

The HAMSTRAD Programme at DOME C, Antarctica

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Outline

- 1. Scientific context
- 2. Dome C station
- 3. Measurements & Analyses
- 4. Conclusions

1. Scientific Context

- 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)
- Setup
 - 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 to date**
 - **permanent indoor setting up**

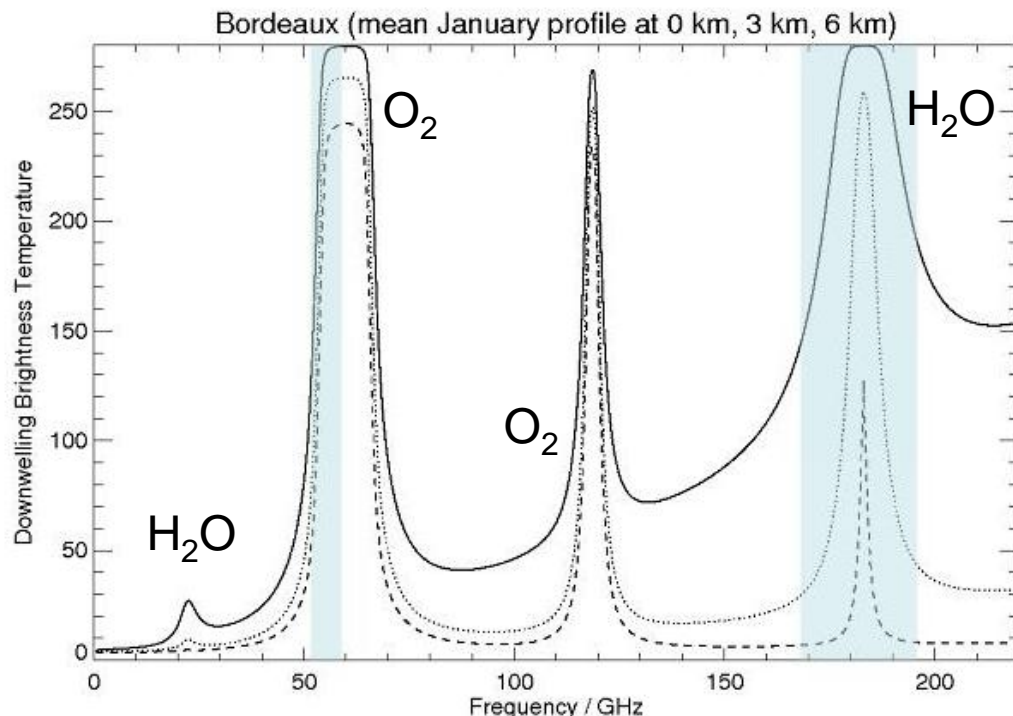
HAMSTRAD Radiometer

- 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)
 - **PBL: 30-50 m (H_2O) & 10-20 m (T)**
- Time resolution: 1-10 min
- Errors (RMS) : 0.01-0.04 g m⁻³ (H_2O) & 0.5-2 K (T)

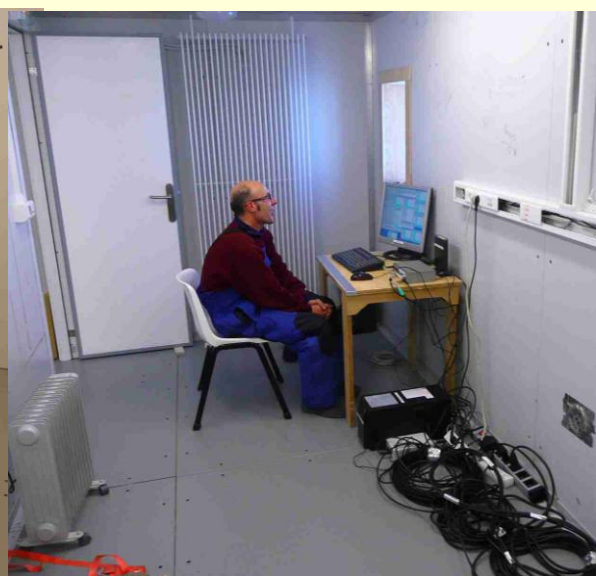
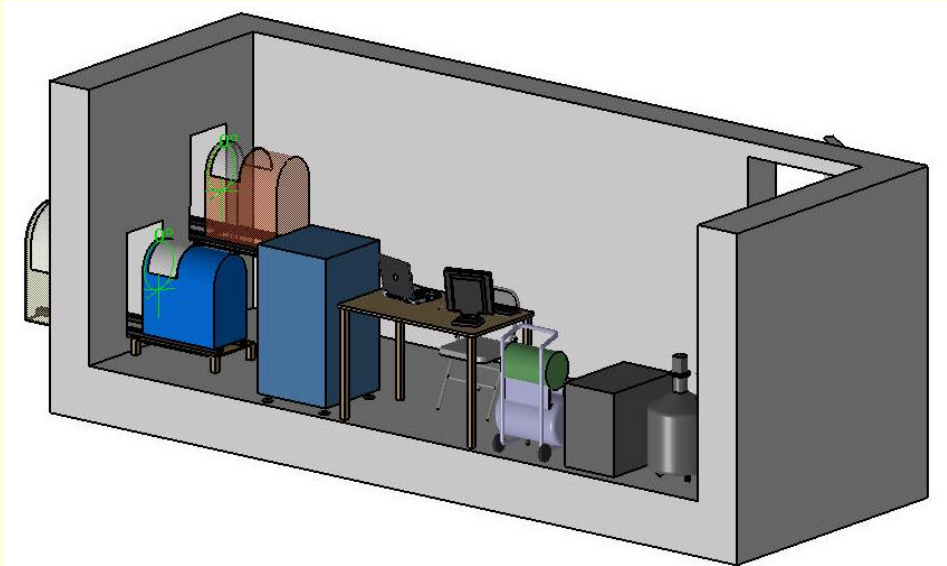


2. Dome C station

Outdoor Measurements



Indoor Measurements

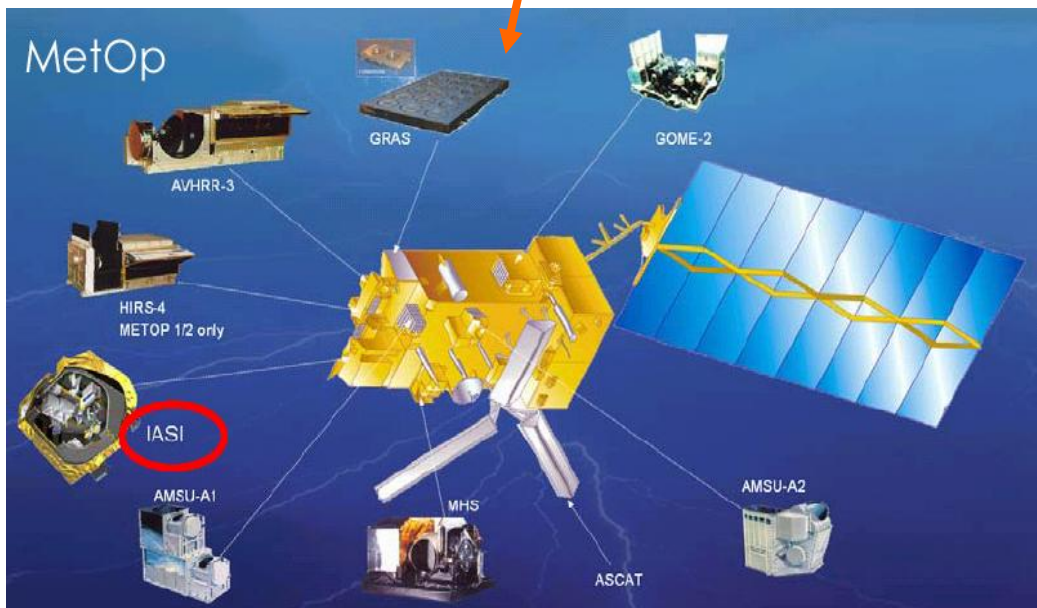


HAMSTRAD Measurements at Dome C

- 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 (twice per year)
 - Outdoor Temperature: from -20°C to -80°C
 - Indoor Temperature: from +1°C to +18°C
 - Daily automated transfer of measurements
- Results
 - Validation & Statistical Analysis (Mean, bias, correlation, ...)
 - **Diurnal variability of T & H₂O in the PBL**
 - **Jan-Jun 2010 (summer to winter)**
 - **Monthly-averaged data**
 - **24 x one-hour bins**

Validation

- Radiosondes (0-10 km)
- In situ sensors (0-45 m)
- Satellites (IASI and AIRS) (0-10 km)
- Analyses from ECMWF (0-10 km)



Seasonal Variability & Statistical Analysis

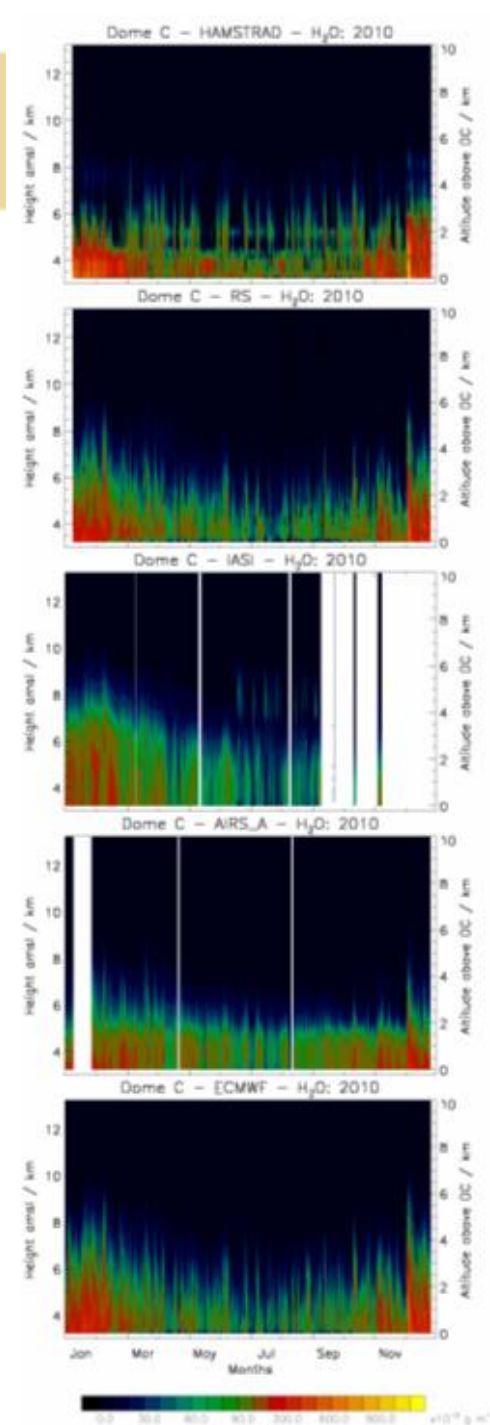
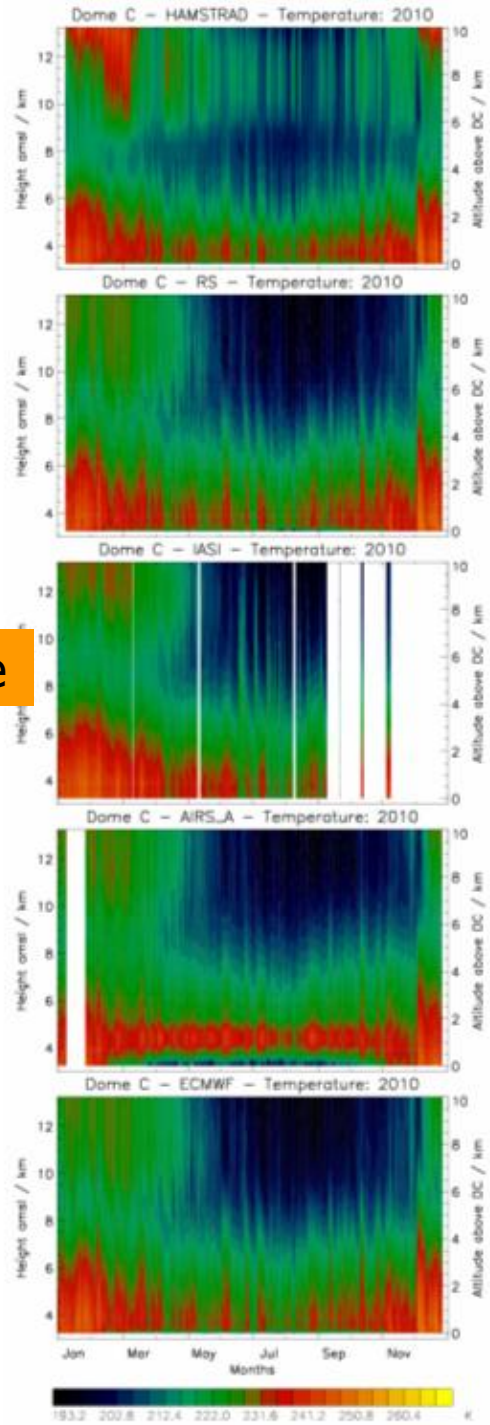
HAMSTRAD

Radiosondes

IASI

AIRS

ECMWF
2010



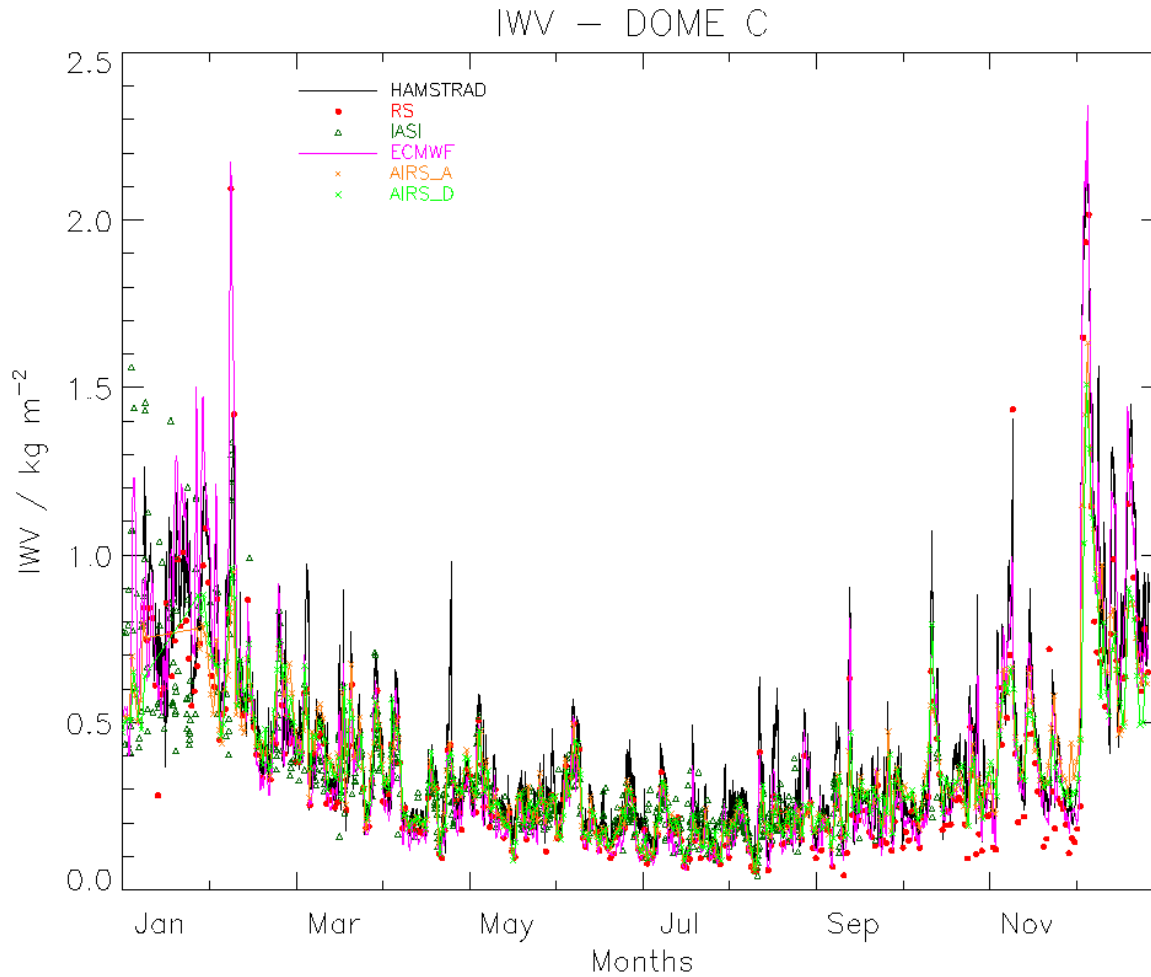
Temperature

H₂O

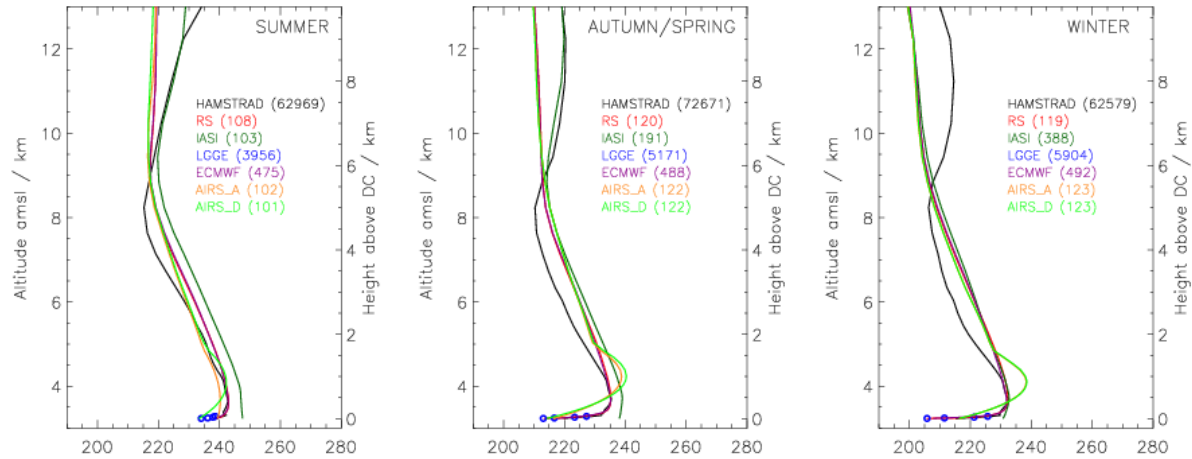
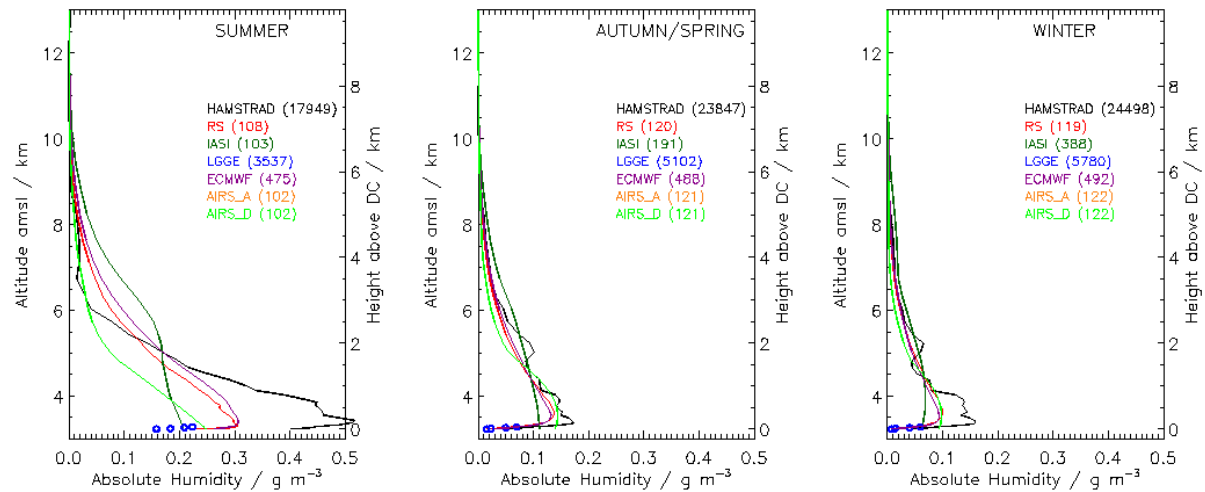
Ricaud et al.,
Antarc. Sc.,
revised. 2013.



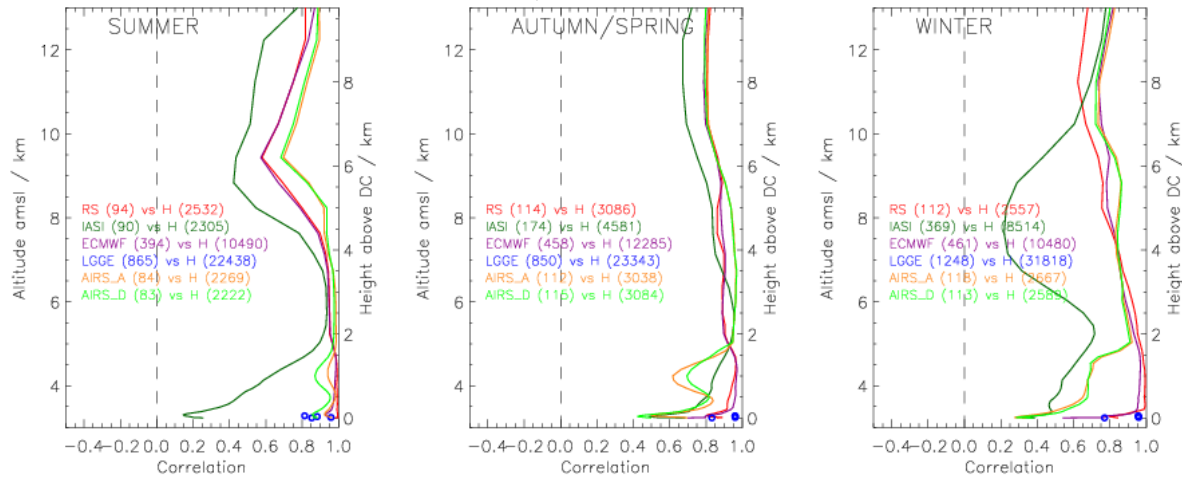
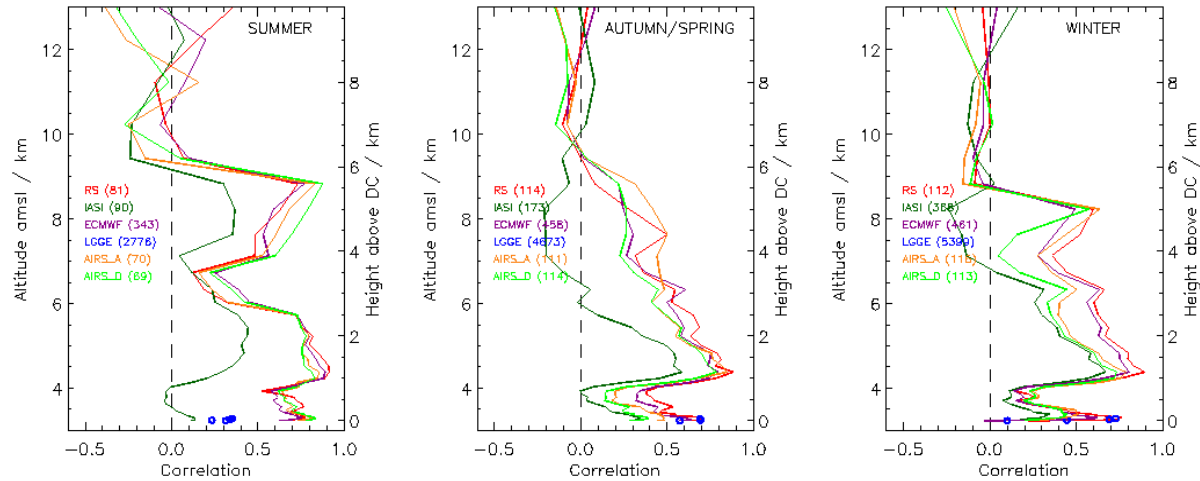
Integrated Water Vapor (I WV) / 2010



Dome C 2010 / Temperature

Dome C 2010 / Averaged H_2O 

Dome C – Temperature Correlation

Dome C – H₂O Correlation

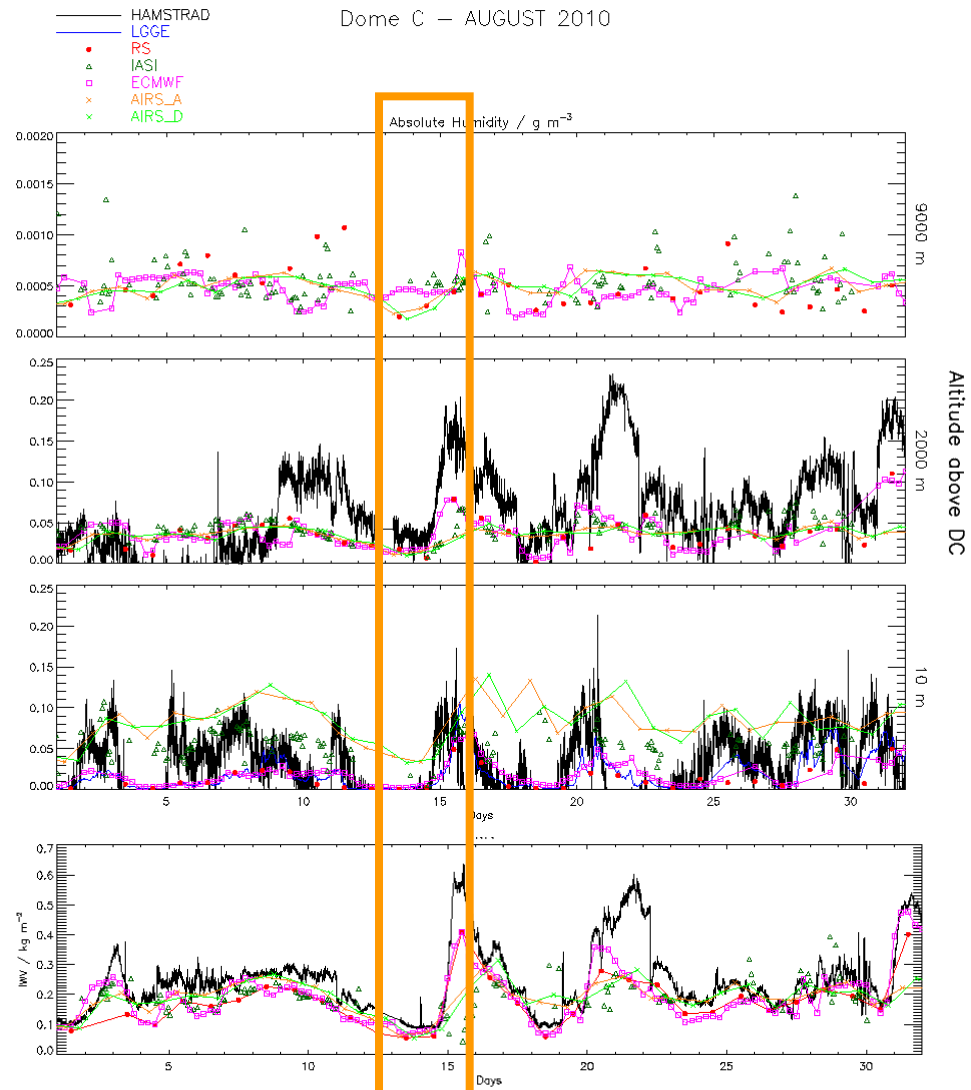
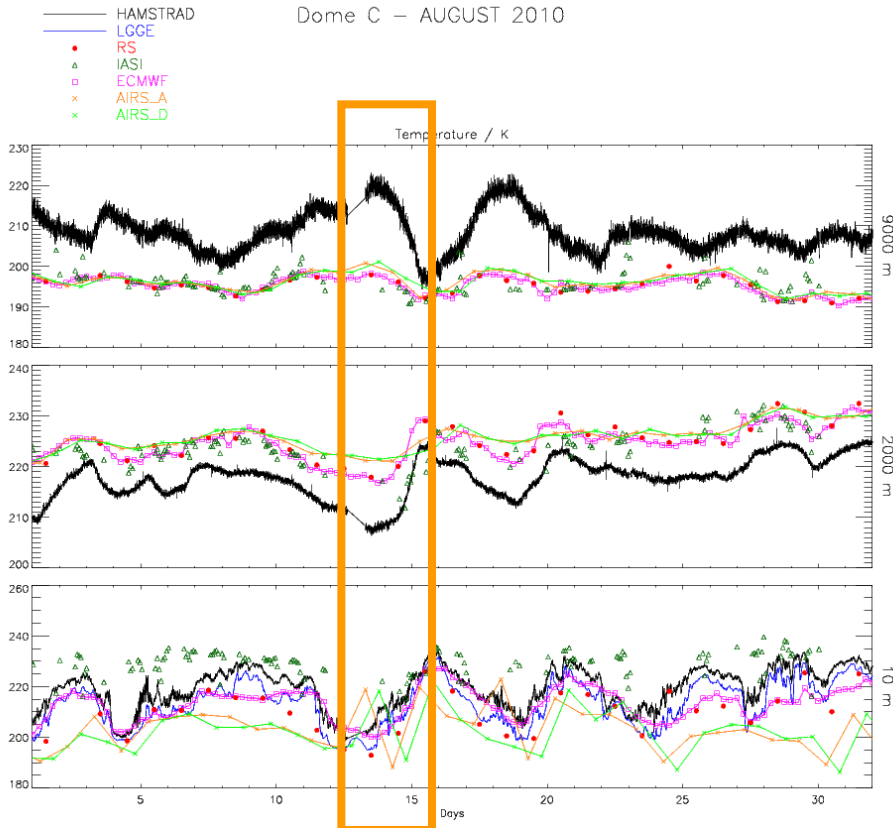
Intra-seasonal Variability

- Origin of air masses
 - 5-day back-trajectories
 - Statistical analysis in 2010
- AROME mesoscale model
 - March-April 2011

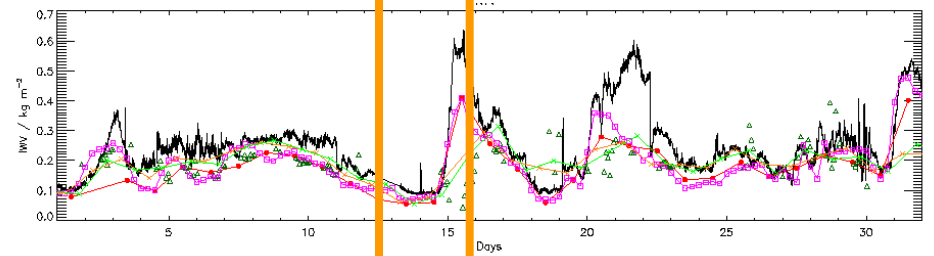
Temperature

August 2010

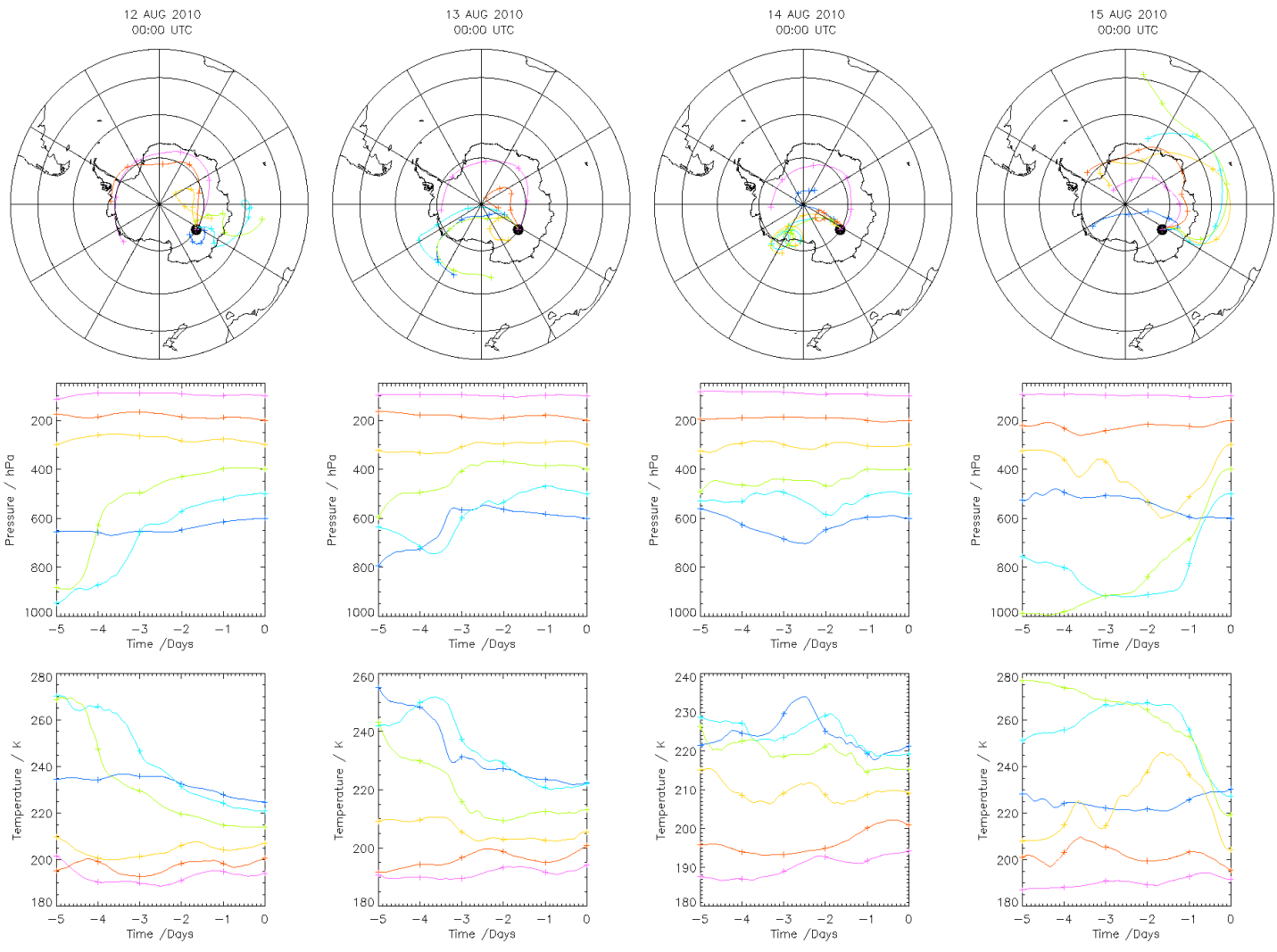
H₂O



IWV



5-Day Back-Trajectories

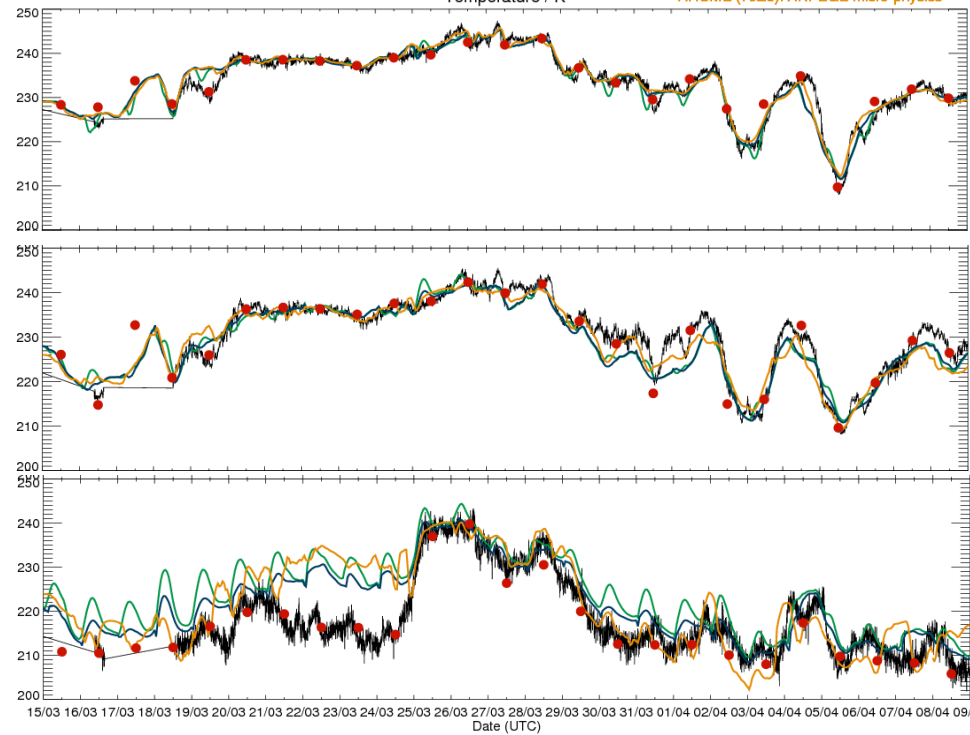


AROME vs. HAMSTRAD

Dome C

HAMSTRAD
 RS
 AROME (79HA): Operational
 AROME (79YG): Operational with Ice tuning
 AROME (79Z6): ARPEGE micro-physics

Temperature / K



100 m

50 m

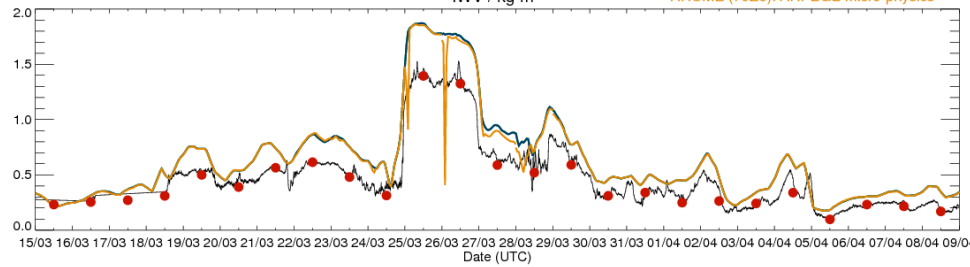
4 m

Temperature

Dome C

HAMSTRAD
 RS
 AROME (79HA): Operational
 AROME (79YG): Operational with Ice tuning
 AROME (79Z6): ARPEGE micro-physics

IWV / kg m²



IWV

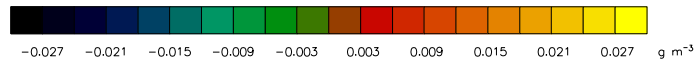
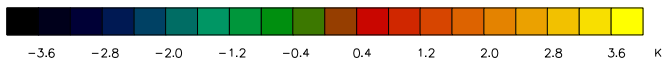
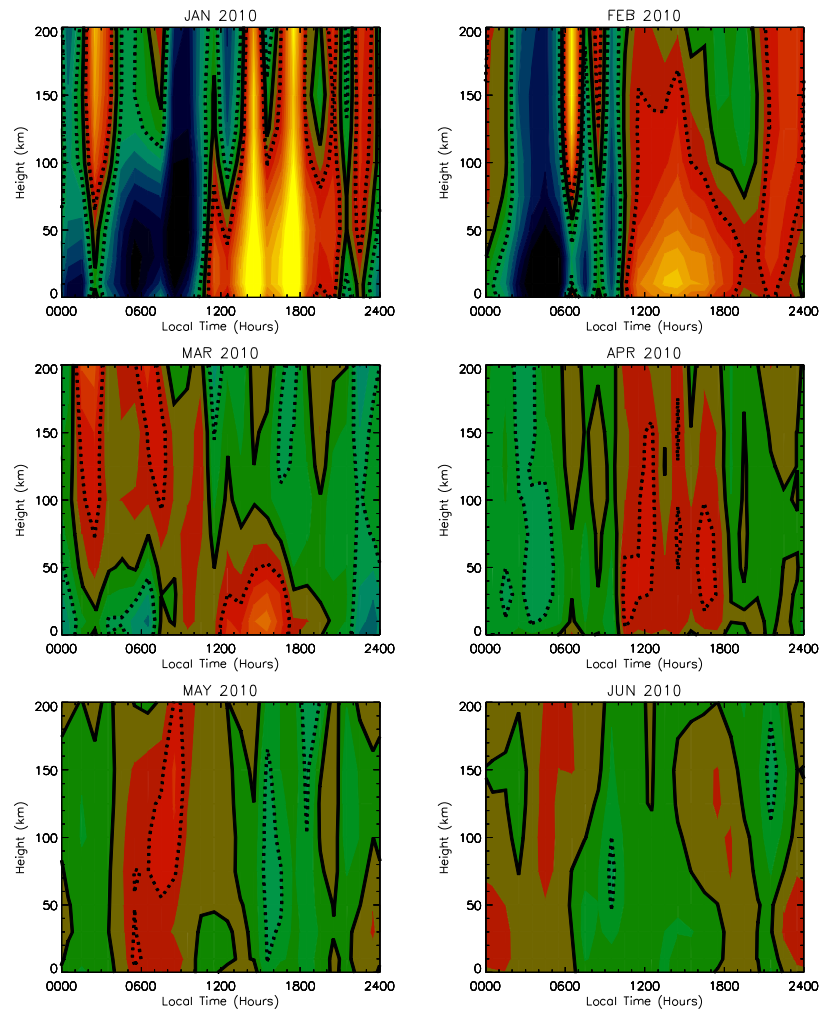
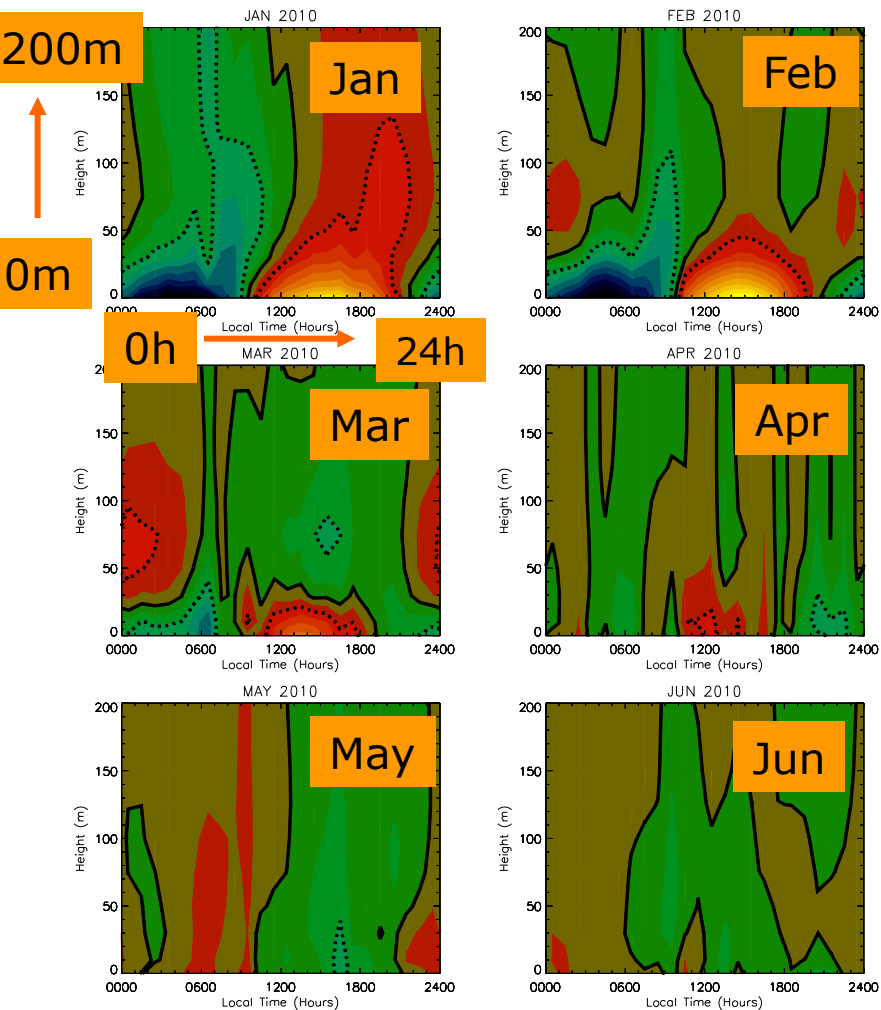
Diurnal Variability

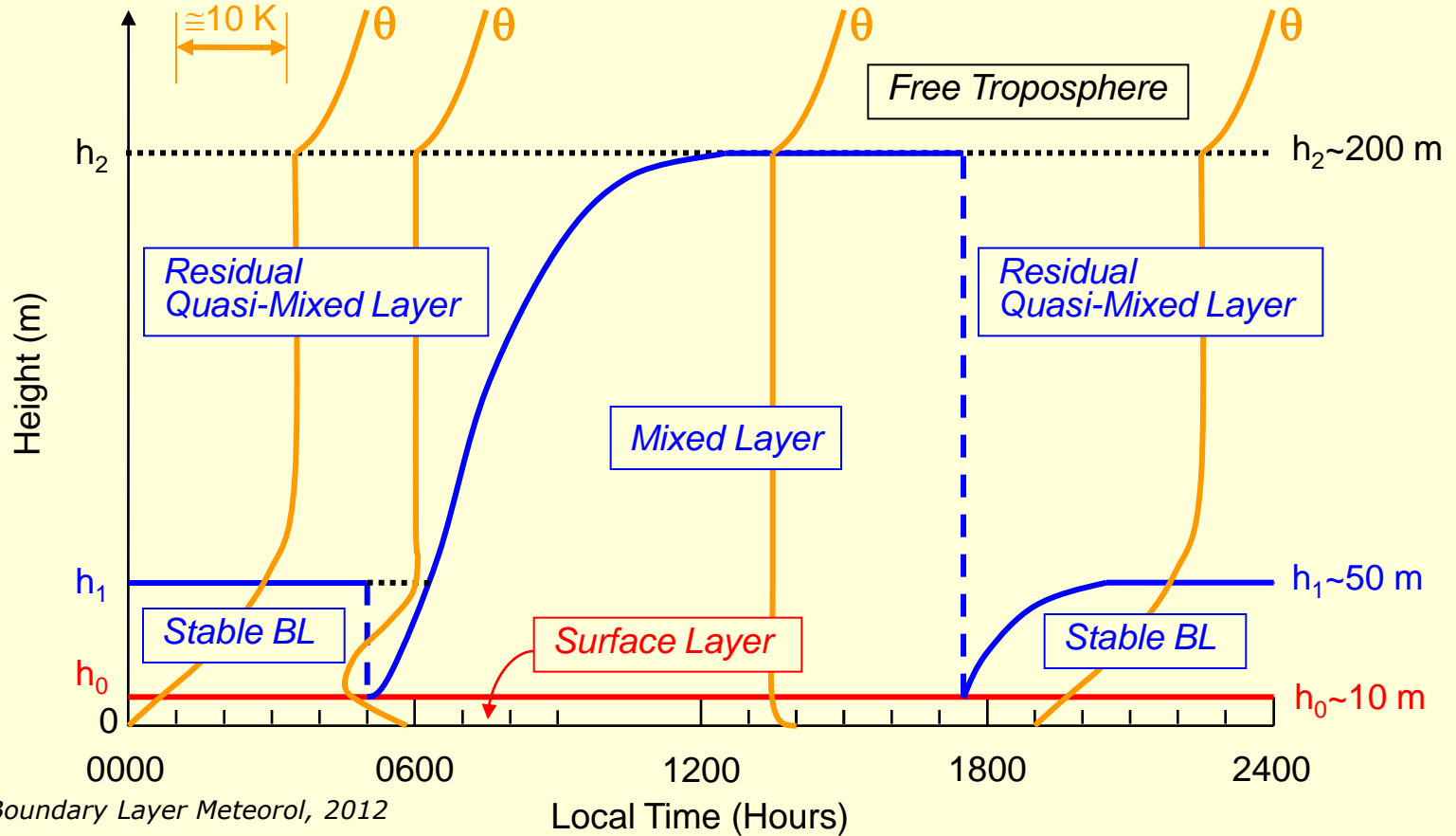
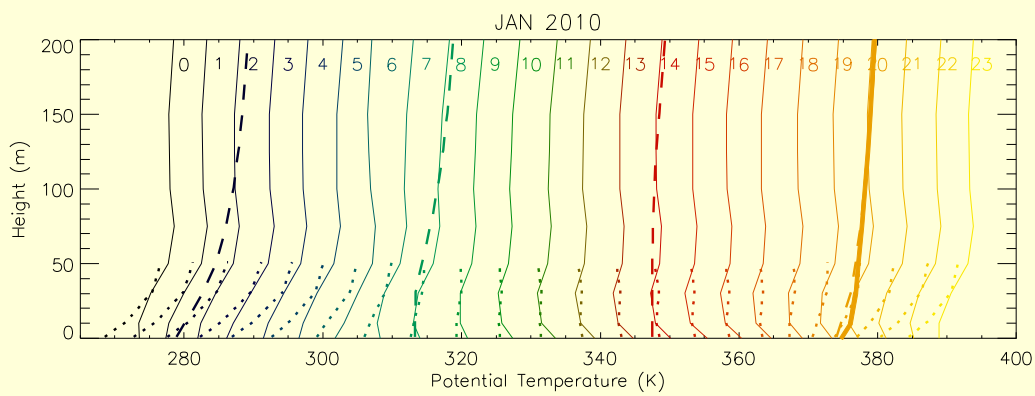
Temperature Anomaly

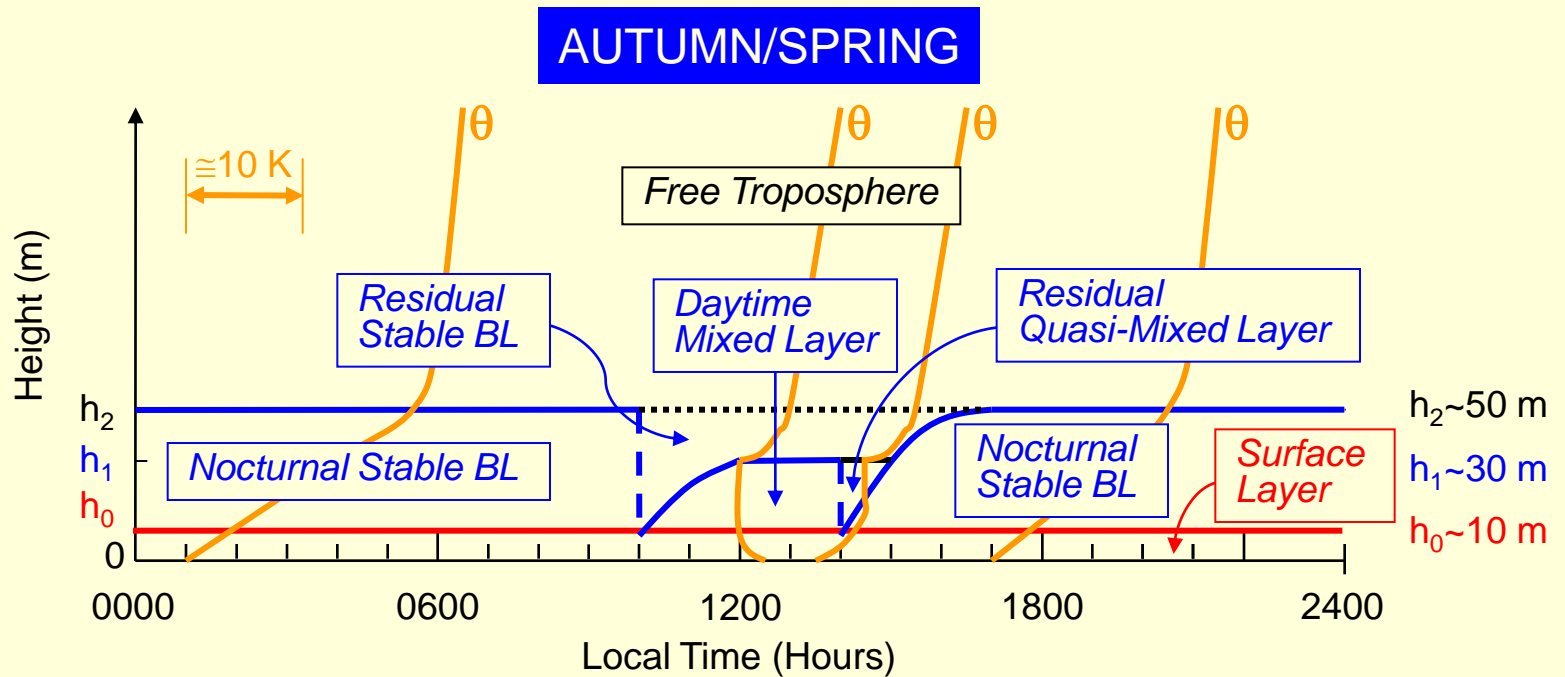
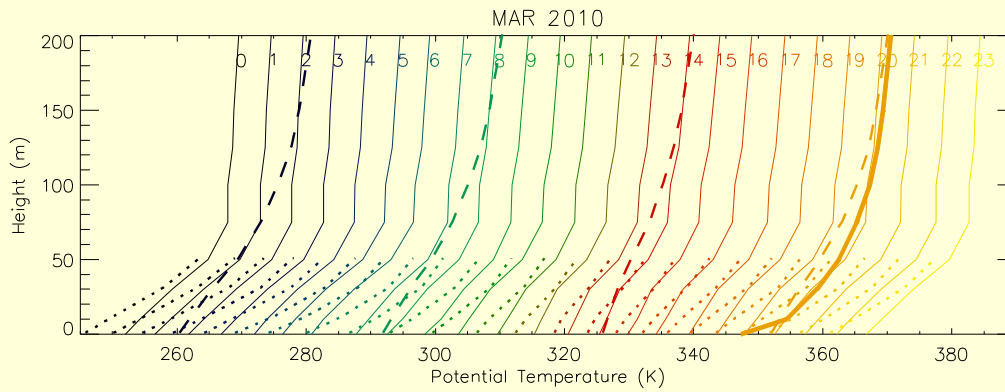
H₂O Anomaly

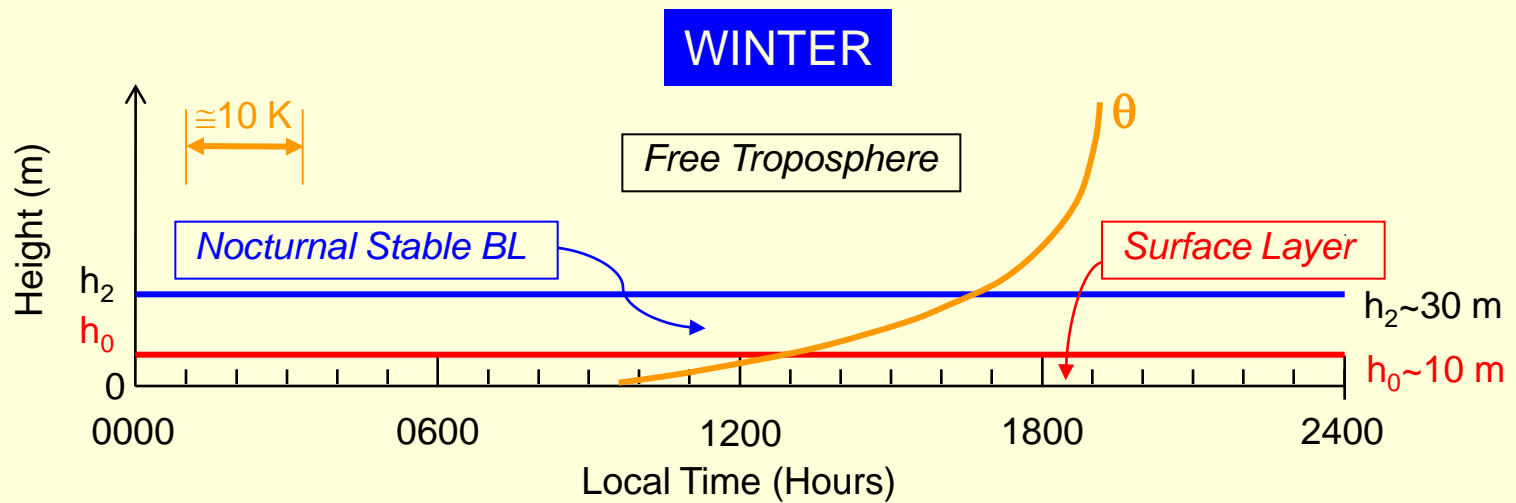
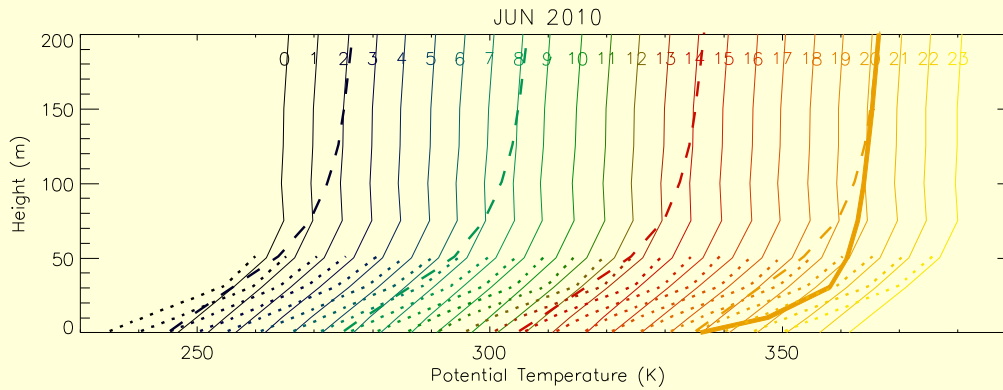
Dome C: Temperature Anomaly

Dome C: H₂O Anomaly









Conclusions

- HAMSTRAD is behaving well at DC since January 2010, except some issues on H₂O-channel stability (noise diode) in June 2011-January 2012
- Validation (whole year of 2010)
 - radiosondes, IASI, AIRS, in situ sensors, ECMWF analyses
 - Temperature: great sensitivity in the PBL, decreasing towards the UTLS
 - Strong biases in the free troposphere and UTLS
 - Good correlation with all the other data sets ($r > 0.9$)
 - H₂O: sensitivity in the PBL, decreasing towards the UTLS
 - Too wet lower troposphere and too dry free troposphere
 - Moderate correlation with all the other data sets ($r > 0.8$)
- Seasonal, intra-seasonal and diurnal variabilities of T and H₂O
 - Solar radiation, origin of air masses & PBL evolution
- Further studies
 - Upgrade of the acquisition system (more elevations) and analysis softwares (fast quadratic regression vs. slow Optimal Estimation Method) → done
 - Reprocessing of data → to be done
 - Comparisons with the mesoscale model AROME → work in progress
 - Analysis of the IASI METOP-B data → to be done
 - Analysis of any reprocessed IASI METOP-A data → to be done