Atmospheric mapping with SAR interferometry

Derivation of Integrated Tropospheric Refractivity from Radar Satellite Data and its Application in Atmospheric Models

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Over the last decades, several case studies confirmed that it is possible to isolate the atmospheric signal delay from synthetic aperture radar (SAR) imagery and showed very promising results. However, the temporal or spatial coverage of the available satellite missions was low, which restricted the application to case studies only. With the launch of the Sentinel-1 satellites a new SAR dataset became available, with unprecedented temporal and spatial coverage. In this study we show that differential integrated refractivity (DIR) from SAR imagery can be a great data source for both validation of weather models validation and for data assimilation in weather forecasts.

To derive the DIR estimates a stack of Sentinel-1 images is processed and continuously updated. The general repeat time of the Sentinel 1a is 12 days at the equator, but by using a combination of overlapping descending and ascending orbits a repeat time of 3 to 4 can be achieved above mid-latitudes. This repeat time can be reduced to 1 to 2 days once the data from the Sentinel 1b becomes available. The DIR values are calculated by subtracting SAR retrievals at different epochs, which are corrected for topography and earth curvature. Then the resulting DIR maps or interferograms are unwrapped and the integrated refractivity of individual epochs is derived using a network approach. Finally, refractivity data from global navigation satellite system (GNSS) is used to convert relative refractivity values to absolute refractivity values.

This method results in refractivity maps with much higher resolution and accuracy than current operational weather models and measurement networks. Therefore, it gives us a unique dataset to validate weather models or improve weather models using data assimilation. Additionally, these refractivity maps could give us more insight in weather phenomena, which are not captured by other measuring techniques. To demonstrate the quality and resolution of this dataset, we will show our results alongside maps of calculated refractivity based on weather model parameters.

The development of these time series is a first step to the generation of an operational refractivity product and the implementation of this product into operational weather models.