Some experiences using the non-hydrostatic model AROME as a driver for the MATCH model

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Outline of the talk

- Non-hydrostatic data in a hydrostatic CTM?
- Background
  - Operational met models at SMHI
  - Characteristics of the MATCH model
- Inconsistency in met data (off-line perpective)
- Balancing of the horizontal wind field
- Do balancing wash out non-hydrostatic information?

Non-hydrostatic data in hydrostatic CTM

- How to deal with non-hydrostatic met data in an essentially hydrostatic CTM?
- Is it possible to treat such data as we handle hydrostatic ones?

Model areas for operational runs

Operational runs

C22 – HIRLAM 0.2º (~22 km)

E11 – HIRLAM 0.1º (~11 km)

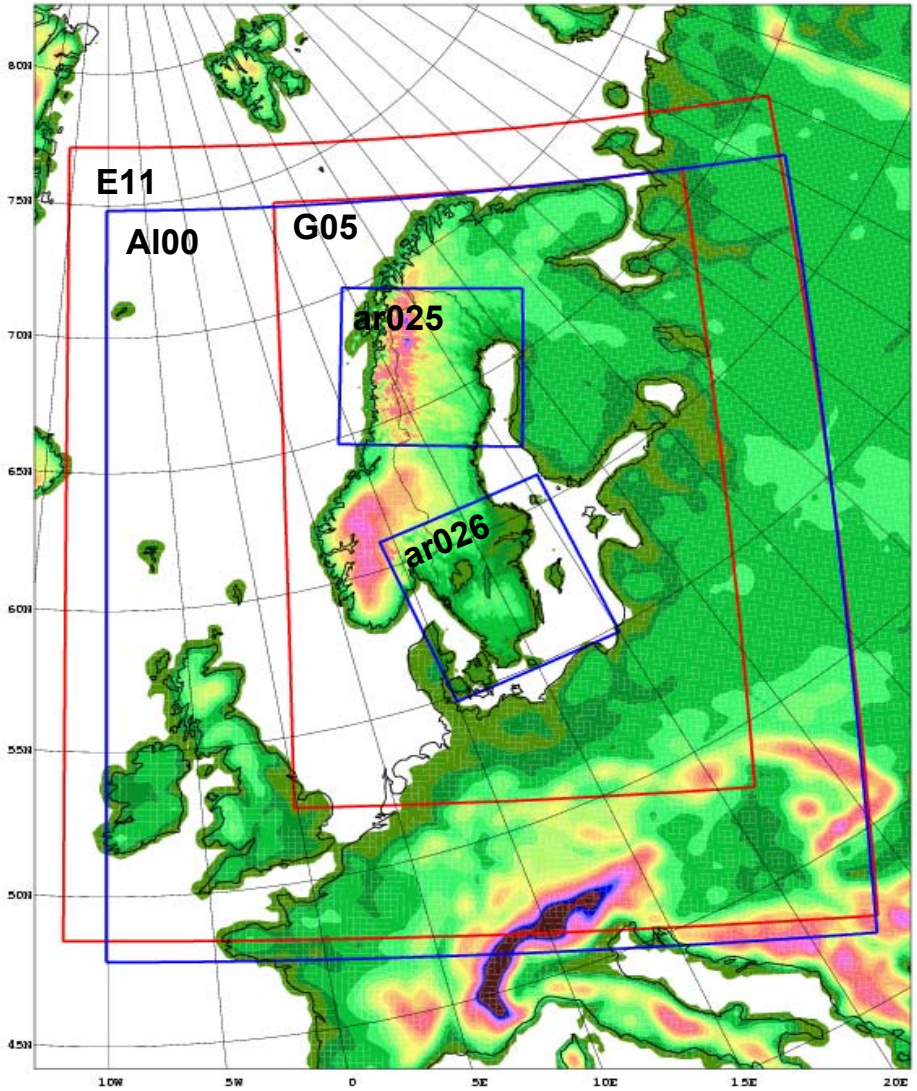
G05 – HIRLAM 0.5º (~5 km)

Pre operational runs

AL00 – ALADIN 11 km, 60 levels

Ar025 – AROME 2.5 km, 60 levels (NH)

Ar026 – AROME 2.5 km, 60 levels (NH)



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Characteristics of the MATCH model

- Off-line model
- Hybrid Lagrangian-Eurerian model
- Simplified random walk model to initialize point sources (includes no chemistry)
- Bott like Eulerian transport scheme
- Transformation ranging from radioactive decay to photochemistry
- All processes are ensured to be mass conserving

- **Hybrid vertical coordinates (η-coordinates)**
- **Diagnostic calculation of relative the vertical wind**
- **Hydrostatic assumption**
- **Initialisation of horizontal winds to ensure mass consistency**

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Why an off-line model

- Applications using various met inputs
  - HIRLAM
  - ECMWF (oper/EPS)
  - ALADIN/AROME
  - Meso-scale analyses
- Runs over an entire year are common applications

General experience using non-hydrostatic models

- MM5: difficulties to transform the output to hybrid vertical coordinates

- ALADIN/AROME: output is given on hybrid vertical coordinates (PnP related to MATCH)

Inconsistency in met data from an off-line perspective

Disruption of the balance between mass and wind field may be induced by

- Spatial interpolation
- Temporal interpolation
- Truncation error in stored data (e.g. GRIB)

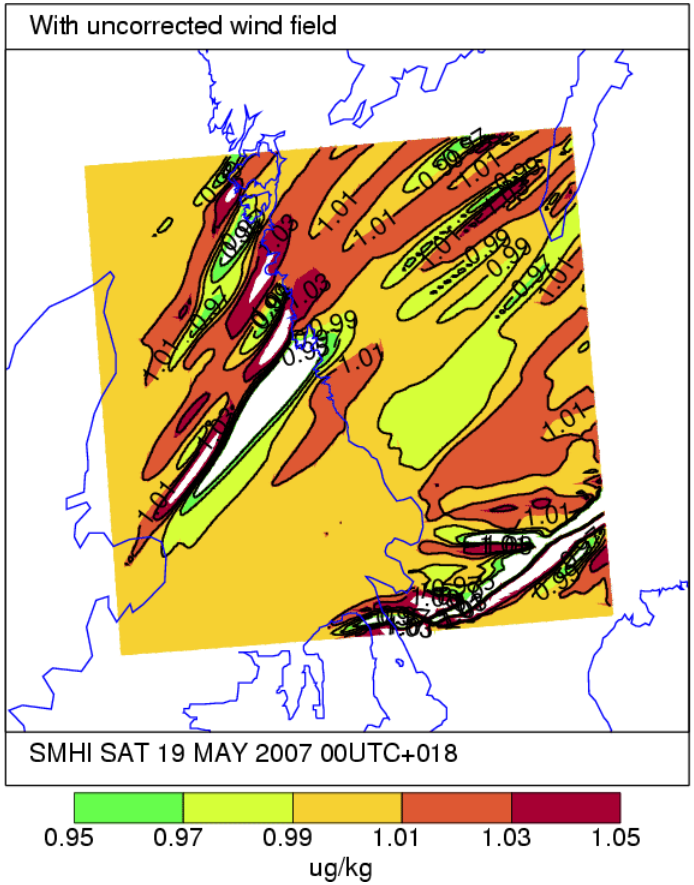
Note: Spectral models providing data on a grid always have unbalanced fields due to interpolation. In addition staggering of wind data have to be applied.

Inconsistency in met data (cont)

Constant mixing ratio do not stay constant when using AROME data as it is

The figure illustrates an example run with a constant mixing ratio of 1 µg/kg and a ±5% shading scale

The errors in this example ranges between -40% up to +100% at some grid cells



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Inconsistency in met data (cont)

Balancing of horizontal wind field according to Heiman and Keeling (1989)

$$\mathbf{F} = g^{-1} \int_0^1 \mathbf{v}_H \frac{\partial p}{\partial \eta} d\eta$$

$$M = g^{-1} p_s$$

$$\frac{\partial M}{\partial t} = -\nabla \cdot \mathbf{F}$$

$$\nabla^2 \psi = -\nabla \cdot \mathbf{F}_{obs} - \frac{\partial M}{\partial t}$$

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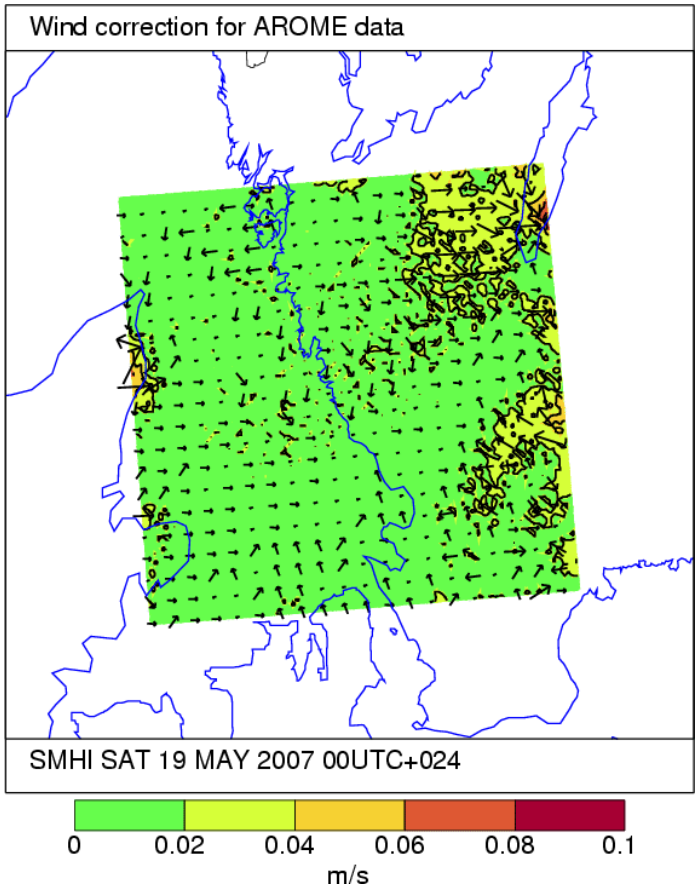
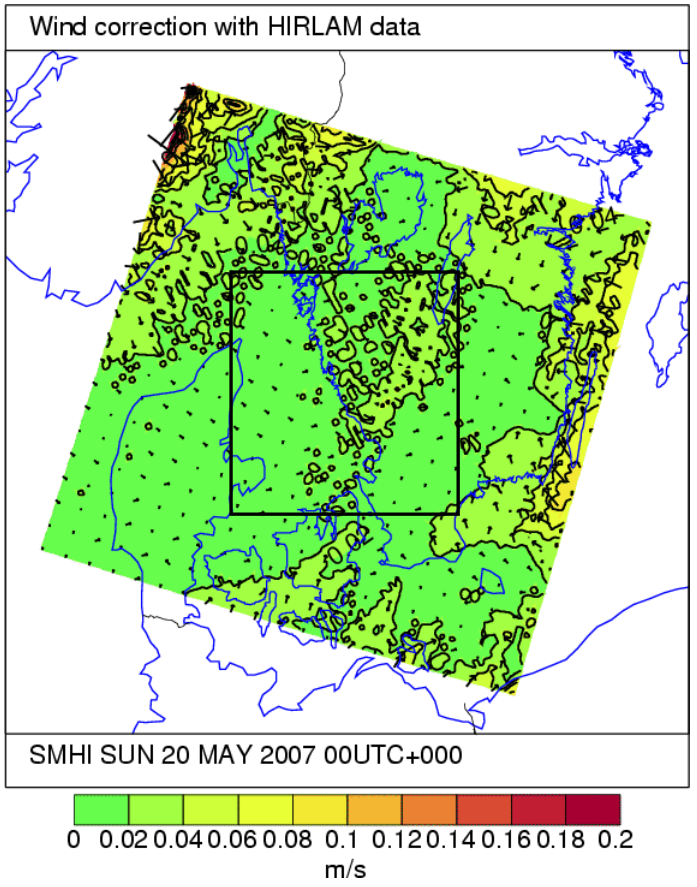
Inconsistency in met data (cont)

Corrections of the horizontal winds are typically of the magnitude a few dm/s





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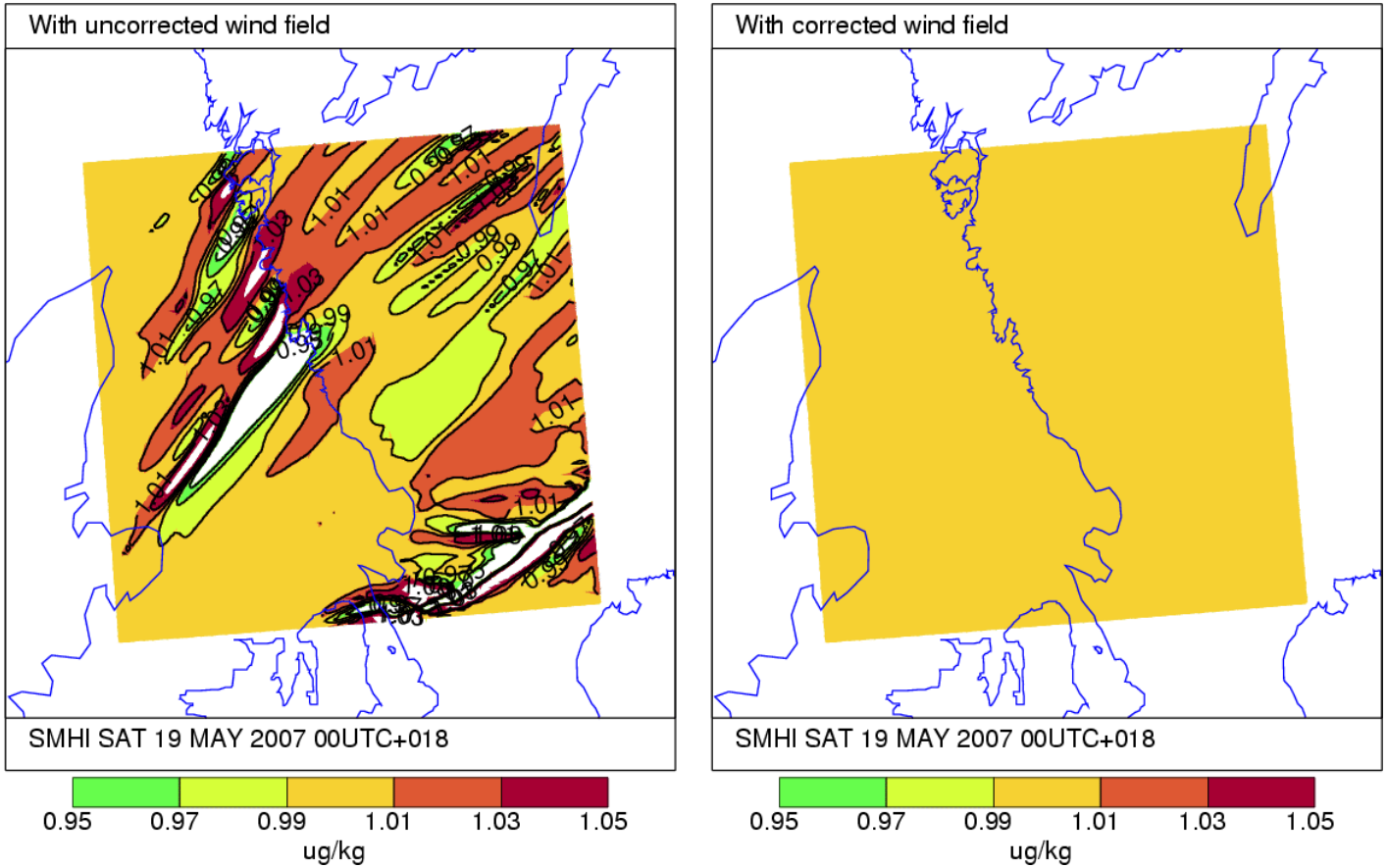
Inconsistency in met data (cont)

Despite the small corrections mass consistency errors vanish (fractions of per mille)



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Do balancing wash out non-hydrostatic information?

- On the horizontal wind: No!

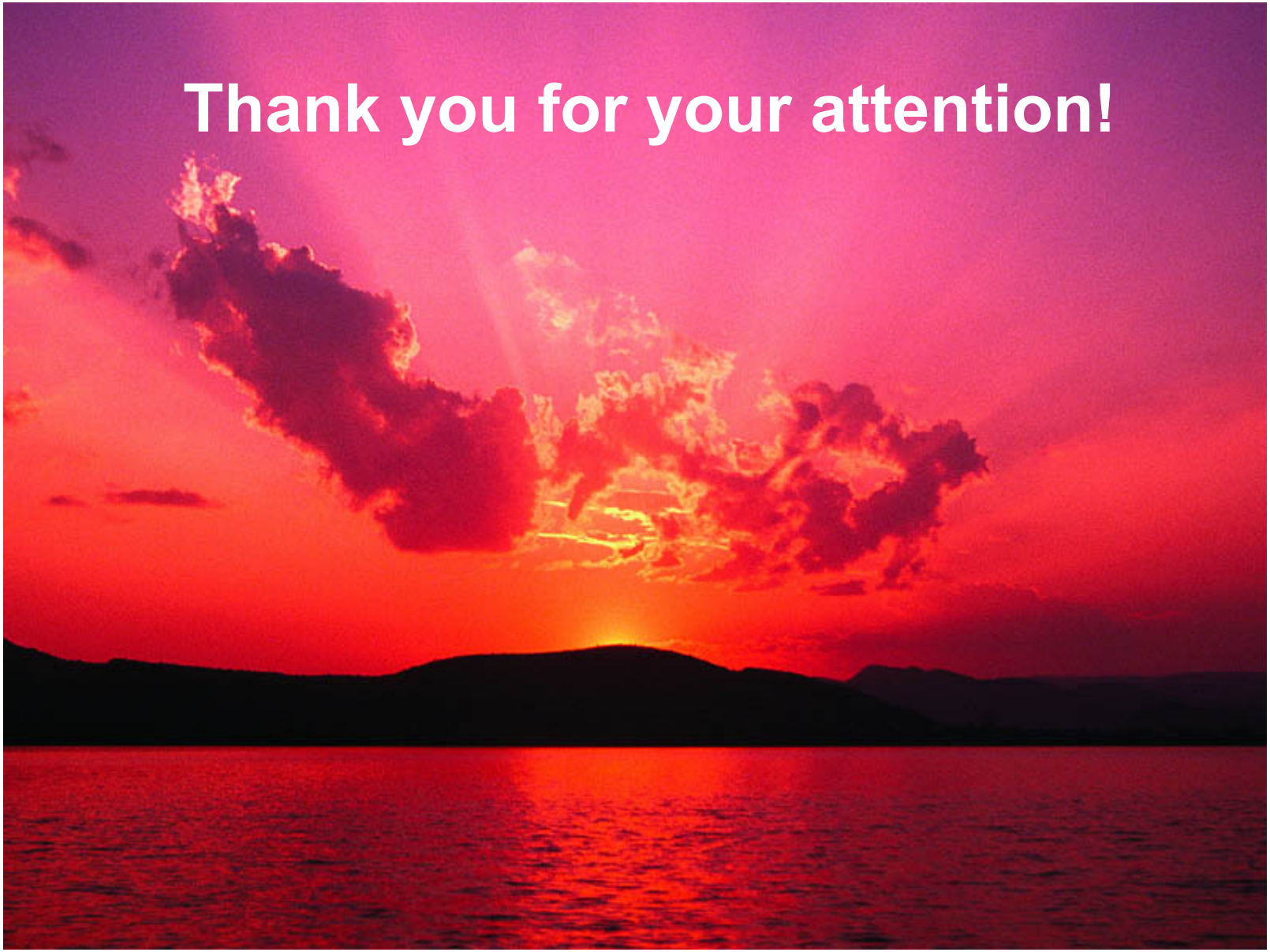
  One would expect larger impact from the non-hydrostatic scheme than then a few dm/s

- On the vertical wind: Yes!

  The vertical wind becomes diagnostic with the hydrostatic assumption

Do the on-line approach solve the problem?

Should we look for a non-hydrostatic advection scheme?



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