UM Model and Kalman Forecasts Verification at SAWS

Robert Maisha*
Estelle Marx*
Louis Van Hemert*

*South African Weather Service

08 June 2009

Helsinki, Finland

We bring weather together!!

South African Weather Service

Outline

- Background
- Aim and Objectives
- Data and methods
- Results (UM and Kalman Filter)
- Discussions
- Summary and conclusions

South African Weather Service

Background

- South African Weather service (SAWS) use numerical weather prediction (NWP) model, Unified Model (UM) to produce forecast guidance daily, from September 2006
- NWP models are subjected to systematic and non-systematic bias, like-wise the UM
- Model bias occurs especially when forecasting near surface events
- This is mostly due to the physical parameterizations
- Systematic errors vary with geographical locations, times of the day and seasons
- Systematic errors are easily quantified as they are due to model's resolution
- The KF, developed by Richard Kalman in the 1960's is an effective and efficient UMOS method to correct systematic bias and improves model forecasts
- The KF is a stochastic, recursive method used to predict or forecast future state of a variable, given the present state of such a system
- KF use most recent forecasts and observations to predict and correct temperature forecast

(Galanis & Anadranistakis, 2002; Crochet, 2004; Emmanouil et.al. 2006; Libotani et. al., 2008, Louka et al. 2008)

South African Weather Service

Aims and Objectives

- **Why verification ++ WMO**

-For quality control

-For decision making

-To aid improvements

-To provide user and stake holder feedback

(*WMO: Guidelines on performance Assessment of Public Weather Services, TD No.1023***)**

- **Aims and Objectives of UM and KF forecast verifications**

-To ensure that products (warnings and forecasts) are technically accurate, skillful and reliable

-To evaluate the performance of the UM model temperature forecasts over SA

-To investigate the improvements of forecast at SAWS over time

-To develop and provide forecastes with an objective UMOS product

South African Weather Service

Data and Methods

UM model forecasts over (grid)

- **Xaana ■12 km resolution for SA and SADC ■ no data assimilation ■ 24 and 48 hrs forecast**
- **Xaang ■12 km resolution for SA and SADC ■ with data assimilation ■ 24 and 48 hrs forecast**
- **Saanb ■ 4km resolution, over SA only ■ with data assimilation ■ 24 hrs forecast**

Variable::Temperature at 850hpa and own analysis

Scores ::Bias
::Rmse
Period :: February 2007-April 2009

UM model, Kalman Filter and human forecasts
:: observations over SA stations

Xaana (no DA), Xaang (DA) ■12 km resolution for SA ■ 48 hrs forecast

Variable:: max / min temperature

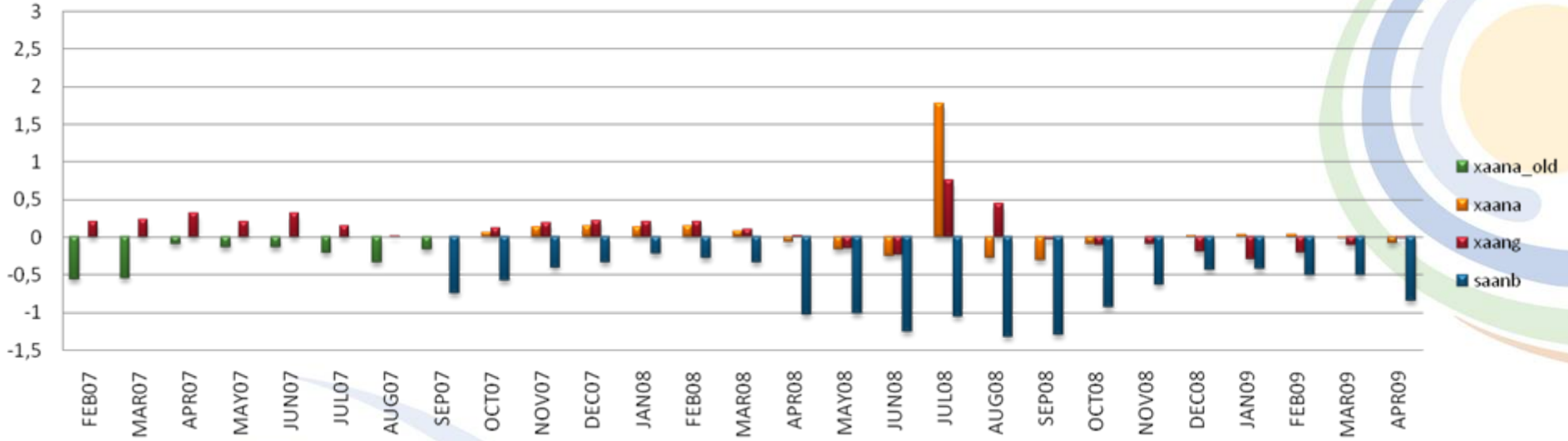
Scores::Bias
::Rmse
::within (+/-) 2degree % percentage scores

Stations: Polokwane
:Durban
Period:: January 2008-April 2009

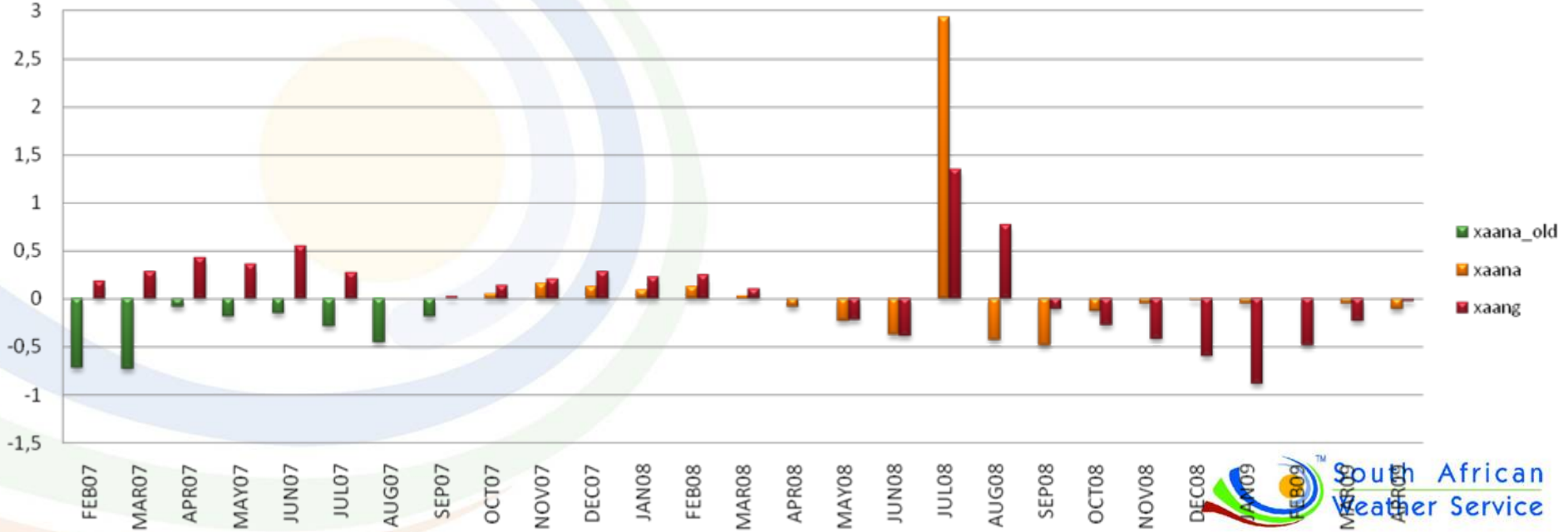
South African Weather Service

Results Bias UM

Bias for temperature at 850hPa for 24 hours

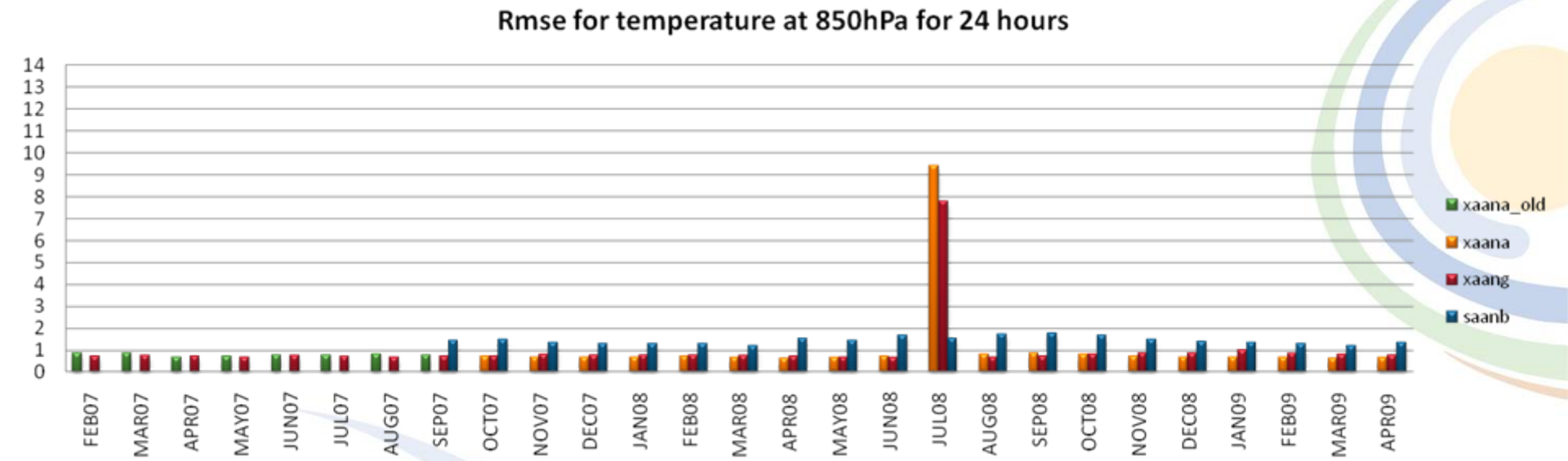


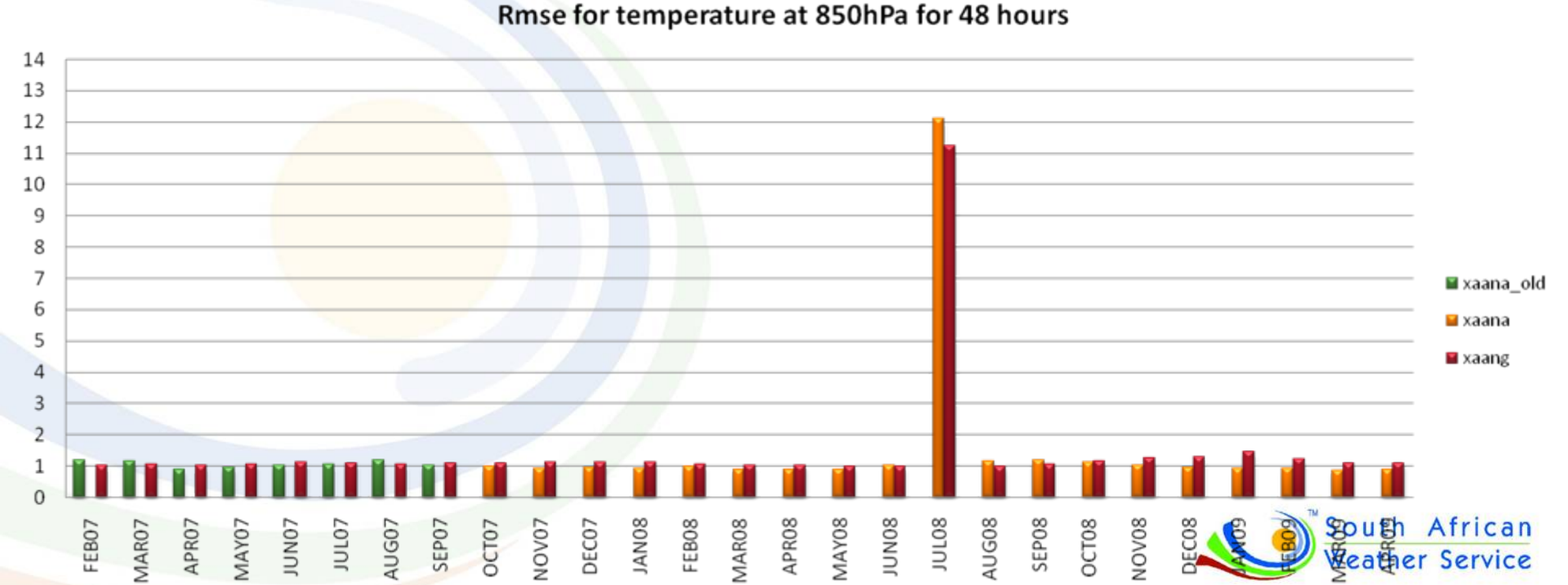
Bias for temperature at 850hPa for 48 hours



South African Weather Service

Results-Rmse UM





South African Weather Service

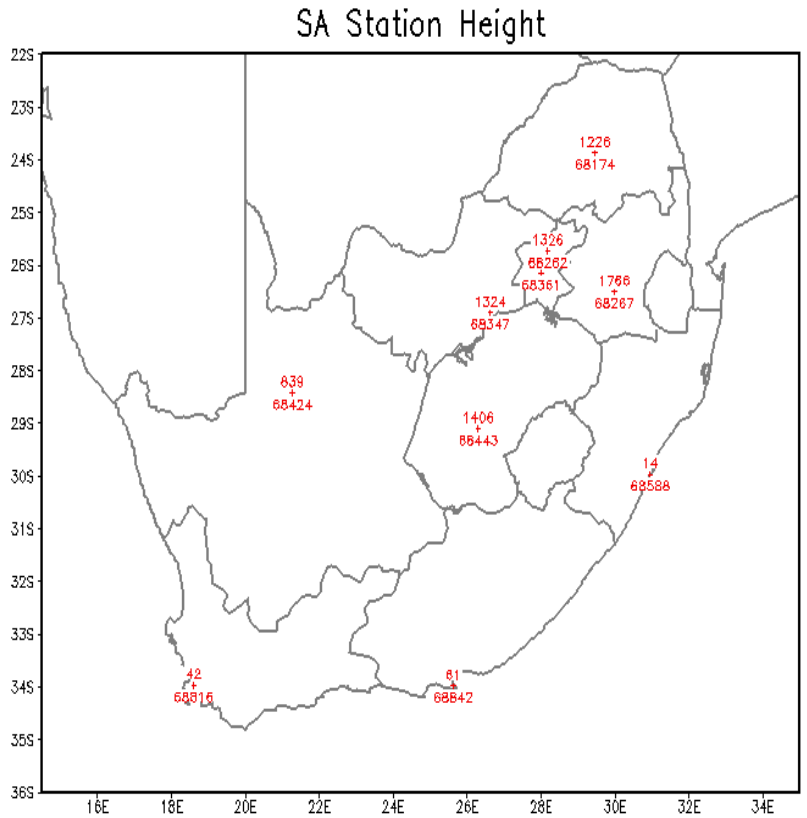
Results : Kalman Filter

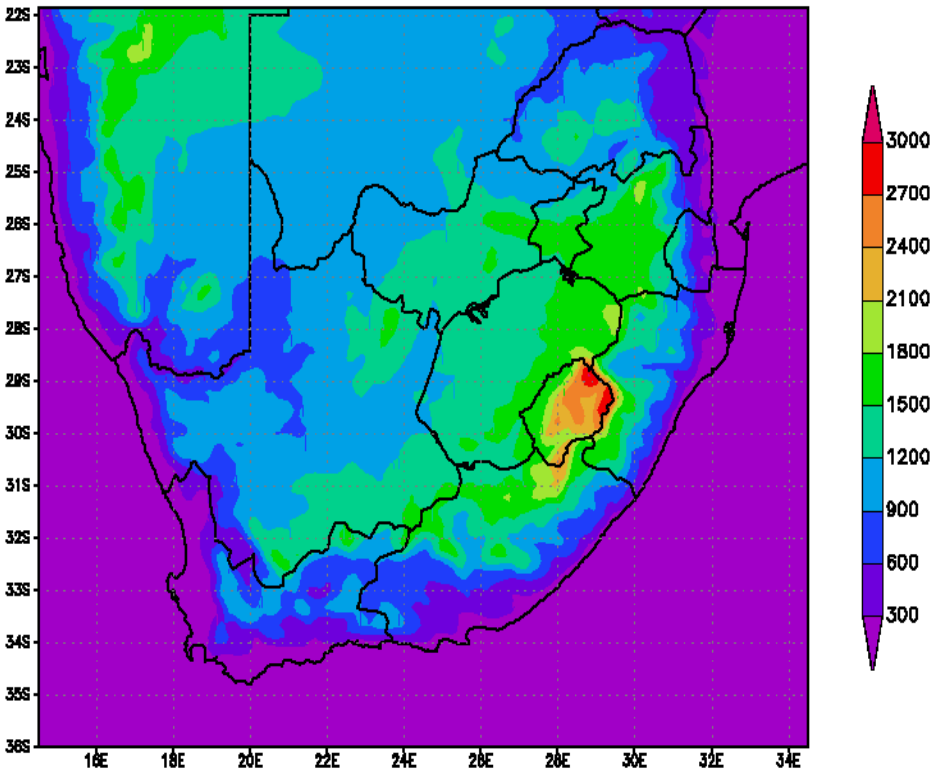
Focus on 48hr/day 2 forecast:

10 major stations are considered:

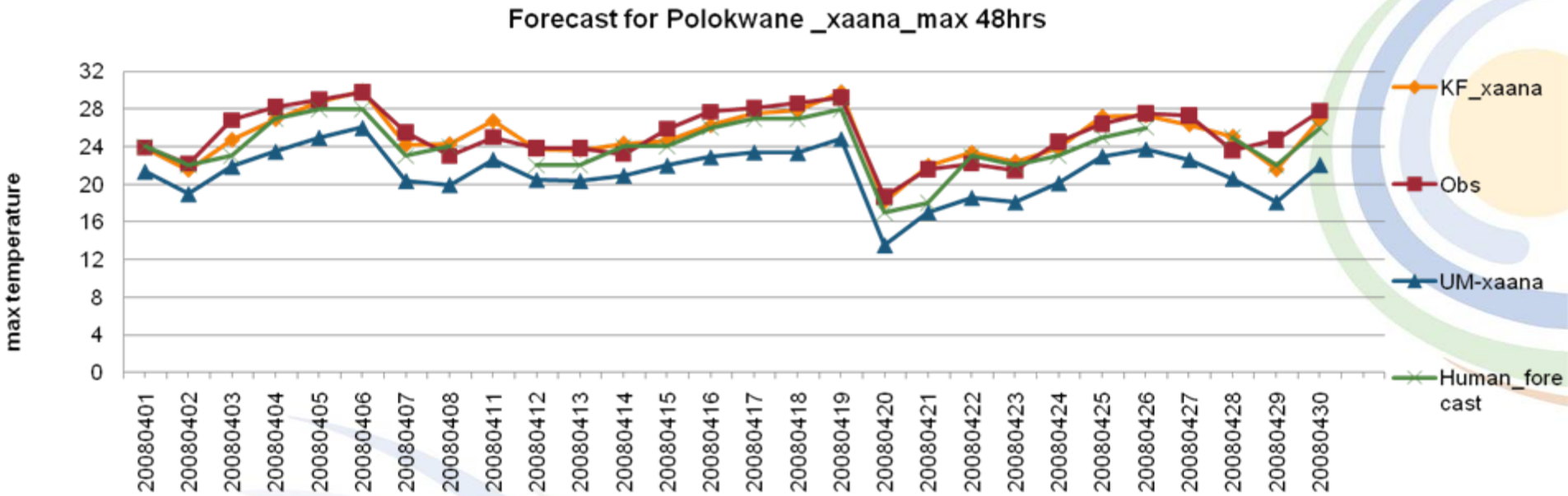
Located at different latitude and longitude

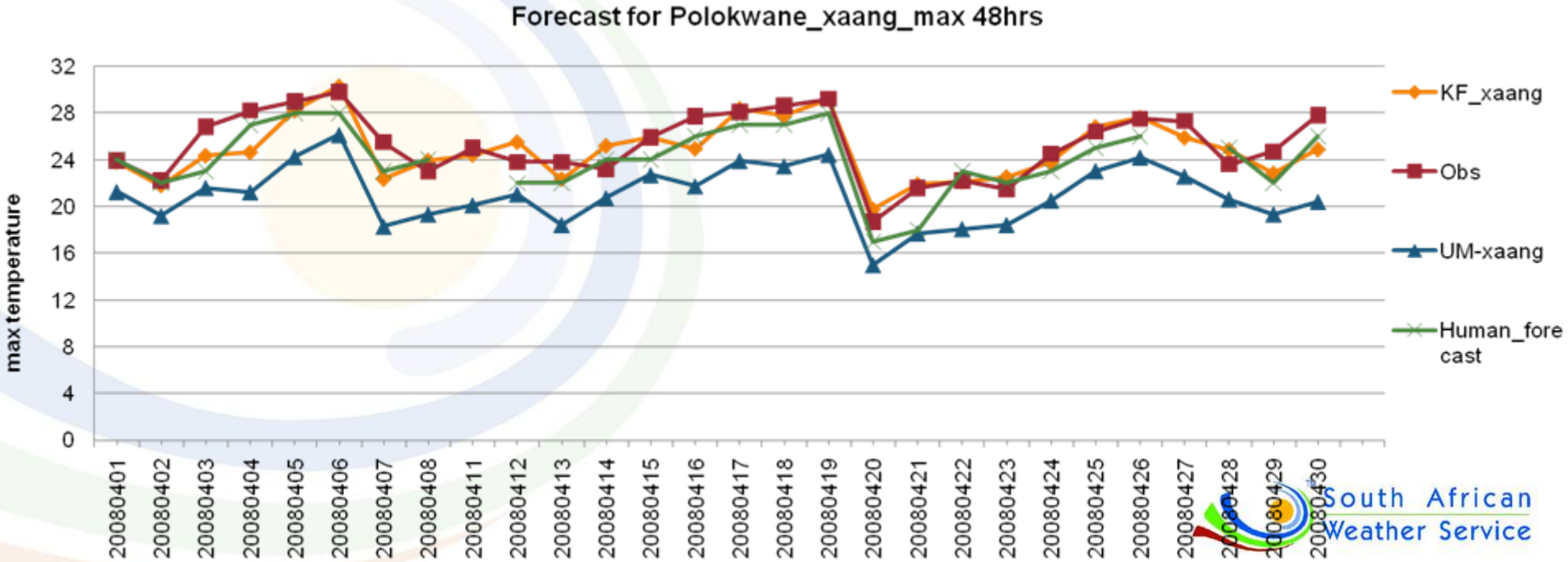
Experience different weather conditions



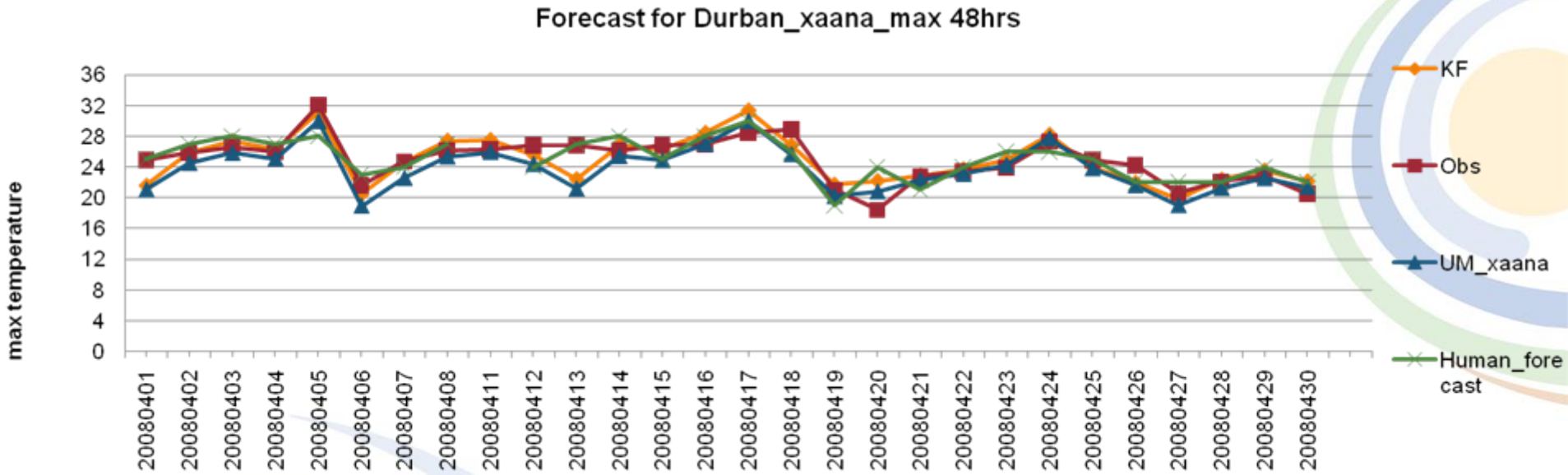


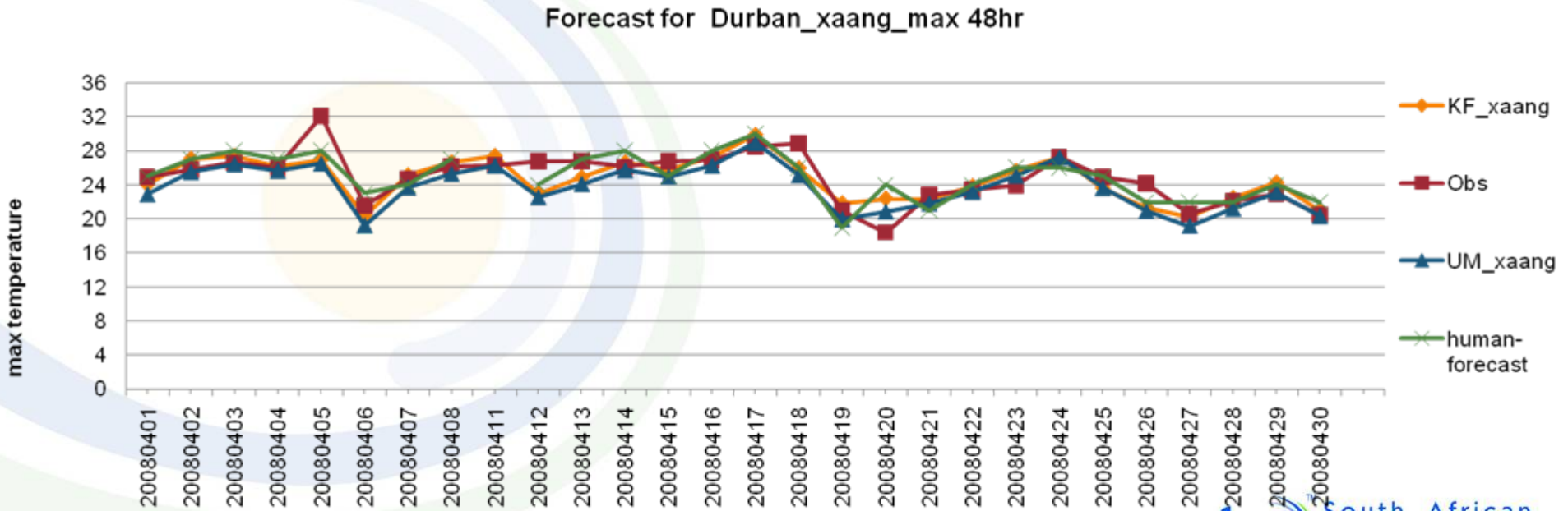
Results: kalman filter System





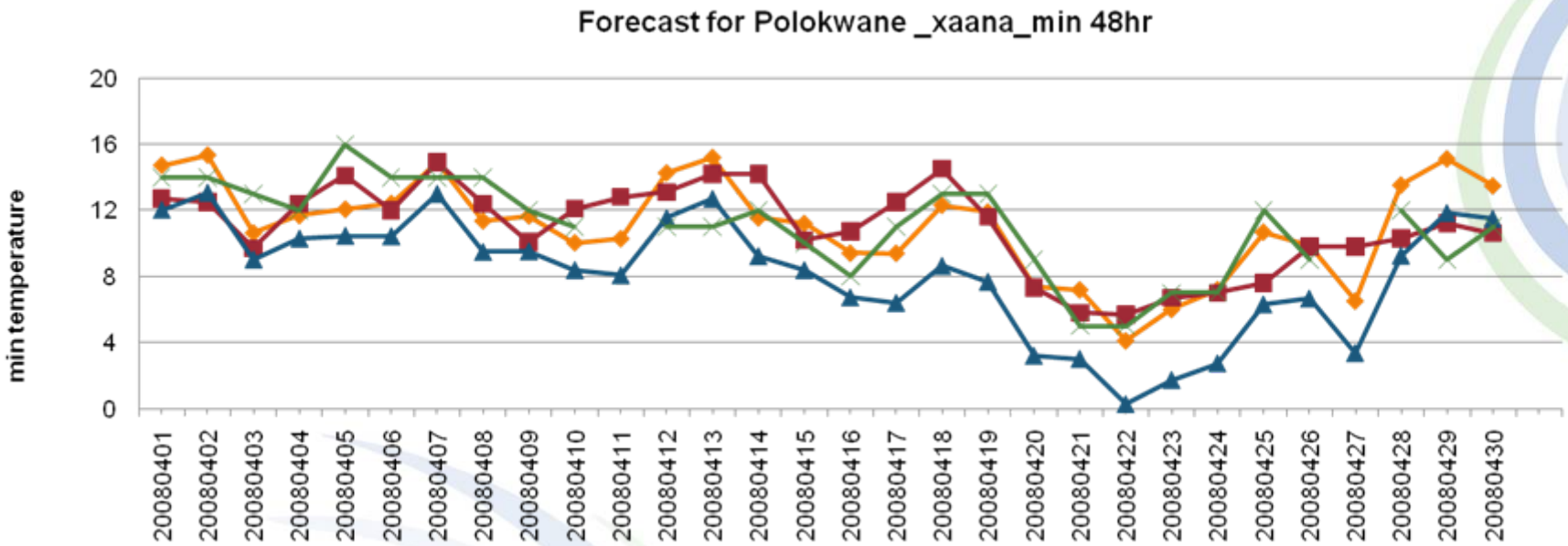
Results: kalman filter System

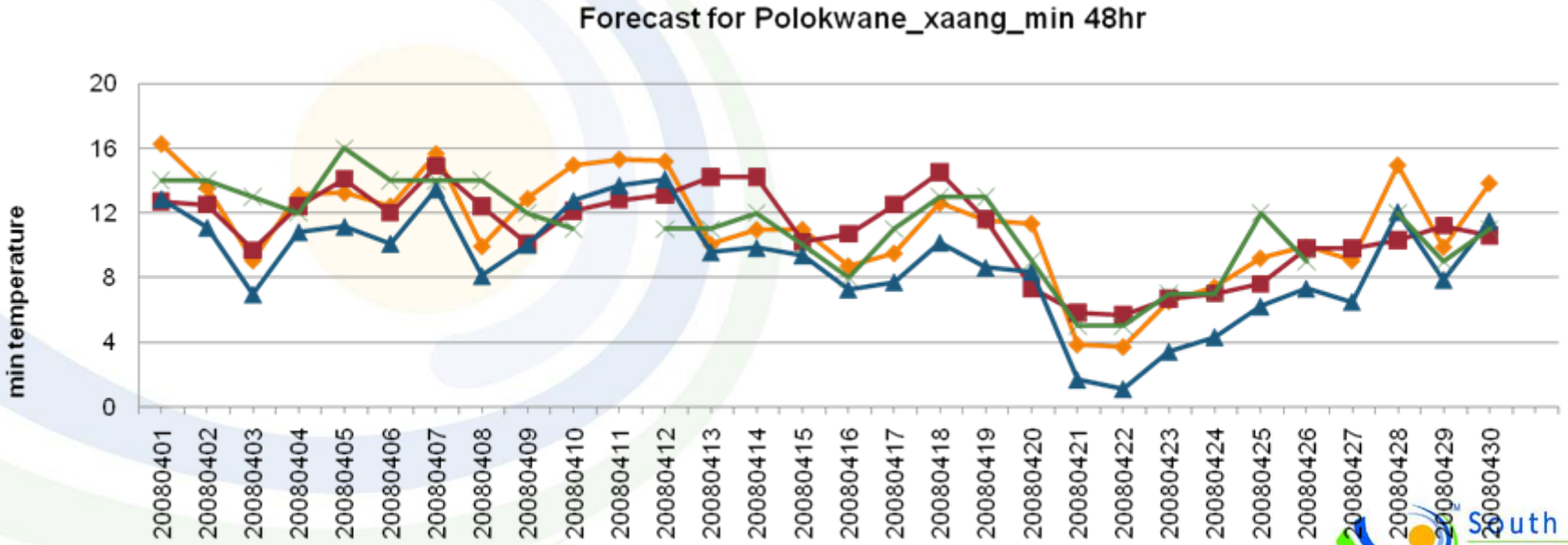




South African Weather Service

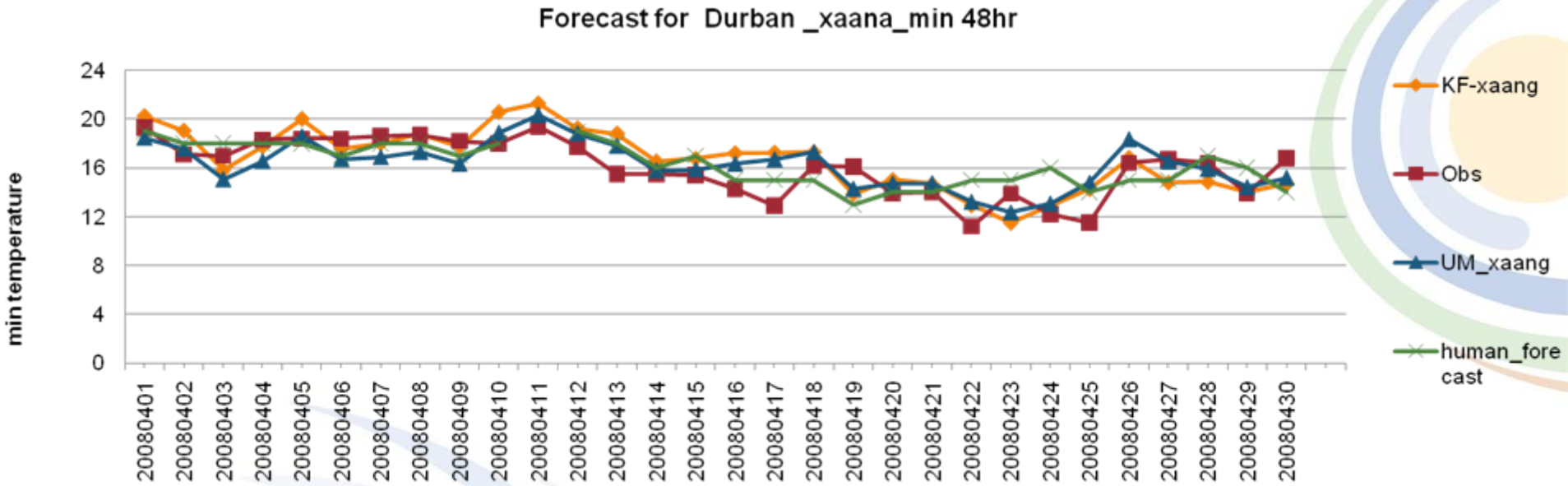
Results: kalman filter System

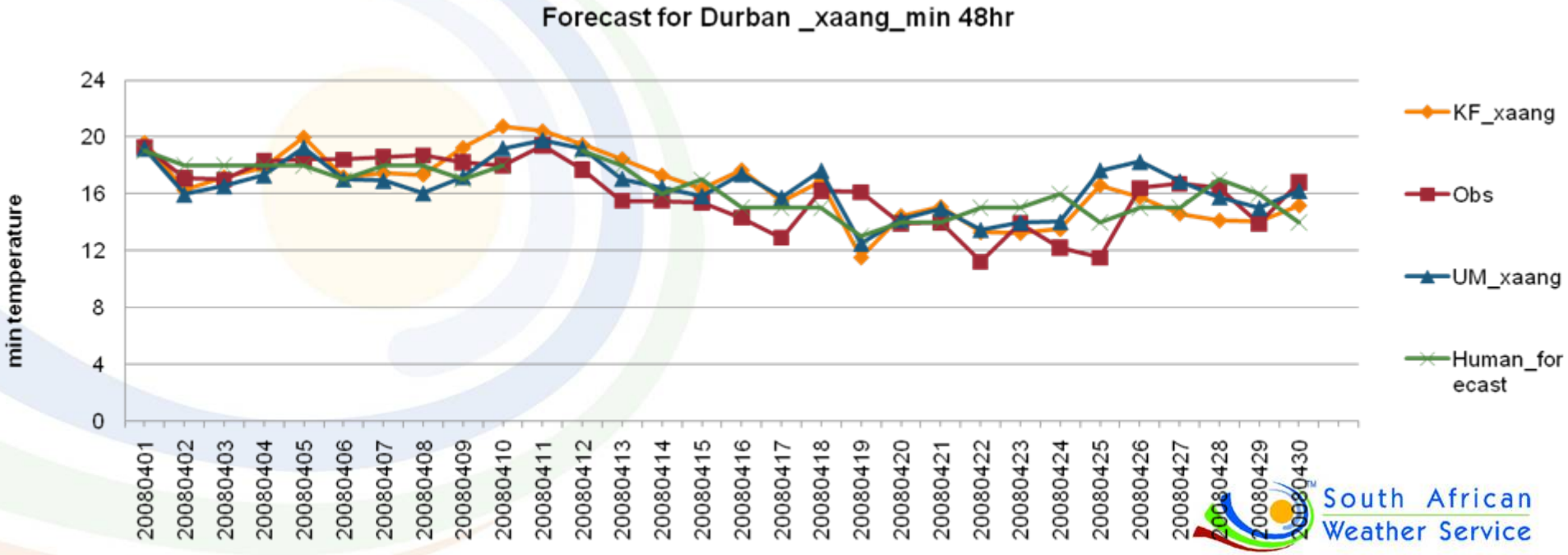




South African Weather Service

Results: kalman filter System





South African Weather Service

Results : Kalman Filter

Bias Maximum Temperatures: Averages					
	bias-KF_xaana	bias-UM_xaana	bias-KF_xaang	bias-UM_xaang	bias-Human_Forecast
Polokwane	0.02	-2.66	0.03	-1.83	-0.65
Pretoria	0.14	-2.88	-0.03	-1.47	-0.39
Ermelo	0.31	-1.01	0.07	0.14	0.05
Klerksdorp	-0.01	-1.58	0.10	-0.18	0.28
Joburg	0.05	-1.71	-0.03	-0.42	-0.60
Upington	-0.12	-2.60	-0.06	-1.41	-0.53
Bloemfont	-0.07	-1.82	-0.09	-0.25	0.24
Durban	0.11	-0.74	0.05	-0.70	0.12
Cape Town	-0.07	-0.14	0.09	-0.13	-0.20
Port Eliz.	-0.01	-1.15	0.09	-1.30	-0.07

South African Weather Service

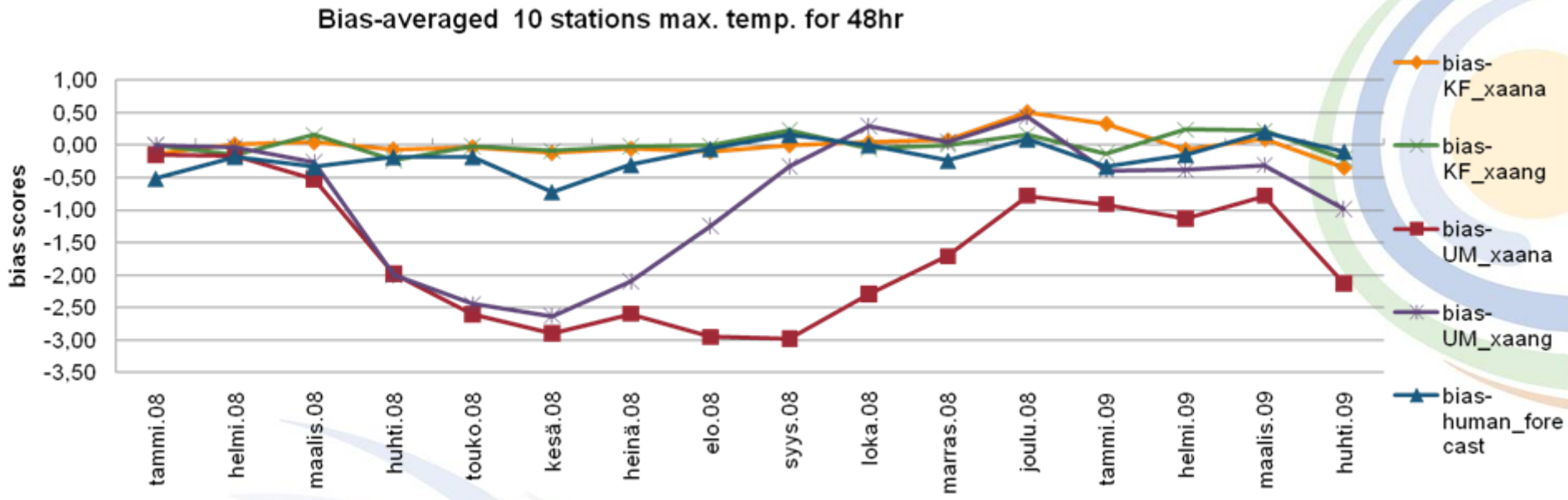
Results : Kalman Filter

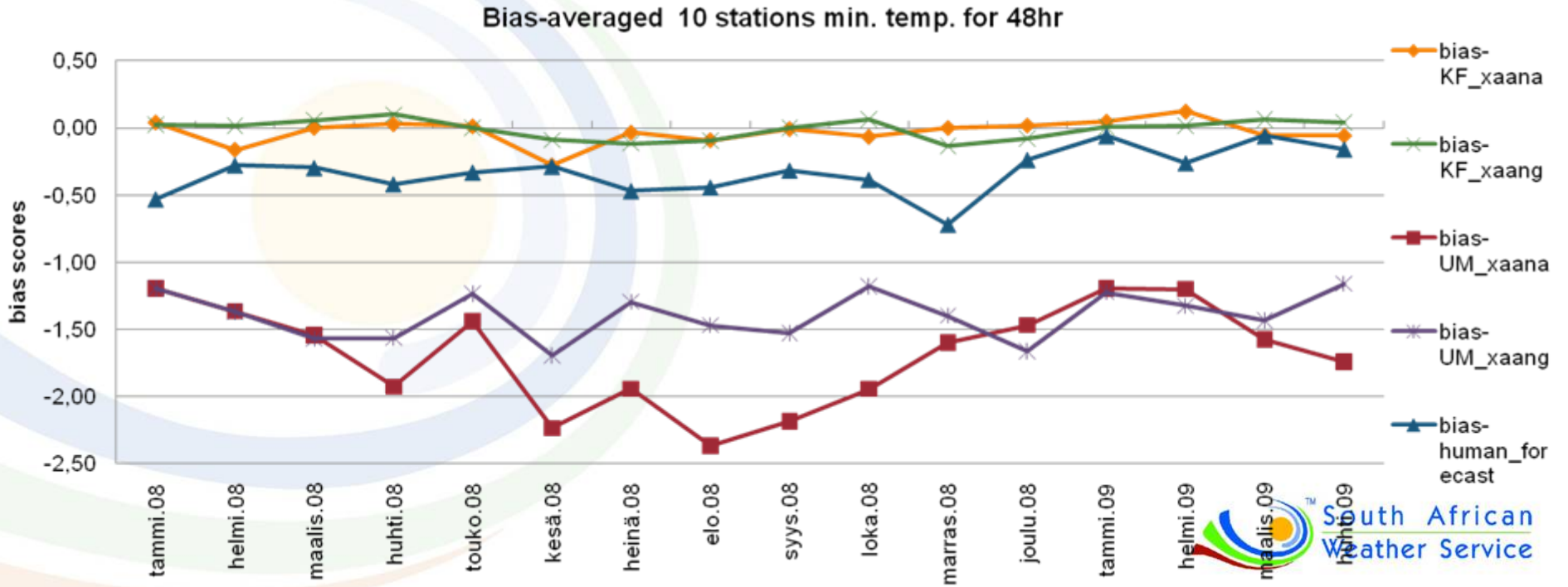
Bias Minimum Temperatures: Averages

	bias-KF_xaana	bias-UM_xaana	bias-KF_xaang	bias-UM_xaang	bias-Human_Forecast
Polokwane	0.00	-2.65	0.03	-2.37	-0.48
Pretoria	0.07	-2.17	0.04	-1.56	-0.16
Ermelo	-0.01	-1.22	-0.04	-1.01	-0.11
Klerksdorp	-0.19	-2.52	-0.17	-1.86	-0.54
Joburg	-0.02	-0.93	-0.02	-0.21	-0.35
Upington	-0.03	-3.33	0.02	-2.71	-0.30
Bloemfont	-0.10	-2.32	-0.11	-2.03	-0.53
Durban	-0.03	-0.42	-0.30	-0.47	0.08
Cape Town	0.03	-2.42	0.13	-2.57	-0.54
Port Eliz.	0.01	1.20	0.06	0.44	-0.62

South African Weather Service

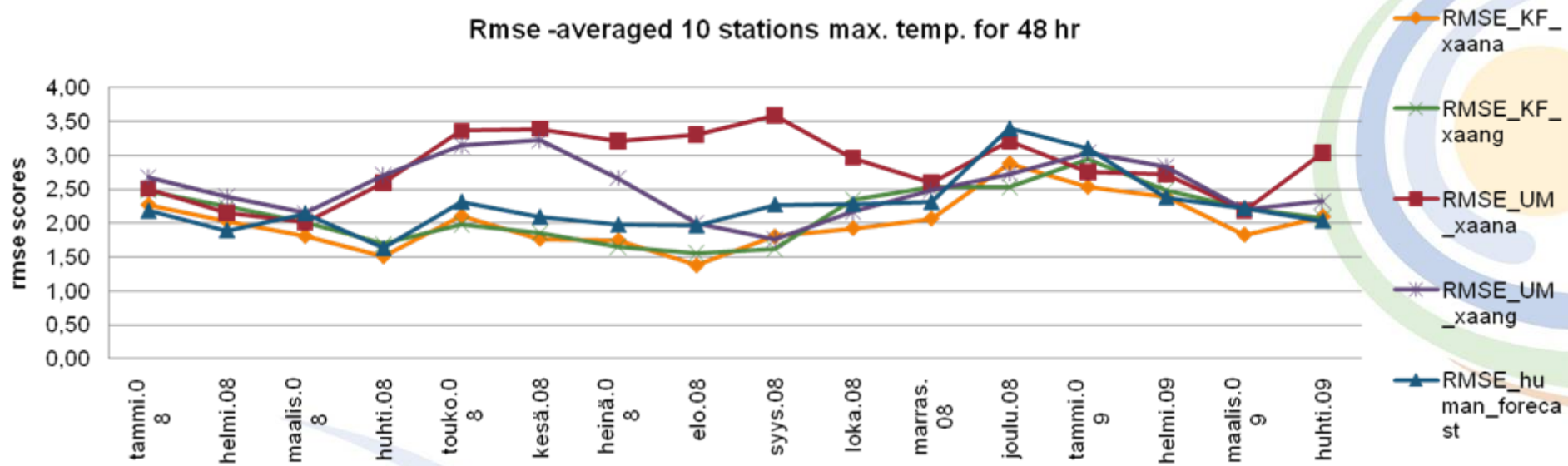
Results: kalman filter System

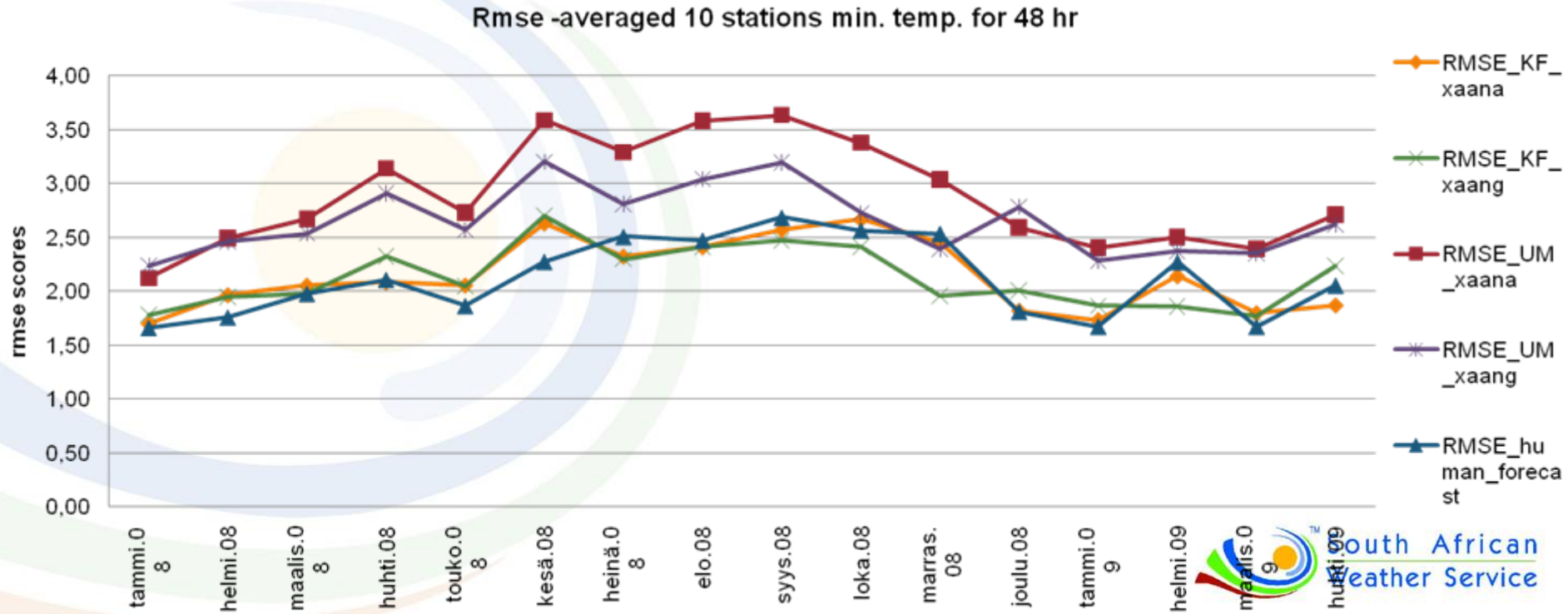




South African Weather Service

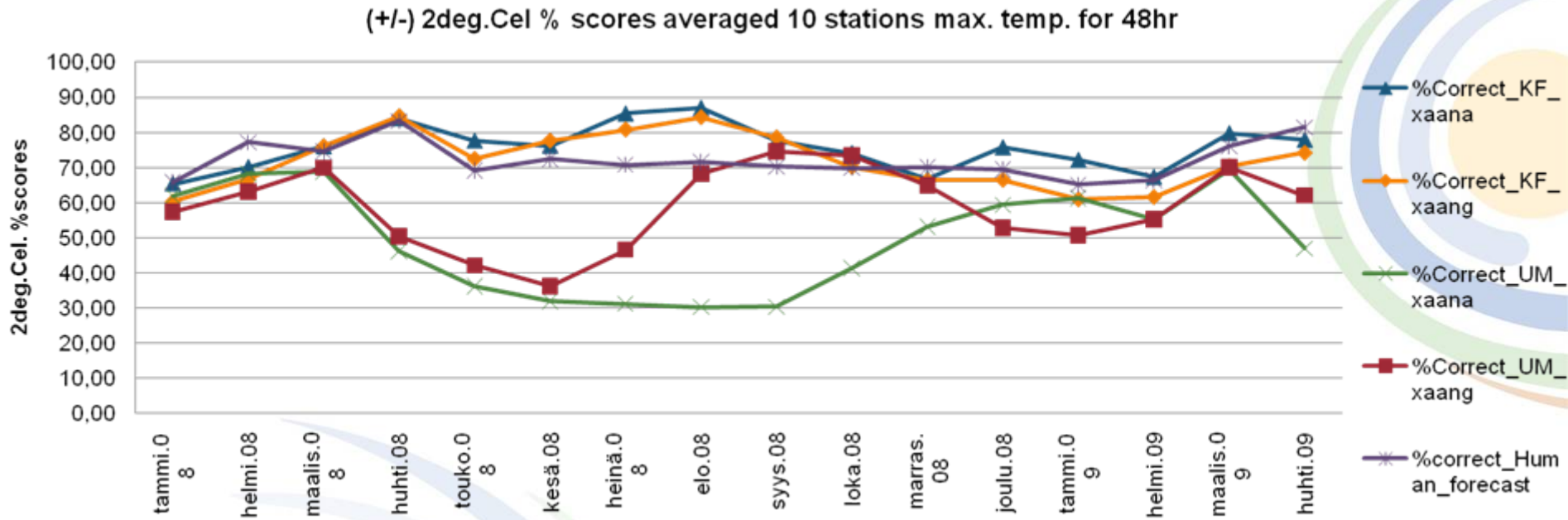
Results: kalman filter System

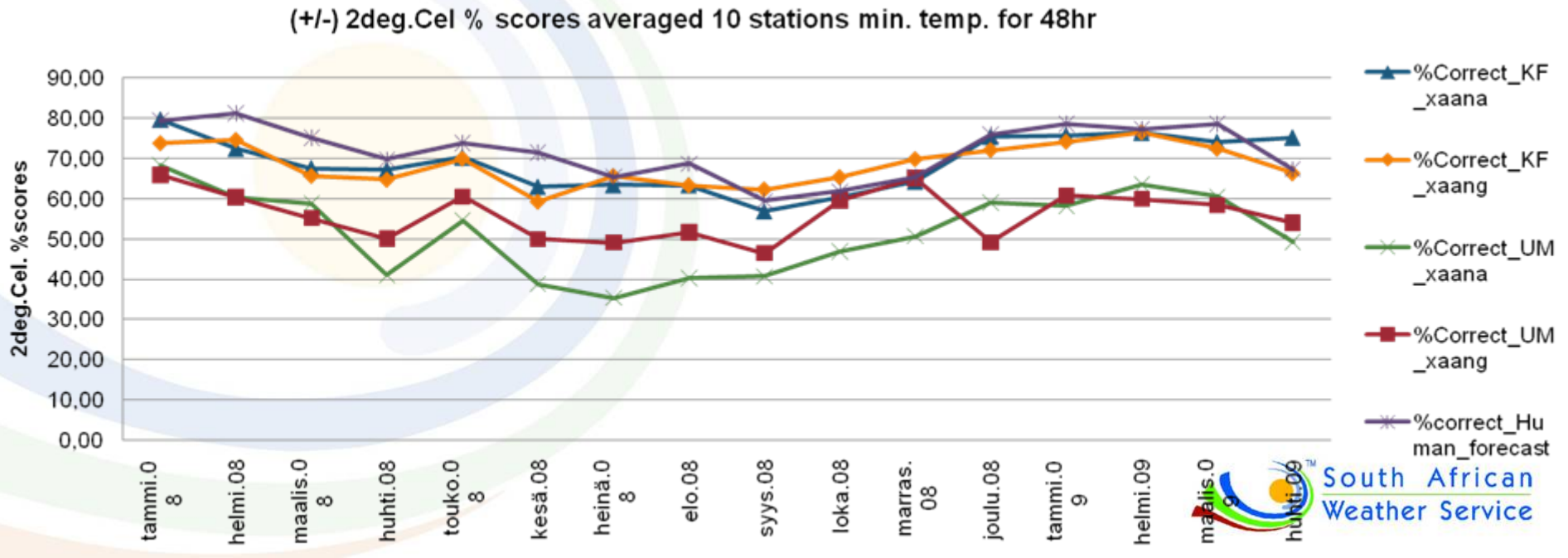




South African Weather Service

Results: kalman filter System





South African Weather Service

Discussions

- **NWP models are subjected to systematic and non-systematic errors**
- **Like-wise, UM forecasts exhibits bias, especially on surface variables**
- **Bias vary from one variable to another, also by season**
- **More bias at 48 hour forecast as compared to 24 hour forecasts**

- ***KF system vs UM vs human forecast:***

***KF is able to correct systematic error/bias and conditional bias, it therefore improves the UM forecasts**

****Bias-**

UM run-ids xaana / xaang forecasts maximum/minimum cold when compared to observations for all 10 stations

Model minimum temperatures where poorly forecasted

Inland stations experience more bias as compared to coastal stations for both minimum and maximum temperatures

On average, bias vary from one station to another, also by season, with more negative bias on winter

****RMSE-**

Model RMSE scores were high for all stations maximum/minimum forecasts

KF was able to reduce RMSE for all stations by up to 60%

****within (+/-) 2 degree Celsius percentage correct**

KF outscores UM and human forecast

South African Weather Service

Summary and Conclusions

**** UM model under-forecast surface variables-bias i.e. temperatures**

- **More bias at 48hr forecasts as compared to 24hr forecasts**

****MOS, like KF is able to remove/minimise model bias**

****By using KF products, Forecasters are able to issue better forcasts**

*****Challenges**

- **KF forecasts quality depends on data quality-observations and Model forecast**
- **Error in data leads to bad KF forecasts**
- **Observations, i.e. maximum are acquired later in a day**

*****Way forward**

- **compile and issue KF forecasts to SADC countries**
- **Develop KF into ensemble KF forecasts**

South African Weather Service

References

WMO: Guidelines on performance Assessment of Public Weather Services, TD No.1023

Libonati, R.,Trigo,I.,& DaCamara, C.C.,2008: Correction of 2m temperature forecasts using Kalman Filtering Technique., Atm. Research, 87 (183-197)

Galanis,G., & Anadranistakis,M., 2002: A one dimensional Kalman Filter for the correction of near surface temperature forecasts.,Meteorol.Applic.,9, (437-441)

Crochet,P., 2004: Adaptive Kalman filtering of 2-metre temperature and 10-mtre wind-speed forecasts in Iceland. Meteorol.Applic.,11, (173-187)

Emmanouil,G.,Galanis,G.,&Kallos,G.,2006: statistical methods for the prediction of night-time cooling and minimum temperature., Meteorol.Applic.,13, (1-11)

Louka,P.,Galanis,G.,Siebert,N.,Kariniotakis,G.,Katsafados,P.,Pytharoulis, I., & Kallos.G.,2008: Improvements in Wind-speed forecasts for wind power prediction purpose using Kalman filtering. J. Wind Eng. Ind. Aerodyn. 96 (2348-2362)

South African Weather Service

END

Thank You

We bring weather together!!

South African Weather Service