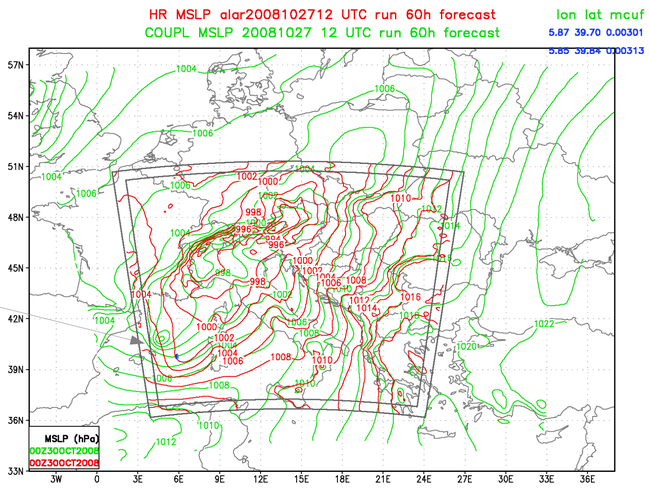
Frequency of rapid changes in surface pressure over Mediterranean

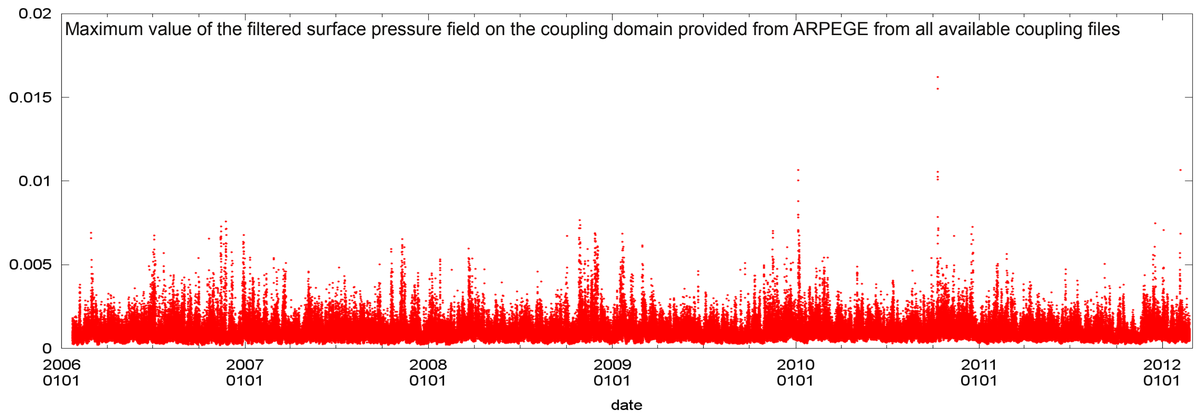
Introduction

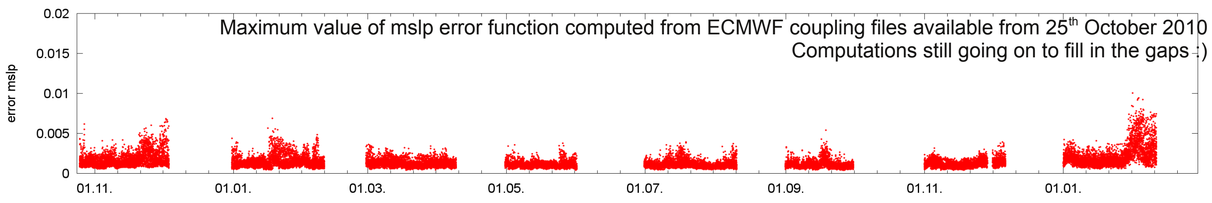
Operational lateral boundary conditions (LBC) data are provided to limited area model (LAM) with time interval of 3h. These data are used at lateral bounadies of the LAM domain every LAM timestep of several minutes. Consequently, LBC data of the large scale model are (linearly) interpolated in time. The interpolation procedure distorts the model fields and can lead to LAM forecast failures in case of fast propagating storms.

The lateral boundary conditions from the global NWP models ARPEGE (run in Meteo France) and IFS (ECMWF) are provided with a 3 hour interval. These are used by the 8km resolution operational model as the lateral boundary conditions in the 8 gridpoints on lateral boundaries by means of Davies coupling scheme and linear interpolation in time. An atmospheric disturbance can enter the domain unnoticed by the coupling scheme. The figure shows mean sea level pressure from the ARPEGE forecast (as provided in the coupling file) and mean sea level pressure from the ALADIN 8km forecast scoupled to it.

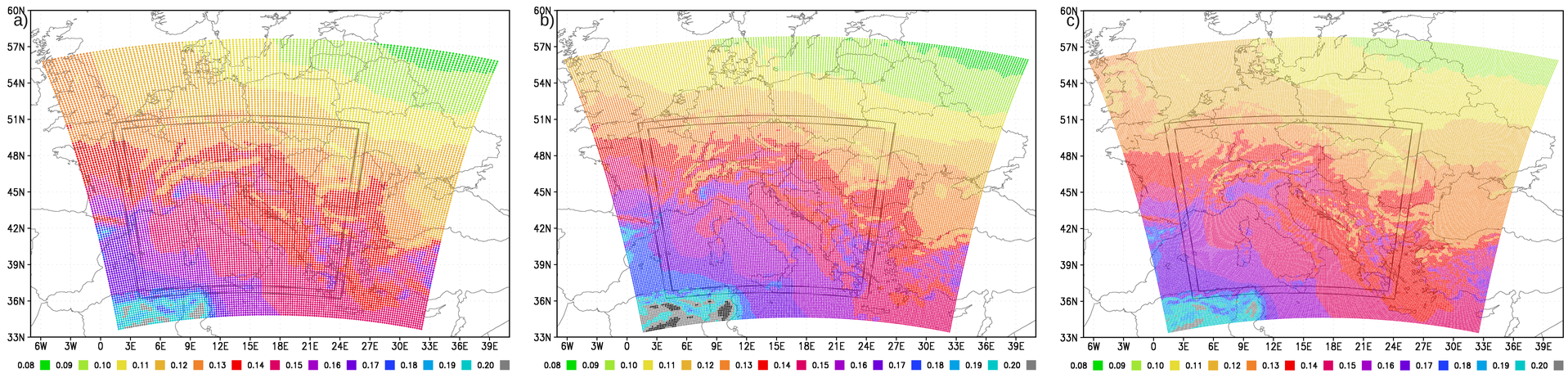


In order to monitor the occurrence of potential LAM forecast failures due to inadequate coupling update frequency, a recursive high-pass filter has been implemented to the ARPEGE model and applied to the surface pressure field. Large values the filtered surface pressure field indicate a rapidly moving disturbance in the surface pressure through that model grid point. This field is provided in the coupling files since 06 UTC run on 23rd January 2006 for the common coupling domain used in 6 countries for lateral boundary conditions (LBCs).

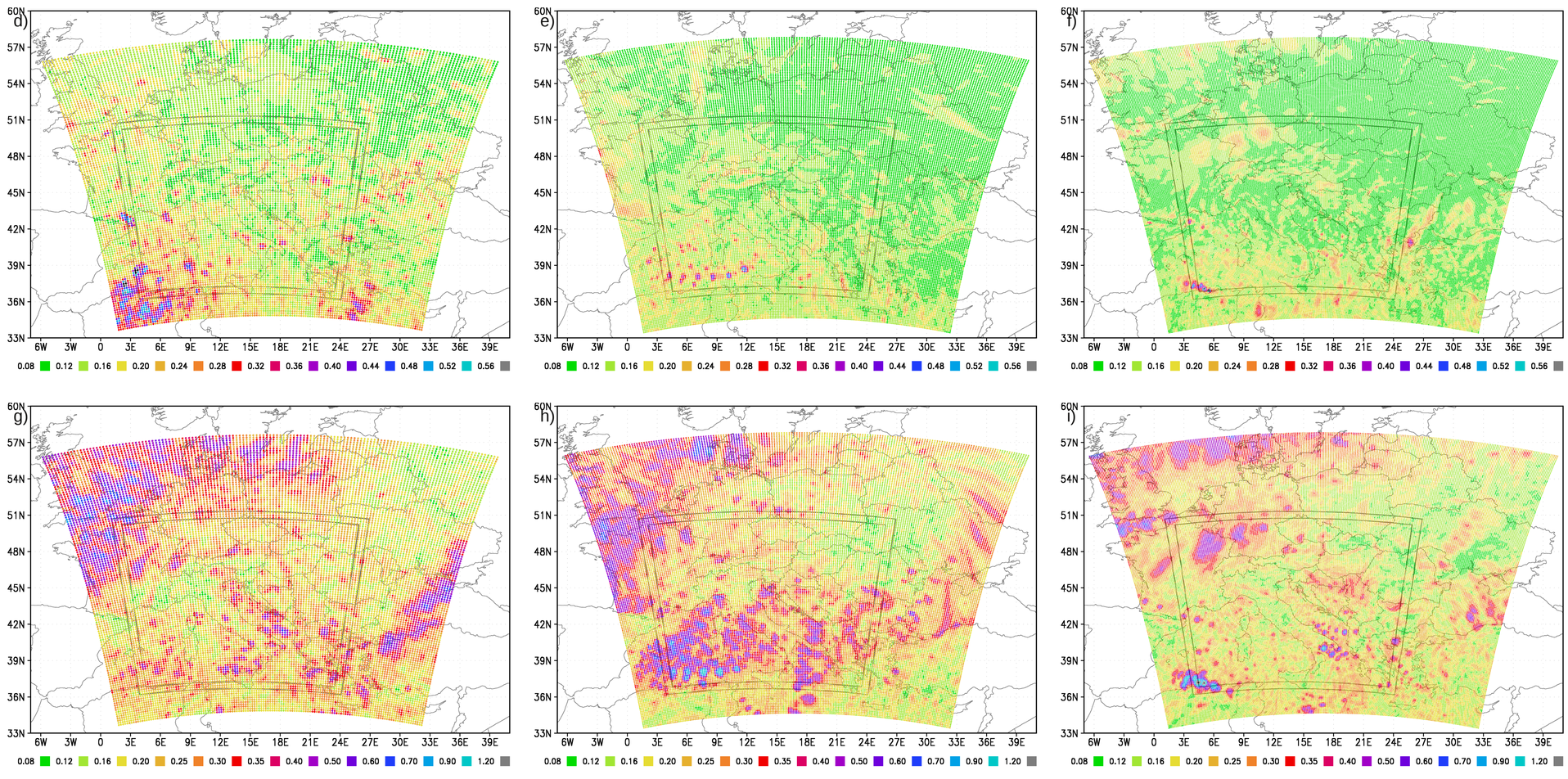




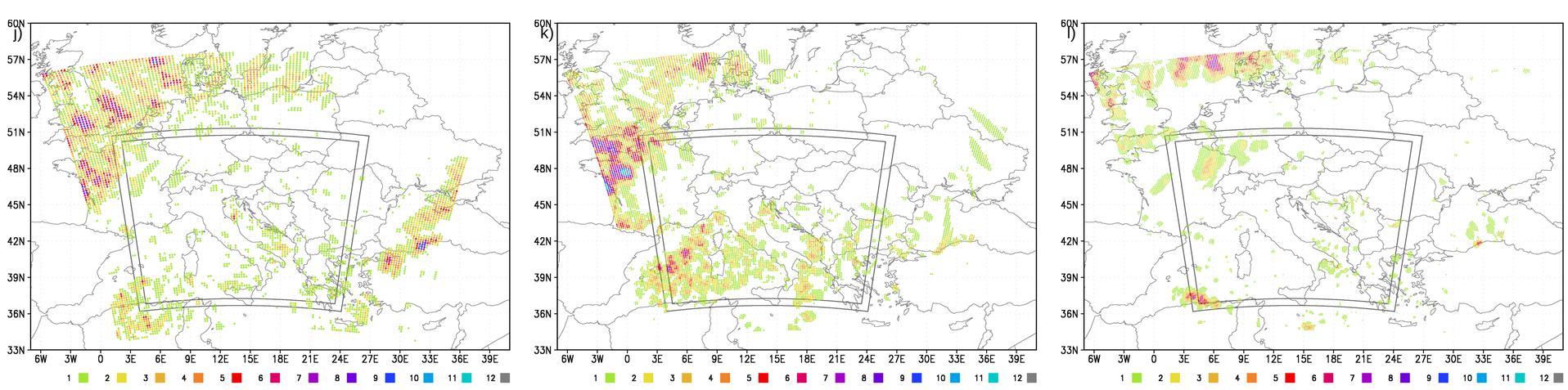
Average filtered surface pressure field (*10^3) for different resolutions of the coupling files (and ARPEGE):
(a) 20.678 km averaged for the period 23rd Jan 2006 to 6th Feb 2008.
(b) 15.4 km averaged for the period 6th Feb 2008 to 11th May 2010.
(c) 10.51 km averaged for the period 11th May 2010 to 21st Mar 2012.
The spatial distribution can be viewed as a map of the storm tracks and areas that support rapid developments in surface pressure.



Maps of maximum (d,e,f) and minimum (g,h,i) values of the filtered surface pressure field show areas of the most rapidly moving storms. The figures represent data from same resolution and period as above. Western Mediterranean is an area with strong rapidly propagating storms. Values are computed for the 3 hourly coupling period, but they are so much larger than the treshold value of 0.003, that even a hourly coupling could miss the storm propagating thorugh the lateral boundary. The problem is only made worse in higher resolution LAM. The coupling zone on the lateral boundaries is 8 grid points wide and shrinks with the resolution increase. The storm needs less time to cross the narrow coupling zone.



Maps with number of occurences when the filtered pressure field is larger than the 0.003 threshold (l,j,k). There are not to many places where to put the coupling zone in order to avoid LAM forecast failure.There are changes from one season to another (more ot less 'stormy'), but there is no apparent increase in the number of fast propagating storm with an increase of the ARPEGE resolution (at least in the range available for study).

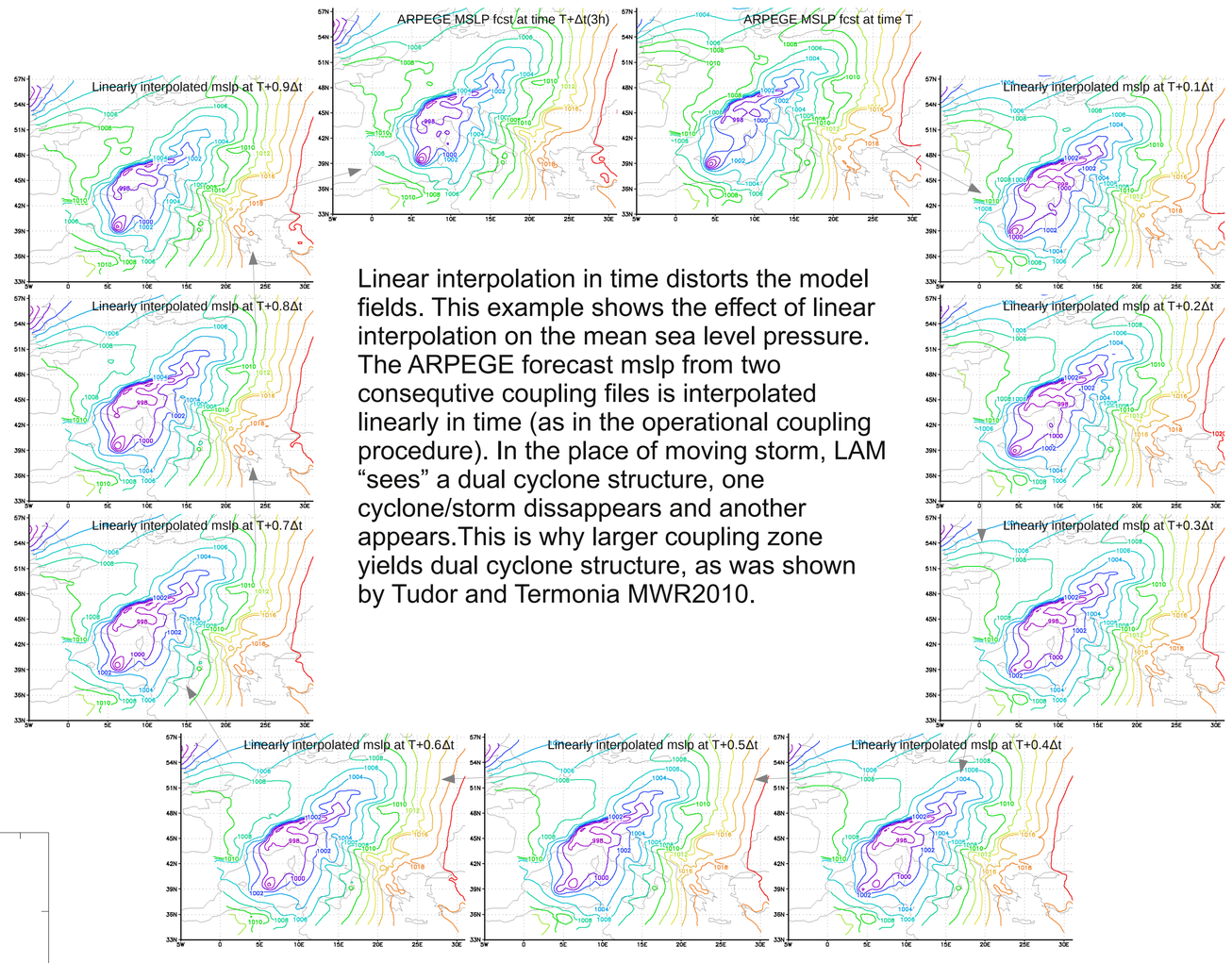


Conclusion

Western Mediterranean is an area where storms frequently propagate with high velocities and can not be resolved in LBCs of a 8 km resolution LAM when provided with 3 hour interval.

In LAM with roughly 3 times larger horizontal resolution, even 1 hour coupling interval would be insufficient.

The effect of linear interpolation illustrated on the example of mean sea level pressure



Linear interpolation in time distorts the model fields. This example shows the effect of linear interpolation on the mean sea level pressure. The ARPEGE forecast mslp from two consequtive coupling files is interpolated linearly in time (as in the operational coupling procedure). In the place of moving storm, LAM “sees” a dual cyclone structure, one cyclone/storm dissappears and another appears.This is why larger coupling zone yields dual cyclone structure, as was shown by Tudor and Termonia MWR2010.

Filtered surface pressure field from ARPEGE

When the filtered surface pressure field is larger than a threshold value 0.003, there is a storm rapidly propagating through the area. If the point with the large value is inside the coupling zone of a LAM, it can be expected that the LAM forecast will miss the storm due to time interpolation of boundary data.

The analysis of the MCUF field from ARPEGE coupling files for the common LACE coupling domain shows that this field is above the threshold far more frequently than acceptable. The maximum value of the MCUF field has been extracted from each coupling file available, for 4 runs per day (starting from 00, 06, 12 and 18 UTC analyses) and extending up to 72 hour forecast with 3 hour interval (60 hours for the 18 UTC run).

Error function values using mean sea level pressure from ECMWF coupling files

The filtered surface pressure field is not availavle in the coupling files provided by ECMWF. This is why an error function of surface pressure and mean sea level pressure was computed for each coupling file. Preliminary results show several episodes with high values, especially in February 2012.