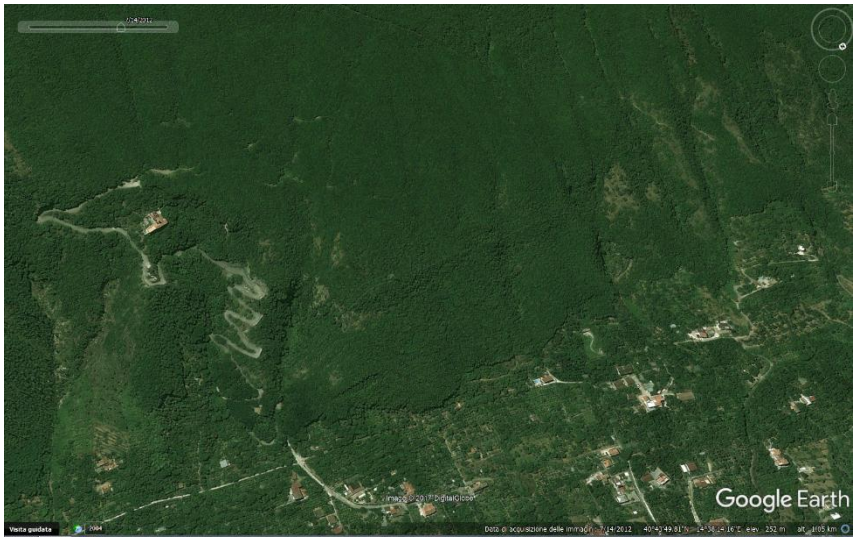
Vegetation stress from IASI spectral radiances and Carbonyl Sulfide (OCS) retrievals: a research based study

Carmine Serio, Giuliano Liuzzi, Guido Masiello, Sara Venafra
School of Engineering, Università degli Studi della Basilicata, Potenza, Italy

Rtaionale and Objective

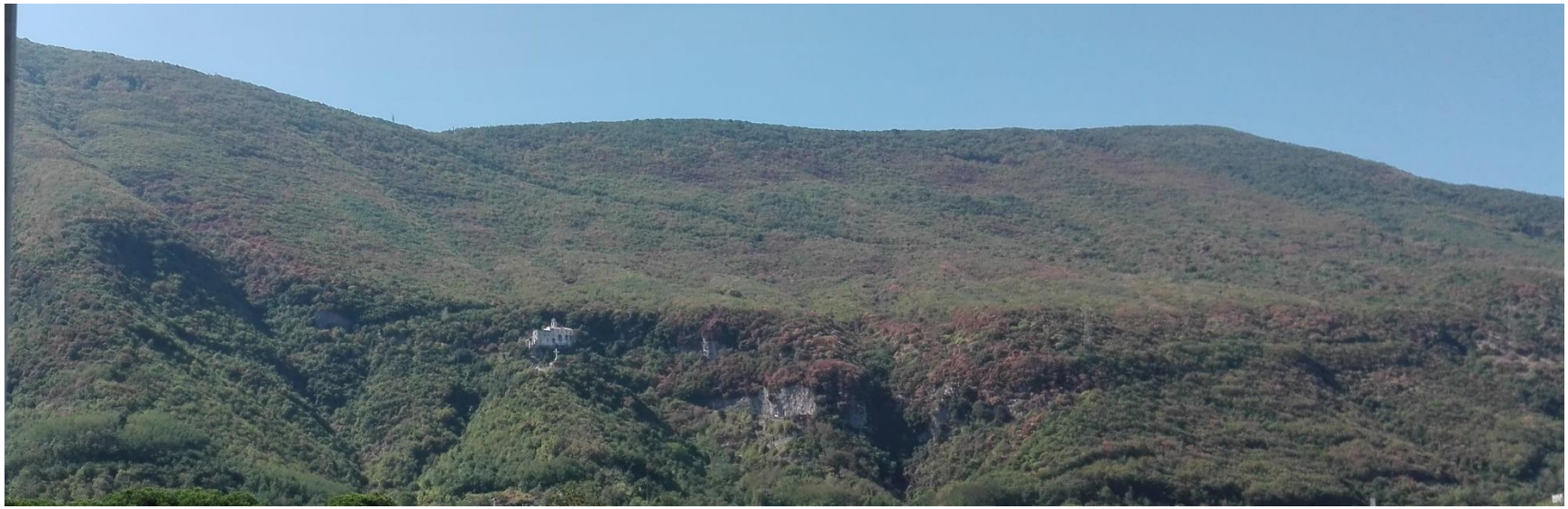
29 June 2016

14 July 2012



Rationale and Objective

September, the 5th 2017



Because of intense heat waves broad-leaf forest in supposedly temperate climates have dried before than expected

Rationale and Objective

September, the 6th 2017,
Motorway to Potenza

Objective and Rationale
(Long-lasting droughts are killing woodlands in temperate climate regions)

nature ecology & evolution

ARTICLES

DOI: 10.1038/s41559-017-0248-x

A multi-species synthesis of physiological mechanisms in drought-induced tree mortality

Henry D. Adams[1*], Melanie J. B. Zeppel[2,3], William R. L. Anderegg[4], Henrik Hartmann[5], Simon M. Landhäusser[6], David T. Tissue[7], Travis E. Huxman[8], Patrick J. Hudson[9], Trenton E. Franz[10], Craig D. Allen[11], Leander D. L. Anderegg[12], Greg A. Barron-Gafford[13,14], David J. Beerling[15], David D. Breshears[16,17], Timothy J. Brodribb[18], Harald Bugmann[19], Richard C. Cobb[20], Adam D. Collins[21], L. Turin Dickman[21], Honglang Duan[22], Brent E. Ewers[23], Lucía Galiano[24], David A. Galvez[6], Núria Garcia-Forner[25], Monica L. Gaylord[26,27], Matthew J. Germino[28], Arthur Gessler[29], Uwe G. Hacke[6], Rodrigo Hakamada[30], Andy Hector[31], Michael W. Jenkins[32], Jeffrey M. Kane[33], Thomas E. Kolb[26], Darin J. Law[16], James D. Lewis[34], Jean-Marc Limousin[35], David M. Love[4], Alison K. Macalady[36], Jordi Martínez-Vilalta[37,38], Maurizio Mencuccini[37,39,40], Patrick J. Mitchell[41], Jordan D. Muss[21], Michael J. O'Brien[42], Anthony P. O'Grady[41], Robert E. Pangle[9], Elizabeth A. Pinkard[41], Frida I. Piper[43,44], Jennifer A. Plaut[9], William T. Pockman[9], Joe Quirk[15], Keith Reinhardt[45], Francesco Ripullone[46], Michael G. Ryan[47,48,49], Anna Sala[50], Sanna Sevanto[21], John S. Sperry[4], Rodrigo Vargas[51], Michel Vennetier[52], Danielle A. Way[53,54], Chonggang Xu[21], Enrico A. Yepez[55] and Nate G. McDowell[56]

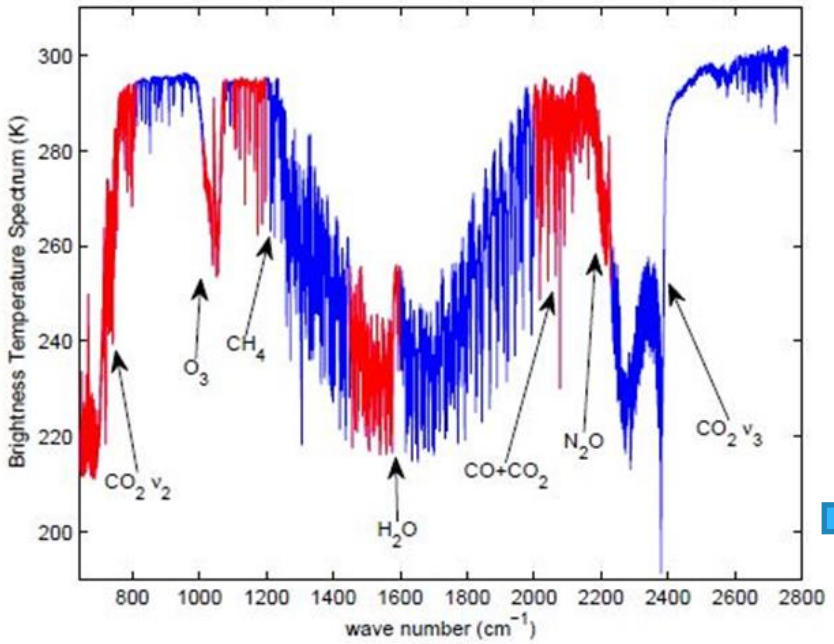
Research issue:
Can Infrared satellite observations help to monitor the vegetation stress and the early drying in summer because of heat waves. Is there any added value with respect to LST-NDVI indices

- Tools:
  - Satellite infrared observations and L2 products
    - surface parameters: T_s and emissivity;
    - Atmospheric parameters: T, H_2O and gases

DATA: WHY IASI?

- IASI is a nadir-view sounder in the thermal infrared. It couples remote sensing of the surface and atmosphere. We can combine surface and atmospheric parameters
- This is a capability with at present is not possible with SEVIRI or from geostationary platforms.
- However, IASI is a polar orbit and does not have the required time continuity for change detection analysis.
- By the way, within three-four years from now, ESA/EUMETSAT should launch MTG-IRS on the geostationary orbit. MTG-IRS is a Fourier transform imaging spectrometer with sounding (atmosphere) and imaging (surface) capabilities

We have developed a L2 processor for IASI, which uses the whole IASI spectral coverage (8461 channels) and simultaneously retrieve parameters and gas species



Retrieved parameters and species include, surface temperature and emissivity (spectrum), Temperature, H_2O, O_3, HDO, CO_2, N_2O, CO, CH_4, SO_2, HNO_3, NH_3, OCS, CF_4 atmospheric profiles.

The L2 processor has been variously validated: Reference Papers

6576 Vol. 55, No. 24 / August 20 2016 / Applied Optics Research Article

applied optics

Demonstration of random projections applied to the retrieval problem of geophysical parameters from hyper-spectral infrared observations

CARMINE SERIO,* GUIDO MASIELLO, AND GIULIANO LIUZZI

Scuola di Ingegneria, Universitá della Basilicata, 10 Ateneo Lucano, Potenza 85100, Italy
**Corresponding author: carmine.serio@unibas.it*

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journal homepage: www.elsevier.com/locate/jqsrt

Physical inversion of the full IASI spectra: Assessment of atmospheric parameters retrievals, consistency of spectroscopy and forward modelling

G. Liuzzi [a], G. Masiello [a], C. Serio [a,*], S. Venafra [a], C. Camy-Peyret [b]

[a] *Scuola di Ingegneria, Universitá della Basilicata, Potenza, Italy*
[b] *Institut Pierre-Simon Laplace (IPSL), UPMC/UVSQ, Paris, France*

Journal of Quantitative Spectroscopy & Radiative Transfer 201 (2017) 197–208

Contents lists available at ScienceDirect

Journal of Quantitative Spectroscopy & Radiative Transfer

journal homepage: www.elsevier.com/locate/jqsrt

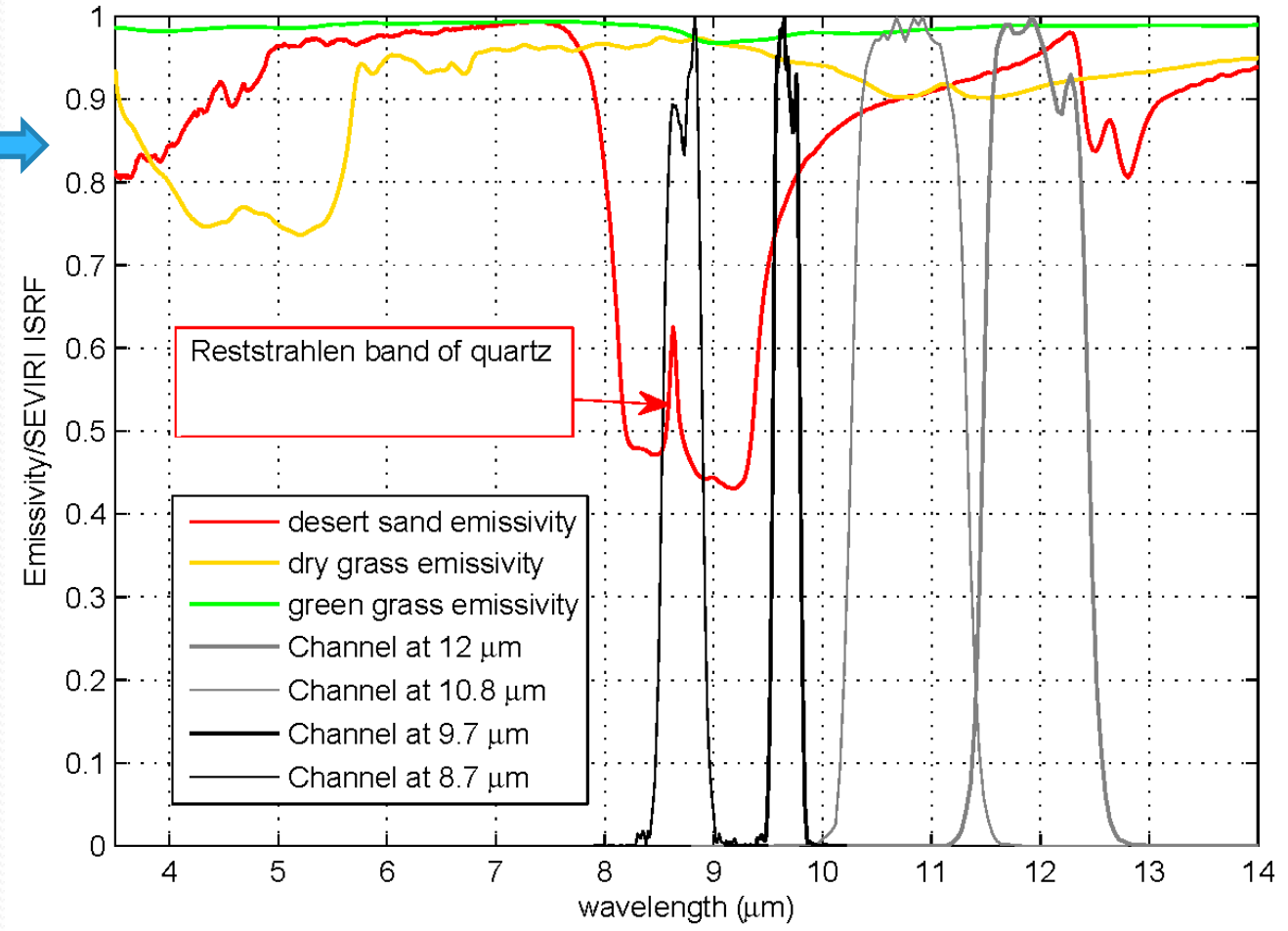
Assessment of IASI capability for retrieving carbonyl sulphide (OCS)

C. Camy-Peyret [a], G. Liuzzi [b], G. Masiello [b], C. Serio [b,*], S. Venafra [b], S.A. Montzka [c]

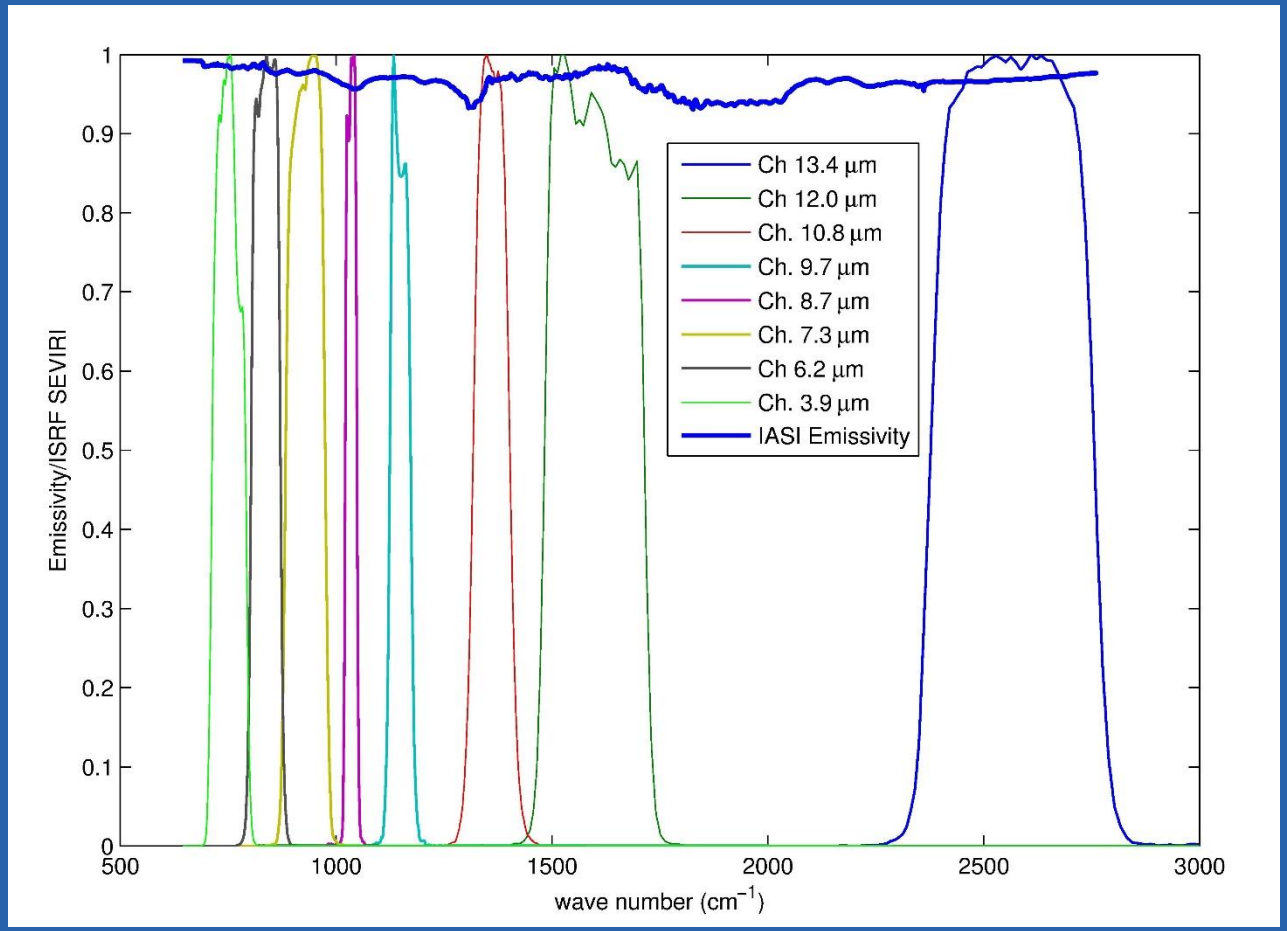
[a] *Institut Pierre-Simon Laplace (IPSL), UPMC/UVSQ, Paris, France*
[b] *Scuola di Ingegneria, Universitá della Basilicata, Potenza, Italy*
[c] *NOAA Earth System Research Laboratory, Boulder, Colorado, USA*

Emissivity and emissivity contrast to identify land cover type channels

The need to have a channel in the SW region to discriminate between green and dry vegetation



Using IASI emissivity spectrum defines 5 SEVIRI channels emissivity in the window regions (12, 10.8, 9.7, 8.7 3.9) μm

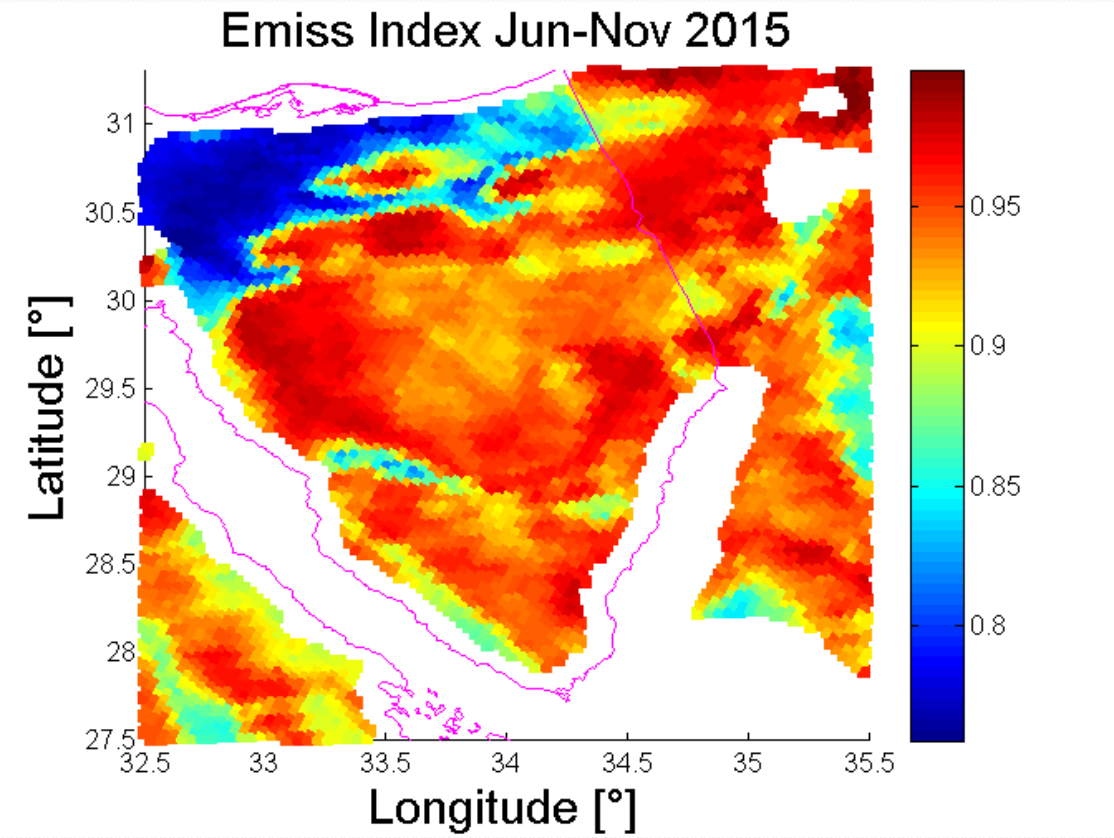


Emissivity Contrast index, ECI

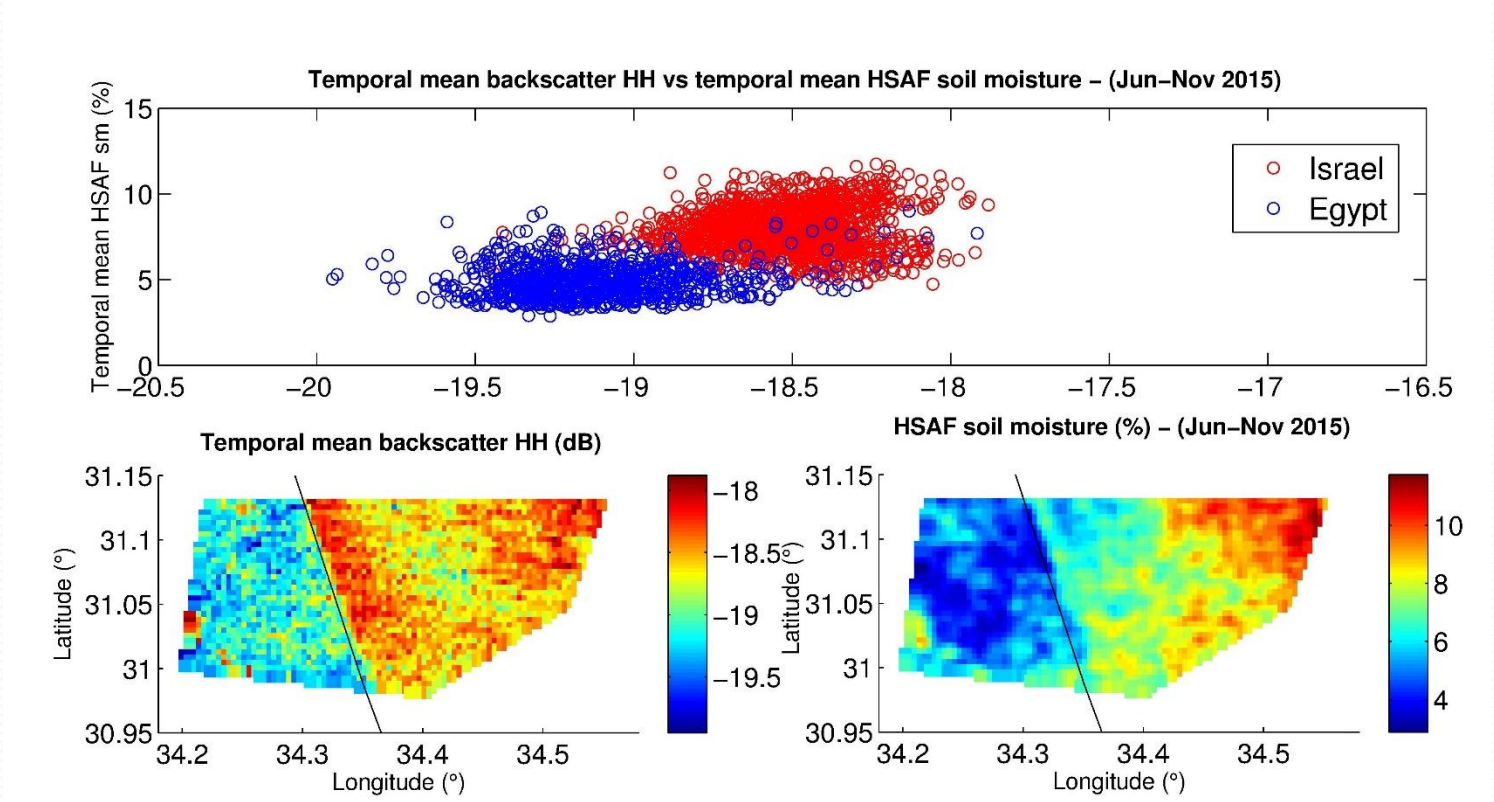
(French et al, RSE, 2000, https://doi.org/10.1016/S0034-4257(00)00115-2)

- $\delta\varepsilon = Max(Channel\ Emissivity) - Min(Channel\ Emissivity)$
- We define the Emissivity Contrast Index (ECI) as $1 - \delta\varepsilon$, ECI varies in range [0,1], the endpoint 1 is the limit of wet green vegetation, 0 that of dry arid soil.
  - For water the contrast is ≈0.01, $ECI \cong 0.99$
  - For bare soil ECI is in between $0.7 - 0.8$ (in the limit of desert sand)
  - Green vegetation typically has a very high emissivity because it is structured and contains water. We expect a contrast in between $ECI \approx 0.98 - 1$
  - Senescent (dry) vegetation has a more variable emissivity, especially in the 3 to 5 μm region, which depends on the type and structure of the cover type, the dryness, and so forth. In this case we expect a contrast in between $0.94 - 0.98$

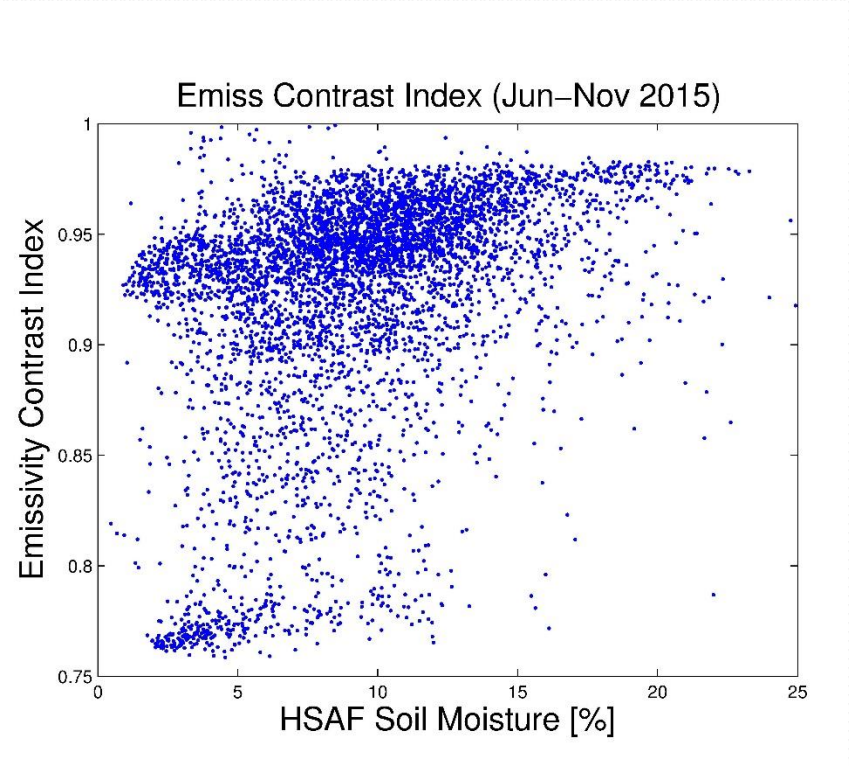
ECI and its correlation with Soil Moisture has been assessed mostly for semi-arid and arid lands, the case of SINAI-NEGEV desert

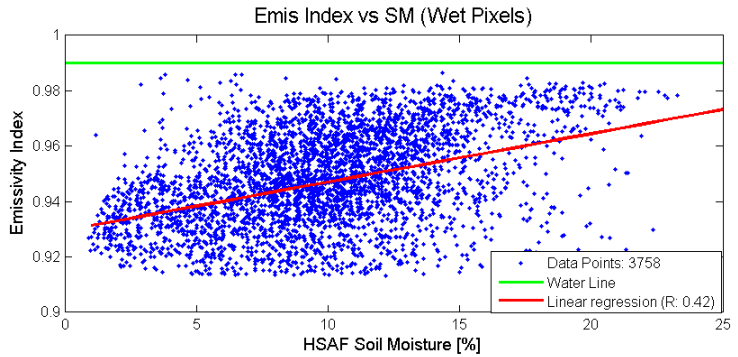


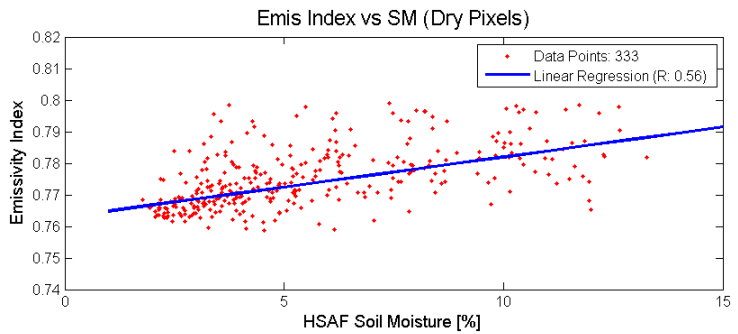
HSAF soil moisture at spatial resolution of 1 km is a good product



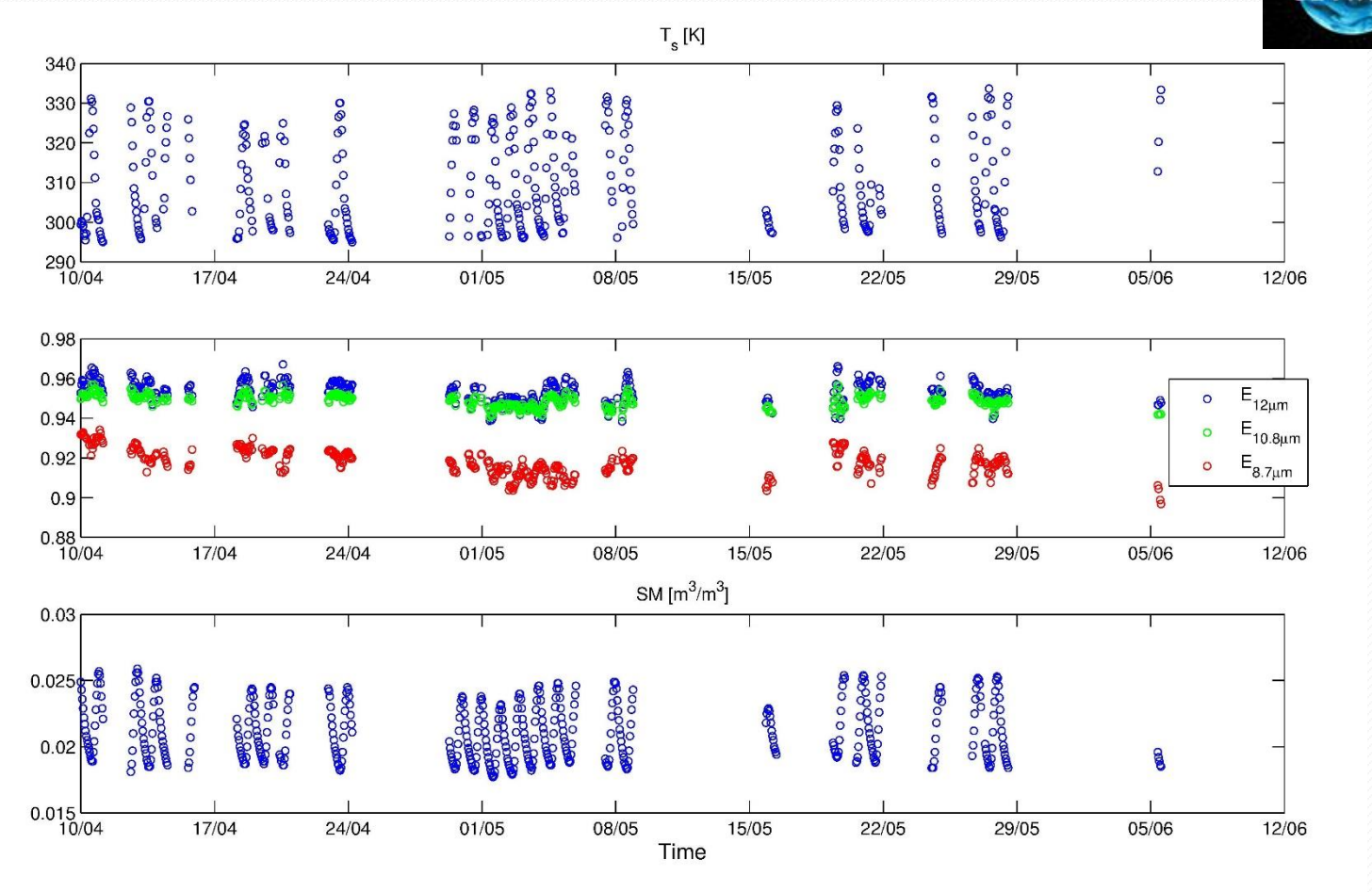
Correlation with Soil Moisture (from HSAF)



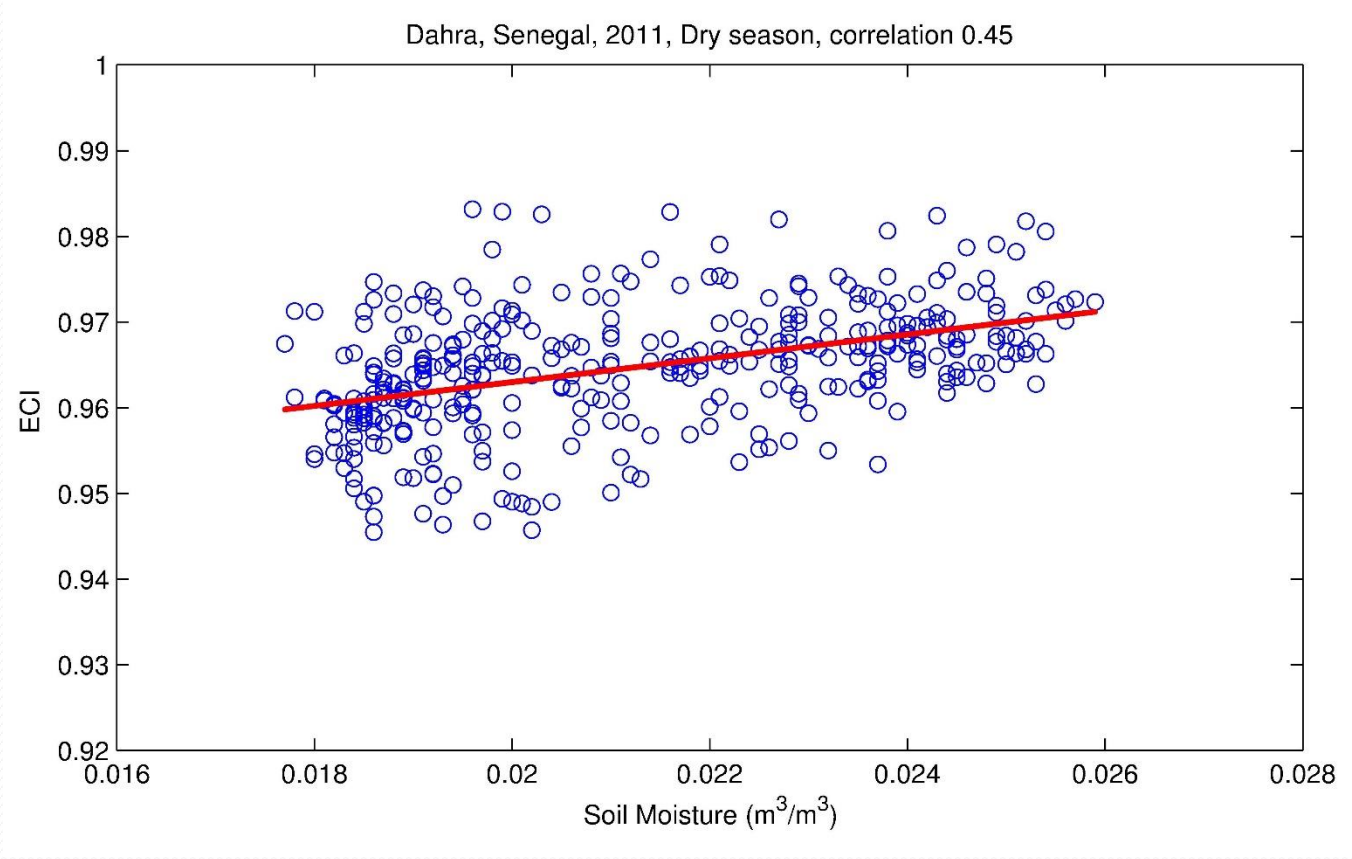




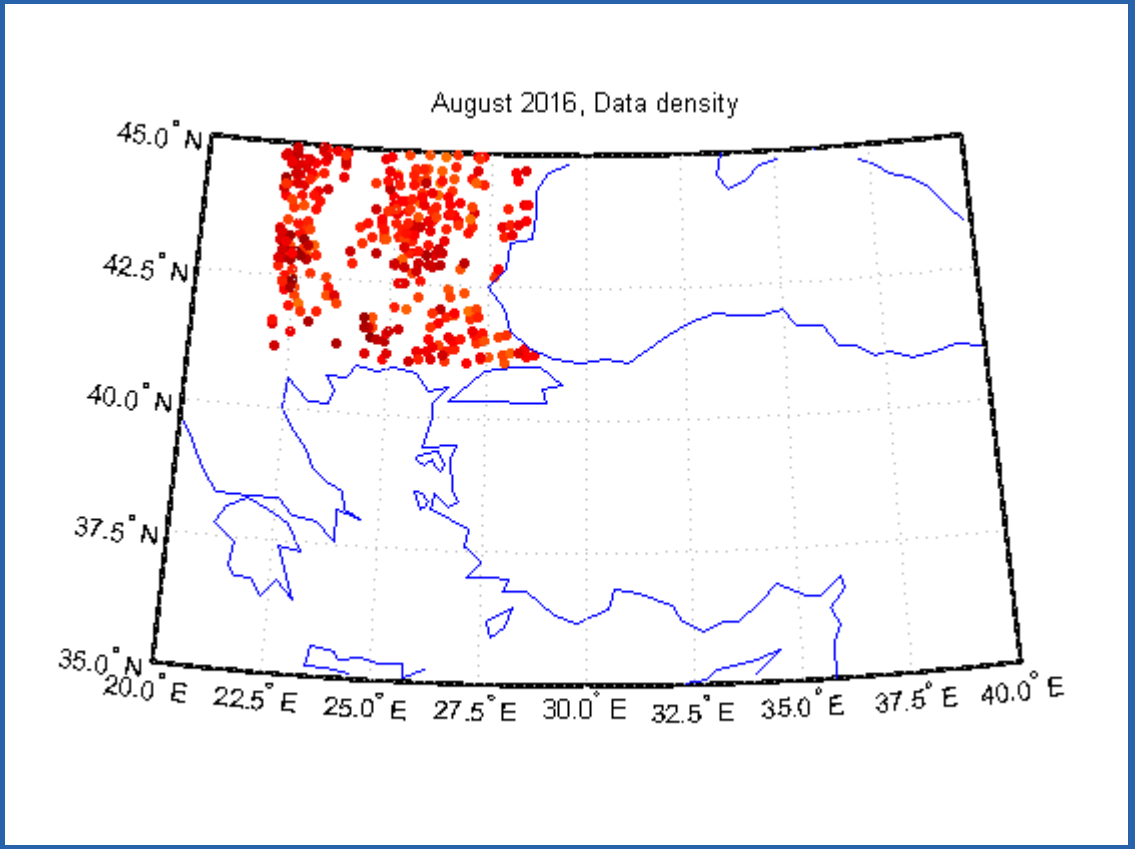
Emissivity Contrast, Dahra Senegal, dry season 2011



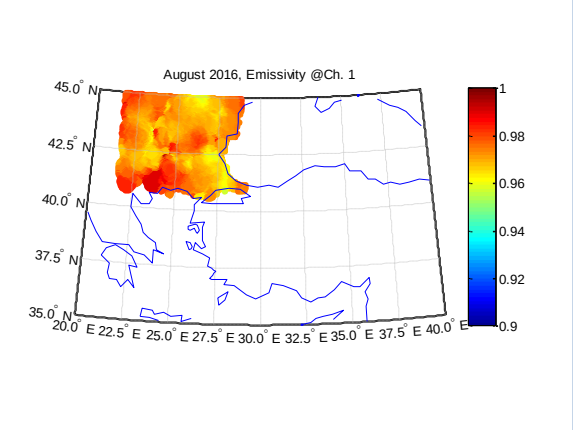
Emissivity Contrast, Dahra Senegal, dry season 2011

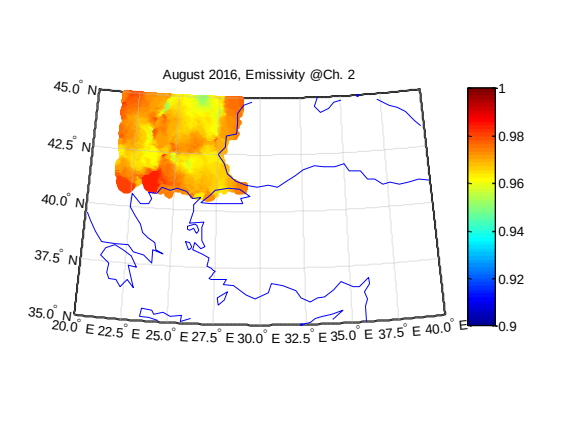


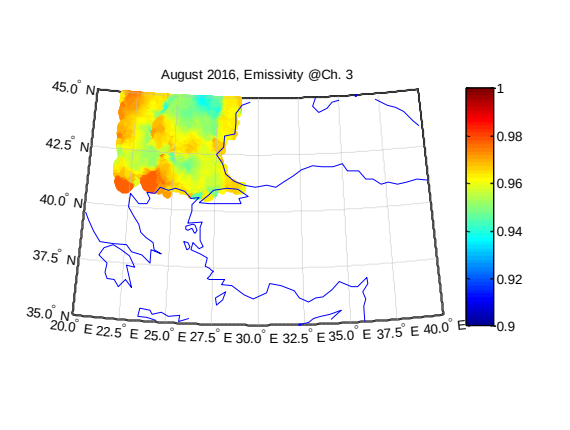
Analysis with IASI. Three days of IASI data over Bulgaria, 20-21 and 30 August 2016

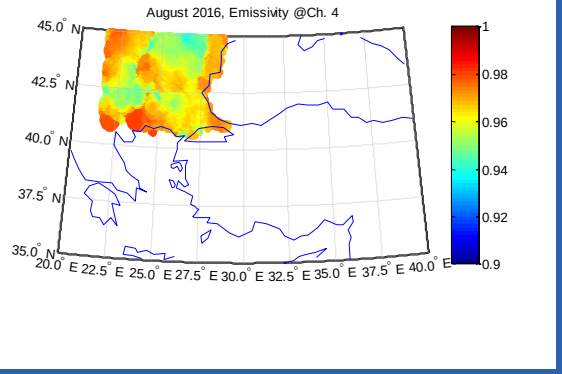


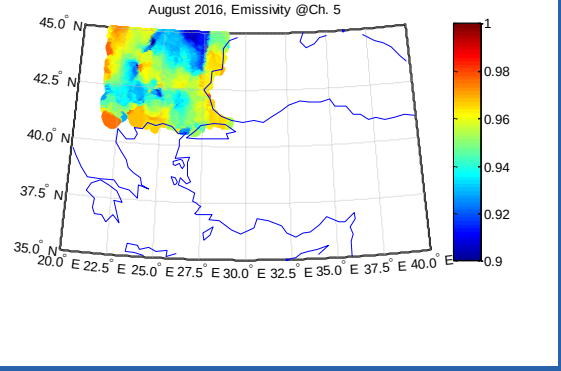
Example of Emissivity for three days over Bulgaria, 20-21 and 30 August 2016



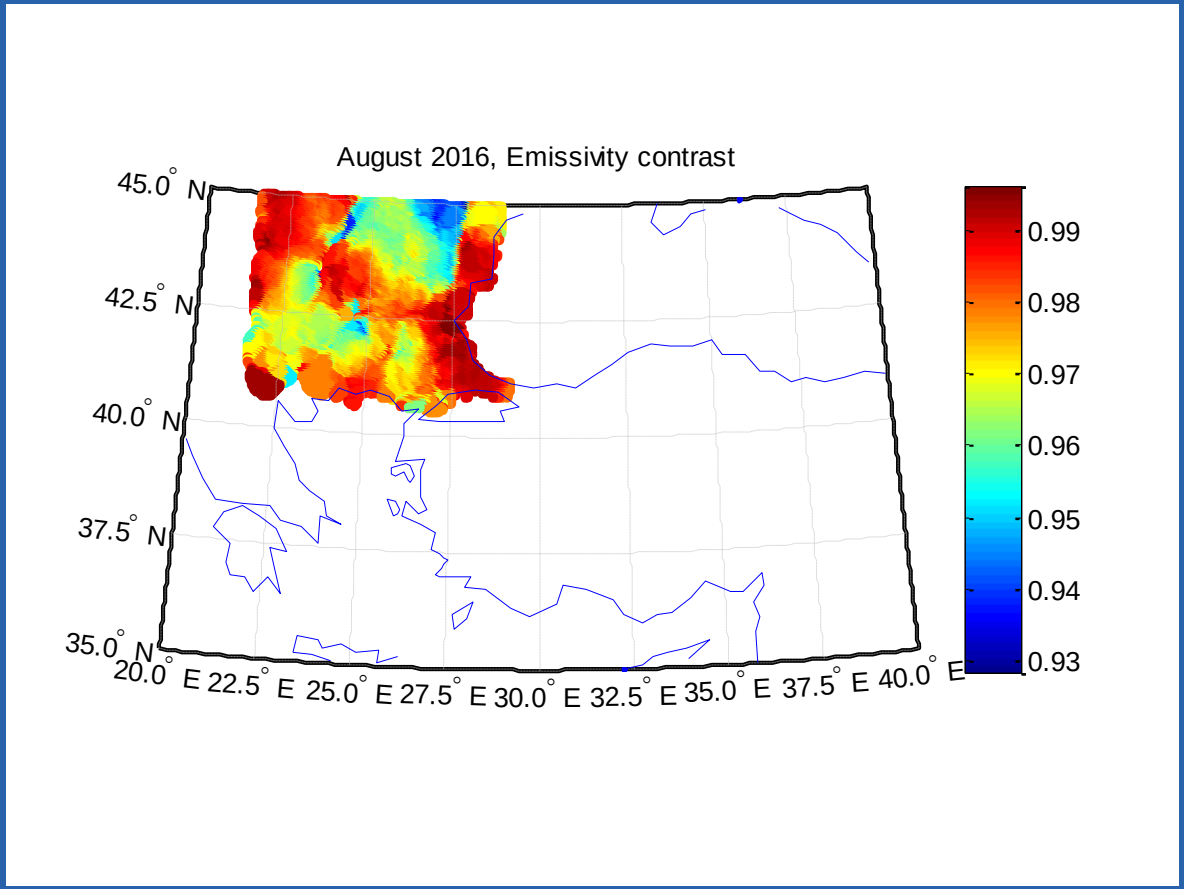




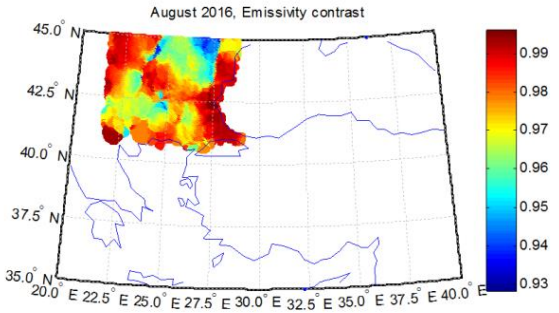




Example of Emissivity for three days over Bulgaria, 20-2 and 30 August 2016. Forming the Emissivity Contrast, $ECI = 1 - \delta\varepsilon$



Middle


August 2016, Emissivity contrast
45.0° N
42.5° N
40.0° N
37.5° N
35.0° N
20.0° E 22.5° E 25.0° E 27.5° E 30.0° E 32.5° E 35.0° E 37.5° E 40.0° E
0.99
0.98
0.97
0.96
0.95
0.94
0.93

Belozem
Cirpan
Gita
Sadovo
Popovitsa
Gradina
Sadovo
Merichleri
Parvomay
Stalevo
Izbeglii
Varbitsa
Krum
Dimitrovgrad
Pàrvomaj
Dobrich
Dragoynovo
Krep
Lenovo
© 2017 Google
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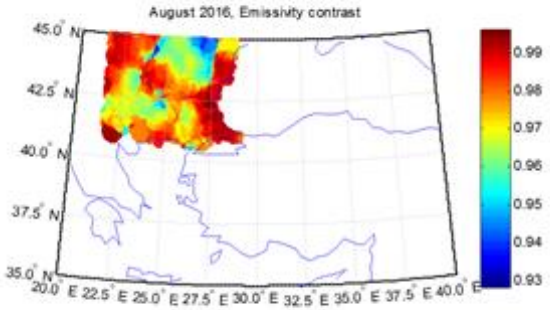
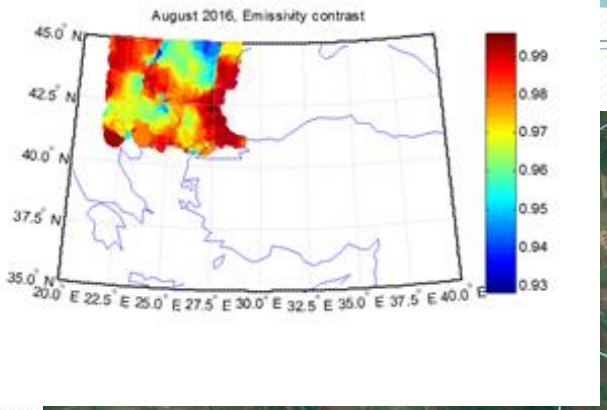
Google Earth
Visita guidata
Data di acquisizione delle immagini: 6/6/2017 42°06'12.97"N 25°14'27.88"E elev 130 m alt 50.60 km

North-Ovest


August 2016, Emissivity contrast
45.0° N
42.5° N
40.0° N
37.5° N
35.0° N
20.0° E 22.5° E 25.0° E 27.5° E 30.0° E 32.5° E 35.0° E 37.5° E 40.0° E
0.99
0.98
0.97
0.96
0.95
0.94
0.93

Galiche
Bardarski Geran
Gostilya
Tarnava
Kneža
Iskăr
Trastenik
Byala Slatina
Bjala Slatina
Tarnak
Sokolare
Iskar
Dolna Mitropolija
Dolna Mitropol
Brenitsa
Barkachevo
Dolni Dăbnik
Koynare
Tarnene
Suhache
Telish
Image © 2017 DigitalGlobe
© 2017 Google
Image © 2017 CNES / Airbus
Google Earth
Visita guidata
Data di acquisizione delle immagini: 8/4/2017 43°27'43.89"N 24°13'14.18"E elev 61 m alt 49.66 km
16:40
12/09/2017

North-East


August 2016, Emissivity contrast
45.0° N
42.5° N
40.0° N
37.5° N
35.0° N
20.0° E 22.5° E 25.0° E 27.5° E 30.0° E 32.5° E 35.0° E 37.5° E 40.0° E
0.99
0.98
0.97
0.96
0.95
0.94
0.93

Aleksandria
Dobrin
Polkovnik Dyakovo
Krušari
Cerchezu
Tervel
Polkovnik Savovo
Tervel
Feldfebel Denkovo
Tyanevo
Kochmar
Dobrevo
Kapinovo
General Toševo
Dobrich-Selska
Lomnitsa
General Toshevo
Orlyak
Karapelit
Lovchantsi
Lyulyakovo
Tsarevets
Medovo
Benkovski
Vrachantsi
Metodievo
Pet mogili
Samuilovo
Pobeda
Dobrich
Dobrič
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Bdintsi
Google Earth
Visita guidata
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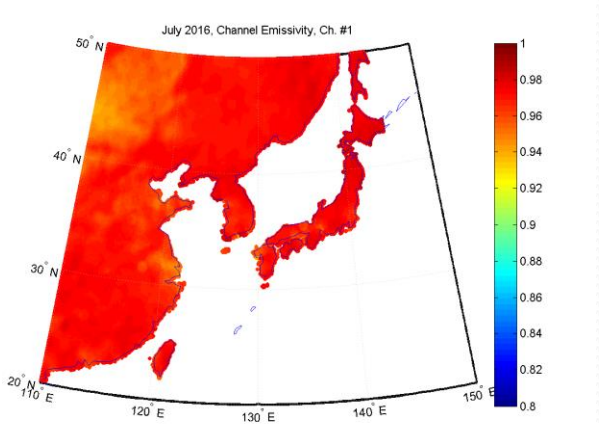
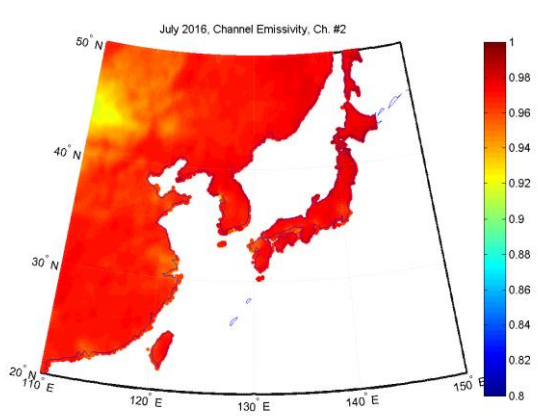
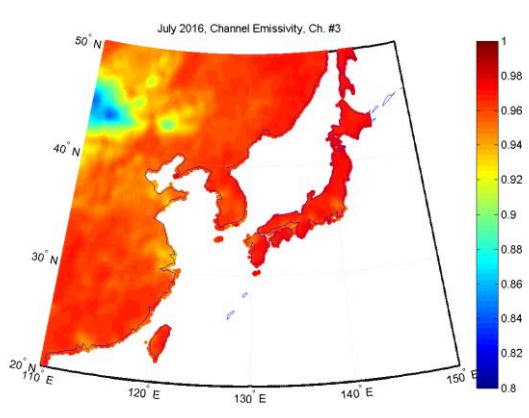
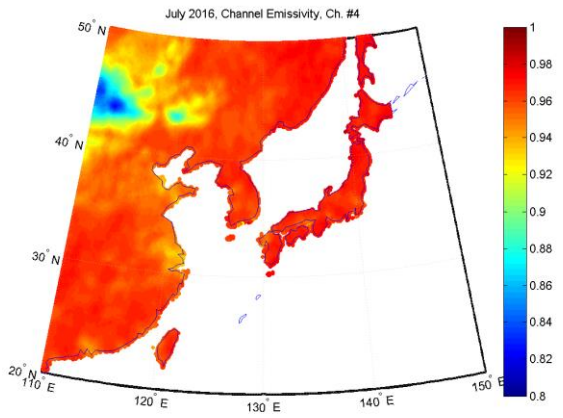
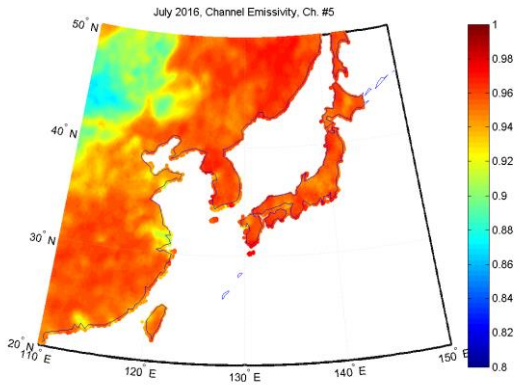
Eastern Asia, July 2016



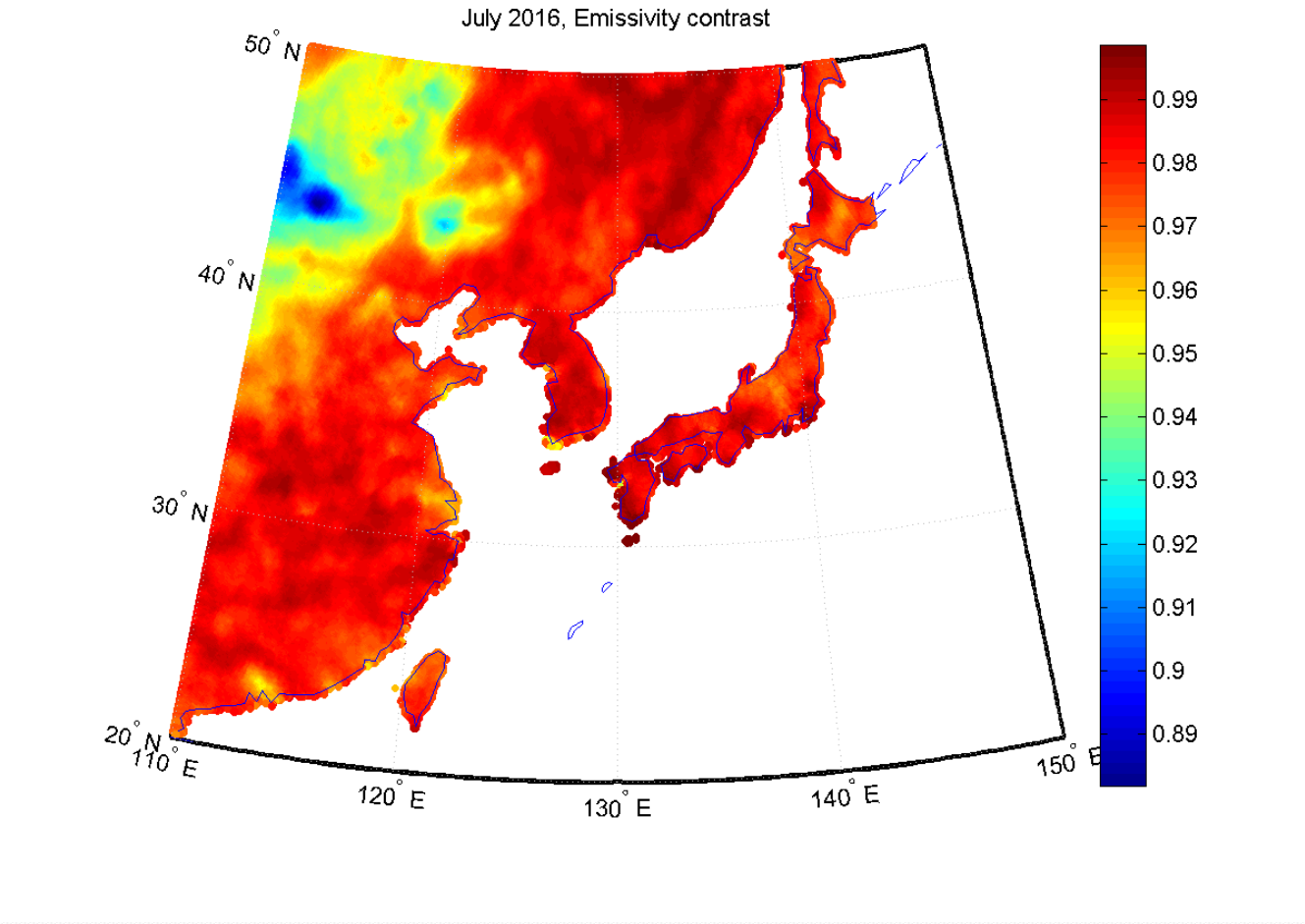




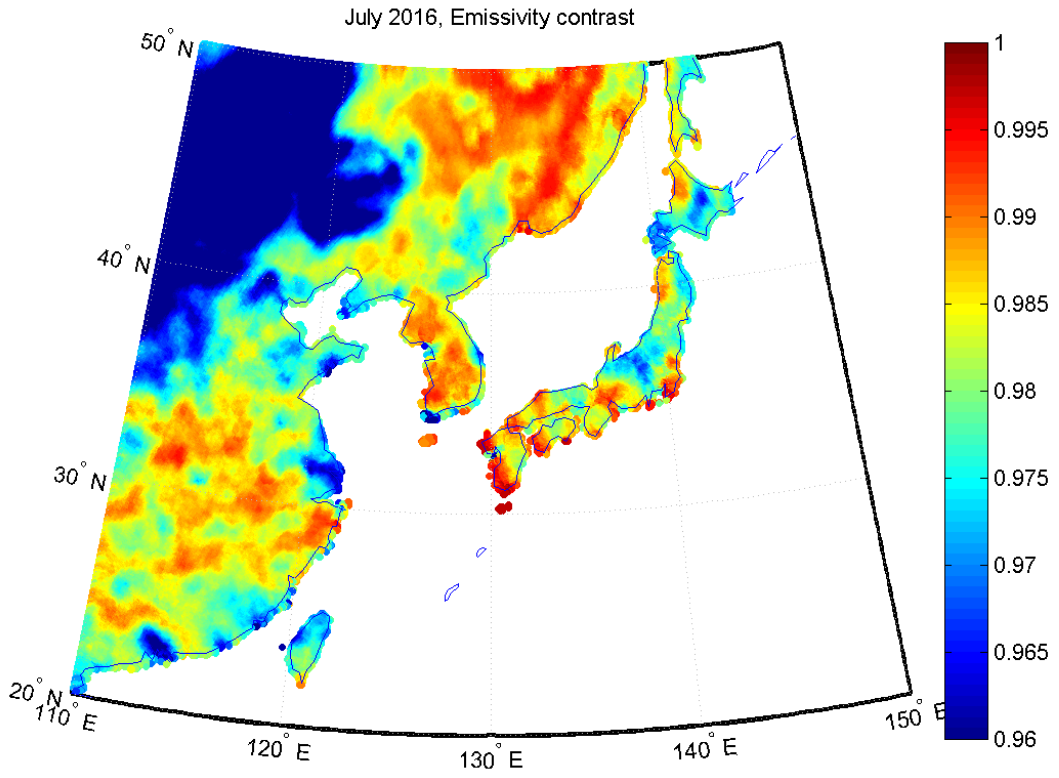




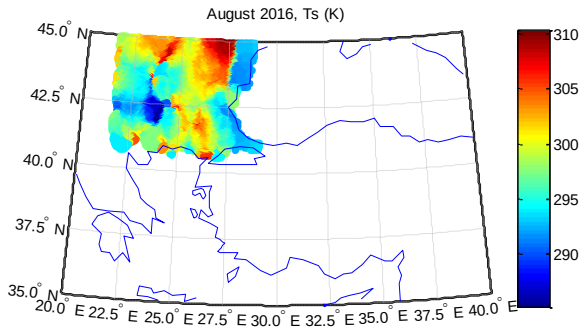
Eastern China, ECI index (1)

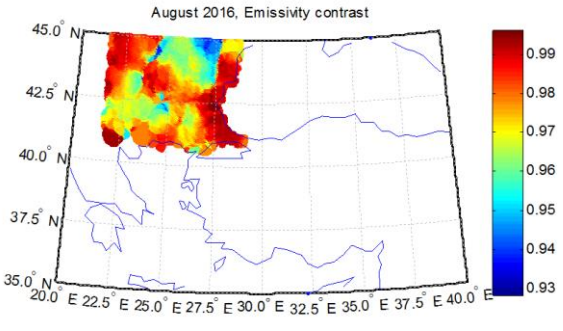


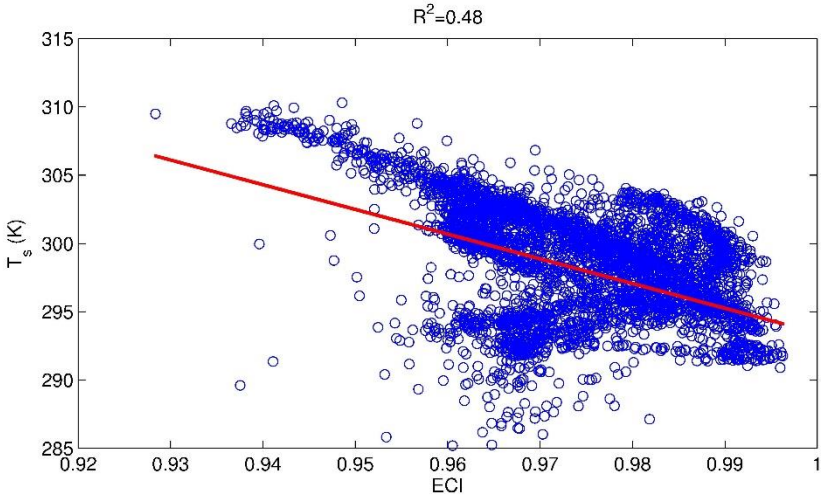
Eastern China, ECI index (2)



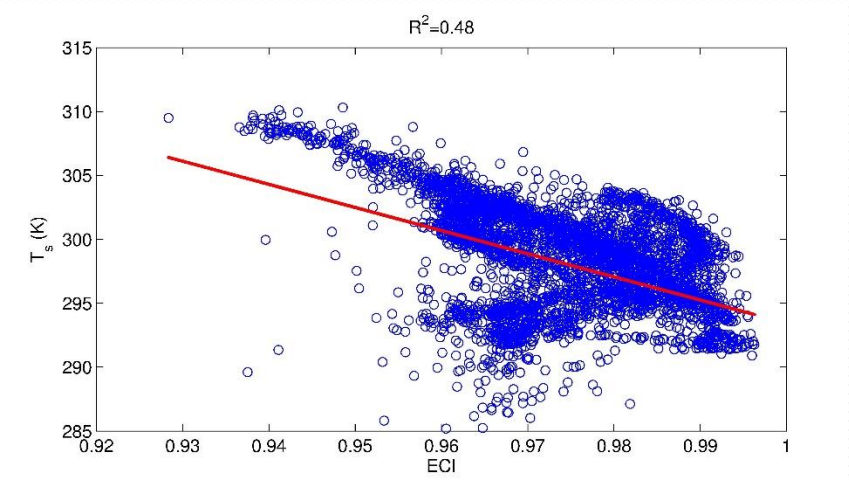
Designing LST-ECI indeces. The case of Bulgaria August 2016 heat wave

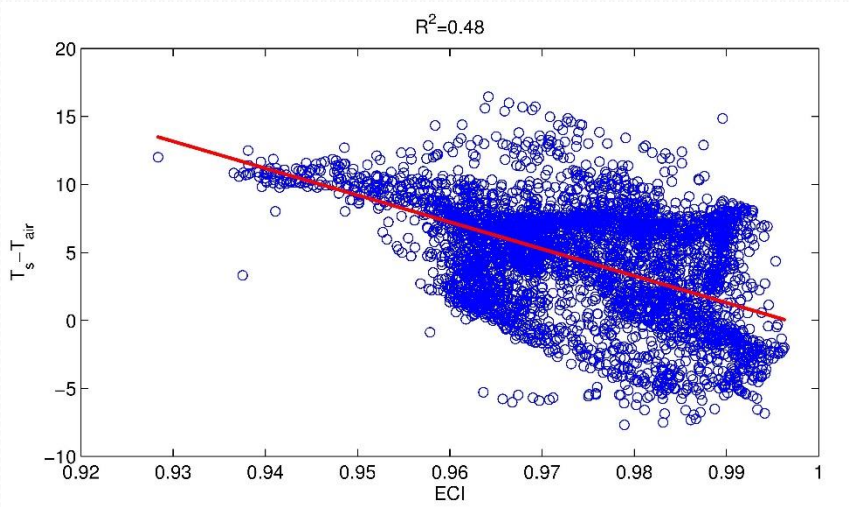




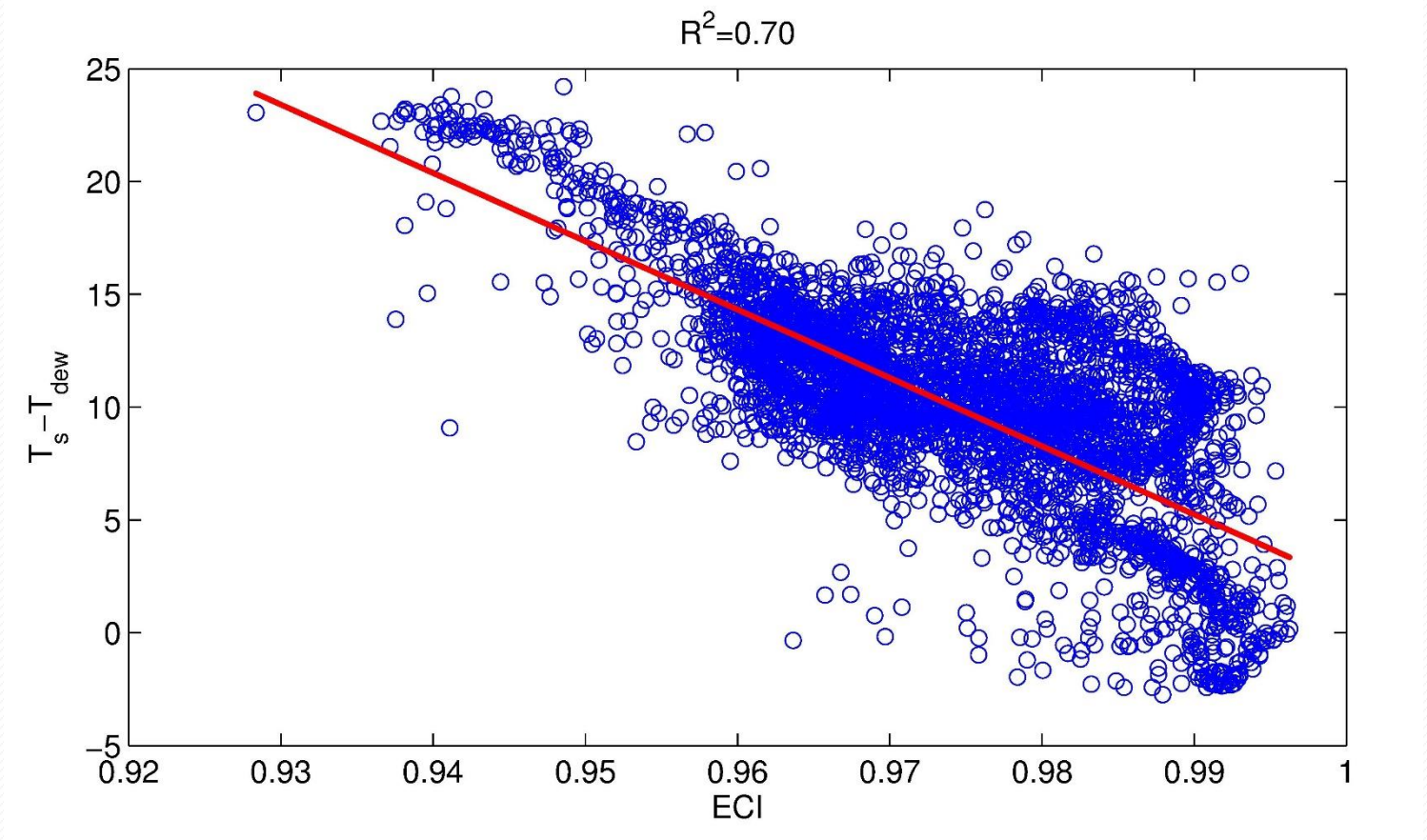


Designing LST-ECI indeces. The case of Bulgaria August 2016 heat wave

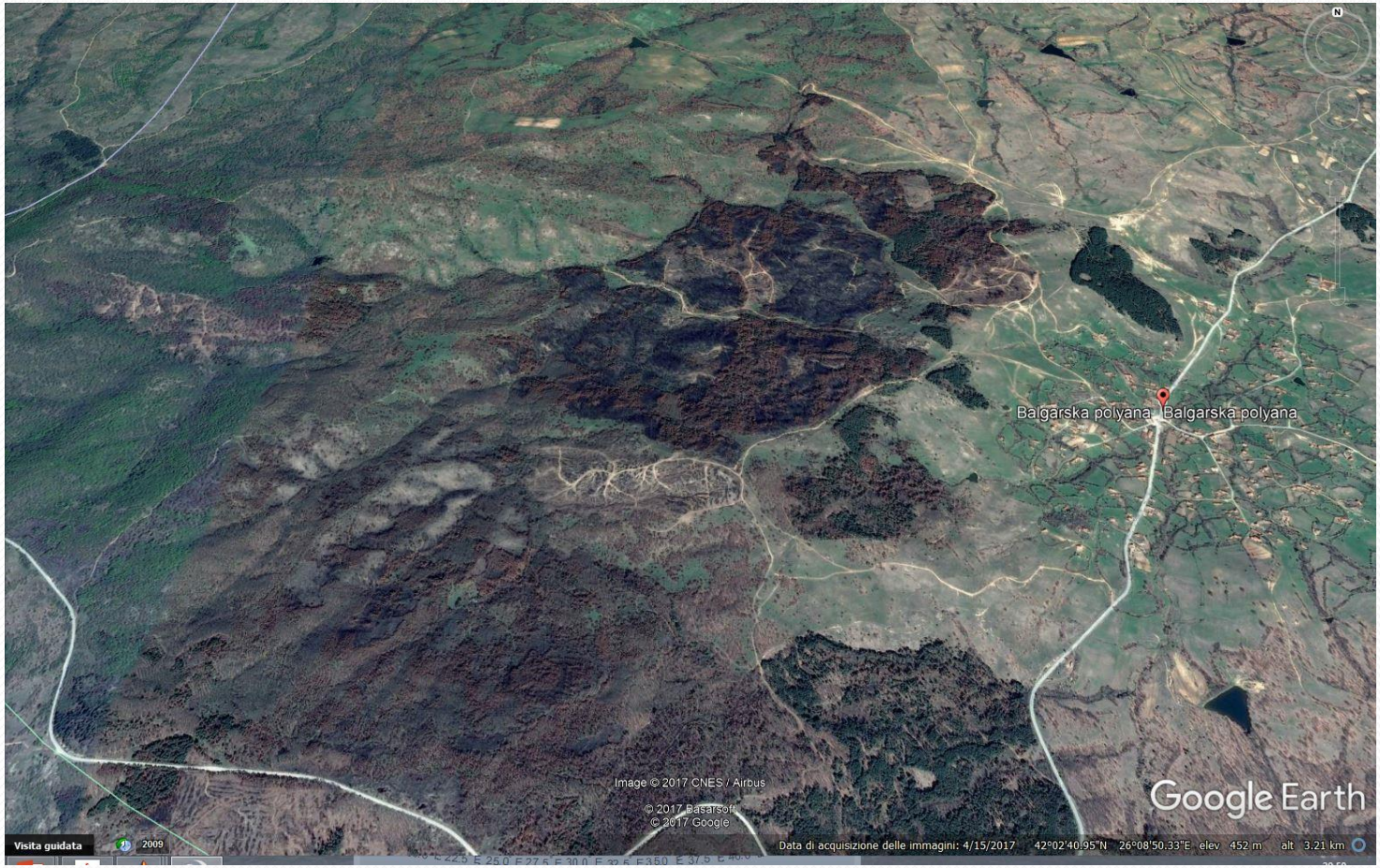




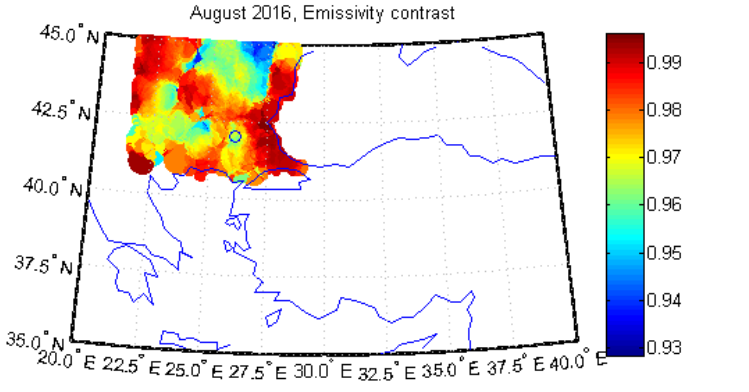
Designing LST-ECI indeces. The case of Bulgaria August 2016 heat wave

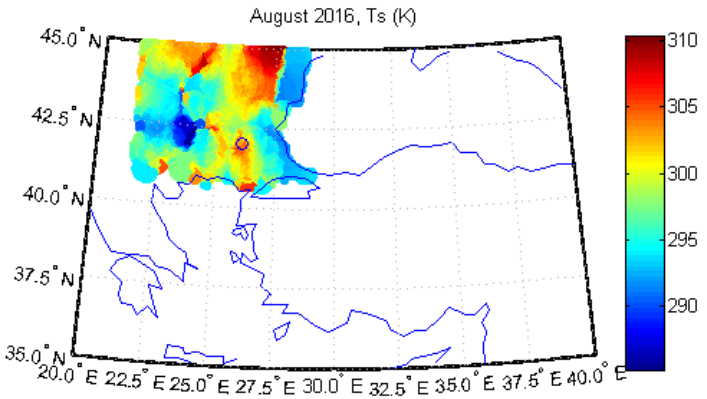


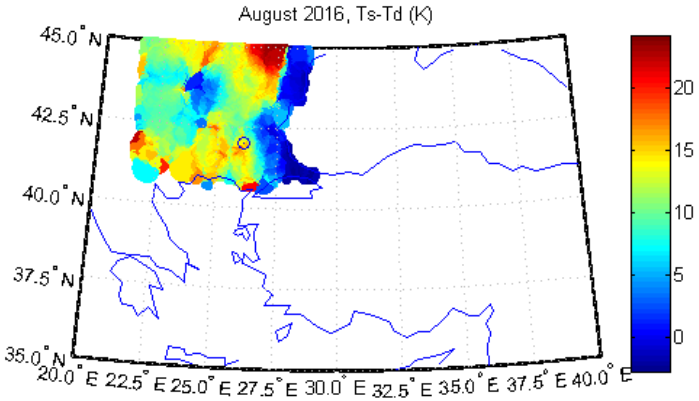
Application to the Bolgarska Polyana area



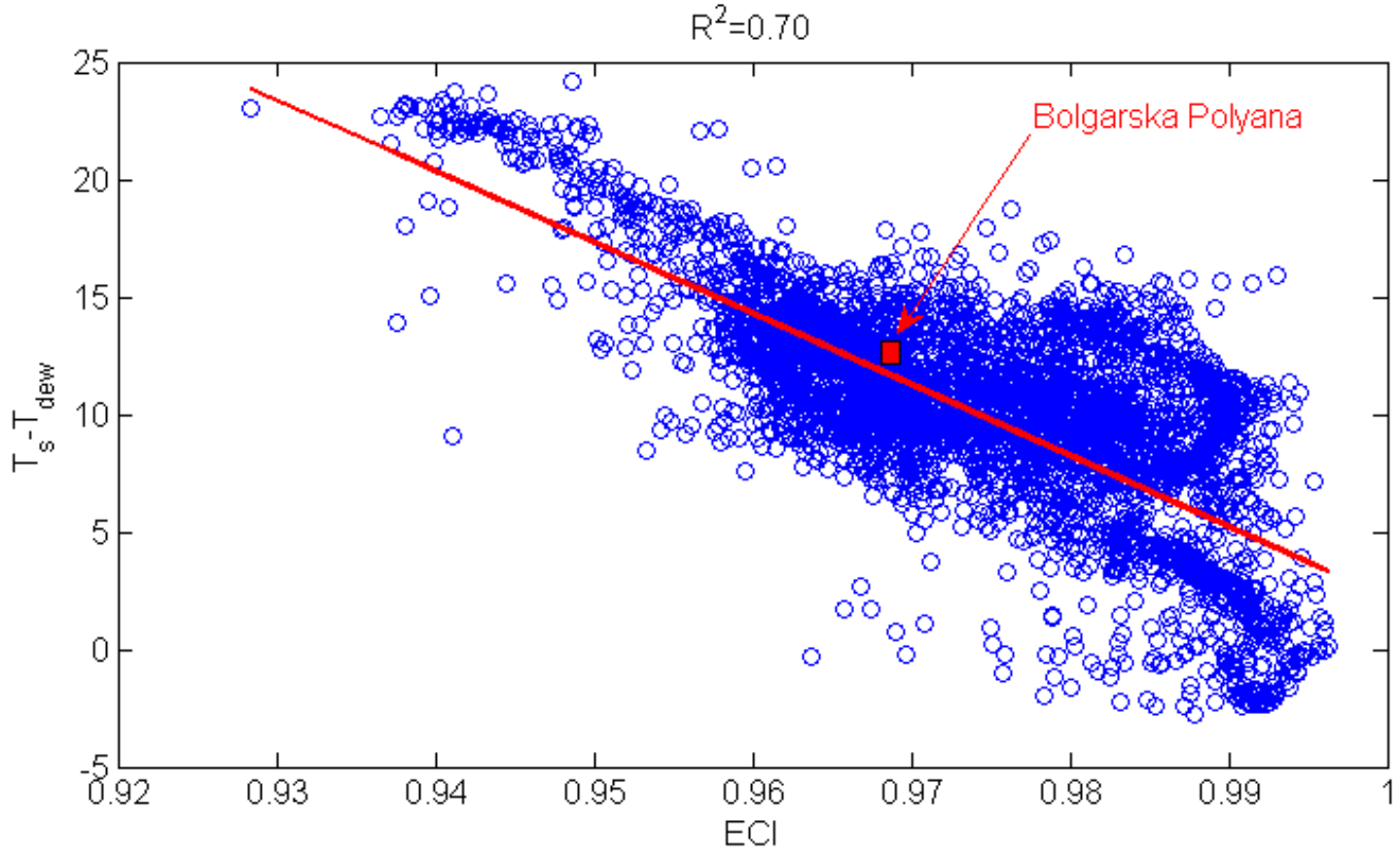
Application to the Bolgarska Polyana area



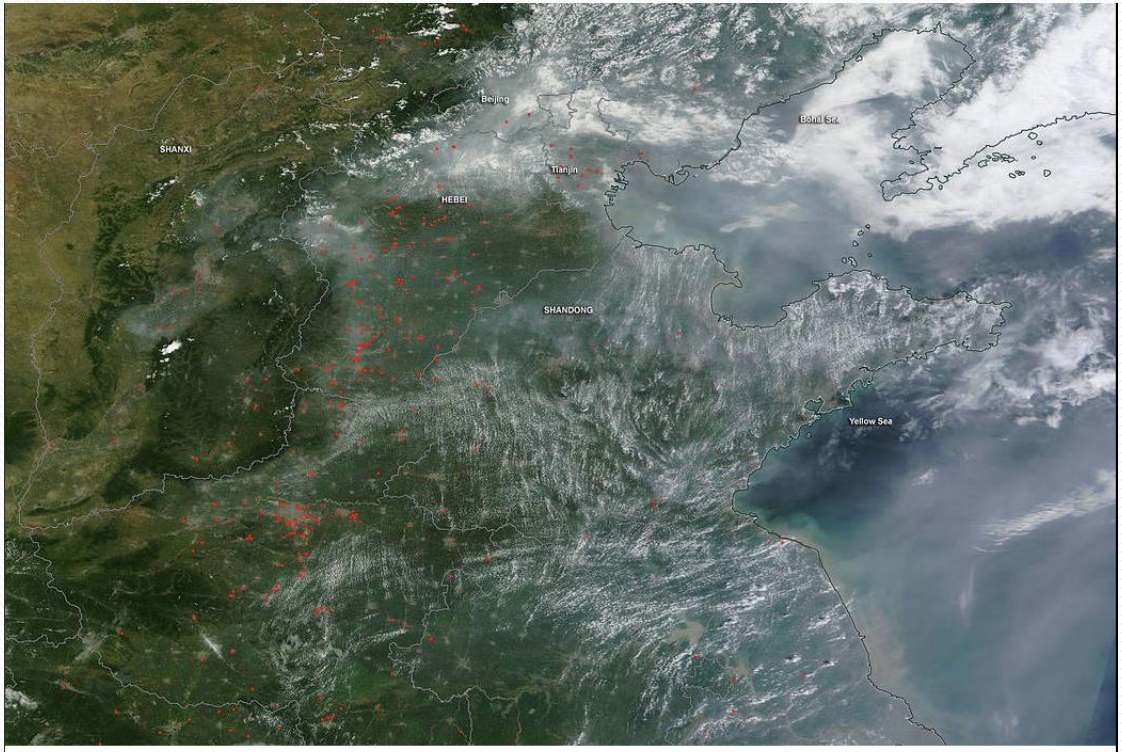




Application to the Bolgarska Polyana area



Fires in Eastern China on 29 July, 2016

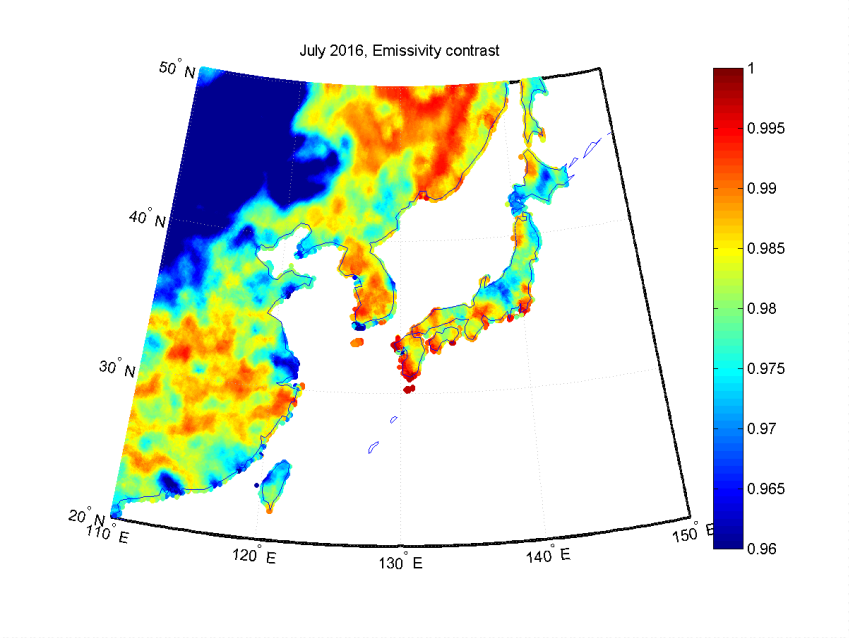


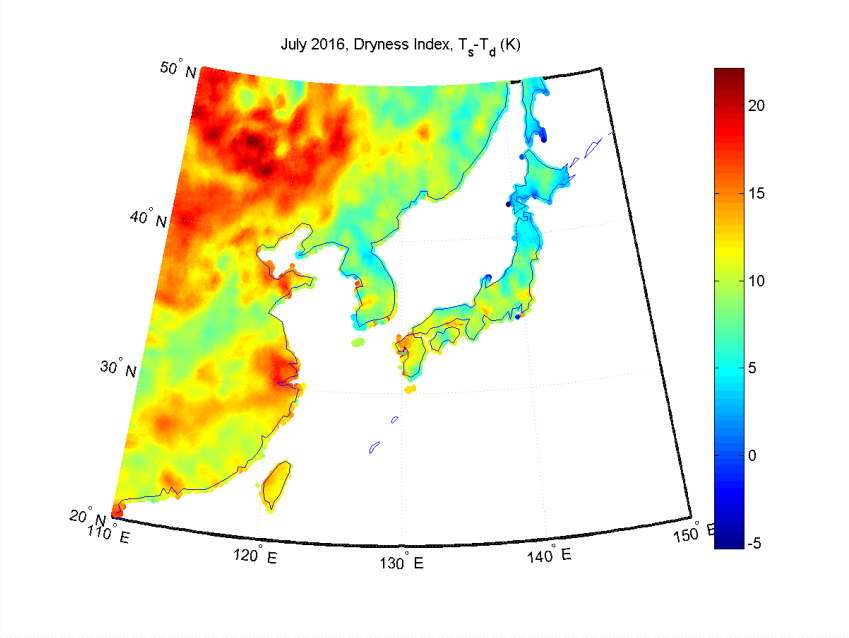
On July 29, 2016, fires peppered the ground while smoke spread across the skies over eastern China. The Moderate Resolution Imaging Spectroradiometer (MODIS) on NASA's Terra satellite captured this natural-color image. Dozens of fires, marked by red outlines, appear south and southwest of Beijing. Smoke appears most thick over the Shandong Bandao peninsula. Many, if not most, of the fires in this image are agricultural fires.

The Shandong Peninsula is between the Bohai Sea to the north and the Yellow Sea to the south, and is part of the Shandong province in eastern China.

Image Credit: NASA MODIS Rapid Response, Jeff Schmaltz, Text: NASA Goddard Space Flight Center, Rob Gutro

Fires in eastern China on 29 July, 2016





OCS

- Carbonyl sulphide (OCS), a sulphur-containing analogue of carbon dioxide, is also taken up by plants, and could potentially serve as a powerful proxy for photosynthetic carbon dioxide uptake, which cannot be directly measured above the leaf scale.

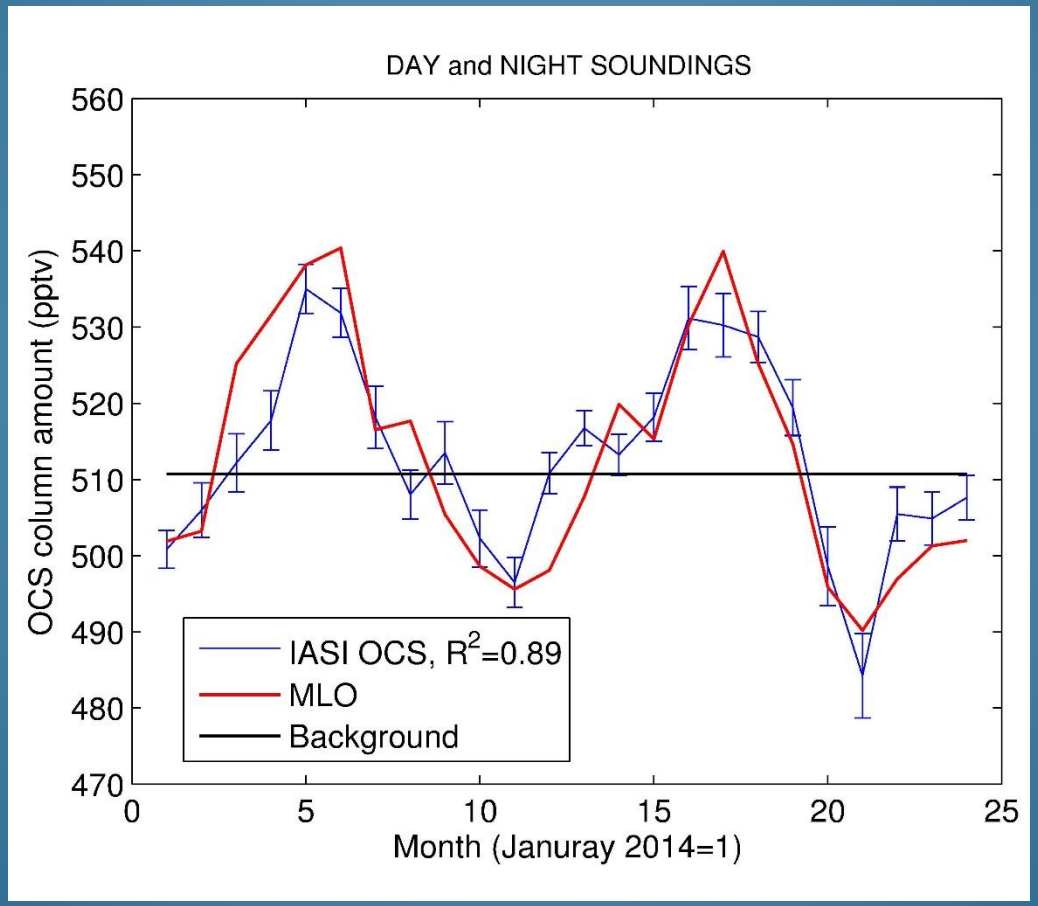
- Furthermore, recent studies (e.g., Asaf et al, 2013, doi: 10.1038/NGEO1730) have shown that carbonyl sulphide holds great promise for studies of carbon cycle processes because it is an atmospheric tracer of photosynthetic Gross Primary Production (GPP).

- Unlike CO_2 which can also released by plants in non-photosynthesis processes, OCS is irreversibly taken by plants in photosynthesis processes.

Monthly mean sequences: IASI vs MLO

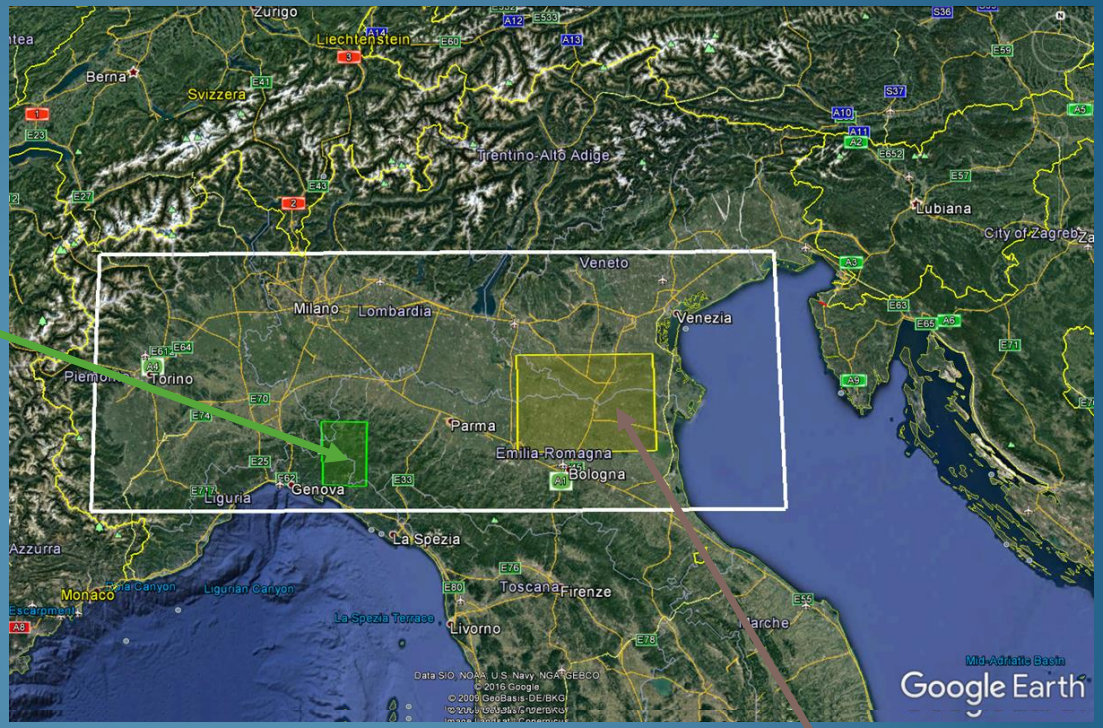
Day and Night:

Mean difference over the whole period 2014-2015, -0.1 pptv



Land surface: Case study over the Po Valley

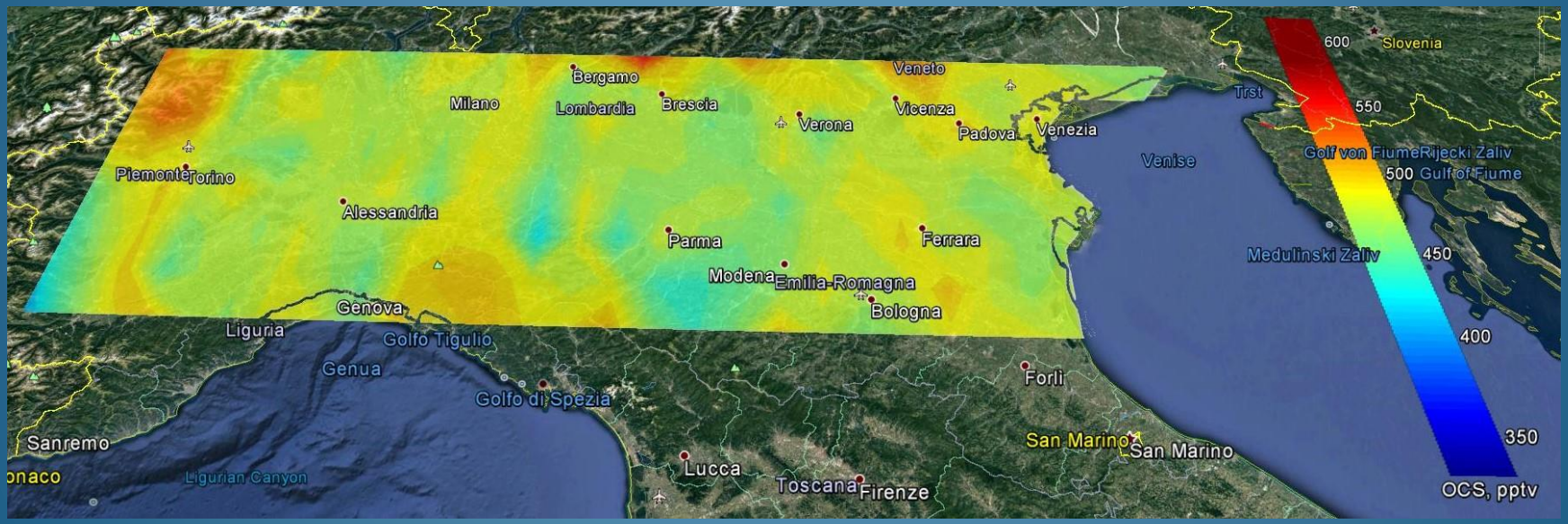
Forest Canopy



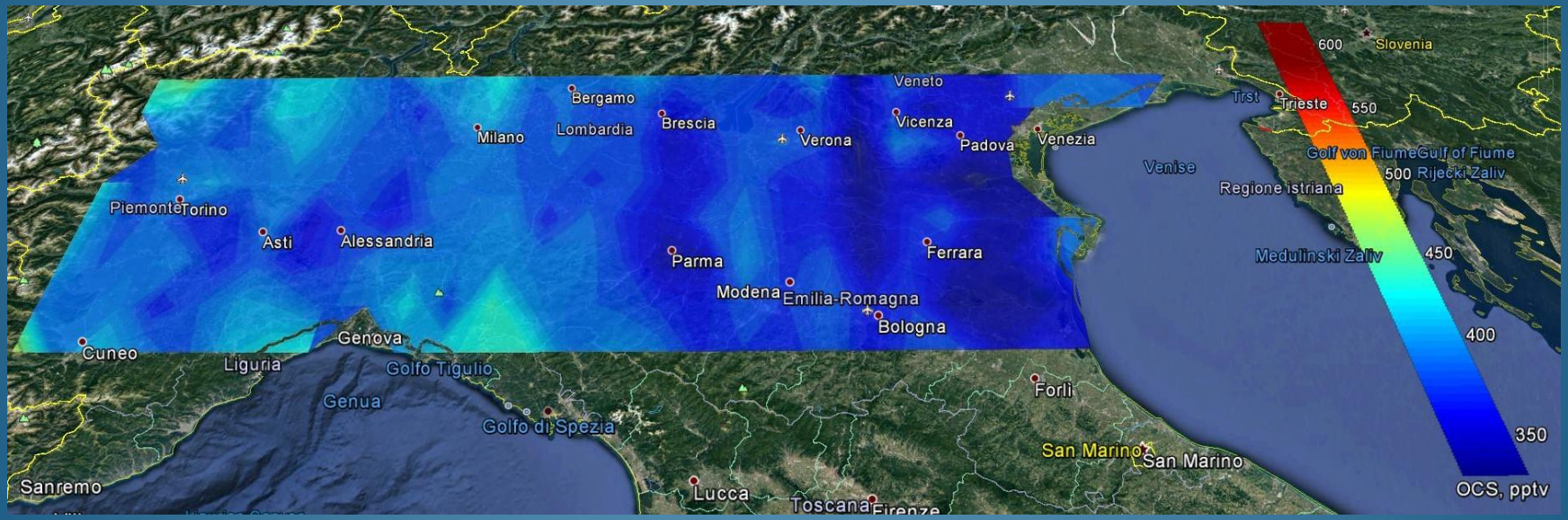
Ogée, et al 2016, doi:10.5194/bg-13-2221-2016 has suggested that OCS soil and leafs uptake, although governed by the activity of carbonic anhydrase (CA), follows different processes. That for soil is also depending on its temperature.

Agricultural Field

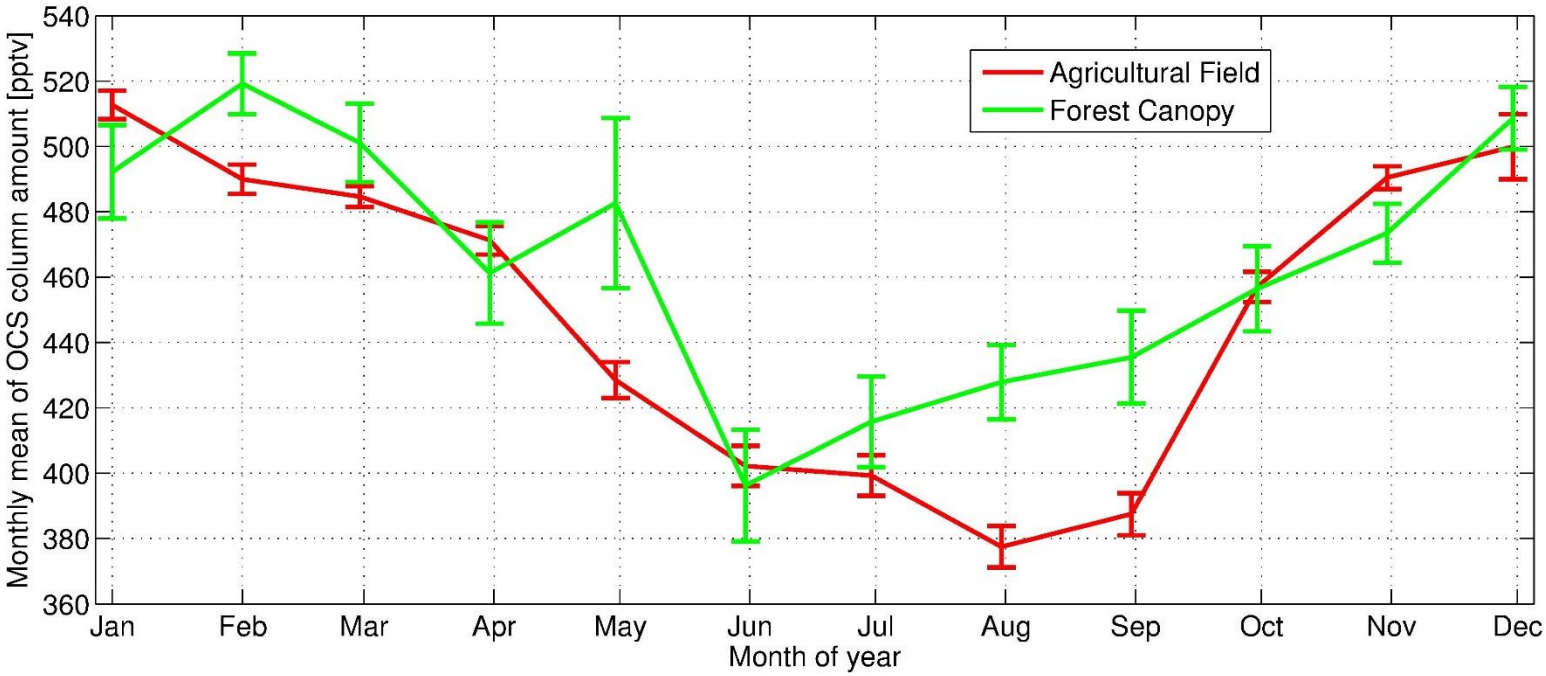
OCS contour map for February 2015



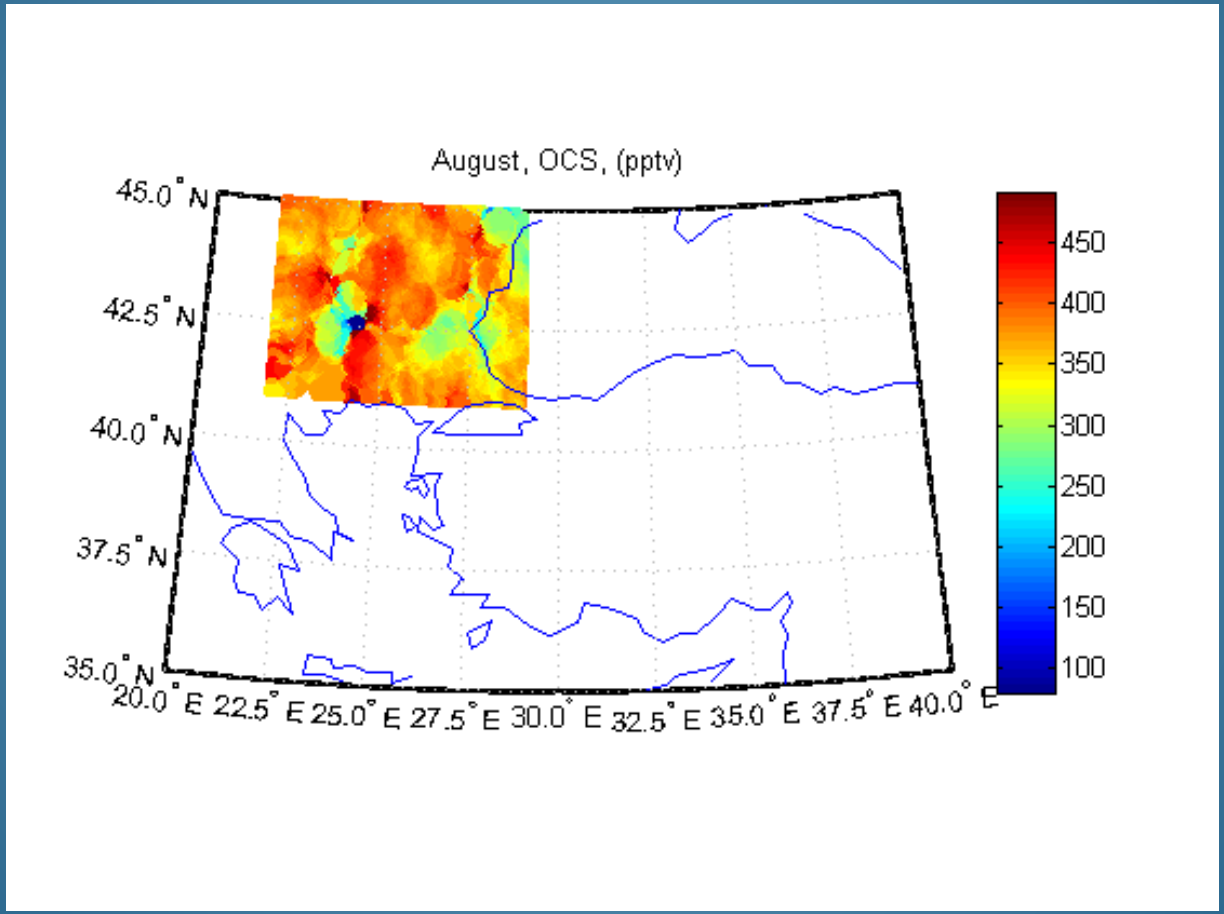
OCS contour map for August 2015



OCS monthly mean sequences



OCS, Carbonyl Sulfide, Bulgaria



Next

- Assess the synergy ECI-NDVI (infrared-visible). SEVIRI-NDVI is operationally produced by EUMETSAT

- ECI≈1, NDVI≈1 → Green Vegetation
- ECI≈1, NDVI≈0 → Dry Vegetation
- ECI≈0, NDVI≈0 → Bare Soil

- Emissivity contrast can distinguish between bare soil and dry vegetation
- Scatterplots $(T_s - T_{dew})\, vs\, ECI$ are effective in defining dry-stress scatterplots for vegetation.
- There is a need to investigate ECI-NDVI synergy. In perspective this could improve SEVIRI capability to monitor vegetation stress and detect changes because of the global warming
- OCS is promising, but the concept needs to be demonstrated.

CONCLUSIONS