Development of a Dynamic Infrared Land Surface Emissivity Atlas based on IASI Retrievals

Rory Gray

rory.gray@metoffice.gov.uk

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Contents

- Background and Motivation
- Atlas Construction
- Preliminary Runs
- Summary and Next Steps

Motivation

NRT atlas

- up-to-date information
- short term variability

• assimilation surface sensitive IR channels over land for NWP (FG for 1dvar)

• apply to other IR instruments such as SEVIRI

• improve Tskin accuracy

• improve land surface emissivity estimates

Emissivity

$$\varepsilon(\lambda) = RAD(\lambda,T) / B(\lambda,T)$$

- $0 < \varepsilon < 1$
- spectral quantity
- LSE varies in time and space, with surface material, roughness, moisture content
- Land surface ε much more variable than sea surface ε

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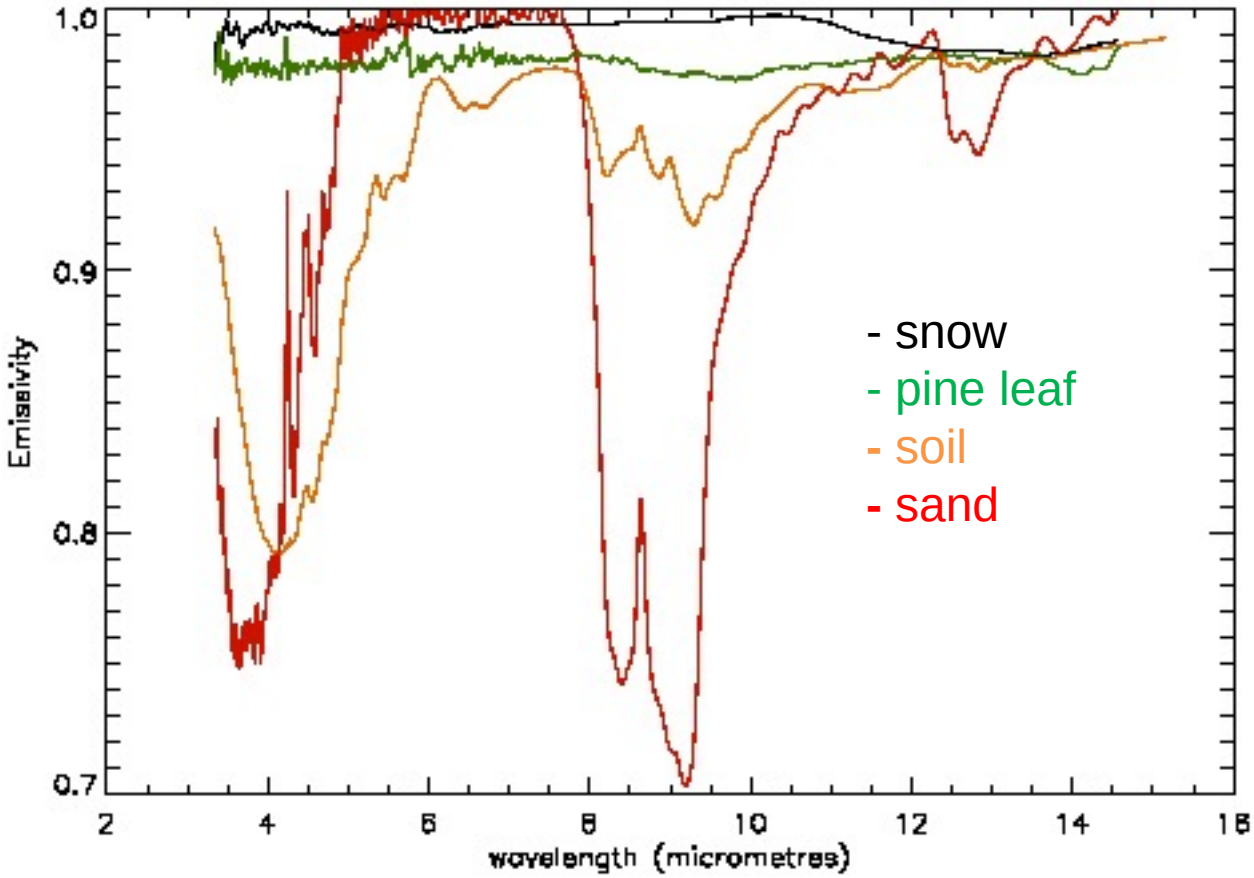
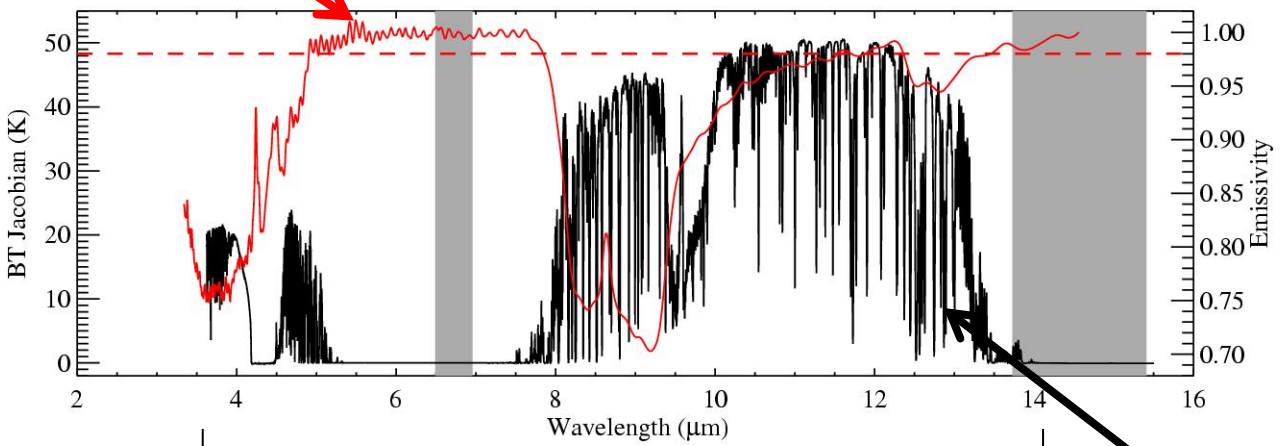
Lab Spectral Emissivities



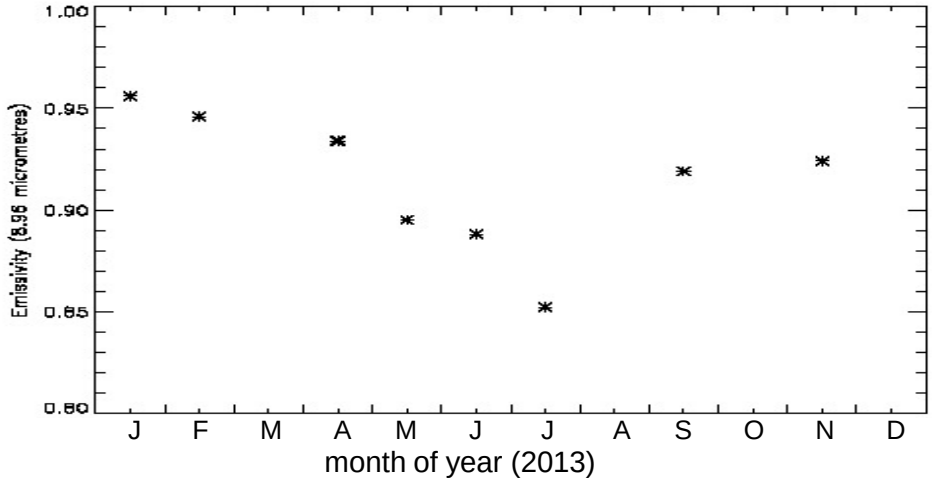
(from UCSB Emissivity Library)

ε of sand (lab spectral analysis)



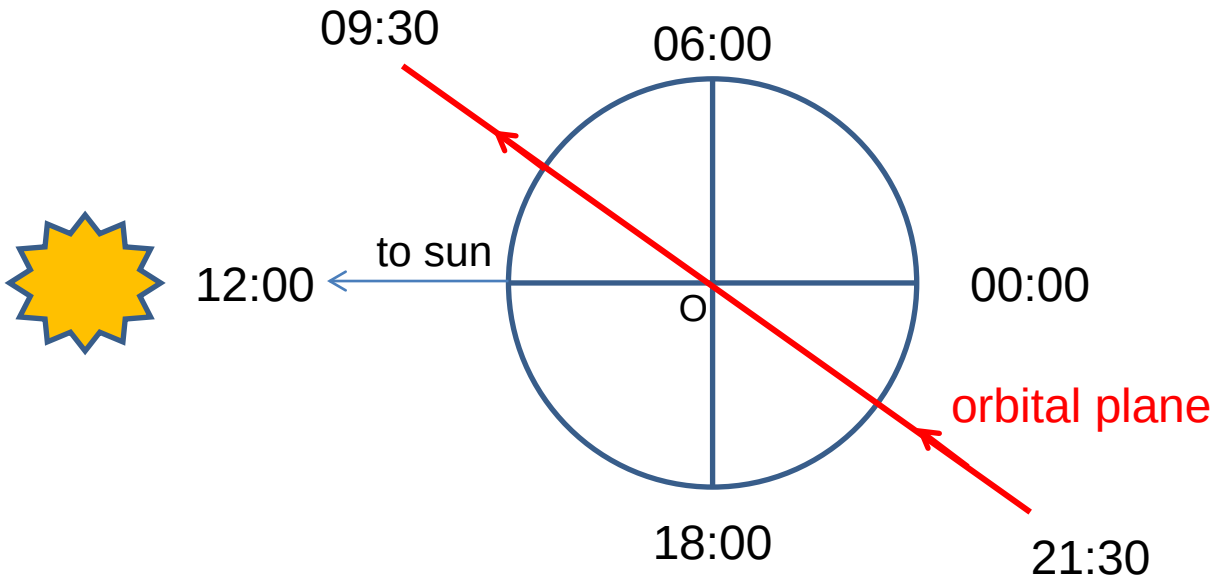
surface emissivity sensitive IR wavelengths

Retrieved Emissivity at [lon,lat]=[-0.50,12.50] at 8.96μm 2013



IASI (Infrared Atmospheric Sounder Interferometer)

- CNES/EUMETSAT
- MetOp-A (2006), MetOp-B (2013)
- Hyperspectral IR Sounder (8461 channels)
- Spectral Range 3.62 – 15.5 μm
- Mid-morning orbit 09:30 (desc) / 21:30 (asc)



1dvar Retrieval of Emissivity

- $\varepsilon(\lambda)$ retrievals from estimation of PC coefficients in 1dvar

- high dimensional data set reconstructed from PC set of reduced dimensionality

- skin temperature, cloud top pressure and cloud fraction also retrieved

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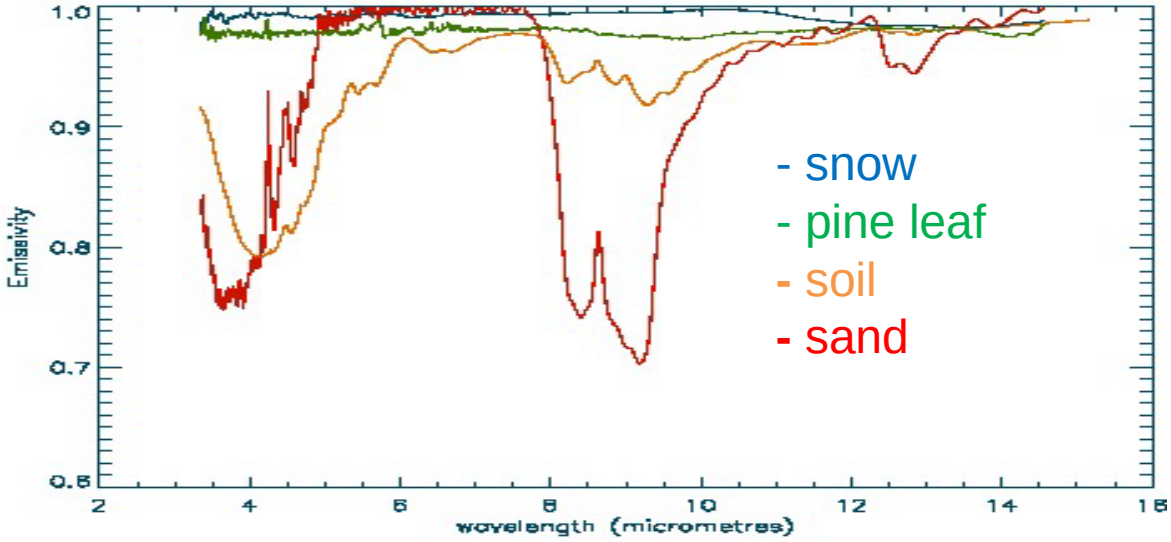
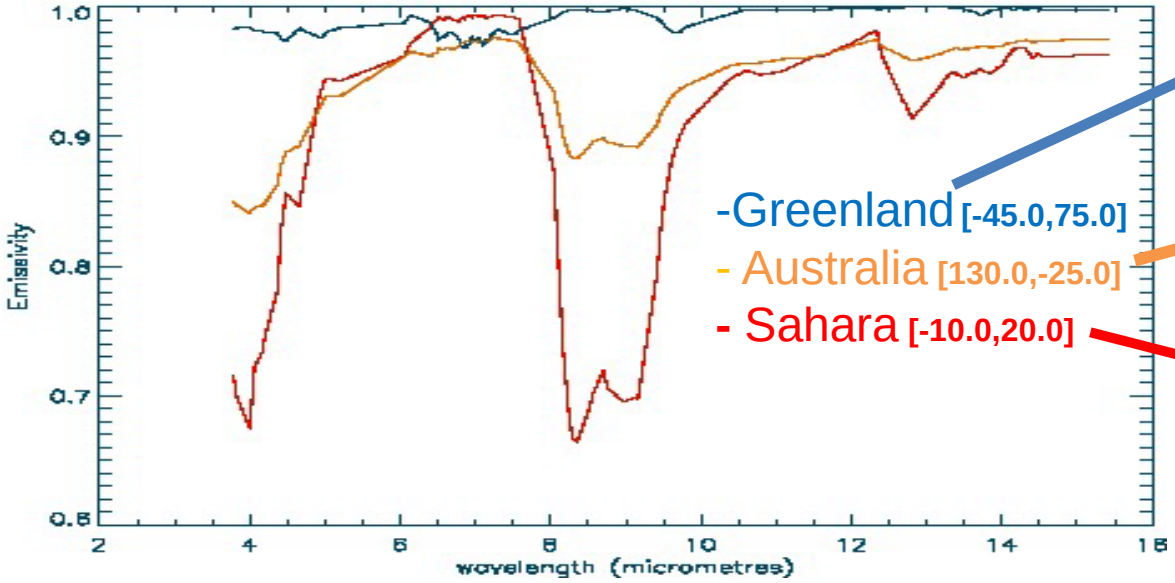
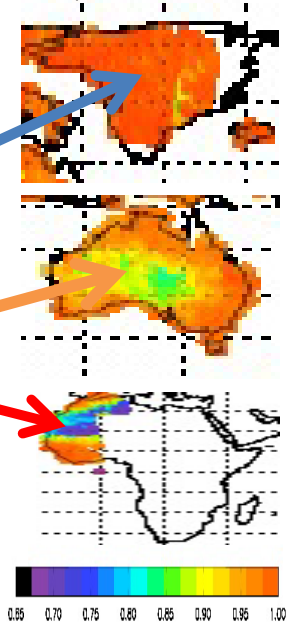
Lab Spectral Emissivities (UCSB Emissivity Library)



1dvar Retrieved Emissivities, 2013010100



8.96μm retrieved ε



Atlas Construction

- Gridded dataset
- emissivity spectral estimate for each gridbox
- NRT updates from 1dvar IASI emissivity retrievals
  - -> initially mean for each gridbox
  - -> eventually data driven Kalman Filter

Kalman Filter Implementation

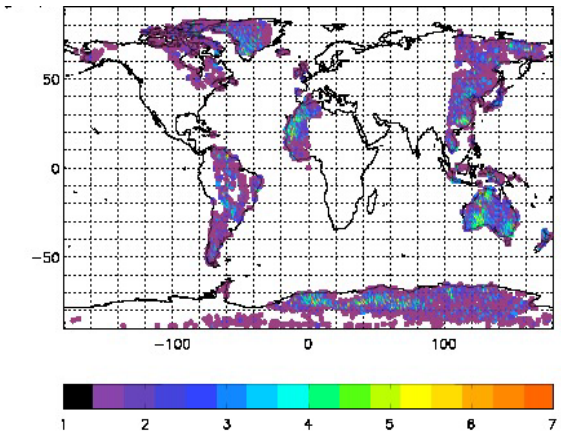
- Initial $\underline{\varepsilon}$ over each gridbox
- persistence model for each $\varepsilon(\lambda)$ in each gridbox
- 1dvar retrievals as measurement updates
- measurement noise from 1dvar analysis covariance matrix
- update $\underline{\varepsilon}$ for each relevant gridbox

Atlas construction IASI chan.1884 (8.96μm)

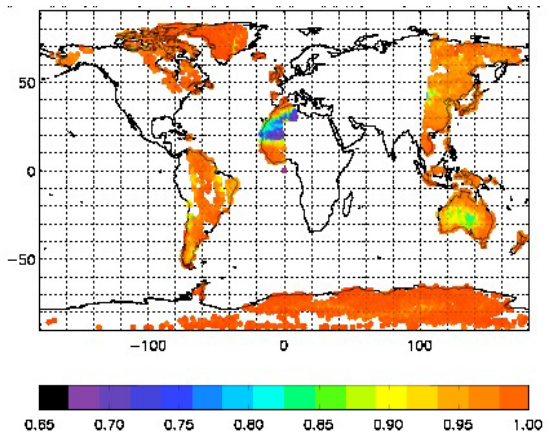
Retrievals

T_0

No. pts per gridbox



Emissivity



Atlas construction IASI chan.1884 (8.96μm)

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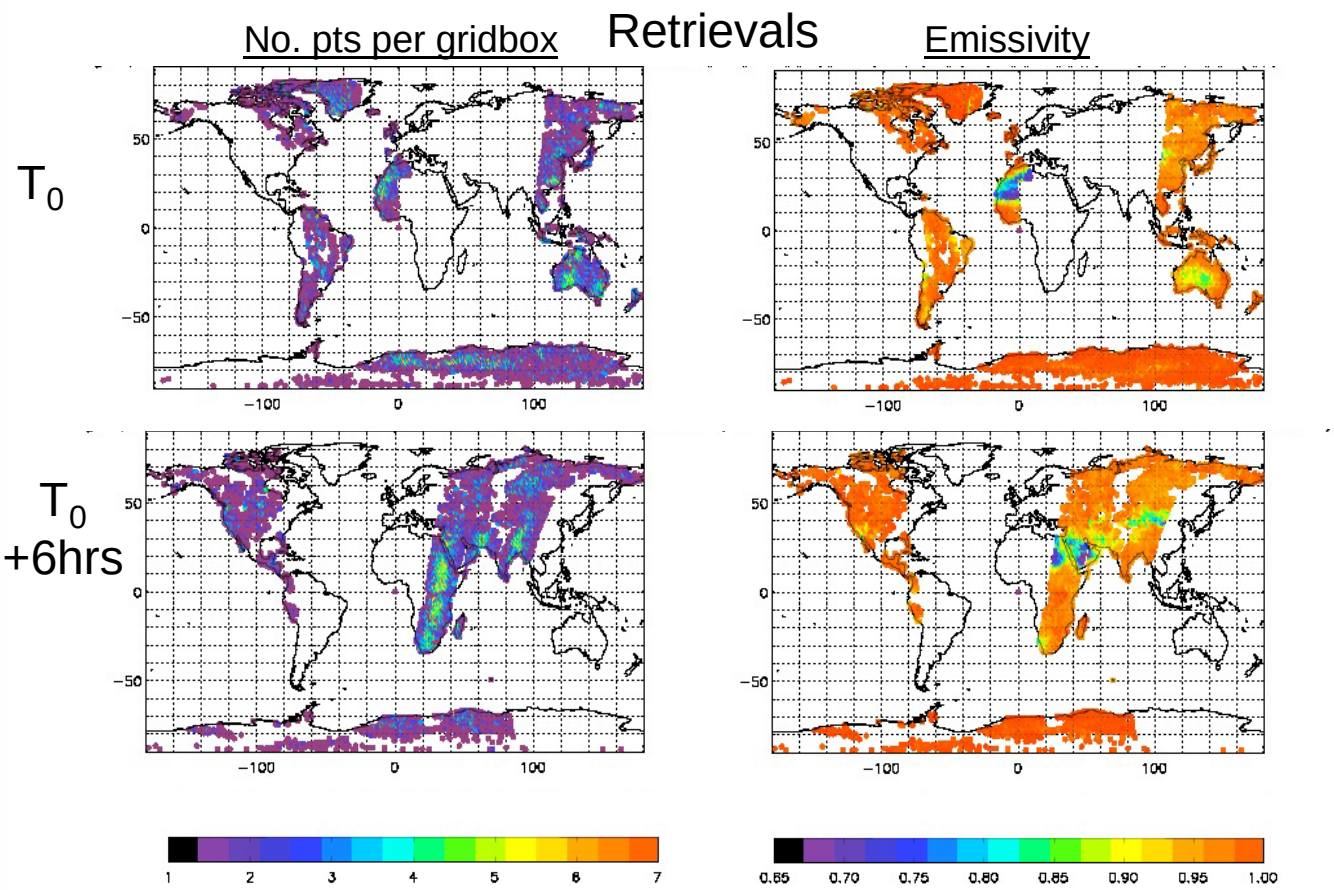

Atlas construction IASI chan.1884 (8.96μm)

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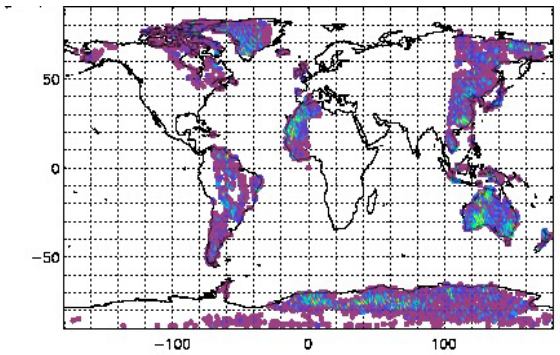
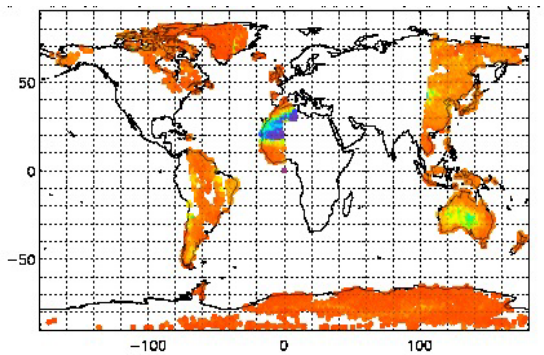
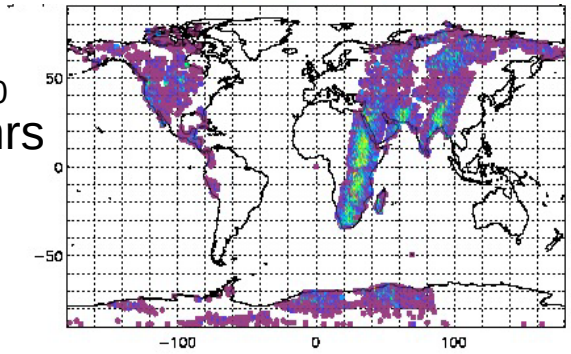
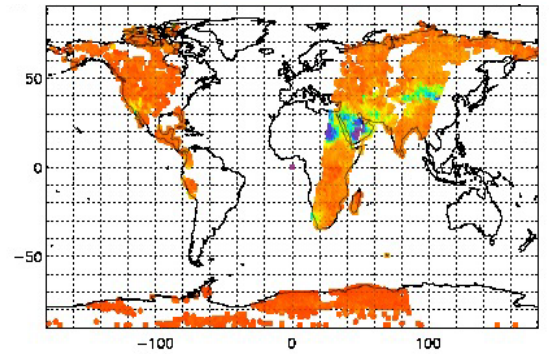
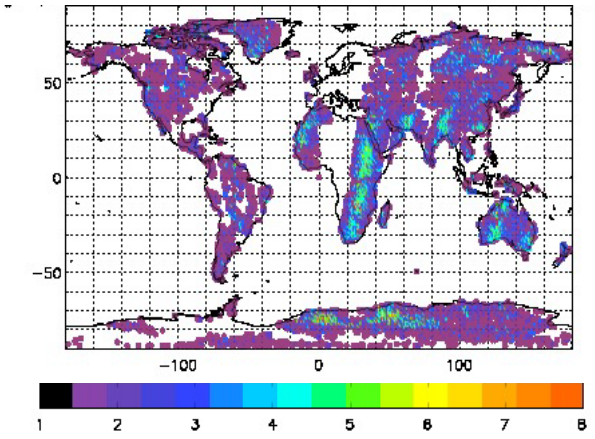
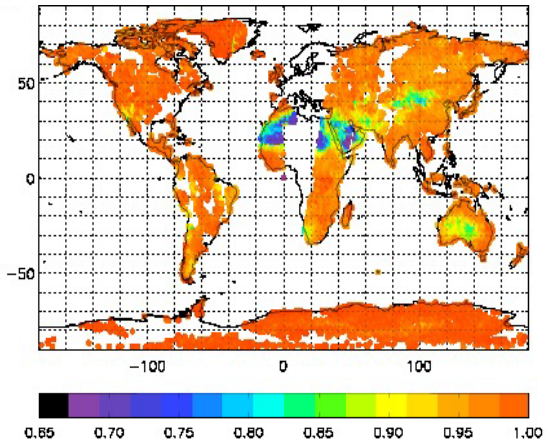
	No. pts per gridbox	Retrievals	Emissivity
T_0			
T_0 +6hrs			

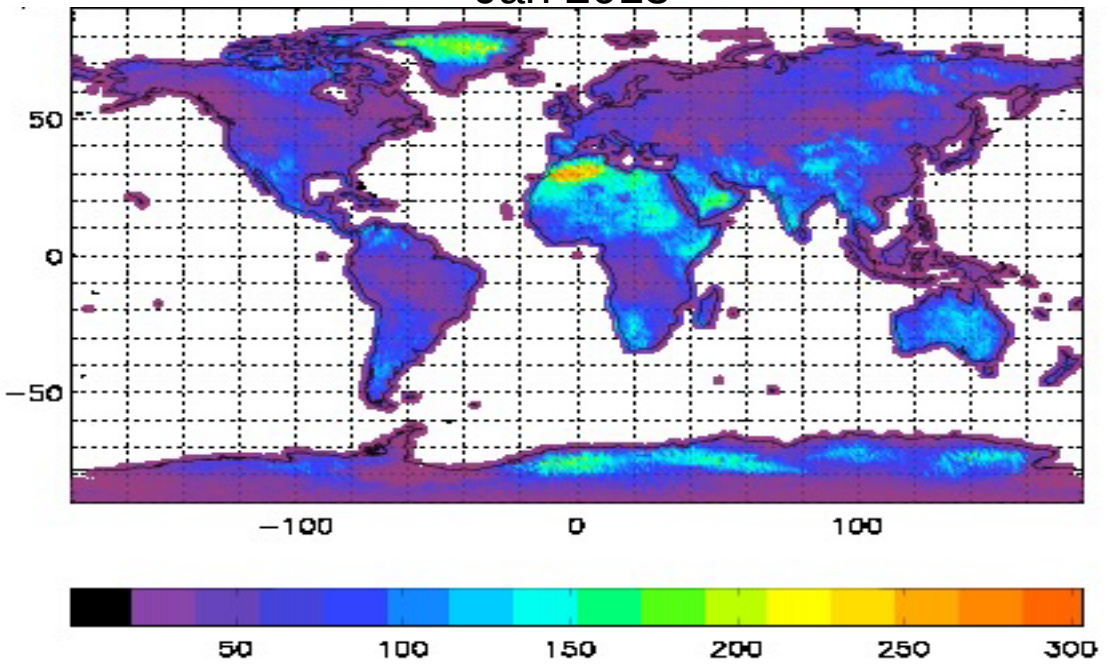
Updated Atlas at T_0 + 6hrs



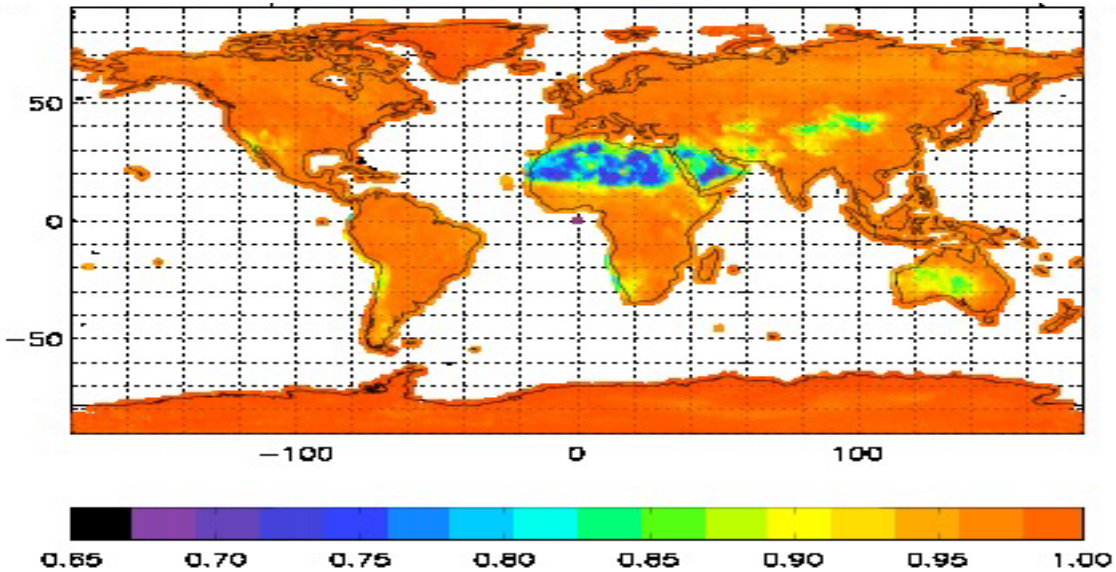


Atlas construction IASI chan.1884 (8.96μm)

Jan 2013



No. pts per gridbox



Emissivity

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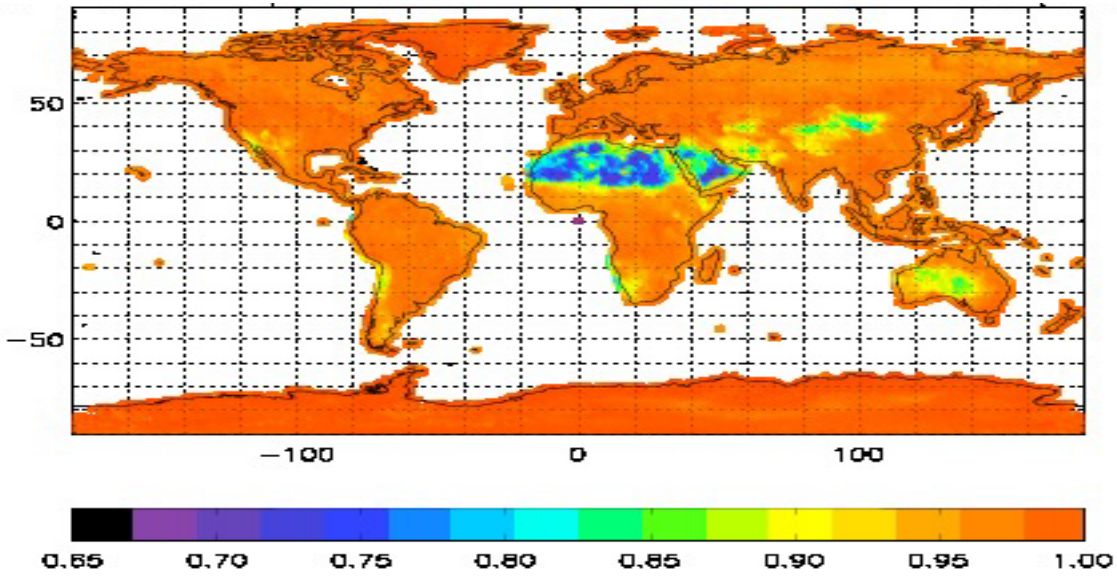
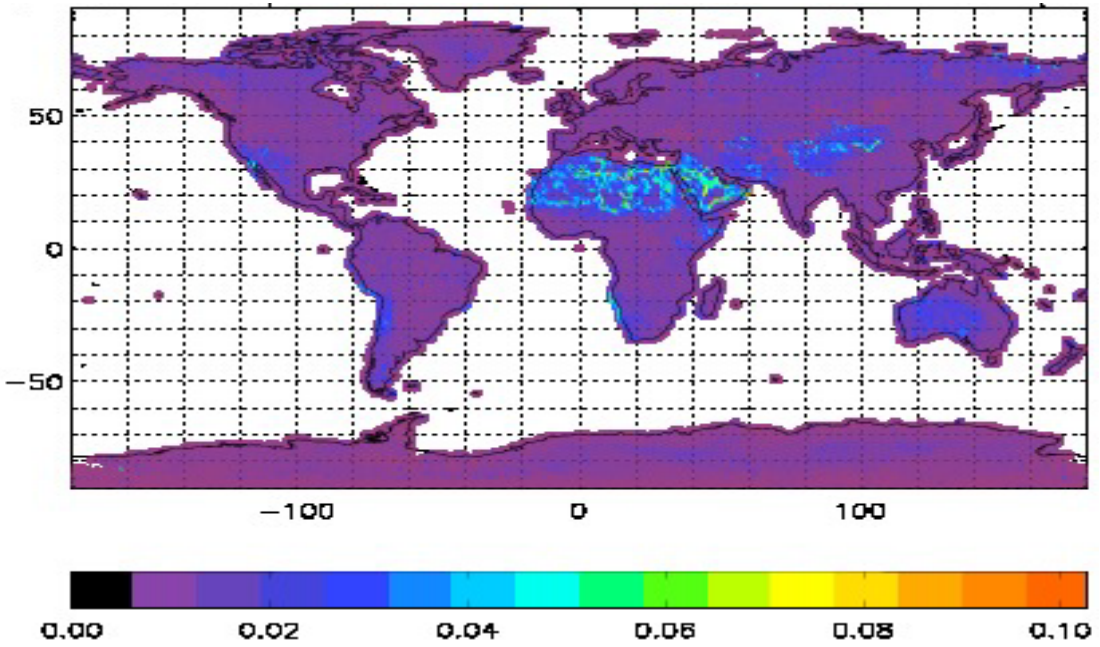
Atlas construction IASI chan.1884 (8.96μm)

Jan 2013



Emissivity



$\sigma_{emissivity}$

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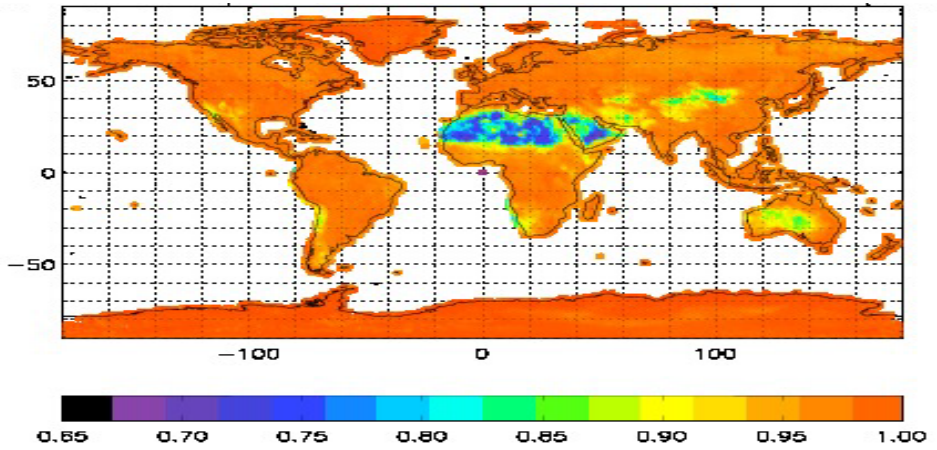
Seasonal Emissivity Variation 8.96μm



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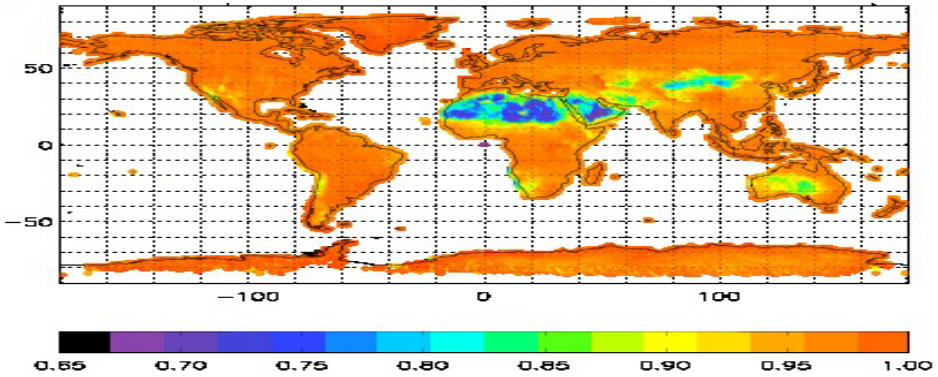
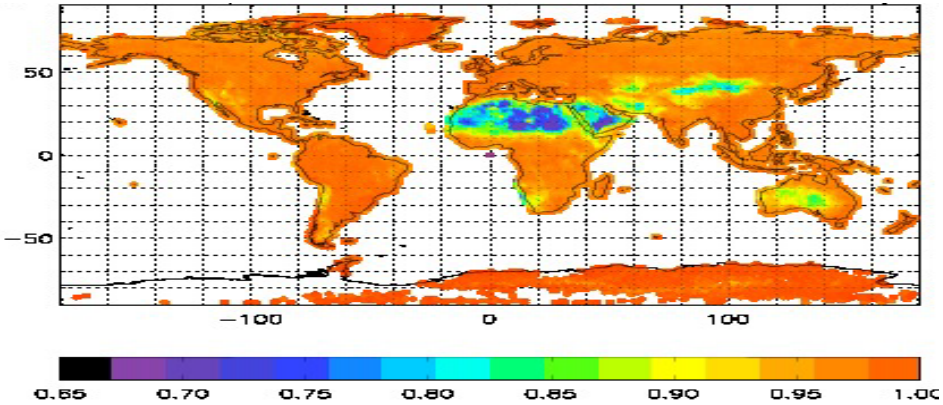


Apr 2013



Jul 2013

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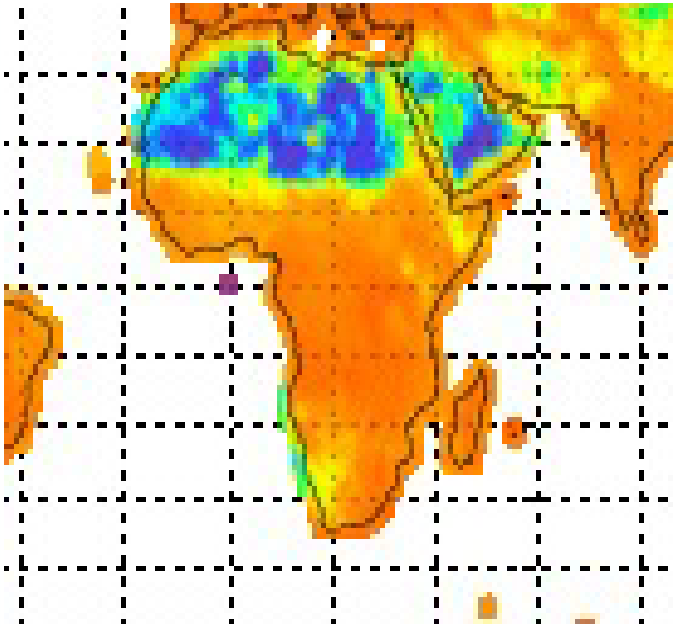

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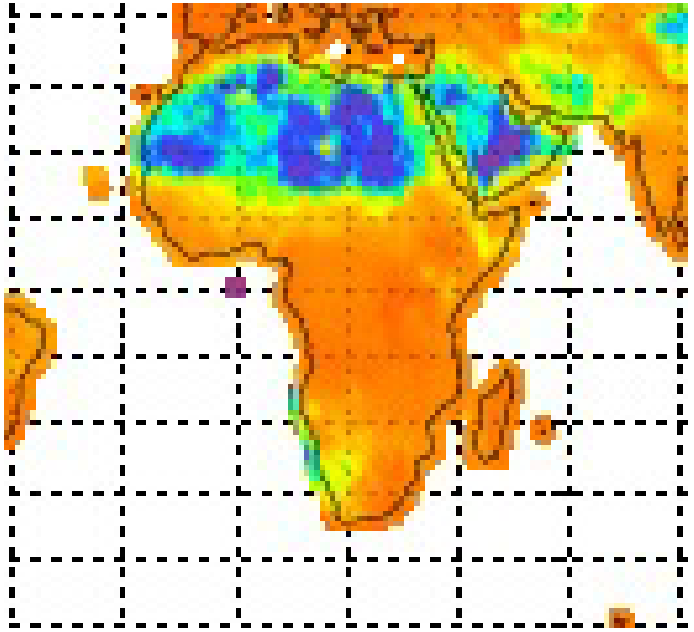
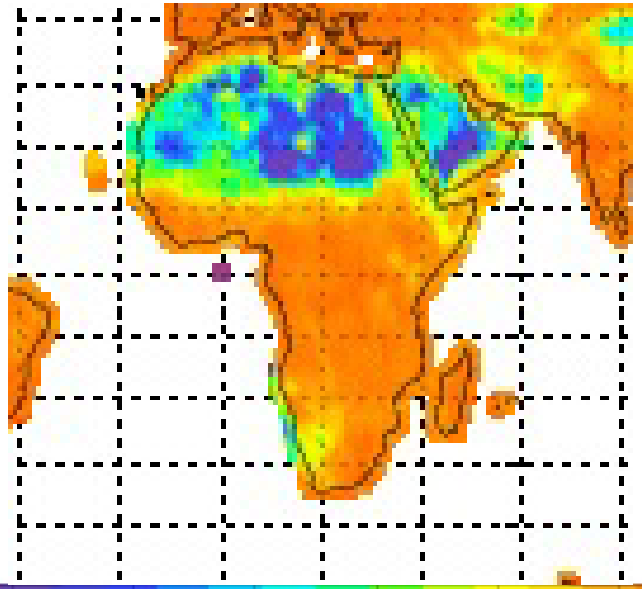


Apr 2013

ε variation over seasons, latitude variation of low ε Sahara region



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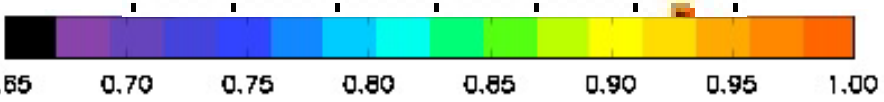
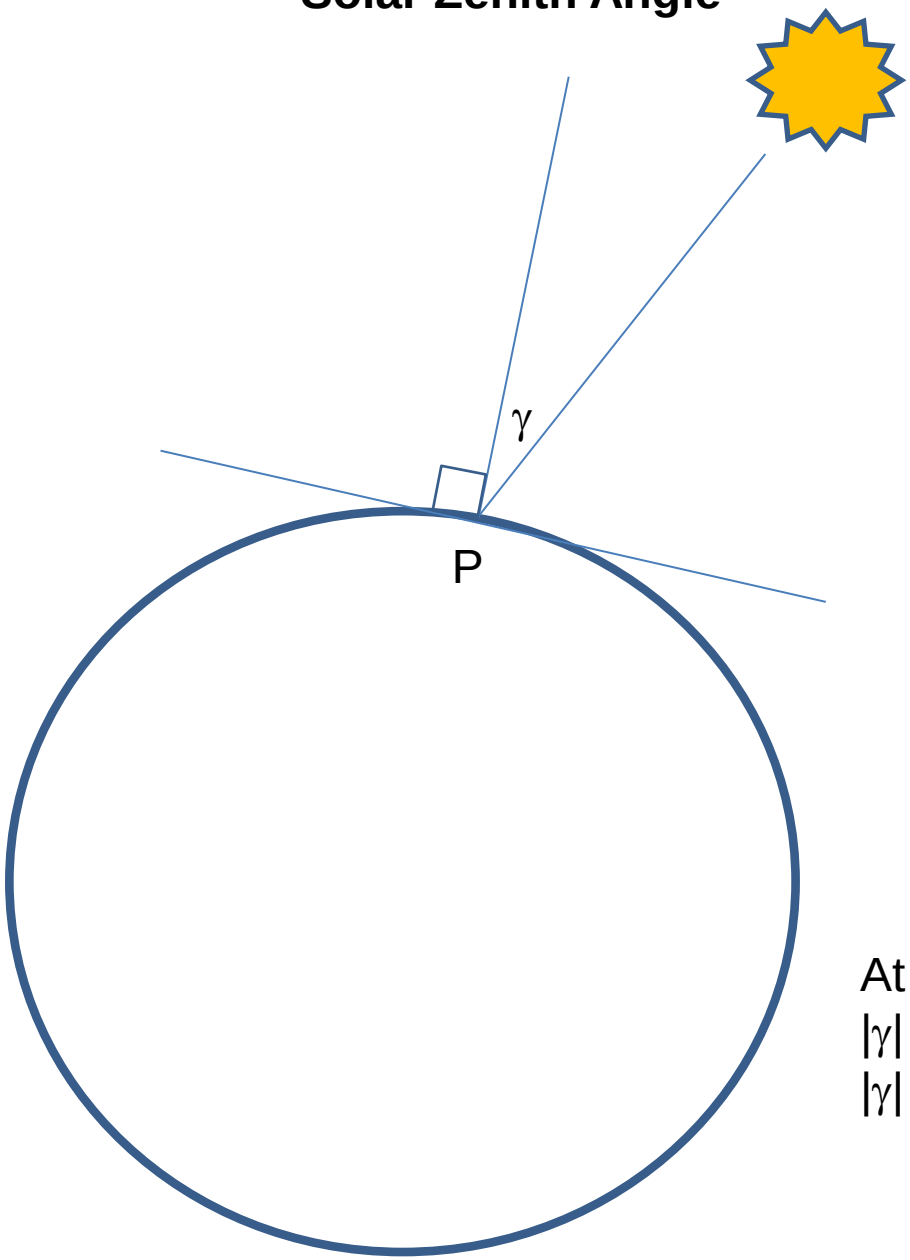


Solar Zenith Angle

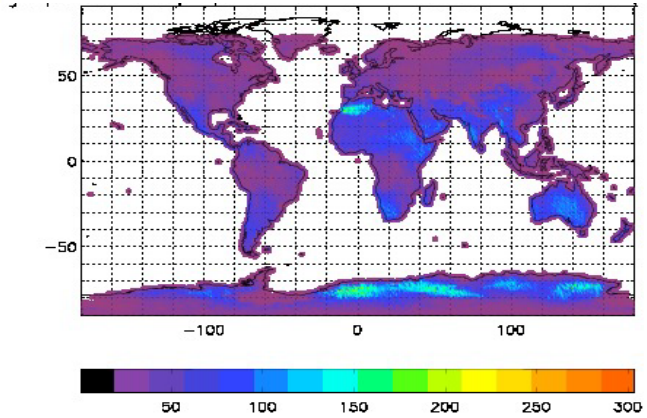


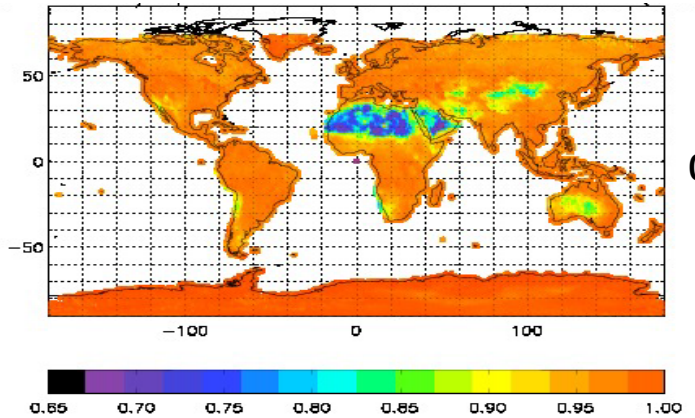
At P:
$|\gamma| > 90^o$ night
$|\gamma| < 90^o$ day

Jan 2013 day-night emissivity differences 8.96μm

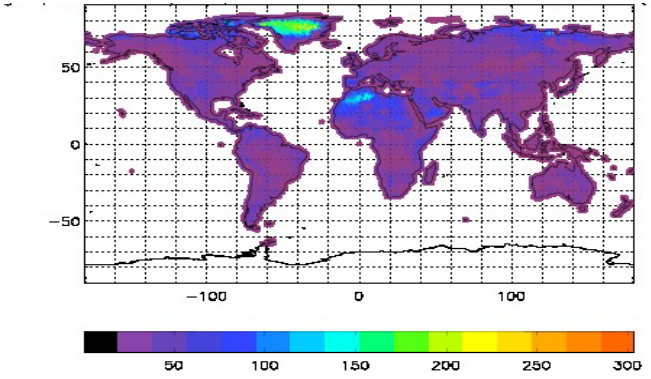
no. pts per gridbox

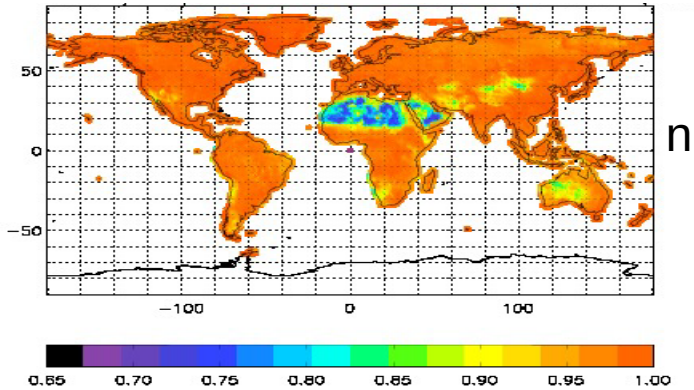
emissivity





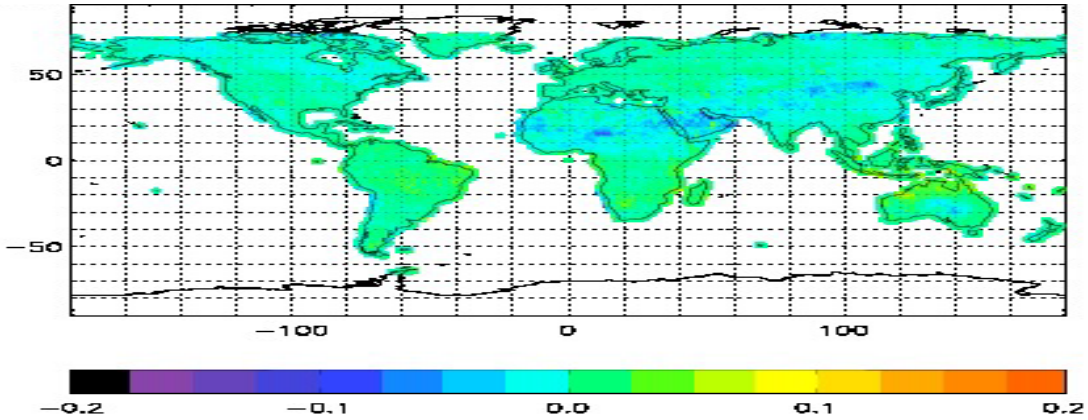
day





night

$\varepsilon_{day} - \varepsilon_{night}$



day-night

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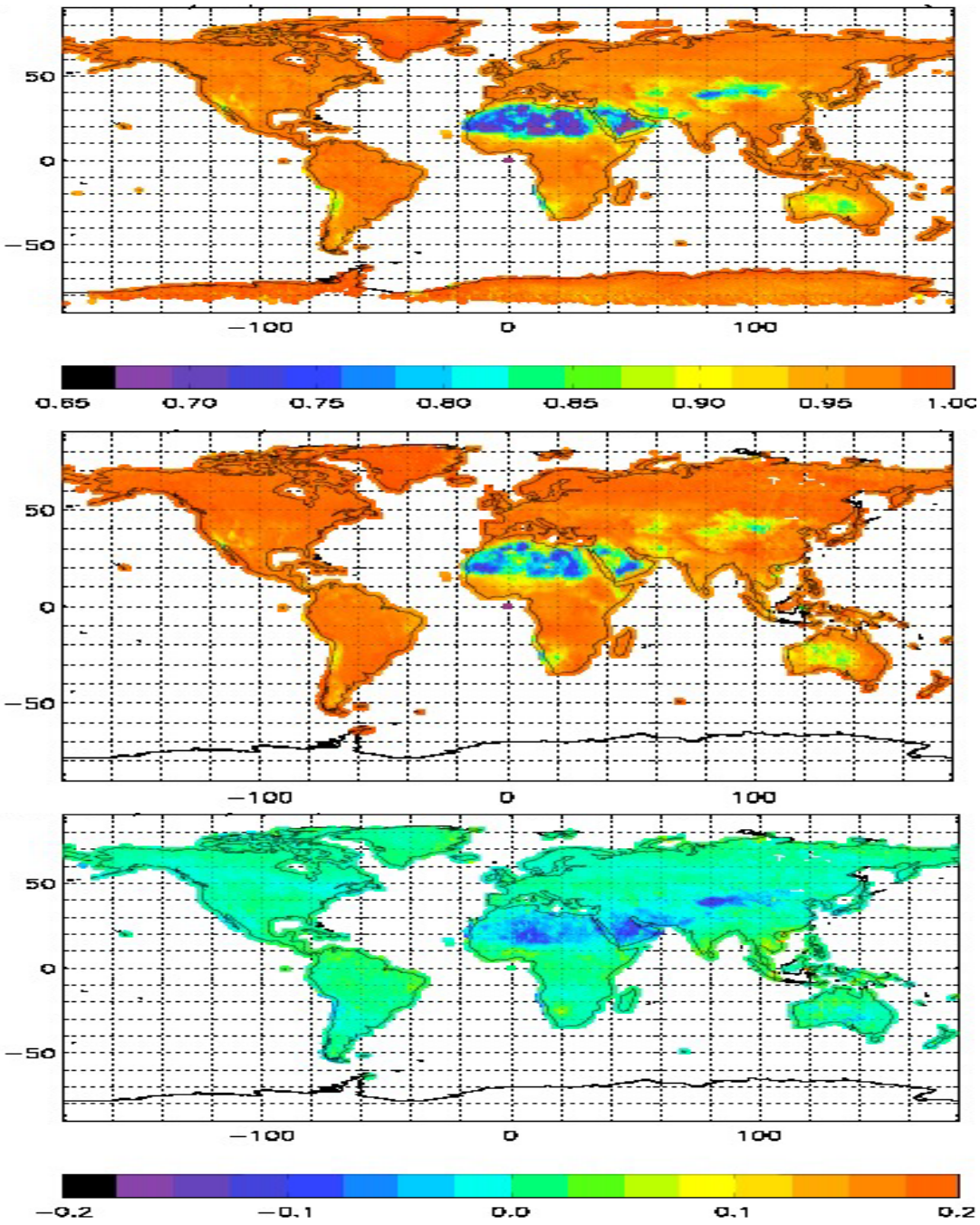
Apr 2013 day-night emissivity differences 8.96μm



day

night

day-night

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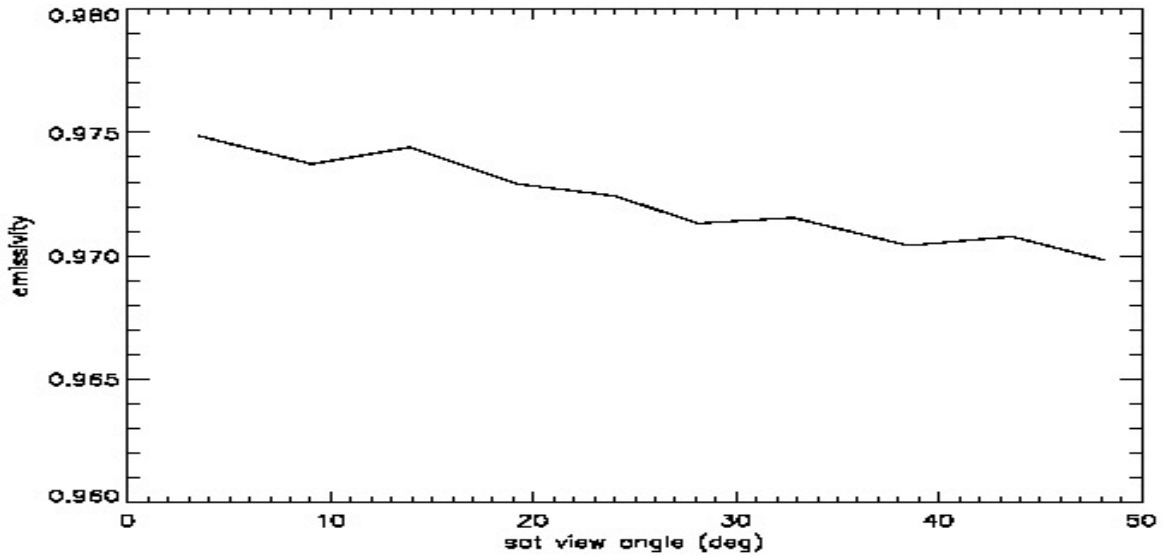
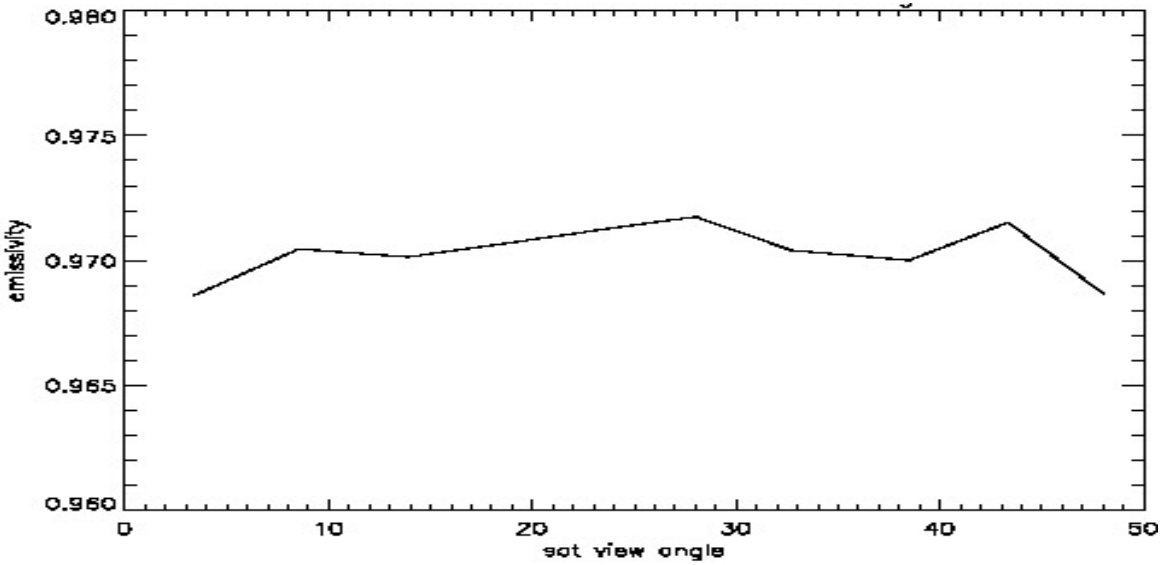
Scan Angle Dependence

IASI window chan 756 (11.99μm, 833.75 cm^{-1})



Jan 2014



July 2014

Summary and Next Steps

- KF implementation
  - R-noise from 1dvar analysis error cov matrix
  - Q-noise from UWIREMIS (or derived variation)
  - P cov estimate

- Snow consideration

$$\varepsilon(\lambda) = (1\text{-sfc})*\varepsilon_{retrieved}(\lambda) + sfc*\varepsilon_{snow}(\lambda)$$

- Diurnal Variation

- Scan angle dependence

- Test and Validation against other sources and instruments

- Application to other current and future IR instruments
  - SEVIRI, HIRS, MTG-IRS, IASI-NG

- Use in Met Office Data Assimilation system

- Available to all centres