

Which AMVs for which model?

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Thanks to

- Regis Borde, EUMETSAT
- James Cotton, Met Office
- Javier Garcia-Pereda, NWC SAF
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- Kenichi Nonaka, JMA
- Ad Stoffelen, KNMI
- Chris Velden, CIMSS

For contributing material and thoughts on this topic

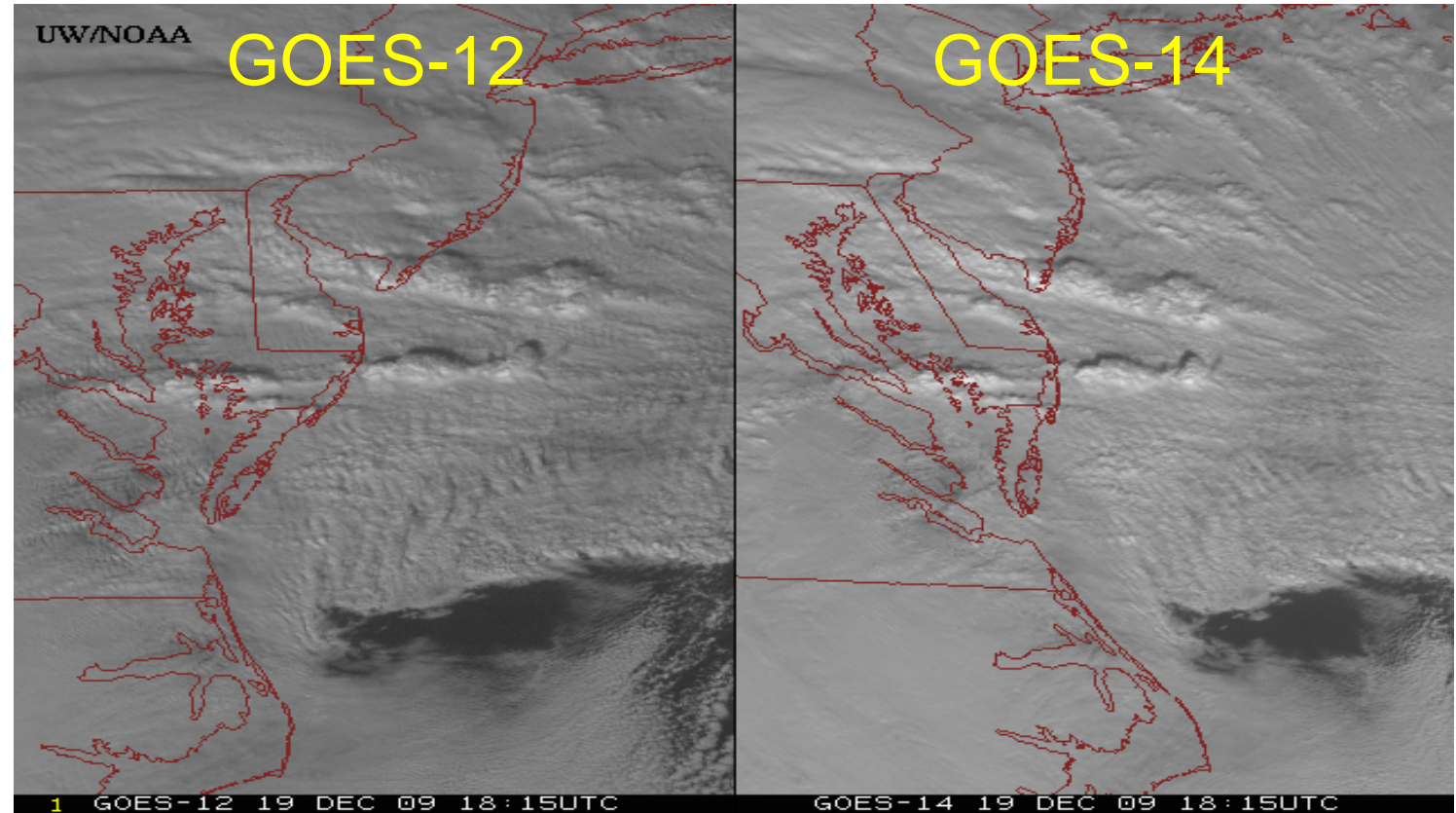
- 1. Motivation**

2. NWP requirements

3. Considerations for AMV production

Motivation

- Most current AMV products capture broad-scale to synoptic-scale flow.
- Can see information available on smaller scales in the imagery.
- Spatial and temporal resolution improving e.g. Himawari-8. GOES-16, MTG
- **Can we derive more useful AMV information for nowcasting or assimilation in high resolution models? Particularly to help with forecasting high impact weather events.**



Visible data from the GOES-14 NOAA Science Test – 1 min imagery, *from Jaime Daniels, NESDIS*

Motivation

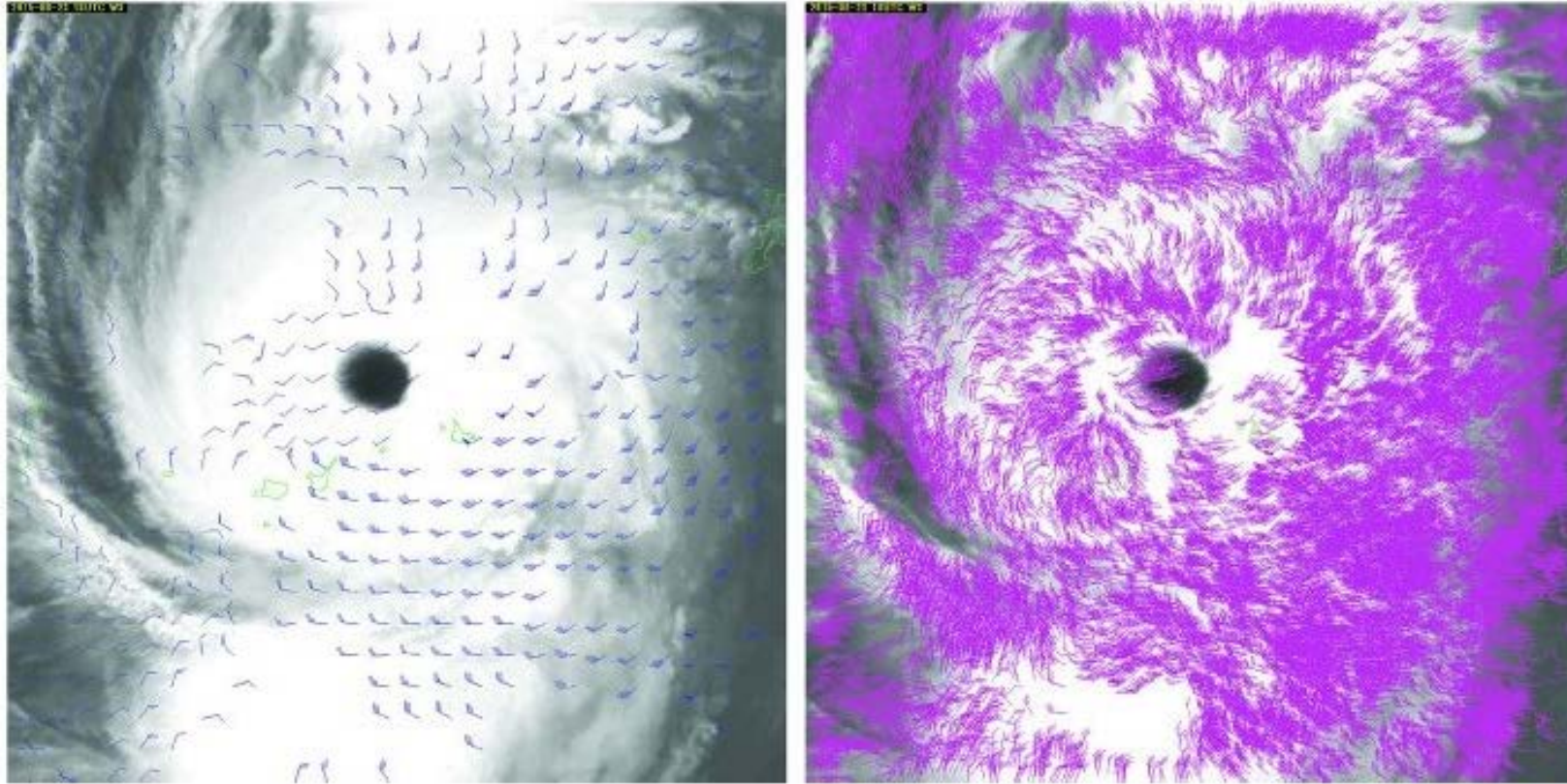
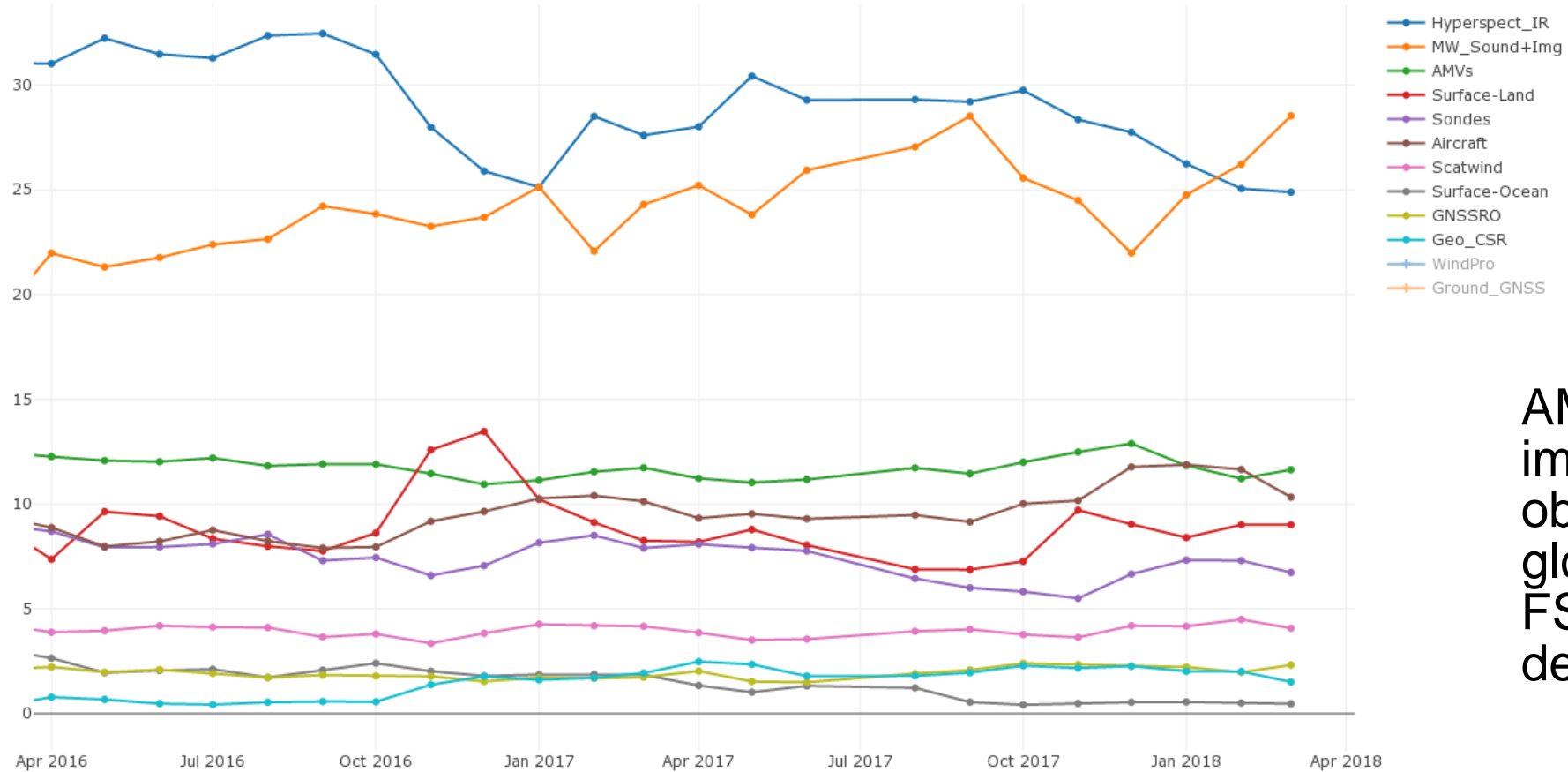


Fig. 5. Spatial distributions of MTSAT WV AMVs (left, blue arrows) and Himawari-8 WV AMVs (right, pink arrows) for Typhoon Goni (1515) at 1800 UTC on 23 August 2015.

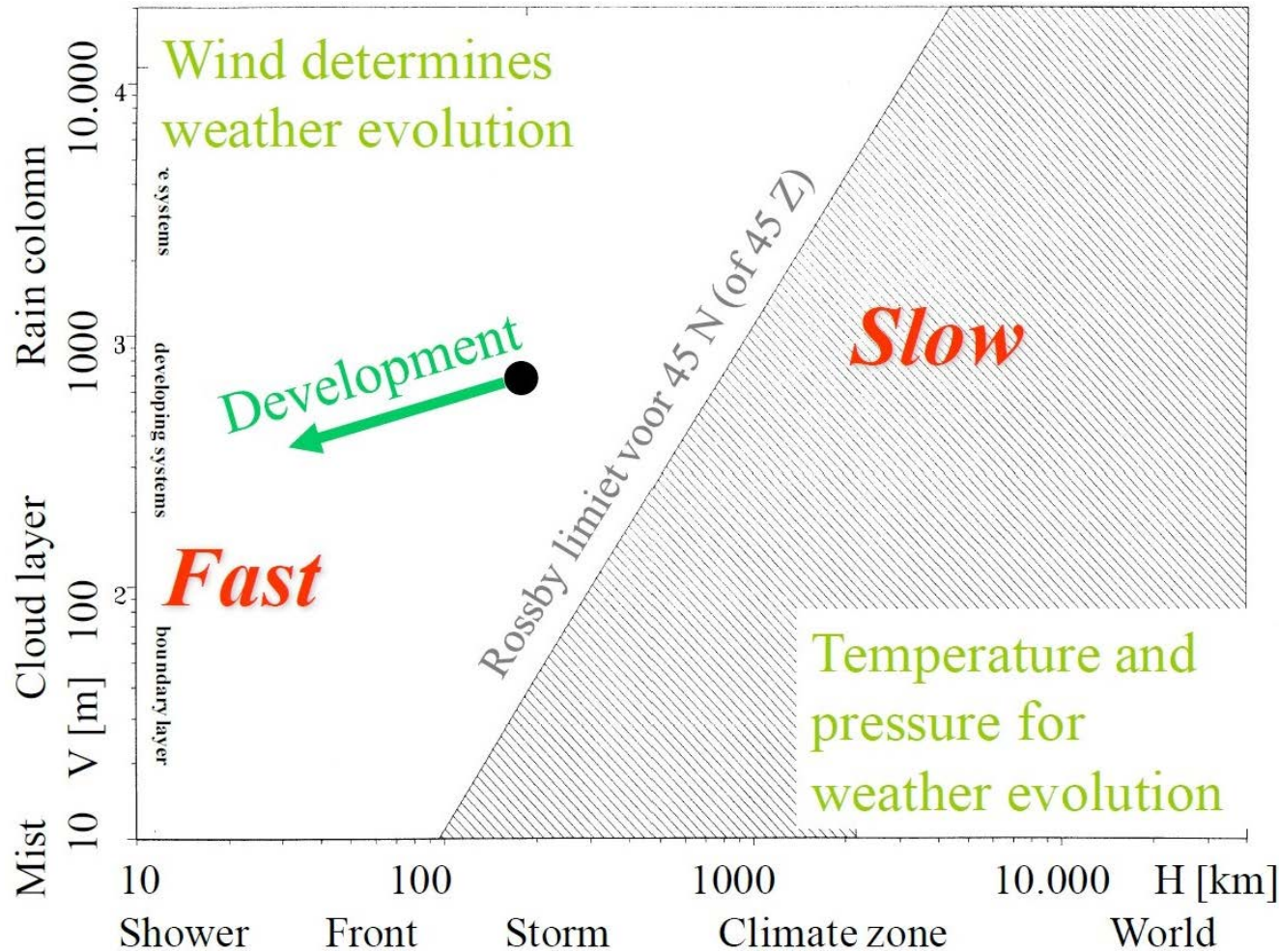
Motivation

Met Office Global FSOI: Total Percentage Impact on 24-hr Forecast Error Reduction (%)



AMVs are an important part of the observing system for global NWP – see in FSOI and data denial studies

Motivation



We also know wind information is increasingly important as move to higher resolution to capture and initialize small-amplitude, fast-evolving and mesoscale dynamical structures.

Divergent part of the wind is no longer considered “noise”, it is the needed “signal”

In NWP smaller scales tend to change fast and represent only modest energy conversion. The 4D quantity and coverage of observations to initialise and evolve these scales is a daunting challenge. Inadequate coverage could compromise the analysis of the larger scales.

Challenge to improve winds part of the Global Observing System to meet these requirements.

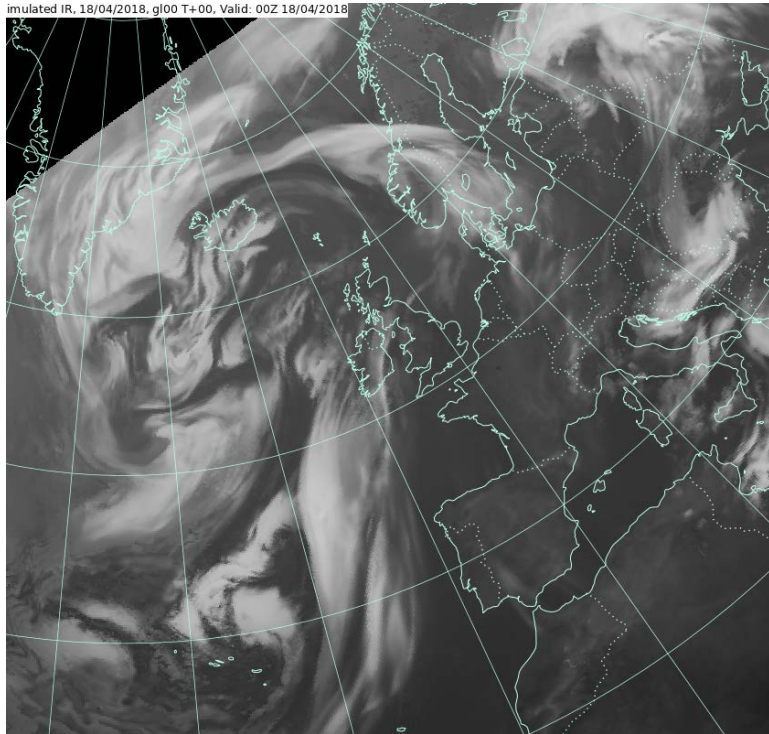
1. Motivation
2. **NWP requirements**
3. Considerations for AMV production

What are the use cases we need to consider?

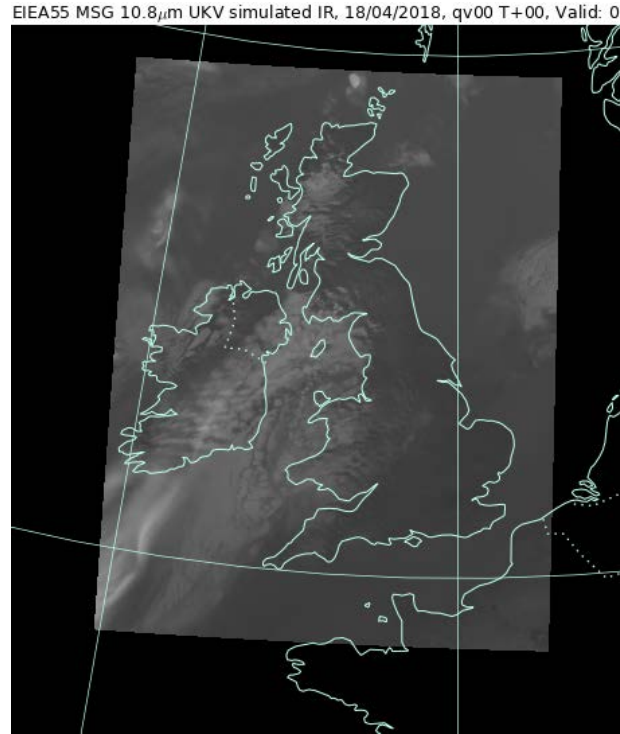
- Global NWP
- Regional NWP
- Nowcasting / diagnostic studies?

Are the requirements different?

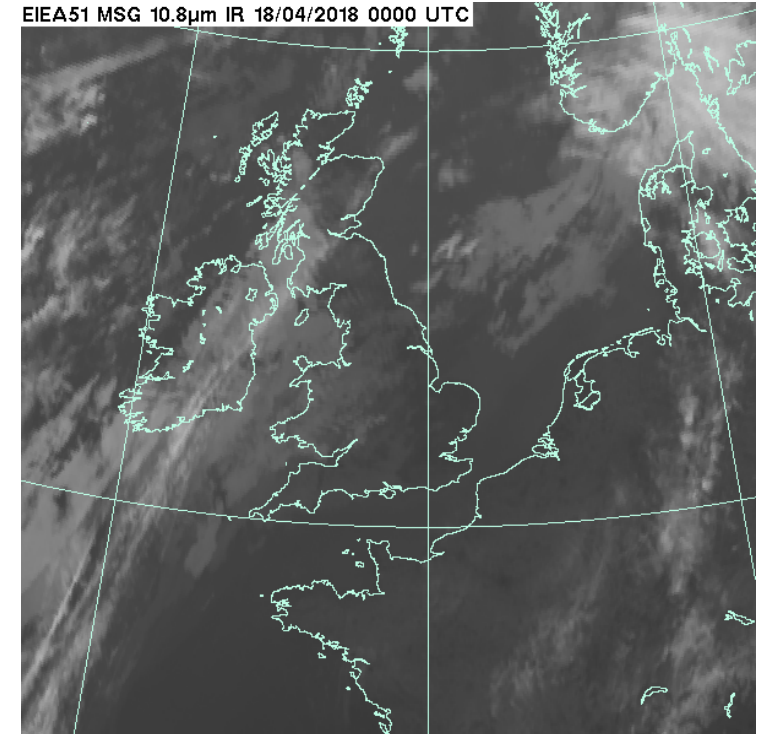
Different models – different requirements?



Met Office Global Model
10 km resolution
Runs every 6 hours
6 hour assimilation window



Met Office UKV Model
1.5 km resolution (over core area)
Runs every hour
1 hour assimilation window
Stricter obs timeliness requirements



Effective model resolution

Several studies have looked at effective model resolution - some differences in both the approach and results, but agree it is several times the grid resolution.

Gert-Jan Marseille et al., 2013 (ESA Aeolus study)

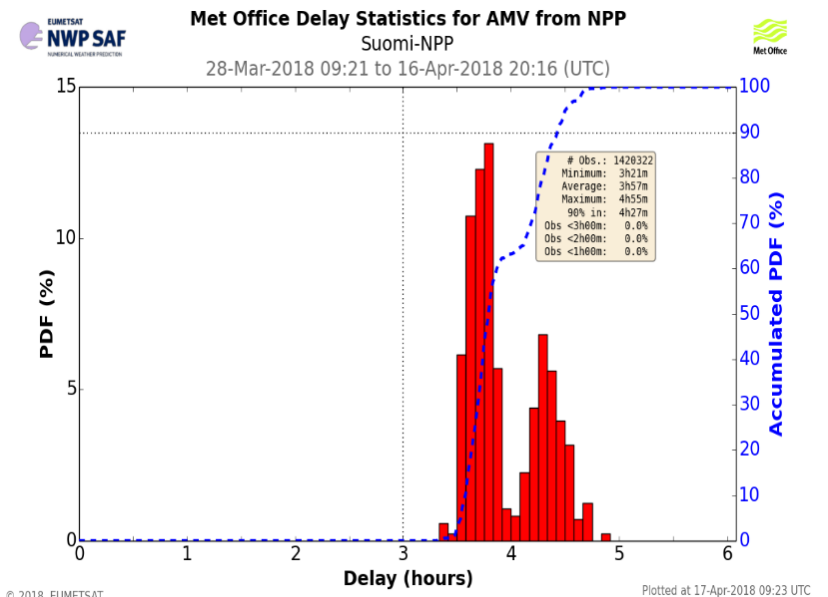
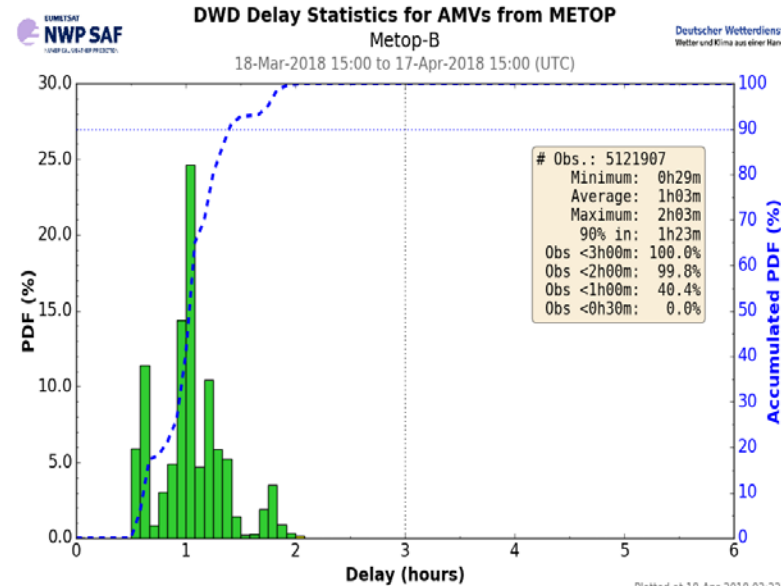
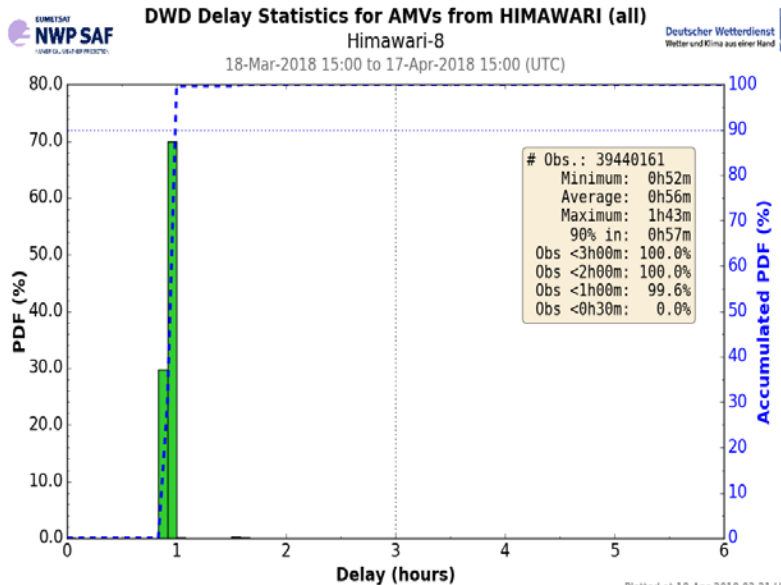
- Spectral analysis using collocated observations (scatterometer, MODE-S winds) and model background winds.
- ECMWF grid resolution = 16 km, effective model resolution of 200-500 km.
- Note also that model underestimates vertical shear by a factor of 2-3
- Conclude that Aeolus and scatterometer resolutions of 80-100 km may be fairly optimal for global model.

Saleh Abdalla et al., 2012 (ESA Aeolus study)

- Calculated kinetic energy spectra using 12 hr forecast fields
- ECMWF grid resolution = 16 km, effective model resolution of 100 km, partially below that.

There has been less work done with high resolution regional models..... We expect the effective resolution will be higher, but perhaps not by as much as you might think.

Timeliness requirements

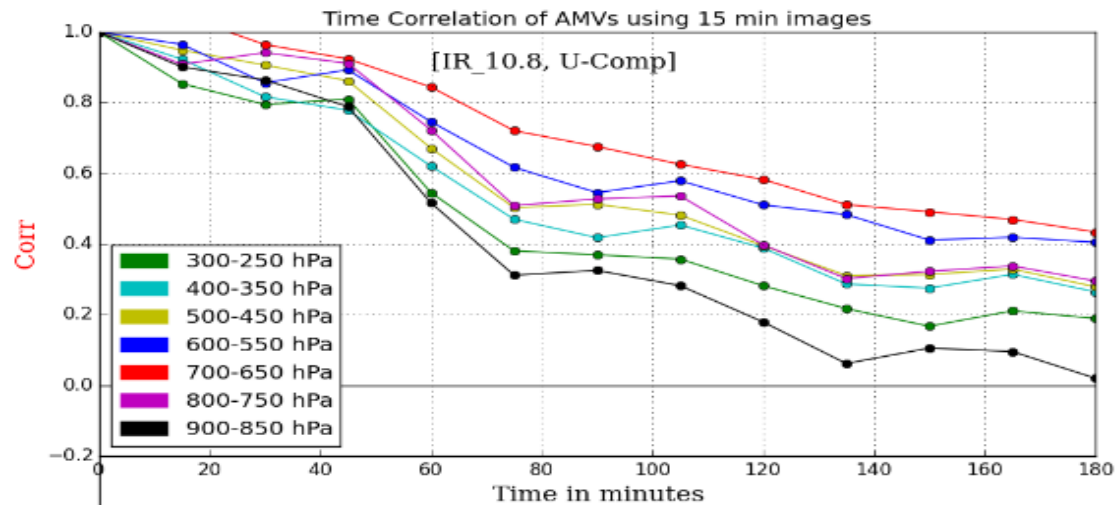
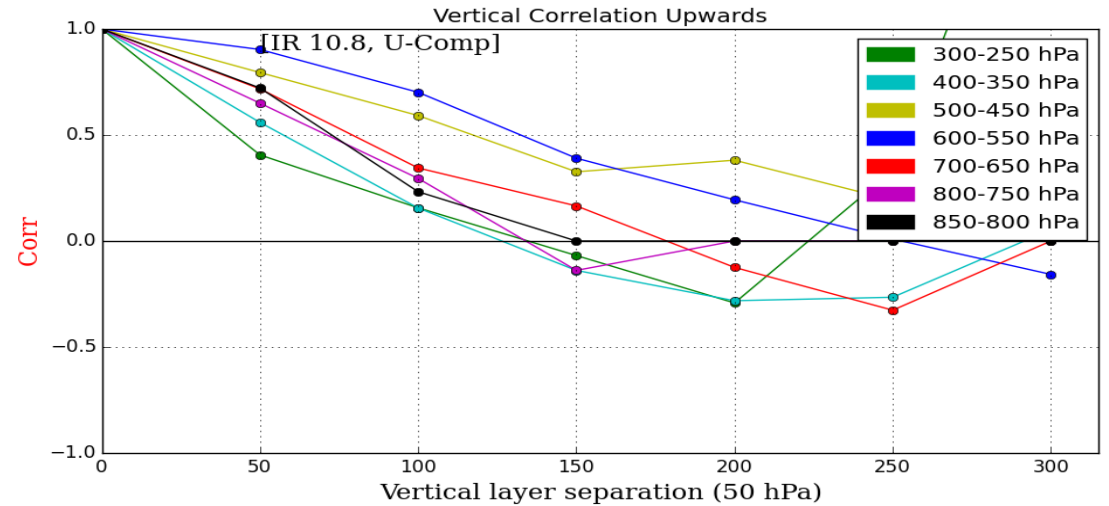
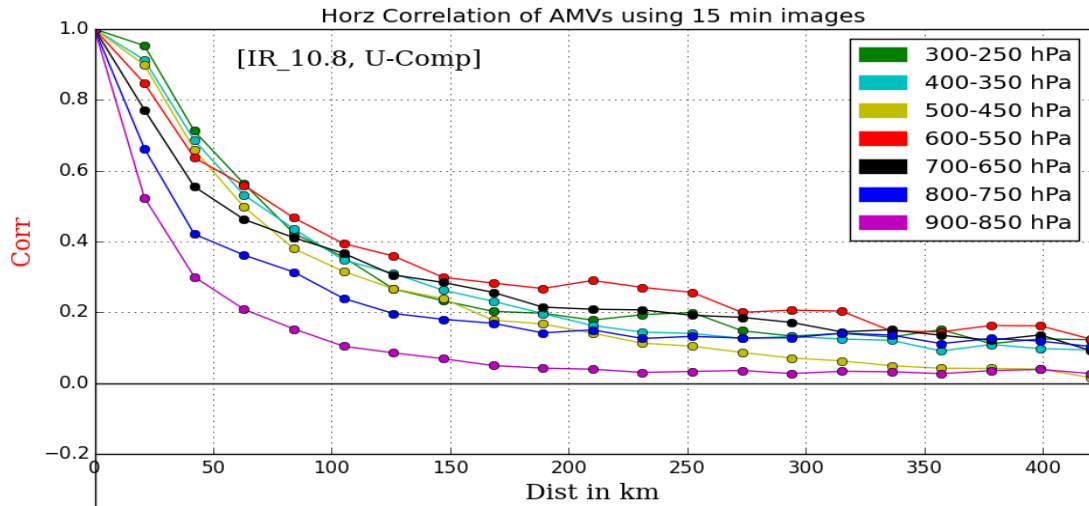


- Global models – in some cases use data up to 3-9 hr old (end-start of assimilation window) in update runs, up to 0-5.5 hr old in main forecast runs
- Regional models – moving towards hourly cycling with shorter cut-offs - UKV use data up to 15-75 min old

New section on NWP SAF web site showing data coverage plots and data timeliness plots. Initial version available; plans for further development

<https://www.nwpsaf.eu/site/monitoring/nrt-availability/>

AMV error correlations



- UKWINDS (NWC SAF) vs UKV model – Desroziers method, 20 km bin
- Horizontal correlations ~140-210 km – low level smallest correlations, mid level highest correlations
- Vertical correlations for IR ~150 km
- Temporal correlations – some levels not dropped below 0.2 after 3 hrs.

Decisions for NWP

- We know that
 1. The AMV data has correlated errors, if we assimilate at too high density we risk overfitting to the data. If we thin too much, we risk losing the mesoscale information of interest
 2. We could allow for correlated error in the assimilation, this tends to assume a simplified correlation falling off with distance, not clear yet how well this would work.
 3. If we cannot adequately initialise the smaller turbulent scales we risk compromising the analysis of the larger scales
 4. Models not able to resolve some of the smaller scale features.
- As a result are we better to try to match the scales we think we can adequately initialise and resolve in the models by either super-modding or superobbing the data? This may vary geographically.
- Correlated error is often handled by either thinning or superobbing the data and potentially also inflating the errors.
- What do we do in more interesting regions including near tropical cyclone – should we attempt to assimilate at higher density in these areas despite the challenges, but assimilating the data at lower density elsewhere to reduce the risks of overfitting the data?

EUMETSAT NWP SAF mesoscale wind data assimilation workshop

Tallinn, Estonia, half a day, during the EUMETSAT Conference 17 to 21 September 2018 – exact date to be confirmed soon

Topics covered include:

- Spatial scales observed and the errors in satellite winds
- Examples of the spatial scales deterministically modelled, but also the spatial scales which are only realistically modelled and not well initialized.
- Spatial representation errors, which often dominate wind measurement observation errors. The pros and cons of thinning, superobbing and “supermodding” will be discussed.
- Bias correction

If you want to be kept up-to-date on this workshop, please register at scat@knmi.nl for the workshop.

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2. NWP requirements
- 3. Considerations for AMV production**

How do we optimize the production and the assimilation?

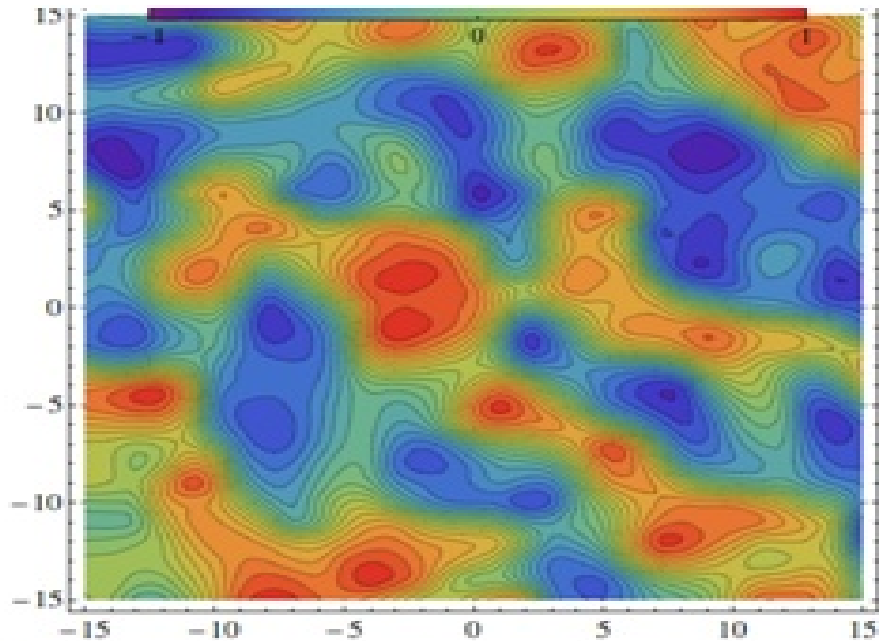
- Temporal image interval
- Target size
- Cross-correlation or optical flow
- AMV grid resolution (avoid overlapping targets?)
- How often should they be produced

Some other considerations for deriving HR AMVs

- More sensitive to satellite image registration errors (but navigation systems are improving).
- Cannot resolve slower winds well with shorter image intervals (less of a problem for high resolution visible channels).
- Current quality indicators tuned to large-scales - penalize spatially varying, accelerating wind features - need new quality control – could use other information from derivation.

High resolution AMVs – some thoughts

Use smaller targets and shorter imager intervals to derive high resolution AMV datasets reflecting the motion of smaller scale features of the flow.



Tracking – becomes trickier

Example correlation surface with 5x5 pixel targets.

BUT more noise - many peaks ->

Information included in target feature is not enough to determine wind vector accurately

From Kazuki Shimoji's IWW12 talk

Need to reduce noise

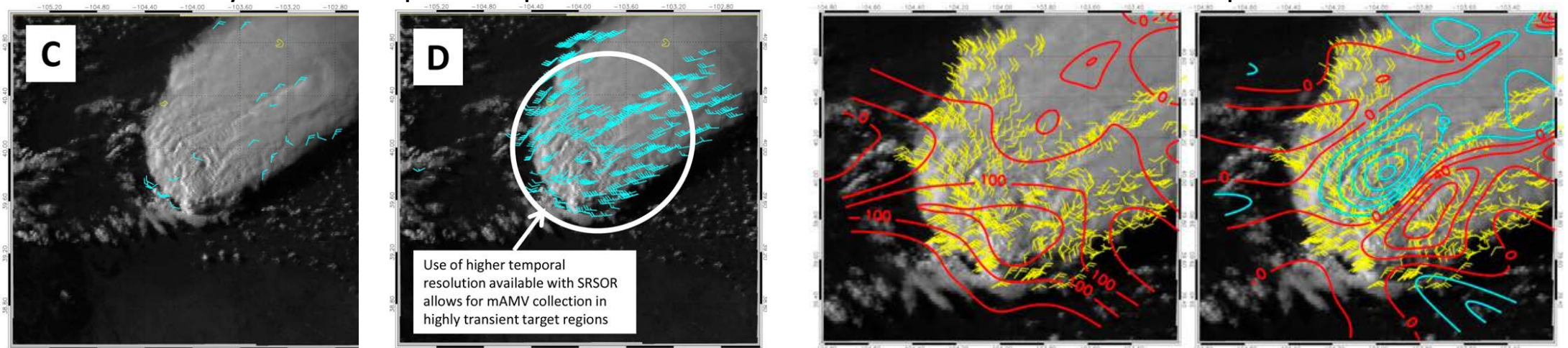
- clustering (e.g. Nested tracking developed at NESDIS)
- use information from correlation surface to filter out poorly constrained cases.
- averaging (see e.g. *Shimoji, IWW12*)

Beyond NWP - visualisation and nowcasting

Potential use for severe weather e.g.

- Tropical cyclone studies - Oyama et al, JMSJ, 2018
- Convective weather events – Apke et al., JAMC, 2016

2337 UTC 20 May 2014 example of supercell in central Colorado – associated with hail up to 6-7 cm in diameter



(c) Current 7-min GOES rapid scan mAMVs as compared with (d) 1-min GOES-14 super rapid scan–derived mAMVs with GOES visible imagery.

GOES visible satellite data with equilibrium-level flow-relative SRSOR mAMVs and (left) cloud top divergence and (right) cloud top vorticity

Distinct signal in divergence and vorticity (couplet pattern) for supercell cases – potential for severe weather prediction. But, more work needed to QC the data (problems near cloud edges, cirrus contamination...)

And finally...

We can continue to use the wiki page on IWWG web page to foster collaboration

<https://groups.ssec.wisc.edu/groups/iwwg/activities/high-resolution-winds-1/high-resolution-winds>