Improving initial conditions in a convection-permitting LAM

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ZAMG - ZENTRALANSTALT FÜR METEOROLOGIE UND GEODYNAMIK

Motivation

- LAMs are less effective at representing large-scale (e.g., synoptic) flow
  - **Include large scale information from global model**
    - Superior data assimilation
    - No lateral boundaries

State of the art

- **Digital filter blending method**
  - Brožková et al (2001)
  - Low-pass digital filter -> blend a large-scale analysis with small scales of LAM
  - Czech Republic, ALADIN-LAEF
- **Include global model information directly into limited area variational assimilation**
  - Guidard and Ficher (2008)
  - **Jk blending method**
  - Adopted to HIRLAM by Dahlgren and Gustafsson (2012)
  - Ensemble Jk method (Keresturi et al., submitted to QJRMS)

Theoretical background – Jk 3D-Var

- **Cost function:**

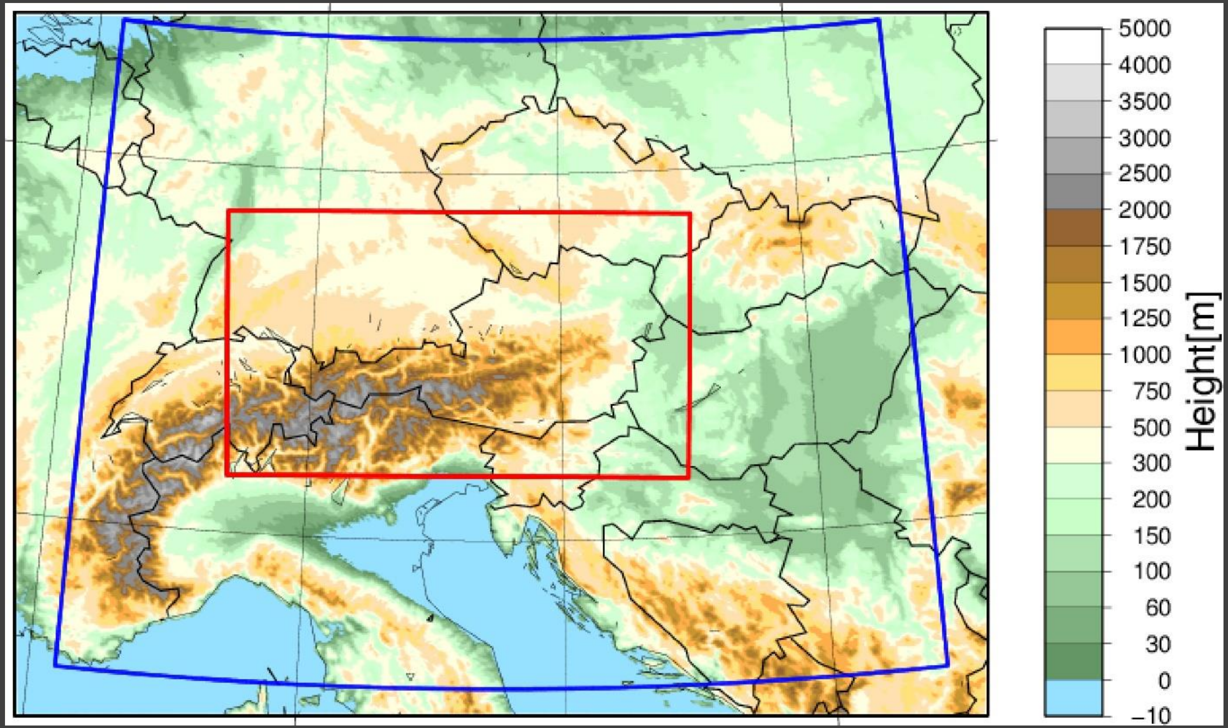
$$J(x) = \underbrace{\frac{1}{2}(x - x_b)^T B^{-1}(x - x_b)}_{J_b} + \underbrace{\frac{1}{2}(y - Hx)^T R^{-1}(y - Hx)}_{J_o}$$

- **Cost function in Jk blending method:**

$$J(x) = J_b + J_o + \underbrace{\frac{1}{2}(x - x_{ls})^T V^{-1}(x - x_{ls})}_{J_k} = J_b + J_o + J_k$$

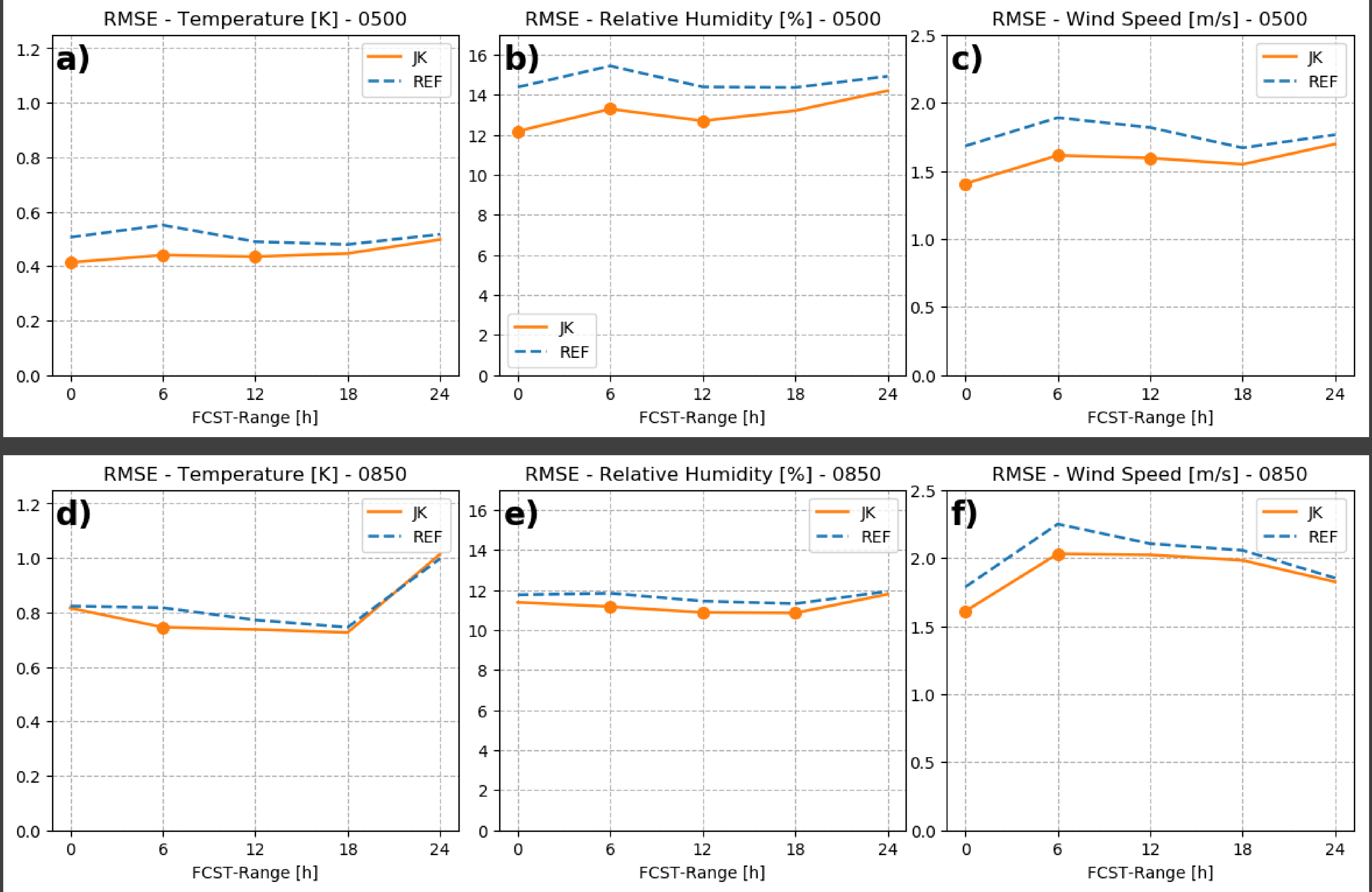
Model setup

- **LAM: AROME**
  - Equation system: nonhydrostatic fully compressible Euler
  - Grid size: 2,5 km
  - Vertical levels: 90
  - No deep convection parameterization
  - Jk blending
- **Driving model: ECMWF**
  - Grid size: 16 km
  - Vertical levels: 91
  - Jk truncation: 135 km

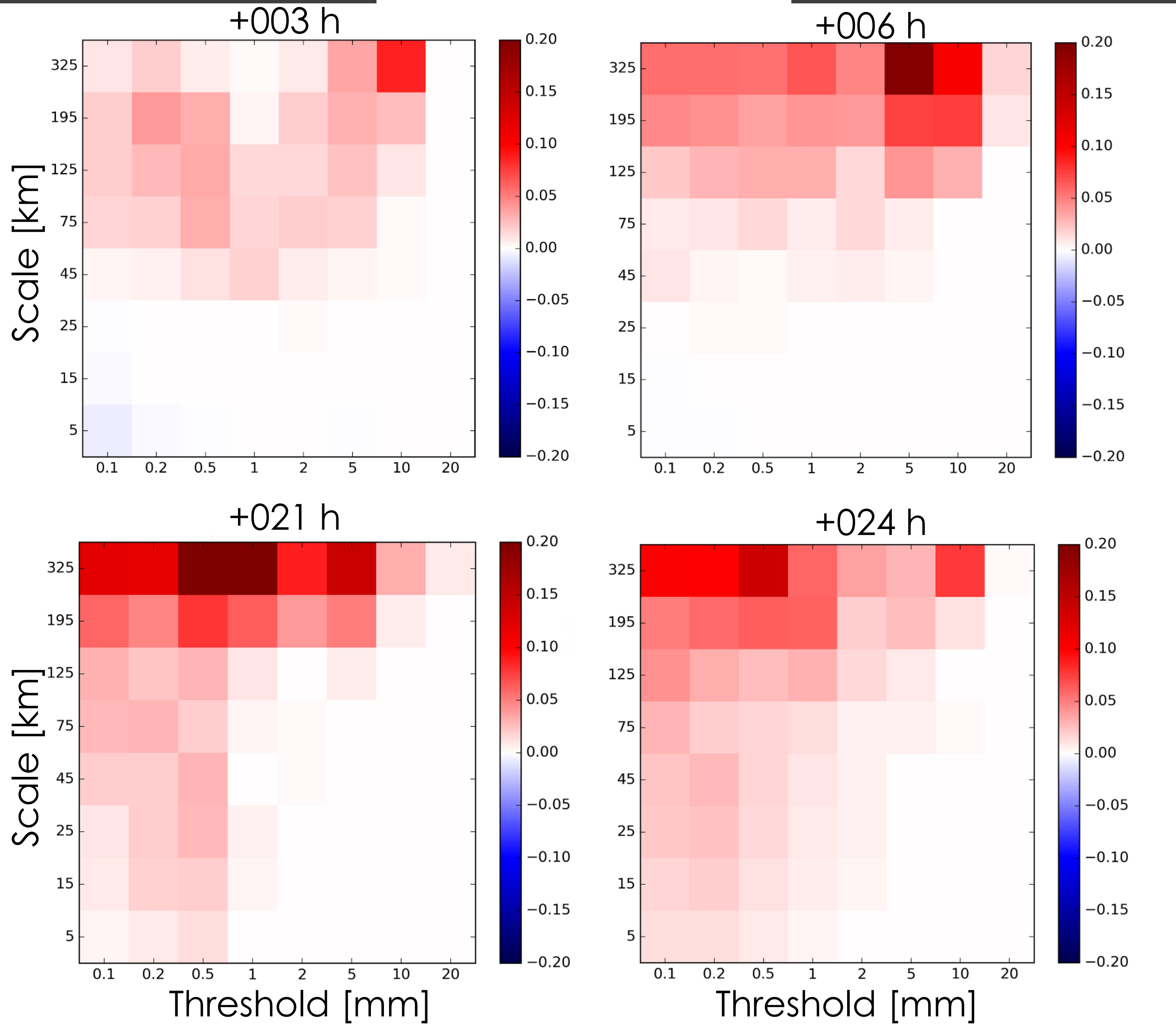


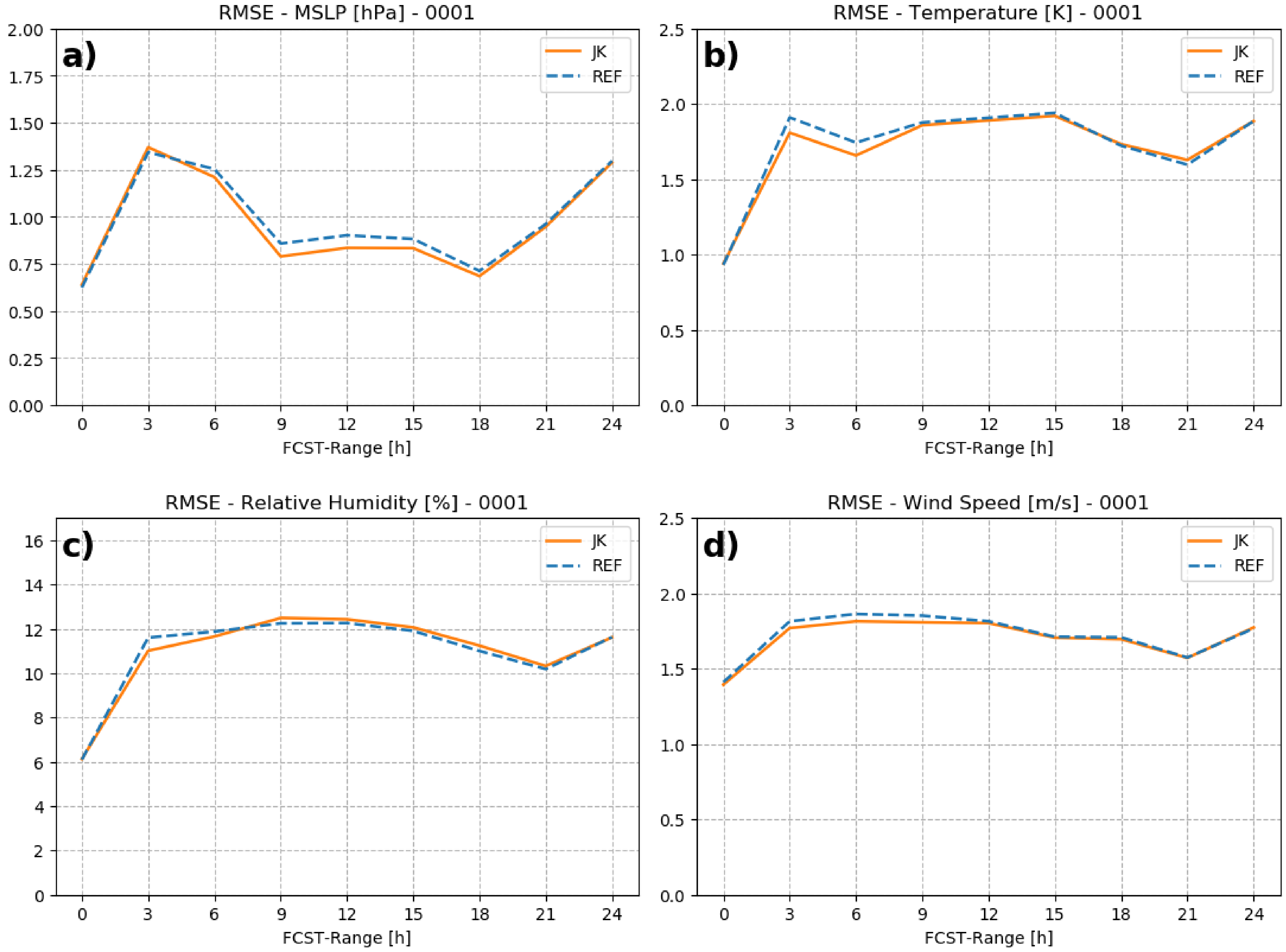
Verification

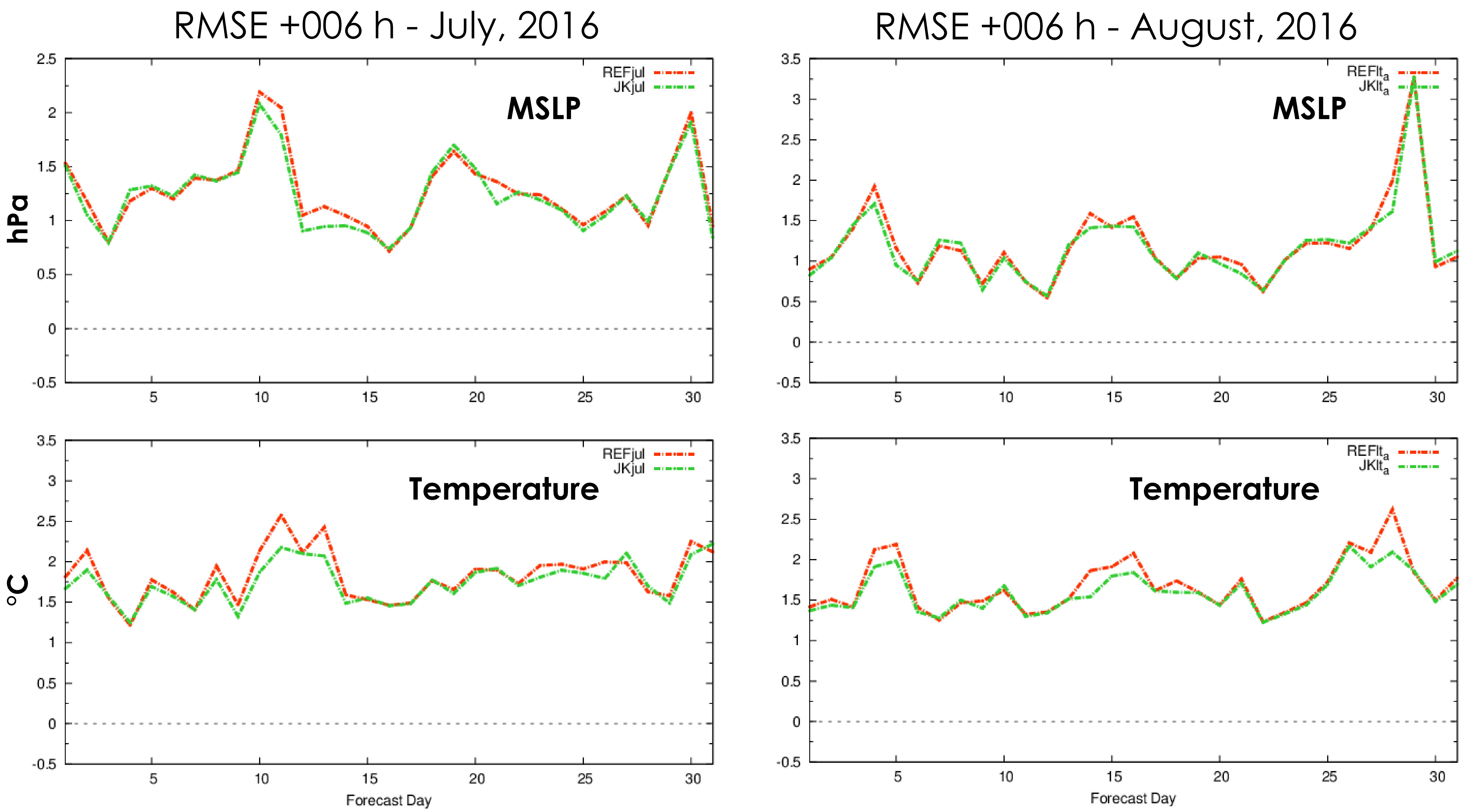
- **July and August 2016**
  - 12 UTC runs
  - Bootstrapping
- **Surface – stations and INCA analyses**
- **Upper air – ECMWF and GFS analyses**


RMSE - Temperature [K] - 0500
a)
RMSE - Relative Humidity [%] - 0500
b)
RMSE - Wind Speed [m/s] - 0500
c)
RMSE - Temperature [K] - 0850
d)
RMSE - Relative Humidity [%] - 0850
e)
RMSE - Wind Speed [m/s] - 0850
f)
JK
REF
FCST-Range [h]
0
6
12
18
24
0.0
0.2
0.4
0.6
0.8
1.0
1.2
0
2
4
6
8
10
12
14
16
0.5
1.5
2.0
2.5

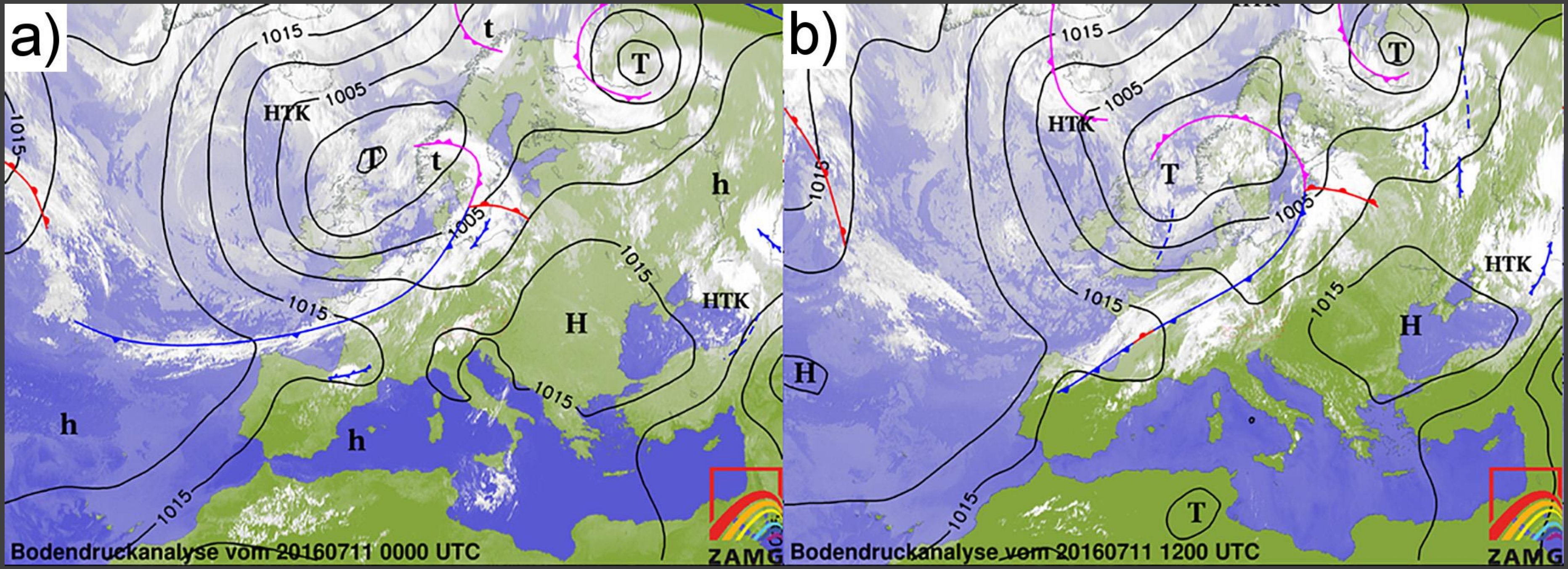
Fractions skill score

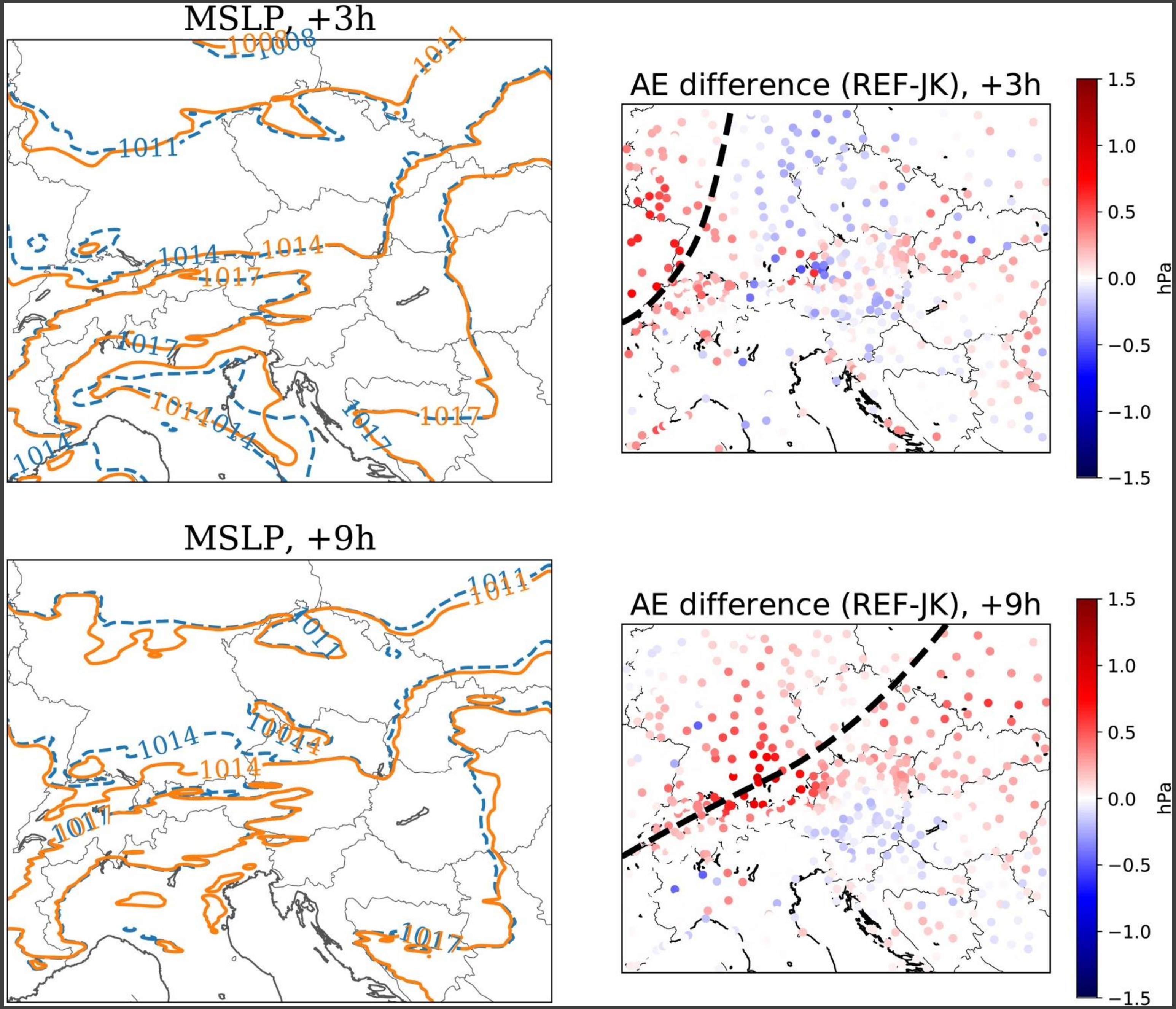



RMSE - MSLP [hPa] - 0001
a)
JK
REF
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
0
3
6
9
12
15
18
21
24
FCST-Range [h]
RMSE - Temperature [K] - 0001
b)
JK
REF
2.5
2.0
1.5
1.0
0.5
0.0
0
3
6
9
12
15
18
21
24
FCST-Range [h]
RMSE - Relative Humidity [%] - 0001
c)
JK
REF
16
14
12
10
8
6
4
2
0
0
3
6
9
12
15
18
21
24
FCST-Range [h]
RMSE - Wind Speed [m/s] - 0001
d)
JK
REF
2.5
2.0
1.5
1.0
0.5
0.0
0
3
6
9
12
15
18
21
24
FCST-Range [h]


RMSE +006 h - July, 2016
RMSE +006 h - August, 2016
MSLP
MSLP
Temperature
Temperature
hPa
°C
REFjul
JKjul
REFlt_a
JKlt_a
Forecast Day
Forecast Day

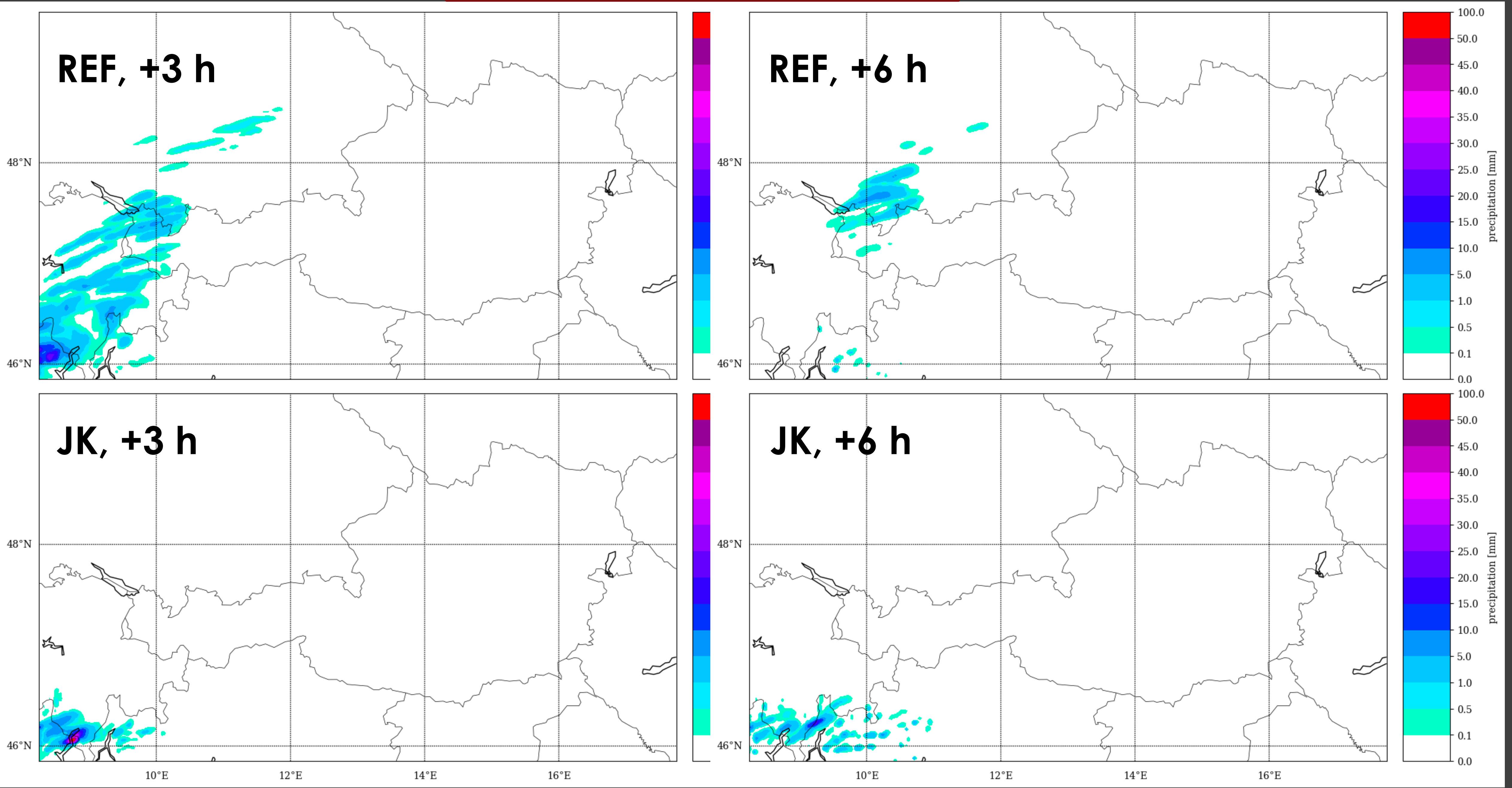
Case study: 11. 7. 2016.





MSLP, +3h
AE difference (REF-JK), +3h
MSLP, +9h
AE difference (REF-JK), +9h
1008
1011
1014
1017
1.5
1.0
0.5
0.0
−0.5
−1.0
−1.5
hPa

11. 7. 2016., 00 UTC run



Conclusion

- Global model information included into convection permitting 3D-Var
- Positive impact on upper air variables
- Positive impact on surface pressure and precipitations
- Improved model performance in some cases

Future plans at DHMZ

- **Test Jk blending in ALADIN/HR**
- **Test AROME (2 km)**
- **Regarding ensembles…**
  - Test AROME EPS (ensemble Jk method)
    - As soon as enough computer power is available…
  - ALADIN-LAEF (5 km) will be available soon