

THE 183-GHZ RADIOMETER HAMSTRAD: VALIDATION OVER THE PYRENEES MOUNTAINS (FRANCE) AND FIRST MEASUREMENTS AT DOME C (ANTARCTICA)

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- 1. Introduction
 - 2. Data sets
 - 3. Measurements at the Pic du Midi
 - 4. Measurements at Dome C
 - 5. Conclusions

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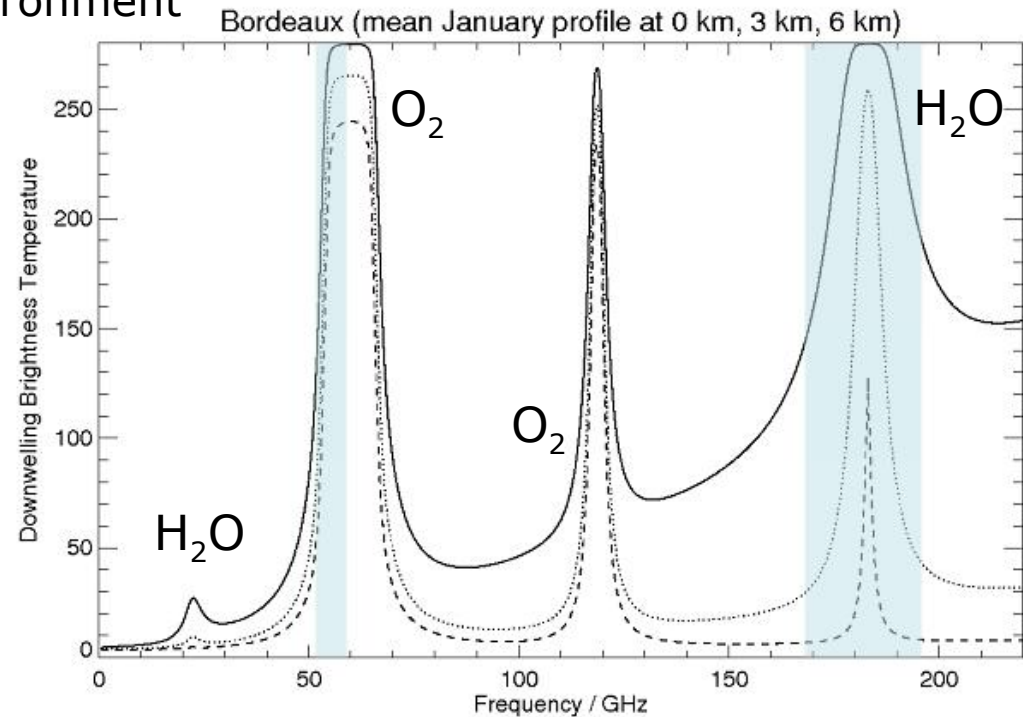
Introduction

- H₂O Trends and impact on climate change
- Measurements from ground-based microwave radiometers
 - NDACC : stratospheric H₂O
 - Pic du Midi, Réunion Island, Dome C
- HAMSTRAD (*H₂O Antarctica Microwave Stratospheric and Tropospheric Radiometers*)
 - 1 microwave radiometer has been funded by CNRS/INSU for Dome C: tropospheric H₂O (and Temperature)
- Installation
 - Pic du Midi (PdM) in Feb-Jun 2008 (validation)
 - 42°56'N, 0°08'E, 2877 m asml, France
 - Dome C in Jan-Feb 2009 (outdoor setting up for 12 days)
 - 75°06'S, 123°21'E, 3233 m asml
 - **Dome C from Jan 2010: definitive indoor setting up**

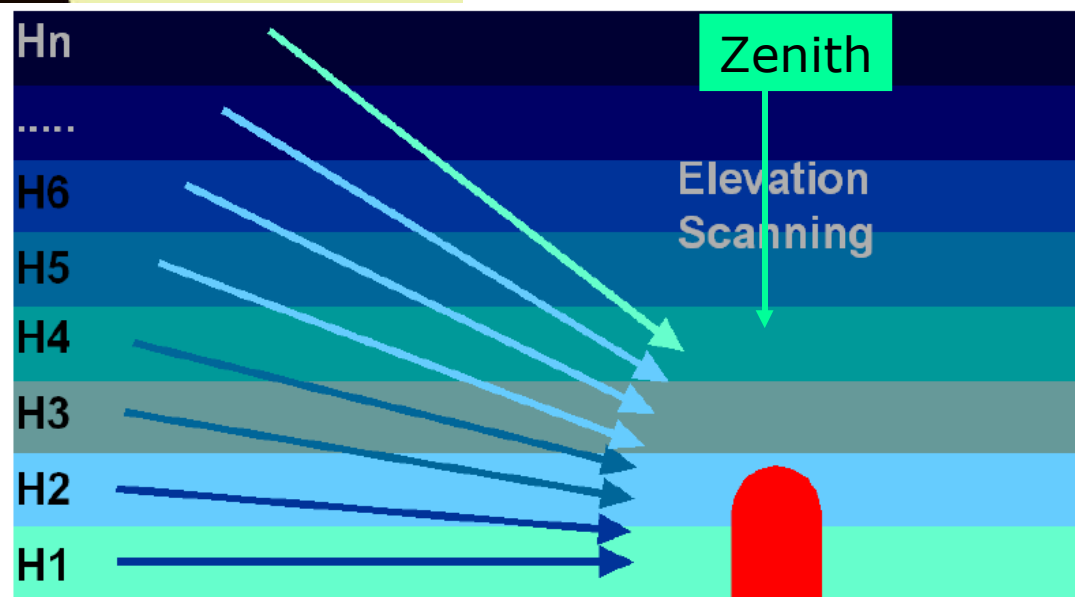
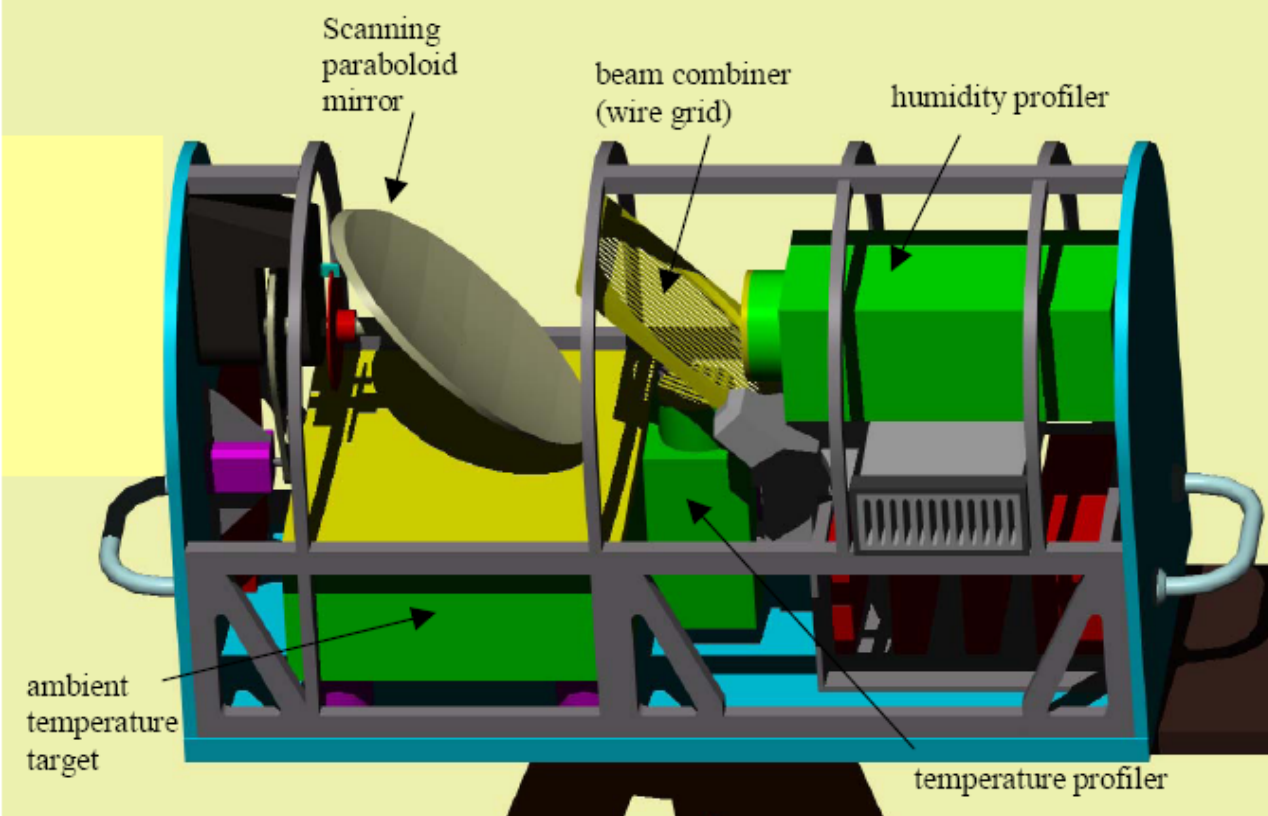
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HAMSTRAD Radiometer

- Original state-of-the-art microwave radiometer, especially developed for DC environment by Radiometer Physics
 - Very cold and dry environment
 - Automated
- 2 bands
 - 60 GHz (O_2)
 - Temperature
 - 0-10 km
 - 7 channels
 - 183 GHz (H_2O)
 - Absolute Humidity
 - 0-10 km
 - 6 channels
- Retrieval
 - Linear Regression



- Vertical Resolution: 80-250 m (H_2O) & 250 m (T)
- Time resolution: 1-10 min
- Errors (RMS) : 0.01-0.04 g m⁻³ (H_2O) & 0.5-2 K (T)



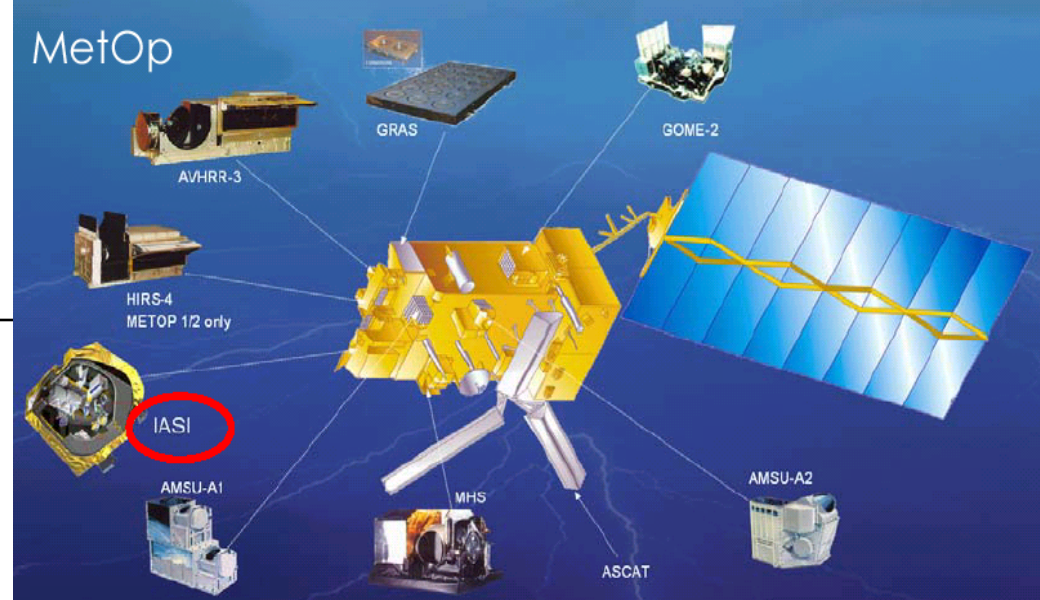
Radiosoundings

- Lannemezan
 - (43°07'N, 0°23'E, 610 m asml, France)
 - [~30 km North-East from PdM],
- Bordeaux-Mérignac Airport
 - (44°49'N, 0°42'W, 50 m asml, France)
 - [~220 km North-West from PdM],
- Zaragoza
 - (41°39'N, 0°53'W, 263 m asml, Spain)
 - [~170 km South-West from PdM].
- Dome C
 - (75°06'S, 123°21'E, 3233 m asml)
- ⇒HAMSTRAD profiles were selected within a 20-min window starting at the time of the sounding launch. This typically corresponds to 2-4 HAMSTRAD profiles.



METOP/IASI


- **METOP** satellites (x3)
- Launched in Oct 2006
- Lifetime: 5 years
- 9 instruments
- **IASI**: Nadir IR remote sensing using an accurately calibrated Fourier Transform Spectrometer operating in the $3.6\text{-}15.5\ \mu\text{m}$ ($645\text{-}2760\ \text{cm}^{-1}$) spectral range with a spectral resolution $0.25\ \text{cm}^{-1}$.
- Pre-operational L2 H₂O data provided by EUMETSAT via Ether
- Selection within a $2^\circ \times 2^\circ$ bin centered at the location of the station, coincidence within one hour
- **PdM**: Irrespective of the presence of cloud in the line of sight, 10-30 twice per day, around 09:00-10:00 and 21:00-22:00 UTC
- **DC**: Cloud-free measurements, from 13:00 to 02:00 UTC (16:00-19:00 and 23:00-02:00 UTC)



PT100 *in situ* Sondes

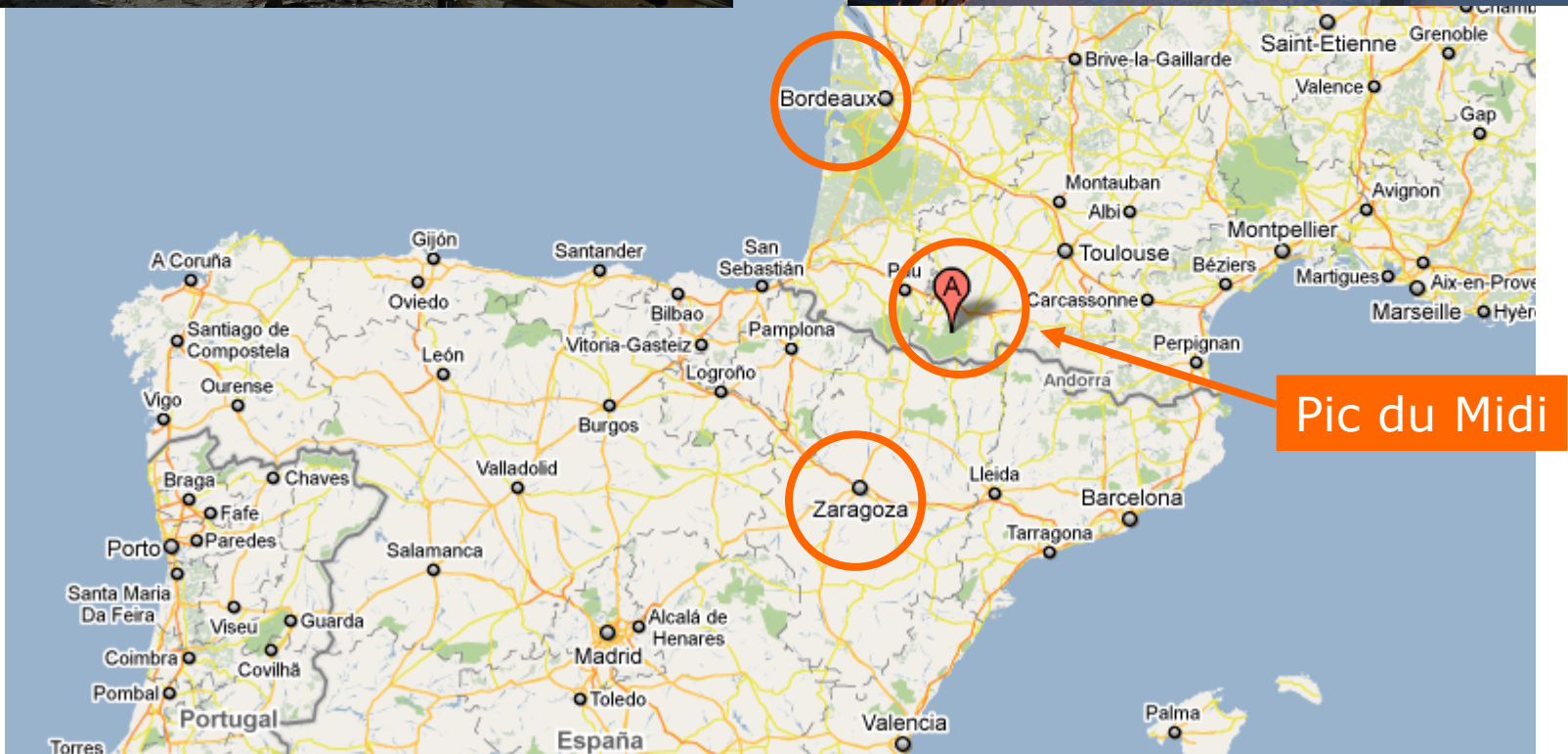
- Dome C
 - H₂O and Temperature
 - 2009 (+2010)
- LGGE
 - Temperature
 - 2009



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la Rochelle



Pic du Midi

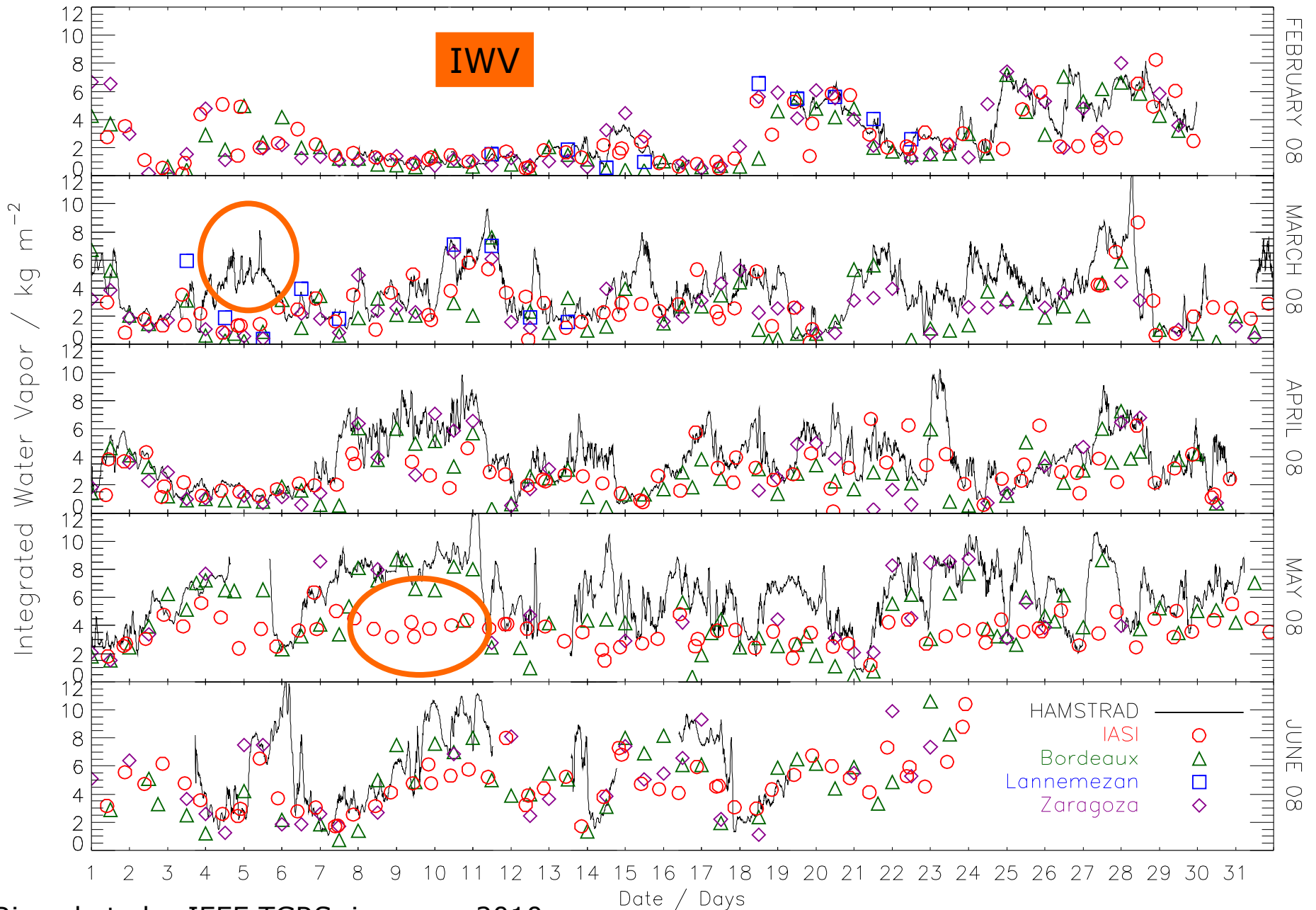
Measurements at the Pic du Midi



- Feb-Jun 2008
 - Outdoor measurements
 - LN₂ Calibration
 - Outdoor Temperature: from -20°C to +10°C

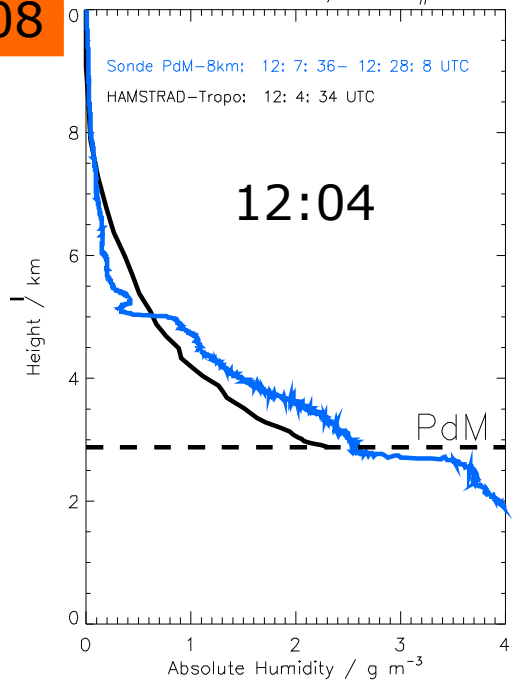
- Results
 - ⇒ H₂O
 - Temporal evolution (Feb-Jun 2008)
 - Statistical Analysis
 - Mean
 - Standard deviation
 - Bias (in coincidence)
 - Correlation (in coincidence)
 - Short-term variability (24h)

Pic du Midi – Integrated Water Vapor

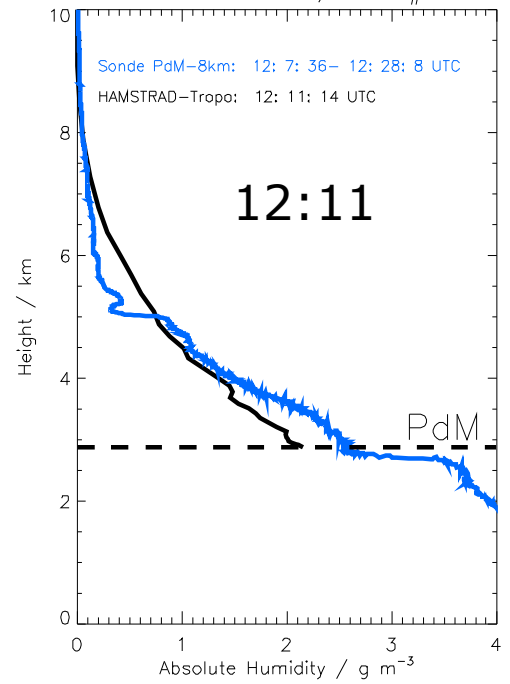


21 Feb 2008

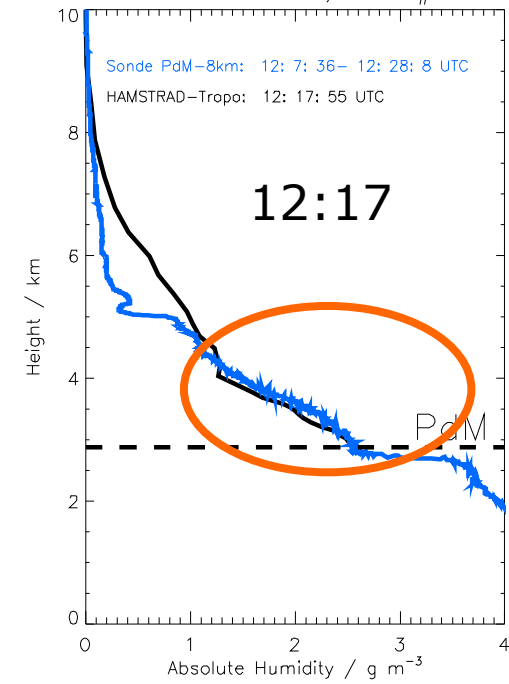
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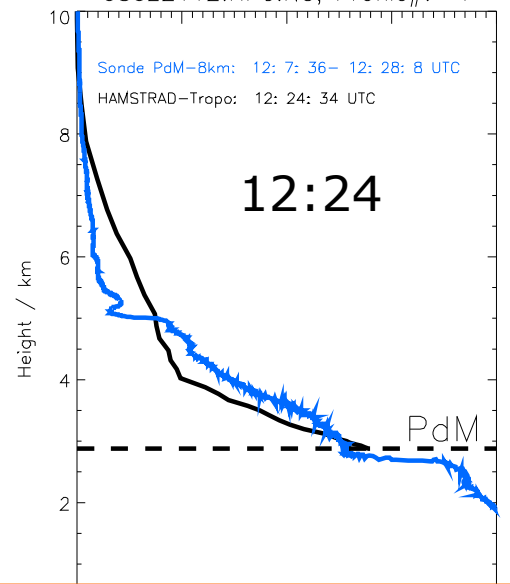
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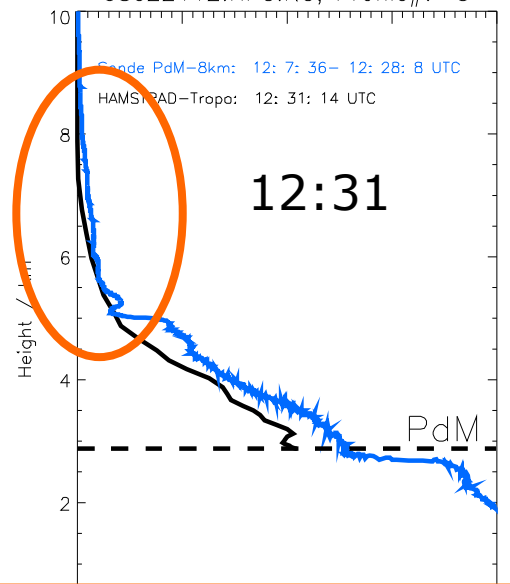
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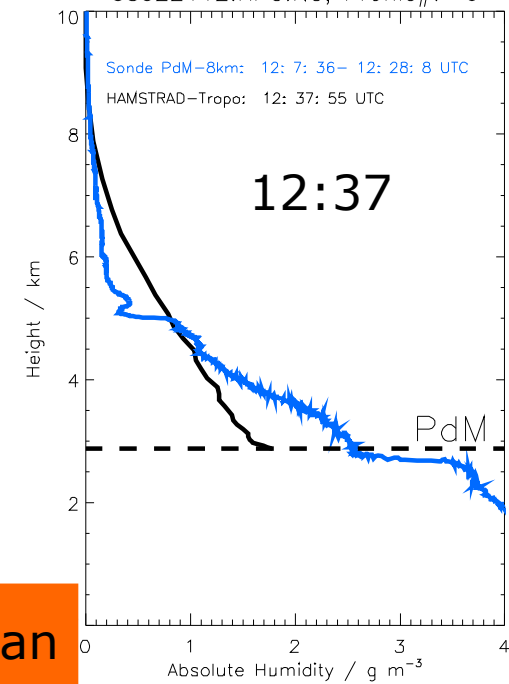
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08022112.HPC.NC; Profile#: 5

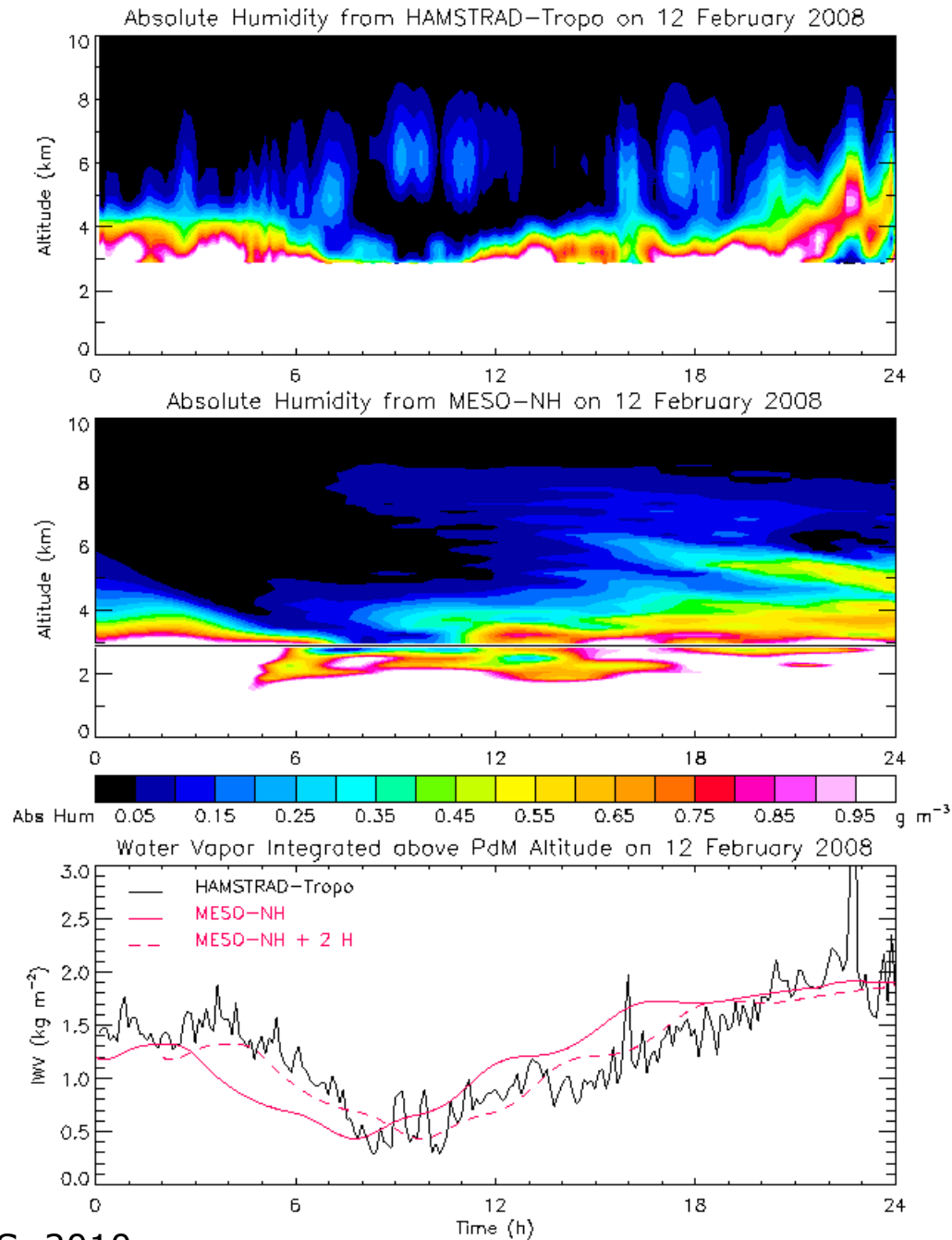


08022112.HPC.NC; Profile#: 6



— HAMSTRAD

— Sondes Lannemezan

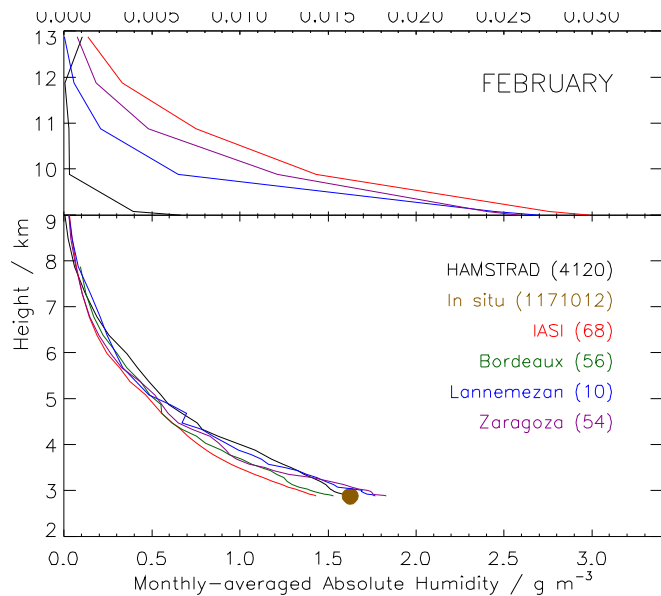


HAMSTRAD

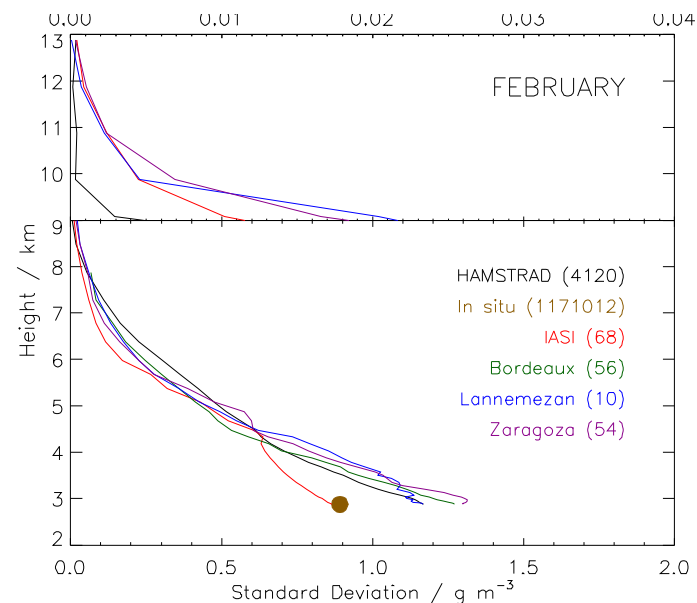
Mesoscale
MESO-NH
Model

IWV

Monthly mean

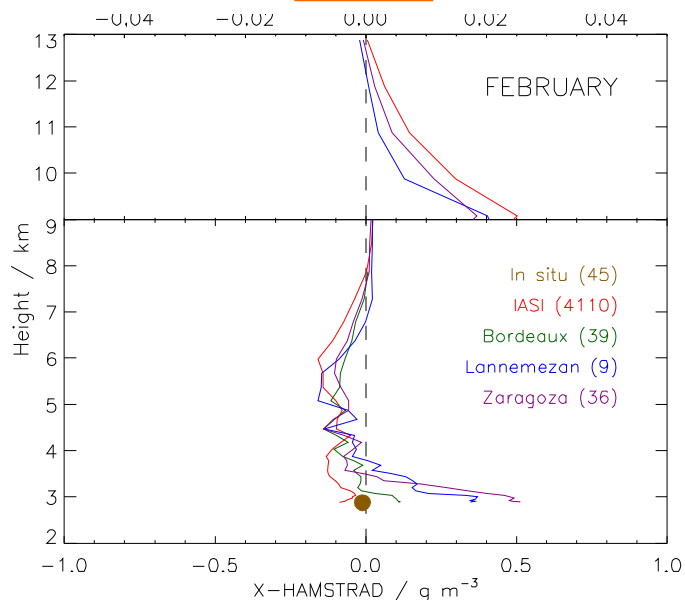


Standard Deviation

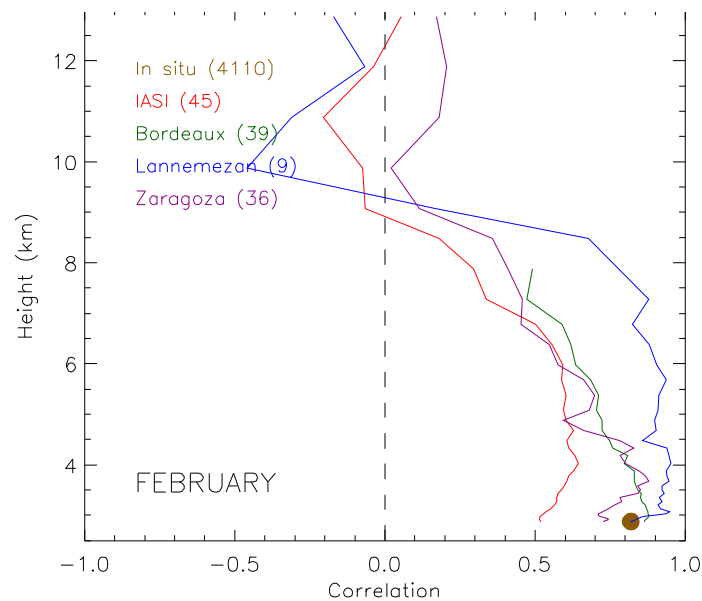



FEBRUARY 2008

Bias

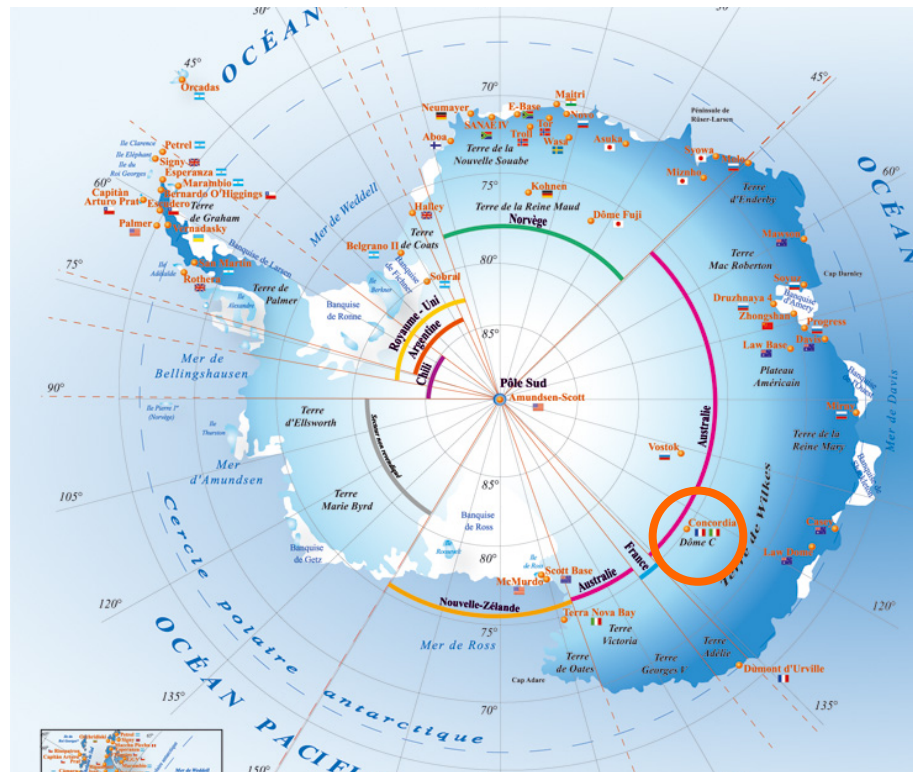


Correlation



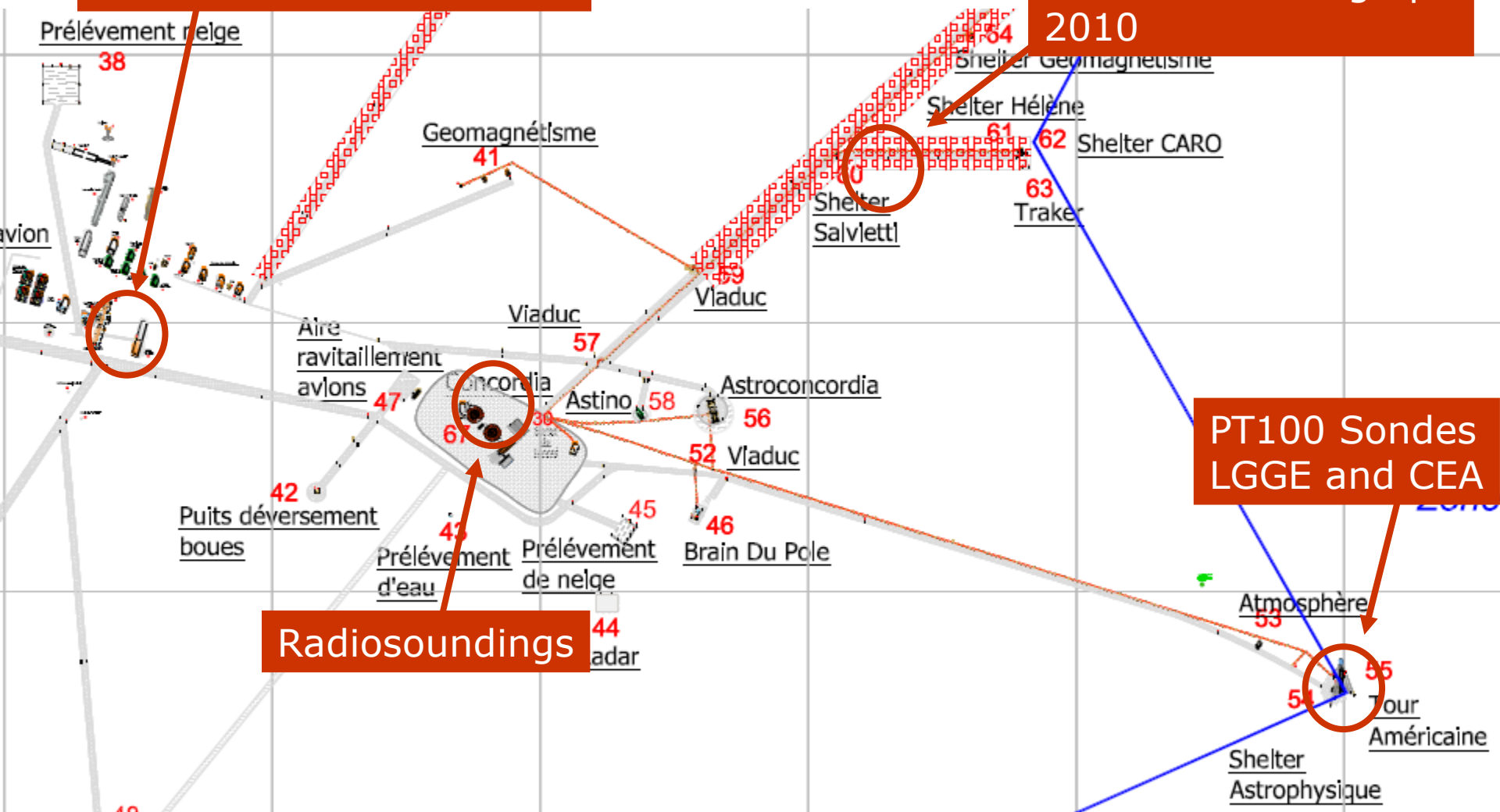
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Dome C



HAMSTRAD
Outdoor Measurements
2009 and 1 week in 2010

HAMSTRAD
Indoor Measurements
Definitive Setting up
2010



Radiosoundings

**PT100 Sondes
LGGE and CEA**

Echelle

1:200 000

0



1

Kilomètre

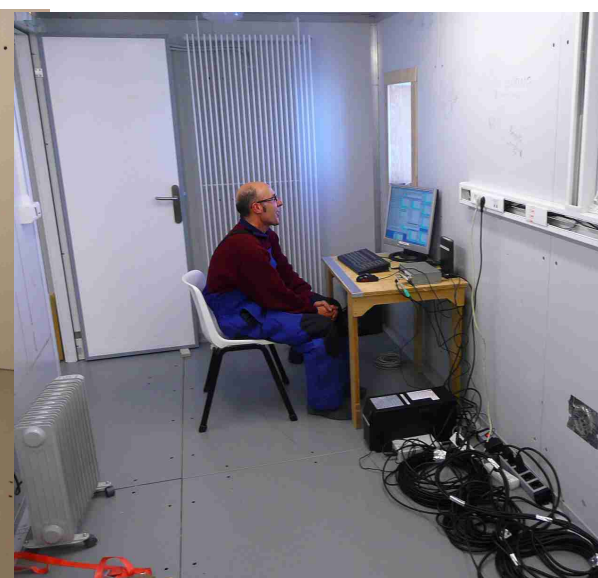
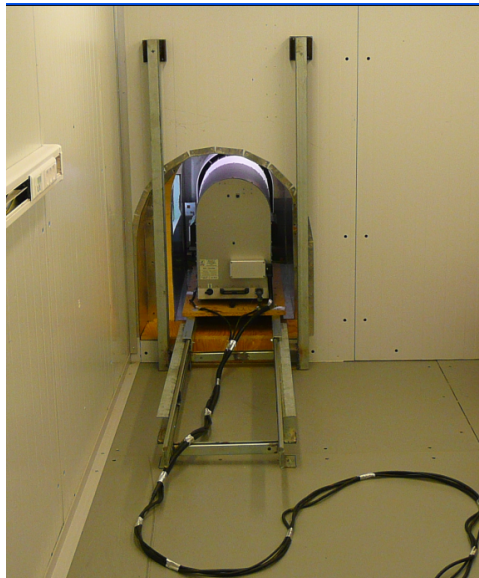
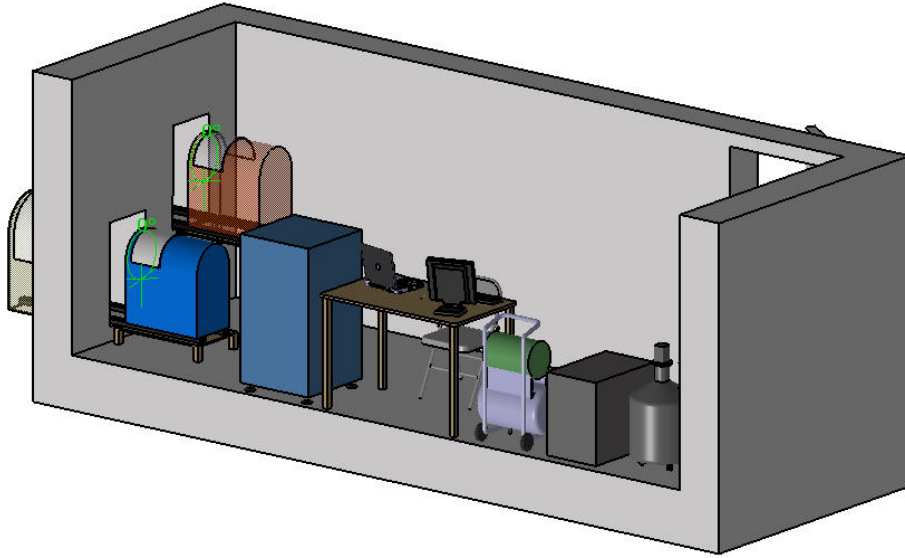
Measurements at Dome C

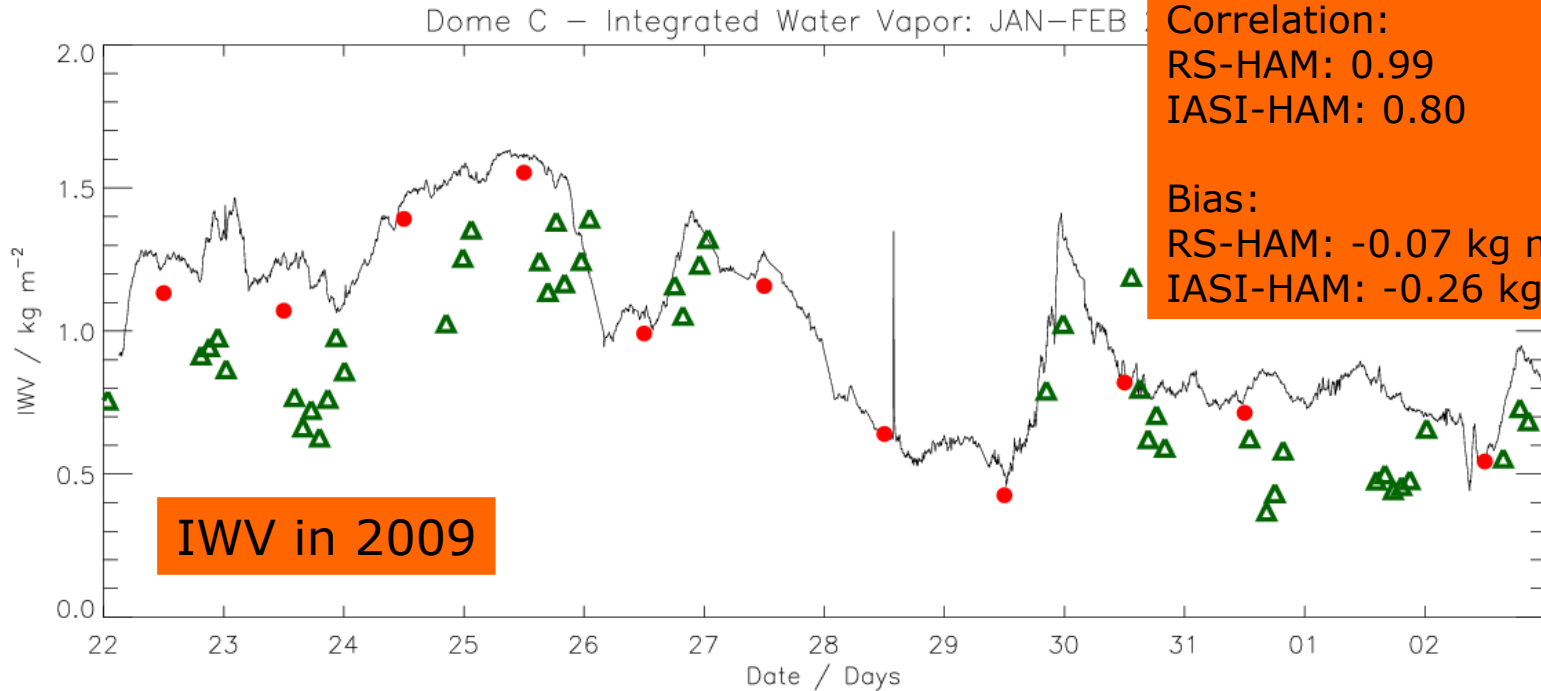
- Jan-Feb 2009
 - Outdoor measurements
 - No LN₂ Calibration
 - Outdoor Temperature: from -20°C to -40°C
- Jan 2010 to date
 - Indoor measurements (exception of 1 week outdoor measurements from 8 to 12 Jan.)
 - LN₂ Calibration
 - Outdoor Temperature: from -20°C to -40°C
 - Indoor Temperature: from +1°C to +18°C
 - Daily automated transfer of measurements
- Results
 - ⇒ H₂O and Temperature
 - Temporal evolution (both periods)
 - Statistical Analysis
 - Mean
 - Standard deviation
 - Bias (in coincidence)
 - Correlation (in coincidence)
 - Short-term variability (24h)

Outdoor Measurements



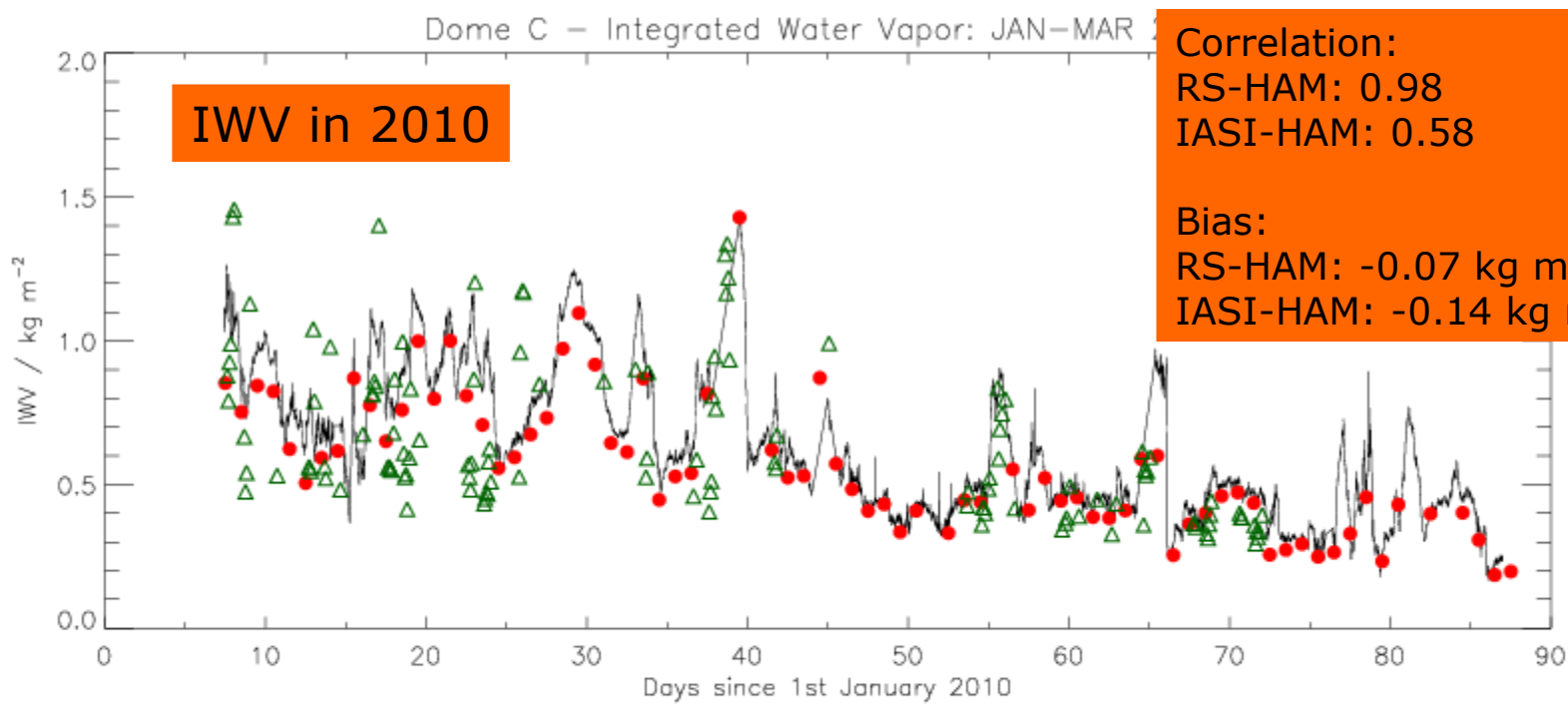
Indoor Measurements





Correlation:
RS-HAM: 0.99
IASI-HAM: 0.80

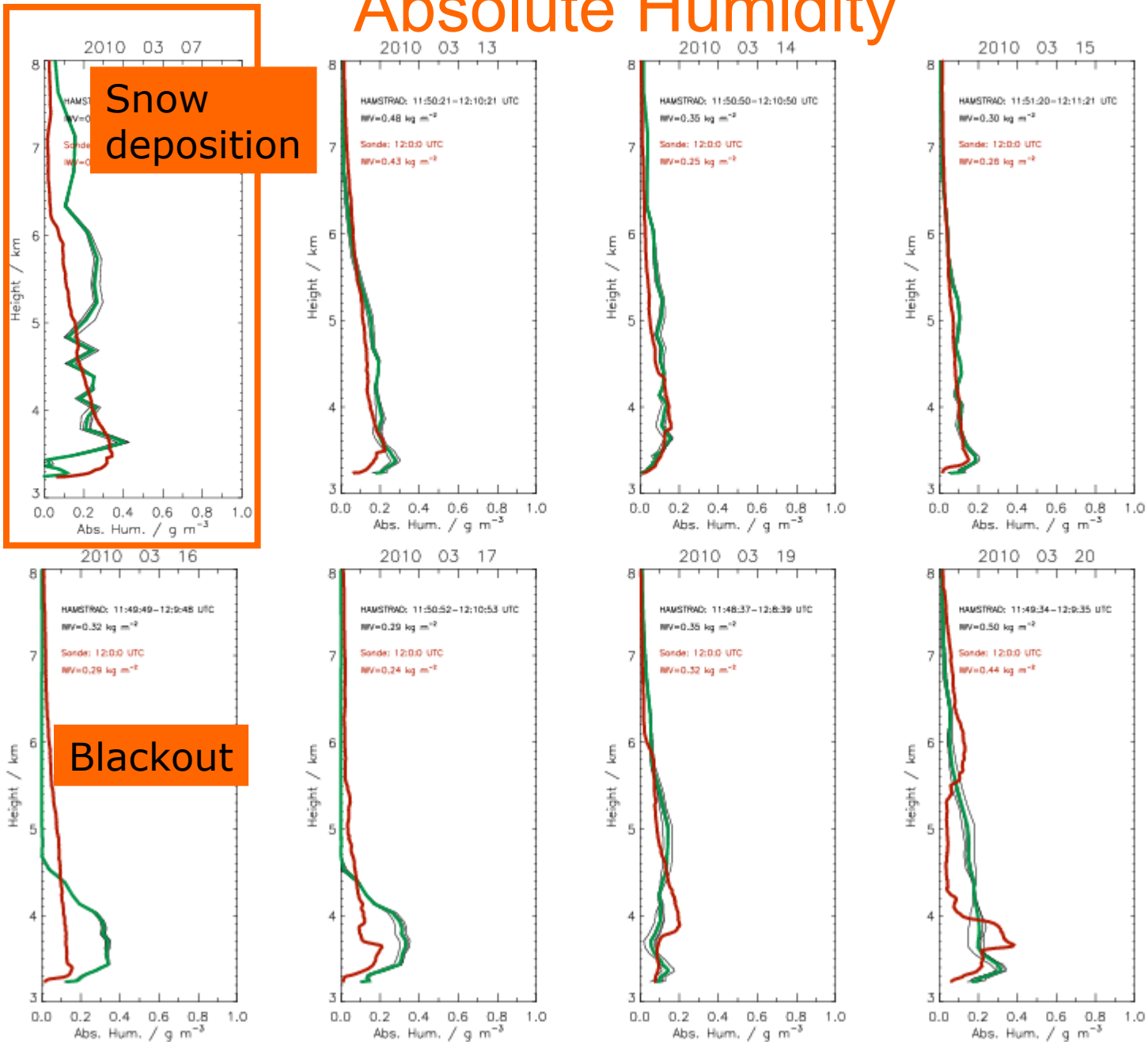
Bias:
RS-HAM: -0.07 kg m^{-2} (-7%)
IASI-HAM: -0.26 kg m^{-2} (-23%)



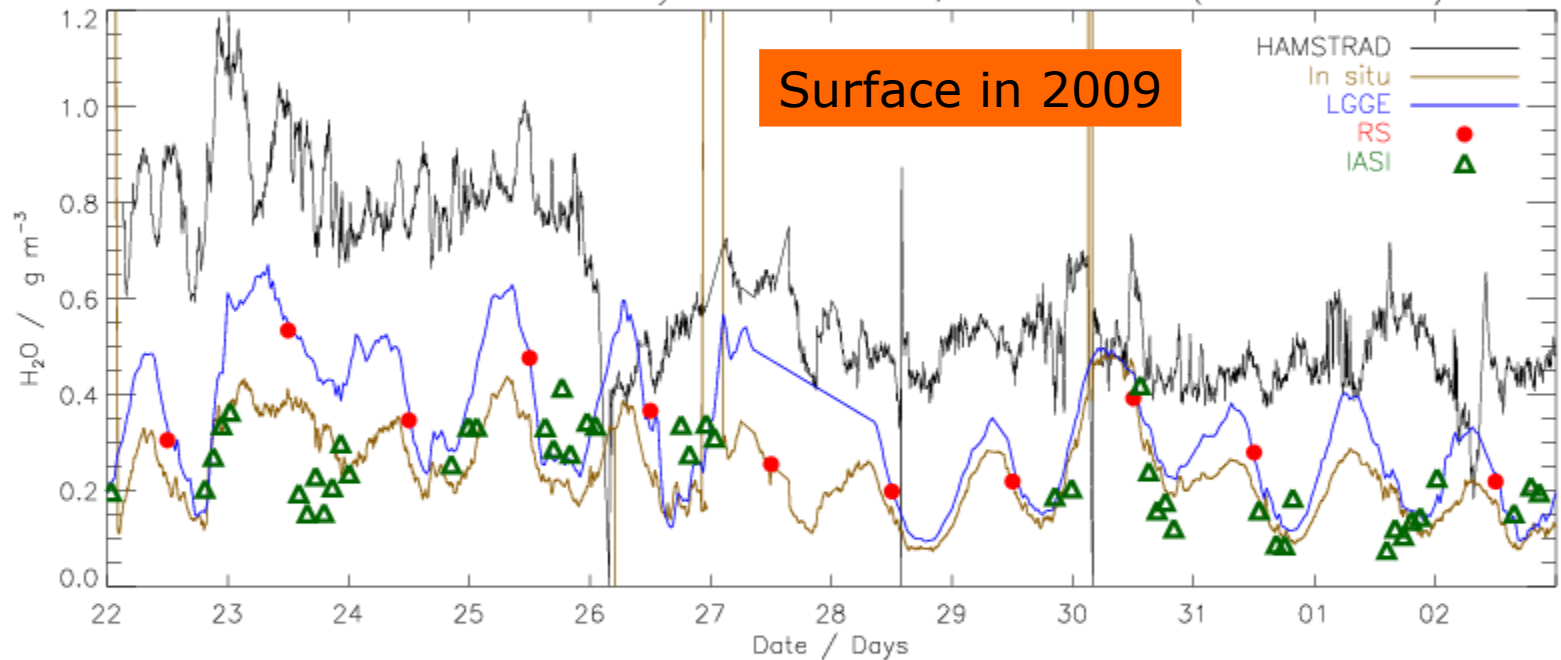
Correlation:
RS-HAM: 0.98
IASI-HAM: 0.58

Bias:
RS-HAM: -0.07 kg m^{-2} (-11%)
IASI-HAM: -0.14 kg m^{-2} (-19%)

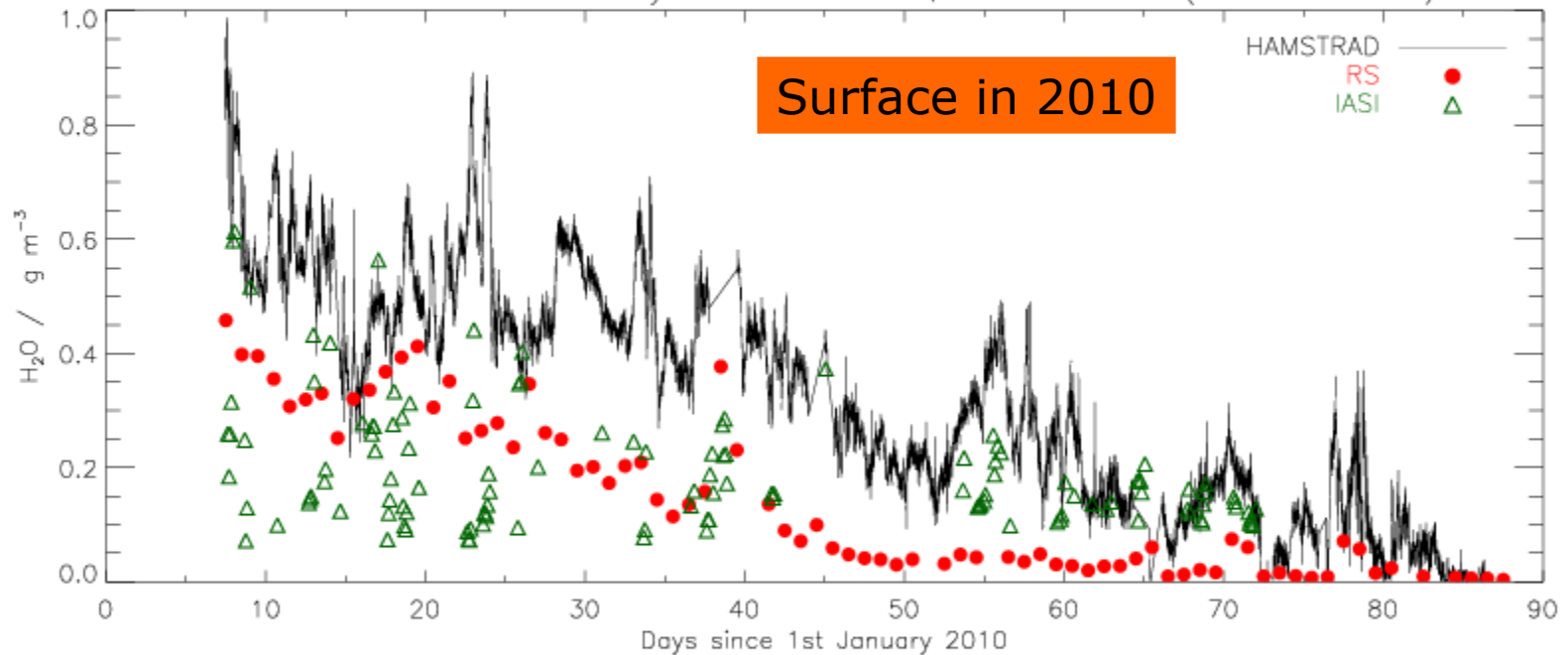
Absolute Humidity



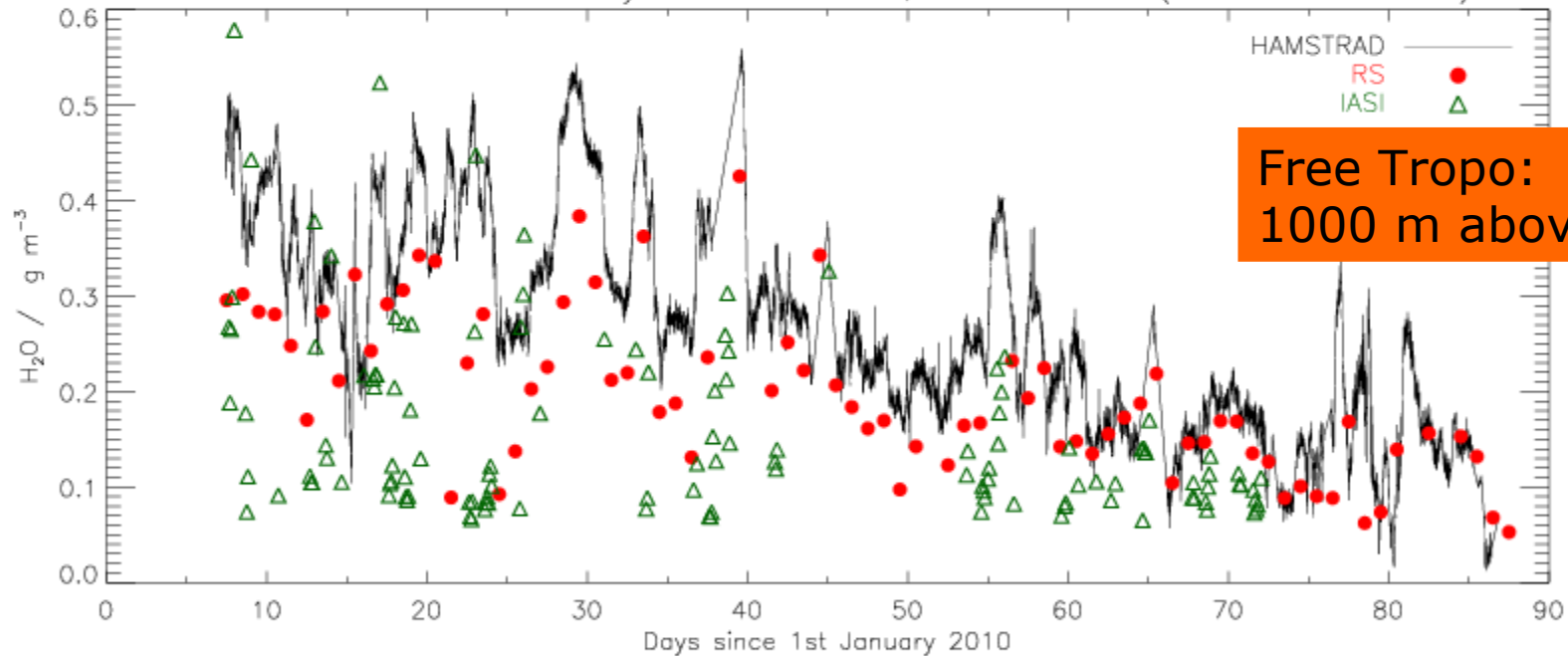
Dome C – Absolute Humidity: JAN–FEB 2009; 3233 m asml (0 m above DC)



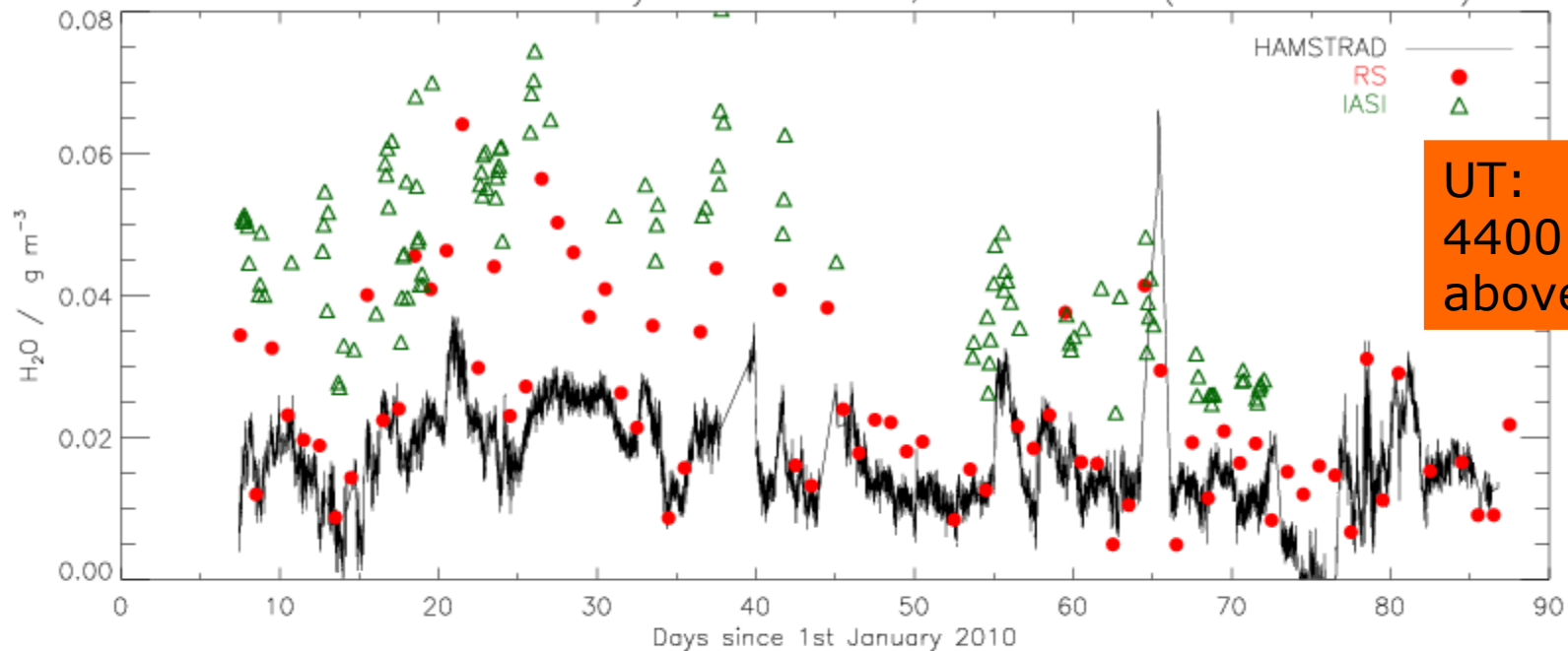
Dome C – Absolute Humidity: JAN–MAR 2010; 3233 m asml (0 m above DC)

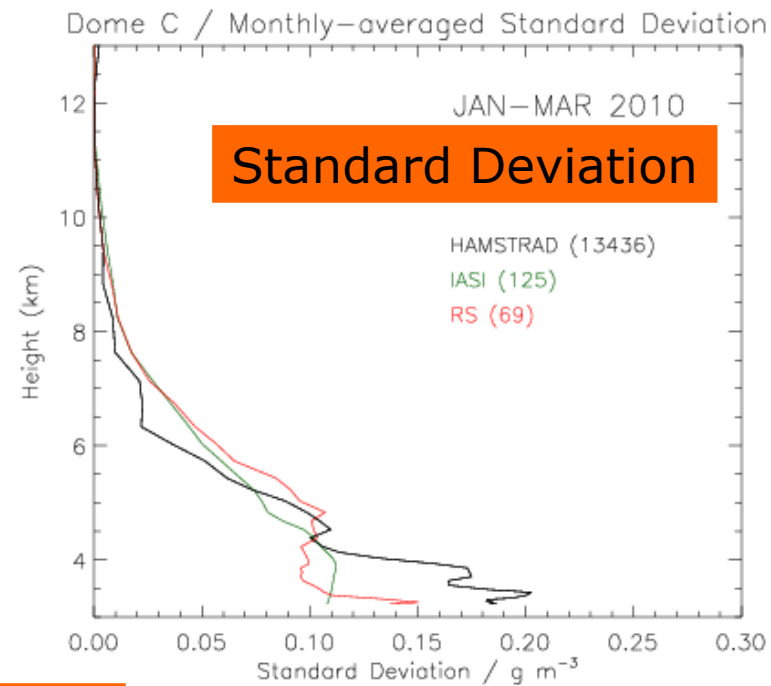
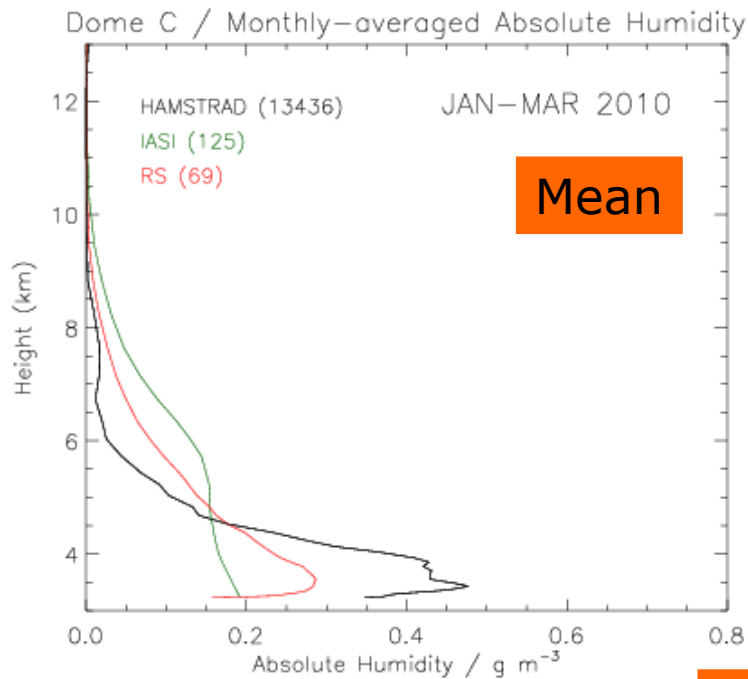


Dome C – Absolute Humidity: JAN–MAR 2010; 4233 m asml (1000 m above DC)

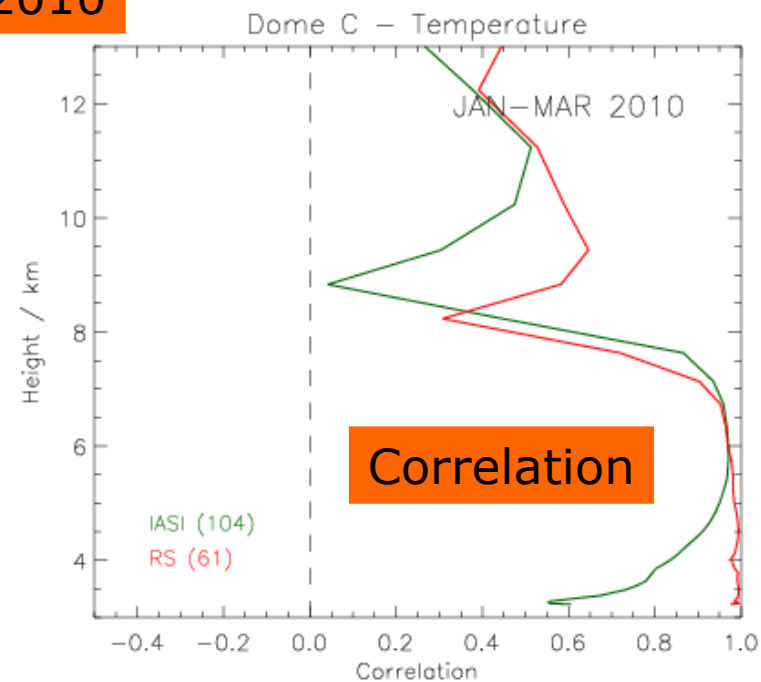
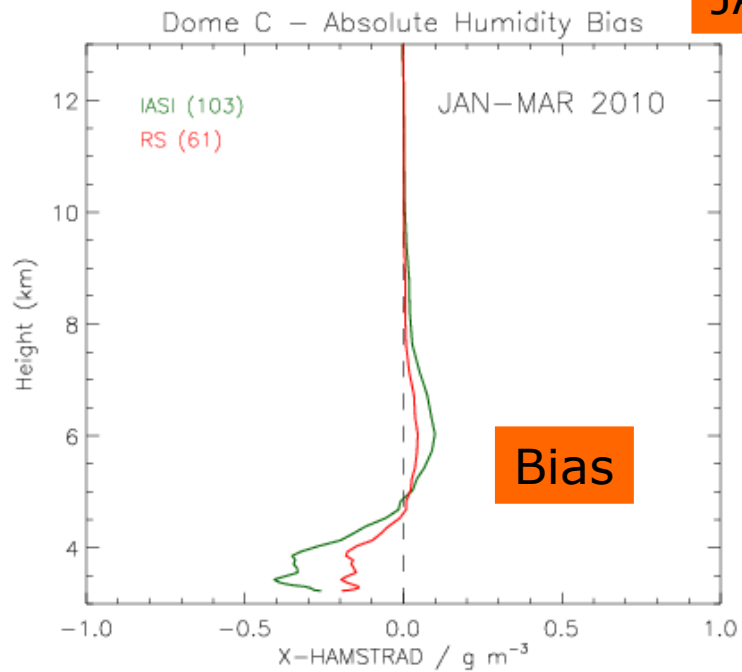


Dome C – Absolute Humidity: JAN–MAR 2010; 7633 m asml (4400 m above DC)

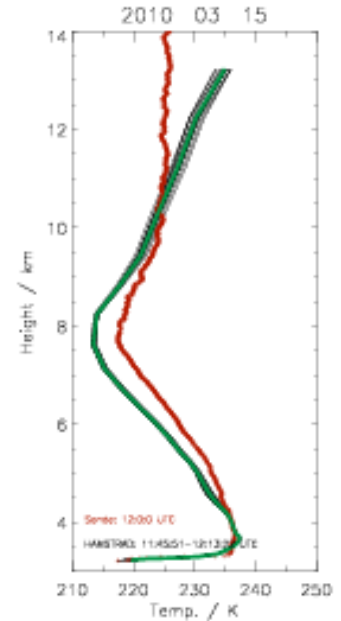
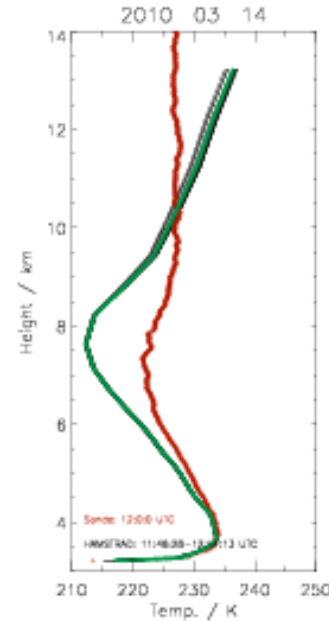
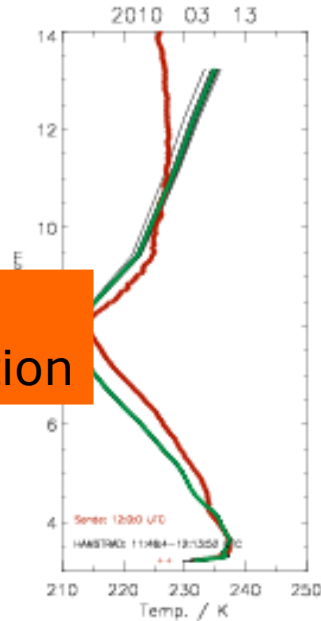
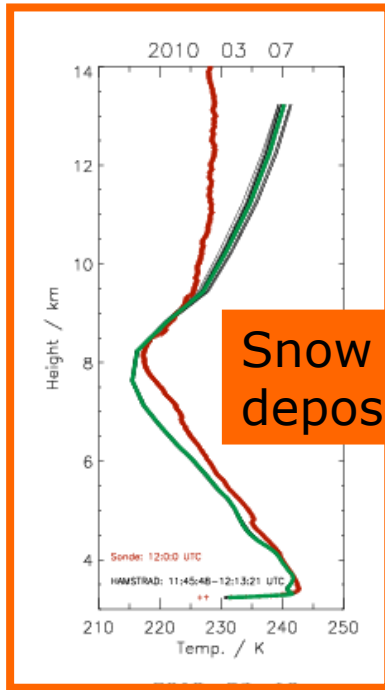




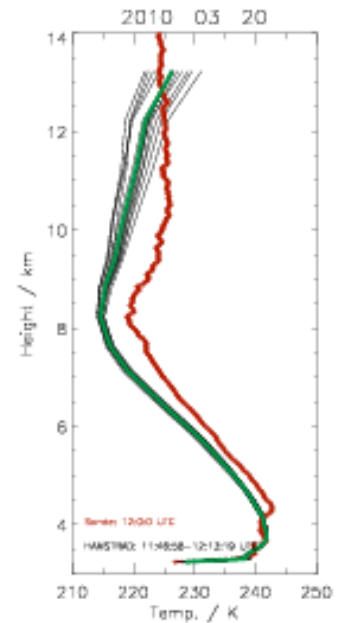
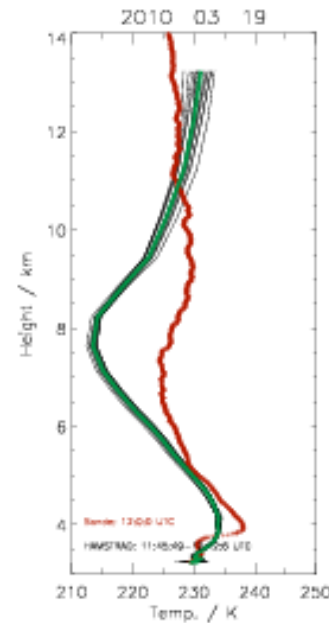
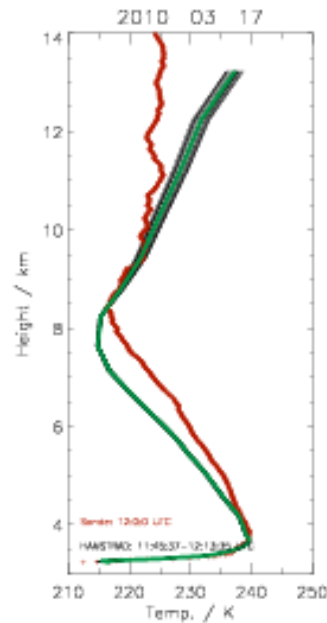
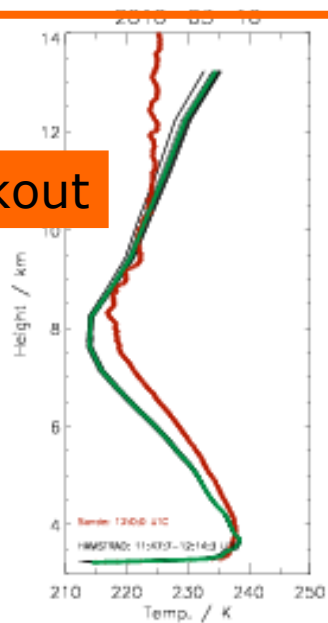
JAN-MAR 2010



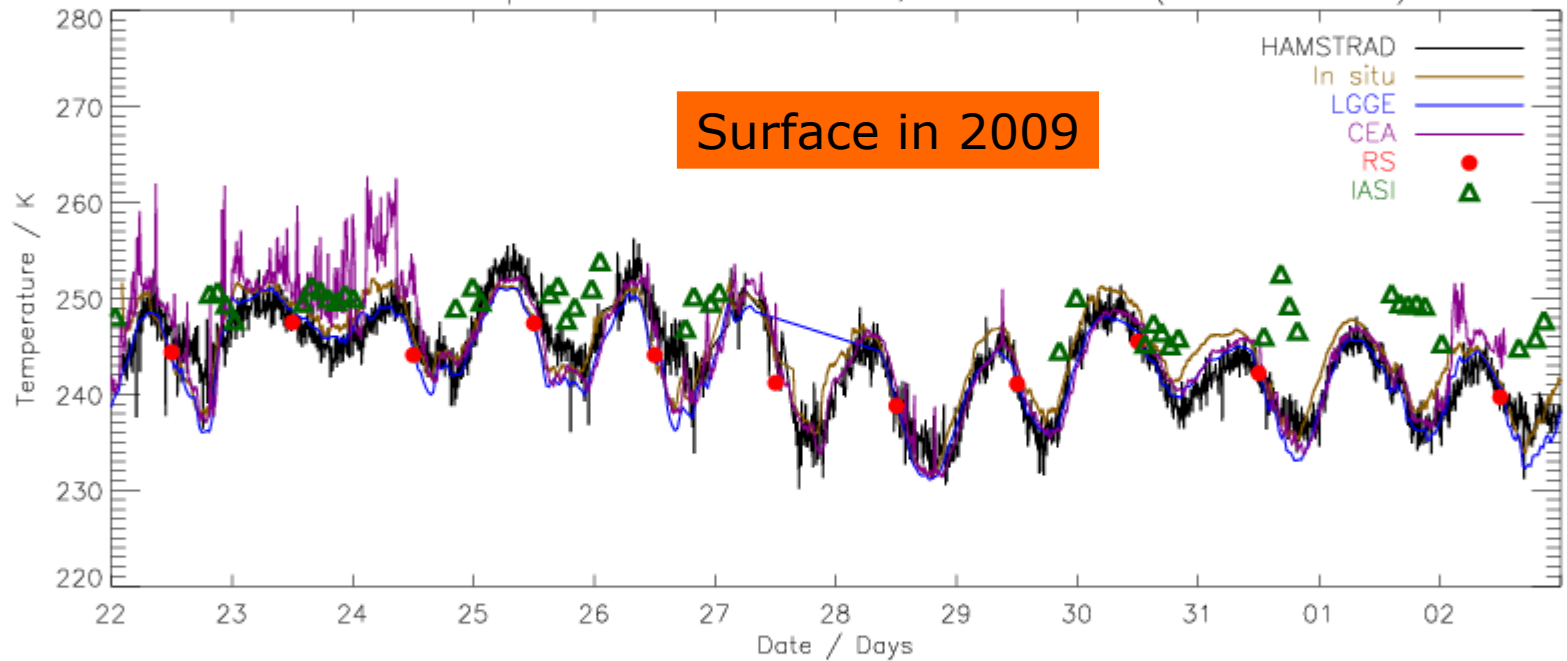
Temperature



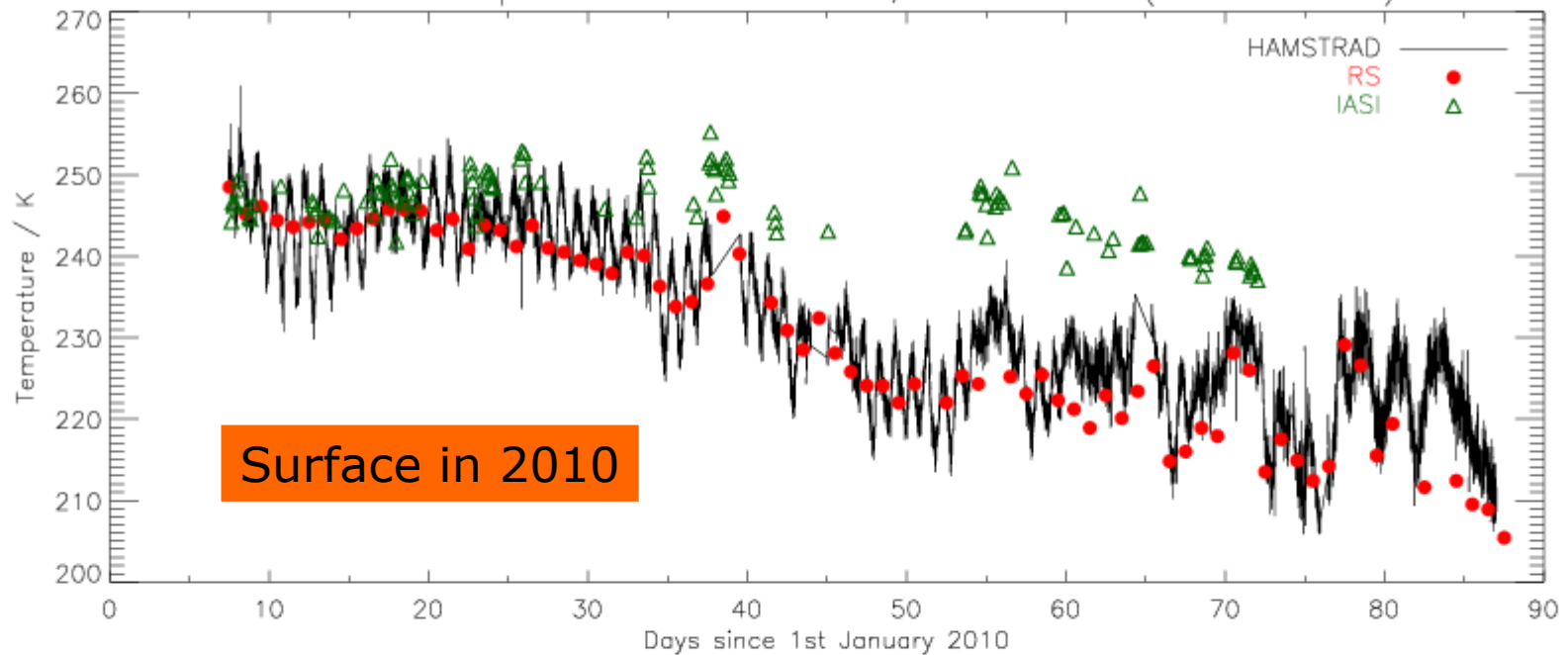
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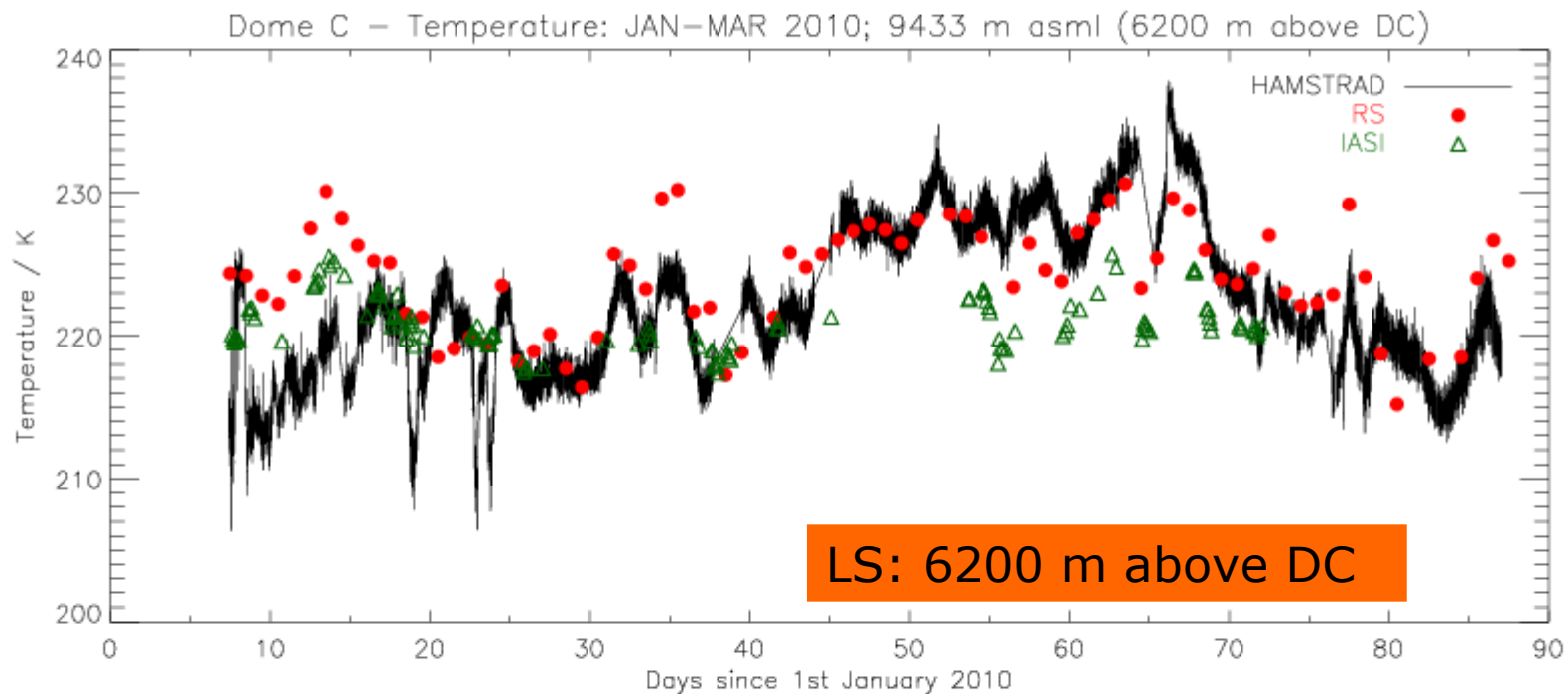
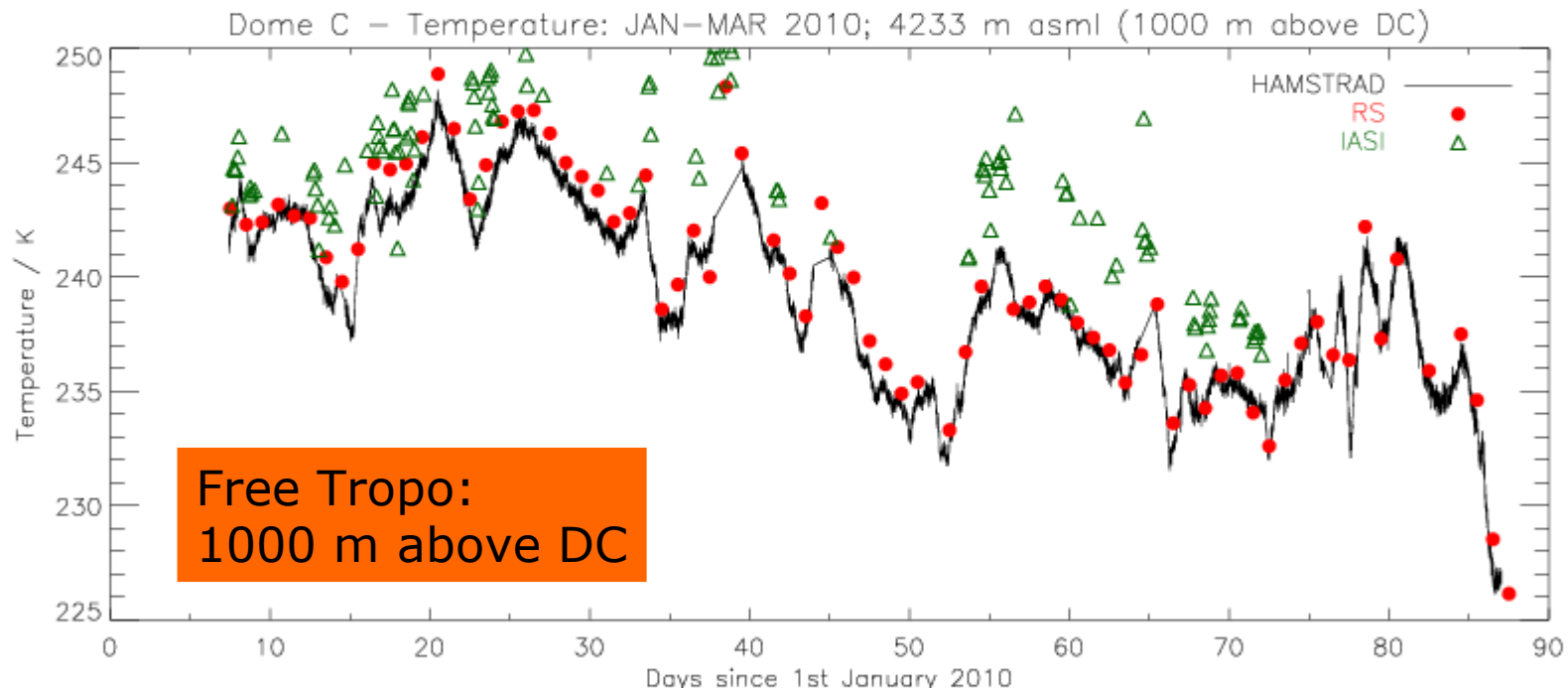


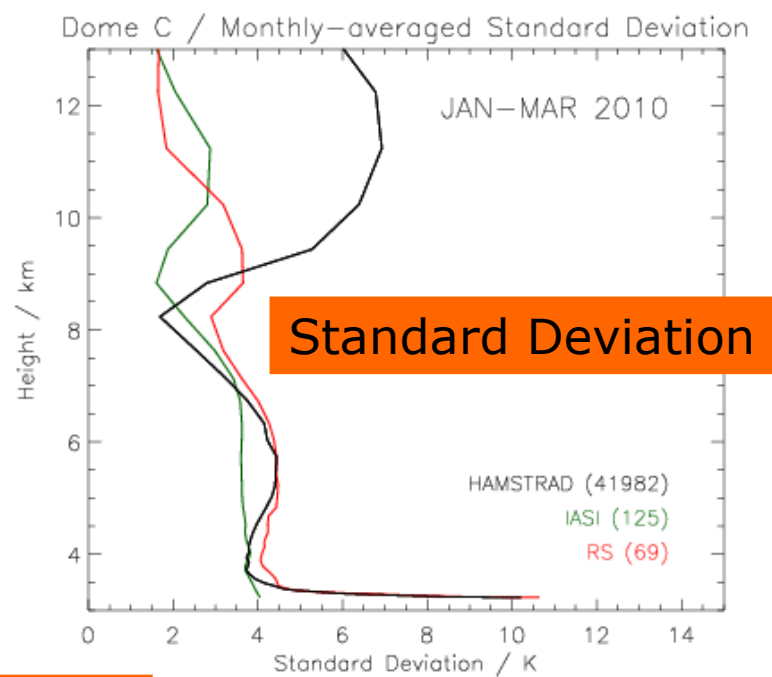
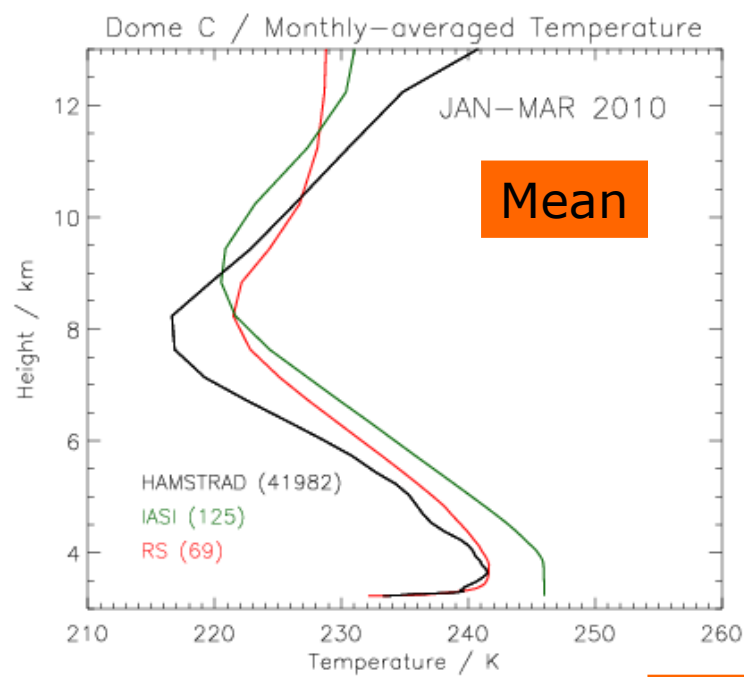
Dome C – Temperature: JAN–FEB 2009; 3233 m asml (0 m above DC)



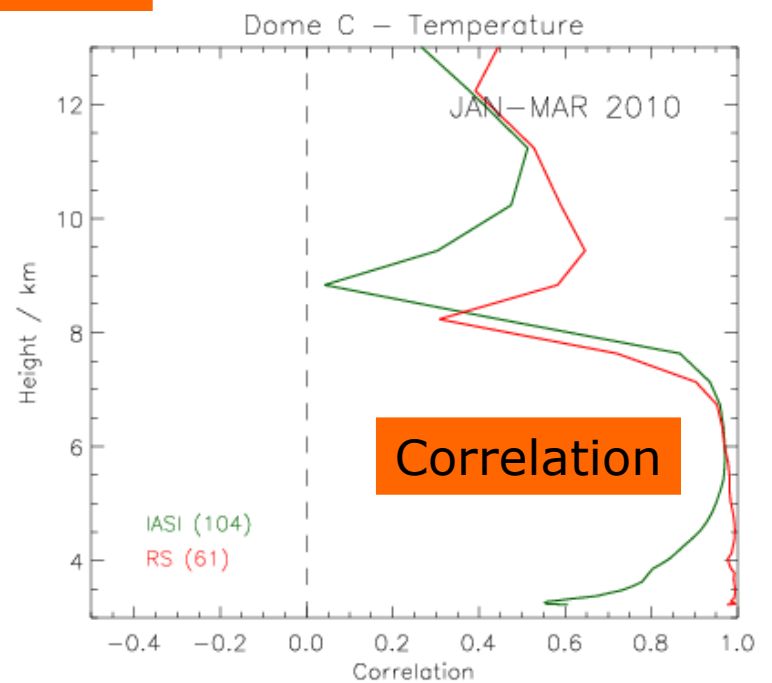
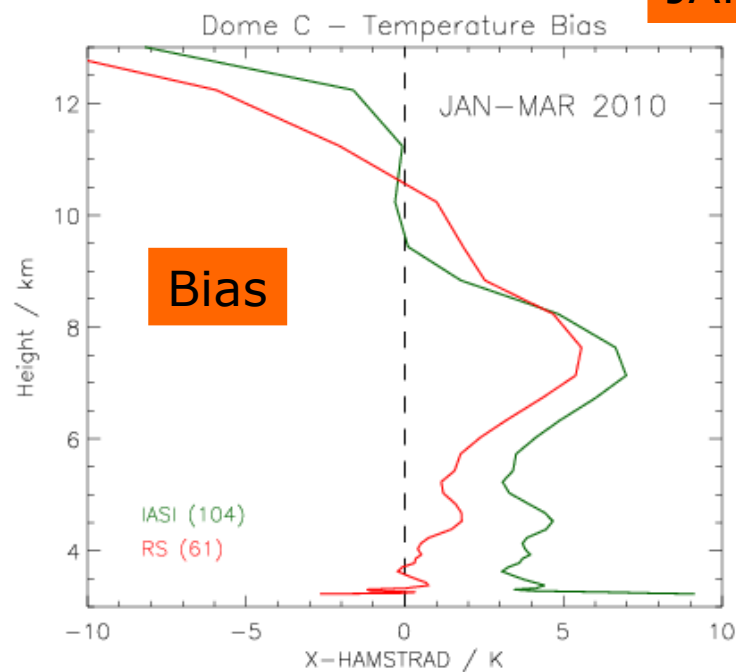
Dome C – Temperature: JAN–MAR 2010; 3233 m asml (0 m above DC)



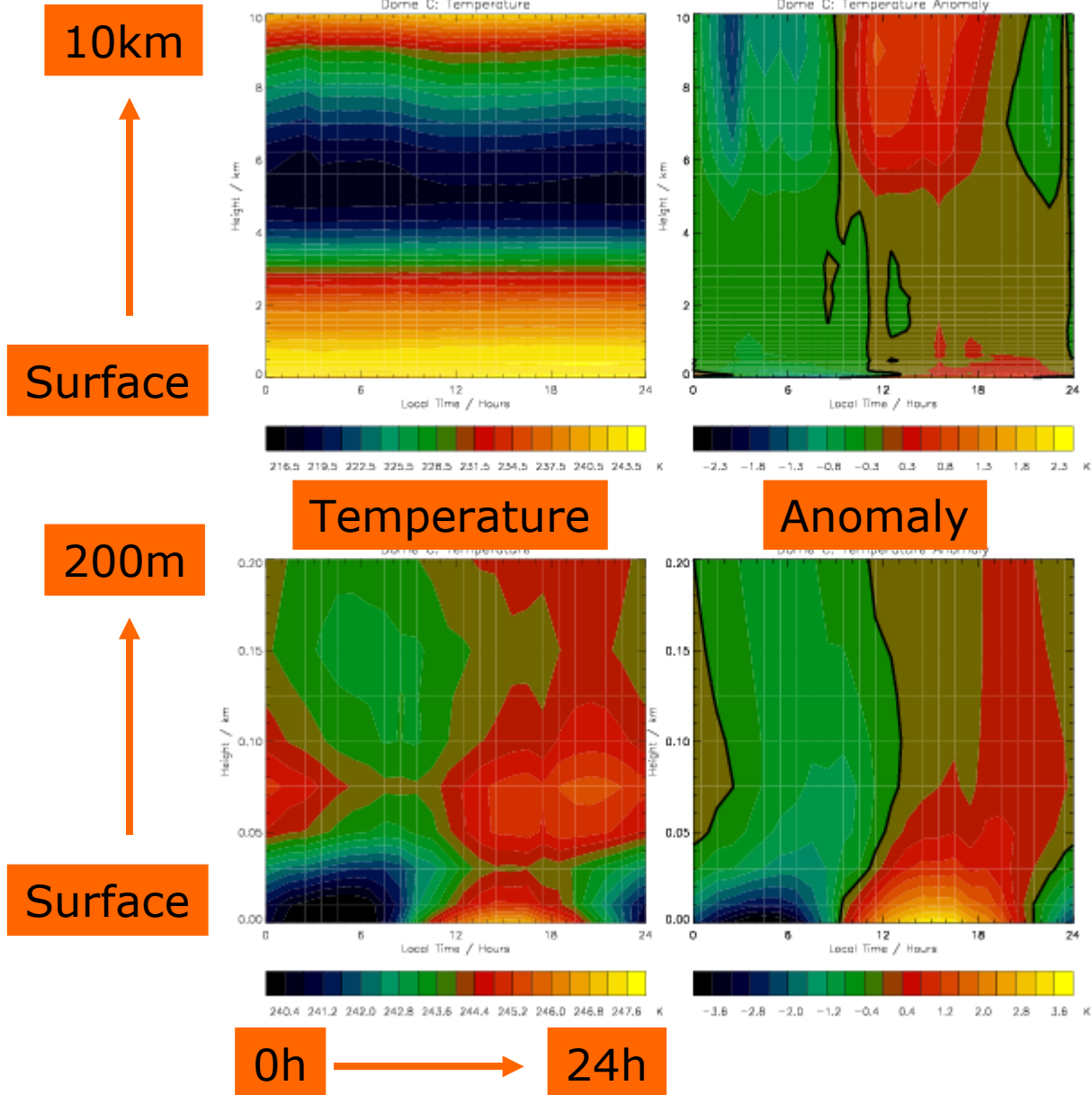




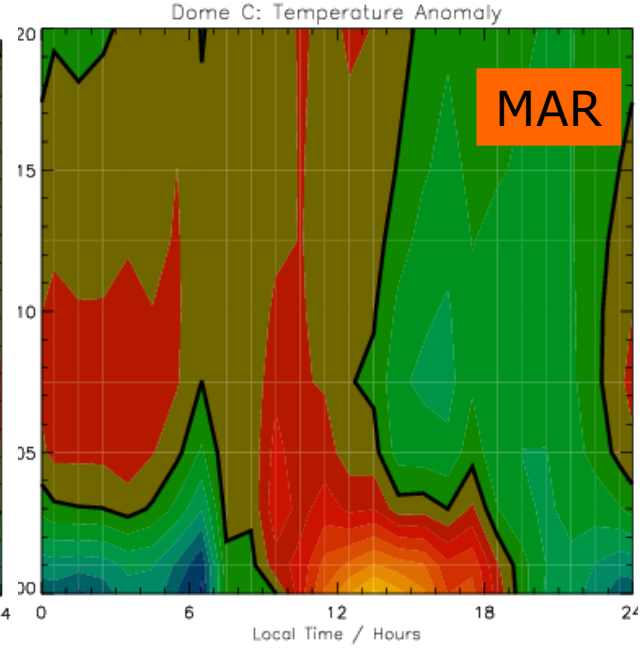
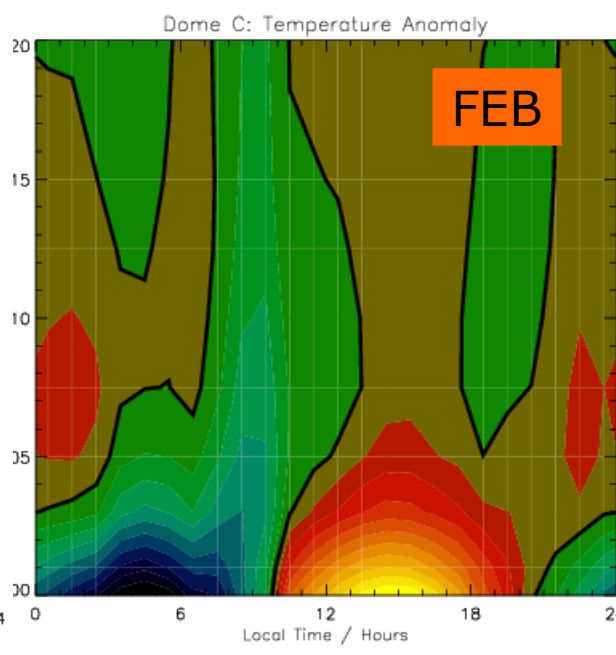
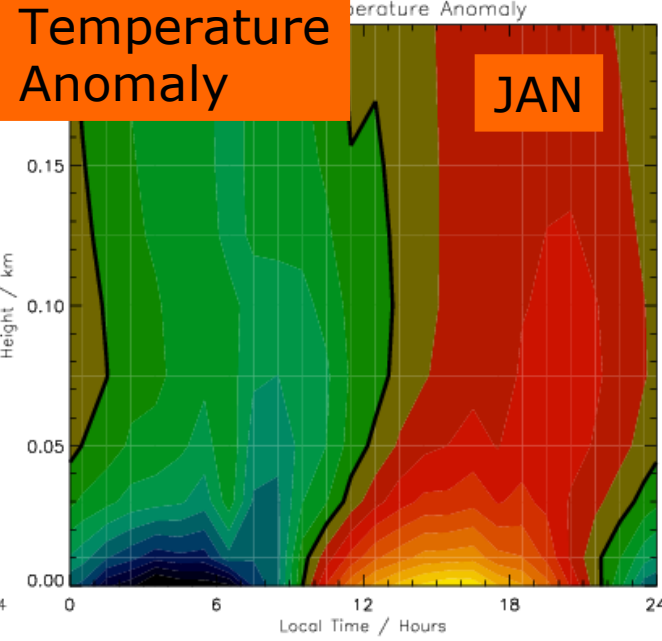
JAN-MAR 2010



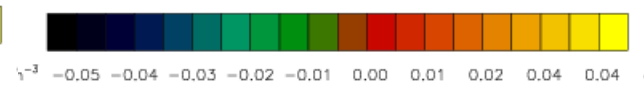
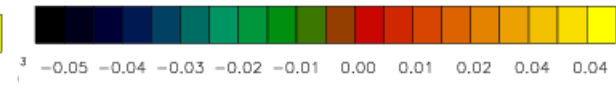
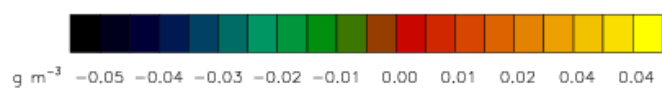
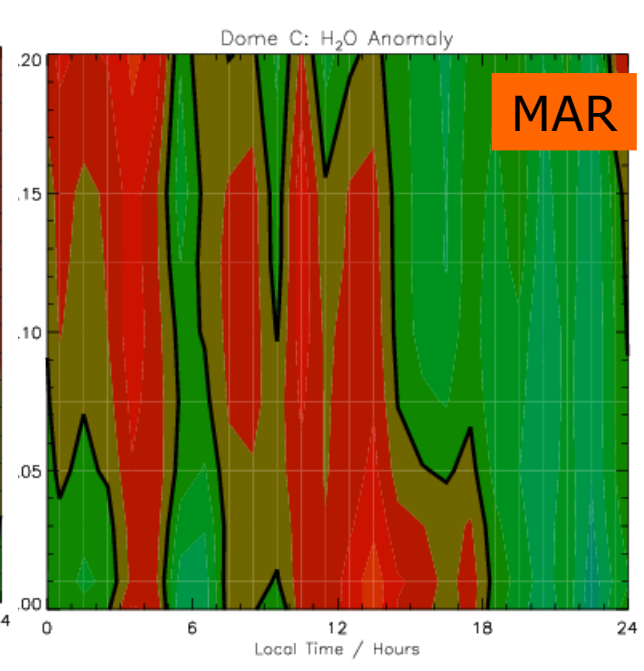
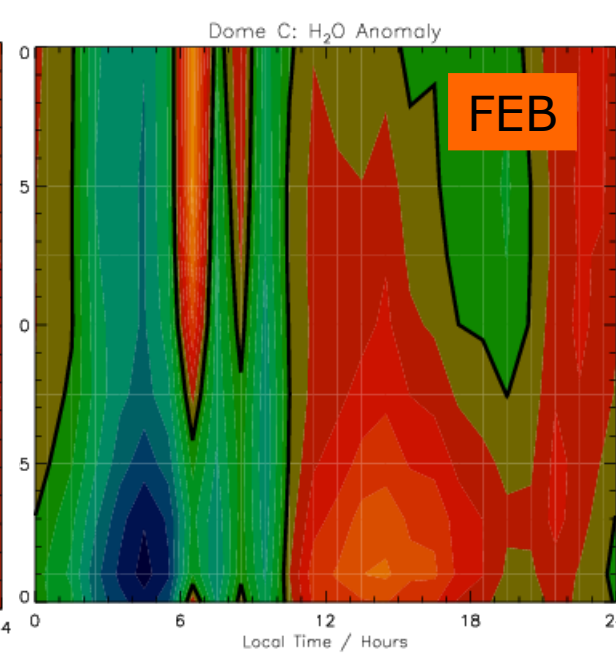
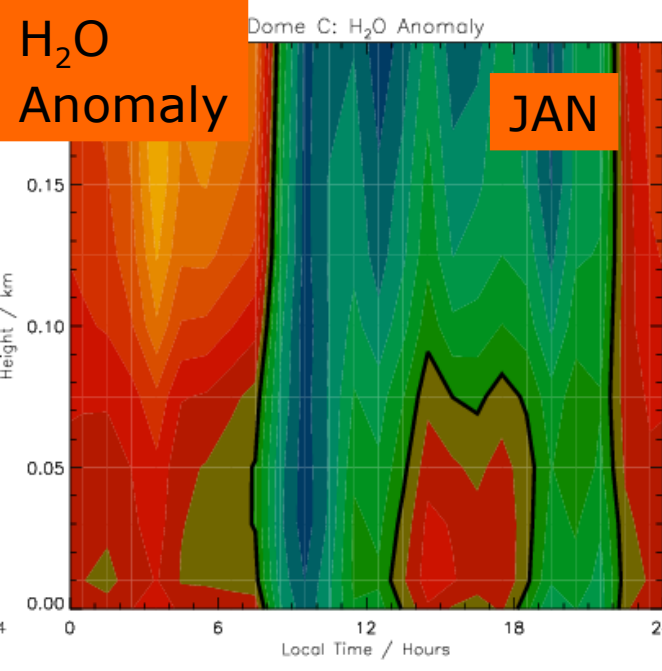
Diurnal Variation of Temperature / January




Temperature Anomaly



H₂O Anomaly



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Conclusions

- HAMSTRAD is behaving well at DC since JAN 2010
- Validation
 - PdM: radiosoundings and IASI (H₂O)
 - DC: radiosoundings, IASI and in situ sondes (H₂O and T)

HAMSTRAD sensitivity		
H ₂ O	PBL	weak
	Free Troposphere	good with bias
	UT	weak
	LS	no
Temperature	PBL	very good
	Free Troposphere	good with bias
	UTLS	weak

- Science
 - surface-atmosphere interaction (PBL), diurnal variation³⁶