Improving cloud detection with correlation interferometry: results from a IASI case study

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Intercomparison of retrieval codes for hyperspectral infrared sounding observations

Stephen Tjemkes,

Poster in this conference

IASI stand-alone cloud detection scheme
The baseline

Test	Method	Threshold
hs-test	Look for similarity in shape of a given observed spectrum with a reference spectrum for clear sky	Critically depending on surface emissivity
Surface temperature test	In super window channels the corresponding BT is almost proportional to surface temperature (need a reference surface temperature)	Depends on surface emissivity
The super-window tests @ 1168 and 830 cm^{-1}	Look at the slope of the window	The slope can depend on surface emissivty
The CO_2 split-window test @ 791 cm^{-1}	Sensitive to the pressure surface	Mostly depending on surface pressure
The LW-SW regression test	Look at the coherency between short and long wave regions of the spectrum sensitive to temperature (CO_2) channels	Depends on the surface properties

Our cloud detection approach and *hs*-methodology for IASI has been largely published in the peer reviewed literature

- Carmine Serio, Alberta Marcella Lubrano, Filomena Romano, and Haruisha Shimoda, "Cloud Detection Over Sea Surface by use of Autocorrelation Functions of Upwelling Infrared Spectra in the 800–900-cm^{-1} Window Region," Appl. Opt. **39**, 3565-3572 (2000)

- Guido Masiello, Marco Matricardi, Rolando Rizzi, and Carmine Serio, "Homomorphism between Cloudy and Clear Spectral Radiance in the 800-900-cm^{-1} Atmospheric Window Region," Appl. Opt. **41**, 965-973 (2002)

- Masiello, G., *Serio*, C., Shimoda, H. Qualifying IMG tropical spectra for clear sky, Journal of Quantitative Spectroscopy and Radiative Transfer, 77 (2), p.131-148, Mar 2003 doi:10.1016/S0022-4073(02)00083-3

- Guido Masiello, Carmine Serio, and Vincenzo Cuomo, "Exploiting Quartz Spectral Signature for the Detection of Cloud-Affected Satellite Infrared Observations over African Desert Areas," Appl. Opt. **43**, 2305-2315 (2004)

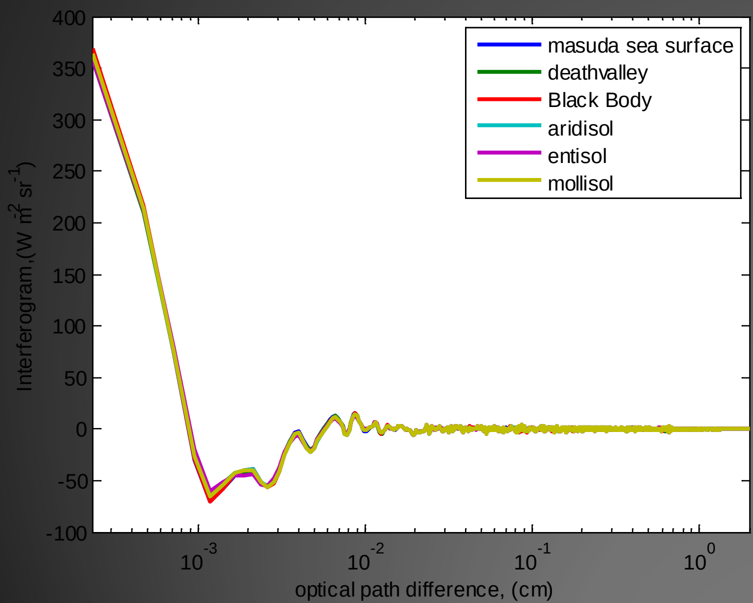
- Grieco, G., Masiello, G., Matricardi, M., Serio, C., Summa, D. and Cuomo, V. (2007), Demonstration and validation of the ϕ-IASI inversion scheme with NAST-I data. Quarterly Journal of the Royal Meteorological Society, 133: 217–232. doi: 10.1002/qj.162

Surface emission can be separated from atmospheric emission with Correlation Interferometry, that is by properly exploiting the concept of partial interferogram

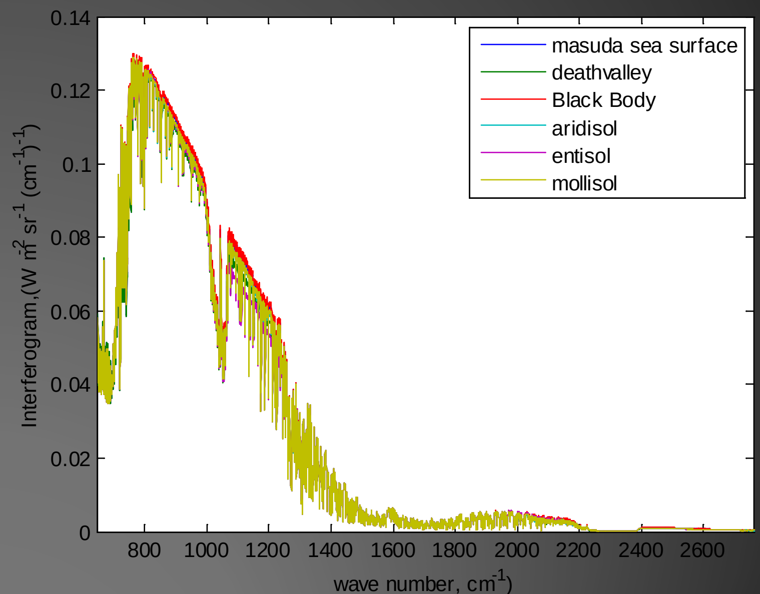
- Kyle, T.G. Temperature soundings with partially scanned interferograms, *Appl. Opt.*, **1977**, 16/2, 586 326-332.
- Smith, W.L.; Howell, H.B.; and Woolf, H.M. The use of interferometric radiance measurements for sounding the atmosphere, *J. Atmos. Science* **1979**, 36, 566-575
- G. Grieco, G. Masiello, C. Serio, R. L. Jones, and M. I. Mead, "Infrared Atmospheric Sounding Interferometer correlation interferometry for the retrieval of atmospheric gases: the case of H_2O and CO_2," Appl. Opt. **50**, 4516-4528 (2011)

Exemplifying the concept of emissivity as a low frequency component through spectra with different emissivity, but same atmospheric state vector. The emissivity signal is very strong in window regions

IASI Interferogram at full range



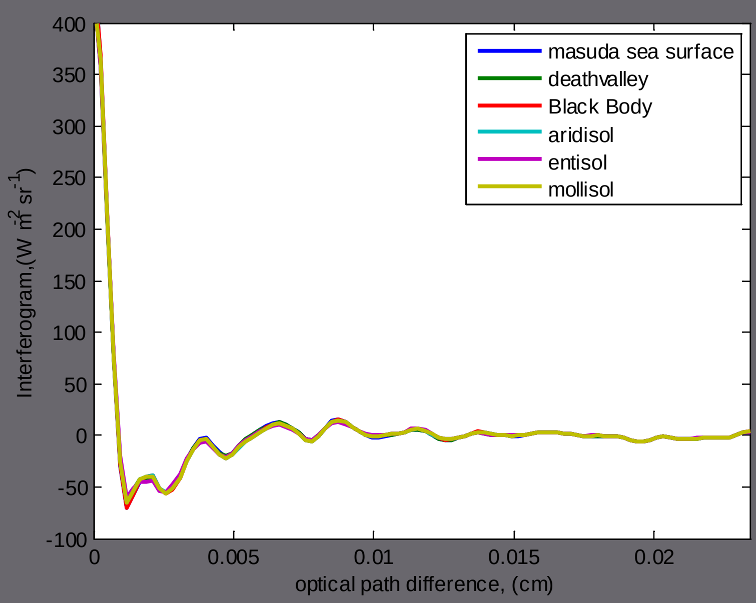
Spectrum

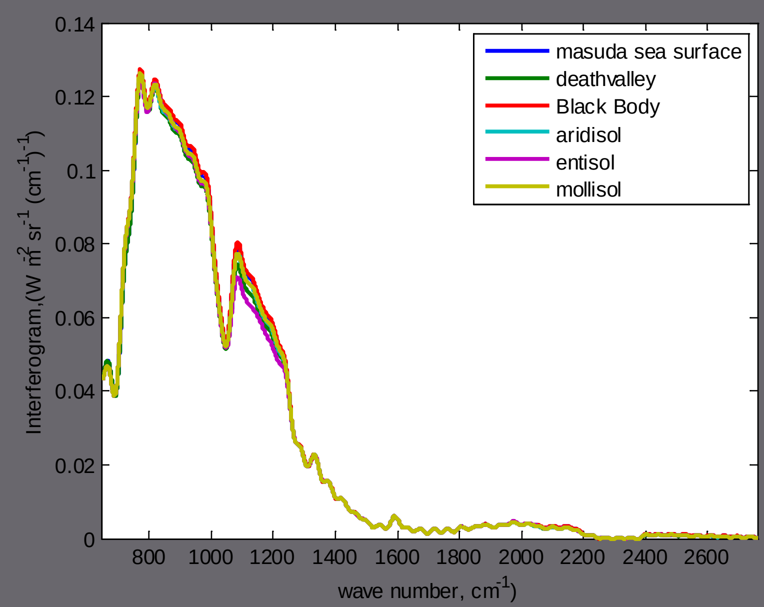


Exemplifying the concept of emissivity as a low frequency component through spectra with different emissivity, but same atmospheric state vector. The emissivity signal is strong at low frequency

IASI INTERFEROGRAM CUT BELOW 0.023 CM

SPECTRUM

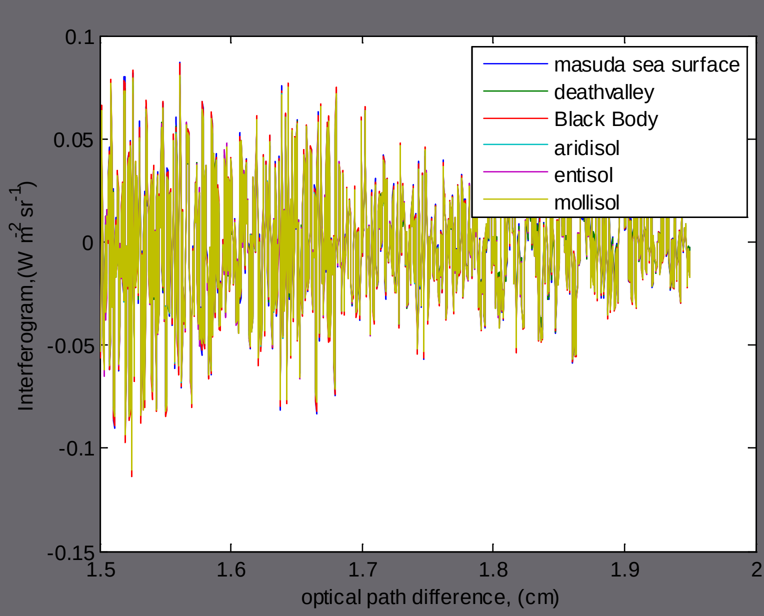


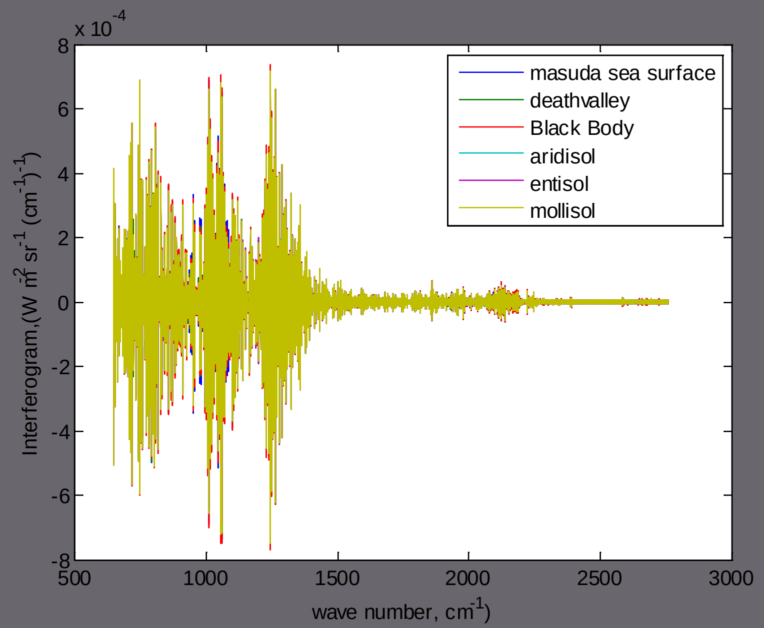


Exemplifying the concept of emissivity as a low frequency component through spectra with different emissivity, but same atmospheric state vector. The **emissivity signal is very low at high frequency**

IASI INTERFEROGRAM BETWEEN 1.5 – 1.9 CM

DIFFERENCE SPECTRUM

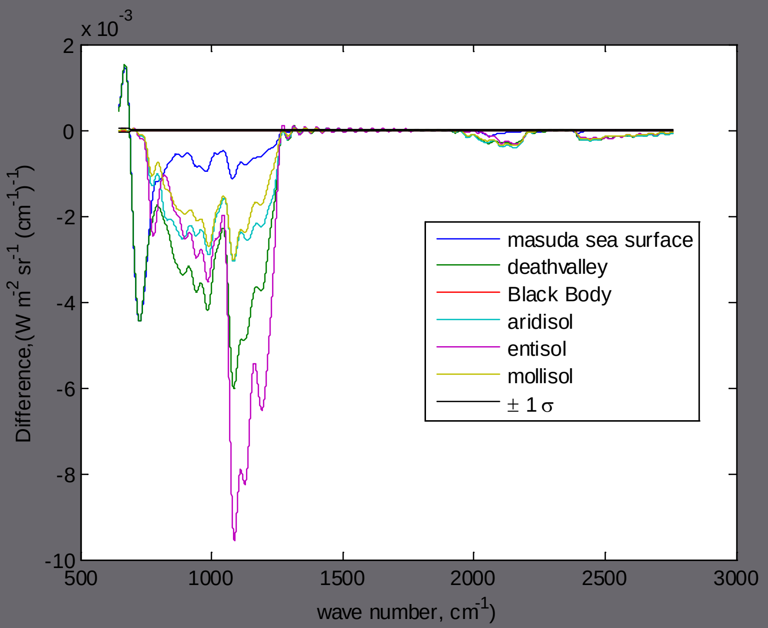




Exemplifying the concept of emissivity as a low frequency component through spectra with different emissivity, but same atmospheric state vector. The Difference with the Black Body spectrum show that the emissivity is seen at low frequency but not at high frequency

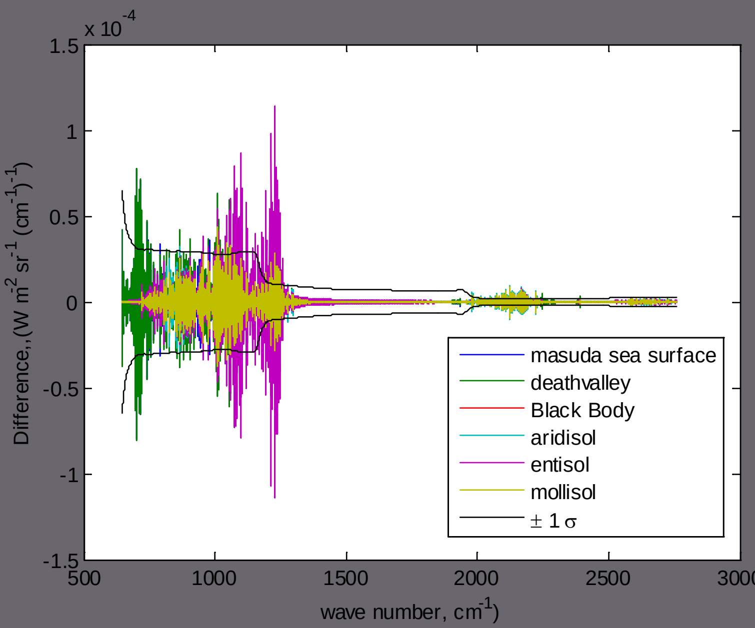
LOW FREQUENCY ANALYSIS

(THE NOISE HAS BEEN PROPERLY SCALED)



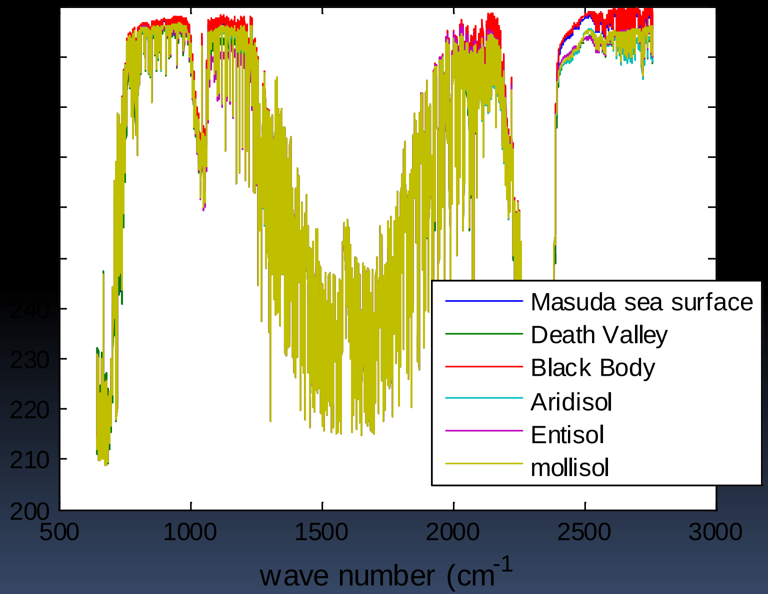
HIGH FREQUENCY ANALYSIS

(THE NOISE HAS BEEN PROPERLY SCALED)

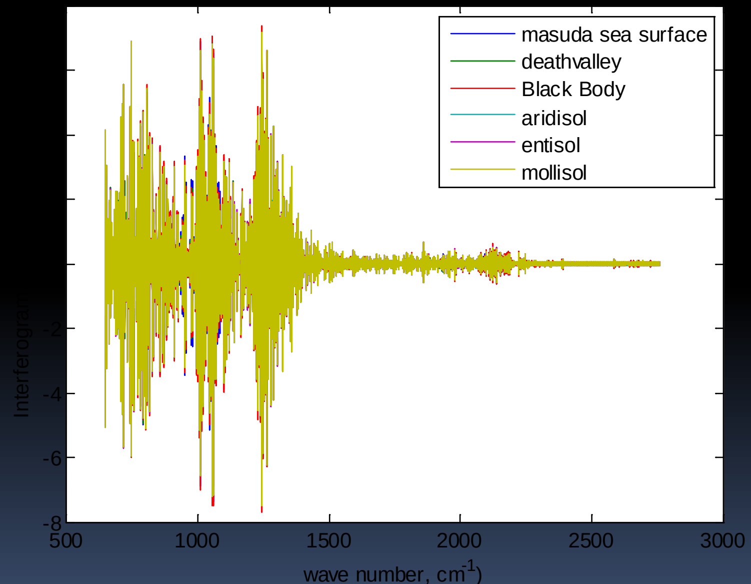


Use the difference spectrum!

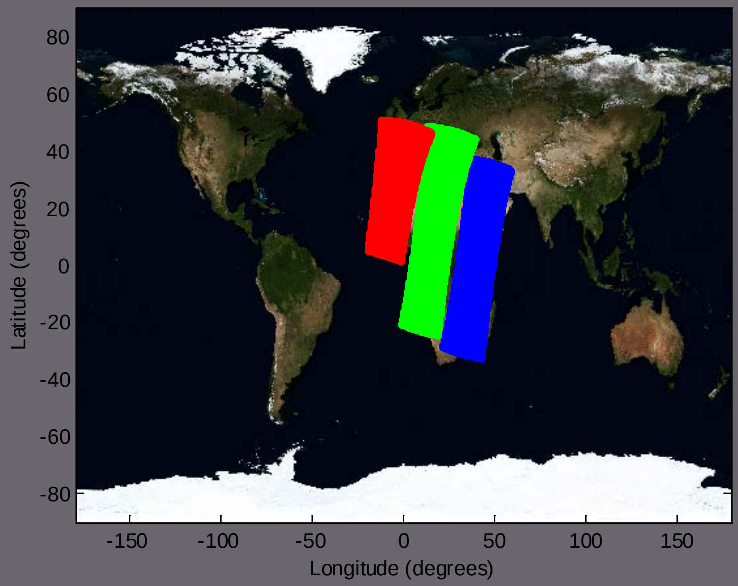
Spectrum

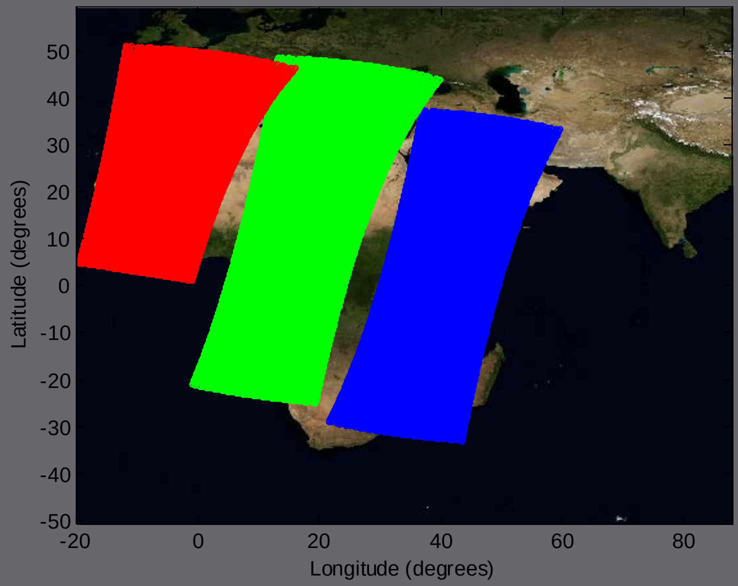


Difference spectrum



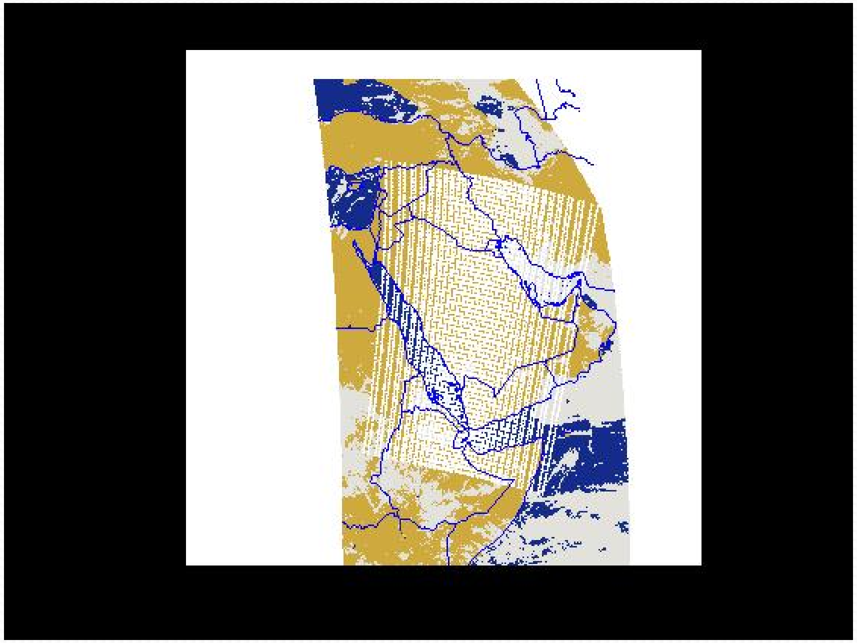
The concept of hs-methodology based on transmittance has been demonstrated with three IASI orbits covering Mediterranean area and Africa



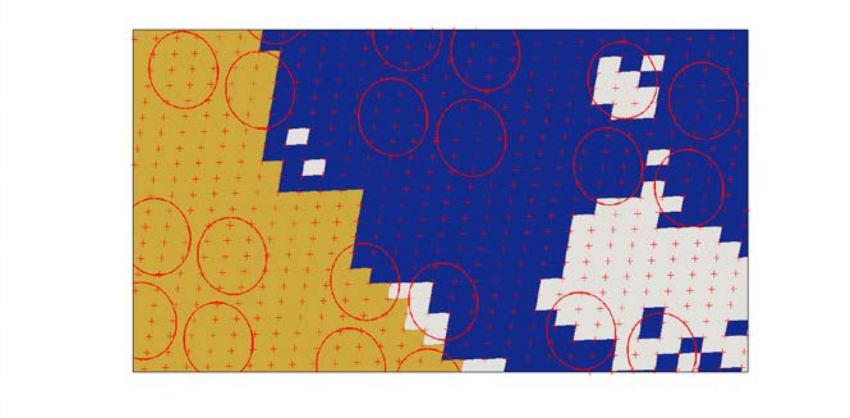


Seviri cloud mask co-located with IASI

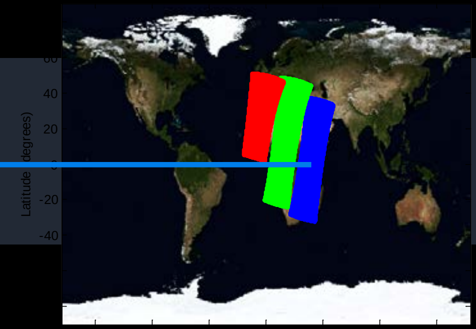
Colocating SEVIRI to IASI



Details of the co-location



Results: orbit 1
Sea Surface: Aden Gulf, Red sea and Indian ocean
Land surface: Turkey and Arabian peninsula, Eastern Africa



Sea surface: coincidence table

Seviri Cloud-mask	*IASI d-spectrum Cloud mask*		
	Clear	Cloudy	Total
Clear	1803 (83%)	377 (17%)	2180 (100%)
Cloudy	189 (18%)	861 (82%)	1050 (100%)

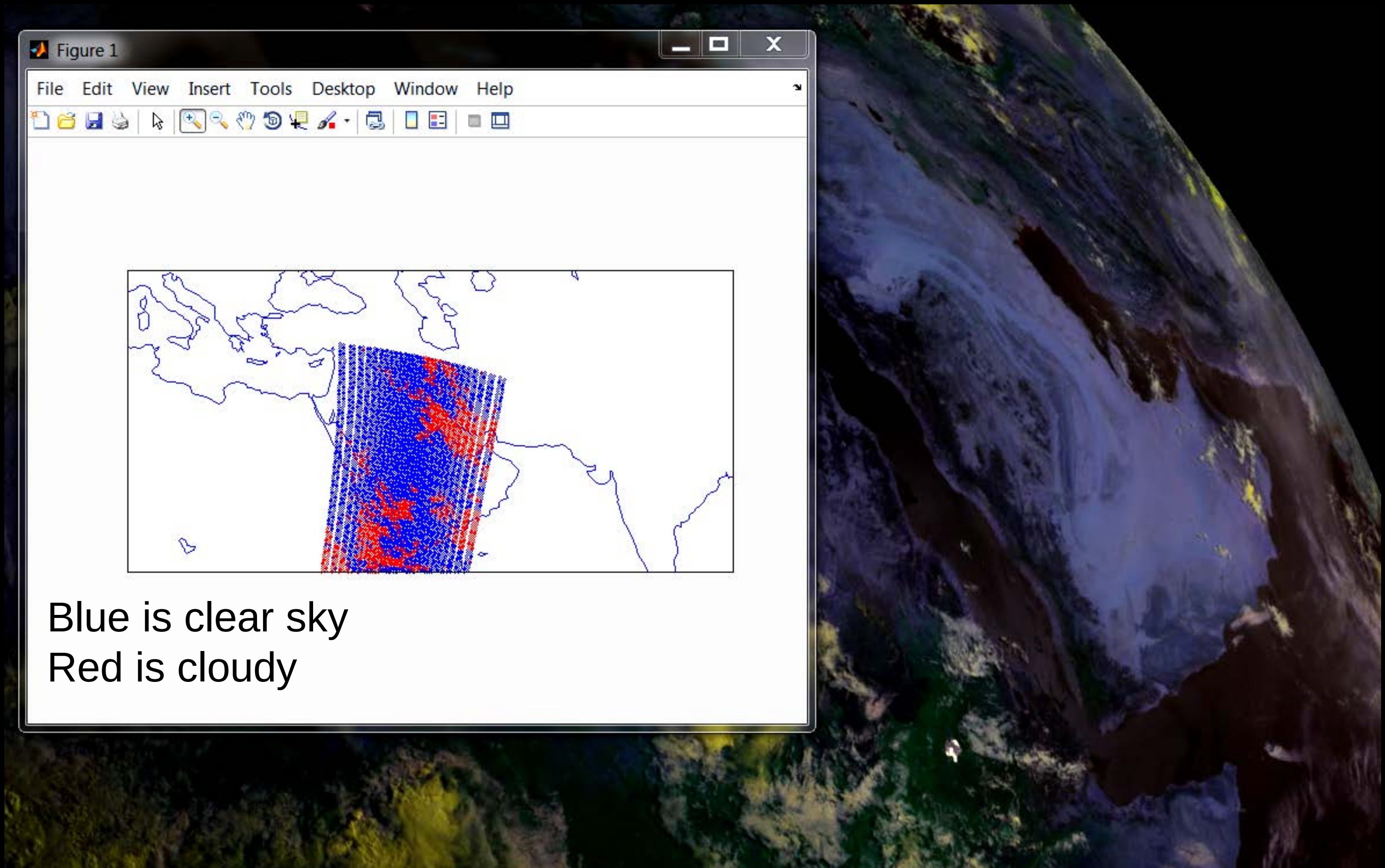
Total coincidence: 82.5%

Land surface: coincidence table

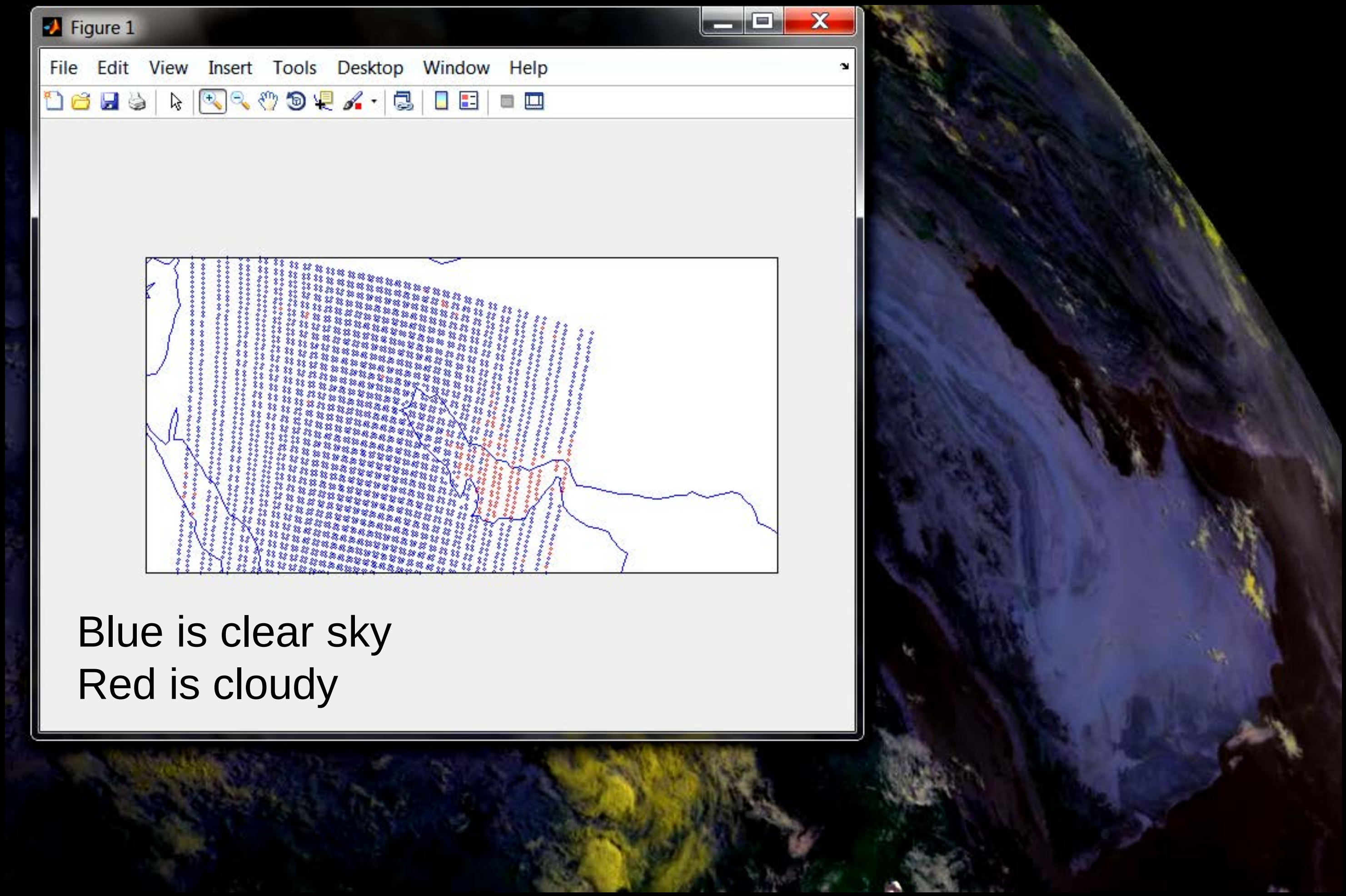
Seviri Cloud-mask	*IASI d-spectrum Cloud mask*		
	Clear	Cloudy	Total
Clear	7639 (89%)	949 (11%)	8588 (100%)
Cloudy	237 (16%)	1250 (84%)	1487 (100%)

Total coincidence: 88.2%

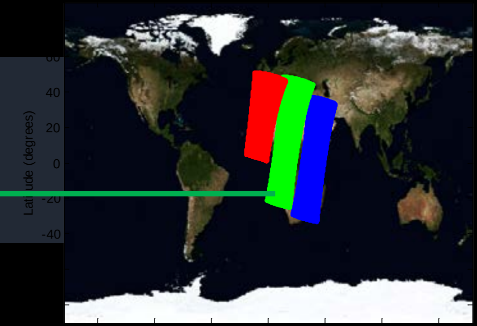
Comparing SEVIRI-IASI cloud mask with the SEVIRI imagery



Comparing IASI cloud mask with the SEVIRI imagery. Orbit 1



Results: orbit 2;
Sea surface: Mediterranean area, Atlantic Ocean (Namibia)
Land surface: Eastern Europe, Sahara desert, rain forest, Kalahari desert



Sea surface: coincidence table

Seviri Cloud-mask	*IASI d-spectrum Cloud mask*		
	Clear	Cloudy	Total
Clear	1758 (89%)	209 (11%)	1967 (100%)
Cloudy	136 (5%)	2584 (96%)	2720 (100%)

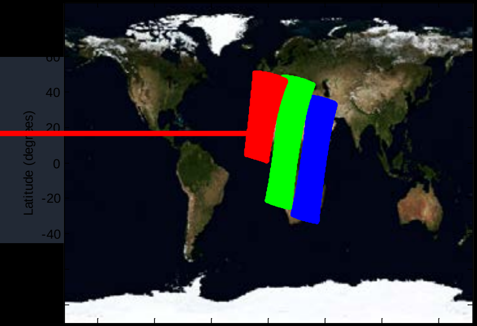
Total coincidence: 92.6%

Land surface: coincidence table

Seviri Cloud-mask	*IASI d-spectrum Cloud mask*		
	Clear	Cloudy	Total
Clear	6748 (97%)	226 (3%)	6974 (100%)
Cloudy	373 (12%)	2794 (88%)	3167 (100%)

Total coincidence: 94.1%

Results: orbit 3;
Sea surface: Mediterranean area, then Atlantic Ocean
Land surface: Western Europe, Western Sahara desert, rain forest



Sea surface: coincidence table

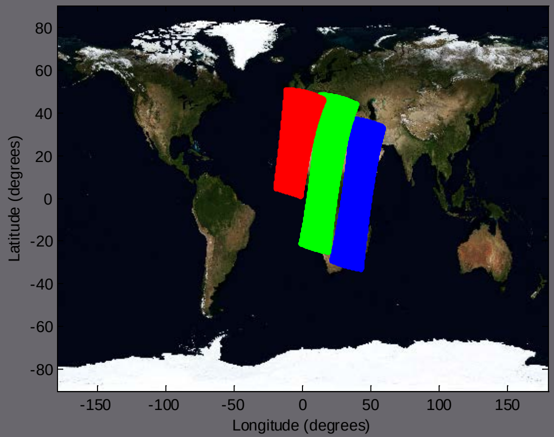
Seviri Cloud-mask	*IASI d-spectrum Cloud mask*		
	Clear	Cloudy	Total
Clear	540 (82%)	121 (18%)	661 (100%)
Cloudy	50 (2.7%)	1764 (97.3%)	1814 (100%)

Total coincidence: 93.1%

Land surface: coincidence table

Seviri Cloud-mask	*IASI d-spectrum Cloud mask*		
	Clear	Cloudy	Total
Clear	4202 (98%)	86 (2%)	4288 (100%)
Cloudy	432 (16%)	2298 (84%)	2730 (100%)

Total coincidence: 92.6%



TOTAL SCORES: 91%

Over 37626 IASI spectra covering

1. Land surface (desert soil, rain forest, organic soil, canopy, mountains)
2. Sea surface

Conclusions

- Combining Correlation interferometry with hs-methodology we have devised a IASI stand-alone cloud detection scheme, which can work on land and sea surface.
- The cloud detection looks at the clear-sky atmospheric fingerprint and does not need any information about the optical properties of the surface (emissivity)
- A method has been developed, which uses the Chevalier data base for the training. The surface emissivity has been modeled with the Masuda sea surface emissivity.
- No real IASI observations have been added to the training data base.
- The comparison with SEVIRI imagery and cloud mask shows a coincidence which is higher than 90%.