

The assimilation of hyperspectral infrared radiances over land

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- Assimilation of AIRS and IASI at the Met Office
 - Effects of surface properties on IR radiances
 - Surface emissivity: retrieval in 1D-Var
 - Simulation study
 - Results of real 1D-Var analysis over land
 - Forecast impact trials
 - Conclusions





Met Office

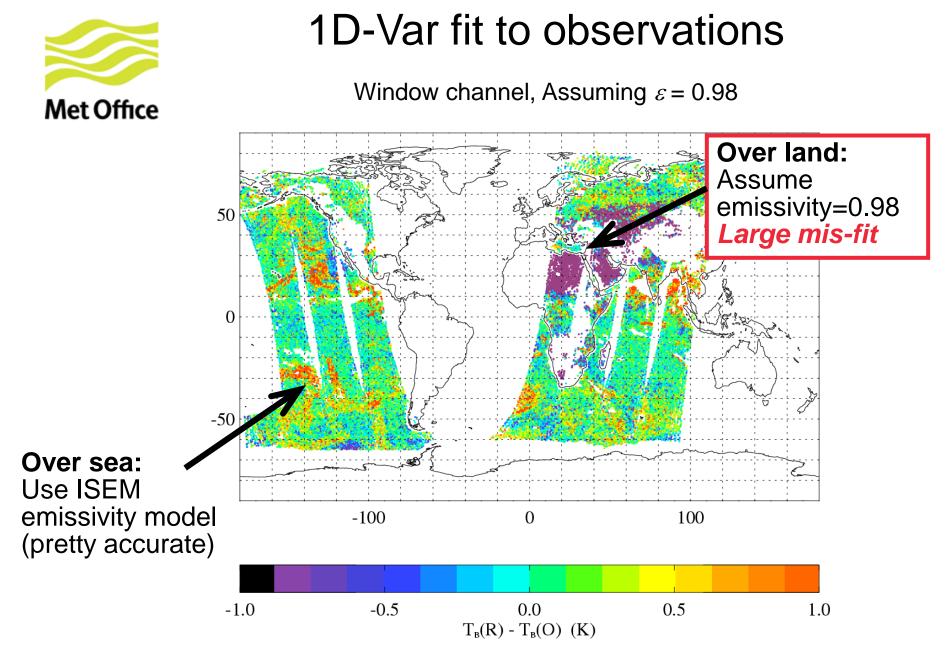
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- AIRS: Warmest FOV; Up to 141 chans
- IASI: Most homog. FOV; Up to 138 chans
- **1D-Var** analysis in OPS (before 4D-Var)
- QC: Check for convergence *before* 4D-Var
- Retrieve auxiliary parameters not analysed in 4D-Var
 - Cloud top height, cloud fraction
 - Surface temperature
- Assimilate radiances directly in 4D-Var

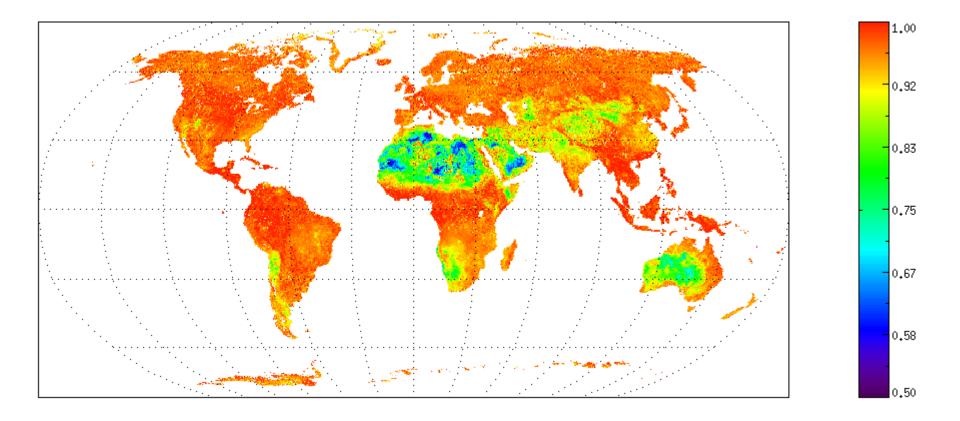


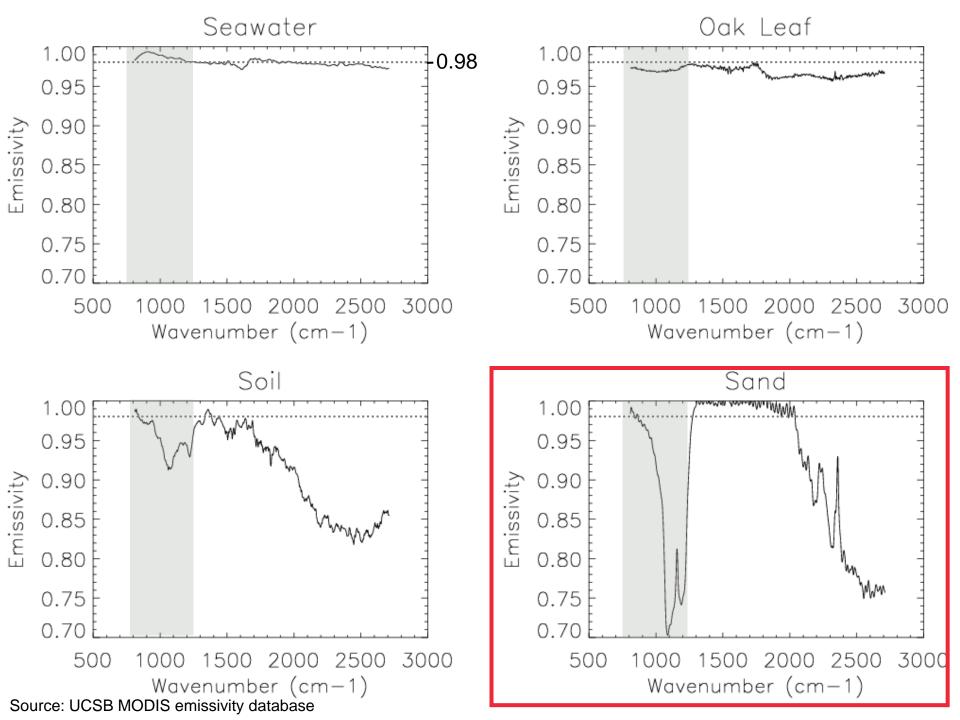
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Land surface emissivity (8.5µm) (From NASA AIRS product, June-August 2008)

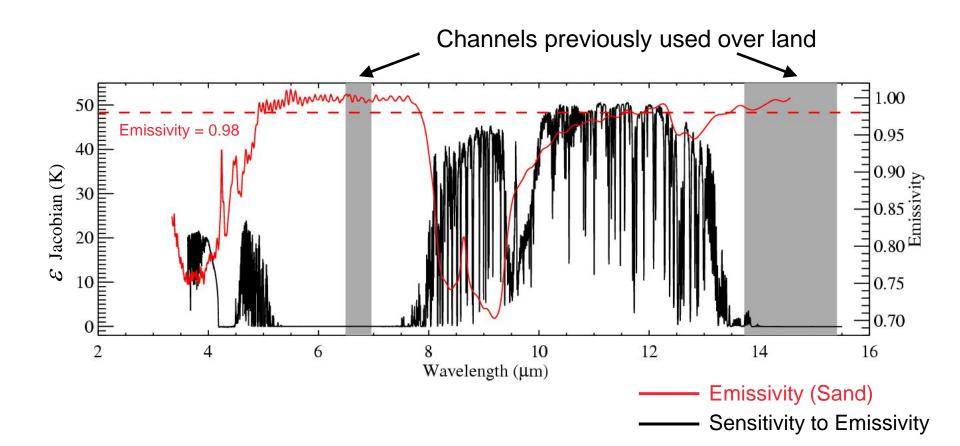


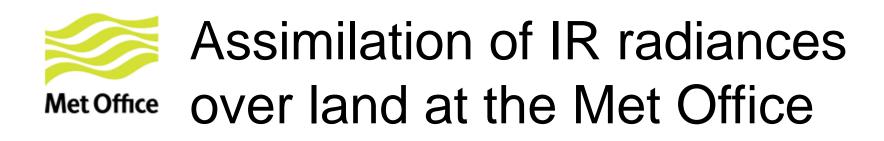




Surface sensitivity of IASI

(US Standard Atmosphere)

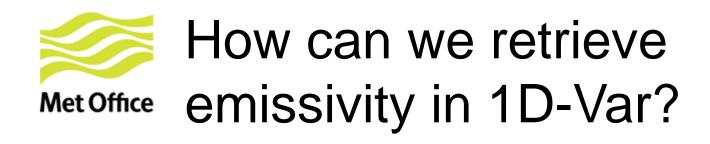




- Until July 2011:
 - Assumed infrared emissivity $\mathcal{E} = 0.98$ over land
 - Not good enough can't use channels peaking below ~ 400hPa
- Options to increase data use over land
 - Use fixed emissivity "atlas"
 - Use land surface model / surface type atlas
 - Retrieve surface emissivity from observations



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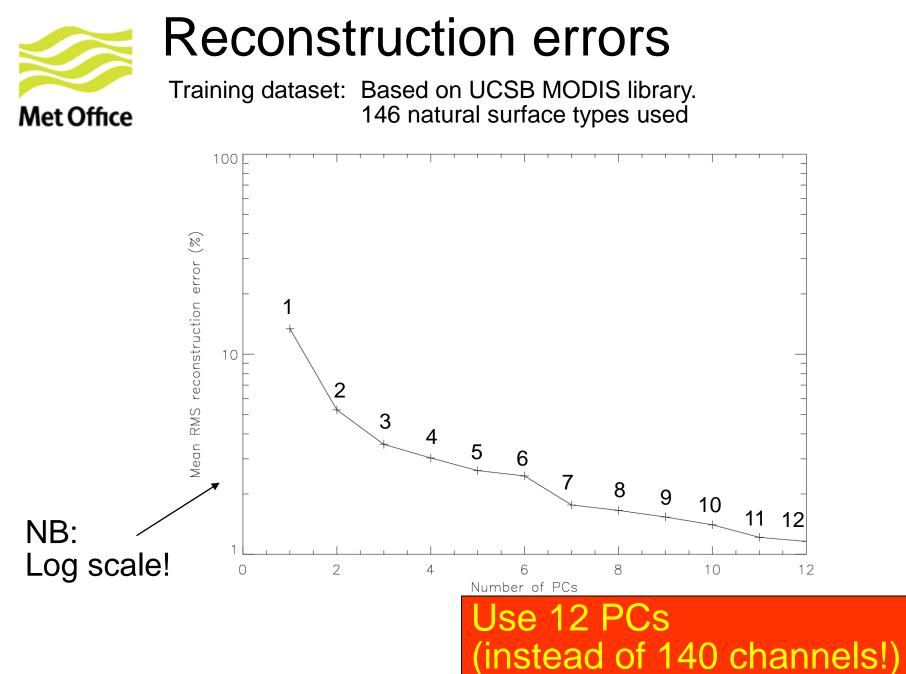
- IR surface emissivity has large spectral variability
- Retrieving emissivity in *n* channels adds *n* unknowns to 1D-Var state vector
- Use principal component analysis to "compress" the emissivity spectrum
 - Just a few unknowns



Advantages of PC-based emissivity analysis

- PC-based approach
 - Use prior knowledge of spectral variation of emissivity (from lab measurements)
 - Constrains solution to realistic values
 - Retains realistic correlations between channels

\rightarrow Helps to separate T_{skin} and $\mathcal{E}(\lambda)$

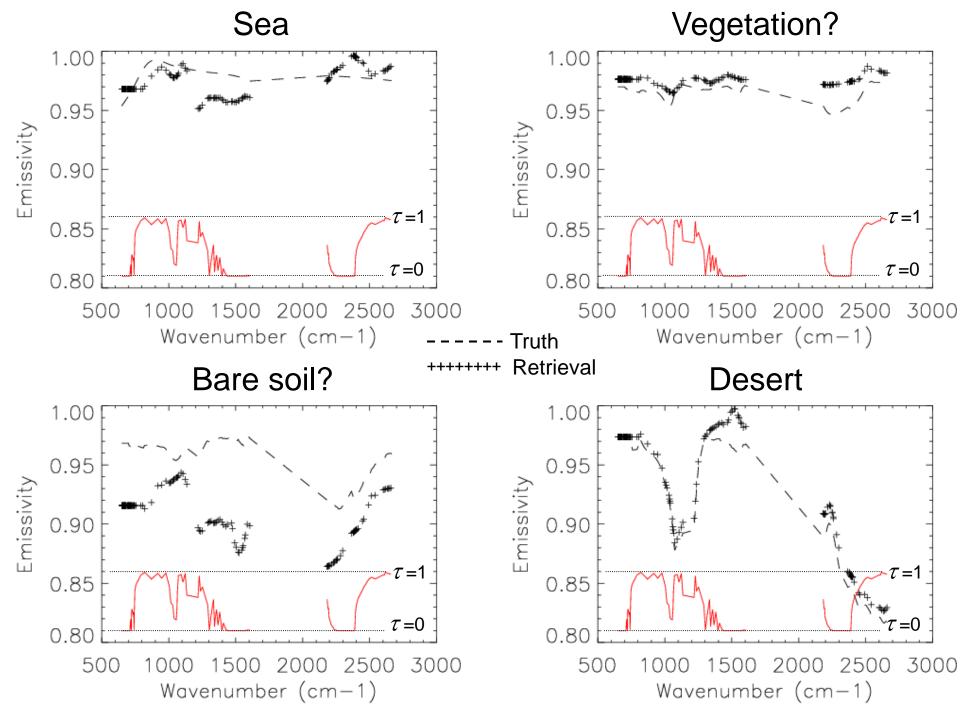


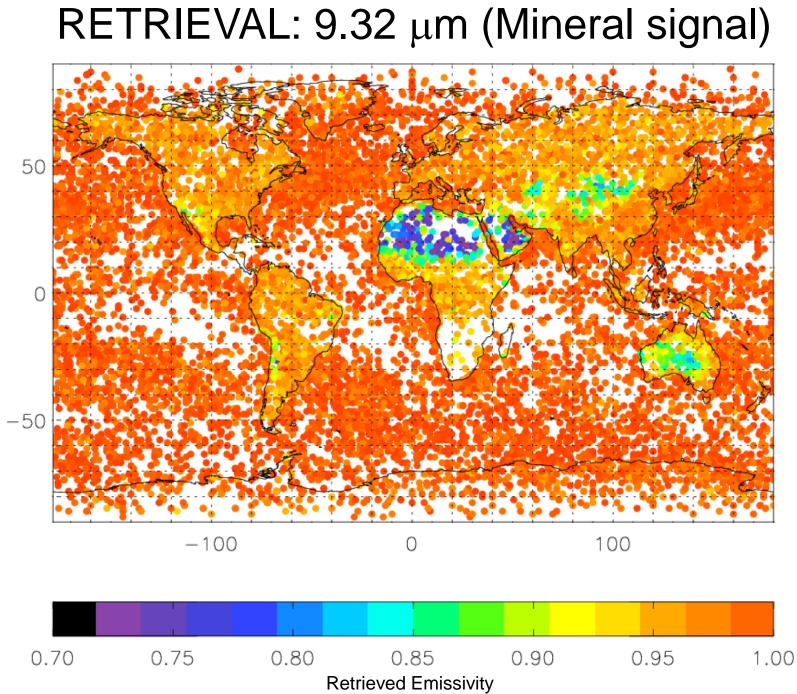


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Experiment: 1D-Var analysis Met Office from simulated AIRS radiances

- Objective: To demonstrate 1D-Var analysis of emissivity
- Radiance simulated using RTTOV
- 13495 atmospheric profiles from ECMWF ERA40 dataset
- Surface emissivity from UWisc/CIMSS IR emissivity atlas (2006 data used)
- Simulated observation errors added to radiances
- Fixed emissivity first guess = 0.98 over land
- 1D-Var includes simultaneous T, q retrieval



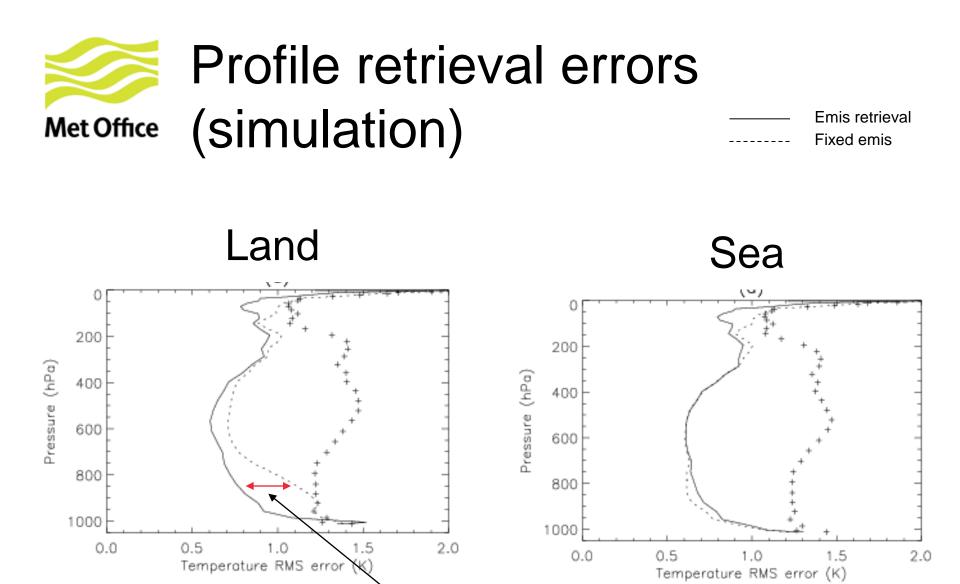


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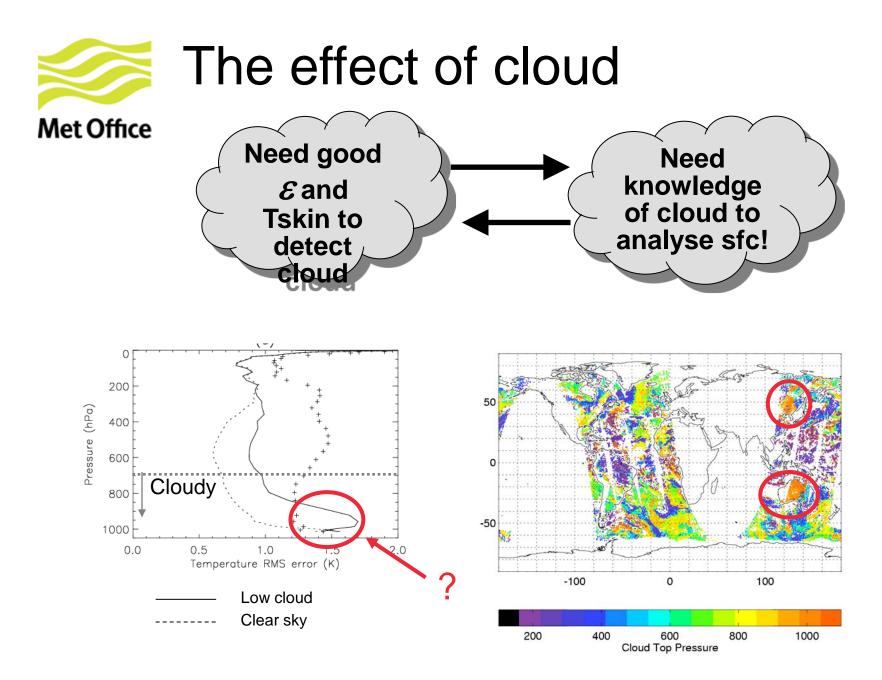


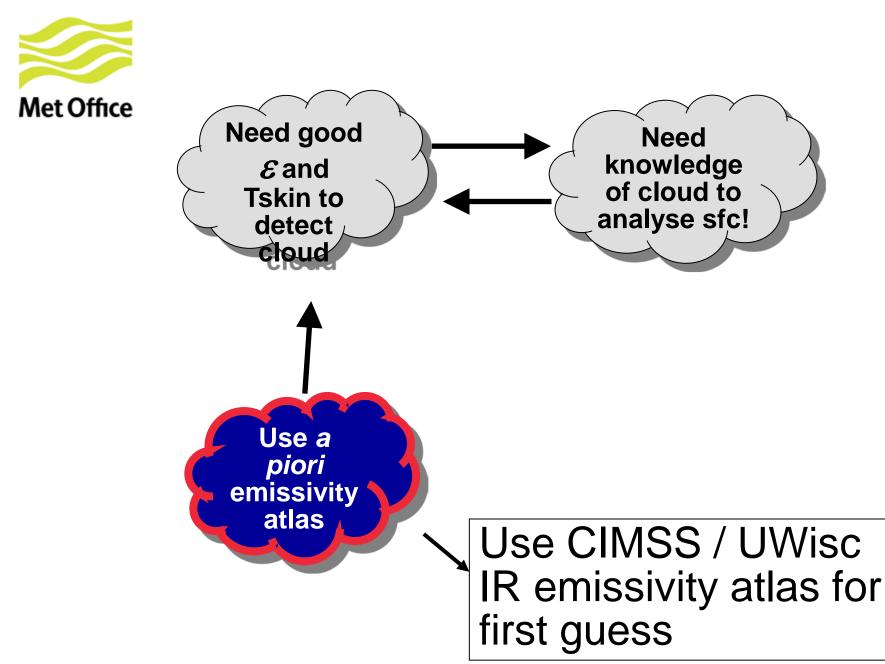
1D-Var simulation results

Met Office \mathcal{E} from 1DVar *E*=0.98 home/h03/frep/ir_land/1dvar/Retrieved_Profiles.d frep/ir_land/1dvar_emis_retr/Retrieved_Profiles.d I_{şkin} bias П --50 -50 -1 -2 0 Bios (K) Bins (K) 03/frep/ir_land/1dvar/Retrieved_Profiles.d 920hPa **TRMS** 0.2 0.4 0.6 8.0 0.2 0.4 0.8 RMS Error / BG Error RMS Error / BG Error



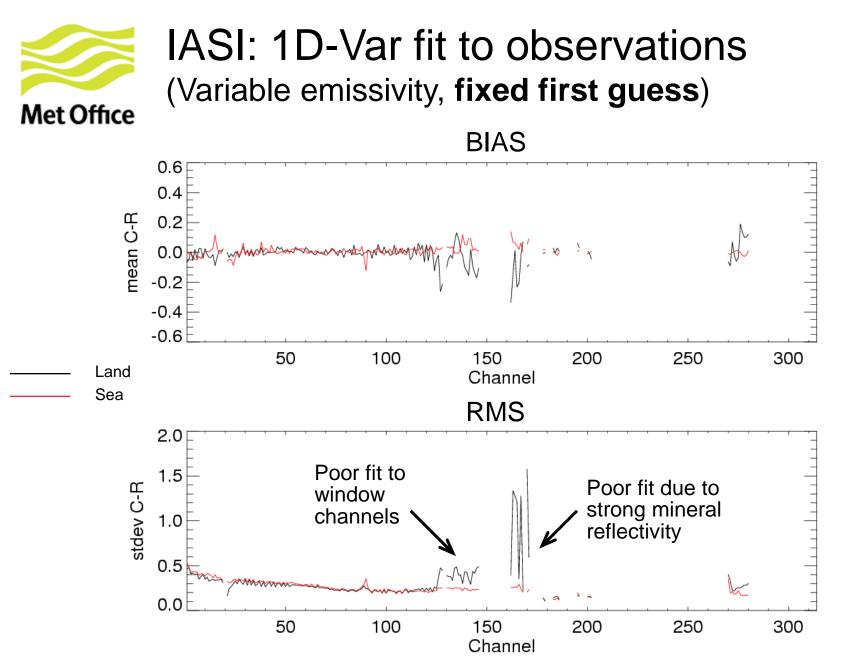
Improvement due to 1D-Var emissivity

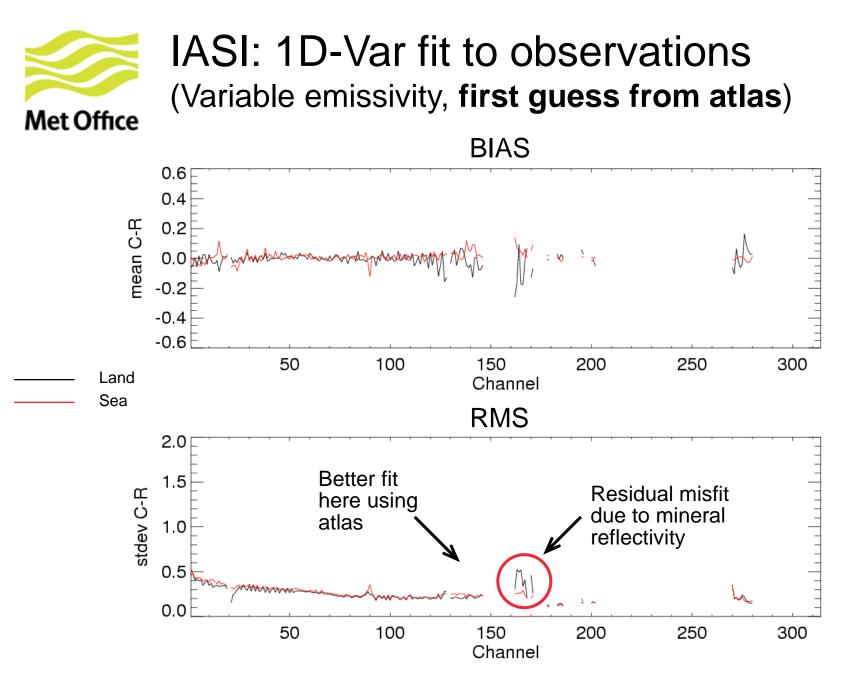


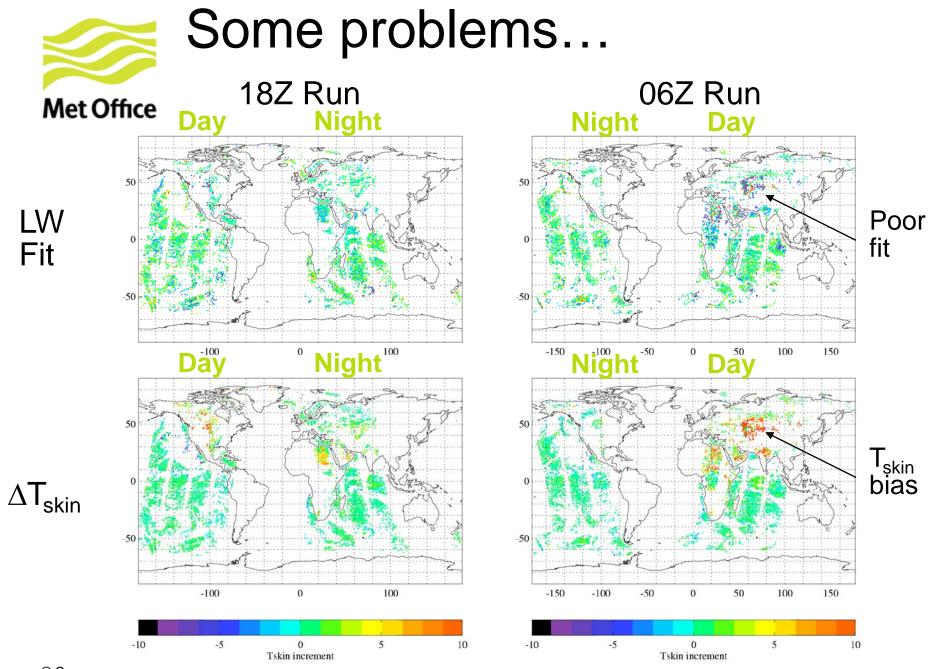




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Day/Night biases Model surface temperature?

- Large surface temperature increments (>10K)
 - Hot / desert surfaces
 - Daytime
- Probably seeing systematic biases in the model surface temperature
- Could be related to...
 - Soil temperature?
 - Surface heating/cooling rates?
 - Fluxes?
 - Soil thermal properties (conductivity, heat capacity)?
 - Soil moisture?



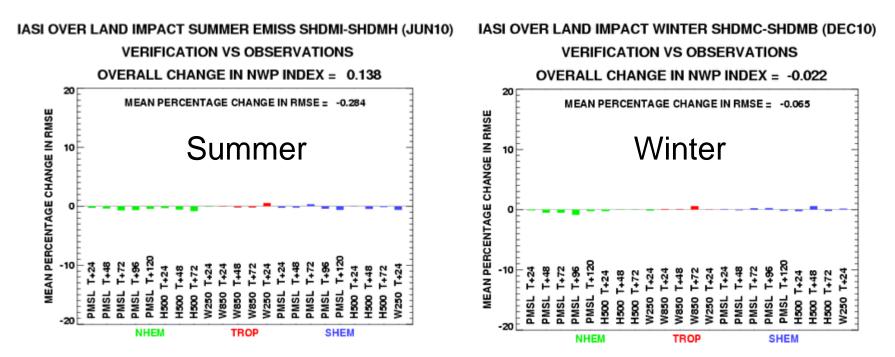
Day/Night biases How to deal with them...

- Interim solution:
 - Use data over land operationally at NIGHT ONLY
- Longer term:
 - Introduce QC / data filtering
 - Avoid "hot" surfaces during daytime? (> 300K)
 - Filter observations by size of T_{skin} increments?
 - Need a better understanding of model T_{skin} biases
 - Assimilation of IASI T_{skin} in land surface scheme



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- Modest improvements in Summer in most fields
- Smaller/neutral impact in Winter



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Conclusions

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- Until July 2011, low-peaking IR sounding channels were rejected over land
- Improvements now implemented for IASI:
 - Analysis of spectrally-varying surface emissivity
 - Assimilate same channels over land and sea (except window channels)
 - "First-guess" global emissivity atlas helps with cloud analysis
- Poor fit to observations over daytime deserts
 - Systematic biases in model surface temperature (work underway to investigate this)
- Using surface-sensing channels **at night only** gave positive impact in trials
 - Modest improvement in NWP accuracy



Questions and answers