Retrievals of land, sea and ice surface properties at the Met Office

Jean-Claude Thelen & Chawn Harlow

Introduction

Recently, it has become standard practice to assimilate raw satellite radiances directly into the forecast models, which has led to a significant increase in forecast accuracy. The study of land, sea and ice surface properties (emissivities, reflecatnces and temperature) in the microwave, infrared and the short-wave have been the focus of several airborne campaigns carried out by the Met Office over the past decade in order to promote and improve the assimilation of radiance measurements into the Met Office Unified Model.

Moreover, there has been a growing interest in hyperspectral remote sensing of the Earth's surface throughout the electromagnetic spectrum, a technique which has established itself as an important tool in a variety of fields ranging from agriculture, defence applications, mineral exploration and environmental monitoring, to archaeology and seismology. Research into the retrieval of the land, sea and ice surface properties at the Met Office leads to a better understanding of the underlying physical processes and thus allows us to gain more and more accurate information about the underlying surfaces.

Instruments and Campaigns

Radiometric Instruments:

Instrument	Spectral Range	Channels	Viewing Angle
Met Office Airborne Research Interferoemeter Evaluation System (**ARIES**)	550-3000 cm^{-1}	~2450	-5° to +55° nadir and zenith with 2.5° FWHM
Met Office Shortwave Spectrometer (**SWS**)	300-1134nm and 941-1706 nm	256, 200	0° to 360° with 4° FWHM
Met Office Spectral Hemispheric Irradiance Measurement (**SHIMS**)	300-1134nm and 941-1706 nm	256,200	hemispherical
Met Office Microwave Airborne Radiometers Scanning System (**MARSS**)	89Ghz, 157 Ghz, 183±1 Ghz, 183±3 Ghz, 183±7Ghz	5	±40° nadir and zenith with 7-11° FWHM
JPL Airborne Visible/Infrared Spectrometer (**AVIRIS**)	400-2500 nm	220	Nadir looking with a field of view of 30°
NASA National Polar - Airborne Sounder Testbed – Interferometer (**NAST-I**)	645-2700 cm^{-1}	~8200	±48°
Infrared Atmospheric Sounding Interferometer (**IASI**)	645-2760 cm^{-1}	~8460	±49°

Campaigns:

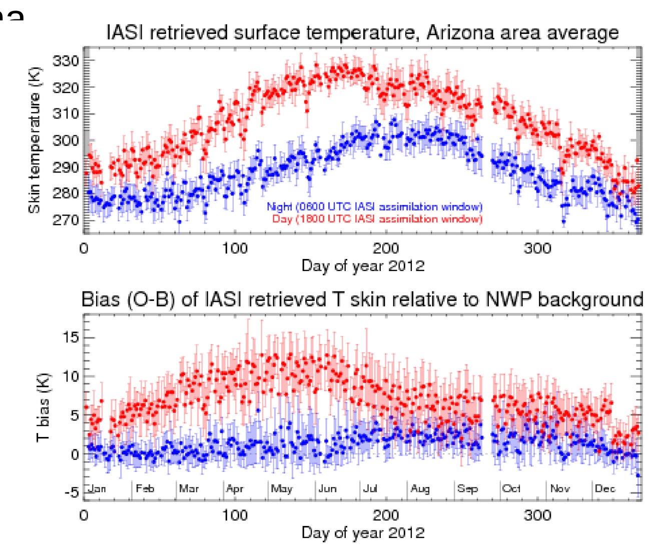
Date	Campaign	Location	Radiometric Instruments	Other Datasets
Apr 2014	MIZ-ISMARS	North West Territories and Newfoundland	ARIES, MARSS, SWS/SHIMMS, HEIMANN	Dropsonde data, field data from pit profiles (grain size, density, wetness) moisture fluxes, ice and snow in situ temperature profiles
May 2013	SALSTICE	Southern Arizona, Gulf of California	ARIES, MARSS, SWS/SHIMMS, NAST-I, AVIRIS, IASI, HEIMANN	Dropsonde data, moisture fluxes, measurements of surface emissivity
Mar 2012	MEVALI	Kiruna, Sweden	ARIES, MARSS, SWS/SHIMMS, HEIMANN	Dropsonde data, field data from pit profiles (grain size, density, wetness)
Apr 2009	MEVEX	Oman	ARIES MARSS, HEIMANN	Dropsonde data
Mar 2008	CLPX-2	Beaufort Sea, Barrow Point, Alaska	ARIES, MARSS, SWS/SHIMMS, HEIMANN	Dropsonde data, field data from pit profiles (grain size, density, wetness)
May 2007	JAIVEx	Oklahoma, Gulf of Mexico	ARIES, MARSS, SWS/SHIMMS, NAST-I, IASI, HEIMANN	Dropsonde data, ARM Site data
Mar 2006	T-Rex	Sierra Nevada, California	ARIES, MARSS, SWS/SHIMMS, HEIMANN	Dropsonde data
Jun 2004	Caviar	Jungfraujoch, Switzerland	ARIES, MARSS, SWS/SHIMMS, HEIMANN	Dropsonde data
Mar 2001	Polex	Svalbard, Sweden	ARIES, MARSS, SWS/SHIMMS, HEIMANN	Dropsonde data

Met Office Data that is over 2 years old is freely available from the British Atmospheric Data centre (BADC).

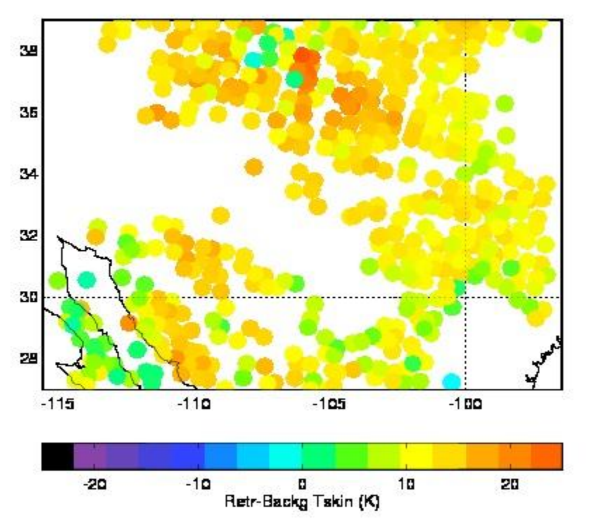
Surface Temperature/Emissivity Retrievals at the Met Office

Salstice: Motivation

Over semi-arid regions such as the south western US and the African Sahel, the Met Office forecast model appears to have a warm bias when compared to satellite measurments. These warm biases can be significant – for example, 10 K temperature differences have been observed over southern Arizona.

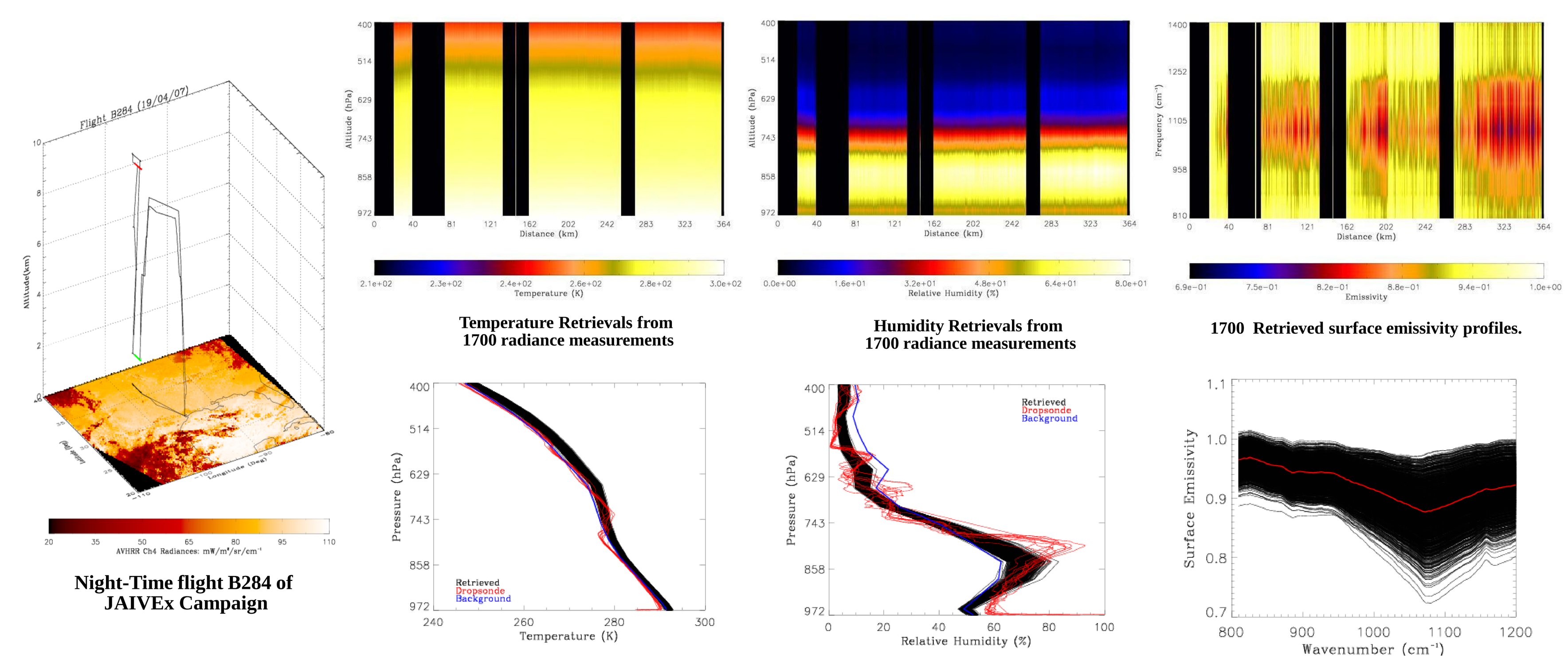


Temperature bias as a function of time between IASI retrievals and the Met Office Unified Model over Arizona in 2012



Bias in skin temperature over Arizona between IASI retrievals and the Met Office Unified Model for IASI footprints.

JAIVEx: Atmospheric Profiles and Surface Emissivity Retrievals using ARIES



Night-Time flight B284 of JAIVEx Campaign

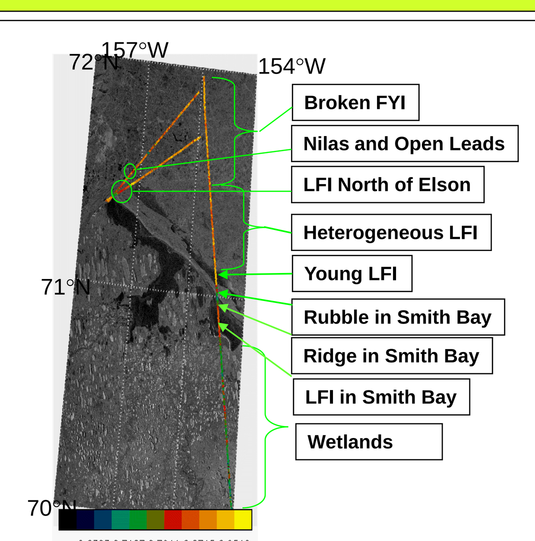
Temperature Retrievals from 1700 radiance measurements

Humidity Retrievals from 1700 radiance measurements

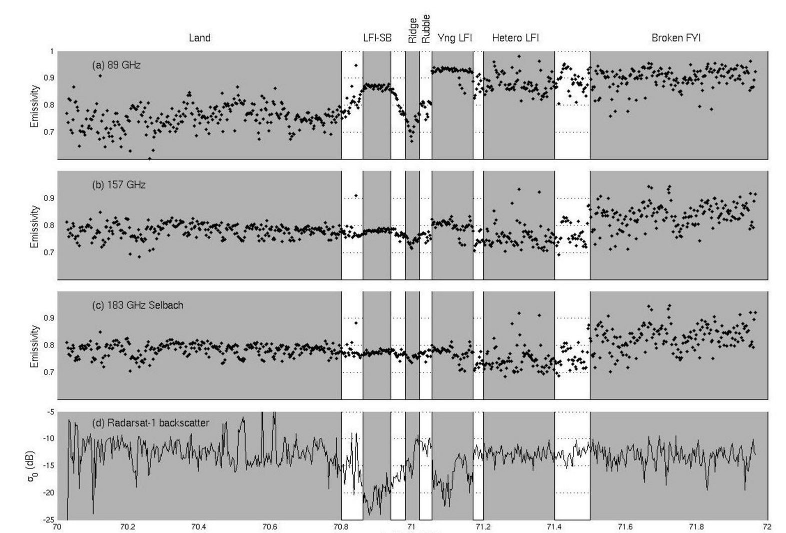
1700 Retrieved surface emissivity profiles.

Reference: J.-C. Thelen et al. QJMRS, Volume: 135 Issue: 645, 2009

CLPX-II: Microwave retrievals of sea-ice using MARSS



The retrieved 89-GHz Lambertian emissivities of the surface along the track of the low-level (1000ft) run of flight B345 (CLPX-II). The flight Track is overlaid on a Radarsat-1 C-band image.



Retrieved Lambertian emissivities and coincident Radasat-1 backscatter during low-level run of B345

Measurements from CLPX-II, in conjunction with the satellite imagery, allowed for the classification of the underlyng surface and provided valuable information about the snow depth and the stratification of snow.

Reference: R.C. Harlow, IEEE Transactions on Geoscience and Remote Sensing, Vol 49, No 4, 2011

Development of the Haveman-Taylor Fast Radiative Transfer Code

- The HT-FRTC code is used in a 1D-Var retrieval scheme which is used to retrieve atmospheric profiles and surface properties.
- It is extremely fast as it is based on principal component analyses, a full hyperspectral radiance calculation (8000 channels) takes less than a millisecond.
- Works in the microwave, infrared and short-wave
- Treats all the gases in the HITRAN database
- Treats any spectrally resolved surface emissivity/ reflectance and incorporates Lambertian, specular and Cox-Munk reflection.
- Includes 20 different aerosols as well as water/ ice clouds and certain hydrometeors such as rain and snow
- Incorporates an exact treatment of scattering as well as the Chou-scaling approximation
- Is able to compute radiances, fluxes and transmittances
- It is sensor- independent, i.e. it can treat any sensor as long as their characteristics are available

Met Office FitzRoy Road, Exeter, Devon, EX1 3PB United Kingdom
Tel: 01392 884438 Fax: 01392 885681
Email: jean-claude.thelen@metoffice.gov.uk