Weather Radar Pointing

Contribution to Error Budget

Theo Mammen, Michael Frech et al
General

- The navigation of the radar data is based on RF-runtime between radar and target, as well as on the measured pointing angles of the radar beam.
- Several effects contribute to uncertainties. They can be grouped into different categories.
- Since an error estimate must be valid for every single direction of the sphere covered by the radar beam, averaging is not applicable.
1. Tower

→ Typ. Basis for a radar system is a tower
→ Towers bend:
→ Due to wind (~ Seconds)
→ Due to single side solar heating (daily cycle)

→ Typ. Max Error: ~ 0.1 deg
2. Radar

2.1 Leveling

- the turning level for the antenna head has to be horizontal
- an inclinometer (or bubble-level) in the head helps to configure shims for adjustment
- bearing wobble present!

- *Typ. Max Error: ~ 0.05 deg*

*(with electronic inclinometer of appropriate resolution and linearity!)*
2.2 Mechanics

Positioning
The drive (typ. No anti backlash gears) points the dish towards a requested direction.

Poiting
The angel acquisition system/track measures the direction of the dish relative to the pedestal. These values are used to tag the data.

Backlash
Gears need some minimal space at all times and position amongst each other for not nor fail.

Tolerances
No Gear or bearing is perfect, e.g. Circular. Such non-linearities add to the uncertainty budget.

→ Typ. Max Error:
→ ~ 0.1 deg
Backlash and Tolerances

Typ. Max Error: ~ 0.1 deg?
3. Adjustment

Besides mechanical adjustments like backlash, also the angle encoders need to be set up.

Two basic methods can be distinguished:

**Mechanical orientation**

- **Azimuth**: compass with mid of dish-mark
- **Elevation**: plumb over frontside of dish

**Direction of microwave beam**

- **Azimuth**: known direction of narrow clutter target
- **Azimuth and Elevation**: SUN

⇒ **Typ. Max Error:**

>~ 1-2 deg?
3.2 Sun

The radar is sensitive for the microwave parts of the sun spectrum. For a know place the sun's direction can be calculated for any time. All sun evaluations are referenced to the microwave beam.

3.2.1 Algorithms

Different Algorithms can be used to calculate the sun's position, with different strengths, e.g.

- DIN 5034, SUNAE, NREL_SOLPOS, libnova

→ Typ. Max Error: ~ 0.01 deg
3.2.2 Sun Track

A SW-Tool controls the Antenna to point towards the estimated sun position. By applying manually offsets in Azimuth and Elevation, the peak of the sun-signal is searched. This provides an offset for the positioning system.

→ **Typ. Max Error:**

~ 0.1 deg?
3.2.3 Sun Scan

A SW-Tool controls the Antenna to point towards the estimated sun position. By applying manually offsets in Azimuth and Elevation, the peak of the sun-signal is searched. This provides an offset for the positioning system.

→ **Typ. Max Error:**

~ 0.05 deg?
3.2.4 Box Scans

Box scans, that take only a few minutes allow for offset measurements as a function of azimuth/elevation.

For this method the production has to be stopped.

If done for every individual site, a partial correction function can be derived.

➔ **Typ. Max Error:**

~ 0.05 deg?
4. Data tagging

At the beginning of the data acquisition there exist two paths:

- Data
- Angles

At some point in the processing, data are tagged with angles. There will be some time difference with respect to point of time for A/D-conversion and angle digitization.

⇒ *Typ. Max Error: ~ 0.05 deg??*
5. Results and Outlook

Several effects contribute to uncertainties in tagging the data with georeferenced angles. These errors may vary with radar design, actual position, i.e. function of AZ and EL, used methods for adjustments of offsets and even the behavior of the radar tower.

Some values can and should be monitored, e.g. angle offsets by sun scans.

Temperature effects on the antenna assembly might also result in pointing errors. This needs further investigation.

Typ. Max Error: > 0.3 deg!?? == “Experts” guess

Monitor error sources and tag data with quality measures