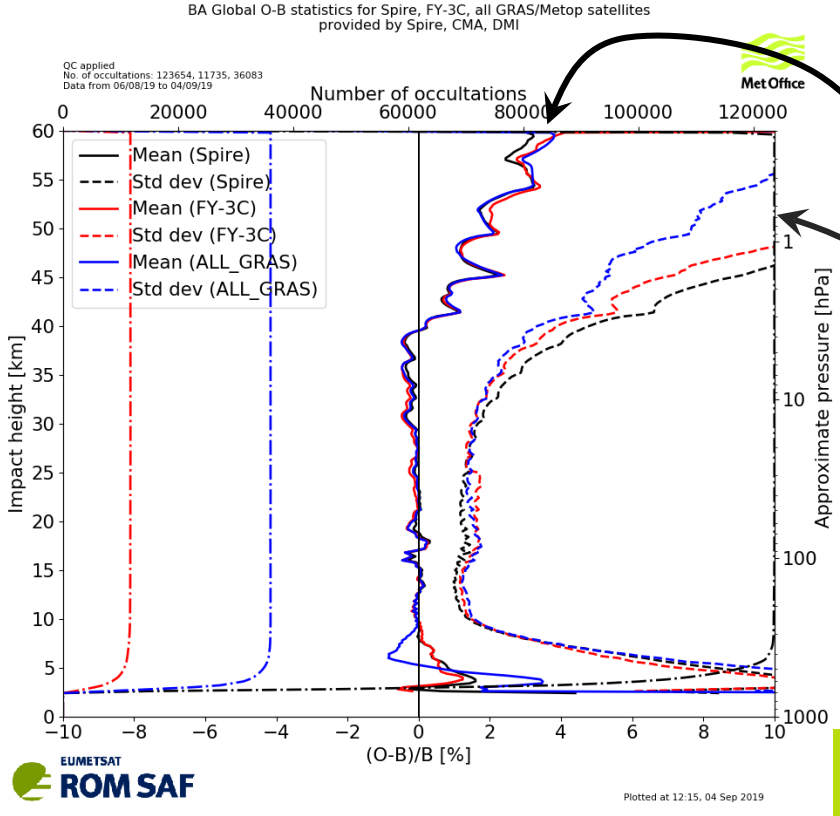
Current assessment

Data volumes



- Number of observations received per day
- A small number of outages have been seen, but are not plotted
- Volumes are close to the target 5000 / day
- (cap late 2018: due to limit in MO software)

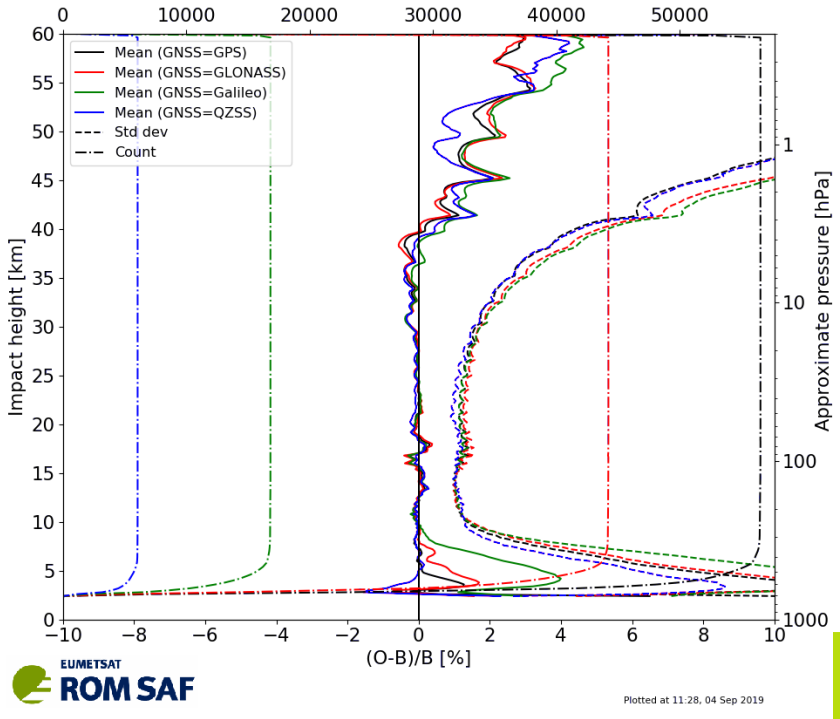
Global mean and standard deviation



- Comparing Spire, Metop and FY-3C satellites
- Biases very similar
  - Troposphere – known bias of Metop data
  - No issues for Spire or FY-3C
- Standard deviations
  - Larger above 40km
  - Smaller in core region
  - Similar in troposohere

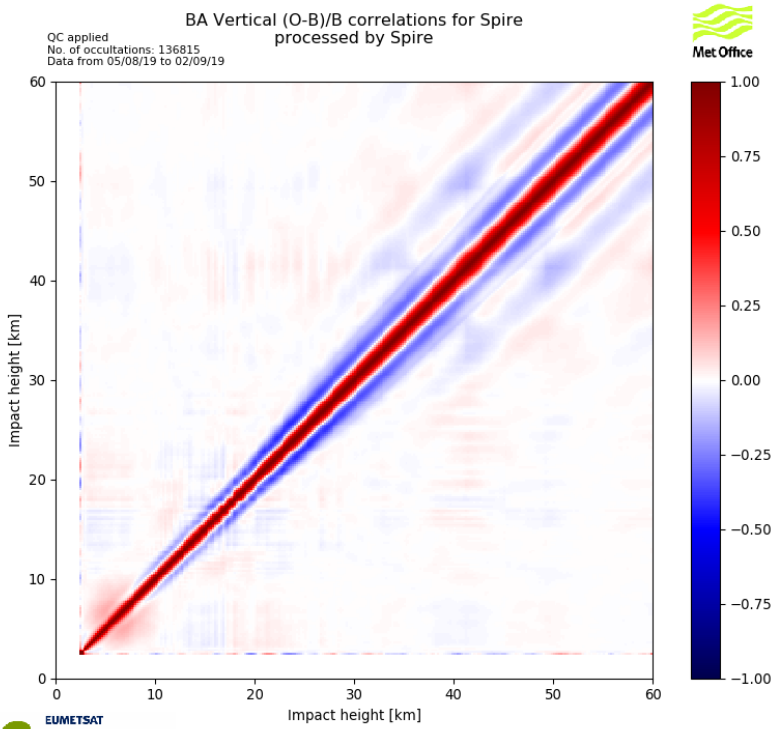
GNSS classification

136443 obs
05/08/19 – 03/09/19



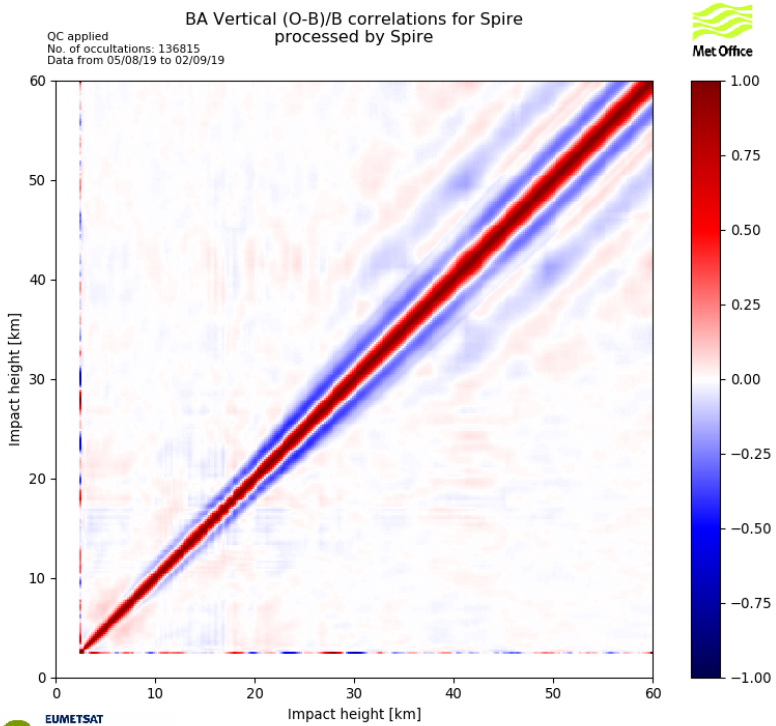
- Number of observations
  - GPS > GLONASS > Galileo > QZSS
  - Related to number of transmitting satellites, and other considerations
- Somewhat similar biases
  - Above 40km – a bit confused
  - Troposphere
- Some differences in standard deviations
  - Galileo larger above 30km and in troposphere
  - GLONASS larger in core region and above 30km
  - QZSS generally smallest (latitudinal sampling)

Vertical correlations – all Spire satellites



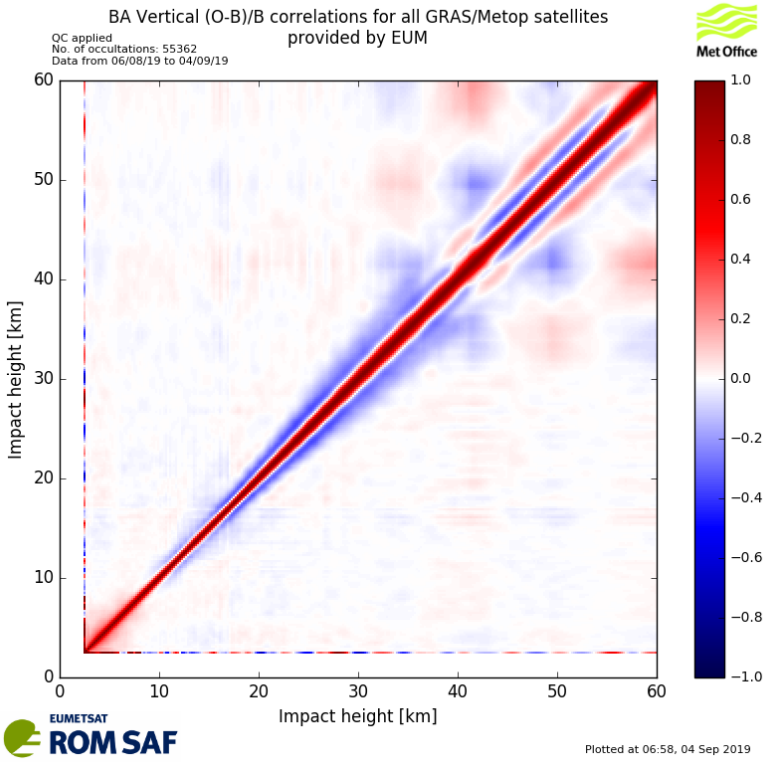
- Long-range positive correlations are gone
- Generally clean
- Long-range positive correlations in troposphere

Vertical correlations – 3 of more recent sats



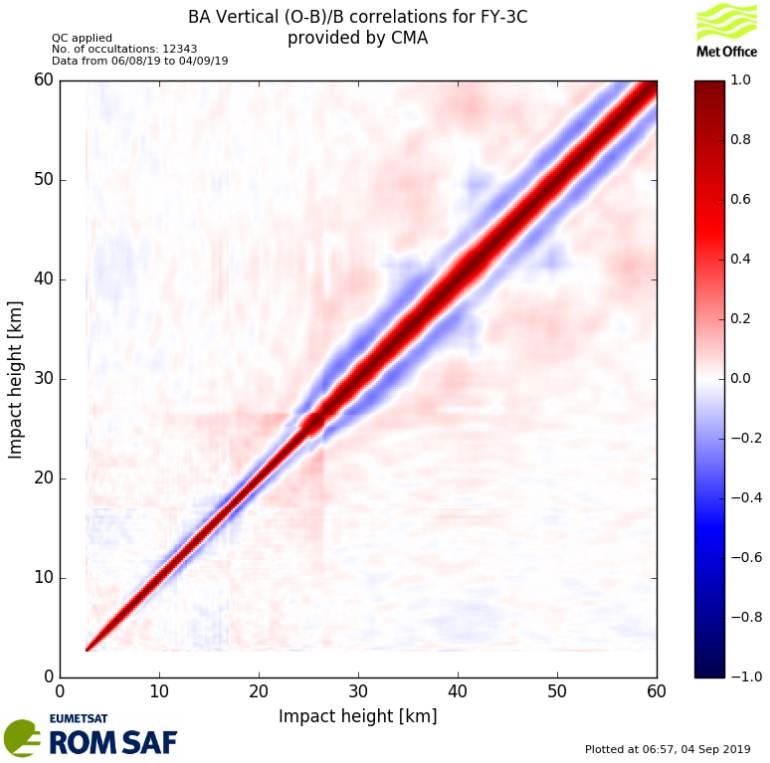
- Latest satellites smaller long-range correlations in troposphere
- Generally clean
- Slightly longer-range correlations in core region than Metop

Vertical correlations – all Metop



- Metop has odd correlation structure above 40km
  - Related to behaviour over winter pole
- Correlation structure generally short-range
- Moderate long-range correlations in troposphere

Vertical correlations – FY-3C

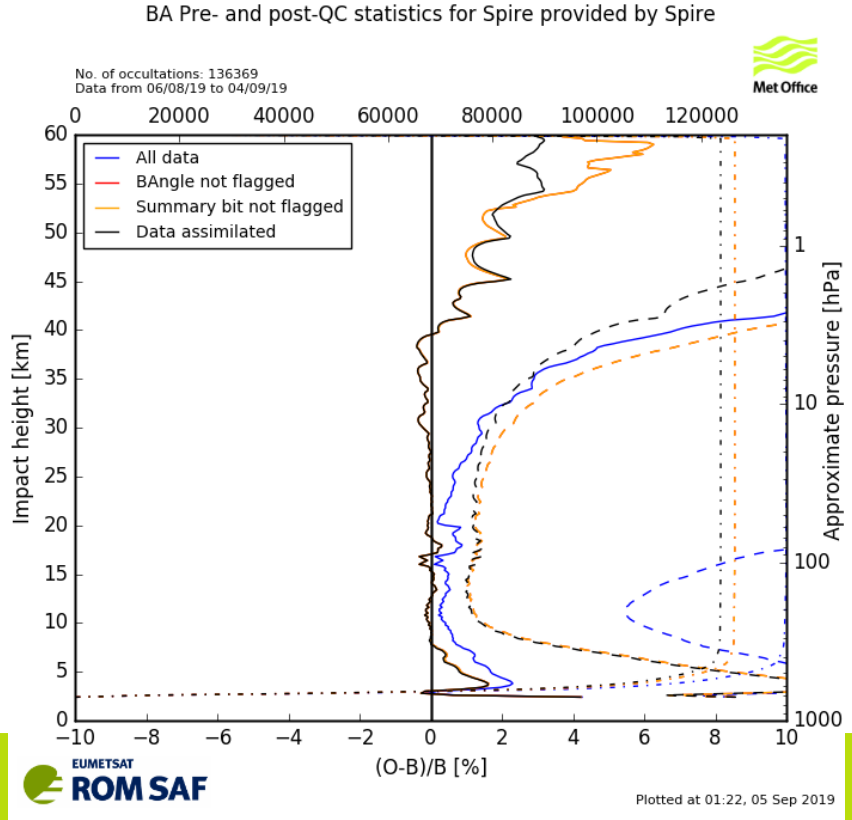


- Clean correlations in troposphere
- Generally some positive long-range correlations

Conclusions

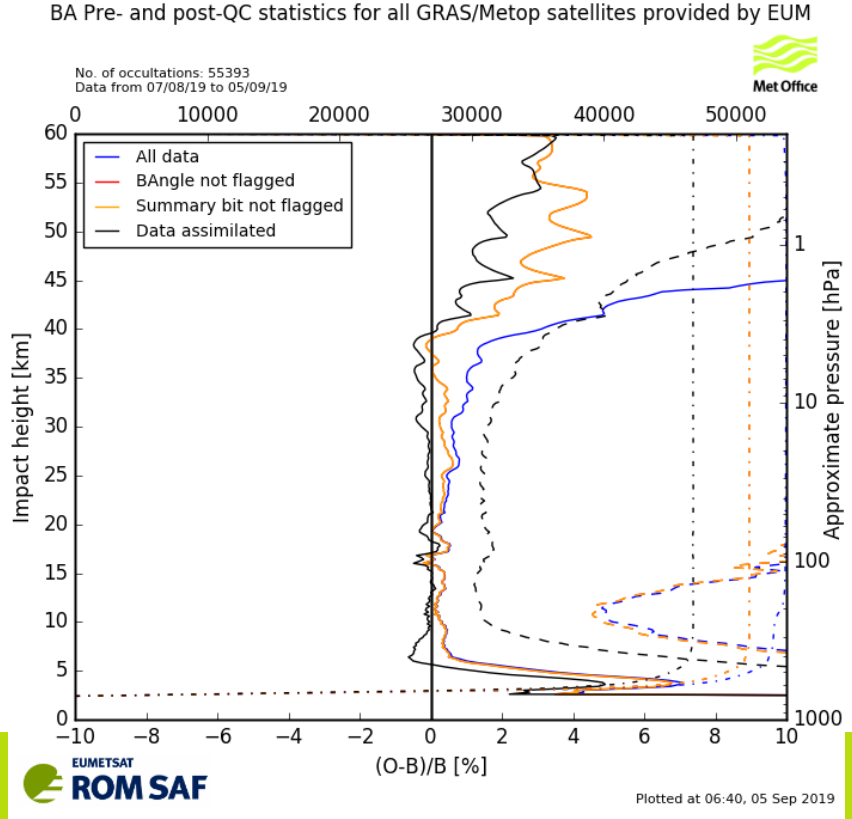
- Been assessing Spire RO data for over 1y
- Early data showed some serious issues
  - Now fixed
- Overall quality similar to established satellites
  - Similar bias and standard deviations in many places
- Outstanding points
  - Some biases / correlations in tropospheric Galileo data
    - Improved (but not entirely fixed) with later satellites
  - Some FMs have different performance to others
  - Data not as timely as we would like
- Assimilation trials

Before/After QC - Spire



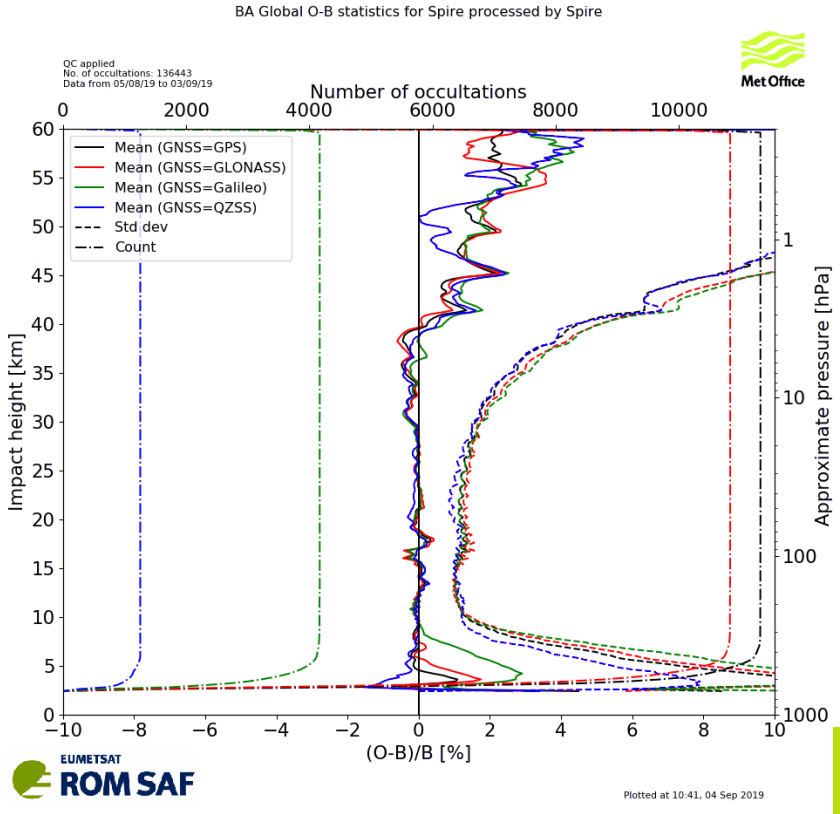
- Spire QC removes most of the poor observations
- Met Office QC removes a few more
- Performs well without removing large numbers

Before/After QC - EUMETSAT



- EUMETSAT QC removes smaller number of poor occultations
  - Clearly some poor occultations remain
- More removed by Met Office QC
- Final percentage similar

GNSS classification – some of newer sats



- Newer satellites
- Slightly reduced bias and standard deviation for Galileo in troposphere