Changes in the operational use of passive sounding data in the ECMWF NWP system since ITSC-23

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Current configuration of the high-resolution global NWP system (47R3)

Spatial resolution: $T_{CO}1279$ (≈9km)
Final incremental analysis resolution: T_L399 (≈50km)
Vertical resolution: 137 levels, up to 0.01 hPa
Assimilation system: 12h 4d-Var with 8h early delivery window; background errors of the day from 50-member Ensemble of Data Assimilations (EDA)

Major system upgrades since ITSC-23:

- **Cycle 47r3 – 12 October 2021**
- **Cycle 48r1 – planned for June 2023**

For full details see https://www.ecmwf.int/en/forecasts/documentation-and-support/changes-ecmwf-model.

Radiative transfer

Currently using RTTOV v12.2

Main changes in 47r3 (12 Oct 2021):

- ***New RTTOV coefficients for hyperspectral IR sounders***

Upcoming changes in 48r1 (June 2023):

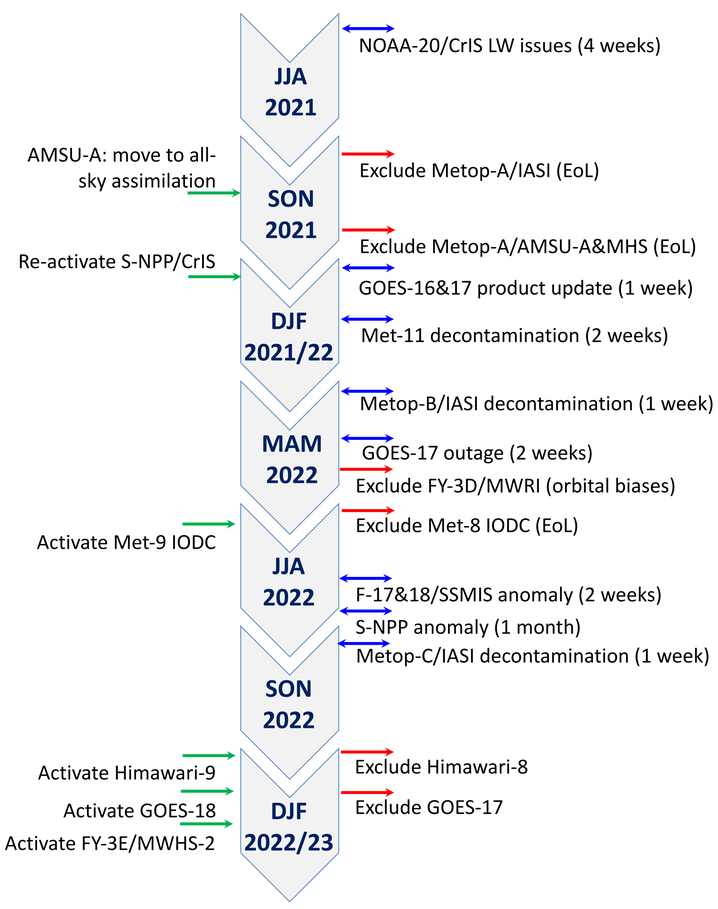
- **Upgrade to RTTOV version 13.0**
  - Major revision to cloud and precipitation microphysics in RTTOV-SCATT
  - Change to v13 predictors for MW sensors
  - Lambertian reflection for ATMS over snow and sea-ice

Current use of satellite instruments with TOVS heritage

A – Assimilated; P – Passively monitored; E – Under evaluation; X – Failed or data excluded due to quality/transmission issues; ⛈ – All-sky treatment
Changes since ITSC-23 are highlighted through orange shading.

Satellite	Present orbit position (LTAN, approx.)	MW temperature sounder	MW humidity sounder	MW imager	IR broadband sounder or imager	IR hyper-spectral sounder
NOAA-15	19:30	A ⛈	X		X	
NOAA-18	22:30	A ⛈	X		X	
NOAA-19	20:30	A ⛈	A ⛈		P	
NOAA-20	13:30	A	A			A
NOAA-21	13:30	E	E			
Aqua	13:30	X	X			A
S-NPP	13:30	A	A			A
Metop-B	21:30	A ⛈	A ⛈		X	A
Metop-C	21:30	A ⛈	A ⛈			A
FY-3C	19:00	X	A ⛈	X		
FY-3D	14:00	P ⛈	A ⛈	P ⛈ & X		E
FY-3E	17:30	E ⛈	A ⛈			
DMSP-F17	18:30		A ⛈	A ⛈		
DMSP-F18	16:00		A ⛈	P ⛈ & E		
GCOM-W1	13:30			A ⛈		
GPM	Mid-incl.		A ⛈	A ⛈		
Meteosat-9	45.5°E				A	
Meteosat-11	0°				A	
GOES-16	75.2°W				A	
GOES-18	137°W				A	
Himawari-9	140.7°E				A	
FY-4A	104.7°E					E
FY-4B	133°E					E

Timeline of main instrument changes since ITSC-23 **(radiances only)**



MW sounders and imagers

Main changes in 47r3 (12 Oct 2021):

- **Move AMSU-A assimilation from clear-sky to all-sky**

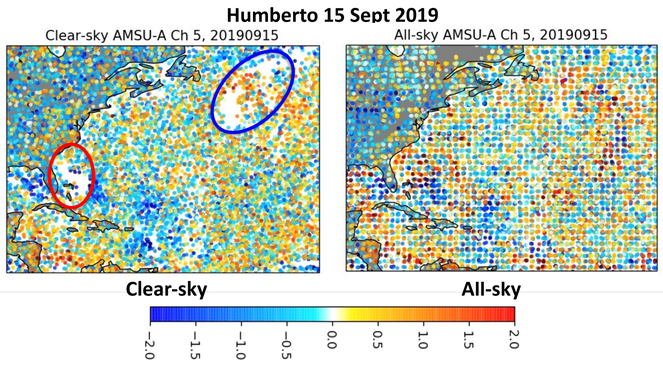
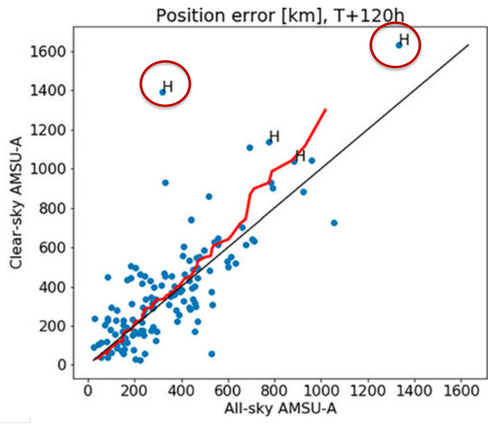
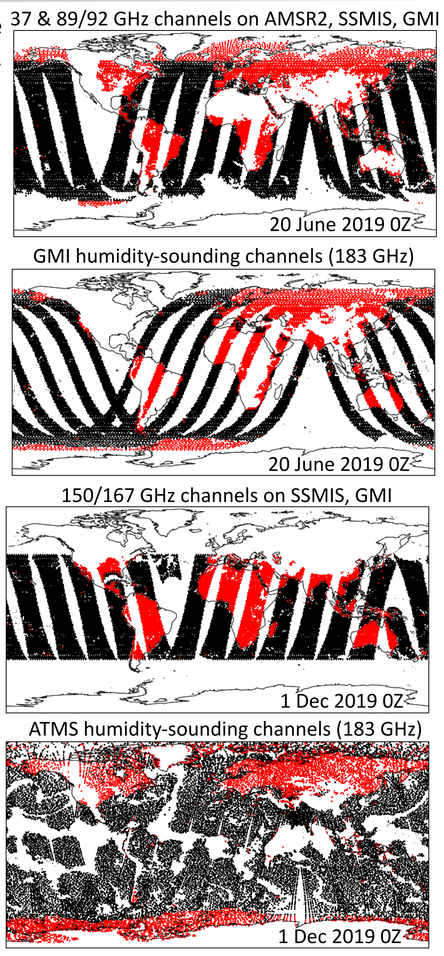


Fig. 1(below): Position errors for the day-5 forecast for tropical cyclones, with AMSU-A assimilated in clear sky (y-axis) vs all-sky (x-axis). The full observing system is used and unchanged otherwise. Period: July-Nov 2019.



Main upcoming changes in 48r1:

- **Extended assimilation of MW radiances over "difficult" surfaces, for imager and humidity-sounding channels (Fig. 2, right):**
  - Window channels (37, 89, 150/166 GHz) over land and polar oceans (AMSR2, GMI, SSMIS)
  - SSMIS and GMI humidity-sounding channels over land and sea-ice
  - Lowest humidity-sounding channels over snow-free land at high latitudes for instruments used in all-sky
  - ATMS humidity-sounding channels over snow (using Lambertian reflection)
  - Improved treatment of mixed scenes
- **Major upgrade of cloud and precipitation microphysics in RTTOV-SCATT, esp for ice-clouds**
- **Slant-path radiative transfer for cross-track MW humidity sounders in all-sky**



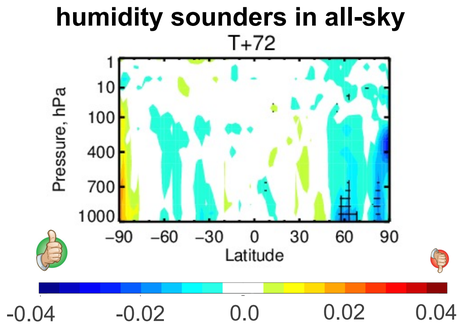


Fig. 2, left: Normalised difference in RMSE of 72 h wind forecasts resulting from the MW radiance upgrade in 48r1 (excl RTTOV-SCATT). Period: 20 June – 30 Sept 2019 & 1 Dec 2019 – 29 Feb 2020. right: Examples of additional coverage activated in 48r1 (red).

IR sounders and imagers

Main changes in 47r3 (12 Oct 2021):

- **New RTTOV coefficients for all hyperspectral sounders (100 layers, updated CO_2 and spectroscopy), Fig. 3**
- **Updated observation error covariance for AIRS (with inter-channel error correlations)**

Main upcoming changes in 48r1:

- **New aerosol-type classification for all hyperspectral sounders (Fig. 4)**
- **Updated trace-gas detection**
- **Allow usage of all IASI pixels (subject to thinning)**
- **Unified VarBC setup for all hyperspectral IR sounders**

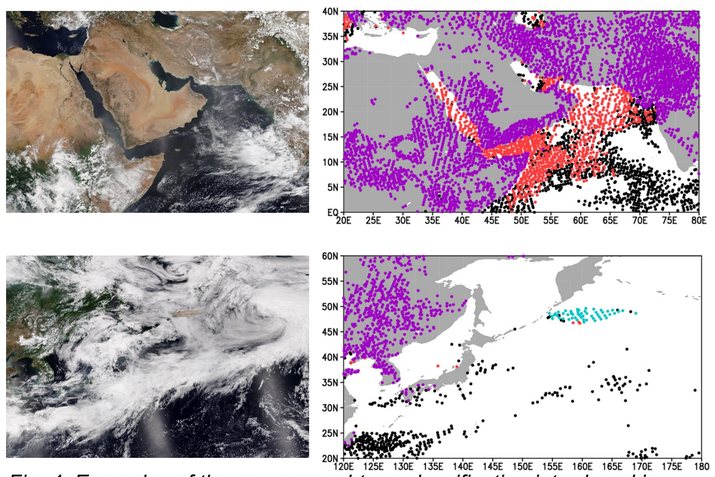


Fig. 4: Examples of the new aerosol-type classification introduced in 48r1 (right) for the situations shown on the left. Purple – aerosol over land; red – desert dust; cyan – volcanic ash; black – other

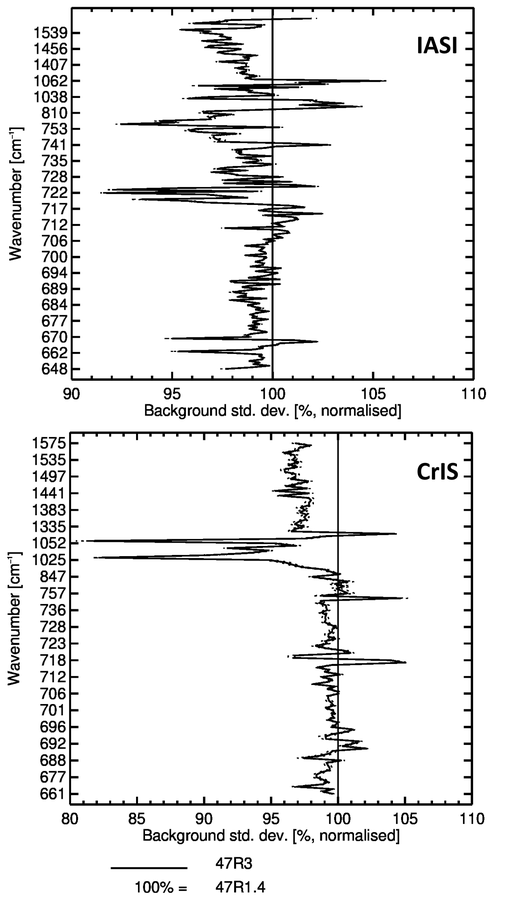


Fig. 3: Stdev(o-b) for used IASI (top) and CrIS (bottom) observations as a result of the IR sounder upgrades in 47r3, normalised by the control experiment. Values below 100% indicate an improvement, mostly from better forward-modelling for the two instruments. Period: 27 June – 11 Aug 2019 & 6 Dec –2019 – 2 Feb 2020

In development/under evaluation

(with relevant ITSC-24 presentation/poster numbers)

- **New or future observations:**
  - Monitoring of visible reflectances (3p.01 – Cristina Lupu)
  - FY-4B/GIIRS (7p.01 – Chris Burrows)
  - FY-3E (15.04 – Liam Steele)
  - TROPICS (8p.03 – David Duncan)
  - Sterna (8.01 – Katie Lean)
  - CrIS SW IR channels (15p.01 – Chris Burrows)
- **Fuller exploitation of window channels incl extraction of surface information in a coupled system** (3.04 – Samuel Quesada-Ruiz; 13.03 – Tracy Scanlon; 10p.03 – David Duncan)
- **Revised thinning and super-obbing for humidity-sounders** (9.05 – David Duncan)
- **Improved observation-error modelling for hyperspectral IR and alternative assimilation approaches** (12.01 – Kirsti Salonen; 12.06 – Cristina Lupu; 15p.14 – Kirsti Salonen)
- **Orbital biases and how to treat them** (2p.01 – Niels Bormann)
- **Machine learning approaches for cloud detection and detection/classification of observation anomalies** (11.03 – Chris Burrows; 11p.03 – Mohamed Dahoui)
- **Assimilation of reprocessed and rescued radiance observations for ERA6** (5.04 – Bill Bell)

Acknowledgements

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