MODELING AND FORECASTING THE ONSET AND DURATION OF A SEVERE DUTCH FOG EVENT.

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Societal Impact

USA:

$ 3.5 billion damage

due to delays & crash

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Current Fog Forecast Quality

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

Table 5-5: Verification of deterministic LVP *categories.* LVP-A *or worse*

HR= Hit rate

$$\mathrm{HR} = (42/86) = 0.49$$

$$\mathrm{FAR} = (34/76) = 0.45$$

FAR = False alarm rate

KNMI-TR-222

Kunkel, B.A., B.A. Silverman, and A.I. Weinstein, **1974**: An evaluation of Some Thermal Fog Dispersal Experiments. *J. Appl. Meteor.*, **13**, 666-675.

Gerber, **1981**: Microstructure of radiation fog, *J. Atmos. Sci.*, **38**, 454-458.

Duynkerke, P.G., **1991**: Radiation fog: A comparison of model simulation with detailed observations, *Mon. Wea. Rev.*, **119**, 324-341.

Clark, P.A. and W.P. Hopwood, **2001**: One-dimensional site-specific forecasting of radiation fog. Part I: Model formulation and idealized sensitivity studies, *Meteorol. Appl.*, **8**, 279-286

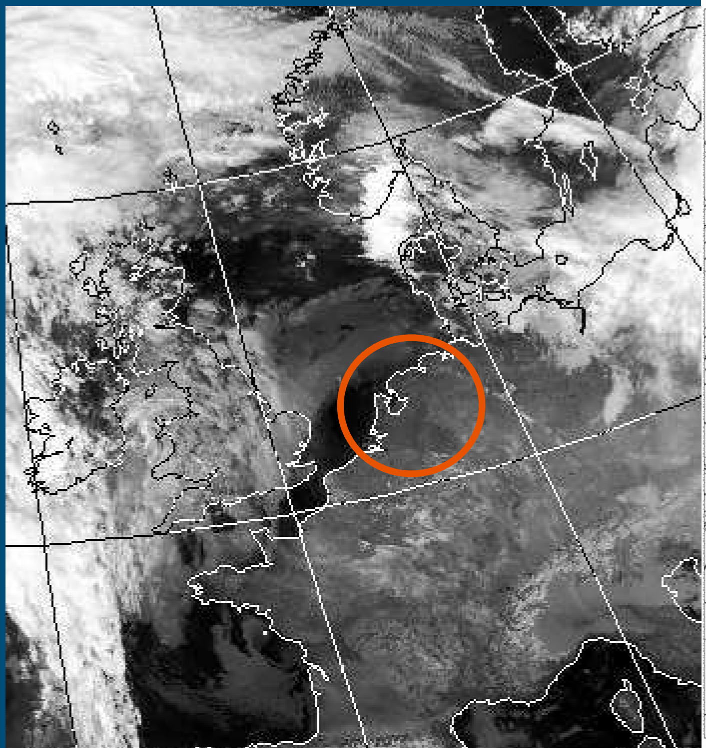
Long lasting problem, room for improvement

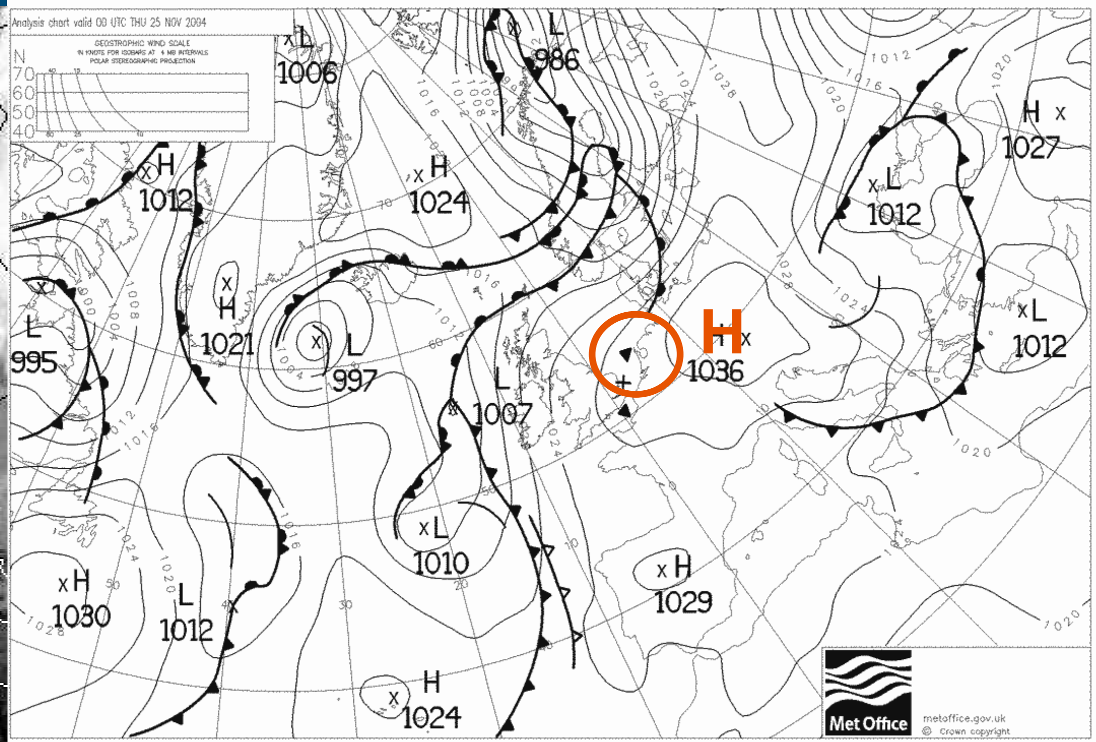
Introduction Case study

Fog event 25 November 2004 starting *early morning*

High pressure system over central Europe. Weak SE wind

Synoptic conditions 25-11-2004; 00.00 UTC





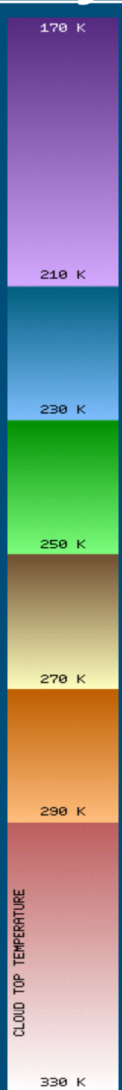
Case analysis and observations

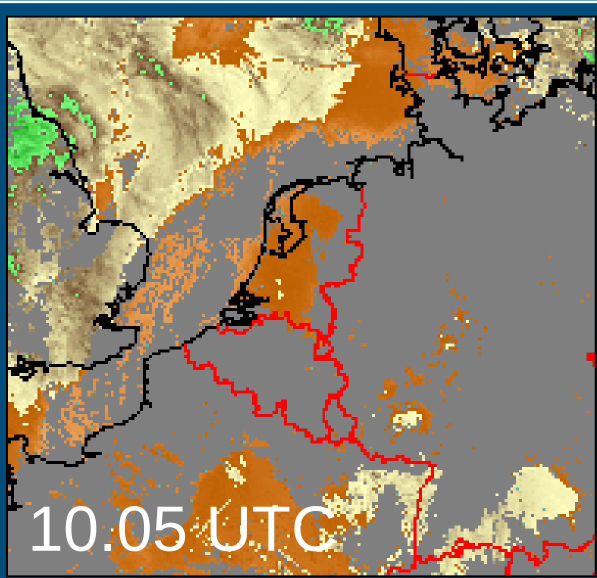
Cloud-top temperature

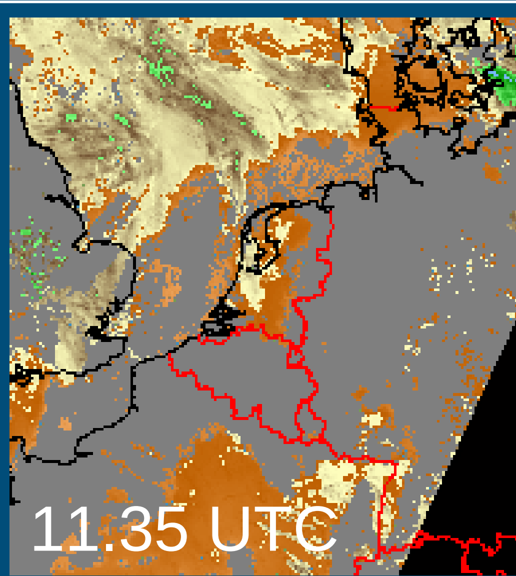
Brown:

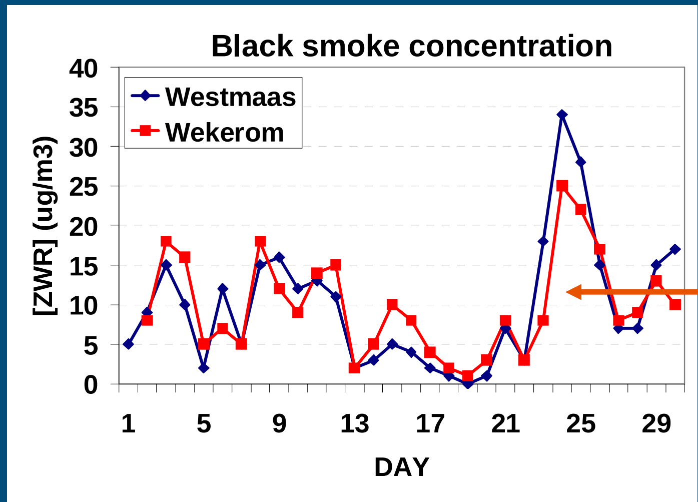
relative warm cloud-tops

=> fog





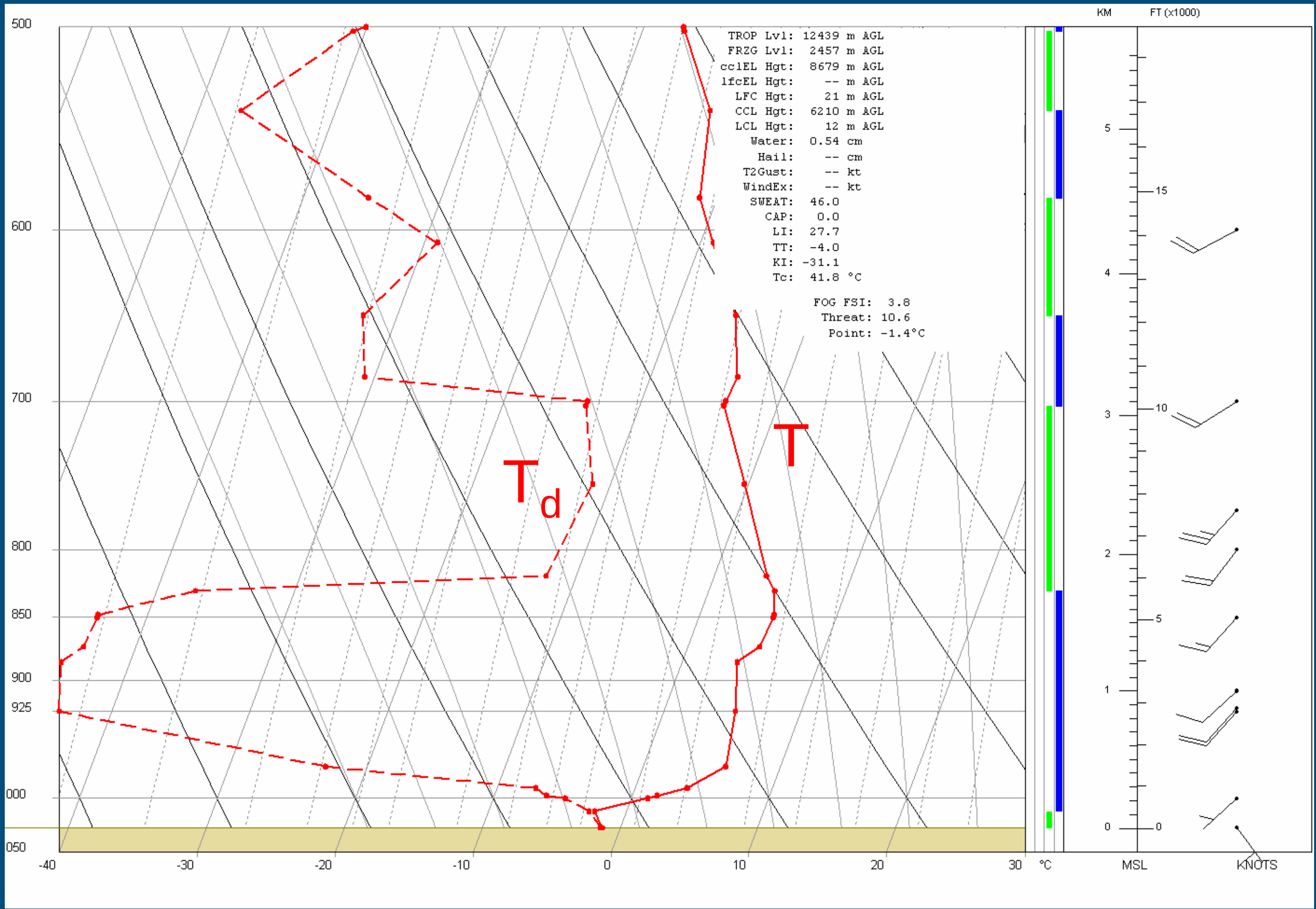




Fog episode

http://www.wdc.dlr.de/apollo/

Special Case: Near freezing point & extremely dry aloft



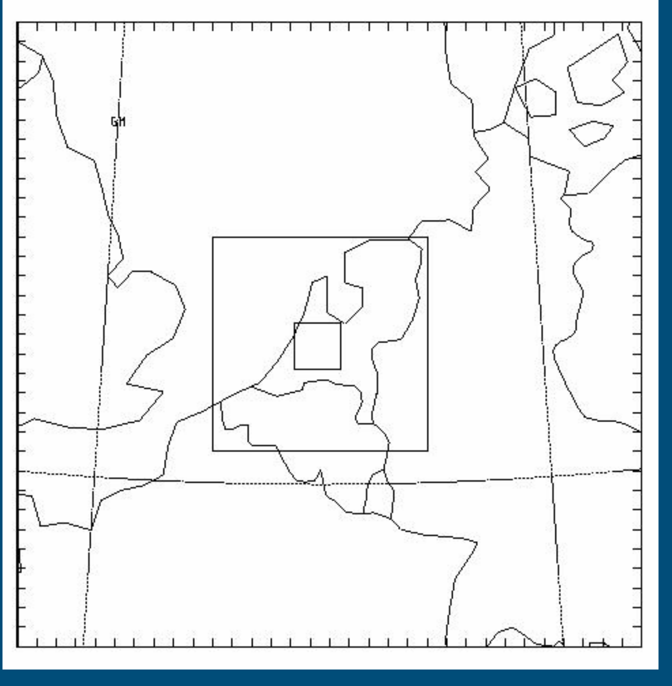
Modelling strategy: 4 different models

- **two limited area models (i.e. regular weather forecast model)**
  - **calculate a regional 3-D forecast**
  - **initialized with data from global models**
  - **in our study: WRF and HIRLAM**

- **two 1-D models**
  - **calculate only the physical processes in vertical column**
  - **are forced by geostrophic wind and horizontal advection**
  - **in our study: 1-D reference model of Duynkerke (1991) and 1-D version of HIRLAM**

WRF (v3) configuration

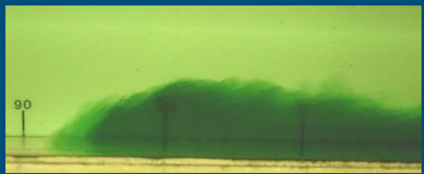
	domain 1	domain 2	domain 3
grid dimensions	30 km 33x33x32	6 km 56x56x32	1.2 km 61x61x32

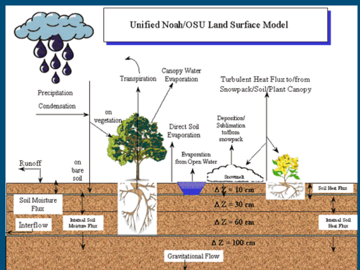


Vert. resolution near the surface

level	height (m)
1	6
2	14
3	18
4	24
5	32
6	41

WRF configuration



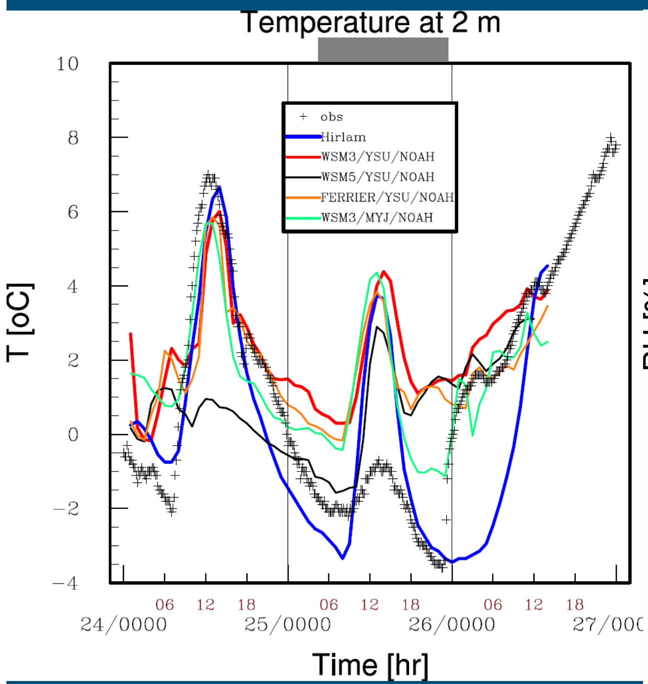


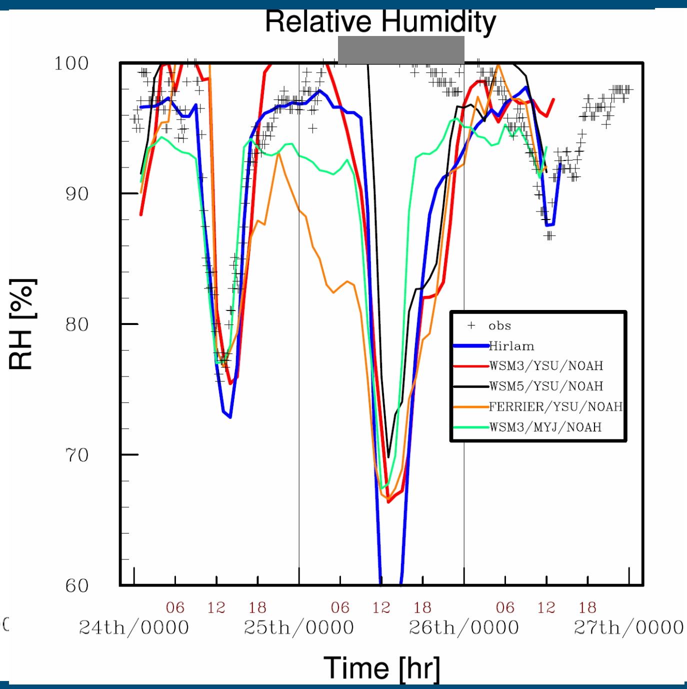
micro-physics	WSM3 *Bulk:* *3 hydro-meteors*	WSM5 *Bulk:* *5 hydro-meteors*	WSM6 *Bulk:* *6 hydro-meteors*	Ferrier *2 moment:* *4 hydro-meteors*
boundary layer	YSU *1st order diffusion*	MYJ *1.5 order TKE-l*		
land surface	5 soil layer *Soil only*	NOAH *Vegetation Soil hydrology*		

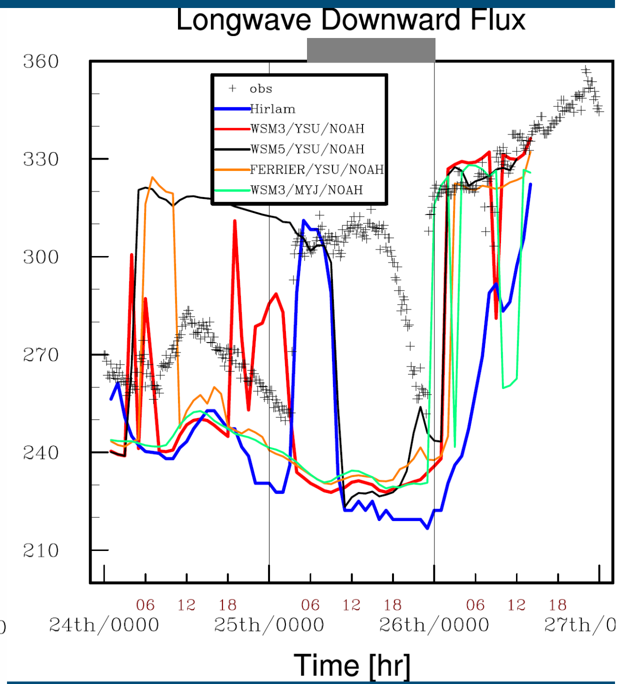
Initial and boundary conditions: NCEP-FNL,

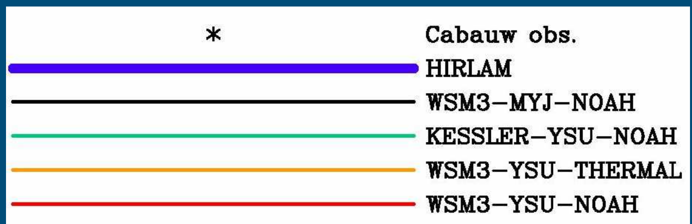
However: same results with ECMWF boundary conditions

WRF results: Cabauw

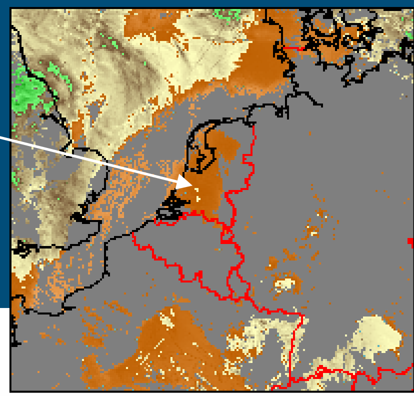




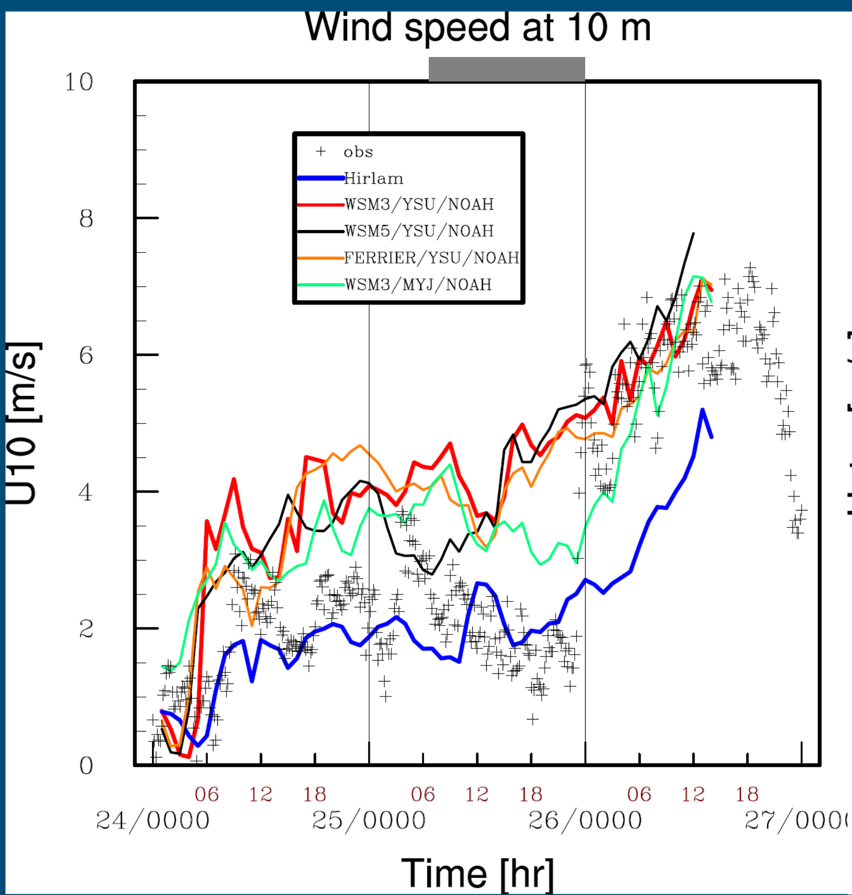


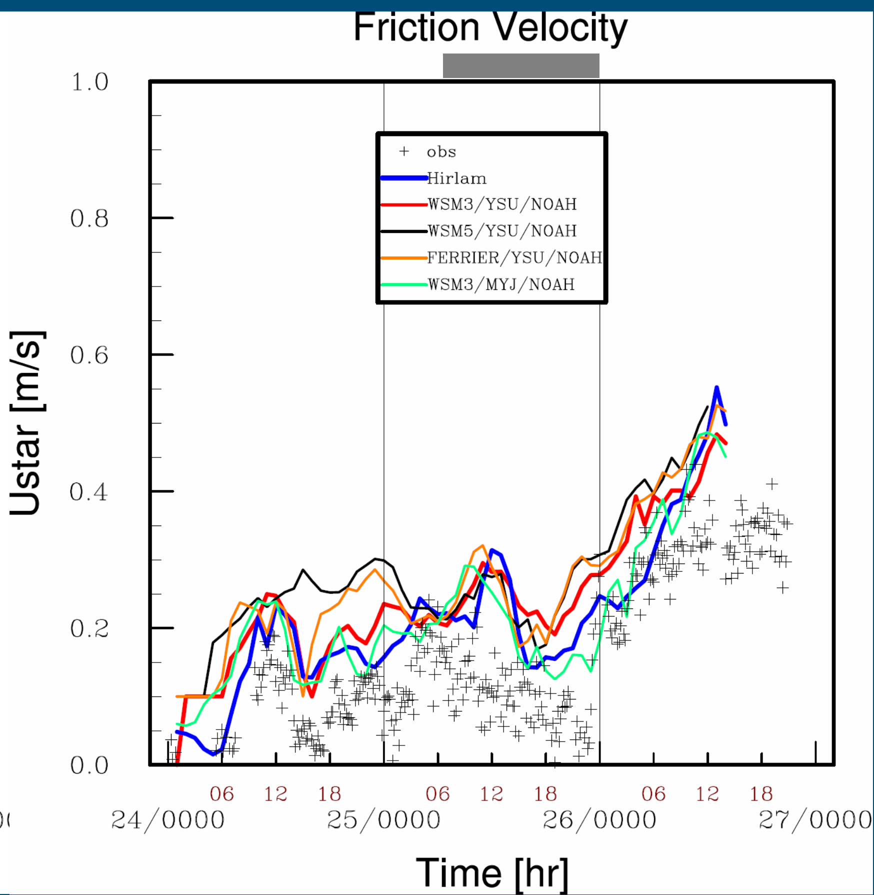


Cabauw

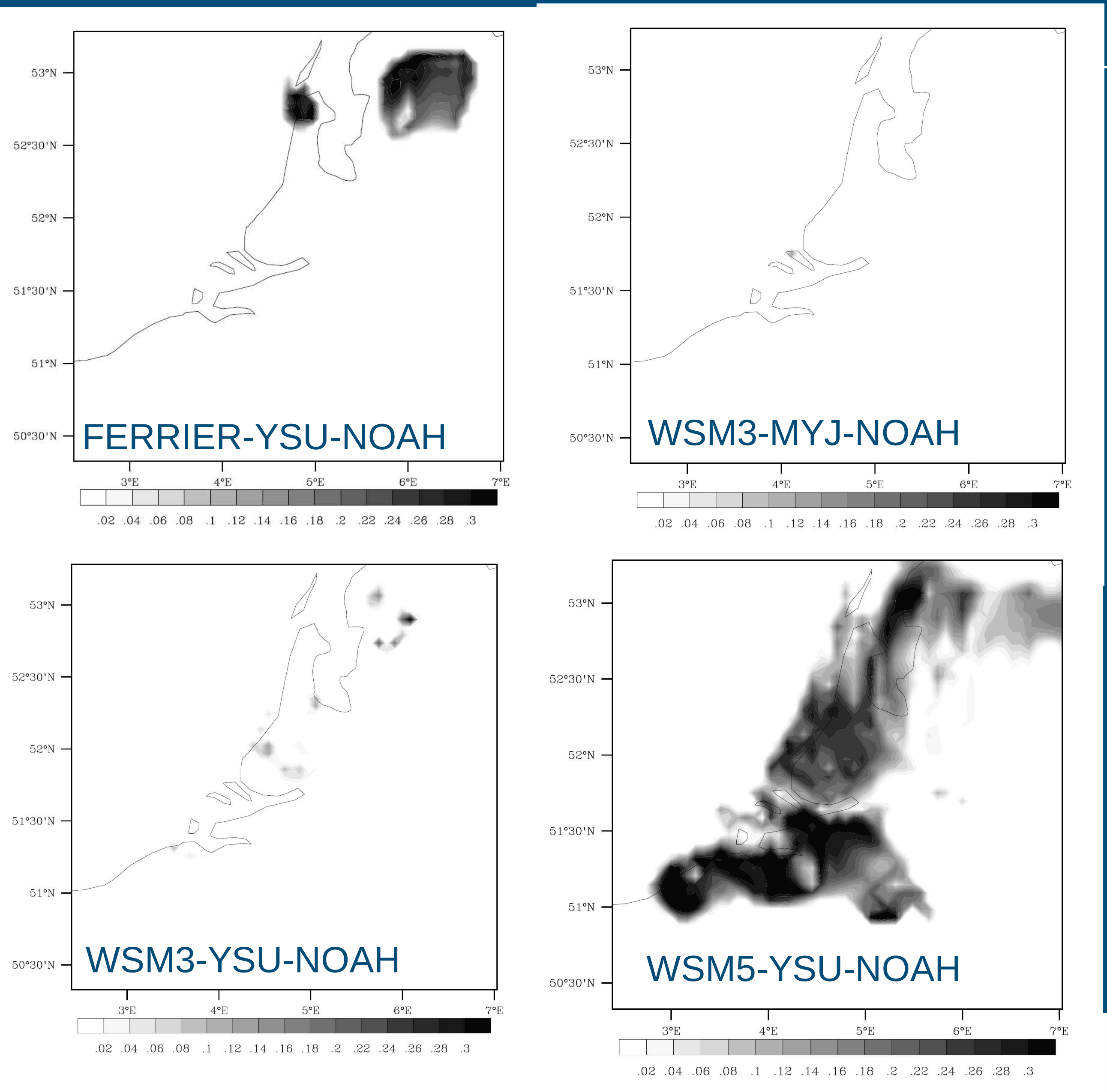


WRF results: Wind and turbulence at Cabauw





WRF results: Liquid Water content: 25 Nov 0000



Note:

In reality fog onset was at ~0300 UTC

Sub-conclusions

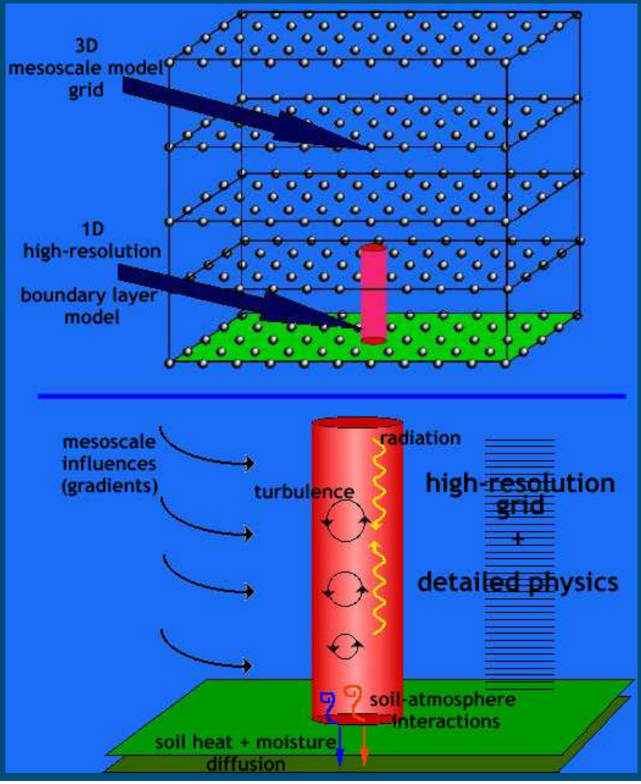
WRF is unable to successfully forecast the severe fog event

HIRLAM is only partly successful fog the severe fog event

…

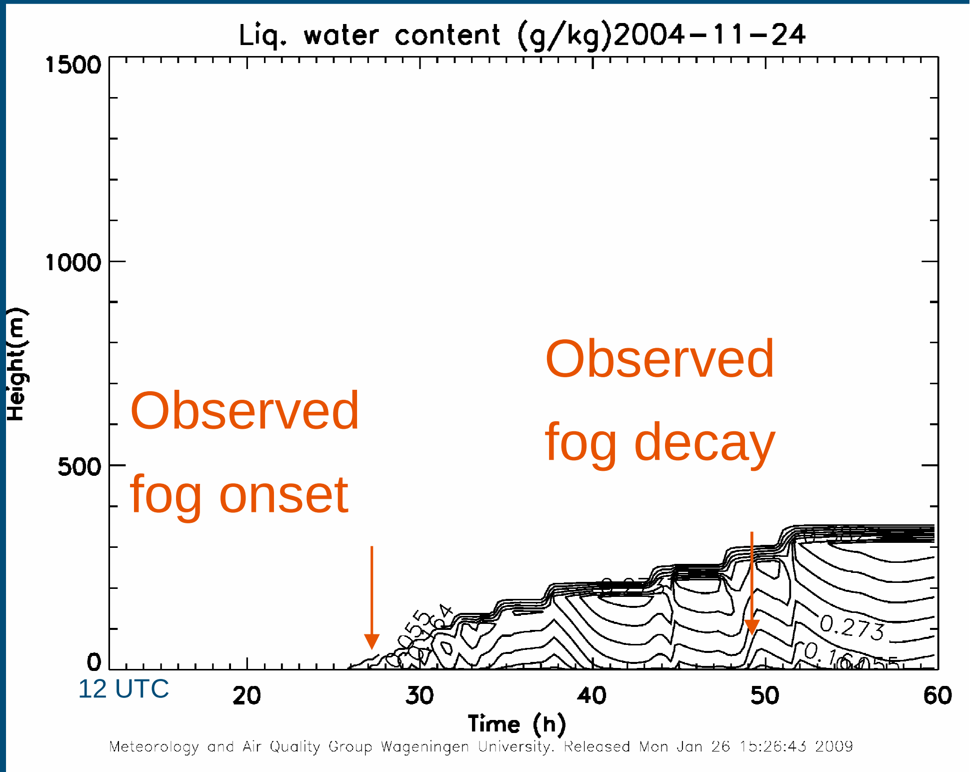
Alternative approach needed:

1D modelling



1-D models: Modeled liquid water content

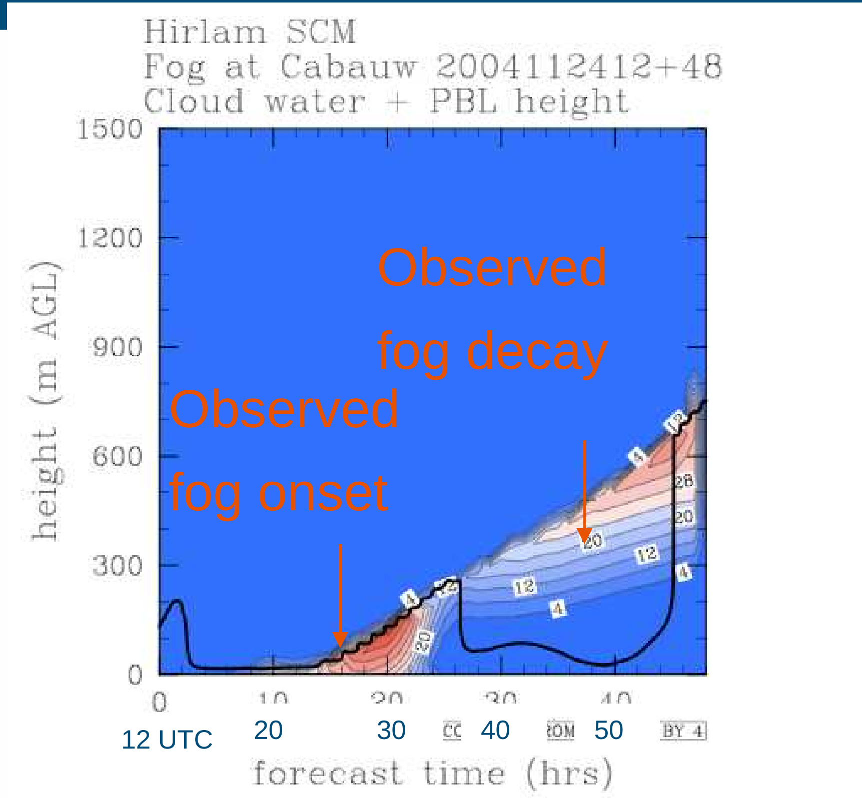
Duynkerke 1991



Fog formation slightly too late

No dissipation

1D HIRLAM



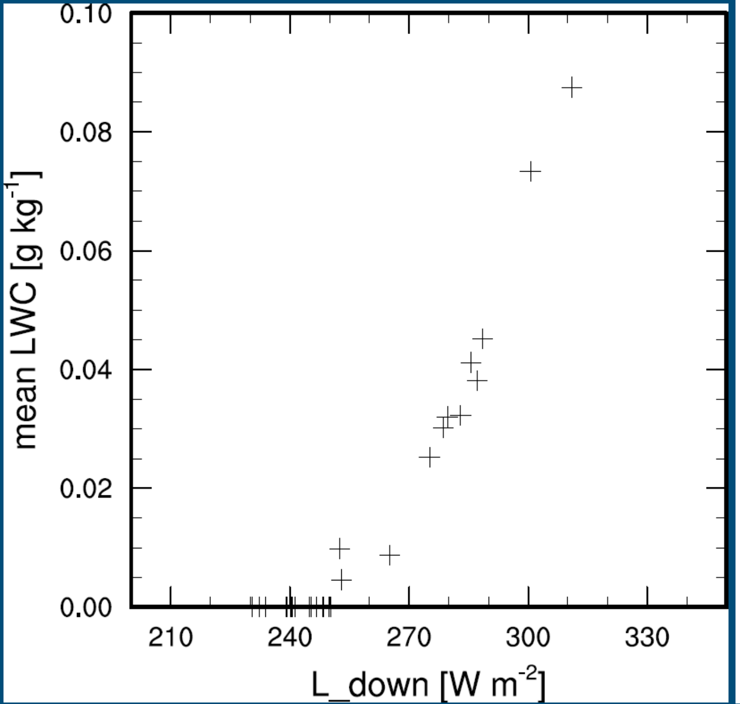
Onset OK,

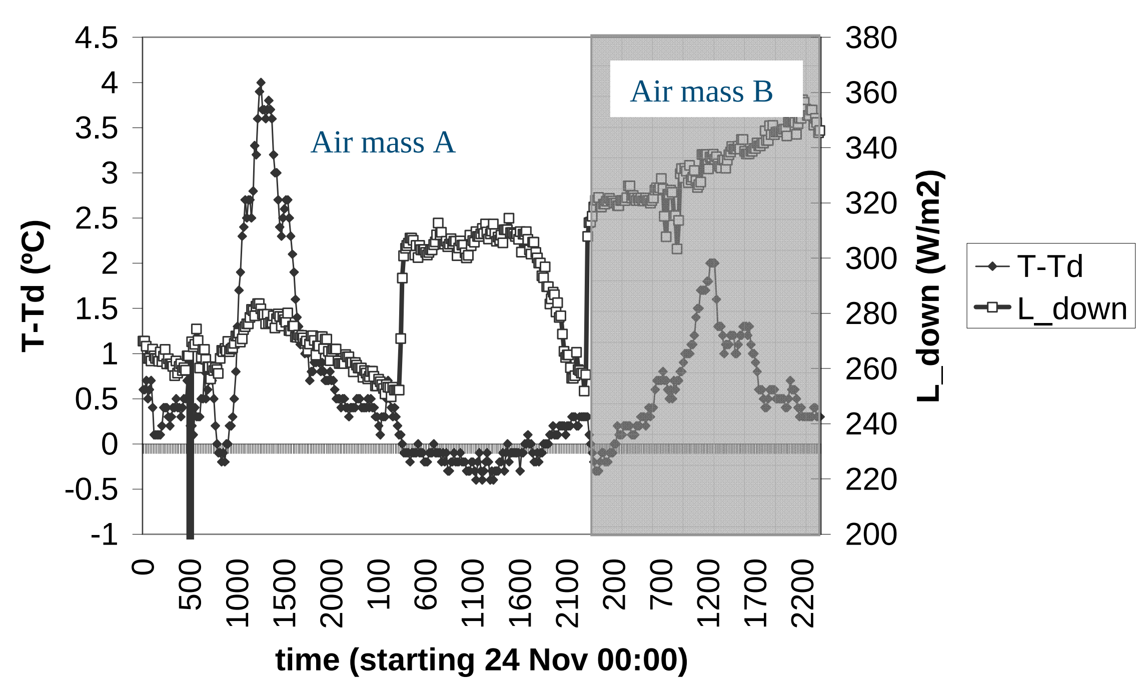
Dissipation too early

Conclusions

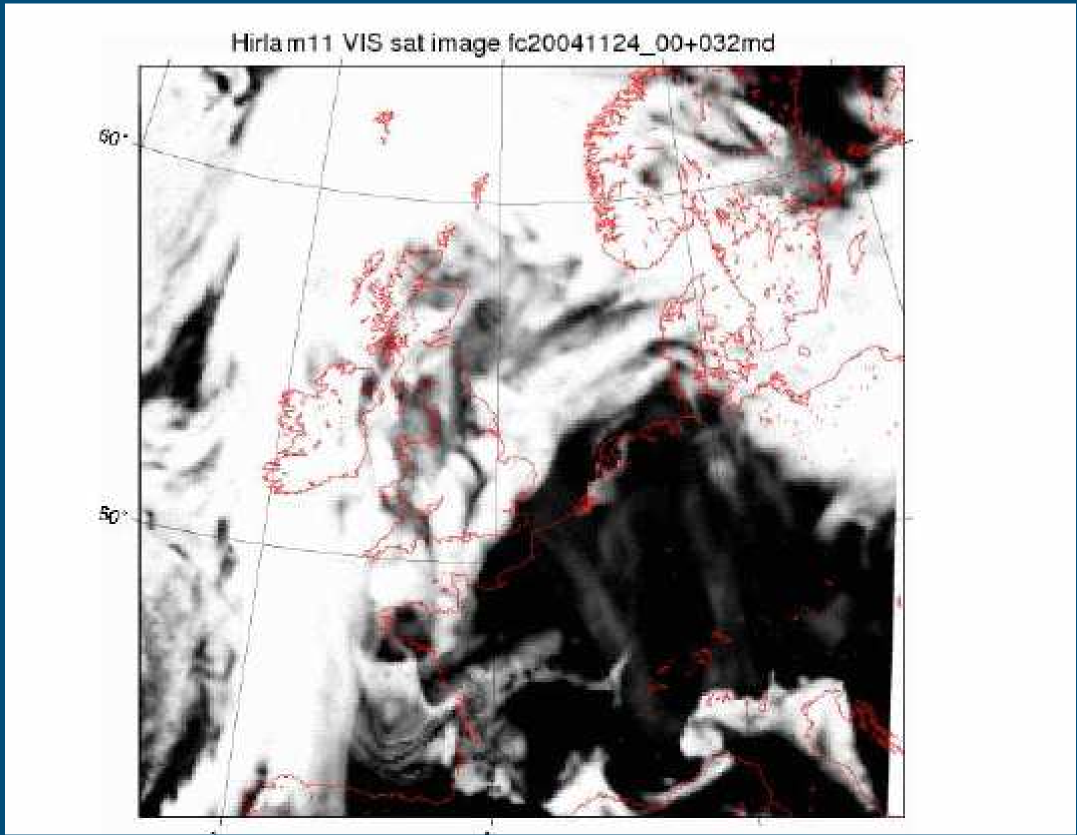
- Fog is a subtile result of a mixture of processes working together
- Current high resolution weather forecast models (WRF + HIRLAM) encounter extreme difficulties in forecasting fog.
- WRF and HIRLAM models can't maintain fog during daylight hours
- Duynkerke 1-D model performs better than 1D HIRLAM; although fog thickness is overestimated.
- More fundamental research on physical processes needed!!

L↓ as fog diagnostic





HIRLAM



D91: impact model resolution

# Layers	Max Liq. Water Content (g/kg)	Fog onset (model start = 12.00 UTC)
40	0.54	28.5
24	0.44	25.8
16	0.45	25.8