



Quantifying the uncertainty and ensuing spurious trends in level-3 AVHRR-based cloud climate data records

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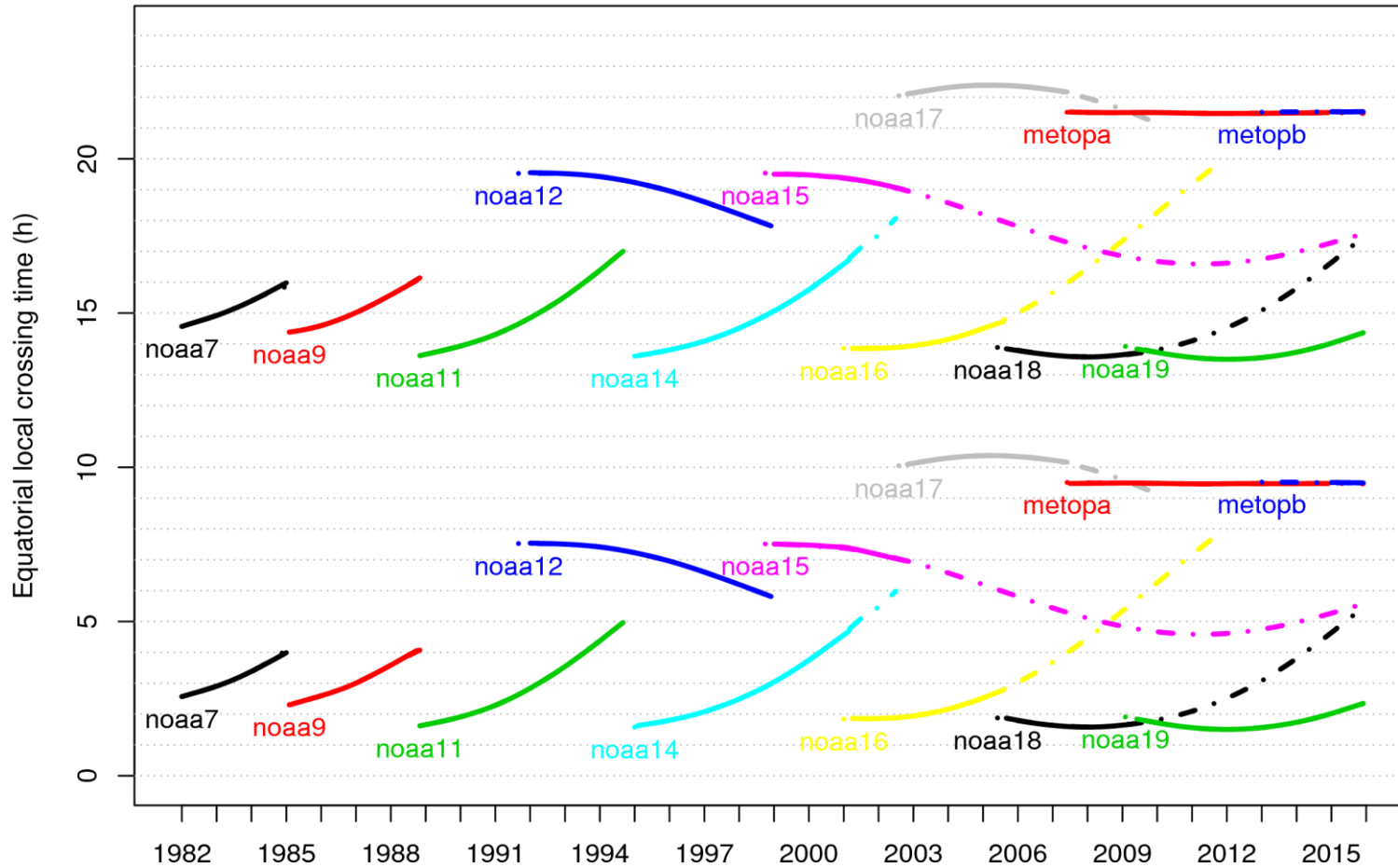
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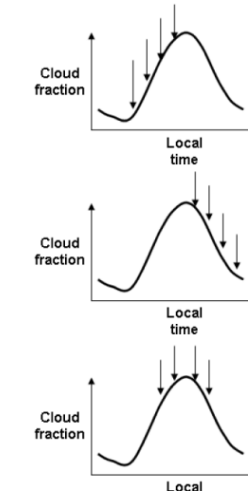
Orbital drift & overlapping satellites



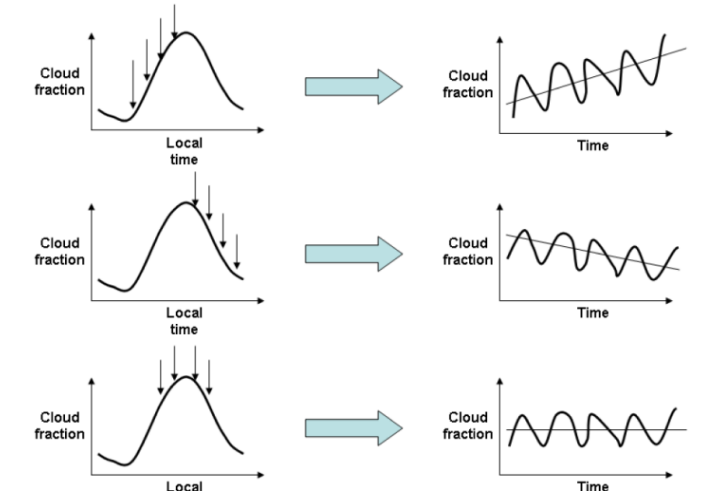
L2 → L3 aggregation

- Orbital drift
- Changing number of observations
- AMs / PMs separately?
- Overlapping satellites

Inconsistent sampling of diurnal cycle of convection



Potential spurious trends in the time-series



(Devasthale et al, 2012)



Objective

Dissect effects on performance and trends in L3 CFC data:

- of **orbital drift** separately for each NOAA/MetOp satellite and each node
- of **diurnal cycle sampling** by changing number of satellites in orbit and their different time of image acquisition



Data & methods

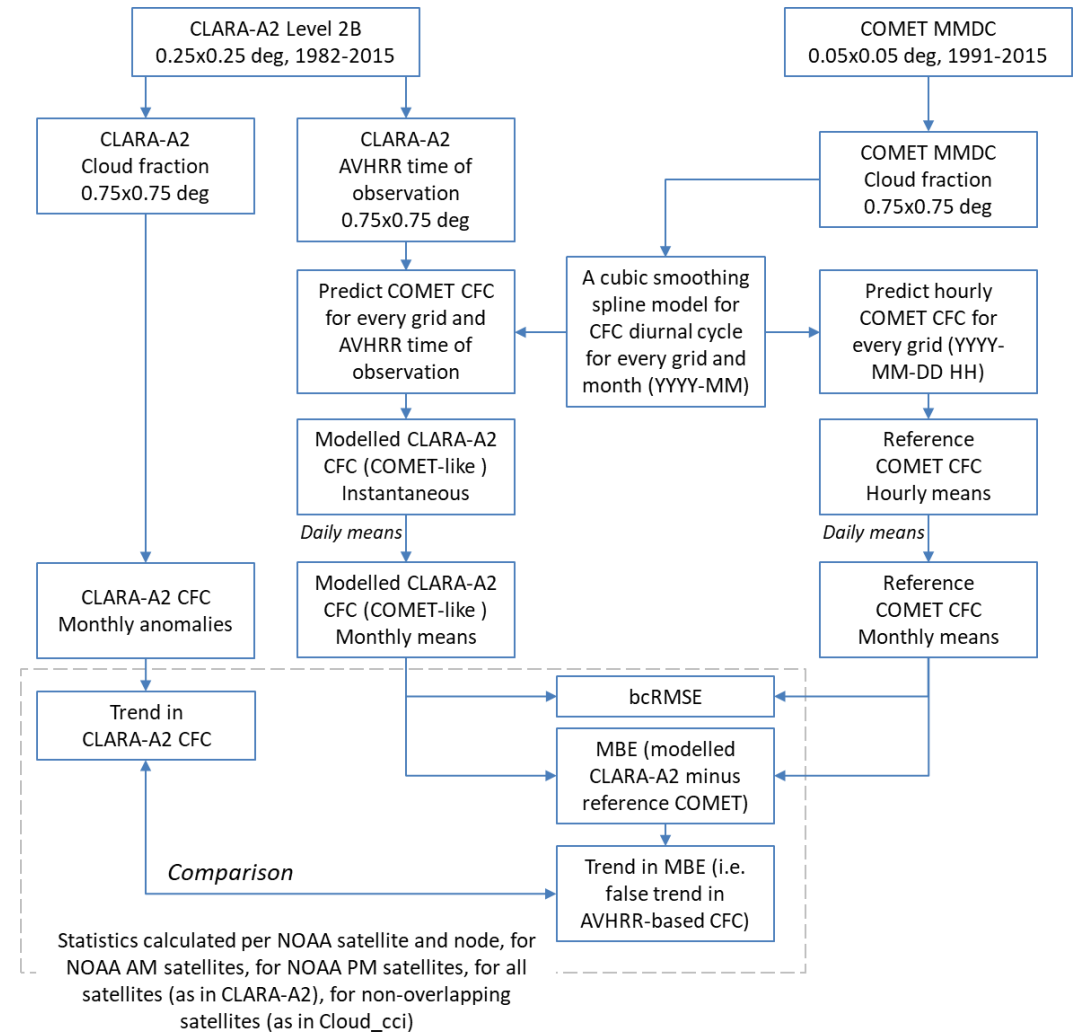
NOAA/MetOp AVHRR acquisition times

- AVHRR per-pixel acquisition times based on CM SAF CLARA-A2
 - 1982-2015 (NOAA-7 to MetOp B)
 - Aggregated to 0.75 degree by a circular median

Reference CFC data with resolved diurnal cycle

- The CM SAF Cloud Fractional Cover dataset from METeosat First and Second Generation - Edition 1 (COMET)
 - MVIRI+SEVIRI: 1991-2015
 - Bayesian-based CFC for each 0.05 deg pixel → aggregated to 0.75 deg
 - Mean monthly diurnal cycle (1 hour resolution) smoothed with splines
 - *Missing years (1982-1990) were replaced by 2007-2015*
 - *Daily diurnal cycle assumed stable for each day during a month*

- No AVHRR-derived CFC used
- COMET retrieval error *not* relevant



Article

Cloud Detection with Historical Geostationary Satellite Sensors for Climate Applications

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Article

Performance Assessment of the COMET Cloud Fractional Cover Climatology across Meteosat Generations

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Meteosat observations of diurnal variation of cloud fractional cover

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Aim
 The study aims at evaluation of the CM SAF Cloud Fractional Cover (CFC) dataset from METeosat First and Second Generation - Edition 1 (COMET) in terms of ability to: (1) reconstruct diurnal cycle of cloud fractional cover, and (2) provide homogenous climate information about trends and variability of amplitude and phase of CFC diurnal cycle. A temporal shift in diurnal cycle of cloud formation may lead to significant feedbacks in the climate system.

Definitions
 CFC amplitude: CFC diurnal range (max-min)
 CFC phase: time of maximum CFC

Data
 Mean monthly diurnal cycles covering Meteosat disc:

Provider	Dataset	Spatial res.	Temporal res.	Coverage
CM SAF	COMET ed. 1	0.05 deg	1 h	1991-2015
CM SAF	CLAS2	0.25 deg	1 h	2005-2015*
NOAA/NCEP	ISCCP-HIGH	1 deg	3 h	1984-2015*
ECWMF	ERA-Interim	0.75 deg	3 h	1982-2010*
ECWMF	ERA-5	0.25 deg	1 h	1979-2010*
ECWMF	SYNOP	111 sites	3 h	1991-2015

* only a common period 2005-2012 was used
 ** selected after a very strict quality control procedure

Validation of COMET CFC diurnal cycle vs SYNOP, 1991-2015

	CFC (h)		Phase (h)		Amplitude (%)	
	BIAS	RMSE	BIAS	RMSE	BIAS	RMSE
Overall	33.11%	0.95	0.72	0.33	5.26	12.66
AMF	18.64%	1.61	0.97	0.34	6.46	12.07
MISG	10.67%	0.11	0.05	0.02	0.97	23.32
DUF	8300	-0.37	10.74	0.39	7.17	-0.18
MARJ	8295	2.82	8.66	0.23	6.89	0.67
JJA	8295	2.79	8.67	0.26	6.39	-0.24
SON	8305	1.60	9.44	0.61	6.17	-0.17
Months	3289	0.98	0.74	0.34	6.29	12.70
Stations	300	0.48	0.72	-0.48	4.81	2.45

Performance statistics (Mean Bias Error and bias-corrected Root Mean Square Error) for COMET against SYNOP at 111 sites. Time series of cloud fractional cover (0-100%), phase (local solar time) and amplitude (0-100%) for COMET and SYNOP at 111 sites. Trend in mean bias error of COMET CFC, amplitude and phase versus SYNOP. The Standard Normal Homogeneity Test (in red) does not reveal any inhomogeneities. T/critical value at 10.2.

CFC diurnal cycles, 1991-2015

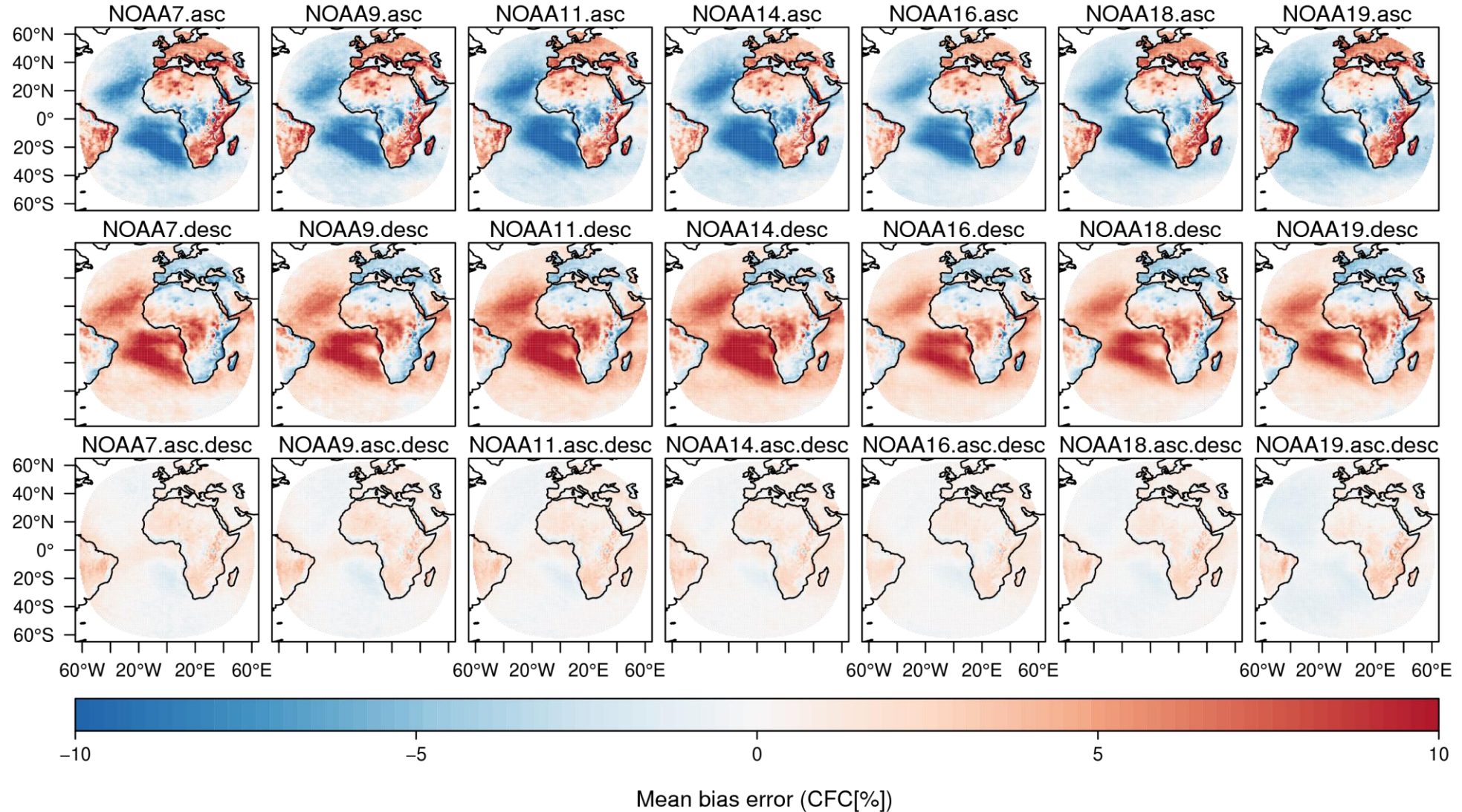
Trends in CFC diurnal cycles, 2005-2012

1991-2015, different legend

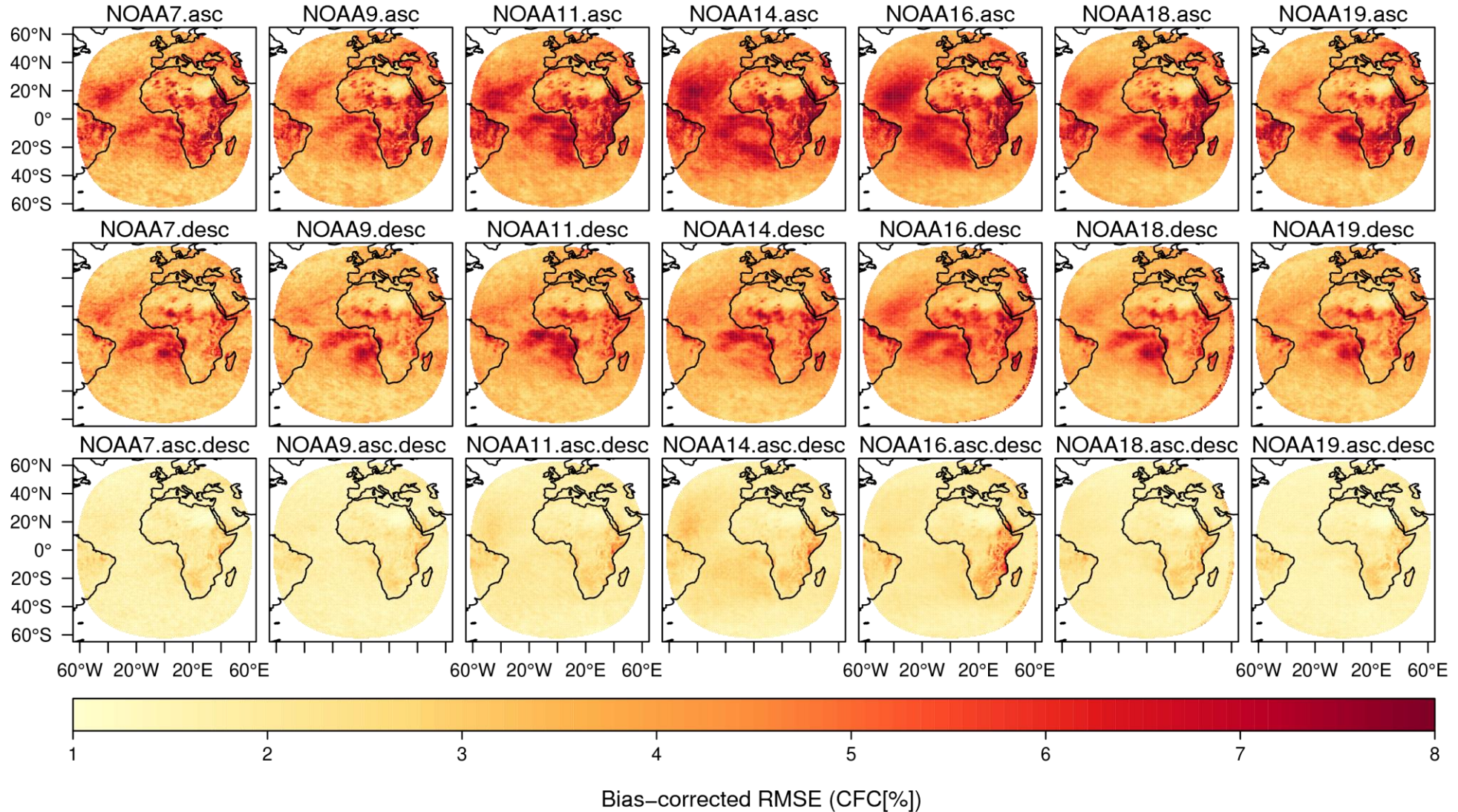
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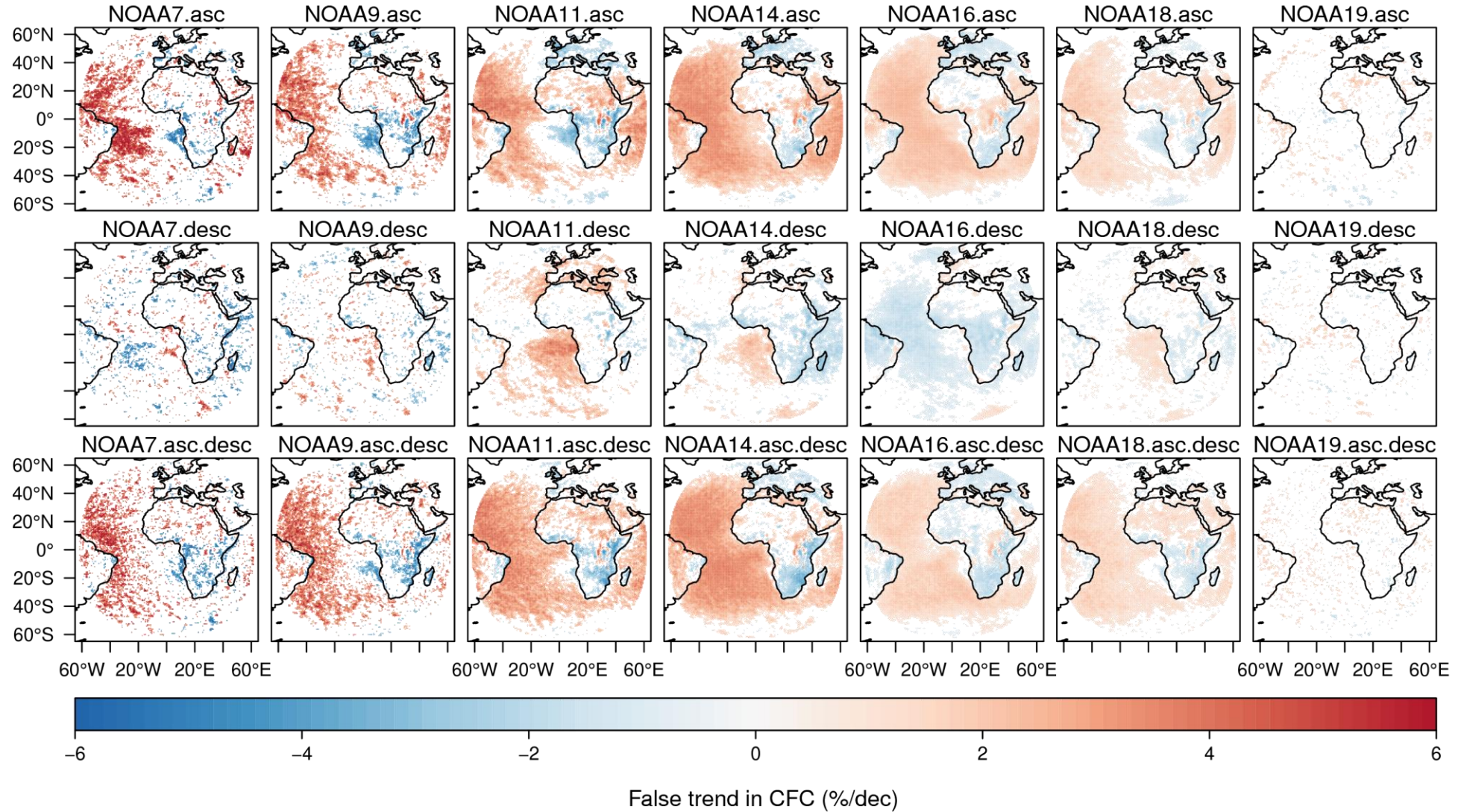
Mean bias NOAA-PM



Bias-corrected RMSE, NOAA-PM

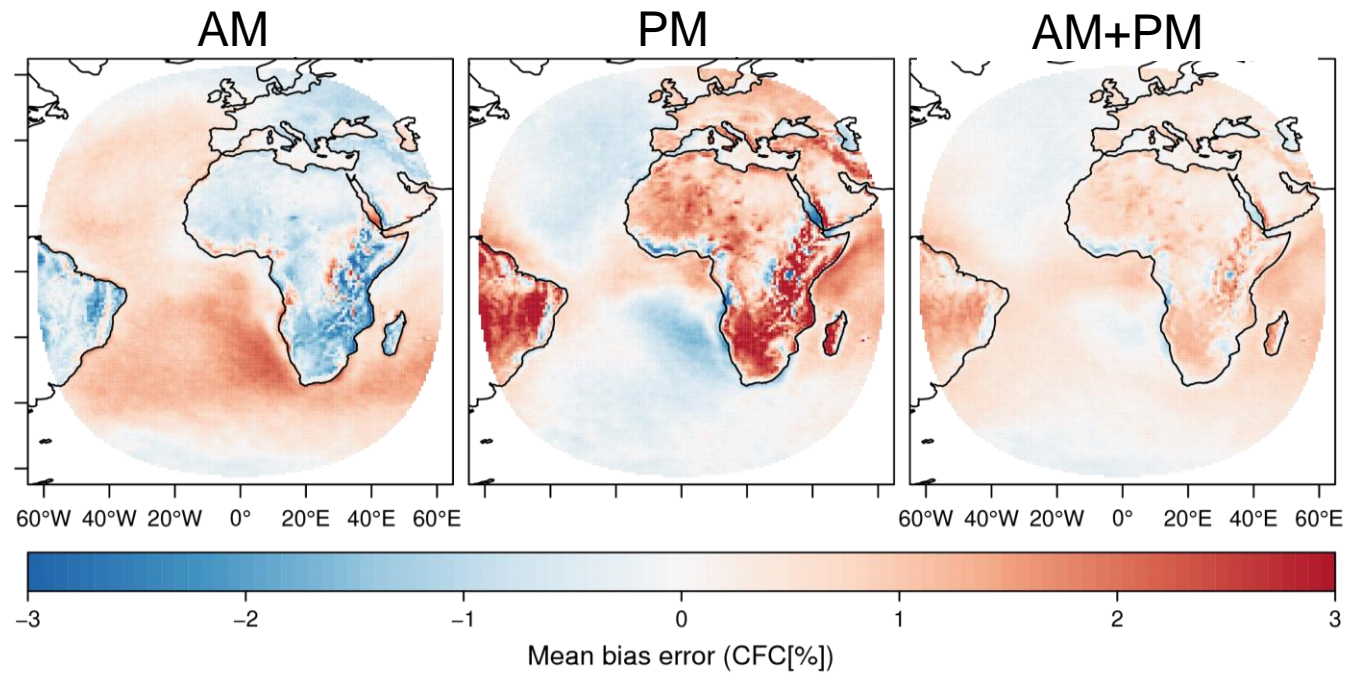


False trends, NOAA-PM

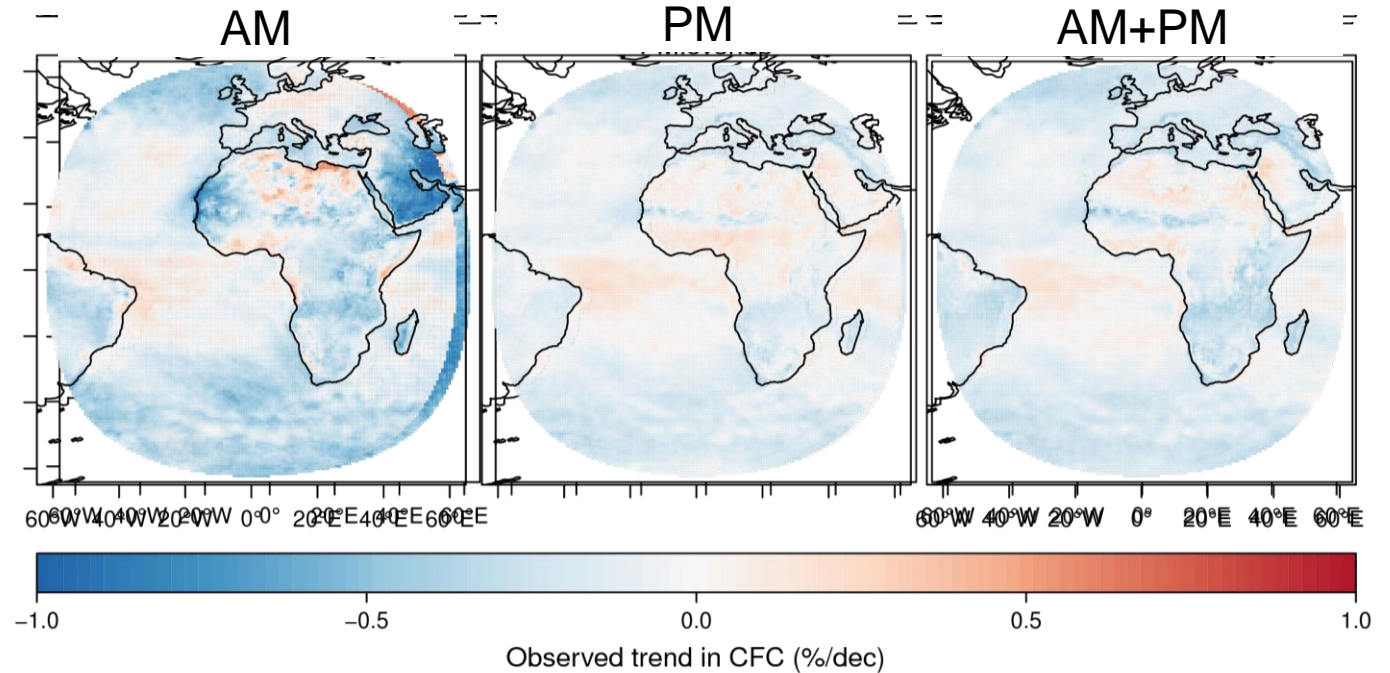




AVHRR CDR bias

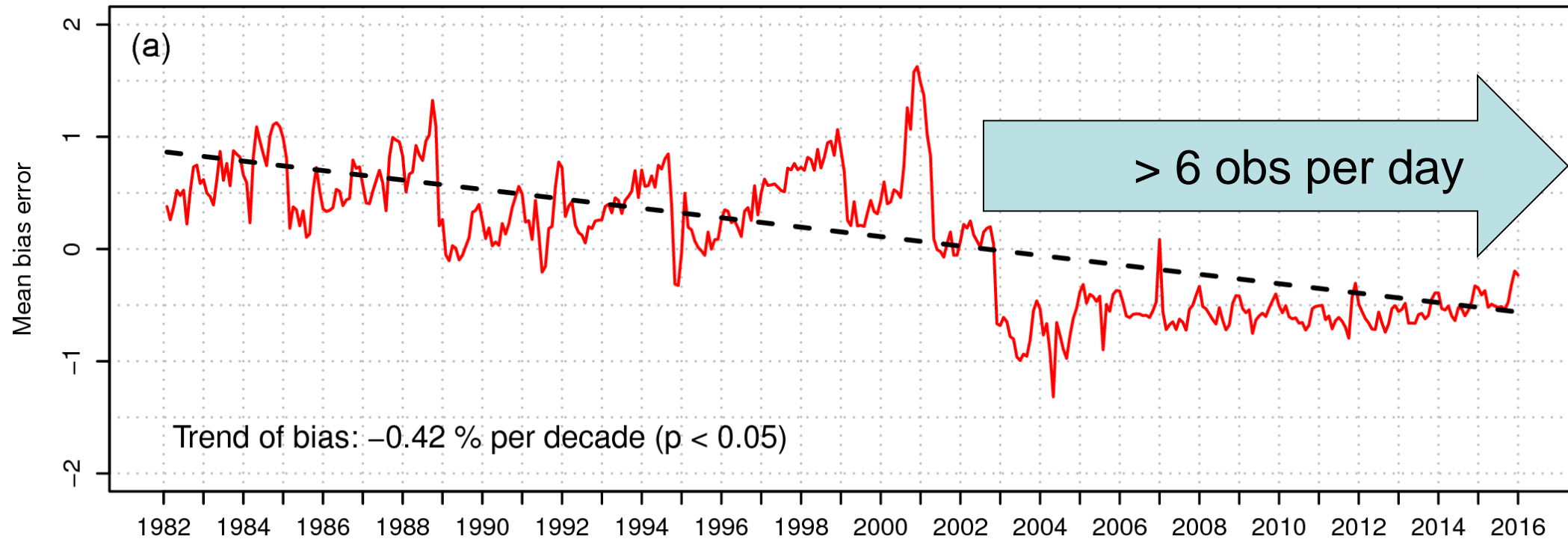


~~AVHRR~~ CDR observed trends



Temporal stability

- GCOS-200: 1%/dec temporal stability





Summary & outlook

- **Orbital drift and sampling errors: $\pm 10\%$ bias, $< 8\%$ bcRMSE**
- **False trends: $\pm 6\%$ per decade (± 1 for merged satellites, -0.42 averaged over Met disc)**
- **Without diurnal cycle correction, L3 data before 2003 don't comply with GCOS requirements**

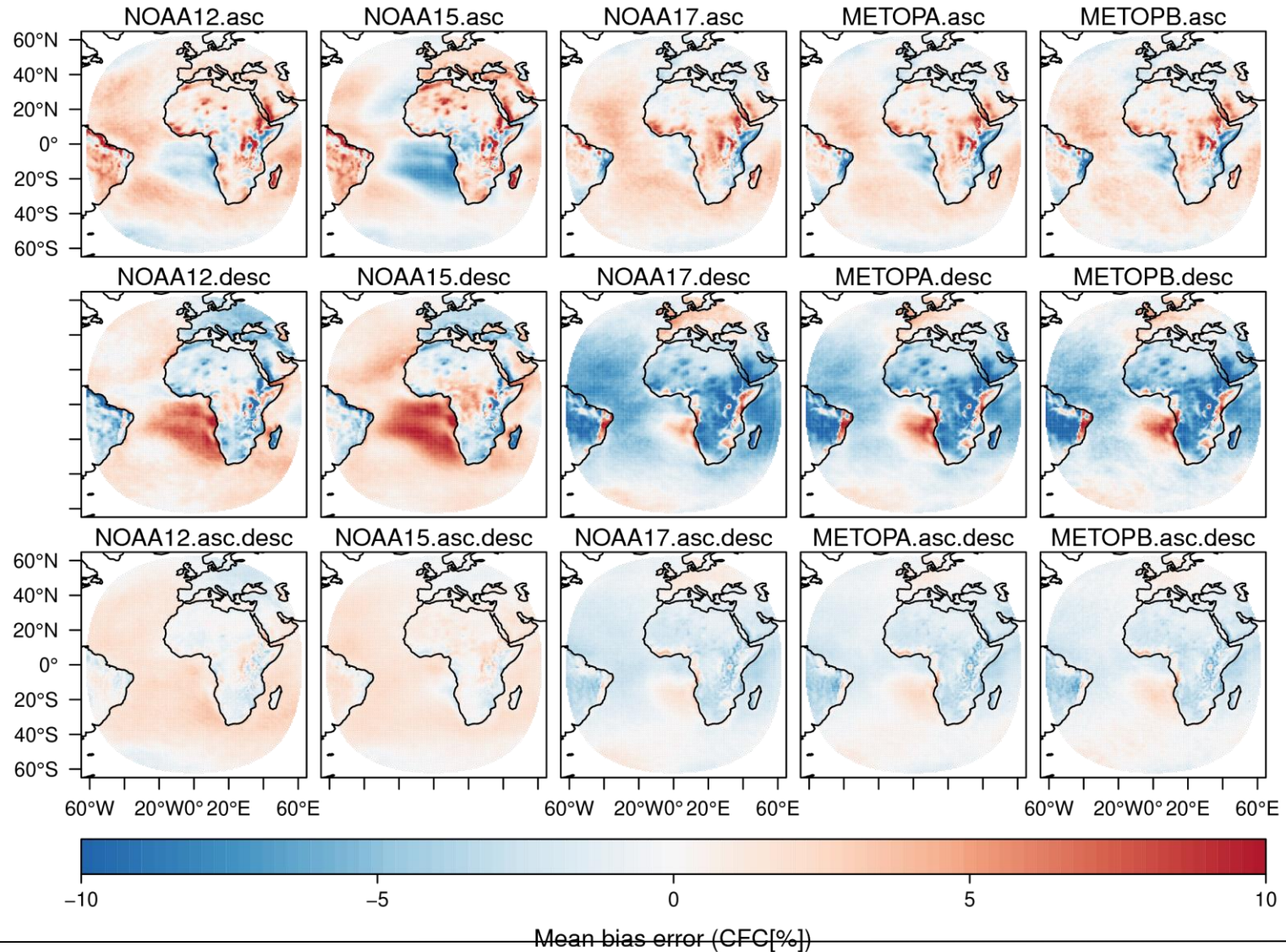
- Aggregated PM-satellites reveal lower false trend than AMs
- No big difference between overlapping and non-overlapping satellites aggregation
- Low correlation between false and observed trends... (why?)

Outlook:

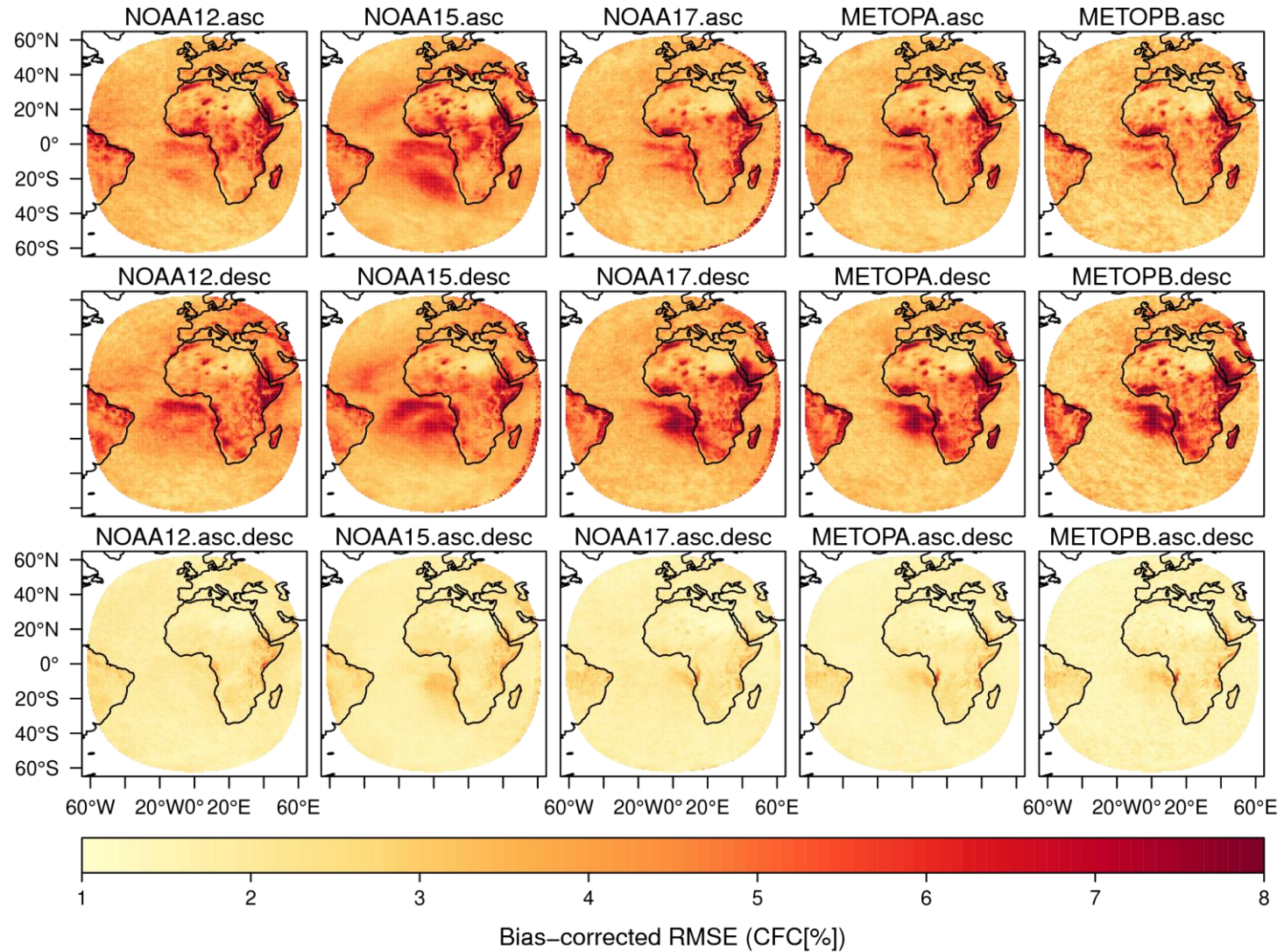
- Global analysis using ERA-5 as a reference
- Comparison of correction methods: Foster and Heidinger, 2013, rotated empirical orthogonal function (EOF, Devasthale et al.. 2012), singular spectrum analysis (SSA)
- Similar study for cloud properties (e.g. based on CMSAF CLAAS as a reference)



Mean bias NOAA-AM

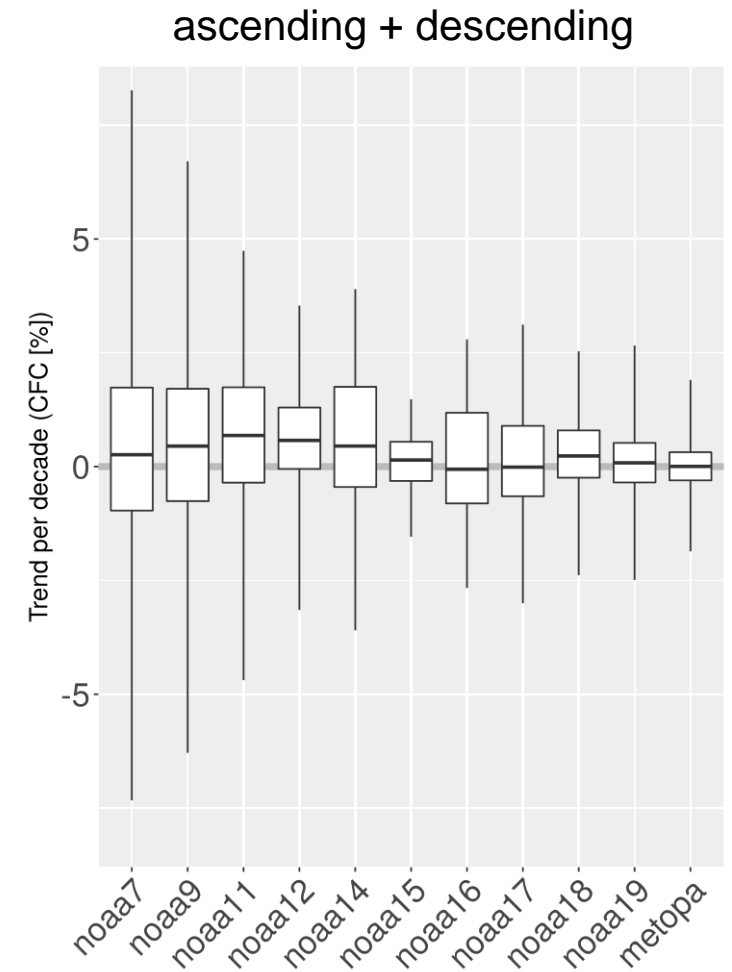
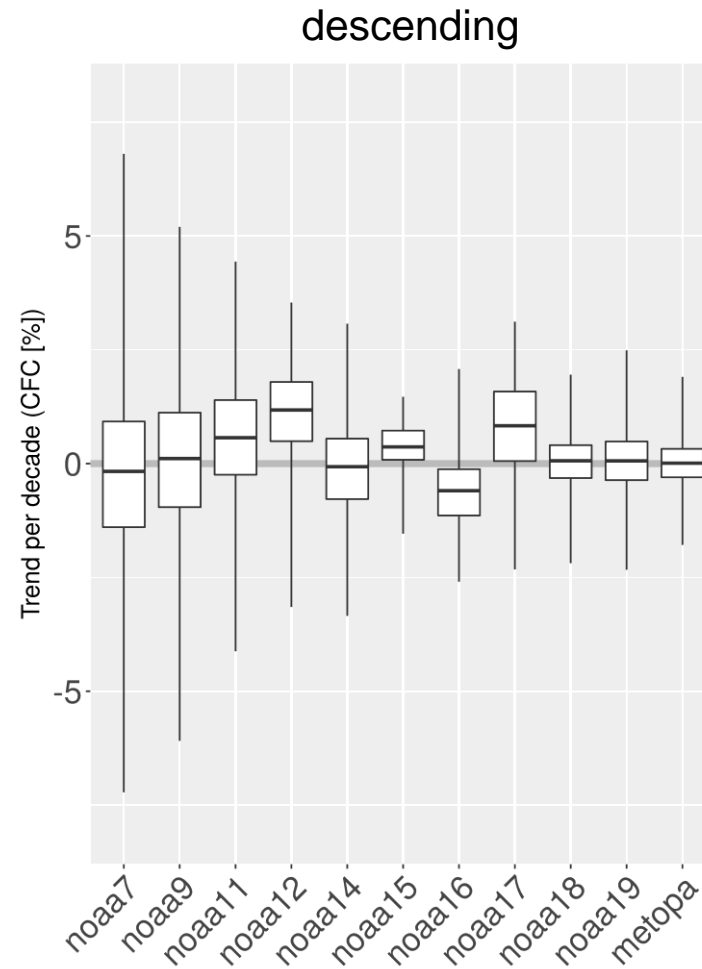
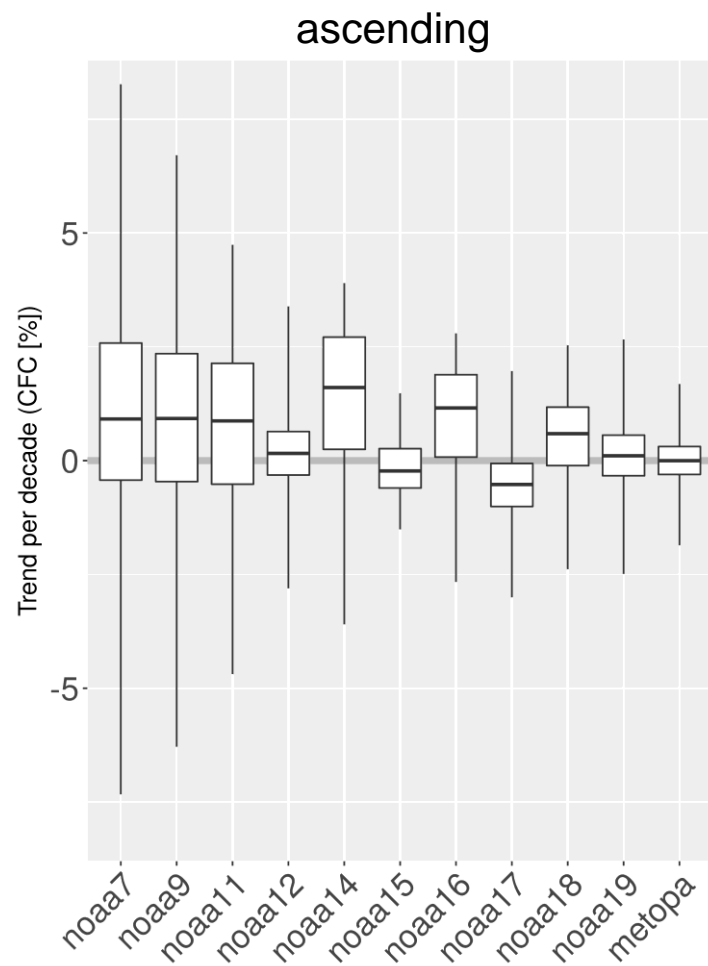


Bias-corrected RMSE, NOAA-AM





False trends by NOAA & node



Bias-corrected RMSE, AVHRR CDR

