

# Atmospheric Effects in Space Geodesy: Plans and Perspectives

Johannes Böhm, Michael Schindelegger, Maria Karbon,  
Harald Schuh, David Salstein, Marcelo Santos

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# Project “GGOS Atmosphere”

- Funded by the Austrian Science Fund (FWF)
- “ .. to provide a detailed understanding of atmospheric involvement in geodesy, as noted in its three pillars: **geometry, rotation, gravity field**”



# Project “GGOS Atmosphere”

- Based on a **common data stream of the ECMWF**, four atmospheric quantities are determined in a consistent way:
  - Atmospheric Pressure Loading Corrections APL
  - Atmospheric Angular Momentum Functions AAM
  - Atmospheric Gravity Corrections AGC
  - Atmospheric Delays

<http://ggosatm.hg.tuwien.ac.at/>



# Data processing: APL, AAM, AGC

- ECMWF **pressure level data** with 1° horizontal resolution: p, T, Z, q, u, v
- **block area mean** values
- **EGM96 for gravity** and undulations
- **ETOPO5-based** surface grid (instead of orography) - simultaneously with the Global Reference Pressure GRP
- **WGS84** for geo-referencing

# Angular Momentum Functions

- Status
  - matter terms and motion terms
  - 6-hourly (from 1980; ERA40 + operational analysis)
  - 3-hourly (from mid-2010; 10-day forecast)
  - center of mass and total mass of the atmosphere

Associated data set (not publicly available)

- 3-hourly (2004-2011; ‘delayed cut-off’ analysis DCDA)

# Angular Momentum Functions

- Perspectives
  - Atmospheric tides:
    - Validation of matter and motion terms by in-situ observations (barometric data in particular)
    - Independent comparison of DCDA-based AAM to that of other 3-hourly analysis data
  - Cross-validation with the results derived from atmospheric torques at various time scales
  - Release of the 3-hourly AAM and torques?

# Pressure Loading Corrections

- Status
  - (R,E,N)-displacements for geodetic sites and global grids ( $1^\circ \times 1^\circ$ ) (Center of Mass)
  - consistent S1/S2 model
  - 6-hourly (from 1980; ERA40 + operational analysis)
  - forecast (next day)
  - Global Reference Pressure
    - GRP memo, data and codes available at <http://ggosatm.hg.tuwien.ac.at/LOADING/REFPRES/>

# Pressure Loading Corrections

- Perspectives
  - Improved Land-Sea mask
  - Add Center of Figure corrections

# Gravity Corrections

- Status
  - gravity field coefficients up to degree and order 100
  - 6-hourly (from 1980; ERA40 + operational analysis)
    - surface pressure approach (1980-now) with GRP
    - vertical integration (2000-now)

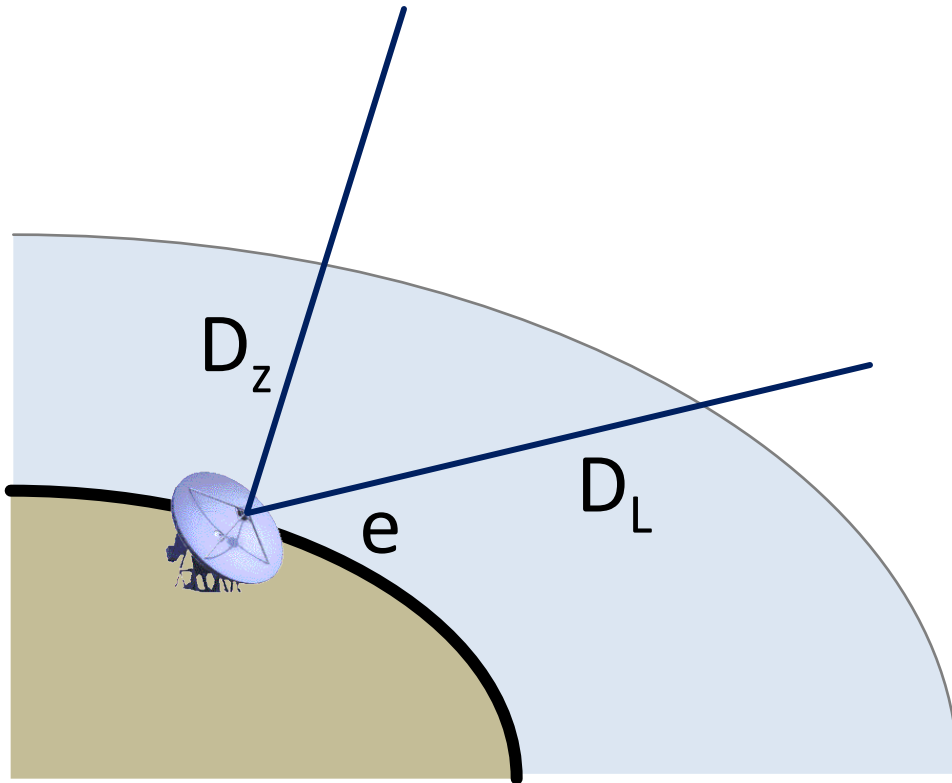
# Gravity Corrections

- Perspectives
  - Including S1, S2 and S3 corrections
  - Validation with the results derived from other NWM data and institutions
    - GFZ (AOD1B)
    - CNES/GRGS (10-day solution)

# Troposphere delays

$$D_L(e) = D_z \cdot m(e) = D_{zh} \cdot m_h(e) + D_{zw} \cdot m_w(e)$$

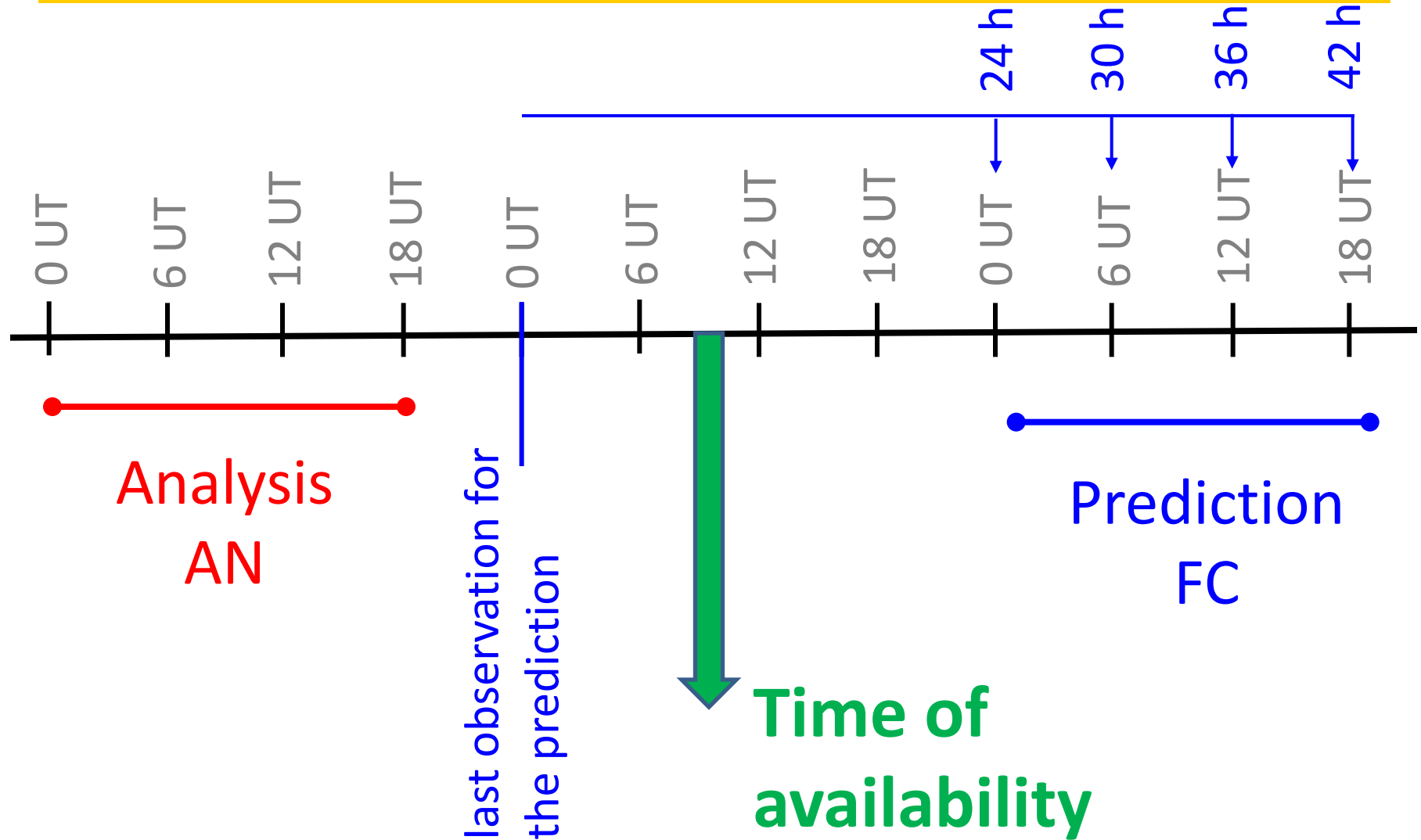
+ gradients



# Vienna Mapping Functions

- Status
  - Coefficients **a** of the continued fraction form for hydrostatic and wet Vienna mapping function
  - Hydrostatic and wet zenith delays
  - $2.5^\circ \times 2.0^\circ$  lon/lat grid
  - ERA40 and operational analysis data
  - forecast for the next day (scientific purposes)

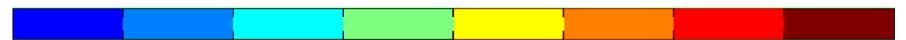
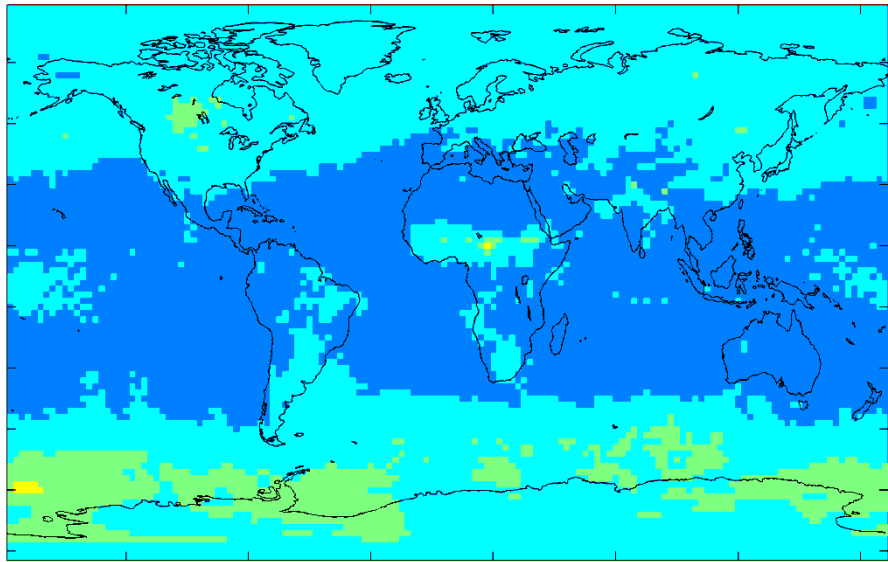
# Availability of VMF1



# AN vs. FC

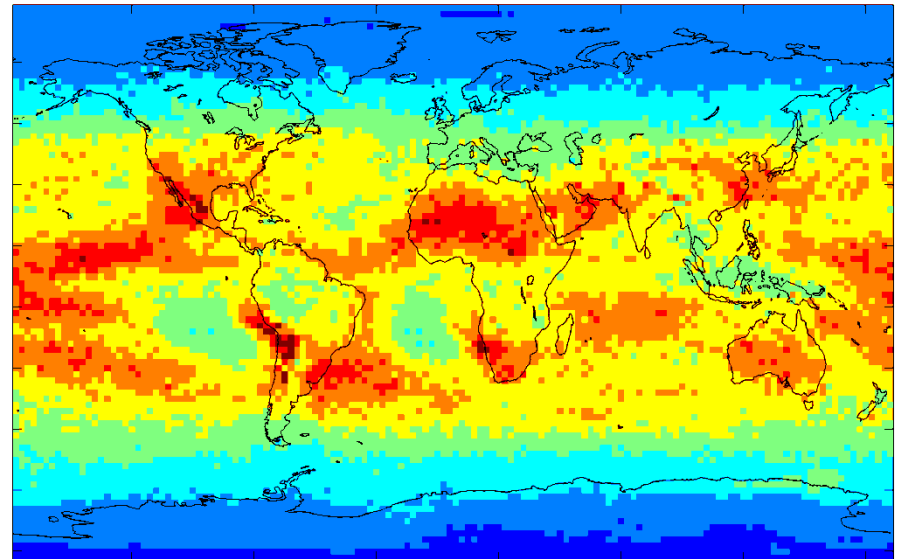
## Height std.dev. after 42 hours

VMF1 hyd.



0 0.8 1.6  
mm

VMF1 wet



0 0.8 1.6  
mm

# Vienna Mapping Functions

- Perspectives
  - add stream with 1° ERA Interim (no discontinuities)
  - improved blind models (GPT, GMF)
  - VMF1 for SLR
- Other providers
  - Goddard for zenith delays
  - UNB for VMF1

# UNB – VMF1 Service

- Improve the availability of VMF1 – less likely occurrence of service disruptions
- Greater compatibility with other derived NWP products, e.g. atmospheric loading from NCEP
- Derived from an independent source (NWP, ray-tracing) – improved robustness of combined products

**<http://unb-vmf1.gge.unb.ca/>**

# UNB-VMF1: Summary of Products

| Product Name | Description                                                       | Parameters    |
|--------------|-------------------------------------------------------------------|---------------|
| unbvmfG      | 2.0x2.5 degree global grid<br>NCEP Re-Analysis 1<br>7 day latency | aw,ah,zhd,zwd |
| unbvmfGcmc   | 2.0x2.5 degree global grid<br>CMC - GDPS<br>1 day latency         | aw,ah,zhd,zwd |
| unbvmfP      | 2.0x2.5 degree global grid<br>CMC -GDPS<br>0 Latency (+1 day)     | aw,ah,zhd,zwd |

# Ray-traced slant delays

- Applications:
  - Hobiger et al. (2008 EPS) for PPP solutions w.r.t. GMF
  - MacMillan/Petrov for VLBI w.r.t. VMF1
  - Nafisi et al. (2012) for VLBI Intensive sessions
  - Gegout et al. (2011)
  - Hulley and Pavlis (2007)
  - ...
- Estimation of residual zenith delays (and gradients) still necessary

# Ray-traced slant delays

- Difficult to provide ray-tracing delays for various reasons
  - large amount of data (infinite?)
  - large computational efforts (GPU, Hobiger)
  - model coefficients need to be fitted to ray-traced delays

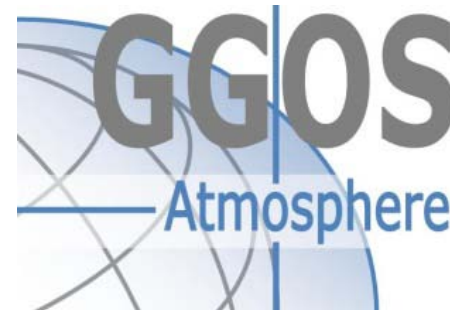
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Acknowledgement:  
P 20902-N10

**FWF**



# Thanks for your attention!

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**FWF**



# unbvmfG (NCEP) AVAILABILITY

CURRENT DAY MINUS 7 DAYS

|     |     |     |     |
|-----|-----|-----|-----|
| 00h | 06h | 12h | 18h |
|-----|-----|-----|-----|



CURRENT DAY

|     |     |     |     |
|-----|-----|-----|-----|
| 00h | 06h | 12h | 18h |
|-----|-----|-----|-----|



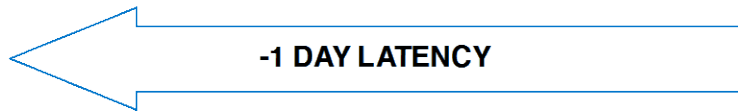
Availability

00z 6h Forecast

12z 6h Forecast



|     |     |     |     |
|-----|-----|-----|-----|
| 00h | 06h | 12h | 18h |
|-----|-----|-----|-----|



CURRENT DAY

|     |     |     |     |
|-----|-----|-----|-----|
| 00h | 06h | 12h | 18h |
|-----|-----|-----|-----|



Availability

# unbvmfGcmc (CMC) AVAILABILITY

# unbvmfP (CMC) AVAILABILITY

