Forecast of the atmospheric parameters at the LBT site in the context of the ALTA project

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OUTLINE

Goals of the ALTA projects

Model configurations in operational setup

Most relevant results of *ongoing* model validation

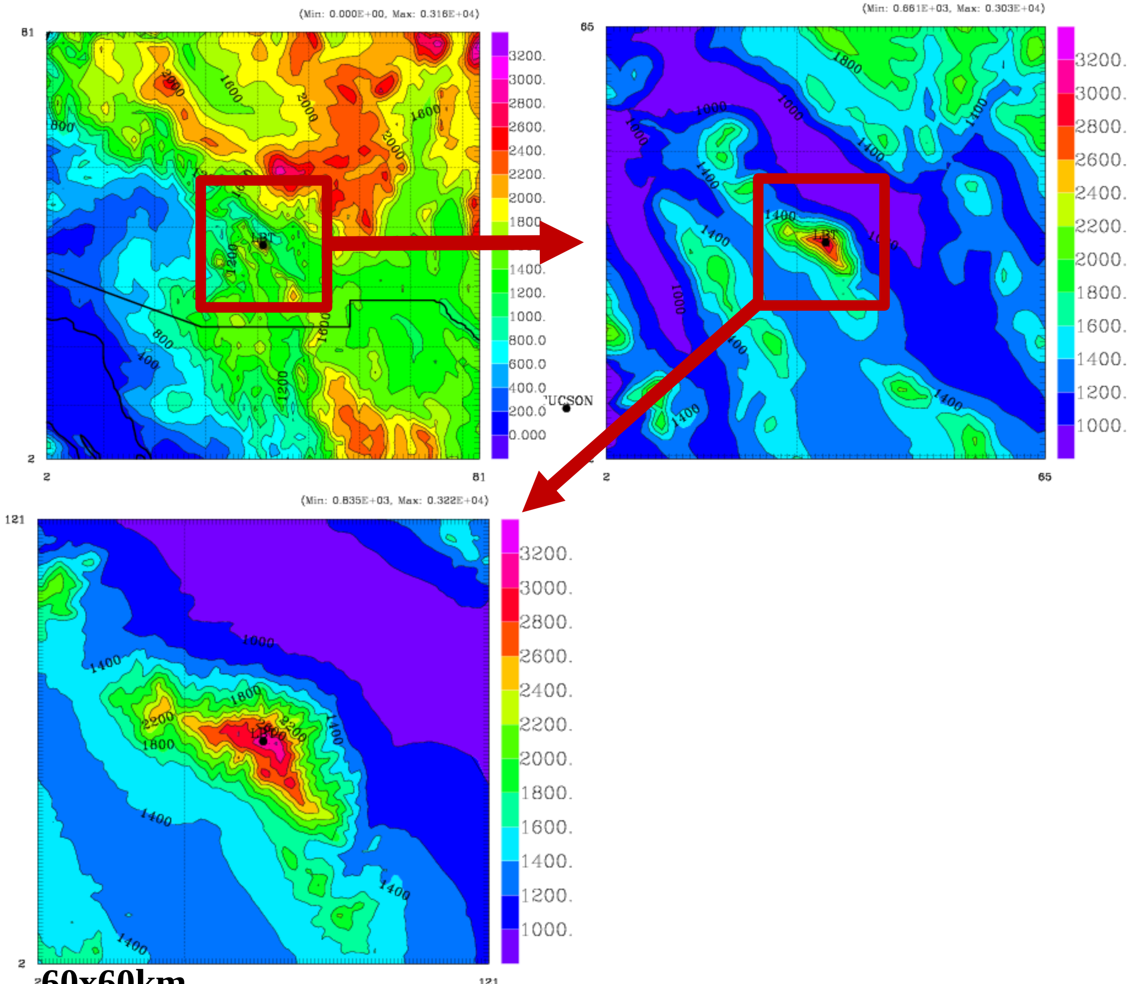
Conclusions

Model Configuration

800x800km
ΔX=10km

160x160km
ΔX=2.5km

Astro-MESO-NH
mesoscale model
Masciadri et al., A&ASS 1999



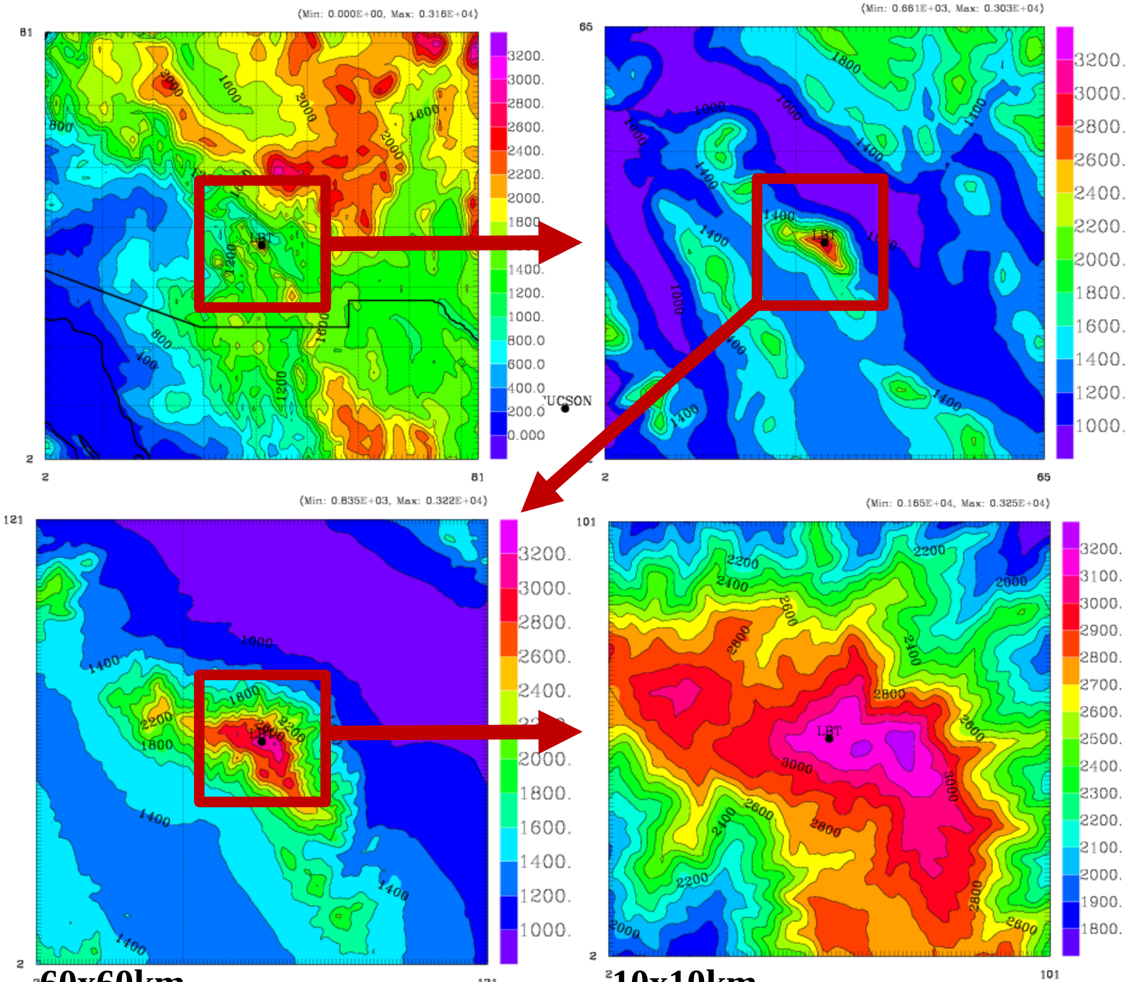
60x60km

ΔX=500m

Model Configuration

800x800km
ΔX=10km

160x160km
ΔX=2.5km



60x60km
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ALTA

Model Configuration

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ΔX=10km

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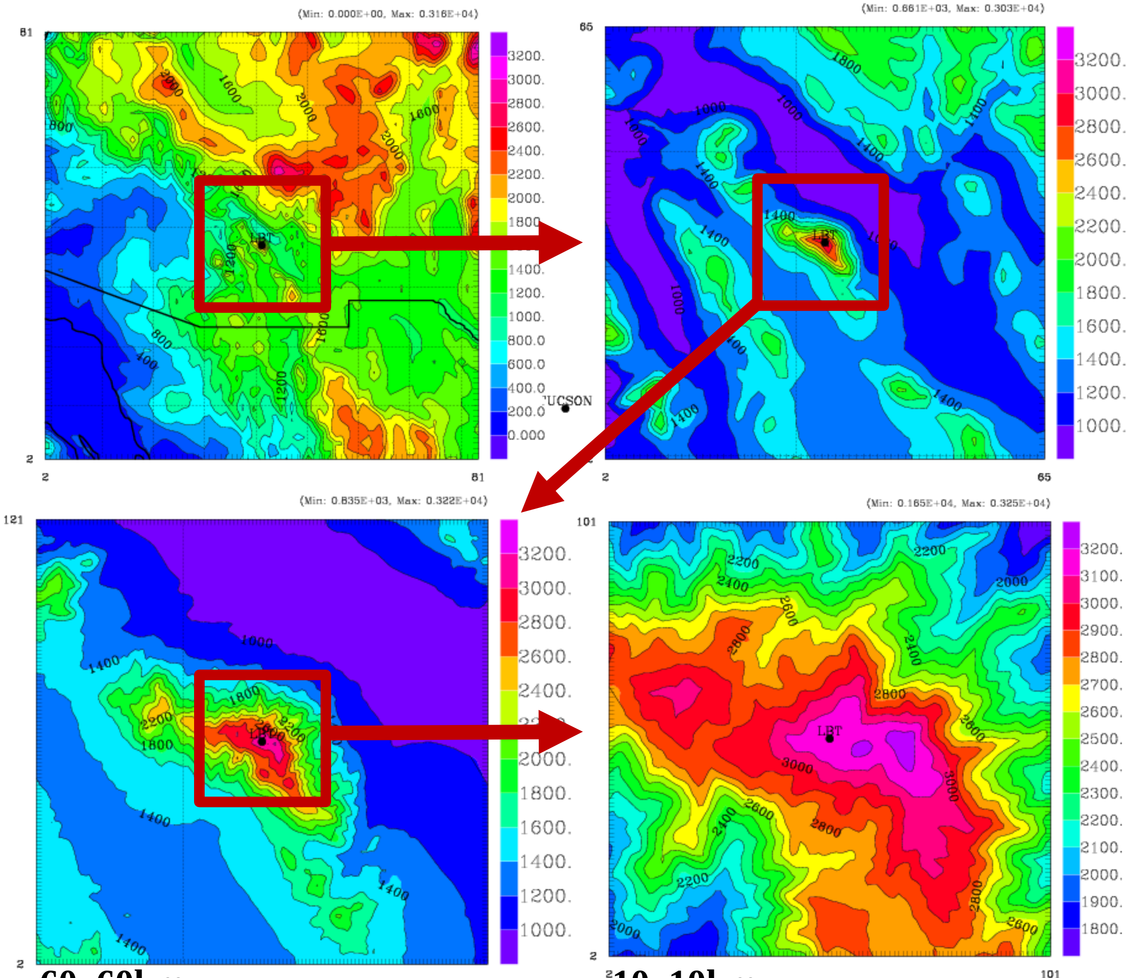


60x60km
ΔX=500m

10x10km
ΔX=100m

Astro-MESO-NH

mesoscale model

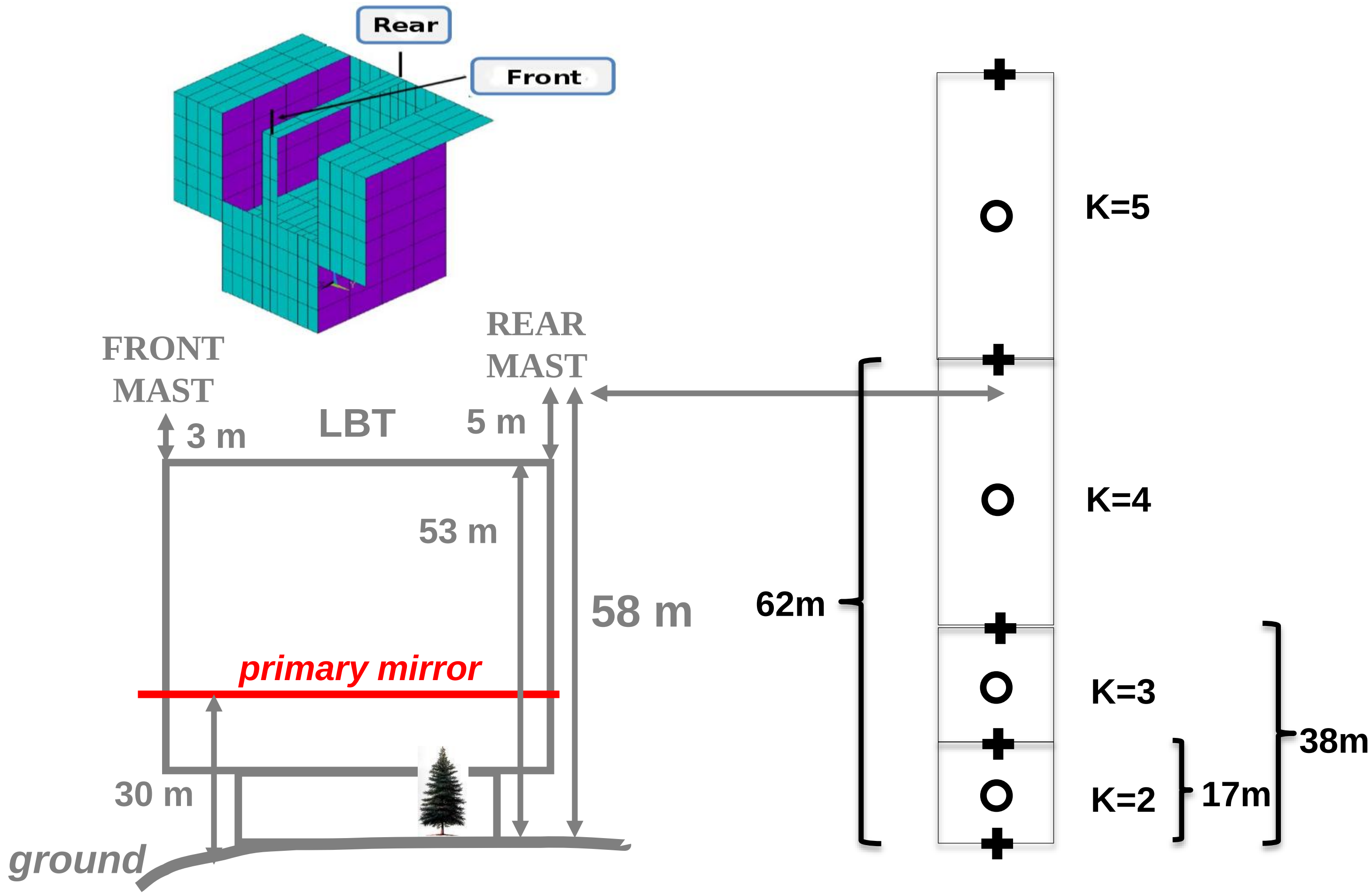
Masciadri et al., A&ASS 1999

- 54 vertical levels
- Δh_0=20 m (because of trees on orography)
- logarithmic stretching up to 3500m a.g.l.
- for h> 3500m, Δh≅600m

Temporal sampling:

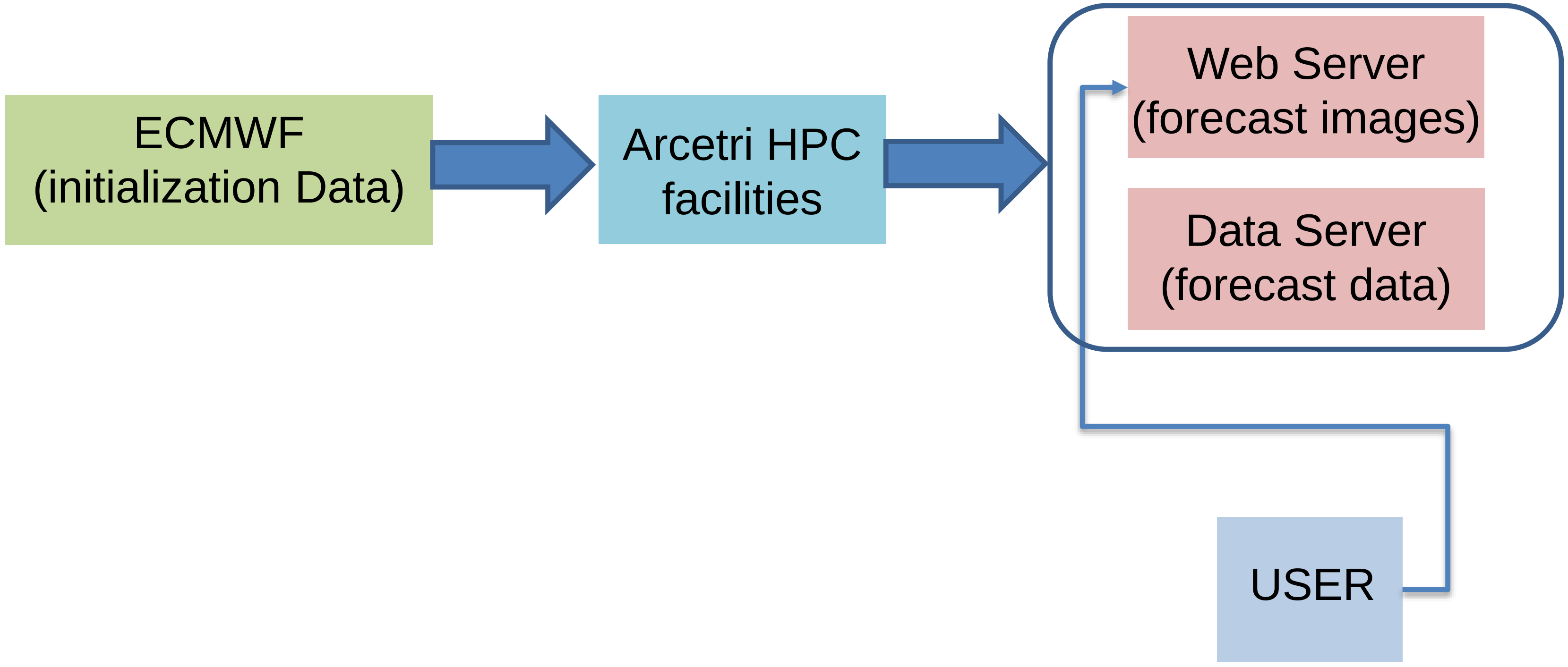
- Vertical profiles 120s
- Ground values ~1s

Model Configuration

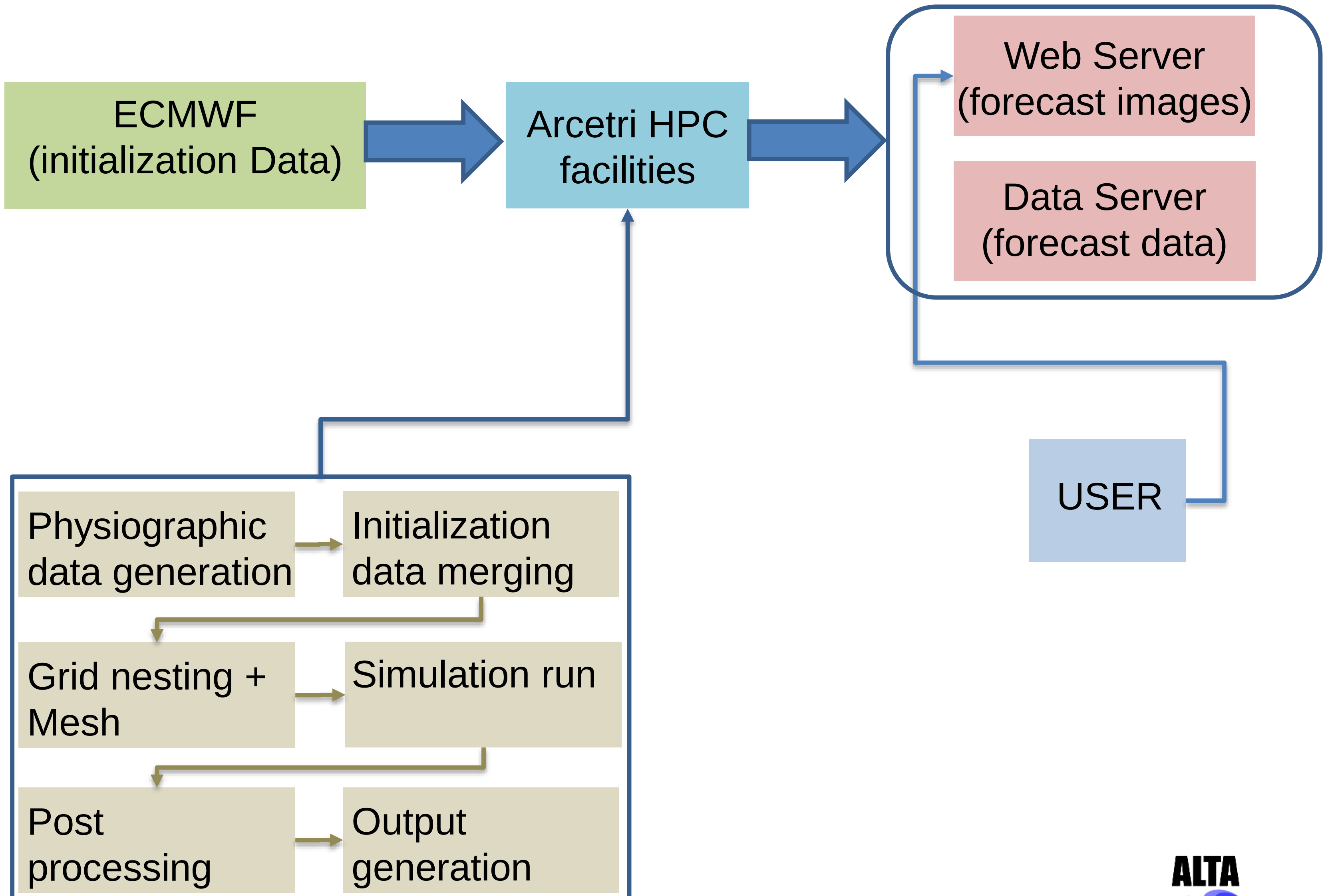


The model level corresponding to the weather masts is K=4 (38-62m)

Operational forecast system overview



Operational forecast system overview



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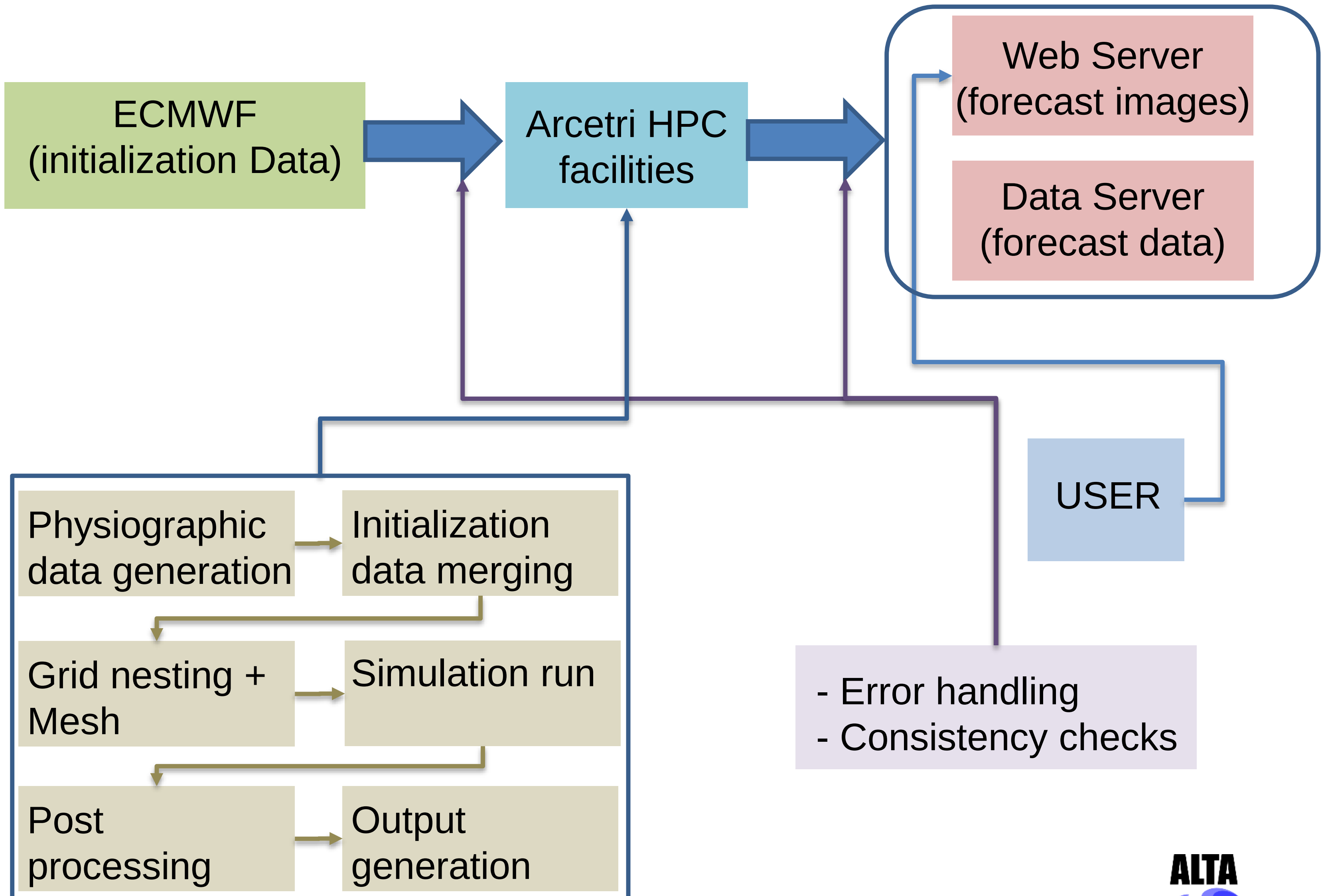
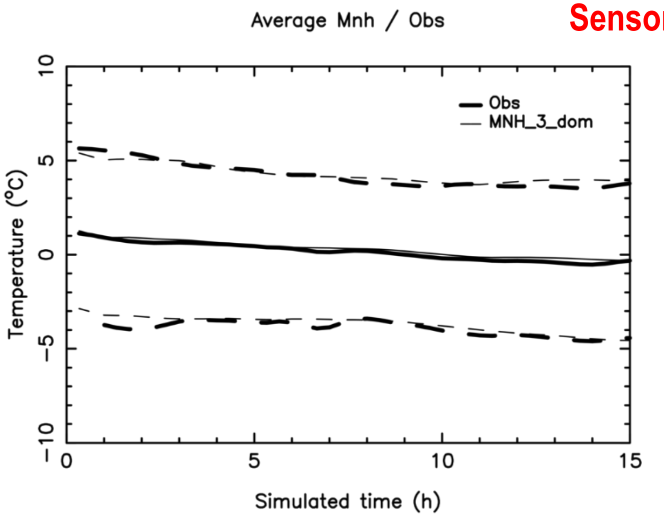
Operational forecast system overview

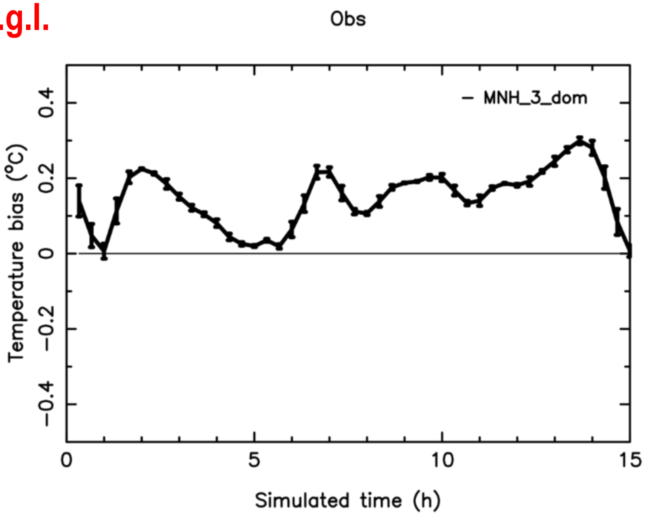


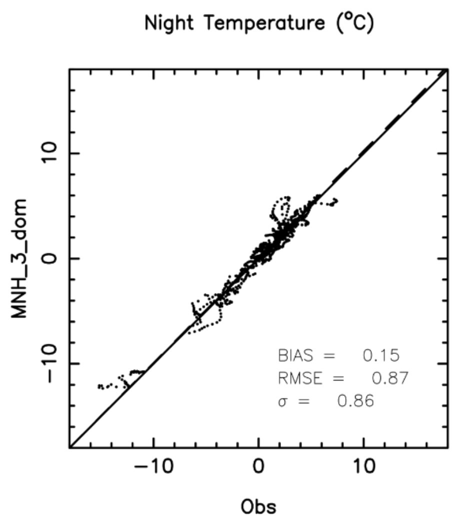
Temperature – 3DOM K=4 Average on 20 nights

Astro-MESO-NH forecasts (MNH) vs observations (OBS)

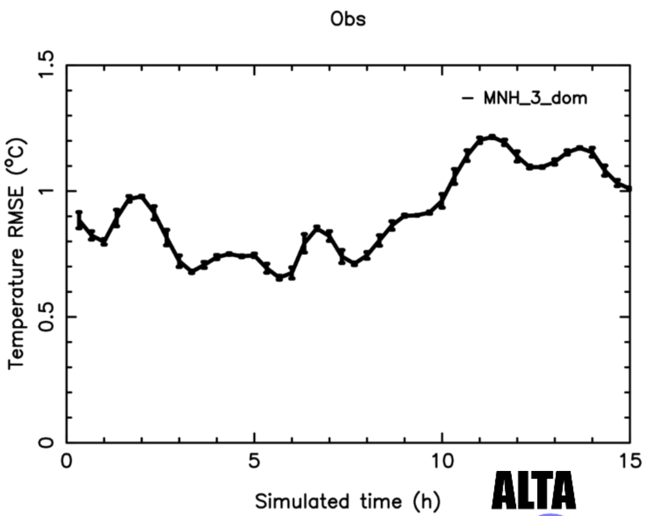
REAR MAST
Sensor height =55.5m a.g.l.







BIAS = 0.15 C°
RMSE = 0.87 C°
σ = 0.86 C°



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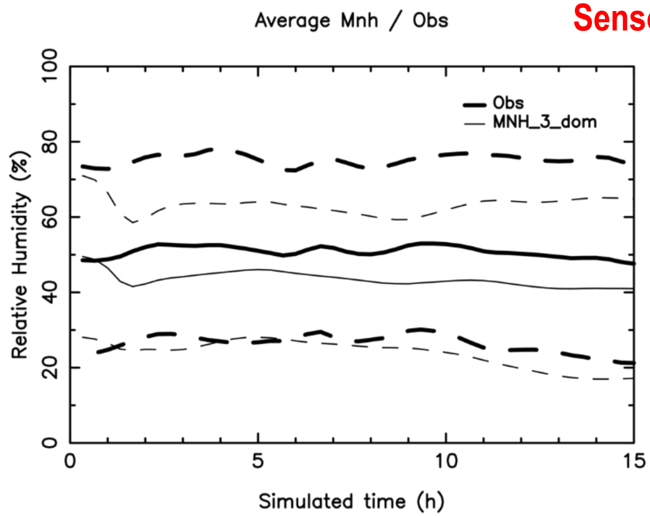
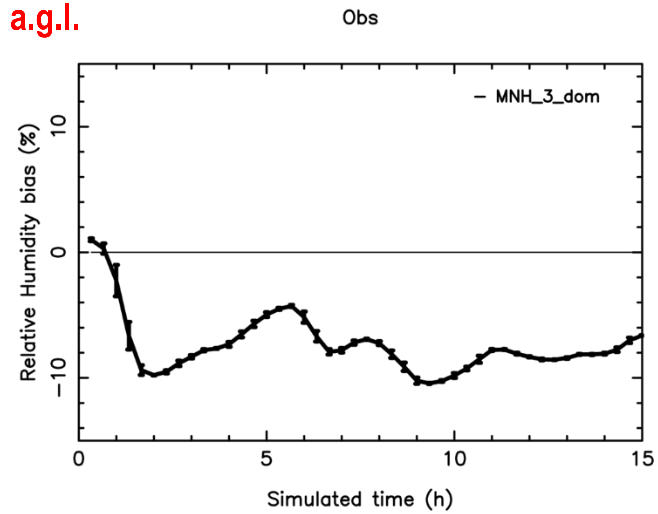
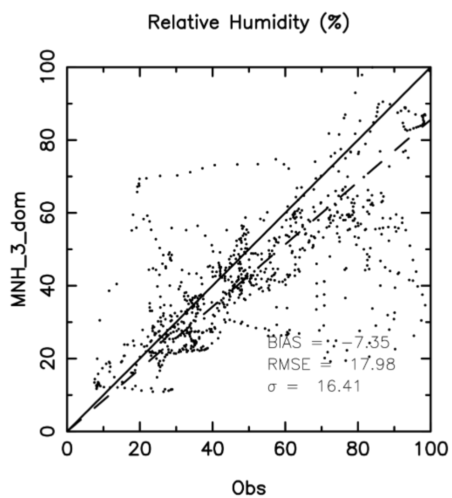
Relative Humidity – 3DOM K=4 Average on 20 nights

Astro-MESO-NH forecasts (MNH) vs observations (OBS)

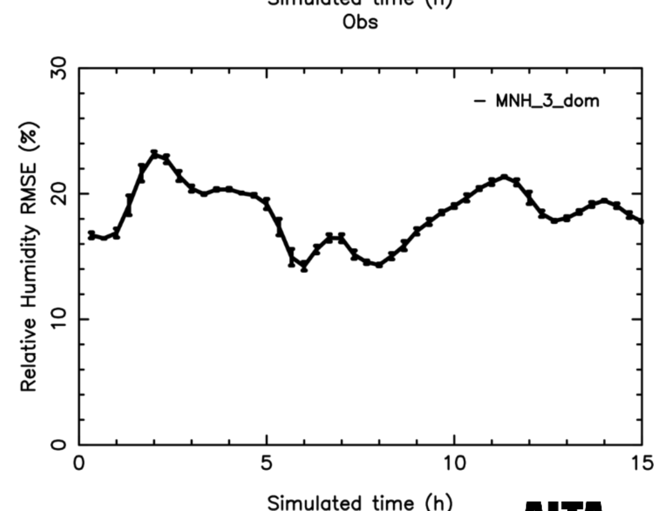
REAR MAST
Sensor height =55.5m a.g.l.







BIAS = -7.3%
RMSE = 18.0%
σ = 16.4%



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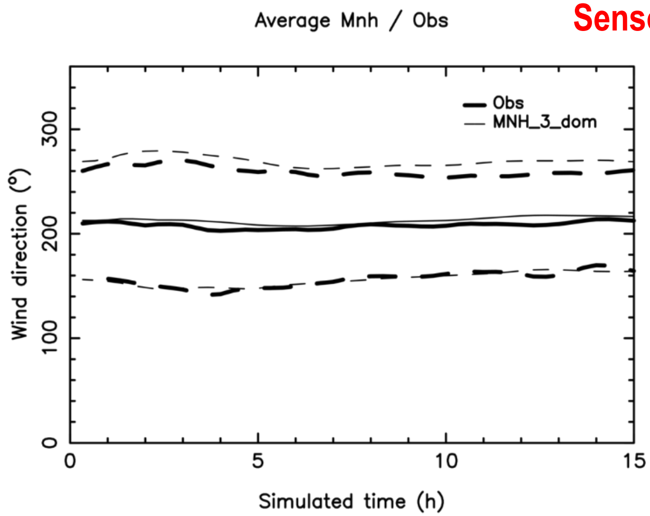
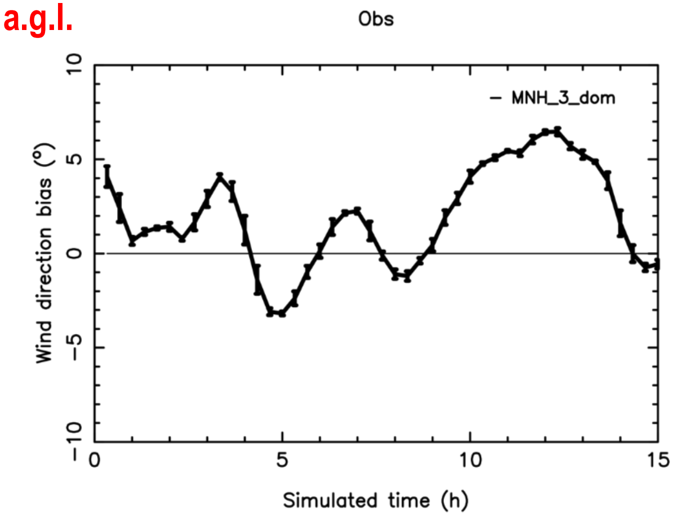
Wind Direction – 3DOM K=4 Average on 20 nights

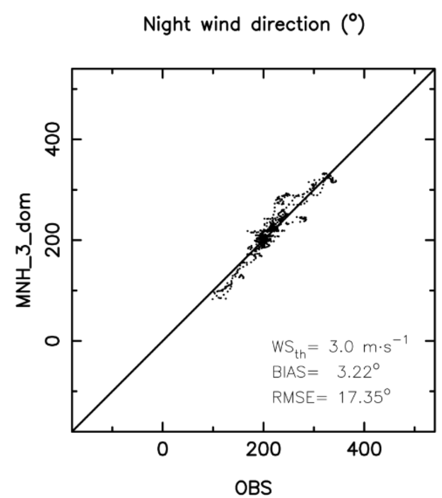
Astro-MESO-NH forecasts (MNH) vs observations (OBS)

REAR MAST
Sensor height =58m a.g.l.

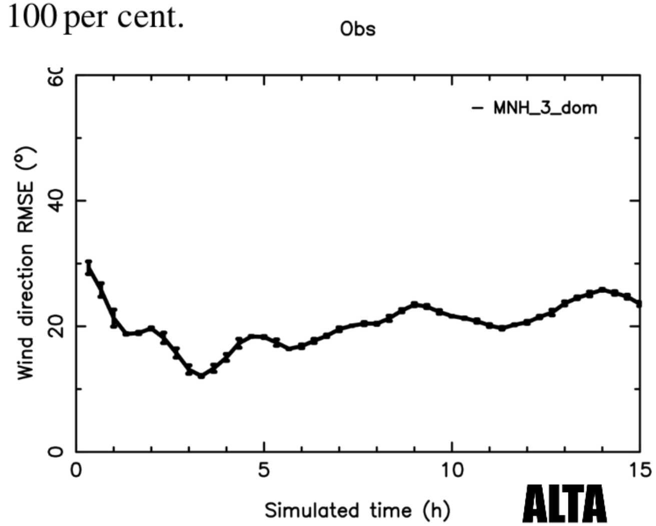




$$RMSE_{\mathrm{rel}} = \frac{RMSE}{180} \times 100 \text{ per cent.}$$



BIAS = 3.2°
RMSE = 17.3°
RMSE(rel) = 9.6%



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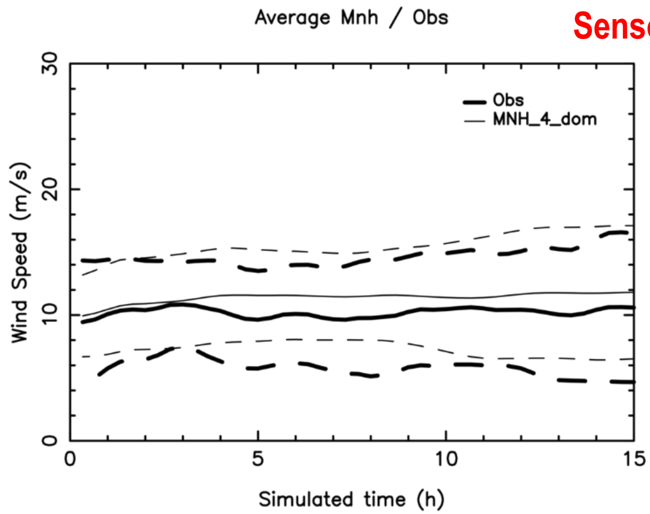
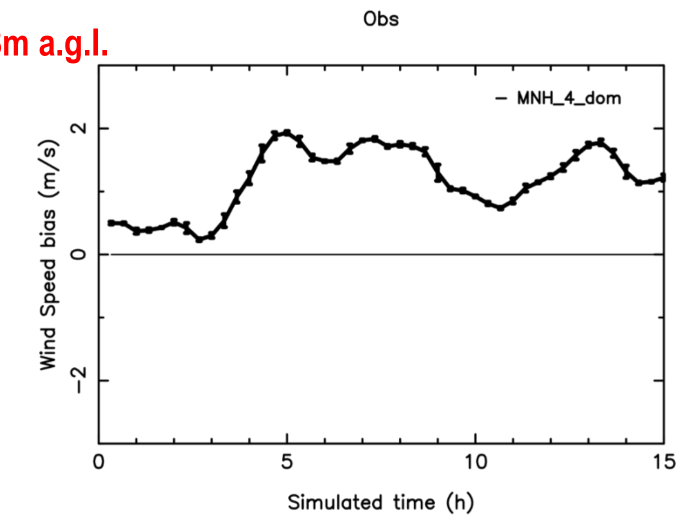
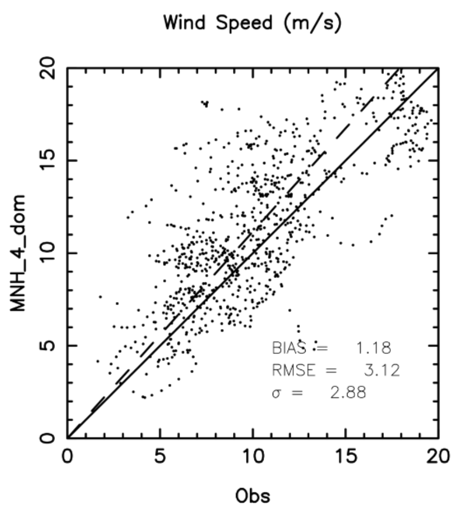
Wind Speed – 4DOM   K=4   Average on 20 nights

Astro-MESO-NH forecasts (MNH) vs observations (OBS)

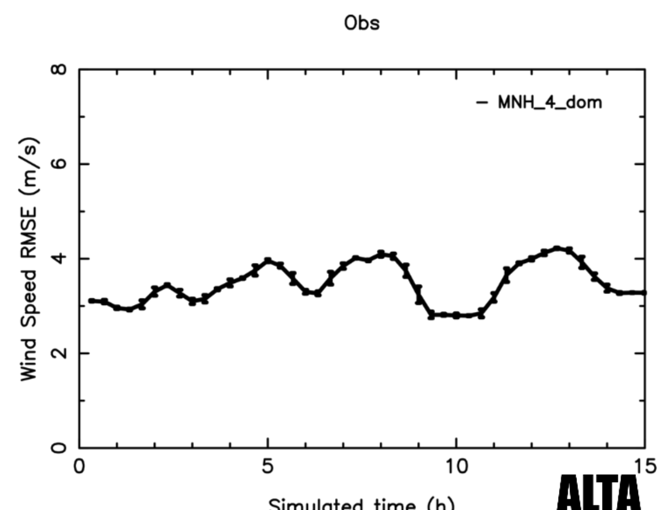
REAR MAST
Sensor height =58m a.g.l.







BIAS = 1.2 m/s
RMSE = 3.1 m/s
σ = 2.9 m/s



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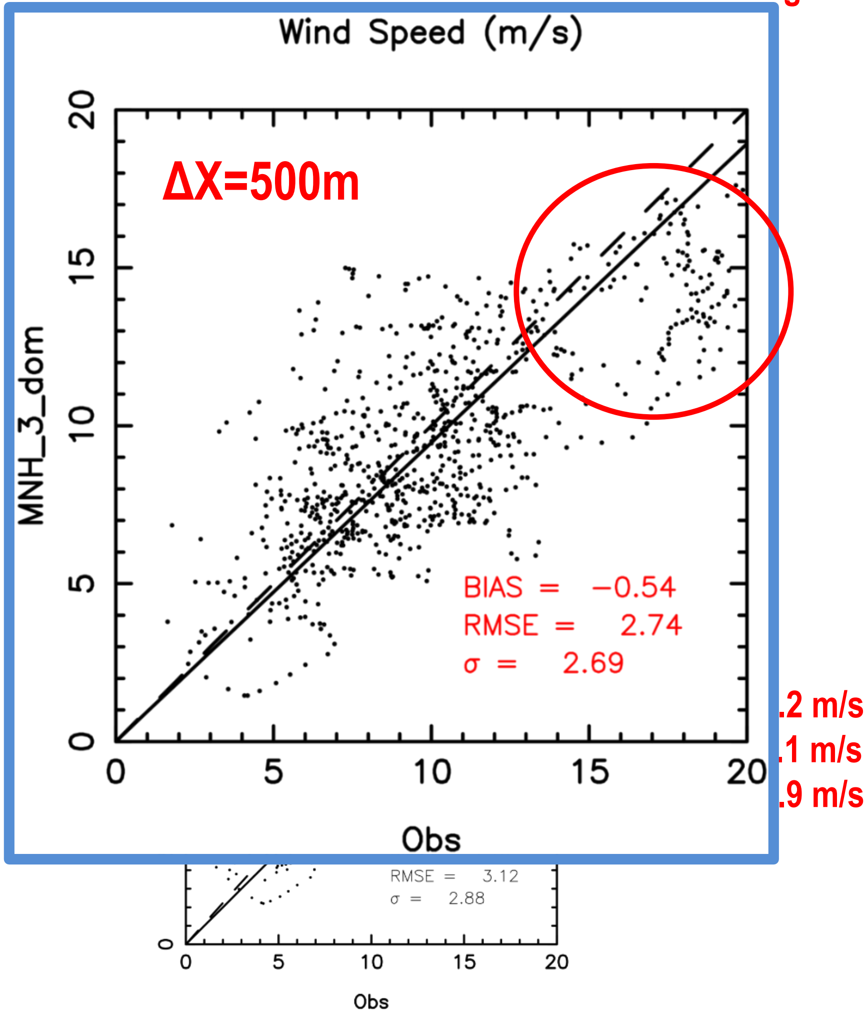
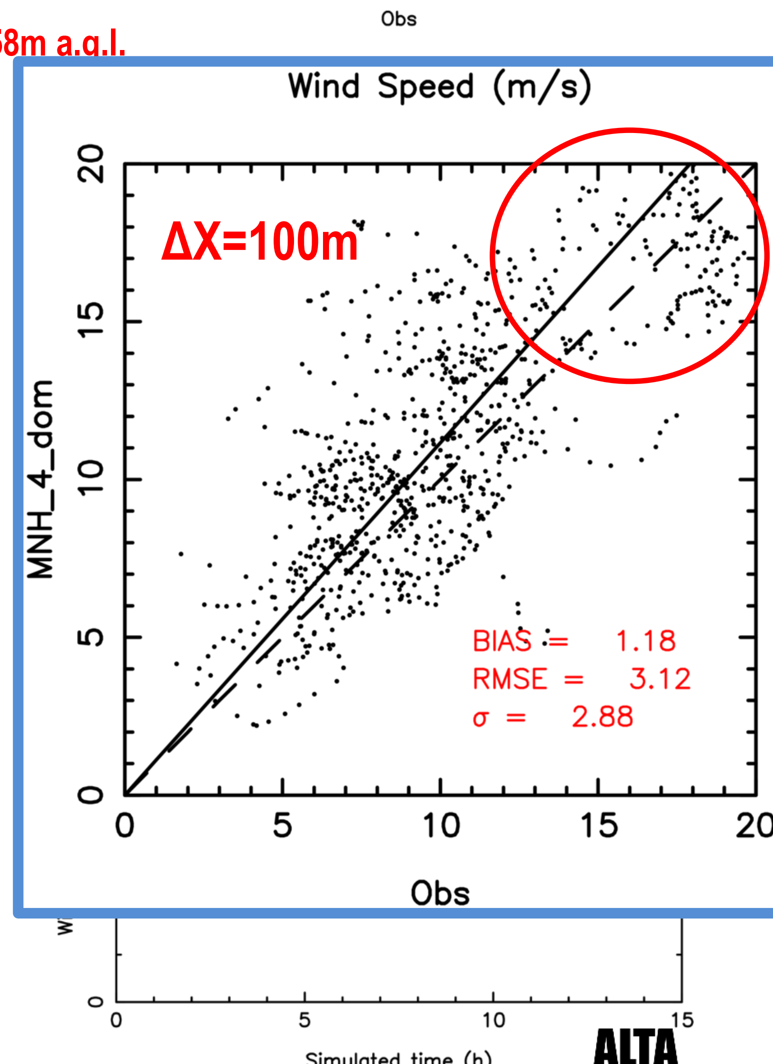
Wind Speed – 4DOM K=4 Average on 20 nights

Astro-MESO-NH forecasts (MNH) vs observations (OBS)

REAR MAST

Sensor height =58m a.g.l.





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How to read a contingency table

A contingency table allows for the analysis of the relationship between two or more categorical variables.
Values are divided into categories (e.g. wind <5m/s, 5m/s<wind<10m/s, ….) and a probability to detect each category is computed.

RANDOM CASE:
PC ~33%
POD ~33%
EBD ~22%

1. **PC=(a+e+i)/N*100**
2. **POD(1)=a/(a+d+g)*100**
   POD(2)=b/(b+e+h)*100
   POD(3)=c/(c+f+i)*100
3. **EBD=(c+g)/N*100**

See Lascaux et. al., MNRAS, 2015

Generic 3 × 3 contingency table.

Intervals		Observations			
		1	2	3	Total
Model					
	1	a (hit 1)	b	c	$a+b+c$ 1 (Model)
	2	d	e (hit 2)	f	$d+e+f$ 2 (Model)
	3	g	h	i (hit 3)	$g+h+i$ 3 (Model)
	Total	$a+d+g$ 1 (OBS)	$b+e+h$ 2 (OBS)	$c+f+i$ 3 (OBS)	$N=a+b+c+d+e+f+g+h+i$ Total of events

Temperature and Relative humidity ΔX=500m

TEMPERATURE contingency table:

Division by tertiles (climatology) MtG - 55,5m		OBSERVATIONS		
		$T < -1.2°C$	$-1.2°C < T < 2.5°C$	$T > 2.5°C$
MODEL	$T < -1.2°C$	232	9	0
	$-1.2°C < T < 2.5°C$	14	342	24
	$T > 2.5°C$	7	69	214

Total points = 911; PC=86.5%; EBD=0.8%
POD_1=91.7%; POD_2=81.4%; POD_3=90.0%

PC = 86.5%
EBD = 0.8%

POD(1) = 91.7%
POD(2) = 81.4%
POD(3) = 90.0%

RELATIVE HUMIDITY contingency table:

PC = 68.4%
EBD = 4.4%

POD(1) = 81.6%
POD(2) = 71.1%
POD(3) = 52.5%

Division by tertiles (climatology) MtG - 55,5m		OBSERVATIONS		
		$RH < 33.9\%$	$33.9\% < RH < 57.7\%$	$RH > 57.7\%$
MODEL	$RH < 33.9\%$	248	80	27
	$33.91\% < RH < 57.7\%$	43	216	117
	$RH > 57.7\%$	13	8	159

Total points = 911; PC=68.4%; EBD=4.4%
POD_1=81.6%; POD_2=71.1%; POD_3=52.5%

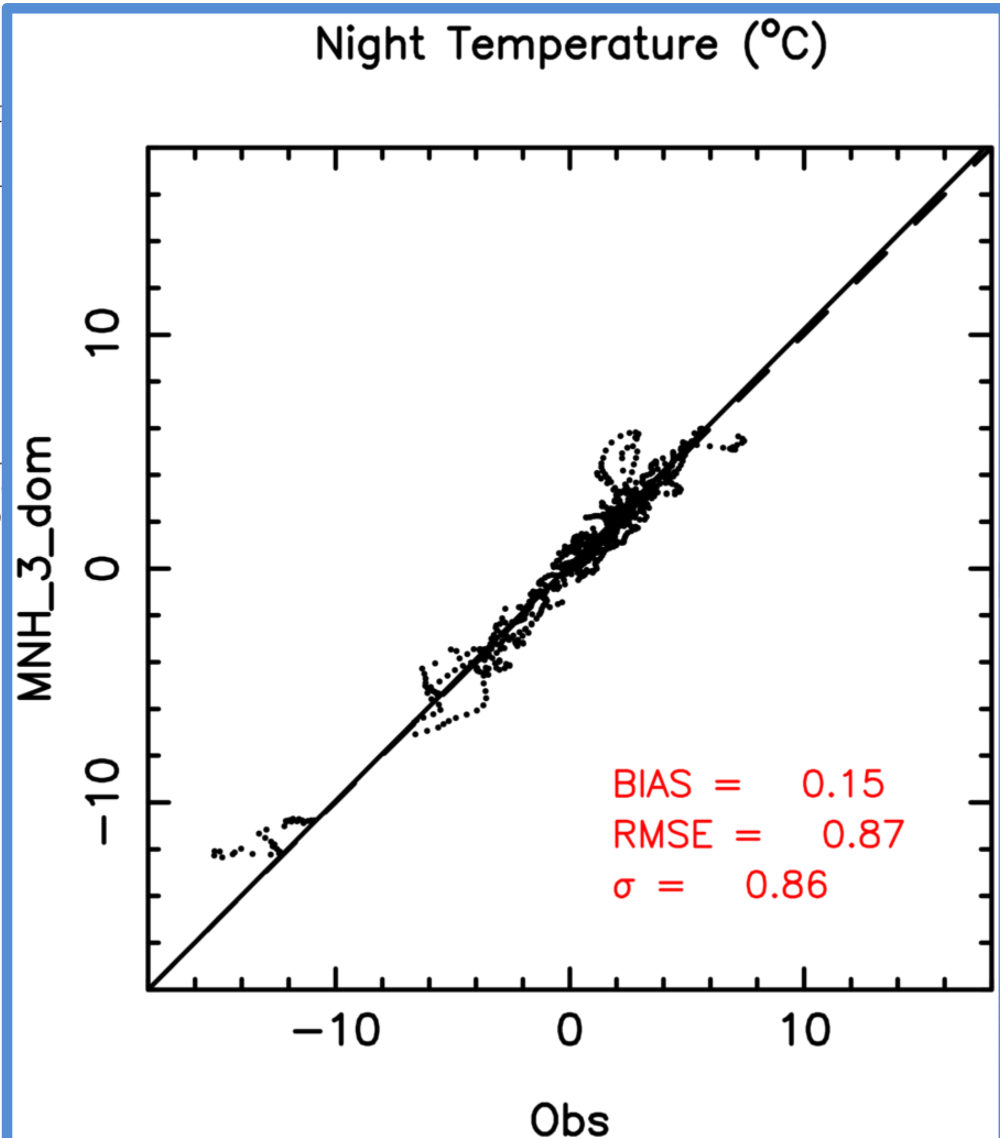
Temperature and Relative humidity   ΔX=500m

Div

MODEL

Tot

PO



$> 2.5°C$

0

24

214

PC = 86.5%
EBD = 0.8%

POD(1) = 91.7%
POD(2) = 81.4%
POD(3) = 90.0%

TY contingency table:

OBSERVATIONS		
$RH < 33.9\%$	$33.9\% < RH < 57.7\%$	$RH > 57.7\%$
248	80	27
43	216	117
13	8	159

BD=4.4%
D_3=52.5%

Temperature and Relative humidity   ΔX=500m

TEMPERATURE contingency table:

Division by tertiles (climatology) MtG - 55,5m	OBSERVATIONS $T < -1.2°C$	$-1.2°C < T < 2.5°C$	$T > 2.5°C$
MODEL $T < -1.2°C$	232	9	0
MODEL $-1.2°C < T < 2.5°C$	14	342	24
MODEL $T > 2.5°C$	7	69	214

Total points = 911; PC=86.5%; EBD=0.8%
POD_1=91.7%; POD_2=81.4%; POD_3=90.0%

PC = 86.5%
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RELATIVE HUMIDITY contingency table:

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MODEL $RH < 33.9\%$	248	80	27
MODEL $33.91\% < RH < 57.7\%$	43	216	117
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Total points = 911; PC=68.4%; EBD=4.4%
POD_1=81.6%; POD_2=71.1%; POD_3=52.5%

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Temperature and Relative humidity   ΔX=500m

TEMPERATURE contingency ta

Division by tertiles (climatology) MtG - 55,5m		$T < -1.2°C$
MODEL	$T < -1.2°C$	232
	$-1.2°C < T < 2.5°C$	14
	$T > 2.5°C$	7

Total points = 911; PC=86.5%; EBD=0.8%
POD_1=91.7%; POD_2=81.4%; POD_3=90.0%

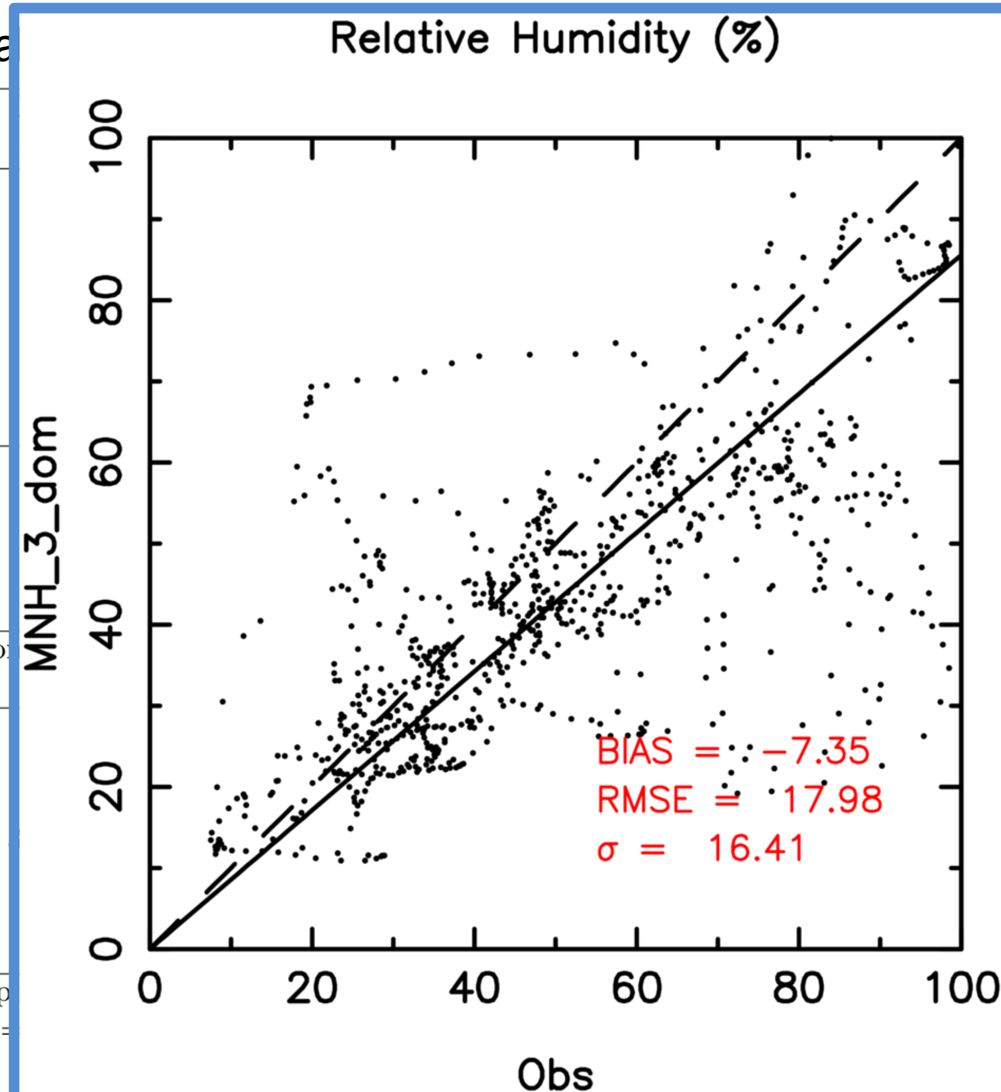
PC = 68.4%
EBD = 4.4%

POD(1) = 81.6%
POD(2) = 71.1%
POD(3) = 52.5%

Divisio… 57.7%

MODEL … 7 … 9

Total p…
POD_1=…



Wind speed, comparison 500m vs 100m resolution

WIND SPEED contingency table, ΔX=500m

Division by tertiles (climatology) MtG - 58m		OBSERVATIONS $WS < 5.9m/s$	$5.9m/s < WS < 9.7m/s$	$WS > 9.7m/s$
MODEL	$WS < 5.9m/s$	51	32	4
	$5.9m/s < WS < 9.7m/s$	36	242	126
	$WS > 9.7m/s$	14	85	321

Total points = 911; PC=67.4%; EBD=2.0%
POD_1=50.5%; POD_2=67.4%; POD_3=71.2%

PC = 67.4%
EBD = 2.0%

POD(1) = 50.5%
POD(2) = 67.4%
POD(3) = 71.2%

WIND SPEED contingency table, ΔX=100m

PC = 68.9%
EBD = 2.3%

POD(1) = 41.6%
POD(2) = 60.2%
POD(3) = 82.0%

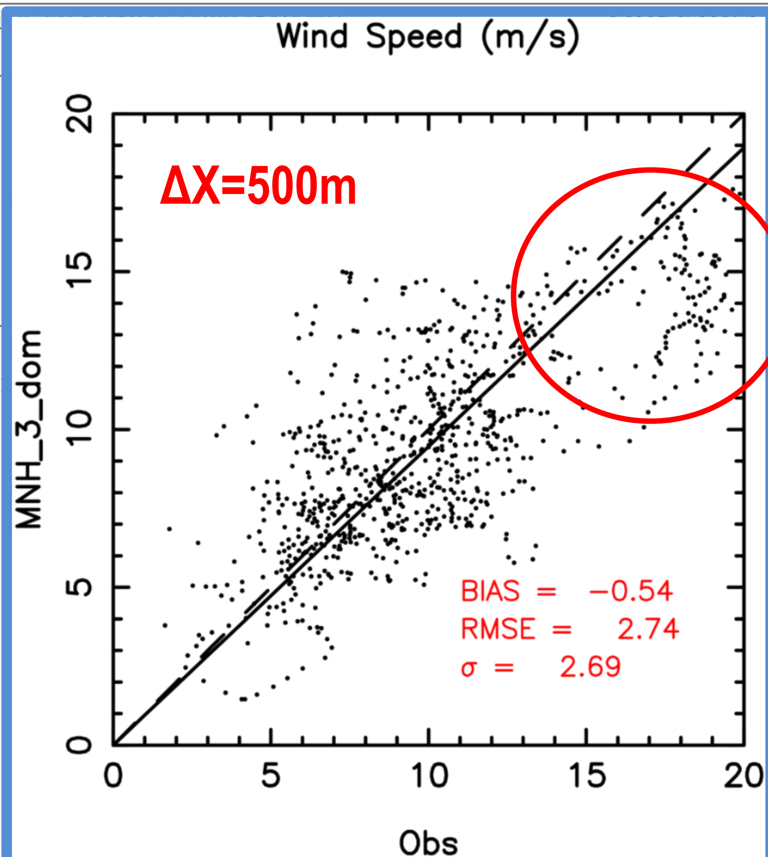
Division by tertiles (climatology) MtG - 58m		OBSERVATIONS $WS < 5.9m/s$	$5.9m/s < WS < 9.7m/s$	$WS > 9.7m/s$
MODEL	$WS < 5.9m/s$	42	25	6
	$5.9m/s < WS < 9.7m/s$	44	216	75
	$WS > 9.7m/s$	15	118	370

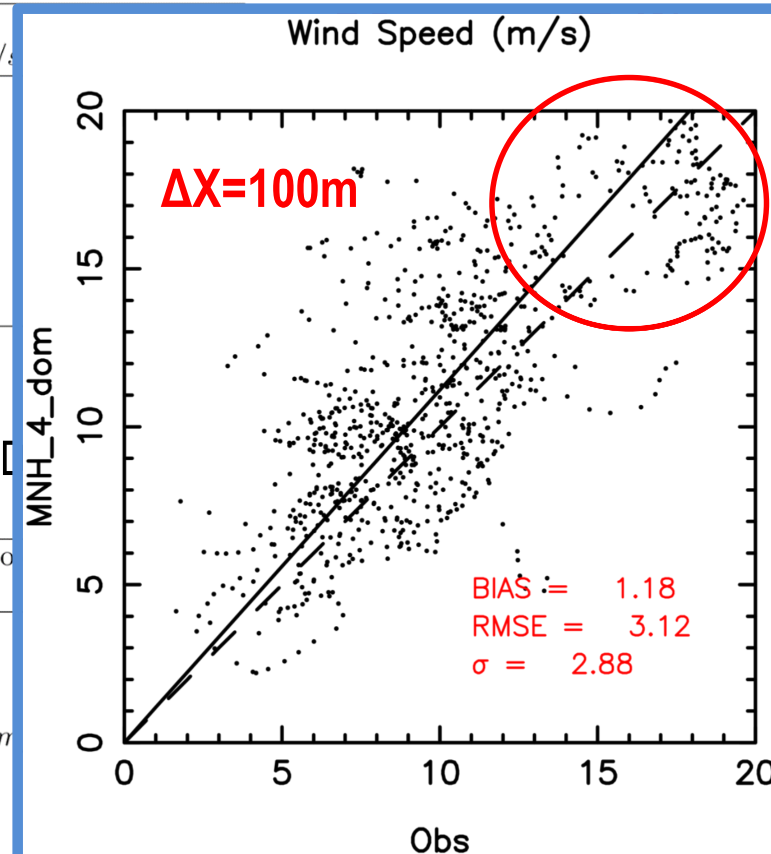
Total points = 911; PC=68.9%; EBD=2.3%
POD_1=41.6%; POD_2=60.2%; POD_3=82.0%

ALTA

Wind speed, comparison 500m vs 100m resolution

WIND SPEED contingency table, ΔX=500m





POD(3) = 82.0%

Total points = 911; PC=68.9%; EBD=2.3%

POD_1=41.6%; POD_2=60.2%; POD_3=82.0%

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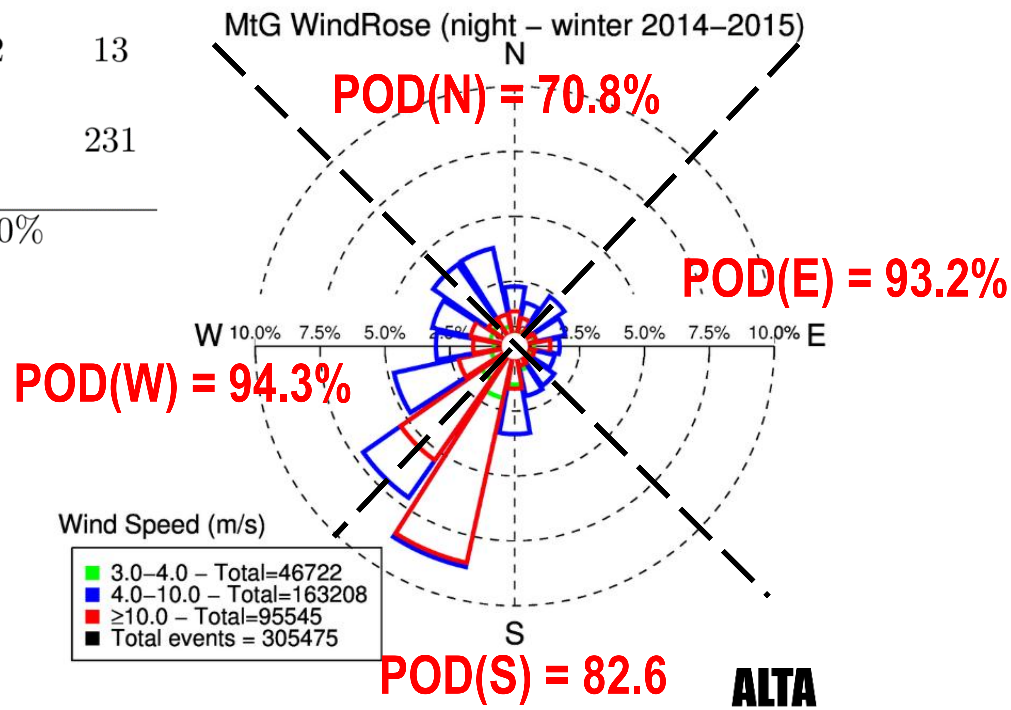
Wind direction ΔX=100m

WIND DIRECTION contingency table, ΔX=100m

		OBSERVATIONS			
MtG - 58m		N	E	S	W
MODEL	N	34	4	0	1
	E	0	55	12	0
	S	0	0	462	13
	W	14	0	85	231

Total points = 911; PC=85.8%; EBD=0%
$POD(N)$=70.8%; $POD(E)$=93.2%
$POD(S)$=82.6%; $POD(W)$=94.3%

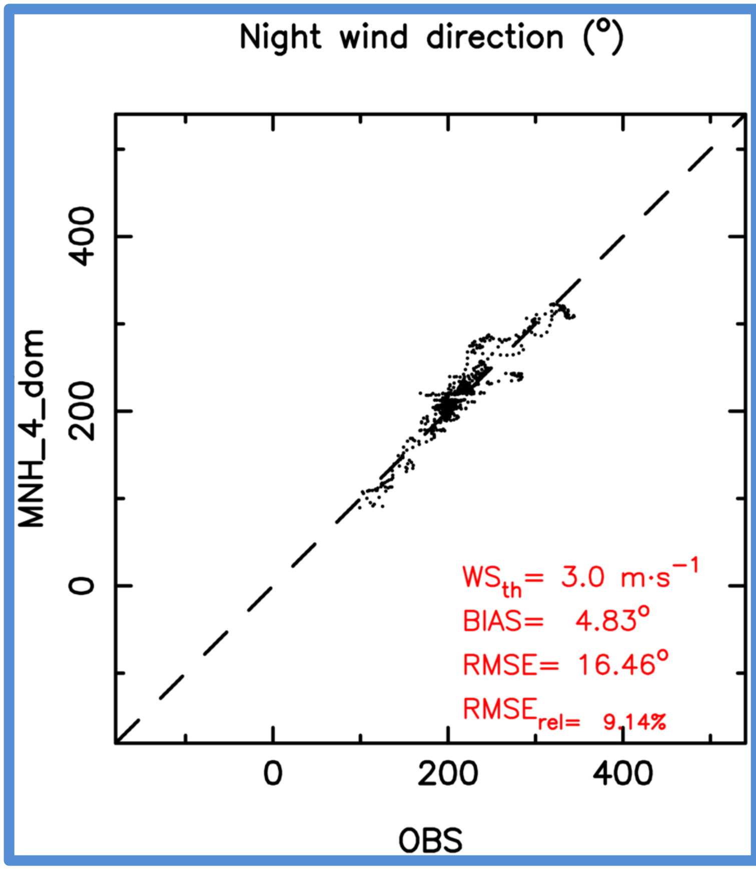
PC = 85.8%
EBD = 0%



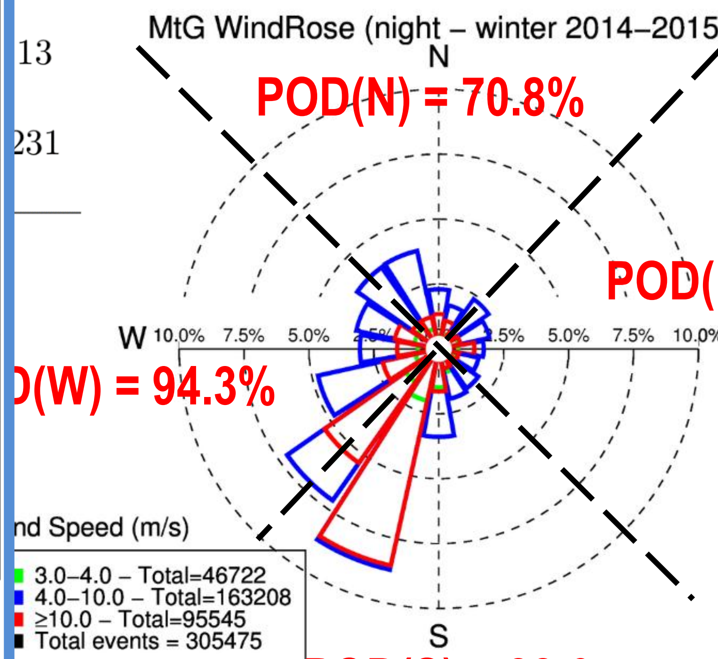
Wind direction ΔX=100m

WIND DIRECTION contingency table, ΔX=100m

		OBSERVATIONS		
MtG - 58m	N	E	S	W
				1
				0
				13
				231



PC = 85.8%
EBD = 0%



POD(N) = 70.8%
POD(E) = 93.2%
D(W) = 94.3%
POD(S) = 82.6

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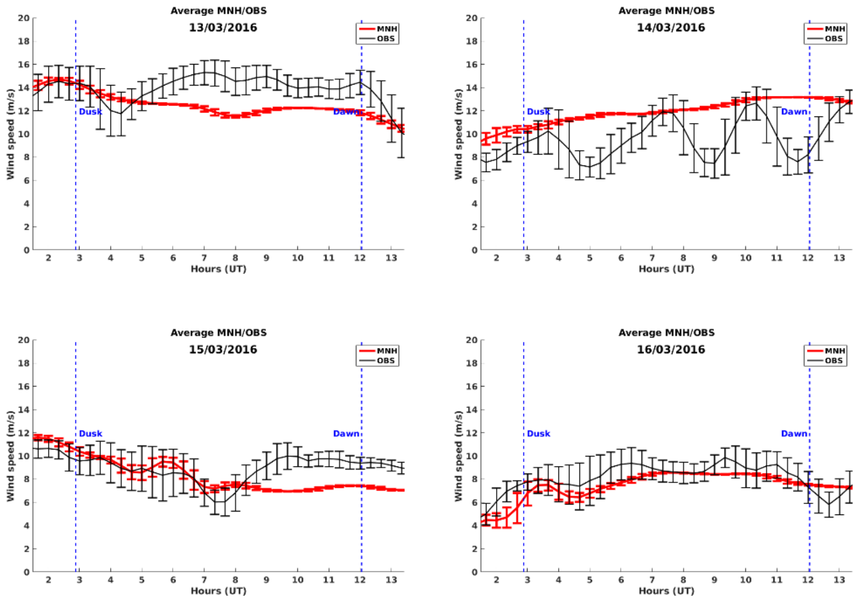
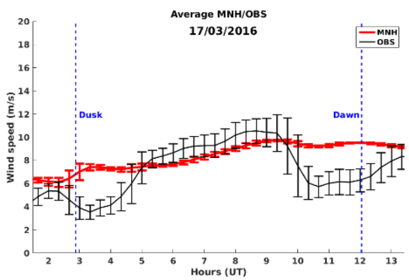
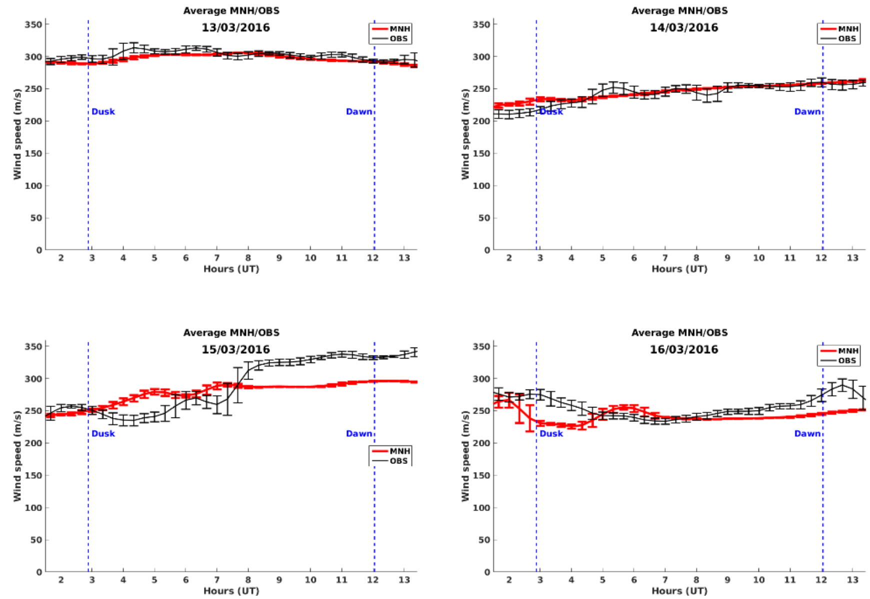
Use case: ARGOS run 13/03/2016 – 17/03/2016 (UT)

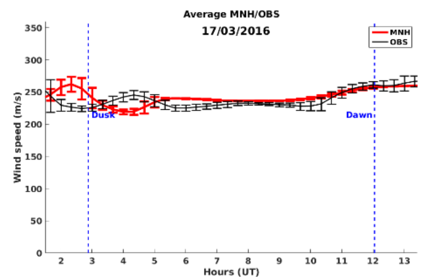




Wind speed

BIAS = -1.2 m/s
RMSE = 2.0 m/s
σ = 1.6 m/s

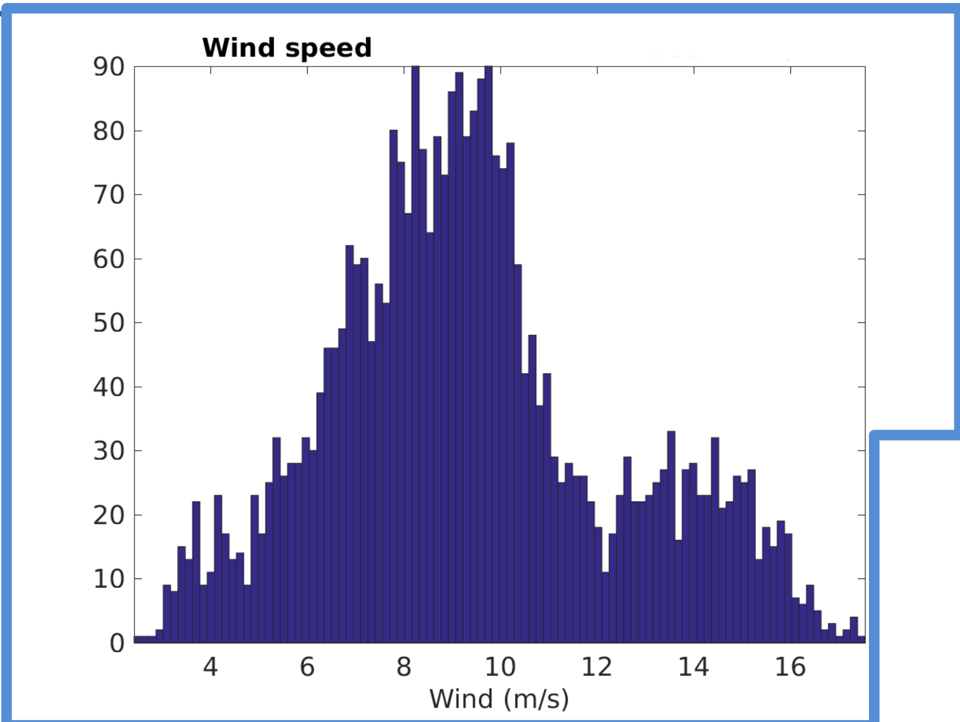


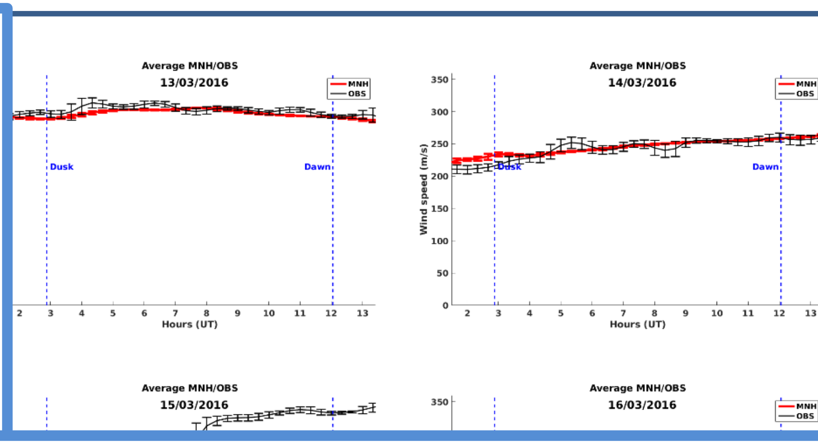


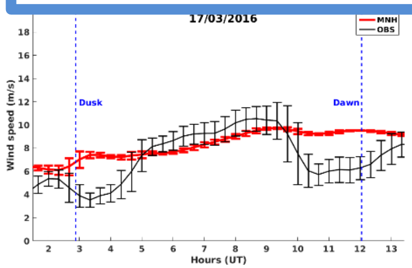
Wind direction

BIAS = 3.0 °
RMSE = 20.2 °
RMSE(rel) = 11.2%

Use case: ARGOS run 13/03/2016 – 17/03/2016 (UT)





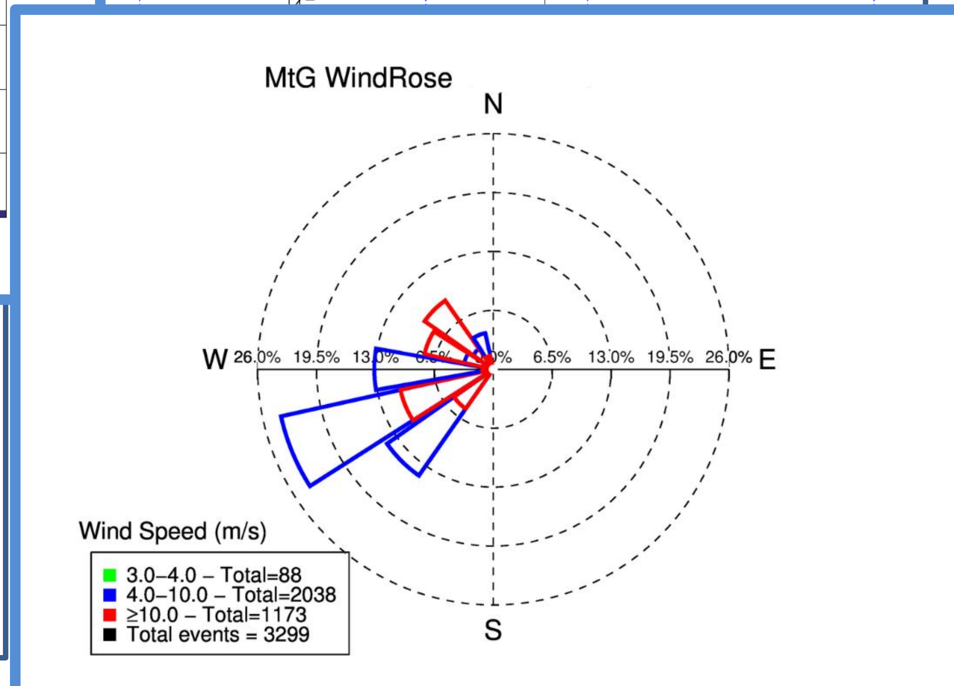


Wind speed

BIAS = -1.2 m/s

RMSE = 2.0 m/s

σ = 1.6 m/s



Conclusions

1. We build an operational forecast model configuration for the LBT site, testing multiple possible solutions. The setup proves to be efficient and able to run within the project's constraints.

2. We started an preliminary validation test on all the possible tested setups, using the telemetry measures taken from LBT instrumentation above the dome. Initial results from the ongoing validation test allowed us to select the best possible configuration. The results for ground weather parameters shown in this contribution show an excellent level of model performance.

3. The sample size will be increased to a richer statistical ensemble of ~140 nights, in order to confirm the validity of the measured performance , however the overall performance is already on par with the state of the art for other sites (e.g. Paranal, Cerro Armazones).
   Masciari et al., MNRAS 2013; Lascaux et al., MNRAS 2013; Lascaux et al., MNRAS 2015

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