The Challenge of Forecasting the Onset and Development of Radiation Fog Using Mesoscale Atmospheric Models

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Background

Fog is a high impact weather phenomenon on the transport sector (Müller et al 2010, Fig. 1), human health, and agriculture. Fog forecasting is challenging since many small scale processes affect the fog life cycle (Van der Velde, 2010; Tudor, 2010, Zhou et al, 2011). We evaluate the WRF and HARMONIE mesoscale models for two contrasting fog episodes in the Netherlands.

Figure 1

Methods

a. Case selection (Fig 2)
Case 1: 5-7 October 2005: Radiation fog
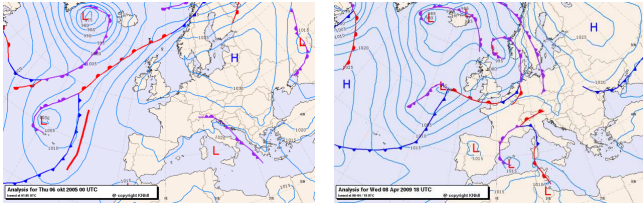Case 2: 8-10 April 2009: Fog behind a cold front

Figure 2

b. WRF Experimental set up

I Role of model domain size and horizontal resolution (YSU & WDM6)
    CONF1: 300 x 300 grids, DX= 2.5 km
    CONF2: 150 x 150 grids, DX= 5 km
    CONF3: 300 x 300 grids, DX= 5 km
II Role of physical parameterization
    PBL: First order YSU model vs 1.5 order MYNN model
    Microphysics: single (WSM3) and double (WSM6) moment schemes
III Role of nesting
    One high resolution domain (CONF2) vs 3 nested domains.
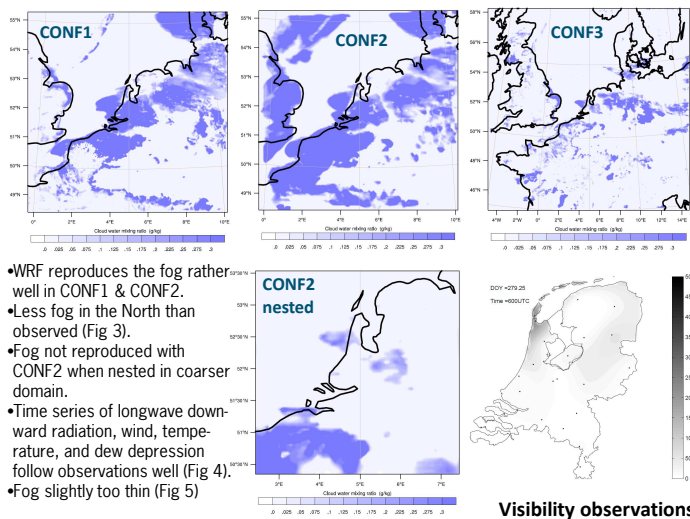
Results 6 Oct 2005 06 UTC

Figure 3

- WRF reproduces the fog rather well in CONF1 & CONF2.
- Less fog in the North than observed (Fig 3).
- Fog not reproduced with CONF2 when nested in coarser domain.
- Time series of longwave downward radiation, wind, temperature, and dew depression follow observations well (Fig 4).
- Fog slightly too thin (Fig 5)

Visibility observations

Results 6 Oct 2005: Time series and profiles at Cabauw
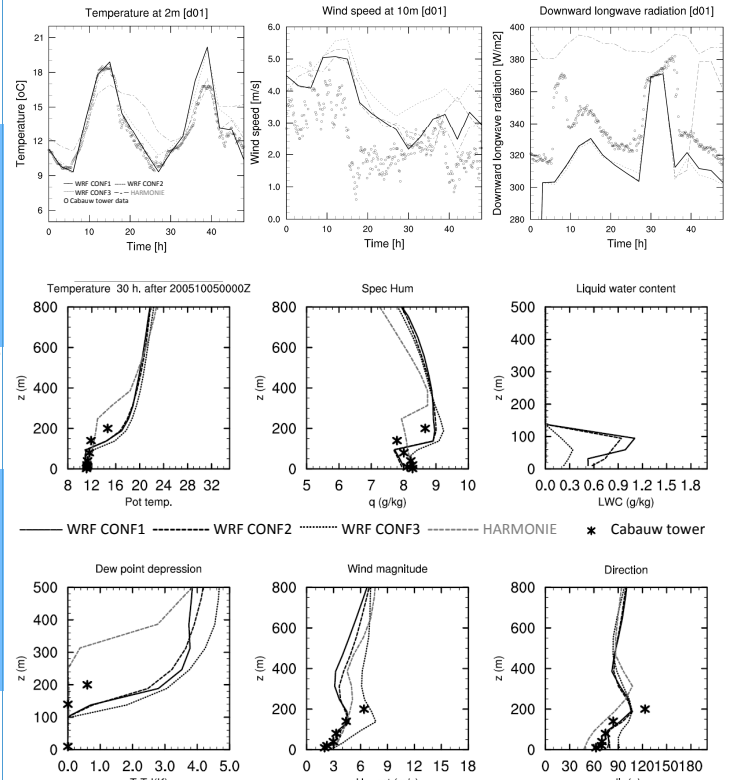

Figure 4

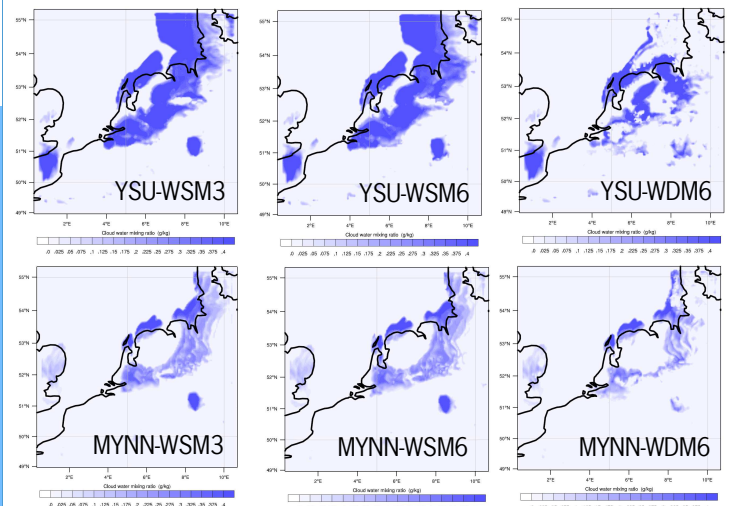**Figure 5**

Results 9 April 2009 06 UTC

Figure 6

Figure 7

- For this case the WRF model forecasts fog spatially more wide than observed.
- The forecasted liquid water content is larger with the YSU than with the MYNN boundary layer scheme (Fig 6 and Fig 7)
- The forecasted fog dissipates earlier with WDM6 than with the WSM family

Conclusions

- WRF reproduces radiation fog accurately; HARMONIE develops a stratus lowering fog
- Model performance can depend strongly on model domain settings.
- Nested domains deteriorate the fog forecast substantially.
- Minor differences between 2.5 km and 5 km hor. resolution

References

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Tudor, M., 2010: Impact of horizontal diffusion, radiation and cloudiness parameterization schemes on fog forecasting in valleys, Met. Atm. Phys., 108, 57-70.
van der Velde, I. R., G. J. Steeneveld, B. G. J. Wichers Schreur, A. A. M. Holtslag, 2010: Modeling and Forecasting the Onset and Duration of Severe Radiation Fog under Frost Conditions. Mon. Wea. Rev., 138, 4237–4253.
Zhou, B., J. Du, I. Gultepe, G. Dimego, 2011: Forecast of Low Visibility and Fog from NCEP: Current Status and Efforts, Pure Appl. Geophys, 169, 895-909.

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Acknowledgements

Further reading
Steeneveld, G.J., R.J. Ronda, and A.A.M. Holtslag, 2015: The challenge of forecasting the onset and development of radiation fog using mesoscale atmospheric models. Bound.-Layer Meteorol., 154, 265-289.