Deutscher Wetterdienst
Wetter und Klima aus einer Hand

Direct Nudging of Radar Radial Velocity Data

(Klaus Stephan)

Enhanced Quality Control of Surface Pressure Data

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pre-processing , done twice (first use time, obs time) for each radar scan

1. at each observation point:
   - correct observed radial wind for sedimentation speed of the hydrometeors
   - calculate observation increment of radial wind component (at obs point)

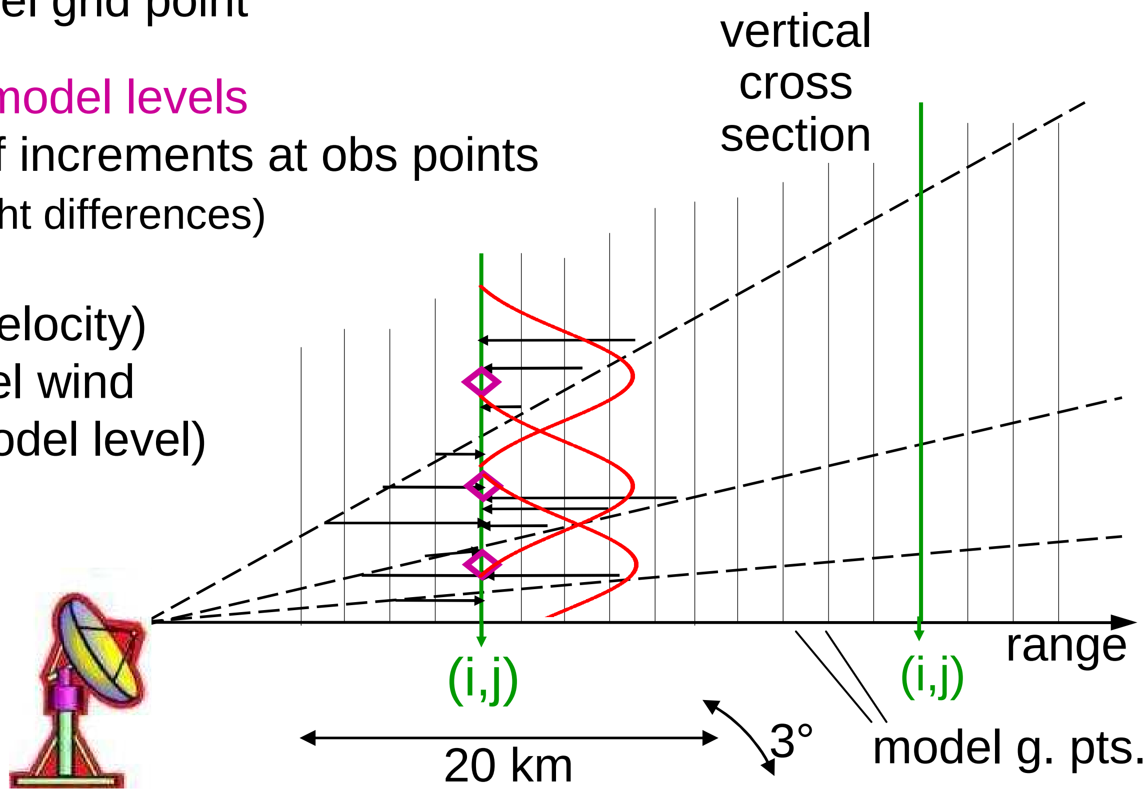
     (requires: - bi-linear interpolation of model horizontal wind to obs point
     - project model horizontal wind to radial direction)
   - re-folding aliased measurements (according to quality flags of the obs)
   - exclude all increments > ± 5 m/s

2. at certain model grid points (i,j) (e.g. every 20 km lat / lon) :
create vertical profiles of pseudo obs (of radial velocity, as a kind of superobbing)

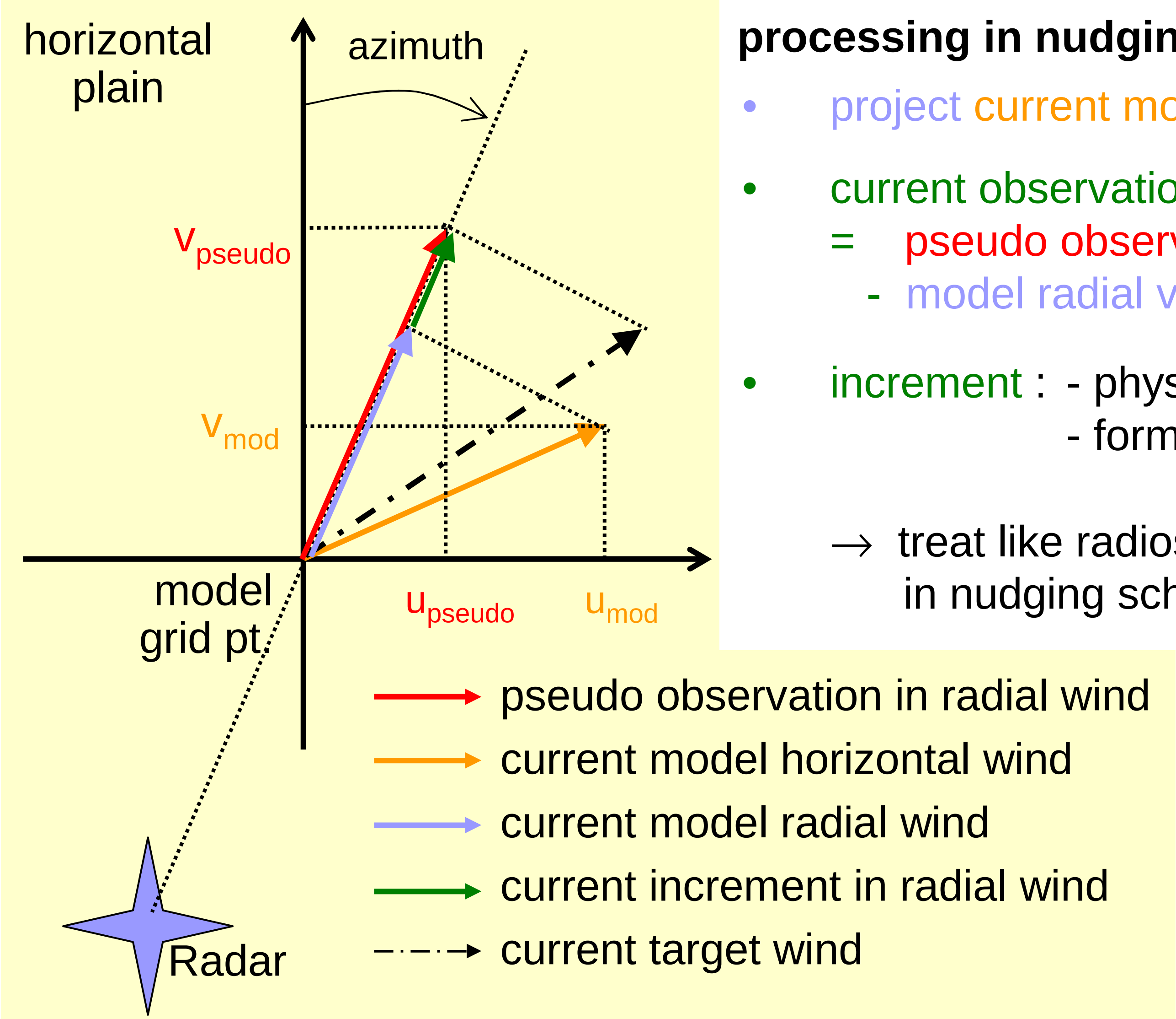
- assign all obs increments (at obs points)
  within ±1.5° (azimuth) and ±10 km (range)
  horizontally to this model grid point

- get obs increments at model levels
  as weighted average of increments at obs points
  (weights depends on height differences)

- pseudo obs (of radial velocity)
  = radial comp. of model wind
  + obs increment (at model level)



nudging of radar radial velocity: methodology



processing in nudging at each time step :

- project current model wind to radial direction
- current observation increment
  = pseudo observation of radial velocity
  \- model radial velocity
- increment : - physically: radial velocity
  \- formally: wind vector, always in radial direction !

  → treat like radiosonde wind increment in nudging scheme

nudging of radar radial velocity: example

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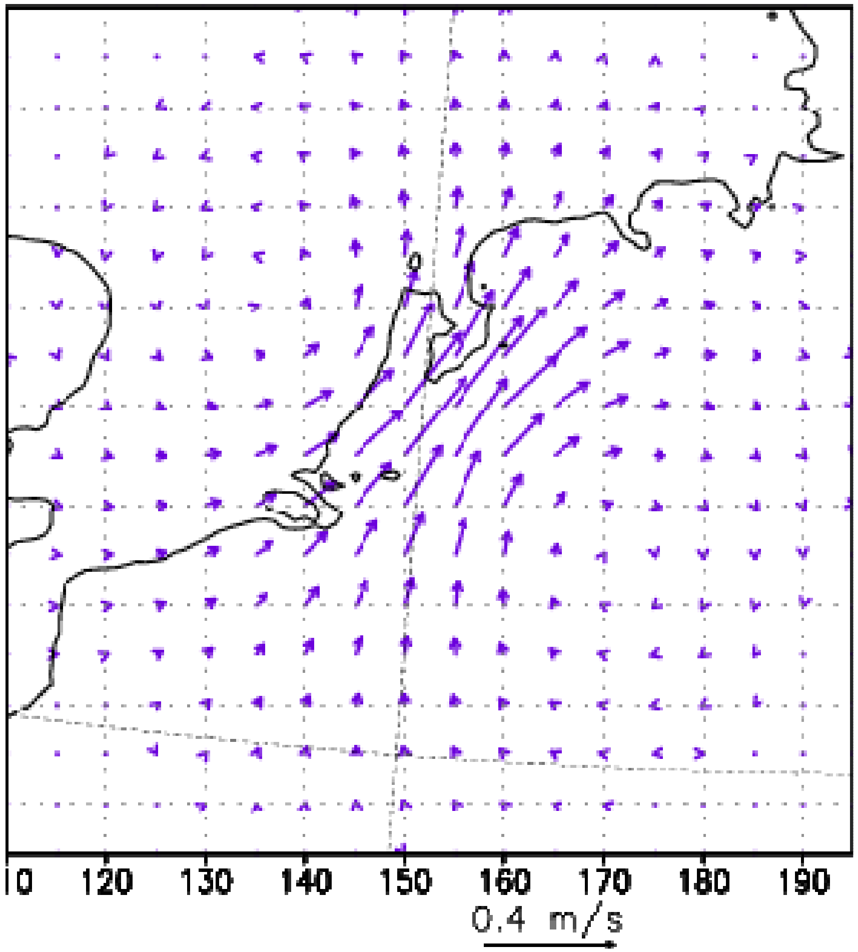
- observation increments are strictly in radial direction (transversal comp. = zero)
- but analysis increments are not !



nudging of radar radial velocity: example

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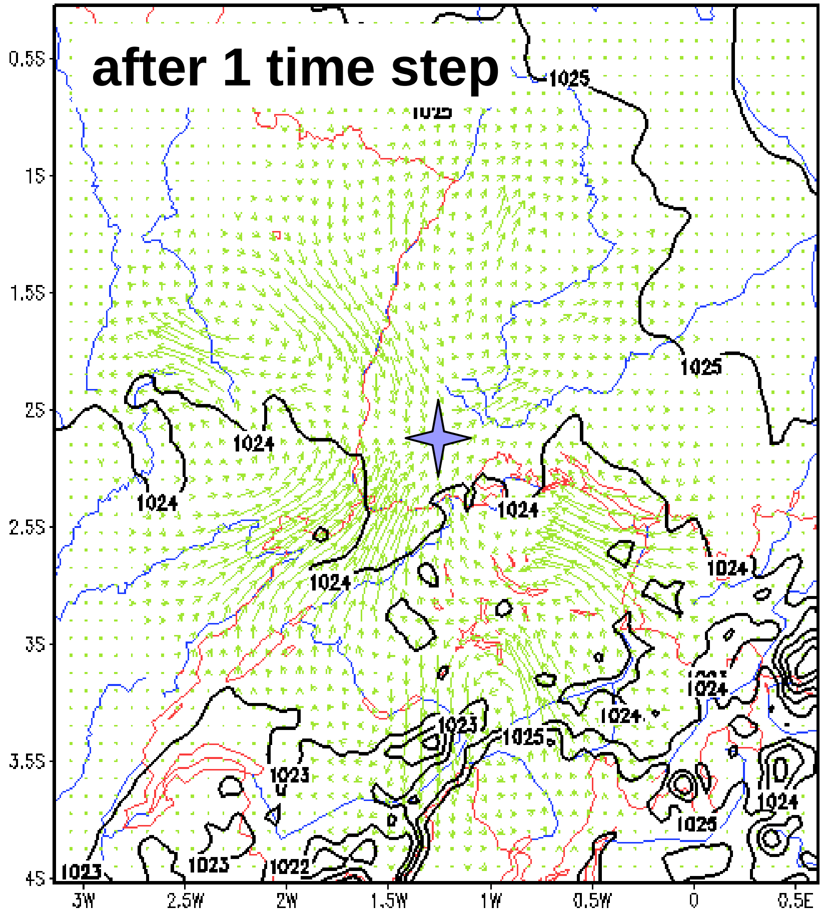

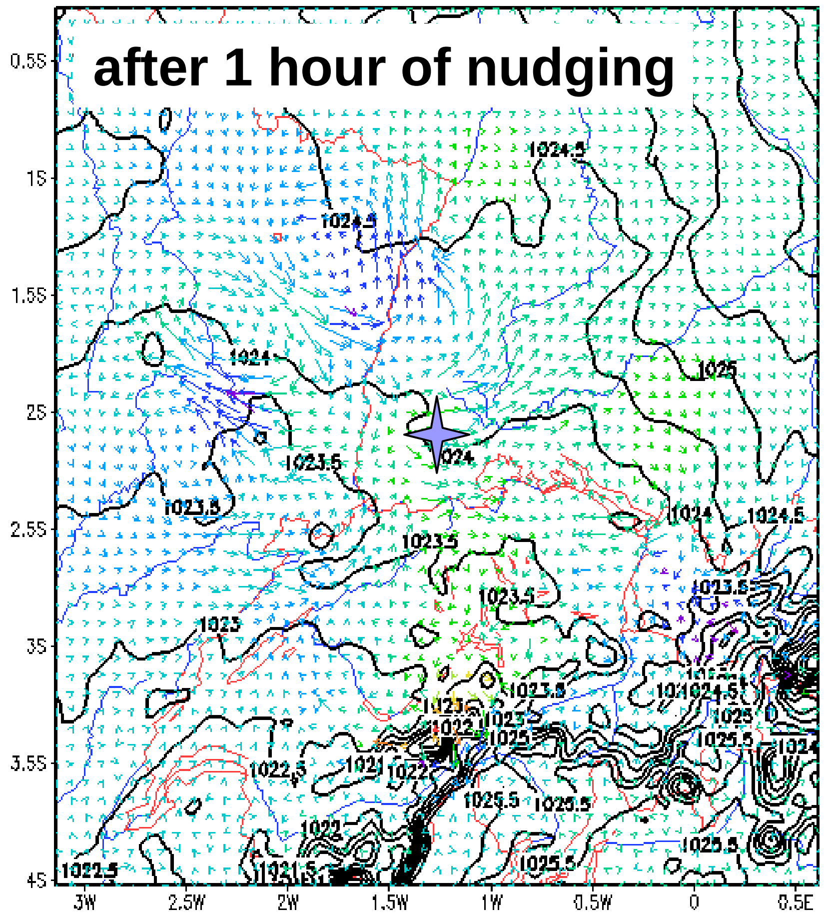

wind increments at lowest model level ; colour: pressure increment in Pa

−6.4 −4.8 −3.2 −1.6 0 1.6 3.2 4.8 6.4 8 9.6 11.2

radar site (Freiburg)

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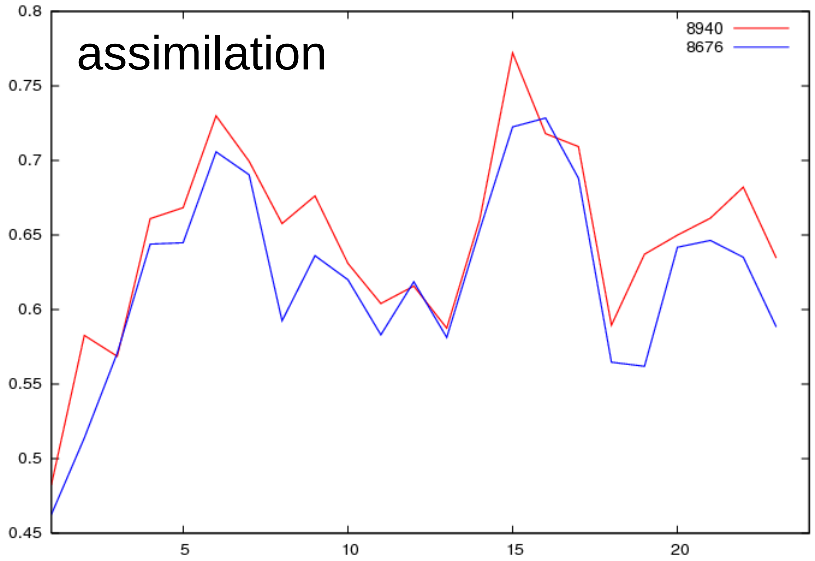
1 – 10 May 2012

precipitation against radar

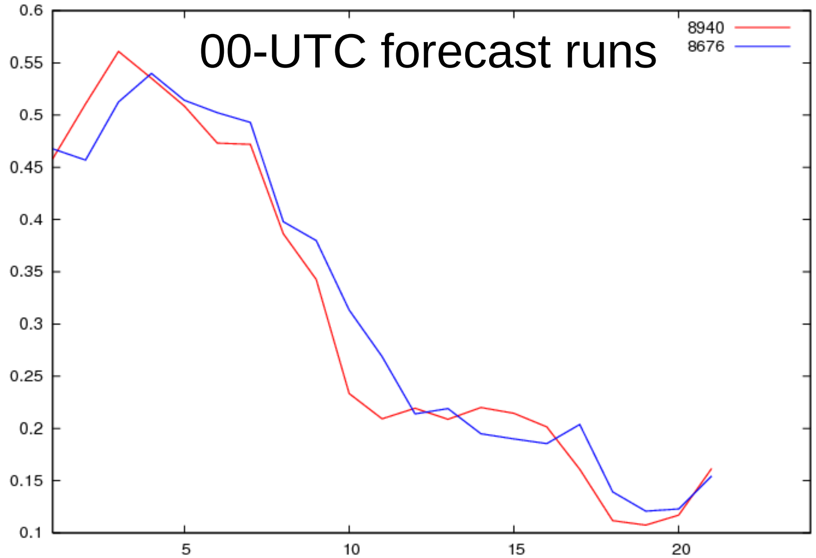
FSS , 11 g.pts. (30 km)

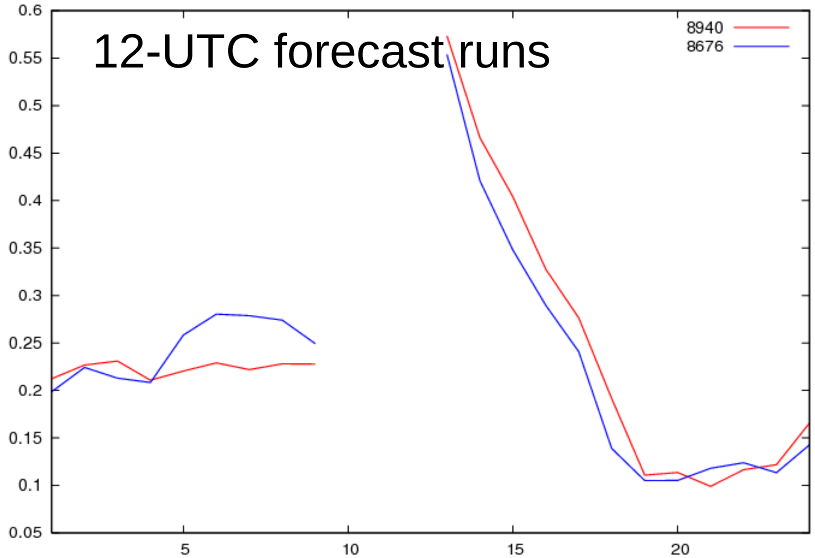
threshold : 2 mm / h



control (COSMO-DE setup, with LHN)

use of radial velocity added





nudging of radar radial velocity: results

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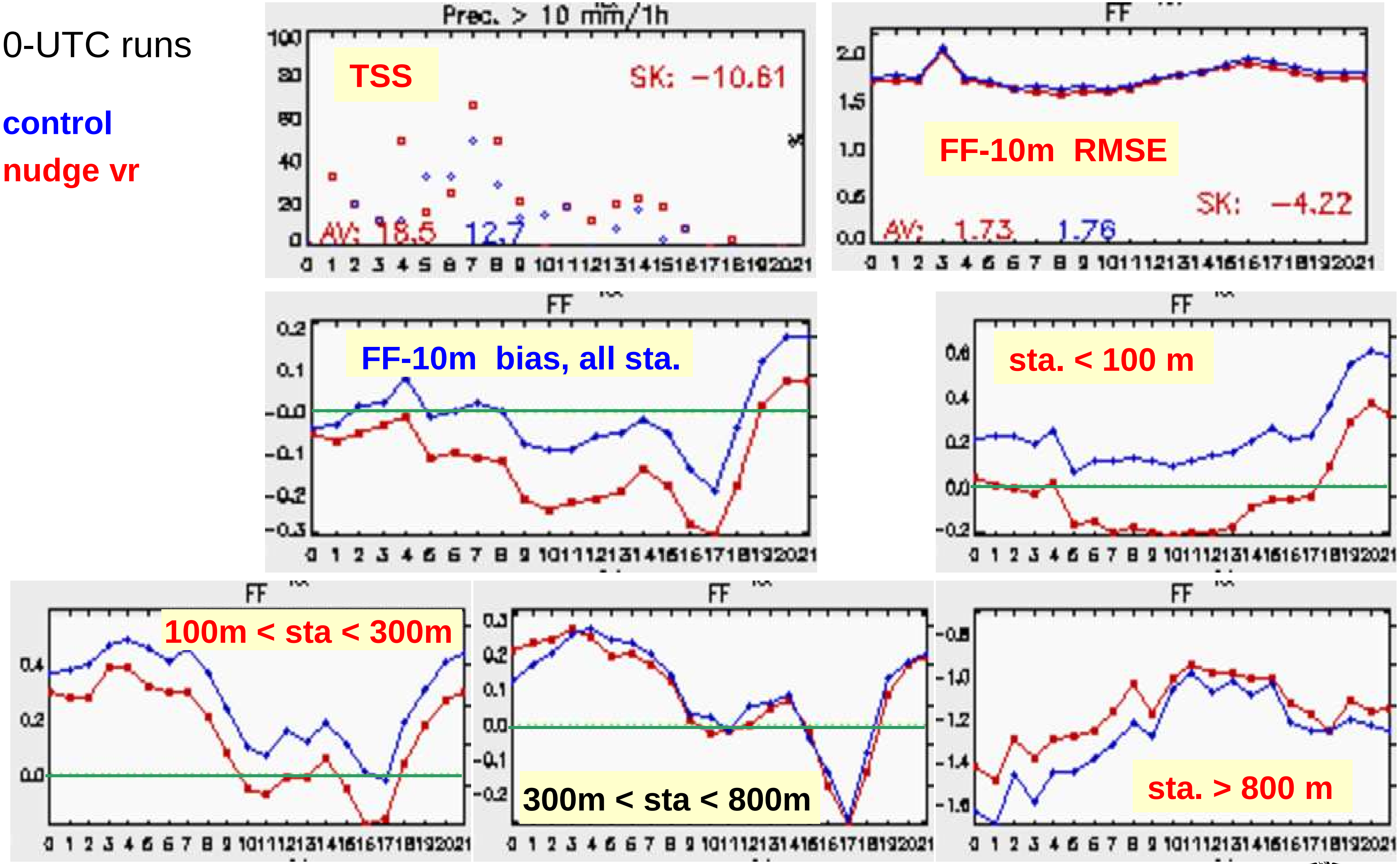
0-UTC runs

control

nudge vr



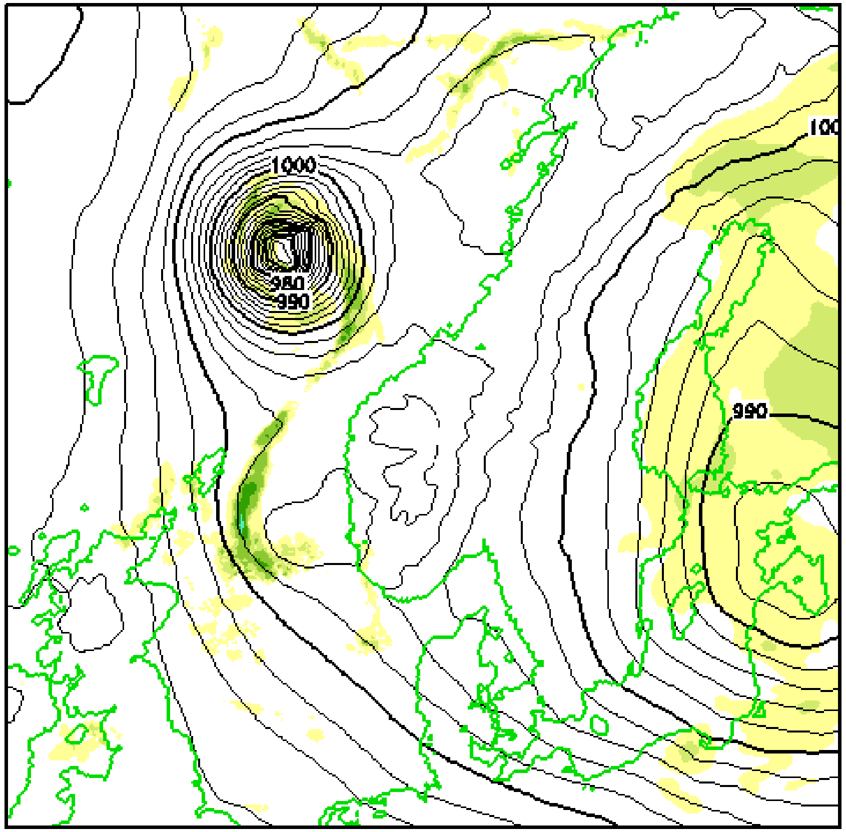
nudging of radar radial velocity: summary

- nudging of radar radial velocity implemented
  (apparently) running correctly
- small impact, overall maybe slightly positive, but too preliminary
- continue / add test periods (with / without LHN)

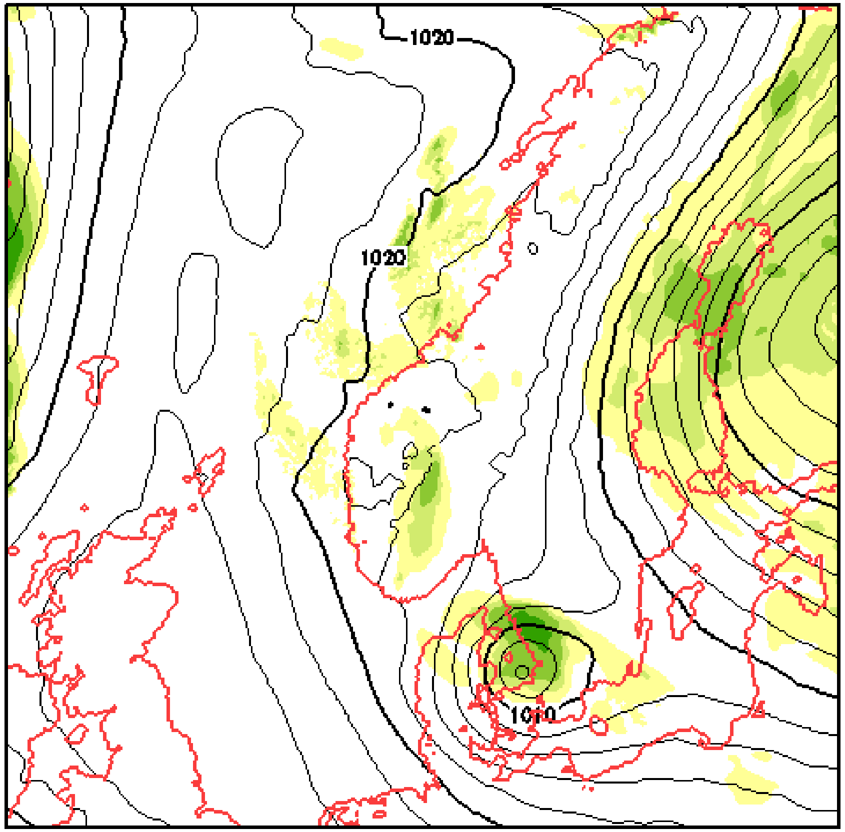
The problem: large errors in COSMO-EU analyses and forecast on 1 – 2 March 2010

plots by Klaus Stephan

COSMO-EU analysis, 2 March 2010, 0 UTC



36-h forecast for 3 March 2010, 12 UTC



reason: assimilation of erroneous observations from buoy 63643

quality control of surface pressure p_s : method

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- 'threshold quality control' (≈ 'first-guess check') :
  use current model field (of nudging run / first-guess fcst.) as estimate for truth)

$$\left| p_{s_k} - p_s(\mathbf{x}_k, t) \right| > p_s^{thr}$$

$$p_s^{thr} = 5\,hPa$$
$$p_s^{thr} = 4.5\,hPa$$
$$p_s^{thr} = \underbrace{4\,hPa}_{p_s^{thr_{const}}} + 0.6 \left. \frac{\partial p_s}{\partial t} \right|_k \left[\tfrac{hpa}{3h}\right]$$

- 'spatial consistency check' (SCC):
  improve estimate for truth by adding analysis increments
  derived from obs increments only from surrounding obs (within ~ ±1 hr)

$$\left| p_{s_k} - \left(p_s(\mathbf{x}_k, t) + \Delta p_{s_k}^{scc} \right) \right| > p_s^{thr_{scc}}$$

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quality control of surface pressure p_s :
case 1

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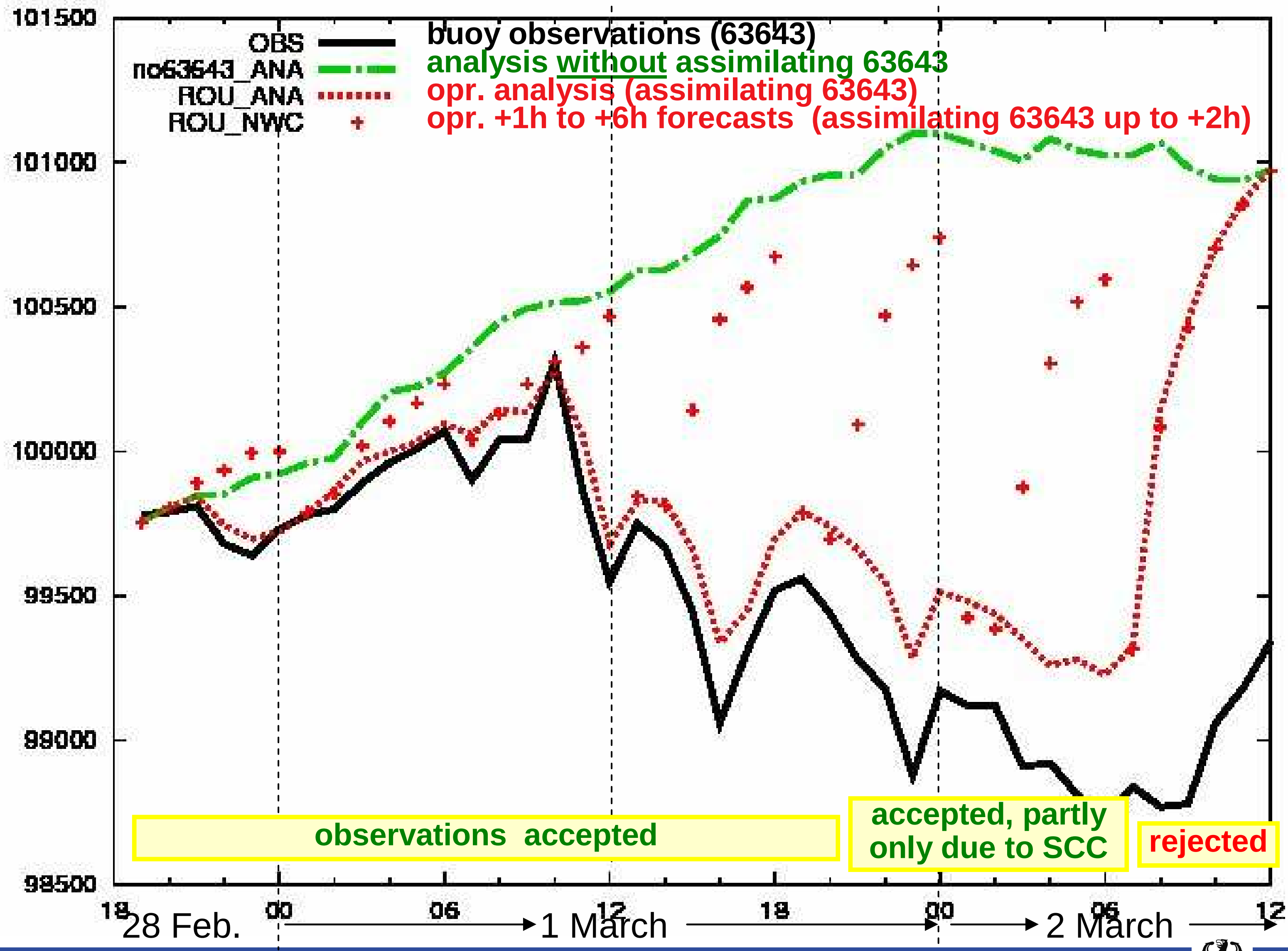
surface pressure

(at the location of buoy 63643)



- 'threshold quality control' ($\approx$ 'first-guess check') :
  use current model field (of nudging run / first-guess run) as estimate for truth)

$$\left| p_{s_k} - p_s(\mathbf{x}_k, t) \right| > p_s^{thr}$$

$$p_s^{thr} = 5\,hPa$$

$$p_s^{thr} = 4.5\,hPa$$

$$p_s^{thr} = \underbrace{4\,hPa}_{p_s^{thr_{const}}} + 0.6 \left.\frac{\partial p_s}{\partial t}\right|_k \left[\tfrac{hpa}{3h}\right]$$

- 'spatial consistency check' (SCC):
  improve estimate for truth by adding analysis increments
  derived from obs increments only from surrounding obs (within ~ ±1 hr)

$$\left| p_{s_k} - \left(p_s(\mathbf{x}_k, t) + \Delta p_{s_k}^{scc} \right) \right| > p_s^{thr_{scc}}$$

$\rightarrow$ 'no-TCC': SCC without checking temporal consistency of obs
(i.e. obs at ±1 hr from same station not used to derive ad-hoc ana. incr. $\Delta p_{s_k}^{scc}$)

quality control of surface pressure p_s :
case 1

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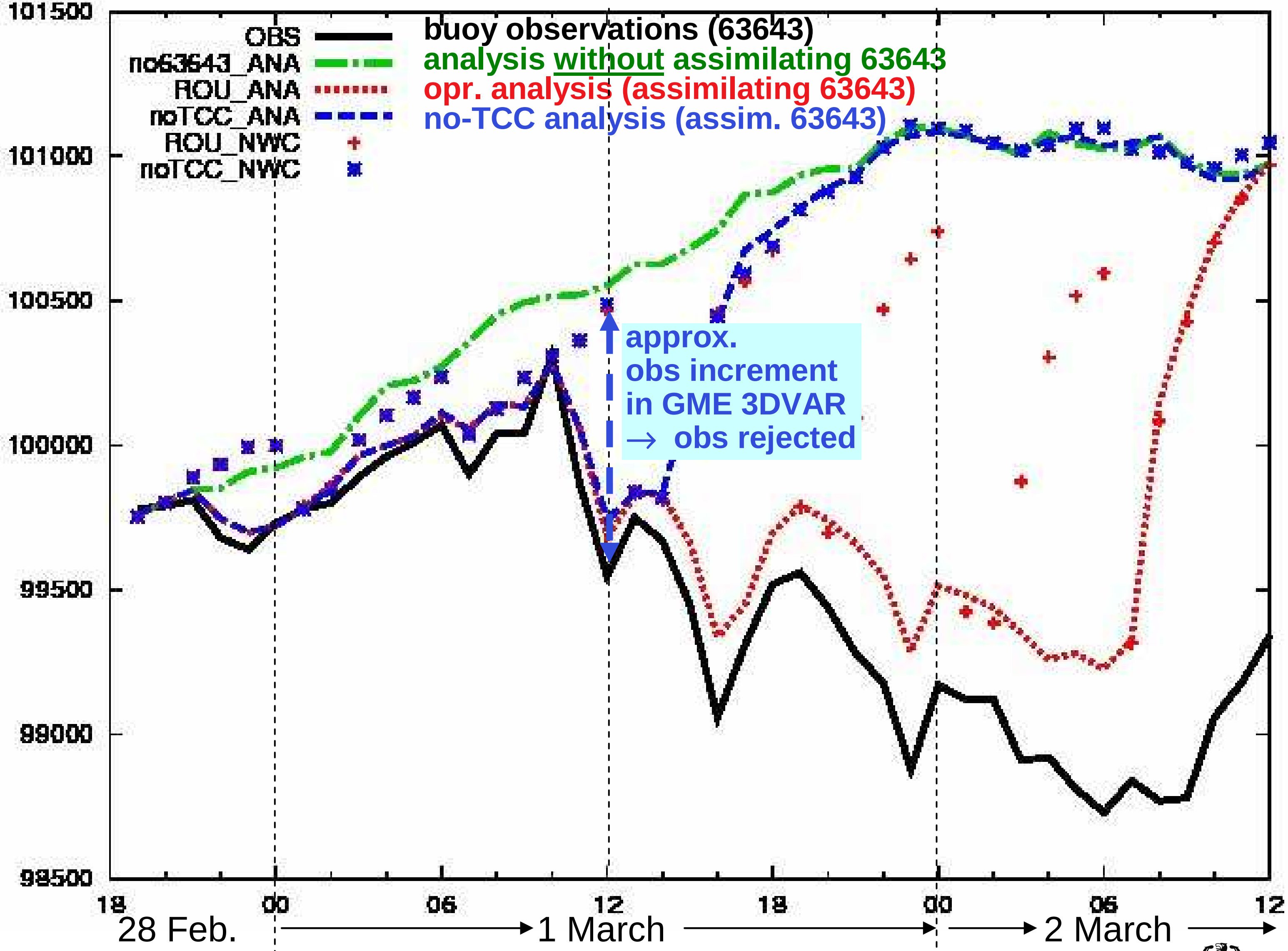
surface pressure

(at the location of buoy 63643)



quality control of surface pressure p_s : new modification

- 'LBC-QC' :

  perform checks using the fields of the steering model (GME), which provides the lateral boundary conditions (LBC), as estimate for truth

$$\left| p_{s_k} - p_s^{LBC}(\mathbf{x}_k, t) \right| > p_s^{thr_{LBC}}$$

$$p_s^{thr_{LBC,const}} = 1.4 \cdot p_s^{thr_{const}}$$

modified 'spatial consistency check' (LBC-SCC) :

$$\left| p_{s_k} - \left(p_s^{LBC}(\mathbf{x}_k, t) + \Delta p_{s_k}^{scc,LBC} \right) \right| > p_s^{thr_{scc,LBC}}$$

quality control of surface pressure p_s :
case 1

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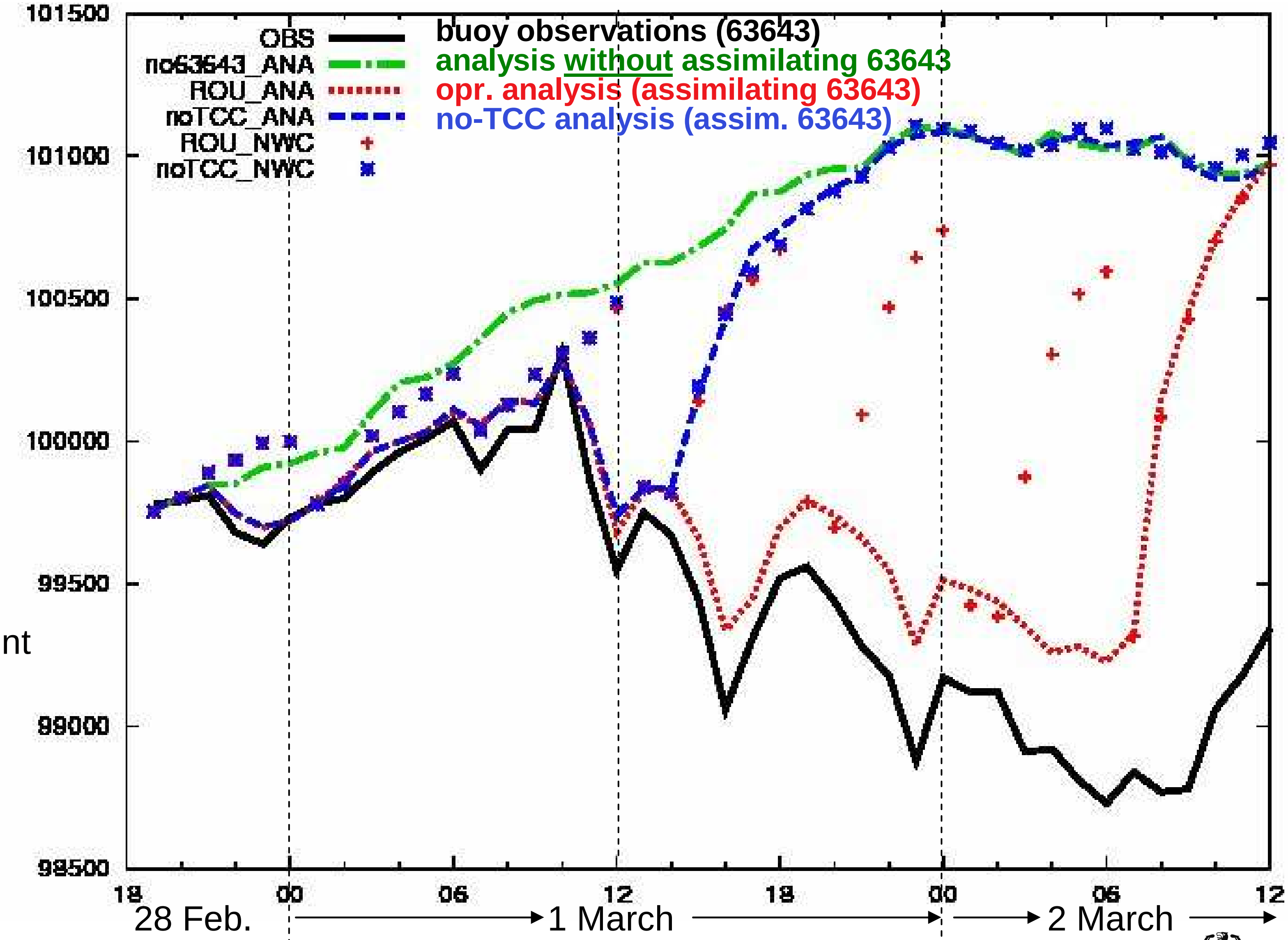
surface pressure

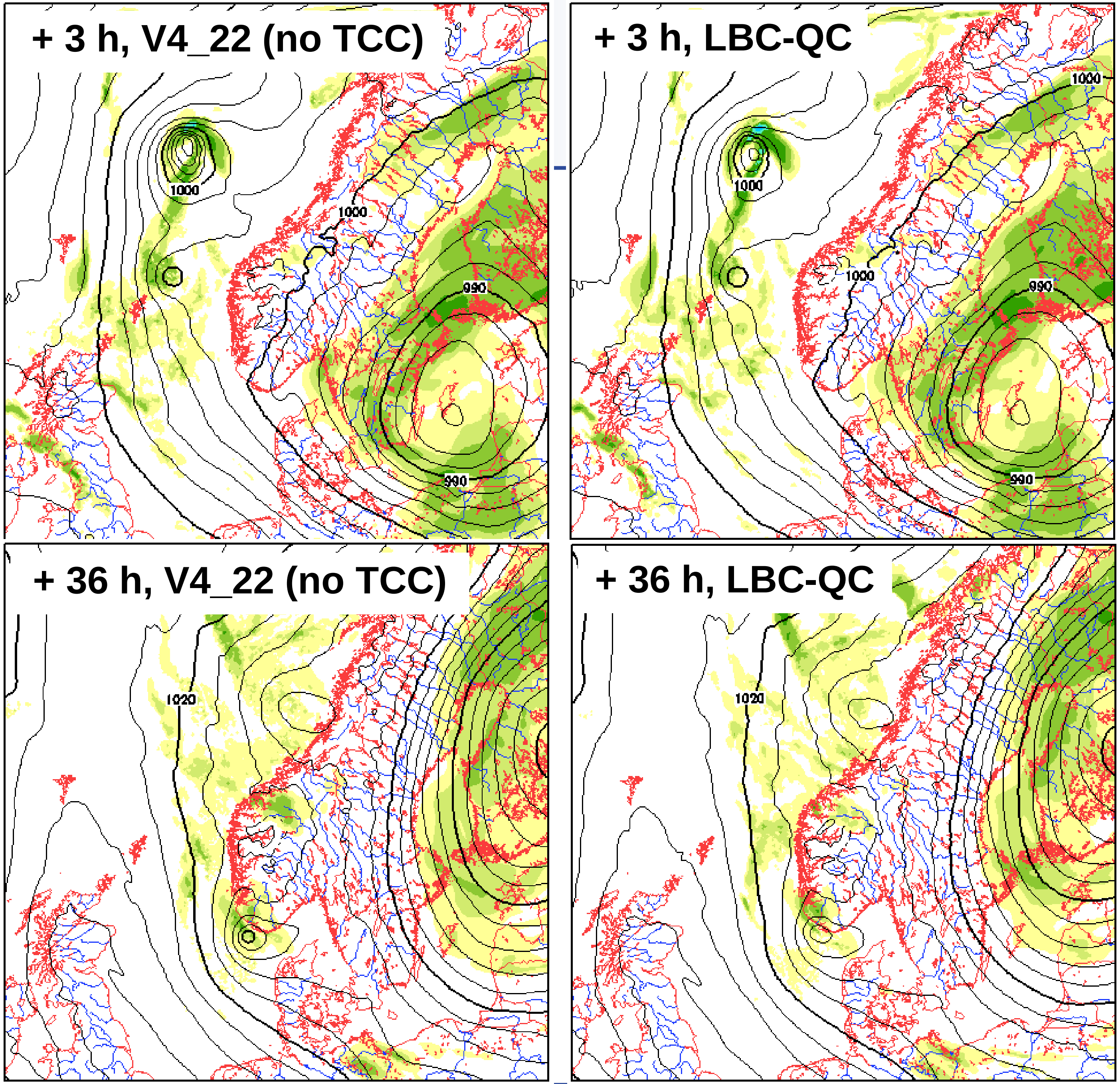
(at the location of buoy 63643)

LBC-QC :
obs rejected at 12 UTC,
from 14 UTC
→ slight (!) improvement



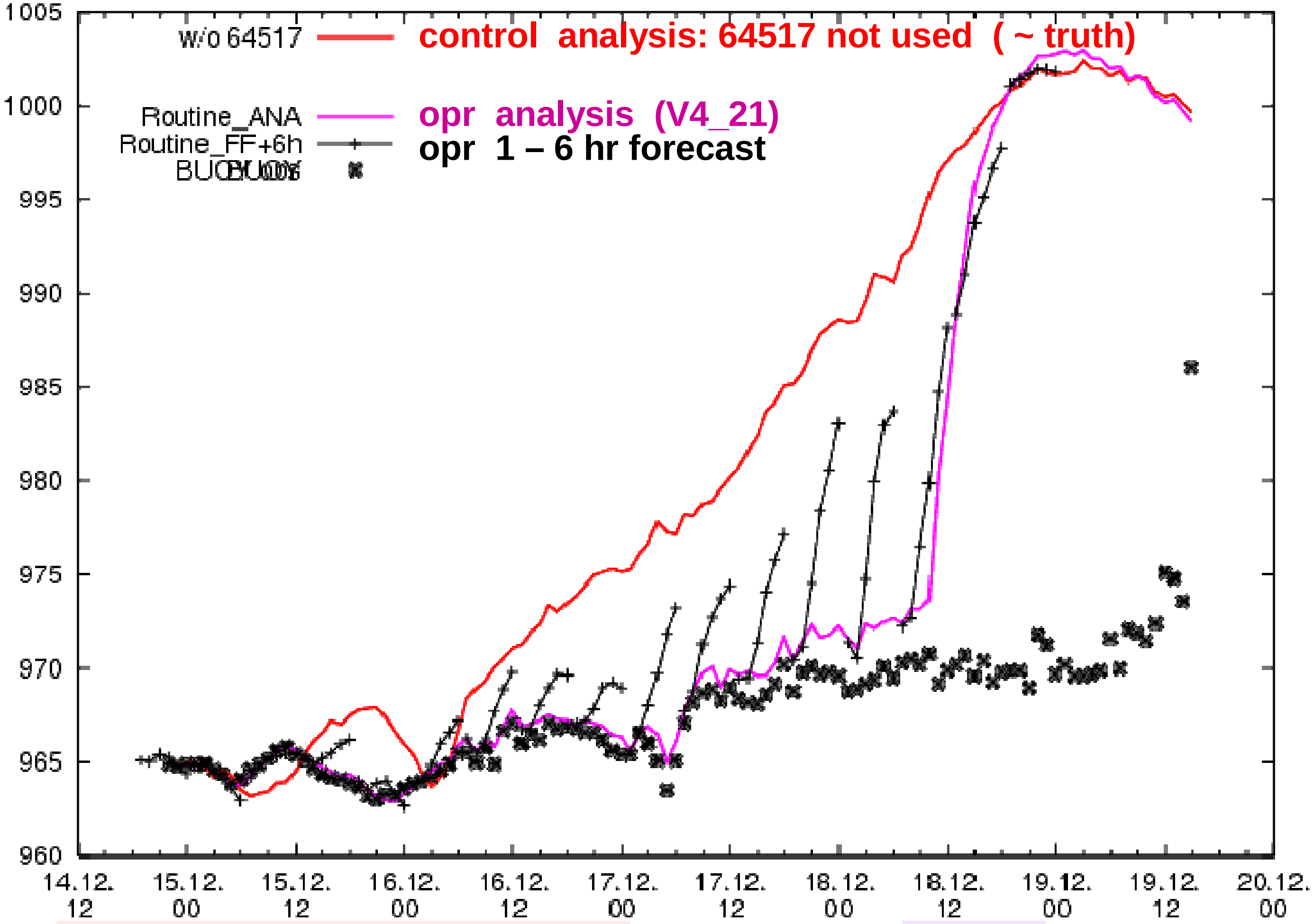
case 1 :

forecast run starting at 1 March 2010, 12 UTC



quality control of surface pressure p_s :
case 2 : 15 - 19 Dec. 2011

surface pressure
(at the location of buoy 64517)



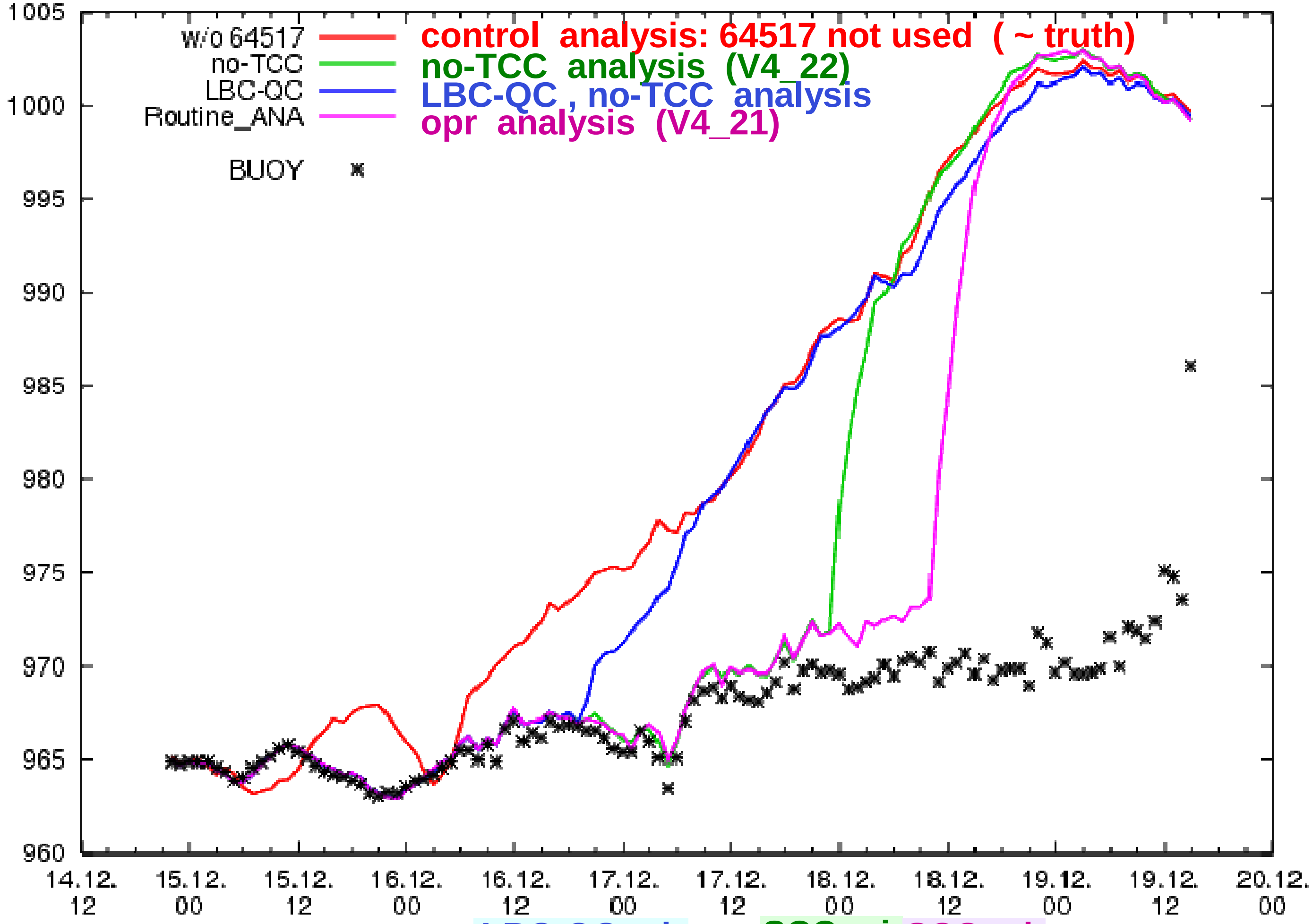
first obs rej. 15 Dec. 19 UTC
all obs rej. from 16 Dec. 13 UTC
(most obs accepted in between)

SCC rej.
19 Dec
10 UTC

quality control of surface pressure p_s :
case 2 : 15 - 19 Dec. 2011

surface pressure

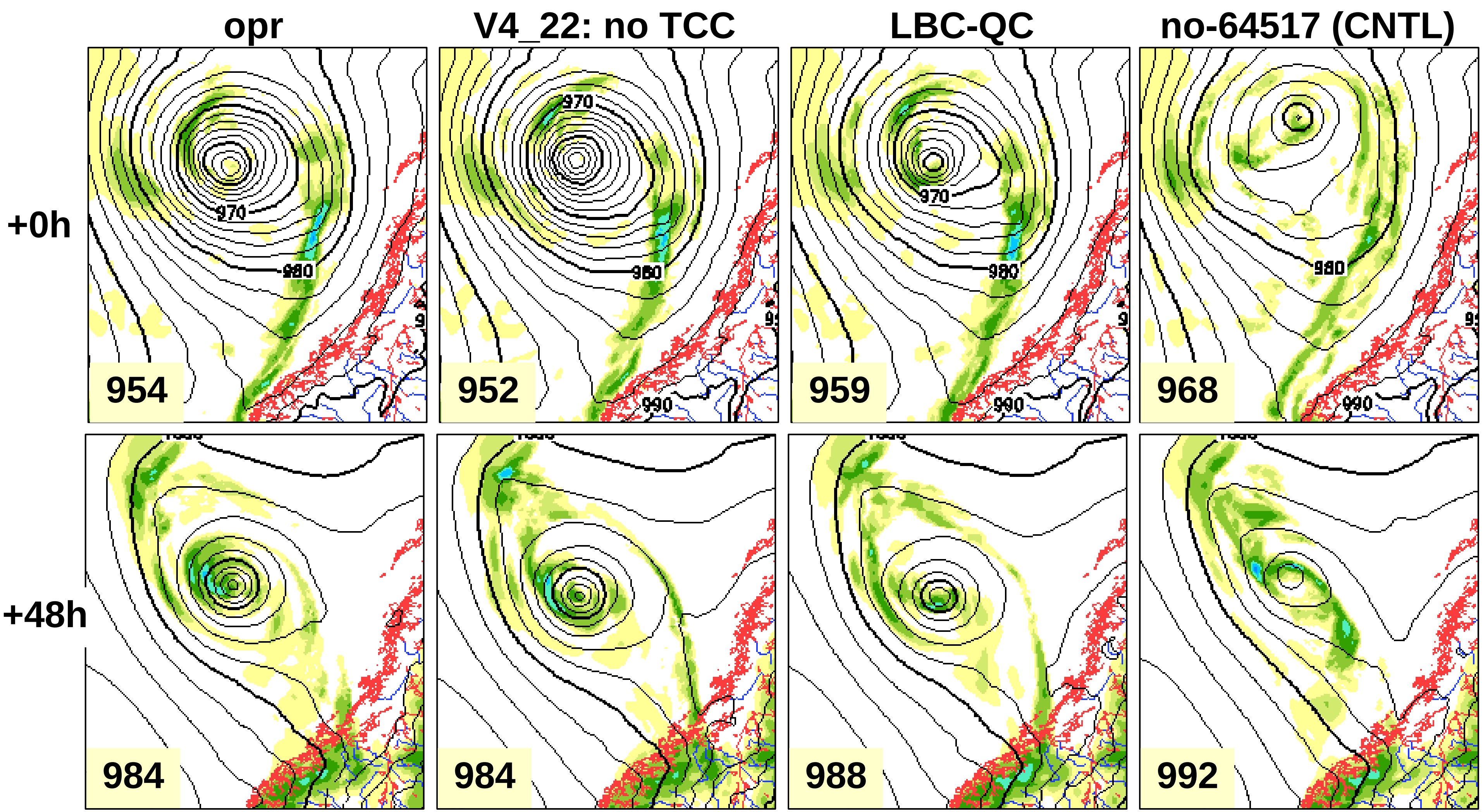
(at the location of buoy 64517)



LBC-QC rej. 16 Dec 20 UTC

SCC rej. 18 Dec 0 UTC

SCC rej. 19 Dec 10 UTC


opr
V4_22: no TCC
LBC-QC
no-64517 (CNTL)
+0h
+48h
954
952
959
968
984
984
988
992
970
980
990

case 2 :
forecast run from 17 Dec. 2011, 12 UTC

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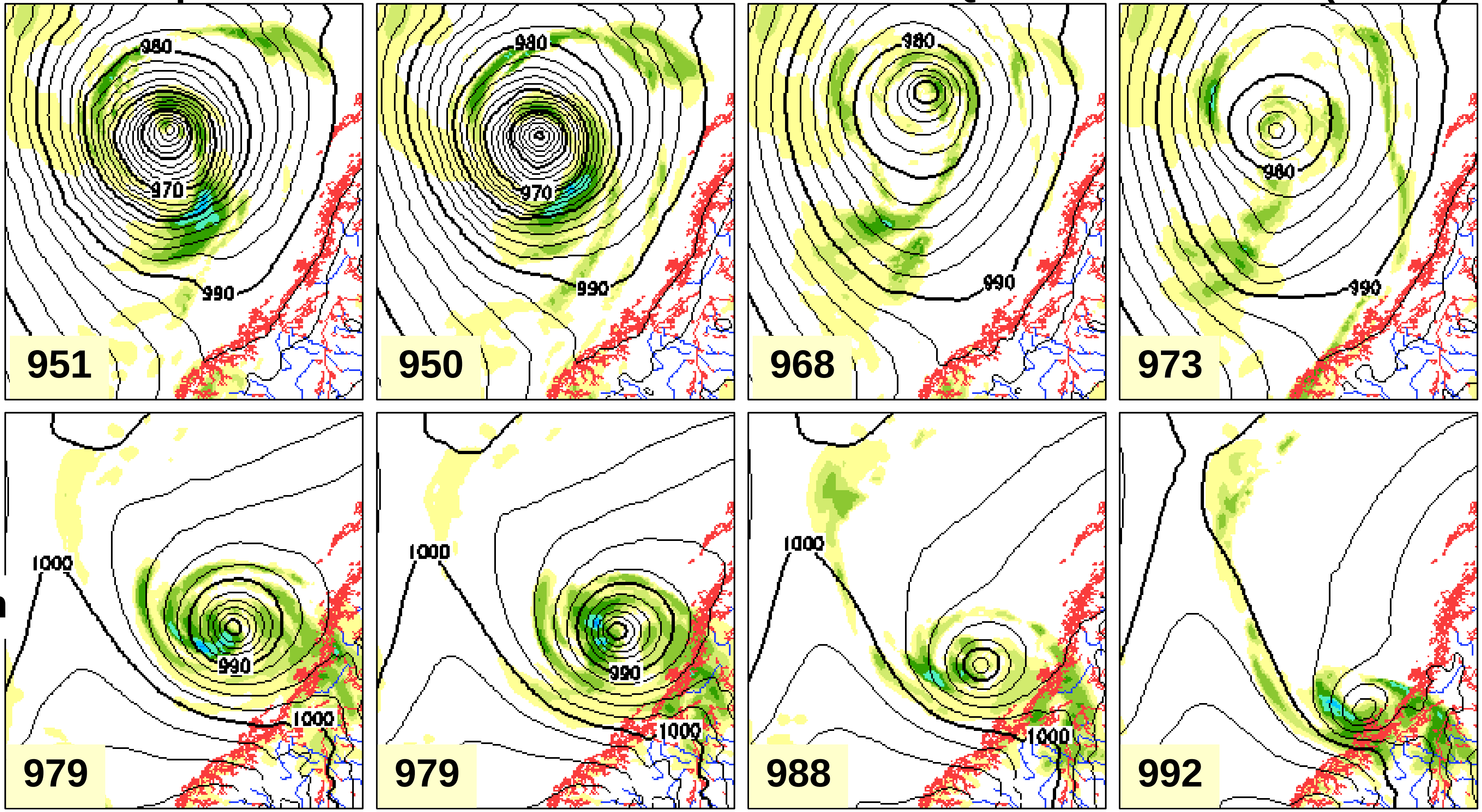
	opr	V4_22: no TCC	LBC-QC	no-64517 (CNTL)
+0h	951	950	968	973
+45h	979	979	988	992



case 2 :
forecast run from   18 Dec. 2011, 00 UTC

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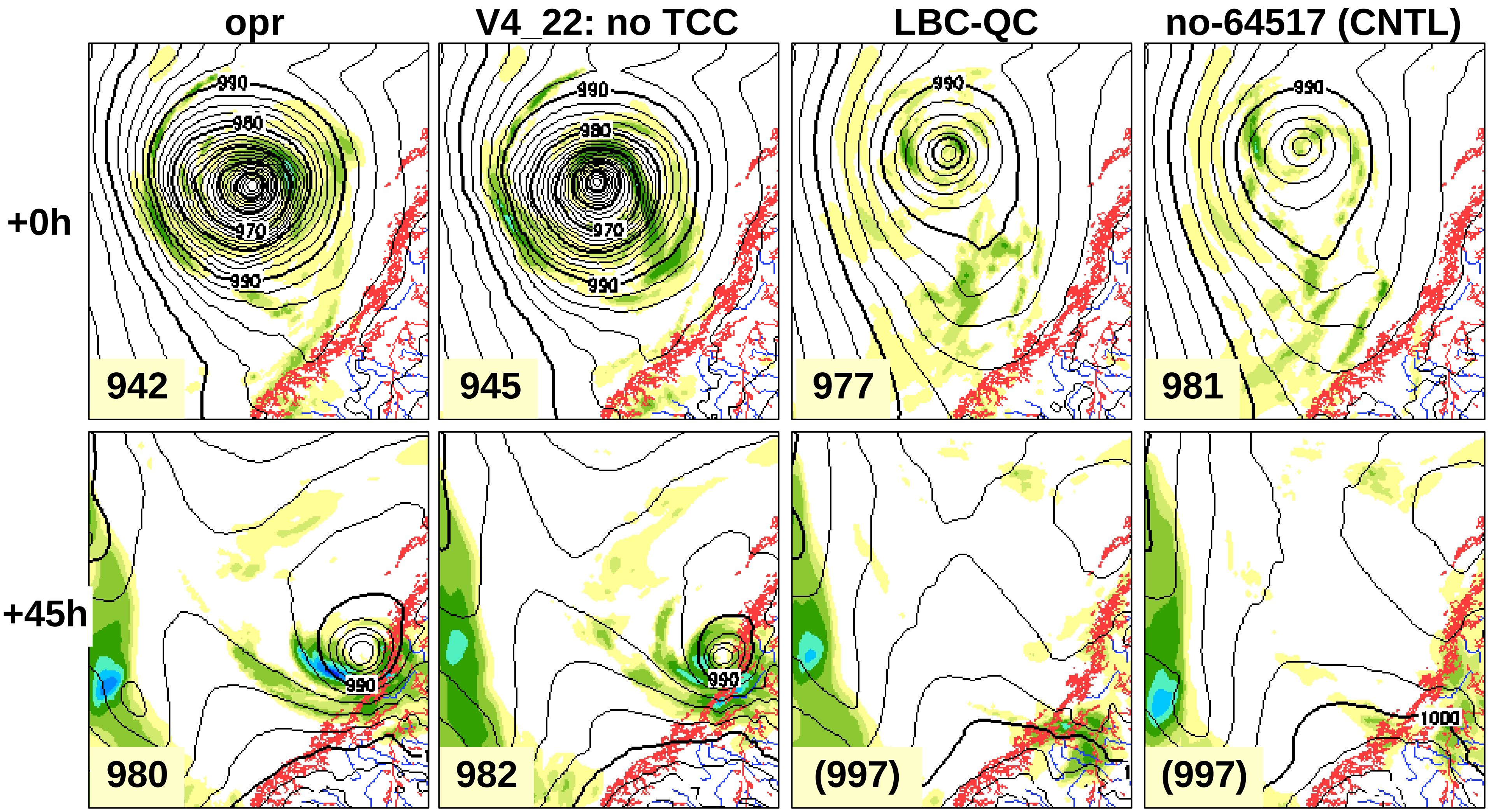

case 2 :
forecast run from 18 Dec. 2011, 12 UTC

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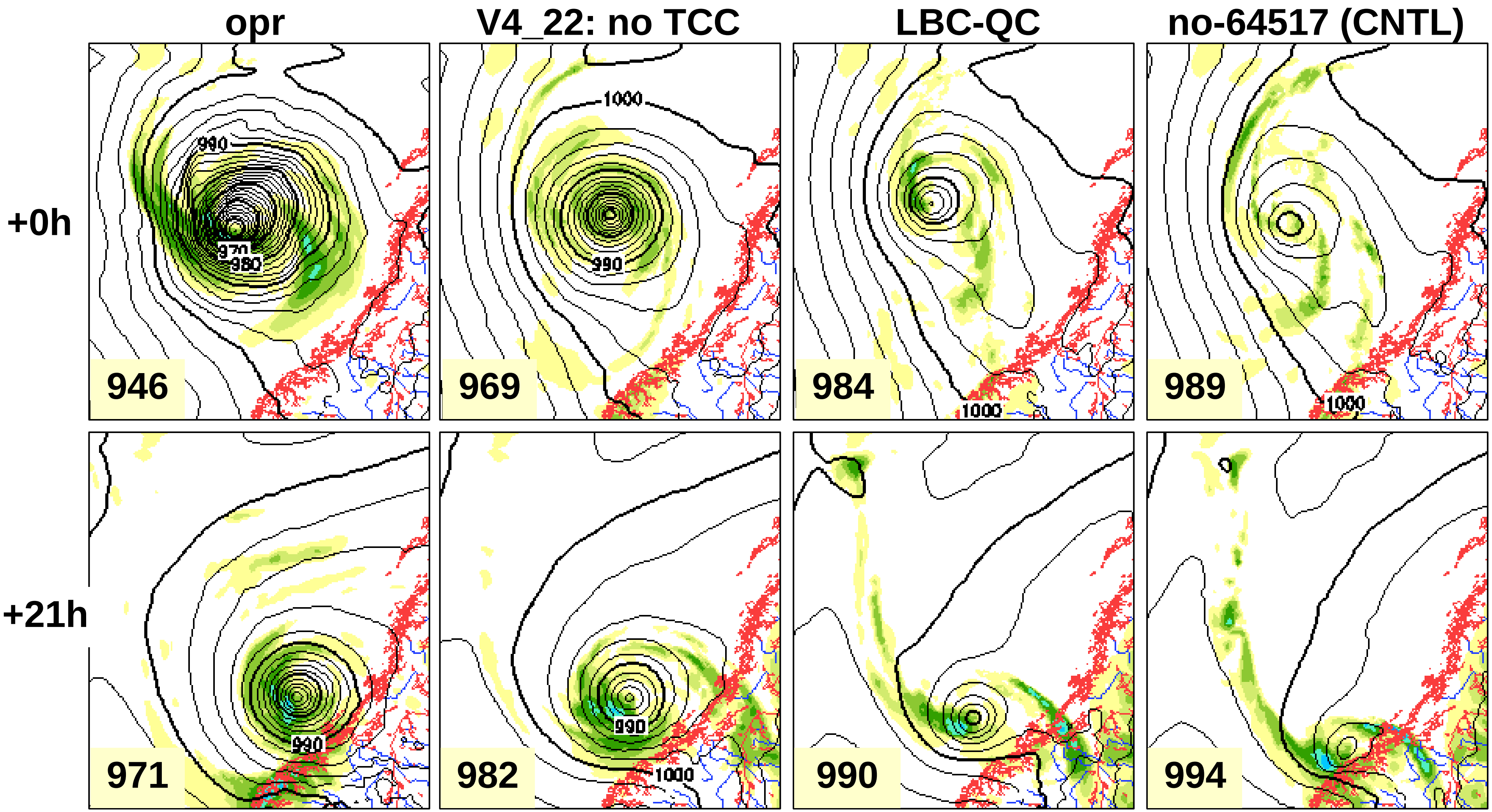

quality control of surface pressure p_s :
case 3 : 5 Feb. 2012

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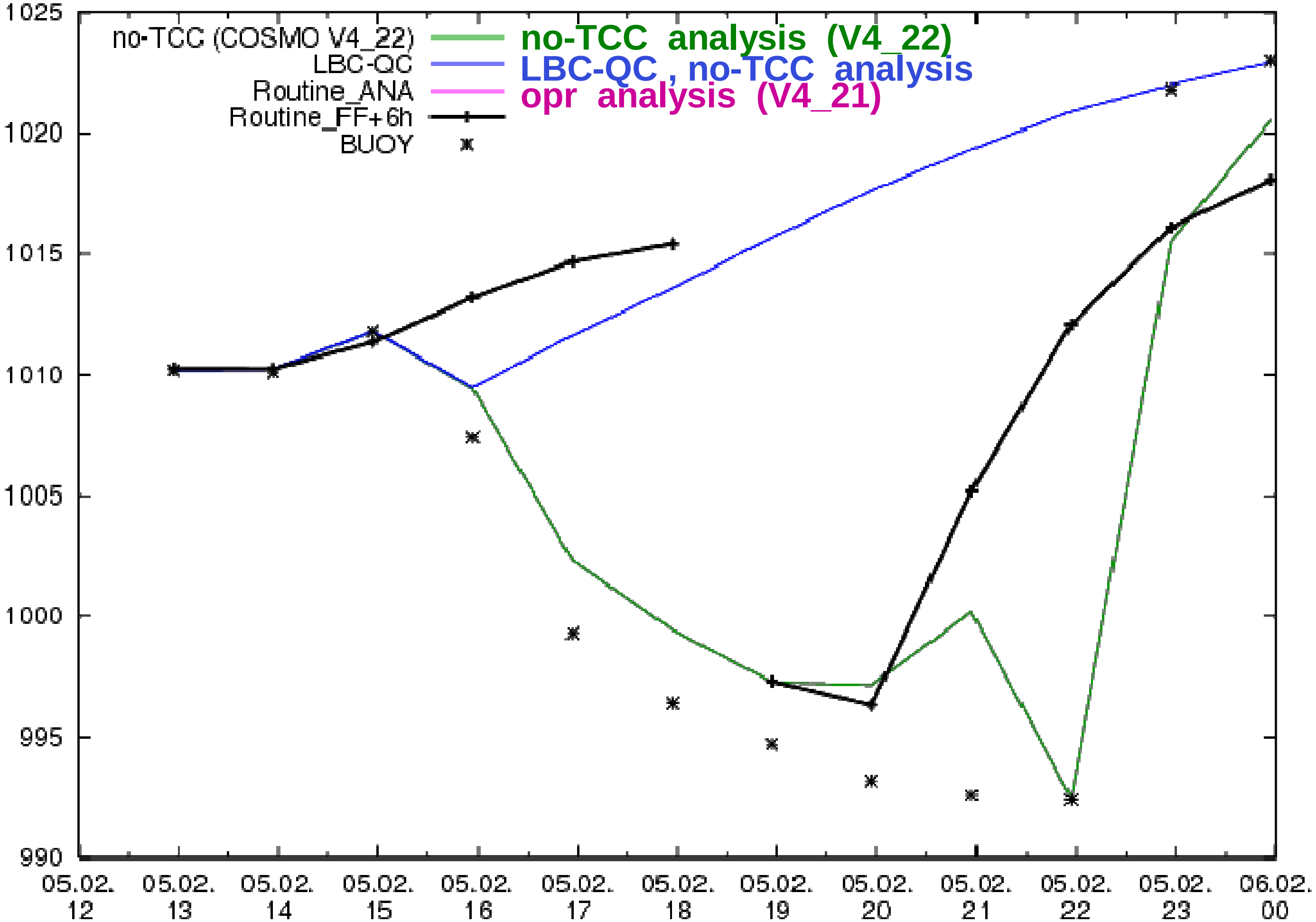
surface pressure

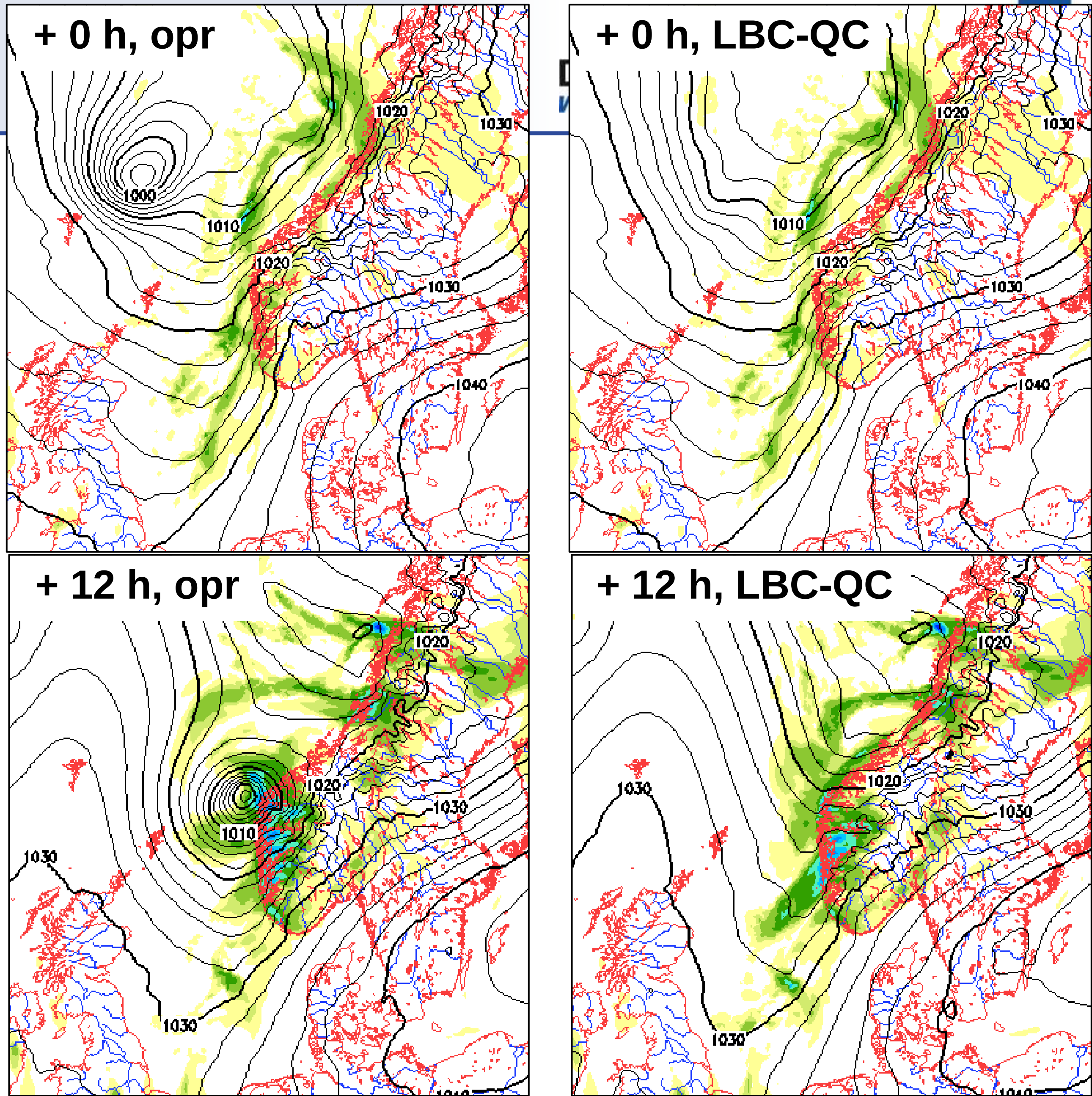
(at the location of buoy 64617)



rejected 21, 22 UTC

case 3 :
5 Feb. 2012

forecast run starting at 5 Feb. 2012, 18 UTC



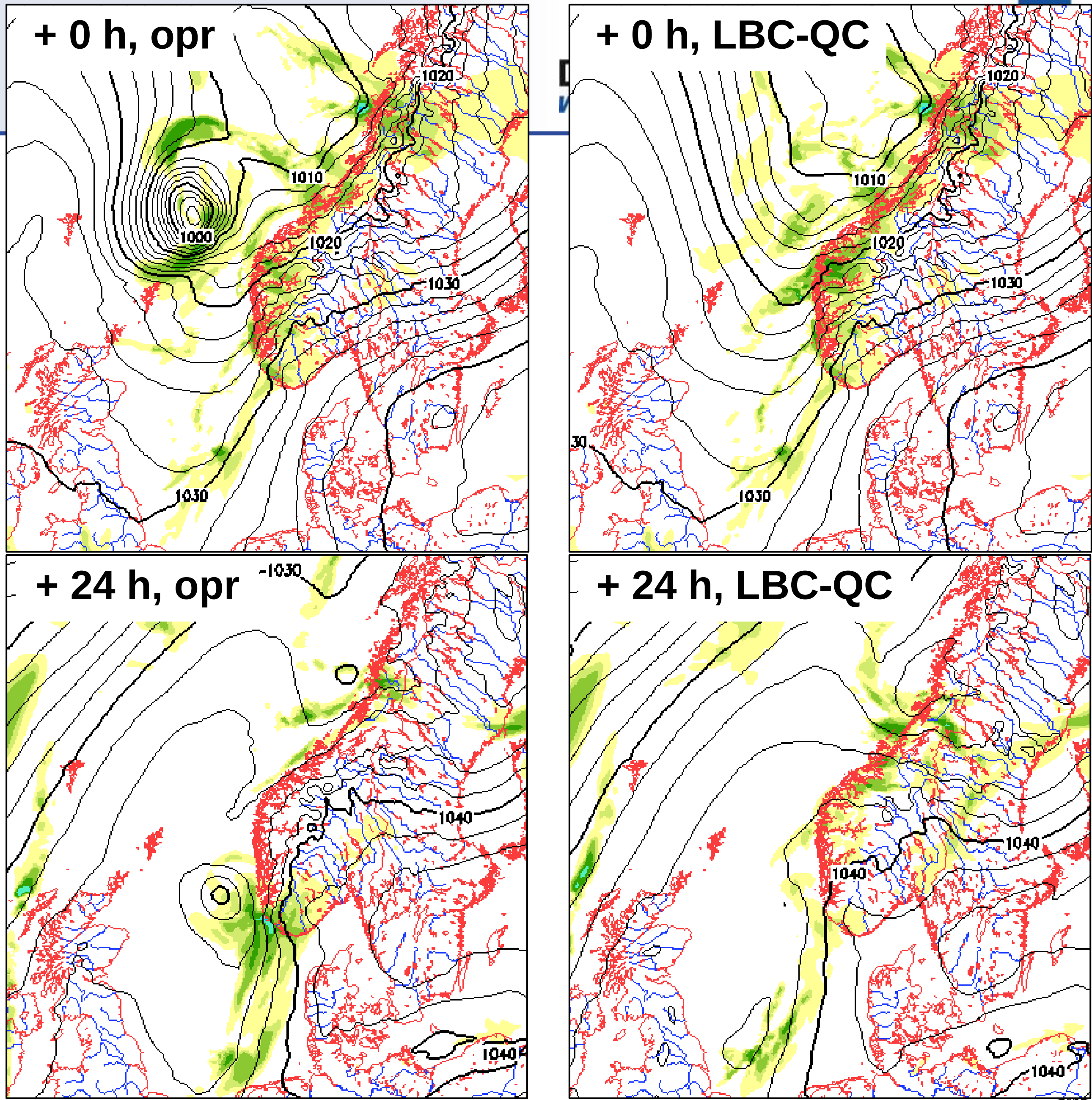
→ **opr same as V4_22: 64617 accepted until 20 UTC, rejected 21, 22 UTC**

→ **LBC-QC: all erroneous obs of 64617 (16 – 22 UTC) rejected**

→ **problem solved completely**

case 3 :
5 Feb. 2012

forecast run starting at 6 Feb. 2012, 0 UTC



→ **opr same as V4_22: 64617 accepted until 20 UTC, rejected 21, 22 UTC**

→ **LBC-QC: all erroneous obs of 64617 (16 – 22 UTC) rejected**
→ **problem solved completely**

check against 'lateral boundary fields'

- strong improvement in 2 cases with sequences of erroneous pressure obs from a single buoy, which led to strong analysis errors
- very little impact in 2-week test (16 April – 1 May 2012, incl. cyclonic cases) (verif. against radiosondes)
- Christmas Storm 26 Dec. 1999: negative impact negligible

  (9 - 12 UTC: 4 obs rejected by LBC-QC, but finally accepted by LBC-SCC
  12 UTC: 1 obs 'behind the storm' rejected by LBC-QC, but no differences
  betw. experiment / control in model surface pressure at obs location)

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