

# AMV superobbing

Mary Forsythe, Howard Berger, Adam Martins, James Cotton

IWW15, April 2021



### Stepping back in time

Superobbing scheme developed at the Met Office by Howard Berger in 2002-03 (VS mission from UW-CIMSS to the Met Office)

• Alternative to thinning

**Met Office** 

- Enables greater use of high density observations that cannot easily be assimilated at full resolution because of spatially and temporally correlated errors.
- Should reduce random error
- Averaging the innovations is safer than averaging the observations. Less likely to average out features in regions of wind shear.

### Met Office Introduction to AMV superobbing



- 1. Sort obs into boxes e.g. 200 km, 100 hPa, 2 hour
- Sum the u and v innovations (O-Bs) for all obs in the box passing QC and calculate the mean
- 3. Find observation closest to average position. Add mean u/v innovation to the background value at that observation location.

### Met Office Superobbing trial results

Trials in 2003 showed slightly negative impact and the work was put on hold. At the time we were reducing the observation errors for the superobbed winds. It was thought we were probably reducing them too much; the plan was always to revisit.....



## Met Office 15 years later!

We now have higher density data - more potential for superobbing approach?



200 km x 200 km x 100 hPa x 2 hr superob box Applied 70N-70S

Majority of superob boxes have only a few observations, but some have more than 50!

- Run a trial without reducing observation errors for the superobs.
- Apply in region 70N-70S. Elsewhere use thinning

Work undertaken by Adam Martins who joined the group on secondment for a year.

#### Trial details:

- 3 months, 4 Jul 30 Sep 2017
- PS41 baseline
- N320, 70 levels global, N216/N108 uncoupled hybrid 4D-Var



good bad

good bad

Overall some small but encouraging signs, fit to AMVs improved by about 10%, but fit to some obs slightly worse e.g. IASI.



Slight concern remains at how well the superobbing handles boxes with more wind shear.

Should we fall back on thinning in these cases?

## Where next?

Dynamic thinning/superobbing



Step 1: Thin everywhere

200 km, 200 hPa, 2 hr

- Selected by thinning
- Rejected by thinning



•

•

- Selected by thinning
- Superob

Fall back on thinning in these boxes

#### Criteria for step 2:

could look at variability of wind speed/direction in box, ensemble output ++

Likely to be dynamically interesting areas e.g. jets, regions of circulation...

### SuperobThin



### Where next?

Dynamic thinning/superobbing

We could take this one step further to look at using the data at higher density in these regions of interest.



Inflate errors?

boxes (purple) 200 km, 100 hPa, 2 hr SuperobFineThin

### Met Office Motivation

- Scientific curiosity
- To make more use of the AMV data (we currently throw over 90% away).
- Can we improve forecasts by using AMVs and/or other observations at higher density in regions of interest (dynamically interesting or poorly constrained regions)?
- To inform strategy for NWP requirements for AMV derivation. Could we benefit from higher density datasets (everywhere / some places?) or are they likely to cost more (in production, storage, processing) and we end up throwing most away.

#### SuperobThin



Initial test applying thinning at 200 km, 100 hPa, 2 hr everywhere and replacing with 200 km, 100 hPa, 2 hr superobbing in regions with less wind variability (sd speed < 3.5 m/s, sd direction < 20 degrees)

#### SuperobFineThin



Initial test applying thinning at 50 km, 50 hPa, 1 hr everywhere and replacing with 200 km, 100 hPa, 2 hr superobbing in regions with less wind variability (sd speed < 3.5 m/s, sd direction < 20 degrees)

### Assimilation trials

#### Started running assimilation trials for

- 1) Superob normal superobbing
- 2) SuperobThin fall back on thinning when criteria met
- 3) SuperobFineThin fall back on thinning when criteria met, thinning round at higher resolution

Criteria to fall back on thinning, any one of following:

- Standard deviation of wind speed in box > 3.5 m/s
- Standard deviation of wind direction in box > 15°
- Vector difference between superob and original ob > 7 m/s
- Based on PS43 baseline
- 3 month trial: 23 Aug 2019 11 Nov 2019
- N320, 70 levels global, N216/N108 uncoupled hybrid 4D-Var

Thinning box size - Control

• 200 km, 100 hPa, 2 hr

Thinning box size - SuperobThin

• 200 km, 100 hPa, 2 hr

Thinning box size - SuperobFineThin

• 100 km, 50 hPa, 1 hr

Superob box size (in all experiments)

• 200 km, 100 hPa, 1 hr

### **Met Office** CAUTION: Very preliminary evaluation (< 1mon) vs ECMWF

#### Superob

SuperobThin

#### SuperobFineThin

							m	ax =	20						
NH_W250			1	1	1	1			1	1		1			
NH_W500			•							•				٠	
NH_W850										•			•	٠	
NH_W10m													1		
NH_T250			L +										1.	٠	
NH_T500								Ŀ	ŀ	•				٠	
NH_T850				•	·										
NH_T_2m															
NH_Z250													•	•	
NH_Z500													•	•	
NH_Z850										•			•	٠	
TR_W250															
TR_W500									•						
TR_W850															
TR_W10m															
TR_T250			1									1.	1.		
TR_T500														•	
TR_T850			۲												
TR_T_2m		•	•												
SH_W250															
SH_W500											1.		1		
SH_W850											1.				
SH_W10m											1.		1.		
SH_T250			Í.								١.				
SH_T500								1.		•					
SH_T850										•	•	١.	1.		
SH_T_2m									٧	ŀ			1.		
SH_Z250			Í.					١.				Ť.	Ť.		
											1.	1	İ.		
_ SH_Z850			٠							1	1	i.		•	
-	Ģ	9	2	4	90	00	0	2	4	90	8	0	22	4	80
	÷	÷	Ŧ	T+2	T+3	T+4	T+6	T+7	T+8	1+9	+10	+12	+13	+14	+16
											÷.	÷.	÷.	÷.	$\vdash$

	_	_	_	_	_	_				_	_	_	_	_	_
NH_W250				1	1		1	1							
NH_W500							ŀ	•	ŀ						
NH_W850								÷							
NH_W10m															
NH_T250			•							•					
NH_T500						•	•	•	•	•					
NH_T850															
NH_T_2m															
NH_Z250					•		•								
NH_Z500								÷							
NH_Z850															
TR_W250															
TR_W500							•	٠	٣	٠	٣	٧	٠	•	
TR_W850															
TR_W10m															
TR_T250														•	
TR_T500													•		
TR_T850					•										
TR_T_2m			•												
SH_W250						•		•	•	•	•				
SH_W500							•	•		•					
SH_W850							•	•	•	•					
SH_W10m								•	•	•	ŀ		ŀ	•	
SH_T250			1			÷	•	•	•		•			•	
SH_T500									•	•			•	•	
SH_T850										•	•			•	
SH_T_2m								•	۷	•					
SH_Z250			1		•	•			•	•			1.		
SH_Z500						•	÷	•	•			1.		٠	
SH_Z850			٠	•	•	•	+	•	•			1.		٠	
	-0	9	12	24	36	8	00	72	34	96	80	50	32	44	80

Fit to AMVs better by 9% Fit to other obs slightly worse Fit to AMVs better by 7% Fit to other obs fairly neutral

	_						m	ax =	20						
NH_W250			1	1	1				1	1	1	1		•	
NH_W500			•	•	•			•	•	•	ŀ	•	•	•	
NH_W850			•	•					•	ŀ			•	٠	
NH_W10m		•											•	•	
NH_T250				•			٠	•	•	٣				٠	
NH_T500				٠	•	•	۳	٠	۷		•		•	٠	
NH_T850															
NH_T_2m															
NH_Z250							٠		•	•	•	•	•	٠	
NH_Z500					•	•	٠		•	•	•	•	•	٠	
NH_Z850						٠	٠		•	•			•	٠	
TR_W250															
TR_W500			٠					•	٠		•	•			
TR_W850															
TR_W10m		•													
TR_T250								•				•			
TR_T500														•	
TR_T850															
TR_T_2m															
SH_W250				٠	•	٠			•	•					
SH_W500				٠	٠	•								٠	
SH_W850					٠								•	٠	
SH_W10m			1		٠						•		•	٠	
SH_T250			٠	۷	٠	٠	ŀ				•	•	•	٠	
SH_T500			٠	٠	۷	۷	٠			•	•	•	•	٠	
SH_T850										•	•	•		•	
SH_T_2m						•			•						
SH_Z250			1	·		•			•					٠	
SH_Z500			۷		•	·								٠	
SH_Z850			٠	•	·								•	۲	
	T+0	T+6	T+12	T+24	T+36	T+48	T+60	T+72	T+84	T+96	T+108	T+120	T+132	T+144	T+168

Fit to AMVs worse by 9% (27% more AMVs assimilated) Fit to other obs slightly worse

### Talk Summary

- 1. Superobbing scheme developed at the Met Office in 2002-03, but gave slightly negative impact.
- 2. More recent trials without reduced observation errors were more encouraging, but not quite there.
- 3. We have developed a basic scheme to use combined thinning and superobbing, including option to use data at higher density in regions of interest.
- 4. Preliminary trials underway. Suspect we might find a configuration that gives a small benefit to superobbing (particularly in combination with thinning).
- 5. Using AMVs at higher density in regions of interest likely to need some refinement!

# Spare slides

### Wind statistics in superob boxes





## Wind variability in superob box

Standard deviation of direction in box



Standard deviation of speed in box

**Met Office** 

Observations in superob box have already passed blacklisting and background checks. Most show relatively low variability of speed and direction within the superob box.

We could define thresholds above which thinning is used instead

#### Data denial study **Met Office**

% Difference (AMV data denial vs. Control) - overall -0.9% RMSE against ecanal for 20190823 to 20191115

	_	_	_			_	m	ax =	20	_	_		_		_
NH_W250					▼	~	▼	▼	•	•	•	•	~	~	
NH_W500			▼	•	•	۷	•	۳	۳	۷	1	۷	•	•	
NH_W850			▼	▼	▼	۷	•	•				1	•	~	
NH_W10m		▼	۷	•	•	۷	•	۷				÷	~	•	
NH_T250			▼	~			~	۷		•		•	*	~	
NH_T500			▼	•	۷	۷	•	•		۷	۳	۷	•	۷	
NH_T850			٠	•	٠	٠	٠	٠	٠	۳		۳			
NH_T_2m						•		•		٠	•		•	•	
NH_Z250			▼	▼	▼	▼	▼	•	•	▼	•	•	▼	▼	
NH_Z500			▼	•	•	۷	•		٠	٠		٠	•	•	
NH_Z850				۳	•	۷	•	۳	•	·	÷	•	٠	▼	
TR_W250			$\nabla$	$\mathbf{\nabla}$	$\mathbf{\nabla}$	▼	▼	•	•	•		•	•	٠	
TR_W500			▼	•	▼	▼	▼	•	▼	▼	۷	۳		ŀ	
TR_W850			▼	▼	▼	▼	•	۷	۷	۷	٧	۷			
TR_W10m		▼	▼	▼	▼	۷	▼	۷	٠	٣	•	•			
TR_T250			▼	▼								۵			
TR_T500				۷	•	•	~	٠		۷		٣	•		
TR_T850			•	•	•	۷	•	•	•	•	•	۷	~		
TR_T_2m		•		٧	٠	٠	v	۷	٠	۷	+	٠		٠	
SH_W250			$\mathbf{\nabla}$	$\mathbf{\nabla}$	▼	▼	▼	▼	▼	•	•	۷	•	٠	
SH_W500			▼	▼	▼	▼	▼	•		۷	•	•	•	٠	
SH_W850			▼	▼	▼	▼	▼	•	▼	۷	•	•	•	٠	
SH_W10m		▼	▼	▼	▼	▼	▼	•	•	•	۷	٠	•	٠	
SH_T250			▼	•	▼	•	▼	۷	۷	▼	▼	۷	▼	•	
SH_T500			▼	•	•	•	▼	•	•	•	•	٠	٠	•	
SH_T850			٧	•		•		۷		۷	•	•		•	
SH_T_2m				•	٠	۷	•	۷	+					•	
SH_Z250			▼	▼	▼	▼	▼	▼	▼	▼	•	•	•	٠	
SH_Z500			▼	▼	▼	▼	▼	▼	▼	٠	•			٠	
SH_Z850			▼	•	▼	▼	▼	▼	▼	•	•		•	٠	
-	T+0	T+6	T+12	T+24	T+36	T+48	T+60	T+72	T+84	T+96	T+108	T+120	T+132	T+144	T+168

% Difference (Scat denial vs. Reference) - overall -0.25% RMSE against ecanal for 20190823 to 20191115

							m	ax =	20						
NH_W250			1		1								1		
NH_W500			•	•											
NH_W850				۷	۳	·	•		•				÷	٠	
NH_W10m		▼	▼	▼	۷	۷	ŀ				•			٠	
NH_T250			•	٠	٠	٠	٠		·					•	
NH_T500			•	٠	•							•	•	•	
NH_T850			•	•	·										
NH_T_2m													•	٣	
NH_Z250			•	•									•		
NH_Z500			•	٠	٠	•						•	•	•	
NH_Z850													•		
TR_W250				•	•	٠	•	*	٠	٠	·				
TR_W500					·	٠	•	٠	٠						
TR_W850			▼	۷	•	•	۷	٣	٠						
TR_W10m		$\mathbf{\nabla}$	▼	▼	•	▼	۳	۳	٠						
TR_T250				*					•	•	٠	•			
TR_T500															
TR_T850												•			
TR_T_2m		٠	۳	٠	٠	•	·	•	·	•	•	•	•	٠	
SH_W250				٧	•	*		~	۷	•	۷		•	~	
SH_W500			•	٠	٠	÷	1		•				•		
SH_W850			▼	•	۷	•	٣	•					•	٠	
SH_W10m		▼	▼	▼	•	۳	۳						÷	٠	
SH_T250			٠	*	٣	•	۳	•	•	•	•	•			
SH_T500				۳	٠	·	۳	٣	·	•	•	•	•	٠	
SH_T850									·			•			
SH_T_2m												•	•	•	
SH_Z250			•		۷	•	•	•		•	•		•	٠	
SH_Z500					•	•	۳	٣	•	•	•	•	•	•	
SH_Z850			4	4						•	•	1	•	٠	
	T+0	T+6	T+12	T+24	T+36	T+48	T+60	T+72	T+84	T+96	T+108	T+120	T+132	T+144	T+168

NH_W500			۷			۳	۳			۳	٣	٧	۳	۷	
NH_W850			٠	۷	٠	٠	٠	٠	٠	٠	٠	٠	٠	٠	
NH_W10m		۷	٠	٧	٠	٠	٠	٠	٠			٠	٠	٠	
NH_T250			٠	۷	۳	۳	٠	٠	٠	٠	٠	٠	٠	٠	
NH_T500				۳	۳	٠	٠	٠	۳		۳		•		
NH_T850			٠	۳		٠	٠	٠	٠	٠	٠	۳	۳	٠	
NH_T_2m		۷	٧	۷	٠	٠	٠		٠	٠	٠	٠	٠	٠	
NH_Z250				V	•	۳	٧	•	۷	۷	۷	▼	▼	v	
NH_Z500			V	▼	▼	۷	۷	•	۷	۷	۷	۷	۷	۷	
NH_Z850				٠	۳	۳	٧	•	۷	۳	۷	۳	۳	۳	
TR_W250			۷	•	•	۷	٧	۳	۳	*	۳	٠	Ŧ	۳	
TR_W500				۷	•	۷	۷	•	۷	۷	٧	۷	۳	٠	
TR_W850			٧	۷	•	۷	٧	•	۷	٠	٠	٠	٠	٠	
TR_W10m		۷	٧	۷	•	۷	٧	٠	۳	٠	٠	٠		٠	
TR_T250			۷	V	▼	▼	۷	•	۳	٠	۲	۳	۳	٠	
TR_T500			٠								٠	٠	٠	٠	
TR_T850			V	۷	•	٠	٠					٠	٠		
TR_T_2m		۷	٧	۷	٠	٠	٠						٠		
SH_W250			V	V	$\mathbf{\nabla}$	▼	▼	▼	۷	۷	۷	۳	۷	۳	
SH_W500			▼	V	$\mathbf{\nabla}$	▼	V	▼	▼	۷	۷	۷	۳	۳	
SH_W850			V	▼	▼	▼	V	V	▼	۷	٧	۳	۳	٠	
SH_W10m		▼	▼	V	$\mathbf{\nabla}$	▼	▼	▼	۷	۷	۷	۳	۳	۳	
SH_T250				۷	$\mathbf{\nabla}$	$\mathbf{\nabla}$	V	$\mathbf{\nabla}$	▼	▼	۷	▼	۷	۷	
SH_T500			V	$\mathbf{\nabla}$	$\mathbf{\nabla}$	$\mathbf{\nabla}$	V	▼	▼	▼	۷	۷	۷	۷	
SH_T850			۷	۷	▼	۷	۷	V	۷	۷	۷	۷	۷	٧	
SH_T_2m		V	۷	V	▼	v	v	•	▼	v	۷	▼	▼	v	
SH_Z250			$\nabla$	V	$\nabla$	$\nabla$	$\mathbf{\nabla}$	$\nabla$	V	▼	۷	۷	۷	۷	
SH_Z500			V	Ŵ	Ý	$\nabla$	$\nabla$	$\nabla$	V	$\mathbf{\nabla}$	V	V	۷	•	
SH_Z850			Ŷ	Ý	V	V	V	$\mathbf{\nabla}$	▼	۷	V	۷	۷	•	
	°+	9	12	+24	+36	48	8	12	48-	-96	108	120	132	144	168
		-	ŕ	ŕ	ŕ	ŕ.	ŕ	ŕ.	ŕ	ŕ	£.	£.	Ĕ.	Ë.	Ě

% Difference (OS43 aircraft denial vs. OS43) - overall -1.03% RMSE against ecanal for 20190823 to 20191115

max = 20

**.......** 

. . . . . . . . . . . .

~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~

. . . . . . . . . . . .

. . . . . . . . . . . .

\* \* \* \* \* \* \* \* \* \* \* \* \*

\* \* \* \* \* \* \* \* \* \* \* \*

\* \* \* \* \* \* \* \* \* \* \* \*

\* \* \* \* \* \* \* \* \*

**. . . . . . . . . .** 

T+10 T+12 T+12 T+24 T+24 T+24 T+24 T+26 T+128 T+120 T+120 T+120 T+132 T+132 T+168

~ ~ ~ ~ ~ ~ ~ ~

. . . . . . . .

**V V V V V V V · · ·** · · ·

- - - - - - - -

\* \* \* \* \* \*

**. . . . . . . . .** 

-------

V V V

**V V V** 

NH W250

NH W500

NH\_W850

NH\_W10m

NH\_T250

NH\_T500

NH\_T850

NH\_T\_2m

NH\_Z250

NH\_Z500

NH\_Z850

TR\_W250

TR\_W500

TR\_W850

TR W10m

TR T250

TR\_T500

TR T850

TR\_T\_2m

SH\_W250

SH\_W500

SH W850

SH\_W10m

SH T250

SH\_T500

SH T850

SH\_Z250

SH\_Z500

SH\_Z850

SH\_T\_2m

% Difference (OS43 mw denial vs.

OS43) - overall -2.57% RMSE against ecanal for 20190823 to 20191115

max = 20 NH\_W250 V V V V V V V V V V V

anl

anl

anl

anl

anl

anl

anl

ani

anl

anl

anl

anl

anl

ani

anl

anl

anl

anl

anl

anl

anl

ani

anl

anl

anl

ani

anl

anl

anl

anl

anl

anl

anl

ani

anl

	RI	MSE	ag	ains	t eo	ana	al fo	r 20	190	082	3 to	20	191	115	
									20						
NH W250		_	٧	7		v		v -	20		Ŧ				-
NH W500				7									٠		
NH W850					v									٠	
NH W10m			٠	٠	v	٠	٠				٠	٠	٠	۷	
- NH T250			V	V	V	v			v						
NH T500				7							٠				
NH T850			٠	۷	٠	٠	٠	٠	٠	٠	٠	٧	٠	٠	
NH_T_2m									٠		٠				
NH_Z250			V	V	▼		v	v	v	۷	٧	٧	v	v	
NH_Z500			V	V	v	v	۷	v	۷	۷	۷	v	v	v	
NH_Z850				۷	٠	۳	٠	۷	۳	٧	٧	v	v	۷	
TR_W250			٠	۳	٠		٠	٠	٠	٠			٠	٠	
TR_W500			v	۷	•	۳	٠	٠	٠						
TR_W850			v	V	▼	v	۷	v	۷	۷	٧	۷	۷	٠	
TR_W10m				۷	۳	۳	٧	۷	۷	٧	۷	٧	۳	٠	
TR_T250			$\nabla$	V	▼	▼	V	7	۷	٧	٧	۳	۳	٠	
TR_T500			٠												
TR_T850			▼	۷	V	۷	٠	٠	٠	٠					
TR_T_2m		V	۷	۷	٠	٠	٠	٠	٠	٠	٠				
SH_W250				۷	۳	۳	۷	۷	۳	٠	٠	٠	٠		
SH_W500			٧	۷	۳	۳	۷	۷	٧	٠	٠	٠			
SH_W850			٧	۷	۷	۷	۷	۷	۷	٠	۷	٠	٠		
SH_W10m			٠	۷	۳	۳	٧	۷	۷	٠	٠	٠			
SH_T250					٠	۳	٧	•	۳	۷	۷	٧	٠		
SH_T500				۷	۷	۷	۷	۷	۷	۷	٠	٠	٠		
SH_T850			۷	۷	۷	۷	۷	۷	۷	٠	۲	٠			
SH_T_2m		٠	•	•	•	٠	٠	۲	٠	٠	۷	۳	۳	1	
SH_Z250			٧	۷	۳	۷	۷	۷	۷	۷	۷	۳	٠	٠	
SH_Z500			۷	۷	۷	۷	۷	۷	۷	۷	۷	۳	٠		
SH_Z850			۷	۷	۷	۷	۷	۷	۷	۷	۷	۳	•		
	0+1	T+6	T+12	T+24	T+36	T+48	T+60	T+72	T+84	T+96	T+108	T+120	T+132	T+144	T+168

% Difference (OS43 irhyper denial vs.

OS43) - overall -1.32%

anl anl anl anl anl anl anl anl anl anl anl anl anl anl anl anl anl anl anl ani anl anl anl anl

anl

anl

anl

anl

ani

anl