Evaluating the model forecasts of plume evolution in BORTAS

Stephan **Matthiesen**, Paul I. **Palmer**, and Mark **Parrington**
School of GeoSciences, The University of Edinburgh, Edinburgh, Scotland (Stephan.Matthiesen@ed.ac.uk)

Executive Summary

We developed a novel forecast quality measure designed to reflect the 3-dimensional structure of biomass burning plumes. It calculates the 3-dimensional displacement that is needed to transform the forecast field into the observed field. This forms the basis for a quantitative **Local Forecast Quality Measure (LFQM)**. It has separate components for the amplitude error, the horizontal and the vertical displacement errors.
The method is used it to evaluate the quality of the plume forecasts that were produced during the BORTAS project.

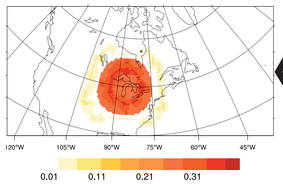
Method - the LFQM

The LFQM is based on the displacement that is needed to transform the forecast field into the target (observed) field. This method extends existing 2-dimensional displacement-based methods (Zinner et al. 2008).

Pyramidal matching and displacement calculation:
A weighted neighbourhood of each pixel of the forecast image is shifted in all directions until the best fit with the target image is found. For efficiency, a pyramidal scheme is used, starting with subsampled images at low resolution, then going stepwise to full resolution. This produces:
- a 3-d vector field of the displacement
- a warped forecast (applying the displacement to the original forecast)

Displacement errors: Magnitude of the displacement (vertical&horizontal)
Amplitude error: RMS error between the warped forecast and the target
Local Forecast Quality Measure (LFQM): The (weighted) sum of the displacment and the amplitude errors, where d_h, d_v and I_0 represent typical magnitudes (here: d_h=16 gridpoints, d_v=8 gridpoints, I_0=50 ppbv):

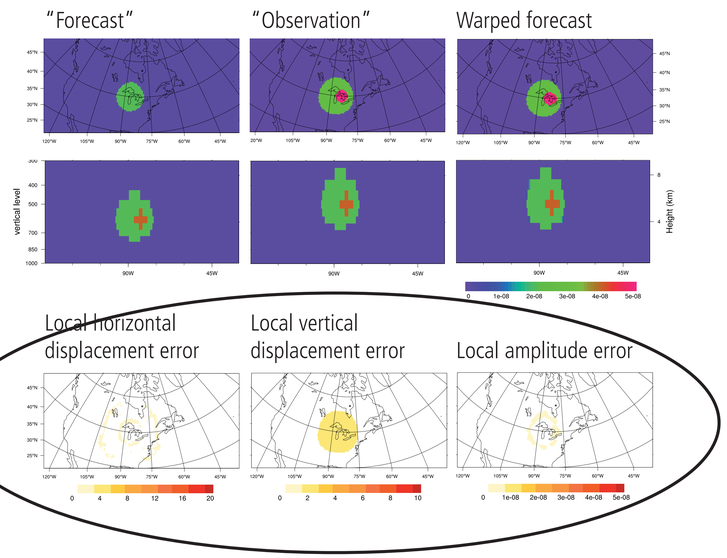
LFQM = DISh/dh + DISv/dv + AMP/I0

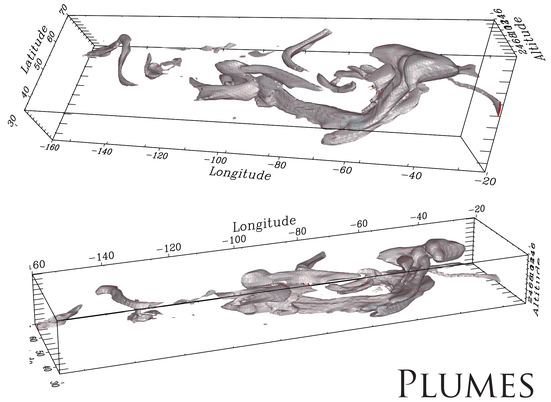


Local Forecast Quality Measure

Testing the LFQM

Does this LFQM represent useful error information? Simple geometric artificial test plumes were used to test the method. Here, the "forecast plume" is 2 levels too low. As expected, the vertical displacement error dominates the LFQM, whereas the horizontal displacement error and the amplitude error only show small computational noise due to the warping algorithm.



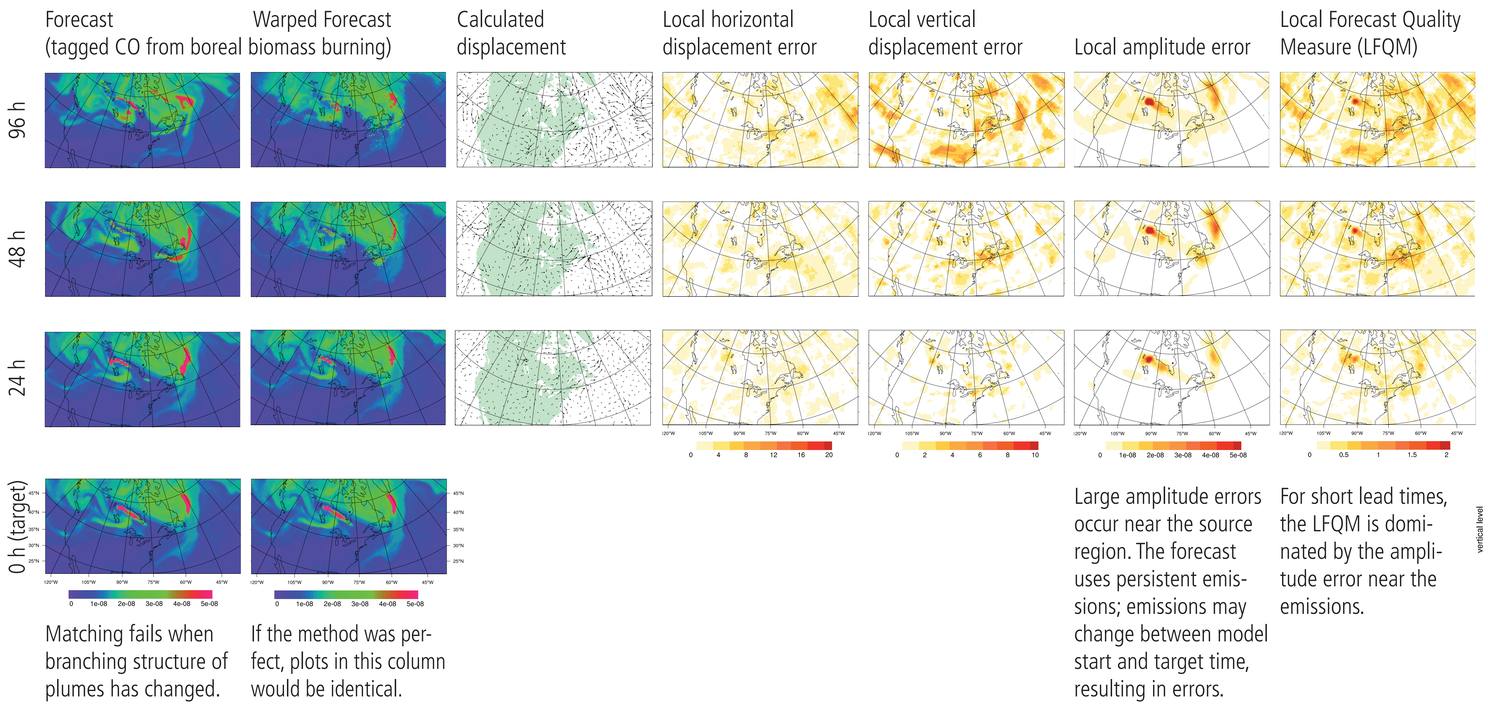


Plumes in 3 dimensions

Biomass burning plumes have complicated 3-dimensional, filamentary structures. These plots show the 25 ppbv isosurface of CO from boreal biomass burning on 21 July 2011 over the North American/North Atlantic region.

Forecast Quality for increasing lead times

Forecasts for the same target time (21 July 2011), but with different lead times, are analysed. They were produced operationally during the BORTAS intense campaign (July 2011), using the NASA GEOS-5 model with FLAMBE emission data. The forecast plots show mixing ratio of tagged CO from boreal biomass burning.



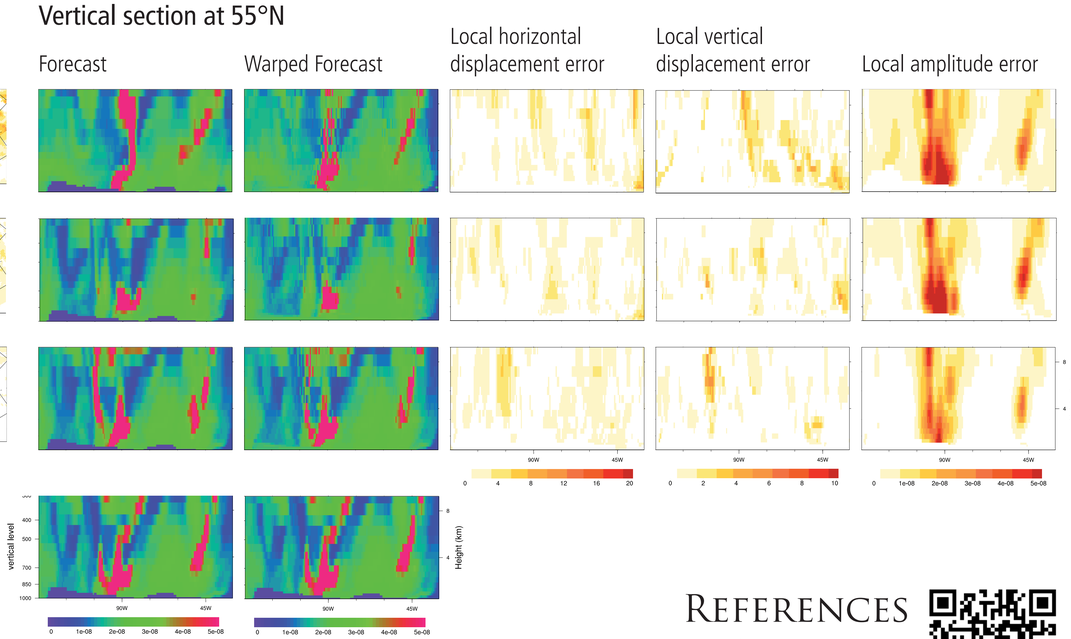
Matching fails when branching structure of plumes has changed.

If the method was perfect, plots in this column would be identical.

Large amplitude errors occur near the source region. The forecast uses persistent emissions; emissions may change between model start and target time, resulting in errors.

For short lead times, the LFQM is dominated by the amplitude error near the emissions.

Vertical section at 55°N



If the method was perfect, plots in this column would be identical.

References

Matthiesen et al. 2013, ACP, in prep.
Zinner et al. 2008, Met.&Atmos. Phys.
see also: Palmer et al. 2013, ACP