Progress and Challenges in African Surface Temperature Science

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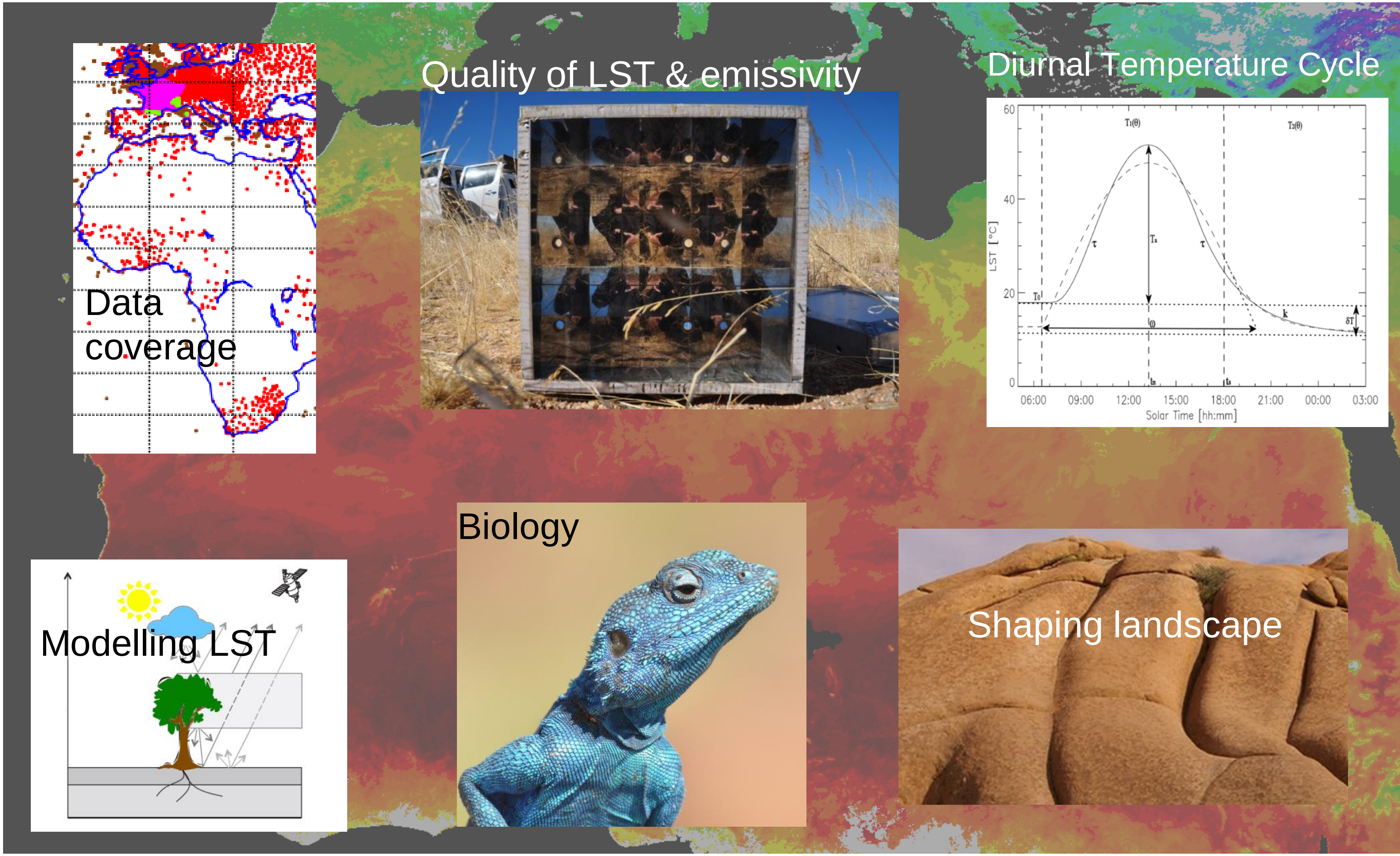
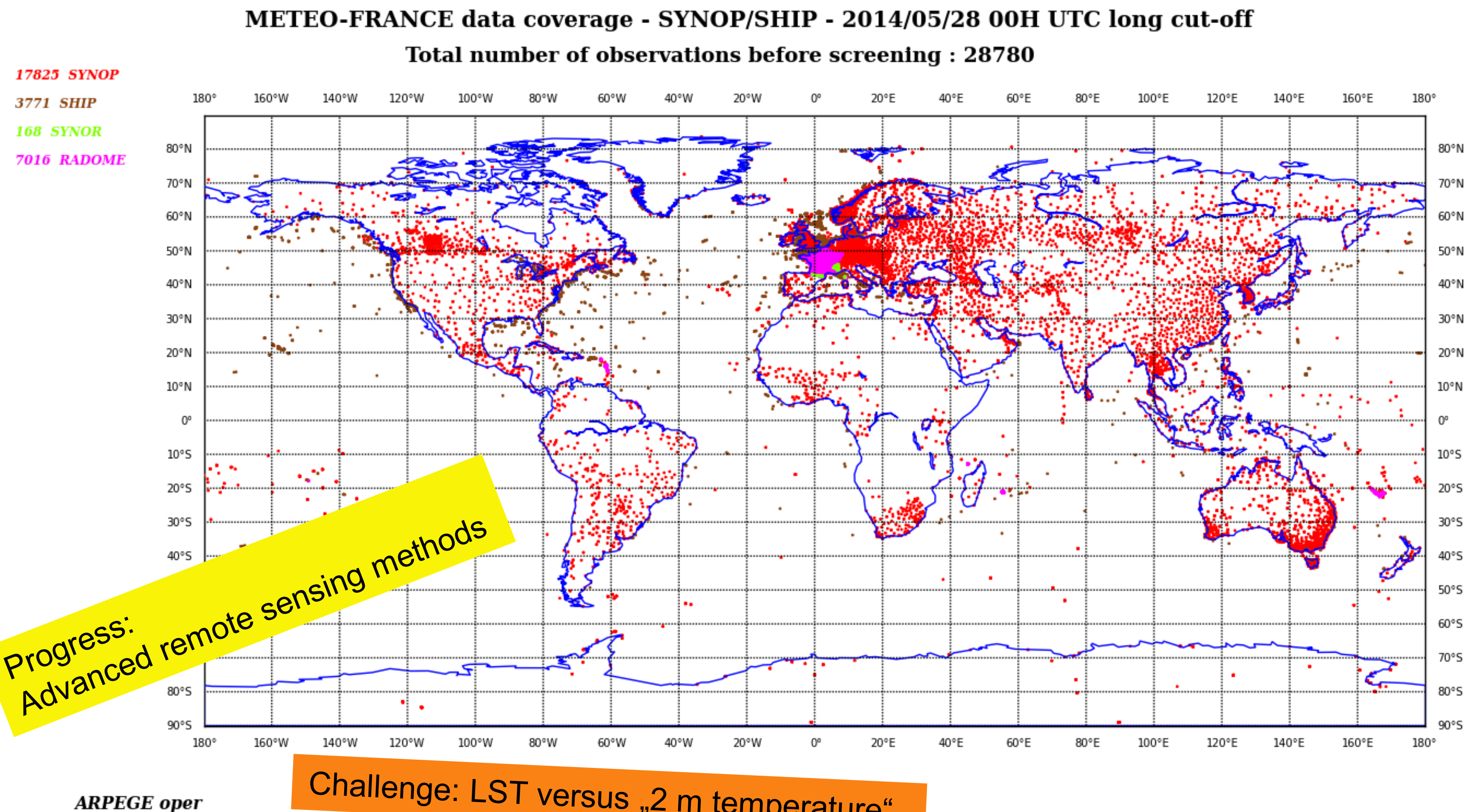


Africa – sparse surface measurements



Progress:
Advanced remote sensing methods

Challenge: LST versus „2 m temperature“

Mean LST 14 UTC LST 1999- 2005 from METOSAT

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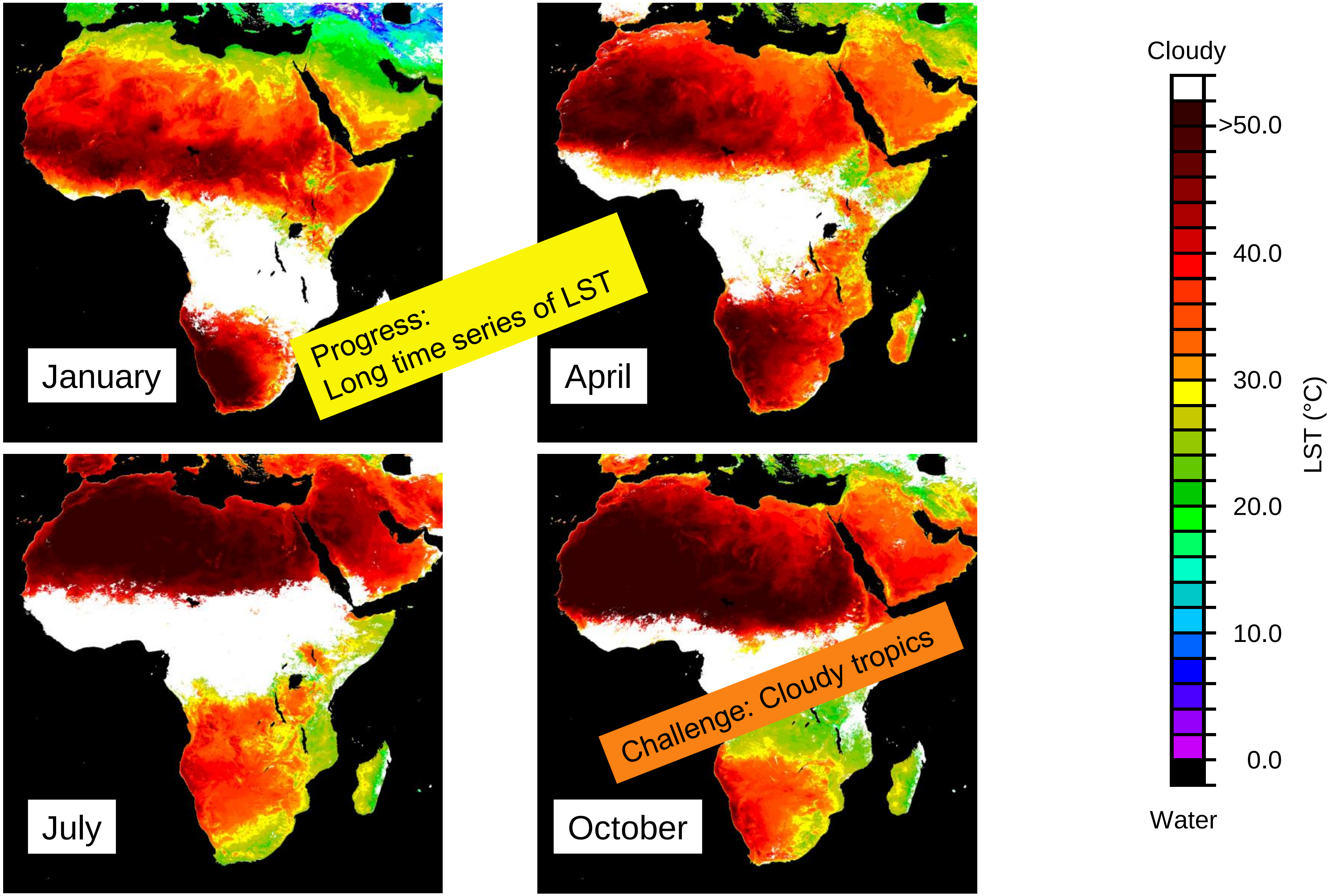
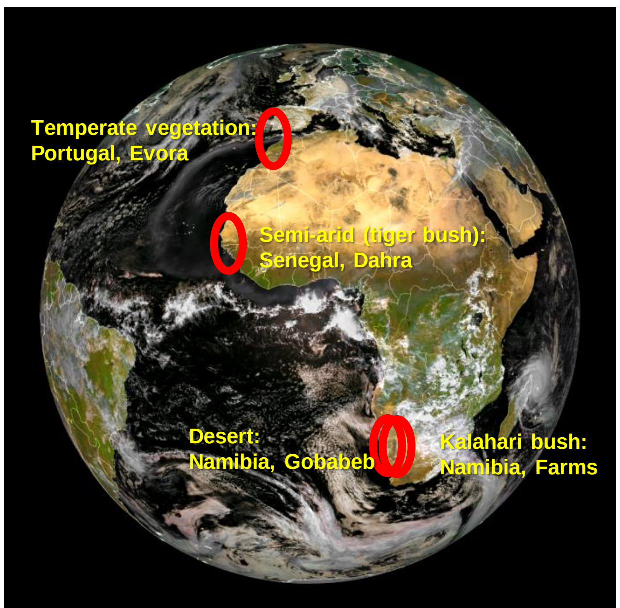


KIT's 4 permanent LST validation stations

- Heitronics KT15.85 IIP radiometer
- Successful radiometer comparison at CEOS
- Proven homogeneity of sites > 100 km²
- Current validation of MSG-SEVIR LST
- Well distributed on MSG-disk



IR-radiometer
Heitronics KT15.85 IIP

✓chopped, precision radiometer: **stability better than 0.12% per year**
✓ narrow band 9.6µm -11.5µm (completely in atmospheric window)
✓ better than ±0.3K absolute accuracy
✓ 0.06K temperature resolution
✓ Full view angle: 8.5°

One KT15 for **each end-member**
One KT15 for **sky radiance** (reflected rad.)

Campbell CR1000 logger sample at **1 min**

KIT's 4 permanent LST validation stations

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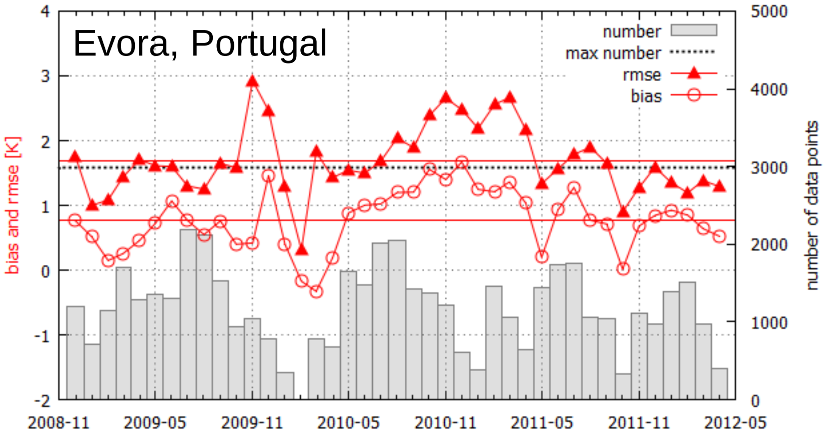
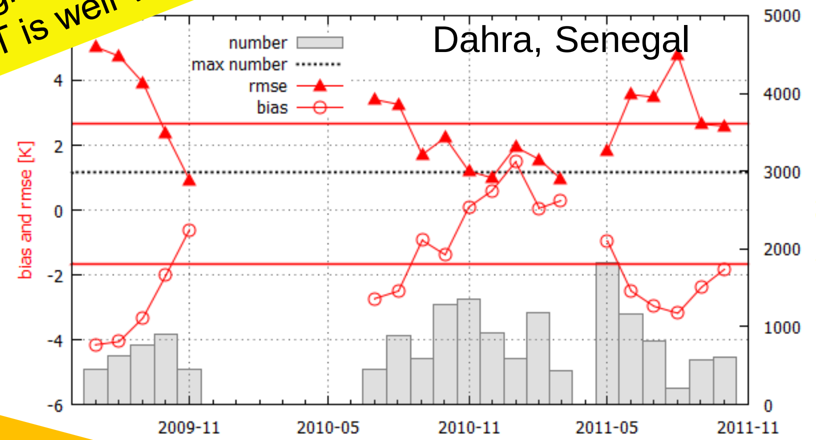
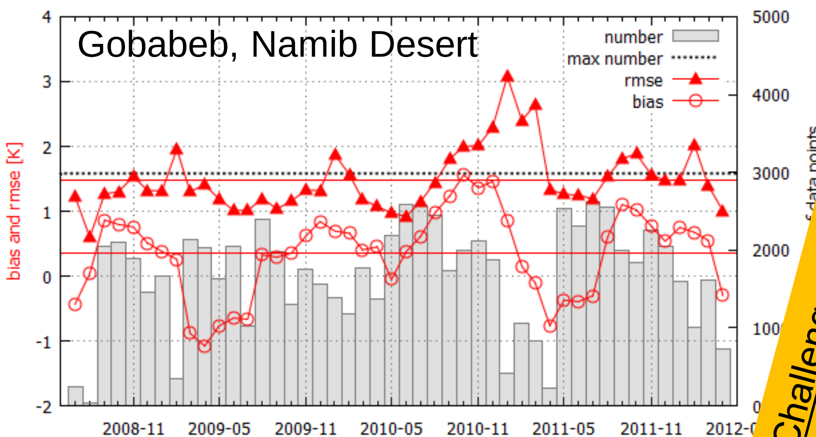
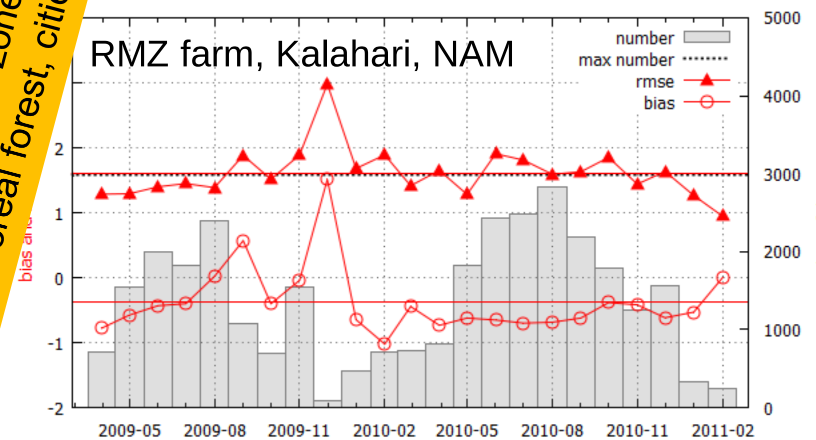
Progress:
LST is well validated





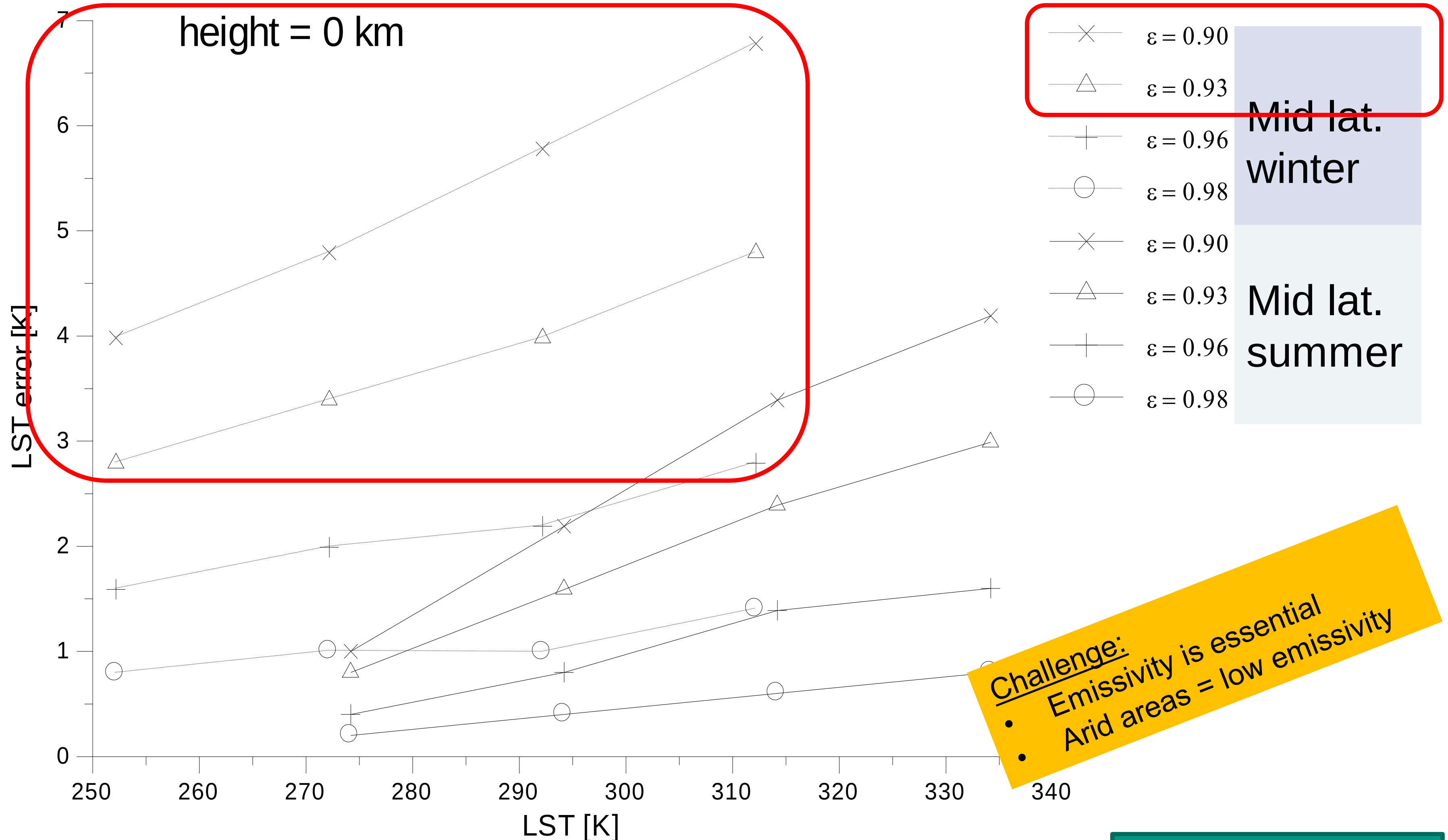




Challenge:
Expand to more climate zones
Snow/polar, boreal forest, cities

Göttsche, Olesen

Emissivity - LST error



Challenge:
- Emissivity is essential
- Arid areas = low emissivity

Schädlich et al. 2001

Emissivity measurement essential in arid areas

Laboratory

Box method

Challenge:
Area covering methods

Natural System

Emitted radiance

Atmospheric radiance

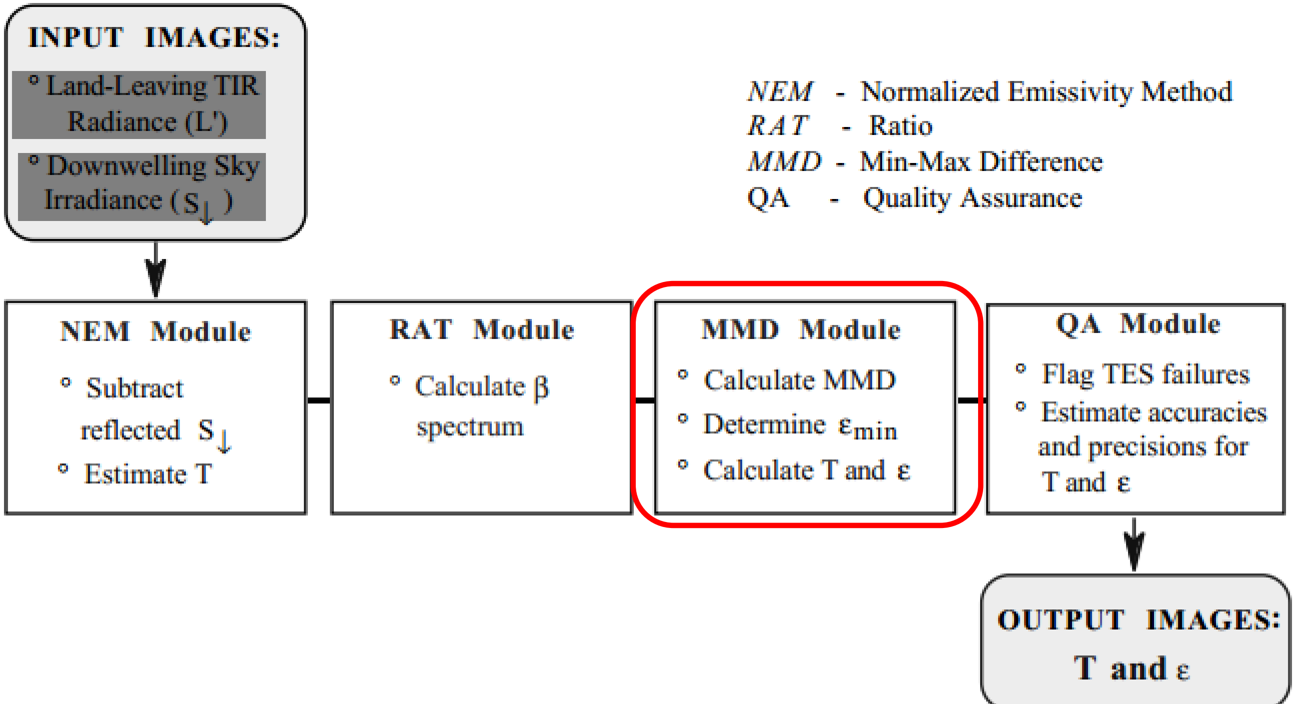
Emissivity

Thermodynamic Temperature

Progress:
Field experiment handling well known
Lab & fiel in good agreement

Poster

Emissivity: „Decoupling Temp/Emiss“

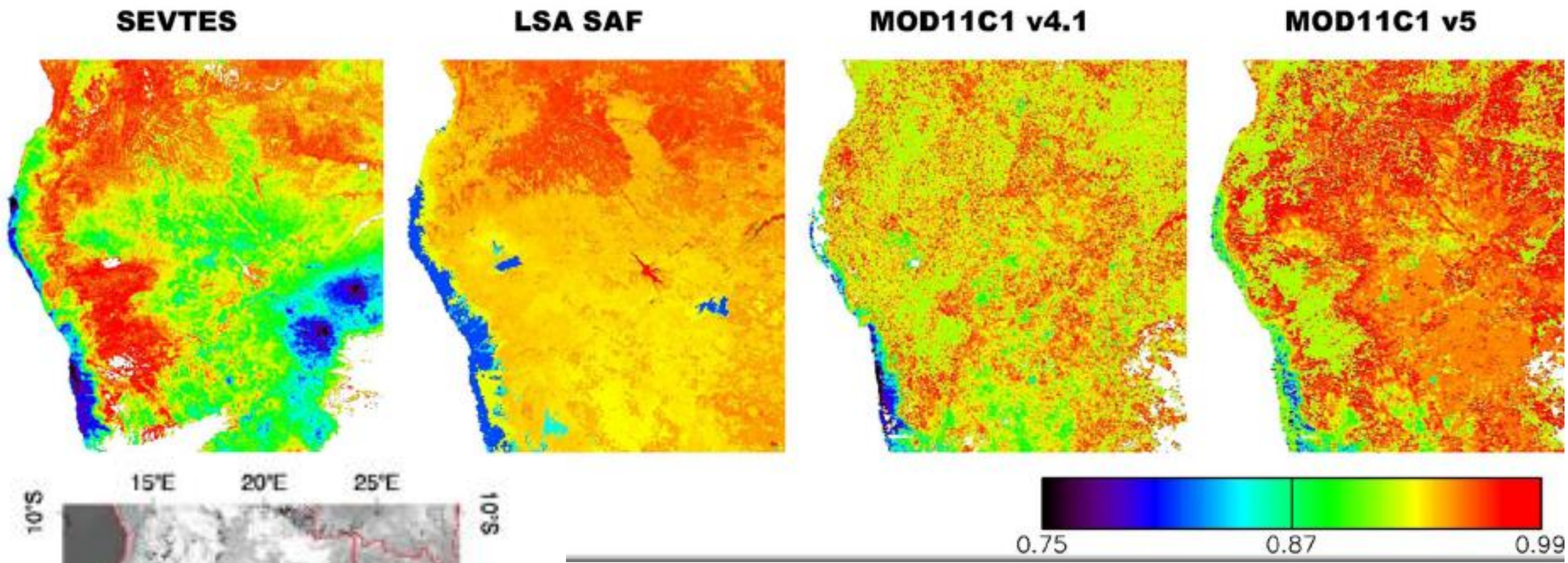


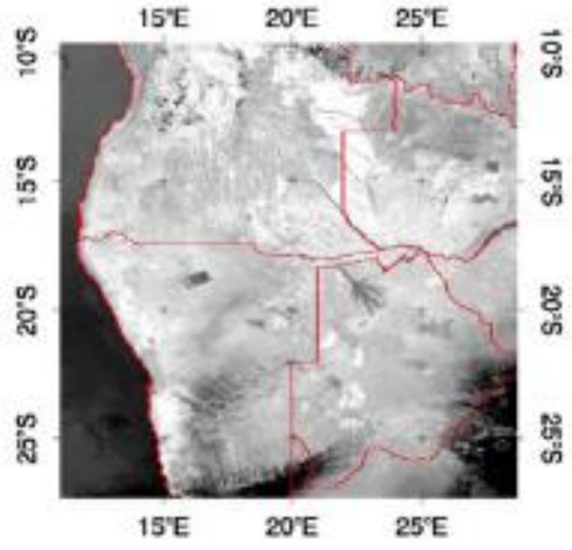
Applicable: ASTER, MODIS, SEVIRI

Progress:
Very promising results over arid (bare) surfaces

Hulley et al.

Emissivity maps for SW-Africa





Big differences

SEVTES most plausible structures

Progress:
Temperature Emissivity Separation method is mature

Jiménez et al. 2014

Extreme temperatures

Maximum: Risk of sensor saturation

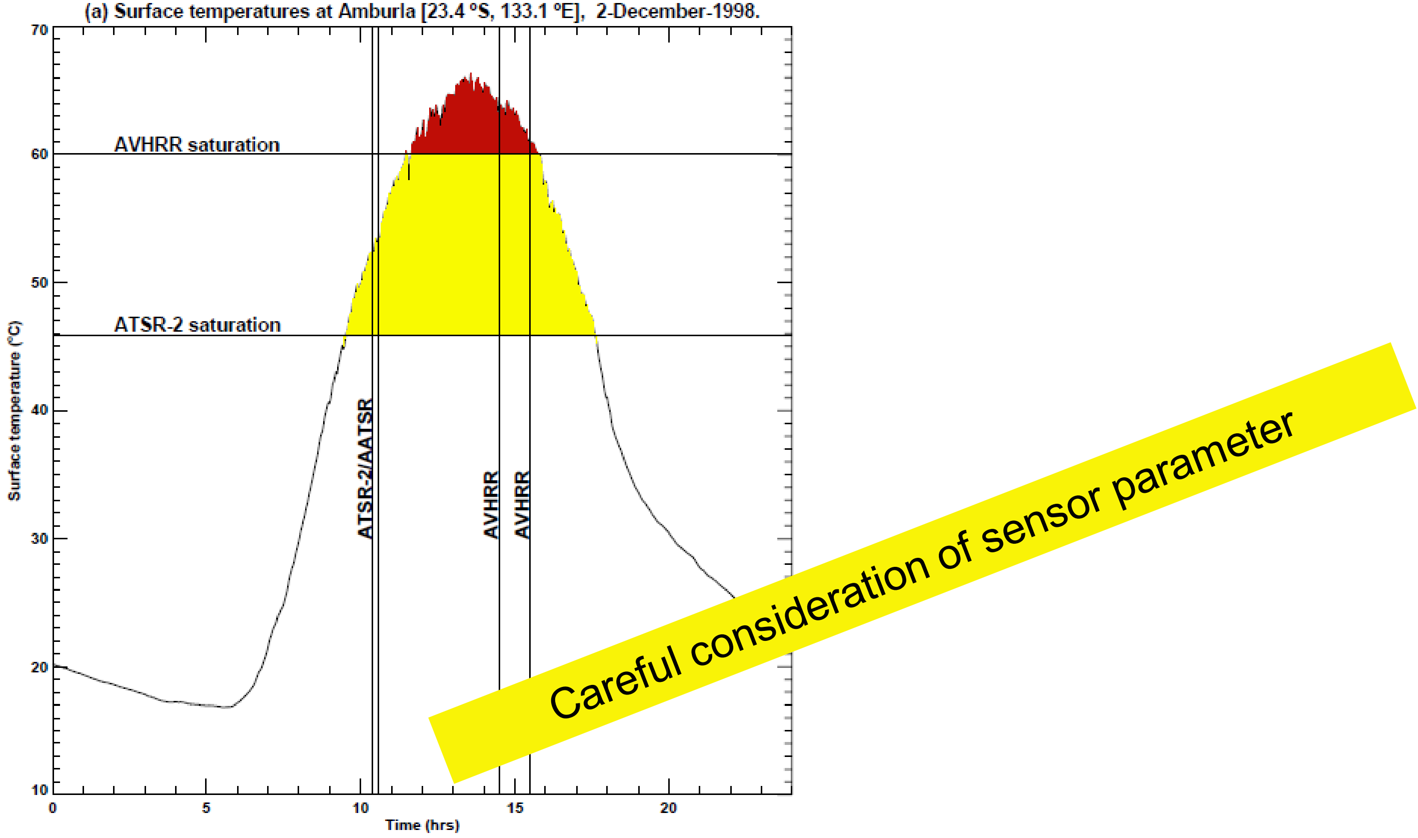
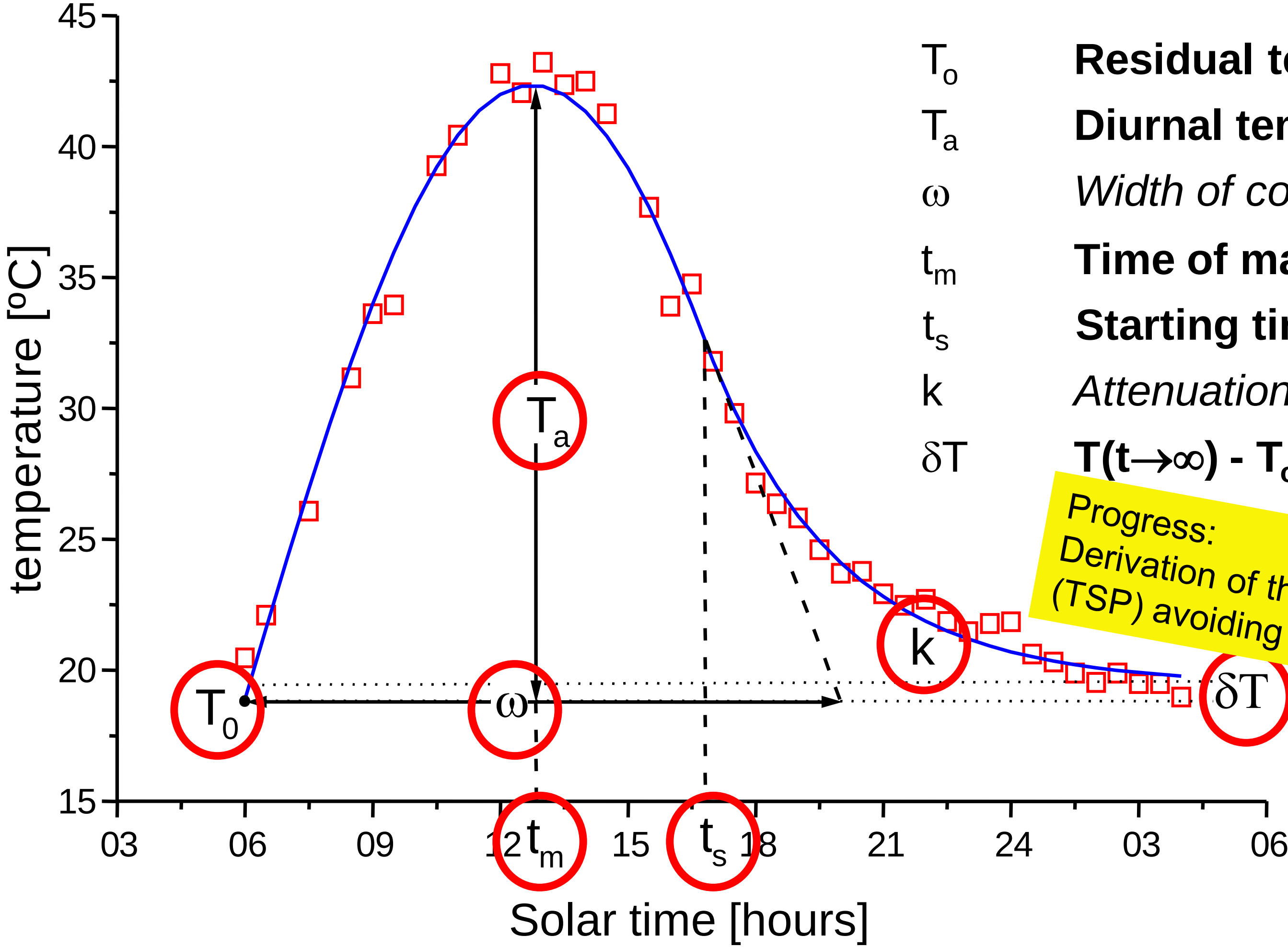


Figure 3 (a). The diurnal land surface temperature cycle at Amburla, NT, Australia during a clear day in summer. The vertical lines show the nominal overpass times of the ATSR-2/AATSR and the AVHRR. The horizontal lines show the current saturation temperatures of the 11 μm channels.

Prata, 2000

Diurnal Temperature Cycle: Determination

Minimum: Risk of undetected clouds - Modelling diurnal temperature wave



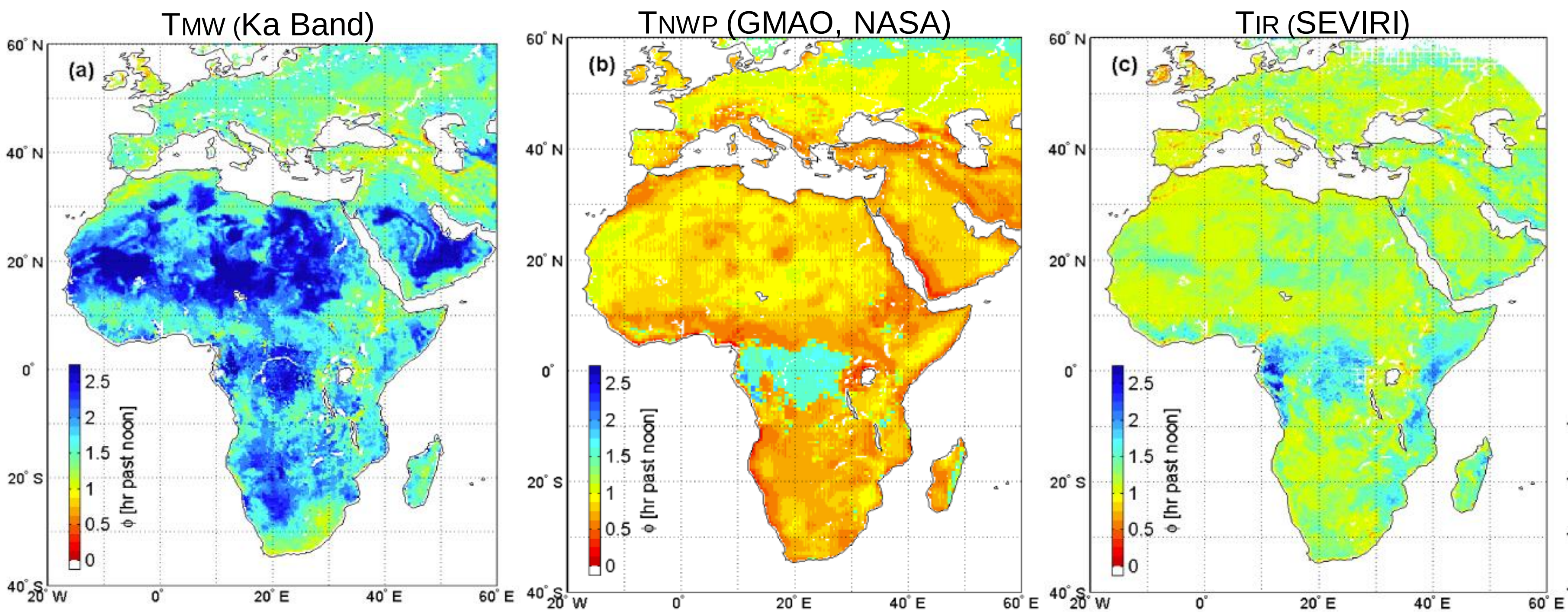
T_o	**Residual temperature**
T_a	**Diurnal temperature amplitude**
ω	*Width of cosine over ± π/2*
t_m	**Time of maximum temperature**
t_s	**Starting time of attenuation**
k	*Attenuation constant*
δT	**$T(t \rightarrow \infty)$ - T_o**

Progress:
Derivation of thermal surface parameter (TSP) avoiding artefacts

Göttsche, Olesen 2009

Diurnal Temperature Cycle: Application

Time shift of maximum temperature against solar noon 2009



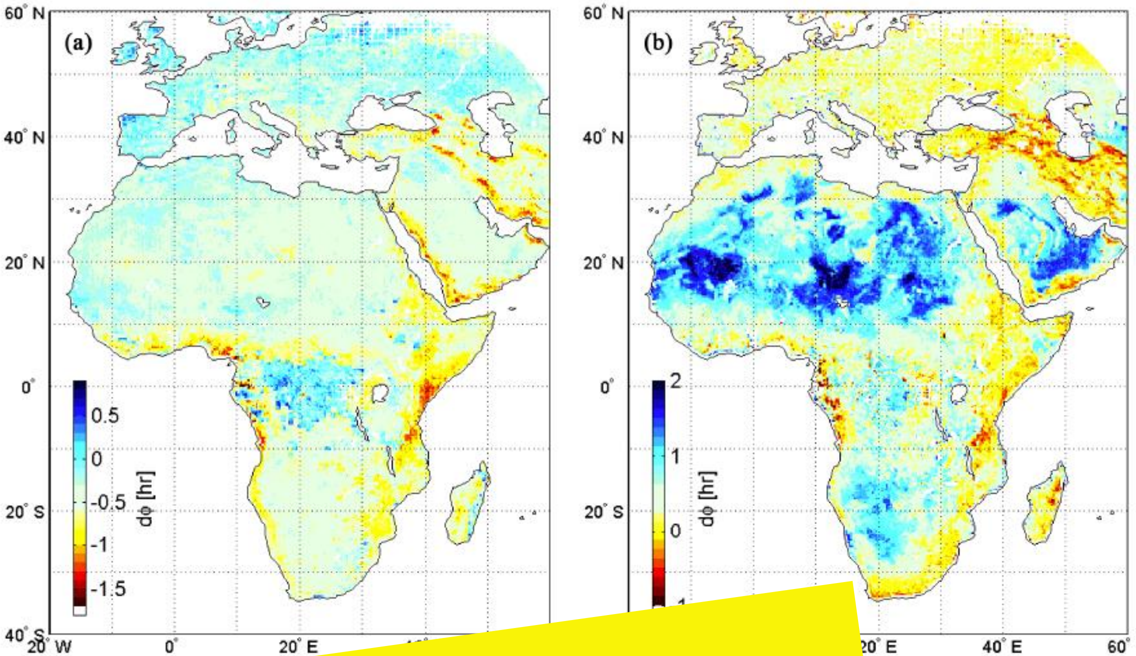
Penetration of Ground | Flux related | Radiance balance

Holmes 2013

Diurnal Temperature Cycle: Application

Time shift of maximum temperature against solar noon 2009

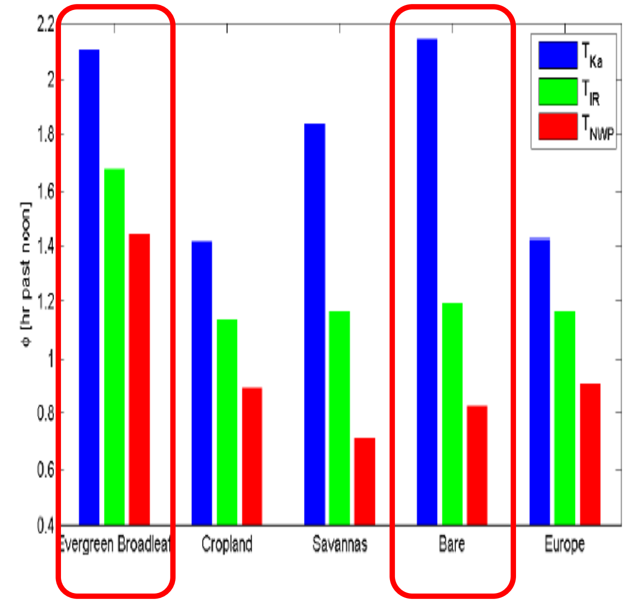
$\Phi(T_{NWP})-\Phi(T_{IR})$ $\Phi(T_{Ka})-\Phi(T_{IR})$



The range of diffences is centered around the avarage:

-23 min for $\Phi(T_{NWP})-\Phi(T_{IR})$

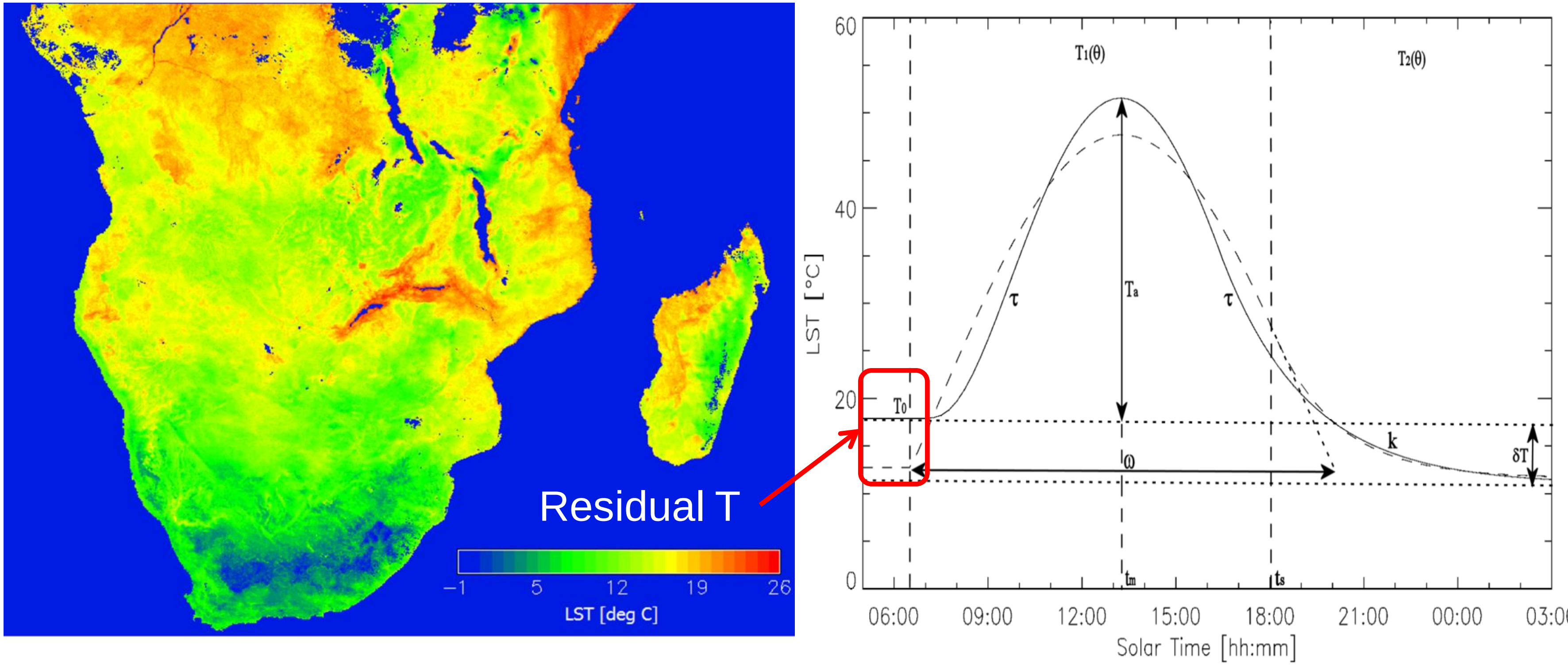
30 min for $\Phi(T_{Ka})-\Phi(T_{IR})$



<u>Progress:</u>
Surface temperatures from various sources is in not the same
Differences in „time of maximum“ can be explained by type of measurement

Holmes 2013

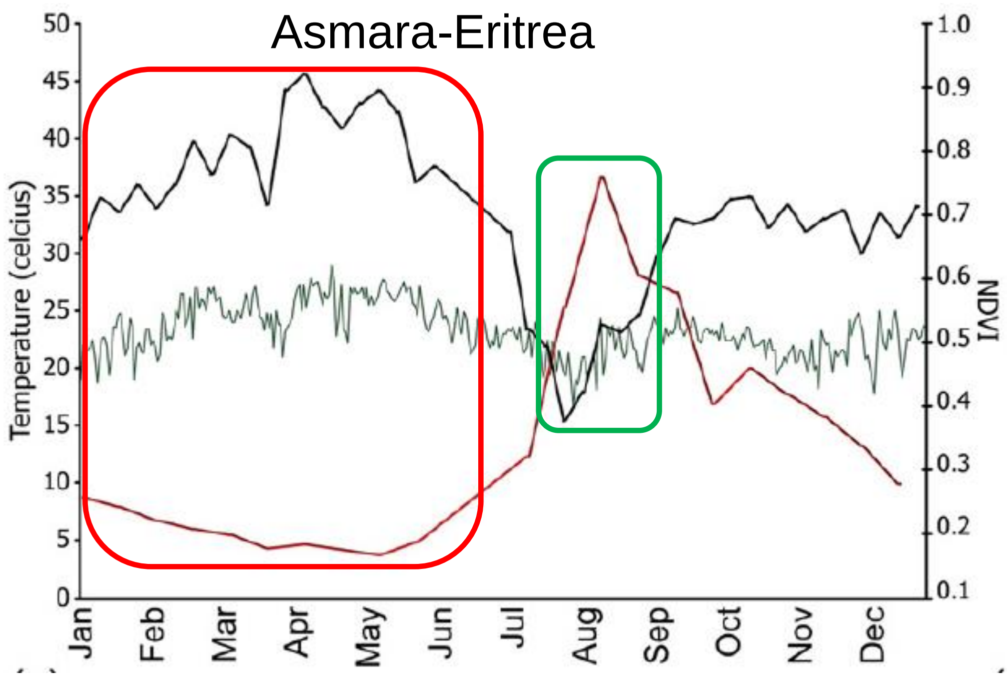
Diurnal Temperature Cycle: 10 day composites



1.-10. Oct. 2009
LST-SAF LST

Göttsche

Near surface air temperature



Black: LST (Modis)
Green: Air temperature (station)
Red: NDVI

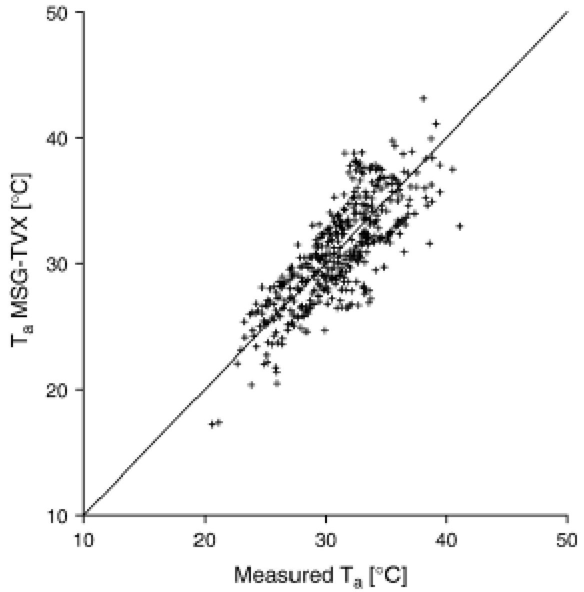
<u>Challenge:</u>
LST and air temperature relationj depends on surface cover

2 m above the ground?

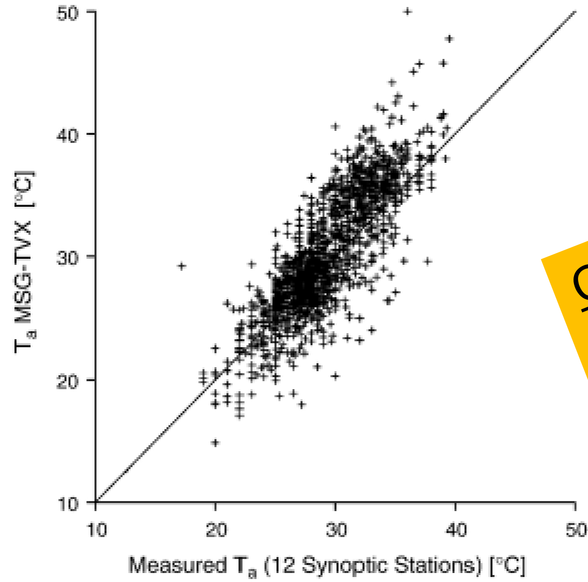
Vancutsem 2010

Near surface air temperature

Ta MSG-TVX = Temperature Vegetation combination to derive air temperature from MSG IR data



Validation station
Dahra – Senegal
(Aug-Oct)

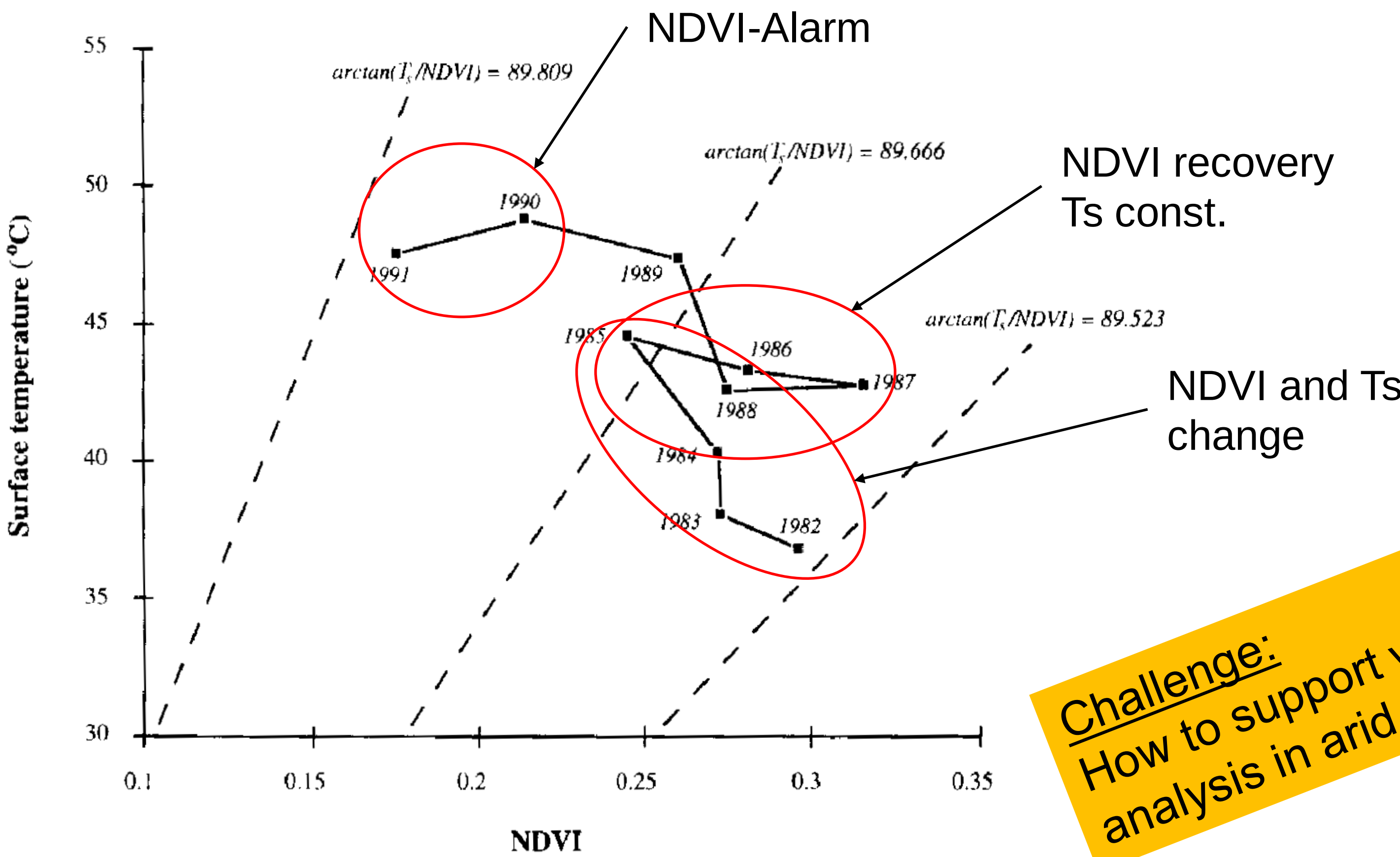


Synop stations
Senegal
(July-Oct)

Challenge:
What is true?

Stiesen 2007

NDVI and LST - Land degradation

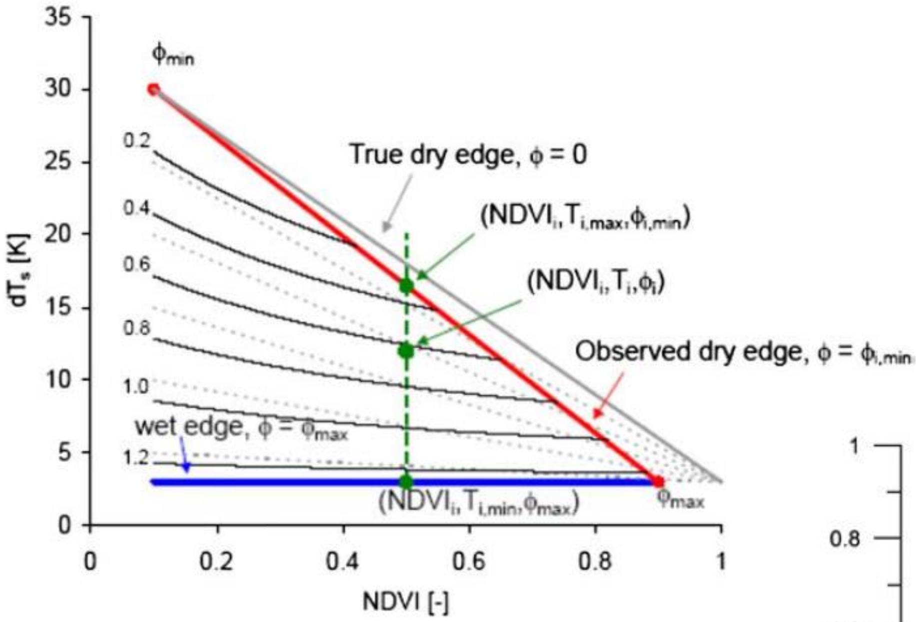


NDVI and Ts averaged over rain-season
Addis Abeba

Challenge:
How to support vegetation analysis in arid regions with LST

(Lambin, E.F. und Ehrlich, D., 1996)

NDVI and LST – Evapotranspiration



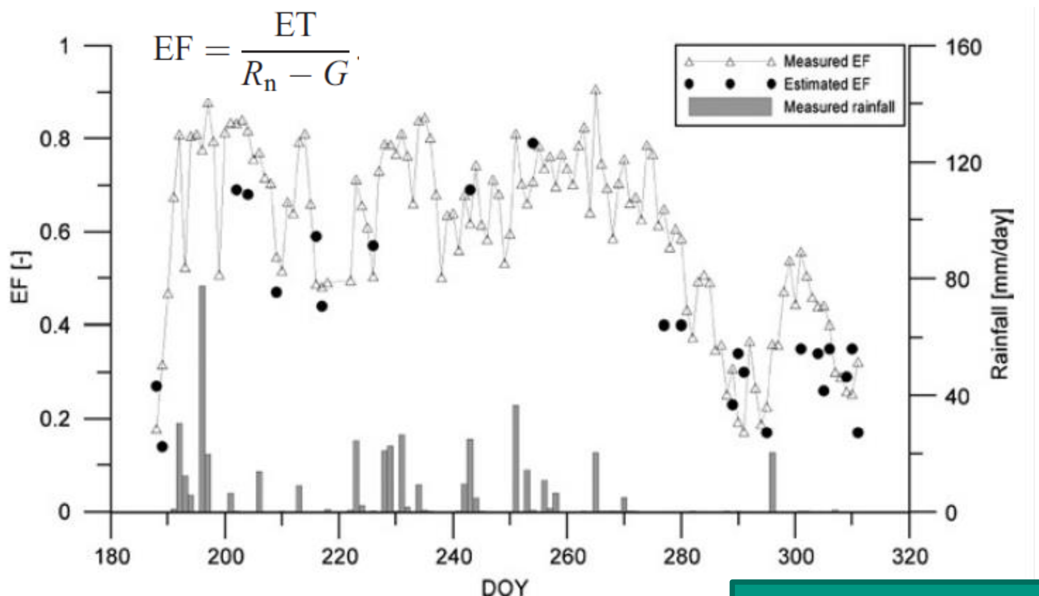
dTs=Ts (noon)-Ts(8:00)

Use MSG-Data

1. 15 min IR data > T dynamic
2. VIS/NIR data > Vegetation

Savannah (Senegal)

$$EF = \frac{ET}{R_n - G}$$



Progress:
EF from satellite data only

Simon Stisen 2008

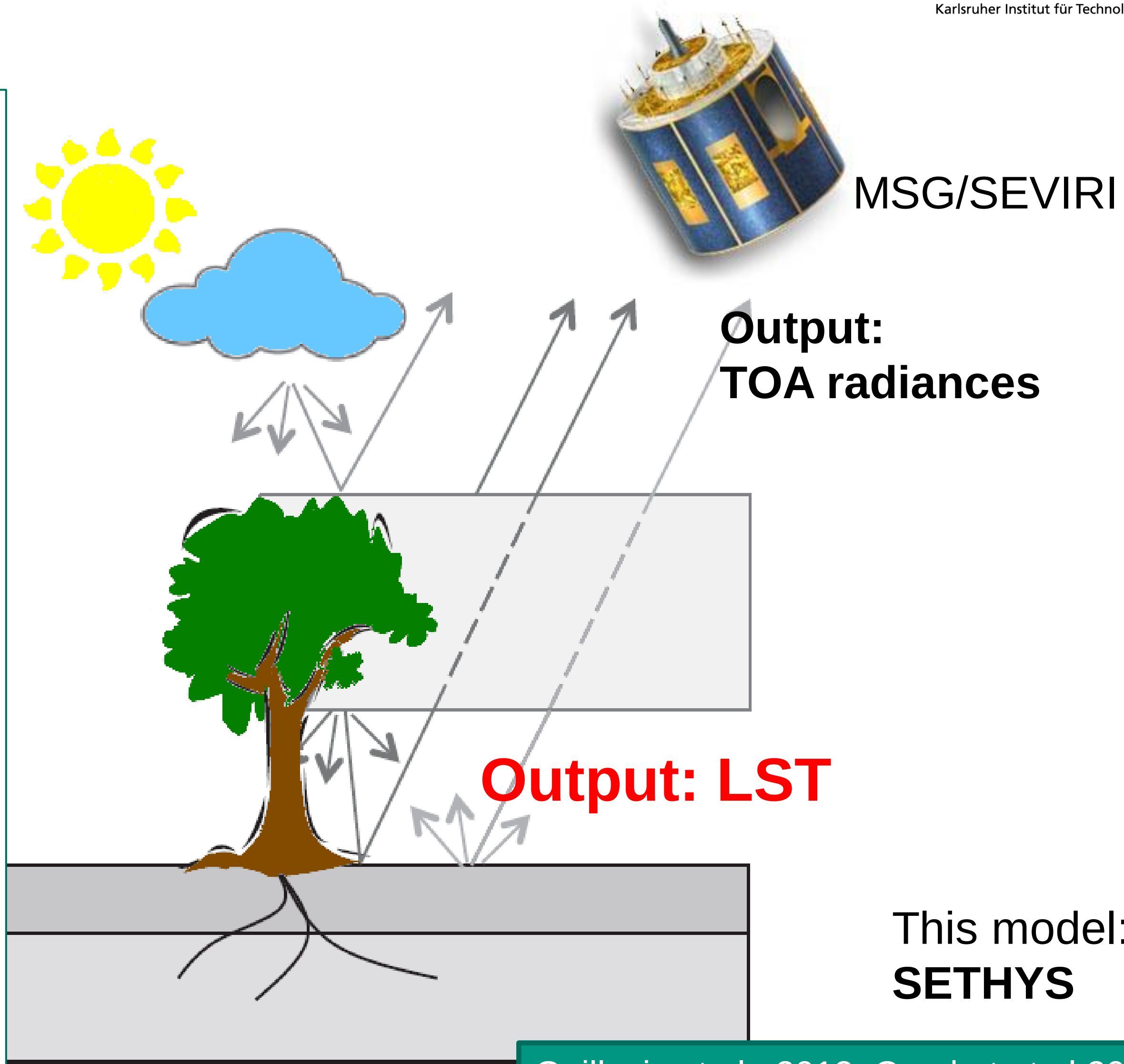
Modelling LST

Input

Dynamic
Atmospheric parameter
Downwelling radiance
(NWP analysis)

Slowly varying
Vegetation ~ LAI
(remote sensing)

Static
Climatological
Soil data

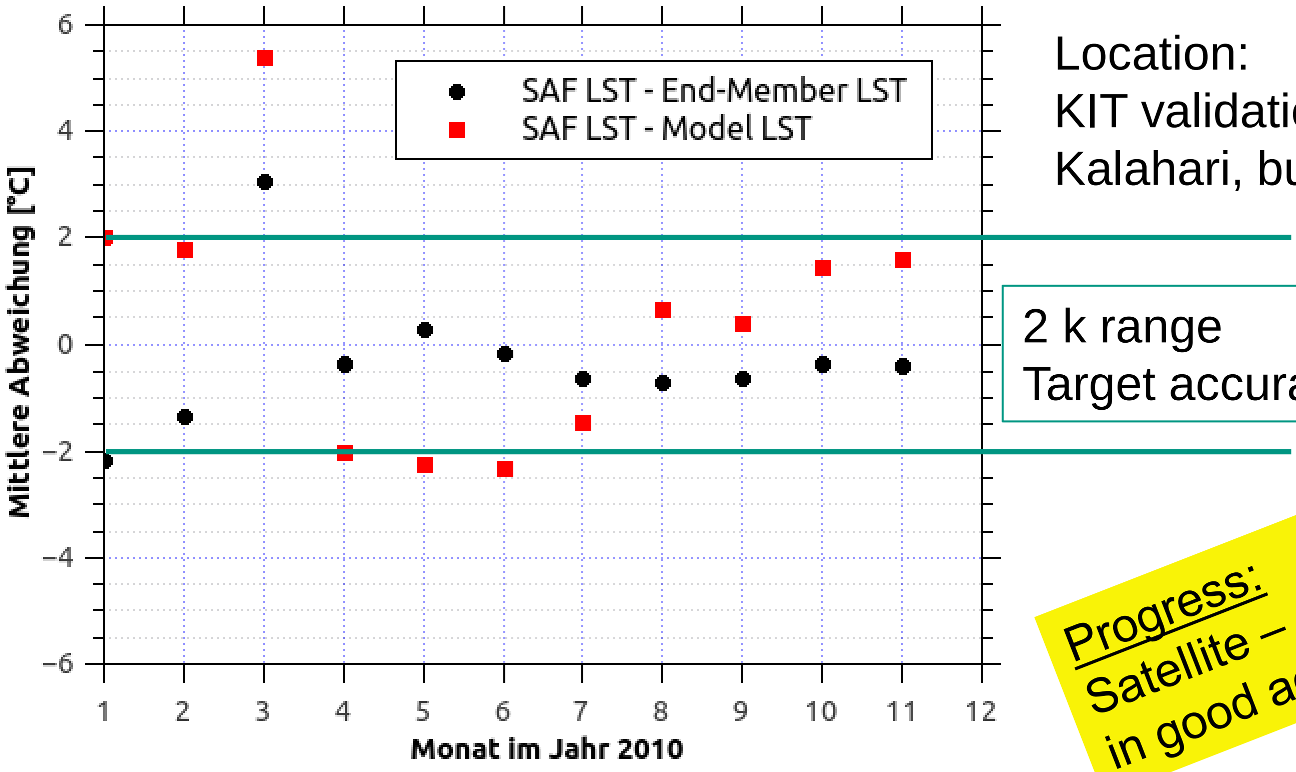


This model:
SETHYS

Guillevic et al., 2012; Coudert et al 2006

LST: Remote Sensing – Model – Ground based

- SAF-LST: from SEVIRI derived by LSA-SAF
- End-Member LST: from Kalahria station data by KIT
- Model LST: from model input (prev. slide) derived with SETHYS-model



Location:
KIT validation station RMZ
Kalahari, bushland

2 k range
Target accuracy of SAF LST

Progress:
Satellite – ground – model
in good agreement

Bork-Unkelbach 2013

Biology

Difference between surface and air temperature is essential to survive on the sand

High temperatures limit the hunting time – limit life

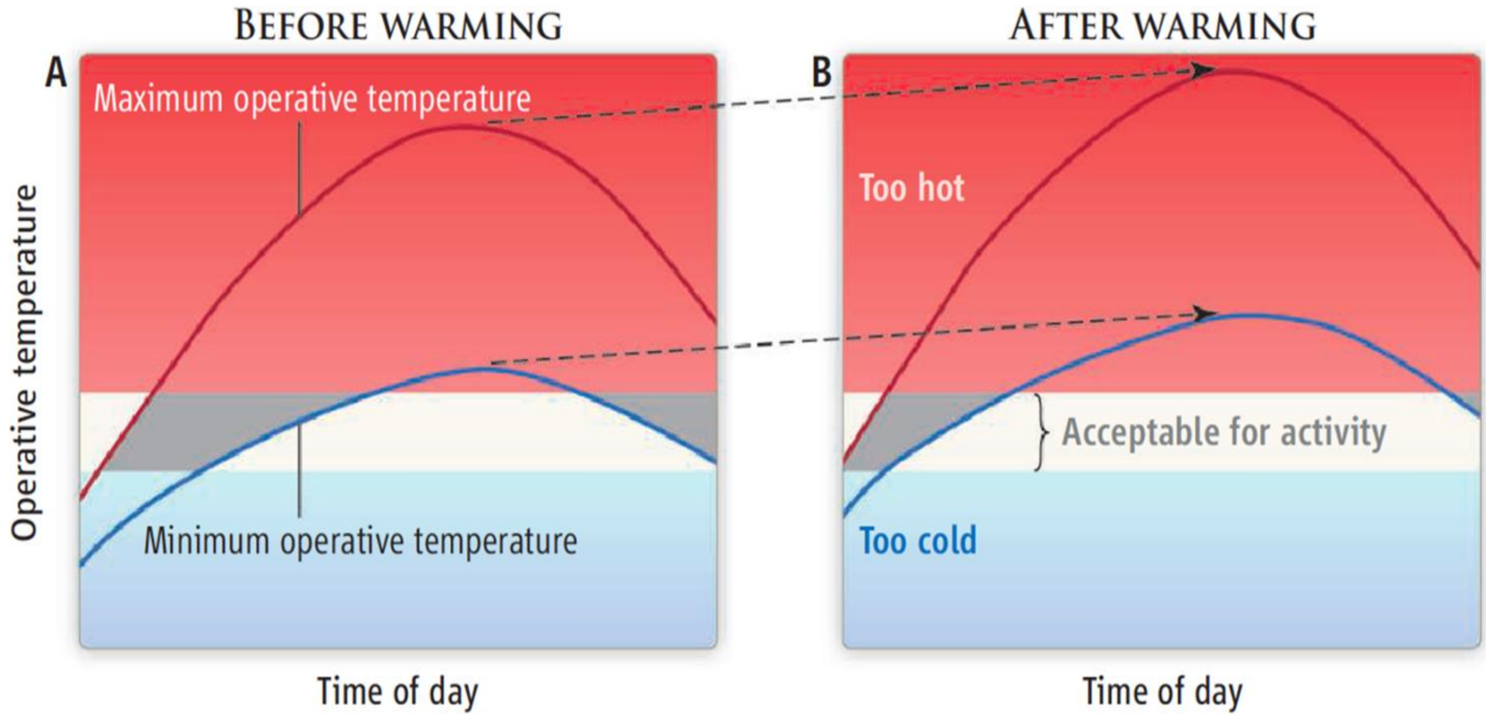
<u>Challenge:</u>
Make more disciplines aware of state of the art earth temperatures

<u>Progress:</u>
Contacts in **Gobabeb** Research & Training Centre

Lizards and surface temperature

Lizards depend on long periods of activity that is temperature dependant

Especially in springtime for reproduction



Operative = body temperature measured in field work.

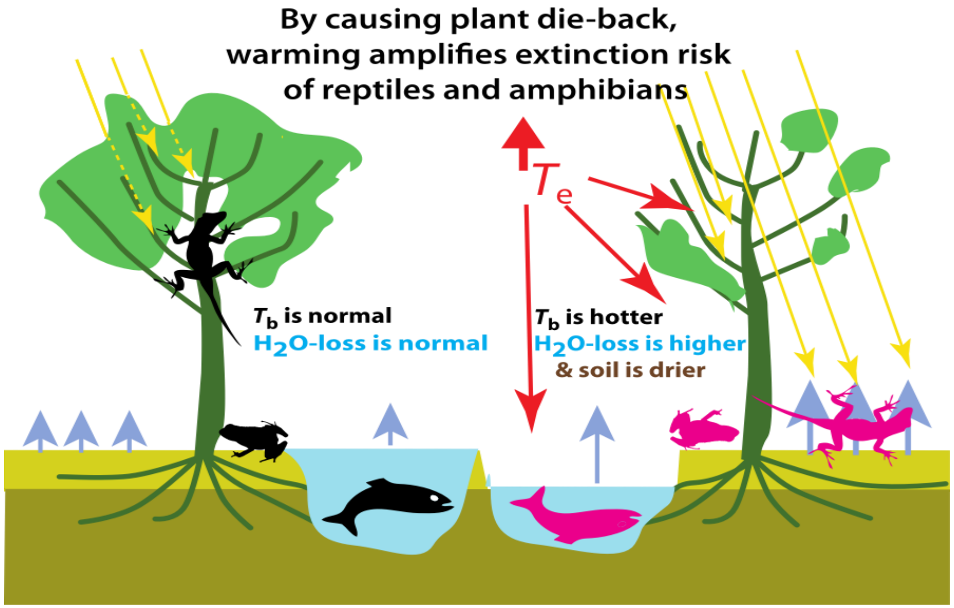
Warming limits time of daily acitivty

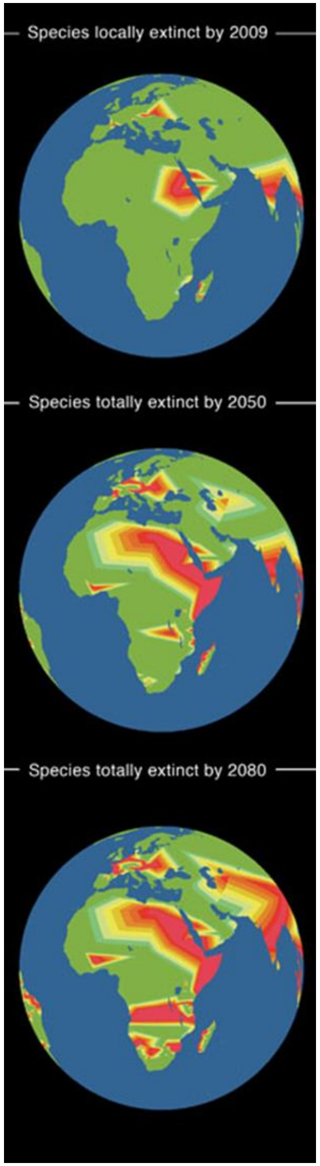
(grey shaded)

Huey et al. (2010) Science

Lizards and surface temperature

Temperature rise
water loss
plant die-back
Extinction of lizards





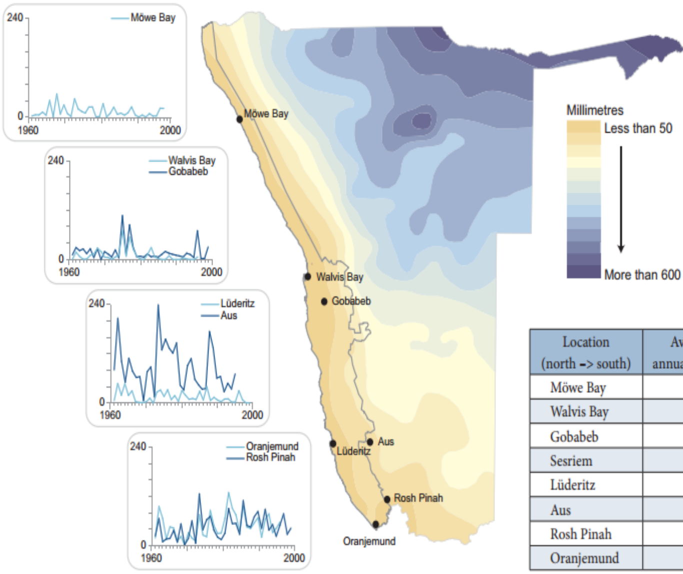
2009
•4% local extinction
•R^2 = 0.72 in a global validation with 8 other lizard families

2050
•6% species extinction
•100% in some areas

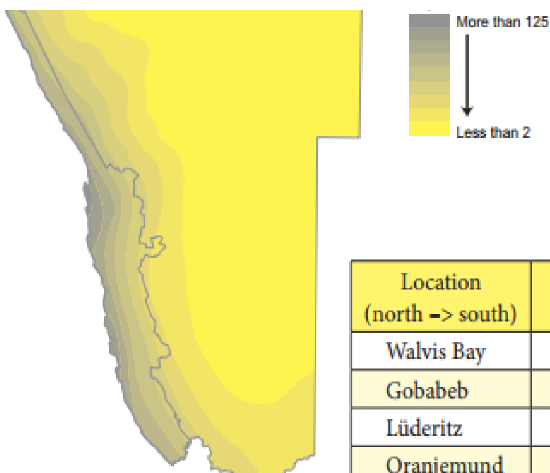
2080
•20% species extinction
•100% in many areas

Sinervo et al. (2010) Science

Namib – Life with out rain



Location (north -> south)	Average annual rainfall
Möwe Bay	13
Walvis Bay	10
Gobabeb	19
Sesriem	81
Lüderitz	16
Aus	91
Rosh Pinah	47
Oranjemund	49



Location (north -> south)	Days of fog [7]
Walvis Bay	140
Gobabeb	94
Lüderitz	117
Oranjemund	81

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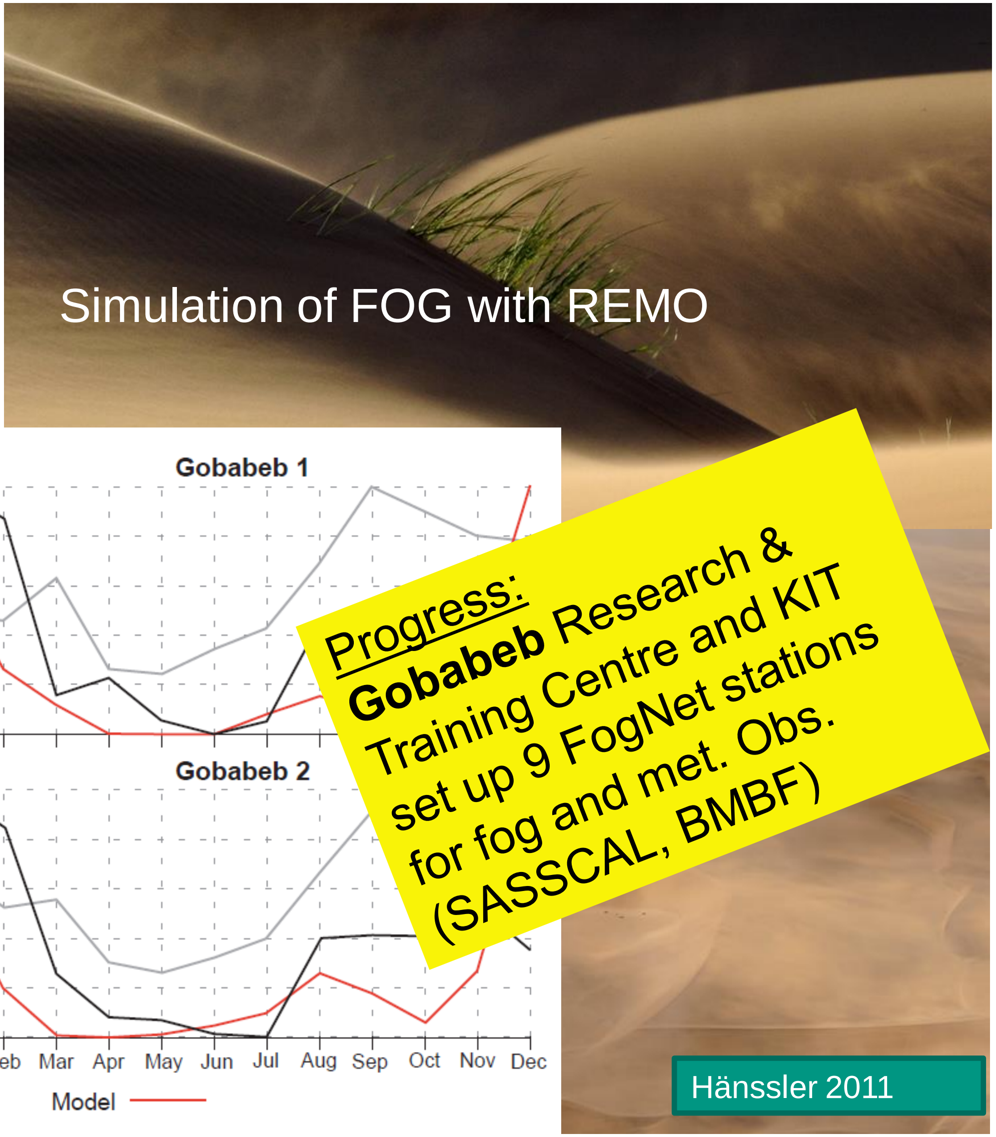
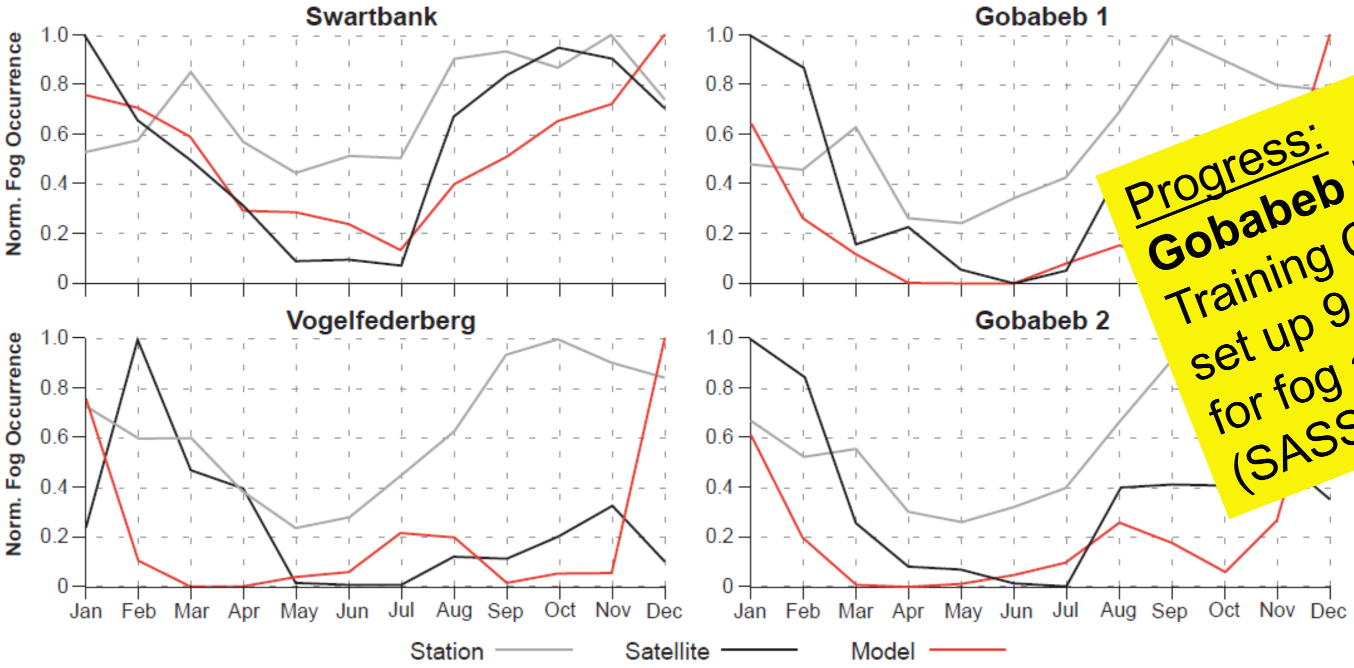
Namib – Life with fog

A complex combination of temperatures

- Warm Atlantic SST
- Cold Benugela current SST
- Strong diurnal change of LST in the desert





<u>Progress:</u>
Gobabeb Research & Training Centre and KIT set up 9 FogNet stations for fog and met. Obs. (SASSCAL, BMBF)

Hänssler 2011

Temperature changes shape nature

Granite peels off due to diurnal heating on small scale

and on big scale

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Summary

Progress

- Satellite – ground – model data in good agreement in desert location
- Satellite derived LST are a mature product
- Temperature – Emissivity separation reliable

Challenges

- Make more disciplines aware of state of the art earth temperatures
- Satellite LST have huge gaps in tropics and some saturate in deserts
- Very few synop data

Add some water to temperature erosion

Discussion