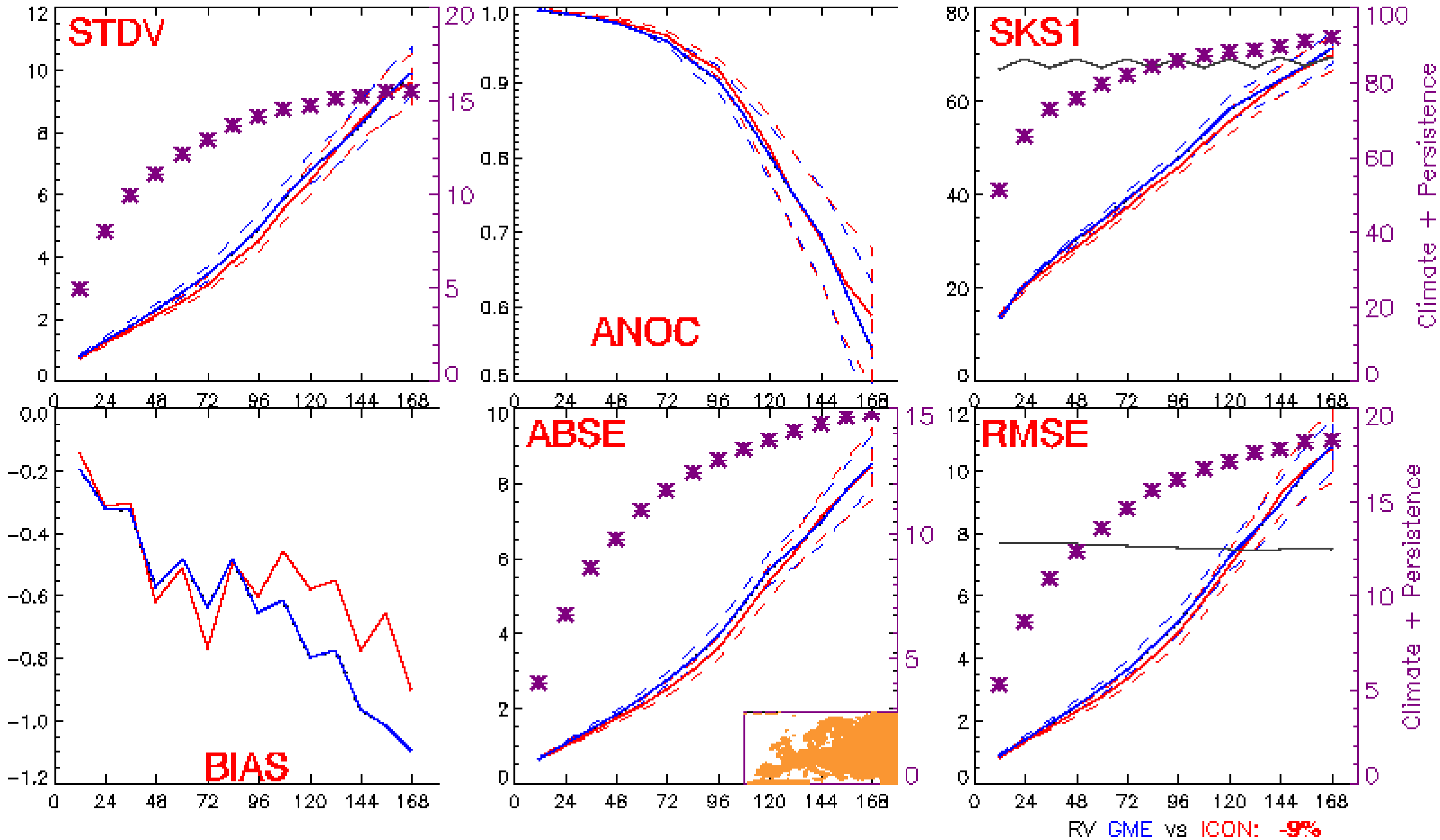
A study on the behavior of root mean square error of forecasts for pressure against SYNOP data

Ulrich Damrath (DWD),
Flora Gofa (HNMS),
Pirmin Kaufmann (Meteo-Schweiz)
and all verificators in COSMO

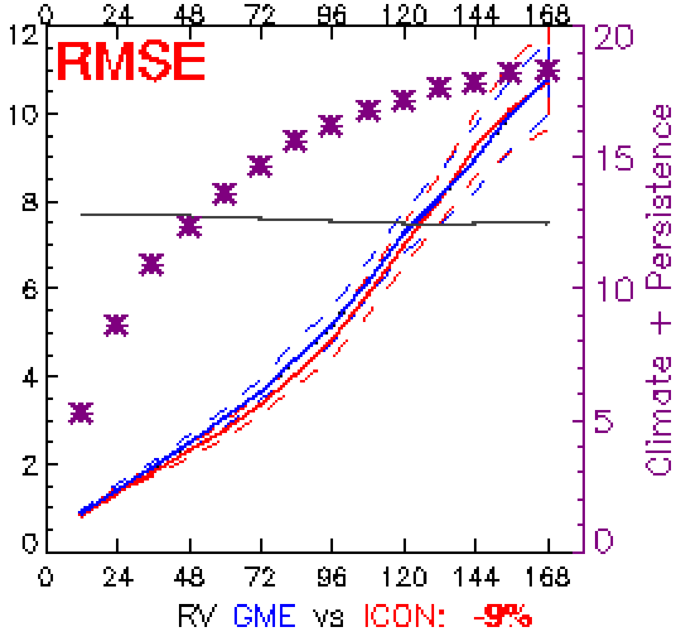
Typical behaviour of forecast errors for mean se level pressure

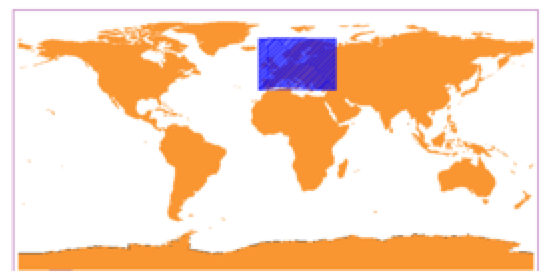
Verification of forecasts from 16.12.2014 12UTC till 09.02.2015 12UTC (area mean) GME __, ICON __, Persistence, Lines: climate(right :
Parameter: Bodendruck, region: EUROPE , Rahmen: Bootstrap Konfidenzintervall 5 – 95 %



Plottime: 20:46:54 17.02.2015

Typical behaviour of forecast errors for mean sea level pressure



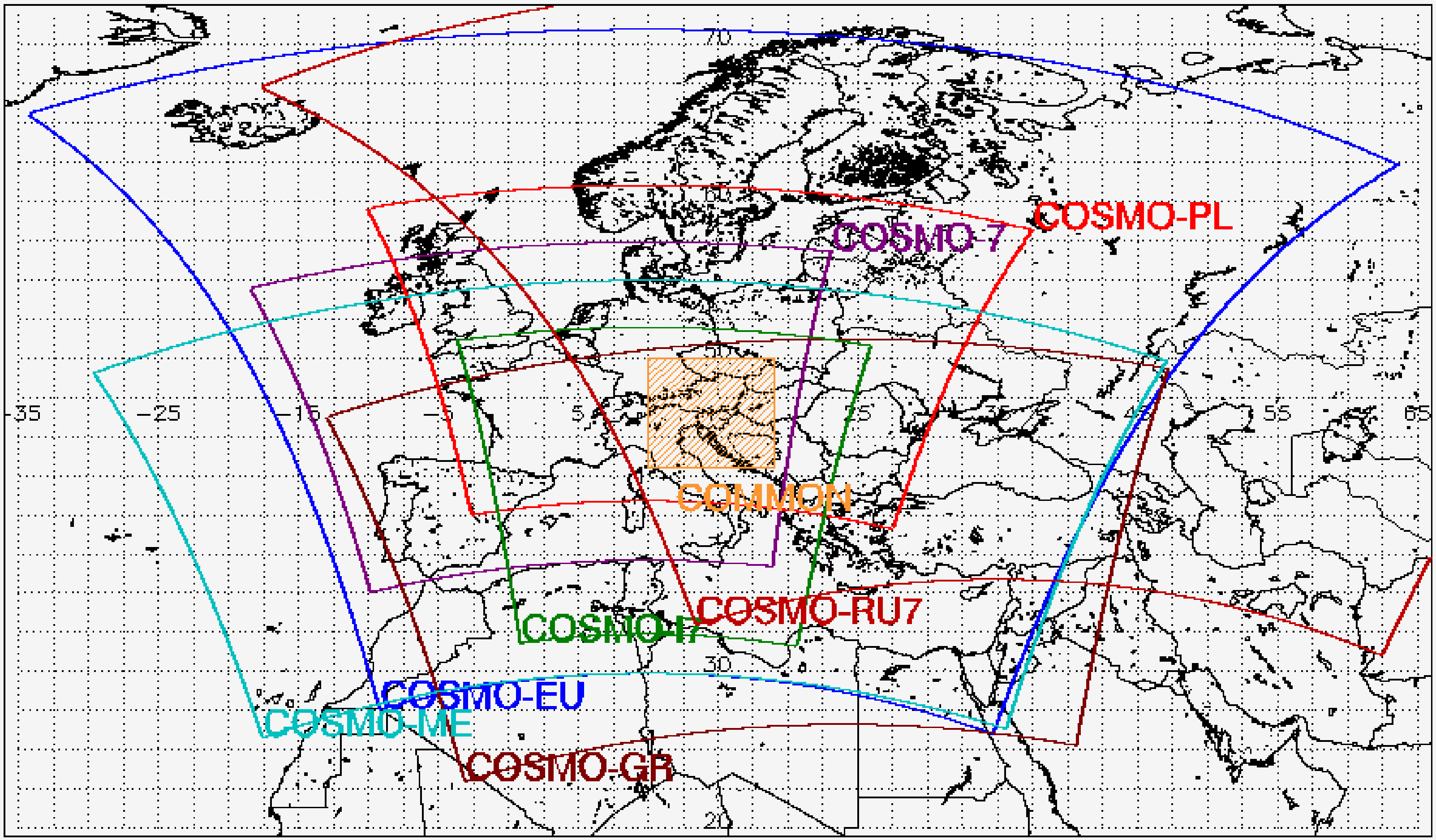


RMSE of forecasts for mean surface level pressure
Period: 16.12.2014 – 09.02.2015
Region: Europe

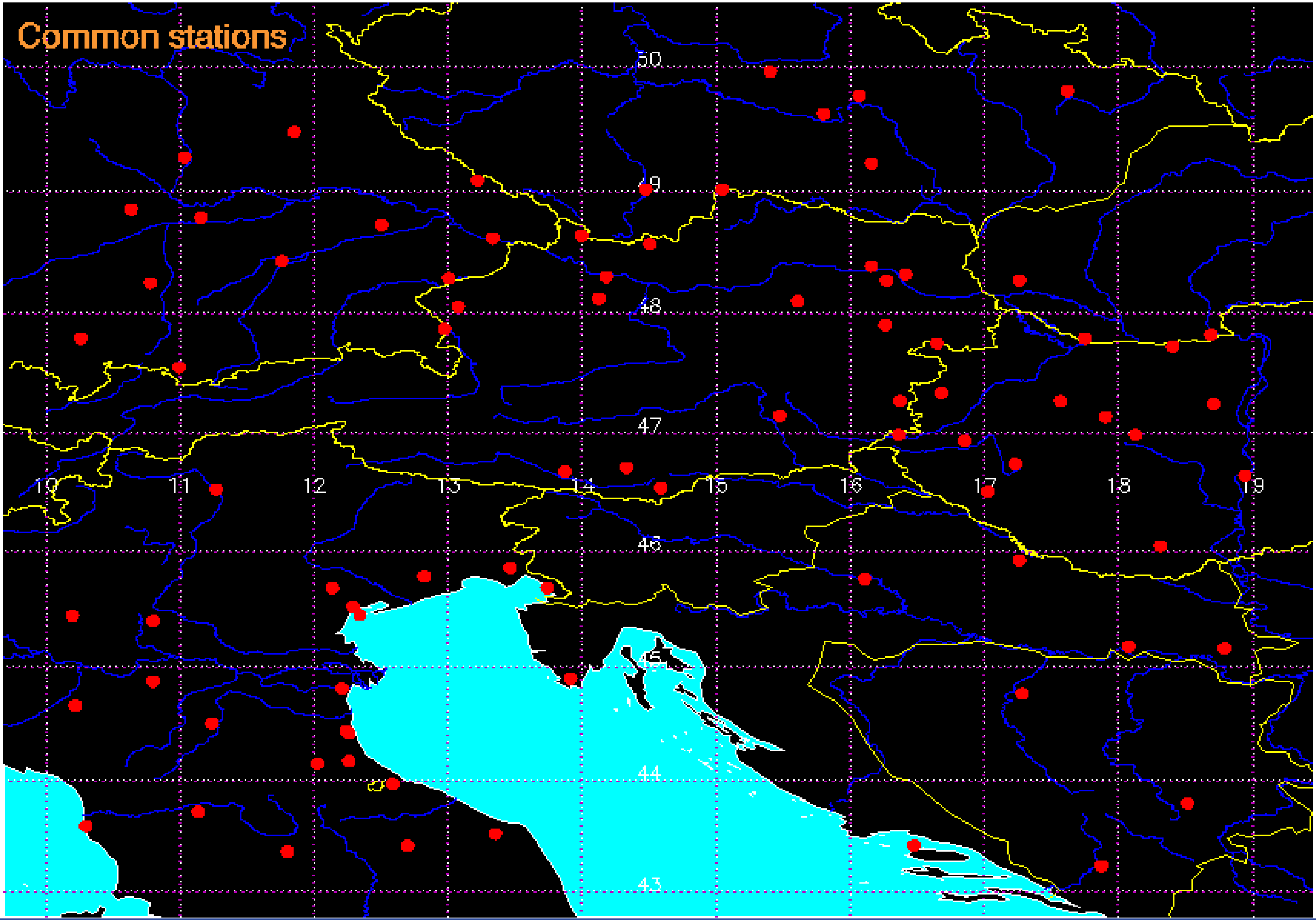
About the common domain

- Typical *qualitative* errors over the common domain
  - Mean surface level pressure in intervals of 3 hours
  - Wind 10m in intervals of 3 hours
  - Precipitation in intervals of 6 hours
  - Goal-setting:
    - Demonstration of differences of forecast quality depending on operational model configuration (boundary conditions, location of model domain, other aspects)

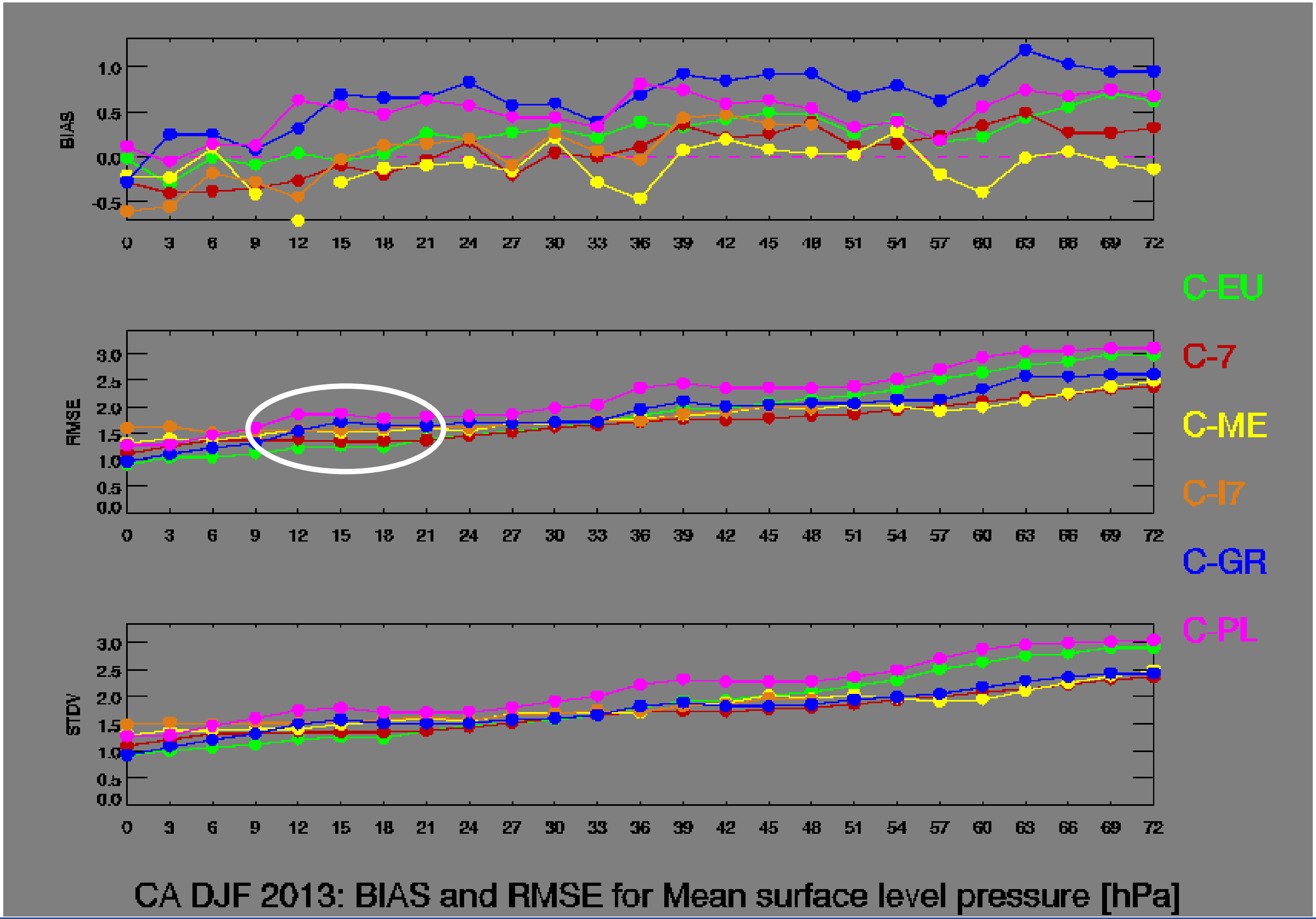
Common domain of COSMO-models



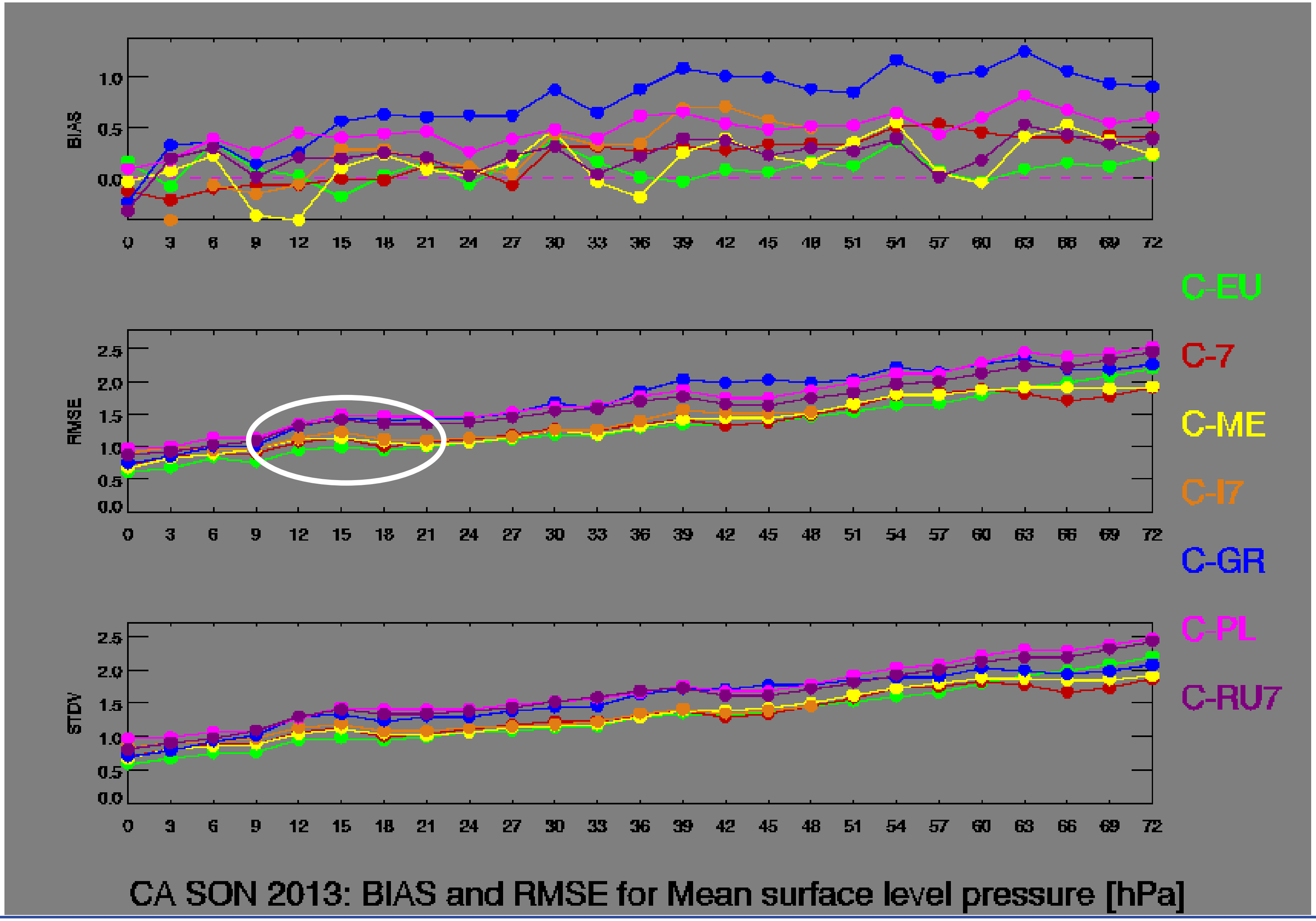
Stations over the common domain



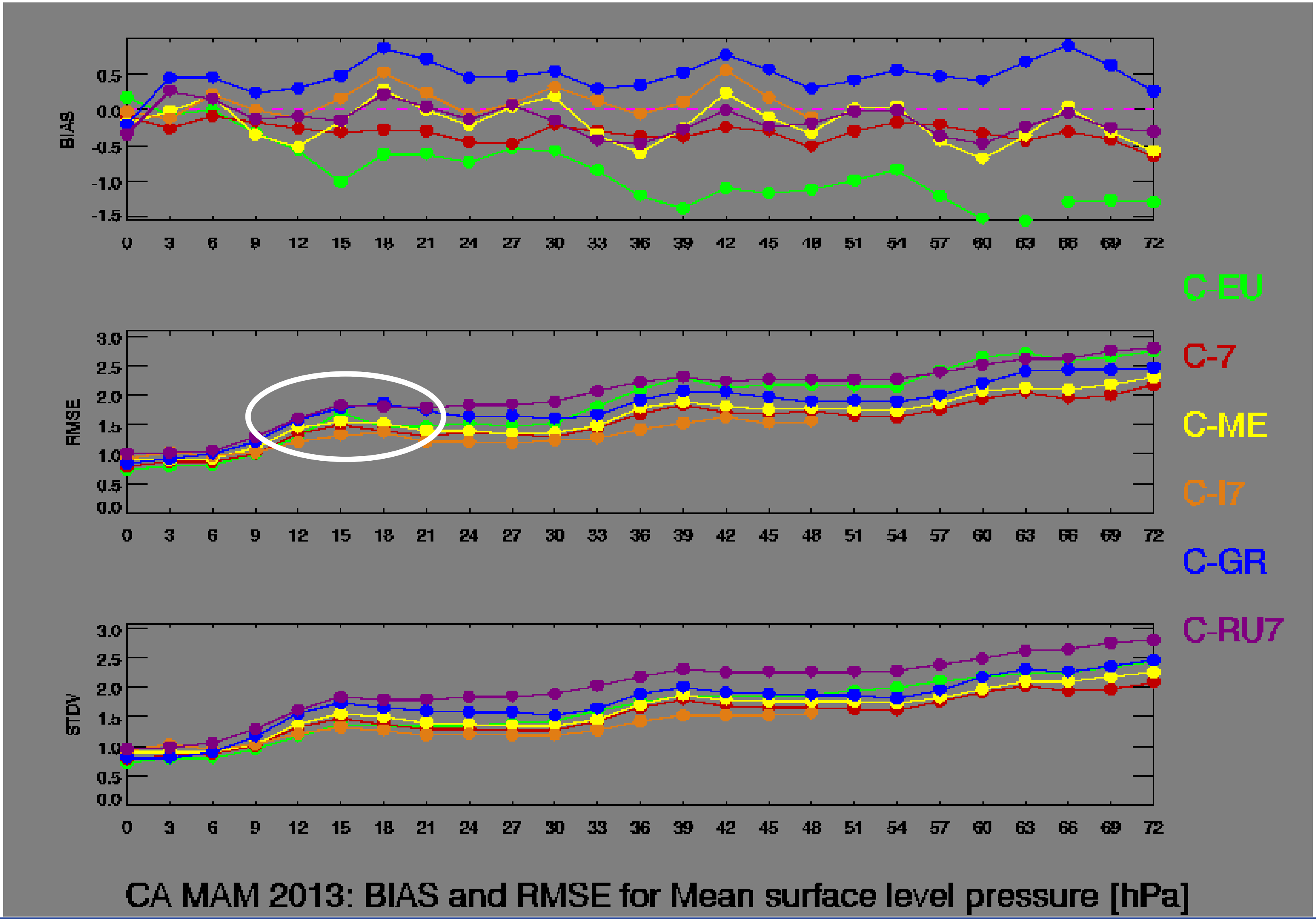
Forecast errors for mean sea level pressure (DJF 2012/2013)



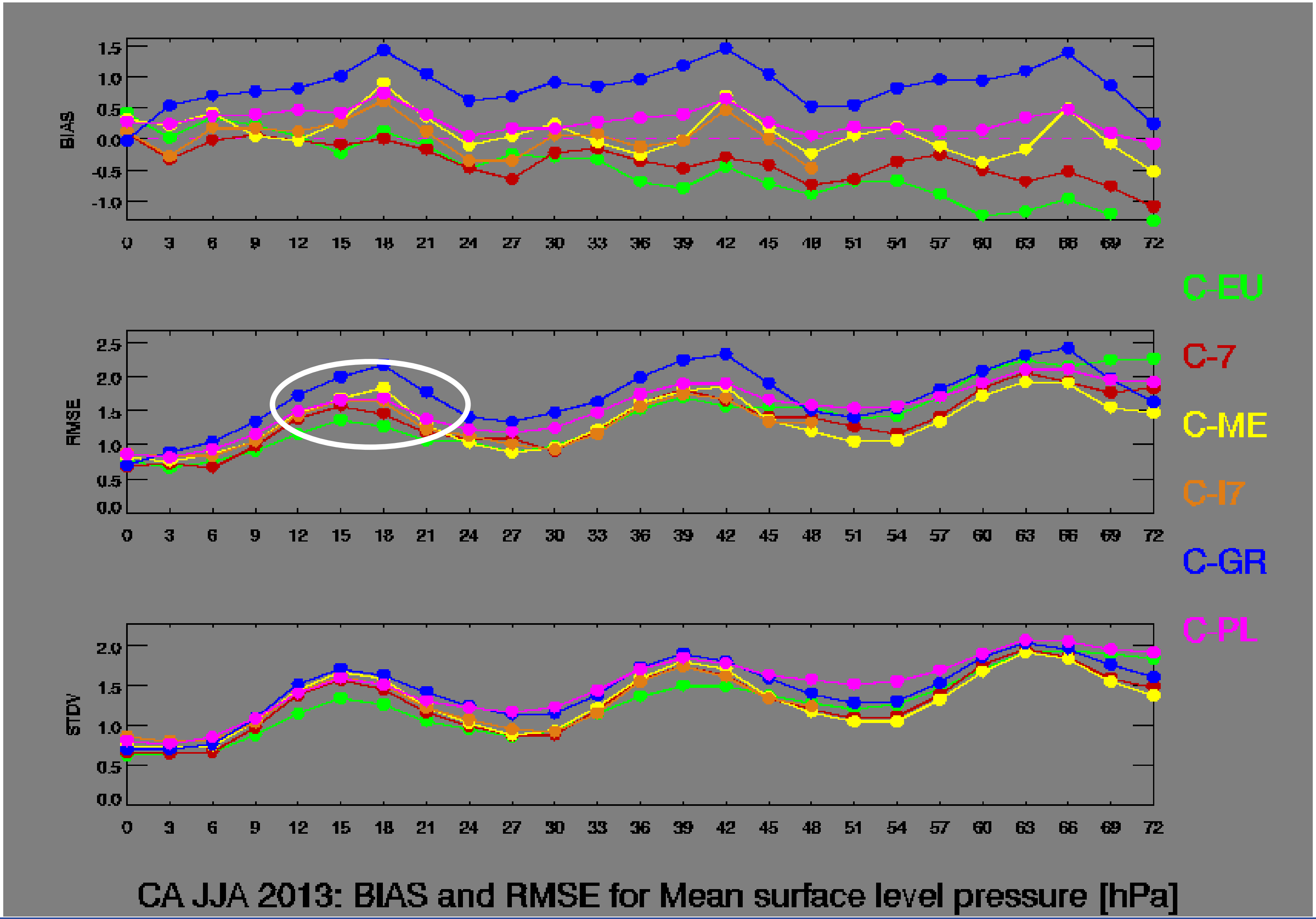
Forecast errors for mean sea level pressure (SON 2013)



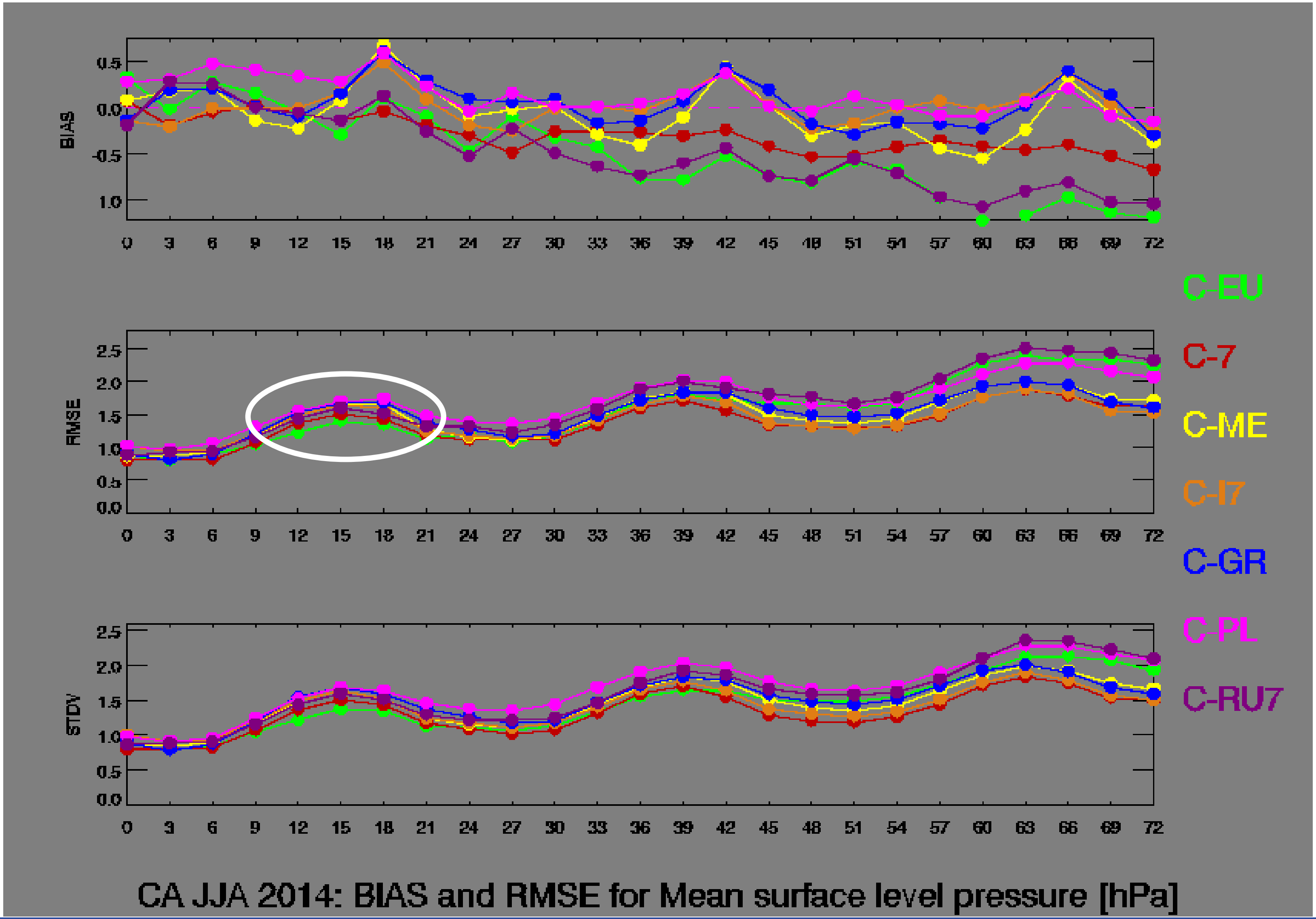
Forecast errors for mean sea level pressure (MAM 2013)



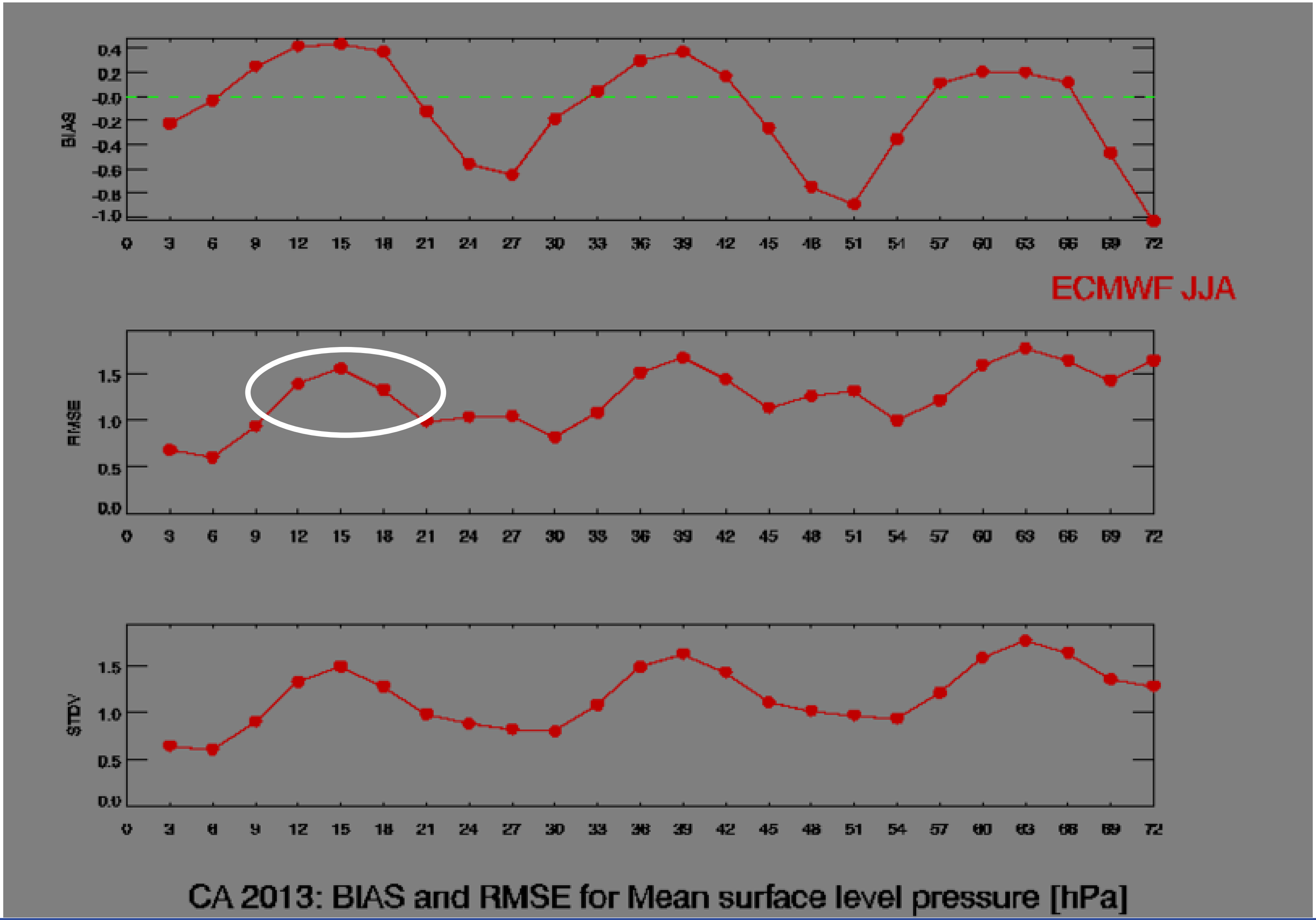
Forecast errors for mean sea level pressure (JJA 2013)



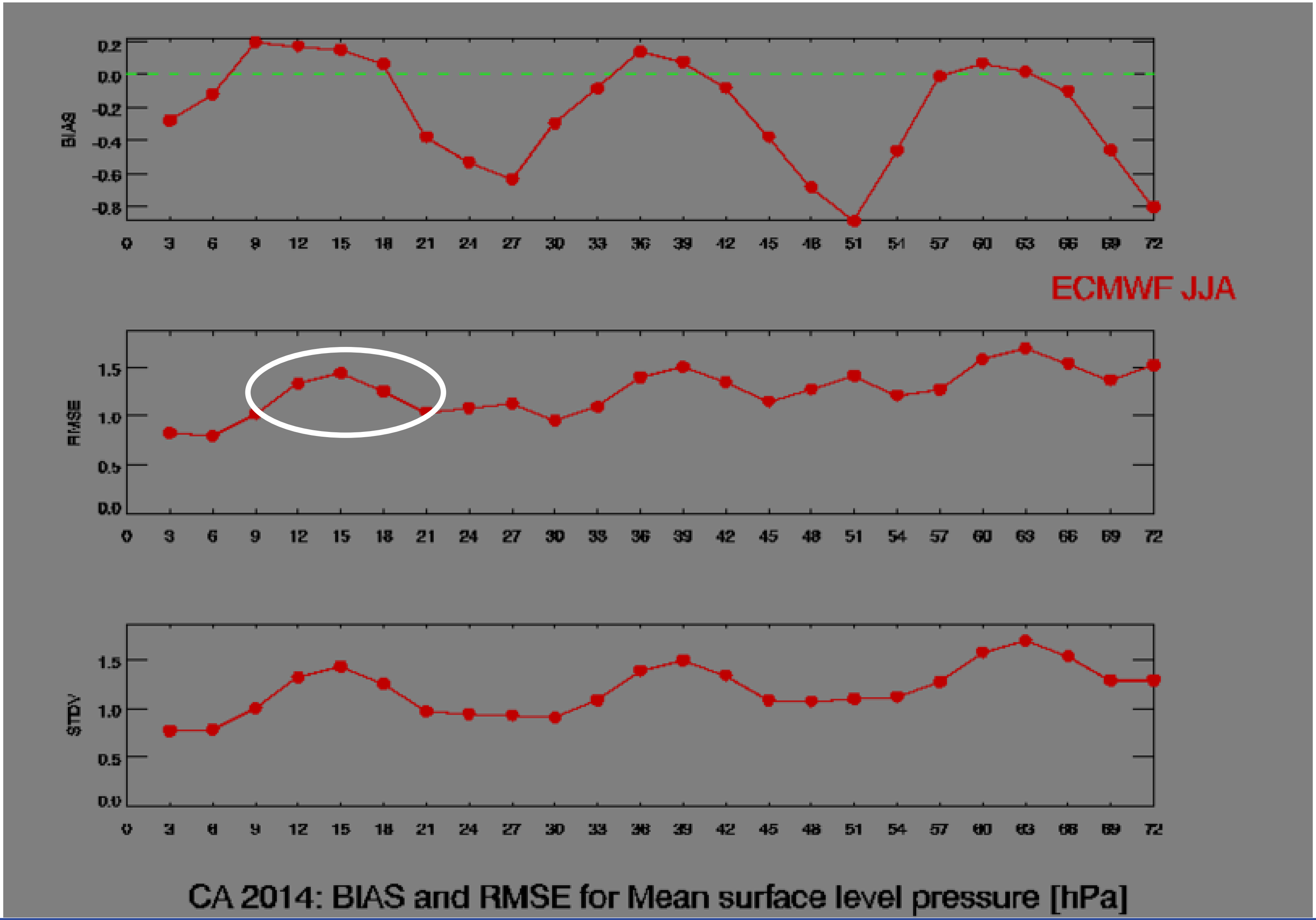
Forecast errors for mean sea level pressure (JJA 2014)



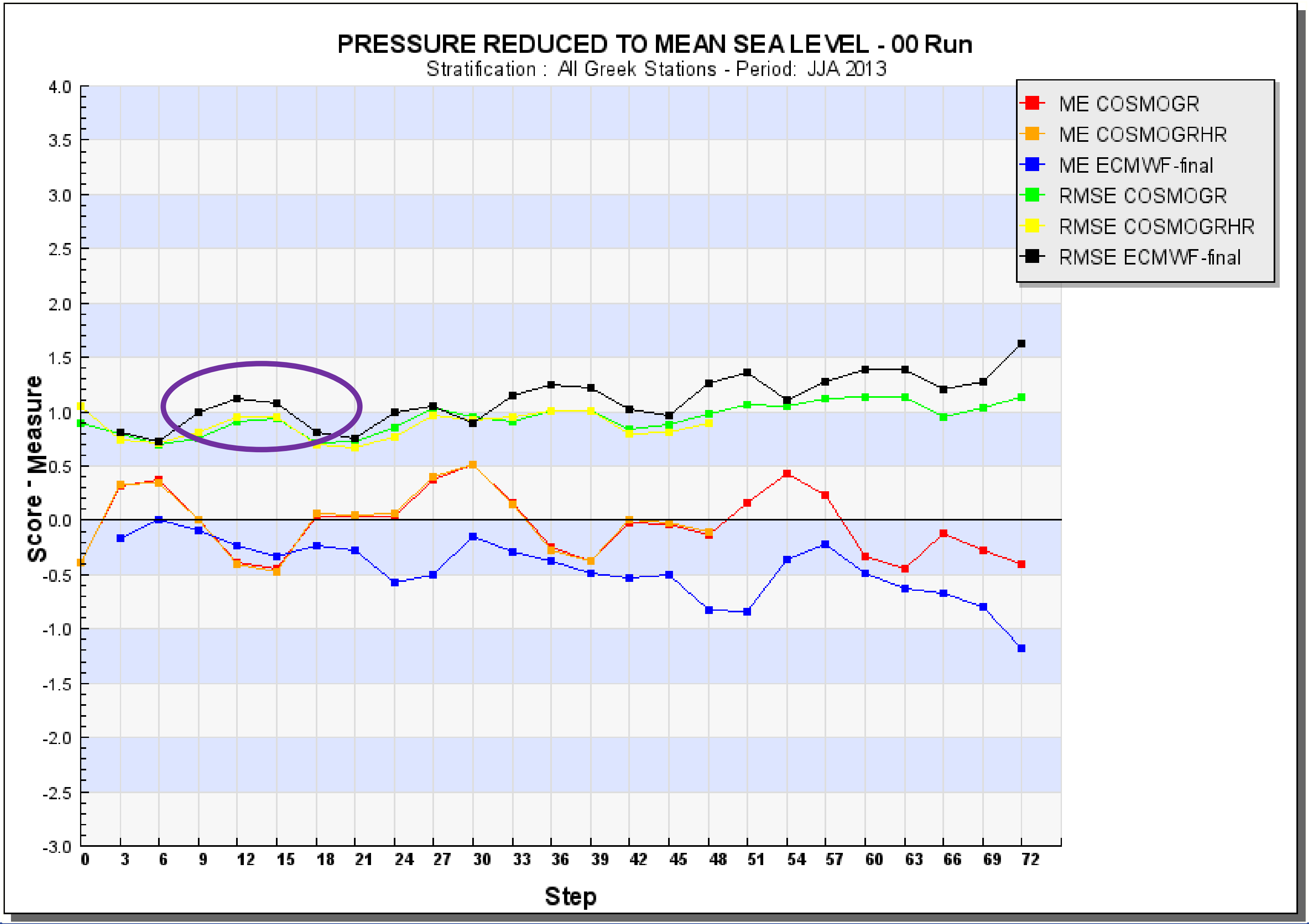
Forecast errors for mean sea level pressure (JJA 2013 ECMWF)



Forecast errors for mean sea level pressure (JJA 2014 ECMWF)



Forecast errors for mean sea level pressure (JJA 2014 COSMO-GR and ECMWF)



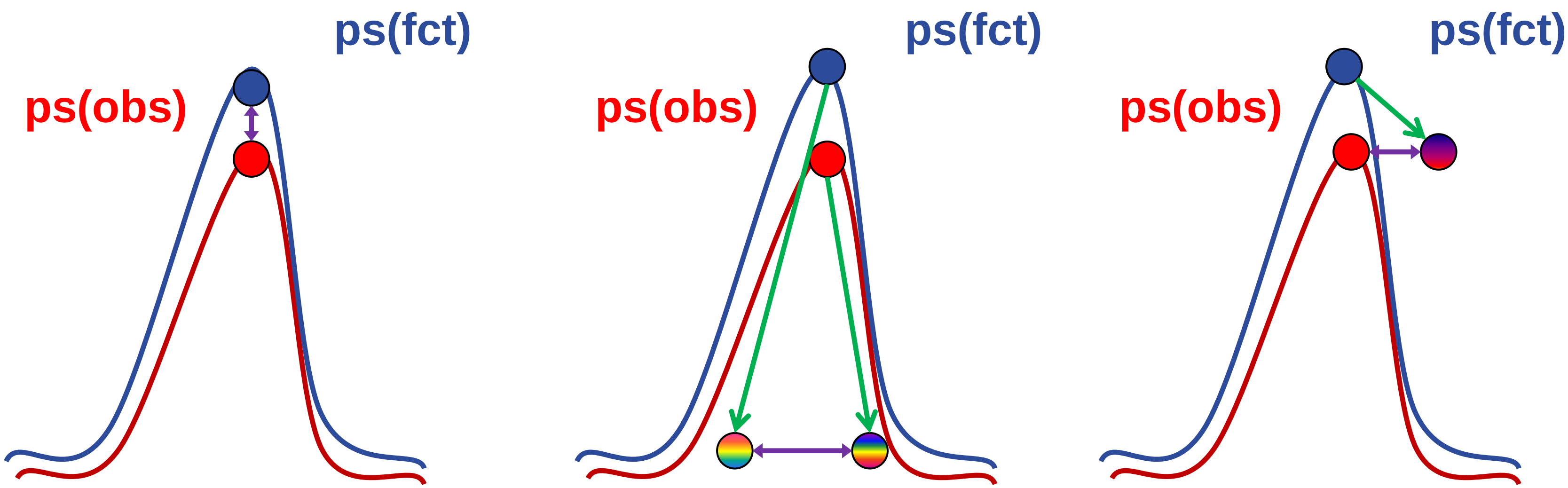
How to get mean surface level pressure from temperature and pressure at station level – assuming hydrostatic conditions

$$p_0 = p_S \cdot \exp\left(\frac{\frac{g_n}{R} \cdot H_p}{T_S + \frac{a \cdot H_p}{2} + e_S \cdot C_h}\right) \qquad (3.2)$$

where g_n is the standard acceleration of gravity = 9.806 65 m s^{-2} and R is the gas constant of dry air = 287,05 J /kg / K.

www.wmo.int/pages/prog/gcos/.../CIMO_Guide-7th_Edition-2008.pdf

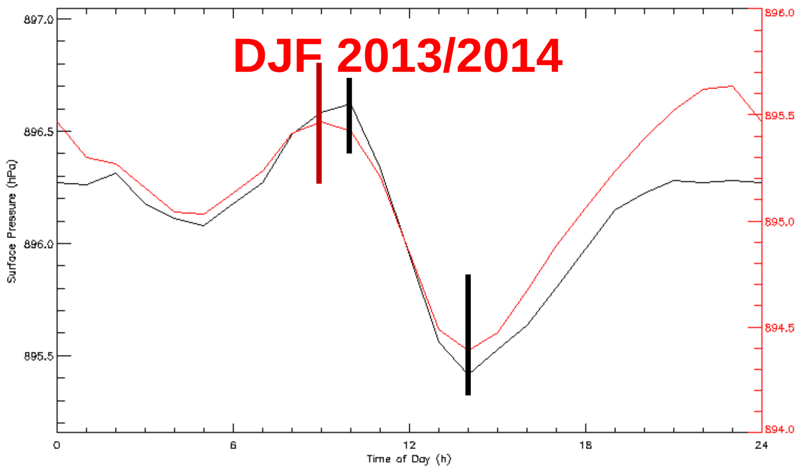
Different possibilities to verify pressure forecasts against observations

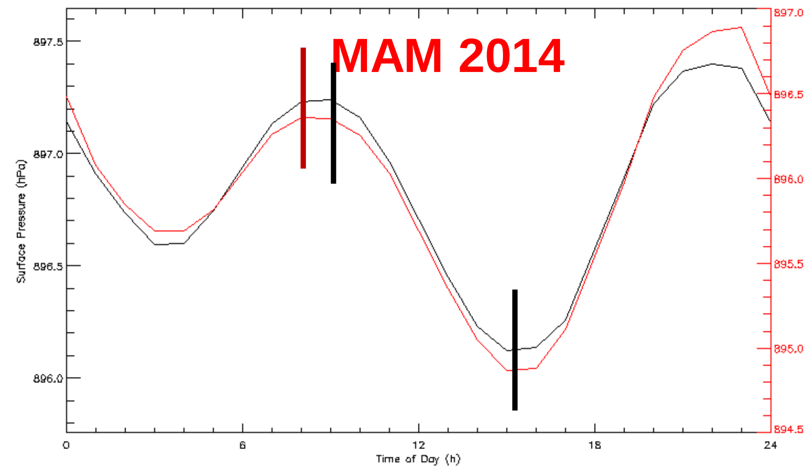


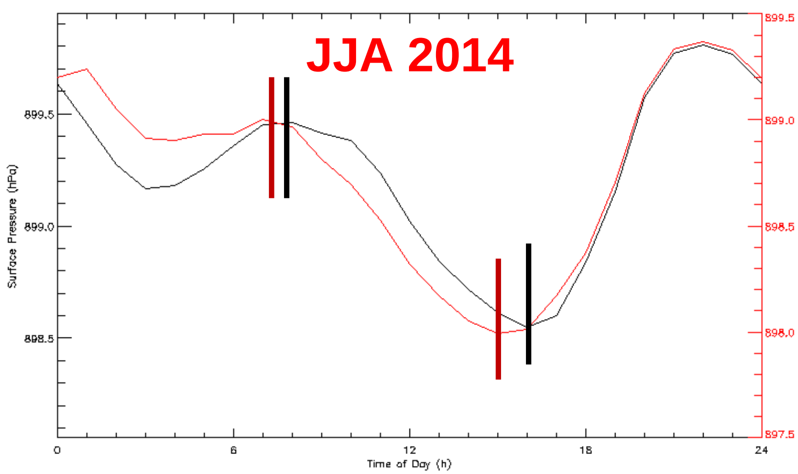
Direct comparison of ps(obs) with ps(fct):	Reduction to msl:	Reduction to station level:
Advantage: no reduction problem	**Advantage:** no effect of different heights if T and lapse rate are reasonable	**Advantage:** small reduction problem
Disadvantage: RMSE is strongly influenced by differences between station heights and heights of model points, results for different models cannot be compared easily	**Disadvantage:** possible reduction problem due to different reduction procedures for observations and forecasts	**Disadvantage:** results for different models may be difficult to interpret

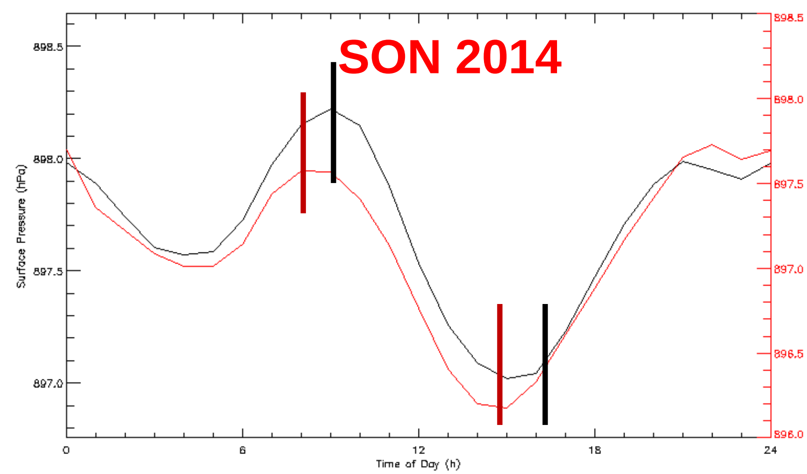
Diurnal cycle of pressure at surface over Switzerland (red : COSMO-7, black: observation)

CONSORTIUM FOR SMALL SCALE MODELING
COSMO









About the diurnal cycle of ps

Discussion began ~300 BC with observations by Pytheas and has been continued by a lot of scientists (Bacon, Newton, Laplace, Haurwitz ...

The atmospheric solar heating, combined with upward eddy conduction of heat from the ground, generates internal gravity waves in the atmosphere at periods of integral fractions of the solar day (primilary at the diurnal and semidiurnal periods). These waves cause regular oscillations at atmospheric wind, temperature and pressure fields, which are often referred to as atmospheric tides.
Dai, A., Wang, J: J. Atm. Sci. 56.(1999), 3874-3891

$$S = \sum_n S_n, \quad L = \sum_n L_n,$$

where

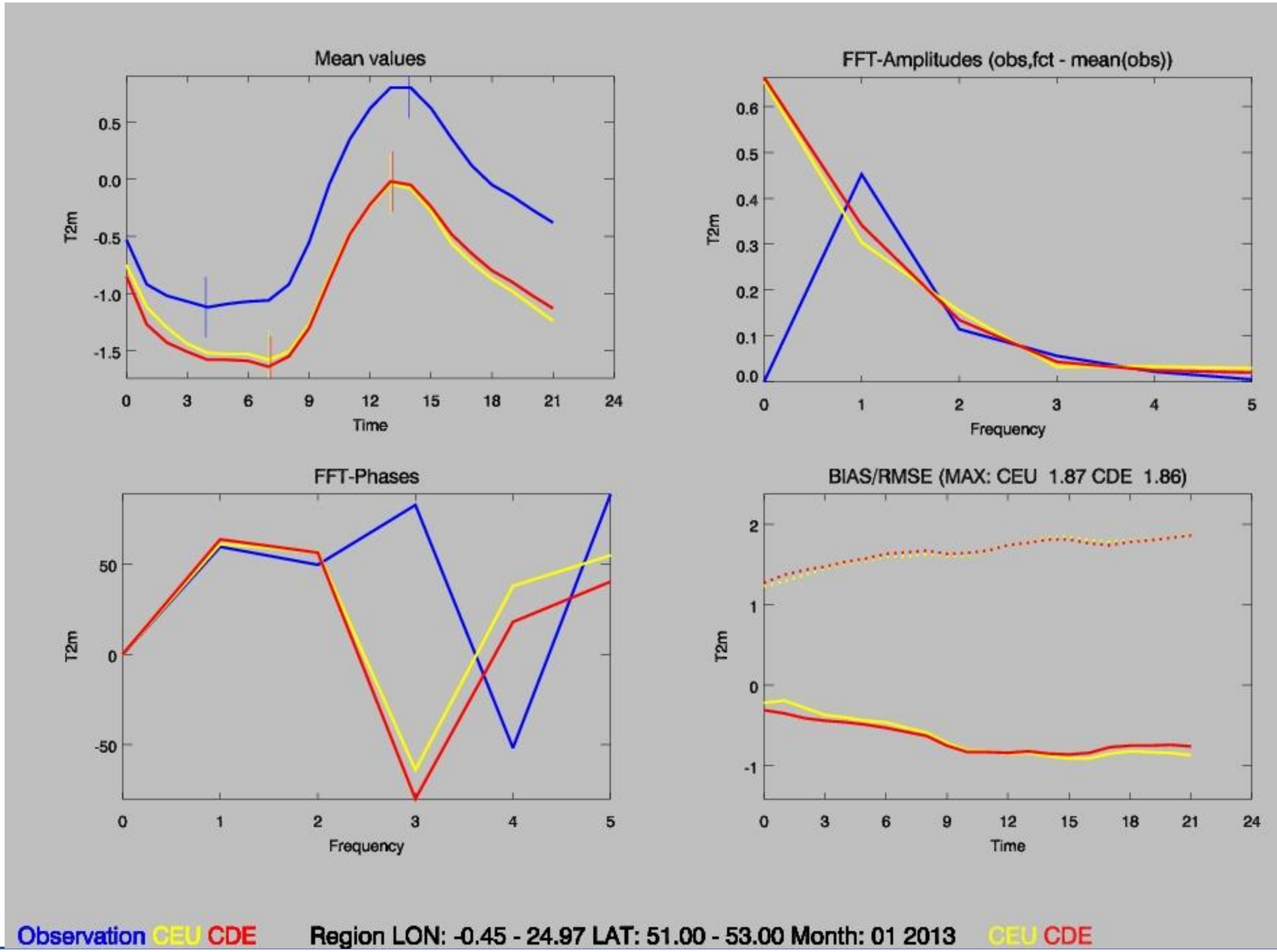
$$S_n = s_n \sin(nt + \sigma_n) = A_n \cos nt + B_n \sin nt,$$

$$L_n = l_n \sin(n\tau + \lambda_n) = a_n \cos n\tau + b_n \sin n\tau.$$

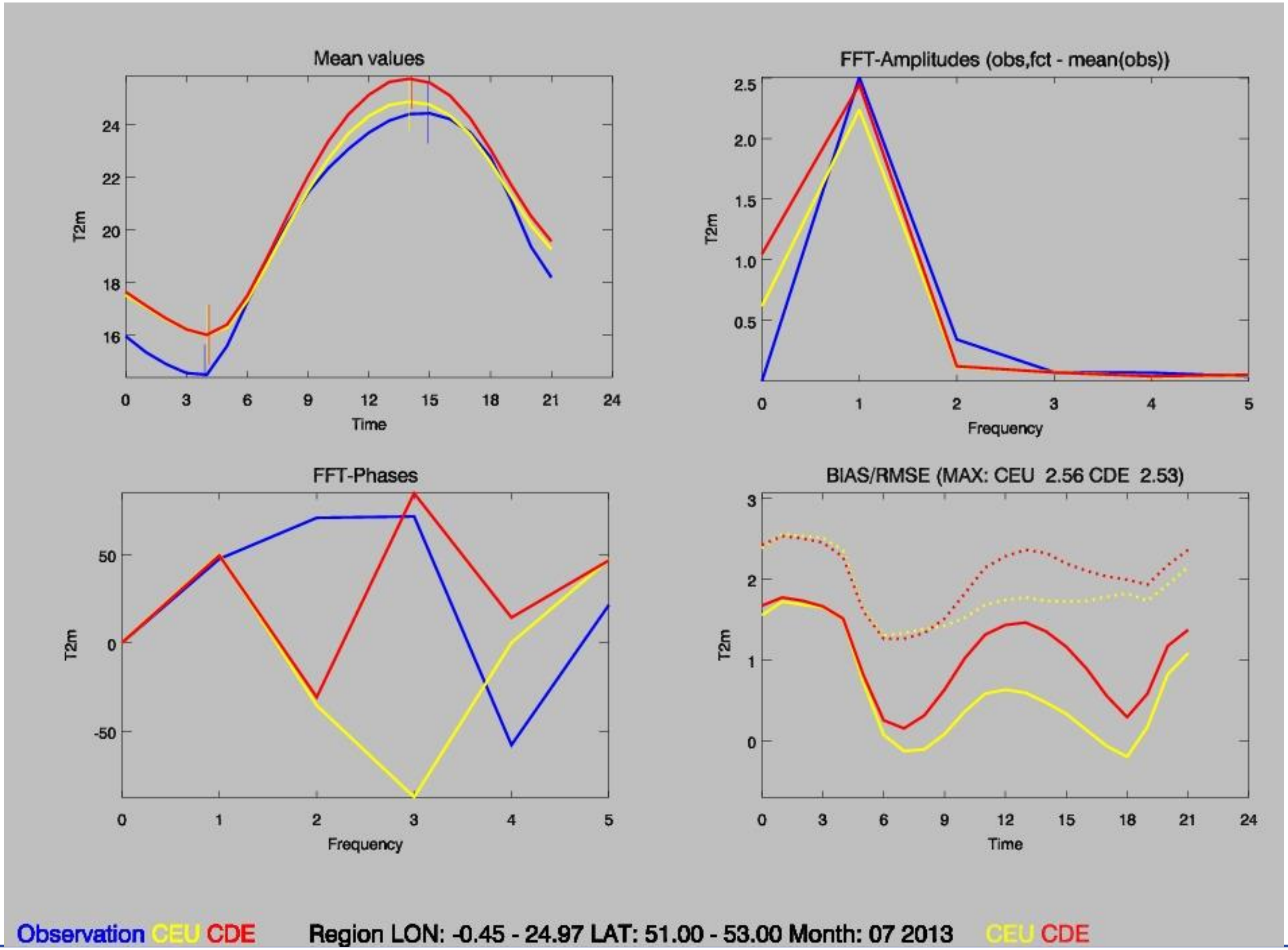
$$A_n = s_n \sin \sigma_n, \quad B_n = s_n \cos \sigma_n, \quad a_n = l_n \sin \lambda_n, \quad b_n = l_n \cos \lambda_n.$$

Chapman,S., Lindzen.R,S.:
Atmospheric Tides,
Reidel Publishing Company, 1970

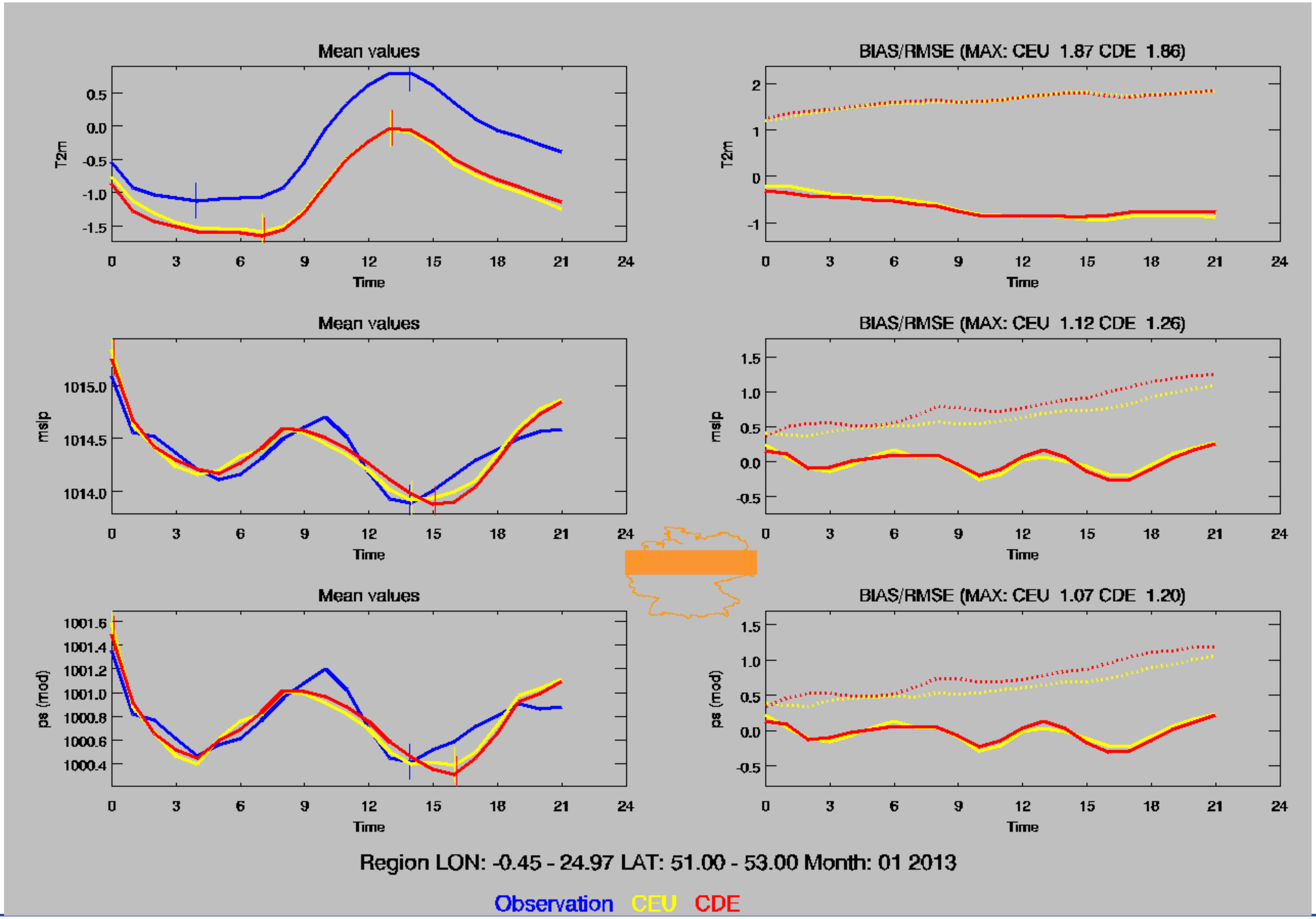
Diurnal cycle of T2m over a part of Germany January 2013



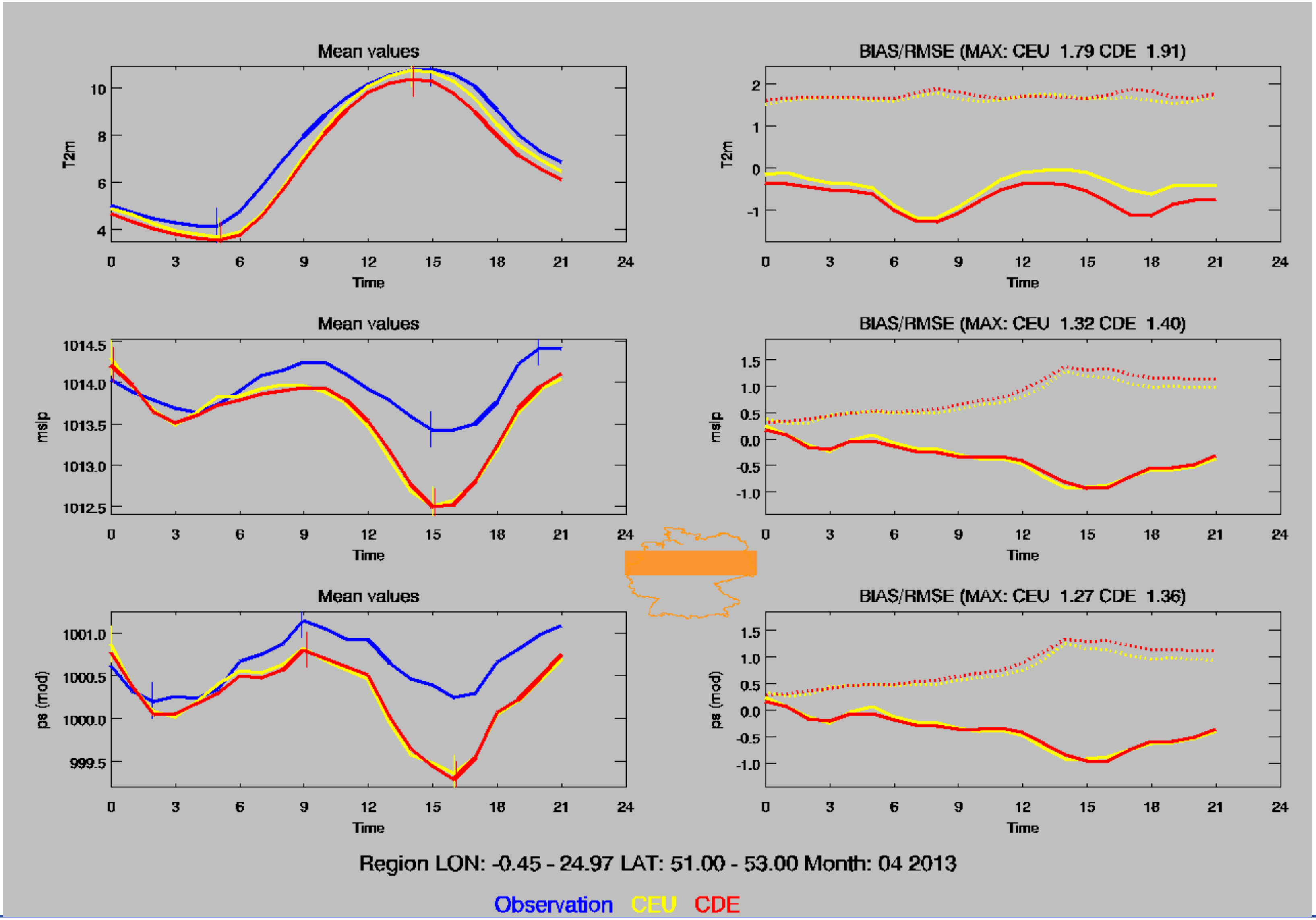
Diurnal cycle of T2m
over a part of Germany July 2013



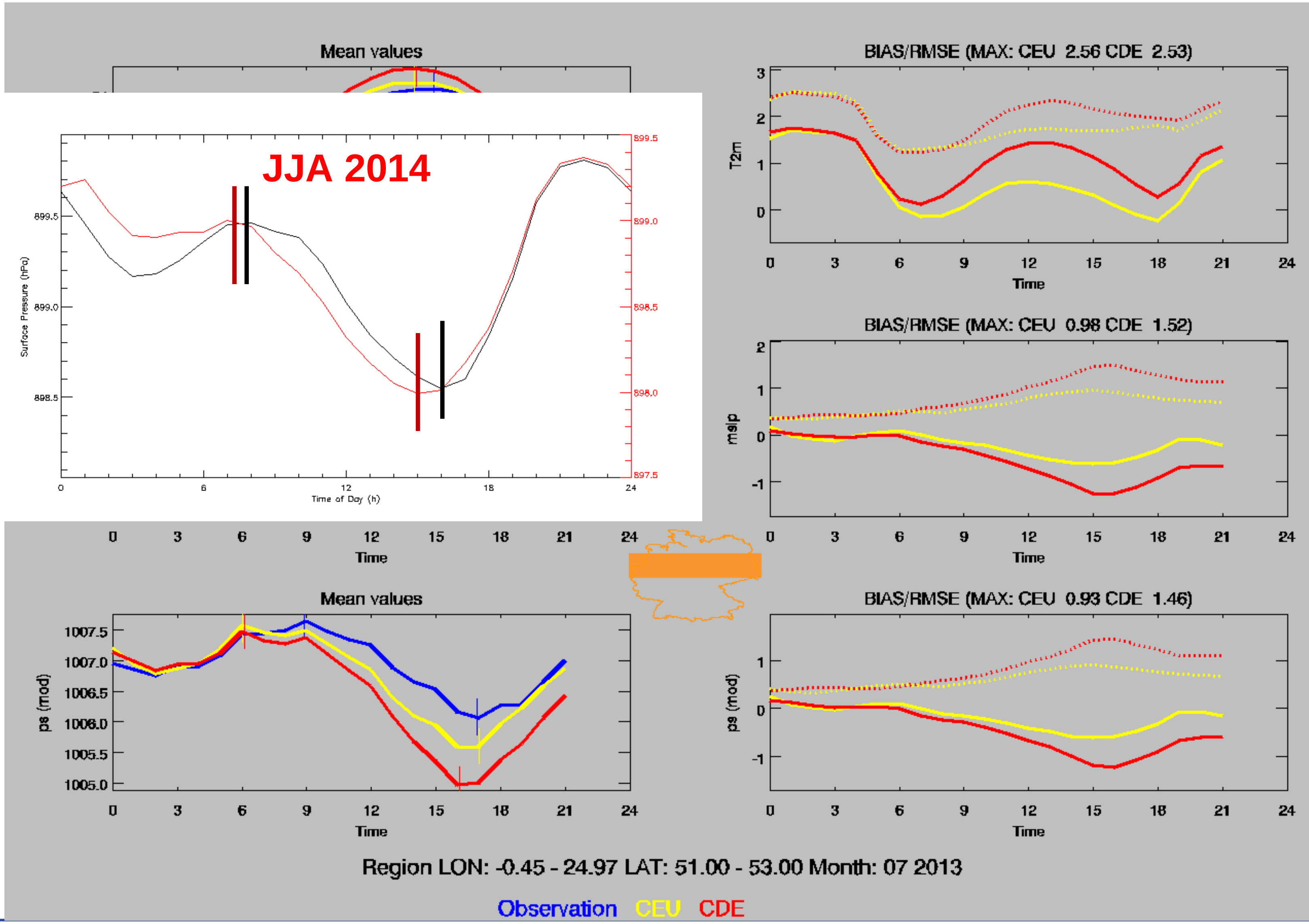
Diurnal cycle of T2m, mslp and pressure at surface over a part of Germany January 2013



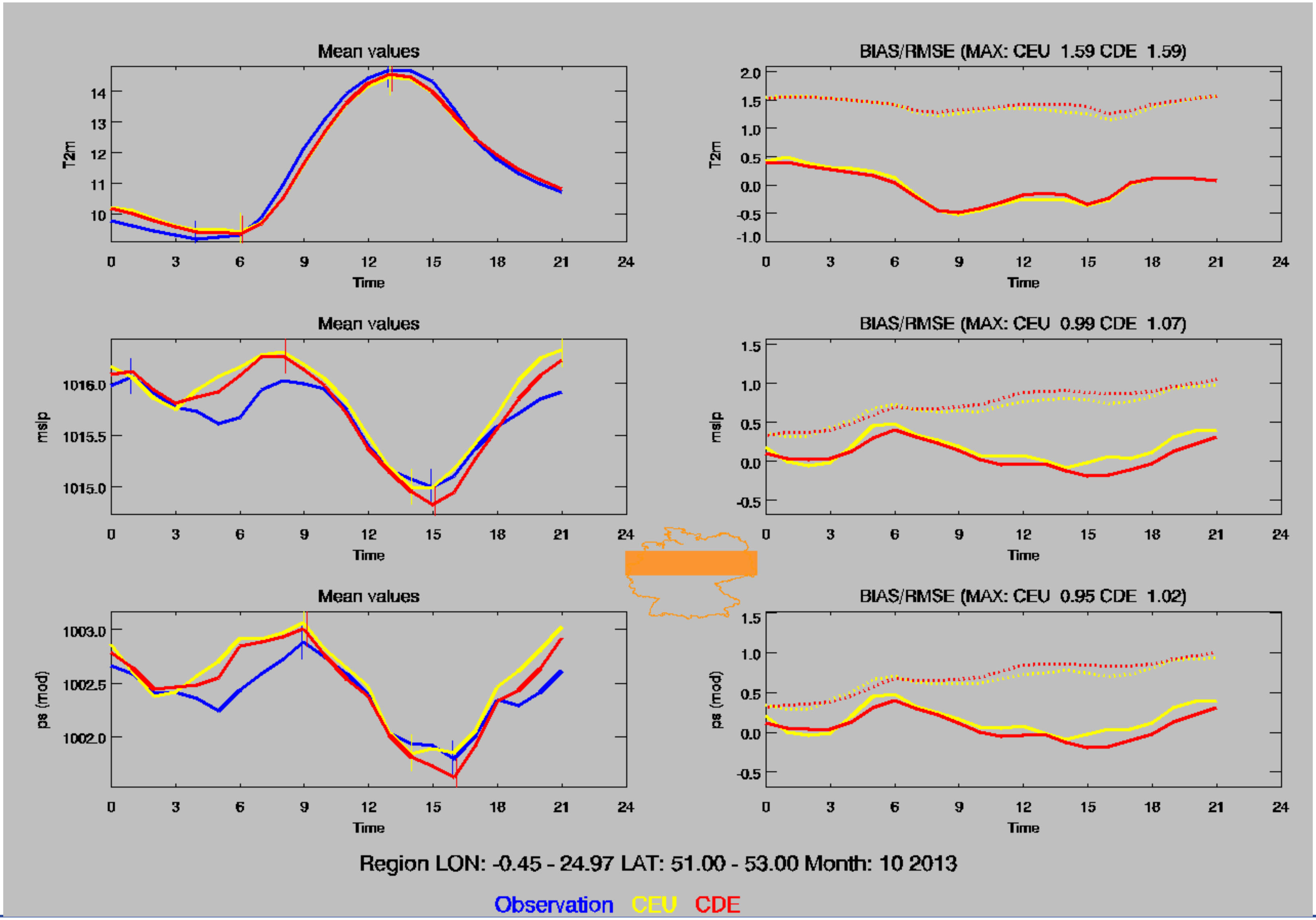
Diurnal cycle of T2m, mslp and pressure at surface over a part of Germany April 2013



Diurnal cycle of T2m, mslp and pressure at surface over a part of Germany July 2013



Diurnal cycle of T2m, mslp and pressure at surface over a part of Germany October 2013



Summary

- The special behaviour of RMSE for surface level pressure has ist origin in the small phase error for pressure at surface generated by the driving model(s).
- Regional models may modulate this behaviour but they cannot solve the general problem.

Parts of verification scores (schematically)

Short forecast times

Long forecast times

General behaviour of forecast errors:

- **Dominant error growth with forecast time**
  - **Elements with small parts of diagnostics or parameterisation**
- **Dominant diurnal cycle of errors**
  - **Elements with larger parts of diagnostics or parameterisation**
- **Measurement errors should be recognised, but the lack of representativeness of measurements should be kept in mind and cannot elimated when using SYNOP observations**