Forecasting radiation fog at climatologically contrasting sites: evaluation of statistical methods and WRF

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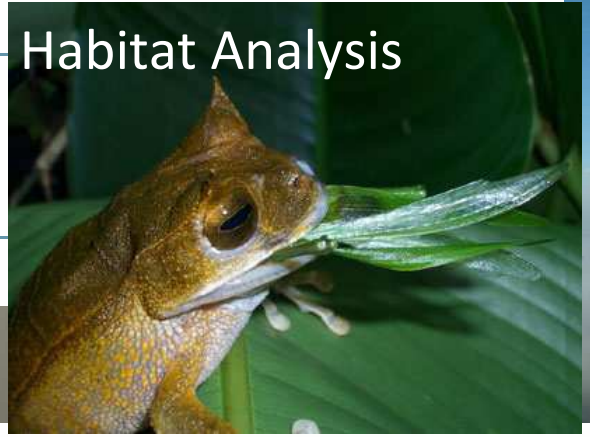
Motivation



Forecast				
Observation		yes	no	
	yes	42	44	86
	no	34	1438	1472
		76	1482	1558

Hit rate= (42/86)=0.49
False alarm rate= (34/76)=0.45

Hardly any skill!

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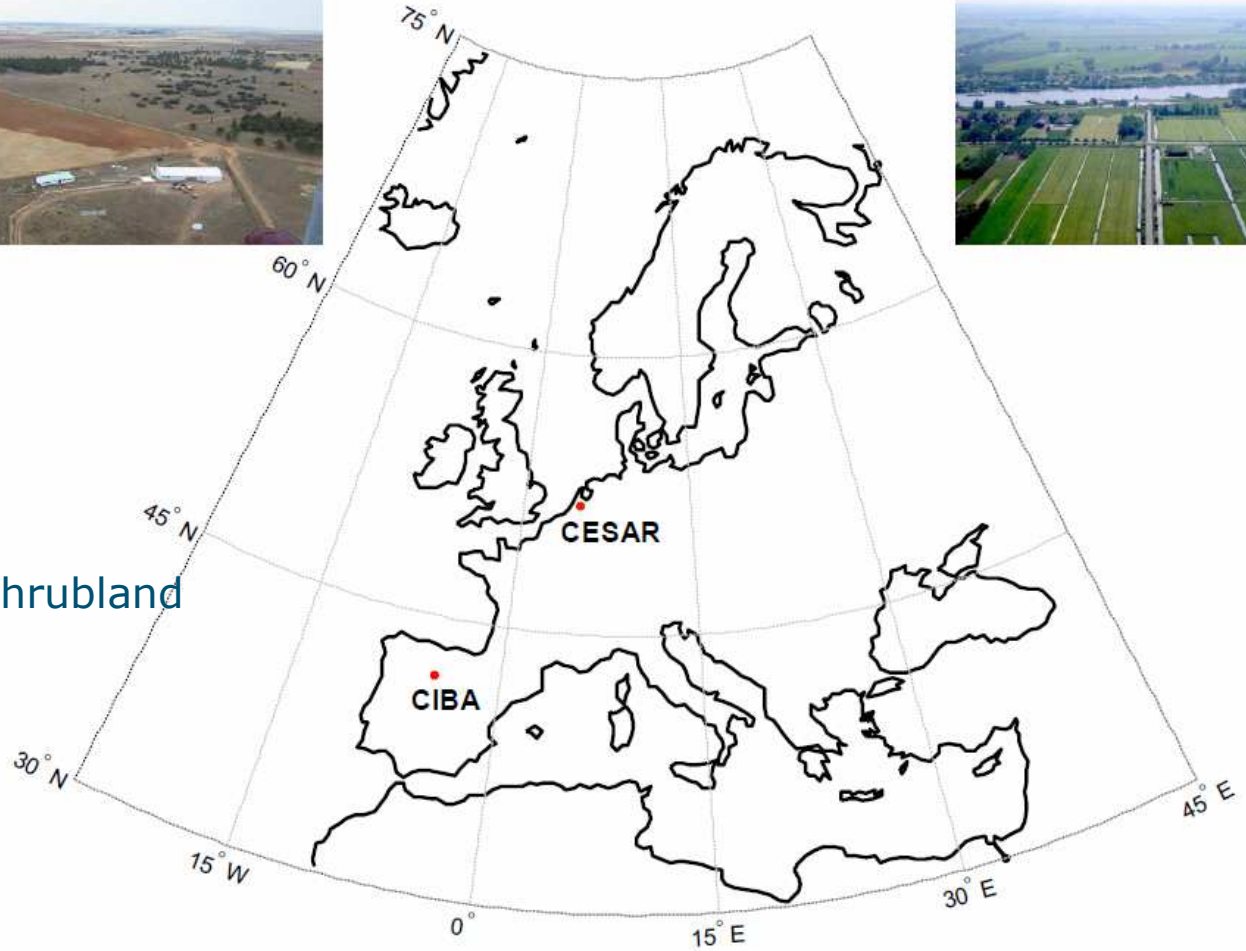
Objectives

- Fog climatology difference between Cabauw (Netherlands) and CIBA (Spain)
- Evaluation statistical forecasting method Menut et al ’14 for Cabauw and CIBA
- Comparison to 3D- WRF model
- A method to estimate fog thickness from screen level surface visibility and friction velocity.

Two contrasting sites

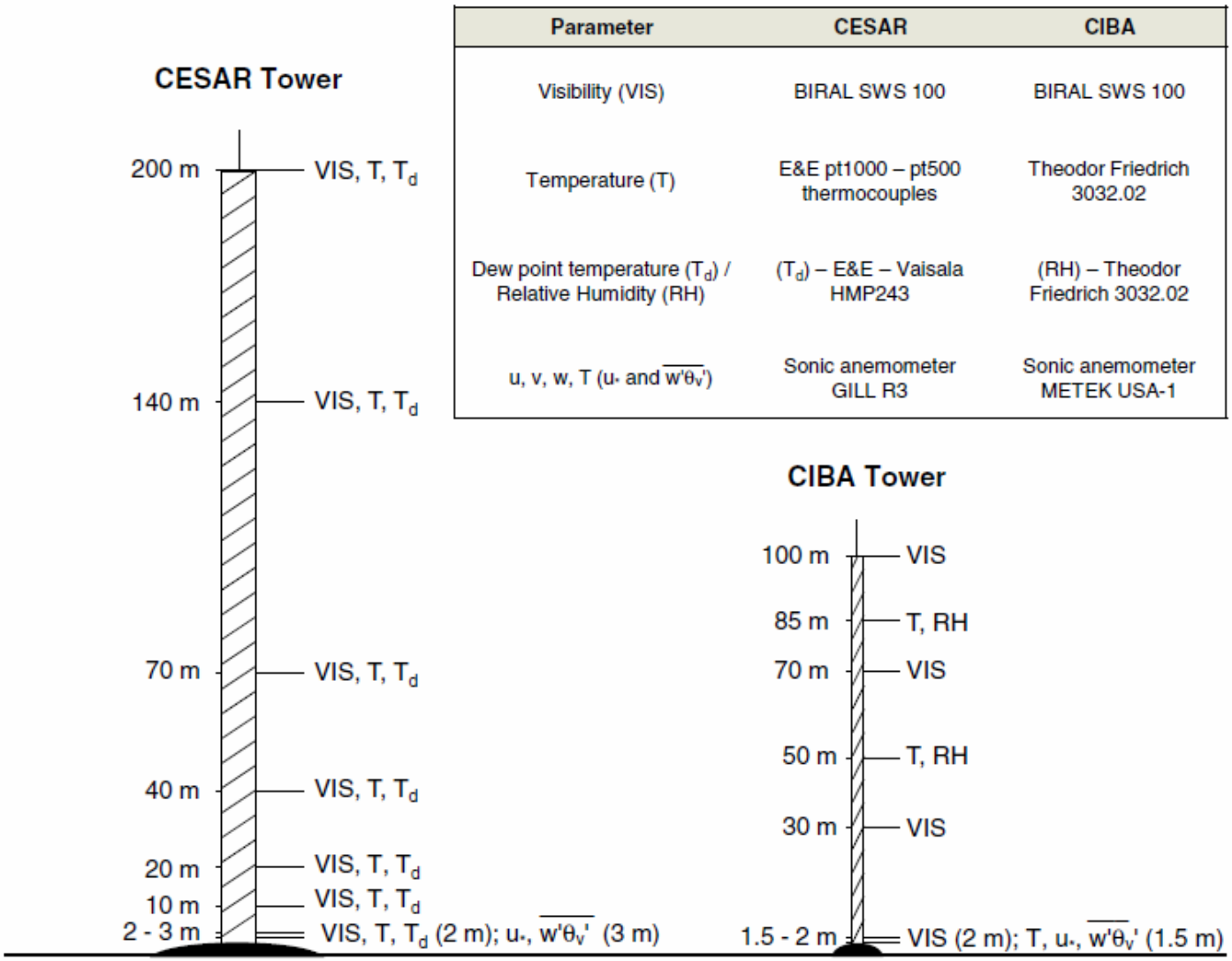
Dry
High pressure
100 m tower
Cropland and shrubland
Inland



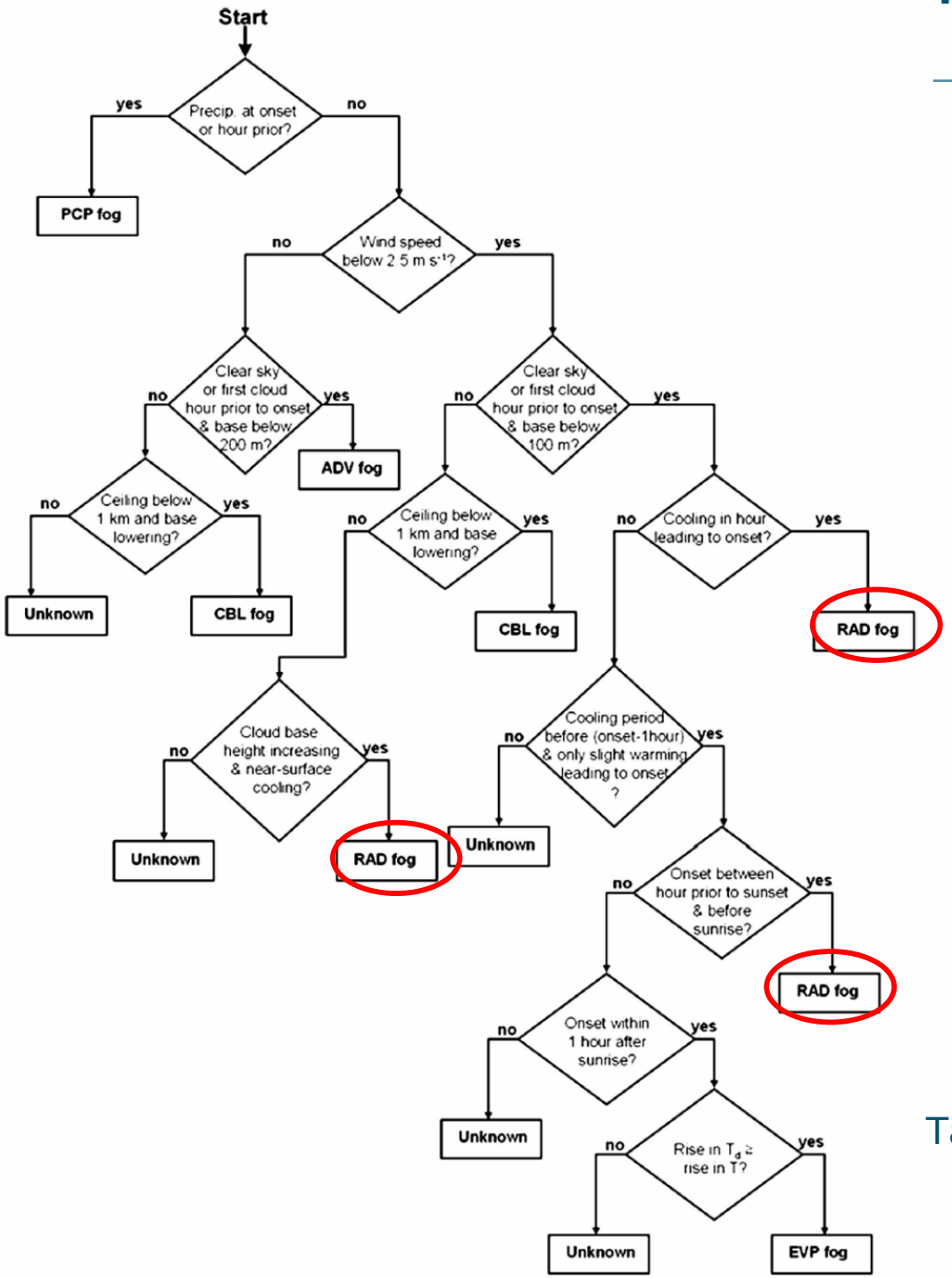
Humid
Westerlies
200 m tower
Grassland
40 km from coast

Available measurements

Parameter	CESAR	CIBA
Visibility (VIS)	BIRAL SWS 100	BIRAL SWS 100
Temperature (T)	E&E pt1000 – pt500 thermocouples	Theodor Friedrich 3032.02
Dew point temperature (T_d) / Relative Humidity (RH)	(T_d) – E&E – Vaisala HMP243	(RH) – Theodor Friedrich 3032.02
u, v, w, T (u_* and $\overline{w'\theta_v'}$)	Sonic anemometer GILL R3	Sonic anemometer METEK USA-1



Fog classification: focus on radiation fog



60% radiation fog at both sites

Tardiff and Rasmussen 2007

WAGE

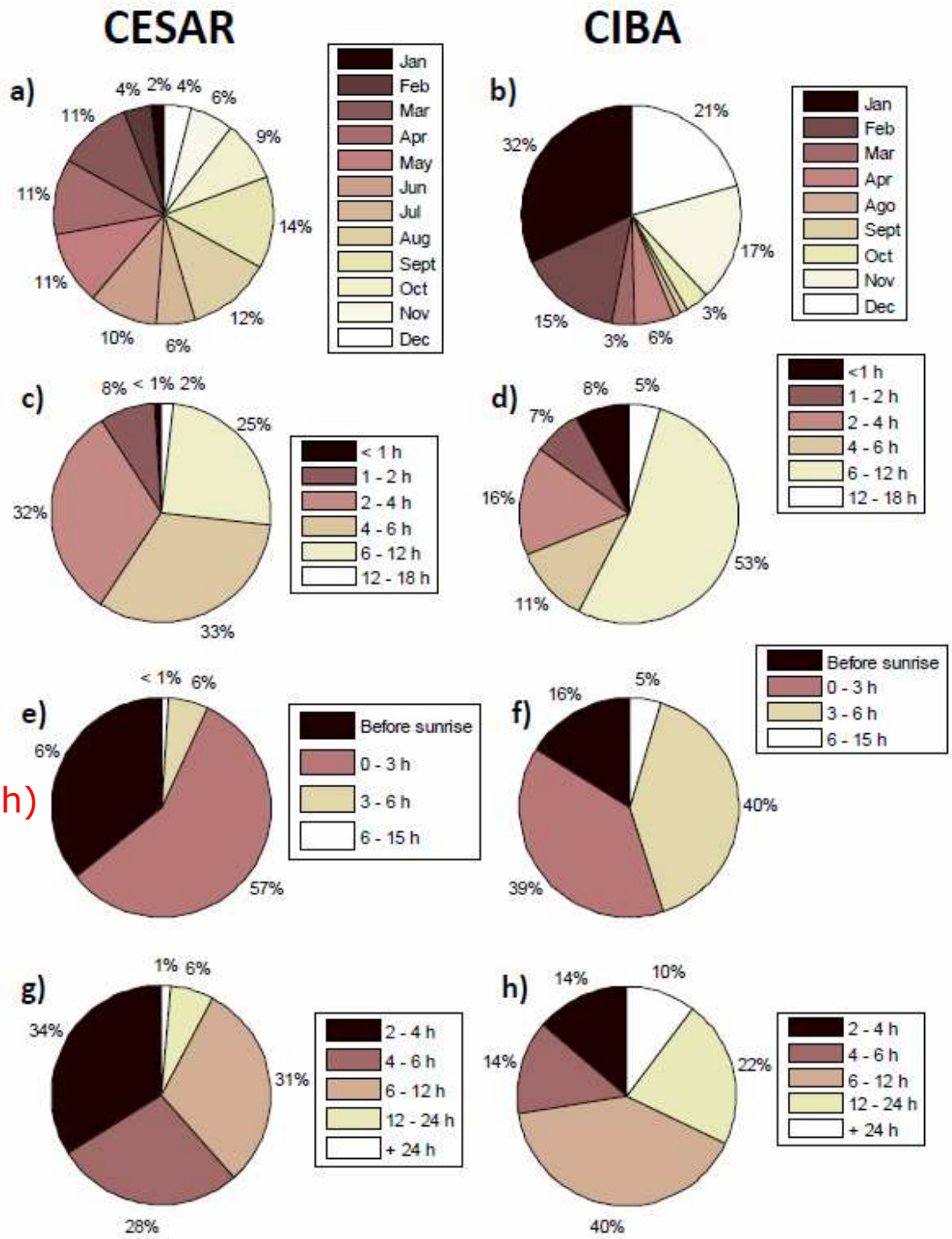
Climatology

Monthly distribution

Onset after sunset (h)

Dissipation after sunrise (h)

Duration (h)



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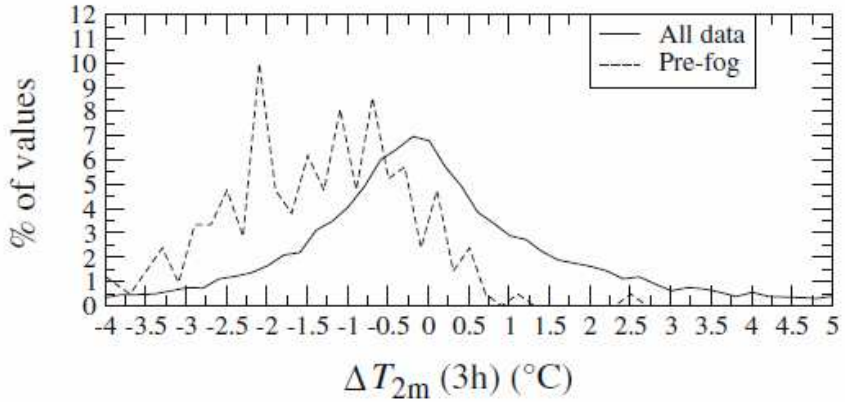
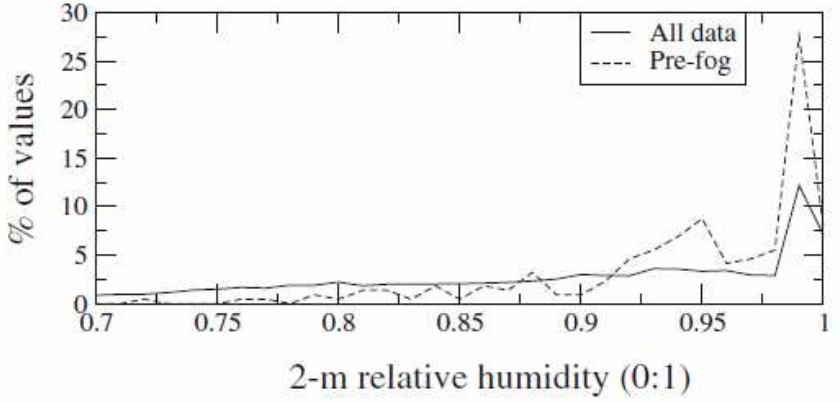
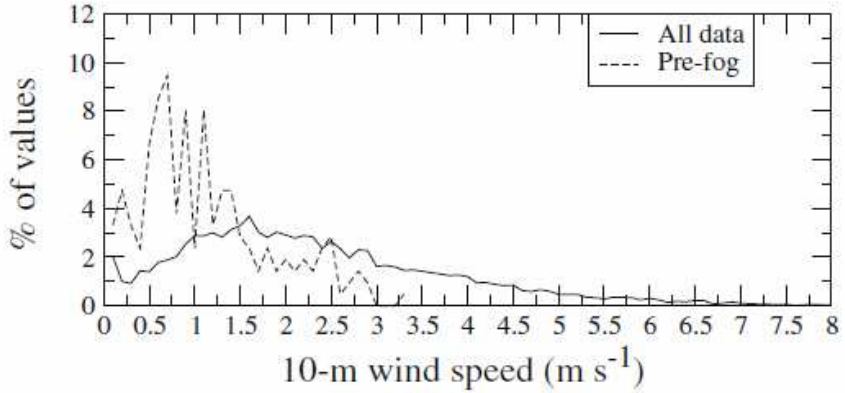
Menut et al (2014) method

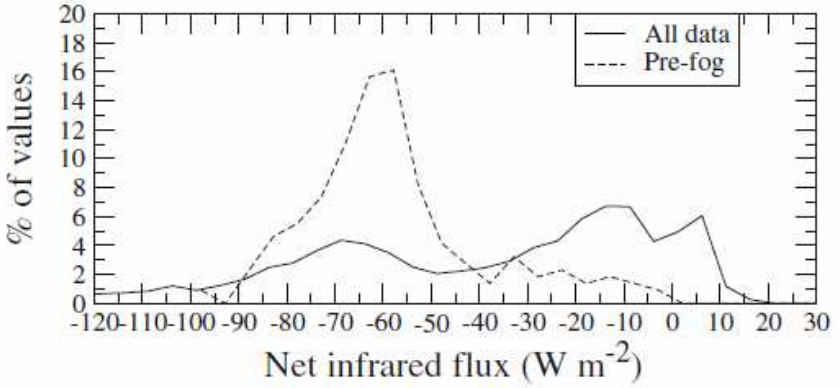
- WRF unable to forecast fog (LWC) for PARISfog campaign
- Though can we use prefog conditions?

PARISFOG









ΔT_{2m} < -0.5K RH_{2m}>90% U10m < 3 m/s Lwnet < -10 W/m^2

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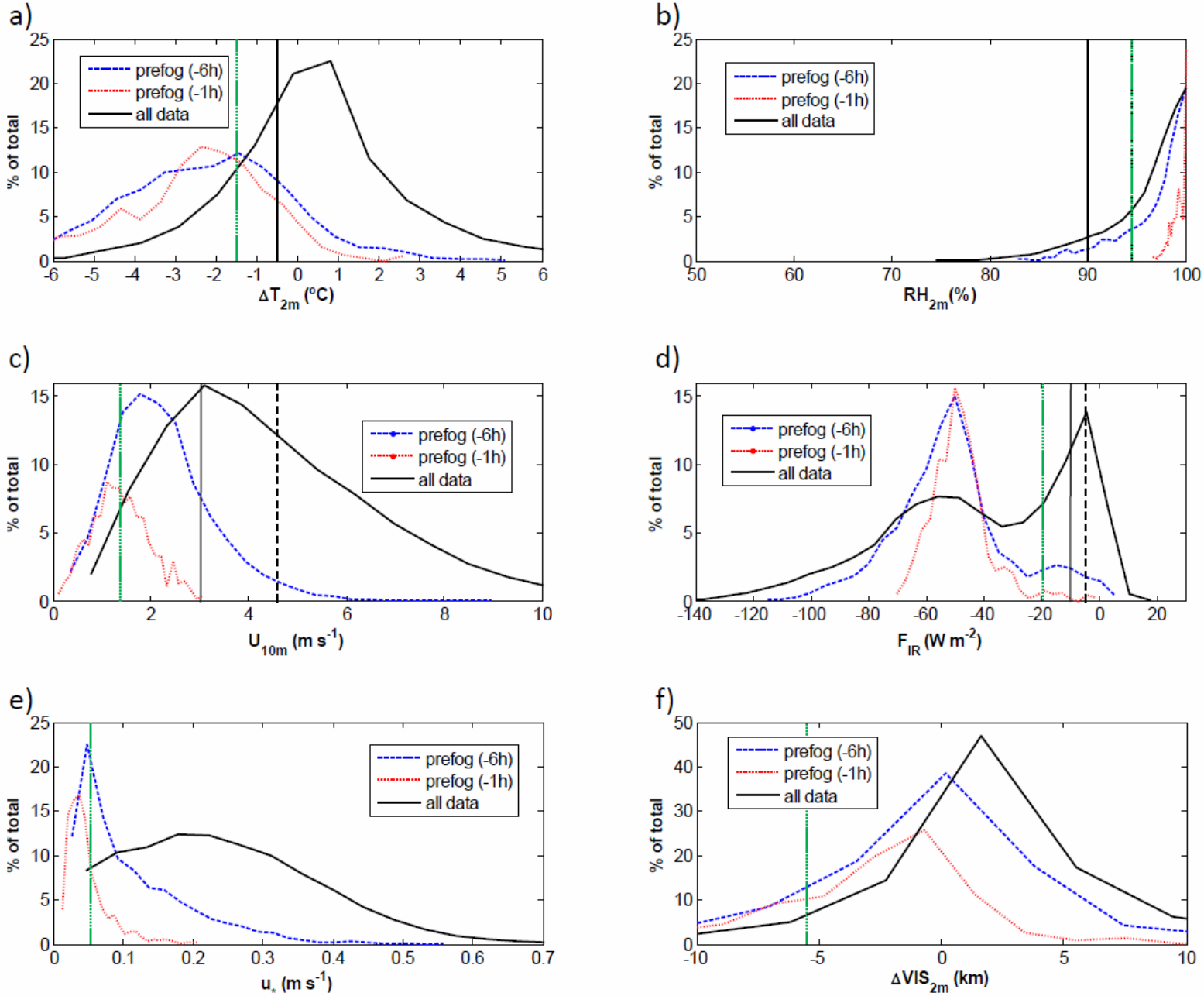
Does it also work for Cabauw?

Menut et al variables

Alternative predictors



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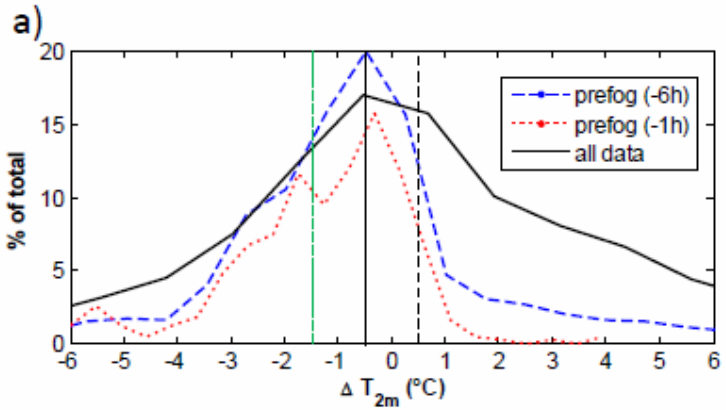
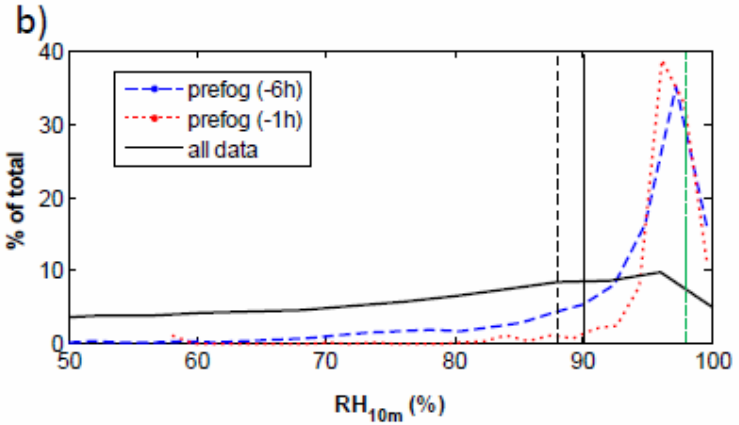
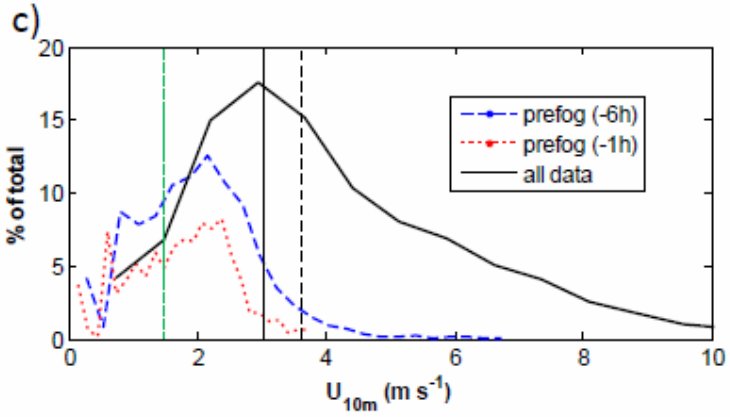
Does it also work for CIBA?

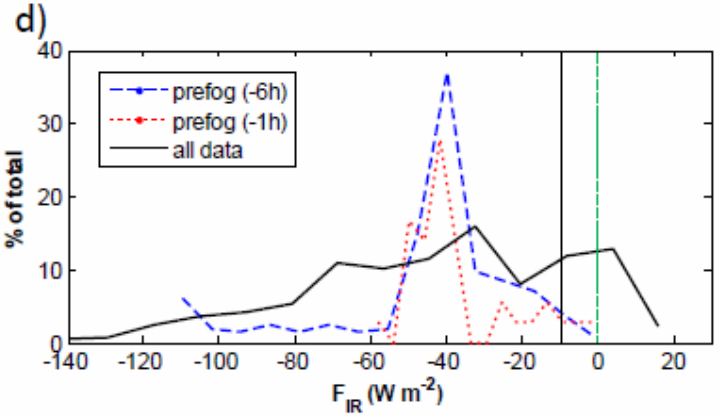
Menut et al variables

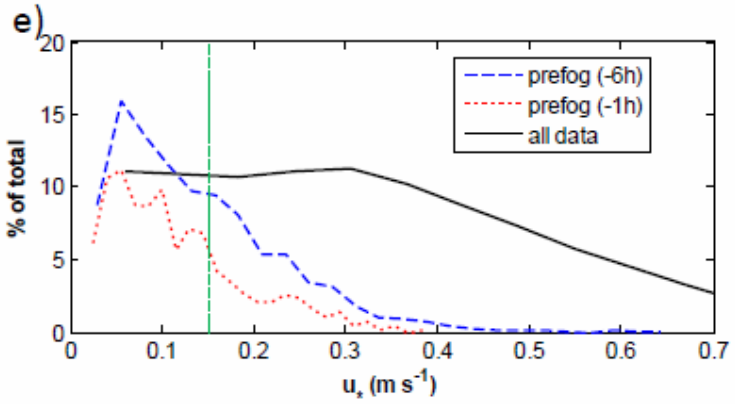
Alternative predictors

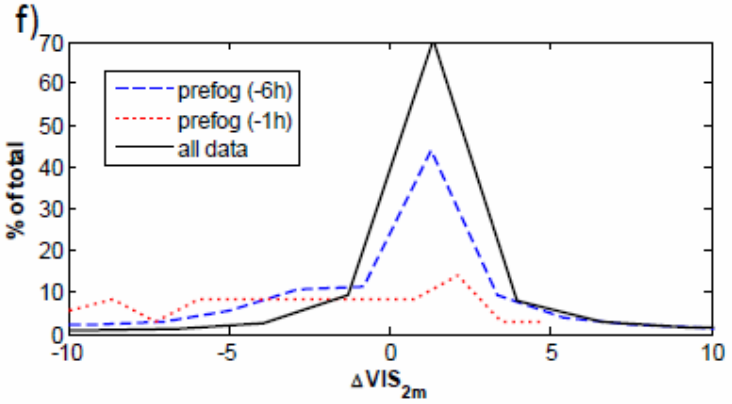












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Overview thresholds

	ParisFog	Cabauw	CIBA
ΔT2m (°C)	<-0.5	<-0.5	<0.5
RH2m (%)	>90	>94	>88
U10m (m/s)	< 3	< 4.5	< 3.6
Lwnet (W/m2)	<-10	<-5	<-5

Stat. forecasting: observations as input

	CESAR Combination	HR	FA	GSS	U_{10m} ($m\,s^{-1}$)	RH_{2m} (%)	F_{IR} ($W\,m^{-2}$)	ΔT_{2m} (°C)	u_* ($m\,s^{-1}$)	ΔVIS_{2m} (m)
1	M14 thresholds	86.7	21.7	0.049	3	90	−10	−0.5	***	***
2	CESAR thresholds	82.1	30.6	0.029	4.5	94	−5	−0.5	***	***
3	Optimum HR	95.5	38.9	0.025	4	88	5	0.0	***	***
4	Optimum FA	29.8	2,0	0.131	1.5	98	−20	−1.5	***	***
5	Optimum GSS	40.4	3.1	0.136	1.5	95	−20	−1.5	***	***
6	$-RH_{2m}$	43.1	3.7	0.128	1.5	***	−20	−1.5	***	***
7	$-RH_{2m}-U_{10m}+u_*$	70.4	12.2	0.074	***	***	−20	−0.5	0.05	***
8	$-RH_{2m}+\Delta VIS_{2m}$	33.0	1.9	0.150	1.5	***	−20	−1.5	***	−5500

	CIBA Combination	HR	FA	GSS	U_{10m} ($m\,s^{-1}$)	RH_{10m} (%)	F_{IR} ($W\,m^{-2}$)	ΔT_{2m} (°C)	u_* ($m\,s^{-1}$)
1	M14 thresholds	64.3	14.0	0.064	3.0	90	−10	−0.5	***
2	CIBA thresholds	73.9	22.3	0.044	3.6	88	−10	0.5	***
3	Optimum HR	80.9	21.0	0.053	1.8	80	5	1.5	***
4	Optimum FA	32.5	0.4	0.265	1.5	98	0	−1.5	***
5	Optimum GSS	41.4	0.7	0.303	1.5	98	0	−1.5	***
6	$-U_{10m}+u_*$	40.8	0.6	0.309	***	98	0	0	0.15

High resolution WRF setup

- 51 layers (28 below 1000 m, 8 below 100 m)
- 300 x 300 grids
- DX= 2.5 km
- Settings:
  - MYNN2.5
  - RRTM
  - WDM6
  - NOAH LSM

Can WRF predict prefog conditions?

Stat. forecasting: coarse resolution WRF as input

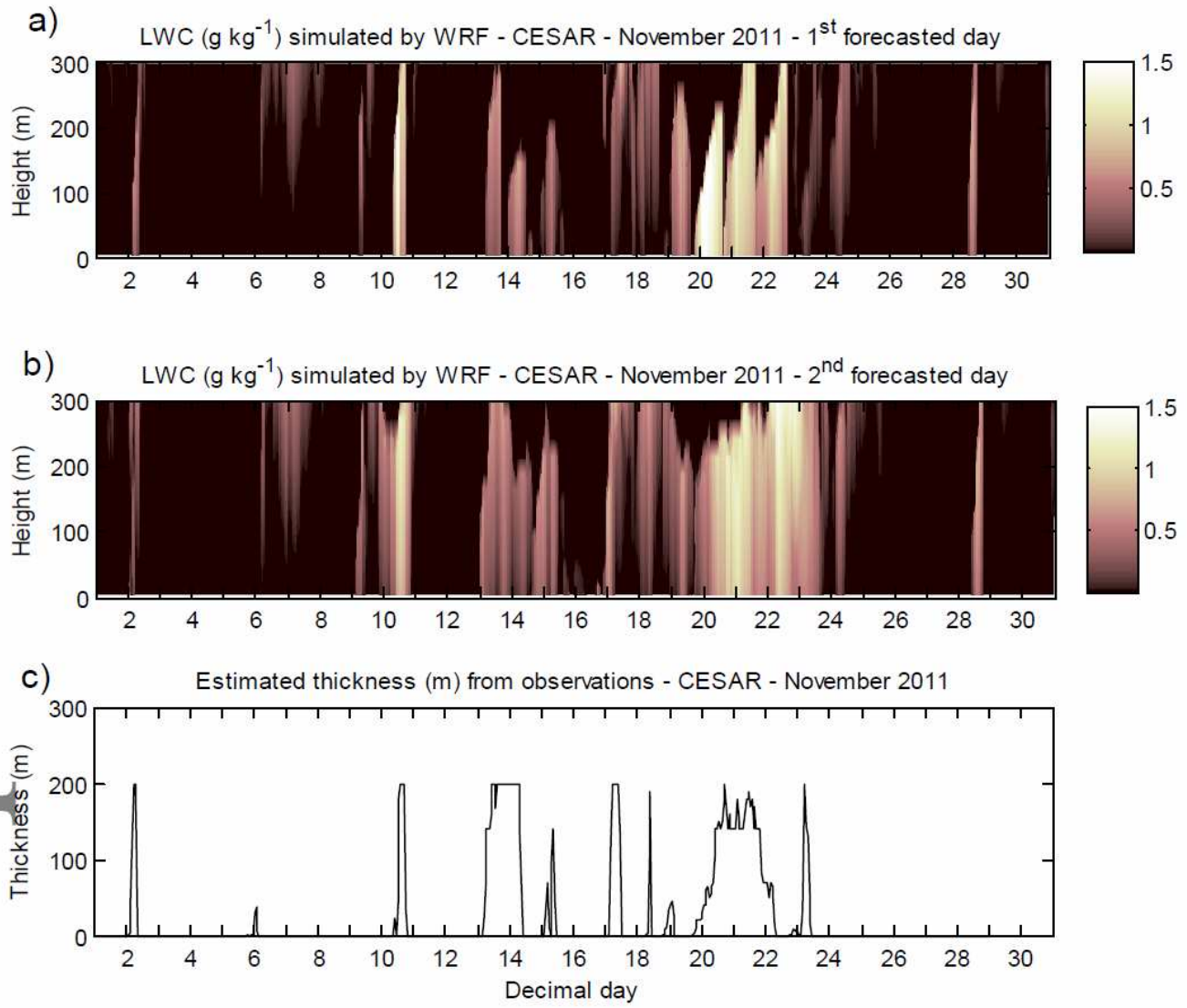
48 h forecast

	HR	FA	GSS	$n°$ for $\alpha_n > 0.9$			
				F_{IR}	RH	ΔT_{2m}	U_{10m}
CESAR							
First forecasted day							
Combination 1 (M14)	33.3	12.2	0.067	351	643	426	276
Combination 5 (GSS)	3.3	0.8	0.022	304	475	117	79
Combination 3 (HR)	73.3	34.7	0.053	657	720	536	427
Second forecasted day							
Combination 1 (M14)	20.0	10.5	0.034	351	653	402	249
Combination 5 (GSS)	10.0	0.4	0.086	304	489	161	50
Combination 3 (HR)	86.7	37.4	0.066	657	720	557	428
CIBA							
First forecasted day							
Combination 1 (M14)	33.7	16.0	0.093	429	532	474	505
Combination 5 (GSS)	17.4	7.6	0.063	705	290	474	321
Combination 3 (HR)	47.8	31.9	0.060	718	632	662	331
Second forecasted day							
Combination 1 (M14)	34.8	17.3	0.089	429	578	479	522
Combination 5 (GSS)	31.5	12.8	0.106	705	391	479	325
Combination 3 (HR)	59.8	35.7	0.086	718	660	674	325

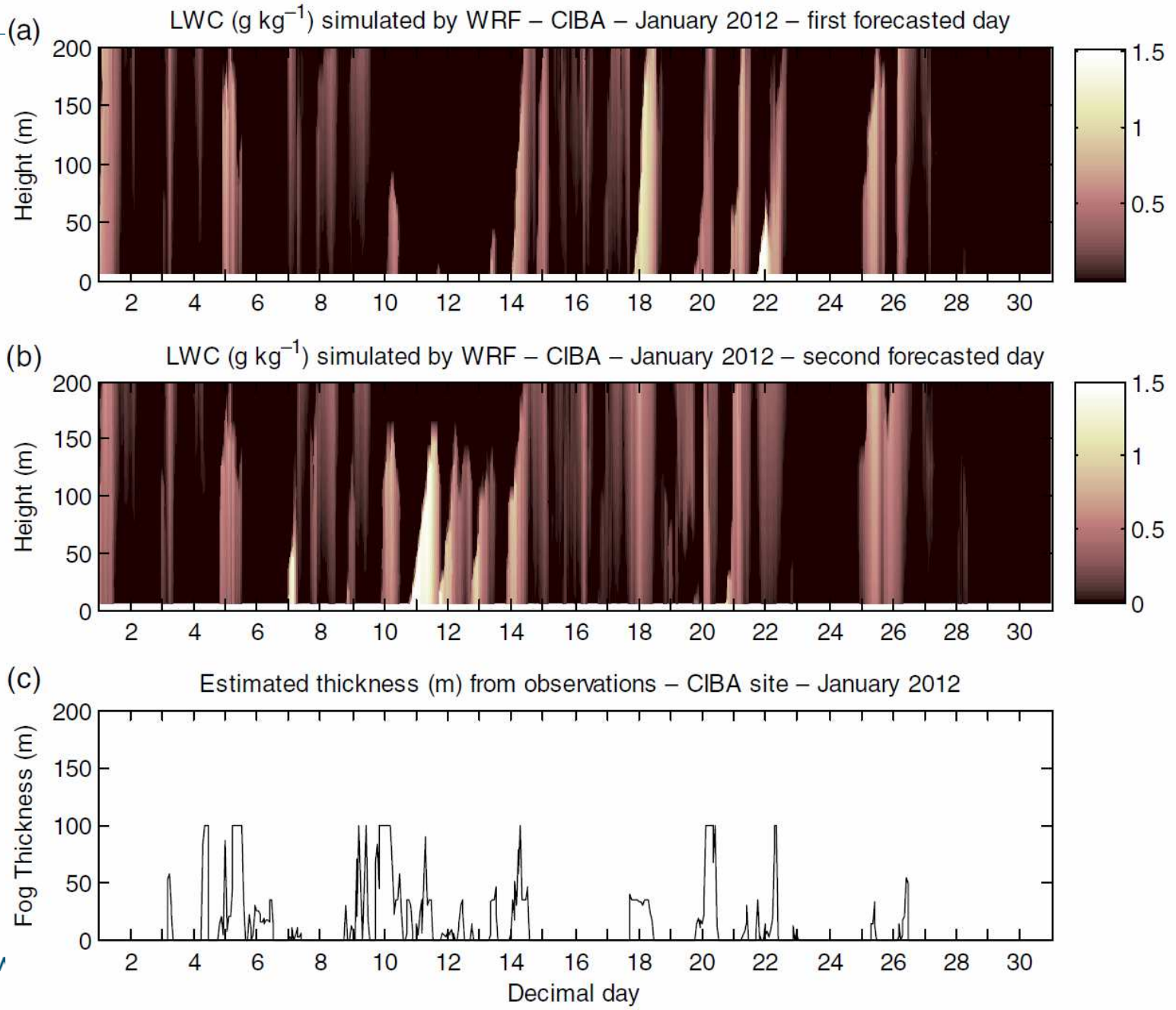
Thresholds from observations not applicable to WRF output

High resolution WRF November 2011 Cabauw

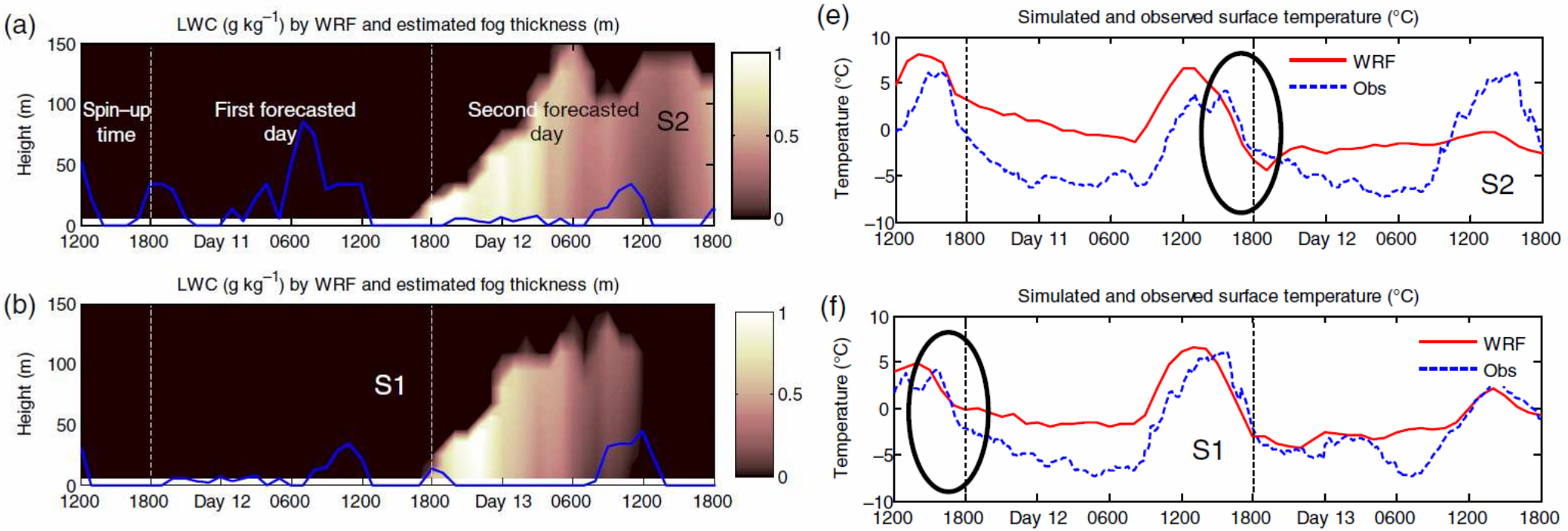
- 51 layers (28 below 1000 m, 8 below 100 m)
- 300 x 300 grids
- DX= 2.5 km
- Settings:
  - MYNN2.5
  - RRTM
  - WDM6
  - NOAH LSM



High resolution WRF January 2012 CIBA

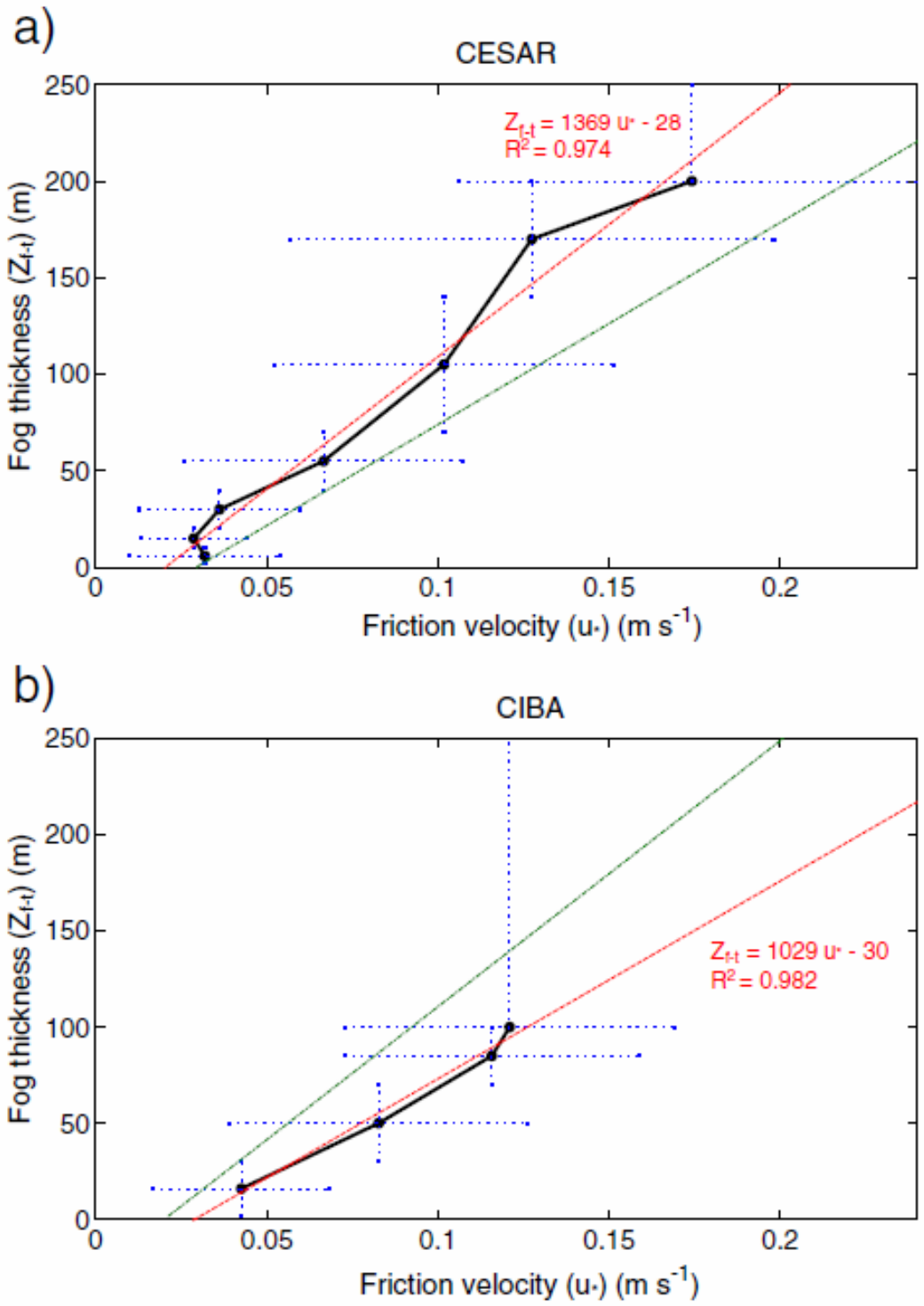


High resolution WRF January 2012 CIBA



Fog thickness

- Essential variable for aviation.
- Can we estimate this based on near surface observations?



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Conclusions

- Fog climatology at CESAR: radiation-fog events evenly distributed throughout the whole year.
- Relatively short living (more than 50% less than 6 hours) and dissipate around sunrise. Fog at CESAR is usually quite shallow and easy to dissipate around sunrise.

- Radiation-fog events at CIBA mainly during late-autumn/winter under persistent anticyclones. The relatively lower humidity at CIBA makes radiation fog forms later in the night in general, after strong nocturnal surface cooling. These radiation-fog events are usually more persistent than at CESAR.

- Evaluation of Menut et al statistical method: thresholds differ per site

- WRF forecasts as input for statistical method: relative poor skill

- Direct model results from high resolution WRF 3D: reasonable forecast of the liquid water content. Surpsiingly the 24-48 forecast range performs better than 0-24 h.

- Fog thickness predictable from surface visibility and friction velocity

Thanks for your attention

References

Román-Cascón, C., G.J. Steeneveld, C. Yagüe, M. Sastre, J.A. Arrillaga, G. Maqueda, 2015: Forecasting radiation fog at climatologically contrasting sites: evaluation of statistical methods and WRF, Q. J. Roy. Meteorol. Soc., in press.

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