Use of IASI in the ECMWF model: evolution and recent advances

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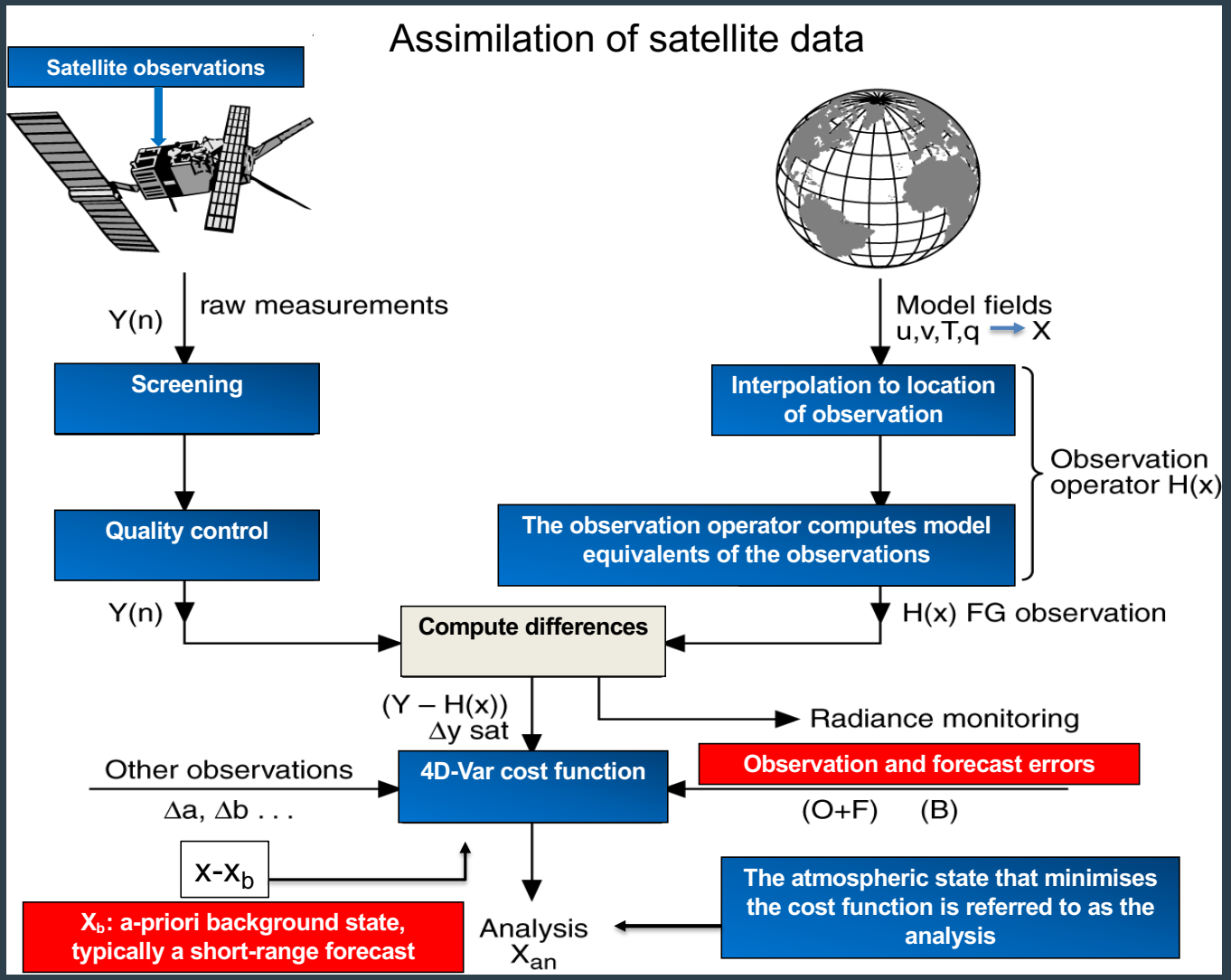
ECMWF

with contributions from Mohamed Dahoui, Reima Eeresmaa, Tony McNally, Kirsti Salonen

IASI Exploitation Review – 27 May 2021

ECMWF

Assimilation of satellite data



Satellites used for NWP at ECMWF

OB TYPE	Satellite / sensors	EUROPE	USA	ASIA
Atmospheric Motion Vectors	METOP A,B,C,DUAL (AVHRR) METEOSAT 8,11 (SEVIRI) HIMAWARI 8 (AHI) NPP, NOAA 20 (VIIRS) NOAA 15,18,19 (AVHRR) GOES 15,16 (I/ABI) AQUA (MODIS)	METOP A,B,C + DUAL (AVHRR) METEOSAT 8,11 (SEVIRI)	NPP, NOAA 20 (VIIRS) NOAA 15,18,19 (AVHRR) AQUA (MODIS) GOES 15,16 (ABI)	 HIMAWARI 8 (AHI)
Atmospheric Sounding Radiances	METOP A,B,C (AMSU/MHS/IASI) NPP, NOAA 20 (ATMS/CrIS) NOAA 15,18,19 (AMSU/MHS) AQUA (AMSUA/AIRS) FY3-B,C,D (MWHS/MWHS2) METEOSAT 8,11 (SEVIRI) HIMAWARI 8 (AHI) GOES 15,16 (I/ABI) GCOM-W (AMSR-2) GPM (GMI) DMSP 17,18 (SSM/IS)	METOP A,B,C (AMSU/MHS/IASI) METEOSAT 8,11 (SEVIRI)	NPP, NOAA 20 (ATMS/CrIS) NOAA 15,18,19 (AMSU/MHS) AQUA (AMSUA/AIRS) GOES 15,16 (I/ABI) DMSP 17,18 (SSM/IS)	FY3-C,D (MWHS/MWHS2/MWRI) HIMAWARI 8 (AHI) GCOM-W (AMSR-2)
GNSS-RO	METOP A,B,C (GRAS) COSMIC2 Spire (2020) TERRASAR / TANDEM FY3 (GNOS) KOMPSAT5 (GNOS)	METOP A,B,C (GRAS) TERRASAR / TANDEM	COSMIC2	FY3 (GNOS) KOMPSAT5
SCAT / ALT	METOPA,B,C(ASCAT) / JASON3 / AltiKA / S3A/B / Cry2	METOP A,B,C (ASCAT) /JASON3 / JASON3 / AltiKA / S3A/B / CRY2		
Doppler Wind Lidar	Aeolus			

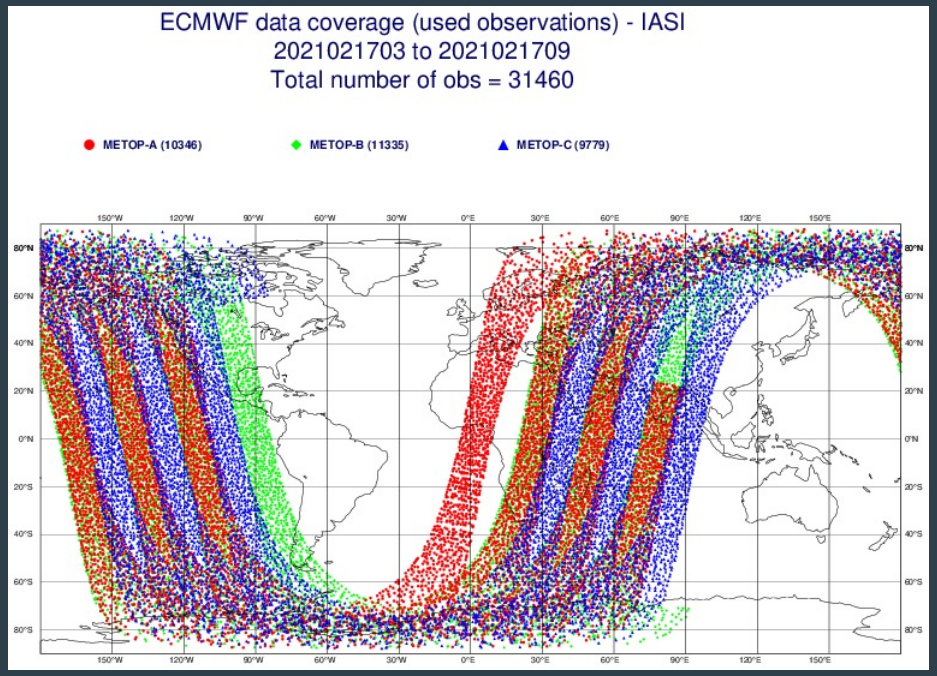
Sensor technology

OB TYPE	Satellite / sensors
Atmospheric Motion Vectors	METOP A,B,C,DUAL (**AVHRR**) METEOSAT 8,11 (**SEVIRI**) HIMAWARI 8 (**AHI**) NPP, NOAA 20 (**VIIRS**) NOAA 15,18,19 (**AVHRR**) GOES 15,16 (**I/ABI**) AQUA (**MODIS**)
Atmospheric Sounding Radiances	METOP A,B,C (**AMSU/MHS/IASI**) NPP, NOAA 20 (**ATMS/CrIS**) NOAA 15,18,19 (**AMSU/MHS**) AQUA (**AMSUA/AIRS**) FY3-B,C,D (**MWHS/MWHS2**) METEOSAT 8,11 (**SEVIRI**) HIMAWARI 8 (**AHI**) GOES 15,16 (**I/ABI**) GCOM-W (**AMSR-2**) GPM (**GMI**) DMSP 17,18 (**SSM/IS**)
GNSS-RO	METOP A,B,C (**GRAS**) **COSMIC2 Spire** (2020) **TERRASAR / TANDEM** **FY3 (GNOS)** **KOMPSAT5 (GNOS)**
SCAT / ALT	**METOPA,B,C(ASCAT) / Saral** **JASON3 / AltiKA / S3A/B / Cry2**
Doppler Wind Lidar	**Aeolus**

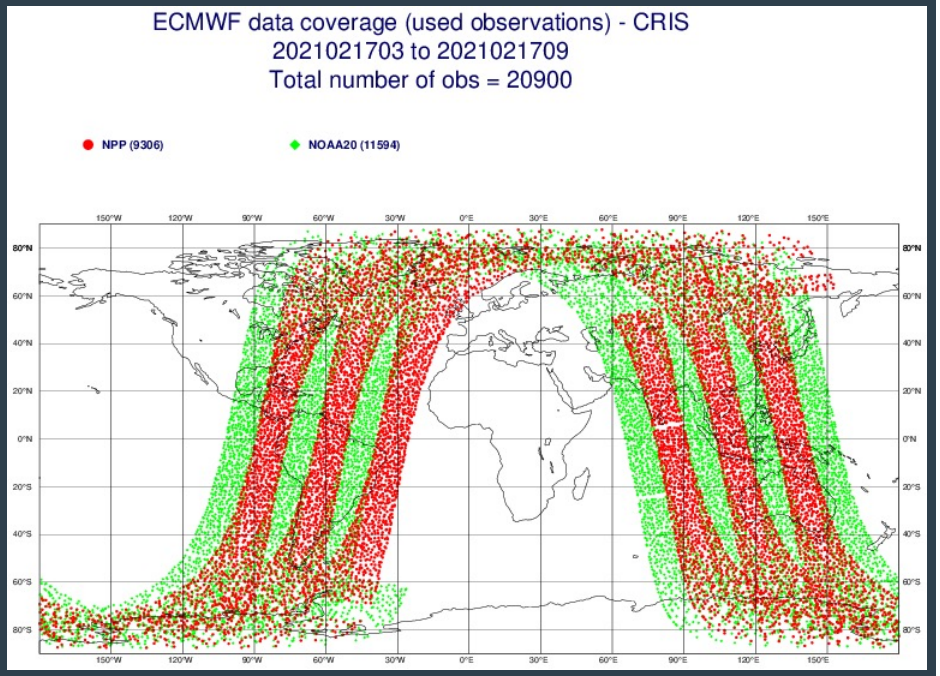
Sensor technology	Processing route
Passive microwave	L1 Radiances
Passive infrared	L1 Radiances / AMV
Radio occultation	Bending angles
SCAT / Altimeter	L2 wind / SLA / SWH
Doppler wind lidar	L2 LOS wind

Passive infrared (Low Earth Orbit)

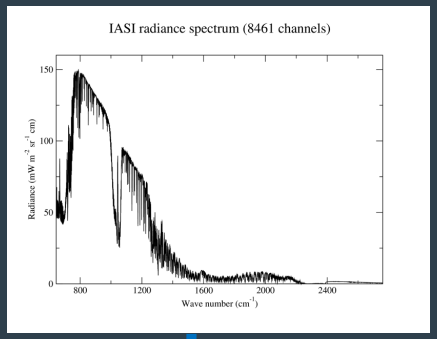
IASI data



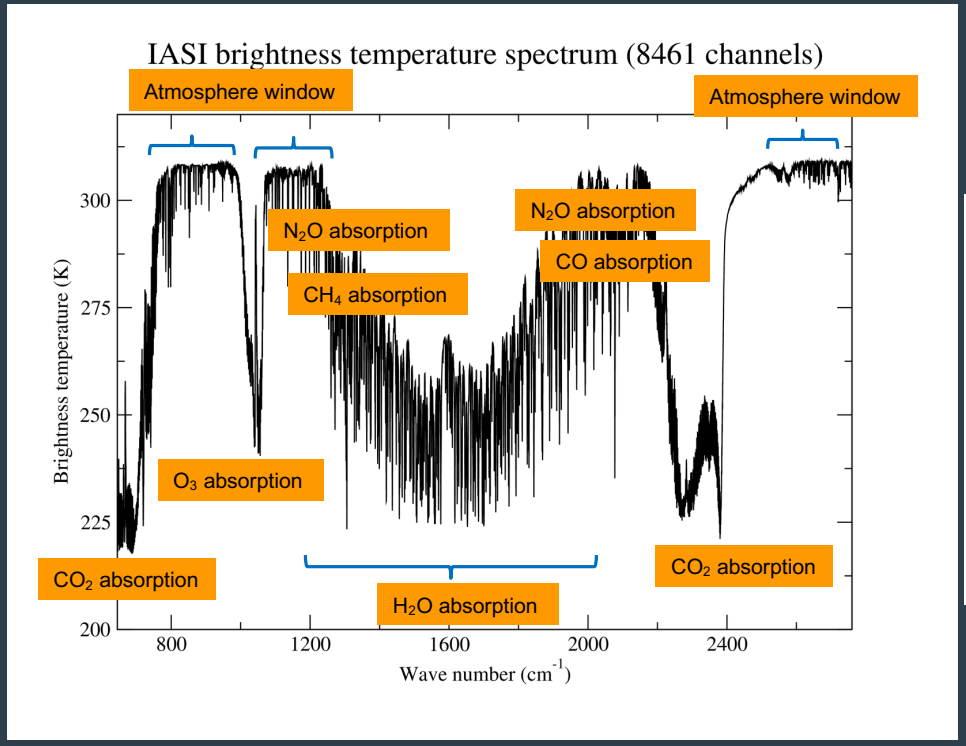
CrIS data



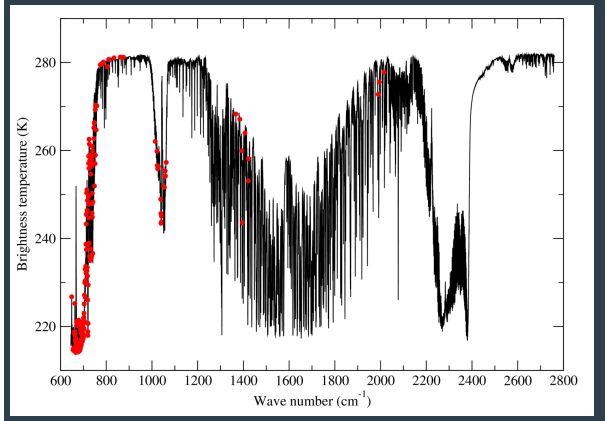
Example of radiance/brightness temperature spectrum



Equivalent brightness temperature spectrum



The 220 operational IASI channels



How do we asses the impact of modifications to the IASI assimilation system? We run assimilation experiments!

Impact on the data assimilation system

We can assess satellite influence upon the analysis by examining the fit to **in situ** observations (radiosonde / aircraft / surface) and how the fit changes when modifications are introduced

We can also assess satellite influence on the analysis by examining the fit to other **independent** satellite observations which are sensitive to the same atmospheric parameter

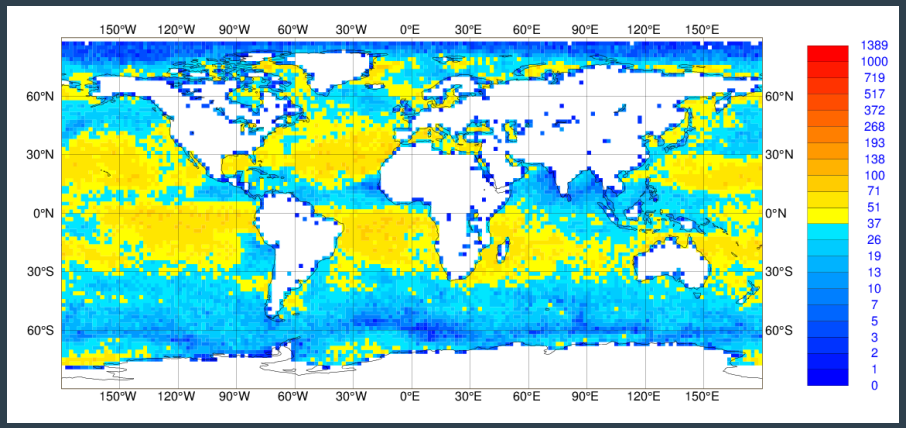
Impact on the forecast system

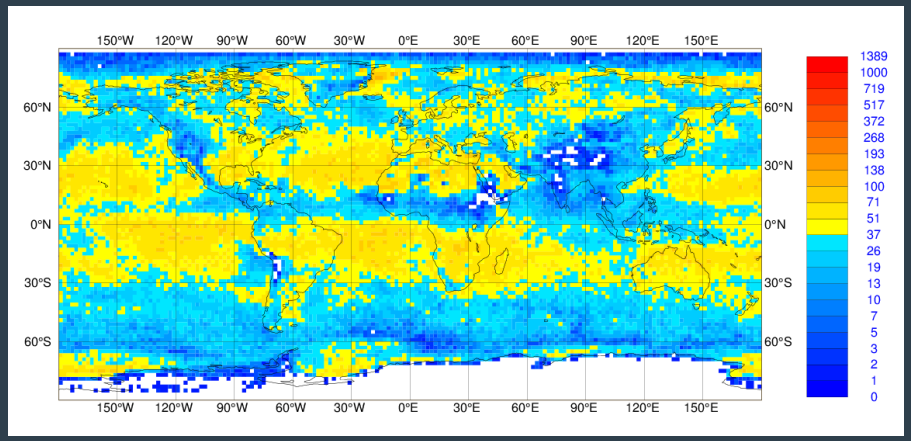
Loss or gain in forecast skill typically looking at forecasts of the 500hPa Geopotential Height (Z)

ECMWF

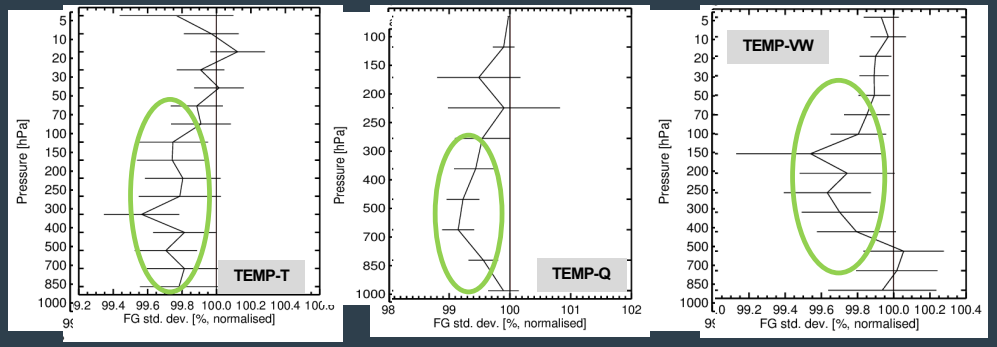
Assimilating IASI spectra over land surfaces

Improved cloud detection over land has allowed hyperspectral IR (e.g. IASI) to be assimilated the same way it is used over ocean



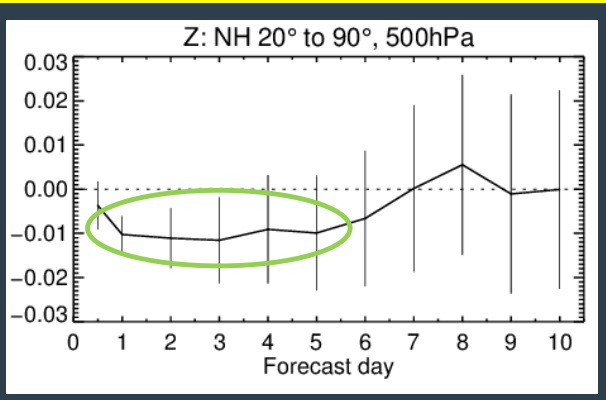


Significant positive impact on the analysis



Significant positive impact on the forecasts

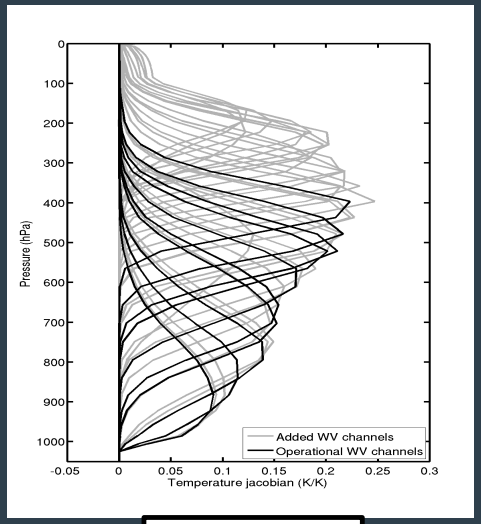
Difference in RMS error normalised by RMS error of control experiment



Note this impact is on top of extensive MW data use over land!

Increasing the number of IASI water vapour channels

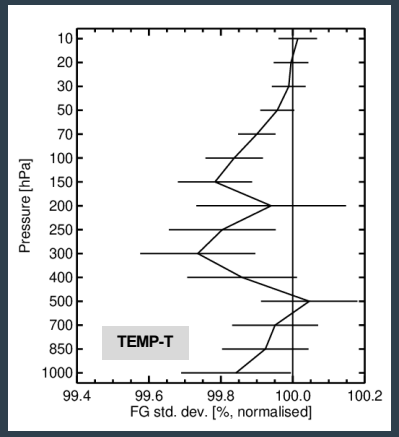
Positive impact on the analysis



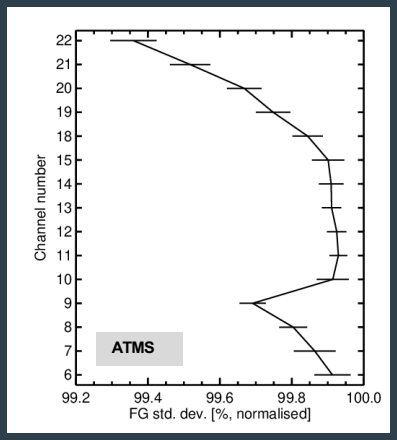
Added WV channels
Original WV channels

Positive impact on the forecasts

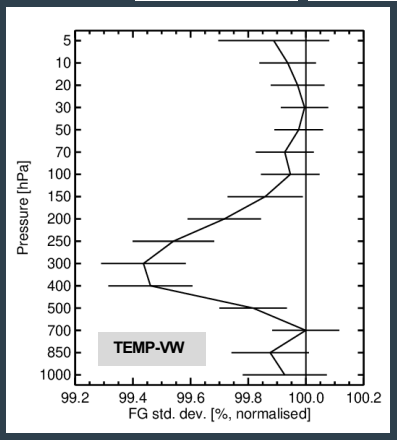
Improvement | Degradation



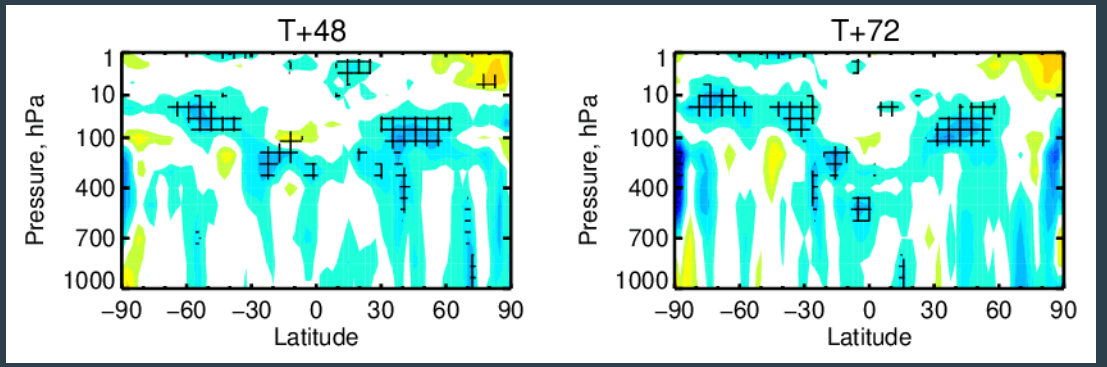
Improvement



Improvement | Degradation



Difference in RMS error normalised by RMS error of CTL

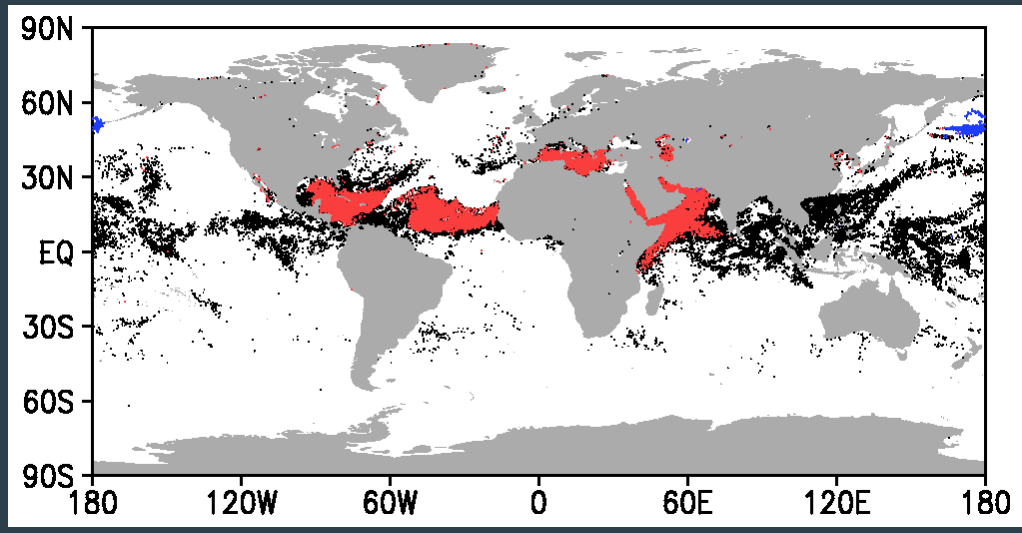


Improvement in the use of IASI data at locations contaminated by aerosols

Previously, the presence of aerosol in the IASI field-of-view resulted in a full-spectrum rejection with no channels being allowed to enter the assimilation.

Now, aerosol-related data rejections are limited to affected channels only. As a result, the amount of assimilated data is considerably increased for stratospheric and upper-tropospheric channels, due to the fact that aerosol layers are frequently confined to the lower- and mid-troposphere.

Aerosol type classification on Metop-B IASI data on 23 June 2019. Red, blue, and black indicate Saharan dust, volcanic ash, and unclassified aerosol, respectively



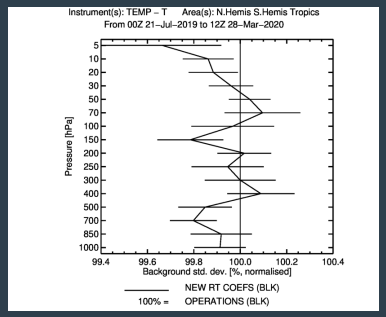
Radiative transfer improvements for IASI

Upgrade of Infrared Radiative Transfer, Spectroscopy and Trace Gas Assumptions used in the IASI simulations

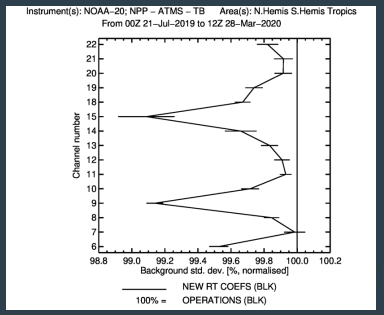
State-of-the-art spectroscopy / CO_2 (CH_4) line mixing / water vapour continuum → more accurate simulations

RTTOV V9 fast transmittance model for variable CO_2 → smaller biases

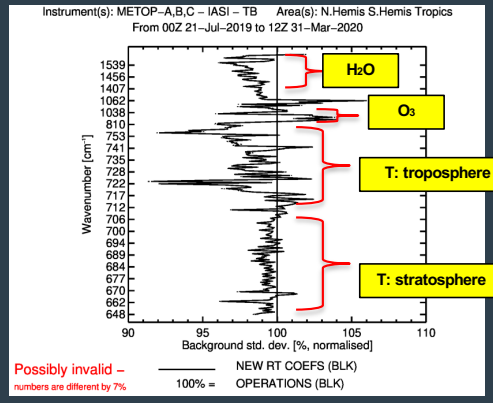
Radiosonde: Temp-T



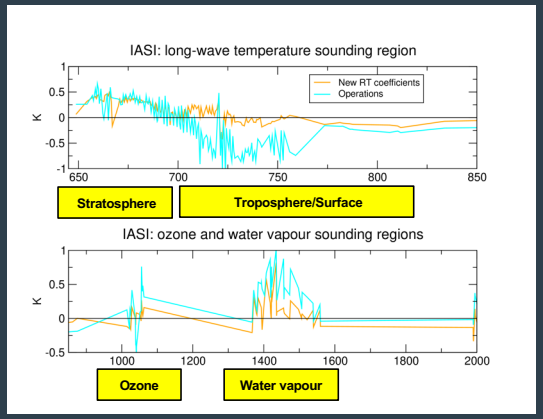
ATMS



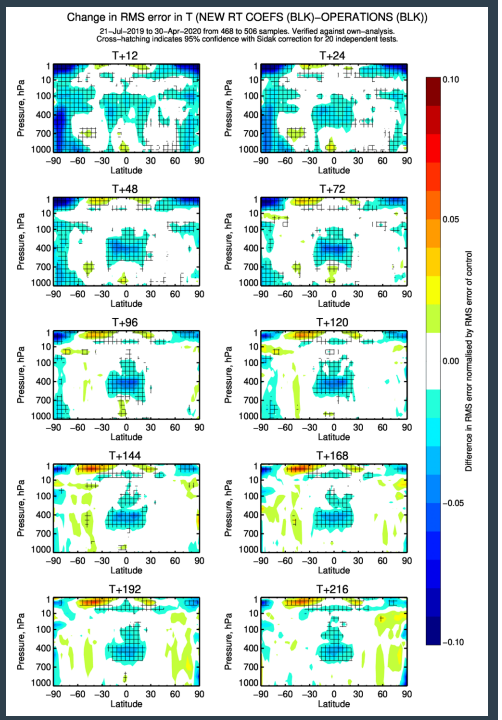
IASI



IASI: bias correction



Forecast scores: temperature



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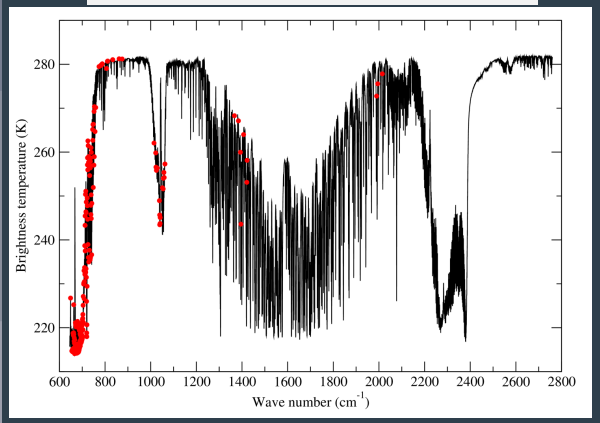
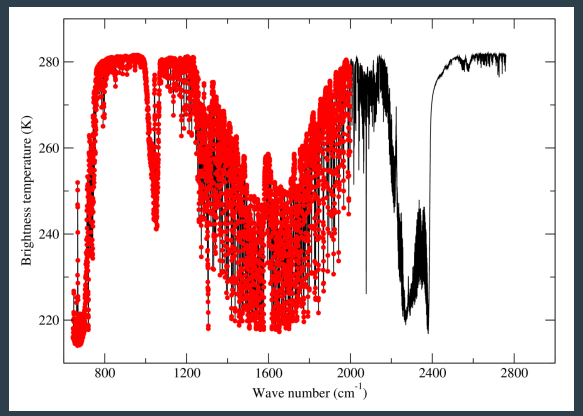
Exploitation of the full information of IASI

Technology is being developed to use the full IASI longwave and midwave spectrum using radiances reconstructed from truncated principal components

The 220 operational IASI channels

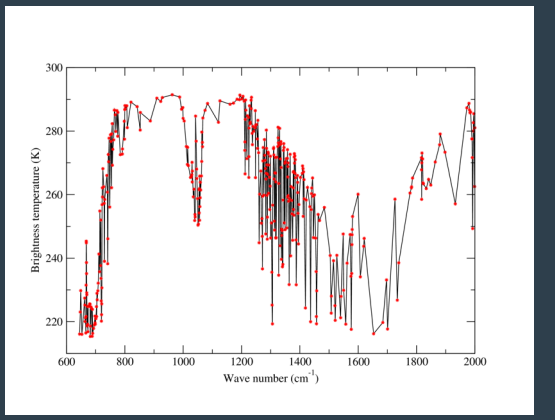


Information of 5421 IASI channels



Assimilating 400 reconstructed radiances

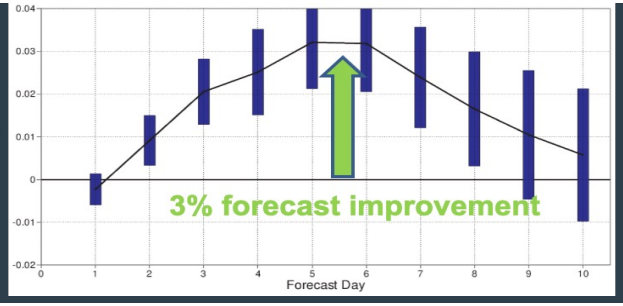
The 400 reconstructed radiances



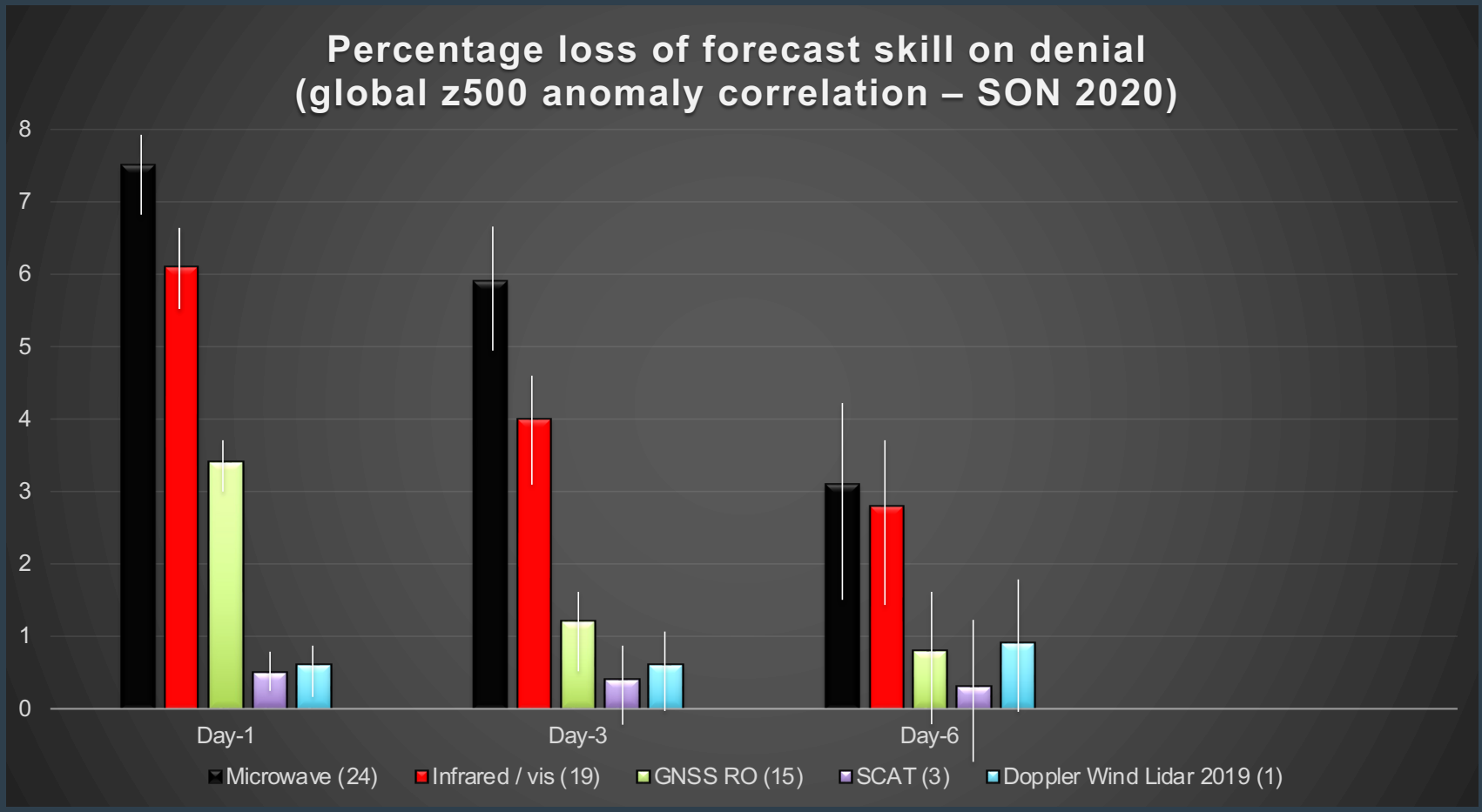
By assimilating the full IASI LW/MW spectrum via reconstructed radiances derived from truncated PCA we can extract even more information from these observations.

Latest results show PCA/RR consistently outperforming traditional radiance channels assimilation

Improvement (compared to operational IASI radiance baseline assimilation) in SH forecasts of 500hPa geopotential height



Impact on the forecast system (500hPa Geopotential)



Impact of IASI: forecast sensitivity to observations (FSOI) time series