Importance of a good model initialisation

Demonstrated with WRF-ARW*

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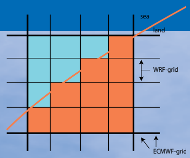
Meteo Consult proposes three ways to optimise WRF initialisation. A proper initialisation of a mesoscale model is crucial for a good forecast. A sub-optimal initialisation can cause significant errors and therefore deteriorate the mesoscale forecast. Meteo Consult has experience with MM5 and is currently exploring the possibilities of the WRF model. The ECMWF model is used as global model for initialisation of both MM5 and WRF. ECMWF provides quite satisfactory data but nevertheless the standard initialisation had some shortcomings. At first, sea surface temperatures can be corrupt because of difference in land/sea mask between ECMWF and the mesoscale model. Second, soil moisture content is not available in ECMWF. Third, the lack of available pressure levels causes a loss of input data.
In order to improve the initialisation of the WRF model, the following changes have been made.

1 Adaptation of the sea surface temperature.
2 Soil moisture content is improved by using GFS data.
3 Introduce ECMWF sigma levels instead of pressure levels.

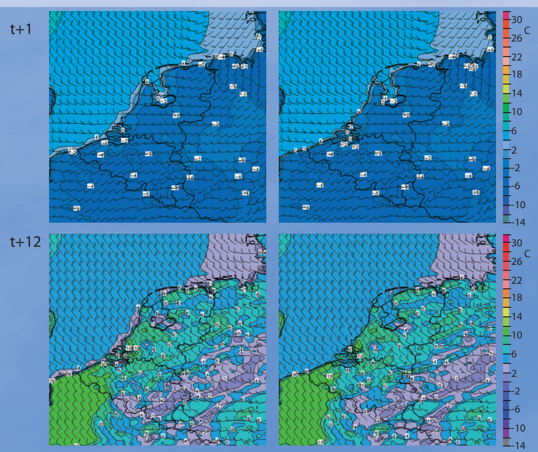
Results of those modifications will be discussed in more detail in sections 1, 2 and 3 below. Current work of Meteo Consult is described in the 4th section. All simulations are done with WRF-ARW version 2.2. The parameterisation schemes used are listed in Table 1 option K. The grid size (Δx) is equal to 18 km (section 2 and 3) or 9 km (section 1).

1 Sea surface temperature (SST)



- Problem: Incorrect SST's near the coast.
- Reason: Difference in land mask between ECMWF and WRF → WRF ***sea*** points get a ***land*** temperature of ECMWF → incorrect SST initialisation.
  SST remains constant during run → large errors near coast.
- Solution: Algorithm that compares the SST of each coastal grid point with the average SST of the surrounding sea grid points. If the difference exceeds a certain threshold → replace SST by average SST for this grid point.
- Effect: In the case below cold coastal spots at t+12 disappear after correction. This is shown by the skin temperature (TSK).

TSK without correction **TSK with correction**

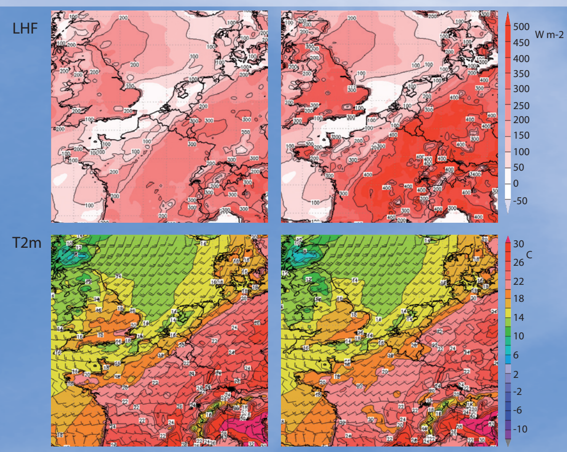


initialisation time 2006030600

2 Soil information from GFS

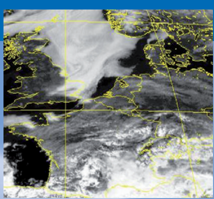
- Problem: WRF produces unrealistic surface fluxes.
- Reason: No soil moisture and only 1 soil temperature in initialisation data from ECMWF → WRF has no actual soil information and uses default values.
- Solution: Besides ECMWF data, add GFS soil moisture and temperature data at 4 layers (0-10, 10-40, 40-100, 100-200 cm depth).
- Effect: More realistic values of latent heat flux (LHF) and 2m temperature (T2m). In the case below: LHF increased and T2m decreased.

without GFS **with GFS**



initialisation time 2006062100, t+12

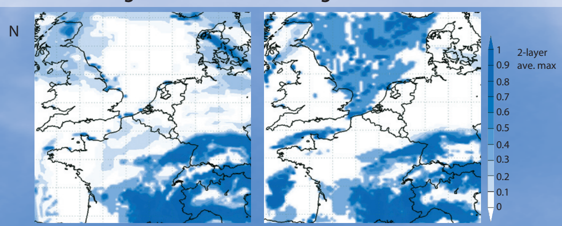
3 Sigma level initialisation



VIS 20070503, 12 UTC

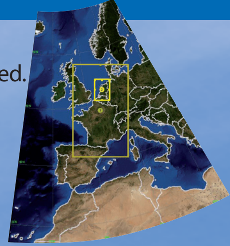
- Problem: Difficulties with shallow cloud layers.
- Reason: Only few ECMWF pressure levels available in lower atmosphere (1000, 925, 850 and 700 hPa) for initialisation.
- Solution: Introduce a selection of ECMWF sigma levels in the initialisation of WRF. Now 14 instead of 4 levels are available between 1000 and 700 hPa.
- Effect: Shallow clouds visible. See pictures below of the cloudiness (N).

without sigmalevels **with sigmalevels**



initialisation time 2007050300, t+12

4 Current work



- To optimise the model settings for Western Europe, all configurations in Table 1 will be tested.
- Period: 20 summer and 20 winter cases (all independent).
- D1: 119x195 points, Δx=9 km.
- D2: 97x127 points, Δx=3 km (no cumulus parameterisation).
- WRF-ARW will be statistically compared to observations, global models and other mesoscale models.

Table1: Different combinations of parameterisation schemes for WRF-ARW

Option	Microphysics	Planetary Boundary Layer	Land-Surface model	Surface Layer	Cumulus	Long wave	Short wave
A	WSM6	MYJ	Noah	MOJ	Grell-Devenyi	RRTM	Dudhia
B	WSM6	MYJ	Noah	MOJ	Grell-Devenyi	CAM	CAM
C	WSM6	MYJ	Noah	MOJ	Grell-Devenyi	RRTM	Goddard
D	WSM6	YSU	Noah	MO	Grell-Devenyi	RRTM	Dudhia
E	WSM6	YSU	Noah	MO	Grell-Devenyi	CAM	CAM
F	WSM6	YSU	Noah	MO	Grell-Devenyi	RRTM	Goddard
G	Thompson	MYJ	Noah	MOJ	Grell-Devenyi	RRTM	Dudhia
H	Thompson	MYJ	Noah	MOJ	Grell-Devenyi	CAM	CAM
I	Thompson	MYJ	Noah	MOJ	Grell-Devenyi	RRTM	Goddard
J	Thompson	YSU	Noah	MO	Grell-Devenyi	RRTM	Dudhia
K	Thompson	YSU	Noah	MO	Grell-Devenyi	CAM	CAM
L	Thompson	YSU	Noah	MO	Grell-Devenyi	RRTM	Goddard

Conclusion

A good and complete model initialisation is crucial for an accurate mesoscale forecast. Three points are presented to improve WRF initialisation:
1) An algorithm to avoid errors in SST due to a different land mask of the global and mesoscale model.
2) Adding GFS soil parameters to obtain more realistic values for surface fluxes.
3) Use ECMWF sigma levels (14) instead of only pressure levels (4) in the lower atmosphere.

References:
*WRF, www.mmm.ucar.edu/wrf/users/, 2007: WRF Users Page
[1] Meteo Consult, Wageningen, The Netherlands