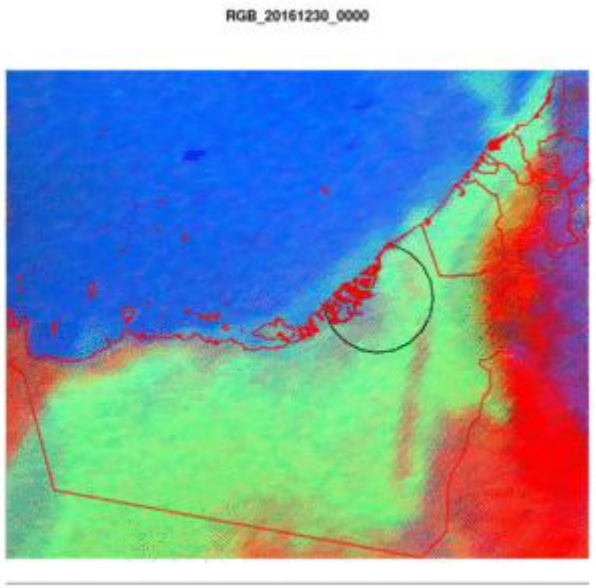
Application of night time fog detection method using MSG~~8~~10 SEVIRI in an arid environment



Application of night time fog detection method using MSG~~8~~10 SEVIRI in an arid environment

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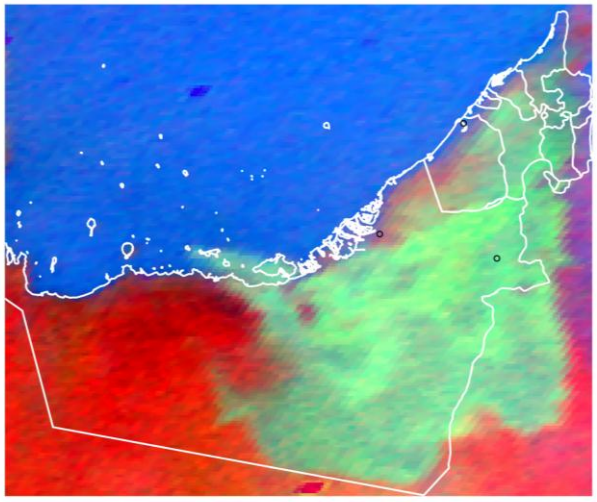
Introduction

The detection of fog and low cloud (FLC) from satellite data remains challenging despite advances in methodologies and technology.

Here we apply the **pseudo emissivity** method (ems(3.9) after Pavolonis and Heidinger, 2005) using the **SEVIRI** instrument on **Meteosat-10** over the United Arab Emirates, and desert region**.**

RGB_20180115_2300



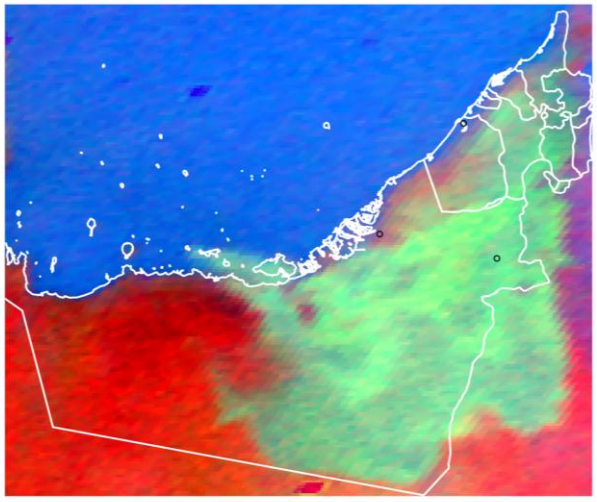
Go from raw satellite data to a binary mask

fogmask_20180115_2300_minus_lowcloud

Objectives

- **Provide spatial frequency of fog days**
- **Identify areas of fog onset**
- **Understand fog dynamics**

RGB_20180115_2300



Go from raw satellite data to a binary mask

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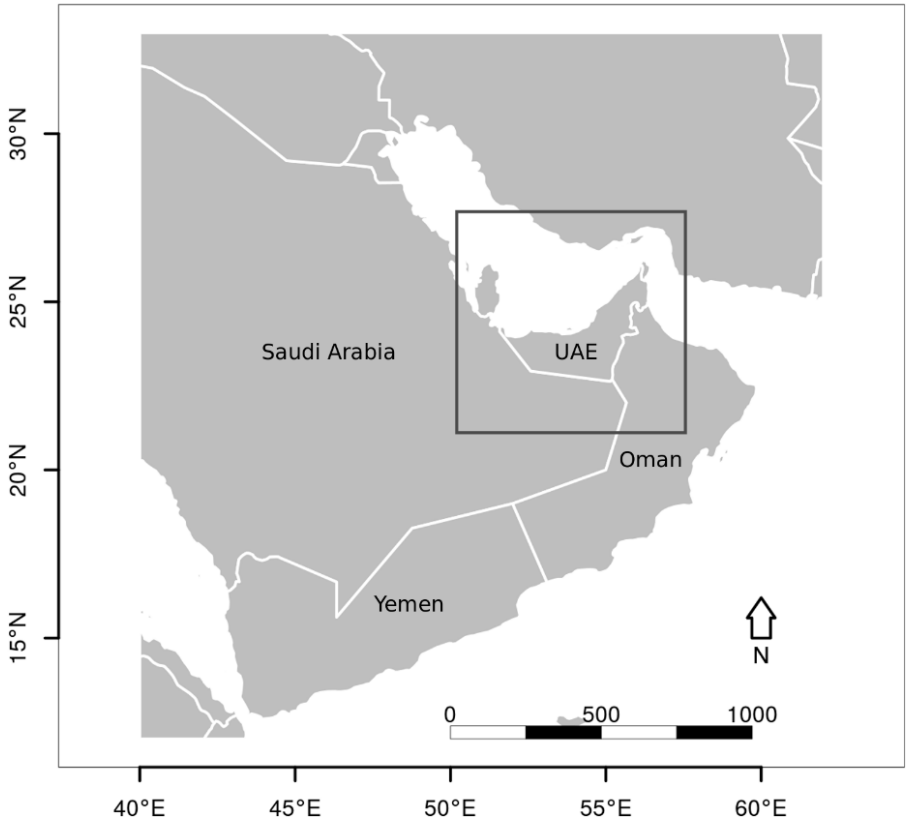
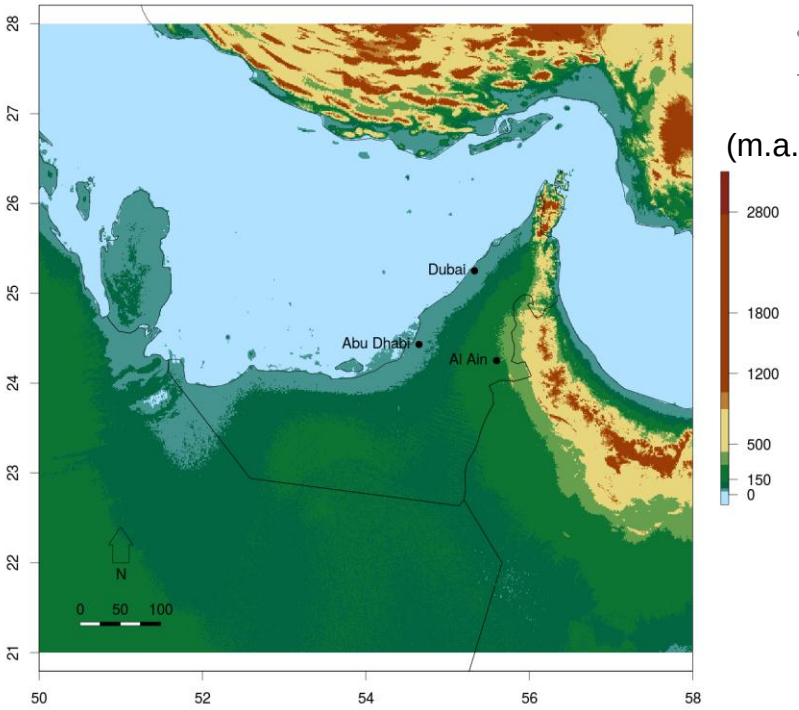
Study Area

United Arab Emirates

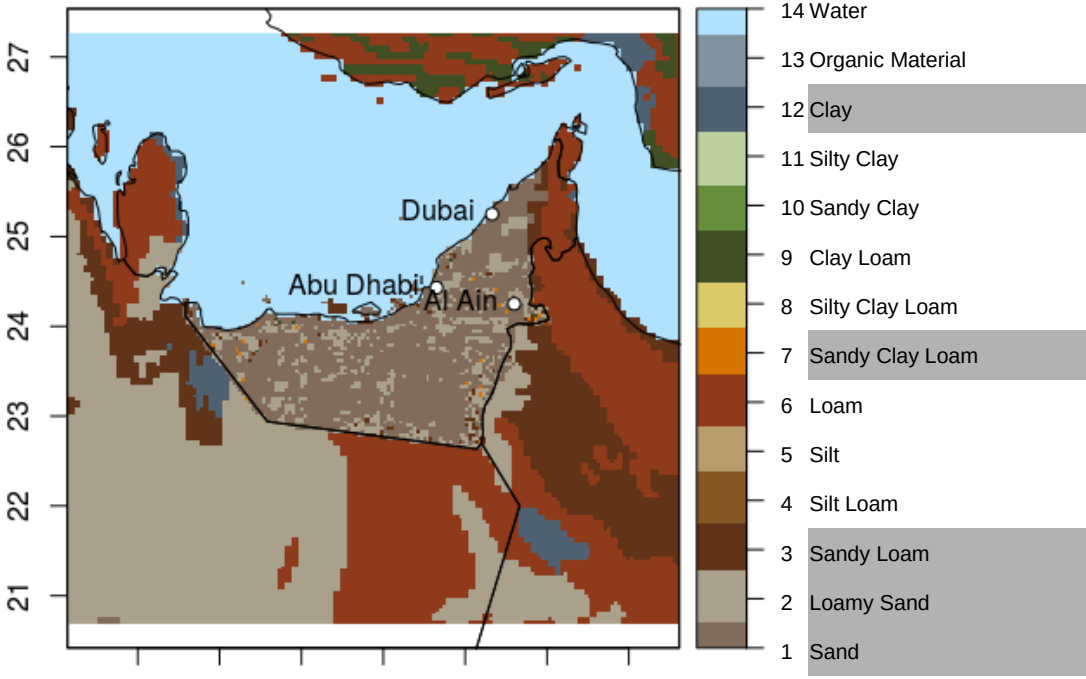


Terrain



Soil type

USGS
+
Abu Dhabi
Survey



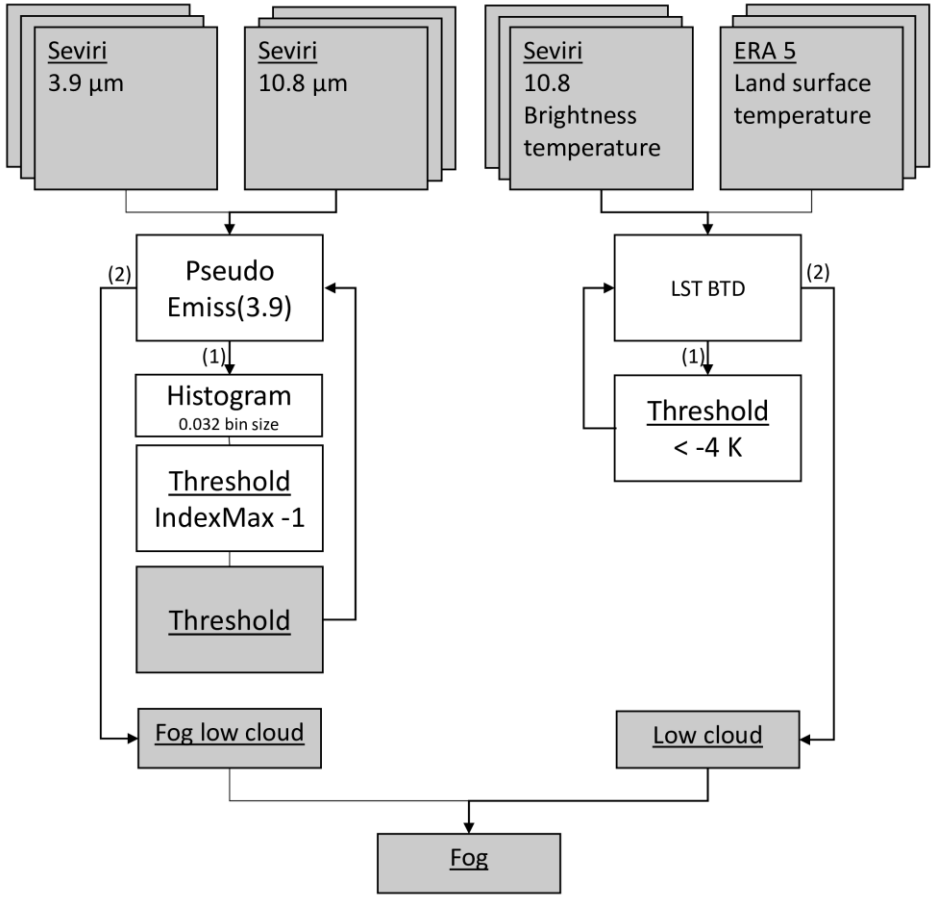
Data sets

- **SEVIRI**
  - Meteosat-10 situated over 9.5 °E
  - Resolution ~3 km
- **ERA5**
  - Global atmospheric reanalysis product
  - Resolution around 30 km
- **METAR (Meteorological aerodrome reports)**
  - NOAA National Climatic Data Center (NCDC) database
  - Data from three stations:
    Abu Dhabi (OMAA, 54.65N, 24.43E),
    Dubai (OMDB, 55.33N, 25.25E)
    Al Ain (OMAL, 55.60N, 24.25E).

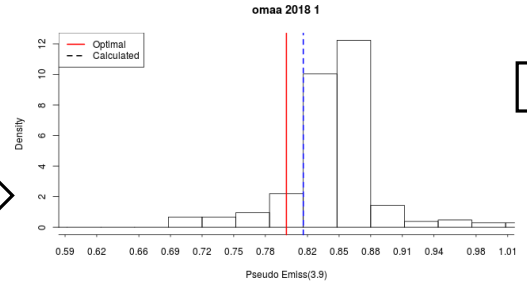
Study period

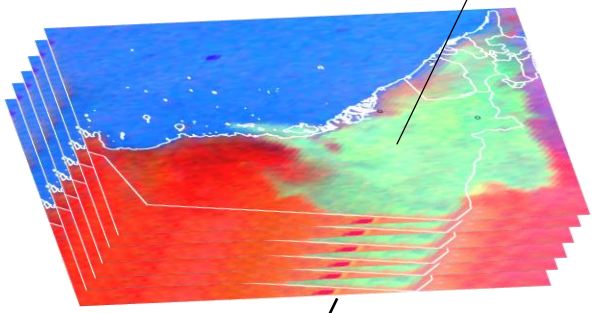
- **Winter months over two seasons**
  - Dec 2016 to Mar 2017
  - Oct 2017 to Mar 2018

Methodology overview

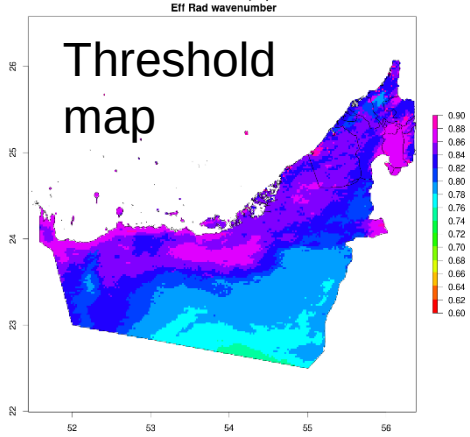


Histogram per pixel

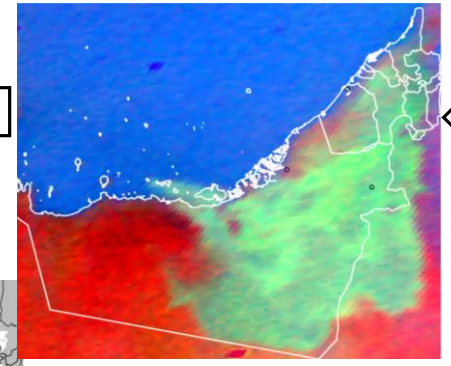




Threshold map



Apply to scene



Remove low cloud (ERA5)

Fog/low cloud detection

Pseudo emissivity was calculated using equation (1) (Calvert and Pavolonis, 2010).

$$ems(3.9) = \frac{R_{Obs}(3.9)}{B(3.9, BT(10.8))}, \quad (1)$$

R_{Obs} = radiance at 3.9μm observed
BT = brightness temperature at 10.8μm
B = Planck function

Planck function defined in equation (2) (Cao and Shao, 2019).

$$B(v,t) = \frac{C_1 v^3}{e^{C_2/v} - 1}, \quad (2)$$

B(ν,t) = blackbody radiance (mW/m^2 -sr-cm^{-1}),
C1 = 1.19104 × 10^{-5} (mW/m^2 -sr-cm^{-4}),
C2 = 1.43877 × 10 (K cm),
ν = wavenumber (cm^{-1}),
λ = wavelength (μm) and
t = blackbody temperature (K).

Verification

Contingency table

	METAR fog yes	METAR fog no
SEVIRI fog yes	Hits	False Alarms
SEVIRI fog no	Misses	Correct Negative

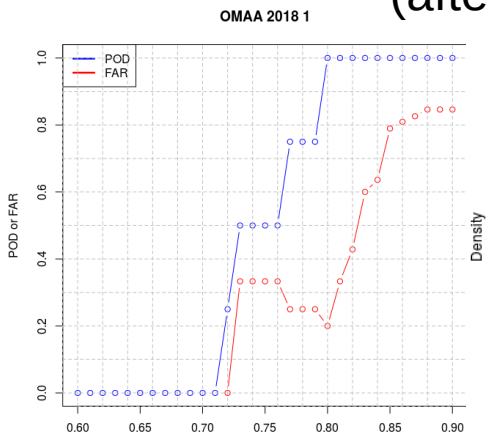
$$POD = \frac{Total\ hits}{Total\ hits + total\ misses},$$

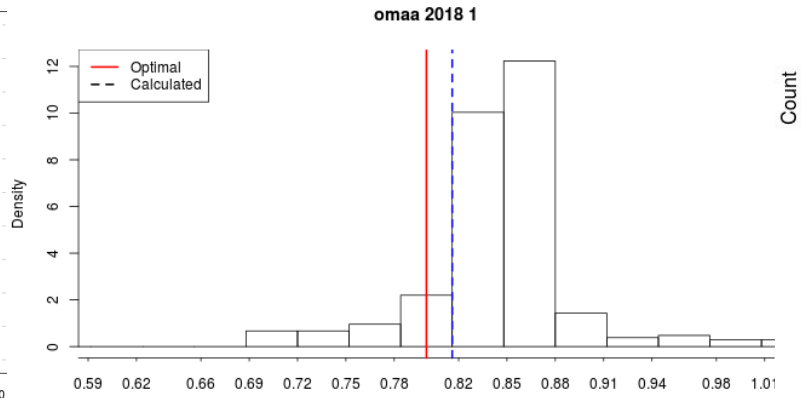
$$FAR = \frac{Total\ false\ alarms}{Total\ hits + total\ false\ alarms},$$

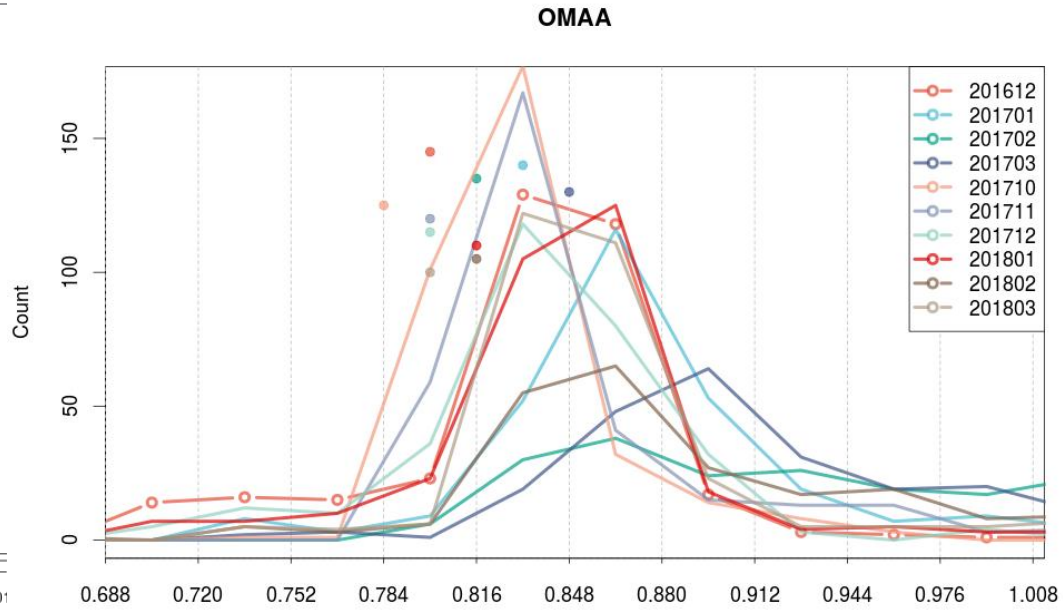
- Verification is performed over a **6 hour window from 00h00 to 06h00** local time
- Time when **fog is most frequent**
- The aim is to **assess daily fog** frequency

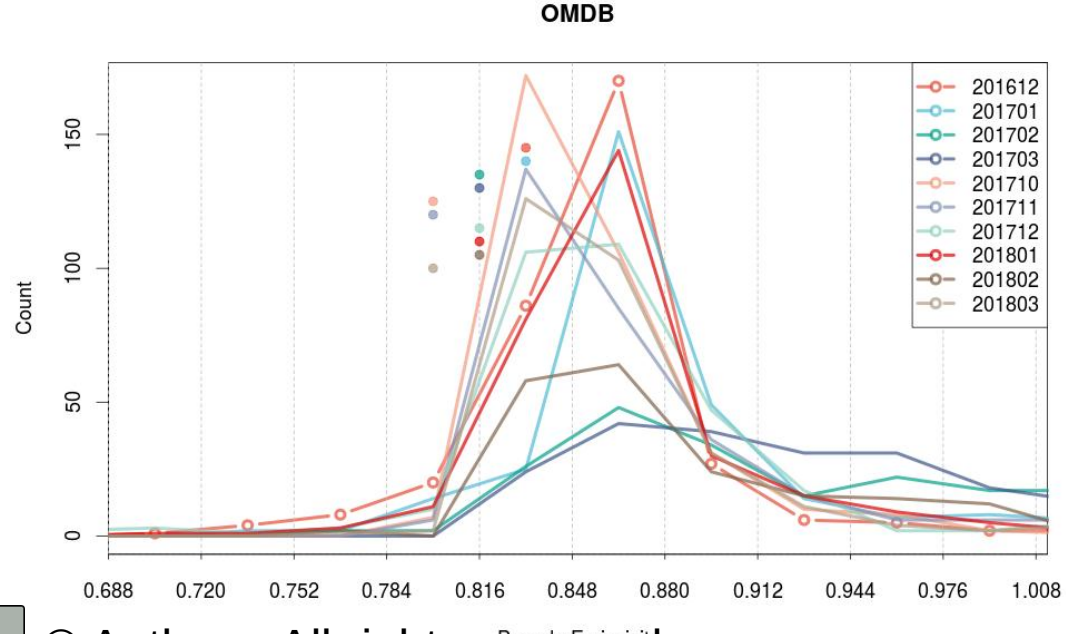
Histograms

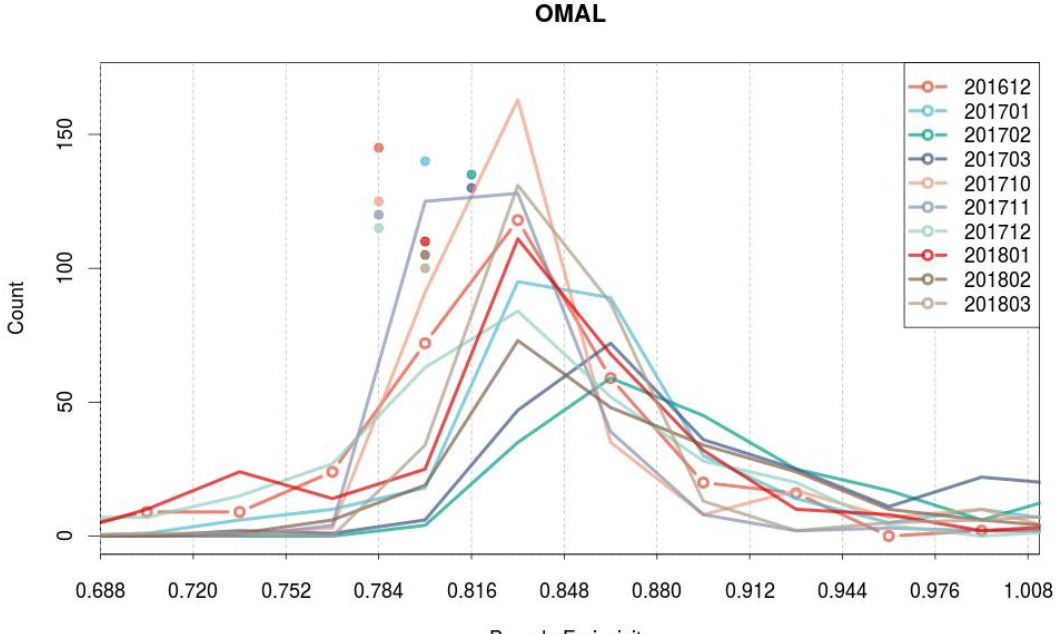
(after Cermak and Bendix, 2008)



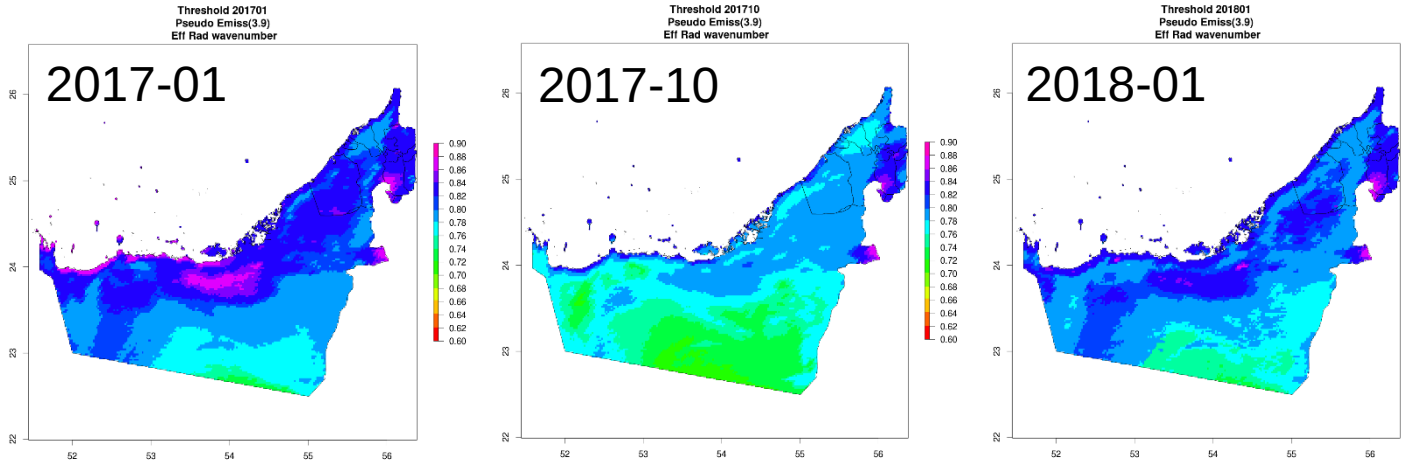


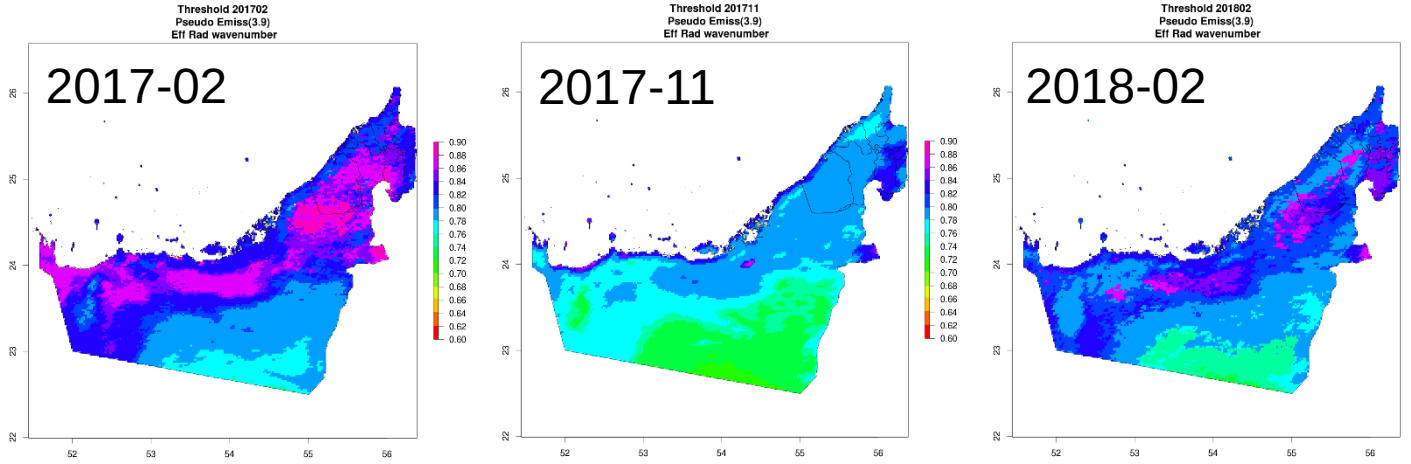


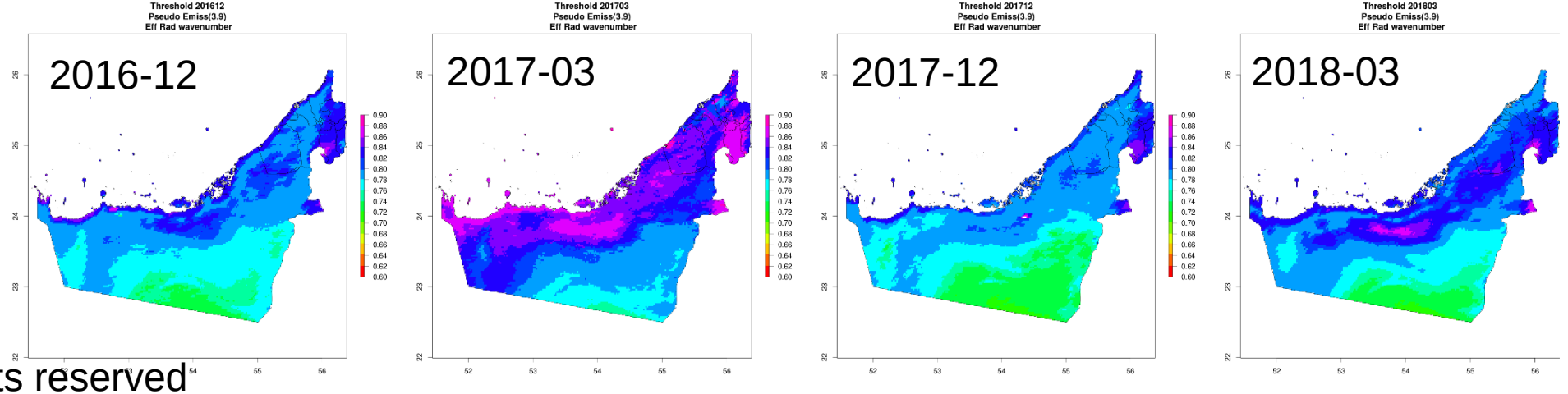




Threshold maps

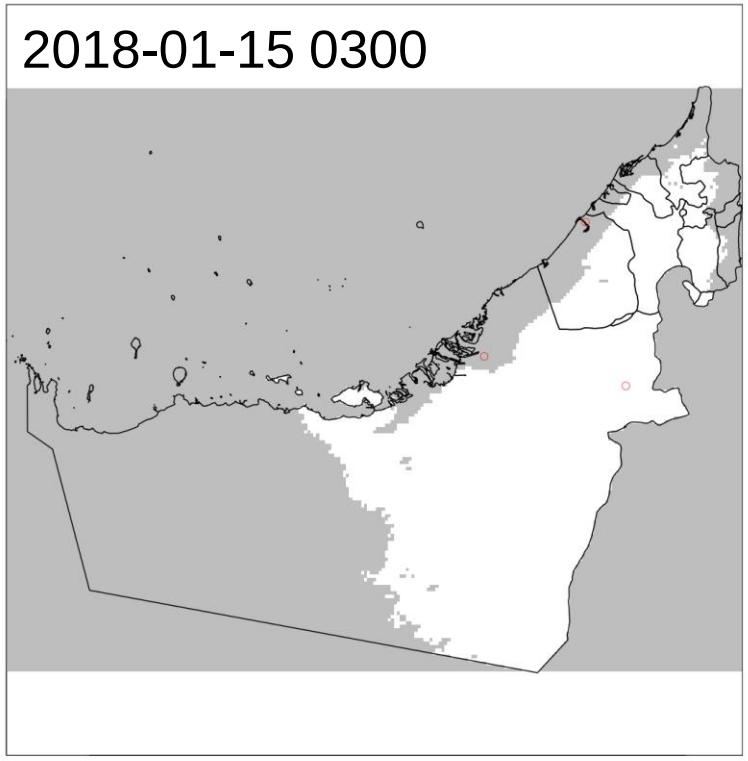






Example

fogmask_20180115_2300_minus_lowcloud



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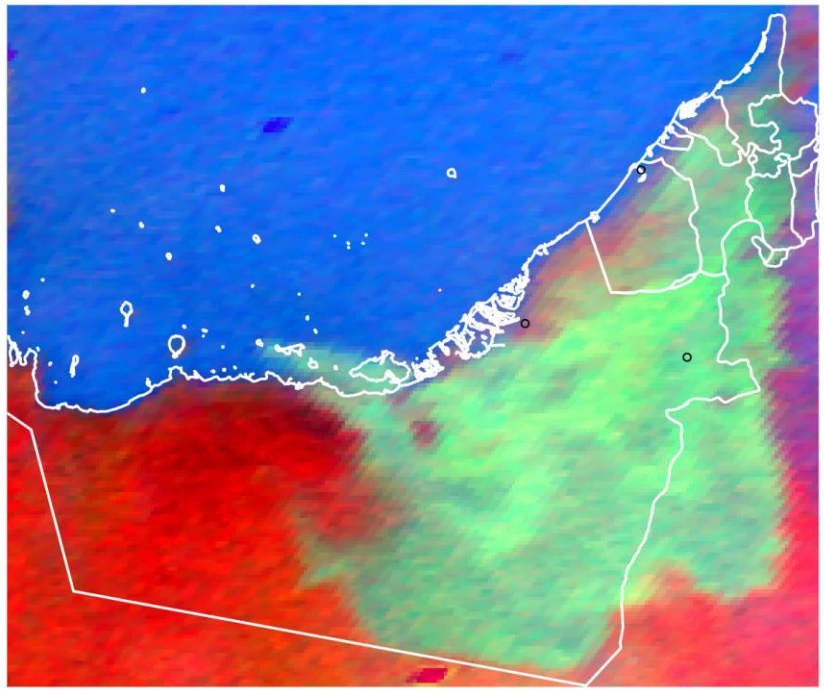
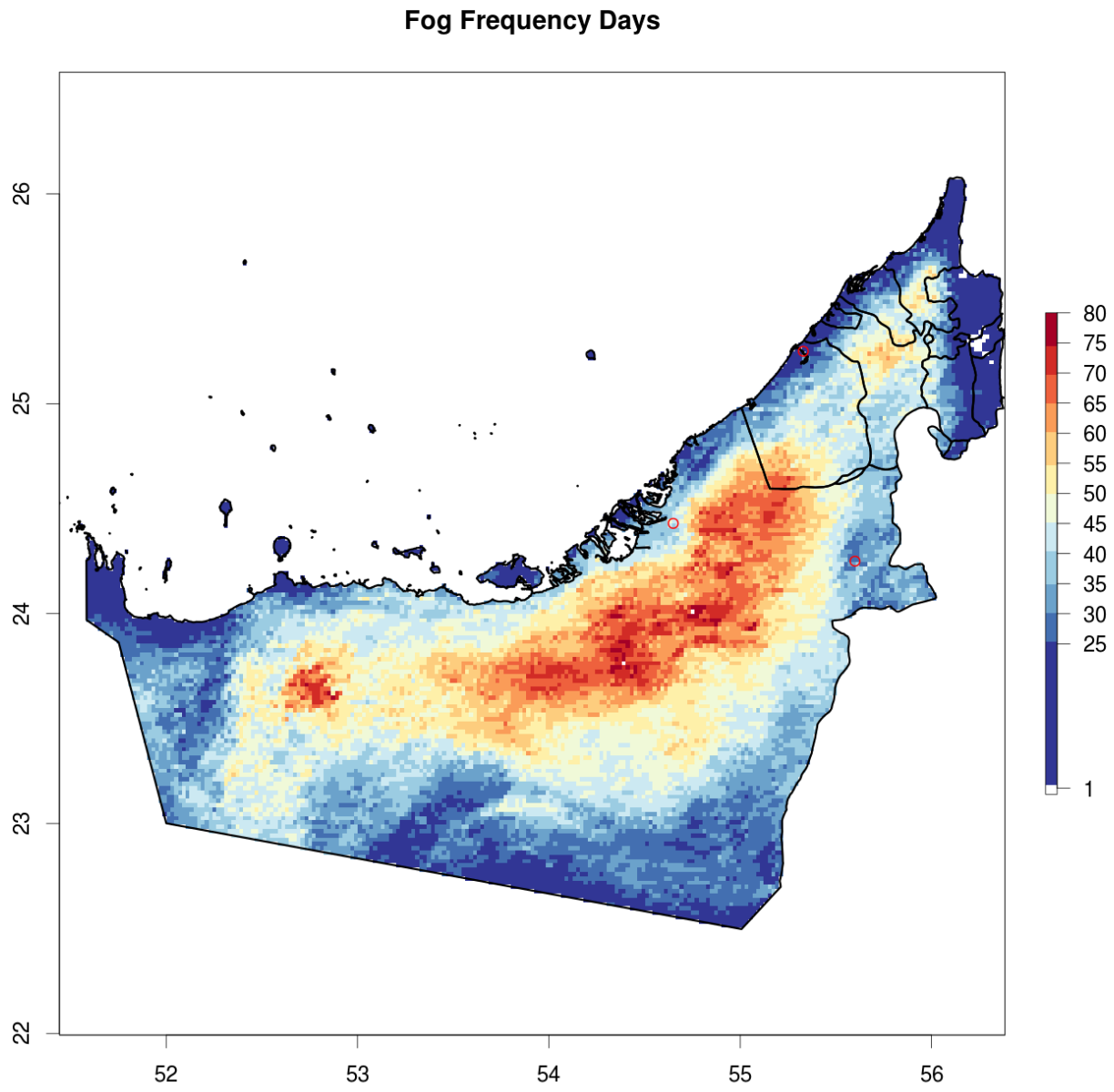
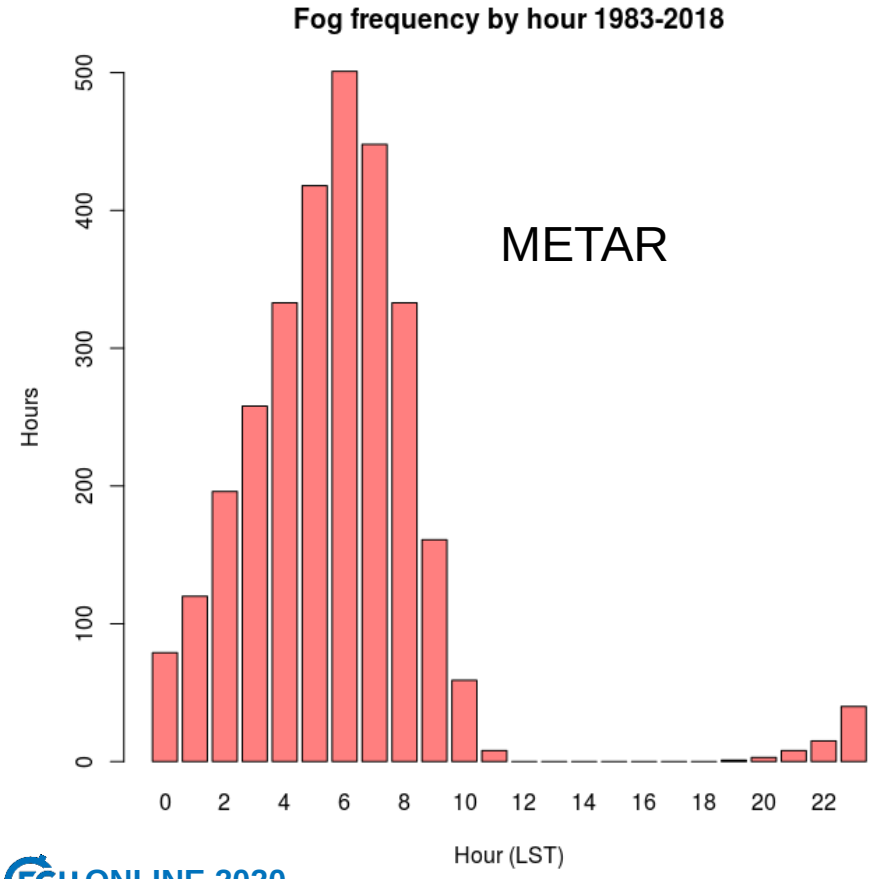


Verification

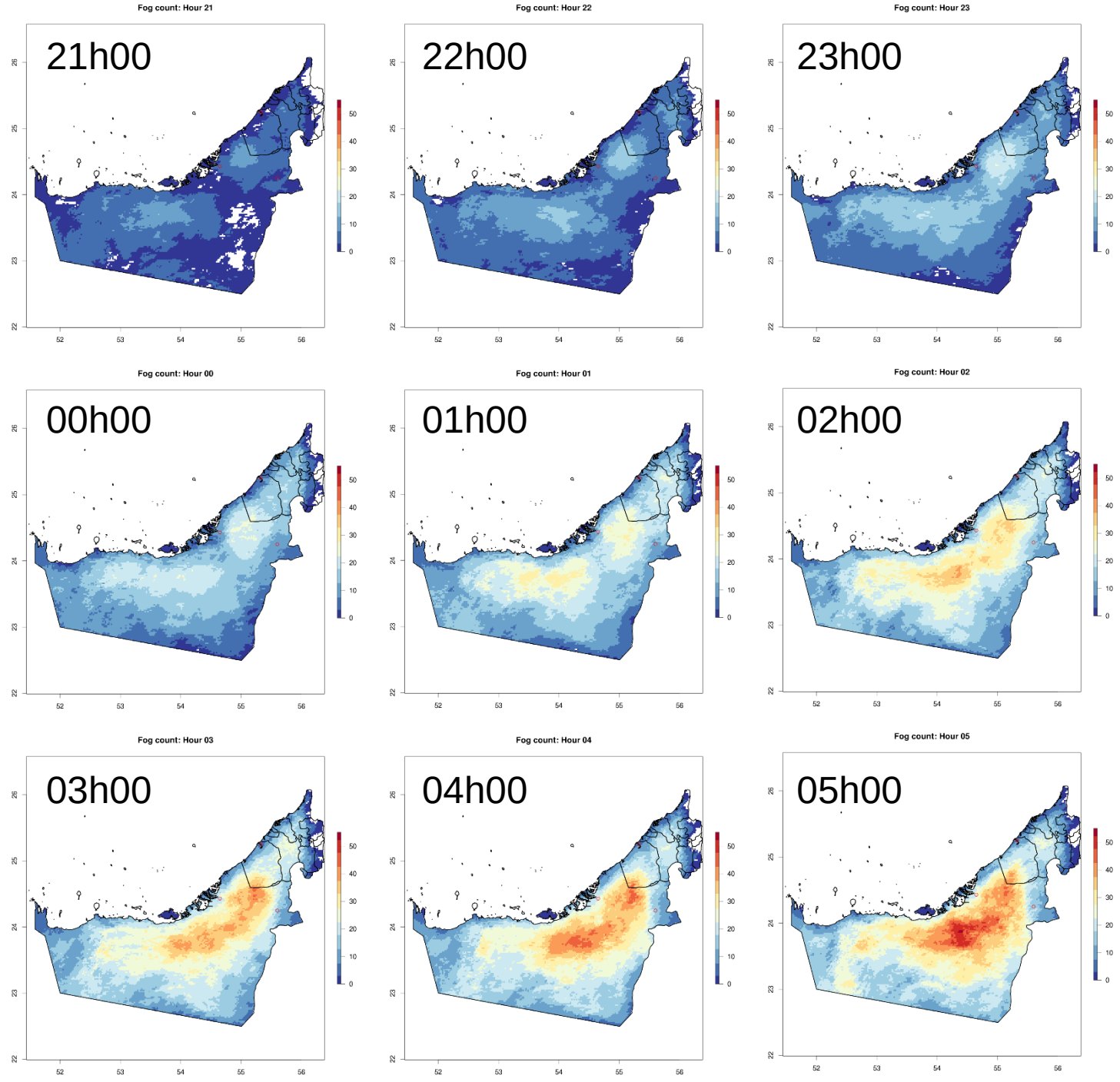
Statistic	OMAA ems(3.9) - Low cloud	OMDB ems(3.9) - Low cloud	OMAL ems(3.9) - Low cloud
Total Hits	26	10	20
Total Miss	6	2	4
Total False Alarms	17	10	10
POD	0.81	0.83	0.83
FAR	0.40	0.50	0.33
Bias score	1.34	1.66	1.25



Diurnal Cycle



METAR



Conclusions

- **What is novel about this study**
  - Pixel based threshold = spatially varying threshold
  - Dynamic method for selecting threshold from histogram
  - Application of Pseudo Emissivity in Meteosat. Previously only used in GOES-R
  - First spatial statistics of fog over the UAE, revealing fog dynamics over the region.
- **Results**
  - The method verified well, with POD (FAR) ranging from 0.81 to 0.83 (0.33 to 0.5)
  - The classification had a **positive bias**, ranging from **25 to 66 %**, mostly due to the inclusion of **haze and mist** in the classification
  - The **hourly frequency** is presented and is **in line with *in situ* measurements**, indicating peak fog frequency at 05h00 local time
  - This method can for the basis for further refinement and investigation

References

Cermak, J.; Bendix, J. A novel approach to fog/low stratus detection using Meteosat 8 data. *Atmospheric Research* 2008, *87*, 279--292, doi:10.1016/j.atmosres.2007.11.009.

Pavolonis, M.J.; Heidinger, A.K. Advancements in identifying cirrus and multilayered cloud systems from operational satellite imagers at night. *Applications with Weather Satellites II* 2005, *5658*, 225, doi:10.1117/12.577640.

Calvert, C.; Pavolonis, M.M.J. *GOES-R Advanced Baseline Imager (ABI) Algorithm Theoretical Basis Document for Low Cloud and Fog*; University of Wisconsin--Madison Space Science and Engineering Center: 2010; pp. 86.

Cao, C.; Shao, X. Planck Function. Availabe online: https://ncc.nesdis.noaa.gov/data/planck.html (accessed on 26 September 2019).