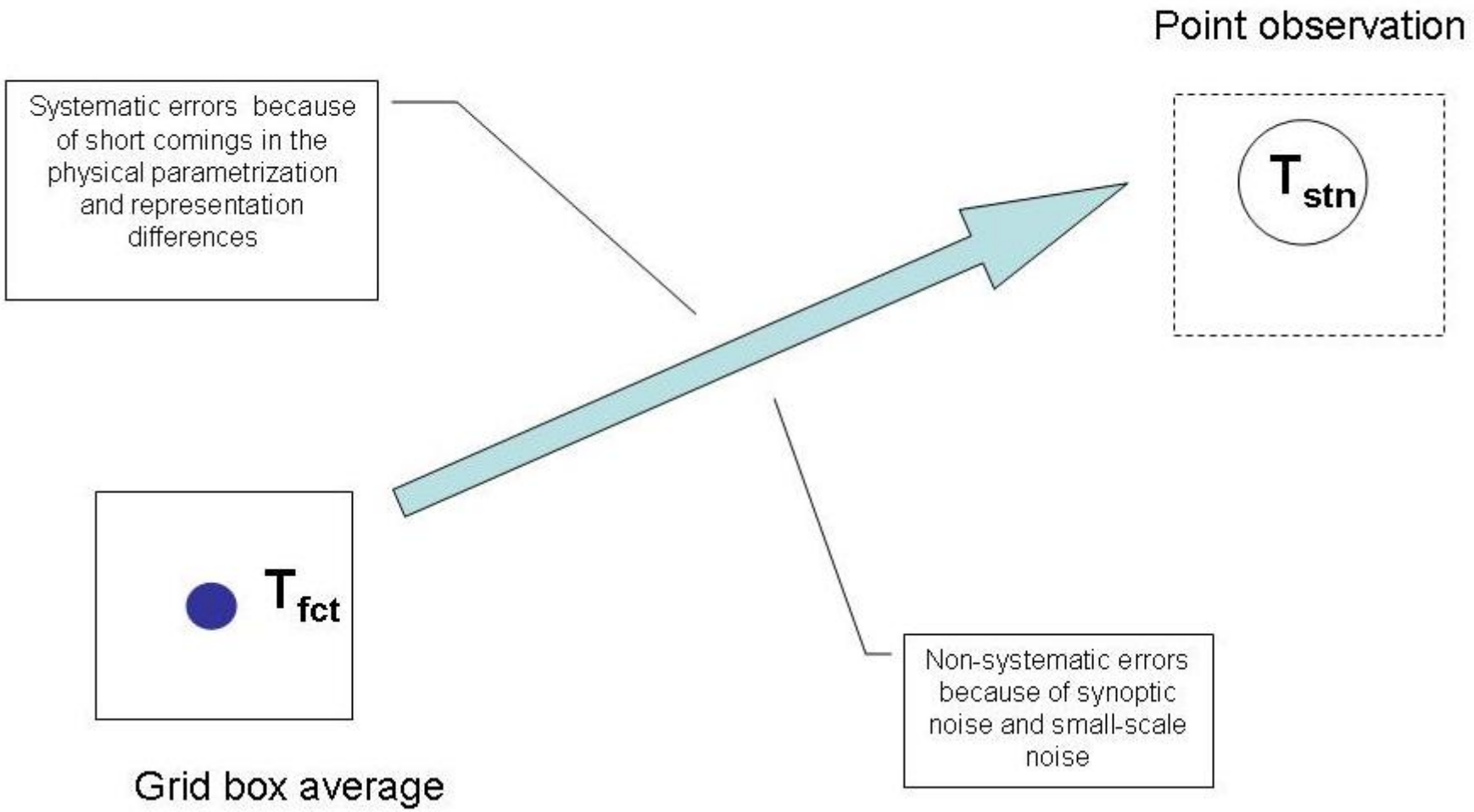
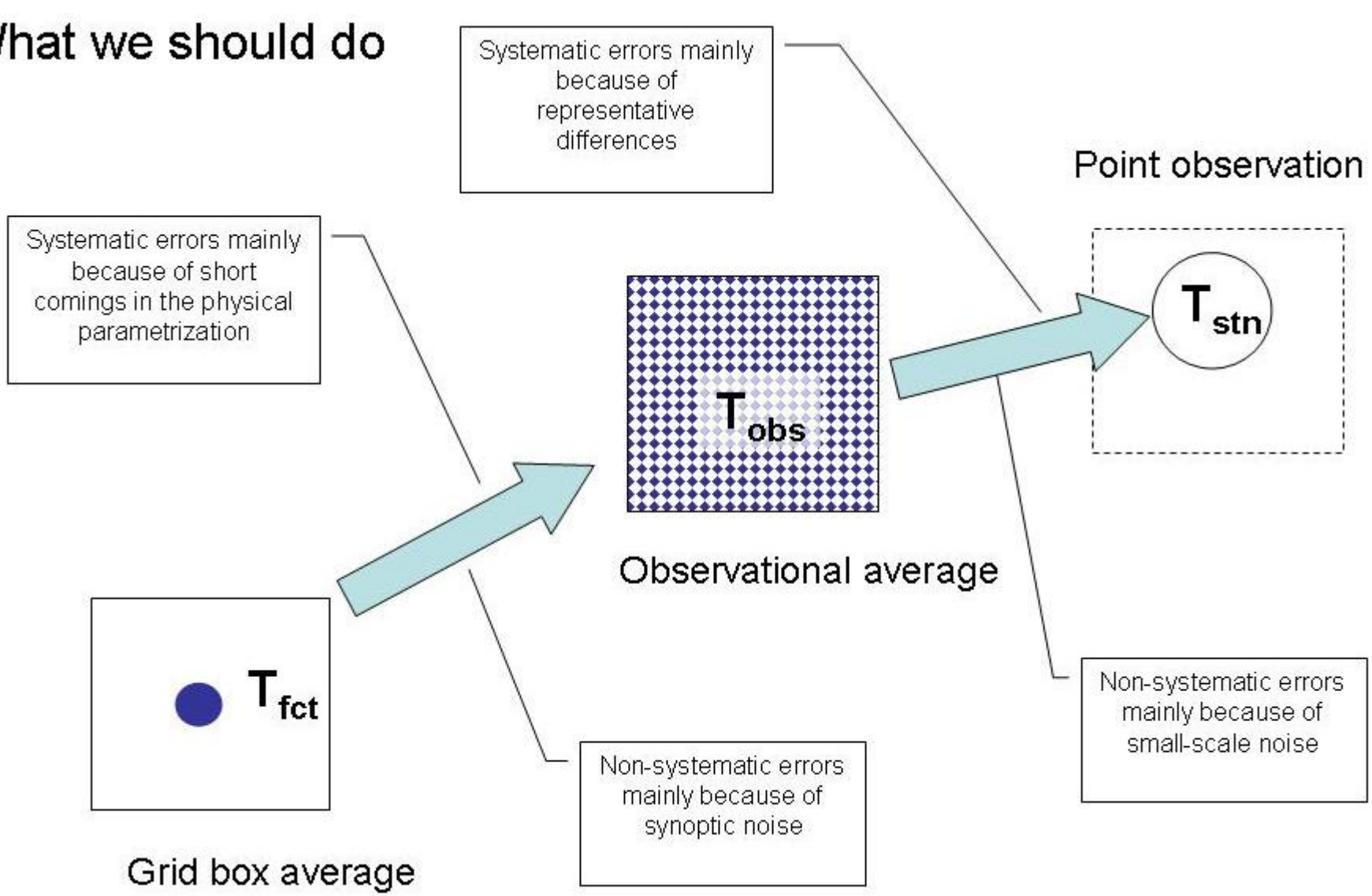
Statistics in meteorology without tears

Part I:Kalman filtering of computer output

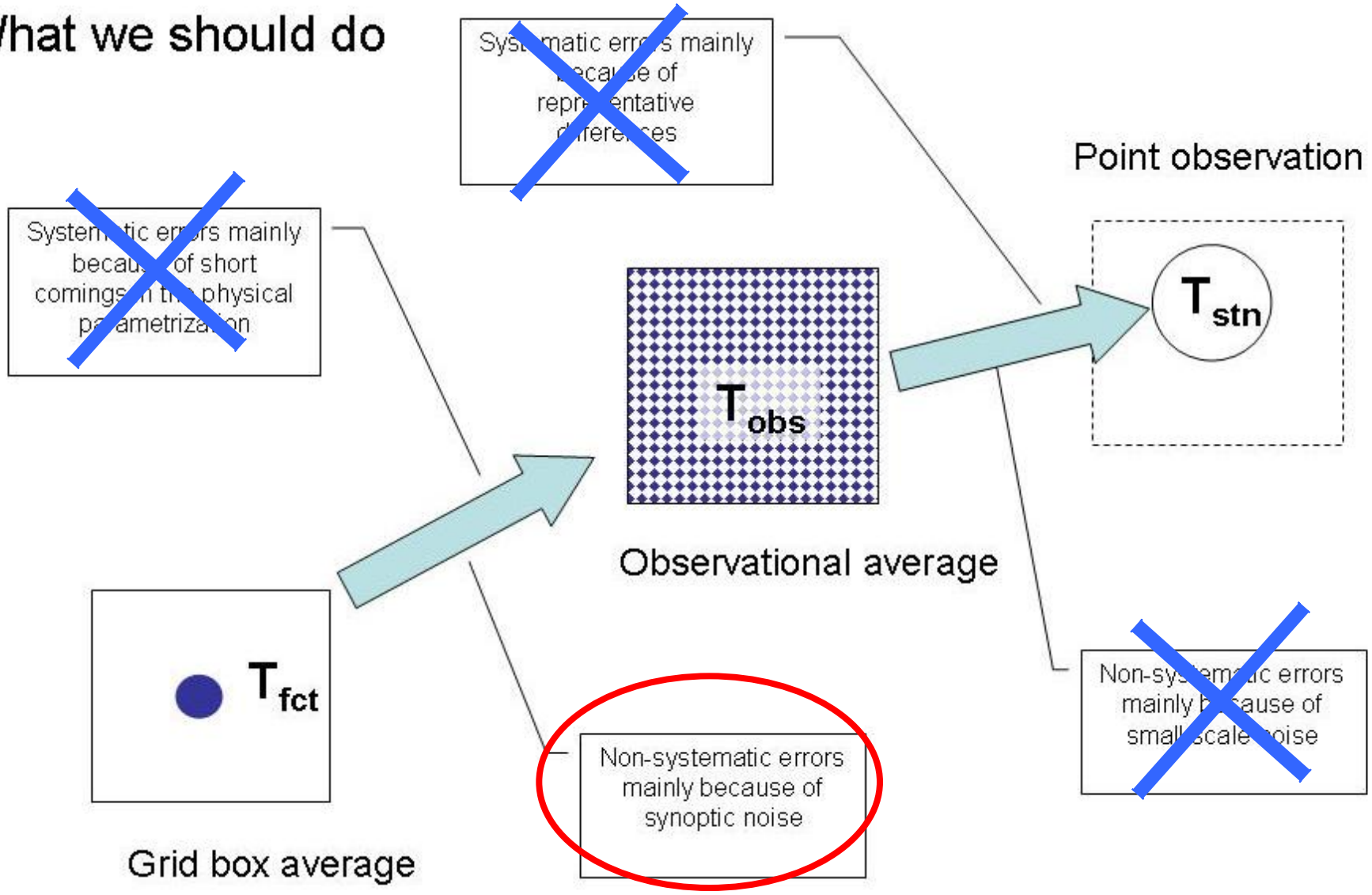
What we do


Point observation
Systematic errors because of short comings in the physical parametrization and representation differences
T_{stn}
T_{fct}
Grid box average
Non-systematic errors because of synoptic noise and small-scale noise

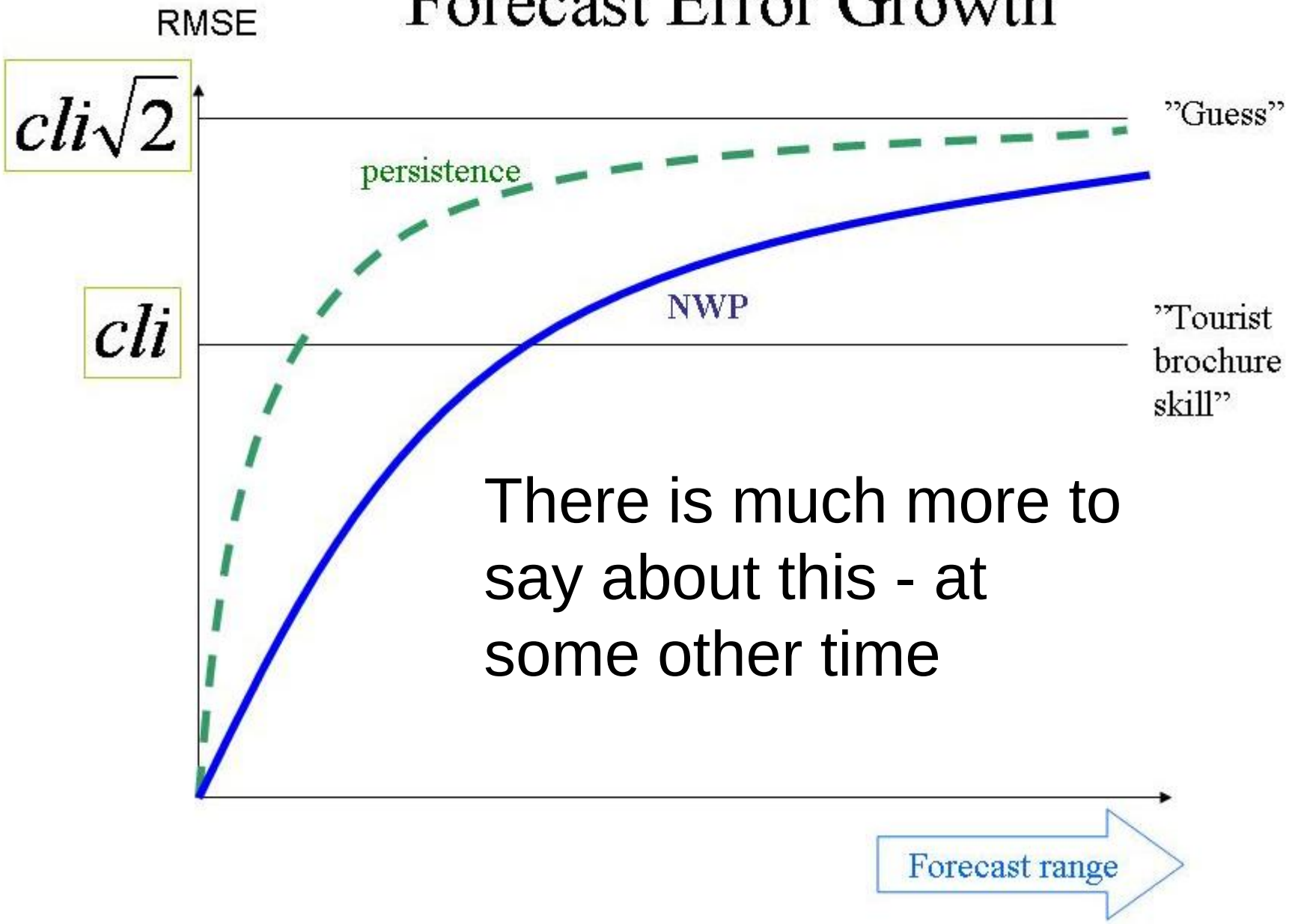
What we should do



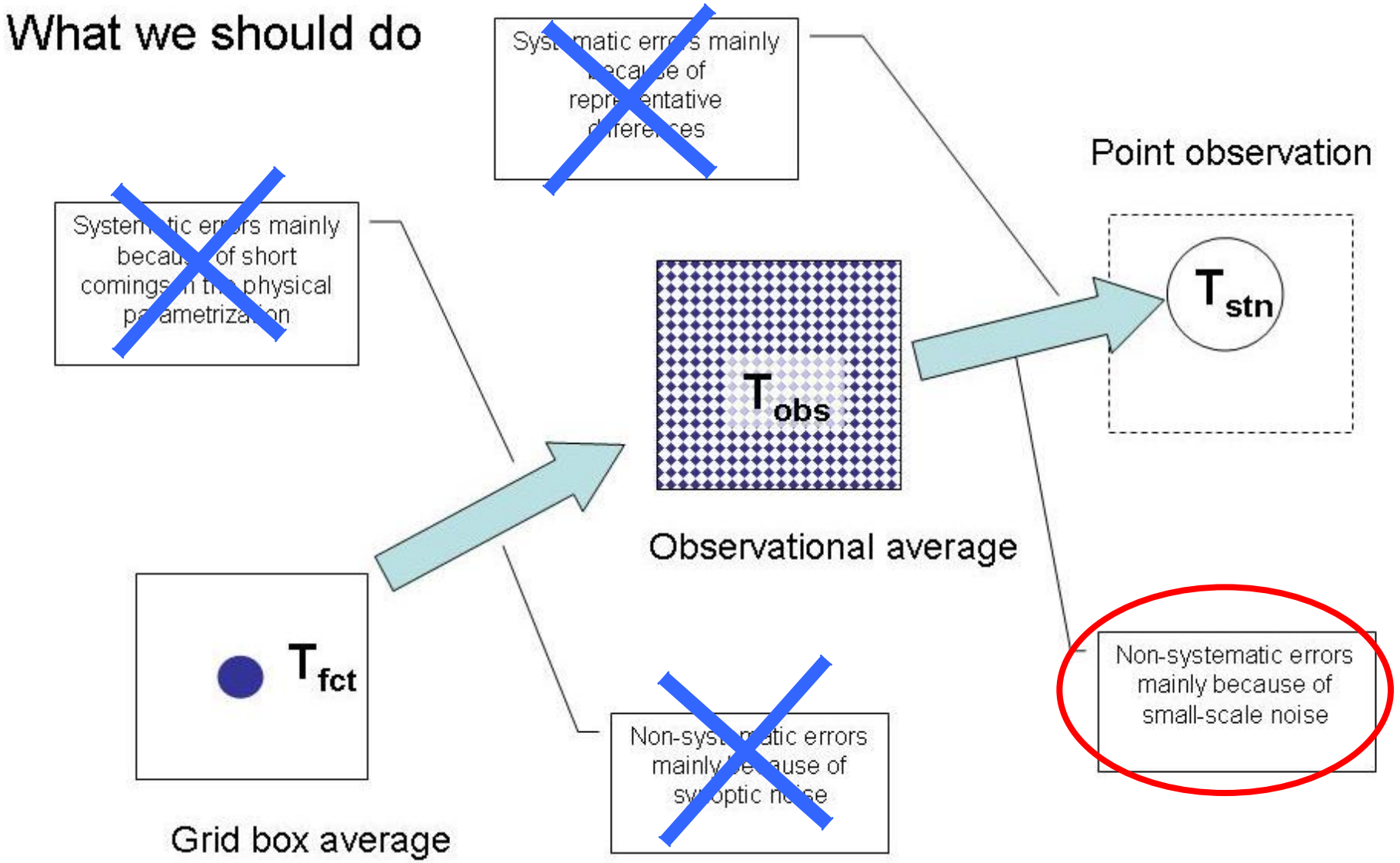
What we should do



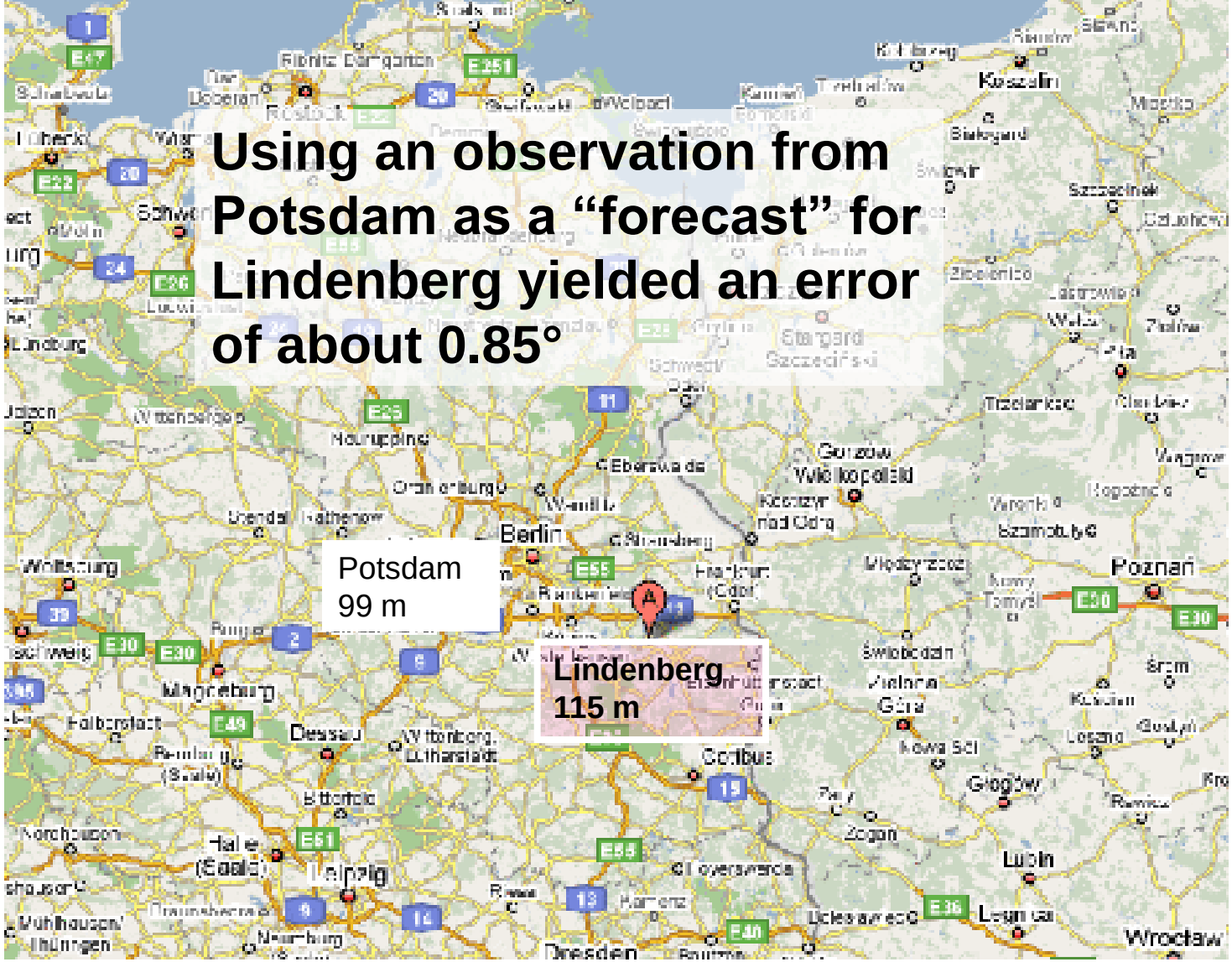
Forecast Error Growth



There is much more to say about this - at some other time

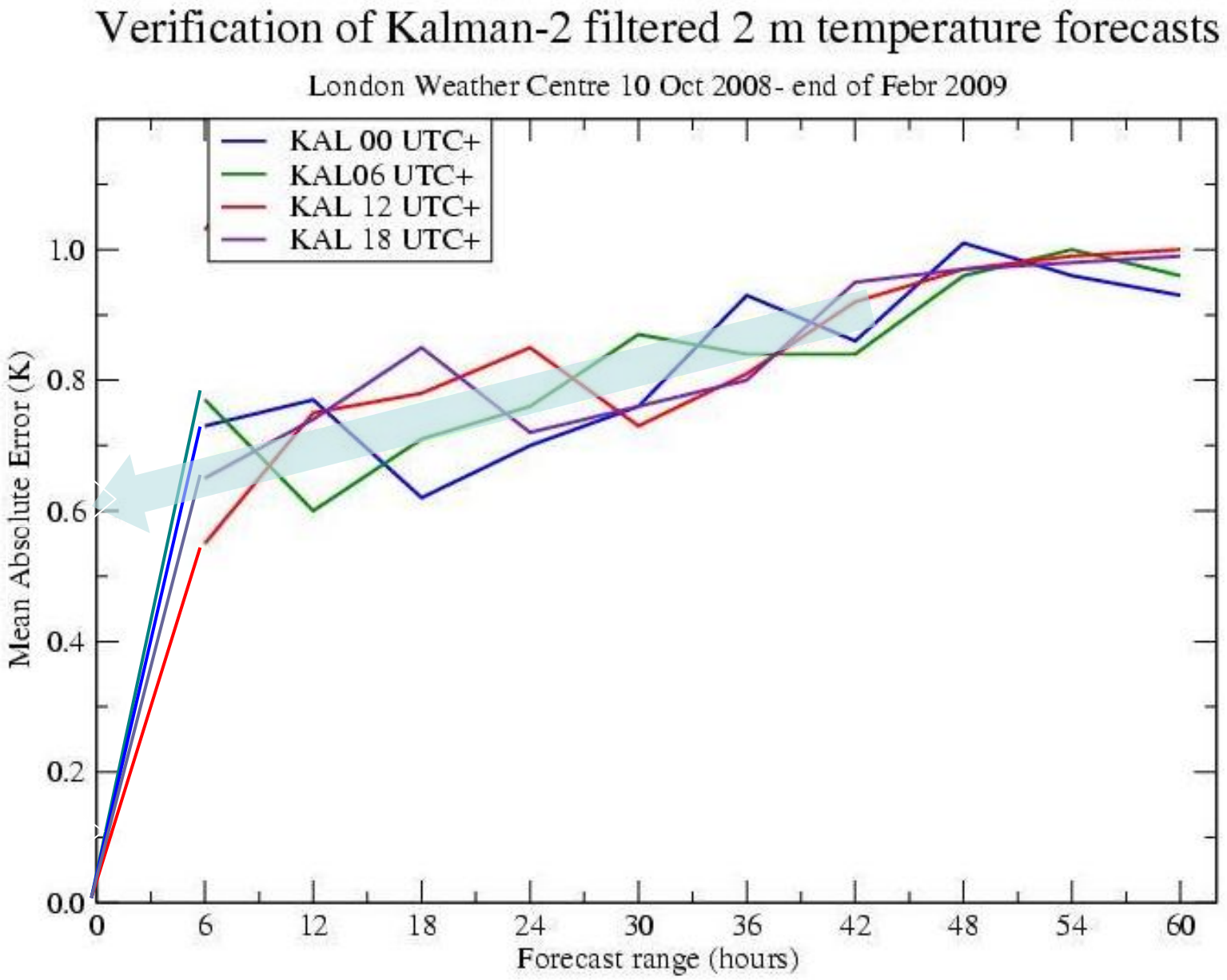


Even when we get rid of systematic errors, make the synoptic forecast perfect and only verify against representative observations – the meso-scale "noise" will still yield "non-perfect" forecasts

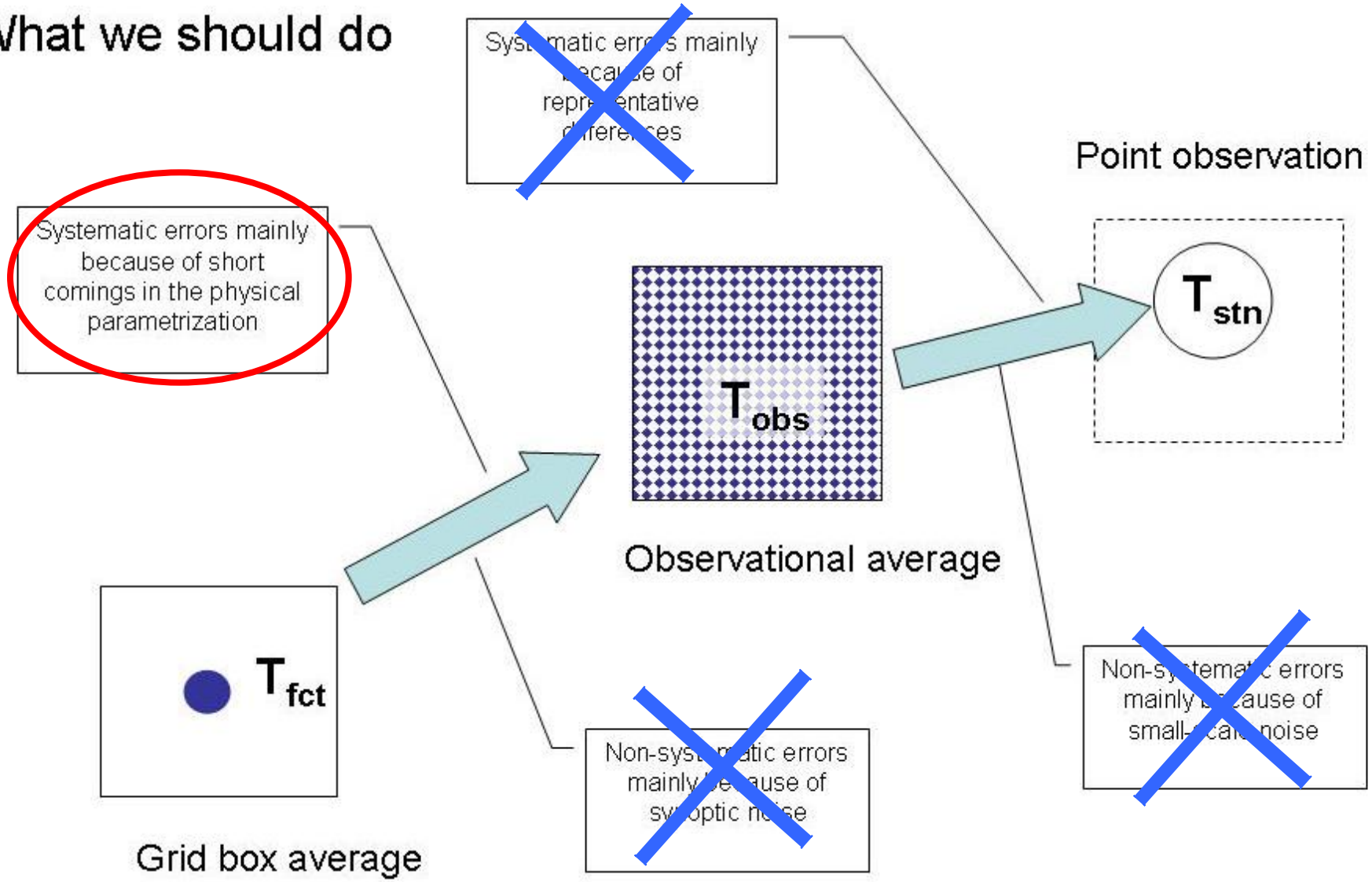

Using an observation from Potsdam as a “forecast” for Lindenberg yielded an error of about 0.85°
Potsdam
99 m
Lindenberg
115 m
Berlin
Poznań
Wrocław

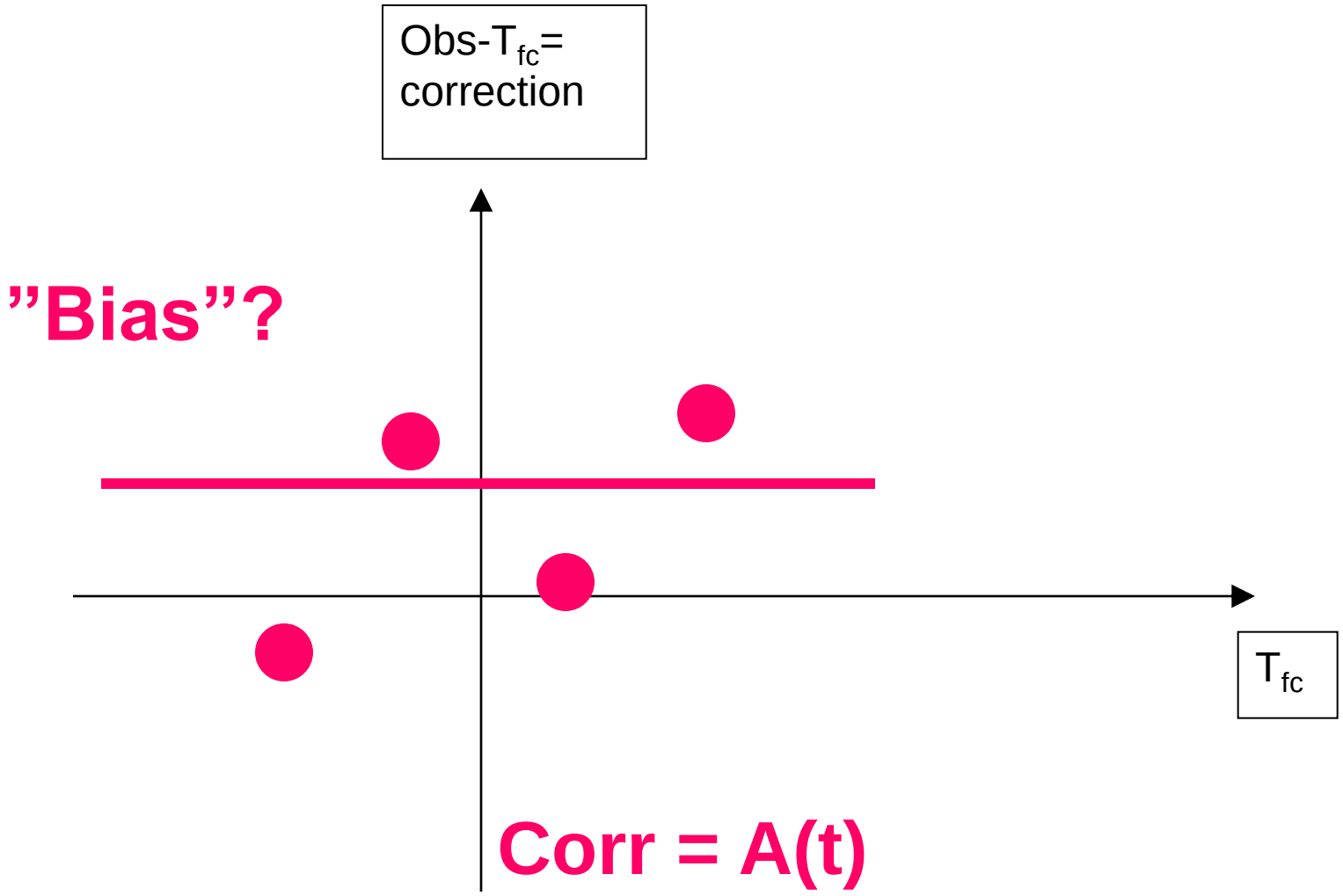
Rather 0.6°

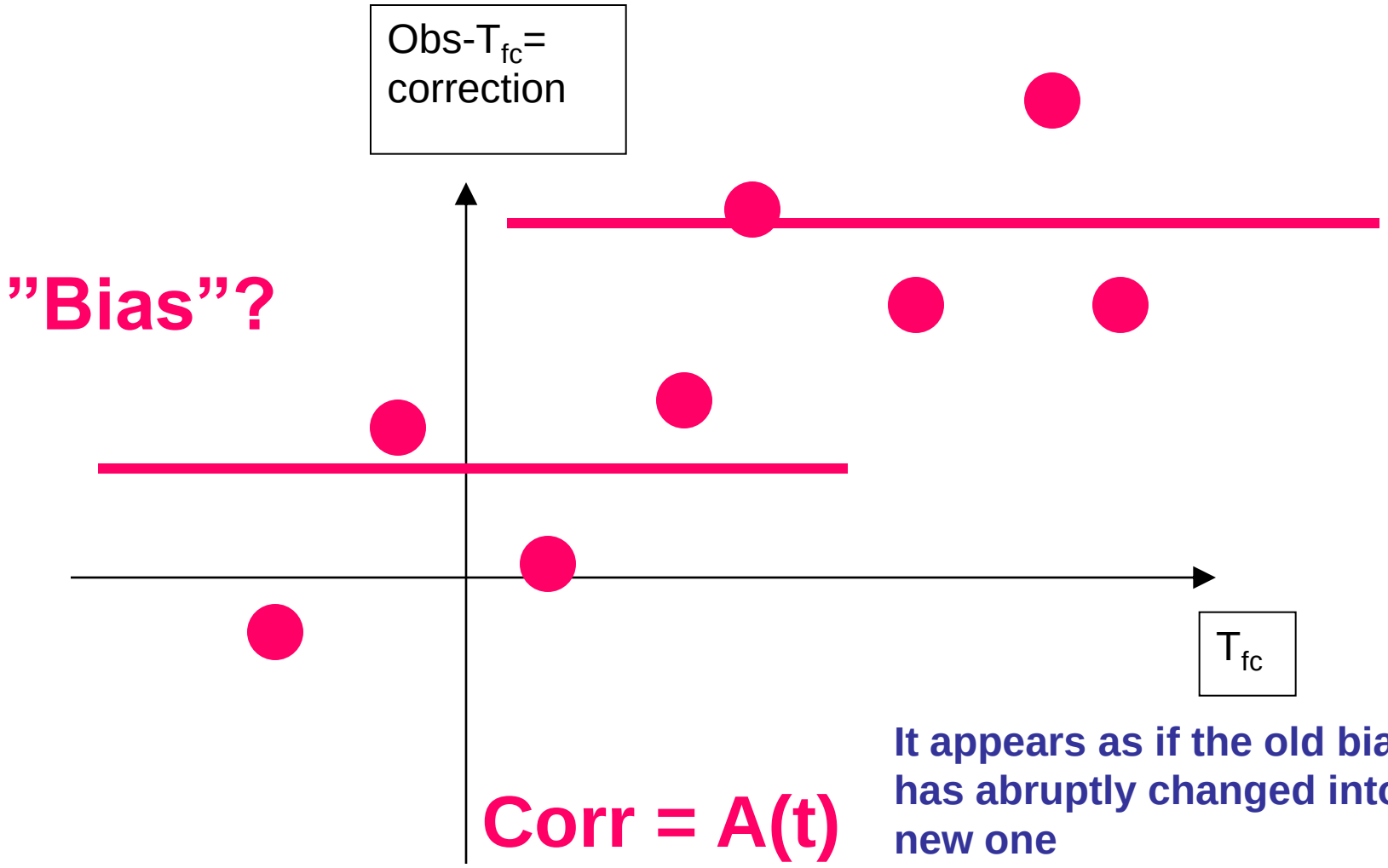
Error=0 at t=0?

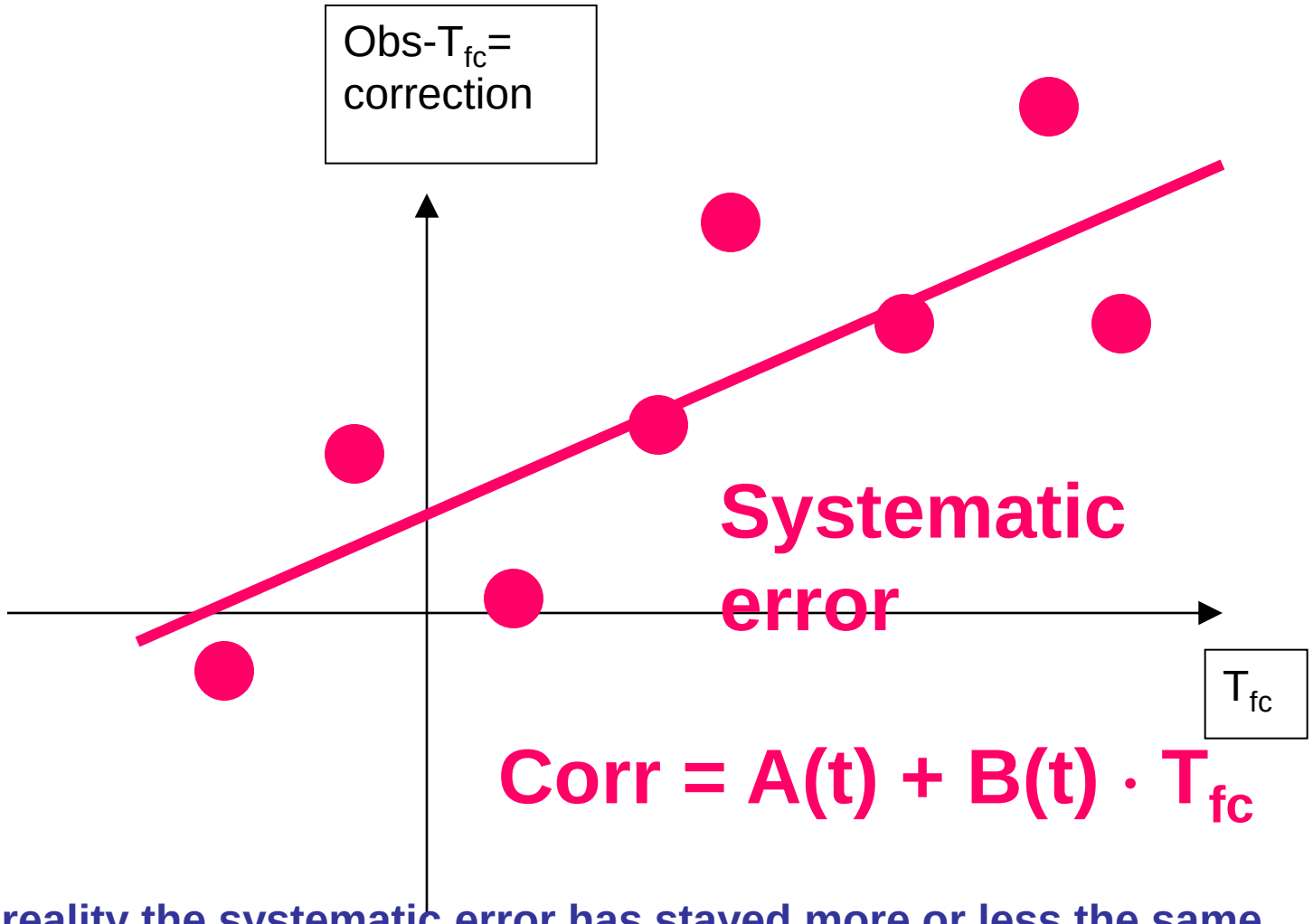


What we should do



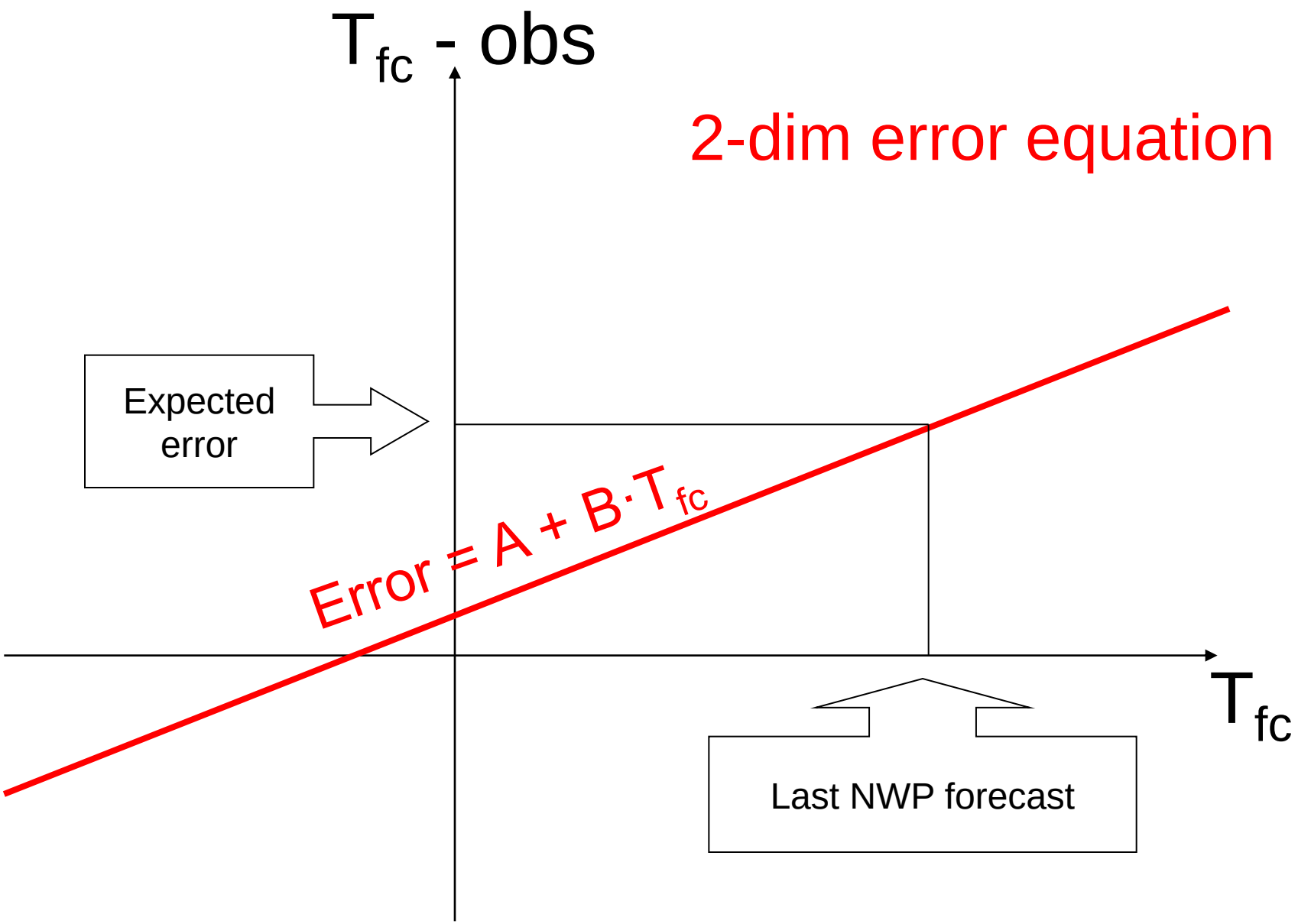

Obs-T_{fc}= correction
"Bias"?
T_{fc}
Corr = A(t)

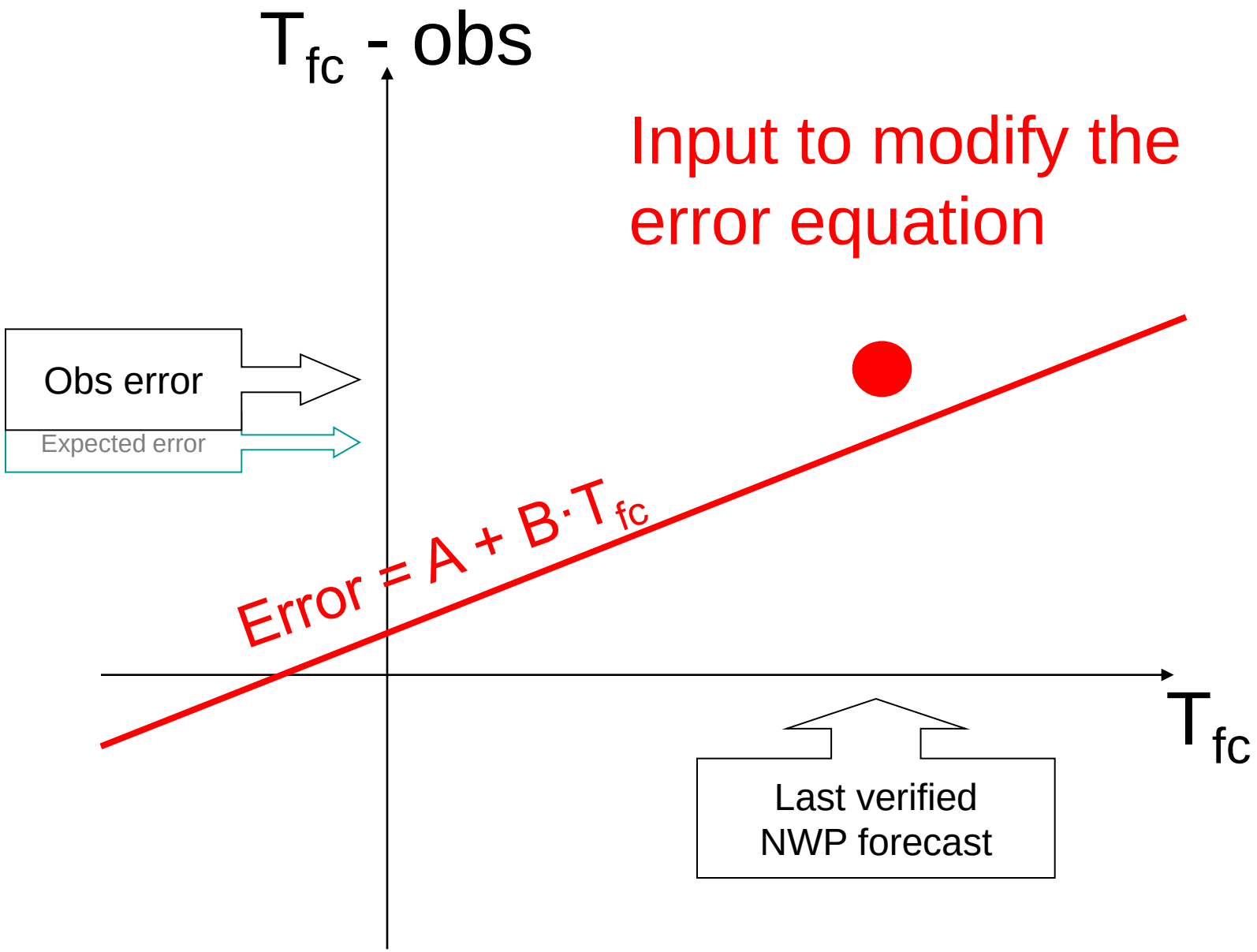

Obs-T_{fc}= correction
”Bias”?
T_{fc}
Corr = A(t)
It appears as if the old bias has abruptly changed into a new one



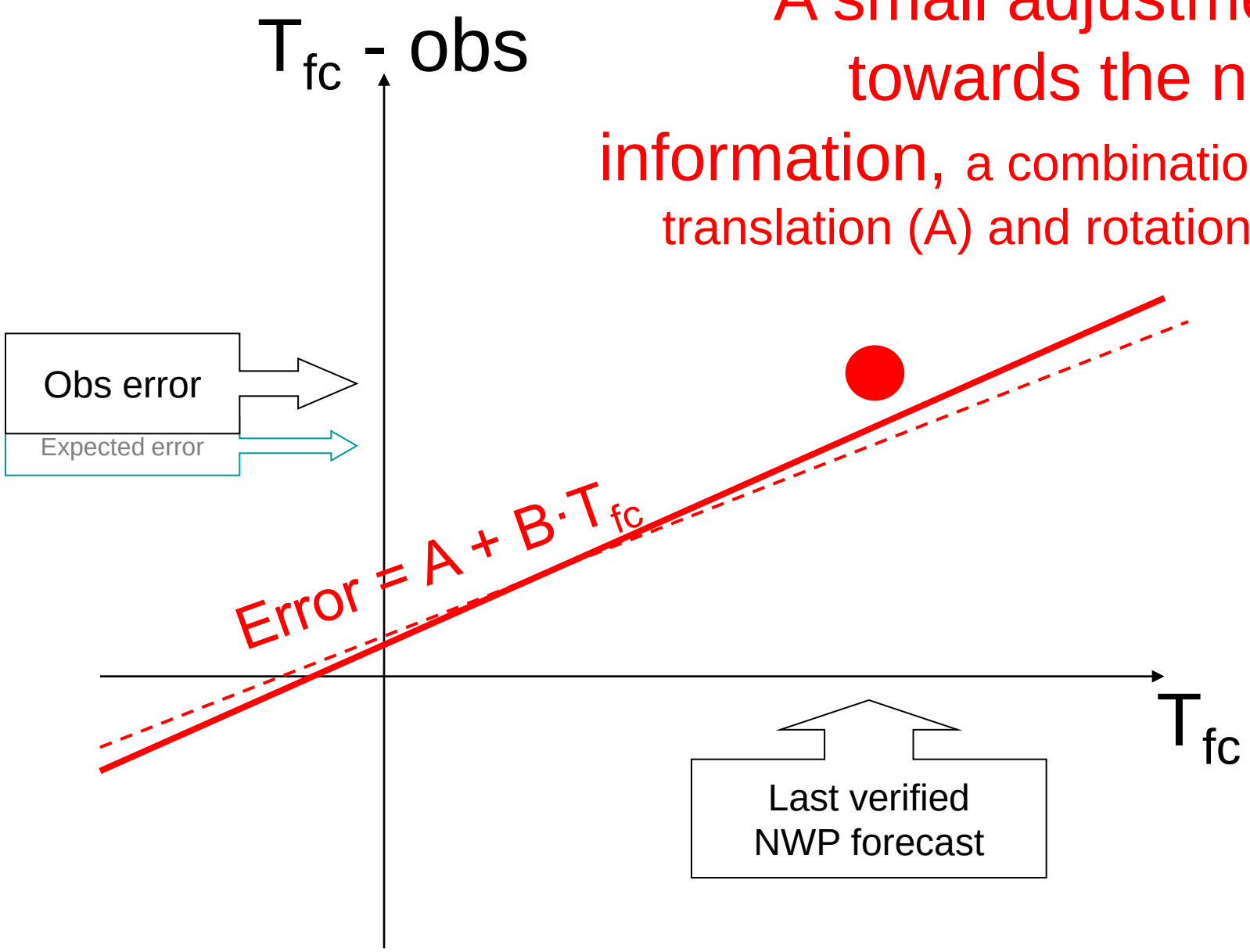
$$Corr = A(t) + B(t) \cdot T_{fc}$$

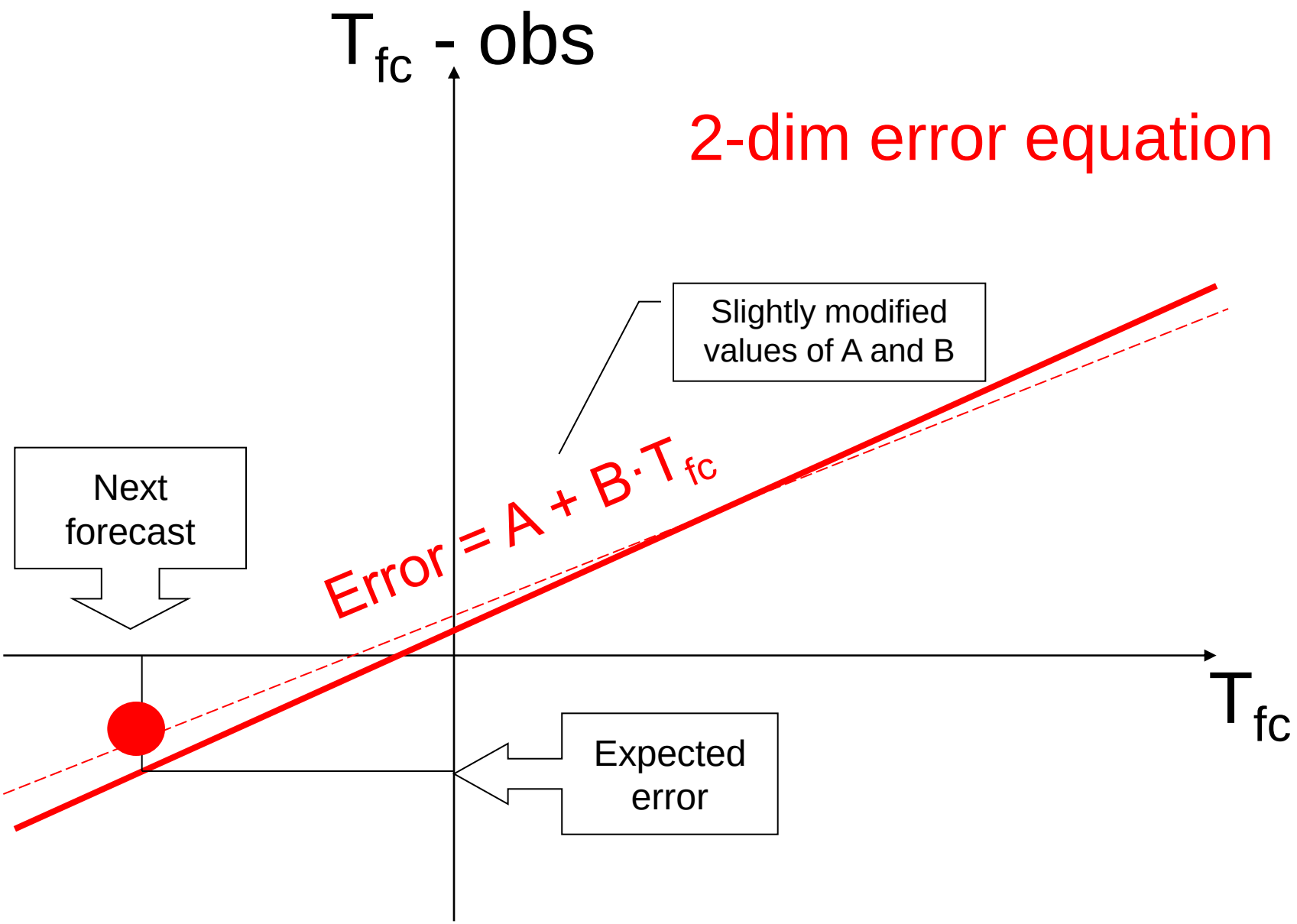
In reality the systematic error has stayed more or less the same, but defined by *two* coefficients, A and B


T_{fc} - obs
2-dim error equation
Expected error
Error = A + B·T_{fc}
T_{fc}
Last NWP forecast


T_{fc} - obs
Input to modify the error equation
Obs error
Expected error
Error = A + B·T_{fc}
T_{fc}
Last verified NWP forecast

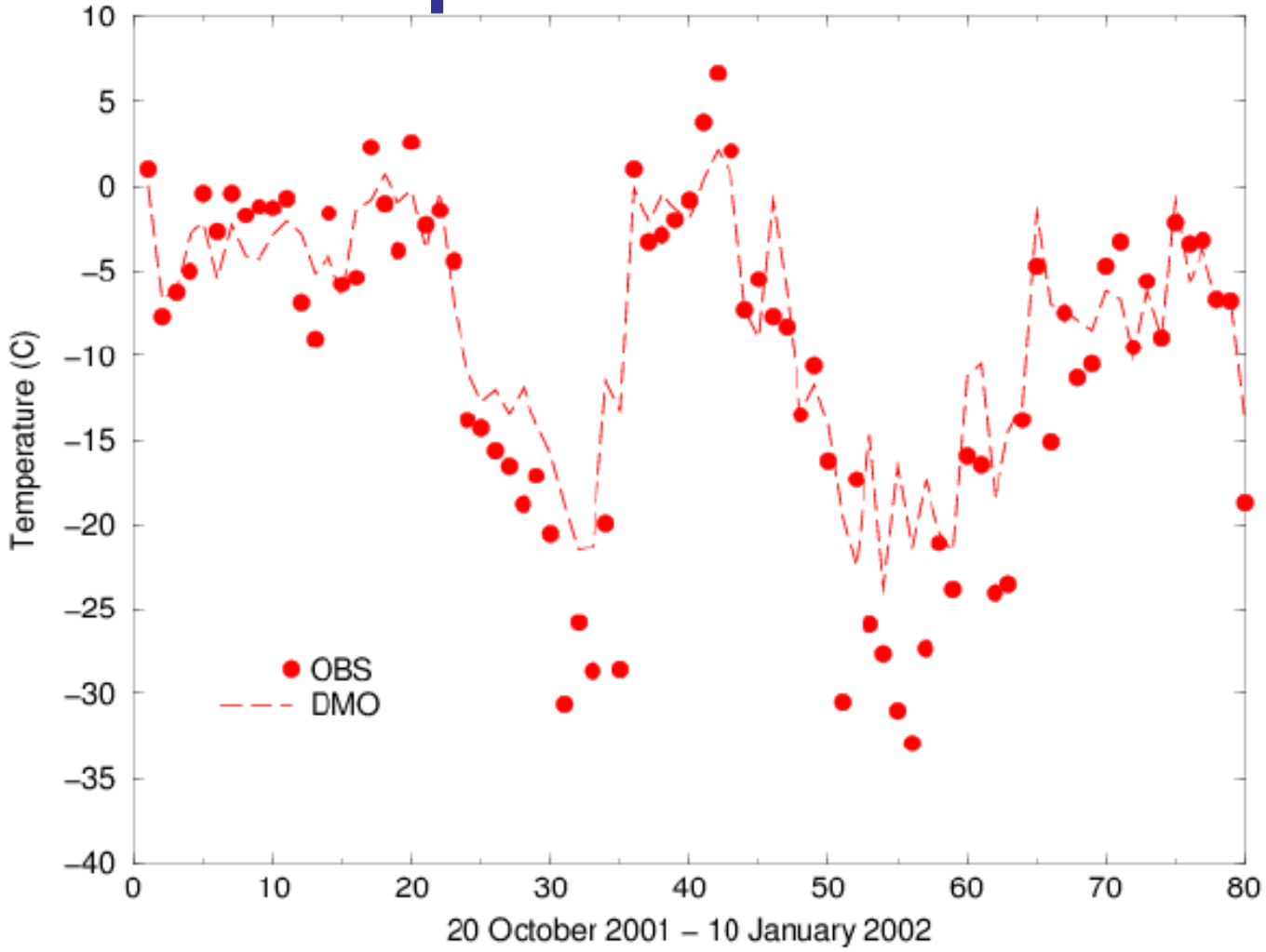
A small adjustment towards the new information, a combination of translation (A) and rotation (B)



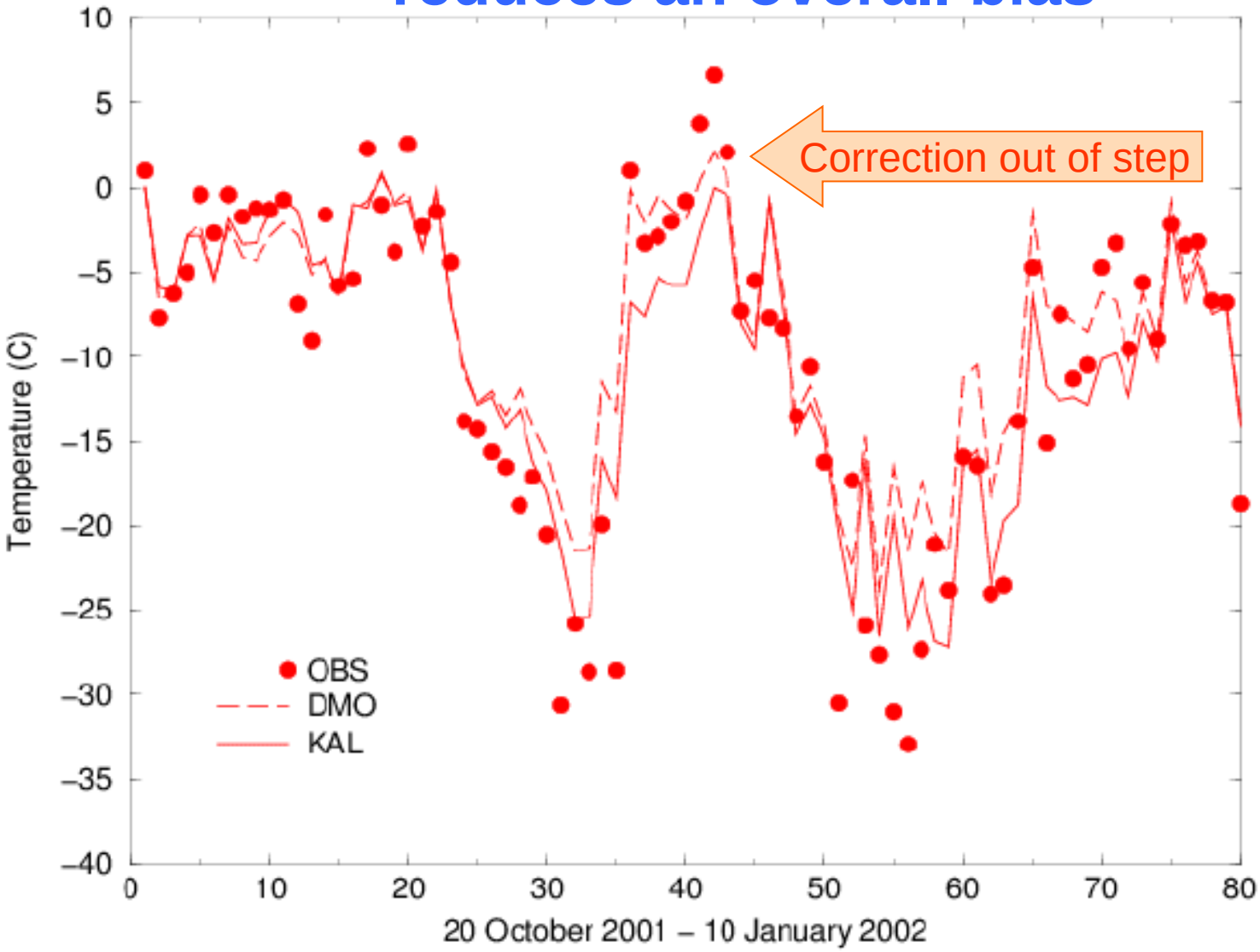

T_{fc} - obs
2-dim error equation
Slightly modified values of A and B
Next forecast
Error = A + B·T_{fc}
T_{fc}
Expected error

There are fundamental differences between 1-dimensional filtering and multi-dimensional

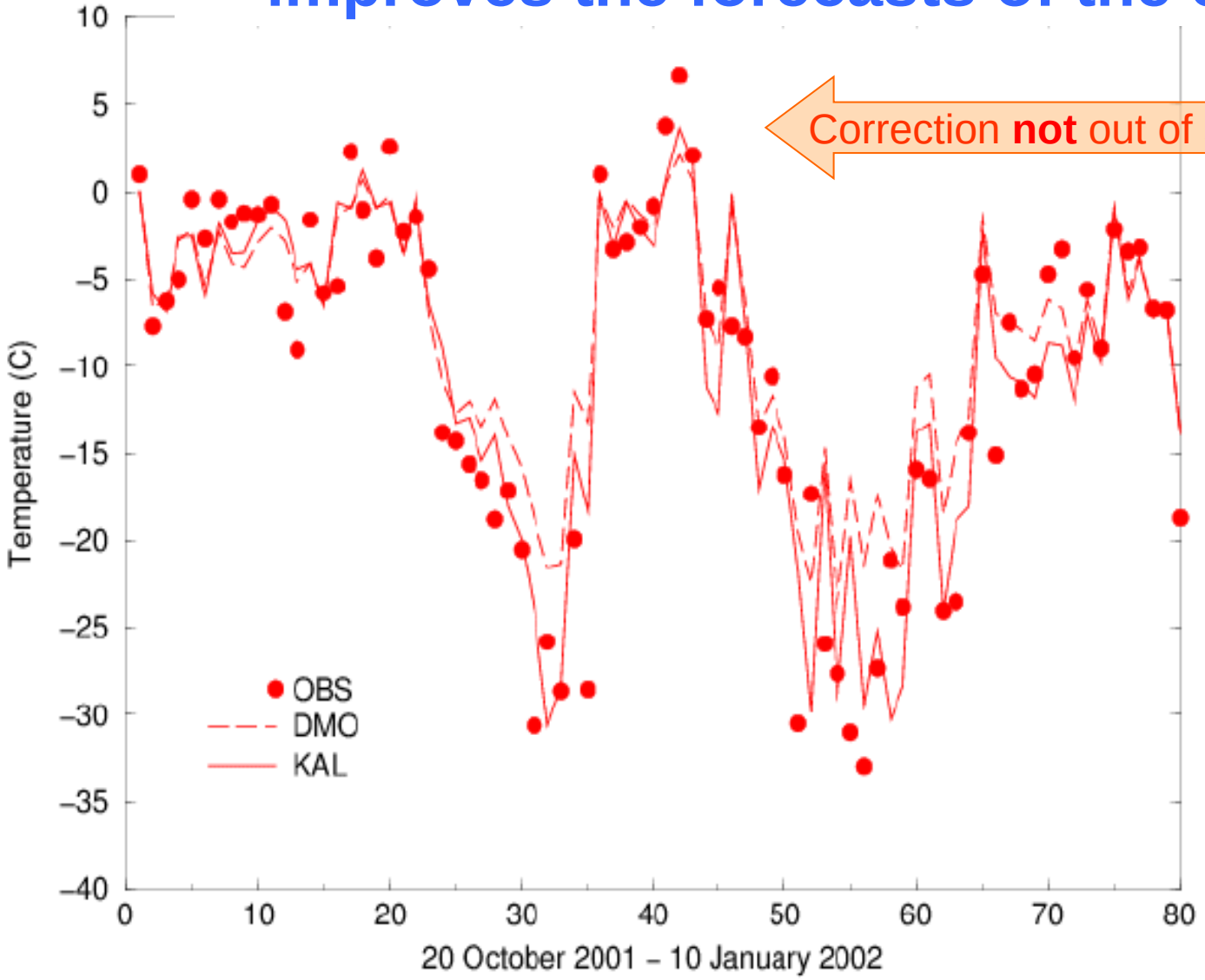
24 hour 2 m temperature forecast for Kiruna in Lapland winter 2001-2002



A 1-dimensional Kalman filter reduces an overall bias

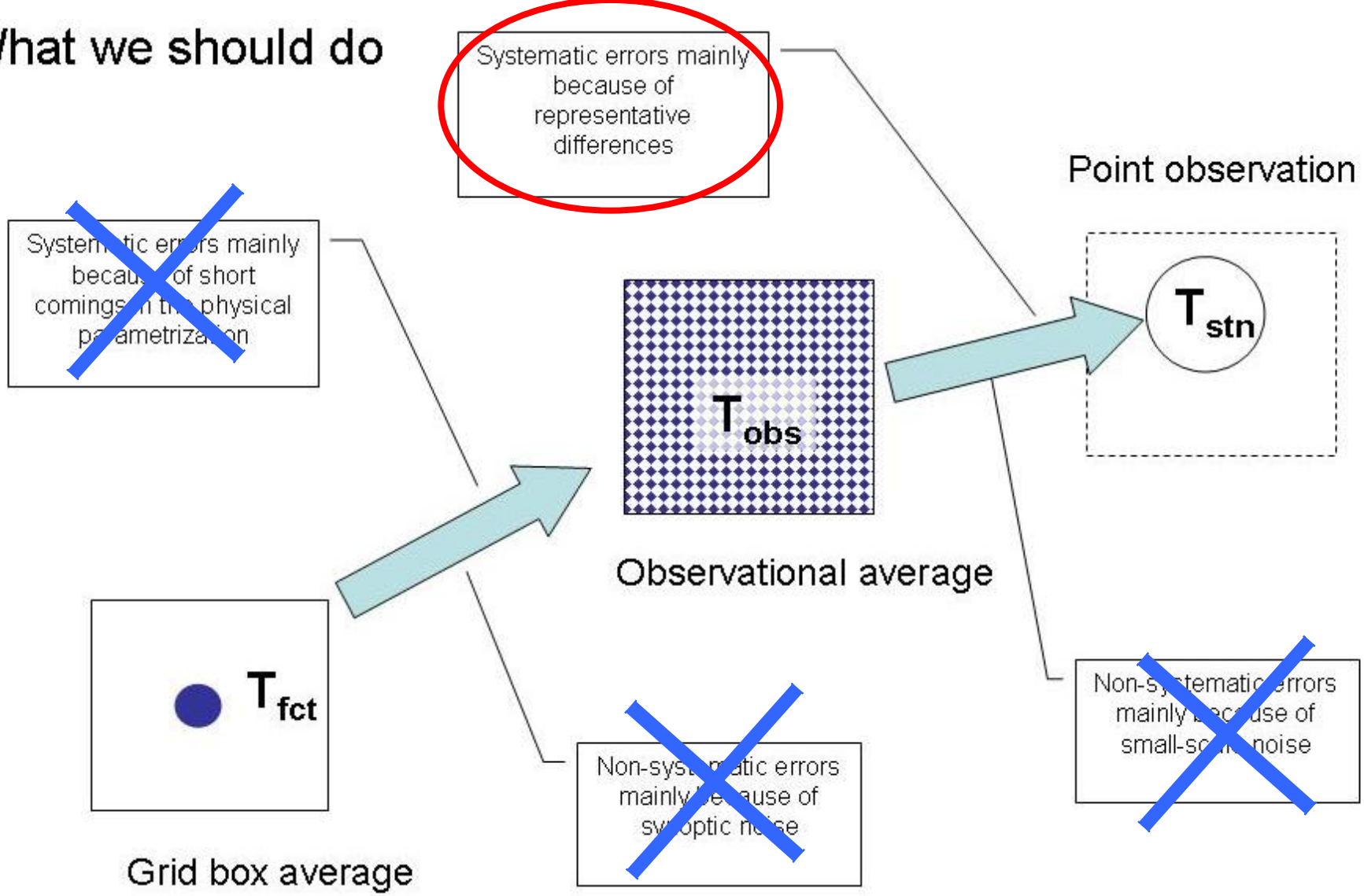


A 2-dimensional Kalman filter system also improves the forecasts of the extremes

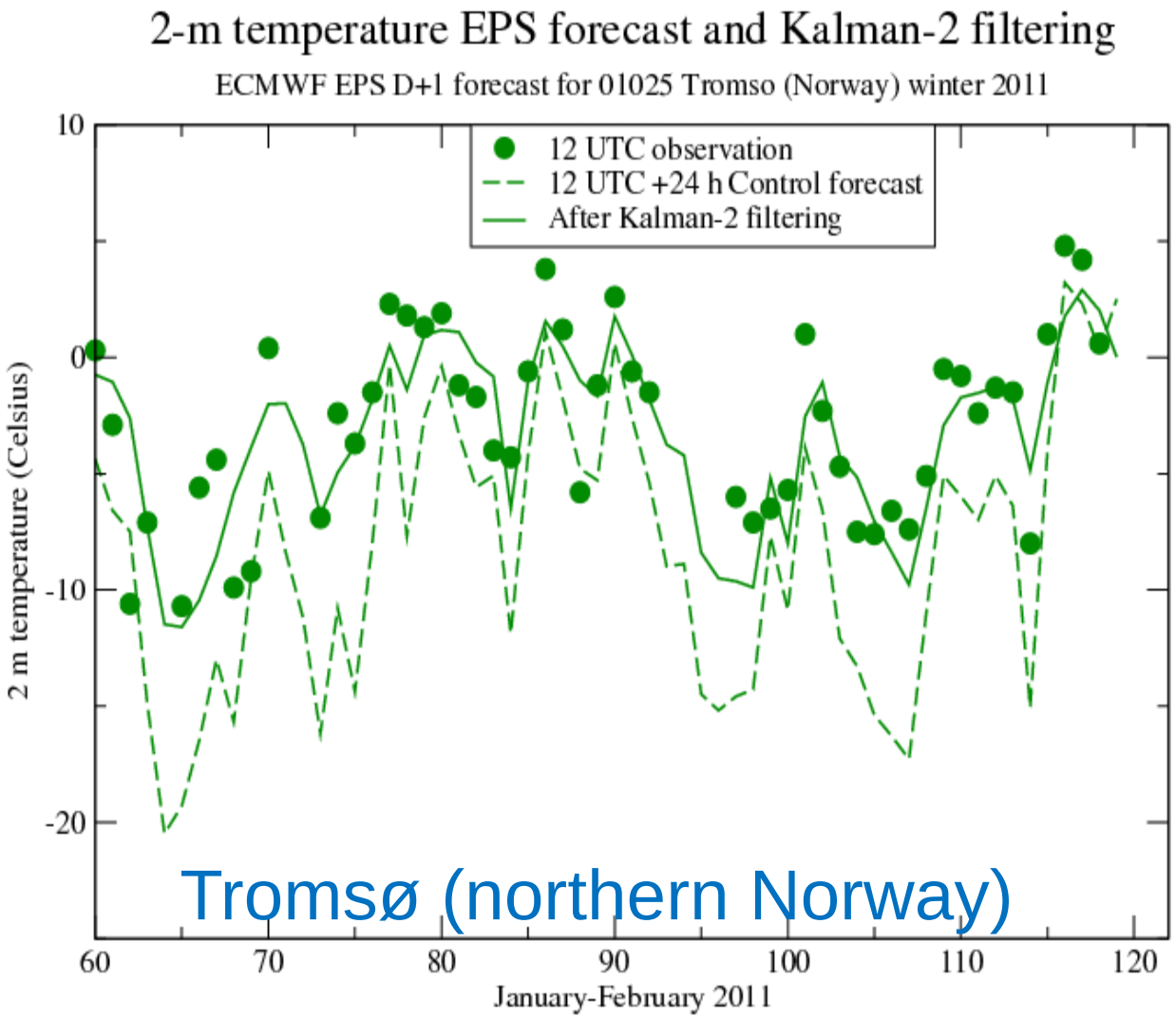


Two good achievements: The Kalman filtering has reduced two systematic errors: a positive mean error and an underestimation of the variability

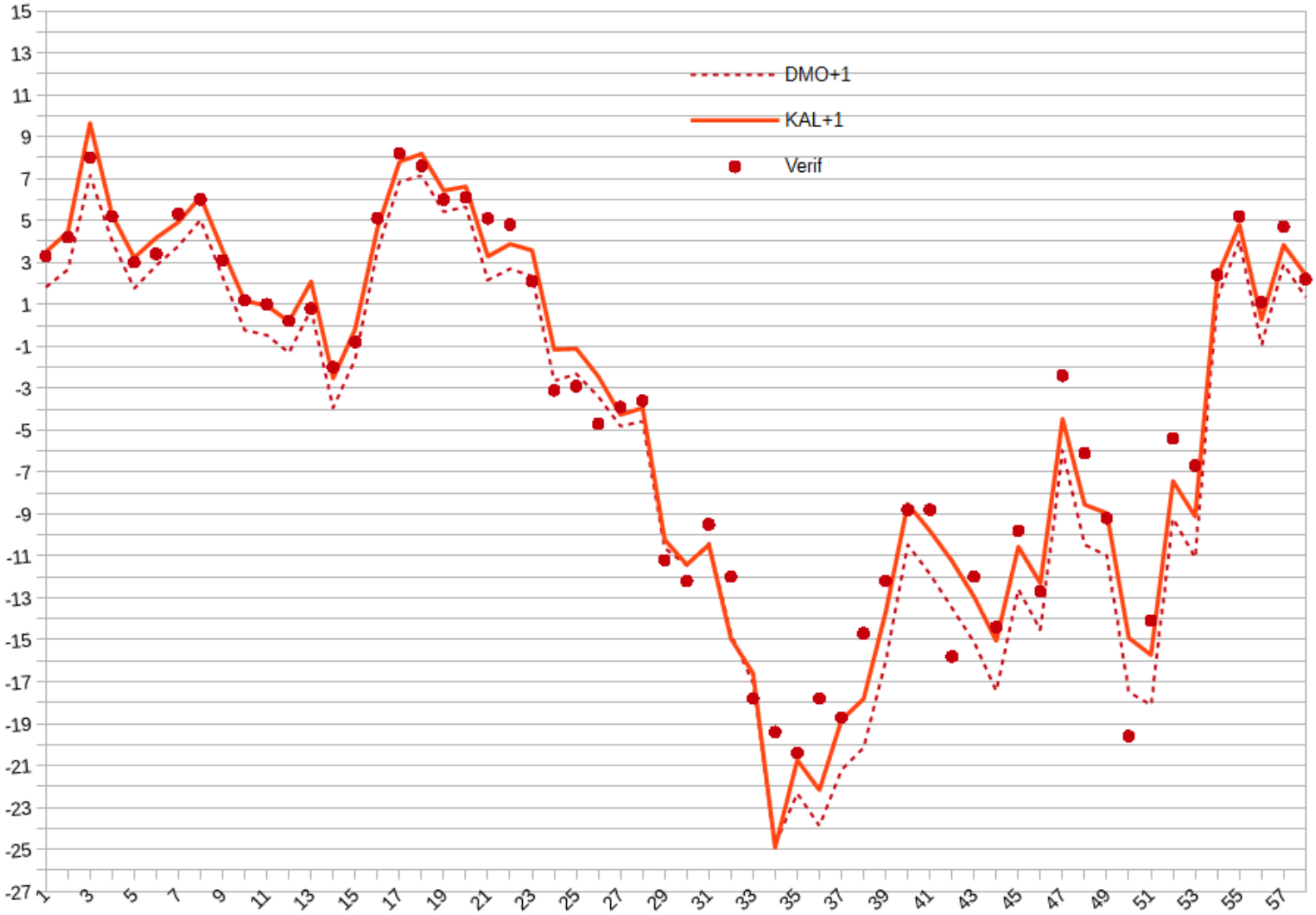
What we should do



The forecast (- - - -) varies more than reality (●). The Kalman filtering (——) corrects for both mean error and over-variability



Recent experiments of Kalman filtering ECMWF D+1 forecast for St Petersburg December 2015-January 2016



END