Met Office

Recent upgrades in the use of satellite radiance observations within the Met Office global NWP system

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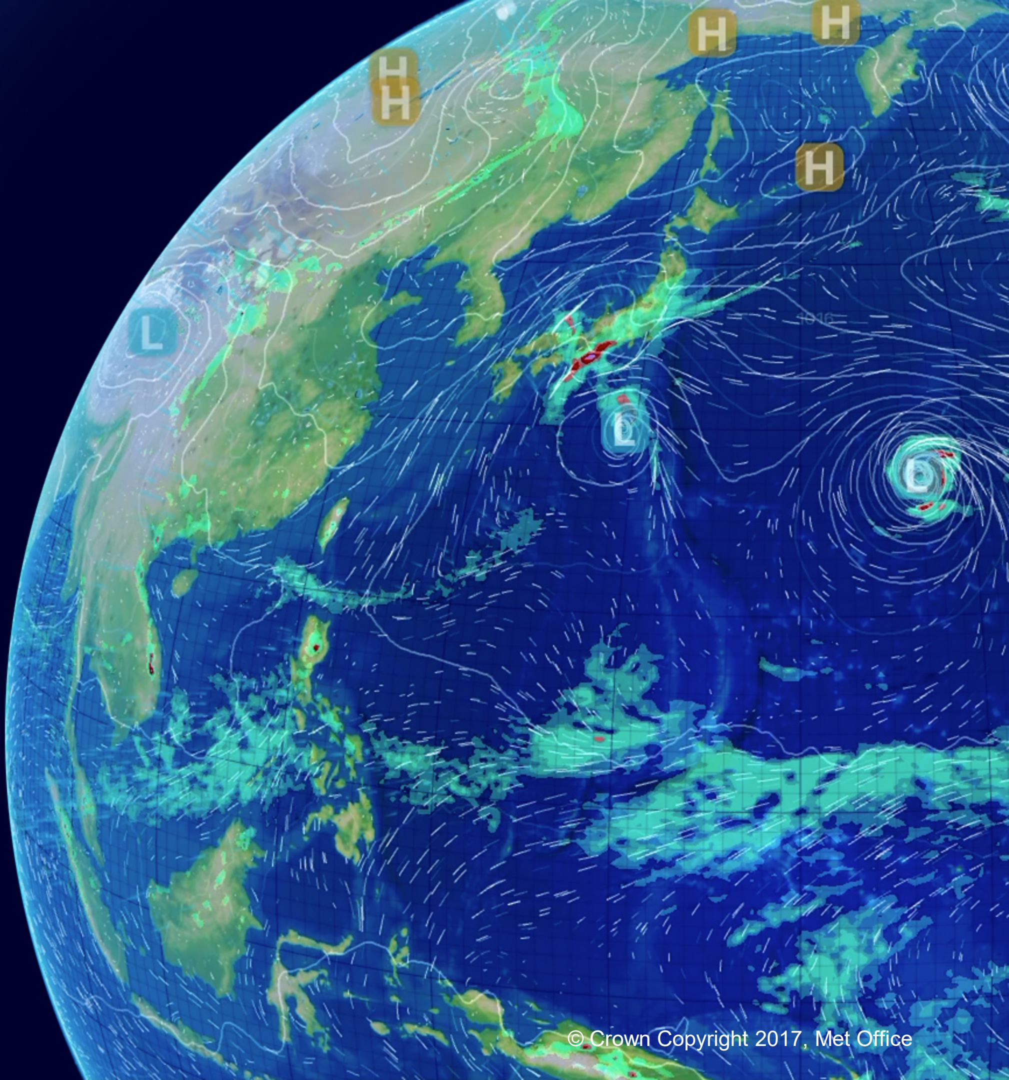

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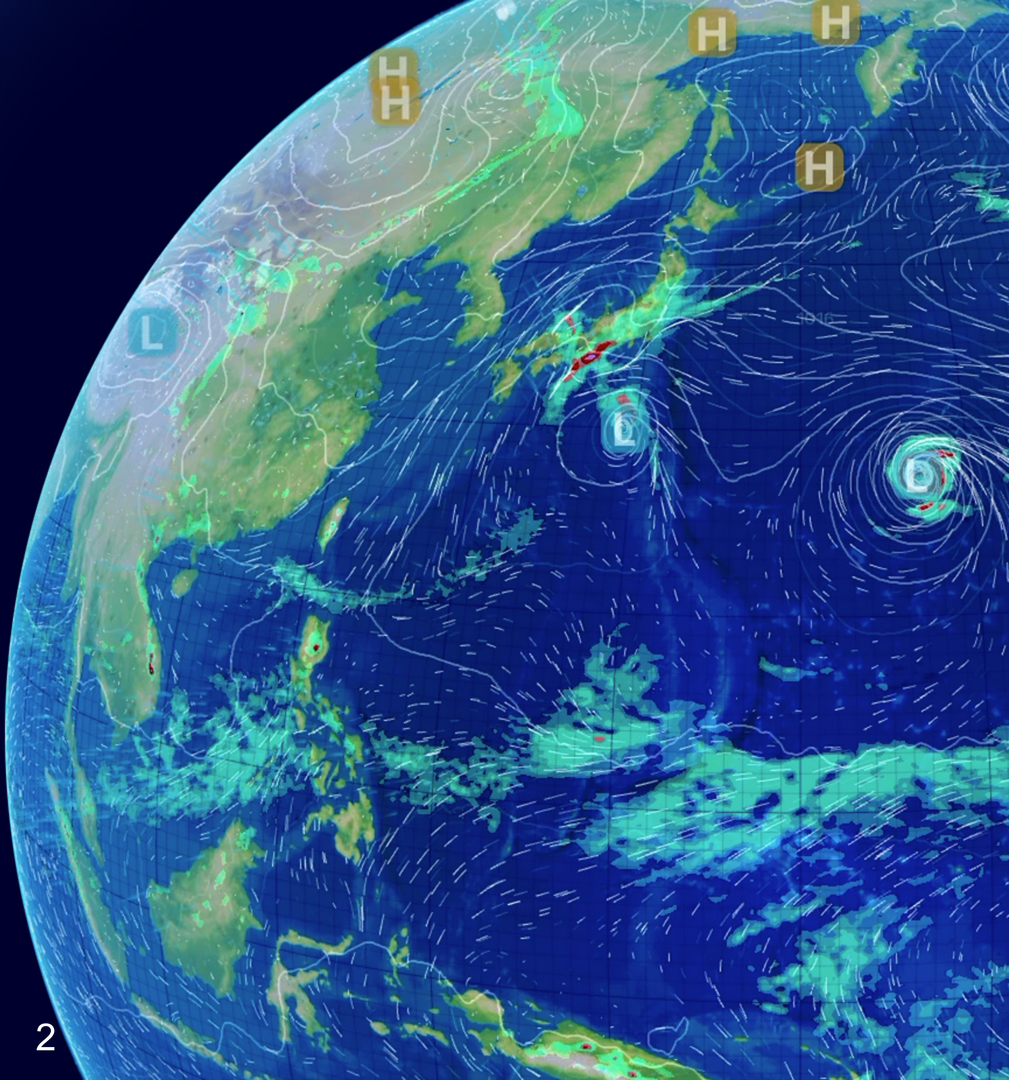
Acknowledgements

Brett Candy[1], Nigel Atkinson[1], Fabien Carminati[1], Michael Cooke[1], James Hocking[1], Byung-Il Lee[2], Stefano Migliorini[1], Stuart Newman[1], Ed Pavelin[1], David Rundle[1], Ruth Taylor[1], Michael Thurlow[1], Simon Thompson[1], Warren Tennant[1], and Emma Turner[1]

[1]Met Office; [2] KMA



Introduction

- Improvements in the assimilation of satellite radiance observations have led to significant performance gains in the Met Office global model over the last two years.
- Upgrades where implemented operationally in packages of changes. However, each individual change was evaluated separately in trials to evaluate its impact.
- Resolution of the deterministic model was N1280 (~10km); trials at N320 (~40km).
- Upgrades in the treatment of satellite radiance data have occurred at model upgrades in Dec 2019 and Dec 2020
- Three broad categories of improvement:

1. Introductions of new instruments
2. Improvements in the use of RTTOV
3. Improved radiance observation processing

Introductions of new instruments

- ABI on GOES-16 (Nov-19)[1]
- MWRI on FY-3C (Nov-19)[2]
- ATOVS[3] and IASI[4] on Metop-C (Dec-20)
- MWHS-2, MWTS-2 and MWRI on FY-3D (Dec-20)[2]

[1]Ruth Taylor, [2]Fabien Carminati, [3]Brett Candy, [4]Mike Cooke

Met Office Satellite radiance data used in NWP in June 2021

Observation type	Satellites
AMSU / ATMS / MHS radiances	3 NOAA + S-NPP + Metop-A+B+C + NOAA-20
HIRS clear radiances	Metop-A+B
IASI, CrIS and AIRS radiances	Metop-~~A~~+B+C + S-NPP + Aqua + NOAA-20
SSMIS radiances	1 DMSP (F-17)
AMSR-2 + GMI + MWRI radiances	GCOM-W + GPM Core + FY-3C
MWHS-2 + MWTS-2 radiances	FY-3C + FY-3D
Geo imager clear IR radiances	MSG, MTSAT/Himawari, GOES-16

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Addition of ATOVS and IASI on MetOp-C

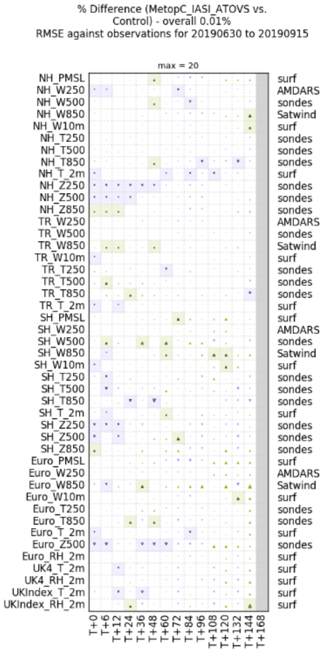
Problematic to introduce additional ATOVS obs

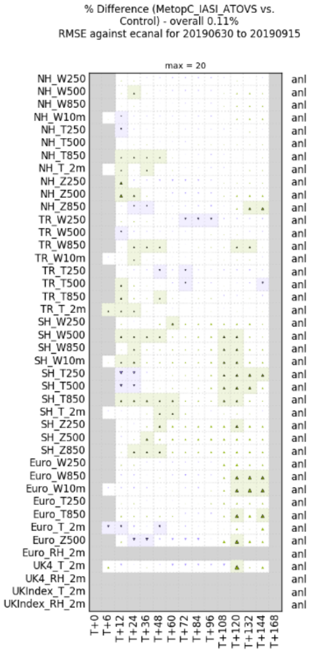
- Thinned separately in our system
- Additional data without accounting for horizontal error correlations.
- Neutral impact found swapping ATOVS A for C

IASI thinned together so neutral impact when introduced without ATOVS.

Best benefit found introducing ATOVS and IASI together

Trial	Change in Scorecard (%)		
	vobs	vanl	vEC
0 – ATOVS C added in	-0.10	-0.20	-0.14
1 – ATOVS swap A & C	-0.02	0.03	0.00
2 – IASI	0.02	-0.01	0.04
3 – IASI & ATOVS	0.01	0.05	0.11





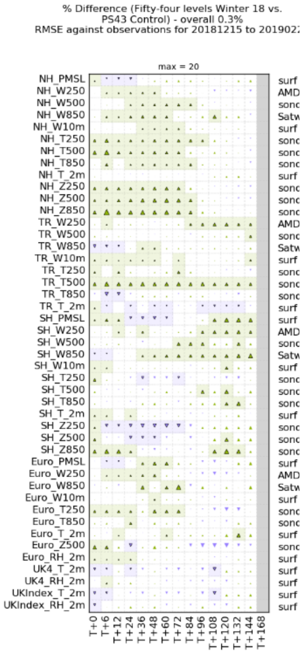
Improvements in the use of RTTOV

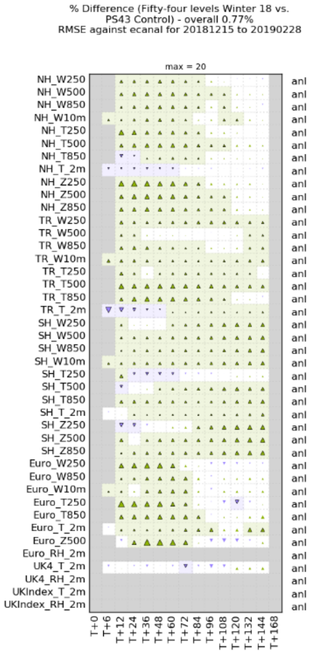
- Move from 43 coefficient levels to 70 model levels in the radiative transfer solving, obviating the need for interpolation of model fields to RT levels.

- Improving the quality of the radiative transfer:

➢ move from 43 to 54 coefficient levels (Dec-20)

Courtesy: David Rundle, Byung-Il Lee, James Hocking, Emma Turner + others





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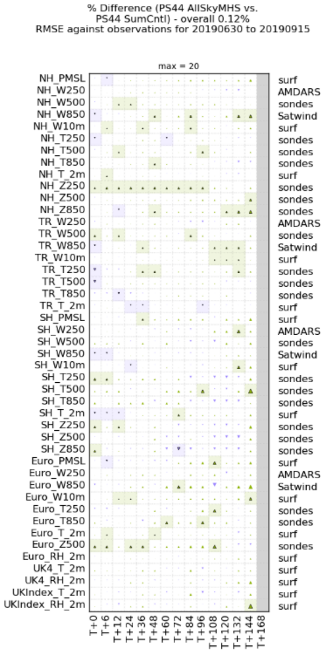
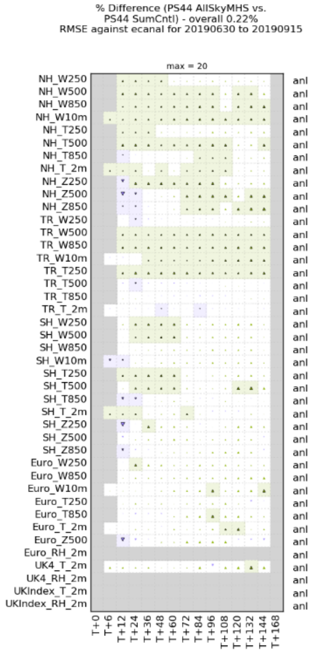
Improved radiance observation processing

- Move to all-sky assimilation of MHS (Dec-20)[1]
- Improvements in the treatment of microwave humidity sounding data over land (Dec-20)[2]
- Improved quality control for cloud screening applied to microwave imagers (Dec-20) [3]

[1]Brett Candy and Stefano Migliorini, [2]Stu Newman, [3]Fabien Carminati





Comparison of Impacts for PS44

PS44 to became operational on Dec. 8, 2020

Scores from two season experiments of the most important satellite changes

Introduction of novel instrument types and enhanced processing of current types lead to appreciable improvements in impact

Update to RT coefficients to 54 L is king of this change.

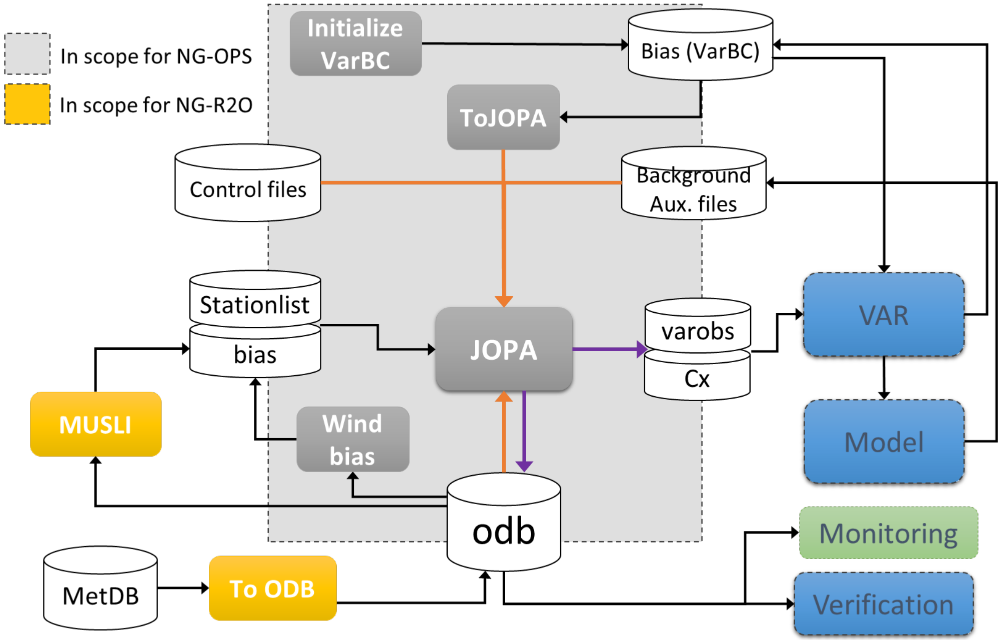
Experiment	% reduction RMSE Obs	% reduction RMSE EC an
Mie winds from Aeolus	+0.08	+0.14
MHS All-sky assimilation	+0.11	+0.20
RTTOV coefs 43 to 54L	+0.22	+0.52
Swap thinning priority for ATMS	+0.06	+0.07
MetOp-C implementation	-0.03	+0.08

Current Work: Porting OPS to JEDI

NG-OPS

- Delivering the Next Generation Observation Processing System within JEDI
- Replicate our current Observation Processing science for atmospheric data assimilation in JEDI (JOPA)
- Initially, we will use JOPA coupled with our current VAR system (ready late 2023).
- A few years later we'll implement a full DA system within JEDI.
- In the short term, this will decrease the scientific impact the Met Office can make.
- Long term we expect JEDI to be more scalable and more flexible.
- Ease collaboration efforts with others in JEDI consortium.

JOPA: Jedi-based Observation Processing Application



Slide courtesy David Simonin

Conclusions

Summary of key developments in radiance assimilation in the last 2 years.

Increases in satellite sounding data availability continues to lead to improvements in forecasts with appropriate assignment of observation errors, observation selection/thinning and quality control.

All-sky assimilation is an example of where improvement in our understanding of the observation errors along with an improved forward model can lead to the assimilation of a greater number of beneficial observations from instruments traditionally only used in clear or mostly-clear skies.

Improvements in radiative transfer also have a very important contribution to these impacts. Improvement in treatment of RT is most positive change for our Dec 2020 upgrade.

Current work focuses on porting OPS science to the JEDI Observation Processing Application, a more future-proof, flexible processing system.