Context & Objectives

Why use offshore GNSS measurements for IWV retrieval?

- Origin of severe weather events.
- Area limited to surface observations or satellite remote sensing.

State-of-the-art

Mode, software  
Constellation  
Area  
Period  
RMS (w/t)

[Roc+05]  
PPI, BCSW  
GPS  
Caribbean Sea  
2 wks (2003)  
1.4 kg m⁻² (RS)

[Fuj+08]  
PPI, RTNet  
GPS  
Indian Ocean  
7 days (2007)  
2.6 kg m⁻² (RTNet)

[Iaa+12]  
PPI, RTNet  
GPS, Glonass  
Mediterranean Sea  
4 mths  
2.4 kg m⁻² (RS)

[Fuj+14]  
PPI, RTNet  
GPS, Glonass, QZSS  
Japan  
1 mth (2013)  
2.0 kg m⁻² (RS/GNSS)

[Sho+17]  
PPI, RTK, RTKlib  
GPS, Glonass, QZSS  
Japan  
10 mths (2016-2017)  
2.8 kg m⁻² (RS)

[Nar+19]  
PPI, RT, RTKlib  
GPS, Glonass, QZSS  
Arctic Ocean  
20 days (2016)  
1.0 kg m⁻² (CORs)

[Liu+19]  
PPI, RT, RTKlib  
GPS, Glonass, QZSS  
Indian Ocean  
3 days (2014)  
1.2 kg m⁻² (ERAI)

[For+19]  
PPI, RT, RTKlib  
GPS, Glonass  
Indian Ocean  
2 mths (2012)  
3.0 kg m⁻² (Arpege-WMED)

Benefits of offshore GNSS IWV retrievals:

- Meteorology: potential of ships of opportunity.
  Requirement for accuracy/latency: 2kg m⁻², 15 minutes for 1h-forecast.
- Climatology: potential of research vessels, already equipped.
  Requirement for accuracy: 1-2kg m⁻².
  Requirement for accuracy: 20 to 40mm (antenna position).

Borda Cruise

- Route from Brest to Toulon (Fr, Aug. 2015).
- PPP_AR using Gipsy-Oasis II 6.4.
- 2 GPS antennas (BRDA + BRD2).
- VMF model (a priori & mapping function).

IWV Evaluation

BRDA (ref) / BRD2  
ERAI  
ER5  
ARO_AN / ARO_FC1  
ARO_AN / ARO_FC6  
MODIS_IR

30s GPS IWV for antennas BRDA and BRD2 using VMF Tm and ER5 Pm,sl  
ECMWF reanalysis, 6h ± 0.75deg (~ 60-80km)  
ECMWF reanalysis, 1h ± 0.25deg (~ 20-30km)  
Meteo-France small scale NWP Arape, analysis and 1h-forecast, 1h ± 1.3km  
Meteo-France global NWP Arpege, analysis and 6h-forecast, 6h ± 7.5km  
Satellite radiometer MODIS, infrared JWV within 20 km & 450s range

Investigation of the possibility of an analysis at t+15min with error inferior to 2kg m⁻² for a forecast at t+60min:

- Use of real-time products from IGS (IGC1) archived by CDDIS
- PPP using Gipsy-Oasis II 6.4 (w/o AMB fixing)
- 6h sessions every 3h (short sessions may be required if transmission rates are limited)
- GPT/CIFM model
- Screening of estimates: σ₂₂D > 4 mm (0.2% of estimates)

Mean deviations: -0.37 ± 2.20 kg m⁻²
68.0% of differences inferior to 2 kg m⁻²

Global consistency between all techniques
Noticeable deviations over certain periods for certain models (e.g. around day 220 or 226)
Significant differences with MODIS_IR
Improvements from ERA5 with respect to ERAI
Analysis better than forecast (ARO & ARP)
Very good consistency between the 2 antennas

Conclusions & Perspectives

- Interest of shipborne GNSS for meteorology and climatology
- Accuracy levels similar to CORS (uncertainty < 2kg m⁻²) could be reached
- Near-real time is still ambitious, but the results are encouraging (standard deviation just over 2kg m⁻² for 6-hour sessions)
- Methodology for analysis still should clarified (contribution of mGNSS, ambiguity, stochastic modeling, etc.)
- Near-real time application still required a robust means of communication for retrieving shipborne data.

References


