Impact of new GNSS-RO datasets Spire and COSMIC-2

Living Planet Symposium 2022 in Bonn

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https://earth.esa.int/eogateway/missions/spire/description

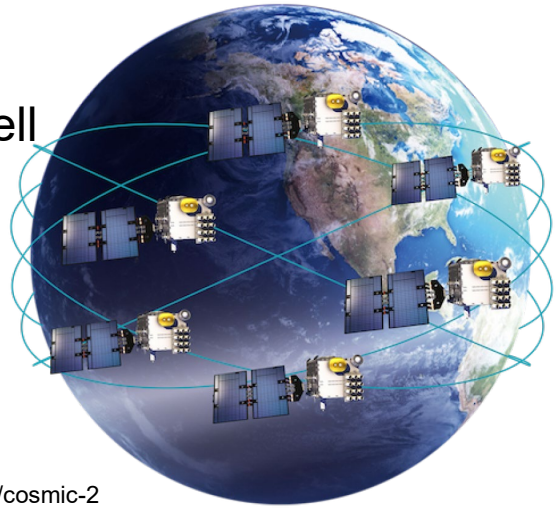
Spire and COSMIC-2 data

Spire

- Collected using their constellation of 3U cubesats, with the nominal lifetime of these satellites being 2+ years.
- Regularly new satellites are launched with an updated hardware [Masters et al., 2019].
- Spire develops the satellites and the GNSS receiver themselves

COSMIC-2 (Constellation Observing System for Meteorology, Ionosphere & Climate – 2)

- Follow up mission from COSMIC-1, which was was very successful.
- Cluster of six satellites were launched on June 25, 2019 and spreads along different low-inclination orbits.
- The main aim of this mission is to obtain temperature and humidity information as well as having a substantial contribution to space weather.



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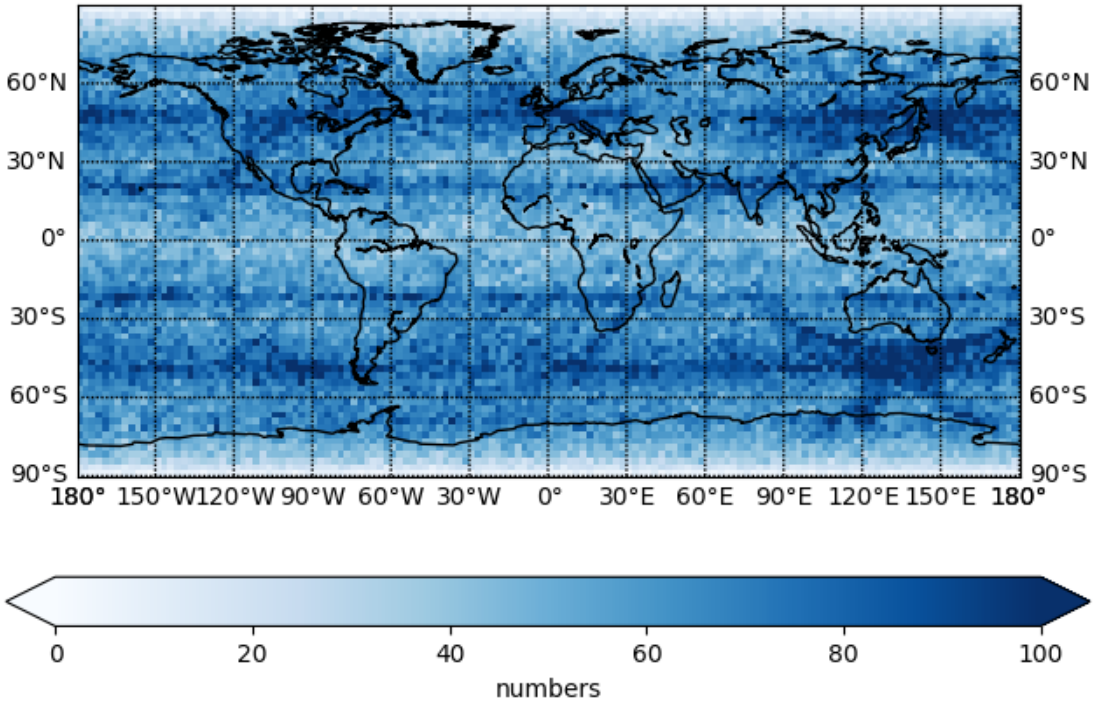
https://www.cosmic.ucar.edu/global-navigation-satellite-system-gnss-background/cosmic-2

Spatial distribution of GNSS-RO data

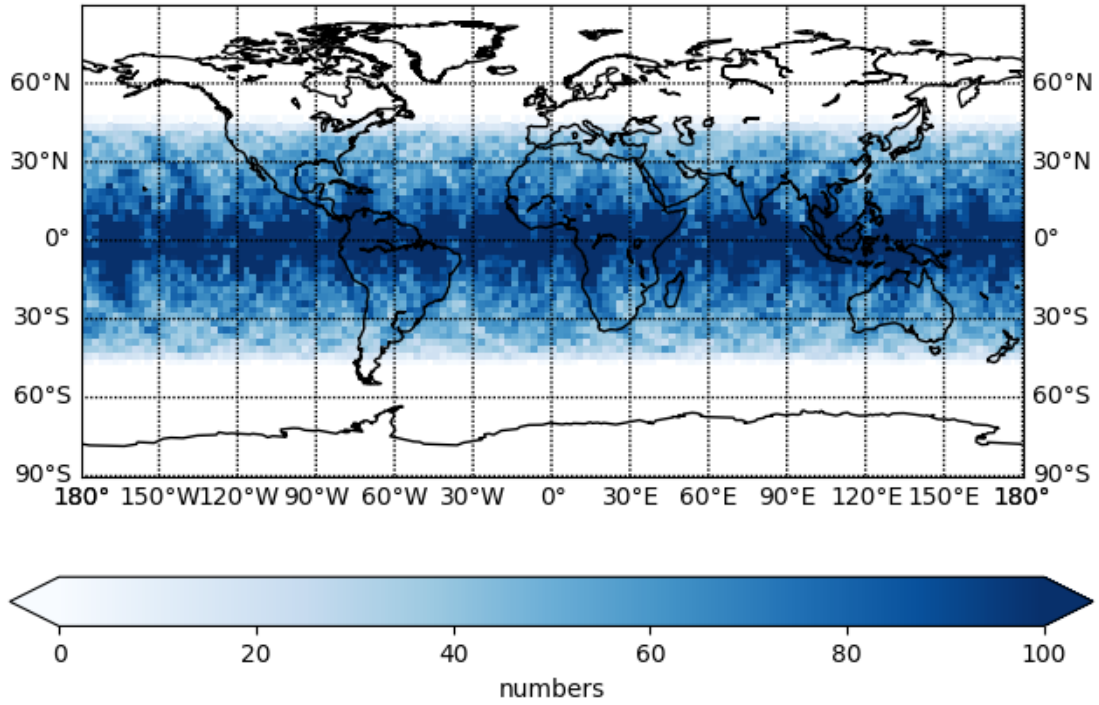
Jan,Feb,March 2020

(gridded to 2.5 x 2.5 lat/lon)

Spire



Cosmic-2



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First set of OSEs: ESA study

ESA Contract No. 4000131086/20/NL/FF/a

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How is Spire and COSMIC-2 assimilated?

	ECMWF
Bending angle operator	2D
Observation error model	global bending angle error statistic
Bias correction	no
Usage of data	Assimilated from surface to 50km impact height
Model	IFS CY47R1, Tco399 (25 km spacing)
Data assimilation cycle	12h
Experiment period	1 Jan – 31 March 2020
Spire & COSMIC-2 data	about 5500 & 4000 occ/day

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* ECMWF only

Data assimilation experiments

– CTL: Operational data available for the period, including the GNSS-RO data
(e.g. ECMWF:3*Metop GRAS, KOMPSAT-5, FY-3C GNOS, TSX,TND =3000 profiles per day)

– **NoRO:** **CTL - all GNSS-RO data**

– **COSMIC2:** **CTL + COSMIC-2 (4000 profiles in ± 40 degrees latitude band)**

– **Spire*:** **CTL + Spire (Spire > 5000 profiles globally distributed)**

– **Spire+COSMIC2:** **CTL + (Spire+COSMIC-2)**

Results

- Medium-range forecast scores (verified against ECMWF operational analysis)
- Fits to independent observations

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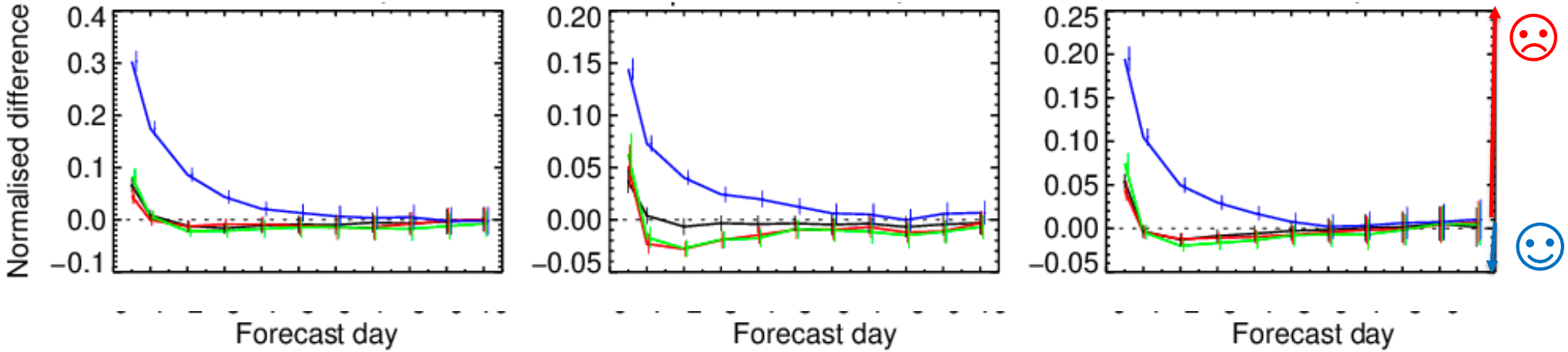
Medium Range Weather Forecast Scores@ECMWF

$$e = forecast - analysis$$

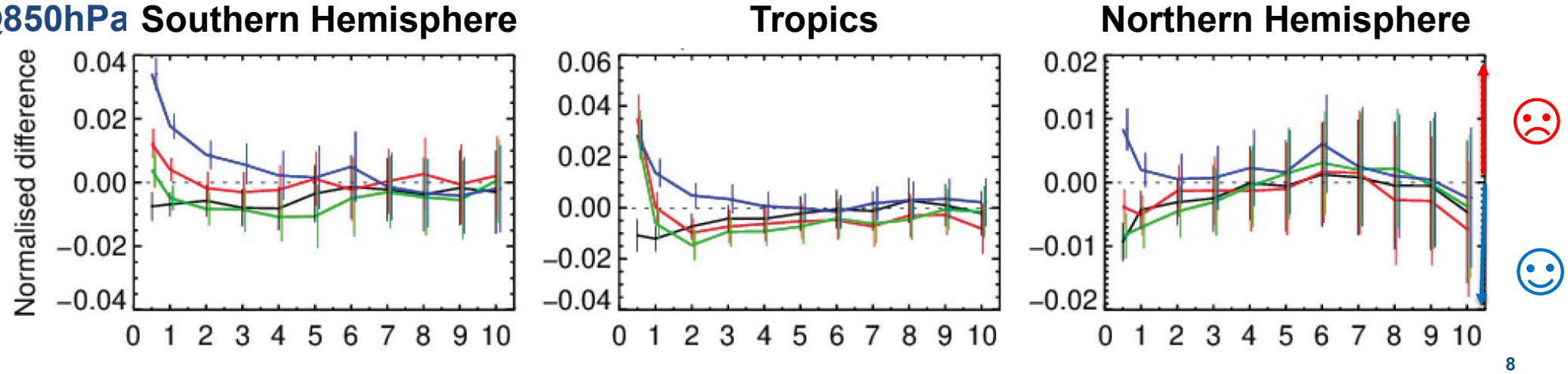
Normalised change of std. dev.

$$norm.\ d\sigma(e) = \frac{\sigma(e)_{exp} - \sigma(e)_{ctrl}}{\sigma(e)_{ctrl}}$$

temperature@100hPa



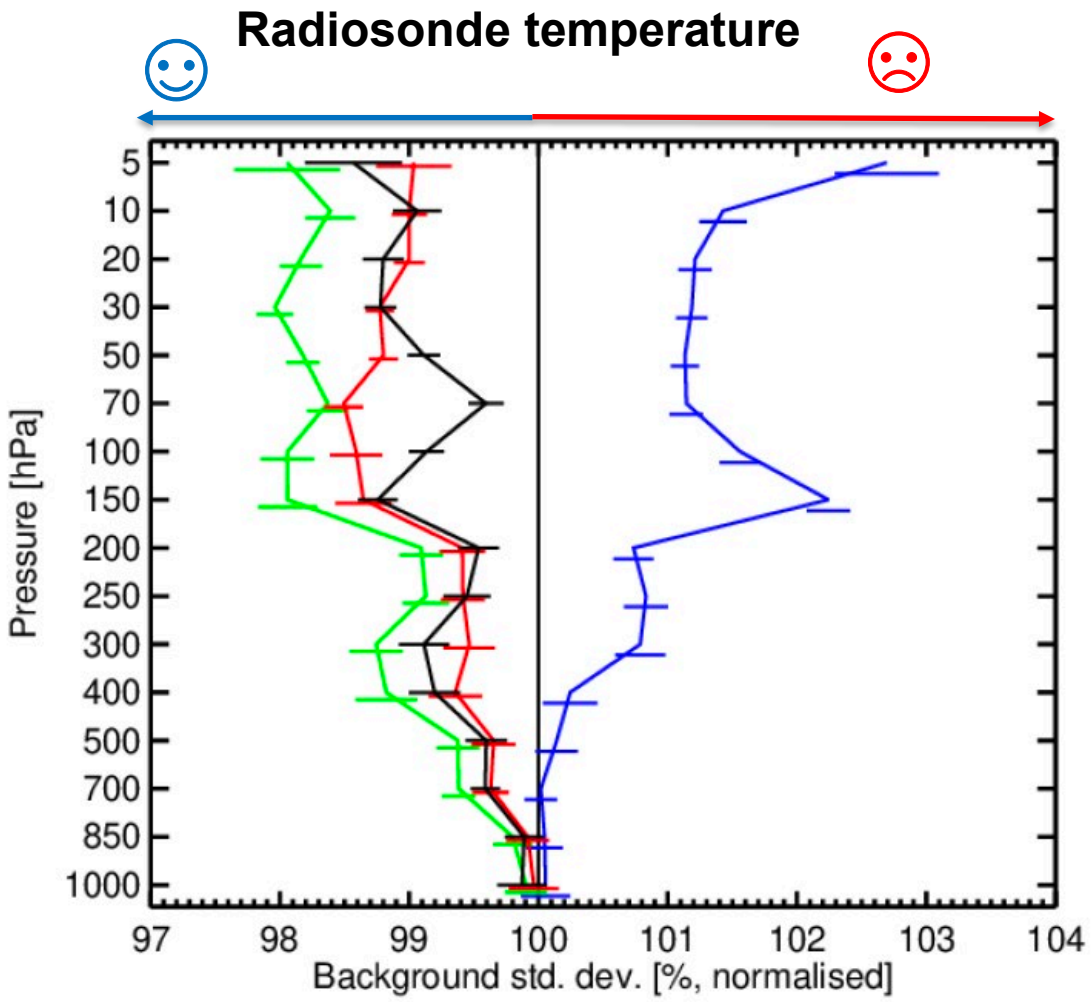
rel.humidity@850hPa

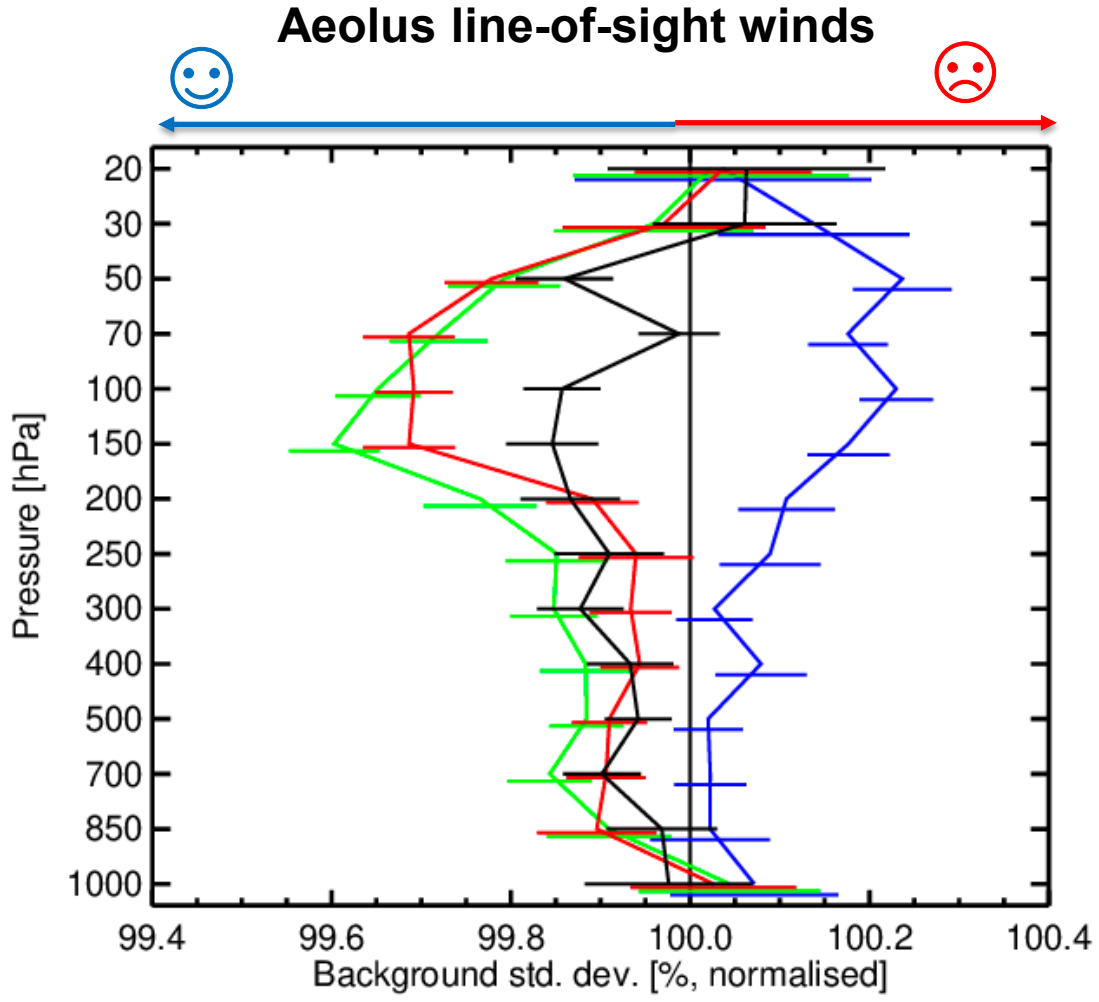


Spire, COSMIC2, Spire+COSMIC2, noRO and CONTROL

Fits to **global** observations @ECMWF

Normalised standard deviation in FG departure





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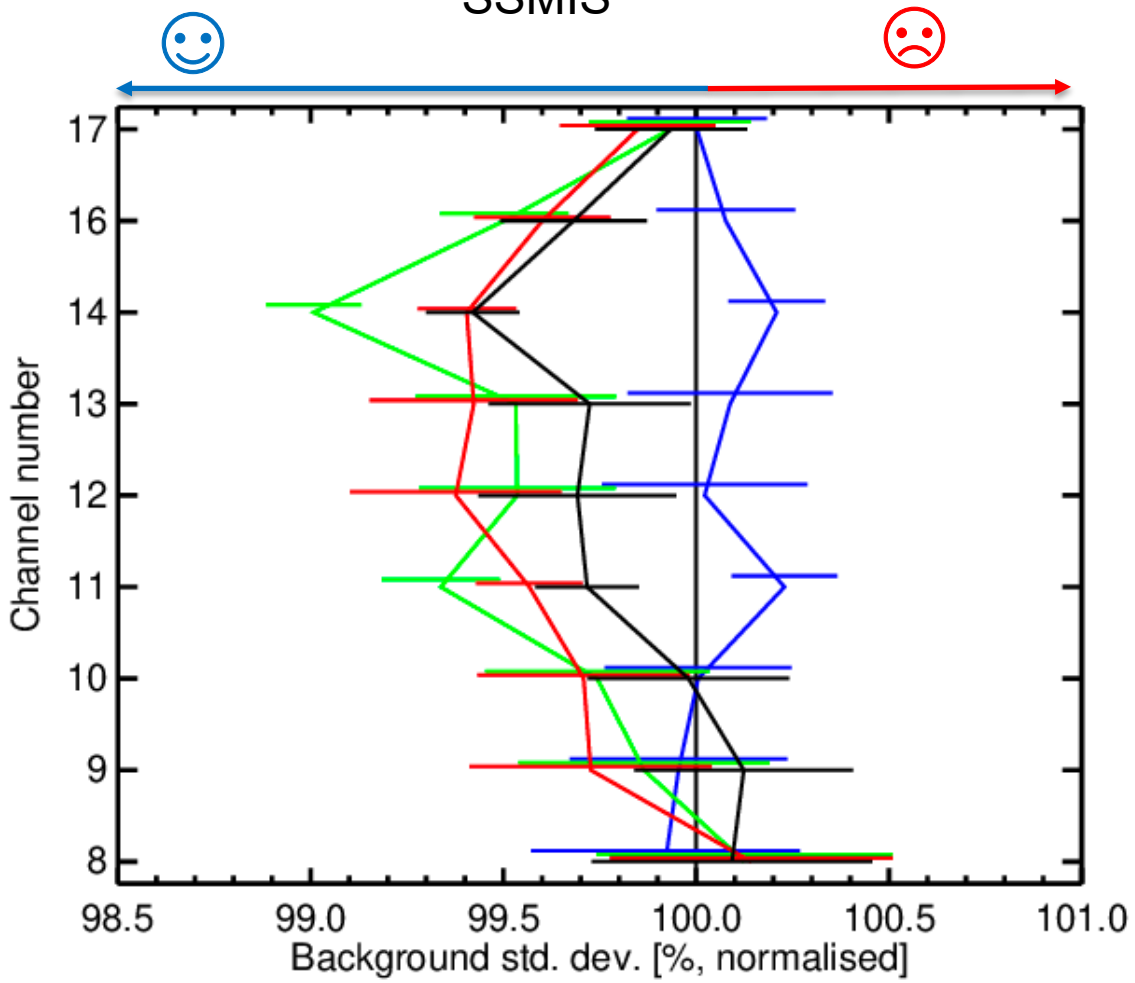
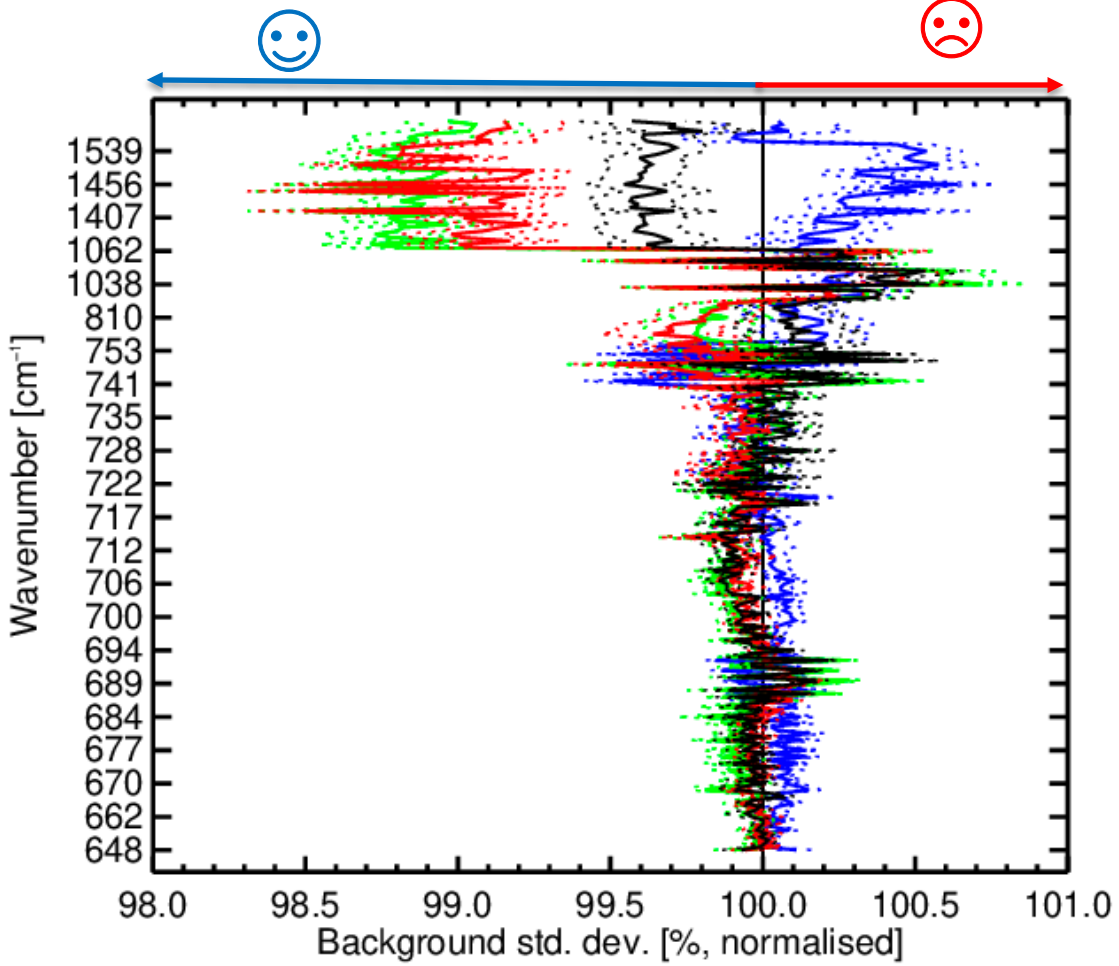
Fits to **global** observations@ECMWF

Normalised standard deviation in FG departure

SSMIS



IASI



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Spire, COSMIC2, Spire+COSMIC2, noRO and CONTROL

Summary

- *Good impact on observing system and forecast scores from both Spire and COSMIC-2*

	Met Office	ECMWF
Similarities	Largest impact seen in higher levels	
	improved fits to temperature and humidity sensitive observation	
	COSMIC-2 has a bigger impact on humidity in the tropics than Spire	
Differences	Improved scores in vector wind	improved fits and scores in wind
	not evident	biggest impact of Spire in SH

- *Both centres would assimilate Spire data*

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Summary

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Differences	Improved scores in vector wind	improved fits and scores in wind
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- *Both centres **will** assimilate Spire data*

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Second set of OSEs: Assimilation of Spire processed by EUMETSAT

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How is Spire and COSMIC-2 assimilated?

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Bending angle operator	2D
Observation error model	global bending angle error statistic
Bias correction	no
Usage of data	Assimilated from surface to 50km impact height
Model	IFS CY47R3, Tco399 (25 km spacing)
Data assimilation cycle	12h
Experiment period	1 Oct 2021 – 14 Jan 2022
Spire data	about 10,000 occ/day

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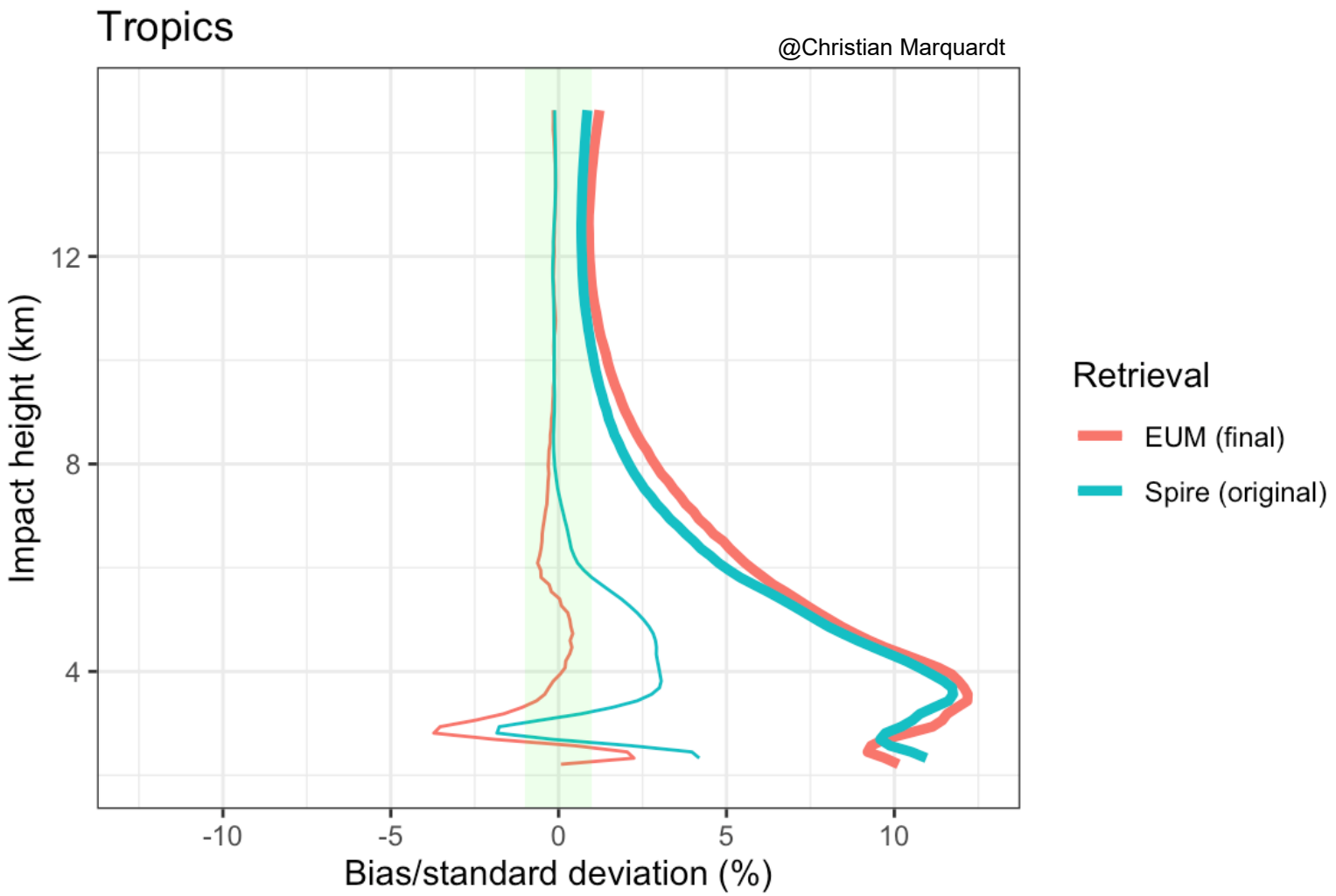
Bias in bending angle for “differently” processed Spire data



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Results

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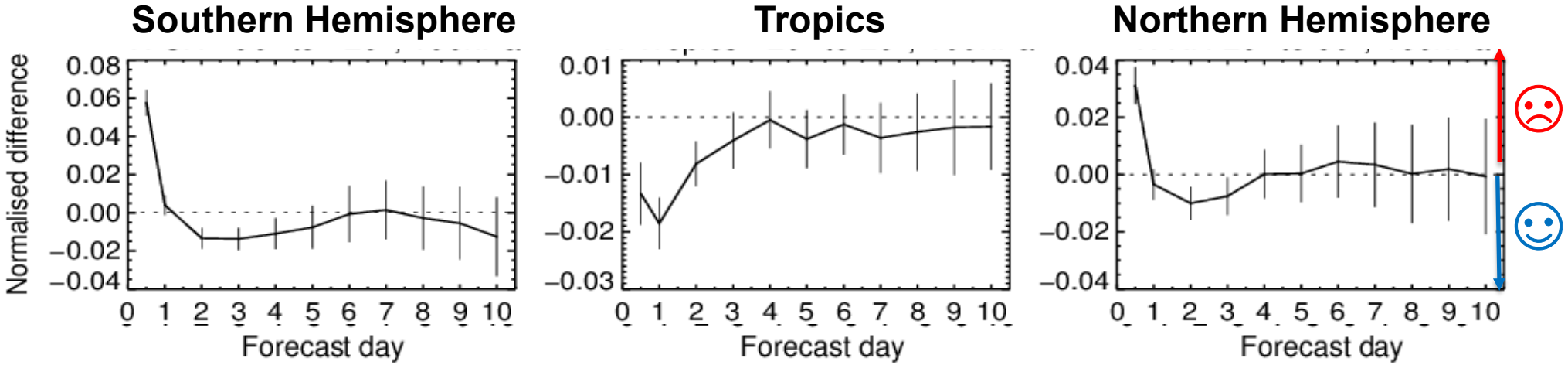
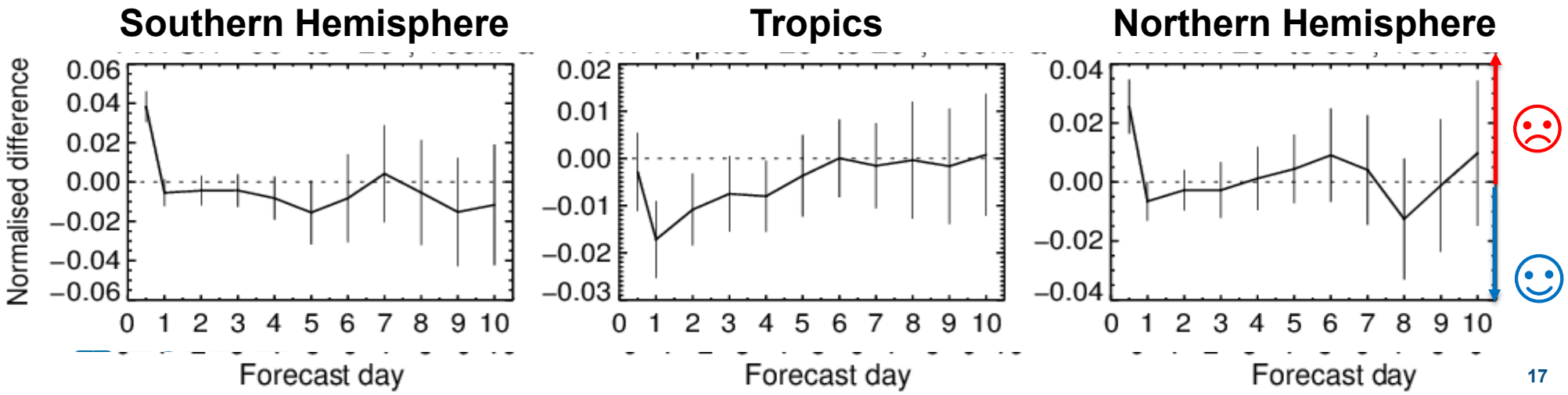
Medium Range Weather Forecast Scores@100hPa

Normalised change of std. dev.

temperature



wind



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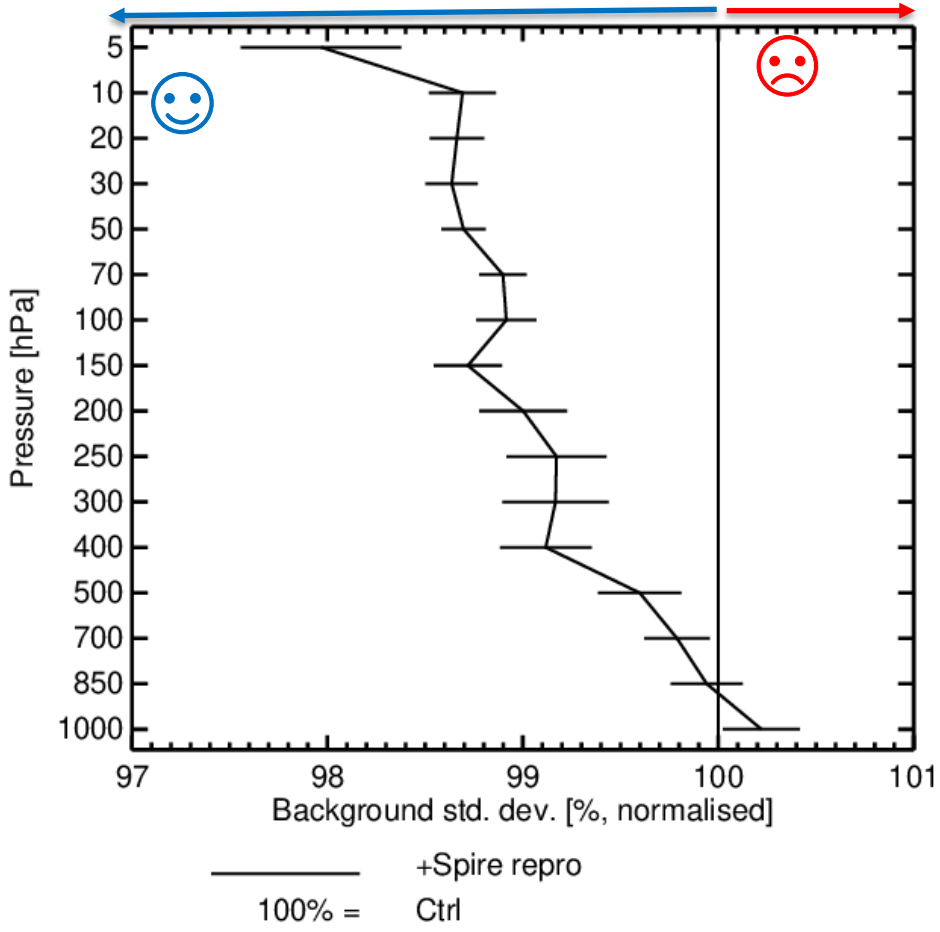
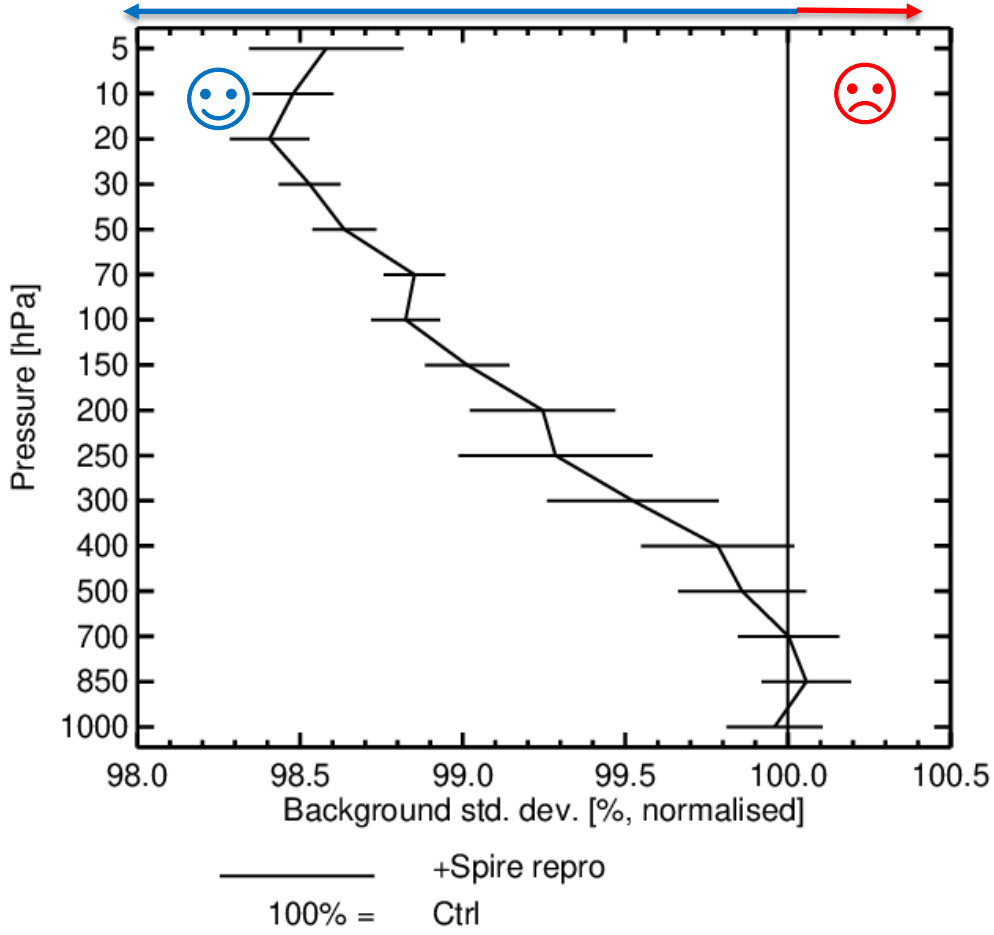
Fits to **global** observations

Normalised standard deviation in FG departure

Radiosonde temperature



Wind profiler



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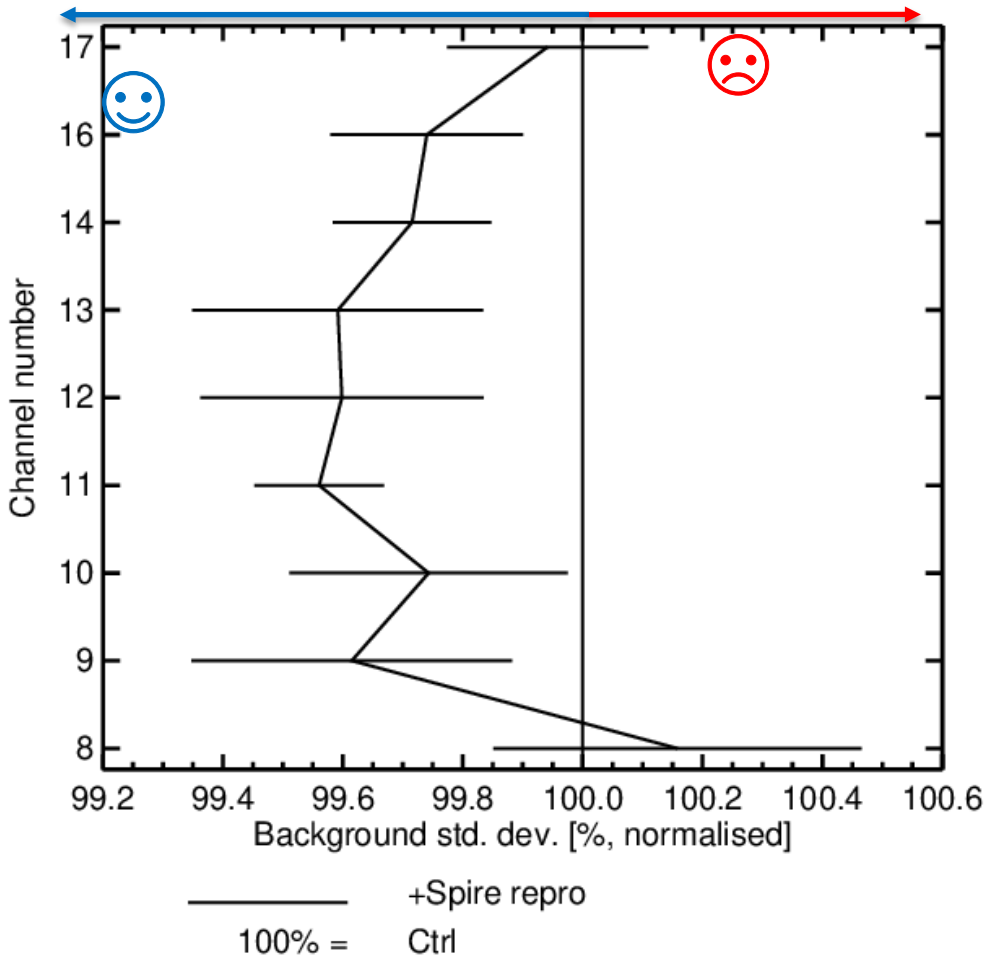
Fits to **global** observations

Normalised standard deviation in FG departure

SSMIS



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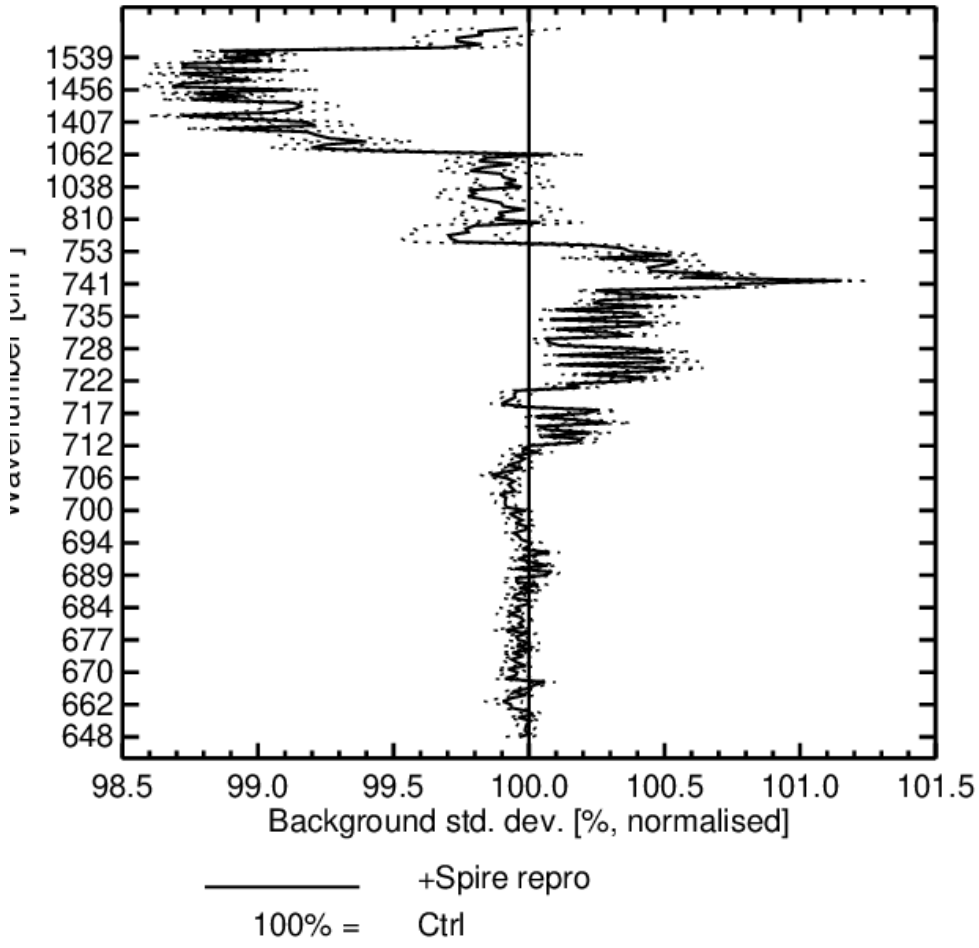

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Summary

- Additional assimilation of Spire data shows positive impact in temperature, wind and humidity.
- Active assimilation of Spire data at ECMWF is happening soon (7 June 2022) using 1000 occ/day provided by EUMETSAT under a world-license.
- We hope to assimilate even more GNSS-RO data (commercial and non-commercial) in the future as we cannot see any ”saturation effect”.

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Backup

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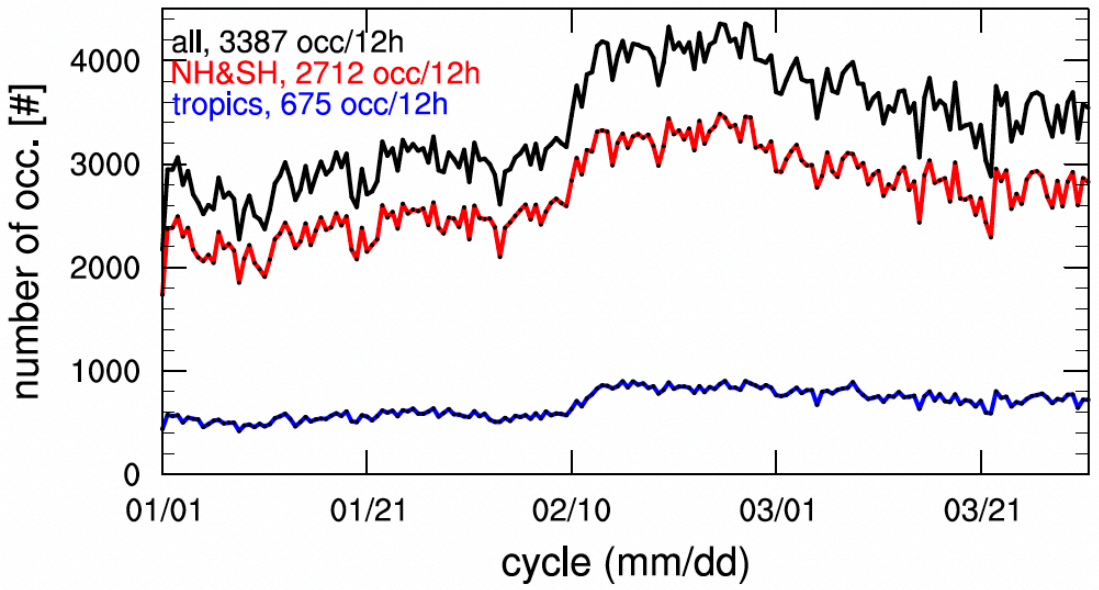
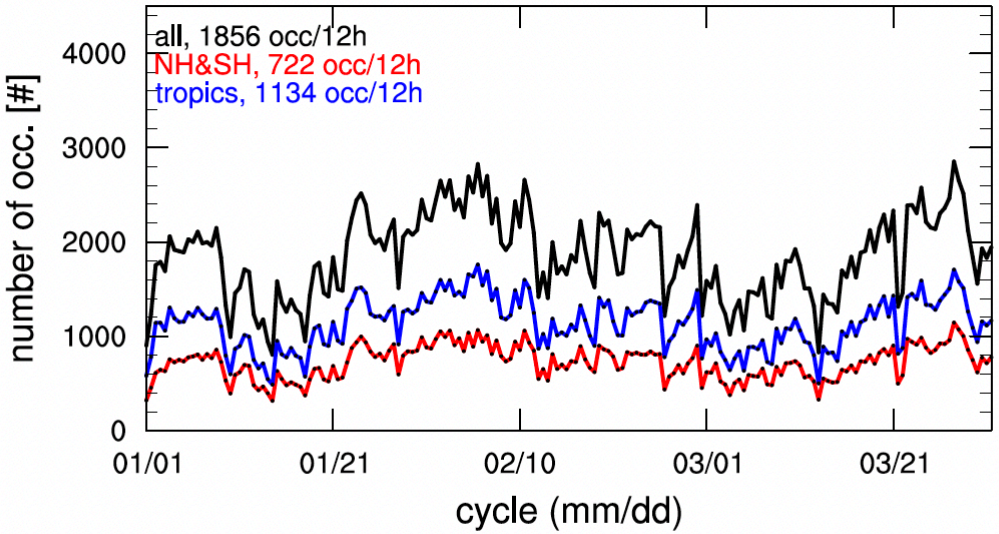
Temporal distribution of GNSS-RO data

Jan,Feb,March 2020

(gridded to 2.5 x 2.5 lat/lon)



(a) Spire



(b) COSMIC-2

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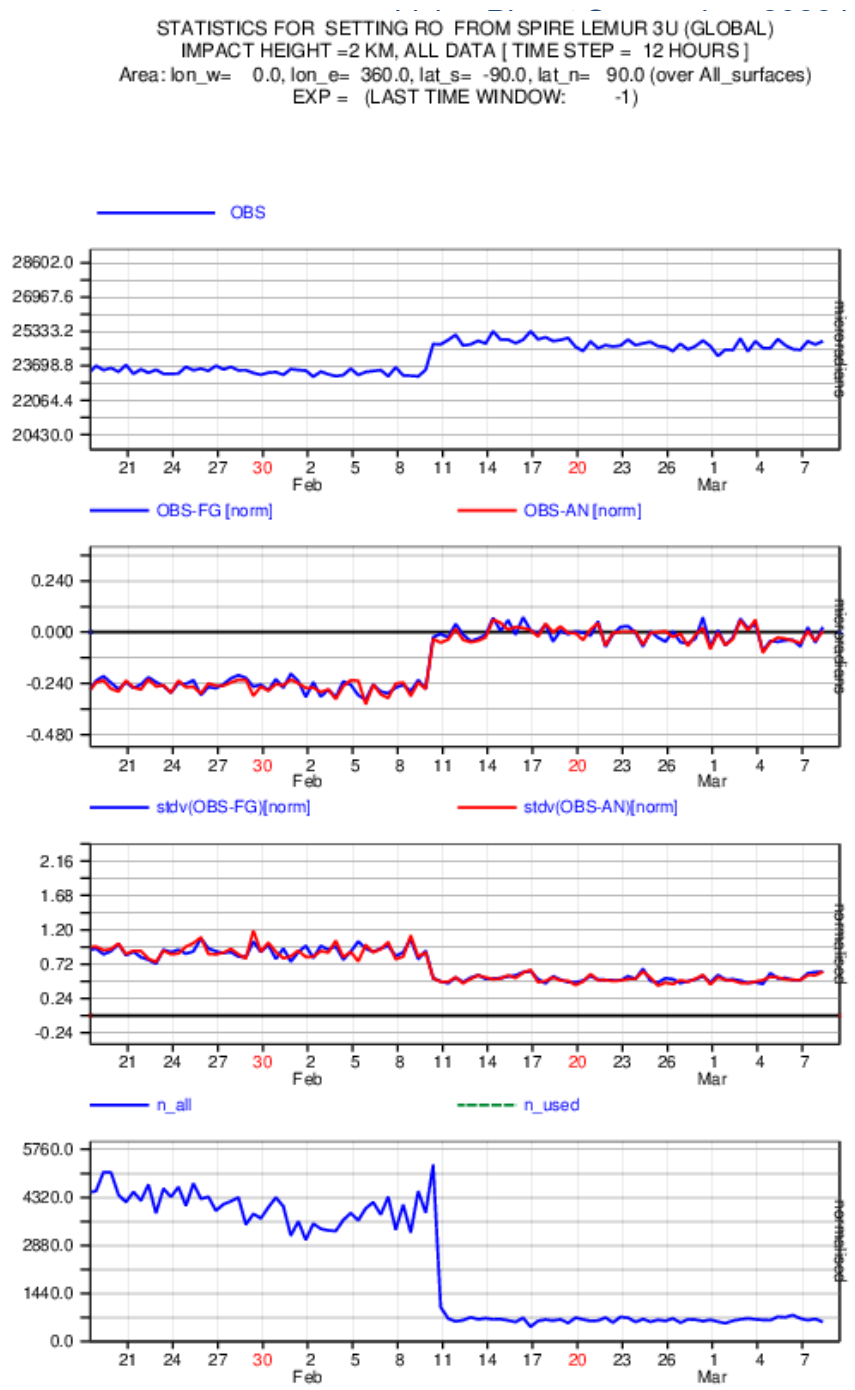
Assimilation of “new” Spire data



ECMWF EUROPEAN CENTRE FOR MEDIUM-RANGE WEATHER FORECASTS

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