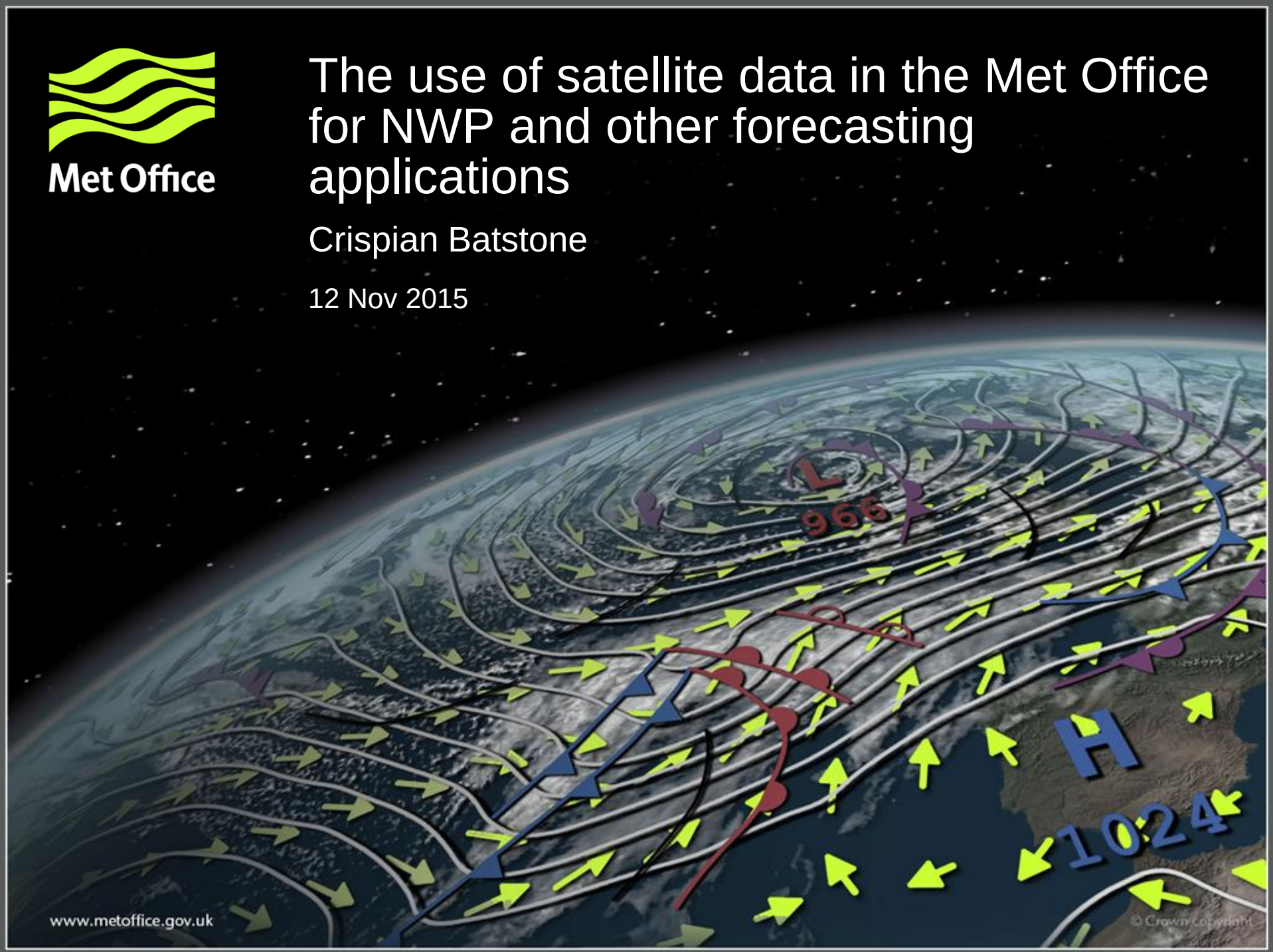
The use of satellite data in the Met Office for NWP and other forecasting applications

Crispian Batstone

12 Nov 2015



Acknowledgements & Partners

Met office

Isabella Ascione, Nigel Atkinson, Bill Bell, Thomas Blackmore, Anna Booton, Fabien Carminati, Mike Cooke, John Eyre, Emma Fiedler, Mary Forsythe, Pete Francis, James Hocking, Simon Keogh, Katie Lean, Stuart Newman, Roger Saunders, Andy Smith, Ruth Taylor

Partners

• Europe: ESA, EUMETSAT members, ECMWF, UK Space, Universities

• USA: NASA, NOAA

• Asia: BoM, CMA, JAXA, JMA, KMA

• S. America: CPTEC/INPE

Outline

- Operational NWP models
- Satellite observations assimilated
- Plans for Himawari-8
- Experiments with AMSR-2
- Other activities (FY-2 / FY-3 / Meteor-M N2)
- Future challenges

2015 NWP Models Seamless Suite

UKV and MOGREPS-UK

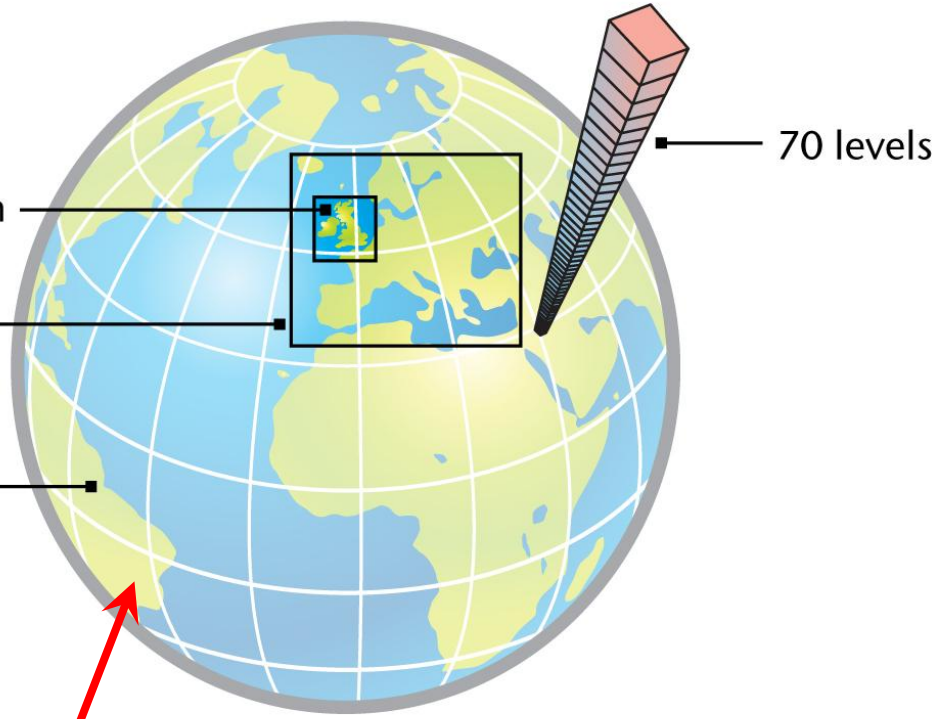
- 1.5km 70L (40km model top)
- 36hr forecast
- 8 times per day
- 12-member Ensemble - 2.2km 4x/day 36h

Euro4

- 4km 70L (40km model top)
- 66hr forecast twice/day
- 144hr forecast twice/day

Global and MOGREPS-G

- 17km 70L (80km model top)
- 66hr forecast twice/day
- 144hr forecast twice/day
- 12-member Ensemble - 33km 4x/day 7d
- 24-member Ensemble - 60km 2x/day 15d



Seasonal: GloSea5

- 60km 85L (80km model top)
- ¼ degree Ocean
- 14-member Ensemble
- 7month forecast once/week

Current NWP configurations

Model	Grid length in mid-latitudes	Grid points	Vertical levels	Forecast length	Run times (UTC)	Initial conditions
Global	17 km	1536 x 1152	70 (lid ~80 km)	6 days (for 00z and 12z)	00, 06, 12, 18	Hybrid Incremental 4D-Var with MOGREPS Ensemble
UKV	1.5 km inner 4 km outer	744 x 928	70 (lid ~40 km)	36 hours	03, 09, 15, 21	Incremental 3D-Var
MOGREPS Global ensemble	33 km	800 x 600	70 (lid ~80 km)	7 days (12 members) 9 hrs (33 members for Hybrid analysis)	00, 06, 12, 18	Global analysis + 45 member ETKF perturbations (of which 12 run to full forecast length at each cycle)
MOGREPS medium-range ensemble	60 km	432 x 324	85 (lid ~85 km)	15 days	00, 12	Global analysis + 22 member ETKF perturbations + 1 Stochastic physics member
MOGREPS UK ensemble	2.2 km	532 x 654	70 (lid ~40 km)	36 hours	03, 09, 15, 21	12 member, perturbations interpolated from global ensemble

Satellite data used in NWP (1)

Observation type	Satellites	NWP models *
AMSU/MHS radiances	4 NOAA + 2 Metop	G, R
HIRS clear radiances	2 Metop	G, R
IASI and AIRS clear+cloudy radiances	Metop + Aqua	G, R
ATMS & CrIS radiances	Suomi NPP	G
SSMIS radiances	F16 used before failure, preparing F17/18	G, R
Geo imager clear IR radiances	MSG, MFG, GOES, MTSAT2	G, R, UK
GPS RO bending angles	5 COSMIC, Metop/GRAS, GRACE-A, TerraSAR-X, CNOFS	G, R
GPS ZTDs	~350 European stations	G, R, UK

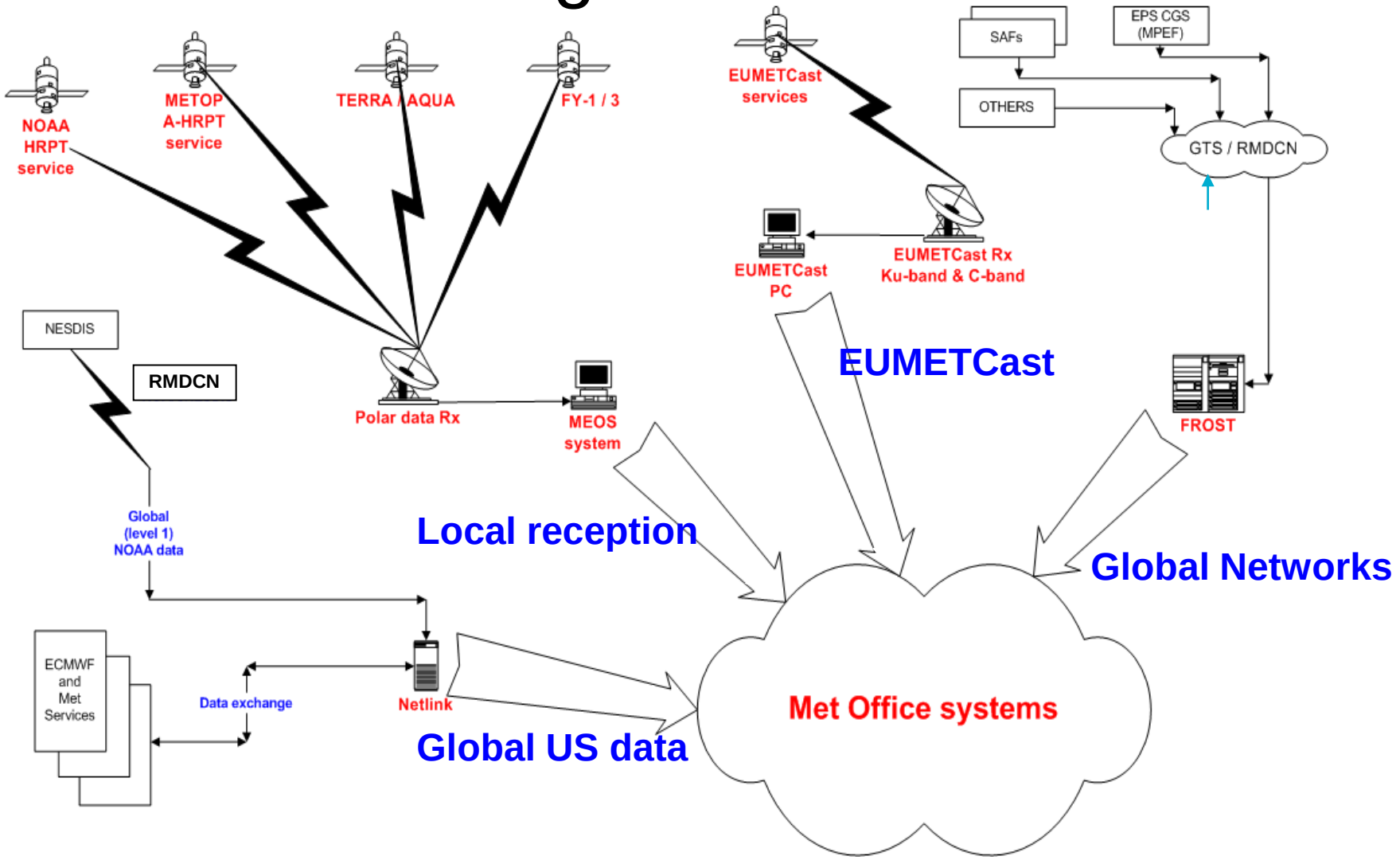
* G = Global, R = Regional = Europe, UK = UK area

Satellite data used in NWP (2)

Observation type	Satellites	NWP models *
AMVs - Geo	5 geo satellites	G, R, UK
AMVs – MODIS and AVHRR	Aqua, Terra, NOAA, Metop	G, R
Scatterometers: sea-surface winds	Metop/ASCAT	G, R, UK
MW imager sea-surface winds	Windsat/Coriolis	G
SEVIRI cloud height/amount	MSG	R, UK
SSTs: AVHRR, AMSR-E…	NOAA, Metop, Aqua	G, R, UK
Soil moisture: ASCAT	Metop	G, R, UK
Sea ice: SSM/I, SSMIS	DMSP	G, R
Snow cover	various	G, R

* G = Global, R = Regional = Europe, UK = UK area

How we get the data



Himawari 8 plans

11 channels @ 2km, every 30 minutes via EUMETCast (MSG SEVIRI-like)

AHI channel number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Central wavelength (microns)	0.46	0.51	0.65	0.86	1.61	2.3	3.85	6.25	7.0	7.35	8.6	9.6	10.45	11.2	12.35	13.3

- October 2015: switch operational imagery from MTSAT2 (single channel / Volcanic Ash), new imagery (e.g. dust RGB)
- Working on cloud mask + products
- Reduced resolution CSRs / AMVs in global model
- High resolution locally processed CSRs / AMVs in SingV model
- Enhanced VA products using both IR window channels
- AOD JAXA product

AMSR-2 in DA for Global Model

Assimilation of radiances for atmospheric global model

VISION:

“To utilize a constellation of AM and PM orbit microwave imagers in our satellite DA system”

GOALS:

- To utilize AMSR-2 as the primary PM orbit imager

- To utilize SSMIS as the primary AM orbit imager

AMSR-2 in DA for Global Model

May 2012: Launch of GCOM-W1 satellite

May 2013: L1B Test Data Available

Feb 2014: Trial service available on EUMETCast

Mar 2014: Met Office begins receipt and storage of data

May 2014: Data storage and retrieval fully operational

Jun 2015: Global NWP assimilation trials of AMSR-2 data

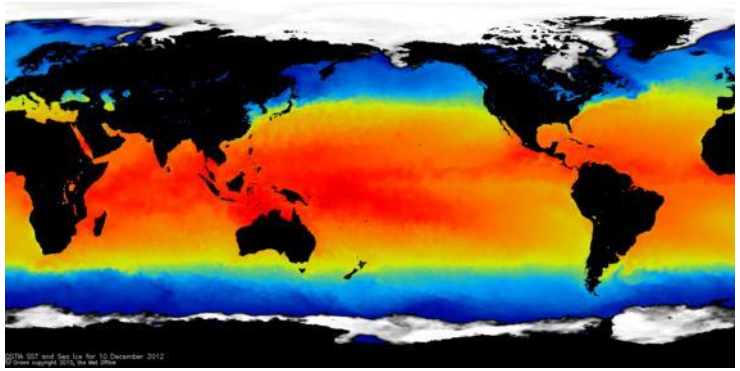
Nov 2015: Expected pre-operations parallel suite 37 start date

Feb 2016: Expected “go live” of AMSR-2 in NWP operations

AMSR-2 in DA for Global Model

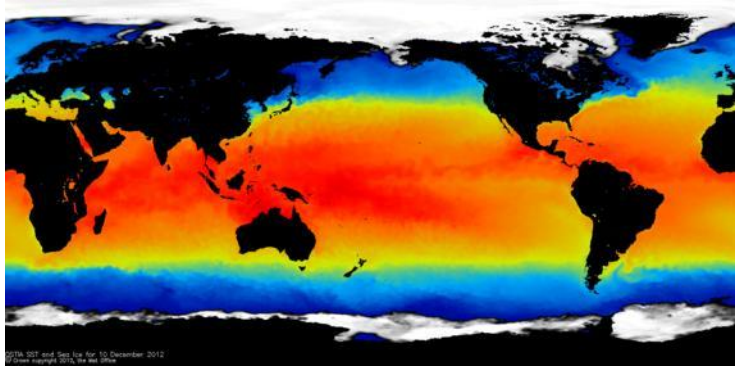
- Code had to be implemented to allow:-
  - Retrieval of AMSR-2 data from the MetDB
  - Quality control and 1d-Var steps within Observation Processing System (OPS)
  - Inclusion in full Variational Data Assimilation (VAR) system
- The data quality from AMSR-2 has been assessed to be good. No orbital biases have been observed.
- The GAIA-CLIM project aims to utilise the power of NWP to study biases in climate related observations. Met Office and ECMWF plan to look at humidity observations from AMSR-2 as part of this project. Collaboration with JAXA would be welcome.

AMSR-2 in OSTIA



- Operational Sea Surface Temperature and Sea Ice Analysis
- Daily analysis, 1/20^{o} grid resolution
- Globally complete, gridded
- Validates well compared to other analyses using independent near-surface Argo observations

AMSR-2 in OSTIA



Data types currently assimilated in OSTIA:

- NOAA-18 & 19 & MetOp-A AVHRR AVHRR
- SEVIRI
- GOES
- In situ (ships, drifters, moored buoys)

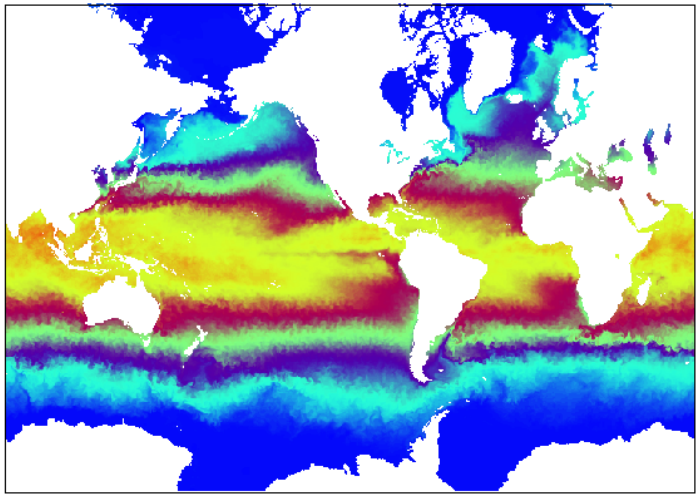
Trial JAXA AMSR2 L2P v2.1:

For a test month of March 2015, a control run and a run assimilating AMSR2 SST observations was conducted.

AMSR-2 in OSTIA: Results

- Biases and RMS errors in the high latitudes are large.
- Likely related to microwave insensitivity at low SSTs for certain channels.
- Comparison run using AMSR2 SST observations produced by RSS (Remote Sensing Systems)
- RSS and JAXA AMSR2 biases compared to OSTIA are quite similar. Both have large RMS errors in the high latitudes, but RSS is smaller.
- Ideally use JAXA AMSR2: RSS do not provide an operational service

AMSR-2 in FOAM

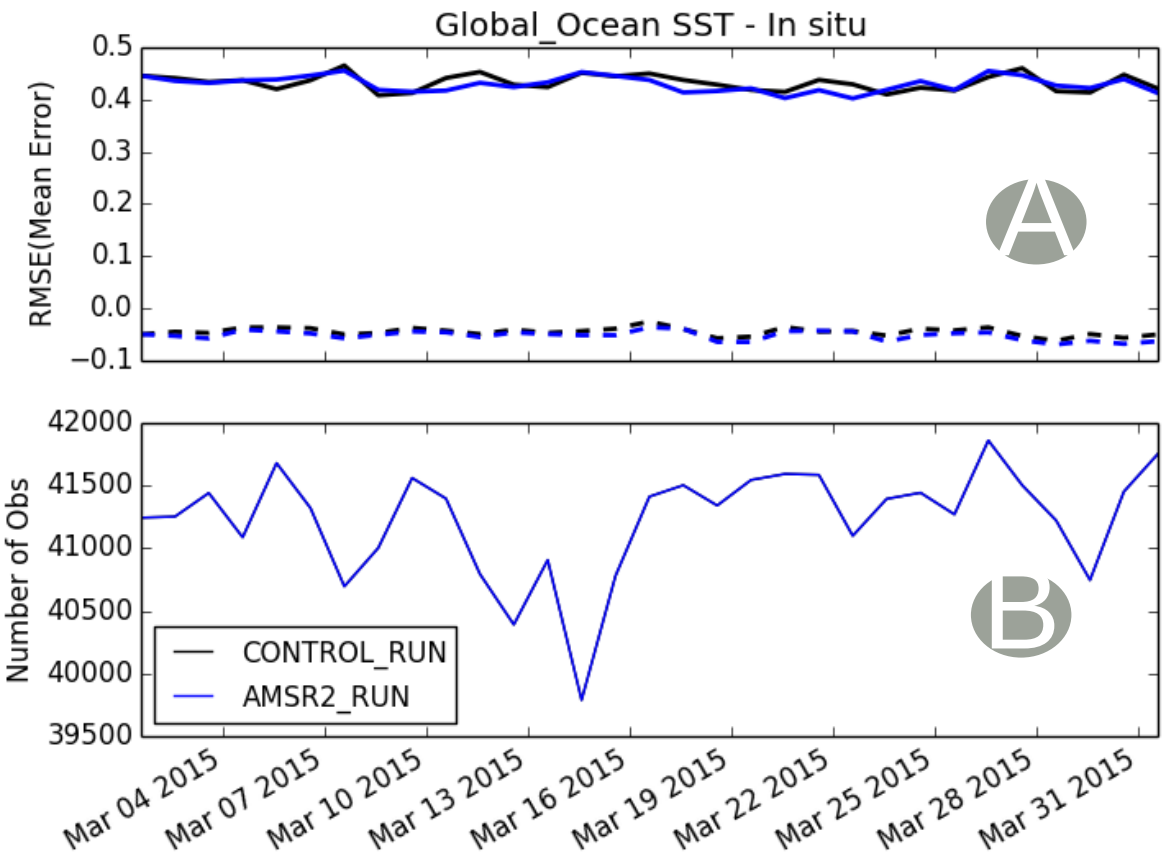


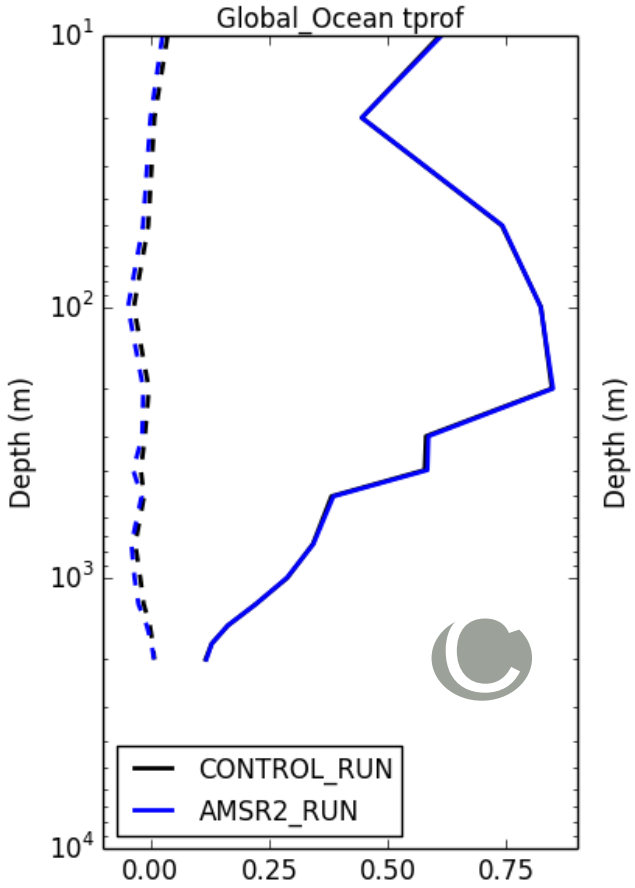
- Forecast Ocean Assimilation Model
- NEMO 3.4
  - Horizontal res. 1/4˚
  - 75 vertical levels
- Data Assimilation:

  NEMOVAR 3D-var
- Forcings : CORE
- CICE Sea Ice Model

Trials: Control / AMSR2 runs

AMSR-2 in FOAM: Results

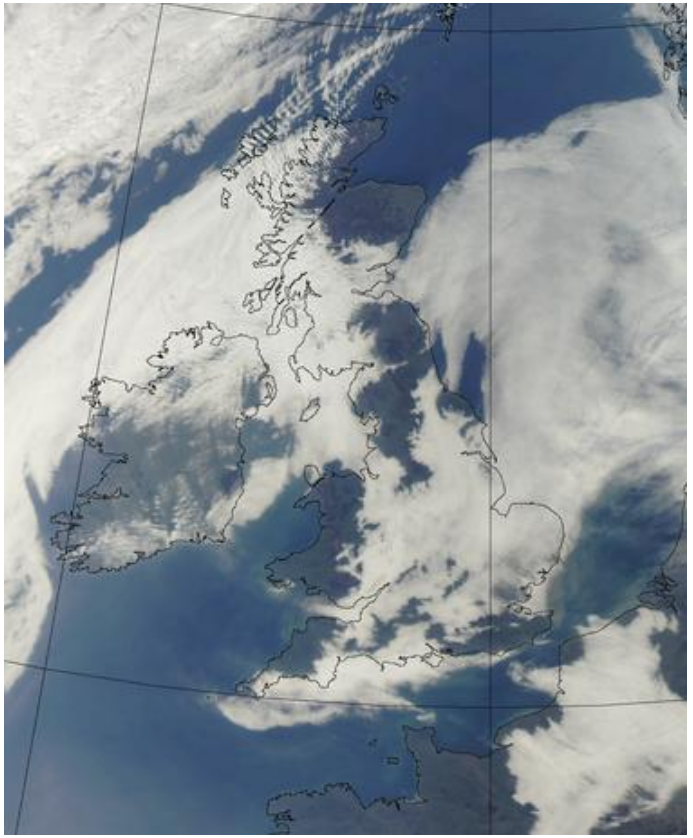




Temp. profile error (ºC)

Other activities

- FY-2 imagery
- FY-3 direct broadcast imagery
- Meteor-M N2 MTVZA-GY

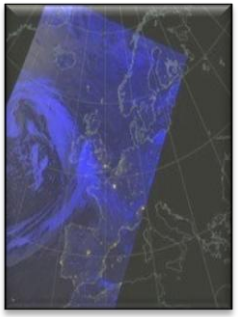


Satellite Imagery for OPS/Hazard Centre

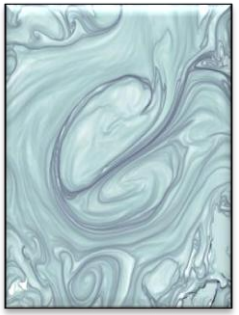
Aircraft icing

Snow cover

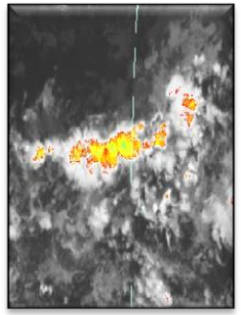
Fog



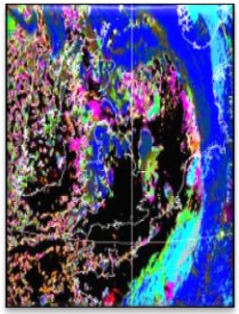
Night imagery



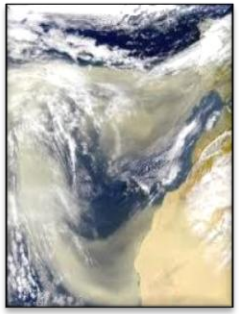
Simulated imagery



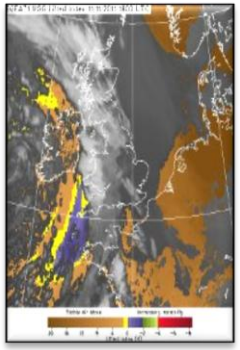
Severe convection



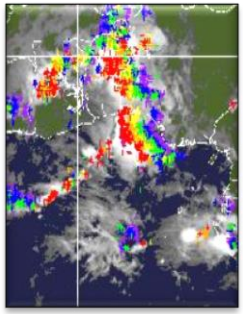
Cloud parameters



Dust



Instability



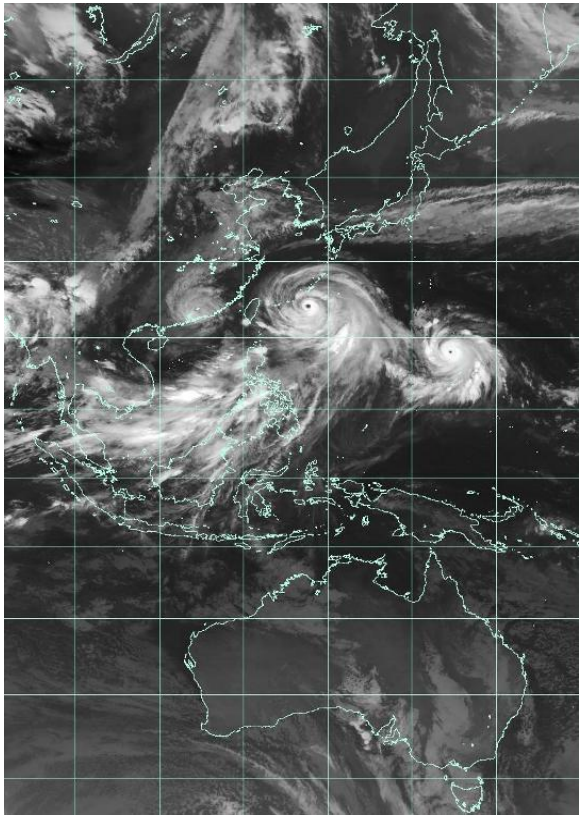
Lightning

Rain

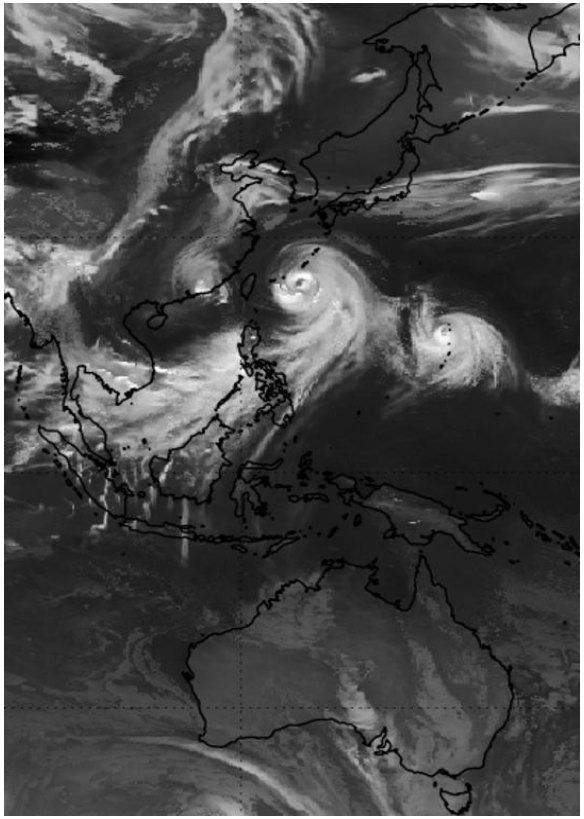
Volcanic Ash

Simulated satellite imagery

9 July 2015 12:00 UTC



MTSAT2



Simulated

Future challenges

GEO

- GOES-R + GLM
- MTG FCI, LI, IRS

LEO

- Sentinel 3
- EPS-SG
- JPSS 1
- GPM GMI
- ADM-Aeolus

Met Office

Thank you for listening!

Questions and (potentially) Answers