Recent impact studies on GNSS-RO data in the Météo-France global 4D-Var system

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Outline

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Recent Observing System Experiments

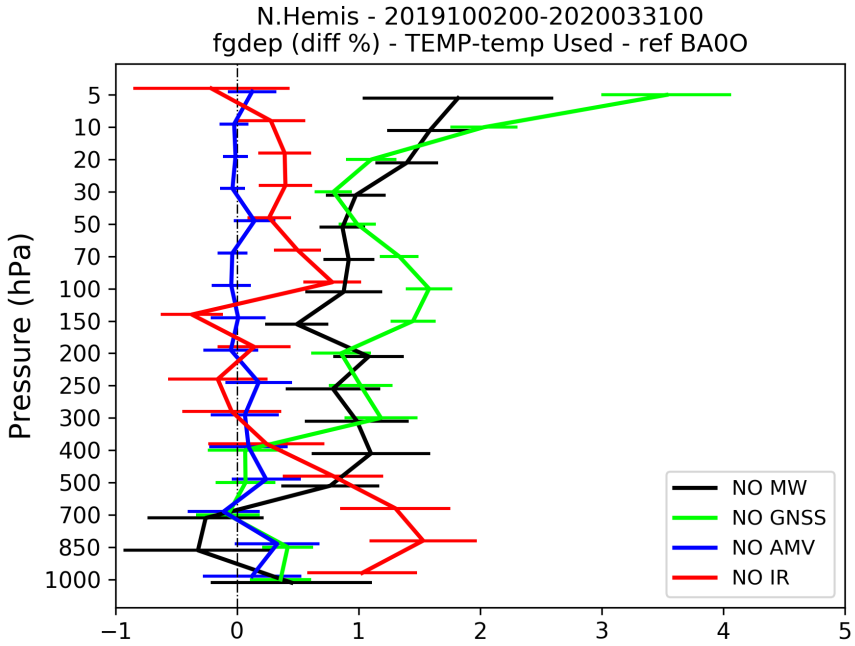
Framework of the OSE study in the global 4D-Var system ARPEGE

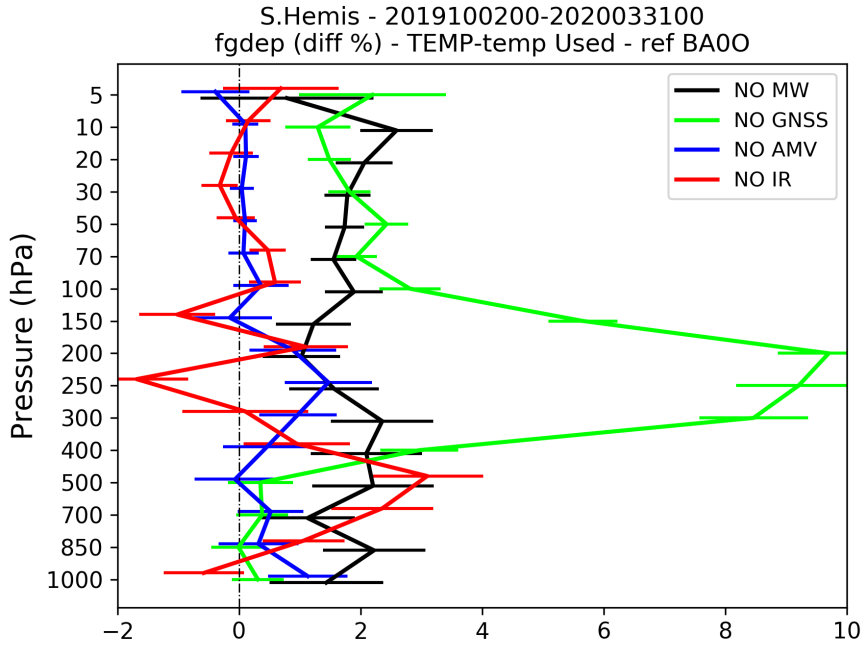
- Period of interest (6-month) : October 2019 - March 2020
- Low resolution 4D-Var system (T798)
- Baseline : all observing systems used in operation during the period
  - GNSS-RO data in the baseline : METOP-A,B,C, TerraSAR-X, Tandem-X, COSMIC-6
- Main denial experiments :
  - no conventional (NO-CONV)
  - no micro-wave radiances (NO-MW)
  - no infrared radiances (NO-IR)
  - no scatterometers (NO-SCATT)
  - no satellite winds (NO-AMV)
  - **no GNSS-RO**

Impact of no GNSS-RO on the short-range forecast

Std of background departures normalized by the Control (ref : radiosondes)

- values $>$ 0 : increase of the error in the background

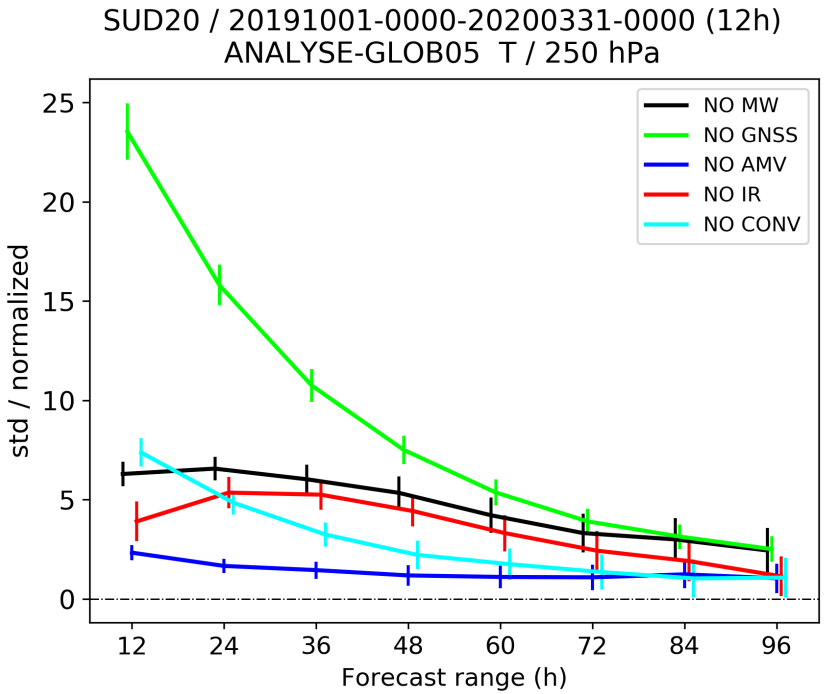


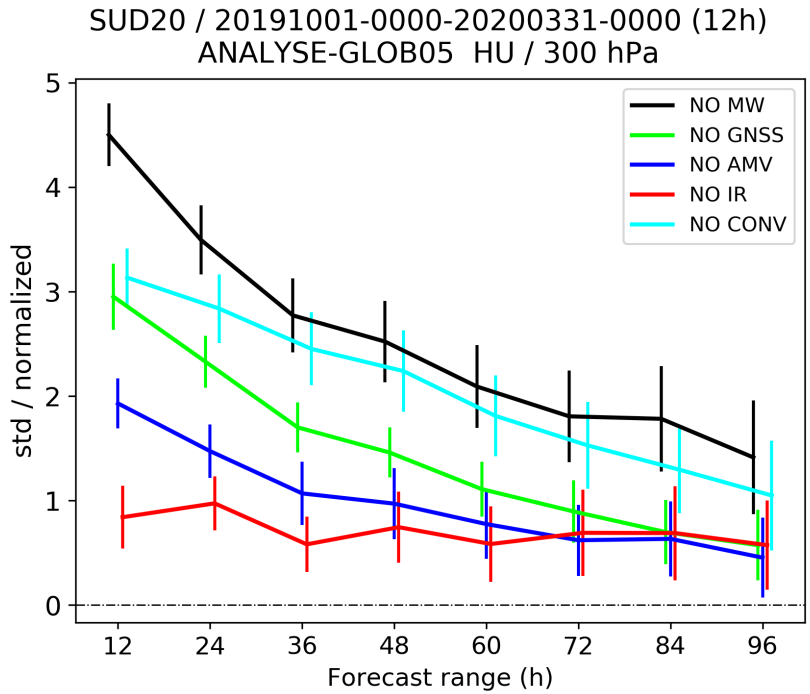


- major impact for the temperature in upper troposphere / lower stratosphere in particular over the Southern Hemisphere

Medium-range forecast impact

Std of forecast errors normalized by the Control (reference : IFS analysis)





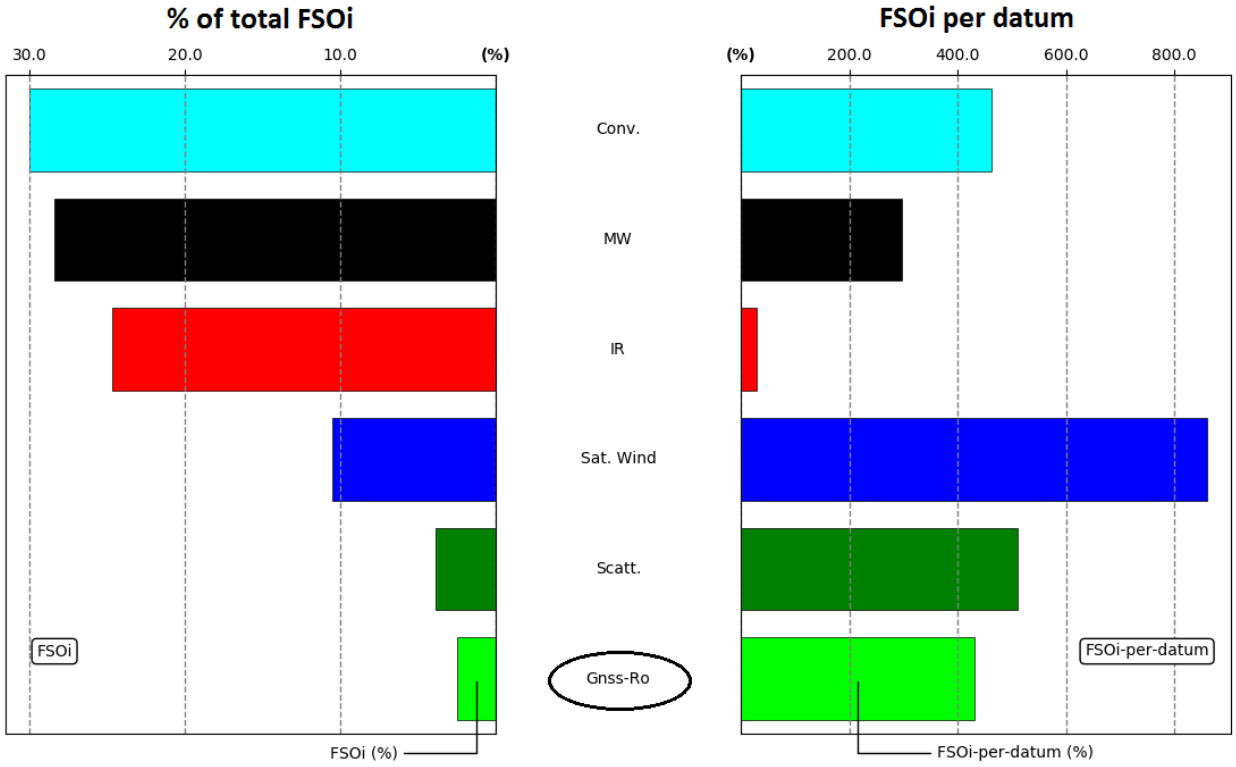
- strong impact on the forecast for temperature in upper troposphere/lower stratosphere (**SH**)
- also a contribution to the forecast skill of humidity (and wind) in altitude in the **SH**

Outline

Contribution to the reduction of the forecast error

FSOi results in ARPEGE on the short-range forecast error

- 24-h forecast error estimated using the total energy norm
- FSOi results with **dry adjoint - dry norm** for the 3-month period **January-March 2020**

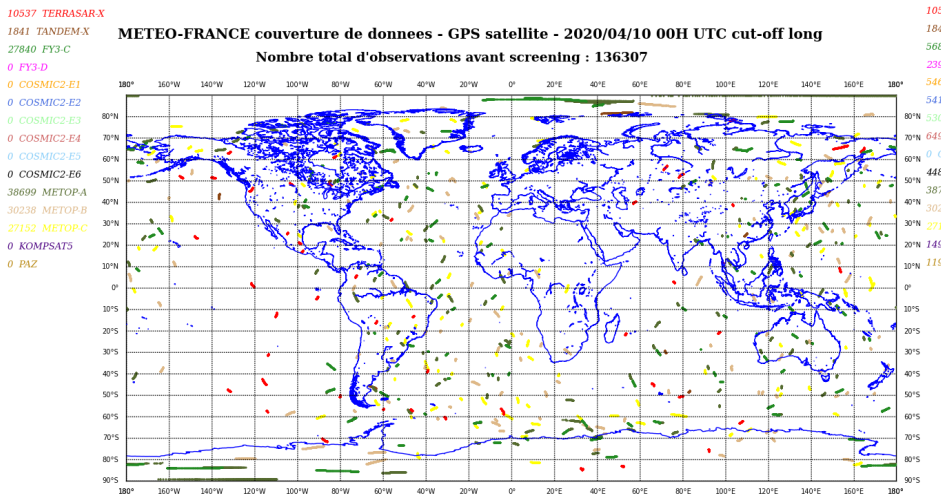


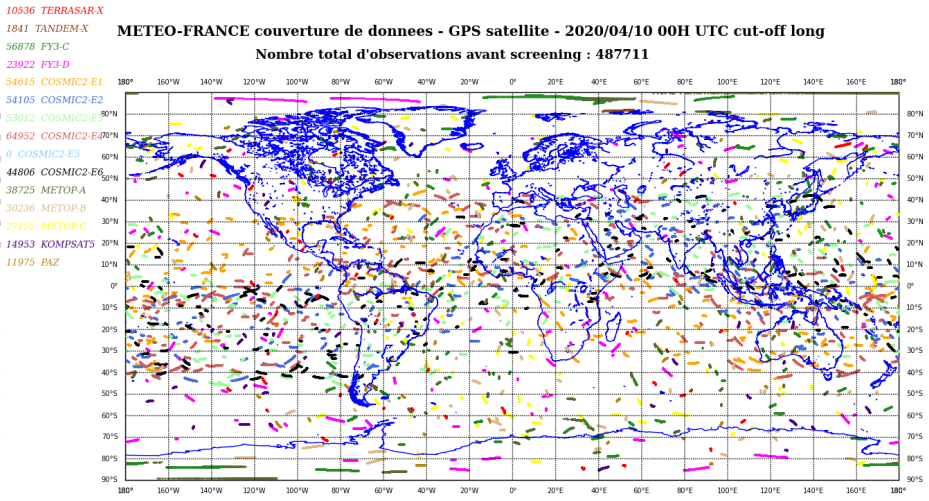
Outline

Impact of the recent use of new data

COSMIC-2, KOMPSAT-5, FY-3D and PAZ in use since late June 2020

- the number of data available multiplied by 4 to 5 !

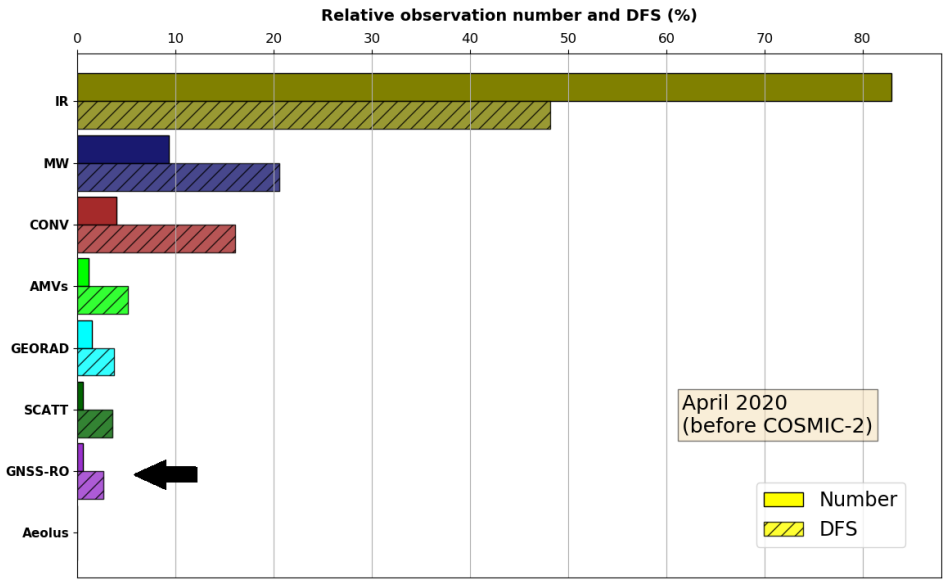


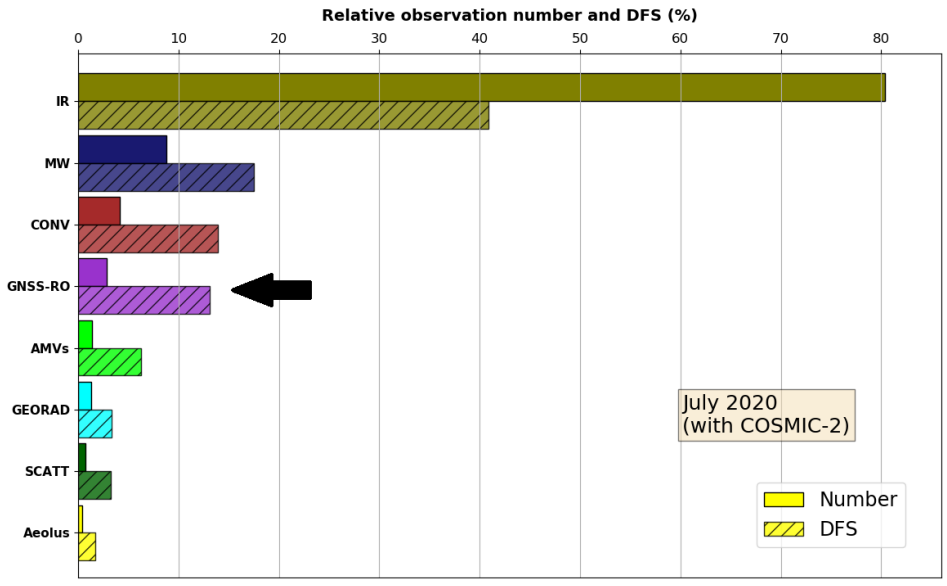


Impact of COSMIC-2 (+ KOMPSAT-5, FY-3D and PAZ)

Information content : DFS diagnosis

- Degree of Freedom of Signal
- Methodology : 1-day with 6 4D-Var assimilations with perturbed observations

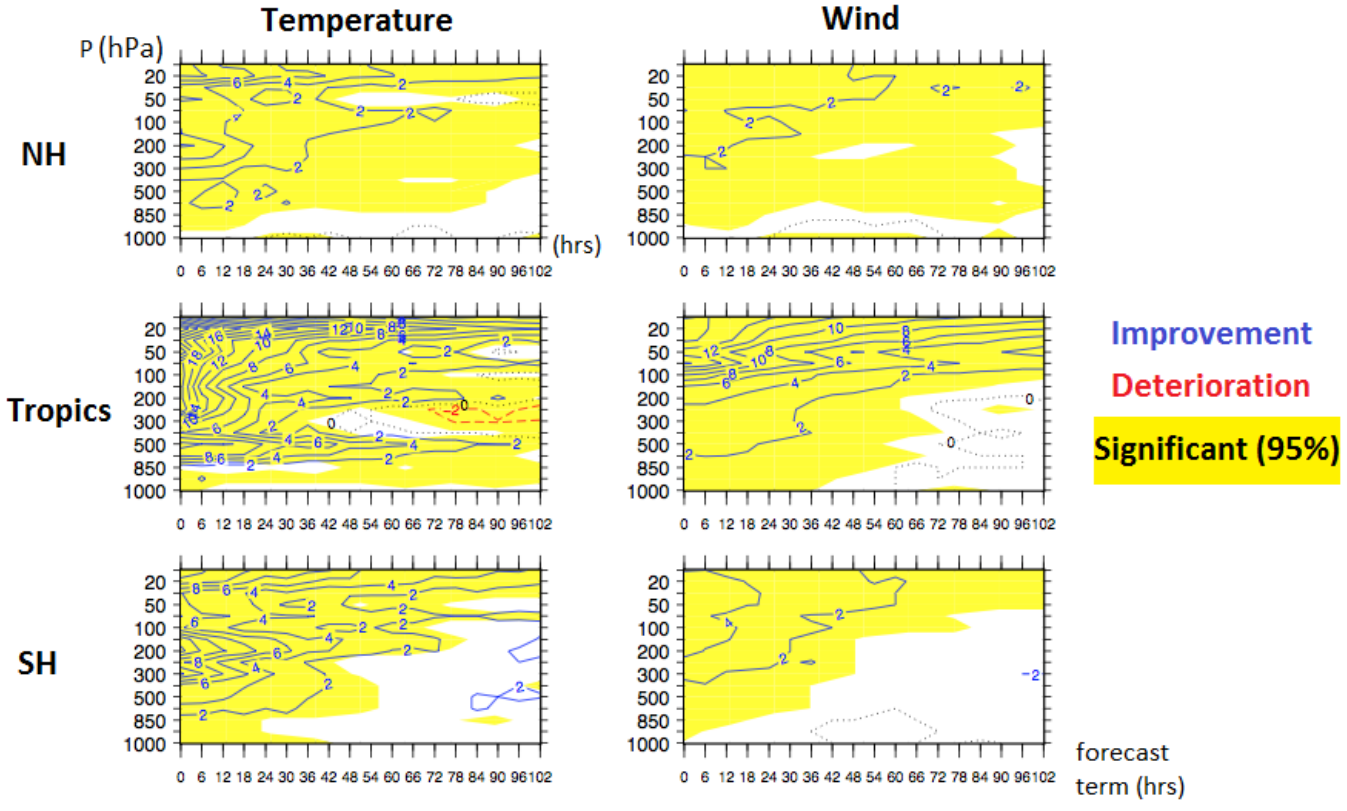




- DFS multiplied by 5 using COSMIC-2, KOMPSAT-5, FY-3D and PAZ !

Impact of COSMIC-2 (+ KOMPSAT-5, FY-3D and PAZ)

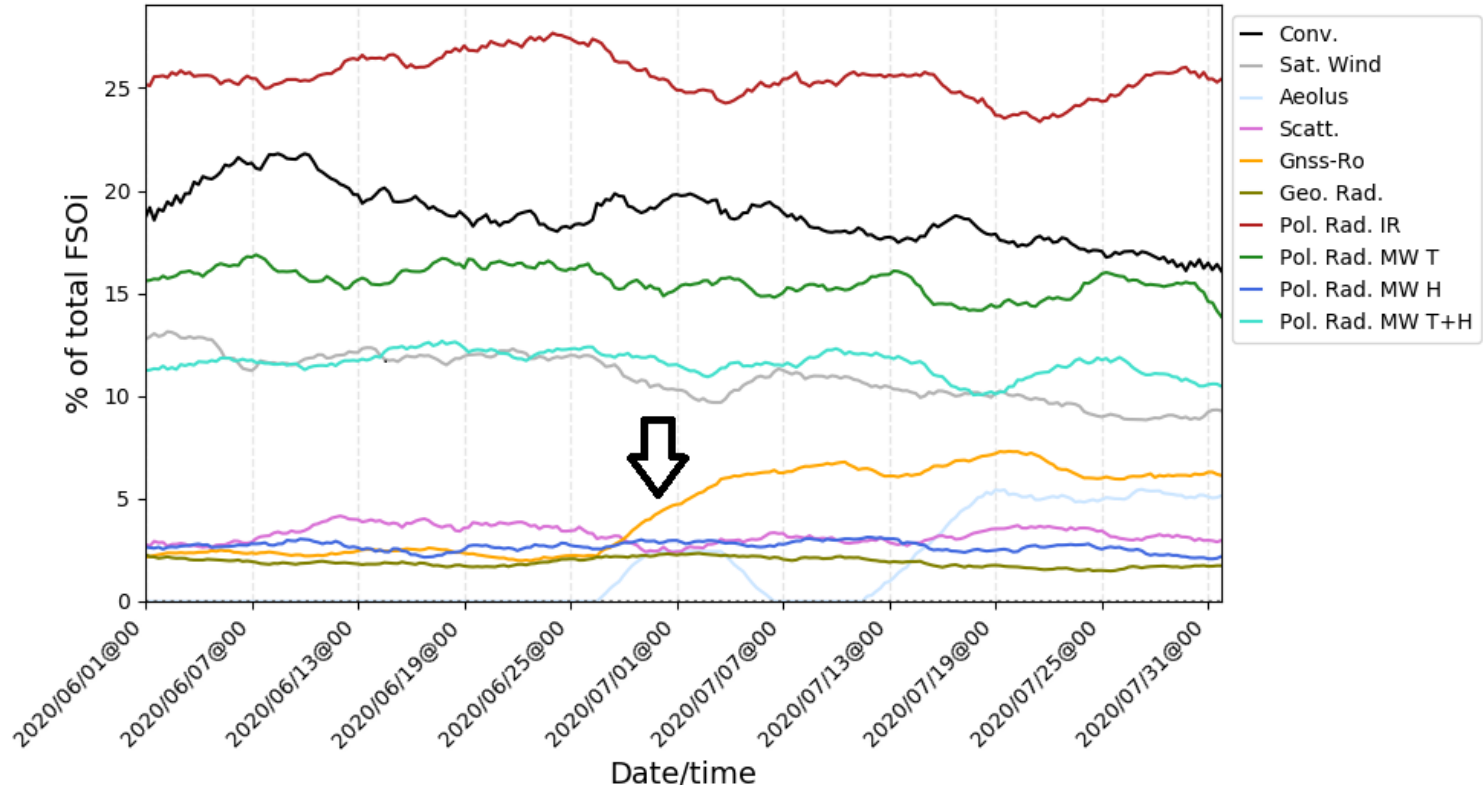
Forecast scores against IFS analysis (April 2020) - Normalized RMSE ref-exp



- significant improvement on temperature over globe up to 3-day term.
- also slight improvement on wind and humidity (not shown) in altitude in the Tropics

FSO impact of COSMIC-2, KOMPSAT-5, FY-3D, PAZ

Relative impact (%) - June/July 2020 - Dry adjoint model / dry norm



- FSO impact multiplied by 3 with the use of new observations

Outline

Conclusion

Use of complementary diagnosis to assess the impact of GNSS-RO in the global Météo-France 4D-Var system

- OSE, DFS, forecast scores and FSOi showed consistent results
- strong impact of the GNSS-RO data on the forecast skills in the upper troposphere/lower stratosphere particularly for temperature at short and medium range
- the recent use of COSMIC-2 in addition to KOMPSAT-5, FY-3D and PAZ data has significantly enhanced the impact of GNSS-RO :
  - increased information content i.e. strong impact on the analysis
  - increased contribution to the reduction of the 24-h forecast error
  - significant improvement of the forecast skills up to 3-day term in particular for temperature over globe but also for wind and humidity in the Tropics