

Routine verification of radiation and cloudiness forecasts at ECMWF using CM SAF data

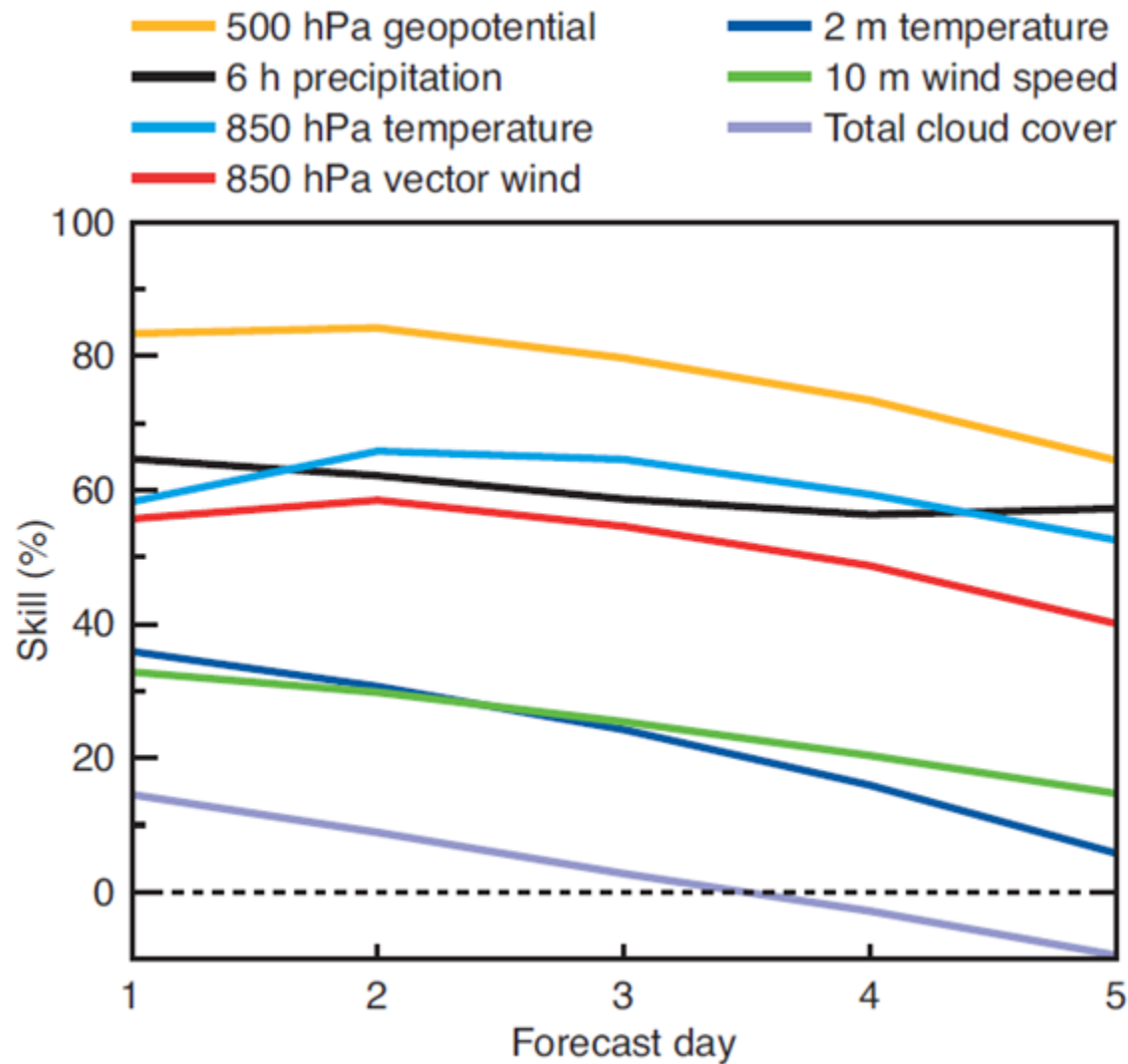
Thomas Haiden

Thanks to: Jörg Trentmann (DWD)

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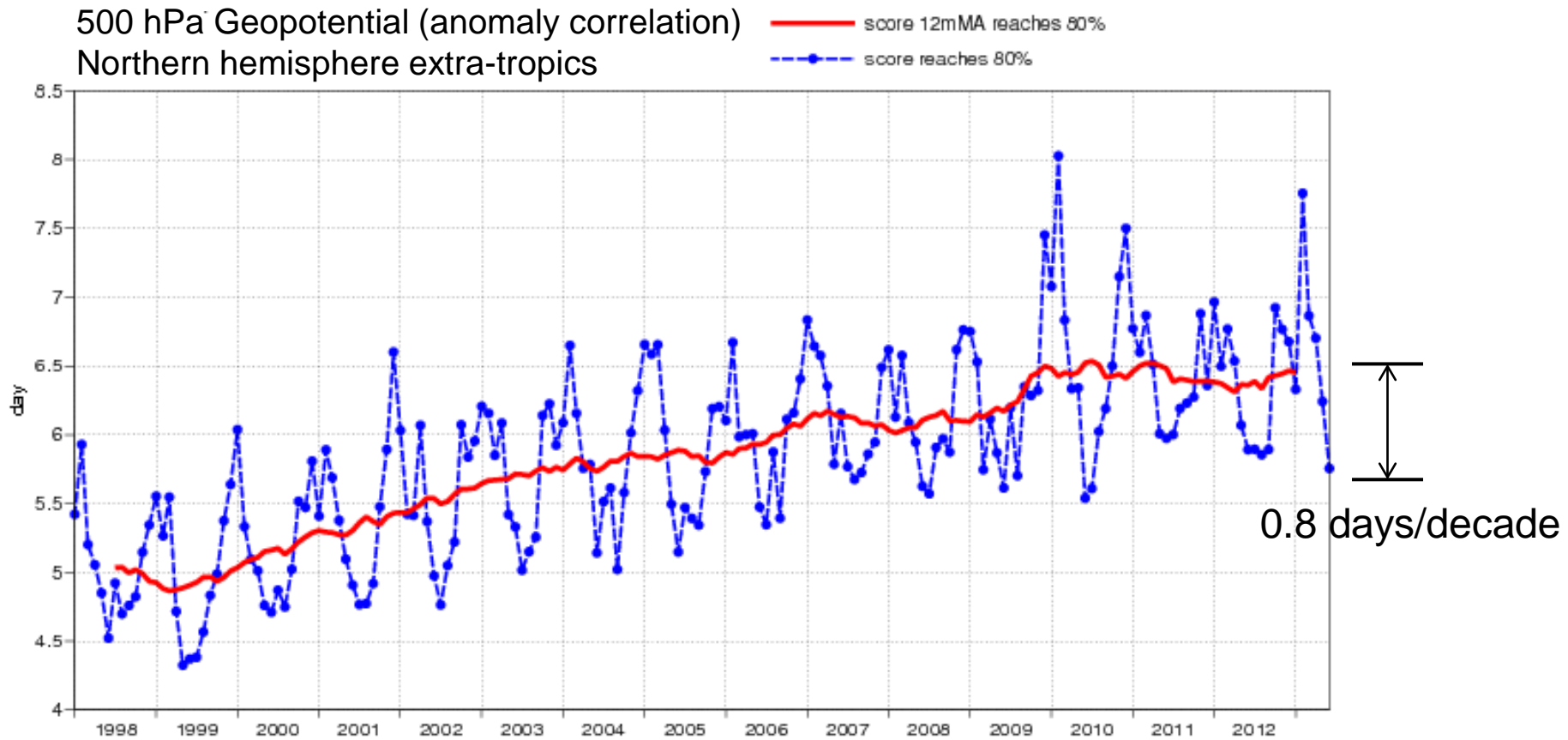
- **Cloudiness forecast skill**
- **Forecast verification using CM SAF**
- **Aerosol (MACC)**
- **ECMWF vs CMSAF vs BSRN**
- **Marine low cloudiness**
- **Continental low stratus**
- **Cloudiness forecast skill revisited**

Forecast skill



Köhler (2005)

Evolution of forecast skill



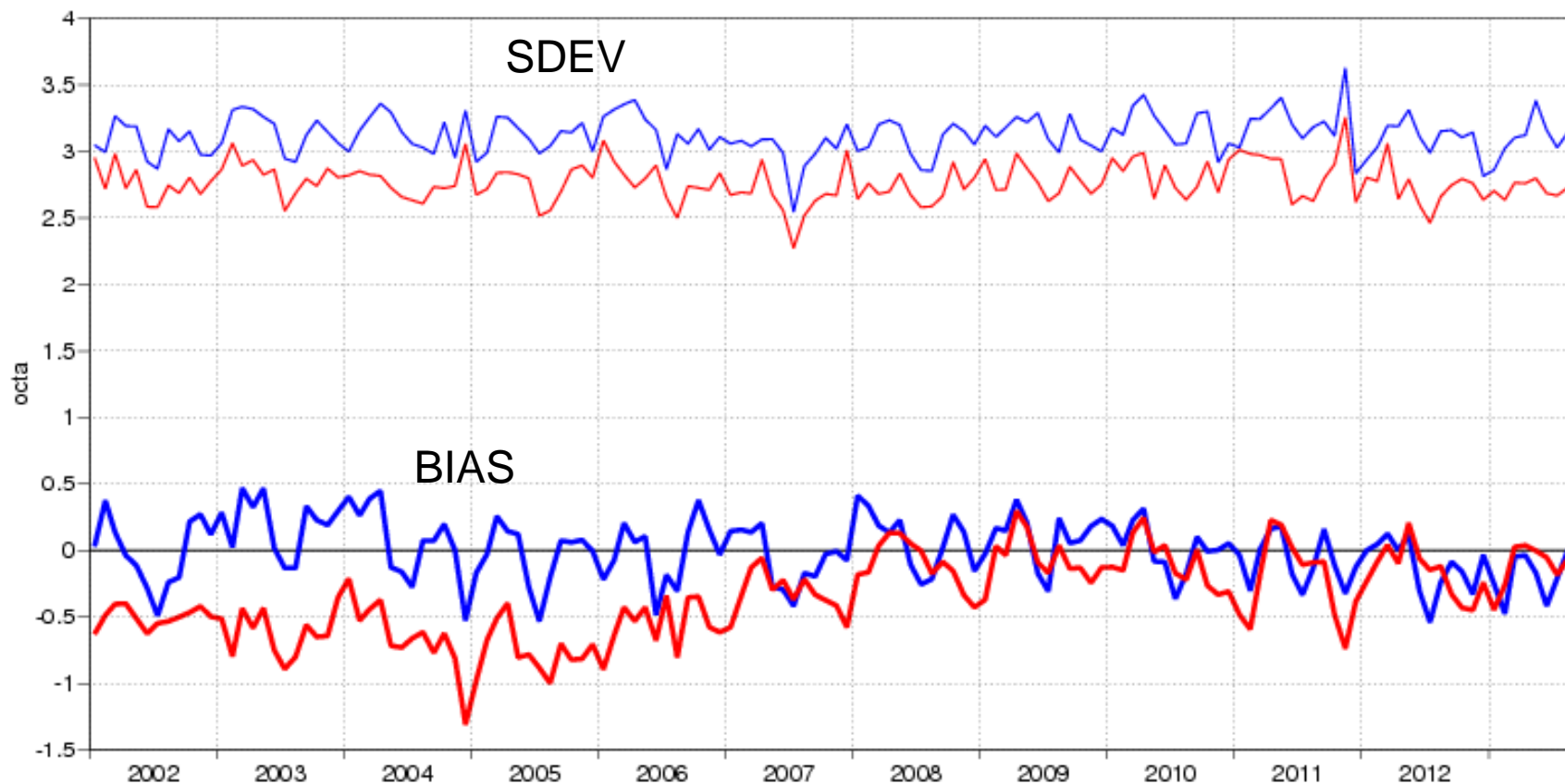
Total cloud cover

Total cloud cover

Europe N Africa (lat 25.0 to 70.0, lon -10.0 to 28.0)

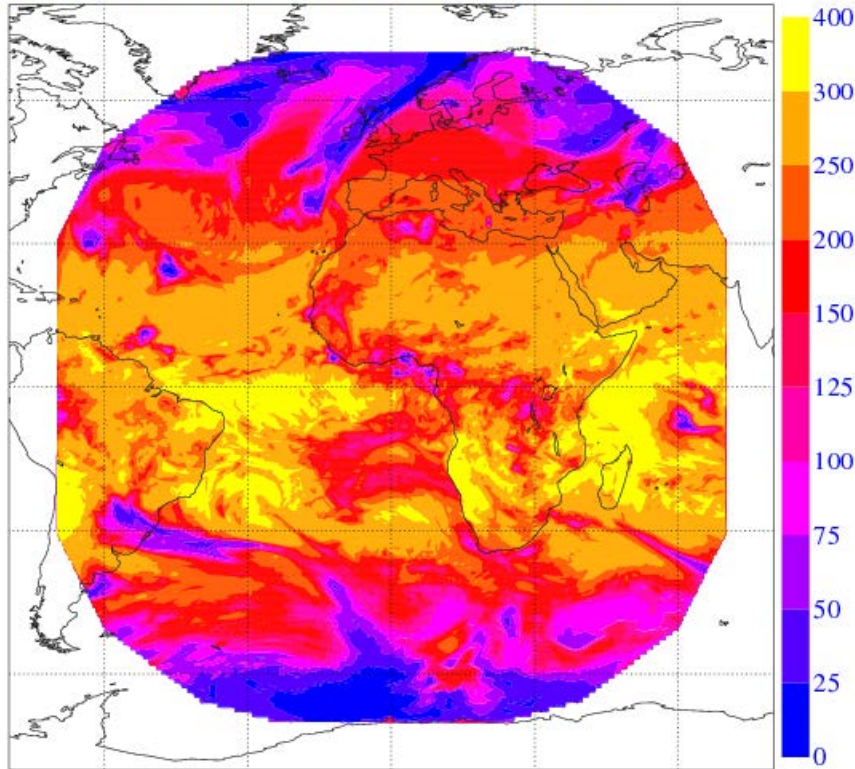
12UTC

- T+72 Standard deviation of forecast error
- T+72 Mean error
- T+60 Standard deviation of forecast error
- T+60 Mean error



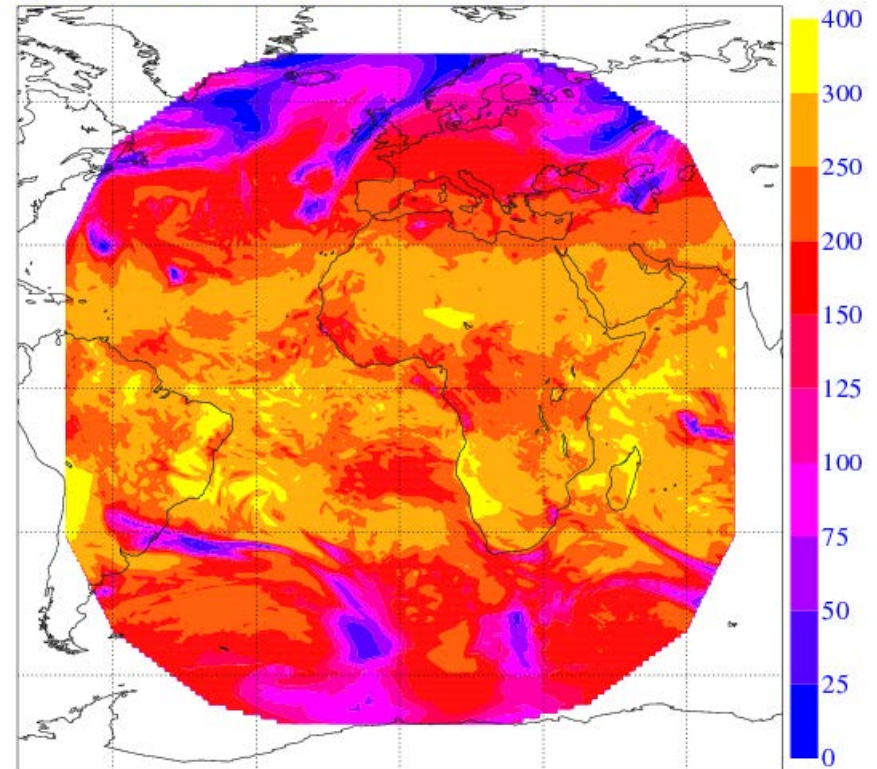
Downward solar radiation (daily means)

Downward surface solar flux (W/m²), obs, 20111001



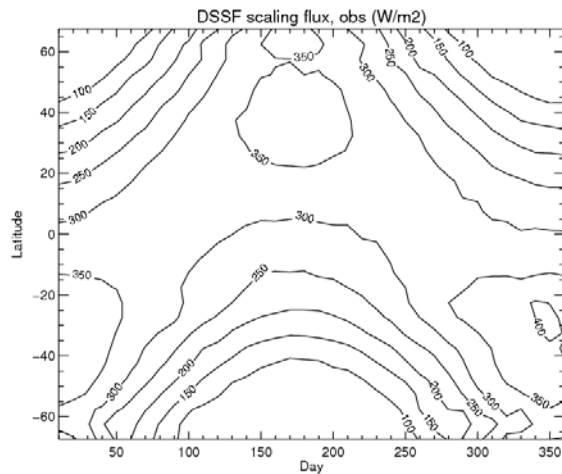
CM SAF

Downward surface solar flux (W/m²), fcst, 20111001

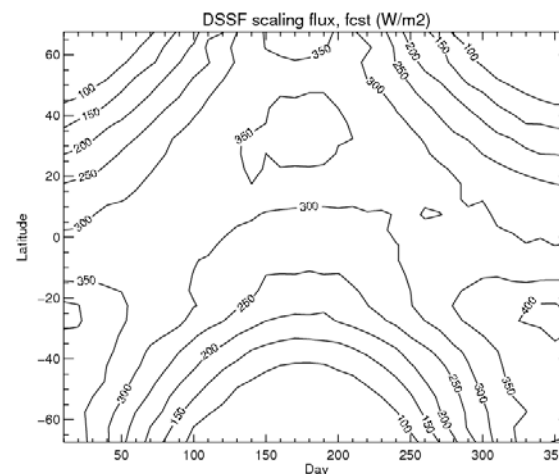


ECMWF (D+1)

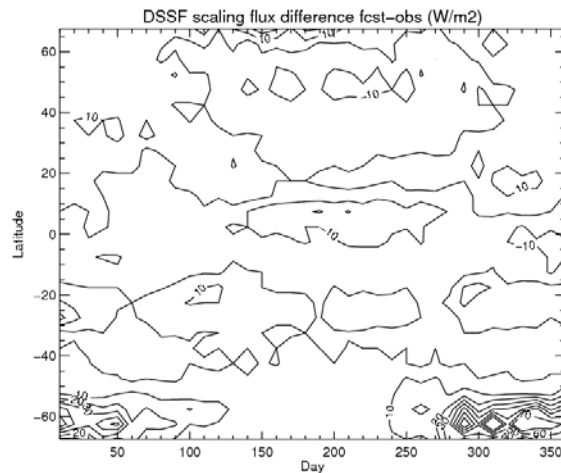
Latitudinal and seasonal scaling



CM SAF



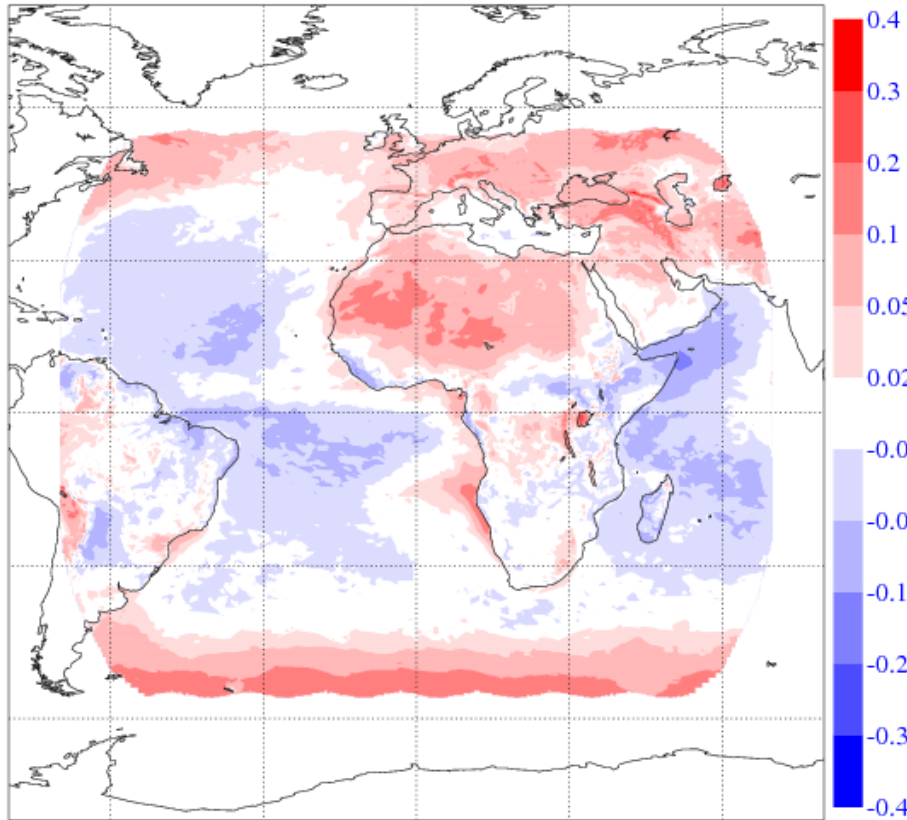
ECMWF (D+1)



Difference

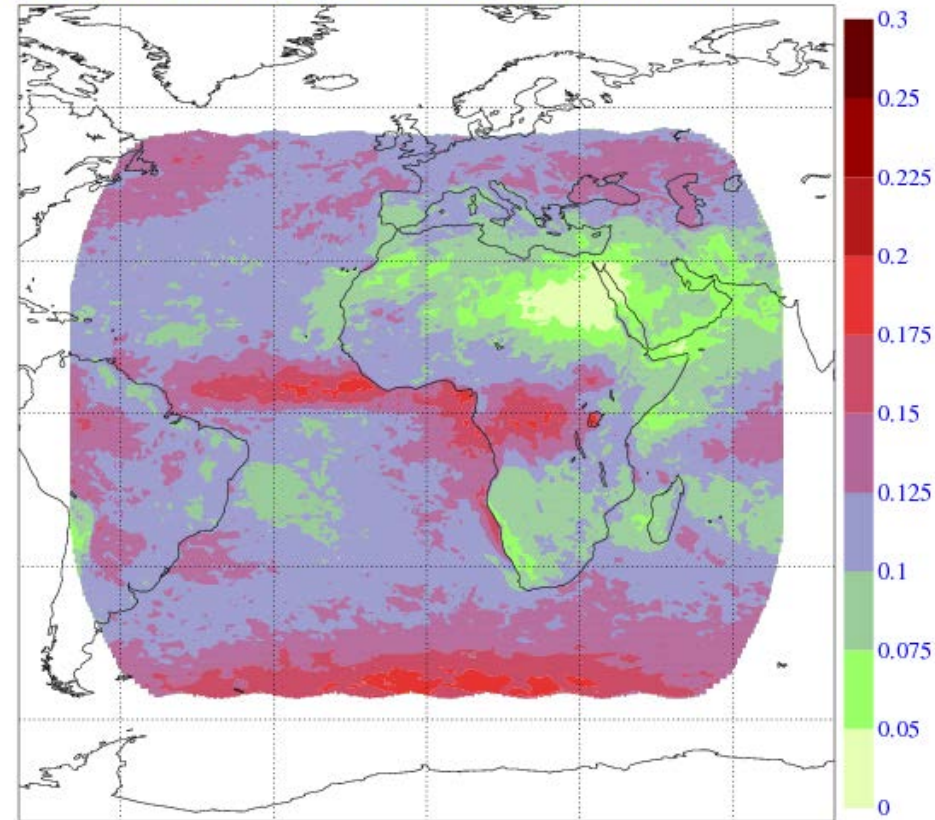
Non-dimensional solar flux

Nondimensional downward surface solar flux, bias, 2011



Mean error (D+1)

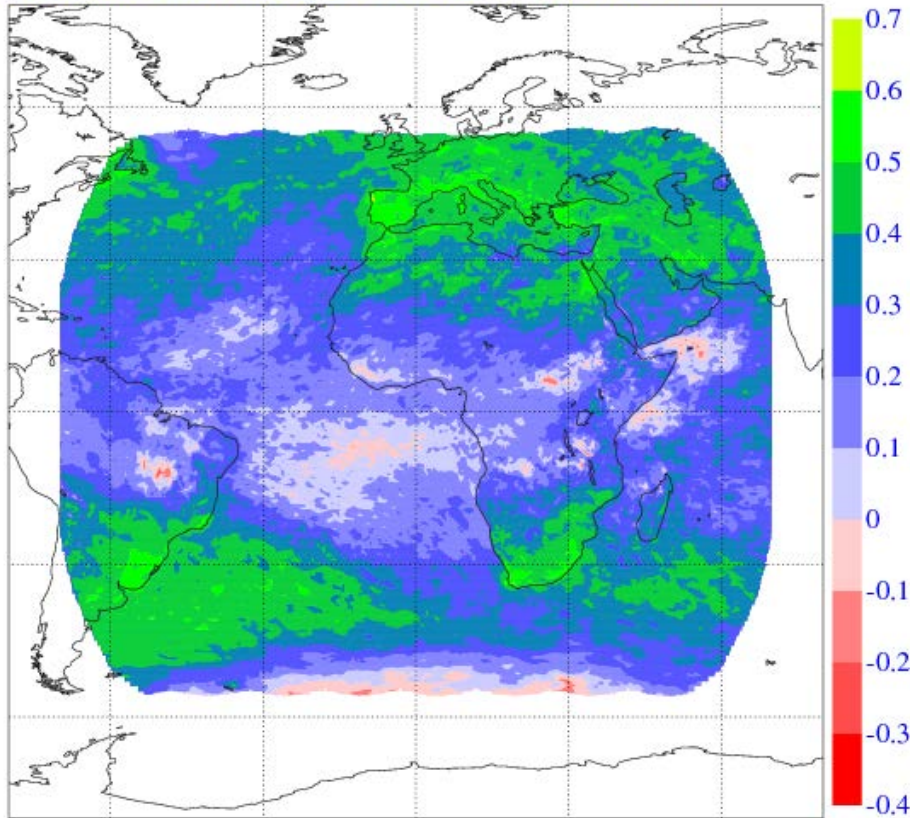
Nondimensional downward surface solar flux, sdev, 2011



Standard deviation (D+1)

Non-dimensional solar flux

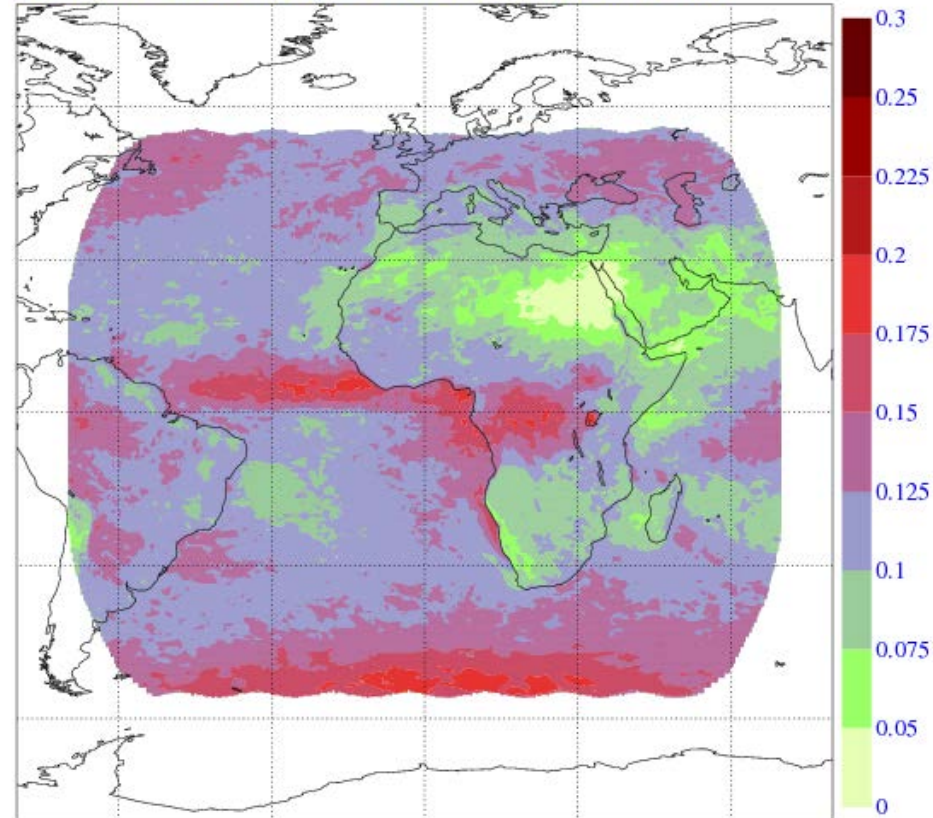
Nondimensional downward surface solar flux, skill, 2011



Skill (D+1)

$$= 1 - \text{SD}(\text{FC}) / \text{SD}(\text{OBS})$$

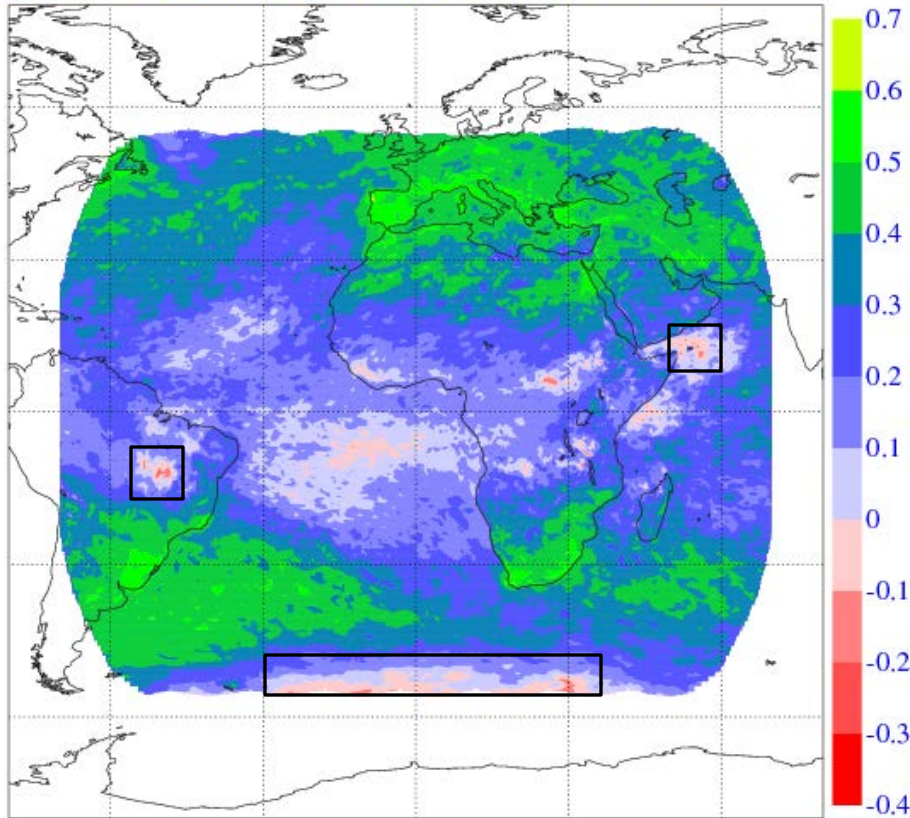
Nondimensional downward surface solar flux, sdev, 2011



Standard deviation (D+1)

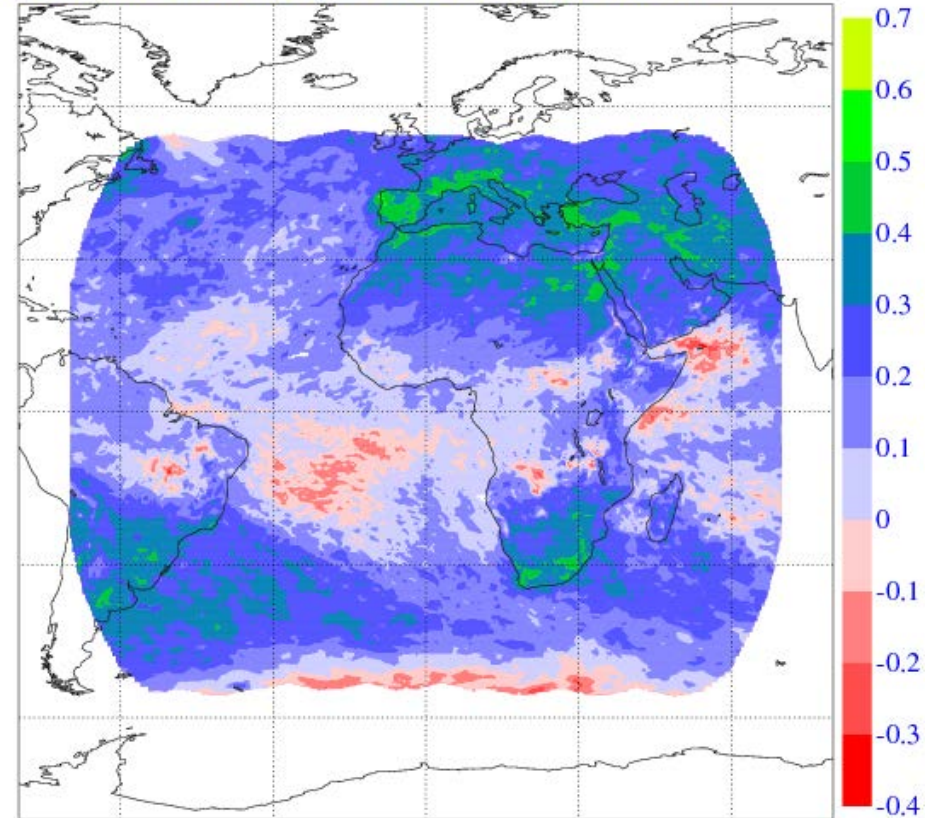
Non-dimensional solar flux

Nondimensional downward surface solar flux, skill, 2011



Skill (D+1)

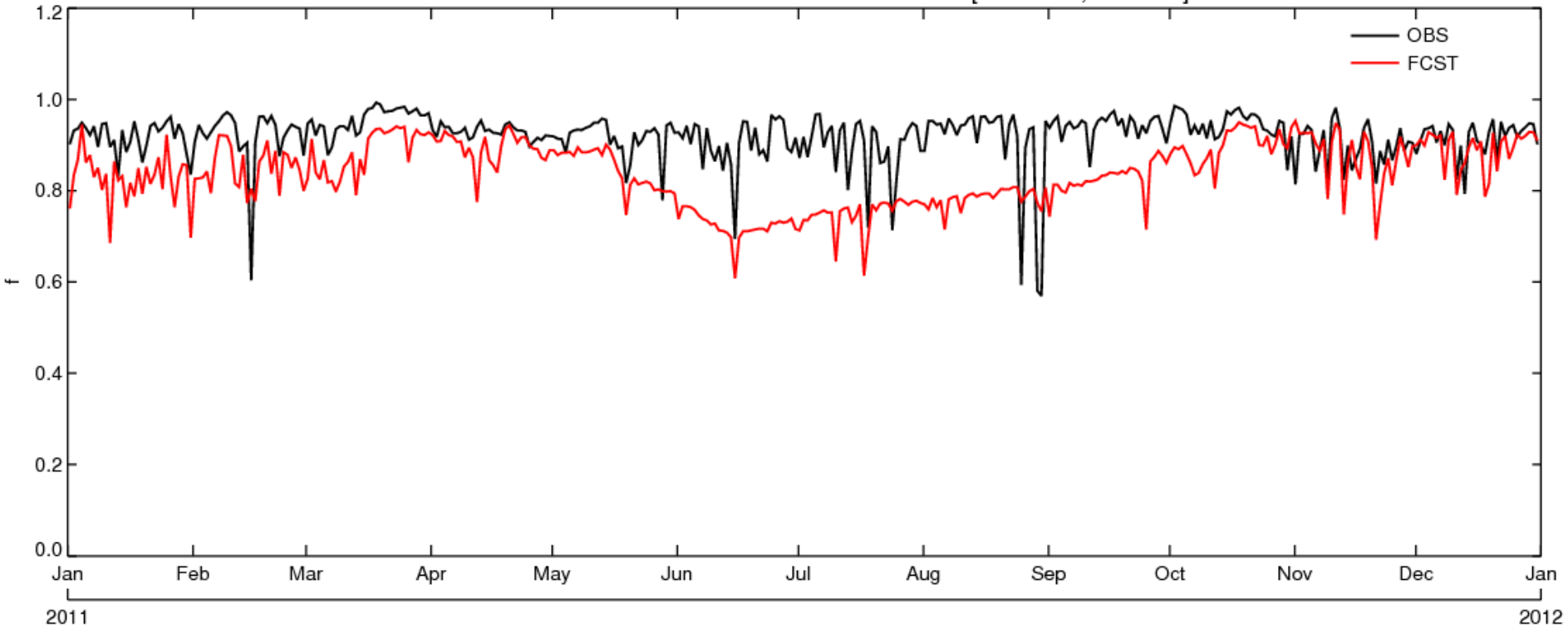
Nondimensional downward surface solar flux, skill, 2011



Skill (D+3)

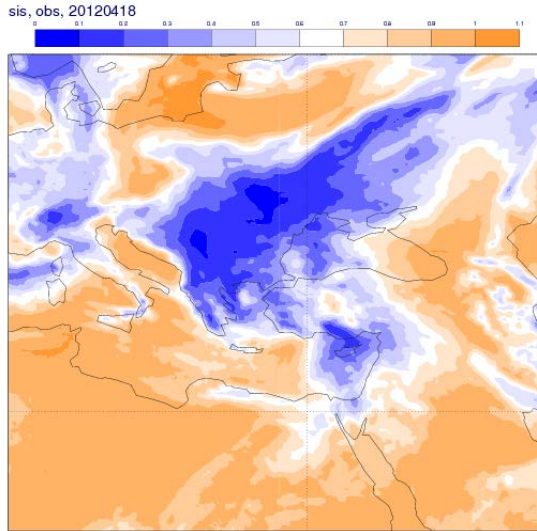
Gulf of Aden

Nondimensional downward surface solar radiation [lon= 48.0,lat= 13.0]

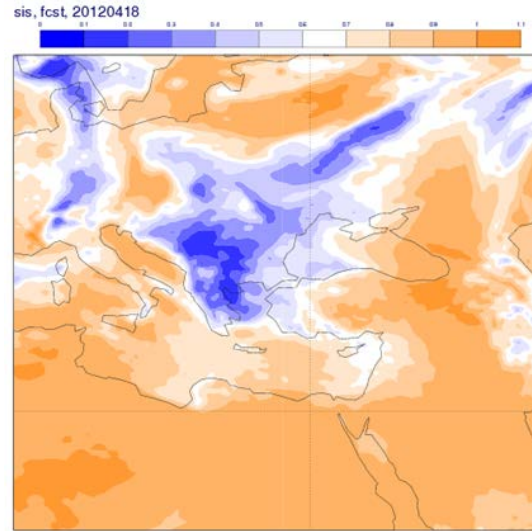


Prognostic aerosol (MACC)

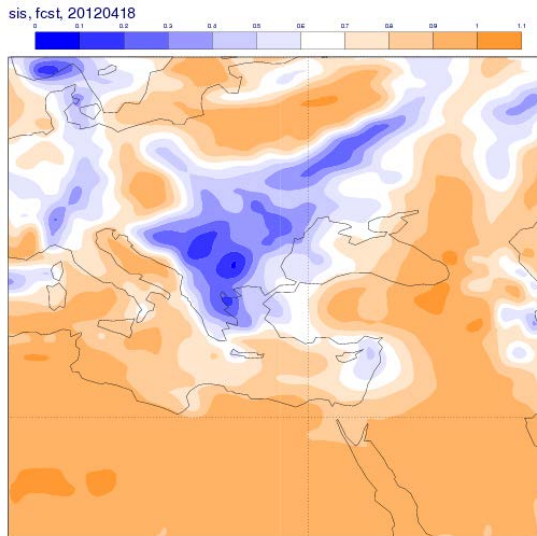
CM SAF



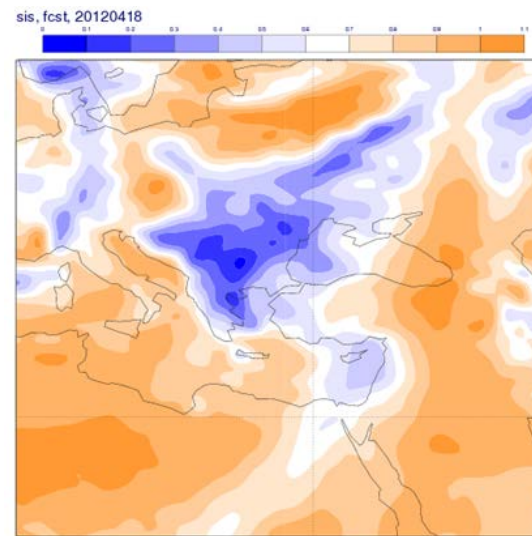
OPER



Climatological
aerosol

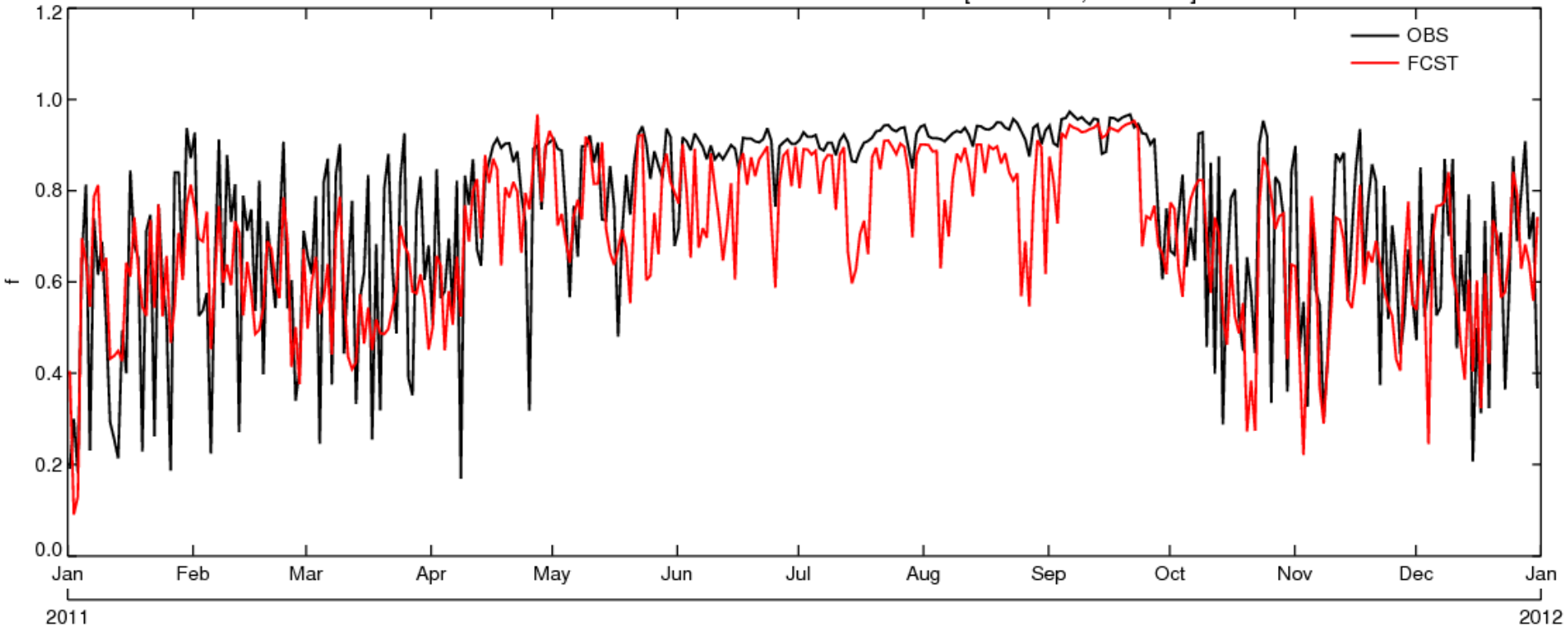


Prognostic
aerosol

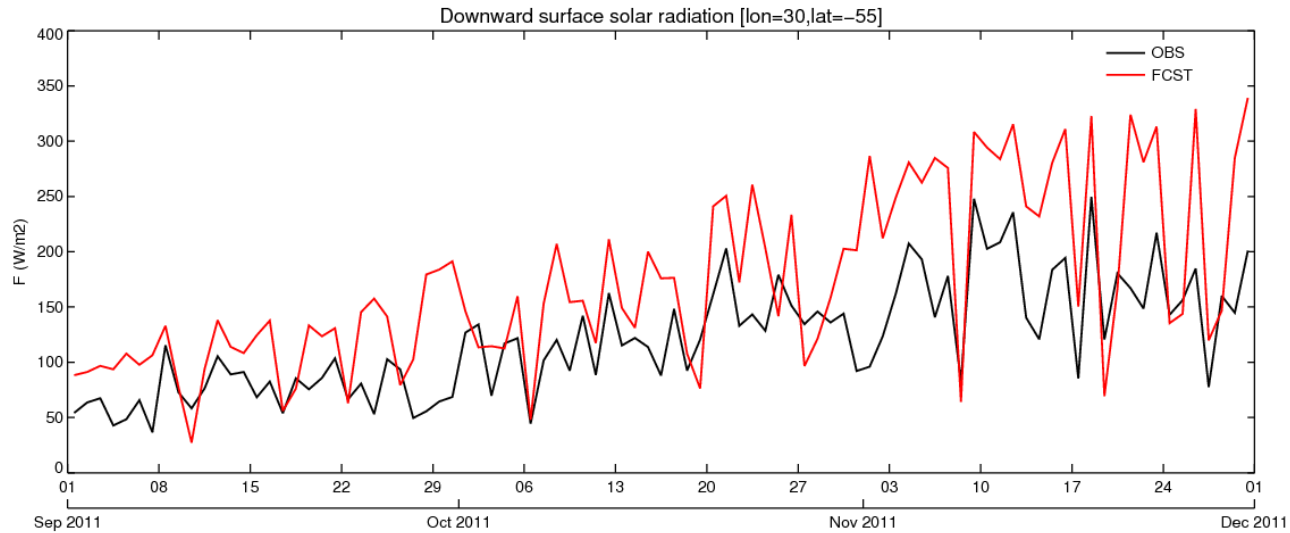


Brazil

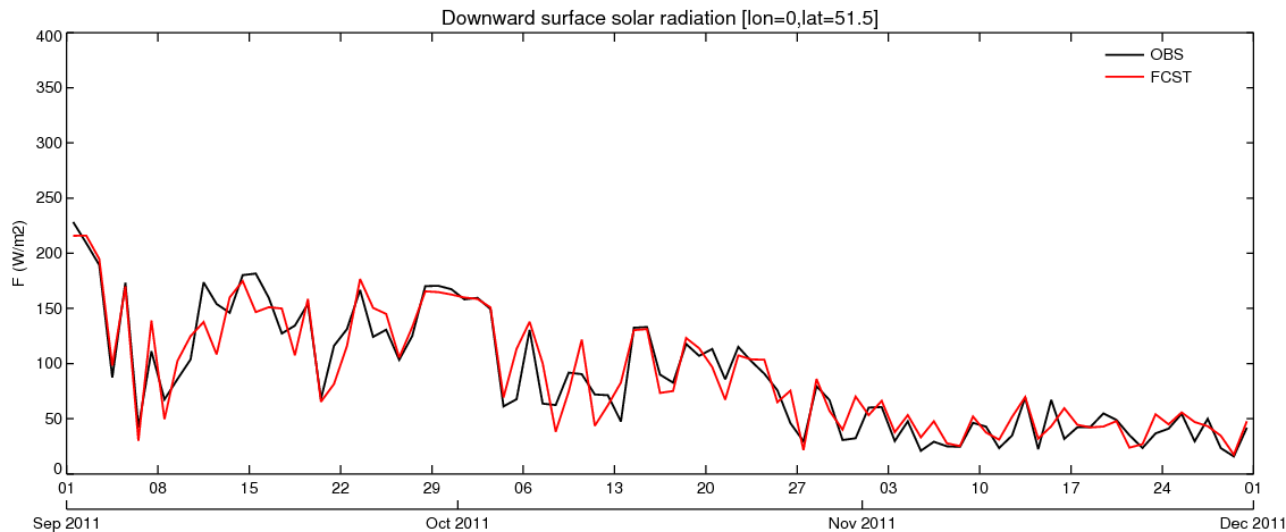
Nondimensional downward surface solar radiation [lon=-50.0,lat=-12.0]



Problem area Southern Ocean

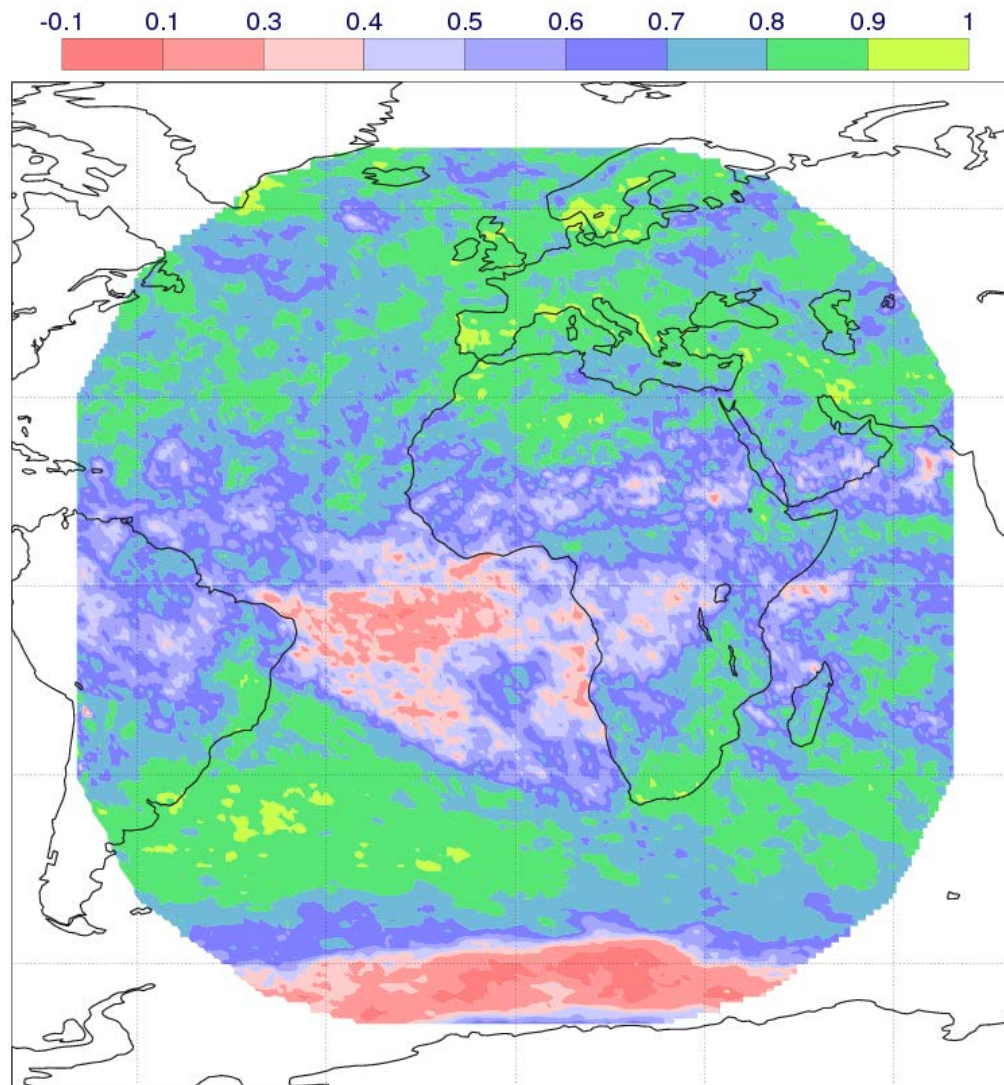


Southern Ocean



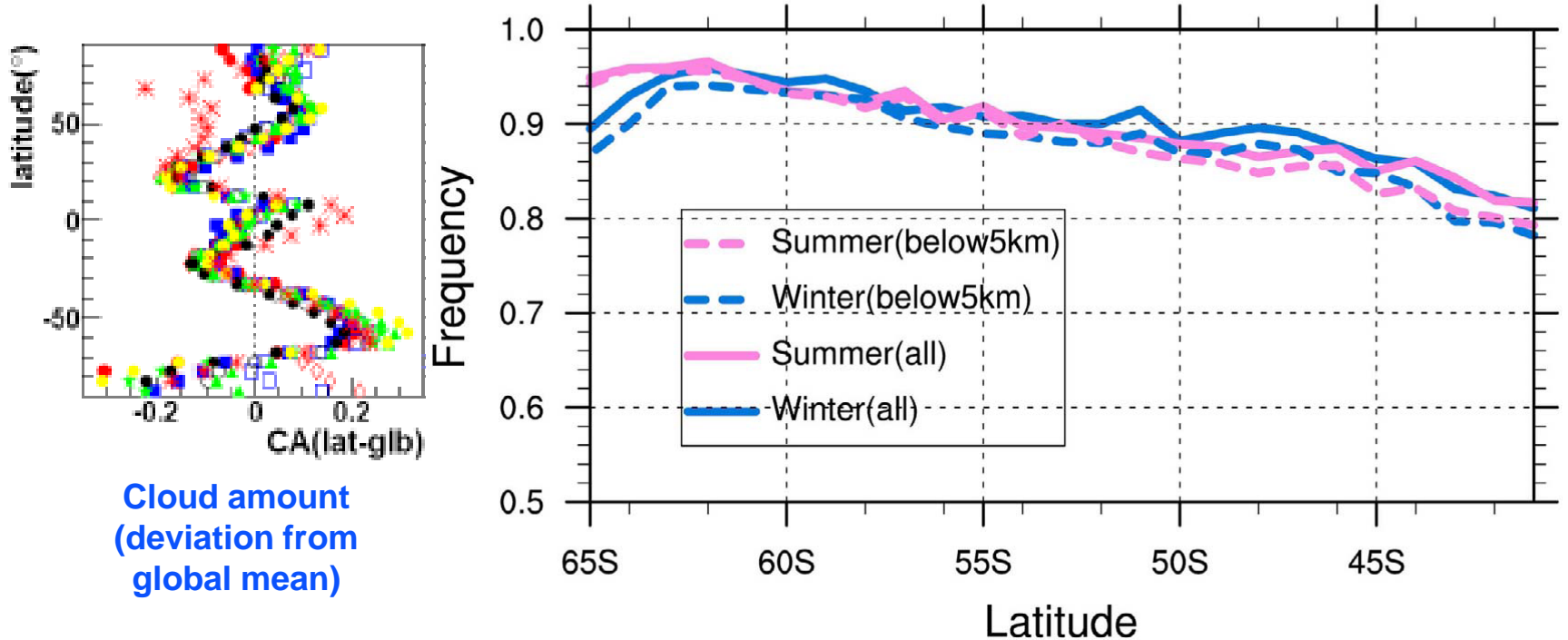
Southern UK

Downward solar, Oct-Dec 2012, correlation



Latitudinal variation of total cloud cover

Fractional Cloud Cover

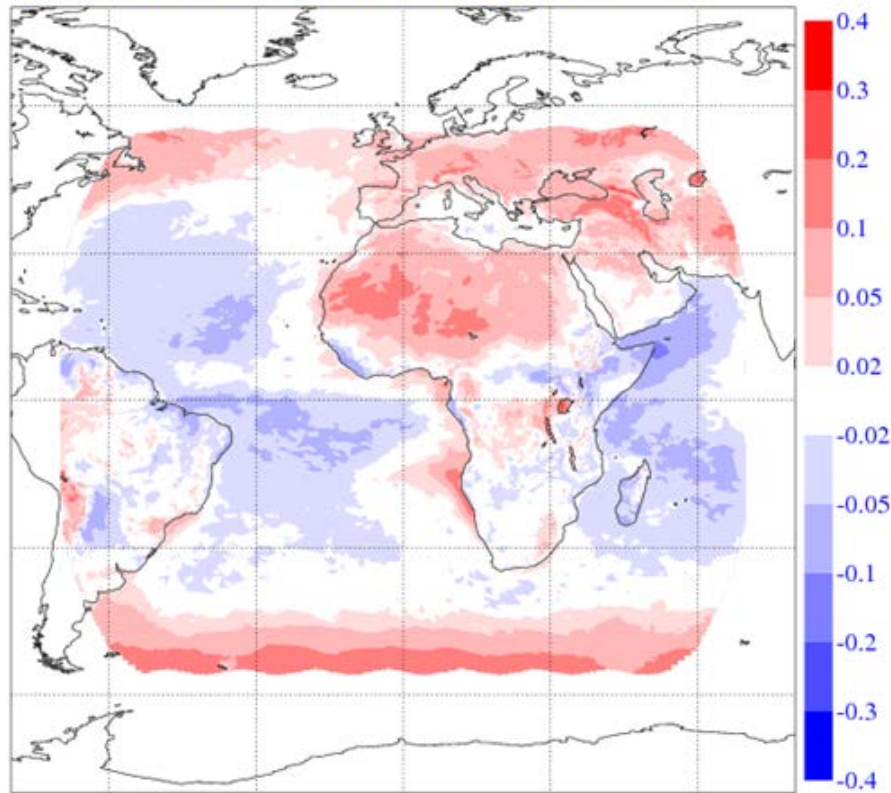


WCRP/GEWEX
Stubenrauch et al. (2012)

A-Train DARDAR-MASK
Huang et al. (2012)

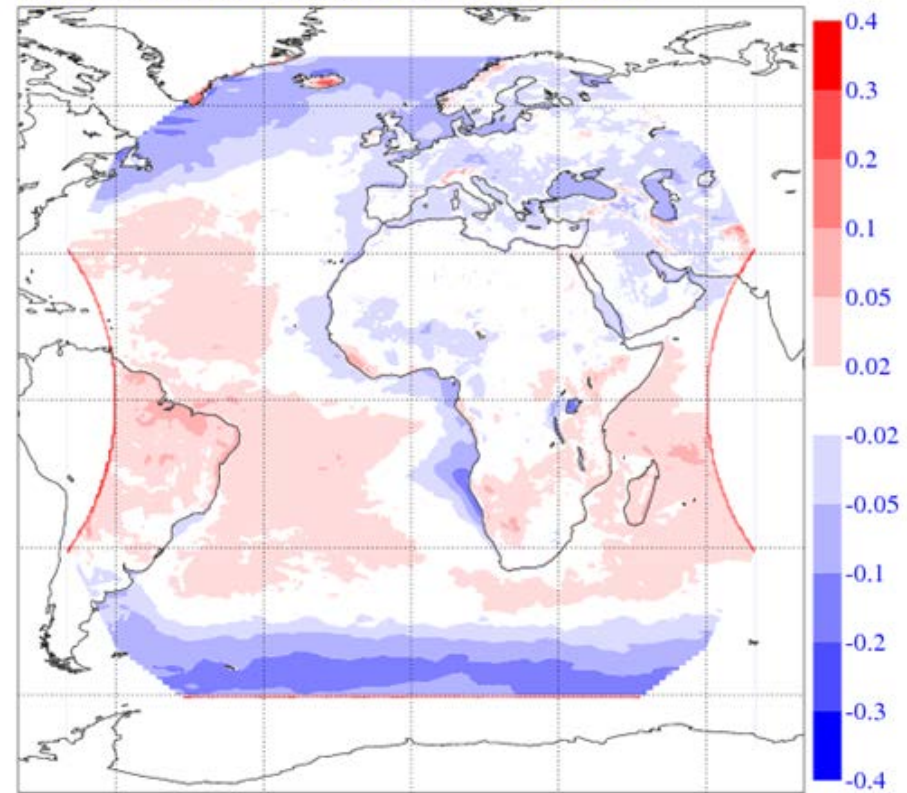
Solar downward vs TOA reflected

Nondimensional downward surface solar flux, bias, 2011



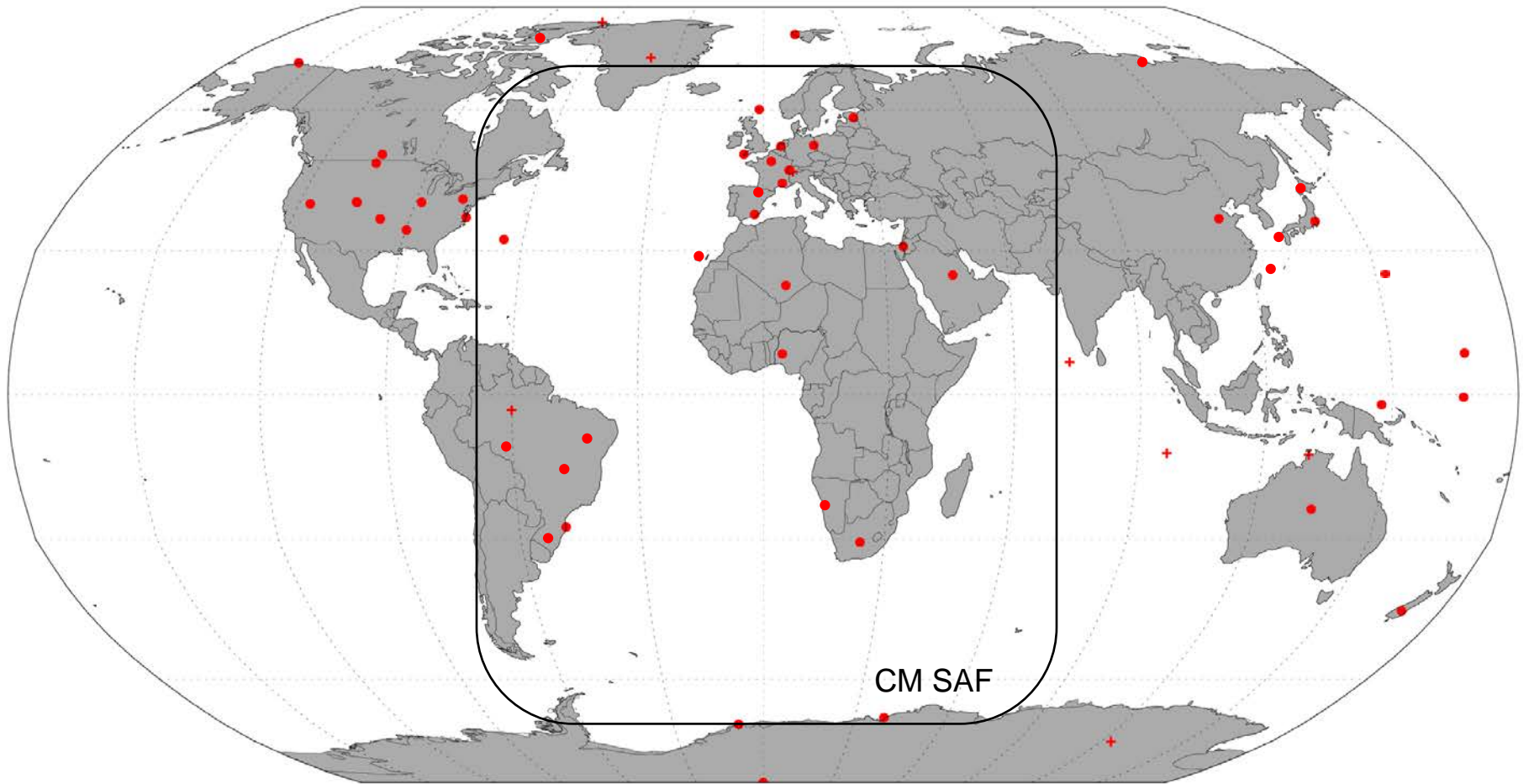
SFC downward

Nondimensional TOA reflected solar flux, bias, 2011



TOA reflected

BSRN observations



Currently 50+ stations, number increasing

Subset with data available up to 2013

Estimated/expected errors

- **Solar downward at the surface**

CM SAF target accuracy (MAE): 10 W m⁻² (monthly), 20 W m⁻² (daily)

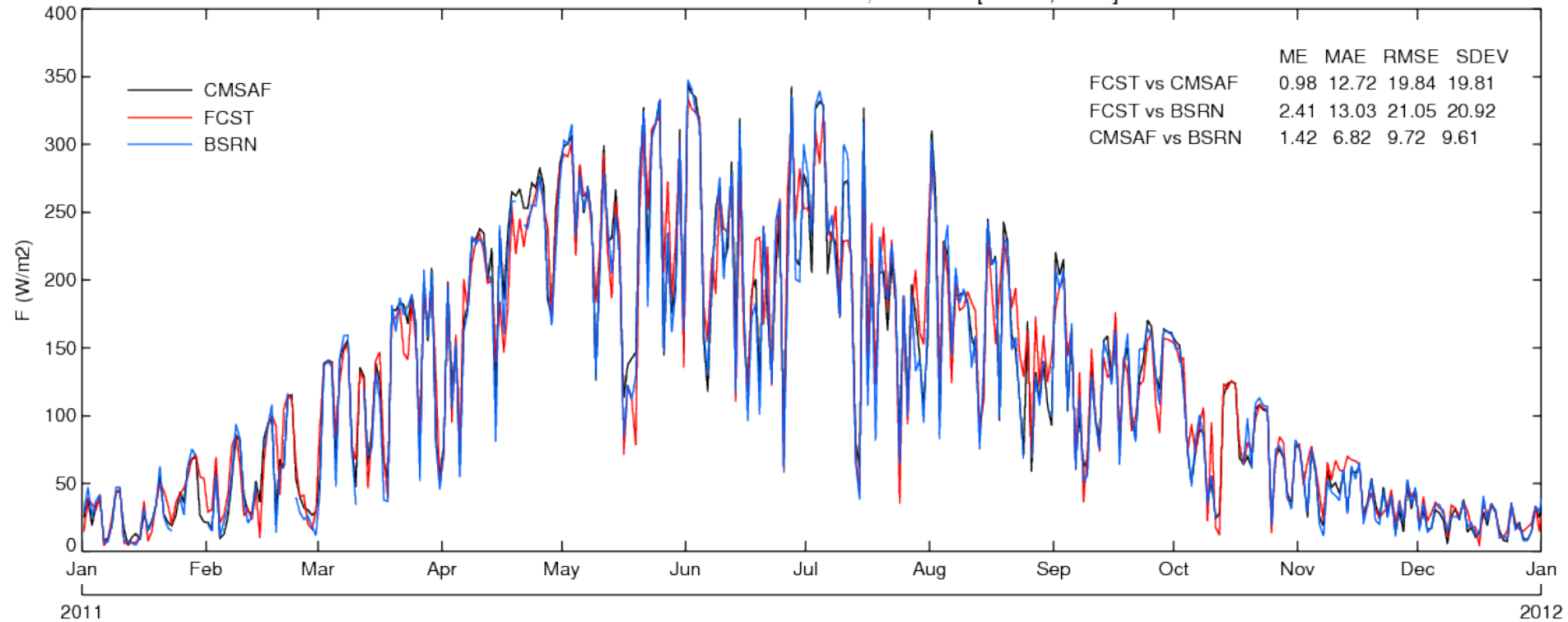
BSRN target accuracy: 5 W m⁻²

CM SAF: Mueller et al (2009), Macke et al (2010), Posselt et al (2012)

BSRN: Ohmura et al (1998), Augustine et al (2005)

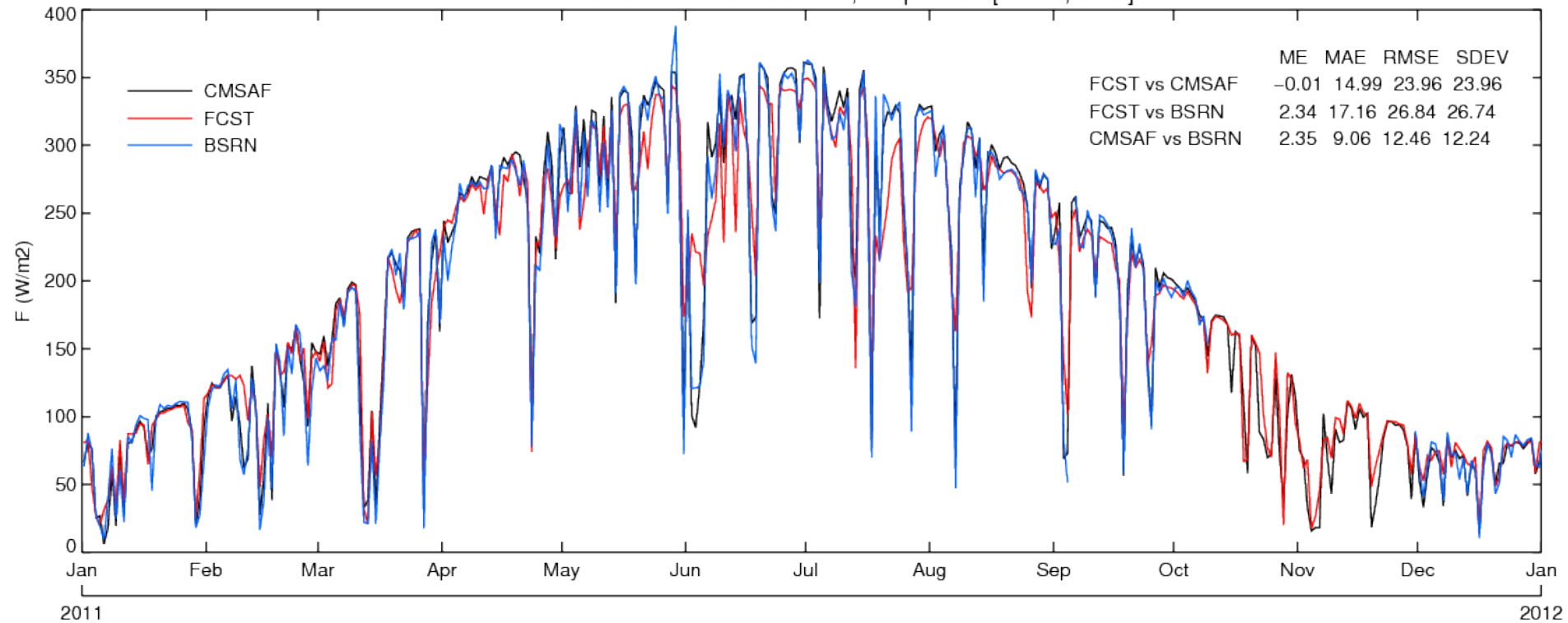
ECMWF vs CM SAF and BSRN

Downward surface solar radiation, Cabauw [52.0N, 4.9E]



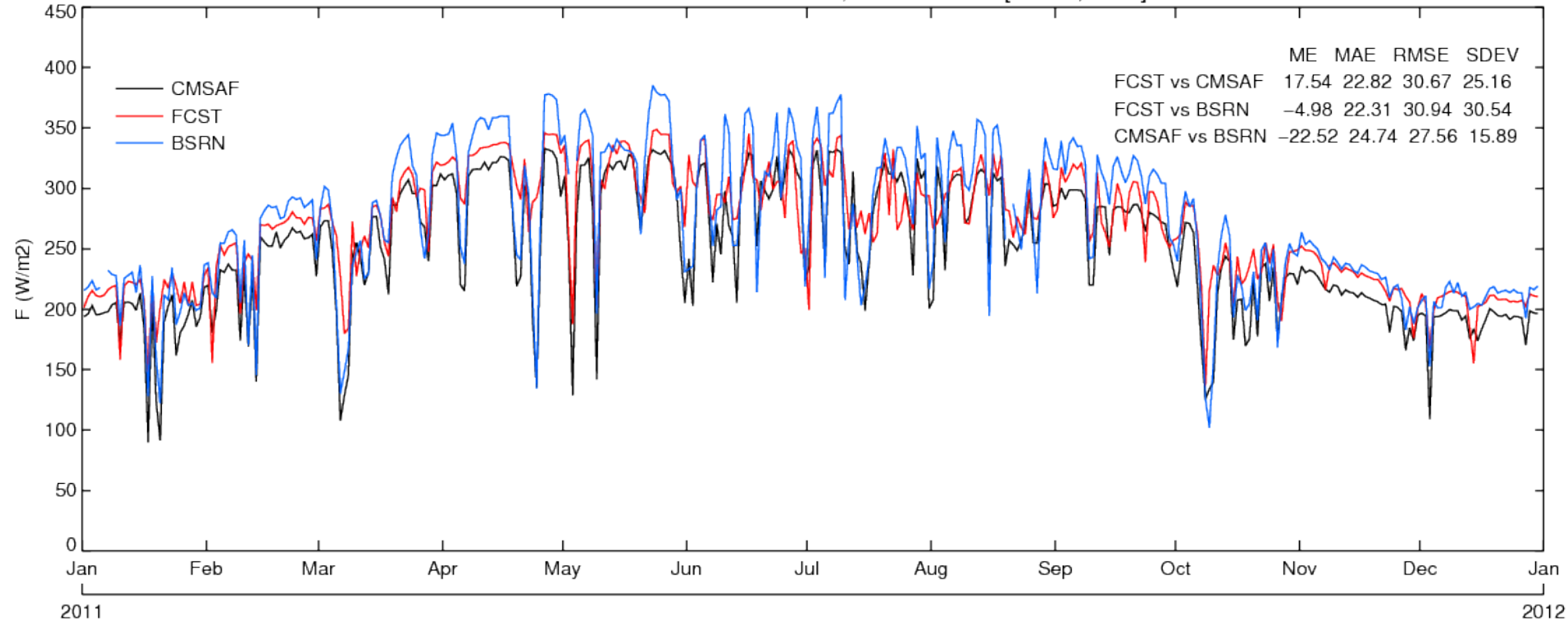
ECMWF vs CM SAF and BSRN

Downward surface solar radiation, Carpentras [44.1N, 5.1E]



Tamanrasset, Algeria

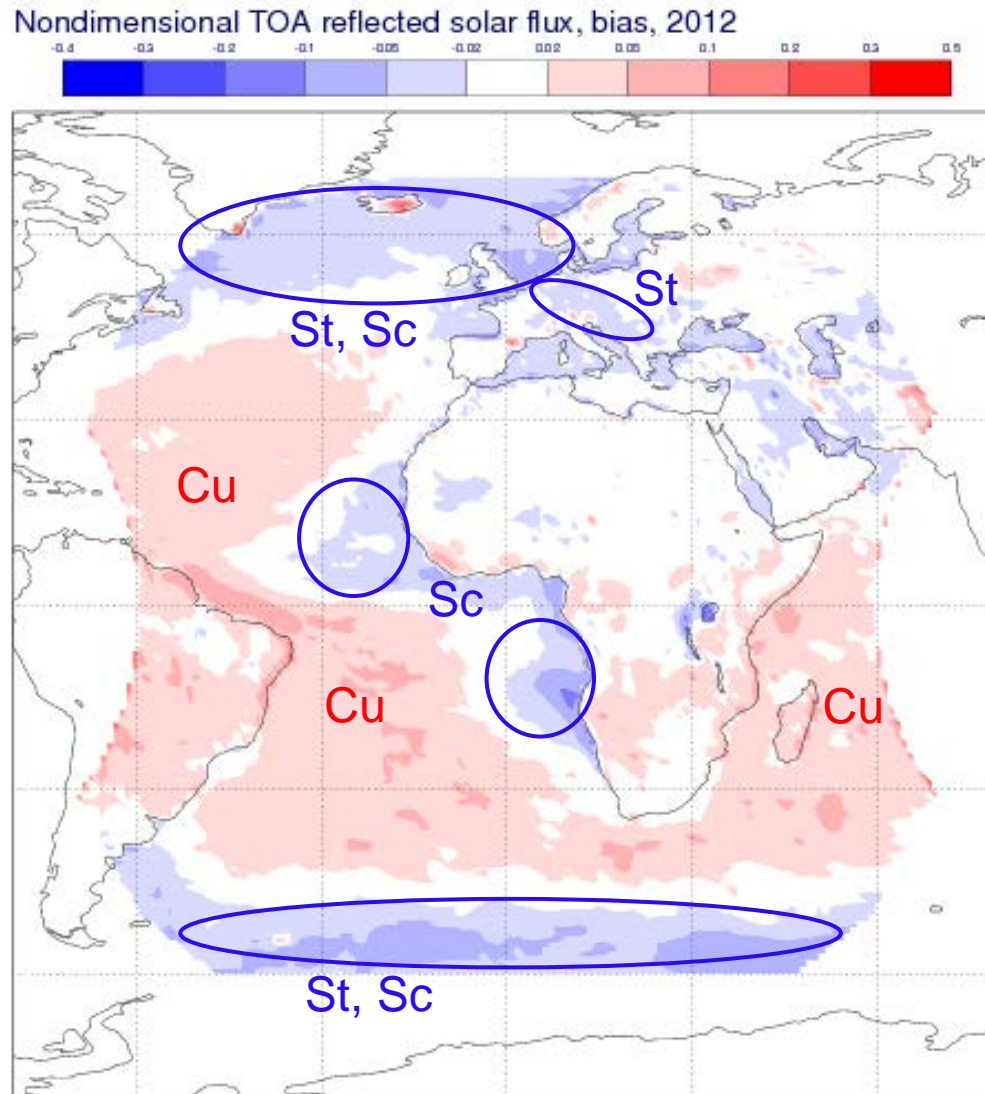
Downward surface solar radiation, Tamanrasset [22.8N, 5.5E]



Difference CM SAF vs BSRN due to aerosol, surface albedo?

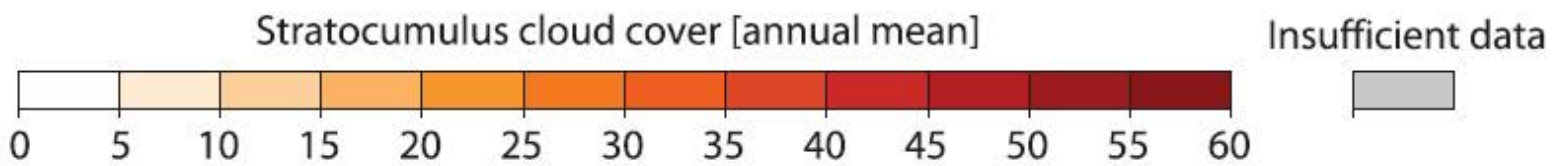
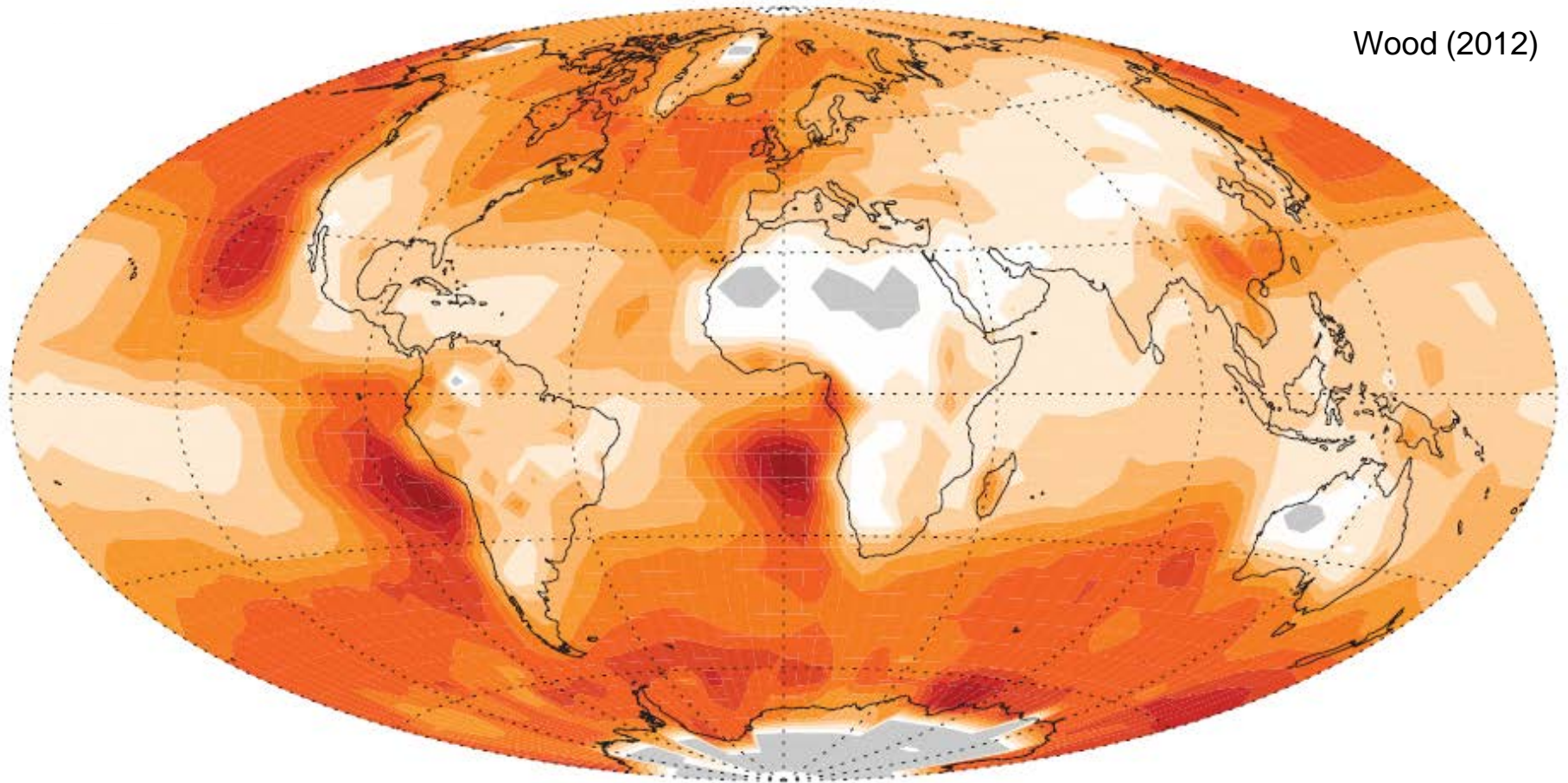
Clear-sky: range of 40 W m⁻² spanned by datasets

ECMWF bias in TOA solar reflected



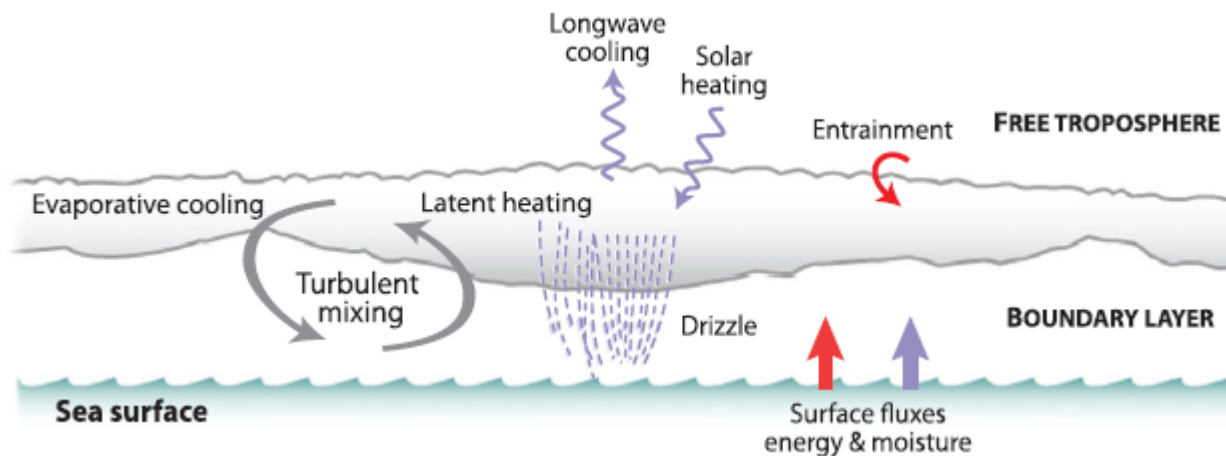
Stratocumulus

Wood (2012)



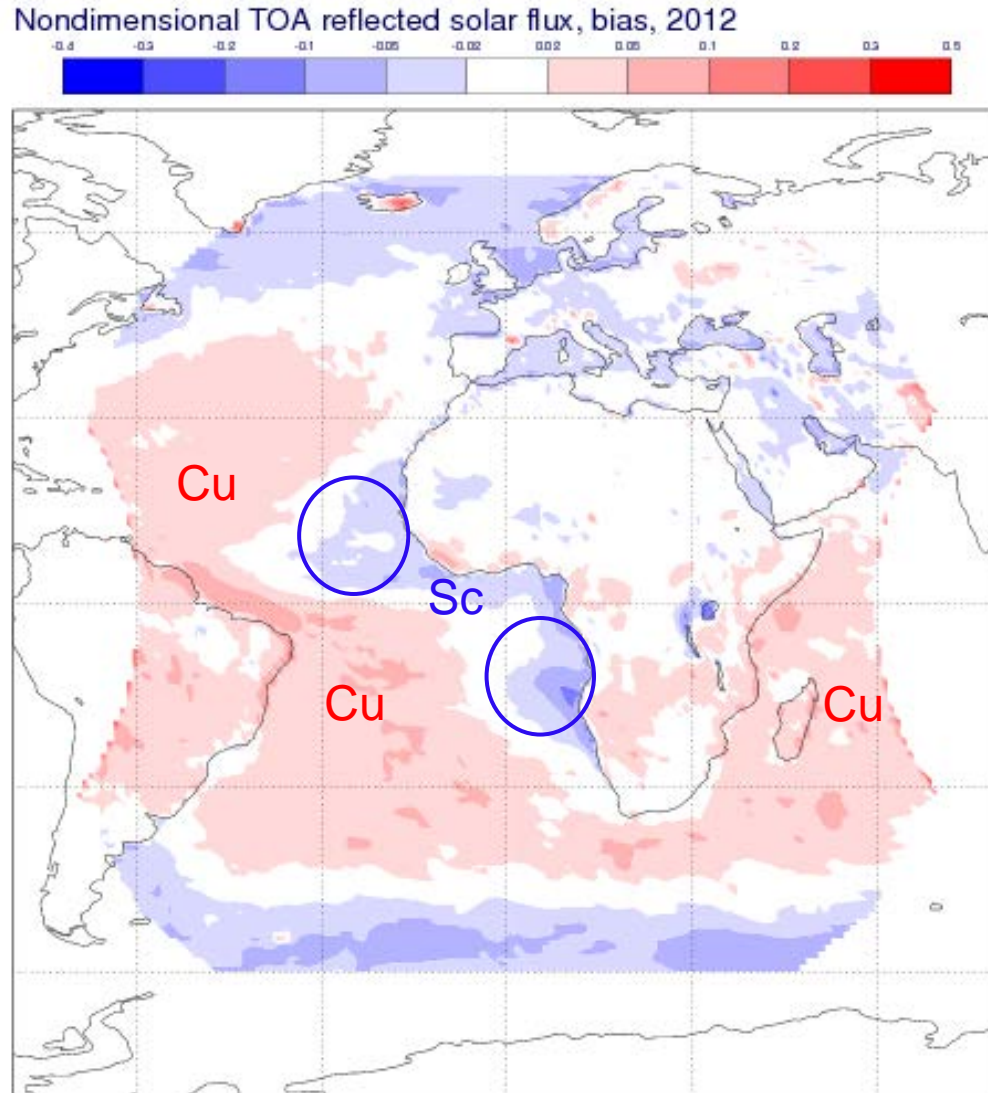
Why is Sc difficult to forecast?

- Small vertical extent
- Weak synoptic forcing
- Subtle interactions between radiation, microphysics, and turbulence
 - Model errors partially 'hidden' by compensation effects

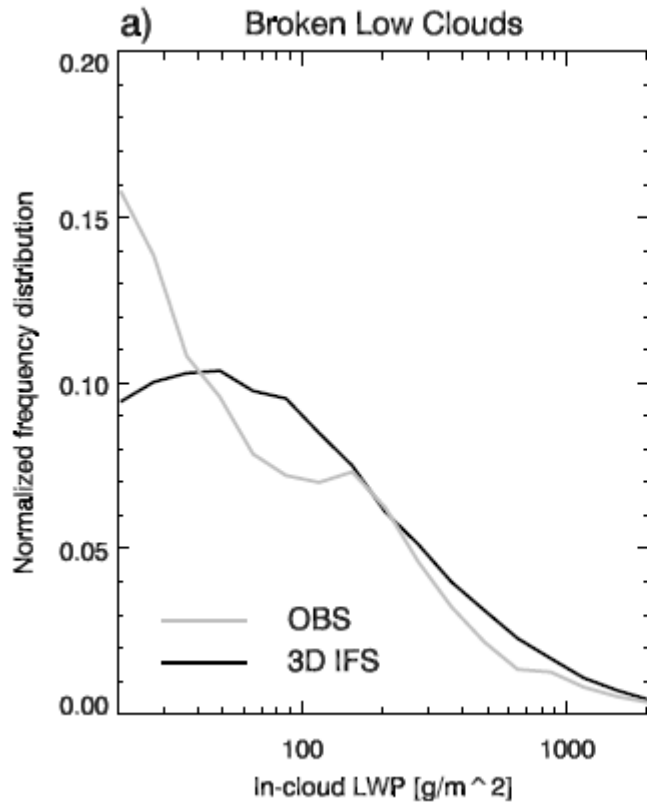


Wood (2012)

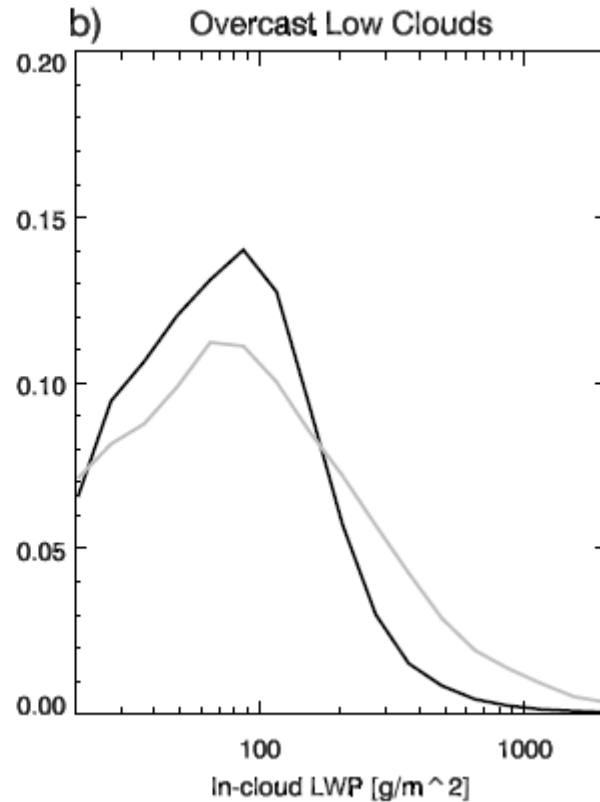
ECMWF bias in TOA solar reflected



Verification of cloud water content (ARM site)



Cu: too reflective

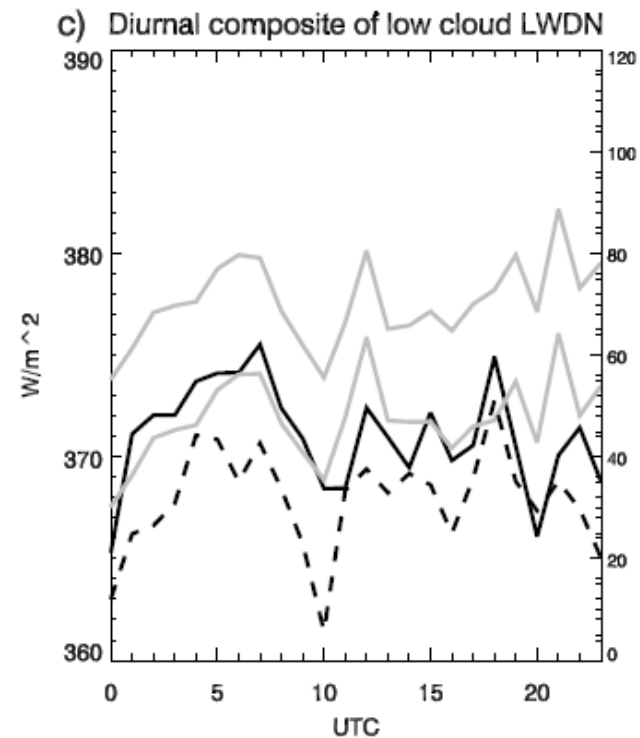
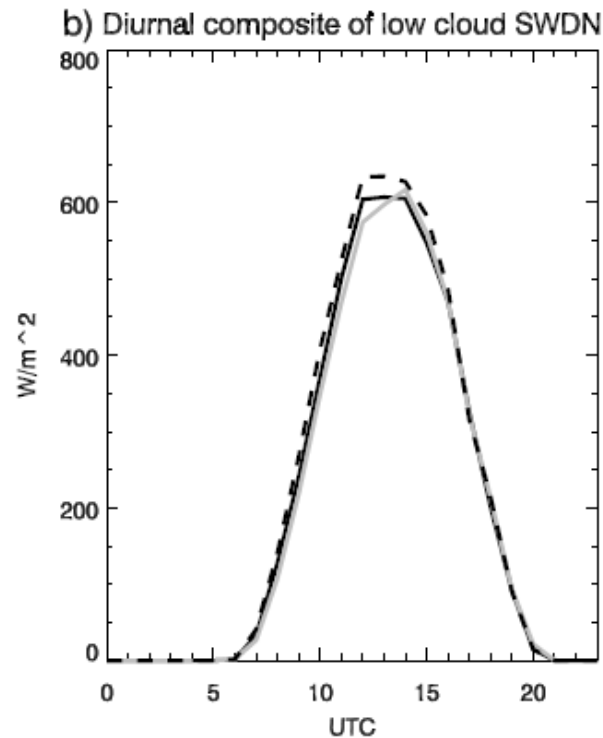
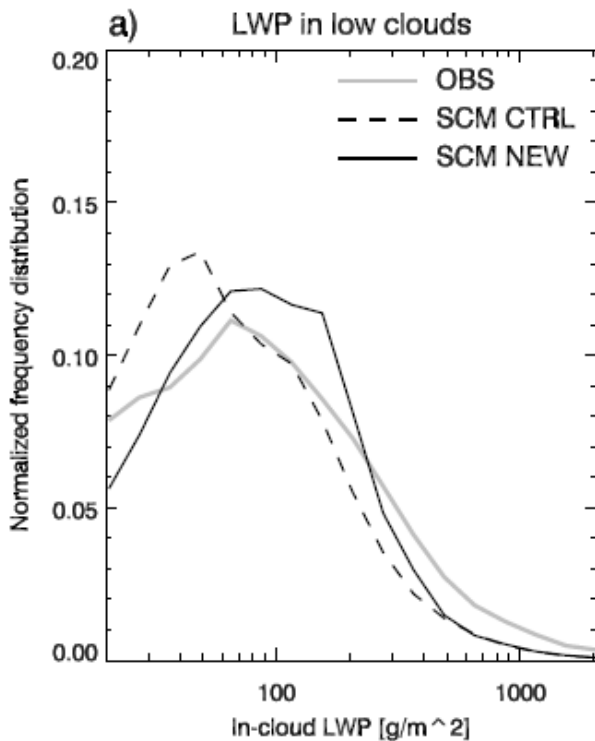


Sc: not reflective enough

Ahlgrimm and
Forbes (2013)

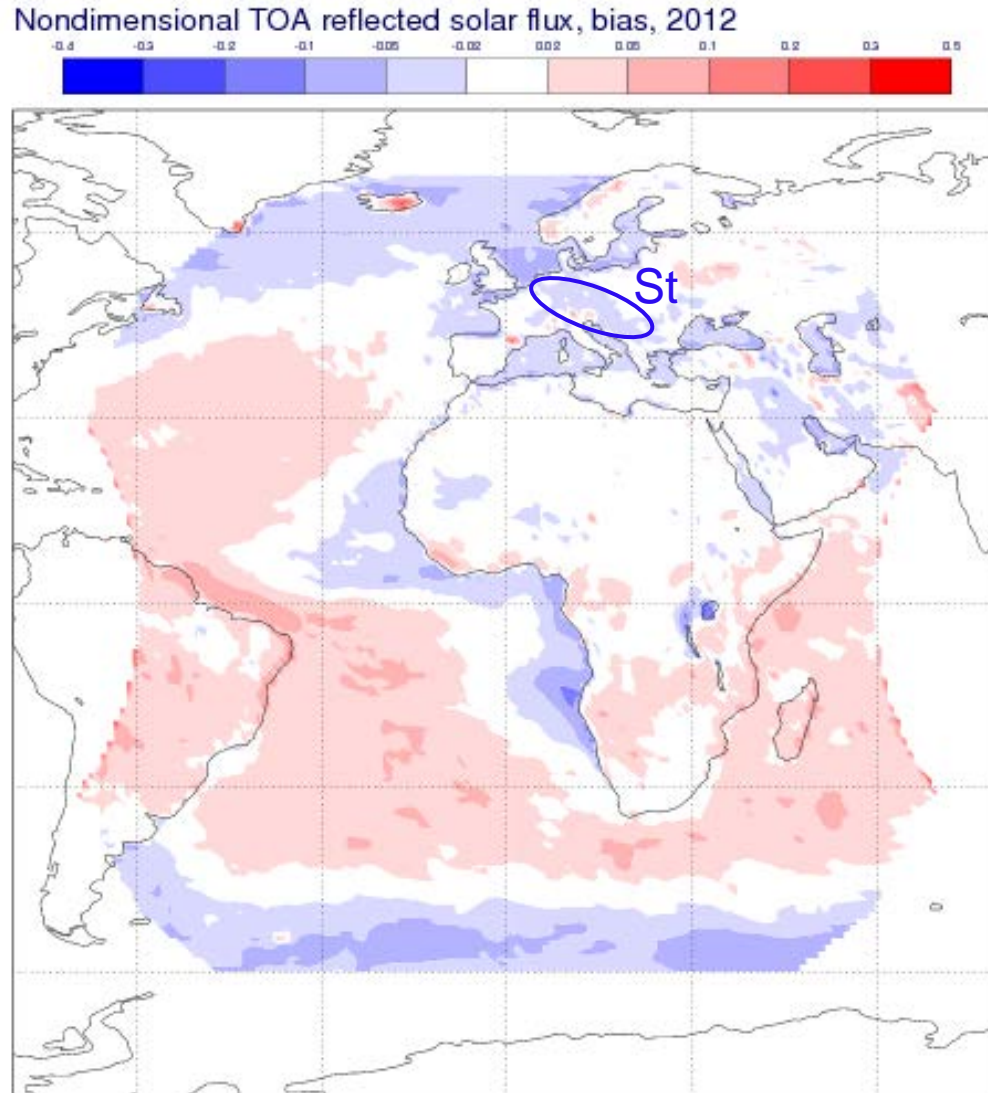
ECMWF approach to reducing Cu/Sc errors

- More consistent test-parcel in PBL cloud scheme
- More nonlinear autoconversion/accretion
- Improved sub-cloud precipitation evaporation

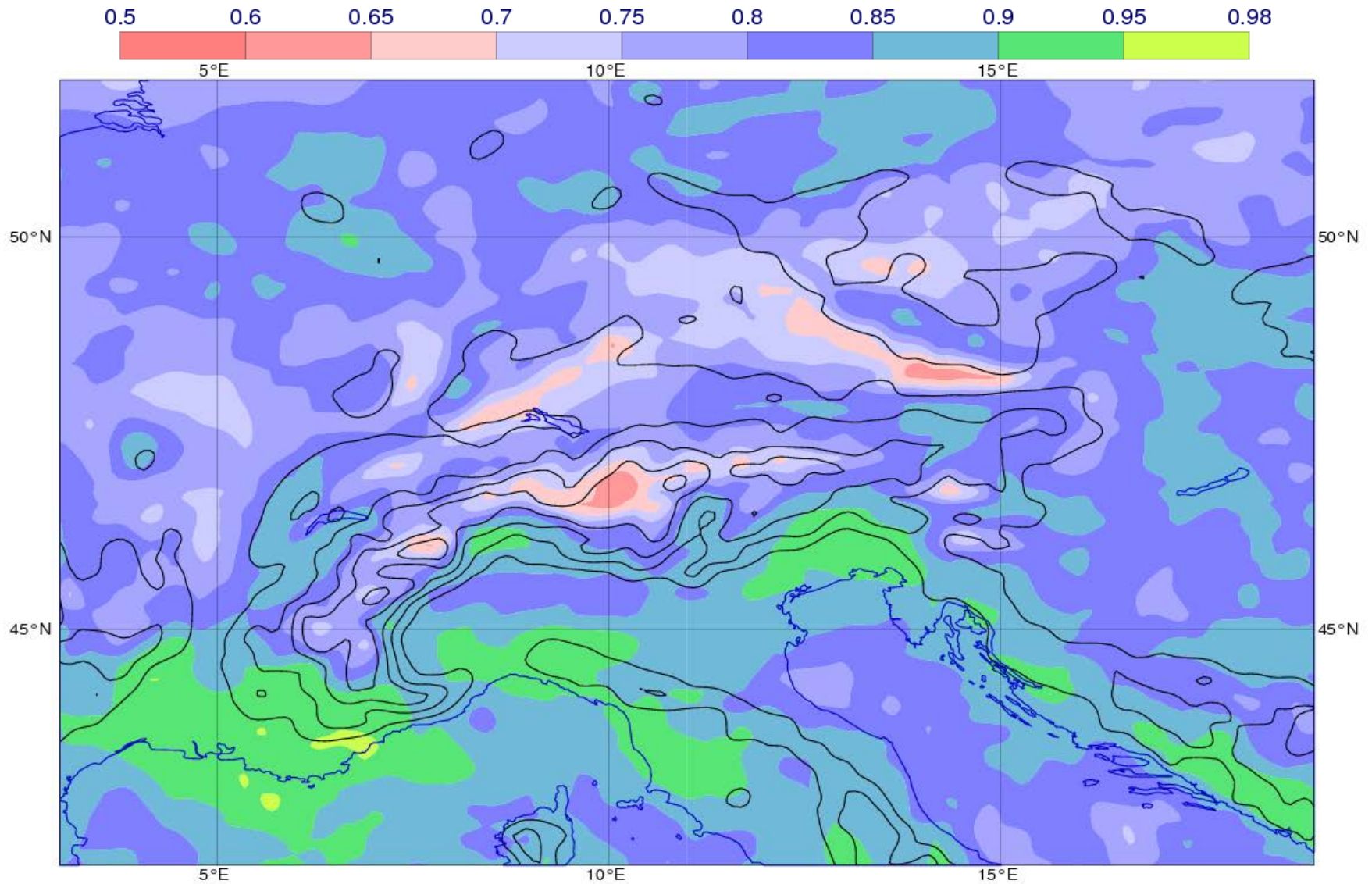


Ahlgrim and Forbes (2013)

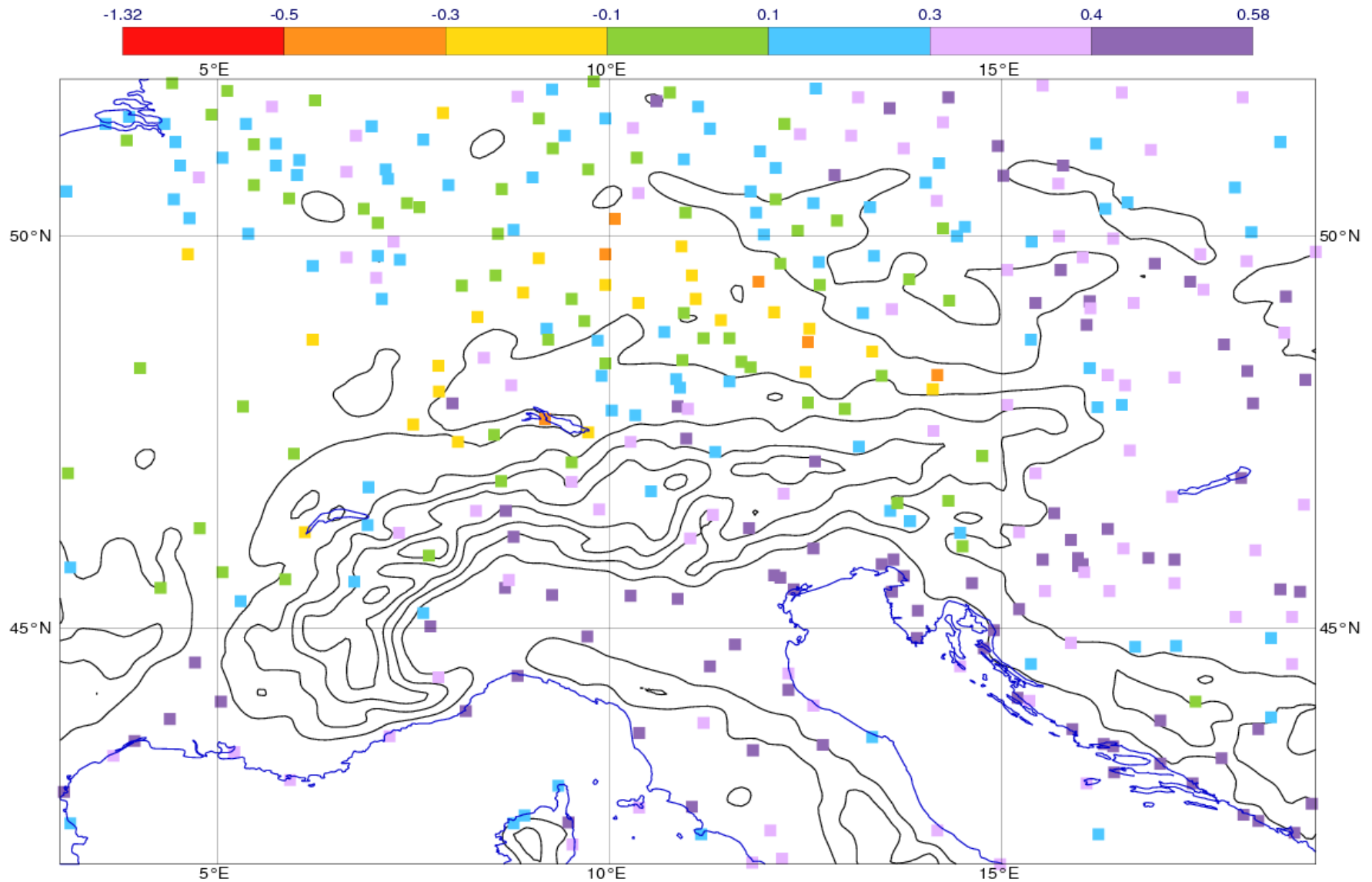
ECMWF bias in TOA solar reflected



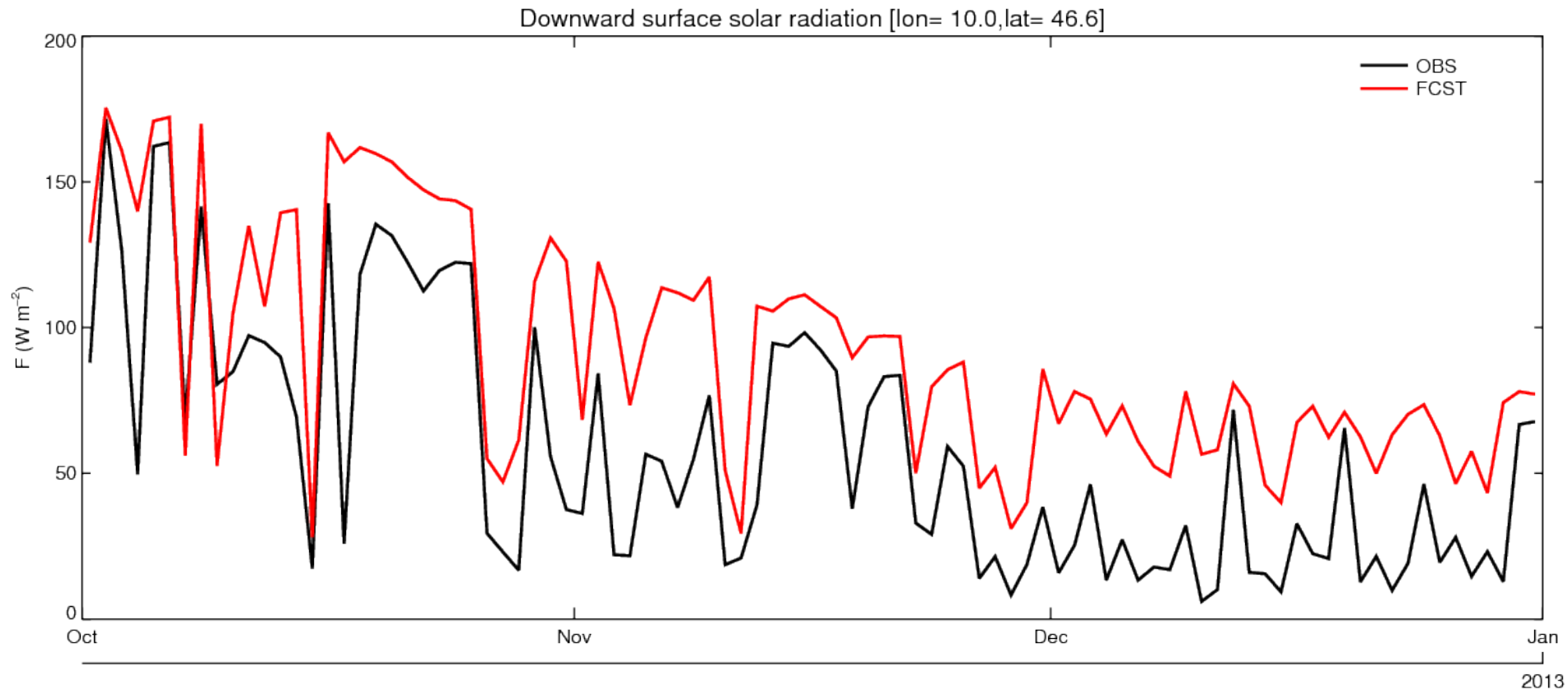
Downward solar, Oct-Dec 2012, correlation



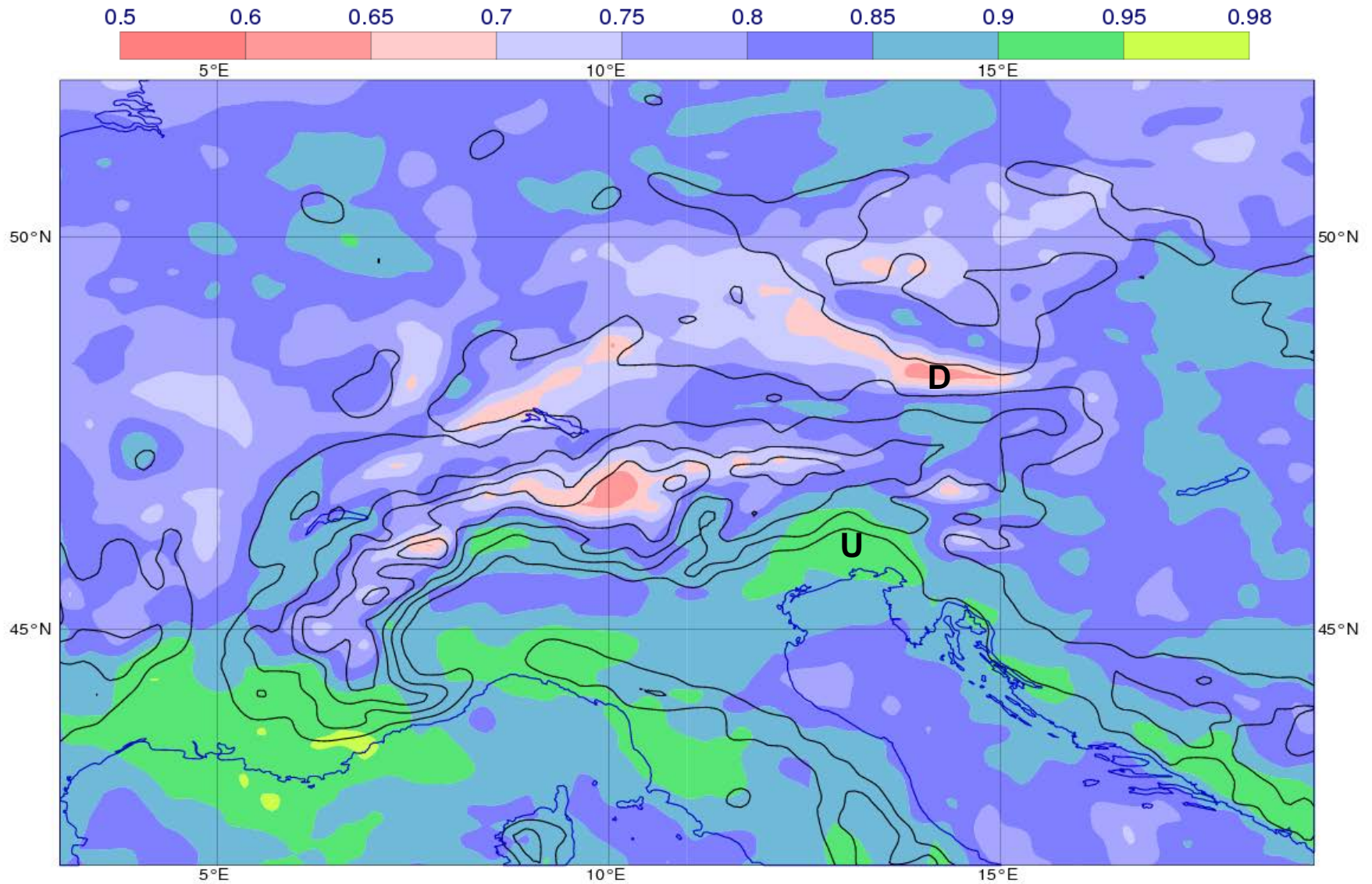
Total cloud cover 06-18 UTC, Oct-Dec 2012, skill



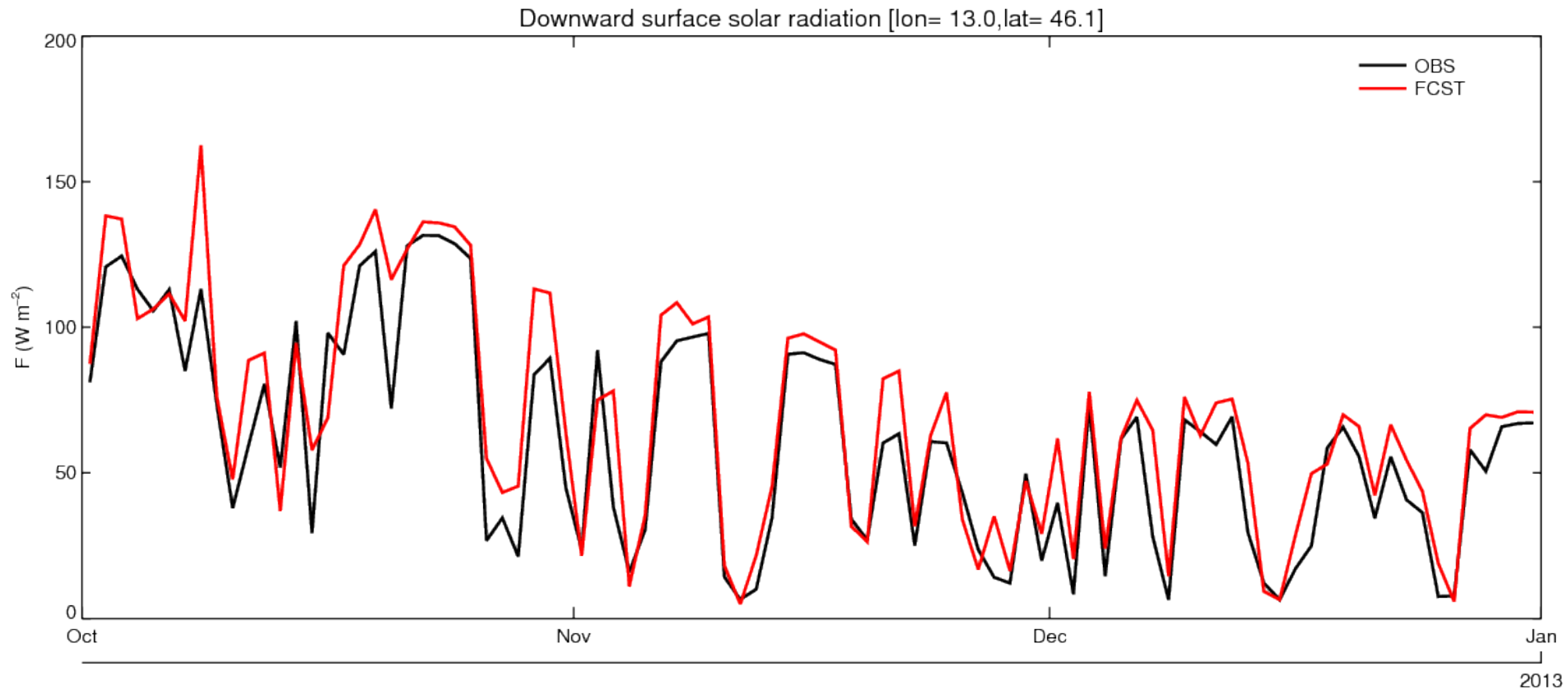
Downward solar, Oct-Dec 2012, central alps



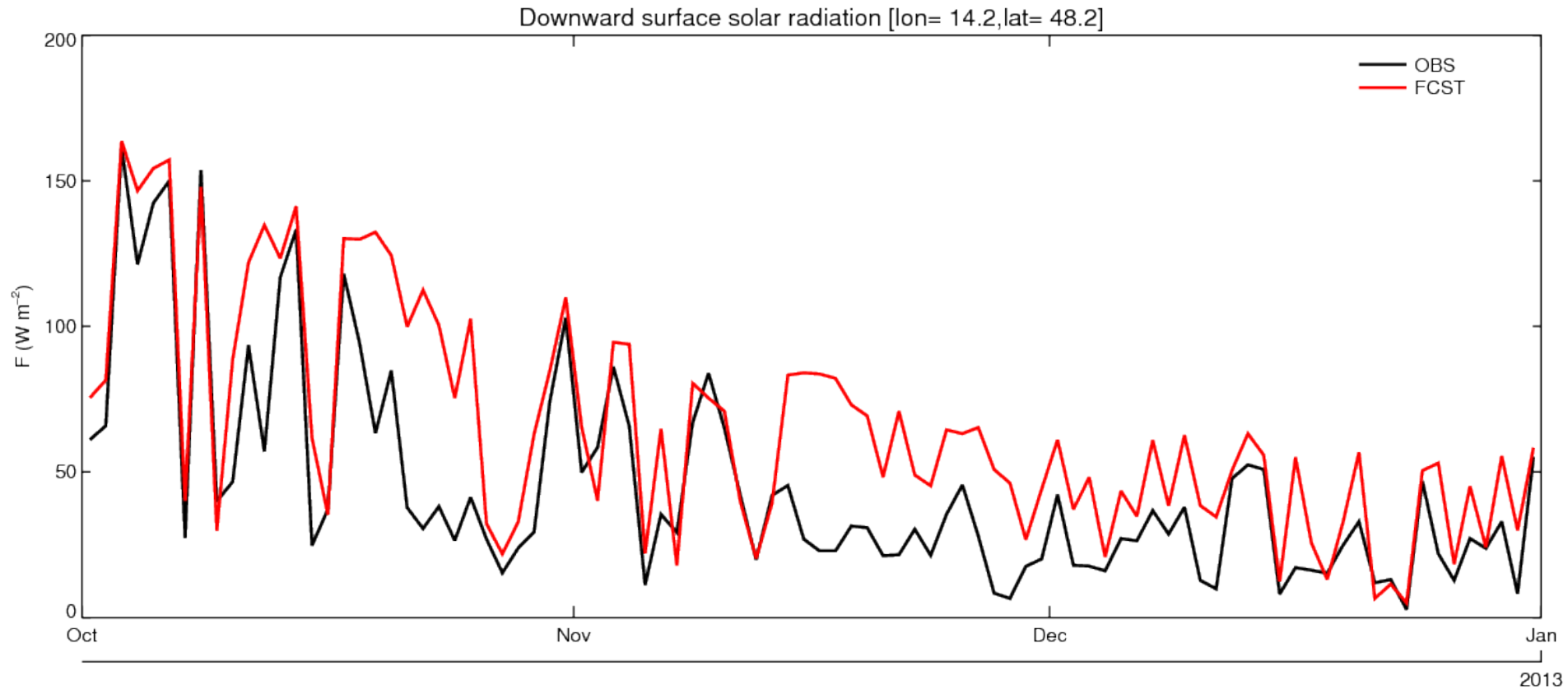
Downward solar, Oct-Dec 2012, correlation



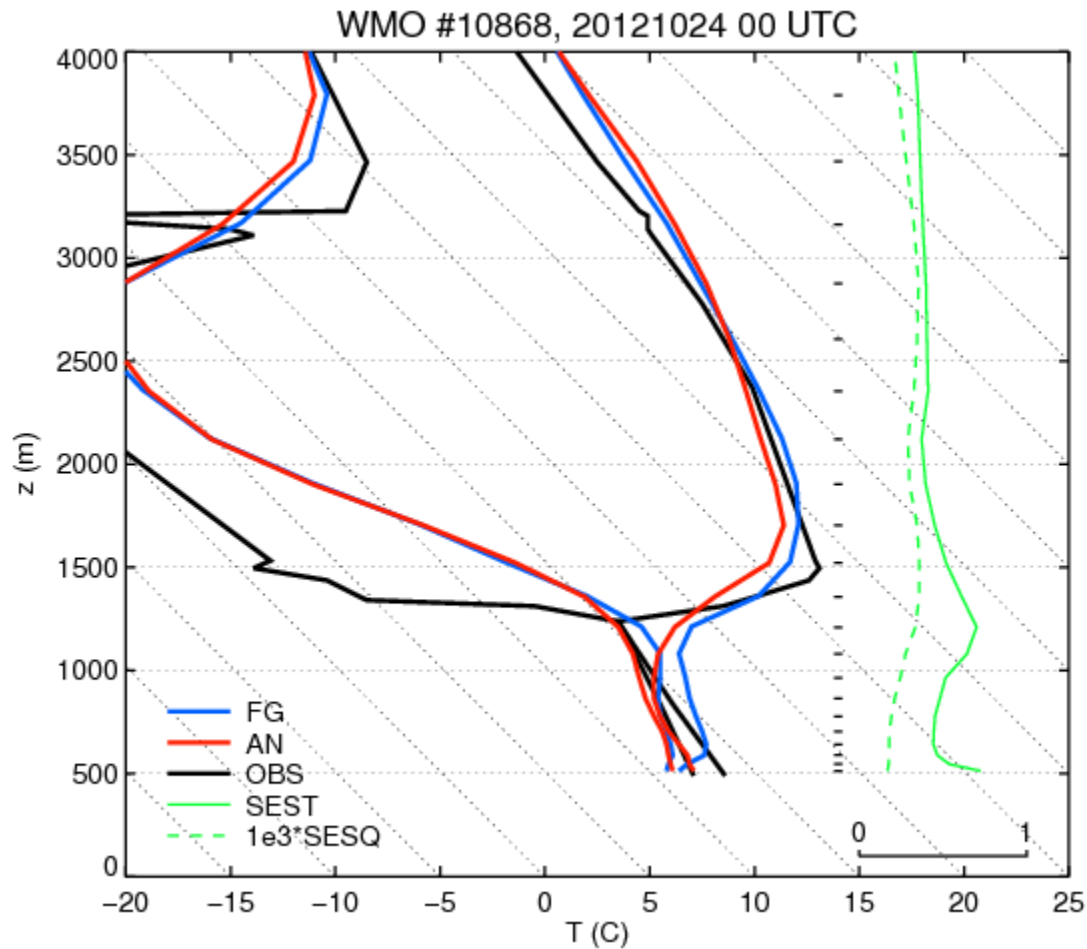
Udine



Danube valley

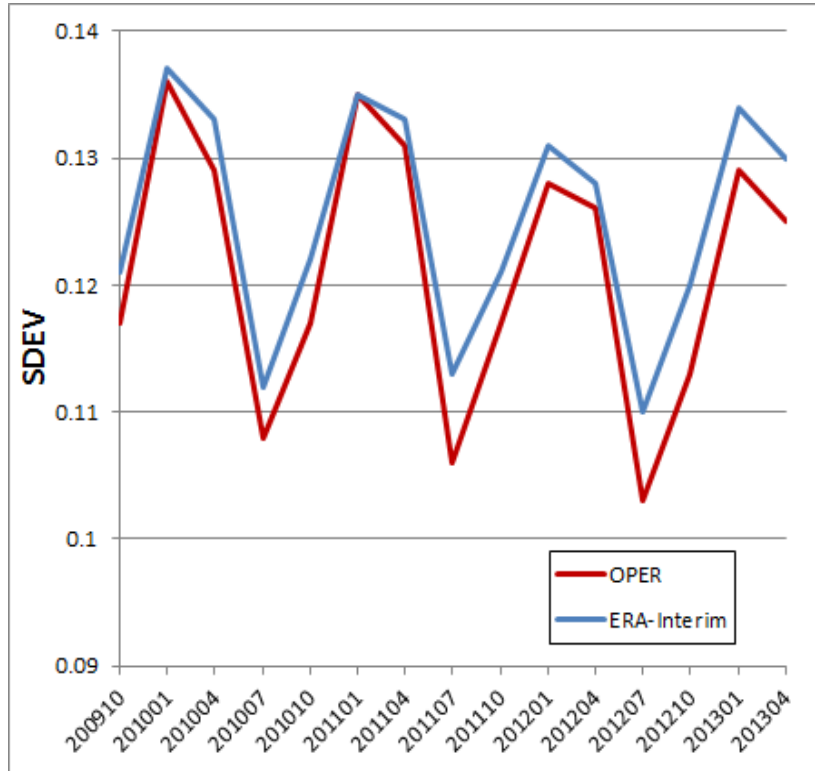


Low stratus representation problem

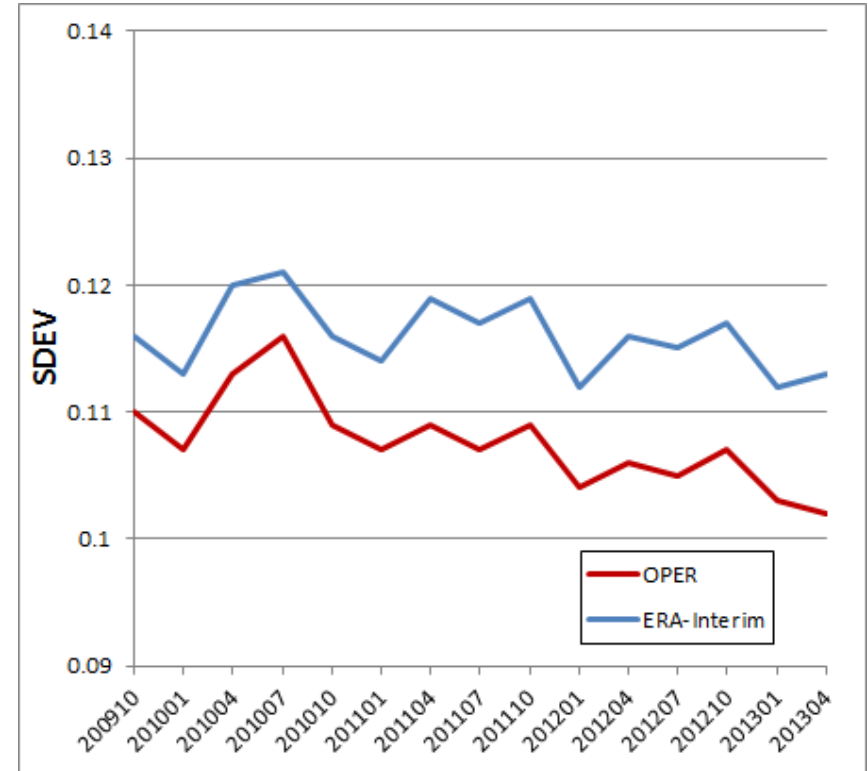


Evolution of forecast skill

TOA reflected solar radiation



N.Hem Extra-tropics

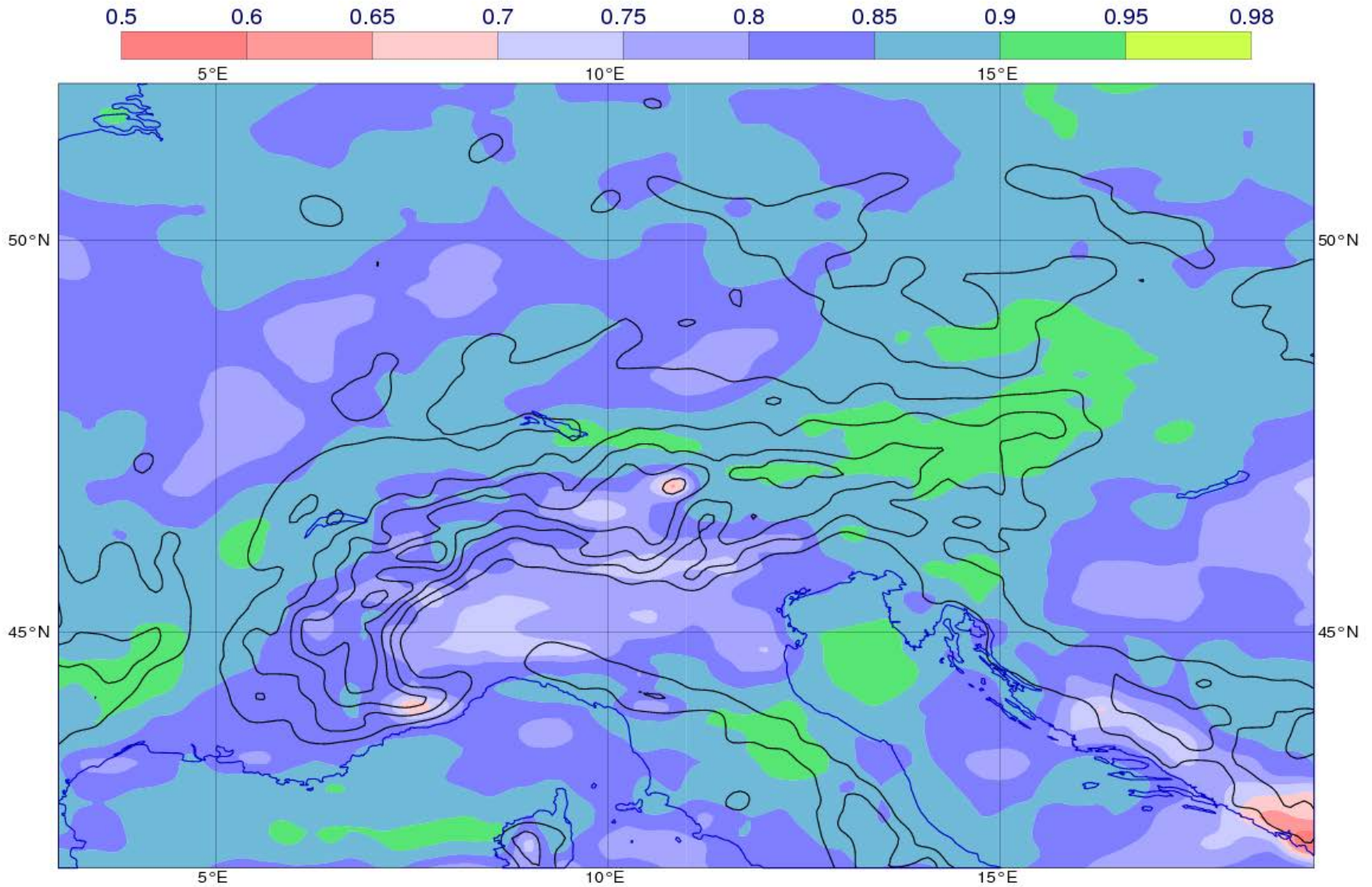


Tropics

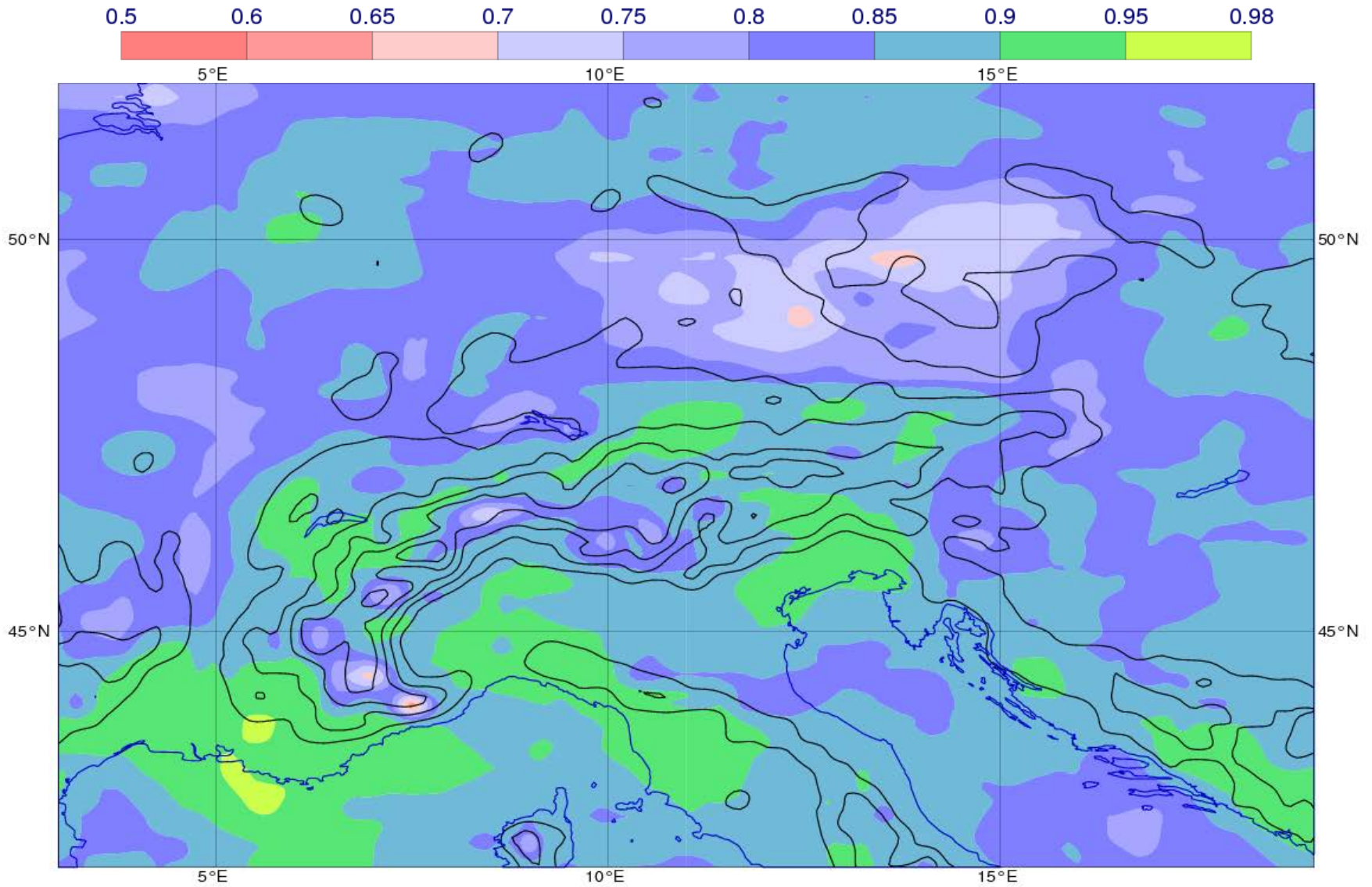
Conclusions

- **CM SAF very useful addition to forecast evaluation**
- **Systematic model errors: interpret with care**
- **Non-systematic errors: highlights ‘problem areas’**
- **Issue of cloud misidentification over snow**
- **Near real-time aspect is important**
- **To-do list at ECMWF**
 - **Extend use of CM SAF products (e.g. cloud fraction, cloud top temperature)**
 - **Evaluate ENS forecast**
 - **Evaluate extended range and seasonal forecasts**

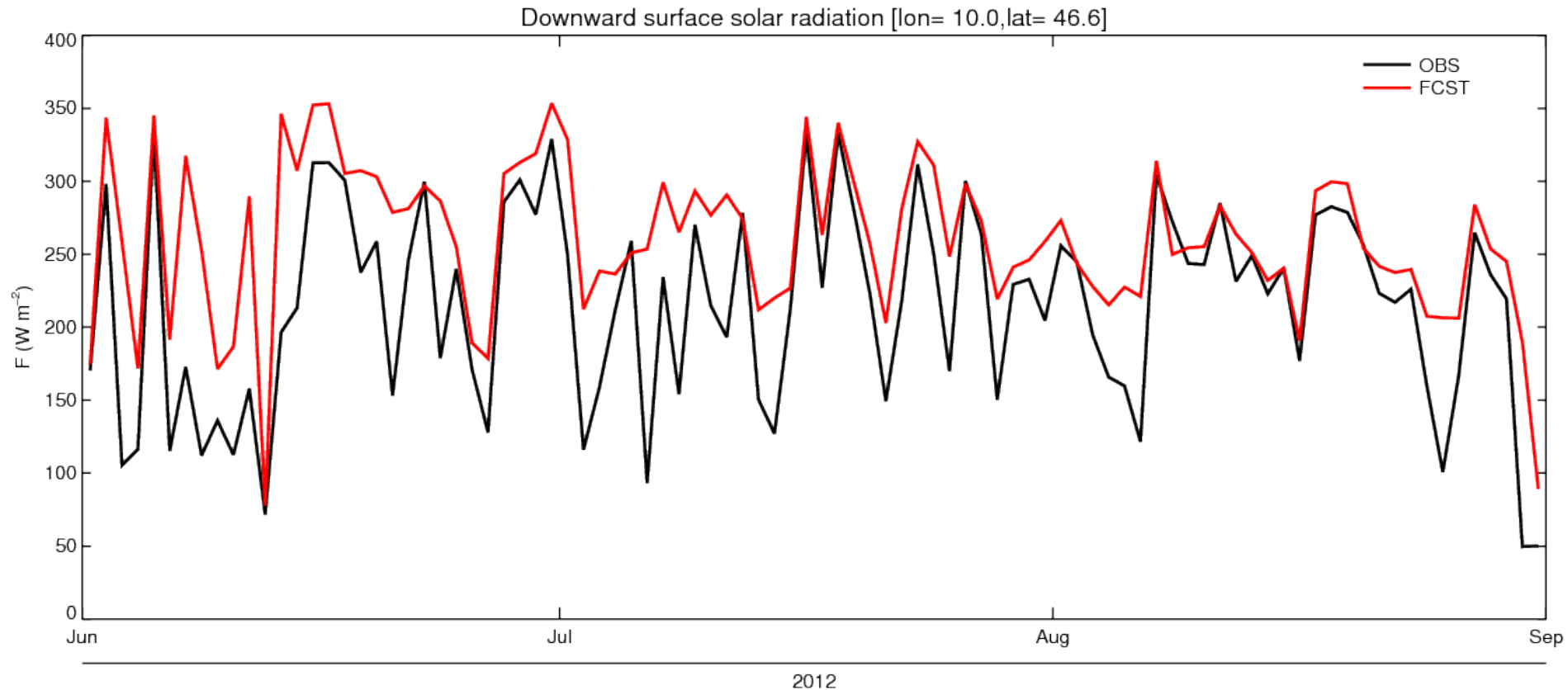
TOA reflected solar, Jun-Aug 2012, correlation



TOA reflected solar, Oct-Dec 2012, correlation

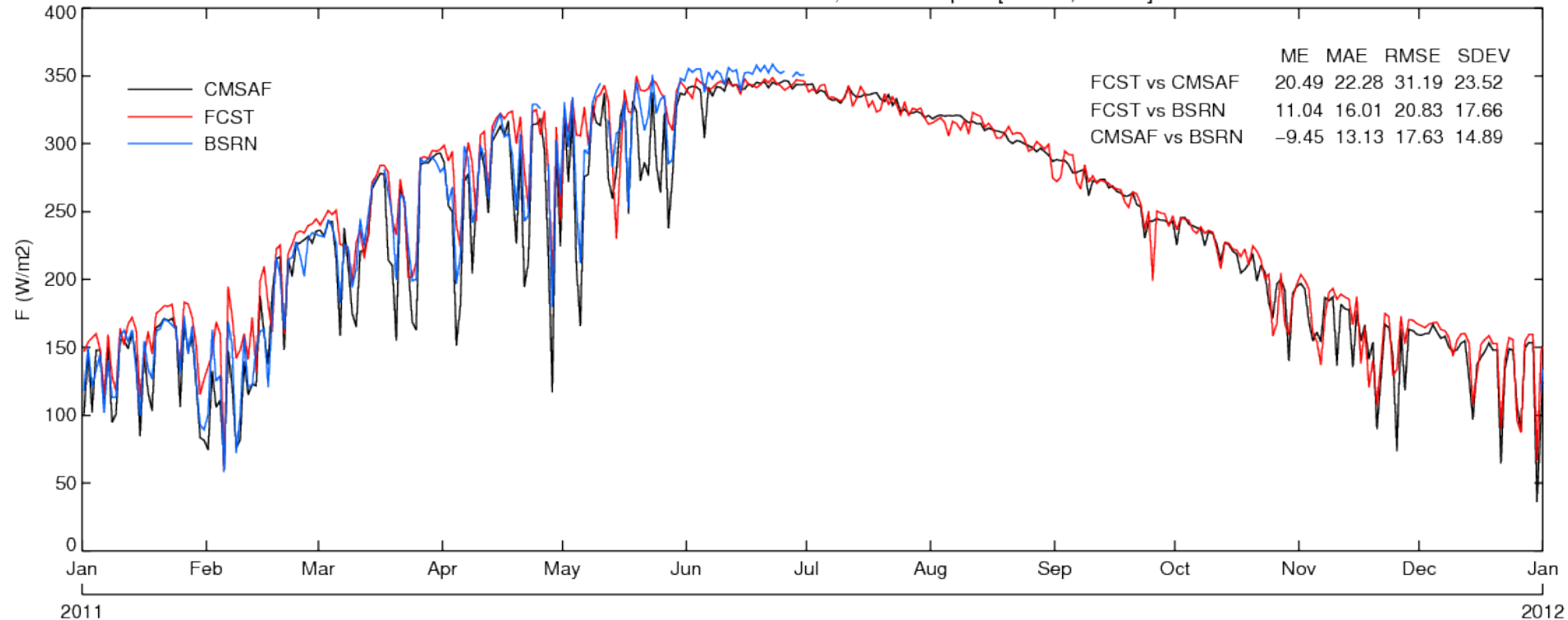


Downward solar, Jun-Aug 2012, central alps



Sede Boquer, Israel

Downward surface solar radiation, Sede Boquer [30.9N, 34.8E]



ECMWF: solar radiation overestimated on disturbed days

CM-SAF: solar radiation underestimated on disturbed days

ECMWF: SDEV similar to European stations

Downward solar, Jun-Aug 2012, correlation

