2.14 SRI: Surface Rainfall Intensity

Overview

IRIS Surface Rainfall Intensity product, SRI, is mainly used of as input into the RAIN1 product, to get the best possible estimates of accumulated precipitation even at longer ranges from the radar.

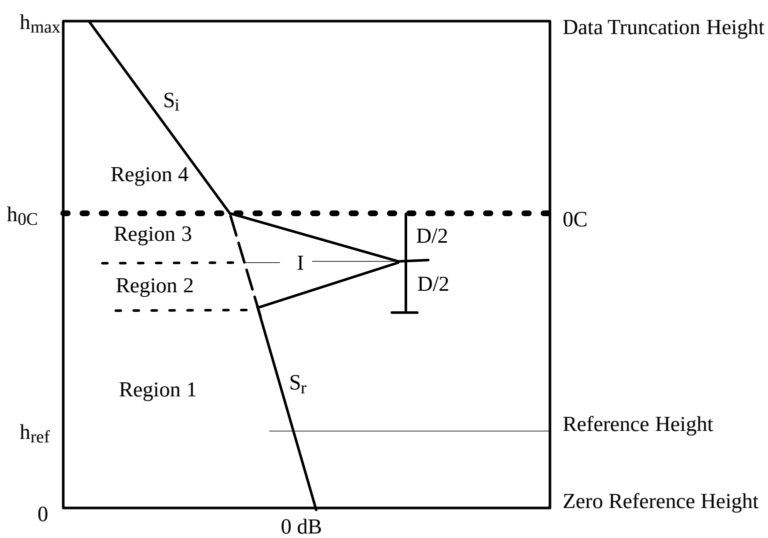
Vertical reflectivity profile is the most important source of error in radar rainfall measurements in cool and moderate climate. Upper parts of precipitating clouds give typically weaker echo than the cloud base, except near melting layer where the echo is much stronger. Thus a correction is needed to estimate surface rainfall intensity.

IRIS SRI allows the user to apply his/her local knowledge and provides several ways to input infomation of the actual reflectivity profile, as well as methods to make educated first guesses. It distinguishes convective cases from large scale precipitation, and applies the correction only to the latter, while for convective precipitation the value of the lowest clutter free bin is presented.

The reflectivity profile and freezing level estimation will not be perfect, but they will improve the rainfall estimates as compared to performing no correction. The typical corrections obtained will be of the order –10 dBZ to +5 dBZ (in mm/h scale up to factor of 4 !) depending on the freezing level altitude, distance from radar and the lowest elevation angle. For a discussion of profile corrections refer to articles mentioned in the end of this chapter.

Algorithm

Figure 2–5: Example reflectivity profile



The profile includes the following features and definitions:

- Height h=0 corresponds to the setup/product “Zero Reference Height”. This is typically set at either the nominal ground level or sea level.
- The max height corresponds to the setup/ingest “Data Truncation Height”
- The reflectivity varies linearly in dBZ above and below the bright band. Separate slopes are used above and below the bright band (S_r for the rain and Si for the ice).
- The bright band starts at the 0C level ($h=h_{0C}$), has depth D and intensity I, defined as the intensity difference between the peak and the intensity the rain would have at the center of the bright band, i.e., determined by the continuation of the rain slope into the bright band.

The surface rainfall intensity at each pixel is calculated by finding the lowest clutter–free bin, and bringing the measured reflectivity there down to reference level by making two corrections:

- 1.) The correction for the beam weighted averaging.
- 2.) The adjustment for the profile to obtain the reflectivity at the reference height.

The SRI product also supports using a terrain map to determine the height that that radar beam is corrected to. The file used is surface_height.conf in the ${IRIS_CONFIG} directory.

Convective check algorithm

In convective precipitation there is usually no detectable bright band or perhaps a very weak one. This is thought to be caused by the types of particles near the freezing level that are typical of convective precipitation. These are usually heavily rimed snowflakes, graupel, frozen drops (carried aloft) and even hail. Since these particles tend to fall more rapidly than snow aggregates, they do not contribute to a bright band in the same way as large wet snow flakes falling at 1 m/s, i.e., there is no convergence of large wet particles.

Thus in cases where the precipitation is convective, it is not appropriate to perform a profile correction that includes a bright band and serious errors could result from doing this. In the SRI product this is handled by detecting convective regions and not applying any profile correction, i.e., the measured value of the lowest clutter free bin is assigned to the reference height. This is done because in convective regions, the vertical reflectivity in the lower altitudes tends to be rather constant in height.

Each range bin is checked to determine if it is a “convective” range bin. The approach is to run an echo tops algorithm within the SRI product for a selectable threshold. Note, this is done entirely within the SRI so there is no need to define a separate TOPS algorithm for this. The product, in cylindrical coordinates, is made at the same resolution as that selected for the SRI product. It is then used as a “mask” for determining convective regions, i.e., any bin in a ray for which the top height is more than a selectable height above the freezing level is assumed to be convective.

2.14.1 Input reflectivity profiles

User defined profiles

Reflectivity profile is defined using five parameters.

- Reflectivity gradient above the melting layer. (7 dBZ/km)
- Reflectivity gradient below the melting layer. (1 dBZ/km)
- Melting layer height. (given in tenths of kilometers)
- Melting layer thickness. (1 km)
- Melting layer peak intensity (7 dBZ)

The melting layer height is given to the **setup**/product. The value can be changed without restarting IRIS by using the **setup_change** utility, thus giving a possibility to adjust the reflectivity profile frequently based on external data sources such as numerical model or temperature soundings.

The reflectivity profile is attached to the ingest file. Hence, in a network of several radars and separate analysis machine, the profile information is given to the IRIS at each radar site.

Changing the setup without restarting IRIS

Normally, when you change the setup files, you have to quit and start IRIS to have the changes valid. For SRI this is not practical, since in the case of fast moving front you might want to update the melting layer height every hour! Changing setups while IRIS is running is made by pushing information through a pipe to a program called **setup_change**.

Open a terminal window and type the following command:

```
$ echo ”iris_setup.misc.ifallspd_melts[1]=20” | setup_change –load
```

This changes the February melting level to 2.0 km. Note the number of the month is UNIX style table index, thus 0 is January, 1 is February etc. The units are in 1/10 of km. You can change many of the profile and melting level setups on the fly.

Several changes can be made at the same time, if the data is put in a file, as follows:

```
$ echo ”iris_setup.misc.ifallspd_melts[1]=20” >testfile
$ echo ”iris_setup.misc.ifallspd_melts[2]=25” >>testfile
$ cat testfile | setup_change –load
```

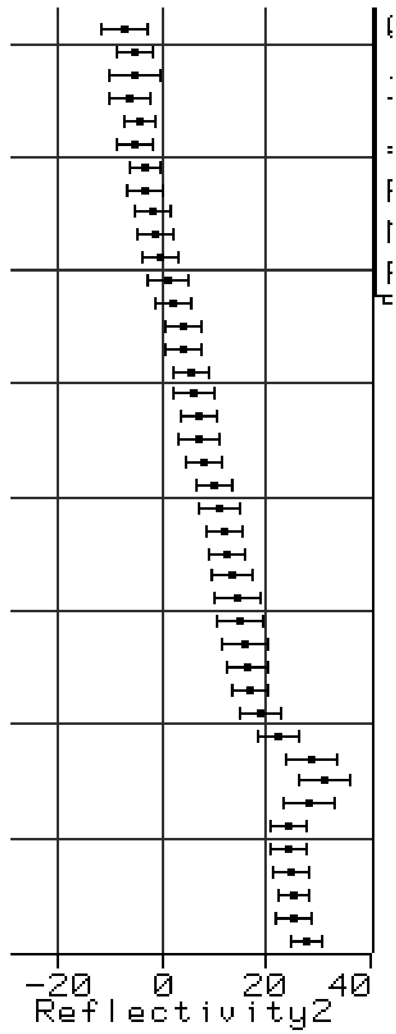
This interface is primarily intended to be invoked from automated script files. To see the current values you can type the following:

```
$ setup_change –list | grep ifallspd
```

Methods to get the input data

The most accurate way to determine the melting layer height is to study measurement from the same radar at the same time when the profile correction is needed. Melting layer is seen nicely in IRIS VVP and XSECT products of either reflectivity or, even better, vertical velocity. However, this is not always available: when the precipitation area is approaching the radar, there is data only from the upper parts of the profile.

Figure 2–6: Example of VVP Reflectivity profile



Numerical weather prediction models and balloon soundings are good sources of temperature profiles.

A bulk method is to take average temperature (daily or even monthly averages) and calculate the melting level height assuming the moist adiabatic lapse rate 6.5 deg C / km. This lapse rate is a rather good estimate during the precipitation event.

To get you started, here is a table to be used if nothing else is available. It describes a first guess of melting level height in three different climates on the Northern Hemisphere.

Table 2–2: Suggested Monthly Melting Height Values

Month	Polar climate	Mid latitudes	Tropics
January	–1	1	2.5
February	–1	1	2.5
March	–1	1.5	3
April	0.2	2	3.5
May	1.3	2.5	4
June	2.2	3	4.3
June	2.5	3.5	4.5
August	2.0	3.5	4.5
September	1.5	3	4.3
October	0.5	2.5	4
November	–1	1.5	3.5
December	–1	1.0	2.5

What if there is no melting level ?

When it’s snowing, there is no melting layer (indicate by –1 in the table above). Then the profile becomes a simple descending line, defined by parameter set

- Reflectivity gradient above the melting layer 7 dBZ/km
- Reflectivity gradient below the melting layer 0 dBZ/km
- Melting layer height. 0 km
- Melting layer thickness. 0 km
- Melting layer peak intensity 0 dBZ

The most demanding task is to get the profile right when the melting layer is close to surface. Even small errors misplace the bright band and thus lead to severe overestimation and underestimation close to the radar. If you can’t change the profile frequently, and the temperature fluctuates below and above zero with bright band appearing and disappearing, we recommend you apply the snow profile as described above. Thus you still have the bright band overestimation problems, but at least you fix all the weakening above the bright band.

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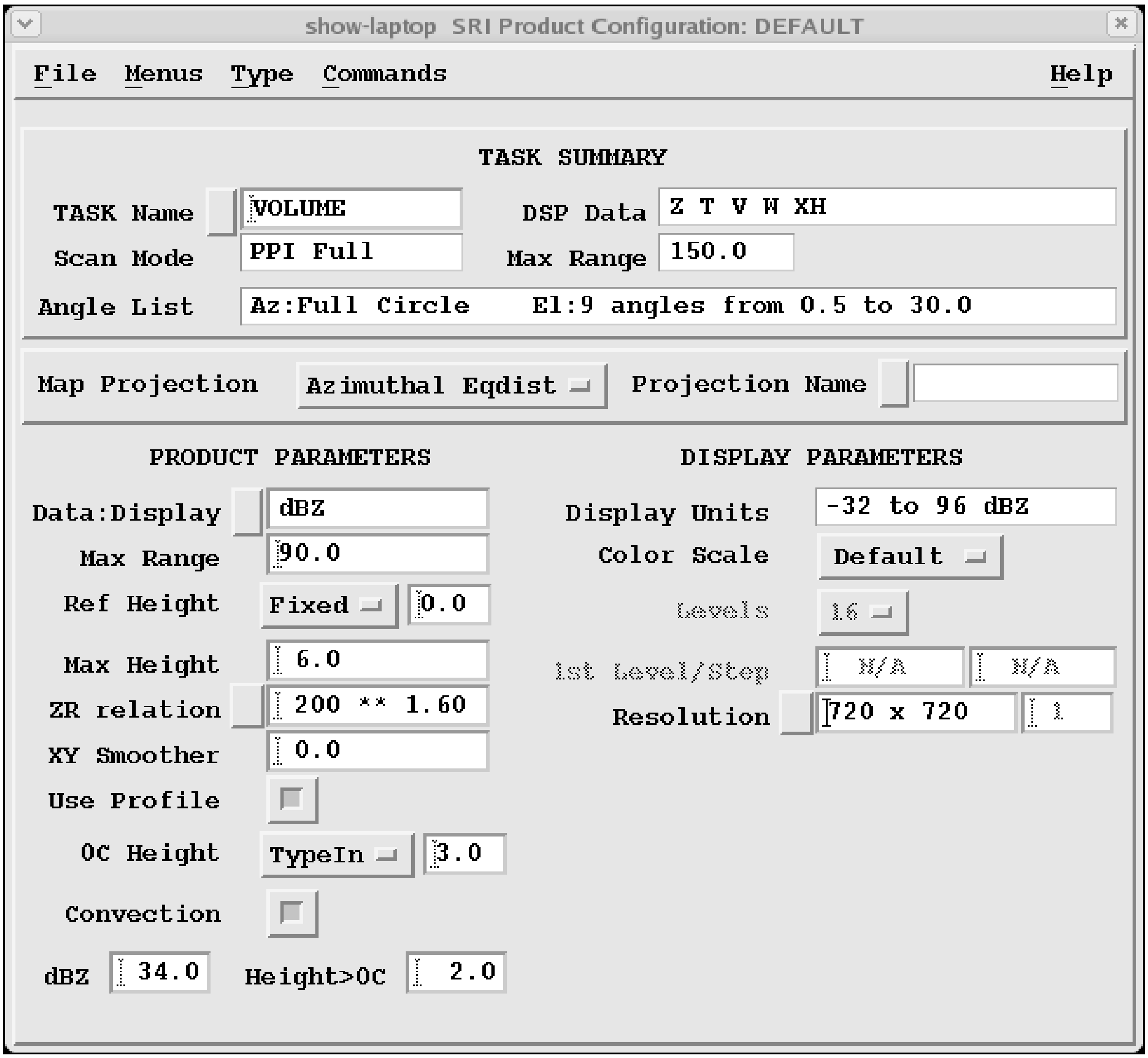
Note: Make sure you give the altitude information from external data source referring to the same reference height (sea level, antenna level) as defined in IRIS setup. Please be careful when the bright band is close to ground.

2.14.2 Product Configuration



This section describes the fields of Product Configuration menu that are unique to SRI products. For general information, see these other sections of this chapter:

- Task Summary area, Section 2.1.1
- Map Projection Area, Section 2.1.2
- Product Parameters, see Section 2.1.2
- Display Parameters area, Section 2.1.4

DSP Data and Data Display

SRI products need two kinds of data as input: T and Z values. Make sure that both are recorded in your task. For Data Display you can select if you want to see the result in dBZ or in intensity mm/h (dBZ:R) . dBZc and dBZc:R the “c” refers to the included corrections for attenuation, beam blockage, etc. as configured for the TASK. Even if you display mm/h, the convection threshold is given in dBZ.

For radar systems that import data, the SRI product can also run without T (Total power) data. In a such a mode, the “lowest clutter–free bin” feature will not be available, but the product can still be run.

Ref Hgt

Reference height to which the height of the SRI product is calculated. This is height above zero reference.

Max Height

Maximum height where the “lowest clutter free bin” is searched for. If there are no clutter free bins below this height, no correction is performed. It is important to set a reasonable level, like below 5 km. Note that at far ranges, when the lowest beam is above the Max height, the lowest beam is still used.

Use profile

Having this button on causes a profile to be used in the correction. HINT: If you want to switch the correction temporarily off, this is an easy way to do it, and you don’t have to change other places of your production chain.

0C Height

There is three ways to input the height of the freezing level: Ingest, Setup, and Type-In. For **Ingest**, the height of the freezing level is extracted from the setup on the radar computer at the time of the measurement. (This is important if you process archived data.) All the other gradient numbers are pulled from the current setup on the product computer. **Setup**, means that IRIS will use the freezing level heights given in General Setup on the product computer. **Type-In** lets you to enter the value in adjacent box, which is very convenient for interactive testing of the product.

If you have a network of radars and make the products centrally in one IRIS analysis, you can set an individual freezing level for each radar at the Setup of the IRIS radar and use “ingest” setting here. If you want to use the same freezing level for all radars and keep adjusting just one file, then you can select “Setup” here.

Convection

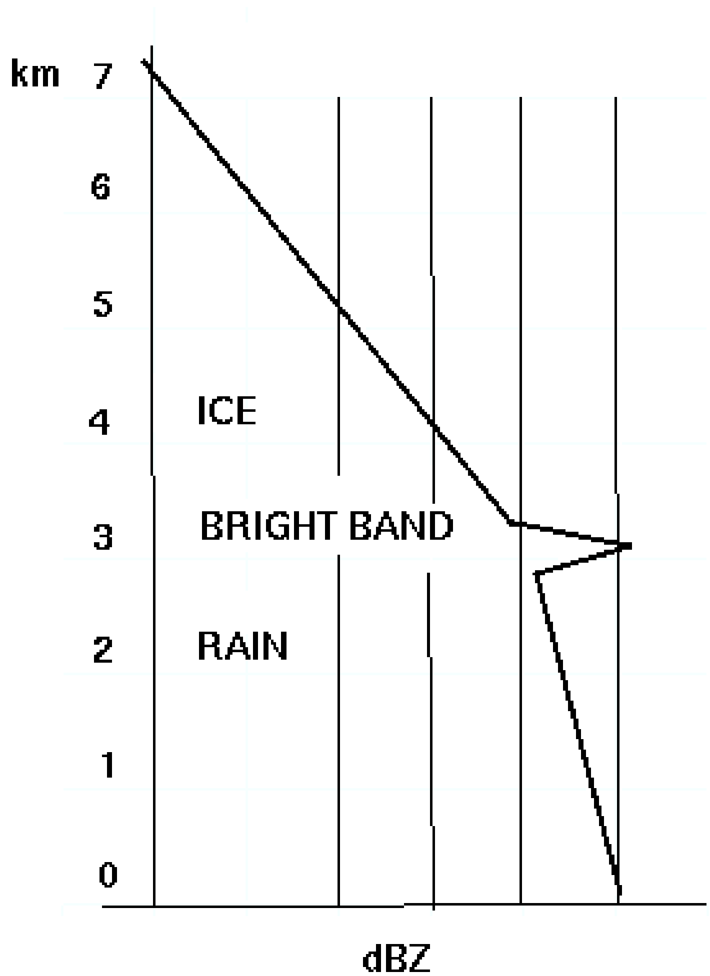
If you switch the convection check button off, all precipitation is corrected with the above given profile. If you have it on, you can define criteria to determine whether precipitation is convective or large scale, and only the later is corrected. Convection is defined as an area of strong (precipitation) echo above melting layer.

The **threshold** (in dBZ) is given in the first box. This would be determined by customers based on the intensity of convection in their locale. Typically a value of 35 to 40 dBZ would be appropriate for most locations in mid latitudes, 20 in cool climate.

The convective top **height** (how much above melting layer it should be, in km) in the next box. This would typically be set at 1 to 2 km to allow some clearance above the bright band. The suitable value for threshold height depends of the accuracy of the melting level height estimate. The smaller the value, the more often pixels are considered convective.

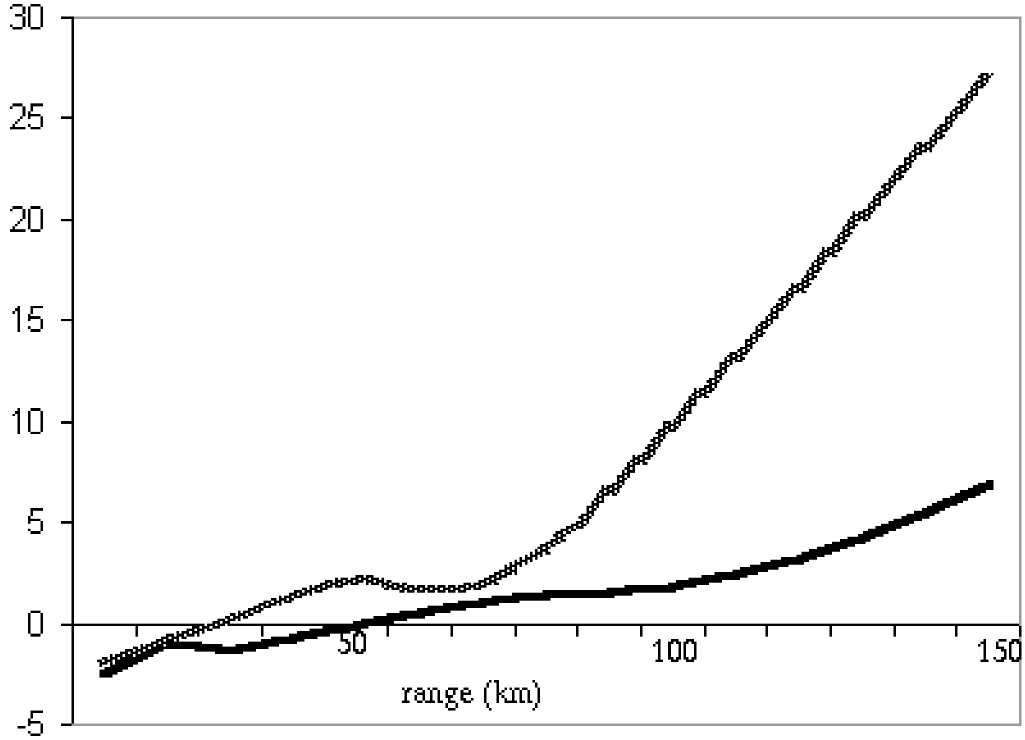
2.14.3 Correction example

Here is an example of the profile correction in a typical situation with bright band at 3 km, gradient below the bright band (in rain) 3 dBZ/km and above the bright band (in snow) 10 dBZ/km. Radar is located at height of 0 km and the reference height is at 1 km. Full power half beam width is 1 degree. The correction is calculated for 2 elevations, 1.0 degrees (in black) and 2.0 degrees (in grey). Note that the correction is negative near the radar where measurement it made below the reference height and that the curves have different shapes since the bright band is filling the Gaussian beam only partially.



The reflectivity profile in the case of the example. Note, that at high altitudes the profile soon reaches values below the minimum detectable signal MDS, and or the cloud top.

Figure 2–7: Example Profile Correction vs. Range



Profile correction in dB as function of distance from radar for elevations 1.0 degree (black) and 2.0 degree (grey).

References

Koistinen, J. (1991). Operational Correction of Radar Rainfall Errors due to the Vertical Reflectivity Profile. In *Proceedings of the 25th International Conference on Radar Meteorology,* AMS 1991, p.91–94

Joss, J. and Pittini, A. (1991): Real–time Estimation of Vertical Profiles of Radar Reflectivity to improve the Measurement of Precipitation in an Alpine Region. In *Proceedings of the 25th International Conference on Radar Meteorology,* AMS 1991, p.828–831

Vignal, B., Galli G., Joss J. and Germann, U. (2000): Three Methods to Determine Profiles of Reflectivity from Volumetric Radar Data to Correct Precipitation Estimate *Journal of Applied Meteorology* 39(10) 1715–1726